CONSTRUCTION PLANNING PROCESS IMPROVEMENT USING INFORMATION TECHNOLOGY TOOLS

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ABSTRACT:
For the last ten years, Computers have been used extensively in the development and procurement of construction projects. This is due to the relatively cheap hardware and software and most importantly the availability of skilful engineers and technicians to use computers effectively and efficiently. Construction site planning and management, however, is largely paper driven and computers are used for administration work rather than planning and managing the process.
This paper describes a collaborative research study being undertaking between the University of Teesside and an international contracting organisation based in the UK. The prime objective of the research is to analyse and develop a formalised construction process model with integrated Information Technology Tools (ITT) as enablers for productivity and performance improvement of the site management processes. Other objectives are: to develop an understanding of the production processes (managing type contracts) and identify key areas in which computers can be used as enabling tools to improve and stream line the processes. In order to achieve the objective a number of tasks have been set, these were: identifying current processes using semi-structured interview; map out processes using IDEF0; benchmark processes and identify key areas in which computer can be used; and development and implementation of an IT based methodology to be used in managing the process. The paper concludes that the one of the major areas within the production process, which could enormously benefit from IT, is change orders due to design change, client variation, etc.
The paper discusses the development of an IT based tool for site planning and change order management as a first phase of the project.

KEYWORDS: Planning, Processes, Construction integration, Data flow model,

1. INTRODUCTION

For the last ten years or so, good practices from other industries (manufacturing industry in particular) have started to influence and penetrate the construction industry. This is due to the fact that the construction industry is genuinely interested in improving its practices and increases its profits. Such good practices are: innovative supply chain management, highly accurate detailed planning and scheduling, utilisation of IT, standardisation of products and processes.
The construction industry is highly fragmented compared with any other manufacturing industries. The degree of this fragmentation is unparalleled in any other sector, with significant impacts- low productivity; cost and time overrun; conflicts and disputes; resulting in claims and time consuming litigation. This has been acknowledged as one of the major causes of performance related problems facing the industry. These problems have led to

significant development in alternative approaches to the delivery of construction products in the last three decades. The results are the cultural changes and ever increasing demand for accurate information at the initiation and pre-contract stages of the projects through to completion. One of the fundamental aspects of those developments is the integration of design and construction stages. The implication is the development and uses of alternative construction organisation processes such as management contracting, construction management, design and build, and other ad-hoc methods. Unfortunately, these approaches have been proved to be inadequate to cope with the increasing complexity of construction projects.

Construction, as a multi-organisations process, is heavily dependent on sharing and exchange of large complex data and information. The successful completion of the project depends on the accuracy, effectiveness and timing of communication and exchange of those information and data between the project team. The inefficiency of the current communication practice has become a barrier to these innovative construction processes being developed for the industry over the past four decades.

Literature review suggests that a high percentage of research efforts in construction is now directed on integration of the construction processes using Information Technology (IT) tools as enabler. All of those studies have contributed towards the development of methodologies, resources, and tools for integrated of construction process with varying degrees of success. Unfortunately their outputs are rarely implemented in practice. A number of reasons have been put forward for this (Betts et al 1995; Anumba, 1998) but it is our contention that the prime reason is lack of understanding of the IT needs of the practitioners in the industry resulting in incorrect and unclear requirements for IT system which in turn results in impracticable system. This suggests that any effort aimed at improving a particular process must start first with the understanding of that process. Questions, such as what activities are involved, how or who does what within the process, need to be answers to enable development of solution that will conform to the requirements of the end-users in the industry. In some cases where requirements are met, proposed IT solutions are too expensive to be economically justifiable to be implemented in practice.

The achievements of this aim, demand the pursuit of four key objectives:

1. To determine the current production processes that are currently in use in the industry (managing type contracts).
2. To identify the IT tools that can be integrated into the processes to improve their performances,
3. Validate the mapped processes, and
4. Development of an IT integrated system to manage the production process.

2. RESEARCH APPROACH

In order to identify and capture the production process, semi-structured interview technique was used to determine the processes. An international construction company was selected as a case study for the processes. A CASE tool was used for Process mapping and modelling. The following details the research methodologies (Detailed of the methodology is presented in Akinsola et al, 1999).

