Ubikids - A Ubiquitous Smart Hyperspace for Kids Care

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Abstract

Following ubiquitous computers (UC) and ubiquitous networks (UN), is a road towards ubiquitous intelligence (UI) or a smart world (SW). This is a collection of smart hyperspaces consisting of interconnected smart spaces or environments including smart objects embedded or attached with small or tiny networked computers/processors. Ubikids is an on-going project aimed to build a ubiquitous smart hyperspace to assist parents, provide them more convenience, be more prompt, reliable, precise, and with the option to remotely take care of their kids. This article describes our visions, motivations, approaches, design issues, problems and so on regarding the project Ubikids.

1. Introduction

The ubiquitous computing (ubicom) field has been going on for about one and a half decade since it was first proposed by Weiser around 1990 [1,2]. Since 1999, it has been also called pervasive computing (percom) by IBM [3,4]. Although many new terms of computing, e.g., invisible computing, disappearing computing, wearable computing, proactive computing, autonomic computing, everyday computing, sentient computing, amorphous computing, ambient intelligence, palpable computing and so on, have evolved since 2000, they can be regarded as something derived from ubicom with some special emphasis on or extensions of some aspects in the broad 'ubiquitous' frontier.

The ubicom or percom research wave can be divided into several phases. The first phase, i.e., from when it started to the end of the last century was characterized by making some samples of smart objects and building few prototypes of aware spaces. The second phase which started from this century is the spread of smart objects and spaces along with the rapid development of ubiquitous computers (UC) and ubiquitous networks (UN). We are still at the second phase. Surely, more and more smart spaces will appear in the next few years. These spaces are currently isolated and look like small islands in an ocean. The third phase which is still to appear, we believe, will be to first interconnect some smart spaces together to form a smart hyperspace, and then integrate all the smart spaces and hyperspaces, as well as the cyberworld to create the smart world (SW), which will be mainly characterized by ubiquitous intelligence (UI).

It is often very hard to develop a smart space as compared with making a web or a conventional distributed application. Further, it is much harder to build a smart hyperspace since its characteristics are not yet clear due to the lack of such available systems at present and many new challenging issues have arisen. A critical issue facing the application of a smart system into practice is the users' concern of privacy [5], which is closely related to but beyond the security of conventional information systems. Although the privacy problem can be solved to some extent within the next few years, the research on smart space and hyperspace should go on without the need to wait for its complete solutions. Actually the right way, we believe, is to challenge the privacy issue along with the development and deployment of smart systems and applications.

Considering both the difficulties in development and privacy issues, our initial fundamental strategy to start the research on smart world is to choose a proper application that covers several closely related spaces to form a representative smart hyperspace, and whose privacy requirements may not be so critical in the beginning but can be gradually improved during its development process and practical use. The kid's care is such an area in ubiquitous applications. This is because, (1) taking care of kids not only exists inside the home but also in other spaces including the yard, road, park, car, etc., which should be virtually linked together so that parents can remotely take care of them; (2) the privacy is not a serious problem due to the special relationships between parents and their young kids.

An interesting survey recently made by [6] reported that 72.5% parents worried about their kids, 82.3% parents felt tired in caring kids, and 91.9% parents had no enough time to satisfactorily take care of their kids. Even so, the unexpected things sometimes happen and small accidents often occur. The kids care, as one important human activities, looks too trivial to be ignored, and they should actually whenever possible, be well supported via ubicom technologies.

Furthermore, although kids are enjoying the fruits of developments brought by IT, i.e., mainly digital games and animations, they have not been specifically treated and well researched as one independent group of important users in most computing fields. Computers and their corresponding environments were originally designed for experts and then moved to ordinary people, mainly adults. We are pleased to know that an international workshop on Interaction Design and Children (IDC) which was first held in the Netherlands in 2002, is now an international annual conference [7] in cooperation with ACM SIGCHI. The IDC themes are nice but are limited and currently without emphasis on the impacts of ubicom. Kids should be studied more widely and should also greatly benefit from computer technologies, especially ubicom.

