Integrating Internet of Things and EHealth Solutions for Students' Healthcare

Temitope O. Takpor and Aderemi A. Atayero, *Members, IAENG*

***Abstract*—Apple Incorporated's recent announcement of its entry device – *The Apple Watch*™ to the wearable's market can arguably be said to put a final seal of authenticity on wearables. The inevitable ubiquity of wearable devices for eHealth monitoring is a fact soon to be reckoned with. Access to the physiological information provided by the wearables through the '*6A Connectivity Concept*' of IoT will find positive applications in various fields, most especially in the eHealth and mobile-Health domain.**

The state of health of a student is key in determining the student's overall academic performance. Health-related issues usually affect the motivation and ability of students to learn. Therefore it is necessary to provide better health services for students in their various schools and institutions. This paper is a study of the integration of Internet of Things (IoT) and eHealth solutions to effectively manage and monitor university students' health. One of IoT's main technologies in healthcare is Radio Frequency IDentification (RFID) technology. In this study, we show how RFID technology is used to implement an eHealth solution known as Electronic Medical Records (EMR) for managing students' health information (which includes students' medical history, prescriptions, laboratory results, Electrocardiography (ECG) results, blood pressure results, and vital signs). This paper also studies wearable devices for monitoring students that are at risk for high blood pressure, which can be due to intense stress, overweight conditions, and family history of high blood pressure.

***Index Terms*—Apple Watch™, eHealth, EMR, IoT, RFID, wearable devices**

I. Introduction

THE benefits of today's fast growing technology and innovation should be adopted to improve access to quality health care services for university students in their university health centers. Health care service delivery is the management and delivery of health services for comprehensive preventive and curative services, according to the needs of individuals over time and across various levels of health system [1]. Quality health care services are important for increasing everyone's quality of health, gaining quick access into a health care system, preventing disease and disability, detecting and treating health conditions, and preventing death [2]. Access to health care services comprises of coverage, services, timeliness and workforce [2]. This paper focuses on university students' health care, which is to improve the health and wellbeing of students in the category of adolescents (ages 16 - 19) and young adults (ages 20 - 24) through the use of IoT and eHealth solutions.

The Director-General of WHO (World Health Organization) stated that ''*a comprehensive, integrated approach to service delivery is needed*'' [1]. Interestingly, Internet of Things (IoT) has emerged as one of the recent advances of information and communication technologies, and it is has great impact when integrated with health services, particularly eHealth. IoT technology links the Internet with different kinds of objects in our daily lives such as everyday sensors and working devices (medical devices, home appliances, etc.) due to their communication and computing capabilities, and this has enhanced the way we interact with our environment [3]. It is anticipated that billions of sensors and actuators will be connected to the Internet via heterogeneous access networks enabled by technologies such as Radio Frequency IDentification (RFID), wireless sensor networks, embedded sensing, real-time and semantic web services [4]. IoT is been applied in areas such as smart city, home monitoring and automation, healthcare, manufacturing, energy and utilities, smart grid, intelligent transportation system, and traffic management [5].

The use of this new technology, IoT, in healthcare services brings comfort to patients and physicians because of its various applications such as real-time monitoring, patient information management system, and health management system [6]. In eHealth, medical devices such as wearable devices can be connected to IoT technology for remote monitoring, real-time monitoring and on-line medical consultations.

The Internet of Things is envisioned to allow for the interconnectivity of *anyone* and *anything* at *anytime* and in *anyplace*. This connectivity should ideally be possible using *any service* over *any conduit*, path or network. This is popularly referred to as The IoT 6A Connectivity Concept [7]. The IEEE IoT Community defines the Internet of Things as: *"… a self-configuring and adaptive system consisting of networks of sensors and smart objects whose purpose is to interconnect "all" things, including every day and industrial objects, in such a way as to make them intelligent, programmable and more capable of interacting with humans''* [8]. This definition of IoT and an understanding of the *IoT 6A Connectivity Concept* are the premise on which this study is based. Fig 1. shows a structure of the connectivity concept of IoT and some of IoT's application areas.

