Transforming Nigeria Health Care System through Wireless Sensor Networks.

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ABSTRACT

An application domain that makes use of wireless sensor network technology can be found in the area of medical monitoring. This field ranges from monitoring patients in the hospital using wireless sensors in order to remove the constraints of tethering patients to big bulky, wired monitoring devices to monitoring people in their everyday lives to provide early detection and intervention for various types of disease. This paper discusses scenarios where these sensors which vary from miniature, body-worn sensors to external sensors such as video camera or positioning devices are applicable and presents a report of ongoing research on telemedicine at FUTA Akure.

(Keywords: medical monitoring, telemedicine, medical sensors, body worn sensors, wireless personal or body area networks, WPAN, WBAN)

INTRODUCTION

Advances in wireless sensor networking have opened up new opportunities in healthcare systems [2]. Recent technological advances in sensors, low-power integrated circuits, and wireless communications have enabled the design of low-cost, miniature, lightweight, and intelligent physiological sensor nodes. These nodes, capable of sensing, processing, and communicating one or more vital signs, can be seamlessly integrated into Wireless Personal or Body Area Networks (WPANs or WBANs) for implementing high quality health care.

Wireless Sensor Networks have gained a lot of attention lately. Due to technological advances, building small-sized, energy-efficient reliable devices, capable of communicating with each other and organizing themselves in ad hoc networks have become possible.

These devices have brought a new perspective to the world of computers: they can be embedded into the environment in such a way that the user is unaware or aware of them. There is no need for reconfiguration and maintenance as the network organizes itself to inform the users of the most relevant events detected or to assist them in their activity. Several main areas of applications have been identified and new areas of applications are still to be discovered as the research and products grow more mature. Wireless sensor networks bring several challenges and often contradictory demands from the design point of view.

Current health care systems structured and optimized for reacting to crises and managing illness are facing new challenges: a rapidly growing population of elderly and rising health care spending.

"*The number of adults age 65 to 84 is expected to double from 35 million to nearly 70 million by 2025 when the youngest Baby retire. This trend is global, so the worldwide population over age 65 is expected to be more than double from 357 million in 2010 to 761 million in 2025. Also, overall health care expenditures in the United States reached $1.8 trillion in 2004. In addition, a recent study found that almost one third of U.S. adults, most of whom held full-time jobs, were serving as informal caregivers – mostly to an elderly parent. It is projected that health care expenditures will reach almost 20% of the Gross Domestic Product (GDP) in less then 10 years, threatening the well being of the entire economy*."

All of these statistics suggest that health care needs a major shift toward more scalable and more affordable solutions. Restructuring health care systems toward proactive managing of wellness rather than illness, and focusing on

prevention and early detection of disease emerge as the answers to these problems.
Wearable Wireless Sensors for continuous health monitoring are a key technology in helping the transition to more proactive and affordable healthcare.

Wearable Wireless Sensor health monitoring systems allow an individual to closely monitor changes in her or his vital signs and provide feedback to help maintain an optimal health status. If integrated into a Telemedical System can alert medical personnel when life-threatening changes occur. In addition, patients can benefit from continuous long-term monitoring as a part of a diagnostic procedure, can achieve optimal maintenance of a chronic condition, or can be supervised during recovery from an acute event or surgical procedure. Long-term health monitoring can capture the diurnal and circadian variations in physiological signals. These variations, for example, are a very good recovery indicator in cardiac patients after myocardial infarction. In addition, long-term monitoring can confirm adherence to treatment guidelines (e.g., regular cardiovascular exercise) or help monitor effects of drug therapy. Other patients can also benefit from these systems; for example, the monitors can be used during physical rehabilitation after hip or knee surgeries, stroke rehabilitation, or brain trauma rehabilitation.

During the last few years there has been a significant increase in the number of various Wireless Sensor health monitoring devices, ranging from simple pulse monitors, and activity monitors, to sophisticated and expensive implantable sensors. However, wider acceptance of the existing systems is still limited by the some important restrictions.

This report will introduce the Wireless Sensor Networks and its implementation to enhance High Quality Health Care.

With the convergence of technologies such as micro electromechanical systems (MEMS) sensor devices, wireless networking, and low-power embedded processing, wireless sensor networks have emerged as an exciting new computing platform with the potential to seamlessly couple the digital world and the physical environment. At the heart of wireless sensor networks is a new class of sensor nodes, which contain small, low-cost, low power and self-contained sensor devices or instruments with sensing, data processing, and wireless communication capabilities.
Wireless sensor networks are increasingly being deployed in many important applications requiring the interaction between users and the physical world. They allow the physical environment to be measured at high resolutions, and greatly increase the quantity and quality of real-world data and information for applications. Important applications of wireless sensor networks include environmental and habitat monitoring, healthcare monitoring of patients, weather monitoring and forecasting, military and homeland security surveillance, tracking of goods and manufacturing processes, safety monitoring of physical structures and construction sites, smart homes and offices, and many other uses that we do not yet imagine.

