Overview of Human-Centric Computing

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Human-Centric Computing is a new technology paradigm in which computing resources are provided to humans anywhere and at any time in accordance with their circumstances. By shifting the paradigm from technology-centric to human-centric, new value will be created in the real world and large markets are expected to be developed in areas where information and communications technology (ICT) has yet to reach. Based on this new vision, Fujitsu is conducting research and development, vertically integrating mobile terminals and the cloud, so as to provide adequate services to humans anywhere and anytime in a natural way. This paper describes the aim of Human-Centric Computing and three fundamental research activities: context-aware service, multi-device collaboration and human interaction technologies.

1. Introduction

Information and communications technology (ICT) has been constantly progressing at a rapid pace but it cannot be said that everybody is fully enjoying the benefits it offers. In many cases, companies have implemented automation only where it is easy and things that really need automation are not sufficiently automated. In addition, inadequately introducing computerization has often turned out to cause an increase in workload, resulting in systems that are unfriendly to users. It is now important to reappraise the technologies from a human-centric perspective and to provide human-centric ICT systems that are readily accessible from any workplace including those that have lagged behind in computerization.

2. Aim of Human-Centric Computing

Figure 1 depicts the aim of Human-Centric Computing. In everyday life, people move around various places and receive services that vary depending on the places. In this process, they are not interested in where the information is and where it is implemented, but should be satisfied as long as processing takes place somewhere around them and appropriate services are always offered in a natural manner. The concept of being human-centric goes one step further than the existing cloud services, in which data centers are remotely accessed. It combines terminals and data centers to realize an infrastructure for constantly offering appropriate services in a natural way in all places where people engage in activities.

This idea is represented from the perspective of evolution in a mobile service environment in **Figure 2**. In the conventional mobile environment, people used services while specifying and switching URLs with mobile phone handsets. With the advent of smartphones, services are now available via applications on handsets. Still, there has been no change to the way people use various services and messaging methods (such as e-mail, Web, Twitter and

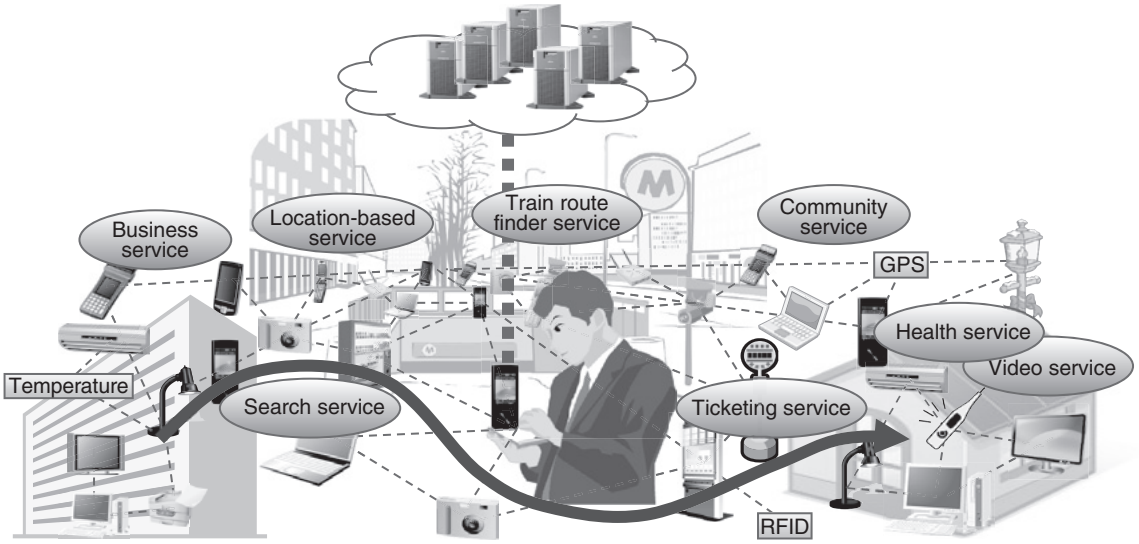

Figure 1
Aim of Human-Centric Computing.

