CONCEPT CLASSIFICATION FOR CONSTRUCTION CONTRACTUAL SEMANTICS: A CASE STUDY ON THE AIA A201 DOCUMENT

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ABSTRACT

The sharing of domain knowledge through ontology is a good way to narrow the knowledge gap between the domain experts and regular construction managers and to improve the practice of construction project contract management. However, little work has been done on taxonomy development in this domain. Based on a literature review of taxonomy development methods and the essence of construction contracts, this study proposes a synthesized methodology for taxonomy development in the domain of construction contractual relationships. This methodology is based on an ontological model extracted from definitions found in the contract, and uses common root concepts as the initial root concept classes, and includes the iterative development and competency questions approaches as well. In the case study, based on the results of a pilot study, an updated taxonomy with a finer structure was developed by applying the methodology on the textual content of clauses in the AIA A201 General Conditions of the Contract for Construction (2007) document. In addition to using the case study for the testing of the validity of this proposed methodology, the taxonomy was compared with the previous version, and its structure was analyzed from the perspective of the ontology description language's semantic modeling primitives. Finally, it was concluded that, the taxonomy has more detailed and finer structure than before, and the proposed methodology is capable of guiding the concept classification for the domain of construction contractual semantics

Keywords: Ontology, semantics, taxonomy, contractual management, construction claims

1. INTRODUCTION

The development of more sophisticated buildings and building systems has led to more complex and consequently, more risky projects in the Architecture/Engineering/Construction (AEC) industry. This trend has made project contract management much more difficult, and consequently, claims and legal issues have become more and more unpreventable due to the increasing complexity and uncertainty involved in projects (Hackett and Dancaster, 2000). Further, for the project contractual parties, the performance of contract management duties and avoidance of contractual claims have an important impact on project success. Contract management requires domain experts' with comprehensive contract knowledge and professional insight. However, due to the restrictions of the project jobsite, a knowledge gap exists between the domain experts and the construction project team. This gap is one significant factor that impacts the performance of project contract management duties. Narrowing this knowledge gap, by representing the experts' knowledge through ontology and sharing it with the contract management team is a good way to solve this problem (Niu and Issa, 2012). At the initial phase of building this domain ontology, solid taxonomies are necessary to classify and organize the related concepts in the contractual relationships between project parties. Currently, little work has been done on building the taxonomies in this specific domain.

According to the conceptualization process in the two prevailing ontology developing methodologies (Noy and McGuinness, 2002; Gomez-Perez et al., 2004), the task following the building of a glossary of terms is building concept taxonomy (often referred to as "define the classes and the class hierarchy"). This task is the most important one in the ontology development process, since taxonomies are a Knowledge Organization System

(KOS) serving as the "backbone" of the domain knowledge for organizing concepts. To develop the taxonomy for the domain knowledge of contractual semantics, this study proposes a synthesized methodology. This taxonomy development methodology starts from a major ontological model generalized from fundamental contract law principles; and then utilizes the common major root concepts to categorize the concepts that appear in the target contract documents. In order to preserve the capability to collaborate with other taxonomies, the major root concepts used in popular upper level taxonomies and/or classifications (e.g. IFC) are utilized to initialize the development of this taxonomy. In order to determine the scope limitations of the taxonomy and to assure consistency of its terms, the following two approaches are also used: competency questioning (Grüninger and Fox, 1995) and iterative development (Gruber, 1995a). Finally, the validity of the proposed methodology is tested using a case study that applies it to the textual content of the clauses in the AIA A201 General Conditions of the Contract for Construction document (2007).