Sensor devices in a wireless sensor network are resource constrained since they have limited sensing capability, processing power, and communication bandwidth. However, with a large number of such devices being deployed and aggregated over a wide area, a wireless sensor network has substantial data acquisition and processing capability. Thus, wireless sensor networks are important distributed computing resources that can be shared by different users and applications.

This paper presents and ongoing research on telemedicine at the Federal University of Technology, Akure.

HISTORY OF WIRELESS SENSOR NODE

History of the development of sensor nodes dates back to 1998 in ***Smart dust project [3]***. Smart dust is a hypothetical network of tiny wireless MEMS sensors, robots, or devices, installed with wireless communications that can detect (for example) light, temperature, or vibration. Below is diagram of one of the first wireless sensors designed in the School of Engineering and Applied Sciences, Harvard University (Figure 1).

This sensor is tagged Code Blue Wireless Sensor Mote and it is designed for health care, (i.e.. collection of vital signs from a patients body). One of the objectives of the project reported in this paper is to create autonomous sensing and communication in a cubic millimeter. Though this project ended early on, it has given birth to a few more research projects. They are **Berkeley NEST** and **CENS**. It was at this period that the researchers involved in these projects coined the term 'mote' to refer to a sensor node.

Figure 1: Code Blue Wireless Sensor Node (Mote).

Traditional Health Monitoring Systems have been based upon using point-to-point real-time videoconferencing connections between locations to replace in-person visits.

Due to the cost and complexity of the equipment, telemedicine contacts were mostly used for consultations between special telemedicine centers in hospitals and clinics in the past. More recently, however, providers have begun to experiment with telemedicine contacts between healthcare providers and patients at home to monitor conditions such as chronic diseases. The approaches to home monitoring range from low-cost and easy to use touch-tone telephone systems to more expensive systems that mimic the real-time videoconferencing approach in traditional telemedicine and web-based systems that allow access to patient data from anywhere an Internet connection is available.

The telephone has proven to be an effective means of monitoring congestive heart failure patients at home where patients enter their blood pressure, weight, pulse, and symptoms into an automated answering system. The advantages of this system are the telephone is a simple device that patients already know how to use, and telephones are inexpensive and nearly ubiquitous. One disadvantage is difficulty in expanding the system to accommodate data that cannot be easily entered by hand, or at least eliminating the manual data entry step as a source of error and inconvenience. To address this need, some manufacturers of videoconferencing systems designed for home telemedicine provide interfaces to various instruments, such as glucometers, blood pressure meters, pulse oximeters, stethoscopes, and scales. The measured data are sent to providers using the data channel in the H.32x videoconferencing standards.

Videoconferencing using these units over Plain Old Telephone Service (POTS) and higher speed lines has been shown to be useful in some cases. Although synchronous videoconferencing with patients at home has been effective, asynchronous messaging could be more convenient for routine monitoring and non-urgent questions.

In recent times, the store-and-forward sensing model has been noted to be more practical than videoconferencing because it eliminates the need to schedule the telemedicine contact. This type of asynchronous sensor has also been extended to home monitoring over the Internet. The system collects blood glucose levels in a PC application separate from the web browser and transmits the data to the central storage server using TCP/IP over the Internet. However, data collection is in an external application and the data are transferred using a separate FTP server.

Now developed is a system that bridges home monitoring via the web with patient-accessible medical records and secure asynchronous messaging. The primary design goal of this system was to streamline the process of adding data to patients' medical records from various instruments that can be used in the home. The task of acquiring data from an instrument, such as wireless sensors, and adding it to their medical record should not require the user to open multiple applications and transfer data between them. We present a system where all the resources required are embedded in a single device. This system provides more information than a simple e-mail and to reduce the workload of physicians' patient's management.

COMPONENTS OF WIRELESS MEDICAL SENSOR NETWORKS

Sensor Network Nodes used in health care are made up of the following components; microcontroller, transceiver, external memory, power source and one or more sensors. The diagram below shows the relationship between the components of a sensor node [4].

