



Implementation of a Remote Bio-Equipment System for Smart Healthy Housing Properties

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ABSTRACT

It is essential to investigate the structure and the main characteristics of BSN (Bio-Sensor Network) platform in built smart healthcare environment while designing healthy housing facilities. For this study, WSN (Wireless Sensor Network) data transmission technologies have been employed with medical sensors, and optimal medical devices would provide various Web 2.0 services by connecting to the WiBro network. The BSN platform normally recognizes in surroundings of WBAN (Wireless Body Area Network) or WPAN (Wireless Personal Area Network), and it is possible to manage sensor nodes by utilizing SOAP (Simple Object Access Protocol) and REST (REpresentational State Transfer). In addition, the feature of SNMP (Simple Network Management Protocol) for mobile gateway is also included for being adapted to huge network structure. Finally, BSN platform will play a role as important clues for developing personal WSN service models for smart healthy housing properties.

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1. Introduction

In accordance with demand for house with more pleasant and comfortable but safe at the same time, smart space service is becoming basic item in the field of housing, too. While home network product is actively utilized centering on large scale apartments already, housing healthy care utilizing remote medical treatment is gaining its attention. Home network industry became activated as former Ministry of Information and Communication carried forward 'Digital Home Demonstration Project' focusing on the apartments in capital area and 5 metropolitan cities. [1] Through this project, home network system was connected to large scale housing area and services of various fields such as medicine, education and banking could be reached and used. However, because of the provision that remove medical treatment, the core of the medical treatment, is only possible for practitioners and medical faculty under current legislation, the situation is relatively slow in its utilization compared to technology advancement and government is preparing system improvement plan for medical law revision to activate remote medical treatment.

Ubiquitous sensor network (USN) technology, the core technology that enables these all remote health care service, grants every object such as living space, living appliances and furniture of human the function of computing and networking as well as providing optimal service through automatic recognition of

building environment condition to residents and enables enhanced convenience and safety of housing life. [2] Especially in the field of integration service within housing space among many USN application services like facility, transportation, shipping, environment and life, the demand for construction of healthy housing environment based on bio signal which provides bio information terminal grafted with U-IT technology used to provide recommended health information referring to the situation index of housing environment and understand the health condition of residents in real time thereby providing easy medical service has been increased. [3]

But present U-Health tends to focus on individual technology development when seen from the commercialization aspect, utilization of measuring sensor technology designed by application of special housing environment condition or unique body characteristics of users can be said yet weak. No matter how advanced technology is applied, if user's demand is not considered, it is doomed to be neglected and it is judged to be a phenomenon caused by passing of technology advancement over uses. In conclusion, when expecting the development direction of bio signal sensor technology (BSN) in housing environment, related terminal should easily be moved and worn focusing on users to enable the embodiment of smart healthy housing in the future and the development of platform as well as effective implant within house are needed.

Thus, this research intends to propose BSN platform and healthy housing service module system based on bio signal that enables

residents to receive health related information using network, further, creates the optimal environment for health condition of residents thereby aiming for housing energy utility increase needed for that by producing sensor that can be worn in the body easily then applying them to wireless sensor network (WSN) module.

2. Introduction of smart health housing

As social demand for people's health and medical service, welfare increases resulting to the concern towards the side effects over whole society such as shortage of medical finance, need for national challenge resolution such as polarization, aging using ICT (Information and Communication Technology) is raising its head as well as need for validation of technological possibility of U-Health for it is expected to be major housing service in future society grafted with ICT.

BSN based healthy care service can be classified into Wellness type provided for health maintenance and improvement and Healthcare(HC) type which aims to treat and manage the disease as traditional medical field according to provided features. HC type is classified into U-Hospital group(for hospital, clinic) and residential HC type(for individual) based on the users of U-IT technology and since it is no meaningful to classify Wellness type according to technology users for there do not exist large institutions such as hospital, thus it is general to classify it into the types of common application for individuals and institutions.

