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LULEÅ TEKNISKA UNIVERSITET

Department of Computer Science, Electrical and Space Engineering

D7030E: Advanced Wireless Networks

Lab 3: Measuring the performance of an ad-hoc network

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Scenario 1 – The effect of signal attenuation on communication ranges in Wi-Fi networks

In this exercise you will explore multi-hop transmission in Ad Hoc network for different number of hops (Figure1). The IEEE 802.11 ad hoc mode (also known as independent basic service set, IBSS) should be used. During all experiments node(0) is a transmitter, the last node is a receiver. You have to measure the average throughput over time.

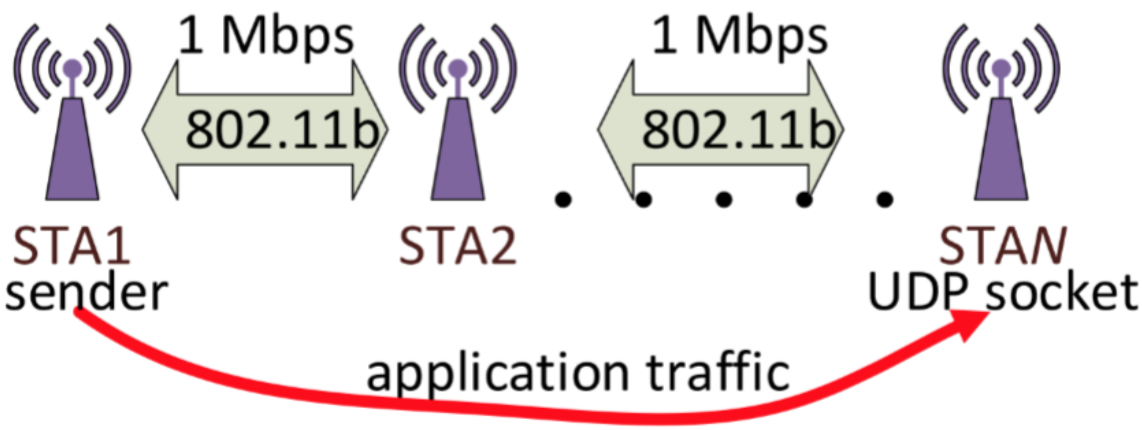

Figure 1. Topology for Scenario

Tasks:

1. Based on your experience from previous Labs fill in missed parts for the Ad hoc scenario. Use the following settings:

- Physical mode is "DsssRate1Mbps"
- Use "ns3::ConstantRateWifiManager" for keeping bit rate constant
- The MAC settings should be set to agree with the IEEE 802.11b specification.
- Use the Two-Ray Ground propagation model
- Place nodes in a line in such a way that only adjacent stations can hear each other. Keep 200m distance between nodes.
- Always open the socket on the last station
- Always install onOff application on the first station
- Enable routing between stations

2. Simulate scenario for different numbers of stations [3, 4, 5,6].
3. Also vary the UDP payload in the range {300B, 700B, 1200B}.
4. For EACH number of stations from the range run experiment with EVERY packet size. Calculate an application-level throughput in bits per second.

The following table shows the application throughput for all scenarios – no. of stations (3, 4, 5, 6) & payload size (300B, 700B, 1200B). Where:

Total throughput (kb/s): is the data rate shown in the .pcap file at the receiver side.

Application Throughput (kb/s): is the application layer throughput.

$$Application\ Throughput = \frac{total\ throughput * payload\ size}{2 * (Payload\ size + header\ size)}$$

header size for UDP traffic = 64 bytes.

Table 1. Readings for UDP payload scenario with different no. of stations and payload size

No. of Ad-hoc Stations	UDP payload size (B)	Total Throughput (kb/s)	Application Throughput (kb/s)
3	300	233	192.032967
	700	260	238.2198953
	1200	291	276.2658228
4	300	147	121.1538462
	700	199	182.3298429
	1200	170	161.3924051
5	300	69	56.86813187
	700	115	105.3664921
	1200	124	117.721519
6	300	71	58.51648352
	700	80	73.29842932
	1200	115	109.1772152

5. Plot graphs showing the dependency of the throughput versus packet size for each number of stations.

The following graph shows the application throughout vs the packet size for each no. of stations:

