Human Centric Engine and Its Evolution toward Web Services

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Through the development of Raku-Raku PHONEs, Fujitsu has been involved in the development of unique technologies to realize a user-friendly interface in terms of "seeing, hearing and talking." It has also been developing original sensing technology for monitoring the user by using sensors integrated in mobile phones. These technologies are restructured to form a Human Centric Engine (HCE) system that is dedicated for smartphones. Further, the HCE-LSI concept has been introduced to achieve low-power consumption and high-performance profiles. HCE not only offers ultimate user-friendliness differentiating the brand from those of other venders but also assumes an important strategic role in supporting the Human-Centric Intelligent Society advocated by Fujitsu as a ubiquitous front-end. In this paper, we will introduce the superiority of our mobile products by describing the objectives of HCE and summarizing the functions to be integrated in the smartphones. We will also describe the development of our service portfolio using HCE.

1. Introduction

Drastic development of information and communications technology (ICT) has been observed globally. It has been leveraged by a rapid improvement in high-speed wireless infrastructure represented by the Long Term Evolution (LTE) system and the concurrent progress of various types of Web services based on cloud computing. Fujitsu perceives this movement to be a paradigm shift to human-centric technology and strives to offer ICT so that people can have safer and richer lives.

As an ideal form of ICT, Fujitsu considers a social infrastructure that can offer appropriate values to individual users on a timely basis by harmonizing networks and service platforms that serve as a backend. In this vertically integrated and Human-Centric Intelligent Society, mobile devices assume an important role as a ubiquitous front-end. Namely, as a tool that is very familiar to each user, mobile devices collect various types of information related to the user as sensing data and offer services based on a linkage between service platforms and networks in the most appropriate format depending on the time and location.

Through the development of Raku-Raku PHONEs[note)], Fujitsu has been involved in the development of unique technologies to realize user-friendliness, and they are integrated in all its phone products. When looking to develop smartphones, these technologies have been systematically employed as Human Centric Engine (hereafter "HCE") and integrated in products since the spring/summer models of 2011.

In this paper, first we describe the objectives of HCE and outline the functions to be integrated in the smartphones. Then, we describe the development of our service portfolio based on the linkage of device functions and network services by using HCE.

2. Objectives of HCE

Through the development of Raku-Raku PHONEs, Fujitsu has been involved in the realization of user-friendliness in terms of a speech communication function. This effort is typically seen in the Clear Voice function, where the mobile phone calculates the

note) Name of an easy-to-use mobile phone series that targets first-time mobile phone users and middle-aged and elderly ones. Its universal design features, and functions are characterized based on ergonomics.

surrounding noise level and makes the voice received clearer depending on the noisiness felt by the receiver (**Figure 1**). Further, we have developed a series of functions that can be used to assist the user in their daily life through a monitoring function depending on the situation of each user. This is based on its unique sensing technology that uses sensors equipped in mobile phones (e.g., a pedometer). These user-friendly functions have been accepted by wide range of users and accumulated sales of Raku-Raku PHONEs have now exceeded 20 million units.[1)]

In the development of smartphones, these user-friendly functions are defined as core features to differentiate Fujitsu's products from those of its competitors, and are systematically implemented as HCE technology. As shown in **Figure 2**, HCE refers to all the technologies that offer smartphone functions in the easiest way by constantly detecting the situation with Fujitsu's original sensing technology. This is based on active use of various sensors integrated in smartphones. For instance, smartphones can detect the surrounding environment and motions around users, the current status of use (e.g., whether or not the user is holding the phone in his or her hand) and physical condition of the user, such as their vision and hearing ability, depending on the age of the individual user. Thanks to these technologies, any user can utilize smartphone functions in the most suitable condition without conducting any special operation.

To further save power and enhance functions, Fujitsu's products have had LSI (HCE-LSI) since 2012, thus giving them advanced sensing technologies in LSI while also offering a power saving feature. This strategy has resulted in superb integration and continuation in terms of the following aspects:

1) User-friendliness and monitoring functions through continuous sensing capability based on super-low power consumption.
2) Ability to implement common spec technologies on all types of carriers and models of every price range by reducing dependency on platforms and OSes, and thus facilitating the application of multiple platforms and multiple OSes.

