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A Health-IoT Platform Based On the Bio-Sensor and Mobile Application

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***Abstract*—In-home healthcare services based on the Internet-of-Things (IoT) have great business potential; however, a comprehensive platform is still missing. In this paper, an intelligent home-based platform, the iHome Health-IoT, is proposed and implemented. In particular, the platform involves an open-platform-based intelligent health analysis system with enhanced connectivity and interchangeability for the integration of devices and services, flexible and wearable bio-medical sensor device (Bio-Patch) enabled by the state-of-the-art inkjet printing technology and system-on-chip. The proposed platform seamlessly fuses IoT devices (e.g., wearable sensors.) with in-home healthcare services (e.g., telemedicine) for an improved user experience and service efficiency.**

***Index Terms*—Internet-of-Things, Health-IoT, Bio-Patch, mobile application (e-health application)..**

I. INTRODUCTION

Now-a-days, global ageing and the prevalence of chronic diseases have become a common concern . Many countries are undergoing hospital restructuring by reducing the number of hospital beds and increasing the proportion of home healthcare. A promising trend in healthcare is to move routine medical checks and other healthcare services from hospital (Hospital-Centric) to the home environment (Home-Centric) . By doing so, firstly, the patients can get seamless healthcare at anytime in a comfortable home environment; secondly, society's financial burden could be Greatly reduced by remote treatment; thirdly, limited hospital

Resources can be released for people in need of emergency care. In-home healthcare and services can drastically reduce the total expenditure on medical care or treatment. Therefore, it is urgent in the near future for the healthcare industry to develop advanced and practical health-related technologies and services by leveraging information and communication technology (ICT), and apply them directly in the home environment. In order to track the physical status of the elderly and in the meanwhile keep them healthy, the following two daily tasks are essential: 1) real-time monitoring and analyzing vital signs to early-detect or predict life-threatening adverse events, 2) checking whether they are following their prescribed treatment, including taking their prescribed medicine on time. However, with rapidly aging populations, these daily tasks have brought great pressure and challenges to global healthcare systems. One review estimates that about 25% of the adult population does not adhere to their prescribed medication, which may lead to poor health outcomes and increased mortality. Poor medication adherence is a major problem for both individuals and healthcare providers. Technology improvements in healthcare facilities and services are highly desirable to meet the requirements of this giant group.

In the meantime, Internet-of-Things (IoT) has been recognized as a revolution in ICT since it started at the beginning of the 21st century . IoT technology provides the possibility to connect sensors, actuators or other devices to the Internet and is conceived as an enabling technology to realize the vision of a global infrastructure of networked physical objects . IoT extends the Internet into our everyday lives by wirelessly connecting various smart objects and will bring significant changes in the way we live and interact with smart devices . Various companies are exploring this domain as it can potentially unlock the door to new business opportunities. As part of IoT – intelligent components, radio-frequency identification (RFID) , embedded sensors and actuators, etc. – have been rapidly developed and significantly expanded in scope. As a consequence, the number of IoT-based applications has boomed as well. All these technologies facilitate the deployment of IoT devices in the home environment for 24/7 healthcare . Some researchers attempt to integrate wearable devices and systems in IoT scenario to achieve better e-health services . As a result, the physical size, rigid nature and short battery life become limiting factors for potential long-term use. Some research groups focus on the user-comfort issues, by leveraging advanced materials to develop user-friendly sensors. Functional textiles are utilized to manufacture a sensorized garment for physiological monitoring, where electrocardiogram (ECG) signals are successfully recorded using fabric sensing elements. A desirable system should be capable of taking care of the patients from all aspects, covering personalized medication, vital signs monitoring, on-site diagnosis and interaction with remote physicians. In addition, the existing systems seldom integrate new materials or apply new manufacturing approaches, which are always the key elements for bringing new devices or solutions into healthcare fields. By taking the forementioned issues into consideration, an intelligent healthcare IoT system and mobile application proposed in this paper. IoT devices (e.g., wearable sensors) are seamlessly connected to the e-health application via a heterogeneous network which is compatible with multiple existing wireless standards. Considering the present and future importance of IHIS and IoT in e-health field, we developed the Health-IoT platform which can well find its applications in patients' home and nursing home scenarios. The proposed system takes the advantages of System-on-Chip (SoC) technology, material technology, and advanced printing technology, to build a patient-centric, self-assisted, fully-automatic intelligent in-home healthcare solution. The functions developed can be applied in various health-related scenarios, including environmental monitoring, vital signs acquisition, medication management, and healthcare services.

