Preferences and CSFs of Ubiquitous Services

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Abstract

Recently, the area of ubiquitous computing has gained a great attention both in academics and in industry.
However, previous research on this area attempts the categorization in part of context and the critical success factors (CSFs) and services of ubiquitous computing unsuccessfully.
The purpose of this paper is to propose a framework on ubiquitous computing, including its context, roadmap, CSFs, and services.

Keywords:
Ubiquitous Computing, Context, Roadmap, CSFs, Ubiquitous services.

Ⅰ. Introduction

Recently, the new IT paradigm is appearing in the Ubiquitous computing area. The word, "Ubiquitous" which is frequently will be appearing in discussion medium, many people agree that the ubiquitous computing will change the domination of future information communication market and the new paradigm.

According to the Ministry of Commerce, Industry and Energy (2003), the size of the world-wide ubiquitous market in 2010, including the potential market that can be in corporated into the ubiquitous network, is expected to be $702.5 billion and the size of the korea market in 2010 is projected to be 51 trillion wons (See <Table 1>).

<Table 1> Size of Ubiquitous Market

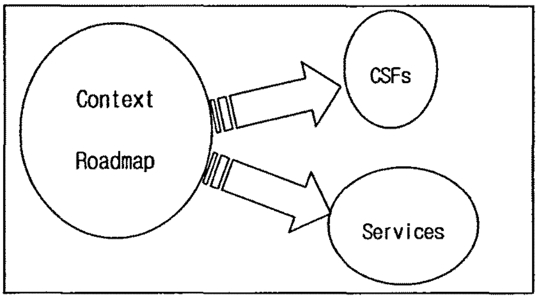
국내외유비쿼터스시장현황

	세계시장(억달러)		국내시장(억원)	
	2005년	2010년	2005년	2010년(6%)
[illegible]	608	2,016	[illegible]	[illegible]
[illegible]	458	[illegible]	[illegible]	[illegible]
합계	2,525	7,025	[illegible]	[illegible]

<Source: MOCIE, 2003>

However, most researchers mainly focus on the issues concerning the trend, forecast and technologies.

The purpose of this paper is to propose a framework an ubiquitous computing, including its context, roadmap, CSFs and services (See <Figure 1>).



<Figure 1> Framework of the Research

Based on the literature review in the area of context in Chapter 2, the research method on the roadmap is proposed in Chapter 3. The CSFs of Ubiquitous services are identified in Chapter 4 and services of Ubiquitous computing is projected in Chapter 5, followed by conclusions in Chapter 6.

Ⅱ. Domain of Context

This Section is to review the previous research on context and suggest a new our categories of context.

2.1 Previous Research on Context

The concept of the context which is used so far is the condition which is not the justice which has become unity anger from the ubiquitous computing.

The many researchers original justice it became objectivity anger with character, critical defines the concept of context the reading for is steadily advanced.

Schilit and Theimer(1994) refer to context as location, identities of nearby people and objects, and changes to those objects. In a similar definition, Brown *et al.*(1997) define context as location, identities of the people around the user, the time of day, season, temperature, etc.

Ryan *et al.*(1997) define context as the user's location, environment, identity and time. Dey(1998) enumerates context as the user's emotional state, focus of attention, location and orientation, date and time, objects, and people in the user's environment. These definitions that define context by example are difficult to apply. When we want to determine whether a type of information not listed in the definition is context or not, it is not clear how we can use the definition to solve the dilemma.

Other definitions have simply provided synonyms for context; for example, refering to context as the environment or situation. Some consider context to be the user's environment, while others consider it to be the application's environment. Brown(1996) defined context to be the elements of the user's environment that the user's computer knows about. Franklin & Flaschbart(1998) see it as the situation of the user. Ward *et al.*(1997*)* view context as the state of the application's surroundings and Rodden *et al.* (1998*)* define it to be the application's setting. Hull *et al.*(1997) included the entire environment by defining context to be aspects of the current situation. As with the definitions by example, definitions that simply use synonyms for context are extremely difficult to apply in practice.

The definitions by Schilit *et al.*(1994) Dey *et a*l.(1999), Schmidt *et al.*(1999), Dey et al (2000) and Pascoe(1998) are closest in spirit to the operational definition we desire. Schilit *et al.*(1994) claim that the important aspects of context are: where you are, who you are with, and what resources are nearby.

