FROM CAD TO IAD

A Working Model of the Internet-Based Engineering Consulting in Architecture

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Abstract. Information technology has become so powerful that what is conventionally called CAD might evolve into **iAD** (Internet Aided Design) in the near future (Zhou 2000). For Internet applications in the AEC industry, most of the efforts and success have been concentrated on project management and collaboration, while in the design and engineering consulting area, limited progress has been made. During the period of Internet development, the nature of the fragmentation of the AEC industry has not been changed. Based on previous research of surveys of development of Internet applications in the AEC industry (Zhou 2001), and the study of information technology both available today and in the near future, we propose a general abstracted model of an Internet-based consulting system by integrating a variety of disciplines and functions of design and construction processes. This model will cover a range of design phases, such as, information gathering, automatic remote consultation, specific problem solving, and collaboration. Finally, in future follow up research, we will apply the proposed model to steel construction in architectural design, and develop a prototype simulation by selecting one type of structural system.

1. Concepts and Philosophy

Our initial research defined the scope, process and activities of engineering consulting in architecture. On analysing the deficiency of the conventional processes of engineering consulting in architecture, as compared to

conventional engineering consulting, we attempted to determine the potential significance of the Internet-based consulting system, and discuss three types of Internet consulting systems in terms of scale and complexity of services.

1.1 DEFINING THE ENGINEERING CONSULTING IN ARCHITECTURE

In order to better understand the entire process of engineering consulting in architecture, we need to define a series of concepts that describe it, such as, the scope, content, activities, relationship among the processes, partners and contents. Figure 1 shows the overall organization of engineering consulting in architecture.
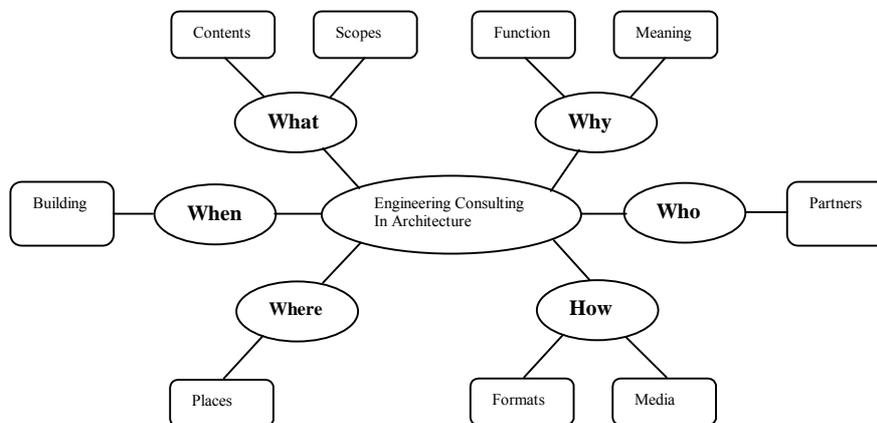

Figure 1. *Definition of engineering consulting in architecture*

A more detailed configuration of this definition is given in Table 1. In this table, we include all major aspects of engineering consulting. For participants or partners, two types are identified as primary participants and secondary participants by the roles they play in the consulting activities. For building process and scope of consulting, all are based on North American modes in general building project types, which may be partially true for the rest of the world. Social factors are very important in introducing any new technology into the AEC industry because its sophisticated social and cultural impact, such as, people's behavior, psychological influence, personal relationship, national and religious influence. "Any activity dependent for its success on a revolutionary change in people's actual attitudes towards their works was unlikely to succeed." (Laiserin 2002). There are at least two concepts that can be applied to the function and meaning of engineering consulting. One is to integrate the responsibility of

engineering issues into the entire architecture process. This is addressed because of the apparent separation of the modern building industry into different disciplines. Second, convert architectural ideas into feasible engineering solutions.