II. PROPOSED HEALTH CARE APPLICATION

A. HOME HEALTH-IOT SYSTEM

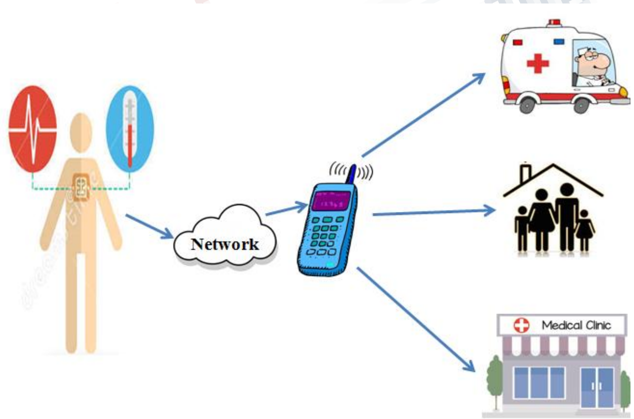

Fig. 1 illustrates the concept of the iHome Health-IoT System

The figure-1 is discussed below:

- The body-worn Bio-Patch can detect and transmit the user's bio-signals to the mobile app in real time.
- All the collected information is interpreted, stored and displayed locally on the mobile application.
- By using e-health mobile application, it automatically intimates to the doctor, emergency services and the family.

One major contribution of the proposed iHome Health-IoT system is that it dramatically expands the scope and coverage of traditional Healthcare Information Systems (HIS), extending from a confined hospital environment to a patient's home. By doing so, the overall healthcare system could be optimized at the top level, turning from the conventional Enterprise Resource Planning into the Entire Resource Planning.

B. DATA FLOW AMONG DIFFERENT LAYERS

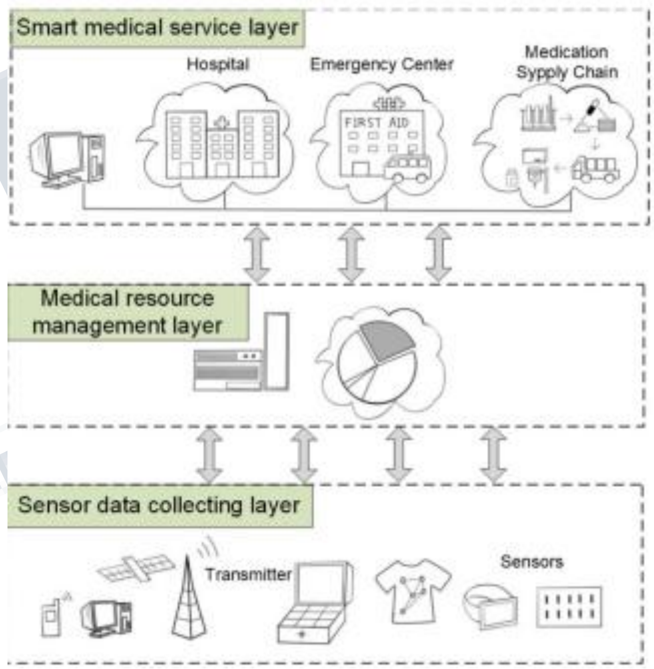

Fig. 2 illustrates the concept of data flow among different layers

I t consists of three different layers i.e , smart medical service layer , medical resource management layer ,sensor data collecting layer.

