An Intranet-based integrated construction project management system

Stephen Mak
Department of Building and Real Estate
The Hong Kong Polytechnic University

Abstract

This paper will explore the feasibility of using Internet technologies to build an integrated construction project management system for a contractor. Internet technologies refer to what are commonly used in the Internet. They include hardware equipment such as computer, modem, telecommunication devices, network cabling; and software such as TCP/IP, HTTP, FTP, SMTP and so on. When these internet technologies are employed in a corporate environment in which there is either (i) no connection to the Internet at all, or (ii) a security system (e.g. firewall) to separate the corporate network from the Internet, the system becomes an Intranet as commonly known nowadays. By using Internet technologies, a contractor can set up a corporate LAN in the head office. Project offices are then linked to the corporate LAN by telecommunication such as dial-up, leased line or frame relay. A corporate database can be set up with a Web interface so that all queries, data input and output to the database can be done via a Web client. Modules that are applicable to a contractor include (i) electronic mail; (ii) tendering and estimating; (iii) purchasing; (iv) quantity surveying (interim payments, claims, variations); (v) document management; (vi) quality assurance; (vii) project accounting. An integrated system is seen as of utmost importance in a contractor's environment. The advantages of using Internet technologies and this system will be discussed. An implementation schedule will be presented. Possible difficulties such as organizational and technical issues will be discussed too. Possible extension of the Intranet to an Extranet will be explored.

Introduction

The construction industry is seen by many as backward in deploying technology, not least information technology. Application of IT has been quite piecemeal and only very few contractors have a comprehensive and integrated information system for its core business, i.e. construction. An exception is perhaps the accounting system. Many reasons attribute to this but it is not the intention of this paper to discuss these. Research by Mak (1994) reveals that contractors generally welcome a system that helps contractors manage their enormous information in various formats.

It is perhaps time that the construction industry captures the fast growing and leading edge information technology development of the Internet and Internet technologies. This paper will discuss a simplified model for information flow within a contracting organization, a proposed model to manage this information and an agenda for research and development.

Information Flow for Contracting

Tendering is the first line operation of a contractor to solicit jobs, and to survive. Ball (1988) has indicated that large UK contractors win an average of 10% of all jobs tendered for. The tender documents for a typical construction project include a Bill of Quantities, Particular Specifications, Drawings, and so on. It is at this stage that the enormous project information arrives at a contractor. When a tender is won, the Quantity Surveying department will take over the tendered project and a project team will be assembled. A site office will be set up. The Purchasing Department will be given a schedule of material requirements. The Accounting and Personnel Departments will make arrangements to set up appropriate files/databases for project accounting/financing and human resources administration. Figure 1 shows a simplified model for information flow within a contracting organization. Even if a job is not won, the tendered project will have to be archived for record and analysis.

It can be seen that the information required by the various sections and departments is derived from the tender documents. Traditional procedures are to organize a general office team to duplicate, i.e. photocopy, the documents for distribution.

This is the start only. Site operations, which can last for 1-3 years depending on the size of the project, will generate enormous information. This situation is further aggravated by the introduction of a quality system in which systematic documentation is essential, or all is about. It is at the site level which generate the enormous amount of documents and information. It is therefore essential that proper management of these documents in order to run the project efficiently.

As can be seen from figure 1, information flows among the various departments in a typical construction project. An electronic mail system is of prime importance for project team members to communicate. This can range from comments and advice from construction and planning managers at tendering stage, to material delivery schedules between site and purchasing department.

Databases

A few databases are required to run a project. The Tendering department maintains a database of tenders submitted. The database contains such information as the priced BQ, particular specifications, locations, job descriptions, clients, architects, engineers, drawings, photos, calculations for building up rates, remarks and decisions made for the tender submission and so on. When a tender is successful, this database is passed to the project team and QS section for running.

The QS department inherits the tender database from the Tendering department when a job is won and maintains databases of all jobs in progress. Interim statements will be generated from these databases and so will be variations, claims and final accounts. Completed jobs will be archived for reference by the tendering department. These cost-oriented databases will have to be accessible by site staff (site QS, project director) for such purposes as updating interim statements and substantiating variations and claims. The QS will also generate a schedule of material requirements for the Purchasing department to negotiate contracts with suppliers.

