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TOWARDS STEP-BASED CAD/CAPP/CAM SYSTEMS

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Abstract: *This paper presents an overview of standard representation and exchange of product data for communication between CAD/CAPP/CAM systems. This standard is known as ISO 10303- Product data representation and exchange, more commonly referred to as STEP, STandard for the Exchange of Product model data. It is also describes the necessary mechanisms to implement STEP in CAD/CAPP/CAM systems. The first part of the paper covers manufacturing features model, tolerances model, etc. All these models are represented using a data modeling language called EXPRESS that was developed specifically for STEP. The other part describes the implementation mechanisms of these models and their data exchange in CAD/CAPP/CAM systems. The research work presented in this paper contributes to the area of integrating CAD/CAPP/CAM systems.*

Key words: STEP, CAPP, CAD, CAM, Manufacturing features

1. INTRODUCTION

With the increase of productivity, part complexity, shortened product life cycle and improved computer technologies, more and more computer aided systems are used in industry to support design and production engineering. Each computer aided system has its own input and output formats of the product data. These formats are different from one system to another. In a production of a single product, different departments of a company and may be different companies will be participated in the design and production engineering of the product. Different computer aided systems will be used in different places. The product information needs to be exchanged between these systems. This brings the importance of standard representation for product data exchange.

On the other hand, different computer aided systems such as CAD and CAM are usually developed independently. Each system supports a separate phase of the whole product life cycle, such as design. The integration issue is considered little in their development. In CIM environment, computer aided systems shall work together to support the life cycle of a product, therefore the production efficiency can be increased greatly. An integrated CAD/CAM system is the main component of a CIM system. The key to the system integration is the product data exchange between CAD and CAM systems [1].

Researchers have tried to devise solutions by creating different product data representation schemes. However, these approaches have their own failings, and would prove useless unless adopted by CAD venders on a wide scale. One solution that offers the most promise is the creation of a standard method for representing product data that would serve the needs of all applications [2]. STEP is such a standard offering the most promise as an answer to these problems.

2. DEFINING STEP

"STEP, Standard for the Exchange of Product Model Data, provides representation of product information along with the necessary mechanisms and definitions to enable product data to be exchanged. The exchange is among different computer systems and environments associated with the complete product lifecycle including design and manufacture. The information generated about a product during these processes is used for many purposes. This use may involve many computer systems, including some that may be located in different organizations. In order to support such uses, organizations must be able to represent their product information in a common computer-interpretable form that is required to remain complete and consistent when exchanged among different computer systems.

STEP is organized as a series of parts, each published separately. These parts fall into one of the following series: description methods, integrated resources, application protocols, abstract test suites, implementation methods, and conformance testing. STEP uses a formal specification language, EXPRESS, to specify the product information to be represented. The use of a formal language enables precision and consistency of representation and facilitates development of implementations. STEP uses application protocols (APs) to specify the representation of product information for one or more applications.

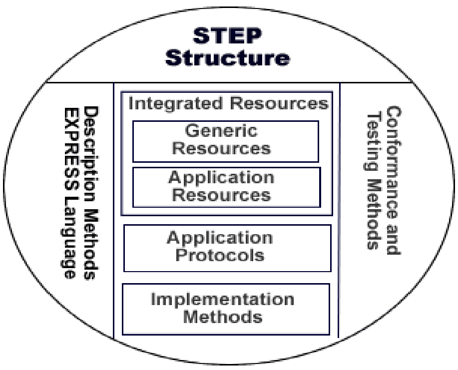


Fig. 1. STEP Structure

The overall objective of STEP is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving. The ultimate goal is an integrated product information database that is accessible and useful to all the resources necessary to support a product over its lifecycle [3, 4].

3. IMPLEMENTING STEP FOR INTEGRATION

Two important prerequisites are considered as the key issue to CAD/CAM systems integration. One is a product data representation model common to CAD and CAM systems. The other is the implementation mechanism for data exchange. The product data that CAD and CAM systems deal with is a part of the total product data model, e.g., CAD deals with geometry and topology data. A global product model is needed, which all systems share common definitions. The product data that each system processes can be a part of the global product data model [2].

