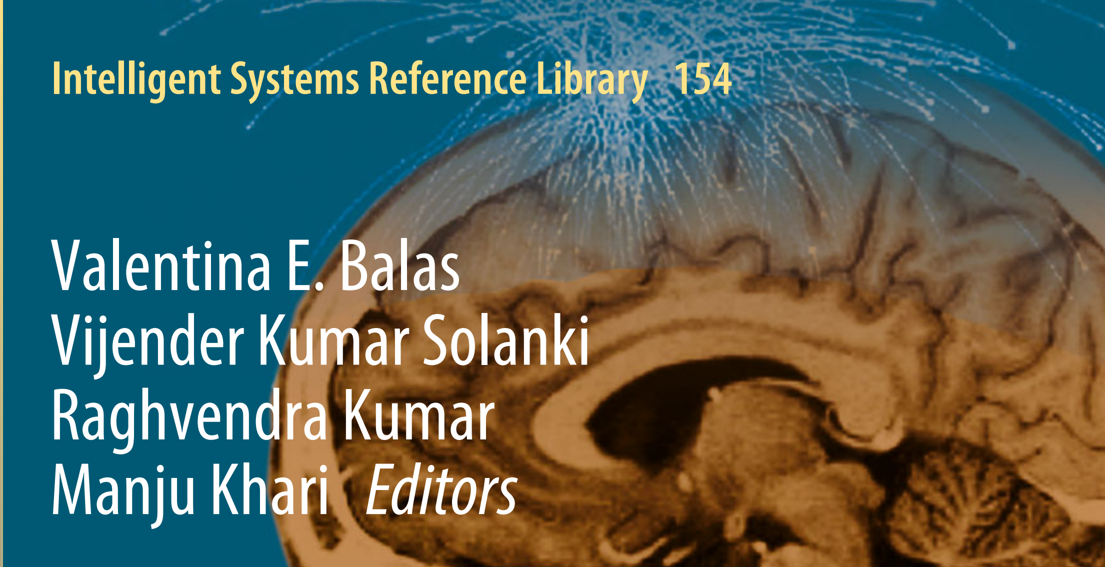
Intelligent Systems Reference Library 154



Valentina E. Balas
Vijender Kumar Solanki
Raghvendra Kumar
Manju Khari *Editors*

Internet of Things and Big Data Analytics for Smart Generation

Springer

Intelligent Systems Reference Library

Volume 154

The aim of this series is to publish a Reference Library, including novel advances and developments in all aspects of Intelligent Systems in an easily accessible and well structured form. The series includes reference works, handbooks, compendia, textbooks, well-structured monographs, dictionaries, and encyclopedias. It contains well integrated knowledge and current information in the field of Intelligent Systems. The series covers the theory, applications, and design methods of Intelligent Systems. Virtually all disciplines such as engineering, computer science, avionics, business, e-commerce, environment, healthcare, physics and life science are included. The list of topics spans all the areas of modern intelligent systems such as: Ambient intelligence, Computational intelligence, Social intelligence, Computational neuroscience, Artificial life, Virtual society, Cognitive systems, DNA and immunity-based systems, e-Learning and teaching, Human-centred computing and Machine ethics, Intelligent control, Intelligent data analysis, Knowledge-based paradigms, Knowledge management, Intelligent agents, Intelligent decision making, Intelligent network security, Interactive entertainment, Learning paradigms, Recommender systems, Robotics and Mechatronics including human-machine teaming, Self-organizing and adaptive systems, Soft computing including Neural systems, Fuzzy systems, Evolutionary computing and the Fusion of these paradigms, Perception and Vision, Web intelligence and Multimedia.

** Indexing: The books of this series are submitted to ISI Web of Science, SCOPUS, DBLP and Springerlink.

More information about this series at http://www.springer.com/series/8578

Valentina E. Balas · Vijender Kumar Solanki
Raghvendra Kumar · Manju Khari
Editors

Internet of Things and Big Data Analytics for Smart Generation

Springer

Editors
Valentina E. Balas
Department of Automatics and Applied Software
Aurel Vlaicu University of Arad
Arad, Romania

Raghvendra Kumar
Department of Computer Science and Engineering
LNCT College
Jabalpur, Madhya Pradesh, India

Vijender Kumar Solanki
Department of Computer Science and Engineering
CMR Institute of Technology
Hyderabad, Telangana, India

Manju Khari
Department of Computer Science and Engineering
Ambedkar Institute of Advance Communication Technologies and Research, Government of NCT Delhi
New Delhi, Delhi, India

ISSN 1868-4394 ISSN 1868-4408 (electronic)
Intelligent Systems Reference Library
ISBN 978-3-030-04202-8 ISBN 978-3-030-04203-5 (eBook)
https://doi.org/10.1007/978-3-030-04203-5

Library of Congress Control Number: 2018961201

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The main objective of this book publication is to explore the concepts of big data and IoT along with the recent research development. It also includes various real-time/offline applications and case studies in the field of engineering, computer science, IoT with modern tools and technologies used. As populations grow and resources become scarcer, the efficient usage of these limited goods becomes more important. The campuses are getting IoT enabled, Sensors and the work data and involvement of networking, is creating smart campuses, corporate houses. The book will be covering edited chapters belong to the IoT and Big Data Technologies.

The book is organized into thirteen chapters. Chapter 1 discusses the insight about Big Data and its journey toward advanced levels for smart generations.

Chapter 2 throws light on IoT, Big data, their relevance, data sources, big data applications, IoT architecture and security challenges, standards and protocols for IoT, single points of failure, IoT code, etc.

Internet of things is the trending technology and embodies various concepts such as fog computing, edge computing, communication protocols, electronic devices, sensors, geo-location. Chapter 3 presents the comprehensive information about the evolution of Internet of things and its present developments to its futuristic applications.

Chapter 4 discusses revolution in the transport environment needs redesigning the infrastructure so that the production of embedded vehicles can be chained to an embedded traffic management system. This instinctual design of the traffic control and management system can lead to the improvement of the traffic congestion problem. The traffic density can be calculated using a Raspberry Pi microcomputer, and a couple of ultrasonic sensors and the lanes can be operated accordingly. A Web site can be designed where traffic data can be uploaded, and any user can retrieve it. This property will be useful to the users for getting real-time information and detection of any road intersection and discover the fastest traffic route.

Chapter 5, explore new encryption algorithm is proposed and designed which is followed by a verification algorithm used to access such Internet of things (IoT)-based systems. A three-layer encryption algorithm (3LEA) is designed to generate a cryptographic Quick Response (QR) tag. In order to use this QR-tag as a secret key with IoT-based systems, a three-process verification algorithm (3PVA) has been proposed to verify QR-tag values. In order to make a decision either to approve or to disapprove a request to access an IoT-based system, a three-layer protection algorithm (3LPA) is proposed.

Chapter 6 explores the difficulties that are posed by the implementation of service automation and social robotics to assist tourists. The basic idea behind wall-climbing robots is that the vacuum can be generated inside a suction cup at the bottom of the robot chassis, which is used to create a grip on the wall on which the robot is to climb. Wall-climbing robots are beneficial to a home automation system as this can enable the robot to not interfere with any human activity in the room. This also reduces the chance of collision with any human or objects in the environment and also avoids any hindrance to human activity in the room in which the robot has been deployed.

Chapter 7 analyzes and presents the smart cities evolution, architectures, applications, technologies, standards, and challenges in detail. It helps the reader to understand the coherence of smart cities development using IoT.

The goal of Chap. 8 is to give a thorough review on the possibility of the sharp city other than their unmistakable applications, preferences, and purposes of intrigue. Likewise, a substantial segment of the possible IoT headways are displayed, and their capacities to focalize into and apply to the unmistakable parts of sagacious urban groups are discussed. The potential utilization of splendid urban territories concerning development headway later on gives another critical exchange in this area. In the meantime, some helpful experiences everywhere throughout the world and the key limits to its utilization are out and out imparted. IoT potential applications can help us for the evolution in smart city infrastructure. In this chapter, we discuss the different potential applications of Internet of things for smart city infrastructure. Discussion about the big data is also considered for enhancing the knowledge about smart infrastructure, and in the last section, I also provide the recommendation for adopting smart city infrastructure earlier.

In Chap. 9, the smart home resources have been taken and implemented through Restlet framework. The generated RDF graph is semantically interoperable and intercommunicated between the IoT-based smart home resources. The proposed framework has been implemented on IoT-based cloud platform and has been compared with the existing state-of-the-art schemes with obtained results. Finally, the obtained results show that the proposed framework is optimized toward the semantic interoperability in IoT domains for smart home applications.

Chapter 10 discusses the major case studies referred in this that are ATMS trail done across Chennai (2009), ATIS in Bangalore and Hyderabad, and APTS in Bangalore, Chennai, and Indore. The Bus Rapid Transport (BRT) across different places across India is an alternative to metro rail at Pune, Ahmadabad, and Chennai. Electronic toll collection (ETC) and advanced parking management are some of the applications of ITS which gained certain ground across India. Ultra-low-power Bluetooth 5 technology, 5G networks, and cellular IoT concept create a lot of opportunities in realizing ITS in India.

Chapter 11 aims to achieve more accuracy, for sarcasm detection, than the prevalent approaches by focusing on the data cleaning process. The purpose is to identify the levels of sarcasm from the text written by the users on social media blogs and online articles and determine their personality traits and any changes observed in the personality traits over a period of time. This classification is achieved using supervised classification algorithms, and a comparative study is performed. Gender-based experiments are conducted to observe changes in the level of sarcasm and personality traits in both the genders along with bloggers from varied professions. The outcome of this research is to understand the effect of events, seasons, gender, profession, etc., on sarcasm and personality traits over the period of time.

Chapter 12 focuses upon the potential knowledge of 4 V's of big data namely Volume, Velocity, Variety, and Veracity by a radical improvement through productivity bottlenecks being unlocked. This will bring a radical change in the quality and accessibility of healthcare automation.

Chapter 13 proposes a case study that will examine and explain a complete design and implementation of a typical IoT-ITS system for a smart city scenario set on typical Indian subcontinent. This case study will also explain about several hardware and software components associated with the system. How concepts like multiple regression analysis, multiple discriminant analysis, logistic regression, conjoint analysis, cluster analysis, and other big data analytics techniques will merge with IoT and help to build IoT-ITS will also be emphasized. The case study will also display some big data analytics results and how the results are utilized in smart transportation systems.

We are sincerely thankful to Almighty to supporting and standing in all times with us, weather its good or tough times and given ways to conceded us. Starting from the call for chapters till the finalization of chapters, all the editors gave their contributions amicably, which was itself a positive sign of significant teamworks. The editors are sincerely thankful to all the members of Springer (India) Private Limited, especially Prof. (Dr.) Lakhmi C. Jain, S. Tigner, and Aninda Bose for providing constructive inputs and allowing opportunity to edit this important book. We are equally thankful to a reviewer who hails from different places in and around the globe shared their support and stand firm toward quality chapter submission. The rate of acceptance we have kept was as low as 16% to ensure the quality of work submitted by the author.

The aim of this book is to support the computational studies at the research and postgraduation level with open problem-solving technique. We are confident that it will bridge the gap for them by supporting novel solution to support in their problem-solving. At the end, the editors have taken utmost care while finalizing the chapter to the book, but we are open to receive your constructive feedback, which will enable us to carry out necessary points in our forthcoming books.

Arad, Romania — Valentina E. Balas
Hyderabad, India — Vijender Kumar Solanki
Jabalpur, India — Raghvendra Kumar
New Delhi, India — Manju Khari

Key Features

1. This book will provide in-depth information about big data and IoT.
2. Technical approach in solving real-time/offline applications.
3. Practical solutions through case studies in big data and IoT.
4. Companies may get different ways to monitor data cong from various sources and modify their processes accordingly to prevent it from catastrophic events through case studies.
5. The Big data and future horizon.
6. The interdisciplinary tools and cases of IoT and Big data.

Contents

About the Editors

Valentina E. Balas, Ph.D., is currently full professor in the Department of Automatics and Applied Software at the Faculty of Engineering, "Aurel Vlaicu" University of Arad, Romania. She holds a Ph.D. in applied electronics and telecommunications from Polytechnic University of Timisoara. Dr. Balas is the author of more than 270 research papers in refereed journals and international conferences. Her research interests are in intelligent systems, fuzzy control, soft computing, smart sensors, information fusion, modeling, and simulation. She is the editor in chief to *International Journal of Advanced Intelligence Paradigms* (IJAIP) and to *International Journal of Computational Systems Engineering* (IJCSysE), editorial board member of several national and international journals, and is evaluator expert for national and international projects. She served as general chair of the International Workshop Soft Computing and Applications in seven editions 2005–2016 held in Romania and Hungary. Dr. Balas participated in many international conferences as Organizer, Session Chair and member in International Program Committee. Now she is working in a national project with EU funding support: BioCell-NanoART = Novel Bio-inspired Cellular Nano-Architectures—For Digital Integrated Circuits, 2M Euro from National Authority for Scientific Research and Innovation. She is a member of EUSFLAT, ACM and a Senior Member IEEE, member in TC—Fuzzy Systems (IEEE CIS), member in TC—Emergent Technologies (IEEE CIS), member in TC—Soft Computing (IEEE SMCS). Dr. Balas was vice president (Awards) of IFSA International Fuzzy Systems Association Council (2013–2015) and is a joint secretary of the Governing Council of Forum for Interdisciplinary Mathematics (FIM),—A Multidisciplinary Academic Body, India.

Vijender Kumar Solanki, Ph.D., is an associate professor in the Department of Computer Science and Engineering, CMR Institute of Technology (Autonomous), Hyderabad, TS, India. He has more than 11 years of academic experience in network security, IoT, Big Data, smart city, and IT. Prior to his current role, he was associated with Apeejay Institute of Technology, Greater Noida, UP, KSRCE (Autonomous) Institution, Tamil Nadu, India, and Institute of Technology and Science, Ghaziabad, UP, India. He has attended an orientation program at

UGC-Academic Staff College, University of Kerala, Thiruvananthapuram, Kerala, and Refresher course at Indian Institute of Information Technology, Allahabad, UP, India. He has authored or co-authored more than 25 research articles that are published in journals, books, and conference proceedings. He has edited or co-edited four books in the area of information technology. He teaches graduate- and postgraduate-level courses in IT at ITS. He received Ph.D. in computer science and engineering from Anna University, Chennai, India, in 2017 and M.E. and MCA from Maharshi Dayanand University, Rohtak, Haryana, India, in 2007 and 2004, respectively, and a bachelor's degree in science from JLN Government College, Faridabad Haryana, India, in 2001. He is editor in *International Journal of Machine Learning and Networked Collaborative Engineering* (IJMLNCE) ISSN 2581-3242, associate editor in *International Journal of Information Retrieval Research* (IJIRR), IGI-GLOBAL, USA, ISSN: 2155-6377 | E-ISSN: 2155-6385 also serving editorial board members with many reputed journals. He has guest-edited many volumes, with IGI Global, USA, Inderscience, and many more reputed publishers. For more details, please visit https://www.sites.google.com/site/vijenderkrsolanki.

Raghvendra Kumar, Ph.D., has been working as assistant professor in the Department of Computer Science and Engineering at LNCT College, Jabalpur, MP, and he received Ph.D. (Faculty of Engineering and Technology) from Jodhpur National University, Jodhpur, Rajasthan, India. He completed his Master of Technology from KIIT University, Bhubaneswar, Odisha, and his Bachelor of Technology from SRM University, Chennai, India. His research interests include graph theory, discrete mathematics, robotics, cloud computing and algorithm. He also works as a reviewer, and he is an editorial and technical board member for many journals and conferences. He regularly publishes research papers in international journals and conferences and is supervising postgraduate students in their research work.

Manju Khari, Ph.D., is assistant professor at the Ambedkar Institute of Advanced Communication Technology and Research, under Government of NCT Delhi, affiliated with Guru Gobind Singh Indraprastha University, India. She is also professor in charge of the IT Services of the Institute and has more than 12 years' experience in network planning and management. She holds a Ph.D. in computer science and engineering from the National Institute of Technology Patna and received her master's degree in information security from Ambedkar Institute technology of Advanced Communication Technology and Research, Delhi, India. Her research interests are in software testing, software quality, software metrics, information security, and nature-inspired algorithms. She has published 60 papers in refereed national and international journals and conferences and has authored six chapters and co-authored two books. She is a life member of various international and national research societies (SDIWC, IAENG, etc.). She is also guest editor of the *International Journal of Advanced Intelligence Paradigms*, reviewer for the *International Journal of Forensic Engineering*, and editorial board member of the *International Journal of Software Engineering and Knowledge Engineering*.

Chapter 1
Theoretical Analysis of Big Data for Smart Scenarios

Vijender Kumar Solanki, Sandhya Makkar, Raghvendra Kumar and Jyotir Moy Chatterjee

Abstract As of late, because of progression of web innovations and instrumentation of all aspects of our life, we have seen an immense flood in information accessible to us. This insurgency is named as Big Data. This Big Data can't be prepared or overseen by any conventional techniques for handling. This has prompted advancement of a few elite and appropriated shared technologies and programming systems. The outline of such frameworks depends on conveyed registering ideas which are actualized as frameworks, for example, Clusters and Clouds, and Big Data structures, for example, MapReduce and Stream Computing. These frameworks assume a vital part in todays' market overview, the scholarly community or businesses by giving the preparing of information produced from an assortment of arranged assets, e.g. huge information stores and data storehouses, costly instruments, internet based life, sensors systems, and media administrations for an extensive variety of uses. The measure of information in our reality has been detonating, and examining expansive informational collections supposed huge information will turn into a key premise of rivalry, supporting new rushes of profitability development, advancement, and buyer excess, as per inquire about by MGI and McKinsey's Business Technology Office. Pioneers in each part should think about the ramifications of huge information, not only a couple of information arranged supervisors. The expanding volume and detail of data caught by undertakings, the ascent of mixed media, web based life, and the Internet of Things will

V. K. Solanki (✉)
CMR Institute of Technology (Autonomous), Hyderabad, TS, India
e-mail: spesinfo@yahoo.com

S. Makkar
Lal Bahadur Shastri Institute of Management, New Delhi, India
e-mail: bajajsandhya@gmail.com

R. Kumar
Department of Computer Science and Engineering, LNCT College, Jabalpur, India
e-mail: raghvendraagrawal7@gmail.com

J. M. Chatterjee
Asia Pacific University of Technology & Innovation, Kathmandu, Nepal
e-mail: jyotirm4@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_1

fuel exponential development in information for a long time to come. In this present chapter, we are trying to provide insight about Big Data and its journey towards advanced levels.

Keywords Big data · Distributed computing · Clusters · Cloud computing
Haddop and MapReduce

1.1 Introduction

The talk of the town recently is the Digital Virtual Assistant. The virtual assistants are all soldiers in the tech world's latest battle in digitization. From Siri to Alexa and Google Assistant to Bixby, now they know more than what you know about you [1–3]. The digital life of a person now revolves around these assistants and they are running the human beings instead the other way around. These assistants are now embedded in the operating systems of smart phones reading our data without a person being aware and providing the right information at right time to us. Sometime, we feel thrilled and magical, the other times; it seems that our privacy is at stake. It can be said that we assent computerized footprints in everything done that involves an advanced activity and these digital footprints accumulate and make huge data. Over this, the measure of machine-created information is quickly growing as well. This growing data is stored and used by the firms to grow their business and is termed as 'Big Data' Concept of 'Big Data' is continually evolving and being reexamined, as it remains the driving power under the umbrella of Artificial Intelligence. Information is created and distributed when our "smart" home devices contact within one another or to their home servers. Industry Machine in plants and processing units far and wide are increasingly furnished with sensors that assemble and transmit data. Be that as it may, what precisely is Big Data and how is it changing our reality, the chapter attempts to answer such questions that are there in everyone's mind. This chapter will provide a broad synopsis of Big Data for executives and managers seeking to implement new technologies in their business processes to avail the optimum usage of loads of data available to them [4, 5]. The chapter is also advantageous for researchers and academicians as it will help them to be abreast with the technologies and market requirement of today. The chapter includes the understanding of Big data together with the current applications for newcomers in the field. It also mentions the historical backdrop of Big data and the emergence of the same. The chapter takes you to the journey from antiquity through the adoption approaches used by the firms together with essential tools and technologies available to organize and manipulate Big data. Discussion on pitfalls and challenges while implementing and using technologies of big data is vital to present in the chapter. In the end the job market for current field is presented [6].

1.1.1 Understanding Big Data

Data is the heart of everything today. It is said that a person is rich if he has data. It is the past we look at, is the present we understand and is the future to predict. According to the reports provided by various websites that give live stats of the happenings on internet, shows some astonishing results that happen in a second. In a second around 46% of people are online on internet. There are around 8093 tweets sent in a second, 853 photos are uploaded on Instagram, 2million emails are sent, 74,226 videos are uploaded on you tube and the list goes on. The numbers of internet users have increased ten folds in 21st century and 48.5% of users are in Asia. These surprising figures generate tons of data. According to IBM, 2.5 quintillion bytes of data are made each day. The sources of information in visible form are social networking platforms, computerized images, motion film, transactions, search engines, global positioning systems etc. in form of numbers, pictures, videos, emails. This makes a data big and its collection, sorting, organizing, analyzing and interpreting is termed as 'Big Data' [7, 8]. The data keeps on growing, but it's irrelevant to keep on collecting the data without its meaning. Therefore, extracting a relevant real time data and analyzing it to take out information according to the need of the study becomes vital. Big Data is now in its nascent phase, evolving and emerging itself. If asked, what big data is for you, the answers could be 'terabyte, gigabyte, petabyte, and exabyte of data 'or' anything beyond the human mind can think of'. The answers could be true but big data is much more than this. According to Gartner 'Big data is high-volume and assortment information utilities that request practical, innovative types of information processing for upgraded insights and decision making'. If data would have been only one of these i.e. either volume (too large) or variety (mix a structured, unstructured, semi structured data) or velocity (growing at a fast pace), it would have been relatively easy to hold it. However, data generated with mix of all three V's complicate the scenario. Above this, the cost of managing the data increase tremendously. The varying veracity and value of data complicate the situation further. Data further generate more data. At business level, the data makes a cycle and grow bigger and bigger.

Volume: Volume refers to the size or extent of data. As discussed earlier there are variety of sources of data generation like social media platforms, digital pictures, videos, purchase transactions, search engines, global positioning systems etc. in form of numbers, pictures, videos, emails etc. Data is also generated by machines, networks and human interaction and data itself generates more data. Therefore, the traditional systems of weighing the data in Giga Bytes and Terabytes cannot be used these days because of presence of enormous volume of data. This data is so huge and is measured in Petabytes and exabytes and its enthralling if one could analyses this huge data to get some useful insights. Within the advent of Artificial Intelligence and Machine Learning, this has been made possible by companies like Google, Facebook, LinkedIn etc. to handle such huge data to extract meaningful information [9].

Velocity: Velocity is the rate at which data is generated and examined. If traditional data is like bullock cart, big data is like a luxurious fast paced car. Because of the various sources of data, it's difficult to have a control on such huge data. The reason of such fast-paced data generation is due to the freely available internet by mobile companies to capture the market, moreover the increased speed of internet is also another reason that generate and communicate data at fast pace. There is variety of digital devices available like smart phones; laptops etc. that even small retail firms are now able to generate data for their business. This data provides information about customers, like the timeline of their location, their buying pattern, their likes and dislikes, their demographics like age, family members, salary etc. This enables firms to create a real-time analysis and capture the market [10].

Variety: Variety refers to structural heterogeneity in data set. Big data is inclusive of all forms of data, for all kinds of functions, from all sources and devices. If traditional data were such as invoices and ledgers like a small store, big data is the biggest imaginable shopping mall that offers unlimited variety [11]. The data can have variety of forms viz. Form as in texts, graphs, maps etc., other is Function that defines the human conversations, songs, movies as in social media platforms and source data from machines like mobile phone, tables, RFID etc. like sensors from machines. When this data lacks structure like in texts, images or audios the data is termed as Unstructured Data or else Structured Data. Spanning a continuation between completely organized and unorganized data, the arrangement of semi-organized data does not fit in with strict models.

Veracity: IBM framed Veracity as the fourth V, which epitomize to the inconsistency or uncertain nature of data. There is always a chance of error in understanding the pattern even when we predict or analyze the data because of complex and uncertain nature of human being or due to chance of error in collecting data [12]. This misinformation or technical error must be rectified to be put to any great use and are dealt with big data analytical tools. All these four characteristics are not independent and work simultaneously; as per say volume of data may provide variety and vice versa. Volume may lead to veracity. According to the survey of Fortune 1000 companies by Harvard Business Review about the Big Data investments following results came out. The respondents were 1000 CEO's Presidents who were interviewed. Nearly one-half of all executives indicated that they have decreased expenses as a direct result of their investments in big data. Around 30% says that they have started to see the increase in revenue but other 70% of population has either started but not seen or not even started to see the revenue. Big transformations take time, and with the advent and further growth of Big data Technologies, it will initiate to give big returns also.

1.1.2 Applications of Big Data Analytics

Analysis of Big data is challenging and empowering. It gives businesses to investigate the insights to generate revenue by tapping customer base. The New

Table 1.1 Real time applications

Companies	Applications
Amazon	Improve customer relations, personalized recommendation system, book recommendations from kindle highlighting, one-click ordering, anticipatory shipping model, supply chain optimization, price optimization, Amazon web services
American Express	Forecast of potential churn and customer loyalty, Big Data, cloud computing and mobile infrastructure laboratory, combining client exchange and interactions data to foresee client changes
BDO	To identify risk and fraud
Capital one	Examination of the socioeconomics and spending propensities for clients, to find ideal occasions to show different offers to customers
General Electric	To create tools and upgrades for increased proficiency
Miniclip: Gaming Platform	To monitor and improve user experience, measure the successful elements, eliminating or improving the problematic components
Netflix	To view habits of millions of international consumers, programme content that appeals globally
Next Big Sound	Give insight into internet based life ubiquity, the effect of TV appearances
StarBucks	To determine the potential accomplishment of each new area, taking information on area, traffic, territory statistic and client conduct into account
TMobile	Information on billing and client relations administration alongside data via web-based networking media use, T-Moblie USA claims they split client abandonments within a single quarter

York Stock Exchange produces around 1 TB of new exchange data every day. Measurement demonstrates that 500 + TBs of new data gets ingested into the databases of web based life webpage Facebook, consistently [13–15]. This data is mainly produced as far as photograph and video transfers, message trades, putting remarks and so on. Single Jet engine can produce 10 + TBs of data in 30 min of a flight time. With numerous thousand flights for every day, age of data comes to up to numerous PBs. The organizations can utilize this data further bolstering their good fortune; automating forms, gaining insight into their objective market and improving by and large execution using the input promptly accessible. Following are some of the top-notch companies using big data for boosting their brand (Table 1.1).

Big Data is also used to understand the behavior of customer and targeting them, accepting and optimizing business forms, individual capability and execution improvement, improvising healthcare, improving science andresearch, enhancing machine and gadget performance, improvising security and law performance, enhancing the traffic flows in and around the cities or countries and financial trading, Forecasting and acknowledging to normal and artificial catastrophes, Preventing crime to name a few more. And with the advent of new technologies, it will keep on giving promising results.

1.2 Emergence and Growth of Big Data Analytics

The evolution of IT, internet and globalization has facilitated enormous data and information. It in turn supported the discovery of Big Data. The story of Big data is not new and we may say that it's evolution started at as early as in 1940s when a Wesleyan University Librarian observed that in every 16 years, libraries of American Universities are doubling in size and by 2040, the Yale University will have over 200 million volumes that would require more than 6000 miles of shelves and 6000 people to manage those shelves. In 1960s, the author of Book 'Automatic data Compression' stated the "The 'information explosion' noted as of late makes it basic that capacity necessities of every data are kept to least possible. A completely programmed and fast 3-section blower that could be utilized having "any" assortment of data to extraordinarily lessen moderate outer prerequisites and to expand the rate of data information transmission done by a PC is depicted in this paper [16, 17]. In 1970s Arthur Miller author of 'The Assault on Privacy' stated "Excessively numerous data handlers appear to measure a man by the number of bits of limit constrain his dossier will have." In 1980, Tjomsl said in his discussion ione of the IEEE symposium that "Those related with capacity gadgets long back understood that Parkinson's First Law might be summarized to portray industries data extends to fill the space accessible". I trust such a huge data were kept on the grounds that clients have no chance to get of identifying out of date data; the punishments for storing out of date information were not much evident that was the punishments for abandoning conceivably valuable information." Another research conducted in Hungary Central Statistics Office measured the volumes of information in bits in 1981. The turning point came when in 1990s the Digital Storage became more economical than paper storage and challenges to store the data became apparent. The following data gives the summary of the progress of big data according to Forbes. According to Gartner, 72% of the organizations intend to increment the investment on big data investigation however 60% really expressed which were needed by individuals having qualitative profound scientific abilities. Only 22% of the information delivered was acceptable esteem, of that rarely 5% of the information was utilized from examination by trading. EMC examine gauges by 2020, 35% of the information created might take acceptable esteem. According to IDC, the ending verge of 2020 trading activities in the internet i.e. B2B and B2C activities might surpass 450 billion consistently. The quantity of IT administrators tracing the information development might surplus by 1.5 times. There may be interest of 75× additional documents and 10× additional servers. End verge of 2020, 1/third of the information created in this advanced world might live on or go within the cloud. Gartner estimated around 4.9 billion items might be connected through Internet in ending verge of 2015 that is required to achieve 25 billion till 2020. Human Genome decipher prior took 10 years till date within appearance of big data examination. In 2015, Google turned into the biggest big data organization on the planet which stores 10 billion GBs of information and procedures around 3.5 billion demands each day. Amazon is the organization with highest amount of servers—the 1,000,000,000 GBs of big data delivered by Amazon and its 152 million clients is put away on in excess of 1,400,000 servers in different information focuses. By the beginning of an advanced period established on information totally, openings in big data business for PC software engineers, clients, business visionaries and other IT persons were developing as big data develops tremendously. Organizations which send a troublesome trade demonstrate their strong spotlight on information might be "The Next Big Thing" within the industry. According the reports of CSC, in 2020, that is not too far, the scenario will looks like the Story of Big Data [18].

1.3 Adoption Approaches

This section provides pointers of execution plans and related challenges while adopting big data analytics. Adoption of big data analytics can provide firms various advantages like, it can diminish dormancy by a request of size, providing openness to data in minutes or seconds rather than hours or days, it increases the ability to store data by a request of extent, moving from TBs to PBs [19–22], it offers a much lower cost of acquisition and operation, the cost, is reduced by an order of magnitude as it requires less administrators. There are two approaches of adopting Big Data Analytics into processes viz. the revolutionary approach and the evolutionary or hybrid approach (Fig. 1.1).

The revolutionary method includes making a fresh out of the box new Big Data Analytics environment. We move every one of the data to the new environment, and all reporting, modeling, and integration with business forms occurs in the new environment. This approach has been received by numerous Greenfield investigation driven organizations. They put their expansive stockpiling in the Hadoop environment and construct an investigation engine on the highest point of that environment to perform orchestration. The conversation layer utilizes the orchestration layer and integrates the outcomes with client facing forms. The put away data can be investigated using Big Data instruments. This approach has given stunning execution however have required high tooling expenses and abilities.

In a normal evolutionary method, Big Data turns into an input to the present BI stage. The data is amassed and broke down using organized and unstructured instruments, and the outcomes are sent to the data distribution center. Standard modeling and reporting instruments currently approach online networking estimations, use records, and other prepared Big Data things. Ordinarily, this approach

Fig. 1.1 The Big Data approach

requires sampling and processing Big Data to hold the stockroom from the gigantic volumes. The evolutionary approach has been received by develop BI organizations. The design has an ease section edge and in addition minimal effect on the BI organization; however it can't give the noteworthy upgrades seen by the Greenfield administrators [22–25]. In many cases, the kind of examination and the general end-to-end speed is constrained by the BI environment. This approach advanced effectively by IBM's Information Agenda group puts the AAP design over existing BI infrastructure. All the Big Data courses through AAP, while conventional sources continue to give data to the data stockroom. We build up several integration points to bring data from the distribution center into the examination engine, which would be seen by the data stockroom as a data store. An example of the AAP data would be coordinated back to the data distribution center, while the vast majority of the data would be put away using a Hadoop stockpiling stage for disclosure. The half breed design gives the better of the two universes; it empowers the present BI environment to function as previously while siphoning the data to the AAP engineering for low-inactivity investigation. Depending on the transition achievement and the capacity to advance abilities, the crossover approach gives an important transition to full conversion. Both the revolutionary and the hybrid architectures significantly challenge the data governance function.

1.4 Implementation Challenges

This section describes the new set of issues and how to handle them. There are three broad categories of questions that are requires attention while implementation.

Merging internal and external data: Due to the access of more and more data, its now possible to firms to tap on consumers likes and dislikes, their demographics and tastes and commerce needs. It becomes necessary to understand that this information should be fully utilized by organizations to grow their businesses and for that they should merge this data with already present information with them [26]. While merging this newly acquired data, they should be careful and closely monitor how the data is being used and how it is being aggregated. All this occurs as we radically change the rules on data privacy, redefine MDM, and encounter new concerns relating to data quality.

Big Data veracity: Customer data comes from a variety of "biased" samples with different levels of data quality. It is vital to homogenize this data for the optimum usage. As it is homogenized, we must establish confidence levels on raw data, as well as aggregations and inferences, in order to understand and remind users of the "biases "built into the sourced data [27].

Information lifecycle management: This is a lot more data than we have ever encountered before. Our current analytics systems are not capable of ingesting, storing, and analyzing these volumes at the required velocities. How do we store, analyze, and use this data in real-time or near real-time, this is a lot more data than we have ever encountered before. Our current analytics systems are not capable of ingesting, storing, and analyzing these volumes at the required velocities. We may decide to store only samples of the data or use Hadoop for the storage and retrieval of large volumes of unstructured data.

1.5 Big Data Under Considerations

Big Data provides with exceptional ideas and openings, yet it additionally brings up concerns and issues that must be tended to:

Data protection: The Big Data currently created having a considerable measure of data of our private life's, most of them having a privilege to kept personal [28]. Expanding, that were requested to keep a harmony among the measure of private information we reveal and the continuance of Big Data-controlled applications and administrations works.

Data safety: Even in the event that we choose we are glad for someone to have our data for a specific reason, would we be able to confide in them to protect it.

Data intolerance: When everything is known, will it turn out to be satisfactory to discriminate against individuals in view of data we have on their lives. We as of now utilize acclaim keeping count to choose which person could acquire fund and coverage is intensely information oriented. We may hope to be investigated and evaluated in more prominent details and responsibility essentially be taken that is not done in the kind that is creating life much troublesome for the individuals who as of now has less assets and approach to data. Overcoming these difficulties is an essential piece of Big Data, and that should be tended to by organizations that need to exploit data. Inability to do as such can leave businesses helpless as far as their reputation, as well as lawfully and financially [29].

1.6 Big Data Market

According to a CRN Report of 2018, following would be the companies recommended to work for in Big Data field. The full list can be seen in [22] Industry persons, academia and other important partners mainly concur that big data have turned into a huge distinct advantage in maximums, if not every, kinds of present day organizations in the course of the most recent couple of years. As big data persists to pervade one's everyday life's, that have been a critical move of center from the publicity surrounding it to finding genuine incentive in its utilization. While understanding the estimation of big data continues to remain a test, other pragmatic difficulties including funding and rate of profitability and abilities continue to remain at the forefront for various diverse industries that are adopting big data. So, a Gartner Survey for 2015 [23] shows that over 75% of organizations are investing or are planning to invest in big data in the following two years. These findings speak to a huge increase from a comparable overview done in 2012 which indicated that 58% of organizations invested or were planning to invest in big data within the following 2 years. By and large, most organizations have a few objectives for adopting big data ventures. While the essential objective for most organizations is to improve client encounter, different objectives include cost reduction, better focused on marketing and making existing procedures more proficient. As of late, data ruptures have likewise made upgraded security a critical objective that big data ventures look to incorporate.

Big data and its application in various industries will enable you to more readily acknowledge what your part is or what it is probably going to be later on, in your industry or crosswise over various industries.

Banking and Securities: An investigation of 16 extends in 10 top investment and retail banks [19] shows that the difficulties in this industry include: securities misrepresentation early warning, tick examination, card extortion detection, authentic of review trails, enterprise credit hazard reporting, exchange deceivability, client data transformation, social examination for trading, IT operations investigation, and IT strategy consistence investigation, among others. Big Data Technologies are heavily used by banks to “Know Your Customer” and fraud mitigation.

Health care Providers: The healthcare area approaches gigantic measures of data yet has been tormented by disappointments in utilizing the data to check the cost of rising medicinal services and by inefficient systems that smother quicker and better human services benefits no matter how you look at it. This is mainly because of the way that electronic data is inaccessible, inadequate, or unusable. Additionally, the social insurance databases that hold wellbeing related information have made it hard to link data that can show designs helpful in the medicinal field. [20] Different difficulties identified with big data include: the exclusion of patients from the decision-making process, and the utilization of data from various promptly accessible sensors.

Education: From an educational point of view, a noteworthy test in the education industry is to incorporate big data from various sources and sellers and to use it on stages that were not intended for the varying data. From a pragmatic point of view, staff and institutions need to take in the new data administration and examination instruments. On the specialized side, there are difficulties to integrate data from various sources, on various stages and from various sellers that were not intended to work with one another. Politically, an issue of security and personal data protection related with big data utilized for educational designs is a test. Colleges everywhere throughout the world are using Big Data to assess the execution of educators and understudies.

Manufacturing and Natural Resources: Increasing interest for regular assets including oil, farming items, minerals, gas, metals, et cetera has prompted an increase in the volume, many-sided quality, and speed of data that is a test to deal with. So also, extensive volumes of data from the manufacturing industry are undiscovered. The underutilization of this information counteracts enhanced nature of items, vitality proficiency, unwavering quality, and better net revenues.

Big data has likewise been utilized in solving the present manufacturing challenges and to gain upper hand among different advantages. In the realistic underneath, an investigation by Deloitte [21] shows the utilization of inventory network abilities from big data at present in utilize and their normal use later on. Apart from the above applications Big data has its applications in other industries like insurance, transportation, retail and wholesale trade, energy utilities etc. A few applications of big data by governments, private organizations and individuals include: Governments utilization of big data: traffic control, course planning, intelligent transport systems, congestion administration (by predicting traffic conditions), Private part utilization of big, Private part utilization of big data in transport: income administration, mechanical improvements, coordination's and for upper hand (by consolidating shipments and optimizing cargo development) and Individual utilization of big data includes: course planning to save money on fuel and time, for movement game plans in tourism and so on.

1.7 Conclusion

Big data analytics is a quickly expanding research territory spreading over the fields of software engineering, data administration, and has turned into a pervasive term in understanding and taking care of complex issues in various disciplinary fields, for example, designing, connected science, solution, computational science, medicinal services, informal organizations, fund, business, government, training, transportation and media communications. The utility of big data is discovered to a great extent in the territory of IoT. Big data is utilized to assemble IoT models which incorporate things-driven, data-driven, benefit driven design, cloud-based IoT. Advancements empowering IoT incorporate sensors, radio recurrence ID, low power and vitality reaping, sensor systems and IoT benefits basically incorporate semantic administration, security and protection safeguarding conventions, plan cases of shrewd administrations. To viably blend big data and convey among gadgets utilizing IoT, machine learning systems are utilized. Machine learning removes significance from big data utilizing different systems which incorporate regression analysis, clustering, bayesian methods, decision trees and random forests, support vector machines, reinforcement learning, ensemble learning and deep learning. Here, we tried to provide insight about Big Data and its journey towards more advanced levels with collaboration of various technologies.

References

1. https://hbr.org/2017/04/how-companies-say-theyre-using-big-data
2. Maheshwari, A.: Big Data. Mc Graw Hill, New Yor (2017)
3. Marron, B.A., de Maine, P.A.D.: Automatic data compression. Commun. ACM **10**(11), 711–715 (1967)

4. https://www.forbes.com/sites/gilpress/2013/05/09/a-very-short-history-of-big-data/#9e0827d65a18
5. Sathi, A.: Implementation section (book 1). In: Big Data Analytics: Disruptive Technologies for Changing the Game, 1st ed. MC Press Online (2012)
6. Job Market: https://www.simplilearn.com/big-data-applications-in-industries-articl
7. https://www.simplilearn.com/how-facebook-is-using-big-data-article?source=CTAexp
8. https://www.icas.com/ca-today-news/10-companies-using-big-data
9. https://www.bernardmarr.com/default.asp?contentID=1076
10. Lyman, P., Hal, R.: Varian at UC Berkeley Publish. How Much Information?
11. Bryant, R.E., Katz, R.H., Lazowska, E.D.: Big-Data Computing: Creating Revolutionary Breakthroughs in Commerce, Science and Society
12. Bohn, R.E., Short, J.E.: How much information? 2009 Report on American Consumers (2009)
13. Cukier, K.: The economist. A Special Report 2010. Data, data everywhere
14. Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., Byers, A.H.: The McKinsey Global Institute 2011. In: Big Data: The Next Frontier for Innovation, Competition, and Productivity
15. Neuman, W.R., Park, Y. J., Panek, E.: Info capacity. Tracking the flow of information into the home (PDF). Int. J. Commun. (2012)
16. Boyd, D., Crawford, K.: Critical questions for big data. Inf. Commun. Soc.
17. http://www.wheelhousesearch.com/wp-content/uploads/2014/02/2014-02-19_093536.png
18. https://www.bernardmarr.com/default.asp?contentID=766
19. Costley, J., Lankford, P.: Big Data Cases in Banking and Securities (2014). https://stacresearch.com/sites/default/files/d5root/BigDataCasesSTAC_may2014.pdf
20. https://www.simplilearn.com/big-data-in-healthcare-sector-rar359-article
21. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Process-and-Operations/gx-operations-supply-chain-talent-of-the-future-042815.pdf
22. https://lcolumbus.files.wordpress.com/2018/05/the-best-big-data-and-analytics-companies-to-work-for-in-2018-final-may-26.jpg
23. https://www.gartner.com/newsroom/id/3130817
24. Kadam, V.G., Tamane, S.C., Solanki, V.K.: Smart and connected cities through technologies. In: *Big Data Analytics for Smart and Connected Cities*, pp. 1–24. IGI Global
25. Sanju, D.D., Subramani, A., Solanki, V.K.: Smart city: IoT based prototype for parking monitoring & parking management system commanded by mobile app. In: Second International Conference on Research in Intelligent and Computing in Engineering
26. Dhall, R., Solanki, V.: An IoT based predictive connected car maintenance. Int. J. Inter. Multimedia Artif. Intell. **4**(3) (2017)
27. Solanki, V.K., Venkatesan, M., Katiyar, S.: Conceptual model for smart cities for irrigation and highway lamps using IoT. Int. J. Inter. Multimedia Artif. Intell. ISSN 1989-1660
28. Solanki, V.K., Muthusamy, V., Katiyar, S.: Think home: a smart home as digital ecosystem. Circ. Syst. **7**(08), 1976 (2016)
29. Solanki, V.K.: Advance automated module for smart and secure city, ICISP-15. Proc. Comput. Sci. 24–32 (2015)

Chapter 2
The Role of IoT and Big Data in Modern Technological Arena: A Comprehensive Study

Sushree Bibhuprada B. Priyadarshini, Amiya BhusanBagjadab and Brojo Kishore Mishra

Abstract In current era of technology, the adoration of Internet of Things (IoT) is rising rampantly with the proliferation in its exciting application prospects and practical usage. Fundamentally, IoT refers to a system of computing devices, persons or animals ascribed with unique identifiers. The data get transmitted without any human to computer or human to human interference. IoT has fundamentally emerged from merging of micro electro mechanical systems, micro services along with wireless technologies as well as internet. The merging assists in bridging between the information technology as well as operational technology, thereby analyzing the machine provoked data in technological platform. Further, Big data indicates large volume of structured as well as unstructured data associated in day to day life. In this context, the amount of data that can be generated and preserved on global level is mostly mind-boggling. However, the relevance of big data does not concentrate on how much data one possesses, however what one carries out on it. The current chapter throws light on IoT, Big data, their relevance, data sources, big data applications, IoT Architecture and security challenges, standards and protocols for IoT, single points of failure, IoT Code etc.

Keywords IoT code · Big data · Data source

S. B. B. Priyadarshini
Institute of Technical Education and Research, Bhubaneswar, India
e-mail: bimalabibhuprada@gmail.com

A. BhusanBagjadab (✉)
Veer Surendra Sai University of Technology, Burla, India
e-mail: amiya7bhusan7@gmail.com

B. K. Mishra
C. V. Raman College of Engineering, Bhubaneswar, India
e-mail: brojokishoremishra@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_2

2.1 Introduction to Big Data, IoT and Hadoop Ecosystem

In current scenario, huge volume of data are produced from several sources viz., health care, government, finance, marketing, social media etc. In this context, developing the Big Data applications has become crucial in recent years and Big Data mechanization have become as a relevant data analysis method for whisking the intelligence within the IoT infrastructure for preferably meeting the aspiration of IoT system. The Big Data has been divided as per the five basic ingredients: volume, variety, velocity, veracity and value. Out of these constituents, volume refers to the size of data, variety represents various types of data from distinct sources, velocity means the data gathered in absolute time. Velocity refers to ambiguity of the data concerned, value means the beneficial aspects in various industrial and academic fields.

The combination of Big Data with IoT technology have constituted privilege leading to enhancement of several services aimed for various complex systems such as smart cities, etc. Various Big Data technologies have evolved for assisting in the processing of huge volume of data that are gathered from distinct sources in intelligent environments. On the contrary, Chen et al. [1] described that the peregrination of IoT and its applications in several domains tend to increase the vast amount of several types of data gathered from different environments. Hence, the combination of Big Data and IoT evolution lead to novel investigative challenges that have still not been known or consigned through the probing association. Basically, as per Akatyev and James [2] IoT has changed the way that technology and human interact. The work done by Rajan et al. [3] details about the IoT generated Big Data employing semantics. Similarly, Khan and Solah [4] detailed the block chain solutions and various open challenges in IoT security. Likewise, Ge et al. [5] surveyed on Big data for Internet of Things (IoT).

Likewise, Hadoop represents an open source processing framework which manages processing of data as well as storage for Big Data implementations. Basically, it is the center of increasing ecosystem of the Big Data technologies for supporting modern analytics initiatives incorporating predictive analytics, machine learning and data mining application prospects. The Hadoop is capable of taking care of several forms of unstructured as well as structured data, thus providing users better flexibility for gathering, processing as well as examining data collected than the data warehouses or relational databases afford.

Basically, Hadoop is made up of modules aimed for carrying out specific tasks. Following are the four modules associated with Hadoop system:

(A) **Distributed File System Module**: The dispersed file organization permits data to be contained in a conveniently operable form through huge count of coupled stashed appliances. Moreover, a file organization represents the technique employed through a computer for storing the data. Generally, this gets indicated by the operating system of the corresponding computer.

(B) **MapReduce Module**: This module has been named as per the two fundamental operations it carries out such as: reading data from the database and placing that in suitable format for the analysis purpose as well as carrying out analytical operations.
(C) **Hadoop Common**: It affords the tool desired for the computer of the intended user. Another task is reading data stored beneath the Hadoop file organization.
(D) **Hadoop Yarn Module**: It is the last segment which manages the system resources preserving the data as well as executing the analysis.

Different other libraries, functions or features have emerged to be taken into account as component of the Hadoop through ongoing years, however, Hadoop Distributed File organization, Hadoop MapReduce, Hadoop Common and Hadoop YARN represent the major ones.

2.2 Big Data Process

The several Big data technologies incorporate distinct activities, techniques and methods deployed for several purposes. This section examines various existing literatures on Big Data processes and considers various activities used for classifying the Big Data approaches employed in IoT. Gandomi and Haider [6–8] get segregated the Big Data processes under two major phases: (a) data management and (b) data analytics.

Out of these two, data management is aimed at gathering data, storing, cleaning and retrieving it for the process of analysis and preparation. On the contrary, the data analytics is concerned with wresting intuition from the desired data that considers sculpting, interpretation and examination. Pakkala and Paakkonen [9] proffered a Big Data allusion planning which cogitates the data origination as well as data repository as the input and infrastructure for Big Data processes.

The Big Data process involves the following major phases, namely,

(a) **Data Extraction**
(b) **Data Loading**
(c) **Preprocessing**
(d) **Data processing**
(e) **Data Analysis**
(f) **Data Transformation and Data Visualization**

(a) **Data Extraction**: Data extraction indicates the process or act of fetching data from data sources for subsequent storage or processing. The implication into the transitional organization is hence pursued by data metamorphosis as well as the possible inclusion of meta data before exporting to any other stage in the work flow.
(b) **Data Loading**: The data loading represents the process that involves taking the transformed data and loading it where the users can access it.

(c) **Preprocessing**: Data preprocessing is fundamentally a data mining approach which transforms raw data into more recognizable form. Practical data is mostly conflicting, deficient or lack in many features. Realworld data may contain many errors. Therefore, for resolving these issues, data preprocessing is a proven method.
(d) **Data processing**: Data processing represents basically the collection and manipulation of data items for generating meaningful information. It may be considered as a sub set of information processing.
(e) **Data Analysis**: Data analysis is basically a process of inspecting, transforming and modeling data with the aim to discover the useful information and assisting the decision making. Data analysis involves several strategies while encompassing various techniques in science, business as well as social science domains [10].
(f) **Data Transformation and Data Visualization**: Data transformation represents the process of converting data from one format or structure into another format or structure. It is a basic direction of many data integration as well as data management tasks like data wrangling, data warehousing, data integration as well as application integration. Data visualization represents any effort to help people consider the connotation of data through putting it in proper perceptible reference. In this context, trends, patterns and correlations may remain undetected in case of text based data.

2.3 Big Data Ultimatums and Features

The prospecting of Big Data affords several alluring opportunities. But, professionals and investigators are confronting various challenges while exploring Big Data sets while retrieving knowledge and value from inspection of information. The heftiness resides at several levels: data ensnaring, storing, searching, sharing, analysis, administration and fantasy. Moreover, there exists both privacy as well as security issues concerned with distributed data driven applications. Following are the major challenges associated with Big Data:

(a) **Volume**: Huge volume of data means huge amount of data that are generally indicated as “tonna bytes” to refer the real numerical scale where the data volume becomes impugn specifically in setting domain specific data.
(b) **Variety**: It refers to complexity and more features per data item, the expletive of dimensionality, combinatorial detonation, various more data types, as well as several data formats.
(c) **Velocity**: It refers to the rate of flow of data items into and out of the system in real time. High rate of data flow may arise threat to the system.
(d) **Veracity**: It is essential for sufficient data to be tested in many distinct hypotheses, huge training samples for more micro-scale model-construction as well as model corroboration.

(e) **Validity**: It refers to quality of data, governance, master data management (MDM) on hefty, various, dispersed as well as divergent, "unclean" data gatherings.
(f) **Value**: It characterizes the corporate value and latent of big data to revamp the institution from top to bottom.
(g) **Variability**: It refers to dynamic spatiotemporal data, time series, seasonal, as well as many other type of non-static feature marked in data sources, clients, objects of study, etc.
(h) **Venue**: It represents discordant distributed data from different platforms gathered out of various owners' systems, having distinct access as well as furcating needs.
(i) **Vocabulary**: Vocabulary refers to schema, data models, ontologies, semantics, taxonomies, as well as other content- as well as context-based metadata which aim at describing the data's structure, syntax, content, as well as provenance.
(j) **Vagueness**: It represents the bewilderness over the semantics of big data.

Following are few other Big Data ultimatums:

- **Big Data Management**: Various ultimatums are encountered by Data Scientists while considering with Big Data. One ultimatum is the way to gather, integrate and keep with lesser software as well as hardware requirements [11, 12]. A major ultimatum is Big Data management.

Proper management is required to facilitate extraction of reliable insight while optimizing the expenses incurred. In fact, a proper data management is the bridge for Big Data analytics. Fundamentally, Big Data management refers to cleaning data for reliability, to combine data coming from several sources as well as encoding the data for security and privacy. Big Data management is carried out for ensuring authentic data which is easily available, manageable as well as secured.

- **Big Data Cleaning**: The crucial ultimatum in Big Data is to handle the complexity of Big Data nature such as: velocity, volume and variety [13] and getting processed it in a dispersed environment with mixed implications. On the contrary, data may retain errors, noises or incomplete data etc. The major ultimatum in this context is the way to clean such large data sets and the way to make decision regarding which data is believable and useful.
- **Big Data Aggregation**: It is essential to combine internal data with external data sources. Internal data refers to the data generated inside the organization and external data includes the third party sources, information regarding market fluctuation, traffic conditions, weather forecasting, etc.
- **Imbalanced Big Data**: Classifying imbalanced dataset is one of the crucial challenge in case of Big Data. In practical scenarios, real world implementations may generate classes having distinct distributions. Further, the classical learning methodologies are not applicable to data sets that are imbalanced. This is due to the fact that the model architecture is based on global search measures without taking the count of instances. In fact, the global guidelines are fundamentally preferred in lieu of particular guideline.

- **Big Data Machine Learning**: The main aim of machine learning is to unfold the knowledge while making intelligent decisions. It is employed in various real life applications like recognition systems, autonomous control systems, recommendation engines, data mining and informatics [14].

Basically, machine learning has been segregated into three major domains: Supervised learning, Unsupervised learning and Reinforcement learning. For detailed study of ML types reader may follow Qiu et al. [15].

- **Deep learning**: In modern era, Deep learning (DL) establishes an exceedingly popular research field in pattern recognition and machine learning. It plays a crucial role in various application prospects of predictive analysis viz. speech recognition, computer vision, natural language processing, etc.

DL is very versatile for resolving learning problems encountered in large data sets [11]. It assists in automatically extracting complex data representations from huge volumes of uncategorized raw data. Furthermore, Deep learning is basically stratified learning and is suitable for simplifying analysis of profuse volume of data.

Further, the crucial characteristics of Big Data can be summarized as illustrated in Table 2.1.

Table 2.1 Characteristic of big data

Volume	The chunk of information produced daily is very large, which can be one among the shaping features of big data
Velocity	The speed at that novel information is being produced, and newer sources appended
Variety	There are many varieties of information produced, as well as structured as well as unstructured forms
Variability	It may consult with inconsistent or sudden values from one supplier field, or might refer to changes within the speed with that knowledge area unit produced or received into information
Validity	It indicates the accuracy of the information that, once acquired and examined, effects the outcomes and meant usage
Veracity	It refers to the amount of trust or belief in oneself within the knowledge, as well as the power to trace it to its main supply and reference (i.e., knowledge inception)
Vulnerability	It refers to how protected are the information as they get into and exist in the concerned database
Volatility	How lengthy shall information go on appropriate?
Visualization	Which graphical illustration techniques may be in usage to infer huge amounts of knowledge in associate understandable way to a large client?
Value	Are the information points within the set relevant? Can the trouble of enormous extent investigation be pricing it?

2.4 Types of Data Sources

Now a days "patient care activities" create huge amounts of knowledge as an essential byproduct of synergy among the "health-care-system". Analytic and numerical knowledge will comprehend not simply supplier nothings, however conjointly information from processed supplier order entry (CPOE) and clinical resolution-making software package, laboratory and radiology outcomes (written-reports and therefore the digital imaging files), automatic outcomes from patient observance devices, and registration and monetary knowledge. Such information is also segregated into 2 extreme divisions as follows.

2.4.1 Structured Knowledge

Structured knowledge are generally those which may be arranged as searchable tables, typically produced from a preplanned set of answering decisions. The values is also elite from a menu by practicing as which act with an EHR, for instance, or could embody a listing of investigative or charge codes.

2.4.2 Unstructured Knowledge

Unstructured knowledge comprises of up to 80% of all "health-care" data, and they represent that which can't be as simply investigated or arranged, like responses got into "free-text fields" by patients or physicians, "narrative-notes", "hand-written" or "scanned documents", "images", etc.

2.4.3 Structured Versus Unstructured Data

The difference between structured and unstructured data is illustrated in Table 2.2.

2.5 Real World Applications of Big Data

The word big-data was first coined by NASA researchers in the article in 1997 as it presented the ultimatums to preserve the quantity of data produced as a results of a brand novel, data-demanding variety of process effort. As the motion of information production has magnified, ultimatums on the far side the power to easily store extensive volumes of information became probable, along with the competence to

Table 2.2 Structured versus unstructured data

Types of data	Comments	Examples
Structured data	Data which are in coded format may be retrieved, combined, and compared a lot of simply, however could lack context concerning the clinical scenario	✓ Age ✓ Treatment codes (i.e., HCPCS) ✓ Disease codes (i.e., ICD) ✓ Lab results
Unstructured data	Narrative text created by clinicians or patients is also an additional wealthy supply of knowledge regarding treatment decision-taking explanation, etc. Various ultimatums stay to extract pertinent data from unstructured sources	✓ Scanned documents ✓ Handwritten notes ✓ Narrative text (e.g., visit notes, procedure and ✓ Diagnostic imaging reports, e-mail contact, etc.) ✓ Images (viz, film or digital CT scan files, etc.)

efficiently govern and with success interpret the data collected. The capability to pay off acumen from these huge armory of information has matured to be the recent ultimatum across regulations, incorporating health affliction.

From time-intensive activities, Information creation in health care has historically appeared like destined analytic experiments, with a often alluded gap of seventeen years from the primary distribution of analysis outcomes to pursuit in clinical observe. To contrast this, the Institute of drugs printed the educational attention System, spotlighting the necessity for a brand new ensample to sooner and ceaselessly integrates the most effective proof out of each rigorous clinical analysis with data attained as a universal projection of patient-care to assure novelty, endowment, security and price in health affliction.

The support key of the shift has been the expanding acceptance of "electronic-health-records (EHRs)", in factor of incited as a results of the HITECH Act, that advertised its uptake &made public, "multi-stage" commit to tested regulation for significant usage supposed for extending information abduction and distribution, make better clinical advancement, and ultimate trial of improved patient results. Although EHRs exhibit great opportunity to abduct and distribute long-term patient-data across multiple medical care and particular settings, these advantages are difficult to comprehend. Even inside one health-care system make use of a similar EHR, Health Insurance-movability-and-responsibleness-Act (HIPAA) necessities and lack of uniform gathering of data practices still limited period to have the facility to get patient data.

At the population stage, these appliances on their self do not seem to be appropriate to arrange or permit simple retrieval of information for quality coverage or analysis purposes, presently distinctive HER products preponderantly perform as a knowledge abduct appliance and archive for patient-data, without a profound analytic part. While the normal methodology to demonstrate the protection and effectiveness of the ongoing latest cancer medicine can stay the multicenter irregular-controlled trial, huge knowledge platforms offer the chance to accelerate development of complementary strategies of proof generation. The provision of massive knowledge platforms permits the chance to explore influence of interventions likewise as effectiveness, enhancing generalizability and also the involvement of public not habitually taking part in restrained clinical trials, like older grownups and people with scarce infections.

The pivotal to the current amendment is that the appreciation that source and therefore the amount of "real world data" created by patients along cancer area unit currently procuring much more promptly and loosely than data from scientific tentatives will be created. Whereas it's going like appearing perceptive to use these information, this becomes vital to outline the features of knowledge components and set that fitly devote to authentic experimental enquiry. In August, 2017, the North American country Food and Drug Administration (FDA) promulgated last steerage on the Use of Real-World proof (RWE) to assist regulative Decision-Making for therapeutic appliances, that afforded acumen into the agency's vista on, however, RWE may be integrated into observation and endorsement decision-making, affording acceptable controls on attributes, efficacy, as well as responsibleness.

Such fields would possibly embrace expedition of contemplative information for getting hypotheses for experimenting in a very intended clinical tentative; genesis of an authentic management association, development of intended repositories with restrained information components to assist later consent and "off-label" observation of instruments and for communal health police work resolutions. The authority acclaimed there may be several authentic inceptions of universal information, like huge easy attempts, or realistic scientific attempts, intended data-based or written account reviews, contemplative info observations, crating narrations, body and soundness consternation prerogatives, electronic health archives, information realized as a component of a mutual fettle examination or routine communal vigor police work, and registries.

Although the background of this credential is restricted to medical appliances, some general arguments might doubtless uses the FDA's aspects on RWE within the narcotic evolution and endorsement method moreover. Here, the numerous kinds of knowledge required to realize acumen into the matters, route, and consequences of the tumor expertise, varied teams, both public and personal, square measure operating to attach analytical, gynic, monetary, way of living, and different kinds of knowledge created by and for meeks with cancer.

This space can likely still apace extend and develop as results of automation and policy enhancement over ensuing days to come.

A leading stimulus for evolvement during such space is that the Cancer Moon shot drive, started in Jan 2016 by Joe Biden. The National-Cancer-Institute and therefore the presidentially delegated The National-Cancer planning board, a badge Panel was appointed to first assess the state of the science, and so develop recommendations in seven topic-areas, one in all that was associate degree increased knowledge sharing unit. Along side the six different operating teams, the total document of decree was free within the fall of 2016. Besides, Bilal et al. [16] showed the vast use of Big Data in industrial applications.

Forty five Recommendations from the improved knowledge Sharing unit enclosed the necessity to make a Cancer knowledge system to supply the same, in knowledge erudition underpinnings which will hook upnumerous inceptions and kinds of malignancy knowledge, as well as carry out therefore with patient commitment, approval, and confidentiality-armaments. The National Cancer Institute had initiated to concern money divulgences through twelvemonth 2019 to assist the implementation of analysis opportunities known by the badge Panel operating teams, assisted partly by funding of the twenty first Century Cures Act. From the Cancer rocket launching cordon bleu Panel increased knowledge sharing working party recommendation. This is a tide of exponential peregrination and aspiration for the conveniences that huge knowledge, knowledge erudition, and real-world knowledge production might produce.

Patients having cancer urgently want novel proof that's a lot of concretized to own clinical, analytical, and canonic features than ever before the technology is quickly exploring, momentous ultimatums stay to create an exhaustive, practical, and easy medicine knowledge framework that delivers on the assurance of RWE. As nurses, we have a tendency to should currently defend for our patients in a very new method—to be told the way to raise the foremost significant queries from among huge datasets, in order that we will regularly progress towards care of the very best attributes and price for the complete patient, not simply concerned tumors.

2.6 IoT Architecture and Security Challenges

A scenario of a common IoT encompasses different devices along with "embedded sensors" connected via a network. Here the devices are identifiable uniquely and are characterized through lesser memory, lower power as well as limited processing feature. Further, the gateways represent the devices that are employed for connecting IoT devices to the external sphere for distant data provisioning and benefits to IoT customers.

2.6.1 IoT Standards and Protocols

General IoT protocols are employed for messaging, forwarding, authentication and various relevant applications. It incorporates the standards as well as protocols ordinarily employed for Low Rate Wireless Personal Area Network (LW-WPANs) and for Low Power Wide Area Network (LP-WAN).

Basically, Physical Layer and the Medium Access Control (MAC) Layer are the two layers described by IEEE standard 802.15.4. In this context, the physical Layer specification is concerned with exchange through wireless channels having different data rates as well as frequency bands. The specification for MAC Layer is concerned with mechanisms for synchronization and channel access. Moreover, each of the appliances in IoT is solely determined through an IPv6 network address. Further, the Routing Protocol for Low Power Lossy Networks (RPL) is employed to assist WPAN environments. RPL affords communication between single point and multi-points [7].

The application framework in IoT includes “User Datagram Protocol (UDP)” for the purpose of exchange due to limited payload. This is owing to the fact that UDP is much more effective as well as comparatively less complex than “Transmission Control Protocol (TCP)”. Again, “Internet Control Message Protocol (ICMP)” is employed for Control Messages (CMs), viz. specifying not reachable destinations as well as neighborhood discovery. Further, the Constrained Application Protocol (CoAP) helps in Asynchronous message exchange and helps in HTTP mapping [6].

2.6.2 IoT Security Requirements

Following are some of the relevant parameters needed for secure IoT deployment.

2.6.2.1 Availability of Service

The various incursions over IoT devices need the accouterment of several utilities via the customary denial of service attack. Several techniques incorporating sink-hole attacks, blocking antagonists as well as replay incursions makes use of IoT integrals at numerous layers to depreciate the Quality of Service (QoS).

2.6.2.2 Authentication, Authorization, Accounting

IoT authentication is essential for securing the communication prevailing in IoT. The devices need to be authenticated for privileged ingress to several services. Moreover, the authorization mechanism indicates that the ingress to system or data is afforded to legitimate users. In addition, the reckoning for resource usage, along with informing afford reliability in proper network management.

2.6.2.3 Data Privacy, Data Confidentiality, Data Integrity

A proper encryption mechanism is needed for ensuring data confidentiality since IoT data moves via several lopes in a network. Owing to various amalgamation of services, the data contained in a device is susceptible to privacy and might cause the traducer to affect the data integrity through changing the hoarded data for mischievous purpose [10].

2.6.2.4 Energy Efficiency

The IoT devices are specifically resource stiffed devices and are having reduced power as well as lowered storage. The various incursions on IoT frameworks gives rise to an hike in energy expenditure through flooding the intended network as well as fatiguing the various IoT resources.

2.6.3 Single Points of Failure

A continuing rise of divergent network may lead to a huge number of single points of failures that might destroy the services afforded through IoT. It needs therefore, a tamper-proof environment for IoT devices and fault tolerant networks.

2.7 IoT Code

The UK government has launched a code called IoT Code for consumer Internet of Things (IoT) products. This assists with the hope to make them less liable to hacking. The Security by Design Report published by Digital Culture, Media and Sport (DCMS) analyzes the recent proliferation in IoT market, however, it also portrays the raise in associated risks owing to failure of several vendors for considering security as part of the product development life cycle.

2.8 Conclusion and Future Scope

Basically, Big data and IoT are two pragmatic features in recent scenarios for various types of organizations and they represent a greater challenge to Information Technology (IT). The major features of Big data are concerned with its volume as well as variety including other features, viz. velocity, value, and veracity, etc. Further, Big data and IoT have impact on both public sectors and private sectors and conjointly scientific and technical zones incorporating healthcare, education systems, etc. Now-a-days, IoT forms a large amount of data in vertical silos. On the contrary, an actual IoT is dependent on the actual availability as well as confluence of rich data sets collected out of various systems. The data can be taken from any source and get examined to attain the answer, thus curtailing the cost as well as time. Furthermore, it helps in smart decision making as well as new product development. Besides, Big data assists in deciding the crucial causes behind any issues or failures or defects and detecting fraudulent behavior in real time. In brief, big data concern with data but IoT is about data, devices as well as the connectivity.

Although the technological conditions for big data management have progressed, they are not at all sufficient since they need to be aggregated and handled by desirably trained personnel. In view of such circumstance, the novel technical skills as well as required qualified and trained professionals are needed for recent technical arsenal. Furthermore, the procedure has to be greater efficient, in many cases needing proper revisiting, either in the user's point of view, or from the technical perspectives while taking into account the human issues for operating Big Data as well as IoT.

References

1. Chen, Z., Chen, S., Feng, X.: A design of distributed storage and processing system for internet of vehicles. In: 8th International Conference on Wireless Communication and Signal Processing, IEEE, pp. 1–5 (2016)
2. Akatyev, N., James, J.I.: Evidence Identification in IoT Networks based on Threat Assessment, Future Generation Computer Systems. Elsevier, pp. 1–8 (2017)
3. Rajan, R., Thakker, D., Haller, A., Buyya, R.: A note on exploration of IoT generated big data using semantics **76**, 495–498 (2017)
4. Khan, M.A., Solah, K.: IoT security: review, block chain solutions and open challenges. Future Gener. Comput. Syst. **82**, 395–411 (2018)
5. Ge, M., Bangui, H., Buhnova, B.: Big Data for Internet of Things: A Survey, Future Generation Computer Systems. Elsevier (2018)
6. https://searchdatamanagement.techtarget.com/definition/Hadoop
7. https://www.bernardmarr.com/default.asp?contentID=1080
8. Gandomi, A., Haidar, M.: Beyond the hype: big data concepts, methods and analytics. Int. J. Inf. Manage. **35**(2), 137–144 (2015)
9. Paakkonen, P., Pakkala, D.: Reference architecture and classification of technologies. Prod. Serv. Big Data Syst. Big Data Res. **2**(4), 166–186 (2015)
10. https://mapr.com/blog/top-10-big-data-challenges-serious-look-10-big-data-vs
11. Chen, M., Mao, S., Liu, Y.: Big data: a survey. Mobile Netw. App. **19**, 171–209 (2014)
12. Najafabadi, M.M., Villanustre, F., Khoshgoftaar, T.M., Seliya, N., Wald, R., Muharemagic, E.: Deep learning applications and challenges in big data analytics. J. Big Data **2**, 1 (2015)
13. Khan, N., Yaqoob, L., Hashem, I.A.T., Inayat, Z., Mahmoud Ali, W.K., Alam, M., Shiraz, M., Gani, A.: Big data: survey, techniques, opportunities and challenges. Sci. World J. (2014)
14. Bishop, C.M.: Pattern recognition. Mach. Learn. **128**, 1–58 (2006)
15. Qiu, J., Wu, Q., Ding, G., et al.: A survey of machine learning for big data processing. EURASIP J. Adv. Sig. Process, pp. 1–16 (2016)
16. Bilal, M., Oyedele, L.O., Qadir, Junaid, et al.: Big data in the construction industry: a review of present status, opportunities and future trends. Adv. Eng. Inf. **30**(3), 500–521 (2016)

Chapter 3
The History, Present and Future with IoT

Neha Sharma, Madhavi Shamkuwar and Inderjit Singh

Abstract Human beings quest for making comfortable life is due to their inquisitiveness about technical arena. Over the last few decades, mankind had experienced technical transformational journey with the inventions of new technology frontiers. These frontiers have interacted with human beings and performed every possible work in shorter period of time and with a much greater accuracy. With the advent of 'Smart Concepts', the world is now becoming more connected. Precisely termed as hyper-connected world. The smart concepts includes smart phones, smart devices, smart applications and smart cities. These smarter concepts forms an ecosystem of devices whose basic work is to connect various devices to send and receive data. Internet of Things is one the dominating technology that keeps eye on the connected smart devices. Internet of Things has bought applications from fiction to fact enabling fourth industrial revolution. It has laid an incredible impact on the technical, social, economic and on the lives of human and machines. Scientists claim that the potential benefit derived from this technology will sprout a foreseeable future where the smart objects sense, think and act. Internet of Things is the trending technology and embodies various concepts such as fog computing, edge computing, communication protocols, electronic devices, sensors, geo-location etc. The chapter presents the comprehensive information about the evolution of Internet of Things, its present developments to its futuristic applications.

N. Sharma (✉)
Society for Data Science, Pune, India
e-mail: nvsharma@rediffmail.com

M. Shamkuwar
Zeal Institute of Business Administration, Computer Application and Research, Savitribai Phule Pune University, Ganesh Khind, Pune 411007, Maharashtra, India
e-mail: madhavi.sh@gmail.com

I. Singh
BCL Secure Premises, Delhi, India
e-mail: Inderjit.barara@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_3

Keywords Internet of things · IoT history · IoT evolution · IoT definition
IoT trends · Sensors · Communication model · IoT architecture
IoT technologies · IoT applications · Future of IoT · IoT · Fog computing
Edge computing

3.1 Introduction

A huge rise in the number of objects connected to the internet, either by wire or wireless has made Internet of Things (IoT) an increasingly growing topic of conversation both in the industry and outside of it [1]. It is predicted that IoT will rival all the past scientific marvels, such as steam engine, printing press and electricity and will surpass all the previous industrial revolutions. The "Internet of things" along with robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, 3D printing and autonomous vehicles, mark the fourth industrial revolution [2]. In particular, IoT is a concept that not only has the potential to impact our lives but also the way we work [3]. It can dramatically improve security, energy efficiency, education, health, and many other aspects of daily life for consumers, through amazing solutions [4–9]. It can also improve decision-making and productivity of enterprises in retail, supply chain management, manufacturing, agriculture and other sectors by reinforcing solutions [4–9].

Now, all kinds of everyday objects can be connected to the internet including cars, thermostats, sporting equipment, microwave oven, fitbit, refrigerators, and even shoes. Internet of Things is an evolution of mobile, embedded application and everything that is connected to internet to integrate greater communication ability and use data analytics to extract meaningful information. The IoT device which is connected to the internet and placed in shoes collects the data like the step counts and can be viewed from another internet connected device like smart phone. All the metrics collected by the shoes can be analyzed like how many calories burnt and can provide personalized fitness advice. IoT is not limited to consumer products. There are city trash cans which sends an alert when it needs to be empty. Sensors on the bridges can check for stress or damage on its structure and many more examples extending to healthcare, manufacturing and agriculture [4–9]. Unfortunately, since the system is controlled by free market, the risk of data protection and data security cannot be excluded. For example, a hacker can easily unlock an internet connected door lock remotely. There would be issues of data privacy which will be a major concern. All these devices are collecting large amount of personal data that can capture our action and location throughout the day.

IoT is a technology wave that would be connecting billions of objects in coming years and its upsurge also indicates beginning of new data age with its benefits and challenges. Two main components of an "IoT object" are its ability to capture data via sensors and transmit data via the Internet [10, 11]. Internet connectivity allows object to have their own identities as well as receive and send valuable communication making them smart. This chapter is arranged as follows: the next section reviews the work done by researchers with similar interest; Sect. 3.3 presents various definition of Internet of Things, its history and evolution of technology trends; IoT communication models, architecture and technology prevalent in present day scenario is discussed Sect. 3.4 and future of IoT is discussed in Sect. 3.5. Finally, Sect. 3.6 summarizes the chapter with conclusion, followed by references which are mentioned in the last section.

3.2 Related Work

The following section provides literature review, which presents the evolution of Internet of Things (IoT) as well as highlights spectrum of possible applications that has potential to improve the human life drastically. Ibarra-Esquer et al. have systematically presented the evolution of concept of the Internet of Things and tracked it across various application domains [12]. Ideally, it is essential to have in place an IoT infrastructure comprised of sensing devices, communication link and user application, to create a smart environment. However, it is not at all essential to have the entire infrastructure in the beginning, it can be added phase wise on priority basis. Laya et al., in their research paper, highlighted multiple factors impeding the adoption of IoT paradigm [13]. As per them, single solution cannot cater to the applications in heterogeneous field. In addition, lack of backend network services and devices to realize IoT network and absence of clear as well as accepted business model are the main reasons behind not being able to attract investments for deploying these technologies [13]. Likewise, there are few more literatures, which has described number of hurdles in implementing IoT based smart solutions for smart cities [14–18]. The obstacle are mainly political (decision-making power to various stakeholders), financial (unclear business model and lack of investors) and technical (heterogeneous technologies and issues of interoperability).

Study by Bellavista et al. have suggested many applications of IoT in varied domains like smart grids, intelligent energy management, mobile health care, medical aids, industry automation, home automation, elderly assistance, smart vehicles, traffic management and many others [19]. Schaffers et al. and Cuff et al. have presented urban IoT paradigm to enhance the public services like maintenance, surveillance and security of public area; efficient parking, transportation, garbage collection and lighting; preservation of cultural heritage and services at schools and hospitals [20, 21]. As per the authors, the deployment of urban IoT has potential to optimize the management of traditional public services, mainly by analyzing the profuse amount of data generated to provide transparent and effective governance.

There are few literatures that have presented a specific areas where IoT can be implemented to enhance the performance. Lynch et al. have suggested the usage of IoT for maintenance of the building by installing different types of specialized IoT devices to monitor building stress due to deformation and vibration, to track environmental conditions due to temperature and humidity and to check pollution level

[22]. The data collected should reduce the periodic structural check by human and assist them in focused maintenance and restoration activity. The data collected from various IoTs will also help in understanding the impact of natural calamity like earthquake on the buildings. Nuortio et al. have presented smart waste management system by installing IoT devices on waste containers to assess the level of load and communicate the information with the garbage collector truck to optimize the route and minimize the cost of garbage collection [23]. Soliman et al. have evaluated the benefits of IoT in learning environment of physical as well as virtual types. They have also presented and discussed the experimental results [24]. Whereas, Elsaadany has worked on smart secure campus environment and smart student feedback using IoT [25]. Atzori and Mashal have attempted to combine social networks and Internet of Things for better user engagement and to promote education in real and virtual environment [26, 27]. Chandrahasan et al. have presented the smart parking to indicate the nearest available free parking space for the vehicle in order to save time and energy [28]. Likewise, IoT devices and sensors can be used to monitor the quality of the air or noise level [29, 30]. It can also be used to offer services like providing information on traffic congestion, energy consumption, smart parking, smart lighting etc. [31–33]. However, all the above applications require initial investment on installation of sensors and their interconnection to a control system.

3.3 Internet of Things (IoT): Evolution

A network connects devices like computers, printers, fax machines, etc. together either by cables or wirelessly by radio or infrared signals to transfer the information from one point to another. A network need not be only for computers, it can be also of analog telephone system and interconnection of such networks is known as internet. Nevertheless, the technological advancement in recent past has transformed the internet to the network where everything is linked and everyday objects can be recognized and controlled via RFID tags, sensors and smart phones. The Internet of Things (IoT) is the network of physical objects that can sense, communicate and accessed through the Internet and becomes its integral part. These objects are embedded with electronics (Microcontrollers and transceivers), software, sensors, actuators and network connectivity that enables them to collect and exchange the data using various protocols [10]. Therefore, IoT offers connectivity of devices, systems and services that goes beyond Machine-to-Machine (M2M) communication and caters to variety of application in different domains.

The quality of life is undergoing fast transformation and will be improved drastically in future. Only 500 million devices were connected to the internet and today it has grown above 25 billion. By 2020, 50 billion devices will be equipped with a unique identifier as shown in Fig. 3.1, so that they can be of great benefit in the field of energy, safety and security, industry, manufacturing, retail, healthcare, independence of elderly persons, people with reduced mobility, environment, transport, smart cities, entertainment and many more [34].

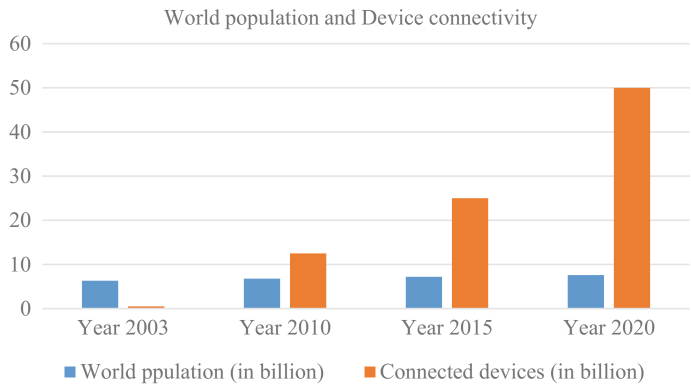


Fig. 3.1 Growth in connected devices as indicated by Cisco [34]

Such predictions regarding Internet of Things (IoT) has made a huge impact on the global economy. However, these estimates slightly vary from each other. As per McKinsey, the growth of IoT market would be from 4 trillion USD to 11 trillion USD by 2025 [35], whereas Gartner predicts it to be 2 trillion USD by 2025 [36] and IDC sees the benefit of 1.7 trillion in 2020 [37]. Therefore it is prudent to understand its evolution in this section. We present various definition of IoT proposed by different sections, its history and several technology trends that are driving it.

3.3.1 Definitions

Ashton coined the term Internet of Things in 1999 for the first time to highlight the power of connecting Radio Frequency Identification Tags to the internet for the domain of Supply Chain Management [38]. Multiple definitions of Internet of Things have evolved in the past decade based of latest technology of that time and the range of applications it caters [39]. However, there is no definition of Internet of Things which is universally accepted. The concept is almost the story of "The Blind Men and Elephant", it depends on the way we perceive and conceive the lucrative power of IoT. Different researchers, scientists define the term in their own way, some focus more objects, devices, Internet Protocols and Internet, while others focus on the communication processes involved. We present the following well known and well-accepted definitions of IoT:

1. Internet Architecture Board (IAB) defines IoT as a communication service [40]. According to them, the term "Internet of Things" (IoT) represents a set of large number of embedded devices, which provides communication services based on the Internet Protocols. The devices are popularly termed as "Objects" or "Smart Objects", these objects communicate with each other and often do not require human intervention.

2. The Internet Engineering Task Force (IETF) refers IoT as 'Smart Object' and were of opinion that it has limited power, memory, and processing resources, or bandwidth [41]. IETF focuses more on achieving network interoperability between several types of smart objects [42].
3. IEEE Communications Magazine relates Internet of Things to Cloud Services [43]. They define IoT as a framework in which each object is uniquely identified on the internet. More precisely, IoT targets to offer various applications and services to eliminate the gap in physical and virtual world using Machine-to-Machine (M2M) communications to enable interaction between objects and applications in the cloud.
4. The definition given by Oxford Dictionaries is very accurate and focuses on use of Internet as a connecting media between devices [44]. It defines IoT as "the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data" [44].
5. Atzori et al. defines Internet of Things as three key ideas i.e. Middleware, which is internet-oriented, Sensors which are things oriented and Knowledge which is semantic-oriented [10]. From definition point of view these three types are different from each other and seems to be an individual entity, however, in reality these three intersects with each other so that that potential benefits of IoT can be derived.
6. Forrester perceives IoT as a smart environment to offer services to various domain like education, administration, healthcare, and transportation etc. with the help of information and communications technology [45].

However, the distinct definitions is that the IoT is a constellations of objects, things, devices, technology, protocols that will change the whole communication process. This can be achieved by a unified framework which includes ubiquitous computing, cloud computing, data analytics and knowledge representation/visualization [46].

3.3.2 History

The first idea of IoT appeared almost two decades ago, but the technologies behind it had already existed and were under development since many years. Let us look at the history of evolution of IoT and its supporting and associated technologies in chronological order—

1. **1969**—Internet, the main technology behind IoT emerged as Advanced Research Project Agency Network (ARPANET) which was mainly used by academic and research fraternity to share research work, to develop new interconnection techniques and to link computers to many general purpose computer centers of defense department of United States and also in public and private sector [47].

2. **1973**—Another essential technology for IoT is RFID (Radio-Frequency Identification). Though the roots of RFID can be traced back to World War-II and the advances continued through 1950s and 1960s, but the first U.S. patent for RFID tag with rewritable memory was received by Mario W. Cardullo in 1973. However, a California based entrepreneur, Charles Walton also received a patent in the same year for passive transponder to unlock the door remotely.
3. **1974**—Embedded computer system was another important technology for IoT. These system are implemented using single board computers and microcontrollers and are embedded in the bigger system to form its integral part [48].
4. **1984**—Early use of IoT without it being christened. A coke machine was connected to internet to report the availability and temperature of the drink [49].
5. **1990**—Proliferation of internet in business and consumer markets. However, its use was still limited due to low performance of network connectivity.
6. **1991**—The concept of ubiquitous computing was proposed by Mark Weiser. The ubiquitous computing made use of advanced embedded computing as a computer to be present in everything, yet invisible. Later, it was known as pervasive computing [50].
7. **Mid 1990s**—Sensor nodes were developed to sense the data from uniquely identified embedded devices and seamlessly exchange the information to realize the basic idea of IoT [1, 12, 51].
8. **1999**—Device to Device communication was introduced by Bill Joy in his taxonomy of internet and the term 'Internet of Things' was used for the first time by Ashton [52, 53]. Besides, the RFID technology was boosted by an establishment of the Auto-ID Center at the Massachusetts Institute of Technology (MIT) to produce an inexpensive chip which can store information and can be used to link objects to the internet [54].
9. **2000 onwards**—As a result of digitalization, internet connectivity became the norm for many applications and all the business and products were expected to have presence on the internet and provide information on-line. However, these devices are still primarily things on the Internet that require more human interaction and monitoring through apps and interfaces. The roadmap of IoT from 2000 onwards is shown in the Fig. 3.2 [55].

The true potential of the IoT has just begun to realize—when imperceptible technology operates behind the scenes and dynamically respond to our expectation or need for the "things" to act and behave.

3.3.3 Trends in IoT

In 2011, Internet of Things has been identified as one of the emerging technologies in area of Information Technology and was added in the Gartner Hype Cycle [56]. A Hype Cycle is a curved graph representing the emergence of innovative technology, peak of inflated expectations, adoption, maturity and productivity [55].

