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Modelling Information Behavior of Communication System Supported by Building Information Modelling

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Abstract. Building Information Modeling (BIM) is in use today and is flourishing in Architecture-Engineering-Construction (AEC) industry. However, the lack of agreement pertaining to the definition and the framework of BIM has stifled its adoption. What is more, how BIM functions during the information communication process has not attracted the expected level of attention, especially from the perspectives of information behavior and communication. The AEC industry and the research community need a systematic model that helps them better understand BIM and its function as a communication platform or processor. Three steps are conducted to fill this gap. Based on Hall's three-dimensional morphology of system engineering, a framework of BIM is proposed from the three perspectives of time, logic and profession. Each perspective is further reduced to detailed components and indexes. In order to study how BIM functions during the information communication process, an information behavior model of a communication system is proposed by integrating and developing models of system, communication and information behavior. Finally, the importance and limitations of the research are discussed. The research thus promotes a common understanding of BIM and its function during the information communication process.

Keywords: Building information modelling, information behaviour, communication, system

1. Introduction

Although BIM is in use today and is flourishing in the Architecture, Engineering, and Construction industry, there has been a lack of a consistent perception about the definition of BIM and its function during the information communication process. If you ask 10 different engineering professionals or organizations, you will receive 10 different answers (Fisk and Reynolds 2009). The AEC industry and the research community need a systematic model that helps them understand BIM better and its function as a communication platform or processor. Therefore, understanding BIM, especially from perspectives of information behavior and communication, shall be instrumental for those who work in the area. This paper reports a three-stage study for this purpose. The three stages of the work are:

- Reviewing BIM-related studies and proposing a BIM framework.
- Reviewing literature about system, communication, and information behavior, and proposing an information behavior of communication system supported by BIM.
- Discussing about significance and limitation of the research.

2. Framework of BIM

2.1. Review on BIM-related Studies

One might think that BIM needs no introduction but it should come as no surprise that currently BIM is an ambiguous term that means different things to different professionals. In a survey of 202 AEC professionals, Suermann and Issa (2007) identified three groups with different definition of BIM from construction and design perspectives. An empirical survey of Aranda-Mena et al. (2008) indicated that BIM

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is not only defined in various ways according to particular professions but that there is also confusion at three different levels, i.e., software, process and approach.

The term BIM as such was originally popularized by Jerry Laiserin, to refer to the ability to use, reuse and exchange information. More recent material offers several BIM definitions. BIM can be regarded as a cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and BIM is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility (NIBS 2007). BIM can also be considered as an integrated process that vastly improves project understanding and allows for predictable outcomes (Autodesk N.D.). In addition, it can be understood as a modeling technology associated with a set of processes to produce, communicate, and analyze building models, interfaces, methods, and applications that are pertinent to BIM technology (Eastman 2008). What is more, BIM is considered as the development and use of a computer software model to simulate the construction and operation of a facility, and results in a Building Information Model, which is a data-rich, object-oriented, intelligent and parametric digital representation of the facility. From the model, views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility (AGC 2006).

All definitions mentioned before seem to agree that BIM is a digital representation of the building and emphasize Information "I" in BIM. However, BIM is a multi-dimensional concept that functions in different ways. Recent research on definition of BIM appears to bias to a certain perspective or profession, and lacks a comprehensive understanding of BIM. This research aims to address this research gap. Based on A D Hall's three-dimensional morphology of system engineering (Hall 1969), a systematic framework of BIM is proposed from the perspectives of time, logic and profession.

2.2. Proposal of BIM Framework

Based on A D Hall' three-dimensional morphology of system engineering, a framework of BIM is proposed from perspectives of time, logic and profession, which are further reduced to detailed components and indexes.

As you can see in Figure 1, the time dimension is segmented by major decision milestones. The intervals between these milestones can be called phases, and they define a coarse structure depicting a sequence of activities in the life cycle of a building project from initiation, design, construction, operation, restoration, to demolition.

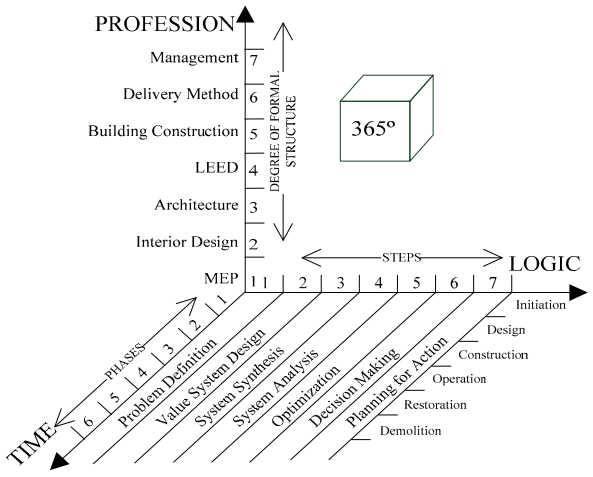

Fig. 1: Three-dimensional morphological box for Building Information Modelling.

