SSWP: A Social Semantic Web Portal for Effective Communication in Construction

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***Abstract*—In the construction industry, there is a pressing need for computer systems that will facilitate information exchange and knowledge sharing among all industry practitioners. The Social Semantic Web Portal (SSWP) proposed in this paper will accomplish three tasks: (1) the streamlining of information exchange about any individual project, (2) the encouragement of knowledge sharing in general, and (3) the virtual grouping of people with similar interests to form communities of practice. A domain ontology is developed in order to encapsulate knowledge about industrial actors and their roles in relation to sibling ontologies that conceptualize construction products and processes. This domain ontology is then tailored to be the cornerstone (the knowledge base) that will enable the semantics of Web services. The concept of the Social Web is employed to validate knowledge items and to connect users with similar interests. The information flow is realized through a content-based publish/subscribe system. The SSWP will semantically connect a user with knowledge items and socially link a user to his/her peers.**

***Index Terms*—ontology, information exchange, knowledge sharing, infrastructure, Semantic Web, Social Web, Publish/subscribe system, Web services**

I. Introduction

It is clear that the construction industry is a large and complex domain. Individual construction projects are complex because of the involvement in them of many sophisticated types of engineering (civil, including environmental and structural, electrical, mechanical, etc.), management (legal, financial and marketing, safety, emergency, etc.) and policy systems. The successful completion of construction projects is highly reliant on effective communication. Numerous information items are exchanged among various individuals and organizations temporarily brought together to execute a project. This kind of activity is undertaken constantly, but has received very little attention from researchers.

Reference [1] argues that, in order to improve the effectiveness of the communication process, it is first of all necessary to understand the process. The development of a perfect definition of the concept of "communication" is not an easy task, even though all people practice this kind of activity constantly in their day-to-day lives. Some researchers have discovered more than 100 definitions that have been formulated during the past few decades [2]. These definitions are usually specific to the context in which communication occurs, and/or closely related to the purpose or field of research. However, if one examines the definitions closely, some underlying similarities may be found; according to the definitions, the essence of communication is the transmission of information and knowledge.

Information or knowledge is not a simple collection of data. Data are numbers, words, or images that reflect the physical quantities in our world. Data, which are meaningless until they are put into a context, become information only when the recipient of a message that contains data comes to share with the sender a common understanding that is based on receipt of the message. Knowledge is the ability to use information collectively to work out solutions for some domain problems. Effective communication occurs when information and knowledge are successfully transmitted. The requirement for successful transmission means that effective communication involves more than a simple exchange of data. In other words, there is a need to distinguish "effective communication" from mere "communication."

Today's Information and Communication Technology (ICT) is very good at managing data, but has very limited capacity to manage information and can hardly deal with knowledge. In the construction sector, there are mainly two reasons for this limitation, i.e., the dynamic characteristics of the construction industry and lame computer systems. This paper first discusses the problems impeding information exchange and knowledge sharing in the construction industry, and then proposes a Social Semantic Web Portal (SSWP) that will facilitate people-to-people communication. The focus will be on how communication problems are addressed in terms of the Semantic Web (using ontologies), the Social Web (encouraging many-to-many communication), and the Publish/Subscribe system (matching contents).

II. The Challenges

A. Construction Industry is Unique

Construction industry has distinctive features that make information exchange and knowledge sharing a big challenge for most project practitioners. The exchange of

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information/knowledge in this industry is characterized by a high number of dynamics; e.g., one actor can be involved in multiple construction projects that play different roles, and, in any given construction project, the actors and their roles are not fixed, but instead dynamically change over the lifespan of the project. This level of complexity poses a great difficulty for the information management system in terms of capturing a regular pattern of information production and consumption regarding actors and roles, since the attributes of the actors and their roles vary greatly from project to project (for example, a domestic project or an international project) and from organization to organization (for example, a private company or a government).

Construction project information, including hard copy documents, databases and knowledge bases, and human know-how, is widely distributed due to the involvement of multiple organizations and the long lifespan of infrastructure projects [3]. This distribution is intensifying, as is the globalization of project procurement. This characteristic of distribution makes many traditional communication methods (for example, face-to-face meetings) not efficient or even not possible at all anymore.

