FLOORBOOK: A SOCIAL NETWORK SYSTEM TO ENABLE EFFECTIVE INTERFACING OF PROJECT ACTORS

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ABSTRACT

Construction project participants constitute a complex social human network composed of a heterogeneous and fragmented set of stakeholders. The disjoint group of actors that team to work on a project constitutes collective entities, social networks at different scales in time and space. The proposed social network system is a semantic resource that leverages the communication and coordination of exchanging and sharing information. It is expected that it will enable an improvement in efficiency of the interfacing of actors and information. This semantic resource helps actors to minimize human intervention for coordination and information searching and retrieval, which are activities that demand costly resources and the use of specialized labor.

Floorbook analyzes the vocabulary of the annotations on the forms of representation used in construction documentation, categorizes and models communities according to the user's role in the shared form of representation, and makes suggestions to the users to optimize their particular world view, so that the suggested annotation is more precise and personalized. The basic rational of the approach is that the position of the users in a social network impacts their use in the system, and that the content of the annotations are part of a categorization model of a specific domain.

The proposed social network system works as an effort of collective intelligence that enables the sharing of the semantics of the tags that are associated with the representations. As an effort of collective intelligence, Floorbook (1) models and extracts semantics from informal communication; (2) categorizes and models communities defined by common interests; and (3) self-learns from the history of user actions in the system to enable new value-added services, such as, for example, suggesting new candidate semantic tags as a result of the analysis of the representations to optimize the particular world view of an individual user.

Keywords: social-networking, communication, collaboration, emerging semantics

1. INTRODUCTION

Advancing the competitiveness and efficiency of the construction industry through innovative methods to connect its workforce is one of the urgent challenges for the researchers in our community. Connecting its workforce is the essence that this research project envisions to improve efficiency of communications amongst construction actors. The importance of efficient communication and management of IT has been stated in the latest National Academies of Science report (NAS 2009). It explicitly states the need to "*deploy technologies to manage and communicate electronic data among project stakeholders*", and to "*improve job site efficiency through a more effective interfacing of people, processes, material, equipment, and information*". Floorbook acknowledges this challenge by providing a technological social media platform that enables the connection and communication of its workforce. Although the system is still in its infancy stage, its adoption promises an understanding of collaboration through the World Wide Web technologies within the construction industry. This social network

system will enable researchers to understand the integrated interdisciplinary problems involved in the collaboration paradigm from (1) social, (2) organizational, and (3) technological angles. The superior quality of interfacing of people is especially important to meet new challenges of efficient communication with less use of resources to move the construction industry forward in the development of global, sustainable practices.

This social system also responds to the need of investigating the interaction of construction workforce and technology from the selected viewpoints (1) social, (2) organizational, and (3) technological. It enables, for example, real time data collection and knowledge discovery by capturing new contexts, variables, and units of analysis to further develop investigations from these viewpoints. New social media systems provide a platform for information sharing, interoperability, and collaboration with new contexts that controlled experiments cannot adequately capture (Shneiderman 2008; Suchman 2007). The adoption of social networking systems endows further research on social actors who manage construction project resources. This system eliminates geographical barriers by connecting actors from the network. The system enables the researchers to support hypotheses on finding new ways of interacting in a construction project.

The creation, contribution, and distribution of information content, its personalization and semantic analysis, and the collaborative evaluation in a social network system, all together are a new ways of interacting with information, called the 'social information processing' paradigm (Lerman 2008). As a social network system, Floorbook serves as research platform for scientific research in collaboration in construction and in the new social information processing paradigm. The collaboration framework of the social network system, the components, and the elements for gaining efficiency in connecting, communicating, distributing information, among other activities, are further explained in the following sessions.

