

# MEDICAL APPLICATION ON INTERNET OF THINGS

Wei Zhao<sup>1</sup>, Chaowei Wang<sup>2</sup>, Yorie Nakahira<sup>3</sup>

<sup>1</sup> ANJIN Medical Technology (BeiJing) Co.,Ltd, Beijing 100082, China

<sup>2</sup> Beijing University of Posts and Telecommunications, Beijing 100876, China

<sup>3</sup> Tokyo Institute of Technology, Tokyo 152-8550, Japan

zhaowei@anjinmt.com, wangchaowei@bupt.edu.cn, nakahira.y.ab@m.titech.ac.jp

## Abstract

Internet technology provides various services via network. With the diversification of terminals and development of internet technology, internet technology has come into the stage of Next Generation Network(NGN) technology. Comparing with the current Internet technology that provides services in the imaginary space, the technology on Internet of Things (IOT) is based on real world. It links things together via sensors and wireless communication technology to collect a variety of information on the condition of people and their surrounding space in the real world. The combination of Internet technology and Technology on IOT integrates physical world and imaginary space on a shared platform to eliminate the constraints of imaginary space and provide intricate, diverse, and advanced services focusing on people, which have not been achieved [1]. The future direction for the integration of Internet technology and technology on IOT, the technology of body sensor network and information services are suggested. This paper analyze the possibility and related issues of providing advanced services for human health management in the real world and research direction of medical technology on IOT.

**Keywords:** Body sensor, Body sensor network, Medical body area network (MBAN), Internet of things (IOT), Healthcare service, Medical and Telecommunications

## 1 Introduction

With the rapid development of Internet technology and communications technology, our lives are gradually led into an imaginary space of virtual world. People can chat, work, shopping, keeps pets and plants in the virtual world provided by the network. However, we human beings live in a real world; human activities cannot be fully implemented through the services in the imaginary space. It is the limitations of imaginary space that restricts the development of Internet to provide better services. To remove these constraints, a new

technology is required to integrate imaginary space and real-world on a same platform. In this new world, a variety of innovative services are provided by unlimited imaginary and creative space. The technology on IOT links the imaginary space and real world; it will bring huge changes to the future society, change our way of life and business models.

With the development of internet technology and its application, people and the surrounding environment are loaded with a large number of low-cost sensors. Data such as time, location, space, status are conveyed to the data center through these sensors and wireless networks. With analysis and processing of these data, some diverse, personalized of services are provided to specific groups or agencies. For instance, people often feel puzzled to find things wanted in shopping malls. In the IOT world, when we enter the shopping malls, Information stored in our mobile phone will be collected at the entrance. , the guide information we are interested in are sent to our cell phone or shopping cart simultaneously. There will also be reminding information when passing by such commodities. When we put something into the shopping cart, commodity origin, validity, material and price information will be showed on the shopping cart display. When shopping carts pass through the checkout, the payment information are transmitted to the cashier automatically. The cashier will acquire payment from our non-contact credit card and send the list to the phone. All of which bring us great convenience to shopping. This is difficult to achieve with current technology so far.

The technology on IOT can offer a lot of information about human, objects, time and space. The integration of Internet technology and technology on IOT provide huge space and possibility for innovative service. Based on a large number of low-cost sensors and wireless communication, the sensor network technology puts forward new demands to the Internet technology. Cloud computing and IPv6 technology

promote the development of integration of internet and IOT. It establishes a larger shared world of real and virtual world to offer more valuable services. Therefore, the development of the Internet, IPv6, cloud computing and the realization of NGN provide more possibilities of port management, data processing, and new services. People can enjoy network services of "whenever, wherever, whoever". Comparing with the "everywhere" features of NGN, IOT provide a variety of "personalized" services focusing on human. It implements the services of "only here, only now, just for you" by means of collecting information of human, objects and space via sensor networks, integrating services in imaginary space [2]. Therefore, several key issues are addressed as follows : (1) sensor and sensor networks collecting Information. (2) Sensor network protocols, standards, data encryption, and identity authentication. (3) Data storage, analysis, management, and extraction. (4) The improvement of social infrastructure such as socioeconomic structure, legal etc, based on the application of IOT and operation models. Here we will discuss these four specific issues on the applications of technology on IOT in the medical field.

