IT SYSTEM FOR ELECTRONIC BUILDING PLAN CHECKING

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Abstract: An integrated network is being developed over the next few years for the construction and real estate sector in Singapore to improve its productivity and competitiveness. Electronic plan checking system is one of the IT system of this integrated network. Its aim is to automate the process of checking of building plans for compliance with the regulations and codes of practice stipulated by the various regulatory agencies. This paper will briefly discuss the various IT initiatives taken to enhance the productivity and competitiveness of the construction and real estate sector and the plan checking system. The paper will also discuss how Product Modelling technology can be applied to capture information generated during the design stage for electronic building plan checking.

Keywords: Information technology, integrated network, electronic plan checking, Product Modelling technology, Artificial Intelligence, Feature-Based Computer Aided Design, collaborative design, project website, electronic procurement

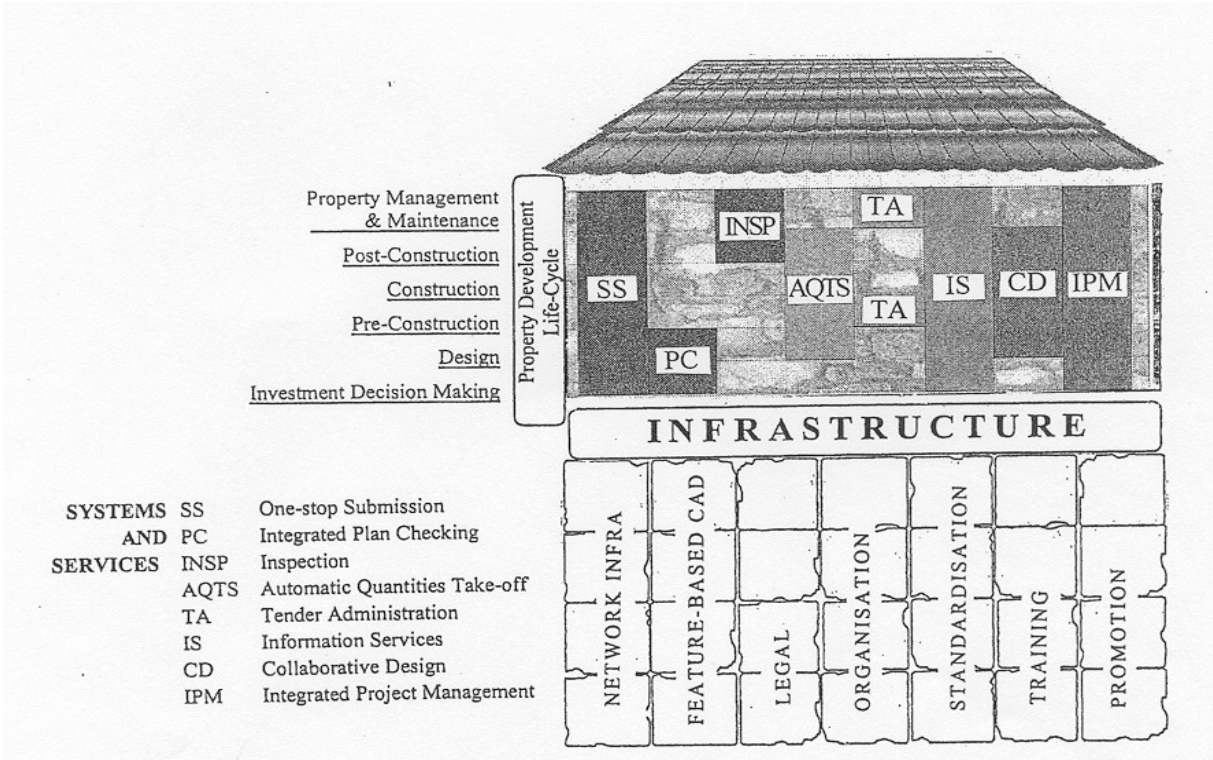
INTRODUCTION

As early as 1993, a national steering committee was set up to re-engineer the construction and real estate sector. The committee consists of leaders representing the regulators, developers, architects, engineers, contractors and quantity surveyors. Eventually the steering committee recommended the development of an integrated network for the construction and real estate sector or COnstruction and Real Estate NETwork (CORENET). CORENET is one of the major IT initiatives identified under the Information Technology Master Plan of Singapore (IT2000) spearheaded by the Ministry of National Development (MND) and supported by the InfoCommunications Development Authority (IDA) and the Building and Construction Authority (BCA).

