Cloud Computing and its Implications for Construction IT

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Abstract

Cloud Computing (CC) has been attracting a huge amount of interest in the post-dotcom boom and bust and the current web 2.0 information technology world. More recently, the momentum gained by the technology has been so significant that GSA (General Services Administration) in the USA has announced a Federal Cloud Computing Initiative (FedComp, 2009). Cloud computing is a general term for anything that involves delivering hosted services over the Internet. The term cloud computing was coined by the cloud symbol often used to represent the Internet in schematic diagrams. National Institute of Standards and Technology (NIST, 2009) in the USA has provided a draft Working Definition of Cloud Computing – "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction".This paper investigates the relevance and impact of CC for Construction IT and proposes a framework for implementing a cloud based system for design and construction.

Keywords: *Construction, IT, Cloud Computing, Design, Construction*

1 Introduction

It has been widely reported in the last few years that some of the characteristics (e.g. fragmentation, majority of the sector comprising of micro to SMEs, project based activity etc.) of the construction industry hinder the adoption of IT by the industry as a whole and this sector is generally behind other sectors in IT uptake. One of these characteristics which appears to drive this phenomenon is the lack of IT infrastructure among the SMEs in the construction sector due to their small size and hence the affordability of these facilities. More than 90% of the sector's companies in most developed countries belong to this category. At least, on some levels, the Cloud approach appears to address some of these issues and hence holds a promise to the industry in that regard, in particular, the usage based pricing model which lies at the heart of cloud computing. A recent paper proposes the idea of creating a software marketplace for SMEs in construction based on a cloud computing model (Hore, 2009).

Concepts like SaaS (Software as a Service) have been around for a little while. However, what appears to give CC an edge is its pricing model. In a sense, the CC concept commoditizes IT far more than any other development in its history so far. CC can be applied to the construction industry in various aspects, including but not limited to architectural design, structural analysis, cost estimating, project planning and control, and procurement management. We have developed an open source service oriented system for construction supply chain management (Cheng, 2009), utilizing technologies that also support CC.

Needless to say, there are also some adverse issues that the technology proponents need to address before the commercial world at large will be comfortable in its adoption. Some of these issues are Trust, Security, Interoperability, etc. The most serious negative factor that needs to be overcome is Trust. Questions such as "will the application always be available for use", and "can a company entrust a third party (through the cloud) with its business sensitive data" are likely to impede the adoption of CC. This paper will discuss the key business factors for successful of adoption of CC in the construction industry, for example, management support, the need for paradigm shift, development of trust, and maintenance of privacy. Key technical factors of success such as ubiquitous network access, reliability of data centers, and stability of message exchanging will also be addressed. Finally, this paper will propose several related areas for future research on CC.

2 Background to Cloud Computing in Construction

Without attempting to redefine the umbrella terms *Cloud Computing* and *Construction IT*, for the purpose of this paper, it can be assumed that the former term is being used in the context provided in the abstract, and the latter, as a domain definition combining both of the terms Construction; "sub-disciplines, such as civil engineering (dealing with infrastructure products, such as roads, waterworks etc.) or structural engineering (dealing with buildings and bridges)" and IT (Turk, 2000).

2.1 Main Issues in Construction IT vis-à-vis uptake

For over two decades, a considerable amount of research effort has gone into construction IT. Despite a large number of research prototypes coming out of university and recommendations by powerful government commissioned reports (Egan 1998, Latham 1994), the uptake of IT in the industry is still relatively low. In particular, the SMEs in this sector have one of the lowest uptakes of IT among most other similar sectors. Some of the reasons for this are thought to be lack of resources (manpower, capital), lack of awareness, training and clear understanding of ROIs (Return on Investment). Although the fundamental concepts surrounding CC are by no means new, it is the specific advantages such as scalability, streamlining data resources, inclusive maintenance etc that make it an interesting concept for usage with the Construction IT platform. This goes to show that "…even with a commodity architecture, there are still opportunities for proprietary advantage." (O'Reilly, 2004).

3 Recent developments surrounding Cloud Computing

It is essential for anyone involved with Construction IT to acknowledge that prior to proceeding with a migration towards CC (as with any emerging technological concepts and business models) the most important aspect is that one should know one's team, know one's required solutions, and finally, understand how the Cloud vendor can benefit one's existing business situation. Only then can it become a feasible option to migrate all IT services into a Cloud infrastructure.