TABLE 1. Definition of engineering consulting in architecture

Participants or Partners	Primary Participants	Architects Engineers: mechanical, structural, environmental , construction	
	Secondary Participants	Owners, contractors, regulators, vendors	
Design & Building Process	Planning Conceptual design Schematic design Analysis Construction documents Shop drawing documents Construction coordination Post occupancy evaluation Building management	Scope of Consulting	Structural engineering Mechanical engineering: HVAC, Plumbing, electricity Information engineering: intelligent building, computer Networking, Communication, … Environmental engineering: acoustics, noise control, air & light quality Construction engineering Building material research Urban development
Contents of Consulting	Engineering analysis Building codes Material selection Specifications Construction advise Vendor references	Formats of Consulting	Numeric information Tabular information Calculations Text documents Physical models Drawings Audio and video
Media of Consulting	Personal meeting and discussion Calculation and analysis Electronic media for communication: email, online meeting	Places of Consulting	Architect offices Engineers offices Construction sites Cyber space

In this proposed model of an Internet-based engineering consulting system, we should consider the scattered and sophisticated nature of the AEC industry, and assemble all of the attributes as shown in Table 1, into a logical and programmable system to integrate all major disciplines.

Next, we examined the relationship among process, participants and activities in the entire design and construction period. Figure 2 shows those basic relationships horizontally and vertically. The workflow or process is the fundamental sequence linking all participants together dealing with the activities occurring in different phases. Several points in this relationship should be considered as key factors while creating an Internet-based consulting model. First, through the entire process, architects and engineers should play a leading role in the design and construction activities. They should be the primary targeted users in the new Internet model. They still play an important role and should not be neglected as secondary users. Second, in each process, there are multi-cross discipline activities occurring simultaneously. We should revolutionize the traditional work model, which

now isolates these activities based on different disciplines, such as, different computer software, different sets of documents, and different working places.
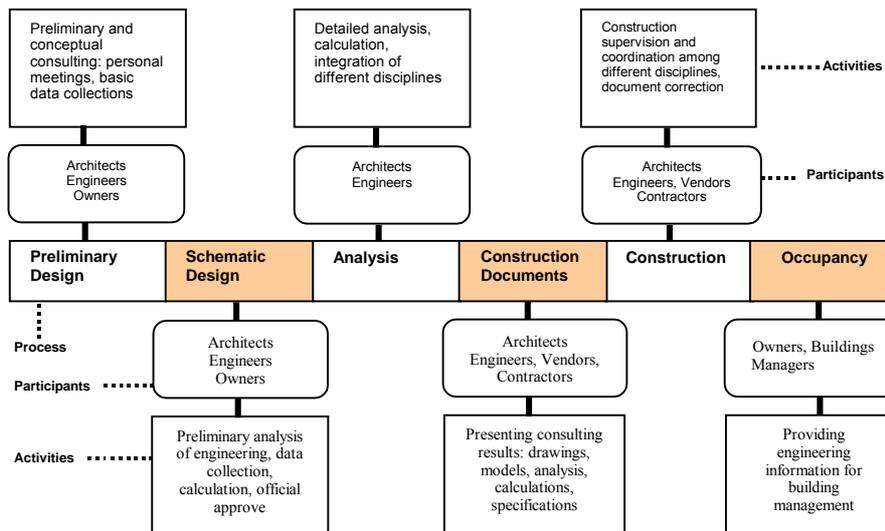

Figure 2. Relationship of process, participants and activities

1.2 COMPARISON OF CONVENTIONAL WORKING MODEL WITH THE INTERNET-BASED WORKING MODEL OF ENGINEERING CONSULTING

Listed here is a series of comparable attributes in two different working models in order to determine the potential of Internet applications in the AEC industry. For efficiency of these two models, we can see that due to the nature of the AEC industry, fragmentation and scattered components of design and construction may result in low efficiency. At the same time, in the engineering consulting process, large portion of consulting services are ordinary routine activities, but still require personal contact and case-by-case solutions, and very low automation. However, an Internet-based working model can largely improve the efficiency by integrating the scattered issues and by remote automation in solving the routine job of personal meeting and contact, and by an integrated digital work flow from design to manufacturing to construction. In the modern movement of architecture, one major direction is towards custom mass production, which follows industrialization and standardization. In this post-industrial period, people are seeking personalized life styles and customized architecture, which usually results in high cost and longer construction time. By using Internet technology, we can

dramatically reduce the cost and save time by a highly integrated digital working format. We already see this development in the manufacturing industry. "Dell computer has demonstrated that assemble-to-order is more efficient than mass production, and even more build-to-order will be more so." (Ping Fu 2002).

