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INTRODUCTION

REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

ACKNOWLEDGMENTS

REFERENCES

APPENDIX/ANNEXURE

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- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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COMPARISON AND ANALYSIS OF WIRELESS NETWORKS FOR HEALTH CARE TELEMONITORING SYSTEM

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ABSTRACT

The inconvenience of transportation frequently causes delay in health care for home-dwelling patients with chronic diseases, resulting in inequality of medical care. This paper proposes a Telemonitoring System (WiMAX Telemonitoring Service) framework for monitoring and delivering health care service to home-dwelling chronic hypertension patients, with the idea of improving the accessibility of medical care by utilizing the benefits of Internet to construct a ubiquitous health care environment. The study compared and analyzed three wireless Networks: WiMAX, WiFi and HSDPA, and found that WiMAX has the best performance regarding to stability as a long-distance health care delivery platform. A questionnaire survey in the hospital also revealed that the medical staff is highly recognized with telemedicine, which supports and serves as a reference for the designing of the telemonitoring system.

KEYWORDS

Telemonitoring service, WiMAX, WiFi.

INTRODUCTION

A brand new health caring model has been built up in recent years in Telehealthcare by measuring the physiological signals, such as, blood pressure, heartbeat, ECG (Electrocardiogram), blood sugar etc.[22] of those elderies or who has chronic diseases at home or in their familiar environment, in transferring the data as measured via internetwork to the medical caring institutes to build Personal healthcare database in computer & information system that healthcare professionals are able to monitor the variation of physiological data at any time and take hold of the patient's condition so that the Telehealth care can be achieved by convenient medical information as obtained[5].Since 1990, Internet technology has been vigorously developed from the early stage low speed dial-up modem to the nowadays high speed Broadband network with transmission technology progressing from wire line, ATM(Asynchronous Transfer Mode) , ADSL(Asymmetric Digital Subscriber Lines), Cable Modem, FTTH/B (Fiber to the Home/Building) as well as wireless network technology; The mobile communication network technology from earlier 1G (generation) analog to GSM (Global System for Mobile Communications) 2G digital technology to GPRS (General Packet Radio Services) 2.5G, the wireless communication has come to a new era. Followed by the development of 3G (WCDMA), 3.5G (HSDPA), 3.75G (HSUPA) activated the era of wireless broadband. The reveal of WiMAX (Worldwide Interoperability for Microwave Access) in 2006, i.e. new 4G wireless broadband technology[6], comes with ultra-high broadband and transmission distance based on IP (Internet Protocol) has defined QoS (Quality of Service) and high security as well as with TCP/IP (Transmission Control Protocol/Internet Protocol) as its primary communication protocol[23], the demand of basic transmission packets includes throughput, jitter, delay, packet loss etc. [7-11], the stability of internet signals which influences the quality of service due to the transmission media or other uncertain factors shall be the issue to study further.

Several already known terms related to Telehealthcare are: telemedicine, telehealth, telemonitoring, E-health, homecare and digital health, etc...Telemedicine means “the purpose to achieve consultancy or teletreatment in improving the patients’ health condition via electronic communication, internet or other network in the exchange of medical treatment information”[12-13]. The application of Telehealthcare is rather extensive but not limited to the clinical service, which could be the digital care of the patients’ website, monitoring the remote physiological condition or care call center etc... Via the technology of electronic communication or internet enable service provider in offering the health promoting activity to the service acceptors at home or nursing institutes. Tele-monitoring is one of the services of Telehealthcare, which provide the residents digital monitoring equipment in transferring their physiological condition for tele-monitoring, i.e. and integrated application of service by utilizing Information/ Communication Technology (ICT).

Wireline network transferring the signal via TCP/IP protocols uses doubled twisted wire, co-axial cable or optical fiber in transferring the signal to the clients’ computer[14][24]. The services provided by network could include information communication, video/ audio service [15], resource sharing and VoIP service etc...The reveal of wireless network has provided users more space without being confined in a limited space for connection, also provide more convenience and usability as that of the cable network. The challenge the wireless network facing is its wireless signal in transmission, where the transmission media in 3-D is confined by space, environment, distance and security with certain influences in utilization that the wireless network should think out of way in difference from the cable transmission to solve the confinement so as to provide suitable application and services, such as, the priority of packet transmission by speed or by accuracy, which is the range of QoS of wireless network should consider.

