Cloud Computing Information System Architecture for Precast Supply Chain Management

Mohammad Abedi[1,a], Norshakila Muhamad Rawai[1,b], Mohamad Syazli Fathi[2,c]and Abdul Karim Mirasa[3,d]

[1]Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 UTM, Johor, Malaysia.

[2]UTM Razak School of Engineering & Advanced Technology, Universiti Teknologi Malaysia International Campus, Jalan Semarak, 54100 Kuala Lumpur, Malaysia

[3]School of Engineering & Information Technology, Universiti Malaysia Sabah, Locked Bag 2073, Kota Kinabalu, Sabah, Malaysia

[a]amohammad22@live.utm.my, [b]norshakila3@live.utm.my, [c]syazli@utm.my, [d]akmirasa@ums.edu.my

Keywords: Precast Construction Industry, Supply Chain, Efficient Communication, Sustainability, Collaboration Tools, Integration, Coordination, Cloud Computing, Competitive Advantage.

Abstract. The precast construction industry is associated with a lot of activities, vast effort, many parties and numerous processes. The precast supply chain phases include the planning, design, manufacturing, transportation, installation and construction. The parties within the precast supply chain phases should have efficient communication and access to precise and latest information contributing to the enhanced collaboration, sustainability and improving the integration. The aim of this study is to explore the collaboration tools with proposing the cloud system architecture for the precast supply chain management. The research findings are according to the comprehensive review of the literature on supply chain management, precast construction industry and cloud computing. Findings demonstrate the major problems within the precast supply chain phases comprised of poor planning, ineffective communications among designers and manufacturers, incompetent employees and damage to raw materials, large size and heavy precast components and the poor on-site coordination. These major problems within the precast supply chain phases could contribute to negative consequences on the efficiency, productivity and effectiveness of precast delivery. Therefore, to mitigate and overcome these major problems within the precast construction, the cloud computing implementation as the valuable alternative could be delivered to enhance the efficiencies and effectiveness of the collaboration systems. This research proposes and establishes the concepts of valuable collaborative tools, for instance the Cloud Computing Information Systems (CCIS). These tools will assist the processes, activities, information and network to improve integration with enhanced collaboration within the precast supply chain management through increasing the opportunities to attain sustainability with higher competitive advantages.

Introduction

The off-site precast construction industry which is launched since 1850, is an integrated construction system comprising of many activities, various products, numerous materials and flow of information and services [1,2]. The precast construction aims to enhance the productivity, decrease the time, and achieve more cost savings among the numerous individuals such as the developers, clients, consultants, suppliers, manufacturers, general contractors, architects/engineers and subcontractors [1,3].

The major issues of precast construction projects will be the integration, assisting and supporting the various stakeholders and numerous supply chain parties on accomplishing the mutual objectives for the precast project. On the other hand, collaborative team workings will enhance the productivity; improve effectiveness and certifying the efficient resources utilisation of precast construction projects contributing to the precast project success. Hence, cloud computing as one of

the most valuable collaborative technologies could mitigate the adverse consequences of difficulties, information-intensive, dynamic and risks within the precast construction projects [4-9]. Therefore, this research is conducted to explore the concepts of collaboration tools for instance the cloud computing utilization along with proposing the system architecture that will eventually enhance the success of precast construction. The next section of this research will discover the definitions, supply chain phases and major problems within the precast construction.

Precast Supply Chain Management

The precast construction is defined as, the moulds will be filled by concrete, secondly, the curing of concrete within a controlled environment, thirdly, the transportation of precast components to the construction site and lastly, they will be positioned to the construction structure [10,11]. Main benefits of precast construction are: improved sustainability [3], reduced construction time [12], modularization [13], and higher quality [14]. On the other hand, the precast system is implemented for the building [3,15-18] and the infrastructure projects [1,11]. The following part of this research will explains the phases within the precast construction industry.

Precast Supply Chain Phases

The precast supply chain phases are categorised to: planning, design, manufacturing, transportation, installation and construction [12,14,15,17,18]. The following section will discover the major problems identified within the precast construction industry.

Precast Supply Chain Problems

Major problems within the precast construction industry which are illustrated in Table 1 could cause negative consequences on the project objectives contributing to time and cost overruns, decreased quality and safety issues.

Table 1: Major Problems within the Precast Construction Industry

Supply Chain Phases	Major Problems
Planning (P)	Poor management of knowledge [15] and poor planning [1,17]
Design (D)	Ineffective communications among designers and manufacturers [13] and poor design [16]
Manufacturing (M)	Incompetent employees and damage to raw materials [12]
Transportation (T)	Large size and heavy precast components [3,13,18]
Installation and Construction (I&C)	Poor specialised contactors [13] and poor on-site coordination [17]

The next section of this research will explore the concepts on the cloud computing consisting of the definitions, types and models.