2.1. U-Hospital

It is expected that ubiquitous hospital which can provide medical service at anytime anywhere using wireless communication will gradually appear. According to BCC Research, the size of hospital market related to IT showed increase by 13.4% from 16.4 billion dollars in 2005 to 34.7 billion dollars in 2011 in U.S.A and it is thought to be more clear considering development trend of related technology. [4] In the nation, the case of Samsung hospital introducing Mobile Hospital system that enables verification of voice information and visual image at anywhere in the nation through PDA phone is seen as the start of remote medical treatment. [5]

Until now, large hospital became the major object of medical informatization technology, however, the objects is going to expand to the field of clinic, housing medical treatment, nursing home and hospice and the in-home system that constructed remote medical treatment and video conference system as well as the system that receives the medical treatment by connecting to the professional doctors from the clinic linked to the large hospital are expected to have faster growth due to its demand. Afterwards, it is

planned to implement electronic prescriptions that can receive the medicine at comfortable time through nearby pharmacy or mail after receiving electronic prescriptions using wire and wireless communication service with the aid of mobile verification by software reserving the hospital or doctor according to the schedule of the patients automatically.

2.2. Housing Healthcare

At present, elders and chronic patients are focus of care and they are continuously managed by being provided remote service such as exercise, diet, administration after checking bio signals including blood pressure, pulse and blood sugar level outside the hospital and it is seen it would become almost necessary factor of healthy housing in the future due to the increase in attention regarding health and wellbeing. After collecting bio signals measured through wired and wireless network centering on the data center, health care workers monitor the condition of patients for 24 hours and provide nurse dispatch and doctor connection service to the patients with abnormality.

According to Forrester Research, housing health care market in U.S.A mainly targeting chronic patients has increased from 97 million dollars in 2006 to 5.7 billion dollars in 2010, and is expected to increase rapidly up to 33.6 billion dollars in 2015 and the trend is that even national large companies are actively entering housing healthcare business targeting elders and chronic patients. Based on the potential demand, Korean housing healthcare market size is expected to grow from 116.8 billion won in 2005 to the level that exceeds 1 trillion won in 2015 and Honeywell, Philips, Healthpia and isubcare are securing the technology at the level of breakthrough. [6]

2.3. Wellness Healthcare

It is a concept that measures the amount of exercise using various motion sensitive sensor and proposes training program attuned to the health condition of users at anywhere and anytime using online and mobile and manages the health of users in integrated way in house and moving space. By putting the sensor to the part of the body and clothes and shoes worn and measuring the travel situation of the user, it shows the result on mobile display and analyzes travel history of one's own on interlocked website or provides the service that recommends media contents suitable for travel.

At the background of various demands of consumers and suppliers of related health care service such as healthy housing model creation with new value based on integrated health information that promotes consumer-oriented health care management in patient-oriented health care management system,

private company and communicative enterprise in many countries are advancing into HC industry in various angle. Especially, NTT DoCoMo of Japan is the case that web enterprise directly provides the service using device in the form of accessory and representative communicative enterprises in the nation as well are preparing BSN based HC service.[7]

3. Introduction and design factors of BSN system

3.1. Introduction of BSN

Thanks to the development of medical technology and information communications infrastructure, in-home remote medical treatment service of smart healthy housing, which was seen impossible just before a few years ago, is being actualized more. Thus, the utilization of healthy housing service that enables continuous health check transmitting personal health information to the doctors by connecting medical diagnostic equipments to the network at home is expected to grow at rapid rate together with reorganization of related bill. This healthy housing industry field basically depends on BT(Bio-Technology) and it is growing into U-Health stage that provides evaluation about health condition, diagnosis and medical treatment at anywhere and anytime using ubiquitous technology beyond the level of E-health that provides communication function with medical experts for health management by integrating ICT technology.