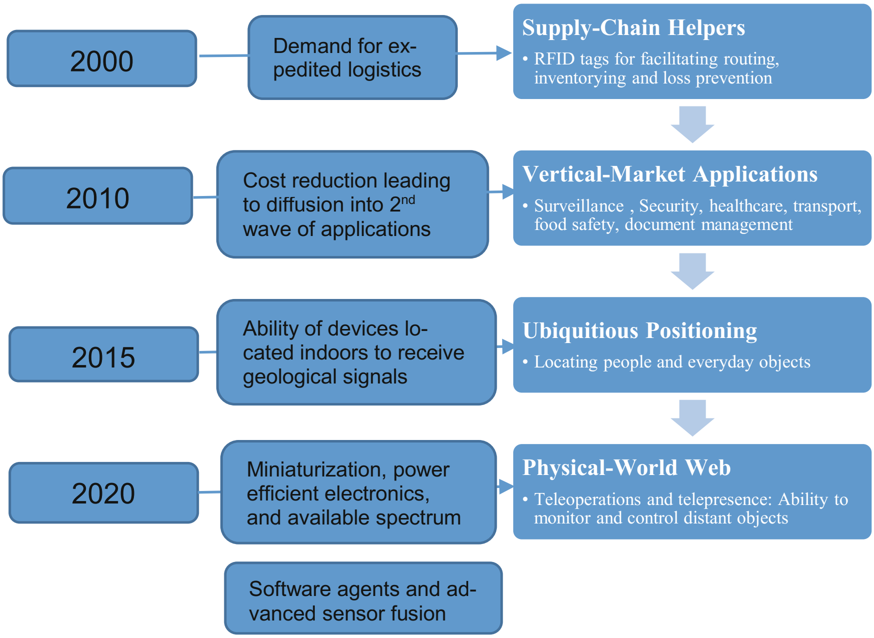


Fig. 3.2 Roadmap of internet of things from 2000 onwards [55]

According to the Gartner hype cycle 2017, it is estimated that IoT platforms will take 2 to 5 years for market adoption as shown in Fig. 3.3.

Google trends allows us to compare the trending patterns of various technologies by their web search popularity. Figure 3.4 compares three recent technologies i.e. Internet of Things, Big Data Analytics and Quantum Computing and shows that IoT is a technology trend setter in last three years [57].

A per the Accenture report 2018, covering 25 countries Tech Vision, 'Internet of Things' is one of the trending technology apart from Cloud, Artificial Intelligence, Blockchain, Augmented and Virtual Reality, Robotics, Quantum Computing [58].

3.4 Internet of Things: Present State

With the exponentially growing rate of the Internet of Things and lots of innovation happening around it in different verticals and technologies, the industries are highly motivated to invest in IoT with an objective of improving business processes, minimizing risks, and enhancing customer experiences. However, IoT is not just about installing sensors on objects and calling it "Smart". Comprehensive IoT solutions needs an appropriate infrastructure and supporting environment for data collection, data analysis and applications to trigger the action. The entire IoT

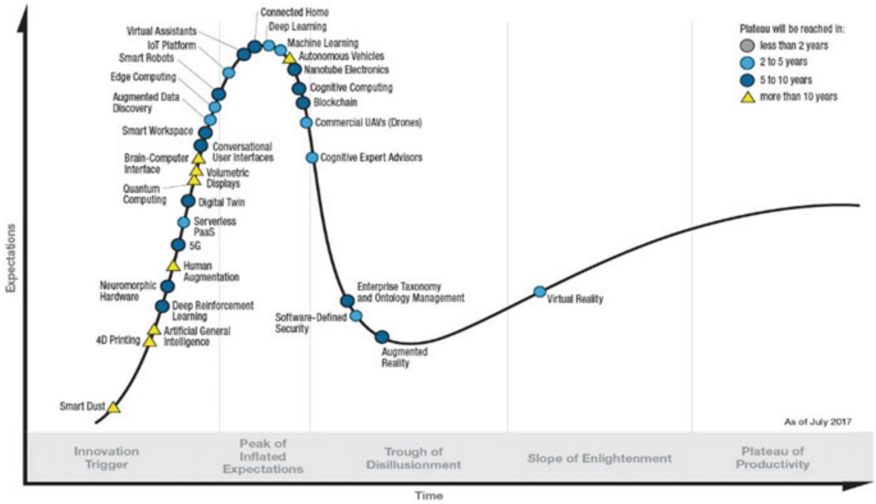


Fig. 3.3 Gartner 2017 hype cycle of emerging technologies (*Source* Gartner Inc.) [56]

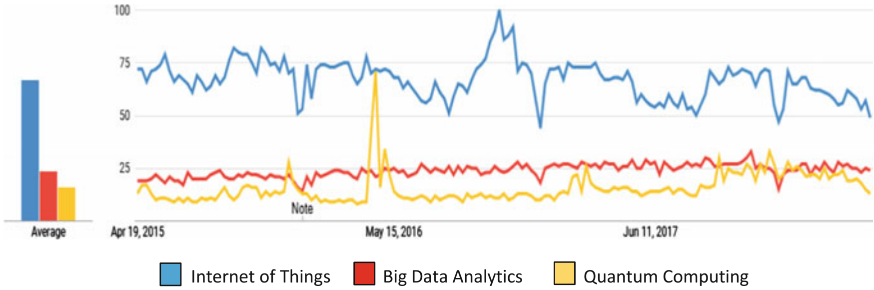


Fig. 3.4 Google search trends since 2015 for terms Internet of Things, Big Data Analytics, quantum computing [57]

ecosystem is driven by Government, Industry and Startups. Therefore, to set the stage properly for a shared vision of IoT in the complete ecosystem, we discuss the present state of IoT communication models, architecture, technologies and possible applications in this section.

3.4.1 Present Communication Models

The basic objective of IoT is to allow people to communicate with everything at anytime, anyplace, with anyone and anything, preferably using any network and any service. The speed with which IoT devices are growing, it's evident that in the future it will be found everywhere and will enable ambient intelligence. Hence, it is prudent to know about various communication models which allows IoT devices to connect and communicate. This section presents four communication models from a guiding architecture document released by Internet Architecture Board (IAB) for networking of smart objects (RFC 7452) in March 2015 [41].

(a) **Device-to-Device Communication Model**

- Communication is between two or more IoT devices as shown in Fig. 3.5.
- Devices does not need intermediary application server to connect and communicate with each other, they communicate directly.
- Communication takes place through Internet or IP networks or any other types of networks.
- Protocols used to establish direct communication can be Bluetooth [59], Zigbee [60], Z-Wave [61].
- Application are typically where small data packets are exchanged at a very low data rate, like home automation system which IoT devices are embedded in locks, bulbs, switches, thermostats etc.
- Limitation of device-to-device communication model- devices are incompatible due to different communication protocols being used by the manufacturers and can communicate only to the devices with same protocol.

(b) **Device-to-Cloud Communication Model**

- The communication is between IoT device and the internet cloud services (like application servers) for the data exchange and message traffic control as shown in Fig. 3.6.
- The communication takes place through traditional wired Ethernet or Wi-Fi connections to establish connection between the device and the IP network, which in turn connects to the cloud service.
- The device takes help of protocols such as HTTP, TCP/IP, TLS etc. to communicate with the cloud services.
- Samsung Smart TV [62] and Nest Labs leaning Thermostat [63] are the examples of IoT devices that have adopted device-to-cloud model.
- These IoT devices records the data, transmits it to the database in the cloud, where the data is analyzed for further use. The cloud technology provides a remote access to these devices, which can be obtained via a web interface or by a smartphone and also provides software updates to these devises.

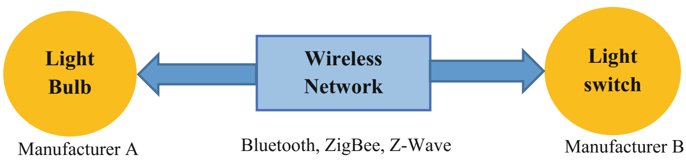


Fig. 3.5 Device-to-device communication model [41]

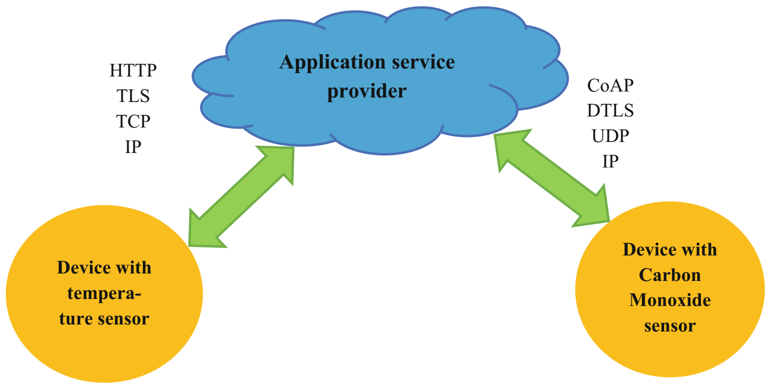


Fig. 3.6 Device-to-cloud communication model [41]

- In this model, the interoperability challenges are often faced when the devices developed by different manufacturers are attempted to integrate. In the present scenario, for this communication model to function properly, the device and the cloud should be from same vendor [64]. This vendor lock-in state prohibits the use of other service providers.

(c) **Device-to-Gateway Communication Model**

- The IoT device takes help of gateway device to communicate to the internet cloud services for the data exchange as shown in Fig. 3.7.
- The gateway device works on application layer and is known as application-layer-gateway. The gateway has an application software operating on it and acts as intermediary between IoT device and the cloud service, mainly supports data or protocol translation and provides security.
- Usually, the smart phones act as a gateway device with an App installed to communicate with an IoT device and transmit the data to a cloud service. An example of such application layer gateway is fitness App in a smartphone, which is connected to the fitness tracker device. This device cannot directly connect to the clouds service and hence depends on the smartphone App as a gateway device to connect.
- Besides smartphones, the hub devices also act as gateway device between IoT devices and cloud services, and are mainly used in home automation applica-tions. Hub devices also bridge the interoperability gap between devices themselves.
- Advantage: This model integrates new smart devices into a legacy system which further facilitates interoperability between devices.
- The challenge is addition of application layer software which adds costs and design complexity to the system.

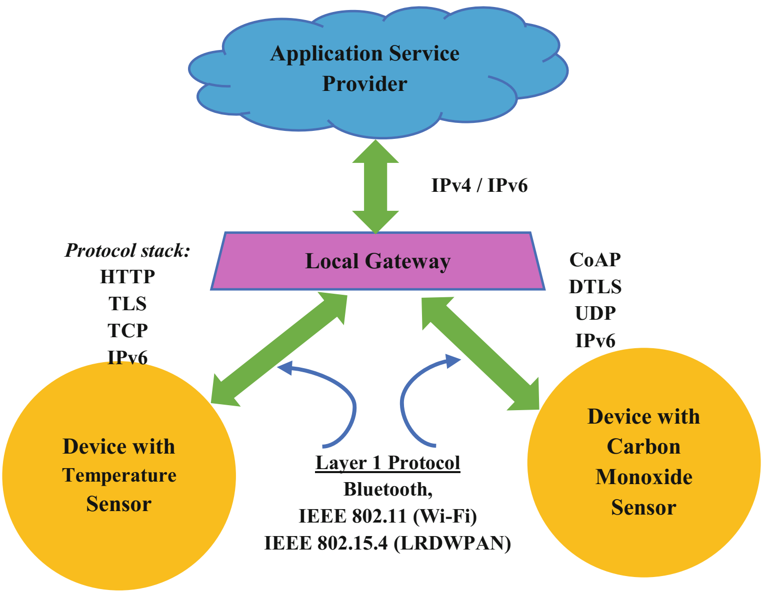


Fig. 3.7 Device-to-gateway communication model [41]

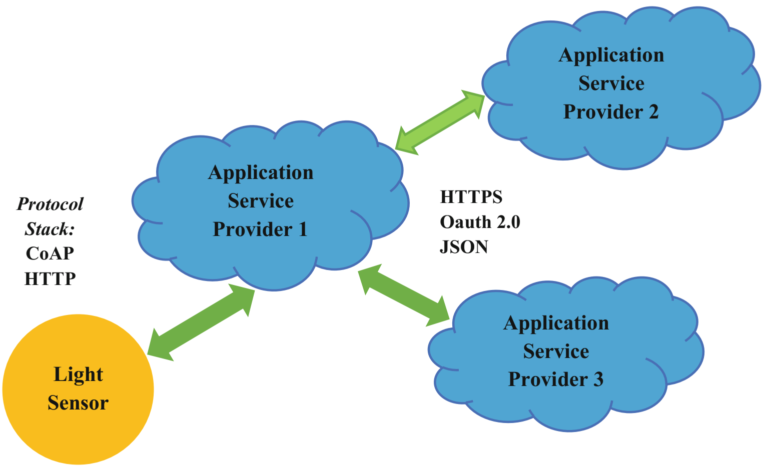


Fig. 3.8 Back-end data sharing communication model [41]

(d) **Back-End-Data-Sharing Communication Model**

- This communication model is driven by the users' wish to share the sensor data stored in the cloud with third parties [41]. Hence, the model empowers the users to export the smart object (IoT device) data from the cloud database and analyze it by integrating it with the data from other sources. The back-end data-sharing model is shown in Fig. 3.8.

- This model is an attempt to overcome the limitations of device-to-cloud model, where data from IoT devices are uploaded to single application service provider in the cloud creating data silos. A back-end sharing model permits to aggregate and analyze the data stream collected from multiple IoT devices.
- The model adopts a federated cloud services approach and achieves interoperability of IoT devices through cloud applications programmer interfaces.

The fundamental architecture used by IoT devices to communicate are divided into four categories of models. While selecting the right communication model for an IoT device being networked, one needs to understand its technical aspect as well as the type (open or proprietary). Right communication model adds value to the users' expectations from the IoT device. They provide a user to have better access to the device and the data generated so the values of device, app and data is augmented. The communication model also serves as a tool which allows to employ data aggregation, big data analytics, data visualization, and predictive analytics technologies to get value of IoT. Each of the communication model have their benefits and tradeoffs, the cloud services renders various applications, however, the costs incurred for the same must be affordable to the user in terms of connectivity of devices.

3.4.2 Present Architecture

The existing architecture of internet was adopted about four decades back in form of TCP/IP protocols, but today it is incompatible to serve the huge network of Internet of Things [65]. Hence, there is a need for a new architecture that can handle the network of over 25 billion connected objects, which is estimated to be available by 2020 [34]. This new architecture should use open source protocol to support existing network applications and provide security and Quality of Service (QoS) [66]. The key challenges for implementing IoT are data protection and data privacy [67, 68]. Therefore, various mutli-layered security architecture for IoT are proposed for its further enhancement. Wang Chen proposed the three layer architecture [69], Hui Sho et al. presented four layer architecture [70], MiaoWu et al. have referred architectures of Internet and Telecommunication management networks based on TCP/IP and TMN respectively to share the idea of five layer architecture [71] and Xu Cheng et al. proposed six layered architecture based on a hierarchical structure is shown in Fig. 3.9 [72].

The six layers of architecture of IoT is briefly discussed below:

- **First Layer—Coding**
  This is the base layer of the IoT architecture, where each object of interest is provided with a code for the sake of unique identification [72].

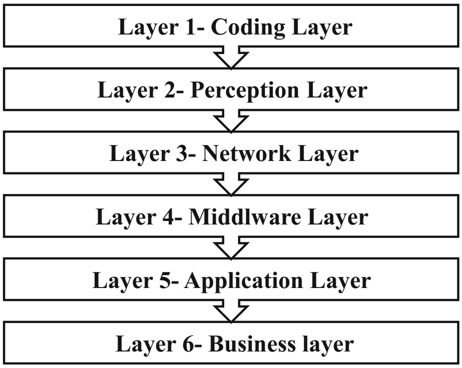


Fig. 3.9 Architecture of IoT proposed by Cheng [72]

- **Second Layer—Perception**
  The object of interest with the unique code is given a physical meaning by attaching an IoT devices to it, hence the layer is known as device layer or recognition layer or perception layer. The devices are usually sensors like RFID tags, IR sensors or other sensors and are responsible for sensing temperature, pressure, moisture, speed, location etc. [73]. In this layer, the data sensor gathers the information from the linked object, convert it into digital signal and transmits it for further action to the Network layer.
- **Third Layer—Network**
  The Network layers is responsible for secure data transmission between Perception layer and Middleware layer. This layer receives the information from the Perception layer in digital form and then further sends it to the Middleware layer for further processing. This layer uses various transmission mediums like Bluetooth, WiMaX, Zigbee, GSM, 3G etc. with protocols like IPv4, IPv6, MQTT, AMQP, CoAP, XMPP, DDS etc. [74], and is a convergence of internet and communication based network.
- **Fourth Layer—Middleware**
  This layer uses the advanced technologies like ubiquitous computing, cloud computing, fog computing, edge computing etc. to access the database directly and store the required information in it. This layer mainly processes the sensor data received from the Network layer, using Intelligent Processing Equipment, and performs a fully automated action based of the result [3].
- **Fifth Layer—Application**
  This layer provides the personalized service on the basis of user needs, using the result of the processed data. Various high-level intelligent applications of IoT is realized for all kinds of industry. The IoT related applications could be disaster monitoring, health monitoring, smart homes, smart transportation, smart planet etc. These applications encourage the expansion of IoT, and hence this layer is very vital in the development of large scale IoT network [71].

- **Sixth Layer—Business**
  The Business layer is the top layer of the IoT architecture, where various business models are generated for the effective business strategies. The applications and services provided by IoT is managed in this layer.

3.4.3 Present Technologies

The development of IoT network enables the object to be uniquely identified and be able to connect and communicate with other objects anytime and anywhere [75]. The seamless communication is achieved by three components of IoT that are mentioned below:

(a) Hardware—Sensors, Actuators, Embedded Communication Hardware
(b) Middleware—Storage tools, Computing tools
(c) Presentation—Visualization tool and Interpretation tool.

In this section, we present few technologies that make up the above components. These technologies help in realizing the entire IoT ecosystem.

Radio Frequency Identification (RFID)
Radio Frequency Identification is a key technology in the field of embedded communication, which aids the design of transceiver microchip for wireless communication [10]. RFID technology helps to identify and track objects in which it is implanted as a tag, that are of rice-grain size and very inexpensive, hence easy to integrate with any object [69]. There are mainly two types of tags i.e. active and passive. Active tags have their own battery, which helps them to be always active and emit the data signals, whereas passive tags are not powered by battery and needs to be triggered to fetch the data [3]. However, both the tags have wide range of application and can be implanted in living or non-living objects. RFID system comprise of tags that contains details of an object to which it is attached, and associated Readers [76]. The tags emit the data signals that contains the information like identification; location etc. regarding the object and that is transmitted using radio frequencies to the Readers, which then is shared with the processors for analysis.

Wireless Sensor Networks (WSN)
Wireless Sensor Networks is a breakthrough technology in remote sensing applications, which uses energy efficient, reliable, low cost, small size device based on integrated circuits and supports wireless communications. Hence, WSN is a sensor network that consists of many intelligent sensors, which collects, process, analyze and disseminates valuable information gathered over a network [51]. Each sensor is a communication, actuation and sensing unit, which is basically a transceiver that has micro-controller, antenna, a circuit which acts as an interface and a power source which could be battery or any other technology for energy harvesting [51,

77]. All of these put together forms the WSN hardware, which is known as a node, and are usually deployed in an adhoc manner for most of the applications. The deployed network is expected to have appropriate topology, MAC layer and routing to ensure the scalability and durability of the network, and be able to connect to the base station for data transmission in either single of multiple hop. The nodes may drop out and consequently the network may fail, hence a WSN communication stack at the sink node acts as a gateway between the Internet and WSN subnet so as to establish communication with the outer world [78].

WSN middleware provides access to sensor resources that are heterogeneous, by integrating cyber infrastructure with a sensor networks and Service Oriented Architecture (SOA) [78]. Open Sensor Web Architecture (OSWA) is a platform independent middleware which is used to develop sensor applications [79]. OSWA is based on Sensor Web Enablement Method (SWE) and Open Geospatial Consortium (OGC), which are the standard set of operations and data representations. Besides, WSN is expected to provide secure and efficient data aggregation method so as to ensure the authenticity of the collected sensor data and enhancing the life of the network [79]. Also, recovery process after the failure a node should be carried out without affecting the data transmission procedure.

Cloud Computing
Cloud Computing is an intelligent technology that is a convergence of many servers on to one cloud platform with an objective to share the resources and access them from anywhere and anytime [80]. Cloud technology is the integral part of IoT as it stores the aggregated data from various IoT devices, processes them and presents the analysis for future action [81]. With increasing number of IoT device interfacing with cloud, there is a need for more development of this technology to unleash its true power as IoT is be totally dependent on the Cloud Computing.

Data Storage and Analytics
Data is generated in profuse amount by IoT, the critical factors affecting the growth of data is its storage, data ownership and data expiry. Out of the total energy generated, 5% consumption is done by internet, which implies that the data centers needs to be energy efficient and reliable. The basic necessity is therefore data storage and its analysis. Algorithms making intelligent use of data should be designed which will be customized as per the need as centralized or distributed based algorithm. New genre of algorithm which are either evolutionary algorithms, genetic algorithms, neural networks are required for effective decision making. The systems thus created must possess characteristics such as interoperability, integration and adaptive communications. The system are based on modular architecture for hardware and software development.

Visualization
Visualization is one of the important aspect while dealing with IoT as it allows user interaction with the virtual environment. The visualization of the IoT application should be developed from layman perspective which is easy, simple and user friendly. This can be easily achieved through the advances in the touch screen and

speech recognition technologies. The change over from 2D to 3D screens implies that information is more organized and structured for the end used. The conversion of data into information to knowledge will lead to faster decision making process. The representation can be customized as the end user requirements and visualized further.

3.5 Discussion on Future of Internet of Things

As landscape of the Internet is growing at a very rapid pace, the entire world is migrating towards IOT which will have a huge impact on our lives in the coming few years. Computers, laptops, smartphones, and tablets are not the only things connecting with the internet, now there will be a multitude of smart devices connected to the internet and also to each other. Starting from home appliances such as refrigerator, microwave oven, doors to big industrial machinery. Everything will become smart. Some technology experts call it as the 'Next Digital Revolution' while others proclaim it as the 'Next Generation of Internet'.

There is a lot of scope for IoT in future. It has been estimated that there would be almost 50 billion connected devices by 2020. IoT is foreseen to touch every industry and people in every domain, optimizing businesses and simplifying people's lives. According to NASSCOM, global market size of IOT is expected to touch approximately USD 3 trillion by 2020. In this landscape, startups are playing a major role in enabling IOT services in the consumer as well as industrial segment. In India, there are more than 60% start-ups who are working in IOT solutions with their highly technical and technological skills.

IOT proves to have a huge scope as it provides a unique opportunity for businesses to turn data into insights. There are a number of contributing factors as well that drive the adoption of IOT such as improved sensors, device connections, the evolution of lifestyle and mobility. Following are some of the predictions about IoT that will see come true in the upcoming years.

3.5.1 Connected Devices

It is estimated that by 2020, the number of connected devices will increase at a much more rapid rate [34]. Commercial and Industrial sectors, powered by building automation, industrial automation and lighting, are expected to account for nearly 50% of all new connected devices between 2018 and 2030. This segment is the fastest-growing at 24.4%, with 5.4 billion IoT-enabled devices slated to hit the market by 2030 [82]. In absolute numbers, communication and consumer electronics account for the largest share of IoT connected devices. By 2030, there would be 22.7 billion such devices in these segments. Automotive and medical sectors follow, accounting for 928 million and 406 million IoT-enabled devices respectively. Figure 3.10 shows the number of connected devices (Internet of Things; IoT)

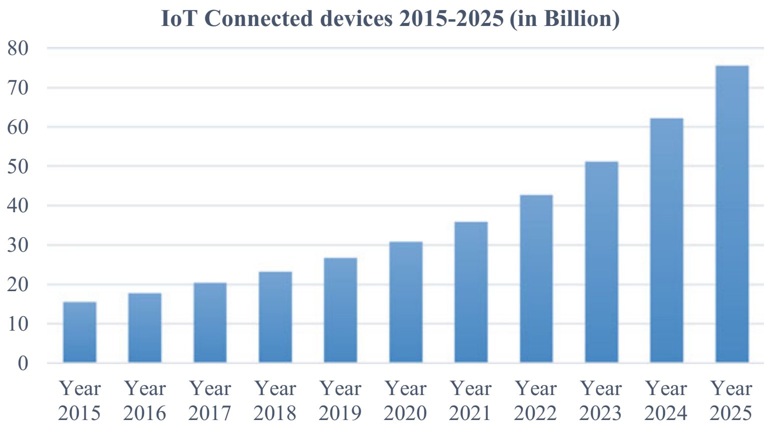


Fig. 3.10 IoTconnected devices installed base worldwide from 2015 to 2025 (in billions) [83]

worldwide from 2015 to 2025. For 2020, the installed base of Internet of Things devices is forecast to grow to almost 31 billion worldwide. The overall Internet of Things market is projected to be worth more than one billion U.S. dollars annually from 2017 onwards [83]. Moreover, for billions of smart connected devices to communicate via the Internet, there is a need of a robust naming architecture to be able to identify a smart object and to establish an access path to the object [84].

3.5.2 IoT for Hackers

Cyber security has emerged as a top concern for IoT adopters. Since IoT devices create a "Complex Management Environment" with multiple technology profiles, processing capabilities, use-cases, physical locations, etc. more data is potentially at risk. In case of IoT-enabled transportation, vehicles in motion could be compromised remotely to have a disastrous effect on passengers. IoT devices can also be embedded into systems that can affect physical health and safety [82].

In Oct 2016, first IoT malware was introduced. It had a strain of malware that has the ability to infect connected devices. This malware could easily access the devices using their default login (username and password). Then, it turns those devices into a Botnet that is then used for DDoS (Distributed Denial of Service) attacks. This attack brought many internet service websites to a screeching halt for hours. Many big hosting companies were also flooded in this attack. The code of this malware is available as open source for modification. As a result, after sometime after this attack, a modified version of this code was introduced that infected many other connected devices. Sadly, it is predicted that hackers will keep using IoT for DDoS in the future, too.

3.5.3 Smart Cities

Smart city devices are new Internet of things (IOT) applications that leverage ubiquitous connectivity, big data and analytics to enable smart city initiatives all over the world. These new applications introduce new capabilities such as the ability to remotely monitor, manage and control devices, and to create new insights and actionable information from massive streams of real-time data. Global smart city device shipments will increase from 202 million in 2017 to 1.4 billion in 2026 [82]. Using such technologies in cities would make it easier for cities to manage and collect data remotely. It will also be easier to automate different processes.

IHS Markit notes vertical applications related to physical infrastructure and mobility show particular potential for growth—in 2026 these applications are expected to comprise approximately 65 and 22% of total device shipments, respectively [83]. It believes the largest market will be Asia-Pacific with more than 700 million smart city device shipments by 2026. Other key regions will be North America and Europe, with more than 400 million and 200 million shipments, respectively.

3.5.4 Secured Routers

Many IoT devices would remain inside our homes and thus, it would be quite difficult to install any security software on them. Marketers are neglecting the security of the IoT products quite a bit. Here, a home router can play a very significant role. They are considered the data entry point of the Internet in your home. They can protect the data entrance to the internet. Today, routers do not have any security software installed on them. This means that the hackers can easily sneak malware through them. In the future, it is predicted that many secure routers will be made available for people to protect the internet from the entry point, too. Some of the features that such routers will have are:

- Data Encryption
- Secure DNS
- Automatic security updates.

3.5.5 Usage of Smart Products

As IoT has expands its reach into the home, businesses, and industrial environment. More and more devices would be connected to share data and for real-time communication and data analytics. From the consumer's point-of-view, following are some of the benefits of using smart products:

- Increased energy efficiency
- Improved safety
- Improved security
- Higher-quality product.

3.5.6 App-Specific Device Ecosystems

A model is put forward to create a semi-closed device vendor ecosystem for applications. The benefit of such a system is that with these services, it is possible for a multi-vendor ecosystem to certify different brands by their IoT gateways. The real issue is that most comprehensive device management is provided by IoT application vendors these days, which means that all the components, are bound together by a single vendor to work. For example, a smart briefcase tag device will work only with the vendor's briefcase tracking application but it is impossible to make it work with any other vendor's briefcase tracking application. In case you desire to switch to some other vendor, in that scenario you will have to buy a new tag to work with that vendor application. But with this solution, consumers can buy devices from different vendors and quickly make them work with an application.

Thus, the IoT industry needs an open device management standardization to ensure interoperability. Such efforts are already being made and will start to come to life shortly. In this way, IoT consumers will surely achieve a new maturity level, and they will then not fear losing their hardware investments.

3.5.7 IoT for Businesses

The business intelligence sector has been analyzing IoT growth for some years. It is predicted that almost USD 6 trillion will be spent on IoT solutions in the coming five years. Business will adopt IoT solutions at a bit faster rate than other sectors. The benefits they will get by following such strategies are:

- Increase in productivity
- lowering the costs of operations
- The government will also take a keen interest in such solutions to improve the quality of life of their people. They are believed to be the second-largest adopter of such solutions.

Consumers will also invest their money in the IoT ecosystems.

3.5.8 Some Awesome Inventions

Multi-application gas sensors are being developed that can detect bio-chemical threats and are able to recognize different diseases just by analyzing your breath. Such sensors are driving other new trends in technology.

Decrease in Air Pollution by Technology
Tired of the smog and air pollution these days? Infact, it may soon be a thing of the past and soon, the situation will be a bit different. There will be a spotlight with embedded video sensors that will be able to adjust the green and the red lights according to the traffic and the time. This solution will reduce congestion and smog, too.

Intelligent Parking System
The vehicles that we see idle at a red light in traffic burn up almost 17% of fuel consumption. The parking system will also be a bit different from what it is right now. Sensors embedded in parking systems will give real-time information about the empty spots through an app. In this way, drivers will be informed about those empty spots by the app. And do you know that almost 30% of congestion is due to drivers who keep carving the streets for hours in search an empty spot to park their vehicles?

3.6 Conclusion

Internet of Things has completely changed the way we live, communicate, play and work, however the potential is yet to be unleased. The sheer power of this technology giant will be fully utilized when the technology will impact the lives of people at every moment. It will change the way people look towards the use of technology and the ripple factor thus created will domesticate IoT. The corporate players are into the production of the devices, companies are into devising new applications, technocrats are designing new technology and protocols; and the users are using IoT solutions and services. Inspite of so much of work being done, the IoT paradigm will take more time to mature, as the technology and related concepts are still in the infant state. The economic and technology era will be helpful for the progress of IoT in the entire globe. However, we should not be blindfold by the power of this promising technology, there are many issues and challenges associated with it. More robust implementation strategies needs to be designed to maximize IoT opportunities and its exposure the world. In this paper, we have discussed past, present and future of IoT, as unless we know the technology evolution we cannot predict it future scope. The chapter is journey for the readers to understand tits and bits of IoT so that new horizons can be set by.

References

1. Khan, R., Khan, S.U., Zaheer, R., Khan, S.: Future internet: the internet of things architecture, possible applications and key challenges. In: Proceedings of Frontiers of Information Technology (FIT), pp. 257–260 (2012)
2. Alkhatib, H., Faraboschi, P., Frachtenberg, E., Kasahara, H., Lange, D., Laplante, P., Merchant, A., Milojicic, D., Schwan, K.: IEEE CS 2022 report; IEEE computer society: Washington. DC, USA (2014)
3. Shen, G., Liu, B.: The visions, technologies, applications and security issues of internet of things. E-Business and E -Government (ICEE), pp. 1–4
4. Pal, A., Mukherjee, A., Dey, S.: Future of Healthcare-Sensor Data-Driven Prognosis. International Publishing Switzerland, Springer Series in Wireless Technology (2016)
5. International Telecommunication Union—Telecommunication Standardization Sector (ITU-T). Recommendation ITU-T Y. 2060—Overview of the Internet of Things; ITU-T: Geneva, Switzerland (2012)
6. Hwang, J., Choe, Y.: Smart Cities—Seoul: A Case Study. ITU-T Technology Watch Report; International Telecommunication Union—Telecommunication Standardization Sector (ITU-T): Geneva, Switzerland (2013)
7. Cisco: The Internet of Things Reference Model; Cisco and/or its Affiliates: San Jose, CA, USA (2014)
8. OECD Committee for Digital Economy Policy: OECD Technology Foresight Forum 2014—The Internet of Things
9. Dutta, S., Geiger, T., Lanvin, B.: The Global Information Technology Report 2015—ICTs for Inclusive Growth. Geneva, Switzerland, World Economic Forum and INSEAD (2015)
10. Atzori, L., Iera, A., Morabito, G.: The internet of things: a survey. Comput. Netw.—Sci Direct **54**(15), 2787–2805 (2010)
11. Zeng, L.: A security framework for internet of things based on 4G Communication. In: Computer Science and Network Technology (ICCSNT), pp. 1715–1718 (2012)
12. Ibarra-Esquer, J.E., González-Navarro, F.F., Flores-Rios, B.L., Burtseva, L., Astorga-Vargas, M.A.: Tracking the evolution of the internet of things concept across different application Domains, Sensors **17**, 1379 (2017)
13. Laya, A., Bratu, V.I., Markendahl, J.: Who is investing in machine-to-machine communications? In: Processing 24th European registration ITS Conference, Florence, Italy, Oct. 2013, pp. 20–23 (2013)
14. Dohler, M., Vilajosana, I., Vilajosana, X., Llosa, J.: Smart Cities: An action plan. Proceedings Barcelona Smart Cities Congress, Barcelona, Spain, Dec. 2011, pp. 1–6 (2011)
15. Vilajosana, I., Llosa, J., Martinez, B., Domingo-Prieto, M., Angles, A., Vilajosana, X.: Bootstrapping smart cities through a self-sustainable model based on big data flows. IEEE Commun. Mag. **51**(6), 128–134 (2013)
16. Hernández-Muñoz, J.M., Vercher, J.B., Muñoz, L., Galache, J.A., Presser, M., Hernández Gómez, L.A., Pettersson, J.: Smart cities at the forefront of the future internet. the future internet. Lect. Notes Comput. Sci. **6656**, 447–462 (2011)
17. Mulligan, C.E.A., Olsson, M.: Architectural implications of smart city business models: an evolutionary perspective. IEEE Commun. Mag. 51(6):80–85 (2013)
18. Walravens, N., Ballon, P.: Platform business models for smart cities: From control and value to governance and public value. IEEE Commun. Mag. 51(6):72–79 (2013)
19. Bellavista, P., Cardone, G., Corradi, A., Foschini, L.: Convergence of MANET and WSN in IoT urban scenarios. IEEE Sens. J. 13(10), 3558–3567 (2013)
20. Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M., Oliveira, A.: Smart cities and the future internet: towards cooperation frameworks for open innovation. The Future Internet. Lect. Notes Comput. Sci. **6656**, 431–446 (2011)
21. Cuff, D.; Hansen, M.; Kang, J.: Urban sensing: out of the woods. Commun. ACM, **51**(3), 24–33 (2008)

22. Lynch, J.P., Kenneth, J.L.: A summary review of wireless sensors and sensor networks for structural health monitoring. Shock Vibr. Digest **38**(2), 91–130 (2006)
23. Nuortio, T., Kytöjoki, J., Niska, H., Bräysy, O.: Improved route planning and scheduling of waste collection and transport. Expert Syst. Appl., **30**(2), 223–232 (2006)
24. Soliman, M., Elsaadany, A.: Experimental evaluation of internet of things in the educational environment. iJEP **7**(3), 50–60 (2017)
25. Elsaadany, A.: Campus crowd sensing platform using mobile computing for smart education environments. In: Proceedings of Fifth International Conference on Information Communications Technology, Alexandria (2015)
26. Atzori, L., et. al.: The social internet of things (SIoT)—when social networks meet the internet of things: concept, architecture and network characterization. Comput Netw **56**(16), 3594–3608 (2012)
27. Mashal, O.A., Chung, T.Y.: Analysis of recommendation algorithms for Internet of Things. In: IEEE Wireless Communications and Networking Conference Workshops (WCNCW), pp. 181–186 (2016)
28. Chandrahasan, M.: Survey on different smart parking techniques. Int. J. Comput. Appl. (0975–8887) **137**(13) (2016)
29. Al-Ali, A.R., Zualkernan, I., Aloul, F.: Amobile GPRS-sensors array for air pollution monitoring. IEEE Sens. J. **10**(10), 1666–1671 (2010)
30. Maisonneuve, N., Stevens, M., Niessen, M.E., Hanappe, P., Steels, L.: Citizen noise pollution monitoring. In: Proceedings of the 10th Annual International Conference on Digital Government Research: Social Networks: Making Connections between Citizens, Data and Government. Data Gov., pp. 96–103 (2009)
31. Li, X., Shu, W., Li, M., Huang, H.Y., Luo, P.E., Wu, M.Y.: Performance evaluation of vehicle-based mobile sensor networks for traffic monitoring. IEEE Trans. Veh. Technol., **58** (4), 1647–1653 (2009)
32. Lee, S., Yoon, D., Ghosh, A.: Intelligent parking lot application using wireless sensor networks. In: Proceeding International Symposium Collaborative Technologies and System Chicago, May 19–23, 2008, pp. 48–57 (2008)
33. Kastner, W., Neugschwandtner, G., Soucek, S., Newmann, H.M.: Communication systems for building automation and control. Proc. IEEE, Jun. 2005, vol. 93, no. 6, pp. 1178–1203 (2005)
34. Evans, D.: The internet of things—how the next evolution of the internet is changing everything. Cisco Internet Business Solution Group (IBSG) (2011)
35. McKinsey Global Institute, Unlocking the Potential of the Internet of Things, June 2015
36. Gartner Inc., The Internet of Things Is a Revolution Waiting to Happen, 30 April 2015
37. International Data Corporation (IDC) Explosive internet of things spending to reach $1.7 Trillion in 2020, According to IDC, 02 June 2015
38. Ashton, K.: That—Internet of things. Thing, RFiD J. (2009)
39. Sundmaeker, H., Guillemin, P., Friess, P., Woelfflé, S.: Vision and challenges for realising the internet of things. Cluster of European Research Projects on the Internet of Things—CERP IoT (2010)
40. RFC 7452: Architectural considerations in smart object networking (March 2015)
41. Thaler, D., Hannes, T., Barnes, M.: Architectural considerations in smart object networking. IETF 92 Technical Plenary—IAB RFC 7452. 6 Sept. 2015
42. Int Area Wiki—internet-of-things directorate. IOTDirWiki. IETF, n.d. Web. 06 Sept. 2015
43. http://www.comsoc.org/commag/cfp/internet-thingsm2m-research-standards-next-steps
44. Internet of Things. Oxford Dictionaries, n.d. Web. 6 Sept. 2015
45. Belissent, J.: Getting clever about smart cities: new opportunities require new business models. Forrester Res (2010)
46. Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M.: Internet of things (IoT): a vision, architectural elements, and future directions. Future Gener. Comput. Syst. **29**, 1645–1660 (2013)

47. Bolt, R., Beranek, L., Newman, R.: A history of the ARPANET: the first decade; DARPA Report No. 4799; Bolt Beranek and Newman Inc.: Cambridge, MA, USA (1981)
48. Manley, J.H.: Embedded computers: software cost considerations. In: AFIPS '74 Proceedings of the May 6–10, 1974, National Computer Conference and Exposition; ACM Press: New York, NY, USA, pp. 343–347 (1974)
49. The "Only" Coke Machine on the Internet, Carnegie Mellon University, School of Computer Science
50. Weiser, M.: The computer for the 21st century. Sci. Am. **265**, 94–104 (1991)
51. Akyildiz, I.F., Su, W., Sankarasubramaniam, Y., Cayirci, E.: Wireless sensor networks: a survey. Comput. Netw. **38**, 393–422 (2002)
52. Jason, P.: Bill joy's six webs. MIT Technology Review, 29 September 2005
53. Ashton, K.: That 'Internet of Things' Thing, RFID J. 22 June 2009
54. Roberti, M.: Jan. 16, 2005, "The History of RFID Technology"
55. Taso (2014) SRI consulting business intelligence—the internet of things roadmap
56. Gartner's hype cycle special report for 2017, Gartner Inc
57. Google trends, google. http://www.google.com/trends (n.d.)
58. Tech vision report https://www.accenture.com/t20180227T215953Z__w__/us-en/_acnmedia/Accenture/next-gen-7/tech-vision-2018/pdf/Accenture-TechVision-2018-Tech-Trends-Report.pdf
59. http://www.bluetooth.com and http://www.bluetooth.org
60. http://www.zigbee.org
61. http://www.z-wave.com
62. Samsung privacy policy—smart TV supplement, Samsung Corp. Web. 29 Sept. 2015
63. Meet the Nest Thermostat. Nest. Nest Labs. Web. 31 Aug. 2015
64. Marsan, D., Carolyn. (2015) IAB releases guidelines for internet-of-things developers. IETF J. 11.1: 6–8. Internet Engineering Task Force
65. From the ARPANET to the Internet by Ronda Hauben-TCP Digest (UUCP)
66. Jian, A., Xiao-Lin, G., Xin, H.: Study on the architecture and key technologies for internet of things. Adv. Biomed. Eng. **11**, IERI-2012, pp. 329–335 (2012)
67. Lan, L.: study of security architecture in the internet of things. Measur. Inf. Control (MIC), 2012, **1**, 374–377 (2012)
68. The Internet of Things, ITU Report, Nov 2005
69. Chen, W.: An IBE based security scheme of internet of things. Cloud Comput. Intell. Syst. (CCIS), pp. 1046, 1049 (2012)
70. Suo, H., Wan, J., Zou, C., Liu, J.: Security in the internet of things: a review. Comput. Sci. Electron. Eng. (ICCSEE), pp. 648–651 (2012)
71. Wu, M., Lu, T., Ling, F., Sun, L., Du, H.: Research on the architecture of Internet of things. Adv. Comput. Theory Eng. (ICACTE), pp. 484–487 (2010)
72. Cheng, X., Zhang, M., Sun, F.: Architecture of internet of things and its key technology integration based-on RFID. In: Fifth International Symposium on Computational Intelligence and Design, pp. 294–297 (2012)
73. Bandyopadhyay, D., Sen, J.: Internet of things-applications and challenges in technology and standardization. Wireless Pers. Commun. **58**(1), 49–69
74. Zhang, Y.: Technology framework of the internet of things and its application. Electr. Control Eng. (ICECE), pp. 4109–4112 (2011)
75. Khoo, B.: RFID as an enabler of the internet of things: issues of security and privacy. internet of things (iThings/CPSCom), pp. 709–712 (2011)
76. Zhang, H., Zhu, L.: Internet of things: key technology, architecture and challenging problems. Comput. Sci. Autom Eng. (CSAE), **4**, 507–512 (2011)
77. Sohraby, K., Minoli, D., Znati, T.: Wireless sensor networks: technology, protocols, and applications. Wiley, pp. 15–18 (2007)
78. Ghosh, A., Das, S.K.: Coverage and connectivity issues in wireless sensor networks: A survey. Pervasive Mobile Comput. **4**, 303–334 (2008)

79. Sang, Y., Shen, H., Inoguchi, Y., Tan, Y., Xiong, N.: Secure data aggregation in wireless sensor networks: a survey. In: 2006 Seventh International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT'06), pp. 315–320 (2006)
80. Rao, B.B.P., Saluia, P., Sharma, N., Mittal, A., Sharma, S.V.: Cloud computing for internet of things and sensing based applications. In: 2012 Sixth International Conference Sensing Technology (ICST), IEEE (2012)
81. Xiaohui, X.: Study on security problems and key technologies of the internet of things. In: Computational and Information Sciences (ICCIS), pp. 407–410 (2013)
82. Global business research and analytics provider IHS Markit https://cdn.ihs.com/www/pdf/enabling-IOT.pdf Accessed 09 Jun 2018
83. https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/, Accessed 09 Jun 2018
84. Kopetz, H.: Internet of things. In: Real-Time Systems. Springer, Boston, MA, USA, pp. 307–323 (2011)

Chapter 4
A Survey on IoT Based Traffic Control and Prediction Mechanism

Sourav Banerjee, Chinmay Chakraborty and Sumit Chatterjee

Abstract Internet of Things (IoT) is the most demanding platform that describes the interconnection of physical devices in near future. Since, the inter-connection of physical devices is getting more popular with the internet day by day, these interlinked devices are capable of integration among themselves in order to operate. Automated vehicles are being produced heavily nowadays and it is considered to be the next technological rage in the field of transportation. This revolution in the transport environment needs redesigning the infrastructure so that the production of embedded vehicles can be chained to an embedded traffic management system. This instinctual design of the traffic control and management system can lead to the improvement of the traffic congestion problem. The traffic density can be calculated using a Raspberry Pi microcomputer and a couple of ultrasonic sensors and the lanes can be operated accordingly. A website can be designed where traffic data can be uploaded and any user can retrieve it. This property will be useful to the users for getting real-time information and detection of any road intersection and discover the fastest traffic route.

Keywords Internet of things · Traffic control · Sensors · RFID
Short range technology · Cloud computing · Image processing

Abbreviations List

IoT	Internet of things
IP	Internet protocol
MPO	Metropolitan planning organization
RFID	Radio-frequency identification

S. Banerjee (✉) · S. Chatterjee
Kalyani Government Engineering College, Kalyani, West Bengal, India
e-mail: mr.sourav.banerjee@ieee.org

S. Chatterjee
e-mail: sumitc219@rediffmail.com

C. Chakraborty
Birla Institute of Technology, Ranchi, Jharkhand, India
e-mail: cchakrabarty@bitmesra.ac.in

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_4

4.1 Introduction

4.1.1 Motivation

Internet of things (IoT) is an idea which suggests every object being connected to each other [1]. These objects can be any electronic device like mobiles, tablets, cameras, censors, LCD/LED displays, speakers or any other kind of electronic gadgets. The devices which are used to form the network must be imparted the ability of recognizing and communicating with each other. The method of communication among the devices is referred to as Radio Frequency Identification (RFID) using electromagnetic waves [2].

4.1.2 Application of IoT

The application of IoT is huge in the day to day life including the switching of TV using remote app in mobile, driving of driverless vehicles etc. Modern days smart city project are using the technology of IoT by installing different sensors and cameras throughout the cities [3]. The idea of IoT was first proposed during the 1980s. The devices which communicate with each other must be assigned distinct Internet protocol addresses. The scarcities of the IP addresses have been efficiently solved by the replacement of IPv4 with IPv6. IoT have been widely used by the business enterprises in order to track their products. Sensors are preinstalled in the products which help the manufactures to collect the information about their products and analyse their performance [2]. IoTs have been applied widely in the following systems viz. smart home, wearable's, connected cars, industrial internet, smart cities, agriculture, traffic control, smart retail, energy management, healthcare and poultry and farming respectively. Internet of Things has become an indispensable thing in the daily lives of today's people. The intercommunication of data between several devices helps to exchange data and thereby aids in the improvement of any distributed system. The smart cities project that is undertaken by different countries throughout the world has become largely benefitted from the use of IoT. Application of IoT in the embedding computing system has helped a lot in environmental monitoring [3]. The use of water and soil measurement device has facilitated the study of agriculture. Monitoring of wild life habit, prediction of earthquakes, storms and tsunamis, managing infrastructure like bridges railways, investigation of product quality in industry, reduction of power consumption via sensors, controlling heart rate or blood pressure via automated healthcare systems, building and home automation, reduction of traffic congestion are some of the areas in which IoT has been widely applied. However challenges like data privacy have been faced while designing and configuring such systems [4]. Some organizations have opposed the use of IoT as they are highly concerned with the leakage of their business related data. However, this challenge has not shown too much impact on the development of embed computing system using the IoTs. The modern trend in the industry is to develop IoT platform for different cases [5]. Industries have decided to adapt standard protocols for collecting the data and managing the communication [5]. There is an approach towards the development of business applications with common interfaces that will work by separating the raw data from the business related data. The major application of big data analytics in the field of IoT can aid in the development of many such technical projects [5].

4.1.3 Objective

The objective of this chapter is to provide a detailed survey of IoT based traffic control and prediction mechanism that are being undertaken in different modern cities throughout the world. The survey provides a details on the smart traffic management system that are deployed in smart cities, context aware traffic management using ontology, designing traffic system for helping emergency vehicles, local traffic smart server based traffic framework, use of semantic web for intelligent traffic monitoring and real time traffic control using cloud computing.

4.1.4 Summary of Chapter

The chapter consists of eight sections in total. The Sect. 4.1 provides the introduction. The Sect. 4.2 gives the description of designing a smart traffic management system using IoT. This section provides the mechanism of using inductive loop detection and video analysis by using infrared sensors and wireless sensor network. The Sect. 4.3 describes the application of ontology in context aware traffic management. MOWL is used as an ontology representation language for tracking traffic situation using deep belief network. The Sect. 4.4 describes designing android applications for helping emergency vehicles. The controller installed inside the traffic signal posts can receive signals from android applications of mobiles of passengers sitting inside emergency vehicles. The controller then allows free passage of the emergency vehicles based on their priority. The Sect. 4.5 gives a description of local traffic smart server based traffic framework. The sensors collect data and send them to the data processing unit of the server which in turn analyses it to reduce the congestion. The Sect. 4.6 deals with application of IoT with semantic web for intelligent traffic monitoring. The interlinking between the vehicles can be detected using Zigbee protocol and the congestion can be avoided the bypassing the traffic through an alternate lane. The Sect. 4.7 deals with real time traffic control using cloud computing. The detection of emergency vehicles like ambulance is achieved by image processing and other vehicles are instructed to allow the emergency vehicles to pass freely. The vehicles that do not follow the instructions are monitored and their numbers are extracted from the name plates and send to nearest police stations. The necessary communication among the stations is done by cloud computing. The Sect. 4.8 draws a conclusion of the entire chapter.

4.2 Design of Smart Traffic Management System Using IoT

IoT platform has been widely applied for the development of intelligent transport system which resulted in the evolution of traffic control and prediction system. It is approaches that uses the mechanism of IoT for controlling the traffic and ensure safety [6]. The task is mainly achieved by the collection and analysis of the real time traffic data.

4.2.1 Objectives of Intelligent Transport System

The objectives of intelligent transport system are:

i. Increasing the Efficiency of Transportation System
ii. Mobility Enhancement
iii. Ensuring Safety and Security
iv. Reduction of Fuel Consumption
v. Increasing Economic Productivity

4.2.2 Techniques Used

In order to achieve the above mentioned objectives, the following methods are applied:

4.2.2.1 Detection of Inductive Loop

Inductive Loops are used for transmitting signals with an aim to recognize objects using metal detector or vehicle indicator. A narrow ditchin the street is filled up with insulated cables which are connected to a controller [7, 8]. The induction inside the wires changes depending on the number of number of vehicles crosses the wires or stops across them. This change in induction also changes the frequency which generates an electronic signal. This signal reaches the control unit and helps to detect the existence of vehicles. This signal is further analysed to find out the number of vehicles within that area and also track their movements.

4.2.2.2 Video Analysis

A smart camera with a data processor, stimuli sensitive sensors and a transmission unit is used for this purpose [7]. The camera is used to capture video which is used for calculation of the traffic statistics resulting in exposure of certain information like vehicle frequency, path occupancy and average speed. However this scheme needs high investment cost and proper Street lightening during nights.

4.2.2.3 Infrared Sensors

Infrared sensors can sense any kind of infrared radiation. They capture the energy emitted from vehicles and road surface which is converted to electrical impulses using infrared reactive objects. These stimuli can be used for traffic checking, signal management, recognition of pedestrians etc. However, infrared sensors can become ineffective due to smoke and fog. The installation and maintenance of these devices is also quiet complex [9].

4.2.2.4 Wireless Sensor Network

Wireless sensors are often employed for detection of traffic to avoid the road congestion. They can transfer information very fast, are easy to install, require less maintenance, and are compact and cheaper than other electronic devices [8, 10, 11]. They can be used to ensure priority for emergency vehicles. Research is going on to monitor and control the real time traffic using Wireless Sensor Network in combination with Bluetooth devices and cameras.

4.2.3 Design of the Traffic Management System

RFID tag is deployed with the vehicles which hold data about the vehicles. The tag can be used to identify other vehicles. Figure 4.1 describes how the real traffic is subjected to the detection system and thereby passed to the control decision.

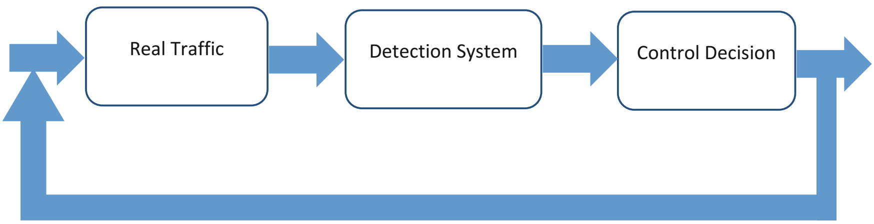


Fig. 4.1 Intelligent transport system

The figure indicates that every signal contains data about the vehicles passing by. The signal is used to count the number of vehicles that passes by. The tragic congestion can be handled by this counting of number of vehicles. The threshold value of the signal is either red or green. The lowest frequency of the vehicle passing by is calculated by the controller. Suppose the maximum threshold value of red is 20 and green is 30. The lowest frequency of vehicle passing by is 5. By default, the controller produces green signal. A peak value of 20 can be used as the starting time by the timer. If the frequency of the passing by vehicles falls below 5, the controller turns the signal to red. The red signal is turned on and the signal of that subsequent connection is changed to green. This process repeats itself in a cyclic way.

The system checks the number of vehicles passing per second and compares it with the threshold value; if it crosses the threshold value then congestion will be detected at that location. On detection of congestion, a notification message is send to the next former's signal controller. When there is no more congestion, the particular signal controller can forward a notification to the previous controller for restarting the traffic [12].

4.2.4 Rfid

The RFID has an antenna which collects the information and stores them in a chip. The RFID controller possesses an interrogator that communicates with the RFID tag. The signal is received by the interrogator and forwarded to the controller. The controller senses the signals and undergoes read or write operations on the RFID tag. It is equipped with an interface for the connecting external GSM/GPRS devices [12]. RFID tag is applied for identification and tracking of objects in mobile devices. There are two types of RFID devices-active and passive. Active RFID has battery installed inside and passive use outside power source. Non volatile memory is used for storing tag data. Each tag possesses a transmitter and receiver with a unique serial number. Figure 4.2 represents the architecture of RFID controller. The timer is initialized to maximum value. Then it is checked whether the timer value is less than maximum value of green and not equal to zero. If yes then turn the signal to red and move to the adjacent signal. If no then measure the actual frequency count. If the actual frequency count is greater than the minimum frequency count then decrement the timer count by 1 and again check the timer value. If the actual frequency count is less than the minimum frequency count then turn the signal red and move to the adjacent signal.

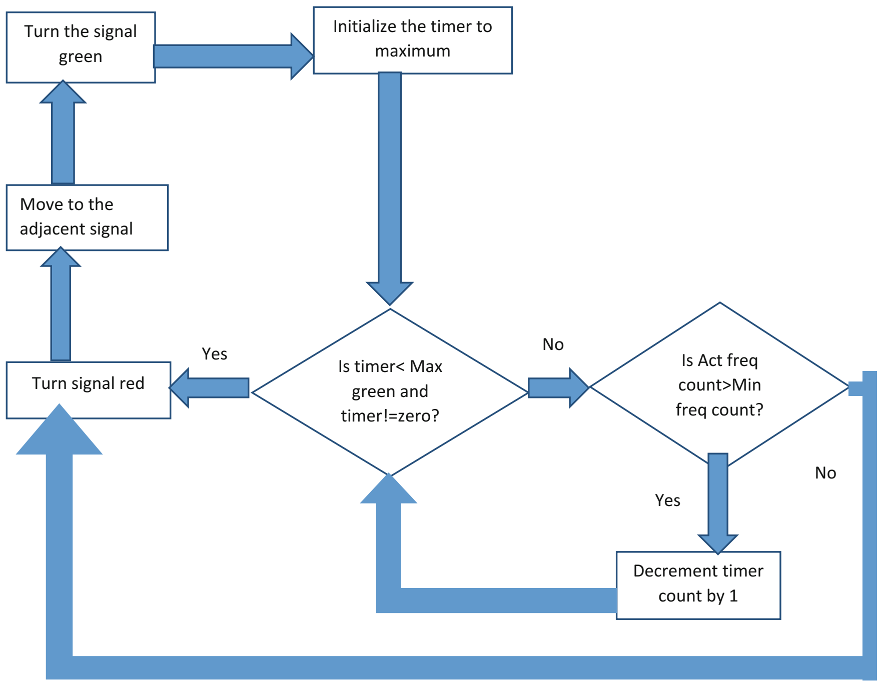


Fig. 4.2 System architecture of RFID

4.2.5 Algorithm Implemented in the RFID Controller

Variables Used:
Max_{th}_Red = Maximum value where red signal is stored
Max_{th}_Green = Maximum value where green signal is stored
Min_{th}_Count = Minimum frequency of vehicles per second is stored
Act_Count = Calculates the real frequency
Clock Rate = Stores the clock rate count
Step 1: *Initial Light must be Green.*
Compare clock rate with highest threshold of green signal & Clock Rate! = 0

> *If (Vehicle main frequency (Act_Count) > minimum threshold of vehicle (Min_{th}_count))*
> *Remain the signal Green & decrease count rate by 1.*
> *Else if (Vehicle main frequency (Act_count) <= minimum threshold of vehicle (Min_{th}_count))*
> *consider Step 2.*

Step 2: *Set the signal Red & adjacent signal as Green.*

Go to Step 1.

The algorithm uses five variables **Max_{th}_Red**, **Max_{th}_Green**, **Min_{th}_Count**, **Act_Count**, **Clock Rate**. The maximum value where signals are red and green are stored in **Max_{th}_Red** and **Max_{th}_Green** respectively. The minimum frequency of the vehicles per second is stored in **Min_{th}_Count**, The variable **Act_Count** calculates the actual frequency and **Clock Rate** stores the clock rate count. In step 1, the initial light should be green. The value in variable **Clock Rate** is compared with maximum threshold value of green signal and **Clock Rate** value should not be zero. If the value in variable **Act_Count** is greater than **Min_{th}_Count**, then retain the signal as Green and decrement the count rate by 1. Otherwise, if the value in variable **Act_Count** is less than or equal to **Min_{th}_Count**, then set the signal Red and set the adjacent signal as Green and then repeat the process from step 1.

4.3 Role of Ontology in Context Aware Traffic Management

Smart traffic management can be achieved with the help of context aware framework that uses heterogeneous sensors to collect data [13]. The GPS and the sensors present inside the car provide the data to the traffic cameras which area analysed to optimize travel time, vehicle volume and flow of traffic. Metropolitan planning organization (MPO) has defined certain standard policies that must be followed in any city. If a person is found to violate any such defined policy in an area where traffic personnel is not present then the system will be able to send notification messages to the traffic authorities. The component of traffic planning is shown in Fig. 4.3. The strategies include different methods and planning that are adopted for urban planning.

4.3.1 MOWL: An Ontology Representation Language

MOWL has been utilised to generate the model to link between the associate perpetual aspects and the probabilistic properties of the media [13]. The uncertain natures of these concepts are represented using Conditional Probability Tables (CPT). MOWL helps in implication of the situations in dynamic scenarios. The oval nodes represent the domain concepts and the boxes represent the media properties [13]. The edges represent the bond between concepts and properties of media. Each link holds a value which is represented with a probability pair $p(m|c)$ and $p(m|!c)$ where c is denotes concept and m denotes node of the media. Three types of ontology are taken into account-user ontology, event ontology and device ontology. User ontology indicates the preferences of a user, their identity, location and time schedule. Event ontology is associated with events and activities that influence traffic. Device ontology is used to specify the sensors and the devices installed at certain locations.

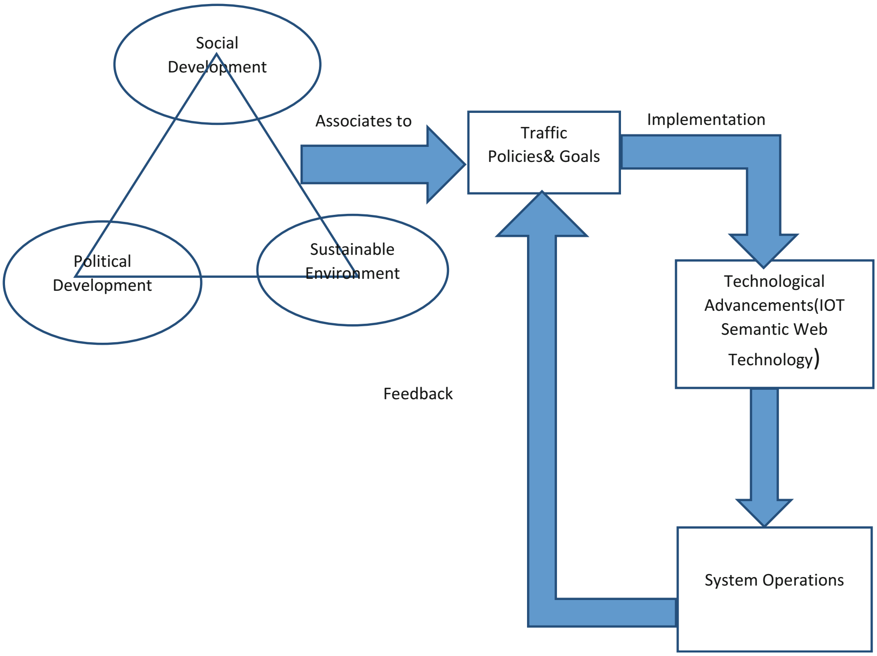


Fig. 4.3 Components of traffic planning

Figure 4.3 describes a prototype of the model achieved by using ontology. The three agendas of the modes are social development, political development and sustainable environment. These objectives are associated to the traffic policies and goals which are implemented using technological advancements. The technological advancements are related to the application of IOT using the semantic web technology.

4.3.1.1 Situation Tracking

Deep Belief Network (DBN) which uses the Bayesian Network can be used for situation tracking [13]. The method proposes three different terms: context state, situation state and dynamic situation.

Context State A context state is represented as $C_i^t = \left(c_1^t,\ c_2^t, \ldots, c_k^t\right)$ where c_k^t is a context attribute. It is related to information like location of physical objects, identity of person etc.

Situation State This state at any instant of time t is predicted based on the context state C_i^t. The method consists of deriving a sub graph called Observation Model [14].

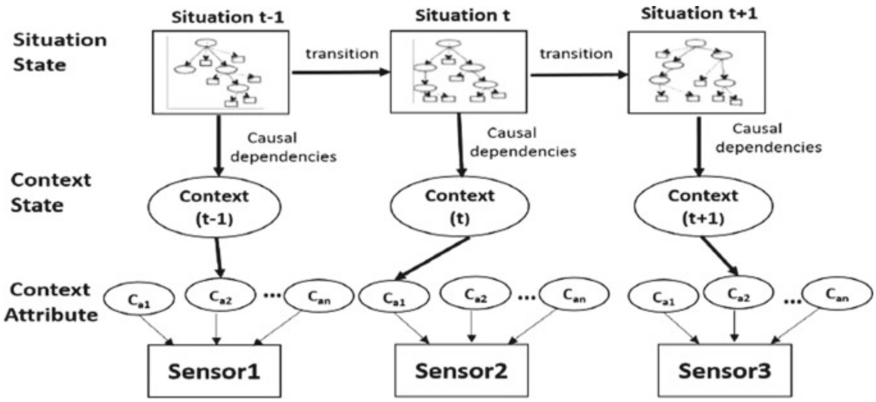


Fig. 4.4 Context aware data fusion using DBN

Dynamic Situation A dynamic situation indicates the frequently changing observations at different intervals of time. The ontology graph representing a dynamic network is interconnected using transition links.

Figure 4.4 represents the use of DBN to represent context aware data fusion. The transition of states from S1 to S2 represented by MOWL ontology. The probability distribution function is given by:

$$P(S, \in) = \prod_{t=0}^{T-1} P(S_t|S_t - 1) \prod_{t=0}^{T-1} P(\in_t |S_t)P(S_0) \tag{1}$$

$P(S_0)$ is the likelihood of the initial state, $P(S_t|S_{t-1})$ are state transitions $P(€|S_t)$ indicates sensor observation probability distributions.

Figure 4.4 represents the context aware data fusion using deep belief network. The transistion between the any three situations states are represented in the diagram. The casual dependencies are identified from the situation states to derive the context states. Context attributes are generated from the context states which are fed to the sensors.

4.3.2 Algorithm Implemented to Avoid Congestion in Context Aware Traffic Management

Input: A set of snapshots of, User Profile (U_p), input video (V). Ontology is used to represent DBN Network with T states.
Output: Ontology sub-graph (ψ)
Description:
For i = 0 in V

Step 1: *Start media detector for obtaining evidences. Let,* $C_{i=0,m}^{i=T-1}$ *be the set of evidences*

where m represents the count of attributes, $1 \le m \le k$.

Step 2: *Update the belief using MOWL based DBN scheme as follows:*

Map $€_I$ *&* U_p *to instantiate nodes in O*

Instantiation outcomes in belief propagation over dynamic network

The highest level component in the sub graph (ψ) indicates the likelihood of the situation.

$$i = i + 1$$

Step 3: *If the aim of belief denotes collision, traffic authorities are alerted or alternate routes are suggested.*

4.3.3 System Architecture

Figure 4.5 represents the system architecture which can be divided into five layers:

IoT Layer This layer functions as a gateway for sensors, embedded systems and RFID tags located at different areas. They help in collecting information like number of passengers, number of vehicles, roads, location etc.

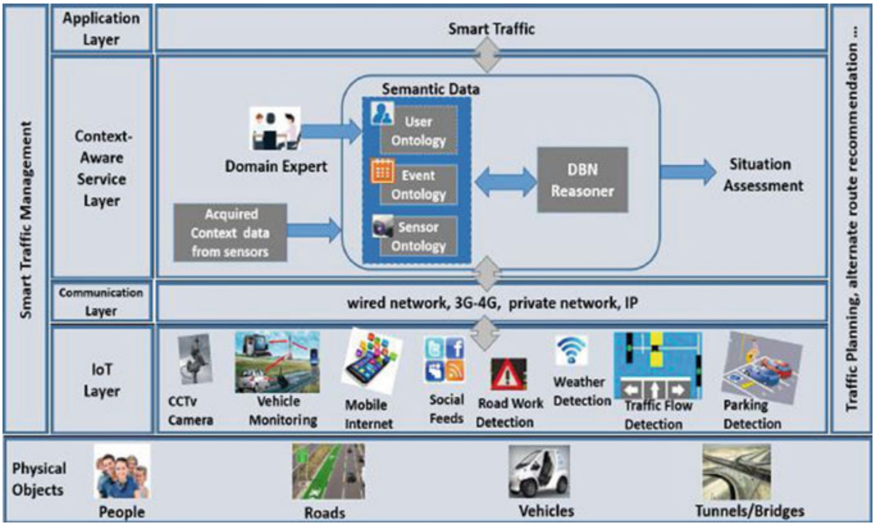


Fig. 4.5 Ontology based smart traffic structure

Communication Layer This layer is engaged in secure and reliable routing of messages and helps in real time transmission of messages between various networks.

Context Aware Service Layer This layer functions in a bidirectional mode. Its aids in functions like data processing, reasoning and fusing high level context, assessment of situation etc.

Application Layer A number of applications are delivered to the users using this layer. It aids to create environment to manage the applications like smart healthcare, smart traffic etc.

4.4 Role of Android for IoT Enabled Emergency Traffic Signal Control

Due to traffic congestion, it becomes difficult for ambulance, fire engines and other emergency vehicles to travel and arrive at the destination in time. This difficulty can be removed through better traffic management by the use of IOT. The method suggests signalling that emergency vehicles are arriving near the traffic signal controller installed in various signal posts. The signal can be given via the android applications installed on the cell phones of the users travelling within the emergency vehicles. Efficient algorithms have been used which will aid the traffic management process.

4.4.1 Hardware Specifications

Figure 4.6 describes the block diagram of the proposed hardware system. A chip Arduino Mega which contains the microcontroller ATMEGA 328 which is installed in the traffic signal controllers present in the traffic signal posts [15]. The microcontroller controls the GSM modules of the android mobiles to send and receive messages indicating the presence of emergency vehicle. The message includes the following information:

(a) Direction through which the vehicle is arriving and the direction through which it will depart
(b) Green On message
(c) Time required by the vehicle to reach the traffic signal post
(d) The hardware first accesses the signal in which the vehicle will depart and take the decision accordingly.
(e) If the signal is red, then it should be changed to green until the vehicle passes the post.
(f) If the signal is green, the same signal should be continued till the vehicle crosses the signal post.

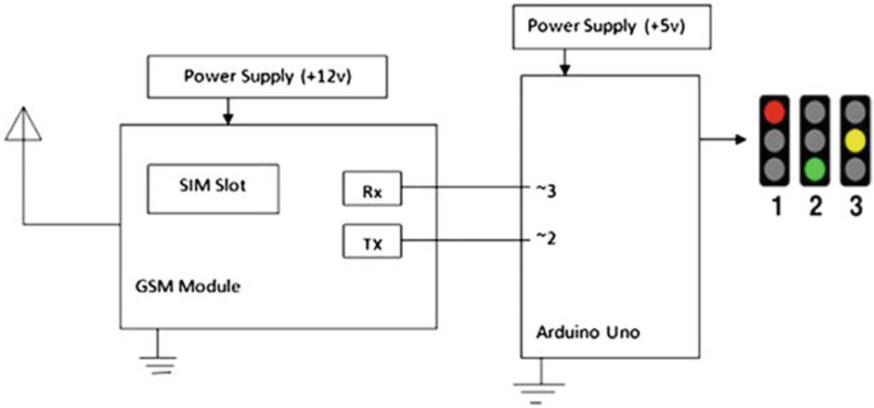


Fig. 4.6 Block diagram of the proposed hardware system

4.4.2 Priority Resolving for Emergency Vehicles

Every emergency vehicle is assigned priorities. The necessary information's can be passes to the traffic controller on the basis of the priority. If two vehicles have same priority then they are served according to first come first serve basis [15]. The vehicle having the maximum priority has been chosen for passing and its entry is deleted from the list.

4.4.3 Software Specification

Figure 4.7 represents the features of the android application. It uses one time password for user authentication. The GPS module of the mobile sends the current location of the vehicle and the destination has to be specified manually [15]. Distance and time to reach the destination can be calculated using speed sensors. The emergency vehicle sends its direction of arrival and departure, green on message and the expected time to reach the signal post and the traffic signal controller takes the necessary action.

4.4.4 Algorithm to Implement Easy Passage of Emergency Vehicles

Step1: The vehicle will send the location to the traffic signal controller using
Step 2: The user enters the destination.

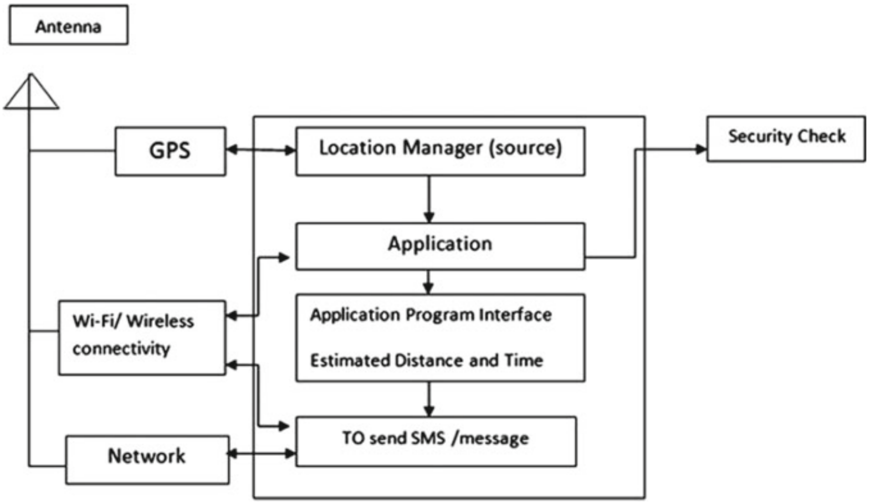


Fig. 4.7 Components of android application software

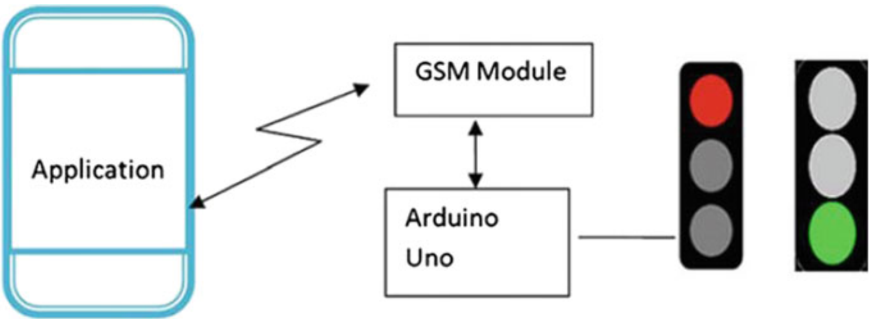


Fig. 4.8 Prototype of the model

Step 3: The mobile transfers messages to the GSM kit of the traffic signal controller
Step 4: Change the signal to green, if red signal achieved towards the direction of departure, otherwise hold the same status.

Figure 4.8 represents the prototype of the entire model. The GSM module is interfaced with Arduino Uno chip. The Arduino Uno receives signals from the traffic signals and the necessary processing is done in the GSM module.

4.5 Local Traffic Smart Server Based Traffic Framework

The aim of the smart server based traffic detection is to reduce the travel time, traffic congestion and improve the safety by integrating IOT with the road infrastructure [16]. Figure 4.9 describes the basic block diagram of the system. Sensors collect the data from the environment and send the signals to the data processing unit. Inductive loop detectors, image detectors and microwave detectors are mainly used for this purpose. The sensors are placed at intersection of the roads and traffic signals to monitor the real time traffic.

The sensors transmit the collected information to the LTSS. The LTSS has large processing power and storage capacity. The RCS and the web servers are connected to the system using TCP and HTTPS protocols. Fibre optical communication network is used for high speed and bandwidth. The LTSS analyses the data and sends it to the RCS [16]. The RCS stores the data for remote access. The passengers can access the RCS via internet and update it with the current traffic data.

4.5.1 Data Processing in the Traffic Server

The data processing in the traffic server is mainly achieved through regression technique. The LTSS collects the data from the sensors at the intersection of the four side track [16]. It aims to reduce the congestion in the direction that has more moving vehicle density and turns on/off the green and the red light accordingly.

Let the track direction of the signal point is denoted as d, track path in each direction around the signal is directed as p, V_p specifies the number of moving vehicle density across the path p. The vehicles moving to the right and left are denoted by r and l respectively. Vehicles waiting to move in the direction left and right are estimated using the equation:

$$V_p = V_l + V_r \tag{2}$$

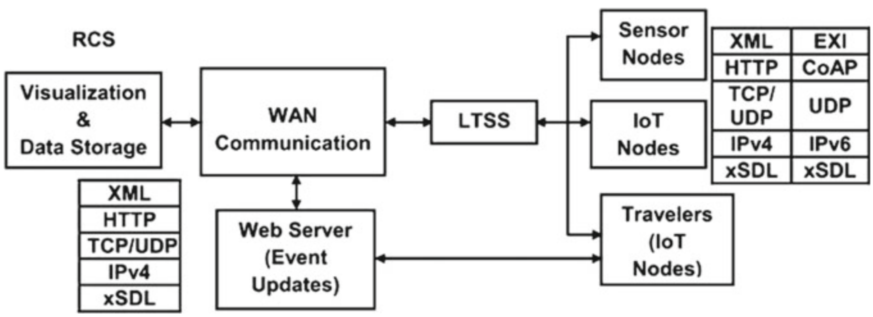


Fig. 4.9 Smart traffic control system framework

4.5.2 Algorithm to Implement Local Traffic Smart Server Based Traffic Framework

Vehicle registration number parsing by RFID reader
Mobility is controlled via *camera which is controlled by LTSS*
Sensors sense the vehicle movement in the left right track
D_l & D_r represents the data of the movements of vehicles collected from the sensor S_i positioned in the tracks l, r towards direction d_i.
Vehicle movement data is collected in d_i, d_j periodically t.
Maximum vehicles mobility M is computed from all tracks of four route directions
diV_p denotes vehicle route density di.
if diV_p value in > djV_p in j then
green lamp is turned on this route d_i track
vehicles approaches towards the target destination
red lamp turned on in dj
else
red lamp turned on in di
vehicles wait for the green lamp
Data in RCS is stored in LTSS for analysing & web access

4.6 Application of IoT with Semantic Web for Intelligent Traffic Monitoring

The concentration on linking of traffic can be determined using Zigbee protocol [17]. The two clusters Light cluster and road information are controlled by a control centre. In order to ensure efficient flow of information, granular ontology language is used. Each of the vehicles transmits the signal using standard Zigbee protocol standard [17].

Figure 4.10 shows the general building block of the control centre. Transreceivers are installed in each of the crossing which sends signal to the nearest Zigbee Transreceiver Tower [17]. The control centre is connected to all the towers. Consider a situation where there are heavy traffic in both lanes, the decision can be

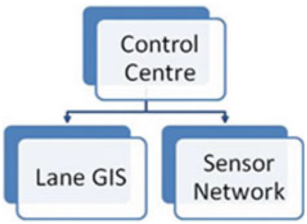


Fig. 4.10 Control centre—basic building block

Table 4.1 Different parameters of traffic management system

LaneGIS	Sensor Tx	Jam detected	TLC	VMS
e_1–e_4	TX_4–TX_3	Yes	Change timing	Activate VMS
e_1–e_2	TX_1–TX_2	No	No change	No signal
e_3–e_4	TX_3–TX_4	No	No change	No signal
e_3–e_4	TX_3–TX_4	Yes	Change timing	Activate VMS
e_4–e_5	TX_4–TX_5	No	No change	No signal

to alter the traffic lights or to bypass the traffic through another lane. The VMS provides the signals to the control centres' drivers. The signals are analysed by the control centres and specific categorization is created with the concept of Rough Set Theory [17].

The different useful attributes of the traffic management system is presented below in a tabular form:

In Table 4.1, the timing is dependent of Jam detected with a degree of k = 1. There exists a relation of discernibility among the attributes. Equivalent classes of the Traffic Management attributes are called granules. The granular classification can be realised by OWL [17]. Two granules can be classified into three categories: Sensor Granule, Lane GIS Granule and Control Granule.

Information is transmitted in ubiquitous mode and is made machine runnable with the help of OWL. The granules are linked for faster processing. A sample of OWL which connects the control centre and Zigbee Sensors is shown below:

< owl: Class rdf: ID = 'ZigBee Sensor'>
<rdfs: subclassof>
<owl: Class rdf: ID = 'Control Centre'/>
</rdfs: subclassof>
</owl: Class>

Figure 4.11 describes the overview of the entire framework. The control canter receives the control signal and analyses the jam information and the emergency of the vehicles.

4.7 Real Time Traffic Control Using Cloud Computing

Any emergency vehicle can be detected using the sensors and the corresponding signal will be sent to the next traffic signal post. A message will be generated to every other vehicle to clear the road. The vehicle which will not follow the order will be spotted under the CCTV camera. The image of vehicle's name plate will be captured and forwarded to the nearest police station.

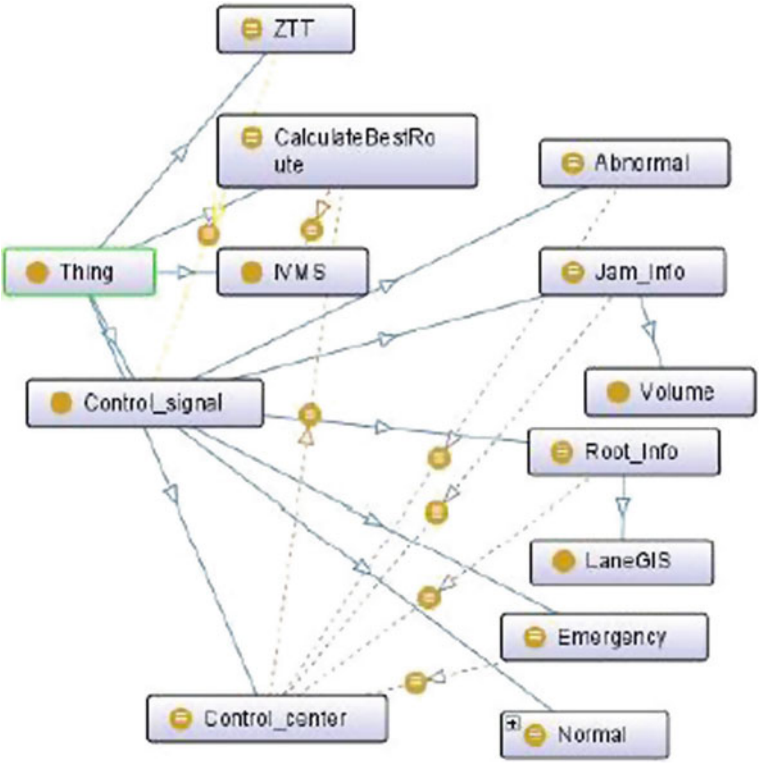


Fig. 4.11 RDF of traffic monitoring framework

4.7.1 System Design and Implementation

MATLAB tool is used for implementing the proposed system model. The work can be divided into following parts:

4.7.1.1 Ambulance Detection and Processing Audio

The ambulance is detected by applying image processing using thresholding, segmentation and template matching [18]. The video of the real time traffic is captured by the CCTV camera which are analysed for detecting the presence of the ambulance. The RGB format images are converted into Gray scale [18]. Gray image is segmented and the ambulance is identified using template matching.

4.7.1.2 Number Plate Detection and Extraction

The camera will help to identify those vehicles which are not abided by the instructions. The snapshot of the name plate is captured and is passed through noise filters top remove the noise [18]. Then thinning of the image is done to extract the characters of the nameplate.

Figure 4.12 describes the block diagram of the entire process. The traffic is kept under observation through the acquisition device. The acquired image is converted

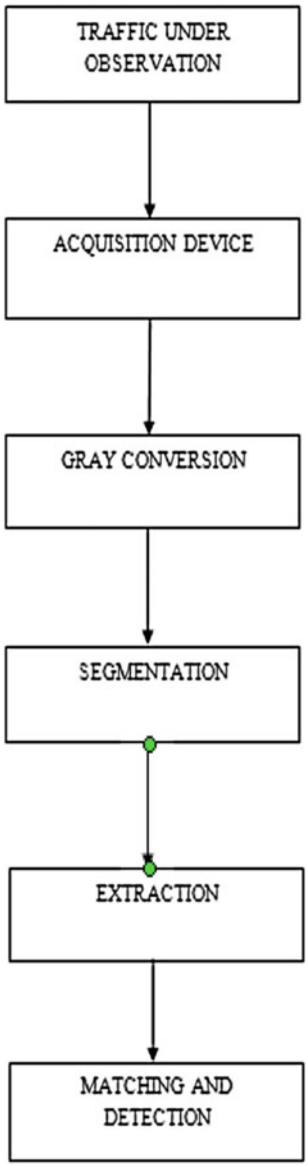


Fig. 4.12 Detection overview

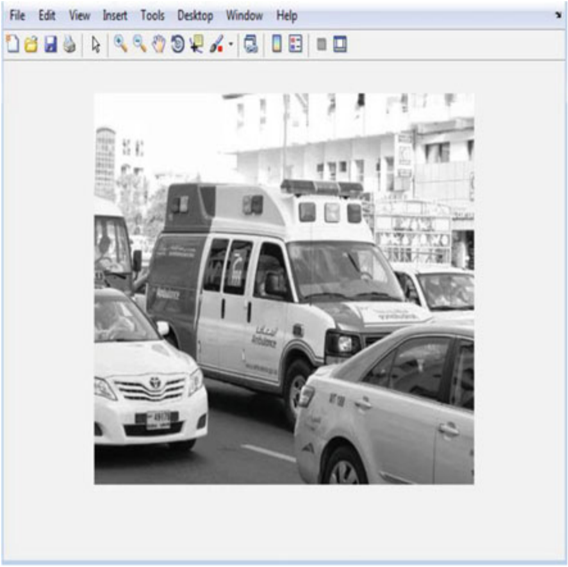


Fig. 4.13 Gray scale image showing the ambulance in traffic

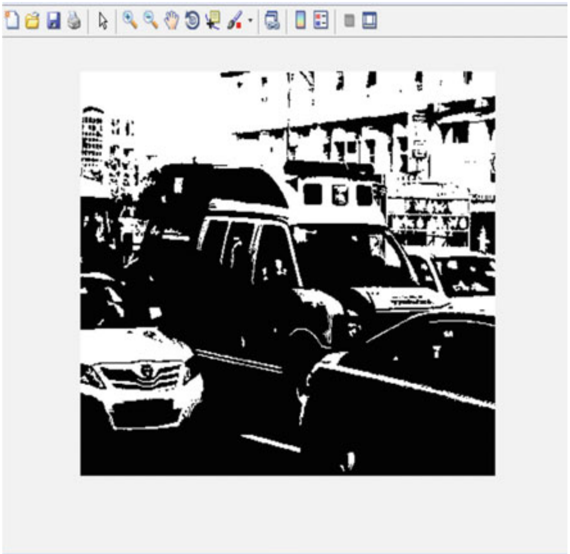


Fig. 4.14 Segmentation of the image

to gray scale mode and segmented. The segmented image is subjected to extraction and matching and detection is undertaken. Figure 4.13 represents the gray scale of the ambulance in the traffic. Figure 4.14 represents the segmentation of the image. Figure 4.15 represents the sample image of the number plate and Fig. 4.16 represents the image with enhanced edges.