CORENET

The systems and services of CORENET are shown in Figure 1. Briefly, they include information services, collaborative design, integrated plan checking, one stop submission, automatic quantities take-off, tender administration, inspection and submission allows building plan approval applications to be submitted electronically to all the government regulatory agencies in a one stop manner anytime and at anywhere. The main objective of the integrated plan checking system is to enhance the overall effectiveness and efficiency of the plan approval process from the consultants' perspective. Artificial Intelligence (AI) and Feature-Based Computer Aided Design (FB-CAD) technologies are used to verify computer-generated plans for compliance to government regulations.

For inspection upon completion of construction, systems will be developed to support the inspection process leading to the temporary occupation permit or certificate of statutory completion approval. With collaborative design, an IT environment where engineers and architects at different locations can carry out design activities as though they are physically working together. Information services system aims to provide a single point access to multiple sources of construction and real estate related information on-line via the Internet. Services provided by regulatory agencies could be accessed anywhere and anytime at http://www.gov.sg/corenet/. Development guide plan, real estate information, circulars to professional institutions, construction economics report, government tender notices and tender results and building control information are regularly updated and made available on the Internet. With Automatic Quantities Take-off, AI


Property Management & Maintenance
Post-Construction
Construction
Pre-Construction
Design
Investment Decision Making
Property Development Life-Cycle
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NETWORK INFRA
FEATURE-BASED CAD
LEGAL
ORGANISATION
STANDARDISATION
TRAINING
PROMOTION
SYSTEMS AND SERVICES
SS One-stop Submission
PC Integrated Plan Checking
INSP Inspection
AQTS Automatic Quantities Take-off
TA Tender Administration
IS Information Services
CD Collaborative Design
IPM Integrated Project Management

Fig. 1 Systems and Services of CORENET

based systems are used to read directly from FB-CAD drawings and automatically generates bills-of-quantities. Tender administration system provides facilities for the calling, submission and award of tenders, as well as for the procurement of contracting and maintenance services, to be done electronically. Lastly, under the integrated project management system, an IT environment is created where project management information can be shared seamlessly among the clients, project managers, consultants reformat and re-enter these information.

For network infrastructure, a broadband and high-speed electronic network infrastructure, known as the Singapore One network where an optical fibre network links every homes and offices, has been put in place to link regulatory agencies with the key players in the construction and real estate sector. In this regard, appropriate CAD technology is being introduced to facilitate modelling, design and production of intelligent electronic drawings. The issue of a legal framework to enable electronic commerce and transaction on the CORENET is being addressed currently. A Construction IT Standards Committee was set up to spearhead standardisation in text and CAD data formats to ensure interoperability across different platforms. A more detailed discussion on the systems and services of CORENET can be found in Kog and Swaddiwudhipong (2000). To date, the IT standards for cost classification, layering and symbols have already been completed. Currently, works on the IT standards for construction resources classification and coding system, colours and line types are in progress and are scheduled to be completed by end 2000. The IT standards for object technology is scheduled to be completed only by 2003.

ONE STOP SUBMISSION CENTRE

The submission of construction documents including drawings for any projects in Singapore to secure the necessary approval for construction involves at least 9 regulatory agencies. The checking and processing of the submitted construction documents are done manually. It takes time and is not always consistent and error free. The immediate objective of CORENET is to develop a sector wide network infrastructure that support a single point for the submission of construction documents electronically to all the regulatory agencies for processing and approval. The integrated submission system consists of a series of IT tools that assist engineers and architects to visually verify computer generated plans for compliance to the requirements of regulatory agencies. These plans can be submitted to the agencies in CD-ROM or over the network. A central agency will be appointed to manage the submission and processing of documents on behalf of the individual agencies under the 'One-Stop Submission' concept. It allows on-line submission, inquiry on the application status, communication with the regulatory agencies and receiving approval notices from the regulatory agencies through the network. All of these functions can be performed from the consultant's premises at anytime and anywhere. It has the ability to track project status by the consultants and the regulatory agencies. It is also able to perform archival of submitted applications and other administrative functions. The central agency performs plan checking activities and routes waiver applications and special cases to individual agencies. It generates Written Directions and the relevant documentation. There is no printing of drawings and forms like the current submission system. Consequently, it leads to faster processing of the submitted construction documents. Payment to the regulatory agencies for the processing of construction documents can be made electronically to the central agency. Tender for the development and operation of the One Stop Submission Centre to be ready by 2001 was called in January 2000 and closed in March 2000.