In the 'Tendency analysis of future housing residents' made through survey targeting real residents of apartment by one communicative enterprise in the nation asking ecofriendly architect research center of Jungang University, necessary functions of ubiquitous house are classified into 6, safety, generation management, ease, health, pleasant environment, leisure and higher portion of respondents showed positive responses toward the demand for health system and consent of it upon actual supply regardless of housing types. Table 1 shows the acceptance order about health system in 3 residential types which

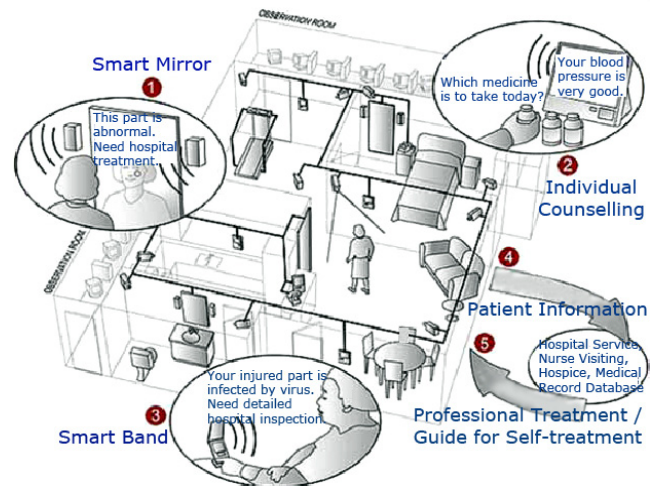


Fig. 1 An example of smart healthy home project (Source: Rochester University, U.S.)

are priorities of U-Health. Elders and residents of general housing showed same result of acceptance tendency regarding health system and higher result in acceptance regarding emergency call or smart automatic check-up. On the other hand, residents who live alone showed high acceptance regarding emergency call considering the features of singles who live without housemate. Besides, residents of single type showed high acceptance in medical information support that they can obtain easier smart automatic check-up and medical information. [8]

Home USN can be considered as information and communication infrastructure technology of BSN that aims to construct this smart healthy housing. The factor technologies of Home USN are largely network technology for sensor related technology and information delivery used by residents in house and housing environment recognition, application technology to service delivered information and through Gateway(G/W), the major device of Home USN, one can not only view the information but obtain and control the data remotely from every system connected by sensor.

3.2. Design Components of BSN

Likewise, for construction of Home USN that supports healthy housing responding and dealing with the body features of residents, small sensor node for body signal extraction and portable G/W, monitoring system development are necessarily needed. Recently, through miniaturization and weight lightening, service that can deliver body signal sensor information at the place users want became possible using wireless protocol such as ZigBee, furthermore, people tend to use WiBro wireless network that has wider bandwidth to deliver various USN data including images at the same time. ZigBee is receiving attention as USN standard at the present due to its many advantages such as miniaturization of module, consumption of low electricity, low electric wave

Table 1. Acceptability of the healthy system by housing types

Rank	Housing Type		
	Regular	Elderly	Single
1	Intelligent Automatic Bio-Test	Intelligent Automatic Bio-Test	Emergency First-Aid Call
2	Emergency First-Aid Call	Emergency First-Aid Call	Intelligent Automatic Bio-Test
3	Intelligent Fitness	Intelligent Fitness	Health Information System
4	Health Information System	Health Information System	Intelligent Fitness
5	Remote Medical Treatment	Remote Medical Treatment	Remote Medical Treatment

(Source: Eco-friendly Environment Research Center, 2006)

