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System Design for Big Data Application in Emotion-Aware Healthcare

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ABSTRACT As the living standards improve and the health consciousness enhances, the healthcare industry has become a hot spot in nowadays society and some health monitoring systems emerge one after another in recent years. However, the mostly existing systems only focus on the logic reasoning but ignore the factor of the user's emotion, which is regarded as an important factor to impact human health. In this paper, we design a system for big data application in emotion-aware healthcare (BDAEH), which pays attention to both the logic reasoning and the emotion computing. Meanwhile, the SDN the and 5G technologies are adopted in the BDAHE system to improve the resource utilization and the overall network performance of the system. The BDAEH system includes the following functions: healthcare data collection, healthcare data transmission, healthcare data storage, healthcare data analysis, and human–machine interaction. The healthcare data are generated by wearable devices or sensing-less sensors, and these healthcare data are regarded as the foundation to expand a series of data processing. The healthcare data transmission is performed through leveraging the SDN and the 5G technologies. In the data center, the related technologies based on cloud computing are utilized to store and analyze healthcare data, which obtains both the emotion and the health state of the users, and the relation between the emotion and the illness. Finally, the BDAEH system returns the analysis result to the users or the doctors for further treatment schemes or rehabilitation advice. The presented system is expected to validly improve the healthcare services by considering the emotion factor.

INDEX TERMS Emotion computing, healthcare big data, 5G, cloud computing, software-defined networking.

I. INTRODUCTION

Nowadays, healthcare is a hot research field and attracts more and more attentions, which combines the medical treatment with the intelligent system to meet the new era of precision medicine. Traditional medical intelligent systems focus on the logic reasoning without what human emotion and genome organization tell. To make the better performance of the precision medicine [1], emotion computing is introduced to capture, calculation and analysis about human emotion to explore the relationship between the emotion and bring out disease, and then provide the precise treatment of disease for special patients, which can improve the success rate of the disease prevention and treatment. For these reasons, emotion computing is an important technology for precision medicine and promotes the developments of personification of control theory and large medical data processing, and contributes to build harmonious human-computer interaction environments [2], [3].

Picard from MIT media lab first proposed emotion computing in 1997 [4], and pointed out that the emotion computing relates to the emotion, derives from the emotion or is even influenced by the emotion. The emotion is a kind of instinct of human being while Goleman et al. also recognize the emotional ability is an important symbol of human intelligence. In general, the human emotion can summarize a label or attribute from four aspects: emotion recognition, emotion expressing, emotion modeling, and emotion interaction. The goal of emotion computing is trying to use the emotion information for the system design, which makes that the system can recognize, understand and express the human emotion, and brings out to respond to the human emotions by providing the harmonious human-computer interaction environment.

Some systems based on emotion computing were proposed in recent years, which are applied in the fields that related to robot, medical treatment, services, household and so on. Lee et al. designed a system named Pepper robot combining cloud computing and big data to analysis the expression and the tone of emotion recognition technology [5]. The Pepper robot can communicate with human and be used as a human emotion escort. However, it does not have the medical functions. Chen et al. proposed an emotional interaction system framework named AIWAC [6], which is based on cloud computing technology and wearable computing to control emotional interaction. Srinivasan et al. designed a wearable device based on AIWAC tested. Such design lacks the indispensable man-machine emotional interaction. Axisa et al. [7] proposed the Marsian, which includes four parts: smart tee-shirt, smart glove, wrist device, data logger(continuous recording). The Marsian can offer information on sense, emotion, intelligence and task reactions to measure the autonomous nervous system activity. Tivatansakul et al. presented an emotional healthcare system that achieves emotion detection by facial expressions using Japanese database [8]. The system focuses on emotional aspects and offers services to solve users' social or mental health problems in daily life. Anliker et al. designed a wearable medical device called AMON [9], which provides monitoring and alerting function according to the result of collection and evaluation of multiple vital signs, intelligent multi-parameter medical emergency detection, and a cellular connection to a medical center. The AMON is benefit for respiratory patients/high-risk cardiac, but its functions are limited. HDFS:Idris et al. proposed a system that provides storage services to the proposed system and analysis services to the physical activities and emotions performed by the users named Hadoop Distributed File System(HDFS). As a convergence platform, HDFS integrates various of technologies to store all multi-structured data and to build warehouse for applications. These systems are the products of combination between artificial intelligence and medical healthcare to promote medical industry to develop. However, the above system structures exist the defect of single function and cannot preferably combine the large medical data of human emotion with the emerging communication technologies.

