A FRAMEWORK FOR AN OPERATIONAL PROCESS BASED INTERNET COLLABORATION PLATFORM FOR INTERDISCIPLINARY BUILDING DESIGN

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To Nurul, Umayr, Munzir, Najwa, Aiman, Eizzah, Aqil and all my family and friends, who make up my life.

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ABSTRACT

Architectural firms in Malaysia have not, as yet, utilized the ICT's full potential for more productive works in design and interdisciplinary collaboration. The main objective of this thesis is to propose a framework for an operational process based internet collaboration portal (ICP) to enhance communication and collaboration between different professionals in a multi-disciplinary building design team. In the process, it was necessary to establish what the problems associated with the process of collaboration and communication are, how the internet has been and can be used to overcome these problems and how to address the problems related to the use of the internet for collaborative design communication. A normative research methodology was utilized to identify the current practices, operations and operational structure of the five case study architectural firms and how these could be improved for the purpose of design collaboration. The supporting research methods employed included principles of opinion research, empirical research, archival research and analytic research. These were justified in their roles in collecting and analyzing the data from the case study and literature research. The thrust of the research was based on the case-study of five small and medium sized architectural firms in Johor Bahru. The case studies revealed the design collaboration practices and the operational structure of the architectural firms. A TOWS analysis established the possibility of using the strengths and opportunities to overcome the threats and weaknesses in consideration of the firms' adoption of the ICP. All these enabled the formulation of a generic operational structure model for architectural firms which incorporated the ICP. Analysis of the case studies as well as literature on collaborative portal developments enabled the formulation of a conceptual framework as well as a working framework for the collaborative portal design. These became the vehicle to develop the detailed framework design which incorporated the operational procedures and the necessary links and tools to enable effective design collaboration via the use of the internet. This is the final and main output of the research. Recommended further efforts could be taken in the development of this framework to include the perspectives of the other main collaborators in the design process. The remaining stages of the Outline Plan of Work, i.e. Stages J (Mobilisation), K (Construction to Practical Completion) and L (Post Practical Completion) is another direction that could be taken as an extension of the framework. The next step is the development of the portal itself. The setting up of training facilities for the use of such a portal would be a necessary step in the incorporation of the system by architectural firms. In conclusion, this research is able to inform the industry and academia of how far the AEC industry in Malaysia has integrated ICT in their collaborative design processes. It proposes a pragmatic approach towards enabling architectural firms of different types and sizes to be more successful in implementing the ICP for interdisciplinary building design collaboration.

