Association for Information Systems

AIS Electronic Library (AISeL)

ICEB 2007 Proceedings

International Conference on Electronic Business (ICEB)

Winter 12-2-2007

Conceptualizing a Knowledge Society in China: A Ubiquitous Network Perspective

Zhu Ge

Sunanda Sangwan

Louis-Francois Pau

Ting-jie Lu

Proceedings of The Seventh International Conference on Electronic Business, Taipei, Taiwan, December 2-6, 2007, pp. 339-344.

CONCEPTUALIZING A KNOWLEDGE SOCIETY IN CHINA: A UBIQUITOUS PERSPECTIVE

Zhu Ge, Nanyang Technological University, Singapore, PG11904143@ntu.edu.sg
Sunanda Sangwan, Nanyang Technological University, Singapore, asunanda@ntu.edu.sg
Louis-Francois Pau, Rotterdam School of Management, The Netherlands, lfpau@rsm.nl
Lu Ting-jie, Beijing University of Posts and Telecommunications, China, lutingjie@263.net

ABSTRACT

Developing Ubiquitous Network Societies (UNS) has been a subject of investigation in last decade. Several policy and technological projects have been proposed and implemented at global level to promote ubiquitous network. This paper focuses on China's preparation towards UNS by analyzing and evaluating the prerequisite technological developments that enable the construction of UNS. The objective of this paper is to identify the notable features of UNS in context to China. Being the nascent area of study our research approach is from technological perspective.

Keywords: Ubiquitous Computing, Ubiquitous Network Society, UNS, China.

INTRODUCTION

Developing Ubiquitous Network Societies (UNS) has been a subject of investigation in the last decade. Several policy and technological projects have been proposed and implemented at global level to promote ubiquitous network. Japan and Korea are considered as pioneers in UNS but most countries including Singapore, Italy and India have incorporated the concept of UNS into their development strategies. Globally many policy and technological projects have been proposed and implemented to introduce the advent of Ubiquitous Network. This paper conceptualizes construction of UNS in context to China by analyzing and evaluating its prerequisite technological and network developments. The objective of this paper is to identify the notable features of UNS from technological network perspective. China has yet to formally embrace the UNS concept as a strategic choice although the National Information Center held a national seminar in 2006 focusing on Ubiquitous Network and IT Development Strategies [1]. Since then the government has begun to realize and recognize the importance of Ubiquitous Network for information oriented development. Broadband adoption is slower than internet adoption but with a target of 200 million internet users by the year 2010, migration to broadband can be expected to grow facilitating the advent of UNS [2]. In this context our research is timely and relevant and provides insights to academics, policy makers and practitioners. Given this is a nascent area of study; our research approach is applied and explanatory to understand the technological context of UNS development. We draw on policy papers, studies in the related fields to identify the characteristics of UNS.

TOWARD A UBIQUITOUS NETWORK SOCIETY

The "Ubiquitous" concept was first articulated by Weiser when he envisioned that interconnected computing devices could be accessed everywhere and used effortlessly and unobtrusively just as the electricity or telephones of today [3]. The notion of Ubiquitous Network was initially brought forward by Murakami in Nomura Research Institute in Japan in 2001. Later he presented his ideas to OECD meeting describing how users can surf the network by suitable terminal equipment anywhere and easily [4]. This prospect was accepted and adopted widely in several countries. For instance, U-Japan (2005) and U-Korea (2004) strategies aimed at developing a ubiquitous society in Japan and South Korea were conceptualized.

The term Ubiquitous Network Societies captures the convergence and connectedness between a number of technological fields as well as their implications for the socio- economic, political and legal aspects of a society [4] [5]. There is no consensus on the term UNS definition. U-Korea document identifies UNS as "a technological society armed with intelligent network, most advanced computing technology and other advanced digital technology infrastructures. In a ubiquitous society, everybody and everything can enjoy the convenience brought by modern information technology". For the purpose of this paper we understand UNS where techniques of wireless communication networks, sensor networks and ubiquitous computing are connected to constructs a society in which everyone can utilize modern information services in a most efficient manner [6]. UNS may be identified by many characteristics and in the next section we examine literature to identify some of the main embryonic features of the UNS.