- A smart medical service layer is directly linked to professional medical facilities such as hospitals, emergency centers, and medicine supply chain. For example, doctors can efficiently manage a large group of patients. They can inspect the medication history as well as the physiological status history of a specific patient, make further analysis of a suspicious portion of patient's bio-signals (e.g., ECG) and based on the analysis, doctor makes a new e-prescription accordingly. The doctors can easily identify the patient group whose health conditions have improved, and make them aware of their progress. Both patients and their family may feel reassured which helps build positive loops into rehabilitation and self-care.

- The medical resource management layer works as a transition auxiliary layer, which involves the administration and management of medical resources in an efficient manner and facilitates the smooth operation of the iHome system. In this layer, cloud computing services are available to health and life science provides an efficient way for data security and patient privacy protection.

- The sensor data collecting layer is the basis of the entire network. It consists of data sensing and acquisition devices, local computing and processing units, data storage devices, and wired/wireless transmitting modules. It is a multi-standard wireless sensor platform, compatible with different wired/wireless protocols, such as Ethernet, RFID, Zigbee, Wi-Fi, Bluetooth, and 3G/4G network. With this three-layer iHome Health-IoT system, interaction between clinical professionals and home-stay patients can easily take place on demand or on a regular basis. In this present work, we have used wireless zigbee to transmit the data. And we have used micro chip sensor to sense temperature, blood pressure and heart beat. The details of the sensors used are explained in the next section.

C. *BIO-SENSORS*

Biological signals, such as ECG and electroencephalograms (EEG), are the most commonly used vital tools for monitoring patients' physical condition and diagnosing diseases. In particular for premature heart attacks, a very high proportion of health attacks happen during sleep or daily activities. The sooner the symptom is detected, the earlier medical treatment and the better prognoses can be made for the patients. However heart diseases, many chronic diseases are asymptomatic which lead to difficulties in accurate detection during a short visit to a hospital. Therefore, long-term continuous health monitoring is essential for detecting and treating diseases. Existing continuous monitoring systems (e.g., Holter system, etc.) are usually uncomfortable and inconvenient for long-term use, due to their physical limitations, e.g., large size, rigid package and twisted wires, etc. In previous work, a wearable ECG sensor node was developed using off-the-shelf components, which successfully detected ECG signals.

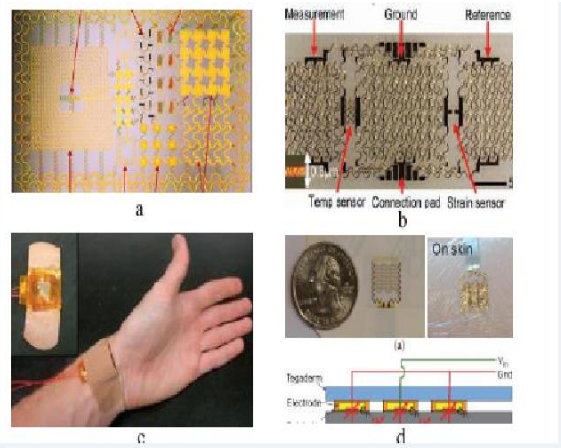

Fig. 3 Bio-chips and micro-sensors

Fig-3 illustrates about bio-chips and micro sensors. However, this sensor node was strap-based. In order to ensure good physical contact between embedded electrodes and human body, the strap had to be tightly pressed against the user's chest, which make it uncomfortable for long-term use. This present study used a new generation of healthcare devices with features such as: 1) low power consumption therefore long battery life, and 2) an affordable price.

Bio-sensors transmit the data to mobile application using wireless zig bee device. The mobile applications and its features are discussed in the next section.

D. *Mobile applications*

The elderly are more likely to forget to take or fail to properly take the medicine as prescribed. The following cases may be common: the user takes a wrong medicine, takes too much or too little of a specific medicine, takes the medicine at the wrong time, or drug reactions happen with the possibility of causing death. According the severity in each case, various levels of alarms should be triggered. Keeping these in view our mobile application provides the following features.

