EXPRESS-G MODEL AND RELATIONAL MODEL FOR INTEGRATED FEASIBILITY STUDY SYSTEM FOR BUILDING PROJECT

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ABSTRACT: At the feasibility stage of a building project, many alternatives must be generated to develop the appropriate type of building. The consideration of alternatives is time consuming and costly. In today’s competitive market, the project team are often provoked by the client to reduce the time and cost of feasibility study process. Previous studies also emphasised that feasibility study is fragmented into many tasks. Therefore, the effort must be coordinated because they should be interdependent and focused on a common goal. The client must coordinate the inputs from the fragmented project team into an automated and integrated system to support his decision-making rapidly and in a cost effective manner. Therefore, a set of models to support the integration and automation of the information of feasibility study is to be developed. The objectives of this paper are to present an information model for feasibility study using EXPRESS-G technique and an implementation model using relational model. A prototype known as Feasibility Study Tool, is developed based on the implementation model. The resulting models are derived from interviews from selected Malaysian construction industry players and literature reviews. The scope of models is limited to building projects and the viewpoint of the models is of the client. It is concluded that the models represent the best practice for feasibility study information structure in Malaysia. The overall result of the research provides basic prerequisites for the development of IT systems for feasibility study in Malaysia.

Keywords: Building Project Feasibility Study, Information Model, EXPRESS-G, Relational Model.

1. INTRODUCTION

The increased use of feasibility study in construction is a result of increasing size and complexity of projects, a need for tighter financial control and shorter construction period (Wong et al., 1999). A project feasibility study is to review a number of alternative ideas and assess the relative merits of each alternative in order to allow the client to make a decision on whether to go ahead or not with the project. Project feasibility study has two main outputs. First is the decision whether to proceed or not with the project under consideration. Second, if the decision is positive, a plan of action to guide the later phases is required. Project feasibility study is a process that needed to be carried out prior to investment decision-making.

Feasibility study is a multi-team effort. Anumba et al. (2000) identified the construction professionals and their tasks as well as the steps in the project feasibility study process. The information processing in the construction industry involves different construction professionals’ skills and interest, and requires the parties to co-operate and exchange information (Munns et al., 1994). Each of them is responsible for a portion of the project knowledge and the analysis and the software tools used are dissimilar in several ways (Luiten et al., 1993). These have resulted in the fragmentation of the feasibility study process (Howard et al., 1989) and contribute to the poor overall productivity improvement (Froese et al., 1997).

Currently, methods for information processing during feasibility study are often manual. Each construction professional prepares report or drawings that which will be forwarded to others for information or review. The documents are then manually interpreted by the construction professionals to identify the key that will influence their analysis. Brandon and Betts (1995) reveal the involvement of many construction professionals and the usage of manual processing would lead to an increase in time waiting for other professionals’ information or results. In addition, problem of inconsistency due to missing or erroneous data or incomplete analysis and evaluation may occur. Using inconsistent basis for evaluation can lead to poor decision-making (Kartam, 1994).

Numerous independent decision support systems for the construction professionals involved in the project feasibility study had been used. However, the process is still a time consuming and costly effort (Divita et al., 1998). The systems have created “islands of automation” and are far from achieving an acceptable level of integration across disciplines. Therefore, project feasibility study is often inconsistent from project to project and from construction consultant to construction consultant. In reality, feasibility study process involves many dependencies. Each construction professional requires results from others’ work to perform their own. Thus, the result of feasibility study is a large body of construction information produced by many sources at many level of abstraction and details.

At the feasibility stage of a building project, many alternatives must be generated to develop the appropriate type of building. The consideration of alternatives is time consuming and costly. In today’s competitive market, the project team are often provoked by the client to reduce the time and cost of feasibility study process. Previous studies also emphasised that while feasibility study is fragmented into many tasks, the effort must be coordinated because they should be interdependent and focused on a common goal. Therefore, the client must coordinate the inputs from the fragmented construction professional into an automated and integrated system to support his decision-making rapidly and cost effective by increasing data sharing, reducing time requirements and errors for data input and output,
accelerating communication among participants, and improving the completeness of information received by each team member (Fischer and Froese, 1992).

Today, effective integration between different participants in the construction processes requires the continuous and interdisciplinary sharing of project goals, data, and knowledge among all construction professionals (Fischer and Froese, 1992). However, the complexity and the vast amounts of information involved in any project feasibility study and the lack of standard has made the task of producing an integrated system very difficult (Sanvido, 1992). 

The objectives of this paper are to present an information model for feasibility study using EXPRESS-G technique and an implementation model using relational model. The development of the models will be a critical step for understanding and improving the project feasibility study performance and is a logical precursor to integration and automation. A prototype known as Feasibility Study Tool is developed based on the implementation model.

