Remote Patient Monitoring System Using Wireless Communication

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Abstract

In recent times, the manifestation of telemedicine developments and the wireless networks implementations in the medical field has covered that how we can best exploit wireless technology to afford the medical sector with apposite solutions. In this paper, a system architecture of telemedicine system for remote patients using wireless communication has been proposed. A prototype of Wireless LAN IEEE802.11 is used as a communication channel. The stored and forwarded packet propagation of wireless communication was implemented by using packet tracer version 4.01.

Keywords and Phrases: RPMSN, TCP, WLANS, HTML, Packet Tracer.

1. Introduction

Telemedicine is well suited for providing care to under-served communities for diagnosis, management, and postoperative assessment of acute medical conditions of patients in remote areas [1, 2]. It defines the investigation, monitoring and management of patients, using systems which allow ready access to expert advice and to patient information, no matter where the patient or relevant information is located [3]. Vital parameters, like ECG, blood pressure, blood glucose level, pulse oximeter, or other vital signs are efficiently and effectively transferred to a storage and monitoring center. The patient information and the transmitted data can be viewed locally or via the Web. In this paper, the remote patient monitoring system using wireless communication architecture using *the prototype of Wireless LAN IEEE802.11* [4] *is* proposed. IEEE 802.11 is an evolving family of protocol specifications for wireless local area networks (WLANs) developed by a working group of the Institute of Electrical and Electronics Engineers (IEEE). All the 802.11 specifications use the Ethernet protocol and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) for path sharing. The original modulation used in 802.11 was phase-shift keying (PSK). However, other schemes, such as complementary code keying (CCK) are used in some of the newer specifications. The recent modulation methods provide higher data speed and reduced vulnerability to interference. A concept of reference design called Remote Patient Monitoring Sensor Node (RPMSN) architecture offers flexibility of reducing development time.

The intuition of delivering vital information wirelessly to handheld devices used by medical practitioners has had some concentration in recent literature. Hung and Zhang [5] emphasize on an implementation of a WAP-based telemedicine system for monitoring patient signals, specifically, ECG and blood pressure. The patient's signals were recorded, sent wirelessly via RF to an indoor receiver station and processed and stored in a PC-based database. This database was accessible by the WAP content server upon request. The WAP 1.1 protocol was used for the authorized enquiries, though the authors themselves suggest the use of WAP 1.2 in future to make use of features for event notification.

Dong and Zhu [6] depict a wireless ECG monitoring architecture that uses Bluetooth for connectivity between an ECG detector and the handheld or PC; and GPRS/Internet for the connection to the hospital server. The ECG detector described is a wearable computer which detects and processes the real time ECG signals. This can then be delivered to the handheld or PC, which in turn connects with a central server.

A framework for wireless communication within a hospital is also given in [7]. Lakas and Shuaib describe a SIP-based architecture including wireless Personal area networks using medical equipment with Zigbee devices that are interconnected through the WLAN infrastructure. The Session Initiation Protocol (SIP) is used to provide event notification and managing or communicating medical tasks. The authors also envisage other extensions including GPRS for communication beyond the hospital walls.

The specialty of this work is to deal with integrated biological and medical data. Data like ECG, blood pressure, Oxymeter, audio, and video have been acquired individually. After that these various data were integrated in a single format. The frame or packet of the integrated data is processed and sent through the channel. At the receiving end, the integrated data is demultiplexed and individual is reproduced. The total algorithm and protocols of this term has been considered for future development. If we compare this context with the other proposed method, they only considered with single data unit generally. To overcome the scope of the integrated data transferring, this paper proposed to introduce a method that would deal with integrated data acquired from the patients by real time or stored and forwarded.

Most of the cases, they considered the routing process through a static routing configuration. Static routing describes a system that does not implement adaptive routing. In these systems routes through a data network are described by fixed paths (statically). These routes are usually entered into the router by the system administrator. An entire network can be configured using static routes but this type of configuration is not fault tolerant. When there is a change in the network or a failure occurs between two statically defined nodes, traffic will not be rerouted. This means that anything that wishes to take an affected path will either have to wait for the failure to be repaired or the static route to be updated by the administrator before restarting its journey. Most requests will time out (ultimately failing) before these repairs can be made. There are, however, times when static routes make sense and can even improve the performance of a network. Some of these include stub networks and default routes.

