# Research on Process-Oriented Enterprise Knowledge Modeling and Integration Management Based on Ontology

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**Abstract.** The society is entering into knowledge-based economy, managing experience knowledge effectively is more important. Process-oriented knowledge management aims is the integration of business process and knowledge management, in order to solve the problem of process knowledge exchange and sharing in enterprise or between enterprises, an ontology-based approach to modeling and integrating enterprise process knowledge was proposed and an Enterprise Process Ontology (EPOnt) was developed. Its fundamental information is represented by the IDEF5 language graphically based on the reasons that most of ontologies have formal semantics but lack of graphical representation currently. Moreover, its precise syntax and formal semantics are defined in the Ontolingua language characterized by traits such as stronger expressiveness and compatibility with multiple representation languages and systems. Based on those, an actual Guangzhou Port Group business case was illustrated to show the application of the EPOnt and the architecture of an EPOnt-based enterprise knowledge integration management platform was presented. The proposed approach provides a common understanding of a relevant vocabulary of terms and enhances the semantic interoperability, reuse and share of process knowledge for improving server efficiency and quality of enterprise.

**Keywords**: *Process-oriented, Ontology, knowledge management, IDEF5 language, Ontolingua language*

## l. INTRODUCTION

BPR (Business Process Reengineering) that swept the world in 90s of the 20th century has gradually faded out of people's vision. Instead, the newly emerging knowledge management (KM) is drawing people's attention. Process-oriented knowledge management (PKM) is to combine process-oriented method with knowledge management [1-2]. By providing the necessary knowledge for the value-added activities of business process, PKM can enhance organizational performance. The results of the first global Delphi study on prospects of Knowledge Management

showed that integrating knowledge management into the business process is not only the most urgent issues that need to be solved about theoretical research, but also the most practical way to solve the problems in the practice of knowledge management [3]. Combining knowledge with business process can improve organizational knowledge management and process management. At present most studies on knowledge management in not only the theory, but also the construction of knowledge management system deal with the acquisition, collate and reuse process [4-7]. China's Cui Shuyin and Ren Hao from Tongji University made preliminary study on process-oriented knowledge management strategy in terms of the management [8]. However, it is rare to see the practices about combining business processes with knowledge management.

With the rapid development of the Internet and information technology, departments inside the enterprise or enterprises need to cooperate to provide users with better services. Therefore, we need to realize electronic service to improve enterprise efficiency and quality of decision-making, and reduce operating costs. In the efficient services of enterprises, all enterprises and departments need good cooperation with each other to exchange and share business process knowledge, such as the services that activities need and the correct logic dependence relationship. However, the business service systems inside enterprise or in different enterprises are independently constructed, and do not share the same program of business process knowledge modeling. These systems may use different names, such as the operation or mission, and lack definitions and descriptions of the full semantic of concepts and terms when they express the same concept. Not clearly definition of the concept and duplication of interpretation lead to inconsistencies of explanation and the use of business process knowledge, make it difficult for different systems within the enterprise or between different enterprises to automatic exchange and share process knowledge, eventually lead to the low efficiency, and even make service impossible.

Therefore, in view of the above questions, this paper proposes the modeling of business process knowledge based on Ontology without ambiguity for different enterprises or enterprise business systems to understand and effectively exchange and integrate process knowledge. Ontology can precisely define and depict the knowledge concept and public terms of relations and semantics, thus can effectively promote the common understanding and interaction of knowledge and semantic interoperability of heterogeneous systems. Currently, the majority of ontology modeling takes on the formal semantics, but lack icons, so it is difficult to express the information of ontology. Therefore, we developed the EPOnt (Business Process Ontology). First we adopted the visual charts ICAM to express Ontology basic information, and use Ontolingua with strong expression and compatibility of many languages and systems to accurately depict grammar and formal semantics. Based on those, an actual Guangzhou Port Group business case was illustrated to show the application of the EPOnt. Finally, we propose the integration architecture of enterprise knowledge management based on EPOnt.

