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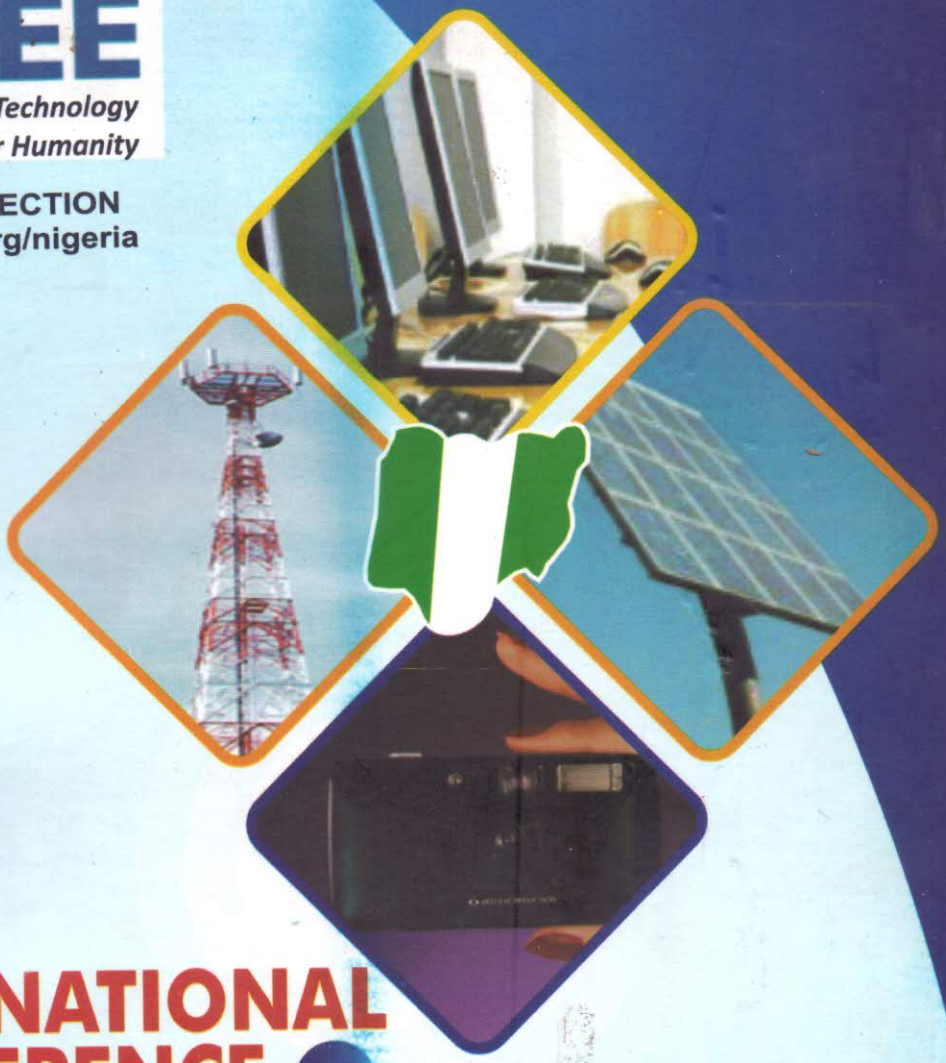

2ND INTERNATIONAL CONFERENCE ON

EMERGING AND SUSTAINABLE TECHNOLOGIES FOR POWER AND ICT IN A DEVELOPING SOCIETY

IEEE NIGERCON 2013

PROCEEDINGS

NOVEMBER 14 -16, 2013

LINKS HOTELS,
NEW OWERRI COMMERCIAL AREA, IMO STATE, NIGERIA.

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Wireless Sensor Networks for Remote Healthcare Monitoring in Nigeria: Challenges and Way Forward

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Abstract-Wireless sensor networks have gained a lot interest in the field of medicine with a wide range of capabilities. In most developed countries wireless sensor networks are being used in monitoring critical illnesses such as Cancer detection, cardiovascular diseases, monitoring asthmatic patient and in the treatment of Diabetes. Wireless sensor networks have enabled medical doctors to monitor patients remotely and give them timely feedback and support; potentially increasing the reach of health care by making it available anywhere at any time The application of Wireless Sensor Networks for remote medical monitoring is relatively new in Nigeria. Recently the Nigerian government embarked on the use of e-health to meet the health requirements of its remote and rural dwellers. In this paper, we discuss some of the core challenges facing the application of wireless sensor networks for remote medical care monitoring in Nigeria, and how these challenges can hinder the application of Wireless Sensor Networks for remote healthcare in Nigeria.