The second dimension models a problem solving procedure, the steps of which must be performed in any order, but each of which must be performed no matter what the problem. These steps may be repeated in successive phases. The flow of logic, not time, is the essential feature of this dimension, and this logic comprises the fine structure of systems engineering.

Hall referred the third dimension to the body of facts, models, and procedures which define a discipline, profession, or technology. Here the third dimension includes professions related to construction project. In decreasing order of formal structure, the intervals along this scale are: Mechanical Electrical and Plumbing (MEP), interior design, architecture, Leadership in Energy and Environmental Design (LEED), building construction, delivery method, and management.

In order to better understand BIM, especially during information communication process, the next section aims to model BIM's function during information communication process from perspectives of communication and information behavior.

3. Modelling Information Behavior of Communication System Supported by BIM

3.1. Review on Studies of System, Communication, and Information Behavior

Information behavior is meant those activities a person may engage in when identifying their own needs for information, searching for such information in any way, and using or transferring that information (Wilson 1999).We can take the origins of research in information behavior back to the Royal Society Scientific Information Conference of 1948 (Royal Society Conference 1948), when a number of papers on the information behavior of scientists and technologists were presented. Throughout the period the one constant complaint of commentators has been that researchers have not built upon prior research in such a way as to cumulate a body of theory and empirical findings that may serve as a starting point for further research (Wilson 1994).

Given the amount of information-related research in various aspects of communication studies, information behavior is a part of human communication behavior. This paper tries to adopt qualitative methods to ally work in social sciences that might offer more robust information behavior model of communication system supported by BIM by integrating models in system, communication, and information behavior.

The abstract structure of system is shown in Figure 2 (Wei 1995). As you can see in the figure, X represents information input, which will be strengthened or weakened by residual error ε. Y represents information output after being dealt by processor, which is intervened by external variable f. Y' representing the feedback originated from Y, inputs the related feedback information to processor again.

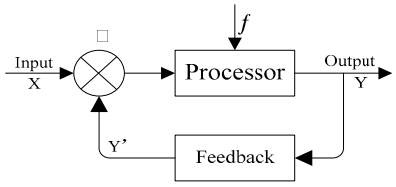

Fig. 2: The abstract structure of system (Wei 1995).

As you can see in Figure 3, Belkin (1978) proposes that the information associated with a text is the generators' modified (by purpose, intent, knowledge of recipient's state of knowledge) conceptual structure which underlies the surface structure (e.g. language) of that text.

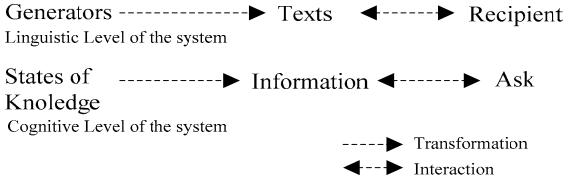

Fig. 3: The communication system of information science (Belkin 1978).

The concept of information, from a perspective of information science, has to satisfy dual requirements (Ingwersen 1992): on the one hand information being the result of a transformation of generator's knowledge

structures (by intentionality, model of recipients' states of knowledge, and in the form of signs); and on the other hand being something which when perceived, affects and transforms the recipient's state of knowledge.

However, the effect of communication on the recipient's state of knowledge is neither expressed in the model nor in the concept statement. The concept in Belkin's verbal description emphasizes the generation and then relies on the context of the communication model while ignoring the effect (Ingwersen 1992).

Wilson (1999) simplifies his model on 1981 to Figure 4, renames information sources 'channels of communication', links the basic model to the communicator as the originator of messages over the channels of communication and shows a feedback loop through which the communicator learns of the recipient's response to the communication. Wilson intends to enlarge the original model to link the fields of communication and information behavior and consider the relationship in the information-seeking process that have not had detailed treatment in information science research.

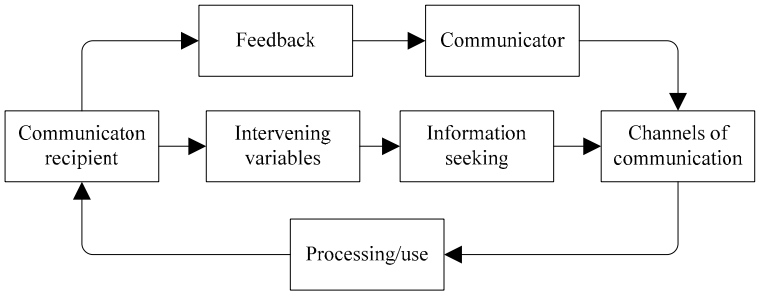

Fig. 4: Relationship between communication and information behaviour (Wilson 1999).

