

Design and Implementation of Health care system based on IOT

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Abstract—In this paper, we propose an architecture and scheme of smart hospital based on Internet of Things (IOT) in order to overcome the disadvantages of the present hospital information system, such as the fixed information point, inflexible networking mode and so on. The key technologies and construction of smart hospital is presented based on understanding of the connotation and architecture of smart hospital. Furthermore, taking a third grade-A hospital as an example, a scheme of smart hospital is given, and its logic structure, application framework, the construction of basic network environment etc. are described in detail. Experiment proves that deployment of smart hospital can effectively solve the prominent problems existing the diagnosis and treatment of hospital and it brings a positive and profound effect for the present diagnosis and treatment mode in hospital

Index Terms—internet of things (IOT), smart hospital, hospital information system (HIS), embedded, electronic medical record

I. INTRODUCTION

In the advancing process of hospital information, the popularity and partial using of HIS (hospital information system) has made the hospital achieve certain degree of informatization. Nevertheless, it also has some deficiencies, such as manual input of medical information, fixed information point, fixed networking mode, single function, relatively independent between each department [1] and so on, which seriously restrict the construction of hospital informatization. For solving the problems mentioned above, rapid rise of internet of things has provided a new idea. Internet of things (IOT), the fourth time industry technological revolution of world information, following technological revolution of computer, internet and mobile communication network, is a network connecting any items with internet to implement information exchange and communication, furthermore to implement intelligent recognition, positioning, tracking, monitoring and management, by means of radio frequency identification (RFID), infrared sensors, GPS, laser scanners and other information sensing equipment, according to conventional protocol

Smart hospital, based on technology of IOT and constructed with the vector of various application service systems, is a new kind of hospital integrated the function of diagnosis, treatment, management and decision. The features of IOT, such as comprehensive perception, reliable transmission, intelligent processing and so on provides technique support platform for the construction and implementation of smart hospital.

Therefore, in this paper, based on the introduction of medical IOT and other related concepts proposed by some scholars, the connotation of smart hospital is analyzed. And based on the introduction of existing three system architectures of IOT, combined with the characteristics of hospital scene, three-layer system architecture composed of sensing layer, network layer and application layer in smart hospital is also discussed in detail. Then, from the aspects of compilation of information specifications and standards, construction of the unified network platform and embedded mobile electronic medical records application platform, the key technology and content in the construction of smart hospital is sufficiently studied. Finally, taking a third grade A hospital as an example, from the aspects in design of logic structure, design of application framework, construction of network environment and so on, a specific application scheme of smart hospital is given, providing meaningful reference for the overall implementation and extension.

II. KEY TECHNOLOGIES OF IOT

IOT will gradually become the main body of the next generation of information network, and it is the internet based on the integration of multiple technologies integrated application, the following describes what the IOT some of the key technologies involved in.

I

A. Internet Technology

IOT, the internet of next generation, is essentially a network, so internet is basic precondition of IOT in order to communicate with any person and object at any time and place.

B. RFID Technology

RFID is a kind of non- contact automatic identification technology for objects or articles through the use of non-contact reading and writing devices. RFID technology can be classified into three categories; passive RFID, active RFID, and semi passive RFID [3]. All RFID systems contain three basic components. The first is the RFID tag that is attached to an asset or item. The tag contains information about that asset or item and also may incorporate sensors. The second component is the RFID interrogator (also called reader), which communicates with (also called interrogating) the RFID tags. The third component is the backend system, which links the RFID interrogators to a centralized database. The centralized database contains additional information, such as price, for each RFID tagged item. Generally speaking, a RFID system is composed of one or more reader (s) and several RFID tags. Communication between RFID tag and reader takes use of electromagnetic induction method, so direct contact is not needed.

D. Wireless Communication Technology

In IOT, it is through wireless communication technology that it automatically transmits the information stored in RFID tag to central information system, so wireless communication technology is core technology in IOT and several common wireless communication technologies mainly include Bluetooth, WIFI (wireless Fidelity), UWB (un~~tr~~awideband), Zigbee, IrDA (Infrared Data Association) and so on.

