Trust-oriented multi-visualization of cooperation context

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Abstract

The building construction activity is uncertain by nature because of its specificities (e.g. heterogeneous stakeholders, ephemeral teams, etc.) and particularly, because it corresponds to a particular mode of production "on site" and it is submitted to variable conditions. So the construction management is essential to warrantee the good progress of the construction activity. Moreover, trust is central in this type of activity to surmount the uncertainty. Therefore we suggest making a connection between the coordination assistance tool and the notion of trust. This paper suggests representing trust in the correct progression of the activity to support the construction management and using it to guide user navigation in a multi-visualization environment. It will describe a methodology to measure trust and implement it in a multi-view prototype.

Keywords--- **Trust representation, AEC** (Architecture Engineering and Construction), Construction management, Multi-visualization, Cooperation context, Coordination assistance.

1. Introduction

Trust is an important feature of our everyday lives (Marsh 1994) and particularly when we consider cooperation between actors. It appears as a factor of organizational efficiency and as a substitute of complex and costly contractual forms (Brousseau et al. 1997). Trust has the capacity to surmount the risk linked to the uncertainty of certain environments (Luhmann 1988). Moreover trust may be particularly important for the the ability of workers to self-organize (Rousseau et al. 1998). When trust is present in an organization, the behaviors preserve the interest of the collectivity and limit the opportunism.

The building construction activity describes an uncertain environment where trust is central. The

uncertainty results essentially from the production mode on site. The building site is submitted to variable conditions of production (e.g. weather, ground...). Moreover stakeholders are heterogeneous and the team is composed for the duration of the project.

Therefore some dysfunctions can appear. (Tahon 1997) identifies four types of dysfunctions on the building site:

- Dysfunctions related to the documents and their circulation (e.g. problems linked to the update of plans)
- Dysfunctions related to the actors (e.g. mistrust between actors limiting the exchanges)
- Dysfunctions related to the construction activity and its progression (e.g. delayed construction tasks)
- Dysfunctions related to the building elements and their execution (e.g. difficulty to construct on site an element as designed).

In this context the actors' autonomy and their sense of responsibility are essential to warrantee to the quality of the results (Bobroff 1994). Moreover, the construction management becomes essential to ensure the correct progression of the activity (i.e. as expected) and limit the impact of these dysfunctions.

In AEC projects, coordination information is complex and dispersed in numerous views, often not coordinated, i.e. planning charts, meeting reports, plans and so on (Kubicki et al. 2007b). Then a major issue for construction managers remains in consolidating heterogeneous pieces of information in order to appreciate risks.

It is suggested in this article to make a connection between trust and coordination activities. The aim of this research is to use the representation of trust to improve the understanding of the state of a cooperation context. A methodology for trust representation is described. Then it is implemented in a prototype intended for the construction manager and providing multiple views on the cooperation context. Finally some validation elements are presented.

2. Towards a representation of Trust

Literature discusses trust as a particular relationship between actors, organizations, and eventually artifacts (e.g. trust in a website) (Sutcliffe 2006). Trust is largely considered as "psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau 1998). In the case of our works, trust is considered more globally in the "correct progression of the activity" and depends on the four dimensions of the activity context (See Figure 1):

- The progress of the *task*,
- The *actor* (in charge of performing the construction task),
- The *building element* (resulting from the construction task),
- The *document* (required to perform the construction task).



Figure 1 Approach of trust in the correct progression of the activity

The approach is based on five steps inspired about (Chang et al. 2006) (See Figure 2):

- 1) Modeling the construction activity knowledge,
- 2) Identifying the aspects which trust relies on,
- 3) Determining the measurable trust criterion,

- 4) Defining a method for calculating trust,
- 5) Implementing trust in a prototype.

The first step relies on anterior research works concerning the study of the particular context of the building construction activity (See (Kubicki 2007b)). Then for each activity dimension, the aspects of trust and the measurable trust criterion have been identified (Step 2 and 3). Table 1 presents an extract of the results.

Activity dimension	Aspect of trust	Trust criterion		
	Progress	State of the		
	ligious	Critical task		
		Number of		
Progress of the	Execution	remarks in the		
construction task		report		
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Table 1 Aspects of trust and trust criterion – Extract of the results

After that, a method for automatically calculating trust on the basis of the value of the trust criterion identified in the previous step has developed. The method is inspired about S.P. Marsh's works (Marsh 1994; Marsh et al. 2005). The method that we suggest relies on the calculation of five trust values:

- The "Global Trust" value corresponds to trust in the correct progression of the construction activity.
- The "Specific Trust" values correspond to trust in the diverse dimensions of the activity:
 - Task Progress-Specific Trust (TP-ST)
 - Actor-Specific Trust (A-ST)
 - Building Element-Specific Trust (BE-ST)
- Document-Specific Trust (D-ST).

