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Web-based construction information management systems

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ABSTRACT

Centralised information systems that are accessible to all parties in a construction project are powerful tools in the quest to improve efficiency and to enhance the flow of information within the construction industry. This report points out the maturity of the necessary IT technology, the availability and the suitability of existing commercial products.

Some of these products have been studied and analysed. An evaluation and selection process based on the functions offered in the products and their utility is presented. A survey of local construction personnel has been used to collect typical weighting data and performance criteria used in the evaluation process.

Keywords—Construction industry, information management systems, Internet, intranet, extranet.

THE NEED FOR CENTRALISED INFORMATION FRAMEWORKS IN CONSTRUCTION

A large variety of forms and types of project information are required at different stages of a construction project. A wide range of professionals from many disciplines uses this information. The data is extremely dynamic, often changing from day to day throughout the project. There is a continuous cycle of creation, storing, manipulation, transmission, reformatting, application and revision. The time for each cycle can be very short.

The consequences of using inappropriate or inaccurate data can be costly and result in unnecessary delay. The efficiency of the construction development and operation cycle depends on the integrity and effectiveness of the information flowing between the client, design engineering, equipment manufacturing, contracting, and facilities management segments of the construction industry (Council on Tall Buildings and Urban Habitat 1995)

A centralised database is an integral part of an appropriately formed information framework. Any changes or modifications to information are recorded and disseminated automatically within the system thus ensuring that every discipline involved is working with the most up-to-date information (Aouad et. al. 1995). Such a system also removes the need for duplication and hence a potential for errors. Centralised Information Systems have been advocated for some time (Construction Industry Development Agency in Australia (Sharpe 1995) and the Construction Industry Institute in USA (The Construction Industry Institute 1993a, b and c) but the advent of high-level computer systems now makes them a viable option.

WEB TECHNOLOGY AND THE NEEDS OF CONSTRUCTION MANAGEMENT

The Internet is an ideal vehicle for integrating and disseminating information around a network of participating groups and organisations. It has become a cost-effective, universally accepted and readily available delivery system. The Web offers unparalleled communication opportunities for the construction industry, particularly its facility to accommodate a wide range of media types (text, voice, objects, etc). It is now possible for construction firms to build up local and/or global information networks with low access cost using affordable hardware and software. The access control and security measures available on the Internet can ensure data protection and integrity.

Web-based construction information management systems can make use of browsers, data handling devices and other Internet technology to create a network for sharing and manipulating corporate information in a way that will assist construction project managers to complete work on time and within budget.

WEB-BASED CONSTRUCTION INFORMATION MANAGEMENT SYSTEMS

By providing an efficient central data facility it is possible to create and maintain goals, schedules, standards, policies and procedures that are shared by all of those involved in the construction process.

Common features of such systems are:

- Access to project information is possible from anywhere and at any time through the Internet.
- Team communication, collaboration and decision-making is improved through the increased transparency in the management process.
- Handling of data is cost effective and not prone to errors and delays caused in duplication.
- Project management is controlled and systematic. Updated information on progress is available to all and shared as soon as it is available.
- The quality of project data is high and meets the real needs of the professionals involved, as a result of the timely transmission of information between designated parties, use of specified task specific formats, data accuracy and backup in well-defined and powerful database repository.

- Historic data for past projects is available for retrieval for new applications, such as for project maintenance needs, new project planning etc.

Users of such systems have increased competitive advantages and opportunities a result of data integration and application.

OBJECTIVES OF THE PROJECT

A project, supported by the Hong Kong Research Grants Committee, has been undertaken to investigate how the use of Internet based construction information management systems could be encouraged and facilitated. The objectives of the project were:

- To identify the most commonly required information/data structures/hierarchy for construction projects and determine the flow of this information.
- To evaluate the feasibility of using and developing/providing a centralised and unified information management system that could be used to manage project information using the Internet as a common user platform.
- To investigate ways to improve the quality of project data in order to streamline the preparation, presentation and re-production of construction documents.

