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MANAGING URBAN DEVELOPMENT PROCESS BY USING SPATIAL INFORMATION SYSTEM: A Case Study of *I-Space*[1]

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Abstract

The advancement in Information and Communication Technology (ICT), particularly in relation to Geographical Information System (GIS), Computer Aided Design (CAD), Database Management System (DBMS), and Facility Management System (FMS), has provided the opportunity for urban government to adopt innovative and effective technologies to aid and improve the management and decision-making in urban development process.

Among the obstacles that hamper effective management and decision-making in urban development process are the absence of integration between the works of the professionals involve in such process and the unavailability of immediate and reliable data to form the basis for sound decision-making. Thus, this paper proposes that a city-wide spatial information system to be developed comprising two major elements: a common platform for integrating the works of the various built environment professionals and a city-wide built environment database. While the common platform will help to streamline the works of the professionals, the database will assists urban government in making sound and informed decision in relation to planning, management, maintenance, and monitoring of the urban built environment.

This paper highlights the efforts of the International Islamic University Malaysia (IIUM) in developing its spatial information system. The system is designed to provide information on the IIUM property that covers buildings, infrastructure, facilities, and space to decision-makers and managers to help them in making sound decision and in implementing effective property management scheme.

Keywords: ICT, GIS, CAD, FMS, *I-Space*, TSIS, Planning Support System.

[1] ***I-Space*** refers to International Islamic University Malaysia Spatial Information and Facility Management System.

INTRODUCTION

Urban development process is a complex and time-consuming process. Managing it using conventional tools and systems is, without a doubt, a daunting task. Fortunately, the advancement in information and communication technology (ICT) has provided the opportunity for urban managers to invent and adopt innovative and effective systems to aid them in performing their tasks. In Malaysia, several local authorities, as the managers of urban development process, have embarked on developing ICT-based systems to manage urban development process. Some have achieved considerable success while others were not so fortunate.

This paper looks at the problems of paper-based systems in managing urban development process and also identifies some of the weaknesses of the ICT-based systems developed by the local authorities for similar purpose. It recommends that a Total Spatial Information System (TSIS) to be developed as a tool to help achieve effective and efficient management of urban development process. It also draws examples from efforts of International Islamic University Malaysia (IIUM) in developing its own TSIS in managing its properties, facilities and assets.

URBAN DEVELOPMENT PROCESS

Urban development process is a complex, interactive, and time-consuming process. It generally begins with the notion to undertake a development project, which then followed by various stages that can be broadly categorised into planning and design, construction, and operation/management stages. It also involves numerous actors whose decisions and influences determine the pattern and trajectory of the development.

Local authorities are key players in urban development process, acting as enablers, decision-makers, managers, and service-providers. Local authorities are the ones entrusted to make decisions on urban development on behalf of the public. During planning and design stage of the urban development process, local authorities play important roles as approving authority. The grant of planning permission, building plan approval, and development order are all under the jurisdiction of local authorities. For instance, for planning application, developers will submit the required plans and documents to local authorities (usually to town planning department or unit) who will then investigate and scrutinise those plans and documents before deciding whether to grant planning permission or reject the proposed development.

Local authorities also manage urban development process so as to ensure controlled and sustained urban development. This is achieved through preparation of development plans and development control guidelines that guide the development of an area.

As a service provider, local authorities are responsible in provision of urban services during the operation stage of development. Among the services commonly provided by local authorities are, for instance, solid waste collection and disposal, landscaping and area beautification, and maintenance of urban roads.

In Malaysia, many local authorities took the task of managing urban development process conventionally that is relying on paper-based systems (Nor Asma, 2002). Over the years, these systems have been identified to possess several inherent problems that give rise to inefficiency and ineffectiveness.

THE PROBLEMS OF PAPER-BASED SYSTEMS

Central to effective and efficient management of urban development process is prompt and accurate decision-making. However, prompt and accurate decision-making can only be achieved if sound and sufficient data and information are readily available to decision-makers. This is where paper-based systems of managing urban development process suffer the most. The problems lie in data flow, storage, updating, and retrieval.

Smooth and swift flow of data and information between the various stages of urban development process is highly desirable if not crucial. However, with paper-based system, this is difficult to achieve. Data and information are being presented to local authorities in files and folders. These files and folders need to be physically moved from one officer to another and from one department to another. Additionally, a file or folder can only be accessed by one officer at a time. This contributes to increasing the possibility of delay in making decision. Not to mention that the 'physical' movement of files and folders can also lead to them being lost along the way. This, unfortunately, is not an unusual occurrence in local authorities' departments. 'Loss of file' further accentuates the delay in decision-making. Paper-based systems also require large space for data or file storage. For instance, a development proposal report submitted to local authority in planning application can easily exceed 50 pages of A3 size paper. Building plans are submitted in A1 or A0 size paper and the number of plans per submission is very much dependent on the requirements of local authorities as well as the height of building. At the very least, a minimum number of 3 sheets of plan

are required per submission for development of a bungalow and the number is much higher for development of multi-storey building. Local authorities keep at least a copy of all the documents and plans submitted for approval. Thus, with the bulky nature of paper-based submission, it is not surprising that some local authorities have to resort to renting a room in another building just for the purpose of storing all the submitted documents and plans.

