Packet size impact on the 802.11 network performances

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Abstract. The 802.11 performances degrade significantly when many access points are deployed within the same interfering area. New series of 802.11x are deployed and other alternative technologies, such as WiMAX, are exist. However, as 802.11 devices are widely deployed, existing technology optimization is less expensive than new technology deployment. This paper reports simulation evaluations of 802.11 performance enhancement by increasing 802.11 packet size. The increasing size can be performed within medium access layer or within transport layer through buffering schemas. The assessment shows that by doubling the packet size, the media access delay in 802.11b can be reduced up to 61%, throughput is increased up to 2.16%, and network utility is maximized up to 2.25%.

1. Introduction
The wireless local area network (WLAN) standard refers to IEEE 802.11 series which was initially published in 1997 [1]. Figure 1 shows the main components of the standard [2]. The infrastructure mode allows clients connect to network through an access point (AP), while ad hoc network allows free mesh configuration. In spite of many standards within 802.11b series, this paper focuses on 802.11b and 802.11g. The 802.11b has maximum data rate of 11 Mbps. This standard appeared in 2000 operating in 2.4 GHz. The IEEE 802.11g standard came in 2003 working on the same channel by using OFDM schema [1]. The 802.11g is able to achieve 54 Mbps data rate. The multiple access technology employed in IEEE 802.11 is RTS/CTS. Nodes should perform carrier sensing before sending packets. If channel is busy, back off algorithm is performed, otherwise, a request to send (RTS) packet is sent to a destination. If a clear to send (CTS) packet is received, data is transmitted. RTS/CTS exist in all 802.11 series.

Figure 1. Wireless local area operation mode.

Research on the 802.11 improvements varies from network modelling, quality of services [3], signal propagation [4], power optimization [5] to cross-layer with other TCP/IP stacks [6]. This paper examines impact of 802.11 frame length to the 802.11 performances. The frame length can be
adjusted manually by determining its size. However, in order to fully load the segment with data, buffer increment can optimize the 802.11 frame. Other way is by adjusting packet size within the transport layer, so that medium access buffer can be maximized. This paper assumes both methods are performed so that the 802.11 frame is maximised to carry data as its maximum length.

2. Research methods
In order to evaluate impact, the size of packets or frames to the overall 802.11 performances, Bianchi model is employed. If a station has probability of $\pi$ transmitting a packet in ac802.11 network, then the successful probability of transmission among n nodes is [7]:

$$p_s = \frac{nn(1-n)^{n-1}}{1-(1-n)^n}$$ [1]

Further analysis on model is able to derive performance parameters such as media access delay, throughput, and utilization. Media access delay is the time required for a packet sent by one node reaches another node within the 802.11 network. It is influenced by the successful transmission $T_c$ after some collision probabilities (m trial), propagation delay $\tau$, back off algorithm $\overline{X}$, and the capacity of the system $g$ producing Equation 2 [8].

$$d_m = \frac{m(T_c+\tau\overline{X})+T_s}{1-gm(T_s+mT_c)/(m+1)}$$ [2]

Throughput shows the maximum capability of the system. It may be expressed by number of bit delivered per second. The performance is influenced by the length of payload $L_{DATA}$, its processing time $T_{D\_DATA}$, acknowledgment delay $T_{D\_ACK}$, inter-frame space $T_{DIFS}$ and $T_{SIFS}$, and back off algorithm window $\overline{CW}$. The throughput is expressed by Equation 3 [9].

$$MT = \frac{8L_{DATA}}{T_{D\_DATA}+T_{D\_ACK}+2\tau+T_{DIFS}+T_{SIFS}+\overline{CW}}$$ [3]

Utilization is defined as how maximum network utilized. The equation can be approximate by Equation 4 [9].

$$U = \frac{s}{(a+i)} \gamma_3 p^{3T_s/\tau}$$ [4]

In order to evaluate packet size impact, uniform packet generation of 4000 bits, 8 packets per second and 8000 bits 4 packets per second are evaluated. Both packet streams have similar rates of 32 kbps. Number of nodes is varied from 2 nodes to 40 nodes with 69 iterations and 100 second simulation time. The RTS/CTS packet threshold is set to 8 bit. The evaluated speeds of 802.11b are 2 Mbps and 5.5 Mbps, while 802.11g rates are 6 and 9 Mbps. The transmission power is approximated to be able to cover 200 feet or 60.96 m area.