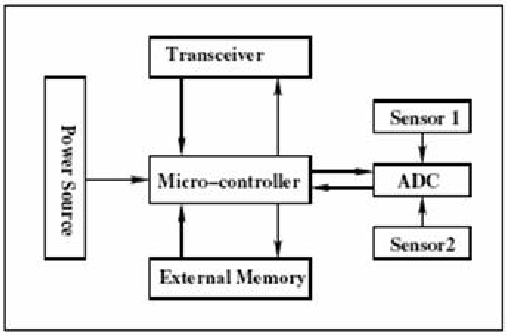

Figure 2: Components of a Wireless Sensor Node.

MICROCONTROLLER

Microcontroller performs tasks, processes data and controls the functionality of other components in the sensor node. Other alternatives that can be used as a controller are: general purpose desktop microprocessor, digital signal processors, and application-specific integrated circuits.

Microcontrollers are most suitable choice for sensor node. Each of the choices has their own advantages and disadvantages. Microcontrollers are the best choices for embedded systems. Because of their flexibility to connect to other devices, programmable, power consumption is less, as these devices can go to sleep state and part of controller can be active. In general purpose microprocessor the power consumption is more than the microcontroller; therefore it is not a suitable choice for sensor node. Digital Signal Processors (DSPs) are appropriate for broadband wireless communication. But in Wireless Sensor Networks, the wireless communication should be modest (i.e., simpler, easier to process modulation and signal processing tasks of actual sensing of data is less complicated). Therefore, the advantage of DSP's is not that much of importance to wireless sensor node.

TRANSCEIVER

Sensor nodes make use of ISM band which gives free radio, huge spectrum allocation and global availability. The various choices of wireless transmission media are radio frequency, optical communication (laser), and infrared. Lasers requires less energy, but need direct line of sight for communication and are also sensitive to atmospheric conditions. Infrared, like lasers, need no antenna but are limited in its broadcasting capacity. Radio Frequency (RF) based communication is the most relevant that fits to most of the Wireless Sensor Network applications. WSN's use the communication frequencies between about 433 MHz and 2.4 GHz. The functionality of both transmitter and receiver are combined into a single device know as transceivers are used in sensor nodes. The operational states are Transmit, Receive, Idle, and Sleep.

EXTERNAL MEMORY

From an energy perspective, the most relevant kinds of memory are on-chip memory of a microcontroller and FLASH memory - off-chip. RAM is rarely if ever used. Flash memories are used due to its cost and storage capacity. Memory requirements are very much application dependent. Two categories of memory based on the purpose of storage a) User memory used for storing application related or personal data. b) Program memory used for programming the device. This memory also contains identification data of the device.

POWER SOURCE

Power consumption in the sensor node is for the sensing, communication, and data processing. More energy is required for data communication in sensor node. Energy expenditure is less for sensing and data processing. The energy cost of transmitting 1 Kb a distance of 100 m is approximately the same as that for the executing 3 million instructions by 100 million instructions per second/W processor. Power is stored either in batteries or capacitors. Batteries are the main source of power supply for sensor nodes. Namely two types of batteries used are chargeable and non-rechargeable. They are also classified according to electrochemical material used for electrode such as NiCd (nickel-cadmium), NiZn (nickel-zinc), Nimh (nickel metal hydride), and Lithium-Ion. Current sensors are developed with the ability to renew their energy from solar, thermogenerator, or vibration energy. Two major power saving policies used are Dynamic Power Management (DPM) and Dynamic Voltage Scaling (DVS) [5]. DPM takes care of shutting down parts of sensor node which are not currently used or active. DVS scheme varies the power levels depending on the non-deterministic workload by varying the voltage along with the frequency.

WIRELESS SENSOR NETWORK PROTOCOLS

While mainstream computers have an abundance of standards, the only official standards that have been adopted for wireless sensor networks are ISO 18000-7, 6lowpan, ZigBee, Wibree, and Wireless HART (WSN, Wikipedia). The network of the sensors that will be described in the course of this project will be based on the Zigbee and IEEE 802.15.4 standards and protocols.

ZigBee and 802.15.4-based networks consist of many devices (mainly sensors) working together supporting sensing and control applications. Several standards are currently either ratified or under development for wireless sensor networks. ZigBee is a mesh-networking standard intended for uses such as industrial control, embedded sensing, medical data collection, building automation. Zigbee is promoted by a large consortium of industry players i.e. manufacturers of wireless sensors.