REVIEW OF WORK TO DATE ON WEB BASED CIMSs

Work carried out in the last few years serves as a good basis for the onward development and improvement CIMS applications. Examples are:

- A prototype system was developed at the Western Michigan University to evaluate the applications of non-conventional data (Abudayyeh 1997).
- A 'virtual teams' approach based on networked computers providing standard services, and plans to extend both the bandwidth of services and the connectivity by transformation to Intranet technology (Line 1997).
- A proposed open infrastructure for electronic construction project document sharing developed under the European Esprit Condor project (Resgui and Cooper 1998).
- A computer system based on use of the Internet for construction information management during the design, construction and maintenance (Sörensen 1998).
- A 'Total Information Transfer System' with six major functions including: data exchange and remote log in, Internet chat enhanced with on-screen drawings, live video-cam, search engine and e-mail system (Tam 1999).
- 'Request For Information' (RFI) used simulation-based modelling to demonstrate a significant reduction in time and cost for implementing Electronic Data Management Technologies (Mohamed et al. 1999).
- Internet based 'Field Inspection Reporting System' was developed for life-cycle costing of construction projects at the University of Colorado (Rojas et al. 1999).
- An Internet-based model (Abdelsayed et al. 1999) in a Web-based environment accessed the project databases resident on the project's main server and was accessible through the project's Web site.
- Mak (2001) developed a Wide Area Network (WAN) technology to manage and transfer of contractors' information between head office and site offices.
- REALMEDIA provides Internet real-estate services with multimedia information, integrating text, graphics, and video clips (Cao et al. 2001).

This selection reflects the rapid development in recent years of both conceptual and practical applications of the Internet developed for construction management activities. These also mirror the rapid development of commercial products for Web-based project management in construction, especially in the U.S.A.

COMPONENTS OF CONSTRUCTION INFORMATION SYSTEMS

The evolution of systems using construction information has led to the development of a data model/hierarchy (Abdelsayed et al. 1999). This can be used as a basic structure and adapted to incorporate the local needs as well as to form a backbone for any development. The data hierarchy has four main components:

- Daily site report (DSR)
- Change order management
- Project control
- Correspondence database

The, project data held in CIMSs are best stored using the four these components utilising a Work Breakdown Structure (WBS) so that storage and retrieval of project data are possible in an organised manner.

THE EVOLVING USE OF THE INTERNET IN CONSTRUCTION

There have been three distinct stages of development of the use of information technology in the construction industry.

In the first phase products were directly used to improve the efficiency in manual processes of information manipulation at operation level (up to late 1970s). The second phase of development saw the introduction of stand-alone packages. From the early 1990s, the third phase of development began the integration of stand-alone systems into strategic electronic platforms for real-time structured data exchange and to maintain supply chain relationships i.e. information systems that hold, manage and use data for a variety of management functions. The Internet is an ideal vehicle for these.

IN-HOUSE DEVELOPMENT VERSUS APPLICATION SERVICE PROVIDERS

There are two options for a construction company when deciding how to implement a web-based project management system, i.e. in-house development or using IT services available from the market (project hosting services)

from an Application Service Provider. An ASP is an organisation that hosts software applications on its own servers within its own facilities. Customers rent the use of the application and access it over the Internet or via a private line connection.

In the first case, a construction company has to invest its own resources such as financial, technical, human and development time in order to develop, upgrade and maintain a customised system. The software runs on the company's own server but users can access it across the Internet.

With the second option, a construction company may use Internet Service Providers, choosing software products/services that focus on the architectural, engineering, and construction (A/E/C) industry. The advantage of such a service is that the application can be run from any computer, and the software is routinely upgraded and maintained by the hosting organisation. Problems with hardware/software incompatibilities are eliminated. A large number of concurrent users can be entertained in complex business applications and often with a relatively low price structure.

