Application of Relationally Integrated Value Networks in the Implementation of BIM for Better Life Cycle Considerations of Buildings

Aoxiang Ren, Mohan M Kumaraswamy, Kelwin Wong and S. Thomas Ng

Abstract

Emerging as an innovative tool with rapidly increasing usage in the construction industry, Building Information Modeling (BIM) can provide a platform to enable two dimensions of information exchange, namely i) information sharing among relevant participants within a certain project phase; and ii) information exchange between two or more project phases. The latter is of vital importance to help achieve potential life cycle benefits of BIM. However, a significant gap exists in information flows in current BIM implementation in Hong Kong, between 'Design & Construction' (D&C) and 'Operation & Management' (O&M). This paper discusses the potential application of a relational management framework named 'Relationally Integrated Value Networks' (RIVANS) to guide the process of information exchange between 'D&C' and 'O&M' in a BIM system. Possible causes of the above information flow gap are explored and proposals are developed based on RIVANS principles to bridge this gap. Findings and recommendations presented in this paper should pave the way for enhancing information flow in BIM across various phases of a construction project, thereby enabling integrated efforts for improving building life cycle performance.

Keywords: Building Information Modeling (BIM), **relational management**, **integrated teams**, **information exchange**, **life cycle approach**.

1. Introduction

Smooth channels for rapid exchange of relevant knowledge and skills among interacting participants through the project life cycle, in terms of design, construction and operations, are increasingly needed (Kumaraswamy, 2011). BIM is one of the promising channels due to its ability to advance the information exchange through the whole project life cycle. The potential life cycle benefits of BIM are commonly acknowledged by the industry across the world, as evidenced in the various definitions of different institutions. For example, the National Building Information Modeling Standard (NBIMS) defines BIM as a digital representation of physical and functional characteristics of a facility and it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward (NBIMS, 2007). Meanwhile, as one of the major BIM software vendors, Autodesk (2011) defines BIM as 'an intelligent model–based design process that adds value across the entire lifecycle of building and infrastructure projects'. 'Life cycle' is a key word that is emphasised in the above two definitions. In the Hong Kong industry, the Hong Kong Institute of Building Information Modeling (HKIBIM) adopts a simple definition that BIM is the process of generating and managing building data during its life cycle (HKIBIM, 2011).

Placing BIM firmly within the ‘life cycle’ umbrella indicates that BIM is able to benefit the various stakeholders in different ways in each project phase, from design to operation. Eastman (2011) summarizes a list of benefits that BIM can generate in different projects phases, such as earlier visualizations for the client in the design stage, improved basis for component fabrication in the construction stage and better facility management in the operation stage. One of the key factors to ensure the realization of the life cycle benefits is the consistency of the BIM system in the project’s whole life cycle. Two kinds of supply chains, namely the 'Design & Construction' (D&C) supply chains and the ‘Operation & Management' (O&M) supply chains, are mainly responsible for the presently segregated two principal phases in a building project’s life cycle. Therefore, in order to achieve the potential life cycle benefits of BIM, an efficient information exchange mechanism between these two supply chains needs to be built into the implementation of BIM.

However, in the Hong Kong industry, most projects implement BIM in their ‘D&C’ phase only. Two reasons might explain this situation: 1) not being aware of BIM’s potential benefits in their ‘O&M’ phase, 2) failing to extend the BIM systems into ‘O&M’ phases due to the poor information exchange mechanisms between the two supply chains mentioned above. To address the first reason or barrier, along with the maturing of BIM implementation, the industry should gradually see the benefits in ‘O&M’ phases. Therefore, this paper focuses on the second barrier, discussing the potential application of a relational management framework named 'Relationally Integrated Value Networks' (RIVANS) to guide and smoothen the process of information exchange between the Design and Construction (D&C) and the Operation and Maintenance (O&M) teams in a BIM system, so as to accelerate and improve the two-way flow across this channel in the Hong Kong industry. RIVANS is a conceptualization of ‘aligning and re-aligning divergent or otherwise conflicting values and behaviours towards integrated team working and a confluence of consolidated high performance levels in both project and strategic networks.' (Anvuur and Kumaraswamy, 2011). While RIVANS was first proposed for ‘D&C’ teams (Kumaraswamy, et al., 2009), its conceptualization has been recently extended into Total Asset Management (TAM) (Kumarawamy et al., 2012). One of its main objectives in this extended and holistic context is to identify common goals and values between “D&C” and “O&M” teams, so as to bridge and synergise ‘D&C’ supply chains with ‘O&M’ supply chains efficiently. Later sections will expand on the above while including specifics. The purpose of this paper is to develop relevant outline proposals based on RIVANS principles and the on-going RIVANS for TAM research to inject more focused and valuable life cycle considerations into BIM implementation in the Hong Kong industry.