In this paper, we aim to build a new system to meet the requirements of big medical data in the precision medicine, which joins the emotion computing and emerging communication technologies. Compared with the traditional systems, the first advantage of our design is more suitable to the big data collection and analysis for medical treatment. Moreover, our designed system uses the 5G technology that is mainly based on SDN to support high performance data transmission, which speeds up the original data collection and further improve the overall performance of the system [10]. In addition, the system provides more functions compared with the previous related medical system. First, the system uses softwares on mobile phones [11], wearable devices or other artificial intelligence devices to gather the user's body temperature, heart rate and respiration, etc. of the patients continuously, transfer these data through 5G architecture [12], store and share the data by cloud computing in the data center [13]. The functions of data analysis and data integration are provided by data center to explore the emotion information of the patients and diagnose illness degree under the different emotional states, such as the risk of the disease for a person with sad emotion. The system also supports the functions of prevention or treatment of the potential diseases according to the analysis results of the users. Generally speaking, the system cannot only shorten the treatment time, but also decrease the injury of the patients' body in the process of diagnosis while improve the effect of prevention and treatment.

The reminder of this paper is organized as follows. Section II reviews some related works. Section III describes the system model and architecture design. Section IV makes detailed function description about each section of the system. Finally, this paper is concluded in Section V.

II. RELATED WORK

Currently, emotion computing provides indispensable support for most of the applications in the medical treatments. Consequently, designing system based on emotion computing has become a topic of intense research interest in the medical domain, and a variety of systems have been proposed. The available technologies are applied to the system design from four aspects: healthcare data collection, healthcare data storage, healthcare data transmission, healthcare data integration and analysis.

To meet the requirement of precision medical treatment, the relationship between human emotional state and illness need to be detected in time, which brings new challenge to healthcare data collection [14]. Fortunately, there are a lot of developed wearable devices that can be used to collect emotional data. Pandian et al. proposed a wearable device called smart vest [15]. The smart vest is integrated by a kind of comfortable vest and sensors, and able to monitor human physiological parameters such as electrocardiogram (ECG), photoplethysmogram (PPG), body temperature, blood pressure, galvanic skin response (GSR) and other signs data. Yang et al. proposed the development of ring sensor, which can get healthcare data by monitoring health state of users all-day and transmit these data to the related software to analyze the health state of users [16]. In addition, apart wearable devices, sensors also detect the affect state of users. Hu et al. proposed the design of BioLoggerder [17], which is a system about wireless physiological sensing and logging. It can monitor and record several kinds of users' physiological signals, and energy saving also is the biggest highlight in the system. By utilizing integration analysis based on these data, the system can judge a person's emotional state: sadness, happy, and so on.

Taking into account the continuous generation of large-scale data, traditional medical treatment enters into the era of "big data" [18], which makes healthcare data storage become an indispensable technology in medical applications. Especially, as an extension of cloud computing extension and development, the cloud storage is a hot spot for large data storage [19]. Drago et al. introduced the characterization of Dropbox about the personal cloud storage to solve dataset [20], they only highlight users' workload in the network traffic in different environment to the system, and also indicate that the current storage structure and storage agreement leads to the possible amount of performance bottlenecks. Sherman et al. proposed a cloud storage system. The system protects the security of users' privacy data through introducing an effective TPA, which can also make the TPA for multiple users at the same time to carry out audit efficiency and execute the preliminary practice of Amazon EC2 to demonstrate fast performance of the system. Alqahtanit et al. put forward a solution [21], which intends to provide a secure data storage based on multiple cloud solutions for mobile cloud computing users. It can execute data segmentation, data encryption, data compression and other data processesory multiple clouds. At the same time, such design keeps a piece of data in the mobile device during healthcare data collection to prevent the unnecessary trouble caused by data stolen or the accident loss [22].