The hardware requirements for the One-Stop Submission system are a Pentium personal computer with minimum 16 MB RAM running Windows operating system, 56kbps modem or ISDN with connection to a local Internet service provider (AADSL modem with high-speed Internet connection to Singapore-One is recommended), Netrust Digital Certificates and Netrust compliant card reader. The software requirements are Web Browser (latest Netscape Navigator or Internet Explorer), email client software (e.g. Outlook Express, Netscape Mail, Eurore Mail), Computer-Aided Design (CAD) software capable of exporting plans to DWG formats (Release 12 onwards), AutoCAD DXF format, or Microstation DGN formats. The One-Stop Submission system is designed to work in the Windows environment. This is because the digital signature, encryption and verification make use of Netrust Digital Certificates that only support the Windows platform at this moment. Macintosh users can still submit building applications using a personal computer link up to the central agency, except that conversion of CAD files in Macintosh format to acceptable DWG, DXF, DGN on the personal computer formats are necessary in the submission process. Netrust as the Certification Authority will validate on issues of

authentication, privacy, data integrity and non-repudiation. The One-Stop Submission system itself is able to track changes to the submitted applications. In addition, a copy of the original encrypted submitted application is retained at the central agency in the event of any disputes.

INTEGRATED PLAN CHECKING SYSTEM

The Integrated Plan Checking System consists of four subsystems. The Integrated Building Plan Subsystem (IBP) focuses on architectural works. IBP is to check the building design for compliance with requirements from the BCA, Fire Safety Bureau (FSB), Urban Redevelopment Authority (URA), Land Transport Authority (LTA), Ministry of the Environment (ENV) and other regulatory agencies. The Integrated Structural Plan Subsystem (IBS) focuses on structural works. IBS is to check structural design for compliance with requirements from the BCA. Tender for the IBP and IBS was called in March 2000 and is scheduled to be ready by 2003. The Integrated External Works Subsystem focuses on external works to ensure compliance of the design with requirements from the URA, LTA, ENV and National Parks Board (NPB). Lastly, the subsystem on the integrated building services (ISP) focuses on M&E design. This subsystem is to check for compliance of building services design with requirements from the FSB, ENV, Public Utilities Board (PUB), Powergrid and Singapore Gas. Tender for ISP is scheduled later and is expected to be ready by 2004.

The benefits of the integrated plan checking system are numerous. There are no more bulky stacks of paper. Instead, a convenient electronic medium can be used to capture the plans for submission purpose. In its electronic form, plans can be archived and retrieved easily and efficiently. This allows public inquiries at the various regulatory agencies to be swiftly addressed. It increases productivity of the sector by allowing for fast, thorough and accurate checking of plans. The checking time per submission has been reduced substantially. For example, URA took 2.7 weeks (on average) to process an application electronically compared to 6 to 7 weeks under the manual system. The number of re-submission is also expected to decrease as a result of self-checking performed by the consultants and pre-consultation provided by the regulatory agencies using the integrated plan checking system. It also guarantees consistent interpretation and application of building regulations, rules and codes in checking of plans. A shorter turnaround time for plans checking means that manpower at the regulatory agencies can be channelled from mundane checking tasks to more complex value-added services to the public.

To compliment the plan checking system, a Building Codes Aider will also be developed. It provides regulatory agencies with useful tools for housekeeping and publishing building codes, circulars and other regulatory information on the CD-ROM and Internet. The Aider also assists the consultants to search and retrieve up to date building regulations, codes of practice and other relevant information from a cross-agency perspective.

To facilitate plan checking, building plans must be produced using FB-CAD which are submitted in CD-ROM disks for the initial phase. This is to protect the electronically submitted building plans from modification. In future, building plans can be submitted over Singapore-One Network, which will encompass other supporting infrastructure such as electronic payment and other transaction-related functions.

