STRATEGIES FOR INFORMATION TECHNOLOGY IN THE CONSTRUCTION INDUSTRY TOWARDS THE NEWLY INDUSTRIALIZED ECONOMY OF SRI LANKA

by

Dr. G.W. Kodikara and D.R.C. Dassanayake

Abstract

A revolution is taking place in our great resource, information, due to innovations and advances in the electronic technology. Different industries in different economies embrace Information Technology (IT) at different levels. Ultimately, all the sectors will fully realise the impact of IT era. Since the Sri Lankan construction industry is lagging behind, every effort must be made to acquire the benefits from the IT era.

This paper demonstrates the current and possible future developments of IT and explains the benefits that can be gained by the engineering consultants, architects, quantity surveyors, and contractors. The strategic approach which should be followed to obtain the maximum benefit from the IT era is discussed and an IT framework for the Sri Lankan construction industry is recommended.

Key words

Computers, Construction, Information technology, Integration

1.0 Introduction

In our society all aspects of our lives are highly dependent upon information. With the tremendous advances in electronic technology, a revolution is taking place in our great resource; information. Information Technology (IT) can be described as a generic term encompassing all those technologies used in the capture, storage, processing, generation, transmission and distribution of information. Thus it involves the technologies of computer hardware, in particular micro electronics, computer software and communications.

For different economies IT era is dawning at different points in time and many industries in those societies have embraced IT at different levels. Construction is one such industry which consists of a number of domains of potential IT applications. This paper attempts to examine the current and future developments of IT, possible benefits to the construction industry from IT and strategies that should be adopted by the Sri Lankan construction industry towards achieving Newly Industrialized Country (NIC) status.

2.0 Background

Many advanced societies have considered IT as a vital component in the context of policies for science and technology development. IT can have marvelous evolutionary effects on industry and can be used for proper management of Gross National Product (GNP), and rapid industrialization. This can go hand in hand with informatisation, thereby raising the quality of life of all citizens in the resulting information economy. Examples for this phenomena are some of the NICs such as Korea, Singapore and Taiwan. Since Sri Lanka is ready with a blue print for NIC status by the year 2000, we may observe remarkable developments in IT sector in this country during the next few years.

Construction industries of different countries are constantly moving through different stages of IT applications and maturity that reflect the economies of which they are a part of. However, the degree of penetration of IT in to the construction industry of a given country with respect to other industries is lagging behind. The main difference of the construction industry with other spheres of industry is its fragmented nature, with a number of participants involved in

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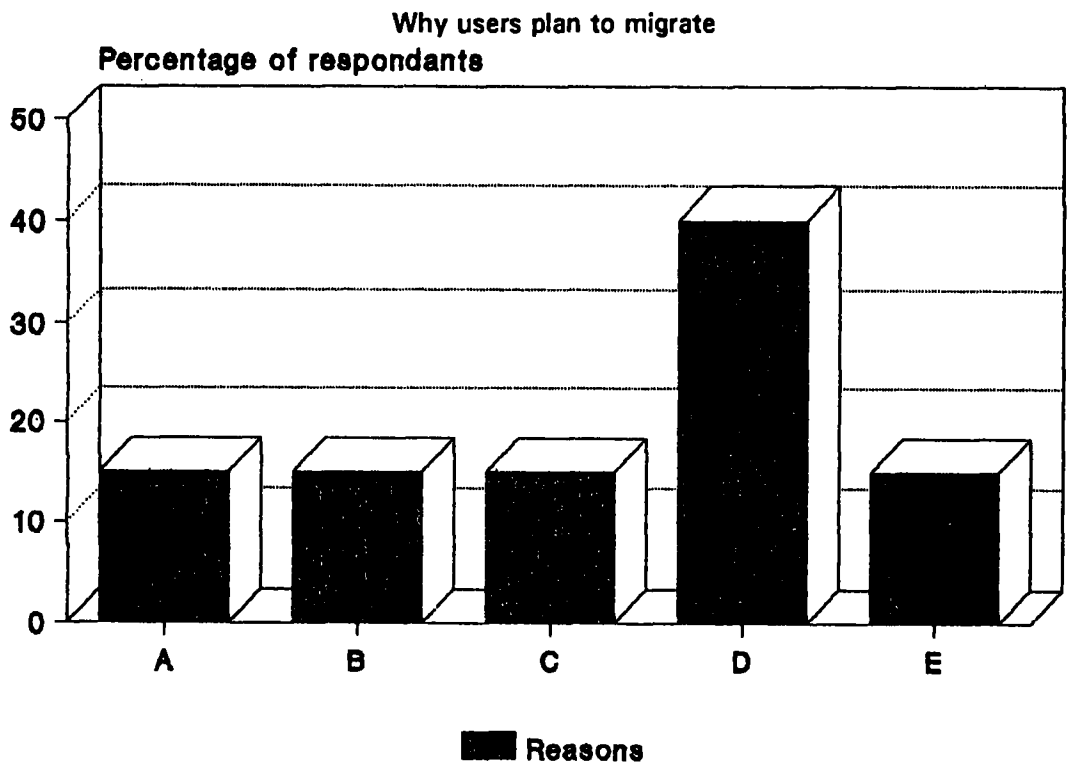
evolving the final product. Thus construction needs a lot of integration among its stake holders.