3. Unique differentiation of device functions by HCE

The core function of smartphones is a telephone. Namely, users want basic functions that make it easy to listen to someone and easy to talk. In addition, functions that give the phone an easy to see display, such as one with a large-size and high clearness, as well as an easy to operate function such as a touchscreen one of the most significant features of smartphones, can be important points. Therefore, in pursuit of user-friendliness through HCE, we have strived to achieve unique functions serving as differentiating points by

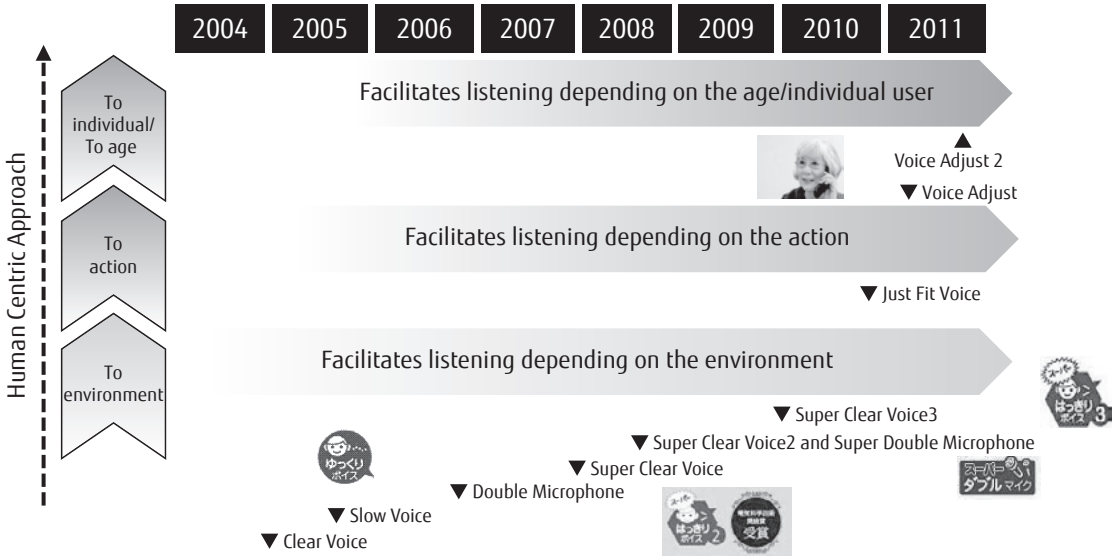

Figure 1
Development of "easy to hear" feature.

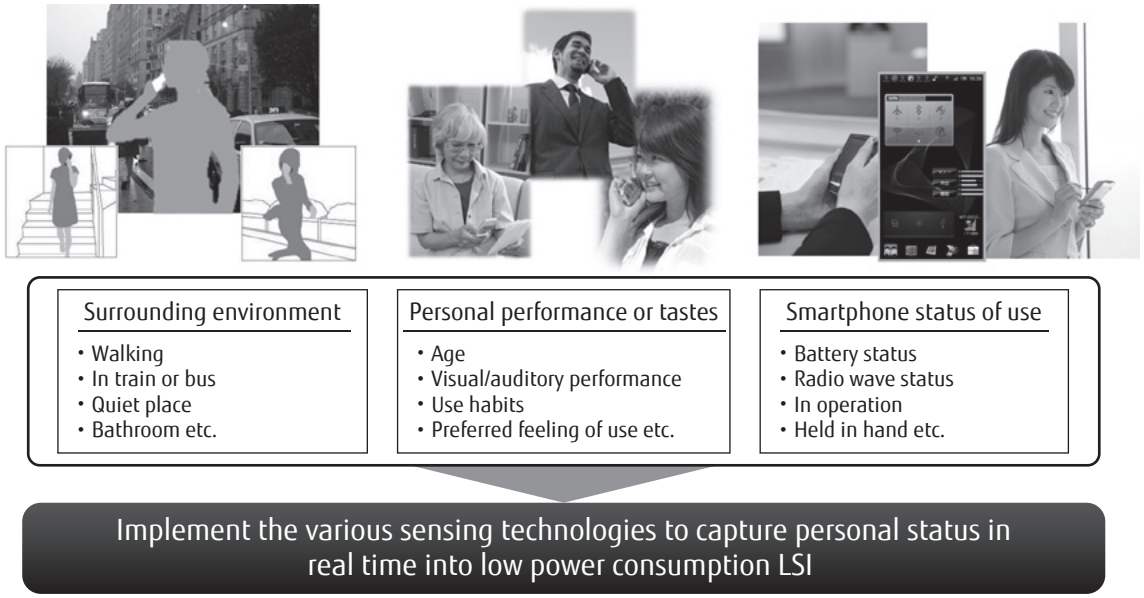

Figure 2
Concept of HCE technology.

thoroughly integrating the user-centered approach based on three senses (i.e., easy to hear, easy to see, and easy to operate by touch) by detecting the environment surrounding the user and his or her status.