IDENTIFICATION OF CHARACTERISTIC AND BENEFITS OF UNS

The main characteristic of UNS self-evidently is its ubiquitous nature relating to the ability to communicate for all. It serves users and non-users of telecommunications and the internet services. The latter segment includes senior citizens, children, or even pets [7]. In this sense UNS offers smart and digital homes, provides better solutions to health and nursing problems particularly for the old. Ubiquitous technology will be embodied in the machines so that they can communicate and exchange information [8]. The real physical things are called U-things if they are attached, embedded or blended with computers, networks, and/or some other devices such as sensors, actors, e-tags and so on. Smart u-things are ones that can sense, compute, communicate and take some responsive or automatic actions/reactions/proactions according to their goals, situated contexts, users' needs, etc. For

instance, in digital homes and smart cities, home electric appliance and public facilities are able to communicate collaboratively and process the information invisibly. The National Institute of Information and Communications Technology of Japan have completed a real-life ubiquitous home testbed for home context-aware service experiments in 2004 [9]. Therefore the concept of UNS aims to not only satisfy the need of industrial and economic development but also bring about revolutionary progress for everyday life.

Another major characteristic of UNS is that computers, machinery and networks are invisible and least intrusive or obstructive to the user and the society. More specifically, computers will not appear as computing facilities, but as information facilities in the forms of embedded processors, memorizers, communications modules and sensors put together [7]. These information facilities can compute, communicate and function as sensors, and can be conveniently combined with traditional facilities. They can easily connect with each other or to the Internet. Most of them are embedded facilities as small as the dust floating in the air, namely the smart dust [10]. These are wearable devices and context-aware technologies which make the networks and computing exist everywhere, but people do not sense their existence and need not look for, perceive or control those [11]. In this intelligent network, user experiences the calm convenience brought by networks and embedded mixed reality of activities in the virtual and physical worlds.

Next, UNS is essentially for the service for users. In this sense it qualifies the electronic age where primary focus is on commercial models [12]. This principle is represented by technological humanism and service humanism [1]. It concern with users daily needs and machine, interactions, information dissemination and processing is calm and this is the most profound delineation form our current environments [13] [14]. This service-like access can also be provided by the system without user participation. Thus ubiquitous network will be dealing in information considered private and public [15]. UNS saves people from handling the complicated machines and machine-to-machine based (M2M) daily activities. This influences work efficiencies and other commercial patterns, harmonizing people and their surroundings, promoting the quality of their life and happiness index [5]. They will eventually cause the transformation of the whole society.

The UNS focus is on serving the user and the humankind and its value derives from various benefits it extends to the society. At business level Ubiquitous communication creates new revenue streams. This is relevant for networks and M2M communications especially from data and voice services, on both fixed and mobile networks. Many other industries the retail, logistics, automotive, aerospace and pharmaceuticals stand to derive commercial benefits from UNS. These include a reduction in process costs, inventory, errors, and cycle times; the improved coordination of the supply chain; and monitoring of critical process parameters [16]. This efficiencies and benefits may affect the social systems comprising legal frameworks, usage practices and value judgments. These benefits can be identified as creating an energetic, worry free, convenient and exciting society [17].

Based on the above discussion we identify three main characteristics and benefits of UNS namely universal, calm and user centered. With the perspective of benefits and values extended by UNS, user readiness to adopt ubiquity warrants further investigation.

ENABLERS OF UNS: A TECHNOLOGICAL PERSPECTIVE

Realization of USN is mainly dependent on the technological development of the wireless communication network, perception technology and ubiquitous computing. The first step toward UNS is to construct an omnipresent wireless communication system on the basis of broadband communication network. The technology of wireless network can be classified into four types: Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN), Wireless Metropolitan Area Network (WMAN) and Wireless Wide Area Network (WWAN).

Wireless Personal Area Network (WPAN)

To improve on current data volume and speed related transmission, WPAN is used to replace entities transmission line to make data synchronization and alliance possible between different systems [18]. Such main wireless communication technology as Bluetooth, Ultra Wide Band (UWB), ZigBee and radio frequency identification (RFID) have their own conditions of development, advantages and disadvantages, and existing problems. For instance, currently Bluetooth is the most commonly used WPAN technology for its ability to enhance short distance communication through faster transmission. It is being widely used in mobile telephones, head earphones, cars, computers, family automation and industrial supervision. Bluetooth faces competition from ZigBee in the field of low rate transmitting, and from UWB in high rate data transmitting field and the cost of Bluetooth is comparatively higher.

