DEVELOPMENT OF ONTOLOGY-BASED BUSINESS PROCESS MODEL FOR PROJECT COLLABORATION IN AEC ORGANIZATIONS

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ABSTRACT

The prevalent process models, written in a highly structured schema, prescribe the collection of activities in some specific orders. As different process models are created and used for different modeling purposes, it is hard for another party to reuse them without understanding the modeling perception behind. For collaboration among different stakeholders, these mechanism-based process models lack the flexibility to model the specific views in different domains. Ontology, as a concept modeling tool, provides such an opportunity to enable a shift from procedure-based software structuring to model-based structuring. This paper describes an ongoing research to develop ontology-based business process models for collaboration in the AEC organizations. The business processes are different from the functional ones as they must create value to the customer. This is essential for modeling organizations as the functional process might be changed or eliminated with the use of new technologies. In this paper, an ontology is adapted from the REA enterprise ontology to model the business process. The adapted ontology reflects the particularity of the business processes in the AEC industry that they interweave with each other throughout the whole production line, rather than a one-point-connection at the sales department. A framework of the ontology-based business process is presented, with an example to illustrate how the ontology-based business process model can help project collaboration in the AEC industry.

KEY WORDS

AEC industry, business process model, ontology, organization, project collaboration

INTRODUCTION

The AEC industry is used to be fragmented with different organizations providing different services in a project. Rather than providing an all-inclusive product to the client, most of the organizations focus on their own businesses, and provide half a job to the client. This phenomenon is different from the manufacturing industry, where the whole production line is within one company. In another word, the business processes in the AEC industry interweave with each other throughout the whole production line, rather than a one-point-connection at the sales department. This particularity in the AEC industry has caused many problems. As

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the increasing awareness of delivering a qualified artifact on time and within budget to the client, collaboration between different stakeholders is highly demanded in the AEC industry. Process modeling, as a means to streamline the business, has played an important role within and across organization boundaries. Various process modeling methods, e.g. IDEF0, UML activity diagram, workflow diagram etc have been used in the AEC industry to model the processes. Common platform for sharing process models have been developed, e.g. IFC and aecXML by IAI. Yet, problems emerge when using these process models. These process models, written in a highly structured schema, prescribe the collection of activities in some specific orders. As different process models are created and used for different modeling purposes, it is hard for another party to reuse them without understanding the modeling perception behind. For collaboration among different stakeholders, these mechanism-based process models lack the flexibility to model the specific views in different domains. Thus, a separation of the content from the mechanism may be needed.

The advent of ontology provides such an opportunity to enable a shift from procedure-based software structuring to model-based structuring. Ontology, as a concept-modeling tool, aims to achieve content harmonization across various domain boundaries. This is achieved with an explicit meaning defining and structure modeling. Thus, ontology is assumed to benefit the project collaboration in the AEC industry.

A process is usually vaguely defined in the AEC industry. It can refer to a collection of activities at various levels, e.g. “a purchase order process” at the task level, or “produce a report process” at the activity level. Comparing to the prevalent researches on process modeling, in particular, this research focuses on the business process modeling. The difference between a process and a business process is the latter investigates how the process adds value to the customer. The customer can be internal or external ones in an organization. As organizations exist in a vibrant environment, where customers’ needs have to be satisfied and competitors’ challenges have to be tackled, the organizations might change the way they do business to correspond to the market needs. With the advent of new technologies, an organization’s aim is no longer to improve the process, but to reinvent it to gain competitive advantage. Under this circumstance, many functional processes may be changed or eliminated. However, the business process won’t be changed unless the organizations change their businesses. In this regard, modeling the business process reveals the perception in each organization about “why” the activities need to be carried out. It models what key activities exist in each organization that adds value to the clients.

This paper describes an ongoing research in the above area. In the following parts, the rationale of ontology is introduced. The existing business process model in the AEC industry, if any, is reviewed. An ontology for business process modeling is adapted from the REA ontology, which is developed to model enterprise information systems. An example on how this ontology-based business process model can benefit project collaboration is illustrated. Relevant researches undergoing and future works in this research are discussed at the end of the paper.

