WIRELESS COMMUNICATION FOR HOME CARE AND HOSPITAL INTENSIVE CARE

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MASTER OF SCIENCE

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ABSTRACT

Many emerging and existing medical applications can benefit from having continuous access to the patients vitals. This paper presents the results of a set of experiments conducted in a medical setting to determine the feasibility of using wireless communication in both home care and hospital intensive care environments.

The study is also done with the intention of developing a new wireless protocol for use in medical settings. This protocol will later be incorporated into different medical devices operating inside a patient room with a view that significant performance improvements should be observed.

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CHAPTER 1

INTRODUCTION

Most devices in hospitals use the 802.3 wired Ethernet standard for communication within a patient room and also within a hospital environment. We know that the reliability is much higher for wired connection. So, why are we thinking of using wireless communication? Even though wired connection is reliable, it does have quite a few significant disadvantages.

It can be very inconvenient and uncomfortable for the patient to have tons of wires around his bed and that can restrict proper mobility for the patient as well as the doctors and nurses. With wireless communication we can remove the cost of wiring. It will improve the interoperability of medical devices, if all devices do not have to be connected to each other using wires. And most importantly, using wireless communication will provide ubiquitous access to information within a hospital setting.

The objective of the experiments was to study several performance metrics of wireless communication in a hospital setting. The experiments were set-up on laptops employing open source wireless drivers. The different communication parameters measured were

1. Received Signal Strength Indicator (RSSI)
2. Average packet Propagation Delay
3. Packet Loss

The main scenario that motivates our work is in the hospital context. The aim is to provide wireless communication between the medical devices in the hospital, and a laptop. Electronic health records has enabled digital recording and storing of patient data. We performed experiments to see the performance of Wi-Fi communication over TCP/IP. The medical device continuously sends packet though Wi-Fi to the receiver laptop.

CHAPTER 2

ARCHITECTURE

We performed the experiments using two laptops where one acts as the transmitter and the other acts as the receiver.

Medical Data was constructed in the form of structures in the C programming language. We studied how it performs when both the laptops are static, and again when we moved the receiver around.

2.1 Static Receiver

The transmitter and receiver laptops are kept fixed in a particular position. It uses the traditional TCP over IP method of communication between the transmitter and the receiver, with the association of an access point.

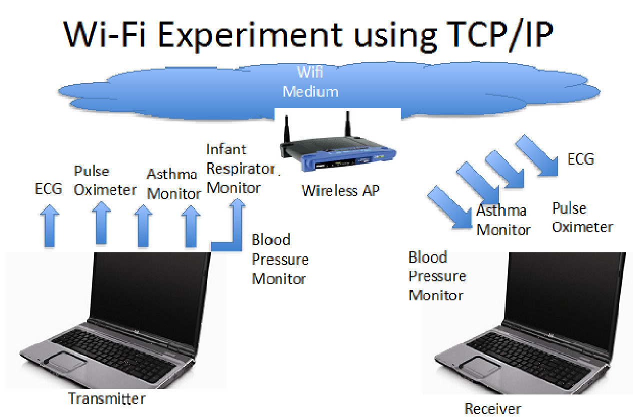

Figure 1. Static TCP/IP Experiment

2.2 Mobile Receiver

The transmitter was kept at a fixed position. But the receiver was mobile. This was done to test the performance when medical packets were forced to change their access points.

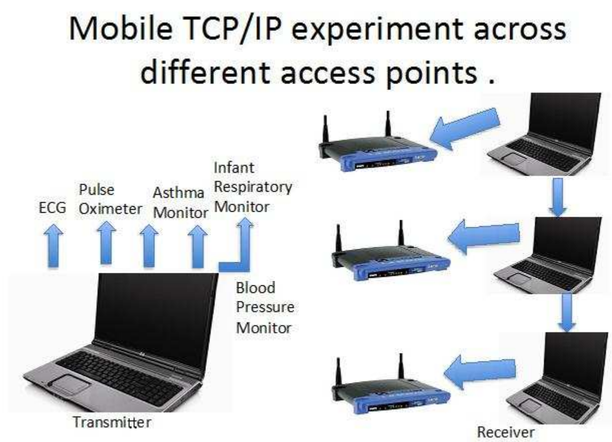

Figure 2. Mobile TCP/IP Experiment Across Different Access Points

CHAPTER 3

PERFORMANCE METRICS

Medical packets of different sizes were being transmitted for the experiments. The packets used were Fetal Heart Rate Monitor – 72 Bytes, Pulse Oximeter - 114 Bytes, Infant Respiratory Monitor - 56 Bytes, Self-Check Glucose Level Monitor – 54 Bytes and Asthma Monitor – 66 Bytes. Each medical packet before being transmitted was stamped with a unique sequence number, type of medical packet ("Pulse-Oxim", "Infant-Resp"), timestamp and other information if relevant.

We measured the following parameters to see how the wireless communication performed in different environments.

1. Packet Reception Ratio

Packet Reception Ratio was calculated as the ratio of the total received count to the last sequence number received

Example: Received packets are 1, 2, 3, 6, 7, 10(sequence numbers). Here Received Count = 6 and Last Sequence number received = 10. PRR = 6/10 = 0.6.

2. Received Signal Strength Indicator

Received Signal Strength or RSSI is a measure of the strength of the received radio signal. We have obtained it from the socket details while performing the experiments using TCP-IP. The higher the value, the stronger the signal is. The values are usually negative numbers, so smaller the number, higher is the signal strength.