There have been a few studies undertaken to observe the IT applications for the Sri Lankan construction industry. Institute for Construction Training and Development (ICTAD) surveyed the extent of computer usage in the Sri Lankan construction industry in 1990. This study however did not establish in detail the usage of software and hardware. A comprehensive research has been undertaken by Kodikara and Costa (1993) which established in detail the current usage of IT in the Sri Lankan construction industry. The study also predicted the future usage in two years time based on the information gathered from the industry. Apart from that many researchers (Gunasekara; 1992, Madusudanadan; 1992) have published proposals on computer application in the construction industry. These are however stand alone applications aiming towards internal productivity of an organization. Again, no thought has been given for the IT as a whole for the construction industry in Sri Lanka. Therefore, the authors of this paper felt that it is necessary at this juncture to research on strategic approaches to IT.

3.0 Future developments of IT

Many writers suggest that IT era has just dawned. But we can observe that IT era has not dawned equally brightly on all sectors of all economies, although such progression is evident. We have to accept that all sectors will fully embrace the IT era at some point in time. Then Data Processing (DP) era will be totally replaced by IT era. Research and development are being carried out in digital electronics and software engineering resulting in dynamic advances in IT. Technological advancement in chip manufacture and fiber optics will bring tremendous advances in IT in the near future (Betts et al; 1991).

Figure 1



Source: John Lamb 1992

Key :

A - Cost
B - Obsolescence
C - Company Policy
D - Dissatisfaction with performance capacity
E - Other

3.1 Downsizing

IT departments have been moving to smaller systems for many years. According to a recent research by Hoskyns (Lamb; 1992) in UK, 93% of mainframe users would expect to change their systems to Personal Computer (PC) networks in the near future. The economic argument is overwhelming when desktop PCs are available with power equivalent to a small mainframe. Figure 1 shows why users plan to migrate or convert their systems to PC networks.

According to Haughton (1992), by the end of year 1994, 686 chip with 20 millions of transistors will arrive in place of todays 486 chip with 1.5 millions of transistors. Operating systems like Windows, NT and Novell will support ten, twenty or hundred 686s in parallel. During the preparation of this paper the authors have got the information that 586 systems have just arrived. Massive proliferation of PCs with Local Area Networks (LAN) in a file server environment facilitates running on work stations. By the end of this decade client server configurations with desktop machines relying on server systems for data and number crunching will be the norm for organizations (Haughton; 1992).

3.2 Development of user interfaces

The interface between the user and the current generation of computers have become a barrier to use them. Therefore, researchers are highly involved in the development of speech recognition systems. Fifth generation computers are evolving characterizing firstly to recognize speech and objects like humans and secondly to react intelligently what is recognized and so give expert advise or perform some other action (McCaffer et al; 1991).

The predictions of the researchers (McCaffer et al; 1991) are;

Speaker independent speech recognition	year 1998
National speech related to context	year 2005
Speech creation with animation	year 2010
Large vocabulary (20,000) systems	year 2015

3.3 Software developments

Current software developed under the traditional methods are expensive and often fail to meet the objectives of the users. But the development of Fourth Generation Languages (4GL) during the last decade would enhance easier programming techniques. The Computer Aided Software Engineering (CASE) came in to force with the development of 4GLs. Current CASE tools facilitate to undertake computer based software design, automatic checking of programs and production of libraries to assist the software developed.

Advances of CASE tools will continue further during this decade. A revolution of software development environment will take place with the development of CASE and 4GLs. According to McCaffer et al (1991) the ultimate aim of the researchers are to provide automatic code generation that will lead to automation of software development with the subsequent reduction in software development costs.

3.4 Paperless trade

Electronic Data Interchange (EDI) will make tremendous impact on business in future. Business transactions will take place with the help of EDI, where all correspondences are exchanged between enterprises using computer networks. Today in some developed economies ordering of goods and invoicing are done in a computer environment using EDI. This concept will become mature when home banking systems are evolved, a further step forward to the todays Master card or Visa card facilities. Bar coding will be further expanded at least in developed economies, and with electronic banking facilities shopping will be done without cash. Ultimate progression will take place to an era in which people will enjoy paperless trade, cashless shopping and electronic banking (Carter; 1987).

3.5 Social implications

As a consequence of the information revolution that is taking place in all aspects of our lives, we can expect tremendous reshaping of our work, our home and leisure activities and economic and social structure. There will be potential for favourable as well as adverse results. In future every one in the earth will enjoy equal access to our greatest resource, information. But on the other hand accessibility of information on each one of us would restrict our freedom.

Offices and factories will increase productivity as a result of automation. Employment pattern will change by replacing old occupations by new breeds. However, there will be a threat of increased unemployment. Some people at work may have to perform monotonous and repetitive tasks while others will have to undertake tasks that were previously impossible and their jobs become broader and more responsible.

3.6 Construction industry computer software

In the last 6-7 years application software systems have been proliferated in a number of areas in the international construction industry. Therefore, construction organizations are now recognizing the benefits in computerizing their

operational functions at both pre-contract and post-contract stages of the construction process. It is evident that general systems such as word processing, financial modelling, accounting and databases are dominant in the construction industry. Estimating, Computer Aided Drafting (CAD) and Project Management systems appear to be the next popular category of software applications whose penetration ranges between 60-70%. Structural analysis systems have become moderately popular among the users. Contractors' stock control, order processing and plant management are yet to be improved as the current usage ranges from 30 - 40% (Kodikara and Costa; 1993, CICA and Peat Marwick Mclintock; 1990).

