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Knowledge-based health service considering user convenience using hybrid Wi-Fi P2P

Kyungyong Chung[1] · Joo-Chang Kim[2] · Roy C. Park[3]

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Abstract Recently, with changing paradigms in health, the focus of healthcare is shifting from treatment after contracting disease to prevention and early diagnosis of disease. Accordingly, the healthcare paradigm is changing from diagnosis and treatment to preventive management, emphasizing prevention of chronic diseases, such as obesity. In particular, obesity in children and adolescents has become a global issue. Lifestyle and health management using BT–IT convergence is needed to improve and manage the health of children and adolescents, and convenience and accessibility must be improved. For that, use of a machine-to-machine (M2M) u-health cluster that allows wireless network connection is increasing, along with wireless networks for measuring biometrics. Expanded to communications between people and objects as well as between objects, M2M refers to the next-generation convergence infra-architecture that offers intelligent services through various media. Because various wireless devices form a cluster when building a service platform using M2M, when the number of users with various M2M devices increases, data traffic increases and causes network overload, deteriorating system performance. To solve this problem, services are increasingly being built by combining a conventional network and Wi-Fi technology. However, in an M2M network, there is a limitation due to low transfer speed, because the network processes biometrics and data through different sensor nodes, and wireless communications based on the system is composed of different wireless sensor nodes. Thus, in this paper, we proposed a knowledge-based health service considering user convenience using a hybrid wireless fidelity (Wi-Fi) peer-to-peer (P2P) architecture. For knowledge-based health services in conventional M2M-based smart health services, hybrid Wi-Fi P2P and wireless devices must be linked. Because there are different ways to link hybrid Wi-Fi P2P devices, depending on the network environment, in this study, a dynamic configuration mechanism is applied to Wi-Fi P2P linkage of wireless devices in an M2M environment. The proposed service provides a high-quality health service (whenever patients use the knowledge-based health service) by building a network using a dispersed cross-layer optimization algorithm that optimizes variables of the transmission control protocol/internet protocol stack in order to improve the energy efficiency of the u-health sensor network and system reliability.

Keywords u-Healthcare · Knowledge-based health · M2M · Hybrid Wi-Fi · P2P · Human UX/UI · Healthcare · Chronic disease

✉ Roy C. Park
roypark1984@gmail.com

Kyungyong Chung
dragonhci@gmail.com

Joo-Chang Kim
kjc2232@naver.com

1 School of Computer Information Engineering, Sangji University, 83, Sangjidae-gil, Wonju-si, Gangwon-do 220-702, Korea

2 Intelligent System Lab., School of Computer Information Engineering, Sangji University, 83, Sangjidae-gil, Wonju-si, Gangwon-do 220-702, Korea

3 Division of Computer Engineering, Dongseo University, 47 Jurye-ro, Sasang-gu, Busan 617-716, Korea

1 Introduction

Recent demographic changes have shifted the healthcare paradigm to home healthcare, which has resulted in an increase in u-health combined with e-health. u-Health uses convergence information technologies to provide prevention of illness, or diagnosis, treatment, and post-management of illness. As an expanded service, in comparison to conventional remote healthcare, u-health encompasses all healthcare services provided, based on a wired/wireless communications infra-architecture and its devices. A u-health system enables remote health management of chronic-disease patients, and health maintenance and health improvement for the general public. Medical services, which used to be limited to individual sessions and treatments, are now available in all areas of life without limitations on time and space, because of this new medical paradigm based on IT, BT, and NT technologies [1–4]. With changes in health paradigms, healthcare is also directed toward prevention and early diagnosis of disease, rather than treatment after diagnosis, which has led to an emphasis on prevention of chronic diseases. In particular, obesity in children and adolescents is becoming a national and global issue [5–7]. Lifestyle and health management using BT–IT convergence is needed to improve and manage the health of children and adolescents, and convenience and accessibility must be improved. For that reason, a u-health system for obese patients is being introduced in Korea and elsewhere, with its clinical efficacy being published. The goal of treating these kinds of chronic diseases is not complete recovery but in preventing secondary disease based on continuous administration and activity recommendations. For effective management, the clinic and patients must cooperate, and this explains active research and development of the clinical decision support system (CDSS) and the health decision support system (HDSS). A CDSS provides an evolved medical service that takes into account various elements by accumulating bases needed for diagnosis [7, 8]. Also, many studies are being conducted to develop an open platform that connects the HDSS and various mobile devices in order to provide accurate health information. In a wireless body area network, a health service includes mobile health management, online medical information, disease monitoring, and telemedicine [9, 10]. A wireless body area network does not have a wide service area, because it is a low-power, small-area network. However, for seamless health service, updates must be available anywhere and anytime. In particular, ZigBee and Bluetooth are widely used for medical-purpose networks and are practically optimized for healthcare, given the current status of the medical environment [11–14]. Wireless communications currently used for health sensor networks means adaptation layer design with a small frame size compatible with the traditional transmission control protocol/internet protocol (TCP/IP) stack for energy efficiency. Through standardization as a u-health application transport layer that is highly compatible with the existing IP, this can be applied to different types of network environment after developing a sensor application based on traditional TCP/IP protocols and applications. However, the conventional adaptation layer requires a gateway that will interlink a wireless sensor network with the internet for seamless integration of the TCP/IP stack, which causes some difficulty when building a u-health sensor network [15, 16, 28]. To solve this problem, in IEEE 802.15.4, to build a local sensor network, the existing network and wireless fidelity (Wi-Fi) technology is combined to build the service. Building a health network through Wi-Fi, in comparison to IEEE 802.15.4 and Bluetooth, enables compatibility with the conventional TCP/IP protocol stack and, thereby, sensor integration with the conventional IP network and old IP devices [17, 18].

In this paper, a knowledge-based health service considering user convenience using a hybrid Wi-Fi P2P architecture is proposed to enable users to enjoy efficient and economic healthcare through correct measurement of various bio-signals, considering mobility and user convenience of machine-to-machine (M2M)-based smart services. A knowledge-based health service requires interoperation of hybrid Wi-Fi peer-to-peer (P2P) and wireless devices under the conventional M2M-based smart service. Because the method of building a hybrid Wi-Fi inter-operational network differs, depending on the network environment, in this study, a four-step dynamic configuration mechanism for various network environments is applied for interoperation of hybrid Wi-Fi with wireless devices in an M2M environment. The proposed service provides a high-quality health service (whenever a patient uses the knowledge-based health service) by building a network using a dispersed cross-layer optimization algorithm that optimizes the variables of the TCP/IP stack in order to improve energy efficiency of the u-health sensor network and system reliability. This means the TCP/IP protocol stack is composed dynamically rather than statically by the distributed background algorithm for a smart health service network based on Wi-Fi controlling the TCP/IP stack, for communications between different types of system. By doing so, it can be smoothly integrated with a ubiquitous Wi-Fi backbone while improving energy efficiency and enabling reliable communications. This allows users, medical staff, and family to monitor, diagnose and even prevent disease anywhere and anytime.

The composition of this study is as follows. Section 2 describes research related to the knowledge-based medical service and mobile healthcare using a hybrid Wi-Fi P2P architecture. Section 3 describes the hybrid Wi-Fi P2P network-based health service. Section 4 describes the knowledge-based health service considering user convenience and activity. Conclusions are given in Sect. 5.

2 Related research

2.1 Knowledge-based medical service

One of the most well-known knowledge-based medical services, the clinical decision support system (CDSS), accumulates grounds for diagnosis in real time and provides an advanced medical service that takes into account various elements. In other words, based on data provided by and accumulated from different patients, it makes a probabilistic judgment and gives advice. Figure 1 shows the clinical decision support system architecture. The CDSS is a system to help a specialist diagnose disease or decide on treatment, and applies accumulated patient information at the time of treatment and improves the quality of the healthcare service. Applicable areas for a CDSS include cautions, interpretations, assistance, criticisms, diagnosis, and management, while core elements required for implementing a CDSS include patient data, a decision-making model or engine, a knowledge base, and user–computer interaction [34, 35, 39, 40]. Although a CDSS cannot replace diagnosis by a specialist, it can improve self-management by automatically providing a message according to rules.