- ***Body analysis*** – shows the entire analysis of heart rate, BP and temperature in different blogs.

- ***Alert*** – Whenever an user is in abnormal condition, an alert message is sent to both doctor and patient's family.
- ***Prescription***- Based on the analysis the doctor sends the prescription to the patient. The message includes user information and the doctor can log into the database and make an estimation to decide whether it is necessary to contact the user immediately or deliver the information to the emergency center.

The doctor can take it as a reference for the next prescription.

- If the patient condition becomes normal within 15 min then the alarm turn off. By this the doctor will decide whether or not to contact the patient's relatives or delivery the case to an emergency center.

III. RELATED WORK

Li Da Xu[6] has proposed thatthe emerging compressed sensing (CS) theory can significantly reduce the number of sampling points that directly corresponds to the volume of data collected. They discussed how CS can provide new insights into data sampling and acquisition in wireless sensor networks and IoT. He briefly introduced the CS theory with respect to the sampling and transmission coordination during the network lifetime through providing a compressed sampling process with low computation costs. Then, a CS-based framework is proposed for IoT, in which the end nodes measure, transmit, and store the sampled data in the framework. Then, an efficient cluster-sparse reconstruction algorithm is proposed for network compression aiming at more accurate data reconstruction and lower energy efficiency. Performance is evaluated with respect to network size using datasets acquired by a real-life deployment.

In this, he proposed a CS framework for WSNs and IoT and introduced how the framework could be utilized to reconstruct the compressible information data into a variety of information systems involving WSNs and IoT. This framework provides a promising approach for compressible signal and data in information systems. It makes an effective new information and data gathering paradigm in networks and information systems.

Antonio J. Jara[10] has proposed that the Communication and information access is the basis to reach a personalized health end to end framework. Personalized health Capability is limited to the available data from the patient. The data is usually dynamic and incomplete. Therefore, it presents a critical issue for mining, analysis and trending. For this reason, he presents an interconnection framework for mobile Health (mHealth) based on the Internet of Things. It makes continuous and remote vital sign monitoring feasible and introduces technological innovations for empowering health monitors and patient devices with Internet capabilities. It also allows patient monitoring and supervision by remote centers, and personal platforms such as tablets. In terms of hardware it offers a gateway. He presents the architecture and evaluates its capability to provide continuous monitoring, ubiquitous connectivity, extended device integration, reliability, and security and privacy support.The proposed interconnection frame work and the proposed protocol for the sensors have been exhaustively evaluated in the framework of the project, which is focused on patients.

G. Kortuem[8], has proposed that the term Internet Of Things refers to networked interconnection of objects of diverse nature, such as electronic devices, sensors, but also physical objects and beings as well as virtual data and environments. He tried to resolve the existing restrictions of current architectural models by integrating both RFID(Radio Frequency Identification) and smart object-based infrastructures. He proposed the architecture that is based on a layered lightweight and open middle-ware solution following the Service Oriented Architecture and the Semantic Model Driven Approach, which is realized at both design-time and deployment–time covering the whole service lifecycle for the corresponding services and applications provided. According to him, one could track the entire existence of an object, from the time before it was made (its virtual representation), through its manufacture, its ownership history. He says IoT as a composition of smart objects that can understand and react to their environments. Through practical experimentation and by prototyping some generations of smart objects. It offers easy-to-use web service interfaces for controlling any type of physical sensor devices irrespective of its network technology. It also incorporates means of device and service discovery, semantic model driven architecture and security.

