Frontiers of Architectural Research (2014) 3, 376–385

HOSTED BY

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/foar

Frontiers of Architectural Research

RESEARCH ARTICLE

Smart partition system – A room level support system for integrating smart technologies into existing buildings

Sheng-Fen Chien*, Hung-Jen Wang

Department of Architecture, University of Cheng Kung University, 1 University Road, Tainan 70101, Taiwan, China

Received 14 August 2014; accepted 23 August 2014

KEYWORDS
Support system;
Smart house;
Open building;
Building renovation module;
Technology integration

Abstract
We proposed a support system called the "Smart Partition System" for infill elements that integrate smart technologies according to the Open Building principles. The design requirements were collected from design practitioners. These design requirements consisted of both architectural and information subsystems. The Smart Partition System was composed of the following multiple levels of smartness: the foundation/core level with an embedded design knowledge in the support system and the utility level with a modular infill that integrate smart technologies. We constructed functional prototypes to demonstrate the feasibility of our proposed support system and some of the possibilities of the smart infill elements. Furthermore, the prototypes were evaluated by design practitioners. We compared our approach with current practices of smart building developments, and we also discussed some future prospects.

1. Introduction

Integrating smart technologies into existing houses generally requires major renovations, which may be as time consuming and/or costly as building a new house. Given that a building may last for decades, the requirements to allow incremental integrations of smart technologies into buildings outweigh those of new smart houses. The open building principles provide a systematic approach for building constructions (Habraken, 1972). Two key concepts of the open building principles are supports and infills. The supports comprise all permanent, shared building services. An infill system is a carefully pre-packaged, integrated set of products and a custom prefabricated off-site for a given dwelling. By decomposing the construction of a building into various components that can be assembled through building

*Corresponding author. Tel.: +886 62757575x54138.
E-mail address: schien@mail.ncku.edu.tw (S.-F. Chien).
Peer review under responsibility of Southeast University.

http://dx.doi.org/10.1016/j.foar.2014.09.002

products, the process enables incremental modifications and improvements of existing buildings.

We propose a support system for infill elements that integrate smart technologies. Considering that residential buildings are the largest building stock for improvement with new technologies in many Asian countries, the system is designed for the interior environment. Particularly, the system supports interior partitions of spaces, whereas the system itself is an infill of the overall structural support system of the building.

2. Supports and infills

Habraken (1972) has introduced the open building principles which divide a building into two levels: supports and infills. This division provides a systematic way of linking building elements and enables variations or customization according to residents' needs. The two levels are also decision-making levels, where residents can decide on the infills needed and the placements of these infills. To realize the open building policies, Habraken and Van Randen have developed the Matura infill system (Kendall and Teicher, 2000; Kendall, 1996). The Matura infill system consists of two elements: the matrix tile and the baseboard profile. The matrix tile system is based on a 10 cm × 20 cm grid that accounts for the positioning of each component and its relationship to other elements. The baseboard profile is a track component that serves as the basis for interior partitions. These components provide design adaptability, fast on-site installation, and future changeability.

The curtain-wall construction of a building facade is one of the first innovations that allowed wall panels, which are infill elements, to be manufactured separately from the building structural framework, which is a support system. For example, the Blinkenlights project in Berlin, the BIX facade of Kunsthaus of Graz, and SPOTS in Berlin's Potsdamer Platz (Hall, 2006) are pioneering works of integrating smart technologies into the infill elements, i.e., curtain wall panels. To facilitate such kind of infill elements, the support system provides not only structural backing but also power supply and information communication. Furthermore, a building may contain various types of smart infill elements, as shown in previous developments (Chien, 2009), and the support system should provide flexibility to allow various types of infills.

3. System design

Integrating smart technologies into the living environment has been a topic of research since the late 1990s. Various projects such as the neural network house (Mozer, 1998), aware home (Kidd et al., 1999), and Easy Living (Shafer et al., 1998) have constructed prototypes or demonstrative houses. To operate these houses, a huge budget for maintenance and a knowledge on smart technologies are needed. Given that smart technologies are becoming affordable for the general public, architects and interior designers are receiving frequent requests from clients to integrate smart technologies, such as smart indoor environmental or lighting controls, when remodeling houses. We aim to develop an infill system that may assist in designing and deploying smart technologies for the clients of architects and interior designers.

3.1. Requirements analysis

To understand the requirements of such kinds of systems, three design practitioners, one architect, and two interior designers are interviewed to collect possible kinds of infill elements or functional supports for interior partitioning walls. A set of keywords regarding activities, spaces, and interior elements (e.g., fixtures, furniture, and appliances) are extracted from the interviewed data. A researcher then works with each design practitioner to analyze the relationships among these keywords using the affinity diagramming method (Beyer and Holtzblatt, 1998) (Figure 1). The resulting affinity diagrams are consolidated into a relationship table of spaces and interior elements, which then sets the functional requirements of our proposed support system.

The following three types of spaces in a house have been identified by the design practitioners: common, designated, and service spaces. The common space is used by all house members, which includes the living room, dining room, and drawing room. The designated space includes the kitchen, study room, and bedroom; these spaces are mostly private spaces used by specific house members for specific functions. The service space includes the entrance hall, corridor, balcony, and bathroom. For the non-movable furniture and building elements (see last three rows in Table 1), cabinets are needed in all these spaces. For the movable furniture (see first six rows in Table 1), a folding screen (a free-standing

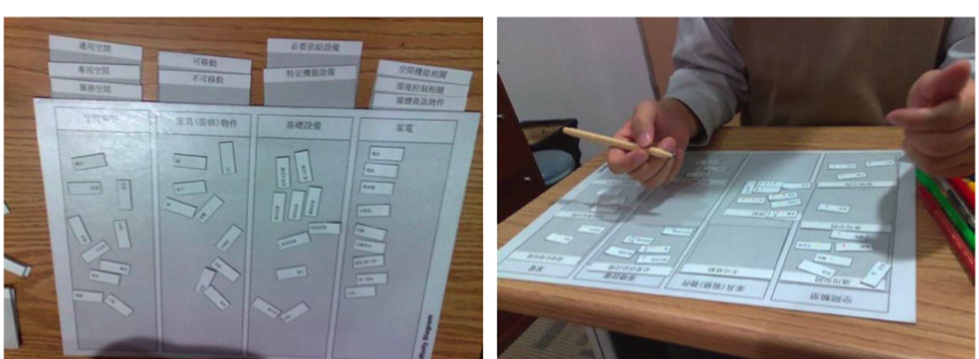

Figure 1 Affinity diagramming analysis.