Medical guidelines are needed in order to provide a decision support system for chronic disease patients through a CDSS, as well as the providence of intelligent services and clinical decisions by the medical staff. Figure 2 shows the service process of the clinical rule editor used for a CDSS. The clinical rule editor is a program used for creating and editing the knowledge base of the inference engine used for clinical decision making and healthcare service personalization. An artificial intelligence method that is mainly used for the CDSS to apply clinical knowledge to actual diagnosis is a rule-based inference. To provide customized recommendations, there should be clear guidelines about the particular state of a patient within the knowledge base for decision making [7, 34].

The condition editor within the system is a program used for creating and editing an inference engine used for clinical decision making and healthcare service personalization. Here, by using an HDSS rule-based algorithm, conditions for each chronic disease are defined and, based on data from the Korea National Health and Nutrition Examination Survey, pure hypertension patients, pure diabetes patients, and pure hyperlipidemia patients were selected and used as data. Examinations that can be used to obtain and attribute data according to chronic disease include blood pressure, heart rate, blood analysis, urine tests, body fat tests, amounts of exercise, smoking, and body mass index. The providence of health and disease data is decided after classifying the data based on the existence of examination results or health type, and messages are provided according to the category [35, 36, 39].

2.2 Mobile healthcare using hybrid Wi-Fi P2P

Exchange of medical data through an internet-based medical infra-architecture and digitalization of medical data is one of the changes that has spread most quickly in the healthcare market. And mobile health is a product of technological advances and constant efforts to improve the healthcare industry [19–21]. Figure 3 shows the tele-health ecosystem of the Continua Health Alliance, which provides healthcare by connecting mobile devices with scales, sphygmomanometers, etc., to the internet. Also, it is an organization founded to review standard technologies and establish design guidelines that enable inter-connection of IT

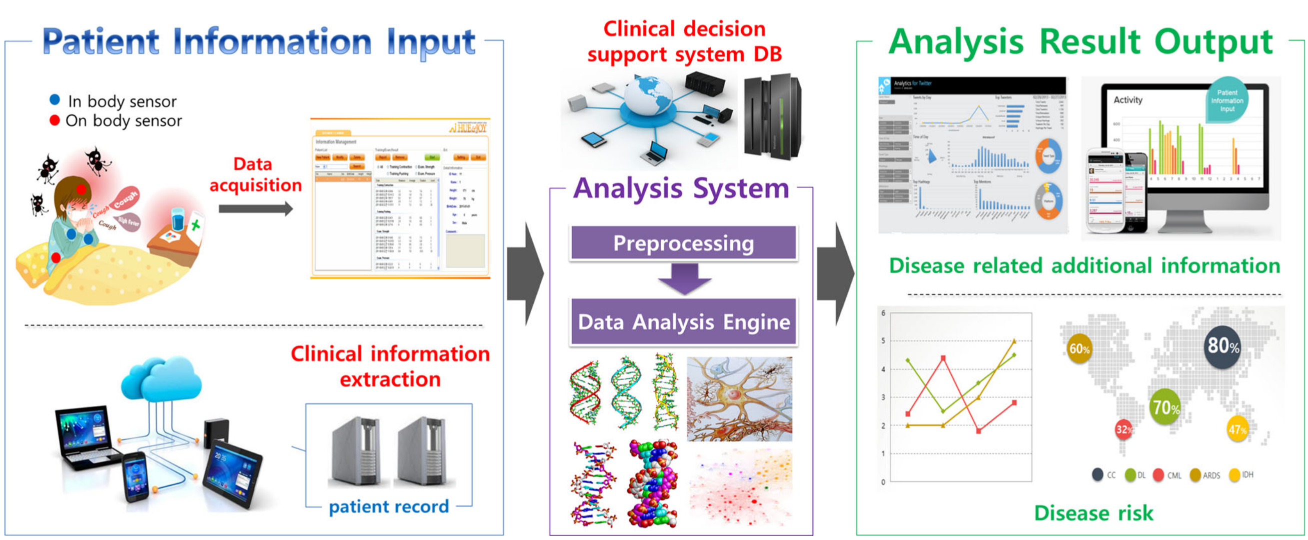


Fig. 1 Architecture of a clinical decision support system (CDSS)

