Construction Collaboration Tools for Precast Supply Chain Management

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There are numerous activities, various parties, enormous effort and many processes involved within the precast construction projects. The precast supply chain parties within the phases of planning, design, manufacturing, transportation, installation and construction are required to have effective communication, accessing to appropriate, correct and up to date information in order to improve collaboration and enhanced integration. This research is aimed to explore and propose the cloud computing technology as the construction collaboration tools for precast supply chain management. The research findings are established according to the study of comprehensive literature on information technology, supply chain management and precast construction industry. Findings shows that the poor planning and scheduling, high cost of precast concrete components, the poor design, lack of architectural creativities, the poor production timing, large size and heavy precast components, wrong deliveries, poor on site coordination, poor specialised contactors and lack of good communication among parties are the main barriers within the precast supply chain. These barriers within the precast supply chain phases may result to adverse consequences on the performance of precast project delivery. Hence, to reduce and eliminate these barriers, the cloud computing technology has huge potential to provide efficient collaboration systems within the precast construction.

Keywords: Precast; integration; cloud computing; collaboration tool; supply chain management

1. Introduction

The off-site precast construction industry which has been existed for 150 years is a system arrangement of numerous activities, products and materials sequences and the

services flow (Al-Bazi et al., 2010) between the various parties including the clients, architects/engineers, developers, manufacturers, general contractors, subcontractors, suppliers and consultants in order to improve productivity, less time and reduce the construction costs (Al-Bazi et al., 2010; Chen et al., 2010). Precast construction is a system in which the concrete will be casted in moulds and then concrete will be cured in a controlled environment, it will be transported to the construction site and finally it will be assembled within the construction structure (Precast/Prestressed Concrete Institute, 2010).

Cloud computing technology was suggested to overcome the characteristics of dynamic, difficulties, hazards and information-intensive within the precast construction projects. Consequently, cloud computing is a distributed system which the users can access and share data between themself in diverse domains (Han et al. 2013). Hence, this research is aimed to discover the utilization of the collaboration tools such as cloud computing implementation which will potentially improve the precast construction supply chain management success.

The following section will discuss the concepts of precast construction including the definitions, supply chain phases and also the problems encountered. Then this paper will investigate the cloud computing models and types. Finally this paper will propose an approach to enhance the precast supply chain management via cloud computing implementation.

2. Precast Supply Chain Management

Precast construction is a construction method that concrete is casted in to the moulds, cured in a controlled environment, transported and installed to the precast structure (Kaner et al., 2008). According to Pheng and Chuan (2001) the precast concrete systems are valuable construction method that will benefits in decrease construction time and cost-effective. The implementation of precast construction are for the building (Dawood and Marasini, 1999; Cheong et al., 2005; Mlinarić and Sigmund, 2009; Ikonen et al., 2013) and the infrastructure projects (Al-Bazi et al., 2010). The following part of this research will explains the phases within the precast construction industry.

2.1 Precast Supply Chain Phases

The supply chain phases within the precast construction industry as illustrated in Figure 1 are classified to: planning, design, manufacturing, transportation, installation and construction (Cheong et al., 2005; Persson et al., 2006; Mlinarić and Sigmund, 2009; Ikonen et al., 2013).

