

CONCEPTUALIZATION OF CONSTRUCTION INDUSTRY ORGANIZATIONS VIA ONTOLOGICAL ANALYSIS

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ABSTRACT

The internal agent's roles within an organization as well as its external interaction with other construction firms are defined by the intuition of the founders of the organization due to the contextual nature of the aforementioned roles. Typically, these organizations have a poor definition of their structure and their agent's roles are ambiguous. This lack of conceptualization creates uncertainty, misinterpretations, and contradictions in defining external or internal interoperability activities.

This study will consist of an ontological analysis of the assumptions made in establishing the roles of the participants in the current organization. This analysis contributes towards a better understanding of the fundamental entities of their social roles. The approach explores the limits of the agent's roles in order to facilitate their interoperability descriptions. The conceptualization of the agent's social role will help reveal ambiguous interpretations of the agent's actions as well as the individual agent's constraints and relations.

The analysis will make an explicit distinction between the entities and their relationships using the intended meaning of the formal vocabulary with the purpose of achieving ontological commitments. The conceptualization will identify individual and collective action that underlies an organization in the construction industry. This approach is not intended to define a model for a specific purpose of an organization but to create formalization through the use of an ontological analysis.

KEY WORDS

Ontological analysis, organization social of roles, semantic interoperability, conceptualization of construction organization

INTRODUCTION

This research introduces an ontological analysis of a construction industry organization, as well as the fundamentals that aid this analysis according to construction participants' social role in the organization. The analysis of organizations comprehends *internal* and *external* relations. *Internal* refers to the relations that are included within the organizations and

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external to the relations outside the organizations or agents. This investigation focuses on internal ontological analysis. Ontology is the study of the existence of entities, and it is the resource used in formalizing *categories*, labeled '*ontology categories*'. Ontology focuses on classification of conceptual entities and physical entities.

For clarity, this approach names construction participants, or actors who belong to construction organization, as cognitive agents. This means that the members of an organization, who play a role in that organization, are entities or agents that are characterized to possess *intentionality*. This ontological analysis, carried out through categories and classifications in organization, is easy to visualize, as the subsumption properties of ontologies⁴ resemble the hierarchy properties of a structure within an organization.

The ontological analysis circumscribes the cognitive agent's point of view, which by definition must be reflected in the agent's organizational role. The analysis makes the explicit distinction between the relationship of the cognitive-agent's social role and concepts under the agent's domain. This research does not peruse an analysis on the organizational areas of construction domain but attempts to show the approach of defining an ontological the areas of knowledge where the agent or construction participant plays a social role in the organization.

The first section presents some aspects of the nature of the organization, current assumptions, and methodology used. The second section of this paper presents an illustration of conceptualizations, which is the strategy employed in this approach in defining the analysis of organization. The third section shows a basic framework that is used to ontologically analyze the entities.

ORGANIZATION AND AGENT'S ROLES

The internal organization of a construction project that is considered for analysis is the one that is recognized by the community or a social group. The organizations embrace social entities in which a group of agents recognize systematic relations within the organization structure. By definition, each structure of the organization contains an area of knowledge of the domain. The cognitive agents who play a role in the structure acknowledge a set of rules that regulates the operations, and ascribe responsibilities within the organization. This research focuses on the nature of the organization through the ontological analysis. For example, the analysis defines what constitutes the nature of a delegated role by another on its behalf and how this role is considered temporal.

The agent acknowledges what he or she needs from the set of responsibilities, the norms and rules of the organization, and the social, contextual relations in order to perform a role. These aspects are essentially institutional facts (Searle 1995). As an illustration of social, context relations and institutional facts, consider the status '*change of order*' concept. This concept must be internally regulated in the organizations by norms and rules that constrain the procedures for manipulation. The '*change of order*' concept is acknowledged in different ways by the construction participants based on its different status. For instance, suppose the

⁴ For further details of subsumptions properties, see Guarino, N., and Welty, C. (2001). "Identity and Subsumption." *01/2001*, LADSEB-CNR,, Padova, Italy.

current status of the 'change of order' is handled by the procurement section of the organization, the 'change of order' is acknowledged by the agents from the purchase section as an 'order of purchase of additional resources'. The internal organization recognizes this concept according to certain rules, norms, and social, contextual relations, which are prescribed as institutional facts.

