



A dedicated collaboration platform for Integrated Project Delivery

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ABSTRACT

To improve efficiency and reduce waste in Architecture, Engineering and Construction (AEC) projects, Integrated Project Delivery (IPD) has been proposed and used in some projects, revealing great advantages. However, IPD depends heavily on “big room” collaboration, which requires the constant presence of nearly all participants and is particularly difficult for small or medium projects. To overcome this problem, this research aims to develop a dedicated collaboration platform for IPD to achieve more efficient collaboration and replace the highly resource-consuming “big room”. Based on requirement analysis and design of the system architecture, a prototype system is developed and tested in a virtual IPD project. When combined with a few meetings, this collaboration platform can replace the “big room”. This will significantly reduce the difficulty associated with implementing IPD projects and thus promote the adoption of IPD.

1. Introduction

The outputs of Architecture, Engineering and Construction (AEC) projects are unique products, and AEC projects require close collaboration among project participants [1]. However, collaboration in traditional project delivery methods commonly adopted in AEC projects, such as Design-Bid-Build (DBB), Design-Build (DB) and construction manager at risk (CM-at-Risk) [2], is prevented by goal inconsistency and implementation fragmentation among project participants. With respect to goal inconsistency, the owners' goals are to achieve better quality, lower project costs and shorter project duration, whereas the constructors' and designers' goals are to receive greater construction fees and design fees, respectively. Thus, each participant fights for his/her own goals instead of for maximizing the value of the entire project. With respect to implementation fragmentation, participants generally conduct their work separately and simply deliver their work results to each other; thus, they cannot easily absorb knowledge and experience from the other participants. These two aspects both contribute to the inefficiency and waste of AEC projects.

Deficiencies caused by goal inconsistency and implementation fragmentation have become increasingly severe in recent years as buildings have become more complex and the AEC industry has become more specialized. A new project delivery method called Integrated Project Delivery (IPD) has been proposed to overcome these deficiencies and thus improve control over the cost, schedule and quality of projects compared to traditional delivery methods [3]. IPD is characterized by the early involvement of all participants, close

collaboration among them, and the combination of each participant's unique contribution to the development and decision process, always with the aim of optimizing the entire project as opposed to seeking the self-interest of their respective organizations. According to the results of a survey on IPD projects, the most commonly observed benefits of IPD include fewer change orders, increased cost savings, shorter schedules and fewer requests for information (RFIs) [4]. Encouraged by these advantages, an increasing number of owners are attaching importance to IPD.

A project delivery method has three general aspects: the organization, which refers to how the participants in a project are organized to establish a project team; the commercial terms, which refer to the contractual responsibilities and associated compensation; and the operation system, which refers to how the project is performed and managed on an overall and day-to-day basis [5]. For an IPD project, the first two aspects are typically specified clearly in IPD contracts, which are signed before the project begins. Some standard IPD contracts have been published for adoption [6–9]. The core of the third aspect is collaborative work among participants. Because of frequent communication, complex processes, management and sharing of mass information and the large number of involved participants, collaborative work is difficult to perform and manage.

Thus far, collaborative work in IPD projects (hereafter referred to as IPD collaboration for brevity) has been conducted based on infrastructures such as the “big room” or collaboration platforms. Our previous review of the literature around the world indicated that 45.5% of IPD projects used a “big room,” 59.1% used a collaboration platform,

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27.3% used both of these infrastructure types, and only 22.7% used neither a ‘big room’ nor a collaboration platform [10]. A “big room” represents a large room facilitating the colocation of the entire project team, where participants work collaboratively. Because this infrastructure requires the near-constant presence of the project participants, it is applicable for large projects where the budget of the project for individual participants can justify full-time allocation of all participants, but it is difficult to implement for medium or small projects, where participants are typically working simultaneously on several projects in geographically disparate locations [11]. For some investigated cases in which a “big room” was not used, regular meetings were held instead, but the effect was rather limited, and considerable time and money must have been wasted on travel to attend meetings.

Due to the limitations of their functions, existing collaboration platforms have largely acted as shared information repositories and are not sufficiently powerful to replace the “big room” or the regular meetings used in previous IPD projects, which hinders the promotion of IPD, particularly for medium or small projects. With the development and maturation of information communication technology (ICT), there is an increasing trend of moving activities from offline to online, as has occurred in the fields of communication, shopping, and education. ICT is also expected to be beneficial for moving IPD collaboration from offline to online. Although current ICT technology cannot yet completely replace face-to-face communication in IPD projects [11], it is still possible and justified to develop more powerful collaboration platforms to reduce the dependence on face-to-face communication, i.e., replace the “big room” with regular meetings and further reduce the frequency of such meetings, which will lower the threshold for implementing IPD.

