Chapter 15
Interactive Architecture: Spaces that Sense, Think, and Respond to Change

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ABSTRACT
This chapter provides an overview of interactive architecture relating to the design and implementation of ubiquitous computing technologies. The kernel of interactive architecture is augmenting spaces that can sense, think, and respond to change. A theoretical framework is provided for contextualization of interactive architecture. A model of interaction is proposed to identify a set of processes, functionality and principles that guide the design of interactive architecture. Key capabilities are identified with respect to interactive architecture: sensitivity, smartness, and responsiveness. Examples of some research projects are provided to demonstrate the capabilities. Methods and techniques for developing such capabilities are described according to the model of interaction. Applications for using ubiquitous computing technologies in interactive architecture are reviewed.

INTRODUCTION
Ubiquitous computing is a paradigm shift whereby computers can be pervasively embedded into the artifacts, spaces, and environments of everyday life. This paradigm shift occurred with the introduction of a new way of off-desktop human-computer interaction. Computing today is moving beyond the assistance of design environments to the augmentation of our living environment.

Advances in ubiquitous computing technologies have opened up new opportunities for changing our living environment in a number of ways. These technological methods include:

- Integrating digital world and physical world
- Embedding computers in a huge range of materials and artifacts
- Making objects and spaces more responsive, sensitive, and smarter

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- Proactively monitoring human activity and our environment
- Pervasively providing information and services when and where desired
- Multimodal interaction with computers in an intuitive manner (such as gesture and speech)

Each of these changes has its own technical difficulties and specialized areas of research in Human-Computer Interaction (HCI). HCI is a term used to refer to the designing of interactions between people and computers. In the late 1970s, the main concern of HCI was usability, involving design and evaluation methods to ensure that technologies are easy to use. During the 1990s, the concerns of HCI started to shift towards communication between people enabled by computers. More recently, HCI has begun to develop techniques for inventing products, spaces, and services that are beyond usability to usefulness. Designers became heavily involved in HCI. The notion of interaction design came to the design practice. During the 1990s, Mark Weiser introduced the area of ubiquitous computing and put forth a vision of augmented environments where information and services are provided when and where desired (Weiser, 1991). The notion of ubiquitous computing was elaborated with respect to HCI (Abowd and Mynatt 2000). The philosophical base of human-computer interaction was addressed by examining the concept of embodied interaction- an approach to interacting with software systems that emphasizes engaged practice rather than disembodied rationality (Dourish, 2004). It has been argued that the ubiquitous computing technology does not obviate the human need for place (McCullough, 2005). A theory of place for interaction design called “digital ground” offers an account of the intersections of architecture and interaction design.

Taking a broader view, we need to re-think some fundamental assumptions about the relationship among humans, computers, and architecture. Digital technologies will continue to proliferate, enabling ever more powerful and networked interactive devices to change the way we interact with our built environment. While computers can be pervasively embedded in built environments, these technologies are likely to change the way in which we live and how buildings perform. Today’s conventional building systems have served us well until now, but they will have to evolve toward a different thinking of architecture.

What may appear to be shifts in emphasis actually represent the convergence on an emerging computer-aided architectural design research area, which is interactive architecture- spaces that can sense, think, and respond to change. This chapter introduces three types of interactive architecture with emphasis on the design of interaction space, network space, and kinetic space. A theoretical framework is described for the development of a modular interactive system that can be widely used in smart spaces of the future. Examples of some research projects are provided to illustrate the concept. The chapter closes with a discussion of research issues, challenges, and future research directions.

Interactive Architecture

The term interactive architecture is concerned with interactive interfaces between humans and computers. A building is an enclosure that defines the boundaries of a space to support varied activities. Enclosures such as walls, floor, and ceilings can be considered as interactive interfaces. Other terms sometimes used for aspects of intelligent and interactive environments include ‘responsive architecture’, ‘intelligent buildings’, and ‘smart home’. These aspects define architecture as a dynamic shape-shifting building system that is susceptible to alter its shape and physical properties in response to environmental conditions and user activities (Sterk, 2005) (Fox, 2009). All mean more or less the same objective: developing an interactive system by extending human capabili-