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# Enterprise Resources Integration System for Rapid Extended Manufacturing

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**Abstract**

*In order to realize rapid extended manufacturing, isomerism data integration method of enterprise resource, based on multi-dimension ontology, is proposed. Enterprise resource classified model is introduced, and process of integration and sharing of enterprise resources is analyzed. Besides, construction method of application view dimension enterprise resource ontology, life cycle dimension enterprise resource ontology and polymerization degree dimension enterprise resource ontology are discussed. Further more, entity relation diagram of enterprise resource integration is introduced, and generating and parsing mechanism of XML file about application view enterprise resources ontology is also stated. The mentioned method can resolve problems, such as enterprise resource isomerism data integration, operating authority control, and state information real-time tracking.*

***Keywords**: rapid extended manufacturing, multi-dimension, enterprise resource, ontology.*

## 1. Introduction

Armament rapid extended manufacturing [1] focuses on capability of coordination and rapid response in networked environment. It resolves the conflicts between limited productivity of enterprise and increasing production order to realize scalable batch production by rapidly organizing resource in a short time [2].Rapid extended manufacturing mode aims at distributed manufacturing enterprise under network environment. Therefore, effective method of enterprise resource information integration and distributed resources library construction are important factors to realize rapid extended manufacturing. The following problems should be solved to achieve the rapid construction of distributed resource library: Firstly, inconsistent of heterogeneous data source in storage and presentation among different application systems; secondly, semantic conflict of resource model needs to be coordinated to realize unified description and operation of the whole life cycle of enterprise resources; at last, real-time acquisition of enterprise resource state information, in terms of polymerization degree dimension, should also be resolved to meet different levels of demands for enterprise resources during the rapid extended manufacturing process.

The engineering problems mentioned essentially refer to heterogeneous data problem of resources. Furthermore, heterogeneous data, a concept with abundant meanings, not only refers to heterogeneous data between different database systems (such as the data store in Oracle database and SQL Server database, respectively), but also includes different structures of heterogeneous data (such as structured SQL Server database data and semi-structured XML data) [3]. Furthermore, it involves the difference in semantic expression between enterprise resources, causing various kinds of contradictions from name semantic conflict to complex structure semantic conflict. The work, mainly aiming at data heterogeneous problem of enterprise resource between relational databases,

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focuses on solving the problem of semantic conflict between enterprise resources based on ontology semantic mapping to construct enterprise resource database.

## 2. Enterprise Resource Concept Model

Enterprise resources [4] are mentioned mainly from the aspects of resources classification, attribution and structure. According to the national main product classification and code standard, they can be divided into technological resources, financial resources, human resources, supply chain resources, customer relationship resources, basic resources, quality management resources, standard resources, manufacturing resources material resources and so on. Each type of resources consists of several subclasses. Taking advantage of derived and inheritance characteristic of object-oriented technology, Figure 1 shows classification model building of enterprise resource through linear classification method. In the classification model, enterprise resource class is determined for a super class inherited by abstract class, such as technical resources class and financial resources class. At the same time, the abstract class is polymerized by other abstract class. Multiple subclasses can be inherited from the abstract class, and only subclass can be instantiated. In other words, each subclass is corresponding to enterprise resource objects. Super class, abstract classes, subclasses, and objects constitute the tree structure of enterprise resource under ASP mode [5][6]. Elaboration and decomposition of enterprise resource data can be realized through data classification method of nested definition.