With paper-based systems, movement of data and information is not only incoherent but also slow. Because of procedures and bureaucracies, a file located in one department may take several days to reach an officer in another department. This affects the ability of local authorities to make prompt decision. Thus, for quick and easy access to data and information, it is a common practice among the departments in local authorities to maintain their own set of data record. So, several records containing similar data might be kept separately by the departments in a local authority. For example, the town planning department might keep a record on the name and address of building owners to determine affected parties of a proposed development. The health and licensing department might also keep a separate record of similar information for licensing purposes. The valuation department might also have a record of similar information for rate assessment purposes. This very practice of departments keeping their own separate records of data and information creates wastage and undermines the consistency and accuracy of data used in decision-making. Maintaining several separate records of similar data creates wastage in terms of space required for storage, the personnel required to maintain the data record, and duplication of jobs. Additionally, manual updating of one data record does not necessarily affect similar update of other data records. This contributes to data inconsistencies that can affect the speed of decision-making process. Inconsistencies in data presented to decision-makers by the departments must be resolved first before any decision can be made. This would involve rechecking of the recent updates among the departments and identifying whose data is the most recent and correct.

Data retrieval under paper-based systems is also time-consuming and problematic. Paper-based systems do not allow ad hoc queries to be made on the data records. Therefore, data searching is done manually and because of the large number of data stored, it would take some time before the required data can be located and analysed for decision-making purposes. Data retrieval can turn out to be more problematic if the data records are not properly maintained. In such cases, data retrieval can take unnecessarily long time or even the required data cannot be located at all.

USE OF ICT IN MANAGING URBAN DEVELOPMENT PROCESS

Since the last few years, several local authorities in Malaysia have embarked on developing systems based on information technology (IT) to aid management of urban development process. Perbadanan Putrajaya has come up with its systems known as SUMBER-PUTRA, short for 'Sistem Pengurusan Berkomputer Pembangunan Bandar – Putrajaya (Computerised Urban Development Management System – Putrajaya). The Selangor State Town and Country Planning Department has also introduced its SEPAS (Selangor Electronic Planning Approval System). Kuala Lumpur City Hall is also coming up with its own system as well as Pulau Pinang Municipal Council.

The decision to develop and adopt IT-based systems for managing urban development process can be attributed to several factors. First is the availability of suitable technology. The advancement in IT, particularly in relation to computer aided design (CAD), geographical information system (GIS), database management system (DBMS), as well as in terms of hardware, has provided the opportunity for local authorities to adopt innovative and effective technologies to aid and improve the management and decision-making in urban development process. With CAD, maps and plans can now be prepared digitally. DBMS allows all the maps, plans and other data to be properly kept and easily retrieved. Using GIS, digital data represented on the maps and plans can then be retrieved and spatially analysed for decision-making purposes.

IT-based systems can also overcome the problems of paper-based systems aforementioned. For instance, under IT-based systems, digital data and information can be transferred using electronic mail or the internet. In such cases, data only takes seconds to reach users. Data can also be kept in one network server where users can access from their own computer and retrieve the required data.

With IT-based systems, data is stored in digital format and thus, storage is easy and requires little 'physical' space. Data is now kept on a magnetic disk (hard drive) roughly the size of an adult palm. Technology has also allowed tremendous increase in terms of storage capability of the disk although its size remains the same. One whole room of data stored under paper-based systems is now possible to be crammed into only one single disk.

With IT-based systems, data can be stored in a central database. Therefore, data update only concerns with one set of data record located only in one location, which is the central database. Update of data will also trigger update of other relevant data.

Government policies and initiatives also help to spur the use of IT-based systems in managing urban development process among the local authorities. The National IT Agenda (NITA), for instance, which was launched in 1996, identifies the need to transform Malaysia into information society and knowledge-based society. Towards this end, NITA provides the foundation and framework for the utilisation of IT in five strategic thrust areas, which were then translated into various initiatives. *Electronic government* or *e-government* is one of these initiatives and currently is one of the flagship applications of the Multimedia Super Corridor.

WEAKNESSES OF EXISTING IT-BASED SYSTEMS

Looking at the IT-based systems already being adopted by the local authorities, or even those that are still in development, one can identify several weaknesses that can hamper the success of those systems as tools in managing urban development process. One of the weaknesses is that they were adopted in fragments. Except for Perbadanan Putrajaya's SUMBER-PUTRA, IT-based systems of other local authorities were developed at departmental, or even sub-departmental, level. The danger is that, by being developed at this level, there is a possibility that the top management of the organisation or institution might not be fully aware of the systems and might not fully appreciate the benefits of such systems. Such situation would result in less support, morally and financially, is given by the top management on the development, operation, and maintenance of the systems.

Because the systems were developed at departmental level, their design was piecemeal in approach. Most of the systems were designed only to handle the tasks relevant to a specific stage of the urban development process which the department is concern about. For instance, the Selangor State Town and Country Planning Department deals mostly with development control, and therefore, developed SEPAS, which only deals with planning application and approval. But planning application and approval is only a part of the planning and design stage in the urban development process. Focussing IT-based systems

to specific stages or process of urban development limits the functions and the number of users of the systems, and therefore, the benefits of the systems. Systems developed by one department will be of no use at all to other departments. Users of the systems are usually restricted to the specific department staff, and perhaps consultants, who are required to submit their application electronically via the systems. Public access to the systems is totally non-existence.

To develop IT-based systems for management of urban development process is not easy. Therefore, most local authorities engage IT consultants to design and develop their systems. The problem is that local authority officers are generally unfamiliar with the cutting edge technology of IT, and thus, unable to clearly and precisely define the type of system to be developed by the consultants that can accommodate their workflow and decision-making process. On the other hand, consultants are unfamiliar with the workings of local authority. So, both parties begin the development of the system with limited understanding of what the output should be like. Over the course of the project, and as things become clearer, changes and amendments will have to be made. Thus, systems development usually takes a long time because consultants have to keep amending of redesigning the systems. There has been a case where consultants have to close shop because they cannot sustain the unexpected prolonged period and additional work they have to undertake in developing the system (Lee, 2000).