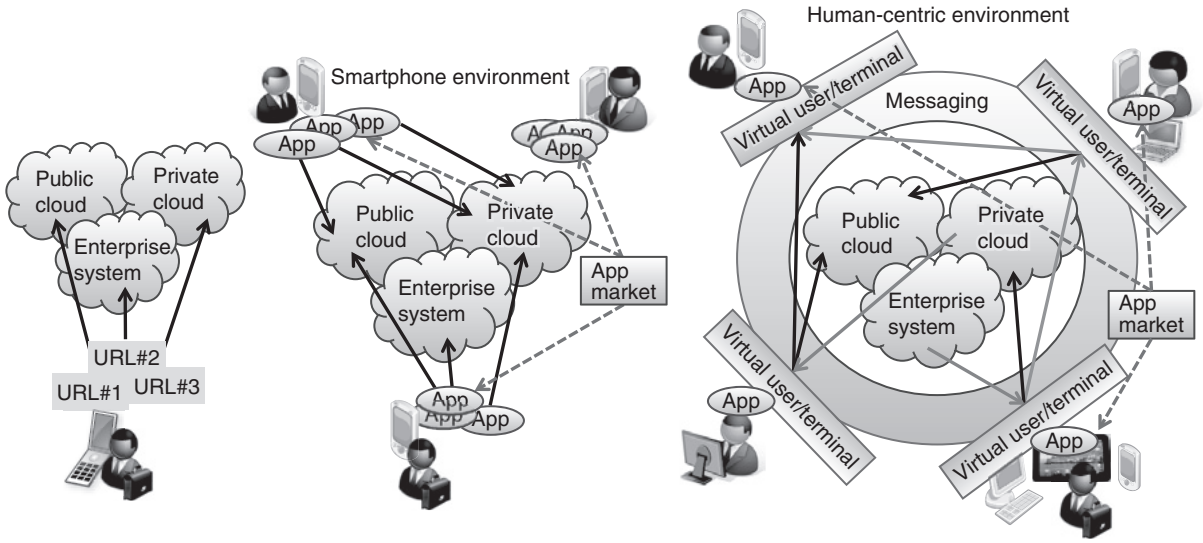

Figure 2
Paradigm shift in mobile services environment.

SNS) as they consciously switch between them. In the future, it will be desirable to devise a new communication layer between people and services so as to unify information distribution between them. To that end, virtual users that correspond to individual persons on a one-to-one basis should be defined on this layer to mediate between services and people. Virtual users have internal states corresponding to people's real-world states and deliver information from different services and messages from other people using appropriate methods and at appropriate timings according to the users' situations. Conversely, users' reactions are immediately fed back to other services and users via the virtual users. Various events are exchanged

asynchronously regardless of the difference in service types and messaging methods, which achieves information distribution as a whole. Human-Centric Computing aims to build a world in which people and ICT collaborate seamlessly by realizing this new messaging environment as a human-centric infrastructure. The following three elemental technologies are important to achieve this aim.

1) Context-aware service technology
2) Multi-device collaboration technology
3) Human interaction technology

The following sections describe these technologies.

3. Context-aware service technology

The configuration shown in Figure 2 (c) needs to be realized to allow users to directly connect to the necessary services, or allow the necessary services to come down from the cloud, rather than requiring users to search for and run applications every time they want to receive a service. For that purpose, we need context-aware service technology that can sense the user's situations, select an application suited to the user's internal states (such as work to be done) and push it to the user's terminal, as shown in **Figure 3**.

To deal with this, we have developed a fundamental technology to automatically carry out a series of processes in relation to applications and data required according to the time and place. These processes include delivery to information terminals, execution and deletion.[1),2)] This technology allows people to use mobile terminals when and where necessary, without requiring them to set up applications and data in advance. For example, by simply taking an information terminal to a meeting room, a person can have the necessary applications and data delivered and immediately view the materials relevant to the meeting. There is no need to set up applications or install data, and the user can immediately do what they want. It is also possible to have the relevant files automatically deleted when the person leaves the meeting room.

To realize sophisticated service delivery, it is necessary to further develop the technology for sensing user's location and behavior (whether they are walking or sitting, for example). Recent mobile terminals have various sensors installed including GPS and acceleration sensors and applied services such as activity measurement and sport-form diagnostic applications are

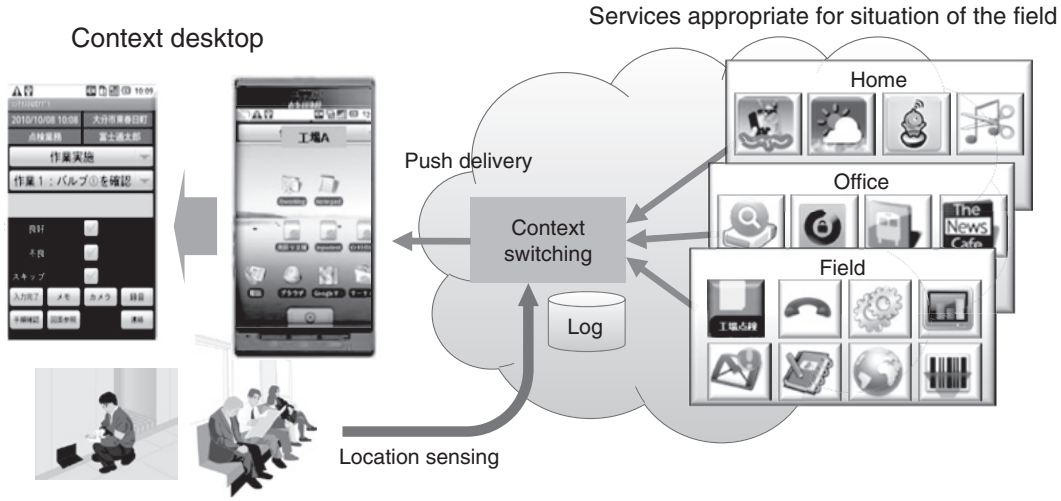

Figure 3
Context-aware service technology.

offered.[3] It is therefore important to combine such information from the mobile terminals with information from environmental sensors including human detection sensors and surveillance cameras in a comprehensive manner to enable appropriate service delivery at an appropriate timing.