Dey *et al.*(1999) define context to be the user's physical, social, emotional or informational state. Schmidt et al. (1999) define context to be self, activity and environment. Dey et al (2000) define context to be location, identity, activity and time. Finally, Pascoe (1998) defines context to be the subset of physical and conceptual states of interest to a particular entity. These definitions are too specific. Context is all about the whole situation relevant to an application and its set of users. We cannot enumerate which aspects of all situations are important, as this will change from situation to situation. In some cases, the physical environment may be important, while in others it may be completely immaterial. For this reason, we could not use the definitions provided by Schilit *et al.*(1994), Dey *et al.*(1999, 2000), Schmidt *et al,*(1999), or Pascoe(1998).

2.2 Our Categories of Context

The literature review on previous research lead us to categories context into entity and environment (See <Table 2>). Entity is broken down into identity, location, activity and Environment is composed of time and situation.

<Table 2> Categories of Context

Research	Entity			Environment	
	Identity	Location	Activity	Time	Situation
Schilit and Theimer, 1994	√	√	√		
Schilit et al., 1994		√			√
Brown, 1996					√
Brown et al., 1997	√	√		√	√
Ryan et al., 1997	√	√		√	√
Brown, 1997		√		√	√
Ward et al., 1997					√
Hull et al., 1997					√
Franklin and Flaschbart, 1998					√
Rodden et al., 1998			√		
Dey, 1998	√	√	√	√	√
Pascoe, 1998	√				
Dey et al., 1999	√				
Schmidt et al., 1999	√		√		√
Dey and Abowd, 2000	√	√	√	√	

Ⅲ. Roadmap of Ubiquitous Computing

3.1 Previous Research

In order to construct a roadmap of ubiquitous computing, previous research and projects on ubiquitous computing are reviewed.

The first ubiquitous computing was the TRON Project began in 1984 when Dr. Ken Sakamura of the University of Tokyo proposed a large-scale effort to design computer architectures and fulfill the ultimate vision of a "computing everywhere" environment, which is recently acknowledged as "ubiquitous computing" or "pervasive computing." One of the many specifications that resulted from this project, ITRON, has become a de facto standard in the embedded systems market, especially in Japan, where it is widely used in cellular phones and other consumer products (www.embeddedstar.com).

Ubiquitous Computing has roots in many aspects of computing. In its current form, it was first articulated by Mark Weiser in 1988 at the Computer Science Lab at Xerox PARC. He describes it like this:

Inspired by the social scientists, philosophers, and anthropologists at PARC, we have been trying to take a radical look at what computing and networking ought to be like. We believe that people live through their practices and tacit knowledge so that the most powerful things are those that are effectively invisible in use. This is a challenge that affects all of computer science. Our preliminary approach:

Activate the world. Provide hundreds of wireless computing devices per person per office, of all scales (from 1" displays to wall sized). This has required new work in operating systems, user interfaces, networks, wireless, displays, and many other areas. We call our work "ubiquitous computing". This is different from PDA's, dynabooks, or information at your fingertips. It is invisible, everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere (www.ubiq.com).

The Active Badge system provides a means of locating individuals within a building by determining the location of their Active Badge. This small device worn by personnel transmits a unique infra-red signal every 10 seconds. Each office within a building is equipped with one or more networked sensors which detect these transmissions. The location of the badge (and hence its wearer) can thus be determined on the basis of information provided by these sensors (www.uk.research.att.com).

Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of *calm technology*, when technology recedes into the background of our lives. Alan Kay of Apple calls this "Third Paradigm" computing (www.ubiq.com).

For several years, HP Labs has been working at the intersection of nomadicity, appliances, networking, and the web. We called our vision of the future cooltown - a vision of a technology future where people, places, and things are first class citizens of the connected world, wired and wireless - a place where e-services meet the physical world, where humans are mobile, devices and services are federated and context-aware, and everything has a web presence (www.cooltown.org).