CONVENTIONAL HEALTH CARE COMPONENTS

In the conventional health care monitoring process, there are some major components or data which forms the basis of the monitoring process [5]. These components enable the physician in charge of the patients to know what to do and the steps to take at every given instance of the monitoring process. Under this section of the report, the three most important components will be looked into. They are:

- Temperature
- Pulse Rate
- Hearth Beat Rate
- Weight
- Height

TEMPERATURE

Temperature is defined as the degree of heat present in a substance, object or place. Putting medicare into consideration, the degree of heat present in human body is examined. Temperature is usually measured before administration of medical care unto a patient to ascertain or confirm the level of infection in the patient. Measurement of temperature is done using a medical instrument called the thermometer (clinical thermometer). The clinical thermometer is calibrated and measured in degree Celsius, centigrade (with its unit as ^{o}C) as shown in Figure 3. A patient without ailment when measured with the thermometer should give a reading between 36.5^{o}C and 37.5^{o}C, any value above or below these are abnormal and calls for serious medical attention. After the temperature readings are rightly done, measurement of other components must also be taken.

Figure 3: Clinical Thermometer.

PULSE RATE

Pulse is described as a series of pressure waves within an artery caused by contractions of the left ventricle and corresponding with the hearth rate (i.e., the number of time the heart beats per minute). It is easily detected on such superficial arteries as the radial artery which is near the wrist and the carotid artery located in the neck. Most times, it is usually used done in conjunction with a stethoscope; an instrument used for listening to sounds within the body, such that those in the hearts and lungs. The average adult pulse rate at rest is 60 to 80 beats per minute, but injury, illness and emotion may produce much faster rates, which is abnormal for the human general health.

BLOOD PRESSURE

The heart is a hollow muscular cone-shaped organ, lying between the lungs, with the pointed end (apex) directed downwards, forwards and to the left. The heart is about the size of a closed fist. Its wall consists largely of cardiac muscle (myocardium). Deoxygenated blood from the vena cavae passes through the right atrium to the right ventricle. This contracts and pumps blood to the lungs via the pulmonary artery. The heart beat rate (blood pressure) can be monitored with the use of equipment called the sphygnamometer. Shown below is the diagram of a digital sphygnamometer. There are different phases of heart beats. First is Diastole (Diastolic), this is the phase when the heart muscle relaxes. Second is palpitation, which is the strong irregular heartbeat. Third is the systole, a phase when the heart muscle contracts and tachycardia, an abnormally rapid heart rate. All these phases of the heartbeat rate contribute to the administration of Medical care to patients with ailments.

Figure 4: Sphygnamometer *(Sphyg).*

WEIGHT

The weight of a body is its relative mass or the quantity of matter contained by it, giving rise to a downward force exerted on the mass of the body by a gravitational field. The weight of the body is usually measured in an ideal healthcare centre before administering any form of treatment. This is done with the aid of the equipment known as the weigh balance and body weight is measured in kilogram. The essence of this practice is to ensure that the patient is feeding well and also confirm that he or she is still within the weight range of his or her age. Naturally, good weight is an indication to a healthy living.

HEIGHT

Height is the measurement of someone from head to foot or from base to top. This measurement is taken using a long ruler calibrated in feet. In most health centers, the weight and height measurements are taken together on the same equipment. The major reason why these readings are taken is to be sure of the quantity of medical treatment to be administered.

ADVANTAGES OF WIRELESS SENSOR NETWORKS

The advantages of a Wireless Sensor Networks are numerous for real-time Medicare, as it provides the following important properties [6]:

Portability and Unobtrusiveness*:* Small devices collect data and communicate wirelessly, operating with minimal patient input. They may be carried on the body or deeply embedded in the environment. Unobtrusiveness helps with patient acceptance and minimizes confounding measurement effects. Since monitoring is done in the living space, the patient travels less often; this is safer and more convenient.

Ease of Deployment and Scalability: Devices can be deployed in potentially large quantities with dramatically less complexity and cost compared to wired networks. Existing structures, particularly dilapidated ones, can be easily augmented with a WSN network whereas wired installations would be expensive and impractical. Devices are placed in the living space and turned on, self-organizing and calibrating automatically.

Real-time and Always-On: Physiological and environmental data can be monitored continuously, allowing real-time response by emergency or healthcare workers. The data collected form a health journal, and are valuable for filling in gaps in the traditional patient history. Even though the network as a whole is always-on, individual sensors still must conserve energy through smart power management and on-demand activation.

Reconfiguration and Self-Organization: Since there is no fixed installation, adding and removing sensors instantly reconfigures the network. Doctors may re-target the mission of the network as medical needs change. Sensors self-organize to form routing paths, collaborate on data processing, and establish hierarchies.