Healthcare data grows rapidly both in the volume and dimension generated from cyber, physical, and social space, which brings great challenges while also playing an important role in healthcare transmission [23]. The traditional network transmission technology cannot balance the relationship between the QoE and QoS in terms of data availability, data response delay, etc [24], [25]. In the system designed in this paper, it aims at a better healthcare data transmission. The system combines 5G network with the technology of software defined network(SDN) which is a new type of network architecture proposed by Stanford university clean SLATE's research team. The SDN split the decoupling between control layer and data layer, which not only makes the network more open, but also can flexibly support upper applications/services. The SDN realizes innovation in the different aspects, including variable QoS, downlink link buffer, packet data connection, selective links and packet switching, etc., and IT staff make network resources independent and end-to-end points or areas in virtue of how the SDN's programming. The 5G network based on SDN provides the best data transmission architecture for medical healthcare data transmission and sharing with high performance and high capacity. The 5G network is responsible for providing the function of data transmission with high transmission rate and meeting the requirements of high network density while the introduced SDN technology can support the diverse needs of different applications in the medical domain.

The collected healthcare data contain abundant and valuable information about medical health field. Detecting the relation and the trend from the collected healthcare data by using effective analysis methods is constantly breakthrough point of the modern healthcare industry. Kauret al. studied what data mining contributed in the medical field based on the technology on rules, decision tree and neural network and so on. The data mining provides methods and techniques to find useful information for decision-making from the piles of healthcare data. In addition, Koh et al. explored the methods of data mining applied in the field of healthcare [26], which mainly uses effective assessment in medical treatment, such as adopting healthcare data management to find several risk factors caused by diabetes.

In general, this paper designs a system that adopts wearable devices for healthcare data collection, cloud storage technology models for healthcare data storage, 5G network and SDN to healthcare data transmission, data integration and analysis for getting the emotional state by using data mining with machine learning techniques to explore and further utilize the emotion information of the patients for diagnosing illness degree and potential risks.

III. SYSTEM ARCHITECTURE

In the medical applications, collecting healthcare data and exploring the most valuable information from massive raw data in real time highly depends on the performance of the system. As mentioned above, emotion-aware healthcare is a new bright spot in the medicine field, which mainly devotes to analyzing the relationship between emotion and sick people. In this section, we propose a new system for big data application in emotion-aware healthcare, named as BDAEH. As shown in Fig.1. the architecture of the BDAEH system mainly consists of the following parts: data center, SDN components, 5G infrastructure, and sensing equipment.

A. DATA CENTER

As the head of the system architecture, the data center consists of high-performance computers (HPCs), storages, accelerators (e.g., nVidia GPU, AMD GPU, Intel Xeon Phi), and various security devices. The HPCs are resource consumers and responsible for receiving the raw healthcare data generated by sensing equipment according to the users' requests. Storages keep all kinds of healthcare data, which are not simply a group of hardware devices but a complex system which consists of network devices and application softwares such as servers, public access interface, storage devices and so on. In order to support stable operations and provide real-time services, the data center also adopts cloud computing technology and provides the function of data mining for further data analysis. Considering the huge kinds of the sensors, the function of cloud storage builds a bridge between the data center and lower layer of the BDAEH system, and supports online uploading and sharing resources for different applications, such as documents, videos, sounds, and pictures. Compared with the traditional storage technologies, cloud storage has many advantages includes low cost, high performance, large capacity, high safety, etc. Moreover, personal cloud storage and synchronous cloud storage are both introduced in