2. LITERATURE REVIEW

2.1 Taxonomy in ontology development

In most of the influential ontology developing methodologies (Uschold, 1995; Uschold and Grüninger, 1996; Gomez-Perez et al., 2004; Noy and McGuinness, 2002), taxonomy (or class hierarchy) is an indispensable part for organizing concepts contained in a body of knowledge. Actually, a taxonomy is a kind of controlled vocabulary known as Knowledge Organizing System (or Knowledge Organizing Scheme), which allows for the organization of concepts into concept schemes. In addition, it is also possible to indicate relationships between the terms contained in the scheme. The advantages of the knowledge organizing scheme in facilitating ontology-based applications include: making searches more robust by related words matching instead of simple keywords matching; more intelligent browsing interfaces by following the hierarchy structure and by exploring broader/narrower terms; promoting reuse of knowledge and facilitating data interoperability through formally organizing domain knowledge, (Yu, 2011).

2.2 Methodologies for building taxonomy

Based on a literature review of taxonomy development in the engineering management area, it was found that the methodology of content analysis is often used in finding a taxonomy from a large amount of textual materials (Chuan and John, 2005; Goodman and Chinowsky, 2000). Content analysis (or textual analysis) is a methodology in the social sciences for studying the content of communication. It gained popularity in the 1960s. Krippendorff (2004) defined content analysis as "a research technique for making replicable and valid inferences from texts (or other meaningful mater) to the contexts of their use." Typically, taxonomy studies using content analysis are mainly focused on determining the presence of certain words or concepts within texts or sets of texts, and then quantifying and analyzing the presence, meanings and relationships of such words and concepts to make inferences about the information in order to classify those words and concepts. However, this method has a large dependency on the text material selected which would bias the result. To minimize this bias, the application of content analysis needs a huge amount of literature sources (e.g. books, journals, documents, web pages etc.) to achieve adequate comprehensiveness.

To weaken the bias in the empirical approach discussed above, some other way of identifying taxonomy incorporating more theoretical concerns is needed. In the domain of knowledge management in construction, Lima et al. (2003) developed the Knowledge Management (KM) environment, e-CKMI, tailored for the Building and Construction (BC) sector in Europe. As a part of it, the e-COGNOS project addressed the need for developing domain taxonomy for construction concepts (El-Diraby et al., 2005). Besides the use of a search engine to find the frequency of concepts/terms, other tools and practices adopted include, briefly, using a process-oriented ontological model, allowing utilization of already existing classification systems (BS6100, MasterFormat, and UniClass), and involvement of domain experts in intensive interviews, as well as the use of iterative development and competency questions. These tools and practices contribute to constructing taxonomy in a more theoretical sense, which makes the results more convincing and solid, compared to solely using content analysis.

3. METHODOLOGY

3.1 Ontological Model behind the taxonomy

Since taxonomy is a concept scheme for organizing terms and concepts in a domain knowledge, the scheme needs to utilize some relationships among the concepts to organize them. Although the taxonomy for ontology development is not exactly the same as in designing classes and relations in object-oriented programming, some important features are shared by these two, like encapsulation, inheritance, and polymorphism. For example, the most common taxonomic relations, "Subclass-Of" comes from inheritance, and "Is-a" comes from polymorphism. Using these relationships, eventually, all the concepts can be categorized into a tree structure. The concept tree is based on several major root concepts (or root concept classes) as the main branches of it. These major root concepts contain all the other specific concepts as their sub-concepts. The major root concepts themselves are at the top level of the whole taxonomy, and no concepts contain them. However, this is not the end, because there still is a need to organize these major root concepts. The scheme, also referred to as top level scheme, needed for this organization, should be able to describe the core semantics of what the target ontology is. Particularly, in our case, the target ontology is about the knowledge domain of contractual relationships between the Owner and the Contractor. Thus, the top level schema should be focused on describing the essence of the contract and the top level scheme for organizing the major root concepts is defined as the ontological model behind the taxonomy. To obtain the ontological model in our case, the legal fundamentals of contract should be studied.