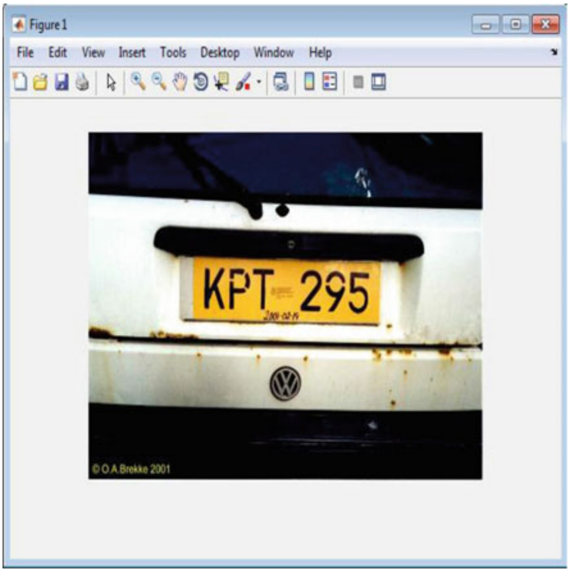


Fig. 4.15 Sample image

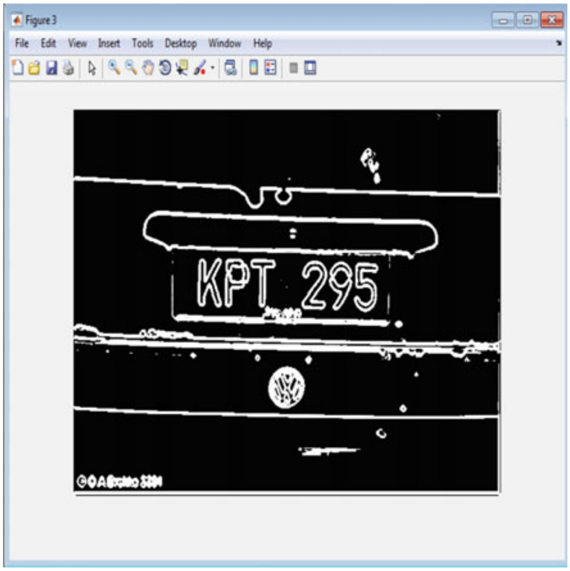


Fig. 4.16 Image with enhanced edges

4.7.1.3 Data Transfer Between Stations by Setting up Server Client and Cloud Computing

The information is exchanged between the stations by setting up client and server machines using cloud computing and TCP/IP protocol is used for this purpose [18]. The experiment is performed on two machines; one pc is configured as a server and the other one as a client. On detection of vehicles, data is sent from the client and the necessary processing is done by the server [19, 20].

4.8 Conclusion

Internet of Things can be applied widely for smart traffic management system. The use of modern techniques like machine learning, deep learning and big data analytics are influencing the use of IoT in this field. Developments of Android applications for traffic management are in progress. The smart cities projects have widely implemented the idea of use of IoT in traffic management. The future work is to see how much robust and fault tolerant system can be designed with the use of the arising technologies.

References

1. Internet of Things, https://www.techopedia.com/definition/28247/internet-of-things-iot. Last Accessed 25 May (2018)
2. What is IoT? Everything you need to know about internet of things right now, https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/. Last Accessed 25 May 2018
3. What is IoT and Why we need IoT? https://www.codeproject.com/Articles/833251/What-is-IoT-and-Why-we-need-IoT. Last Accessed 27 May 2018
4. What is internet of things and why it is important? http://www.technologyguide.com/feature/internet-of-things/. Last Accessed 27 May 2018
5. reasons why you need an IoT platform? https://www.amplia-iiot.com/10-reasons-why-you-need-iot-platform/. Last Accessed 27 May 2018
6. Kamoji, S., Nambiar, A., Khot, K., Bajpai, R.: Dynamic vehicle traffic management system. IJRET Int. J. Res. Eng. Technol. (2015)
7. Lanke, N., Koul, S.: Smart traffic management system. Int. J. Comput. Appl. **75**(7), 0975–8887 (2013)
8. Kafi, M.A., Challal, Y., Djenouri, D., Doudou, M., Bouabdallah, A., Khelladi, L., Badache, N.: A study of wireless sensor network architectures and projects for traffic light monitoring. ANT (2012)
9. Wu, B.F., Kao, C.C., Juang, J.H., Huang, Y.S.: A new approach to video-based traffic surveillance using fuzzy hybrid information inference mechanism. IEEE Trans. Intell. Trans. Syst. **14**(1) (2013)
10. Kafi, M.A., Challal, Y., Djenouri, D., Doudou, M., Bouabdallah, A., Badache, N.: A study of wireless sensor networks for urban traffic monitoring: applications and architectures. In: 4th

International Conference on Ambient Systems, Networks and Technologies (ANT 2013), pp. 617–626. Elsevier, Procedia Computer Science 19 (2013)
11. Lee, U., Gerla, M.: A survey of urban vehicular sensing platforms. Comput. Netw. **54**, 527–544 (2010)
12. Das, A., Dash, P., Mishra, B.K.: An innovation model for smart traffic management system using internet of things (IoT). In: Sangaiah A., Thangavelu A., Meenakshi Sundaram V. (eds) Cognitive Computing for Big Data Systems Over IoT. Lecture Notes on Data Engineering and Communications Technologies, vol. 14. Springer, Cham (2018)
13. Deepti, G, Santanu, C, Hiranmay, G.: An IoT approach for context-aware smart traffic management using ontology. In: Proceedings of the International Conference on Web Intelligence (WI '17), pp. 42–49 (2017)
14. Anupama, M., Hiranmay, G., Santanu, C., Gaurav, H.: MOWL: an ontology representation language for web-based multimedia applications. ACM Trans. Multimedia Comput. Commun. Appl. (TOMM) **10**, 1 (2013)
15. Sneha, T., Ragunathan, T., Battula, S.K., Varsha Rani, B., RaviBabu, P., Raghu, R.R.N., Jorika, V., Reddy, V.M.: IOT-based traffic signal control technique for helping emergency vehicles. 1st International Conference on Computational Intelligence and Informatics. Advances in Intelligent Systems and Computing, vol. 507, pp. 433–440. Springer, Singapore (2016)
16. Kuppusamy, P., Kalpana, R., Venkateswara Rao, P.V.: Cluster Comput. (2018). https://doi.org/10.1007/s10586-018-2172-5
17. Darbari, M., Yagyasen, D., Tiwari, A.: Intelligent Traffic Monitoring Using Internet of Things (IoT) with Semantic Web. In: Satapathy, S., Govardhan, A., Raju, K., Mandal, J. (eds) Emerging ICT for Bridging the Future- Proceedings of the 49th Annual Convention of the Computer Society of India (CSI) Volume 1. Advances in Intelligent Systems and Computing, vol. 337. Springer, Cham (2015)
18. Vardhana, M., Arunkumar, N., Abdulhay, E., Vishnuprasad P.V.: IoT based real time traffic control using cloud computing, Cluster Computing, pp. 1–10. Springer, US (2018) https://doi.org/10.1007/s10586-018-2152-9
19. Wang X., Ning, Z., Wang, L.: Offloading in Internet of vehicles: a fog-enabled real-time traffic management system. IEEE Trans. Ind. Inf. https://doi.org/10.1109/tii.2018.2816590
20. Rajalakshmi, V., Ganesh Vaidyanathan, S.: Efficient traffic management on road network using edmonds–karp algorithm. In: Panigrahi, C., Pujari, A., Misra, S., Pati, B., Li, K.C. (eds) Progress in advanced computing and intelligent engineering. Advances in Intelligent Systems and Computing, vol. 714. Springer, Singapore (2019). https://doi.org/10.1007/978-981-13-0224-4_52

Chapter 5
A New Encryption Scheme Method (ESM) Using Capsulated-Layers Conception for Verified QR-Tag for IoT-Based Smart Access Systems

Abbas M. Al-Ghaili, Hairoladenan Kasim, Marini Othman and Zainuddin Hassan

Abstract A new encryption algorithm is proposed and designed which is followed by a verification algorithm used to access such Internet-of-Things (IoT) based systems. A three Layer Encryption Algorithm (3LEA) is designed to generate a cryptographic Quick Response (QR) tag. In order to use this QR-tag as a secret key with IoT-based systems, a three Processes Verification Algorithm (3PVA) has been proposed to verify QR-tag values. In order to make a decision either to approve or disapprove a request to access an IoT-based system, a three-Layer Protection Algorithm (3LPA) is proposed. 3LPVA applies math operations to authenticate confidentiality, integrity, and availability of QR-tag (i.e., smart key). Thus, once the smart key is verified, an access to the IoT-based system is allowed. The 3LEA, 3PVA, and 3LPA are designed in such a way and capsulated using a new Encryption Scheme Method (ESM). The ESM contributes much to IoT technology era in terms of systems security; it is used as a smart key designer and verifier for IoT access systems. The ESM is evaluated in terms of security factors, decryption time, robustness, unpredictability, and 3LEA's technical evaluation. Results show good performance of robustness and an unpredictability behavior of 3LEA.

Keywords IoT · Computer security · Encryption scheme · QR tag

A. M. Al-Ghaili (✉) · M. Othman
Institute of Informatics and Computing in Energy (IICE), Universiti Tenaga Nasional (UNITEN), 43000 Kajang, Selangor, Malaysia
e-mail: abbas@uniten.edu.my

M. Othman
e-mail: marini@uniten.edu.my

H. Kasim · M. Othman · Z. Hassan
College of Computer Science and Information Technology (CSIT), UNITEN, 43000 Kajang, Selangor, Malaysia
e-mail: hairol@uniten.edu.my

Z. Hassan
e-mail: zainuddin@uniten.edu.my

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_5

5.1 Introduction

The technique of Quick Response (QR) tag has been used by several information systems. In Literature, the number of QR-tag related studies is rapidly increasing specifically in this decade compared to last three decades, as shown in Fig. 5.1. One of reasons is that QR-tag features have attracted researchers' attention from different scientific fields. One of these features is the simple design of QR-tag that helps store a huge number of information. This feature has enabled the QR-tag to be used as a smart key for many Internet-of-Things (IoT) based systems since a QR-tag is easy-to-scan [1]. Thus, it has been exploited by many IoT systems [2, 3]. However, it is of necessity that such a smart key (i.e., QR-tag) has a high level of security to protect IoT stored data [4, 5], authentication systems [6, 7], smart home applications [8, 9], smart cities related applications [10], identification purposed systems [11, 12], data protection [13], automation processes [14, 15] embedded systems [16] … etc.

The key point here is that aforementioned IoT related examples require a strong QR-tag encryption scheme and verification procedure implemented to achieve a high level of securely cryptographic data [17]. There have been several security factors considered by the IoT application related research study. For example, data integrity is one of the most important security goals any smart system must achieve; so that any change to the system's contents has to be in an authorized manner.

Even though QR-tag based IoT algorithms dealing with smart applications still face challenges to cover security factors. Nevertheless, QR-tag features are exploited by many researches to achieve a limited level to which the smart application is expected to reach in terms of security. For example, the proposed work in [18] has designed a QR-tag based authentication method for users achieving good performance in terms of threats prevention. Some other methods [4] used a remote user authentication process with smart cards.

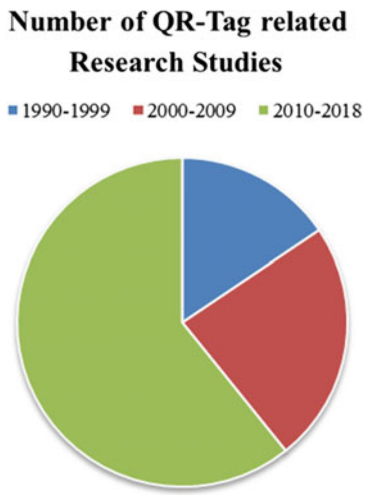


Fig. 5.1 Number of QR-tag related research studies and topics

Once, QR-tag contents have been extracted, the verification procedure is an importantly performed step to make sure that contents are identical to original ones. Thus, the QR-tag verification is essential in IoT applications, because it affects the whole system in terms of accuracy and privacy.

Many QR-tag related researches have used a simple layer of encryption. Such a layer is however suitable with smart applications but those which include sensitive data might be vulnerable to threats and attacks. Therefore, to achieve a high level of privacy, a new ESM is introduced using a capsulated layers conception for encryption. Additionally, a three Processes Verification Algorithm (3PVA) is designed to make sure that encrypted values generated by a three Layer Encryption Algorithm (3LEA) are authenticated and original. Then, this verification process is followed by a further protection level by introducing a three Layer Protection Algorithm (3LPA) to make a decision to allow a safe and secure access to the IoT-based system.

This chapter is organized as follows: Sect. 5.2 gives a simple introduction into the proposed Encryption Scheme Method (ESM). In Sect. 5.3, the proposed 3PVA is discussed in detail to attain security objectives. In Sect. 5.4, the proposed algorithm 3LPA dedicated to make a decision on QR-tag authentication and originality as a smart key for IoT-based systems to increase its security will be explained. The 3LEA will be step-by-step explained in Sect. 5.5. Performance evaluation is discussed in Sect. 5.6. In Sect. 5.7, Conclusion is depicted.

5.2 The Proposed Encryption Scheme Method for (ESM) for Verified QR-Tag

5.2.1 ESM Block-Diagram

The block-diagram of the proposed ESM consists of four processes, as depicted in Fig. 5.2 (marked by three colored lines), which are as follows: the first process encrypts original user's information using a new capsulated-layer conception to increase the privacy. The second process receives information from QR-tag when access to IoT system is wanted whereas the QR-information is verified. The third

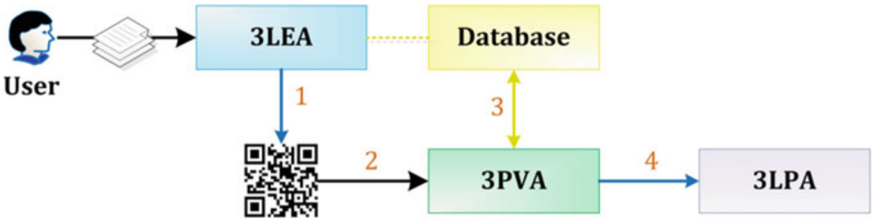


Fig. 5.2 The proposed ESM block-diagram for verified QR-tag

process exchanges verified results between 3PVA and database that stores original values. These results are sent to 3LPA to make a decision whether to allow the access or not.

5.2.2 Introduction to the Proposed ESM

This sub-section introduces four units of which the ESM consists. These units are shown in Fig. 5.2, which are the 3LEA, 3PVA, Database, and 3LPA.

The first unit acts like an input for ESM. The second and third units (i.e., 3PVA and database) are central processing units to process a request for an access to the IoT smart system; whereas the third one is the decision making unit and acts like an output unit. The second unit receives instructions from the input unit (3LEA & QR-tag) made by a user who is interested to access an IoT system. In the second unit, the user's request is verified by applying a number of verification procedures. The user request is processed between 3PVA and Database units. The third unit feeds the 3PVA with updated results. The obtained results will be sent to the output unit in order to validate and verify user inputs' values. Finally, if the verification result is true, the 3LPA accepts the request and then allows the system access.

5.2.3 ESM Scenario

An interactive scenario can be illustrated in Fig. 5.3. The most important part in this scenario is QR-tag being used as a secure key for the IoT-based system.

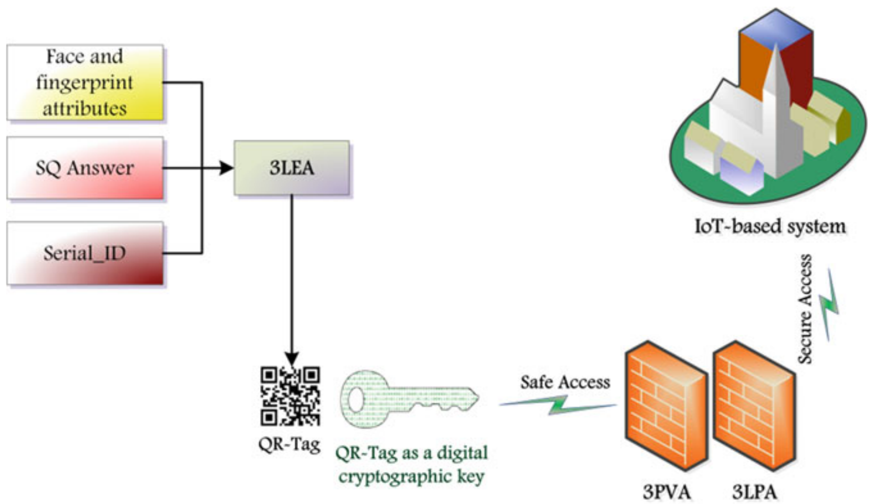


Fig. 5.3 ESM scenario phases

For a better reading the ESM scenario, it is divided into three phases which are top-left, bottom-middle, and top-right. During the top-left phase, the original and row information will be encrypted and stored in the 3LEA. Then, the 3LEA digital values are cryptographically converted into a 2D QR-tag image used as a smart key for a safe access. During the second phase, the smart key will be verified using two algorithms which are 3PVA and 3LPA both of which act as firewalls for the IoT-based system. During the top-right phase, to achieve a safe and secure access to the IoT-based system, it can be occurred thru two firewalls i.e., 3PVA and 3LPA.

5.3 The Proposed Three Processes Verification Algorithm (3PVA)

5.3.1 Introduction—Overview

The 3PVA includes three essential procedures applied on the QR-tag to completely and successfully verify encrypted values.

The first procedure is the QR-tag Contents Verification which is dedicated to verify the integrity of QR-tag contents. The second verification procedure is the QR-tag Expiry Time Verification that verifies the QR-tag authentication and confidentiality. The third one is the QR-tag related Database Verification which is adopted in order to make sure the QR-tag is available and responsive when an access is needed. They are explained as follows.

5.3.2 QR-Tag Contents Verification (QR-CV)

In this type of verification, three sub-routines are applied which are biometrics-, Serial_ID-, and security question- based verification. The technical process thru which they are interactive is illustrated in Fig. 5.4. Once the QR-tag is scanned, its contents (e.g., biometrics pre-stored and pre-encrypted) are extracted and verified. The user is asked to provide a Serial_ID and also needs to answer a Security Question (SQ). The result is sent to the 3LPA. If they are wrong or missed, the user is required to redo the access's request.

Biometrics Based Face Access Verification Procedure. The main 3PVA sub-routine is to check user information specifically face-image and fingerprint features. The purpose is to do a successful and trust comparison between QR-tag and original pre-stored information and contents. As illustrated in Fig. 5.5, information asked by the user and information stored in the database are checked whether they are equal or not in order to allow an access to the IoT-based system or deny.

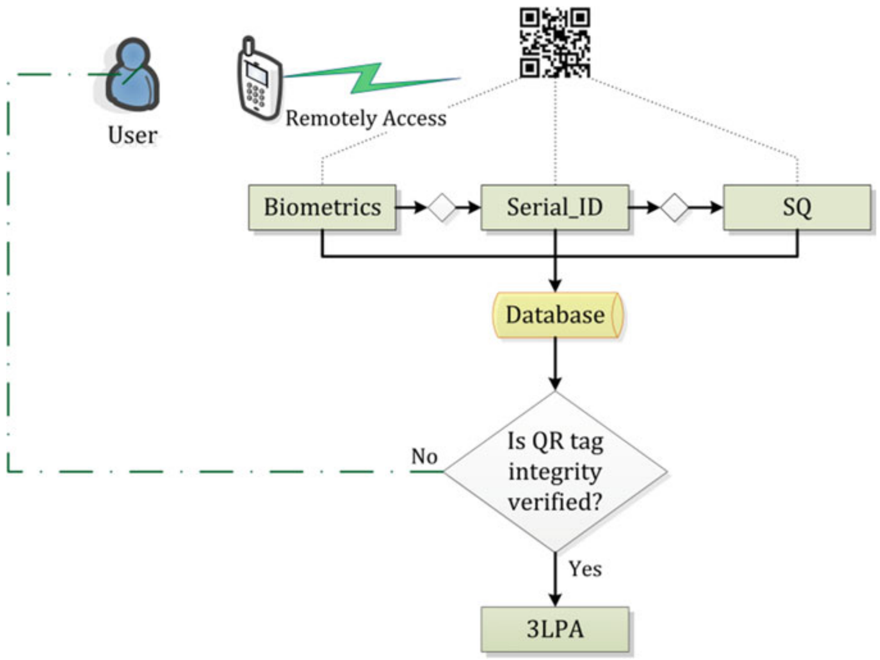
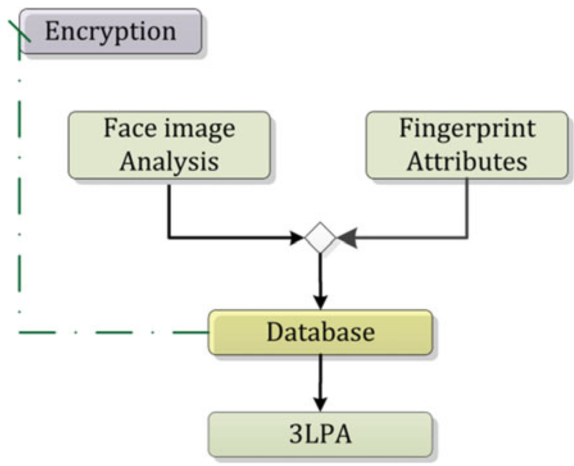


Fig. 5.4 QR-tag contents verification

Fig. 5.5 Biometrics verification procedure



In this figure, certain information stored in the database will be recalled to check whether they are identical to information collected from the user. Here, biometrics values are compared to QR-tag values. If they are correct, the process goes forward to a further verification step; otherwise, the process is halted.

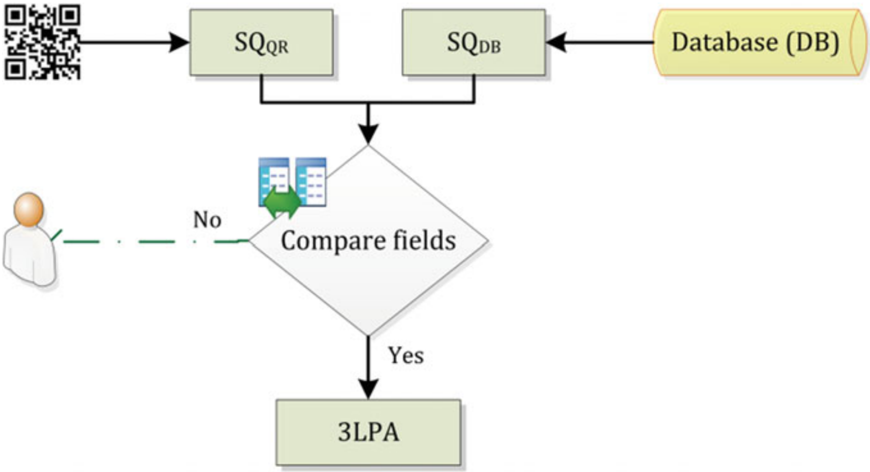


Fig. 5.6 SQ verification procedure flowchart

Security Question (SQ) Verification Procedure. This consists of two procedures each of which is partially separately verified as shown in Fig. 5.6. The first one extracts real values from the Database (DB) whereas the second one extracts the SQ message (M) from the user's QR-tag. Then, both values are verified and compared. The aim is to guarantee that the SQ is continuously updated.

The proposed pseudo-code of Fig. 5.6 verifies results taken from both sides of the abovementioned flowchart (left-side and right). If it is approved, the result is passed to 3LPA; otherwise, the SQ verification procedure is rejected.

Serial ID Verification Procedure. Usually users are given distinctive Serial_IDs. To implement Serial_ID Verification Procedure, the user is going to key-in the Serial_ID first. Then, a series of decryption-based math operations will be applied to verify the correct value. A comparison is applied to check whether they are identical or not. Finally, the approval result is sent to 3LPA to do a further decision. This is simplified in Fig. 5.7.

5.3.3 QR-Tag Expiry Time Verification (QR-ETV)

Usually, each generated QR-tag is provided a special label with which the time the QR-tag has been created is stored, L_{QR}. The proposed label denotes the QR-tag's validity starting for the time specified. QR-ETV is aimed to verify the date/time in which the label was created. The QR-tag's expiration time is controlled by the label. QR-ETV focuses on the time during which the QR-tag has been generated and not its contents. This is shown in Algorithm 1. Finally, the label has considered a periodically generated QR-tag policy every a certain period of time, say: T_{QR}.

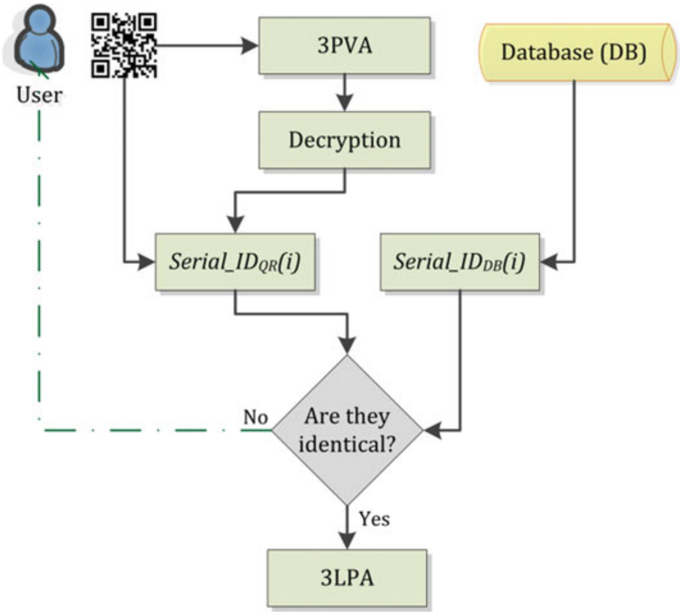


Fig. 5.7 Serial_ID verification procedure flowchart

Algorithm 1: QR-ETV Verification Procedure

Start
Scan QR-tag
Match QR-tag with its user #i
Extract the time label (L_{QR})
IF($L_{QR} \leq T_{QR}$)? // read the current time to compare with the time the QR-tag was created
    Allow QR-tag scan procedure
  Else
    Disallow QR-tag scan procedure
End

5.3.4 QR-Tag Related Database Verification (QR-DV)

QR-DV considers the system database modification caused by an authorized access. QR-DV is designed to store and update the database with recently modified values. To reduce accesses to the database, QR-DV has determined the database access upon necessary requests. That is, once the process has been completely done, certain values are stored in such a way to reduce data size and number of access times.

5.4 The Proposed Three-Layer Protection Algorithm for Decision Making (3LPA)

5.4.1 Introduction into 3LPA

The 3LPA aims to keep the IoT-based system continuously safe and secure. This can be done by protecting the most important part of IoT systems which is, in our case, the QR-tag. Thus, QR-tag contents must be protected in terms of confidentiality, integrity, and availability. In order to give a more clarification, a simple block-diagram depicts this proposed conception in Fig. 5.8.

This illustrates an IoT-based system with its smart key; i.e., QR-tag. This figure shows the relationship between security objectives and proposed verification procedures discussed aforementioned. It is clear that, to achieve a security objective e.g., *Integrity* (marked by '1'), QR-CV is applied. Similarly, by applying the QR-DV, the security objective '*Availability*' could be achieved. In case the QR-ETV, for example, has not been applied, thus the QR-tag is not confidential and therefore the IoT smart system might be attacked. These three layers must be combined together for a better protection for IoT smart system to increase its privacy and security.

However, the way the technical procedure of 3LPA is implemented to decide either to allow an access to the IoT smart system or not, is explained below.

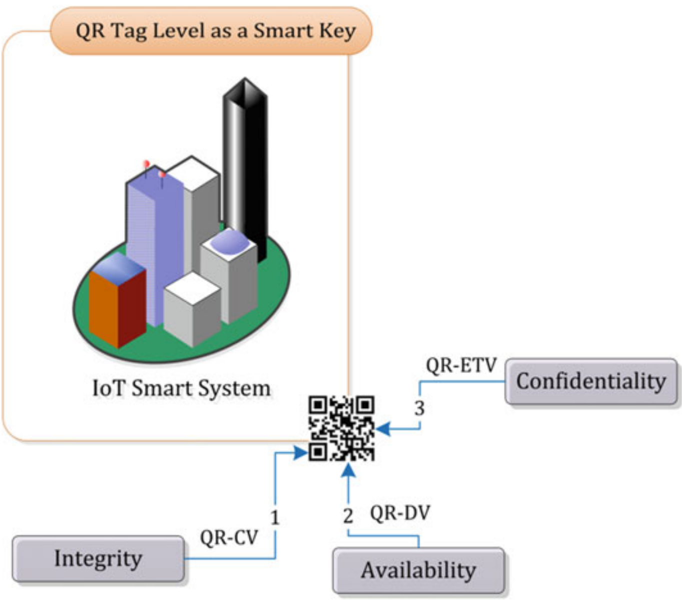


Fig. 5.8 3LPA in one smart key; QR-tag

5.4.2 The Proposed 3LPA for Decision Making

The decision making factor verified is denoted by: *vote*. One of the measures that *vote* needs to verify is the Serial_ID predefined earlier. Other required steps to verify their values are however biometrics attributes, SQ, and the L_{QR} of QR-tag. Their hash values are compared to original ones stored in the database. This is shown in Algorithm 2 to guarantee the QR-tag authentication.

Algorithm 2: One Smart Key Verified Contents based Decision Making Process

```
//initialization process: vote=0;
  Scan QR-tag;
    verify Biometrics_attributes();
    If (verified_value==1)
        vote1=vote1+20;
    verify Serial_ID();
    If (verified_value==1)
        vote1=vote1+20;
    verify SQ(); //LQR
    If (verified_value==1)
        vote1=vote1+20;
    verify expiry_date(); //LQR
    switch case (LQR)
    {
            1%×TQR ≤LQR≤25%×TQR? vote=vote1+24;
            26%×TQR ≤LQR≤50%×TQR? vote=vote1+18;
            51%×TQR ≤LQR≤75%×TQR? vote=vote1+12;
            76%×TQR ≤LQR≤100%×TQR ? vote=vote1+6;
            TQR<LQR? vote=--vote1; // it is expired
    }
```

This algorithm verifies the time period of the QR-tag. If the period is so long e.g., $T_{QR} < L_{QR}$, the QR-tag is considered expired. If, for example, the period of QR-tag time is short whereas $1\% \times T_{QR} \leq L_{QR} \leq 25\% \times T_{QR}$, then the QR-tag is recent and can be used as a smart key for the IoT system. This case indicates the QR-tag is has recently been generated therefore the IoT system is considered highly safe. Subsequently, the period is getting longer and longer, the IoT system is getting easier to be threatened and attacked. Thus, the 3LPA must create and encrypt a new QR-tag to start using it as a smart key for a safe and secure IoT system. Technically, when the period of QR-tag is getting longer, the system is low, thus its *vote* is assigned a lower value than the period is short, as clearly noticeable in Algorithm 2.

5.4.3 3LPA Based Security Objectives Verification

In this sub-section, four security objectives: (integrity, confidentiality, authentication, and availability) are addressed. While the 3PVA always verifies the user entries and QR-tag's contents to ensure QR-tag is verified. Therefore, its integrity achievement is verified thru the database comparing original values to inputs.

In regard to confidentiality, once user's information has been collected, it is encrypted and bounded by a specific time which is L_{QR}. To disallow any information leakage, the 3PVA is designed to make sure that such a decryption attempt needs time more than the $\mathrm{L_{QR}}$; i.e., $L_{QR} < \textit{Time of a decryption attempt}$. Additionally, the SQ value is always changing and it is then considered to increase the system privacy while it has privately cryptographic values.

As for authentication, by updating user information frequently and periodically, the QR-tag is generated; every 'L_{QR}' *time_unit*, in order to authenticate both user and access procedure. All related values, e.g., SQ are frequently updated in advance in order to authenticate the system database. That is, with specific interval of time, the system is given a new QR-tag to reduce vulnerability in the system design. During the next L_{QR}, a new updated QR-tag is generated again using different inputs, i.e., SQs to guarantee more security.

Finally, the QR-tag availability and responsiveness are addressed. The policy of *offline* database storage is considered and connected to the 3PVA. Every encrypted value is stored and updated accordingly. The QR-tag is generated using updated values re-called from the *offline* database to guarantee an authorized access to database by other verification procedures anytime and also to prevent an unauthorized access caused by attacks.

5.5 The Proposed Three Layer Encryption Algorithm (3LEA)

5.5.1 Introduction to 3LEA

The 3LEA proposes a distinctive design of encryption scheme. That is, the encryption scheme consists of three sequential functions. It is a function of functions.

5.5.2 General 3LEA Equation

The 3LEA equation, denoted by $\mathrm{E_{3LEA}}$, is an encryption function of consistent multi-functions as mathematically expressed in Eq. (5.1):

$$E_{3LEA} = E(f_{E1}, f_{E2}, f_{E3}) \tag{5.1}$$

whereas

- E_{3LEA} is the encryption algorithm formed in a general definition
- $E()$ is the applied encryption scheme function
- f_{E1}, f_{E2}, and f_{E3} represent encryption functions specified for Biometrics_attributes, SQ, and Serial_ID values, respectively. Despite those encryption functions look like identical to each other, each one has a distinctive design of plaintexts inputs and secret keys; this is to be explained herewith.

5.5.3 3LEA Equation Architecture

The architecture of the general design of 3LEA equation(s) applies '*a function of functions*' basis. At the first, they are designed and ordered in a tree relationship having a predecessor and a successor, as shown in Fig. 5.9.

They have been designed in a way whereas each encryption function uses its predecessor encryption function as input. It goes reversely to increase the security of ciphertext being generated. This is mathematically represented in the following equations.

E1 Equation. This equation is dedicated to encrypt *biometrics_attributes* values extracted from a binary image. Certain values are extracted from binary images (i.e., user's face image and fingerprint image). A simple mathematical procedure is applied on the selected binary image to extract a number of values to be stored in a binary matrix, M_b. Subsequently, binary values are stored in a one-dimension matrix, M_b. Therefore, the process of encryption is mathematically provided in Eq. (5.2) as follows:

$$C_b = E(M_b, k_b) \tag{5.2}$$

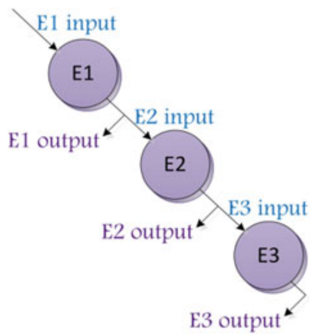


Fig. 5.9 Tree-based *function of functions* encryption scheme architecture

whereas

- C_b is the ciphertext of biometrics attributes values; it is denoted by *E1 output* in Fig. 5.9
- $E()$ is the encryption function applied on biometrics attributes values
- M_b is a 1D binary matrix in which biometrics values are stored, it is the plaintext of E1
- k_b is the secret key used to encrypt values of biometrics attributes, it is the 2nd input of E1.

E2 Equation. Usually, each user will be provided a SQ whereas its related correct answer is only known by the corresponding user. This answer will be encrypted and stored in the system database for further verification procedure purposes. In this sub-section, the value of the answer is defined as a plaintext and mathematically denoted by: M_{SQ}. Similarly, SQ answer is converted to a binary value and then stored in M_{SQ}. As the proposed scheme uses '*a function of functions*' rule and also as can be seen in Fig. 5.9, E2 Equation has a further input which is E1 Output. This is mathematically formulated in Eqs. (5.3) and (5.4):

$$C_{SQ} = E(C_b, M_{SQ}, k_{SQ}) \tag{5.3}$$

$$C_{SQ} = E(E(M_b, k_b), M_{SQ}, k_{SQ}) \tag{5.4}$$

whereas

- C_{SQ} is the ciphertext of SQ Answer; it is denoted by *E2 output* in Fig. 5.9
- $E(E())$ is the encryption of encryption function applied on SQ Answer in binary values
- $E(M_b, k_b)$ is the first input of E2
- M_{SQ} is a 1D binary matrix in which SQ Answer binary values are stored, it is the plaintext of E2
- k_{SQ} is the secret key used as an input for the encryption function of SQ Answer, it is the 3rd input of E2.

E3 Equation. This is the third encryption function which fulfills '*a function of functions*' basis. This function relates to theser ID. Usually, each user is given a Serial_ID that must be secret and will be used for verification for a secure access to such an IoT smart system. In this step, the Serial_ID is being encrypted. There will be two other inputs used as plaintexts for the third encryption scheme mentioned in Fig. 5.9. This is mathematically represented in Eqs. (5.5) and (5.6):

$$C_{ID} = E(C_{SQ}, M_{ID}, k_{ID}) \tag{5.5}$$

$$C_{ID} = E(E(E(M_b, k_b), M_{SQ}, k_{SQ}), M_{ID}, k_{ID}) \tag{5.6}$$

whereas

- C_{ID} is the ciphertext of Serial_ID; it is denoted by *E3 output* in Fig. 5.9
- $E(E(E()))$ is the encryption of encryption of encryption function applied on Serial_ID in a binary form
- $E(E(M_b, k_b), M_{SQ}, k_{SQ})$ is the first input of E3
- M_{ID} is a 1D binary matrix in which Serial_ID are stored as a series of 1s and 0s; it is the plaintext of E3
- k_{ID} is the secret key used as an input for the encryption function of Serial_ID, it is the 3rd input of E3.

5.5.4 3LEA Equation—Security Layers Conception Definition

As discussed above, the 3LEA general equation consists of three equations applied on user's inputs and information to increase the security and privacy. In Fig. 5.10, there will be three layers graphically represented to add more clarification to the proposed security layers.

In this figure, there are three secure layers each of which differs from each other in terms of confidentiality. However, the security level is being increased with layer starting from E1. Meaning, the E3 layer is more secure than E2.

5.5.5 3LEA Equation Layers—The Proposed Layer-Security Conception

The proposed 3LEA defines the security conception achieved by the three layers (E1, E2, and E3) depicted in Fig. 5.10 in two main issues:

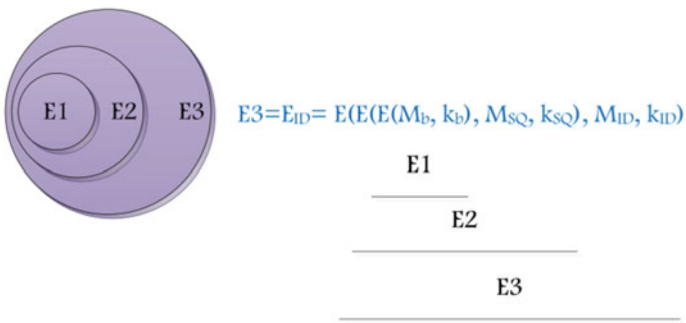


Fig. 5.10 3LEA security layers

1. Each layer has a different number of inputs in terms of plaintext and secret keys. Specifically, the successor layer compared to its predecessor, i.e., E2-to-E1 relation, has more inputs. Thus, the layer E3 has the largest number of inputs (plaintexts and secret keys) as shown in Fig. 5.10. This definitely would increase the data protection consideration and decryption complexity as well.

   (a) It is unknown for attacks and/or threats how many inputs each layer has. This is to increase the unpredictability level.
   (b) Each successor layer (i.e., E3–E2, E3–E1, or E2–E1) increases the privacy of data being encrypted once the number of inputs is also increased. There is a directly proportional relationship between number-of-inputs and protection level. This will reduce the number of successful threats/action to find a vulnerable issue in the QR-tag contents and whole IoT system.
   (c) Another security issue that could be achieved is that the decryption difficulty. Since each layer has different architecture, the chance of such a layer being decrypted successfully, does not mean the other layer will be decrypted using the same decryption scheme. Therefore, the decryption needed for such a QR-tag will be defined by two factors. Meaning, the decryption computational time will have a directly proportional relationship either an exponential or power, as mathematically expressed in Eq. (5.7):

$$D_{QR} = f_{ep}(L_k, L_{3LEA}) \tag{5.7}$$

whereas

- D_{QR} is the function of time needed to decrypt one QR-tag
- $D_{QR} = f_{ep}(L_k, L_{3LEA})$ is a function consists of two mathematical functions with a relation to their computational time(s) in which the computational time for the decryption scheme is determined by the operator both functions have, i.e., the function f_{ep} controls the decryption time whereas the relationship between the decryption time of attacks and $f()$ is directly proportional with relation to operators L_k and L_{3LEA}
- L_k is the secret key length of a decryption function such as brute force attack
- L_{3LEA} is the secret key(s) lengths of multiple keys proposed by the 3LEA

Therefore, in Eq. (5.7), to derive the operator function; it is clear that every attempt of decryption of L_k will be determined by the number of subsequent attempts of L_{3LEA}. That means, the number of D_{QR} times is determined by a multiplication function. That is mathematically formulated in Eq. (5.8):

$$f_{ep}(L_k, L_{3LEA}) = L_k \times L_{3LEA}. \tag{5.8}$$

Therefore, Eq. (5.7) can be re-formulated in Eq. (5.9):

$$D_{QR} = L_k \times L_{3LEA} \tag{5.9}$$

2. The layers are ordered to resemble the capsulation form. That design should have enhanced the protection of each internal item. As for 3LEA, the internal items are E1 and E2. Each item is capsulated by its self and the layers of its successors. Meaning, E1 is capsulated by two layers which are E2 and E3 respectively as well as its layer, E2 is capsulated by the E3 layer and its layer, and E3 is capsulated only by its layer. This conception is easily applied to increase the 3LEA security in general. However, the security strength each layer has depends mainly on the number of layers acting as a capsule. Suppose that an attack has performed a successful action and decrypted E3; then the following three ingredients/inputs are disclosed. $E(E(M_b, k_b), M_{SQ}, k_{SQ}), M_{ID}$, and k_{ID}. Notwithstanding, two inputs of E3 were disclosed, other two layers are secure and fully encrypted. Additionally, the capsulated and non-decrypted layers, $E(E(M_b, k_b), M_{SQ}, k_{SQ}) \equiv$ E2 and E1, have different encryption scheme and cannot be decrypted using the same way by which the E3 has been decrypted.

5.5.6 Secret Key Design

This subsection explains how the secret key assigned. It should have answered these two following questions: What is the optimal secret key length? What are criteria controlling its length? The 3LEA has supposed that: "*each key has a different length*" AND "*at every period of time such a QR-tag being encrypted, there will be different key length from its previously used time*" to ensure a high level of security for data being used with the related IoT-based system.

To ease the conception of secret key to readers, one important issue is that the encryption scheme (i.e., 3LEA) has two inputs which are plaintext and secret key. The proposed 3LEA has adopted that both inputs have the same length. Since, the plaintext discussed above denoted by a 1D matrix e.g., M_b has a specific length of binary numbers to which the designed secret key must be identical. Depending on the length of the plaintext, the secret key needs to be mathematically formalized using Eq. (5.10):

$$L_{k_i} = f_{norm}(M_i, L_{M_i}) \tag{5.10}$$

whereas

- L_{k_i} is the normalized length of the designed secret key
- i represents the case the key is designed for; whereas $i = b, SQ$, or ID for E1, E2, or E3, respectively
- f_{norm} is the normalized function by which the appropriate length of security is calculated and obtained

- M_i is the selected plaintext for such an assigned encryption scheme ex. E1, E2, and E3
- L_{M_i} is the plaintext length the secret key length needs to follow.

In order to design an appropriate key, there is a need to consider two procedures one of which is discussed in Eq. (5.10). In addition to the key length, the secret key's values are also of importance to be taken into account. In order to strengthen the values assigned for such a key, a pseudorandom number generator (PRNG) is used to generate a value for each key with a pre-defined length as discussed in Eq. (5.10). The key value k_i is then could be generated in a way that PRNG must produce a series of bits for the secret key with a length of L_{k_i}. Simply, this procedure is mathematically expressed in Eq. (5.11):

$$k_i = f_{PRNG}(S, L_{k_i}) \quad (5.11)$$

whereas

- k_i is the secret key value with a pre-defined length equals to L_{k_i}
- f_{PRNG} is the PRNG-based function used to produce a secure number
- S is the seed used by f_{PRNG} to produce a cryptographically secure PRNG.

5.5.7 3LEA Equation Layers—Technical Definition

The proposed 3LEA scheme design is illustrated in a block-diagram to highlight its inputs, outputs, and layers' architecture as a reverse-direction conception, as shown in Fig. 5.11.

This figure shows that there will be three security layers. There are read in a reverse-direction path. Meaning, the E3 has a cryptographic layer, i.e., ciphertext ($C3$) for its inputs ($C2, k_{ID}$, and M_{ID}). If this layer has been attacked, $C2$ is still secure as a cryptographic form. Similarly, $C2$ is a secure cryptographic layer for E1. Even with, $C3$ is a secure layer for E1 whereas there should have been two

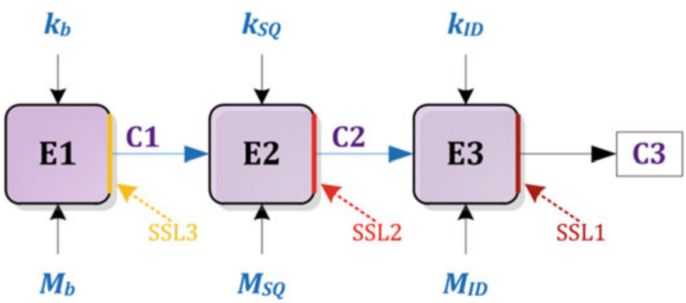


Fig. 5.11 The block-diagram of 3LEA scheme's ingredients—encryption part *only*

successful attacks in order to reach outputs of E1 (i.e., $C1$) and not inputs of E1; there is a need to have three attacks in order to reach the plaintext of E1.

5.5.8 Mathematical 3LEA Properties

As shown in Fig. 5.11, there are three layers SSLi protecting encryption schemes (E1, E2, and E3), the way these are designed would have produced a number of mathematical properties between those encryption schemes. In addition, the design each encryption scheme has in terms of its inputs has added several relations as listed below:

Supersets Properties

$$\mathrm{E3} \supset \mathrm{E2}; \mathrm{E3} \not\subset \mathrm{E2}; \mathrm{E2} \supset E1; \mathrm{E2} \not\subset E1; \because \mathrm{E3} \supset E1; \mathrm{E3} \not\subset E1$$

Elements of sets Properties

1. $\forall u_i \in E_k \Rightarrow u_i \in E_{k+1}; k = 1, 2, 3$
   $\because u_i \in E_2 \Rightarrow \therefore u_i \in E_3; k = 2; E_2 \equiv E2$
2. $\forall u_i \in E_k \not\Rightarrow u_i \in E_{k-1}; k = 1, 2, 3$
   $\therefore u_i \in E_2 \not\Rightarrow \therefore u_i \in E_1; k = 2$

Union and Intersection Properties

- $E_k \cap E_{k+1} = E_k$
  $E1 \cap E2 = E1; E_1 \equiv E1$
  $E1 \cap E3 = E1$
  $E2 \cap E3 = E2$
  $(E1 \cap E2) \cap (E1 \cap E3) = E1$
  $(E1 \cap E2) \cap (E2 \cap E3) = E1$
  $(E1 \cap E3) \cap (E2 \cap E3) = E1$
- $E_k \cup E_{k+1} = E_{k+1}$
  $E1 \cup E2 = E2$
  $E1 \cup E3 = E3$
  $E2 \cup E3 = E3$
  $(E1 \cup E2) \cup (E1 \cup E3) = E3$
  $(E1 \cup E2) \cup (E2 \cup E3) = E3$
  $(E1 \cup E3) \cup (E2 \cup E3) = E3$

5.5.9 3LEA Processes

Technically, there are four processes to encrypt biometrics attributes and features, SQ, and Serial_ID discussed as follows:

Process 1: biometrics 'Plaintext' Encryption. Information of user biometrics attributes is collected first as raw images. The aim is to pass binary values of images to the encryption scheme i.e., E1. Once, face image features and fingerprint properties have been extracted using a series of digital image processing conversions, they are encrypted. Then, obtained values are stored in M_b in a binary form whereas Eq. (5.2) is applied. Once, this processes has been done, two further procedures are performed which are: storing encrypted values in database and sending them to the 3PVA as a QR-tag once an access is required by the user, refer to Fig. 5.12.

Process 2: SQ Encryption. The SQ has been designed in a way that it is frequently and periodically changing to produce a new value. Thus, it is mainly dependent on user activity that is continuously changing to guarantee generate a new value therefore whole subsequently encrypted scheme is different. This is to produce new SQ and also new encrypted values generate a new QR-tag. Using

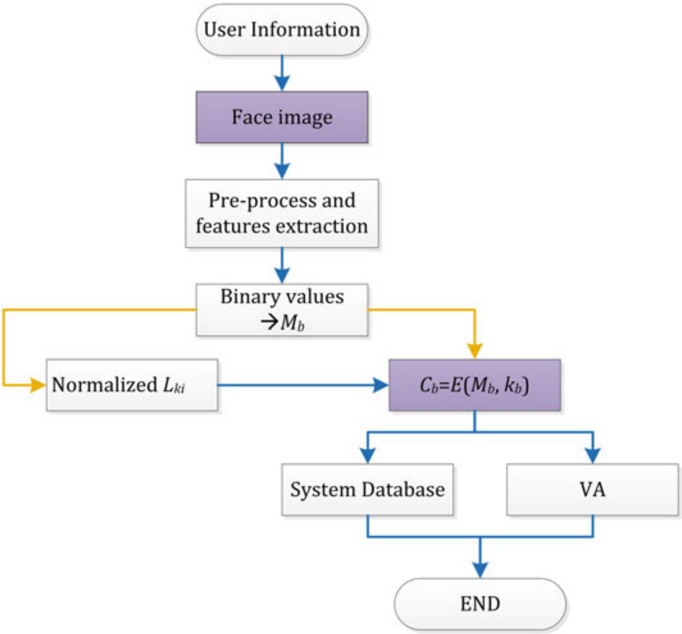


Fig. 5.12 Scheme encryption for E1 (process 1)

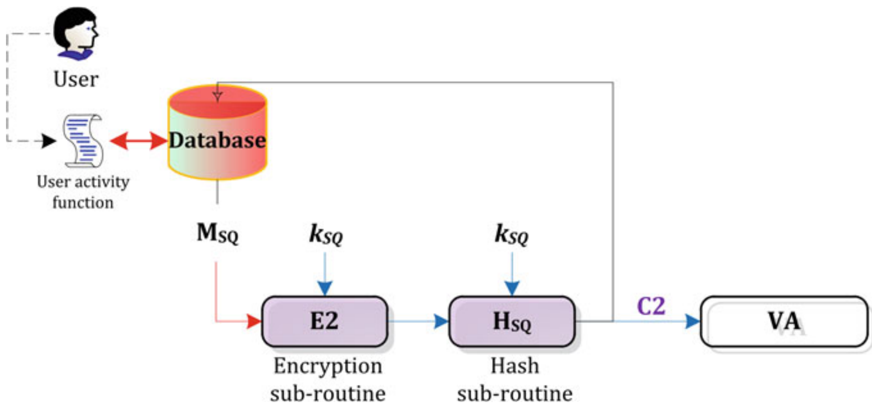


Fig. 5.13 SQ encryption scheme (process 2)

some user's activities for analysis, certain values are candidate to be selected for M_{SQ}. Next, Eq. (5.4) is applied. After that, encrypted values (i.e., C2) are sent to database and VA, as graphically represented in Fig. 5.13.

In this graphical figure, additional process is implemented to increase the security of E2's output whereas a hash-based function is applied on C2 using 1-session secret key generated using Secure Hash Algorithm 1 (SHA-1). Thus, C2 and secret key inputs are combined and hashed.

Process 3: ID Encryption. This process is dedicated to encrypt a Serial_ID. But, before that, this process is aimed to obtain a strong cryptographic Serial_ID to be used as a seed for the encryption scheme i.e. E3 where the output of this process is the C3 and therefore C3 is normalized as a Serial_ID as depicted in Fig. 5.14. A series of encryption and hash functions has been used in this process to generate a strongly encrypted distinctive Serial_ID. During the encryption process, a hash function has been used to generate new Serial_ID with the help of real values taken from database for each user. The Serial_ID will be converted to a binary form and then passed to M_{ID} after a normalization process has been applied. This normalization function is needed to change the binary form of Serial_ID leading to increase the M_{ID} privacy. Additionally, to increase the complexity of vulnerability possibility, each Serial_ID is hashed depending on two neighboring IDs. There is a hash function is used before the 1st round encryption is applied. At the decryption part, there will be two-round decryption processes applied by the VA, refer to Fig. 5.2 to extract the Serial_ID, i.e. C3.

Process 4: QR-Tag Final-step Encryption. This process finalizes the output of three abovementioned processes. It applies a combination union-based hash function to produce a cryptographic secure number, say: H_{QR}. Finally, an encryption scheme is applied on H_{QR} to produce the encrypted QR-tag. This process is illustrated in Fig. 5.15.

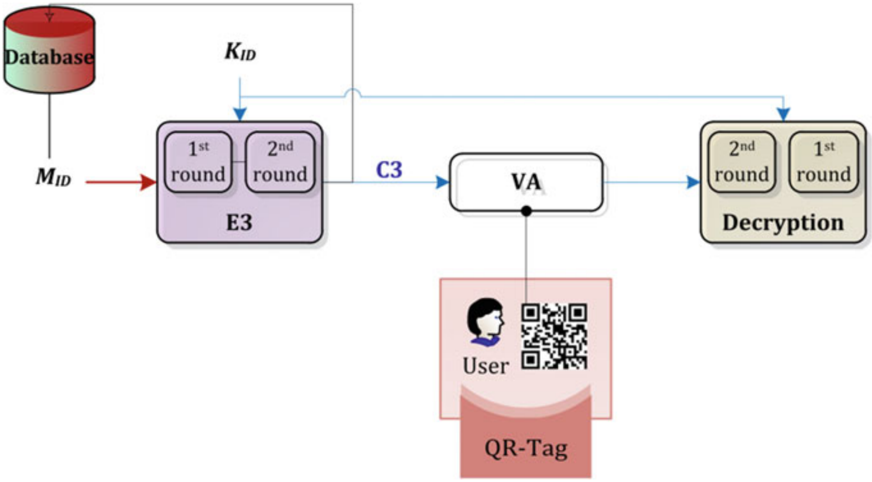


Fig. 5.14 ID verification (process 3)

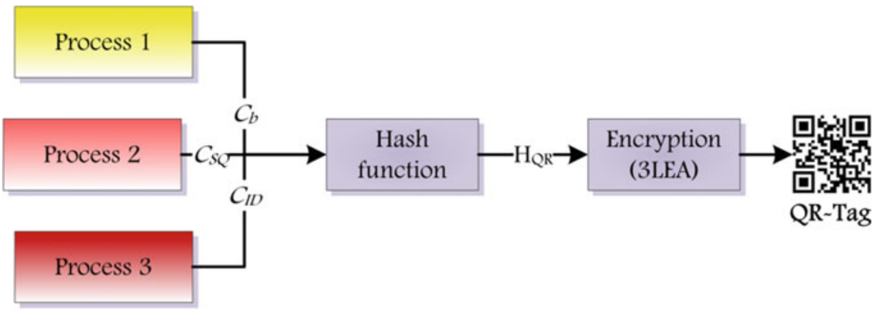


Fig. 5.15 QR-tag encryption process

5.6 Performance Evaluation

This section evaluates the proposed ESM performance. This section is explained in three sub-sections which are 3LPA, 3LEA, and ESM evaluation in terms of data privacy. The two algorithms (i.e., 3LPA and 3LEA) are the key parts of making a strong decision in terms of ESM's privacy and security. And depending on the 3LEA's design strength, the 3PVA could be strong. At each section, security factors are evaluated as well other related factors.

5.6.1 3LPA Security Factor Based Evaluation

Confidentiality. The QR-tag is periodically re-generated using a temporary secret key to increase information confidentiality. The secret key is designed using a very long series of bits to ensure the decryption time being lengthily increased. If the key has successfully decrypted QR-tag contents, then the time needed has been surely exceeded the L_{QR} therefore the QR-tag used for access is new and the one decrypted is already expired.

Integrity. QR-tag contents are verified in order to ensure the integrity. If there is any mismatch between original values (database) and scanned (QR-tag), then the 3PVA-3LPA has no integrity and therefore the verification process is stop. Thus, a third party has modified the QR-tag contents or it might be the original QR-tag is expired i.e., $L_{QR} > T_{QR}$. Based on that, the user QR-tag and other contents are protected by rejecting any attempt to access.

Availability. There will be no access by a third party but only one authorized source is allowed to access thru the *offline* database given a certain period of time.

Authentication. This evaluation performs a *vote*-based process in order to measure the authority of the QR-tag. That is, a several steps of processes are verified to make sure that the QR-tag is issued by an authentically original source. Additionally, it measures the percentage of QR-tag authentication.

Robustness. As for Algorithm 2 at Sect. 4.2, to verify the 3LPA robustness, all three verifications must be correct none some. Thus, if the QR-tag has been used successfully and one or more of other verifications was wrong or mismatched to original values, the user can't access. Meaning, suppose that the two verification processes '*Serial_ID*()' and '*SQ*()' are correct but '*Biometrics_attributes*()' isn't; then the '*vote1* = 40' value and if $1\% \times \mathrm{T_{QR}} \leq \mathrm{L_{QR}} \leq 25\% \times \mathrm{T_{QR}}$, then '*vote* = 64 < 66' will be rejected. Thus, this procedure is used to test the 3LPA robustness. Hence, a more robustness level against unauthorized attempts to prevent threats and actions is achieved.

5.6.2 3LEA

Encryption Schemes' Layers—Technical Evaluation. In this evaluation, encryption schemes (E) vs. Secure Shielded Layers (SSL*i*) is discussed and evaluated. As marked by dark red, light red, yellow colored lines in Fig. 5.11, these act as a secure-shield layer (SSL) for encrypted data. However, each encryption scheme has a different number of SSL giving more strength in terms of privacy as shown in Table 5.1.

This table shows that E1 has three SSLs increasing its data privacy and safety. Even though, E3 is protected by only SSL3, its inputs are several and a combination of others' encrypted values (i.e., C1 and C2) which increase its encrypted data (i.e., C3) leading to increase the whole privacy of E3.

Table 5.1 SSL_i to each encryption scheme (E)

	SSL1	SSL2	SSL3
E1	✓	✓	✓
E2	✓	✓	×
E3	✓	×	×

Unpredictability. In this type of evaluation, the layer design for encryption vs. number of inputs (i.e., plaintext and secret keys) will be discussed. The first layer which is SSL1 dedicated for E3 in which its output is C3 as illustrated in Fig. 5.16, has two inputs as items and one as a function of function, as shown in Table 5.2. The second layer (SSL2) relates to E2 whereas its output is C2, refer to third and fourth columns in Table 5.2. SSL2 has two inputs as items and one function. The third layer SSL3 has two items of inputs with no function.

This mixture of encryption scheme design could produce an unpredictable decryption scheme. So, any decryption scheme must be of strength to change its design in order to alter its predictability which looks difficult because the number of layers randomly changes.

Confidentiality. The proposed ESM has adopted to design its encryption algorithms (i.e., E1, E2, and E3) in such a way that the number of inputs is being increased starting from E1 to E3. This increment leads to increase the confidentiality whereas it becomes difficult for a decryption scheme to crack an encryption scheme with a high number of inputs e.g., E3 using the same technique used to crack an encryption scheme having fewer inputs e.g., E2 or E1. Therefore, the proposed design for encryption schemes keeps their data private.

Decryption Complexity in terms of Time. The time that each decryption algorithm needs is given in Eq. (5.12):

$$T_D = f\left(t_{L_{k_i}}, t_{3LEA}\right) \tag{5.12}$$

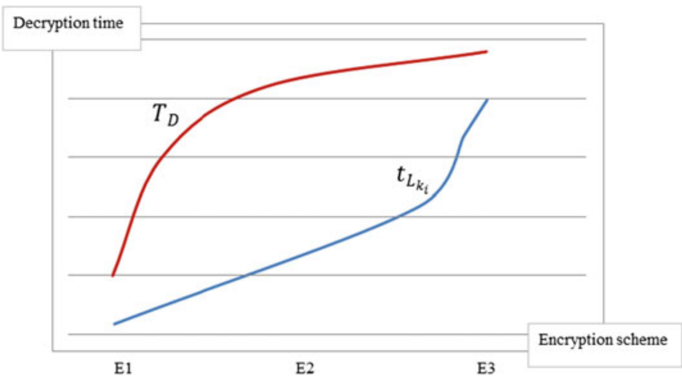


Fig. 5.16 Decryption time versus encryption scheme of the proposed T_D and $t_{L_{k_i}}$

Table 5.2 SSL_i versus no. inputs

SSL1		SSL2		SSL3	
1 item	k_{ID}	1 item	k_{SQ}	1 item	k_b
1 item	M_{ID}	1 item	M_{SQ}	1 item	M_b
1 *function of function*	$f(f) \equiv C_{SQ}$	1 *function*	$f \equiv C_b$	–	–

whereas

- T_D is the total decryption time needed to crack one encryption scheme of 3LEA
- $t_{L_{k_i}}$ is the time needed to decrypt a scheme (e.g., E1) by using such an *brute attack force*
- t_{3LEA} is the decryption time needed after proposing the three layers architecture
- $f()$ is the computational function of both $t_{L_{k_i}}$ and t_{3LEA}; its mathematical operator might be exponential or multiplicative

A Cartesian-based plot of behavior of Eq. (5.12) is shown in Fig. 5.16 in order to show how the complexity of decryption time has been increased.

This figure shows that the computation time needed to decrypt such an encryption scheme using one of well-known attack algorithms e.g., brute force attack has a $t_{L_{k_i}}$ function marked in a blue color as shown in Fig. 5.16. But, to decrypt an ESM's encryption scheme, the time needed has a logarithmic-like curve which is higher in y-values as marked in a red color in Fig. 5.16. The curve of T_D has more computation time than the $t_{L_{k_i}}$ curve, so that the decryption algorithm will be slower when the ESM has been used to encrypt the QR-tag. Therefore, the IoT-based system should have been enhanced in terms of privacy and decryption complexity in terms of computation time.

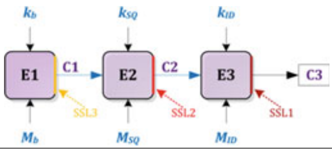
Secret Key Design. The main point has been considered by the 3LEA with the secret key design is its length. The 3LEA has supposed that: "*each key must be not equal to the other key in length and value*". Therefore, to increase the data privacy and as well as the IoT-based system's security, each secret key has its own distinctive length. Therefore, to complicate the decryption process and hence to reduce the vulnerability of IoT-based system, it is highly necessary to design the encryption scheme differently to increase the decryption's processing time. One of the most important parts any encryption scheme has is its secret key because once the secret key has been deduced; its plaintext could be readable easily. Therefore, the 3LEA has concentrated more on the design of the secret key using a technique that guarantees to assign unequal values to each sing secret key. Meaning, $k_b \neq k_{SQ} \neq k_{ID}$. Based, if a decryption algorithm has successfully discovered the plaintext of E3, other plaintexts of E2 and E1 cannot be discoverable using the same technique of the decryption process. Subsequently, while other information is not ready with the attacker, the QR-tag cannot be discoverable as well. Then, the IoT-based system could not be accessed while the correct smart key (i.e., QR-tag) is not available. Therefore, an enhancement on the performance of the 3LEA and as well the ESM is noticeable existent. Hence, this distinctive design should have enhanced the security level of IoT-based systems.

5.6.3 ESM—Data Privacy and Security for IoT-Based Systems

Capsulation Conception for IoT-based System Security. The ESM has proposed a new conception to be used with an encryption scheme which is the capsulated encrypted layers discussed earlier. In this sub-section, the capsulation conception is evaluated in terms of data privacy and security. As shown in Table 5.3, the number of layers needed to be decrypted in order to find out the relative plaintext is mentioned per each encryption scheme.

It is better to read this table from right-to-left. Suppose that an unauthorized access e.g., '*action is trying to decrypt the QR-tag*', the ciphertext the attacker has is normally $C3$. In this case, there will be 2 inputs which are k_{ID} and M_{ID} the attacker can get if the action has been successfully performed. However, there are still capsulated (i.e., *hidden*) inputs those which are ciphered by $C2$. As for the first layer SSL1, the attacker needs to decrypt one-layer to get a determined number of plaintexts (e.g., k_{ID} and M_{ID}) as shown in Fig. 5.17 whereas there will be two more layers to decrypt whole plaintexts which is difficult to occur in a short time using a straightforward decryption scheme due to the secret key differs in length. Thus, this complicated process is important to keep data private. As a result, this has enhanced the privacy and security of IoT-based systems.

Table 5.3 Number of layers and inputs per each encryption scheme



$C1 \equiv C_b$	$C2 \equiv C_{SQ}$	$C3 \equiv C_{ID}$
1 layer: k_b	1 layer: k_{SQ}	1 layer: k_{ID}
1 layer: M_b	1 layer: M_{SQ}	1 layer: M_{ID}
–	1 layer: C_b	1 layer: C_{SQ}
	2 layers: k_b	2 layers: k_{SQ}
	2 layers: M_b	2 layers: M_{SQ}
	–	2 layers: C_b
		3 layers: k_b
		3 layers: M_b

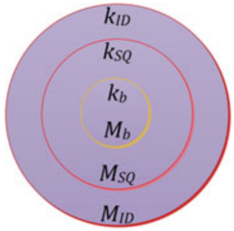


Fig. 5.17 Capsulated encrypted layers

5.7 Conclusion

An encryption scheme method has been proposed in order to do two simple security processes used with any IoT-based system. Processes are the encryption of QR-tag and verification of its originality and authentication. In the first process, a complicated cryptographic scheme has been used to generate encrypted values and then used to generate a cryptographic QR-tag. The second one verifies the QR-tag authentication by proposing two algorithms (i.e., 3PVA and 3LPA) acting as a firewall for the IoT-based system to increase its security level. The proposed QR-tag can be used as a smart key for several smart systems such as IoT automatic systems, smart home applications, and security gates. The 3PVA is proposed to authenticate the QR-tag and measure how authenticated it is. The proposed ESM has adopted the capsulated values in three layers to make sure that such an attack will face much difficulty to find a vulnerability or weakness point to decrypt the QR-tag by designing different secret keys in terms of length for encrypted layers. The ESM overall performance has been evaluated in terms of security factors. Evaluation sections have discussed different factors such as integrity, availability… etc. Results have shown good performance in terms of 3LEA unpredictability that supports the ESM robustness for such a potential attack or threat that might occur to IoT-based systems.

Acknowledgements This research study is funded by UNIIG (J510050781/2017-B2).

References

1. Lin, S.S., Hu, M.C., Lee, C.H., Lee, T.Y.: Efficient QR code beautification with high quality visual content. IEEE Trans. Multimedia **17**, 1515–1524 (2015)
2. Rane, S., Dubey, A., Parida, T.: Design of IoT based intelligent parking system using image processing algorithms. In: 2017 International Conference on Computing Methodologies and Communication (ICCMC), pp. 1049–1053 (2017)
3. Alshattnawi, S.: Effective use of QR codes in religious tourism. In: International Conference on Advanced Computer Science Applications and Technologies, pp. 497–501 (2012)
4. Huang, H.-F., Liu, S.-E., Chen, H.-F.: Designing a new mutual authentication scheme based on nonce and smart cards. J. Chin. Inst. Eng. **36**, 98–102 (2013)

5. Hung, C.H., Fanjiang, Y.Y., Chung, K.C., Kao, C.Y.: A door lock system with augmented reality technology. In: IEEE 6th Global Conference on Consumer Electronics (GCCE), pp. 1–2 (2017)
6. Tkachenko, I., Puech, W., Destruel, C., Strauss, O., Gaudin, J.M., Guichard, C.: Two-level QR code for private message sharing and document authentication. IEEE Trans. Inf. Forensics Secur. **11**, 571–583 (2016)
7. Rodrigues, B., Chaudhari, A., More, S.: Two factor verification using QR-code: a unique authentication system for Android smartphone users. In: 2016 2nd International Conference on Contemporary Computing and Informatics (IC3I), pp. 457–462 (2016)
8. Kanaris, L., Kokkinis, A., Fortino, G., Liotta, A., Stavrou, S.: Sample size determination algorithm for fingerprint-based indoor localization systems. Comput. Netw. **101**, 169–177 (2016)
9. Samuel, S.S.I.: A review of connectivity challenges in IoT-smart home. In: 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC), pp. 1–4 (2016)
10. Ota, K., Kumrai, T., Dong, M., Kishigami, J., Guo, M.: Smart infrastructure design for smart cities. IT Prof. **19**, 42–49 (2017)
11. Chen, Y.H., Tsai, M.J., Fu, L.C., Chen, C.H., Wu, C.L., Zeng, Y.C.: Monitoring elder's living activity using ambient and body sensor network in smart home. In: 2015 IEEE International Conference on Systems, Man, and Cybernetics, pp. 2962–2967 (2015)
12. Kavitha, K.J., Shan, B.P.: Implementation of DWM for medical images using IWT and QR code as a watermark. In: 2017 Conference on Emerging Devices and Smart Systems (ICEDSS), pp. 252–255 (2017)
13. Lin, P.Y.: Distributed secret sharing approach with cheater prevention based on QR code. IEEE Trans. Ind. Inf. **12**, 384–392 (2016)
14. Nazemzadeh, P., Fontanelli, D., Macii, D., Palopoli, L.: Indoor localization of mobile robots through QR code detection and dead reckoning data fusion. IEEE/ASME Trans. Mechatron. **22**, 2588–2599 (2017)
15. Xiao-Long, W., Chun-Fu, W., Guo-Dong, L., Qing-Xie, C.: A robot navigation method based on RFID and QR code in the warehouse. In: 2017 Chinese Automation Congress (CAC), pp. 7837–7840 (2017)
16. Ghaffari, M., Ghadiri, N., Manshaei, M.H., Lahijani, M.S.: P4QS: a peer-to-peer privacy preserving query service for location-based mobile applications. IEEE Trans. Veh. Technol. **66**, 9458–9469 (2017)
17. Kirkham, T., Armstrong, D., Djemame, K., Jiang, M.: Risk driven Smart Home resource management using cloud services. Future Gener. Comput. Syst. **38**, 13–22 (2014)
18. Kim, Y.G., Jun, M.S.: A design of user authentication system using QR code identifying method. In: 2011 6th International Conference on Computer Sciences and Convergence Information Technology (ICCIT), pp. 31–35 (2011)

Chapter 6
Internet of Things Enabled Robot Based Smart Room Automation and Localization System

Rajesh Singh, Gehlot Anita, Shiv Capoor, Geeta Rana, Ravindra Sharma and Shivani Agarwal

Abstract This chapter explores the application of smart automation and social robots in the hospitality and tourism industry. There has been much advancement in the field of social robotics but we still observe that the research on incorporating robots in the tourism and hospitality industry has been fairly limited. This paper aims at partially filling this gap. This chapter looks especially at automation of service in restaurants and hotels, amusement parks, theme parks, airports, car rentals, travel agencies, tourist information booths and art galleries and museums. The chapter explores the difficulties that are posed by implementation of service automation and social robotics to assist tourists. The basic idea behind wall climbing robots is that the vacuum can be generated inside a suction cup at the bottom of the robot chassis, which is used to create a grip on the wall on which the robot is to climb. Wall climbing robots are beneficial to a home automation system as this can enable the robot to not interfere with any human activity in the room.

R. Singh (✉) · G. Anita
Lovely Professional University, Jalandhar, India
e-mail: srajssssece@gmail.com

G. Anita
e-mail: eranita5@gmail.com

S. Capoor
University of Petroleum and Energy Studies, Dehradun, India
e-mail: shivcapoor95@gmail.com

G. Rana · R. Sharma
Swami Rama Himalayan University, Jolly Grant, Dehradun, India
e-mail: geetarana@srhu.edu.in

R. Sharma
e-mail: ravindrasharma@srhu.edu.in

S. Agarwal
KIET School of Management, Ghaziabad, India
e-mail: jindal.shivani24@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_6

This also reduces the chance of collision with any human or objects in the environment and also avoids any hindrance to human activity in the room in which the robot has been deployed.

Keywords Robot · Smart room · Automation · IoT

6.1 Introduction

With the increasing popularity of Internet of Things in the field of automation there has been a constant increase in its application on home, cities, office and industry automation. Home automation systems which incorporate controlling of lights, fans and other electrical devices in a house using Internet of things is widely preferred in recent days. We propose a system which allows any appliance to be plugged into our room automation [1]. In this paper we aim at creating an Internet of Things (IoT) based home automation system platform which uses mobile robots for interaction between the system and the user. This paper implements a technique for a mobile robot to be positioned in an indoor setting with the help of static wireless nodes. The static nodes are strategically placed in the room. The receiver node is placed on the robot. The wireless nodes will send packets to the mobile robot with data about the movement of for navigation in a given environment without colliding with obstacles. This feature makes the network node intelligent [2]. In this paper, we discuss RSSI analysis for the localization of the mobile robot [3]. Some lights and fans can be made fully autonomous based on sensor inputs. Lights can be controlled based on the inputs from motion sensors and the fans based on the ambient temperature. Door locks can be controlled by means of voice commands. The system employs Natural Language Processing in order to enable voice commands to be understood by the mobile robot [4]. With domestic social robotics on the rise, the complexity of smart-home devices is becoming an important challenge for interactive design. We present a novel design for a home control interface in the form of a social robot. These findings suggest that social robots could provide for an engaging interface with high situation awareness, but also that their usability remains a considerable design challenge [5]. Compared to other methods, suction cups are more widely preferred for wall-climbing robots on non-magnetic surfaces. But there is a need for pneumatic components such as solenoid valves is a vacuum pump approach is to be used for the robot [6–8].

The major aspects for smart homes can be taken care like resource utilization (water, energy etc.), security and comfort. To achieve comfort, these smart homes will reduce the overall expenditure by eliminating waste. In order to complex security, system is to identify unauthorized entries of theft etc. The Nest learning Thermostat is making use of IoT concepts and able to reduce the 15% cooling bills and 12% on heating bills as an average. The Philips Hue is the other example of smart home. In this system, the bulb changes 600–800 color lumens as per mood of the occupant in that room. The air quality-sensing network made up by using different sensors. The system senses the CO and NO_2 and other pollutants in home environment and determine the air quality. The other home appliance is the Amazon Echo. The seven microphones were inbuilt and being highly sensitive listener of your words from across various noises, and answer the same. Menegatti et al. [9] suggested the technique for the localization of the movable robot whilst at the same time location of node to Wireless Sensor Network (WSN) as part of mapped utilizing one range measurement. Distance of WSN to the closest node are calculated through calculating the RSSI concerning the obtained radio messages using Extended Kalman Filter SLAM algorithm with an error of less than 1 m is obtained [9]. Li and Lili [10] raised the issue of exact area for the portable robot underground coal mine, propose three-point computation of close separation and Gaussian channel, utilize the established logarithmic separation weakening model as a stage, make a hub back stepping calculation demonstrate. The principle research of the calculation is as per the following: how to decide the reference hub which is the nearest to the versatile hub and the parameters the nearest to the portable hub; how the reference hub to manage the RSSI data got from the other reference hubs can acquire the best A, n esteem utilized for situating [10]. Zàruba et al. [11] explained that the sensor perusing utilized for the area estimation is the gotten flag quality sign (RSSI) as given by a RF interface, e.g., Wi-Fi. Remote flag quality maps for the situating channel are gotten by a two-stage parametric and estimation driven beam following way to deal with record for retention and reflection attributes of different obstructions. Area evaluations are then processed utilizing Bayesian separating on test sets inferred by Monte Carlo examining [11]. Lu [12] discussed a simulation model for the autonomous robot for indoor environment is designed, which contains a gas source emitting chemical concentrations, which varies with wind speeds and directions [12]. Awad et al. [13] explained that if low cost approaches are demanded, then the most challenging issue is localization in WSNs. In the paper the approaches are analyzed and discussed relying on the RSSI (relative received signal strength). By employing values of RSSI the advantage is in which zero additional equipment (e.g. ultrasonic or infra-red) is required for network-centric localization. The measured RSSI values are affected by different factors. At the end for the estimation of distance two methods are evaluated the initially method is actually depending upon analytical techniques as well as the 2nd one, an artificial neural network is actually utilized towards estimation of the distance [13]. Graefenstein et al. [14] explained the difficulty to determine the physical location of radio nodes in WSN. This paper helps us to get the location of mobile robot. RTK GPS helps us to determine its position. A method is proposed to derive relative bearing using radio hardware between static node and mobile. When experimentally performed there is a standard deviation of 5 only. An average error of 13 cm is determined in the position [14].

Perkins et al. [15] discussed two ways of distance sensing between robots. RSSI doesn't require any additional hardware but Time Difference of Arrival (TDOA) for communication and processing makes use of commercially available wireless sensor. TDOA needs a microphone and sound source. TDOA is found to be superior to RSSI in accuracy. Two techniques concerning distance-only sensing for the limited robotic systems have already been investigated and compared [15].

6.2 System Description and Hardware Development

The challenging competencies required for a mobile robot is one of the most critical task like Navigation that require the success in the four different prospective are perception, localization, cognition and control [20]. With these four competencies, the mobile robot can extract the data from the sensors, can determine its position in the environment, decide how to act in order to achieve its goals and finally the robot must modulate its motor outputs to achieve the trajectory for desired position. The recent research has focused mainly on these fours components and fruitful research has been made about this context. We have explore the previous research over these components. Figure 6.1 shows the robot localization classification.

There are two techniques that mostly preferable in the robot localization (a) Local Techniques (b) Global Localizations Techniques. The second technique is the most powerful technique because local techniques aims to compensating the odometric error during the navigation and require the initial location and is not possible recover if they lost their track and as so the global techniques having capability to localize the position without any prior knowledge of the initial position [16].

The generalized block diagram of the entire system is shown in Fig. 6.2. This consists of a mobile robot platform which receives signals from the localization beacon modules placed around the room and performs RSSI analysis on the signals which will help the robot to determine its position in the room and help it navigate. The robot will also transmit signals to the smart switch boards. These will in turn control the devices connected to it based on the control signals received from the mobile robot.

Figure 6.2 shows the block diagram for the mobile robot. As per the schematic shown in Fig. 6.3, the mobile robot uses a TI Launchpad controller. Wireless communication is handled by the XBee module and the two motors are driven by a

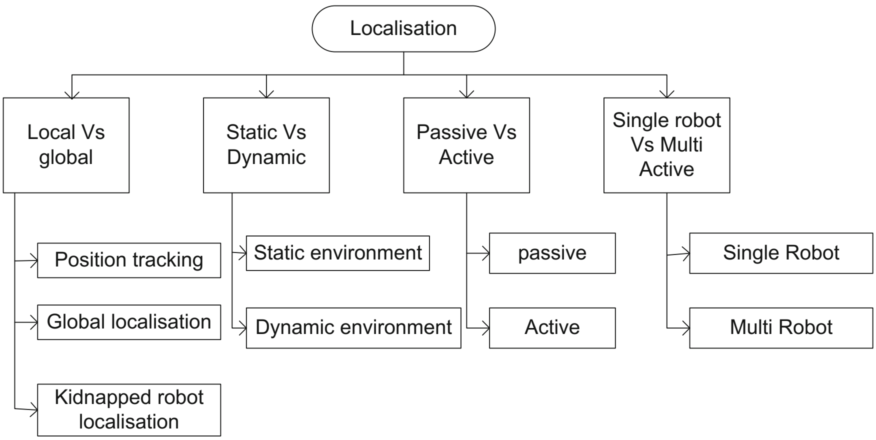


Fig. 6.1 Robot localization classification

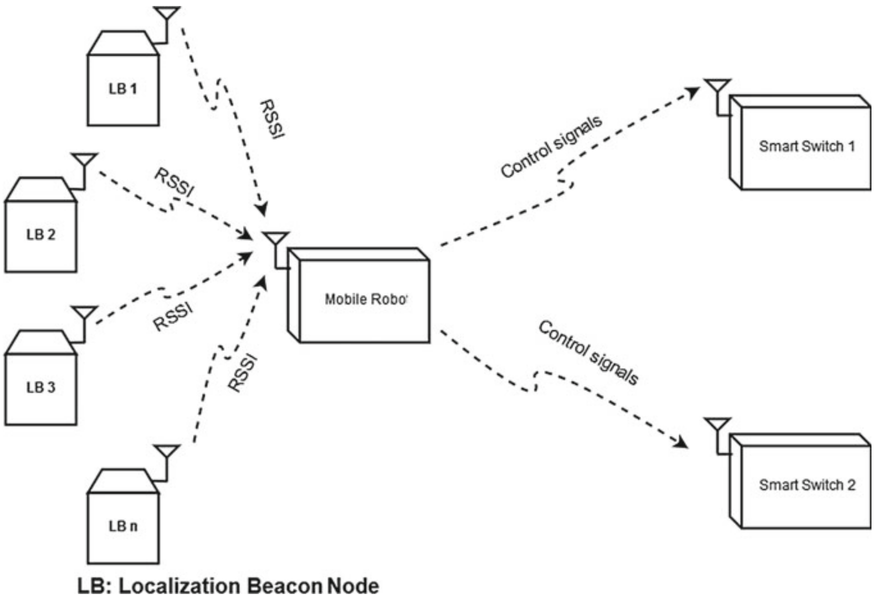


Fig. 6.2 Generalized block diagram

dual H bridge motor driver. It also has an LCD module to display information to the users regarding the robot status or other relevant information [17]. The robot also has a magnetometer which will help improve its navigation capabilities.

Figure 6.4 depicts the architecture of the smart switch board. This board will receive control signals from the mobile robot to turn on or off various devices connected to it. Only the mobile robot has the authority to command the smart

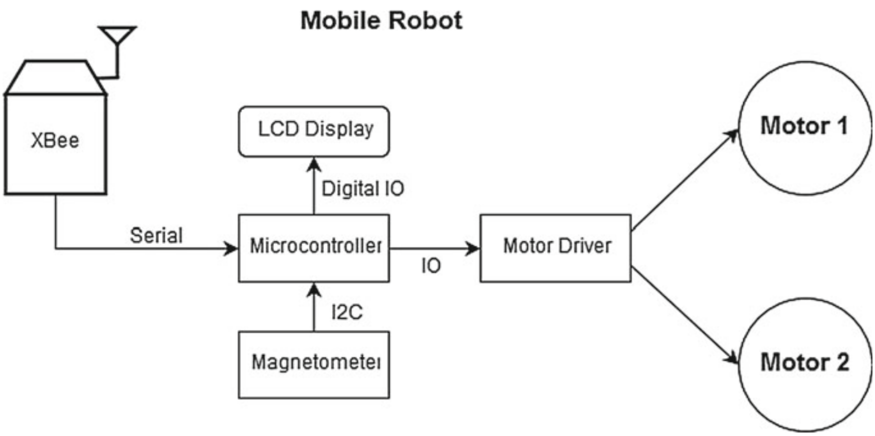


Fig. 6.3 Block diagram of mobile robot

switch board to turn any device on or off. The schematic for the smart switch board is shown in Fig. 6.6. Here it is evident that the smart switch boards are using another TI Launchpad controller. The board also consists of an LCD display module which will show relevant information to the user. Devices are connected through a relay module which is operated by means of a transistor receiving control signals from the controller.