Currently, the construction industry still uses a traditional linear model of communication among persons. In this basic model, a message is sent by an information source (a person) via a communication channel to a destination (another person). Reference [4] summarizes the following elements of a communication process: a communication source, an encoder, a message, a channel, a decoder, and a communication receiver. This model is still popular in many circumstances because people are accustomed to following a pre-defined channel to send and/or acquire information. The linear model of person-to-person communication does not meet the requirement for knowledge sharing that will enable those involved in construction projects to address communication issues. In a complex and dynamic domain like construction, there is no way to have all necessary communication channels pre-defined. It is impossible for an information producer to know in advance all the destinations that may need a piece of information, or for an information consumer to know all the possible sources to consult.

B. Existing Computer Systems are Lmited

Most IT applications available on the market are not suitable for knowledge sharing due to (1) lack of knowledge representation that would support information and knowledge processing, and (2) dependence on one-of-a-kind database designs, which are not interoperable.

Construction projects are carried out by project teams with members from a variety of professions. People working for the same project normally do not have the same educational backgrounds, and, thus, information and knowledge representation systems are heterogeneous. Existing data models and/or knowledge bases in the domain are scattered and do not support interoperable performance across different organizations and professions. There needs to be an interoperable knowledge representation system in the domain of construction. Knowledge Representation (KR) refers to representations intended for processing by modern computers, in particular, representations consisting of explicit objects and of assertions or claims about the knowledge in a domain. Representing knowledge in such an explicit form enables computers to draw conclusions from knowledge already stored. This will empower the interoperability, which is the ability of various system components to work together to accomplish a common task.

Current computer systems in the construction domain are oriented to the exchange of data. Most of the legacy systems are based on what could be viewed as a static AI format (expert systems, for example). Most of these systems, which are based on database technology, focus on data flow and provide little support for information or knowledge exchange. Furthermore, the dependence on databases means that these systems are highly structured. This structuring is a major deterrent to interchange in a very dynamic industry that is based on an extensive need for knowledge sharing. Many knowledge items are highly unstructured, e.g., documented in natural language or pictures, etc., and thus can not be managed by database systems.

Systems currently used for communication in the construction industry are not suitable for the increasing complexity of the domain. There are two ways for people working in construction projects to get informed. The traditional way of acquiring information includes routine communication channels, internal/external information sessions, regular visits to relevant websites or bulletin boards, subscribing to relevant magazines, participation in professional forum discussions, and so on. The information obtained by these methods is reliable, but the extraction of relevant information is very dependent on people's knowledge levels about what information to look up, and where and when to do it. The increasing application of online search engines, for example, Google and Yahoo, has led to the development of a new way to search for information, i.e., on the Web. However, the efficiency of this kind of search and the quality of the information obtained are questionable. Some information on the Web is outdated or even incorrect. Information and knowledge need to be "certified" by a reliable party in order to be useful.

III. Social Semantic Web Portal

Knowledge sharing is central to the success of all knowledge management strategies. Effective knowledge-sharing practices enable reuse and regeneration of knowledge at the individual and organizational levels. Much research has been done in the field of organizational theory in order to address knowledge sharing and its mechanisms. Most of the resesearch has focused on intraorganizational activity; however, for an very complex industry like construction, which involves multiple organizations, knowledge sharing and information exchange should be extended to interorganizational levels in order to cross the boundaries of organizations and treat the interaction as people-to-people (interpersonal) knowledge sharing. With respect to the problem raised in section II, a Social Semantic Web Portal (SSWP) is proposed in order to facilitate information exchange and knowledge sharing in the civil infrastructure domain. The concept of the Social Semantic Web subsumes situations in which social interactions on the Web lead to the creation of explicit and semantically rich knowledge representations. The Social Semantic Web can be seen as a Web of collective knowledge systems, which are able to provide useful information on the basis of human contributions and which get better as more people participate [5]. The following section focuses on the three service scenarios of the SSWP and on the SSWP's functions.

A. Three Service Scenarios

The basic service scenario of this research envisions various individuals and organizations coordinating action or information with each other in individual construction projects. The individuals and organizations are treated as actors (or stakeholders) who are playing their respective roles. The reason for differentiating actors and roles is that information needs are not determined solely by the types of actors; information needs are also closely related to roles the actors are playing. For example, there may be several electrical engineers (who are actors) working on a project that includes various roles, such as designer (from a consulting firm), supplier (from a manufacturing company), inspector (from a government department), and contractor (from a contracting firm). They normally have different perspectives on a certain project and thus different information needs.

Throughout the life cycle of a construction project, different actors playing various roles need to have information about other related activities; for example, infrastructure designers need to know about co-located systems and the corresponding constraints, and general contractors and subcontractors need to know the schedule of other co-constructed projects and regulations regarding traffic control. The project owner needs to learn about any changes in schedule or cost from the project manager. The maintainer needs to know about the deterioration of supporting infrastructure. This is the kind of information exchange that is required at the project level.