# 2. PROCESS-ORIENTED AND ONTOLOGY

## 2.1 Process-oriented

During the 1990s, Hammer and Champy proposed the theory of business process reengineering [9]. It emphasizes that organization should put business process as the center but not functions. The process can describe the most of activities in organization in some case more than 90% [10]. The process is made up of activities, and a shallow definition of the process is a group of related activities [11]. For enterprise organizations, business is a series of activities that is engaged in by them to achieve operational objectives, and that is also the main daily work of enterprises. The business process is the activity of changing one or more input into output that is valuable for the customers. Process-oriented stresses the process, the output of the process and the customer satisfaction.

## 2.2 Ontology

Ontology that originates from philosophy is widespread paid attention to among the field of information science in recent years [12-13], and its importance has been demonstrated in many ways and has been widely recognized [12][14-15]. There are a number of definitions about the ambiguous term “ontology”, and different definitions have different level of detail and logic. Gruber’s theory and Guarino’s theory are two representations [12][16]. Gruber’s definition of Knowledge System Laboratory (KSL) of Stanford University is at large accepted: An ontology is an explicit specification of a conceptualization [16]. Ontologies embody human knowledge via symbols that are machine processible. Therefore, ontologies benefit machine reading the data when we use ontologies to index data and to express the metadata [17]. Ontology facilitates capture and construction of domain knowledge and enables representation of skeletal knowledge to facilitate integration of knowledge bases irrespective of the heterogeneity of knowledge sources [18].

## 2.3 Ontology Description Language: IDEF5, Ontolingua

IDEF5 is developed by KBSI of America [19]. Figure 1 shows parts of IDEF5 schematic language symbols, and kind and individual of IDEF5 are corresponding to class and instance of ontolingua. Ontolingua is developed by Knowledge System Laboratory (KSL) of Stanford University, and it can express class, class hierarchy, n variables relationship, function, axiom and instance etc [20]. The definition of ontolingua includes three parts: the head part of the definition, the non-formal definition part that is described by natural language and the formal definition part.

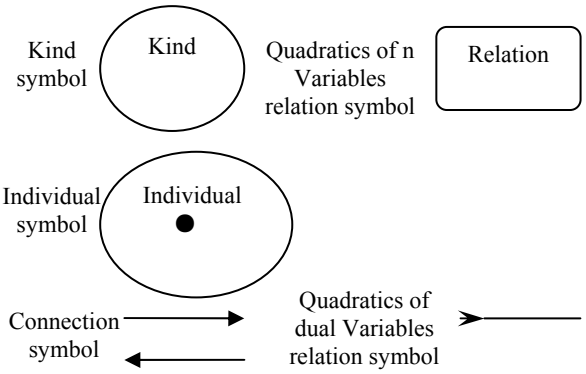


**Figure 1. Parts of IDEF5 Schematic Language Symbols**

## 3. PROCESS-ORIENTED ENTERPRISE KNOWLEDGE MODELING BASED ON ONTOLOGY

The purpose of developing EPOnt is to provide shared vocabulary for describing the transfer process of business. The whole business process can be said by a "flow" activity. Each activity is associated with input, output, resource and constraint, and it also has a proper logical links with other related activities. This expression method that is unified and activity-oriented is helpful to construct modular process activities base, and it can add or delete process activity independently [21]. EPOnt includes framework ontology and parameter constraint ontology, and that can help we reuse its vocabulary, such as individual-thing and constraint etc. Figure 2 shows parts of the fundamental information of the EPOnt represented by IDEF5 schematic language. Here we omit the analysis of main entities and formal description of EPOnt.

## 4. CASE STUDY

The business of Guangzhou port, such as scheduling business, the container business and so on, can be described by the terminology and precise semantics of EPOnt. EPOnt can describe the activities, parameters and connectivity relationship of specific activities and establish the process knowledge of specific business areas that is exchangeable and sharable. All these are the content of knowledge base. Now we give the knowledge describes for cargo handling cost service of Guangzhou port that is based on EPOnt.

Figure 3 shows the flow of cargo handling cost service, and it includes three activities: submitting cargo kind and quantity, computing cargo handling cost and

paying cargo handling cost. These three activities form sequential connection relationship.

