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ABSTRACT

Interoperability is hard to tackle in both business and IT domains since semantic transaction loss exists in terms of concepts transformation from one design stage to another in information systems development. It results from different interpretations and representations of various requirements in design domains. Without an explicit structural specification of semantic linkages among design domains, the transformation cannot be efficiently identified in an appropriate way. These call for effective architectural solutions that coordinate powerful technologies with business applications to enable seamless integration. The main objective of this paper is to investigate ontology types and build ontology meta-model for IAIS (Isomorphic Architecture of Information Systems) which was built in our previous work to reach seamless and unified semantic linkages. The ontology meta-model is proposed to bridge the gap among different processes in information systems development with the same structure unit. The secondary objective of this paper is to study how to prevent semantic loss in analysis and design processes with the meta-model.

INTRODUCTION

Information systems development can be seen as a series of semiotic transformations across business and IT domains. But the transformations usually proceed separately to keep integrity in each process. However, concept divergence, which refers to the incoherence of concept structure in the processes, often exists and causes transaction loss which happens during transformations among processes of system analysis, system design and system implementation (Gan, Han and Liu, 2007). When a model in business domain needs to be transformed to IT domain, semantic incoherence will be introduced during the transformation. This problem will consequently cause inconsistency between the evolution of the information system and the business change.

Organisational semantics, software issues and semantic gaps are the three aspects of the semantic barrier. It is said that the capability to understand the different perceptions of others is quite important for people to share knowledge in system development from the perspective of organisational semantics. The software based tools which represent and model the business also have semantic problems in terms of integration with other systems and with people. Thus, the semantic barriers reveal a gap between the developers of systems and the real world of the organisation. Defining and formalising different levels of a shared conceptual understanding and what it represents in the changing business context is a major challenge in system development.

Concept divergence and transaction loss in information system development is addressed in this paper through introducing ontology meta-model for IAIS which reveal the isomorphic transformation process from business domain to IT domain. The mechanism in the meta-model is proposed to assist with the problem through connecting different aspects of information systems with a precise and coherent representation. With the mechanism, transformation begins with the analysis of business objects in business domain, and finishes by generating corresponding structural components in IT domain. Components and their relationships in each domain are endowed with correlated semantic interpretation. The processes of transformation are illustrated through signs and their structure in an organisational semiotic perspective. The mechanism which acts as a set of signs for a desired

mapping is aimed to reduce the semantics complexity in order to prevent the transaction loss among design processes in the two domains and to facilitate business changes with simultaneous evolution of the IT infrastructure.

RELATED WORK

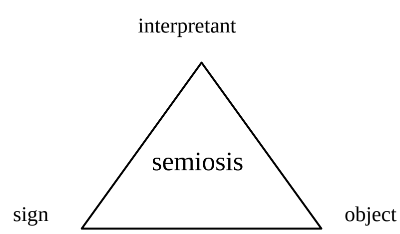
Organisational Semiotics

Semiotics is the science which studies the phenomena of signification, meaning and communication in natural and artificial systems (Nöth 1995). Its main artefact is the notion of signs, and its main approach is to explain different kinds of phenomena as being sign processes (Gudwin, 2003). Both natural and artificial systems can be modelled semiotically.

When it comes to signs, it is actually about the meaning it conveys to different users (i.e., model designers) who encode the meaning in a model design process (Xu and Feng, 2003). In order to make a conversation or communication with others, the meaning of the signs being used must be shared, although it could be only part of the semantic information carried by the sign or the pragmatic meaning of the sign. The contribution of the semiotic perspective is on three aspects (Connolly *et al.* 2002). First, it makes it clear how a single term can mean different things in relation to different levels in the hierarchy. Second, it in turn helps to organise our thinking when designing or evaluating a system, motivating us to consider the implications of design principles at the various levels of syntactics, semantics and pragmatics. Third, it is important that inter-level relationships need to be given consideration.