2.1 Semi-structured interview

There were no formal written procedures or otherwise available that describes the construction process in use by the company under study to projects and to provide a starting point for the research team. To identify processes, one requires answers to a range of questions, e.g. what the processes are, who is responsible for them, what is needed to do it, etc. Answers to this nature of questions and reviewed of previous research studies enable the team to identify and determine the activities; decisions, procedures, information needs, and tools required for the processes, therefore, a formal meeting with company staff was arranged.

The meeting addressed the research aim, objectives and benefits to the company as well as the proposed research methodology. The nature of information that would be required in order to achieve the research aim and objectives were explained in order for the forum to identify members of the company's production team that will be appropriate to interview by the researcher team. The attributes of the project team members interviewed are shown in Table 1.

Table 1: Attributes of company project team participants

Interviewee	Position	Process
1	Design Co-ordination	Core processes
2	Development Manager	Production (A3)
3	Quantity Surveyor	Production (A3)
4	Project Manager	Production (A3)/Construction (A4)
5	Project Manager	Production (A3)/Construction (A4)
6	Senior Site Engineer	Production (A3)/Construction (A4)
7	Site Engineer	Production (A3)/Construction (A4)
8	Site Quantity Surveyor	Construction (A4)
9	Site Administrator	Construction (A4)

2.2. Detailed Mapping and Modelling

Following the interviews and discussions, detail mapping and modelling of the identified processes were carried out using a CASE (Computer-Aided Software Engineering) tool. The processes were mapped to two or three levels of details. The only restriction placed upon us was the inaccessibility of the research team to these processes outside our industrial partner's control.

The information captured and analysed from the interviews were used to develop the process models based on IDEF0 (Integrated DEFinition) method. The description and explanation of this methodology is given in the appendix. The adoption of this modelling technique is based on its popularity in the industry, the experience and knowledge of the method within the team, and its suitability to the research objectives. The generic model of the construction process is shown in figure 1. The figure shows the abstract grouping of the processes involved in the construction of a retail commercial building procure through form of partnering agreement between the client and the contracting organisation. These four main groups are:

- Inception/feasibility process (A1);
- Concept/scheme design process (A2);
- Production/detail design process (A3); and
- Construction process (A4).