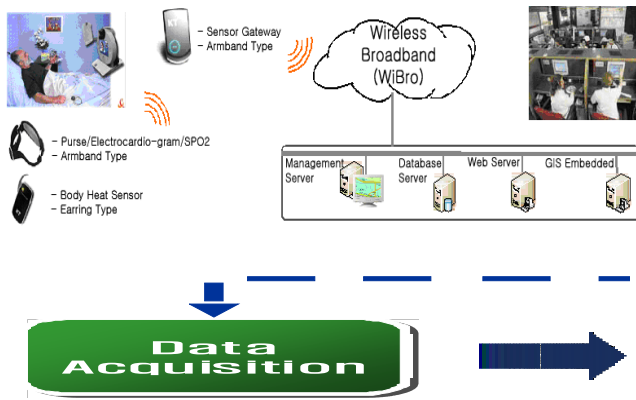


Fig. 2 Overall architecture of the BSN system

interference factor, easy installment of relay node, high interoperability possibility and it is expected to be applied in various industrial fields in the future for it is suitable for the use that integrates and controls the device on the network with low volume data. [9] Fig. 2 shows major components of Home USN based BSN.

Sensing part is the one that detects the change of physical and chemical phenomenon occurring in the human body. Many physical and chemical reactions that try to keep the life according to the homeostasis occur in the human body and in order to sense the information such as personal health and the kinds of disease and its degree, suitable physical phenomenon should be changed into manageable electric signals. Thus, to sense the bio information in ubiquitous environment, sensing principle and signal delivery information system different from prior sensing method should be considered.

Monitoring part is where primarily processes sensed bio information and is composed of filtering management to choose meaningful signal components and analysis process to make them into meaningful information, the process to visualize this. The information printed here can only be interpreted with professional medical knowledge and ordinary users find it hard to understand its meanings. Almost all of existing medical apparatuses have sensing part and monitoring part as their components but the understanding of users about the result was really low. Thus, BSN platform based smart healthy housing system should not set its ultimate goal as direct provision of drawn result from the monitoring part to the users.

Analyzing part not only simply monitors current situation but is a analyzing process of tendency that finds new health index such as health condition, life pattern from the data obtained for a long time. When analyzing bio signals accumulated for a certain period of time, the fact that there is a rapid change in bio signal pattern related to the personal life pattern, health and disease connotes many meanings. Especially in the view of preventive medicine, the health baseline of individual can differ, however, since abnormal

change in baseline means the possibility of a certain disease, the findings likewise provide a very important clue in health management system. Furthermore, by recognizing abnormal health condition of residents, active environment control suitable for that and efficient customized energy provision are possible. Thus, in BSN platform based health housing system, change detection in health baseline in daily lives should be regarded as very important factors.

Feedback part means the process of notifying users of change in life or health baseline detected over a long period of time in the form of behavior change or users or warnings. It is just that the way these can efficiently delivered to the users should be considered firsthand. In the view of medical service field, the role of experts such as doctors and nurses are accentuated here.

Considering the form of medical service and current level of the technology, the parts that should be included for embodiment of smart healthy housing service are sensing part, analyzing part and feedback part. When considering technological aspects, development in the field of sensor and module with new concept that can enable the detection of bio signal related to personal health in house and travel environment is needed in the field of sensing. Besides, in analyzing and feedback field, various meaningful health signals sensed over a long time should be analyzed to find new health index and there will be a need for technological approach to deliver this to the user effectively.

4. BSN system embodiment and application

In this paragraph, we would like to present the sample of data management system and structure of platform for BSN system drive and suggest the composition of unit module to apply this to the house.

4.1. Composition of BSN platform

Data collection in BSN healthy housing system can be done in two ways; sensing using mobile device in the form of wearable terminal embedding sensors inside or acquiring data without intentional sensing endeavor of users by embedding sensor in the living environment that residents live. Wearable system form embeds the sensor for body signal monitoring in the ring, watch, breast rope or clothes and environment sensor is installed in bed, toilet, chair and bath that users regularly use to monitor the body signal and amount of action of users. Each method has technological pros and cons of its own so they should complement each other according to the living environment or condition of residents.