One of the improvements of Wilson's model was the recognition of the effect of communication on recipient as feedback. What is more, the initiative information seeking process of recipient is also presented. Information arises as a consequence of a need by recipient, who, in order to satisfy that need, seeks information through channel of communication (Wilson 1981).

Although Wilson intends to draw attention to information processing/use (Wilson 1981), the model does not detail the processing/use process nor channels of communication (information sources).

3.2. Proposal of Information Behavior Model of Communication System

The various models represent different aspects of the overall problem: they are complementary, rather than competing. This analysis of various models leads to a model integrating ideas relating to system, communication, information behavior with issues of processor (information sources) design (see Figure 5).

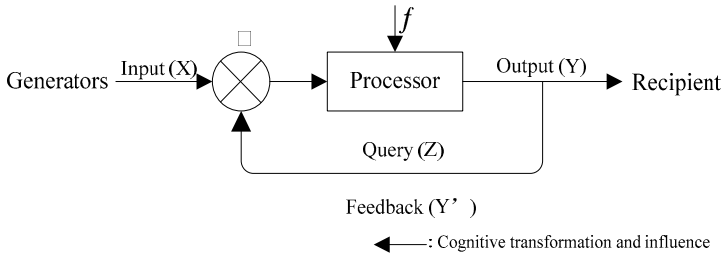

Fig. 5: Information behaviour of communication system.

When we examine this model, we can see its close resemblance to other models mentioned above. In particular, the input-output framework resembles the system structure; Belkin concerning information science with a cognitive view of the situation is also displayed through cognitive transformation and influence in the model; Wilson's model of communication and information behavior is also expressed in a more simple and precise way: we can see that information is created in two ways. On one hand, information (X) is originated from communicator, passing through channels of communication as (Y) to recipient, who then sends feedback (Y') to the communicator and on the other hand, information (Z) arises as a consequence of a query by recipient.

Besides integrating models above, a number of other elements are made explicit: first, within each area of the model, the functions of generator, recipient and processor are the result of explicit and implicit cognitive models of the domain of interest at that particular point. Thus, generators or recipients have models of their work-task or their information need, or their problem or goal, which are usually implicit, but often capable of explication. Again, processor is an explication of the system designer's cognitive model of what the system should do and how it should function.

Secondly, the needs for these models or cognitive structures and their transformations to be effectively communicated throughout the 'system' are pointed out, which will include the generator, the recipient and the processor.

Third, the processor is brought into the picture, which suggests that a comprehensive model must include the system that points to the information objects or settings that may be of interest to the enquirer.

Finally, the model is applied in the context of Architecture-Engineering-Construction (AEC) industry, in which Building Information Modeling (BIM) serves the function of the processor in the model, as you can see in Figure 6 below.

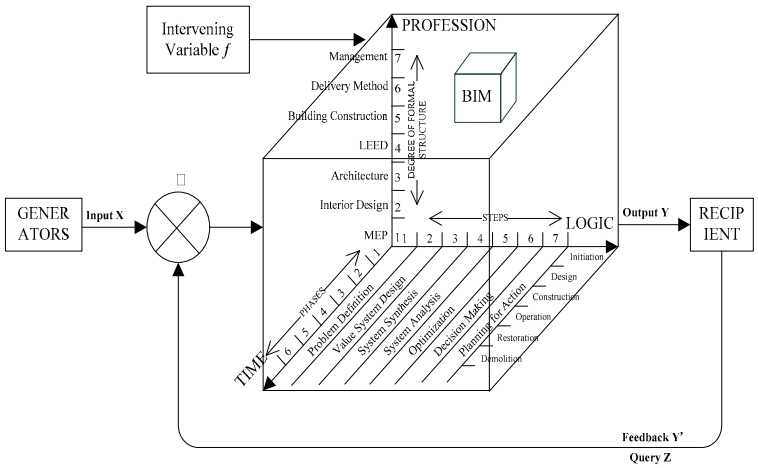

Fig. 6: Information behaviour of communication system supported by BIM.

4. Conclusions

One of the reasons that led to the research was the recognition that research about BIM's role during information communication process had received little attention and, within information science, that statement is still relatively true today. Nor has much attention been devoted to the integrative and comprehensive framework of BIM. The identification of these areas as relatively lacking in research attention demonstrates one of the functions of these models. Meanwhile, the inclusion of other theoretical models and suggestion of causative factors make the model of "Information Behavior of Communication System" a rich source of hypotheses. What is more, AEC professional working with BIM can use this research to better understand BIM, and its role especially during information communication process. This could assist in moving past the initial barriers of adopting BIM on construction projects.

As mentioned earlier, this paper aims to provide a theoretical model that helps understand BIM better and draw attention to gaps in research. The limitation for this research is to what extent the 'information behavior model of communication system' is complete or reasonably complete representation of the reality of the information communication process. And future research is also needed to test validity of the model by conducting empirical surveys on project adopting BIM in AEC industry.

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