CATEGORIES OF PROJECT MANAGEMENT SITES ON INTERNET

By 2004 the total online business of the US construction industry is expected to reach US$141 billion (Bryant and Pitre 2001), almost 11 percent of total construction spending. The investment in using the Internet in the construction industry is growing rapidly. Not only has the number of internet companies focusing on AEC project management doubled every six months during 1998 and 1999, but the services provided are expanding into three specialised subcategories.

PROJECT INFORMATION PORTALS (PIP)

Information intended for public use such as codes of practice, permit procedures, economic trends, product information, cost data, and planning information that construction professionals would use for a project are available on this type of management website. Users can also find news and general public information about the industry, job positions and resumes, schedule of AEC seminars, presentations of previous seminars etc. An example of a PIP can be seen at www.aecdirect.com. Access to these sites is usually free.

PROJECT COLLABORATION NETWORKS (PCN)

PCNs provide an environment designed for sharing project specific documents, communications and workflow thus supporting online document management systems for project teams during a project. Members of the construction team may upload or download drawings and construction documents from the holdings in the database on the PCN's server. Some vendors offer PCN solutions packages that companies can install on their own servers. Monthly costs for using a PCN depend on the intensity of use of the database, amount of storage required and number of user accounts created. The cost may typically vary from US$50 to US$1500. Examples of a PCN can be seen on Internet site www.constructware.com.

PROJECT PROCUREMENT EXCHANGES (PPE)

These sites deal with exchange of information and data between the contractors and material suppliers or manufacturing firms. Benefits can be expected from reducing participant's internal cost of managing estimates, quotes, bid and proposals, reducing cycle time as the result of improved coordination, reducing mediation with business intermediaries such as brokers, wholesalers and dealers. Because of its fragmented nature, the construction industry is regarded as an ideal environment in which to use project procurement exchanges (PPE). Examples of PPEs are located at; www.buildpoint.com and www.buildnet.net.

In recent years, most of the leading companies have built up their business working in one of the three areas listed above. They have added features to their products according to perceived opportunities and business needs. For example, Bidcom (www.bidcom.com) and Cephren (www.cephren.com) started as PCNs, and later they included PPE type services to their businesses. Another package is Busssaw.com (www.busssaw.com) that started as a PCN and added PIP features to its site.

REVIEWING AND USING EXISTING SERVICES AND PACKAGES

The development of Internet based services for the construction industry has been exponential in the last three years and the availability and access to these systems is relatively easy and practical. There is no longer a need to develop new systems as those commercial products now available meet most or all of the needs of the construction profession. Rather, there is a need to develop a system whereby the (typically non-IT expert) construction professional can select the most appropriate service/package to suit their specific needs.

Accordingly this research has focused on the identification and evaluation of products that can effectively enhance the integrity and the effectiveness of site-level information flow amongst construction personnel i.e. to utilise existing products rather than develop new software. To serve this purpose, a practical process for evaluation of the available products has been developed.

The investigation began with identification and review of available products, a preliminary assessment of their features, creation of trial accounts, identification of key features made available to users and then grouping these features into categories of service. Later a survey of potential users of these systems working in the construction industry was undertaken to ascertain the perceived importance of the various features.

Initially, an Internet search of products for web-based project management for construction was carried out with reference to Skibniewski and Abduh (2000), Schulz (1999), Smith (2001) and Doherty (2000). There are also exhaustive product lists available from the Internet, such as the comparison matrix given by Schulz and product lists in http://www.extranets.cc; http://www.extranetnews.com and http://www.archrecord.com.

Another source of product information was product demonstrations and press releases.

Trial accounts in Busssaw.com, Cephren.com, E-project.com, and Bidcom.com (at this stage not merged with Cephren) were set up. This was followed by the identification of the important features and function of the packages. These were then organised and grouped by function into a checklist to be used as part of the system for measuring and evaluating performance.

EVALUATION OF PERFORMANCE OF CIMS

A weight-scored evaluation checklist for software packages selection was developed (following a pattern developed by Avraham (1994) and Harris (1977)). A trial assessment to rank the packages being reviewed was run and weightings were given according to the relative importance and for the performance of each feature considered.