The law applicable to construction projects falls into three major categories: contract, tort, and statutory/regulatory (Kelleher and Smith, 2009). However, since this study mainly focuses on contractual management issues, only contract law is selected to be studied. Traditionally, the definition of contract used comes from Restatement (Second) of Contracts (American Law Institute, 1981) as "a promise or set of promises, for the breach of which the law gives a remedy, or the performance of which the law in some way recognizes as a duty". Thus, a contract is basically a set of promises made by one party to another party, and vice versa. Further, it also defines "breach of contract" as the result when one party fails in some respect to do what that party has agreed to do, without excuse or justification. In the context of construction, a breach of contract may be instantiated. For example, as a contractor's failure to complete the work on time, or failure to achieve the required performance of the work; likewise, if an owner unjustifiably fails to make periodic contractual payments to the contractor as portions of the work are completed, that failure constitutes a breach of contact. Therefore, from the definitions of "contract" and "breach of contract", a naïve ontological model for the taxonomy of construction contractual domain knowledge can be defined as "When a project party unjustifiably fails to fulfill its contractual promises (obligations), a breach of contract occurs, which entitles the other project party to a corresponding remedy".

3.2 Major Root Concepts in Other Common Taxonomies

Besides the concern for the contract itself, since the context is the construction industry, the taxonomy development work should take into consideration the scheme and content of some commonly existing taxonomies and classifications. Particularly, classification systems about the product model and/or process model (e.g. IFC and MasterFormat) provide us with existing external taxonomies to use when there is a need to refer to certain objects which belong to the product or process model. Thus, it is valuable to integrate existing classification systems in order to make the desired taxonomies work together with them.

A literature review of the existing popular taxonomies in the construction area yielded five major root concepts which are very common in most taxonomies, like IFC and many of the construction classifications (Gruninger et al., 1997). These taxonomies are continuously being adopted or extended in other taxonomy development efforts in the context of construction (El-Diraby et al., 2005; El-Diraby, 2012). Specifically, the five major root concepts are: Project, Actor, Product, Process, and Resource. In certain taxonomies, each of these major root concepts has different sub-concepts as its descendants. Although these taxonomies using the five major

root concepts are not specifically designed for the domain of construction contract and claims, it is assumed that they could be used as a reliable basis for initializing the concept classification work and be able to be adapted and modified later to meet the desired taxonomy's needs. Actually, these five major root concept have been revised into eight in a pilot study (Niu and Issa, 2013b) to better model the construction contractual semantics.

3.3 Competency Questions and Iterative Development

To control the limit of an ontology's scope, the method of Competency Questions (Grüninger and Fox, 1995) is adopted in this study. This is a way to determine the scope of the ontology by compiling a list of questions that a knowledge body based on the ontology should be able to answer. Since the scope of an ontology is controlled by the taxonomy, this method is actually applied during the taxonomy development task.

Competency questions are a set of consistent questions that the ontology developer has to ask and adhere to upon the development of each phase. These questions are designed for testing the ontology limits during the ontology-design process. In practice, the competency questions should be used as follows to test the ontology's limit:

- Does the ontology contain enough information to answer these types of (competency) questions?
- Do the answers require a particular level of detail or representation of a particular area?

Additionally, in the whole process of ontology development, the importance of the iterative development approach is proposed and emphasized by many ontologists (Gruber, 1993; Gruber, 1995; Noy and McGuinness, 2002; Yu, 2011). More specifically, an initial ontology is created in a rough first pass and it is then revised and refined, with the details provided and filled out. Subsequently, the initial version of the ontology should be tested and evaluated in applications, and should be discussed with domain experts. Similarly, the revised version should be put back through the previous cycle for more fine-tuning. As the skeleton of the ontology, the taxonomy development work also should follow this iterative development approach.

In summary, all of the methods and approaches described in this section consist of a synthesized taxonomy development methodology. In the next section, this methodology will be used in a case study to test its validity and to help revise and modify it through the analysis of problems encountered in practice.