3.1 Cloud Service Models

There are generally speaking the following three service models for cloud computing, viz. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). This work is concerned primarily with the SaaS service model.

3.2 Cloud Deployment Models

Following are the main deployment models for CC. As described later, the framework proposed here utilizes all these models in different ways, viz. Private Cloud, Public Cloud, Community Cloud, Hybrid Cloud.

3.3 Ontology Standards

A recent 2009 panel report published by the KDD (Knowledge Discovery and Data Mining) titled '*Open Standards and Cloud Computing'* provided within it the following comment "Standards emerge only at a time when a domain achieves some maturity, allowing competitors to come to a single table and discuss their common concepts," (Zeller et al., 2009). This statement coincides with the ethos that standards are required within the Cloud operation so that potential customers knowingly choose the best possible mix of cloud features available to benefit their organization. The NIST seeks to promote cloud standards such as, roadmaps for standards, to act as a catalyst to help industry formulate their own standards and to promote government and industry adoption of cloud standards.

3.4 Technical barriers obstructing on-demand web services

Data Security and Governance – Data safety in the cloud is not a trivial concern. Firstly, some online storage vendors such as The Linkup and Carbonite have lost data, and were unable to recover it for customers. Secondly, there are data access governance concerns, because there is the danger that sensitive data could fall into the wrong hands. ***Compliance in the Cloud -*** If one has customer data in the cloud (files, documents, emails, memos, scanned images, etc.) what controls are available to ensure compliance with the published privacy policies and with the privacy and freedom of information regulations in all of the countries where one does business? ***Integration with Legacy Systems –*** Of course one is not going to rely entirely on the Cloud, far from it. Therefore, there will be plenty of integration work integrating Cloud Applications with the Legacy Systems. ***Can Applications Move From One Cloud to Another –*** There are two main issues here: interoperability and migration cost policies**.** Regarding interoperability, Cloud vendors will have to adopt standards-based technologies in order to ensure true interoperability.

4 A Framework for Cloud Computing in Construction

In this section, we present a framework (Figure 1) for implementation of cloud-based IT services in the construction domain. The central idea this framework uses is the separation of public and private cloud based data and activities. It is proposed that all the proprietary software systems that the construction project stakeholders use will be on the public cloud whereas the private cloud will store and manage the project-specific data and models like BIM (Building information model). The public cloud will provide multiple versions of a software program which can be deployed and distributed as separate cloud applications. For example, energy simulation system can include daylight simulation, HVAC (heating, ventilation, and air conditioning) system simulation, air flow simulation, etc. Similarly, document management can include the management of contracts, building permits, purchase orders, regulations, etc.

4.1 Interoperability Issues

Interoperability issues have long been investigated in the traditional approaches to construction IT (IAI 2000, Froese et al., 2000). Clearly, interoperability issues present themselves in different forms both at the system as well as information and data levels (see figure 2). Blue solid arrows indicate software interoperability to support connectivity among applications and the black dotted arrows show information interoperability to support cross-representation integration of applications. Different standards may be used in separate cloud platforms and environments, either private or public clouds. Therefore, the interoperability issue in a cloud computing model is

more complicated in context. The cloud computing interoperability issue can be summarized into four categories (figure 3). First, interoperation among applications should be allowed inside a single cloud environment. This requires connectivity of the applications as well as semantics alignment of the data exchanged among the applications. Second, applications should be able to exchange information and trigger operations across different cloud environments. It is a challenging task because of the different standards and configurations used in separate cloud environments. Third, software programs should be able to connect multiple cloud environments and to integrate data and applications across clouds in a unified manner. Therefore, cloud environments that are neutral to programming languages and operating systems are desirable. Finally, migration of a cloud application from one cloud environment to another should be facilitated. The mechanisms that enhance portability of cloud applications are now an active research area.

Currently there is no implementation of a cloud computing framework in the construction industry. However, some researchers have attempted to build SaaS-based framework for construction applications leveraging standard web services technologies. For example, Cheng (2009) has developed an open-source web services framework, namely SC Collaborator, for integration and collaboration among individuals involved in a construction supply chain. The technologies to be used in the implementation of the proposed framework will largely resemble the ones used in SC-Collaborator with the addition of usage management services for implementing pricing models used. In particular, the following standards will form the basis on which the framework will be implemented (Cheng, 2009):

- *Simple Object Access Protocol (SOAP)*, an XML-based protocol and encoding format specification released by World Wide Web Consortium (W3C) for data exchange between web services,
- *Web Service Description Language (WSDL)*, an XML-based specification released by W3C for describing web services, and
- *Business Process Execution Language (BPEL)*, an XML-based specification released by Organization for the Advancement of Structured Information Standards (OASIS) for composition and orchestration of web services.