In order to systemise the checklist the features were grouped by function. This structure is shown in Figure 1.

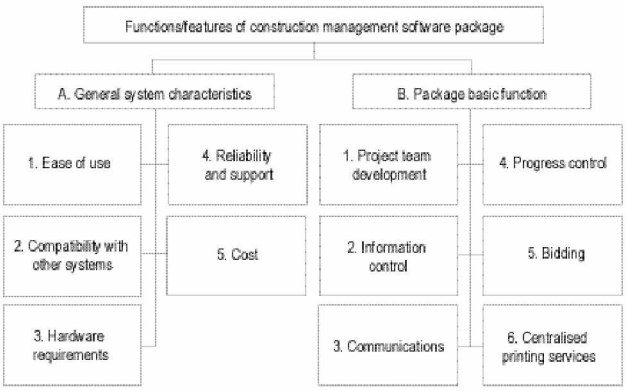

Figure 1: Hierarchy of features and functions in web-based CIMS selection

Each feature was assigned an 'importance ranking' or weighting value of 1 to 4 (marginally useful, useful, very useful, and essential). For its performance each feature was assigned a score from -1 to 3 (not available, poor, fair, satisfactory, and good). The final score of each package was then calculated as the sum of the products of the assigned weightings and performance of each feature/function.

At this stage the trial was used not to identify the 'best' product (as the performance and ranking used were subjective values introduced by the researchers) rather it was used to establish the validity and utility of the method of assessment.

In order to develop an evaluation tool to a level where it could be legitimately used and relied upon by construction professionals, it was necessary to collect information on the opinions and needs of construction professionals [as opposed to the features provided by IT organisations]. This information was collected as feedback from professionals at a symposium, from recent product reviews and from an interview survey.

SURVEY OF CONSTRUCTION PERSONNEL

To collect opinion from the construction industry of Hong Kong to support the assessment method and to serve as a basis for further refinement of the feature list a survey was undertaken. A group of potential uses of CIMS systems in the industry, particularly those without a background in Information Technology completed the questionnaire giving their weightings of the various features.

FEEDBACK FROM INDUSTRY AND PROFESSIONAL USERS IN CONFERENCE

The Engineers', Architects and Surveyors professional institutions of Hong Kong (HKIE, HKIA and HKIS), along with the Hong Kong Productivity Council jointly held a conference/workshop entitled 'Future Outlook of Construction IT' (http://www.hkisqsd.com/constructIT/main.htm) in June 2001, designed to present and consolidate the latest IT applications and technologies, related to productivity improvement, mobile and virtual enterprise solutions, on the construction industry.

Examples of local in-house e-project management were demonstrated. There were also examples of locally developed project hosting services. International vendors also offered solutions like IcFox (licensed with Citadon to offer ProjectNet) and myconstruction.com.

IT experts and specialist discussed and emphasised the advantages of deploying such advanced techniques in the construction industry of the Asia, in particular in the Chinese market after being admitted as an official member in the WTO (World Trade Organisation). The key features identified are the same as those outlined earlier.

Each vendor or developer continues to develop their own solution with the features different to that offered by others but with similar broad areas of functionality.

REFINING OF THE LIST OF FEATURES/FUNCTIONS

The viability of the evaluation process having been established (as described earlier) the information collected from vendors and users was used to develop more industry orientated weightings and performance ratings.

The features included in the initial trial were checked against the evaluation summaries offered in the web site: www.asptip.com. On this site there are a collection of tables of evaluations for the top ASP products. Using this the

checklist was revised to better reflect the range and groupings of features The overall groupings and features originally used in evaluation, however, needed little modification to reflect industries' priorities and needs.

Additional useful information was collected by Perlman (1998) related to user interface evaluation (available on: www.acm.org/~perlman/question.html). This used questionnaires specifically designed to evaluate aspects of web-user interface satisfaction. This gave useful insight into human-computer interaction factors (such as learnability, adaptability to user needs, reliability, feedback and error messages) related to ease of use and usability of software packages.