PROJECT WEBSITE

Project Website is a web-enabled platform that serves as a central repository of project information and a focal point for remote communications through electronic means. It creates an Internet-based environment for online sharing of project information. The objective of Project Website is to enhance cross discipline collaboration and multiparty co-ordination among the project team throughout the project life. This will reduce cost and time of through out the project life cycle resulting in greater efficiency for the entire project team involved in the project. The Project Website requires the setting up of industry infrastructure comprising data centres, network equipment and servers, leased line with backup and subscription, software development and service installations. Test run pilot projects at various stages of the design and construction phase of the project life cycle will be identified. This includes requirements study, hands-on training, data preparation, hardware and software acquisition, system customisation, testing and commissioning, user acceptance tests and recommendations. To date, six major developers and more than 100 consultants have agreed to participate in the pilot projects and the target is to have 10 pilot project web sites by February 2000 and 50 project web sites by 2004.

ELECTRONIC PROCUREMENT SYSTEM

This is an Internet-based environment for electronic procurement activities at the industry and enterprise level. The purpose is to create a trading and processing platform to support electronic acquisition of machines, products, materials, labour and services at the construction stage between main contractors and their subcontractors and suppliers. The objective is to reengineer the existing business and procurement practices for greater efficiency and to move the construction industry to incorporate electronic procurement as part of their normal business process. Hopefully, it will create a vibrant electronic marketplace for construction resources for local and regional projects. The procurement value is projected to account for 70% to 80% of the annual contract value of S$15-23 billion. The tangible benefits is estimated to be S$100-500 million of saving from reduced resources cost due to more competitive bid and direct access to source and improved productivity via automation of procurement and documentation. The current scope of the system is to set up industry infrastructure comprising data centres, network equipment and servers, leased line with backup and subscription, software development and service installations. Other scope includes requirements study of legal and contractual framework, cost and resource standardisation, business and process mapping, migration strategies, installation and maintenance.

There are currently at least two such systems that have been launched and will be launched soon. One of this is AsiaBuilders.com which was launched recently in April 2000. AsiaBuilders.com offers a comprehensive and detailed product and equipment catalogue. It provides an extensive database of companies and professionals and information content which includes industry updates, new product introductions, tender information, special features and reports, interviews with industry professionals plus coverage of regional trade shows and exhibitions.

The other electronic procurement system will be championed by the Singapore Contractor Association Limited. Tender to set up the system was closed in early April 2000. Currently, it is in the tender evaluation stage. The system will be set up in 6-12 months. The first phase will cover 20 top contractors and 20 of their subcontractors and supplier for major and high value resources. It covers inter- and intra-organisation procurement functions/activities and inter-portal communication. Of course, the security and legal matters will need to be addressed during the first phase.

PRODUCT MODELLING TECHNOLOGY

All the requirements for building plan checking are encapsulated in codes of practice and requirements from regulatory agencies. As a pioneer project of this nature world wide, there is no existing developed system which can be followed to capture the abundant information needed for building plan checking. Zhong (1998) has studied the use of Product Modelling technology for the building plan checking system and the following discussion is largely based on his study.

The product modelling concept was first introduced during the late eighties in CAD systems for integration purpose after geometric modelling concept, represented by IGES, was found to be inadequate to support the design task (Luiten, 1994). Currently, ISO TC184:DIS13584-1 (1998) and IAI (1997) have adopted the Product Modelling methodology in their respective modelling and implementation approach for the building construction sector. Therefore, it is logical that Product Modelling technology will be adopted for the integrated plan checking system in CORENET because of its proven track record in modelling of the building construction sector and its increasing popularity among software vendors.

Product Modelling is a way of communication on a high semantic level. In a product model, information on the product is stored as objects with attributes, representing the product and its properties. The product information is stored in a standardised format independent of the application. A product model is a particular type of conceptual schema. Product Models for plan checking systems are to ensure consistent interpretation of the building plans submitted by the engineers and architects. It is used as a data exchange standard between CAD systems and plan checking engine.