E. Embedded Technology

In essence, IOT is an embedded system based on internet. Just because more and more intelligent terminal products have the requirements to network, it hasten the production of IOT concept [6], so IOT is the inevitable outcome of embedded technology development and it cannot do extensive use without embedded technology supporting

III. SMART HOSPITAL

On the technology of IOT applied in the medical field some scholars put forward IOT in medical care[7], medicine based on IOT [8], IOT in health care[9] and other related concepts, which have the same essence, only different in angle and range of description. Smart hospital, based on the technology of IOT and constructed with ~~the vector~~ of various application service systems, is the concentrated reflection of IOT applied in the special place of hospital and it is a new kind of hospital integrated the function of diagnosis, treatment, management and decision. And also, integrating the concepts of informative hospitals, intelligent hospital [10] and digital hospital [11], it is the more specific, comprehensive, dynamic description about hospital. Through the implementation of smart hospital, it can implement the application system based on digital environment and people can fast and accurately obtain the relevant service information, thus it can realize diagnosis ~~informatization~~, management standardization and scientific decision. At the same time, through the integration and fusion of application service, it can realize information acquisition, sharing and service in hospital, so as to promote the implementation process in smart diagnosis, smart treatment, smart management, smart decision and smart service.

IV. ARCHITECTURE OF SMART HOSPITAL

Many researchers has carried out relevant research on networking architecture, and there are three kinds; the architecture based on EPCGlobal [12], on the basis of RFID technology, the application architecture based on sensor network [13], mainly referring to WSN, the application architecture based on M2M (machine-to-machine) [14], having the most extensive application scope and including partial content of EPCGlobal and WSN. In the medical field, though there is no literatures to directly mention the architecture of smart hospital, some related articles have appeared, for example a model of sensing hospital having no boundaries proposed by[15], a model of digital surround intelligent hospital proposed by[16]. In view of the current existing research foundation and the actual environmental characteristics of hospital, smart hospital takes the third architecture mentioned above, composed of perception layer, network layer and application layer, as shown in figure 1.

A. Perception Layer

Perception layer is divided into two sub layers, which is respectively data collection layer and access layer. Data acquisition layer is to identify hospital networking nodes, perceiving and acquiring related data, such as identity information about doctor and nurse, identity information and medical information about patient, basic information and location information about pharmaceuticals, medical equipment and medical waste, physiological information and location information about inpatient, the environment information around hospital and so on.

Access layer is to transmit the data acquired from sub layer and access it to the backbone network, namely global object-conjunction network. There is a variety of access ways, such as by mobile network, by wireless network, by fixed network, by cable TV network [17] and so on, where the access by mobile network will become the main way to access to smart hospital because of its wide coverage, low construction cost, convenient deployment and mobility characteristics. In practice, it needs to be determined by concrete conditions, for example, system with fixed using location, like outpatient management system and medical technical management system, is suitable to adopt access by fixed network , and hospitalization management system is suitable to adopt access by mobile network or wireless network, using wireless medical with unfixed workstation for physician and nurse.

B. Network Layer

Network layer is divided into two sub layers, which is respectively network transmission platform and application platform. Network transmission platform is the backbone of hospital network, having real-time, barrier-free and high-reliable transmission of information perceived by perception layer, using technology of Ethernet, mobile communication, M2M and so on. Application platform is to implement the integration of various data, including description of unified data, unified data warehouse, technology of data middleware, and on this basis to constitute a service platform to provide an open interface for the various services of application layer [18], so that the third party can develop various applications on this platform for medical staff, patients and other related personnel to use.

C. Application Layer

Application layer includes two parts, which is respectively hospital informatization application and management decision and application. Hospital informatization application includes informatization of outpatient management, hospital management, medical technology (inspection, examination, radiology, pathology, physical therapy and so on) management, drug management, equipment and material management, medical management, financial management and so on. Management decision and application is the senior application, such as disease analysis (onset time, geographical distribution and treatment cost of various diseases), patients analysis (regional distribution, age distribution, proportion of free medical service and visiting time of patients), clinic analysis (outpatients visits , inpatients visits and doctor visits in each time quantum), drug analysis (amount, quantity of consumption and profits of various drugs) , department analysis (cost for diagnosis and treatment of every department in different periods) and so on.