4. CASE STUDY

In this case study, AIA A201 General Conditions Contract Document (hereinafter referred to as the AIA A201 Document), 2007 edition, was chosen as the domain knowledge source to apply the proposed synthesized taxonomy development methodology to. More specifically, the domain knowledge about the contractual relationship between the Owner and Contractor is articulated and regulated by the AIA A201 Document, and it has been widely accepted and used by the industry and academia. The AIA A201 Document is able to serve as a reliable domain knowledge source on which to do the conceptualization work.

In the pilot studies (Niu and Issa, 2013a, 2013b), the glossary attached to AIA A201 was selected to be used as the test object, from where the taxonomy development work started. Although that glossary provided a good reference as a pool of concepts, most of the terms in it are considered as quite abstract and general ones, which are good enough for developing the top level of the taxonomy but not suitable for the further development of more specific concepts. For example, many of the terms in the attached glossary actually contain a cluster of concepts and relations, like a "block" rather than one single term (e.g. like the form of "*Conditions related to …*", and "*…'s relationship with …*"). Additionally, in the taxonomy developed in the pilot studies, some large root concept classes (e.g. *Promise*, *Behavior* and *Product*) contained a very large amount of concepts which needed further classification into more detailed hierarchy. Therefore, as the test object, the attached glossary of AIA A201 limits the further development of the taxonomy into a more specific and detailed level, due to the limitation of the terms contained in it. To address this problem, the test object was changed to be the text of the clauses.

To conduct this case study, the following development procedure was used. First off, the meaning of a clause should be learned and understood well. Then, based on the revised ontological model and the eight major root concepts from the pilot studies, as well as the basic knowledge representing model of "Subject-Predicate-

`Object`" from the ontology description language, the meaning of the text of the clause is analyzed and the corresponding concepts in it are identified. Note that in this step, it is necessary to tell the difference between a "concept" and the "attributes/properties" of a concept, and although the attributes/properties of a concept are also a crucial part in semantic modeling, here the focus is only on extracting out the concepts from the text and ignoring the concepts' attributes, in order to avoid unnecessary confusion. Once the concepts are identified from the text of the clause, each concept should be properly put into a root concept class and the clause's code is recorded as the provenance information. The process is executed on one clause at a time, and then the same process is repeated on the subsequent clauses. With the progress of this development process, more concepts are accumulated under each root concept class. Then, it is easier to identify the nuances among those concepts and create appropriate intermediate concept classes to further classify those concepts. This process follows the middle-out approach for taxonomy development (Uschold and Grüninger, 1996). Note that, for this case study, it was decided that the scope of the work only covers the first three Articles (General Provisions, Owner and Contractor) of the General Conditions of the AIA A201 Document for demonstration purposes. Because the contractual relationship between owner and contractor is the core and typical part for the AIA A201 Document, and it is good enough to provide us an illustration of applying and validating the proposed methodology. The concept classes developed for this taxonomy are shown in Figure 1.

The concept classes shown in Figure 1 are defined and explained as follows:

- *Environment* which emphasizes the things out of the project *Actors*' control, and which could substantially affect the execution of the Contract. It has three major sub-concepts:
    - *Legal environment* (e.g. *applicable laws, statutes, ordinances, codes, rules and regulations, and lawful orders of public authorities*),
    - *Physical environment* (e.g. *site conditions, existing construction*) ,
    - *Force majeure* (e.g. *weather delay, labor dispute*).
- *Actor* includes all the major players involved in the contract. This class include the sub-concepts:
    - *Party* (e.g. *Contractor's superintendent, Architect's project representative*), *organization* (e.g. *contractors*),
    - *Agent* (e.g. *Owner's authorized representative, Contractor's authorized representative, superintendent),*
    - *Non-party* (e.g. *government agencies, municipality*),
    - *Role* (e.g. *Initial decision maker, Surety*).
- *Product* means all the needed items to be provided by a certain Actor as required by the contract. It may include tangible construction products (like a building, or a bridge), necessary construction activities to produce the construction products, and related service required by the contract. All of these products come with a certain *Resource* consumed. For brevity, *Product* class has three sub-concepts:
    - *Document* (e.g. *Instruments of service, submittals, schedules, evidence, record*),
    - *Construction Work* (e.g. *the Project, the Work, construction or operations*),
    - *Service* (e.g. *access to work, design service*).