[1] Sonam V. Maju proposed An IoT application in the health platform which involves sensors for reading the human heart rate in digital format and an intelligent medicine box with a light sensor to indicate the variations in the medicine slots like counting the number of tablets a patient is consuming, alarms are there for consuming wrong medicine and more than that this medicine box will act as medication reminders. An IoT-based intelligent home-centric healthcare IOT platform, which flawlessly connects smart sensors attached to human body for biological monitoring and intelligent medical packaging for daily medication management. It includes the scenario of assisted living for people with physically and mentally disabled, where users can intermingle with smart objects

deployed in a home environment to ensure their health and well-being. The Med Box serves as a home healthcare station providing strong interoperability and network connectivity. The Internet of Things will change our society, and will bring seamless 'anytime, anywhere' personalized healthcare and monitoring over fast reliable and secure networks. This implies that we are approaching the end of the divide present between digital, virtual and physical worlds.

[2] Z. PanG proposed that "Technologies and Architectures of theThe emerging technology breakthrough of the Internet-of-Things (IoT) is expected to offer promising solutions for food supply chain (FSC) and in-home healthcare (IHH), which may significantly contribute to human health and well-being. In that thesis, he investigated the technologies of the IoT for these two applications called Food-IoT and Health-IoT respectively. He intended to resolve a series of research problems and integration architectures. In order to reduce the time-to-market and risk of failure, he took the business aspects into account. The challenges about enabling devices that he have addressed include: the WSN mobility and wide area deployment, efficient data compression in resource-limited wireless sensor devices, reliable communication protocol stack architecture, and integration of acting capacity to the low cost intelligent and interactive packaging (I2Pack). At the system level, he had addressed the challenges about effective integration of scattered devices and technologies, including EIS and information integration architectures such as shelf-life prediction and real-time supply chain re-planning for the Food-IoT, and device and service integration architectures for the Health-IoT. The emerging technology breakthrough of the Internet-of-Things (IoT) is expected to offer promising solutions for food supply chain (FSC) and in-home healthcare (IHH), which may directly contribute to human health and well-being. To reduce the time-to market and risk of failure, business aspects should be taken into account more than before in the early stage of IoT technology development because the technologies and applications are both immature.

[5] K. Ashton Personalized Health Assistants have gained popularity over the last few years. Such technologies allow users to monitor their health information in real time and often integrate with their smart devices, especially smart phones. Augmented Quick Health (AQH) is such an intelligent health monitoring system, which uses multiple sensors to read heartbeat, body temperature and sweat rate information. The sensor readings are used together to determine the health condition of a subject. With the resulting output, it interacts with a smart device and data is pushed in to a robust cloud-based infrastructure via the device (e.g. Smartphone). The system is designed to be extensible and flexible, so adding new sensors and/or use-cases is straightforward. While there are other personalized health monitoring systems, AQH incorporates location based search, presented using augmented reality, which has proven to be an effective tool in emergency situations.

[7] E. Welbourne work objective is the discussion of challenges and requirements for pervasive healthcare computing towards an integrated service-oriented platform for the management of mission critical Healthcare Environments (HEs), such as Intensive Care Units (ICUs). Due to the large amount of equipment and technologies for patient monitoring, especially for those patients in intensive care as well as the vast amount of available information about patients' health to deal with, there is a great motivation related to the environment integration on an intelligent computing platform capable of processing messages, providing healthcare services, and eventually, making decisions autonomously and safely, to ensure the health and well-being of patients. The challenge of integrating medical equipment for monitoring patients' health goes beyond the economic and social aspects, i.e. deals with aspects related to technology, infrastructure and even technology acceptance by institutions, physicians and society, in general. Regarding to the technological aspects is possible to physically integrate medical devices through different communication networks, since equipment is available in each ICU, and specific communication protocols are defined. Moreover, several issues related to the HE requirements, and specifically towards to patients monitoring, suffer an impact from barriers imposed by proprietary medical equipment specifications that need to be prepared to be integrated on the PHE.

IV. CONCLUSION AND FUTURE WORK

Health Related IoT applications is the need of the present smart city concept. Since the diseases are chronic and severe, these types of applications will be more helpful. In our present study, we have developed a prototype. Our future work focuses on reducing cost and dropping the inconvenience while using the strap.

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