2. COLLABORATIVE FRAMEWORK

Construction project participants are entities who play dynamic roles not only in one but in multiple projects. However, they have a constrained ability to coordinate actions and communicate information. The significant number of specialists who intervene in a project, the complexity of the language of building codes and local regulations, the sensitive risk for litigious actions, the complexity of the actors' relationships, and business fragmentation are elements that hinder effective collaboration and communication. Even with the adoption of new procurement methods to improve coordination and collaboration among actors, barriers for communication remain if traditional methods to share and exchange information are still in practice in organizational structures.

The collaborative framework in Floorbook and the associated methods are designed to monitor and adapt project teams to efficiently coordinate construction business processes or teamwork activities where quicker responses, up-to-date information, and reliable information channels of the teamwork are required. An extended list of benefits of team collaboration, at the organization and project levels through the *new social features* provided by the social network systems, is expected with the implementation of Floorbook. The system not only provides the social networking features, but also brings actors together in a virtual set of sessions for team work. Actors will define their relationships to one another in a rich set of ties to the social network. The purpose is to solve the complex interplay of relations and dependencies, which ultimately lead to a success in communication, as actors define their relationships as teams and not as a set of individuals (Foley and Macmillan 2005). For example, as effective team work requires a good management of the nature of specific actors' competencies (Salas et al. 2000), Floorbook will facilitate the search for actors in the network that has the skills, level of expertise, experience, and availability, among other requirements, according to the need that the construction activity demands.

This research framework views the underlying groups of actors that form around interests and expertise as distinct communities in the network. The research takes into account a social layer in the network and does not consider actors as individual entities. Actors are members of communities that center around specific interests and they share their expertise within a team to which they are associated to contribute to an activity of a construction

project. The team has a mixture of actors with different views of the problem, topic, and motivations. The actors from the social network participate in virtual meetings or virtual sessions for construction activities, such as construction progress meetings, technical meetings, cost reviews, or problem solving. The challenge for this research is to search for the implicit communities and to find the underlying categories that inform how each community views the world.

The benefits of this collaborative framework are, but not limited to: the improvement of idea sharing and project relationships and accurate responses to project team activities through the use of a collective intelligence; the reduction of errors, omissions, misinterpretations, and rework/reentry of the shared information by connecting accountable actors through effective informal communication; the identification of key actors and strategic partners to assemble project teams through the recognition of communities of interest; and the optimization of resource allocation and systematic capture of design and construction decisions through self-learning from the history of user actions.

2.1   Social network systems and computer supportive collaborative environments

Floorbook is a social network system that has collaborative functionalities. As a social system, its collaborative functionalities intersect with the functionalities of the systems that feature the Computer-Supportive-Collaborative-Work (CSCW) environments (Grudin 1994; Schmidt and Bannon 1992). The social system, however, is conceived for the purpose of connecting users or actors to others with whom they share connections or latent connections. These collaborators may be individual humans or groups from an organization. The social-network-system actors create online representations of themselves (Boyd and Ellison 2008) and working spaces for collaboration. The social network systems help to communicate information, share documents and rich media, and perform transactions among the actors.

Collaborative project management system (CPMS) for the construction industry, such as Aconnex (Aconex 2010) and Prolog (Meridian 2010), target formal and explicit aspects of collaboration activities. Formal features include the applications of document management and document sharing within project workflows systems in a collaborative working environment. Floorbook as a social system targets implicit knowledge and informal information (Yang and Chen 2008), but also has some features to manage formal information and explicit knowledge. Social-network systems assume direct or indirect relationships between actors that build a framework to investigate actors' awareness regarding collaborators' long-term efforts directed at specific objectives (Carroll et al. 2009; Dourish and Bellotti 1992). This framework also serves to research key resources that have been used by the communities of actors. In sum, social systems and CPMS might share collaborative features, but their frameworks are different.

3.   FLOORBOOK STRUCTURE

Construction project actors continuously generate information to communicate construction concepts within the social network. They create, organize, and distribute information with different types of content in a electronic form of representation (e.g., drawings files and specifications in digital forms). The purpose is to communicate such content to be interpreted by other actors in the network. Floorbook as a social networking system captures and identifies the social actors who share the forms of representation. The representations are generated by a source, shared, and distributed with other actors within the network. The distribution is done along the path of the connections within the social network. In order to describe the structure of the system and have a good understanding of its components, actors and social network relationships are briefly analyzed.