Based on the above fundamental ideas, we have launched the project Ubikids to build a ubiquitous smart hyperspace to assist parents, provide them more convenience, be more prompt, reliable, precise, and with the option to remotely take care of their kids. Ubikids will be able to actively anticipate parents' and kids' needs to provide automatic and even proactive services while knowing and adapting to the rich dynamic contexts of parents, kids, physical environments and the digital world. Through our research in building the hyperspace, we also intend to deeply probe the questions in smart space integrations and contribute to the coming of the third phase of ubicom wave, i.e., the smart world. In the following sections, we will first describe the Ubikids characteristics and functions, then discuss its conceptual design and important non-technical factors, and finally our concluding remarks and future work.

2. Ubikids: assumptions and characteristics

Recently, there have been many ubiquitous applications developed or under development, such as the health monitoring for the elderly, home media appliance management for adults, learning support for students, location-aware mobile service for customers, etc. However, as to our knowledge, there are only very few ubiquitous research for kids. From our current survey, Ubikids seems to be the first project specially focused on kids care, which somehow looks simple but actually involved a series of hard issues, such as knowing where the kids are, what they are doing, when do they need help, and how to optimally help them, etc. Many similar theoretical and technical issues in other ubicom systems will certainly exist in Ubikids.

First, it is necessary to have some basic assumptions in creating the Ubikids environment so as to avoid unnecessary confusions and make its development contexts clear to some extent. Another objective is to reasonably limit the scope of users and spaces so that complexities of the system design can be manageable and its development can be carried out step by step. After explaining these assumptions below, the basic characteristics of Ubikids will be given in the rest of this section.

2.1 Basic assumptions

We assume that Ubikids is aimed at two classes of users, i.e., parents and kids. There are usually two parents (father and mother) and one or more normal children. A family with a disabled member may have a stronger need to use such kids care system, but this case will not be studied in the current stage since extra medical or health cares are necessary. Ubikids can be used for a single parent family, but this will not be treated as a typical case in our research. At the moment, a family with grandparents, a nurse or a housekeeper in the household is not taken into account. In our model, at least one parent has a job at some working site, perhaps with certain distance from home.

The kids' age ranges from 2 to 12 years old. Although some Ubikids functions can be used for taking care of babies less than 2 years old, they will not be particularly focused on since special cares are needed for them. Children over 12 are usually able to manage their daily lives without permanent and very frequent parents' attention. They start to have their own way of thinking and privacy, and may not feel happy if they are always being watched by parents. Kids in Ubikids are roughly divided into three groups: 2-5 years old, 6-8 years old and 9-12 years old. The kids' characteristics and the ways of caring them changes very much for kids in different ages. Some may disagree on this group division and would probably prefer some finer division. Any opinion on this should be respected, where the point is its value in designing and building a kids' care environment.

Ubikids, as a hyperspace, must include a set of smart spaces. Currently, the possible spaces are the home, road, park, office and car, etc. Parents and kids may or may not be at the same place. In an extreme but typical case, the father is at the office, the mother is doing shopping, the daughter is reading a book at home and the son is playing in the yard with his friends.

The great heterogeneity in kids care exists widely in different families, countries, cultures, etc. In the preliminary stage of Ubikids, our research is mainly focused on kids' care styles and its corresponding functions for the typical Japanese families. We expect more and more researches from people all around the world in this area so that a variety of kids care technologies and spaces can be created to adapt to this heterogeneity.

2.2 Basic characteristics

The two fundamental characteristics of Ubikids are:

- Targeting kids care with multi functions
- Emphasizing integration of multi smart spaces

These will be explained, respectively, in the following.

2.2.1. Targeting kids care with multi functions.
Ubikids functions are divided into three categories:

- Kids Awareness -- space eye/ear
- Kids Assistance -- space mouth/hand
- Kids Advice -- space brain/head

Thus it is characterized by **3A**, which can be seen as space perception organs (eye/ear), space motion organs (mouth/hand) and space thinking organs (brain/head).
The kids awareness functions are for parents to know the kids contexts, such as location, activity and states. The above contexts are physical information related to kids. Mental and emotional information is much harder to capture, and will not be studied at the moment although they are very interesting and useful. The context is a term with broad meanings referring to some states and situations of a human, animal, plant, natural object, artifact, virtual thing and so on as well as their spatial, temporal, social and other relations in both the real physical world and the virtual cyberworld. To be simply understood, the context can be regarded as 5Ws, i.e., who, where, when, what and why [8]. The kids assistance functions are for helping kids to do something, such as finding a toy, looking for a parent, adjusting light brightness for a kid who is reading, guiding a kid on the road, etc. The kids advice functions are to give prompt advices and reminders to kids and/or parents when necessary, such as an umbrella reminder, giving advice to keep quiet, recommending a care approach, etc. These functions often need more contexts, perhaps including all '5Ws' plus 'how'.