But we introduced the total process could be operated in moving vehicle. What can happen when the user changes its network locally? To remedy the situation, Dynamic Host Configuration Protocol (DHCP) services can be used. DHCP distributed addresses are not permanently assigned to hosts but are only leased for a period of time. If the host is powered down or taken off the network, the address is returned to the pool for reuse. This is especially helpful with mobile communication or GPRS users that come and go on a network. Users can freely move from location to location and re-establish network connections. The host can obtain an IP address once the hardware connection is made, either via a wired or wireless LAN. In moving vehicles, users get connected to the network from any places. During the moving places, if one changes the coverage of the switch or local gateway to anther switch or gateway, the connection will be made automatically by using the DHCP services. Besides, most of the other proposal considered LAN technology. This paper tried to propose the architecture of remote patient monitoring wireless network using both LAN and WAN technology, and has been implemented by using the packet tracer version 4.01.

2. Proposed RPMNS Architecture

In this architecture, the vital parameters whether it is an ECG, blood pressure, blood glucose level, pulse oximeter are acquired by RPMSN either real time or stored and forwarded. RPMSN defines both the hardware and software for sensor node. These data are sent to the hospital server through the wireless network as shown in Fig.1. Doctor’s PDA (Personal Digital Assistant) or Laptop is connected to the server in a client-server environment and thus able to make advice by looking at the parameters that are appeared in Web-page interface at the receiving end. In this context, sensor node (sensor devices like PCI 1710) senses or acquires the data from the patient's body and integrates into a single data unit. Using matlab program or integrated devices, it is multiplexed. The wireless access point is used to provide Wireless LAN. It could be connected to Local Server to connect internet using Wireless router.

In the context of protocol operation and data encapsulation, when sending messages through a network, the protocol stack on a host operates on layers from top to bottom. In the web server, one can use the TCP/IP model to illustrate the process of sending an HTML web page to a client. The Application layer protocol, HTTP, begins the process by delivering the HTML formatted web page data to the Transport layer [8, 9]. The application data is broken into TCP segments. Each TCP segment is given a label, called a header, containing information about which process running on the destination computer should receive the message. It also contains the information to enable the destination process to reassemble the data back to its original format.

The Transport layer encapsulates the web page HTML data within the segment and sends it to the Internet layer, where the IP protocol is implemented. Here the entire TCP segment is encapsulated within an IP packet, which adds another label, called the IP header. The IP header contains source and destination host IP addresses, as well as information necessary to deliver the packet to its corresponding destination process.

Next, the IP packet is sent to the Network Access layer Ethernet protocol where it is encapsulated within a frame header and trailer. Each frame header contains a source and destination physical address. The physical address uniquely identifies the devices on the local network. The trailer contains error checking information. Finally the bits are encoded onto the Ethernet media by the server NIC. The data is decapsulated as it moves up the stack toward the end user application.

As application data is passed down the protocol stack on its way to be transmitted across the network media, various protocols add information to it at each level. This is commonly known as the encapsulation process. The form that a piece of data takes at any layer is called a Protocol Data Unit (PDU). During encapsulation, each succeeding layer encapsulates the PDU that it receives from the layer above in accordance with the protocol being used. At each stage of the process, a PDU has a different name to reflect its new appearance. Although there is no universal naming convention for PDUs, in this course, the PDUs are named according to the protocols of the TCP/IP suite.