EasyLiving (MS, 1995) is developing a prototype architecture and technologies for building intelligent environments. The key features include:

- Computer vision for person-tracking and visual user interaction.
- Multiple sensor modalities combined.
- Use of a geometric model of the world to provide context.
- Automatic or semi-automatic sensor calibration and model building.
- Fine-grained events and adaptation of the user interface.
- Device-independent communication and data protocols.
- Ability to extend the system in many ways.

(research.microsoft.com)

The Affective Computing research group aims to bridge the gap between computational systems and human emotions. Our research addresses machine recognition and modeling of human emotional expression, machine learning of human preferences as communicated by user affect, intelligent computer handling of human emotions, computer communication of affective information between people, affective expression in machines and computational toys, emotion modeling for intelligent machine behavior; tools to help develop human social-emotional skills, and new sensors and devices to help gather, communicate, and express emotional information (www.media.mit.edu).

The Things That Think (TTT) project is based on the idea that everyday objects such as coffee cups, frying pans and toys should use computers to enhance their normal usage. Smart. Things That Think is inventing the future of digitally augmented objects and environments. We bring a unique, boundary-breaking perspective to research, uniting leaders in science, engineering, design, and art. Grounded by extensive corporate sponsor interaction, our prototypes and demonstrations aim to inspire the products and services of tomorrow (ttt.media.mit.edu).

Grid computing enables the virtualization of distributed computing and data resources such as processing, network bandwidth and storage capacity to create a single system image, granting users and applications seamless access to vast IT capabilities. Just as an Internet user views a unified instance of content via the Web, a grid user essentially sees a single, large virtual computer (www-1.ibm.com).

At its core, grid computing is based on an open set of standards and protocols — e.g., Open Grid Services Architecture (OGSA) — that enable communication across heterogeneous, geographically dispersed environments. With grid computing, organizations can optimize computing and data resources, pool them for large capacity workloads, share them across networks and enable collaboration (www-1.ibm.com).

The Smart Dust project is to demonstrate that a complete sensor/communication system can be integrated into a cubic millimeter package. This involves both evolutionary and revolutionary advances in miniaturization, integration, and energy management. We aren't targeting any particular sensor, in fact there is no direct funding for sensor research in the project (but we've got quite a few to choose from based on a decade or two of outstanding MEMS work at Berkeley and elsewhere). We're funded by DARPA, so we will demonstrate Smart Dust with one or more applications of military relevance. In addition, we're pursuing several different applications with commercial importance, and we've got a long list of applications to work on if we only had the time (robotics.eecs.berkeley.edu)

Pervasive computing encompasses the dramatically expanding sphere of computers embedded within and intrinsically part of larger devices. This issue presents an essay and eleven papers on the underlying technologies and the human impact of this field (www.ibm.com).

Ubiquitous networks are an IT paradigm comprising network infrastructures featuring broadband, mobile and constant Internet access, diverse information equipment that provides access to Internet Protocol Version 6 (Ipv6), and seamlessly linked interactive contents (www.nri.co.jp).

Peer-to-Peer (P2P) network where all connected PCs, called clients, can talk to one another directly, without having to connect through a centralised server. Each networked PC can act as a server, providing files and other information to any other computer on the network (www.ipnetworks.it).

Oxygen Project, In the future, computation will be human-centered. It will be freely available everywhere, like batteries and power sockets, or oxygen in the air we breathe. It will enter the human world, handling our goals and needs and helping us to do more while doing less. We will not need to carry our own devices around with us (oxygen,ics,mit,edu).

The Aware Home Research Initiative (AHRI) is an interdisciplinary research endeavor at the Georgia Institute of Technology that addresses challenges facing the future of domestic technologies. A unique and critical resource in this activity is the Georgia Tech Broadband Institute Residential Laboratory, a three-story, 5040-square-foot home that functions as a living laboratory for interdisciplinary design, development and evaluation (www.cc.gatech.edu).

U-commerce is a dynamic convergence of the physical and the digital, the interface of brick-and-mortar commerce with Web-based wireless and other next-generation technologies in ways that will create new levels of convenience and value for buyers and sellers (Accenture, 2001).