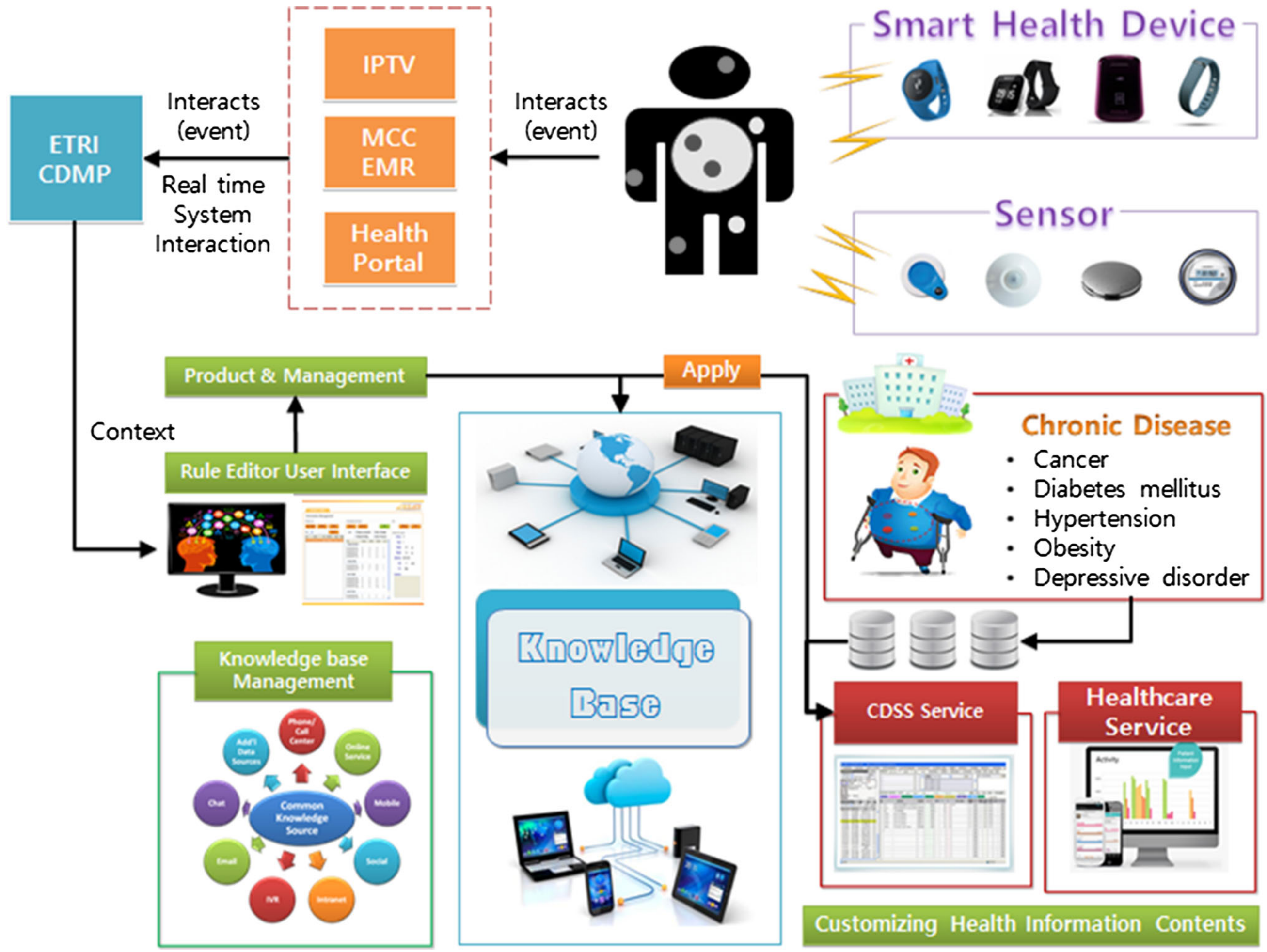


Fig. 2 Service process of the clinical rule editor used for CDSS

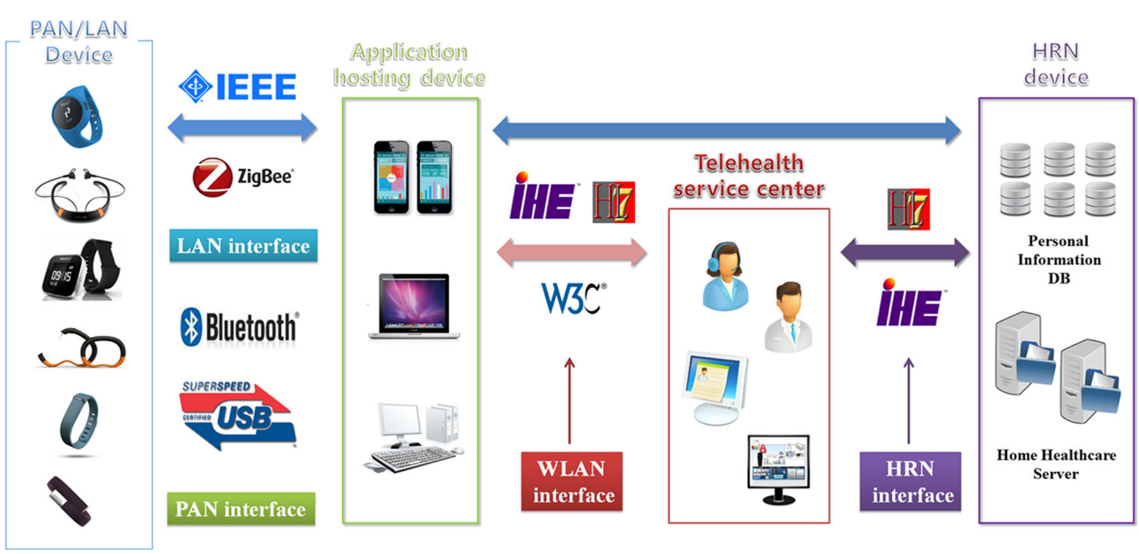


Fig. 3 Tele-health ecosystem of the Continua Health Alliance

technologies and healthcare devices [22, 30–34]. Currently, over 230 global corporations, such as GE, Phillips, Intel, Motorola, and Sony, are participating in this organization. Continua divides devices into PAN-IF, LAN-IF, WAN-IF, and HRN-IF for compatibility. This is part of an integrated treatment process for a mobile healthcare service and allows patients to manage their condition in their daily lives. Patients can obtain customized education information according to their needs and receive help in changing their lifestyle, their medicines, and in tracking the treatment process [23, 24, 28].

For special cases in particular, it provides services by linking with a telemedicine health service. Currently, the Korea Coast Guard provides remote medical services on the sea through the convergence of telemedicine and an M2M-based health service [25, 28, 32]. Figure 4 shows the maritime telemedicine for Korean coast guard. This is expected to be efficient by enabling the coast guard to perform first aid during transportation from the dispensary in the coast guard ship. In the ship, an automated external defibrillator (AED), a patient bio-signal monitoring device (for blood pressure, heart rate, oxygen saturation, breathing rate, temperature, ECG), a webcam, and a wireless headset are installed and, by using the wide-area network called KOSNET, the medical data are transferred between the ship and the hospital to provide guidance on treatment.

3 Hybrid Wi-Fi P2P network-based health service

3.1 Mobility scenario of conventional M2M-based smart health service

The knowledge-based health service proposed in this study should be able to provide mobility, regardless of the situation of a user, to deliver accurate data. In other words, when a network moves and changes nodes on the internet, the terminal within the internet must be able to connect to the internet without changing its address. Mobility of the conventional M2M-based smart health service [28, 41] is represented as the network architecture in the inside and the outside scenarios shown in Fig. 5. In the outside scenario, because the user carries both a smartphone and a sensor, both are within transmission range, and a star topology is created, with the smartphone in the center acting as an IP gateway. In the inside scenario, other static sensors forming the network can interfere with communication between a smart health device and a sensor. Particularly when it has an access point (AP) like a picocell or a femtocell, the signal of the AP is stronger than the sensor signal, so the ISI and ICI of the sensor signal is generated. Because the sensor communicating with a u-health device can go out of range, a link is required to reach the destination [32]. Also, incompatibility with IP caused by the sensor network access method in an M2M environment demands a particular gateway, which has a negative effect on optimal energy efficiency and network design.

In an M2M-based smart health service, network requirements of the sensors will be different because it uses various types of sensors. For instance, data from sensors like a monitor need to reach the destination with minimum delay and high reliability. By contrast, the sensor that measures simple momentum does not necessarily have to send the data, so a long delay is allowed. For instance, in order to prevent data transmission through a link with low reliability and subsequent energy inefficiency, the sensor can buffer the data while the patient is being transported and, when the patient is not moving, the data can be sent in one large batch. To solve this problem and provide a seamless knowledge-based health service in various

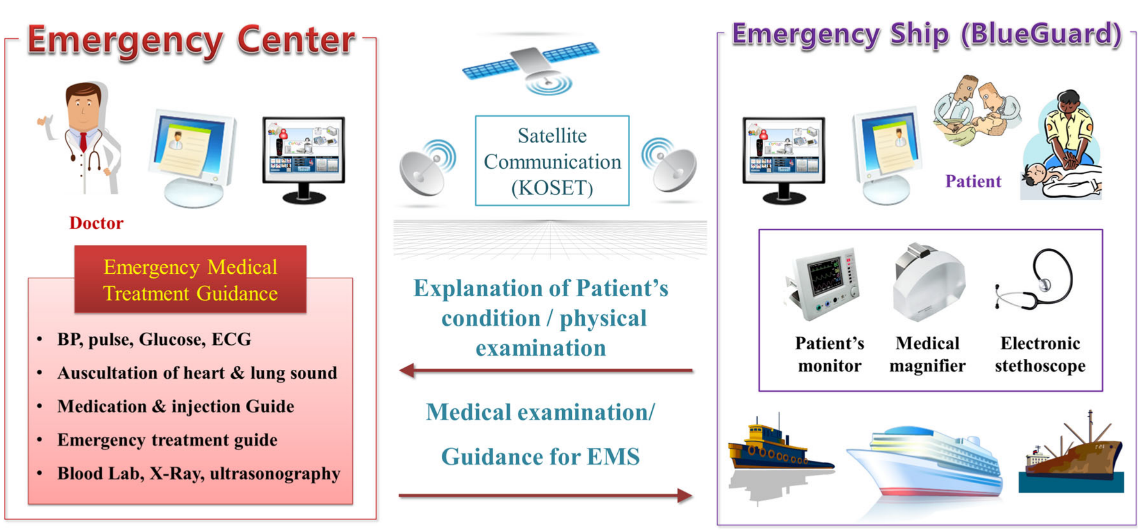


Fig. 4 Maritime telemedicine for Korean coast guard

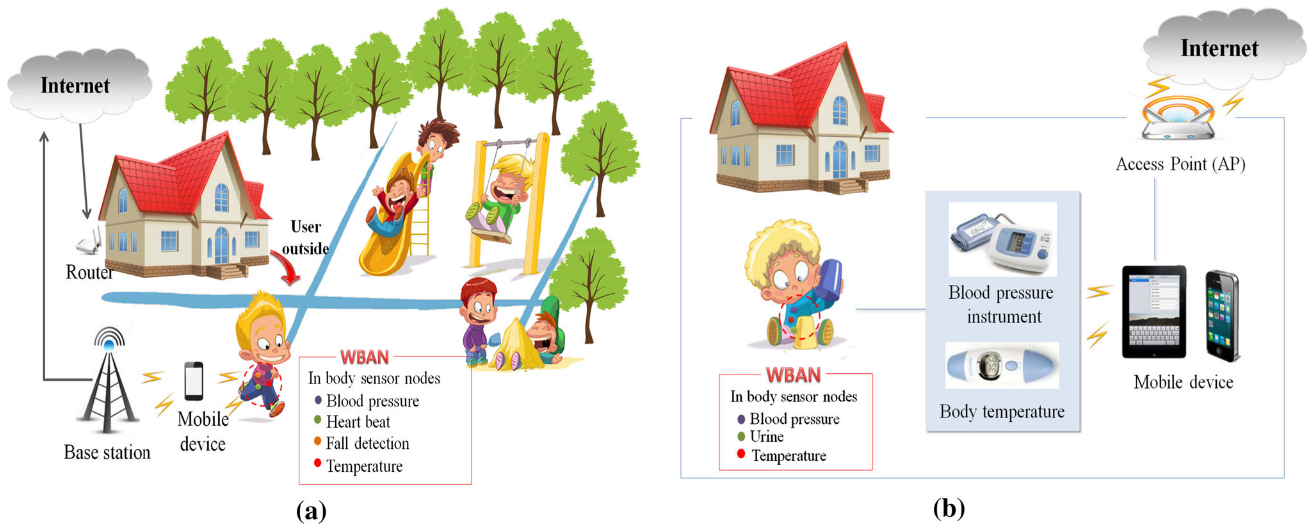


Fig. 5 Mobility scenarios of an M2M-based smart health service. **a** Outside scenario. **b** Inside scenario