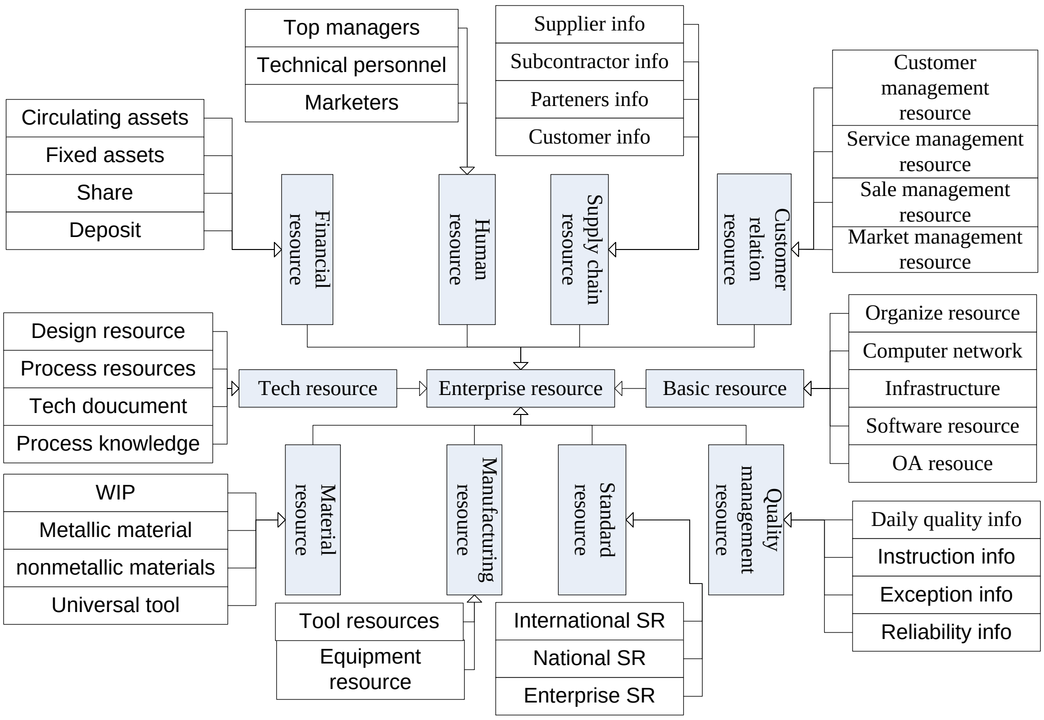


**Figure 1. Enterprise Resource Concept Model**

By analyzing information characteristics of enterprise resource in each stage, attribute information of enterprise resource is divided into the eight types—basic information, usage information, historical information, inventory information, technical parameters, source information, maintenance information and plan information.

 

## 3. Process Analysis of Integration and Sharing of Enterprise Resource

In terms of the demand for rapid extended manufacturing, internal resource information of enterprise is integrated based on the multidimensional enterprise resource ontology. Information about manufacturing capacity, physical composition and resource state are fed back to main production enterprises through ontology mapping relationship. Thus, the goal of resource sharing between enterprises is achieved. In the work, heterogeneous data of enterprise resources are encapsulated by composite ontology method. Moreover, Application view dimension local ontology and lifecycle dimension global ontology of enterprise are constructed, and then enterprise resources polymerization degree dimension ontology is defined (See Figure 2).

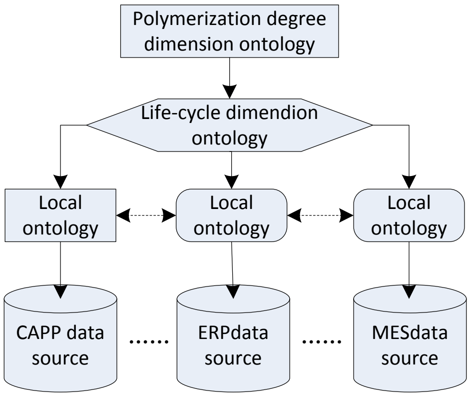


**Figure 2. Enterprise Resource Integration Method based on Multi-dimension Ontology**

Enterprise resources integration and sharing interaction process can be described by UML sequence diagram [7] (See Figure 3). Its detailed description is shown as follows:

(1) Ontology information of enterprise resources is defined, including the concept hierarchy, attributes, units, constraints, etc.

(2) Underlying database opening degree of resources application system (such as CAPP, MES and ERP system [8]) is analyzed, and encapsulation method of heterogeneous data is determined (communicating with databases natively or API).

(3) Mapping relationship of application view dimensions local ontology and dimension globe ontology of lifecycle is defined.

(4) In terms of virtual method thought in information integration, enterprise resources information of application system is integrated logically, and distributed enterprise resource database constructed.

(5) By RDQL language, OWL [9] files from enterprise resources are queried. Moreover, integration and sharing of the multidimensional enterprise resources are realized through data source encapsulation, query decomposition and transformation, mapping relationship acquisition and database operation.

(6)Enterprise resource status information of polymerization view dimension is fed back to the main production enterprise in form of OWL files.

