

# Towards the Context-oriented Model of Project Management for Virtual Enterprises

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**Abstract**—A virtual enterprise is a dynamically formed coalition of parties from different organizations who want to cooperate with one another to reach a common goal, often within a very short time frame. The advantage of flexibility facilitates the prevalence of virtual enterprise in business, government, educational and many applications. However, the traditional project management technology will not satisfy the need of virtual enterprise since the virtual enterprises requires rapid deployment and have information sharing needs that cross traditional organizational boundaries.

Accordingly, consistently describing the distributed project resources becomes rather important in project management for virtual enterprise. Thus, we proposed the context-oriented approach to achieve the purpose. Also, emphasizing the relationships among resources is such critical in the work to identify the connection within the distributed resources. The advantage is valuable for a project manager to find the right person and the right resources conveniently even in the communication-deficient virtual environment. Consequently, context-oriented model delivering the concrete description for distributed project resources is helpful for facilitating project management in virtual enterprises.

**Index Terms**—virtual enterprise; virtual organizations; context-oriented; virtual team; RDF

## I. INTRODUCTION

Research indicates that online groups have to overcome more obstacles in comparison to face-to-face groups; and the former type of enterprise is not always successful [22]. Virtual Enterprise is a multi-form cooperation, through different organizations, task groups or project team. Virtual Organization is a kind of virtual enterprise that is a term being used to describe how different organizations come together to explore business opportunities, and collaborating on a temporary basis [9]. The flexibility of virtual organization facilitates the prevalence of virtual organizations in business, government, educational and many applications. Nevertheless, its nature of being dynamic has made virtual organizations a rather complex difficulty to manage project processing when compared to the traditional organizations. Forming projects for different

goals of tasks is a popular work-type in the rapidly changing environment [1]. The accomplishment of a project indeed involves many activities, models, tools and solutions which are the valuable project resources [13][1]. To allocate the suitable project resources becomes more difficult because the dispersion, multiple locations, harass the communication and understanding in virtual organizations.

Therefore, we proposed the context-oriented model for annotating the situations and relationships among project resources. It is very helpful for a project manager to realize where to find the right resources and how to utilize the resources in a communication-deficient virtual organization. Also, XML/RDF is applied for the implementation and interoperability of the proposed model. Thus, the developed context information is accessible and understandable for computers and human in virtual organizations. Therefore, facilitating project management and improving the understanding in virtual organizations are herein fulfilled in the research.

## II. PROJECT MANAGEMENT

Project management is the method of planning, organizing, and managing resources to touch off the successful completion of specific project goals and objectives. Project management can be defined as “The manner of implementation, of expertise, paraphernalia, knowledge and modus operandi to an extensive range of activities for the fulfillment of prerequisite of the specific project. Project management knowledge and practices can be defined upon individual processes. These individual processes can be: Initiating, Planning, Executing, Controlling and Closing” [20].

The project management in the management of a virtual enterprise becomes more difficult because the virtual enterprise may be across different organizations or groups combination. Therefore, the project management in virtual enterprise applications requires special attention to relations and organization of interaction links. The operation of virtual enterprise resources in the project tracking and management is the focus of this study. Context-oriented technology combined with the use of project management of virtual enterprises in the projects in progress related to the occurrence of important

information can be recorded to provide project knowledge base for future use and reference.

II. VIRTUAL ENTERPRISE

Benefit from the acceleration of information technology and network, virtual enterprise becomes a new organizational form characterized by a temporary or permanent collection of geographically dispersed individuals, groups or organization departments not belonging to the same organization. Virtual organization will be the concept of enterprise point of view, derived from virtual organizations and virtual team to discuss ways of cooperation. Virtual enterprise or virtual organization is an important theme in many fields related to collaborative networks. The common keywords from the definitions of virtual organizations and virtual enterprises have been cooperation and complementarities, distributed and networked organization, temporary organization, infrastructure supporting interoperation [15]. Many problems that the managers have frequently encountered in the last few decades are the problems of business globalization, competitive surrounding, rapid changing technologies, work structure and more. The main characteristics of virtual enterprises contains an alliance for a common goal, concentration on knowledge products, temporary nature of an organization, flexibility of working time and place, diversified and multicultural workforce, mobility of work force, vertical integration, and no hierarchy, decentralized and decreased use of offices[21]. The life cycle of virtual enterprise is classified into six phases [11]. The relevance in different phases is shown in Figure 1 and the statement for each phase is given as follows.

