

## Ubiquitous computing and its effects on small businesses

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**Abstract** Much of the previous literature on ubiquitous computing (UbiComp) has been limited to case studies, reporting innovative practices of specific technologies (e.g., RFID) and social issues. There is a general paucity of research on strategic application of UbiComp, especially to small businesses. To address this issue, this study provides a broad overview of the current practices of UbiComp in leading countries and presents possible future directions. Then, the effects of UbiComp on small businesses are discussed. Through a cross-national comparative analysis, we present four strategies to provide some guidance to the countries that are currently considering entering into the UbiComp race.

**Keywords** Ubiquitous computing · RFID · Cross-national comparative analysis · Small businesses

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## 1 Introduction

Introduced by Mark Weiser more than a decade ago, ubiquitous computing (UbiComp) is a paradigm shift in information technology (IT) and a vision of the future information society where technology becomes virtually invisible in our lives. Based on networks with massive quantities of chip sensors that are interlinked through wireless connection and accessible using mobile devices from virtually anywhere and at any time, UbiComp is expected to bring major changes to our daily lives from e-commerce to ubiquitous lifestyles. Today, global competition is the catalyst for a rapid development of the ubiquitous technology. Advanced countries are striving to develop ubiquitous technology of their own and ultimately an intelligence-based society. The main reason for this trend appears to be the apparent economic benefits and opportunities created by new markets through UbiComp. This new trend in the IT area has stimulated many nations to prepare for a technological base for UbiComp and to establish national strategies.

The most technologically advanced countries, particularly the U.S., Western European members of the E.U., and several developed countries in Asia, are leading the global phenomenon of UbiComp as they have in the information and communication technology (ICT) industry. These countries have pioneered the global standards and implemented a variety of policies related to UbiComp. They have exerted their efforts on establishing mid- and long-term strategies, development of core technologies, and commercialized products and services.

Much of the previous UbiComp literature focuses on projecting its benefits in the future society, application design issue, new classes of future business, or on social issues (e.g., *CACM* 2002 December issue on ubiquitous computing). Radio frequency identification (RFID), one of the embedded technologies of UbiComp, enables new types of service. Creative applications of RFID can be found in a variety of areas: the EZ-Pass at the highway toll gates, the Delta Air Lines baggage tracking system, and so on (see *CACM* 2005 September issue on RFID).

The potential wide application of UbiComp will involve some important issues, especially privacy and security (Gershman and Fano 2005). Many people are concerned about technologies that support ubiquitous society, such as RFID technology, as surveillance systems to monitor their behavior. Lack of trust caused by security and privacy problems is one of the most frequently cited reasons for people not to accept new technologies and ubiquitous commerce (Lee et al. 2007). Solutions for RFID-related privacy issues have been proposed by many researchers, including adoption of more secure techniques or guidelines. Thus, without resolving the privacy and security concerns, it might be difficult to realize the ubiquitous society.

This paper presents the trends and application practices of UbiComp in some of the leading technology country. Then, the effects of UbiComp on small businesses are examined in leading countries. Strategies for UbiComp for the follower countries are also suggested.

## 2 Ubiquitous computing practices in leading countries

Here we provide a concise review of current practices of leading UbiComp countries, namely the U.S., the European Union, and some countries in Asia. We chose these three regions because not only were they the most technologically advanced countries which were pioneers in the adoption of the Internet, e-commerce, and advanced ICTs, but also they have been leading the way with the UbiComp initiatives.

### 2.1 The United States

The total R&D investment in science and technology in the U.S. is the largest in the world and has brought immeasurable benefits to the economy, national security, and welfare over the past 50 years. The U.S. is leading the global standards of UbiComp under the government's initiative, with an astronomical amount of R&D investment in the development of core technologies and business models. The core technologies developed include smart dust, RFID systems, and ubiquitous sensor networks. At the core of the practices of UbiComp in the US is a program supported by the federal government, the Networking and Information Technology Research and Development (NITRD) program.