Figure 6.5 shows the localization beacon. It consists of an XBee module which is used to send RF signals to the mobile robot on which RSSI analysis is done. This is done to allow the robot to calculate its position in the room and navigate accordingly. Figure 6.6 shows the schematic for this node. It consists of a 4 × 3 keypad so that each beacon node can be configured to change the node ID and other parameters. It is battery powered and uses a TI Launchpad controller to run the beacon.

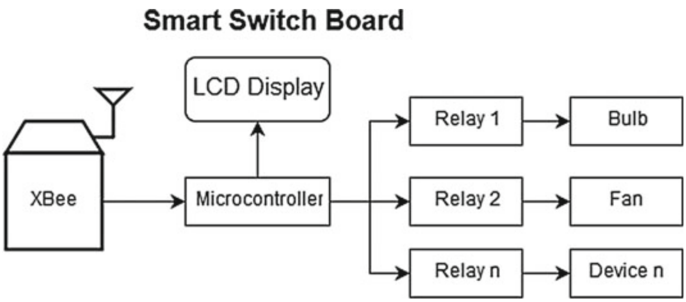
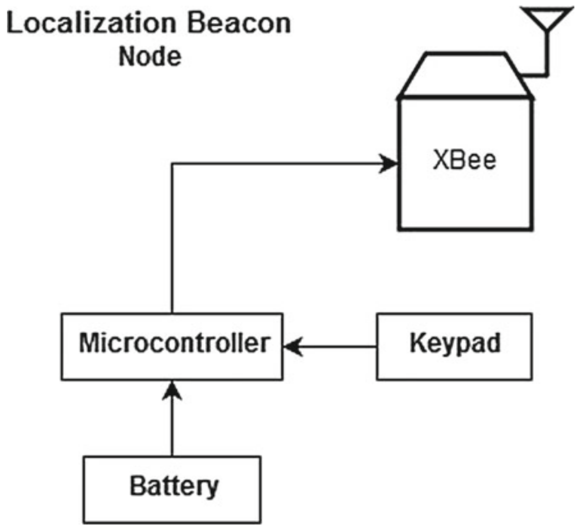


Fig. 6.4 Block diagram of smart switch board

Fig. 6.5 Block diagram of localization beacon node



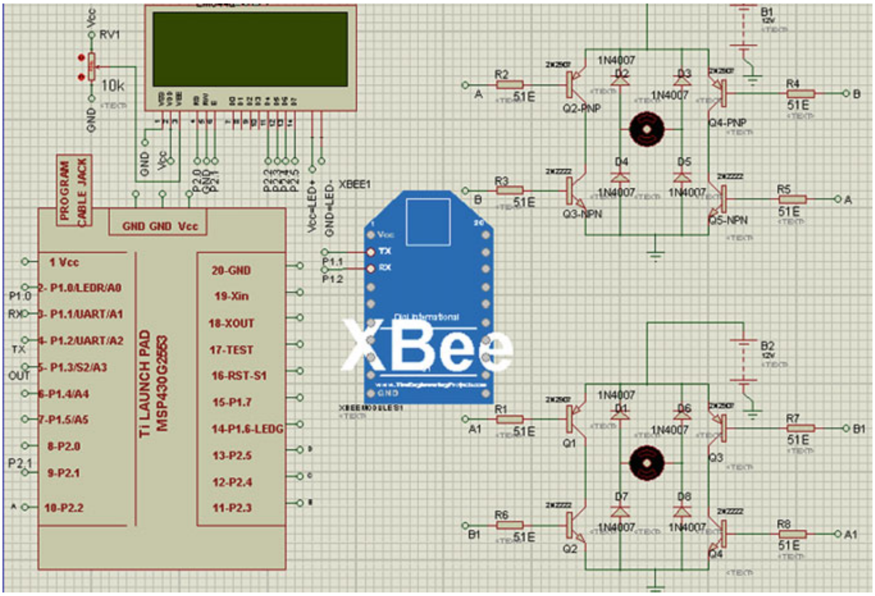


Fig. 6.6 Schematic of mobile robot

The complete system comprises of three sections mobile robot. Smart switchboard and localization beacon node. The mobile robot comprises of TI LaunchPad, Power supply, LCD, Motor driver, XBee modem. The smart switchboard comprises of TI LaunchPad, Power supply, LCD, XBee modem and relay board. The localization beacon node comprises of TI LaunchPad, Power supply, LCD, XBee modem, and keypad. The system is designed so that mobile platform can be controlled wirelessly using XBee modem and responsible to take care of smart switch board. The objective of the project is to design a robot, which is controlled by localization beacon Node using XBee. The localization beacon Node, smart switch board and mobile robot of the project we have to make by using discrete components as given above in the transmitter section.

Figure 6.6 shows the circuit schematics of mobile robot using TI Launchpad. Figure 6.7 shows the circuit schematic of smart switch board. Figure 6.8 shows the schematic of localization beacon node.

Circuit connection of mobile robot is as follows:

1. +5 V pin of power supply is connected to Vcc pin of launch pad and NodeMCU.
2. GND pin of power supply is connected to GND pin of launch pad and NodeMCU.
3. Pins 1, 16 of LCD are connected to GND of Power Supply.
4. Pins 2, 15 of LCD are connected to +Vcc of Power Supply.

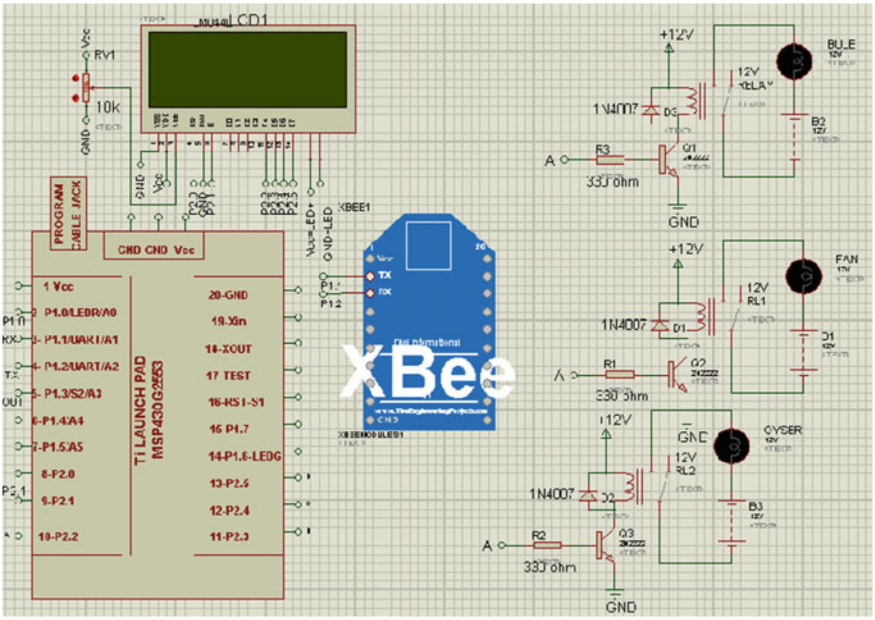


Fig. 6.7 Smart switch board

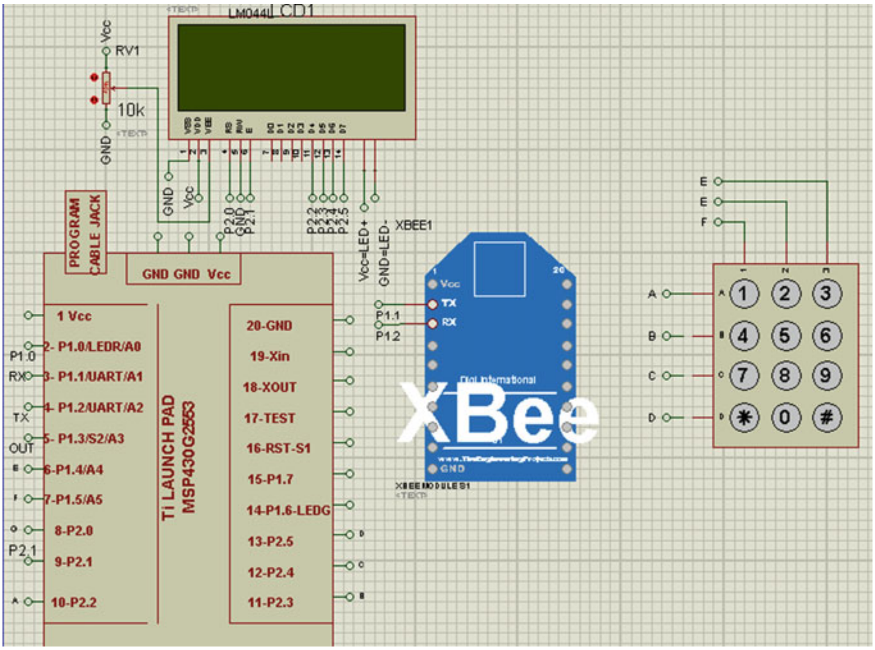


Fig. 6.8 Localization beacon node

5. Two Fixed lags of POT are connected to +5 V and GND of LCD and Variable lag of POT is connected to pin 3 of LCD.
6. RS, RW and E pins of LCD are connected to pins D1 = P2.0, GND and D2 = P2.1 of Ti Launch PAD.
7. D4, D5, D6 and D7 pins of LCD are connected to pins D3 = P2.2, D4 = P2.3, D5 = P2.4 and D6 = P2.5 of Ti Launch PAD.
8. 1, 9 and 16 pins of L293D motor driver to +5 V pin of power supply respectively.
9. Connect 4, 5, 12 and 13 pins of L293D motor driver to GND of power supply.
10. Connect Pins 2, 7, 10 and 15 of L293D motor driver to D1, D2, D3 and D4 pins of NodeMCU.
11. Connect Pins 3, 6, 11 and 14 of L293D motor driver to M1 (+ve), M1 (−ve), M2 (+ve), and M2 (−ve), pins of first and second motors.
12. The Vcc, GND and TX and RX pins of XBee n modem should be connected to +5 V, GND, RX and TX pins of TI Launch Pad.

Circuit connection of smart switch board is as follows:

1. +5 V pin of power supply is connected to Vcc pin of launch pad and NodeMCU.
2. GND pin of power supply is connected to GND pin of launch pad and NodeMCU.
3. Pins 1, 16 of LCD are connected to GND of Power Supply.
4. Pins 2, 15 of LCD are connected to +Vcc of Power Supply.
5. Two Fixed lags of POT are connected to +5 V and GND of LCD and Variable lag of POT is connected to pin 3 of LCD.
6. RS, RW and E pins of LCD are connected to pins D1 = P2.0, GND and D2 = P2.1 of Ti Launch PAD.
7. D4, D5, D6 and D7 pins of LCD are connected to pins D3 = P2.2, D4 = P2.3, D5 = P2.4 and D6 = P2.5 of Ti Launch PAD.
8. Connect output pins (NO and COM) of relays to the appliances.
9. Supply the +12 and GND to the relay board.

Circuit connection of smart localization beacon node is as follows:

1. +5 V pin of power supply is connected to Vcc pin of launch pad and NodeMCU.
2. GND pin of power supply is connected to GND pin of launch pad and NodeMCU.
3. Pins 1, 16 of LCD are connected to GND of Power Supply.
4. Pins 2, 15 of LCD are connected to +Vcc of Power Supply.
5. Two Fixed lags of POT are connected to +5 V and GND of LCD and Variable lag of POT is connected to pin 3 of LCD.
6. RS, RW and E pins of LCD are connected to pins D1 = P2.0, GND and D2 = P2.1 of Ti Launch PAD.

7. D4, D5, D6 and D7 pins of LCD are connected to pins D3 = P2.2, D4 = P2.3, D5 = P2.4 and D6 = P2.5 of Ti Launch PAD.
8. Connect switch to the TI LaunchPad.

Tables 6.1, 6.2 and 6.3 shows the components list to design mobile robot section, smart switch board and localization Node using TI LaunchPad.

Table 6.1 Components list mobile robot

Component/specification	Quantity
Power supply 12 V/1 A	1
TI LaunchPad	1
Chassis	1
DC motors	2
Free wheel	1
Motor driver up to 2 A	1
XBee modem	1
Jumper wire M-M	20
Jumper wire M-F	20
Jumper wire F-F	20
Power supply extension (To get more +5 V and GND)	1
LCD 20 * 4	1
LCD patch/explorer board	1
5 push button array	1
XBee explorer board	1

Table 6.2 Components list for smart switch board

Component/specification	Quantity
Power supply 12 V/1 A	1
TI LaunchPad	1
XBee modem	1
Jumper wire M-M	20
Jumper wire M-F	20
Jumper wire F-F	20
Power supply extension (To get more +5 V and GND)	1
LCD 20 * 4	1
LCD patch/explorer board	1
3 relay board	1
XBee explorer board	1

Table 6.3 Components list for localization beacon node

Component/specification	Quantity
Power supply 12 V/1 A	1
TI LaunchPad	1
XBee modem	1
Jumper wire M-M	20
Jumper wire M-F	20
Jumper wire F-F	20
Power supply extension (to get more +5 V and GND)	1
LCD 20 * 4	1
LCD patch/explorer board	1
5 push button array	1
XBee explorer board	1

6.3 Software Development and IoT

The basic architecture of internet of things comprises of sensors, actuators and their enabling machine language. Artificial Intelligence, its connectivity and its active engagement can be used by small devices. **Artificial Intelligence** is a mathematically developed man made machine intelligence, developed in order to perceive the natural environment to achieve the target. The Internet of things enabled Artificial Intelligence have the smart algorithm to collect the data and self-communicating among connected devices through their networks. Example—In a smart bin system of a production line, if the material gets over, then data will be transfer to ERP system, followed by order received by supplier from ERP and refills the intelligent smart bin. **Connectivity** is a major issue in most of the places. Earlier the industries had connectivity. At present, the XBee, RFID, RX/TX 433 MHz and Wi-Fi are the devices to provide network connectivity to realize the IoT applications. The Sensors are required to detect the physical parameters and communicates its data to the destination through embedded system.

Active Engagement of the internet of things is being an active engagement of technologies makes a paradigm shift over today's passive engagement among service and product managements. The internet of things is a **small device**, which enables and ensure more precision, scalability and versatility. The merits of IoT is as follows:

1. In the today scenario, the internet of things becomes a part of personal as well as business life of individual.
2. It improves the customer engagement with product service.
3. It is optimized way to use the technology.
4. The data collection is easy.

The demerits of IoT is as follows: Though IoT addressed so many meritorious things, it also has some challenges as well:

1. Security—These days everyone is listening the word 'Cyber security' is because of each individual communicating with each other through virtual networks and this becomes advantage for hackers.
2. Complexity—To make systems/processes more simpler and user friendly complexity of developing them always increases.
3. Compliance—Any service or technology in the real business needs to be comply with regulations.

The Internet of Things is integration of sensing, communication and its analytic capabilities raised overall conventional technologies. The IoT area promises in helping automotive industry by directly manages their existing assets at different places, supply chain and after sales service, dealers and customer relationships helps to understand and access the data/information as and when required.

We now present the flowchart for the mobile robot in the Fig. 6.9. Here the robot mainly performs two tasks. Firstly, it listens for voice commands from the user and accordingly sends control signals to the smart switchboards placed in the room. Secondly, it analyses the RSSI signals from the localization beacons and implements a path planning and goal seeking algorithm to move about the room.

Figure 6.10 shows the flowchart for the smart switch-boards. This module will listen for control signals from the mobile robot and accordingly activates or deactivates the respective relays while updating relevant information to the LCD display module [18].

Figure 6.11 shows the flowchart for the localization beacons. The localization beacons constantly transmit a pulse signal to the mobile robot to perform the RSSI signal analysis on to help it localize its location in the room. It also reads keypad inputs to change various parameters, which the user might want to change, for instance, the node identification number.

6.4 IoT implementation

Arduino is probably the best starting point for embedded based IoT and most common in use. Basic Android boards do not come with Ethernet shield so it is interfaced with Arduino to make it work as IoT device. Android Yun is a board that comes ported with Ethernet shield. **Raspberry Pi**—It is being used for IoT. Wide range of data driven application can be developed with Raspberry Pi (e.g. Home automation server, home multimedia server, file server etc.). It has general-purpose IO pins to interface the I/O devices. **Intel Edison**—It is also very efficient board, which integrates BLE and Wi-Fi with other features. It supports wide range of Industry standard hardware via 70-pin interface. The most important thing is, it supports wide range of platforms including Arduino. **Intel Galileo**—It is another good board offered by Intel, which is similar as Arduino Uno. It has many features of controller like Raspberry Pi, which makes this an attractive board. Galileo also has in built Ethernet shield. **Netduino**—In past, Microsoft used to dictate

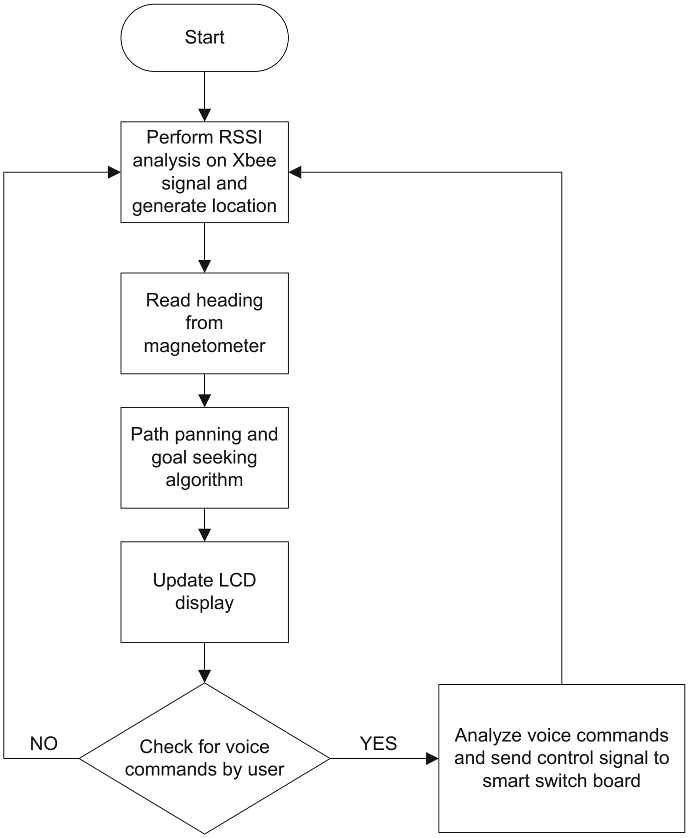
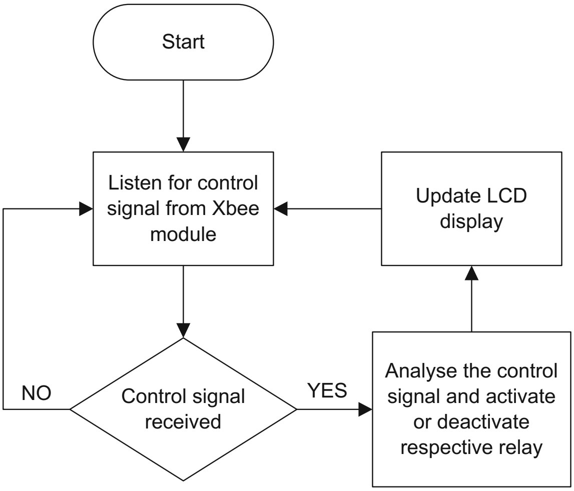


Fig. 6.9 Flowchart for mobile robot

Fig. 6.10 Flowchart for smart switch board



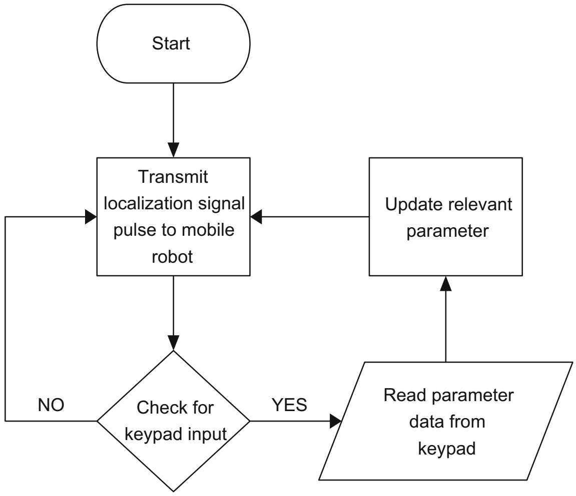


Fig. 6.11 Flowchart for localization beacon

technologies and trends and industries has followed it. However, with several companies gunning for a space in wearable sector, Microsoft seems to be doing all the catching up and does not look too impressive at this moment. None the less Netduino is a .Net Micro framework based platform where hardware is similar to Arduino. Netduino has 12 bit ADC as against 10 bit Arduino ADC channels and uses 32 bit Controller. The reason why Arduino is a better than Netduino, is lower cost. The cost of Arduino Dueminolova is not more than $10, whereas the cost of Netduino is about $60. Although Netduino really has better multitasking, but cost is a big factor for DIY. **OpenIoT**—It is an open source IoT platform that provides the services like—unique sensing as a service. Google has already integrated location services with its cloud. Location extracted from your devices is silently put in your status updates in Facebook and twitter and are used for more personalized searches. Cloud APIs has a great potential in IoT in all levels starting from firmware to hardware architecture. A level 1 IoT system has a single node/device that performs sensing and/or actuation, stores data, performs analysis and hosts the application as shown in fig. The system are suitable for modeling low cost and low complexity solutions where the data involved is not big and the analysis requirements are not computationally intensive. Example is **home automation** where single node that allows controlling the lights and appliances in a home remotely. A level 5 IoT system has large number of nodes end nodes and one coordinator. The end nodes that perform sensing and/or actuation. Coordinator node collects data form the end nodes and sends to the cloud. Data is stored and analyzed in the cloud and application is cloud based. The system is suitable for solution based on WSN, in which the data involved is big and the analysis requirements is computationally intensive.

Figure 6.12 shows the IoT level1 implementation in the home automation system

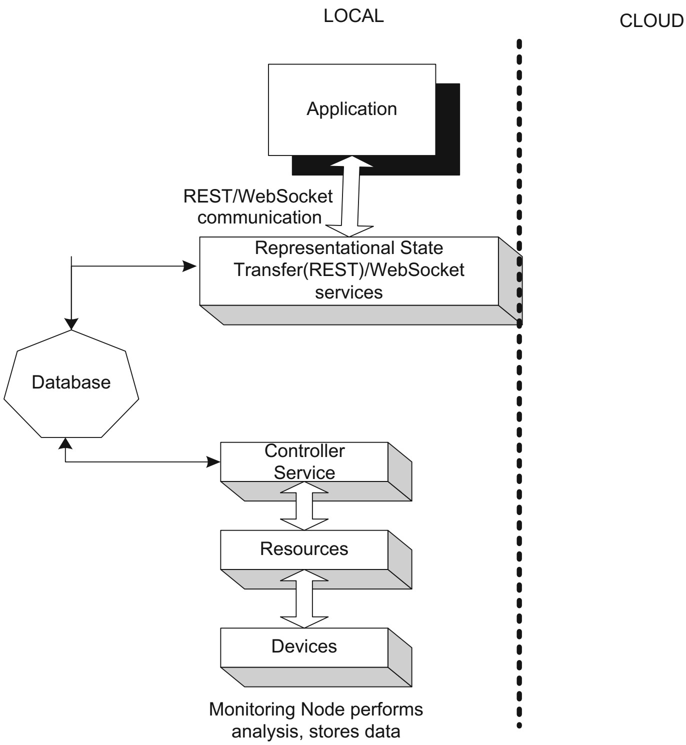


Fig. 6.12 IoT level 1

6.5 XBee Configuration

To configure the XBee module the following steps are follows

1. Step 1: Download X-CTU Software
2. Step 2: Put together your XBee breakout board
3. Step 3: Configure 1st XBee as a coordinator
4. Step 4: Configure 2nd XBee as Router
5. Step 5: Test the configuration.

Download XCTU from link https://www.digi.com/products/xbee-rf-solutions/xctu-software/xctu#productsupport-utilities **and install [XCTU v.6.3.10]**.

Tomake **router** the following setup should be done as follows by setting the following parameters

1. PANID-1000
2. JV channel verification = Enabled [1]
3. CE coordinator Enable = Disabled [0]
4. DL destination address low = [0].

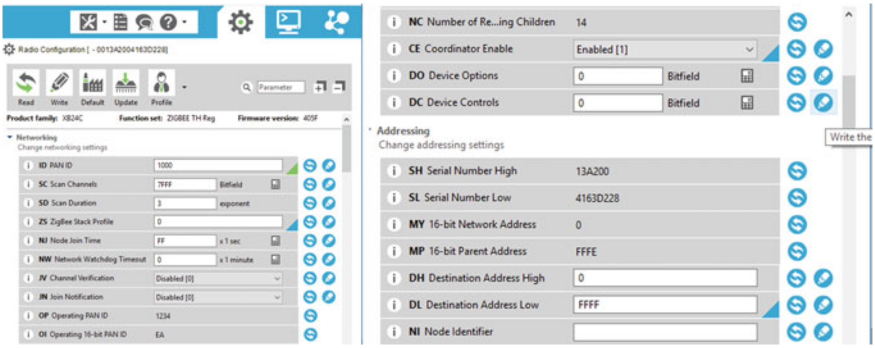


Fig. 6.13 Snapshot of the setting for coordinator

Now for making the **coordinator** the following setup should be done as follows

1. PAN ID-1000
2. CE coordinator Enable = enabled [1]
3. DL destination address low = FFFF.

Figure 6.13 shows the snapshot of setting for Coordinator.

6.6 Blynk APP Development

Blynk is iOS and Android platform to design mobile app. To design the app download latest Blynk library from https://github.com/blynkkk/blynk-library/releases/latest.

Mobile App can easily be designed just by dragging and dropping widgets on the provided space.

Tutorials can be downloaded from http://www.blynk.cc.

The following steps are follow to design Blynk App as given below

1. **Step 1:** Download and install the Blynk App for your mobile Android or iPhone from http://www.blynk.cc/getting-started/
2. **Step 2:** Create a Blynk Account
3. **Step 3:** Create a new project-Click on + for creating new project and choose the theme dark (black background) or light (white background) and click on create.
4. **Step 4:** Authentication token is a unique identifier, which will be received on the email address user, provide at time of making account. Save this token, as this is required to copy in the main program of receiver section.
5. **Step 5:** Select the device to which smart phone needs to communicate e.g. ESP8266 (NodeMCU)
6. **Step 6:** Open widget box and select the components required for the project. For this project, five buttons are selected.

7. **Step 7:** Tap on the widget to get its settings, select virtual terminals as V1, V2, V3 and V4 for each buttons, which needs to be defined later on the program.
8. **Step 8:** After completing the widget settings, Run the project [20].

6.7 Result

Figures 6.14 and 6.15 shows the view 1 and view 2 of the application developed in BLYNK APP. The buttons are useful to switch ON/OFF the home appliances. The motion sensors 1 and 2 show the status of motion occurred by human being. The digital HIGH shows the motion happened otherwise NOT.

Figure 6.16 shows the CAD designs for the mobile robot unit. The mobile robot consists of an antenna to receive signals from the localization beacons as shown in Figure and perform RSSI analysis for navigation. On the top are mounts for the two BLDC motors to generate suction for it to work as a wall climbing robot. In the bottom view the suction cups are visible; the BLDC motors mounted on the top will generate a vacuum which will help the suction cups to grip the wall. This robot can also function as a normal ground robot by using the wheels attached to the sides of its chassis. The same wheels will also allow it to scale walls as the height of the suction cups is equal to the wheel diameter.

Figure 6.17 shows the smart switchboard module. This module too contains an antenna to receive control signals from the mobile robot. It consists of an LCD display module which can be used to display relevant and useful information to the user. There are 4 sockets per board but this number can be modified based on

Fig. 6.14 View1 of APP develop in BLYNK

Fig. 6.15 View2 of APP develop in BLYNK

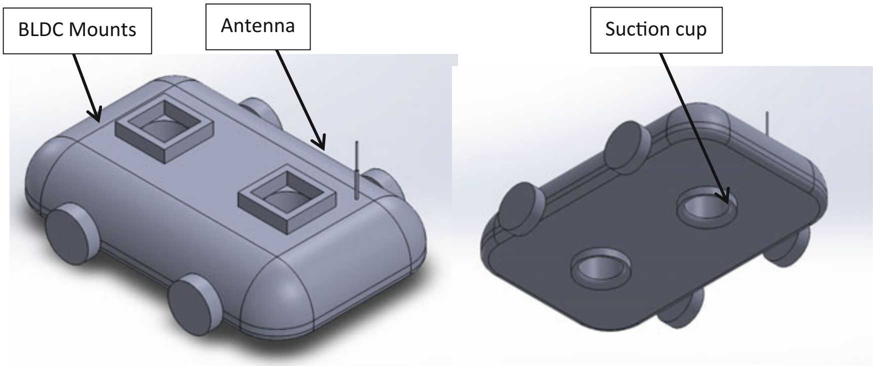


Fig. 6.16 Perspective view from top and bottom of the mobile robot unit

design requirements to support the spirit of modular design. Below each socket is an LED indicator which will indicate if the corresponding socket is on or off.

In Fig. 6.18 the design is given for the localization beacon module. This module contains an antenna to transmit signals to the mobile robot which will then perform RSSI analysis on this. Along with this is an LCD display module to display the relevant and useful information to the user. A 4 × 4 keypad is provided in this module to enable reconfiguration of its parameters such as node ID, power saving mode configuration, etc. It also has provision for batteries so it can perform even if external supply is not available thereby providing for a robust and reliable operation.

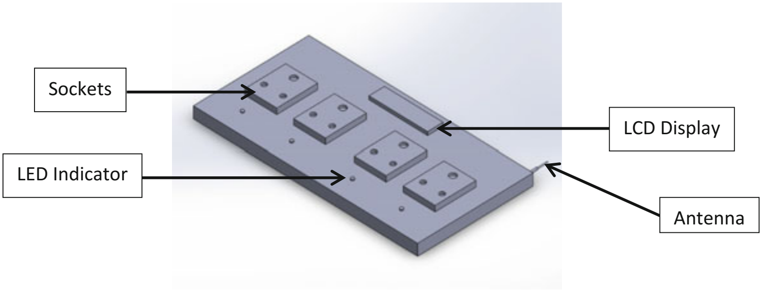


Fig. 6.17 Perspective view from top and bottom of the mobile robot unit

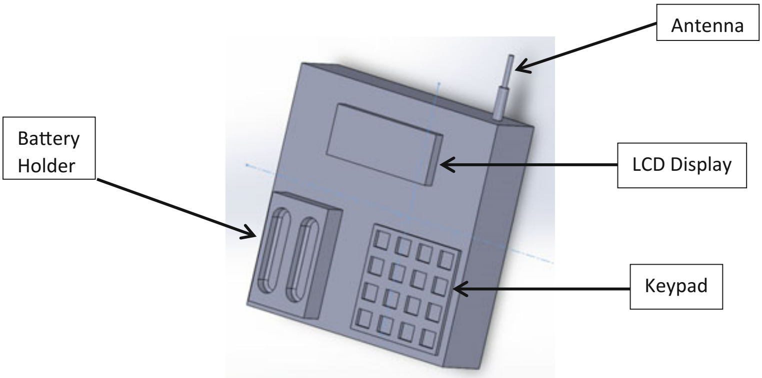


Fig. 6.18 Perspective view from top and bottom of the mobile robot unit

6.8 Conclusion and Future Scope

There are a few vital parameters in a home automation system such as EAs, personal preference and control strategies. These factors will vary based on different home environments. Hence we have to design a way to adjust these parameters. In order to resolve this issue, this research proposes five components based integrated home automation design. This allows the automation system to be re-configured without much alteration for various special requirements. Home automation systems are becoming smarter because of their ability to collect data from the Internet. All the proposed components have been implemented in our architecture. We also created a real implementation of home environment and a virtual simulation to be controlled by our HA system. The process of designing a powerful home automation system will encounter many problems. In this paper, we kept the possible problems in consideration and tried finding an efficient solution for these problems at the software level. Living in an intelligent home is the trend of the 21st century.

Appendix 1: Program for the System

Sections 1.1, 1.2, 1.3 and 1.4 discusses the program code for TI Launch Pad using erergia IDE (integrated development environment) which is most likely to Arduino IDE (integrated development environment).

1.1 Code for Mobile Robot

```
#include <LiquidCrystal.h> // add library of LCD
LiquidCrystal lcd (P2_0, P2_1, P2_2, P2_3, P2_4, P2_5); // pin of LCD connect to TI launch
PAD
    int APPLIANCE1 =P1_3;// pin1 of electrical Appliance relay1  is connected with P1_3
    int APPLIANCE2=P1_4;// pin2 of electrical Appliance relay 2 is connected with P1_4
    int APPLIANCE3=P1_5;//pin3 of electrical Appliance relay 3 is connected with P1_4
    void setup()
    {
     lcd.begin(20, 4); // Initialize the LCD
     Serial.begin(9600); //  Initialize the serial communication
     pinMode(APPLIANCE 1,OUTPUT); // set pin1 of Appliance relay 1  as output
     pinMode(APPLIANCE 2,OUTPUT); // set pin2 of Appliance relay 2  as output
     pinMode(APPLIANCE 3,OUTPUT); // set pin3 of Appliance relay 3 as output
      lcd.setCursor (0,1); // set cursor on Liquid crystal display
     lcd.print (“smart switch board”); // print string on Liquid crystal display
    }
    void loop()
    {
```

```
int ROBOT_VAL=Serial.read(); // read serial data
if(ROBOT_VAL==100) // check condition
{
 lcd.clear(); // clear the contents of  Liquid crystal display
 digitalWrite(APPLIANCE 1,HIGH); // make pin1 HIGH
 digitalWrite(APPLIANCE 2,LOW); // make pin2 LOW
 digitalWrite(APPLIANCE 3, LOW); // make pin3 HIGH
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
  lcd.print (“appliance 1 ON . .”); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==200)
{
 lcd.clear(); // clear the contents of  Liquid crystal display
 digitalWrite( APPLIANCE 1,HIGH); // make pin1 HIGH
 digitalWrite( APPLIANCE 2,LOW); // make pin2 LOW
 digitalWrite(APPLIANCE 3, LOW); // make pin3 HIGH
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
  lcd.print (“appliance 2 ON . .”); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==300)
{
  lcd.clear(); // clear the contents of  Liquid crystal display
 digitalWrite( APPLIANCE 1, LOW); // make pin1 HIGH
 digitalWrite( APPLIANCE 2, HIGH); // make pin2 LOW
 digitalWrite( APPLIANCE 3, LOW); // make pin3 HIGH
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
  lcd.print (“appliance 3 ON . .”); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==400)
{
```

```
lcd.clear(); // clear the contents of  Liquid crystal display
digitalWrite( APPLIANCE 1, LOW); // make pin1 HIGH
digitalWrite( APPLIANCE 2,LOW); // make pin2 LOW
digitalWrite( APPLIANCE 3,HIGH); // make pin3 HIGH
 lcd.setCursor (0,2); // set cursor on Liquid crystal display
 lcd.print ("ALL OFF . ."); // print string on Liquid crystal display
delay(10); // wait for 10 mSec
} }
```

1.2 *Code for Smart Extension Board*

```
#include <LiquidCrystal.h> // add library of LCD
LiquidCrystal lcd (P2_0, P2_1, P2_2, P2_3, P2_4, P2_5); // pin of LCD connect to TI launch
PAD
   int M1_POSITIVE=P1_3;// pin1 of motor controller is connected with D1
   int M1_NEGATIVE=P1_4;// pin2 of motor controller is connected with D2
   int M2_POSITIVE=P1_5;//pin3 of motor controller is connected with D3
   int M2_NEGATIVE=P1_6;//pin4 of motor controller is connected with D4
   void setup()
   {
    lcd.begin(20, 4); // Initialize the LCD
    Serial.begin(9600); //  Initialize the serial communication
    pinMode(M1_POSITIVE,OUTPUT); // set pin1 of motor controller as output
    pinMode(M1_NEGATIVE,OUTPUT); // set pin2 of motor controller as output
    pinMode(M2_POSITIVE,OUTPUT); // set pin3 of motor controller as output
    pinMode(M2_NEGATIVE,OUTPUT); // set pin4 of motor controller as output
     lcd.setCursor (0,1); // set cursor on Liquid crystal display
    lcd.print ("robot control system"); // print string on Liquid crystal display
   }
   void loop()
   {
    int ROBOT_VAL=Serial.read(); // read serial data
    if(ROBOT_VAL==10) // check condition
    {
```

```
  lcd.clear(); // clear the contents of  Liquid crystal display
  digitalWrite(M1_POSITIVE,HIGH); // make pin1 HIGH
  digitalWrite(M1_NEGATIVE,LOW); // make pin2 LOW
  digitalWrite(M2_POSITIVE,HIGH); // make pin3 HIGH
  digitalWrite(M2_NEGATIVE,LOW); // make pin4 LOW
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
 lcd.print ("FORWARD . ."); // print string on Liquid crystal display
  delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==20)
{
 lcd.clear(); // clear the contents of  Liquid crystal display
  digitalWrite(M1_POSITIVE,LOW); // make pin1 LOW
  digitalWrite(M1_NEGATIVE,HIGH); // make pin2 HIGH
  digitalWrite(M2_POSITIVE,LOW); // make pin3 LOW
  digitalWrite(M2_NEGATIVE,HIGH); // make pin4 HIGH
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
 lcd.print ("REVERSE. ."); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==30)
{
  lcd.clear(); // clear the contents of  Liquid crystal display
  digitalWrite(M1_POSITIVE,HIGH); // make pin1 HIGH
  digitalWrite(M1_NEGATIVE,LOW); // make pin2 LOW
  digitalWrite(M2_POSITIVE,LOW); // make pin3 LOW
  digitalWrite(M2_NEGATIVE,LOW); // make pin4 LOW
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
  lcd.print ("LEFT . . ."); // print string on Liquid crystal display

 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==40)
{
```

```
 lcd.clear(); // clear the contents of  Liquid crystal display
digitalWrite(M1_POSITIVE,LOW); // make pin1LOW
digitalWrite(M1_NEGATIVE,LOW); // make pin2 LOW
digitalWrite(M2_POSITIVE,HIGH); // make pin3 HIGH
digitalWrite(M2_NEGATIVE,LOW); // make pin4 LOW
lcd.setCursor (0,2); // set cursor on Liquid crystal display
lcd.print ("RIGHT . . ."); // print string on Liquid crystal display
delay(10);// wait for 10 mSec
}
if(ROBOT_VAL==50)
{
 lcd.clear(); // clear the contents of  Liquid crystal display
digitalWrite(M1_POSITIVE,LOW); // make pin1 LOW
digitalWrite(M1_NEGATIVE,LOW); // make pin2 LOW
digitalWrite(M2_POSITIVE,LOW); //make pin1 LOW
digitalWrite(M2_NEGATIVE,LOW); // make pin1 LOW
 lcd.setCursor (0,2); // set cursor on Liquid crystal display
 lcd.print ("STOP . ."); // print string on Liquid crystal display
digitalWrite; delay(10); // wait for 10mSec
}
}
```

1.3 Code for Localization Beacon Node

```
#include <LiquidCrystal.h> // add library of LCD
LiquidCrystal lcd (P2_0, P2_1, P2_2, P2_3, P2_4, P2_5); // pin of LCD connect to TI launch
PAD
   int Button1=P1_3;// pin1 of motor controller is connected with P1_3
   int Button2=P1_4;// pin2 of motor controller is connected with P1_4
   int Button3=P1_5;//pin3 of motor controller is connected with P1_5
   int Button4=P1_6;//pin4 of motor controller is connected with P1_6
```

```
int Button5=P1_7;//pin4 of motor controller is connected with P1_7
void setup()
{
  lcd.begin(20, 4); // Initialize the LCD
  Serial.begin(9600); //  Initialize the serial communication
  pinMode(Button1,INPUT _ PULLUP); // set pin1 of motor controller as input active low
  pinMode(Button2,INPUT _ PULLUP); // set pin2 of motor controller as input active low
  pinMode(Button3,INPUT _ PULLUP); // set pin3 of motor controller as input active low
  pinMode(Button4,INPUT _ PULLUP); // set pin4 of motor controller as input active low
pinMode(Button5,INPUT _ PULLUP); // set pin4 of motor controller as input active low
   lcd.setCursor (0,1); // set cursor on Liquid crystal display
  lcd.print (“beacon Node”); // print string on Liquid crystal display
}
void loop()
{
int one=digitalRead ( Button1 );
int two=digitalRead ( Button2 );
int three=digitalRead ( Button3 );
int four=digitalRead ( Button4 );
int five=digitalRead ( Button5 );
 if(one ==LOW) // check condition
  {
    lcd.clear(); // clear the contents of  Liquid crystal display
    serial.print (10); // send value serial
    serial.print (‘\n’); // add new line char in serial
    lcd.setCursor (0,2); // set cursor on Liquid crystal display
   lcd.print (“FORWARD . .”); // print string on Liquid crystal display
    delay(10); // wait for 10 mSec
  }
  if(two==LOW)
  {
    lcd.clear(); // clear the contents of  Liquid crystal display
    serial.print (20); // send value serial
    serial.print (‘\n’); // add new line char in serial
```

```
 lcd.setCursor (0,2); // set cursor on Liquid crystal display
 lcd.print ("REVERSE. ."); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(three==LOW)
{
  lcd.clear(); // clear the contents of  Liquid crystal display
  serial.print (30); // send value serial
  serial.print ('\n'); // add new line char in serial
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
   lcd.print ("LEFT . . ."); // print string on Liquid crystal display
 delay(10); // wait for 10 mSec
}
if(ROBOT_VAL==40)
{
  lcd.clear(); // clear the contents of  Liquid crystal display
  serial.print (40); // send value serial
  serial.print ('\n'); // add new line char in serial
  lcd.setCursor (0,2); // set cursor on Liquid crystal display
  lcd.print ("RIGHT . . ."); // print string on Liquid crystal display
  delay(10);// wait for 10 mSec
}
if(ROBOT_VAL==50)
{
  lcd.clear(); // clear the contents of  Liquid crystal display
  serial.print (50); // send value serial
  serial.print ('\n'); // add new line char in serial
   lcd.setCursor (0,2); // set cursor on Liquid crystal display
   lcd.print ("STOP . ."); // print string on Liquid crystal display
delay(10); // wait for 10mSec
 }
}
```

1.4 Blynk Code

```
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h> // add  ESP8266 library
#include <BlynkSimpleEsp8266.h> // add Blynk library
char auth[] = "8507cac915f04a1bb4b00987e420afa0";////add token here
char ssid[] = "SchematicsMicroelectronics"; // add HOTSPOT/ router ID
char pass[] = "hellohru";// add HOTSPOT/ router password

BLYNK_WRITE(V1)
{
  int FORWARD = param.asInt();  // read V1 pin of Blynk APP
  if(FORWARD==HIGH) // check condition
  {
    Serial.write(10); // send 10 in serial
    delay(50); // wait for 50 mSec
    }
}
BLYNK_WRITE(V2) //
{
  int REVERSE = param.asInt(); // read V2 pin of Blynk APP
  if(REVERSE==HIGH) // check condition
  {
   Serial.write(20); // send 20 in serial
   delay(50);// wait for 50 mSec
    }
}
BLYNK_WRITE(V3)
{
  int LEFT = param.asInt();  // read V3 pin of Blynk APP
  if(LEFT==HIGH) // check condition
  {
    Serial.write(30); // send 30 in serial
    delay(50); // wait for 50 mSec
   }
}
```

```
BLYNK_WRITE(V4)
{
 int RIGHT = param.asInt();  // read V4 pin of Blynk APP
 if(RIGHT==HIGH) // check condition
 {
  Serial.write(40); // send 40 in serial
  delay(10); // wait for 50 mSec


  }
}
BLYNK_WRITE(V5)
{
 int STOP = param.asInt();  // read V5 pin of Blynk APP
 if(STOP==HIGH) // check condition
 {
  Serial.write(50); // send 50 in serial
  delay(50); // wait for 50 mSec
  }
}
void setup()
{
 Serial.begin(9600);
 Blynk.begin(auth, ssid, pass);
}

void loop()
{
 Blynk.run();
}
```

References

1. Lohrs, C., Tanguy, P., Chen, Y.: Plug and play your robot into your smart home: illustration of a new framework. KI-Künstliche Intell. **31**(3), 283–289 (2017)
2. Samkaria, R., et al.: Network-guided robot. *Advances in Fire and Process Safety*, pp. 123–133. Springer, Singapore (2018)

3. Choudhry, V., Singh, R., Gehlot, A.: RSSI-based indoor robot localization system using LabVIEW. In: Proceeding of International Conference on Intelligent Communication, Control and Devices. Springer, Singapore (2017)
4. Baby, C.J., et al. "Home automation using web application and speech recognition. In: 2017 International Conference on Microelectronic Devices, Circuits and Systems (ICMDCS). IEEE (2017)
5. Luria, M., Hoffman, G., Zuckerman, O.: Comparing social robot, screen and voice interfaces for smart-home control. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. ACM (2017)
6. Luk B.L., Cooke, D.S., Galt, S., Collie, A.A, Chen, S.: Intelligent legged climbing service robot for remote maintenance applications in hazardous environments. Robot. Autonom. Syst. **53**, 142e52 (2005)
7. Zhang, H., Zhang, J., Zong, G., Wang, W., Liu, R.: Sky cleaner 3: a real pneumatic climbing robot for glass-wall cleaning. Robot. Autom. Mag. IEEE **13**(1), 32e41 (2006)
8. Sun, D., Zhu, J., Lai, C., Tso, S.K.: A visual sensing application to a climbing cleaning robot on the glass surface. Mechatronics **14**, 1089e104 (2004)
9. Menegatti, E., et al.: Range-only SLAM with a mobile robot and a wireless sensor networks. In: IEEE International Conference on Robotics and Automation, 2009. ICRA'09. IEEE (2009)
10. Li, Q., Lili, W.: Mobile robot localization in coal mine based on Zigbee. In: Mechatronics and Automatic Control Systems, pp. 411–418. Springer International Publishing (2014)
11. Zàruba, G.V., et al.: Indoor location tracking using RSSI readings from a single Wi-Fi access point. Wirel. Netw. **13**(2), 221–235 (2007)
12. Lu, T.-F.: Indoor odour source localization using robot: initial location and surge distance matter. Robot. Autonom. Syst. **61**(6), 637–647 (2013)
13. Awad, A., Frunzke, T., Dressler, F.: Adaptive distance estimation and localization in WSN using RSSI measures. In: 10th Euromicro Conference on Digital System Design Architectures, Methods and Tools, 2007. DSD 2007. IEEE (2007)
14. Graefenstein, J., et al.: Wireless node localization based on RSSI using a rotating antenna on a mobile robot. In: 6th Workshop on Positioning, Navigation and Communication, 2009. WPNC 2009. IEEE (2009)
15. Perkins, C., et al. Distance sensing for mini-robots: RSSI vs. TDOA. In: 2011 IEEE International Symposium of Circuits and Systems (ISCAS). IEEE (2011)
16. Silva, J., Lau, N., Neves, A.J.R. Localization techniques for autonomous mobile robots. Electrón. Telecomun. **5**(3), 309–316 (2011)
17. Singh, R., et al.: Arduino-based embedded systems: interfacing, simulation, and LabVIEW GUI. CRC Press (2017)
18. Singh, R.: Embedded system based on ATMEGA microcontroller: simulation, interfacing and projects. Narosa, Alpha Science International Limited (2017)
19. Choudhry, S., Pandey, P.S., Singh, R., Gehlot, A, Singh, B.: Power line carrier communication and Arduino based automation. Research India Publication (2018). ISBN: 978-93-87374-01-0
20. Singh, R., Gehlot, A., Singh, B., Choudhury, S., Sharma, M.: Wireless methods and devices to control the mobile robotics platform. GBS Publisher (2018). ISBN: 978-93-87374-53-9
21. Gehlot, A., Singh, R., Saini, D.K., Yadav, M., Singh, B.: IoT enabled smart microgrid….. rapid prototyping. GBS Publisher (2018). ISBN: 978-93-87374-41-6

Chapter 7
Smart Cities & IoT: Evolution of Applications, Architectures & Technologies, Present Scenarios & Future Dream

Krishnan Saravanan, E. Golden Julie and Y. Harold Robinson

Abstract Smart cities plays vital role in the growth of the nation. Most of the countries already contribute huge investment in the implementation of smart cities, which emphasizes its importance. Smart City is a common notation for many sectors such as healthcare, education, transport, water, energy, communication, security & safety, citizen services and so on. All these sectors should adapt and equip with modern technologies such as Internet of Things (IoT), cloud and big data. Evolution of smart cities is majorly depending with these key enabling technologies. Hence, it is necessary to explore the different aspects of smart cities with IoT in the past, present and future. In this chapter, we analyzed and presented the smart cities evolution, architectures, applications, technologies, standards and challenges in detail. It helps the reader to understand the coherence of smart cities development using IoT.

Keywords Smart IoT · Smart cities · Smart IoT architectures · IoT applications Urban IoT

K. Saravanan (✉) · E. G. Julie
Department of Computer Science and Engineering,
Anna University Regional Campus, Tirunelveli, Tamil Nadu, India
e-mail: saravanan.krishnan@auttvl.ac.in

E. G. Julie
e-mail: goldenjuliephd@gmail.com

Y. H. Robinson
Department of Computer Science and Engineering, SCAD College of Engineering and Technology, Tirunelveli, Tamil Nadu, India
e-mail: yhrobinphd@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_7

7.1 Introduction

Smart Cities exploit the advancements of Urban IoTs for the better citizen services. There are various heterogeneous domains benefit from the IoT implementation in urban development. Though many definitions given for smart cities, there is no absolute definition of a smart city indeed [7]. IEEE Smart Cities [39] community articulated the definition that "A smart city brings together technology, government and society to enable the following characteristics: Smart Cities, a smart economy, smart mobility, a smart environment, smart people, smart living and smart governance". Cocchia [6] listed the various smart city definitions with wide spectrum of meanings across different verticals. Smart city is referred with different names such as Digital city, Ubiquitous city, Eco-city, Knowledge based city and Virtual city/ information city [2]. Detailed review of publications related to smart city is presented in this research.

IBM envisioned that smart cities implementation is a journey and the city should be prepared for the smart IoT revolutionary changes in the city progress [31]. Smart city requirements can be categorized into two types: (1) citizen-centric services (Targeting to end users and devices in the city, utility based applications), (2) Operational services for city administrators to efficiently govern the municipal system [24]. Smart IoT fulfils these requirements by tailoring the cloud applications accessed through IoT devices. Smart cities should develop the prevention strategies rather than post decision-making after the incidents. IoT helps to share the data for analytics to give the best strategic decision. E.g., fire detection, crime prevention, floods and climate prediction are those come under. The interconnection of IoT devices such as sensors and actuators is emphasized in smart city architecture, thereby allowing information sharing across platforms through a unified framework. The widespread adoption of Information and Communication Technologies (ICT) in the cities development has led to the appearance of smart cities. Smart cities are the typical implementation IoT applications. Mainly three components involved here: data generation, data management, and application handling.

Due to growing urbanization, smart cities are inevitable in today's technology world. Half of human population today lives in cities. Smart cities market size is estimated to USD 2.57 trillion by 2025, according to [11]. Smart citizens are always connected in Home, public places and offices to seamlessly share the data. IoT acts a key driver for Industry 4.0 revolution and in the year 2020, it is estimated that there will be 20.8 billion interconnected IoT devices across the world. The goal of smart cities is to provide a safer, better quality of life with reduced economic costs [1]. Securing IoT devices with minimal energy is a challenging task in smart cities projects [16]. Figure 7.1 represents that IoT layers such as data generation and acquisition, data management and processing and application handling are invariably used in smart city projects.

This chapter is dedicated for the exploration of technologies implemented smart cities. The existing IoT technology applied for smart cities is known as Smart IoT. Also, future IoT related technologies such as fog computing, software defined

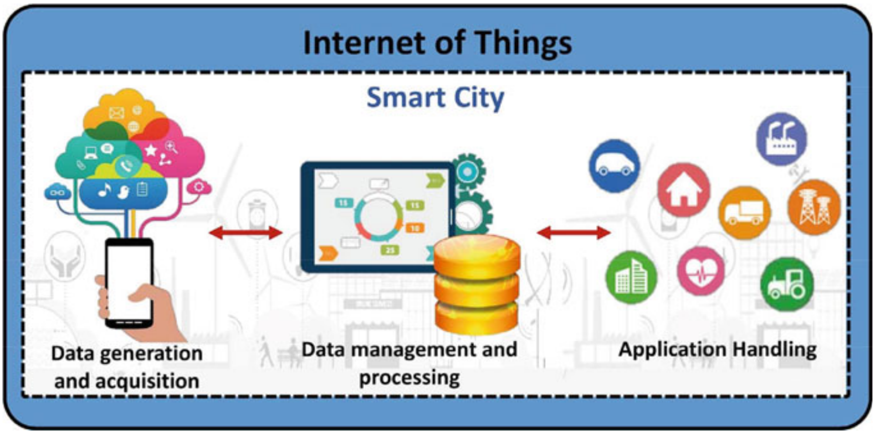


Fig. 7.1 Smart cities & IoT [32]

networking and cyber physical systems are also discussed. This chapter is dedicated to 360° view of Smart IoT. Section 2 presents the evolution of smart cities and IoT. The smart cities architectures, diversified IoT applications and smart cities technologies are discussed in Sect. 3. Further, smart cites case studies/use cases along with implemented projects are detailed in Sect. 4. Smart cities standards are presented in Sect. 5 and challenges in smart IoT deployment is discussed in Sect. 6. Finally, Sect. 7 concludes the chapter.

7.2 Evolution of Smart Cities & IoT

Though smart cities span across multiple domain verticals, IoT sensors are pivotal elements in each of these. Without IoT technology adaption and implementation, smart cities development is more like a dream. Smart cities improve the quality of living of the citizens, reliable communication with better infrastructure in all the urban fields. Smart cities contribute majorly in the country's economic growth. In India, 100 smart cities mission is initiated with US$15 billion to make sustainable and citizen friendly cities in cost effective way [34]. It is indicated that 63% of India GDP comes from cities. Empirical analysis of smart cities with IoT is done [4] in which the key factors affecting successful implementation of Artificial Intelligence in Smart Cities of India are identified. Different cities from all the states are selected for this mission implementation. Smartnet, resource-rich ecosystem is developed to provide a horizontal learning and knowledge sharing platform for exchange between cities, practitioners, academia, researchers and technologists.

Smart cities evolution—Due to urbanization and population growth, cities become the core business and economic part of the nation. Also, major cities are the symbol for attracting the tourism and business from other countries. Hence, it is vital to enhance & equip the city with modern ICT methods. Urban development, not only improves the city growth, but also the prosperous living of the citizen. Most of the metropolitan cities around the world already initiated such processes to make their cities as ‘smart’ by adopting the technologies in various sectors such as e-governance, health, transport, energy, water & waste management, etc. It is inevitable that the growth of smart cities will make the future world more connected.

IoT evolution—Internet of Things, Cloud of Things, Internet of Everything are the terms indicating that anything (any devices) can be connected to Internet to offer the services. IoT technology evolution happened because of the predecessor three technologies—cloud computing, sensors and communication protocols. More number of sensors is deployed in current industries and they become ubiquitous. They generate more data which need to be processed in real time. Cloud offers that facilities to store, process, query and display the data using services (Anything as a Service). Internet is the carrier for cloud and transfers the data in lighting speed with the help of 4G/5G wireless technologies. All these technological advantages helps the sensor devices to act as thin client, which only generates the data. Processing is done at the cloud and shared to other devices, known as M2M (Machine-to-Machine communication).

Smart Cities IoT evolution—The niche of IoT is major in the smart cities evolution and sustainability. Almost all the sectors in the smart cities implementation require the deployment of IoT smart devices. Smart IoT devices are simply the brain of smart cities. Sensing and actuating are the core services in IoT. It is needless to say that without IoT, cities could not become smart. Many projects already implemented in top cities such as London, San Francisco, Barcelona, Santander, Padova and Singapore, etc.

7.3 Present Smart IoT (Applications, Architectures, Technologies)

(i) **Smart Cities Applications**

Figure 7.2 collated the different IoT applications for smart cities. Almost all the verticals in the implementation of sustainable smart city development require the IoT. Sensors for monitoring the traffic rate, water flow, environment conditions, video surveillance are using IoT technologies intensively. Saravanan and Srinivasan [30] examined the different IoT applications utilize the cloud services as hosting platform. Sensor cloud integrates the sensors with its consumers and publishers. SenaaS (Sensor as a Service), SAaaS (Sensing and Actuation as a Service) are the examples of cloud IoT based applications. IoT applications for smart city development spread in different domains such as smart home automation, transport, water distribution, security monitoring, environmental pollution monitoring, energy efficiency, smart education, smart healthcare, citizen online services and so on. Here, each of these IoT applications are detailed.

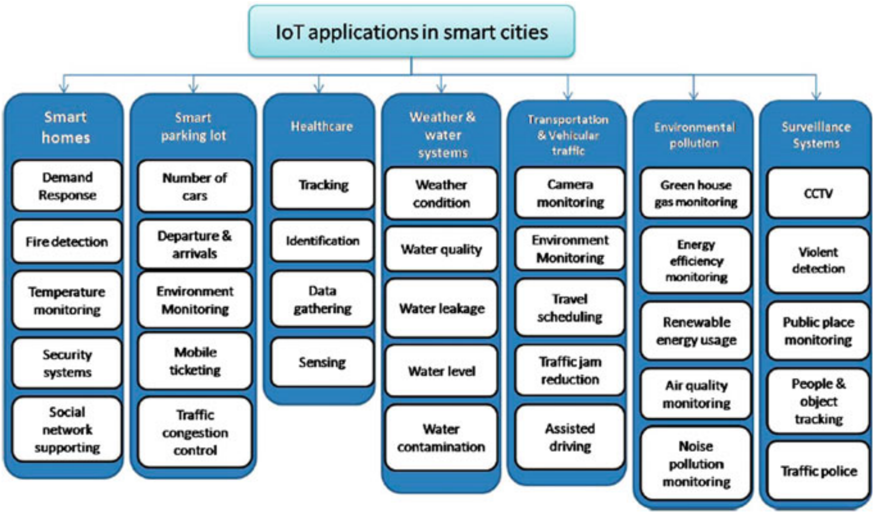


Fig. 7.2 Smart cities applications [36]

Smart Home: Using wireless communication such as WiFi/RF/ZigBee/NFC, most of the home devices such as Air conditioners, Washing Machine, Television, LED lights, Motor, Microwave oven, secure door locking are monitored and controlled from anywhere in home, even from outside home.

Transport & Traffic: Smart parking based on the arrival and departure of vehicles using IoT sensors will reduce the traffic congestion. Automatic vehicle number plate recognition and counting the vehicles in the highways, traffic signal automation, smart lightning are part of the smart transport. E.g., street lamp intensity can be controlled by the current weather conditions and timings [40]. Vehicular adhoc networks (VANET) provides better solutions in smart transport. Citizen can be notified about the congestion level of streets, alternative routes, alternative transportation mediums using IoT systems. It ensures the safe travel and reduces the travel time and cost by giving accurate prior information to the passengers. London transportation system is one the key example for it. Accident prevention with the help of active traffic monitoring and reduction in carbon emission helps in smart cities sustainability.

Smart Water distribution: System such as SCADA (Supervisory Control and Data Acquisition) can help the active distribution and monitoring of the water flow, tank water level, pressure, Leakage, volume consumed, pH & other water parameters in the city water tanks [26]. SCADA system is employed with IoT sensors to gather, transmit and process the real time data.

Smart Healthcare: Citizen services to avail health facilities such as online appointment, health monitoring using wearable sensors, elderly assistance, tracking of patients status in 24 $\times$ 7. Applying the IoT bio-medical equipment with wearable sensors for conventional medical services is termed as smart healthcare.

It manages the health records of the patients in centralized cloud server and authenticates restricted access to the doctors and nurses. It heightened the quality of healthy life assured to the urban people. Mobile health (m-health) platforms are introduced [35] to deliver the health services through mobile platforms for global monitoring capabilities, wide availability, and immediacy. It allows easy access to an unprecedented number of services and knowledge.

Environmental Monitoring: IoT sensors for air pollution, water pollution and noise level monitoring helps the clean and sustainable environment in the smart city. Fire & smoke detection, gas level identification are very important in the oil & gas industries environment. More number of air conditioners in the cities naturally increases the air temperature. Hence, it is necessary to sustain the environmental conditions for the healthy citizen life. IoT sensors can monitor the live situation and alert the authorities if hazardous events occur.

Smart Waste Management: Waste management consists of different processes such as collection, transport, processing, disposal, managing, and monitoring of waste materials [23]. Different sensors are used to detect the information such as garbage level, types of garbage and placed in trucks also. IoT system reduces the money, time, and labor significantly.

Smart Education: By adopting the modern ICT tools, smart classrooms are implemented aimed with better teaching pedagogy. Not only part of the smart cities, online education system such as MOOC (Massive Open Online Courses), video conference and ICT education is growing fast.

Smart Retail: The entire supply chain management in retail operations is automated using IoT system such as automated scanning, express self-shopping, high-/medium-volume checkout, and so on [22]. It reduces the operational cost drastically and also enhances the customer experience in shopping.

Urban Agriculture & Livestock: With the growing population and urbanization, smart agriculture methods also developed using IoT devices in cities environment. Vertical farming, smart greenhouses and IoT-empowered open field agriculture are the examples for modern cities agricultural methods. Sustainable livelihood in the cities can be achieved by the urban agriculture [21]. Also, smart livestock system to live monitor the health status of the animal husbandry is promoted using IoT sensors. [29] developed animal healthcare monitoring for heartbeat, temperature and physical gestures via wearable IoT collar device in livestock.

According to [38], smart city applications are categorized into four domains: Government (Efficient), Citizen (Happier), Business (prosperous) and environment (sustainable). Further, critical infrastructure components and services for a smart city are identified: city administration, education, healthcare, public safety, real estate, transportation and utilities [37].

(ii) **Architecture**

Yin et al. [38] proposed data-centric smart cities architecture proposition (stated in Fig. 7.3) which consists of four layers. (i) data acquisition (source of data such as IoT, urban and network data), (ii) data vitalization layer (Processing and display of multidimensional data), (iii) common data and service layer (Query engine, SOA

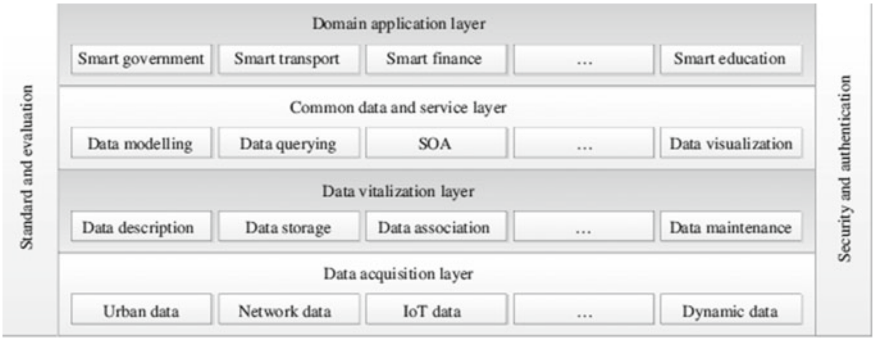


Fig. 7.3 Data-centric smart cities architecture [38]

and cloud computing) and (iv) domain application layer (smart IoT applications leveraging the underlying layers). These layers are also mentioned in different names such as sensor layer, network layer, platform layer and application layer in this study [19]. Also, three stakeholders of smart city are—Government (Municipal and administration department), Market (Business vendors and companies interested to invest in smart IoT) and Society (public sectors such as schools, university, police and hospitals).

Figure 7.4 shows four level of smart IoT Semantic model ranging from data collection, data processing, data integration and reasoning and device control and alerts. These layers collect the raw data and finally aggregate to deploy into IoT applications. In level 2 & 3, semantic technologies such as ontology and RDF framework can also be used to reason the sensor data and integrate into common format. Here, Dempster-Shafer rules are used to learn the new rules and combine the different smart city domain data. Further, [27] developed search engine for finding the required service level agreements that meets the QoS criteria of the consumers.

Figure 7.5 depicts smart IoT architecture with the core element called Integrated Information Centre [9]. This element is act as service provider for all the business applications running in IoT. Cloud computing provides the different services such as SaaS, PaaS and IaaS for the IoT platforms. Also, four types of IoT platforms are identified: (1) eGovernance for city/state services offered by the government authorities, (2) enterprise-oriented for the internal IoT operations, (3) company-based, which is similar to previous but includes all the activities such as production management, warehousing, distribution, transportation, logistics, marketing, and supply chain management and (4) pure business-oriented platforms deals with direct end users IoT platforms such as RFID tags. It will facilitate the business customers to use the IoT services offered by the business on their own. e.g., parcel tracking using the reference number.

Kyriazopoulou [18] has done the literature survey of different architectures for smart IoT such as (1) Architectural Layers (AL), (2) Service Oriented Architecture (SOA), (3) Event Driven Architecture (EDA) and IoT. Also based on the combination of these, derived architectures are formed: IoT-AL, IoT-SOA, IoT-EDA,

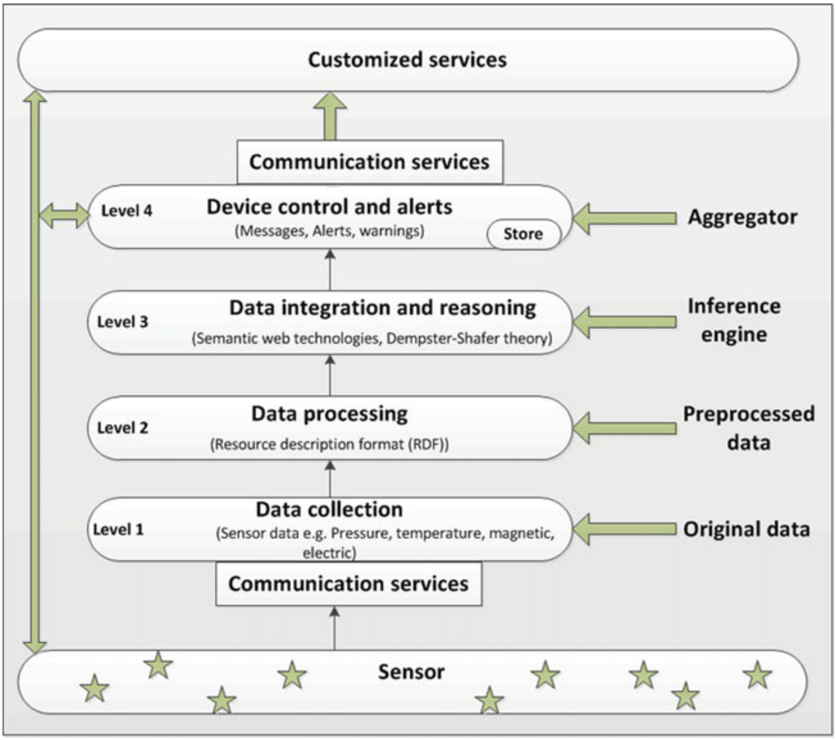


Fig. 7.4 Smart city semantic model [10]

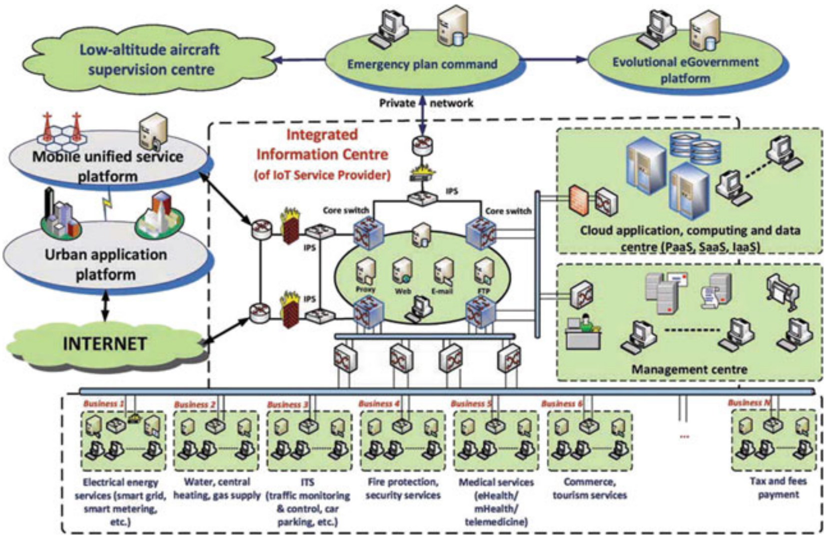


Fig. 7.5 Smart IoT architecture [9]

IoT-EDA-SOA-AL. AL framework offers layered approach in which each layer is physically and logically dissociated from the others. SOA is request-response based approach to collect, communicate, compose and interact with services of different providers. EDA is triggered by actions and executed upon and related to uncertain changes and asynchronous conditions. The IoT architecture is the most prevalent approach used today.

Smart cities mission of India proposed three models of smart cities development [33]: (1) Retrofitting of existing area to be more efficient and liveable. (2) Redevelopment by replacing the existing with new layout plan, (3) Greenfield development offers smart solutions for vacant areas using innovative IoT technologies. Besides, pan-city feature is also included for the entire city smart solutions.

(iii) **Technologies**

The three technologies which plays major roles in smart cities are: IoT, Cloud/Fog Computing, Big data. These three are inseparable in today web application development and convergence of them help the smart cities in perfect synchronization. The impact of each of them is described as follows.

Cloud/Fog Computing: Cloud offers tailor-made easily configurable dynamic services ranging from SaaS, PaaS and IaaS. These services are provisioned rapidly using virtualization technology. Most of the web applications in today business are mostly runs on cloud since its advantages such as scalable, reliable and on demand access. Fog/Edge computing applies decentralized approach that facilitates substantial part of computation and storage in the edge IoT devices itself. The reason behind is to save the network traffic and provide better Quality of Services (QoS) by close proximity of IoT end devices. Cloud connects the IoT devices to synchronize the data and knowledge and better decision arrival. Smart cities require cloud computing for storage, processing, internetworking and analytical services. Citizen e-services can be hosted in cloud and accessed by city people on anytime, anywhere. Fog computing brings sustainability to the smart city applications. Service Level Agreements (SLA) for cloud services are more flexible [28] and offer service credits for the consumers, if the SLA doesn't meet as per the QoS criteria. e.g., cloud offers 99.99% availability. Fogflow, IoT smart city platform, offers elastic IoT services easily over cloud and edges [5]. It has been demonstrated with three use cases to reduce energy consumption in IoT devices.

Big Data: IoT devices generate real time data in massive scale on daily basis [8]. The real benefit of IoT sensors data lies in the big data analytics using machine learning and AI. The four V's of big data (Volume, Variety, Velocity and Veracity) typically matching for the IoT sensor devices. Every smart city which handles millions of past and present records, is in need of the big data technologies for capturing, storage, analysis & search, sharing, transfer, visualization, querying, updating and information privacy.

Apart from that, network & communication protocols role is crucial in the smart city interconnection and data transfer. These protocols and technologies are categorized based on the network layers as follows [32]. Physical & Data link layers: RFID, WIFI, NFC, BLE, M2M, IEEE 802.15.4, 6LoWPAN. Network layer: IPV6, ZigBee, RPL. Transport Layer: TCP, UDP and ZigBee. Application Layer: CoAP, HTTP, MQTT, AMQP, DDS. Then, LTE Volte, 5G wireless technologies also important criteria.

7.4 Smart IoT Projects & Case Studies

There are several smart city projects already implemented in various part of the world. Cities In Motion Index (CIMI) listed the top smart cities in the world based on the economy, technology, human capital, social cohesion, international outreach, environment, mobility and transportation, urban planning, public management, and governance [3]. All these cities capitalized the use of IoT system in various sectors to provide intelligent citizen services. Some of the smart city excerpts are given here.

London (United Kingdom): Smart London Plan, which enables new market opportunities for deploying efficient waste management. City data is connected to centralized server to view them in real time by authorities.

San Francisco (United States): Green smart city offers online tools for recycling the compositing the waste. Smart energy, smart community, and next generation payment systems are part of it.

Barcelona(Spain): Placing the space vacancy sensors in multi-storied car parks is the example for smart parking to increase the efficiency of a parking space as well as the store sales revenue.

Santander (Spain): SmartSantander project is aimed to provide live testbed for smart city experiments with widespread deployment of 12,500 sensors across the Santander city. These sensors monitor number of pedestrians, available parking spaces, remaining volume of trash containers, etc.

Nice (France): Payment system using NFC technology enables the citizens to make the transactions easier, faster and secure. Also, smart GPS devices are provided for the drivers to identify the best route using mobile platform. Nice grid is another energy management framework implemented here by converging distributed electricity, thermal and solar energy.

Padova (Italy): It uses WSN gateway to monitor the environmental parameters and public street lighting. It has three levels of sensors for data collection, data processing, and applications. Smart lightning reduces the manual inspection and operational cost significantly.

Padova Smart City (A2A Smart City): University of Padova developed proof of concept for smart city test bed with more than 300 nodes. It helps the early adoption of ICT solutions in the city administration, thus reduces the operational cost and administration overhead. Now, this platform is merged and named as A2A Smart City. It has fiber optic cables network that connects various Italian cities such as Brescia, Bergamo and Milan. The smart services offered in A2A are: smart mobility, smart parking, smart healthcare, smart building, smart lighting and Smart Bin.

Yokohama Smart City Project: Focussed on environmental sustainability, this Japanese project promises for energy recycling using home energy management systems (HEMS), solar panels and electric vehicles (EVs). Also, Yokohama City developed smart resilient virtual power plant project as Demand Response (DR) power sources.

LIVE Singapore Project: This open platform project collects the real time data from smart devices and made available to the public and authorities to take actions immediately on the basis of actual state of the city. It reduces the feedback loop and turnaround time between the data generation and implications of the data. In this way, citizens are more synchronized with the current status of the city information. The project leverages semantic web technologies to annotate places, data, and IoT devices to search and query the meaningful data in real time.

City Science Initiative: It is the MIT University project for urban planning and development that focus on three themes: Places for Live/Work, Urban Modeling, Simulation & Prediction and Mobility on Demand. They developed open source tools for implementation and deployment of smart city initiatives. Some of them are: City Science Lab Hamburg (modules for walkability, neighborhood connectivity, energy efficiency, and economic activity), CityScope Boston BRT (nable community members to engage in neighborhood and street-level decisions including alternative bus corridor designs), CityIO (Cloud-Based Urban Data Platform which allows remote participation, database augmentation and high-end complex visualization). Andorra, which is a mobile application enables visualization of 3D mapping of the city and facilitates to annotate the tags in the city places.

Smart Cities Council: It proposes the implementation of smart cities with three core values – livability, workability and sustainability. Also five principles for smart urban development such as strategic, connected, aware, responsive and innovative are also given with detailed guidelines.

ASCIMER Project: It is the Universidad Politecnica of Madrid (UPM) project [20] to define the Smart City concept and to develop a methodology to assess and prioritize Smart City projects. Also to develop guidelines of implementation and management Smart City Projects.

URBACT Project: This project is funded by European Union with 29 countries and 550 cities, aimed for integrated urban development activities such as strategic city planning, energy efficiency, financial engineering, city branding, food, health and employment in the smart cities.

IBM Smarter Cities Challenge (SCC): Smarter Cities Challenge is the IBM project [31] aimed for identifying the challenges in the city eco system and implementing the solutions to those urban problems using IBM technologies (Experts and tools). It was a three year project with the funding ranging from $250,000 to $400,000. This SCC challenge project unveils the IBM technical expertise to make the sustainable, interconnected and instrumented smart city development. It also helps the common citizen to access the IBM technology services in day-to-day life.

VITAL Project: Cloud of Things (CoT) is the technical term refers to the integration of cloud with IoT paradigm. VITAL project [24] has developed an architectural solution for smart city by using CoT. In the smart city context, CoT is envisioned as a key technology to solve the computation and storage problems and large scale integration of multiple, heterogeneous IoT platforms. VITAL is platform-agnostic empowered with Virtualized Universal Access Interfaces for IoT devices. It has datastore object to store and share the stakeholder's data in real time. These services can be offered as Things as a Service (TaaS) paradigm.

7.5 Smart Cities IoT Standards

There are three standards defined by smart cities council-strategic standards, process standards and technical standards [33]. They are implemented across many countries in national and international level for smart city solutions and guidelines. Some of the standards are specific for IoT such as PAS 212:2016, IEEE Standard 1686, TR39, ISO 8000–8:2015, IEEE P2413, PAS 185. Brief descriptions of these IoT standards are given below.

PAS 212:2016 (Automatic resource discovery for the Internet of Things)—developed by UK, it is an open, international standard for IoT interoperability. It mandates common file format for representing a catalogue of linked-data resources, annotated with metadata as well as security mechanisms to protect access and to prove provenance.

IEEE Standard 1686 (Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities)—Security regarding the access, operation, configuration, firmware revision and data retrieval from an IED are addressed. This standard states what safeguards, audit mechanisms and alarm indications are developed. The encryption for the secure transmission of data both within and external to the IED secure perimeter is also part of this standard.

TR39—Implemented in Singapore, it defines three types of Internet of Things (IoT) Standards-sensor network standards, IoT foundational standards and domain-specific standards.

ISO 8000-8:2015 (Information and Data Quality standard) – It defines three types of quality such as syntactic, semantic and pragmatic quality. It deals with information and data measures applied in the quality management and processes.

IEEE P2413—It defines an architectural framework for the Internet of Things (IoT), including descriptions of various IoT domains, definitions of IoT domain abstractions, and identification of commonalities between different IoT domains.

PAS 185—UK standard, defined for security for smart cities. It outlines the potential security threats to a smart city. PAS considers security in holistically, looking at governance, personnel, physical, and technological security issues and solutions.

7.6 Smart IoT Future Challenges

Smart cities challenges are categorized into city traffic, citizen behavior and city planning [38]. Sensors for GPS, GIS attached with vehicles can analyze the traffic in real time. With the help of GPS data, taxi passengers travel statistics is analyzed in Sweden [15]. When comes to city planning, two issues are found. Overlap of urban areas and the dependency of semantic characteristics. Big data research challenges of smart cities [13] is categorized into two. Business challenges (Planning, Sustainability, Cost, Integration with Cloud computing), Technological challenges (Privacy, Data analytics, Data formats and QoS).

Smart city challenges originate from its design to operation such as design & implementation cost, technology identification, heterogeneity of devices, volume of data, cyber security issues, dynamic future adoption, and connectivity speed. With the available network technologies and mechanisms, smart city is getting matured and more realistic.

Design and Implementation Cost—Smart IoT requires procurement and installation of new devices and software for stepping into cloud & big data paradigm. Most of the existing city administrative procedures have to be changed accordingly. Placing the sensors in the appropriate locations without affecting the people's convenience and privacy is still concern.

Heterogeneity—The devices, technologies, software, platform are different for each IoT system. All these data should be integrated and processed in the cloud. Interoperability issues impact the IoT integration and device communication. Though standards are exists, it is not evolved completely to manage the different IoT platforms.

Volume of data & devices—Considering multiple thousands of sensors installed in the city and monitored almost of the day (24×7) in real time, volume is so huge to handle. Data generation, communication and processing require separate tools and strategy for each IoT system. Sensor and IoT devices deployment at large scale in a city poses significant challenges [17] in managing, processing, and interpreting the big data they generate.

Cyber security—Prevention of intrusion is important in cyber physical systems. As the internet is the backbone of IoT, cyber attacks are very common and hackers try to steal the citizen data. Hence, it is necessary to design and implement IoT system against these types of attacks. A recent study [12] of crime statistics in Japan revealed that urbanization is one of the leading factor in the cause of city crime.

Dynamic adoption—IoT technologies are getting matured every day and adapting to the newer with the existing IoT system is quite challenging with minimal changes. IoT sustainability is required for the long run of smart cities by identifying the system which accepts the new technical viability.

Connectivity speed—Most of the IoT systems generates real time data and should be processed and available immediately. Hence, high speed networks such as 4G/5G is essential in the IoT communication gateway.

Security Issues—Smart IoT should be secure since it involves lot of citizens data to be handled and available in the network. Security & privacy of the IoT network is the major challenge in the smart cities project. Though there were many technological solutions available, intrusion may happen, which is inevitable. Both proactive and reactive measurements have to be placed in the IoT design. Ijaz et al. [14] has categorized the smart city security issues into 3 types as follows.

1. **IoT Technologies:** RFID (Abuse of tags, DoS, spoofing, Jamming), WSN (Tag killing, Battery exhaustion, confidentiality & integrity issues), M2M Communications (protocol attacks, side channel attacks, Man in the Middle attack, DoS), smartphones (GPS/Bluetooth/WiFi threats, Botnets, malwares),
2. **Governmental Factors:** Utility (Data Misuse, Exploitation), critical Infrastructure (Issues in health domain, telecommunication, energy and power supply), smart mobility (location and individual privacy),
3. **Socioeconomic Factors:** Smart communication (cyber security, data integrity), Banking(cyber crimes, phishing, internet frauds), individual privacy (social networking, use of smart phones, location privacy), ecommerce issues.

7.7 Future of Smart Cities & IoT—Research Perspective

Despite the challenges, it is envisioned that IoT will be massively deployed in smart city projects around the world, without any doubt. IoT devices are growing exponentially in different applications and almost part of human day-to-day life. Here, we listed some of the research directions in future IoT applications in smart city projects.

Artificial Intelligence—AI & Machine learning algorithms are more powerful in making mimic of human intelligence to IoT devices. Knowledge sharing and learning are important in future IoT and plenty of research is left in this direction. Many tools are already developed and provisioned by major cloud providers such as Amazon, Google and Microsoft.

Robotics—IoT assistants in the form of robots will reduce the human efforts and potentially deployed in automated jobs in smart cities sectors. Design and development of robots with higher accuracy and fault-free is still challenge. Cloud robotics is emerging to offload the computing to cloud and robots can be thin-client [25].

Semantic IoT—Applying the semantic knowledge in the IoT devices for annotation, meta data extraction, question answering and domain knowledge sharing is still an open research issue. IoT devices generates huge open data, hence mining and extracting the meaningful knowledge in real time is necessary and challenging.

Smart Villages Versus Cities—As more focus comes into urbanization and smart cities development, villages should not be shaded out. There are more number of IoT applications developed for smart villages such as smart farming, animal monitoring and e-governance services. The connectivity between the cities and villages drastically reduce by improved communication, fast transport, infrastructure development and e-commerce.

7.8 Conclusion

This chapter focused on the smart cities implementation using IoT technologies. In the urban infrastructure development, IoT plays big role in maximizing the productivity and reliability of the systems. Smart cities evolution is achievable only by the deployment of IoT. The amalgamation of IoT, big data and cloud computing make the smart cities more realistic and sustainable. We detailed the different aspects of smart cities with IoT technologies in this chapter. Smart cities evolution, architectures, applications, technologies, standards and challenges are discussed intensively.