2. EXPRESS-G MODEL

An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. An information model can provide a sharable, stable, and organized structure of information requirements for the domain context (Lee, 1999). The need to define information models has led to the development of semantic information modelling techniques. An important benefit of having a fully developed, semantic information model is that the model can be used to define various applications and build sharable databases. Information modelling techniques provide a way to develop specifications for shared databases. The project feasibility study information model has been developed using EXPRESS-G graphical representation tool based on EXPRESS, an object-flavoured information modelling technique. (Schenck and Wilson, 1994).

EXPRESS-G diagrams are an aid for understanding large information models. The diagrams show relationships and structure more clearly than the plain EXPRESS text. The EXPRESS information models within STEP application protocols can become quite complex. EXPRESS-G diagrams help to master this complexity. EXPRESS-G is easy to understand. It was designed for domain experts and non-modelling specialists rather than computer experts (Wilson, 1998). The EXPRESS-G notations are described in detail in Annex D in STEP Part 11 (ISO, 1994c). According to the ISO document, EXPRESS-G describes graphically the EXPRESS language with three conventions, i.e. definition, relationship and composition.

EXPRESS-G had been successfully used in STEP and in many Computer Integrated Construction (CIC) research and development projects (Froese, 1995; Froese, 1996b). They had undergone the international standardization process, which represents significant consensus that the language meets the needs of industry (Wix, 1997).

3. THE EXPRESS-G MODELLING PROCESS

Prior to the development of the information model, the scope has to be specified. The scope of the model comprises all information related to feasibility study for building project. The relevant information is derived from literature, practices and case building information in Malaysia construction industry. Once the scope for the development of the model has been identified, all the information pertaining to the project feasibility study is gathered, organised and classified to allow for the systematic creation of the model.

The modelling process for the project feasibility study draws on the classification structure that is divided into three main elements. They are participant, process activity and component of a building project. Each element is divided into several sub-elements. The sub-elements will be further divided if necessary. The starting point for the information modelling was conducted by using the top-down approach, whereby the information was first analysed and modelled at a high level, followed by the lower levels of abstraction. In certain parts of the model, however, the different levels of abstraction need to be cross-referenced. The result is a mixture of top-down, bottom-up and middle-out strategies.

The paper adopted the approach recommended by Schenck and Wilson (1994) for the development of computer-aided feasibility study tool. The approach comprises a three-phase approach. Although the recommended approach requires progressive refinement, the actual process turned out to be iterative. These phases are:

Phase 1: basic objects
Phase 2: relationship and attributes
Phase 3: completion of constraints

3.1 Phase 1: Basic Objects

The main objective of the phase is to develop the major aspect of the items and the general structure of the model. It is important to define the scope of an information model. In this paper, the general structure covers to the development of project feasibility study model. This lays the groundwork for the later phases that are more concerned with refining the details. It is the most difficult part of developing a model. This phase attempts to identify the entities according to the attributes of entities, categorisation of entities and constraints applied to entities. One of the problems that had been encountered is to synchronise the terms that were used by literature and practice. Based on the classification structure, the basic entities defined in this model include “project”, “component”, “activity” and “participant” as in Figure 1.
Once the basic entities have been identified, the next stage involves finding and identifying their attributes. The attributes are properties of the entities. During the process, more complex ones also emerge, which may require further entities for the information model. This results in the identification of a new entity that is then added to the model. For example, “project_identification” was initially identified as an attribute of “project”. With further analysis, it was discovered that this attribute is in itself a large source of information that can be further sub-divided. This leads to the formation of the “project_identification” entity.

![Figure 1: Basic entities of feasibility study “project”](image)

The next step is to find out whether the entities can be categorised and whether there are any specialisation relationships between the entities. This involves recognising that some entities may be a special type of another entity, which will result in a supertype/subtype relationship. This normally leads to the identification of the more general entity, i.e. a more general name for the supertype, which can then be added to the model. For instance, the subtypes added to the “component” entity were “market”, “site”, “building” and “financial”. The subtypes are shown in Figure 2.

![Figure 2: Supertype/subtype relationship of “component”](image)

To facilitate with the process of understanding the model, the entities and attributes are documented by describing the intended meaning of all the constructs in the model. This is followed by the examination of the simple types to make sure that they are appropriately used. At the end of the phase, the model is reviewed to ensure that the developed entities and attribute represent all the information required for the development of the project feasibility study information system.

### 3.2 Phase 2: Relationships and Attributes

This phase is essentially refining the model developed in the first phase. This phase decide the manner in which entities are associated with each other, define any constraints on these relationships, and review and refine the categorisation structures any additional attributes. When several entities have common attributes, the concept of super-type and sub-type will be used. A super-type has these common attributes and sub-types of the super-type have their own individual attributes. A hierarchy of entities can be thus constructed.