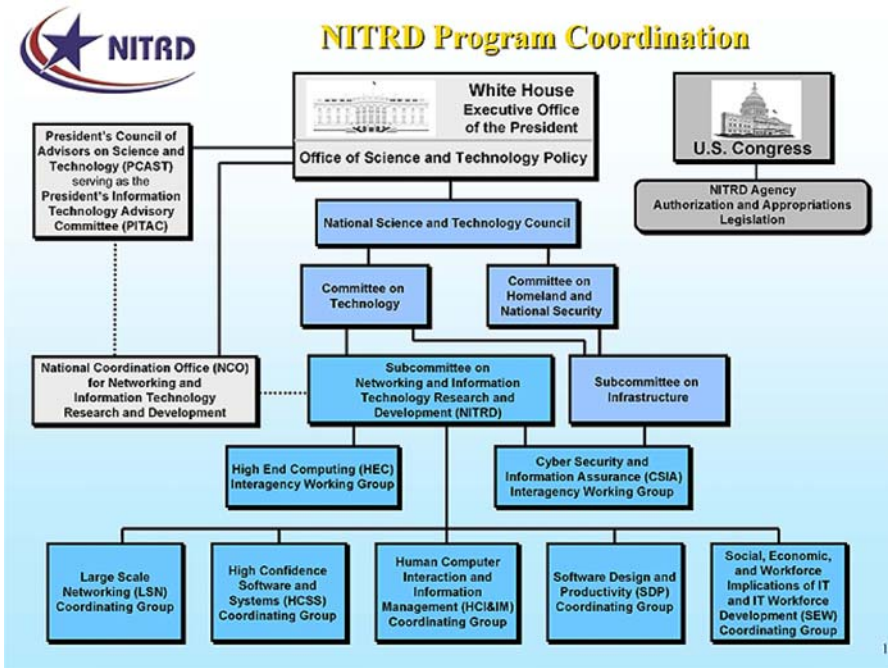
The NITRD program was instituted by the High-Performance Computing Act of 1991 and the Next Generation Internet Research Act of 1998. The NITRD program, as shown in Fig. 1, represents the coordinated efforts of fourteen federal agencies that support R&D in networking and information technology. The budget for NITRD has grown sixfold from \$489 millions in 1991 to \$2.97 billion in 2007. The 2008 budget is estimated to be over \$3 billion (Networking et al. 2007). The Presidential IT Advisory Council recognizes NITRD as one of the exemplary programs by the federal government, as about 40% of the total number of patents issued in the U.S. in 2004 was attributed to the research output of NITRD.

In addition, the U.S. has invested intensively in nanotechnology, which has been recognized as a core technology for implementing UbiComp. The budget for the National Nanotechnology Initiative has grown approximately three times from \$464 million in 2001 to \$1.35 billion in 2007, and the budget for 2008 is estimated to reach \$1.45 billion (National Science and Technology Council 2007).

### 2.2 The European Union

The informatization strategy of EU is divided into two sectors: policy and R&D. The two sectors function cooperatively, the policy sector providing directions for R&D and the R&D sector providing practical feedback to the policy sector (Europe's Information Society 2007).

EU's vision of UbiComp-related policy centers on the concept known as Ambient Intelligence (AmI). EU believes AmI is the next generation informatization vision for making Europe a world-class information society that can serve as a test bed based on open software providing a user-friendly interface and network

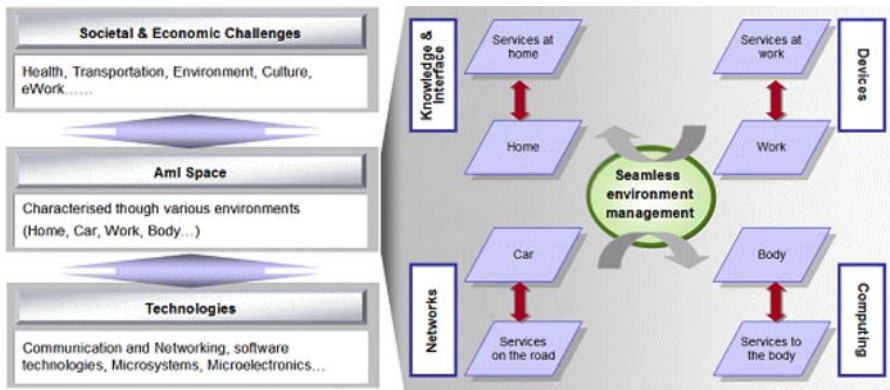


**Fig. 1** NITRD Program Coordination. *Source:* <http://www.nitrd.gov/subcommittee/orgchart.html>

infrastructure (Information Society Technologies 2002). AmI has been broadly embedded in Information Society work programs and became the core concept in developing the Information Society Technologies sector of the 7th Framework Program (years of 2007–2011).

