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Internet-Based ICT usage in Construction Project Management: A Global Appraisal

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Abstract
The use of Internet as a means of communication can help information transfer occur faster and more effectively. The technology can enable new opportunities for development of shared and distributed information systems crossing organizational boundaries and providing a unique opportunity for effective teamwork and workflow automation. Despite its enormous potentials the use of Internet-based ICT tools in the construction industry is still low.

This paper aims to present the global perspective on the use of Internet-Based ICT in construction project management. Focus is laid on the web-based project management system (WPMS) in construction management. A detailed literature review is included to identify the current status of the use of ICT. It has been found that the patterns of ICT usage are different depending on the regions. Driving forces behind ICT usage are varied, as well. In Asia, owners (governments) are more proactive in introducing ICT in project management while in other regions such as the North America, United Kingdom and Australia, drive is usually self- motivated. It is also found that there is a general hesitance towards the use of ICT. Both internal and external factors are influencing the potential use.

Keywords
Intranet, Extranet, Internet, WPMS

1. Introduction

Information and communication technology (ICT) is providing critical and essential tools for management of information and communication in construction processes. Walker and Betts (1997) argue that ICT, such as the Internet, opened up opportunities for construction businesses to operate globally. Researchers believe that the use of ICT improves coordination and collaboration among entities participating in a construction project, leading to effective communication practices (Rojas and Songer 1999; Villagarcia and Cardoso, 1999). The most prominent benefits of using ICT includes, an increase in the quality and timeliness of documentation, an increase in speed of work, better financial controls and communications, simpler and faster access to common data, and a decrease in documentation errors (Nitithamyong and Skibniewski 2004; Love et al., 2004). However it is axiomatic to suggest that despite increased use and optimism ICT to improve communication among various stakeholders in a construction project anything other than localized benefits has yet to accrue. The major reason is that the technology push alone cannot lead to the full business potential of any ICT solution, therefore, only the use of technology without bring necessary changes to organization is unlikely to bring a competitive advantage (Alshawi, 2007). The extent of ICT use varies from country to country as revealed in a survey carried out by Hewage et al. (2008). It was found that the percentage of total annual revenue spent on ICT in Canada varies from 0.5% to 3% (average being 1%) depending on the project and the company. The survey respondents identified the need for their corporations to increase spending on ICT because they believe it would give them a competitive edge. A survey of small and medium UK companies indicates that 90% of the organizations are willing to improve their ICT and are open to implement the latest technology to improve their business performance (Chien and Barthorpe, 2010).

Patterns of ICT usage also differ by organizational size. The Bureau of Economic Analysis (BEA) (2004) data indicate that in the U.S., the distribution of ICT usage differs according to the size of firms. Smaller firms tend to be less ICT intensive than large firms because they are less able to incur potentially risky investments. The use of *intranets* and some forms of electronic document management is commonplace in medium to large construction organizations. Intranet serves their in-house communication needs. Web-based collaboration portals are proliferating quickly to facilitate transfer of information and work flow processes among multidisciplinary team members. The web has become an important channel for sharing project information and providing an up-to-date communication platform (Sarshar et al. 2002).

Furthermore, the current use of ICT in construction firms continues to be 'piecemeal' (Mak, 2001): few contractors are fully able to integrate ICTs with their business processes. Bookkeeping and invoicing are the most common ICT applications even in the relatively advanced countries (Samuelson, 2002). Email attachments constitute the most 'sophisticated' use of the Internet for the majority of the construction firms (Björk and Ruohtula, 2003).

The current use of internet-based tools and systems in global construction industry are identified in this paper. The remainder of the paper is organized as follows: the next section includes a brief review of ICT tools suitable for construction management, followed by the extent of ICT use across several regions such as North America (US and Canada), UK, Australia and Asia (Hong Kong, Japan, and India). At the end, a brief discussion based on the findings of this study is provided.

2. ICT Tools for Construction Management

Among all ICT applications, the Internet is the technology that best facilitates a collaborative working environment in a construction project. Walker and Betts (1997) postulated that the Internet, and more specifically the World Wide Web (WWW), would be the key to a change in global construction business in the near future and would impact professions, collaboration, and the construction business structure. Fourteen years after their prediction, it is apparent - based on today's state of the construction industry worldwide - that they were right on target.