Ultra Wide Band (UWB) refers to any radio technology with bandwidth larger than 500 MHz or 25% of the center frequency 3.1GHz～10.6GHz. UWB uses nanosecond narrow pulse to launch wireless signal. It has a very wide transmission bandwidth, very low transmission power and a powerful transmitting rate from dozens to hundreds of Mbps. It is suitable for high rate, short distance wireless personal communication and its spectrum can be shared with many other businesses. Although currently, its frequency resource is rather limited, UWB raises a new way of spectrum management and distribution, creating efficiencies in the spectrum [19]. UWB is a type of carrier free communication technology, and it omits the large energy for the launch of carrier. The power consumption of UWB wireless link is only one percent of the general wireless link. This allows the device to work without battery. UWB has a strong ability of anti multi path interference, and is particularly suitable for high speed transmission

in the indoor complex environment. Its current business usage is in printers, digital cameras and other production needing to exchange data with PC. It is considered as a technique for future home-based wireless broadband network [20].

ZigBee is a unified wireless standard mainly used in short distance wireless connection as a simpler and more practical wireless network protocol. It can send and receive electric waves at rate as low as 9.6 kbps. The main technical characteristics of ZigBee are short distance, low complexity, low power, low data rate, low-cost two-way wireless communication technologies. It is primarily suited to auto control, sensing, monitoring and remote control, and so on. It can be embedded in equipment to support Geographic Information System (GIS) even be implanted into the human body to assist medical doctors in monitoring their patients' conditions.(Harsanyi 2000). The systematic complexity of ZigBee is much less than Bluetooth therefore overall cost of the network is relatively low [21]. From this point, ZigBee is very suitable for the network with a large number of terminal equipments, such as sensor networks, smart home. Low power consumption is one of the most important features of ZigBee and experts believe that ZigBee technology will provide the first technology platform from theory to reality of UNS. It formulates the way for the fourth wave of computing technology and ZigBee standards set an application framework for different manufacturers to share network resources for vast commercial prospects.

Radio Frequency Identification (RFID) is a key enabler of the ubiquitous network society [22]. RFID refers to those technologies that use radio waves to automatically identify and track individual items. The unique function of RFID technology is that it can mark anything or anyone in a virtual world from the real world with the function of "marking", "address number" and "sensing". However a typical RFID system generally consists of RFID label (divided into passive and active tag), antenna, reader and the computer system. The price of passive tag has been as low as RMB 1-2 Yuan.

China has opened up the 950 – 956 MHz band for RFID trials. The Standardization Administration of China (SAC) announced in 2004 that it has set up an RFID Tag Standards Working Group to develop China's national standards. The size of RFID market already has exceeded 1.5 billion RMB in 2005, and will grow to 30 billion RMB by the year 2009 by IDC (2006). It is obvious that demand of market and range of application are very large in China. Various personal access and sensor technologies are also under development. China enterprises like Haier Ltd. are also reacting to the trend and design for U-home by intelligent domestic electrical appliances such as refrigerator, air-condition and so on.

Individual consumers are constantly exposed to RFID in action: on toll roads, in offices, and in libraries [23]. Over the next few years, these small tags are expected to be increasingly used at various value adding applications. With wireless systems and intelligent software, RFID has the potential to provide more efficient medical care, increase convenience at points of sale, improve fraud prevention, and streamline business processes by improved visibility and control of supply chain [24]. Near-term growth in RFID use will continue to be driven by business applications with consumer applications growing in the mid to long-term. RFID can bring drastic transformations to a large manufacturing country like China.

Wireless Local and Metropolitan Area Network (WLAN, WMAN)

Compared to personal network (WPAN), local network (WLAN) can provide the more powerful wireless network link capacity, and it could cover a distance of about 100 meters. Recently, the data transmission rate has been increased to higher than 100 Mbps. Similarly Metropolitan Area Network (WMAN) can cover large geographical areas, such as the city or the suburb. Under ideal conditions and without impediment, its highest speed in data transmission and range can reach 70 Mbps and 50 kilometers. Wireless is limited in its frequency range and wire is limitless in its bandwidth. But WiMax as wireless metropolis area network technology addresses some of these problems and is now considered the pioneer in the wireless section of Broad Band [25]. The biggest advantage of WiMax is its high rate of transmission and low cost in building the network. The disadvantage is its low mobility and incompatibility with 2G network, which make it unable to compare with the telecommunication service. Therefore, it can only work as a supplement of 3G. With the development of this technology, its future remains to be observed. In China, China Mobile Ltd has been authorised to construct a WiMAX network for the 2008 Olympics, while China Netcom has announced plans to deploy a rival technology, the Multicarrier Wireless internet Local Loop (McWiLL). McWiLL is based on the SCDMA technology in the 400-MHz band and has been developed by Beijing Xinwei Telecom Technology [26].