EU has established numerous R&D sectors and projects that must now be executed in order to develop and implement the AmI vision. To answer how AmI should be implemented over the next 10 years, the Information Society Technologies Advisory Group (ISTAG) studied and presented a new concept called the Ambient Intelligence Space. This refers to a space where technology, infrastructure, applications, and services are combined in order to deploy and manage a seamless environment in which AmI can be implemented (Information Society Technologies 2004).

The ambient intelligence space concept has thus far been an abstract concept that can be utilized for building specific environments, and ISTAG has established a 3-layer model to further materialize the concept (See Fig. 2). The top layer represents societal and economic challenges while the base layer is for technological challenges, and the middle layer, or ambient intelligence space, fills the gap between the societal/economic challenges and the technological challenges. Thus, the ambient intelligence space is not simply composed of infrastructure, hardware platforms, services, and applications in a physical aspect, but also refers to a state wherein all those elements are combined into one.



**Fig. 2** The ambient intelligence space. *Source:* E.U. ISTAG

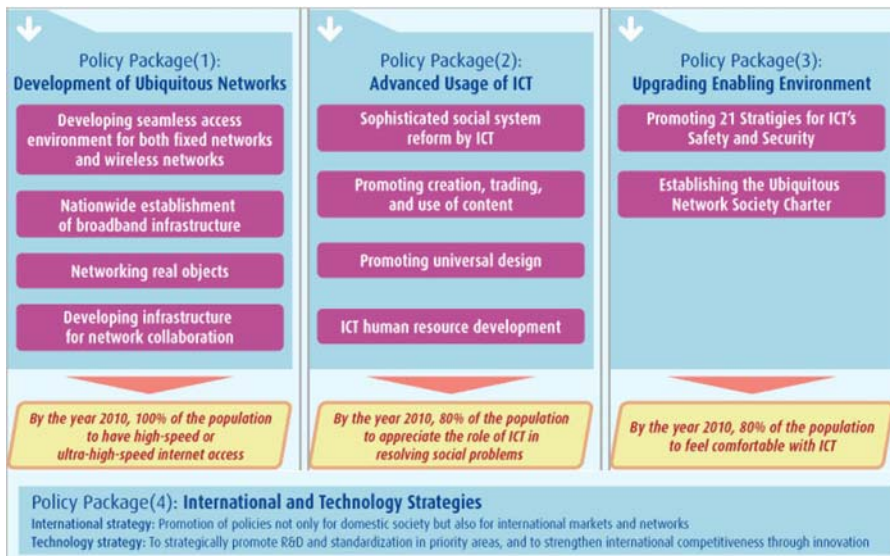
Traditionally, Europe has had its own IT R&D culture and environment, different from the US. Europeans conceive new information technologies such as UbiComp from a more human-oriented perspective as a means of changing the way of life and ensuring an affluent lifestyle, rather than from a technical point of view. Accordingly, EU views AmI as a vision that addresses social needs of Europeans and the labor class. EU's concept in approaching ubiquitous informatization clearly states its welfare-oriented ideology of providing user-friendly services (Information Society Technologies 2002).

### 2.3 Japan

The Ministry of Internal Affairs and Communications of Japan launched the Ubiquitous Network Society Meeting in March 2004. The Economy and Finance Advisory Council proposed the *u-Japan Vision* in May 2004 to realize the ubiquitous network society. In December of 2004, Japan proclaimed the *u-Japan Policy* as the mid-term vision for realizing the next generation ICT society by 2010 (see Fig. 3).

The objective of the *u-Japan Policy* is to ensure Japan's front runner status and secure its place as a leading ICT nation by 2010. The policy includes three major issues: (1) a seamless ubiquitous network to make the high-speed or super high-speed Internet available to 100% of the population by 2010; (2) advanced utilization and development of ICT to build a society where 80% of people can use ICT to help solve major problems by 2010; and (3) development of the user environment to build a society where 80% of people can rely on ICT for everyday activities by 2010 (Ministry of Internal Affairs and Communications of Japan 2005).

