1. INTRODUCTION

In the past two decades, information technology has been widely utilized in medicine Electronic health records(EHRs), biomedical database, and public health have been enhanced not only on the availability and traceability but also on the liquidity of data. As healthcare-related data are consistently explosive, there are challenges for data management , storage, and processing, as follows.

- **Large Scale**: With the improvement of medical informationization , particularly the development of hospital information systems, the volume of medical data has been increasing . In addition, the promotion of wearable health devices accelerates the explosion of healthcare data .
- **Rapid Generation**: Most medical equipment, particularly wearable devices, continuously collects data. The rapidly generated data need to be processed promptly for responding to emergency immediately .
- **Various Structure**: Clinical examination, treatment, monitoring, and other healthcare devices generate complex and heterogeneous data (e.g., text, image, audio,or video) that are either structured, semi-structured, or non structured at all
- **Deep Value**: The value hidden in an isolated source is limited. However, through data fusion of EHR and electronic medical records (EMRs), we can maximize the deep value from healthcare data, such as personalized health guidance and public health warning .

With the assistance of cloud computing and big data, healthcare data from cyber-physical systems (CPS)(e.g. huge files, complex structures, and different features) can be efficiently managed. Inspite of the innovations in healthcare field, there are some issues that need to be solved, particularly the heterogeneous data fusion and the open platform for data access and analysis . For example, although studies are focused on the interconnection between body area networks (BANs)and the cooperation between BANs and medical institutions, it is difficult to fuse the multisource heterogeneous data and the corresponding managements without unified standards and systems. Thus, the healthcare data stored together on the physical layer are still logically separated. However, the greatest challenge of building a comprehensive healthcare system is in the handling of the heterogeneous healthcare data captured from multiple sources. The contributions of healthcare CPS using technologies of cloud and big data (Health-CPS) can be summarized as follows:

- A unified data collection layer for the integration of public medical resources and personal health devices.
- A cloud-enabled and data-driven platform for the storage and analysis of multisource heterogeneous healthcare data .

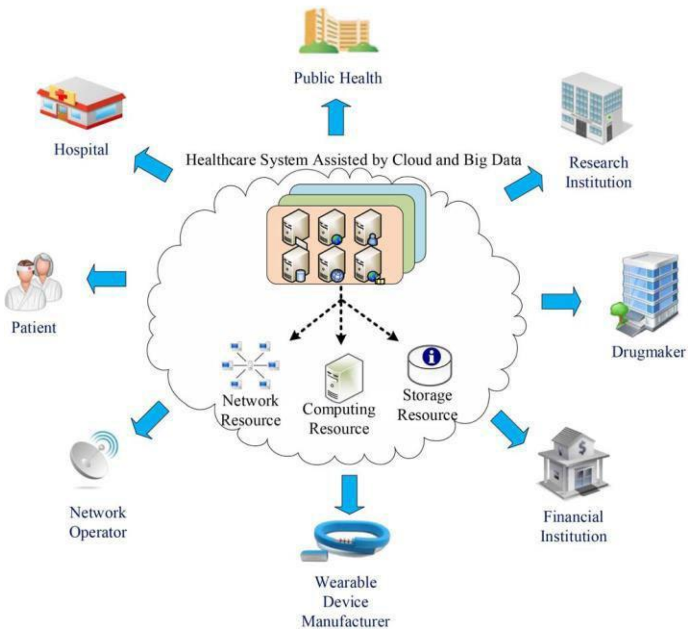

Fig: 1.1. Illustration for the extended healthcare ecosystem.

- A healthcare application service cloud,which provides a unified application programming interface (API) for the developers and a unified interface for the users.

2. LITERATURE SURVEY

[1] J. Wan *et al.*, "Cloud-enabled wireless body area networks for pervasive healthcare," *IEEE Netw.*, vol. 27, no. 5, pp. 56–61, Sep./Oct. 2013.

Due to several recent technological advances new concepts, such as wireless body area networks (WBANs) and low-power wireless communications, pervasive health monitoring and management services are becoming increasingly popular. However, efficient management of the large number of monitored data collected from various WBANs is an important issue for their large-scale adoption in pervasive healthcare services. Since WBANs have limited memory, energy, computation, and communication capabilities, they require a powerful and scalable high-performance computing and massive storage infrastructure for real-time processing and data storage, as well as for online and offline data analysis. Mobile cloud computing (MCC) is gradually becoming a promising technology, which provides a flexible stack of massive computing, storage, and software services in a scalable and virtualized manner at low cost. The integration of WBANs and MCC is expected to facilitate the development of cost-effective, scalable, and data-driven pervasive healthcare systems, which must be able to realize long-term health monitoring and data analysis of patients in different environments. In MCC, mobile devices do not need a powerful configuration, such as high CPU speed or large memory capacity, since their data and complicated computing modules can be stored and processed in the clouds. The seamless integration of WBANs and MCC introduces several advantages, which include:

• Richer functionalities and services: With MCC capabilities, a wider range of services, including more medical video streaming and medical data mining (MDM) can be provided to meet richer application requirements.