Cloud Computing

Cloud computing is the recent technology development which could be applied globally at any time in anywhere via internet network [4-9,19-20]. It is an approach to outsource data with the aim of decreasing the data storage and reducing the management issues [21]. Main benefits of cloud computing implementation are: less infrastructure investment, convenience, flexibility, enhanced performance and cost reduction [5]. Furthermore, the cloud computing delivery (deployment) models comprises of: public, private, community and hybrid [22]. Consequently, [19,22,23] classified the cloud computing types to: Infrastructure as a Service (IaaS) such as Salesforce and Amazon web services, Platform as a Service (PaaS) such as IBM and Amazon's EC2 offerings, and lastly, the

Software as a Service (SaaS) such as Amazon and Google Apps including Google Calendar, Gmail and Google Docs. The following section will propose the architectural cloud system.

Cloud Computing System Architecture within the Precast Construction Industry

Cloud computing technology sends and retrieves the data and various applications via the utilisation of internet and central remote servers including the application servers and the database server. The integration of cloud computing, mobile clients (such as the smart mobile devices including the smartphones and tablets), servers and data center [4-6,9,19,23] and logistics management [24] could be applied for the precast supply chain management. As illustrated in Figure 1, the architectural system of cloud computing for the precast supply chain management is illustrated.

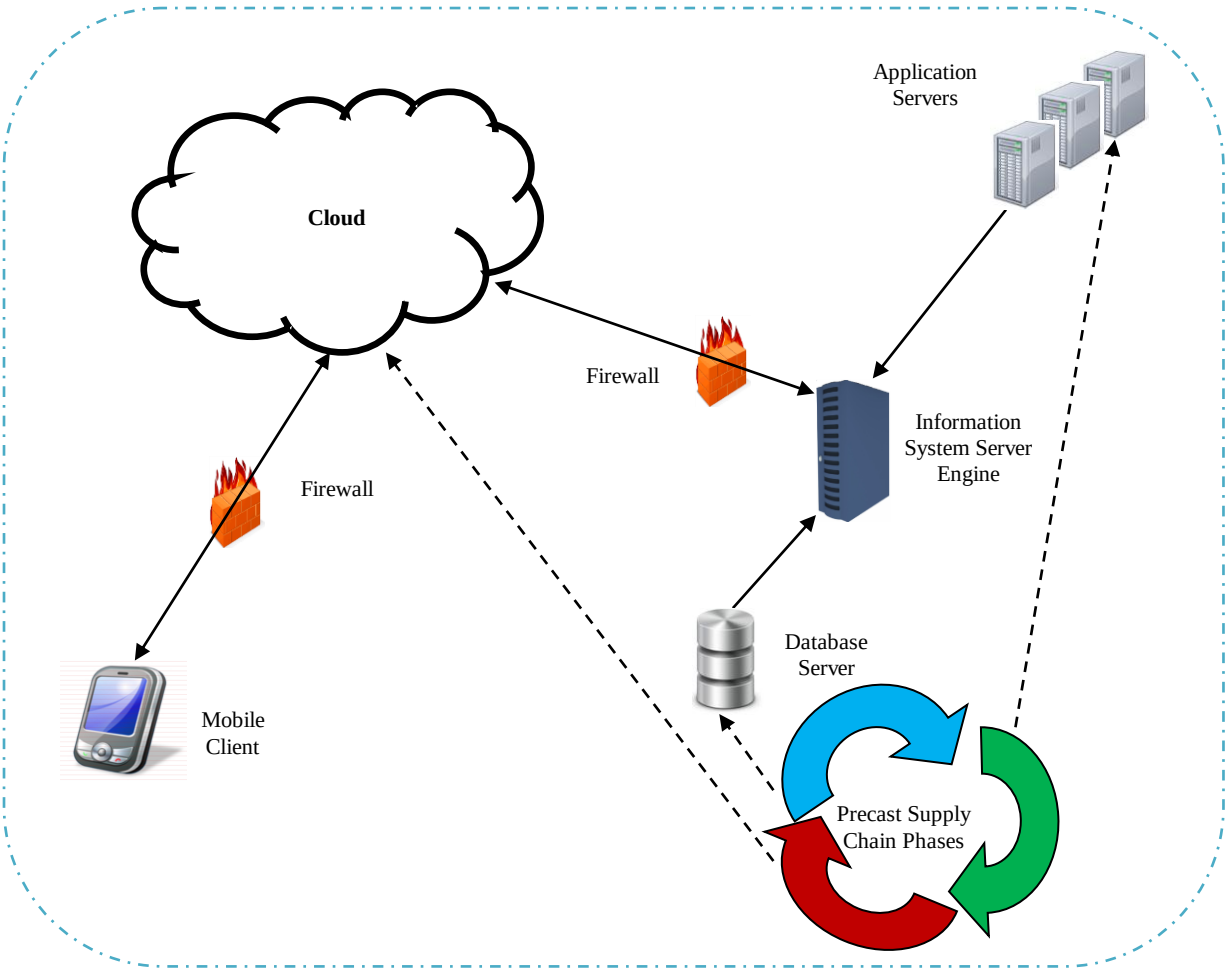

Figure 1: Cloud Computing Information System (CCIS) Architecture for Precast Supply Chain Management

Figure 1 illustrates that firstly, the data within the precast supply chain phases will be delivered to the database server and the application servers and secondly, it will be transferred to the Information System server engine (IS server engine). Fundamentally, the architecture of Cloud Computing Information System (CCIS) is comprised to four core components:

(1) The Mobile Client: Smart mobile devices such as the smartphones, tablets and mobile computers which are capable of sending the data and information within the precast supply chain phases to the Information System server engine via the utilisation of the cloud. Besides, the mobile client will attain the information within the precast supply chain phases by the cloud;

(2) The Firewall: Two firewalls has been considered; first one is among the cloud and mobile client whereas, the other firewall is among the IS server engine and cloud. Firewalls in the precast supply chain phases will secure the information that is transferred and delivered to the devices;

(3) IS Server Engine: The data within the precast supply chain phases that are delivered by the mobile clients, database server and application servers will be processed via the IS server engine; and

