FROM CAD TO iAD

A Prototype Simulation of the Internet-based Steel Construction Consulting for Architects

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Abstract. Information technology has become so powerful and interactive that what is conventionally called CAD might evolve into iAD (Internet Aided Design). For Internet applications in the AEC (Architecture, Engineering and Construction) industry, most of the efforts and applications have been concentrated on project management and collaboration, while in the area of design and engineering consulting, limited progress has been made. Even with some of this success, contemporary development has not changed the nature of the fragmentation of the AEC industry. Based on previous research surveys (Zhou & Krawczyk 2001) of the development of Internet applications in the AEC industry and the proposal of a conceptual model of Internet-based engineering consulting in architecture, this research will apply these theories and concepts into a specified area of steel construction consulting for architects. The first phase of this research will define the content and scope of steel construction consulting and the potential Internet application. Second, a proposed solid working model is developed covering organizational structure, user network, services provided and technology. In the third phase (as this paper presented), a prototype simulation is used to apply the concepts and methodology in a preliminary design application to demonstrate how this Internet-based consulting model would work.

1. Web Organization

Internet technology has been becoming more practical and feasible in applying into all major industries (Abdelmawla 2002). To show how this model works by using the new Internet features, a prototype simulation is developed by using structural consulting in the conceptual design phase as a simplified application of the entire system. Web Service (Vaughan 2002) technology will provide a basic platform. Figure 1 shows the web organization of this prototype simulation.