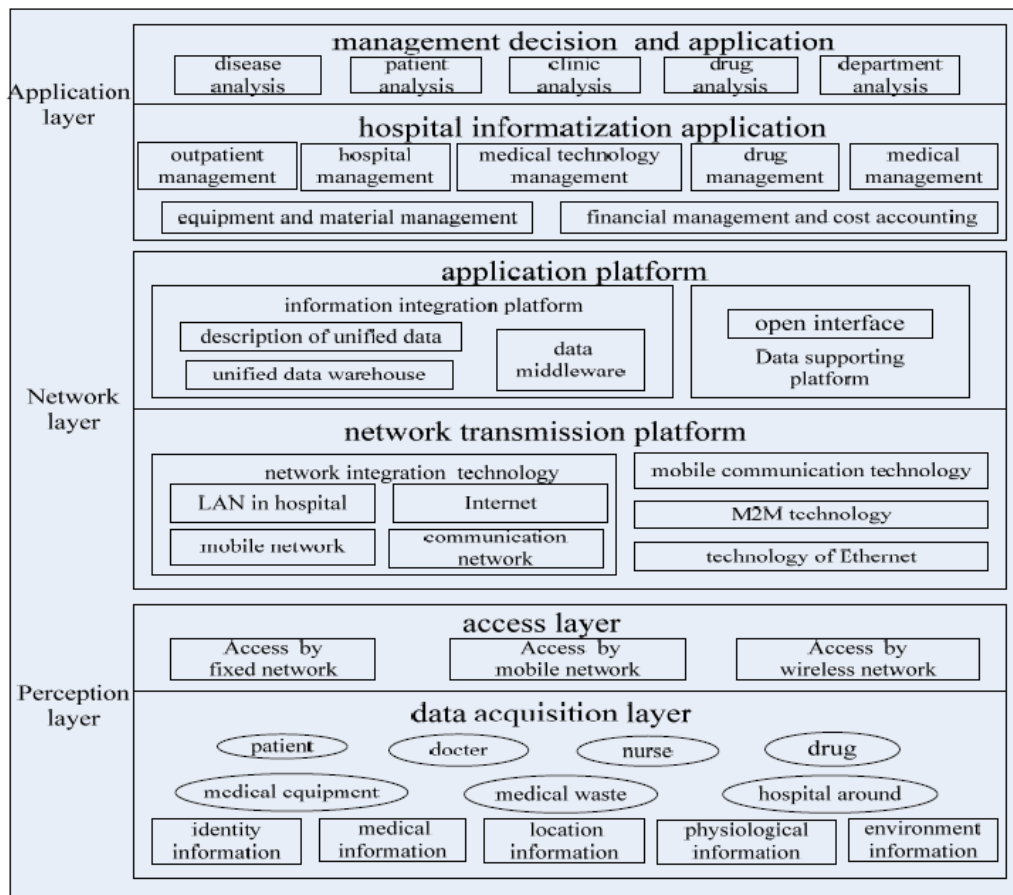


Figure 1. Architecture of smart hospital

V. KEY TECHNIQUE AND CONTENT OF SMART HOSPITAL

The key technique and content in smart hospital involves several aspects listed below.

A. Compilation of Information Specification and Standard

Informatization standard is the basic content in construction of smart hospital, including the content listed below.

- 1) It is to form coding standard of whole hospital, including information terminology standard of hospital, information classification coding standard of hospital, so as to realize unified code resolution mechanism.
- 2) It is to analyze and formulate data exchange rule of whole hospital, so as to form data exchange standard. At present, there has been standard of HL7 [11] (Health Level seven), DICOM3.0 [11] (Digital Imaging and Communication on Medicine) and ASTM [11] (the American Society for Testing and Materials);
- 3) Because of the characteristic of openness of smart hospital platform, the third party can easily develop application service for medical staff and patients on this application platform, so it needs to formulate standard of development technology, data description, interface of data communication, data warehouse and middleware [17] in application system of hospital, so as to form the specification of application system.
- 4) Based on the analysis and combing of business process in smart hospital, it forms business process standard of smart hospital, such as new pattern of clinical path management in the environment of smart hospital, the process of payment with medical insurance card through integrated information service platform.