(4) The Cloud Server: Information which is created by the IS server engine, with the firewall authorization will be delivered to the cloud. Moreover, the information via the cloud will be distributed to the mobile client within the precast supply chain phases.

Summary

The features of the precast construction industry are distinctive compare to other major industries such as being highly project-based. Cloud computing will significantly impact on how efficiently the information systems should be utilised in order to create the services and applications. This collaborative technology could be applied at any time in anywhere and globally with not much concern on applying new infrastructure, software licenses and employee trainings. Overall, this paper has proposed an intelligent collaborative tool via the cloud computing implementation. Furthermore, the cloud computing implementation within the precast construction industry, will deliver significant opportunities for improving the effectiveness and enhancing the appropriate information flow along with accessing to data, information and services. This study reveals that the implementation of cloud computing could contribute to the efficient delivery of a consistent information system, improved productivity, enhanced effectiveness within the precast construction industry.

Acknowledgement

This work was partly financially supported by Universiti Teknologi Malaysia and the National Institute of Valuation, Malaysia under National Real Estate Coordinator (NAPREC) research grant (Universiti Teknologi Malaysia grant no: 4B086).

References

[1] A.F. Al-Bazi, N. Dawood and J.T. Dean: *Improving Performance and the Reliability of Off-Site Precast Concrete Production Operations Using Simulation Optimisation*. J. Info. Tech. Cons. (ITcon), Vol. 15 (2010), p.335-356.

[2] A.G.F. Gibb: *Standardization and Pre-Assembly- Distinguishing Myth from Reality Using Case Study Research*. Construction Management and Economics, Vol. 19, No. 3 (2001), p. 307-315.

[3] Y. Chen, G.E. Okudan and D.R. Riley: *Sustainable Performance Criteria for Construction Method Selection in Concrete Buildings*. Automation in Construction, Vol. 19, No. 2 (2010), p. 235-244.

[4] M. Abedi, M.S. Fathi and S. Rawai: *Cloud Computing Technology for Collaborative Information System in Construction Industry*. Proceedings of the 18th International Business Information Management Association (IBIMA 2012), Istanbul, Turkey, (2012), p. 593-602.

[5] M.S. Fathi, M. Abedi, S. Rambat, S. Rawai and M.Z. Zakiyudin: *Context-Aware Cloud Computing for Construction Collaboration*. J. of Cl. Com., Vol. 2012 (2012), p. 1-11.

[6] M.S. Fathi, M. Abedi and N.M. Rawai: *The Potential of Cloud Computing Technology for Construction Collaboration*. Int. J. of Ap. Mech. and Mat., Vols. 174-177 (2012), p. 1931-1934.