The private sector is actively participating in ubiquitous network research and the *u-Japan Policy*. According to the recently announced mid-term management strategy of NTT, its objective includes contributing to the realization of the *u-Japan Vision* by actively creating a broadband ubiquitous market. To this end, NTT plans to invest 5 trillion Yen by 2010 to provide an optical fiber communication service to



**Fig. 3** Overview of u-Japan policy package. *Source:* [http://www.soumu.go.jp/menu\\_02/ict/u-japan\\_en/new\\_plcy\\_pkg.html](http://www.soumu.go.jp/menu_02/ict/u-japan_en/new_plcy_pkg.html)

30 million subscribers, or half of the fixed phone subscribers, and a full-scale transition from the existing fixed phone networks to next generation IP networks. Not only NTT but also other major Japanese IT enterprises are responding positively by organizing departments dedicated to the ubiquitous network.

#### 2.4 South Korea

South Korea is ranked as the world leader in terms of broadband penetration and e-government. The vigorous growth exhibited by the Korean ICT industry is attributed to the government's strong policy for informatization and the IT mindset of the private sector (Lee 2003). Since 2004, the Korean government has released development strategies for realizing a ubiquitous society. For example, the *IT839* Strategy refers to a strategy to stimulate the advancement of the IT industry by promoting eight new services, to attract investment in three key wire/wireless communication and broadcasting infrastructures, and to induce the growth of nine state-of-the-art device, terminal, and software content industries (Chin and Rim 2006). As the *IT839* strategy progressed from the initial market formation phase to the commercialization phase, it evolved into the *u-IT839* strategy and the strategic items were readjusted to strengthen the interfaces between the eight services, three infrastructures, and nine new growth engines, and to enhance the focus on software policies.

*u-KOREA Master Plan* was drafted in 2005 and finally confirmed by the Informatization Promotion Committee chaired by the Prime Minister in March 2006. *u-KOREA Master Plan* which seeks to build the first *u-Society* on the best

u-Infrastructure is a mid- and long-term national informatization plan implemented by the Korean government. Under the plan, the government intends to achieve the five key visions of Friendly Government, Intelligent Land, Regenerative Economy, Secure and Safe Social Environment, and Tailored u-Life Services. It also intends to optimize four major engines: Balanced Global Leadership, Ecological Industrial Infrastructure, Streamlined Social Infrastructure, and Transparent Technological Infrastructure.

### 3 Effects of UbiComp on small businesses

In this section, we will present the effects of UbiComp on small businesses. Since UbiComp is a relatively new technology, its effects on small businesses are yet to be realized. However, a glimpse of the powerful impact of UbiComp on small businesses can be found by examining RFID applications in the most advanced ICT countries. The examples presented can be model applications of UbiComp for small businesses in other countries, especially followers.

#### 3.1 The United States

The process of deploying UbiComp is taking place among many small and medium enterprises (SMEs) in the United States. A study by Correia and Biscotti (2005) suggests that inventory-intensive SMEs that implemented UbiComp solutions such as RFID can reduce errors by up to 90%, increase productivity by 12%–15%, and decrease inventory-counting time by 35%–40%. With the convergence of multiple technologies, this trend will become more pronounced. One of the examples is Cephalon, Inc., a biopharmaceutical company based in Seattle, Washington. The company currently markets six proprietary products in the United States. Cephalon embarked on a series of RFID pilot tests to address serious concerns facing the pharmaceutical industry such as electronic pedigree mandates and the prevention of counterfeiting and diversion. Cephalon began evaluating RFID technology in 2004. The initial phase of the pilot program, which captured the movements of placebo product and prototype packaging in a distribution center, was completed in December 2005. Phase 2 of the pilot program, completed in July 2006, consisted of shipping tagged product to an RFID-enabled wholesaler. Cephalon has recently finished the last phase of the pilot program, which tests RFID-tagged cases and pallets in a manufacturing environment (O'Connor 2005). Cephalon is experiencing significantly improved packaging line throughput. Most importantly, the company has demonstrated that pharmaceutical manufacturers and distributors can use an RFID solution for protecting, authenticating, and tracking their products.

