

Performance Evaluation of 802.11 Mobility and Interference Issues

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Abstract. This paper deals with the performance evaluation of 802.11 mobility when the mobile nodes roam between access points and also on the interference issues when the adjacent channel frequencies are the same. In the simulations done, two infrastructure wireless networks were used for mobility study, where the nodes roam to both sides and the throughput graph is drawn. Two ad hoc wireless networks were also used for interference study, where the nodes move and overlap in channel frequency and the delay graph was noted. Existing simulation models were used to come up with the performance graphs in this study.

Keywords: 802.11 mobility, roaming, channel interference, throughput measurement

1. Introduction

In the recent years, wireless networks are getting more attention and are becoming popular. With the advent of 802.11g standard that supports up to 54 Mbps or more and with the precipitous drop in wireless local area network (WLAN) hardware price, ubiquitous computing is becoming a reality. Though there are other wireless technologies like Bluetooth, broadband wireless access and 3G networks, they are not experiencing the rapid growth of 802.11. The main impetus for 802.11 products is the wireless networking at home, in the office and the WiFi public hotspots. The wireless spectrums allocated for 802.11 are around 2.4 GHz and 5GHz bands. The 2.400 to 2.485 GHz band is available in many countries. The 5.15 to 5.35 GHz and 5.725 to 5.825 GHz are available in U.S, Japan and Europe. The rest of the paper is organized as follows. Section 2 s on WLAN roaming and interference, section 3 is on simulations and results and section 4 is the conclusion.

2. WLAN Roaming and Interference Issues

When a mobile node moves from the range of one Access Point (AP) to another in the same subnet, it needs to find the best AP, decide when to roam onto it, associate with it and do any authentication required, as per the security policies. Then the wired network has to re-learn the location of the client, so that data can be sent to it. All of this takes time and there are various delays associated with it. The scanning and decision making part of the roaming process allows the client to find a new AP on an appropriate channel as the user moves. When this happens, the client must associate with the new AP. It must then, reauthenticate with the authentication server. These steps are transparent to the user – but the delay in this happening may not be. During roaming, as the mobile node moves from one access point to another, handoff happens. Handoff delay measured for different client wireless adapter and access points from different vendors as per [1] and [2] and we can find the average delay values to be as follows: Average probe delay = 238.52 ms; Average authentication delay = 2.12 ms; Average reassociation delay = 3.25 ms. It clearly shows that probe delay is the biggest of all delays. It is well known that for running multimedia applications in a wireless network effectively, the average handoff delay should be less than 50 ms.

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Signal interference happens when two radio signals are transmitted on the same frequency at the same time. Interference can occur if the two or more simultaneous signals have similar relative transmit power, in which case they will likely mutually interfere, or if one signal has relatively greater power, in which case the weaker signal will suffer interference from the stronger. Interference from other WLANs is typically co-channel interference, usually between two access points on the same channel, or adjacent-channel interference resulting from two access points operating on abutting or overlapping channels. Since WLANs employ a “listen-before-talk” protocol, based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), any interference between WLAN networks tends to work out somewhat cooperatively, with the two networks often sharing channel capacity [1]-[3].

3. Simulation Performed

3.1. 802.11 mobility with roaming node

The network simulations were performed with already existing software simulation models in ns-2, OPNET etc. So there is nothing new with the simulation results in this paper, other than the understanding we gained on how wireless roaming is performed in terms of throughput and how channel interference can increase delay or response time. Various related works on performance comparisons and roaming of WLAN can be found in [6]-[12].

In the first scenario, we wanted to study on the roaming capability of wireless node between access points in an infrastructure network. The network had eleven nodes including the two access points (AP 1 and AP 2), which were not connected to each other. Hence they formed independent basic service sets. There were four nodes on the left and five on the right excluding the access points. There are also two target nodes on the right side – Target 1 and Target 2, to which the nodes on left and right are sending traffic. Refer to table I for selected simulation parameters.

Table I. Network roaming simulation parameters

Simulation parameters	Value
Traffic Generation_start time (sec)	uniform (0.02, 0.0203)
Traffic Generation_ON state time (sec)	constant (3600)
Traffic Generation_OFF state time (sec)	constant (0)
Packet Generation_Inter arrival time (sec)	exponential (0.1)
Packet size (bytes)	normal (1024, 10000)
Physical Characteristics	Direct sequence
Data rate (bps)	2 Mbps (for left and right BSS)
Transmit power (W)	0.005
Packet reception – Power threshold (dBm)	-95