Keywords-- Wireless Sensor Networks; Healthcare systems; Biosensors; Remote medical Delivery

I. INTRODUCTION

Recent technological advances in integrated digital electronics and miniaturization of sensor devices, microprocessor, and radio frequency devices into a single micro-chip has led to the emergence of very lightweight, ultra-low power, monitoring sensors devices[1][2][3]. These sensor devices have the capability of sensing, processing and transmitting vital physiological signals using wireless technology [4]. Sensor nodes are integrated into wireless sensor networks (WSN) which can be used for industrial automation, environmental monitoring, military surveillance, emergency cases and health care monitoring [5]. Interest in wireless sensor networks for healthcare practice has been rapidly increasing. Traditionally, medical sensors such as the blood pressure monitors, pulse oximeters and electrocardiograms were physically attached to patients by wires. Nowadays, these high cost time consuming tasks can be avoided. In other words, patients can be liberated from all the instrumentation by the application of wireless sensor networks for remote medical monitoring [6]. Wireless Sensor Networks are being used in developed countries to monitor real time physiological parameters such as heart beat rates, blood pressure rate, pulse, body temperature and blood flow rate; sensors are also used for biochemical examination [7].

The World Health Organization stated that heart disease accounts for the high mortality in the developed world; 17 million deaths (about 30%) annually throughout the world are caused by heart failure and 80 percent of all deaths recorded in China were caused by chronic heart disease [8]. About half of those who die do so within one hour of the start of symptoms and before reaching the nearest hospital [8]. Wireless Sensor Networks is a key technology that is being used by developed countries to provide real-time monitoring of cardiovascular patients by continuously sensing, processing and transmitting physiological data from a remote station to a central server, where the physician makes use of captured data to diagnosis patients.

The Nigerian government is presently reforming its health sector with the vision of attaining a level of healthcare that will enable all Nigerians to live a healthy and economically productive life [9] [10]. There are three tiers of healthcare delivery levels in Nigeria, namely: primary, secondary, and tertiary healthcare systems. The health sector is faced with several challenges in delivering healthcare services to the people, especially in the primary healthcare system where the beneficiaries are mostly remote and rural dwellers. These rural dwellers make up 70% of Nigerian population and have no adequate access to

978-1-4799-2017-4/13/$31.00 ©2013 IEEE

emergency treatment. They have no adequate infrastructure, no access to information dissemination and lack qualified medical personnel. With these many inadequacies coupled with a growing demand for improved healthcare system, the government in its health sector reforms adopted the use of e-health in form of telemedicine to tackle the numerous challenges of medical healthcare delivery in Nigeria [9] [10]. Telemedicine is the use of electronic sensor devices and wireless communication to deliver healthcare support when participants are separated by distance [11]. The use of biosensors in monitoring patient with critical diseases is also being considered by the government.

In this paper, we have reviewed the generic system architecture of Wireless Sensor Networks for remote medical application, the application of Wireless Sensor Networks in remote health monitoring in Nigeria; the main challenges facing the application of Wireless Sensor Networks for remote medical monitoring in Nigeria and proffer plausible solutions.

II. GENERIC SYSTEM ARCHITECTURE FOR WIRELESS SENSOR NETWORKS

The generic system architecture of a wireless sensor network is a multi tier system, the first tier comprises of intelligent sensor devices; the second tier is a personal server (personal digital assistant (PDA), Smartphone, or personal home computer); and the last tier encompasses series of remote medical care servers and related health services (Physician, caregivers and the Clinic) [12]. Each tier constitutes a fairly complex subsystem portably organized to ensure efficient, secured and cost effective system.

The generic architecture of a wireless sensor network for remote healthcare monitoring is made of three main sections [12].

A. Wireless Body Area Network (WBAN)
B. Personal Server using intelligent personal digital assistant (PPS).
C. Medical Server for remote healthcare monitoring.

A. Wireless body area network

The core of this section is the user called the patient. Sensors nodes attached to the body of the patient acquire and transmit data to the sink nodes. Sensor nodes are very tiny in size, inexpensive and have batteries that can last for longer duration; sensor nodes have limited computing and communication capability. Sensors consist of microprocessors, memory, radio transceivers and power supply unit [12][13].

B. Personal Server (PPS) using intelligent personal digital assistant

The personal server is the interface between the WBAN nodes and the remote medical server at the hospital; it communicates using wireless protocols such as Zigbee or Bluetooth technology.

C. Medical Server for remote healthcare monitoring

The third tier is called Medical Server for Remote Healthcare Monitoring (MSRHM). It receives data from the personal server; it is the backbone of the entire architecture. It is situated at medical centers or hospitals where health services are provided. It is the database of all remotely monitored patients. Medical server keeps electronic records of registered patients, which can be accessed by different medical staff, including general practitioners, specialists, nurses and doctors from their offices in the hospital over the internet as depicted in the figure 1[13].