The theory of semiosis in semiotics shows the sign could be anything that refers to another concept other than itself and the linking between the *sign* and the *object* indicates their relationship (see figure 1). The following triangle shows that the interpretant of the signs enables transformation between objects and signs (Peirce, 1960 cited by Stamper *et al.*, 2000; Liu *et al.*, 2002a; Gudwin, 2003).

Figure 1: A version of Pierce's semiosis triangle.



Different aspects of information systems can be regarded as sign systems, ranging from pure technical to social and organisational issues (Goldkuhl and Ågerfalk, 2000). Organisational processes can be described in terms of sign processes, which is the main idea behind organisational semiotics.

Ontology

Ontology which was defined by Aristotle as 'the science of being' can be reformulated as 'the science of being with regards to the aspect of being' [1]. As a branch of philosophy, ontology is the science of what is, of the kinds and structures of the objects, properties and relations in every area of reality. 'Ontology' in this sense is often used in such a way as to be synonymous with 'metaphysics'. In simple terms it seeks the classification of entities [2]. Ontology is descriptive, which means focused on the classification of existing entities [3]. In recent years the use of formal tools in information system modeling and development represents a potential area of research in computer science. In 1967 the term ontology appeared for the first time in computer science literature as S. H. Mealy introduced it as a basic foundation in data modeling

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A meta-model had decided a series of models expressed by a certain language. An ontology meta-model is explained in a specific concept and its classification from the ontology viewpoint as well as the general rules that

must be observed as expressed. A meta-model essentially always "connotation", because it took one language the foundation, had decided expresses any connotation or the extension model possibility and the necessity by this language.

REALIZATION OF THE ONTOLOGY META-MODEL FOR IAIS

In business domain and IT domain, objects and components can be abstracted as a set of signs which consists of three elements: Organisation, Process and Resource (OPR). Each element has its own hierarchical structure separately, which can be viewed as a sign representing an object (component). Each of the three represents a corresponding aspect of business objects or IT components using signs.

In an enterprise information system isomorphism architecture meta-model refers is take one language as the concept foundation model, including a series of basic concepts and the rule. Meta-models for information systems are on the foundation of object conceptual models in the business domain and gets together the development processes through OPR [17] (organization, flow and resources).

The storage and dissemination of information in information systems needs to follow certain grammar. At present non-rule object abstract and description way cause the universal complex in information system analysis and design, which lacks nimble structural definition of objects and the meta-model semantics description of objects to different types, enables the system analysis design without standard and foundation.

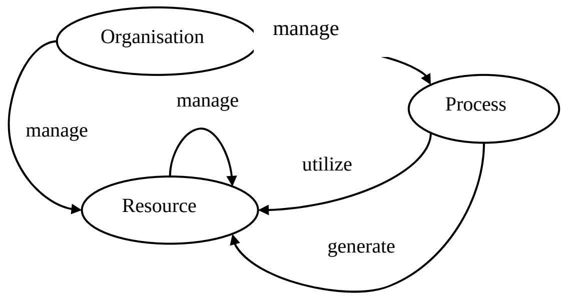
Ontology meta-model

The simplification of abstraction and description way for objects needs meta-models have unified and standard relations on syntax level. OPR simplifies the abstract collection computation as a foundation establishes pulls out the element model take the resources as the center with the object type correlation granularity consistent service - IT domain object, forms between the OPR various elements based on the semantic analysis certain ontology relationship.

The IAIS is called abstractly this kind the enterprise architecture an object isomorphism Yuan model. In the meta-model, the responsibility unit has defined whose responsibilities also included the organization, the business processes and the resources mutually relations. Usually, the meta-model has a fractal structure and the behavior aspect, namely may carry on any rank the nesting, and all maintains the similar behavior or the structure characteristic in any level.