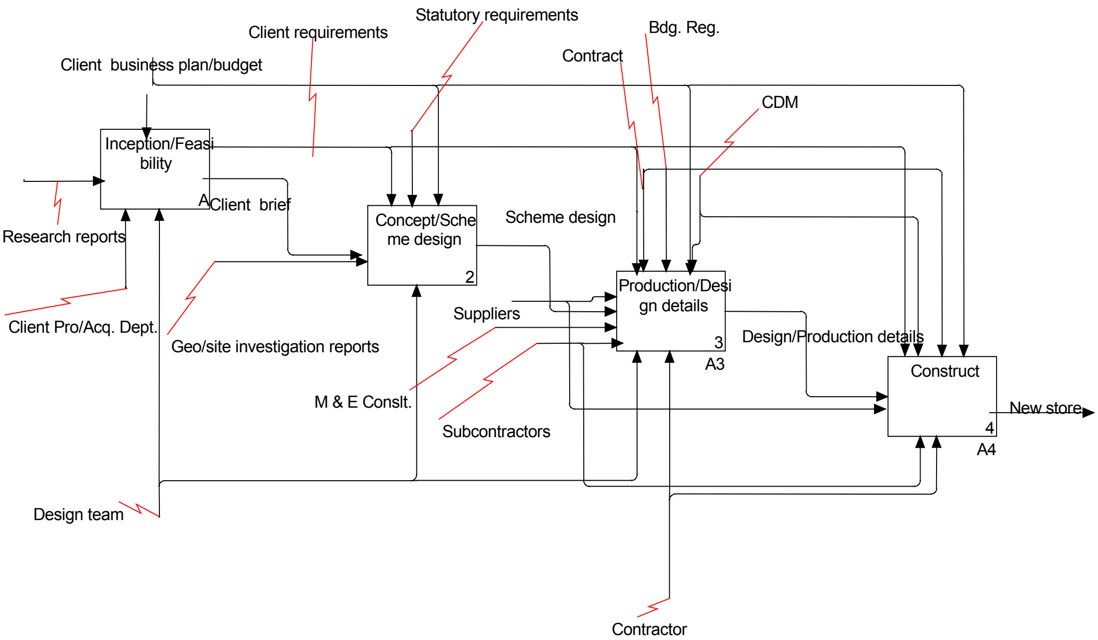

Figure 1: The generic process model

Inception/feasibility (1) consists of activities carried out within client's Acquisition/property department that identified the needs for expansion of existing store or new store leading to the appointment of the project team. The main input into this process is the market research Study. The study, identify opportunities and need for expansion or new store in particular location and produce a report upon which decisions for development or of a new store or expansion of an existing store are be based. The report will often contain information such as, forecast of the consumer needs in the proposed location, profit forecast, and other marketing and investment information. Constrains of this process are the client's overall business plan and available budget for new development. The output is the brief consisting of the statement of needs and requirements for the specific store building use of space and quality standards. This, consequently, led to development of the client brief and the appointment of the client's consulting team. The decisions such as the size of the building would be based on the location and forecasts of consumer needs and profit forecast, constrained by the client's budget and business plan.

Concept/scheme design (2) comprises of functions that define and communicate the client's needs and requirements to the contractor. The consulting team employed by the client carries out the activities involved in this process. The team produces sets of design and cost information for approval by the client. Other inputs are geological and feasibility study reports. The client approval and its company standard specifications document, statutory requirements, building regulation and codes are the process constraints. The scheme design and specification information produces will form the inputs into the next process.

Production/Detail design process (3) consists of all functional activities required to produce the construction plan. These activities translate the client's information into executable plan and construction documents that would allow the construction of the building to required standard and specification. The process is managed by the contracting organisation with authority to retained the design team or appoint another to produce the working drawings. The design activities will involves the whole of design team (architect, structural engineer, M & E engineer, etc) with contracting organisation responsible for cost estimating, detail construction planning, and overall management of the whole process. The supplier/manufacturers and subcontractors also provide inputs into this process. The client's approvals and constrains such as contracts, design changes, and CDM (Construction Design Management) regulation are the control inputs.

Construct process (4) is the actual construction of the building. The activities of this process would include the site activities relating to the construction of the building, from site preparation to completion and hand over of the building. The inputs are the detail working drawings and specifications, cost and construction planning, and detail method plan information from the last process. Other resources such as material, labour, subcontractors/suppliers would also form inputs into the process. The completed building will be the output of the process.

The “production/detail design” and “construct” processes that are responsibilities of the contractor define the boundaries of this report. The detailed mapping and definitions of sub-processes of these two main processes are described in the next section.

2.3 Validation of the model

The mapped and developed models are checked and validated for errors and omissions by the interviewees. The validation exercise focused on determining whether the mapping and grouping of the functions and the models were correct, checking flows in the models for errors and omissions. This procedure was applied at each stage of the mapping and modelling phase. The feedback indicates the team high confidence in the validity of the final models.

3. PRODUCTION PLANNING PROCESSES (site activities)

This consists of four sub-processes (A31-A35) encompasses all functions required to realise the client's needs and methods to achieve these. These functional activities translate client's scheme designs and specifications into detailed drawings, cost and execution plans. Major constrains are the client's requirements and budget, contract, building regulations and CDM requirements. IDEF0 model of the process is shown in figure 2, and detail descriptions of the four sub-processes are given next.