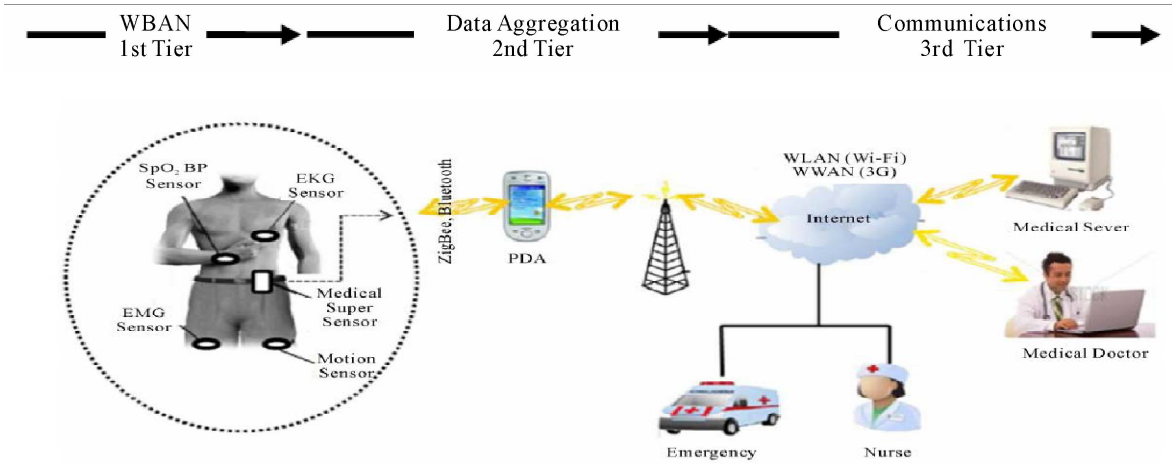

Figure 1: Generic Architecture of wireless sensor networks for remote healthcare monitoring system [13]

III. WIRELESS SENSOR NETWORKS FOR REMOTE HEALTHCARE PRACTICE IN NIGERIA

Remote healthcare practice using wireless sensor networks is relatively new in Nigerian. The government is presently implementing reforms in the health sector, with the aim of improving the health status of all Nigerians. To achieve this, it has adopted the use of e-health as one way of attaining the primary health care needs of the rural population. The Federal Ministry of Health has already launched a Telemedicine project and research is being conducted in some teaching hospitals and universities on the use of biosensors to diagnose patient remotely [14]. Telemedicine can be defined as the use of telecommunication technologies to provide remote medical information and diagnoses [14]. It may be as simple as a patient discussing his case with a doctor over the telephone, or as sophisticated as using satellite communication to relay consultation between healthcare centres in two countries using videoconferencing equipment. Nigerian telemedicine is a pilot projects of the Nigerian Communication Satellite (NigComsat-1), which promises to improve remote medical delivery to rural Communities[15].Telemedicine application is new in Nigeria is expected to provide remote and rural communities easy access to healthcare at real time relying on the backbone of NigComSat-1 thereby saving lives, time, cost and scarce resources while achieving the objective of the Nigerian Health Sector reform. Biomedical sensors combined with telemedicine can be used to remotely monitor patient with chronic diseases like diabetes, hypertension, rheumatism and heart defects. These biosensors measuring vital data sends signals via wireless communication provided the GSM companies to the remote medical server. The doctor or specialist response quickly and the patient receives directive on his PDA or mobile phone [16]. Figure 2 shows a simple architecture for a mobile- phone based patient compliance system, patients are motivated to perform optimal self-management while the doctor monitors compliance from a distance [17].

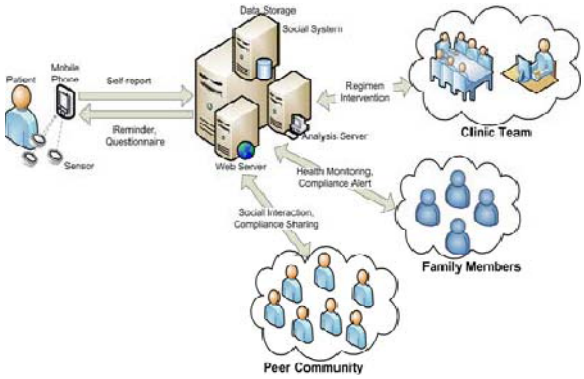

Figure 2. Mobile-Phone based Patient Compliance System [17].