RATIONALE OF ONTOLOGY

WHAT IS ONTOLOGY

Ontology is a term borrowed from philosophy into the field of Artificial Intelligence (AI). In philosophy, ontology studies what exists in the world, and how the world is configured. In AI, concepts can be modeled using computing tools to enable a mutual understanding between the computer and people, or among computer programs. It is under widespread development especially as the demand of E-business. Being one of the supporting tools of Semantic Web, it displays a profound impact on shaping the future knowledge base systems. Using ontologies, computing tools can communicate not only at the symbol level, but also at the concept level, which can be illustrated by Ogden's meaning triangle model (Ogden, 1991, cited in Turk, 1998) in Figure 1.

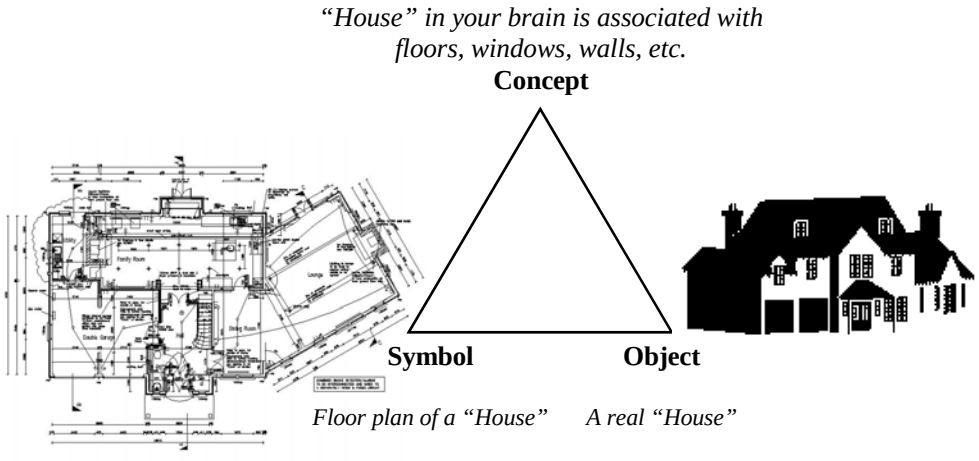

Figure 1: Ogden's Meaning Triangle with an Example

According to cognitive science, when we want to communicate the concept "house", we use symbol, such as a floor plan to represent the object, i.e., a real house. Then in our mind, we will visualize the look of a real house, and this image is associated with the concept that "it has floors, windows, walls, etc". During this communication process, human perceive the object, represent it as a symbol, and interpret it to a concept.

The result of such an explicit formalization of our mental models is called ontology (with a lower-case o) in the Artificial Intelligence (AI) community. It is defined as "a formal, explicit specification of a shared conceptualization" (Gruber 1993, cited in Fensel 2003). According to the above example, for computing tools to conduct semantic interpretation on the term "house", they should not only recognize it as a symbol, but also be able to interpret it as "something with floors, windows, walls, etc" through commitment to the ontology.

FROM OBJECT-ORIENTED PROGRAMMING TO ONTOLOGY-DRIVEN MODELING

As such, the basic use of an ontology is to facilitate a *separation of concerns* (Bertrand and Bézivin, 2000). When dealing with a same system, different models can be developed

according to different ontologies. These models remain related, and to some extent the reverse operation may also apply; namely, a *combination of concerns*. By separation of concerns, we can deal with problems in natural language vocabularies such as synonymy, homonymy and metonymy. For example, when an architect and a software engineer talk about "windows", they may refer to different concepts. The advantages of an ontology are therefore regarded as *sharing* and *filtering* (Bertrand and Bézivin, 2000). Sharing means that an agreement may exist between different agents based on the acceptance of common ontologies. That is they have the same understanding of a given concept. Filtering is linked to abstraction. As we model the world, a lot of undesirable characteristics, which are out of our concerns, can be filtered out. An ontology defines what should be extracted from a system in order to build a given model of the system. A model is always built for a given purpose, usually to gain an understanding of some aspects of a source system. This purpose should be clearly defined and associated with the ontology. In this respect, ontologies can be modularized and reused according to the modeling purposes.