#### 3.2 The European Union

Recently, Europe has undertaken a leading role in helping European SMEs, which are experiencing significant cost barriers to RFID deployment. Funded by the

European Commission (FP7), the ASPIRE project is intended for a radical change in the current RFID deployment paradigm. In Europe, most SMEs have high potential for efficiency gains through the use of RFID, but many of them do not have sufficient equity capital to invest in RFID, which is where the project is aiming to change. The ASPIRE project plans to develop and provide a lightweight, royalty-free, innovative, programmable, privacy friendly, middleware platform that will facilitate low-cost development and deployment of innovative RFID solutions. ASPIRE hopes to significantly lower SME entry costs for RFID technology. In addition, ASPIRE plans to help SMEs to adopt RFID technology to their business process easier for a successful RFID implementation without the help of RFID specialists and an expensive system.

### 3.3 Japan

A recently released report by the Ministry of Economy, Trade and Industry (METI) suggests that SMEs, which comprise almost 99% of all companies in Japan, have not successfully raised productivity through ICT, particularly in the service sector. One of the retailers that successfully improved productivity is Maruetsu Inc., a supermarket food supply chain. The company has identified consumers' top shopping priorities. First, Japanese consumers want good quality products that are cheap, safe, and reliable. Second, they want a pleasant shopping experience and no queuing. Maruetsu is using RFID to address these issues. Maruetsu has started an experiment to put RFID tags on about 90 items. When the customers hold the tag up to one of the four scanners in the store, they can obtain detailed information about food ingredients, place of origin, the manufacturer's message and cooking suggestions. According to the company, about 15% of buying customers used the terminal to check the product information before purchasing. Sales of the items with tags increased significantly during the test period. Although the cost of the tags is still expensive, the company believes that the system will benefit the consumer in many ways (Harrop 2005).

### 3.4 South Korea

In order to promote industry-wide adoption of mobile and ubiquitous technologies, the Ministry of Commerce, Industry and Energy (MOCIE) of the Korean government has recently developed RFID implementation strategies. One of them is designed to provide benefits to small and medium-sized enterprises (SMEs), which often cannot afford not only RFID systems but also the consultancy, installation, and maintenance services (ORANEWS 2007). Specifically, MOCIE has drawn up four plans for SMEs.

First, MOCIE plans to develop and distribute low-price business group-based RFID packages. New RFID systems can be easily integrated into the existing enterprise applications such as enterprise resource planning (ERP) and supply chain management (SCM). The feature helps SMEs improve business processes and reduce costs. MOCIE initially targets about 100 SME suppliers in the automobile industry.

Second, MOCIE plans to encourage large corporations to share their expertise on RFID projects with their suppliers. MOCIE believes that relationships between large corporations and their smaller suppliers are largely asymmetric. Large corporations play an important role in coordinating suppliers and often champion the introduction of RFID in their supplier networks. However, the benefits from RFID are distributed unevenly and skewed in favor of large corporations.

Third, MOCIE plans to offer a variety of RFID training programs for SMEs. These programs are designed to provide current IT managers with RFID expertise in order to enable them to play a leadership role in the application of RFID in SMEs. Eventually, MOCIE hopes to increase the pool of experts in SMEs to successfully implement RFID projects.

Fourth, MOCIE plans to set up “RFID Adoption Support Center” in industrial complexes to provide solutions, applications, training, and consulting service. The center will serve as a test bed for analysis and evaluation of new RFID applications. The center will be equipped with an elaborate infrastructure that will allow SMEs to set up a test environment that simulates the real world. In addition, MOCIE believes that the application service provider (ASP) will be another popular choice for most SMEs that are seeking benefits from RFID implementation at a reasonable cost. MOCIE aims to develop the center in cooperation with major universities, research institutions, and public authorities. The center will become a “total RFID solution” service hub for SMEs to enhance their business growth and competitiveness in the most cost effective manner.

#### **4 Strategies for follower countries**

Based on the evolution of current practices of leading countries, we propose four strategies for the follower countries in establishing and executing their national informatization and UbiComp strategies, especially for small businesses.