Collaboration platforms are used to improve the efficiency of collaboration, which can be further divided into synchronous and asynchronous collaboration, and management and sharing of information, which can further be divided into structured and unstructured information [12]. In the following, previous research on collaboration platforms will be reviewed in terms of these four aspects.

For synchronous collaboration, many technologies are already sufficiently mature to be applied, such as video meetings and instant messages. Some new technologies, such as 3D [13], virtual and mixed reality [14,15], have been used in synchronous collaborations.

For asynchronous collaboration, Chen et al. developed an online collaborative modeling platform to support team members from multiple disciplines in the collaborative creation of Building Information Modeling (BIM) models with fewer design iterations for conflict resolution. To achieve this objective, a multi-specialty BIM model to be developed is divided into BIM sub-models according to different parts of the building. Then, using the platform, these BIM sub-models are developed in parallel and separately from each other. Each part of the BIM sub-model corresponding to a different specialty, such as architecture, structure, and HVAC, is developed successively on the platform by the specialized teams following a linear workflow, such that each part is built based on a previous part [16,17]. Choo developed a collaboration platform that integrates the Analytical Design Planning Technique (ADePT) to automate the creation of the work plan and minimize design iterations and the Last Planner System (LPS) to guide the flow of the creation, execution and adjustment of the work plan to allow the work plan to be realized reliably [18].

Regarding the aspect of management and sharing of unstructured information, existing commercial platforms support the use of hierarchical folders along with authorities corresponding to the folders. Forcada et al. developed a web-based tool that can automatically generate an organizational document structure according to project information such as lifecycle phases, stakeholders, contractual arrangements, working areas, and document types. The structure can then be downloaded and applied in a collaboration platform with the aim of ensuring that all stakeholders work with the same well-structured folder and file structure [19]. Mao et al. proposed a method to connect

elements in structured information, such as building components, construction process and project management information, to unstructured information to create its metadata and applied the method to the development of a collaboration platform on which project participants are able to quickly locate the relevant information needed to understand and process a construction document [20].

For management and sharing of structured information, Faraj et al. developed an Industry Foundation Classes (IFC)-based model server environment (WISPER) to facilitate BIM data exchange among project participants [21]. Rosenman et al. developed a virtual collaborative environment that integrates BIM models of different specialties by building mappings among the elements in the BIM models [22]. Plume et al. used a typical BIM-based collaboration platform in a project and identified the functional requirements that are necessary but not realized by current BIM-based collaboration platforms according to the problems encountered during the process [23]. By conducting Focus Group Interviews (FGIs) in a case study on an architectural project using a state-of-the-art BIM server and a critical review of current collaboration platforms, Vishal et al. established a theoretical framework of technical requirements for developing a BIM server to be used as a multi-disciplinary collaboration platform [24]. The platform BIMserver.org has been developed as an open-source BIM server that supports the storage, maintenance and query of industry foundation class (IFC)-based BIMs. The platform can be extended, and many applications have been developed, such as those for visualizations, clash detection and flexible queries and filters [25,26].

Although the abovementioned research studies have responded to the requirements of online collaborative work in traditional projects, few studies have focused on IPD projects. In a previous study, we analyzed IPD project cases, clarified functional requirements that are not implemented by existing collaboration platforms to serve IPD projects, and highlighted the necessity of developing a new collaboration platform dedicated for IPD projects [28].

The aim of this research is to clarify and implement the major functions in a collaboration platform dedicated for IPD projects to facilitate improving the efficiency of IPD collaboration and replacing or at least minimizing the “big room” or regular meetings. The remainder of this paper is organized as follows. In Section 2, a process model for IPD collaboration is established by investigating industry-accepted documents specifying the implementation of IPD projects, and the major functional requirements for the new collaboration platform are summarized. In Section 3, the architecture of the new collaboration platform is established based on the requirements. In Section 4, the technology and tools adopted in the development of a prototype system of the collaboration platform are briefly presented. In Section 5, the prototype system is tested in a virtual project, and feedback is collected from the project participants to validate its effectiveness.

2. Establishing the process model and major requirements

As noted above, our previous study clarified the functional requirements that are not implemented by existing collaboration platforms to serve IPD projects, such as supporting users in the creation of multidiscipline workflows and recording the proposals accepted by the IPD team [28]. Based on these unimplemented requirements, a more systematic analysis of requirements is conducted here to propose further functional requirements from the perspective of providing more powerful tools for IPD collaboration. The functional requirements summarized in the previous study and those presented in this paper will be used jointly as the basis for the development of the new collaboration platform.

2.1. Investigation of IPD collaboration

As the foundation of the requirement analysis, it is necessary to clarify how IPD collaboration is conducted. For this purpose, we

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