3.1   Actors and social network

Actors' relationships within the social network play an important role in successfully communicating the representations. The term *actor* in this research does not refer merely to individual humans, but also to

organizational units that play a role in the project. The actors' understanding of social network relationships will leverage the ability to identify their roles and obligations within any construction process to delineate and track responsibilities and efficient management of problem-solving and of performance or routine activities. It is expected, for example, that the understanding of the network relationships will benefit the coordination of actors for checking semantic consistency of the content of the representations that is distributed among them. This research claims that actors can arrive at better decisions regarding any type of information-handling activities with the knowledge of social network composition.

The basic assumption is that the communication among actors takes place with the interaction of actors in their manifestation of social individuals within the social network. This research regards organizations as systems of social individuals that create a social structure. This investigation considers actors as social entities, which can be defined as discrete individuals, units of organizations, or collective social units (Wasserman and Faust 1994). These actors are linked to one another and are inter-independently associated by inter-organizational or organizational sets of relationships defined by common, specific objectives to build a project. These actors constitute a dynamic social network, a structure composed of actors who may be human or organizations (Kadushin 2004) that have one or multiple relationships among them.

3.2   Interpretation of Forms of Representation and Acts

The interpretation of the distributed forms of representations is the actor's rationalization and identification of the representation's meaning or the representation's intended semantics. The interpretation involves a sense-making process in which the actors turn circumstances into a situation that are comprehended explicitly (Weick et al. 2005). The explicit organization of such circumstances influence actors' actions. Therefore, actors' actions are driven by the interpretation of the semantics of the representations. The actors' actions are constrained by social contexts, such as institutional constraints of the construction organizations. For clarity, the firms' constraints can be expressed in organizational rules such as the rules to deliver a construction document within the workflow.

Construction project actors in a social network are virtual teams, as defined by Maznevski and Chudoba (2000), where geographic boundaries become imperceptible by the information system platform. They perform organizational decisions and actions and each of those comprises a communicational activity. Actors and their virtual teams interpret information and perform actions. These actions of the individual actors can be analyzed as *acts*. This research takes into account two types of acts in the *social structure* as Dietz (2006) suggests, *production acts* and *coordination acts*. These *acts* are basic pieces to understand the actors' operations within a social network. However, actors' roles in a construction project are typically not aligned to the defined roles assigned by the organization. The roles that the actors play in organizations are defined as the authority and responsibility as the executor of a transaction (Dietz 2006) within a routine or non-routine activity.

For an illustration, consider Figure 1, which illustrates *production* and *coordination acts*. The relationship between the form of representation and the actor or interpreter is articulated according to the semiotic framework developed by Mutis (2008b) that explores the understanding of forms of representation employed in the construction industry. The semiotic framework explains the roles of symbols, the way in which actors act according to the social rules that are used, for example, for coordinating teamwork members. Therefore, we can identify the steps where the proposed social networking system can provide efficiency in interpreting and collaborating activities.
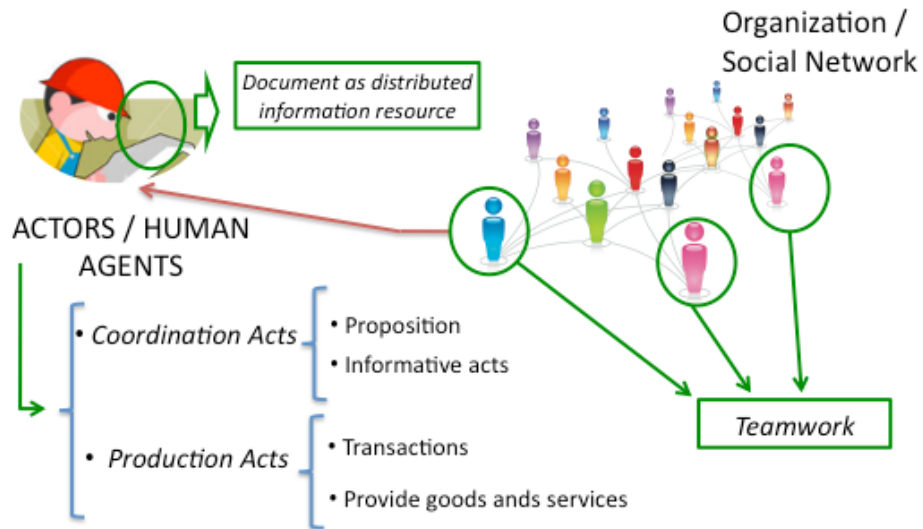
Figure 1: Coordination and production acts (Dietz 2003) and virtual teamwork