1.3 CATEGORIES OF INTERNET CONSULTING SYSTEMS

There can be three categories of Internet-based consulting in terms of scope and format. One is comprehensive services, including design, collaboration, management, so called "one stop shopping" like Wal-Mart, the biggest comprehensive retailer in the world. Second is categorized services, to include one or two aspects required in the AEC industry, such as project management, one discipline consultation, similar to Toys"R"Us, a major toy products store. The third is task specific, such as online printing, online library, like Tiffany and Co., a jewelry retailer.

2. Technology and Tools in the Near Future

Our proposed model is based on both current and near future information technology, part of which will be needed and applicable to the AEC industry. Three types of tools are essential in creating this working model.

2.1 UNIVERSAL INTERNET PLATFORM

An open and universal platform allows applications to communicate and share data over the Internet, regardless of operating system, device, or programming language, which ultimately will result in a seamless integration of internal and external web applications, such as what Microsoft .NET technology intends to do. In our proposed model, we need such an open Internet platform in which, various kinds of web sites, software, information and services can be linked and integrated into entity for seamless workflow.

2.2 Fully ASP

ASP (Application Services Provider) is defined as "the provider of a web based environment where applications and data are centrally stored" (Emmerik 2001). It is estimated that in next three to five years, ASPs will be the standard platform for delivery of all business applications (Unger 2001). In the proposed model, all applications are designed as ASP format, which can greatly reduce the cycle time and cost of updating software. Also, it will meet one of the requirements for the AEC industry to revolutionize the entire process by standard digital workflow from design to manufacturing to construction.

2.3 CLIENT SERVER INTERFACE MODEL

The interfaces for the model will consider to fully 4D objects, virtual reality, hand and voice input for direct and convenient interaction, following the nature and habits of what the AEC professionals used to in conventional ways. The CAD fields already evolve towards the direction of object-oriented and user-friendly working environment.

3. Proposed Working Model

3.1 GENERAL TARGETS AND UNIVERSAL PLATFORM

The Internet changes the way of work in all major phases in the AEC industry. In this proposed model, we assume that most of the activities and contact will happen in cyberspace. Figure 3 shows these relationships. Architects will play the principal rule in organizing the entire project process. To all of the participants, architects no longer have to have face-to-face contact and consult with them except with clients or owners because social and cultural affairs still need human contact between clients and representative designers, the architects. All partners can work with each other through the Internet consulting central server.
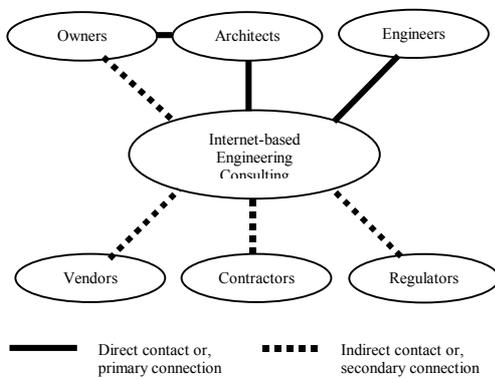

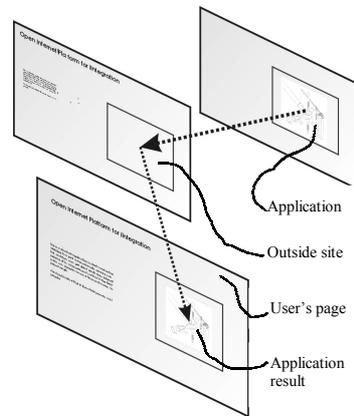Figure 3. *General model and its targets*