environments, the service must combine an M2M-based smart health service and a hybrid Wi-Fi P2P architecture [28]. Hybrid Wi-Fi P2P is a standard established to support direct communications between Wi-Fi modules by the Wi-Fi Alliance, implementing peer-to-peer between devices through wireless communications. This replaces Bluetooth and ZigBee, supports a high transmission speed and a wide transmission range, and is expected to spread rapidly, replacing part of the existing Bluetooth market. In addition, as shown in Fig. 6, it allows up to eight devices to be connected simultaneously through P2P without an AP. Hybrid Wi-Fi P2P uses most physical layer protocols except 802.11b of IEEE 802.11 for data communications. Currently, most Wi-Fi chips support IEEE 802.11 g or 802.11n and can be used by firmware upgrade and middleware transplanted from a device with a Wi-Fi chip, which facilitates fast distribution [26]. Both IEEE 802.11 g and IEEE 802.11n used for hybrid Wi-Fi P2P use the orthogonal frequency division multiplexing physical layer protocol, and offer various transmission rates according to the modulation system. When the application of Wi-Fi Direct expands, it can be used for a home network and M2M. It can lead to the introduction of a network service for various devices, like home appliances, lights, and cooling and heating devices. Also, when it is expanded to industrial devices, a broadband M2M service capable of large-capacity data transmissions, such as a real-time image service, will become available [27, 28, 40]. Hybrid Wi-Fi P2P technology is hybrid network communications combined with flow net and power line communications. Wi-Fi is becoming more widely distributed to various devices, and, even for devices such as air conditioners, refrigerators, and robot cleaners, low-power Wi-Fi is used for integrated device management.

3.2 Network architecture of the proposed knowledge-based health service

For the knowledge-based health service proposed in this study, the authors propose an interworking architecture between the existing M2M-based smart health service and a hybrid Wi-Fi P2P network. For it, hybrid Wi-Fi P2P and various wireless devices must interoperate in an M2M-based smart health service, and Wi-Fi network interoperation differs, depending on the network environment. Interoperation of hybrid Wi-Fi P2P in an M2M-based smart health service uses an architecture and protocol stack shown in Fig. 7. The data plane has a direct influence on data flow. The core network component of the data plane is the network gate, composed of BS and NG, and the data plane supports a mobility anchoring function through tunneling between network gates. Although the network control plane manages the overall connection service, it is not directly involved with data flow. Also, it is responsible for network access control, mobility management, security management, and session management. This is a cross-layer method to improve energy efficiency and system reliability of the knowledge-based health service network. This architecture not only offers service continuity so that users can receive service without resetting the activated session when they are moving, but it also offers high quality of service (QoS) even during hand-off. Therefore, it can provide real-time service, even when patients are moving, according to hand-off optimization of the data link layer and the network layer.

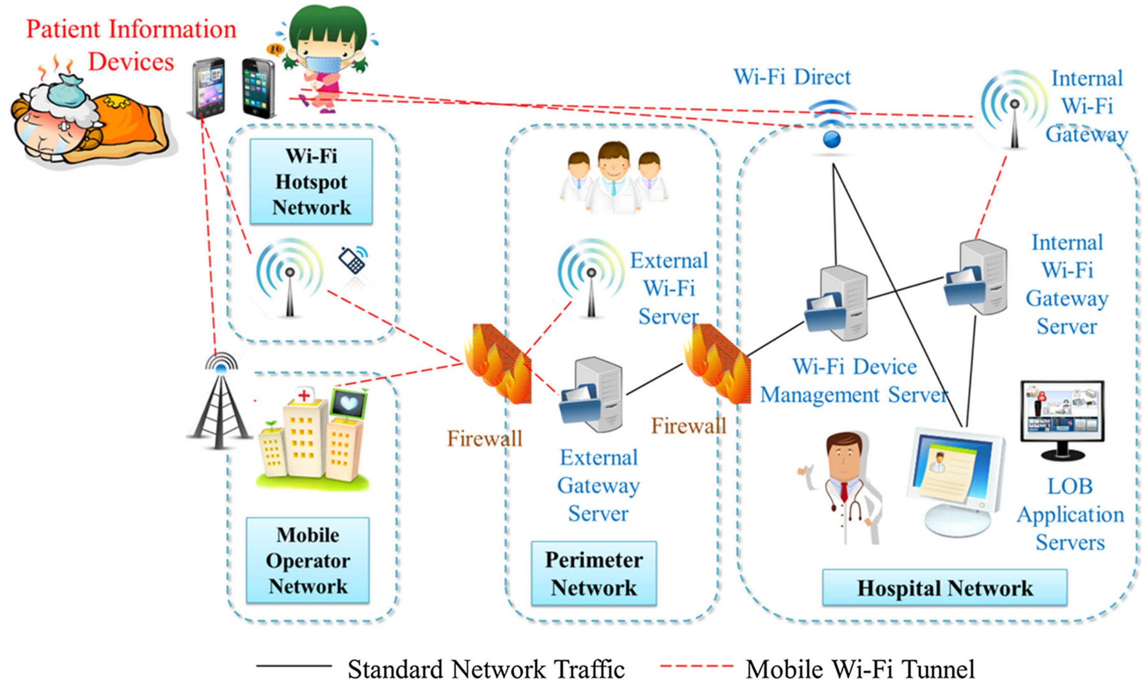
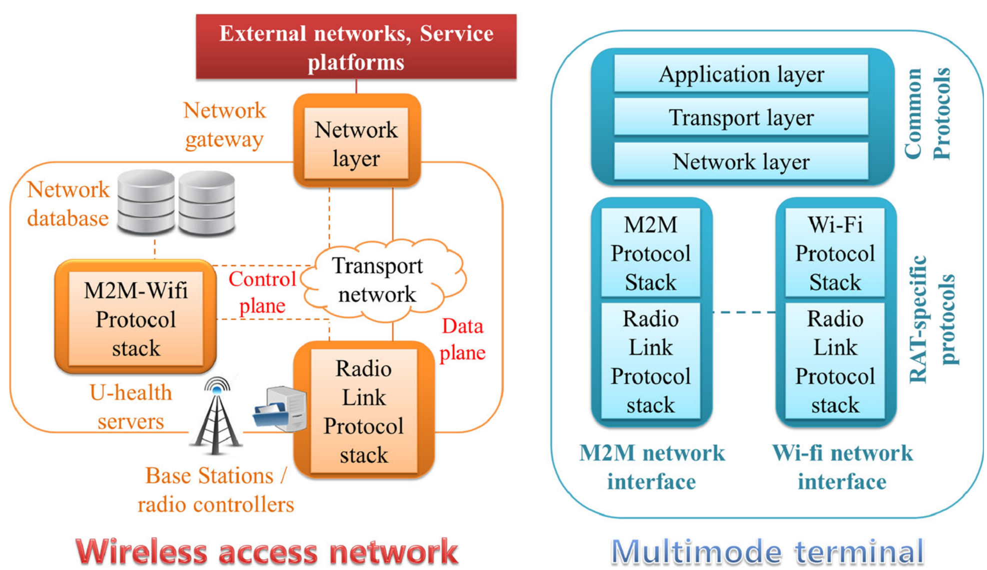


Fig. 6 Structure of a Wi-Fi P2P network

Fig. 7 Internetworking architecture of the M2M-based smart health service and hybrid Wi-Fi P2P



4 Knowledge-based health service considering user convenience and activity

4.1 Mechanism of knowledge-based health service

Figure 8 shows the mechanism of the proposed knowledge-based health service. The service mechanism is expanded between the M2M network and the Wi-Fi network [32] as a network interconnection stage in the existing study [28–30] of the Network Mobility Home Agent Architecture. A Level A mechanism requires a framework to support authentication methods for health devices in the hospital, and a network between gateways to connect them, and must use a function, such as diameter, related to the proxy-relay and signaling interface between networks. Also, the interface for communications between devices and server must be defined. On level B, layer 2 tunneling protocol (L2TP), IPsec tunnel mode, IPsec ESP protocol, and other functions are needed as a mechanism to enable services that are only available on the ward network. Level C is a