TOTAL SPATIAL INFORMATION SYSTEM

Although IT-based systems can benefit local authorities in managing urban development process, the true benefits of the systems can only be achieved if the systems are developed in total. This is what we termed the 'Total Spatial Information System' (TSIS). TSIS is a non-fragmented and integrated system that utilises spatial/geographically-referenced data (as well as non-spatial data) to enhance the management of and decision-making in urban development process. Four elements are necessary in making a TSIS. They are organisation, procedure, technology, and data (Reeve D. 1999).

Organisation

TSIS must be developed at organization or institution level. Decision to develop such system must be made by the top management of the organization and such decision must be disseminated to departmental level. This is to ensure that

everyone in the organization is aware of the project and to garner full support for the development, operation and management of the system.

Vital to the TSIS is the users of the system. Users of the system must not be limited to those within the organisation but also the clients and public. For local authorities, clients such as consultants and developers should be able to use the system to submit their applications, monitor the application approval progress and status, and submit queries. The public should also be able to use the system, for example, to check on proposed development in their area, to make objections to proposed development that affect them, and to submit queries and complaints to local authorities.

To encourage use among people outside the organisation, the system must be designed to incorporate easy to use graphics user interface (GUI). The system can also incorporate means to restrict access to data and information depending on who the users are and how sensitive the data is. Nevertheless, it has to be noted here that over-secrecy or over-protection of data might encourage the use of the system among the public, as they cannot gain useful information through it.

Procedure

TSIS must be designed to cater all the tasks or job scope of the organisation. In the case of local authorities, the system must be able to incorporate all the stages of the urban development process from planning and design to construction to operation/management. Including the whole of the urban development process would increase the functionality, as well as benefits, of the system.

What works under paper-based systems does not necessarily appropriate under IT-based systems. Therefore, essential to TSIS is the reengineering of the organisation workflow in order to take advantage of the capability and functionality of the system.

Before reengineering of the workflow can take place, it is only logical for the system developers (either in-house expertise or consultants) to study the existing workflow of the organisation and its departments. It is important to understand what their tasks are and how they go about completing the tasks. Users must also be made aware of the efforts to develop the system and to get their feedback on what they expect from the system. From here, the system developers can begin to modify the workflow where necessary to capture the advantages of the system and to introduce innovative features into the system that can simplify or expedite the workflow.

Technology

Technology refers to the hardware and software for use in the system operation. Appropriate hardware and software must be acquired to ensure the system can be use to its full potential. Hardware includes networking to connect the system to users, network server to keep the database and the system engine, personal computers for accessing the system and retrieving data and information from the system, printers and plotters for printing data and information retrieved from the system, and scanners for scanning data and information into the system. Software includes all tools or computer programmes useful for data management and transmission as well as analysis. What constitute appropriate hardware and software depends on various factors such as the size of data and information to be handled, data analysis capability, simplicity of use, and also availability of funds.

It is important for local authorities to recognise that TSIS is a 'living' system. It will require maintenance and system capacity building from time to time. Accordingly, sufficient funding must be made available. Funding is required for manpower to operate and maintain the system, and for capacity building, which include hardware and software upgrades as well as the overall improvement of the system.

Data and databases

Urban development process deals with both spatial and non-spatial data. Thus, TSIS must be able to handle both types of data successfully. This includes data storage, data retrieval, data analysis, data update, and data sharing. Appropriate tools must be designed within the system to perform these data handling tasks.

Data retrieved and analysed under TSIS is useful for decision-making in urban development process. The more accurate the data, the more reliable the decision made. Hence, local authorities cannot accept data they received at face value. It is necessary that the accuracy of those data be verified on the ground, especially spatial data. Accurate spatial data does not only lead to accurate and sound decision, but also can save costs. Future development can be planned and designed straight from the data retrieved from the system database without the need to conduct another ground survey. And these plans, having being drawn using accurate spatial data can also be used for tender purposes (i.e., e-procurement), which helps to expedite the process.

IIUM SPATIAL INFORMATION SYSTEM

IIUM Spatial Information and Facility Management System or known as ***I-Space*** is an integrated, ICT-based decision support system of properties and assets inventories developed through a combination of several sub-systems including geographical information system (GIS), computer aided design (CAD), image management system (IMS), facilities management system (FMS), and database management system (DBMS). The system allows management of IIUM properties, facilities, and assets to be undertaken based on geographically referenced data and projection. The system aims to reduce wastage, enhance efficiency and effectiveness, and create a better working environment through computerisation of tasks and procedures of development of plans, documentation, production of letters and reports, procurement, space utility planning, inventory, and supplies.

The system is planned to be adopted at all IIUM campuses. However, its development is being carried out in several phases. The first two phases will cover the IIUM main campus at Gombak, Kuala Lumpur, and the following phases will cover other IIUM campuses. The first phase was completed in July 2002 and the second phase is due to commence in 2003.

The development of the first phase of ***I-Space*** was undertaken through three main stages, which are:

i. preparation of inventory and development of central database related to land and properties of the project area;
ii. development of applications or system's interfaces related to planning, management, commissioning and monitoring of buildings, facilities, and activities within the project area; and
iii. development of communication networking and accessibility to the system through arrangement of information and communication technology (ICT) facilities at each identified hub.

In order to ensure that the benefits are wide-ranging and long-lasting, the system was developed incorporating the four essential elements of a TSIS (see Figure 1 for the data model).