## 2 The Problem on Healthcare

Due to population growth, rural urbanization, declining birthrate, population aging, economic growth and social unbalanced resource utilization, some social problems have become increasingly apparent in the healthcare field.

- (1) China is gradually stepping into the declining birthrate and aging society. Under the current imperfect state of healthcare, the daily health management of the elderly has placed an increasingly heavy burden on the family and society, which has become more and more serious social problem gradually. Therefore, the health management level and the incapability of responding to emergency is a pressing social problem.
- (2) There is a serious shortage in medical staffs, institutional facilities. Especially is rural areas, lack of medical facilities, low level of treatment, inadequate healthcare system result in that a large number of patients concentrate in big hospitals. The difficulty and high costs in getting medical service has become a social focus and major issue that affects people's livelihood.
- (3) The incapability to respond to emergent illness are mainly shown in two aspects. Firstly, the procedure for first aid measures is not widely known. The people around the patients cannot perform first aid adequately. Secondly, there is a huge demand for more professional first-aid techniques and better emergency system.

- (4) Large amounts of lifestyle diseases patients and potential patients have significant impact on the national economy and the people's livelihood. Whereas, the prevention, the treatment level of lifestyle diseases, and the imperfect diseases prevention system cannot meet the national strategy requirements to safeguard the health of the citizen. Thus, this has become an increasingly heavy burden on economy, individuals, families and state.
- (5) Inadequate disease prevention and early detection capability. The treatment usually starts when the patients will ill or even after the disease has already been very severe. This leads to the increasing number of the patients and the difficulty in treatment, which not only increase the economic and emotional burden to the patients and its family, but also inflict severe financial loss and disharmony factors to the state.

To solve these social problems, it's crucial to strengthen the construction of social healthcare infrastructure and enhance the treatment of disease. In addition, the prevention of disease and early detection capability should be improved by enhancing the healthcare system and the allocation of medical resources. The development and application of IOT technology in healthcare field provides a possible technique approach to solve above-mentioned problems. Although we cannot predict the future of IOT technology on healthcare, there's no doubt that it will have great effect. This paper explains the body sensors and sensor network solutions, indicates the application of IOT in healthcare management and reveals the related research direction and issues.

## 3 The Healthcare Application Solution on IOT

It is reported that there are about 170 million elderly people in China currently and the number is expected to increase to 280 million by 2015. Hypertension is the most common cardiovascular disease. Up to 160 million people suffer from it [3]. The incidence of hypertension and heart disease is trending to ascend. With the accelerated pace of life, people's sub-health state is becoming more and more serious. The prevalence of sub-health groups is close to 70% of the total population [4] and is gradually getting younger. It can be clearly seen that groups and potential groups of hypertension, heart disease and other lifestyle disease are huge. Treatment, prevention and early detection of these diseases have tremendous effect on the health level of the whole population; they are also important issues to be solved as soon as possible. Remote Monitoring and Management Platform of Healthcare information (RMMP-HI)

can provide monitoring and management of these lifestyle diseases so as to reach the purpose of prevention and early detection.

Regardless of restrictions of location, time, and users' activity state, RMMP-HI can collect human body medical information timely through a variety of body medical sensors loaded in the human body or surrounding space, extract useful information by data encryption, storage, comparative, analysis and processing. When abnormal appearance is found, users are notified taking early treatment; this enables the early detection and prevention. Through real-time monitoring, when user is in emergency or hazardous state, it is available to notify emergency agencies or relevant authorities, which improve medical emergency treatment and response capacity. Furthermore, it is also efficient to establish national health management records, to provide prevention and decision-making basis for lifestyle diseases, epidemic and regional disease through monitoring, comparing analyzing and processing healthcare information of associated group. In this way, capabilities of disease prevention, early detection and early treatment are improved enormously.