Another service scenario relates to sharing generic domain knowledge. The first scenario mentioned above deals with the exchange of project-related information within a single construction project. Work that may be more valuable and important is the distillation, representation, and reuse of the knowledge gained through work on projects. For example, if someone shares a case study about a power failure caused by water main breakage that flooded the electrical machine room, the information is a piece of generic knowledge that may be subscribed to and used by future/other actors such as emergency management officers, members of the water main maintenance crew, and electrical engineers. In addition, when the SSWP is fully populated, it will serve as a knowledge base that may be used to answer general queries and train new professionals.

The last service scenario involves offering support for the creation of communities of practice or virtual teams. In addition to information searches and the location of relevant knowledge, industry practitioners sometimes want to find information about other people. The motivation in such cases could be a need for help, or a wish to work together and/or share experiences about common interests. In this context, an individual user would be linked to other users on the basis of his/her profile so that users could form various virtual groups.

B. SSWP Functions

The most important function of the SSWP is to support the service scenario that involves exchanging project information. Each user will need to present on the Portal a basic profile that describes himself/herself. This profile should include both the intrinsic and extrinsic attributes of the user. Intrinsic information includes the "hard" attributes that will not change dynamically over a long time span, for example, name, profession, industry affiliation, location, and experience. Extrinsic information includes "soft" attributes that probably would change dynamically, for example, the roles a user is playing in various projects and some role-related attributes, such as responsibility, information needs, and authority (power).

All the concepts used to define a user's profile are from an Actor Ontology (see section IV.B), which encapsulates knowledge about actors and their roles in the construction domain, for example, what role an electrical engineer (an actor) usually plays or what kind of information a contractor (a role) normally needs. The system asks a user to define himself/herself as an actor in the Portal, and then uses the Actor Ontology to suggest the roles and role-related attributes of the user. Of course, the user has the option of accepting or changing/adding more information in the process of defining the profile.

The exchange of information is realized by a content-based publish/subscribe system (see section IV.D). All Portal users are able to publish (share) knowledge items to the system. A knowledge item is a piece of metadata about a digital file (a document, a picture, a video clip, a webpage, etc.) that describes the digital file on the basis of the Actor Ontology. This is the key to empowering the semantics of the SSWP (see section IV.B for more details). Users have also subscribed to the pertinent knowledge items and defined their information needs in their profiles. As soon as a knowledge item is injected into the system, it will be routed to the users who have subscribed to this kind of information, and it will be available the next time they log into the Portal.

In addition to the knowledge items that are automatically pushed to the user by the system, knowledge items can be pulled by users whenever they want by querying the Portal. This pulling is another important function of the SSWP. The advantages of the Social Web (see section IV.E) are realized when a sufficient number of system participants contribute to the system. The Portal will then serve as a knowledge base that will answer either generic questions about domain knowledge or project-related questions. Sometimes users may want to search for knowledge items that are not described in their profiles. In these cases, users do not want to subscribe to those items; instead, they are interested in them only on a one time basis. This function will be extremely useful for new professionals in this domain.

The third major function of the SSWP is to enable a user to find other users with similar interests and to form a virtual community of practice. A user can explicitly indicate what kind of groups he/she wants to join and whether his/her profile should be visible to other users. Prospective group members will be listed for all group members to see, and any user can browse all the public communities. The Portal also supports the function of private communities. Users are also able to search semantically for people with specific attributes. For example, a general contractor may need to search in his/her locality for a subcontractor who has special skills.

IV. Supporting Principles and Technologies

The functions of the SSWP have been described in Section III. This section focuses on the principles/technologies that are incorporated together in the SSWP in order to address all the problems mentioned in Section II and also on how the SSWP works.

The creation of a collective intelligence that will benefit all users of the Portal requires an interoperable information system that connects people, maintains a user-contributed knowledge repository, and accommodates the dynamics of the industry. An interoperable information system here refers to a semantic, content-based publish/subscribe system that uses a common language (ontologies) that is shared by all actors in their contribution and acquisition of knowledge. The knowledge-enabled system is being recognized by many researchers as a promising information management approach, and the application of ontologies is gaining favor as an alternative to traditional database technology. The Social Web is the new trend in the use of the Internet for the collective gathering of information and knowledge from a group of people who have certain similarities. Knowledge-enabled systems and the Social Web are a perfect combination to deal with information and knowledge exchange in a large and complex but distributed setting like infrastructure. Fig. 1 illustrates the schematic system design of the SSWP; the system ontology is the "brain" that holds all semantics of any publication, subscription, or query. A Social Web environment is created to connect all users of the system and the central indexing server. Most functional components of the system are designed like agents to perform particular tasks. System users communicate with the system through a Web user interface.