Each type of Specific Trust is calculated according to the values of the trust criterion. Then a weighted average of the Specific trust values enables to measure the Global Trust. Each type of trust is associated to a numerical value comprised between -1 (for the weakest



Figure 2 Process for representing trust in the correct progression of the activity



Figure 3 Scale of trust

level of trust) and 1 (for the highest level of trust). (Guerriero et al. 2008) describes in detail the method for calculating trust.

3. Implementing trust in a prototype

The use of the representation of trust in a tool to support the decision is not a new approach. Some ebusiness services use trust to support the transaction between the vendors and the customers (e.g. $eBay^1$, Amazon²) or to inform about the quality of a product (e.g. Amazon). In the AEC sector some applications relying on the notion of trust are appearing. We can cite for example AEC Performance³ or Webses (Arslan et al. 2008) allowing the evaluation of the actor's performance. The approach suggested in this article proposes a more global vision about trust in the correct progression of the activity and not only in the actor's performance. It suggests using trust indicators to support the construction manager's activity.

3.1. Representation of trust

In order to propose a visualization of trust, the first stage was to analyze the existing representation on the ecommerce services. Moreover a study of the information visualization has enabled to structure the approach. J. Bertin's works (Bertin 1967) on the semiology of graphics has provided a matrix combining the common task related to the information visualization (i.e. association, selection, order, quantity) and the retinal variables (i.e. size, value, texture, color, orientation, shape) (Spence 2001). We studied diverse combinations of these elements. The principal constraint was to consider the reduced space for the display of the different type of trust indicators and the fact that they had to be placed side by side. In addition, it was important to suggest a representation of trust that could be familiar for the user.

Therefore this analysis led us to consider the symbol of "star" largely used in the e-commerce interfaces (e.g. eBay or Amazon) to represent the user's evaluations. The color and the number of stars appear as the most frequent variables in the interfaces. So the choice is to combine these two variables in order to define a scale of trust (See Figure 3) that associates a graphical value to a numerical value of trust (resulting from the calculation of trust method). This scale suggest two yellow stars for the highest level of trust (numerical value = 1), one grey star for the neutral value of trust (numerical value = 0) and two red stars for the lowest level of trust (numerical value = -1).

3.2. Specific trust and related AEC views

Global and specific trust indicators inform on the state of the progress of the activity. In order to better understand it, the actors make use of "business-views" representing the cooperation context, e.g. meeting reports, planning views and so on. These views manipulate distinct sets of data. But conceptually they could be considered as a whole: a single project cooperation context.

Techniques of multiple window-based visualization (Wang-Baldonado et al. 2000) have demonstrated their efficiency when applied to text collections (Eler et al. 2008), network traffic analysis (Kauer et al. 2008) or software development (Therón et al. 2007). Multi-visualization of the cooperation context based on AEC-specific views has been treated in (Kubicki 2007b) and led to the design of a multi-views prototype "Bat'iViews". This work demonstrated the interest of coordinating multiple views to address AEC coordination problems. But it lacked in facilitating the navigation of its users in complex cooperation contexts.

Based on this experience, trust indicators are envisaged as guiders enabling to facilitate the user's navigation in configurations of multiple views.

An AEC dedicated model-based infrastructure has been introduced in (Kubicki 2007b). It suggests distinguishing between a cooperation context (i.e. domain) model and view modes models. It enables to select appropriate content for visualization but also to manage interactions between views (e.g. relationship between a task in planning view and a remark in meeting report view). Following this modeling approach several

¹ <u>http://www.ebay.com</u>

² http://www.amazon.com

³ <u>http://www.aecperformance.com</u>



Figure 4 View of the trust-based dashboard

view models have been designed in order to be implemented in a prototype interface.

3.3. Presentation of the Bat'iTrust multi-views interface

Based on these previous works about multivisualization and the results about trust and its calculation, the Bat'iTrust prototype is developed. The proposition suggests including a view dashboard based on trust in the Bat'iViews prototype (described before) for guiding the navigation in the views of the cooperation context. This approach helps us in going beyond the limits related to navigation capabilities identified in Bat'iViews. The proposition focuses on the construction manager's activity during the construction stage and on the information he has at his disposal to assure the coordination of the construction activity. Bat'iTrust proposes a new way for monitoring the construction activity based on a dashboard centered on the concept of trust.