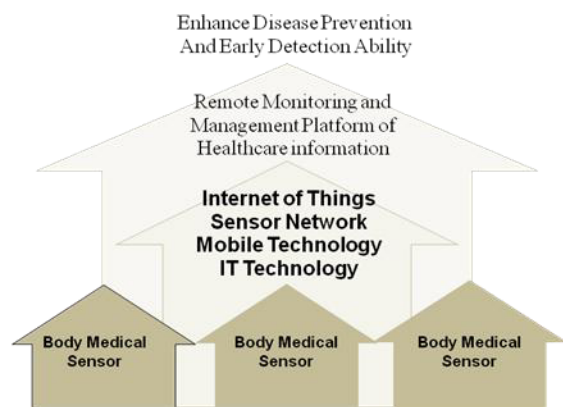


Figure 1 The Solution of Medical Application on IOT

The platform can be used to monitor and manage medical health information, behavioral state information of patient groups and non-disease groups. Non-disease groups refer to the elderly, children and other groups whose health information and behavior status need to be supervised. The users of RMMP-HI include hypertension and hypertension-related disease such as brain obstruction, stroke, diabetes, and kidney disease, heart disease and cardiac surgery patients, patients with chronic lung disease, and sleep breathing disordered patients, In addition, patients suffering from health disorders such as heart palpitations, chest tightness, dizziness, disorders of consciousness and other guardianship groups.

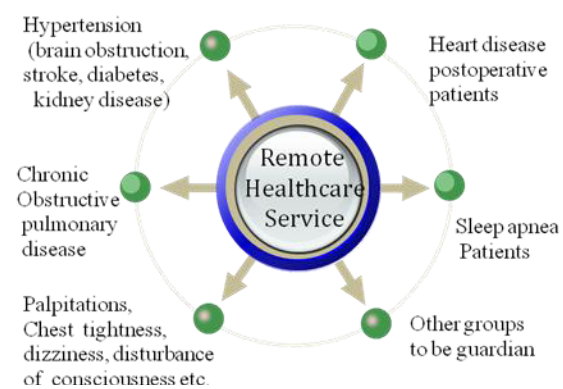


Figure 2 Users of RMMP-HCI

### 4 Remote Monitoring and Management Platform of Healthcare Information

Remote Monitoring and Management Platform of Healthcare information (RMMP-HI) is consist of e body sensors for collecting data, sensor network for connecting sensor, short-range wireless communication module, mobile phone or home gateway, body medical information storage, analysis and processing platform, professional medical staff and telemedicine services, etc.

Body medical sensors can register and delete, constituting Medical Body Area Network (MBAN ) automatically. Short-range wireless communication sensor module will transmit human medical information to 3G mobile phone or home gateway. This medical information is uploaded to data storage and processing center timely. Then the important health guidance will be fed back to the patient, family members of patients or medical institutions after analytical processing of expert system or the inspection of professional medical staff in health service center. In the state of emergency, first-aid notification is delivered to medical institution by health service center to provide emergency services to patients.

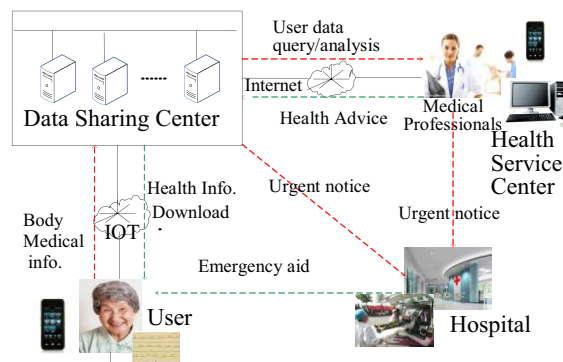


Figure 3 The framework of Healthcare Service by RMMP-HCI

### 4.1 Body Medical Sensor

Body medical sensor can be divided into two kinds, i.e. wearable sensor and implant sensor. They are required to be characteristic of low power consumption, small and lightweight, reliable wireless communication function and minimally invasive to human body. The advantage of wearable sensor is its convenience to use. However, its application is restricted since the sensing mode that is limited to the body surface is confined. The implant sensor largely expanded its usable range, but sometimes it must be buried into human body via operation and thus bring difficulty to use and manipulate. For example, wireless capsule type endoscopy can transmit image signal outside from the body through wireless communication.