B. Construction of Unified Network Supporting Platform

IOT was essentially a network, which is the most basic precondition in order to communicate with any person and object at any time and place. A significant advantage in medical informatization of smart hospital is the mobile medical treatment, so the terminal access by wireless is the necessary condition for implementation of smart hospital. If totally abandoned the existing wired network platform of hospital, the cost is too big,

however, coverage binding with wired and wireless network is a very effective network architecture, providing fixed or mobile application environment, supporting wired or wireless access method, and this network structure is flexible and extensible [19], which is an effective way to implement access of ubiquitous perceptual information and interconnection of multi-source information. Then smart hospital adopts this structure mentioned above.

C. Construction of Shared Data (base) Platform and Uniform Identity Authentication Platform

To establish the shared data (base) platform, it must ensure the uniqueness and validity of data source and standardize the whole information process from acquisition, processing, exchange to comprehensive utilization. And also, it should define the responsibility of

data source and data, and the one who produce data should take responsibility, for example, charge person in related charge window is responsible for charge data of patient, outpatient or inpatient doctor is responsible for disease, diagnosis, prescription and medical order, nurse on duty is responsible for signs of patients and nursing records, relevant medical technician is responsible for test results or imaging findings of patient.

Uniform identity authentication platform, through unified authorization mechanism and convenient and safe password authentication method provided by hospital information centre, allows user enjoy all information service of authorized role on the network of smart hospital by a single username and password, wherever in the fixed terminal of home or office, wherever in the mobile terminal of mobile phone, PDA and other ones.

D. Construction of Integrated Information Service Portal Platform

Integrated information service platform is to make polymerization for distributed and heterogeneous application in hospital and information resources, so as to achieve seamless access and integration of every application system, providing an integrated environment supporting information access, transmission and collaboration. According to the function orientation of hospital, integrated information service portal platform mainly includes management service, treatment service, decision-making service, virtual hospital service, scientific research service, life service, external interface and so on. Management service includes information system of financial management, registration and charge of outpatient and emergency, admission, discharging and transferring of patient, drug storehouse management, pharmacy management of outpatient and inpatient and so on, treatment service includes application system of outpatient doctor workstation, hospital doctor workstation, clinical nurse workstation and embedded mobile electronic medical records platform, virtual hospital[20] includes consulting and booking services of outpatient, department and expert, and external interface includes medical insurance interface to medical insurance office and medical dispute consulting interface to legal aid center. In particular, each kind of personnel has different permission on this platform because of their different identity, so user is required to access the integrated information service platform only by the unified identity authentication platform.

E. Construction of Embedded Mobile Electronic Medical Record Application Platform

Relative to HIS, the core of smart hospital is mobile and wireless medical treatment, so it is required to transplant the traditional electronic medical record system under the internet platform to the IOT platform. This system is also called embedded mobile electronic medical record system, based on the technology of RFID and WSN, operating in the handheld wireless terminal equipment (such as PDA) in essence the IOT information management system of hospital achieved patient-centered networking, and it is the key of successful implementation of smart hospital, also the core content of smart hospital. Its main function is as follows; identification and management of patient identity information (including patient name, gender, birth date, phone number, social security number or ID number, photograph), storage of patient basic physiological information (such as blood type, whether have the medical history of diabetes, epilepsy and hypertension or not, drug allergy etc.), automatically schedule of independent registration and treatment number in clinic, input and storage of diagnosis and treatment information (patient medical records) written by outpatient doctor, reading and modification of inpatient medical records written by medical staff and input, storage and modification of electronic medical order written by doctor (can realize mobile ward inspection), nurses' query of electronic medical order and record of patient medication in clinic care (can realize mobile care of nurse), electronic billing and payment of medical expenses tracking and positioning of patient and related access management.