This data was further used to refine the evaluation process being developed and confirmed the need for a system that allows the potential user (construction professional) to be able to incorporate their own needs, weightings etc in a process that is free from supplier bias and which consistently allows comparisons of rival products.

CLASSIFICATION OF FUNCTIONS OF CMIS SYSTEMS

Using the data collected from all of the investigations of CIMS products (as set out in figure 1), the basic generic functions were classified as; project team development, information control, communications, progress control, bidding module and a reprographic module. These functions can be summarised as.

- Project team development allows users to; create individual user accounts/password, contact management, set permission control for assessing documents, members in functional groups, allow user participation in more than one project;
- Information control allows use of; transaction workflow, submittals, change orders, customisable folder structure, upload or download files, viewing of particular file types such as AutoCAD, online meetings, and system report generation;
- Communications: support of web and non-web messaging such as email, fax, Palm Pilot interface (for collaboration), automatic notification of any change of document to users;
- Progress control: use of web camera for online assessment or transfer of site conditions;
- Bidding module: standard process for exchange of necessary information in managing subcontracting matters with subcontractor; and
- Reprographic module: remote printing with delivery services by printing company for hardcopy of drawings and document.

Besides meeting the functional requirements mentioned above, more general system requirements should also be considered such as ease of use, compatibility with other systems, hardware requirements, reliability and support and cost.

- Ease of use: the user friendliness that assists the learning cycle of users, user adaptability, feedback and error messages, all of which contribute to savings in training costs and time.
- Compatibility with other systems: capacity for viewing common file formats such as MS Office and those intensively used in construction field such as AutoCAD files, browser capability, use of wireless device such as PDA, redlining, online meeting capacity.
- Platform requirements: platform compatibility with Windows 95/98/NT, Mac OS or Unix etc.
- Reliability and on going support: high levels of support offered by each vendor during hosting and archive facility for all project data after project completion, other local information may be provided such as calendar and climatic information.

Cost factors may need to be considered as a separate issue. Priorities/importance of cost will be significantly different in different organisations. Cost is usually not so much a weighted factor as a go/no-go criterion with a fixed upper bound.

SPECIFIC CRITERIA FOR ASSESSING FUNCTIONALITIES OF CMIS PRODUCTS

Decisions on appropriate systems/packages should be made on the basis of their utility and application from the point of view of construction professionals not IT specialists. Opinion and weightings were gathered from construction personnel who are either the current users or potential users of Web-based construction information management systems.

Weightings for these revised factors were gathered using a questionnaire survey to collect views and experience from thirty non-IT construction professionals working in Hong Kong. The sample size and structure was chosen to give an response representative of construction professionals who are not IT experts. Thirty personnel selected to complete the questionnaire were drawn from the different sectors of the construction industry (consultants, contractors and Government) in approximate proportion to their representation in the industry.

Twenty percent of the respondents had experience in using this kind of package in daily construction management works. This is typical of the low penetration of Web-based products in construction industry of Hong Kong. The remainder of the respondents where personnel with experience of handling construction project information and who recognised the potential of Web-based products in construction management without having had direct experience of using related IT applications

The questionnaire required the respondents to rate their own preference (weightings) for each of the specified features/functions on a 1 to 10 scale.

A. General system characteristics:

A1—Ease of use had an average score of 8.50 with standard deviation 1.36. Most considered that ease of use was a very important factor in the selection process, as this would reduce the investment of time and cost to train construction personnel. The more user-friendly the package is, the less errors, costs and misuse there will be during operation.

A2—Compatibility with other systems had the averaged importance score of 8.53 and standard deviation 1.48. This is the highest score of all factors. The greater the ability to share different file formats, the more the project information can be shared. This indicates that construction personnel are willing to use the most up to date technology if it leads to greater efficiency and flexibility, and multiple use of records

A3—Platform requirements achieved an averaged importance score of 7.10 and standard deviation 2.22. This may reflect the expectation that systems now being developed will use common operating systems such as Windows, Windows NT, Mac OS, Unix, AIX etc. Thus the concern about incompatible platform requirements is low.