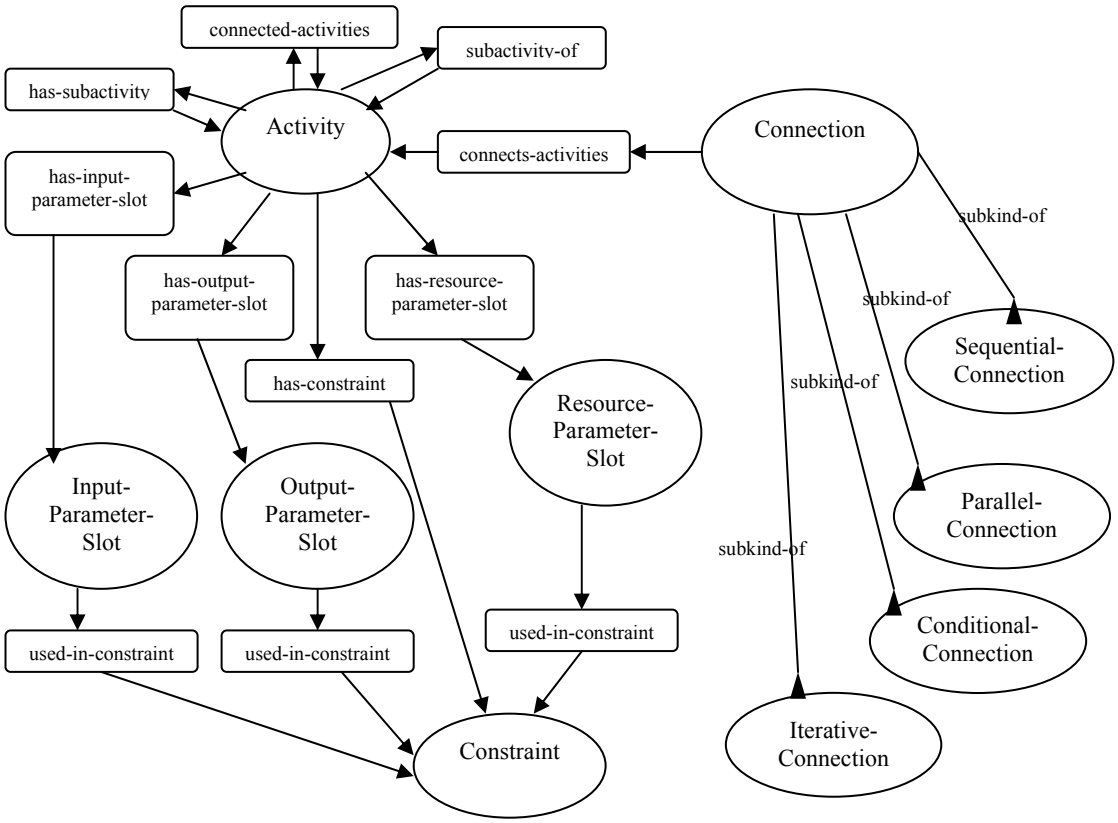


**Figure 2. Fundamental Information of the EPOnt Represented by IDEF5 Schematic Language**

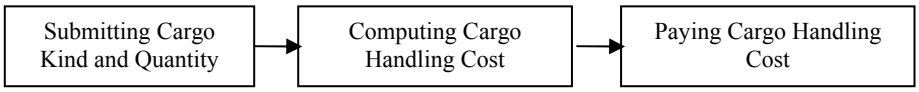


**Figure 3. Cargo Handling Cost Service Flow Chart**

Figure 4 shows the process knowledge for cargo handling cost service

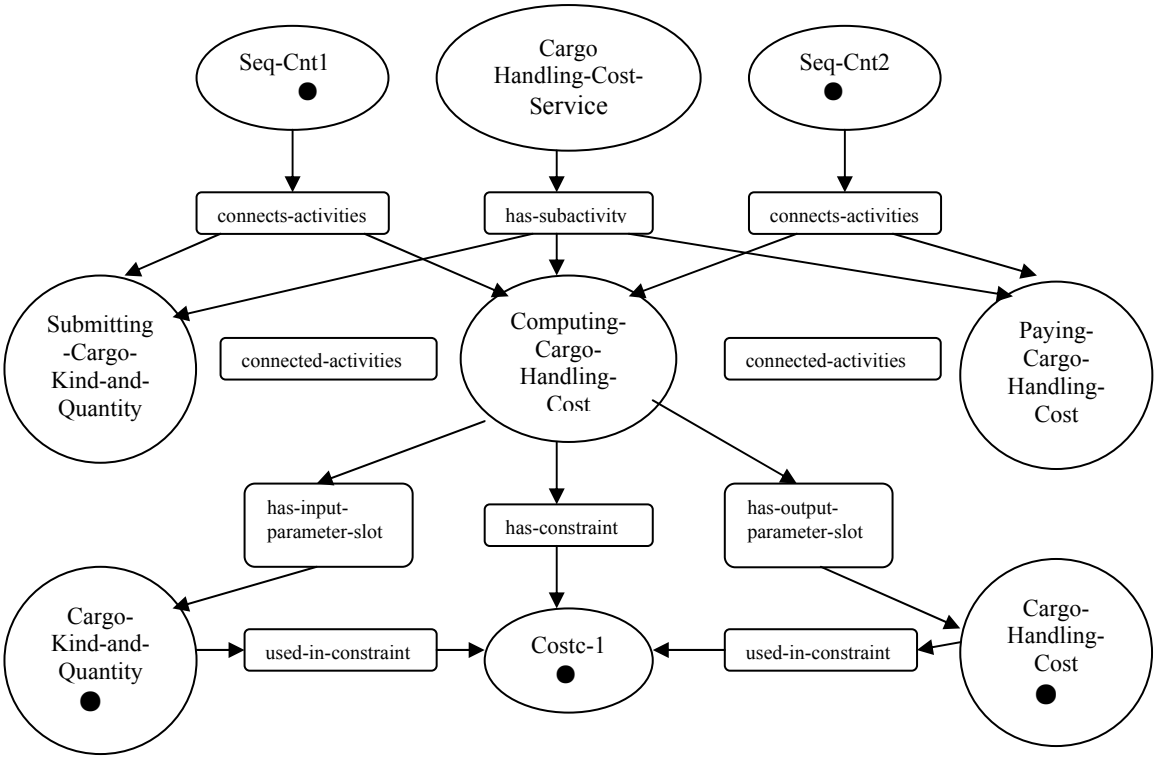


**Figure 4. Process Knowledge Chart for Cargo Handling Cost Service**

*Cargo-Handling-Cost-Service* is the sub-activity of *activity*. The following is the definition of *Computing-Cargo-Handling-Cost* that is included in *Cargo-Handling-Cost-Service*.

```
(define-class Computing-Cargo-Handling-Cost (?x)
   : def(and (Activity ?x)
   (has-input-parameter-slot ?x Cargo-Kind-and-Quantity)
   (=(value-cardinality?x Cargo-Kind-and-Quantity)1)
   (has-output-parameter-slot ?x Cargo-Handling-Cost)
   (=(value-cardinality?x Cargo-Handling-Cost)1)
   (has-constraint?x Costc-1)
   (exist?y(=>Submitting-Cargo-Kind-and-Quantity?y)
        (connected-activities?x?y))
   (exist?z(=>Paying-Cargo-Handling-Cost?z)
       (connected-activities?x?z))
```