The tender is for CAD vendors to customise their respective CAD systems for compliance with the plan checking requirements which are stipulated in a number of codes of practice and regulatory agencies' regulations. The Plan Checking Engine developed need to provide a static data model capturing all building plan data at high semantic level in order to perform the compliance checking.

In view of the complexity of plan checking process, some of the concerns and suggestions to overcome these concerns will be discussed briefly as follows. As there is a large quantity of information encapsulated in a number of codes of practice and regulations, the bottom up approach was necessary to avoid the risk of missing data. Stand-alone models can then be built according to each clause or requirements from codes of practice or regulations within each regulatory agency. These

models are then integrated through a harmonisation exercise as shown in Figure 2.

Each agency requires a specific domain of information for its plan checking needs. Some objects, such as Building, Space and Wall are needed by all the agencies. On the other hand, some other objects are needed by one agency only, such as Hydrant by FSB. This same principle is also applied to the attributes. For example, only in FSB extension model is Habitable Height associate with Zone. For this reason, The product models for plan checking have to be defined in two layers, namely common model layer and extension model layer, as shown in Figure 3. Product models developed for the plan checking systems must be based on IFC Pre-release v1.5 models to ensure interoperability.

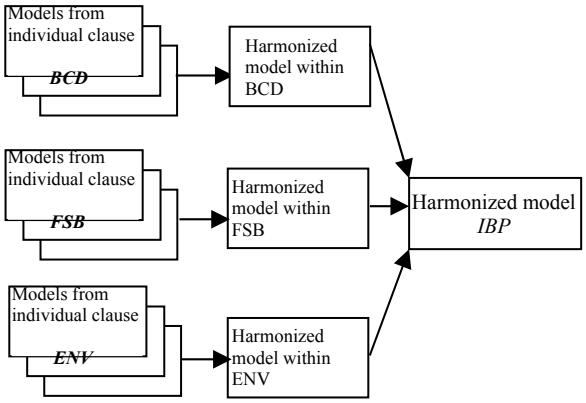

Fig. 2 Schematic Diagram of Harmonisation Model

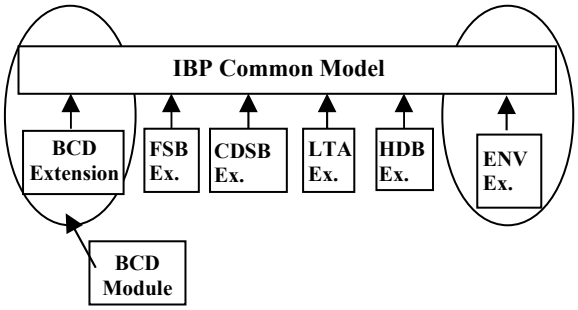

Fig. 3 Two Layers Model for Plan Checking

Product models are constructed to facilitate the information transfer from digital design files to plan checking systems as shown schematically in Figure 4. When in operation, digital CAD files will be submitted by engineers and architects to regulatory agencies for approval. The submitted CAD files must semantically comply with the definition of product models for plan checking and syntactically comply with a predefined CAD file format such as STEP Physical file format or DXF, DWG format. After mapping, CAD files will be processed by the Plan Checking System.

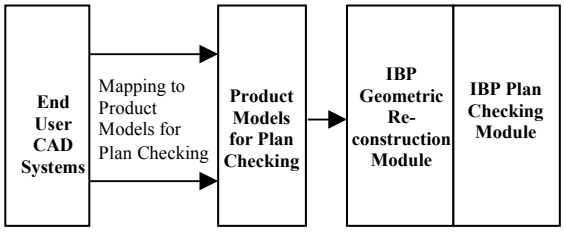

Figure 4 Schematic Overview of the Plan Checking Process

CONCLUSION

The construction and real estate sector in Singapore has embarked on a very ambitious program to embrace IT to raise the productivity and the competitiveness of the whole sector. It is heartening to see the involvement of all the practitioners of the sector in shaping the entire CORENET program right from its inception. Some of the difficulties of the plan checking system have been highlighted and suggestions to overcome them have also been discussed. It is expected that there will be practical problems when the system is being developed and implemented in full and this may lead to modification of some aspects of the system or the product models. Another constraint that may retard the pace of the implementation is technology. Nevertheless, the construction and real estate sector in Singapore is poised to turn a new leaf in the next millennium with IT.

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