Wireless Wide Area Network (WWAN) is the digital mobile communication network used by mobile phones and digital devices and run by the telecommunication operators. It can cover a large area but up to now it has a low transmission rate. Two technologies adopted in WWAN all around the world—GSM and CDMA are predicted to develop widely. Recently, GSM and the relevant wireless digital technologies—GPRS and the new generation of EDGE (Enhanced Data GSM Evolution)—have occupied two thirds of the market in Europe, Asia and North America. The new generation of EDGE can be 3 or 4 times faster than GPRS in transmission. In addition, an extended technology called HSDPA (High-Speed Downlink Packet Access) will be constructed with a transmission rate higher than 3.6 Mbps. The recently proposed "beyond 3G/4G" can provide a data transmission rate as high as 100 Mbps or even higher. It can provide voice to multimedia services including real-time streaming media service. Wireless network and the wired network form the basic network of UNS.

PERCEPTION TECHLOLOGY

Perception technologies are the nerve of the wireless communication network, through which valuable data can be collected. This field relates to wireless sensor network, multi-functional perception, context-aware technology and virtual reality

technologies toward building UNS.

Sensor network is a novel technology about acquiring and processing information. The addition of wireless communication capabilities to sensors traditional functions significantly extends their potential, giving them more autonomy and collaborative potential. The variety of sensors embedded in the network node can measure heat, infrared, sonar, radar and seismic signals in surrounding environments. These networks can detect many physical phenomena including temperature, humidity, noise, light intensity, pressure, soil composition, the size and direction of mobile objects, and so on. For the mode of communication, though there are several choices, like cable, wireless, infrared light and light, it is generally believed that short distance wireless low-power communication technologies are most suitable for sensor networks [27]. China has achieved major progresses in a range of key sensing technologies, including wireless intelligent sensor network telecommunication, micro sensors, sensor nodes, point clusters, and associated applications.

Contexts like gestures, emotions, and situations are very useful when a person interacts with other persons or nearby situation in UNS. *Multifunction awareness* means that computers can interact with humans through using not only keyboard and mouse, but also gestures, facial expressions, voice and other methods. It includes images perception, speech perception, natural language comprehension, body language comprehension and is suitable to the human-centered feature of UNS [28].

Context awareness technology means to automatically provide users with appropriate services (including tasks, location, time, the identity of the user, etc.) in current scenes by using the context information. This relates to the calm characteristic of UNS and improves ease of use. Context awareness technology is the key technology to create intelligent environment. Human-computer interaction or M2M requires that the equipment perceive the context associated with the interaction in the current circumstances, and make a judgment accordingly, then make decisions and automatically provide corresponding services [29].

Virtual reality is an area where perception technology and computer technology are used to generate a simulated three dimensional visual, auditory, olfactory, or tactile world. Users can then do some browsing and interactive inspection to the virtual world from their perspectives. Its main characteristics can be attributed to immersion, interaction and imagination. Application area driving this technology include the computer games industry, e-commerce (desire for talking heads type presenters), virtual environment researchers seeking dynamics, and artificial intelligence researchers seeking good testbeds. An agent must have emotion to be believable because humans have emotions. Currently, virtual reality technology is being been used in scientific research, product design and manufacturing, military training, incident simulation and other fields. Japanese DoCoMo is already able to do the scene show when combined with the communication technology [30]. It is believed to enter human's daily life in future.

UBIQUITOUS COMPUTING

Ubiquitous computing is the origin of UNS. It embodies the basic conception of "U" as the core technique for UNS implementation. It changes the traditional way of computer operation but adopts the mode of "computer at people's service" [3]. In terms of construction of UNS, on one hand, there are countless terminals; on the other hand, each terminal has limited calculating performance for its small capacity. Therefore distributed computing, such as grid computing and Peer-to-Peer computing needs to be involved. In addition, the mobility of these terminals makes motion computing available such as agent, adaptation strategy and so on.

Distributed computing is a method of computer processing in which different parts of a program run simultaneously on two or more computers that are communicating with each other over a network. However, the technique emphasizes the integration capability that mainly targets Client and Server computing and focuses on the terminal uses. Grid computing and Peer-to-Peer computing are also major distributed computing styles. Grid Computing pays more attention to the large-scaled information share, creativity use and high performance computing. It is a cooperative information share and problem solving between mobile multi-frameworks, numerous organizations. Peer-to-Peer computing utilizes the brink sources of Internet such as memorizer, CPU, and human and computes on the Internet [31]. Each computer is taken as one peer: terminal, server or router and all the peers can share the information on the internet, information processor, and information storage and so on. Peer-to-Peer is a dispersive and ad hoc network system which weakens the central server but emphasizes the function of the individuals in UNS.