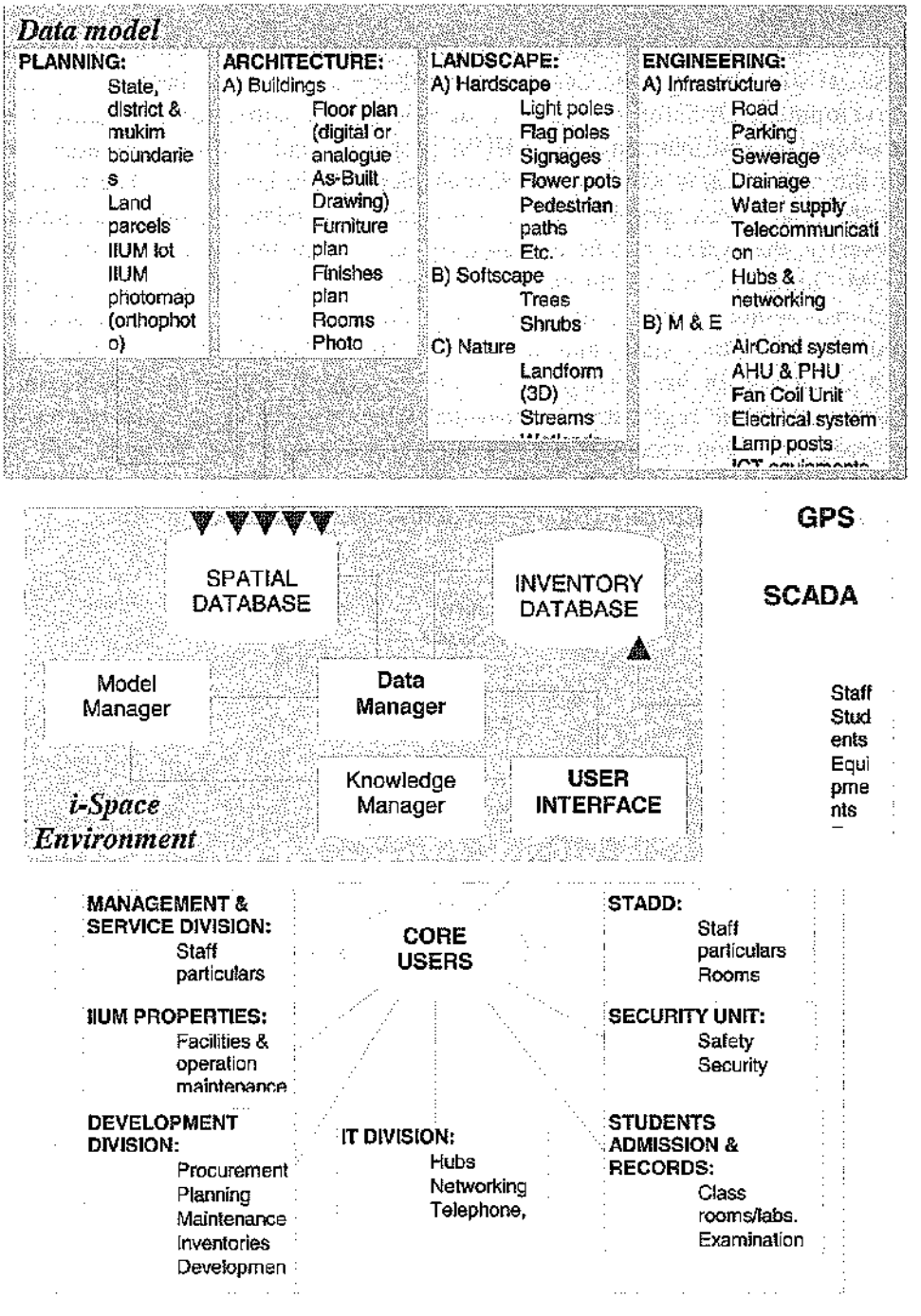


FIGURE 1: ***I-Space*** structure and data model.

Organisation

The development of the ***I-Space*** was undertaken at organisation level, in this case IIUM. Although the development of the system was initiated by the Development Division of IIUM, a division responsible for managing the development and maintenance of IIUM properties and facilities, the approval for the project came from the top management of the University. The funding for the project was approved by the University's Standing Finance Committee. Presently, the system can be accessed by users from hubs located within the IIUM Gombak Campus through a local area network (LAN) that supports high-bandwidth communication for short distances. Users include academic and administrative staff, and students of IIUM. Users' access to the data and information are being restricted through assigned username and password. Online registration is provided where username and password will be assigned. Upon accessing the system (refer Figure 2 and 3), users will be prompted to enter username and password. Access to data and information are being restricted according to users and data sensitivity.