Where, a set of scheduling in algorithm is developed to solve this problem. The current mobile communication network and wireless network, such as 3G(WCDMA, CDMA-2000) 3.5G(HSDPA)、3.75G(HSUPA)、4G(WiMAX), is primarily the base type in cell structure[25]; where, the mobile devices users are facing the base interchange problem in mobilizing that the bases should "handover" to continue the signal in transmission[16][17]; for a connection of in homogeneous network, such as, WiMAX, WiFi, WiMAX and 3G, it is called vertical handover; While a transaction carried out Under the same network protocol is called horizontal handover; where, a handover algorithm is in processing to achieve the requirement in mobilizing [18-19].

METHODOLOGY

FIGURE 1: TELE MONITORING SYSTEM FRAMEWORK

One of the aims of the present paper is to design a Telemonitoring System (WiMAX Telemonitoring Services) framework (as shown in Fig.1)for blood-pressure monitoring, in which the Telemonitoring Server not only save the data including blood pressure and pulse but also provide a Web page as an information platform that end users can retrieve and view the data. The physiological data of blood pressure taken by an electric sphygmomanometer is first digitized and transmitted through the Telemonitoring gateway to the server and then saved for further retrieving. When all the components are connected, the process of data transmission in a Telemonitoring System framwork is as the following (as shown in Fig.2):

1) TELEMONITORING CLIENT

Step 1: The pressure signal sensed by the cuff fixed on the arm of the patient, and the readings of blood pressure and pulse are obtained through the working cycle of the electric sphygmomanometer.

Step 2: The electric sphygmomanometer upload the data via RS 232, and the data are transmited in digital form to the computer of Telemonitoring Gateway.

2) TELEMONITORING ACCESS NETWORK

Step 3: The computer of Telemonitoring Gateway upload the data via the mobility mode of the WiMAX IEEE 802.16e, and than in the fixed form through the IEEE 802.16d to the information plateform of the Telemonitoring Server computer, and save the data in its database.

Step 4: Once the data uploaded successfully, the user can retrieve those data through the WiMAX network to acquire the blood pressure record. This step is determined by the user (shown in Fig. 2 with the dotted line).

3) TELEMONITORING SERVER

Step 5: When abnormal blood pressure above the previously set threshold is noted, the surveillance manager of the information platform would call the family doctor in charge and send the abnormal data to his/her portable communication device immediately.

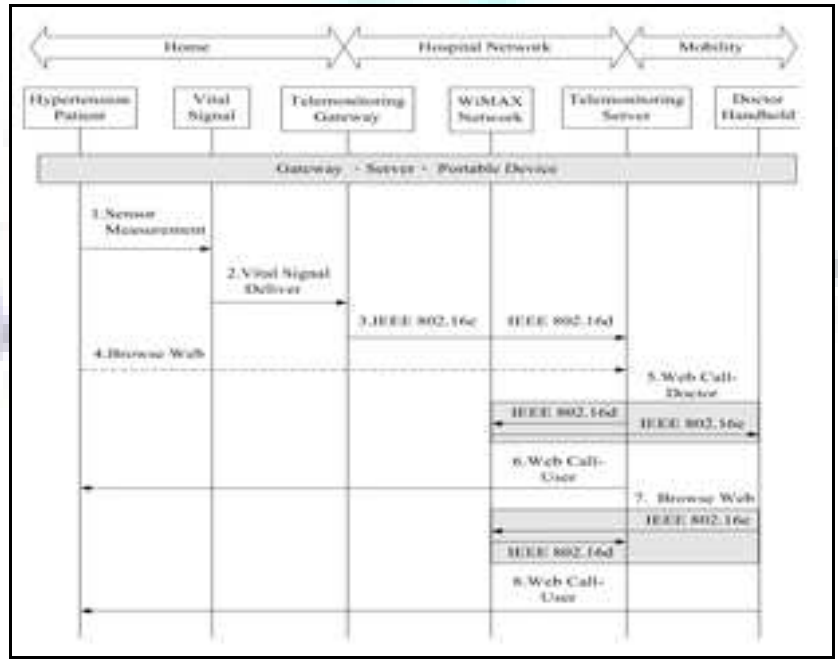
Step 6: The surveillance manager of the platform call the end user of the WiMAX netwrk to notify about starting of the responding mechanism.