The global product data model can be achieved by selecting an appropriate standard representation. The STEP standard categorizes the various types of product data around Application Protocols (AP). Each Application Protocol defines all the data needed for a particular application domain. The first question to answer when planning a STEP implementation is what application protocol will be used. To be STEP-conformant, software systems have to be able to support all the data defined by the Application Protocol. This ensures that all data can be translated in and out of this format without any loss [5, 6, 7]. In this paper, the Application Protocol 224 will be discussed and its data representation will be classified.

4. STEP AP224

STEP AP224 specifies the requirements for the representation and exchange of information needed to define product data necessary for manufacturing single piece mechanical parts. The product data is based on existing part designs that have their shapes represented by form features. AP224 covers the following [8]:

- Product data that defines a single piece machined part to be manufactured.
- Product data that covers parts manufactured by milling or turning.
- Product data that is necessary to track down the customer order in the shop floor.
- Product data necessary to identify the status of a part in the manufacturing process.
- Product data necessary to track raw stock certification.
- For features that are necessary for defining shapes necessary for manufacturing.

STEP AP224 is based on a three layered architecture:

1. Information requirements layer.
2. The logical layer.
3. The physical layer

4.1 Information requirements layer

This layer specifies the information required for the definition of product data for mechanical product definition for process planning using machining features. The information requirements are categorized as shown in fig. 2. Each information requirement item in this layer contains a number of application objects with their data associated. The application objects in the manufacturing features information requirement are classified as shown in fig. 3. The application objects associated with measurement limitations are classified as in fig.4.