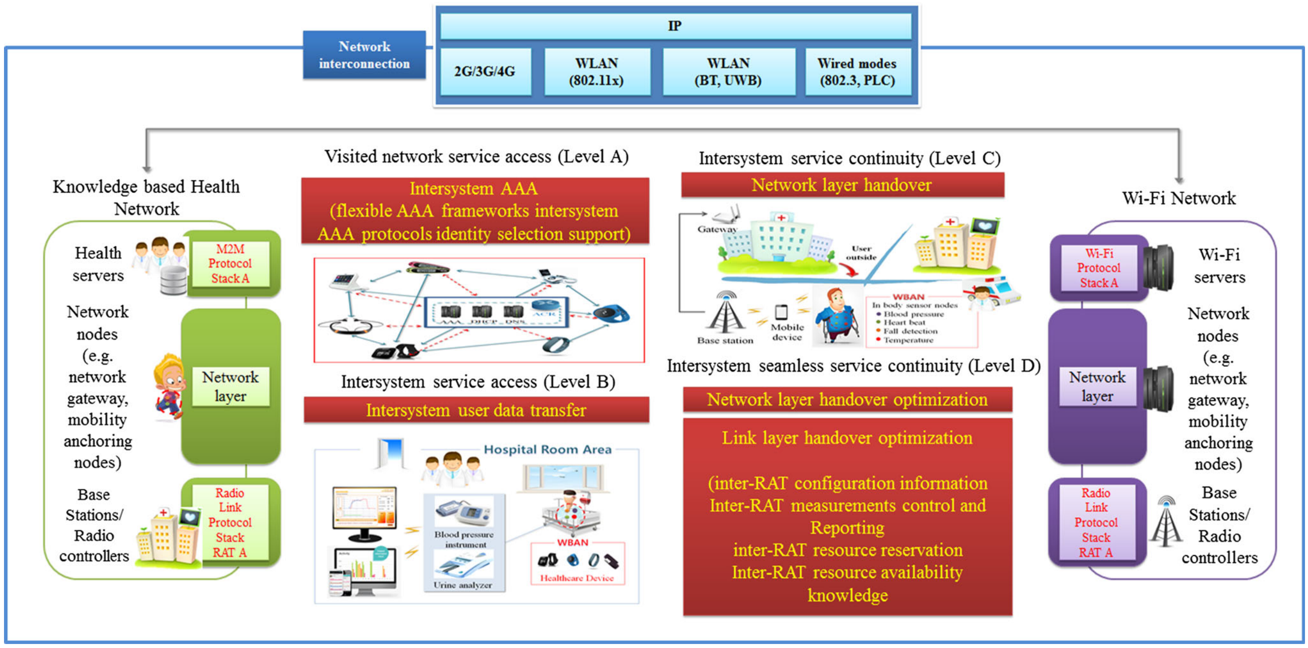


Fig. 8 Mechanism of the proposed knowledge-based health service

mobile protocol of the network layer that can provide service continuity for patients when they move within or outside the hospital. This mechanism is included when service continuity and patient mobility is desired. Level D includes not only delay of each link during the handoff of each network but also that of the network layer, as well as request repeat for user data during handoff. This architecture provides service continuity for users to receive service without resetting the activated session, even while they are moving, and also a high QoS during handoff. This enables real-time service while moving through optimization of the data link and the network layers.

4.2 Knowledge-based health service using hybrid Wi-Fi P2P

The mobility mobile device of WBAN collects data measured by the sensor and sends it to end system corresponding to destination through broadband router etc. This end system may be a healthcare service provider and some of a wireless service provider. Data measured here are stored in a web-based system, promptly sent to the provider and monitored by a person in charge in the medical agency. A personal area network targets short-range heterogeneous networks in the smart health service. Communication consists of Bluetooth, IETF 6Low-PAN, Wi-Fi, and wireless HART. Zigbee, which is mainly used in personal area networks, can play various roles as a coordinator, router, and end devices, etc. For medium access control layers, IEEE 802.15.4 defines two channel access methods, which are access methods with or without a beacon. The beacon method includes a coordinator that creates and sends the beacon for synchronization. In the non-beacon method, a device adopts carrier sense multiple access with collision avoidance system to compete channel access. A mobility mobile device is a terminal not communication module simply processing only routing function and information of all sensor modes can go through a mobility mobile device. Its limitation is that communication is possible only when the user should always carry a mobile device. According to user mobility and network status, when there is no IP core network, an inter-operational network can be formed by building a Wi-Fi P2P network server farm [29, 30, 34]. Figure 9 shows a knowledge-based health service using a hybrid Wi-Fi P2P architecture. In this case, the hybrid Wi-Fi P2P network is placed below the ACR of the knowledge-based health service network to perform LMA of the ACR. On the other hand, to build a safe hybrid Wi-Fi P2P network, security technology is required for user authentication based on IEEE 802.1X, use of WPA2, change of default SSID, filtering of MAC addresses and allocation of fixed IP addresses, activation of a firewall between computer and router, and physical protection of the router and AP. Here, a dynamic configuration mechanism is applied to optimize resource use in the network.

In Fig. 10, this mechanism relies on a configuration mechanism and a context manager, and the configuration mechanism receives input from the context manager to apply the configuration set to the nodes. Here, considering the dynamic environment for sensor operation, specific

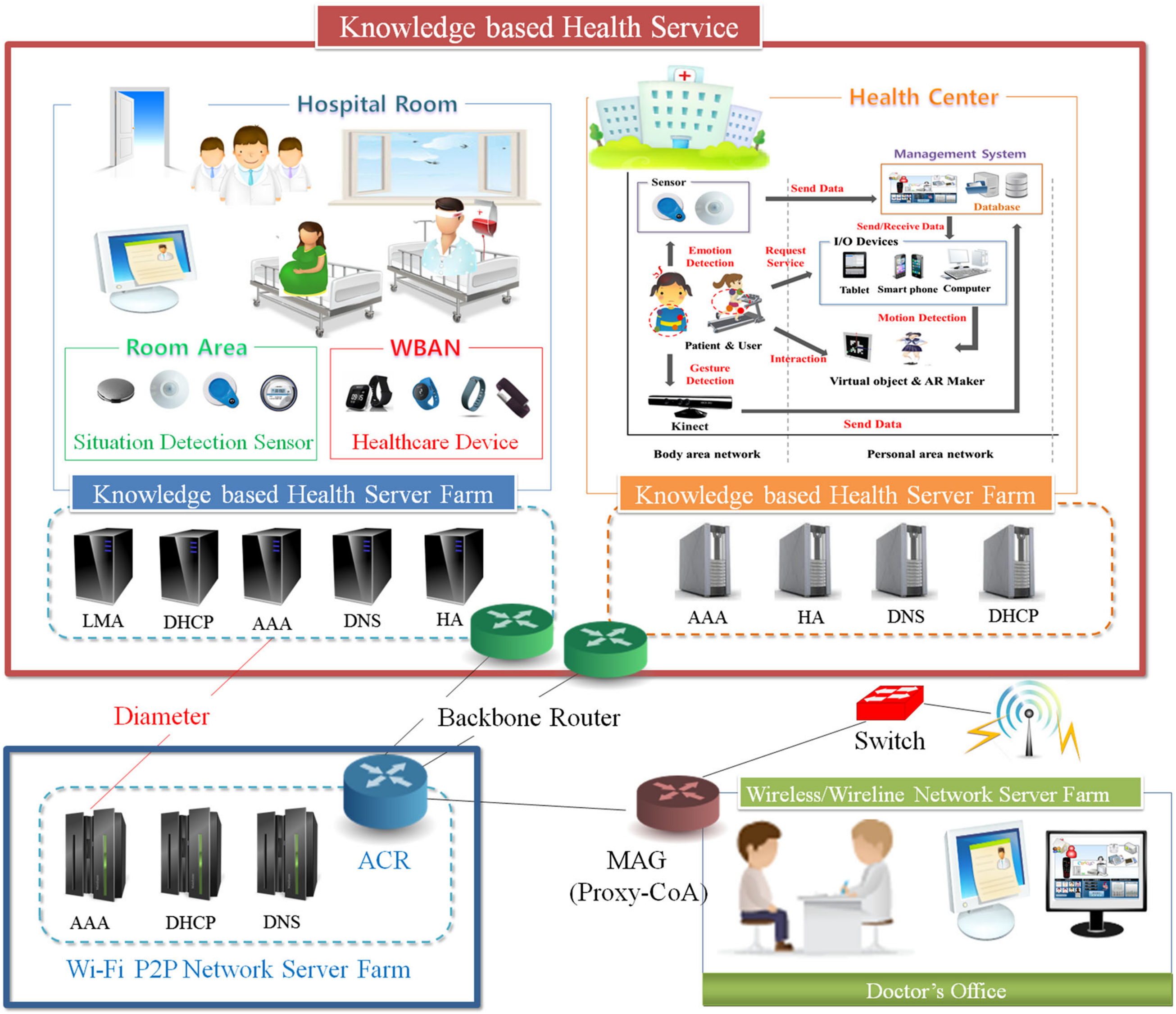


Fig. 9 Example of a knowledge-based health service using a Wi-Fi P2P architecture

traffic types and patterns, relevant communications distance, relevant sensor types, reliability, and delay conditions, optimal values relating to maximum transmission in each protocol layer, frame size, temporary pause of request repeat, duty cycle, and connection speed are decided. As a result of variable optimization, the sensors consider a frame size that maximizes MAC transmission efficiency, frame error ratio, and frame repeat, and reduces idle time between frame transmissions.