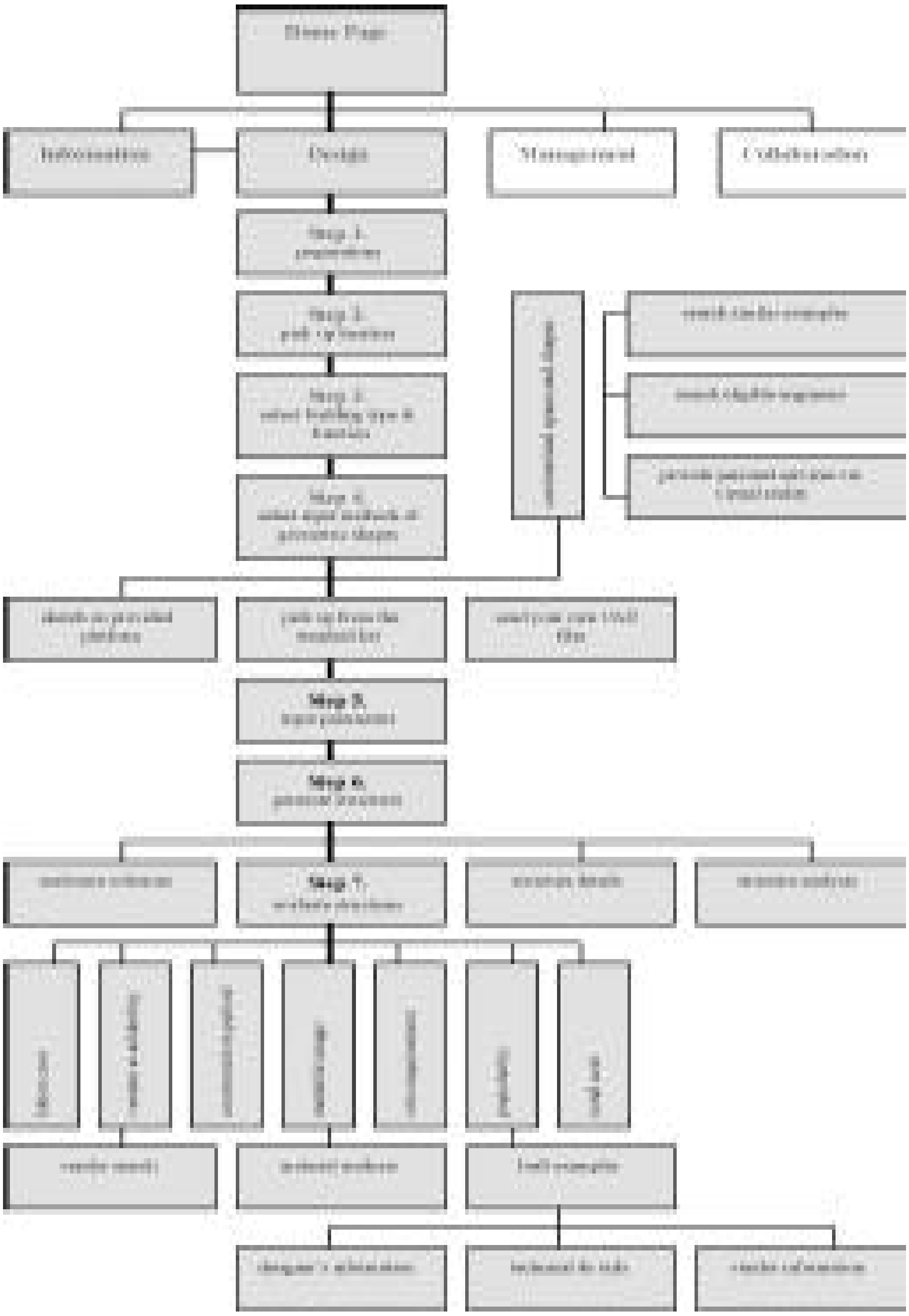

Figure 1. Web Organization of the Prototype Simulation

The home page has four main categories: Information, Design, Collaboration and Management. In this prototype simulation, only the design consulting will be implemented along with the related information contents. Future research will propose in the last chapter that the collaboration and project management of steel construction will be integrated into a complete comprehensive system. If there is a need at each step of the consulting there could be a feedback from the designer's previous step.

A series of new concepts and methods are presented to show how Internet based consulting could be implemented. At each step of this consulting there is a web page showing the procedure and result along with some explanation of how it is accomplished. Some of the applications are not possible with today's technology and the detailed issues are discussed to show they could be resolved in the future.

There are three phases to this web-based simulation. The users must first input a series of parameters and select preconditions. The system will then generate structural systems and evaluations. The third phases produces information searching related to the user pre-selected structure.

And at any time during the consulting, the designer also can check or track their consulting sequence by clicking the records bar. There are three main functions or services in this simulation:

- First is to provide structure consulting for architects during their con ceptual design phase.
- The second is to provide architectural enclosure solutions for selected structural system.
- The third is to provide information related to the selected structural system.

In the following sections, detailed procedures will be discussed along with the theoretical analysis and explanations.

2. Interface Design

Figure 2 shows the interface design for this web-based simulation. The page has been divided into three parts. The left part is relatively static showing the major service categories of design, information, collaboration and management. In this prototype simulation, only run the design service will be demonstrated. To the right at the top of the page is a sub category of the left area. For example, when the user clicks a design button on the left area, a number of procedure buttons show up at the top of the page.

The main area is a standard platform for the balance of the page on which both in-house applications and third party or external resources are provided.

This is the most dynamic and interactive portion of the page. As the content and web sites change in this area, or an external website is introduced, the other two areas will remain static and unchanged. In this way, users can never lose their home site while running either in-house or outside applications.