The Smart-Its project is interested in a far-reaching vision of computation embedded in the world. In this vision, mundane everyday artefacts become augmented as soft media, able to enter into dynamic digital relationships. In our project, we approach this vision with development of "Smart-Its" - small-scale embedded devices that can be attached to everyday objects to augment them with sensing, perception, computation, and communication. We think of these "Smart-Its" as enabling technology for building and testing ubiquitous computing scenarios, and we will use them to study emerging functionality and collective context-awareness of information artifacts (www.smart-its.org).

Invisible mobile will pick up where *visible mobile* is beginning to show signs of a slowdown. Not only is the visible mobile sector limited by the number of humans, but also by human limitations and the excruciating financial cost of bringing new mobile services to humans (www.forrester.com).

A new technology from Microsoft Research, called Smart Personal Objects Technology (SPOT), implants always-on wireless connectivity in simple accessories from watches to pendants. SPOT will update your watch with the local time and weather wherever you are via a unique identifier in each device (www.microsoft.com).

3.2 Roadmap

According to Oh (2003), platform, network, and applications are three components of ubiquitous computing. The component of interest in each of the previous research/projects is checked in <Table 3>.

<Table 3> Roadmap of Ubiquitous Computing

Year	Research/Project	Platform	Network	Applications
1984~	TRON(Ken)	√		
1988	Ubiquitous Computing (Xerox PARC)	√		
1989~ 1992	Active Badge System (Lancaster University)	√		
1991	Ubiquitous Computing (Weiser)	√		
1993	The Xerox PARCTAB (Xerox PARC)	√		
1994	Cooltown Project (HP PARC)		√	
1995	EasyLiving Project (MS)			√
1995	Affective Computing (MIT Midia Lab)			√
1995	Things That Think (MIT Media Lab)	√		
1997	Grid Computing (IBM)		√	
1998	Smart Dust (Berkeley Univ)	√		
1998	Pervasive Computing (IBM)	√		
1999	Ubiquitous Network(NRI)		√	
1999	P2P e g, Napster, Messenger		√	
1999	Oxygen Project(MIT AL Lab)			√
1999	Aware Home (AHRI)			√
2001	Ubiquitous Commerce (Accenture)			√
2001	Smart-Its (Lancaster, ETH Zurich, Karlsrushe University)	√		

2002	Invisible Mobile(Forrester Research)			√
2002	SPOT(MS)	√		

This roadmap indicates that the area of ubiquitous computing started with the component, platform. Then this area evolved with network, followed by applications. The area is expected to advance with the component, applications.

Ⅳ. CSFs of Ubiquitous Services

This Chapter reviews the previous research on ubiquitous business models and proposes a new C3AT Strategies.

4.1 Previous Research

Kim and Oh (2002) suggests 3Cs + 1T (See <Table 4>) as the strategy of the mobile business. This strategy includes not only the existing 3C but also Technical Aspects.

<Table 4> 3C+1T Strategies

Constructs	**Subconstructs**	***Items***
Cost Leadership	Cost	Contents Fee Packet Transmission Charge Mobile Device Price
Differentiation	Convenience	Timeliness Screen Interface Input
	Contents Character	Exclusivity Personalization Panache Localization Utility Compulsive
	Contents Management	Accuracy Variety, Updatedness
	Technical Aspects	Success in Access/Communication Security, Speed

(Source: Kim and Oh, 2002)

Ebling et al. (2002), Key success factors have the CSFs of the ubiquitous business in generally (See <Table 5>).

<Table 5> Key Success Factors

Key Success Factors	**Explanation**
Synchrony	Applications that base their real-time operation on the present context (e.g., deliver this message to the telephone nearest Andy) will require synchronous operations whereas applications that need to be activated upon a particular context (e.g., deliver this message when Andy is free) will find asynchronous operation more useful.
Privacy	Any service that maintains context information knows much about its subject. Our instincts impressed upon us the need to protect the privacy of context subjects to the greatest possible extent.
Quality of Information	Context information often involves real world entities. Thus, it makes sense to measure the quality of context information (QoI), or the extent to which the data corresponds to the real world. The quality of context information can vary, perhaps substantially, depending on the context source.
Extensibility	Because context-aware computing is relatively new to the computing world, services supporting a general notion of context must be easily extensible to accommodate new and unanticipated sources of context information.
Scalability	We expect it will need to scale to very large numbers of users. Our initial goal is to support on the order of 10 million subjects with as many as 1 million clients active at any given point in time.