ABSTRAK

Firma-firma Arkitek di Malaysia masih belum menggunakan sepenuhnya potensi teknologi maklumat dan komunikasi (ICT) di dalam kerja-kerja rekabentuk, dan kolaborasi antara disiplin. Tujuan utama tesis ini adalah untuk menghasilkan rangka-kerja portal kolaborasi internet (ICP) berasaskan proses operasi yang dapat memudahkan komunikasi dan kolaborasi diantara golongan professional dari pelbagai disiplin didalam sebuah pasukan merekabentuk bangunan. Untuk tujuan ini, adalah perlu untuk mengenalpasti masaalah berkaitan proses kolaborasi dan komunikasi, bagaimana internet telah dan boleh digunakan untuk mengatasi masaalah ini dan juga masaalah penggunaan internet untuk kolaborasi dan komunikasi. Metodologi penyelidikan secara normatif digunakan untuk mengenalpasti amalan, operasi dan struktur operasi masakini didalam lima kajian kes firma arkitek, dan bagaimana ia dapat diperbaiki untuk tujuan rekabentuk secara kolaborasi. Kaedah lain yang membantu didalam penyelidikan ini termasuk penyelidikan pendapat, kajian empirikal, penyelidikan arkib dan penyelidikan analitis. Kaedah-kaedah ini berfungsi di dalam proses mengumpul dan menganalisa data dari kajian kes dan juga penyelidikan literatur. Tumpuan awal penyelidikan ini adalah terhadap lima kajian kes firma arkitek di Johor Bahru berukuran sederhana dan kecil. Kajian kes ini menunjukkan amalan kolaborasi rekabentuk firma-firma arkitek ini dan juga struktur operasi mereka. Analisis TOWS menunjukkan kemungkinan menggunakan kekuatan dan peluang sedia ada untuk mengatasi ancaman dan kelemahan dalam pertimbangan firma-firma untuk menerima penggunaan ICP. Ini semua dapat memungkinkan perumusan sebuah model struktur operasi generik untuk firma arkitek yang menggabungkan ICP. Analisis kajian kes ini dan juga kajian literatur berkaitan perkembangan portal kolaborasi memungkinkan pembentukan sebuah rangka-kerja konsep dan rangka-kerja fungsi untuk rekabentuk ICP. Ini digunakan untuk membina sebuah rangka-kerja terperinci yang menggabungkan prosedur operasi dan kaitan-kaitan yang perlu serta alatan yang membolehkan kolaborasi melalui internet yang berkesan. Ini merupakan hasil thesis yang akhir dan utama. Langkah lanjut yang boleh diambil untuk memperkembangkan rangka-kerja ini boleh mengambil kira perspektif ahli kolaborasi selain arkitek didalam proses rekabentuk. Selain dari itu ianya juga boleh dikembangkan dengan mengambil kira peringkat lain di dalam rangka perancangan kerja ia itu peringkat J (mobilisasi), K (pembinaan dan penyiapan praktikal) dan L (pasca penyiapan praktikal). Langkah seterusnya adalah untuk menyiapkan portal itu sendiri. Adalah juga penting untuk menyediakan kemudahan latihan penggunaan portal tersebut untuk memudahkan penerimaan sistem ini di kalangan firma-firma arkitek. Sebagai penutup, penyelidikan ini dapat memaklumkan kepada akademia dan juga industri setakat mana industri AEC di Malaysia telah menggunakan ICT didalam proses rekabentuk berkolaborasi. Ia mencadangkan satu pendekatan yang pragmatik kearah membolehkan firma arkitek pelbagai jenis dan saiz untuk lebih berjaya menggunakan ICP untuk kolaborasi rekabentuk bangunan antara disiplin.

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LIST OF ABBREVIATIONS

AEC	-	Architectural, Engineering and Construction
ASP	-	Application Service Provider
CAD	-	Computer Aided Design
CADCAM	-	Computer Aided Design/Computer Aided Manufacturing
CNC	-	Computer Numeric Control
CSCW	-	Computer Supported Cooperative Work
EDT	-	Electronic Data Transfer
GII	-	Global Information Infrastructure
HVAC	-	Heating, Ventilation and Air Conditioning
ICP	-	Internet Collaboration Platform
ICPIBD	-	Internet Collaboration Platform for Interdisciplinary Building Design
ICT	-	Information and Communication Technology
IFC	-	Industry Foundation Class
LAN	-	Local Area network
VRS	-	Voice Recognition Software
WAN	-	Wide Area Network
WBTCT	-	Web Based Team Collaboration Tools

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CHAPTER 1

INTRODUCTION

1.1 Background

The advent of the global community, the world-wide-web, and the extensive use of technology is the reality being faced by all in everyday life and in professional practices. For the architectural profession, this reality has been advancing since the 1960's when computers were used as problem solvers, through the 1970's with the use of Computer Aided Design and Draughting in mainframe computers and in the mid-eighties on personal computers. These eventually warranted a significant change in the way the practices were run. Since then the use of "technology" in the process of design has developed from just being a tool for production drawings in individual architectural firms to the use of computers for visual presentations, design inception, design development and visualization. More recently, the development of the internet and the world-wide-web has allowed the use of Information and Communication Technology (ICT) to facilitate the flow of information between building professionals.