This reported research is a part of a study which aims to advance BIM implementation through integrated working arrangements and the reported findings in this paper formulate the theoretical foundations for developing long term integrated working arrangements for the whole research project.

2. Research methods overview

This reported research is supported by findings from individual interviews conducted in the Hong Kong industry, a BIM case study in Hong Kong, proposal development based on RIVANS principles and interim findings from an on-going research project entitled ‘RIVANS for Total Asset Management (TAM)’. Since most of the data was collected in the Hong Kong industry, the conclusions of this paper are more applicable in Hong Kong, but similar methods may be used to elicit and compare findings from other jurisdictions. To avoid duplication, the research methods are described along with the respective findings in the following sections.

3. Current gaps between D&C and O&M in BIM teams implementation in Hong Kong

The captioned gaps were explored through 18 separate semi-structured interviews and a case study.

All of the 18 interviewees were experienced BIM practitioners or researchers in Hong Kong industry, covering a wide range of stakeholders in terms of clients (private and government), main contractors, BIM consultants, architects and Mechanical-Electrical-Plumbing (MEP) contractors. They provided their opinions on the question about changes and issues in information exchange mechanisms in projects that adopted BIM.

The case study was conducted on a representative BIM project (named Project A in this paper) in Hong Kong. Planned in 2004 and completed in 2008 by a private client, Project A was one of the first projects that implemented BIM in Hong Kong. Since there was very limited previous BIM project experience to refer to, Project A could be regarded as a meaningful pilot project that tried to implement BIM across the whole project life cycle, also providing a benchmark in the context of Hong Kong industry, for later projects to reference in the areas of information exchange mechanisms, operation flow and organizational structure, in the context of Hong Kong industry.

The proposed or ‘as expected’ life cycle information flow in Project A is illustrated in Figure 1, showing the ideal scenarios of information exchange at each connection point between any pair of project phases. BIM models created in the previous project phase were supposed to be directly enhanced to new BIM models that could be used in the next project phase. In this case study, BIM models created in the design phase could be named as the ‘tendering BIM’ and BIM models created in the construction phase could be called the ‘construction BIM’, while BIM models created in the operation phase could be named as the ‘operation BIM’. It was expected that ‘Tendering BIM’ should be able to be enhanced directly into ‘construction BIM’ and ‘construction BIM’ should also be able to be enhanced directly into ‘operation BIM’.