• Performance efficiency: Since the resource constraints mobile devices and network bandwidth limitations in WBANs have hampered further improvement of service quality and large deployment of mobile pervasive services, the mobile services and cloud servers are considered as a whole to enhance the performance efficiency of pervasive healthcare applications in terms of computation, storage, communications, and energy.

• Patient-centric services: Since WBANs are evolving to enable a highly flexible and scalable infrastructure for mobile services assisted by cloud computing, MCC applications can be designed in such a way that patients can control their own data and activities with strong privacy and security protection.

• **Reinforced reliability: Since medical data from a patient is stored on** multiple servers in the cloud, even if some data is lost in the mobile device there are still backup copies in the cloud. Furthermore, when the battery of a mobile device dies, the applications can still continue running in the cloud without interruption.

Nevertheless, the research into cloud-enabled WBAN platforms (also called wMCC platforms) is still in its infancy, several technical issues and challenges are to be addressed in order to fulfill the research promises. Current studies related to wMCC platforms focus on architectural design to realize a health monitoring and analysis system. With the support of mobile cloud computing, wireless body area networks can be significantly enhanced for massive deployment of pervasive healthcare applications. However, several technical issues and challenges are associated with the integration of WBANs and MCC.

[2] G. Kim, S. Trimi, and J. Chung, "Big-data applications in the government sector," *ACM Commun.*, vol. 57, no. 3, pp. 78–85, 2014.

Big data, a general term for the massive amount of digital data being collected from all sorts of sources, is too large, raw, or unstructured for analysis through conventional relational database techniques. Approximately 90% of it is unstructured. Still, the overwhelming amount of big data from the Web and the cloud offers new opportunities for discovery, value creation, and rich business intelligence for decision support in any organization. Big data also means new challenges involving complexity, security, and risks to privacy, as well as a need for new technology and human skills. Big data is redefining the landscape of data management, from extract, transform, and load, or ETL, processes to new technologies (such as Hadoop) for cleansing and organizing unstructured data in big-data applications. Although the business sector is leading big-data-application development, the public sector has begun to derive insight to help support decision making in real time from fast-growing in-motion data from multiple sources. Many white papers, journal articles, and business reports have proposed ways governments can use big data to help them serve their citizens and overcome national challenges (such as rising health care costs, job creation, natural disasters, and terrorism).

First the two sectors are compared in terms of goals, missions, decision-making processes, decision actors, organizational structure, and strategies. The attributes and challenges of big data have been described in terms of "three Vs": volume, velocity, and variety. Volume is big data's primary attribute, as terabytes or even petabytes of it are generated by organizations in the course of doing business while also complying with government regulations. Velocity is the speed data is generated, delivered, and processed. In addition, sharing information across national boundaries involves language translation and interpretation of text semantics (meaning of content) and sentiment (emotional content) so the true meaning is not lost. Dealing with language requires sophisticated and costly tools. Data sharing within a country among different government departments and agencies is another challenge.

The most important difference of government data vs. business data is scale and scope, both growing steadily for years. Governments, both local and national, in the process of implementing laws and regulations and performing public services and financial transactions accumulate an enormous amount of data with attributes, values, and challenges that differ from their counterparts in the business sector. Government big-data issues can be categorized as silo, security, and variety. Each government agency or department typically has its own warehouse, or silo, of confidential or public information, with agencies often reluctant to share what they might consider proprietary data. Communication failure is sometimes the issue for data integration. Another challenge for sharing and organizing government data involves finding a cohesive format that would allow for analytics in the legacy systems of different agencies. Even though most government data is structured, rather than semi-structured or unstructured, collecting it from multiple channels and sources is a further challenge. Then there is the lack of standardized solutions, software, and cross-agency solutions for extracting useful information from discrete datasets in multiple government agencies and insufficient funding due to government austerity measures to develop and implement these solutions extract value from that conventional information technologies are not effective for its management. Variety is that data comes in all forms: structured (traditional databases like SQL); semi-structured (with tags and markers but without formal structure like a database); and unstructured (unorganized data with no business intelligence behind it). The concept of big data has evolved to imply not only a vast amount of the data but also the process through which organizations derive value from it. Big data, synonymous today with business intelligence, business analytics, and data mining, has shifted business intelligence from reporting and decision support to prediction and next-move decision making.