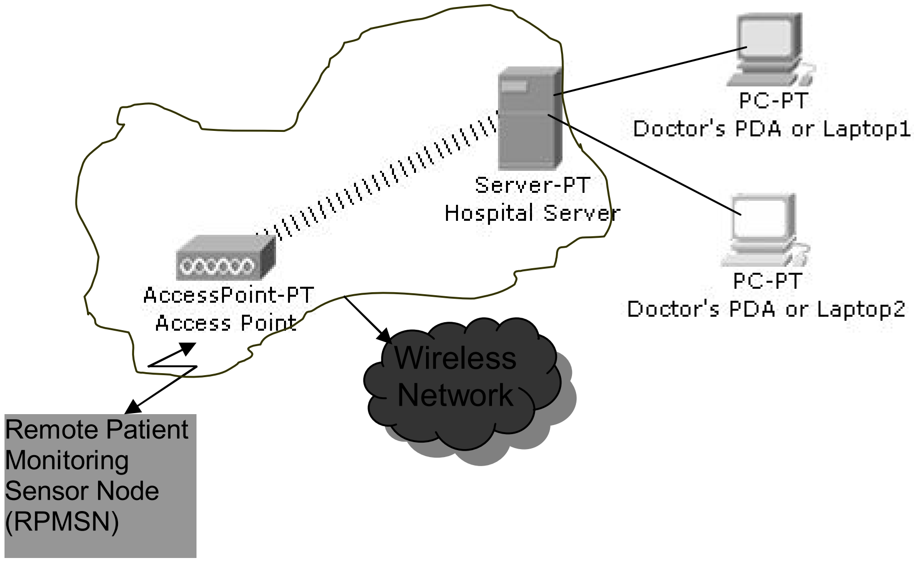
Data - The general term for the PDU used at the Application layer

Segment - Transport Layer PDU

Packet - Internetwork Layer PDU

Frame - Network Access Layer PDU

Bits - A PDU used when physically transmitting data over the medium



Application
TCP
IP
LLC
802.11 MAC
802.11 PHY

LLC	
802.11 MAC	802.3 MAC
802.11 PHY	802.3 PHY

Application
TCP
IP
LLC
802.11 MAC
802.11 PHY

Fig. 1. Remote Patient Monitoring System Architecture

3. Simulation and Testing

In this context, we have illustrated the data transformation of the patients' acquired by the RPMSN. At the sending end, different data either real time or stored and forwarded could be multiplexed and send to the destination (Doctor's Laptop or PDA) through the wireless WAN technology. The Local LAN connected with router may connect another LAN also connected with router with wireless communication shown in Fig. 2, 3, and 4. At the beginning of simulation, we first create a topology where patient Pc and Doctor's Pc are connected with the serially connected routers (router 0 and router 1). In order to send a packet from patient PC to Doctor's PC, there is a wireless path. During the passage of packets from source to destination, the information of devices and type of packet are visualized while the last status of packet tracing appears in progress. After passing the packets to the destination, the information of devices and type of packet are visualized while the last status of packet tracing appears successful. A packet at the sending end (Patient's Information PC) (in Fig. 2) was started to transmit to the receiving end (Doctor' PC). Then the packet was attempted to reach the destination (in Fig.3) through Wireless LAN and router while the status of the packet tracing was appeared in progress.