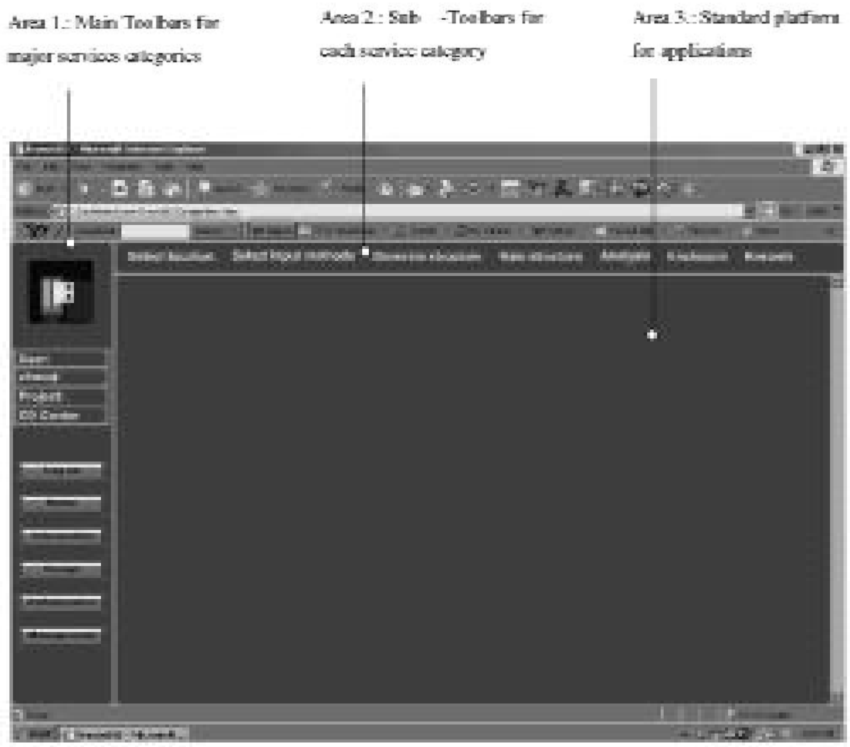

Figure 2. Interface Design

3. Pre-conditions and Parameter Input

First initiative of this design consultation in structural systems is for designer to select a number of project conditions and input a series of parameters as basic pre-analysis data for the further generation of structural systems.

3.1 PROJECT LOCATION

The Project location tells the system to search for physical conditions and building codes and official regulations for this specified project. After the designer selects the project location, the system will search for information from database and external Internet web sites. The information search process and database organization are shown in figure 3.

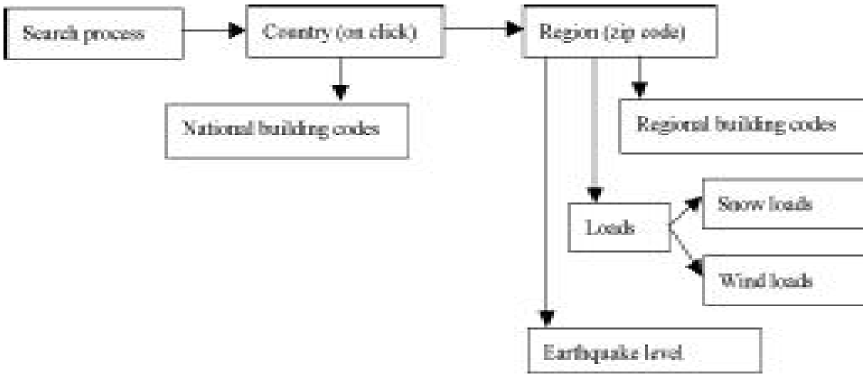

Figure 3. Information Search Process on Project Location

3.2 STRUCTURE AND BUILDING TYPES

There is an order for these two selections. The first step is to select the structural type, and then select the building type based on the structural system because for certain type of structural systems, there are few building types that are appropriate for the structure.

There is a basic question of how to comprehensively include and organize all possible structural types and related building types. In this system, the idea is to separate the two kinds of project types. One is for normal, or conventional projects, which can be considerate as standard types with deep knowledge base of experience. The other is a highly customized project. In this consulting system, we take these two types of projects have completely different consulting solutions. For the conventional project, there are certain rules and methods to organize both structural types and related building types into a database of systematic order.

3.3 GEOMETRIC SHAPE

This is a significant parameter for collecting the project pre-conditions because the geometric shape plays a controlling role for the system to generate structural systems. This is especially important during the conceptual design phase because it is only necessary to know the rough structural configurations based on the defined limited conditions and there is no need for detailed analysis and calculations.

There are three choices to input the geometric shape. One is to sketch on a sheet-like platform which is more user-friendly and an ideal media for architects to work with during their creative brain-storming activities. As was noted before, there is lack of matured technology to really have a pen-paper interface for designers that can give them the freedom and comfort of a sketch environment.

The second choice is to select a shape from the standard geometric shape list. This is a good, simple method appropriate for conventional project types and space. For the user selecting a single long span structure, the system is able to provide most of possible shapes. In figure 4, a cluster of shapes is listed for single long span structures and the options can be expanded. In this case study, a rectangular box is selected for a simplified simulation to show how the system works.