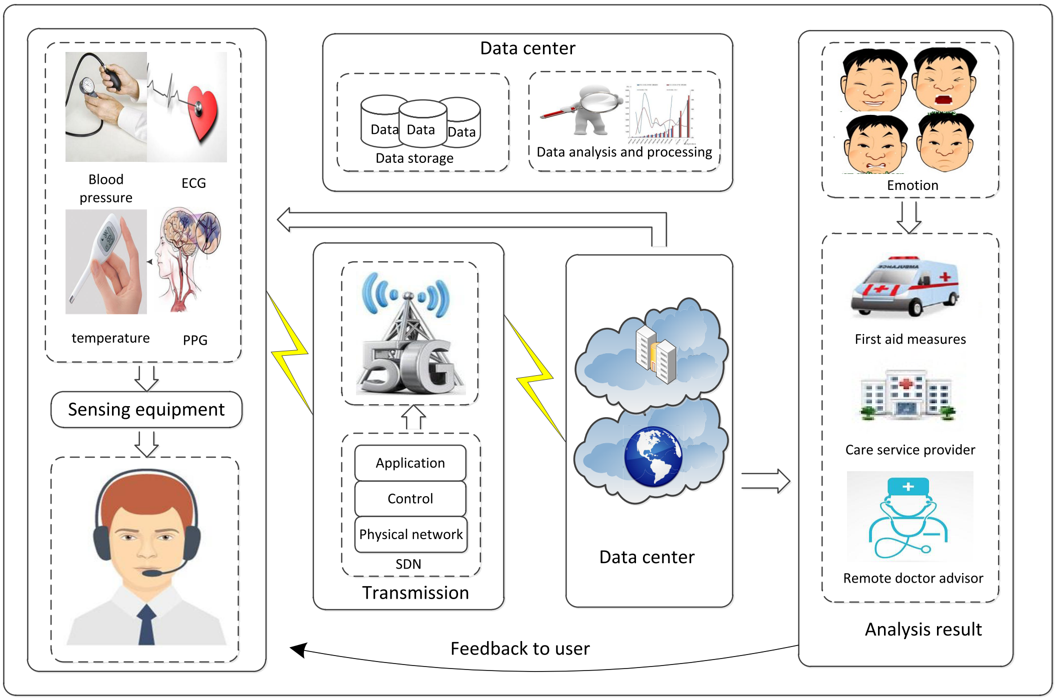

FIGURE 1. **The architecture of the BDAEH system.**

the BDAEH system to storage healthcare data in the individual device respectively. The synchronous mechanism is required to provide individual user cross-platform between these two kinds of cloud storage structures. Users only need one account to store their important data when using personal cloud storage service, which avoids the inconvenience of carrying storage equipment. In addition, cloud storage technology increases the data security by using online encryption technology. By adopting some existing technologies such as parallel computing and distributed computing, the data center supports comprehensive and intelligent analysis for real-time data analysis to connect the collected raw data from lower layer with the health status of the users. The high computing ability of data center supports the data mining technologies to explore the information hidden in raw healthcare data of the user, such as statistical method, machine learning, neural network and so on. It also supports distributed data analysis techniques include Hadoop, Spark, Cassandra etc. The proposed BDAEH system adopts distributed data analysis techniques to realize the healthcare data processing and analysis. For example, the adopted Hadoop is a distributed system infrastructure to process data in a distributed way and developed by the Apache foundation while HDFS and MapReduce are the core of the framework of Hadoop. The HDFS is a distributed file implemented by Hadoop system, which is responsible for storing all the files on Hadoop storage nodes. The MapReduce engine provides distributed data processing. All the results of data analysis can be accessed by the users or shared to the doctors for understanding the users' health status.

B. SDN COMPONENTS

SDN components consist of SDN flow switches and controllers, which realize the connection and the soft-defined function in the architecture to improve the utilization of network resources, control the network, and collect users' information effectively. The SDN flow switches are mainly responsible for managing healthcare data collection from the lower layer of the proposed BDAEH system architecture. The SDN controllers utilize OpenFlow technology to control the flow table of SDN flow switches and support the integrated control of the BDAEH system. An SDN flow switch receives healthcare data from the lower layer(5G infrastructure) and determines the next transmission port for each healthcare data after checking the local flow table. Considering the situation that there is no matching port for a healthcare data, the data is transmitted to the SDN controller, which can select a suitable transmission port by using global information of the BDAEH system. Specifically, SDN components play an important role in managing and allocating the resources and tasks in the BDAEH system. In a word, the programmable SDN separates the network into control layer and data forwarding layer, and can realize the management of data resources. The SDN also shortens the period of product upgrade and replacement.

C. 5G INFRASTRUCTURE

5G infrastructure consists of 5G base stations. Each base station is deployed in the center of a macro cell and responsible for local communication and spectrum management of all kinds of sensing devices in the lowest layer of the BDAEH system. Considering the requirements of big data application in emotion-aware healthcare, various of sensors generate healthcare data continually and these data need to be collected in real time. Compared with traditional applications, the sensing equipment for emotion-aware healthcare requires more kinds of devices. Fortunately, the emerging 5G technology gives a chance to provide high performance of data transmission for a large scale network with millions of devices by utilizing new communication methods and spectrum. The 5G infrastructure contains abundant network resources such as spectrum and each base station is capable of covering a large physical area with equal size. The base station is responsible for the local management and the communication between each other. For the different abilities and operation modes, the virtual cell is also introduced to improve data transmission rate and throughput. According to the real-time resource requirement of each sensing equipment, the base station can organize many virtual cells and allocates the spectrum resource for them, which aims to utilize the network resources effectively. The virtual cells also need to consider the blockage of signals caused by obstacles in their coverage areas. More devices and tasks in a virtual cell demand more spectrum and other resources. In order to make the sensing devices access the network at any time, 5G adopts flat IP network architecture integrated many kinds of wireless access technology as a core network to realize the devices' joining and exiting at any time, which can improve the flexibility of the network.