Hadoop, an open-source platform, is the most widely applied technology for managing storage and access and high-speed parallel processing. However, Hadoop is a challenge for many businesses, especially small- and mid-size ones, as applications require expertise and experience not widely available and may thus need outsourced help. Finding the right talent to analyze big data is perhaps the greatest challenge for business organizations.

[3] K. Lee, T. T. Wan, and H. Kwon, "The relationship between healthcare information system and cost in hospital," ***Pers. Ubiquitous Comput.*****,vol. 17, no. 7, pp. 1395–1400, Oct. 2013.**

Healthcare information system (HIS) has been emphasized as a mechanism to achieve efficient operations. It is expected that they could play an important role in addressing the financial problem of the healthcare industry. HIS application is expected to have hospitals to use less resource for patient care. This will save cost and increase overall profits. A study analyzed the adoption of automated notes and records, computerized physician order entry (CPOE), and clinical decision support (CDS) system with cost in hospital. It found that HIS could lower hospital admission cost. Other studies analyzed the effects of electronic medical record (EMR) and found that adoption of EMR could lower cost. These studies proposed that lowering cost will due to the enhanced healthcare delivery and transaction efficiency. COPE and electronic medical administration record (EMAR) were proposed to reduce cost per admission in select services. Most of the previous studies analyzed the partial relationship between specific technologies and limited areas of hospital performance HIS was defined as a set of interrelated application systems working together. Each application system consists of diverse sub-applications used at different sites within a hospital. Hospital systems are categorized into four functional areas such as administrative, medical, patient management, and facilities management. The objective was to analyze the relationship between HIS and total expense in hospital. And also, it tried to identify organizational factors that affect the adoption of information system in US acute care hospitals. The use of computer-based information systems could have positive impacts on organizational performance. Health care organizations are no exceptions for this. But if one wishes to identify the effects of IT on the delivery of care, one must be able to characterize IT for organizational purposes. The measurement of hospital information system was based on the automated information system applied to the core functions of hospitals. In terms of the total cost in hospital, the adoption of HIS application may lead to reduction in the total expense in hospital. Although the relationship was not statistically significant, it could provide implications for hospital CEOs. Investment in HIS is viewed as a strategic decision of hospitals to minimize the cost in patient care. It is reported that controlling cost is the main motivation for adopting HIS. Healthcare industry has been focused on the financial aspects. Prior findings implied that HIS enables hospitals to spend less time for patient care, and it could save labor cost. It is estimated that saving from the information system such as EMR is more than the cost for adopting the system. Hospital size and system hospitals were significant predictors of the adoption of information system. As the number of beds increased, the adopted number of system increased. It is estimated that system hospitals are more likely to invest in IT. The location of hospitals was a predictor of the adoption of HIS.

Hospitals in an urban area were more likely to adopt the application system than those in a rural area. These environmental factors may have influenced hospitals to effectively adopt new information technologies. Also a great deal of expertise is needed to understand the system better.

[4] M. Chen, Y. Ma, S. Ullah, W. Cai, and E. Song, "ROCHAS: Robotics and cloud-assisted healthcare system for empty nester," in *Proc. BodyNets,*Boston, MA, USA, Sep. 30–Oct. 2 2013, pp. 1–4.

In recent years, provisioning of human-centric services through body area networks, robotics technology and cloud computing is continuously attracting extensive attention from both academia and industry. A novel robotics and cloud assisted healthcare system (ROCHAS) is proposed, which combines these three technologies to provide pervasive healthcare services and especially the mental healthcare for empty-nester who are typically old-aged, lonely and depressed.

Empty-nesters do not live with their children or do not have children. Due to old age and long-time loneliness, they suffer by so-called "empty-nest" syndrome, which generates several consequences. Since empty-nesters are old, weak and lonely, they often feel depressed with inappetence and insomnia, which may easily cause mental diseases. According to the statistics, 60% empty-nesters have psychological problems and the number of empty-nesters who have diseases and need medical attention and psychological intervention come at 10%-20%.

While the large number of empty-nesters has become a social problem that can not be ignored, the health monitoring industry on empty-nesters is still in the preliminary stage. To address this critical issue, a *Robotics and Cloud-assisted Healthcare System* (ROCHAS), is proposed which combines three technologies in terms of body area networks, robotics and cloud computing.

