

# Design through Information Filtering

*a search driven approach for developing a layperson's CAAD environment*

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**Key words:** Information filtering, Design knowledge encapsulation, CAAD for non-designers

**Abstract:** We propose a CAAD environment for non-designers. It is a new way to enable effective user participation during the design process. This CAAD environment contains an encapsulation of design knowledge and utilises information filtering as an interface to the design knowledge. Two prototypes are implemented as testbeds. So far, our experience has suggested that the approach has a promising future.

## 1. INTRODUCTION

Architects design by searching through some spaces of designs to find feasible solutions. Clients (usually non-designers) then search through alternative solutions (provided by architects) to identify their desired solutions. In essence, both architects and clients are solving design problems; nevertheless, the corresponding search spaces differ significantly.

Traditionally, the clients' search spaces are fairly small, which often contain five to three, or sometimes only one, solutions. For some design projects (for example, private houses), successive communications between clients and architects will allow architects to put more alternatives into clients' search spaces. Yet for many other design projects (for example, public housing), actual clients (i.e. the eventual users of these buildings) have very little chance communicating with architects and are forced to accept solutions that are not suitable for their needs.

We are interested in strengthening the communication between architects and users so that the resulting designs are tailored to user needs. User participatory design seems to be the answer, but it is very costly in terms of time and finance. Besides, to achieve effective communications between designers and non-designers (which users often are) is itself a challenging task. We suggest a new way to look at user participation: by enabling users to make a wider range of design decisions intelligently, that is, providing them a search space with rich design solutions and a mechanism to search through this space for desired solutions.

## 2. DESIGN KNOWLEDGE ENCAPSULATION

*How can "providing users a search space of designs" address the communication issue between designers and non-designers?*

Archea (1987) describes the way architects design as follows: "[t]hey seek sets of combinatorial rules that will result in an internally consistent fit between a kit of parts and the effects that are achieved when those parts are assembled in a certain way." In a way, design solutions—those parts and assemblies of parts—have captured certain design knowledge in their existence.

The encapsulated design knowledge is not the general design knowledge at all; rather it is the knowledge for a specific design project. Therefore, for a different design project, an architect should provide a different search space of designs. To construct such a search space, a systematic structure is needed. We find Habraken's (1972, 1998) *open building* concept, in particular the hierarchically refined support-infill relationship, very suitable to form the underlying structure of the search space.

Under this concept, building components (parts) are organized into a hierarchical structure according to the support-infill relationship. "Support" is a fix context (e.g. the structural frame of a building), within which "infill" (e.g. wall panel) can be attached, removed or substituted. "Infill" can become the "support" (e.g. wall panel) of its lower-level "infill" (e.g. window). Organizing design knowledge in such a hierarchical fashion accommodates the knowledge of structural design as well (Gomez, 1998).

### 3. INFORMATION FILTERING

*What technology is suitable as an interface to the encapsulated design knowledge?*

The development of *information filtering* has grown from techniques to dynamically display information relevant to a user's interest, and become an essential information technology to support knowledge management (Borghoff and Pareschi, 1998). The design knowledge encapsulated in a search space has to be presented in a way that is understood by non-designers. In addition, we believe that the complexity of design knowledge should be hidden. This means that users should see the system (the interface) as a glass box, within which the lower level component (the search space) acts as black box (Karlgren, Hook, 1994).

Given the hierarchical structure of encapsulated design knowledge, the information filtering process will begin by locating the "supports" of a particular state. From this state, users can explore variations of "infills". By interactively identify filtering criteria, the system may lead a user to specific design solutions.

### 4. WIDE

WIDE, a web-based interactive design environment, is designed based on the "search" behavior of designers and non-designers to support user participation in the development of apartment buildings (Chien and Shih, 2000). Most apartment units in Taiwan are sold before ever been built. Apartment buyers can customize their units until the construction takes place. This customization process has become a very unique form of user participation. WIDE is intended to be a CAAD environment for non-designers. By working closely with several building developers, we have analyzed the activities and information flows in the customization process (Shih and Chien, 2000). To encourage user participation, WIDE aims to provide design interactions in a controlled customization process using information filtering as the key mechanism.

WIDE takes the stand that non-designers design by searching through the space of design solutions, which are prepared by designers. From this perspective, two issues are key to the development of WIDE: first, the construction and contents of this space of design solutions, and second, the human-computer interaction to support this searching process. We propose to use a component-and-assembly database as the design space, and to adopt

information filtering (i.e., database query) as the search mechanism. However, the information filtering mechanism should be provided through a graphical interface where users can see the design result at all time. We plan to offer three levels of design interaction:

1. Apartment unit and layout arrangement selection: users can look for suitable apartment units according to their preferences, and can select different types of pre-designed layout arrangements that are suitable for a specific apartment unit and visualize the result.
2. Interior finishes/equipment selection: users can tryout different options of finishes and kitchen/bathroom equipment; and see the result of selection through computer rendered still images or virtual-reality walkthrough.
3. Advanced layout adjustment: users can customize interior layout for special needs through an intelligent design aids. For each confirmed change, the system visualizes the result in various ways to help users make their decisions.