4) TELEMONITORING WORKERS

Step 7: The family doctor acquires the client's physiological data by connecting his portable communication device to the WiMAX network.

Step 8: After viewing the client's physiological data on the portable device, the family doctor makes evaluates the condition and makes clinical decision, and calls back to the client to remind some health care points (such as rest, taking medications, or visiting the hospital, etc), or make an urgent call to the local home-care nurse to visit the client and initiate medical managements needed.

FIGURE 2: TELEMONITORING SYSTEM FLOW CHART



PERFORMANCE EVALUATION

WiMAX NETWORK SYSTEM

The hardware of WiMAX system consists of several blocks, the BS, access to service network and network administrating system, Network Topology (as shown in Fig.3) of WiMAX to the CPE equipment at client end, it is mainly in receiving wireless signal of Down-Link and sending Up-Link which is handled by the processor in access control layer of media and hardware accelerator. The function of access control layer in data processing of WiMAX BS media is the same as the CPE equipment at client end; but it is symmetrical to the user station in the system management, i.e. BS is ready to sent the broadcasting, while the client end is ready for receiving and interpreting the broadcasting information. As a BS would have to support multiple under that it is necessary to consider the expandability of hardware and the flexibility of software in design.

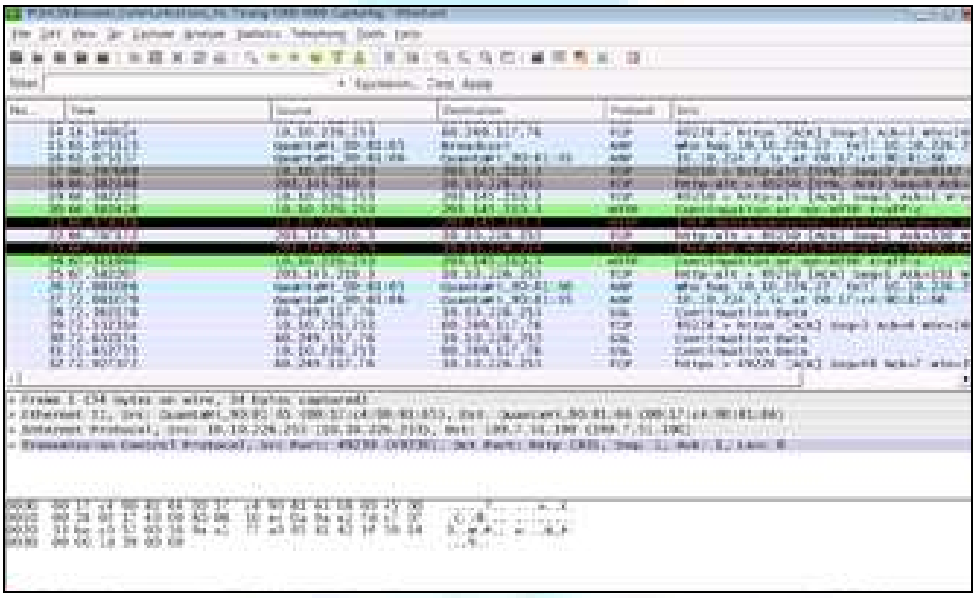
System starts up WiMAX wireless signal in connection to test the equipment of user's end (SS/MSS), including Notebook and WiMAX USB dongle CPE. After having connected CPE terminal device and BS successfully, note down every connecting parameters via operating interface, and starts up electronic sphygmomanometer in connecting with the PC in measuring successfully, finally transmits the data to the remote Web Server for storage that the web data on the information platform can be inquired via web browser.