The use of Internet as a medium of communication can help information transfer occur faster and more effectively and enable new opportunities for the development of distributed systems that can cross

organization boundaries and provide a unique opportunity for teamwork and workflow automation. The Web can also overcome the incompatibilities of data formats through smart browsers and servers. The current use of Internet in the construction industry can be broadly classified in terms of *Intranets* and *Extranets*[1]. Figure 1 highlights the major characteristics of Internet, Intranet and Extranet. The concepts of Intranet and Extranet are briefly described in succeeding paragraphs.
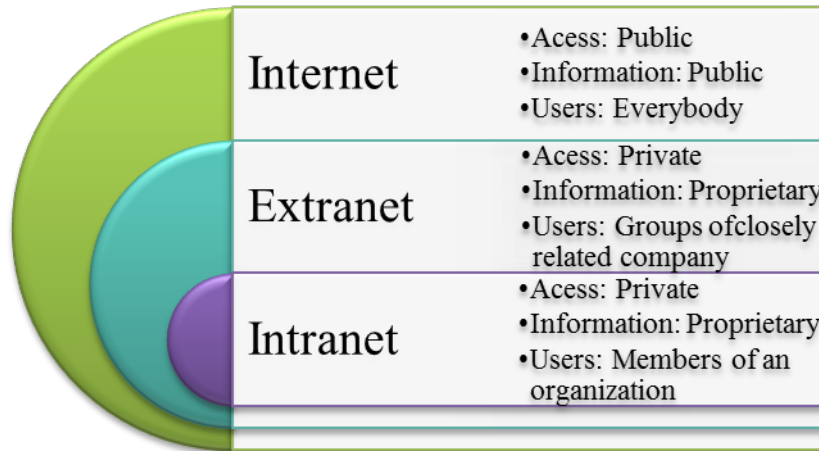

Figure 1: Comparison between Internet, Intranet and Extranet

Intranet is utilized by individual organizations for their internal operations (Slyke and Bélanger, 2003), and is normally equipped with electronic templates and mail functionality for communicating corporate documents, providing departmental or divisional information, as well as enabling searches through an in-house directory of information for knowledge sharing. One example of Intranet is Electronic document management system (EDMS) which is commonly used in construction organizations for handling the sharing, storage, and retrieval of drawings and documents. Modern EDMS are Internets with external collaboration capability as compared to earlier versions which were only workable on Local area network (Hjelt and Björk 2007). Another recent advancement in intranet is the Enterprise resource planning (ERP). It has also recently introduced a packaged suite of software with which an organization can control its various functional activities (such as material procurement, human resources, finance, plant hiring, etc.) Despite the intended functionality of these all-in-one systems, based on a survey of 101 respondents in the U.S. construction industry by Tatari et al. (2007) only 12.7% had full internal integration, while 48% of the firms used commercially available ERP systems.

Extranets are used to exchange information securely by providing access to a portion of an organization's Intranet or by using a common network that links all the business partners (Wong 2007). Figure 2 describes how an Extranet is networked with Intranet.

Virtual private network and application service provider (ASP) are commonly used to provide the link. For example, Web-based project management systems (WPMSs) is an electronic project management system conducted through the "Extranet", which is a private network using Internet protocols to transmit information and only accessible by authorized users at different predefined levels. Figure 3 depicts functional scheme of WPMS. Project data are stored on centralized servers, and a standard web browser is used as a gateway to access, exchange, and share information from remote locations at any time, eliminating the problems that occur in linear communication schemes (Thorpe and Mead, 2001).