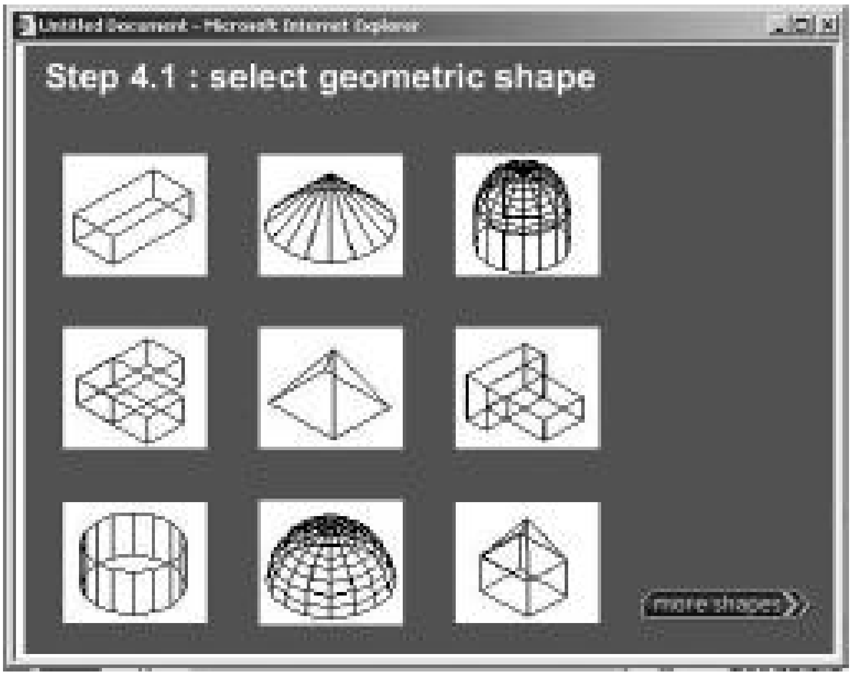

Figure 4 . Select Geometric Shapes from the Standard Shape List

The third input method is to send the user's CAD drawing directly to the system by uploading the standard CAD file, such as DWG or DXF. This is suitable for non-conventional shapes and highly customized types of projects

and spaces.
3.4 DECIDE PARAMETERS FOR THE SELECTED SHAPE

Decide parameters for the selected shape. The simplest shape of a rectangular box has been selected for further implementation. In Figure 5, the system asks the designer to input all of the decisive geometric parameters. The system is now ready to generate structural systems based on all of the pre-conditions and parameters.

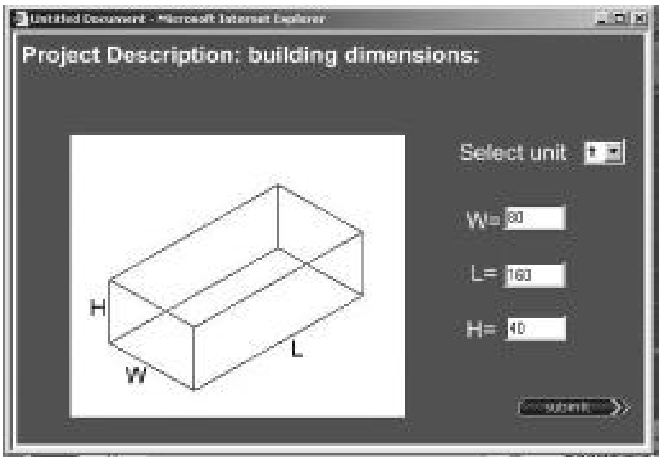

Figure 5. Input Geometric Parameters

4. Structural System Generation

For normal typical projects, there is a way to preliminarily select the structural systems based on some of the preconditions that have been identified. Figure 6 shows the basic procedures for the structural system generations.

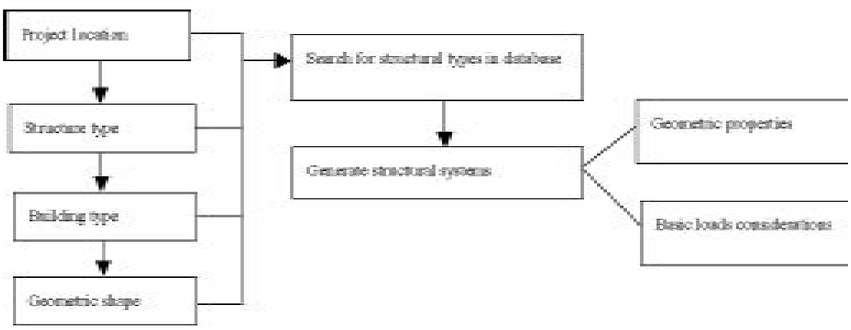

Figure 6. Procedures for Structural System Generation

Based on above information and analysis, the system searched the database, for this single story and middle span structure of normal building types. The results are shown in figure 7. Here, it is assumed that four structural systems are generated with structural dimension and components, which fit the previous criteria. These systems are: simple frame structure, space frame structure, tri-point frame structure, and curved truss structure.