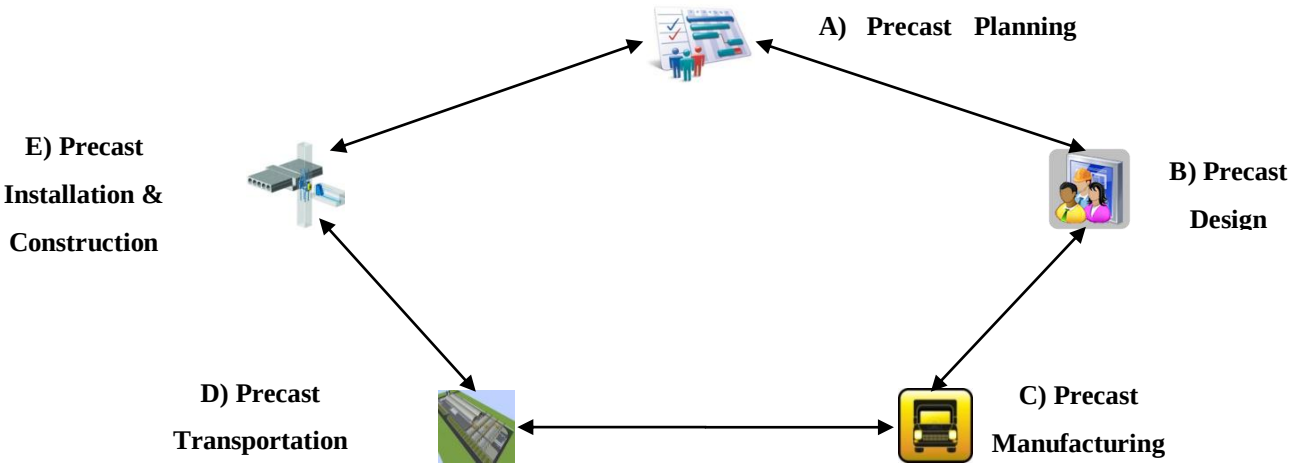

Figure 1: The diagram of the precast supply chain phases (Adapted after Cheong et al., 2005; Persson et al., 2006; Mlinarić and Sigmund, 2009; Ikonen et al., 2013)

In planning phase, the manufacturing drawings and time scheduling, installation and construction drawings, assembly/installation plans and cost estimations will be generated (Persson, 2006). While as, in the installation and construction phase, the precast elements will be assembled (installed) according to the drawings, scheduling and instructions that have been created in the planning phase (Rönneblad and Olofsson, 2003). Consequently, if any problem occurs, the parties within the precast supply chain phases should have to get back to the planning phase which all the plans, budgeting, scheduling and resource management will be produced (Dassori and Frasani, 2002). The next part of this research will briefly clarify the problems within the precast construction industry.

2.2 Precast Supply Chain Problems

There are various problems within the precast construction industry as shown in Table 1 that may have adverse consequences on the project objectives causing to delays, quality and safety issues and overrun costs.

Table 1: Problems within the Precast Construction Industry

Planning (P)	Poor planning and scheduling (Mlinarić and Sigmund, 2009; Al-Bazi et al., 2010).
	High cost of precast concrete components (Polat, 2010)
Design (D)	Less flexibility in design (Cheong et al., 2005)
	Lack of architectural creativity (Polat, 2008)
	Poor design (Kiong and Akasah, 2011)
Manufacturing (M)	Improper stocking of products on the yard (Dawood and Marasini, 1999)
	Poor production (manufacturing) timing (Precast/Prestressed

	Concrete Institute, 2010)
Transportation (T)	Late deliveries and poor weather (Pheng and Chuan, 2001)
	Large size and heavy precast components (Cheong et al., 2005; Chen, et al., 2010)
	Wrong deliveries (Wu and Low, 2011)
Installation and Construction (I&C)	Rejected components due to poor quality and bad weather changes (Pheng and Chuan, 2001)
	Poor on-site coordination (Mlinarić and Sigmund, 2009)
	Poor specialised contactors and lack of good communication among parties (Polat, 2010)

The following part of this research will discover the cloud computing development with its concepts.

3. Cloud Computing

Cloud computing is the latest IT industry developments of technologies which could be applied and be implemented worldwide without too much investment for the new infrastructure, employee trainings and software licenses at any time in anywhere via internet network (Abedi et al., 2012; Fathi et al., 2012; Lee et al., 2013; Rawai et al., 2013). As illustrated in Figure 2, all the information, services such as storage, OS (operating systems), information systems and applications will be delivered via the cloud to the variety IT tools including the smartphones, laptops, netbooks, tablets, desktops, databases and remote servers.