In addition, the implementation tools that may be used are the family of open source tools from the Apache Software Foundation such as *Apache Axis2*, a framework that supports deployment of web service units and provides system accessibility using standardized SOAP and WSDL technologies, *Apache Orchestration Director Engine (ODE)* is an execution engine that deploys and implements BPEL processes, *Apache Struts*, a framework that offers system accessibility using web browsers or wireless devices and enables control of page flows and management of consistent layouts and *Apache Tomcat*, a servlet container that executes web applications which are programmed and packaged using the Java Servlet technologies, management, and blogging. Other proprietary software houses like Microsoft have also brought out a family of products for Cloud-based systems like, Windows Azure and SQL Azure.

5. Summary and conclusions

This paper has summarized the current developments in relation to cloud computing and concluded that it may hold promises for solving some of the pressing needs of construction IT. In particular, it is thought that notwithstanding technical challenges, cloud computing may help accelerate the uptake of IT within the SMEs of construction mainly because of the pricing models it supports. A framework for implementation of cloud-based systems for construction was

proposed where it was concluded that interoperability issues for systems as well as information holds the key to its successful adoption by the industry at large.

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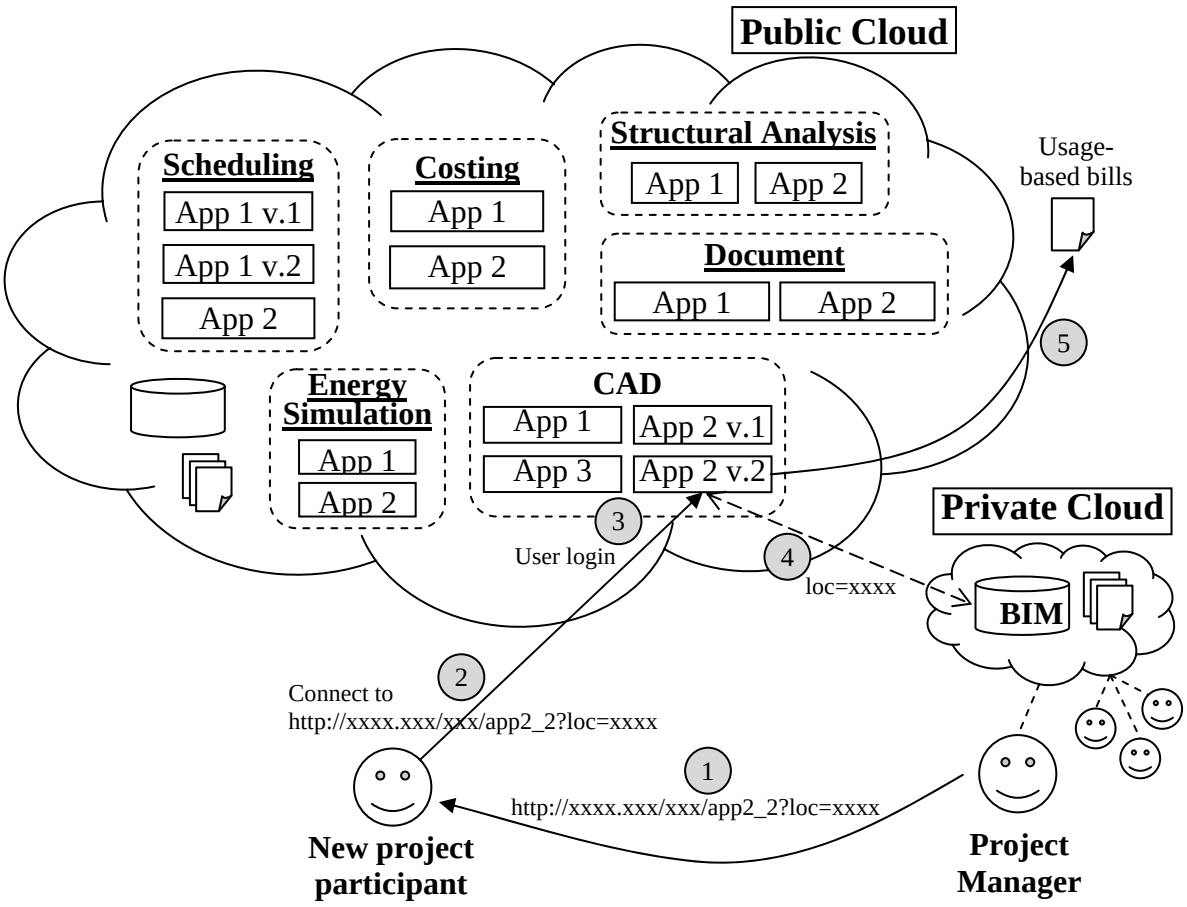