ROCHAS includes four major components, i.e., robotics-assisted health monitoring and healthcare services, wireless and wired networks, cloud-assisted healthcare system, and healthcare service supporting infrastructure. ROCHAS mainly has the following characteristics:

- A household low-cost robot serves as bridge for empty-nester to communicate with his/her children in other places, which is mainly realized by the function of mobile multimedia communications. In addition, the robot also has intelligent speech recognition and entertainment functions. These three functions mainly provide spiritual consolation for empty-nester.
- Body sensors are deployed in or around empty-nester to collect physiological data, while environmental sensors are equipped in the robot. Both physiological and environmental data will be pre-processed by the robot, which further transmits the sensory data to a cloud health monitoring system in a real-time or on-demand fashion.
- The personalized health related data of elderly people will be stored and analyzed in the cloud-assisted healthcare system, which will properly provide expert-level services for empty nesters in terms of the mental status analysis, eating habits monitoring, early prevention of diseases, and other health-care services.

The development of ROCHAS involves artificial intelligence, machinery and electronics, intelligent speech recognition, mobile multimedia communication, wireless sensor network, body area network, tele-medicine, and cloud computing, etc. Therefore, it is a comprehensive inter-discipline with the following key technologies.

There are many challenges that still need to be addressed, especially on high bandwidth and energy efficient communication protocols, low cost robot, and interoperability between robot and cloud platform.

[5] M. Chen, "NDNC-BAN: Supporting rich media healthcare services via named data networking in cloud-assisted wireless body area networks," ***Inf. Sci.*****, vol. 284, pp. 142–156, Nov. 2014.**

Wireless Body Area Network (WBAN) is broadly utilized for health monitoring and remote medical care. Wireless Body Area Network (WBAN) or Body Area Network (BAN) contains a set of wearable body sensor nodes which are typically placed on or around human body, collecting data and sending it to access point through various wireless technologies, among which Zigbee is mostly used. Though the network parameters are fine-tuned to meet particular quality of service (QoS) requirements in Zigbee based intra-BAN and inter-BAN, existing network architectures are hard to support high mobility for both patients and physicians due to the intrinsic features of low data rate and channel dynamics. Nowadays, this problem can be alleviated by using mobile device, such as iPhone/iPad, android phone, even a robot, as a personal server to interconnect intra-BAN with outside world. The mobile device should have at least two interfaces, i.e., one Zigbee interface to communicate with Zigbee-enabled body sensor nodes within intra-BAN, the other interface to forward body signals to external network. When the physiological information collected in WBAN is distributed to cloud computing platform, a new healthcare service mode is enabled by ‘‘cloud-assisted WBAN’’, where user’s body signals can be stored, processed, managed and analyzed over a long-term period. The experimental results conducted by OPNET verify the viability of NDN and adaptive streaming to support the healthcare services involving the transmissions of rich media contents between WBAN and internet. Since cloud computing provides a low-cost approach to support extensive data storage and computing-intensive analysis of healthcare big data, the provisioning of healthcare services is largely enhanced via cloud-assisted WBAN

Though the provisioning of healthcare services is largely enhanced via cloud-enabled technologies, more challenging issues are raised due to the increased user's requirements on quality of experience (QoE) in terms of user mobility, content delivery latency, and personalized interaction, etc. In order to tackle these challenges, various solutions are proposed like a novel integration of WBAN with Long Term Evolution (LTE) to support high user mobility, an efficient scheme to distribute contents by leveraging the emerging named data networking (NDN) technology, to support rich media healthcare content delivery without service interruption while achieving low cost and bandwidth saving, the use of adaptive streaming to adjust suitable content size according to the dynamic bandwidth.. However, more challenging issues are raised due to the increased user's requirements on quality of experience (QoE) in terms of user mobility, content delivery latency, and personalized interaction, etc.

3. PROPOSED SYSTEM

For the healthcare industry, cloud and big data not only are important techniques but also are gradually becoming the trend in healthcare innovation. Nowadays, medicine is relying much more on specific data collection and analysis, whereas medical knowledge is explosively growing. Therefore, medical knowledge published and shared via cloud is popular in practice. Patients typically will know more than a doctor. As such, the information and knowledge base can be enriched and shared by the doctors over the cloud. The patients can also actively participate in medical activities assisted by big data. Through smart phones, cloud computing, 3-D printing, gene sequencing, and wireless sensors, the medical right returns to the patients, and the role of a doctor is as a consultant to provide decision support to the patients. The revolutions of cloud and big data may have a strong impact on the healthcare industry, which has even been reformed as a new complex ecosystem.