> The increasing fragmentation and growing specialization in the building industry have led to a division of tasks across organizational boundaries, resulting in communication and contractual barriers to cooperation among design and

> construction participants. The designer is increasingly alienated from the actual "makers" of the building, such as specialist contractors and manufacturers, and often has to make design decisions with incomplete construction knowledge. The continuing computerization of the building industry, and the emergence of networking phenomena such as EDT, WAN and the Internet, provide a promising situation for overcoming these barriers. Examples from other industries have shown how the introduction of inter-organizational information systems improved the way organizations operate by augmenting the flow of information between the different value chains (Huang, 1997).

Huang further states that the problem of design organizations is a problem of collocating design decision rights with the relevant specific knowledge. With the technology that is available today, these specific problems can be overcome.

> Architects, civil engineers, building services engineers, quantity surveyors, construction managers, landscape architects, and interior architects are required to work with a very high level of integration during design development. There are pressures to reduce lead-time, to reduce costs, to reduce defects, to lower environmental impact, to increase client satisfaction and, in the process, to minimize errors. Simultaneously, there are pressures to adopt computer-based tools and methods - partly so as to address the above issues. The result of these pressures has been that today more professionals participate in computer supported cooperative work (CSCW). As it evolves, this emerging type of cooperation often requires new visualization and collaboration platforms.
>
> Wang & Dunston (2008)

1.2 Statement of the Problem

The traditional method of collaboration is inefficient and time consuming. The internet has the potential to overcome this problem, but it is not effectively utilized, especially in the Malaysian context. Factors that contribute to this are in relation to issues of the people working in the architectural firms who are expected to utilize the platforms, technical considerations in the adoption of new methods and technology for any organizations, the process of work that is carried out within the organization, and what are the major selection considerations if the organization were to expand the use of internet based collaborative platforms (Penland, 2002).

Collaborative processes in the AEC industry involve not only professionals that are trained in similar educational backgrounds but also differing backgrounds. As such even without the use of ICT based collaborative platforms, there are generic issues that need to be identified and established in order for any new ICT based system to function effectively as a collaboration platform. The internet has been used as a means of communication between different professionals to a limited extent. This needs to be further enhanced in order to overcome the inherent problems associated with multidisciplinary collaboration. It is necessary to identify the problems that are associated with the adoption of such a platform so that it can be duly addressed in the development process.

This research proposes a mechanism to enable, encourage as well as enhance the use of internet-based collaboration for building design from the operational aspect. This involves the development of a framework for an appropriate internet portal that achieves the intended goals of enhancing communication between the different building design professionals. It addresses the problems related to enabling and enhancing the user experience, basing it on existing generic operational processes within the organization in order to facilitate the adoption of the platform itself.

1.3 Research Questions

The thesis addressed the following research questions:

1. What are the recurring problems in collaborative design that can be addressed by the use of ICT?
2. How can the use of ICT address these problems?
3. What is the criteria and nature of the portal for the effective use of the internet in collaborative building design?

1.4 Justification/Significance of the Study

Engineering News Record estimated that the expenditure for the Architectural, Engineering and Construction (AEC) industry globally is US$3.7 trillion (Penland 2002). Projects awarded for the building industry in Malaysia amounted to about RM50 billion in 2005 with 66% coming from the private sector and 34 percent from the Government (CIDB, 2006).

Overall, in the 10th Malaysia Plan, there is an allocation of RM230 billion (Euro 52.26 billion) development fund and RM20 billion (Euro 4.54 billion) facilitation fund where out of the RM230 billion (Euro 52.26 billion), 60% or RM138 billion (Euro 31.35 billion) will be spent on physical development to be undertaken directly by the construction sector. On the other hand, the RM20 billion (Euro 4.54 billion) facilitation fund will open doors to the private sector and investments worth RM200 billion (Euro 45.44billion) is estimated to roll in which will involve the construction sector (An overview of the Malaysian Construction Sector (December 2010).