From what we describe above, the way we model the world has shifted from a procedure-based software structuring to an abstract development level, which is called *model-oriented technology* (MOT) (Bertrand and Bézivin, 2000). This trend shows that the object-oriented technology cannot satisfy our needs to model the abstract concepts, e.g. "commitment". Moreover, it cannot differentiate two concepts associated with one entity, e.g. "windows" for a building and windows for operation system in a computer. With ontology-driven modeling, we can integrate these two concepts under a meta-ontology, e.g. roles. Under this meta-ontology, concept "windows" plays the role of a building component from the concern of an architect, whereas it plays the role of an operation system from the concern of a software engineer. By this means, information can be exchanged in a semantic rich manner. Ambiguities and inconsistencies can be resolved to facilitate effective communication without human intervention.

EXISTING BUSINESS PROCESS MODELS IN THE AEC INDSUTRY

WHAT IS A BUSINESS PROCESS MODEL

A business process is a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer. With this definition, it is different from the vague concept widely used in practice to mean anything from a single functional activity, e.g. producing a report, to an entire transaction cycle, e.g. construction process. In this research, it refers to the entire transaction cycle. A business process:

- Has an objective
- Has a number of *activities* that are performed in some *order*
- Uses *resources* as input
- Has specific product or service as *output*
- Is executed by *agents*
- Creates some kind of *value* for the *customer*; the customer may be internal or external

- Is *enabled* by certain *condition*, e.g. trigger event, information needed, managment rules

EXISTING BUSINESS PROCESS MODELS IN THE AEC INDUSTRY

The process models in the AEC industry have been developed to describe the activities in a business process. Yet, most of them are modeled from a functional perspective rather than a business perspective, e.g. those in IFC. IFC uses the EXPRESS language and the EXPRESS-G schema to model the buildings and the associated process elements. e. g. cost, resource, schedule, etc. It is a building product model developed for common data exchange. Current applications can exchange shared common data if they are IFC-compatible. The process models in IFC cannot satisfy the need to model business processes. The business process models in the AEC industry, if any, may be those in aecXML. aecXML is developed for e-business. When different project stakeholders, e. g. a contractor and a material supplier, do business online, they need to communicate with each other in a standard way. aecXML serves this purpose. It has certain business process models, but relatively thin. More works will be needed to expand its scope. Moreover, XML has limited semantics comparing to RDF, or OWL files.

ADAPTED REA ONTOLOGY FOR BUSINESS PROCESS MODELING IN THE AEC INDUSTRY

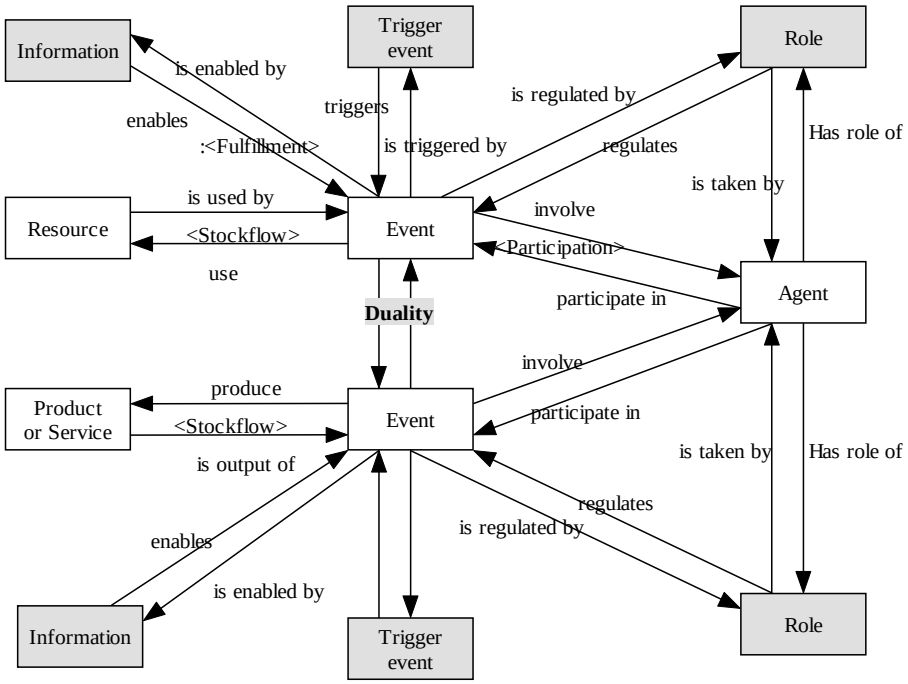

Figure 2: Conceptual Model of the Adapted REA Ontology

An ontology for modeling business process is adapted from REA enterprise ontology, which is developed for modeling enterprise information system (Dunn et al 2005). This REA ontology, i.e. Resource-Event-Agent, defines a stockflow relationship between resource and