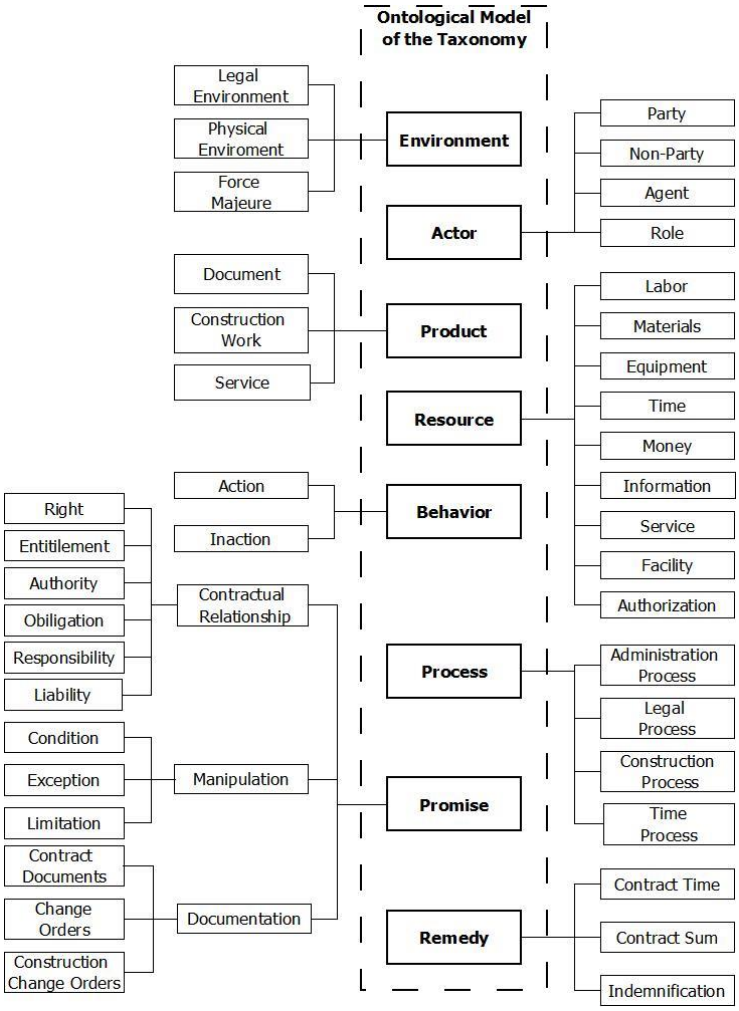

Figure 1: Concept Classes in the Taxonomy for the semantic of AIA A201 General Conditions

- *Resource* is the thing which has value, needs efforts to obtain, and is something indispensable without which a certain needed work cannot be properly performed by an *Actor*. *Resource* can be specified into five sub-concepts: besides the five of *Labor*, *Materials*, *Equipment*, *Time* and *Money* as usual, four more were added,
    - *Information* (e.g. *information for preparing a mechanic's lien, information under the Owner's control and relevant to the Contractor's performance of the Work*),
    - *Service* (e.g. *service under the Owner's control and relevant to the Contractor's performance of the Work*),
    - *Facility* (e.g. *water, heat, utilities, transportation, and other facilities*),
    - *Authorization* (e.g. *approvals, easements, assessments and charges required for construction, use or occupancy of permanent structures or for permanent changes in existing facilities*).
- *Behavior* represents the *actions* and/or *inactions* of the *Actors* which may lead to certain contractual consequences. Instances of *action* are commonly verbs in the clauses, which are abundant (e.g. *authorize*, *execute*, etc.); whereas the number of instances of *inaction* is limited (e.g. *fail to, withhold, delay, ignore*, etc.).

