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Desert Nomads Healthcare Monitoring Application Based on BSN and Wi-Max

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Abstract: Wireless sensor networks consist of small nodes with sensing, computation, and wireless communication capabilities. Among applications of WSN, healthcare monitoring in large-scale areas is an important technique which offers tracking and controlling patients at anywhere and anytime via the Web/Dabase and cellular network technologies.Due to the emerging demands of medical equipment nowadays, the wireless body area network (WBAN) is imperative. In the case of an emergency, doctors and/or nurses will be contacted automatically and immediately through their handhelds or smart phones. This paper describes the design of a system which allows real-time monitoring of nomads people those are in isolated areas as desert locations. This system helps to save the patient's life especially those who suffer from chronic diseases and in their case the medical intervention become impossible. This solution combines RFID tags and readers, BSN nodes incorporated in the patient body. All biomedical collected data will be sent periodically to the medical specialist staff in a remote hospital center through a Wi-MAX network. The proposed scheme has been simulated by OPNET tool to demonstrate the efficiency and the convenience of the developed approach. This solution facilitates the emergency intervention and the localization, in real time, of the patient targets whose are in far areas and they need a help.

Keywords: Real Time Monitoring, RFID, Wi-Max, Web Server, Body Sensors, Healthcare.

I. INTRODUCTION

A sensor network is an infrastructure comprised of sensing (measuring), computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. The administrator typically is a civil, governmental, commercial, or industrial entity. The environment can be the physical world, a biological system, or an information technology (IT) framework. Patient monitoring systems become an important topic and research field today. Research on health monitoring were Developed for many applications such as military, homecare unit, hospital, sports training and emergency monitoring system. Patient monitoring systems are gaining their importance as the fast-growing global elderly population increases demands for caretaking. One of the major challenges of the world for the last decades has been the continuous elderly population increase in the developed countries [1]. One promising application in this field is the integration of sensor networks that enable people to be constantly monitored [2]. In fact many application have been designed to ensure a constant monitoring in narrow area based on wireless sensor networks as smart home [3,4].That will increase early detection of emergency conditions and diseases for at risk patients and also provide wide range of healthcare services for people with various degrees of cognitive and physical disabilities [5]. On the contrary in very remote areas the idea of smart home is no longer suitable. To remedy this problem the researchers thought of designing application that monitoring via satellite. VSAT (Very Small Aperture Terminal) is a system based on geostationary satellites for transmitting and receiving data from a device small-scale system. VSAT is the power of the order of 1 Watt, against several hundred Watts sees Kwatts for large fixed stations [6]. Obviously that this way for monitoring is the most suitable in isolated areas depending on its guaranteed bandwidth and his ensures real-time communications, but it seems that is too expensive and consumes more energy. Our staff is designing an application that guarantees a real-time communication and consumes less energy based on the combination between wireless sensor networks and wireless telecommunication Wi-Max. Researchers in computer, networking, and medical fields are working together in order to make the broad vision of smart healthcare possible. The importance of integrating large-scale wireless telecommunication technologies such as 3G, Wi-Fi Mesh, and Wi-Max, with telemedicine has already been addressed by some researchers. Further improvements will be achieved by the coexistence of small-scale personal area technologies like radio frequency identification (RFID), Bluetooth, ZigBee, and WSN, together with large scale wireless networks to provide context-aware applications. Therefore the need for intelligent, context-aware healthcare applications will be increased. In this work, we use the Radio Frequency Identification (RFID) technology to solve the monitoring problem. The main reason behind preferring RFID technology over others is in the relatively low cost and the variety of available options. RFID has also been successful in solving a wide span of problems in various domains [8, 9, 10, 11]. The remaining paper is divided as follows. Section 2 describes WSN topology used. Section 3 presents the general equipments needed for the proposed solution. Section 4 shows the results of testing and simulating the proposed approach. The paper is concluded in Section 5.

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II. WIRELESS SENSORS NETWORKS

A. Motivations and Applications

Micro-electromechanical systems, embedded technology, sensor technology and wireless communication technology has become more sophisticated and progressive, to promote wireless sensor networks (WSN) generation and development, WSN become the current research in the field of IT hot, and has been widely used in many fields. Actually, this technology is omnipresent in application that requires communication with their components to transmit relevant quantities or values like light, temperature, humidity and more. A WSN, sensor nodes are organized into fields "sensor fields" (fig.1). Each of these nodes has the ability to collect data and transfer them to the gateway node (called "sink" in English or sink) via a multi-hop architecture. Well then transmits this data via the Internet or satellite to the central computer "Task Manager" to analyze and make these decisions.