A4—Reliability and support had an average importance score of 8.07 and a standard deviation of 1.62, the third highest among all factors. This suggests that a key factor in the success of new packages is to offer reliable and supportive services to customers so that they can achieve the greatest benefits from products.

A5—Cost had an averaged importance rating of 6.70 with standard deviation 2.34. The score was rather a low one with opinions wide ranging. This lead to the conclusion that cost is not so much a feature to be weighted but more of a 'given', related to how willing an organisation is to embrace IT support.

B. CIMS functions

B1—Package's basic functions, (Project Team Development etc), scored an averaged importance of 6.90 and a standard deviation 1.97. This implies that the facility to allow the use of a system by many project team members is viewed as quite important.

B2—Information control had an averaged importance rating of 7.20 with standard deviation 1.21, a relatively high score. This indicates that proper control of information is considered important. Included in this feature are document version control, use of customisable folder structures, personal data management, task management, use of workflow process and retrieval of documents.

B3—Communications had an average importance rating was 7.07 with standard deviation 1.87, a high score, indicating that Web-based systems should be capable of receiving both Web-based data, such as email and non Web-based data, such as fax and paging.

B4—Progress control: For automated progress control using means such as web camera's, the average importance was 6.37 with standard deviation 2.30. A fairly low score, suggesting progress assessment by 'manual' methods is preferred at this stage.

B5—Bidding facility; the score for incorporation of a bidding module is 5.40 with standard deviation 2.13. This, the lowest score suggests that such complex issues such as bidding are not considered suitable for computer based systems.

B6—Reprographic features scored an average importance of 6.37 with standard deviation 2.17. This relatively low score suggesting that sophisticated graphics, printing and graphing are considered to be of low priority.

USING THE INDUSTRY WEIGHTINGS IN THE EVALUATION SYSTEM

The weightings for the different features obtained from each of the construction professionals were used in the evaluation system (replacing those used by the researchers in the earlier tests of the system) to rank the software packages under review.

The final score of each package with each series of weightings was calculated using the formula;

> Final score = Sum(Feature/function weight x performance rating)

Cost may or may not be included in this calculation. If not included cost may be taken simply as a go/no-go prior to this calculation. However, when it is included as a factor it can be seen in Table 1 that this has no significant effect on the rankings of the various products.

The resulting rankings were found to be similar to the rankings resulting from the earlier pilot evaluation exercise.

SENSITIVITY OF EVALUATION SYSTEM TO CHANGES IN FACTOR WEIGHTINGS

A series of tests (W1 to W6) were carried out to investigate the sensitivities of the process to changes in weightings. This is done to test the effect of users choosing weightings significantly different from those given by the industry sample. Weighting changes only become significant when the ranking changes. As a basis or starting point the average weighting given by the 30 respondents was used, test W1. The general and functional characteristics A1–A5 and B1–B6 in the following tables correspond to those identified in the previous section.

For weighting set W1, all weightings were equal to 1. For set W2, a factor of 4.5 was used to replace 1 as the weighting. This was applied to give a maximum overall score of 100 [i.e. a 'percentage score'] by using the multiplier 100/(11*2) since there were eleven sub-sections and each used score 2 as maximum. This is not part of the sensitivity analysis but serves to modify the evaluation procedure such that a 'percentage' score is produced.

For test W3, weightings were assigned to increase the importance of the more fundamental features of a CIMS package. No change of ranking occurred.

For sensitivity tests W4, W5, and W6, weightings were adjusted to test extreme weights such that the 'best' package was no longer Busssaw. This was done to determine under what circumstances (weightings) would the 'best' package be replaced by others i.e. the sensitivity of the evaluation to changes in the weighting of different features was examined.

Extreme (and unlikely) variations to weightings had to be used before any change in 'best' [ranked first] was achieved and because of this it can be concluded that the process of evaluation using this checklist approach is insensitive to weighting variations.