- *Process* contains certain procedures and should be followed for certain activities by *Actors*. It can be divided into four sub-concepts:
    - *Administration Process* (e.g. *Communications facilitating contract administration*),
    - *Legal Process* (e.g. *Meditation, Arbitration*),
    - *Construction Process* (e.g. *Construction means, methods, techniques, sequences*),
    - *Time process* (e.g. *bids are received, award of the Contract, commencement of the Work*).
- *Promise* is about the contractual relationships among certain *Actors*. It is the core part of the whole taxonomy, so it has a more complicated structure than others. Specifically, *Promise* consists of three sub-concepts, and each one can be further classified into several sub-sub-concepts:
    - *Contractual Relationship*
        - *Right* (e.g. *copyright, ownership, mechanic's lien right, right to stop the Work*),
        - *Entitlement* (e.g. *reply on the accuracy, increase in Contract Sum or extension of Contract Time, Change Order, reimbursement*),
        - *Authority* (e.g. *consent, enforce obligation against*),
        - *Obligation* (e.g. *report promptly, reasonable infer, secure and pay, indemnification*),
        - *Responsibility* (e.g. *jobsite safety, loss and damage, warranty, acts and omission of agent*),
        - *Liability* (e.g. *pay avoidable costs and damages, loss caused by patent or copyright infringement*).
    - *Manipulation*
        - *Exception* (e.g. *damage or defect caused by abuse, improper or in sufficient maintenance*),
        - *Condition* (e.g. *failure of payment, material change in the Work*),
        - *Limitation* (e.g. *extent of indemnification*).
    - *Documentation* (e.g. *Contract Documents, Change Orders, Construction Change Directives*).
- *Remedy* is deemed as a makeup for extra and excusable *Resource* consumption. Simply, it is mainly instantiated as *Contract Time*, *Contract Sum* and *Indemnification*.

5. DISCUSSION OF RESULTS

5.1 Improvement on the previous version

Compared with the taxonomy based on the attached glossary of the AIA A201 Document (Niu and Issa, 2013b), this updated taxonomy based on the text of the clauses keeps the eight root concept classes, but has a more specific and more detailed hierarchy of the sub-concepts under each root concepts classes. Especially, for some root concept classes which contain a large number of concepts, like *Promises*, substantial in-depth classification was done on them; and some more sub-concept classes were added into some root concepts, like *Resource*, *Actors* and *Process*. Meanwhile, note that the ontological model for the taxonomy, as shown by the dash box in Figure 1, is still the one developed in the pilot study without any changes (Niu and Issa, 2013b), since the root concept classes are intact. Moreover, taking the semantics of the clauses' textual content, instead of the attached glossary, as the test object for conceptualization does not have to deal with the problem of "block" terms, and allows the conceptualization work to be performed on a more detailed and finer level. This also lets the conceptualization have a stronger capability for expressing the semantics of the domain knowledge.

However, in practice, in the application of conceptualization to the textual content of the clauses, too many details and fineness can make it difficult to determine which concept needs to be added to the classification schema. Particularly, sometimes it is really hard to identify and extract a concept from a group of sentences or a paragraph in a clause, and thus to determine the concept classification schema. Fortunately, when dealing with this problem, the method of competency questions comes into play. When the developer feels lost in facing too much details, the competency questions work as a criteria to test the boundary of the necessary detailed level that the expected ontology should reach. According to the boundary found by the competency questions, those details beyond the boundary are considered as surplus and should be just ignored in order to reduce confusion. So, the use of competency questions should be emphasized through the execution of this case study.