3.7 Telecommunications

The construction industry can harvest the immense benefits of EDI or paperless trade which allows computer systems to communicate. EDICON, the UK construction industry's official paperless trade organization (Ediconstruct and DK Bygg are the French and Swedish counterparts) has published a series of manuals (Coomber and Chevin; 1990) for electronic invoicing of goods, purchase orders and even for tender invitation including bill of quantities and technical specifications.

As EDI is playing a vital role in the international construction industry, various countries have begun to adopt their own standards, for example X.12 standard for American National Standard Institute (ANSI), EDI Council of Australia (EDICA) in addition to those mentioned earlier. The United Nations backed standard body, EDI For Administration Commerce and Transport (EDIFACT) has now evolved and it will be the accepted and practiced as the international standard (Kannegietor; 1993).

What is most significant is the transferring of CAD files through EDI. CAD data can be transferred using Data Exchange Format (DXF) interface. This has been developed by Autodesk, the manufacturer of AUTOCAD and has become the defacto industry standard. The international CAD data exchange format STEP is in the pipe line and will emerge in the latter half of the decad (Coomber and Chevin; 1990).

Facsimile transmission has become universal in most of the construction companies. The use of telex is significant but its growth is stagnant. We can expect a dramatic growth in E-mail and EDI with the development of Integrated Services Digital Network (ISDN) facilities and CAD data exchange formats.

Although the Sri Lankan Construction Industry is lagging behind in the use of communication technologies compared with computer technology, it could be expected to catch up fast in the near future. We are still confined to the facilities offered by Telephone, Radio and Facsimile (Kodikara & Costa; 1993). This is mainly due to the bottleneck of voice communication dominance without giving sufficient attention to other services including data communication at national level (Induruwa; 1989).

4.0 IT in the construction industry

Unlike other industries, the construction industry does not emerge as an innovative leader. Most of the recent advances in IT are not created by the needs of the construction industry's market pressure. Thus the development of IT or computing in the construction sector can be seen as opportunistic, taking advantages of advances in IT and applications proved successful in other industries. Therefore, we have to accept the fact that the construction industry is not in the forefront with all the recent development of computer technology or other IT applications.

It is obvious that all the available hardware in computing and telecommunication can be acquired by an industry. But the question is whether there are sufficient software applicable to the industry and whether the construction industry is geared to reap the maximum benefits from those facilities.

There is a large number of software available for specific needs of different areas of the construction industry such as; planning, estimating, cash flow, cost control, drafting and structural analysis. Except for few examples, integration among those are not common in the world, yet comprehensive construction IT systems have to evolve. The current use of software in the Sri Lankan construction industry is also restricted to stand alone systems (Kodikara and Costa; 1993).

Construction projects provide a broad spectrum for expert systems application not only because they involve many professionals in different specialties but also because solutions of associated problems need greater range of options, more information, expert knowledge, judgment and field experience (Scott and Yang; 1991, Moselhi et al; 1991). Some of the popular topics covered in the construction management in particular are cost estimation, quality control, contract variation analysis, risk analysis, and site selection.

Decision support systems are feasible tools to aid in decision making regarding contractor pre-qualification (Russell; 1992). Expert systems provides promising decision aid in diagnostic work such as assessment of building defects (Bright; 1992). Neural network theories and architectures are more suitable for construction industry problems requiring analogy based solutions. Possible application areas of Neural networks suggested by Moselhi et al (1991) are; deciding optimum mark up, selection between alternatives, estimation and classification, functions synthesis, diagnostic problems, dynamic modelling, optimization tasks, and real time applications.

CAD systems can be used as a productive IT tool in drafting. Current CAD systems have limited facility to integrate with other systems such as estimating and spreadsheets. AUTOCAD has a powerful programming interface called AUTOLISP which enables the user to customize the program to cater for his own requirements. Apart from AUTOCAD there is a number of CAD packages being used in different countries, some of which are integrated.

According to the construction computing estimating guide (Stephenson; 1991), out of the ten established estimating systems considered five systems offered Optical Character Recognition (OCR) facility and eight systems offered digitizer take off facility. Some of those are linked to AUTOCAD and accounting systems while 'Estimating Management' marketed by Techsonix (UK) is linked with various other systems.

Number of Project Management software are available in the market. Commonly used systems are Havard Total Project Manager (HTPM), Time line, PERT Master Advance, and Primavara. Although most of the project management software provides many useful information to a project manager they are not linked with estimating and material management.

Several structural analysis systems exist and could be used for frame analysis and finite element analysis. Microafeap developed by AIT Bangkok offers plane frame analysis facility currently and an advanced version capable of 3D frame analysis is in the development stage.

Some developed economies have started expanding their certain activities of the construction to reap the benefits of Computer Aided Manufacturing (CAM). Highly sophisticated microprocessor controlled construction equipment like earth moving equipment are being used in some construction projects. However,the question will be whether most of these advances are appropriate to the Sri Lankan context. Continuous and uniform productive activities such as batch mixing of cement concrete and asphalt concrete and asphalt paving operations are some of the relevant areas where CAM could be effectively applied. Already some of the mixing plants used in major construction projects have the facility to use the mix proportions pre-programmed. String lines used for level sensing in asphalt pavers could now be replaced with the computer. Pavest system used in an on bound computer which is developed by Australian Company Systems can be used for automatic height and level control for paving machines (International Construction; 1993).