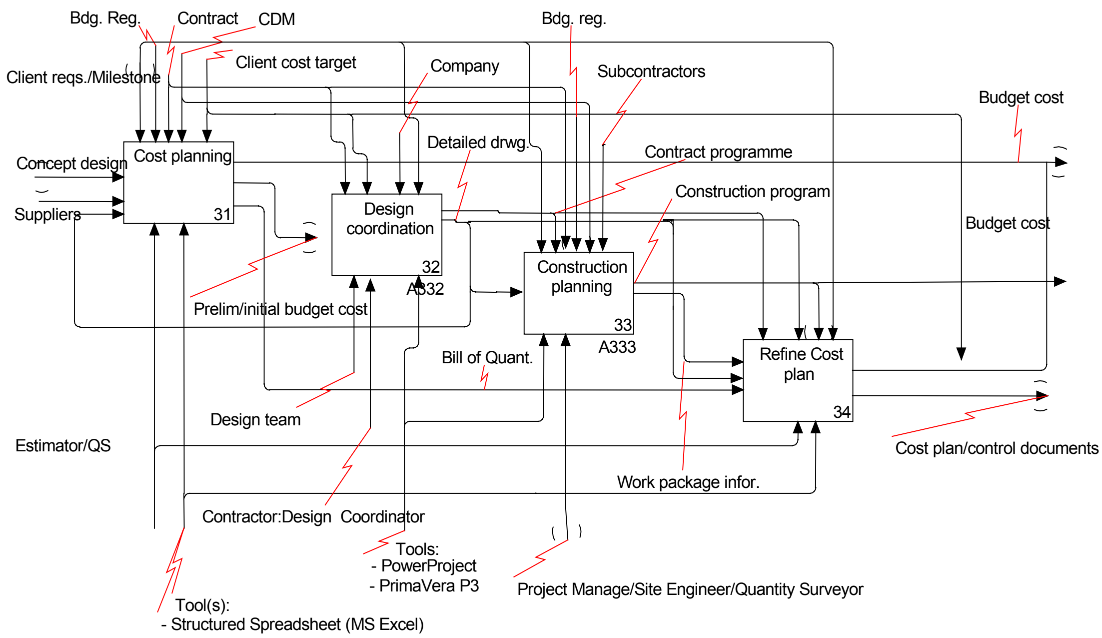

Figure. 2: Production/detail design process model

Cost planning (A31)
In this process, the estimator develops bid price and plan based on the project size, work scope initials budget and past historical data. The developed price and cost plan, along with other information, will be used to get the client approval for the project to continue. The cost plan will continue to evolve in detail and accuracy during the whole process. The whole process encompasses of four activities as shown in figure 3.

Design co-ordination (A32)
The management of detailed drawing production, values analysis, and development of contract program constitutes the activities of this process. The control imposes on these activities are clients' requirements and approval, and other external constrains. IDEF0 model of the process is shown in figure 4.