- Business opportunity: opening a new business field and identifying a business opportunity through market analysis.
- Major partner identification: defining the major value chains for the business realization and seizing the core business capabilities needed in each major value chain. After identifying and classifying major participants that can take responsibility for the managing of the value chains, selecting the most suitable participants preferentially as major business partners of the virtual enterprise.
- Enterprise configuration: defining the architecture that can be used to develop the virtual enterprise models including business processes, system, information, resources, etc. On the basis of this architecture, concretizing the roles and the mutual agreements about the business plan among business partners. According to these, defining and standardizing the business scenarios and business processes, as well as defining the relevant information and communication technologies, systems, and shared resources.
- Enterprise operation: operating the virtual enterprise by executing the collaborative business

processes. Since the virtual enterprise should react to the changes of business environment sensitively, the business processes that are being executed and the current market situations are monitored continuously.

- Enterprise evolution: re-defining of the virtual enterprise models to be more efficient depending on the business environment or internal situations, by means of re-designing or optimization of the value chains, the business scenarios, the business processes or the business partners.
- Enterprise dissolution: dissolving the virtual enterprise after stopping the execution of the business processes, depending on the disappearance of the business opportunity.

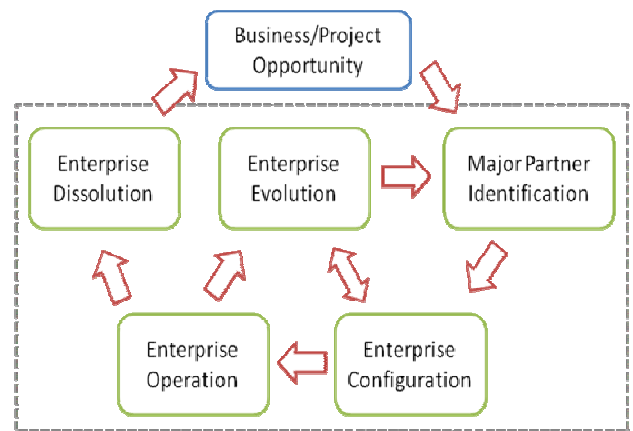


Figure 1. Lifecycle of a virtual enterprise

A. Virtual team I

Virtual team is the most popular working-type in virtual enterprises. The concept of virtual team as an interdependent group working on a project across time and space relies on information and communication technologies. There exist different variants of the virtual teams are so called, “distributed teams”, or “cross-organizational teams”. A virtual team is generally defined as a small number of people with complementary skills who are committed to a common purpose, performance goals, and the approach for which they hold themselves mutually accountable [10].

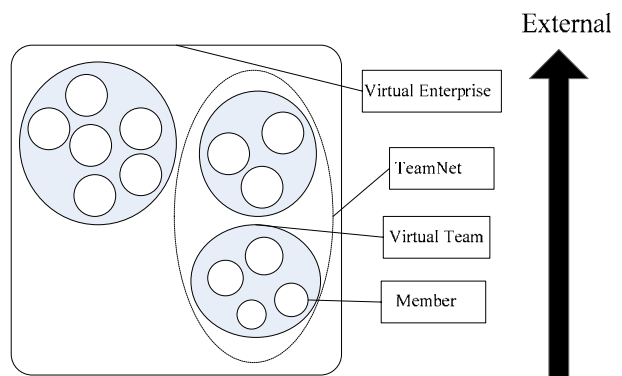


Figure 2. Virtual enterprise vs. Virtual team

Extensible Markup Language (XML), derived from SGML, is a core technology that defines a universal standard for structuring data. XML version 1.0 was defined in 1998 by the World Wide Web Consortium and the Second Edition was published in 2000 [18]. XML is a global standard for storing structured data in an editable file that is useful for data storage, data exchange and document publishing on the Internet. XML is a textual data format, with strong support via Unicode for the languages of the world. Although XML's design focuses on documents, it is widely used for the representation of arbitrary data structures, for example in web services. There are a variety of programming interfaces which software developers may use to access XML data, and several schema systems designed to aid in the definition of XML-based languages. As of 2009, hundreds of XML-based languages have been developed, including RSS, Atom, SOAP, and XHTML. XML has become the default file format for most office-productivity tools, including Microsoft Office, OpenOffice.org, AbiWord, and Apple's iWork [24].

RDF (Resource Description Framework) provides the foundation for metadata interoperability across different applications via a Syntax specification and Schema specification. The concrete RDF syntax uses the XML by which RDF can specify semantics for data in a standardized and interoperable manner. RDF although often referred to as "language", but in essence, is a data model. The basic construction of RDF pattern is object-attribute-value of the triples; this is called a "statement". The basic concept of RDF is the Resource, Properties and Statements:

- Resource: any use of RDF / RDFS description of the temple a few things, or things that use URL. Resources can be the author, URL of the Web site, Web pages, books and more.
- Properties: it is used to describe the characteristics of the relationship between the characteristics or resources. For example: Web site creator, creation date and book author.
- Statements: a statement is "object-attribute-value" of the triples, which is a resource, property and the value of the composition; RDF statements are the basic framework RDF language.