This paper is organized as follows: Section II presents the statement of the problem (i.e. health-related issues affect the

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T. O. Takpor and A.A. Atayero are with Electrical and Information Engineering Department, Covenant University, 112233 Ota, Nigeria (phone:_-+234-816-892-2697;_-email:_-temitope.takpor@covenantuniversity.edu.ng).

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motivation of students to learn). Section III discusses how IoT and an eHealth solution (i.e. Electronic Medical Records) are used to manage students' health information.

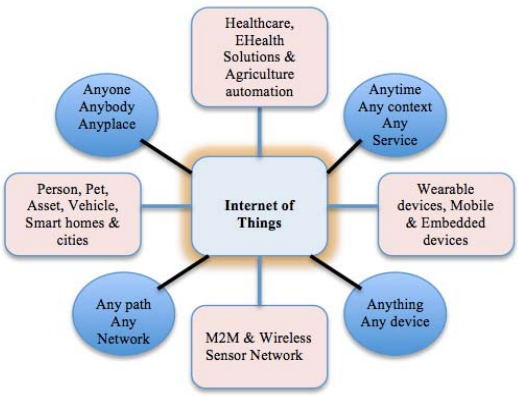

Fig. 1. IoT's connectivity concept and application areas.

Then, section IV discusses how IoT and wearable devices are used to monitor students' at risk for high blood pressure. Conclusions are given finally in section V.

II. Statement of The Problem

Students' academic progress will be very limited if students are not motivated and able to learn [9]. It has been proven that health-related issues would affect a student's wellbeing thereby limiting the students' motivation and ability to learn, reduce class and examination attendance, which will eventually affect high academic performance [2]-[9]. These health-related issues are linked to various environmental factors such as family, peer group, school, and neighborhood [2]. It is stated that healthier students are better learners [9]. Students' health outcomes are strong predictors of their overall academic successes and achievements [2].

WHO defines health as, "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [10]. Recent report shows that adolescents and young adults are the key targets to the on going and emerging public health global goals and agendas. [11]. Adolescents and young adults have been the focus of global health conferences and several recent United Nations initiatives and resolutions [11]. This shows that the health status of adolescents and young people is of utmost importance to the World.

Students' health is very important because it has an enormous effect on students' capacity to concentrate and work well in their various institutions. Being in a state of complete health helps students to achieve their full potentials and hence they are able to perform at their best and contribute as much as they can to their educational activities [11]. Therefore being careless about providing quality health care services to students could be detrimental to their future. Health care services and information should be improved upon and made easier for students to access in order to receive medical attention promptly. Promoting a safe and healthy university environment, which includes comprehensive and quality health care services, improves students' academic engagement.

III. IoT and Ehealth Solutions

IoT technology can be integrated with eHealth solutions. The main focus of this paper is to show how IoT's main technology (RFID) is incorporated with students' Electronic Medical Records (EMR) to enable each student have secured and easy access to his or her medical records in their various university health centers. The students' EMR is an eHealth solution that is used to manage the health information of students. Each student will be issued a Radio Frequency IDentification (RFID) tag to access his or her medical records that is stored in the database server of the health center.

A. RFID Technology

IoT technology enables the information discovery about a tagged person or a tagged object by browsing database entry or internet addresses that is connected to a specific active RFID tag with sensing capability [5]. RFID is a wireless non-contact system that stores sensitive data and uses radio-frequency waves to transfer data from an RFID tag attached to a person or an object, for automatic identification and tracking [12]. RFID is a superior technology compared to the traditional barcode system because it provides both read or write capability, it requires no line-of-sight contact with RFID readers and can read many RFID tags simultaneously [6]. In eHealth, RFID technology is being used within IoT for tracking of medical assets and patients' medical records, newborn and patient identification, medical treatment tracking and validation, and surgical process management.