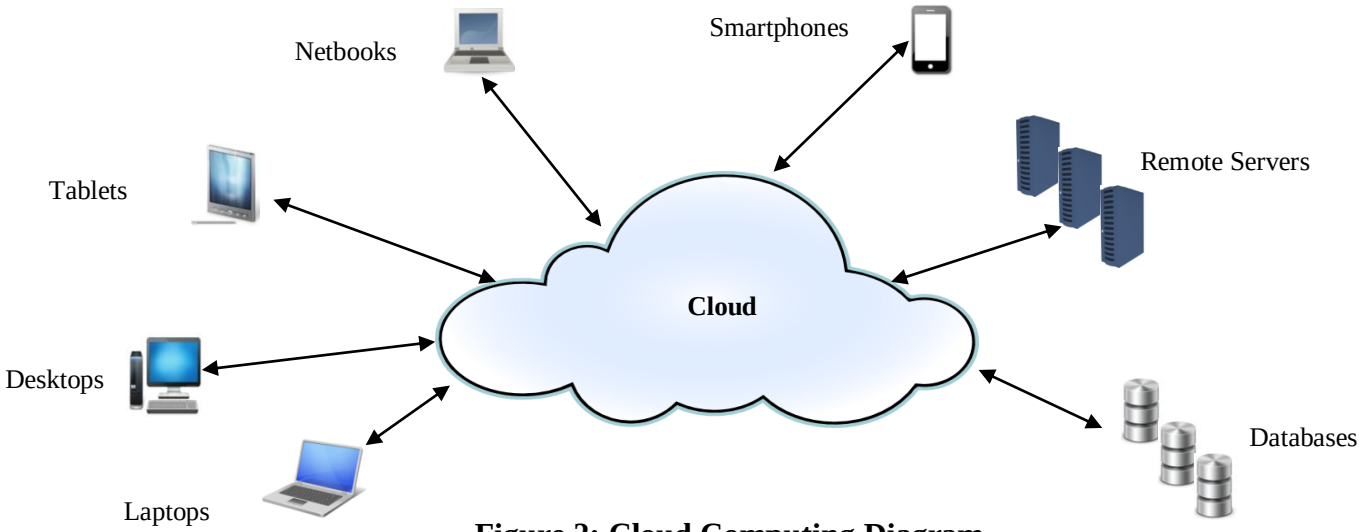

Figure 2: Cloud Computing Diagram

Different cloud computing definitions will be presented in the next section of this research.

3.1 Definitions of Cloud Computing

Major benefits of using the cloud computing includes the minimal investment, flexibility, scalable access, elastic services, convenience, cost reduction, performance advantages and rapid deployment which allow the organisations to take care more attention to their core business objectives rather than taking any effort to the technical issues such as the maintenance problems (Lee et al., 2013; Rabai et al., 2013). For better and clear understandings on the cloud computing technology, Table 2 explores the different definitions of cloud computing.

Table 2: Cloud Computing Definitions

Author(s)	Definition
Cui et al. (2013)	A convenience and ubiquitous evolutionary for applying powerful computing resources such as the networks, servers, storage, applications and services.
Rabai et al. (2013)	An evolving paradigm of computing which substitutes the computing of a personal commodity to a public utility.
Sultan et al. (2012)	Collections of distributed computers like data centres and servers delivering on-demand services and resources over Internet.
Mell and Grance (2011)	A model which facilitate on-demand accessing to the ubiquitous, convenient and network which has a joint pool of computing resources.

According to various definitions of Table 1 and in order to simplify the perception on cloud computing, it is mainly the dissemination and utilisation of services, applications and resources in order to drive the business with no concerns regarding to the management, ownership and maintenance. Additionally, cloud computing is a collection of software and hardware that businesses can implement at anywhere in any time via the internet. The following section of this research will investigate on the cloud computing models and types.

3.2 Cloud Computing Models and Types

Cloud computing deployment models (delivery models) includes: public, private, community and hybrid. Whereas, Cohen et al. (2013) explained the public cloud such as an open system for the public which is built as a pay-as-you-go approach to any users while, a private cloud that is a closed system and will be accessed just for the special business users to internal data-centres that are not open to the public (Nurmi et al., 2009). On the other hand, the community cloud is created to be controlled and

operated in a collection of organisations that have mutual profits while as, the combination of public cloud and private cloud will create the hybrid cloud (Mell and Grance, 2011).