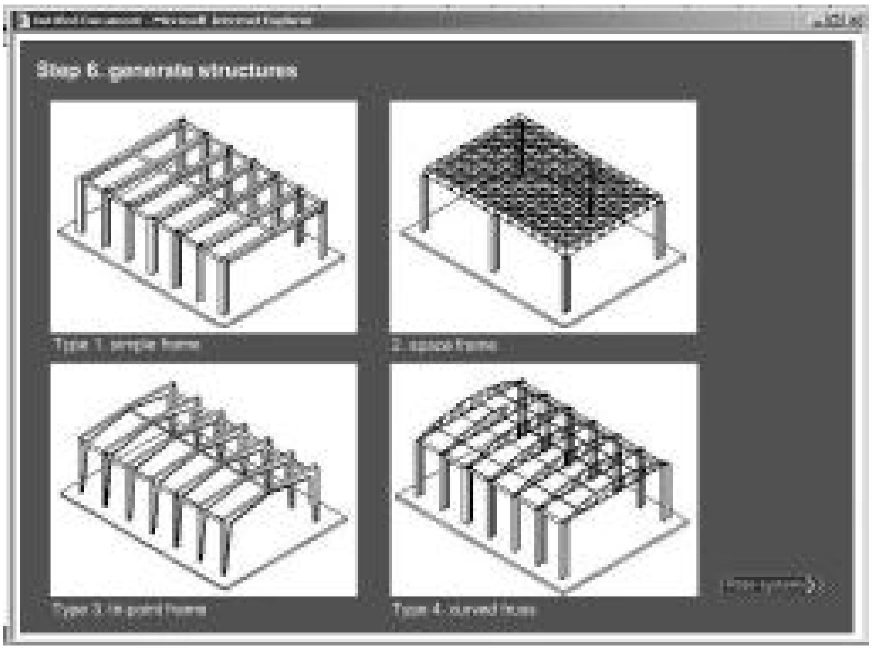

Figure 7. Generate Structural Systems

5. Evaluation of Structural Systems

After these structures are generated, the system also advises the designer on how to refine the choice and decisions by the automatic evaluation of the generated structural systems. Figure 8 is an example for middle span, single story structures evaluations. In this rate table, every factor has a hyper-link to either an in house database or outside resources to provide additional investigation if required to make preliminary decision.

In this case, four structural systems are rated by a number of factors including steel, efficiency, labor cost, construction period, site requirement, vendor availability, total cost, and finally, general use and available examples. In this table, the number, 1 is the neutral factor and all rating numbers are either larger or smaller than 1 in the comparison.

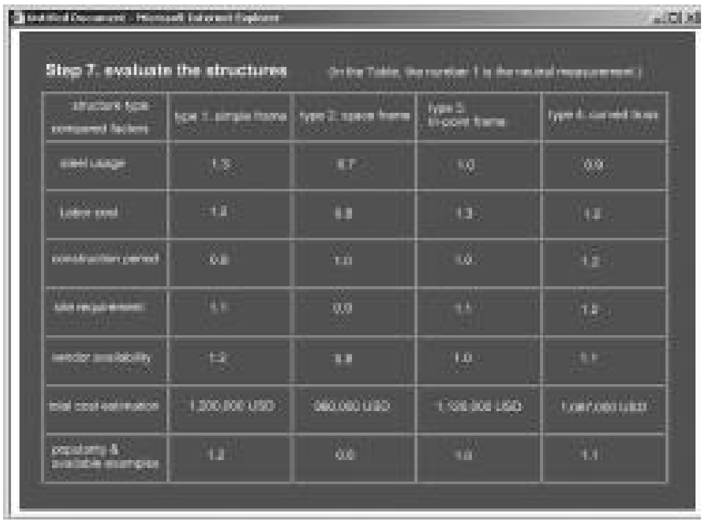

Figure 8. Structure Systems Evaluations

For example, to confirm vendor availability for the tri-point frame, the user can have detailed information available by a click its rating number. This function reflects the power of the Internet by using Web Services technology. All applications are running on the server side and unlimited information can be available throughout the world wide web but can also be tightly related to what designer needs and when and how the information is needed.