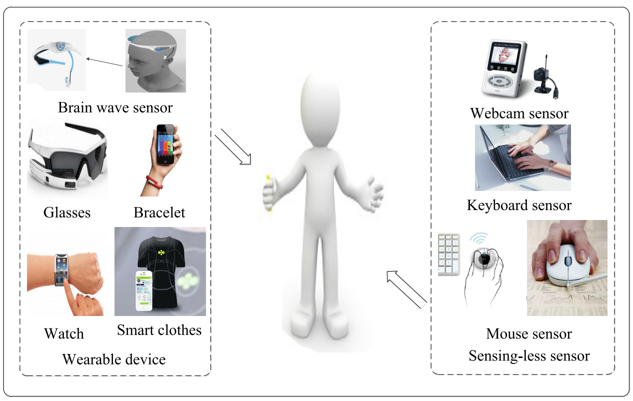

FIGURE 2. Healthcare data collection equipment.

D. SENSING EQUIPMENT

As the bottom of the BDAEH system architecture, sensing equipment consists of different kinds of devices to meet the application requirements of emotion-aware healthcare, such as biosensors, motion sensors, wearable devices with sensors, and some sensor-less devices. As shown in Fig. 2, the wearable devices include the smartphone, smart watch, smart clothes and so on to obtain abundant and valid healthcare data by equipping with different sensors. The smart clothes may be equipped with temperature sensor, galvanic skin sensor, blood pressure sensor and other sensors, and need to synthetically consider many factors such as the type of sensor, the position of sensor on the clothes, comfortable degree of users, etc.. Specifically, sensor-less devices are used for some potential applications to detect the users' emotion without adding additional sensors. These low-cost devices have their own functions but their generated signals can be used to explore the users' emotion. For example, the mouse is the device that is equipped with almost every computer, the information of clicking mouse has a direct relationship with the emotion of the users. The variety of sensing equipment is an effective guarantee for the collection of emotion status of users. Sensing equipment also has a certain computing, storage and communication capabilities to ensure the effective collection of healthcare data. In addition, interaction interfaces are applied to the information exchange between users and sensing equipment. The interfaces in the BDAEH system can be equipped with a smartphone, computer, or sensor devices.

IV. THE FUNCTION DESCRIPTION OF THE BADEH SYSTEM

In the section, we mainly describe the function information of BDAEH system. Firstly, the overview functionalities of the BDAEH system is presented. In addition, the functions achieved by each module and the processing flow of healthcare data are introduced in detail based on the composition of the BDAEH system.

The main purpose of the BDAEH system is integrating emotion computing and emerging communication technologies into the processing procedure of healthcare data, which remarkably improves the efficiency of healthcare data collecting, transmitting, storage, and so on. As shown in Fig. 1, the data center provides the storage, integration and analysis functions of healthcare data. Through analyzing and mining the massive data, the system not only gets the users' emotional state and physical condition real-timely but also explores all kinds of relations between them hidden in the healthcare data. In addition, in order to improve the performance of healthcare data transmission, the SDN is utilized in the BDAEH system. Meanwhile, the SDN provides transmission control, network route, load balance and NFV function. Therefore, the system can effectively access network anytime and anywhere and transmit the healthcare data received from the lowest layer (sensing equipment). Utilizing the powerful data processing ability and valid emotion aware, the BDAEH system helps users to know their own physical conditions, provides personalized improvement suggestion for them to keep a stable physical condition, and sends the physical information to the families neighbors or doctors. Doctor, as another type user of the system, can timely acquire the patient's condition and gain convenience for formatting reasonable treatment scheme so that patients can enjoy more effective treatments. Big healthcare data are produced when the number of users is huge and the system operation time is long. These data can be validly utilized to predict the state of