3.1. CLOUD AND BIG DATA ASSISTED ARCHITECTURE

The architecture of Health-CPS consists of three layers, namely, data collection layer, data management layer, and application service layer.

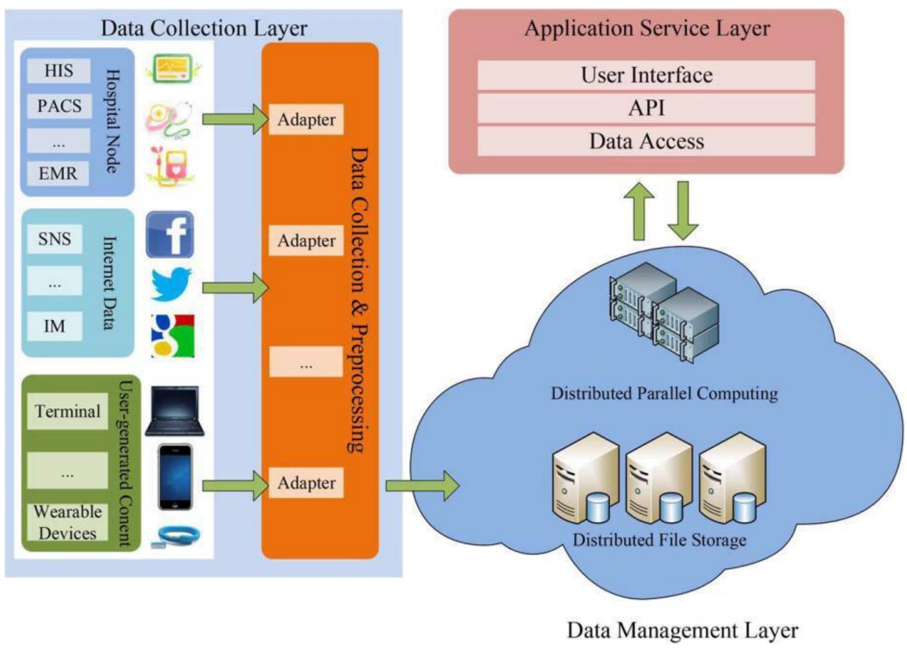

Fig: 3.1. Health-CPS architecture.

- **Data collection layer**: This layer consists of data nodes and adapters, provides a unified system access interface for multisource heterogeneous data from hospitals, Internet, or user-generated content. Through an adapter, raw data in a variety of structures and formats can be pre-processed to ensure the availability and security of the data transmission to the data management layer.
- **Data management layer**: This layer consists of a distributed file storage (DFS) module and a distributed parallel computing (DPC) module. DFS will enhance the performance of the healthcare system by providing efficient data storage and I/O for heterogeneous healthcare data, DPC provides the corresponding processing and analysis methods.
- **Application service layer**: This layer provides users the basic visual data analysis results. It also provides an open unified API for the developers aiming at user-centric application to provide rich, professional, and personalized healthcare services.

3.2. DATA COLLECTION LAYER

In the data collection layer, various healthcare data are collected by the data nodes and are transmitted to the cloud through the configurable adapters that provide the functionality to pre-process and encrypt the data.

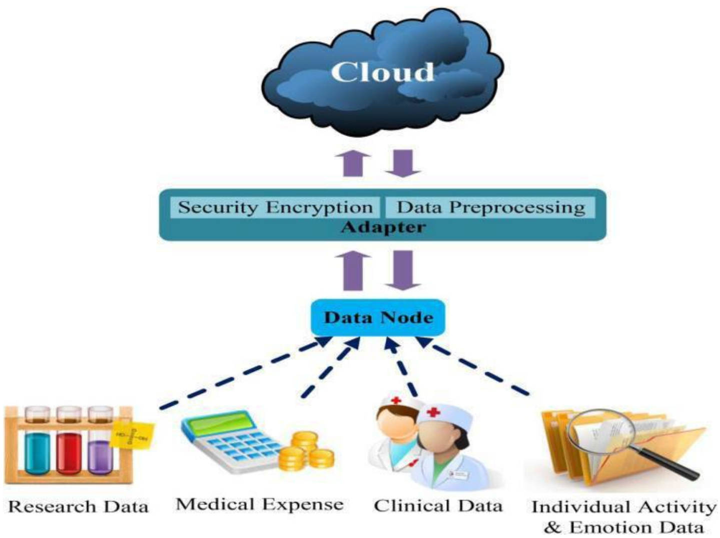

Fig: 3.2. Data collection layer.

Data Node

Data nodes can be divided into the following four groups.