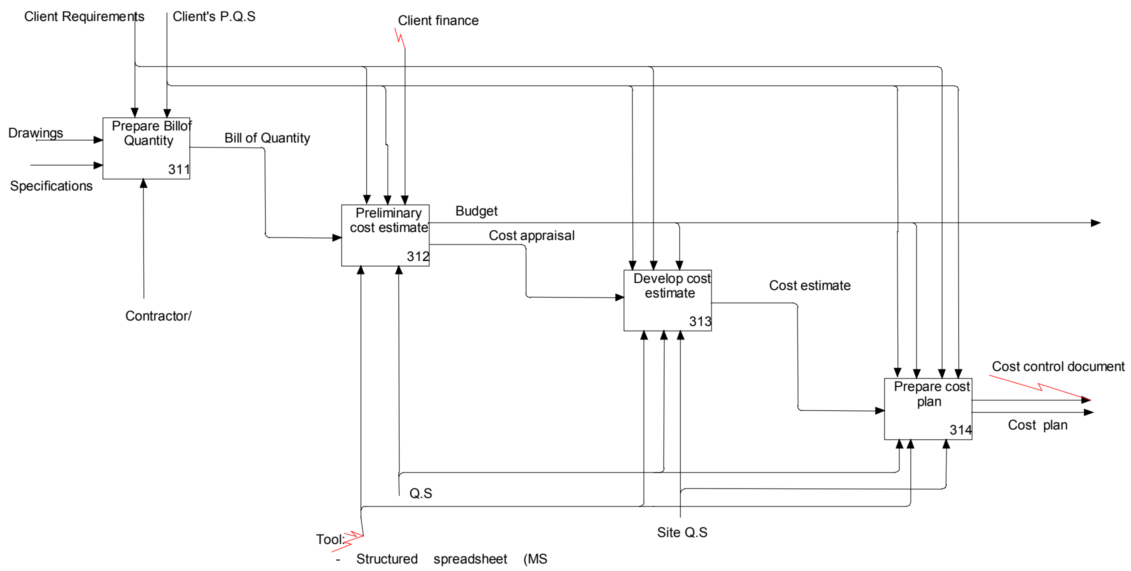

Figure 3: Cost planning model

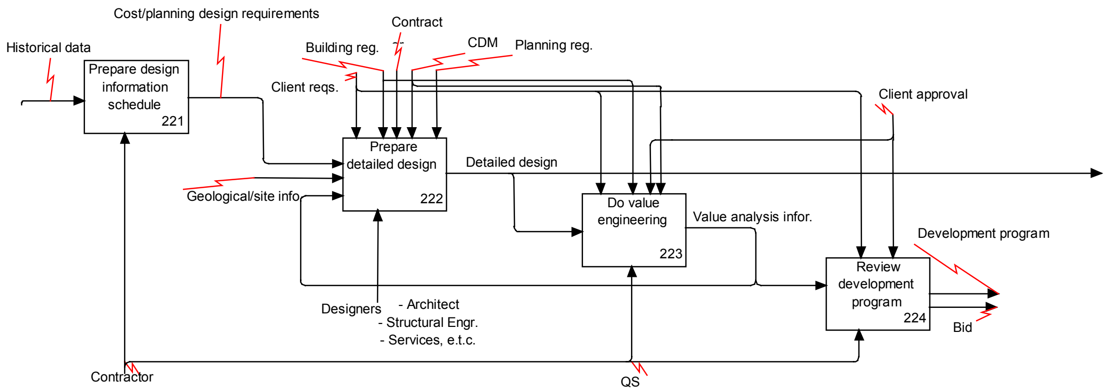

Figure 4: Design co-ordination process model

Construction planning (A33)

The construction planning function consists of four sub functional activities, as defined below. The primary output is the construction execution programs, which establishes the strategies for organising the construction activities and resources. The execution program comprises of the procurement schedule, subcontract plans, and project execution plan. Figure 5 below presents the model of this function with flow details.

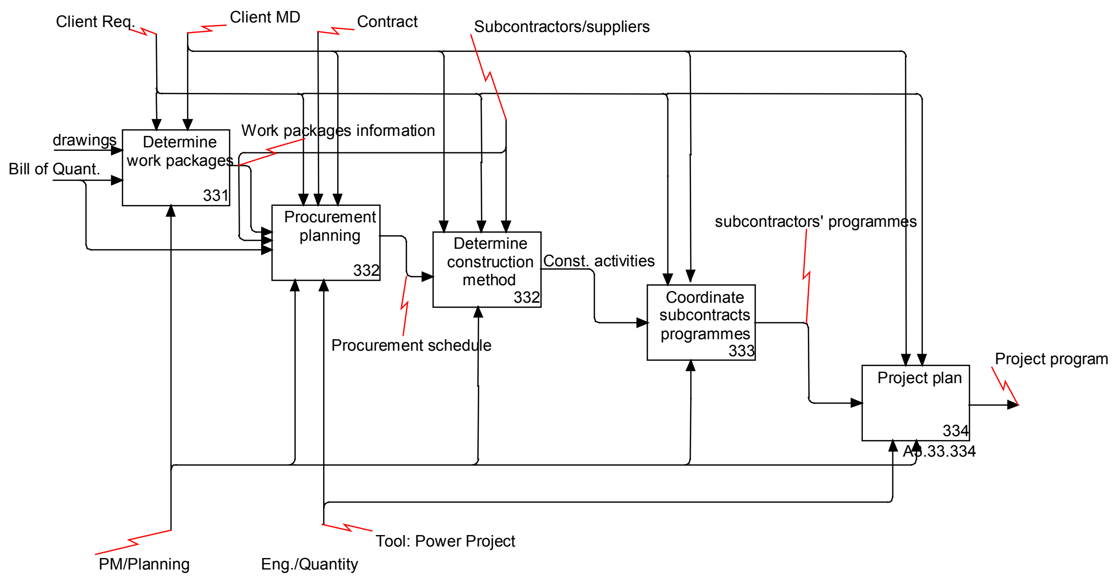

Figure 5: Construction planning process

A331 Determine work packages

The project work packages are identified with the scope of works involved. The outputs are the defined work packages with detailed information.