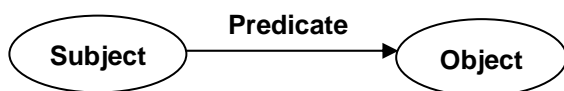


Figure 3. RDF graph

A. Graph data model

The underlying structure of any expression in RDF is a collection of triples, each consisting of a subject, a predicate and an object. A set of such triples is called an RDF graph. This can be illustrated by a node and

directed-arc diagram, in which each triple is represented as a node-arc-node link (hence the term "graph").

Each triple represents a statement of a relationship between the things denoted by the nodes that it links. Each triple has three parts: a subject, an object, and a predicate (also called a property) that denotes a relationship. The direction of the arc is significant: it always points toward the object.

The assertion of an RDF triple says that some relationship, indicated by the predicate, holds between the things denoted by subject and object of the triple. The assertion of an RDF graph amounts to asserting all the triples in it, so the meaning of an RDF graph is the conjunction (logical AND) of the statements corresponding to all the triples it contains [17][14].

IV. CONTEXT-ORIENTED MODEL

Context can be a list of situational factors or any information to characterize the situation of an entity [4]. Many researchers have discussed various applications on context, including information retrieval, document analysis and ubiquitous computing. [1][3][11] [18] [19].

The temporary nature of virtual enterprise diversified workforce and decentralized control increase the difficulty of communication as managing projects since the project resource, including people, skill, funding, facilities, equipment, activities and others, are widely distributed over network. Therefore, the context information is proposed for describing the background and condition of the distributed project resource. For example, the context of a people may have the name, belonging company, contact information or working experience. Then, the project manager can rapidly understand the distribution of project resource in the virtual environment, and easily locate the internal or external resources.

Furthermore, the connection relationship among project resources is important context information. Some resources fully support each other, or some are mutually exclusive. The context information indicating how the resources collaborated in projects is indeed the practical experiences of project management in virtual enterprises.

Therefore, the context-oriented model is proposed for annotating the context information of project resources which are dispersedly located in virtual enterprise. The inevitable communication-deficient problem is herein further considered. As shown in Figure 4, the distributed project resources, such as people, skills, funding, facilities or equipment, are consistently annotated with formally context information in XML/RDF technology. The increasing understanding between the project manager and resources can help project manager to identify and deploy the project resources for efficient project management. Furthermore, XML/RDF technology provides the interoperability and conceptual support of the developed context information in virtual enterprises. Accordingly, the human and machine readable context information becomes the efficient means of communication in virtual enterprises.

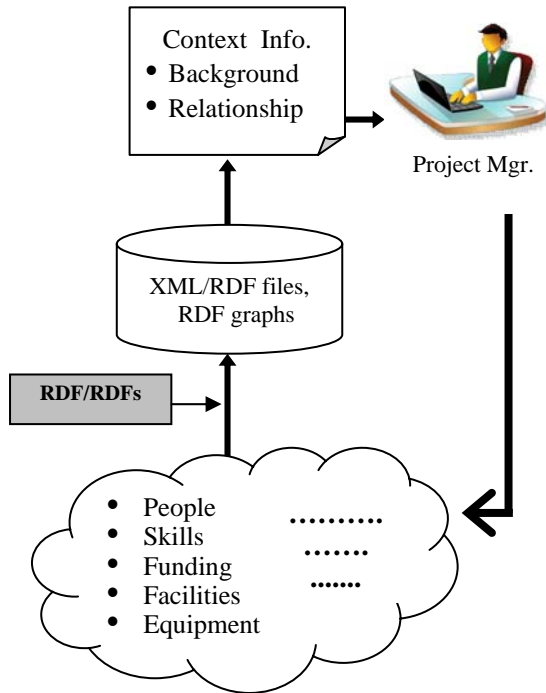


Figure 4. The context-oriented model

The context-oriented model is proposed for supplementing the performance of the traditional project management tool. As shown in Figure 5, the traditional project management tool can list the task, duration, start and finish time, predecessor and assigned resources for a project as the resources are reachable in an organization. However, lack of the description of distributed resources easily causes the difficulty and confusion of resource identification in virtual enterprises. For that reason, the context information is proposed for improving the gap of understanding in virtual enterprises.