To conclude, due to their compatibility certain degree of competition exists in these technologies, but UN technologies will continue to co-exist and complement for the benefit of the whole structure. Constructions on network base and technology base are well under way in China and some key technologies such as Micro-Electro-Mechanical Systems (MEMS) are at par with international levels.

UBIQUITOUS NETWORK IN CHINA

Although China did not formally extended the concept of UNS until the National Information Center held a seminar called "Ubiquitous Network and IT Development Strategies of China" in 2006. The government then recognized that the importance of Ubiquitous Network for information-oriented development. The construction of Ubiquitous Network base has been in the pipe line and some key technologies such as MEMS are advance as international level. Over the past two decades, China has built a national transmission backbone network consisting of eight "vertical" and eight "horizontal" transmission backbones

sub-networks that cover the whole country. Following Next Generation Networks (NGNs) and Internet Protocol (IP) based networks, the ChinaNet Next Carrying Network (CN2) began initial services in 2004. This is the largest commercial network in China and aims to become the largest IPv6 network for commercial use in the world. Further, acceleration of competition in China's telecom industry through 3G licensing is aimed to propel building UNS. China has announced its own national standard for RFID, in the 900 MHz band. In December 2006, Automatic Identification Technology Association (AIM China) formally released nine Association standards, such as labels and readers. This should facilitate the adoption of UNS but a variance in standards may also be a challenge to its development.

There are more than 880 million telephone users in China, including 372 million fixed-line phone users and 508 million mobile phone users [32]. The large numbers of telephone subscribers are the potential strength for broadband adoption which activates the coming ubiquitous network application. The demand from users is evident especially in megapolises.

Technological, market and user's demand perspective indicates that construction of UNS in China is feasible and inevitable. China government is now actively making out the long-term U strategy. We recommend the following to accelerate UNS construction:

1. Support UNS by making information development strategies and relevant polices; propose U plans for metropolises and industries according to China's conditions; propose information strategies such as U-China which will accelerate the progress of China's UNS.
2. Intensify the research on Ubiquitous technology, program the application of wireless frequencies, actively participate in the discussion and establishment of the relevant technology standard and obtain China's own knowledge property rights by learning from the current international standards.
3. Quicken the construction of the seamless ubiquitous network and provide a fine industrial environment for the providers of ubiquitous technology.
4. Promotion of advanced use of UN in business and daily living in a creative way. The government could use ubiquitous network to resolve social problems. On the other hand, it is necessary to study the changes in social life which will be brought about by UN; Focus on putting forward solutions to the problems such as network safety, privacy and vicious information, both technologically and legally.

REFERENCES

[1] Liu Libo. "Entering a new era of ubiquitous network", *Journal of MoneyChina*, http://magazine.moneychina.cn/d/2006 /12/15/1166161316469.html.

[2] Feng Xiaofang. China's number of netizens reaches 144 million; 97 million are broadband internet users. *XinHua Net*. http://www.sinofile.net/saiweng/sip_blog.nsf/d6plinks/YZHI-73E3MQ.

[3] Weiser M. (1991) "The computer for the 21st century", *Scientific American*, Vol. 265, No. 3, pp. 94-104.

[4] Murakami, Teruyasu (2001) "The Network for the 21st Century". *Paper presented to OECD General Assembly Meeting*.

[5] Murakami, Teruyasu (2004) Ubiquitous Networking: Business Opportunities and Strategic Issues. *Nomura Research Institute*.

[6] Gadzheva Maya (2007) "Privacy concerns pertaining to location-based services", *Intercultural Information Management*, Vol. 1, No. 1.

[7] Gellersen H W, Schmidt A, Beigl. M. (2000) "Adding some smartness to devices and everyday things", *Third IEEE Workshop on Mobile Computing Systems and Applications. New York: IEEE*.

[8] Ponekanti S. R., B. Lee, A. Fox, P. Hanrahan, T. Winograd. (2001) "*ICrafter: A service framework for ubiquitous computing environments*", *Proc. of UbiComp*, pp 56-75.

[9] Yamazaki, T. (2005) Ubiquitous Home: Real-life Testbed for Home Context-Aware Service. *Tridentcom2005, pp. 54-59*.