IV. CHALLENGES FACING THE APPLICATION OF WIRELESS SENSOR NETWORKS FOR REMOTE HEALTHCARE MONITORING IN NIGERIA.

The application of wireless sensor networks in remote healthcare monitoring has brought major advantages to the existing healthcare services in Nigeria. However, this emerging technology has several key challenges. These challenges vary from the lack of technical infrastructures that hinders access to information and emergency treatment to the inadequate qualified medical personal [18]. Other challenges include the reliability of the technology, the digital divide among the participants and ethical implication of this system on the culture of Nigerians. While Biosensors and Telemedicine for remote healthcare is certainly promising in Nigeria, the above mentioned challenges must be addressed for the project to be successful.

A. Security and Reliability of the system

There are competing security threats to sensor networks for remote medical application or telemedicine application. An outsider or insider attacker can be launched on the health information that is been transmitted via wireless from one point to the other. In an outsider attack, the adversary is not an authorize user, he eavesdrops and records encrypted messages which he later decodes to discover secret keys [19]. The insider attack is more dangerous because the attacker physically captures node, read their memory; he then obtains key materials and forges nodes messages [19]. These security threats brings to question the reliability of this technology and data received from the system. Healthcare system application demands strict

requirements on system reliability. This is because the data being considered has to do with the live of an individual. End users require measurements that are reliable and precise. Environmental factors can also affect the reliability of the system; the location where these sensor devices are deployed may not favor radio frequency transmission. This could be as a result of high interference or barrier such as metal doors [20]. It has also be been discovered in recent research that packet losses for radio frequency devices operating the IEEE 802.15.4 standard is higher in hospital than other indoor places [21].

B. Ethical and Cultural Issues

Ethical and cultural issues can be major impediments that may hinder the application wireless Sensor Networks for remote healthcare in Nigeria. The diversity in culture and different religious beliefs amongst Nigerians can restrict the application of e-health. The system may be associated with a lot of ethical issues, of major concern are the security and confidentially of patient information because decisions are usually taken on patient without personal contact [22]. The issue of vulnerability of patient's privacy and confidentiality in e-health has been deliberated upon by many researchers; most have expressed concerns at security and potential abuse of confidential medical data via IT. They have pointed out that IT medicine, specifically telemedicine and biomedical sensors used for remote healthcare can result in ambiguous doctor -patient relationships [23].

C. Legal and Policy Issues

This challenge ranges from restriction on medical practices across the nation to issues of litigation due to misdiagnosis or malpractice. With the use of wireless sensors networks for remote healthcare application in its infant stage in Nigeria, legal and policy issues are major challenges; this is because it lacks legal framework and a strategic policy [24].

D. Inadequate IT infrastructure

Inadequate IT facilities are major impediment to the application of e-health in Nigeria; IT facilities include computer systems, software and bandwidth. More than 50% of Nigerians are in the rural areas and have no access to the internet due to absence of IT infrastructure [25].

E. Epileptic Power Supply

The epileptic power supply can hinder the success of the remote medical delivery project in Nigeria [25].

F. Digital Divides/Literacy

Digital divide refers to gap that exist in computer literacy between one group of individuals and another. It is obvious that the level of computer awareness among Nigerians is very low. For the remote medical programme of the Federal government of Nigeria to succeed, the challenge of computer literacy has to be surmounted

V. THE WAY FORWARD ON THE APPLICATION OF WIRELESS SENSOR NETWORKS FOR REMOTE MEDICAL DIAGNOSES IN NIGERIA

The use of wireless sensors networks for remote healthcare delivery Nigeria is very promising; it can reduce mortality and poverty rates if well the following steps are taken.

- Information and Communication Technology should be included in all schools curriculum; this will enable Nigerians to have knowledge of information technology. Also enlightenment and awareness programmes on the basics of Sensor networks, telemedicine and other forms of e-health should be carried out for adults in the rural and urban centres of Nigeria.
- Adequate ICT Infrastructure and professionals should be made available to support the system at all tiers government.
- The government should improve electricity power supply to the country; only a stable power supply will support the implementation of the programme.
- A strategic plan and policy on the application of Wireless Sensor Networks for remote medical practice should be established by the federal government and legislation on the use of e-health in Nigeria should be enacted by the parliament.
- Finally, IT should be given high attention in the yearly budget to sustain all the e-health projects.

VI. CONCLUSION

Although wireless sensor networks for remote healthcare have been implemented in different forms, the principle and objective of the system remain the same. That is achieving remote medical treatment by using miniature electronic devices to communicate through wireless medium over a distance. Nigerian e-health projects have a lot of potentials, which cannot be exploited completely when all the above challenges are not solved. In this paper, the architecture of Wireless Sensor Networks for remote

medical application has been discussed. We also present key challenges facing the application of Sensor Networks in Nigerian and recommend steps to be taken for a better implementation of the remote e-health projects in Nigeria. In future work, a survey should be carried out across Nigeria measuring some indices among health workers and the general public on the feasibility of using Wireless Sensor Networks for remote medical application in Nigeria.

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