event, and a duality relationship between two events. The duality relationship states an economic phenomenon in the business process model as one event gives something up with another event receiving something. It demonstrates a powerful way to differentiate a value added event from a functional event. However, this REA ontology doesn't include those items essential for business process modeling the AEC industry, i.e. the constraints. As the production line is contributed by different parties, many events will trigger or affect the business process. The different roles that agent take will regulate the process of business process. The information needed, e.g. the drawings, contracts, specifications, etc. also decides whether a business process can proceed or not. Therefore, the proposed ontology for business process modeling in the AEC industry expands the REA ontology to include the concepts of information, trigger event and role of agent, as shown in Figure 2. An example on using this ontology to represent the construction process is shown in Figure 3.

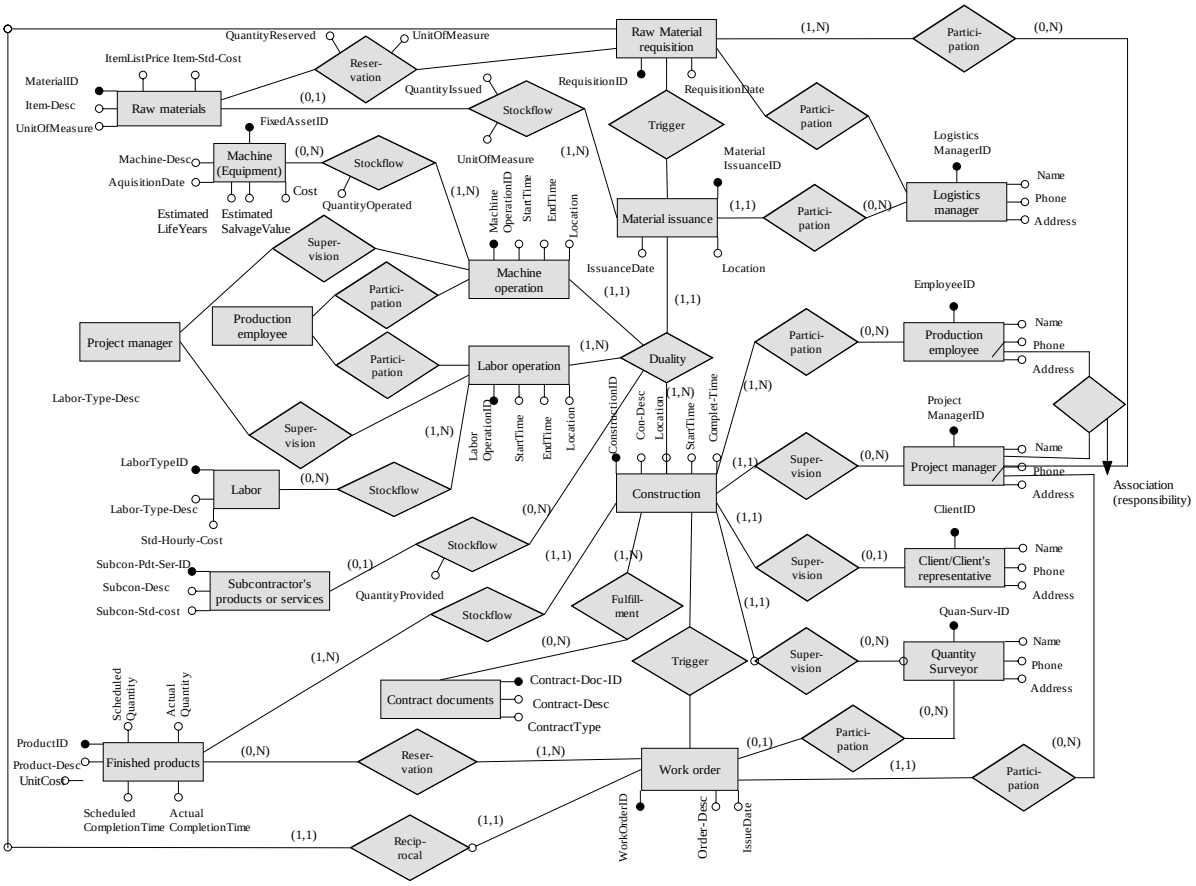

Figure 3: An Example of The Adapted REA Ontology for Construction Process

FRAMEWORK OF AN ONTOLOGY-BASED BUSINESS PROCESS MODEL FOR COLLABORATION IN AEC ORGANIZATIONS WITH AN EXAMPLE

With the adapted REA ontology as the backbone to support the business process models, a further study on how this model can help project collaboration is needed. A framework is demonstrated in Figure 4.