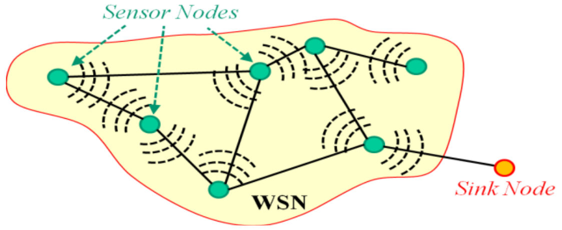

Figure 1: sensor network field architecture

A wireless sensor network (WSN) consists of a number of low cost sensors which co-operate to monitor some physical or environmental variables. WSN have emerged as a popular solution to many applications in both controlled and uncontrolled environments in fields as varied as rescue and ambulance, in nuclear reactors conducts a periodic surveillance, transport (plane and car) VANETs (Vehicle Ad hoc Networks), animal control, natural disasters (earthquakes and volcanoes) for the purpose of surveillance, weather sensing, wildlife monitoring, building safety, traffic monitoring, law enforcement and military among others. With the recent advancement in technology such as the size of the sensors becomes smaller and the capabilities increase, sensor networks are envisioned to cover an even broader range of applications.These devices (motes or sensors) are able to capture and collect information sensitized in the environment monitoring , and then you send it wirelessly from one sensor to another in cooperation with each other to a the base station (sink), which is a computer that collects information from wireless sensors scattered, processed and analyzed.

B. Chalenges and Constraints

The capabilities and constraints of sensor node hardware will influence the architecture of sensor networks can be summarized as follows:

- ✓ *Battery power/Energy*: Energy is the greatest constraint to sensor node capabilities. We assume that once sensor nodes are deployed in a sensor network, they cannot be recharged.
- ✓ *Sleep patterns*: sensor nodes spend a majority of their operational time in low-power sleep modes and only awake when required to processes an event (e.g., a tank detected).
- ✓ *Fault Tolerance*: Some nodes may generate errors or stop working because of a lack of energy, a physical or interference.
- ✓ *Scale*: The number of nodes deployed for a project may reach one million. Such a large number of nodes generates a lot of transfers inter nodal and requires that the well "sink" is equipped with lots of memory to store the information received.
- ✓ *Production costs*: Today's consumers expect low cost sensor networks nodes which provide high functionality. The price of a node is critical in order to compete with a network of traditional surveillance. Currently a node does not often costs much more than $ 1.
- ✓ *The environment*: The sensors are often deployed en masse in places such as battlefields beyond enemy lines, inside large machines, the bottom of an ocean, fields biologically or chemically contaminated.
- ✓ Therefore, they must operate unattended in remote geographic areas.
- ✓ Network topology: The deployment of a large number of nodes requires maintenance of the topology. This maintenance consists of three phases: Deployment, Post-deployment, and Redeployment of additional nodes
- ✓ *Material constraints*: The main constraint is the physical size of the sensor. Other constraints are that energy consumption must be reduced so that the network will survive as long as possible, it adapts to different environments (extreme heat, water...), it is very durable and autonomous since it is often deployed in hostile environments.
- ✓ *The media transmission:* In a sensor network, nodes are connected by a wireless architecture. To allow operations on these networks worldwide, the transmission medium must be normalized. We mostly use the infrared (which is license-free, robust to interference, and inexpensive), Bluetooth and ZigBee radio communications.

C. Body Sensor Networks (BSN)

The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records through the Internet. A number of intelligent physiological sensors can be integrated into a wearable wireless body area network, which can be used for computer-assisted rehabilitation or early detection of medical conditions. This area relies on the feasibility of implanting very small biosensors inside the human body that are comfortable and that don't impair normal activities [12].

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BSN technology represents the lower bound of power and bandwidth from the BAN use case scenarios. Actually, this kind of structure, usually, uses cellular network (3G) or WSN infrastructure to transmit data concerning patient to the base station and to the doctor (fig.2).