A. Actors and Roles

The complexity of construction has led to a great interdependence among the specializations and hence among organizations; hence, effective communication among different project actors is required. The information flow among project actors or stakeholders is based on various roles played by those actors or stakeholders. They normally have different perspectives on a project, which are associated with their different interests, responsibilities, rights, and many other attributes; therefore, understanding the relationships among the many actors and roles becomes essential to management of communication on construction projects.

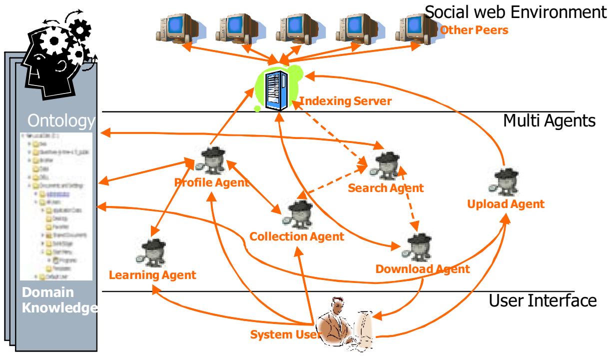

Figure 1: SSWP system illustration

Actors in the civil infrastructure domain are individuals and organizations who are directly or indirectly involved in construction projects. A role is largely defined as a set of connected behaviors and attributes that are conceptualized by actors (role players) in a given individual social position. This individuality means that roles are situated in various settings where their behaviors and attributes could be very different from those associated with comparable roles in other settings. A construction firm is normally a contractor with respect to the project owner, but a client to its supplier; the two roles definitely have different attributes. From the perspective of a functionalist, a role is a set of acknowledged attributes and expectations about behaviours that a society places on an individual. By unspoken consensus, certain behaviors and attributes are deemed "appropriate" and others "inappropriate." One of the major objectives of modeling roles is to differentiate appropriate and behaviors and attributes from inappropriate ones.

This research employs the functionalist perspective on roles, which treats roles as more-or-less universally agreed upon and relatively inflexible. The functionalist approach remains a concept that is fundamental to understanding roles in the civil infrastructure industry, even though the approach's static perspective has been criticized. The functionalist approach remains relevant because this industry is relatively stable in terms of role behaviors and attributes. The domain is envisioned as a setting in which entities (individual actors and organizational actors) that occupy distinct positions participate in various construction projects. Each of these positions entails a role, which is a set of functions performed by the entity in the setting.

Several representations of roles have been proposed in previous research in computer science [6], including named space, specialization/generalization, and adjunct instances. All of these representations have advantages and limitations in the context of different situations. The proposed ontological Actor-Role model in this research admits roles as adjunct instances and separates natural types and role types into different hierarchical structures. Many researchers have treated roles as independent types, whose instances are carriers of role-specific states and behavior, but not of identity. From this perspective, an object and its roles are linked by a special relation played-by. In reality, the role of an object is not a different object, but simply its appearance in a given context. From this reality arises the requirement that role instances should not have distinct identities.

B. Actor Ontology to Empower Semantics

This section presents an ontological Actor-Role model, which is a formal and interoperable representation that is intended to encapsulate knowledge about industry actors and their roles in civil infrastructure.

The argument about how to differentiate Roles from natural types (Actors in this case) has never stopped since the concept of role modeling was introduced by [7]. In that article, Sowa distinguishes between natural types "that relate to the essence of the entities" and role types "that depend on an accidental relationship to some other entity." However, the author of [8] believes that the coexistence of both natural and role types in the same type hierarchy weakens modeling practices.

This paper employs [9]'s perspective about the ontological distinction between role and natural types: a natural type is not founded but semantically rigid; a role type is founded but lacks semantic rigidity. Being "founded" means that the instance must engage in relationships with other types, and being "semantically rigid" means that the entity cannot drop its type without losing its identity.

The social functionalist perspective is employed in the definition of roles in the construction industry, and the institution is seen as a combination of architectural, engineering, and construction societies. Each entity holds one or more roles; each role is associated with expected behaviors (a set of relationships) and possesses a set of role-specific attributes.