5.0 Benefits that can be achieved

Information Technology has an enormous potential as a benefit manifold in construction industry like for other industries. However we have found that IT in the construction sector so far has not embraced strategically but entertains piecemeal approach in individual productivity gains. This situation is dominant in the local construction industry.

5.1 Engineering Consultants

In the initial stage of a project, Engineering Consultants have to contribute with their inputs within a limited time frame. They have to interact with other parties and should consider various alternatives to meet the client's requirements. Telecommunication can play a vital role where information on an evolving project saved in a computer could be accessed instantly. Engineers of different disciplines could work separately and their inputs be communicated to the central information system using compatible systems. They can consult each other on the important design decisions.

Building designer can automate structural drawings based on his calculations. Productivity can be increased by customizing a CAD package to meet specific requirements. Detailing of reinforcements can be done by simply defining bar diameter, spacing and limits such that CAD software can automate necessary drafting and text. Top and bottom reinforcement in a slab could be assigned two different layers. An ink-jet plotter will save time considerably although the initial investment is high.

Preparation of tender documents will be an easy task once all the standard conditions of contract and specifications are saved in the computer. Minor modifications of additions or omissions of clauses will be straight forward and whole documents can be prepared quickly. Pre-qualification of contractors and tender evaluation can be done using expert systems or knowledge based systems. In such situations the

system will not allow any kind of personal favours to any interested party.

While the construction is going on, the head office and site can communicate using EDI or E-mail facility. Drawing a revision or any other key decision can be conveyed quickly using computer networks. This is very attractive in international construction contracts, compared with high costs and time involved in travelling and mailing respectively (Kannegietor; 1993).

These applications are available in the international industry as stand alone systems or partially integrated systems. A strategic approach is necessary to obtain the maximum benefit out of these systems.

5.2 Architects

The Architect's role is mainly involved with graphic designs from the inception to the completion. An architectural design process is confined to drawings and involves very little calculations. Therefore CAD software has become the dominant IT application in many architectural firms. In Sri Lanka AUTOCAD is the widely used CAD software among architects as is the case for other drafting works.

According to architects interviewed in this research, who are involved in computer aided designs, justification of computer application is depended upon the size and nature of the project. Perhaps for a smaller project one could do a design manually faster than a computer. But in a larger and complex work where there are lot of repetitive work and several alternatives to be considered, benefit from CAD is immense. Flexibilities offered by AUTOCAD can help the designer to produce alternative designs very quickly. For example, repetitive items such as windows and doors saved in blocks could be used to increase the productivity.

Another advantage gained by the architect is that the design they work on CAD can be considered as final. This will not only reduce manpower but also minimize intermediate participants taking part in the design process. This will save the designers checking time of the final product and minimize errors induced by communicating to other supporting staff (Kannegietor; 1993).

5.3 Quantity Surveyors

According to a senior Quantity Surveyor, computing has a greater potential in the estimator's task. The current ICTAD formula for price fluctuation needs inputs that to be included in the tender documents. Without the computer it is impossible to include all the items in order to achieve 100% accuracy.

Our traditional Bill of Quantities is trade based (ex: Excavator, Concretor, Bricklayer etc.) and the other forms available are Elemental Bill and Activity Bill. Computers can be used to make either Activity Bill or Elemental Bill using the original unit rate bill. This is very important when some clients are interested to know the cost of each element in order to take key financial decisions.

Advanced estimating software used in developed countries facilitates integration with project management and material planning software. Tendering time could be saved considerably by using OCR facility and stand by labour, material, subcontractor, and plant inputs.

Quantity surveyor's input at the initial stage of a project is very significant. He can interact with the architect, structural engineer, electromechanical engineer and the client through communication networks. All the material, plant and sub contractor inquiries can be made using EDI through his computer. When the construction is on going site measurements could be collected at the head office using Wide Area Networks (WAN). Monthly statement can be transferred to the consultant's system using a network facility. The consultant's quantity surveyor can check the contractor's monthly statement and payment certificate can be passed on to the client while the corrected bill can be transmitted to the contractor through a computer link. The employer can advice his bankers to make the payments from his office using a computer link (Kannegietor; 1993).

5.4 Contractors

The Contractor's burden of work can be eased to a greater extent with the help of IT. In the tender stage what is most required is the accurate data for pricing, which could be accessed quickly. This can be achieved by using a proper estimating system where all the rate break downs of items and updated prices of materials, labour,plant and subcontractors are contained within the software itself. Even at a later stage, modifications can be done if necessary.

From the time of contract was awarded the contractor has to plan the work, organize the material and perform a lot of financial management activities. Once the bill of quantities are stored in the computer during the tendering stage, the input data required for project management, material management and stock control could be generated and transferred automatically. However, as far as the local construction industry is concerned a major problem encountered is the time overrun. If we have a proper project monitoring system one could detect this at early stages and can take preventive measures at the correct time and at least reduce the time overrun.

