An Approach for Solving the Unfairness Problem in WLANs

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We consider a performance problem that arises in IEEE 802.11 wireless LANs in the infrastructure mode. In a typical set up, an access point (AP) acts as a bridge for wireless stations: either it forwards frames between stations or interconnects the wired and the wireless parts of the network by forwarding data flows in two directions (upload or download) on behalf of wireless stations. As most of the traffic goes through the access point, it requires more transmission attempt probability than wireless stations. However, this requirement is not currently supported by the standard IEEE 802.11 DCF (*Distributed Coordination Function*) access method that provides approximatively equal channel access probability to all devices in a wireless cell. Thus, if there are N wireless stations in a cell, the access point only benefits from $1/(N+1)$ of channel access probability, which leads to important performance degradation of flows transmitted over the wireless link known as the *unfairness problem* largely studied in the literature. Figure 1 illustrates the problem: the left diagram shows the measured performance in the scenario with one download TCP connection competing with 4 uploads under DCF—the upload connections obtain a significantly larger throughput. When real-time flows such as VoIP coexist with TCP connections, their delay may also become unacceptably long. The main cause of the unfairness problem is a complex interaction of transport layer protocols with the MAC layer mechanism.

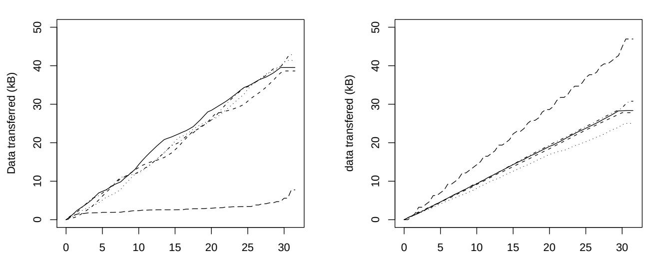

Fig. 1. Data transferred vs. elapsed time, 4 downloads and 1 upload. Left: DCF, right: AAP.

In this presentation, we propose to solve the unfairness problem in a simple and elegant way at the MAC layer. We define the operation of an *Asymmetric Access Point* (AAP) that benefits from a sufficient transmission capacity with respect to wireless stations so that the overall performance improves both for TCP connections and UDP VoIP flows. The asymmetric operation consists of giving to the *Asymmetric Access Point* a transmission capacity that is k times greater than the capacity of *all* the wireless stations in the cell. Factor k reflects the common principle of the TCP acknowledgment scheme in which a receiver acknowledges every k data segments, k being 2 in most of the current TCP implementations. We show that this allocation is necessary in the worst case of all download connections and it leads to an increased overall throughput and good fairness in scenarios of mixed upload/download connections. The allocation can be achieved by the following surprisingly simple principles:

1) *The Asymmetric Access Point sets its contention window to a constant value, which is independent of the number of active wireless stations.*
2) *Wireless stations use the* Idle Sense [1] *access method and its contention window adaptation mechanism.*

The principles of our solution give preference to download flows with respect to upload, which is similar to the asymmetric capacity allocation in ADSL access networks. The main advantage of our solution consists in faster draining of the packet queue at the *Asymmetric Access Point* to improve the overall performance at transport layer. Shorter queues also means that real-time UDP flows may benefit from shorter delays.

We derive the constant values of the contention window that should be used by the *Asymmetric Access Point* to obtain transmission capacity k times greater than all active stations for different variants of IEEE 802.11 PHY and MAC layers. We have implemented the proposed method on Intel wireless cards and measured its performance. Figure 1, the right diagram, shows the performance of our solution—the download connection obtains better throughput than the upload ones and fairness is improved. Moreover, the RTT is shorter because the packet queue of the AAP becomes almost empty.

References

[1] M. Heusse, F. Rousseau, R. Guillier, and A. Duda, "Idle Sense: An Optimal Access Method for High Throughput and Fairness in Rate Diverse Wireless LANs," in *Proc. of ACM SIGCOMM 2005*, August 2005, vol. 35, pp. 121–132.