According to Goscinski and Brock (2010), Abrishami et al. (2013) and Cohen et al. (2013) the three general types of cloud computing services models are categorised to:

(1) **Infrastructure as a Service (IaaS):** The main computing resources for instance, the processing features, storage capabilities, selection of operation system, servers and networking fundamentals will be served to the users via the cloud providers such as Amazon web services and Salesforce;

(2) **Platform as a Service (PaaS):** A platform for developing and operating the applications will be served to the users via the cloud providers such as Amazon's EC2 offerings, IBM and Microsoft Azure, and

(3) **Software as a Service (SaaS):** The users will have the opportunity to serve an application. While as, they don't have any control on the processing features, storage capabilities, selection of operation system, servers and networking fundamentals. Additionally, the cloud providers for serving the Software as a Service (SaaS) are Google Apps comprising of Gmail, Google Calendar, Google Docs and also the Amazon.

The next section of this research will briefly describes the discussion with the potentials research for future studies which could improve the collaboration, efficiencies, integration and productivity for the precast construction industry.

4. Discussion and Future Research

As mentioned in the section two of this research, other than lack of communication between parties, poor on site coordination and complexities, same information is accessed, shared, analysed, processed, deployed and distributed within the precast construction industry. Accordingly, there will be productivity deterioration due to activities such as the designs are re-designed, scheduling are re-scheduled, resources are replaced, lists are altered, quantities are repeatedly counted and materials are substituted. Hence, the most important objective is to improve the coordination, team workings, more integration, enhanced communications and collaboration via the earlier parties participation within the precast supply chain phases as in design/build procurement which the architect and contractor participates in the project beginnings towards constructing continuous communication and enhancing the efficiencies.

It is hoped that by proposing the cloud computing implementation, all precast supply chain parties and the project stakeholders, comprising of the owner,

consultants, designers, engineers, manufacturers, general contractors, transporters, suppliers and sub-contractors will have the opportunity to more cooperate, integrate, improve the productivity and collaborate much accurately and efficiently compare to the traditional approaches and processes. Furthermore, cloud computing technology will assist the users (businesses and individuals) to access, share and disseminate the data; applications and services form the various servers via only the internet. Moreover, it assists the users to implement the applications with no concerns regarding to the installation which allows them on accessing to their various data through the internet on any computer or mobile devices. It should be signified that cloud computing utilisation allows the users by integrating storage, memory, processing capabilities and network bandwidth to have much efficient and effective implementation of information technology services which could significantly lower the costs. The final section will briefly discuss on the conclusions derived from this research.

5. Conclusion

The precast construction industry has specific characteristics of the supply chain phases and parties included compare to other major industries. Moreover, the precast construction industry is associated with many processes, various information and numerous parties which have diverse objectives. Hence, to attain efficiently and effectively the precast construction project objectives based on the assigned time, specified budget and standard quality with considering the safety parameters, the choice and execution of the collaboration tools is highly significant. Consequently, cloud computing as a significant collaborative tool will improve the integration, communication and collaboration for the parties and stakeholders within the precast construction industry. Currently, with the improvements of mobile devices such as tablets and smartphones, speed enhancements of mobile applications and wireless communication tool have facilitated the cloud computing technology as the potential collaborative and information management tool within the precast construction industry.

This study has accomplished in order to investigate and propose the fundamentals of cloud computing implementation as valuable collaborative tools for assisting the precast supply chain procedures, activities, parties, connections and networks to develop and increase the opportunities for attaining improved competitive advantages within the precast construction industry. Lastly, the study conducted in this paper is an initial survey that is a division of on-going research, which will ultimately endeavour to further improve the practices and utilisation of cloud computing as one of the major valuable construction collaboration tools. This advanced and available resource could

eventually create the opportunity to introduce and distribute the computing resources services and information technology (IT) applications among the world industries, such as the precast construction industries. If properly applied and adjusted, it will ultimately increase the productivity; improve efficiency and effectiveness within the precast construction industry. It should be noted that cloud computing will be able to develop and distribute computing services and information technology (IT) applications among various industries, such as the precast construction industries. The anticipated result of utilization of cloud computing would be increased productivity, enhanced efficiency and effectiveness through the precast construction industry.

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