Among them, the two *value-cardinality* clauses provide only one input *Cargo-Kind-and-Quantity* and one output *Cargo-Handling-Cost*. The process of transforming input into output is limited by constraint instance *Costc-1*, and the content of *Costc-1* is defined by relevant provisions about cargo handling charges

from the ministry of communications, contractual agreement signed with users. Here we omit its formal definition.

In addition, there are two sequential connection instances, one is between *Submitting-Cargo-Kind-and-Quantity* and *Computing-Cargo-Handling-Cost* that is named *Seq-Cnt1*, the other is between *Submitting-Cargo-Kind-and-Quantity* and *Paying-Cargo-Handling-Cost* that is named *Seq-Cnt2*. The following is the definition of *Seq-Cnt2*.

```
(define-instance Seq-Cnt2(Sequential-Connection)
    : assertions(exist(?y?z)
    (=> (and(Computing-Cargo-Handling-Cost?y)
    (Paying-Cargo-Handling-Cost?z)
    (connects-activities Seq-Cnt2?y)
(connects-activities Seq-Cnt2?z))))
```

## 5. THE ARCHITECTURE OF PROCESS-ORIENTED ENTERPRISE KNOWLEDGE INTEGRATION MANAGEMENT PLATFORM

Figure 5 shows the EPOnt-based enterprise knowledge integration platforms. The main function of this platform is to support the exchange of process knowledge and semantic interoperability for business systems in enterprise or between enterprises.