The RFID technology comprises of the following three main components:

--RFID Tag: consists of a microchip, an antenna and a dedicated hardware for cryptographic operations [6]. The information about the tag is stored electronically in terms of bits and it communicates with the RFID reader [12]. The tag is also called a transponder, which is read as soon as it is in the coverage area of the reader, and its details are listed out in the computer system. Depending on the type and application requirements, the RFID tag may be: passive tag or active tag. Passive tags derive their power when they are within the field of the reader. They are less expensive than active RFID tags. An active tag has a small battery and a radio transceiver, and can be read from distances of several hundred feet depending on the antenna type and its environment.

--RFID Reader: transmits an encoded radio signal to interrogate and activate the RFID tag [12]. The reader is composed of a radio transmitter, a radio receiver, a control unit, and a memory unit. The main function of the reader is to enable the RFID tag and the server to exchange messages and achieve mutual authentication [6].

--Server: is a trusted entity that is used to achieve the purpose of mutual authentication. The server stores all the RFID tag's identification information in its database and uses the stored information to determine the validity of the tag.

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B. Students' EMR

EMR is a digital version of paper-based medical file records of an individual. EMR systems help to provide quick access to health care information remotely, at anytime and anywhere with the availability of IoT technology. EMR takes away the process of structured or unstructured paper form, which could be cumbersome to access at a glance.

In this paper, a student's medical information is entered into an EMR system in his or her university health center in the first year of enrolment into the university. The EMR of the student will be updated continuously throughout his or her stay in the university, and linked to an RFID tag. The EMR of the student includes the following stored information: student's bio-data, diagnostic information (from medical devices such as ECG device), medical history, prescriptions, laboratory results, blood pressure results, vital signs and medical bills. Whenever a student seeks medical care in the university health center, the doctors will retrieve the health information of the student from the EMR system through the use of RFID technology. Then, the retrieved information would help in to analyze and diagnose the student's illness. Doctors can further take expert advice by sharing the information with consulting specialists if the need arises [13]. This system ensures structure, efficiency and security because no other student can use another's medical file.

IV. IoT and Wearable Devices

IoT technology and wearable devices have made monitoring and recording of patient's vital signs to be done remotely and comfortably. These advances are possible as a result of miniaturization of electronic devices and sensors [14]. Wearable devices can be used to measure the physiological parameters (such as temperature, heart rate and blood pressure) of an individual non-invasively, for real time feedback or offline medical analysis [15]. Wearable devices are majorly used for non-invasive, non-obtrusive ways to monitor physiological signals over long periods of time [14].

Students with high blood pressure deserve in-school monitoring to help ensure that they receive quality health care on time when the need arises. Blood Pressure (BP) is a continuous physiological parameter, which can be caused by various influences such as intense stress, overweight conditions, and family history of high blood pressure. BP is one of the most important factors for predicting cardiovascular diseases, and an uncontrolled high blood pressure can lead to life-threatening complications and fatal heart attack [16]. Therefore, universities should provide wearable devices for monitoring the blood pressure of at-risk students. The wearable device for monitoring high blood pressure is an electronic device that is worn on the wrist or finger, and consists of a blood pressure sensor that senses the blood pressure of the student. Whenever there is a variation in the fixed range of the student's blood pressure, the wearable device sends an alert to the student's smart phone or tablet, and to the doctor or care giver for medical analysis.

V. Conclusion

This paper has addressed the need for integrating IoT technology with eHealth solutions and wearable devices to improve students' health care. Thus providing quick and secure access to students' EMR, and ensuring that at risk students to high blood pressure are continuously monitored. This will tremendously help to provide a comfortable health care environment for university students, which will then contribute to their excellent overall academic performance. If EMR records are readily available for quick analysis and external consultation of medical specialists, it will aid quick diagnosis of a student's illness and lead to fast recovery process.

Further work would be done to implement the system and deploy it to various university health centers.

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