VI. APPLICATION SCHEME OF SMART HOSPITAL

After full analysis above on smart hospital’s connotation, architecture, key technology and main content of construction, combined with the implementation about smart hospital project of First Affiliated Hospital of Anhui University of Traditional Chinese Medicine, this paper gives a specific application scheme. At present, the hospital has completed basic construction of wireless network supporting environment, and has taken some departments for the pilot, in certain range achieving wireless and mobile medical treatment for medical staff, changing the current existing clinic model of hospital and achieving satisfactory results. Next, this paper elaborates the application scheme from the aspects of logical structure, application framework and network supporting environment.

A. Logic Structure

The project aims to build an integrated information service platform with the characteristic of openness, innovation, collaboration, and intelligence, on which the majority of medical personnel, administrative personnel, logistics personnel, patients and their family members can customize personalized service based on their roles, thus it can comprehensively perceive each resources of application service in hospital and obtain interconnected, shared and cooperative environment of treatment and working. According to the construction goal, combined with the actual operation situation of hospital's current HIS application system, it designs the logical structure of smart hospital, as shown in figure 2. All kinds of application systems can integrate services through integrated information service platform and every user can customize information service within the purview of its role through this platform

B. Application Framework

Application framework is the embodiment of architecture. On the whole, it follows smart hospital’s architecture with three general layers, composed of perception layer, network layer and application layer, but it should be specific and detailed according to hospital actual scene, as shown in figure 3, consisting of 7 layers, from below in sequence of goods on first layer, connection with objects and perception of information on second layer , network fusion on third layer, data fusion on fourth layer, integration of service on fifth layer, unified portal and identity authentication on sixth layer , and user of seventh layer. The first layer and seventh layer are added in order to ensure the integrity of the frame, needing no introduction, second layer is corresponding to perception layer in general architecture , third layer is corresponding to network layer in general architecture , and fourth, fifth and sixth layer is corresponding to application layer architecture in general architecture . Next, emphatically introduces network fusion layer, data fusion layer, service layer and user layer.

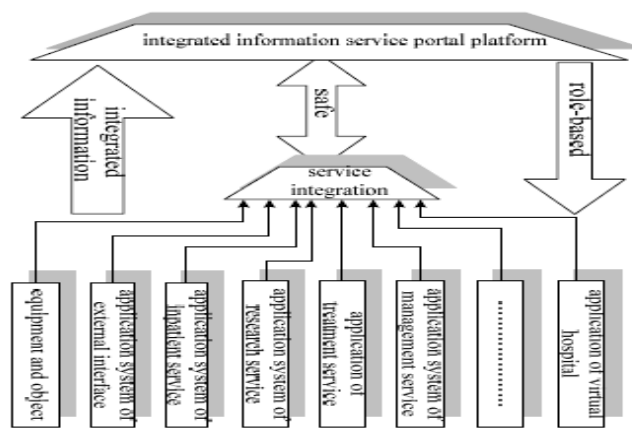


Figure 2. Logic structure of smart hospital

Network fusion layer is to integrate with each application network in hospital, such as cable network of previous arrangement, internet, communication network and so on, and to implement the unified management and control, so as to form a unified hospital object-joint network, providing network communication security for the application of smart hospital. Data fusion layer is to have the integration of identification data (such as patient's name, gender, birth date, phone number, social security number or ID number, blood etc.), application data (such as disease, diagnosis, prescription, medical order, test results and imaging findings of patients, symptoms and nursing record of patients, medical cost of patients etc.), perceptual information, and integration of data storage, middleware and supporting software. Service integration layer is to realize ability exchange and data share of multi service platform (such as hospital management service, medical service, decision-making service, virtual hospital service etc.), which is the construction purpose and form of smart hospital