 

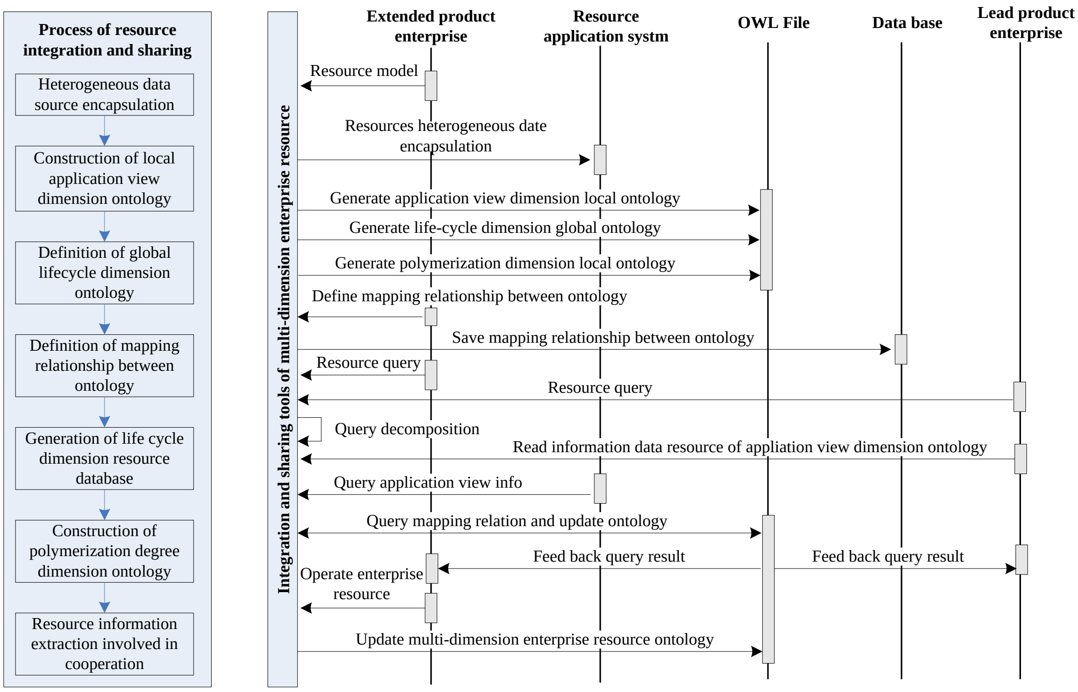


**Figure 3.UML Sequence Diagram in the Process of Enterprise Resource Integration**

# 4. Multi-dimension Enterprise Resource Ontology Modeling

## 4.1. Construction of Application View Dimension Enterprise Resource Ontology

Enterprise resource data of application view dimension scattered in their own application database system. There is a close connection between its enterprise resource model and database structure of the application system [10]. At present, most data are managed by relation schema, and universal database description model of the enterprise resource application view dimension is abstracted. Figure 4 shows that enterprise resources of each application system are described by five entities—resource class, resource object, resource attribute, attribute data description and data source description. Besides, resource class is correspond with tables and views of relational database, and its code, name and parent class name may be implicit in the database. Resource attribute is equivalent to the fields in the table or view, from the attribute name, data type, size, and whether it is null. Units related to the attribute and resource class is generally implicit. Resource object is the main part of enterprise resource information corresponding to several records of a table or view. Data source description mainly describes the application system database, providing services to generate OWL files of enterprise resources and unify operation.

Figure 5 shows generating and parsing mechanism of XML file about enterprise resources of application view. Integration and sharing tools seek for enterprise resource information in database by data source wrapper, and the processed result is sent to JDOM[11] document object mode. Finally, the XML file generator creates the XML file corresponding to manufacturing resources application view according to the results of the JDOM.