Globalisation poses a significant challenge to the AEC industry, and particularly to the Malaysian industry. The dismantling of international borders for business and the economy will mean greater opportunities for those who are prepared. Globally, the AEC industry has been significantly slow in adopting and implementing effective ICT for the various stages of design. Nonetheless all firms

need to factor in the incumbent flood of international cooperation and collaboration that is taking place and will continue to take place even more profusely. Malaysian AEC firms are significantly behind other countries such as the United States of America (USA), Great Britain, the European Union (EU), Japan, Korea and Taiwan, not only in the Research and Development (R&D) of the technology, but also in its application. In order for Malaysian companies to compete at home, let alone globally, they need to be more Information and Communication Technology (ICT) oriented. Globalisation is opening international borders and allowing AEC companies to vie for projects anywhere in the world. AEC firms in developing nations need to make use of the crucial ICT tools in order to survive in the market. As yet, most of these firms tend to limit the use of the Internet to the sending and receiving of messages and data by e-mail (Hussein 2003). Such firms need to adopt a more Information and Communication Technology (ICT) intensive approach. This research is one step towards achieving this goal. There are several factors which justify the use of ICT for Building Design Collaboration:

- Home based firms need to be competitive with foreign firms in its internal functions and external collaborative methods in vying for projects.
- Home based firms need to be prepared to collaborate with potential international firms in domestic developments
- Home based firms need to collaborate with International firms in the global market
- Home based firms need to compete with international firms in the global market

The usage of the internet as a collaboration tool in the Malaysian AEC industry is minimal. There is a need to develop a mechanism that enables the transition to the use of internet-based collaboration. This research is intended to facilitate in the introduction and effective use of internet based collaboration technology for small to large local firms involved in the building design industry. This research focussed on some of the firms involved and proposes a framework that can be adopted to ensure the effective use of the internet for the purpose of building design collaboration.

The significance of the study lies mainly within the domain of the Architectural, Engineering and Construction (AEC) industry in general and in the architectural design team specifically. These are:

1. The use of a more established and ubiquitous internet based collaboration platform can ensure that the resources available in the AEC industry as indicated above are able to drive the industry forward and specifically result in more efficient methods of collaboration that minimizes on inherent wastages in terms of time, expertise and physical resources.

2. In the design offices or design studios, the Internet based platform that is based on the framework proposed by this thesis could be used to monitor the building design project implementation from remote locations, and by various related and authorized parties, particularly the collaboration partners.

3. For the architect in practice, be it in the public or private sector, the proposed platform will be seen as a dynamic and progressive new method to collaborate and communicate with the multi-disciplinary design team members which include other professionals in the AEC industry.

1.5 Scope of the Study

The use of the internet in enhancing communication in collaborative architectural design is a relatively new area, but like most developments related to the ICT, it is developing at a phenomenal rate. Globally, research into the various aspects of its development has been conducted which includes research into the technology, hardware, software, portals and platforms as well as the management, organizational and human issues. Although the technology to implement web-based collaboration in building design is available to some extent, widespread acceptance by a majority of AEC firms is significantly limited.

This research is focussed on the development of an operational framework for the design of an internet portal that will enhance communication between the architect, civil and structural engineer, mechanical and electrical engineer, the quantity surveyor and the client during the post inception phase of the building design project prior to the tendering stage in a traditional operational based design process. The portal is to act as an interface for the various collaboration members to interact and communicate in cyberspace. This research is also based on the needs and capabilities of the Malaysian architectural firms in general, and the five case study architectural firms in particular. The scope of the research is limited to the following:

a. Wide based background study on collaborative building design using the internet.
b. Case Studies of a sampling of Architectural firms in Johor Bahru, Malaysia.
c. The Post-Inception Design Stage to the Tender Documentation Stage of the Building Design Process, related to the RIBA Outline Stages of Work.
d. A proposed framework for the design of an internet portal suited for the collaborative environment of the Malaysian Building Design Team.