For example, in the case of wearable system, accurate data can

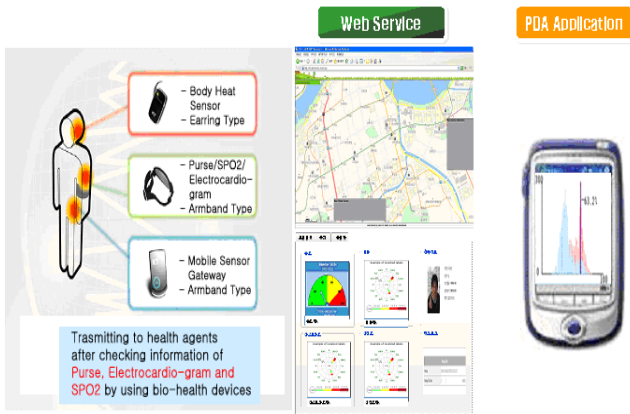


Fig. 3 Application scenarios for the BSN platform

be obtained but users should bear unpleasantness of wearing and when sensors are dispersed to the surrounding environment of users, data in natural condition can be obtained but can be also inaccurate unless users pay conscious attention. To add, when there are many residents, additional technology such as one that automatically identifies users using electrocardiogram pattern and behavior pattern is needed for user recognition.

As shown in Fig. 3, BSN based healthy housing system at present comprises temperature, pulse, ECG and degree of oxygen saturation sensor as wearable system. Temperature is an earring type and pulse, ECG, degree of oxygen saturation sensors are attached to the body as wrist band type. Sensing health related information of individuals accurately in ubiquitous environment is the most basic requirement of BSN platform based healthy housing system. The sensitivity of residents regarding medicine related data tends to be big but since data acquisition changes a lot because of surrounding environment or condition of residents, accuracy and reliability of acquired data decide the usefulness of the system.

If this embedded sensor device can directly be connected to the outer network, relevant signal can directly be delivered to the service provider, too. However, if it is the device with only communication function at close range, relevant information is delivered to the outer network through G/W. In BSN healthy housing system, relevant signal is delivered to the outer wireless network after being delivered to the mobile G/W by communication at close range using 802.15.4 of 2.4 GHz. Here, G/W can also have the primary valid data decision function that filters unnecessary data and analyzes relevant information when the amount of data to be delivered is vast aside from the function of simply delivering data. Further, since health related data is very private information, code at a certain degree must be applied upon delivery to outer public network through G/W.

On the other side, service provider can provide individualized information contents based on the received information or directly deliver medical action guideline on the spot when emergency.

Users decide whether to use relevant service or not according to provided service contents in the final step. Thus, embodiment system of smart healthy housing service should not only simply show the measured data value but find various plans to draw active and continuous service usage in house focusing on residents and personalized, customized service provision is necessary.

4.2. Data management system of BSN

Digitalized sensing data of temperature, pulse and ECG delivered through wireless network Zigbee from vital sensor is processed to the data compatible with U-web server. Processed data is made in the form that statistics and data base can be done and they are made into regulated form of value data. Besides, G/W delivers real time data using communication protocol and fixed form through fixed U-web server using WiBro network by integrating current location information and real time image data to the sensing data through GPS module. The communication method between G/W and U-Web is based on HTTP protocol and data is delivered in this way, data structure uses XML. BSN data management system can largely be divided into sensor data receiver, sensor data processor and sensor data transmitter like following.

Accurately checking health related information of individual in ubiquitous environment is the most basic requirement and the most sensitive are of BSN HC service. Although users are very sensitive about medicine related data, it is judged that accuracy and reliability of acquired data will be the ones that will decide whether to use the system or not since data acquisition can have rapid changes by user condition and surrounding environment. Besides, what we have to be careful when we apply the bio sensor to the health housing field is housing psychological understanding about