Other Advantages: Other advantages of making use of the Wireless Sensor Networks to improve Medicare includes eradication of monthly continuous monthly charges, there are options of running VoIP (Voice over IP to which further reduce operating expenses. Wireless video consulting could also be enabled to reduce the diagnostic times and the cost of traveling from patients home to the health centre.

SYSTEM ANALYSIS AND DESIGN

We identified and examined the performance of the existing system with a view of designing the newly proposed system (*SensorNetCare*). The said examination is carried out to detect the weakness and strengths of the system presently in use in various heath care centers and then present the proposed system which is targeted at improving the mode of monitoring patient using the Wireless Sensor Networks with the intention of making it replace the present system in use.

OVERVIEW OF THE EXISTING SYSTEM

The current method in use is the physical contact measurement practice. This entails the use of specialized equipments to measure certain body conditions which in turns guide the administration of the appropriate medical care. Example of such measurement is the use of the Clinical Thermometer to measure the body temperature, use of sphygmomanometer, (popularly referred to as *sphyg*) an instrument for measuring blood pressure in the arteries.

All the measurements stated above are usually carried out in a separate department in a health care centre i.e. somewhere very far away from where the physician who will administer care to the patient is actually located. The results of the measurement are transferred from the measurement center down to the physician who reexamines the patient to confirm the correctness of the measured datum. After concluding these activities, the appropriate care would be administered.

OBJECTIVES OF THE EXISTING SYSTEM

The existing system implemented in use by most medical care outlets (hospitals and clinics) is aimed at getting ensuring that the complaint made by patients is confirmed by taking accurate measurement of body parameters to aid the drug administration and also give the physician the idea of the patient's responsiveness to the administered care. Another important reason why this system is in use is to prevent wrong drug administration i.e. treatment of wrong ailment due to deceiving symptoms.

PROBLEMS OF THE EXISTING SYSTEM

Though the existing system has being in use for a very long time now, and also being implemented adequately, it still has some problems associated with it which will in one way or the other hinder the speedy delivery of high quality health care. These problems include:

1. Inadequate readings from clinical equipments due to human error.
2. Incorrect readings from some equipment due to parallax error.
3. Untimely delivery of readings to technical personnel in charge of care administration.
4. Insufficient staff to handle existing equipments.
5. Inadequacy in record keeping.

THE PROPOSED SYSTEM'S ARCHITECTURE

Owing to the faults and the problems of the existing system, a new system that will solve the impending problem of the existing system stated above is being proposed. This architecture comprises of one or more wireless sensors which are attached to patients whose vital signs are to be captured. These wireless sensors will be networked to a server which serves as the monitoring unit. Other monitoring units could also be connected to the first monitoring unit (the server) in case more than one physician is required to attend to the patient wearing the sensor [8].

Apart from the server which serves as the monitoring interface to the sensors, a smart mobile phone or a Personal Digital Assistance (PDA) could also be used. Most importantly, these monitoring units must possess a wireless means of communicating with the wireless sensors already attached. Residing on the Server, the PDA or the smart phone is the designed application (SensorNetCare). This application processes the signals received from the wireless sensors. All these wireless networking is done using the Zigbee wireless link based on IEEE 802.15.4 standard, a standard meant for the interconnection of home and hospital equipments. All these in turns translates to the delivery of qualitative health care. The proposed system will meet the following requirement:

1. Provides a well computerized means of taking readings from patients.
2. Encourage remote administration of health care.
3. Affords the flexibility of use of medical equipments.
4. Enhances speedy delivery of patient's status information the physicians.
5. Enables effective medical health responsiveness and reduces health hazards.
6. Eliminate unexpected death due to improper health monitoring.
7. Reduces human error in taking readings from patients.
8. Prolonged monitoring of patient's vital signs.

THE SYSTEM'S ARCHITECTURE

Figure 5 illustrates the basic structure Wireless Sensor Network's architectural design. Shown in the diagram are two patients wearing wireless sensors. The sensors are connected to a laptop computer which serves as the server and the resident of the SensorNetCare application. Also in the diagram is another laptop computer which could serve as a visualization terminal, one could have one or more of such. The sensor nodes use ZigBee wireless link based on the IEEE 802.15.4 standard protocol in connecting with the server and the PDA.

The wireless connection protocol enables wireless connectivity within 200Meters range with little or no loss in the connection. This mode of connectivity consumes less battery which means that the sensors can be worn for a very long period of time without recharging it, though it could be recharged when power its power is used up.

The wireless sensor nodes run TinyOS which is developed by U.C Berkley, a major contributor to the sensor's energy efficiency. The Tiny Operating System manages both the hardware and the wireless network which is in built to the sensor, this include taking body measurements, making routing decisions, and controlling power dissipation.