The Purchasing department will maintain a database of material suppliers, costs, contracts and contacts. It will receive material schedules from the QS department once a job is started. Actual delivery schedules will be communicated from site. Delivery dockets and invoices will be exchanged between site offices so that proper payment instructions can be made to the Accounting department.

The Accounting department will set up a database to handle outgoing payments (to suppliers, subcontractors and site personnel), incoming payments (from client), job costing and financial status of a particular project.

The Personnel department will maintain a record of site employees which can be project-based or permanent staff of the company.

At site office, the project needs to run a number of databases. These include a quality system to handle the QA process; a document system to handle correspondence, instructions, drawings, and so on. It will access the project payment system maintained by the QS department for updating interim statements, variation orders and claims. It will also keep records of project planning and progress monitoring, minutes of meetings, sub-contractor information, method statements, material stock and so on.

Internet, Internet Technology and Intranet

The Internet has appeared for some time after the BITNET. Both were used by academics in the first instance. Serious use of the Internet, apart from electronic mail, did not start until the World Wide Web (WWW), a multi-media and hyper-text-like system, hit the Internet since 1979. The WWW was limited by its non-hierarchical file organization and static data. Organizing the files within a WWW server can be very demanding especially when constant changes of the contents are required.

The Internet was originally built on the unix system and therefore its infrastructural protocol is the TCP/IP. A distinguished feature of the Internet is that it is predominantly a client/server system which makes it very suitable for multiple and heavy access without too much degradation in performance. Internet services (or applications) include electronic mail, gopher, world wide web, telnet, ftp (file transfer), wais, to name a few more common ones.

Commercial use of the WWW was first limited to marketing of products in which information can remain fairly static and can be browsed by many people. The WWW started to take off when more and more software developers began porting their applications to the Internet and WWW. A very important aspect of this development was in database links. Major RDMBS suppliers have provided common gateway interfaces (CGI) and even application program interfaces (API) to integrate their database system with the WWW. With a database link, information can be made much more dynamic and organized more systematically. It has also widened up the scope of applications.

A very recent trend of Internet technology deployment is adaptation to enterprise network; that is, building a corporate network using Internet technology and applications. This has became a Intranet. The Intranet can be as small as a LAN (local area network) within a

company or can be very large spanning over continents using private WAN (wide area network) connections. It can further be connected to the Internet via a firewall device to bar access from outside the corporation but letting users within the corporation to access the Internet.

Advantages of Using Internet Technology

The deployment of Internet technology (and services) provides advantages in three aspects; namely, cost, technical support and end-user training.

Heterogeneous environments can be tied together by the TCP/IP protocol, regardless of the existing protocols and network configuration. As TCP/IP is an open standard, it can run in parallel with other proprietary protocols such as IPX, NETBEUI, AppleTalk and so on.

Further, heterogeneous platforms, which usually cannot "talk" to each other, are made more compatible as many Internet applications, including server and client applications, are now available in virtually all major platforms such as Windows-NT, Windows95, Macintosh, and a variety of unix boxes. Therefore, new investment can be minimal if an existing network is available.

Set up cost for a database (RDBMS) server is also comparatively low. By using CGI and API, the number of user licences that is required can be as few as 1 if development and programming is also done via the WWW system. This is because of the peculiar design of CGI and API that users accessing the database server via them are treated by the server as one user. Therefore, normally a five-user licence is more than enough for application, administration, development and maintenance. This compares favourably with a per-user licensing system on traditional computing platforms.

In terms of technical support, the Internet is the answer. With its world-wide support and effort to develop novel and sophisticated applications, it is much easier for programmers to top into the virtually unlimited resources. Co-operative efforts are further made possible by the numerous discussion groups, mailing lists and Usenet News groups. The bottom line is that it makes very little difference between programming on the WWW and on proprietary application interface. Stored procedures, two-way commit, transaction processing techniques are equally important for using the RDBMS for serious applications on the WWW.

End-user support and training has always been an obstacle in implementing information technology in construction. However, with Internet, there is one interface to learn, i.e. a Web browser such as Netscape. It has to be borne in mind that using Internet technology to implement business applications is a little different from surfing on the WWW. The latter is characterized by random and casual processes whereas the former has dedicated applications such as fill in the form, querying for information and updating databases. Furthermore, more and more plug-ins are available to reduce the need to use external viewers to complement the browser. A good example is the PDF viewer plug-in for Netscape. The learning curve can be envisaged to be of geometric shape.