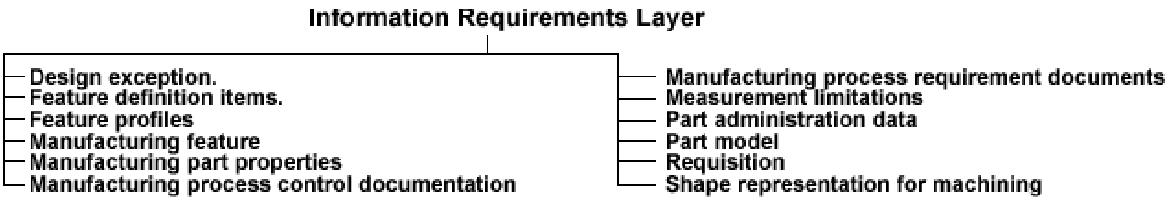


Fig. 2. Information requirements layer

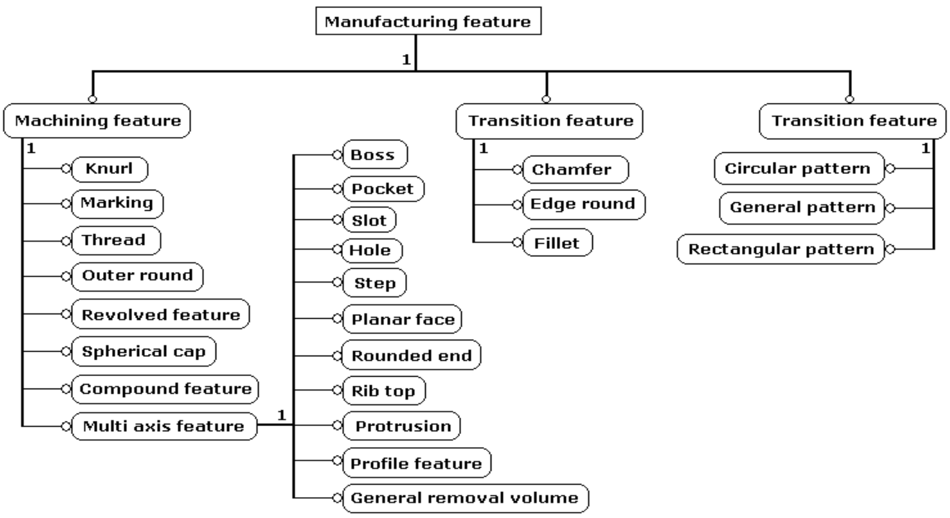


Fig. 3. Manufacturing features information requirement

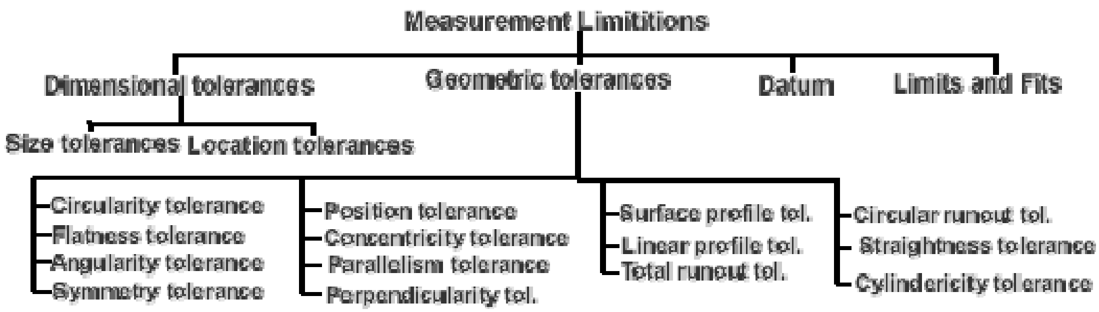


Fig. 4. Measurement limitation information requirement

4.2 The logical layer

In this layer, the data associated with each application object in the information requirements layer is defined using a formal language called EXPRESS. This formal language enables precision and consistency of representation and facilitates implementation. The representation of EXPRESS is two fold. The first one is a formal language that uses a lexical notation and syntax defined by a grammar. The second one is a graph representation, namely EXPRESS-G, which provides a very compact and rich illustration. The EXPRESS specification defining, for example, BOSS feature is shown below

```
ENTITY boss
    SUPERTYPE OF (ONEOF (general_boss, circular_boss, rectangular_boss))
    SUBTYPE OF (multi_axis_feature);
        top_condition:     boss_top_condition;
        boss_height:       linear_path;
        fillet_radius:     numeric_ parameter;
        top_radius:        numeric_parameter;
END_ENTITY;
```

and EXPRESS-G specification is shown in fig. 5 below.