2.2.2 Emphasizing integration of multi smart spaces

Lots of research on aware/smart spaces have been made. Such research can be traced back to Boulder's Adaptive Home in 1993 and Buxton's Reactive Environment in 1995. In the late 1990s, several famous research projects were developed such as Georgia Tech's Aware Home, Inria's Smart Office, Stanford's iRoom, H-P's Cool Town, etc. A broad vision on the future smart space was called ambient intelligence or AmI [9] by ISTAG, European Community, in 2001. The AmI refers to electronic environments that are sensitive, adaptive and responsive in the presence of people. More smart spaces are expected to appear in the next few years. However, almost all of them are limited on a single well defined space, such as home, office, laboratory, floor, library, hospital, car, and so on. As argued in the previous section, it is very important and necessary to integrate these isolated spaces together to form a hyperspace. Due to the existence of multiple spaces in kids care, the Ubikids project naturally offers a good chance to study how to integrate spaces together.

3. Ubikids: conceptual system design

Ubikids is a completely new type of system, which we have no experience in building before. It is a long term project, and its research will be divided into several phases. In short, we will make it clear what exactly the system is all about as compared to others, what are the special research issues and models, how to make some sample kids care applications, etc.

3.1. System organization

Figure 1 is a conceptual organization of the Ubikids system.

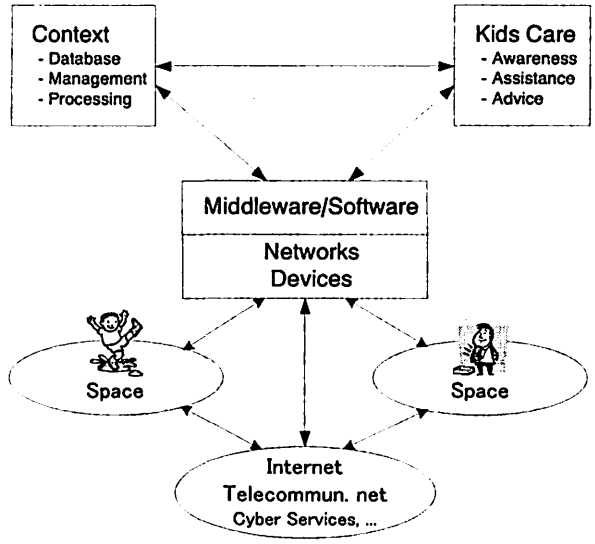

Fig. 1. Basic system organization.

In a ubiquitous smart system, there are often many devices that are distributed to spaces, real objects and users. Some devices are immobile while others are mobile. Their sizes range from very small ones like smart sensors [10] and RFIDs [11], to middle ones like PDAs, cell phones and RFID readers, to large ones like laptops and PCs. Devices will be organized into groups according to their types and purpose, and each group of devices are connected by some wired or wireless network. Several or more networks often co-exist in the physical spaces for a ubiquitous system with multiple functions like Ubikids. These networks should not interfere with each other.

To control these devices and process the data from them, software platforms are necessary. Such software may be device or network dependent, and different programming languages may be used for the low level programming on these devices and networks. The middleware is for hiding the details of the

device/network's dependency on hardware/software to provide relatively more general programming frameworks and environments in developing ubiquitous systems or applications.

The context is a necessary and fundamental part of a ubiquitous smart system and its existence as one of the basic components is greatly differentiated from conventional computing systems. The key issues related to the contexts are how to process the raw data from devices, manage the context information from different sources, and to keep the information into some kind of database for meeting many usage requirements.