6. Information Search for Selected Structural System

In the steel construction consulting for architects, some information way play a more important role in the decision making for a structural system selection than the structural engineering data. In this simulation, two types of information search from both an internal database and external resources will be demonstrated. One is a vendor availability search and the other is built examples. Here the key issue is about the search methodology, which is different from a current text-based search engine like Google or Yahoo. Content-based search is required to achieve the consulting functions.

6.1 SEARCH FOR VENDOR AVAILABILITY

The primary consideration for a vendor search is the distance range from the project location. Figure 9 shows the process of such an inquiry and answering process. First, the system asks the designer to input their estimated range of the distance and then the system will search the database to find experienced vendors with the same criteria.

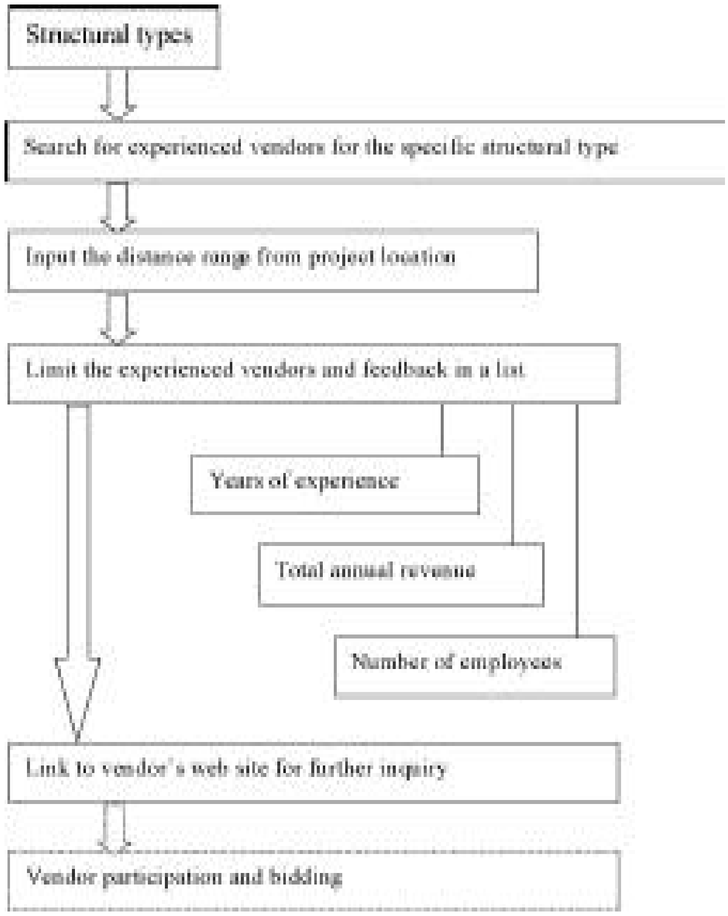

Figure 9. Vendor Search Process and Functions

6.2 SEARCH FOR BUILT EXAMPLES

Many architects are interested in finding and comparing built buildings with structures similar to what they may want to use. This is a typical practice in normal design activities. But a manual search is usually difficult and time consuming. This consulting system will also demonstrate how the Internet-based information system can efficiently identify these buildings of interest.

By selecting structural type, its scale, building function and other related factors, the system can search from the built example database to locate similar realized buildings that the designers can use as a reference to support their own decisions.

7. Highly Customized Shapes or Structures

So far only conventional steel structures that are the majority of building types in the steel construction industry have been considered. It is very difficult to have fully automatic solutions for highly customized geometric shapes and structures. However, there are some applications of Internet technology for those kinds of special projects that may be applicable. Figure 10 shows a potential consulting procedure and services.