3. Average Packet Propagation Delay

The delay per packet has been calculated using the formula

$$\frac{(T2` - T1) - (T2 - T1`)}{2}$$

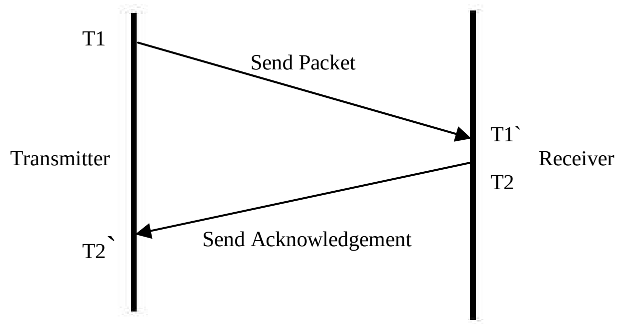

Figure 3. Average Propagation Delay Calculation Method

CHAPTER 4

EXPERIMENTS

Each of the experiments was performed in three different environments – at home, on the university campus, and in the hospital. The Figures 4, 5 and 6 show the variations in the recorded values depending on where the experiments were performed.

4.1 Static Receiver

Table 1 below, shows the values for Packet loss Ratio, Average Signal Strength and the average Propagation Delay for each of the three scenarios when the receiver is in a fixed position. It was observed that in the apartment high burst losses were absent throughout, which resulted in minimum packet loss. Since there was less queuing of packets, the average propagation delay was quite low.

In the university, high burst loss was low, but since there were other devices on the network, the packet loss was higher than that in the apartment.

In the hospital, since there were many access points, the packet loss was low, and there was very good signal strength.

Table 1. Results for Static Receiver

	Apartment	University	Hospital
Packet Reception Ratio	92.5%	92.7%	87.66%
Average Signal Strength	-49.7	-51	-47.68
Average Propagation Delay	7.6	13.6	83
Burst-Loss	Low	Low	Low

4.2 Mobile Receiver

Table 2 below shows the values for Packet loss Ratio, Average Signal Strength and the average Propagation Delay for each of the three scenarios when the receiver is mobile.

In the apartment, there wasn't much change in the packet loss, or signal strength. The performance was about the same as when the receiver was static.

In the university, packet loss was somewhat higher, because of the multiple access points, and some dead points where the device could not get a connection. The propagation delay fairly increased as a result of continuously changing access points.

At the hospital, some packets were lost because of switching between access points. But high burst loss was avoided because of the close proximity of the access points. There were several dead points when moving out of the vicinity of the access points, like when the patient is moved from one floor to another.

Table 2. Results for Mobile Receiver

	Apartment	University	Hospital
Packet Reception Ratio	90.39%	83.81%	82%
Average Signal Strength	-54.3	-45.6	-50.9
Average Propagation Delay	7.3	18.46	112.8
Burst-Loss	Low	Medium(Due to Dead spots)	Medium(Due to Dead spots)

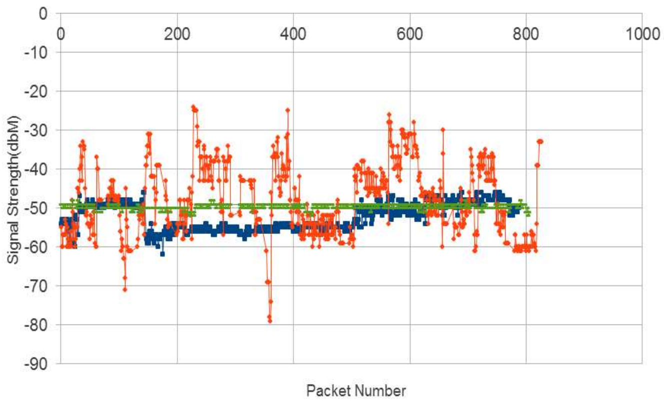

Figure 4. Comparison Of Signal Strength

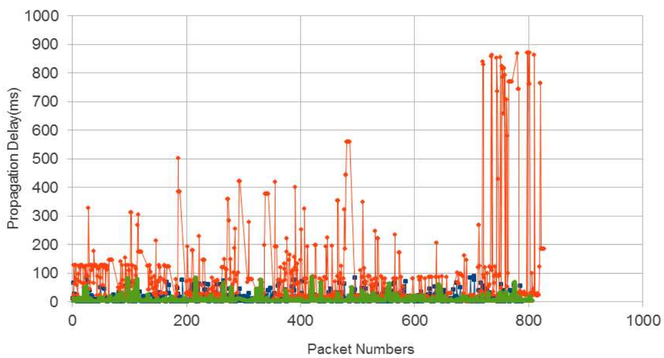

Figure 5. Comparison Of Propagation Delay

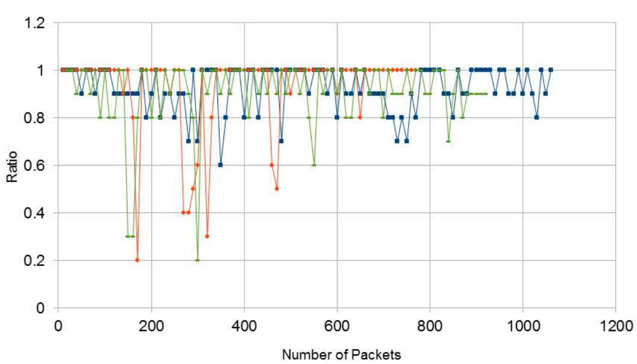

Figure 6. Comparison Of Ratio

CHAPTER 5

CONCLUSION

Wi-Fi over TCP/IP performs well in a hospital setting like Surgical Intensive Care patient rooms. And it can be used for patient care. For future work, a real-time networking solution can be built with real time requirements for efficient monitoring and treatment. Integrity would have to be maintained, because an incomplete dataset is of no use. Higher throughput would be required for audio and video.

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