Bat'iTrust puts into relationship a dashboard view (displaying the construction tasks and their diverse indicators of trust) (See Figure 4) with different configurations of views corresponding to the four dimensions of the activity (i.e. task progress, actor, building element, and document). Each of these configurations is composed of AEC-specific views well adapted to understand a dysfunction occurring on a specific dimension. Let us consider for example the "task progress" configuration of views. It is composed of:

- The view "Planning" that illustrates the construction process.
- The view "Remarks in the meeting report" that displays the open remarks which have been identified during the building site meeting.
- The view "Weather forecast" that states the weather forecast on the building site.

In the Bat'iTrust multi-views interface, the dashboard based on trust is the "master" view structuring

the user's navigation. It consists in the entry point for the user. The configurations of views are updated in function of the selection in the dashboard and allow the user to better understand the value of the indicators of trust.

Therefore the dashboard based on trust informs the construction manager about the potential dysfunctions on the building site thanks to the trust indicators. When the user selects a specific trust indicator (i.e. TP-STI, A-STI, BE-STI, D-STI), Bat'iTrust returns the appropriate arrangement of views established in order to provide the pieces of information necessary to understand the nature of the problems potentially detected. For example (See Figure 5), when the user selects a building element – specific trust indicator, Bat'iTrust provides a specific configuration of views highlighting the pieces of information related to the construction task under consideration:

- The view "3D model" highlights the building element resulting from the construction task under consideration.
- The view "Description of the building element' displays the specifications of the building element.
- The view "Budget monitoring" displays information related to the budget of the building element (i.e. cost, cost overrun...).

The Bat'iTrust prototype relies on SOA architecture. It consists in a RIA (Rich Internet Application) application implemented with the Flex technology (Adobe) and a set of business services implemented on the basis of the REST technology (Richardson et al. 2007). At the moment, only the data coming from three applications can be used: a task management tool, a meeting report management tool and a document exchange management tool (Kubicki et al. 2007a). Therefore, some applications have still to be developed to cover all the cooperation context dimensions and then to allow the automatic calculation of trust indicators.

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Figure 5 Description of the navigation in the Bat'iTrust prototype

4. Validation

At this stage of this research work, two phases of validation have been carried out:

- The first phase of validation has allowed us to validate the trust criterion thanks to a survey which has allowed confronting them with the practitioners (14 people: architects, engineers, constructors, and construction managers).
- The second phase relies on the use of the Bat'iTrust multi-views interface by some experimental subjects representative from the construction sector.

This second stage was intended to identify the interest of the proposition for supporting the coordination of the construction activity. Seven people (architects (3), architects-researchers (2) and students (2)) tested the prototype on the basis of a scenario close to a real project. The experimental subjects expressed an interest for the dashboard based on trust. They estimated that trust indicators allowed guiding the navigation in identifying the potential dysfunction and that they were

reliable to assure the coordination of the construction activity. The post-experiment survey especially demonstrated that the content of the specific configurations of views were adapted to their usage. Some of the experimental subjects identified that the multi-views interface presented a large density of information. Nevertheless it did not appear as a problem possibly because the views included in the multi-views interface look like the paper documents that the subjects use in their daily work.

5. Conclusion

Trust representation is often used in e-business interface to assist the decision processes (e.g. eBay). In light of this observation, this article suggests using trust representation as support for the construction management. It has suggested a connection between the notion of trust and the construction assistance tool and to consider the concept of trust more globally in *"the correct progression of the activity"* (i.e. in the diverse dimensions of the activity and not only the actors). This paper has described a method for measuring and a visualization mode to represent trust. A multi-views interface results from this approach: the Bat'iTrust prototype. This prototype consists in a multi-views interface inside of which the navigation is guided by a trust-based dashboard representing the trust indicators in the construction tasks. It goes beyond the limits of the Bat'iViews prototype developed before, by using the dashboard as a "master view" to guide the user in navigating in the interface.

This result allowed carrying out a first phase of validation. Even if it is not a real-world experiment, this one allowed demonstrating the potential of the representation of trust 1) to assist the coordination of the construction activity and 2) to guide the user in the navigation in the cooperation context. The feedback expressed by the experimental subjects was very positive. At this time of this research, the target is now to propose new applications required for calculating automatically trust indicators in order to soon carry out an experiment in a real context of construction activity.

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