- **Research data:** Drug research and development institutions and other scientific research institutions have accumulated a large amount of research data. These digital data can help identify the drug side effect and the new effect.
- **Medical expense data:** Medical behaviors generate massive expense data, such as medical bill and medical insurance reimbursement, which are not the traditional healthcare data, but it can be used to analyze and estimate the medical cost.
- **Clinical data:** This is the typical medical data, usually collected by medical service providers for clinical diagnosis such as EMR, and medical image. These data can be unified, managed, and opened to researchers with a necessary precondition for ensuring the privacy of the patient, to maximize the value of clinical medical data mining.
- **Individual activity and emotion data:** This kind of data is generated apart from the healthcare sector, but it is also relevant to personal health. For example, individual retail consumption records can reflect living habits, which can be used to evaluate individual health risk and make a personalized health plan. Furthermore, based on the physiological data collected by wearable devices, the health status of a user can be easily monitored and traced. The individual emotion data are available to be collected through the information published on the social networks, which can be used in the mental health measuring and affective computing.

  Particularly for the recovering patients, a doctor may be able to adjust the treatment plan according to a patient’s emotion. An emotion-aware healthcare service promotes the innovation of modern medical with humanistic treatment.

Adapter

Adapter is a middleware to provide a data node with access to the system, which is not only a physical data link but also a raw data preprocessor and encrypter. Apart from cleaning data, removing redundancy, and doing compression, the preprocessing module supports data format transformation. According to the type of collected data, the adapter adopts a system-defined data standard for the format conversion. The encryption module encrypts the preprocessed data to ensure security through a hierarchical privacy preservation mechanism. Any unauthorized devices cannot decrypt the data package even if they have access to the system. To improve the scalability of such a system, the functional unit of an adapter is configurable. When the following conditions are met, the corresponding modules of the adapter can be updated online.

- **Data node variation**: When the data node is replaced or upgraded, if the data format of the updated device is not consistent with the former one, the functional units will not work properly. Then, the adapter must send a request to the server for reconfiguring the preprocessing module to make it compatible with the updated one, whereas the server records the kind of updated data node and reauthorize the encryption module online.
- **Data standards update**: When a new type of device without a system-defined data standard has access to the system, the data standard library should be extended, which is expected to be pushed to the corresponding module for update.

3.3. DATA MANAGEMENT LAYER

The data management layer consists of a DFS module and a DPC module to support efficient management and analysis of heterogeneous data.

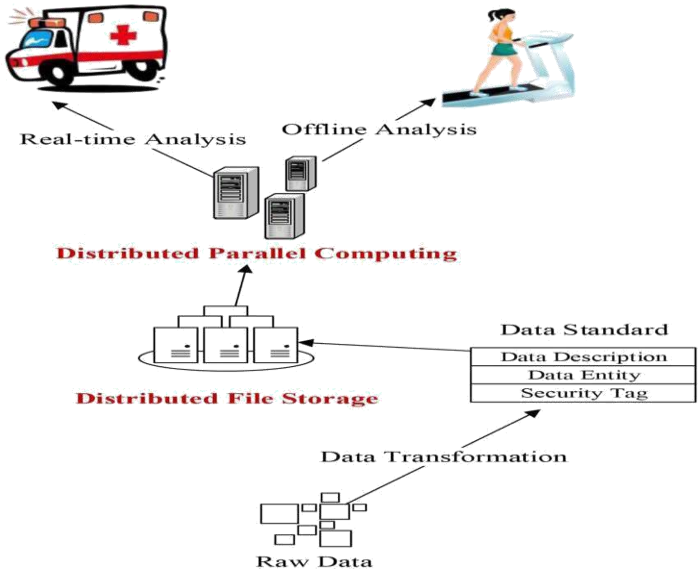

Fig: 3.3. Data Management Layer

DFS Module

The primary challenges of big healthcare data are how to establish an efficient distributed storage mechanism for massive data and how to support efficient data processing and analysis. Health-CPS deploys DFS techniques to provide big healthcare data with efficient storage, high-throughput data upload and download, high data fault tolerance, multitenant user management, access control list, and rapid data retrieval and exchange. To uniformly manage multisource heterogeneous data, the following three components are involved to establish the data standards.

- **Data Description**: Considering data availability, reliability, and traceability, the stored data are expected to provide a description including data source, data size, metadata number, data age, and data administrator.
- **Data Entity**: As mentioned above, to support the integration of data in the same category, unified standards are essential for data transformation. Data entity is a standardized definition of data objects, which includes attributes, type, value range, and the relationships with other objects.
- **Security Tag**: It defines data security and authorization levels.