The nodes have roaming capability except the access points so that they can connect to a better AP when the signal quality with their current AP falls below the acceptable signal threshold level. As the source and destination nodes are connected to different disconnected access points, in the initial positions, the traffic sent by nodes on left cannot reach Target 1. Around 15 seconds the left nodes start moving to the right and reaches by 50 seconds, wherein they would get disconnected from AP 1 and gets connected to AP 2. Thus AP 1 traffic drops and traffic in AP 2 doubles. As a result of this movement, Target 1 also starts recording throughput since now it receives traffic from its sources successfully, which are connected to the same AP. Refer to figure 1 and figure 2. During the period from 55 seconds to 75 seconds, the nodes on right would traverse to the left. This causes AP 1 traffic to spike and AP 2 traffic to drop. In a like manner traffic drops at Target 1 also as its source of traffic moves away. Target 2 also moves together with its sources. The results show a sharp drop in the throughput around 65 seconds, which is the period when it and its sources leave AP 2, scan for a new AP, and eventually find and select AP 1.

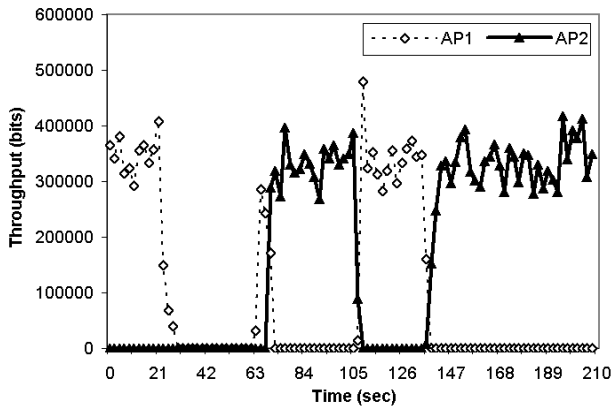


Fig. 1: Throughput of Access Point 1 and Access Point 2

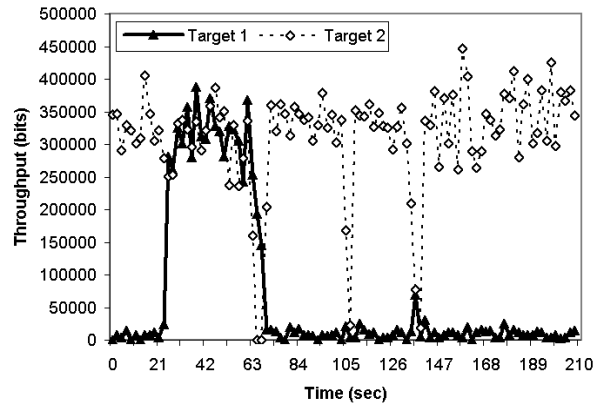


Fig. 2: Throughput of Target 1 and Target 2 nodes

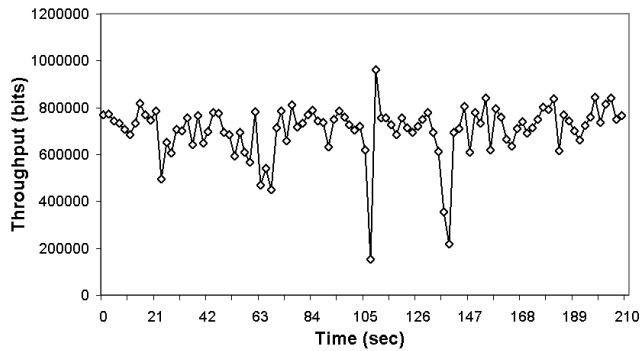


Fig. 3: Global or Overall throughput of Wireless networks

Between 90 and 150 seconds, the APs start moving and nodes are stationary. Thus nodes are handed over between the APs during this period causing temporary communication losses which appear as sharp drops in global/overall throughput and Target 2 throughput around 100 and 145 seconds. Towards the end of the same transient moments of APs movement, a small amount of throughput is also recorded at Target 1 for short periods of time, as Target 1 and its traffic sources are associated with the same AP for a very short time while APs are traversing their trajectory path. Figure 3 shows the effective throughput of the wireless network.

3.2. 802.11 Interference Issues

The second scenario studies the impact of the interference between two ad-hoc wireless networks when some specific application traffic is flowing in these networks. Related works on performance comparisons of WLAN can be found in [13]-[14]. Refer to table II for selected simulation parameters.

The network contains two WLAN IBSSs (Independent Basic Service Sets), BSS_Left and BSS_Right. Each network has some traffic generated through four FTP clients performing frequent upload operations on an FTP server. The WLAN data rate is configured as 2 Mbps in BSS_Left and as 5.5 Mbps in BSS_Right. BSS_Left uses channel 1 and BSS_Right uses channel 6 and their frequencies overlap. Since these channels overlap with each other, the two IBSSs interfere each other, which become critical when the distance between the two networks gets smaller. The nodes of BSS_Left move along their trajectory. They pause at the beginning and in the middle, and they complete their movement before the end of the simulation. When they pause in the middle for two minutes, the two IBSSs become on top of each other, and their nodes practically reside in the same geographical location. Due to movement of BSS 1 and change of distance between two IBSSs, the impact of the interference is also expected to vary proportionally as a function of the distance.