Under the WiMAX basic architecture, the wireless signal transmission in cell network is primarily based on TCP/IP; where the digital signal was transformed into analog signal and added carrier wave and transformed into wireless signal for transmission. The wireless signal is transmitted in 4-D, which penetrates through the broadband media in air and challenge some certain factors, such as the barrier of large obstacles, code interference in multiple channel, frequency dispersion due to position moving (Doppler extension), noise and interference etc.; moreover, data packet missing when wireless channel traffic jam, false signal lagging, ACK compression and signal temporarily interrupted, etc…

There are many service functions provided on internet, where the applicable service layer transmits down to the lower layer under the restriction of parameters, it will packed up and transformed into TCP and UDP protocol, and finally transmitted out via data link layer to the real entity layer. The significant difference between TCP and UDP is that TCP protocol is reliable linking orientation which requires "3-directional handover procedure" regulation with mechanism of data transmission confirmation, it also uses Sliding Windows in transmitting data; while UDP protocol only send out the data packet.

The data as measured by electronic sphygmomanometer in this experiment has been transmitted via WiMAX wireless network, which uses packet retrieving program Wireshark (as shown in Fig.3), shows the data as measured by sphygmomanometer at receiving end where the packet was transmitted (Sending end IP: 10.10.226.253 , Receiving end IP: 203.145.210.3). Data packet in transmission: first the sending end uses HTTP protocol to transmit the packet to the receiving end. After packet has been received, the receiving end transmits TCP protocol to the sending end and confirms data received.

FIGURE 3: TRAFFIC PACKET CHART



THE METHOD OF EVALUATING PERFORMANCE

1). AVERAGE DELAY TIME

The time elapsed from wireless signal travel from sending end to the destination is called "delay time", which divided into 4 periods. Add up each period and sums up to total delay time.(a)Source processing delay: Time requires transforming the data processing at the sending end.(b)Propagation delay: The time elapsed for signal propagates through cable or wireless media.(c)Network delay: Time elapsed for signal transmitted in network.(d)Destination processing delay: Time required for signal arriving PC at destination end and transformed data.Where, parameter PacketArrivali is the time the ith packet arrived destination end;PacketStarti is the time the packet left source end; n is the total packets.

2). AVERAGE JITTER

In data network, jitter is a variable measurement criterion in passing a network within a certain period f time. When signal is in the transmission, it's shifting on time or phase will result in deviation and synchronic loss that influences the correctness of packet in arriving. Measuring jitter can determine the performance of network and stability of QoS. Calculate time elapsed of a (i+1)th packet arriving target end and leaving source end, and time of ith packet arriving target end and leaving source end, subtract both absolute values and sum up. n is the total packets.

3). PACKET LOSS OR CORRUPTION RATE

The reason of packet loss or damage has some occasions: when web traffic is large and exceeds the loading capacity of channel or network equipment, or circuit quality unstable in network will cause partial packets loss during transmission. The packet loss rate is an index to determine if network is in traffic jam. Parameter Lost Packet Size j is the jth packet lost; Packet Size i is the ith packet sent from source end. The meaning of formula: the ratio of packet lost in sum and the packet size sent from the source end in sum.

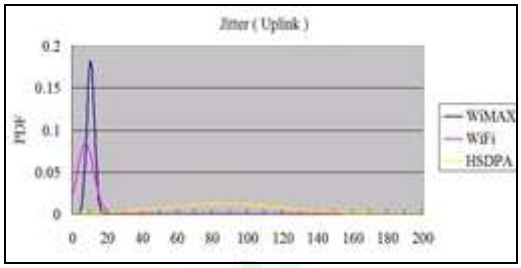
THE MEASUREMENT OF JITTER

1). UPLINK DATA PACKET IN MEASURING OF PDF

Various average values are calculated from the measurement of uplink jitter: WiMAX=10.3ms, WiFi=7.4ms, HSDPA=85.6ms, STD deviation: WiMAX=2.2ms、WiFi=4.7ms、HSDPA=32.4ms, put them into EXCEL calculating form and derive normal distribution curve of PDF (as shown in Fig. 5). The WiFi

data are located within 0~20ms, and concentrated at 7.4ms.WiMAX data are located within 6-16ms, and concentrated at 10.3ms. While, HSDPA data located within 10~170ms, and concentrated at 85.6ms. It is known that the performance of WiMAX and WiFi is the best; the jitter of HSDPA is the largest. The inferior performance of HSDPA in uplink throughput is the result of measurement.