References

1. AlEnezi, A., AlMeraj, Z., Manuel, P.: Challenges of IoT based smart-government development. In: Green Technologies Conference (GreenTech), 2018, pp. 155–160. IEEE, Apr 2018
2. Anthopoulos, L.G. Understanding the smart city domain: a literature review. In: Transforming City Governments for Successful Smart Cities, pp. 9–21. Springer, Cham (2015)
3. Berrone, P., Ricart, J.E.: New York edges out London as the world's smartest city. IESE Insight Review (2016)
4. Chatterjee, S., Kar, A. K., Gupta, M.P.: Success of IoT in Smart Cities of India: An Empirical Analysis. Government Information Quarterly (2018)
5. Cheng, B., Solmaz, G., Cirillo, F., Kovacs, E., Terasawa, K., Kitazawa, A.: FogFlow: Easy Programming of IoT Services Over Cloud and Edges for Smart Cities. IEEE Internet Things J. **5**(2), 696–707 (2018)
6. Cocchia, A.: Smart and digital city: a systematic literature review. In: Smart City, pp. 13–43. Springer, Cham (2014)
7. Dameri, R.P., Rosenthal-Sabroux, C.: Smart City and Value Creation. Smart City, pp. 1–12. Springer, Cham (2014)
8. Elhoseny, H., Elhoseny, M., Riad, A.M., Hassanien, A.E.: A framework for big data analysis in smart cities. In: International Conference on Advanced Machine Learning Technologies and Applications, pp. 405–414. Springer, Cham (2018)
9. Ganchev, I., Ji, Z., O'Droma, M.: A generic IoT architecture for smart cities (2014)
10. Gaur, A., Scotney, B., Parr, G., McClean, S.: Smart city architecture and its applications based on IoT. Proc. Comput. Sci. **52**, 1089–1094 (2015)
11. Grandview Market Research Report: Smart Cities Market Size, Share & Trends Analysis Report by Application (Education, Governance, Buildings, Mobility, Healthcare, Utilities), by Component (Services, Solutions), and Segment Forecasts 2018–2025. Report ID: 978-1-68038-270-9. https://www.grandviewresearch.com/industry-analysis/smart-cities-market, Feb 2018
12. Halicioglu, F., Andrés, A.R., Yamamura, E.: Modeling crime in Japan. Econ. Model. **29**(5), 1640–1645 (2012)
13. Hashem, I.A.T., Chang, V., Anuar, N.B., Adewole, K., Yaqoob, I., Gani, A., Ahmed, E., Chiroma, H.: The role of big data in smart city. Int. J. Inf. Manag. **36**(5), 748–758 (2016)
14. Ijaz, S., Shah, M.A., Khan, A., Ahmed, M.: Smart cities: a survey on security concerns. Int. J. Adv. Comput. Sci. Appl. **7**(2), 612–625 (2016)

15. Jiang, B., Yin, J., Zhao, S.: Characterizing the human mobility pattern in a large street network. Phys. Rev. E **80**, 021136 (2009)
16. Khan, Z.A.: Using energy-efficient trust management to protect IoT networks for smart cities. Sustain. Cities Soc. **40**, 1–15 (2018)
17. Khatoun, R., Zeadally, S.: Smart cities: concepts, architectures, research opportunities. Commun. ACM **59**(8), 46–57 (2016)
18. Kyriazopoulou, C.: Architectures and requirements for the development of smart cities: a literature study. In: Smart Cities, Green Technologies, and Intelligent Transport Systems, pp. 75–103. Springer, Cham (2015)
19. Li, Y., Lin, Y., Geertman, S.: The development of smart cities in China. In: Proceedings of the 14th International Conference on Computers in Urban Planning and Urban Management, pp. 7–10. July 2015. LIVE Singapore! Project: http://senseable.mit.edu/livesingapore/research.html (2018)
20. Monzon, A.: Smart cities concept and challenges: bases for the assessment of smart city projects. In: Smart Cities, Green Technologies, and Intelligent Transport Systems, pp. 17–31. Springer, Cham (2015)
21. Olivier, D.W.: Urban Agriculture Promotes Sustainable Livelihoods in Cape Town. Development Southern Africa, pp. 1–16 (2018)
22. Perera, C., Qin, Y., Estrella, J.C., Reiff-Marganiec, S., Vasilakos, A.V.: Fog computing for sustainable smart cities: a survey. ACM Comput. Surv. (CSUR) **50**(3), 32 (2017)
23. Perera, C., Jayaraman, P.P., Zaslavsky, A., Georgakopoulos, D., Christen, P.: Sensor discovery and configuration framework for the internet of things paradigm. In: 2014 IEEE World Forum on Internet of Things (WF-IoT), pp. 94–99. IEEE. Mar 2014
24. Petrolo, R., Loscri, V., Mitton, N.: Towards a smart city based on cloud of things. In: Proceedings of the 2014 ACM International Workshop on Wireless and Mobile Technologies for Smart Cities, pp. 61–66. ACM. Aug 2014
25. Saravanan, K.: Cloud Robotics. Detecting and Mitigating Robotic Cyber Security Risks, pp. 261–274. IGI Global (2017)
26. Saravanan, K., Anusuya, E., Kumar, R., Son, L.H.: Real-time water quality monitoring using Internet of Things in SCADA. Environ Monit Assess **190**(9) (2018)
27. Saravanan, K., Radhakrishnan, A.: Dynamic search engine platform for cloud service level agreements using semantic annotation. Int. J. Seman. Web Inf. Syst. (IJSWIS) **14**(3), 70–98 (2018)
28. Saravanan, K., Rajaram, M.: An exploratory study of cloud service level agreements-state of the art review. KSII Trans. Internet Inf. Syst. **9**(3), 843–871 (2015)
29. Saravanan, K., Saraniya, S.: Cloud IOT based novel livestock monitoring and identification system using UID. Sensor Rev. **38**(1), 21–33 (2018)
30. Saravanan, K., Srinivasan, P.: Examining iot's applications using cloud services. In: Examining Cloud Computing Technologies Through the Internet of Things, pp. 147–163. IGI Global (2018)
31. Scuotto, V., Ferraris, A., Bresciani, S.: Internet of things: applications and challenges in smart cities. A case study of IBM smart city projects. Bus. Process Manag. J. **22**(2), 357–367 (2016). https://doi.org/10.1108/BPMJ-05-2015-0074
32. Silva, B.N., Khan, M., Han, K.: Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. Sustain. Cities Soc. **38**, 697–713 (2018)
33. Smart Cities Council: Best practice guide for smart city standards. www.smartcitiescouncil.com, May 2018
34. Smart Cities India: http://smartcities.gov.in/ (2018)
35. Solanas, A., Patsakis, C., Conti, M., Vlachos, I.S., Ramos, V., Falcone, F., Postolache, O., Pérez-Martínez, P.A., Di Pietro, R., Perrea, D.N., Martinez-Balleste, A.: Smart health: a context-aware health paradigm within smart cities. IEEE Commun. Mag. **52**(8), 74–81 (2014)

36. Talari, S., Shafie-khah, M., Siano, P., Loia, V., Tommasetti, A., Catalão, J.P.: A review of smart cities based on the internet of things concept. Energies **10**(4), 421 (2017)
37. Washburn, D., Sindhu, U., Balaouras, S., et al.: Helping CIOs understand 'smart city' initiatives. Growth **17**, 1–17 (2009)
38. Yin, C., Xiong, Z., Chen, H., Wang, J., Cooper, D., David, B.: A literature survey on smart cities. Sci. China Inf. Sci. **58**(10), 1–18 (2015)
39. Yokohama Smart City Project: http://www.city.yokohama.lg.jp/ondan/english/yscp/ (2018)
40. Zanella, A., Bui, N., Castellani, A., Vangelista, L., Zorzi, M.: Internet of things for smart cities. IEEE Internet Things J. **1**(1), 22–32 (2014)

Chapter 8
Evolution in Smart City Infrastructure with IOT Potential Applications

Rohit Sharma

Abstract It is evaluated that 70% of the total populace, more than 6 billion individuals, will live in urban areas and adjacent districts by 2050. The fast increment of the populace thickness inside urban situations, foundations and administrations has been expected to supply the necessities of the subjects. In this way, urban communities should be keen, if just to make due as stages that permit monetary, social and natural security. Brilliant city is the one that utilizations data and interchanges innovations (ICT) to make the city administrations and observing more mindful, intelligent and equipped. Sagacity of a city is driven and empowered innovatively by the developing (IoT) Internet of Things—a radical advancement of the present Internet into a worldwide system of between associated objects that not just accumulates data from the situations (detecting) and collaborates with the physical world, yet in addition utilizes existing Internet models to give administrations to examination, data exchange and applications. Past showcasing and innovation, a successful brilliant city technique takes a city's social, financial, ecological, and topographical substances into account and requires coordinated effort between partners from approach producers to natives—with help from put stock in, experienced data and correspondence innovation (ICT) accomplices. Development and the best possible execution of new innovations into a brilliant city system require cautious consideration. ICT accomplices assume a urgent part in the venture's advancement and usage, and along these lines its definitive achievement (Rathore et al. in Comput. Netw. 101:63–80, 2016, [1]). A key objective of a smart city is to upgrade the utilization of open assets, expanding the nature of administrations offered to its residents while decreasing operational expenses. While this goal can't be accomplished with innovation alone, utilizing the organization of IoT inside a city can go far to achieving this objective. The goal of this chapter is to give a thorough review on the possibility of the sharp city other than their unmistakable applications, preferences, and purposes of intrigue. Likewise, a substantial segment of the possible IoT headways are displayed, and their capacities to focalize into and apply to the unmistakable parts of sagacious urban groups are discussed.

R. Sharma (✉)
SRM Institute of Science and Technology, Ghaziabad, India
e-mail: rohitapece@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_8

The potential utilization of splendid urban territories concerning development headway later on gives another critical exchange in this area. In the meantime, some helpful experiences everywhere throughout the world and the key limits to its utilization are out and out imparted (Rathore et al. in Comput. Netw. 101:63–80, 2016, [1]). IOT potential applications can help us for evolution in smart city infrastructure. In this chapter we discuss about the different potential applications of internet of things for smart city infrastructure. Discussion about the big data is also considering for enhancing the knowledge about smart infrastructure and in the last section I also provide the recommendation for adopting smart city infrastructure earlier.

Keywords Smart city evolution · Internet of thing · Big date

8.1 World View of IOT

These days, web and world are recognized as two distinct things for the most part rely on human intercession i.e. interfaces. A few applications are presently working shrewdly to programmed screen or control on things in genuine. As talked about over, these smart applications are fundamental IoT applications. IOT may have dynamic control over day by day life and industry; enhance the asset usage proportion, better connection amongst human and nature, framing a scholarly element by incorporating human culture and physical frameworks, Resource proficiency vitality protection, contamination and calamity evasion [2].

There will associate with 40 splendid urban zones comprehensive by 2025. There will be the change in 2020 of Mega city corridors, facilitated and orchestrated astute urban territories. By 2025 more than 60% of the aggregate people is depended upon to live in urban zones, urbanization as an example will have isolating impacts and effects on future individual living and compactness. Quick augmentation of city edges, driven by increase in people and structure change, would urge city edges to broaden outward and overpower the including young lady urban zones to shape uber urban groups, each with a masses of more than 10 million. By 2023, there will be 30 uber urban groups globally, with 55% in making economies of India, China, Russia and Latin America. This will provoke the advancement of splendid urban territories with eight shrewd features, including Smart Buildings, Smart Economy, Smart Mobility, Smart Information Communication and Technology, Smart Energy, Smart Planning, Smart Governance and Smart Citizen [2]. The world driving countries and its improvement in IoT showed up in Fig. 8.1 gives the diagrammatic depiction of the Internet of Things events and contraptions related per 10 people.

The Smart City Mission in India centers around enhancing fundamental urban framework in urban communities was propelled by Narendra Modi (Prime Minister) in June 2015. Under the program, every city will get Rs. 1000 crore focal subsidizing for its far reaching improvement and compelling conveyance of open administrations. Keen city covers the regions like debacle administration, urban

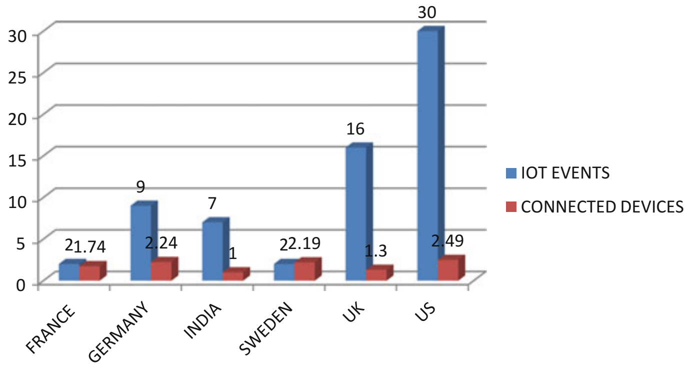


Fig. 8.1 IoT events and devices with respect to countries

portability and waste administration. Under territory based advancement, 76% region will be retrofitted, 19% will be created as green field improvement and 5% zone will be redeveloped. Urban savvy city incorporates clever movement framework, activity direction, zebra crossing on streets, and street broadening [3].

There are different obstacles that take after blockers (obstruction) are emerging, for instance, political, particular, and money related. Under the political estimation, the fundamental obstacle is the attribution of essential administration vitality to the different accomplices. A possible technique to remove this boundary is to sort out the entire decision and execution process, centering the fundamental organizing and organization of the insightful city points into a lone, submitted division in the city [2].

8.2 Smart Cities Architectures and IOT

To comprehend the fundamental qualities of IoT and keen urban communities, it is helpful to break down the arrangement of a common IoT arrangement and show how the engineering can be mapped to that of shrewd urban communities. Figure 8.2 delineates a rearranged layered engineering of IoT.

Hardware layer is the base of the structure is the, where substantial equipment components, for example, actuators, sensors, radios and chips are found. The components in this layer regularly cooperate specifically with the earth, with other equipment components, or in some cases with the clients/buyers. The following layer is the Communications layer, which is once in a while called "network." This layer associates and ties distinctive parts in the Hardware layer with the goal that data can stream between layers or between equipment segments. This is the place surely understood advances, for example, Wi-Fi, Ethernet, cell, and short-extend remote are found. For a few applications, the Communications layer is negligible (e.g., downsized to an inward transport or to rearranged availability among various equipment parts) [4]. Notwithstanding, it ought to likewise be noticed that this layer

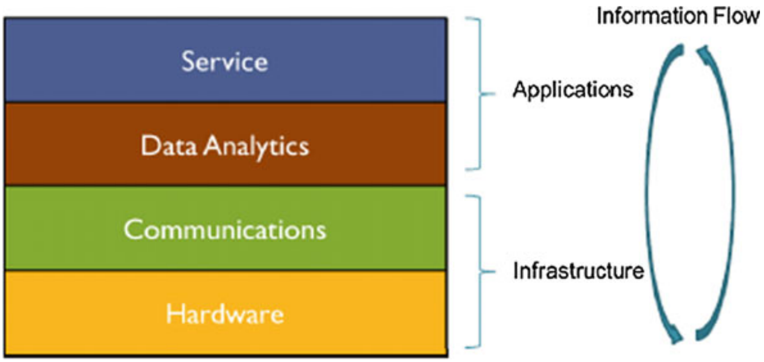


Fig. 8.2 Simplified IoT and Smart Cities Architecture

could be generally thin and straightforward, particularly on account of implanted applications. At the end of the day, the Data Analytics layer does not really infer the requirement for an enormous database and a to a great degree quick processor [2].

Numerous dispersed IoT-based control frameworks utilize a generally little scale Data Analytics layer. A case of a little scale layer can be found in a keen indoor regulator that could likewise work as a nearby leader inside the home system. Then again, numerous IoT arrangements sent at a citywide scale may require a major concentrated information vault and all the more intense processors to deal with a bigger measure of information from different divisions and applications. A case of such a framework could be a city's debacle war room that is intended to give concurrent perceivability into various offices (e.g., water, vitality, transportation, social insurance, and so forth.) [4].

The fundamental capacity of the Data Analytics layer is to gather information from the lower layers and concentrate helpful data from the arrangement of information. Note that the arrangement of information itself might not have huge esteem and may not be extremely helpful to the client. The data extricated from the information, be that as it may, could be significant in taking activities and accomplishing a coveted final product.

The Service layer is essential since it is in the situation in the design to make the most elevated an incentive for the clients of the framework. Numerous business choices are made in this layer, incorporating human-tuned in activities [5].

Once the choice of the subsequent stage is made at the Service layer, now and then (yet not generally) data begins streaming in the switch way (i.e., from Service layer down to the Hardware layer). This is particularly valid for frameworks in light of some kind of self-sufficient control. Then again, it is in some cases a person who settles on the choice and executes it. In either case, the final product is some sort of activity that shuts the circle of the data stream. A comparative portrayal of IoT information stream was proposed in another article. Numerous designers view IoT as the mix of simply the two base layers (Hardware and Communications). It is critical to note, be that as it may, that these two layers are just a piece of the entire

IoT engineering. By and large, the main two layers (Data Analytics and Service) assume more essential parts in characterizing and delivering the genuine incentive from the framework. Likewise as a rule, the plan and usage of the best two layers might be more unpredictable and vague than the last two layers [4].

As a rule, the best two layers are vigorously combined with business cases that are vital factors in deciding supportability and replicability of the arrangements. On account of shrewd city applications, usually less demanding to conceptualize the design as two gatherings of layers—Infrastructure and Applications. "Framework" regularly alludes to the last two layers of the IoT design, and "Applications" alludes to the main two layers. Now and again, be that as it may, the Data Analytics layer could have a place with the foundation gathering, contingent upon the idea of its usefulness. Numerous arrangements/items that have a place with the application amass have more adaptability in organizations than the ones having a place with the foundation gathering. This straightforward IoT engineering can fill in as an underlying layout to outline keen city answers for assemble agreement on their specialized interoperability, which is fundamental in tending to the difficulties in quickening the market force for IoT and shrewd urban areas [5].

8.3 Advancing IOT Is a Challenges in Cities

Smart cities utilize shrewd innovations, for example, IoT and CPS to enhance the personal satisfaction of the inhabitants and subjects. Despite the fact that advance in sending IoT arrangements has been very noteworthy, the IoT showcase still experiences the issue of infrastructure, and the shrewd city pieces of the overall industry comparable concerns. Numerous shrewd city arrangement ventures are detached and intensely depend on custom-arrangement improvements. Normally, a significant number of them are "one-off" activities with overwhelming accentuation on customization and insufficient thought for future upgradability and extensibility. Therefore, these organizations are confined and despise economies of scale. Albeit numerous urban areas share similar issues (i.e., stopping issues, congested driving conditions, air contamination, and so forth.), they frequently don't share best practices and wind up reexamining the wheel. In this scene, it is extremely hard to make regular norms for advancement and sending of interoperable arrangements [6].

8.4 Smart City IOT Use Cases

Utilize cases, for example, keen road lighting where investment funds can be immediately acknowledged regarding vitality utilization and lessened downtime have turned out to be ordinary in numerous districts, as have shrewd stopping, ecological observing, and activity administration.

Numerous urban communities are presently hoping to extend the utilization IoT to enhance administrations like waste administration, water administration and quality, and vitality utilization in broad daylight structures. Also, the utilization of relevant examination to give constant data to nationals and specialists are developing in prevalence [7].

HPE has the abilities and experience to help these utilization case and more through a blend of the HPE Universal IoT Platform and different items and administrations.

8.4.1 Smart Parking

The explanations behind brilliant city speculations shift by district however regularly start with the need to diminish operational expenses. For some urban occupants, enhancing versatility is of exceptional intrigue [5].

Particular objectives regularly include:

- Reduce time and cost of transportation when making a trip to and from the work environment
- Avoid roads turned parking lots and occurrences while in transit
- Have plentiful stopping promptly accessible upon entry
- Experience less pressure and a more beneficial lifestyle.

Native grievances about drive times or stopping accessibility in focal business areas can drive interests progressively activity data frameworks and savvy stopping meters. The auto parks area in Europe and North America is quickly improving toward shrewd frameworks. Notwithstanding receiving propelled mechanization arrangements and programming for the booking and installment of stopping, rising patterns include [8]:

- Rapid advancement of remote innovation (both cell and LPWA)
- Ability to dissect volumes of information gathered from stopping and different sensors, (for example, movement)
- Short-run correspondences (NFC) contactless and other installment techniques.

Keen stopping applications empower new income streams for urban areas by making it workable for stopping to be sold by means of associated auto applications direct to the vehicle, opening up discount accomplice connections between auto makers and rental organizations. Another choice is the capacity to give supported stopping administrations to nearby organizations: save a parking spot when you book an eatery [8].

8.4.2 Smart Lighting

With the increasing expenses of vitality, joined with expanded natural and administrative weights toward vitality proficiency, numerous nearby governments are hoping to enhance their road lighting activities and framework. Road lighting, an imperative group benefit that adds to natives' feeling of wellbeing and security, expends as much as 40% of an administrator's vitality utilization. In addition, they're costly to oversee.

Inheritance High Pressure Sodium (HPS) lights and their supporting foundation are especially wasteful and regularly work for up to 12 h per day at full power. Notwithstanding utilizing encompassing light sensors to switch singular streetlights on and off, the vitality expenses of giving this administration are high. Also, absence of checking or recording vitality utilization inside individual lights, administrators frequently pay in view of utilizing a couple of metered lights increased by the quantity of lights inside their foundation, paying little heed to real utilize. Blackouts in road lighting affect open wellbeing and open administrations risk. With HPS, streetlights regularly having a short life expectancy—around five years, so it's normal for administrators to supplant roughly 20% of these lights every year. This prompts eccentric administrations and support costs. To address these issues, numerous administrators are moving to new, vitality productive LED-based streetlights which empower bring down vitality utilize combined with giving IP network and IoT sensors into the lighting foundation to give remote administration and checking [9].

Keen road lighting requires new, savvy/associated illuminators and control units (weights) to be fitted. In a joint effort with our accomplices, the HPE Universal IoT Platform is fit for dealing with a shrewd lighting arrangement that use the two HPS lights and new LED-based lights. Utilizing conventional HPS lights in an oversaw domain diminishes the venture required to actualize the new framework, as a great part of the current light can be reused. By utilizing more up to date, more proficient power units, dealing with the lights, and enhancing their utilization, implies adding huge reserve funds to the administrator. Given the advantages and moderately ease of sending by reusing the current framework, the ROI for such a redesign for the most part takes under three years [5] (Fig. 8.3).

Furthermore, giving IP availability to streetlights opens up countless to administrators to utilize that network for extra shrewd administrations as appeared previously. Cases include:

- Using streetlights as access focuses for a Wi-Fi or little cell work to give Internet get to
- Enabling sensors to oversee movement or stopping, for example, activity light controls or savvy stopping administrations
- Providing access focuses or concentrators for home computerization administrations or savvy metering availability.

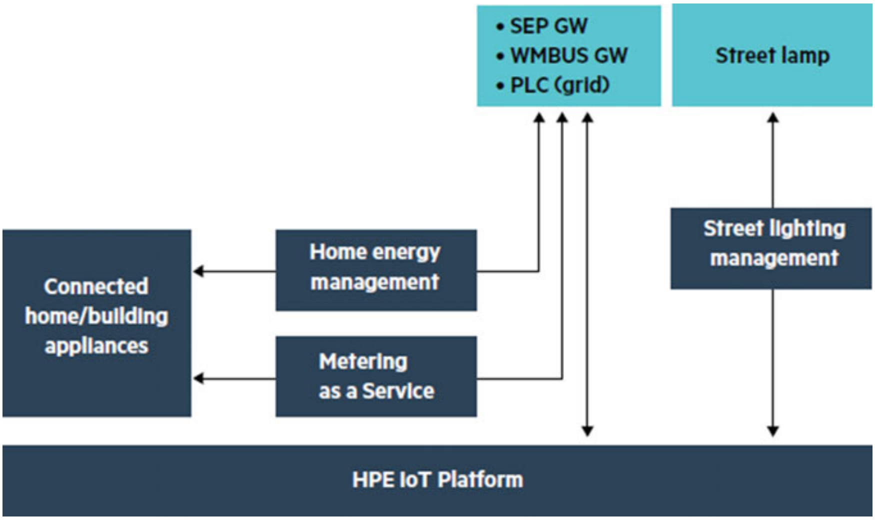


Fig. 8.3 Managing streetlights; offering connectivity to smart city services

8.4.3 Smart Waste Management

Waste management is a noteworthy issue in urban regions as far as natural administration, cost, and resident fulfillment. As a rule where squander accumulation occurs on a settled course at foreordained circumstances, a few canisters are just incompletely filled while others are flooding and ought to have been discharged before [2].

By introducing sensors and availability in squander containers to screen the level of the garbage inside, gathering courses can be enhanced so the canisters are exhausted when they should be, regardless of whether that implies a few receptacles are purged two times every day and others just every couple of days. This conveys cost reserve funds, lessens CO_2 emanations from the accumulation trucks, and expands subject fulfillment as waste receptacles are never again flooding [2].

Shrewd waste administration arrangements controlled by HPE Universal IoT stage and the HPE investigation portfolio can give ongoing experiences and screen the sensor information originating from squander receptacles. A HPE consider more than two years of container filling and accumulation conduct for a waste receptacle in France, for instance, has given bits of knowledge and distinguished waste gathering/booking designs that enlighten techniques to enhance effectiveness.

8.4.4 Smart Fleet Management

The fleet administration industry is experiencing a noteworthy change because of IoT enabled by cell correspondences innovations. Armada administration delivers a few difficulties particular to cost control of fuel and support, driver and traveler wellbeing, and conveying great client benefit. More solid associations and consistent scope crosswise over wide geological zones and remote areas gives new IoT chances to enhance armada execution and consumer loyalty. Armada administration arrangements can be utilized by keen urban areas to deal with their armada vehicles all the more effectively and break down the reasons for activity blockage through information caught by those vehicles [4].

HPE has expanded its armada administration comprehension and arrangement capacities through certifiable driving exploration. A current cooperative investigation with Ford, 7 for instance, propelled a typical vision around uniting information, portability, and examination to investigate better approaches to convey better client encounters, new income streams, and lower fuel and upkeep costs in the car business.

Fleet management encompasses use cases that include:

- Route upgrade: Dynamically convey undertaking assignments in view of vehicle area and stock levels to decrease the quantity of vehicles and conveyance time windows
- Workforce administration: Wirelessly track specialist area continuously, empowering drivers to remotely check in and out and enabling organizations to track an opportunity to finish errands
- Driver conduct administration: Provides moment input to drivers to decrease driver blunders and accomplish better gas mileage. Input incorporates the formation of itemized plans to exhort drivers on the most proficient method to maintain a strategic distance from dangerous driving practices like speeding, quick cornering, and hard breaking
- Geo-fencing: Tracks that a vehicle remains inside a characterized geographic zone, generally sending a caution if limits are crossed
- Telematics: Provides information, for example, fuel utilization rates, tire weight, mileage, speed, and braking style to empower armada chiefs to tweak their activities
- Diagnostics: Helps distinguish support prerequisites and updates drivers on an assortment of execution measurements to evade roadside breakdowns, lessen expensive repairs, upgrade wellbeing, and enhance vehicle productivity [5].
- Smart observation: Enables ongoing checking to advance security by using remote video streams
- Operations administration: Increases vehicle and conveyance effectiveness.

8.4.5 Smart Energy Management

Brilliant vitality administration can encourage generous vitality reserve funds for customers and undertakings alike. From associated indoor regulators in the home, for example, NEST or Hive, to refined frameworks that oversee warming, ventilation, and cooling (HVAC) for office edifices and shopping centers, IoT is as of now having a considerable effect on decreasing vitality costs.

In broad daylight structures, adjusting HVAC requests with outside climate conditions together with inhabitance/throughput of individuals is an intricate issue. The privilege IoT sensors joined with world-class investigation and information administration, in any case, renders this test effortlessly figured out how to create bring down expenses, line up with ISO 50,001 necessities, and convey a superior general ordeal for clients of the building [5].

8.5 Development of a Smart City Affected by the Trends

A Smart City is continually impacted by new patterns. Thus, the city must be adaptable and versatile so as to stay aware of fast improvements. The patterns likewise have coordinate effect on particular territories inside a Smart City, where bigger measures of information, for instance, force higher requests on information stockpiling and the hidden correspondences framework [2].

Patterns having affected on the framework of a Smart and big City are depicted in the accompanying segment. This segment has been separated into specialized patterns, application and market display patterns. These three patterns are characterized as takes after:

- Technical patterns: Patterns in interchanges innovation and other specialized advances, for example, 5G, major information and cloud administrations. These patterns will make keen urban areas conceivable, yet will likewise put higher requests on the basic correspondences foundation, among else.
- Patterns for Application: Refers to devices that assistance residents, organizations and city organizations create benefits in new and existing zones. There are various application regions in a Smart and large City, including human services and transport.
- Market demonstrates patterns: How a city arranges and obtains its answers and how these influence the city's part as the facilitator of a proficient Smart City.

8.5.1 Technical Trends

The specialized patterns depicted in this segment were touched base at by recognizing and evaluating countless as indicated by three criteria—significance, timing and size keeping in mind the end goal to distinguish the patterns most essential to the framework of a Smart City [10] (Fig. 8.4).

The patterns surveyed as most applicable are the Internet of Things (IoT), 5G, major information and cloud administrations.

8.5.2 Internet of Things (IoT)

Internet of Things alludes to the utilization of many sensors little gadgets that can perform the recording of different kinds of information, for example, speed and weight, warm, light—and remote correspondence in different sorts of physical items on a substantial scale, where gadgets are associated with the web and work without human connection. At the point when numerous sensors are associated, this makes huge information, enabling the physical world to be broke down in detail and, much of the time, progressively. The data can be utilized for purposes including upgrading a city's foundation and utilizing its assets all the more productively. Some IoT administrations put requests on limit and it is in this manner imperative to have a framework that can oversee the two sections [2].

There are a few general patterns in the IoT territory that put requests on the foundation of a Smart City.

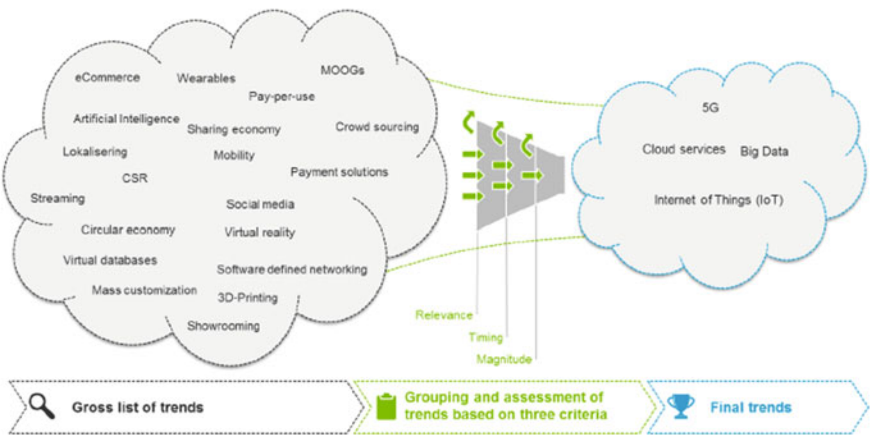


Fig. 8.4 Recognizable proof of the specialized patterns most essential to the framework of a smart city

- Multiple applications: later on, Internet of Things arrangements will be find in for intents and purposes all zones and an immense number of physical gadgets, for example, road lights and structures, should be fiber-associated.
- Powerful development in IoT: The quantity of IoT gadgets is assessed to develop by around 30% consistently until 2020.7

8.5.2.1 IoT as a Key Technology Enabler

IoT has the potential to facilitate beneficial decision-making that no stand-alone device could collect and process on its own. Example: merging data from weather, traffic, and environment sensors to predict and manage air quality along major roads and networks. The treasure trove of data coming online for the first time is of limited value however unless the devices generating the data can be managed and the data itself can be verified as trustworthy, analyzed, and monetized into new revenue streams, cost savings, or improvements in user experience. Without all of that, the true value cannot be fully realized [6].

The explosion of connected objects will not only depend on the appropriation of uses, but also on the management of radio frequency congestion, network capacity, and how public and private networks are interconnected. Across a smart city, different use cases will likely require different types of connectivity. For example, an IP surveillance camera requires the high bandwidth available from cellular, Wi-Fi, or fixed-line connectivity, whereas smart parking sensors require long battery life and therefore a low-power connectivity method such as LoRa (or Narrowband LTE as it becomes available).

IoT is already delivering benefits to cities like Los Angeles 5 and Oslo, 6 which have experienced energy savings of more than 60% by moving to smart street lighting. Other cities have seen similar significant savings by deploying smart waste management solutions, reducing CO_2 emissions, and increasing citizen satisfaction through smart parking and traffic management. In many cases, however, these are only isolated point solutions. To truly exploit the benefits of IoT within a smart city, a holistic approach is required such that the infrastructure deployed is flexible enough to support multiple use cases rather than building multiple silos.

As such, a thorough study of setting up IoT networks and solutions is needed to respond adequately to specific smart city project requirements. Policy makers must fully comprehend and organize the interaction between IoT systems and multiple connectivity networks to accelerate the transformation of data these systems generate into value and services. The future city represents an extensive melting pot of innovation potential. Several cities are already driving knowledge exchange in schools, universities, and laboratories. Innovation labs are expected to marry technology innovation to services and business models to create more contextualized residential and enterprise benefits [6].

8.5.2.2 Connectivity Options

Given the requirement for connectivity, many see IoT as an obvious fit for communication service providers (CSPs), such as mobile network operators, although connectivity is a readily available commodity and therefore of low value. In addition, a growing number of IoT use cases are introducing different connectivity requirements in terms of both economics and technical capabilities.

Matching the IoT use case to the appropriate connectivity option is key. With connected cars, for example, mobility and access to high-bandwidth services is critical and therefore ideally suited to a 3G/4G network. In other cases, like smart parking/waste management sensors or smoke detectors that only transmit data when triggered, a low throughput network is a better connectivity option as the costs of a substantially underutilized 3G/4G wireless module are impractical [7].

Wireless access technologies can be fundamentally categorized along two dimensions—range and throughput—as depicted here (Fig. 8.5):

Choosing the right connectivity option, however, is not as straightforward as checking range and throughput attributes. Many IoT use cases are characterized by a low average revenue per unit (ARPU). Examples include soil quality sensors for agriculture and smart building monitoring where a large number of sensors are typically spread across a large area, which predictably deliver a low ARPU.

Other use cases present technical challenges such as the need for long battery life due to the difficulties or cost of maintenance. With traffic sensors embedded in the roadway, for example, low-power consumption is a must [7].

For such use cases, traditional 2G/3G/4G cellular network connectivity and SIM-based devices are not feasible. Mobility offers scant benefit for fixed devices, just as a high-bandwidth cellular network is wasted on a smoke alarm with infrequent traffic and a miniscule amount of data to transmit.

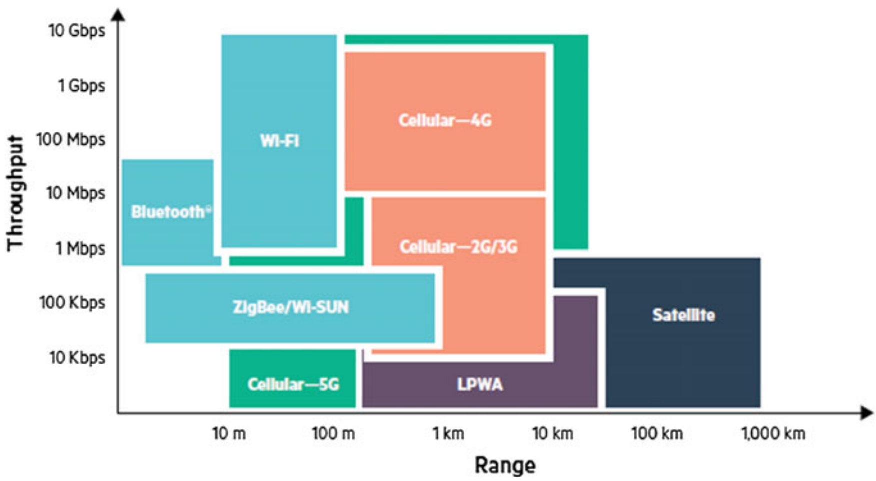


Fig. 8.5 Range/throughput characteristics of wireless access technologies

A new type of connectivity option is required to increase efficiency and return on investment (ROI) of such use cases. Examples include Low Throughput Networks (LTNs) such as SIGFOX or LoRa as well as emerging cellular standards, including LTE-M and the new Narrow Band IoT recently introduce by 3GPP, which is in the process of standardization. The IoT infrastructure deployed by smart cities needs to be able to handle devices and objects connected via any connectivity method.

An application enablement platform like the HPE Universal IoT Platform, which is agnostic with regard to connectivity, device, protocol, and use case enables smart cities to manage most of their IoT services via a single platform, therefore reducing total cost to service as well as enabling the "mash up" of use cases and data to provide new and innovative services [7].

Assessment

Notwithstanding the general patterns, a few variables are encouraging fast improvement of IoT [4]:

- Sensors Price weight: The sensors cost has fallen throughout the previous many years and assessments show that it going to keep on dropping by around 5% every year finished the following few years. The value drop will make it less expensive to introduce sensors on an extensive scale, which is frequently required to associate countless in a city.
- Fibre framework: If a city has a sweeping fiber foundation, it determination speedier development of the sensor organize in light of the fact that the framework will be required whether the sensors transmit data straightforwardly by means of the fiber arrange or through remote systems.
- Wireless scope: Most sensors require remote system access to transmit information in light of the fact that different associations, for example, fiber, are not accessible in all areas. Access to remote systems will be made conceivable through expanded advancement, extension and accessibility of 5G, LoRa, WiFi and for instance.
- Better processors and capacity: The huge information produced by sensors must be put away and prepared, which was not once in the past conceivable to an indistinguishable degree from now because of inadequate stockpiling limit and processor speed.

Notwithstanding fast advancement in the IoT zone, various difficulties remain, which will require extensive ventures [5].

- Privacy and security: The huge information delivered and particular information (or mixes of information) can involve touchy issues of protection and constitute a weakness for society and nationals. Subsequently, an unmistakable system encompassing security and information mystery is fundamental.
- Supply of Electricity: Big quantities of some sensors will be introduced in areas where there is as of now no power. Either the power framework will need to be extended or the utilization of batteries as well as sun oriented cells should be expanded.

- Obsolete stages and sensors: It will be troublesome for more established stages to deal with the sum and kind of information and data made by IoT gadgets and interests in new stages are required. As of now introduced sensors, in industry for instance, additionally have their confinements, the same number of these can't demonstration self-governingly as Internet of Things gadgets.
- Fibre thickness: To empower sensor association, sufficient fiber thickness will be required in the road space, which will involve huge speculations for urban communities where fiber isn't as of now introduced.

8.5.3 5G

The cutting edge versatile system—5G—is frequently called the system that will have the capacity to interface and "offer information anyplace, whenever by anybody and anything." That which will make 5G conceivable is in all probability not a solitary, progressive new innovation, yet rather a mix of extending and expanding the quantity of portable poles and staged redesigning of existing advances in versatile interchanges [10].

The 5G organize will need a substantially larger number of stations per unit region, i.e., denser situation of poles and locales than is the situation for the present versatile system. This will require an extension of the fiber framework in the road space. The improvement of 5 Generation will be driven to a great extent by business performing artists and worldwide research coordinated efforts. The initial 5G arrange is relied upon to be financially accessible in 2020.10 [10].

Assessment

It will be different many years previously the initial 5G systems are required to be introduced for business utilize, which implies that it isn't one of the patterns with the best effect in the close term. Be that as it may, 5G will have real effect later on when business 5G systems turn out to be all the more broadly accessible [10].

5G will make countless city applications conceivable. A couple of illustrations:

- Self-driving and Smart autos: Self-driving autos require an association with low dormancy, which is one of the necessities recognized for 5G. For instance, if there is a mishap, a self-driving and associated auto can rapidly caution different autos behind it and ensure that different activity and climate conditions can be quickly imparted.
- The shrewd home: Good gadgets at house will have the capacity to speak together and the screen vitality utilization of TVs and PCs, for instance.
- Administrations at Emergency: Crisis reaction groups, for instance, will have the capacity to utilize head protectors that can do video streaming continuously that transmitted in a split second to directors who can give guidance about how to oversee unsafe circumstances.

- Virtual reality medicinal services: The low inactivity of 5G can empower remote conveyance of social insurance. A specialist will be able to utilize an association with low idleness to remotely perform examinations or even medical procedure.

8.5.4 Big Data

Enormous information alludes to the immense amount of information created and accessible in the advanced society and in addition the new open doors for breaking down and utilizing the data. The amount of information is developing exponentially and over 90% of all information on the planet was produced over just the last few years. Data is frequently portrayed as organized (e.g., framework created information) or unstructured (e.g., information from online networking or email) [11].

Huge information has basically 2 applications.

- Analytical enormous information: Analytical huge information is gone for examining and contributing substantial amounts of information so as to increase better understanding into something. Investigative huge information innovation can be connected to both organized and unstructured information [12].
- Operational huge information: Describes the utilization of huge information in continuous activities with constant investigation. This frequently includes both perusing and composing of information, which by and large requires organized information sources to be conceivable. Operational huge information requires low inertness systems.

Assessment

Big data is a gigantic asset for a smart city and is assessed to create immense esteem. It is along these lines vital that a city has a system for maintaining a strategic distance from secure impacts that may emerge when different performing artists control the city's information. It will accordingly be an essential errand to guarantee open access to the city's information for subjects and different partners [11].

Utilized legitimately, huge information can empower an expansive number of new answers for Smart Cities. A couple of cases:

- Improved movement administrations: With the assistance of RFID labels or associated autos, street activity can be all the more effortlessly observed and regions that are especially inclined to half backs, for instance, can be distinguished and broke down quicker. Sensors in the streets can be utilized to gauge activity and contamination and information can be transmitted to a movement war room that can utilize the information to divert activity, for instance, to lessen discharges in particularly defenseless territories.
- Parking: Big information can likewise be utilized to divert autos to the closest accessible parking spots. City organizers can utilize information to comprehend which zones have the best requirement for stopping.

- Waste accumulation: City organizers can likewise utilize enormous information for purposes, for example, perceiving how different zones contrast and utilize the data to additionally enhance the productivity of waste gathering.

8.5.5 Cloud Services

"Cloud services" are advancements in which substantial, versatile assets—for example, preparing force, stockpiling and highlights—are given as online administrations. Rather than clients owning and be in charge of these assets, they can without much of a stretch access and utilize them by means of the web, either specifically from the web program or by means of exceptional programming and applications. Cases of usually utilized cloud administrations incorporate (Gmail), CRM frameworks (Salesforce.com), web mail online information stockpiling (Dropbox) and Today, about portion of all organizations utilize cloud benefits in some shape [10].

Cloud services are normally partitioned into three classifications, contingent on what is given as an administration [10].

- Software-as-a-Service or SaaS: Users programming on the cloud specialist co-op's system and don't need to regulate the hidden framework, for example, equipment, working frameworks, stockpiling, and so on.
- Platform-as-a-Service or PaaS: Users, normally software engineers or framework designers, access different improvement situations to make their own applications and programming.
- Infrastructure-as-a-Service or IaaS: The provider gives handling force, stockpiling and system segments that make it workable for clients to introduce and run any product, including working frameworks.

Cloud services are likewise for the most part said to have three distinctive appropriation models.

- Cloud for Public: The administration is accessible to people in general, possessed and controlled by the supplier and shared by various clients and clients. The general population cloud is frequently connected with cloud administrations.
- Private cloud: The framework and included administrations are run solely for a solitary firm or association. These might be overseen in-house or by an outer seller and be put in both inner and outside PC focuses.
- Hybrid cloud: A mix of different cloud benefits that empowers the mix of these cloud administrations.
- There are a few cases of cloud administrations being utilized for shrewd urban communities today: A couple of illustrations
- Smart Santander Project, Santander, Spain: The phone administrator Telefónica is utilizing cloud administrations to enable the city to enhance the effectiveness of sanitation administrations, for example, squander gathering.

Assessment
Cloud services are required to pick up a more grounded position, on the grounds that a Smart City and its performing artists can utilize cloud administrations to keep away from starting expenses and guarantee more noteworthy adaptability. While picking outside performers, a city must have clear comprehension of the responsibility for city's information, as issues identified with individual protection may emerge if unapproved people approach the city's information.

8.5.6 Application Trends

A few applications are typically specified regarding the expression "Brilliant City". At display, there is no obvious categorisation of uses that all performing artists utilize, yet a few repeating topics for the most part emerge regarding shrewd urban communities. Six of these applications are sketched out beneath [4].

Traffic Services for Smart City
Shrewd transport frameworks are administrations that encourage the vehicle of individuals or products and which enhance the proficiency of the utilization of different assets by making transport strategies all the more effectively oversaw or all the more effortlessly accessible [10].

Cases of administrations and capacities incorporate different kinds of shrewd activity checking, stopping frameworks, movement arranging and frameworks for estimating transport, for instance, amid different circumstances and courses. Cases of urban communities where keen transport frameworks have been trialed or actualized include:

- Smart movement framework, Singapore: Singapore's canny activity framework incorporates electronic installments and sensors on taxis, which produce an extensive amount of movement information. The city investigations this information, making it conceivable, for instance, to outline conditions at different circumstances of the day.
- Zaragoza, Spain, Smart movement observing: In 2010–2011, Around 150 sensors were actualized in the city, which measure around 90% of city activity. The gathered data is transmit to the war room of city's where it is utilized for purposes like figuring drive times for regular courses, yet in addition for long haul arranging of the street organize.

8.5.7 Energy Services for Smart City

Energy services for Smart city incorporate those that fundamentally empower more effective and more brilliant utilization of different kinds of vitality. These administrations may include, for instance, more brilliant approaches to convey vitality, more vitality effective capacities and more brilliant approaches to outline use [10].

One case of a savvy vitality benefit is shrewd lighting, both inside and outside, that is actuated or deactivated relying on whether there are individuals in the region. Administrations like brilliant power frameworks and savvy power meters that can speak with each other can likewise make a critical commitment to more productive utilization of vitality and are classed as shrewd vitality administrations. Different cases may incorporate dispersed vitality generators or more proficient vitality stockpiling capacities.

Cases of urban areas where keen vitality frameworks have been trialed or executed include:

- Glasgow, Scotland, Smart road lights: Glasgow has propelled a pilot venture in which road lights are furnished with light weight sensors that identify any individuals moving around the region. The point is to examine what vitality reserve funds can be accomplished by permitting road lights to consequently kill and on relying on whether a man is strolling past.
- Stockholm Royal Seaport, Smart districts, Sweden: It is one of the greatest urban improvement extends in Europe. Manageability issues pervade the whole venture, which has been made conceivable to a limited extent through the use of ICT.

8.5.8 Smart Agencies and Administrations

Smart administrations and offices are regularly specified regarding arrangements went for enhancing the proficiency of open administrations. This applies, for instance, to different sorts of advanced collaborations between government offices and natives, organizations or government representatives. Savvy arrangements may expand straightforwardness among organizations and make it less demanding for different on-screen characters to communicate with them [1].

Cases of regions that may profit essentially may be savvy instruction frameworks, open security and access to open information.

Cases of urban areas where brilliant organization frameworks have been trialed or actualized include:

- All inclusive sensors, Spain, Santander: One of the world's most extensive pilot ventures including far reaching sensors has been propelled in Santander, where in excess of 120,000 sensors are gathering information on everything from the accessibility of parking spots to air quality.
- Smart participation stages, Italy, Florence: Florence propelled an open information activity in which open data, information and measurements were made accessible on an open site in 2012. There are in excess of 200 consistently refreshed datasets on everything from the most well known infant names to

maps of cycle stopping territories. The point of the activity is to advance the improvement of computerized administrations.

8.5.9 Smart Resources

Smart resources incorporate administrations that streamline and enhance water and waste administration using ICT arrangements. For instance, savvy water metering frameworks, keen answers for squander administration and air quality estimation frameworks can be classed as "shrewd assets."

Cases of urban areas where savvy asset frameworks have been trialed or actualized include [1]:

- Resource administration framework, Cologne, Germany: The city of Cologne has sent brilliant vitality meters in excess of 30,000 families, which measure utilization of power, gas and water. The utilization information is gathered by vitality organizations, which have likewise created administrations that enable occupants to see their vitality utilization on their telephones and enable them to control their utilization of vitality requesting machines to times amid the day when water or power costs are lower.

8.5.10 Smart Buildings

Smart house and buildings can be portrayed as frameworks that make it workable for structures to learn and anticipate different necessities, for example, for temperature and space, for lighting and accessibility. Cases of these capacities may be brilliant lighting, prescient warming, water and sanitation frameworks and building mechanization [2].

Cases of urban communities where savvy building frameworks have been trialed or executed include:

- Shrewd structures, "The Edge", Netherlands Amsterdam: Around 6000 LEDs and 30,000 sensors of various sorts have been presented in Deloitte's Amsterdam office, "The Edge". The LEDs are related by methods for web joins and each ha its own particular exceptional IP address and can check infrared, temperature and dampness. The sensors can easily identify that which parts of the structure are used the most, which rooms need to be cleaned and which coffee machines or paper towel devices ought to be refilled. All limits add to decreasing essentialness use and make it both not so much requesting but rather more secure to use diverse limits in the building.
- Micro-frameworks, Greenwich, London, England: A neighborhood gathering in London has chosen to build up a nearby system of sensors in the Royal Borough of Greenwich. A huge number of sensors have been conveyed in structures, streets, light posts and different places in the city. The gathered information is

then investigated in a "working framework" for savvy urban areas, worked to a limited extent to empower M2M usefulness between associated gadgets. The stage can be utilized by benefit engineers who can create applications in view of gathered information.

8.5.11 Health Care for Smart City

Smart health services incorporates administrations that utilization ICT answers for increment access to social insurance, benefits that can remotely analyze or forestall disease and different administrations that can empower successful human services at bring down cost. Cases of these are telemedicine, associated restorative gadgets and different techniques to keep the spread of ailment [2].

Cases of urban communities where keen social insurance arrangements have been trialed or executed include:

- Swedish Association of Local Authorities and Regions (SALAR), the LEDA wander: SALAR has taken 10 Swedish urban groups, including Västerås, to be a bit of a pilot wander for many sharp courses of action. One case is that instead of staff affecting rounds of rooms in a senior care to home in the midst of the night to guarantee all is under control, cameras and sensors have been presented for watching [2].
- Sensor sort out for senior nationals, Norway, Oslo: Systems are being attempted in Norway that were created to make it less requesting for senior inhabitants to direct without any other individual at home. The structure fuses screens on dividers that more settled people can use to talk with therapeutic administrations staff, signs of step by step assignments that are examined so anyone can hear and remote sensors that sound alerts if, for example, the stove is left on too long or a door is opened in the midst of the night. The framework makes step by step living less requesting for senior inhabitants and makes it less complex for their families to watch that everything is as it should be while making colossal social protection cost speculation reserves for open specialists.

8.5.12 Digital Social Development with Smart City

For a Smart City to get advantage from and impact the important patterns and create productive keen administrations, the accompanying territories are basic to consider [13]:

- As a Smart City, inhabitants and organizations the chance to enhance and create administrations moved down by an open and stable foundation.
- Technical patterns and savvy administrations will make immense open doors for a Smart City, however it will be basic for city to have a deliberately formulated system for the basic foundation, for example, fiber and remote systems. It is

basic to stay away from unaligned guidelines and to encourage open and administrator impartial access to the framework, which is an essential for higher advancement execution and adaptability in a Smart and big City.

- Firms that convey brilliant administrations to a Smart City should center around authority skill instead of conveying complete arrangements. This concentration is fundamental regarding obtainment of shrewd administrations on the grounds that the secure impacts are exacerbated when one firm has control more than a few layers in a Smart City. Clear reasoning in connection to acquisition will drive computerized benefit advancement and development in a positive course.
- The specialized patterns Internet of Things and 5G will build requests for an extensive and powerful fiber and remote system.

8.6 Smart City Reference Model

An varying complex environment of quick improvement of innovative fields, showcase models and applications is producing a need to make a general view and for the ability to thoughtfully structure the different parts that together make effective answers for urban areas. A typical technique for conceptualizing a field is to outline a "reference show" which, in view of rearrangements, constitutes a state of flight for building particular, situational models. A reference show is a conceptual system for understanding segments and their interrelationships in a specific domain and can along these lines be utilized as a reason for preparing, and also to disclose examples and relationships to non-experts. A reference demonstrate is typically not concrete with regards to the subtle elements of execution, but rather is rather proposed to give normal semantics that can be unmistakably utilized crosswise over and between particular models and encourage correspondence, learning and examinations of the models [14, 15].

A general reference display for the fundamental segments connected to brilliant urban areas is portrayed in the accompanying segment. For this situation, the "principle parts" are bigger ICT zones that together shape the stage of and empower the different utilizations of a Smart City.

The beginning stage for the keen urban areas reference display is a division of the primary parts into six particular "layers": framework, interchanges, sensors, information stage, applications and security [5] (Fig. 8.6).

The generally basic model gives a chance to impart and look at particular arrangements and models crosswise over associations and intrigue gatherings, while empowering examination of the favorable circumstances and disadvantages of particular arrangements. In more solid terms, the model gives the accompanying advantages [5]:

- It constitutes a reason for picking and contrasting the favorable circumstances and disadvantages of various market models and for deciding how a city can impact/fortify administration advancement.

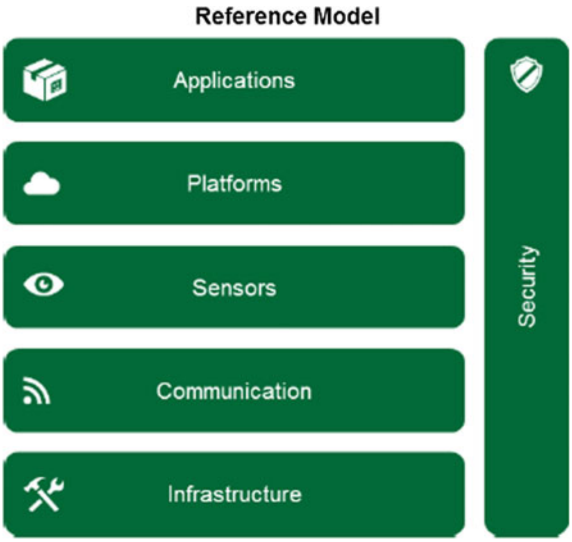


Fig. 8.6 Smart city reference model infrastructure

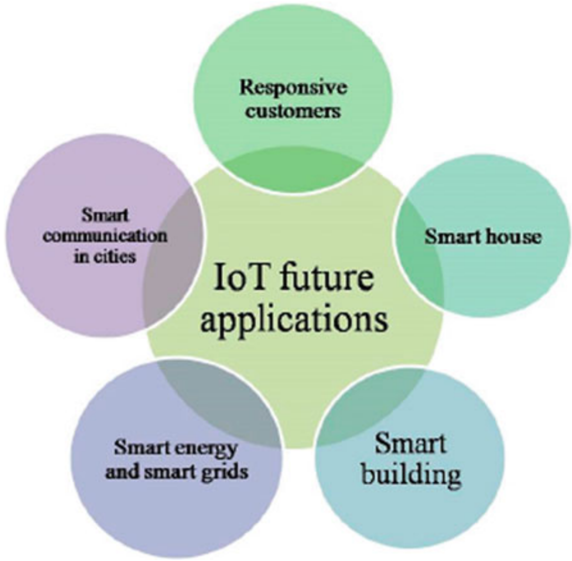
- It gives a chance to better shared comprehension and accord over a city's different units, organizations and firms with joint obligation regarding different Smart City arrangements and applications.
- It advances the improvement of even arrangements and clarifies the impacts of vertical arrangements.
- It makes the conditions and ability to build up specialized norms and determinations for singular arrangements.

Flat joining is a vital key to accomplishing coordinated effort among the different units of a city and boosting resident benefit [16]. Integrating all units inside a city isn't a simple arrangement, as a city frequently comprises of thousands of units and frameworks, yet it is vital to have a procedure from the start for on a level plane incorporating every one of the layers in a Smart City's foundation. This applies the distance from establishment of the essential fiber foundation for broadband and its administrations to the stages that gather information.

8.7 Smart Cities and IOT Potential Applications

Figure 8.7 shows a few conceivable uses of the Internet of Things for the keen city which are clarified in this area.

Fig. 8.7 Internet of things potential and smart cities



8.7.1 Communities and Smart Cities

The profitable execution of the Internet of Things may instigate the making of several associations which take an interest with the earth. In this way, it can demonstrate distinctive prospects for contextualization and geo-mind. Similarly, add up to data influences structures for addressing to and giving the tenants ace and power [3].

8.7.2 Smart Buildings and Homes

Using the IoT arrange in the houses and structures, heterogeneous mechanical assembly associates with the computerization of relative and general exercises. Doubtlessly, through changing things into mechanical gatherings' information which are completely related by applying the Internet can understand benefits through web interfaces [4].

8.7.3 Responsive Customers

The controlling/watching point of confinement of each and every electrical contraption refreshes to some degree a dynamic client in the framework development which is called DR. Request side exercises shape an indispensable piece of centrality approach choices of the (IEA) International Energy Agency, due to the particular and monetary positive conditions. Truly, (DSM) Demand Side Management is the change of clients' criticalness use turn as indicated by fluctuating power cost after some time and some other segment motivations from advantage affiliations. The fundamental central purposes of DR are to confine the client's impact charge, the errand cost of the impact cross segment impact difficulty and ozone debilitating substance surges and develop move top load inquire. The focal controller in adroit cross area outlines centrality utilization of homes' mechanical congregations as appeared by the client's inclinations in a technique that limits the power charge and builds the security and steady nature of the system [5].

The assumptions about up and coming electrical frameworks are for the most part centered around the noteworthiness of shrewd lattices, sustainable power sources, discharge lessening, and created DR programs. Shrewd matrices focused on the naturally based plans consolidating different inexhaustible assets and DR for giving different decisions to clients and enhancing the use of offices. The DSM issue can be actualized at different levels of the progressive brilliant matrix foundation. By thinking about it at the level of home premises, purchasers' security will be kept. Running DSM at larger amounts, more enhanced planning design is created which both of buyers and service organization take its favorable circumstances. To improve the viability of charging and discharging booking strategy, sensors accumulate information about battery state and zone and electric vehicles' identity.

8.7.4 Smart Grids and Smart Energy

The utilization of the IoT licenses insightful organization and control of imperativeness allocation and likewise usage in heterogeneous conditions. The IoT center point has distinctive limits like distinguishing and frameworks organization that extension the probability of perfect change of imperativeness providers. This organization can be made for emergency conditions. Some basic consequences of the said change are accuse region, disengaging and furthermore advantage revamping. Accomplishment this part due to the IoT may give a dynamic contraption that describes the region of the broken portions, disengages them and practices changing exercises to recover the sound section. So also, at the pushed level, this endeavor is extended by advancing a concentrated exertion repairing approaches which can impel the dedication of the buyers and appropriated generators. Applying these systems will provoke trustworthiness change, control quality update and advantage improvement [13].

8.8 The World Practical Experience

In like way, the IoT will be an essential asset for huge information later on. The basic procedure, standards, and consequences of an astonishing city have been spoken to by the Intelligent Community Forum endowments from 1999 to 2010, for the running with urban gatherings. (South Korea) Suwon and Seoul, (Taiwan) Taipei, (Japan) Mitaka, Waterloo, Singapore and (Canada) Calgary, (Scotland) Glasgow, Georgia (USA) and New York City, and (Iran) Tehran which have been perceived for their endeavors, and accomplishment in arranging broadband systems and e-associations to help dynamic eco-structures. There are two or three cases far and wide which demonstrate the difference in redesigned encounters in people, affiliations, and society [5].

8.8.1 The Netherlands, Amsterdam

In Amsterdam different endeavors were pushed in 2006, The Netherlands, including related open lighting inside the sharp city. Created lighting acknowledge a critical part in urban domains for the reduce day and age and furthermore for the respect of the city which picks the city's level of capacity to welcome others there for business or tourism. Along these lines, LED lighting was related with astute controllers for lessening the use, which can make importance hypothesis resources of up to 80% and spare resources of around 130 billion euro, while giving a more huge conclusion security for local people and more vital perceptible quality. Furthermore, these frameworks have been interconnected by joining controls through the Internet which prompts more prominent centrality hold saves. In this way, rather than physical disappointment examination as in consistent lighting endeavors, the lighting disappointments are accordingly distinct by remote checking in a novel strategy. Similarly, vitality utilization was generally evaluated beforehand, at any rate now unbelievable meters precisely discover the significance utilize. Likewise, lights are diminished amidst low development hours to spare vitality or updated when foreseen that would enhance the flourishing [11, 17].

8.8.2 New York, USA

In New York, a stage called City24/7 has been made to illuminate, ensure and reestablish the city. To this end, open correspondence wound up being more available at whatever point, wherever on any contraptions with the true objective that the stage masterminds data from open government programs, neighborhood tenants and business to give mind. Consequently, this program passes on the data that individuals need to know. Some shrewd screens are in transport stops, design stations, strip shopping centers and redirection working environments to get these information. This can be gotten to through Wi-Fi on close-by PDAs or PCs. These sharp screens urge individuals with data that is material to their smart closeness, promise them by giving neighborhood police and fire division citywide perceiving and correspondence limits. With the headway of sharp screens wherever all through the city, the measure of information makes and passes on logically an inspiration to urban gatherings, affiliations and nationals [2, 3].

8.8.3 South Korea, Busan

In Busan, South Korea, the administering body obvious the potential for giving openings for work to school graduated class and budgetary change through utilizing ICT. Busan has a traditional correspondence framework which drew in the association to build up the cloud foundation. It interfaces schools, associations, occupants and government for driving sensible urban change. It can enhance city undertaking, singular satisfaction and nationals' way to associations. Beginning now and into the not so distant, a colossal number of employments or application change thoughts has been gotten; some new affiliations chose as new associations and different people selected as ace application makers. Thusly, engineers through a normal stage can work with the city to make awe inspiring city associations [2].

8.8.4 Nice, France

In Nice, France, the potential for usage of the web of vitality (IoE) was explored, and the IP-empowered innovation engineering, financial model and social advantages of IoE were tried and approved. At that point four shrewd city administrations were built up including keen lighting, brilliant flow, savvy squander administration and keen condition checking. As indicated by this venture, they discovered it is conceivable to apply logged information crosswise over various administrations. For instance, information caught by sensors for activity examples can serve for shrewd stopping and natural checking [3].

8.8.5 Padova, Italy

In the University of Padova, Italy,, as a team with the district of the city, began a task called Padova Smart City, which is a conspicuous case of private and open collaboration for running a brilliant city. The district as a money related support gives the required framework and spending plan and the college as a hypothetical gathering actualizes the brilliant city idea. As per this venture, different sorts of sensors are set on road light shafts and associated with the Internet through portals for gathering natural and open road lighting information by methods for remote hubs [3].

Natural parameters, for example, CO level, air temperature and moistness, vibrations, clamor, et cetera are gathered, while giving a straightforward however exact instrument to check the right task of the general population lighting framework by estimating the light force. In spite of the fact that this pilot venture is basic, it incorporates various gadgets and layer advancements that are illustrative of the greater part of the basic issues which ought to be dealt with it for plan a urban IoT.

8.9 IOT Smart City Fabric: Further Discussions

One of the missing connections in quickening the organization of IoT/CPS and keen city arrangements is the absence of an "availability texture"—a usually shared IoT/CPS arrange framework among urban areas and groups. Starting today, there is no simple component for an IoT answer for be sent and wind up operational in an attachment and-play way. For instance, a straightforward surge level sensor sent in one city may not have a similar spine framework required to trade information with sensors in different urban areas. The present scene of IoT and brilliant city is like that of the correspondences framework of pre-Internet days [14].

Beginning with its Challenge programs, NIST has officially made strides toward advancing agreement around reference structures for interoperability. Educated by GCTC, NIST has ventured out build up a global specialized open working gathering to help build up an "IoT-Enabled Smart City Framework."

8.10 Recommendations and Conclusions

Change of smart city game-plans and applications is continuing with apace, controlled by factors joining fast particular advance in zones, for example, IoT, cloud associations and gigantic information. For a city, with its a broad assortment of units and activities, making amazing open doors for interoperability among applications and types of progress and guaranteeing accommodating energies and economies of scale crosswise over completed them all is a basic test. Keeping up a key division from vertical designs that go about as storerooms is a fundamental key to progress. This will require a level point of view in which customary layers are made for different zones, with clear benchmarks and rules for applications and movements. It will be a key errand for each city to depict a "procedure" for its progress towards changing into a Smart City, i.e., what figured model for improvement is picked and how the city can make an open region that enables rivalry and OK collection and thusly change and change of new and productive advances and applications. Consistently, the associations gave by urban gatherings—everything from development control to senior care—are moving into a pushed situation or are being given automated bits or partner associations [18]. In this specific situation, it is fundamental that a city recognizes duty regarding the moved foundation, relatively as it authoritatively recognized obligation regarding direct associations and frameworks and guaranteed that they worked suitably together. Along these lines, the city will guarantee its key association and movement of the zones for which it is gifted, now and later on [10].

The reference demonstrate made inside the game plan of this report may fill in as a superior than normal clarification behind portraying the found out vision that each city needs to create and which ought to be away to make level strategies and stages that decrease the danger of vertical applications that can't be merged. Furthermore, the reference model may fill in as a state of excursion for discusses savvy associations proposed to facilitate for various urban zones and zones at the ordinary and national level. For typical reasons, the purpose of union of this report has been the bit of urban gatherings in relationship with the Smart City. Regardless, the national and EU-level moreover acknowledge an essential part in making the general conditions for a Smart City, both as impelling forces and clear picks of the distraction that help progress. Moreover, the national and EU level may have an integrative point of confinement and contribute with limits and trade of consideration [16].

8.10.1 The Smart City Reference Model

The reference show we have composed depends on six layers. By need, the model is a rearrangements of the real world, however it gives a city a common picture on which to base talks, inside and with different partners, of focal issues significant to a Smart City, for example, proprietorship, obligation, interoperability and gauges [4]. The six layers cover:

Foundation

- The foundation layer incorporates the settled framework, where fiber is the best and most future-confirmation arrangement. Fiber has no specialized restrictions and it conveys symmetrical, and significantly higher, information transmission speeds than alternate choices. Proprietorship and control of the foundation are indispensably vital to a city that needs an open and administrator impartial market demonstrate for its Smart City that empowers rivalry in the upper layers in the reference show.

Sensors

- The sensors layer alludes to the different gadgets (IoT gadgets, signals, and so on.) that are utilized to gather information and data inside the city. A Smart City ought to have a reliable procedure for the utilization of sensors with respect to models and conventions for encouraging information correspondences and making uniform information. The point here is to maintain a strategic distance from costs that may emerge later on when different verticals must be incorporated [5].

Information Stage

- The information stage level alludes to the total information and data that the city gathers and oversees. The city must guarantee receptiveness to huge information for the city's partners with the goal that the partners will have the capacity to join information focuses from various verticals keeping in mind the end goal to make valuable and productive administrations and applications. It is additionally vital for a Smart City to assemble an adaptable information stockpiling arrangement so as to evade pointless interests in framework that may quickly wind up out of date.

Applications

- The applications layer alludes to the arrangements and applications created for the city's partners and subjects. Most importantly, the city should go about as a specifier for applications, where it might ensure that whatever is left of the framework is set up to encourage for different on-screen characters to build up their applications.

Security

- The security layer alludes to the innovations, arrangements, and so forth, that will guarantee information security and protection over the city's answers and applications. The city ought to have a focal procedure for security and the introduction ought to be to have a fundamental on-screen character that is in charge of general control of the city's different even layers.

Market Models

The finish of the evaluation is that the Collaboration Model is the most appropriate for making a future-evidence, adaptable and development empowering model for Smart Cities. As per the Collaboration Model, the city accepts fundamental accountability for [4]:

- The fiber foundation, where the city itself and outside providers approach an administrator unbiased fiber framework, prompting an open and development benevolent Smart City.
- The indicating association that sets measures and techniques for the parts of both inward and outer performing artists in the model, and with level arrangements as an unmistakable target.

With respect to different parts of the reference show, the on-screen character that is most appropriate for the undertaking ought to be dependable; here, the city can play out these parts itself in the event that it is the most reasonable. Despite the decision, it is imperative that even arrangements and stages describe the brilliant city, with a view to evading vertical bolt ins that can conceivably turn out to be expensive and wasteful for a city from a long haul point of view.

References

1. Rathore, M.M., Ahmad, A., Paul, A., Rho, S.: Urban planning and building smart cities based on the internet of things using big data analytics. Comput. Netw. **101**, 63–80 (2016)
2. Zhu, C., Leung, V.C.M., Shu, L., Ngai, E.C.H.: Green internet of things for smart world. IEEE Access **3**, 2151–2162 (2015)
3. Botta, A., de Donato, W., Persico, V., Pescapé, A.: Integration of cloud computing and internet of things: a survey. Future Gener. Comput. Syst. **56**, 684–700 (2016)
4. Hancke, G., Silva, B., Hancke Jr., G.: The role of advanced sensing in smart cities. Sensors **13**, 393–425 (2012)
5. Strategic Opportunity Analysis of the Global Smart City Market: Available online: http://www.egr.msu.edu/~aesc310web/resources/SmartCities/Smart%20City%20Market%20Report%202.pdf. Accessed on 24 Feb 2017
6. Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M.: Internet of things (IoT): a vision, architectural elements, and future directions. Future Gener. Comput. Syst. **29**, 1645–1660 (2013)
7. Atzori, L., Iera, A., Morabito, G.: The internet of things: a survey. Comput. Netw. **54**, 2787–2805 (2010)
8. Internet of Things in 2020: Roadmap for the Future. Available online: http://www.smart-systemsintegration.org/public/documents/publications/Internet-of-Things_in_2020_EC-EPoSS_Workshop_Report_2008_v3.pdf. Accessed on 24 Feb 2017
9. Kosmatos, E.A., Tselikas, N.D., Boucouvalas, A.C.: Integrating RFIDs and smart objects into a unifiedinternet of things architecture. Adv. Internet Things **1**, 5 (2011)
10. Rawat, P., Singh, K.D., Chaouchi, H., Bonnin, J.M.: Wireless sensor networks: a survey on recent developments and potential synergies. J. Supercomput. **68**, 1–48 (2014)
11. Jaradat, M., Jarrah, M., Bousselham, A., Jararweh, Y., Al-Ayyoub, M.: The internet of energy: smart sensor networks and big data management for smart grid. Procedia Comput. Sci. **56**, 592–597 (2015)
12. Sharma, R.: Steps for implementing big data and its security challenges. In: Data Intensive Computing Application for Big Data. Advances in Parallel Computing series, vol. 29. IOS PRESS (Scopus Indexed) (2018). ISSN 1879-808X
13. Kyriazis, D., Varvarigou, T., White, D., Rossi, A., Cooper, J.: Sustainable smart city IoT applications: heat and electricity management amp; Eco-conscious cruise control for public transportation. In: Proceedings of the 2013 IEEE 14th International Symposium on "A World of Wireless, Mobile and Multimedia Networks" (WoWMoM), Madrid, Spain, pp. 1–5, 4–7 June 2013
14. Zanella, A., Bui, N., Castellani, A., Vangelista, L., Zorzi, M.: Internet of things for smart cities. IEEE Internet Things J. **1**, 22–32 (2014)
15. Jha, S., Kumar, R., Chatterjee, J.M., Khari, M.: Collaborative handshaking approaches between internet of computing and internet of things towards a smart world: a review from 2009–2017. Telecommun. Syst. 1–18
16. Ashton, K.: That 'internet of things' thing. RFID J. **22**(7), 97–114 (2009)
17. Xia, F., Yang, L.T., Wang, L., Vinel, A.: Internet of things. Int. J. Commun. Syst. **25**(9), 1101–1102 (2012)
18. Kopetz, H.: Internet of things. In: Real-time Systems, pp. 307–323. Springer, Boston (2011)

Chapter 9
Towards an Optimized Semantic Interoperability Framework for IoT-Based Smart Home Applications

Sivadi Balakrishna and M. Thirumaran

Abstract Nowadays, in the Internet of Things (IoT) applications, semantic interoperability is the new and disruptive buzzword for exchange the resources information in a consistent manner. Billions of heterogeneous resources are connected to the internet, not only from sensors and actuators but also from various IoT deployment models, a huge variety of data, high volume of data and low-level descriptive resources. Semantic interoperability problem is carried out in these heterogeneous IoT resources. To accomplish semantic interoperability in the Internet of Things (IoT) is a vital challenge. In retort to this, towards an optimized semantic interoperability framework has been proposed for generating the resources automatically. The corresponding semantic graphs are determining through IoT-based smart home resources from RESTful principles and to do operational behavioral of implicit links among IoT resources. In this chapter, the smart home resources have been taken and implemented through Restlet framework. Then the generated RDF graph is semantically interoperable and intercommunicated between the IoT based smart home resources. The proposed framework has been implemented on IoT-based cloud platform and has been compared with the existing state of the art schemes with obtained results. Finally, the obtained results show that the proposed framework is optimized towards the semantic interoperability in IoT domains for smart home applications.

Keywords Internet of Things (IoT) · Semantic interoperability
smart home · RESTful · Restlet · RDF

S. Balakrishna (✉) · M. Thirumaran
Department of CSE, Pondicherry Engineering College,
Pondicherry University, Pondicherry, India
e-mail: balakrishna.sivadi@gmail.com

M. Thirumaran
e-mail: thirumaran@pec.edu

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_9

9.1 Introduction

Nowadays, in the Internet of Things (IoT) applications, billions of heterogeneous resources are connected to the internet. Not only heterogeneous resources coming from sensors and actuators but also from various IoT deployment models, a huge variety of data, high volume of data and low-level descriptive resources. Semantic interoperability problem is carried out in these heterogeneous IoT resources. Already existing applications are vertically communicated with each other; therefore there is a gap for horizontal integration of IoT platforms. Various IoT Platforms like OpenHAB [1] and FIRWARE [2] have proposed management operations and non-linear data structures along with their own specifications. In these types of cases, heterogeneous IoT applications can not directly communicate with each other for accessing global information and more effort required across the IoT platforms. Up to now, achieving semantic interoperability is not the current needs of IoT applications. In simple words, we can say that semantic interoperability means understanding the exact meaning of resources and it should be operable in any platform which it is.

The year 2010 onwards, researchers have analyzing and implementing the IoT-based smart home applications by applying various kind of frameworks and approaches. To make the service as universally maintainable, web accessibility and accurately open IoT by combining web and Internet of Things emerges as the web of Things (WoT) [3]. To succeed the adaptation of Internet of Things to Web of Things most appropriate REST architectural style is used for IoT platforms [4]. The first to attain semantic interoperability, merging IoT with REST principles for performing resource manipulation and uniform operation, which is the one approach for getting the IoT-based heterogeneous resources and gains the service accessible. Nevertheless, semantically annotated data is losing in IoT platforms and resource consignments are vertically deployable along with independent silos owing to the heterogeneity of data models and the low-level resource descriptions. To achieve semantic interoperability, the key task is to combine the IoT via Semantics. Undoubtedly, the term smart home will improve the human's living day to day life become wider and smarter. The key idea for making things wider and smarter is to semantically interconnect the resources available in smart home domain. So that, our goal is reached by providing humans living life more reliable and maintainable. In the Internet of Things (IoT) applications, semantic interoperability is the new and disruptive buzzword for exchange the resources information in a consistent manner. Billions of heterogeneous resources are connected to the internet, not only from sensors and actuators but also from various IoT deployment models, a huge variety of data, high volume of data and low-level descriptive resources. Semantic interoperability problem is carried out in these heterogeneous IoT resources. To accomplish semantic interoperability in the Internet of Things (IoT) is a vital challenge. In retort to this, towards an optimized semantic interoperability framework has been proposed for generating the resources automatically to the corresponding semantic graphs through determining IoT based smart home resources from RESTful principles, glossing descriptions of resources and to do operational behavioral of implicit links among IoT resources. In this chapter, the smart home resources have been taken and implemented through Restlet framework tool. The generated RDF graph is semantically interoperable and intercommunicated between the IoT based smart home resources. Finally, the results show that the proposed framework is optimized towards the semantic interoperability in IoT domains for smart home applications.

9.1.1 Objective of the Proposed Work

The proposed semantic interoperability framework may contains the following list of objectives.

1. To propose an optimized semantic interoperability framework for IoT-based smart home applications using RESTful approach.
2. To provide the semantic annotations for the smart home resources.
3. To evaluate the performance of the proposed framework.
4. To compare the results of proposed work with existing approaches.

The rest of this paper is organized in the following manner: In Sect. 9.2 shows the background of the study, it includes-ontologies and standards, Mapping technologies for data models, integration of data and exchange systems and semantic annotations. The notations and modules used in this paper are elaborated in Sect. 9.3. Section 9.4 deals implementation architecture of the proposed framework and Sect. 9.5 show the Experimental results and analysis and finally the Sect. 9.6 can be conclusion and future work.

9.2 Related Work

In this section totally discuss related work of semantic interoperability in IoT platforms. Haslhofer and Klas [5] shown that comparative analysis and reports on metadata interoperability. Ibrahim and Hassan [6] proposed the semantic interoperability level for traditional service oriented systems and seamless interoperable applications. Zhang et al. [7] discussed how the cloud-based infrastructures will accomplish the interoperability. Representational State Transfer [REST] as an architectural style to provide well-known uniform interfaces by adopting IoT platforms to achieve semantic interoperability. The authors surveyed that, to gain semantic interoperability in IoT platforms, mainly divided into four categorical approaches. These are illustrated as follows:

1. Ontologies and Standards
2. Mapping Technologies for Data Models
3. Data Integration and exchange systems
4. Semantic Annotations.

9.2.1 Ontologies and Standards

These are the olden and reference approaches to achieve semantic interoperability in IoT domains. These Ontologies and standards also provide referenced data models for IoT platforms. Let us consider the approaches like GSMA [8] proposed to shows how IoT platforms and RESTful resources to manage semantic interoperability producing a declarative data model. OneM2M model based on Ontology [9] defines an acceptable framework for describing the semantically integrated data that have been managed in the execution of IoT based applications. These data declarative models gave a sound reference knowledge for thinking innovative way and to solve interoperability problems in IoT platform but solely not useful for overcome interoperability.

9.2.2 Mapping Technologies for Data Models

Peters [10] established a mapping model for combining linguistic and terminological approaches for obtaining interoperability. The mapping data models and technologies mainly helpful to track the information of the relation between syntax and structures. Nevertheless, mapping data models are individually specified models and resources can be constructed and integrated into vertical platforms without any flexibility to integrate external resources.

9.2.3 Data Integration and Exchange Systems

Lehti and Fankhauser [11] provides a data integration mechanisms for supposing different types of resources in a uniform way. While Thuy et al. [12], mentioned data exchange systems to restrict the data as per the global sources way. So far, both data integration and exchange systems require highly configurable mechanisms as well as taking consideration of new data models for every heterogeneous resource.

9.2.4 Semantic Annotations

Nowadays, these are the most powerful and popular mechanisms to achieve semantic interoperability in IoT platforms. The existing data models are updates with semantic annotations on providing semantic labels to become model elements. Andrew et al. [13] classifies their survey on semantic annotation approaches of RESTful services from the perspective of collaboration type, vocabulary type, and structural complexity. Saquicela et al [14] presented an approach semantic annotation using RESTful web services of cross-domain ontology technology, which will generate a good external resource for annotating IoT platforms. Even though these are good to provide external resources but still there is a limitation of semantic annotation approaches in the capture of implicit relationships between IoT platforms and resources.

Khaled and Helal [15], Proposed an interoperable framework for combining RESTful and topic-based protocols in IoT environment. They mentioned that the proposed ATLAS framework was taking low energy consumption for to design the IoT based heterogeneous resources or things. Jacoby et al. [16] have proposed a framework for to deliver the data communication between the Cloud to IoT applications in a optimized and efficient manner using appropriate benchmark algorithms for providing semantic interoperability. Plageras et al. [17] dealt that for embedding the things in smart home or smart building. They concluded that for analysing and operating the things in smart home applications there is a need of big data technologies to process the high volume of data occurring from various sensor devices.

In Internet of Things based applications, the smart home concept is the emerging space in recent years. To make the things to be smart in smart home applications, available all resources in that room is connected to the internet. Ghayvat et al. [18] proposed a smart home framework by integrating IoT devices like sensors, RFID cards, and Actuators to make resources smart using various kinds of wireless technologies. Soliman et al. [19] dealt on smart home appliances using ESP8266 platform and Arduino kit for embedding the resources wider. Lin et al. [20] convey their efforts in home automation using ZigBee technology and proposed home automation model by taking sensors and actuators. Antunes et al. [21] proposed an Iot-based smart home system for embedding service oriented approaches and IoT to make heterogeneous resources be semantically interconnected in smart home.

Lee et al. [22] deal that security is an emerging problem especially in IoT-based smart home application. The security issues might be consisting of physical security, authentication, confidentiality and integrity. For processing and implementing smart home application, the semantically interoperable things to be taken to the overall architecture or framework.

A sound number of frameworks and architectures are studied under literature survey. However, these all are not meet the needs of the users. So, in this chapter proposed a new and innovative semantic interoperability framework using RESTful resources and Ontology based matching and reasoning algorithms for smart home applications. Towards a merging combination of IoT and Cloud technologies is always give a better results in terms of efficient, reliable, scalable and secure compare to the state of the art schemes.

9.3 Semantic Interoperability Framework

In this section completely describes how the proposed semantics interoperability framework works. At first, REST resources have taken as input for IoT platforms and then get a semantically rich RDF graph iteratively through semantics interoperability. The semantic interoperability framework mainly consists of three modules namely-Syntax Processor, Semantic Annotator, and Correlation Analyzer. The Syntax Processor again divided into two sub-modules namely-REST Crawler and Syntax Extractor. The Semantic Annotator module again divided into three sub-modules namely-Ontology Matcher, Semantic Reasoner, and Classifier. These all are iteratively run through cycles and illustrated in Fig. 9.1.

Syntax processor goes for creating a preparatory RDF graph through finding the smart home resources and separating syntax data from smart home resource descriptions; Semantic annotator is used to semantically distinguishes the data and surmises the idea of graphs and nodes (i.e. sb as subjects, pr as predicates, and ob as objects) by partner them with ontology components (i.e. classes and properties);

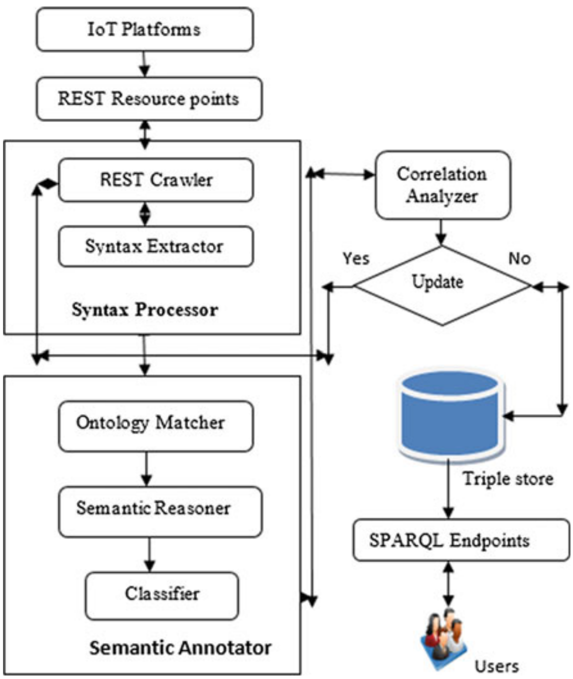


Fig. 9.1 Overview of the semantic interoperability framework

Then the Correlation Analyzer is used to catches the probable connections among smart home resources and domains by examining information designs.

Each and every inner module keeps running in succession toward the finish of one module cycle, the produced graph with RDF is sent to higher levels i.e. syntax processor to begin another cycle for upcoming destinations. Right off the bat, certain RDF graph components found by consecutive modules should be utilized by past modules in a next cycle to distinguish new graph components and graph relations. Besides syntax processor refreshes RDF graph if resources portrayals have changed amid the past cycle. The RDF graph naturally and incrementally becomes through these cycles. The emphasis has been stops when the corresponding graph has not yet refreshed from the past cycle. The produced RDF graph has the semantic descriptions of IoT resources and is the yield put away into a triple store giving a SPARQL endpoint to client objects. Also, IoT semantics extractor can continue the cycle when new data is acquired by any methods for example, by means of observing and notifications about any graph components and correspondently refresh the RDF graph. The following are the notations and modules used in this paper.