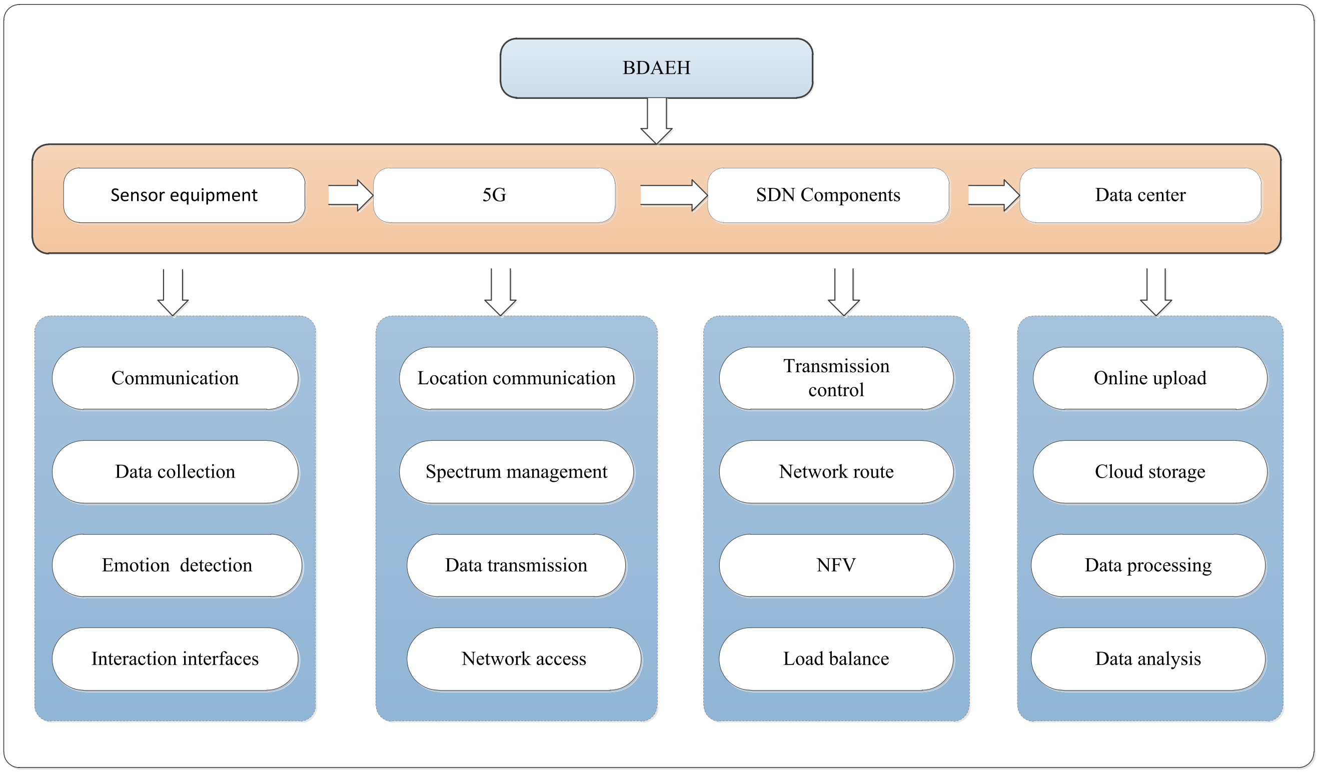

FIGURE 3. The functions of the BDAEH system.

human physical health even across generations, which have an active impact on medicine area. The BDAEH system is also expected to increase patients participation and improve individuals' health quality.

A. THE DETAIL FUNCTIONALITIES OF THE ARCHITECTURE

1) FUNCTIONS OF SENSING EQUIPMENT

The module, as the bottom layer of the system, provides healthcare data sources for the total process. In the module, using sensors, wearable devices, and sensor-less devices, body vital signs of signal data is effectively collected: temperature, ECG, PPG, GSR, blood pressure, physical content etc.. Especially, the emotion-aware methods are integrated into the BDAEH system. These healthcare data are not only used as the foundation to monitor health state of users but also used to analyze the emotion state of users: happiness, sadness, indignation and so on because most changes of vital sign parameters are caused by the subtle change of emotion. For example, every morbidity of chronic diseases is not an accident. If the system can accumulate enough healthcare data, these data are able to be used to predict the occurrence pattern of illness so that users could obtain the timely treatment. In addition, through using sensors, wearable devices, and sensor-less devices, healthcare data could be collected at home [27], on the road or anywhere. Users can obtain the information about their own physical condition to meet their requirements. Therefore, the usage of these sensing equipment can avoid the complex process of going to a hospital in many cases.