Better communication facilities in a contractor's organization can help to coordinate construction projects by keeping the senior managers informed of the status of projects at a given point in time. This ability is critical when senior managers have to monitor remote sites from the head office. Benefits from computer networks are substantial for a construction manager who is adopting centralised control of either remote sites or those located close to head office. He can take important decisions, if up to date information are available via a computer network.

In order to get those benefits what is most important is the accuracy of the data collection at sites. Unfortunately what we learn from the local construction industry is that we can hardly depend on the accuracy of the data collected at sites. There is a great resistance to paper work from second level site officers. Only a limited support can be expected from most of the officers for innovative changes to the system. Poor record keeping systems and lack of systematic approach which is inherent to our society, although intelligent to tackle problems, is another stop gap in the evolutionary process of information management. Therefore it is a prerequisite to have a psychological revolution created in the minds of all employees to make any information system a success. It is also essential to analyse the situation considering the initial investments and the return or benefits. That is why strategic thinking is necessary where everybody should sit together and organise the investments with the help of governing institutions.

6.0 Best approach to get the maximum benefits

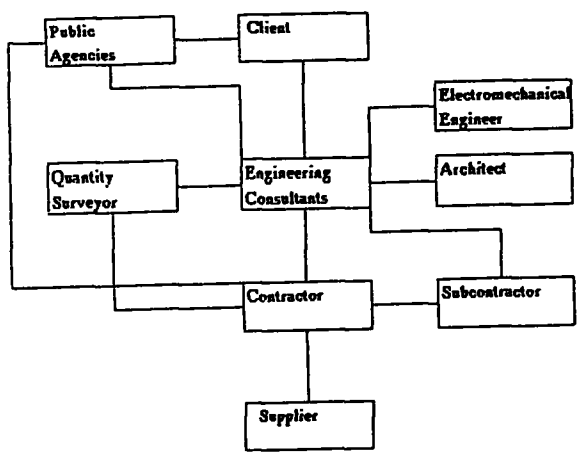
The difference between the DP era and IT era is that IT should be carefully managed and used strategically by organizations. To exploit the full benefits of the IT by any industry, creation of compatible social and technical systems is a prerequisite and cannot depend only on technical design itself. This has to be achieved by carefully planned changes created in the users willingness to exploit the technical capabilities. This gives the opportunity for people at all levels of the organization to take part in the design process and collective learning process. The changes in both organizational and human behavior should be evolved on the basis of mature reflection. As many writers suggest that neither the application area nor its underlying technology that makes IT strategically important, but the specific role of a particular technology application to a given industry at a point in time (Betts et al; 1991).

6.1 The problems of IT implementation in the construction industry

First we should understand the causes of failure to successful strategic application of IT. Secondly, a tremendous amount of inertia is required to overcome these problems in order to succeed IT revolution.

As we are aware, the construction industry differs from other industries due to its fragmented nature. There are many stake holders and enterprises who are involved in the process of evolving any construction project as shown in Figure 2. The main problem associated with the implementation of IT in the construction sector is the integration. The exchange of information among the client, designers, contractors and government agencies is an important issue. A relatively easy approach would be for all participants to use the same information system and share their central database.

Figure 2
Construction IT stake holders & Communication links



In the design process of a project, the architect, engineers, client and government authorities have to communicate very frequently in order to create the design. The current CAD systems does not offer external productivity, though it is being used mostly as an individual design aid. For example; the architect's CAD files cannot be read by the structural engineer's software in structural analysis, or by the estimator's software in generating quantities or by the government authority for automatic checking. However, this problem is being resolved though not widely spread, and some firms in UK are using software in generating quantities from CAD files. As mentioned elsewhere it is also now technically feasible to exchange CAD data between dissimilar systems with the introduction of Data Exchange Format (DXF) by the Autodesk, the manufacturers of AUTOCAD (Coomber and Chevin; 1990).

In the construction phase, the project planning and resources planing are not fully benefitted by the current IT tools. With the commercially available sophisticated project management software we can perform scheduling and planning work. But very often the data required for these programs are to be generated from CAD drawings separately. Here again the data in a CAD file does not benefit in strategic use.

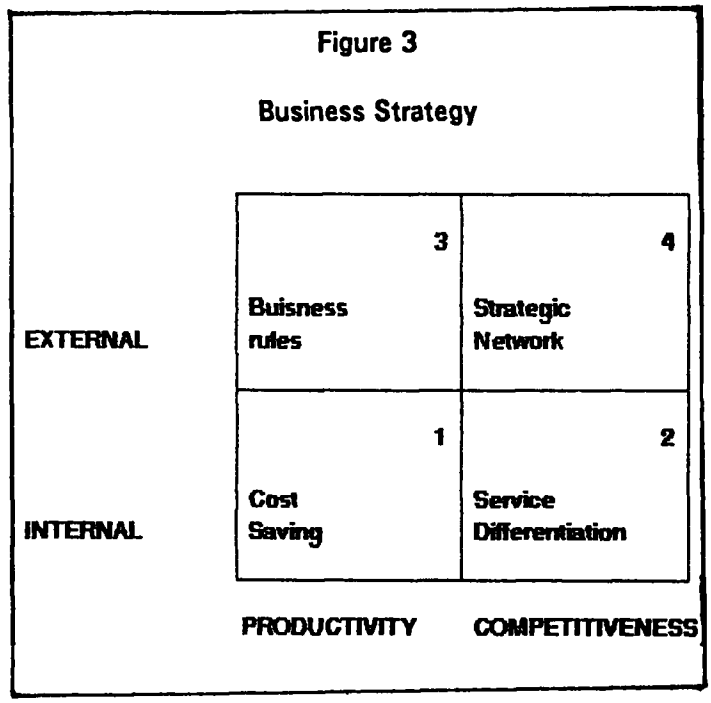
In the pre-tender stage, the architect, engineers, cost advisors and client share their knowledge and interchange information in the evolution of design. If all the participants do not use compatible IT tools which can communicate with each other, we can not expect one party to invest in IT independently. When IT becomes critical to the construction industry every participant is compelled to use common IT tools. In Australia, a common software called CLIENT is used in some contracts (Betts et al; 1991). All the enterprises engaged in the project has a terminal to share knowledge and exchange information. The client makes the use of the system compulsory for all the participants and the cost is treated as an overhead to the project.