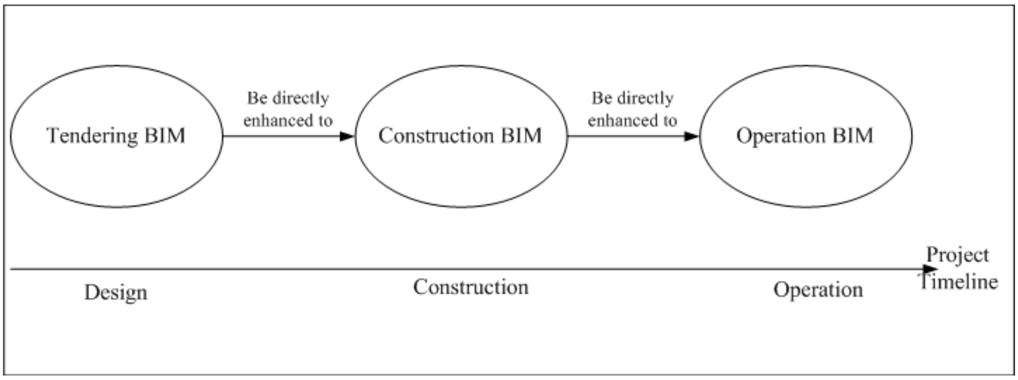

Figure 1：Proposed information flow in Project A

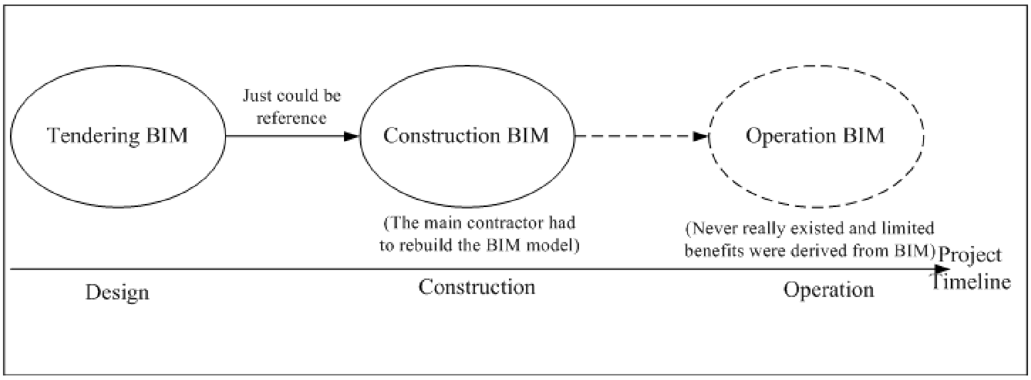

Figure 2: Real information flow in Project A

However, the ‘as happened’ real BIM implementation process in Project A is illustrated in Figure 2. Huge gaps between ‘tendering BIM’ and ‘construction BIM’ made the proposed direct transformation impossible. It was alleged that the main contractor spent almost twice the efforts, as spent on the ‘tendering BIM’ to create a usable ‘construction BIM’ that was applicable in the construction phase. Information exchange between the ‘D&C’ and ‘O&M’ teams was even more difficult and the expected ‘operation BIM’ never really materialized.

The main gaps between ‘D&C’ and ‘O&M’ teams in BIM implementation were identified and categorized through the individual interviews and case study as follows:

There were no relevant standards in the industry to define an appropriate BIM implementation process which was supposed to include efficient information exchange mechanisms to guide the stakeholders. This confusion was reported by some clients who decided to implement BIM in new projects. Clients needed to set up BIM based information exchange mechanisms by themselves, of course drawing on the services of BIM consultants. Regular coordination meetings were the main approach to ensure timely information exchange within a particular project phase. However, for the information exchange between two project phases, few projects could develop an efficient system for BIM.

Specifications about BIM models were too vague to answer the question of what kind of information should be contained in the 'D&C' team's BIM models so as to benefit the 'O&M' team. The 'D&C' team built BIM models based on their own needs and knowledge. They were unwilling and/or unable to reflect 'O&M' team's needs in their BIM models.

Current project processes restricted the formation of efficient life cycle information exchange mechanisms in the BIM system. BIM is a system that requires the early involvement of key participants, while most projects in the Hong Kong industry are delivered by Design-Bid-Build, leaving little room for this to happen, given the staggered and discontinuous involvement of key team members.

Facility managers were inexperienced in expressing their BIM requirements to upstream stakeholders, such as designers and contractors. Some BIM consultants mentioned that some clients were indeed willing to extend BIM into operation phases, but the facility managers did not know what kind of information should be contained in the earlier BIM models. They did not have the experiences of adopting BIM in the operation stage, suggesting a 'chicken or egg' type 'stale-mate' in this particular learning curve.

Since BIM required extra efforts from stakeholders but benefited the clients most, conflicting value objectives seemed to be generated by individual parties' goals vs the project's whole life cycle goals. Aligning different stakeholders' value objectives is always a critical issue in the industry and BIM implementation requires a higher level of focus on identifying and/or aligning the common value objectives among the participants.

4. Introduction to Relationally Integrated Value Networks (RIVANS)

4.1 Basic concepts of RIVANS

Focusing on the last (but certainly not least) 'gap' as listed in the above section, this is indeed a typical problem in the construction industry in general. Although many high-powered industry improvement reports in different jurisdictions, e.g. Latham (1994), Egan (1998), Construction Industry Review Committee (CIRC) (2001), have urged integrating the teams in 'D&C', this has yet to happen to yield the expected benefits, despite some advances through for example, partnering and alliancing type initiatives. Hypothesizing that such integration would not materialize unless stakeholders identify and focus together on common value objectives, a concept of 'Relationally Integrated Value Networks' (RIVANS) was proposed through the Centre for Infrastructure & Construction Industry Development (CICID) of The University of Hong Kong (CICID, 2007). RIVANS aims to develop a holistic conceptual framework for 'relational' integration of hitherto mutually suspicious project participants into cross-linked 'value networks' '(CICID, 2008). The basic thrusts of RIVANS are shown in Figure 3 (Kumaraswamy *et al*., 2012). Stakeholders in the supply chains form the value networks based on their relational integration, to deliver both one-off projects and a series of projects. There are two basic ideas in RIVANS that can illustrate its core concept:

‘Relational Integration’ and ‘overall value of the network’. Relational integration can be achieved by directing a common focus on the ‘overall value’ of the ‘network’, while members of more integrated teams are more likely to be engaged and empowered towards both short term and long term overall ‘network value’ (Kumaraswamy *et al*., 2009).