As shown in Figure 1, actors that belong to a social world framework of norms, laws, values, and beliefs perform interpretations of signs. These signs have meaning and validity, and the actors must identify the intentionality in its framework. This framework constitutes a pragmatic approach to sign (Dietz 2003). Therefore, the actors secure the semantic consistency of such sign by verifying the validity in the pragmatic framework, which is done through (1) conversations, (2) dialogs, and (3) negotiations. These actions are coordination acts. What the actor interprets is a set of signs that are syntactically expressed by a formal structure, such as a data file, syntax language, etc., which are carried in some physical material such as hardware or paper-based traces, as illustrated in the distributed information resource in Figure 1.

When performing coordination acts, the actors attempt to comply with commitments or make agreements towards production acts. In coordination acts, the performer directs a communicative act to the addressee (Dietz 2003). These acts are more defined acts than general illocutionary acts (Searle 1969; Searle 1985). Request, promise, accept, and deny are examples of speech acts that indicate actions for any role as a performer, addressee, or interpreter. Mutis (2008a) introduced speech act theory to the communicative acts in construction and identified the interpretation as a central act based on the semiotic layers. Therefore, this research designs a framework for communication and coordination based on the satisfaction of semiotic tenets.

3.3 Representation-actor-tag relationship

The proposed social networking system will connect members of the network to enable virtual teamwork sessions, as they are executed in face-to-face meetings. Figure 2 shows team sessions (t_j) of a virtual team from a project (n_i). The system enables the controlling of multiple projects (n_i), with multiple sessions (t_j). The system supports the creations of projects (n_i) from the connections of a social network. As was aforementioned, the system supports the distribution, sharing, and exchanging of forms of representation of information. The members of the project input into the system the digital forms of representations, and they explicitly retrieve specific information from the project. The purpose is to have discussions about the representations (e.g. construction drawings) within the sessions, share specific information among the virtual team, and tag such representations. The virtual team explicitly shares information within the session that ranges from construction documents to 3D models. The session dialogs and tags are indexed to be stored and later retrieved in the system repository, and analyzed within a reasoning module in the system.

As shown in Figure 2, one actor with a set of bonds ties another explicitly with a project (n_i). The proposed system will register and combine all individual contacts to create a social network. For this purpose, the social networking system enables a teamwork activity to perform communication acts in group sessions through written dialogs within the sessions (t_j). To assist the actor in the interpretation, communication, and coordination of the shared information in the network, the proposed system has the ability to provide, for example, intelligent tags through a folksonomy to reduce the semantic or pragmatic distortion of the shared information. The shared information, which is associated with each virtual team's work, is documents that are typically employed in construction projects, such as drawings, specifications, and project manuals, as shown in Figure 2. For example, a virtual teamwork A105, which is connected by the social network system in the project Austin Commercial 1, is interpreting a detail of a two-dimensional structural drawing S3501 of the 79th floor of the main project building.