[10] Warneke B, Last M, Liebowitz B, Pister KSJ. (2001) Smart dust: communicating with a cubic-millimeter computer. *IEEE Computer Magazine*, Vol. 34, No. 1.

[11] Mann, Steve and Niedzviecki, Hal. (2002) "Cyborg: Digital Destiny and Human Possibility in the Age of the Wearable Computer, *Toronto: DoubleDay Canada*.

[12] Nardi, Bonnie and V. O'Day. (1999) *Information Ecologies: Using Technology with Heart*, Cambridge: MIT Press.

[13] Galloway Anne (2004) "Intimations of Everyday Life: Ubiquitous computing and the city", *Cultural Studies*, Vol. 18, No. 2/3, pp. 383-407.

[14] Weiser. M, John Seely Brown (1999) The coming age of calm technology. *Xerox PARC*.

[15] Raento M, Oulasvirta A. (2005) Privacy management for social awareness applications, *IEEE Pervasive Computing*.

[16] ITU Background Paper (2005) Ubiquitous Network Societies: Their impact on the telecomunication industry.

[17] Anonymous (2004) "Building a ubiquitous network society that spreads throughout the world", *Information and Communications in Japan*.

[18] Dow S, T. S. Saponas, Y. Li, and J. A. (2006) "Landay External representations in ubiquitous computing design and the implications for authoring tools", *Proceedings of the Conference on Designing Interactive Systems (DIS'06)*, pp. 241-250.

[19] Cuomo F, Martello C, Baiocchi A. (2002) "Radio resource sharing for Ad Hoc networking with UWB", *IEEE Journal on Selected Areas in Communications*, Vol. 20, No. 9, pp. 1722-1732.

[20] Nakagawa M, Zhang H, Sato H. (2003) "Ubiquitous homelinks based on IEEE 1394 and ultra wideband solutions", *IEEE Communications Magazine*, Vol.41, No. 4, pp.74-82.

[21] Pekhteryev G., Sahinoglu Z., Orlik P., Bhatt i G. (2005) "Image transmission over IEEE 802.15.4 and ZigBee networks", *IEEE International Symposium on Circuits and Systems (ISCAS 2005)*, Vol. 4, pp. 3539-3542.

[22] Srivastava Lara. (2005) "Ubiquitous Network Societies: The Case of Radio Frequency Identification, background paper", *ITU Workshop on Ubiquitous Network Societies*, March 2005.

[23] Weiss S. (2004) "RFID privacy workshop: concerns, consensus, and questions", *IEEE Security & Privacy*, Vol. 2, pp. 48-50,.

[24] Gao X.G., Xiang Z., Wang H. and Shen J., Jian Huang, Song Song. (2004) "An approach to security and privacy of RFID system for supply chain", Proc. *IEEE International Conf. E-Commerce Technology for Dynamic E-Business*, pp.164-168.

[25] Yano K, J. Kawakami and K. Homma (2005) "Evaluation of the countermeasure for flaming problem on the regional network community service", *IPSJ (Information Processing Society of Japan) Journal*, Vol. 146, No.3.

[26] Future Forum. Netcom surrenders right to build WiMAX network to China Mobile (2007), http://www.future-forum.org/en/print.asp?id=1083.

[27] Heinzelman W, Chandrakasan A and Balakrishnan H. (2000) "Energy efficient communication protocol for wireless microsensor networks, *Proceedings of the 33rd Hawaii International Conference on System Sciences. Maui: IEEE Computer Society*, pp. 3005-3014.

[28] Brezillon Patrick (2003) "Focusing on context in human-centered computing", *IEEE Intelligent Systems*, Vol 18, pp. 62-66.

[29] Gilles Private (2005) "Smart Devices: New Telecom Applications & Evolution of Human Interfaces", *Keynote presentation at CASSIS Int'l Workshop, Nice*, March 2005.

[30] Tetsuro Ogi, Koji Yamamoto, Toshio Yamada, Michitaka Hirose (2001) "Experience of Immersive Virtual World Using Cellular Phone Interface", *Springer Berlin/Heidelberg*, Vol. 2195/2001.

[31] Stoica I, Morris R, Karger D. (2001) "Chord: a scalable peer-to-peer lookup service for Internet applications", *Proceedings of ACM SIGCOMM 2001*, August, San Deigo, CA, pp. 149-160.

[32] iResearch (2007) http://english.iresearch.com.cn/html/wireless_service/detail_news_id_8602.html