Twenty-two types of unique functions as shown in **Figure 3** were integrated in the spring/summer models of 2012:

1) Visual sense

Integrates four functions to facilitate viewing: e.g., screen color adjustment depending on the surrounding color temperature; function to keep the display active while the phone is held in the user's hand.

2) Auditory sense

Integrates nine functions to facilitate hearing and talking: e.g., a function to make it easier to hear on the phone depending on the user's motion judging from the surrounding environment and his or her hearing ability.

3) Touch sense

Integrates four functions to ensure comfortable operation: e.g., a function to allow users to accurately point at icons even if they are located far from the fingers holding the smartphone; giving comfortable feedback on fingers based on articulate vibration upon operation.

The fundamental part of the life assistance functions for monitoring the user's daily life is comprised of Fujitsu's unique sensing technology. As shown in **Figure 4**, the conventional sensing functions integrated in smartphones include an acceleration sensor and gyro sensor. In addition to these, original sensing features have been realized that can capture the status and activities of each user based on the number of steps they take or such like. This is achieved by consolidating various types of information from sensors and image and audio information (i.e., sensor fusion) by utilizing the camera and microphone as part of the sensors. To be specific, they include activity sensing by using an acceleration sensor, 3D motion sensing that captures the 3D body motion of the user by using an acceleration sensor and gyro sensor, image sensing by using the camera, and motion-sound sensing by using an acceleration sensor and microphone sound.

The first application utilizing one of these sensing technologies was the pedometer integrated in Raku-Raku PHONEs in 2003. Since then, in the process of developing feature phone functions, an active mass meter that can measure the activity level of each user based on his or her Metabolic Equivalent of Task (MET) or Ex (i.e., exercise level) units as well as a pulse meter based on a camera function have been integrated. In 2010, some other functions were commercialized including a golf swing diagnosis function and a Walking/Running Clinic. A Beauty Body Clinic function based on

Figure 3
Unique features serving as differentiating points in spring/summer models of 2012.

the measurement of body balance and unturned status from simple motions was also commercialized.

As an HCE dedicated for smartphones, the 3D motion sensing technologies that have been developed to date were combined with sound sensing technology in 2012 to realize a Sleep Log function that can monitor the status of each user during his or her sleep. By detecting vibration and the sound of a user turning over and breathing during his or her sleep and combining these pieces of information, it is possible to judge whether or not the user is snoring or breathing irregularly. Thus, by visualizing the status during sleep, the phone may help the users discover their physical problems that they would not otherwise know about in their daily life. In Fujitsu's smartphones, this Sleep Log can be further combined with daytime pedometric and activity level data to enable 24 hours a day, 7 days a week (24/7) monitoring of the daily life of each user.

To ensure 24/7 monitoring of the user status and realize a continuous monitoring function, the device's power consumption should be reduced to the minimum level. To address this issue, a novel super-low power consumption HCE-LSI has been developed for smartphone application and introduced to products from 2012 (**Figure 5**). Each type of sensor device on smartphones is connected to the HCE-LSI. When the device activity is suspended, only the HCE-LSI and sensor devices are kept active without actuating the main CPU so that various types of information can be sensed with the minimum power consumption. For instance, with