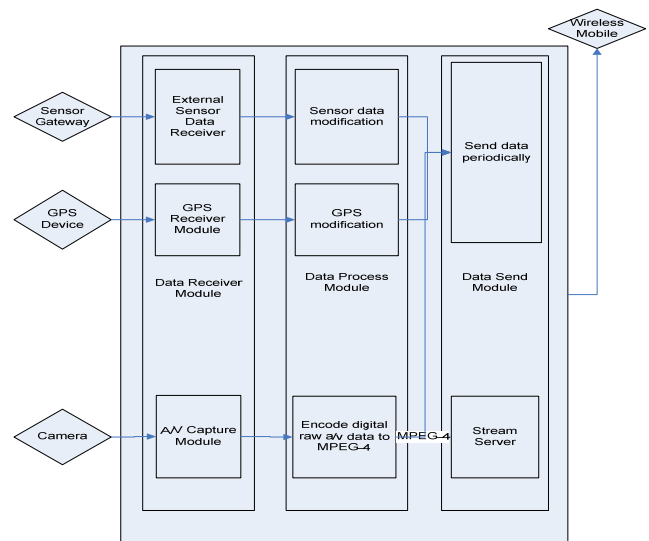


Fig. 4 Architecture of the BSN data transaction system

final users. Usually people think top priority user class of health housing system is chronic patients who need regular monitoring such as elder or disabled people and primarily construct limited system design for them. However, most population of physical and psychological people has a low technology reception regarding new technology or system. Thus, in order to make residents with disabilities to accept the new system without difficulties, research about user interface that can easily be understood and used is required aside from a simple technological aspect of system.

4.3. BSN module composition within house

Among the bio signal that can be checked in the human body by interlocking with BSN, temperature sensor node and degree of oxygen saturation sensor node are the ones in relatively close relation with other efficiency factors within house such as housing energy. BSN Gateway of proposed system collects and monitors current bio signal of residents and deliver the situation identification result of residents and demanded cooling and heating energy analysis data to the building administrator and facility system of HVAC, delivering them as well to the moving control terminal through WiBro wireless network that supports remote management control.

As we can see in Fig. 5, bio signal data sensed through wireless communication module MTM-BC1000 is delivered to BSN and the signal put in sensor board goes to MCU(Micro Controller Unit) after passing amplifier. The signal came to MCU again goes to ADC(Analog- Digital Converter) and is changed into digital bio signal through calculation then delivered wirelessly to Gateway through RF (Radio Frequency) Chip and it takes the method that decides the amount of energy needed and optimal indoor temperature customized for the residents by collected bio signal information in Gateway.

Wireless communication module (MTM-BC1000) for delivering sensed temperature data to Home USN embedded and applied Tiny OS, the operation system used in general wireless sensor network. Breakdown of frequency used is 2.4~2.4835 GHz and it is designed to support communication speed of 250 Kbps in

average. Embedded Chip antenna meets basic requirement of Home USN drive for it reaches approximately 10 m inside and it reaches about 80 m when applying it outside. Additionally, it can have accurate sense value for it has ADC with the resolution of 12bit together with 3 channels.

The wireless sensor network technology applied in this research can not only save the cost of present wired one but be applied in more various fields compared to the wired one. Especially, with the development of low electricity wireless sensor network based bio sensor module, the effect of securing industry based technology of next generation that can be applied in not only architect energy field but also in various devices for building industry, device and service solution technology development is expected and it is considered that it would develop into the factor technology that actualizes the concept of Smart Space that will be embodied with ubiquitous network in cyber apartment, automation office, automobiles, hospitals, department stores and airports. [10]

But in order to make these development results to be provided validly in real life, intent and housing psychological factor analysis of residents should follow in using the relevant system and analyzing enough experiment data targeting actual living environment and residents. We expect active utilization of BSM that promotes customized energy facility suitable for residents' characteristics by sensing body features of residents and monitoring the change of it grafting U-IT technology beyond the previous view that supervises building environment and controls building facility for future efficient energy usage.

