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Congestion Control in Multi Channel 802.11b and 802.11g Wireless Networks

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Abstract. Wireless Networks are being deployed everywhere as an alternative to Wired Networks. Most of people configured wireless networks using default configurations, as a result they may not achieve maximum network performance. Selection of frequency channel-pattern and physically placement of Access Points are main reasons for poor network performance. In this research we experimentally analyzed the performance of wireless networks consisting of IEEE 802.11b/g devices by using both overlapping and non-overlapping frequency channels patterns. We concluded that better throughput can be achieved by using non-overlapping frequency channels-patterns.

1. Introduction

A WLAN consists of many mobile nodes communicate each other by using a mobile hub called Access Point. WLAN provides easy network access where network cables cannot work. Different IEEE network devices are available in market, but 802.11b and 802.11g are mostly used now a days. Most of network administrator configure access point by using default frequency channels. If a network have more than one access points, then they must configure access points by using different frequency channels-patterns. Tremendous growth and wide usage of IEEE 802.11 with increasing user access has raised issues like quality of service, channel interference, and network load management. [1]. Several aspects, such as the number of hops, number of channels, node/antenna placement, throughput and delay requirements, and other application demands will have an impact on the performance and cost of these networks [2]. Modeling the effect of multiple interferers is challenging as the interference level not only depends upon the number of interferers but also on their relative positions [3]. In IEEE 802.11b and 802.11g devices there are total 11 frequency channels-patterns. 1,6 and 11 are considered to be non-overlapping, in our research we configured WLAN with both non-overlapping and overlapping channels to compare the data transfer rates. We experimentally analyzed both TCP and UDP traffic using iperf and repeated readings 5 times. Results showed that better throughput can be achieved by using non-overlapping frequency channels and we showed how maximum available throughput can be achieved. We repeated our experiments with 802.11b and 802.11g standards in two different locations. The rest of paper is organized as follows. In section 2, we discuss the related work. Section 3 describes the experimental setup. Performance evaluation methodology is explained in section 4. The results obtained are described in section 5; we present our conclusion and discuss future work in section 6.

2. Related Work

Lee et al. (2002) [4] worked on the design of a wireless local area network (WLAN) and stated that maximum throughput can be achieved by determining the optimal placement of access points (APs) and assignment of channels to them. [4] proved that APs should be installed such that the sum of signal measured at each traffic demand point is maximized. AP placement should be carefully decided to maximize the throughput by considering load balancing among APs and channel interference for the user traffic demand. In his research, he proposed an approach of optimizing AP placement and channel assignment in WLANs by formulating an optimal integer linear programming (ILP) problem. Aki (2006) [1] worked on QOS and channel interference, he stated that Tremendous growth and wide usage of IEEE 802.11 with increasing user access has raised issues like quality of service, channel interference, and network load management. The increase in deployment of access points (APs) leads to co-channel interference from neighboring APs degrading the network throughput. Issues related to resource management and interference impedes the performance of WLANs. Frequency assignment is a major problem in designing wireless networks. All APs share the same frequency, which leads to interference that should be minimized and avoided if necessary, using efficient assignment of channels. Mishra et al. (2006) [5] worked on Interference created by overlapping frequency channels , he stated that Interference has always been considered as an unavoidable peril in wireless networks. A single data transmission is useful to some nodes and becomes interference to others. Based on channel of origin, interference can be categorized into co-channel (from transmissions on the same channel as the receiver) and adjacent-channel (transmissions on adjacent and overlapping channels). Murray et al. [6] presented a detailed performance study of a set of long-distance 802.11b links at various layers of the network stack, and documented the various non-obvious experiences during their research. They observed that at least one of the link to be robust to rain and fog, but any interference on the long-distance links can be decrimental to performance. (2010) [7] experimentally compares the performance of three different multi hop *ad hoc* network routing protocols.

3. Experimental Setup

We conducted our experiments on two d-link IEEE 802.11b/g access points, two d-link IEEE 802.11b/g wireless network cards and two same configuration IBM Think Pad T22 laptops. Laptops were equipped with IEEE 802.11 b/g PCMCIA wireless network cards on the each of them. In test-bed laptops were acting as receiving devices and access points were acting as transmitting devices. Each laptop was position at 7 feet from the access point. Both the access points and the laptops were placed 5 feet above the ground. We used Iperf tool to generate TCP and UDP packets at a desired rate and measured the throughput and response time. At first we conducted experiments in an indoor university class room and then conducted experiments on an open space. The test-bed for home wireless netowrk is shown in Fig. 1.