1.6 Rationale for Approach

Malaysian architects like many architects world-wide do not see the need to adopt ICT integrated processes particularly in their collaborative efforts. This is mainly due to several factors as highlighted by Hussein (2003), Baldwin (2004), Abukhader et al (2004) and Tanyer (2004), among them the unawareness of the availability of internet-based collaboration platforms, and the assumption that the adoption of such processes would cause too much disruption to their existing operations. The benefits of adopting the technology are not initially apparent. The cost of adoption was thought to be not worth the returns. Many approaches to adopting IT require that the organization be reengineered from the ground up to adapt to the available technology in order to maximize benefit. Though this may be true, it is also one of the main barriers to the adoption of the technology by most architectural firms in Malaysia. Most extranet sites from Application Service Providers (ASP's) offer systems that help to manage communication via a repository

system without addressing the issues of online collaborative design. Though helpful, the applications are limited.

Therefore, this thesis proposes the framework for a collaboration system that takes into account existing contemporary operational design process. This was done based on the understanding of said process and extrapolating the design collaboration and communication that occurs at each stage of the process between each collaborator in the design team. The nature of the communicational process was identified and analyzed. This thesis proposes how each of the processes can be enhanced by the use of contemporary IT. A framework is developed based on this process in order to facilitate the transition to on-line collaboration

The identification of the criteria and characteristics for the platform is based on making the platform appealing to the majority of architectural firms which already utilize CAD and basic ICT systems. The proposed platform is intended to go beyond being merely a repository by assisting communication and visualization while providing appropriate design collaboration aids without being overly complex for the user. Contemporary generic abilities of ICT systems can be adopted to formulate a system that grows and learns over time and can benefit the end user in their current projects as well as concurrent and subsequent ones.

1.7 Aims and Objectives

The aim of this thesis is to propose a framework system for the development of an internet-based portal that will enhance communication and collaboration between different professionals in a multi-disciplinary building design team. This framework is based on problems identified and addressed in a study of building design teams headed by architects in Malaysia.

In order to do so, the following objectives were pursued:

- Establishing the problems associated with the process of collaboration and communication between architects and other building design professionals in the design team, with and without the use of the internet.
- Establishing how the internet has been and can be used to overcome the problems of communication between multidisciplinary design team members.
- Addressing the problems related to the use of the internet for collaborative design communication
- Developing a framework for an internet portal for the effective communication between different building design professionals involved in a building design project.

1.8 Research Methodology

Developing a methodology to come up with a framework for the design of an internet based collaboration platform is an important factor in this research. The identification of the nature of the envisaged platform will be based on the specific requirements of the AEC firms in Malaysia, taking into account their current practices and exposure to the ICT for AEC.

A qualitative-exploratory normative methodology is appropriate for this research in order to identify how architectural practices and collaborating professionals and their clients interact in the real world throughout specific stages of the design process. This becomes the basis by which proposals for improvements can be formulated within the scope of the usage of ICT systems. For this purpose, a qualitative assessment on a number of case studies is carried out based on actual practices of on-going projects.

The research also involved elements of the following research methods:

- Opinion research – where the researcher seeks the views, judgments or appraisals of other persons with respect to a research problem. The researcher is thus

engaged in opinion research that might involve questionnaires, opinion polls and interviews.

- Empirical research – where the researcher experience things for him/herself rather than through the mediation of others. This research involves case studies, field studies or laboratory study.
- Archival research – this is concerned with the examination of recorded facts such as original documents or official files or records, or published data gathered by other investigators.
- Analytic research – this research relies on the use of internal logic on the part of the researcher. The researcher has the resources required for solving the problem within himself and no explicit reference to external sources is necessary.

The analysis of the data acquired was translated into conceptual models of current practices. This was compared to current generic models that suggest where ICT can be implemented in the collaborative process. Based on these and the Literature Review on relevant subject matters, a conceptual framework was developed that proposed a method by which architectural firms in Malaysia can adopt a more integrative approach to the use of ICT in the process of collaborative design. The conceptual framework was developed into a more detailed framework that traced the possible communicational linkages that occured between the relevant parties in the collaboration team.