First, based on the context-oriented model, the background of resources is required to be timely annotated in RDF file. For example, the background of Mary and the tasks she was involved are the important context information based on the example shown in Figure 5, Then, RDF is applied for formally describing the context information of Mary and the result is shown in Figure 6.

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:bc="http://www.ocu.org.tw/VC/basic#">
  <rdf:Description
    rdf:about="http://www.ocu.org.tw/project/CRM007/people/Mary">
    <bc:fullname>Mary Cheng</bc:fullname>
    <bc:nationality>Taiwan</bc:nationality>
    <bc:company>Data Super Inc </bc:company>
    <bc:seniority>6</bc:seniority>
    <bc:task>
      <rdf:Bag>
        <rdf:li>Requirement specification</rdf:li>
        <rdf:li>Meeting with users</rdf:li>
        <rdf:li>Contract preparation </rdf:li>
        <rdf:li>The final critical review</rdf:li>
        <rdf:li>The performance report </rdf:li>
      </rdf:Bag>
    </bc:task>
  </rdf:Description>
</rdf:RDF>
```

Figure 6. The context of background information in RDF

The context information of Mary, including the background, seniority, specialties and contact information, provides the concrete description for identifying the distributed resource the virtual space. Moreover, the consistent statements can be interpreted according to RDF triple, comprising subject, predicate and object. The advantage is intensely useful for diminishing the gap of understanding. Some facts interpreted from the RDF description given in Figure 6 are illustrated as follows.

- The full name of Mary is Mary Cheng.
- The seniority of Mary is 6.
- The nationality of Mary is Taiwan.
- The company of Mary is Data Super Inc.
- The tasks of Mary are Requirement specification, Meeting with users, Contract preparation, The final critical review and The performance report.



Figure 5. An example of project management