The ontological Actor-Role model for civil infrastructure includes major concepts for this industry, which can be viewed as belonging to two categories, i.e., entities (the major players in construction projects) and supporting concepts. The category of "entities" includes five classifications that are common to all industries – *Actor*, *Process*, *Product*, *Project*, and *Resource*. "*Supporting concepts,*" which pertain to actors and roles, include *Attribute*, *Parameter*, *Constraint*, and *Mechanism*. A highly abstract structure of the Actor-Role model is shown in Fig. 2.

In the Actor-Role model, a Role is played by one or more Actors and has *Role Attributes* (*Responsibility*, *Setting*, *Right*, etc.). An *Actor* has Actor Attributes (also known as *Natural Attributes* such as *Address*, *Age*, etc.). An Actor or a Role is subject to *Constraints* and *Mechanisms*. A Role or an Actor has relationships (approve, design, manage, inspect, etc.) with other *Entities*. *Natural Attributes* are intrinsic attributes, and *Role Attributes* are extrinsic attributes. This relationship is shown in Fig. 3.

Despite this standard structure, the details involved in representing an object and the roles it plays (assigning a Role to an Actor) vary from context to context, for example, in a traditional design-bid-build project and in a design-build project. In this ontological model, there are few possibilities for the relationships among actors and their roles; it is difficult to cope with the flexibility of a complex industry like construction when a relatively rigid functionalist perspective is employed, as shown in Figure 3 (similar situation exists when assigning attribute to Actors and Roles):

- An Actor will "always be" a Role: a solid circle in Figure 3. For example, a *Structural Engineer* is always a *Designer* (This actor actually could have other roles such as *Site Inspector*).
- An Actor "could be" a Role: an empty circle in Figure 3. For example, some government agencies (such as Ontario's Ministry of Transportation, an instance of a *Government Executive Department*) have in house design staff that act as a *Designer* in a project.
- An Actor will "never be" a Role: A blank intersection. For example, a *Plumber* is never a *Designer*.

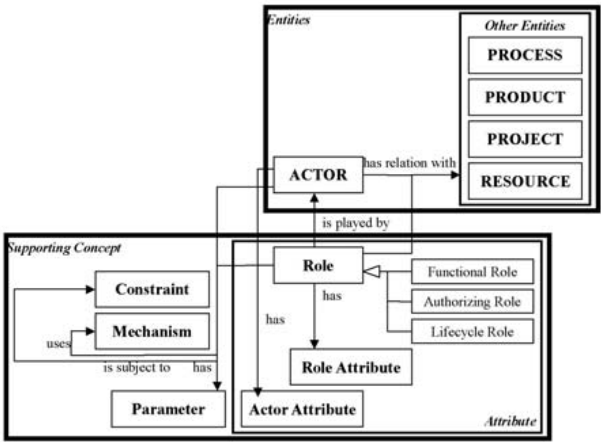

Figure 2: Abstract of Actor-Role Model

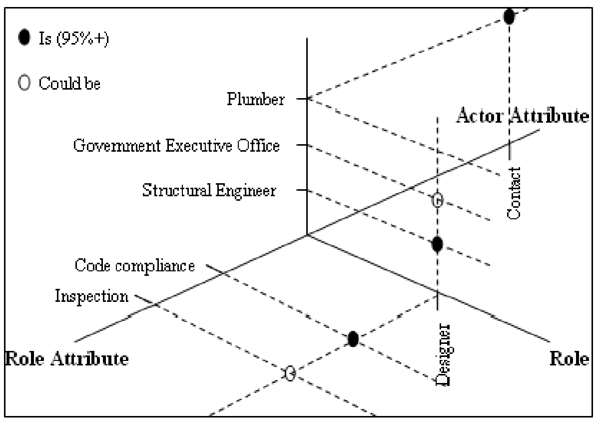

Figure 3: Flexibility of Actor-Role Model

UML diagrams, which are very popular in the object-oriented modelling approach, are employed to illustrate the ontological relationship (aggregation/specification and behaviours). The Actor-Role model was built in layers:

- The 1st level models the major actors and roles in construction projects and their relationships with other entities.
- The 2nd level focuses on the major roles discussed in the 1st level and models each of them in one dedicated UML diagram that expresses the relationships and their attributes.
- The 3rd level is used to model those roles and actors that are introduced in the 2nd level. In addition, some roles only appears in certain kind of projects, for example, a *Heritage Building Review Officer* is involved only if a project has any impact on heritage buildings. Those roles and concepts are important to the industry, but will not appear in the first two levels as general concepts. They will be addressed here.