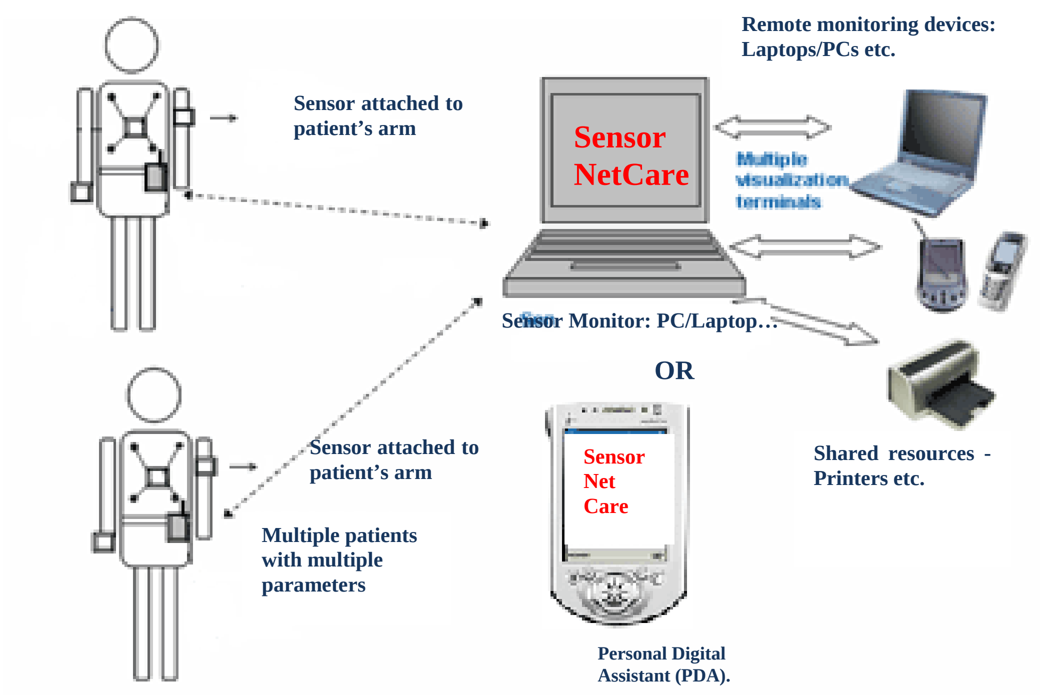

Figure 5: Wireless Sensor Network Architectural Design.

INPUT DESIGN

The input design of this project comprises the programming language used in the design of the SensorNetCare application and the dot net framework installed on the computer system and the mobile devices that makes it portable on all system platforms.

C SHARP.NET (C#.net)

This is a programming language developed from the C family of object oriented language. It has the capability of solving programming problems with little efforts. In this project, it is used as the main tool of implementation from the scratch till completion. For example, it is used in the design of the SensorNetCare interface shown below.

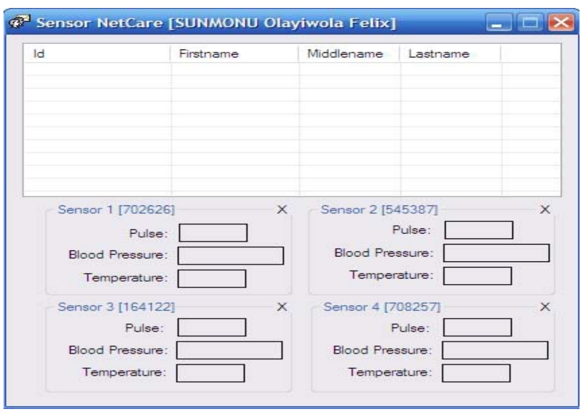

Figure 6: SensorNetCare Application Interface.

SENSOR STATUS INDICATOR

SensorNetCare has two different signal status indicators for each signs that are being sensed. (i.e., Temperature, Heart beat and Pulse sensors). First is the green color and second is the red color. There will always be a physician in charge to monitor the change in these visual indicators.

The green color indicates a normal health condition. At this point, the physician doesn't need to attend to the patients wearing the sensors as their state of health is normal and doesn't need any attention. On the contrary, the red color indicates a change in the vital body signal which is sequel to abnormal health condition. At this point in time, the health physician in charge of monitoring the application quickly attends to the patient whose indicator shows critical condition on the application interface [9].