Also, choosing a transport layer that satisfies reliability and delay conditions and minimizes wasted energy can maximize network efficiency and reduce energy consumption [38–40]. Through context variables, the context manager infers surrounding network information based on network variables and user behavior and status. Characteristics are decided based on data easily obtained from the protocol stack, including network topology (single/multiple hop), connectivity, interference level, number and type of nodes, information that can be obtained from nodes, such as traffic pattern, and connection requisites. When there is strong interference due to mobility within the network, unimportant nodes suspend transmission in order to prevent efficiency deterioration. Also, to prevent loss of packets, nodes that contain important data move the data to reliable nodes for transmission. User context is interfered by data collected by nodes. When a user is on a network receiving u-health service, some static nodes are formed, and because a node can be used as a packet intermediary, a multiple-hop route can be configured through each node. If a user does not move in an outdoor

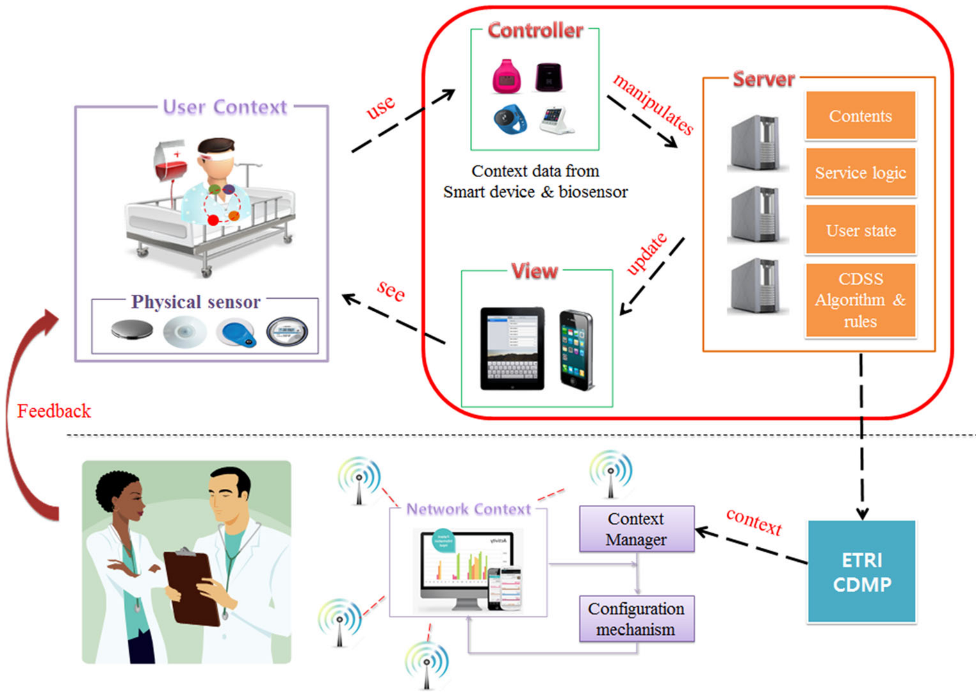


Fig. 10 System architecture of a dynamic configuration mechanism

Table 1 Traffic characteristics by traffic class

	Conversation	Streaming	Interactive	Background
Maximum bit rate	≤Wave2 Spec	≤Wave2 Spec	≤Wave2 Spec	≤Wave2 Spec
Maximum packet size	≤1500	≤1500	≤1500	≤1500
Packet error rate	10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-4}, 10^{-5}
Transfer delay	150 max	250 max	If available	None

environment, network stability is maintained for a short time. Therefore, in case of low interference, the node sends the suspended packets and prevents resending.

4.3 Simulation result

For simulation of the proposed method, we used a micro mobility model [37] for inter-cell mobility, and a Markov model [38] with two states. The model presents two states: one is mobility (M), and the other is stationary (S). It is assumed that, when the channel state is mobility, its moving speed has a constant value. In addition, the traffic of a user with mobility was classified as shown in Table 1.

Conversation traffic is a traffic class to provide the highest QoS between networks. To offer remote medical service and patient status information in real time over a u-health network, it is necessary to provide high QoS. Streaming traffic is a traffic class to provide a streaming service in real time. To give feedback smoothly according to each patient's state, it is necessary to guarantee QoS to provide medical images and the images of the patients' states in real time. Interactive traffic is a traffic class to provide a web service. To provide web-based patient information through a P2P network service, it is necessary to provide QoS to control the web service, which can cause extra traffic. Background traffic is a traffic class related to the web service, similar to interactive traffic. It is aimed for e-mail service and file transfer protocol service. Since this traffic features the best-effort transmission on the web, it needs to provide as high a QoS as interactive traffic.

In the traffic environment, simulation for extended mechanism levels was performed in between the M2M network and the Wi-Fi network. The next figure illustrates the processing amount of each traffic class in the extended mechanism levels. As shown in Fig. 11, conversation traffic showed a high processing amount in Level A to Level D. That was because the best QoS should be provided for a remote medical service. In particular, in the case of Level D, service continuity should be guaranteed when users move in the network; and QoS, including retransmission of user data, should be provided at the time of hand-off. Therefore, the processing amount was high.