```

<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:bc="http://www.ocu.org.tw/VC/basic#"
  xmlns:r="http://www.ocu.edu.tw/VC/relationship#">
  <rdf:Description rdf:about="http://www.ocu.org.tw/project/CRM007/Relationship">
    <r:Team>
      <rdf:Bag>
        <rdf:li rdf:resource="http://www.dsc.com.tw/John"/>
        <rdf:li rdf:resource="http://www.dsc.com.tw/Mary"/>
        <rdf:li rdf:resource="http://www.ocu.com.tw/RD/Cathy"/>
        <rdf:li rdf:resource="http://www.ocu.com.tw/RD/Candy"/>
      </rdf:Bag>
    </r:Team>
    <r:Order>
      <rdf:Seq>
        <bc:ERP_server rdf:resource="http://www.abc.com.tw"/>
        <bc:Client_SDK rdf:resource="http://www.abc.com.tw"/>
        <bc:Test_database rdf:resource="http://www.aaa.com.tw"/>
        <bc:Network_supervisor rdf:resource="http://www.ppp.com.tw"/>
      </rdf:Seq>
    </r:Order>
    <r:Selection>
      <rdf:Alt>
        <rdf:li>Consultant Fee</rdf:li>
        <rdf:li>Research Fee</rdf:li>
        <rdf:li>Investigation Fee</rdf:li>
      </rdf:Alt>
    </r:Selection>
  </rdf:Description>
</rdf:RDF>
  
```

Figure 7. The context of relationships of team, order and selection in RDF

Second, the relationship within project resources is also important context information in the proposed model. Applying the proper resources together for efficient collaboration is helpful for improving the project management. In the other hand, avoiding the usage of incompatible resources in a project can reduce the chance of error, waste, and failure. Furthermore, RDF technology supplies sufficient grammars for annotating different types of relationships.

It is supposed that John, Mary Cathy and Candy are suitable members to work as a group in a project even

they came from different companies, based on the example given in Figure 5. The relationship of team can be illustrated by the rdf:Bag element in RDF, as shown in Figure 7. Accordingly, the context information of team-like relationship is useful for project managers to locate the suitable resources that can support each other in a project.

Next, the usage order of project resources is also an important relationship in the proposed model. For example, the project resources of ERP server, Client SDK, Test database and Network supervisor tool, given in

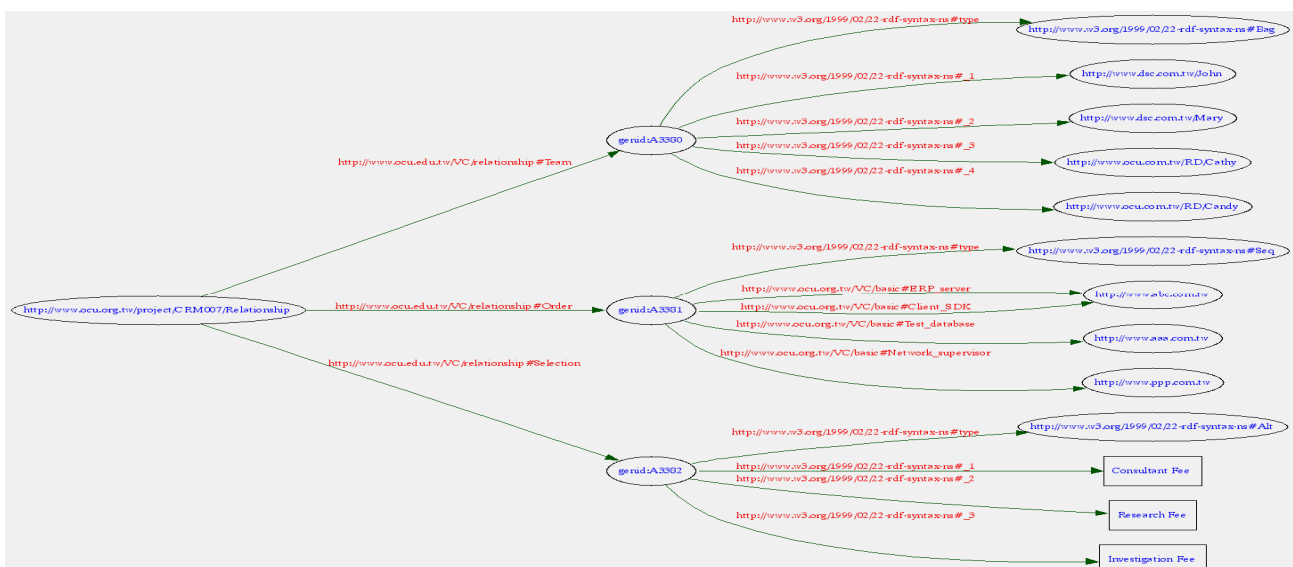


Figure 8. The context of relationships of team, order and selection in the correspondent RDF graph

Figure 5, are basically applied in sequence as processing a project. The incorrect order of resource assignment easily causes the delay, waste, and even the failure of the project. To avoid these risks, the relationship of order is illustrated by the `rdf:Seq` element in RDF, as shown in Figure 7.

Moreover, the relationship of selection is important for a project manager for sufficient decision-making. Some resources are mutually exclusive in a project. It is assumed that only one type of expense can be chosen from the set of Consultant fee, Research fee and Investigation fee. The equivalent `rdf:Alt` element in RDF is illustrated in Figure 7. The relationship of selection is practically collected in the context information. Furthermore, as different companies define various rules as using resources in virtual enterprise, the relationship of selection is the helpful context information for preventing the conflicts as handling external resources over the network.

The context information proposed in the model is helpful for delivering the valued experience of project management in virtual enterprise. Besides, the conceptual support in RDF graph increasingly improves the understanding as sharing the context information. The RDF directed graph consists of a set of nodes connected by arcs, forming a pattern of node-arc-node. Additionally, the nodes come in two main varieties: `uriref`, blank nodes, and literals. A `uriref` node consists of a Uniform Resource Identifier (URI) reference that provides a specific identifier unique to the node. Literal values represent RDF objects only, never subjects or predicates. RDF literals are drawn with rectangles around them. Based on above symbols, the concept support and the timely website references are herein accomplished in the proposed model.

As shown in Figure 8, the correspondent RDF graph indicates three important relationships of team, order and selection which are described in RDF triple in Figure 7. The advantage improving the understanding and communication in the virtual enterprise is helpful for facilitating the accomplishment of project management.

## V. CONCLUSION AND FUTURE WORK

The comprehensible description for project resources is very important since the inevitable disagreements, conflicts and gaps in virtual enterprises always cause lots of difficulties in project management. The context-oriented model is mainly employed for describing the background information and the relationships among project resources. Therefore, the risk of misusing or overlooking project resources is moderately controlled based on the interpretable context information.

Furthermore, XML/RDF is applied for the implementation. Therefore, the developed context information is widely accessible across different systems in virtual enterprise. The better communication and knowledge sharing in virtual enterprises are constantly accomplished in the context-oriented model. The semantic expression of context can be gradually enhanced

by RDF technology in the future. Also semantic query is another important research topic in the model for selecting the related part of context information to users.

In the future research, data mining methods are suitable for sufficiently discovering relationship patterns. The relationships currently concluded by the project managers and experts will confine the progress of the model. In fact, the relationship patterns are the substantial experiences and knowledge learned from previous projects. Extracting more practical relationships intelligently will be an interesting challenge and an essential improvement in the research.

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