 

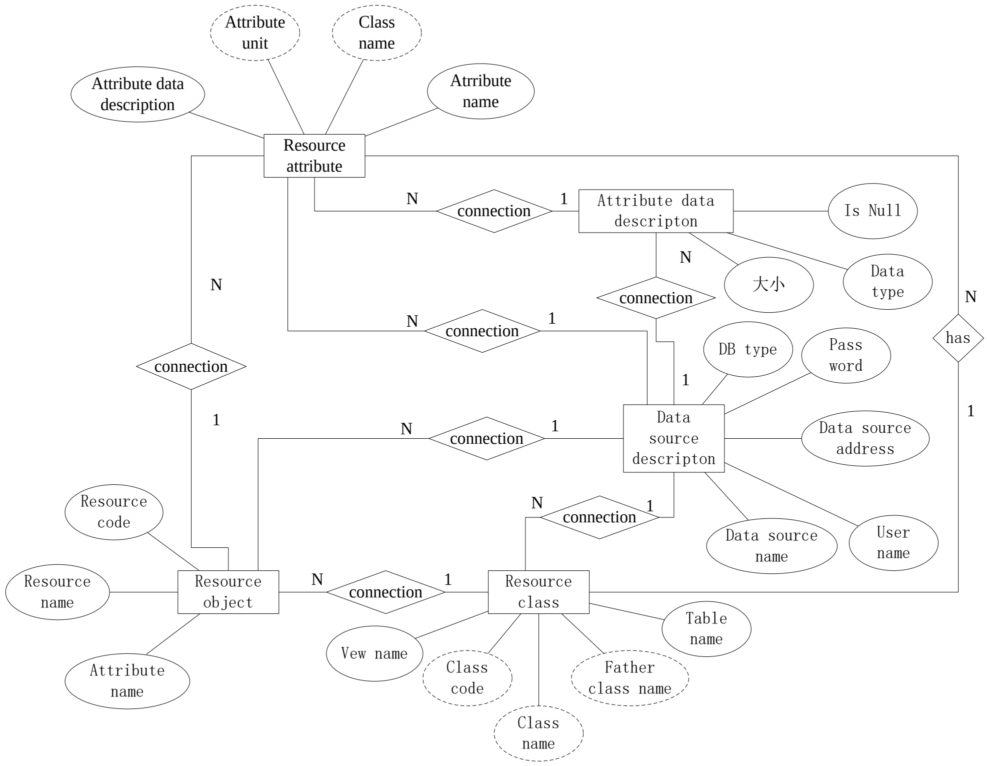


**Figure 4. Entity Relation Diagram of Enterprise Resource Integration**

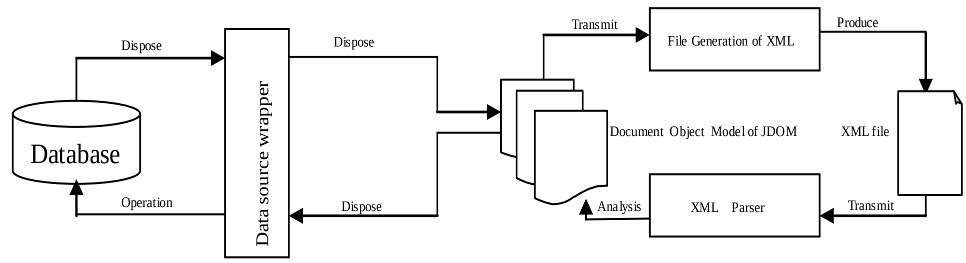


**Figure 5.Generating and Parsing Mechanism of XML File about Enterprise Resources of Application View**

XML document parsing process is contrary to its generating process. Firstly, an XML file is analyzed through XML file parser. Secondly, processing result of JDOM document object model is fed back to data source wrapper. Lastly, database is operated by the wrapper. Java code about generator and the parser's of XML documents (See APPENDIX B). Besides, management system of description equipment is generated automatically by the generator and the XML file about manufacturing resource information of CAPP system.

### 4.2. Construction of Life Cycle Dimension Enterprise Resource Ontology

Figure 6 shows enterprise resource ontology approach, and lifecycle dimension enterprise resource ontology is core part of multi-dimension enterprise resource ontology. It eliminates semantic conflicts among local ontology, and feeds back information about status and capacity to polymerization degree dimension enterprise resource ontology. The construction of dimension enterprise resource ontology of lifecycle consists of three parts:

 