6.2 Strategy for the construction industry

In order to exploit IT strategically we must focus on its application to gain competitive advantage, to improve productivity and performance, to enable new ways of managing organization and to develop new business. Betts et al (1991) suggests these perceptions in a different orientation illustrated using a strategic grid as shown in Figure 3.

Construction industry as a whole is still in the quadrant 1 as we have seen most construction enterprises use IT as internal productivity tools. Banking services and Airline services have now reached the quadrant 4.

Figure 3



Professional bodies and government institutions should now examine the ways of improving external productivity, internal competitiveness and external competitiveness by IT strategies. The approach would be to;

(a) Improve internal productivity and quality of work within an organization,

(b) Improve external productivity and quality of work outside of an organization,

(c) Improve internal competitiveness within the construction industry, and

(d) Improve external competitiveness outside the construction industry.

In the UK, the Royal Institution of Chartered Surveyors (RICS) has a Building Cost Information Service, which is a central database of price information supplied and stored by subscribing members. This system will improve internal productivity, external productivity, and external competitiveness with the availability of better quality data.

A similar form of IT tool is offered by the Royal Institution of British Architects (RIBA) through the RIBACAD system with a library of standard architectural details which will improve external productivity but not the external competitiveness. External influence plays a major role for an organization to become IT necessary for its existence. A central body should take the responsibility of making IT critical by interfacing with all construction enterprises. In Singapore, the Construction Industry Development Board

(CIDB) stipulates the submission of tenders for public sector projects in the form of magnetic disk. In the U.K., newly introduced Co-ordinated Project Information System is adopted in the industry. All the projects commissioned by Property Services Agency require to follow the procedures and documentation recommended by the Co-ordinating Committee of the Project Information system.

The working committee formulated by Mr. W.J.R. De Mel of ICTAD to prepare an estimating guide for the whole industry may be treated as a stepping stone for strategic thinking in the case of data usage in the Sri Lankan construction industry. If the committee can produce a comprehensive document (a fully detailed Building Schedule of Rates), it can be stored centrally with individual access for different organizations. This will increase the internal productivity, external productivity and internal competitiveness. The simple point that no single organization is able to fund such a project proves that strategic thinking is necessary to improve our industry.

6.3 An IT framework for the Sri Lankan construction industry

By examining the present status of IT in the Sri Lankan construction industry, one would conclude that the concept of integrated information system is of less important in respect of the needs of the industry as a whole. Some experts interviewed in this research support this idea primarily because, it is feasible to perform most of the tasks with the combination of traditional methods and piece meal approach to IT tools. But on the other hand because of the competitiveness within the business community, we cannot isolate ourselves from the rest, and at some point in time we have to embrace technological advances of the evolving society. Therefore, no doubt that the Sri Lankan construction industry will be geared to advent IT strategically in near future. It is now appropriate to consider implementation of a comprehensive information system for the Sri Lankan construction industry.

