

# Chapter 8.11

## Concept of Symbiotic Computing and its Agent-Based Application to a Ubiquitous Care-Support Service

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### **ABSTRACT**

In this paper, a concept of “symbiotic computing” is formalized to bridge gaps between Real Space (RS) and Digital Space (DS). Symbiotic computing is a post-ubiquitous computing model based on an agent-oriented computing model that introduces social heuristics and cognitive functions into DS to bridge the gaps. The symbiotic functions and agent-based architecture of symbiotic applications are also discussed. Based on the concept, func-

tions, and architecture of symbiotic applications, we develop an agent-based care-support service to enable supervision of persons by their families and friends easily while protecting privacy. In this application system, a hierarchical structure of multi-agents is organized dynamically using heuristics in agents based on the situation of a watched person and watching persons. The system appropriately alters the contents and quality of the live video. The flexible system construction scheme using a multiagent framework facilitates

the symbiosis of RS and DS by bridging the gaps in the care-support service domain.

## **INTRODUCTION**

The growth of Web technology enables many people to get various kinds of information from the internet using high-performance search engines and recently advanced web services. People have come to live in virtual communities with related social networks as they do in real communities. Furthermore, the recent rapid growth of the ubiquitous technology provides more convenient services to people who can make full use of them [Lyytinen, 2002]. The technologies have led from a traditional society to a modern information network society in which people can exchange information easily and efficiently via the internet.

On the other hand, emerging problems have come with the internet society: the digital divide, security, network-based crimes, and so on. These problems have been caused by social and human difficulties rather than by computer and network technology per se. Nevertheless, technology should tackle these difficult problems by inclusion of sociality and humanity into computing models.

Symbiotic computing, which we propose, provides a framework to bridge gaps between Real Space (RS) and Digital Space (DS). We consider that a gap, which causes some problems in our internet society, exists because of the lack of mutual cognition between RS and DS. That is, people cannot receive its advanced services without IT skills, and DS cannot provide a service that is suitable to a person depending on that person's situation and preference. Furthermore, DS cannot provide a safe and secure service without heuristics to describe a person's activities in a society, such as customs, laws, and expertise. We define symbiotic computing based on ubiquitous computing, Web computing, and models of AI and

Cognitive Informatics [Wang1, 2007]. A model of cognitive properties to include human factors and social relations into information processing was discussed by Wang [Wang, 2005; Wang2, 2007]. The concept of symbiotic computing was also defined based on so-called calm computing proposed by Mark Weiser [Weiser, 1996]. The word "symbiotic" is adopted to describe the mutually interrelated character of RS and DS, which enables mutual cognition to provide safe and suitable services for RS.

A model of the symbiotic computing in this paper is formalized based on an agent-oriented model to include social heuristics and cognitive functions into DS to bridge the gaps. To realize the concept of symbiotic computing in a real situation, advanced abilities of systems such as flexibility, adaptability, and sociality are required to construct applications that bridge the gaps. For that reason, we use a multiagent-based framework for symbiotic applications. In our framework, agents construct and reconstruct organizations dynamically according to the situations of RS—locations, preferences, requirements, and conditions of users—and the status of devices and networks around the users. The agent organization, which is customized to diverse situations in RS, can integrate necessary and sufficient functional elements and information in DS; it can also provide situation-aware services to users in RS. This flexible system construction scheme is a basic function of symbiotic computing [Suganuma 2003]; it plays an important role in facilitating the symbiosis of RS and DS by bridging the gaps.

In this paper, we describe the application of symbiotic computing to care-support systems for supervision of elderly people or children. This is a typical example of the gap that prevents a symbiotic relationship between persons and communities and between persons and DS. For this reason, we decided to develop a care-support system for supervision as an experimental system of symbiotic computing. Users of the system, a watching persons and a watched person, are

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