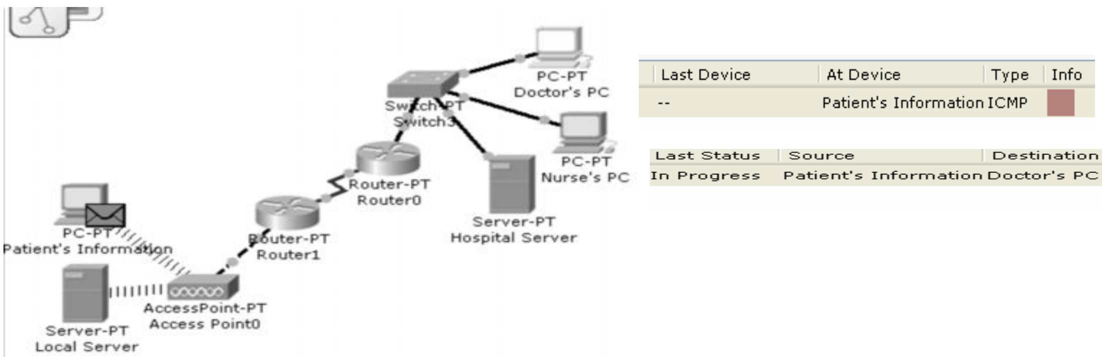


Fig. 2 Initialization of Packet delivery

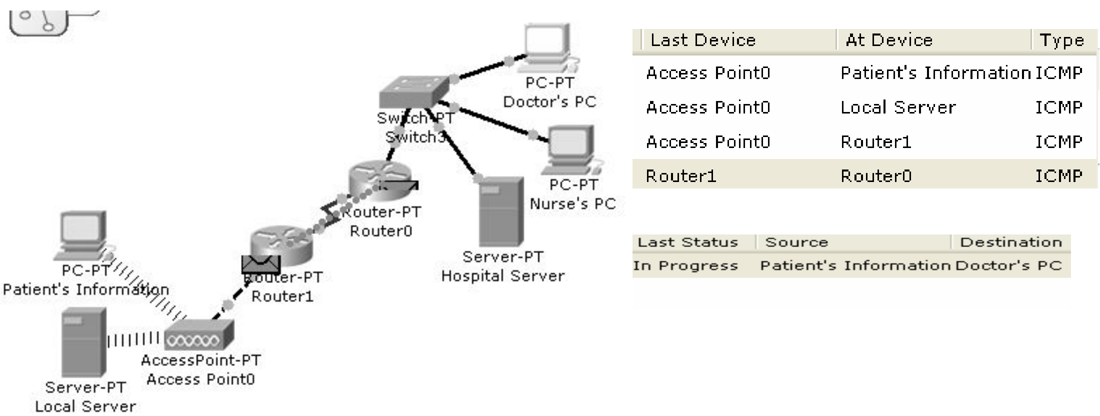


Fig. 3 Packet delivery in progress.

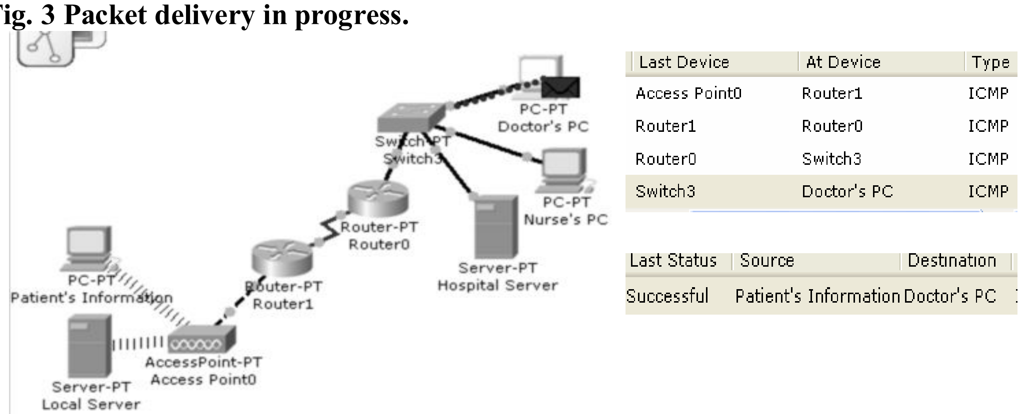


Fig. 4 Successful delivery of packet.

Finally, the packet was reached at the receiving end (in Fig. 4) successfully while the last status of the packet tracing was appeared successful.

4. Web-Page Interface and File Storage

The RPMSN is connected to the central server via a wireless network as seen in Fig.1. The RPMSN functions as a HTTP web-server which allows it to host webpages consisting of different multiplexed patient's information. It has a series of webpages that allows the vital instruments parameters' output to be viewed, especially ECG, patient picture, and other vital parameters as shown in Fig.5. Each webpage consists of a Common Gateway Interface (CGI) script that controls the vital parameters instrument to translate and display the real time or stored and forwarded data. A typical output of an ECG is viewed using the Webpage interface. Now one can able to reveal that doctor at the receiving end monitors the latest available patient's information appearing in the webpage interface that would be effectual and favorable for the patient which is consulted by the concern doctor.