Notation 1: For Ontology

According to Cardoso et al. [23], an ontology 'Ont' consists—P is the core Ontology, Ax is the axioms, KBase is the knowledge base, and Lx is the lexicon and is mainly characterized by using 4-tuple:

$$\mathrm{Ont} := (\mathrm{P}, \mathrm{Ax}, \mathrm{KBase}, \text{and Lx})$$

Moreover, the core ontology P is described as 5-tuple: $\mathrm{P} := (\mathrm{CL}, <=\mathrm{CL}, \mathrm{RL}, \sigma, <=\mathrm{RL})$

Here, CL, RL is the two disjoint sets and these corresponding elements are outlined concepts 'cl' also known as 'classes' and relations 'rl' and some cases is also known as properties.

Notation 2: For RDF

RDF stands for Resource Description Framework (RDF) and outlined as for how to describe the resources available on the internet such as website content. This is also called as the directed graph having node set N and predicate set P.

$$\mathrm{RDF} := (\mathrm{NS}, \mathrm{PS}) \text{ where } \mathrm{n}s \in \mathrm{NS}, \mathrm{p}s \in \mathrm{PS} \text{ and } \mathrm{PS} = \mathrm{NS} * \mathrm{NS}$$

Here RDF statement is symbolized as Stmt and is demarcated as Stmt = <sb, pr, ob>, ($\mathrm{s}b \in \mathrm{NS}$, $\mathrm{p}r \in \mathrm{PS}$, $\mathrm{o}b \in \mathrm{NS}$) and sb is the subject, 'pr' is the predicate, and 'ob' is the object of the given statement.

9.3.1 REST Crawler

Sometimes REST Crawler behaves like web crawler and it takes REST resources as input entry points to discover RESTful resources and generates a URI graph of that particular resource. REST resource is well-designed and exposed links in external using HATEOAS [4] principle. So that the RESTful client resources are allowed to use media-type and resource identifiers in the process of service discovery.

So many numbers of formats are supported for HATEOAS principle usage in RESTful resources design. Out of these formats, mainly, categorized as two ways: one is the link along with a simple input URI demarcated as link.uri and another one is the simple URI along with return type of that resource demarcated as link. rel. The Link Header [24] and CoRE Link [25] formats are specified for RESTful design resources. The service discovery for extending smart thing using different formats are applied [26]. No need to understand much more about these formats, because these all are out of discussion scope. This process is formalized in the following Fig. 9.2. REST Crawler identifies the resource formats on the basis of a recursive process via media type discovery and extract the resources or links and presenting the appropriate RDF graph.

```
Algorithm for REST Crawling Process

Input. W: A group of REST entry resources.        Output:  RDF Graph
Resource Extraction
 for w ∈ W do
     RDF.M = RDF.M∪ {n}
        w. description = getDescription(w)
        w. format = getFormat (w. description)
        EL = extractLinks (w. description, w. format)
        (Here EL is the branch of the gathered links)
     Generating the Graph
        for resource ∈ EL do
            if(resource.rel≠null) ∩ (resource.uri ≠w)
                then RDF = RDF.addResource(<w, resource.rel, resource.uri>)
                    else if(resource.rel==null) ∩ (resource.uri ≠w)
                        then RDF = RDF.addResource(<w, rdf: predicate, resource.uri)
                                recuseLinkExtraction(resource)
                        end
                    end else if
                end
            end if
        end for
 end for
```

Fig. 9.2 REST crawling process

9.3.2 Syntax Extractor

In the first iteration, the REST crawler takes input entry points as resources and extracts the appropriate RDF graph. In the second iteration process, syntax extractor updates the extracted RDF graph as per the resource discovery media-type—so many other alternative ways are existing for extract the data from REST resources of various formats to generate a RDF graph. The syntax extractor role in our framework is illustrated as following simple steps and the algorithm for syntax extraction process is shown in Fig. 9.3.

1. Take a JSON based resource URI and corresponding "Subject" is to be developed.
2. Then use key-value pairs, here keys are used to produce predicates for the RDF graph and the values are generated for the objects.
3. If one value of a key k is not matched with the object Obj of JSON format, then create a dummy node called "anode" for the object k key object and a key-value pair behaves like Obj. "rdf: predicate" as subject is generated as the predicate of given array list of elements and the RDF objects are the value of array elements.
4. If there is a redundancy in generated RDF graph an elimination algorithm [27] is applied for reducing redundancy.
5. After successful execution of above steps, one end of the extraction process, each and every REST resource corresponding RDF graph is generated with class is "rdfs:Resource" and each and every literal corresponding to RDF graph generated with class is "rdfs:Literal".

Here, presented a recursive iterative process is to produce a RDF graph from the given JSON document format structure. If any other format is not in JSON, first it may transform to JSON format and processed. JSON format is built on two ways: (1) key-value pair (2) array. Syntax extractor is used to updates the RDF graph (comes from REST Crawler output). It records the changes in resource and provisions the information in a table "TP" and change "Chng" is defined using a four-tuple principle as follows.

$$\text{Chn}g = <\text{Uri}, \text{Timestamp ts}, \text{Key k}, \text{Value v} > \ \text{and Chng} \in \text{TP}.$$

Here, Uri is the changed resource URI, Timestamp is the changed timestamp, Key is the changed key, and Value is the changed value.

9.3.3 Ontology Matcher

In this module, it identifies the RDF graph data established on semantic key words. By using these semantic keywords, we matched the RDF graph predicates of REST resources and descriptions against the properties and classes respectively. Khan and Safyan [28] implemented the semantic matching algorithm for ontology hierarchies.

Algorithm for Syntax Extraction Process

```
Input. SEP: RDF            Output: RDF
Syntax Graph Extraction
for w ∈ RDF.W do
    RDF.W = RDF.W∪ {e}
        w. description = getDescription(w)
        RDF =  extract Descriptions( w.description, JSON)
    for w ∈ RDF.W do
        if (w.hasURI())
            then RDF=RDF.addResource(<w, rdf:type, rdfs:Resource or Thing>)
                else RDF= RDF.addResource(<w, rdf:type, rdfs:Literal or Constant >)
                end else
            end
        end if
    end for
end for
Repeat N (n>1). Then Update the Graph
 if ∃chng∈TP, (chng.TimestamRepeat_n-2) ∩ (chng.Timestamp<Repeat_n)
     then RDF = RDF.updateDescriptions(chng, JSON)
      end
 end if
```

Fig. 9.3 Syntax extraction process

Let us consider the notation "$A \overset{m}{=} B$" symbolizes that a RDF graph element A is matched with another RDF graph element B. The ontology matching algorithm process is shown in Fig. 9.4. In order to deal with multiple matching items with one RDF graph to another RDF graph, the ontology alignment algorithm [29] is applied.

9.3.4 Semantic Reasoner

Semantic reasoner deals with properties and classes occurred in RDF graph established on ontology ranges and domains. Therefore, RDF graph is enriched by adding supplementary predicates and the inference process of semantic reasoner is shown in Fig. 9.5. Finally, RDF graph is refined by adding semantic rules. Again, to understand how one RDF graph elements is matches with another RDF graph elements, an ontology alignment algorithm [29] is applied.

The semantic reasoner enriching process is shown in Fig. 9.6. This entire process is based on 5 simple features of the properties used in ontology specified in Ontology Web Language (OWL) as like this, here P is the ontology property and a, b, and c are the three RDF nodes.

Algorithm for Ontology Matching Process

```
Input: RDF Graph                                Output: RDF Graph
Class Matching
 for w ∈ RDF.W do
   if ∃ uri,  ∃c∈Ont.S.C, (w.hasURI()) ∩
     (uri == <w, rdf:type, rdfs:Resource>)∩ (c ≞ w)
        then RDF= RDF.removeUri(uri)
             RDF = RDF.addUri(<w, rdf:type, c>)
        end
     end if
  end for
Property Matching
 for pr ∈ RDF.PR  do
     if ∃rl ∈ Onto.SeR, ¬(pm.hasNamespace()) ∩ (pm ≞ rl)
         then RDF = RDF.replace(pm, rl)
                         (Here predicate pr is replaced by relation rl)
               else if  ∀rl ∈ Ont.SeR, ¬(pr.hasNamespace()) ∩ ¬ (pr ≞ rl)
                    then RDF = RDF.replace(pr, rdf:predicate)
                    end
               end else
            end
       end if
  end for
```

Fig. 9.4 Ontology matching process

(i) TransitiveProperty: $\mathrm{p}(\mathrm{a}_1, \mathrm{b}_1) \cap \mathrm{p}(\mathrm{b}_1, \mathrm{c}_1) = > \mathrm{p}(\mathrm{a}_1, \mathrm{c}_1)$
(ii) SymmetricProperty: $\mathrm{p}(\mathrm{a}_1, \mathrm{b}_1) = > \mathrm{p}(\mathrm{b}_1, \mathrm{a}_1)$
(iii) FunctionalProperty: $\mathrm{p}(\mathrm{a}_1, \mathrm{b}_1) \cap \mathrm{p}(\mathrm{a}_1, \mathrm{c}_1) = > \mathrm{b}_1 == \mathrm{c}_1$
(iv) InverseOf: $\mathrm{pl}(\mathrm{a}_1, \mathrm{b}_1) = \; > \mathrm{p2}(\mathrm{b}_1, \mathrm{a}_1)$
(v) InverseFunctionalProperty: $\mathrm{p}(\mathrm{b}_1, \mathrm{a}_1) \cap \mathrm{p}(\mathrm{c}_1, \mathrm{c}_1) = \; > \mathrm{b}_1 == \mathrm{c}_1$.

In this case, the uri is the uniform resource identifier exists, here uri1 = <room1, dogont: hasSensor, PresenceSensor>. "dogont: hasSensor" is generated the property "dogont: SenseOf" and is same as InverseOf the property. Then the semantic reasoner combines another "uri" to the RDF graph:

$$\mathrm{uri2} = <\mathrm{presenceSensor}, \mathrm{dogont:}\ \ \mathrm{sensorOf}, \mathrm{room1} >$$

For reasoning and classification of the taken smart home resources, the semantic reasoner is to deliver a RDF graph as much as rich and well-connected.

These are the semantic rules for semantic reasoner refining process for RDF graph elements. Here, 'SeR' is the Semantic Reasoner and is in the form of implication rule among ancestor 'anc' and consequence 'conseq' has been stated as:

Algorithm for Inference process of a semantic reasoner

```
Input is RDF Graph.                         Output is RDF Graph
Inferring the Class
 if ∃uri  ∃rl∈Ont.SeR, (uri. pr==rl) ∩ (domain(rl) ≠ null) ∩ (rang(rl) ≠ null
    then RDF = RDF.addUri(<uri. s, rdf: type, domain(rl)>)
         RDF = RDF.addUri(<uri. o, rdf: type, rang(rl)>)
    end
end if
Matching the Property
 if ∃uri  ∃rl∈Ont.SeR, (rdf: type (uri. s, ran(rl)) ∩ (rdf: type (uri. o, domain(rl)) ∩
    (rdfs: subClassof (rl, uri. pr))
     then RDF=RDF.addUri(<uri. s, rl, uri. o>)
          RDF=RDF.removeUri(uri)
     end
 end if
```

Fig. 9.5 Inference process of semantic reasoner

$$\mathrm{SeR} := (\mathrm{anc} => \ \mathrm{conseq}), \mathrm{SeR} \in \mathrm{SeRL}$$

where SeRL is the semantic rule set. In our framework 'SeR' role taken from two different approaches:

(i) The first one 'Ax' is the axioms in the definition of ontology and
(ii) The automatic extraction of patterns from our linked object's data by applying mining algorithm [30] and making semantic rule transformation.

The entire semantic reasoning iterative process is symbolized as in Fig. 9.7. This comes from the semantic reasoner enriching process. Let us consider the taken smart home application RDF resources, here, d is an ontology instance class is going to support "rdfs: Resource" and the 'uri' is the uri statement occurs in the RDF graph, where

$$\mathrm{uri1} = <\mathrm{d}, \mathrm{dogont} : \mathrm{hasSensor}, \mathrm{doorSensor} >$$

The semantic rule of the above uri1 rule exists as

$$\mathrm{St} = (\text{dogont: hasSensor}(\mathrm{x}, \text{dogont: DoorSensor}) = > \mathrm{rdf} : \mathrm{type}(\mathrm{x}, \text{dogont: Door})$$

The semantic reasoner can be refining that d is the resource instance of class "dogont: Door".

Algorithm for an enriching process of a semantic reasoner

Input: RDF. Output: RDF
Enriching Transitive Property (TP)
if ∃link, ∃a_1, a_2, a_3 ∈ RDF.A, $\exists b \in RDF.B$, b (a_1, a_2) ∩ b (a_2, a_3) ∩
(link==<b, rdf: type, owl: TransitiveProperty (TP)>)
then RDF=RDF.addLink(<a_1, b, a_3)
end
end if
Enrichment for Symmetric Property (SP)
if ∃link, ∃a_1, a_2, ∈ RDF.A, $\exists b \in RDF.B$, b(a_1, a_2) ∩
(link==<p, rdf: type, owl: SymmetricProperty (SP)>)
then RDF=RDF.addLink(<a_2, b, a_1)
end
end if
Enrichment for Functional Property (FP)
if ∃link, ∃a_1, a_2, a_3 ∈ RDF.A, $\exists b \in RDF.B$, b (a_1, a_2) ∩ b (a_1, a_3) ∩
(link==<b, rdf: type, owl: FunctionalProperty (FP)>)
then RDF=RDF.addLink(<a_2, owl: sameAs, a_3>)
end
end if
Enrichment for Inverseof (Iof)
if ∃link, ∃a_1, a_2, ∈ RDF.A, ∃b_1, $b_2 \in RDF.B$, b (a_1, a_2) ∩
(link==<b_1, rdf: type, owl: Inverseof (Iof)>)
then RDF=RDF.addLink(<a_2, b_2, a_1)
end
end if
Enrichment for Inverse Functional Property (IFP)
if ∃link, ∃a_1, a_2, a_3 ∈ RDF.A, $\exists b \in RDF.N$, b (a_2, a_1) ∩ b (a_3, a_1) ∩
(link==<b, rdf: type, owl: InverseFunctionalProperty (IFP)>)
then RDF=RDF.addLink(<a_2, owl: sameAs, a_3>)
end
end if

Fig. 9.6 Enriching process of a semantic reasoner

9.3.5 Classifier

When none of the efficient rule is useful for to support the semantic reasoning then classifier is used to analyze the RDF graph resource with other relation elements with pre-trained classification approach to reassemble the RDF graph. Gao and

Algorithm for refining process of a semantic reasoner

Input is taking as RDF graph. Output is generated RDF

1. **if** $\exists SeR \in$SRL, SeR=(anto=>conseq), ∃subgph, subgph==anto
2. // here subgph is the graph generated from RDF graph
3. **then** RDF=RDF.addSubGraph(conseq)
4. **end**
5. **end if**

Fig. 9.7 Refining process of a semantic reasoner

Mazumdar [31] proposed the ontology classification algorithm for "exploiting the linked open data" is used in our approach to develop the classifier and use classification model for better optimization using class induction. In order to produce classification model, the training process is dynamic nature consists of three steps: (i) Pre-processing of data (ii) Feature extracting of data (iii) Training the classifier.

9.3.6 Correlation Analyzer

The role of correlation analyser is to add supplementary inbuilt links by taking data change correlations among IoT resources. Data change correlation supports more than two resources to pattern the data at a time. Anyone of the resource states is changing, at a time period 'tpp', the other resource state also correspondingly changes. This situation happens between these resource states more than a number of times 'ttm' then said to be that correlation pattern is in a well-defined manner and detected as denoted as 'ptrn'. Then the correlation analyser reduces the concealed association exists among two IoT resources. The relation of resources "biotop: PhysicallyConnectedTo" is processed for the connected resources. This entire process is depicted in the following Fig. 9.8.

In this semantic interoperability framework, we clearly noticed that whenever the "room1" presence state changes, automatically the "corridor" presence state also changes. After that, the presence nature state of "corridor" changes, subsequently the "room2" presence state is also changes. Finally, after careful observation of these presence state changes, we are going to create two on going relations between "corridor" and "room1" is "skos: related" and same is also used among "corridor" and "room2". This entire iterative process is auxiliary refined using classifier approach.

Algorithm for Link Extraction process

Input is taking as RDF and TP   Output is corresponding RDF graph

Coincidental Detection
  for $chng_i \in TP$, $chng_j \in TP$, $i \neq j$
    if ($chng_i$, tstamp-$chng_j$. tstamp<tpp)
      then $ptrn_{ij}$ = <$chng_i$.uri, $chng_j$.uri>
        PTRN= PTRN ∪ {$ptrn_{ij}$}
          // PTRN denoted as repeatable group of patterns
      end
    end if
  end for
  Generating the Relation
    if $\exists p_1 \in$ RDF.P, $\exists p_2 \in$ RDF.P (PTRN.countPattern(p_1, p_2)>ttm)
      then RDF=RDF.addUri(<p_1, skos: related, p_2>)
      end
    end if

Fig. 9.8 Link extraction process

9.4 Implementation Architecture

In this section, completely shows the implementation architecture of the semantic interoperability framework modules as shown in Fig. 9.9. To implement this, we need to install Restlet framework available on (https://restlet.com) and create a REST server and REST client for storing and developing the framework respectively. DELL laptop with the sound network configuration is: 4 GB RAM, 1 TB HDD, Windows 10 operating system. The REST crawler is implemented on Restlet using JSON format data. The syntax extractor is developed on Restlet by taking GSON format from JSON format to extract the syntax of the given resources. Here REST server plays a crucial role in changing the client resources sent by the server events. In smart home application, the tp value is set to 2 min as minimum and the tt value is set to 20 min as the maximum.

To demonstrate the idea of semantic interoperability framework in IoT platforms, we took a smart home application, in which one big corridor is connected to two separate rooms on the same floor of the same building. Here first room is furnished with an electric lock door and a presence sensor. The second room is having presence sensor and a door sensor. The presence sensor is suited for the corridor.

The three smart home entities use various IoT domain properties to produce their specifications. Datavenue [32] is for room1, FIWARE [2] is for room2, and OpenHAB [1] is for corridor. We can clearly observe that these all are different types of formats used in smart home applications. So that, this type of IoT based

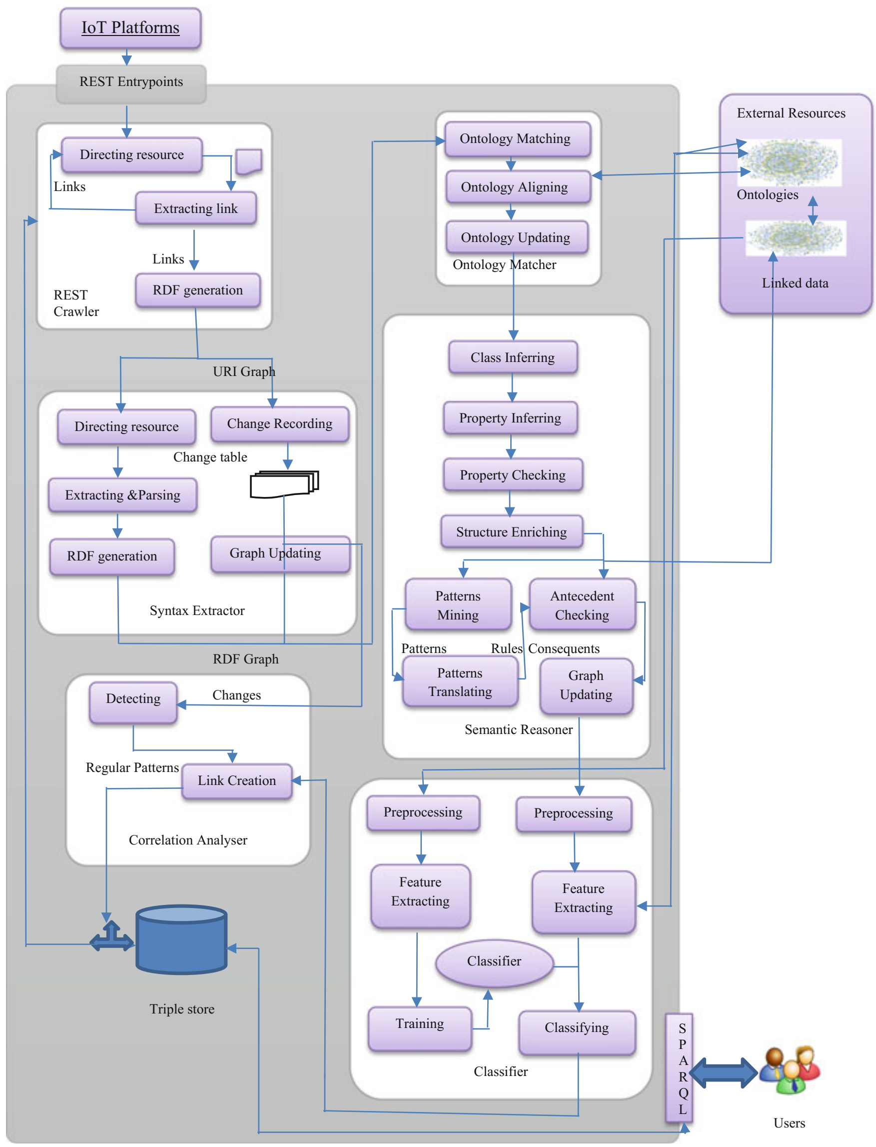


Fig. 9.9 Implementation architecture

smart home structure facing two problems—The first problem depicts how these IoT domains internally communicate with each other even though they are using different formats and APIs. The second problem is how the global information of the proposed smart home application is to be obtained. Technically these all problems can be solved by accessing and deploying these in separately. So at that time, no problem can be faced. But in order to interoperable in one form that is a big task.

The using of three different formats of resources can expose their REST URIs through user interfaces and descriptions. In the earlier stage, we get three distinct URIs for three different formats. Here we are presenting semantic interoperability frame work in smart home applications using IoT interfaces, which incrementally produces the semantically efficient and well-connected RDF graph from the smart home domain REST interfaces.

REST Crawler has been applying an iterative process of recognizing the smart home resources using MIME-media type like HTTP header. The following Fig. 9.10 shows the equivalent RDF graph after mining links from URI descriptions.

After that, syntax extractor is applying on crawling result by means of RDF graph, which comes from the REST crawlers output. The below Fig. 9.11 depicts the equivalent syntactically extracted RDF graph. The produced RDF graph along with the three generated sub graphs supports three different IoT domains. In order to enrich the process depiction, we used only RDF nodes highlighted in the syntax extractor graph output.

In [33] dogont ontology is obtained for usage of RDF graph. Thereafter, the resources “doorActuator”, “presenceSensor”, and “room1” is acknowledged with “dogont: DoorActuator”, “dogont: PresenceSensor”, and “dogont: Room” respectively. Using ontology matching algorithm, the subgraph is generated according to the iterative way of process as shown in Fig. 9.12.

Once the process of ontology matching is completed, then the subject “room1” along with the object “presenceSensor” predicate is available and still it is not identified. So, we can add the predicate as “dogont: hasSensor” as shown in Fig. 9.13. The refinement of semantic reasoner and second cycle of inferring semantic reasoner process is shown Fig. 9.14.

In [34, 35], the ontologies are defined of type SKOS and S4EE. For this case, “skos: related” is one relation between the two rooms and one corridor with the help of correlation analyser comes in subsequent unit. The classifier can again be divided this relation into “biotop: physicallyConnectedTo” and is shown in the following Fig. 9.15.

The Fig. 9.16 shows the final output generated by the semantic interoperability framework and the Linked Open Vocabularies [36] is used ontologies in this process. Finally, achieved our target as to support the internal communication

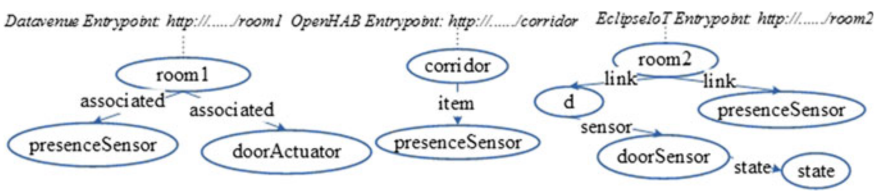


Fig. 9.10 REST URIs

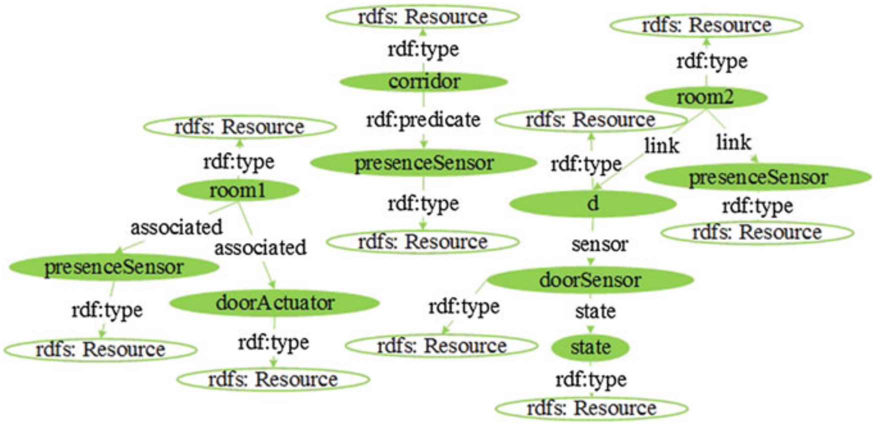


Fig. 9.11 Syntax extractor output

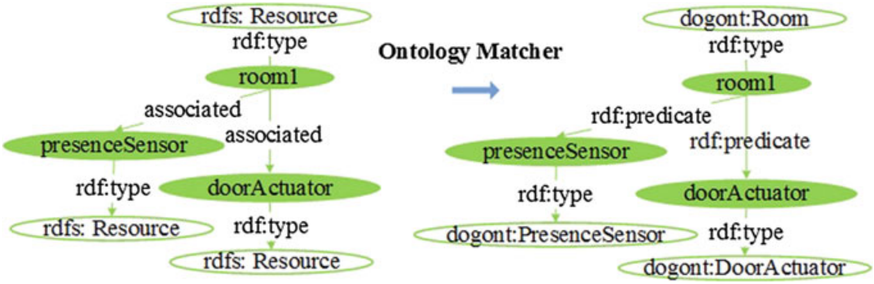


Fig. 9.12 Ontology matching

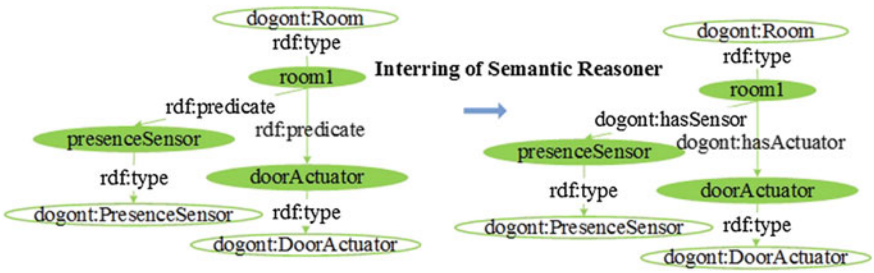


Fig. 9.13 Inferring of semantic reasoner

between the three IoT domain resources and accepts the global query using uniform interfaces isolation like SPARQL. Compare with previous resource URIs used in the RDF graphs, as it will be more beneficial towards the user satisfaction of global query interaction.

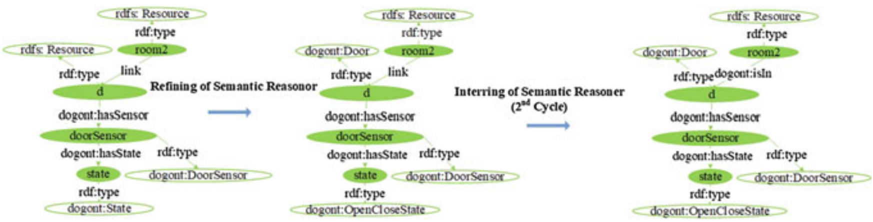


Fig. 9.14 Refining of semantic reasoner

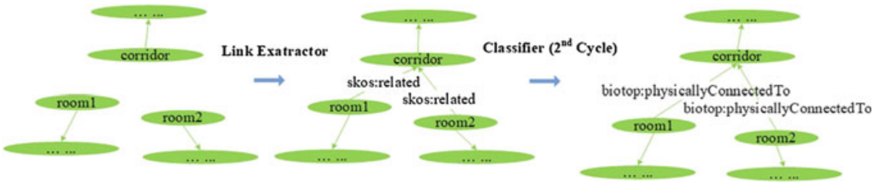


Fig. 9.15 Link extraction and classifying

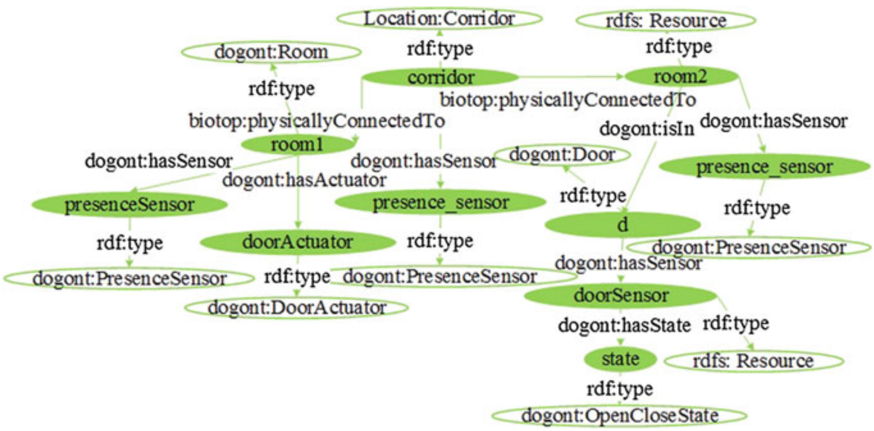


Fig. 9.16 Semantic interoperability framework generated RDF graph output

9.5 Experimental Results and Analysis

Experimented the proposed semantic interoperability framework in a public domain Cloud platform provisioned by Amazon EC2. To address the problem of interoperability in smart home applications and measure the performance of this framework by consideration of qualitatively analyze and evaluation.

Table 9.1 Public cloud platform configurations for smart home

Public cloud platform	Configuration details			
	Hardware	OS	Virtualization s/w	Management s/w
ThingSpeak cloud	CPU used: Intel Xeon E9-5840v5 RAM: 4 GB Memory: 1 TB	Windows 10 Home	VMware vSphere s/w	VMware vCenter s/w
Ubidots cloud	CPU used: Intel Xeon E6-4381v4 RAM: 4 GB Memory 1 TB	Ubuntu server 16.04 LTS	KVM s/w	OpenStack s/w

9.5.1 Experimental Setup

These experiments are carried out by a smart home public Cloud platform, which has to be reinforced by the IoT analytics cloud platform and also an Ubidots public Cloud platform for smart home is accredited by Table 9.1 shows the smart home cloud platform configurations. In the first ThingSpeak public cloud platform that executed home devices and supporting home appliances on testing various network connection technologies are provisioned by divergent vendors. In the second Ubidots public cloud platform executed bathroom and kitchen home devices and supporting the appropriate home appliances are provisioned by divergent vendors and testing various network connection technologies.

9.5.2 Performance Measures

For effective communication between the smart home applications for supporting semantic interoperability over the heterogeneous platforms. Response time and Standard deviation are taken for evaluating performance.

9.5.2.1 Response Time

This is the total time counts the interval between a request and responses. The response time is the maximum executing time connected by the smart home applications through the systems tasks. The main reason for these cloud platforms is using to measure the response time among the smart home applications. Subsequently, the performance is to be calculated our proposed semantic interoperability framework with reference to this measured response time of chosen smart home resources.

9.5.2.2 Standard Deviation

Standard deviation is a statistical measure and is used to apply on dispersion of big data sets. This is represented by sigma 'σ'. It is relative to the mean value and is square root of variance. The standard deviation is denoted as 'STDEV' and for calculating samples using this formula.

$$STDEV = \sqrt{\frac{\sum (x - \bar{x})^2}{N}},$$

where x is the number of samples and $\bar{x}$ is the mean of the samples.

9.5.3 Performance Evaluation

Let us consider the two network bearings of different category. The first chosen network bearing is without any workload and the second chosen network bearing is with loads (512 kbps). Here, mainly concentrating on consumers as well as their supporting smart home target devices and these was be experimented on two test beds—namely in Fig. 9.17a shows the same public cloud platform the response time is find out by taking 500 samples of smart home resources. In Fig. 9.17b shows the different private cloud platforms the response time is find out by taking 500 samples of smart home resources to achieve semantic interoperability problem in IoT platforms. Finally, the results in Table 9.2 shows that our proposed framework is optimized towards the semantic interoperability in IoT domains of smart home appliances.

9.5.4 Comparison of the Proposed Framework with Exiting Approaches

For comparing the obtained results with existing approaches using two different conditions. The first one is evaluating the performance in same cloud platform and second one is different cloud platform. Table 9.3 shows the average response time in same cloud platform on various frameworks with loads (512 kbps) and without any loads. The authors has calculated average response time with loads as 34.62 (ms) and without any loads as 21.54 (ms). So, these results has been compared with existing framework results as shown Table 9.3 and it concludes that the proposed framework is more optimized for smart home applications

Table 9.4 shows the average response time in different cloud platform on various frameworks with loads (512 kbps) and without any loads. The authors has calculated average response time with loads as 64.28 (ms) and without any loads as

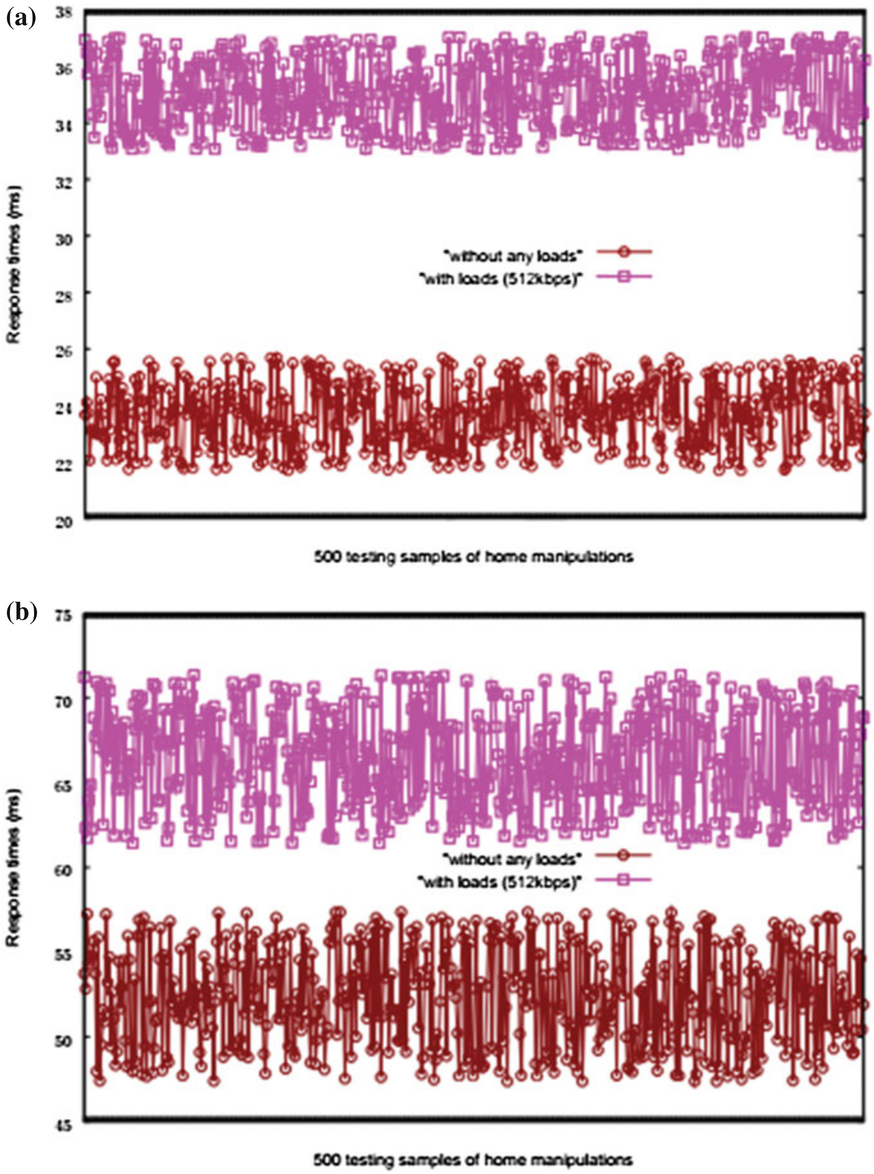


Fig. 9.17 **a** Response times in same public cloud platform **b** Response times in different public cloud platforms

51.03 (ms). So, these results has been compared with existing framework results as shown Table 9.4 and it concludes that the proposed framework is more optimized for smart home applications.

Table 9.2 Response times comparison for smart home appliances

Performance evaluation		Same public cloud platform	Different public cloud platform
Average response time (ms)	With loads (512 kbps)	34.62	64.28
	Without any loads	21.54	51.03
Standard deviation (ms)	With loads (512 kbps)	10.45	14.56
	Without any loads	5.86	7.58

Table 9.3 Performance evaluation using average response time in same cloud platform

Frameworks	With loads (512 kbps) (ms)	Without any loads (ms)
One M2M [9]	83.52	51.35
GSMA [8]	65.64	45.86
symbIoTe [16]	71.23	41.46
ATLAS [15]	50.26	30.40
Proposed	**34.62**	**21.54**

Table 9.4 Performance evaluation using average response time in different cloud platform

Frameworks	With loads (512 kbps) (ms)	Without any loads (ms)
One M2M [9]	196.2	144.03
GSMA [8]	125.56	90.58
symbIoTe [16]	104.38	75.35
ATLAS [15]	84.31	67.23
Proposed	**64.28**	**51.03**

Table 9.5 Performance evaluation using standard deviation in same cloud platform

Frameworks	With loads (512 kbps) (ms)	Without any loads (ms)
One M2M [9]	20.75	12.86
GSMA [8]	17.76	10.16
symbIoTe [16]	14.50	8.68
ATLAS [15]	13.87	7.92
Proposed	**10.45**	**5.86**

Table 9.5 shows the standard deviation time in same cloud platform on various frameworks with loads (512 kbps) and without any loads. The authors has calculated got standard deviation time with loads as 10.45 (ms) and without any loads

Table 9.6 Performance evaluation using standard deviation in different cloud platform

Frameworks	With loads (512 kbps) (ms)	Without any loads (ms)
One M2M [9]	24.64	17.92
GSMA [8]	21.32	14.88
symbIoTe [16]	19.16	12.45
ATLAS [15]	17.20	10.34
Proposed	**14.56**	**7.58**

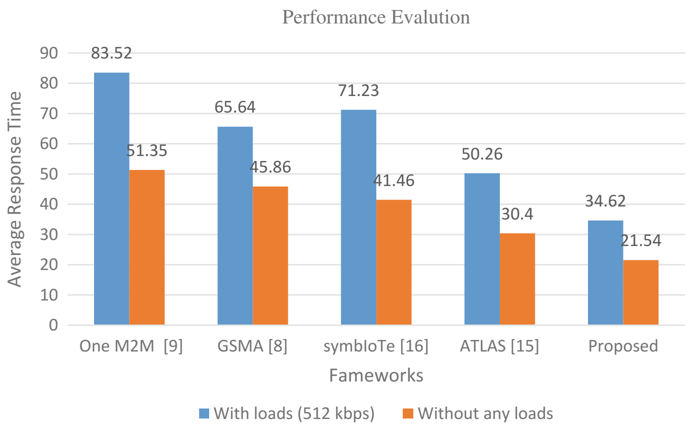


Fig. 9.18 Performance evaluation in same cloud platform

as 5.86 (ms). So, these results has been compared with existing framework results as shown Table 9.5 and it concludes that the proposed framework is more optimized for smart home applications.

Table 9.6 shows the standard deviation time in different cloud platform on various frameworks with loads (512 kbps) and without any loads. The authors has calculated the standard deviation time with loads as 14.56 (ms) and without any loads as 7.58 (ms). So, these results has been compared with existing frameworks as shown in Table 9.6 and it concludes that the proposed framework is more optimized for smart home applications.

The Figs. 9.18 and 9.19 shows the corresponding average response time values of Tables 9.3 and 9.4 respectively. Both Figs. 9.18 and 9.19 showing that comparison of average response times with various frame works by applying with loads (512 kbps) and without any loads on same cloud platform and different cloud platforms respectively. Finally, it concludes that the proposed framework is more optimized for smart home applications.

The Figs. 9.20 and 9.21 shows the corresponding standard deviation time values of Tables 9.5 and 9.6 respectively. Both Figs. 9.20 and 9.21 showing that comparison of standard deviation times with various frame works by applying with loads (512 kbps) and without any loads on same cloud platform and different cloud

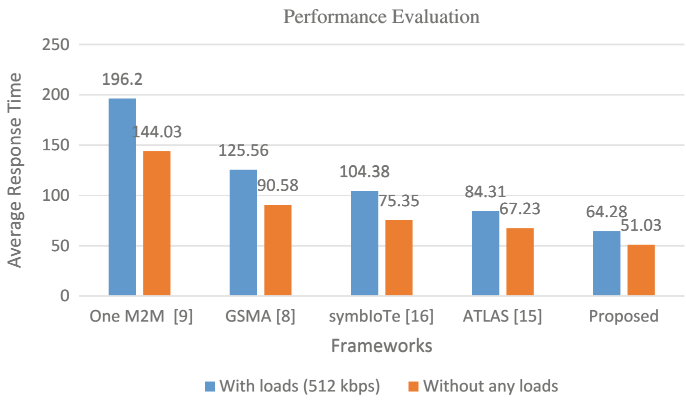


Fig. 9.19 Performance evaluation in different cloud platform

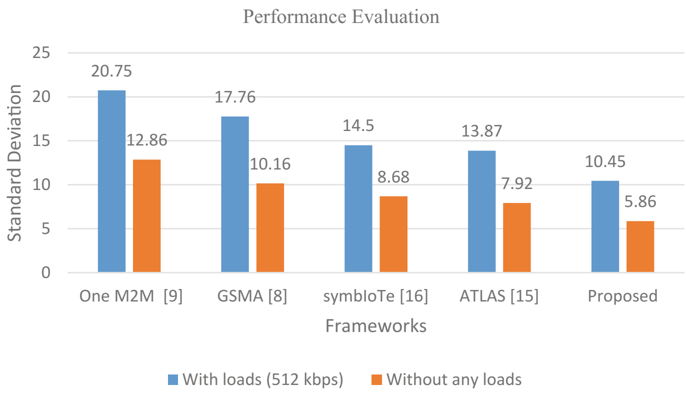


Fig. 9.20 Performance evaluation in same cloud platform

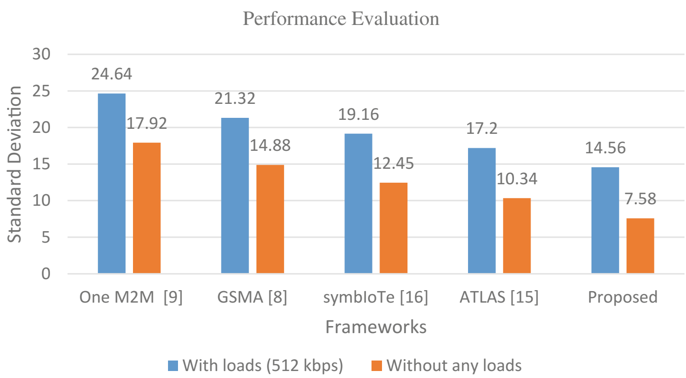


Fig. 9.21 Performance evaluation in same cloud platform

platforms respectively. Finally, it concludes that the proposed framework is more optimized for smart home applications.

9.6 Conclusion and Future Work

Supporting semantic interoperability in Internet of Things domains is a big task in and over the field. We have presented the semantic interoperability framework for automatic generation of RDF graphs (semantically rich and well-connected) using REST principles. It also supports syntax data, semantically rich, semantic annotations and providing additional functionalities and relations between IoT domains by considering smart home resources. Applying the smart home IoT -based resources using Restlet framework through systematic iterative manner for succeeding semantic interoperability problem. Finally, the authors generated the RDF graph for making the smart home resources is interoperable and inter-communication.

Even though our framework is developed with IoT REST principles, the same framework process can also have applied by considering heterogeneous databases and SOAP protocol for other IoT interfaces in one side. And in other side the proposed framework has been implemented on IoT-based cloud platform for measuring response time. Finally, the framework is compared with existing framework and the obtained results shown that proposed framework is optimized for smart home applications. In future work, the framework is backtracked with more enriched descriptions and interfaces for semantically well. The correlation analyser module can improve by providing the rich vocabularies and correlation patterns for effective validating the IoT resources.

References

1. OpenHAB.: https://my.openhab.org/docs
2. Connection to the Internet of Things FIWARE.: https://www.fiware.org/devguides/connection-to-the-internet-of-things/
3. Petrolo, R., Loscri, V., Mitton, N.: Towards a smart city based on cloud of things, a survey on the smart city vision and paradigms. T. Emerg. Telecommun. Technol., IEEE, **28**(1), pp. 1–19 (2017)
4. Richardson, L., Ruby, S.: Farnham O'Reilly "RESTful web service" (2007)
5. Haslhofer, B., Klas, W.: A survey of techniques for achieving metadata interoperability. ACM Comput. Surv. **42**(2), 1–37 (2010)
6. Ibrahim, N.M., Hassan, M.F.: A Survey on Different Interoperability Frameworks of SOA Systems towards Seamless Interoperability. In: Information Technology (ITSim), 2010 International Symposium in, vol. 3, pp. 1119–1123 (2010)
7. Zhang, Z., Wu, C., Cheung, D.W.: A survey on cloud interoperability: taxonomies, standards, and practice. ACM SIGMETRICS Perform. Eva. Rev. **40**(4), 13–22 (2013)
8. GSMA.: IoT Big Data Harmonised Data Model (2016)
9. OneM2M Technical Specification.: Base Ontology (2015)

10. Peters, W.: Establishing Interoperability Between Linguistic and Terminological Ontologies, pp. 27–42 (2013)
11. Lehti, P., Fankhauser, P.: XML data integration with OWL: Experiences and challenges. In: Applications and the Internet, pp. 160–167 (2004)
12. Thuy, P.T.T., Lee, Y.-K., Lee, S., Jeong, B.-S.: Exploiting XML Schema for Interpreting XML Documents as RDF, pp. 555–558 (2008)
13. Andrews, P., Zaihrayeu, I., Pane, J.: A Classification Of Semantic Annotation Systems (2010)
14. Saquicela, V., Vilches-Blázquez, L.M., Corcho, Ó.: Semantic annotation of RESTful services using external resources, Springer (2010)
15. Khaled, A.E., Helal, S.: Interoperable communication framework for bridging RESTful and topic-based communication in IoT. In: Future Generation Computer Systems, pp. 1–24. Elsevier, (2018)
16. Jacoby, M., Antonic, A., Kreiner, K., Lapacz, R., Pielorz, J.: "Semantic interoperability as key to IoT platform federation" in LNCS 10218: Interoperability and Open-Source for the Internet of Things, pp. 3–19 (2017)
17. Plageras, A.P., Psannis, K.E., Stergiou, C., Wang, H., Gupta, B.B.: Efficient IoT-based sensor BIG Data collection-processing and analysis in Smart Buildings. In: Future Generation Computer Systems, pp. 1–16. Elsevier (2017)
18. Ghayvat, H., Mukhopadhyay, S., Gui, X., Suryadevar, N.: WSN-and IOT-based smart homes and their extension to smart buildings. Sensors **15**(5), 10350–10379 (2015)
19. Soliman, M., Abiodun, T., Hamouda, T., Zhou, J., Lung, C.H.: Smart home: Integrating Internet of Things with web services and cloud computing. In: IEEE International Conference on Cloud Computing Technology and Science (CloudCom), IEEE, vol. 2, pp. 317–320 (2013)
20. Lin, H.T.: Implementing smart homes with open source solutions. Int. J. Smart Home **7**(4), 289–295 (2013)
21. Antunes, M., Gomes, D., Aguiar, R.: Towards IoT data classification through semantic features. In: Future Generation Computer Systems, pp. 1–14. (2017)
22. Lee, C., Zappaterra, L., Choi, K., Choi, H.A.: Securing smart home: Technologies, security challenges, and security requirements. In: IEEE Conference on Communications and Network Security (CNS), IEEE, pp. 67–72 (2014)
23. Cardoso, J., Sheth, A. (eds.): Semantic Web Services, Processes and Applications. Springer, New York (2006)
24. Nottingham M.: Web Linking. https://tools.ietf.org/html/rfc5988, IETF (2017)
25. Constrained RESTful Environments (CoRE) Link Format.: https://tools.ietf.org/html/rfc6690
26. Mayer, S., Guinard, D.: An Extensible Discovery Service for Smart Things. In: Proceedings of the Second International Workshop on Web of Things (2011)
27. Pichler, R., Polleres, A., Skritek, S., Woltran, S.: Redundancy Elimination on Rdf Graphs in the Presence of Rules, Constraints, and Queries. In: Web Reasoning and Rule Systems, Springer, pp. 133–148 (2010)
28. Khan, S., Safyan, M.: Semantic matching in hierarchical ontologies. J. King Saud Univ. Comput. Inform. Sci., **26**(3), 247–257, Elsevier (2014)
29. Cheatham, M., Hitzler, P.: String Similarity Metrics for Ontology Alignment. In: The Semantic Web–ISWC 2013, Springer, pp. 294–309 (2013)
30. Zhang, X., Zhao, C., Wang, P., Zhou, F.: Mining Link Patterns in Linked Data. In: Web-Age Information Management, Springer, pp. 83–94 (2012)
31. Gao, J., Mazumdar, S.: Exploiting Linked Open Data to Uncover Entity Types. Presented at the Semantic Web Evaluation Challenge, pp. 51–62 (2015)
32. Datavenue.: https://datavenue.orange.com/live-objects-api
33. DogOnt.: http://elite.polito.it/ontologies/dogont/dogont.html
34. Biotop.: http://purl.org/biotop/biotop.owl
35. SAREF4EE.: http://ontology.tno.nl/saref4ee/
36. Linked Open Vocabularies.: http://lov.okfn.org/dataset/lov/

Chapter 10
Implementation Challenges and Opportunities of Smart City and Intelligent Transport Systems in India

Shajimon K. John, D. Sivaraj and R. K. Mugelan

Abstract Intelligent Transport System (ITS) is a part of Internet of Things (IoT) which gives intelligence to vehicles, Infrastructure and provides communication between them for a smart transportation. For improved safety, mobility and efficiency of the transport system a real time communication between Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), Infrastructure to Vehicle (I2V) and Infrastructure to Infrastructure (I2I) is mandatory. Real time database helps in improving the development of Advanced Traffic Management System (ATMS), Advanced Traveler Information System (ATIS), Advanced Vehicle Control System (AVCS), Commercial Vehicle Operations (CVO), Advanced Public Transport System (APTS), Advanced Rural Transport System (ARTS), etc. Different countries developed different models of ITS suited to their own specific conditions. There are some limited case studies and implementations occurred in India. A full fledge ITS could not developed looking into the Indian perspective. The traffic condition, vehicle management and infrastructure requirements need lot of up gradation in this respect. The major case studies referred in this are ATMS trail done across Chennai (2009), ATIS in Bangalore and Hyderabad, APTS in Bangalore, Chennai and Indore. The Bus Rapid Transport (BRT) across different places across India as an alternative to metro rail at Pune, Ahmedabad and Chennai. Electronic Toll Collection (ETC) and Advanced Parking Management are some of

S. K. John (✉)
Department of Electronics and Communication Engineering,
Saintgits College of Engineering, Kottayam, Kerala, India
e-mail: shajimonkalayil@gmail.com

D. Sivaraj
Department of Electronics and Communication Engineering,
PSG College of Technology, Coimbatore, Tamil Nadu, India
e-mail: dsrecepsg@gmail.com

R. K. Mugelan
School of Electronics Engineering, Vellore Institute of Technology (VIT),
Vellore, Tamil Nadu, India
e-mail: mugelan.r.k@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_10

the application of ITS which gained certain ground across India. Ultra low power Bluetooth 5 technology, 5G Networks and Cellular IoT concept creates lot of opportunities in realizing ITS in India.

Keywords Internet of things · Intelligent transport systems · Smart city

10.1 Introduction

The globalization has made its impact on the urban community on its socio, economic, and structural aspects. The advancements occurring in the field of technology supported by the developments in communication system and internet have changed the outlook of rural and urban life over the past decade. Human beings always look for means by which how technology can impact their life in the positive way. Smart cities is one of such concept conceived during the fag end of 20th century aiming in employing the user friendly communication and information technology application for a better sustainable urban living. They look for technological improvements in the current infrastructure on an environment friendly energy, traffic and transport model. During the course of its development over the years it has look into the future global issues like climate change and scarcity of resources. More than half of world population belongs to urban space and it is on the rapid increasing trend with two third of its total population will reside in urban space by 2050. These rapid increases of population density over the cities will bring lot of challenges for urban administrators on all type of basic resources like energy, clean water and waste disposal and on infrastructure resources also. These high demands in resources have to be fulfilled for a sustained urban development without causing population explosion. The changes like rise in temperature and uneven rain fall is another issue which causes many environmental problems. Cities are responsible for three fourth of the total greenhouse gases created worldwide. We need to find solutions for this pollution problem. To achieve the tag 'smart', cities need to find developments supporting economic viability, better social structure, and sustained environmental models to improve the life and its surroundings of the inmates. The smart city concept can be implemented on the broader space in; Energy and Environment, Transport and Mobility, Urban Development and Planning, Public Services and Utilities, and Integrated Socio-Economic Development. More specifically, we have to develop sustainable model for urban space in eco friendly systems—smart supply and disposal systems, energy management—intelligent systems for energy generation, storage and consumption, Governance—more transparency and people participation in planning, implementation and monitoring, Economy—provide active support in life-long learning and to become global citizens, Mobility—innovative traffic and transport systems with a focus on integrated transport systems with eco friendly transport models like car pooling, Society—provide better health and hygienic environment with plurality and cohesion among citizens [1–6].

Implementation of smart cities has a direct impact on the developments and innovations happening in the Internet of Things area. The various sensor technologies that helps in the implementation can be listed as; transportation congestion sensors, water and waste water monitoring systems, parking kiosk and support systems, automated cars, waste management sensors, drones, surveillance cameras, body cameras, infrastructure inspection sensors, lighting, fire detection systems, energy monitoring systems, wearable's, smart freight systems, solar systems, vehicle fleet communication systems, broadband infrastructure. Integration of all these and many more sensors and detectors, analyzing and communicating the necessary support messages will help in developing a city into smarter living space. In short; smart city can be an integration of smartness into existing infrastructure, public services, and mobility, energy and water resources. Smartness can be incorporated into infrastructure by providing better eco friendly more into green buildings, smart or automated homes, and better physical infrastructure. In the energy sector more thrust can be given to renewable energy, smart grid, meters, and gas distribution systems. In the mobility sector the improvements can be done in traffic management, mass public transport systems, electric vehicles, smarter tools and congestion controlling systems. The public services which can become smarter are safety, health, education and lighting systems. Water collection, storage and distribution can be automated for better efficiency. Figure 10.1 sows the basic core components integrated in a smart city concept [5, 7, 8].

All human activities are related to the transportation systems in different ways. The basic travel they do on a routine basis to all the commodities and consumables humans are in need depend on the transportation models in one way or other. Various studies conducted across the globe have concluded that almost half of the population spends at least an hour on road on each day. These facts and figures show the immense opportunity and challenge the transportation systems designs have. As the percentage of population and the number of vehicles increases in the road, the immediate result is congestion. This become a major hurdle in every part

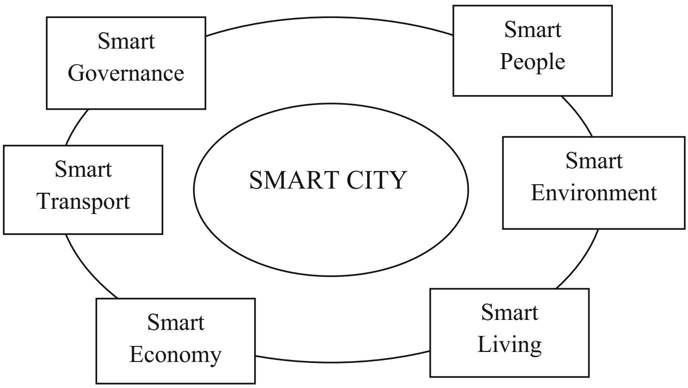


Fig. 10.1 Simple smart city integration

of the world as it causes multiple problems like economic issues like increased fuel consumption, health issues like increased air pollution and wastage of time and energy of human beings associated with the congestion. Another major issue associated with the traffic congestion is the rate of accidents occurs during congestion period. Studies already proved that accident level increases when the congestion level is high. But the there are many hurdles in reducing the traffic congestion due to non systematic means of developments happened over the period. Most of the accidents attributes due to the human error rather than technical faults. Hence the need to reduce accidents related to traffic congestion and to minimize its impact on the victims. Development of new planed infrastructure is the best solution for this but finding suitable land for such new infrastructure projects like express highways, freeways is a major headache for many countries due to the shortage land resources. How good the transportation model of a country performs have a direct impact on its economic stability and productivity [4, 5, 7–9].

India being one of the largest growing economies over the globe for last two decades has its impact on the infrastructure requirements and life support resources. One of the most affected or need urgent attention is in the field of transportation. Transportation is defined as the action of transporting someone or something or the process of being transported. This can be private or public transport or movement of goods across different places. Since the opening up of Indian economy for foreign trade as a part of liberalization, the vehicle industry has been in the upward growth trend. Hence the transportation needs and the wants also changed accordingly to meet the global standards. The ever changing and smarter technology has also brought its direct impact on the transportation industry too. Based on the data published by the government of India in 2015, an estimated 21 cores of vehicles are registered across our country with more than a core vehicle registration in seven states. Hence the following aspects have a direct impact on this; (1) The infrastructure and all supporting systems also saw changes accordingly. Different surveys had highlighted the major problems of Indian transportation industry as (a) loss due to waiting time and congestion at various points including toll plazas (b) loss of human life due to accidents (c) steeling of vehicles above all the average road infrastructure conditions and limited use of technology. The road density to vehicle density according to the twenty fifth five year plan (2012–2017) over India shows very big gap. (2) The major losses associated with these problems amount to almost $6 billion in every year according to the World Bank report. The major reason behind this is the wider gap between the road infrastructure availability and requirement along with the typical road condition with different types of vehicles, two, three, four and higher order vehicles along with a large pool of pedestrians. Figure 10.2 shows a typical Indian road [6, 8, 10–12].

Fig. 10.2 Typical Indian road

10.2 Intelligent Transport System Models

Intelligent Transportation Systems (ITS) can be defined as cohesion of sensors, analyzers, controllers and communication systems to improve safety, mobility and efficiency of all components in the transportation systems which includes vehicles, human beings, and infrastructure. The major benefits of ITS can be summarized as better traffic management, ease of traffic congestion with minimal environmental issues for sustained benefits to its users generally public. ITS have been influenced a lot by the major revolution occurring the Internet of Things (IoT) technology. According to researchers the important application of IoT are building and home automation, smart cities, smart manufacturing, automotives, wearable, health care and precision agriculture [11, 13, 14].

ITS even after coined almost 4 decades back has got its stand in the right putting after the integration of IoT into it for developing more reliable and efficient transport systems models. Figure 10.3 illustrates the basic IoT model in which different users/connected devices are used to sense, transmit and analyze data and communicate with different users/connected devices through internet. ITS can support and help transport policy makers and planners in setting up objectives to achieve on certain areas like; traffic congestion, environmental issues, improved

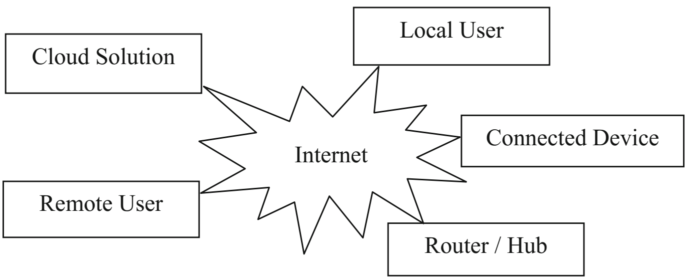


Fig. 10.3 The basic IoT model

travel conditions, and economies of scale. The concept of intelligent transport was coined way back in 1970s but the first world congress in Paris, 1994 was the kick start of various application developments in ITS. Since then ITS models were concentrating in developing sustainable models for the efficient, eco friendly and integrated system for transportation. These systems were developed according to the geographic, environment, and socio economic background by each countries/ regions. The major components of ITS, travelers, vehicles, control center and road and its premises included in these models to support the goals of ITS. The traveler consists of remote traveler support systems and personal information access systems. The vehicle part consists of different types of vehicles starting from two wheels to heavy to extra heavy vehicles along with emergency vehicles. Road and its premises includes roadway, toll collection systems, parking management models and check post for commercial vehicles. The ITS control centers are the heart of this which includes traffic management systems, emergency management systems, toll management systems, commercial vehicle administration, maintenance and administration, fleet and freight management, transit management, information service and emissions management. All these components are connected over communication either wired mode or wireless mode to transfer information between them [15–18].

The major components of an ITS can be described broadly into, traveler, vehicles, ITS control center and road and its premises. Each of these can be brought under the design perspective of ITS like; for a traveler how better travel comfort level can be achieved, how an intelligent/smart eco friendly vehicle can contribute to a pollution free environment, high quality road infrastructure with better safety and accident free travel which all together contribute to smart city concept. There are many reasons why ITS models could not able to find its major impact on Indian transport systems. To name a few: lower quality of road infrastructure, lack of planning and policy implementation, lower level of automation at different points, heavy growth rate of urbanization, budgetary constraints etc. ITS implementation is done at three levels, vehicle level, infrastructure level and corporative level. Vehicle level includes WiFi, Global Positioning System (GPS), General Packet Radio Services (GPRS), camera, speaker, display boards supported with different sensors, control and communication units to for data collection, processing and transfer among different units. The infrastructure level includes sensors along the roadsides, traffic signals and signal alerting systems. These along with vehicle components support the driver and the vehicle with necessary instructions alerts and signals for the smooth driving and movement. The corporate level includes communication between the vehicles, between the infrastructures and between vehicle and infrastructure. The major applications of ITS on different groups are given in Table 10.1. All the above applications are formulated to achieve the four important goals; Safety, Management and Revenue Collection, Mobility and Energy and Environment [17, 19–22].

Traffic Management Center is the heart of any traffic management model. This collect, process and disseminate multiple data received from various sensors and other devices for the optimized use of available resources to manage the complex

Table 10.1 Applications of ITS

Traveler information	Pre-trip information On-trip driver information Route guidance and navigation On-trip public transport information Personal information services
Traffic management	Traffic control Transportation planning support Incident management Enforcing traffic rules Infrastructure maintenance management
Vehicle	Vision enhancement Automated vehicle operation Collision avoidance Safety measures
Commercial vehicle management	Vehicle administrative process Automated roadside safety support On-board safety monitoring Commercial fleet management Automated diagnostic systems
Public transport	Demand responsive transport management Shared transport management Public transport management
Emergency	Emergency notification Emergency vehicle management Incident and hazardous material notification
Electronic payment	Electronic financial transactions
Safety	Intelligent junctions Safety for public travel Safety enhancement for road users

transportation network. The traffic management server receives data from different sources like inputs from on road traffic control persons, current road restrictions due to any maintenance from the maintenance and construction team, emergency requirements from emergency management team, roadway information from the users. The server will process all these data and sends required control and support messages to different users. The efficiency of these systems depends on the data acquisition systems, communication links, and analysis tools and methods. A well defined data acquisition system is the most important component for an efficient ITS model design. The major equipments in that are sensors, cameras, automatic vehicle identifiers, automatic vehicle locators based on GPS. The early day sensors are mainly based on optical detectors, acoustic detectors, pressure sensors, piezo-electric sensors. Advancements in sensors technology helped a lot in the effective implementation of ITS with introduction of magnetic sensors, sensors based on reflection of radiation like infrared sensor, ultrasound sensor etc., inductive loop sensors, sensors based on vibration along with video based sensors. The most commonly used sensors are inductive loop detectors, magnetic detectors and magnetometers to collect information of vehicles like speed, volume and occupancy. The advancement in video image processing techniques helped developers to use video recording systems for the real time monitoring of road and road side conditions. Automatic vehicle identifiers used tags in vehicles, road side vehicle readers to collect information regarding the vehicle. The data received from all these sources has been used to develop useful travel information to the users through different means like short messaging services, public announcements, speed control mechanisms, etc [18, 22–26].

Intelligent Transportation Systems (ITS) have find increased prominence due to its potential to meet the various challenges that are already facing and the future challenges that may come across in the transportation sector. This lead to high level of research activities in this field to find solutions to reduce road accidents, automated driving systems, safer environment friendly transportation models, etc. Six major categories are reviewed from a technological perspective as depicted in Fig. 10.4 are: "(i) Advanced Traffic Management System (ATMS), used to improve traffic service quality and to reduce traffic delays. (ii) Advanced Traveler Information Systems (ATIS), used to supply real-time traffic information to travelers. (iii) Fleet Management and Control System (FMCS), use different ITS technologies to increase the safety and efficiency of commercial vehicles. (iv) Advanced Public Transportation Systems (APTS) make use of electronic technologies to improve the operation and efficiency of high occupation transports, such as buses and trains. (v) Advanced Rural Transportation Systems (ARTS) used to solve problem arising in rural zones. (vi) Advanced Vehicle Control Systems (AVCS) include sensors, computers and control systems to assist and alert drivers or to take part of vehicle autonomous driving". The central theme of AVCS is to improve the throughput and safety of highway traffic by using automatic control with its precision and fast reaction to replace human drivers. Ultimately, in a more futuristic goal, AVCS might enable a complete driver less automated transport model [5, 19, 25–28].

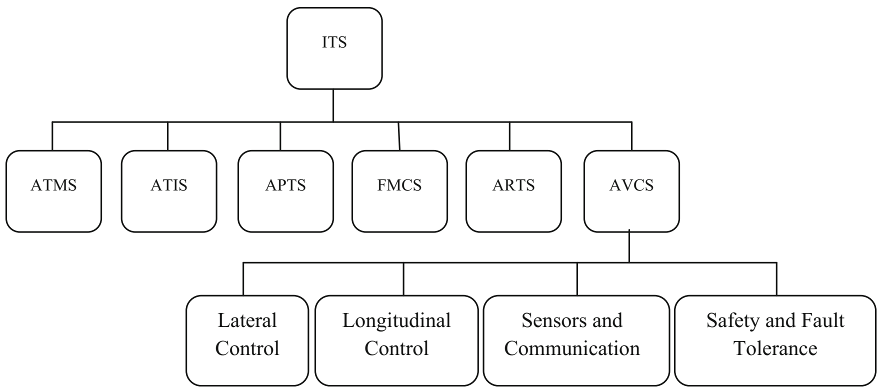


Fig. 10.4 Intelligent transportation system hierarchies

10.3 Implementation of Smart City Across the Globe

The history of ITS is started with the setting of "Electronic Route Guidance System (ERGS)" in USA way back in Nineteen Sixties to support drivers with real time road traffic conditions. During seventies this system had been updated with more clear support like digital maps is called as "Automatic Route Control System (ARCS)". During the same time Japan Germany and some more developed countries developed customized models to suite their requirements like; "CACS (Comprehensive Automatic Traffic Control System)" by Japan and ALI by Germany. These lead to multiple models being used and implemented at different levels across different countries during eighties and nineties. Traffic management is one of the most commonly implemented area in ITS. In this dynamic traffic conditions were analyzed using onboard as well as off board sensors, CCTVs and other supporting systems and communicated using multiple communication means. This helps in effective planning and operations in dynamic traffic control, emergency freeway operations, real time incidents management. Travel information models is another ITS sub model being implemented at different levels across the globe.

This includes real time travel information like route selection, estimated time of journey, with real time messaging systems of any accidents or any other incidents. Another area which basically the vehicle manufacturers work on and continuously upgrading is the vehicle control systems. These systems help in enhancing driver's control over the vehicle for better safety and comfort. Collision warning systems, auto break systems are examples for this. Commercial vehicle management is another area where lot of models has been developed and implemented. These models help the central office to continuously monitor and support their fleet. "Smart cities use different technologies like communication networks, wireless sensor technology and intelligent data management in real time decision making for its components like infrastructure". Now a day's lot of thought process has been in place to make our cities a better place to live. But the demographical and financial issues are major road block in implementing these changes. The decisions on converting our living place a better and happy place to live require long term visionary outlook with consistent policies. Considering the various factors, Table 10.2 summarizes the major hurdles or points we have to address to achieve our motto. The major challenge any smart city implementation is the challenges caused by the governance model. Smart cities require an integrated governance model with inclusions of politics as well as people contribution [28–31].

Across the globe basically two models of ITS are used by the practitioners namely, framework based architecture and model based architecture. Framework based architecture use a set of user lead service support specifications for different applications with flexibility for improvement. This model can support stand alone development based on the requirements either on local, regional or national level. The best example for this model is the European ITS model developed. The major advantages of this model are; it can integrate different sub systems based on a pre defined standards and norms, it can be developed to accommodate different country

Table 10.2 Challenges for smart cities

Governance	Economy	Mobility	Environment	People	Living
Flexibility	Unemployment	Sustainable mobility	Energy and eco-friendly	Unemployment	Affordable housing
Expansion of city limits	Expansion of city limits	Inclusive mobility	Expansion of city limits	Social cohesion	Social cohesion
Territorial cohesion	Economic decline	Multi-model transport system	Energy and environmental issues	Poverty	Health problems
Combination of formal and informal governance	Territorial cohesion	Under ecosystem under pressure	Under ecosystem under pressure	Ageing population	Emergency management
	Mono-sector economy	Traffic congestion	Climate change effects	Social diversity as source of innovation	Urban sprawl
	Sustainable local economy	Non-car mobility	Urban sprawl	Cyber security	Safety and security
	Social diversity as source of innovation	ICT infrastructure deficit			Cyber security
	ICT infrastructure deficit				

specific requirements, it can also support additional services as and when required. The “Kent County Council (KCC)” have developed a framework based ITS model. Model based ITS architecture have developed to suit the region or local based specific requirements. This model does not have the flexibility like a framework based model. The USA’s national ITS architecture is an example for this type of implementation. ITS implementation success depends on the implementation team. There are many stake holders for the ITS model. The major ones are; drivers, vulnerable road users, other travelers, specialist users, ITS operating firm employees. These stake holders can again be categorized based on their age, gender, type of journey and type vehicle used. Vulnerable users include older persons, persons with disability, cyclists, two wheelers, pedestrians, young drivers, inexperienced drivers, etc. the major challenge of ITS design lies in its wide range of stake holders; an expert driver to an inexperienced driver, older driver to young driver [31–34].

10.4 ITS Implementations Across the Globe

Around the world different organizations both government and private and institutions have developed and implemented geographically suited ITS models driven by the socio economic and environmental needs. The “RITA (Research and Innovative Technology Administration)” is the specific task force under the US government transport department to coordinate and implement ITS across the country. Various departments, organizations and institutions support RITA in developing the state art technology. “IntelliDrive” is one of such multimode initiative based on wireless technology to communicate between vehicles, infrastructure and personal communication devices. “Next Generation 9-1-1” is another initiative to establish a public emergency communication services using all possible communication modes. Initiatives to reduce urban traffic congestion are another area where lot of different models tested. The “Clarus initiative” aims at providing clear accurate and relevant information about whether, accidents, road repairs and other delays to the users. The emergency transport operations integrates three areas of operations namely, traffic incident management, emergency transportation operations during disasters, traffic management for planned special events [34–36].

ITS find a very footing in Japan where the systems are developed to collaborate between the advances in navigation systems, support for public transport, electronic toll collection, increasing efficiency in commercial vehicles, assisting safe driving, optimization of traffic management, support for pedestrians, increasing efficiency in road management, and support for emergency services. “The Comprehensive Automobile Control System (CACS) implemented during 1970s in five major areas; route guidance system, driving information system, traffic incident information subsystem, route display board subsystem, public service vehicle priority subsystem”. Japan automotive manufacturing companies are the pioneers in navigation systems. “The CACS system was further developed through RACS (Road Automobile Communication System) and AMTICS (Advanced Mobile Traffic Information and Communication System)”. This further merged to VICS which uses radio, optical and IR beacons, FM multiplexed broadcasting media, 2.5 GHz radio wave data dissemination, along with in vehicle navigation system supported with digital maps. “The Universal Traffic Management System (UTMS)” is another model which aims to provide the drivers with real time traffic and guidance information. “UTMS consists of public transportation priority systems, mobile operation control systems, advanced mobile information systems, dynamic route guidance systems, intelligent integrated ITV systems, environment protection management systems, driving safety support systems, help systems for emergency life saving and public safety, pedestrian information and communication systems, and fast emergency preemption systems”.

“Road Transport Informatics (RTI)” is the model developed for the mainland Europe. RTI integrates two interacting programs; “Road Infrastructure for Vehicle Safety in Europe (DRIVE) and PROgram for European Traffic with High Efficiency and Unprecedented Safety (PROMETHEUS)”. System development is the primary goal of PROMETHEUS while DRIVE concentrates on human behavior issues and implementation systems. The “eSafety program” promotes the development, deployment and use of intelligent vehicle safety systems to enhance road safety throughout Europe. “INVENT is a program which aims to improve the overall traffic system through eight specific programs namely; detection and interpretation of driving environment, anticipatory active safety, congestion assistance, driver behavior and human machine interaction, traffic performance assistance, network traffic equalizers, traffic management in transport and logistics, traffic impact, legal issues, and acceptance". "PReVENT" is another program which integrates multiple measures to create a safety belt around vehicle. There are many models like "CONNECT, DELTA and ETNITE" which are currently running across Europe to make the transport systems more intelligent. The "NextMAP" is a model to improve in vehicle driver assistance systems with the support of digital maps.

United Kingdom is one country where many successful implementations of ITS occurred. The major initiatives are "Transport for London (TfL)" a free map service to all users which provides the information of city's speed control limits through digital maps. Other initiatives are managed motorways, installation of cameras through ring of steel program, motorway traffic viewer, and electronic toll collection management systems. Another major program is the convert all public transport facility from traditional fuel to hybrid fuel systems. Canada is another country which successfully implemented different ITS models. The "407ETR, Toronto" is the first fully all electronic toll high way implemented in the world. "BIFA (Border Information Flow Architecture)" is a collaborative project between Canada and USA to deploy systems to control border crossing issues using ITS models. The ITS architecture of "Canada support eight different user services namely, travel information services, traffic management services, public transport services, electronic payment services, commercial vehicle operations, emergency management services, vehicle safety and control systems, and information warehousing services". The "98 B-Line is the first BRT (Bus Rapid Transit) service" developed fully though high ends ITS system modeling. The major models utilized are transit management, traffic signal priority, real time passenger information, automated voice and digital next stop. The university network formed across various Canadian universities have implemented different ITS models, like ITS for school bus drivers.

The basic ITS model is given in Fig. 10.5 covers all the five core areas in which ITS research and development happening. The data centers are the major management areas of transport systems. These data centers use incoming data from all sensors deployed across different points and objects analyses the data and shares required information with stake holders. This information is shared using different medium like short message services to the stake holders. These data centers does processing of data with respect to (1) any emergency situations happened or incidents occurred; (2) all issues related to traffic like congestion and traffic management; (3) all aspects related to transit from one point to another related to freight operations; (4) managing all public transportation means; (5) toll collection and management; (6) to reduce carbon level by regular pollution checks and emission control mechanism. The data centers do data analytics, report generation and management of historical data. All type of vehicles from passenger cars to heavy construction vehicles are monitored and managed using these systems. Parking space management is another aspect ITS developers are giving more thrust since it becomes a major hurdle in urban transportation management. The final aspect which comes under the ITS is the traveler experience; ITS developers had given very good information management to road users by different means. Figure 10.4 explains the basic functions of the ITS system.

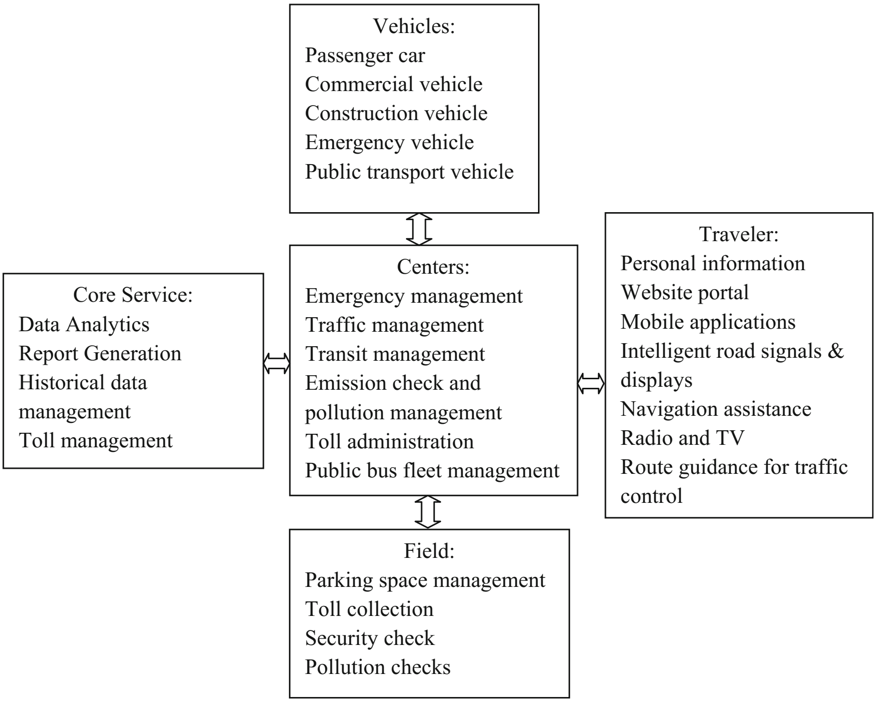


Fig. 10.5 Intelligent transport systems components

Let us look into a specific case of ITS model as in-vehicle system development. Figure 10.6 depicts the different support sub-systems that can be implemented in a vehicle. This includes power train control and chassis control to provide necessary support for automatic driving system through engine control, transmission control, body control modules to take care of instrument control, automatic climate control systems, door locking. Infotainment sub-system looks after all information and communication support systems like telephone, entertainment modules like audio and video and navigation support systems to the traveler. There are many sub control units which govern the in vehicle intelligent systems. Almost all the manual mechanical functions are now automated with intelligence like engine control which continuously monitors the engine performance, airbag control system to control the automatic opening of airbag as and when required. These operations and communications can be done with the support of Bluetooth, USB and GPS. The data received from different sensors are processed and analyzed using the ECU to generate necessary support actions.

The major technologies used at different levels of implementation in an ITS model are given in Fig. 10.7. Most of the communications vehicle to vehicle, vehicle to center or center to center is now a day happening through various wireless communication models. Sensors are the most important component in the

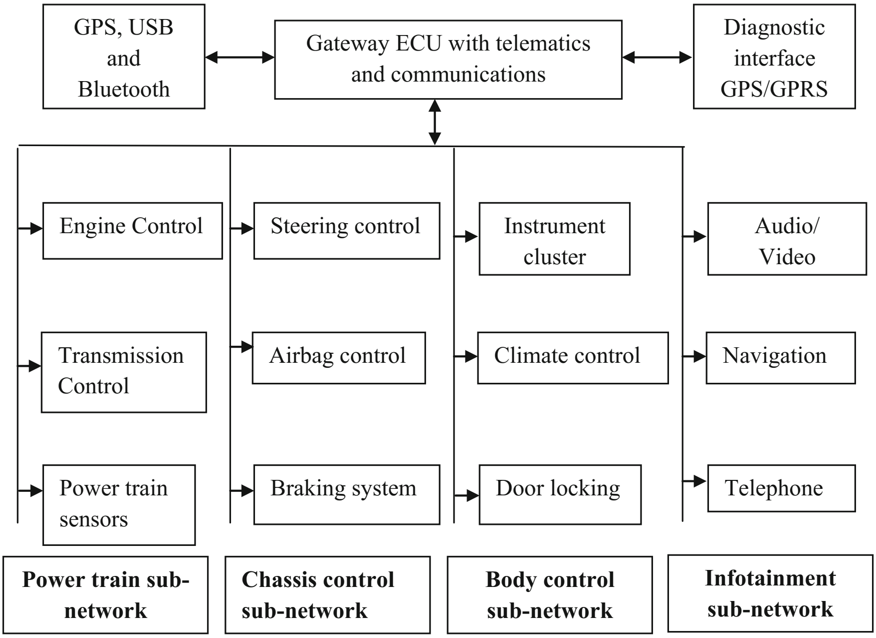


Fig. 10.6 In-vehicle systems

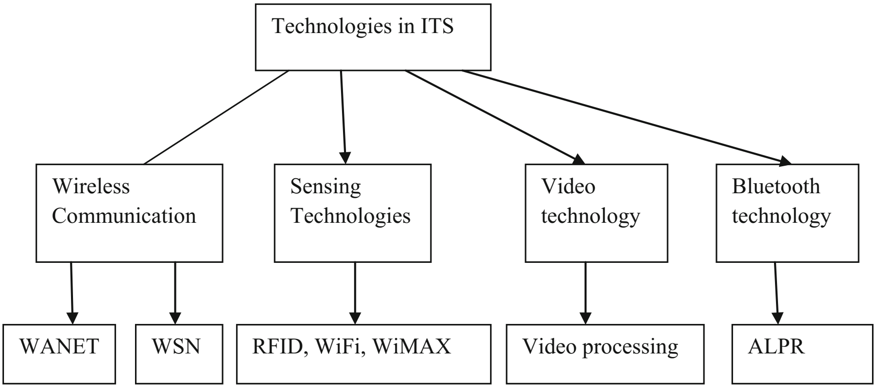


Fig. 10.7 Technologies in ITS

design and implementation of the ITS. Various sensor technologies support this starts from basic RFID technology to WiMAX. Another major technology used in ITS is the image and video processing technologies. The images or videos captured by different cameras were analyzed for interpretation and decision making. Most of the direct communications mostly nearby devices uses Bluetooth technology. The technology changes happening across various areas have a direct impact on the devices and supporting technology in ITS too. Dedicated Short Range Communications (DSRC) is the communication method used to communicate between the vehicle and road side specific locations like toll plaza. "Continuous Air interface Long and Medium range (CALM) provides continuous communication link between the vehicle and the road side using different communication means".