4. Multi-device collaboration technology

Recently, various types of mobile terminals including smartphones and tablets have become widespread. People flexibly use these different devices according to the situation and a system to offer seamless services accessible from any terminal is required. As shown in **Figure 4**, many different types of devices such as projectors and printers are expected to be wirelessly connected in the near future and a system to allow flexible use of those devices is also important. Multi-device collaboration technology, which fills these needs, consists of:

1) Technology that makes multiple different terminals look like one terminal as seen from a user or application
2) Technology to dynamically use devices around a moving user

1) is realized by adding to the virtual user described in the previous section a function to centrally manage the types and states of terminals used by the user. The local data on the terminal are controlled to always synchronize with the data of the virtual user. In this way, the user can work in the same way regardless of the terminal used and flexibly use different terminals according to the given situation.

As a means to achieve the device collaboration technology in 2), several collaboration mechanisms exist such as Bluetooth, Universal Plug and Play (UPnP) / Digital Living Network Alliance (DLNA) and Bonjour. Of these, we are currently focusing on UPnP, which is widespread for PC peripherals and home audio visual (AV) devices and provides the basis for Inspirium HomeNetwork Library for AV distributed by Fujitsu. UPnP provides a system for a control application on a terminal to search, find and control peripheral devices. We have used the application delivery technology mentioned in the previous section to develop a mechanism for delivering control applications from the server to Android terminals. This eliminates the need to install various control applications on user terminals in advance and only what is necessary can be automatically downloaded on the spot. For example, an "all-

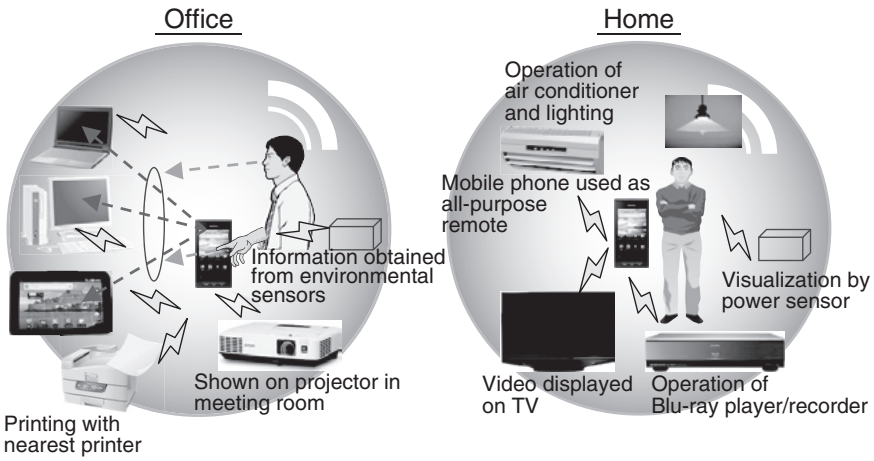

Figure 4
Concept of multi-device collaboration.

purpose remote" capable of controlling nearby devices can be easily realized. We aim to link such mechanisms with cloud to widely support protocols other than UPnP in the future.

5. Human interaction technology

To unify information distribution between people and services, as described in relation to Figure 2 (c), it is important to have interfaces extended into the real space in addition to the existing display-based human interfaces. For example, seeing a robot as a personified real-space interface allows this concept to be extended. We are working on developing a bear cub social robot, which fits in well with scenes of daily life and lives together with users as if it were their friendly companion.[4),5)] What we are aiming at is the realization of a new terminal that can appeal to users' emotions and let them form an attachment and bonds with it, not a dull terminal just for delivering information. For that purpose, we are developing human interaction technology that realizes social behavior such as eye contact and motion entrained with users while making a terminal move autonomously and biologically as if it had its own will. It has been well received by many people irrespective of their nationality, ethnicity, age or sex through trade shows in Japan and overseas and demonstration experiments at facilities for the elderly. It shows a notable effect of opening up the user's mind and bringing out a natural smile. In the future, we intend to work on providing face-to-face services through friendly interaction with users by using a camera mounted inside the nose of this robot or other devices.

6. Conclusion

As cloud and smart terminals become widespread, a paradigm shift to human-centric systems is expected to progress rapidly in the future. We expect this paradigm shift from technology-centric to human-centric system design will create new value in the real world where people engage in activities, leading to the cultivation of a new big market, into which ICT has not sufficiently permeated so far.

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