An Intranet-based Construction Management System

Although an Intranet can be as small as a simple LAN with a few computers, its is much more useful if the network is larger requiring some sort of WAN connections.

A contractor can benefit from the Intranet as it is typical for a contractor to have a head office and a few site offices. This resembles multi-national corporations as far as information management and sharing among "offices" are concerned. Figure 2 shows a typical layout of a corporate LAN and WAN for a contractor. Each department has its own LAN which connects to the corporate backbone. Each will share and contribute information to the central database. Telecommunication equipment is used to connect site offices to the headquarter. Larger sites will have their on site LANs whereas smaller ones might have a single PC using modem to dial-up to the head office. In this way, wherever one locates, one can access the most up-to-date and single source of information.

Benefits to a contractor are several-fold. First, it allows common documents such as the general specifications, the BQ and particular specifications to be "published". This eliminates a great deal of paper documents and space, in particular site office. At tender stage, these documents can be circulated within the tendering department or selectively sent to project managers or directors for reference and queries. Good quality scanners with sheet feeders and OCR (optical character recognition) are available which are capable of handling contract/tender documents normally found in the construction industry.

Second, it eliminates discrepancy and mis-understanding in the versions of documents, in particular drawings. With a single repository of documents, amendments are reflected immediately. Correspondence, be it received in the site office and head office, can be scanned into the database for reference and discussion between decision makers geographically scattered.

Third, records can be kept in multi-media format. This is particular important for future reference. For example, progress photos, new/novel construction methods, accident scenes, and the like are useful for (i) claims substantiation, (ii) tendering for new projects, and (iii) training of new staff such as graduate trainees. These photos can also act as marketing materials.

Last but not least, with the use of WAN technology, the project databases can be kept at head office. This prevents the usually dusty and sub-optimal conditions for computing equipment (disk and tapes) in site office. Computers in site offices become terminals/workstations only so that any equipment fault or accidents (e.g. theft) will not affect the integrity of the databases. Further, project team members can dial into the head office and get information even they are out of the site office, i.e. work at home.

Possible Disadvantages and Considerations:

1. Apart from native unix systems, many corporation's networks do not have TCP/IP. Though TCP/IP is an open system protocol, it may pose difficulties to include this protocol to the existing network.
2. Unlike a traditional LAN such as Novell in which security is built-in, security for internet services is lacking. Implementing a security system can be tedious. Normally, security provided by a web server is by means of a username and password for