Because The MBAN sensors in RMMP-HI focus on human, they need to take into consideration the sensor mobility, portability, automaticity and integrity for measuring, anti-interference and high adaptability. Because many medical sensors at present cannot satisfy the features mentioned above, novel sensors with new measuring principle, technique and material are required to be researched. Generally, the common sensors in MBAN are body temperature, EEG/ECG, SpO<sub>2</sub>, blood pressure, blood sugar, breathing CO, alcohol, position, body local angle, weight and some momentum sensors on exercise, etc.

### 4.2 Medical Body Area Network (MBAN)

Wireless sensors and wireless communication standards related to wireless sensor network are essential for the successful application of RMMP-HI. Now a study group [4] related to body area network is established by the International IEEE802 Standardization Committee. Its goal is to research the application range of wireless communication network and its standard specifications within the scope of the human body. The following is the BAN application category [5].

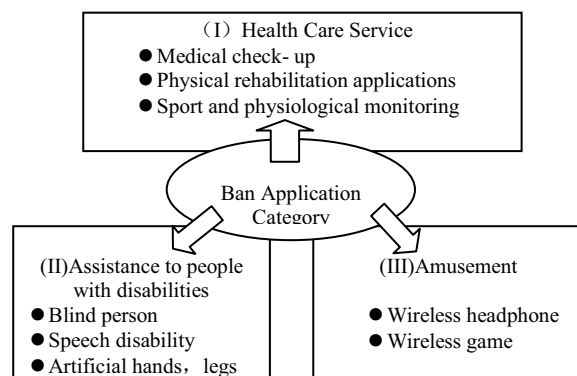


Figure 4 BAN Application Category

BAN needs to be capable of highly reliable wireless transmission function. At present,

overseas studies indicate that wearable sensor is prone to use 2.4GHz and implant sensor tends to use 400MHz as its frequency range [6]. Nowadays, our country also assigns the mentioned two frequencies for ISM. It is better to adopt the means of bi-directional communication. The communication rate is about 1Mbps-10Mbps, considering power consumption. As BAN is used in human body, certain characteristics like human mobility, change of the surroundings and other medical devices carried possibly should be taken into account. The application of BAN should particularly consider the following issues.

- (1) The security and reliability of networks. The security, reliability of networks and services should be guaranteed by safe and reliable encryption technique and authentication technique, because the application needs to process human medical information and the required services.
- (2) The interference of devices. There are wireless devices in the surroundings of a person, and there are also medical devices inside or outside of human bodies such as pacemaker. Thus, BAN should attach great importance to the issues concerning the electromagnetic interference in the surroundings, inside and outside of human bodies, including the interference of wireless devices and channel, as well as the mutual interference with the medical devices being used.
- (3) The power supply and power consumption of devices. In the application of BAN, the power supply and power consumption of devices should not be overlooked. The demand for the sensors loaded on the fixed position around the body is not very strict, in addition to this, no matter wearable sensors or implant sensors are quite critical for power supply mode and power consumption. The devices generally adopt electromagnetically induced mode and battery supply according to characteristics of sensors. The key point when applying and developing BAN is to reduce power consumption as much as possible. The power supply duration of wearable mobile sensors should be at least 24 hours, and that of implant devices may range from several hours to several years due to their different purposes.
- (4) Small and lightweight, easy to carry and operate. BAN's shape, weight and portability should take body activities into consideration. It is more important especially for the implant devices. Their monitoring and controlling process require high level of automation and few human interventions. The operation should be as easy as possible.
- (5) The security of devices. As the devices may directly touch the body or put inside the body, the shape and material toxicity of devices

should be considered in detail. Non-poisonous materials should be used and the shape should not harm the body. Besides, since the devices have electromagnetic radiation, the amount of electromagnetic radiation absorbed by body should also be considered.