Attempts to change the lower rankings also proved inconclusive. With the typical selection of packages used it seems that a system, using assessed performance ratings, is relatively insensitive to variations in values assigned to the weightings of features. i.e. the 'best' choice is most dependent on performance of the packages, not on users' weightings of the features.

The other way to assess sensitivity was to calculate the scores for the packages using the weightings given by each respondent and compare these with the result calculated using the mean weightings (W1). These results are shown Tables 1, 2 and 3. Again the rankings varied very little. Although the variations in the actual scores and the rankings for those packages with lower scores were greater, there was no variation for those with the higher rankings.

	Briesnet	Buzzsaw	Cladon	Constructware	e-builder	Ironspire	Briesnet	Buzzsaw	Cladon	Constructware	e-builder	Ironspire
CI profil	(Scores)						(Rankings)					
1	70.7	80	77	71.2	75	74	6	1	2	5	3	4
2	71	82	77	73	75	72	6	1	2	4	3	5
3	73	84	78	72	76	71	4	1	2	5	3	6
4	69.6	79	76	69.8	74.1	73.7	6	1	2	5	3	4
5	71	84	77	69	75	68	4	1	2	5	3	6
6	72	80	79	71	76	75	5	1	2	6	3	4
7	73	82	79	69	77	71	4	1	2	6	3	5
8	73	82	80	68	77	71	4	1	2	6	3	5
9	68.8	82	75	72	73	69.2	6	1	2	4	3	5
10	72	79	77.9	71	75	77	5	1	2	6	4	3
11	69.9	83	76	69.8	74	68	4	1	2	5	3	6
12	71	80	77	68	75	70	4	1	2	6	3	5
13	70	81	76	70.9	74	70.6	6	1	2	4	3	5
14	72.2	83	78	72.0	77	71.9	4	1	2	5	3	6
15	66	84	70	72	68	62	5	1	3	2	4	6
16	73	86	79	74	76	72	5	1	2	4	3	6
17	72	83	76.2	71	75.7	70	4	1	2	5	3	6
18	75	83	81	70	80	74	4	1	2	6	3	5
19	76	84	82	69	80	73	4	1	2	6	3	5
20	71	80	77	66	75	68	4	1	2	6	3	5
21	65	81	72	68	70	63	5	1	2	4	3	6
22	72	83	77	67	75	66	4	1	2	5	3	6
23	69.3	82	75	70	73	68	5	1	2	4	3	6
24	71	82	77	70	75	69	4	1	2	5	3	6
25	73	79	79.8	62	77	69	4	2	1	6	3	5
26	72	83	78	71	76	70	4	1	2	5	3	6
27	72	81	78	69	75	71	4	1	2	6	3	5
28	71.2	83	77	70.9	75	70	4	1	2	5	3	6
29	71.3	81	79	71.5	76	74	6	1	2	5	3	4
30	70	80	77	66	75	68	4	1	2	6	3	5
Mean	71.2	81.9	77.3	69.7	75.2	70.3	4.6	1.0	2.0	5.1	3.1	5.2

Table 1: Scores and rankings calculated using construction personnel's weightings including cost as factor