10.5 Smart City and ITS Implementation Initiatives—India

Smart cities can be modeled as system which integrates energy, materials, services, people and finance with suitable urban planning with a close association of its social and economic metabolism towards quality life. Government of India in its mission statement and guidelines for smart cities published in 2015 has listed ten core infrastructure elements in the smart city projects to be implemented in India. "They are; adequate water supply, assured electric supply, sanitation including solid waste management, efficient urban mobility and public transport, affordable housing especially for poor, robust IT connectivity and digitalization, good governance especially e-governance and citizen participation, sustainable environment, safety and security of its citizens, particularly women, children and elderly and health and education". The basic smart solutions to be included in the project are:

E-governance and citizen service
Public information and grievance redressal
Electronic service delivery
Citizen engagement
Citizen-city eyes and ears
Video crime monitoring
Water management
Smart meters and management
Leakage identification and preventive mechanism
Water quality monitoring
Others
Tele- medicine and tele-education
Incubation/trade facilitation centers
Skill development centers
Energy management
Smart meters and management
Renewable sources of energy
Energy efficient and green building
Urban mobility
Smart parking

(continued)

(continued)

Intelligent traffic management
Integrated multi-modal transport
Waste management
Waste to energy and fuel
Waste to compost
Waste water to be treated
Recycling and reduction of C&D waste

Some of the typical features defined are; "promoting mixed land use in area based developments, housing and inclusiveness, creating walkable localities to reduce congestion and air pollution, preserving and developing open spaces, promoting variety of transport options, making governance citizen friendly and cost effective, giving an identity to the city, and applying smart solutions to infrastructure and services". This project aims to convert 100 Indian cities to smart cities during 2015 to 2020. "The strategic components defined in the area based development are city improvement, city renewal and city extension with a pan city initiative for smart solutions". The recent ITS initiatives across are; One of such initiative is the advanced traffic management system implemented in Chennai with help of automatic number plate reading cameras, supported with wireless infrastructure to monitor motorists who violate traffic rules. Multiple CCTV also installed to monitor the traffic activity across the important junctions in the city. Automatic traffic control system is successfully implemented in many cities in India with support of technology across metros as well as smaller cities. GPS based vehicle mainly public transport is implemented in Bangalore and Indore with display boards within the vehicle and at the passenger waiting points. Many cities tried and implemented Rapid Bus Transit Ways to reduce congestion. Another ITS initiative successfully implemented across India is the Electronic Toll Collection systems at selected road corridors. Advanced parking system was implemented at many points both public and private places with certain points having multilayer parking model. Mysore city in 2012 has developed a smart city projects with stake holders as; sustainable urban transport project—to develop greener environment, Karnataka state transport corporation—to implement efficient urban transport system, Ministry of urban development—to formulate policies, monitor and coordinate different authorities to find solutions for urban development issues, World Bank—for financial support, Ministry of environment and forest—to coordinate environmental and forest related policies, and ITS system developers.

The challenges in India are very unique when compared to other countries across the world. The challenges can be viewed from the point of consumers, last mile transportation, traffic management, transit, back bone infrastructure and mass transit system. Let us discuss all these in detail. When we consider the consumer, they are quite unique in nature and their expectations. There is high demand of travel both in rural and urban places across the country. The number of trips between points is much higher when compared to other countries. The distance between the points is also on the higher side. All these issues occur due to the fact that the overall population is much higher in India which is having the second largest population. The next case is the transportation issues. Since the distance between places is higher and no proper infrastructure for walking or bicycle, people have to look into private or public transport for the movement. But the urban planning, design and maintenance is very poor across the country. Most of the cities are developed and still expanding without any proper plan or design. Another major factor is the poor quality of internal roads within the country. Even in highways the lane demarcation is a major issue with only limited lane traffic rules have been in practice. Traffic management is the next level with limited staff for traffic management as well as law enforcing makes the traffic system still a clumsy affair. The real time data collection and analysis is very limited with minimal traffic projections or directions.

Another major issue is the frequent breakdown of system due to many known or unknown factors. Since the urban planning is at low level the transit is another area which requires major revamp. There is an acute shortage of parking space and multi mode transit points. Since the real time data collection is very limited hence the online travel information is also affected. Due to this the cargo and fleet management, asset management have its own limitations. There is no optimized route planning mechanism in place. The backbone infrastructure network is very limited which affects the overall development process itself. Since the demand projections based on overall capacity, peak capacity and other parameters were not done on time, made the infrastructure needs total restructuring to meet the present and future requirements. The condition of road and rail tracks is another major issue. All these are backed with lower financial support from all quarters made the infrastructure not meeting the demands. The lack of public transport with minimal peak or average travelers data availability along with no support for future projections is a major issue. There is no adequate funding for sustainable public transport system. The present public transport suffers from poor quality of service, improper maintenance schedules and aging of equipments.

The modification of conventional vehicles is a major factor in the development of a fully fledged ITS model. The conversion of the typical present day vehicles into fully automated vehicles is a task which involves money and time with the risk of real time testing. Even the Google car and other alternatives are still facing major hurdles with respect to the real time testing in the busy roads. Due to this many of the researchers are still working with high level of simulation of their developments rather than real on road testing. This work mainly concentrates on the prototyping of sensors and lane sensing algorithms, lateral and longitudinal control algorithms in real time which a major part in the prototyping of AVCS in ITS.

This specific work uses small scale test bed vehicles with a scale down ratio of 1:17 which implements human driving experience. The test bed vehicle consists of track sensing modules; lateral (steering) control modules; longitudinal (speed) control modules; obstacle detection modules, communication module and controller module (MCU) which controls all operations as shown in Fig. 10.8. Using these modules, the major part of AVCS which includes lane detection, obstacle detection, vehicle position identification, lateral control, longitudinal control and vehicle

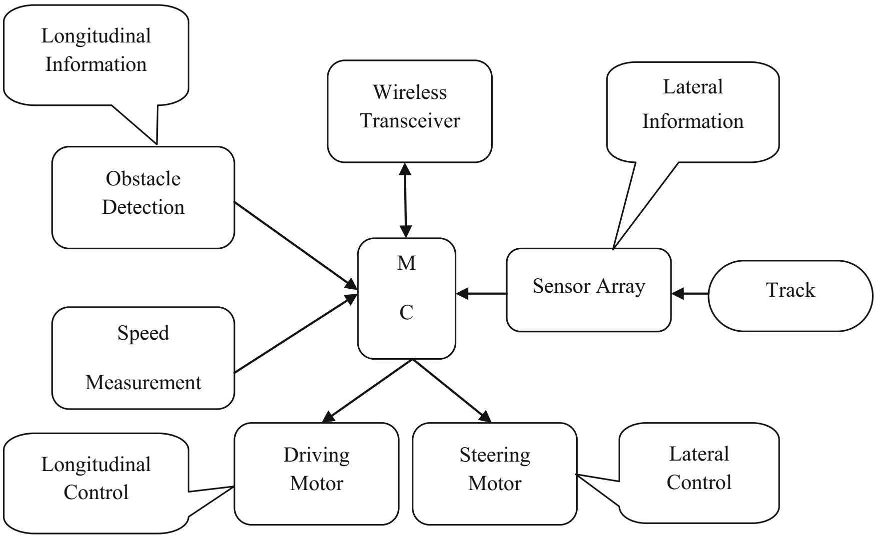


Fig. 10.8 Block diagram of prototype vehicle

platooning is tested in real time. Inter vehicle communication system and Infrastructure controlled vehicle systems are also implemented and the performance is analysed using this prototype vehicles. Two different vehicle prototypes are used in this work. One with Freescale HCS12x (16-bit) microcontroller with IR sensor array based lane sensing method and other with Freescale MPC5604 (32-bit) microcontroller with Linear Sensor Array (LSA)/Line Scanning Camera based lane sensing method with differential drive mechanism is used for the evaluation of the algorithms. The vehicle system can be modeled and the simulation analysis can be done [37].

Two test tracks are used for testing the performance of the algorithms in real time. Track-1 has 15 m length and Track-2 has 28 m length, both with a black track of width 2.5 cm are used. Both the tracks have straight lines, curves of different radius to create a real road environment. The prototype vehicle under test is allowed to travel in different radii of curves. The time taken for the vehicle to complete the lap is taken as the metric. The vehicle is tested with different algorithms and “the performance of the sensing algorithms, lateral control algorithms and longitudinal control algorithms” are analyzed in real time using this test bed track. Detecting and localizing the lanes from a road image is an important component of many ITS applications. The work proposes two algorithms to identify the position and orientation of the vehicle in the track with some common assumptions about road conditions. The lane sensing strategies include road modeling, road marking extraction, pre-processing, vehicle modeling, position tracking, and comparative analysis. Two types of sensing strategies are used in the work. Prototype-1 uses Infra-Red (IR) sensor array and Prototype-2 uses 128×1 linear sensor array. For IR based sensing, five different methods of sensing algorithms are used and its sensing performance is analyzed. For 128 × 1 linear sensor array based sensing, the sensor outputs at different lighting conditions are plotted and the problem due to light intensity variations during sensing is analyzed. The adaptive sensor calibration algorithm is used to make track sensing independent of light intensity variations. Sensor calibration is followed by threshold setting. The position and orientation of the vehicle in the track is identified by the error values obtained from the sensor after threshold setting. Finally the abnormalities due to the slanting rays and its impact are being discussed. Thus, by combining sensor calibration algorithm, threshold setting techniques and slanting ray removal techniques, which make the lane detection independent of light intensity variations and other uncertainties? Lateral control forms the major and most critical part of the autonomous vehicle. The algorithm used for lateral control must be fast, accurate, reliable and stable. Filter based approach, Proportional Integral Derivative (PID) based approach and the cascaded Kalman with PID approaches are simulated and their performance, accuracy and stability are analyzed and finally implemented in the prototype vehicle to evaluate the performance of the algorithms in real time environment.

The steer of the vehicle is managed by two layer control architecture. The top layer is used to generate the error signals/values using a Kalman filter by pre processing the sensor outputs to reduce noise. Using these error values the orientation and position of the vehicle is calculated. The bottom layer receives the error values from the top layer which consist of a PID controller. The PID controller controls the servo motor for closed loop lateral control of the steering mechanism. This model has following the cascading control architecture paradigm. The performance of the lateral control in real time is measured using the metric tracking accuracy. It is a subjective analysis based on the number of deviations in the track during the total lap completion. It is found that the cascaded Kalman and PID controller system provides better steering accuracy when compared to conventional steering algorithms. The turning time varies with respect to the turn angle, where, the algorithm maintains almost constant time to turn all kinds of curves however sharp or blunt. In the lateral control algorithm the time taken to align with any kind of curve is always nearly 1.5 s.

One of the main changes included making driving a happier event by reducing the driver from different tedious tasks and streamlining the traffic flow is the main aim of the longitudinal control mechanism. Human drivers have reaction time between 0.25-1.25 s, which necessitates an inter vehicle spacing of around 30 m or more at 60 m/h. Further, other human driving behaviours such as stop-and-go at low speed, and the diversity of driving behaviours also decrease highway throughput. “Intelligent Cruise Control (ICC) is an important part of advanced vehicle control systems that aims for automatic vehicle following in a safe and reliable manner”. ICC triggers an articulate control system that manages an appropriate actuator action for safe speed and distance control. “The longitudinal control mechanism of a vehicle includes three different algorithms when combined enables the vehicle to maneuver the track in optimal speed which forms ICC. The first of the three calculates the critical speed with which the vehicle can travel for the given turn radius of the track which is obtained by the steer value of the vehicle and thereby setting the base speed of the vehicle. The second algorithm tries to maintain the actual speed of the vehicle as close to base speed of the vehicle irrespective of the external conditions which is achieved by providing necessary speed boosts and brakes whenever required. Third focuses on altering the speed depending on the confidence obtained". The delta difference between the present and past deviation is used for acceleration/deceleration. The speed is inversely proportional to the present deviation and past deviation. This algorithm makes the vehicle to travel in the maximum speed in straight line as well as when the error is minimum, thus makes the vehicle to complete the desired lap is short duration of time. Thus, the algorithms make the vehicle to travel the test bed track with optimum speed, independent of the load, friction, etc. Obstacle detection and collision avoidance algorithm identify the presence as well as the distance of the obstacles and the speed of the vehicle is varied according to the distance of the obstacle which makes the vehicle to maintain the safe distance with vehicle ahead. "Vehicle communication is established for implementing intersection collision avoidance between vehicles which forms cooperative vehicle systems". Implementation of Infrastructure controlled system helps the roadside infrastructure unit to predict and control the traffic flow by communicating with the vehicles within the zone which prevents traffic congestion and provides smooth traffic flow. Vehicle platooning concepts are analyzed with four vehicles in platoon. These algorithms are implemented in multiple prototype vehicles. Test results prove that these algorithms are vehicle independent. Thus, the major features of AVCS in ITS is implemented in this work and its performance is analyzed in simulation environment as well as in real time environment.

10.6 Conclusion

Many researchers have concluded that the major factors that affect the success of a smart implementation are (1) Stakeholder benefit—the project should have clear outline of the benefits associated with the project with respect to each stake holders along with measureable outcome. (2) Engagement and buy-in—the project should have the full commitment from all the departments, regional stakeholders, its citizens and business community. How good the project connected with the people that much higher the chances of success. (3) Regional alignment with a community focus—the project should have regional economic strategies equally benefiting all its stakeholders. It also should address and reflect the needs and aspirations of its citizens, focusing on the quality of life with positive growth plans. (4) Strategy momentum and foundational initiatives—it should identify some early win initiatives to create the momentum and goodwill among its stakeholders. Developing communication and marketing of what is being done and what is to be done creates a sense pride and awareness among its citizens. (5) Clarity—public messaging with clarity and branding of the smart city strategy is a key to support initiatives along with giving a positive message to its stakeholders the key points behind this project.

(6) Dust proofing the strategy—the strategy should provide balance between the detailing of project with support of high level framework that relevant over the time. The project should be flexible enough to accommodate the technological change happening over the time. (7) Lessons learned—the project should have done proper in-depth study of the previous implementations in similar cities and also from its own earlier initiatives. (8) Urban integrations—immersion of its citizens into the benefits of the project through providing high quality life with integration technology is very essential. The technology deployment should offer benefits to its stakeholders are not visually interfering in public dominion, are implemented with a long term vision which can accommodate the innovations. (9) Performance indicators—setting of key performance indicators relevant to the specific city. These KPIs should be meaningful to its citizens with reports understandable to common man. (10) Creating a lasting culture—the involvement of all relevant stakeholders with in the city is the key to generate or create a lasting culture.

References

1. Bishop, R.: Intelligent vehicle applications worldwide. IEEE Intell. Syst. Their Appl. **15**, 78–81 (A review of vehicle based systems in use and future prospects)
2. Brandy, H., Carter, M.: What have we learned about its? In: Arterial Management, 18pp. Department of Transport, Washington DC, USA (Critical review of experiences in US)
3. Brookhuis, K., de Waard, D.: Intelligent transport systems for drivers. In: Garling, T., Steg, L. (eds.) Threats Form Car Traffic To The Quality Of Urban Life: Problems, Causes, and Solutions, pp. 383–400 (2007)
4. Central Statistics Office Ministry of Statistics and Programme Implementation, Government of India, New Delhi: Infrastructure Statistics, Third Issue, vol. I, pp. 1–82(2014)
5. Chennai Metropolitan Development Authority: Draft Master Plan II for Chennai Metropolitan Area (2008)
6. Rao, C.S., Parida, M., Jain, S.S.: Performance evaluation of the intelligent transport system in Delhi, Institute of Town Planners. India J. **8**, 1–14
7. Dean Zabrieszach in "ITS activity in Australia". In ISO TC 204, WG 9 Meeting, Seattle, Washington, USA (2013)
8. Mohan, D.: Intelligent Transportation Systems (ITS) and The Transportation System, Information Technology and Communications Resources for Sustainable Development. In: Jhunjhunwala, A. (ed.) Encyclopedia of life support systems (EOLSS), developed under the auspices of the UNESCO, pp 1–15. Eolss Publishers, Oxford. Retrieved 21 Sept 2009
9. Kandar, D., Sur, S.N., Bhaskar, D., Guchhait, A., Bera, R., Sarkar, C.K.: An approach to converge communication and RADAR technologies for intelligent transportation system. Indian J. Sci. Technol. **3**(4), 417–421 (2010)
10. GAO: Highway congestion: intelligent transportation systems' promise for managing congestion falls short, and DOT could better facilitate their strategic use. GAO-05-943, Washington (2005)
11. van Geenhuizen, M., Thissen, W.: Uncertainty and intelligent transport systems: implications for policy. Int. J. Technol. Policy Manage. **2**, 5–19 (2002) (Generic typology of ITS uncertainties, their causes, and possible ways to deal with them)
12. Singh, G., Bansal, D., Sofat, S.: Intelligent transportation system for developing countries—a survey. Int. J. Comput. Appl. **85**(3), 34–38 (2014)

13. Hung, M.L., Ronny, S.L., Jianhao, D., Sijian, Z., Gangfeng, Y., Weihua, S.: Development of a small scale research platform for intelligent transportation systems. IEEE Trans.Int. Trans. Syst. **13**(4), 1753–1762 (2012)
14. ITS/Operations Resource Guide 2007: US Department of Transportation, Research and Innovative Technology Administration, Washington DC. http://www.resourceguide.its.dot.gov/ (A comprehensive listing of over 400 resources related to ITS)
15. Ismail, A.H., Ramli, H.R., Ahmad, M.H., Marhaban, M.H.: Vision-based system for line following mobile robot. In: IEEE Symposium on Industrial Electronics and Applications (ISIEA), Kuala Lumpur, Malaysia, pp. 642–645 (2009)
16. Intelligent Transportation Systems and Road Safety: European Transport Safety Council, Bruxelles (Review of ITS use in road safety), 80pp (1999)
17. Junping, Z., Fei, Y.W., Kunfeng, W., Wei, H.L., Xin, X., Cheng, C.: Data driven intelligent transportation systems: a survey. IEEE Trans. Int. Trans. Syst. **12**(4), 1624–1639 (2011)
18. Huang, S. N., Tan, K.K., Lee, T.H.: Autonomous cruise control using neural networks in platooning. Adv. Robot. (2005)
19. Vanajakshi, L., Ramadurai, G.K., Anand, A.: Synthesis report on ITS including issues and challenges in India. Transportation Engineering Division, Department of Civil Engineering, IIT Chennai (2010)
20. Leviäkangas, P., Lähesmaa, J.: Profitability evaluation of intelligent transport system investments. J. Transp. Eng. **128**, 276–286 (2002) (Evaluation methods for intelligent transport system (ITS) investments)
21. Lin, C., Ahmad, B.R., Wai, L.C.: An intelligent longitudinal controller for application in semiautonomous vehicles. IEEE Trans. Ind. Electron. **57**(4), 1487–1497 (2010)
22. Absar Alam, M., Ahmed, F.: Urban transport systems and congestion: a case study of Indian cities. Transp. Commun. Bull. Asia Pacific **82**, 33–43
23. Prasad Babu, M.S., Rukma Rekha, N.: Secured GPS based traffic monitoring system in pervasive environment. In: 2014 IEEE 5th International Conference on Software Engineering and Service Science (2014)
24. Panwai, S., Dia, H.: Comparative evaluation of microscopic car following behavior. IEEE Trans. Int. Trans. Sys. **6**(3), 314–325 (2005)
25. Peters, A., Von, K.S., Heier, M., Trentinaglia, I., Hormann, A., Wichmann, H.E., Lowel, H.: Exposure to traffic and the onset of myocardial infarction. New England J. Med. **351**(17), 1721–1730 (2004)
26. Sen, R., Raman, B.: Intelligent transport systems for Indian cities. ITS Synthesis for Indian cities, Department of CSE, IIT Mumbai (2012)
27. Chakroborty, P.: Sustainable transportation for Indian cities: role of intelligent transportation systems. Curr. Sci. **100**(9), 1386–1390 (2012)
28. Bertini, R.L., Monsere, C.M.: Benefits of intelligent transportation systems technologies in urban areas: a literature review, pp. 1–24. Portland State University, Center for Transportation Studies (2004)
29. Shawe, T.J., De, B.T., Cristianini, N.: Data mining, data fusion and information management. Proc. IEE Int. Trans. Syst. **153**(3), 221–229 (2006)
30. Smiley, A.: Behavioral adaptation, safety, and intelligent transportation systems. Transp. Res. Rec. **1724**, 47–51 (2000) (Discussion on ITS and behavioral adaptation)
31. Stough, R.R.:Intelligent Transport Systems, 227pp. Edward Elgar Publishing Co., Northampton (2001) (Compendium of ITS projects and experiences in US)
32. Sunan, H., Wei, R.: Autonomous intelligent cruise control with actuator delays. J. Intel. Robotic Syst. **23**, 27–43 (1998)

33. Sussman, J.M.: Perspectives on Intelligent Transportation Systems. Springer, New York (2005)
34. Twelfth Five Year Plan (2012–2017): Planning Commission, vol. 1. http://planningcommission.nic.in/plans/planrel/12thplan/pdf/12fyp_vol1.pdf
35. Zheng, N.N., Tang, S., Cheng, H., Li, Q., Lai, G., Wang, F.Y.: Toward intelligent driver-assistance and safety warning systems. IEEE Trans. Int. Sys. **19**(2), 8–11 (2004)
36. 19th ITS World Congress: Congress Report, Vienna, Austria (2012)
37. Sivaraj, D., Kandaswamy, A., Vetrivel, S.: Development of navigation system for autonomous vehicle. In: 2012 International Conference on Machine Vision and Image Processing (MVIP) (2012)

Chapter 11
Detection of Personality Traits of Sarcastic People (PTSP): A Social-IoT Based Approach

Preeti Mulay, Rahul Raghvendra Joshi, Ayushi Misra and Rajeev R. Raje

Abstract Micro blogging sites and online platforms are prevalent mediums of choices these days to express views, thoughts, and opinions on various topics, events etc. throughout the year. The text/comments/opinions are entered using smart IoT based devices. Opinion mining can be applied to analyse such large amount of textual data. One interesting analysis is the ability to automatically detect sarcasm from the opinions entered by people online, use it for various applications domains and to indicate personality trait(s) of people, sarcastic or non-sarcastic. This research work aims to achieve more accuracy, for sarcasm detection, than the prevalent approaches by focusing on the data cleaning process. The purpose is to identify the levels of sarcasm from the text written by the users on social media blogs and online articles and determine their personality traits and any changes observed in the personality traits over a period of time. This classification is achieved using supervised classification algorithms and a comparative study is performed. Gender-based experiments are conducted to observe changes in the level of sarcasm and personality traits in both the genders along with bloggers from varied professions. The outcome of this research is to understand effect of events, seasons, gender, profession etc. on sarcasm and personality traits over the period of time.

Keywords Sarcasm detection · Personality traits · Big Five model
Supervised classification · Twitter · Social media

P. Mulay (✉) · R. R. Joshi · A. Misra
Symbiosis Institute of Technology, Affiliated to Symbiosis International (Deemed University), Pune, India
e-mail: preeti.mulay@sitpune.edu.in

R. R. Joshi
e-mail: rahulj@sitpune.edu.in

A. Misra
e-mail: ayushi.misra@sitpune.edu.in

R. R. Raje
Indiana University-Purdue University Indianapolis, Indianapolis, IN, USA
e-mail: rraje@cs.iupui.edu

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_11

11.1 Introduction

The IoT revolution has started its seamless incorporation in all aspects of our society. This pervasiveness of the IoT paradigm can be used to serve the humanity better in many different ways. Socialization between micro-, macro-smart objects to social objects [1] can further boost the pace of the IoT proliferation in today's world. Associations among co-site, co-possession, co-occupation and close relation among buddy objects [1] will provide a platform to exchange services, information, computing, other resources and output. This technological extension of the IoT paradigm is known as the Social—Internet of Things (S-IoT). Union of smart objects and social media can set up novel social communications by permitting the things having own social networks and interactions. Based on activities, interests and profiles, smart objects can set up their social relationships. Such social networks, social media and IoT have their own challenges viz., trustworthiness, interaction, and interfaces to name a few. However, the S-IoT is at its nascent stage due to standard of core technologies, its concepts viz. connectivity, sensing and edge processing are now established well and different efforts from traditional and latest solutions from literature offer the best solution out of those technologies [2, 3]. Social media is the most adapted communication tool of today's younger generation. So, it is important to know the strong impact of digital worlds on human brains and psyches and to explore unintentional side-effects of technology usage [4]. For example, research questions such as: *"does human personality alter due to regular communications with virtual realities?"*, *"do traits such as sarcasm change over time due to changes in one's personality?"* and *"is it possible to efficiently and accurately detect sarcasm by analysing online texts, and social media articles?"* need a thorough investigation. An exploration of such and similar questions will assist not only in devising future digital worlds but also will assist in creating a cordial cyberspace for all users. Inaccessibility, unobservablity to entire social media are the challenges in exploring such research questions. This chapter describes a novel supervised classification technique for detection of personality traits of sarcastic people, which in turn contains a comparative analysis based on gender and profession of writers. Hundreds of millions of people leave text footprints on social media. These text footprints can be analyzed using psycholinguistic analytics (Big 5, needs and values) to derive personality portrait. The five broad personality traits are extraversion, agreeableness, openness, conscientiousness, and neuroticism [5]. We knew social media was important for the job search, which is revealed by Fig. 11.1 showing social job seeker categorization in terms of age, income and education. PTSP system once incorporated as integral part of any system, it can be used by HR of any industry to hire people, based on their social media presence, to know the personality trait based on sarcasm. It is also feasible to gauge the compatible or non-compatible levels between two personnel using PTSP. Self-learning can be achieved using PTSP, to know whether oneself have reduced the sarcasm level and improved personality or not, if it is essential of the wellbeing of an individual.

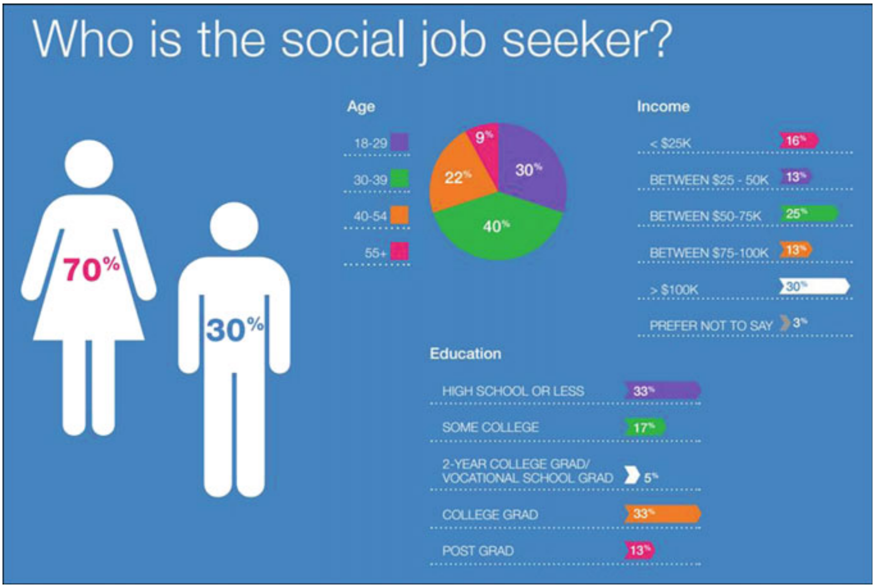


Fig. 11.1 Social job seeker statistics, November 2017 [6]

11.1.1 Research Background

Social media analytics has become one of the most popular research areas in recent past. These analytics mainly analyse the text written by online users, to determine critical facets such as their emotions, sentiments, religious and political orientations. Due to the availability of the Internet and global platforms, such as Facebook and Twitter, the outreach of all information is vast and quick. There has been a constant rise in the number of users and data posted online daily, according to Global social media research summary 2018—4.021 billion internet users (53% penetration) worldwide, 3.19 billion active social media users (42% penetration) worldwide. Social media, due to its vastness and significance outreach, has become one of the popular areas for sentiment analysis, opinion mining, and utilizing these people views for further analysis of their personality traits. Various investigations have been performed to detect positive, negative, and neutral sentiments from the social media blogs and online shopping sites like Twitter, Facebook, Amazon [7]. Such efforts have proven useful in determining important features such as religious inclinations, gender, age, product preferences, and personality traits of writes and correlations between these factors [8].

The automatic detection of personality traits and sarcasm levels using online text/views of people have recently been explored in many studies [9]. There are number of psychological models to depict the personality traits of a person including following:

- Myers–Briggs Type Indicator (MBTI) Model [10],
- NEO-PI Five Factor Model [11],
- Ten Item Personality Indicator (TIPI) Model [12] and
- Big Five Model [13].

Among all these models, the Big Five Model has been the most accepted and widely used model. The Big Five Model was proposed by Goldberg in 1981 [13]. According to this model, the personality traits of a person can be broadly classified under five dimensions and they are:

- Extroversion (EXT),
- Agreeableness (AGR),
- Conscientiousness (CON),
- Openness (OPN) and
- Neuroticism (NEU).

Extroversion is characterized by factors such as sociability, expressiveness, assertiveness, and excitability. With the presence or absence of these attributes, a person is said to be extrovert or introvert. Agreeableness is the presence of attributes such as trust, empathy, affection and kindness. Agreeable people are pro-social, are friendly and have a helping nature. Conscientiousness dimension is defined by will, thoughtfulness, good impulse control, organized attitude and goal-directed actions. Openness is related to intellect, imagination and insight. Neuroticism trait is the presence of attributes such as sadness and emotional instability. People with low neuroticism tend to be more emotionally stable. There is a relationship between humour and personality and Big Five model serves as a tool for the same [14].

The sentiment analysis performed over social media also includes sarcasm other than the positive and negative sentiments. Sarcasm detection and analysis has also been among the recent research areas in the text analysis. Among all the texts and data available online, 11% of the data is said to be sarcastic in nature [15]. This has attracted the interest of the researchers to propose various sarcasm detection techniques. Detection of sarcasm is a difficult task as the user actually wants to convey the exact opposite of what he speaks. So, it becomes even more difficult when the detection has to be done on texts, as the emotions and sentiments of the writer are difficult to analyze sarcasm in written form. Twitter has been the main dataset used for the sarcasm detection research due to the fact that the size of the tweets is limited and a lot number of sarcastic people use twitter to depict sarcasm [16]. Various sarcasm detection techniques have been developed in past two decades which detect sarcasm up to certain accuracy and precision up to 95% [17]. But still no such technique has been developed which can be generalized for all the sarcastic data online due to inability of handling all data online or there is no consolidated repository of such data.

11.1.2 Problem Statement

The existing research work on social media towards sarcasm is limited to detection of sarcasm. This although useful, does not address some of the related concepts such as the connection between personality traits and sarcastic behaviour of a writer. Different approaches have been used for the detection of sarcasm which are discussed in later sections of this chapter. The first challenge in such an analysis is to improve the accuracy of the sarcasm detection technique by designing a noise removal algorithm to remove the unwanted data from the dataset. The other challenges are mapping between sarcasm and personality traits as per gender, profession, their time variant statistical analysis. This research describes a new technique to tackle this noise removal challenge. Another contribution of this research is analysing the personality traits of people who write sarcastically on social media like Twitter and blogs and differentiate them on the basis of gender and profession as it presents more realistic analysis. The automatic analysis of personality traits from text is a new domain of research and is challenging due to difficulty in exploration, accountability and engaging the user. To address the underlying challenges, this research performs a deep investigation into the related areas such as political, social, and online, works on determining the personality traits of people over a period of two years. It also investigates if any changes are observed in the personality traits over a period of time. The next contribution of this research is to determine the personality traits based on events occurred such as political (e.g., demonetization), social (e.g., plastic ban in Maharashtra in June 2018), and online (e.g., change of word limit of Twitter). The personality trait of the writer might show some variations under certain circumstances and the system aims to analyse the results. To accomplish all these granularities like correlation between sarcasm and personality traits and noise removal, this research has created a proto typical system to collaboratively detect Personality Traits of Sarcastic People (PTSP).

11.1.3 Aims and Objectives

The objective of the PTSP research is to design a novel sarcasm detection framework for analysing online textual data. The proposed framework includes a noise removal algorithm to improve the accuracy of classification and another technique to determine the different personality traits of people who speak and write sarcastically and the evolution of these traits over time. The PTSP system developed is empirically evaluated by performing a comparative analysis with the previously developed techniques, such as rule-based, supervised and unsupervised approaches of sarcasm detection using different accuracy measures like Precision, Recall and F1-Score.

11.1.4 Personality Detection Techniques

In the age of Internet, people communicate with their friends and families over social media. The texts written by people reflect their personality traits which have been greatly researched upon [18]. Recent developments have been made to gain more psychological insights with the increase in the availability of large datasets from Facebook and Twitter and the increased storage and computational power [19]. This approach is significant as it enables large scale accessibility and observation to social media.

Qiu et al. in 2012 performed their research to detect personality traits of 142 participants using their tweets [20]. The outcome of this study is personality traits are connected with precise linguistic cues in micro blogs.

Schwartz et al. in 2013 worked on variations in language with personality, gender, and age used in social media to gain psychological insights of the personality of the users [21]. Facebook status of 75,000 users was extracted as dataset and for further research. The main features that were taken into consideration were gender and age of the users which distinguishes people on the basis of vocabulary, word category used by them.

Liu and Zhu in 2016 proposed a deep learning algorithm to perform an unsupervised extraction Linguistic Representation Feature Vector (LRFV) to detect personality traits of people over social media [22]. They worked on the Sina microblog for their research which is an information-driven Online Social Network

Majumder et al. in 2017 developed a novel modelling technique based on Convolutional Neural Network (CNN) feature extractor for automatic personality detection over Twitter. The highlight of their work was the feature extraction at word level, sentence level, and document level separately [23].

Junjie Lin et al. in the same year (2017) proposed a personality based refinement for sentiment classification of online users based on Big Five model [24]. They developed a rule-based approach to predict the personality traits of the users. By this approach, the personality based refinement for sentiment classification could capture better features for microblog classification. This work is among the first to explicitly explore the role of user's personality and its sentiment classification in social media analytics.

11.1.5 Techniques and Approaches for Sarcasm Detection

The task of detecting sarcasm from text is not an easy one. It requires analysing both the grammar and the sentiment involved in it. Various techniques to detect sarcasm in text have been developed in different researches. These techniques can be broadly classified under.

11.1.6 Rule-Based Approach

The rule-based approach applies a set of rules that collectively represent knowledge captured by the system. It follows the if-else conditions to implement the techniques. Rule-based approaches are Dictionary-based or Corpus-based.

Maynard and Greenwood in 2014 proposed an approach for analyzing the impact of sarcasm on sentiment analysis [25]. Their work focuses on hashtags in Twitter to determine the effect of sarcasm scope on the polarity of tweets. They developed a hashtag tokenizer for General Architecture for Text Engineering GATE to detect the sentiment and sarcasm within hashtags. Their work not only identifies whether a tweet is sarcastic or not, but also considers the range of the sarcasm modifier on the polarity of the sentiment expressed.

Khattri et al. in 2015 used the historical tweets of an author as well that would provide an additional context called incongruity as a basis of feature design, and describe two kinds of features: implicit and explicit incongruity features for sarcasm detection [26]. Their approach used two components: a contrast-based predictor to identify if there was a sentiment contrast in the tweet and a historical tweet-based predictor to identify the sentiments of the author towards the target in the past. These two components establishes link between sentiments of present and past tweets.

Hiai and Shimada in 2016 proposed a three-stage approach in which firstly the input text is classified into 8 classes [27]. The second stage is based on boosting rules about the sentences in which the sentences which contain certain words or phrases are termed as sarcastic and the final stage is about rejecting the sentences which contain such words or phrases. The results of this result outperformed in comparison with baseline simple rules.

11.1.7 Supervised Learning Based Approach

Supervised learning based is another approach for detecting sarcasm. It is a machine learning based approach in which a function is generated which maps the inputs to desired outputs called “labels”. New data can be put under these labels.

Rajadesingan, Zafarani and Liu in 2015 introduced an effective behavioural modelling technique for sarcasm detection on Twitter [28]. They studied the psychology behind sarcasm, identified its different forms and demonstrated how these forms are manifested on Twitter. They focused mainly on the historical information collected from past tweets to detect sarcasm. This approach was 83% efficient for the data, which contained historical information but was not effective if no previous tweets were found or for real time streaming data.

Hernandez et al. in 2016 proposed a novel approach, emotIDM, which was an extension of the model developed by Hernandez et al. in 2015 for irony detection [29]. It focuses on the affective information from the tweets apart from the sentiment related features. The affective features captured three main values, which were activation, imagery and pleasantness. They evaluated this approach using distribution and correlation analysis over 10 K tweets and the results proved that affective features can prove useful for detection of irony on social media.

11.1.8 Semi-supervised Learning Based Approach

In semi-supervised approach, the training dataset is comparatively smaller and large dataset is used for testing.

Davidov et al. in 2010 proposed a semi-supervised approach for sarcasm detection on Twitter as well as Amazon product reviews [30]. Their algorithm utilizes two modules: one for identifying the sarcastic patterns which is a semi supervised pattern acquisition module that works as a feature for the classifier. The second module is for classification which classifies the sentence into a sarcastic class using Twitter #sarcasm hashtag and structured information for Amazon dataset.

Riloff et al. in 2013 devised an iterative bootstrapping algorithm which detects sarcasm which arises from positive/negative contrast [31]. The algorithm learns from phrases which depict positive sentiments and negative situations. The assumption for this approach is that in sarcasm, positive sentiments occur simultaneously with negative situations. They used a single seed word "love" and a set of sarcastic tweets as training set to automatically detect positive sentiments and negative situations. However, not all the tweets follow this convention which make this approach less efficient achieving lowest recall of 13% in case of ordered +preds and −situations.

Mulay et al. in 2017 devised Ants Feeding Birds distributed algorithm, which coined a new term called Internet of Everything (IoE) [32].

Mulay et al. in 2017 proposed Correlation Based Incremental Clustering Algorithm (CBICA) using Pearson's coefficient of correlation [33]. The CBICA proved to be superior in comparison with the Incremental Closeness-Factor Based Algorithm (CFBA) using threshold-based approach in post-clustering to adopt new influx of data.

Mulay et al. in 2018 proposed personalized approach using Incremental CBICA which proved to be efficient with accuracy of 87% which is higher than CFBA for analysis of diabetes [34].

Alzahrani et al. in 2018 developed IoT enabled mining machine for twitter sentiment analysis with special focus on sarcastic tweets [35]. The system proved to be useful for microblogs sentiment analysis of people's attitudes with accuracy of 99.2%, which can be further used for marketing, decision analysis, and political campaigns.

11.1.9 Platforms for Machine Learning, Data Mining and NLP Tasks

TensorFlow: TensorFlow is a platform which implements a number of machine learning algorithms and computations built at Google [36]. For each operation in TensorFlow, a data flow graph is created with nodes and edges. The nodes represent the mathematical operation and the edges represent the multidimensional data arrays called tensors communicated between them. The operations can be performed both locally as well as in a distributed environment.

ClowdFlows: ClowdFlows [37] is a web-based application using GUI which supports construction and execution of data mining workflows. The computations are performed on the server using Map-Reduce. The tasks are distributed on the server and performed independently by the by the workstations. CLowdFlows integrates analytical tools such as Weka, oarange and Sci-kit Learn.

TextFlows: Textflows [38] is a platform implementing various text mining and NLP tasks using GUI. Its design is similar to ClowdFlows but it performs NLP tasks such as sentiment analysis, tokenization. TextFLows integrates various algorithms from NLTK, Latino, and Sci-kit Learn. It provides an efficient workflow management with the use of widgets. The computation of tasks is performed similarly to ClowdFlows by distributing the processes over different workstations.

These different platforms will be useful for NLP tasks, mining of required text but for detection of sarcasm out of these texts, there is a need of new approach called PTSP.

11.1.10 Comparative Gist of Previous Work

Table 11.1 shows the research conducted in the domain of sarcasm detection in the recent years. The techniques include rule-based approaches, supervised approaches and semi-supervised approaches.

Similar to the research conducted for sarcasm detection, Table 11.2 represents the work done in the personality detection on microblogs and social media in the recent years.

11.2 Methodologies Used for Implementation of PTSP

11.2.1 Collaborative Methodologies

Figure 11.2 represents the collaborative methodologies used in the design of the PTSP framework. The dataset is collected from twitter accounts, blogs through their APIs. The next step is the data pre-processing, which involves stemming,

Table 11.1 Sarcasm detection comparative analysis

Dataset	Technology/methodology	Approach	Output
Hashtags in Twitter (2014) [25]	Use of Hashtag tokenizer to detect sentiment and sarcasm	Rule-based	Polarity of sentiment and sarcasm detection
Twitter (2015) [26]	Historical tweets of author towards target and contrast based predictor to identify sentiment contradiction in the tweet	Rule-based	Sarcasm detection based only on the historical tweet of author towards a target
Amazon Reviews (2016) [27]	Classify sarcastic sentences into 8 categories based on rules and reject sentences which do not confirm to these rules	Rule-based	Sarcasm detection
Twitter (2015) [28]	Behavioral modeling technique which included past information about the data	Supervised	Differentiate between sarcastic and non-sarcastic tweets
Twitter (2015) [29]	Focused on affective information from data as a feature for detection of sarcasm	Supervised	Detect the presence of irony in tweets using affective features
Twitter and Amazon Reviews (2010) [30]	A semi-supervised pattern acquisition module which acts as a feature for classifier. The classifier classifies the sentence into a sarcastic or non-sarcastic class	Semi-supervised	A pattern acquisition module as a feature. Differentiate the sarcastic sentence from the non-sarcastic one
Twitter (2013) [31]	Bootstrapping algorithm to detect sarcasm arising from positive sentiments and negative situations in a single statement	Semi-supervised	Distinguish sarcastic tweets from non-sarcastic ones which followed the positive/negative contrast

tokenization and stop-word removal. Another task towards data cleaning is to remove the unwanted noise such as the URLs and links. The next steps include the feature extraction via grammatical, social behaviour, sentiment, punctuation related features for both sarcasm detection and personality detection. The features for both the processes are extracted separately as the detection of sarcasm requires different features form than that of personality detection. Pearson's Correlation is used to identify a relationship between the sarcasm level of the writers and their highest personality trait. The final step is to determine the performance scores from the obtained results.

Table 11.2 Personality detection comparative analysis

Dataset	Technology/methodology	Approach	Output
Sina Microblog (2015) [22]	Deep Learning based algorithm to perform unsupervised LRFV extraction to detect personality traits of users	Unsupervised	Personality traits of the users depending upon the posts written on microblog
Twitter (2017) [23]	CNN based feature extraction at word sentence and document level and co-relate the extracted features with the Marriese baseline features to determine the personality traits	Supervised	Personality traits of Twitter users
Tweets from Sina Weibo (2017) [22]	Personality based method to refine sentiment classification. Initially classify the tweets groups. Construct a personality based sentiment classifier	Rule-based	Personality traits of the users of microblog

11.2.2 System Architecture of PTSP

The system architecture diagram, shown in Fig. 11.3, indicates relationships between different modules of the PTSP system.

Mathematical Model used to build PTSP
The sarcasm level of a person writing the statement and his/her personality traits is depicted as follows:

$$P = \{S,\ T\}$$

where

P Person
S Sarcasm Level and S is a 4-tuple as;

$$S = \{Se, Pu, Sy, Pa\}$$

where

Se Sentiment Features
Pu Punctuation Features
Sy Syntactic and Semantic Features
Pa Pattern Related Features
T Personality-Traits and T is a 5-tuple as;
T {Ext, Opn, Neu, Con, Agr} (based on the Big Five Model)

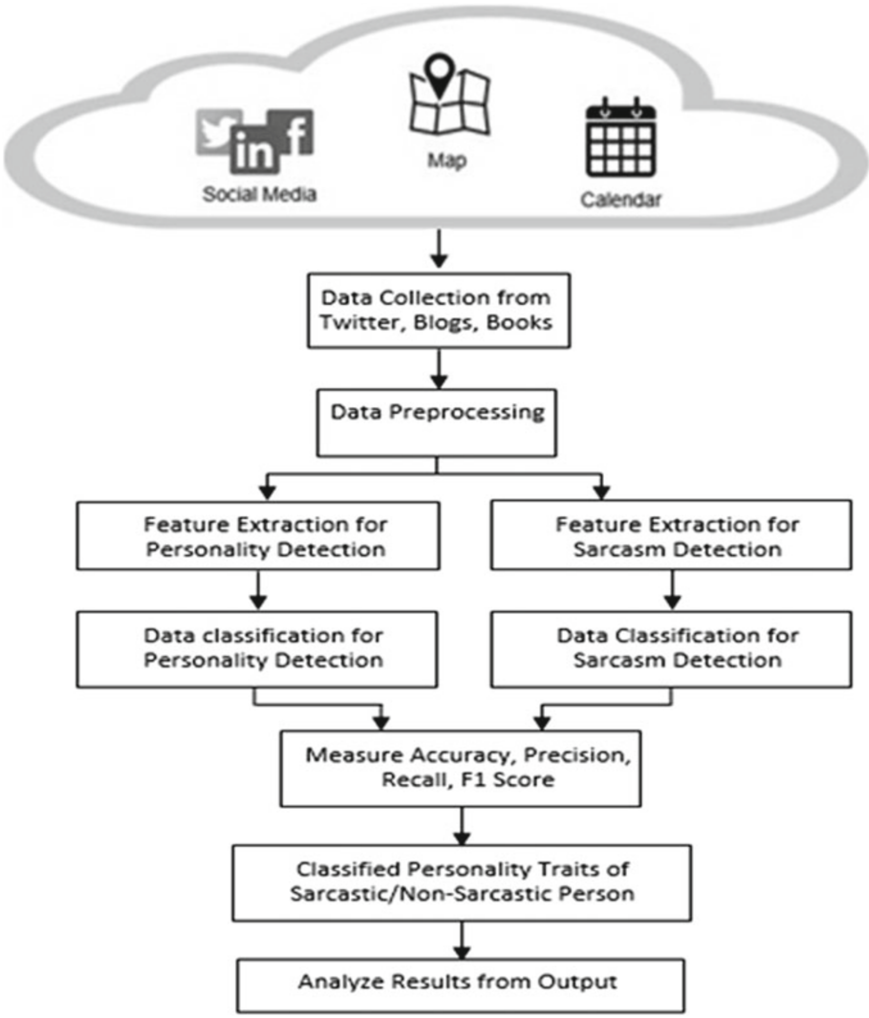


Fig. 11.2 Collaborative methodologies used for PTSP

where

Ext Extroversion
Opn Openness
Neu Neuriticism
Con Conscientiousness
Agr Agreeableness.

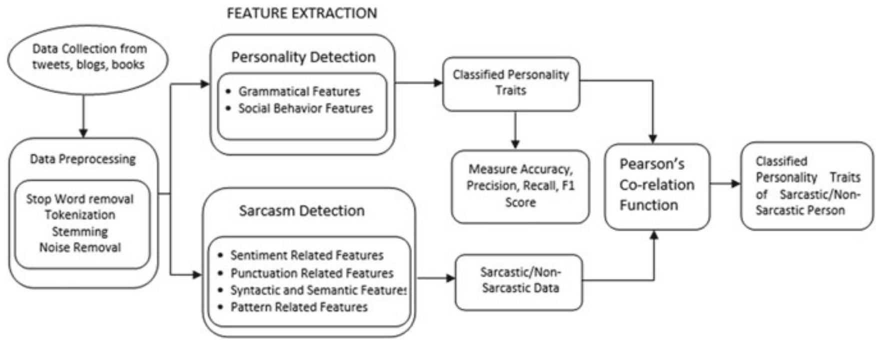


Fig. 11.3 System architecture of the PTSP system implementation

11.2.3 Algorithm for the Implementation of PTSP

PTSP's collaborative approach collects the data from Twitter and other social media platform for different genders, age groups, professions, etc. Various text mining techniques, such as tokenization and stemming, are applied to generate required outcomes. The following section describes the detailed steps of the proposed model:

Input: Tweets collected from Twitter in text format and online books and articles in text format.

Output: Level of sarcasm (1–6) of the person and his/her personality traits (Ext, Opn, Neu, Con, Agr) P = {S, T}

Method:

- Step 1: Perform the following data pre-processing steps:
  - Stop word removal: Remove stop words like "is", "the", "a", "that" etc.
  - Tokenization: Form tokens of the data in text files.
  - Stemming: Extract the stem words.
- Step 2: Perform Feature extraction for to determine the level of sarcasm and personality traits:
- For determination of level of sarcasm, extract the following features:
  - Sentiment features:

    Positive Sentiments: "love", "happy", "joy", "hope", etc.
    Negative Sentiments: "hate", "angry", "depress", "cruel", etc.
  - Punctuation Features: "!!!", "…", "???"
  - Syntactic and Semantic Features: "aaa", "Oh! Really", "hahaha", "Yeah!", etc.
  - Pattern related Features: Tag words with POS tagger. Extract the "GFI" and reject the "CI"

- For determination of personality traits, extract the following features:
  - Grammatical features:

    No. of question marks
    No. of exclamation marks
    No. of positive words
    No. of negative words

  - Social Behaviour Features:
- For e.g.: Extroversion: “easy”, “like”, “learn”, “festivals” etc.
- Step 3: For sarcasm detection, map the features extracted from tweets and data from books to the Bag of Words (BOW) library
- Step 4: The classification of sarcasm is obtained using Supervised popular Classification techniques such as Random Forest, SVM, Naïve Bayes
- Step 5: For personality trait detection, the social behaviour words of each personality trait are mapped with the Bag of Traits(BoT) which is a self-created dictionary
- Step 6: Sarcasm percentage is mapped with each personality trait using the Pearson’s Correlation coefficient

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\left[N\sum X^2 - (\sum X)^2\right] * \left[N\sum Y^2 - (\sum Y)^2\right]}}$$

- Step 7: Measure the performance of the results obtained using Accuracy, Recall and F-score methods and a comparative analysis is performed.

11.3 Implementation Details of PTSP

11.3.1 Hardware and Software Requirements

The minimum hardware and software requirements for PTSP are hard drive of 20 GB and 4 GB of RAM, can be run using Python, R Studio on NetBeans IDE, and MySQL at the backend.

In all 5 K tweets were extracted, for training the sarcasm detection model, around 4500 tweets were extracted from twitter using the twitter API which contained the keyword “#sarcasm”. Another 500 tweets were separately used for testing the model.

11.3.2 Feature Extraction for Sarcasm Detection

Following is the list of features that are to be extracted for detection of sarcasm. They are of four types as given below:

- Sentiment Related Features
- Punctuation Features
- Syntactic and Semantic Features
- Pattern Related Features.

11.3.3 Feature Extraction for Personality Traits

Following are the features that are to be extracted for examining personality traits. They are of three types as given below:

- Social Behaviour Features
- "About" section of an individual
- Event, season and major-change based activities.

11.4 Results and Discussion by PTSP

After the data pre-processing steps have been performed, the above mentioned features are extracted for the detection and classification of sarcasm into different levels.

11.4.1 Time Variant Analysis of Sarcasm and Personality Traits

To observe the changes in the level of sarcasm in the writing of the persons, the data is extracted over a period of two years as major activities happened during that period in India like demonetization, GST implementation, and the period is dived into two sets of a year each. The time period considered for the analysis of sarcasm and personality traits of both the writers is from January, 2016-December, 2016 and January, 2017-December, 2017. This analysis is performed for the writers of both genders. Table 11.3 shows the results of a male commercial writer who is known for writing sarcastic and witty tweets on social media. Similarly, Table 11.4 shows the results of a female commercial writer/actor.

Table 11.3 Variation analysis in personality traits and level of sarcasm over time of gender male

Duration	EXT (%)	CON (%)	NEU (%)	AGR (%)	OPN (%)	Sarcasm percentage (%)	Level of sarcasm (%)
Jan16–Dec16	19.35	17.97	3.26	5.40	22.40	47.06	3
Jan17–Dec17	33.33	22.22	3.44	7.27	30.65	46.34	3

Table 11.4 Variation analysis in personality traits and level of sarcasm over time of gender female

Duration	EXT (%)	CON (%)	NEU (%)	AGR (%)	OPN (%)	Sarcasm percentage (%)	Level of sarcasm (%)
Jan16–Dec16	18.19	9.45	2.43	2.51	11.07	38.25	3
Jan17–Dec17	24.50	13.37	2.70	4.57	16.77	35.56	3

The above analysis show that there are minute changes in the sarcasm level for both the writers over the period of two years in terms of sarcasm percentages. Variations in the personality traits for both the writers can be observed from the results. Significant increase can be observed in the Extroversion and Openness personality traits for both the writers over the time period considered.

11.4.2 Gender Variant Analysis of Sarcasm and Personality Traits

The gender-based analysis was performed for 40 social media users from Twitter. Out of which 20 users were males and 20 were females in order to achieve unbiased and realistic analysis. Tables 11.5a, b show the results obtained from the analysis of writers from different profession. The gender-based analysis of the sarcasm and personality traits of people who belong to various professions observe the Extroversion trait to be high in professions like commercial books writers and academicians, actors and politicians. People belonging to professions such as HR and related to social works are observed to be containing high Agreeableness personality trait. Another conclusion that can be drawn from the results is that, most of the male writers have high Extroversion trait in comparison to the female writers.

When a gender-based analysis is observed from the academic profession, male academicians are observed to contain a comparatively high extroversion and openness personality traits from that of female academicians. The female academicians are observed to pertain high conscientiousness and agreeableness personality trait as compared to male academicians.

By analysing the results of the academicians separately, medians of individual personality traits are calculated for male and female academicians. It is observed that highest sarcasm percentage in case of male academician is 34.60% which is

Table 11.5 Sarcasm and personality traits analysis based on gender from different profession

Personalities	Gender	Profession	EXT (%)	CON (%)	NEU (%)	AGR (%)	OPN (%)	Sarcasm (%)	Level of sarcasm
(a)									
P1	Male	Commercial writer	47.34%	17.02	3.55	16.34	23.33	49.30	3
P2	Male	Actor	45.50	16.40	3.40	19.44	38.45	14.25	1
P3	Male	Politician	53.76	19.44	6.80	8.45	28.90	17.50	1
P4	Male	Politician	58.62	13.45	19.34	13.45	34.44	21.30	2
P5	Female	Actor/writer/producer	39.45	16.23	2.33	9.57	27.70	45.70	3
P6	Female	Social activist/writer	32.49	34.50	1.30	39.50	23.40	15.50	1
P7	Female	HR	23.88	19.46	3.56	34.44	23.77	34.23	2
P8	Female	HR	26.45	38.45	2.40	12.80	21.34	14.34	1
P9	Female	Politician	51.30	23.40	1.50	34.44	20.87	23.57	2
P10	Female	Children books writer	35.56	23.70	1.20	52.38	20.30	12.40	1
P11	Male	Academician	45.56	13.45	1.50	28.28	23.50	23.50	1
P12	Male	Academician	39.45	19.45	2.60	31.30	34.00	24.78	1
P13	Male	Academician	28.45	12.30	1.30	23.40	35.23	14.50	1
P14	Male	Academician	45.60	9.30	2.50	24.50	32.34	18.50	1
P15	Male	Academician	34.76	13.40	3.50	20.50	32.77	19.40	1
P16	Male	Academician	29.40	10.30	2.67	23.50	29.50	34.60	2
P17	Male	Academician	39.23	10.20	2.34	23.78	34.40	29.50	1
P18	Male	Academician	49.50	11.60	1.50	20.50	31.65	22.10	1
P19	Male	Academician	51.40	12.30	1.80	21.40	32.45	32.70	2
P20	Male	Academician	48.90	12.70	1.60	26.70	28.44	20.78	1
P21	Male	Academician	43.50	14.40	3.56	34.56	30.50	19.40	1
P22	Male	Academician	34.56	12.40	2.50	26.80	34.44	18.50	1
P23	Male	Academician	45.30	10.40	2.67	23.60	34.78	23.40	1
P24	Male	Academician	28.60	10.60	3.56	24.50	35.80	12.40	1

(continued)

Table 11.5 (continued)

Personalities	Gender	Profession	EXT (%)	CON (%)	NEU (%)	AGR (%)	OPN (%)	Sarcasm (%)	Level of sarcasm
(**b**)									
P25	Male	Academician	29.40	11.44	3.70	22.40	39.50	34.60	2
P26	Male	Academician	32.40	11.33	1.45	21.30	36.40	27.50	2
P27	Male	Academician	46.50	12.40	1.40	21.78	34.90	19.30	1
P28	Male	Academician	34.40	12.00	1.20	23.50	38.50	16.30	1
P29	Male	Academician	34.50	9.00	2.44	25.60	32.45	24.50	1
P30	Male	Academician	32.33	12.30	2.34	27.67	32.67	12.50	1
P31	Female	Academician	37.88	21.30	3.44	34.50	21.88	18.50	1
P32	Female	Academician	41.32	23.40	1.87	32.30	26.12	14.48	1
P33	Female	Academician	30.10	23.40	1.80	32.40	34.50	7.50	1
P34	Female	Academician	32.20	25.50	1.30	34.60	23.40	7.40	1
P35	Female	Academician	27.40	24.50	3.40	39.40	22.40	12.40	1
P36	Female	Academician	23.40	28.50	2.10	35.30	20.37	12.80	1
P37	Female	Academician	26.70	23.30	1.67	40.45	21.67	17.50	1
P38	Female	Academician	23.50	23.40	1.50	41.34	25.60	12.30	1
P39	Female	Academician	24.66	22.30	1.50	32.56	24.50	8.45	1
P40	Female	Academician	27.80	20.40	1.30	34.23	30.50	9.45	1
P41	Female	Academician	29.40	20.40	1.10	38.40	23.54	15.30	1
P42	Female	Academician	25.60	23.80	0.30	32.44	23.80	12.30	1
P43	Female	Academician	23.60	24.60	0.34	34.21	22.56	12.60	1
P44	Female	Academician	23.89	25.40	1.30	33.20	27.50	10.11	1
P45	Female	Academician	26.23	23.40	1.90	36.56	26.34	5.34	1
P46	Female	Academician	23.40	23.90	2.40	32.44	23.40	7.23	1
P47	Female	Academician	23.90	24.60	2.56	37.50	23.44	15.34	1
P48	Female	Academician	23.45	24.56	1.34	34.50	21.34	13.23	1
P49	Female	Academician	29.60	27.50	1.60	35.89	31.80	14.67	1
P50	Female	Academician	32.54	28.46	2.90	34.60	23.70	13.39	1

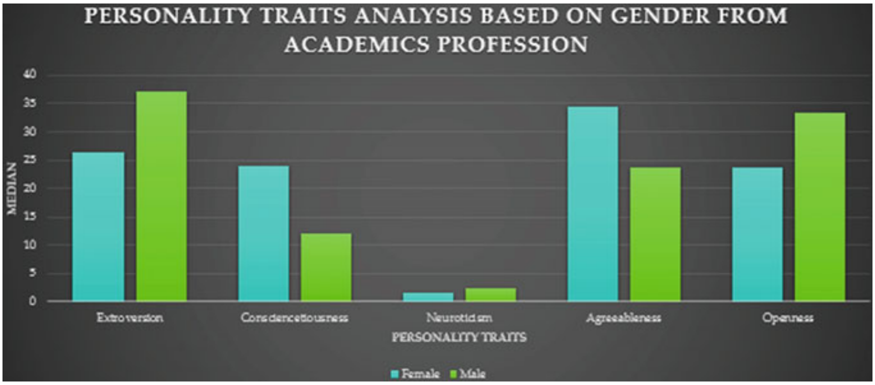


Fig. 11.4 Gender based analysis of academicians

18.5% in case of female academician. Figure 11.4 show the median personality traits obtained for the male and female academicians respectively.

It is observed that the Neuroticism trait is low for both the genders in the profession. However, the male academicians exhibit high Extroversion and Openness trait as compared to the female academicians. From Fig. 11.4 it is also clear that the female academicians have high conscientiousness and agreeableness personality traits in comparison to the male academicians.

11.4.3 Situation-Based Analysis of Sarcasm and Personality Traits

Situation-based analysis is done to identify if some changes can be observed in the personality traits of the writers and in the level of sarcasm under certain situations. The situation analysed in this study is the demonetization announcement made by the Government of India in November, 2016 [39]. The personality traits of some writers and their sarcasm levels are studied and changes are observed over the period of November, 2016 to March, 2017 as demonetization hampered lot to people in India.

The personalities observed for the study are of a commercial writer, and politicians from two different political parties. The dataset used for this analysis is the tweets of the respective writers. The results of the analysis are discussed below.

Figure 11.5 shows the results of personality traits and sarcasm for the tweets written by the commercial writer and a compared with the personality traits and sarcasm observed over a period of two years. It can be observed that the level of sarcasm is constant throughout the time period but a considerable rise can be observed in the Extroversion and Neuroticism traits during the demonetization period during June 16 to March 17.

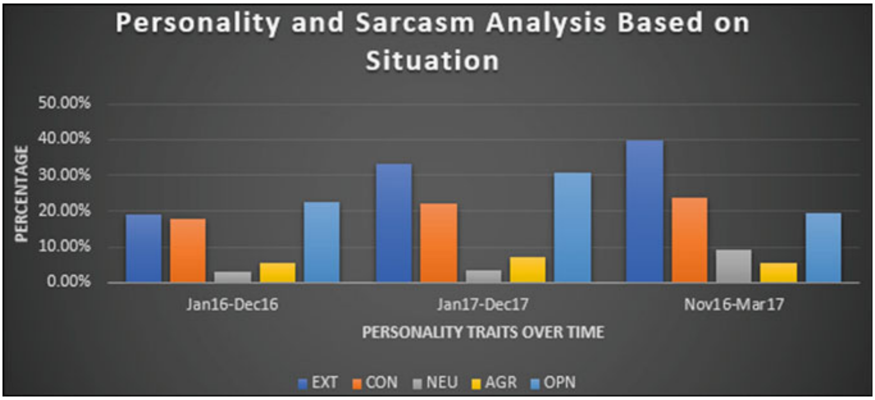


Fig. 11.5 Situation-based analysis of sarcasm and personality traits of commercial writer

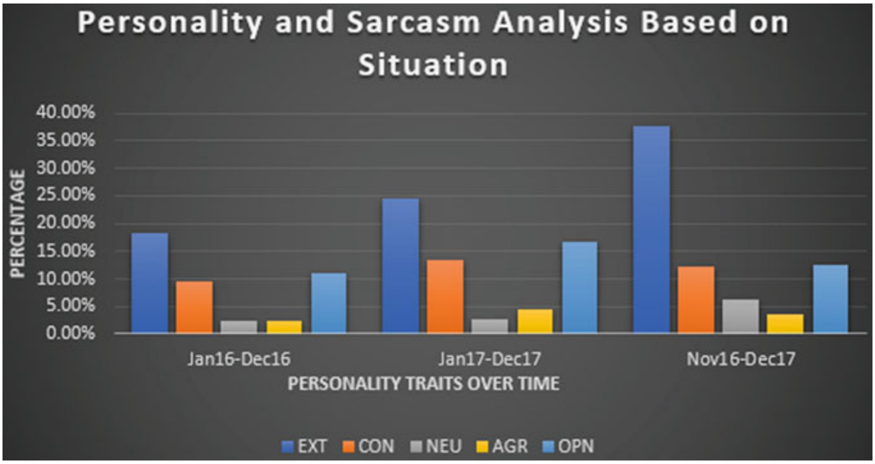


Fig. 11.6 Situation based analysis of sarcasm and personality traits of politician1

Figure 11.5 shows a high Extroversion rate as compared to the traits observed in the two years duration from 2016 and 2017.

Similarly, Figs. 11.6 and 11.7 show the analysis of changes observed in the personality traits and level of sarcasm for politicians who belong to different political parties. The situation and the time period considered is same as mentioned above.

Figure 11.6 shows the analysis of the politician who belongs to the opposition political party. The results show rise in the Extroversion and Neuroticism personality traits. But the level of sarcasm is reduced during the demonetization period.

Table 11.6 shows the results of the politician who belongs to the ruling party. The Extroversion trait is high for the writer but no considerable change is observed

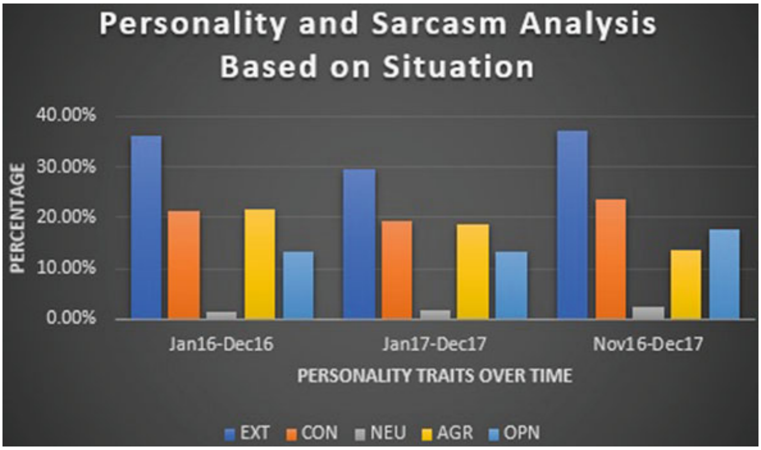


Fig. 11.7 Situation based analysis of sarcasm and personality traits of politician2

Table 11.6 Situation based analysis of personality traits and sarcasm of politician2

Duration	EXT (%)	CON (%)	NEU	AGR (%)	OPN (%)	Sarcasm percentage (%)	Level of sarcasm
Jan16–Dec16	36.19	21.40	1.43	21.61	13.45	33.25	2
Jan17–Dec17	29.60	19.34	1.80	18.67	13.50	17.56	1
Nov16–Dec17	37.20	23.44	2.34	13.66	17.78	28.40	2

in the Neuroticism trait. Figure 11.7 shows the analysis in the graphical form and it is observed that there is high percentage of extroversion and less percentage of openness during the specified period. Also, low level of sarcasm is observed during Jan to Dec 17 of politicians.

11.4.4 Performance Measure

Performance scores are obtained for the classification done for sarcasm detection and analysis. The accuracy of the classification results obtained is the highest using Random Forest Classifier as shown in Table 11.7. The results are obtained from the model, which was trained using the training data and tested on the testing data using 90–10% approach. A comparative analysis is performed with Naïve Bayes (NB) Classifier and Support Vector Machine (SVM). Both NB and SVM give less accurate results for the classification due to small amount of training dataset.

Table 11.7 Performance measure for classification

Classifiers	Overall accuracy (%)	Precision (%)	Recall (%)
Random forest	82.10	78.30	71.20
SVM	78.46	74.20	40.30
Naive Bayes	68.50	82.30	74.40

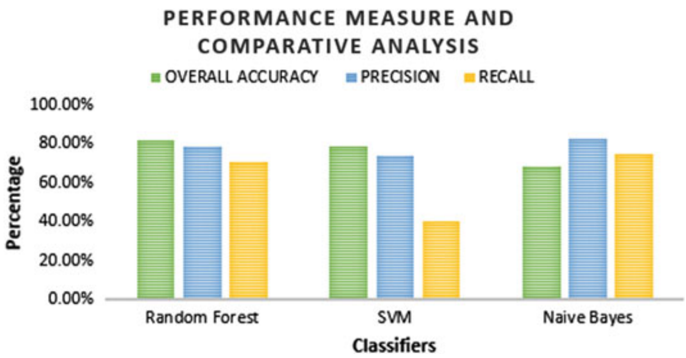


Fig. 11.8 Performance measure and comparative analysis of different classifiers

Figure 11.8 shows a graphical representation of the performance score obtained using different classification models, Random Forest, SVM, and Naïve Bayes. The accuracy obtained is the highest for Random Forest classification.

11.4.5 Mapping Between Sarcasm and Personality Traits

The sarcasm percentage obtained for the writers and their individual personality traits are mapped using the Pearson's Correlation function. The results obtained from the correlation are shown in Table 11.8.

From the results obtained, it can be observed that Sarcasm can be positively correlated with Extroversion, Neuroticism, and Openness but a negative correlation is obtained for Conscientiousness and Agreeableness traits which in a way portraits competitive, outspoken, easy-going and careless personality traits.

Table 11.8 Correlation of sarcasm with personality traits

Personality traits	Correlation with sarcasm
Extroversion	0.422
Conscientiousness	−0.469
Neuriticism	0.155
Agreeablesness	−0.513
Openness	0.191

11.5 Conclusion and Future Directions of PTSP

The research work succeeded to gain insights into the personality traits of people from a different perspective based on Big Five and proposed PTSP model. The contributions of this work are correlation between sarcasm and personality traits, attainment of overall 82.1% accuracy through Random Forest classifier. The proposed research has applications in a number of areas such as education, business, psychology and sociology and sentiment analysis. With the determination of personality traits of sarcastic people, more effective recommender systems can be built for online businesses so that people can get realistic views about their decision. This study aims to provide assistance to teachers in schools to deal with students who are sarcastic in nature. It would also support further researches for psychologists and psychiatrists to deal with the people of certain personality traits. The business people would be assisted in the hiring of job associates who have a certain personality type and are suitable for a certain profile. The most research work currently is focused on analyzing the personality of people efficiently who post sarcastic comments while buying products online. This system would help the researchers to differentiate the positive comments from those which are sarcastic and build and efficient recommendation system. PSTP is compared with three different classifiers viz., Random Forest, Naive Bays and SVM classifiers in terms of accuracy, precision and recall. In case of Random Forest, it outperforms for these three indicators. This study considers two years of span for sarcasm analysis as this is a substantial period to judge personality traits via sarcastic texts of people.

The future work of the research can be related to perform analysis of the sarcasm levels and personality traits with the age perspective. More interesting results are expected to be achieved by using other classification methods as well like neural networks. In addition to using Twitter and Facebook contents, it is necessary to include views of leading newspaper sites, TV channel's websites, various blogs by experts from different domains, Kindle versions of books to understand traits of writers, and many more such possible ever growing sites online. The PTSP system can be deployed on Cloud for use by other researchers too, with flexibility of inputs from various sections of writers, including multi-lingual approach.

References

1. https://www.journals.elsevier.com/future-generation-computer-systems/call-for-papers/enabling-technologies-for-social-internet-of-things. Accessed on 20 June 2018 at 8.45 PM
2. Son, H., Kang, N., Gwak, B., Lee, D.: (2017). An adaptive IoT trust estimation scheme combining interaction history and stereotypical reputation. In: Consumer Communications and Networking Conference (CCNC), 2017 14th IEEE Annual, pp. 349–352. IEEE
3. Abdelghani, W., Zayani, C.A., Amous, I., Sèdes, F.: (2016). Trust management in social internet of things: a survey. In: Conference on e-Business, e-Services and e-Society, pp. 430–441. Springer, Cham

4. https://www.slideshare.net/LeonGou/share-me-45232556. Accessed 12 June 2018 at 3.45 PM
5. https://www.verywellmind.com/the-big-five-personality-dimensions-2795422. Accessed on 15 June 2018 at 2.45 PM
6. http://linkedinpedia.com/wp-content/uploads/2017/11/social-job-seeker.jpg. Accessed on 10 June 2018 at 1.45 PM accessed on 8 June 2018 at 11.15 AM
7. Rajan, A.P., Victor, S.P.: Web sentiment analysis for scoring positive or negative words using Tweeter data. Int. J.Comput. Appl. **96**(6) (2014)
8. McCollister, C.: Predicting Author Traits Through Topic Modeling of Multilingual Social Media Text. Doctoral dissertation, University of Kansas) (2016)
9. Rajadesingan, A., Zafarani, R., Liu, H.: (2015). Sarcasm detection on twitter: a behavioral modeling approach. In: Proceedings of the Eighth ACM International Conference on Web Search and Data Mining, pp. 97–106. ACM
10. https://en.wikipedia.org/wiki/Myers%E2%80%93Briggs_Type_Indicator. Accessed on 2 June 2018 at 9.45 PM
11. https://en.wikipedia.org/wiki/Revised_NEO_Personality_Inventory. Accessed on 7 June 2018 at 5.45 PM
12. http://fetzer.org/sites/default/files/images/stories/pdf/selfmeasures/Personality-TenItemPersonalityInventory.pdf. Accessed on 19 June 2018 at 4.45 PM
13. https://en.wikipedia.org/wiki/Big_Five_personality_traits. Accessed on 13 June 2018 at 6.45 PM
14. Mendiburo-Seguel, A., Páez, D., Martínez-Sánchez, F.: Humor styles and personality: a meta-analysis of the relation between humor styles and the Big Five personality traits. Scand. J. Psychol. **56**(3), 335–340 (2015)
15. Huang, L., Gino, F., Galinsky, A.D.: The highest form of intelligence: sarcasm increases creativity for both expressers and recipients. Organ. Behav. Hum. Decis. Process. **131**, 162–177 (2015)
16. Bindra, K.K., Gupta, A.P.A.: Tweet Sarcasm: Mechanism of Sarcasm Detection in Twitter
17. Bharti, S.K., Vachha, B., Pradhan, R.K., Babu, K.S., Jena, S.K.: Sarcastic sentiment detection in tweets streamed in real time: a big data approach. Digital Commun. Netw. **2**(3), 108–121 (2016)
18. Pennebaker, J.W., Mehl, M.R., Niederhoffer, K.G.: Psychological aspects of natural language use: our words, our selves. Annu. Rev. Psychol. **54**(1), 547–577 (2003)
19. Kim, Y., Choi, K., Natali, F.: Extending the Network: the Influence of Offline Friendship to Twitter Network (2016)
20. Qiu, L., Lin, H., Ramsay, J., Yang, F.: You are what you tweet: personality expression and perception on Twitter. J. Res. in Pers. **46**(6), 710–718 (2012)
21. Schwartz, H.A., Eichstaedt, J.C., Kern, M.L., Dziurzynski, L., Ramones, S. M., Agrawal, M., … & Ungar, L.H.: Personality, gender, and age in the language of social media: The open-vocabulary approach. PloS One **8**(9), e73791 (2013)
22. Liu, X., Zhu, T.: Deep learning for constructing microblog behavior representation to identify social media user's personality. Peer J. Comput. Sci. **2**, e81 (2016)
23. Majumder, N., Poria, S., Gelbukh, A., Cambria, E.: Deep learning-based document modeling for personality detection from text. IEEE Intell. Syst. **32**(2), 74–79 (2017)
24. Lin, J., Mao, W., Zeng, D.D.: Personality-based refinement for sentiment classification in microblog. Knowl. Based Syst. **132**, 204–214 (2017)
25. Maynard, D., Greenwood, M.A.: Who cares about sarcastic tweets? Investigating the impact of sarcasm on sentiment analysis. In: LREC, pp. 4238–4243 (2014)
26. Khattri, A., Joshi, A., Bhattacharyya, P., Carman, M.: Your sentiment precedes you: using an author's historical tweets to predict sarcasm. In: Proceedings of the 6th Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis, pp. 25–30 (2015)
27. Hiai, S., Shimada, K.: A sarcasm extraction method based on patterns of evaluation expressions. In: 2016 5th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI), pp. 31–36. IEEE (2016)

28. Rajadesingan, A., Zafarani, R., Liu, H.: (2015). Sarcasm detection on twitter: a behavioural modeling approach. In: Proceedings of the Eighth ACM International Conference on Web Search and Data Mining, pp. 97–106. ACM
29. Sulis, E., Farías, D.I.H., Rosso, P., Patti, V., Ruffo, G.: Figurative messages and affect in Twitter: differences between# irony,# sarcasm and# not. Knowl. Based Syst. **108**, 132–143 (2016)
30. Davidov, D., Tsur, O., Rappoport, A.: (2010). Semi-supervised recognition of sarcastic sentences in Twitter and Amazon. In: Proceedings of the Fourteenth Conference on Computational Natural Language Learning, pp. 107–116. Association for Computational Linguistics
31. Riloff, E., Qadir, A., Surve, P., De Silva, L., Gilbert, N., Huang, R.: Sarcasm as contrast between a positive sentiment and negative situation. In: EMNLP, vol. 13, pp. 704–714 (2013)
32. Mulay, P., Patel, K., Gauchia, H.G.: Distributed system implementation based on "ants feeding birds" algorithm. Detecting Mitigating Robot. Cyber Secur. Risks **51** (2017)
33. Shinde, K., Mulay, P.: Cbica: Correlation based incremental clustering algorithm, a new approach. In: 2017 2nd International Conference for Convergence in Technology (I2CT), pp. 291–296. IEEE (2017)
34. Mulay, P., Shinde, K.: Personalized diabetes analysis using correlation-based incremental clustering algorithm. In: Big Data Processing Using Spark in Cloud, pp. 167–193. Springer, Singapore (2019)
35. Alzahrani, S.M.: Development of IoT mining machine for Twitter sentiment analysis: mining in the cloud and results on the mirror. In: Learning and Technology Conference (L&T), 2018 15th, pp. 86–95. IEEE (2018)
36. https://www.tensorflow.org/. Accessed on 23 June 2018 at 10.45 PM
37. http://clowdflows.org/ accessed on 23th June 2018 at 10.45 PM
38. http://textflows.org/. Accessed on 23 June 2018 at 10.45 PM
39. https://en.wikipedia.org/wiki/2016_Indian_banknote_demonetisation. Accessed on 10 June 2018 at 10.45 PM

Chapter 12
Utilizing Big Data for Health Care Automation: Obligations, Fitness and Challenges

Sherin Zafar

Abstract The impact of big data in healthcare ranges from medical diagnosis to the lifestyle quantification. Ponemon Institute in 2012 declared that around 30% of electronic data comes from the industry of healthcare so the situation is quite alarming for managing this huge amount of big data being generated. As specified that the extraction of knowledge of big data is fast, cheap and quite effective so it can bring a change in patients life by improving health and services. Health care analytics new doors has been opened by big data as it provides answers for "what happened", "why happened", "what will happen" and "how to make happen for description, diagnosis and prediction". This chapter namely "Big data for health care automation, obligation, fitness and challenges" focuses upon the potential knowledge of 4 V's of big data namely, Volume, Velocity, Variety and Veracity by a radical improvement through productivity bottlenecks being unlocked. This will bring a radical change in the quality and accessibility of health care automation.

Keywords Big data · Health care automation · Diagnosis · V's of big data

12.1 Introduction

A survey specifies that around 8% workforce of world and 10% GDP are accounted by health care sector and the expenditure of public health care is expected to increase in 2060 to about 1/3rd, due to rapid rate of aging population, chronic diseases prevalent in society and in huge costs involved in medical technology. A sustainable improvement is required for the current healthcare models due to increased share of spending public health care in the expenditure of the government and consolidation of balances of government budgets.

With the improvement in health care systems productivity, there will be huge increase in public spending. A lot of positive impact has been started to be looked

S. Zafar (✉)
Department of CSE, SEST, Jamia Hamdard, New Delhi, India
e-mail: zafarsherin@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_12

upon in healthcare fields of medical diagnosis, imaging data, medicine, fitness industry, lifestyle quantification through big data technologies. Still the healthcare industry is lagging in taking up big data approaches [1, 2]. A hidden knowledge specifies that life of a patient can be changed to huge extent with adoption of big data analytics in health care automation, as the extraction of big data knowledge is fast, cheap and effective approach. Health care analytics new doors has been opened by big data as it provides answers for "what happened", "why happened", "what will happen" and "how to make happen for description, diagnosis and prediction".

The economic as well as social relevance of big data technology is a boost for organizations leading to improved business models. This chapter namely "Big data for health care automation, obligation, fitness and challenges" focuses upon the potential knowledge of 4 V's of big data namely, Volume, Velocity, Variety and Veracity by a radical improvement through productivity bottlenecks being unlocked. This will bring a radical change in the quality and accessibility of health care automation. Figure 12.1 describes the hindsight, insight and foresight of big data patterns which provides a graphical representation of "What Happened" referred as Descriptive Analysis, "Why did it Happen"; Diagnostic Analysis, to "What will happen" specification of Predictive Analysis and Prescriptive Analysis by "How can we make it happen".

Due to the prevalence of chronic diseases in elderly, there is an increase in demands and automation of big data industry. Figure 12.2 depicts Iron Triangle of healthcare to describe the healthcare challenges in terms of quality, access and cost which further relates to efficacy, value and outcome, hence provides a reflection of

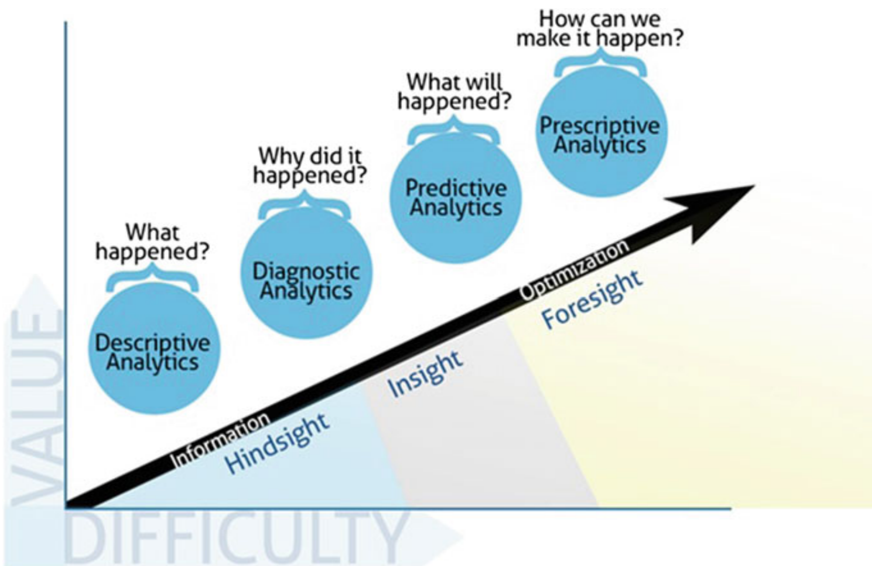


Fig. 12.1 Hindsight, insight and foresight of big data patterns

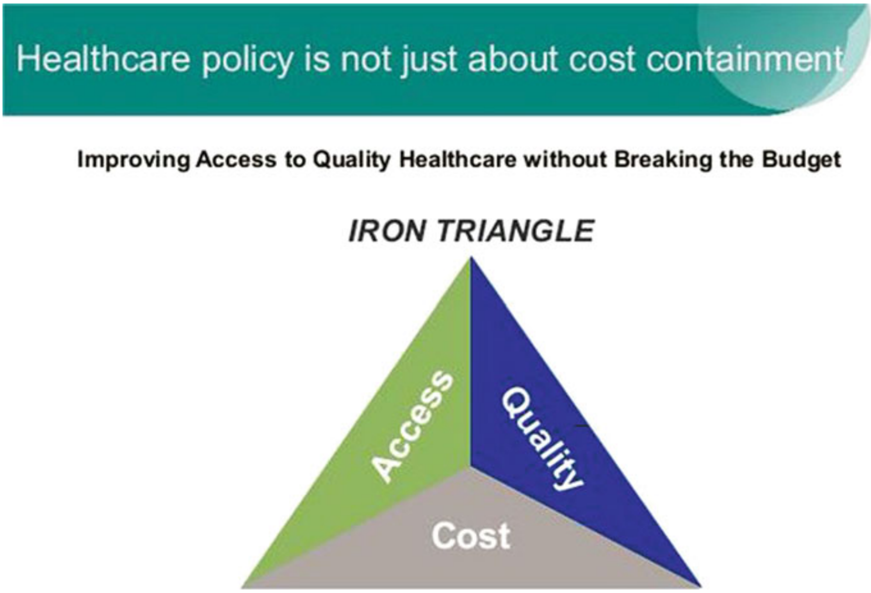


Fig. 12.2 Iron triangle of health care

improved quality of healthcare systems. "Reception of care on need" is described by access, whereas price tag and affordability of patients is specified by cost. In the healthcare sector components of access, quality and cost are in competition with each other. There is a tradeoff that improving one or two components will increase the expense of the third component. A minor change can be brought in Iron Triangle of Health Care with various optimization approaches. Only with the help of a radical breakthrough disruption can be brought in all the three components of Iron Triangle of health.

Since the healthcare is one of the most intensive industries of the world with volume, variety and veracity in high multitude so a disruption in Iron Triangle can occur through value of data sources. There is a need of process facilitation of conversion of huge amount of healthcare data from hard copy format to digital form. Health research 1314 has provided wide range of definition of big data; "Encompassment of volume, diversity in high multitude for biological lifestyle, environmental and clinical data collected from single patient to large cohorts" defines "Big data in health", specific to health, and wellness status in one or several points of time. Mckinsey Global Institute defines big data through data sets which cannot be captured, managed and analyzed by traditional data base software [3, 14].