Especially, the sensor-less sensor provides the possibility that daily equipment can be used as the sensor to collect medical information. For example, some sensor-less sensors such as mouse pad are used to collect the vital sign signal, which can be regarded as the indicators of mental health. The occurrence of sensor-less makes the emotion computing universal and unobtrusive. Sensing equipment not only realizes healthcare data detection and collection but also be used as an interaction tool between user and machine. Through sensing equipment, users' signals of the sign are transmitted to the software equipment with the form of machine language. Furthermore, the analysis result of healthcare data can be displayed to the users with the form of the word, graphicness or video.

2) FUNCTIONS OF SDN COMPONENTS

As a new network technology, the SDN separates forward layer and control layer by OpenFlow to achieve flexible control of network traffic and more intelligent network. In the BDAEH system, the SDN is used as the pipeline of healthcare data transmission. Network function virtualization(NFV) provided by the SDN makes network equipment in the BDAEH system not rely on dedicated hardware resources, which can flexibly share healthcare big data. The development and deployment of new tasks and other virtual functions can reduce the cost of network hardware. What's more, when transmitting the healthcare big data to the controller layer and application layer from the lower layer(5G infrastructure), the SDN can choose the optimal network router interface. Anything else, the corresponding algorithms implemented in the SDN build service group to provide the normal load for improving the transmitting level of healthcare data. The network load is approximately equal to the state of load balance. The SDN also increases the network capacity and make it more elastic to cope with healthcare big data traffic growth. The fast deployment and instant adjustment can meet the requirement of healthcare data, which is better for SDN to control transmission.

3) FUNCTIONS OF 5G INFRASTRUCTURE

This module uploads the vital signal data collected from sensing equipment to the data center for data storage and data processing. 5G provides cell-level, dynamic spectrum allocation and QoE management for each macrocell by utilizing global information. In the achievement of elaborate management, spectrum sharing of middle and high frequency is utilized to improve spectrum utilization. By using co-frequency co-time full duplex technology, 5G implements the flexible usage of spectrum resources and the local communication among base stations and solves the problem that mutual interference existed in adjacent base stations. In addition, device-to-device(D2D) communication is adopted in the module to realize direct communication between communication terminals, which expands network connection and access way, and then improve network throughout by avoiding unnecessary healthcare data transmission via the network in cellular communication. On the other hand, the small cell or virtual cell at the bottom is used as the network access point of the base station. It can solve the limitation caused by the network blind area covered by the macrocell and make the users normally surf the internet effectively in the network coverage area. 5G infrastructure ensures the consistent service of the BDAEH system under varieties of scenarios, which not only solves network congestion but also increases the healthcare data transmission speed. Even though converting to each connection point, healthcare data transmission speed can achieve to 200 Mbps, which is the biggest gospel for mobile medical equipment [28]. Therefore, in the system, the functions of 5G infrastructure enable the raw healthcare data to be transmitted to the data center or the doctors in real-time [29].

4) FUNCTIONS OF DATA CENTER

The data center is the complex module that realizes three main functions based on the cloud: healthcare data storage, healthcare data process, and healthcare data analysis. The data center supports online upload between the users and the equipment. Data center stores healthcare data collected from sensing equipment through the configurable virtual storage provided by the cloud and the related data service. Cloud storage not only realizes the storage of large-scale healthcare data but also ensures the safety of healthcare data through encryption technology and senior user authentication technology. Considering the large scale information system may encounter the low integration level, poor interconnectedness, scattered information management and else problem, data center ensures the smooth and effective operation of the BDAEH system through using healthcare data cleaning, healthcare data cutting, and healthcare data sharing. Meanwhile, the unvalued and redundancy healthcare data are reasonably removed through related data integration technology. In addition, healthcare data analysis plays an important role in the data center. Data center analyzes healthcare data by utilizing data mining, machine learning, data analysis algorithm, visualization and other related technology. Visualization is not only the key technology to analyze healthcare data but also the core technology to display the analysis result. The analysis results are returned to the users through sensing equipment. Moreover, the results can be shared with the doctors, and the doctors can further make a diagnosis or give a rehabilitation proposal.