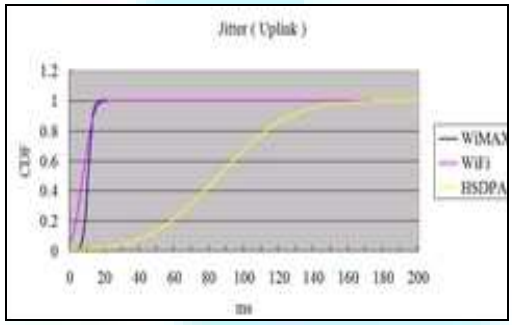
FIGURE 4: THE PDF CURVE OF JITTER UPLINK



2). UPLINK DATA PACKET IN DATA MEASURING CDF

Replace the uplink jitter as measured into EXCEL calculating form and calculate the accumulative distribution curve of CDF (as shown in Fig. 6), and found it is in reverse of PDF curve, which is drafted by total probability value within 0~1. It is found WiMAX data fall within 6~16ms; WiFi's figure fall within 0~20ms, and HSDPA's fall within 10~170ms. In comparison of graphs of the three, it is found WiMAX comes with the steepest slope, i.e. its jitter concentrated at a small range, with more stable performance than that of the WiFi and HSDPA.

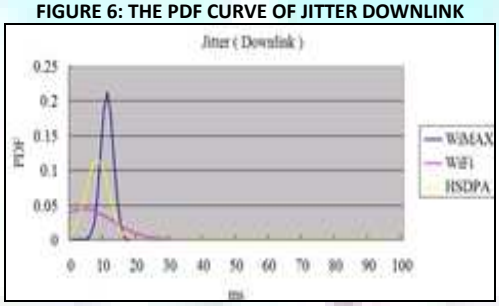
FIGURE 5 GRAPH OF JITTER UPLINK OF CDF



3). DOWNNLINK DATA PACKET IN MEASURING OF PDF

Various average values are calculated from the measurement of downlink jitter: WiMAX=11.0ms WiFi=3.8ms, HSDPA=8.1ms, STD deviation: WiMAX=1.9ms, WiFi=9.1ms, HSDPA=3.5ms put them into EXCEL calculating form and derive normal distribution curve of PDF (as shown in Fig. 7). It is found WiFi data located within 0~30ms, concentrated at 3.8ms; WiMAX's is within 8~16ms, concentrated at 11.0ms.The HSDPA data are located within 0~20ms, and concentrated at 8.1ms. It is known that the performance of WiMAX and HSDPA is the best; the jitter of WiFi is the largest. The inferior performance of WiFi in downlink decreases with the sending distance increasing.

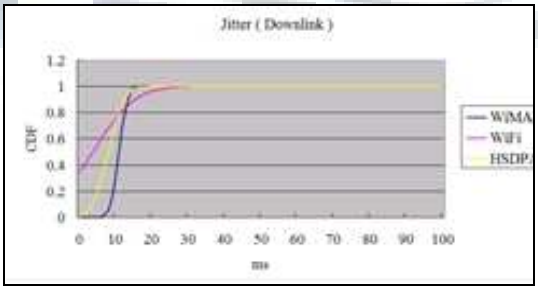
FIGURE 6: THE PDF CURVE OF JITTER DOWNLINK



4). DOWNLINK DATA PACKET IN MEASURING CDF

Replace the downlink jitter as measured into EXCEL calculating form and calculate the accumulative distribution curve of CDF (as shown in Fig. 8), and found it is in reverse of PDF curve, which is drafted by total probability value within 0~1. It is found WiMAX data fall within 8~16ms; WiFi's figure fall within 0~30ms, and HSDPA's fall within 0~20ms. In comparison of graphs of the three, it is found WiMAX comes with the steepest slope, i.e. its jitter concentrated at a small range, with more stable performance than that of the WiFi and HSDPA.