#### **4.3 Health Information Data Storage, Analysis, Management, Retrieved**

Medical information collected by BAN is varied and informative. The data of personal Health Record (PHR) is huge and increasing rapidly as well. We assume that each sensor carries on the test data with 32 bytes. When 1,000,000 people is detected, it can be seen from the following binary data computation that the data quantity is very large.

When testing weight once a day:

$$32\text{byte} \times 365\text{day} \times 1,000,000 \approx 0.1\text{TB}$$

When testing blood pressure twice, every morning and evening:

$$32\text{byte} \times 2 \times 365\text{day} \times 1,000,000 \approx 0.2\text{TB}$$

When testing the breath once a second for continuous eight hours every day:

$$32\text{byte} \times 3600 \times 8\text{H} \times 365\text{day} \times 1,000,000 \approx 3364\text{TB}$$

Large amounts of data need automatic classification, comparison, analysis and processing, information needed is available to all service providers. For example, health service centers can provide health guidance to users by extracting their health information; rehabilitation centers provide remote rehabilitation guidance in accordance with a variety of recovery information.; hospitals supply remote diagnostics under medical signs information and implement remote treatment based on wireless body dosage system; Emergency Service Centers do first aid according to the emergency information extracted; disease prevention and emergency control centers detect and control status and causes of group disease, epidemics and regional disease in advance through the extraction of health information of specific groups for early prevention; Safety Service Centers supply security services with activities information of specific populations and individuals. All of these require a huge number of scattered information and network resource sharing means. In addition, an effective means to extract information is needed. Moreover, the protection of our private information from abuse or evil using is similarly essential.

#### **4.4 Build and improve socio-economic structure and the social foundation environment based the RMMP-HCI application and business models**

To effectively use RMMP-HI, a series of problems needs to be solved. At present, it is difficult to carry out RMMP-HI application because of the

non-uniform electronic information standards in medical institutions, social administrative function division, management authority restrictions, distribution structure of socio-economic benefits, and lack of relevant legal. This is mainly shown in the following aspects:

- (1) Non-uniform standards of electronic medical information management systems and electronic medical records obstacle in mutual medical diagnosis and treatment information sharing among medical institutions. It brings difficulty in linking RMMP-HI with the information system of these medical agencies. Solving medical information sharing is a key issue to improve medical services level and address the uneven use of medical resources.
- (2) In the co-existence social system of healthcare management and diseases prevention, community and regional hospital, they own their different management systems and management authority, service and data resources sharing are still not realized. Thus, the application of RMMP-HI has been limited. Only all the relevant administrative departments are needed to promote the construction and application of RMMP-HI, the construction of interface related with other systems jointly, It can comprehensive benefits for social for real.
- (3) The sharing of hardware, software and service resource, as well as RMMP-HI service, involve co-responsibility and legal related service. In the remote diagnostic and treatment services, health guidance services and emergency services, the key issues need to be solved that how to define the responsibilities of the parties to provide services, how to ensure service quality, It's necessary to develop and improve relevant management systems and industry standards, to complete the legal basis for providing RMMP-HI service .
- (4) The service chain of RMMP-HI consists of sensor network equipment, infrastructure, data-sharing service, RMMP-HI service, professional medical service providers and health service management side. All of sides in the service chain need to be integrated effectively and developed a reasonable mechanism for distribution of profits. Only in this way can maintain a viable RMMP-HI service, and bring multi-benefit to individuals, businesses and countries.