In the same way, organizations can perform a role by means of some member agents who play particular roles inside it (Bottazzi and Ferrario 2005). These agents are construction project participants in the construction domain case. In other words, organizations must perform roles, but it is the construction participants who ultimately perform the social role. In fact, there is no unique relation between roles and construction participants; one agent of an organization can play different roles, and even the same agent can play these roles at the same time.

STRATEGY FOR ONTOLOGICAL ANALYSIS

The research aims to perform an ontological analysis of the construction organizations. The strategy for the analysis seeks to define the nature of the cognitive agents or construction participants who are members of the organization, and the nature of the structure of the organization. The reader is reminded that this structure is specified through a set of rules or norms. Thus, this analysis will explicitly focus on defining the relation between the agents and the set of rules or norms that define the organization's structure.

Our research anticipates the complexities in defining properties of organization structures due to their nature of social concepts, which by definition are abstract notions. These concepts are not objects that have geometric or perceptual characteristics. The approach must be based on other characteristics of social concepts. The ontological analysis must take into account social concepts where *intentionality* aspects can be defined. This analysis is based on the agents who ultimately perform the role in the organization and on the social concepts. Social concepts are constituted through *contextual relations*. Examples of social concepts include social roles that define the functional characteristics of a concept in an organization (e.g. the role of an approval unit in revising permits and inspections).

The *contextual relations* rest on the cognitive agent's purpose in interpreting a construction concept. This research takes *contextual relations* when considering a valid construction participant's interpretation. This line of characterization of the interpretation has roots in the semiotic tradition (Luger 2002). *Contextual relations* attempt to identify the possible social agent's relations, which might influence the current concept interpretation, and to link such relations to other concepts.

ONTOLOGICAL CATEGORIES ON REPRESENTATIONS

As was previously mentioned, ontology is the study of the existence of entities, and it is the resource used in formalizing *categories*. This research attempts to find classifications in categories of the social concepts of the construction organization. We attempt to find categories of the social concepts through their intentionality.

This research embodies our approach on the trichotomy of ontological categories proposed by Pierce: Firstness, Secondness and Thirdness (as cited in, Sowa 1999). Pierce

explained that the first ontological category of any concept is the existence that is *independent* of anything else, the second is the conception of being *relative* to, and the third is the conception of *mediation* where the first or the second are brought to a relation.

Figure 1 illustrates Pierce’s proposition by using an example from the construction domain. Each layer of the Figure represents an ontological category. In the *independent* category, an architectural drawing of the doors concept is specified in the drawings. It exists by itself. The drawings without any interpreter are simply an entity of papers and ink. The *relative* category that the pattern of drawings reflects is a shape of doors. Thus, there is relation between the drawings and the patterns of drawings, which take the shape of doors. The *relative* category is possible under the abstractions of the interpreter who performs the relations. And the *mediating* category describes the purpose of the pattern of the shapes, which is to construct a physical door on a specific building. The interpreter’s purpose is to transform the drawings, which contain the construction concept ‘doors’, into a physical structure. The drawings *mediate*, through the intentions of the interpreter, the abstraction of the patterns ‘doors’ in order to transform them into the physical entity ‘door’ of a building. The representations such as image schemas of *doors* are *metaphors*, which are subject to interpretation by the cognitive agent.