5.2 From the perspective of ontology description language

Through the practice of the concept classification to the textual content in the clauses, it was found that the structure of some clause could be very complicated, and some concept classes are not easy to be defined and need verbose descriptions to express them clearly in English. However, the semantic modeling primitives provided by the ontology description language of RDF (Resource Description Framework) (W3C, 2004), RDFS (RDF Schema) (W3C, 2004) and OWL (Web Ontology Language) (W3C, 2009) are able to deal with these issues quite effectively. The following are just a few examples of these are dealt with.

In the AIA 201 Document clause 3.12.8, for the "deviation existing between approved submittals and the Contract Documents", there is a default priority of the two in terms of the power to be complied with. To this situation, the type resource of `rdf:Seq`, one of the RDF Containers, is a suitable construct to express this kind of priority, since it represents a group of resources or literals in a certain order, which are able to show that one is more important than the others – the Contract Documents is more important than the approved submittals in this case.

In RDFS, the property of `rdfs:subClassOf` can be used multiple times when defining a class. So, all the base classes introduced by `rdfs:subClassOf` will be ANDed together to create the new classes. Actually, this feature allows multi-inheritance, which exists a lot in the construction contractual semantics. For example, under the *Contractual Relationship* class of *Promises* class, many concepts could be under both the *authority* and *obligation* classes. For example, the "Architect's enforcing the obligation against the Contractor", is the Architect's authority since there is no direct contractual relationship between the Architect and Contractor, while at the same time it is also an obligation of Architect. The concepts with multi-inheritance are many under the class of *Contractual Relationship*.

By using the set operators in OWL, new classes can be easily constructed by unions, intersections and complements of other existing classes. For example, the concept of the impact of a document on the "most recent schedules submitted to the Owner and Architect" in clause 3.10.3, can be defined by the intersection of the two sets of concepts: one is all anonymous document classes with the property of `submittedDate`, and the other set is the class `schedule` which represents all the schedules submitted and the selected value for this property is the date of the most recent schedule. This kind of class which needs a verbose description to be defined is quite common in the semantics of contract clauses.

Therefore, the ease of expressing the complicated concepts in contract clauses by the semantic modeling primitives of the ontology description language provide the potential and foundation for better domain knowledge representation. In addition, when performing the conceptualization development, being aware of the semantic modeling primitives' features would appreciably benefit the developer in identifying the underlying semantic structure in the textual material.

6. CONCLUSION

In the case study, a taxonomy for the AIA A201 Document was obtained by applying the proposed taxonomy development methodology to the textual content of the clauses. Additionally, through the analysis of the results, it

was found that, the taxonomy has more detailed and finer structure than the old one developed in the pilot study based on the terms in the attached glossary AIA A201 Document. Meanwhile, the original ontological model is still valid since the root concept classes stays intact. Therefore, it was concluded that applying the proposed methodology (including an ontological model, major root concepts from other recognized taxonomies in construction, as well as the iterative approach and competency questions) onto the textual content of clauses, is capable of guiding the taxonomy development process for the domain of construction contractual semantics. Furthermore, although the existence of its imperfectness is admitted, the taxonomy itself provides a foundation for further ontology development in the domain of construction contractual relationships. The rest of tasks in ontology development can proceed from this taxonomy, including defining ad hoc relationships and attributes of concepts. Using the proposed ontology, a series of applications for the practice of construction contract and claim management can be developed. For example, a construction claim document production system can be developed using the proposed ontology (Niu and Issa, 2012); also, construction legal analysis and claim consulting are better realized using the proposed ontology than the pure rule-based expert systems developed in 1980s and 1990s.

The limitations of this taxonomy is that it was only based on the first three articles out of the fifteen in the AIA A201 Document. However, it was sufficient to serve as a proof of concept that the proposed methodology works. Future efforts should focus on developing a practical and feasible validation method. Since a taxonomy is a system for organizing concepts derived from professional expertise and insight, the validation method needs to also focus on the interaction with domain experts as well as take into consideration legal case precedents.

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