Healthcare industry utilizes big data not only for size/volumes but for many dimensions, multiple sources, types and format as variety, quality and validity of data through veracity and to be available at real time by velocity. Data security in terms of trustworthiness, protection and privacy due to sensitivity in managing data are the issues that also need to be looked upon. The above all aspects of protection,

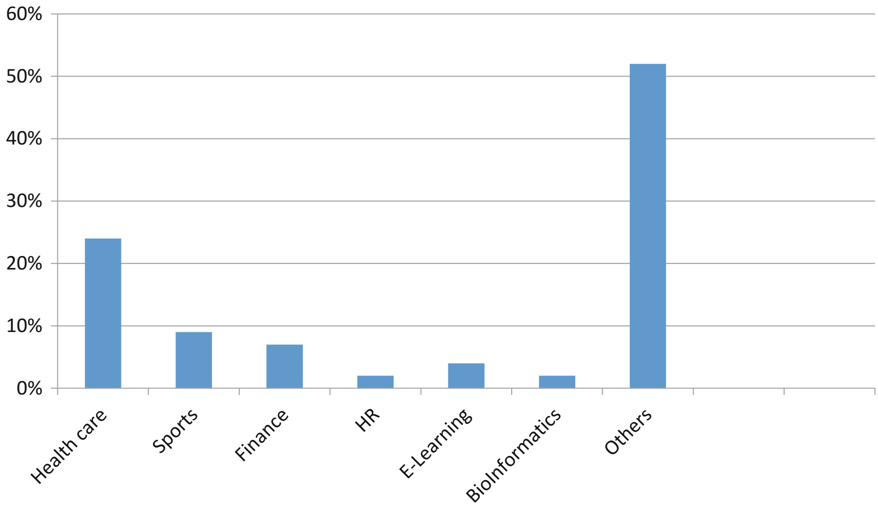


Fig. 12.3 Diagram depicting healthcare industry as most talked with big data

trustworthiness, privacy, security, quality, validity and veracity require new techniques, approaches and algorithms for handling new challenges. Big Data Value Association (BDVA) has promoted a document focusing on challenges and impact of big data on the domain of healthcare. Figure 12.3 depicts that healthcare industry nowadays is most talked/related with big data when compared with other industries like finance, HR, sports etc. Upcoming sections of this chapter focus on **key business healthcare challenges, followed by big data challenges in healthcare automation, data analytics, and advantages for healthcare through big data utilization. Tools and Platforms for utilizing big-data analytics for healthcare automation is discussed in later sections of this chapter followed by conclusions and recommendations**.

12.2 Key Business Healthcare Challenges

Traditional approaches utilized Data Warehousing Mechanism, Business Intelligence Tools (BIT) for reporting and analyzing financial results and optimizing the facilities operation and to measure outcomes related with care quality [5]. Huge benefits could be reaped by utilizing data reservoirs through Hadoop or SQL databases and by advanced analytics. Big data involvement in healthcare targets the goals listed below:

- Reduction of readmission in hospitals.
- Accountable Care Organization (ACO) for predictions in high risk patients.

- Improving quality of care and outcomes through simulation analysis of patient reports.
- Strategic Portfolio Modeling (SPM) to accelerate market of new therapies.
- Healthcare costs to be quantifies and recommendations provided by intervention and wellness.
- Emerging Reimbursement Models (ERM) need to be analyzed for their financial risks and incentives through simulations.

Figure 12.4 describes the benefits that big data can bring to boost an organization by improvement in customer insight, decision making improvement, competition spirit, creation of innovative service, operating costs to be controlled and reduced, increased productivity, reduction in time for marketing of products and services and evaluating potential for business.

Table 12.1 provides an analysis of how important is big data for healthcare industry automation. Healthcare providers differentiate themselves for improved patient outcomes, experience of patients that leads to referral by patients as well as medical personnel. Services should be delivered in a safe as well as predictable manner by offering transparency to both payers as well as the regulatory agencies. Intelligent forecasting of the impact of changes in coverage models utilized by payers must be done and new business models need to be developed that can cause overlapping of various services that are being provided at hospitals, clinics,

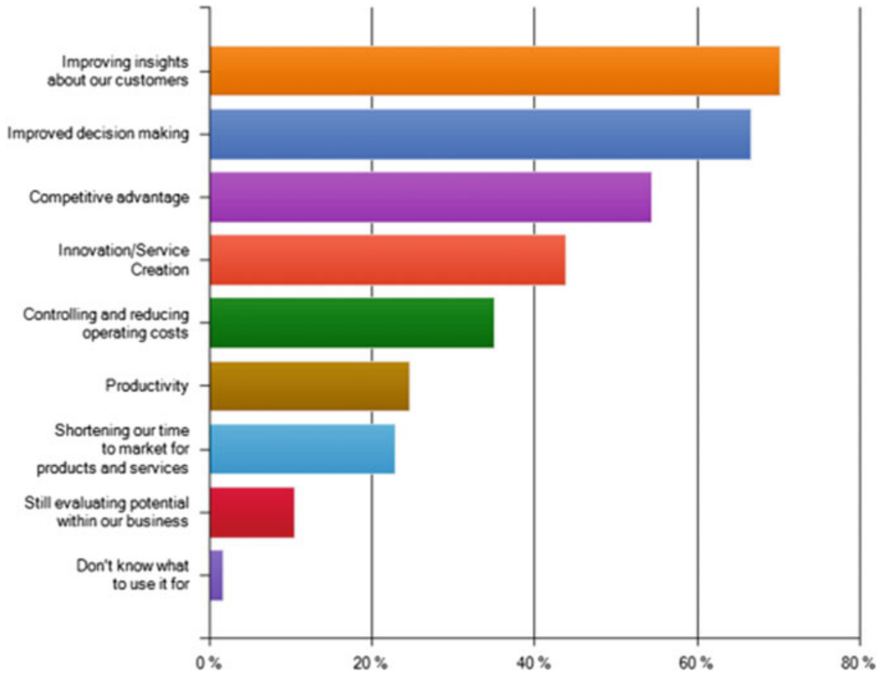


Fig. 12.4 Top benefits of big data for an organization

Table 12.1 Analysis of importance of big data in healthcare automation

S. No	Functional area	Challenges of business	Opportunities
1	Caring through improved quality and planning	Right care at lowest cost leading to achievement of best outcomes	• Doctors and staff providing improved care • Patients referrals and satisfaction criterions • Early identification of patients with risk • Reimbursement in timely gain payer • Reduction in litigation costs • Viability of lower cost facilities for patients
2	Management of clinical performance	Healthcare givers like doctors and nurses to provide improved quality	• Reduction in litigation potential • Improvement through educating underperformers • Quality care improvement • Reduced care costs
3	Monitoring In/Out patients	Patients to be centrally monitored	• Reduced cost of staff, home bound and offsite patients • Timely detection as well as prevention leading to quality care improvement • Increased patient satisfaction
4	Administration of financial and human resources	Hospital staff to be optimally managed	• Profit gain • Hiring and maintaining correct mix of staff at right place and time • Prediction of demand of services • Underutilized floors/ facilities need to be taken offline
5	Management of supply chain	Supply facilities of drugs/ medicines, food need to be optimally managed	• Reduced waste of warehousing • Improved care quality • Detection of fraudulent activities
6	Promotion through marketing	Achieving profitable business results through reduced/ optimal spending on promotion	• Maintaining and gaining patients • Existing cross/up sell • Community profile improvement
7	Right care at lowest cost leading to achievement of best outcomes	Equipment and Facilities need to be optimally maintained and scheduled	• Breakdown minimized • Liability potential to be minimized • Equipment life to be extended

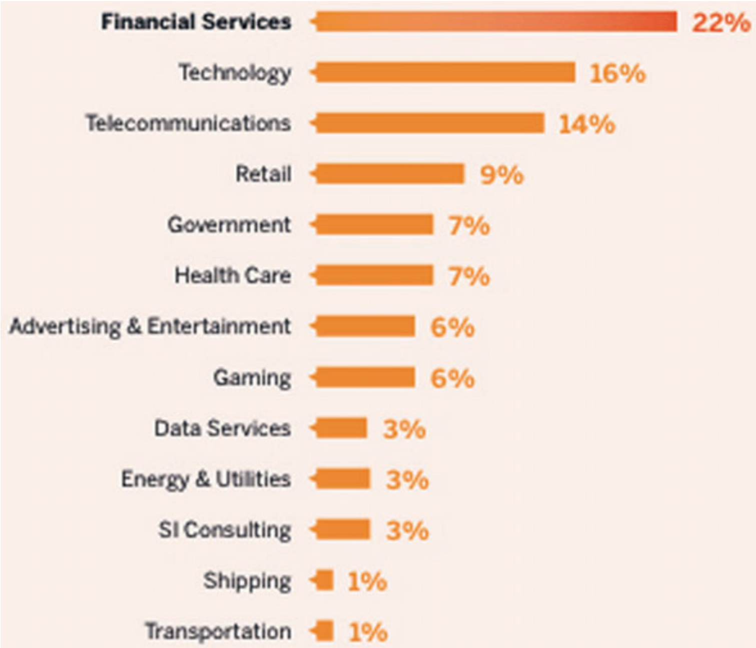


Fig. 12.5 Big data usage by industry

rehabilitation centers (RC) etc. Planning for various changes is easily done by predictive analysis. Since the home bound patients have led to increase prevalent usage of sensors and the associated applications, it will lead to growth in health care provider of accessible data records [13].

How much an industry is utilizing big data is depicted in Fig. 12.5. Starting with 22% big data involvement in financial industry, 7% in healthcare and around 1% in shipping and transportation industry is depicted in the figure.

The volumes of data can dwarf traditional data warehouses and require for processing and reporting big data management systems. Various issues of efficiency improvement, cost management, understanding staff, utilizing facilities trends, business running costs of supply and maintenance are looked upon by data warehousing methodology. Prediction of current trends and their possible implications are analyzed by predictive analytics. Information of facilities, maintenance and inventory supply is provided by sensor driven data. Understanding of opportunities of maintenance with affording efficiencies and cost management needs to be looked upon.

Big data management through Hadoop provides predictive analytics solutions which are gaining popularity in various applications. Figure 12.6 depicts the major components of information architecture. The figure specifies appropriate acquiring and organization of data to analyze for making various meaningful business decisions. Various platforms play critical role for management security as well as government issues.

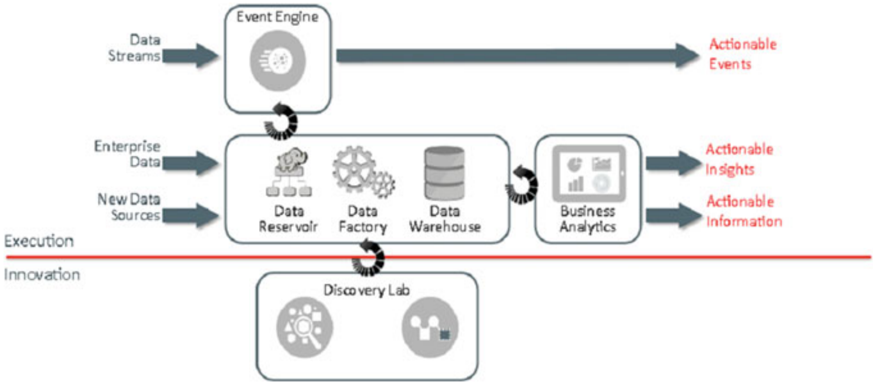


Fig. 12.6 Major components of information architecture

12.3 Big Data Challenges in Healthcare Automation

A number of challenges listed below are important to be met for health care automation:

- Complex as well as heterogeneous patient sources are inferred for knowledge.
- Patient data correlation based longitudinal records are being leveraged.
- Unstructured clinical notes need to be understood in the right context.
- Large volumes of medical/imaging data need to be efficiently handled for useful extraction of information and biomarkers.
- Computationally intensive task of analyzing genomic data to be combined with clinical data standard in nature to add and addition complexity layer.
- Patient behavioral data to be captured through various sensors specifying and analyzing their social interaction as well as communications. Figure 12.7 specifies how imaging technique of healthcare generates huge amount of data (MB and GB) and requirement of big data analytics is the need of hour.

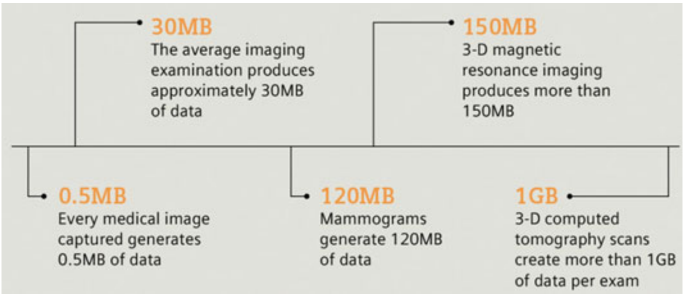


Fig. 12.7 Imaging technique of healthcare generating huge amount of data

Various examples are presented below which show how big data can provide a boost for healthcare automation:

- **First Example: Prize for Heritage Health**.
  Unnecessary hospital admission costs are about $30 billion. High risk patients need to analyzed and specific treatment to be provided. Algorithms need to be developed for prediction of the days next year a patient will spend in hospital. By utilizing big data methodology new strategies need to be developed by health care providers for caring the patients which can lead to reduction of unnecessary hospitalization. Patient health to be improved with decrease in care cost. Combined several predictive models are utilized as winning solutions [11].
- **Poor Care Penalties: Readmission in 30 days**.
  Health care cost of about 2 trillion annually is accounted by hospitalization which is about 30% overall. In 30 days of previous discharges 20% of admissions occur in hospital. These are expensive and quite harmful potentially and are preventable. Hospitals are penalized by Medicare having high readmission rates among patients with heart attack/failure and pneumonia. Patients with readmission risks can be identified that can provide a guideline for utilizing resources efficiently and can lead to saving million health care dollars. Various novel and advanced analytical models need to be developed for making effective prediction for various complex hospitalization data [19].
- **Brain Initiative Unveiled by White House**.
  Brain Research through Advancing Innovative Neuro-technologies (BRAIN) is a $100 million research initiative that is designed by White-House, USA for revolutionizing and human brain understanding [6, 12, 25].
  Figure 12.8 specifies importance of big data in genomics for healthcare automation. New ways and methodologies need to be looked upon for treating;

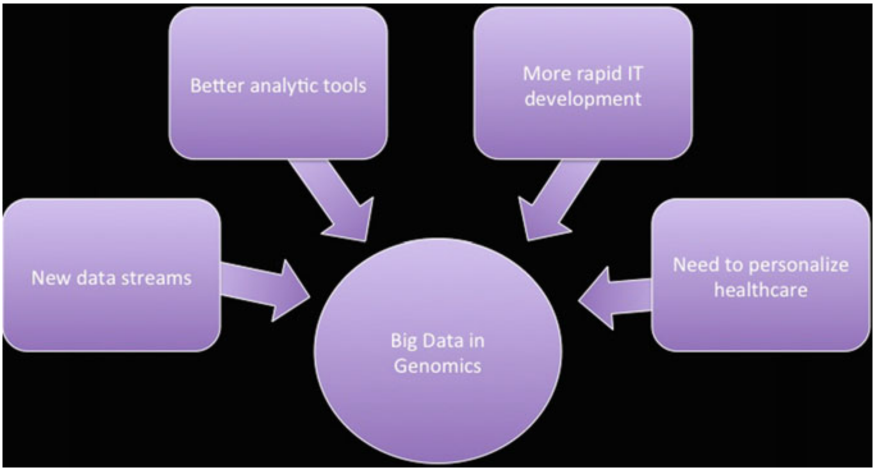


Fig. 12.8 Importance of big data in genomics

curing and preventing brain disorders like Alzheimer disease, epilepsy disease and brain injuries traumatic in nature. Big data advancements are quite required for analyzing huge volumes of generated information and understanding thoughts, memories, actions and emotions brain represents.

12.4 Data Analytics

Data driven science controlled through clinical trials randomly is the basics of medical research. Utilization of fields driven by big data is the need of hour due to advancements in fields of omics-technologies, medical imaging, and electronic health records comprehensive in nature and various smart devices. Current big-data technologies advancement in analytics can profit significantly to doctors, patients, management, patient, insurance and politics [17, 28]. Numbers of challenges are reported below to develop specialized approaches and methods for big data analytics:

- **Data Multimodal in Nature**: Standardized, structured and well curated are the features of big data analytics, data that is quite optimal for healthcare records electronic in nature. Still there is presence of huge amount of unstructured data, coming from sensor readings real time in nature like ECG measurements, clinical text data reports, generated by doctors, natural language based medical literature, imaging and omics-data for personalized medicine. Use of lifestyle data for management of diseases, geo-spatial data is gaining popularity for information retrieval. Valuable information should be accessed from such heterogeneous data so that the information can be available to clinicians and for knowledge incorporation for clinical history of patients [22].
- **Background Knowledge Complex in Nature**: Complex phenomena's coming from multilevel data of patient, information lifestyle, bio-bank and trial based repositories are described through medical data, accompanying complex meta-data that needs to be optimally analyzed for drawing conclusions and finding appropriate hypothesis, supporting clinical based decisions [23].
- **End Users to be Highly Qualified**: Doctors researchers and bio-informaticians are the end users of medicine based analytics tool that are highly qualified having high responsibility of expectations for analytical tools approach before utilizing and trusting them for patients treatment. Analytical approach optimal in nature should generate patterns that are understandable allowing cross-checking results and developing trust in the attained solutions. For controlling analytics process expert must be provided with self-expert driven service [27].
- **Complex Decision to be Supported**: Medical decisions of noisy data and complex situation possibly missing information comes from imaging data, pathology data, monitoring of intensive care and multi-morbidities treatment. Guarantee to optimal solution is not provided by humans or algorithms yet their requirement comes in taking important decisions in minimal time. Patients using smart assistants through smart phones, wearable devices and sensor based

technologies are high future impact based medical decision support areas that can help management of patient diseases to help them lead a healthy life[16].

- **Privacy**: Strong legal safeguards are required for highly sensitive information carried by medical data. Analysis of medical data requires a legal framework that is adequate for practical application of the impact of data driven medicine on healthcare [7, 8].

Data analytics are addressed by below mentioned approaches:

- **Advanced/Reinforced Machine Learning**
Multimodal data like images, videos, signals, 3D models, genomic data, reports etc. needs to be processed/analyzed efficiently to provide significant benefit for healthcare applications [10, 18]. Machine learning system quite advanced in nature are utilized for learning as well relating information from multiple sources for identifying hidden correlations that lag visibility when one data source is considered. E.g. When CT scan, radiograph images are combined with text performance of solutions could significantly improve. Fusion of various data sources of health help in study of various diseases phenotype in nature and risk factors that are difficult to be characterized from genomic point of view. Development of Automatic Diagnostic Tools (ADT) and personalized medicine will be enabled. Full potential of big-data sources will be leveraged by this technology. Analysis of various lifestyle data collected through smartphone apps contains risk factor based information of diseases and their management through a specialized hardware activity, tracking GPS, tracking mood that cannot be collected otherwise reliably. Recommender/Learning systems use this information for monitoring patients, raising alarms and property advising them for disease handling. Advanced machine learning paradigm is referred as reinforcement learning which proves to be quite promising and utilizes various trail and error learning through rewards and punishments. Alpha go system of Deep Mind utilized trial and error learning method for breakthrough innovation and heath care domain for discovering and optimizing automatically treatments sequential in nature for various chronic as well as life-threatening diseases [9, 21].
- **Approaches Based on Knowledge Base**
Reasoning as well as knowledge representation utilizes description logic paradigm due to the advent of semantic web. With the advent of oncology, sophisticated ontologies utilize knowledge bases for expressing complex medical knowledge and to support, structure, manage, integrate quality medical data. Complex data types like graphs etc. utilized various biological network applications like pathways or structures secondary in nature of RNA and DNA for learning purposes. Growth of such occurrences is rising and leads to yielding of concise, rich semantic based descriptive patterns reflecting intrinsic properties by learning technique. Much more clinical relevance is discovered through these patterns [4, 15].
- **Deep Learning**
Algorithms utilizing machine learning (ML) algorithms inferring deep hierarchical models that capture low level, unstructured relationships to some high

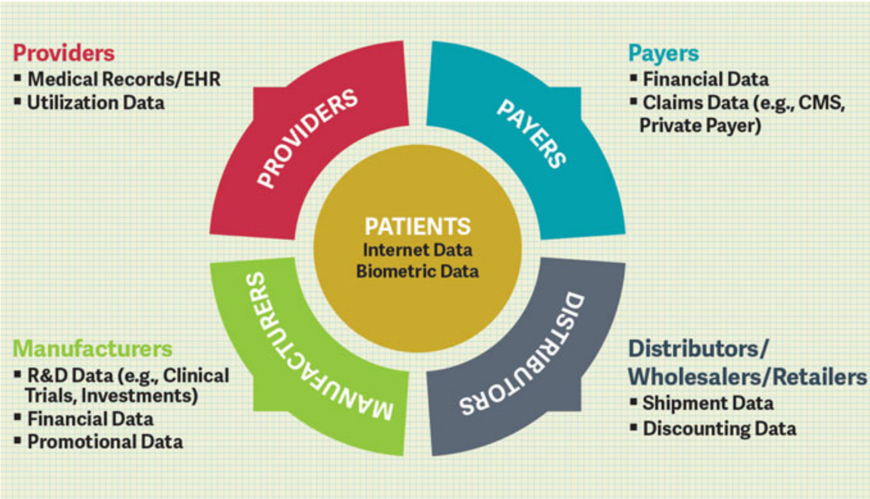


Fig. 12.9 Healthcare stakeholders benefitted through big-data utilization for health care automation

level concepts is referred as deep learning. Deep learning algorithms can easily be parallelized for enabling analysis of quite complex and big data like medical images, videos and other unstructured and text data [24, 26]. Example includes improving efficiency/accuracy by utilization of current approaches for analysis of medical images. Medical specialists like radiologists and pathologist who has dependency from insights of medical images needs quick analysis and support. Artificial Neural Networks (ANN) are referred as deep hierarchical models having more than three hidden layers and other related approaches are Deep Restricted Bolzmann Machine (DRBM), Deep Belief Networks (DBN) and Deep Convolutional Neural Networks (DCNN). Deep learning method success is enabled by the use of advance algorithms and high performance computing technology allowing analysis of large datasets [20]. Advances of deep learning include several domains like Image Analysis (IA), Speech Recognition (SR) and Natural Language Processing (NLP) (Fig. 12.9).

12.5 Tools/Platforms for Utilizing Big-Data Analytics for Healthcare Automation

Number of tools/platforms is available for utilizing big-data analytics for healthcare automation, depicted in Fig. 12.10 and listed and defined in Table 12.2.

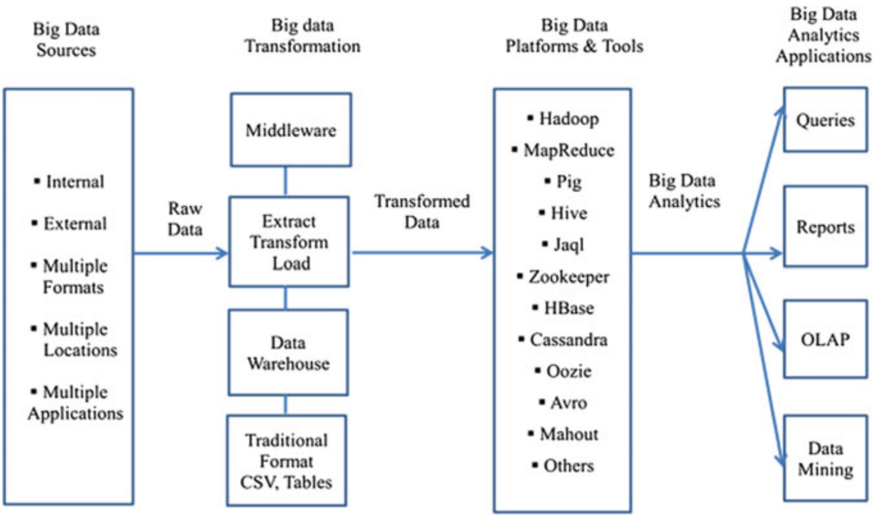


Fig. 12.10 Tools and platforms for utilizing big-data analytics for health care automation

Table 12.2 Tools and platforms for utilizing big-data analytics for health care automation

S. No	Platform/tool	Description
1	The HADOOP distributed file system (HDFS)	The underlying HADOOP cluster storage is enabled by HDFS. This is done by HDFS through division of storage into smaller parts and distribution across various servers/nodes
2	Map reduce (MR)	It provides an interface for subtasks distribution and outputs gathering. After tasks execution MR tracks and process various server/nodes
3	Pig and pig latin (PIG AND PIGLATIN)	Assimilation of structured/unstructured data is done through PIG programming language based configuration. PIG LATIN and its runtime versions of execution are key modules of PIG
4.	HIVE	Leveraging of SQL through HADOOP platform is done by Haddop's Hive support architecture. SQL programmers are permitted for developing Hive Query Language (HQL) statements for various SQL statements
5	JAQL	For processing large data sets functional and declarative based JAQL query language is designed. It also facilities parallel processing for conversion of "high-level" queries into "low-level" consisting various MR tasks
6..	ZOOKEEPER	Synchronization for various server clusters is done by Zookeeper providing a centralized environment
7	HBASE	HBASE is non SQL based approach that is a DBMS which is column oriented residing HDFS top

(continued)

Table 12.2 (continued)

S. No	Platform/tool	Description
8	CASSSANDRA	A distributed database system (DDS) specified as top-level project is modeled for handling big-data that is distributed across various server utilities is referred as Cassandra. It's a NO-SQL system providing reliability with no failure points
9	OOZIE	An open source project referred as OOZIE, streamlined workflow and coordinates various tasks
10	LUCENE	Several open source projects (OSP) are utilized for incorporating text analytics/searches by LUCENE
12	AVRO	Services are serialized by utilizing AVRO facilities incorporating versioning and version control (VC)
13	MAHOUT	APACHE project for generating free application of distributed, scalable machines and learning algorithms is referred as MAHOUT

12.6 Conclusions and Recommendations

This chapter has focused by representing the potential to deliver targeted, wide-reaching and cost effective health care automation through exploitation of current based big-data technologies. Also the discussions and brief explanations represented in above sections that are specific challenges in healthcare domain that targets on effort and research for realizing full potential of growth. The various characteristics of big-data are access, availability, quality, knowledge of healthcare, ethics and privacy, multimodal and data analytics. The sophisticated technologies used by healthcare providers are transformed through the potential of big-data analytics for insight analysis of clinical repositories and decision making. A rapid and widespread implementation of big-data technology and analysis is likely to be seen in near future. As big-data analytics will take its mainstream position in healthcare automation, issues like privacy to be guaranteed, security to be safe-guarded, governance standard establishment and technology improvement will gain more attention. Big-data in healthcare automation is at its nascent development stage and their maturing stage is specified by rapid advancement in tools and platforms.

References

1. Anya, O., Tawfik, H.: Leveraging big data analytics for personalized elderly care. Appl. Comput. Med. Health, 99–124 (2016). https://doi.org/10.1016/b978-0-12-803468-2.00005-9
2. Baker, L.A.: Do our "big data" in genetic analysis need to get bigger? Psychophysiology **51** (12), 1321–1322 (2014). https://doi.org/10.1111/psyp.12351

3. Bakker, L., Aarts, J., Redekop, W.: Is big data in healthcare about big hope or big hype? early health technology assessment of big data analytics in healthcare. Value in Health **19**(7), A705 (2016). https://doi.org/10.1016/j.jval.2016.09.2058
4. Bates, D.W., Saria, S., Ohno-Machado, L., Shah, A., Escobar, G.: Big data in health care: using analytics to identify and manage high-risk and high-cost patients. Health Aff. **33**(7), 1123–1131 (2014). https://doi.org/10.1377/hlthaff.2014.0041
5. Bian, J., Topaloglu, U., Yu, F.: Towards large-scale twitter mining for drug-related adverse events. In: Proceedings of the 2012 International Workshop on Smart Health and Wellbeing —SHB'12 (2012). https://doi.org/10.1145/2389707.2389713
6. Blair, L.M.: Publicly available data and pediatric mental health: leveraging big data to answer big questions for children. J. Pediatr. Health Care **30**(1), 84–87 (2016). https://doi.org/10.1016/j.pedhc.2015.08.001
7. Brewka, G.: Artificial intelligence—a modern approach by Stuart Russell and Peter Norvig, prentice hall. series in artificial intelligence, Englewood Cliffs, NJ. Knowl. Eng. Rev. **11**(01), 78 (1996) https://doi.org/10.1017/s0269888900007724
8. Cercone, F'IEEE, N.: What's the big deal about big data? Big Data and Inf. Anal. **1**(1), 31–79 (2015). https://doi.org/10.3934/bdia.2016.1.31
9. Dhar, V.: Big data and predictive analytics in health care. Big Data **2**(3), 113–116 (2014). https://doi.org/10.1089/big.2014.1525
10. Gong, A.: Comment on "data science and its relationship to big data and data-driven decision making". Big Data **1**(4), 194–194 (2013). https://doi.org/10.1089/big.2013.1514
11. Marconi, K., Dobra, M., Thompson, C.: The use of big data in healthcare. Big Data Bus. Analytics, 229–248 (2013). https://doi.org/10.1201/b14700-15
12. Mahoney, B.: Big earth 2014; big data! In::2012 Conference on Intelligent Data Understanding (2012). https://doi.org/10.1109/cidu.2012.6382180
13. Nambiar, R., Bhardwaj, R., Sethi, A., Vargheese, R.: A look at challenges and opportunities of big data analytics in healthcare. In: 2013 IEEE International Conference on Big Data (2013). https://doi.org/10.1109/bigdata.2013.6691753
14. Nemis-White, J., MacKillop, J., Montague, T.: Canada's future healthcare: can it be better? will it be better? HealthcarePapers **12**(2), 51–59 (2012). https://doi.org/10.12927/hcpap.2012.22984
15. O'Regan, G.: IBM. A brief history of computing, 71–84 (2012). https://doi.org/10.1007/978-1-4471-2359-0_6
16. Raghupathi, W.: Data mining in healthcare. Healthc. Inf. 211–224 (2010). https://doi.org/10.1201/9781439809792-c11
17. Ripberger, J.T.: Capturing curiosity: using internet search trends to measure public attentiveness. Policy Stud. J. **39**(2), 239–259 (2011). https://doi.org/10.1111/j.1541-0072.2011.00406.x
18. Ruths, D., Pfeffer, J.: Social media for large studies of behavior. Science **346**(6213), 1063–1064 (2014). https://doi.org/10.1126/science.346.6213.1063
19. Sinnott, R., Duan, H., Sun, Y.: A case study in big data analytics. Big Data, 357–388 (2016). https://doi.org/10.1016/b978-0-12-805394-2.00015-5
20. Schoen, H., Gayo-Avello, D., Takis Metaxas, P., Mustafaraj, E., Strohmaier, M., Gloor, P.: The power of prediction with social media. Internet Res **23**(5), 528–543 (2013). https://doi.org/10.1108/intr-06-2013-0115
21. Sweeney, L.: k-anonymity: a model for protecting privacy. Int. J. Uncertainty, Fuzziness Knowl-Based Syst. **10**(05), 557–570 (2002). https://doi.org/10.1142/s0218488502001648
22. Velthuis, E., Malka, E., Richards, M.: 'Big data' in health care. What does it mean and will it make a Difference? Value in Health, **16**(7), A479 (2013). https://doi.org/10.1016/j.jval.2013.08.906
23. Viju Raghupathi, W.R.: An overview of health analytics. J. Health Med. Inf. **04**(03) (2013). https://doi.org/10.4172/2157-7420.1000132

24. Walker, R.: Impact of analytics and big data on corporate culture and recruitment. From Big Data to Big Profits, pp. 184–201 (2015). https://doi.org/10.1093/acprof:oso/9780199378326.003.0009
25. White, S.: A review of big data in health care: challenges and opportunities. Open Access Bioinform. **13** (2014). https://doi.org/10.2147/oab.s50519
26. Wilkinson, Z.: Oh, how pinteresting! an introduction to Pinterest. Library Hi Tech News **30** (1), 1–4 (2013). https://doi.org/10.1108/07419051311320904
27. Yasseri, T., Sumi, R., Kertész, J.: Circadian patterns of wikipedia editorial activity: a demographic analysis. PLoS ONE **7**(1), e30091 (2012). https://doi.org/10.1371/journal.pone.0030091
28. White, D.S., Le Cornu, A.: Visitors and residents: a new typology for online engagement. First Monday **16**(9) (2011). https://doi.org/10.5210/fm.v16i9.3171

Chapter 13
IoT Based Intelligent Transportation System (IoT-ITS) for Global Perspective: A Case Study

S. Muthuramalingam, A. Bharathi, S. Rakesh kumar, N. Gayathri, R. Sathiyaraj and B. Balamurugan

Abstract Big data analytics helps in analyzing a huge set of data whereas IoT is about data, devices and connectivity. Internet of Things (IoT) involves connecting physical objects to the Internet to build smart systems and universal mobile accessibility advanced technologies like Intelligent Transportation System (ITS). IoT solutions are playing a major role in driving the global IoT in Intelligent Transportation System. Communication between vehicles using IoT will be a new era of communication that leads to ITS. IoT is a combination of storing and processing sensor data and computing using data analytics to achieve and assist in managing the Traffic system effectively. IoT based Intelligent transportation system (IoT-ITS) helps in automating railways, roadways, airways and marine which enhance customer experience about the way goods are transported, tracked and delivered. A case study on Intelligent Traffic Management System based on IoT and

S. Muthuramalingam
Department of Information Technology, Thiagarajar College of Engineering, Madurai, India
e-mail: smrit@tce.edu

A. Bharathi
Department of Information Technology, Bannari Amman Institute of Technology, Sathyamangalam, India
e-mail: bharathia@bitsathy.ac.in

S. Rakesh kumar · N. Gayathri
Anna University, Chennai, India
e-mail: rakesherme@gmail.com

N. Gayathri
e-mail: gayathrierme@gmail.com

R. Sathiyaraj
Department of Information Technology, G.G.R. College of Engineering, Anna University Chennai, Chennai, India
e-mail: rsr026@gmail.com

B. Balamurugan (✉)
School of Computing Science and Engineering, Galgotias University, Greater Noida, India
e-mail: kadavulai@gmail.com

V. E. Balas et al. (eds.), *Internet of Things and Big Data Analytics for Smart Generation*, Intelligent Systems Reference Library 154,
https://doi.org/10.1007/978-3-030-04203-5_13

big data, which will be a part of, smart traffic solutions for smarter cities. The ITS-IoT system itself forms an eco-system comprising of sensor systems, monitoring system and display system. There are several techniques and algorithms involved in full functioning of IoT-ITS. The proposed case study will examine and explain a complete design and implementation of a typical IoT-ITS system for a smart city scenario set on typical Indian subcontinent. This case study will also explain about several hardware and software components associated with the system. How concepts like Multiple regression analysis, Multiple discriminant analysis and logistic regression, Cojoint analysis, Cluster analysis and other big data analytics techniques will merge with IoT and help to build IoT-ITS will also be emphasized. The case study will also display some big data analytics results and how the results are utilized in smart transportation systems.

Keywords Intelligent transport system · Internet-of-things · Data analytics

13.1 Introduction

The cities in India are aimed at achieving "smartness" by improving the economic structure an technology. The system aims to address the public with grievance redressal. Internet of Things (IoT) [1] links the objects of the real world to the virtual world, and enables anytime, anywhere connectivity for anything that has an ON and OFF switch. It constitutes to a world where physical objects and living beings, as well as virtual data and environments, interact with each other. The notion of IoT is to take a broad range of things and convert them into smart objects —anything from cars, watches, fridges and railway tracks large amount of data is generated as large numbers of devices are connected to the internet. So this large amount of data has to be controlled and converted to useful information in order to develop efficient systems. Big Data Analytics plays a major role in generating useful information from the generated data.

The term big data existed long before IoT arrived to carry out analytics. When the information demonstrates veracity, velocity, variety and volume, then it is interpreted as big data. This equates to a large quantity of data that can be both unstructured and structured, while velocity refers to data processing speed and veracity governs its uncertainty. The data from IoT devices lies in big data and this information is measured against it. Soon, IoT will touch each and every facet of our lives: smart homes, manufacturing, transportation, and consumer goods like wearables, smartphones and more.

The idea of internet of things (IoT) was developed in parallel to WSNs. The term internet of things was devised by Kevin Ashton and refers to uniquely identifiable objects and their virtual representations in an "internet-like" structure. These objects may range from huge buildings, planes, cars, machines, any sort of goods, industries, to human beings, animals and plants and even their specific body parts. One of the major evolutions of WSNs will be after they are integrated with IoT. This paper aims to develop an intelligent transportation system.

The Internet of Things (IoT) is fundamentally transforming the transportation industry. Next generation intelligent transportation systems will optimize the movement of people and goods, improving economics, public safety, and the environment. Smart transportation systems will automate our roadways, railways, and airways, transform passenger experiences, and reshape the way cargo and merchandise are tracked and delivered, creating substantial business opportunities for system integrators, independent software vendors (ISVs), service providers, and other solution providers.

With the acceleration of urbanization, motorization, the pace of modernization, the urban population increase, growing faster vehicles, urban traffic congestion and clogging growing, urban transport system overwhelmed, the consequent environmental noise, air pollution, energy waste and other factors plaguing today's transportation in major cities, has become a serious problem around the world now industrial countries and developing countries. So, faced with in today's world of globalization, information technology development trend, the traditional means of transportation technology and no longer meet the requirements of economic and social development, intelligent transportation is the inevitable choice for urban transport development, is a revolution in urban transport undertakings. Things appear to intelligent transportation industry breakthrough brings rare opportunities to bring new horizons for the development of intelligent transportation, smart transportation to provide a wider space for development, and therefore modern urban transport calling for "Internet of things". "The new generation of intelligent transportation" developments provides important technical support for the realization of real-time, efficient, accurate, safe, energy-saving intelligent transport objectives and provide technical support for the Internet of Things technology, networking technology will bring a intelligent urban traffic The new upgrade.

The growing population in the metropolitan areas in this modern age requires more smart services of transportation. Achieving smart and intelligent transportation requires the use of millions of devices equipped with Internet of things (IoT) [2] technology. For example, The Toronto Intelligent Transportation Systems Centre and Testbed, developed a system known as MARLIN-ATSC (Multi-agent Reinforcement Learning for Integrated Network of Adaptive Traffic Signal Controllers) [3] to improve traffic flow with smart signals that process traffic information locally. Tests of the system on 60 downtown Toronto intersections at rush hour showed a reduction in delays of up to 40%. The test also showed it cut travel times by as much as 26%.

Singapore has adopted an Intelligent Transport strategy and set of systems. It has one of the least congested major cities, with an average car speed on main roads of 27 km/h, compared to an average speed of 16 km/h in London and 11 km/h in Tokyo. The city uses an Electronic Road Pricing system where the tolls vary according to traffic flows. It has an Expressway Monitoring and Advisory System that alert motorists to traffic accidents on major roads. It also has a GPS system installed on the city taxis, which monitors and reports on traffic conditions around the city. Information from all of these systems is feed into the Intelligent Transport System's Operations Control Centre, which consolidates the data and provides real-time traffic information to the public.

13.2 Related Works

This paper [4] deals with developing an analysis environment for systems to analyse and optimize the Intelligent Transport System (ITS). This uses the phenomenon of the co-simulation that helps in modeling systems with high flexibility. The concept of virtual ITS is being implemented by selecting various components which run on different platforms. These components are simulated by using pre-existing packages such that all of the packages operate with same time stamp or in multiples of smallest time stamp. Thus the proposed system is cost effective by avoiding the need for the calculation in the real time. The integrated system analysis environment developed helps ITS with seamless integration of various models thereby assembling the existing structure that functions far better than the existing models. Thus the process of the system integration is streamlined and made ITS setup to be implemented throughout the country without any obstacles. The proposed application of co-simulation concept for ITS can be extended to incorporate timing, thus making it time-based simulation.

An efficient traffic light system is proposed [5] which uses genetic algorithm for evaluating the stochastic data thereby arriving at an optimized transport system. The data is processed, each traffic light is coded and then cumulative for each route is calculated to find the optimum state. The simulation is done based on the route length and average speed of the vehicle. The simulation helps to find the optimum state in which maximum vehicles can move with the proposed traffic lights. The simultaneous analysis of more objects using some statistical measure is given through multivariate analysis [6]. By this technique, there occurs simultaneous analysis on more than two variables. Various multivariate analysis techniques have been proposed which could be applied as per the necessity.

This paper [7] proposes a prototype of vehicle which is capable of interacting with the other roadside vehicles and also with the internal electronic device. The model also specifies the various components adopted in the proposed on-board unit. This also provides various applications that could apply this technique for efficient operations. The proposed work [6] gives an overview of the various requirements for designing an efficient ITS system. Based on the real world scenario, simulations are done using MATLAB to determine the accuracy of the proposed system. The observations show that the proposed environment helps in identifying the vehicle position in different environments. The algorithm is analyzed in terms of running time and also based on the accuracy of the results. The paper [8] proposes a new system which integrates Internet of Things with the proposed intelligent transportation system so as to provide better transportation. The system [9, 10] uses the sensors to monitor the environment which is then used by the monitoring system for informing the drivers regarding the positioning of the device and details pertaining to it. Thus the data is displayed as the current bus route to the passengers. This system determines the number of tickets obtained as it decides the efficiency of the proposed technique.

Ref. No.	Publication year	Proposed technique	Traffic safety	Energy efficient	Merits
[11]	2009	Pollution-free transportation	No	Yes	Handles traffic in an efficient manner
[12]	2014	Pollution-avoidance transportation	Yes	Yes	Reduction in emission of CO_2 by using electric vehicles
[13]	2015	Green transportation	No	Yes	Traffic handling with sustainability is given importance
[14]	2015	Safe and sustainable transportation	Yes	Yes	Traffic congestion is handled efficiently
[15, 16]	2016	Green transportation	Yes	No	Proposes a pollution free technique which helps in vehicular movement
[17, 18]	2016	Collision-free transportation	Yes	No	Determination of braking response time and steering response time
[19, 20]	2017	Collision-free transportation	Yes	Yes	Safe system design with collision warning
[21]	2018	Congestion avoidance transportation	Yes	Yes	Time of arrival (TOA) based localization, using automatic braking for collision avoidance

13.3 Smart Cities and IoT

Smart cities utilize multiple technologies to improve the performance of health, transportation, energy, education, and water services [22] leading to higher levels of comfort of their citizens. This involves reducing costs and resource consumption in addition to more effectively and actively engaging with their citizens. One of the recent technologies that have a huge potential to enhance smart city services is big data analytics. As digitization [23] has become an integral part of everyday life, data collection has resulted in the accumulation of huge amounts of data that can be used in various beneficial application domains. Smarter cities are based on smarter infrastructure. There are many ways that IoT can help governments build smarter cities [24]. One method is through optimizing services related to transportation, such as traffic management, parking, and transit systems. There is no single consensus definition of a smart city, but there is some agreement that a smart city is one in which information and communication technology (ICT) facilitates improved insight into and control over the various systems that affect the lives of residents.

Smart transportation, a key internet of things vertical application [25] refers to the integrated application of modern technologies and management strategies in transportation systems. These technologies aim to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer and ‘smarter’ use of transport networks.

Intelligent IoT–enabled transportation systems improve capacity, enhance travel experiences and make moving anything safer, more efficient and more secure. The local police, emergency services and other government services can use these sensor networks with smart traffic management to gain citywide visibility to help alleviate congestion and rapidly respond to incidents. IoT based intelligent transportation systems are designed to support the Smart City vision, which aims at employing the advanced and powerful communication technologies for the administration of the city and the citizens.

Cities, as we all know facing with complex challenges—for smart cities the outdated traditional planning of transportation, environmental contamination, finance management and security observations are not adequate. The developing framework for smart-city requires sound infrastructure, latest current technology adoption. Modern cities are facing pressures associated with urbanization and globalization to improve quality-of-life of their citizens.

The expansion of big data and the evolution of Internet of Things (IoT) technologies have played an important role in the feasibility of smart city initiatives. Big data offer the potential for cities to obtain valuable insights from a large amount of data collected through various sources, and the IoT allows the integration of sensors, radio-frequency identification, and Bluetooth in the real-world environment using highly networked services. The combination of the IoT and big data is an unexplored research area that has brought new and interesting challenges for achieving the goal of future smart cities. These new challenges focus primarily on problems related to business and technology that enable cities to actualize the vision, principles, and requirements of the applications of smart cities by realizing the main smart environment characteristics. In this paper, the state-of-the-art communication technologies and smart-based applications are used within the context of smart cities. The visions of big data analytics to support smart cities are discussed by focusing on how big data can fundamentally change urban populations at different levels. Moreover, a future business model of big data for smart cities is proposed, and the business and technological research challenges are identified. This study can serve as a benchmark for researchers and industries for the future progress and development of smart cities in the context of big data.

Intelligent Transportation Systems are advanced applications that aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and smarter use of transport networks. Experfy deploys advanced analytics on a wide range of Intelligent Transport System technologies such as car navigation; traffic signal control systems; container management systems; variable message signs; automatic number plate recognition; speed cameras. Experfy also provides analytics for advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems, weather information, and bridge de-icing systems.

In 2010, the European Union had defined Intelligent Transportation Systems (ITS) as systems "in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport."

Smart transportation includes the use of several technologies, from basic management systems such as car navigation; traffic signal control systems; container management systems; automatic number plate recognition or speed cameras to monitor applications, such as security CCTV systems; and to more advanced applications that integrate live data and feedback from a number of other sources. ITS technologies [26] allows users make better use of the transportation network and also paves the way for the development of smarter infrastructure to meet future demands. The evolution of intelligent transportation systems is providing a growing number of technology solutions for transportation managers as they seek to operate and maintain the systems more efficiently and improve performance.

According to the Intelligent Transportation Society of America, ITS technology makes it possible to:

- Use a navigation system to find the best route based on real-time conditions.
- Alert drivers of potentially hazardous situations in time to avoid crashes.
- Be guided to an empty parking space by a smart sign.
- Ride a bus that turns traffic lights green on approach.
- Detect and respond promptly to traffic incidents.
- Reroute traffic in response to road conditions or weather emergencies.
- Give travelers real-time traffic and weather reports.
- Allow drivers to manage their fuel consumption.
- Adjust speed limits and signal timing based on real-world conditions.
- Improve freight tracking, inspection, safety and efficiency.
- Make public transportation more convenient and reliable.
- Monitor the structural integrity of bridges and other infrastructure.

An example of the benefits of the implementation of smart transportation technologies can be found in Austria, where the country's Autobahn and Highway Financial Stock Corporation (ASFiNAG), turned to Cisco's Connected Roadways solutions to bring the "internet of things" to its roadside sensors [27]. The result is a highway designed to monitor itself, send information to drivers and predict traffic to ensure lanes stay clear of congestion.

By all accounts, the Internet of Things (IoT) and Big Data represents a huge opportunity for cost savings and new revenue generation across a broad range of industries. Researchers provided a primer on IoT and described how IoT impacts the manufacturing industry [28] in the first two briefs in the IoT series. This brief will highlight several examples of how IoT is being used to create smarter cites. In its most basic definition, the Internet of Things describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired network connections. The Internet of Things will connect inanimate objects as well as living things. IoT will connect everything from industrial equipment to everyday objects that range from medical devices to automobiles to utility meters.

13.4 Big Data and Its Challenges

When huge volume of data emerged and has to be managed at certain time and speed, it became necessary to evolve a new phenomenon namely Big data. Big data technologies [29] capture, store, process and interpret the data in a distributed environment. The following limitations of the Relational Database Management System [30] led to the beginning of big data.

- Data Volume increased exponentially and it turned out to be a challenge for RDBMS to handle such a huge data.
- To cater to this need, RDBMS increased the memory as well as the number of processors which resulted in increase in cost.
- Also nearly 80% of the data were in unstructured and semi-structured format and RDBMS cannot handle it.

13.5 V's of Big Data-An ITS Perspective

Big data exhibits special characteristics [31, 32] with varied dimensions. There are four dimensions of Big data which is described below.

The first dimension is the data size. This term is referred as volume in Big data terminology. Data which is generated and processed increases exponentially. The major sources of data include data from social media, online banking transactions, sensors in vehicles. This increasing data volume claims high scalable and reliable storage system. The tremendous increase in the number of vehicles paves way for the data to be processed with the help of bigdata analytics with impact on the IoT.

Variety Refers to data format that Big data supports. Various formats of data includes structure, semi-structure and un-structured format. Structured data refers to data organized in tables, in the form of rows and columns. Semi-structured data is the combination of structured and un-structured data. Xml data is semi-structured which does not fit into tables and contains tags which organizes fields within the data. Un-structured data has no definite structure, e.g.: Data from sensors of vehicles. The vehicular data is analyzed in terms of velocity and various parametric structures that helps in easy organization and implementation of smart transportation.

As the volume of data increases, the speed with which the data is generated also increases. In the big data era, data arrives so fast that it becomes difficult to capture and process it. For e.g.: Face book generates 3.3 million post and google gets 3.1 million searches in a minute. The velocity of the data in vehicular systems makes.

Veracity implies the abnormality and uncertainty in the data. This is due to inconsistency in the data. Data should be reliable so that when analyzed produces exact results.

13.6 Challenges Faced by Big Data Technology

Huge volume of data poses lot of challenges when dealt with, when some data could be stored in traditional tables, others which are un-structured such as videos and pictures could not fit into it. Though these data can be efficiently managed independently, major issues arises while integrating data from various sources [33].

The following are the major challenges.

- Data is heterogeneous in nature as data comes from multiple sources and so data has to be structured before performing analysis.
- Sometimes data may be incomplete or missing, which may create problem when taken for analysis, in such a case null values have to be inserted in the place of missing values, such that it does not affect the rest of the data and successful outcome is obtained.
- Managing huge volume of data is the biggest issue in the big data era. The more the data, longer is the processing time needed.
- The higher velocity of the big data introduces the challenge of processing the real time data at a faster rate in which it arrives.
- Data storage in big data should be in such a way that it is scalable at latter point of time, when the data grows exponentially. The data should not only be scalable but also be fault tolerant and trust worthy.
- Data privacy is a growing issue with increasing data volume. So stringent access control mechanism should be introduced in various stages of Big data life cycle. Data sharing should be restricted such that the available data provides the needed business knowledge. Even when the data is to be given for analysis, sensitive information should be protected and then delivered for processing.

13.7 s-ITS System Overview and Preliminaries

For an efficient Intelligent Transportation System, the components such as Central Server, RFID device, Sensors, Lighting control unit and EBOX II. Central Server plays a major role in providing resilience during any mis-functioning of the system.

RFID helps in communicating in data flow information between the cars to EBOX II. This RFID device has tags, antennas to communicate information and readers to decode the data.

13.8 Design Requirements of ITS System

- RFID tag operates on some specified frequency. The ITS System to be built is required to have ultra high frequency. This helps in reaching the good distance and recognize data for about 4–6 m.
- The energy needed for working of RFID device and lighting control unit is provided by extra chargers (Fig. 13.1).

13.9 Design Goals

The system considers the following parameters in designing a new ITS system.

- **Scalability**

The s-ITS system designed must cater to the growing data world namely bigdata. The information should be portable and it is ensured that the settings are remotely operated without any hindrance.

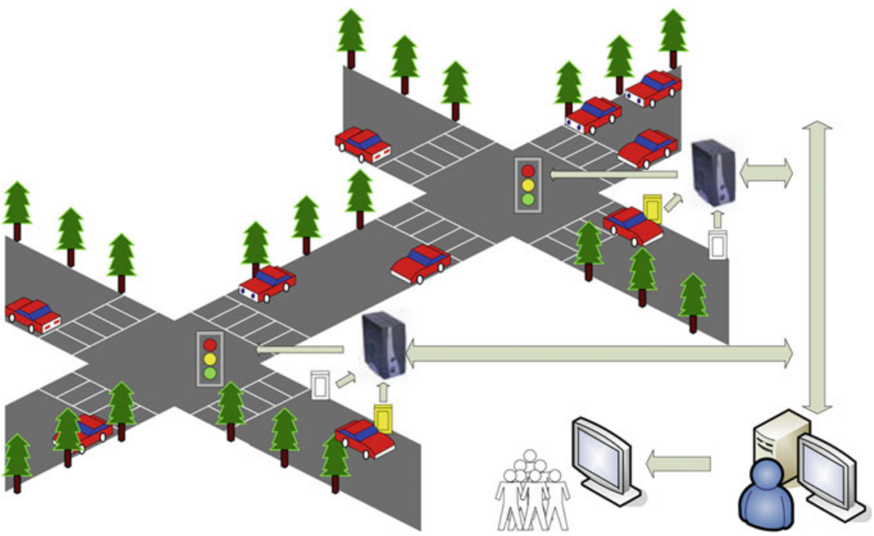


Fig. 13.1 Proposed model- intelligent transport system

- **Reliability**

As the smart transportation system is designed to operate without any manual intervention by human, it is of utmost importance that the system must be reliable. It should also be designed to handle any unexpected situations in an efficient way.

- **User-Friendly**

The user need not be aware of the entire implementation. Rather, the user needs to know the initialization in a single click and the admin must also be able to manage the mishaps that occur in the server side.

13.10 Experimental Design

The proposed system smart intelligent transport system (s-ITS) involves the smart building of the intelligent transport system with the ability to tackle the real-time issues. The intelligent system is built to address the following modules (Fig. 13.2).

(a) Vehicular location Tracking
(b) Intelligent vehicle parking system
(c) Communication within a VANET
(d) Vehicular Big-data Mining.

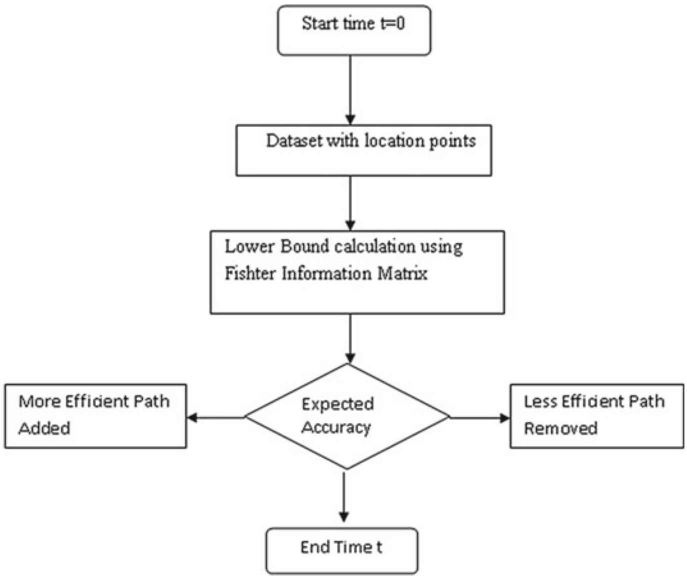


Fig. 13.2 Flow of the s-ITS vehicle localization

The proposed algorithm helps in selecting those paths that provide maximum accuracy. With the lower bound value accuracy value as the benchmark, the model is checked for its performance. So if the model achieves the targeted accuracy than that of the lower bound, then it implies there are enough paths which are efficient an all other less connection paths are discarded. Whereas if the lower bound is more than the expected accuracy rate then it implies that there are no enough paths in the selected ones. Further the necessary routes are added to the set for effective vehicle localization.

Pseuocode for Vehicle location Tracking by path sensing

Inputs: C_i^l represents the connections of a vehicle at time l.

N_i^{l-1} represents the connections composed by the proposed algorithm at time l-1

$\beta(l-1)$ Represents the vehicle's position at time l-1.

D[K], location of the unit at the time k

α, the expected accuracy.

Step1: $Z_i[k] = A\beta_i\,[l\,|l-1]$ which represents initial elements.

Step 2: $N_i^l = N_i^{l-1} \cap C_i^l$

Step 3:if $|C_i^l| > 5$ then I= fisher (D[k], $Z_i[k]$,$\sigma_{ij\,2}$)

Step 4: Else I=0.5 α^{-2} end if

Step 5:$\mu = \sqrt{Trace\{I^{-1}\}} - \alpha$

Step 6: if α <20% α *then*

Step 7: $N_i^l = N_i^l - M_i^l$

Step 8: for I ϵN_i^l do

Step 9:Z= fisher(D[k], $Z_i[k]$,$\sigma_{ij\,2}$)

Step 10:[b]=Trace{$I^{-1}\, Z\{I^{-1}$ }

Step 11:end for

Step 12:Elseif if α >20% α *then*

Step 13:if $N_i^l \cap C_i^l - D^k = \emptyset$ then

Step 14: $N_i^l = N_i^l - M_i^l$ else

Step 15: for I $\epsilon N_i^l \cap C_i^l - D^k$ do

Step 16: Z= fisher(D[k], $Z_i[k]$,$\sigma_{ij\,2}$)

Step 17: [b]=Trace{$I^{-1}\, Z\{I^{-1}$ }

Step 18:end for

Step 19:I_{max}={j ϵ N_i^l[b]={max{b}}}

Step 20: $N_i^l = N_i^l + i_{max\ end\ if}$

Step 21:else

Step 22: $N_i^l = N_i^l$

Step 23:end if

The vehicle localization algorithm predicts the location of the vehicle at time l. This involves the storing of the predicted set and later measuring if the count of the predicted set is greater than 5. If so then fisher value is calculated. If less than 5 then fisher value is not calculated and it is ensure that new more connections are added. Then as per the flow the lower bound accuracy calculate from Fisher matrix is compared with the predicted value. If there is improvement in the predicted accuracy value then extra connections could be removed. Thus the proposed algorithm has the advantage of reducing the time period of the selection of paths for the vehicles as well as easy location estimation.

(b) **Intelligent vehicle parking system**

Sensors play a major role in this module. They help in collecting information about the geographic location of the vehicle, availability of the parking lot, Prior reservation details, position of the parking, details regarding the vehicle and current traffic information. Thus the big data plays a major role here as it involves the real-time application with the facility to provide an intelligent system for transportation.

The vehicle parking decision is made by the outcome factors like occupied or free factor. If the place is free and available for parking, then it is marked as free. Whereas, if there are vehicles in the location, then it is marked as occupied. The decision of parking is based on the application of the outcome value which will be updated over a period of time through sensors. The decision is then updated in the server. The features are compared against the given threshold value for final decision of the parking slot (Fig. 13.3).

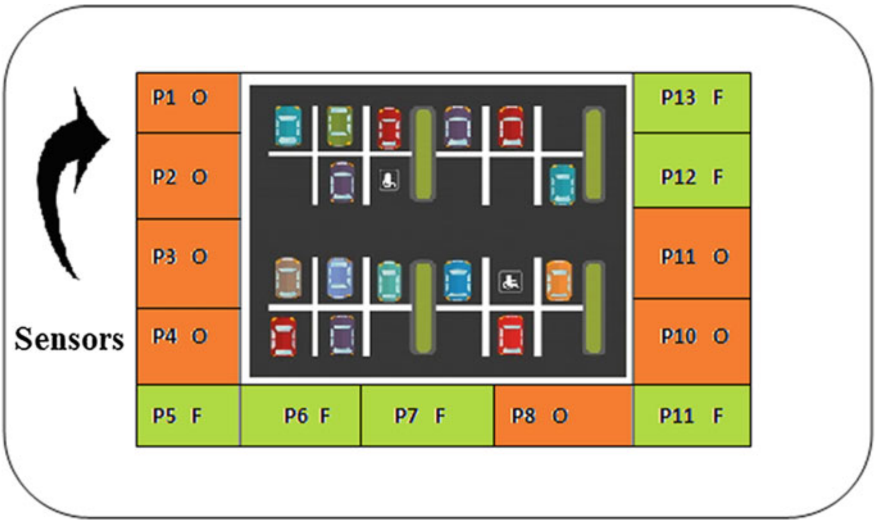


Fig. 13.3 Parking scheme of s-ITS

(c) **Communication within a VANET**

With the help of the prior registration of the vehicle and its device, the sensors track the location of the vehicle and its status in the current traffic scenario. By using the sensor systems of IoT, the data is transferred and transmitted between the vehicles such that it helps in avoiding the traffic and also ensure safe journey.

(d) **Vehicular Big-data Mining**

The system built is made to inform ahead of the traffic condition, dangerous road situations as well as must be capable of handling the unforeseen accidents and situations with data so that it could be intimated ahead to vehicles for safe driving. It is of importance that the signals be communicated to the vehicles through the mining of the huge volume of previous similar data and also based on current traffic status.

13.11 Implementation

The implementation of the s-ITS involves ensuring that the proposed system achieves a smartness in transportation through the localization and by avoiding traffic through some bigdata techniques. In the example below, Chennai city is taken and the traffic levels in various roads are represented through different colors in the map. The various bigdata techniques and their application for ITS is depicted below (Fig. 13.4).

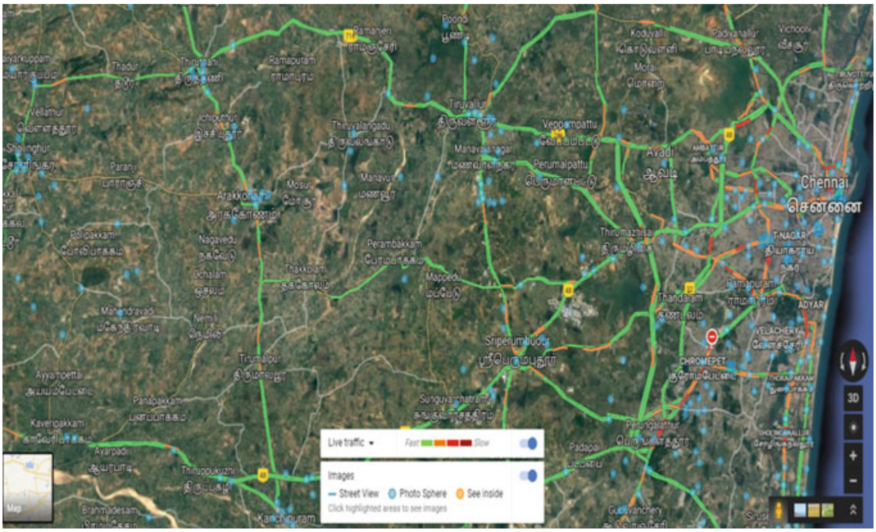


Fig. 13.4 Map of Chennai for indicating traffic levels of s-ITS

13.12 Big Data Techniques in ITS

Multivariate analysis involves analyzing more than two variables at a time thereby delivering some useful results in a shorter period of time. Univariate is extended to hold more variables for analysis. In case of linear regression, two variables are analyzed, whereas in multivariate structure, more number of predictor variables are used.

13.13 Classification of Multivariate Techniques

The classification is based on variable's ability to get segregated into dependent and interdependent forms. Dependent form is one in which a variable is declared as dependent variable which is to be predicted by other variables which are independent variables. An interdependent form is one in which no variable is dependent or independent. The following flowgraph shows some of the multivariate techniques (Fig. 13.5).

- **Multiple Regression Analysis**:

The method of multiple regression aims to predict the changes in dependent variable in response to changes in an independent variable. This technique is found to benefit when the problem to be addressed involves a single dependent variable related to two or more independent variable. This is achieved by the method of least squares.

$$\underset{\text{(metric)}}{Y_1} = \underset{\text{(metric,nonmetric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

This multiple regression can be applied to ITS, wherein the time (Dependent variable) at which the vehicle reaches the destination could be predicted by using the traffic in the route, speed of the vehicle (Independent variables)etc. This makes the prediction simpler and it can be depicted in a metric and nonmetric form as in the equation.

- **Multiple Discriminant Analysis**

This technique is suitable when total population could be divided into several groups based on a dependent variable which has several relevant classes. The main objective is to understand the differences between the various groups and to predict the likeliness of an object to any of the groups based on the independent variable.

$$\underset{\text{(nonmetric)}}{Y_1} = \underset{\text{(metric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

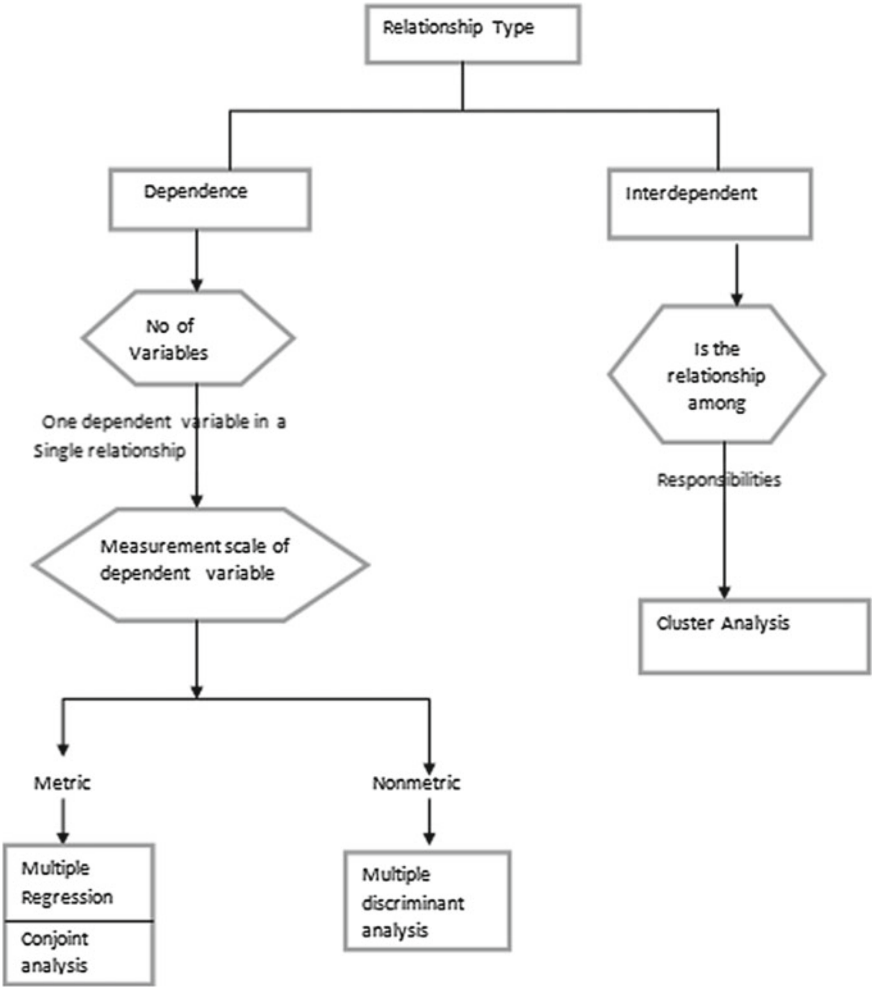


Fig. 13.5 Classification of the multivariate techniques with relevance to s-ITS

Applying this technique to ITS, the best shortest routes that avoids traffic and helps in reaching the destination earlier are obtained. This involves usage of time factor and also the location based route map.

- **Logistic Regression**

The logistic regression model is the combination of multiple discriminant analysis and multiple regression. This is different from multiple regression as this

- **Conjoint Analysis**

This analysis paves way for both consumers as well as product researchers. When a product is designed with some attributes and parameters, the customers are only concerned about the certain parameters while they leave out the other parameters which do not fascinate them. Whereas the product researchers take keen note of all the attributes that decides the marketing of that product. When relating this to s-ITS, the users of the vehicular system are concerned only about the safe collision free travel. They intend to know the parameters and techniques that would aid them in safe travel without congestion. Whereas, the system is intended to consider various aspects of the vehicular movement and parameters that decide the uninterrupted travel with constant velocity. This is depicted as below

$$\underset{\text{(nonmetric)}}{Y_1} = \underset{\text{(metric)}}{X_1 + X_2 + X_3 + \cdots + X_n}$$

- **Cluster Analysis**

Cluster analysis involves grouping the values to some groups or clusters which determine the variations in the data elements. The process of clustering is done for a set of elements by finding the similarity of the similar objects. Once the similarity is identified, the elements are grouped into respective clusters. The final step is to profile the final variables. In s-ITS, the parameters related to vehicle motion are grouped based on their relevance in determining the various factors of ensuring the vehicular motion so that the transportation is made effective and collision-free.

13.14 Experimental Results and Discussion

The experimental results show that the proposed system outperforms the existing ITS techniques in terms of throughput and packet delivery. It serves best in case of delay and latency. The below graphs depict the various parameters and their relevance with respect to different network schemes for communication of data in the form of packets (Figs. 13.6 and 13.7).

The proposed system shows the varied delay in different network scenarios. The recent version of network namely Enc 802.11 p gives higher packet delivery ratio and lower delay.

The observations are made based on the time and distance factor with respect to the metrics RMSE and MAPE. The proposed s-ITS is compared with existing technique such as fuzzy control rule [2016 531] and also fuzzy rule based on Genetic algorithm to determine their effectiveness. The observation is done for the Chennai region mainly on peak hours and traffic prone regions to find the best

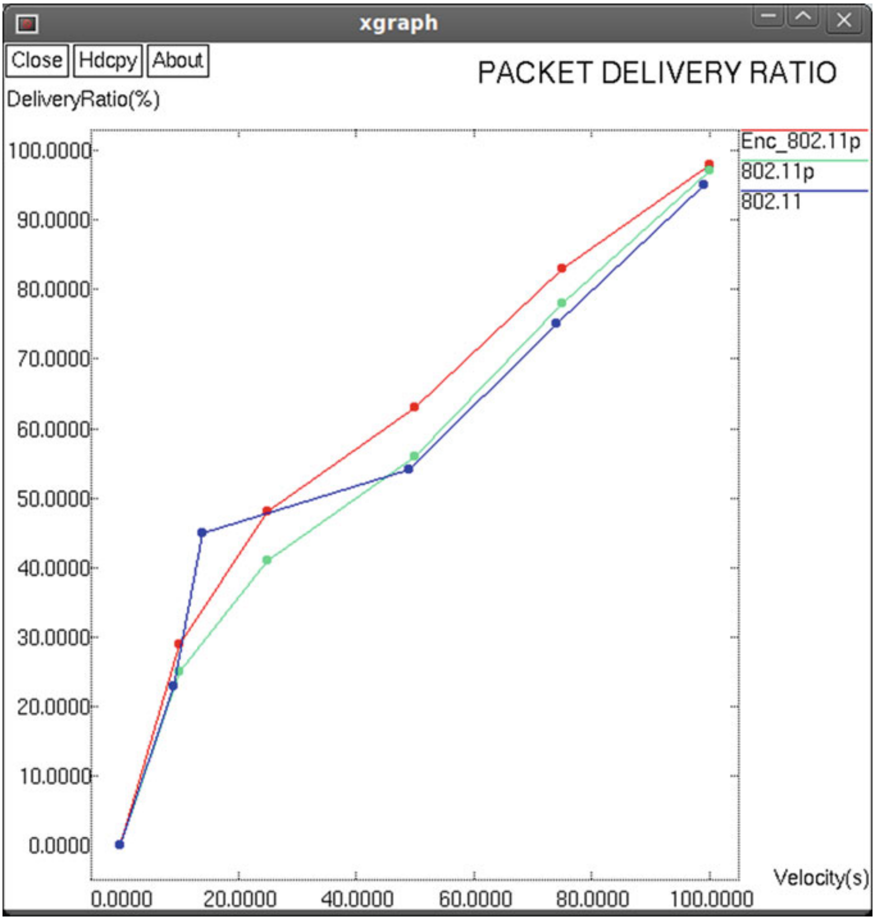


Fig. 13.6 Packet delivery ratio comparison in various network environments

route. The proposed s-ITS helps in effective traffic monitoring as well as aid in easy parking as the vehicles are rerouted in case of traffic in a particular location (Fig. 13.8).

Analyzing the traffic condition further based on the parameters like vehicle speed, density and traffic volume, the current traffic is estimated and vehicles are rerouted to reach destination without further collision (Fig. 13.9).

The vehicle density is less with increase in distance for the proposed system as the new system resolves traffic without much trouble. Also the vehicles are diverted to the alternate path such that no traffic occurs. So the proposed system outperforms the other existing fuzzy based and VANET based systems by minimizing the vehicle count in a particular road without traffic.

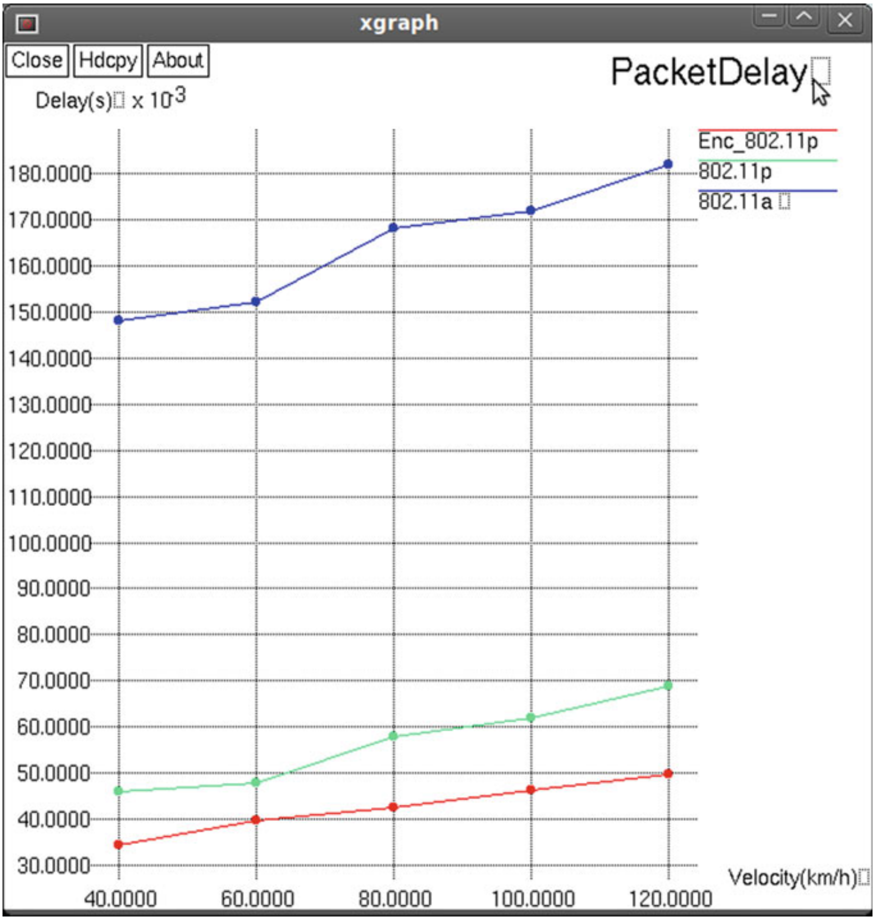


Fig. 13.7 Comparison of packet delay in varied network environment

13.15 Conclusion and Future Work

The emerging paradigm namely Bigdata and IoT plays a major role in day-to-day applications. The technologies of bigdata aid in easy preprocessing and thereby providing pre-processed data to be processed in the next level. The traffic data which is processed is then subjected to IoT and bigdata techniques and a framework namely s-ITS is obtained. The proposed framework helps in location tracking of vehicles, smart parking and applying bigdata technology for designing efficient transportation system. The system helps in monitoring the vehicle's motion thereby determining the traffic in the particular area. The proposed system is evaluated for its performance in terms of packet delivery, network delay and it is found that the

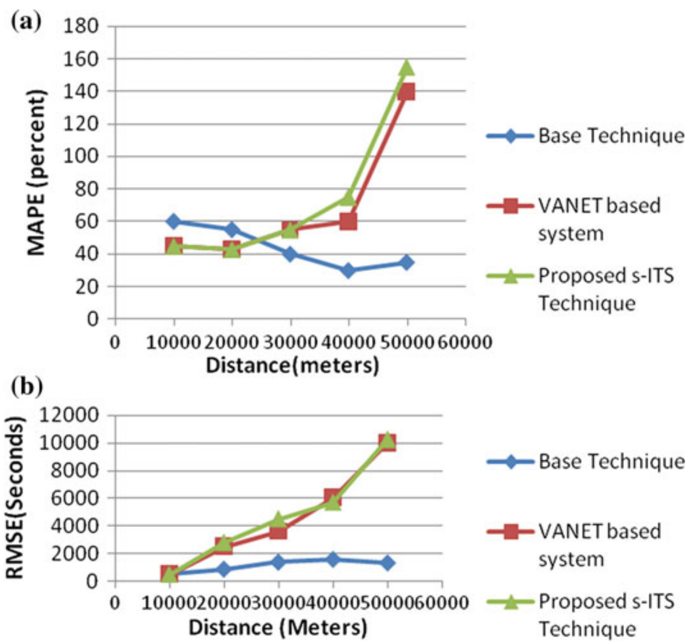


Fig. 13.8 **a** MAPE values versus distance. **b** RMSE values versus distance

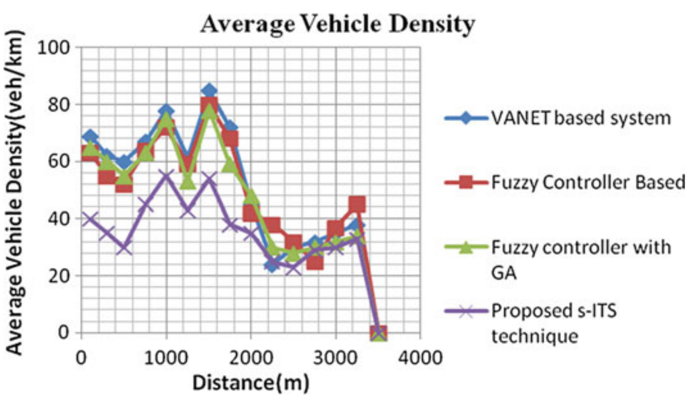


Fig. 13.9 Comparison of vehicle density in various mechanisms

proposed s-ITS system performs better than existing conventional systems. It is also exhibited through MAPE and RMSE values.

The energy efficient mechanisms could be implemented in the ITS system and the system efficiency could be made more promising for dealing with the current road scenario. This could be the future work targeting the decrease in energy for effective transportation system which is smart and robust.

References

1. Kyriazis, D., Varvarigou, T.: Smart, autonomous and reliable Internet of Things. Procedia Comput. Sci. **21**, 442–448 (2013)
2. Sheng-nan, L., Pei-pei, D., Jian-li, F., Xiao-he, L.: The implementation of intelligent transportation system based on the internet of things. J. Chem. Pharm. Res. **7**(3), 1074–1077 (2015)
3. Sherly, J., Somasundareswari, D.: Internet of things based smart transportation systems. Int. Res. J. Eng. Technol. **2**(3), 1207–1210 (2015)
4. Aceves, S.M., Paddack, E.E.: Developing intelligent transportation systems in an integrated systems analysis environment. World Congress on Intelligent Transportation Systems, pp. 1–10 (2002)
5. Shandiz, H., Khosravi, M., Doaee, M.: Intelligent transport system based on genetic algorithm. World Appl. Sci. J. **6**(7), 908–913 (2009)
6. William, H., Barry, J., Rolphe, E.: Multivariate Data Analysis. Pearson Publication, pp. 4–761 (2010)
7. Petracca, M., Pagano, P., Pelliccia, R., Ghibaudi, M., Salvadori, C., Nastasi, C.: On-board unit hardware and software design for vehicular ad-hoc networks. IGI Global, pp. 1–23 (2015)
8. de la Garza, J.M., Taylor, C.J.E., Sinha, S.K.: An integrated framework and smart algorithm for vehicle localization in intelligent transportation systems, pp. 2–115 (2013)
9. Bojan, T.M., Kumar, U.R., Bojan, V.M.: An internet of things based intelligent transportation system. In: IEEE International Conference on Vehicular Electronics and Safety, pp. 1–7
10. Ashokkumar, K., Sam, B., Arshadprabhu, R., Britto.: Cloud based intelligent transport system. Procedia Comput. Sci. **50**, 58–63 (2015)
11. Grob, G.R., Iseo, E.S.: Future transportation with smart grids & sustainable energy. In: Proceedings of the SSD 2009 6th International Multi-Conference on Systems, Signals and Devices, Djerba, Tunisia, pp. 23–2 (2009)
12. Costa, E.; Seixas, J.: Contribution of electric cars to the mitigation of CO_2 emissions in the city of São Paulo. In: Proceedings of the 2014 IEEE Vehicle Power and Propulsion Conference (VPPC), Coimbra, Portugal, pp. 27–30 (2014)
13. Mehar, S., Zeadally, S., Remy, G., Senouci, S.M.: Sustainable transportation management system for a fleet of electric vehicles. IEEE Trans. Intell. Trans. Syst. **16**, 1–14 (2015)
14. Iturrate, M.; Gurrutxaga, I.; Oses, U.; Calvo, P.M.: Sustainable transport at the university of the basque country in San Sebastian. In: Proceedings of the 2015 4th International Work Conference on Bio inspired Intelligence (IWOBI), San Sebastian, Spain, 10–12 (2015)
15. Harilakshmi, V.S., Rani, P.A.J.: Intelligent vehicle counter—a road to sustainable development and pollution prevention (P2). In: Proceedings of the 2016 International Conference on Energy Efficient Technologies for Sustainability (ICEETS), Nagercoil, India, 7–8; pp. 877–880 (2016)
16. . Fabbri, G., Medaglia, C.M., Ippolito, M., Saraceno, E., Antonucci, M., Fiorentino, L., Bistolfi, M., Cozzolino, P., Gallarate, M.: An innovative system for a clean and sustainable public transport system in smart cities. In: Proceedings of the 2016 IEEE 25th International Symposium on Industrial Electronics (ISIE), Santa Clara, CA, USA, 8–10 June 2016; pp. 974–979 (2016)
17. Abdalla, A.M., Abaker, M.: A survey on automobile collision avoidance system. Int. J. Recent Trends Eng. Res. **2**, 1–6 (2016)
18. Jurecki, R.S.: An analysis of collision avoidance maneuvers in emergency traffic situations. Arch. Automot. Eng. Arch. Motoryzac. **72**, 73–93 (2016)
19. Desai, S., Desai. S.: Smart vehicle automation. Int. J. Comput. Sci. Mobile Comput. **6**(9), 46–50 (2017)
20. Petrov, T., Dado, M., Ambrosch, K.E.: Computer modelling of cooperative intelligent transportation systems. Procedia Eng. **192**, 683–688 (2017)

21. Agarwal, Y., Jain, K., Karabasoglu, O.: Smart vehicle monitoring and assistance using cloud computing in vehicular Ad Hoc networks. Int. J. Transp. Sci. Technol. **7**, 60–73 (2018)
22. Kyriazisa, D., Varvarigoua, autonomous and reliable Internet of Things.: Smart autonomous and reliable Internet of Things. International Workshop on Communications and Sensor Networks (ComSense), pp 442–448 (2013)
23. Gaura, A., Scotneya, B., Parra, G., McCleana, S.: Smart city architecture and its applications based on IoT. In: The 5th International Symposium on Internet of Ubiquitous and Pervasive Things (IUPT 2015), vol. 52, pp 1089–1094 (2015)
24. Angelidou, M.: Smart cities: a conjuncture of four forces. Cities **47**, 95–106 (2015)
25. Sta, H.B.: Quality and the efficiency of data in "Smart-Cities". Future Gener. Comput. Syst. **74**, 409–416 (2017)
26. Khajenasiri, I., Estebsari, A., Verhelsta, M., Gielena, G.: A review on Internet of Things solutions for intelligent energy control in buildings for smart city applications. In: 8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11–13 Sept, vol. 111, pp. 770–779 (2017)
27. Kim, T.-h., Ramos, C., Mohammed, S.: Smart city and IoT. Future Gener. Comput. Syst. **76**, 159–162 (2017)
28. Kummitha, R.K.R., Crutzen, N.: How do we understand smart cities? An evolutionary perspective. Cities **67**, 43–52 (2017)
29. Archenaa, J., Mary Anita, E.A.: A survey of big data analytics in healthcare and government. In: 2nd International Symposium on Big Data and Cloud Computing, vol. 50, pp. 408–413 (2015)
30. Saravana kumar, N., Eswari, T., Sampath, P., Lavanya, S.: Predictive methodology for diabetic data analysis in big data. In: 2nd International Symposium on Big Data and Cloud Computing, vol. 50, pp. 203–208 (2015)
31. Anuradha, I.: A brief introduction on BigData 5vs characteristics and Hadoop Technology. In: International Conference on Intelligent Computing, Communication and Convergence, vol. 48, pp. 319–324 (2015)
32. Oussous, A., Benjelloun, F.-Z., Lahcen, A.A., Belfkih,S.: Big Data technologies: a survey. J. King Saud Univ. Comput. Inf. Sci. (2017)
33. Wang, Y., Kung, L.A., Byrd, T.A.: Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technol. Forecast. Soc. Change **126**, 3–13 (2018)