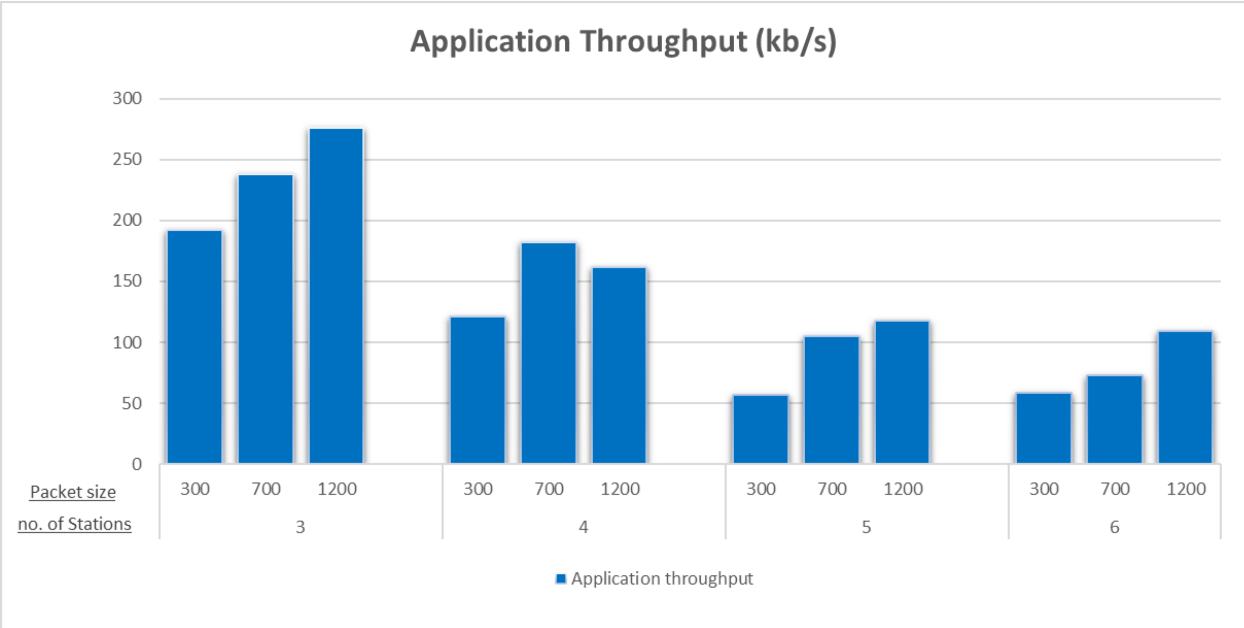

Figure 2. Application Throughput for each scenario

6. Plot a graph showing the dependency of the throughput versus the number of stations for packet size 1200B.

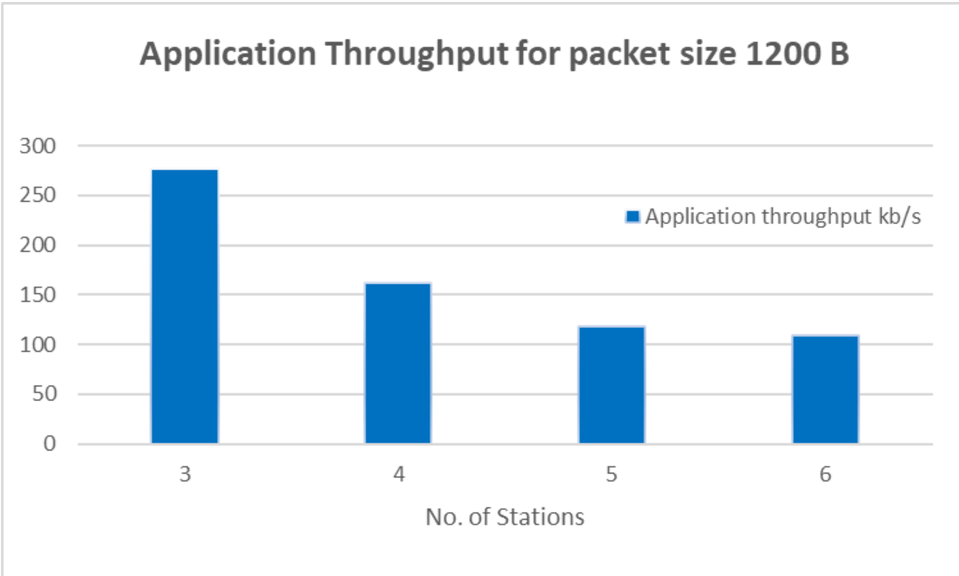

Figure 3. Application throughput for packet size 1200 B

7. Compare nominative bitrate of physical layer and real throughputs on application layer. Be able to explain dependencies on your plots.

The physical data rate was set to 1 Mb/s. By referring to the previous figures and table, two trends are visible:

The first behaviour is that as the no. of stations in our ad-hoc scenario increased, the application throughput decreased. This is due to the following factors:

- When the no. of stations sharing the physical channel increase, each station will require bandwidth resources to transmit resulting in lower transmitting throughput for each node.
- As the ad-hoc network expanded, more retransmissions were required to route UDP traffic to its destination & hence the traffic travelled for longer distances. This will lead to higher packet loss and collision probabilities.
- The propagation losses from our two-ray ground model also affect the transmitted signal characteristics.
- Other hardware and system losses will also become higher with more stations.