3.2. Interactive versus proactive mechanisms

Many current computers and related technologies have been made based on interactive mechanism, i.e., a process of request and response dialogs between human and computer. In this mechanism, a user give commands via some input devices, and receive replies from some output devices. The user is often an activator of a sequence of computer and network actions, and the computers/devices plays relatively passive roles. In contrast to this, the proactive mechanism is to make computerized systems more active and they may decide by themselves to take some actions by anticipating the users' needs with reference to the rich contexts. Both interactive and proactive mechanisms are needed in Ubikids, but our emphasis will be on the proactive mechanism since it is one of the main basic characteristics of ubicom systems as compared with conventional systems.

To be concrete, let's check the kids care functions. For an interactive kids awareness system, a parent is able to freely choose a convenient machine and tool to access the system. Once receiving the parent's request, the system will send a kid related information (location, activity, state, etc.) to the parent. Such system is always ready to serve parents' requests, but never actively interrupts parents. For a proactive kids awareness system, it will first receive some rules or policies from parents, and then start to monitor both the kids and parents as well as their environments. When some events related to kid happens, the system will check if such an event is necessary to be sent to parents or not based on the pre-defined rules and policies. If not, it either ignores the event or saves it into the space database for possible utilizations later. If yes, the system needs to further detect the parents' contexts, and then decide a suitable device/tool and presentation style to inform one or both parents in a good location/situation at the right time. Once a parent gets the information, he/she may send other requests interactively to the system if more information is needed.

This principle is also applicable to the kids assistance and advice functions. For example, the function of a toy finder will be perhaps interactive, and the function of a light adjustor to be proactive. Many functions in the kids advice will work more likely in the proactive mechanism. Not only in the system functional designs, but also many other parts in Ubikids should follow the same principle.

3.3. Devices and networks

It can be seen that many new devices are needed for our system. Each conventional computer devices, such as disc drivers, printers, audio players, digital cameras, cell phones and so on, can do one or multiple tasks. However, a single sensor or RFID may not be able to do a whole task by itself alone. For example, detecting a user's location at home can only be accomplished by a group of sensors, which form a task oriented net and a dedicated distributed system. Therefore, in a smart space there may be multiple and different dedicated nets for connecting different types of devices. The conceptual network architecture in a space is proposed as shown in Fig. 2.

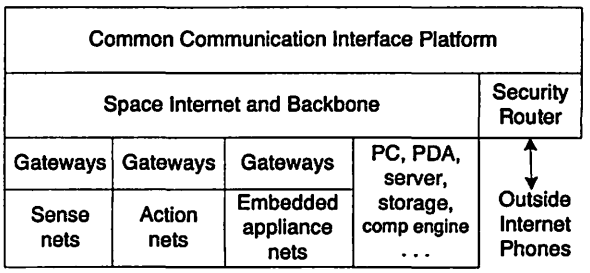

Fig. 2. Concept network architecture in a space.

Each sense net interconnects a set of sensing devices, which collect low level context data from an environment or a user in a space. The possible classes of sense nets related to Ubikids are:

① sensor net to acquire ambient contexts, e.g., light, temperature, humidity, pressure, object movement, velocity, acceleration, etc., via sensors
②RFID net to sense and identify objects
③some other net for indoor positioning
④GPS net for outdoor positioning
⑤camera net to capture visual information
⑥microphone net to capture audio information
⑦bio-sensor net to get human psychological or measure medical data

For each action, the net interconnects a set of actuation or controllable devices whose states and/or working behaviors can be remotely operated by programs. The following are examples of the action nets:
①light control net
②temperature/humidity control net
③door/window control net
④home appliance control net

⑤speaker net distributed over spaces
⑥display net for connecting various displays placed or hanged somewhere in a space
⑦bio-actuator net

Some devices may include both a sensor and an actuator. Such an example is a camera with zoom and tilt controls by electric signals. Many new types of micro-machines including both sensing and actuation functions will soon appear by using MEMS/NEMS. Those devices may use two separate nets for sensors and actuators, or share one net by both of them. For many of these devices, it may be difficult or unnecessary to embed a full functional system chip which will be able to install general OS and run rich software. Special communication technologies and low level programming environments are often used for connecting those devices. A particular device such as a RF reader is needed to interact with them and also connect to a high level network. Some Bluetooth and Zigbee enabled devices are expected to be utilized.