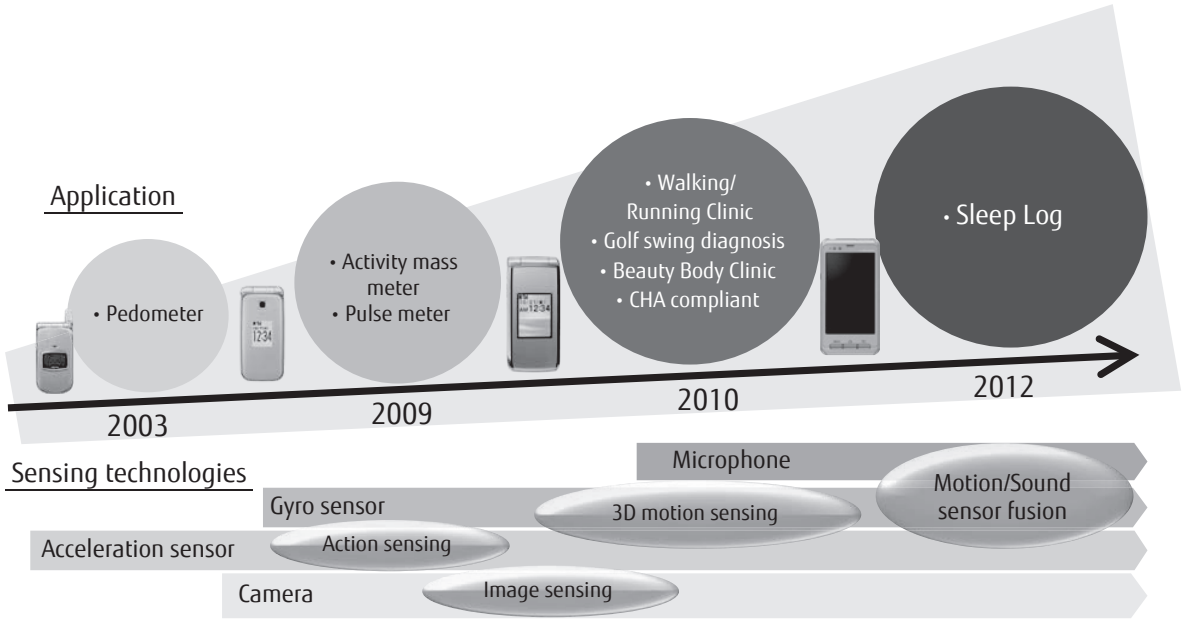

Figure 4
HCE features for health and daily lifestyle support.

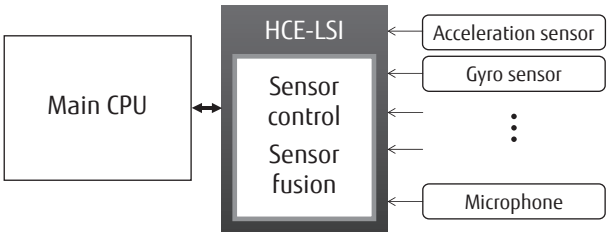

Figure 5
HCE-LSI configuration.

regard to the Sleep Log, a microphone is connected to the HCE-LSI to allow sound analysis within the HCE-LSI. Through this approach, power consumption was cut down to about 1/100th that of the conventional approach where sound analysis is executed in the main CPU.

Because this configuration allows the HCE-LSI and sensor devices to be independent from the platform or OS, it has become easier to use multiple platforms and multiple OSes or upgrade to a newer OS. Thanks to this advantage, these applications can be integrated in all smartphone models offered by Fujitsu.

4. Service deployment

The smartphone has high affinity with cloud services, which has been cited as one of its advantages, based on its ability to easily connect to a high-speed Internet. Actually, the rapid spread of smartphones has led to activation of the mobile service market.[2] The large amount of data generated by sensing phone users using HCE on a 24/7 basis can be stored and analyzed by using cloud framework. Hence, the possibilities of new services have been expanded (**Figure 6**). As a part of cloud services, watching over elderly people and a healthcare service are cited here. Advantages for users in each service obtained by using the information collected through HCE sensor functions are described below.

1) Service to watch over elderly people

Because Japanese society is aging now[3], Fujitsu aims to further support the elderly so that their life becomes safer and more comfortable by having cloud services actively used as a continuation of Fujitsu's long-term efforts in development of Raku-Raku PHONEs for the elderly.

One of the biggest concerns for elderly people is their health. While the number of senior citizens living alone has been increasing in recent years, many of them are worried that no one will take care of them when they are sick.[3] Their family members living away from them are also concerned about their age-related