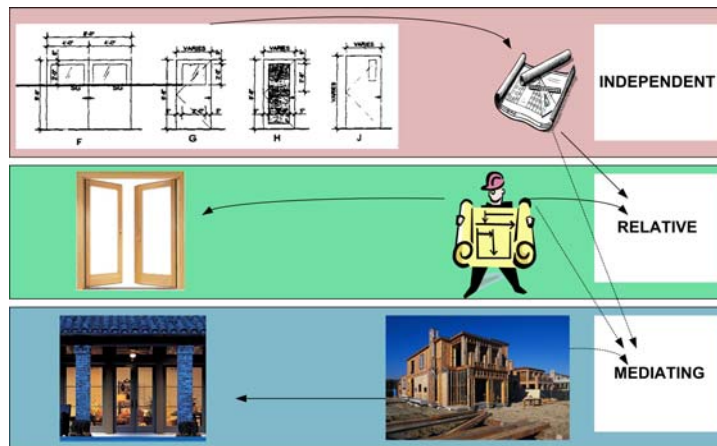


Figure 1. *Conceptualization on a domain*

The reader must be intrigued as to why this approach bases the interpretation of social concepts on ontology categories. This approach claims that there exists a strong link between cognition and social concept, the former represented by a human being (how the world is interpreted) and the latter by the social phenomenon of the real world (how the social concept of the real world is represented). An ontology, which reflects this link, should be elaborated in a way that reflects the generalization of specific concepts of the real world. What is most important within the introduction of Pierce’s categories into an ontology, is that this research recognizes the importance of the intentionality of the cognitive agent. The cognitive agent’s purpose or intention is to direct the agent’s attention to an observed concept cognitive agent. The intention guides the agent’s attention to what is considered relevant of an observed

concept. Pierce's categories are top ontological categories. Top ontological categories capture the reasoning of a social concept and classifies it into categories of existence (Gangemi et al. 2001; Sowa 1999). These categories indicate a common denominator of the social concepts of the domain, for a more redefined domain.

The definition of *categories* is possible through conceptualization of social roles. The next section explains conceptualization fundamentals. The importance of this illustration is that a further analysis of conceptualizations make possible the definition of an axiomatization of the social concepts of organization, which lead to define enterprise models.

CONCEPTUALIZATION ON SOCIAL CONCEPTS

A *conceptualization* accounts for all intended meanings of a representations use in order to denote relevant relations (Guarino 1997). This means that a *conceptualization* is a set of informal rules that constrain a piece of a physical construct concept or an abstraction concept. In this study, the conceptualization attempts to make explicit the informal rules of the pieces of areas of knowledge in a construction project organization.

An actor or observer uses a set of rules to isolate and organize relevant relations. These are the rules that tell us if a piece of a concept remains the same independently of the *states of affairs*. Guarino further clarifies the *conceptualization* notion, which refers to a set of conceptual relations defined on domain space that describes a set of *state of affairs*, by making a clear a distinction between a set of state of affairs or possible worlds and intended models (Guarino 1998).

The intended models weakly describe a state of affairs by an underlying *conceptualization*. A *conceptualization* of any entity, or abstract notion such as a construction project organization, must include details that will independently describe the construction concept from its states of affairs. *Situational conditions* will be needed to describe some extensions of the concepts in order to reflect common situations or relevant relations to the *states of affairs*. Situational conditions include social, contextual relations and *status conditions*.

Conceptualizations are described by a set of informal rules used to express the intended meaning through a set of domain relations. These meanings are supposed to remain the same even if the some *situational conditions* change (Guarino 1997). One particular set of rules, which describes an extension to the world, is called the intended model. An example of this would be a model with a rigid structure of a specific construction organization. The rules that define the model must use some syntax to be implemented. The syntax can be a natural language (e.g. English words), a programming language (e.g. LISP syntax), or any visual representation. An intended model uses a particular interpretation of the language and it is used to elaborate representations and create the constraints. The syntax of the languages composes what it is called a vocabulary. This vocabulary is used to define the intended models. These models fix a particular interpretation of such a language (Guarino 1998).

For a better illustration of *conceptualization*, consider Figure 2, which schematically depicts a *conceptualization* in to a specific domain, and indicates components that help define a *conceptualization*. The components are minimal ontological definitions of the entity, logical axioms that use syntax and vocabulary of a language, and additional semantic relations, which help describe several states of affairs.

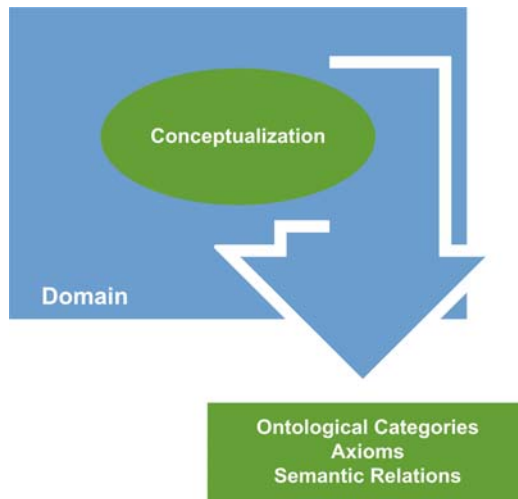


Figure 2 *Conceptualization on a domain*

Consider the following example as an illustration. Lets consider a physical concept in the construction domain (see Figure 3). The *conceptualization* of this ‘wood frame window’ involves an explicit description of the ontological definition. This ‘wood frame window’ concept description breaks down into details and into the details’ specifications of their relations. Additional descriptions of the concept intension, which comprehend context relations and other constraints that do not change with the states of affairs of the concept (e.g. the relationship ‘set by’ and ‘on’ of a detail do not change with the position of the product), will help to define ‘wood frame window’ for further interpretation.