#### **4.5 About Business Model of RMMP-HI**

We need a reasonable return mechanism, a competitive and healthy development operation model for promoting effectively RMMP-HI applications. Japanese scholars put forward an open platform proposal for the BAN-PHR. The

users of BAN use their own health records and send health data to public health operation institutions automatically. The public health operation institutions provide a database as a PHR open platform which looks like Google open distributed database. It achieves platform functionality with low cost [7]. Its main problem is how to establish the open distributed database platform. In this paper, the following business models are proposed:

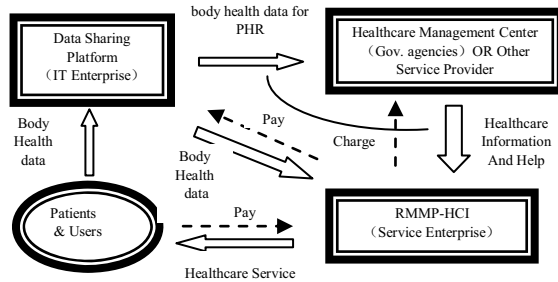


Figure 5 The business model of RMMP-HI

- (1) RMMP-HI service providers contract with the user and provide paid health services to user.
- (2) RMMP-HI service providers pay data-sharing service provider, and furnish users data to government healthcare organizations for establishing health records or third-party service providers as paid service.
- (3) Government health authorities send medical information, notification and assistance information to users and residents with the help of network of RMMP-HI providers.

## 5 Conclusions

From what has been discussed above, we can see technology on IOT offers a mass of information such as person, object, time and space, which is difficult to achieve with traditional means.

The integration of technology on IOT and Internet technology provide huge space and possibility for innovative service to implement personalized service of "only here, only now, just for you". Facing with so many health-related social problems, the development of the application of IOT in the medical field are potential technical means and convenient approach to solve the above-mentioned problem. Establishing remote healthcare information monitoring and management platform is an effective way to solve these problems. In order to establish remote monitoring and management platform, and promote its application effectively to improve community health, a series of issues need to be overcome and resolved. These topics include:

- (1) Develop new sensors and various devices to meet working conditions and requirements of MBAN.
- (2) Formulate uniform standards and protocols of MBAN.
- (3) Establish secure data sharing space that extracts, processes, and analyzes useful information.
- (4) Establish unified inter-institutional standard of electronic medical information management systems, electronic medical records and community health records. Standardize intersystem interfaces and medical health information sharing platform.
- (5) Develop and improve RMMP-HI related management, legal system, cooperation mechanisms of impelling its application jointly. Improve the social environment of development and application of RMMP-HI.
- (6) Integrate, strengthen the service chain. Develop reasonable, competitive revenue mechanism and service mode.

With these issues resolved, we can see a new world sharing integrated technology of IOT and Internet, strengthened relationship of imaginary space and real-world. In the word of abundant network resources and information resources, we can pick up the information needed at ease, enjoy freely a highly personalized service, and arrive in a real HQoL social.

## References

- [1] Real world oriented Ubiquitous Networks, Ahiroyuki Morikawa, masateru minami, Technical report of IEICE Japan. PRMU, 104(523), 59-64, 2004-12-09
- [2] One way to ubiquitous networking, Hiroyuki Morikawa, Masaki Minami, Yuki Aoyama, ISJP Magazine Vol.43, No.6, June, 2002
- [3] Issued by the Ministry of Health China National Nutrition and Health Status, 2004/10
- [4] National Mental Health Workshop guidance and education science, Xinhua, 2006/9, [http://news3.xinhuanet.com/health/2006-09/17/content\\_5101342.htm](http://news3.xinhuanet.com/health/2006-09/17/content_5101342.htm)
- [5] H.-B. Li, et al, IEEE802.15-06-0241-00-0BAN, May 2006.
- [6] By simulation study of 400MHZ band built wearable and implant BAN channel model, Takahiro Aoyagi, Kenichi Takizawa, Jun-ichi Takada, Ryuji Kohno, Technical Committee on Medical Information and Communication Technology Period, 2008.7.29
- [7] Body Area Network (BAN) and its application to medical and health sector efforts to standardize, NICT, Japan Masahiro Kuroda, 2011-1, P40