(Source: Ebling et al., 2002)

According to Satyanarayanan (2001), the first research thrust is the *effective use of smart spaces.* A space may be an enclosed area such as a meeting room or corridor, or a well-defined open area such as a courtyard or quadrangle. By embedding computing infrastructure in building infrastructure, a smart space brings together two worlds that have been disjoint until now.

The second thrust is *invisibility.* The ideal expressed by Weiser is complete disappearance of pervasive computing technology from a user's consciousness. In practice, a reasonable approximation to this ideal is *minimal user distraction.*

The third research thrust is *localized scalability.* As smart spaces grow in sophistication, the intensity of interactions between a user's personal computing space and his/her surroundings increases.

The fourth thrust is the development of techniques for *masking uneven conditioning* of environments. The rate of penetration of pervasive computing technology into the infrastructure will vary considerably depending on many nontechnical factors such as organizational structure, economics, and business models. Uniform penetration, if it is ever achieved, is many years or decades away. In the interim, there will persist huge differences in the "smartness" of different environments - what is available in a well-equipped conference room, office, or classroom may be more sophisticated than in other locations.

Funk and Christopher (2001) argues that this willingness to pay depends the factors such as accuracy, freshness, scope, initiation time, resolution, and reliability of a Quality of Services (QoS) (See <Table 6>).

<Table 6> Quality of Services

Factors	Explanation
Accuracy	How accurate is the information with regards to world truth? How accurate does it need to be?
Freshness	How old is the information; how fresh does it need to be?
Scope	How much of the range of possible values needs to be conveyed?
Initiation Time	How long does it take to initiate the connection to provide information?
Resolution	How precise does the information need to be?
Reliability	How certain is the information to get through to its receiver complete and intact?

(Source: Funk and Christopher, 2001)

Trevor et al (2002), Usability includes learnability, efficiency, memorability, error handling, and user satisfaction. We primarily concerned with learnability and efficiency, or general ease of use, of our alternative interfaces. Our assumption was that usability would decrease with portability due to the limited displays and input mechanisms provided by portable devices.

Availability, We suspected our embedded interfaces would be more available than our portable interfaces for numerous reasons. First, users might forget to bring their portable device with them, while embedded interfaces are always available at the shared device. Second, portable power sources and networking are far less reliable than embedded power sources and networking.

Privacy means users are comfortable that their sensitive information will not be revealed to others. Because our system displays interfaces derived from a user's recent file activities, it does reveal information regarding what the user has been doing in his or her private office. We assumed that portable interfaces, being smaller and more personal, would provide users a greater sense of privacy.

Trust means users believe their personal data is safe from corruption or misuse. Trust is an import issue for many applications, particularly Web sites seeking users' personal information.

Utility is functionality that users perceive to be useful. Our comparative methodology called for our embedded and portable interfaces to provide the same basic underlying functionality. Thus, we did not expect to find significant differences in utility between the two approaches.

Dey (2000), Accuracy is a type of quality of service metric. Other metrics include reliability, coverage, resolution, frequency and timeliness. The Context Toolkit should be extended to deal with all these metrics.

Reliability defines how tolerant the application is with regard to sensor failures. Usually, application designers will require high reliability. The Context Toolkit deals with reliability by recognizing when components become available or are no longer available, but expects that the sensors can detect their own failures or that Discoverers can. Coverage and resolution are related notions.

Coverage, as described earlier in 6.3.2, defines the set of all possible values for a context attribute, and *resolution* defines the actual change that is required for the context attribute to change. These notions are easily illustrated with location. Suppose we wish to write an application that locates people in a home (as in the Communications Assistant). The required coverage for the location of people is the entire house. A resolution level of "room" is sufficient. Suppose an application is designed to turn on a light whenever people are within 6 feet and to dim it when people are within 9 feet. We need a resolution of at least 3 feet and, at a minimum, a non-contiguous coverage area that includes all 9 feet-radius spheres around fixtures.