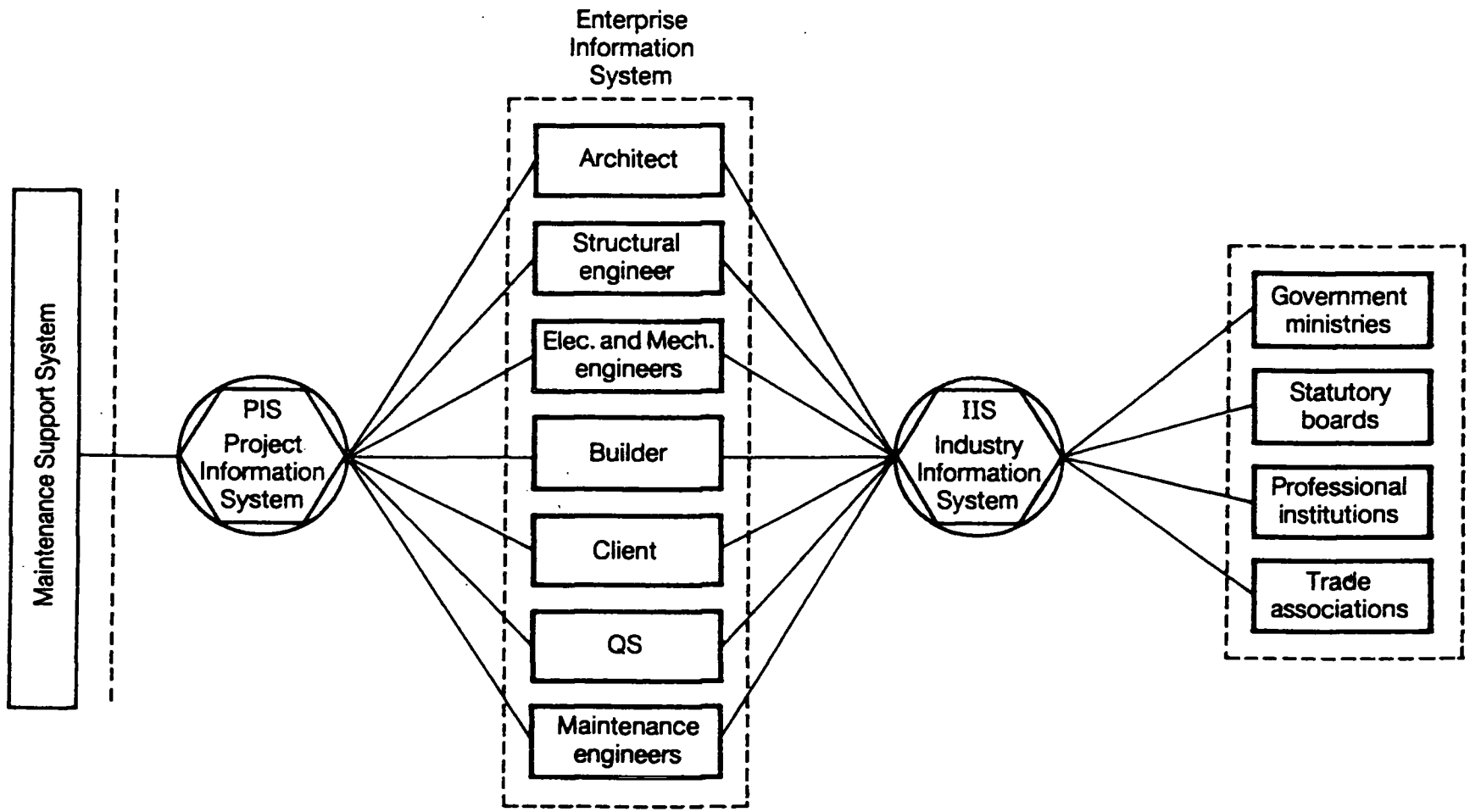
Betts et al (1991) developed an IT frame work for the Singapore construction industry as given in Figure 4. They identified three distinct conceptual information systems in practice within the construction industry. The Project Information System (PIS) is used during the planning, design and construction phases, and retained throughout the life of the project. Information is drawn from an Enterprise Information System (EIS) and an Industry Information System (IIS) to develop the PIS. Thus EIS and IIS could be considered to be general information systems supporting the development of the project-specific PIS.

The information usage, specially the use of estimating data in the Sri Lankan construction industry is highly complex (Kodikara and McCaffer; 1993). However, as in the Singapore industry, the professionals in the Sri Lankan construction industry generate and use information which are specific to the project during the construction process. These information are obtained either from the enterprises they are associated with or from the available information in the public domain. As the project develops, this project information base expands quickly due to high interaction among the participants and the outside supporting organisations. The participants involved in the project depend on a large information base which they have developed over a period of time through their involvement in other similar projects. They will provide ample information to the project information base from these large enterprise information bases. Public and private organisations which support the construction industry such as suppliers, planning authorities and professional institutions have their own information base which they have developed over the years. While updating and maintaining these information bases they also provide important information to the earlier said project information base. Therefore, we can observe Project Information Systems, Enterprise Information Systems and Industry Information Systems in the Sri Lankan construction industry.

The IT frame work suggested by Betts et al (1991) can be used in the Sri Lankan industry with little modifications to suit the local industry. This is illustrated in Figure 5. The Institute for Construction Training and Development (ICTAD) can be considered as the statutory body dealing with the construction industry. There are many proposals and cabinet papers forwarded by the ICTAD with direct impact to the construction industry. Therefore, ICTAD could be in charge of IIS. The IIS shall be generated from the information from the past experience of the industry, the government policies and legislation from professional institutions and data from trade associations. This could be made available to the industry stake holders by charging a subscription.

All the participating enterprises can be grouped to three distinct information bases such as Client, Engineer (Consultant), and Contractor. The overall information base is the EIS. In the design stage, the designers can use IIS for planning, designing and preparation of tender documents. The EIS could be used by the organizations to their own specific requirements with consultation of IIS and PIS. The PIS is specific only to the project concerned and its information base will grow as the project evolves. The PIS has communication channels through which the client, engineer and the contractor can communicate with each other (Dassanayake; 1993).

Figure 4 - An IT framework for the construction industry



7.0 Recommendations

Based on the study undertaken in this research the following recommendations are proposed to achieve the maximum benefits from IT for the Sri Lankan construction industry.

(a) Construction organizations should explore benefits of IT beyond internal productivity, and consider the advantages of internal and external competitiveness.

(b) Professional bodies and central agencies in the construction industry should develop comprehensive IT tools integrating entire construction process from the inception to the completion.

(c) Professional institutions must influence their members to embrace IT by educating them of the potential benefits in all levels and functions through continuing professional development programmes.