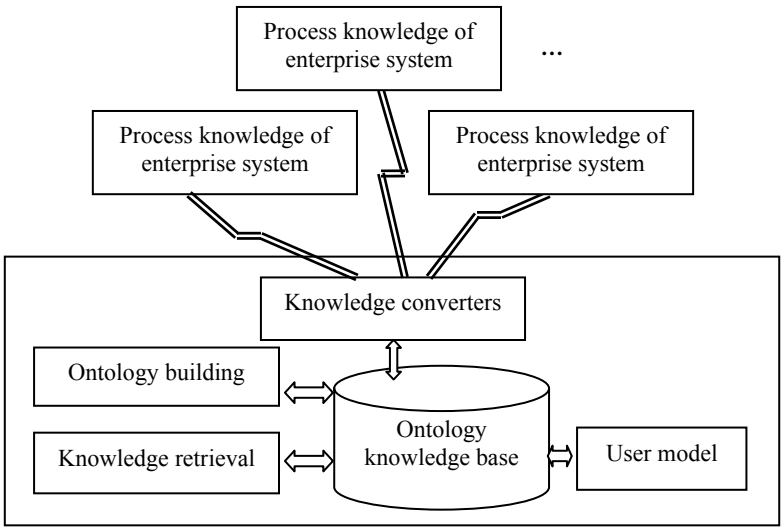


**Figure 5. EPOnt-based Enterprise Knowledge Integration Platforms**

Ontology knowledge base is an important foundation for system running, and the process ontology and process knowledge instance are stored in it. The ontology of the

business systems involved in one operational service has defined syntax, terminology and the semantic in process knowledge. Different enterprises look EPOnt as the intermediate exchange format, and knowledge converters achieve semantic interoperability of process knowledge between multiple heterogeneous systems. EPOnt-based process knowledge integration includes three steps: (1) Terminology mapping. (2) Grammar conversion. (3) Semantic change. Through these three steps, it can change the terminology, semantics and grammar of different enterprise systems into EPOnt's.

Ontology building provides graphical defining way and formal definition modes to update ontology or create ontology-based process knowledge. The process knowledge that are converted from or created by users is stored in knowledge base. Through the function of knowledge retrieval, users can search process knowledge that can be used directly or modified according to the need. In the process of retrieval, users can give query conditions and weight on the basis of vocabulary and terminology. User model provides the function of editing the type of process knowledge and other forms of personal preference etc.

## 6. CONCLUSIONS

In order to integrate business process in enterprise or between enterprises, it requires integrating the services and exchanging flow knowledge of the services. But the business service systems of different enterprises and sectors have not provided clear and consistent semantic for the terms and terminology of the process knowledge. So this paper proposes an ontology-based approach to modeling and integrating enterprise process knowledge and describes the architecture of an EPOnt-based enterprise knowledge integration management platform. Ontology provides semantic foundation for the exchange of knowledge, and it can effectively promote common awareness for knowledge and semantic interoperability for heterogeneous system. EPOnt that is developed in this paper, its fundamental information is represented by the IDEF5 language, and its precise syntax and formal semantics are defined in the Ontolingua language. Using the EPOnt, we can construct the process knowledge of specific business areas. EPOnt can provide public terminology and vocabulary for the different operational systems, which can promote the semantic interoperability, reuse and sharing of business process knowledge in enterprise or between enterprises. That can enhance business efficiency and service quality of enterprise, and promote the achievement of the integration of business.

The application of the EPOnt in Guangzhou Port Group business case shows that EPOnt is a flexible and efficient tool. In this paper, the study of process-oriented enterprise modeling and integration of knowledge management based on ontology is only a preliminary result. In future we also have a lot of work to do.

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