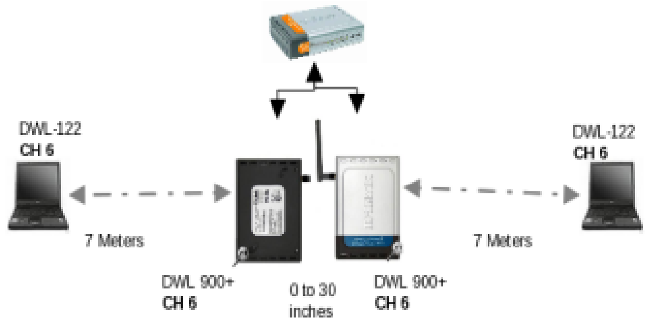

Fig. 1. Test Bed for Home Wireless Network.

4. Performance Evaluation Methodology

4.1. Performance Metrics

In our experiments we characterized the results on the basis of two metrics, Throughput and Response time. We measured the effect on the above mentioned metrics by varying the following factors:

- Antenna Separation: Antenna Distance 0, 10, 20 and 30 inches.
- Transmit power: Transmit Power, Full, Half and Minimum.
- TCP Windows Size: Window Size 50K to 1000K at interval of 50K.
- UDP Buffer Size: Buffer Size 400K to 1065K at interval of 35K.

4.2. Experiment Methodology

In our research, we used two sets of experiments, details are given in Table 1.

Table 1. Frequency Channel Scheme

Node1	AP1	AP2	Node2	Overlapping Channel (1-1-1-1)
Node1	AP1	AP2	Node2	Non-Overlapping Channel (1-6-11-1)

Here node1 and node2 are IBM laptops and AP1 and AP2 are access points.

4.3. Iperf Syntaxes

In our experiments we used iperf tool. The syntaxes of iperf used in research is given as under. Iperf commands at data receiver laptop.

- iperf s D w 50K
- iperf s D w 500K
- iperf s D w 5000K
- iperf s D n 10M w [50K-1000K]
- iperf s D w 500K u b 11M—54M l 5000
- iperf s D w 500K u b 11M—54M l 10000
- iperf s D w 500K u b 11M—54M l 15000
- iperf s D w 100K u b 11M—54M n 10M l [400-1065]

Iperf commands at data sender laptop.

- iperf c ms-client1 w 50K t 100 i 1
- iperf c ms-client1 w 500K t 100 i 1
- iperf c ms-client1 w 5000K t 100 i 1
- iperf c ms-client1 n 10M w [50K-1000K]
- iperf c ms-client1 u b 11M—54M w 50K l 5000 t 100 i 1
- iperf c ms-client1 u b 11M—54M w 50K l 10000 t 100 i 1
- iperf c ms-client1 u b 11M—54M w 50K l 15000 t 100 i 1
- iperf c ms-client1 w 100K u b 11M—54M n 10M l [400-1065]

First of all we arranged laptops on a table in such a way that there was 0 inch distance between the antennas of two access points. We configured access points by different combinations of non-overlapping frequency channels, then we configured the transmission power to full, we used three transmit power combinations (Full, Half and Minimum). At each transmission power combination, we measured the throughput and response time of TCP and UDP by changing TCP window size and UDP buffer size respectively. Then we repeated the above measurements by configuring access point with overlapping frequency channels (same frequency channels). Then we arranged the laptops at 10, 20 and 30 inches and repeated the above whole process. At the end we got a large number of data. It was very difficult for us to manage such a huge data manually, so we decided to use Statistical tool SPSS, that helps us very much. Firstly we put all the data in MS Excel then copied all data in SPSS and managed the data with different techniques.

5. Experimental Results

In multi access point network, two network access points were used for throughput measurements. The two access points were place very close to each other, and the distance was increased in inches, measurement were done by 0, 10, 20 and 30 inches distance between antennas of two APs. Two APs were connected by a network switch. Two client laptops were connected to appropriate APs. The distance between AP and client laptop was 7 meters. Traffic was generated between laptops by iperf and ping tools. During experiments interference APs configured with channel 6 were presented. The summary was divided into three factors, distance, frequency channel and TCP windows size. The detail of theses factors are given as under.

5.1. Distance between Antennas of two APs

Better throughput was achieved in (6-1-11-6) frequency case in both 802.11b and 802.11g standards. That means using non-overlapping frequency channels, we can achieve more bandwidth. The graph showed that overall high TCP Throughput was achieved by using non-overlapping frequency scheme in both 802.11b and 802.11g as shown in Fig. 2.