Table II. Network Interference simulation parameters

Simulation parameters	Value
Application	Heavy FTP
Application_start time (sec)	uniform (90, 100)
Application_Inter repetition time (sec)	exponential (300)
Packet size (bytes)	normal (1024, 10000)
Physical Characteristics	Direct sequence
Data rate (bps)	1 Mbps on left BSS and 5.5 Mbps on right BSS
Transmit power (W)	0.005
Packet reception – Power threshold (dBm)	-95

Since the workstations in BSS_Right are further to their server compared to distance between the workstations of BSS_Left and their server, the interference is expected to have a larger negative impact on application traffic in BSS_Right. Additionally, the higher data rate used in BSS_Right (5.5 Mbps versus 1 Mbps) makes its transmissions also less robust against the interference because of the lower processing gain.

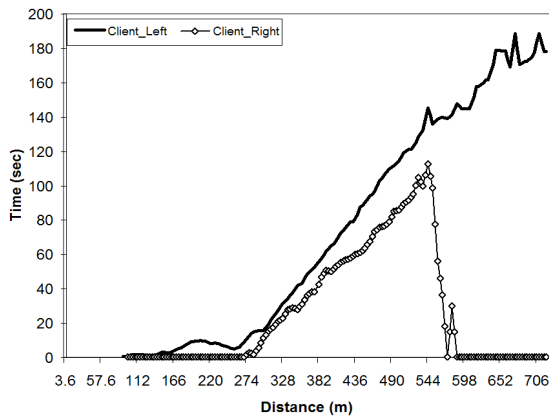


Fig. 4: FTP upload delay in clients on left and right BSS

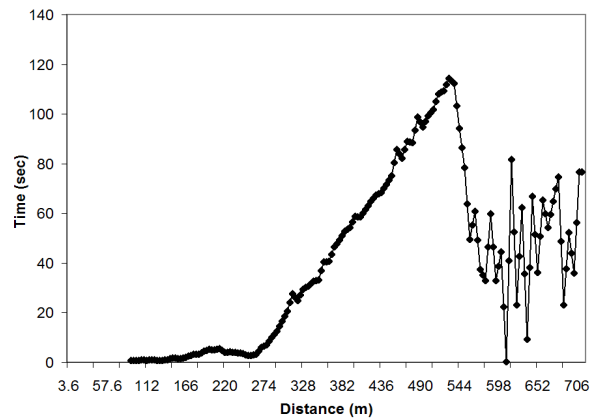


Fig. 5: Overall FTP upload delay in WLAN network

Refer to figure 4. It shows the FTP upload response time observed by clients in BSS_Right: This graph clearly indicates the negative effects of interference on application traffic for these clients. When the IBSSs are far from each other, the interference is low and FTP uploads take around 0.3 second. On the other hand, while two IBSSs are on top of each other, interference is high and the uploads take around multiples of ten seconds. When the distance between two IBSSs is in a certain range, the application observes very high response times. At this critical distance, the interference is strong enough to cause bit errors, but not strong enough to be sensed by the WLAN MAC. Hence, unaware of the existing interference, MAC performs transmissions, which are not successfully received by the destination node due to bit errors, causing high number of retransmissions and very high end-to-end delays. When the IBSSs are closer, then the interference is stronger and can be sensed by the MAC's receiver as noise. So it can defer the transmissions during high interference and prevent transmission failures and retransmissions. Though, the delays are still higher compared to very low interference because more time spent while deferring before each transmission. Refer to figure 4 again. It shows the FTP upload response time observed by clients in BSS_Left. During low interference, upload response times are higher compared to BSS_Right client because of low data rate used. The application performance is negatively affected by the high interference, but worst case values are not as high as BSS_Right client as expected. The graph in figure 5 summarizes the relation between the neighbor-BSS-interference (i.e. distance) and the application performance. The initial part looks fine as there is no interference. The delays are higher when the LANs are close to each other and then the interference is high.

4. Conclusion

The study of 802.11 wireless networks was conducted with respect to roaming and interference issues. As the wireless node roams from once access point to the other as tested in infrastructure networks, handoff has to happen and packets would be dropped as the node changes connection from the current access point to the new one. These lost packets would be retransmitted if needed. The adjacent channel interference can also affect the throughput and upload response time as tested in ad-hoc networks, as packets would be lost and re-transmissions would increase.

5. References

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