##### **4.1 Network convergence (NC) strategy**

NC is defined as construction of network infrastructure required for establishing the ubiquitous environment. NC includes the next generation network (NGN), 4G network, and ubiquitous sensor network (USN). The NC strategy aims to develop a ubiquitous network which optimally links all three networks. This strategy will have profound implications to small businesses that typically rely heavily on mobile technologies in follower countries. NGN is the next-generation IT infrastructure for broadcasting and telecommunication, providing quality-assured broadband services by integrating wire and wireless, voice and data, communication and broadcasting services with RFID applications, and wireless broadband services.

##### **4.2 Industry convergence (IC) strategy**

The transition toward a UbiComp environment transforms the way business is conducted and tasks are performed in all sectors of the society. The objective of IC

strategy of a nation is not only to ensure the continuous growth of the IT industry, but also to enhance the competitiveness of other industries such as agriculture, manufacturing, and services through UbiComp.

New industries can be created by converging UbiComp technologies with traditional industries. A good example is the convergence of the construction industry and UbiComp, u-City (Ubiquitous IT City), in Korea. As a next generation city of development, u-City refers to an integrated cyber city a third city space through UbiComp. The u-City project is expected to develop a new paradigm for the next generation of cities as it could overcome the space and time constraints of the traditional city.

#### 4.3 Technology convergence (TC) strategy

The TC strategy aims at a new IT paradigm where a human and an object, an object and an object, and even an environment and a situation can be linked organically and communicate with each other. UbiComp is expected to transform itself into a technology that can integrate the most advanced core technologies of the twenty-first century, such as biotechnology, nanotechnology, and neural science. The TC strategy seeks ways to maximize the opportunities and possibilities in the future market by developing the state-of-the-art core technologies through selection, concentration, and global partnerships. As an example, iPod is capable of performing multiple tasks for photos, videos, games, contact information, email messages, Web bookmarks, and calendars. In addition to being an entertainment device, the iPod has also become accepted as a business device. Government departments, major institutions, and international organizations have turned to the iPod for the use of business communication and training. The Royal and Western Infirmaries in Scotland, for example, are using iPods to train new staff [BBC NEWS \(2006\)](#).

#### 4.4 Barriers to uTrust convergence (UC)

A computing environment centered on portable devices would have various information security vulnerabilities of previously unknown kinds such as war driving, in which eavesdroppers drive by buildings outside and try to intercept wireless network traffic. In addition, it is very difficult to guarantee confidentiality and integrity of data over a wireless network. As local-area communications are expected to be the chief category of traffic within ubiquitous wireless network environments, the risk of exposure to interception is bound to be greater. The UC strategy can address security and privacy issues and ultimately enhance users' trust toward the UbiComp society.

## 5 Conclusion

Based on the existing research and government reports on UbiComp, we have discussed the current practices of UbiComp and presented possible future directions in terms of the impact of UbiComp on people's life style, a nation's economy, social

systems, and small businesses. We also conducted a cross-national comparison of current UbiComp practices among the leading countries, particularly the U.S., EU, and some advanced ICT countries in Asia. Since UbiComp is at the beginning stage, this study represents a broad stroke review of current practices and some future strategies of leading countries. Thus, a detailed comparative analysis of specific categories, examples of success and failure, is still needed.

It seems evident that UbiComp practices mirror each country's ICT diffusion and government efforts toward designing for the future ubiquitous society. Therefore, the current practices of leading countries are not the same. Each country tends to set up a development model which utilizes the strengths of its infrastructure. It is clear that government efforts (such as strategies and investment) and best practices are most prevalent in North America, selected EU member nations in Western Europe, and several Asian ICT leading nations. In most countries, advanced UbiComp activities are planned at the federal or national level.

As UbiComp is an emerging set of technologies, its effects on small businesses are yet to be fully realized. RFID, an important UbiComp technology, has already shown the potential application of UbiComp in small businesses. UbiComp is advancing at a rapid rate and resilient small firms will have much to contribute to the development and application of UbiComp in creating new value.

Based on the evolution of UbiComp practices in the leading countries, four strategies were suggested that can help the follower countries to develop and implement their national strategy for UbiComp. However, a good understanding of the strengths and weaknesses of their current ICT industry is needed for developing such strategies, especially for small businesses.

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