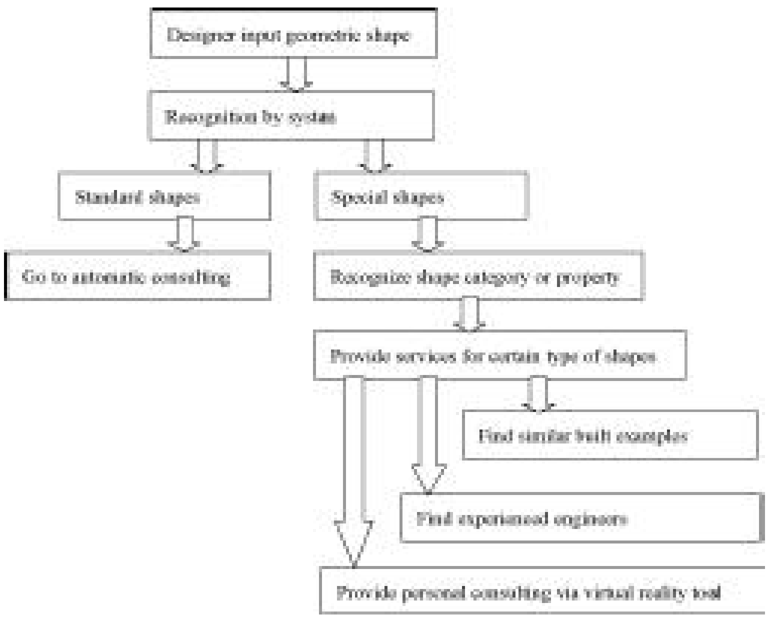

Figure 10 . Consulting Procedure for Highly Customized Shapes

8. Consulting Tracking and Recording

At any stage or moment of consulting, the system should have a functional way to track and record what has happened during the consulting activity so that designer can come back at any time even though they stopped during the consulting session. For this purpose, a tracking system by project and individual has been designed to provide a log and a record system for every project. Figure 11 shows an example of the tracking and recording result. In this tracking table, the designer can review and edit any consulting activity by a click on each content title.

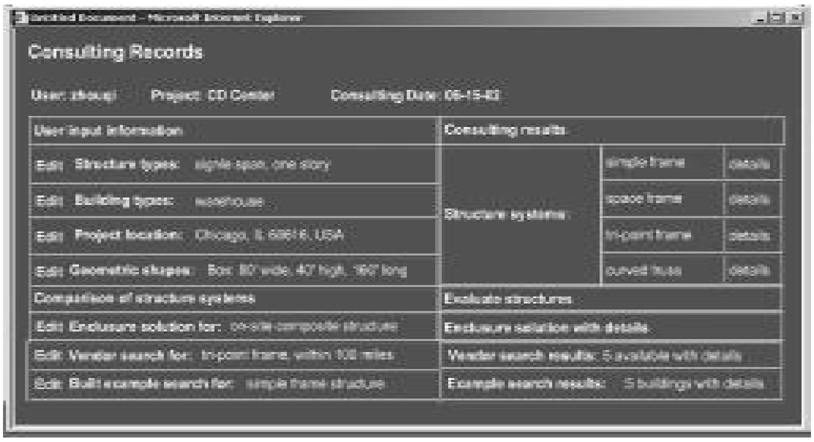

Figure 11. Consulting Tracking and Recording Table

9. Database Organization

In this proposed model, there are many database related applications including project examples, vendor information, building codes, structural systems, joints detailing, product information, and CAD libraries. Some of these databases could be established in the system as an "in-house database", but most of them are difficult to do within the system. There are two basic reasons. One problem is that it would require a tremendous effort to include data on building codes because this kind of information is dynamically changing all the time. The second reason is the legal issues. For example, drawings and photos of built examples usually have a copyright by the designers or other institutions.

It would be necessary to create an open system for integrating the external resources of database information and applications that have been reviewed in the previous chapter about web services as the ultimate future Internet platform. Figure 12 shows the conventional database structure, which is table formatted within the internal system. As the user asks for certain data, the system begins to search and query by certain roles and sends back the information to the user. This type of database can be used to create an internal information system that would include structural systems and some of the CAD libraries. However, most of the database needs a second type of data organization because of two reasons. One is that information and databases are changing all the time, and it is very difficult for an independent web server to collect the new information and update the entire database. Secondly, the information technology has demonstrated the trend of maturing gradually in making a truly web-based database exchange with seamless flowing to different platforms and systems.