FIGURE 7: THE CDF CURVE OF JITTER DOWNLINK



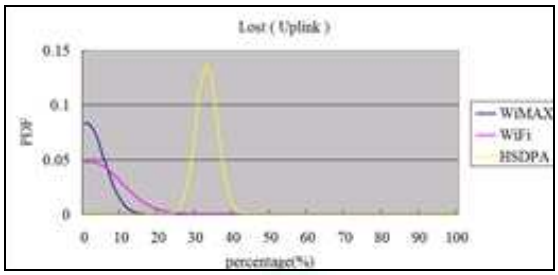
D. THE MEASUREMENT OF PACKET LOST RATE

1).UPLINK DATA PACKET IN MEASURING OF PDF

From the result of measuring uplink packet lost rate, various average values can be derived: iMAX=0.6%, WiFi=1.7%, HSDPA=32.9%, STD deviation : WiMAX=4.8%, WiFi=8.3%, HSDPA=2.9% normal distribution chart of PDF (as shown in Fig. 9).Data of WiFi located within 0~26%, which concentrated at 1.7%; WiMAX located within 0~14%, concentrated at 0.6%; HSDPA data located within 25~41%, concentrated at 32.9%. As all measurement is performed under the

same condition and parameters, it is known that WiMAX and WiFi have the optimal performance, HSDPA comes with the max. lost rate, the uplink throughput and jitter of HSDPA is the most inferior that its performance is fair.

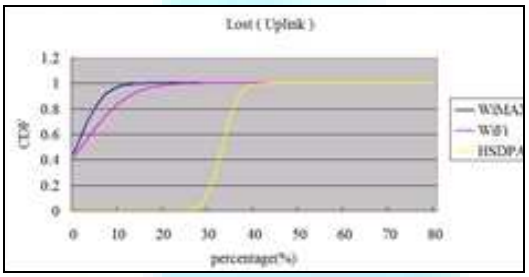
FIGURE 8: THE PDF CURVE OF LOST IN UPLINK



2). UPLINK DATA PACKET IN MEASURING CDF

Replace the lost rate as measured into EXCEL calculating form and obtain CDF accumulation distribution chart (as shown in Fig. 10) with the PDF in reverse, drafted based on the sum of probability value of 0~1. It is found WiMAX data fall within 0~14%; WiFi's figure fall within 0~26%, and HSDPA's fall within 25~41%.In comparison of graphs of the three, it is found WiMAX comes with the steepest slope, i.e. its lost rate concentrated at a small range, with more stable performance than that of the WiFi and HSDPA.

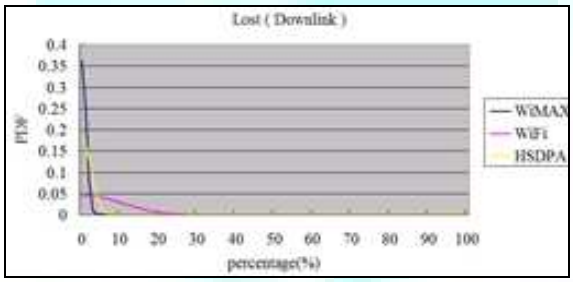
FIGURE 9: THE CDF CURVE OF LOST IN UPLINK



3). DOWNLINK DATA PACKET IN MEASURING OF PDF

From the result of measuring downlink packet lost rate, various average values can be derived: WiMAX=0.1%, WiFi=1.8%, HSDPA=0.2%, STD deviation: WiMAX=1.1% , WiFi=9.1% 、 HSDPA=2.2% , put them into EXCEL calculating form and obtained normal distribution chart of PDF (as shown in Fig. 11). WiFi's data fall between 0~26% with figure concentrated at 1.8%. WiMAX data fall between 0~4%, with figure concentrated at 0.1%. HSDPA data located within 0~8%, concentrated at 0.2%. The result has shown WiMAX and HSDPA comes with the optimal performance, the lost rate of WiFi is the largest, HSDPA downlink performance is better that lead to in reversed effect in uplink; while the performance of WiFi becomes inferior when sending distance increases.