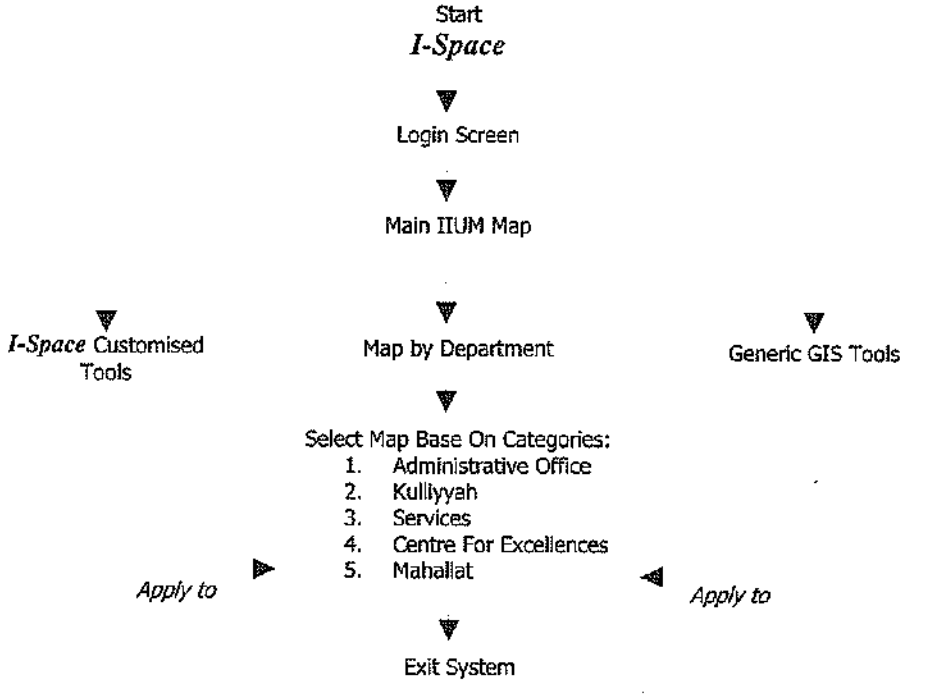


FIGURE 2: General system flow of ***I-Space***.

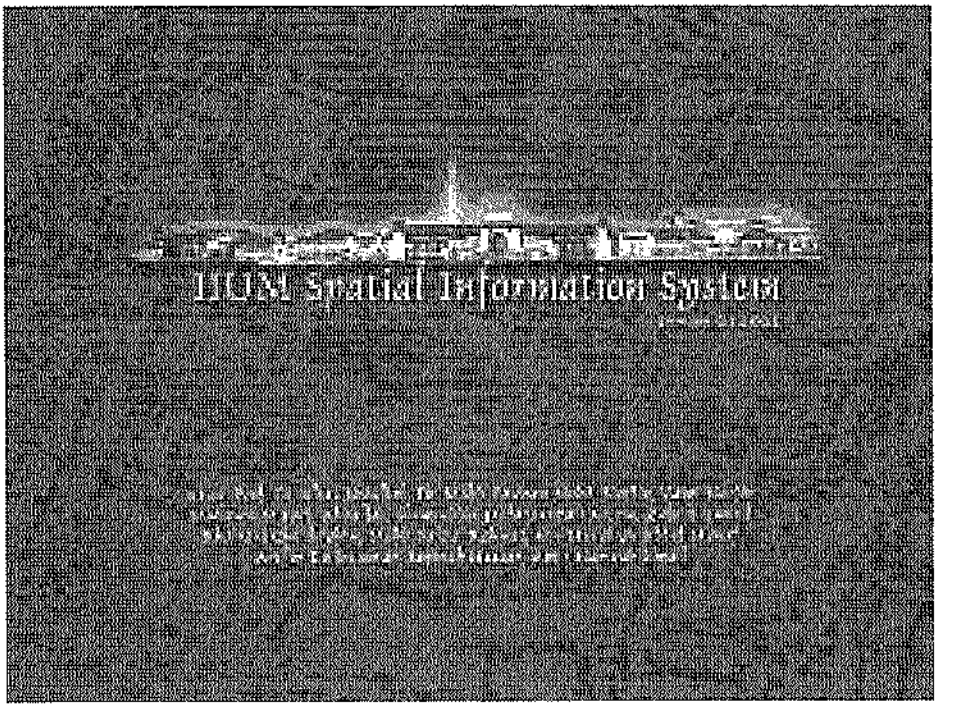


FIGURE 3: Start of *I-Space* screen.

It is anticipated that the userbase of the system would increase once the system is made available on the internet. The second phase of the system development internet. Once on the internet, the public can use the system for a variety of purposes such as direction-finding and facilities-booking.

Procedure

A team of consultant, comprising mainly lecturers from the IIUM Kulliyyah of Architecture and Environmental Design, and officers from IIUM IT Division, was appointed to develop the system. Prior to undertaking of system development works, the team conducted a user need study where a meeting was arranged with representatives of the users in order to inform them about the project, the benefits of the system, and also to get their feedback on what they expect from the system. Findings from this meeting become one of the important inputs in devising appropriate workflow for the system.

Technology

In developing the system, the team realized that it is important to acquire hardware and software with the right capability and functionality to perform users required tasks. In terms of software, the primary desktop application used in system development includes MapInfo, AutoCAD, MapBasic, and Visual Basic.

The system employs the client-server network technology where data are being kept in a centralise database. For database management system, the system uses Oracle as the main engine.

Two key hardware components required by the system are personal computers, from where users access the system, and network server, where the database is being kept. Most personal computers available in the market would be able to access the system. The only apparent difference between using high performance computers and low performance computers in accessing the system would be the speed of data download. The speed of data download for low performance computers would be significantly slower than high performance computers. In terms of network server, at present the system is using a network server with the following specification.