Although the Actor-Role model uses a flexible approach to accommodate the dynamics of construction projects, it still needs a way to explicitly express the relationships and attributes for different contexts. The Actor-Role model therefore includes some extensions that fulfill this need. For example, the first level uses the traditional design-bid-build as the default context of the project delivery system, and also has two extensions (design-build and construction management) that cover other commonly used project delivery systems. Fig. 4 shows an example of the first level (default) model of the system.

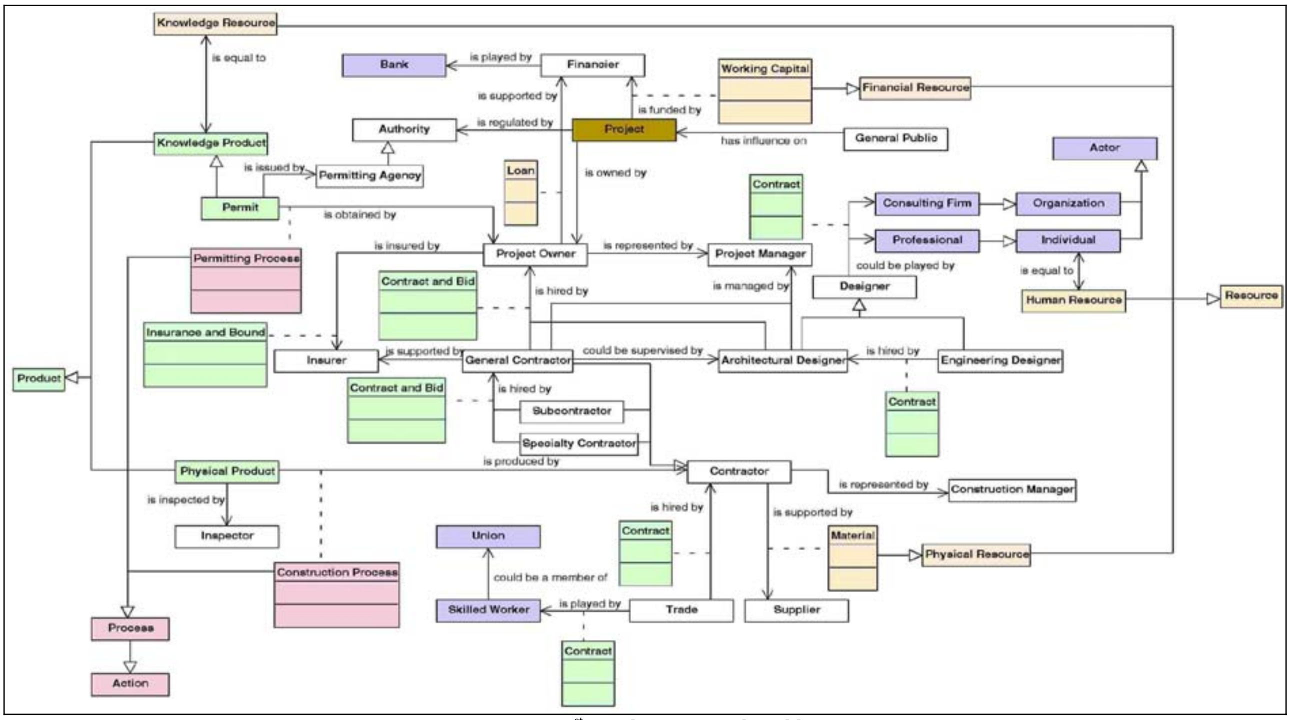

Figure 4: 1st Level (Design-Bid-Build)

C. A Communicaiton Model

In many circumstances, a linear communication model is still popular for the technical communication of information between persons. In the basic model, a message is sent by an information source (a person) via a communication channel to a destination (another person). Reference [4] summarizes the following elements of a communication process: a communication source, an encoder, a message, a channel, a decoder, and a communication receiver. In this research, the communication model is extended to include three more concepts: attribute, communication mechanism, and communication constraint. Fig. 5 shows the basic model.

In this model, the communication of information is composed of six elements:

- A *Source*: This is the initiator of information communication. It is also called a *Sender* and has few other alternative names in different contexts, for example in publish/subscribe (pub/sub) systems it is normally called a *Producer* or a *Publisher*.
- A *Destination*: This is the *Receiver* of the information. Similarly in pub/sub systems it is called a *Consumer* or a *Subscriber*.
- A *Knowledge Item (KI)*: This is the thing to be communicated. [4]'s theory focused on information science and strictly applies to the communication of a piece of *Message*. Our model tries to cover information communication in a more general scope. The thing to be communicated is anything that carries information, ranging from a hard copy of some documents to a computer file.
- A *Communication Channel*: This is the method by which the *Knowledge Item* is communicated.
- A *Composer*: As the principle part of information communication has been extended to a *Knowledge Item*, *Encoder* is no longer to be valid in this model as it is in [4]'s model for a *Message*. The concept of *Composer* is proposed to handle the

composition of a *Knowledge Item*.