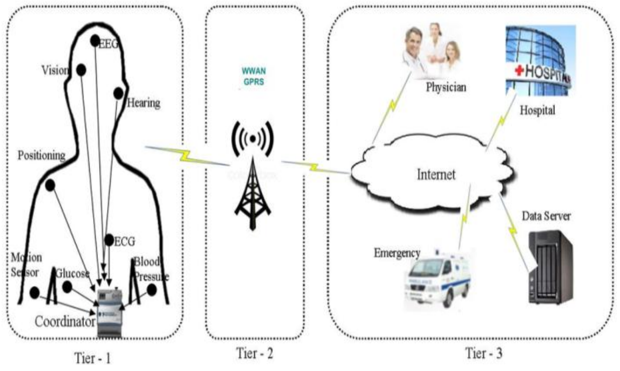

Figure 2: Body Sensor Network architecture

Compared with existing technologies such as WLANs, BANs enable wireless communications in or around a human body by means sophisticated pervasive wireless computing devices. Using this technology, it is possible to obtain measurements of heart rate, oxygen saturation, pressure, and temperature. We expect that, over time, an increasing array of sensors with sophisticated capabilities will become available. Most BAN applications use infrastructure-based, inter-BAN communication that assumes an environment with limited space, e.g., a waiting room in hospital, home and office, etc. This topology offers the advantage of centralized management and security control.

Wireless technologies for inter-BAN communication are mature, and include: WLAN, Bluetooth, ZigBee, cellular, GSM, Wi-Max and 3G, etc. More technologies that have a personal server support easier a BAN to be integrated with other applications. Even though Bluetooth has a very good communications mechanism over a short range, it is not a very feasible solution for BANs. A key component of the ZigBee protocol is the ability to support mesh networks. ZigBee is used nowadays for communications between sensors in a network [14]. The IEEE 802.16 technology Wi-MAX is a promising alternative to 3G or wireless LAN for providing last-mile connectivity by radio link due to its large coverage area, low cost of deployment and high speed data rates. The standard specifies the air-interface between a Subscriber Station (SS) and a Base Station (BS) [19, 20].

III. RFID AND GENERAL EQUIPEMENTS FOR PROPOSED SOLUTION

A. *Radio Frequency Identification (RFID) System*

Radio frequency identification (RFID) can identify an object, follow the path and know the characteristics remotely using a label that emits radio waves, attached or incorporated with the object. RFID technology allows reading labels even without direct line of sight and can penetrate thin layers of materials (paint, snow, etc...). This identification is transmitted in the form of a serial number that distinguishes each object from the other. The RFID system is composed of a RFID reader and a Tag. The tag is composed of a microchip connected to an antenna; microchip can store a maximum of 2 kilobyte of data, which can include information about the product, the manufacturing date, the destination, among other information. The data stored in the tag can be retrieved by the reader which is a device that emits radio waves, these radio waves are received by the tag which activates the microchip and then the data get transmitted. RFID tags are further broken down into two categories:

Active RFID tags: are battery powered. They broadcast a signal to the reader and can transmit over the greatest distances (100meters). Communications from active tags to readers is typically much more reliable than the communications from passive tags to readers. With this feature the active tags can be used in much more applications than the passive tags.

Passive RFID tags: tags do not contain a battery. Instead, they draw their power from the radio wave transmitted by the reader. The reader transmits a low power radio signal through its antenna to the tag, which in turn receives it through its own antenna to power the integrated circuit (chip) [16]. The tag will briefly converse with the reader for verification and the exchange of data. As a result this type can transmit information over shorter distance (0 to 5meters) than active tags, recently a new passive, tag uses mall solar panels to perform like a battery-assisted, has been developed with claims that it can be read from a distance of 25 meters [17].

Semi-Passive RFID tags: they have a battery to power the integrated circuit however they use the power from the

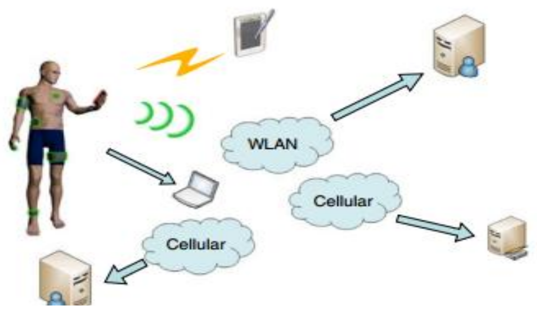

Figure 3: Inter-BAN communication architecture: infrastructure based mode

electromagnetic waves that the reader sends in order to retrieve the data present on the tag. There are three basic types of chips available on RFID tags, Read Only tags, Read-Write tags and Worm tags.

Read Only Tags: This type of tags has information stored on them during the manufacturing process, and this information cannot be changed.

Read/Write Tags: This type of tags has separate writable memory areas. This is a very important feature because the information contained in the microchip can be written and after that changed, especially if the information changes overtime [16, 17].

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WORM Tags**:** WORM tags stands for Write Once -Read Many. The information contained in this tag can only be changed once, but can be read as many times.