Frequency and timeliness determine the "real-time" requirements of the application. *Frequency* defines how often the information needs to be updated. For example, if the application is a driving assistant that helps locate the nearest gas station, it may not make sense to update the location of the vehicle every second. An update every few minutes or under certain conditions detected by the application or other context-handling components (gas tank on empty, children hungry) is sufficient.

Timeliness defines the time the application allows between the actual context change and the related notification to the application. If a person comes close to a light fixture, the light must turn on immediately. However, in the case of the application that locates people in the house, the application may allow a delay of a couple of minutes between the time a person comes home, and its identity is ascertained and known to the application. Once again, designers would ideally specify a zero timeliness but they must be ready to tradeoff with the actual capabilities, and transmission and computation delays due to sensors and distribution.

4.2 C2AT Strategies

<Table 7> summarizes the prior research (e.g., Kim and Oh, 2002; Ebling et al., 2001; Satyanarayanan, 2001; Funk and Miller, 2001; Trevor et al., 2002; Dey, 2000) on the CSFs of Ubiquitous Services.

Based on the prior research, we propose ubiquitous strategies, C2AT.

<Table 7> C2AT Strategies

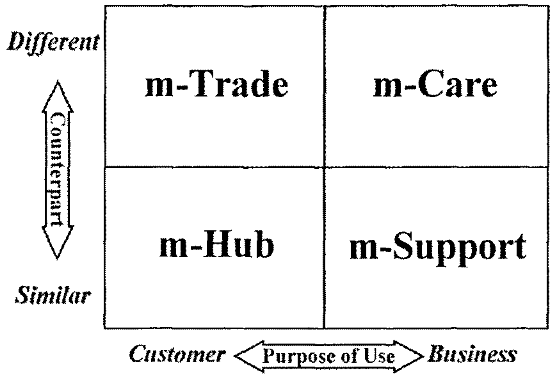
Constructs		Kim and Oh (2002)	Ebling *et al.* (2001)	Satyanarayanan M. (2001)	Funk and Miller (2001)	Trevor *et al.* (2002)	Dey (2000)
Control			-Privacy			-Privacy -Trust	
Cost		-Cost					
Applications	Characteristics	-Contents	-Quality of Information -Extensibility		-Accuracy -Freshness -Scope	-Utility	-Accuracy
	Management	-Technical Aspects	-Scalability	-Effective Use of Smart Space -Localized Scalability -Masking Uneven Conditioning	-Initiation Time -Resolution -Reliability		-Reliability -Resolution -Coverage
Technology		-Convenience	-Synchrony	-Invisibility		-Usability -Availability	-Timeliness -Frequency

V. Services of Ubiquitous Computing

5.1 Previous Research

Kim and Oh(2002) introduces the 2×2 Matrix as a new classification scheme of mobile business(See <Figure 2>).

The X-axis is divided into Business and Customer on the basis of Purpose of Use and the Y-axis is divided into Different and Similar on the basis of Counterpart.



(Source: Kim and Oh, 2002)

<Figure 2> The 2×2 Matrix

According to NRI (2002), Ubiquitous health and security concierge services refer to a system that offers various health and safety related services for our everyday lives very much similar to what is offered by a concierge in a hotel who provides appropriate advice and suggestion in a comprehensive manner according to the situation.

Ubiquitous automobile network systems offer a comprehensive link connecting vehicles, drivers and road administrators on a real-time basis via the network. As such, they assess road conditions as well as deliver the collected information to the road administrators and drivers.

Ubiquitous education and learning systems are intended to provide a network linking individuals, enterprises, universities and schools in order to enable participation in a wide range of educational programs (training, course programs, mock exams, etc.) and prepare for various qualification examinations (See <Table 8>).

<Table 8> Major Services Provided by Ubiquitous Commercial and Public Infrastructure Applications