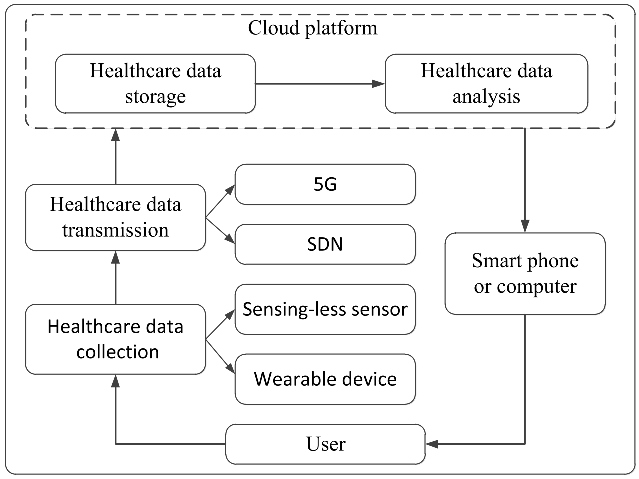

FIGURE 4. Fundamental produce of the BDAEH system.

B. FUNDAMENTAL PROCEDURE OF THE BDAHE ARCHITECTURE

As shown in Fig.4., the general process operation of the BDAHE system is concretely introduced. The BDAHE system collects healthcare data through sensing equipment at the bottom of the system. Then the healthcare data are timely transmitted to the control layer of the SDN with high throughput capacity, which is achieved through the 5G network technology . Finally, the data are forwarded to the data center via the application layer of the SDN and simultaneously stored in the cloud platform. On the cloud platform, the BDAHE system deals with healthcare data by using a series of related technologies and validly obtains both the emotion state and the health state of the users, and explores the relation between the emotion and the illness.

Many healthcare systems have different abilities for the sake of solving different problems in medicine applications.

TABLE 1. Comparison between BDAEH and some healthcare system.

System name	Sensing-less sensor	Emotion computing	Cloud computing	Software-defined Network	5G	Data mining
Health-CPS	NO	NO	YES	NO	NO	YES
ReTiHA	NO	NO	YES	NO	NO	NO
Live demonstration	NO	NO	YES	NO	NO	YES
AIWAC	NO	YES	YES	NO	NO	NO
HCloud	NO	NO	YES	NO	NO	YES
BDAEH	YE	YES	YES	YES	YES	YES

Health-CPS is a cyber-physical system based on the cloud computing and the big data mining analytics technologies, which aims at the patient-centric healthcare applications and services [30]. ReTiHA is a service system that can provide healthcare service in remote areas through continuously monitoring the vital physical signal of patient and offering real-time prognosis and healthcare advice [31]. Live demonstration is a mobile ECG healthcare platform system which can monitor the ECG waveform in real-time, and put some lightweight monitoring function in mobile phone to provide important services such as user location information and an emergency alarm [32]. AIWAC is an affective interaction architecture through wearable computing and cloud technology [6], which enhances emotion analysis, forecasting models, and controllable emotion interactions. HCloud is a preventive healthcare service system possessing the parallel computing capability [33], where cloud platform with the feature of loose coupling algorithms section is deployed. We make a series of comparisons between the systems above and the proposed BDAEH system. As shown in table 1, compared with other systems, the presented BDAEH system has the following novel and improvement performances by adopting some new technologies, such as the sensing-less sensor to collect healthcare data, the SDN to improve transmission speed, the cloud computing to storage healthcare data, and the data mining to analyze healthcare data.

V. CONCLUSION

In this paper, we design a system for big data application in emotion-aware healthcare, which not only considers the traditional idea that the system focuses on logic reasoning but also integrates emotion computing. The BDAEH system realizes the functions includes collecting users' vital physical signal as the healthcare data through sensing equipment, transmitting healthcare data by adopting 5G network technology, forwarding the healthcare data to data center via the SDN, storing and processing healthcare data on the cloud platform, and finally displaying the analysis result to the users or the remote doctors. The BDAEH system adopts sensor-less sensing in the sensor equipment at the bottom of the system, which improves the adaptability of healthcare data collection and makes the emotion computing unobtrusive. In addition, the 5G and the SDN technologies ensure the BDAEH system get higher data transmission rate and network throughout. The BDAEH system effectively monitors and records vital physical signal of users, meanwhile increases the storage capacity and improves the security of stored healthcare data on account of cloud storage technology. This paper presents the detail description of the BDAEH system architecture and the functions of each part. Moreover, the preponderance of the BDAEH system is analyzed by comparing with some existing healthcare systems.

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