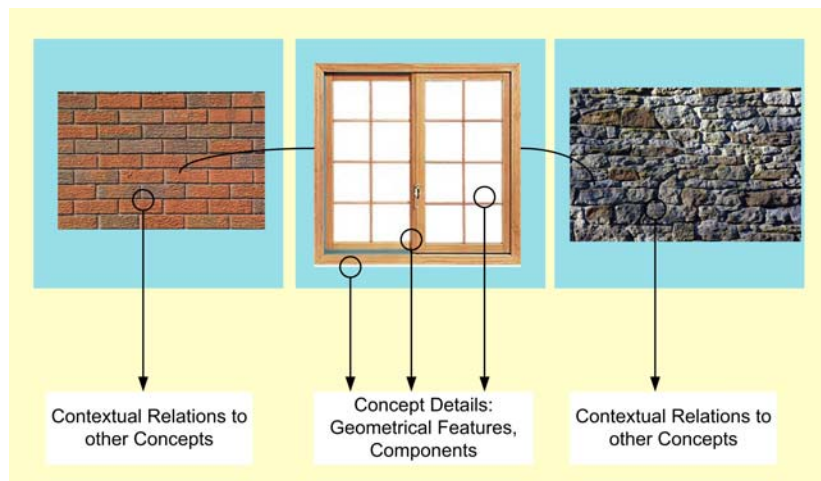


Figure 3. Context relations and details for conceptualization.

The reader is reminded that this research considers an organization as an abstract concept and that the situational conditions embrace the social, *contextual relations* and the status conditions. Specifications or ontological refinement processes are explicit formalizations of the situational conditions. Reifying a concept denotes an understanding of the *conceptualization* of the representation. Explicit formalization of concepts is by definition an ontology specifications (Gruber 1993; Guarino 1997; Zúñiga 2001).

As it is illustrated in Figure 2, *conceptualizations* become extractions of the domain knowledge and are specified by ontological categories, relationships, and constraints or axioms. Categories are forms of classifications of the ways cognitive agents see the world. *Conceptualizations*, through the use of relationships and constraints or axioms, attempt to formally define the cognitive agent's views or their perception of the world according to the nature of the concepts themselves and the categories employed.

BASIC FRAMEWORK FOR ANALYSIS

The scheme in Figure 4 is a good approach for the intended, ontological analysis. The scheme contains aspects to start an ontological analysis. It is derived from the work of Zachman and Sowa (Brachman 1979; Guarino 1993; Sowa 1999; Zachman 1987), who proposed a framework to define knowledge for information system architectures, as well as from Brachman's and Guarino's suggestions concerning levels of representation (Brachman 1979; Guarino 1993). However, this scheme is deliberated to bring the observer's world or cognitive agent's world close to the representation of the construction concept.

It is critical to highlight how ontological categories back this framework and how different levels of representations intercede in the scheme (see Figure 4). The proposed scheme is based on the identification of Pierce's triadic relation: representation, relation, and purpose. This relation is reflected when the cognitive agent needs to perform a function that is defined by a social concept. The agent recognizes the social concept itself, finds semantic relations, and identifies ontological aspects of the concept (e.g. the cognitive agent's *role*, in the schema of Figure 4). In addition, this triadic relation holds top ontological categories *per se*. In the scheme the top ontological categories captures the instances in which an agent reasons about a concept. Top ontological categories guide a classification of the concept into categories of existence. These categories identify a common denominator of the analyzed social concept within a domain, which is by definition an ontological specification of the concept.

Figure 4 shows the proper top ontological categories backing each of the guidances ('*what*', '*how*', '*where*', '*who*', '*when*', '*why*') of the scheme. An analysis of a concept through the scheme must at least be defined by the categories shown. Although the purpose of this research is not to design a methodology for concept ontological analysis, this investigation does suggest that this framework must follow a systematic analysis of concepts. Other valid ontological analysis methods, which define top ontological categories (Guarino and Welty 2002; Sowa 1999), can be applied to the framework. This research does not recognize universal methods to define top ontological categories, but emphasizes a systematic conceptual analysis.