- A *Viewer*: Similarly the concept of *Decoder* is replaced by a new concept of *Viewer* which will be responsible to present the *Knowledge Item*.

This model also proposes three new concepts to better represent the communication of information:

- *Mechanism*: This is the collection of concepts that support information communication, including any methods, guides, and measures. For example, *Communication Means*, *Composition Means*, *Archival Means*.
- *Constraint*: This represents an umbrella of concepts that control information communication. For example, *Communication Channel Capacity*.
- *Attribute*: Attribute is used to describe features of information communication. This is also the building block of defining an *Information Event*.

Knowledge Item can be categorized from two perspectives: the type of content and delivery method. Based on the type of content defined by [10], *Knowledge Item* has the following subclasses:

- *Document*: This subclass includes items that are mainly composed of text (plain text or rich text). *Document* has many subclasses like *Report*, *Contract*, *Agenda*, *Notice*, *Request*, *Bid*, *Quotation*, *Specification*, etc.
- *Image*: This subclass represents all items that are mainly images, including *Drawing*, *Picture*, *Photo*, *Chart*, *Figure*, *Diagram*, etc.
- *Audio*: This includes items that mainly are voices like *Voice Recording*.
- *Video*: This is video item like *Video Recording*.

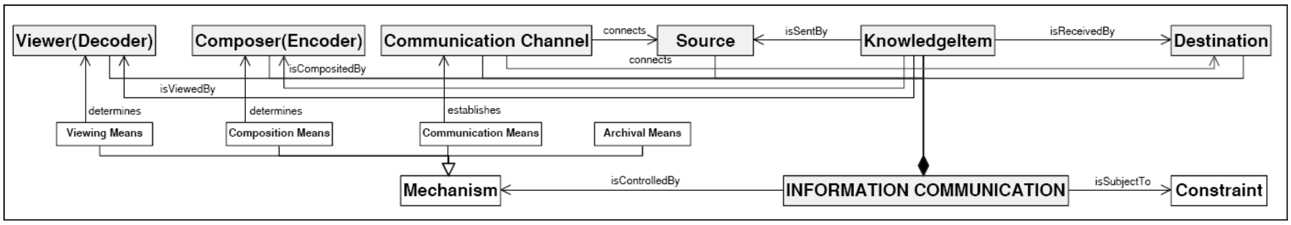

Figure 5: Basic Communication Model

- *Application*: This subclass includes *Software* and *Web Application*. It is composed of *Code*, *Database*, *GUI*, and other components.

Based on delivery method, *Knowledge Item* has the following subclasses: *Email*, *Mail* (any hard copy material could be a *Mail* that can be physically delivered), *Website* which is composed of *Web Pages*, *Computer File*, *Fax*, and *Conversation* including *Phone Conversation* and *Face To Face Conversation*.

Source and *Destination* share the same groups of subclasses: *Individual*, *Organization*, and *Information System*. Any entity in these three subclasses could be a source or a destination of the communication. *Individual* and *Organization* are two major subclasses of *Actor* in Actor Ontology.

Communication Channel has the subclasses like *Emailing*, *Mailing*, *Web Presenting*, *Automated System Processing*, *Faxing*, and *Personal Communication*.

Composer/Viewer has the subclasses like *Human Being*, *Fax Machine*, and *Composition/Viewing Software*.

The most important work in communication model is to categorize attributes which are used to define *Information Event* in the pub/sub system. Each communication component has their own attributes and *Knowledge Item*, *Source*, and *Destination* hold the majority of attributes.

Source/Destination Attribute includes *Source/Destination Type* (the value is from class *Source/Destination*, for example *Engineer*), *Role* (the value is from class *Role* in Actor Ontology, for example *Owner*), *Intrinsic Attribute* (the value is from *Actor Attribute* in Actor Ontology, for example *Name*), and *Extrinsic Attribute* (the value is from *Role Attribute* in Actor Ontology, for example *Responsibility*).