Figure 4. *Universal platform*

Figure 4. shows the universal platform, which connects the home server with outside resources, such as, individual project information and related applications. The results of applications either from in-house or external resources should be able to directly feed back to user's project page. For this consulting model, as design applications are the main function rather than management, or collaboration, we naturally take designers as the primary users. At the same time, as the functionality goes into the other engineering

phases, and as other partners become involved in the design, developers, contractors and vendors can also use this service.

3.2 MODEL ORGANIZATION

Some key concepts and methods have evolved in organizing the model, such as, integration of disciplines, self-cycling of process, combination of remote automatic problem solving and on-line personal interviewing, and optimisation of business models.

3.2.1 Discipline Integration and Process self-cycling

Unlike the separated conventional engineering consulting based on different disciplines, this is a self-cycling process for engineering consulting, integrating all applications from architecture, structure, mechanic system and environmental systems as displayed in Figure 5.
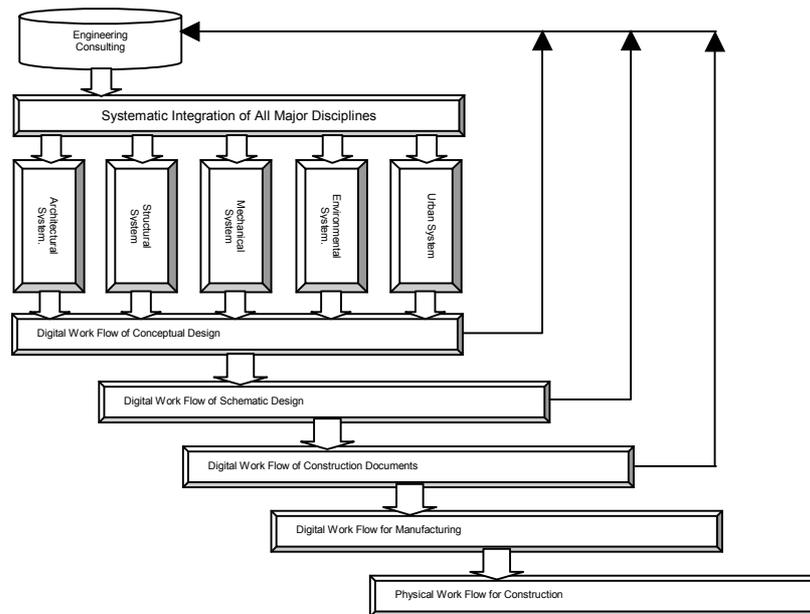

Figure 5. *Integration and cycling process*

Users login to the central server, enter their initial project parameters on an designer friendly and familiar interface, the system generates applications in each design phase, and users revise the results and progress to next design phase until the final and satisfied results reached. The result is an integrated product, containing conventional construction documents and digital work flow to manufacturing, then as physical work flow to construction.

3.2.2 Combination of Remote Automation and Customisation

The majority of engineering consulting is routine and can take place by using programmed expertise. In this model, all of these implementations are ASP based, in which, remote, automatic and instant solution can take place. For some special customized engineering issues, virtual reality tools could be used on personal expertise basis. A project-oriented approach is adopted in this model, in which, all major applications are related directly to design and construction processes. This proposed model includes information gathering, design and consulting applications, procurement, project management, and on-line collaboration.

3.2.3 Consideration on Marketing and Business Models

Profitability is a key issue for all web vendors to survive. However the fact is that most of the contemporary vendors are not profitable, as we have seen the Internet bubble burst in recent years. The fundamental reason is the lack of mature integrating service for the AEC industry, and still low use of Internet technology. As this model is intended to be an integration of the entire building process with engineering consulting and design services as the core, there are number of methods to generate revenues, such as, subscription based application services, project based services, commission based third party services, and finally technology licensing.

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