The system also captures the following representation-actor-tagging relationships: (a) the association between the explicit tags to the shared documentation, which is the subject of discussion in the session, and the actors in the session; (b) the association between the vocabulary employed in the explicit tags and the actor who produces such tags. The purpose of modeling the vocabulary is to populate the system's folksonomy, which is the result of personal tagging done in a social environment of information and resources for one's own retrieval (Gruber 2007; Smith 2006; Vander Val 2007). One of the objectives of the system is to personalized vocabulary through the folksonomy. The tag vocabulary provides a rich understanding of the information resource (d_j) being tagged.
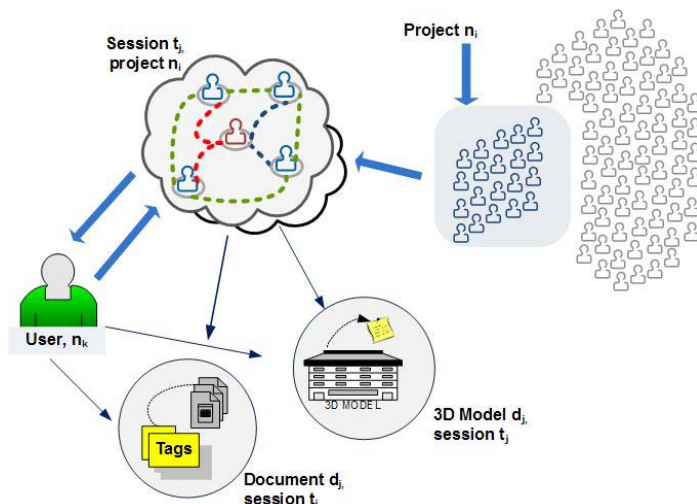

Figure 2: Instances of annotated representations and their social dimensions
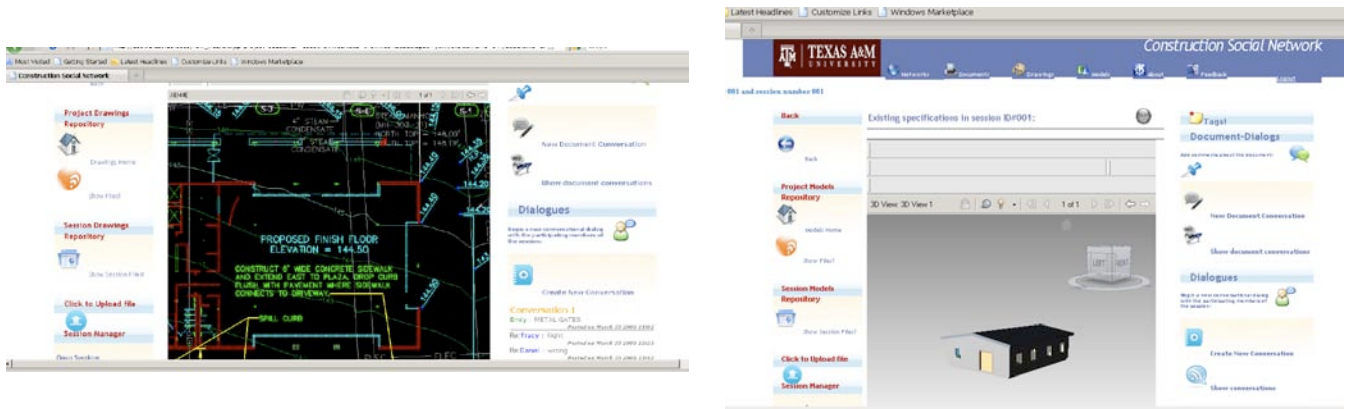
4. FLOORBOOK SOCIAL NETWORK SYSTEM

Floorbook is a social networking system that collects information from users through tags and dialogs to aggregate information for information discovery. As it is explained in Mutis' semiotic framework (2008), there is a social dimension associated with the representations, in this case instances of documents. The assumption is that the aggregation of individual actors' interactions within a network would lead to an effect of semantic discovery of collective actions. New efforts in the same directions have focused on large-scale folksonomies from community web-ontologies from web-pages (Mika 2007).