Knowledge Item Attribute is grouped into following subclasses:

- *General KI Attribute*, including *KI Type* (indicating the type of KI), *KI Project Affiliation* (indicating the item is about which project), *KI Process Affiliation* (indicating the item is about which process), *Copyright Owner* (who owns the copyright of the item), *Composition Language* (in which language the item is composed of), *Keyword* (similar to many other keyword classification systems), *Author* (who is the author of this knowledge item), *Creation Date* and *Creation Time* (when is it created), *Security Clearance* (who is able to access the item), and *KI Domain* (what is the item about based on domain classification).
- *Specific KI Attribute*, specifying attribute for particular KI type. For example, if the KI has a type of *Email*, then it has attribute like *Sender/Receiver Email Address*, *Attachment*, and *Subject*.

D. Metching Mechanism in Pub/Sub System

Publish/subscribe is an increasingly popular communication paradigm for many-to-many communication in large-scale distributed systems. Participants in the communication are a combination of producers (publishers) and consumers (subscribers) of information. A publication (an event) is a set of attribute-value pairs that describe a piece of knowledge, while a subscription (another event) is a conjunction of predicates that specifies the constraints on attributes in the publication. In a content-based pub/sub system, the subscriptions express the content of a knowledge item posted by a publisher.

A typical application scenario is one where a system user can inject a piece of knowledge as a publication, P. In this instance, P is a case study of short circuits in electrical design. Another user issues a subscription, S, which specifies anything published by an electrical engineer regarding electrical design that is in PDF file format, but with a file size not over 10M:

P={(SourceType, ElectricalEngineer) (SourceRole, Inspector) (KIType, CaseStudy) (KIDomain, ElectricalDesign) (KIType, ComputerFile) (FileType, PDF) (KIKeyword, ShortCircuit) (FileSize, 1M)}

S={(SourceType = ElectricalEngineer) (KIDomain = ElectricalDesign) (FileType = PDF) (FileSize < 10M)}

Then **P** matches **S** and the subscriber will get this information.

In the proposed model, four types of events are defined: a knowledge item publication event (PE-KI), a knowledge item subscription event (SE-KI), a user profile publication event (PE-P), and a user profile subscription event (SE-P). Matching knowledge of the industry is a matter that involves matching PE-KI and SE-KI, and matching knowledge of people is a matter that involves matching PE-P and SE-P.

E. A Social Web Approach

The Semantic Web is an ecosystem of data, where value is created by the integration of structured data from many sources. The Social Web is an ecosystem of participation, where value is created by the aggregation of many individual user contributions [11]. The SSWP aims to synthesize the strength of these two approaches in order to create a new level of value that is both rich in human participation and powered by well-structured knowledge items.

Tim O'Reilly, who described well the architecture of Social Web systems [12], indicates that the primary driver of value is user participation. The SSWP would be useless if there were not enough knowledge items published by users. Another major function of the Social Web involves a user who is able to tag resources (published knowledge items), using the concepts in the Actor Ontology in order to further enrich the semantics of those items. The user is also able to report wrong tags associated with any item in a way that will improve the quality of the knowledge base maintained. For example, if a user publishes a PDF file that reports a trenchless approach used in a gas pipeline project, and the file is tagged with the keyword "trenchless," then all users who have subscribed to the topic of "trenchless approach" would be able to receive this item automatically. However, if many other users further tagged this item with the notation "recipient = gas engineer" after they read the article, then this piece of knowledge item would be routed to all users who have "gas engineer" as the value of the attribute "profession" in their profile, even though they may not subscribe to anything related to the trenchless approach.

The Social Web also allows users to tag/comment on other users. One example of the use of the Social Web to tag users is eBay, which gains the trust of its users on the basis of ratings from other users.

V. Conclusion and Further Work

This paper presents an innovative information Portal that will facilitate knowledge sharing and information exchange in the civil infrastructure domain with respect to infrastructure system interdependencies. This proposed SSWP employs an ontology specially created to empower the semantics of knowledge items and user communication within the system. The SSWP also utilizes the Social Web's approach to the collective aggregation of the intelligence of all system users in order to ensure the quality of the maintained knowledge base. The combination of the Social Web and the Semantic Web creates a collective knowledge system. The data flow of knowledge sharing and information exchange is realized through a content-based publication/subscription system that encourages many-to-many communication so that the system overcomes the weakness of traditional one-to-one linear communication modes.

This Social Semantic Web approach is a general method to deal with knowledge sharing and information exchange in any kind of domain; as such, it may be easily adopted by other industry sectors. Because the ontology is extensible and scalable, the Actor Ontology can be incorporated into other ontologies in the construction domain for other applications, or the SSWP can incorporate other ontologies in order to expand the area of service.

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