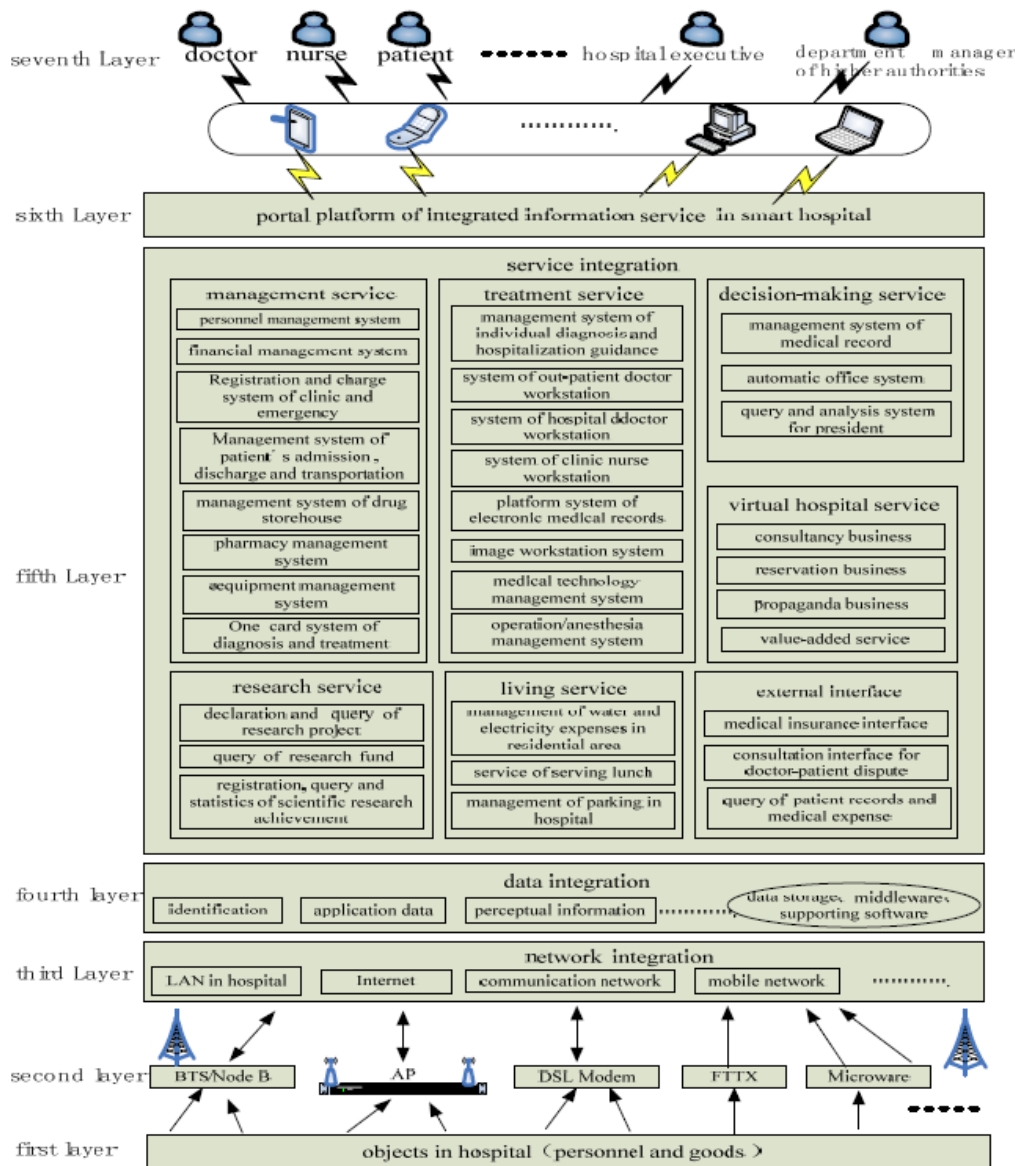


Figure 3. Application framework of smart hospital

C. Network Supporting Environment

As shown in Figure 4, this hospital's network structure adopts wired and wireless combination structure, based on its original wired network architecture deploying the wireless network to realize the wireless coverage of outpatient building, surgical ward building, medical ward building, medical technology building, pharmacy