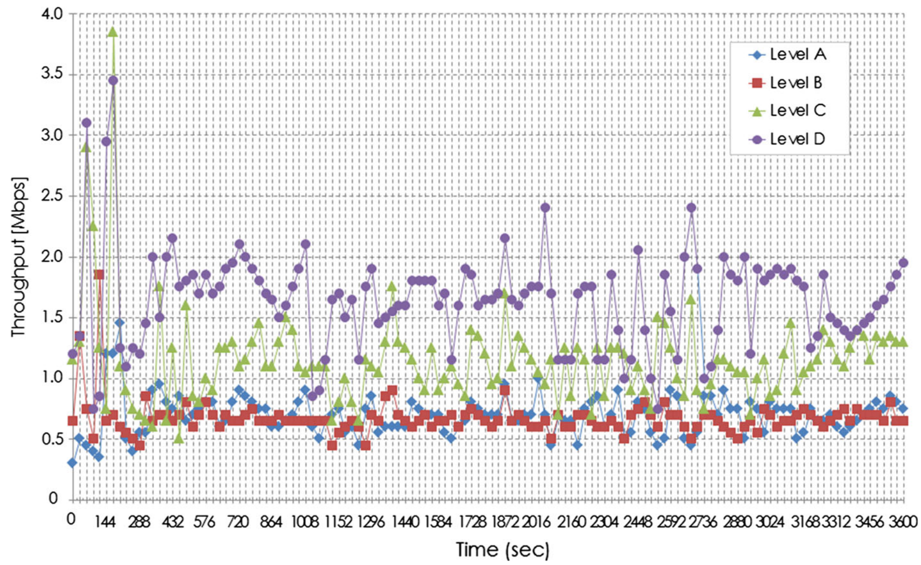


Fig. 11 Throughput of conversation traffic

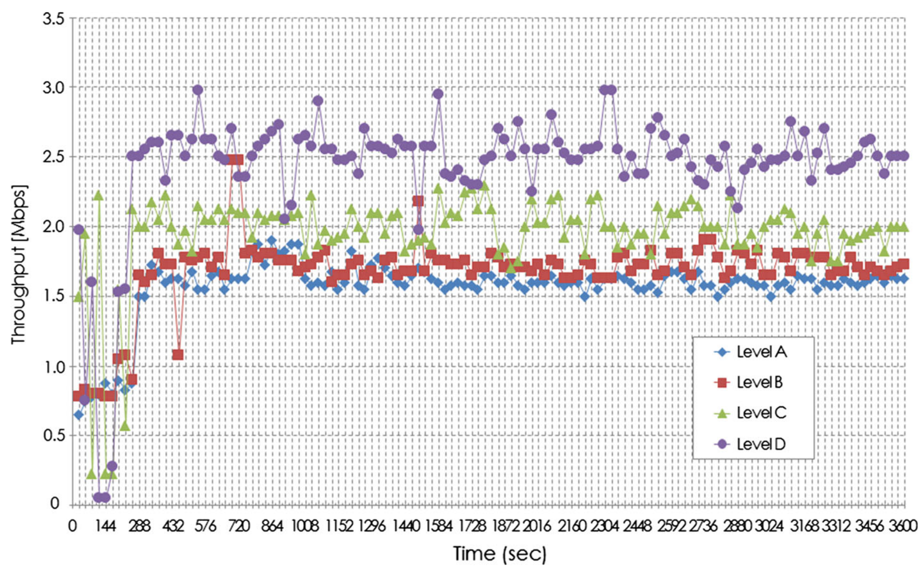


Fig. 12 Throughput of streaming traffic

Figures 12 and 13 show the throughput of streaming traffic and interactive traffic. The reason that the early data processing amount for streaming traffic and interactive traffic fell was that the mechanism, in which users in Level A and Level B are allowed to use specific services only in the home network, did not guarantee service continuity at the time of mobility. However, in Level C and Level D, service continuity was guaranteed on the basis of mobility protocol, and seamless handover QoS was supported. Therefore, in the levels, a high processing amount appeared.

Figure 14 shows the throughput of background traffic. In background traffic, as described below, because it is transmitted through web of best-effort characteristics, even for users with movement at all levels, it can be seen that seamless data transmission and reception are provided.

The average delay time of traffic is presented in Table 2. The average delay time for streaming traffic was larger than that of interactive traffic, for continuous traffic transmission occurred, and thereby, there were a lot of packet losses in the handover process. However, its standard deviation was smaller than that of interactive traffic, which caused discontinuous traffic transmission.

In Level A and Level B of the extended mechanism, delay time was long in the four classes of traffic [41]. Therefore, it is not difficult for users to receive services that are allowed only in a home network, but there is a restriction in providing mobility in an actual u-health network. In Level C and Level D, the average delay time fails to meet the requirements for each type of traffic, which makes it possible for service continuity in an actual

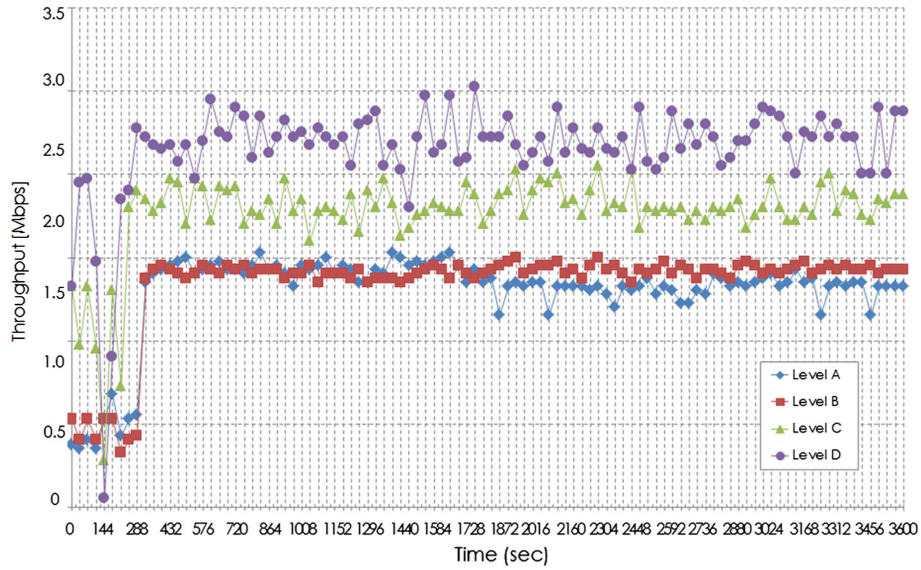


Fig. 13 Throughput of interactive traffic

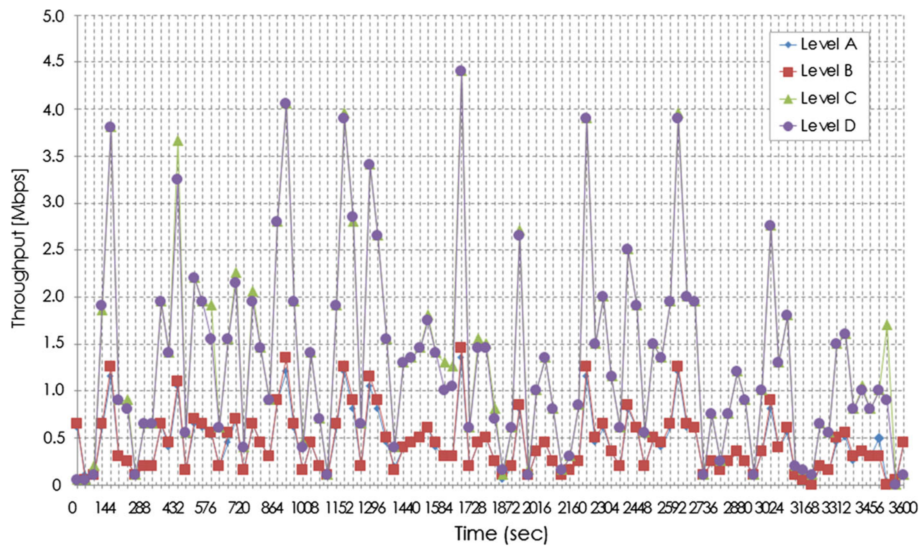


Fig. 14 Throughput of background traffic

Table 2 Traffic of average delay time

	Conversation	Streaming	Interactive	Background
Level A				
Avg. (s)	1618	4821	3929	11,090
Max (s)	9125	11,065	14,864	41,693
Level B				
Avg. (s)	1576	3012	2461	4901
Max (s)	2832	4198	8889	26,631
Level C				
Avg. (s)	278.29	497.44	620.18	1518.43
Max (s)	415.58	1172.21	2360.8	2581.11
Level D				
Avg. (s)	119.65	365.4	486.2	925.67
Max (s)	201.21	691.8	1227.5	1821.9

u-health network. Therefore, it is possible to provide real-time images and support mobility smoothly. In particular, in the case of the Level D Intersystem Seamless Service Continuity, it is possible to support diverse applications and continuity in the u-health network through the required condition and optimization process in the interoperability of actual networks.

5 Conclusion

In this paper, we proposed a knowledge-based health service considering user convenience using a hybrid Wi-Fi P2P architecture. This service was designed for a program that integrates a medical program into daily life, so that users can easily predict and manage both health and disease. While research and development of the conventional patient management system has focused on professional monitoring systems in hospitals, this system considers user convenience for patients to receive continuous health service without interfering with daily life while operating more economically and efficiently. The proposed network service, based on a hybrid Wi-Fi P2P architecture, not only provides service continuity through optimization of TCP/IP stack variables to improve energy efficiency and system reliability of the knowledge-based health service network, but also high QoS during handoff. This enables a real-time service while moving through optimization of the data link layer and the network layer. In an M2M-based smart service, the hybrid Wi-Fi P2P architecture and each wireless device should interoperate, and the method differs depending on the network environment. In this study, a four-step dynamic configuration mechanism for various network environments was applied for interoperation of hybrid Wi-Fi with wireless devices in an M2M environment. Also, a dynamic configuration mechanism was applied to optimize P2P connections among devices and the use of resources within the network. Considering the sensor environment, at each protocol layer, optimal values are decided for each variable. As a result of variable optimization, the sensors consider a frame size that maximizes MAC transmission efficiency, frame error ratio, and frame repeat, and reduces idle time between frame transmissions. Here, each device detects a change in Wi-Fi status through a connection manager and performs P2P connection between devices, to manage device data and peer data by using data generated by the event. Upon direct Wi-Fi connection, to share peer data with each other, devices can exchange data through the internal communication module based on socket. The proposed u-health network service based on Wi-Fi P2P access for mobility support, is already operating on TCP/IP and, therefore, does not need a new adaptation layer when building the network. And, by analyzing a scenario through the proposed mechanism, available resources can be maximized to reduce overall energy consumption. Furthermore, through real-time monitoring of context variables, the network can be applied to various conditions and requisites, and the proposed network configuration is expected to be easily integrated with existing wireless devices because the MAC layer is not defined.