- Processor – Intel Xeon 1800 Mhz/512K
- Network Card – Integrated Broadcom Gigabit Network Card
- Processor 2 – Intel Xeon 1800 Mhz/512K
- Memory – 1024 Mb
- Hard drive – 36 Gb, U3/U160 SCSCI
- Monitor – 15" colour monitor
- CD-ROM drive – 12/24X Max

Besides providing sufficient budget to acquire the required hardware and software for the initial development of the system, the University has also decided to allocate budgets for system operation and future capacity building of the system. Operating budget will be used towards recruitment and training of personnel to maintain and manage the system. The personnel will be positioned in the Development Division where the network server will be located. The capacity building or system budget will be used for purchasing hardware and software upgrades when necessary and also for system improvement as a whole. Another network server may need to be purchased when the data storage capacity of the existing one is already at the maximum. New software or software upgrades may need to be acquired when more functions are to be included into the system. For instance, the second phase of the system development will see a new function added into the system, which is 3D spatial

analysis. At the moment, the system is only capable of performing 2D spatial analysis. However, due to the undulating landscape of the study area, it is necessary that 3D spatial analysis to be added into the system. Therefore, new software that can generate 3D data from the existing 2D will have to be purchased. A new application tool also needs to be designed and developed to allow users to perform the 3D analysis. Inclusion of this new 3D analysis is seen as an improvement to the system as a whole.

Data and Databases

I-Space utilises both spatial and non-spatial data. The data model adopted by the system is as shown in Figure 1 above. Data has been classified into planning, architecture, landscape and engineering.

Data collection involved two main stages. First stage (data collection stage) was where spatial data were gathered from construction and as-built drawings of IIUM. In the following stage (data verification stage), the accuracy of the data obtained from the drawings was then verified on the ground through built survey. Any discrepancies between data obtained from drawings and from survey were rectified before those data were input into the database.

Visual representations of the spatial data were also captured in the form of photographs. Availability of photographs would help users in identifying the data on the ground and also help users in making selection of the facilities they want to book or use. For instance, users who would like to use IIUM's seminar or conference room can check the photographs of the rooms before deciding on the one they preferred. The photographs would give a clearer picture on, for example, the layout of the room, the lighting or furniture design, and the wall finishes (refer Figure 4, 5, 6, 7, 8 and 9; and Photograph 1 and 2).

A number of tools were designed and incorporated into ***I-Space*** to allow easy data retrieval and analysis. These tools are presented to users in clear and easy to use GUI. Several customised and powerful query tools were also included for advanced users who wish to perform a more complicated analysis of the data and information. Selected MapInfo tools such as query, ruler, and select tools were also included in the system. Figure 5 below highlights the location of the tool buttons on the system application window.

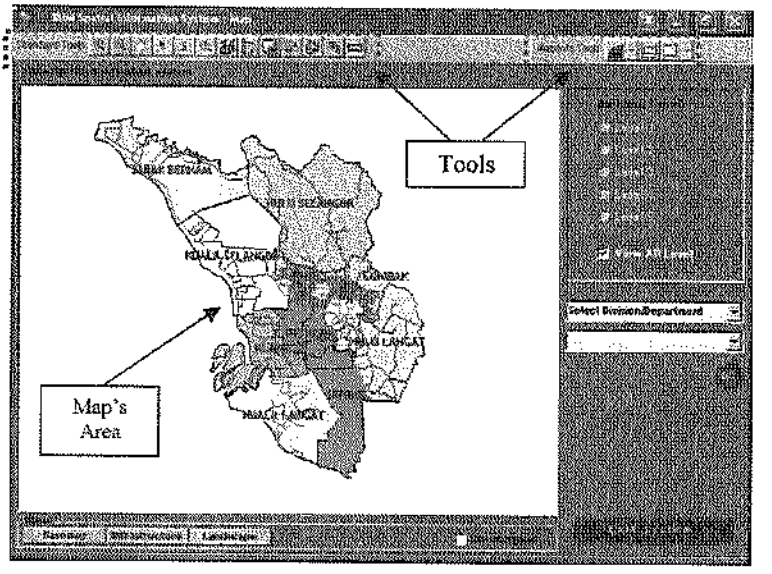


FIGURE 4: The *I-Space* GUI and tools.

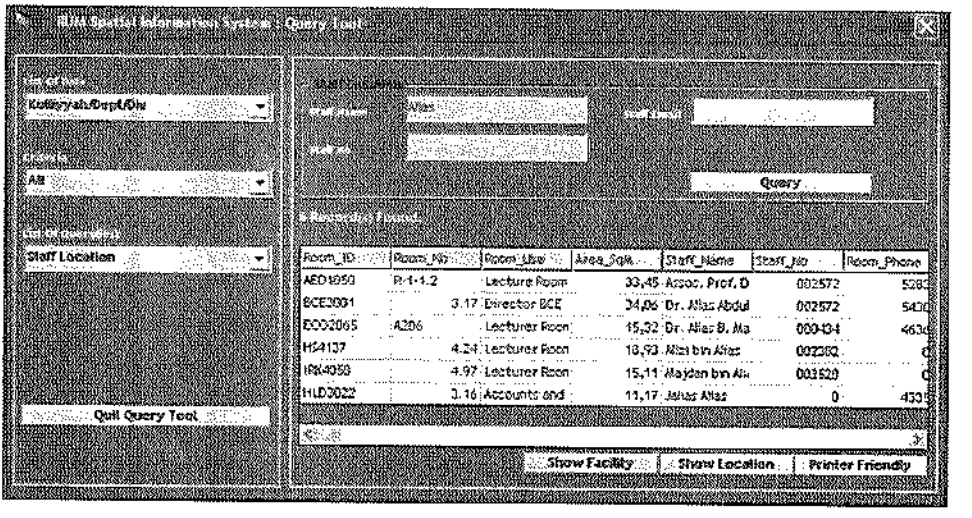


FIGURE 5: *I-Space* Query Tool.