There are two implementations of WIDE. WIDE-Kindom is the very first prototype. It is specially tailored for a specific apartment building project. The component-and-assembly database of WIDE-Kindom contains components (such as walls, rooms) and assembly tables, which record feasible component assemblies (such as alternative layout arrangements of an apartment unit). These components and assemblies are created upfront manually as well as through a set of macro commands based on design solutions by architects and modification guidelines (that allow architects' original designs to be modified to a certain extend).

WIDE-Kindom prototype implements the first two levels of design interaction: it allows users to identify suitable apartment units according to size, price, and Feng-Shui considerations and to customize selected units through various means. The results of user interaction in WIDE-Kindom are results of the information filtered through the component-and-assembly database. Figure 1 and 2 illustrate how design solutions change when a user identifies different design concerns.



Figure 1. An example of using wall finishes and floor surfaces as filters in WIDE-Kindom.



Figure 2. An example of using room combinations as filters in WIDE-Kindom.

WIDE-Roadhouse is the second prototype. It is specially tailored for roadhouses, which are typical in rural areas of Taiwan. During the 921 earthquake in 1999, many roadhouses were destroyed. WIDE-Roadhouse prototype is set up to allow users quickly evaluate possible designs for rebuilding. The component-and-assembly database of WIDE-Roadhouse is similar to that of WIDE-Kindom. The knowledge encapsulated in this prototype is a roadhouse building system with improved structural performance and constructional efficiency (see Figure 3).

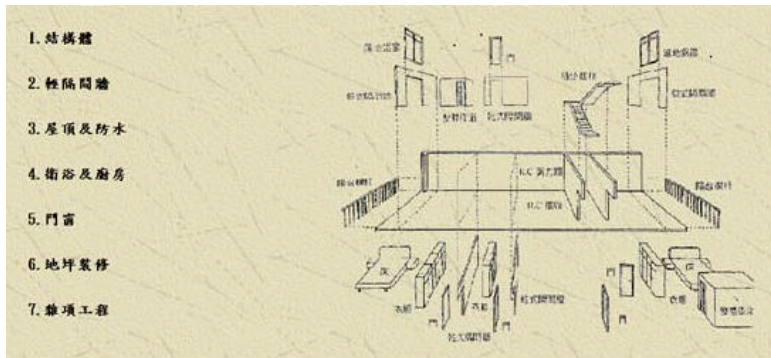


Figure 3. Components in the roadhouse building system (source: Easylines Building System Co. Ltd.).

WIDE-Roadhouse prototype implements the first and third levels of design interaction: it allows users to identify suitable roadhouse configuration according to orientation, lot size, and primary functions; and to customize selected rooms through various means. Figure 4 illustrates how a user may examine and modify the interior arrangement of selected rooms.



Figure 4. A sample of using room-function assignment as a filter in WIDE-Roadhouse.

Both WIDE-Kindom and WIDE-Roadhouse prototypes were exhibited in the "Construction and Automation 2000" exposition in Taipei. During the weeklong exposition, these prototypes were tested by visitors and received encouraging comments.

## 5. DISCUSSIONS

Compared to architects or designers, laypeople do not have design expertise, yet they need to make design decisions based on their individual needs, which may be quite different from person to person. The information filtering/search driven approach taken by WIDE provides an environment with encapsulated design knowledge (in the component-and-assembly database) and enables laypeople to make proper and reasonable design decisions. Although many do-it-yourself home design software applications (e.g., 3D Home Architect) allow laypeople to design, our approach aims to address some common limitations that are inherent in these applications.

1. design drawing as the means of communication: most of these applications assume laypeople understand design drawing (e.g., plans, elevations, sections) has use it as the primary form of communication, while we consider people should be able to design without having to understand design drawings (and in fact many people could not read design drawings) and the drawings should only be a kind of outputs produced by the design environment.
2. fixed design knowledge base: these software applications are tailored to specific types of designs (e. g., the design knowledge encapsulated in many applications is only suitable for use in North America but not for Taiwan), whereas our approach establishes a framework for design knowledge encapsulation which is not based on a particular building type nor a specific locality.
3. closed environment: these applications use proprietary data format that do not allow easy information access; our approach, however, is

based on the concept of information sharing and uses open network information exchange standards.

Our experience gained from implementing two WIDE prototypes has suggested that the information filtering/search driven approach has a promising future. The user interface designs of these two prototypes have borrowed concepts from primitive GIS systems. We plan to employ advanced information filtering mechanisms to support dynamic user interactions. Furthermore, this approach requires architects to design a family of solutions rather than one solution for a design problem. For the two prototypes, we have been working with architects who are familiar with the open building concept and specialized in architectural systems. Even after architects have designed families of solutions, however, constructing a component-and-assembly database (i.e., encoding design knowledge) is time-consuming, and will be a bottle-neck when we scale up the system. We are planning to employ generative mechanisms to create contents of the component-and-assembly database on the fly while users are interacting with the system. We hope to report the progress on these issues in the conference.

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