DPC Module

The DPC module analyzes and processes data from DFS and ultimately discovers knowledge. DPC provides offline computation for massive unstructured data, supports real-time data analysis and query, and integrates various data mining and machine learning algorithms. In different scenarios, DPC supports real-time analysis as well as offline analysis.

- **Real-time analysis**. In the scenarios of intensive care, sudden disease detection, or vital signs monitoring, the changing data reflects individual health status in real time. Therefore, these data need to be processed rapidly, and the analysis results are expected to return quickly for responding to emergency situations. With the memory analysis framework, hotspot data, such as heart rate, blood pressure, and other relevant data, will be kept in memory for improving the analysis efficiency.
- **Offline analysis**. In the scenarios without high expectations of response time (e.g., health status evaluation, medical recommendation, or health planning), common offline analysis methods are available in DPC, including machine learning, statistical analysis, and recommendation algorithms.

3.4. APPLICATION SERVICE LAYER

Framework of Application Service Layer

The application service layer provides an operating platform, a management platform, and a development platform for both users and developers.

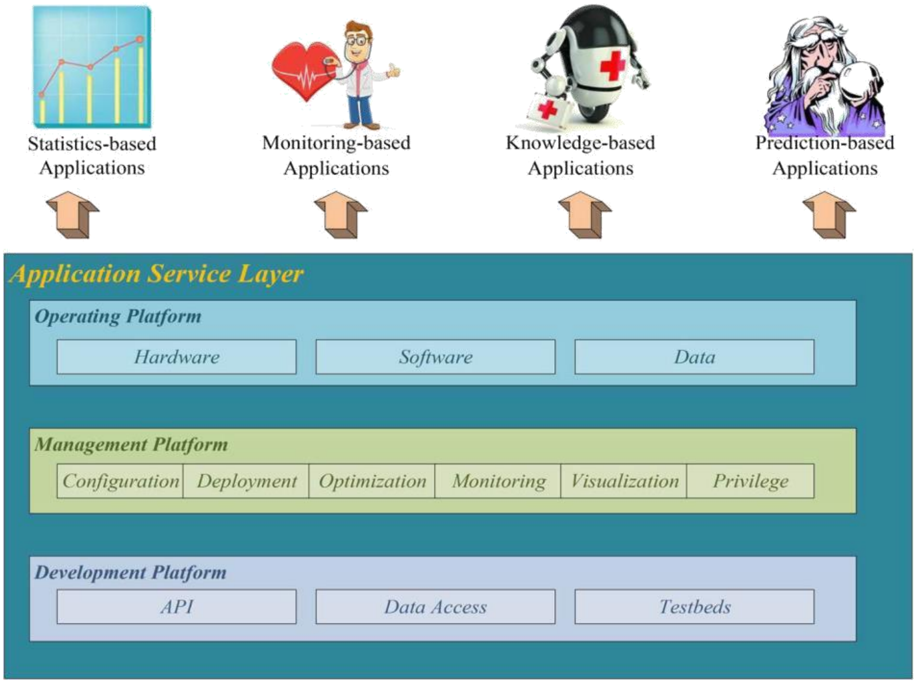

Fig: 3.4. Framework of the application service layer.

- **Operating platform** provides resources for running healthcare applications, i.e., hardware, software, and data.
- **Management platform** manages various applications in Health-CPS, including configuration management, deployment management, optimization management, monitoring management, visualization management, and privilege management.
- **Development platform** provides a uniform API, data access, and test beds.

Data-Oriented Healthcare Applications and Services

According to the technical complexity and commercial value, the applications can be divided into the following four groups.

- **Statistics-based** applications only provide basic statistics and report services. For example, an individual health status report is the representative application. In addition, drug misuse and outdate reports are available through the statistics of clinical trial data.

- **Monitoring-based** applications are typically utilized to monitor individual vital signs. Through real-time analysis, a user's physiological changes can be immediately detected to avoid sudden diseases. Through offline analysis of historical data, the recovery procedure can be traced, which supports treatment optimization.
- **Knowledge-based** applications are the most representative big data application. Supported by data mining and machine learning techniques, it is available to discover data correlation and dependence. Typical applications include chronic disease diagnosis, genetic disease analysis, treatment evaluation, side effect identification, and public health warning.
- **Prediction-based** applications have the highest technical complexity and greatest commercial value. For example, individual eating habits can be deduced through retail records, and some potential health risks can be predicted, particularly diet-related diseases, such as obesity and high blood pressure. In addition, considering individual physiological features, individual treatment simulation is available to assess risk and make the optimal medical plan.