A332 Procurement planning

This process involved acquiring all the resources information required to plan and construct the project. Output of the process is the detailed work packages' information such as the schedule for tendering, order placement, and the lead-time for the work packages activities. The composition of this process is shown below in Figure 5. Activities of this sub-process included:

- *A3321 Identify subcontractors/suppliers*

  Based on the information from A331 and the applicable constraints, the potential subcontractors and suppliers for the work packages are identified.

- *A3322 Prepare work packages & tender document detail information*

  The functional requirements and scope of the work packages are defined. Based on the work packages, the tender documents are prepared and send out to the selected subcontractors and suppliers for bidding for the works, and quotes for materials or components.

- *A3324 Review offers*

  Offers from the subcontractors and quotes from suppliers are evaluated and reviewed.

- *A345 Determine lead-time and programme*

From the accepted offers, the lead-time and duration for the subcontract works or materials supplies are elicited and feed back into A33 (Construction planning process).

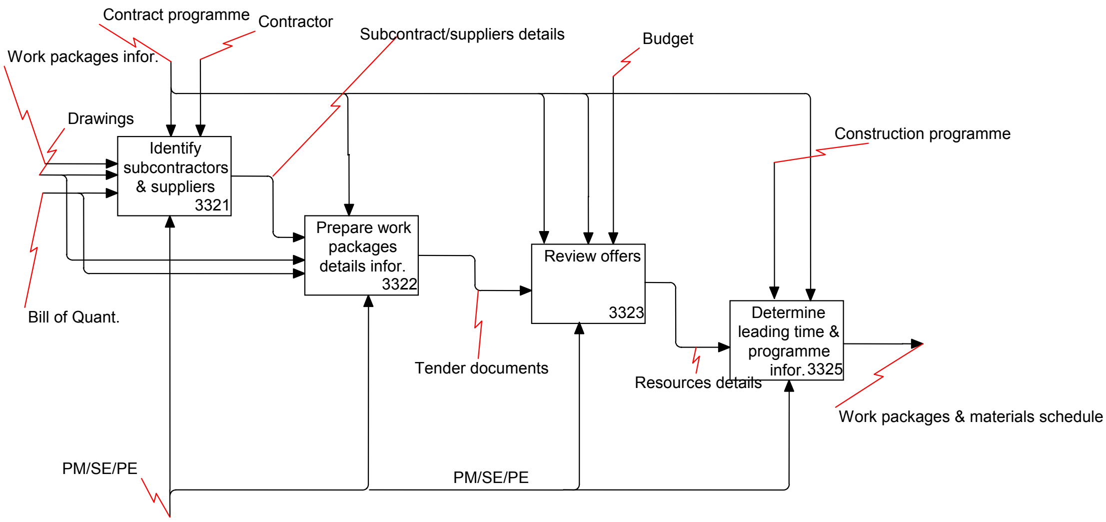

Figure. 6: Procurement planning model

4. CONSTRUCT FACILITY PROCESS

The final process is the actual construction of the building. The activities of this process would include the site activities relating to the construction of the building, from site preparation to completion and hand over of the building. The process is broken down into five functions as shown in figure 7 below. Each is explained as follows:

Resources procurement (A41) In this function, the required resource are physically mobilised on site to their appropriate work areas in accordance with project program and procurement schedule.

Site planning and progress (A42) detailed site plan of the works are developed based on the project program. The progresses of the works are monitor and control.

Progress reporting and contract account (A43) the documented progress information is used to produce regular review and report to the office. The progress report with cost information is produce monthly or weekly, depending on the progress and stages of the project.

Cost control (A44) the cost control function consists of ordering, recording and monitor subcontract and supply works. The information is use to control cost based on the cost plan.

Measurement and valuation (A45) The activities in this function consists of measuring and valuing of works already completed for cost accounting, record and payment purposes.