The interaction among OPR elements is focused on every single layer of their hierarchical structure. At each single layer, each element has basic affordances with each other (see figure 3): Organisation manages Process and Resource. Process utilizes and generates Resource while Resource manages itself. Based on object-oriented technology and theory, objects (components) can be illustrated through Inherence, Encapsulation and Polymorphism of OPR at one layer, which can be given certain characters from upper layers where their sup-classes exist as OPR as well. This structure can be described in IT domain with the isomorphic structure and can be mapped to different realizations according to a certain technology projection. (This paragraph will be further extended in the final version)

Figure 2: The relationship between Organisation, Process and Resources.



Since OPR in business domain and IT domain can be described in the same way. The structure of them can help different sets of signs in domains following a same structure to organize the relationship of components. Thus it connects the two domains together with a union structure of signs and makes components in both domains interact with each other. The structure of OPR also affects significantly the performance of flexibility and agility in information systems. The rules for interaction among different sets of signs are defined, which will make behaviour of the components in both domains follow the same structure of OPR without supervising every component individually.

Ontology meta-model with norm analysis

OPR can keep the whole development process follow the same isomorphic structure. Norm Analysis (Liu, 2000) helps keep the isomorphic structure in the design processes and maintain the semantical integrity to reduce transaction loss. The construct of a norm has several elements:
<condition>: defines context and specify triggers.
<agent>: a individual member or a group in an organization.
<action>: links to Process and can be categorized as several types of sub-actions.
<D>: a deontic operator to describe the responsibility such as obligation, permission and prohibition.

The semiotic structure of a norm, <condition>→<D><agent><action>, can be explained by the design pattern of OPR. <action> is linked to Process while <agent> is part of the Organisation and <action> can be categorized as several types of sub-actions. *Knowing* and *doing* are the top categories of the action. Within *doing* action, *utilizing* and *producing* are the second level categories of the action. Resource is always associated with <action> as signs and objects. The deontic operator with <agent> in every <action> is labeled by <D> with certain responsibilities of OPR. The context and trigger is labeled by <condition>. (This paragraph will be extended in the final version)

The responsibility of a certain object class comes from the analysis of business objects consisting OPR. <agent> inherits all the responsibilities of its sup-classes and is endued with the responsibilities of its own object class. The responsibilities are explained using Norm Analysis (this sentence will be explained in the final version).

Name of element	Definition of element
Organization	Manage Process, Resource and other Organization，take charge of certain processes. An organization coordinates the relation of OPR. All the business objects search for OPR components and negotiate about visiting and utilizing OPR components through organization.

Process	An aim-oriented activity-sere supported by resources, utilize or visit resource, with the ability of establishing the correlation with resource directly, which means having the ability to cite certain resource for a long time in order to emphasize or generate other resources which can enhance value.
Resource	The knowledge unit of value, cost and actions in organizations. The representation of the business value, job and information used by other OPR.

The abstract and the relation of business in the meta-model form a pattern and concentrates alternately in each layer of their hierarchical structure. In a certain layer, each element has its basic affordance with other elements (to see chart 4. 1): Organization manages Business process and Resource, Business process uses and generates Resources, Resource manages itself. Resource is the core.