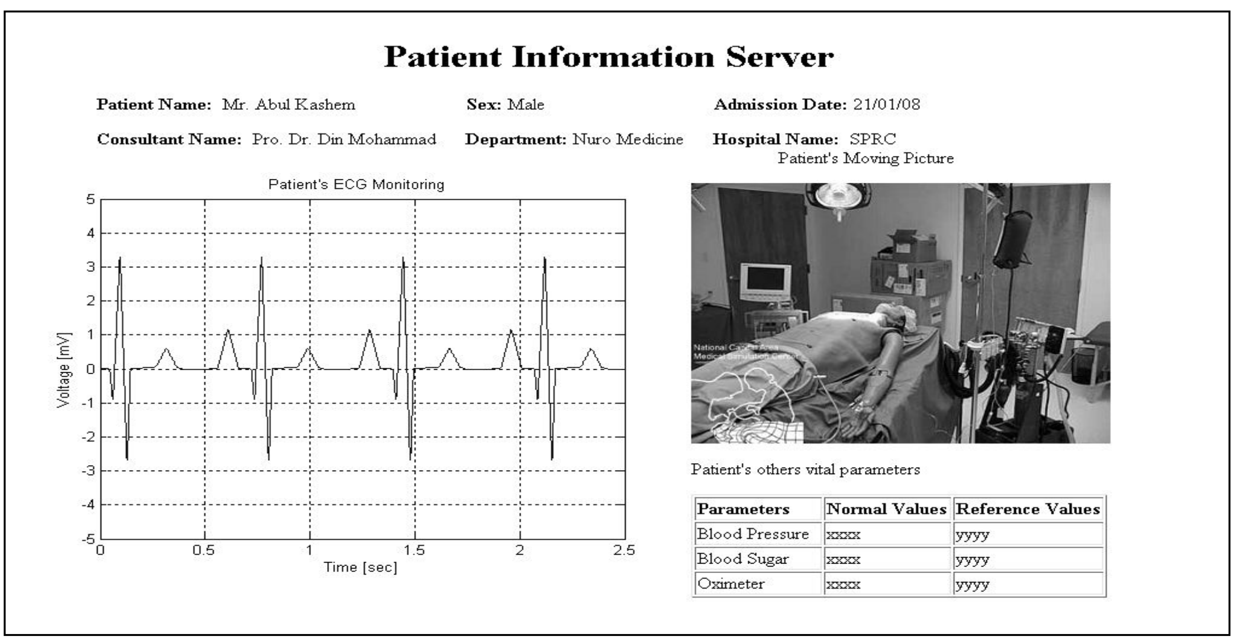


Fig. 5 HTTP Web-server

In or order to establish the situation demand of this network, Dynamic Host Configuration Protocol (DHCP) services can be used. Generally, there are two types of IP configuration services. One is Static and another one is Dynamic. Static services are assigned permanently for the users and difficult to get connected to the local server or gateway without changing the IP configuration. To remedy the situation, DHCP introduces the services for the wireless devices wherever the coverage appears. DHCP distributed addresses are not permanently assigned to hosts but are only leased for a period of time. If the host is powered down or taken off the network, the address is returned to the pool for reuse. This is especially helpful with mobile communication or GPRS users that come and go on a network. Users can freely move from location to location and re-establish network connections. The host can obtain an IP address once the hardware connection is made, either via a wired or wireless LAN. In moving vehicles, users get connected to the network from any places. During the moving places, if one changes the coverage of the switch or local gateway to anther switch or gateway, the connection will be made automatically by using the DHCP services.

DHCP makes it possible for us to access the Internet using wireless hotspots at any places. As we enter the area, our laptop DHCP client contacts the local DHCP server via a wireless connection. The DHCP server assigns an IP address to our laptop.

5. Conclusion

In this paper, we have presented the architecture of telemedicine system for remote patient either real time or stored and forwarded using *the prototype of Wireless LAN IEEE802.11* has been implemented. Vital parameters like ECG, patient moving picture, blood pressure, blood glucose level, pulse oximeter, or other vital signs are effectively transferred to a monitoring center enabling accurate diagnosis. In terms of requirements, the architecture of remote patient monitoring wireless network has been implemented by using the packet tracer version 4.01. A Common Gateway Interface (CGI) script that controls the vital parameters instrument to translate and display the real time or stored and forwarded data. The patient information and the transmitted data have been viewed locally or via the Web based on RPMSN. Here, especially off-line packet propagation (stored and forwarded) was implemented by using packet tracer software and real time packet propagation may be considered for future development.

6. References

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