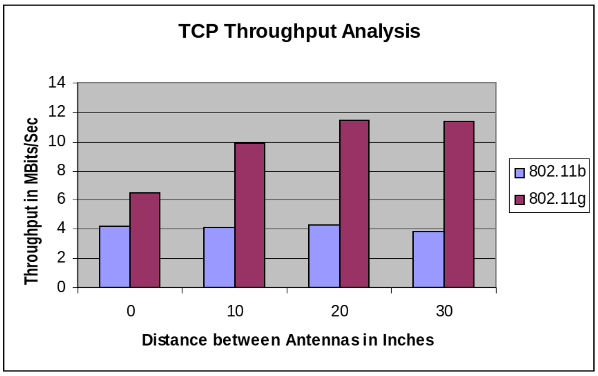

Fig. 2. Overall TCP Throughput Analysis, by Distance.

By using 802.11g devices, UDP throughput was increased with the increment in distance between antennas. But by using 802.11b devices, minute change in performance was noticed as shown in Figure 3.

5.2. Frequency-Channel-Schemes of APs

Big variation in throughputs of 802.11b and 802.11g was notices as shown in Figures 4 and 5. Less response time noted when using non-overlapping frequency channels which showed good performance.

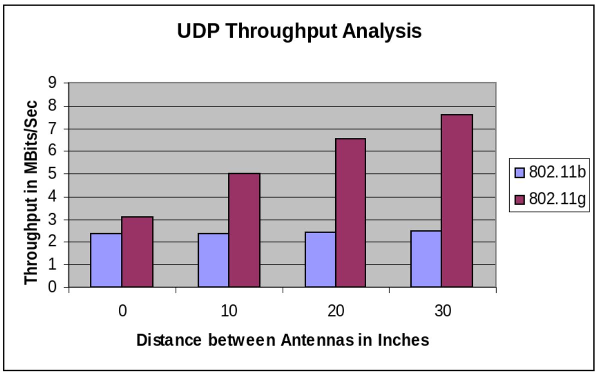

Fig. 3. Overall UDP Throughput Analysis, By Distance.

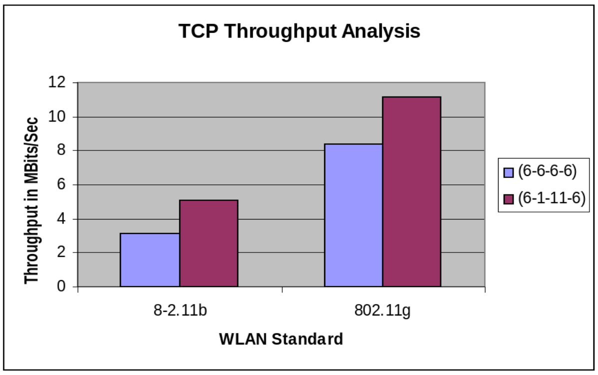

Fig. 4. Overall TCP Throughput Analysis, By Frequency Channel.

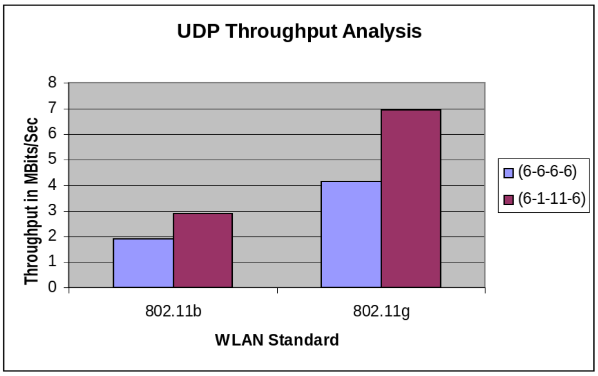

Fig. 5. Overall UDP Throughput Analysis, By Frequency Channel.

5.3. TCP Window Size of Packets used in Transmission

In 802.11b standard no clear change was noticed by changing TCP window size, but in 802.11g standard a minute change was seen as shown in Figure 6.

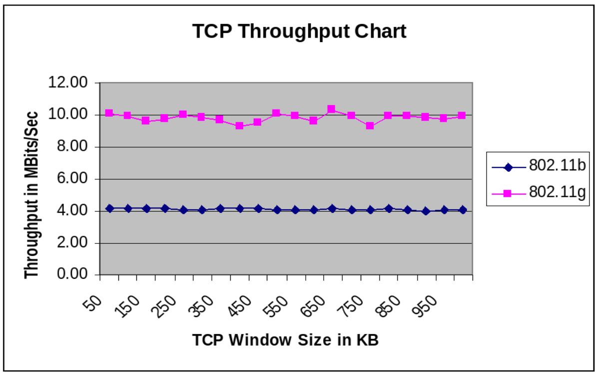

Fig. 6. Overall TCP Throughput Chart, By TCP Window Size.