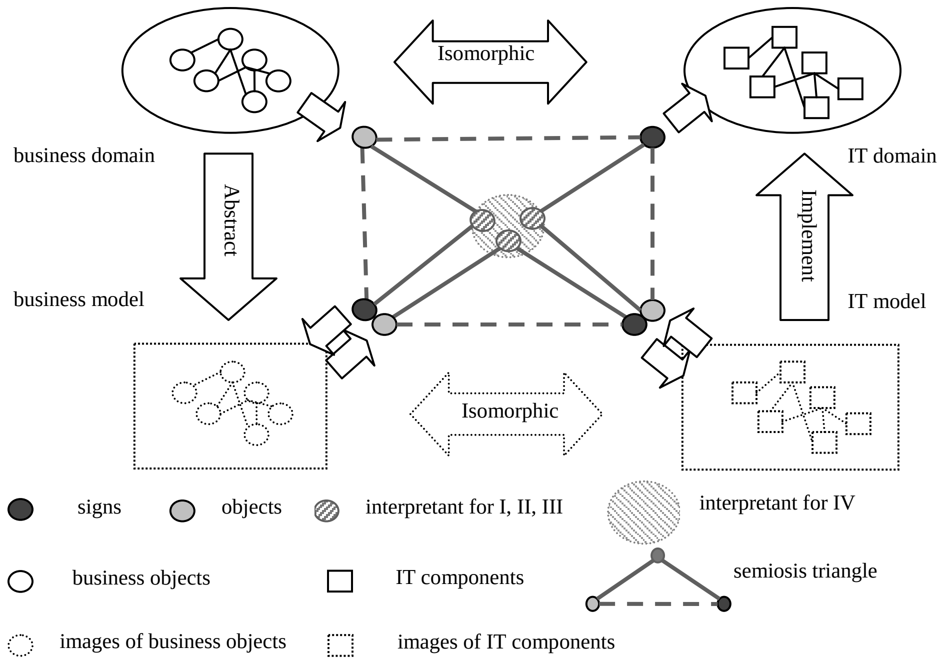
Semantics can be divided into three types by the elements of the ontology meta-model, which are Organization, Process and Resource. With the traditional classification of organization semiotics, namely the correspond relation between *agent* and *affordance*, Organization corresponds *agent*, Process and Resource correspond *affordance*. It is the frame of ontology chart for the semantic model which combines the Semantic Analysis and the Norm Analysis with *simiosis*. *Affordance* and *agent* is a set of signs, which refers to the different signification in various domains (*interpretant*). Therefore, to establish the meta-model is an effective method to solve the concept incoherence on syntax level.

A SEMIOTIC VIEW OF THE ONTOLOGY META-MODEL

The transformation process is focused on the realization of isomorphic structure consisting of OPR and the transformation mechanism based on them on configuration and is analyzed and explained from organisational semiotics point of view in this chapter.

An assumption is that both business domain and IT domain can be separately abstracted as a certain set of structured signs being OPR, which enables the transformation. The intention of the purposive activities in the mechanism is to make the processes coherent semantically and consolidate them as a whole to produce integrity in domains. See figure 2. Business domain can be regarded as a set of *objects* (in semiosis I) with a certain configuration (Gan, Han, & Liu, 2007).

Figure 3: The semiosis view of isomorphic transformation between business and IT domains.



Transformation processes with the meta-model

In the process of information systems analysis, business objects have been abstracted into a business model as a set of *signs* (in semiosis I) with certain concepts which have been defined in former part as ontology meta-model. This process of transformation can be viewed as from *objects* (business objects) in business domain to a corresponding *signs* (as images of the objects) in the business model with the same structure of ontology meta-model. It models the business world through *interpretant* (in semiosis I) and represents the process of system analysis. Isomorphism means coherence between business domain and the description (i.e., the model) of it in the business model.

The business model can be also viewed as a set of *objects* (in semiosis II) in the process from business model to IT model. Then IT model is achieved as *signs* (in semiosis II) through the isomorphic transformation with the mechanism of the ontology meta-model which guarantees the isomorphic configuration of both sets of signs (objects). A sign in each model can be transformed into another corresponding sign in the other context. *Interpretant* (in semiosis II) is represented and explained through the mechanism. This process of transformation represents system design and can be viewed as from *objects* (in the business model) to *signs* (in the IT model) through *interpretant* (the mechanism of isomorphic transformation).

In IT model, the configuration of the set of signs reflects components and their structure in IT domain. In the process from IT model to IT domain, the set of signs in IT model achieved in the process I acts as a set of *objects* (in semiosis III) being transformed through *interpretant* (in semiosis III) to a set of *signs* (components and their structure) (in semiosis III) in IT domain. This process represents system implementation. IT domain is regarded as *signs* and the images of IT domain (IT model) are regarded as *objects* in semiosis II.