A variety of electricity power line networks, such as CAN, CEBus, LonWorks, X10, etc., have been used for home networking in European and North America countries in recent years. Similar power line networks have been also developed in Japan, but it is said that their practical uses are prohibited due to some Japanese laws. The BAN (body area network) possibly used for human wearing devices (not depicted in Fig. 2) may be used in our future system. To make communication protocol conversions between different networks, a number of gateways are often necessary. A gateway may also play a role of device management.

Small computer systems can usually be embedded into many home/office appliances such as printer, TV, DVD/MD player, refrigerator, etc. These embedded systems are powerful to run a variety of software. All of UPnP, Jini, OSGi, Salutation, SLP, Bluetooth SDP, WSDL/UDDI and so on are targeted for this. The home appliance net will not be our research focus, but the above related networking technologies, generally called service oriented architecture, may be useful in our system.

All of the above nets need to be further interconnected to form a space internet. Conventional PC, PDA, server machine, large data storage device, space high performance computational engine and so on will also connect to the space backbone network directly or indirectly. It is however unclear yet which network will be chosen as a backbone which is suitable for such interconnections of a variety of different physical nets. Perhaps a high speed network is required for a home as there are many different media data from various sources with diversed requirements. However, for some space such as inside a car it will be enough to have a reasonable bandwidth network, e.g., Bluetooth. The space internet is often necessary to link to the Internet via a router.

By means of all the physical networks and the space backbone, all the devices are theoretically connected with each other. To let them really work, a common communication interface platform is necessary to enable all devices to be uniformly addressable, discoverable, communicable, manageable, programmable, etc. It is a key but hard issue to have such a platform. The issue is related to handling interoperability, scalability, heterogeneity, integration and transparency among different devices, networks, software, service architectures, etc.

4. Non-technical factors

Due to the very close and complex relationships between human and smart spaces as compared to those between human and desktop computers, the non-technical factors become more and more important in ubiquitous smart spaces [12]. Technology-oriented research is necessary, but far not enough to successfully create truly practical ubicom environments. Non-technical factors of human, society, culture, psychology, moral, feeling and so on should also be taken into account in designing and implementing smart spaces. Ubikids are related to the following issues:

- ✧ Common characteristics shared by many kids
- ✧ Special characteristics for individual kids
- ✧ Characteristic changes along with growing kids
- ✧ Relationships and roles of family members
- ✧ Features of kids care activities
- ✧ Heterogeneity in kids cares
- ✧ Culture and law in kids care
- ✧ Psychological behavior in a smart space
- ✧ Child's personality development
- ✧ Child's habit and moral cultivation
- ✧ Child's independence improvement
- ✧ Child's intelligence increase
- ✧ Feeling/love enhancement of parents-kids
- ✧ ...

The study of the above non-technical factors must be taken from the grounds of wide and deep knowledge in child psychology [13], physiology [14], behavioral science, education, etc. Parent psychology, whenever available, will be needed as well. It is such knowledge that can give us real insights on the non-technical issues and lead our research into truly valuable and trustworthy Ubikids applications.

5. Concluding remarks and future work

Beyond PCs or computerized games, kids are definitely an important group of ubicom users. Kids learn from their everyday interactions with the environment including objects, toys, surroundings, parents, teachers, friends and

others. During their growing process, the environment plays very important roles in forming their characteristics, behaviors, habits, personalities and so on, which may largely influence the rests of their lives. Children are the future of human beings. Both positive and negative impacts of ubicom on kids need to be seriously and deeply investigated, and solutions to overcome the negative aspects must be discovered. This article is mainly for raising important issues in building a ubiquitous kids care application rather than providing the solutions.

The followings are our future research challenges, which will be conducted step-by-step in a long term basis in the next few years.

- Smart space management – S2M
- Smart space proactive behavior – S2P
- Smart space networking - S2N
- Smart space security – S2S
- Smart space interface – S2I
- Smart space collaboration - S2C
- Smart space database - S2D.
- Smart space engineering – S2E
- Smart world framework
- Personal and social issues in smart spaces
- Impacts of smart spaces on kids' growth
- Relations between real and virtual worlds

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