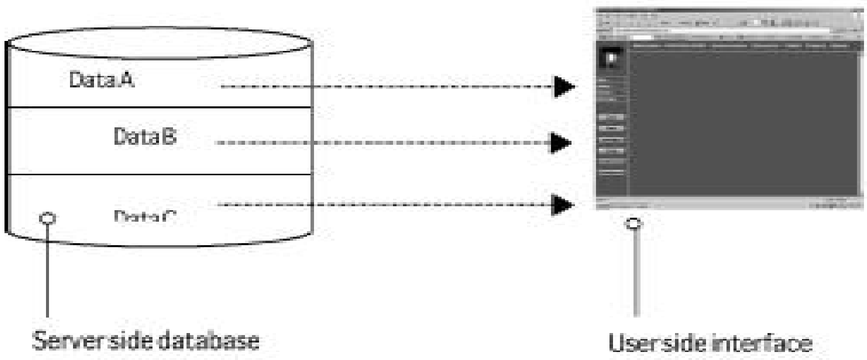

Figure 12. Internal Database Organization

Figure 13 shows the basic concept of the external database organizations. Generally, every single web server is served as an open universal platform to integrate both internal and external information systems in re-organizing and analysing scattered information for the end users.

Finally, the following conclusions represent all of the basic requirements and issues to be resolved before creating this open database systems:

- It is necessary to have an appropriate infrastructure to realize the mutual integration and exchanging of different database from different locations and different systems, such as, XML technology.
- It is more realistic for special industry to have common sharing database systems similar to the efforts of AEC-XML.

· This consulting model needs two types of database systems. One is an in-house system and the other is an external integration system. Additional research is needed to analyse what and how to make the correct choices.

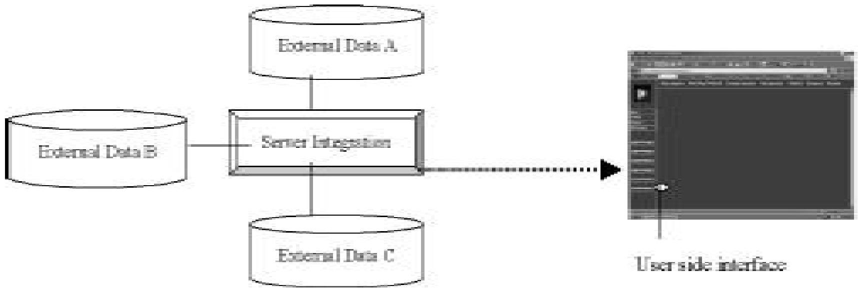

Figure 13 . External Database Organization

10. Observations and Findings

Web Services technology will become the main stream for the Internet in the near future by gradually shifting its function from a delivery tool into an integration of computing and networking. In the AEC industry, third party Internet services will provide not only information but also more reliable and sophisticated applications, which will partially replace PC based software applications, especially for engineering consulting.

It can be more effective and informative for designers to get information by introducing an online consulting tool into design process because of the unlimited access to the external resources of Internet.

Architects could be more effectively educated with an understanding of structural engineering by using a dedicated Internet application system for a specific engineering area that follows the traditional working behavior and sequence of activities.

Not only can collaboration and project management take the advantage of information technology, but design and consulting would also benefit from this new tool by transforming the entire AEC industry.

11. Future Research

Continue to review Web Services technology and its leadership applications in the manufacturing industry because they could develop the ultimate platform for computing and networking integration.

Determine more effective methods and technologies of Internet applications in design consulting to improve the creative process and reduce the routine computer functions (balance between creation and automation).

Develop further studies of steel construction technology in the entire production chain to extend this working model to the whole building process from design, to construction, to management.

Apply these theories and methods of steel construction consulting to a more specific area of a prefabricated multi-story structural steel housing system. There are a number of reasons for doing so. One is that this system would have the industrialized properties of standardization and mass production that could make a major housing contribution in developing countries like China. The second reason is that it is much easier to organize the whole production chain by using Internet technology in housing because it has comparatively simple building components and construction. The third reason is that if this comparatively simple construction can succeed, then it would be possible to transfer these lessons and apply them to Internet-based consulting and construction in more sophisticated areas.

References

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