Also, because it supports service mobility, the proposed service can enable users to receive accurate data regardless of the user context and help patients manage their health and respond to emergency situations at home. Furthermore, it can help solve problems, such as obesity in children and adolescents, healthcare costs, and national health problems.

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References

1. Michael R (2007) Applying emergent ubiquitous technologies in health: the need to respond to new challenges of opportunity, expectation, and responsibility. Int J Med Inform 76(3):349–352
2. Lim JE, Choi OH, Na HS, Baik DK (2009) A Context-aware fitness guide system for exercise optimization in U-health. IEEE Trans Inf Technol Biomed 13(3):370–379
3. Kim JK, Kim J, Lee D, Chung KY (2014) Ontology driven interactive healthcare with wearable sensors. Multimed Tools Appl 71(2):827–841
4. Park R, Jung H, Shin DK, Cho YH, Lee KD (2014) Telemedicine health service using LTE-Advanced relay antenna. Pers Ubiquit Comput 18(6):1325–1335
5. Khan AM, Lee SW (2013) Need for a context-aware personalized health intervention system to ensure long-term behavior change to prevent obesity. In: Proceedings of the 2013 5th international workshop on software engineering in health care (SEHC), pp 71–74
6. Valentin G, Howard AM (2013) Dealing with childhood obesity: passive versus active activity monitoring approaches for engaging individuals in exercise. In: Proceedings of ISSNIP biosignals and biorobotics conference, pp 1–5
7. Jung EY, Kim JH, Chung KY, Park DK (2013) Home health gateway based healthcare services through U-health platform. Wirel Pers Commun 73(2):207–218
8. Kang SK, Chung KY, Ryu JK, Rim KW, Lee JH (2013) Bio-interactive healthcare service system using lifelog based context computing. Wirel Pers Commun 73(2):341–351
9. Han DS, Lee MK, Park SJ (2010) THE-MUSS: mobile u-health service system. Biomedicine 97(2):178–188
10. Elgazzar K, Aboelfotoh M, Martin P, Hassanein HS (2012) Ubiquitous health monitoring using mobile web services. Proced Comput Sci 10:332–339
11. Kim JH, Chung K (2014) Ontology-based healthcare context information model to implement ubiquitous environment. Multimed Tools Appl 71(2):873–888
12. Cheng SH, Huang CY (2013) Coloring-based inter-WBAN scheduling for mobile wireless body area networks. IEEE Trans Parallel Distrib Syst 24(2):250–259
13. Ayyildiz C, Erman K, Ozgul ME, Erman AT, Gungor C (2012) TeleHealth: intelligent healthcare with M2M communication module. In: Proceedings of the 2th ACM workshop on mobile systems, applications, and services for healthcare 2012. doi:10.1145/2396276.2396285
14. Oh JY, Kim JK, Lee HS, Choi SS (2010) Phase rotation shift keying for low power and high performance WBAN in-body systems. In: Proceedings of the international conference on information and communication technology convergence, pp 28–32
15. Shon T, Koo B, Choi H, Park Y (2009) Security architecture for IEEE 802.15.4-based wireless sensor network. In: Proceedings of the 4th international symposium on wireless pervasive computing, pp 1–5
16. Higuera JE, Polo J (2011) IEEE 1451 standard in 6LoWPAN sensor networks using a compact physical-layer transducer electronic datasheet. IEEE Trans Instrum Meas 60(8):2751–2758
17. Ayoub ZT, Ouni S, Kamoun F (2011) Association criteria to optimize energy consumption and latency for IEEE 802.15.4/ZigBee wireless sensor networks. In: Proceedings of the 4th joint IFIP wireless and mobile networking conference (WMNC), pp 1–4
18. Lee MJ, Zhang R, Zheng J, Ahn GS (2010) IEEE 802.15.5 WPAN mesh standard-low rate part: meshing the wireless sensor networks. IEEE J Sel Areas Commun 28(7):973–983
19. Xin Q, Manne F, Zhang Y, Wang X (2012) Almost optimal distributed M2M multicasting in wireless mesh networks. Theoret Comput Sci 439:69–82

20. Park Y, Min D (2013) Design and implementation of M2M-HLA adaptor for integration of ETSI M2M platform and IEEE HLA-based simulation system In: Proceedings of the 5th international conference on computational intelligence, modelling and simulation, pp 315–320
21. Hung SH, Chen CH, Tu CH (2012) Performance evaluation of machine-to-machine (M2M) systems with virtual machines. In: Proceedings of the 15th international symposium on wireless personal multimedia communications (WPMC), pp 24–27
22. Benner M, Schope L (2011) Using continua health alliance standards—implementation and experiences of IEEE 11073. In: Proceedings of the IEEE 12th international conference on mobile data management, pp 40–45
23. Piniewski B, Muskens J, Estevez L, Carroll R, Cnossen R (2010) Empowering healthcare patients with smart technology. Computer 43(7):27–34
24. Wartena F, Muskens J, Schmitt L, Petkovic M (2010) Continua: the reference architecture of a personal telehealth ecosystem. In: Proceedings of the 12th IEEE international conference on e-health networking applications and services (Healthcom), pp 1–6
25. Jo S, Lee TK, Bang EW, Kim CJ, Im HJ, Kwon YJ, Jo YB, Baek DM, Joo YS (2010) Factors associated with unmet needs for medical care among island inhabitants in Korea. Korean Soc Agric Med Commun Health 35(2):151–164
26. Kbar G, Mansoor W, Naim A (2010) Voice over IP mobile telephony using WIFI P2P. In: Proceedings of the 6th international conference on wireless and mobile communications (ICWMC), pp 268–273
27. Rajasekhar S, Khalil I, Tari Z (2004) A scalable and robust QoS architecture for Wifi p2p networks. In: Proceedings of the first international conference on distributed computing and internet technology, pp 65–74
28. Park R, Jung H, Shin DK, Kim GJ, Yoon KH (2015) M2M-based smart health service for human UI/UX using motion recognition. Clust Comput 18(1):221–232
29. Lee SH, Chung KY, Lim JS (2014) Detection of ventricular fibrillation using hilbert transforms, phase-space reconstruction, and time-domain analysis. Pers Ubiquit Comput 18(6):1315–1324
30. Chung KY (2014) Recent trends on convergence and ubiquitous computing. Pers Ubiquit Comput 18(6):1291–1293
31. Jung H, Chung K (2015) Knowledge based dietary nutrition recommendation for obesity management. Inf Technol Manag. doi:10.1007/s10799-015-0218-4
32. Park RC, Jung H, Chung K, Yoon KH (2015) Picocell based telemedicine health service for human UX/UI. Multimed Tools Appl 74(7):2519–2534
33. Chung K, Boutaba R, Hariri S (2014) Recent trends in digital convergence information system. Wirel Pers Commun 79(4):2409–2413
34. Jung H, Yang JG, Woo JI, Lee BM, Ouyang J, Chung K, Lee YH (2015) Evolutionary rule decision using similarity based associative chronic disease patients. Clust Comput 18(1):279–291
35. Jung H, Chung K (2015) Sequential pattern profiling based biodetection for smart health service. Clust Comput 18(1):209–219
36. Medical Device (2012) Mobile health (mHealth) technology, revolution of medical service and management, GilKorea
37. Ibrahima N, Ousmane S, Claude L, Hamadou SH (2014) Enhanced HIP-based micro-mobility and macro-mobility management by proactive signaling scheme. In: Proceedings of the IEEE international conference on parallel and distributed system, pp 780–786
38. Lindberg DV, More H (2014) Blind categorical deconvolution in two-level hidden Markov models. IEEE Trans Geosci Remote Sens 52(11):7435–7447
39. Rho MJ, Kim HS, Chung K, Choi IY (2015) Factors influencing the acceptance of telemedicine for diabetes management. Clust Comput 18(1):321–331
40. Kim SH, Chung K (2015) Emergency situation monitoring service using context motion tracking of chronic disease patients. Clust Comput 18(2):747–759
41. Boutaba R, Chung KY, Gen M (2014) Recent trends in interactive multimedia computing for industry. Clust Comput 17(3):723–726