1.9 Thesis Structure

This thesis is presented in 6 Chapters which includes the following:

- Introduction
- Literature Review
- Research Methodology
- Analysis and Findings
- Results and Discussions
- Conclusions.

Chapter 1 is the Introduction which was elaborated above and included an elaborate discussion on the problem areas related to the use of ICT for interdisciplinary design collaboration especially in Malaysia. Three main research questions that need probing were identified in relation to the problems that exist in current AEC collaborative design that can be addressed by the use of ICT; how ICT can mitigate these problems and what would be the nature and character of the platform that can be used to facilitate collaboration. The justifications and significance of the research is discussed in relation to the need for efficient and effective methods of collaboration, the need for ICT to be the main instigator and the need for architectural practices and other building design professionals to adopt an ICT based approach to collaboration.. The scope of the research is determined in this chapter as covering a generic background study on the use of internet in collaborative building design, case study of architectural firms in Johor Bahru, the design stages covered by the framework and the design of the framework itself.

Chapter 2 discusses the literature review covered during the research as part of the initial background studies as well as for the formation of the conceptual framework of the thesis. These include studies in the areas of organizational structure, the use of computers in architectural firms, building design as a process, the operational perspective of the design process, the use of ICT in architectural practices, the collaborative process in architectural design, internet-based collaboration, generic issues for adopting ICT based collaboration, enabling technologies and barriers to the implementation of ICT based collaboration.

Chapter 3 presents the detailed methodology of the research. It contains the method of acquiring the data for analysis and analysing the data leading to the outline of the development of the Framework for An Operational Process Based Internet Collaboration Platform for Interdisciplinary Building Design. This chapter determines the use of the normative research methodology as the overarching methodology of the thesis research. It specifies the research methods utilised for each stage of the whole research process, including the peripheral studies and case studies. The stages of the research are presented from the background stage, the development of concepts and theories, the establishment of the functions of the proposed framework, and its possible applications. This chapter also clarifies the research

procedures undertaken for each stage of the research and the instruments utilised including questionnaires and interviews as well as observational instruments such as the Design Process Communication Mapping Matrix. The conceptual framework, working framework and detailed framework for the building design collaboration portal is also introduced, as are the case study architectural firms.

Chapter 4 presents an analysis of the findings from this study. The findings are presented and analyzed within the context of the research objectives. There are two main sections of the analysis that is geared towards the design of the Internet Collaboration Platform (ICP) framework. The first section is an analysis of the general findings for generating the conceptual framework for the ICP. The second section is an analysis of the case studies that were conducted to determine the context in which the framework is to be applied and the characteristics of the framework that can be applied.

In Chapter 5 the operational structure of the architectural firm is presented with the Internet Collaboration Portal (ICP) located within it. The conceptual, generic and detail frameworks for the ICP are also established.

Chapter 6 discusses the conclusion of this research. There is a summary of each of the chapters in the thesis. There is an emphasis on the results that were obtained from the case-studies and the resultant framework design and its role in the development of an internet-based collaboration portal for building design. Following the research findings there are suggested recommendations for the next steps to be taken in the development of such a portal. Finally there is a section of concluding remarks that gives an overall conclusion to the thesis.

1.10 Summary

Chapter 1 discussed the background to the problem that lead to the problem statement and the research questions in relation to the need for the development of the framework for the Internet Collaboration Portal ICP). It further discussed the justification for the use of internet based collaboration in general and the justification for the research. The scope of the study was defined as being the design of the framework based on a number of selected architectural firms in Johor Bahru, covering a portion of the Stages of Work in the architectural practice. The rationale for the approach taken in the thesis was put forward and the aims and objectives of the research defined. Finally there was an introduction to the Normative Research Methodology as the overarching research methodology which incorporated various research methods. The structure of the thesis was also presented in this chapter.

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