4. ROCHAS: A TESTBED FOR HEALTH-CPS BASED ON ROBOT TECHNOLOGY

Here, as an example, a brief introduction to a robotic testbed is given to provide home users with user-friendly healthcare services via CPS.

4.1. Testbed Architecture

The testbed consists of the following components.

- **Robotics-assisted user interface** includes: 1) robot hardware, e.g., mechanical devices, environment sensors, biosensors, and camera, and 2) embedded software, e.g., motion control for robot, speech recognition, and sensory data preprocessing.
- **Health-CPS** provides a robot with healthcare services supported by a cloud-assisted system, and communication to the doctor, family, and emergency.
- **Cloud-assisted healthcare system** provides rich networking, computing, and storage resource for sensory data analysis and health modeling.

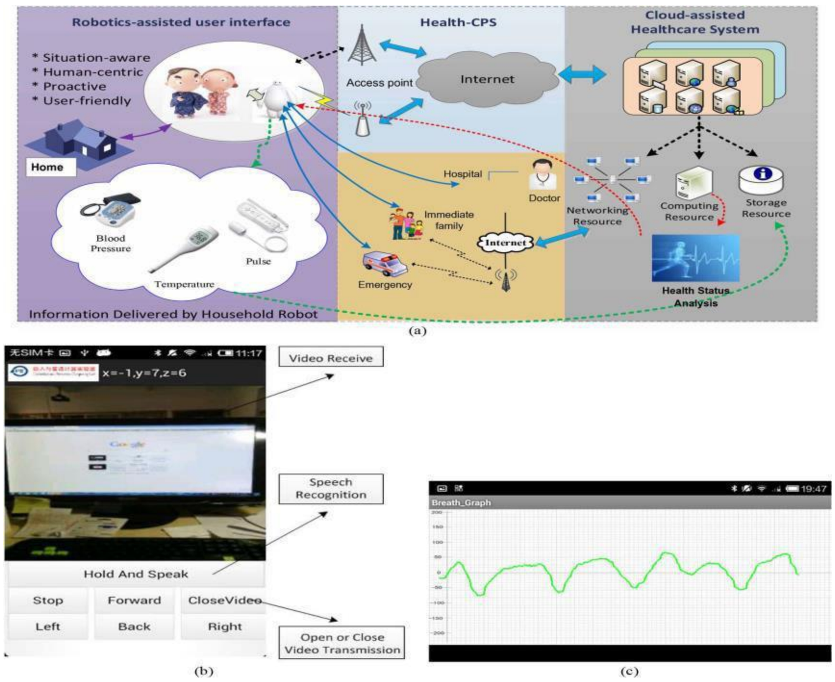

Fig: 4.1. ROCHAS testbed architecture and software interfaces. (a) ROCHAS testbed architecture. (b) Interface to control robot. (c) Sensory data representation.

4.2. Technical Details

The controller of the robot is an ARM board integrated with Cortex-A8, and the operation system is Android 4.0. The embedded and driver software are written in C, whereas the interface is written in Java. The robot is equipped with various sensors to collect temperature, humidity, heart rate, and electrocardiogram. As shown in Fig.(b), both home and remote users can control the robot via a smart phone, such as mechanical movement, speech recognition, and video transmission. As shown in Fig. (c), after processing of sensory data, various physical conditions are stored in the cloud and represented in the user interface, which can be used for the assisted decision of treatment.

5. CONCLUSION AND FUTURE WORK

Nowadays, space (from hospital to home and carry) and time (from discrete sampling to continuous tracking and monitoring) are no longer a stumbling stone for modern healthcare by using more powerful analysis technologies. Medical diagnosis is evolving to patient-centric prevention, prediction, and treatment. The big data technologies have been developed gradually and will be used everywhere. Consequently, health care will also enter the big data era. More precisely, the big data analysis technologies can be used as guide in lifestyle, as a tool to support in the decision-making, and as a source of innovation in the evolving healthcare ecosystem.

Although with the occurrence of many practical applications, the Health-IoT has become a research hotspot, the theories and technologies in this aspect are at the development stage, and are not mature enough. For example, during the designing period of sensor nodes, more attention shall be centralized on the node miniaturization and energy saving, and the designers shall pay attention to how to prevent the human body from being injured due to the heating of sensors implanted into the human body. When designing the data processing algorithms and communication protocols, the energy consumption problem and the robustness problem due to node moving also shall be solved. In addition, the Health-IoT is closely related to the human health, so there are still many moral and law restrictions during the practical application. In short, the Health-IoT is an integration of multiple fields and multiple subjects, and the research personnel needs further exploration to solve key technology problems of relevant fields.

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