DOT NET FRAMEWORK STANDARD DEVELOPMENT KIT (SDK)

The Dot net framework development kit is an application developed for dot net enabled programming languages; it helps enhance the programming language's portability as they can be used on any device that has the dot net framework installed on it. The extent of its portability has also been extended to mobile, a platforms which makes the SensorNetCare application developed in this project executable on mobile devices such as Personal Digital Assistant (PDA) and smart phones running windows OS or Symbian OS.

OUTPUT DESIGN

The design of this project is dual output oriented as it gives the user of the developed application a visual alert to visualize the result of the sensed signals and at the same time an audio alert which alarms as soon as the signs are in critical conditions. Figure 7 show SensorNetCare showing normal signal obtained from the sensors while Figures 8 and 9 show the application interface with colored background to indicates abnormal health status.

The green color indicates that the reading sensed from the sensor is normal and the red indicate abnormal health condition. In an efficient medical care setup, the above result calls for urgent attention of the physician in charge. In fact this status calls for a state of emergency because almost all the vital signals abnormal.

To cap it all up, the SensorNetCare application also contain a patient's Information Editor pane as shown in Figure 8, this pane captures the patient's information at the point of allocating a sensor to the patient. The following information is contained in the patient's information pane: The patients Sensor Identity (number), First Name, Middle Name, Last Name, Date of Birth, Address, Height, Disability Status, Complaint, Ailment, Color of the Eye and the patient's weight.

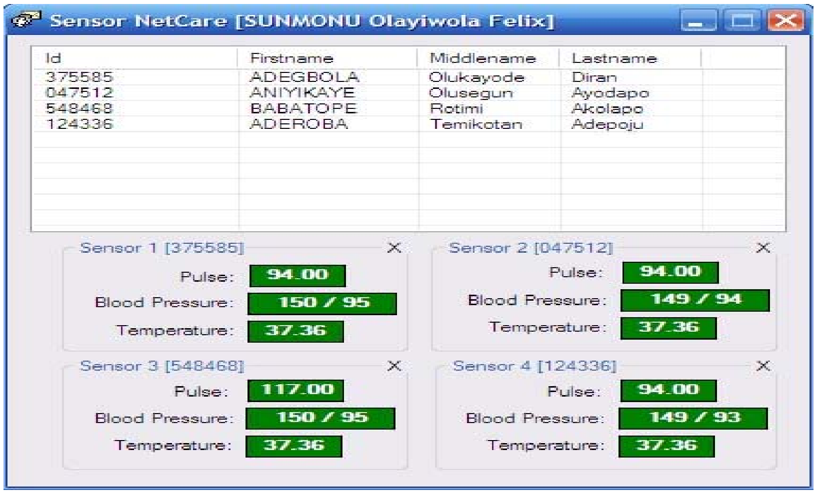

Figure 7: SensorNetCare: Normal Health Status Report.

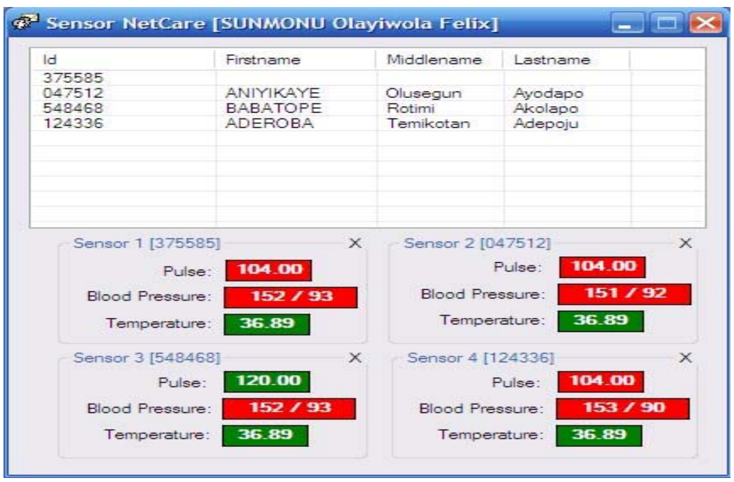

Figure 8: SensorNetCare Showing Critical Health Conditions.