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[1] While the web is open to anyone the Intranet is private and is protected from public visual by its firewalls security systems with specialized software to prevent outsiders from invading private networks and Extranet is private intranets that are extended to authorized users outside the company
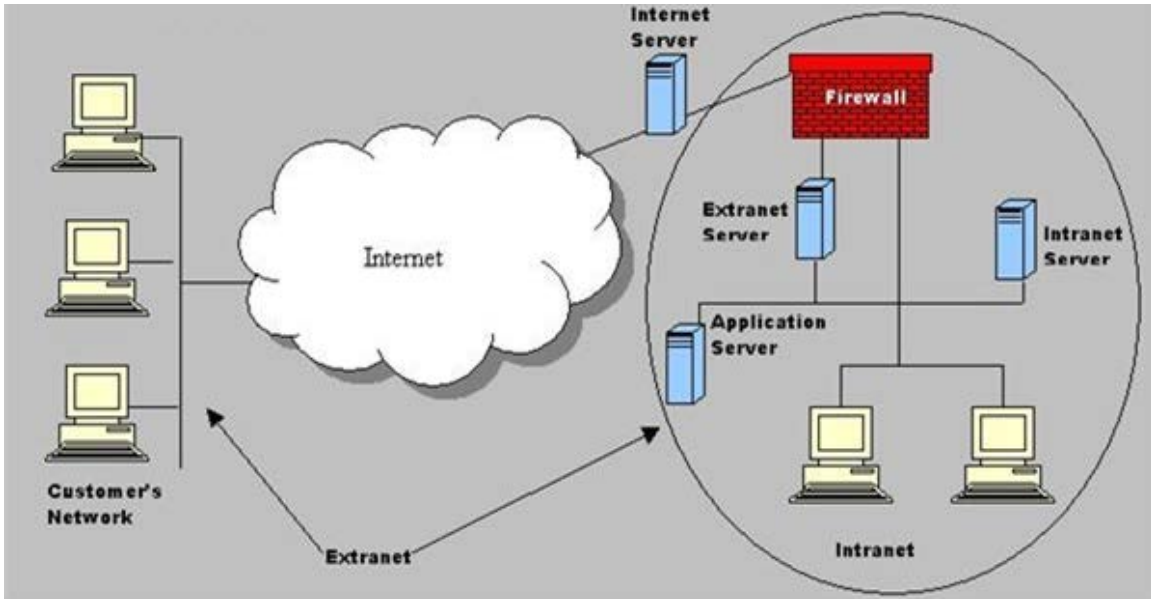
Figure 2: Network connection between Intranet and Extranet

In some large organizations, the integration of Intranet and Extranet into a single platform has brought some definite advantages, such as the convenience of file transfer from internal archive to external parties, but the potential security threat has to be carefully assessed and controlled (Patrick et. al., 2010).

After the brief introduction of the Internet-based ICT tools in construction, regional usage pattern of these tools in different areas across the globe is presented in the following section. This discussion is based on previously published research studies. As noted earlier, regions included are; North America (US and Canada), UK, Australia and Asia (Hong Kong, Japan, India and Singapore).
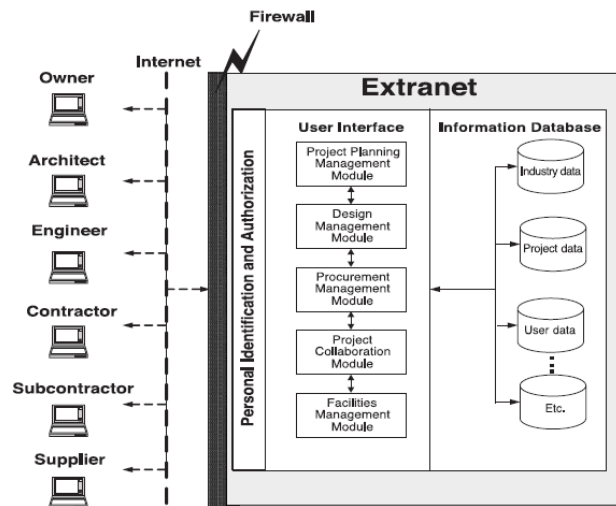

Figure 3: Functional scheme of WPMS
[Adapted from Nitithamyong (2003)]

3. Current State of Regional Use of ICT

3.1 North America

In North American region, the overall trend of using ICT tools for project management is increasing. Hurtado (2003) reported number of A/E/C firms using WPMS had risen by 16% as compared to previous two years and the number of firms acquiring ''virtual'' project teams using the WPMS are doubling every 6 months. However the penetration is still not very deep in the industry. Ilich et al. (2006) found that many new teams in the USA had started their projects without using any project collaboration. Schriener (2005) reported fewer than 20% of all construction firms use WPMS. It is understandable because the use of ICT in the construction industry is only ten to fifteen years old. Expecting complete penetration and adoption of ICT within this short period is unrealistic.

In United States, the majority of WPMS and online project collaboration systems users are big companies, specifically owners and then large general contractors and well established A/E/C companies (Issa *et al.*, 2003, Becerik and Pollalis, 2006). It is logical o conclude that established companies can spend more on these technological advancements. Some other trends found were that the use of ICT was higher in commercial projects, tools were used more on discretionary basis rather than obligatory, and standardized as well as customized systems were in use.