B. Worldwide Interoperability for Microwave Access (Wi-Max)

Wi-Max deployment with optimization is not easy task. In this particular area we also considered about number of users. Since we know that Wi-Max coverage is 50km in radius but when we have take practical consideration it's up to 25 to 30km. We have also observed that one directional antenna and one Omni-directional antenna has been required for last mile operation or for total coverage. There are many advantages for using Wi-Max:

- ✓ Real time data transfer.
- ✓ Packets from one user will be sent via different time slots.
- ✓ User can share time slots.
- ✓ User will be always connected even if he is not sending any data.

C. System Requirement

A system can be characterized according to its functional and non-functional requirements. Functional requirements describe the primary functionality of a system while non-functional requirements describe attributes like reliability and security, etc. The system's functional requirements are as follows:

- ✓ System needs to support mobility.
- ✓ System must use minimum power.
- ✓ System must be accessible from the Internet 24/7.
- ✓ System must be compact.
- ✓ System must mostly use off-the-shelf devices, components, and standards.
- ✓ System must support two-way communication between the client and the server.
- ✓ System must be field-configurable.
- ✓ System should be easy to deploy.
- ✓ System must support accurate and continuous real-time data collection

Non-functional requirements for the system dictate that the system is reliable, portable, accurate, maintainable, secure, accessible, and usable. In addition, the system must support performance standards for an adequate response time and storage space for data.

IV. DESIGN ARCHITECTURE

The main goal of the proposed design is to represent a simple, inexpensive, and effective solution that provides real-time sensing, processing, and control will augment and preserve body functions and human life. The design consists of two components:

(1) a server stationed at the Department of Health centre.

(2) a nomads people placed at various wide locations that are to be monitored.

The server typically consists of a Web/Database server and a Wi-Max module that can be used to send message alerts. Coordinator is an instrument aboard the target compound of body sensors connected to a microcontroller that communicates with both a Wi-Max modem and an RFID tags. The overall system architecture is shown in Figure 4. The major of existing applications using RFID are focused just on the identification of patient and determine their location. This approach is at this moment, an innovation of the healthcare monitoring applications in real time. In this context, we propose a hybrid architecture based on sensor networks using BSN and able to locate remote people. We assume that the measurements of monitored persons can be collected by body sensors dispatched to single-chip microcontroller as analogue-to-digital converter connected with RFID tags and Wi-Max station. We note here, that just patients declaring that they suffer from health problems (Cardiac, Imbalance in pressure, Diabetic…) who must be equipped by these sensors mainly ECG signal. The ECG signal is stored both in transmission and reception following SCP-ECG standard. It is well known that for an efficient transmission, an ECG compression technique has to be used. In our case, a real-time ECG compression technique based on the Wavelet Transform is used. Therefore there is a trade-off between transmission rate and received ECG signal quality. Thus, there exists a minimum transmission rate to be used to transmit a useful ECG for clinical purposes, which was selected in collaboration with cardiologists after different evaluation tests. The minimum transmission rate used in our implementation (625bits per second and per ECG lead) leads to a clinically acceptable received ECG signal. Regarding blood pressure, oxygen saturation and heart rate, these signals have low bandwidth requirements and, therefore, are not compressed. Due to the variable and scarce wireless channel resources shared between all medical user services, it is necessary to prioritize them to provide an adequate treatment in real-time. In fact, real-time services are very sensitive to channel conditions (mainly bandwidth, delay and packet loss rate). For this reason, the most priority services are the medical data. As shown in Figure 1, agents and doctors can then identify, in real-time, the measurement of each patient using two convenient options: SMS service or Web/E-mail using Http service. The SMS option is available for users who don't have access to an internet connection. The Web allows users to create personal profiles and set customized SMS/Email alerts for specific patient to stay up-to-date with the state conditions. The Web portal will automatically notify the user when specific conditions occur on the selected monitored areas.In another part, leaders of these persons may contact the base station or center for any absence of patient from his group, at that time an alert is broadcasted in the network to locate lost person. Indeed, coordinator Wi-Max plays an important role by searching neighboring RFID tags and then indicates its position to leaders and coordinator of concerned area. By broadcasting the patient ID request which refers to body sensor ID. The concerned ID sends a Replay to the near coordinator. This information can be transformed to base station over a routing mechanism as mentioned at [18].

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V. SIMULATION AND DISCUSSION

In wireless transmission environment where there are many kinds of interferences, such as noise and multi-path and so on and time-varying characteristics of the channel is more obvious [5]. Thus building a reasonable simulation for wireless channel is more difficult the wireless module of OPNET Modeler provides a special fourteen stages transceiver pipeline to evaluate the characteristics of wireless communication. The performances have been evaluated by simulation. Table 1 gives the simulation parameters. The figure 4 illustrates the simulation OPNET scenario for the desert nomads localized in two wide areas covered by a Wi-Max network.