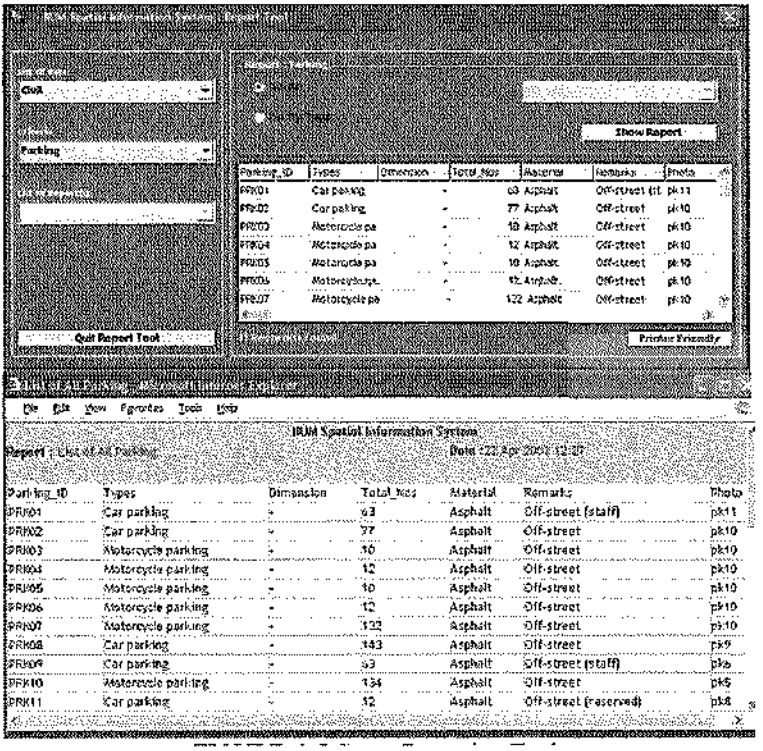


FIGURE 6: *I-Space* Reporting Tool.

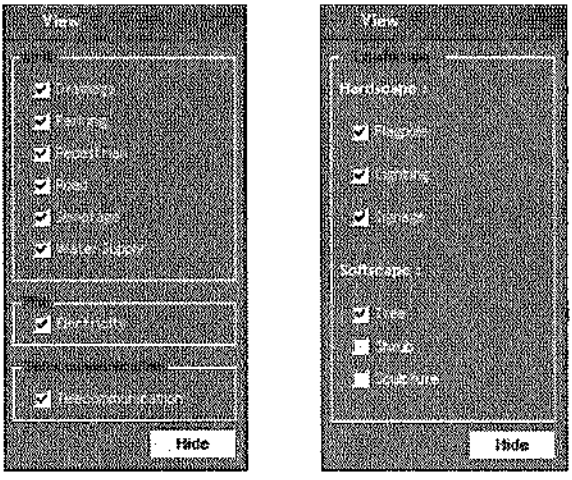


FIGURE 7: *I-Space* Viewing Tools for engineering and landscape aspects.

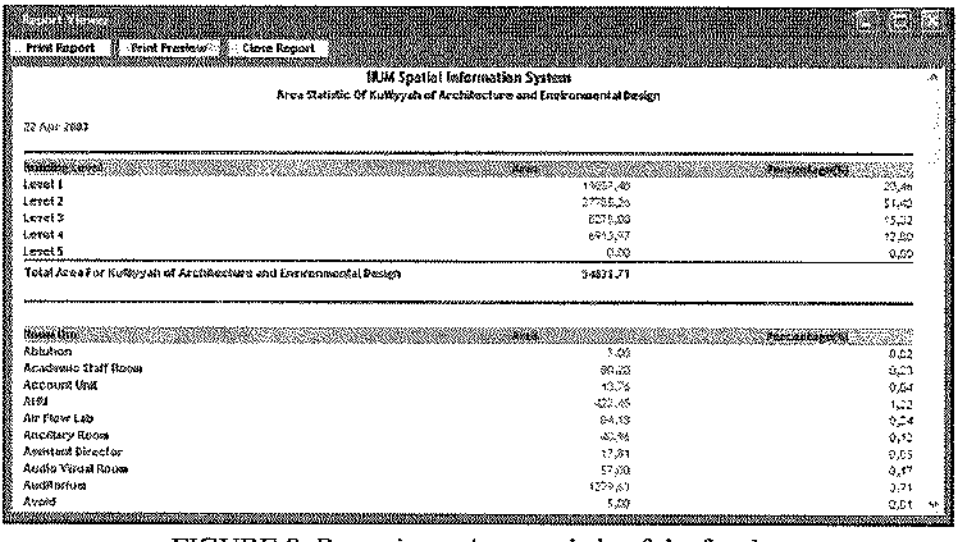


FIGURE 8: Reporting – Area statistic of the faculty.