As mentioned above, the production line in the AEC industry is not isolated from each stakeholder. Although organizations do their business in their own domains, their value chains are connected at some points by some trigger events in a project, for example, a change request. These organization value chains must converge in the project value chain to deliver the ultimate value to the client. The business process model plays a role as the middleware to connect task level and value chain level in a collaboration project. As different agents in different organizations cope with the change request, their different concerns in the process are captured and supported by the ontology. This will enable a flexible reuse in another time.

DISCUSSION

As ontology shows great potential in modeling the processes, there are also other research works undergoing in business process modeling, e.g. the third wave of business process management. This research takes a process-centric view where people are taken into account, and the customer is in the loop. There is a migration from procedures and functions to objects, then to content. By this means, the business analyst "don't bridge the business-IT divide, obliterate it", as said by Smith and Fingar in their book "Business Process Management – the third wave" (2003). Figure 5 below shows the absent of the software architect in an organization.

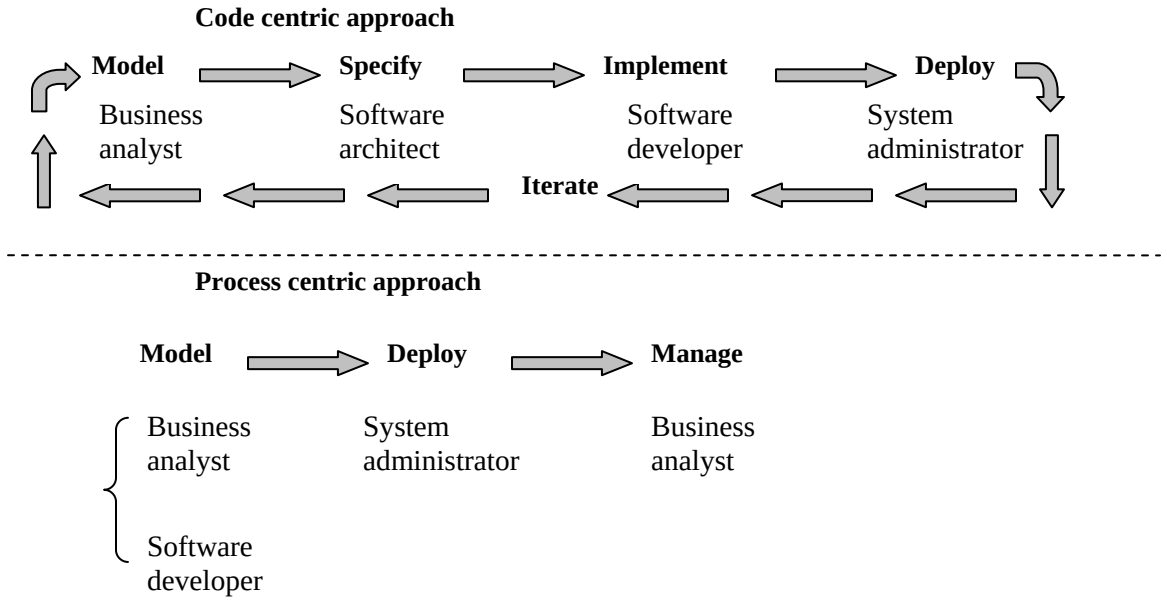

Figure 5: Software versus process development lifecycle (Source: Smith & Fingar, 2003)

Currently, the research efforts are undergoing with development of core business ontology, industry-specific ontology, and organization-specific ontology. Yet, few of them are mature enough. This research will contribute to the development of industry-specific ontology.

