

# MAPMAKER: LINKING PLAYS AMONG IDEAS, CASES AND LINKS

IH-CHENG LAI

*Graduate Institute of Architecture, National Chiao Tung University, Hsinchu, Taiwan.*

*Department of Architecture, Chaoyang University of Technology, Taichung, Taiwan.*

*ihcheng@arch.nctu.edu.tw*

**Abstract.** Idea association involves a dynamic linking process among ideas, cases and the links themselves. Based on the knowledge representation issue-concept-form proposed by Oxman (1994), design ideas, cases and links are elucidated. Furthermore, various and dynamic linking plays are involved in two steps: divergent, in which alternative idea entities are linked, and convergent, in which these idea entities are selected. These linking plays provide a computational mechanism for indexing prior design cases dynamically. Finally, an index prototype for supporting the linking process of idea association, called *Mapmaker*, is proposed in this paper.

## 1. Introduction

Design is a creative behaviour that depends on the evolution of many ideas, especially in the conceptual design stage. *Idea association*, as identified by Osborn (1963), is an important behaviour for generating diverse ideas by linking the long-term memory. Furthermore, Osborn (1963) argued that there are three linking principles to associate ideas: similarity, contrast and contiguity. Each linking principle has its individual linking mechanism to connect ideas and memory. Through the three linking principles, two steps involve in the linking process of idea association: divergent in which alternative ideas are linked (Lai, 2004a), and convergent in which these ideas are selected.

In addition, idea association is a method by which one idea leads to another idea by linking prior design cases (Lai, 2004b). Thus a computational mechanism, called case-based reasoning (CBR) (Kolodner, 1993), is brought into our implementation consideration for supporting the linking process. In employing knowledge from prior designs in order to aid in current design problems, relevant design ideas may be accessed from design cases (Maher et.al, 1995). Thus, the knowledge representation of the design case plays an important role in linking relevant design ideas. The case representation issue-concept-form proposed by Oxman (1994) provides a potential method for exploring the linking relationships between ideas and cases in the conceptual design stage.

Computational mechanisms for supporting the linking process of idea association are elucidated in this research by exploring the dynamic linking relationships among ideas, cases and links. Finally, an indexing prototype called *Mapmaker* is proposed to support search and browsing of related ideas within design cases in the conceptual design stage.

## 2. Ideas, Cases and Links

Idea association involves a dynamic linking process among ideas as well as between ideas and design cases (Lai, 2004b). During a design process, designers always decompose a design into several architectural elements, and use these elements' attributes as keys to link relevant design ideas (Mitchell, 1990). Furthermore, these design ideas always originate from prior design cases (called design precedents) (Oxman, 1994).

For exploring the dynamic linking mechanism among ideas, cases and links, the definition of design ideas, the knowledge representation of design cases and the linking relationships between them should be investigated.

### 2.1. IDEAS

In Greek, the word 'idea' means 'appearance of thing'. Rhodes (1961) defines idea as: '...a thought which has been communicated to other people in the form of words, paint, clay, metal, stone, fabric, or other material'. Ligt (2000) argues that ideas need to have been communicated to others, be related to the task at hand and provide some kind of a solution during brainstorming. Besides, designers always express their ideas by using domain concept vocabularies accompanied by multimedia.

Based on the above description, a design idea contains two parts: a design problem and its solution. Furthermore, each solution includes an abstract concept and a concrete example represented by conceptual vocabularies along with multimedia. As a consequence, each design idea contains three elements: a design problem, an abstract concept and a concrete example.

### 2.2. CASES

Designers are used to searching relevant ideas from prior design cases for generating new ideas. ICF schemata proposed by Oxman (1994) provide a potential method to represent knowledge through decomposing design precedents into separate independent chunks (called stories). Each story can be considered as an idea entity including three properties: the *issue*, the design *concept* and the *form* solution. The three properties can be respectively analogized with the design problem, the abstract concept and the concrete example described above.

Besides focusing on the conceptual knowledge embedded within prior design cases, ICF schemata have the following characteristics for the linking plays among ideas, cases and links.

1. Design case knowledge is decomposed into separate independent idea entities rather than instances of design cases.
2. A linking network among issues, concepts and forms connects the idea entity with idea entities from other design cases.
3. Idea entities begin to form a lexical vocabulary of issues, concepts and forms related to the design problem task.

These idea entities are clustered into design cases, and form a dynamic linking network. Furthermore, these properties within idea entities are organized into a semantic net based upon the domain concept vocabularies accompanied by different kinds of information such as keywords or multimedia.

### 2.3. LINKS

Three types of links with different linking principles (similarity, contrast and contiguity) provide various relationships among these idea entities. By integrating the characteristics of ICF schemata with these links, this approach provides designers for linking ideas dynamically in the process of idea association. From any node of issue, concept or form in the linking network, any related idea entities within design cases could be associated. Finally, these idea entities and links construct a graph-like idea structure of nodes and edges that we called an *idea-map*.

## 3. Linking Plays in Two Steps

Idea association should contain two kinds of steps – divergent and convergent (Liu et al., 2003). Each step has different linking plays for linking idea entities. In a divergent step, all related idea entities are linked through three linking mechanisms. Followed by a convergent step, the selection of these idea entities is made through three control strategies. These linking plays provide designers with the ability to generate a meaningful and particular idea-map for design inspiration.