Isomorphic Structure

With the ontology meta-model, the set of *signs* (in semiosis III) in IT domain reflect the realization of the set of *objects* (in semiosis I) in business domain at last. When the two domains are focused on through hiding the other two models being images of them, it can be found in semiosis IV that the set of *objects* (in semiosis IV) is transformed to the set of *signs* (in semiosis IV) with an isomorphic structure from business domain to IT domain through *interpretant* (in semiosis IV) (the combination of the three former processes of transformation). Thus the isomorphic structure where one model (set of signs) reflects both business and IT domain is realized. The design pattern is described as the union set of signs being ontology meta-model.

Thus the whole transformation process finishes with sets of isomorphic structured objects (components) in both domains. Since the three sets of signs in different contexts have same structure and each sign can find a corresponding sign in every other context, the meta-model can be used to represent these different sets of signs. The combination of the three interpretants is described as the one in semiosis IV. In the combined interpretant, the meta-model acts as rules for the transformations between contexts.

The semiosis processes enable the mechanism of concept transformation in domains as well as concentrate analysis of semantic in each context. Thus, whenever changes happen by adding, deleting or adjusting business objects or their structures, corresponding changes in IT domain can follow them to realize a synchronizing coherence between both domains. The mechanism of this implementation is maintaining isomorphic structure in sets of concepts in domains and models through transforming *objects* to *signs* with a continuous feed-back loop through the ontology meta-model. When we get the information system in IT domain, the transformation processes can be utilized in the other direction (from *signs* to *objects* in all the four semiosis triangles) through which the verification of the coherence between domains can be realized. The other parts of information system development such as assembly testing, integration testing, user acceptance testing will be accomplished by following this direction of transformation processes and the theories of loose-coupling and reduced abstract set computing. Thus the transaction loss between different transformations can be solved consequently based on the isomorphic structure.

DISCUSSIONS AND FUTURE WORK

This paper analyzes and explains the transformation processes from business domain to IT domain in information systems development from a semiotic perspective. A mechanism is proposed to enable images in business model and IT model to be isomorphic. It makes objects (components) in business domain and IT domain follow an isomorphic structure to enable synchronizing changes in the two domains. With an isomorphic concept structure of different sets of signs, the mechanism for interaction and corresponding between the two domains will be obtained. This mechanism is also supposed to be an effective approach to reduce semantic transaction loss.

OPR is introduced as core elements in every domain as well as the union set of signs in every model. Thus these models can be transformed into each other to reduce the transaction loss among different processes, which can be clearly connected and described by isomorphic structured objects (components). The automate transformation between business and IT domains in information systems development can be put into reality through using technology project component.

This solution leads the design of information systems to be a synchronized process and produce an isomorphic concept structure to avoid concept divergence in domains (models). Systems which are designed using the isomorphic structure are proposed to be understandable, maintainable and easily modified in response to the changing business conditions.

Following the current, future work will focus on the implementation of the transformation mechanism and the hierarchical structure of OPR in both domains as well as the isomorphic structure of their configuration. To put it into reality, technology project component will be discussed to support the realization, with which the automatic transformation is proposed through using the mechanism introduced. Transaction loss will be analyzed and solved at

two aspects which are design method and design process of an information system. The mechanism is achieved through using several transformation rules among sets of signs in information systems design, which define constraints, conditions and policies for how the components are configured and assembled. A schema is required to model the relationships among OPR elements for transformation based on the mechanism, which requires establishing rules for specifying relationships and assembling a set of objects (components) to achieve certain goals in business (IT) domain. On the other hand, actors and their responsibilities in information systems development will be discussed with Norm Analysis to guarantee the realization of the transformation mechanism.

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