(drug storehouse), administration building and outdoor public places. The original wired network architecture needs no introduction, so here we put emphasis on discussing the wireless network architecture and specific proposal is as follows; It is to take the technology of IEEE 802.11 a / B

As the standard of constructing hospital wireless network; architecture is to use thin AP way, adopting the management of centralized authentication and unified portal service layer provides uniform access portal and business interface, providing different individualized exhibition for different authorization role (department director, person of ward in charge, head nurse of department, outpatient doctor, hospital doctor, on-duty nurse, patient, family members of patient).

control; outpatient building, medical technology building, pharmacy (drug storehouse) and administration buildings is to take access of wireless network by indoor AP, originally having implemented the access of cable network; surgical ward building and medical ward building is wholly to take wireless network by indoor AP so as to facilitate medical treatment and nursing of mobility and meet on-line needs of patients and their families, originally implementing access of cable network only in the office of duty doctor and platform of duty nurse and all wards having not implemented network access; other outdoor public places is to have coverage by outdoor AP and make connection of wireless network between dispersed buildings in hospitals through outdoor wireless bridge

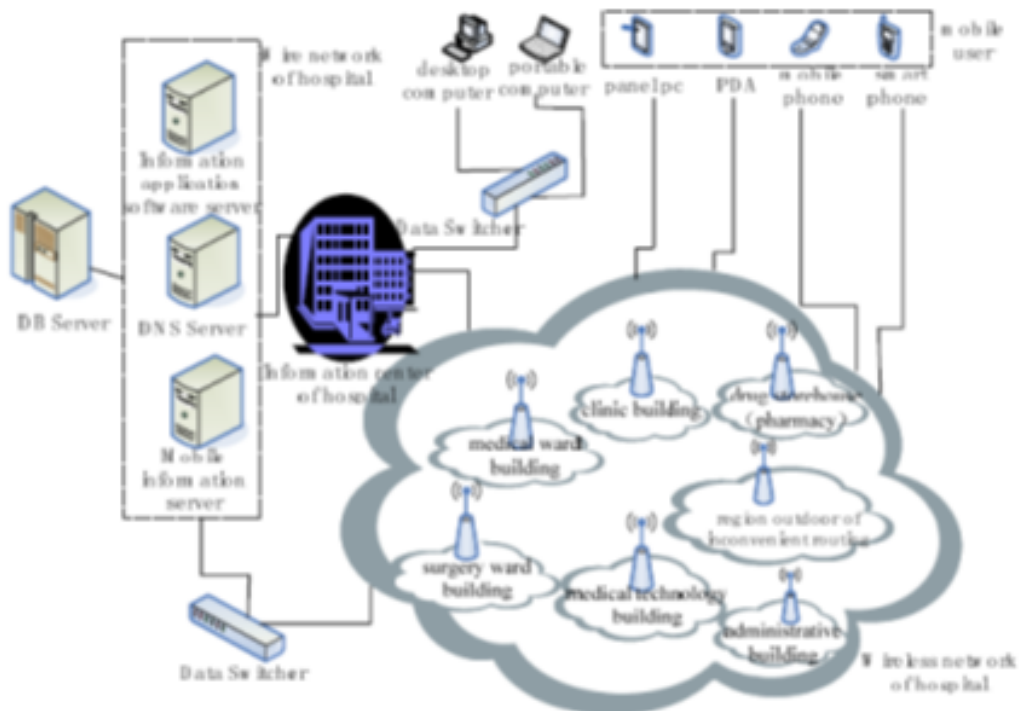


Figure 4. Network structure of smart hospital

VII. CONCLUSION

In this paper, based on the sufficient analysis of smart hospital's connotation, architecture, key technology and construction, combined with the implementation about smart hospital project of First Affiliated Hospital of Anhui University of Traditional Chinese Medicine, we propose a concrete application scheme and it changes the existing hospital clinic model, having achieved satisfactory result. Next, based on the perfection and integration of original application system in HIS, with the breakthrough point of embedded mobile electronic medical records application platform, we will have related research on the marking format and data format in embedded mobile electronic medical record, so as to lay the solid foundation for overall implementation and extension of smart hospital.

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