Simulation runs on Sony Vaio SVE14AA11W computer with Intel® Core™ i5-2450M CPU @ 2.50GHz (4 CPUs), 2.5Ghz, Memory: 4096 MB RAM and Windows 7 Home Premium 64 Bit operating system. The selected 802.11 parameters are assumed as depicted in Table 1. A 100s simulation is repeated 7 times with RTS/CTS multiple access. Threshold is 8 bit with uniform traffics.
3. Evaluation results

As simulations run for 802.11b rates of 2 Mbps and 5.5Mbps, and 802.11g rates of 6 Mbps and 9 Mbps, media access delay; throughput and utilization of networks are recorded and plotted in following figures.

Figure 2 shows the 802.11 performances for 802.11b with rate of 2 Mbps. The transmission delay increases as number of nodes increases. As network approaches saturated condition starting for number of nodes 28, delay of network with traffic 4000 bits packet size and 8 packets per second experiences tremendous increment. Delay jumps more than 4 times. On the other hand, traffic 8000 bits per packet with 4 packets per second results a slower increment.

This significant delay differences can be explained as follows. Since 4000 bits packet size produces more frequent packet transmissions, the probability of collision increases. This collision is neglected when system capacity is higher than total traffics generated by transmitting nodes.

However, collision is significantly affecting network performance when number of nodes is higher than 28 nodes, which are saturating the network. As results, not only delay increases, throughput and utilization decrease as well.

| No | Parameter                          | Value      |
|----|-----------------------------------|------------|
| 1  | Seed                              | 7          |
| 2  | Time Simulation (Sec)             | 100        |
| 3  | Number of values per statistic    | 100        |
| 4  | Access Mechanism                  | RTS/CTS    |
| 5  | RTS Threshold (bits)              | 8          |
| 6  | Packet Length Distribution        | Uniform    |
| 7  | Packet Generation Rate Distribution | Uniform   |
The same patterns are occurred when examining 802.11b with 5.5 Mbps rate. Delay of system with 4000 bits packet size is lower when traffics are not dense. But delay worsens when number of nodes producing traffics higher than network capacity. It can be seen from Figure 3a that delay starts increasing higher than 8000-bit traffic when number of nodes is higher than 30 nodes.

**Figure 2.** Performances for 2 Mbps 802.11b.
Throughput and utilization of network with traffic of 8000 bits per packet are higher than of 4000 bits per packets. Unlike the 802.11b, in the 802.11g network, delay of 8000 bits packet consistently produces higher delay than 4000 bits packet. However, the throughput and the utility of networks are consistently better. The performance graphs are shown in Figure 4 and Figure 5.

**Figure 3.** Performances for 5.5 Mbps 802.11b.
Figure 4. Performances for 6 Mbps 802.11g.
4. Conclusions
This paper has reported the assessment of 802.11 performances when packet size varied. In general, increasing number of nodes results increasing delay. By using the same rate, traffic of 8000 bits produces lower delay than traffic of 4000 bits in saturated condition in 802.11b network. In opposite, delay of 8000 bits is consistently higher than of 4000 bits. In saturated 802.11b network, double the packet size results up to 61% media access delay. But it produces up to 20% delay increment in 802.11g. In both networks, double the packet size causes throughput and utility consistently increase up to 2.16% and 2.25%.

Figure 5. Performances for 9 Mbps 802.11g.
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