For example, Floorbook system's purpose is to have the ability to extract semantics of the representations and of the annotations to suggest information for particular users. An analysis of the existing connections of the network in a construction project and discovery of implicit connections within the social network is performed. The basic

rationales are that (1) the position of the users in a social network impacts their use in the system and that (2) the syntax of annotation associated with the documents or the distributed information in forms of representation is comprised in a categorization model of the construction domain.

To illustrate the dialog and tag systems that annotate the distributed information in the network, see Figure 3 (a, and b). The figure shows two screenshots of the Floorbook network system prototype. It displays components of the system that are designed to enable coordination acts. These acts facilitate the necessary and sufficient conditions through informative acts to guarantee semantics and reduce the information distortion in the actors' social framework or social layer. The purpose is to satisfy the actors' understanding of the semantics of shared information. The system has services components, which are functional for simulating the virtual project sessions. At this initial infancy stage of Floorbook, the current services are:

1. Project (n_i) document repository. It provides a repository service for the retrieval of electronic documents. The repository has permission privileges to allow updates of project documents by specific project actors. Any member of a social network that has been included in the project (n_i) can view the documents. However, new permissions are possible to set up for further users' restrictions. Currently, Design Web Format (DWF) and (DWFx) based on ISO/IEC 29500-2:2008, Portable Document Format (PDF), and some image file formats are accepted to be downloaded to the users' browser. See left side of the screenshots from Figure 3 (a) and 3 (b).
2. Session (m_j) document repository. It provides a repository service for the retrieval of electronic documents for session (m_j). The repository has permission privileges to allow updates and storage of project documents by specific project actors. Any member of the social network that has been included to the session (n_i) can view the documents. See left side of the screenshots from Figure 3 (a) and 3 (b).
3. Annotations. Floorbook has the following annotation services: (1) annotations of documents, (2) annotations of documents with dialogs, (3) annotations of the virtual sessions of actors' conversations. See right side of the screenshots from Figure 3 (a) and 3 (b).
4. E-mail notifications. The system notifies users when they are invited to a project or a session of a specific project and when an update of the documents of a session occurs.
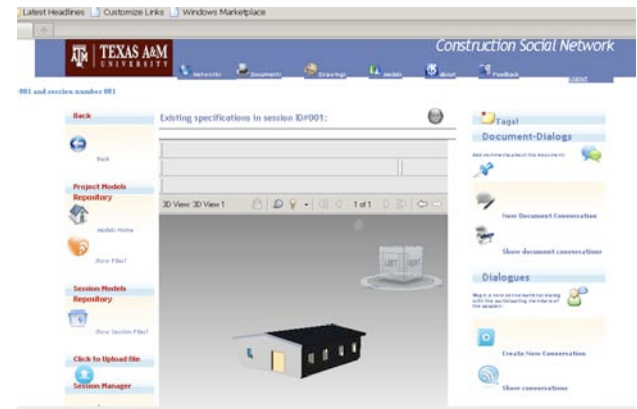
(a) Drawing tab   (b) 3D modeling tab
Figure 3: Floorbook Screenshots.

5. CONCLUSIONS AND FUTURE WORK

Floorbook is a social network system that is used as a research platform to investigate a new class of collaborative semantic social networking among actors in the construction domain. Floorbook is a novel approach that leverages the communication of information and coordination of teamwork within the dynamic social network grid to improve efficiency of current collaborative methods through a more effective interfacing of actors and information. The networking is a social semantic knowledge sharing system that enables communication and coordination of teamwork members by sharing and annotating electronic forms of representation in construction, such as drawings, specifications, and other construction documents. The system connects construction project actors who belong to the network community and discovers communities of practice where actors have common interests and where specific levels of expertise are required. The underling theories of the system are based on the semiotic framework that explains the roles of symbols and the way in which actors act according to used social rules. It is expected that Floorbook will provide significant efficiency in interpreting representations as sources of information for collaborating activities in construction projects.

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