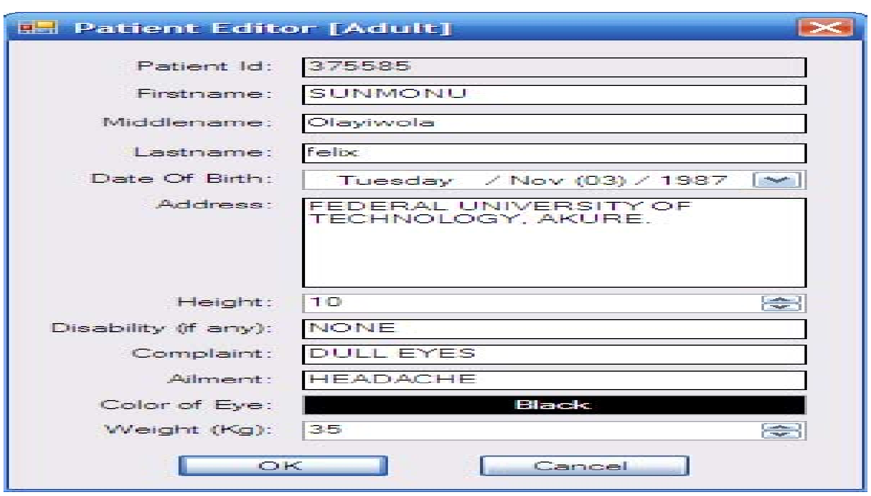

Figure 9: SensroNetCare Patient's Information Editor Pane.

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SYSTEM IMPLEMENTATION

This chapter introduces the full documentation of designed system. The design of the system and how it is used to implement high quality health care. The software and hardware requirements needed for the system, its installation and configuration, and also the testing of the system to actually confirm that it meet the design requirement.

SOFTWARE REQUIREMENT

The designed system needs a couple of software applications to be able to run and perform the designated functions. The following is the software requirements for the system development and deployment are:

1. Operating System – Windows XP or higher
2. CSharp .NET (C#.net) Compiler.
3. DotNet Framework (.NET Framework 2.0)

HARDWARE REQUIREMENT

The Hardware requirement for the system includes the following:

1. A wireless Sensor Node (with Temperature, Hearth beat rate and Pulse rate sensing capability)
2. WiFi and Bluetooth enabled computer system
3. Pentium 4 or higher processor
4. 512MB of RAM or higher
5. 60GB Hard Disk Drive minimum
6. 15" Monitor
7. A Printer
8. Optical Drive: DVD -/+RW
9. Uninterrupted Power Supply
10. Stabilizer and
11. A generator.

SYSTEM INSTALLATION AND CONFIGURATION

After having the above hardware and software requirements in place, the developed system is ready to be installed. As it has been said earlier, the dotNet framework must be installed before the application can function properly and the right version (version 2.0) of the framework must also be installed. To acquire the dotNet Framework, one would need to proceed to Microsoft website, search by using the following search criteria, "dotNet framework version 2.0 or .NET Framework 2.0". On the click of the search tab, a link leading to the dotNet Standard Development Kit (SDK) will be provided. Clicking this link will initiate the download of the .NET Framework Version 2.0. When the download is complete, the installation must be done to get it running on the system where the developed system is to be installed.

Wit the dotNet Framework in place, the developed system must be installed by clicking on its icon from the storage media which could be a Flash Drive, a Compact Disk, a DVD or an external Hard Drive. The Installation process is very interactive, so the installation instruction should be followed properly.

The overall system installation must be in the following order after meeting up with the hardware requirements:

1. Download dotNet Framework.
2. Install dotNet Framework.
3. Acquire SensorNetCare.
4. Install SensorNetCare.

After ordering the steps above properly, the system is ready for use.

SYSTEM TESTING

Testing is an important operation to prove the effectiveness and efficiency of any designed software application. The simplified structure of the SensorNetCare and its installation process makes its implementation easier. This testing ensures that all possible events as specified in the system requirements have been catered for by the designed software.

However, this system is just a pilot system which operates in the absence of Sensor Nodes because it's not readily available and also has cost limitation for Sensor Nodes which have been carefully modeled.

SYSTEM IMPLEMENTATION

The proposed implementation method for this system is the direct implementation method. Here it is proposed that the health clinic totally switches to the newly developed system. This is because health matters are not to be taken lightly, whatever is worth doing at all is worth doing well. This is to ensure adequate measurement of patient's health status as it skyrockets into high and qualitative health care administration.

CONCLUSION

Health care delivery systems are very sensitive systems. This is because they have much to do with life, and this is the most momentous reason why implementation methods should be accurate and be without errors. The proposed system eliminates several errors which are associated with the conventional method of health care implementation by introducing the use of the network of Wireless Sensor Nodes. This is used to collect patient's parameters and deliver it to the health care physician in charge. The physician then acts on the patient based on the parameters delivered by the sensor or sensors.

Based on the parameters received from the wireless sensors, the physician carries out the health care for the patient. Considering the potential benefits associated with this system, it is high time hospitals begin to use this technology in health care delivery.

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