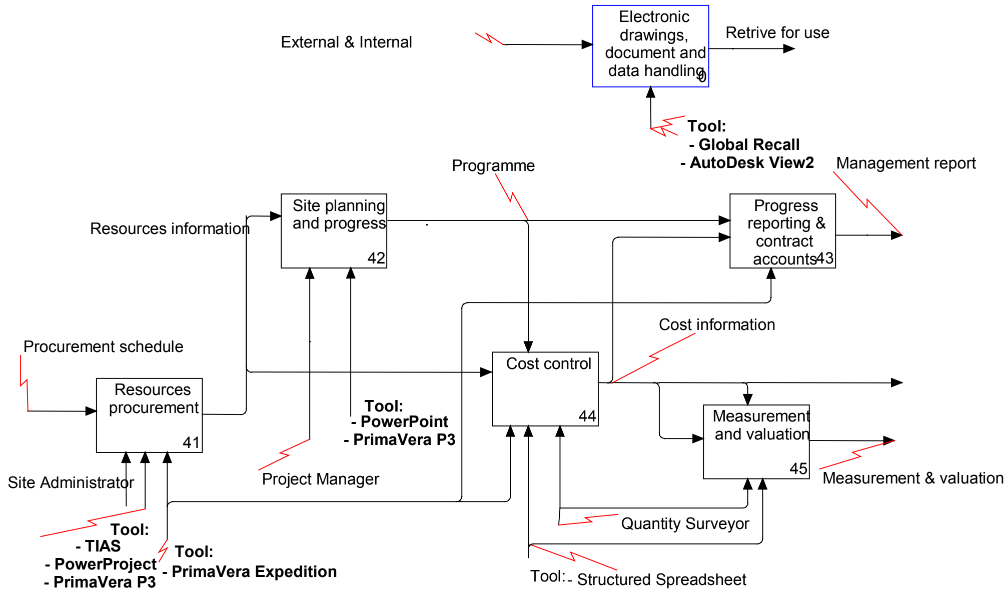

Figure. 7: Construct facility process model

5. BUSINESS PROCESSES: DISCUSSION

The whole construction process for the types of projects under study, from contractor viewpoint, consists of four core processes, from the inception to completion and hand-over of the project. Two of the core processes- 'production/detail design' and 'construct' processes define the role and responsibility of contractor in the process. The contractor main responsibility is to manage the pre-production and construction phases of the project. There are specific and important observations from the study, these are summarised as follows:

- The current construction process is different from traditional processes. The key difference is the elimination of the competitive tendering activities of the traditional approach because of the partnering agreement with the client. The process, however, is similar to management contracting in terms of the role and responsibility of the contractor in the process.

- Contrary to the general perception, IT facilities are mainly used for administrative activities (e.g. writing letter, memo, report etc.). For the core processes, such as planning and estimating, IT tools are used mainly for presentation purposes i.e. using bar chart to present schedule and progress.

- The traditional paper-based culture of information exchange within the process is still the norms. Drawings and other documents are still being issued and circulated in paper format in spite of the available IT facility that can be use to exchange these document electronically. An estimated saving of over 80%, in man-hour copying and distribution time, could be achieved if those facilities are uses.

- Adequate licensed software packages for planning and resources scheduling are available in-house but they are not fully employed to allow integration or exchange of information and data with other packages.

6. OVERVIEW OF THE PROPOSED INTEGRATED SYSTEM

Literature on construct information technology studies have suggested a number of construction process Information integrated (CPII) approaches. The one proposed in this research is based on client-server approach with centralised data repository. It consists of three main parts: the client, user interface and the server. The server contains a central repository made up of two databases: 'project specific', and 'project general' databases. 'Microsoft Access' was used for the databases designed. The project specific database stores' information that is specific to the project. For example information such as drawings, change orders information, project programme, etc. is in this database. Project general database stores information that is general to all the projects. Examples of general information are site forms and documentation, the client's standard specification for design, building regulation, health and safety regulation, etc.

The client side consists of a computer workstation, which contains construction application software, web browser and Plug-in application viewers with Internet connection. The viewer allows certain forms of data to be view by the user. An example of a viewer is the AutoDesk's 'WHIP!' Plug-in that allows drawings saved in DWG format to be open and view by the browser. The client's server will also contain application software such as the Computer Aided Drawing (CAD), project planning or cost estimating packages. The user interface, through the browser, provides the link between the two servers. The user interface is set up as a set of dynamic web pages with menus and links to the central repository databases. The interfaces, through the active menu buttons, enable the user to submit, retrieve, process, manipulate data or interrogate the databases.