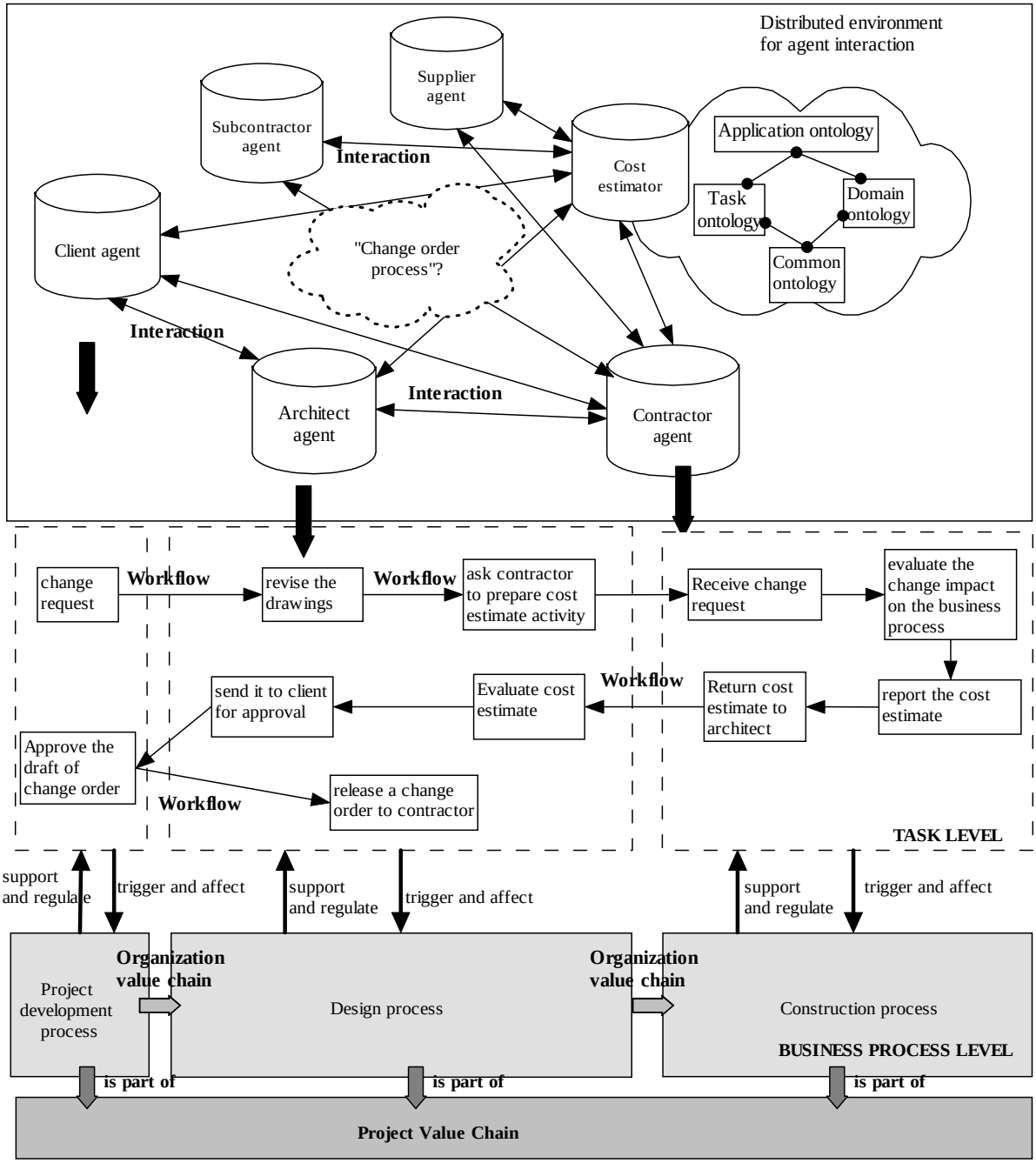

Figure 4: Framework of Ontology-based Business Process Model for Project Collaboration with An example

CONCLUSION

This paper describes an ongoing research to develop ontology-based business process models in the AEC industry. Ontology is used to separate the content from the mechanism in the business process models. It models "what" exists in the process instead of "how". Future research will be conducted to refine the proposed ontology based on some case studies. The business process models in different domains will also be developed.

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