In addition, these linking plays are based on the following assumptions: 1) designers have the same design ontology, and 2) use similar domain concept vocabularies to describe their ideas.

### 3.1. DIVERGENT STEP

There are three linking plays in divergent step: similarity linking, contrast linking and contiguity linking. For providing a more semantic and flexible linking

mechanism, any two properties within an idea entity can dynamically match two of the analogous properties within the other idea entities.

1. **Similarity linking:** the linking focuses on linking other idea entities with similar design solutions for a specific design problem. By matching similar conceptual vocabularies of two properties (issue and concept), all related idea entities with new forms are linked.
2. **Contrast linking:** the linking focuses on linking other idea entities with contrasting design concepts. By matching similar conceptual vocabularies of two properties (issue and form), all related idea entities with new contrast concepts are linked.
3. **Contiguity linking:** the linking focuses on linking different design problems with the same design solution. By matching similar conceptual vocabularies of two properties (concept and form), all related idea entities with new issues are linked.

### 3.2. CONVERGENT STEP

The literature suggests that although hundreds of ideas may be linked in the divergent step, only five to twenty of them will be seriously considered (Ulrich and Eppinger, 1995). For making an understandable idea-map, a deliberate decrease of the idea entity number within the idea-map should be made. Basically, there are three different, but related levels of control strategies that are applied in this step: entity control, link control and depth control. The three control mechanisms are described as follows:

1. **Entity control:** the idea-map can be reduced by deciding the number of idea entities directly.
2. **Link control:** the idea-map can be reduced by selecting the types of links and deciding their number.
3. **Depth control:** in addition, the range of idea-map can be reduced through decreasing the length of the paths from an initial idea entity to terminal idea entities.

For matching text effectively, three knowledge maps function as a dictionary, with a graph-like vocabulary structure, provide a dynamic matching mechanism for computing textual similarity. They are the issue map, the concept map and the form map. Based on these linking plays, an indexing prototype for supporting idea association is proposed.

## 4. Mapmaker: An Indexing Prototype

Due to the limitation of the short-term memory, designers always have production

blocking problems for associating ideas. By applying the mechanisms of the linking play described above, Mapmaker as an indexing prototype provides designers to search and browse related ideas within prior design cases in the linking process of idea association. Basically, Mapmaker has the following characteristics for linking ideas effectively:

- Semantic relationships provide understanding in the problem type, problem context and the complexity of real world design solutions.
- Dynamic linking process allows users to use different linking mechanisms for linking diverse ideas with in design cases.
- Creative exploration of ideas emerges out of different relationships between idea entities rather than idea entity itself.

Basically, Mapmaker composes of three linking cards (similarity, contrast and contiguity) that allow a designer to link diverse idea entities (within design cases) to current ideas. Besides, he/she can use the controlling card to reduce the idea-map (Figure 1). By proceeding Mapmaker, he/she can dynamically construct an individual idea-map for design inspiration in the conceptual design stage.

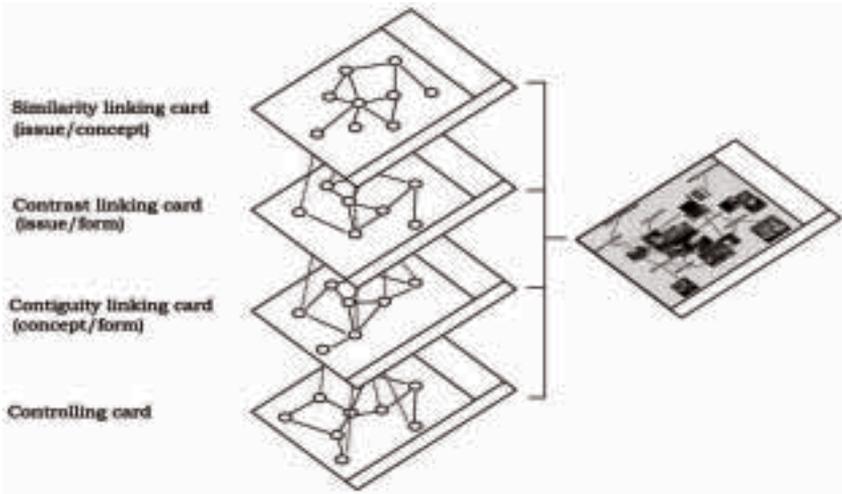


Figure 1. Three linking cards and a controlling card in Mapmaker.

## 5. Conclusion

This paper provides a digital design method for linking ideas dynamically by applying the technology of CBR. The case representation issue-concept-form provides a powerful mechanism for linking diverse ideas within design cases in the conceptual design stage. Through the linking plays in two steps, a promising idea-map can be generated dynamically. In the divergent step, a meaningful and

tremendous idea-map is constructed through the three linking interplays. In the convergent step, three levels of control interplays deliberately decrease the number of the idea entities.

As an indexing prototype, Mapmaker applies these mechanisms of linking plays for supporting search and browsing of related and meaningful ideas in conjunction with the other participants' ideas during the process of idea association. Therefore, designers can construct their individual idea-maps to support creative exploration of ideas. Also, designers can access conceptual knowledge embedded in previous projects dynamically.

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