Applications for the ubiquitous commercial and public infrastructure	Major services and contents		
Ubiquitous health and security concierge systems	Mental and physical care services	Health maintenance and management	• Physical checkups at home ([illegible] healthcare for exercising, automatic analysis of meals and providing advice)
		Support and care for physically and mentally challenged persons	• Monitoring physical condition, remote [illegible] monitoring
		Emergency care	• Emergency notifications (automatic type), emergency notifications (manual type)
		Support for transporting physically and mentally challenged persons	• Ambulant navigation, assistance in transporting disabled persons
	Residential environment care services	Residential environment care services	• Indoor environment control, room temperature and humidity control, indoor nighttime guidance systems
		Crime and fire prevention	• Indoor and outdoor surveillance
Ubiquitous automobile network systems	Service for drivers	Offering spatial and temporal information	• Advanced navigation systems, [illegible] traffic violations, guidance for roads and fuel [illegible]
		Offering vehicle information	• Monitoring and warning of vehicle conditions
		Automatic toll/fee collection systems	• Collecting tolls on roads, collecting various fees
		Providing network contents	• Advertising geared to drivers [illegible], delivering contents such as music and video
		Emergency support	• Car theft warning and prevention systems, traffic accident notifications
	Service for road-related management	Offering spatial and temporal information	• Real-time monitoring of traffic conditions, tolls on roads, management of traffic demand and guidance, prosecuting traffic violations
		Offering vehicle information	• Monitoring road conditions via vehicles, monitoring weather conditions via vehicles
Ubiquitous education and learning systems	Services for learners	Offering learning programs	• Participating in qualification-training programs offered by companies, universities and other schools (in the form of lectures, tutoring services, self-learning, or examinations)
		Support for learning and qualifications training	• Management of personal academic records, tutoring services, Q&A services

(Source: NRI, 2002)

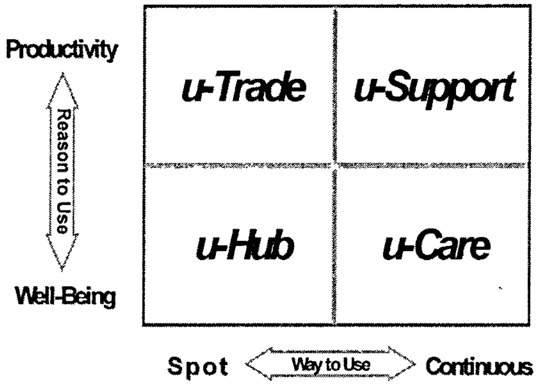
5.2 Proposed Services

In order to develop the classification scheme of ubiquitous services in a systematic manner, the seminal work of Kim and Oh (2002), NRI (2002), and Lee (2003) are analyzed (See <Table 9>).

<Table 9> Services of Ubiquitous Computing

Constructs	u-Services	Kim & Oh (2002)	NRI (2002)	Lee (2003)
u-Trade	Transaction Payment/Advertising Finance Entertainment	Transaction Finance Entertainment Advertising Info service		Sales & Payment
u-Hub	Community UMS Realtimechatting File sharing	Communications		
u-Support	ITS/Telematics Telemetry FFA/Remote Support v-Conferencing	LBS FFA Remote Support Managerial Support	Service for drivers Service for road-related management	Public traffic services Telemetry Telemedicine Industrial applications Fleet management
u-Care	Digital Home HealthCare Managerial Assistance Education Security	Telemedicine Education	Residential environment care services Mental and physical care services Services for learners	Home applications Telematics/In-Vehicle Security and surveillance

Based on the analysis, we develop the u-Matrix as shown in <Figure 3>: a tool that breaks down ubiquitous services into four categories. In the u-Matrix, the X-axis is divided into Spot and Continuous on the basis of Why to Use and the Y-axis is divided into Productivity and Well-Being on the basis of Reason to Use.



(Source: Oh, 2004)

<Figure 3> The u-Matrix

VI. Conclusions

The contributions of this study are fivefold. First, we proposed a framework on ubiquitous computing. Second, the literature review on previous research lead us to categories context into entity and environment. Entity was broken down into identity, location and activity and environment is composed of time and situation.

Third, the proposed roadmap indicated that the area of ubiquitous computing started with the component, platform. Then this area evolved with network, followed by applications. The area is expected to advance with the component, applications.

Fourth, the CSFs of ubiquitous services include cost, followed by convenience, control, Application, and technology.

Fifth, the u-Matrix is a new classification scheme of ubiquitous computing. The X-axis is divided into Spot and Continuous on the basis of Why to Use and the Y-axis is divided into Productivity and Well-Being on the basis of Reason to Use.

Limitation is heavily based on previous literature review, but is not empirically tested.

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