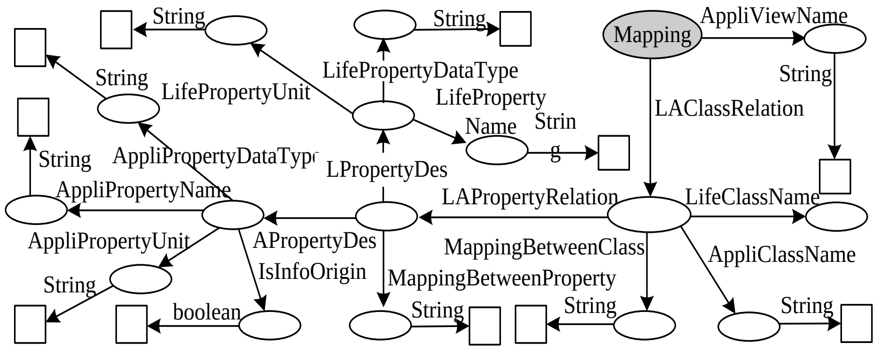


**Figure 6. Directed Graph of Enterprise Resource Concept Description**

(1)Lifecycle dimension ontology is formalized;

(2)The mapping relationship between the lifecycle dimension global ontology and application view dimension local ontology is defined;

(3)OWL file of life-cycle dimension enterprise resource ontology is generated and analyzed.

(4)Refer to the generation of global and local information mapping relationship, information integration system of atomic layer enterprise resources is set as *S*=<*L*,*A*,*M*>. L represents lifecycle dimension enterprise resource ontology; A the application view-dimension enterprise resource ontology; M the mapping relation among the ontology. The goal to construct M is to realize double-side mapping between lifecycle dimension ontology (L) and the application view dimension local ontology (M), namely L↔A. M is mainly described by *AppliViewName* and *LAClassRelation* aspects, while *LAClassRelation* by *LifeClassName*, *AppliClassName*, *LAPropertyRelation* and *MappingBetweenClass*. Using triples description method {predicate, subject, object} in RDF, the LA ontology mappings relation M can be represented as a directed graph (See Figure 6). Appendix A shows the details and OWL type of description.

**Table1. Detail Description of for Concept of Mapping Relationship Directed Graph**

| Concept in M | OWL | Remark |
|---|---|---|
| LAOntologyMapping | Class | Mapping relation between LA ontologies |
| LAPropertyMapping | Class | Property mapping between LA ontologies |
| LProperty | Class | LA ontology Property |
| AppliClassName | DatatypeProperty | Local ontology class name |
| AppliPropertyDataType | DatatypeProperty | AV ontology Data type |
| AppliPropertyName | DatatypeProperty | AV ontology property name |
| AppliPropertyUnit | DatatypeProperty | AV ontology property unit |
| AppliViewName | DatatypeProperty | Applying view name |
| APropertyDes | ObjectProperty | Local ontology property description |
| IsInfoOrigin | DatatypeProperty | Is information origin? |
| LAClassRelation | ObjectProperty | Class relation description between ontologies |
| LAPropertyRelation | ObjectProperty | Property relation description between ontologies |
| LifeClassName | DatatypeProperty | Global ontology class name |
| LifePropertyDataType | DatatypeProperty | GO property data type |
| LifePropertyName | DatatypeProperty | GO property name |
| LifePropertyUnit | DatatypeProperty | GO property unit |
| LPropertyDes | ObjectProperty | GO property description |
| MappingBetweenClass | DatatypeProperty | Mapping relation in classes |
| MappingBetweenProperty | DatatypeProperty | Mapping relation in property |
| AProperty | DatatypeProperty | Application view ontology property |
| LAClassMapping | class | Class mapping in LA ontology |

 

### 4.3. Construction Polymerization Degree Dimension Enterprise Resource Ontology

The purpose of constructing resource ontology is to meet the needs of multi-level configuration of enterprise resources. It essentially belongs to the semantic description of business resources on different abstraction levels, focusing on the following issues:

(1) Analysis and formalization description of polymerization degree dimension enterprise resource;

(2) Parsing and generating of polymerization degree dimension enterprise resource ontology file;

(3) Veracity and real-time capability problems about status information of polymerization degree dimension ontology;

(4) Unified query and the access and operation right control of enterprise resource unit information.

State information of polymerization degree dimension enterprise resource ontology is made up of the equipment running status, load conditions and tooling stock. In order to meet the needs of enterprise resource rapid configuration, integration and sharing tool should access resources status information in time. Its typical process is as follows:

(1) Enterprise ontology instance namespace of polymerization degree dimension is obtained by *getNSInstName*() methods from *MulMROntoModelMgr* class. Object property information is queried through RDQL, and instance information about described range class is obtained. If the range class belongs to enterprise resource of device layer, instance information is added to the Java List.