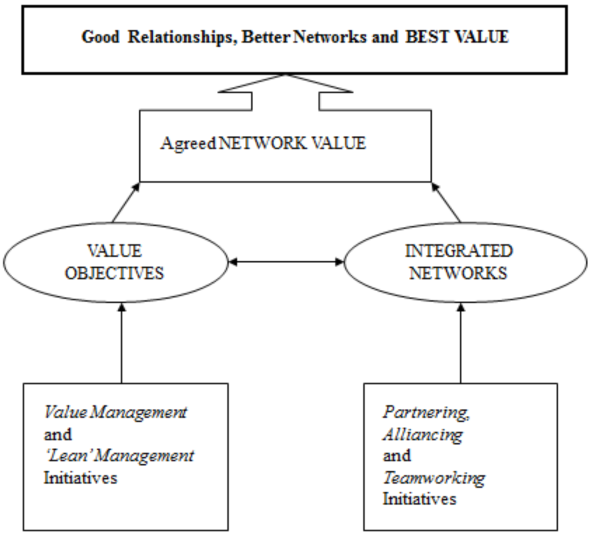

Figure 3: Basic Thrusts in RIVANS

Relational integration implies a higher and deeper level of integration than the structural integration that is expended from organizationally integrating say, the design and construction teams in the Design-Build. It emphasises genuine trust and long term cooperation among the various participants to achieve better project performance. Given its trust and trust-based operational arrangements (Rahman and Kumaraswamy, 2012), higher levels of information exchange efficiency can be expected among diverse participants in the relationally integrated team members.

Overall network value in RIVANS implies that diverse members in the project’s supply chains, such as the ‘D&C’ supply chain and ‘O&M’ supply chain, should focus on the common best value for the whole project, instead of only on their own benefits. Joint Risk Management (JRM) and ‘pain share gain share’ mechanisms need to be established in RIVANS through the project life cycle to achieve ‘best for project’ scenario, of which there are scattered examples as in the case study reported by Kumaraswamy and Rahman (2006).

The above two terms of ‘relational integration’ and ‘overall network value’ represent general principles that can be derived from RIVANS to help address the gaps in BIM implementation that were indentified in the previous section. More applicable and directly relevant to the present research would be an exercise to extend RIVANS into the area of Total Asset Management (TAM), so as to encompass the whole life cycle of the built asset. Such a project has commenced as outlined below.

4.2 RIVANS for Total Asset Management (TAM)

RIVANS for TAM is an on-going research project that aims to 1) identify synergies and added value that can be achieved through well-structured and focused collaboration between those engaged in Infrastructure Project Management (IPM) and Infrastructure Asset Management (IAM), and 2) develop concepts and working arrangements for RIVANS for TAM (Kumaraswamy, et al., 2012).

A questionnaire survey has been conducted to collect input from 'D&C' teams and 'O&M' teams in the Hong Kong industry. Participants were invited to indicate their level of agreement on a series of activities (such as the implementation of BIM) that may contribute to better value/synergies by linking the supply chains in the project lifecycle.

In addition, two organizations that were both engaged in 'D&C' and 'O&M' works were selected to conduct case studies to identify the information exchange mechanisms, working arrangements and communications between 'D&C' teams and 'O&M' teams.

Interim findings derived from the case studies while not specific to BIM, are more relevant to help lay the foundations for developing proposals to achieve better life cycle considerations of BIM. Most of these arise from the organizations' current good practices in the areas of information exchange mechanisms, working arrangements and communications between 'D&C' teams and 'O&M' teams. Interim findings about these good practices that are directly relevant to the indentified gaps in this reported BIM research, were recently summarized by Kumaraswamy and Wong (2012):

1) 'O&M' teams get involved in the project quite early and their design input was provided to the 'D&C' teams for consideration;

2) 'O&M' teams conducted design reviews to ensure that their requirements had been sufficiently reflected in the designs;

3) A series of high and mid-level management meetings were held to serve as the platform for information exchange, working arrangements and communication between 'D&C' teams and 'O&M' teams;

4) Monthly Technical Management Steering Committee (TMSC) Meetings served as a bridge between the operation division and project division to share technical issues related to new technologies, technical feasibility and previous experiences.