In the Canadian construction industry, although the use of Internet is widespread and nearly all public entities are equipped with the facility (Peterson 2001), the ICT tools for project management are still used by early adopters (Rivard. et. al., 2004), specifically those who consider it to provide a competitive edge over their competitors. Web portals and other in-house software and custom web sites are still at the budding stage in Canada, whereas in the USA similar tools are already being used to address advanced issues of project management (Rivard. et. al., 2004).

In the North American region, there are two different types of obstacles to the construction organizations, internal and external. Internal obstacles are due to the weakness in the organizations in-house working patterns such as, organizations' incompatibility with the information system (Azhar et. al., 2007). An external obstacle that hinders organizations' complete confidence on ICT for construction project management is the litigious nature of the construction industry. All stakeholders prefer to keep hard copies (sometimes even multiple copies of same record) as physical evidence with blue ink signatures to protect them against any fraud and/or claim (Ilich et. al 2006). It is difficult to authenticate an electronic document and its verification is not always completely reliable. Therefore electronic documentary management, that is possible without any paper at all, coexist with hard copies.

Interestingly, availability of widely diverse ICTs also poses a problem in a project environment when different stakeholders using different systems team together. Questions arise about which of them should be used for project collaboration. Owners usually do not take interest in this matter, so depending on the contractual relationships of the project, either the CM or GC dictates which tool is implemented (Ilich et. al 2006). This can cause frustration in the team, especially for A/E, consultants, and subcontractors as they are forced to use new tools as they join a project team. The result is information disparity, potentially long learning curves, and resistance to using these tools

3.2 United Kingdom

In UK studies identified that the use of WPMS is in its early stage however early adopters are already realizing some of the benefits to be gained (Price Waterhouse Coopers, 2002). Intranet and Extranets are being utilized mainly by large organizations like architect, engineers and contractors and subcontractors. These individuals are unlikely users of WPMS. Speed of communication, ease of documentation and information dissemination, improved knowledge sharing within geographically-dispersed virtual teams and enhanced business environment have motivated these initiators to invest in ICT (Irani and Love, 2001; Jones and Hughes, 2001).

The users are still uncertain about the use of WPMS. A survey by the Network for Construction Collaboration Technology Providers (NCCTP) showed that 44 percent of users in the UK were satisfied with their WPMS experience but undecided whether to adopt WPMS on every project; 3 percent were essentially unsure whether WPMSs are worthwhile; and 1 percent were unsatisfied and rejected any future use (NCCTP, 2006).

Uncertainty is due to the fact that justification of investment on the basis of return on investment cannot be performed using the traditional upfront methods and requires post implementation evaluation of benefits. It was also found that organizations use different tools for managing different departments of the same organization depending on their own priorities. For example, an organization interested in corporate communication would select tools to match its needs rather than an integrated tool useful to other departments in the organization (Wong, 2007).

Security threat is the main reason behind perceived lack of reliability of ICT tools. Companies are worried that confidential information could be hacked and used against the interest of the company in various ways.

3.3 Asia

In the region of Asia emphasis was laid on Japan, the largest shareholder of international construction in Asia and two the fast growing construction industries of Hong Kong and India.

In Japan owners are found to be more proactive towards the adoption of web- based tools, it shows a different pattern from the above two regions where it is mostly organization-driven rather than imposed in the contracts. In Japan, owners dictate their designers and contractors to use Internet-based ICT systems (Tulacz and Rubin, 2004). JACIC (2004) reported that 42% of large Japanese construction companies (each having over 1,000 employees) are using application service providers that offer WPMS. By comparison, of all the contractors in Japan, less than 10% are using these systems. Further, JACIC (2005) reported that large general contractors have developed in-house systems and are developing WPMS to share project information with other stakeholders (JACIC 2005). However, smaller firms in the industry have not yet adopted this technology.

Similar trends were found in Hong Kong where the public sector is more upbeat in the propagation of ICT. Their government is found to be actively working in the areas of research and development and is also formulating standards for use of various ICT tools in the construction industry. "HOMES" acronym for the (housing construction management enterprise system) was designed by the Housing Authority as one-stop information for all in-house needs, in addition to providing an online collaboration and knowledge sharing platform among internal and external working parties involved with its public housing projects.