[7] M. Abedi, M.S. Fathi and N.M. Rawai: *The Impact of Cloud Computing Technology to Precast Supply Chain Management*. Int. J. Con. Eng. and Mgt., Vol. 2, No. 4A (2013), p.13-16.

[8] N.M. Rawai, M.S. Fathi, M. Abedi and S. Rambat: *Cloud Computing for Green Construction Management*. Third International Conference on Intelligent System Design and Engineering Applications (ISDEA 2013), China, Hong Kong, (2013), p. 16-18.

[9] M. Abedi, N.M. Rawai, M.S. Fathi and A.K. Mirasa: *Cloud Computing as a Construction Collaboration Tool for Precast Supply Chain Management*. J. Teknologi, Vol. 70, No. 7 (2014), p.1-7.

[10] Precast/Prestressed Concrete Institute: *A Guide to Designing with Precast/Prestressed Concrete*. Chicago (2010): Precast/Prestressed Concrete Institute (PCI).

[11] W.T. Chan and H. Hu: *Constraint Programming Approach to Precast Production Scheduling*. J. Constr. Eng. Manage., Vol. 128, No. 6 (2002), p. 513-521.

[12] P. Wu and S.P. Low: *Lean Production, Value Chain and Sustainability in Precast Concrete Factory-A Case Study in Singapore*. LCJ, Vol. 2010, No. 1 (2011), p. 92-109.

[13] G. Polat: *Precast Concrete Systems in Developing vs. Industrialized Countries*. J. Civil Eng. Manage., Vol. 16, No. 1 (2010), p. 85-94.

[14] E. Dassori and M. Frasani: *Support System for Project Management and Production of Concrete Precast Elements*. Ad. in Bui. Tech., Vol. 2, No. 1 (2002), p. 1689-1696.

[15] J. Ikonen, A. Knutas, H. Hämäläinen, M. Ihonen, J. Porras and T. Kallonen: *Use of Embedded RFID Tags in Concrete Element Supply Chains*. J. Info. Tech. Cons. (ITcon), Vol. 18 (2013), p. 119-147.

[16] N.B. Kiong and Z.A. Akasah: *Maintenance Factor for Precast Concrete in IBS: A Review*. Proceedings of National Postgraduate Conference (NPC 2011), Universiti Teknologi PETRONAS, Malaysia, p. 1-6.

[17] V. Mlinarić and Z. Sigmund: *Problems in Large Scale Precast Construction Projects*. Proceedings of CIB Joint International Symposium 2009: Construction Facing Worldwide Challenges, Dubrovnik, Croatia, p. 182-188.

[18] Y.W. Cheong, H.P. Kwan and A.D. Hariyanto :*Quality Control in Precast Production: A Case Study on Tunnel Segment Manufacture*. DIMENSI, J. of Arc. and Bu. Env., Vol. 33, No. 2 (2005), p. 153-164.

[19] R. Ranjan and L. Zhao: *Peer-to-peer service provisioning in cloud computing environments*. TJS, Vol. 65, No. 1 (2013), p. 154-184.

[20] J. Lee, J. Cho, J. Seo, T. Shon and D. Won: *A Novel Approach to Analyzing for Detecting Malicious Network Activity Using a Cloud Computing Testbed*. Mobile Netw. Appl., Vol. 18, No. 1 (2013), p. 122-128.

[21] C. Liu, L. Zhu, M. Wang, Y.A. Tan: *Search Pattern Leakage in Searchable Encryption: Attacks and New Construction*. Inf. Sci., Vol. 265 (2014), p.176-188.

[22] J. Cohen, I. Filippis, M. Woodbridge, D. Bauer, N.C. Hong, M. Jackson, S. Butcher, D. Colling, J. Darlington, B. Fuchs and M. Harvey: *RAPPORT: Running Scientific High-Performance Computing Applications on the Cloud*. Philos. Trans. A Math. Phys. Eng. Sci., Vol. 371, No. 1983 (2013), p. 1-15.

[23] P. You and Z. Huang: *Towards an Extensible and Secure Cloud Architecture Model for Sensor Information System*. Int. J. of Dis. Sen. Net, Vol. 2013 (2013), p. 1-12.

[24] B.P. Lin, W. Tsai, C.C. Wu, P.H. Hsu, J.Y. Huang and T. Liu: *The Design of Cloud-based 4G/LTE for Mobile Augmented Reality with Smart Mobile Devices*. Proceedings of 7th International Symposium on Service Oriented System Engineering (SOSE 2013), Redwood, USA, p. 561-566.