5. Proposals for applying RIVANS in BIM implementation for better life cycle considerations

Based on the key principles of RIVANS and directly relevant interim findings in the RIVANS for TAM research, a set of proposals are developed in this section to achieve more mutually beneficial BIM implementation from a life cycle consideration.

1) The industry should develop localized BIM guides or specifications to define and/or clearly identify: a) appropriate BIM processes which contain efficient information exchange mechanisms spanning the project life cycle by linking various supply chains, such as 'D&C' teams and 'O&M' teams, and b) the necessary data and information that need to be input into the BIM models so as to benefit all the participants in different project phases. When developing BIM-based life cycle information exchange mechanisms, the industry can refer to findings from the on-going RIVANS for TAM research. Early involvement of the 'O&M' teams, design review rights for 'O&M' teams and the monthly held TMSC meetings are all useful measures to be considered;

2) In order to motivate all the participants, especially the 'D&C' teams, to create and contribute to the BIM models from a life cycle perspective, not only for their own interest, Relational Contracting (RC) which allows for joint risk management and pain/gain share in Target Cost Contracts is suggested to be gradually adopted by projects in the Hong Kong industry (Kumaraswamy, 2012). As a Hong Kong-based RC proposal, RIVANS appears applicable in Hong Kong projects to align the various participants' values in different supply chains to the common best value for the whole project. Once RIVANS are established in the projects, participants, including the current least benefited architects or consultants, may adopt more life cycle concerns while creating BIM models. BIM models created in the early project phase will be more usable for the participants in the next project phase, therefore, a smoother BIM model transferring between the 'D&C' phases and 'O&M' phased can be expected;

3) Large clients (named as 'ongoing clients') who must manage a continuous project flow, i.e., not just on one-off or on-off projects, may be advised to build their own RIVANS. The efficiency of information exchange will be increased among participants in the RIVANS due to the trust-based operational arrangements. Participants in the RIVANS which were established for long-term cooperation would develop strong bonds after the completion of several projects. In such scenarios where various participants understand each others needs and are also willing to consider these needs in the BIM models, BIM can serve as a truly smooth channel to meet the needs of rapid exchange of information, knowledge and skills. Only then can the full potential of BIM be realized. An example of a large client's RIVANS in the project management phase is illustrated in Figure 4 (CICID, 2012).

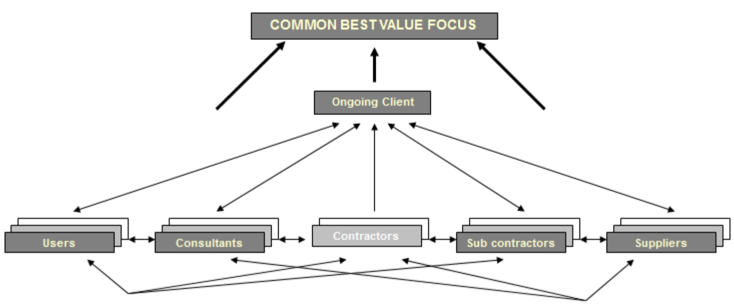

Figure 4: RIVANS of an 'Ongoing Client' in 'D&C' Phase

6. Conclusions

BIM is an innovative tool that has the inherent potential to provide a highly efficient platform for information exchange and knowledge through the whole project life cycle. However, this ‘potential’ is currently not translated into reality in the Hong Kong industry. Gaps in BIM implementation from a life cycle consideration, especially between ‘D&C’ supply chains and ‘O&M’ supply chains, were identified by interviews and a case study in this reported research. Proposals based on RIVANS principles and interim findings from the RIVANS for TAM research are developed from the industry level, projects level and organizational level (particularly for ‘on-going’ clients) in this paper. The proposals show possible long term measures for the participants to adopt, so that they are able to derive broader potential benefits from BIM through the project lifecycle.

The case study in this reported research was conducted on a project completed in 2008 and the current scenarios have changed in some aspects. Also, RIVANS is a holistic conceptual framework, while RIVANS for TAM is still an on-going R&D initiative and the findings therefrom will need validation before the final outcomes. The above points highlight the main limitations of this paper. Future works will include a BIM case study of a recent project and relevant adjustments to the proposals along with the maturing of RIVANS principles and RIVANS for TAM research.

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