(d) Universities and other academic institutions should ensure the IT awareness of students by incorporating them in their curriculum.

(e) Government policy makers should launch a National IT plan in which construction industry will be a subset. Respective ministries should take the responsibility of funding research and development of industry specific IT frame work.

(f) Software developers should focus in research and development in interfacing CAD with other areas such as estimating, tendering, project management, cost control and accounting.

(g) Further research should be carried out in designing information systems in an appropriate IT framework for the Sri Lankan construction industry. The proposal given in this paper can be taken as a guide for such detailed research.

8.0 Conclusions

It is evident that with the powerful innovations and tremendous advances in the electronic technology, a revolution is taking place in our great resource, information. However, for different economies Information Technology era is dawning at different points in time. The different industries in those societies embrace IT at different levels, hence it is not right to say that the IT era has dawned equally brightly in all sectors of all economies. However, we have to accept the fact that all sectors will fully realise the impact of IT era at some point in time. We, the Sri Lankans may be lagging behind in this situation, but every effort must be made to close the gap and obtain the full benefits from the IT era, specially if we want to achieve the NIC status in the near future.

This paper highlighted possible future developments of IT as an attempt to generate interest among the professionals. The Information Technology in the construction industry was explained and the benefits that can be achieved by the engineering consultants, architects, quantity surveyors, and contractors have been discussed. The current use of IT in the Sri Lankan construction industry is limited to individual productivity gains with no indication of integration. The Sri Lankan construction industry should explore the benefits from IT beyond the piece meal approaches in individual productivity gains. The professionals in the construction industry should request the government institutions and other relevant authorities to examine the ways of using IT strategically to improve external productivity, internal competitiveness and finally the external competitiveness. The recommendations given in this paper, specially the IT frame work as illustrated in Figure 5, can be considered as an initial step towards strategic approach to achieve the maximum benefits from IT era.

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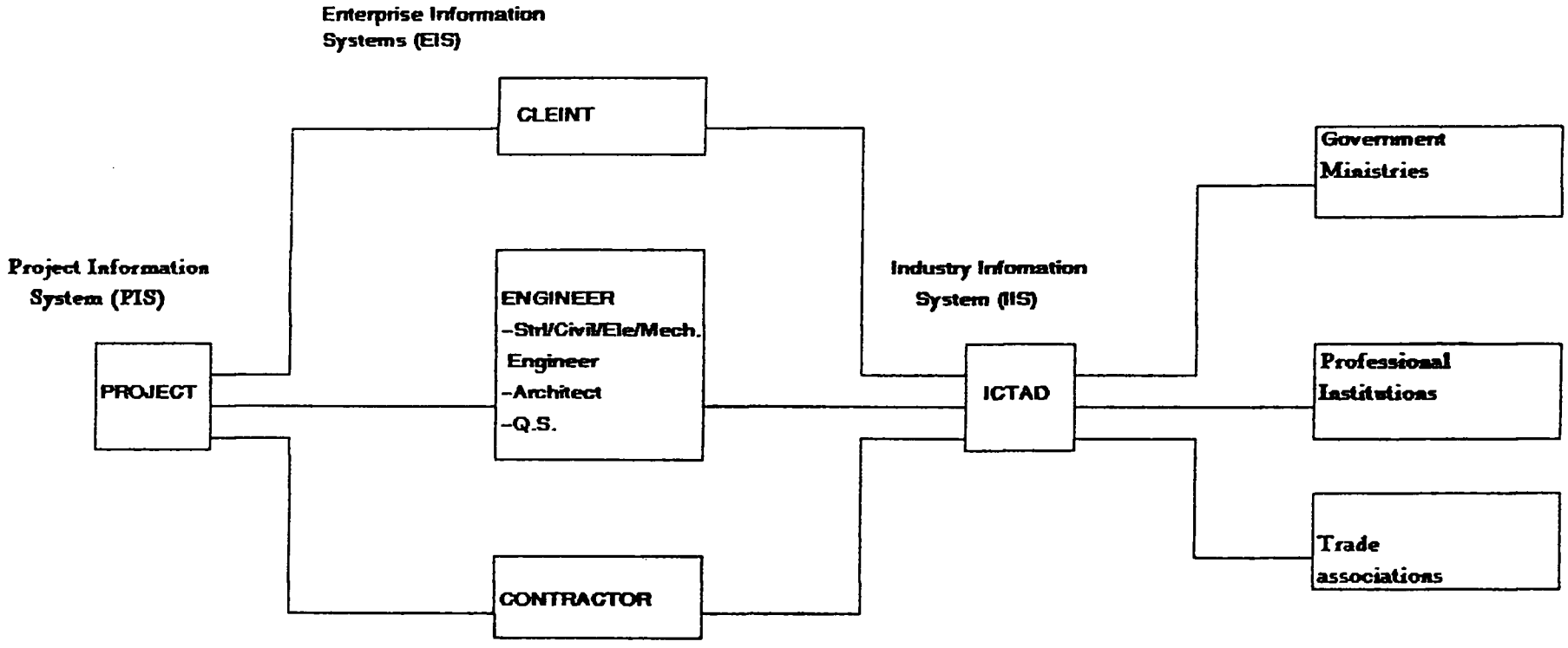
Figure 5- An IT framework for Sri Lankan Construction Industry



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