Figure 1 A Framework for Cloud Computing for Construction

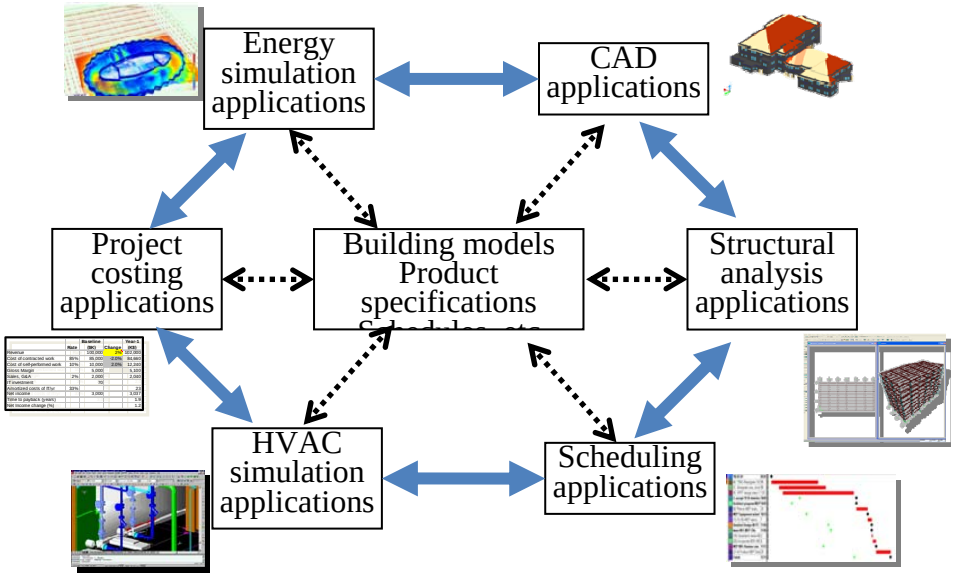

Figure 2 Software and Data/Information Interoperability

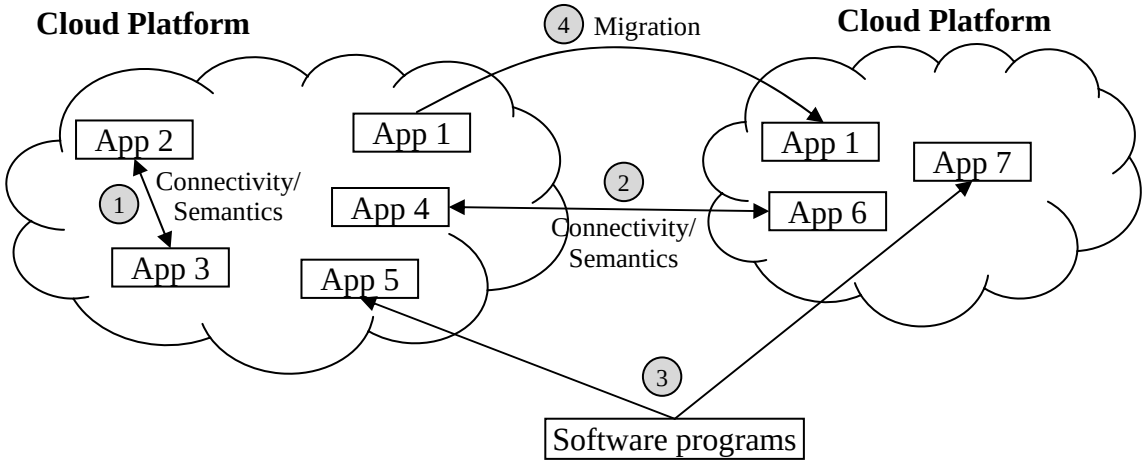

Figure 3 Types of interoperability between applications in the Cloud