Implementation of the system will be based on incremental and modular approach. This approach is adopted to support and tolerate changes in end-users' requirements and the uncertainty of the construction project needs. The advantage of this approach is that each modular solution can be developing, implemented, test and release for uses.

7. CONCLUSIONS

The construction process is highly fragmented and complex compared with any other manufacturing industries. The degree of this fragmentation has led several integrated research studies over the past four decades. The need to integrate the construction processes with information has now been widely acknowledged in the industry. It can now be realistically achieved using the evolving information technology especially the capability of web technology. The collaborative research that is reported in this paper has been exploring this possibility.

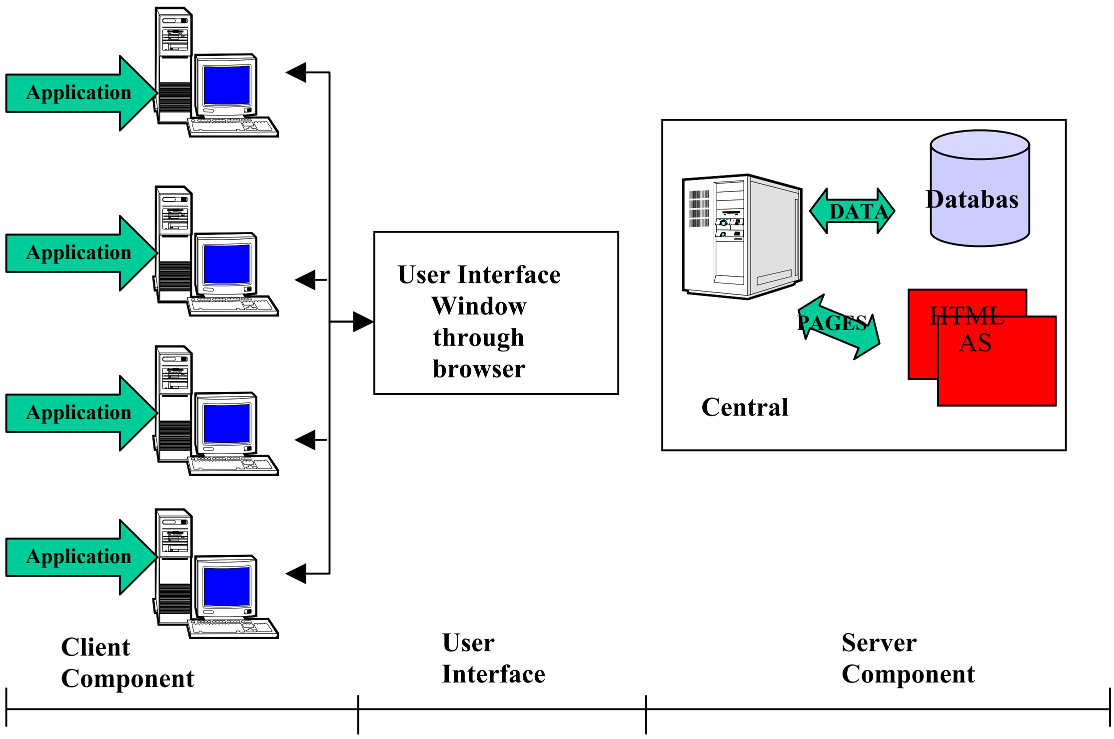

Figure 8. System architecture

The paper has described and discussed the research approach adopted to map and model the construction processes for delivering retail commercial buildings. The paper has identified and formalised the processes involved in the delivery of retail type. It has defined the functions and activities all participants involved. It has also determined and described in details these processes that define the boundaries of the contractor responsibility in the delivery of the project. The proposed process model is conceptual but provides documentation to aid in understanding which function or activity would influence a particular or related process, and how these can be related to the project as a whole. Also, the framework of the proposed IT integrated system was also described.

The next phase of the research is focusing on the development of the planning module of the system. Integration effort will be focused on developing a system that link and integrate planning and design tools together to enable information and data to be exchange between the tools through the central database.

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