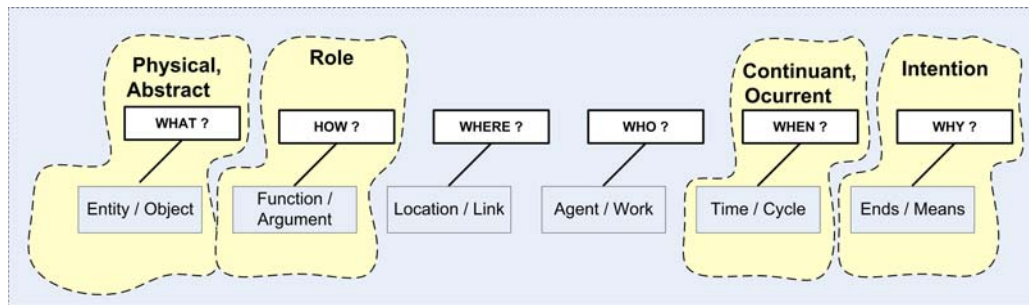


Figure 4. Basic framework

Figure 4 illustrates how top ontological categories act upon the proposed research scheme. For example, top ontological categories defined as *continuant*--which is the category that describes an object or abstract that has stable characteristics over a period of time-- or *occurrent* top ontological categories (Sowa 1999)--that describes a social concept that has enduring characteristics--, can be set up by using the scheme.

As was previously explained, the first layer indicates a direct description of the top ontological categories. In addition, the boxes associated with each guidance are examples that help the readers analyze the social concept.

The '*what*' guidance in Figure 4 conceives the description of the social concept. A close analysis of this '*what*' guidance leads to *contrasting* other entities or abstracts from other concepts. This contrasting identifies *relationships* between the analyzed concept and the other. The boxes in the '*what*' guidance are examples of the possible form in which the concept is represented. These examples also will guide further analysis concerning computational aspects and the analyzed concept.

The '*how*' guidance conceives the function of the analyzed social concept, and, if it contains components or parts, how the parts are organized for a given function. When the concept contains parts, the categories can define one or more functional relationships among them. The functional relationships describe the role of the social concept to others within the concept's space-time region. The role of the concept is to describe ontologically the functionality of the concept itself. The analysis of relationships can be extended to other social concepts when it is performed on functional aspects.

The '*where*' guidance describes the physical relations in which the analyzed concept is found. The analysis must identify situational conditions, which embrace the concept's location, position, site, place, and setting, as well as *situational conditions* concerning *context relationships*. A concept can be instantiated having a unique reference in the world. This guidance situates the concept when the relationship of a specific place or location is instantiated for that concept.

The '*when*' conceives the status condition of the concept during its life in the time-space region. This is a specification of the stage of the concept during its lifetime. It takes into account the process's ontological category. It considers that an entity is either, in Sowa's top ontological definitions, *occurrent* or *continuant*. If the concept is seen within a different time scale, it could be considered as a process, part of a process, or a stable entity. Thus, the

concept status is a view, which defines the entity at its unstable or stable state at a given period of a time scale. This situation is named here as *situational conditions*, specifically *status conditions*.

The 'why' specifies the intention behind the interaction of the concept with others. It defines a purpose or reason categories. The purpose is a dichotomy of the cognitive agent's intention. The 'why' guidance is the first attempt to associate the intention of the cognitive agent with the social concept by listing the intention of whys. An example could be: why the concept "Request for Proposal (RFP)" is relevant to the project manager.

CONCLUSIONS

The paper presents our approach in defining ontological analysis of organization through conceptualizations. This study shows the research group advancements on ontological analysis on construction project organizations, as well as the first conclusion. We identify that a link of the intentionality of the agents in the organization to social concepts must exist. This intentionality should implicitly be included into the ontological definitions of the social concepts of the construction organization

We are currently working in inducting the proposed ontology, which is the next step of this research. The core of the activities is based on knowledge engineering strategies. Roughly, they consist of contrasting existing construction industry standards, performing surveys with experts within construction companies, and consultations with other construction industry participants.

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