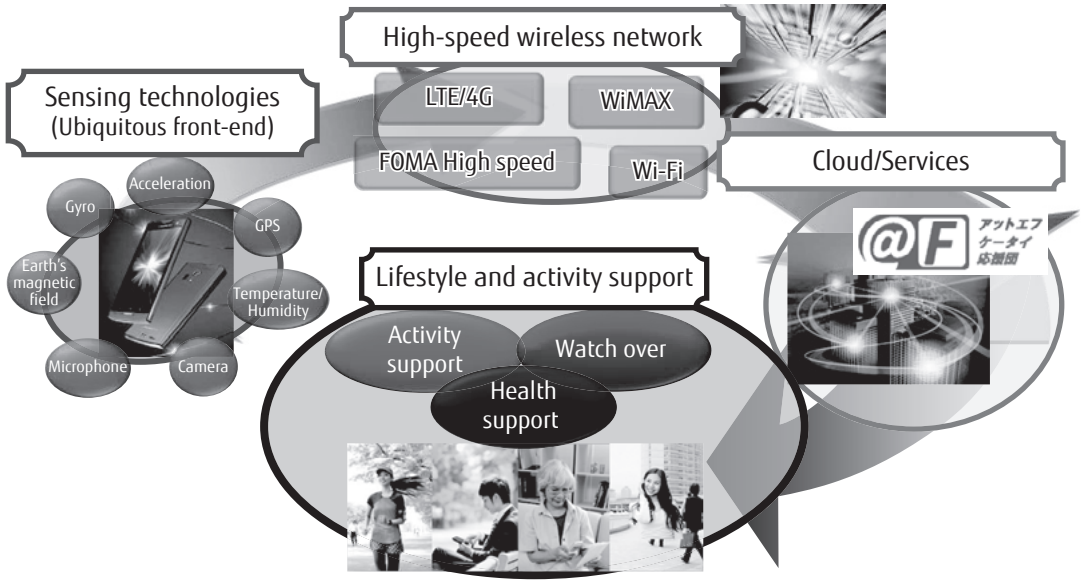

Figure 6
Deployment of HCE services.

health issues such as weakened lower body functions and susceptibility to illness.[4)]

To address these issues, more services are being provided that allow users to remotely confirm the safety of elderly people. For instance, NTT DOCOMO offers a service called "Iki-Iki Pedometric Data Transfer Service" that sends an e-mail to family members living somewhere else to report the pedometric data collected by a Raku-Raku PHONE. Because the family members can confirm the pedometric data of the Raku-Raku PHONE users on a daily basis, it is possible to detect any abnormality at an early stage from the drastic changes in pedometric values and they can contact the elderly people immediately by phone and so forth. By actively using HCE sensing functions, more detailed information such as the surrounding situation of the user can be transmitted in a timely manner. We consider that these features will open up possibilities of new services that offer a feeling of safety through continuous watching by Fujitsu's smartphones.

2) Healthcare service

The 21st century is an era of drastic change from treatment to prevention in the field of healthcare. The Ministry of Health, Labor, and Welfare in Japan has been promoting its program "Healthy Japan 21" since 2000 to increase health span and improve the quality of life (QOL).[5)] Disease prevention is categorized into primary prevention, secondary prevention and tertiary prevention. While primary prevention refers to improving a person's life habits and promoting a healthy life, secondary prevention refers to early detection of disease and prevention of its aggravation. Tertiary prevention refers to the recovery of functions through health-related guidance during treatment and rehabilitation.[6)] To help prevent diseases, it is essential to collect and accumulate data on users' physical conditions in their daily life for a long time and provide feedback.[7)] The HCE sensing feature is the most suitable tool to make this easy and effective.

With regard to primary prevention, information on a person's activity level and sleep status sensed by HCE can be accumulated in the cloud and it is possible to analyze changes in life habits or problems by using the data accumulated for a long period. The healthy life of the users is maintained by raising their awareness and giving guidance to them so as to improve their life habits when there is any unhealthy factor in their daily life such as insufficient exercise or irregular sleep. In terms of secondary prevention, our technology helps users consult healthcare professionals by detecting and informing them of changes in their body conditions that are otherwise unknown to them based on snoring or irregular breathing during sleep. Further, more accurate advice can be offered because it is possible to analyze

the relationship between the information factors and diseases after accumulating sensing data on the cloud. With regard to tertiary prevention, it is possible to offer a service to monitor patients' compliance status based on the sensing data accumulated on the cloud. For instance, it is possible to monitor whether patients are complying with their doctor's advice to walk 10 minutes every day. If there is any concern, the issue is reported to their family member or doctor so that they can take action at an early stage.

In any application, it is essential to collect information on daily activities and life habits via smartphones. We plan to develop a comprehensive range of health services by collecting data with HCE.

5. Conclusion

In this paper, we described the objectives of HCE by stating our approaches to adapting the technologies so far developed for Raku-Raku PHONEs to smartphone frameworks. Then, the HCE features integrated in the spring/summer models of 2012 developed around this concept were explained. Further, we described how we are developing a service to watch over elderly people and a healthcare service by linking the HCE features on devices and cloud services.

There are several issues to address, including a privacy issue, before sensing data can be actively used on the cloud. Fujitsu is committed to solving these issues and further developing its HCE technologies in future so as to realize a Human-Centric Intelligent Society.

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