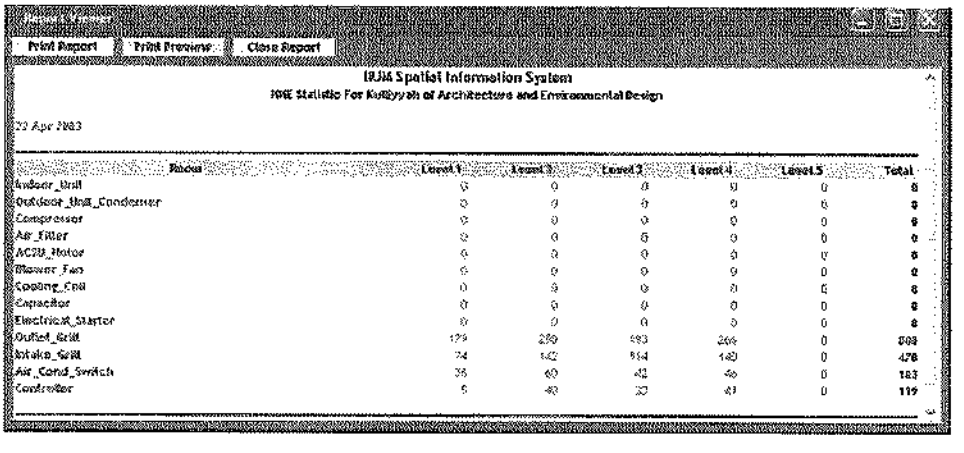
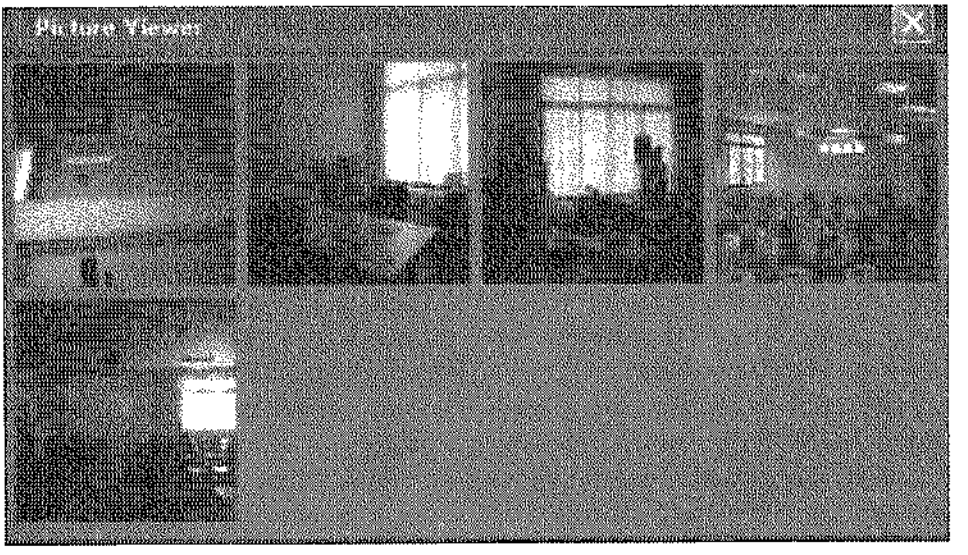


FIGURE 9: Reporting – M&E statistic of the faculty.



PHOTOGRAPH 1: ***I-Space*** Thumbnail Viewer

PHOTOGRAPH 2: Enlarged photograph of a lecture room.

EXPERIENCE DEVELOPING *I-Space*: DATA ACCURACY

One of the main objectives of developing ***I-Space*** is to allow management decisions to be made based on accurate, geographically-referenced spatial data. In fact, there have been proposals that data retrieved from ***I-Space*** should be fit for tender purposes. Thus, to the team developing the system, the accuracy of the spatial data is given utmost importance.

During the early stages of the system development, it was thought that as-built drawings would be the main resource for accurate spatial data since these drawings were drawn based on pre-computation plans. Thus, the team continued to gather and compile all the as-built drawings for all development projects within IIUM main campus. However, it was later discovered that not all drawings were available for use by the team. Some of the drawings (especially the old ones) were badly damaged and some were already lost and could not be traced. As a result, the team decided that it was necessary to conduct a comprehensive built survey. However, the built survey only involves capturing data on topographical features (such as location of trees, lamp poles, and roads) and building perimeter. Thus, to complete the information on buildings floor plans, the as-built drawings (for buildings which as-built drawings were not available, the building floor plans were redrawn) were overlaid on top of the building perimeter obtained from the survey. However, the team experienced difficulties in overlaying the as-built drawings onto the building perimeter as many of the as-built drawings did not fit onto the building perimeter. Upon further inspection, it was found that many of the as-built drawings were actually inaccurate and did not reflect the actual constructed buildings on the ground[2].

The overlay technique actually revealed the inaccuracies that persisted in the as-built drawings. It was rather fortunate that some of the as-built drawings were missing or badly damaged; otherwise, the team would have not carried out the built survey and would have not discovered the inaccuracies within the as-built drawings. Further discussion with professionals in the built environment revealed that it is quite common for discrepancies to occur in as-built drawings. Therefore, to others who wish to develop similar system, the team, to an extent, would recommend that a comprehensive built survey to be conducted if accuracy of spatial data is of significance in the context of the system development.

[2] A separate study will be done in future on commercial, residential and office as-built drawing with a reference to the JUPEM developed cadastral database and built survey parameters. This will determine the appropriateness of using as-built drawing for managing urban development process and e-submission (procurement).

CONCLUDING REMARKS

It is hoped that this paper has been able to demonstrate the deficiencies of paper-based systems in managing urban development process and to highlight the shortcomings of existing IT-based systems developed by local authorities for similar purpose. While IT-based systems hold many advantages over the conventional paper-based systems in the context of management of urban development process, they have to be developed taking into account the four elements of total IT-based system before their true benefits can be reaped. Incorporating the four elements of TSIS will increase the functionalities and capabilities of the system, increase its support and userbase, and ensure its benefits are wide-ranging and long-lasting.

IIUM's ***I-Space*** is an example of TSIS developed at a project level (at university level). It can become the model for systems to be developed by local authorities at a more strategic level (urban level). Nevertheless, some modifications would be required to suit the system to the requirements of local authorities' roles and functions, the types and amount of data, and the larger number of public users.

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