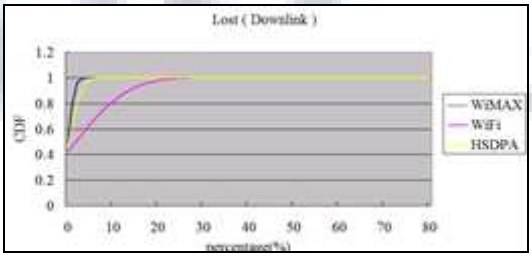
FIGURE 10: THE PDF CURVE OF LOST IN DOWNLINK



4). DOWNLINK DATA PACKET IN MEASURING CDF

Replace the lost rate as measured into EXCEL calculating form and obtain CDF accumulation distribution chart (as shown in Fig. 12) with the PDF in reverse, drafted based on the sum of probability value of 0~1.It is found WiMAX data fall within 0~4%; WiFi's figure fall within 0~26%, and HSDPA's fall within 0~8%.In comparison of graphs of the three, it is found WiMAX comes with the steepest slope, i.e. its lost rate concentrated at a small range, with more stable performance than that of the WiFi and HSDPA.

FIGURE 11: THE CDF CURVE OF LOST IN DOWNLINK



From the result of analyzing throughput of TCP and UDP, the comparable table of packet jitter and lost of WiFi 、 HSDPA and WiMAX has been established (as shown in Table 1); where, WiFi has been found to have sufficient performance in wireless LAN, as long as the distance away from the access point (AP) increasing, the total broadband will decrease; away from hot region of 100m, it is unable to connect.The performance of downlink of HSDPA in wireless wide area network comes with absolute advantage to that of the uplink; where, most mobile network activities are primarily browsing and downloading data which conform to the application of mobile mode. WiMAX being the new generation 4G wireless metropolitan network, it is found from the data measured, there are the same broadband width and performance on uplink and downlink, which can provide users dual work service in wireless connection, such as the application of mobile VoIP; it also comes with advantageous service of 3.5G mobile network of activities.

TABLE 1: COMPARISON TABLE OF WIMAX, WIFI AND HSDPA

Items	WiMAX	WiFi	HSDPA
TCP Throughput (Uplink)	Good	Excellent	Normal
TCP Throughput (Downlink)	Good	Excellent	Good
UDP Throughput (Uplink)	Good	Excellent	Normal
UDP Throughput (Downlink)	Good	Excellent	Good
Jitter (Uplink)	Good	Normal	Normal
Jitter (Downlink)	Good	Normal	Good
Lost (Uplink)	Excellent	Normal	Normal
Lost (Downlink)	Excellent	Normal	Good

CONCLUSIONS AND FUTURE WORK

This paper is to apply WiMAX wireless network in transmitting the measurement of electronic sphygmomanometer via home network gateway and WiMAX wireless network to the information platform on motoring server; where all the data as measured can be correctly stored at the Telemonitor Server so that patients, administrator and health care personnel can browse the blood pressure information on the internet.

Based on the characteristics of long distance transmission and high bandwidth of WiMAX, more medical treatment and video information can be transmitted in the remote health care project, such as 24 hrs ECG, blood sugar machine, blood oxygen monitor etc. They can help patients with heart disease, diabetic and breathing respire. Since WiMAX has sufficient bandwidth, the ECG monitor can transmit data 24 hours. The adding of video information application can provide more interaction as well. As to the promotion of health care project, using WiMAX wireless network as the transmitting station has the advantage of mobility and can let the user not to be limited to the cable network, but anytime, anywhere the network is ready to use. In the integration of wireless network, it can integrate both WiMAX and WiFi into the proxy for accessing indoor/outdoor transmission; both can help developing their advantages so that more wireless networks can be constructed.

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