The process of categorising the entities is repeated in this phase. The entities are categorised to identify any inheritance, subset or specialisation relationships between them. Further categorisation takes place, especially at the lower levels of detail. Throughout the phase, the categorisation structures in the model are reviewed and refined. During this phase, entities, relationships, attributes, and types are added to the model. The phase is iterated at various levels of abstractions until the model reaches the desired level of detail. The model is then reviewed to ensure that all the relevant information has been embodied. Finally, the resulting entities, attributes and relationships are documented and are shown in Figure 3.

### 3.3 Phase 3: Completion of Constraints

In order to maintain the consistency of the information model, the specification of constraints is necessary. Constraints can be divided into local and global constraints by the location where they are specified. Local constraints operate between attributes in the entities, while global constraints represent the relationships between entities or between instances of those entities. The resulting information model portrays the full representation of the information required for the development and presentation of the project feasibility study analysis tool.
4. RELATIONAL MODEL

The developed EXPRESS-G for project feasibility study describes the logical structures that are software or language independent. The EXPRESS-G model must be mapped into implementation technology before use. The implementation model chosen is the relational model.

The relational model is chosen due to many reasons. The relational model is the current database implementation standard (Ranges et al., 1997; Klein et al., 2001). The advantages of relational database are that they are the most popular and best developed of the systems to date. Relational databases have a very well-known and proven underlying mathematical theory (Codd, 1970). The relational model allows a high degree of data independence (Connolly et al., 1996). It means that application programs must not be affected by modifications to the internal data representation such as changes of file organisations, record ordering and access paths. In addition, the relational database management system (DBMS) supports Structured Query Language (SQL), which has become the formal International Standards Organisation (ISO) and the de facto standard relational language (ISO, 1987). SQL allow user to create database structure, to perform basic data management tasks such as insertion, deletion and modification, and to perform simple and complex queries to transform raw data into information, with minimal user effort and relatively easy to learn (Connolly et al., 1996).

The procedures used to map the EXPRESS-G information model into relational model are based on Rangnes et al. (1997), STEP Tools Inc. (1991), Klein et al. (2001) and Adachi (2002). An example of the resultant schemas is as follows:

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Participant (ParticipantID, Name, Title, Role, Involvement_Level, Responsibility, OrganisationID, ProjectID)
PRIMARY KEY: ParticipantID
FOREIGN KEY: OrganisationID REFERENCES Organisation
FOREIGN KEY: ProjectID REFERENCES Project
ENUM String: Involvement_Level, Responsibility
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5. FEASIBILITY ANALYSIS TOOL

The final step is to implement the relational model into a prototype. A relational database management system, Microsoft ACCESS and Visual Basic Application (VBA), are used in the development of the prototype. This is due to a number of factors. First, database plays an important role in the management of information in feasibility study
domain. Second, there is a need to develop quickly the prototype at minimal expense. Microsoft ACCESS and VBA serve the both purposes. The scope of the prototype implementation is restricted to analysis requirement for limited multi-storey residential buildings with an elevated car parking area. The prototype serves as an assistant in appraising feasible options quickly and to sufficient detail to decide a preferred solution. The prototype is called Feasibility Analysis Tool, known as FEAST. The development of FEAST followed the general procedure for developing Microsoft Access application. The Microsoft Access allows the creation, use and preservation of interrelated set of coordinated database objects. Microsoft Access database has a set of tools in Data Access Objects (DAO) that consist of tables, which in turn consist of fields. Figure 4 shows an example of one of the tables created, i.e. Site Table, with its fields and data types.

The aim of FEAST is to demonstrate the utility of the implementation of the prototype in support of the feasibility study process as an IT tool. There are several benefits of FEAST. FEAST enables consideration of many project options in a relatively short time. A user can generate a project option rapidly if adequate data is available. A user also can perform what-if situation and obtain rapid feedback. FEAST automatically creates clear design versions for each chosen site. FEAST instantiates a project model with a unique name for each design option. On each analysis, FEAST displays the design option and its relevant project data in its screen. Every data derived from FEAST analysis shares a common database structure. Therefore, there will be a consistent basis for creating and comparing project options. By using the prototype, future instances of data can be accumulated and stored progressively into the system. This can lead to knowledge asset management of the client organisation for project feasibility study.

![Figure 4: Site Table](image)

6. CONCLUSION

This paper has shown that the project feasibility study entities and their constraints can be structured using EXPRESS-G model. The EXPRESS-G has been shown to be a good tool for capturing the underlying details of project feasibility study model. The information model developed is independent of any implementation software or language and should be able to capture all various entities and constraints. However, the feasibility study EXPRESS-G model is important to support the relational model that lead to the implementation of the prototype to support the project feasibility study. The mapping procedures provide a necessary link to prototype design prior to the implementation of the database application. The prototype would be useful to the client’s organisation serving as a tool to support project feasibility study process. It can be conclude that it is possible to capture and integrate the project feasibility study information, and model and automates them. The overall result of paper provides basic prerequisites for the development of integrated system for project feasibility study in Malaysia.
REFERENCES