Table 1: Simulation parameters

System Parameters	
Simulation time (sec)	3600
Data traffic rate	11 Mbps
Basic rate	1.5 Mbps
Service Class Name	Silver/UGS
Antenna Gain	15 dBi
PHY profile	Wireless OFDMA 20MHz
Max. Transmit power	0.5 Watt
Path loss	Pedestrian
BS MAC address	Distance based
Nodes Mobility	1 m/s
Network Area	5km*5km

Computer simulation results are shown in the following figures. Referring to the figure 5 Traffic received by the BSN nodes has a good value and it increases significantly with the time increasing and it takes a fixed maximum value.

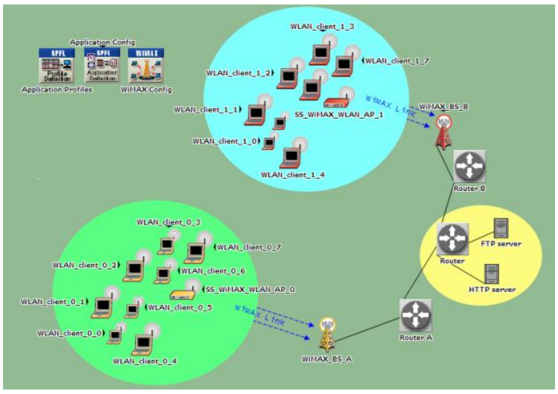

Figure 4: Wi-Max Desert Nomads Healthcare Monitoring OPNET Scenario

Computer simulation results are shown in the following figures. Referring to the figure 5 Traffic received by the BSN nodes has a good value and it increases significantly with the time increasing and it takes a fixed maximum value.

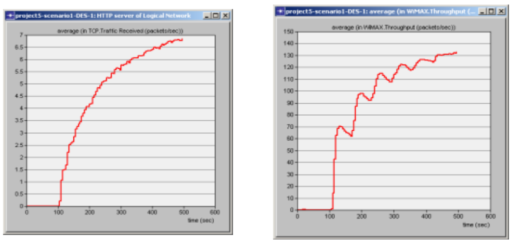

Figure 5: Traffic received and average Throughput

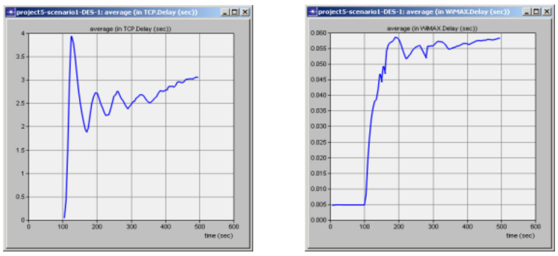

Figure 6: average TCP Delay and average Wi-Max Delay

Based on figure 6, it seems that the throughput in Wi-Max base station increase until 130 packet/sec and improve traffic sent and received by FTP server. We have seen that Wi-Max doesn't take several delays using TCP to transmit packets data because it has a good real time throughout. This delay time reaches 0.06sec in our simulation. Indeed, it is observed that the two base stations are well sufficient to cover the desired area in 30km because increasing the base station number somehow can lead well decrease network load but it causes cost increasing.

VI. CONCLUSION

The implementation of telemedicine requires the application of a multidisciplinary approach. The main contribution of this paper is to design an advanced on-line healthcare monitoring system, by study and analysis. This paper outlines a solution to one of the most problems, health, control and localization of nomadic people in wide areas. The proposed telemedicine scheme can be considered as an improvement of basic health services. In this system communication is based on IP and combines FTP and Web/Database client/server technology to copy differents data measurements received from the differents sensors installed in nomads bodies using Wi-Max networks which demonstrates really its effectiveness in real time data traffic. This intelligent system has many benefits: low cost, it can be used for fixed or mobile patient's surveillance, control the health of patients and locate the lost persons in order to intervene in time to save lives and guide the lost target to the near center. It provides also monitoring the health of patients and locates lost people due to a sudden health crisis to intervene in suitable time to save their life's and guide them to the nearest hospital. The future work will be focused on the development, deployment and evaluation of this biomedical monitoring system in the practice.

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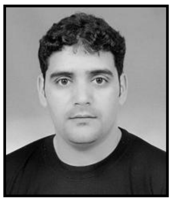
BIOGRAPHIES



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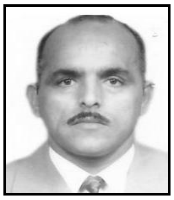

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