	Bricsnet	Buzzsaw	Citadon	Constructware	e-builder	Ionspire	Bricsnet	Buzzsaw	Citadon	Constructware	e-builder	Ionspire
CI profil	(Scores)						(Rankings)					
1	64	73	71	65	69	67	6	1	2	5	3	4
2	59.5	70	66	61	64	60.5	6	1	2	4	3	5
3	60.9	72	66	60.7	64	60	4	1	2	5	3	6
4	65	74	72	66	70	69	6	1	2	5	3	4
5	65	78	71	64	69	62	4	1	2	5	3	6
6	63	71	70	62	67	66	5	1	2	6	3	4
7	63	72	69	59	67	61	4	1	2	6	3	5
8	63	72	70	58	67	61	4	1	2	6	3	5
9	61.0	74	67	64	65	61.4	6	1	2	4	3	5
10	57	64	63.4	56	61	62.9	5	1	2	6	4	3
11	62.4	75	68	62.3	66	61	4	1	2	5	3	6
12	65	75	71	62	69	64	4	1	2	6	3	5
13	61	73	67	62.1	65	61.8	6	1	2	4	3	5
14	60.9	72	67	60.7	66	60.6	4	1	2	5	3	6
15	55	74	60	61	57	52	5	1	3	2	4	6
16	60	73	65	61	63	58	5	1	2	4	3	6
17	65	76	69	64	68	62	4	1	2	5	3	6
18	69	77	75	64	73	67	4	1	2	6	3	5
19	66	73	71	59	70	62	4	1	2	6	3	5
20	67	76	73	62	71	64	4	1	2	6	3	5
21	63	78	70	65	67	61	5	1	2	4	3	6
22	63	73	68	57.3	66	56.6	4	1	2	5	3	6
23	60.8	73	67	61.3	65	59	5	1	2	4	3	6
24	60	72	66	59.1	64	58.8	4	1	2	5	3	6
25	66	73.0	73.4	55	71	63	4	2	1	6	3	5
26	62	73	68	61	66	60	4	1	2	5	3	6
27	63	72	69	60	66	62	4	1	2	6	3	5
28	62	74	67	61	65	60	4	1	2	5	3	6
29	66.0	76	73	66.1	71	69	6	1	2	5	3	4
30	63	73	70	59	68	61	4	1	2	6	3	5
Mean	63	73	69	61	67	62	4.8	1.0	2.0	5.1	3.1	5.2

Table 2: Scores and rankings calculated using construction personnel's weightings without including cost. All but one of the results give the same package the first ranking, similarly, the same package was consistently ranked second.

Scheme	"Best", ranked 1	Relative Weightings										
		A.1	A.2	A.3	A.4	A.5	B.1	B.2	B.3	B.4	B.5	B.6
W1: Unity Weighting	Buzzsaw	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
W2: Max score 100	Buzzsaw	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
W3: Emphasis on sections A.1, A.2, A.4, B.2, B.3, B.4	Buzzsaw	5.0	5.0	3.5	5.0	4.0	4.0	5.0	5.0	5.0	4.0	4.0
W4: Emphasis on section A.1, A.4, B.3	Buzzsaw	6.0	4.5	3.0	6.0	4.0	4.0	5.0	6.0	5.0	3.0	3.0
W5: Emphasis on section A.2, B.3	Buzzsaw and Citadon	6.0	7.0	2.5	6.0	4.0	4.0	4.0	7.0	4.0	2.5	2.5
W6: Emphasize the most on section B.3	Citadon	6.0	7.0	2.0	6.0	4.5	4.0	4.0	8.0	4.0	2.0	2.0

Table 2: Summary of modified weightings in sensitivity tests

CONCLUSIONS WITH RESPECT TO CIMS SOFTWARE

There have been a significant number of commercial software packages released in the last two years that can handle the various features required in construction information management. There are likely to be many more released in the future. The main need now is for a system that will evaluate the utility of a CIMS package with respect to the specific needs of a potential user in the construction industry.

Such a system has been developed and its use has been demonstrated here by applying it to CIMS packages already available commercially. The evaluation procedure uses the potential users' assessment of function/features of packages and their assessment of the extent to which the packages perform these functions effectively. Supporting data and information have been collected from a variety of sources; reports, Internet surveys, symposium discussions and a survey of construction professionals.

Compatibility with other systems and ease of use were considered to be the most significant and important features by the CI professionals surveyed. The cost of the packages is not the most critical or decisive factor, as might have been supposed.

The sensitivity of the evaluation system results to variations in the weightings assigned to features was low. Performance of packages with respect to the features was much more significant.

The method of evaluation offers a clear and easily applied process and a step-by-step method to help construction personnel, who are not well versed in the technology of IT, to evaluate all commercially available CIMS packages for use in their own organisations.

The authors wish to acknowledge that this research project [B-Q284] was undertaken with the support of the Hong Kong Research Grants Council.

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