According to Patrick et. al, (2010), a 2008 survey on an independent sample (sample size 127) of practitioners in Hong Kong found that intranet was the most widely used medium for in-house communication. About 52% of respondents used EDMS internally. The use of web-based platform accounted for 27% for internal communication and 24% for external information exchange.

In an attempt to investigate the vertical penetration of ICT tools in Indian construction industry Ahuja et. al. (2008) investigated the status of SMEs (Small and Medium Enterprises). It was found that although main offices are equipped with the Internet facility, site offices often lacks the availability. In 93% of the surveyed organizations, all the computers within office were connected through LAN. But, only 38% of the organizations had established Intranet / Extranet facilities for connecting all office and site staff and providing them access to centralized information and databases and 58% utilized both the methods. Internet

enabled communication technology is in use in the Indian construction industry, but comprehensive web based project management solution like WPMS had not been adopted by SMEs.

If we talk about the overall difficulties that the spread of ICT is facing in this region, the majority of causes will be no different from the rest of the world. Reliance on hard copies and manual operation in parallel to the electronic systems puts tremendous pressure on management operations by creating additional work instead of facilitating the process. The unpreparedness on part of the users to update information regularly into their ICT systems also creates "data holes," which are time consuming to trace and plug. Cultural barriers like preference of face-to-face communication over teleconferencing also impede time-saving and productivity.

3.4 Australia

References to the Australian construction industry indicate that wide variety of ICT applications are used by a disproportionately large number of bigger construction contracting and project management organizations (Stewart and Mohamed, 2003). Studies have indicated that a high percentage of large contractors are utilizing a variety of ICT applications and tools including: Internet, Intranet, e-mail; Local Area Networks (LAN), Wide Area Networks, Web Based Project Management Applications (WPMA), Video conferencing, and On-line remote networks. The results of a survey reported by Stewart and Mohamed (2004) also indicated that the larger construction organizations have been proactive in planning for innovative IT implementation with 85% of respondents indicating company strategy as the primary driving force. Only a small fraction of respondents indicated client requirements as the primary driving force.

4. Conclusions

It can be concluded from the above discussion that the patterns of ICT usage are different depending on the regions and also the driving forces behind ICT usage are varied. As observed in Asia owners (usually government in case of public projects) took initiatives to introduce ICT in project management while in other regions such as the North America, United Kingdom and Australia, the drive is usually self motivated. Current levels and nature of usage of WPMS in the global construction industry are summarized in Table 1. It is evident that the use of WPMS is derived by self motivation of early adopters. This is why the extent of use is usually low and only those organizations who are financially strong and can foresee the future benefits of adopting the technology. Another reason of low usage in particular regions is that the technology is fairly new in those regions.

There is a general hesitance towards the use of ICT, and factors like organizational culture, threats to confidentiality of sensitive document and other real or perceived legal issues related to contract management seems to be a hurdle everywhere. Steps should be taken by the industry to legalize the status of electronic documents. Management responsibility increases if hard copies are maintained as record along with electronic documents. With such practices, ICT tools become part of the problem, not the solution.

Compatibility issues and conflicts among various users are also adding to the problem as project stakeholders continue to use their own tools and systems. The issue of ICT compatibilities must be considered during the selection or appointment of project participants or entities for fostering healthy project collaboration. Otherwise, long learning curves and anxieties will result defeating the very purpose of collaboration.

Table 1: Current Status Use of WPMS in Construction Industry

Region		Motivation		Extent Of Use			Age of Use of WPMS	
		Self	Government	Low	Medium	High	>10 years	< 10 years
North America	US	●			●		●	
North America	Canada	●		●				●
Europe	UK	●			●		●	
Asia	Japan		●			●	●	
Asia	Hong Kong		●	●				●
Asia	India	●		●				●
Australia	Australia	●		●				●

In the long term, the construction industry needs to engage in research and development programs, linking local and global industry needs to current and future technological advancements. In addition, appropriate training and support services can enhance the extent of ICT usage by reducing resistance by the users. Focus on creating a supply, and demand relationship among the academics and industrialists to maximize exploitation and commercialization of technologies and knowledge can be helpful in producing professionals that are prepared and wiling to employ advanced technologies. It is important to learn from the experiences across the countries.

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