5. Conclusion

We examined the embodiment of linked BSN system and application plan of smart technology which embodies housing environment helpful for the health of residents health-friendly through research. BSN is a system that senses bio signal of residents and environment situation of the space using motion and various building environment sensitive sensor and proposes information responding to the health condition of users at anytime and anywhere using online and mobile thereby managing the health of users in integrated way in house and moving space. Although technology development in resident bio information based building energy situation identification using BSM remains in initial stage, it can be said meaningful in that it usggested a clue that can make enhancement of housing efficiency by linking BSN.

BSN based health care service is expected to expand to U-Hospital, U-healthy housing and U-Wellness in order and it means that temporal and spatial expansion of medical service is possible. Thus, the space that medical service is offered is

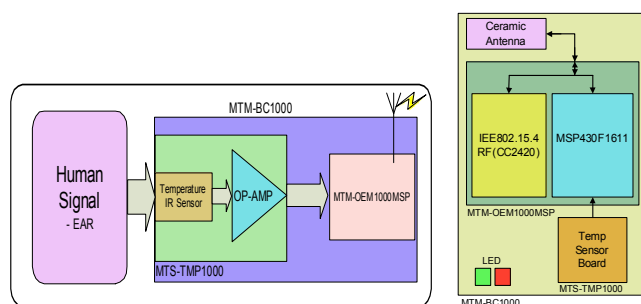


Fig. 5 BSN operation using a mobile communication module
(Source: S. Han, 2008)

expanded from limited medical institutions area at the present to the across the area of real life such as house, fitness club, roads. With the development of network, now it is possible to have health counseling or consultation with medical faculties at anywhere and anytime using wireless video communication and use the medical service thanks to the sensing technology development which senses ECG and blood pressure of patients while moving. Temporally, it means medical service is evolved from temporary disease treatment to regular lifetime treatment concept. As personal health information is accumulated across the whole lifetime, personal customized service and prevention service are possible and service that continuously monitors the condition of patient for 24 hours in the case of chronic patients becomes possible.

Likewise, with the advent of new medical paradigm, temporal and spatial expansion of corresponding healthy housing model and medical service will draw providers and demanders of various medical service and there will appear health management SP (Service Provider) that connect patients and doctors through health information database aside from existing hospital as well as communication and medical apparatus company providing environment and infrastructure that enables users to use medical service at anywhere and anytime. On the other side, consumers of medical service will no longer be limited to the patients but expanded to the general customer who pursue health promotion through active disease prevention action. Thanks to the increase of attention regarding health and improvement in standard of living, consumers will be changed to the active consuming subject and increasing medical cost because of population aging and chronic disease will be saved by various service of smart healthy housing.

But from health care IT service to healthy housing embodiment, bio signal based U-Health cannot be embodied perfectly with the technology of only one field. Innovative technology is needed but embodiment of successful smart healthy housing is only possibly when the demand of residents, who will be beneficiaries of technology, is reflected enough. Especially, healthy housing environment with true meaning cannot be actualized unless legal and institutional environment under current legislation is furnished. So examination and improvement in various fields such as allowed scope and liability of remote medical service linking housing space and medical institutions, medical insurance application, specific apparatus standard of remote medical apparatus targeting housing space, allowed e-commerce for drugs, framework act on social security are needed and most part of it is under progress. Also, legislation dealing personal information protection differs according to the applied fields, too, so there is need for integrated maintenance of privacy information act for activation of integrated fields.

At present, the fact that there is no advantage to draw the active participation of medical experts, the objection of current medical institutions, legal problems, prudent side of relevant policy department, absence of profitable healthy housing model are obstacles for the healthy housing service supporting remote medical service. It is seen that unless cultural and perceptual change of users breaking the current social norms that medical service can only be offered in medical institutions are accompanied, the attention towards smart healthy housing would end as just once-boom. For now, the endeavor to continuously inform people of usefulness and value of new technology and draw the demand of residents beforehand by actively providing demo service would be needed.

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