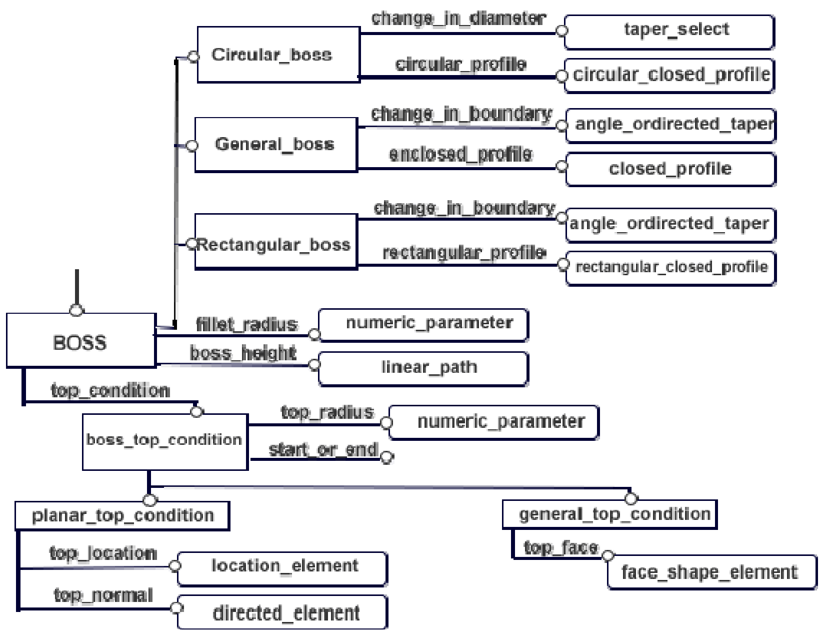


Fig. 5. EXPRESS-G specification of BOSS feature

4.3 The physical layer

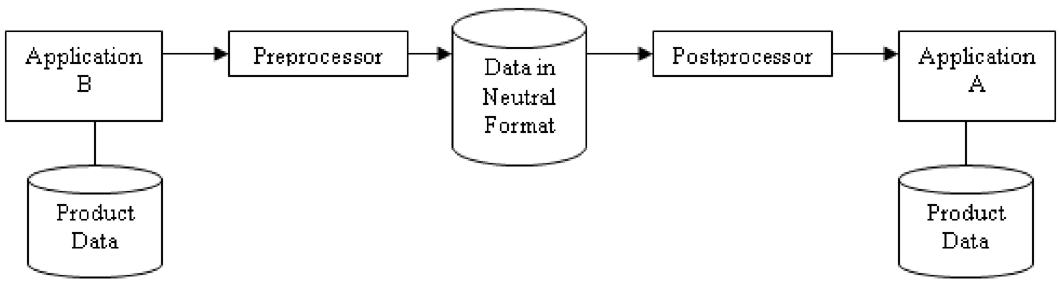
This layer defines the communication file structure called STEP file. This file transfer mechanism represents the static aspect of STEP which allows exchange of product data. This file is obtained by translating the EXPRESS schemes defined in the logical layer to a STEP AP224 file structure as illustrated in fig. 6. It describes product containing a circular boss.

```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION(('AP224 File'),'1');
FILE_NAME('boss.224','1997-01-21T14:20:13-05:00',('RPTS Operator'),('SCRA'),'RPTS
MP 5.3','PTC Pro/ENGINEER Version 15.0','RPTS Operator');
FILE_SCHEMA(('FEATURE_BASED_PROCESS_PLANNING'));
ENDSEC;
DATA;
………..
#3800=(CHARACTERIZED_OBJECT('','circular')FEATURE_DEFINITION()INSTANC
ED_FEATURE()MACHINING_FEATURE()BOSS()
SHAPE_ASPECT('','',$,.T.));
#3801=PROPERTY_DEFINITION('$_','$_',#3800);
#3802=PRODUCT_DEFINITION_SHAPE('$_','$_',#3800);
#3803=CARTESIAN_POINT('$_',(20,20,0));
#3804=DIRECTION('$_',(0,0,1));
#3806=AXIS2_PLACEMENT_3D('$orientation',#3803,#3804,#3805);
#3807=SHAPE_REPRESENTATION('$_',(#452,#486,#508,#536,#552),#29);
……….
```

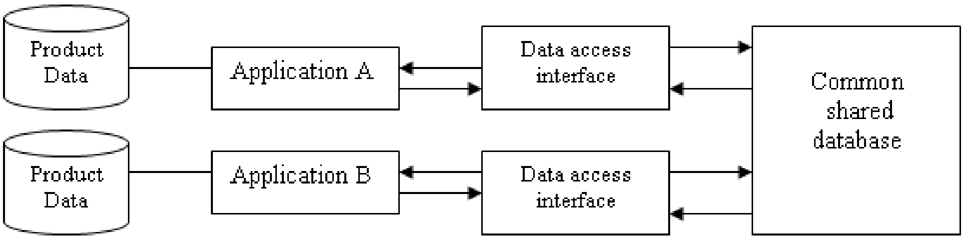
Fig. 6. Part of a STEP AP224 file

5. PRODUCT DATA EXCHANGE IN STEP

There are two distinct approaches to data exchange: data translation and data sharing as shown in fig. 7. Data translation means that local input/output data of an application is interpreted into a neutral format via a preprocessor and is transformed for reuse by another application by its postprocessor. This is a straightforward approach because the data exchange is always between two systems at a time and each input/output file is translated independently. Data sharing means that all applications can access the same neutral data via some kind of data access interface and derive local data based on it. STEP supports the two approaches of the data exchange mentioned above [9].



a) Data translation



b) Data sharing

Fig. 7. Product data exchange mechanisms

6. CONCLUSION

Product data representation and exchange based on STEP standard are the key answer to CAD/CAM integration. The application protocol AP224 covers most of the information required during the whole lifecycle of the product. By using EXPRESS language this information can be represented in an unambiguous format, facilitates software development and provides mapping to a final STEP format. This format can be used as a transfer mechanism between different computer aided systems.

7. REFERENCES

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