(2) Lifecycle dimension class and instance namespace of enterprise resource ontology are obtained by *getNSClassName*() and *getNSInstName*(), and *LA* mapping relation by *getNSClassName* (). If there is resource object in ontology, information can be queried in RDQL.

(3) According to instance information of the mapping relationship of *LAOntologyMapping*, it’s easy to determine the query conditions of application view dimension ontology.

State information of application view dimension can be obtained through the data source wrapper to query the database. Based on this, the state information of lifecycle dimension resource instance is obtained, and instances state information of polymerization degree dimension ontology is updated. Figure 7 shows real-time temporal logic of polymerization particle degree dimension ontology status information by swim-lane activity diagram.

 

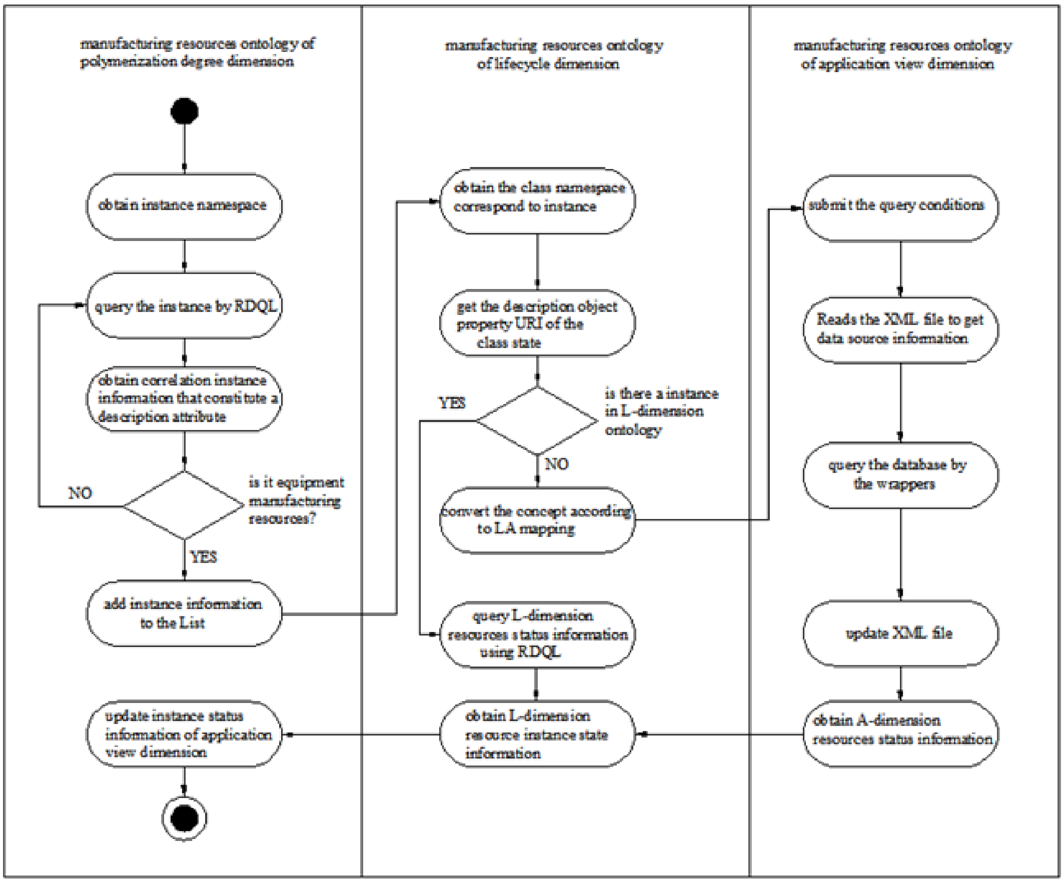


**Figure 7.Status Information of Real-time Temporal Logic based on Polymerization Degree Dimension Ontology**

The goal of integration and sharing of multidimensional enterprise resources is to eliminate semantic conflict of resource application system, and enterprise resource unified operation is achieved. Enterprise resource unit information is abstracted to form polymerization degree dimension enterprise resource ontology to ensure the real time status information of ontology. According to analysis above, unified operation of enterprise resource unit mainly involves application view dimension ontology and lifecycle dimension ontology. It is the basic requirement of effective management on enterprise internal resources. It mainly includes the decomposition of enterprise resource unit operating statements and performing of operation clause. The process is similar to temporal logic of life cycle dimension and application view ontology (See Figure 8). The detailed work is as follows:

 

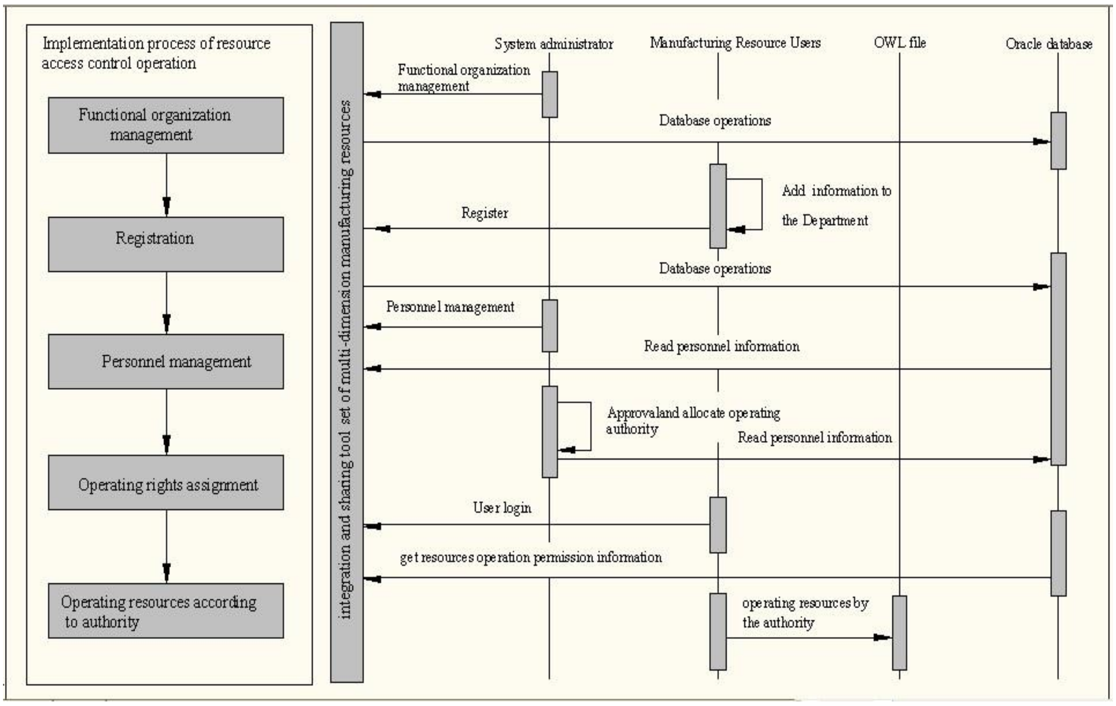


**Figure 8. Control Strategy Implementation Process of Enterprise Resource Unit Operation Permissions**

(1) Command of resource unit unified operation is acquired;

(2) When new resource unit is set up, a resource instances of the class can be added to lifecycle dimension ontology through *addInstance*() method directly;

(3) If stored in life cycle dimension ontology, resource unit can be modified, deleted or updated, respectively, by *editInstance*(), *delInstance*() and *updateInstance*(). Otherwise, concept conversion is realized by querying LA mapping relation in the lifecycle dimension in RDQL. The operation command is decomposed into the operational statements to satisfy the analysis of XML and identification of wrapper in application system.

(4) Instances information of lifecycle dimension ontology can be queried by RDQL, and query of enterprise resource application system is realized by XML parser and data source wrapper. Lastly, query results are fed back to user in form of array.

## 5. Conclusion

With the development of armament rapid extend manufacturing, problems of enterprise resource data heterogeneity is becoming increasingly fierce. Enterprise decision makers and engineers are considered to make use of enterprise resource information reasonably and effectively. Multi-dimension enterprise resource ontology method can effectively solve the problem of information integration of enterprise resource. It maintains the integrity of original data, and promotes security degree in resources sharing between enterprises. The method is applied to shaanxi province automobile manufacturing enterprise, and enterprise productivity is increased greatly.

 

## Acknowledgment

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