Throughput increased with the increment in datagram size in both 802.11b and 802.11g devices. More data variation was seen in 802.11g devices, as shown in Figure 7.

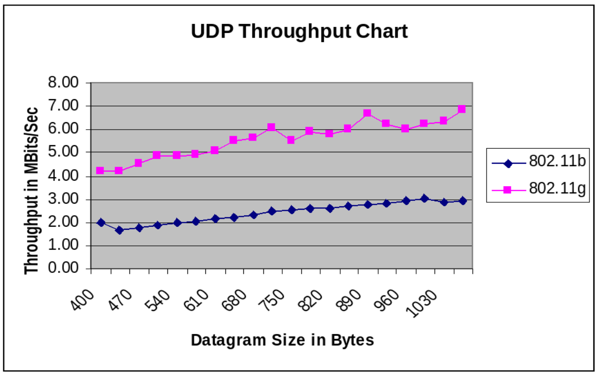

Fig. 7. Overall UDP Throughput Analysis, By Datagram Size.

6. Case Study: Bandwidth Requirements of Medical Applications with Critical Data and high flux

The applications related to medical informatics, appliances, and apparatus generate sensitive and critical data related to the patients, environment, and about their own self. Then these devices are connected to each other or accessed remotely, it is important that the data that is exchanged to/from these devices is reliable. In the low cost medical diagnosis project at Qatar University, we seek out motivation from dramatic rise in the number of people with illnesses and high costs associated with managing and treating them two mission-critical schemes should be enforced without delay to ensure that low-cost and qualitative health services can be delivered to Qatar. Firstly, the usual hospital-based healthcare should be transformed to personal-based healthcare, which encourages the participation of the whole nation for the prevention of illnesses or early prediction of diseases. Secondly, cutting-edge technologies have to be developed with the aim of reducing medical costs in the following aspects:

- Innovative & low-cost medical device without professional involvements.
- Precise and reliable automatic diagnosis system to avoid unnecessary clinical visits and medical tests.
- Telecommunication technologies to support caregivers in remote accessing and diagnosing the patients status.

Bearing in mind the above mentioned facts, a comprehensive solution is proposed which comprises of wearable and WBAN-based health monitoring system, automatic diagnosis system and wireless application protocol (WAP) based telemedicine system. In our experiments, we experience records in excess of 500,000 for an Electrocardiography (ECG) WBAN device. The processing and transfer of this much context over a wireless link is prone to errors, congestion, and packet loss. Through this research mentioned above, we could evaluate the wireless technologies at disposal for inclusion in the prototype of our project.

7. Conclusion and Future Work

Most of the research has been done on TCP traffic only, but we worked in both TCP and UDF traffic and achieved the maximum available throughput using non-overlapping frequency channel patterns by changing in distance among access pints, transmit power. Overall high throughput was achieved in both 802.11b and 802.11g standards by using TCP and UDP traffic generated by iperf when the APs were configured with non-overlapping frequency channels. In research different parameters were used like distance, antennas transmit power, TCP window size, UDP datagram size, frequency channels. Different experiments were conducted by using different frequency channels schemes. But a high result was achieved by using non-overlapping frequency channels only. In future researchers can conduct experiments by using 802.11n standard. They can make comparison among 802.11n, 802.11b and 802.11g standards. They can use more combinations of frequency channels as 802.11a have more non-overlapping frequency channels as compared to 802.11b and 802.11g.

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References

[1] Aki R., Arepally A., *Dynamic Channel Assignment in 802.11 Networks. Portable Information Devices*, 2007. PORTABLE07. IEEE International Conference , pp. 1–5, IEEE.

[2] Liese S., Wu D., Mohapatra P. (n.d.), *Experimental Characterization of an 802.11b Wireless Mesh Network*, Science, pp. 1–11.

[3] Brook S. (n.d.), *Characterizing Interference in 802.11-based Wireless Mesh Networks. Evaluation.*

[4] Lee Y., Kim K., Choi Y., *Optimization of AP placement and channel assignment in wireless LANs*, 27th Annual IEEE Conference on Local Computer Networks, 2002, Proceedings LCN 2002, pp. 831–836. IEEE Comput. Soc. doi:10.1109/LCN.2002.1181869.

[5] Mishra A., Banerjee S., Arbaugh W., *Weighted coloring based channel assignment for WLANs*, ACM SIGMOBILE Mobile Computing and Communications Review, vol. **9**, pp. 19–31, 2005.

[6] Chebrolu K., *Performance Measurements and Experience*, Media, pp. 74–85, 2006.

[7] Murray D., Dixon M., Koziniec T., *An Experimental Comparison of Routing Protocols in Multi Hop Ad Hoc Networks*, Networks, pp. 159–164, 2010.