accessing a particular folder. Integrating this with the existing network is still lacking. However, restricting access to a database system is a lot more complicated especially when it is on a web based system.
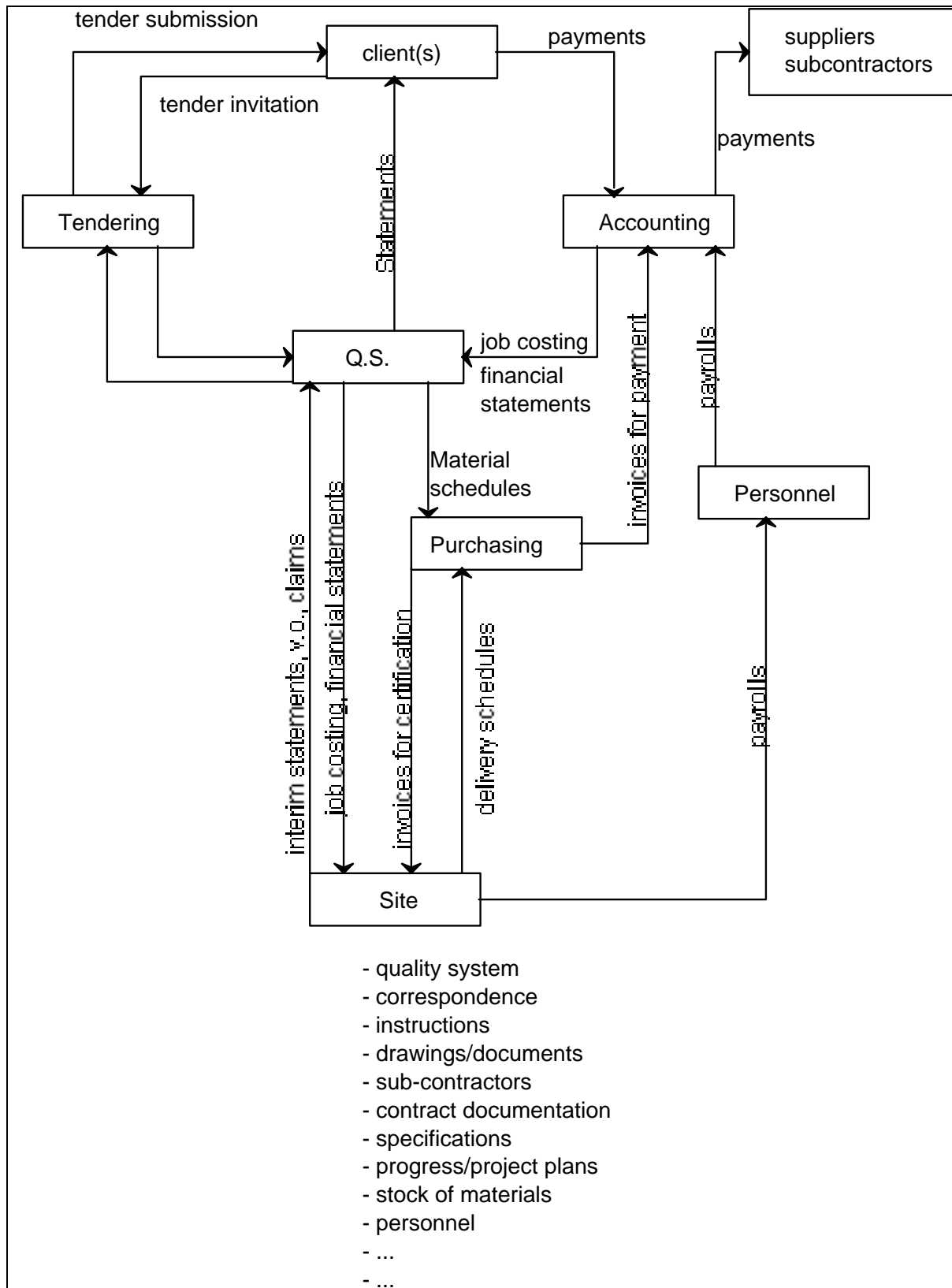
3. Traditionally, estimators, project managers, quantity surveyors alike usually treat information possessed by themselves personal. It is envisaged that in early stage of implementation it will be difficult for these people to 'surrender' their personal information to a system.

4. Communication by electronic means is perceived by some people intangible. Legally, it is also arguable if electronic mail or scanned images are acceptable in a court of law should disputes arise. This aspect should be studied further with advice by legal experts and proper solutions devised.

5. As an end user, using dial-up facilities offered by Internet Service Providers (ISP) is easy. When it comes to setting up a WAN by organizing the hardware, leased lines, modems, authentication and the like, it is not as simple. Not only is the equipment expensive it also requires technical expertise in telecommunication to support only this section of the network.

Conclusion

The construction industry has been slow in catching up with the pace of information technology development. Many reasons contribute to this among which is the humanistic characteristic of the industry with many human parties participating. The development of the Internet and internet technologies in the last decade has provided, among others, the construction industry to step up its IT deployment. Globalization and regionalization of the construction industry in many countries has increased opportunities for the contracting business to go overseas. These opportunities are however associated with increased competition and uncertainty. Though IT itself cannot help resolve uncertainty, it can certainly help increase efficiency and thereby increase competitiveness and competitive advantages of a contracting firm. Internet technologies have solved many problems inherent in the more legacy systems such as telecommunication and platform dependence. These technologies have provided new scopes of applications with its various advantages such as open system standard, certain considerations such as human and organizational aspects are to be taken into account if they are to be implemented properly.

References

Ball, M. (1988) *Rebuilding construction*. London:Rutledge.

Krol, E. & Ferguson, P. (1995) *The whole Internet guide*. New York: O'Reilly.

Mak, S. (1994) A study of information technology implementation of Hong Kong contractors: Directions for future development. In Isaacs, N. & Bowler, J. (eds.) *Informing a diverse industry: NZIOB Papers 1994*. New Zealand: Centre for Building Performance Research, Victoria University of Wellington

Figure 1 Information Flow within a Contractor

Figure 2 Typical layout of LAN and WAN of a contractor