The second observed trend is that as the packet size increased in each no. of stations scenario, the application throughput increased. This is due to the following:

- The UDP header size is 64 bytes, which is a considerable number of bytes in short packets. As the packet size increased from 300 to 700 and then 1200 bytes, the useful data ratio per packet increased & more application data were sent.

8. Reflect (speculate) on how one can theoretically predict the best packet size in order to minimize transmission time for 1GB of data in Ad Hoc multi-hop scenario.

Considering the scenario of transmitting 1 GB of data, the following table demonstrates the total size of overhead to be sent considering different packet sizes.

Table 2. Total Overhead for different packet sizes

Payload (MB)	Packet size (B)	No. of packets (Millions)	Total Overhead (MB)
1000	300	3.33	213.12
1000	700	1.43	91.52
1000	1200	0.833	53.312

By referring to this table & throughput results in the previous experiments, we can tell larger packets are more efficient to use to achieve higher throughputs.

In real-world scenarios, where wireless and wired networks are interconnected, the maximum transmission unit for frames shouldn't exceed 1500 bytes due to ethernet limitations. Additional simulations were carried out to compare the app throughput when using 1200 bytes compared to the MTU size (payload size = 1500 – 64 = 1436 B) as shown in the following figure:

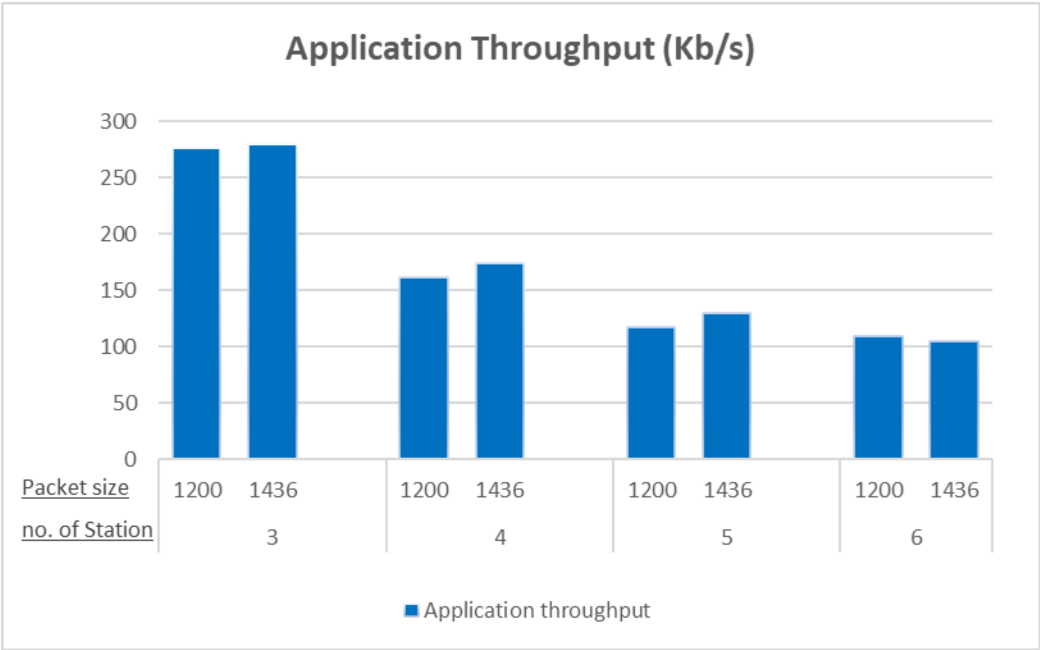

Figure 4. Comparing App throughput for 1200 & 1436 bytes packet sizes

There is a slight enhancement in the application throughput when transmitting 1436 bytes per packet. Hence, it's the recommended packet size.

9. Change type of traffic to TCP, i.e. uncomment corresponding part of code for the TCP socket and delete the UDP socket. Simulate scenario for 3 stations and two different lengths of packets 300B and 1200B. Calculate application level throughput for stations 3. Compare results with corresponding values for UDP traffic. Draw your conclusions.

The following table shows the throughput for both TCP & UDP server/client applications:

Table 3. TCP vs UDP Application throughput

No. of Stations	Payload (B)	TCP		UDP	
		Total throughput kb/s	App Throughput kb/s	Total Throughput kb/s	App Throughput kb/s
3	300	290	224.2268041	146	113.5810859
	1200	290	270.1863354	295	238.5045722

From the previous results, the application throughput increased when the datagram size increased from 300 B to 1200 B. When increasing payload sizes, more useful application data will be sent with less overhead resulting in higher throughput.

In the TCP scenario, the total throughput remained the same for both 300B & 1200B while the application throughput varied slightly compared to the UDP scenario. The reason is that TCP is a byte-stream protocol that uses flow and congestion control mechanisms to send data.

TCP will buffer the data and fill a socket buffer before transmitting each packet to make more efficient use of the available bandwidth while UDP immediately transfers small packets thus congesting the network & causing multiple packet losses.