Controlling transmissions to mitigate WiFi overloads

Hui Xia[1], João Reis[1], Luís Oliveira[1], Frederico Santos[2], Luís Almeida[1]
[1] Institute of Telecommunications
Faculty of Engineering, University of Porto, Portugal
{ee08334, jprr, loliveira, lda}@fe.up.pt
[2] ISEC - DEE
Polytechnic Institute of Coimbra, Portugal
fred@isec.pt

I. INTRODUCTION

Excess load on WiFi networks caused by multiple concurrent users leads to an increase of collisions and substantial degradation of network performance. In order to mitigate this phenomenon, there are multiple techniques, some of which are integrated into the IEEE 802.11 protocol [1], such as the Collision Avoidance mechanism of the base CSMA/CA access method, and others based on software that runs on the side of access stations. A solution of the latter type, specifically designed for teams of cooperating robots is the Reconfigurable and Adaptive TDMA protocol [2]. This solution operates at the level of the data link layer and is based on a self-synchronization of the nodes involved to create a logical round in which the participating nodes transmit in disjoint windows (slots). In this work we address the problem of service degradation in WiFi networks under overload and we use the Reconfigurable and Adaptive TDMA (RA-TDMA) protocol to allow attenuating such problem.

In this long abstract we will briefly explain the experiments that were carried out and we present some preliminary experimental results that confirm the expected benefits.

II. WIFI UNDER OVERLOAD

The medium access control of WiFi in its most common Distributed Coordination Function (DCF) mode is based on CSMA/CA. According to this access method, when the medium is sensed free, any node can start transmitting immediately. Conversely, if the medium is busy, a node has to wait until it becomes free and then wait for a synchronization interval (DIFS). After that, a node computes a random number initially between 0 and 31 and waits for this number of slots of pre-specified duration. A collision can only occur if two or more nodes wait for a similar number of slots, situation which the random nature of this mechanism tries to reduce. Despite that, as the traffic on the wireless medium increases, many transmissions are to be performed simultaneously, leading to delays, failed messages, and timeouts. Since the maximum random number of slots can grow from 31 up to 16 times that value, this problem is exacerbated by multiple wait operations.

Acronym for Time Division Multiple Access, TDMA is a common temporal multiplexing scheme for periodic communications in which each node has a dedicated fixed duration transmission window or slot. These slots are then organized in a round that repeats continuously in time. Since transmissions from different nodes are separated in time (they occur in different slots) the occurrence of collisions when accessing the medium is precluded. Given the periodic round pattern, the typical implementation of TDMA schemes relies on a global clock synchronization service that allows determining and enforcing the occurrence instants of all slots into the future. In order to address such drawback, protocols such as the RA-TDMA, modified the TDMA paradigm in order to support loose synchronisation requirements. Namely RA-TDMA avoids the need for global clock synchronisation by using the instant in which a message is received to resynchronise with the other nodes. In more detail the protocol implements a phase-shifting strategy that delays transmissions to accommodate delays from the other nodes, i.e. if a message is received with delay, then all nodes delay their transmissions, thus maintaining the synchronisation. In order to be able to cope with loosely synchronised nodes, this protocol keeps the CSMA/CA from the WiFi protocol. Nevertheless, since nodes are synchronised, CSMA/CA is only needed to cope with sporadic delays and the interference of alien traffic.

III. THE EXPERIMENTAL SETUP

In order to test the impact of using synchronisation, namely RA-TDMA, in high-traffic/overload conditions we setup an IEEE802.11 access-point (AP). Then, we configured four laptop computers to execute the RA-TDMA protocol with a round of 100ms, and send an ICMP packet after the protocol payload. That ICMP packet was sent to a fifth computer that simply replied to the ICMPs. This scheme, similarly to the ping command, allows the computers to measure the time required to transmit the message and receive the response, i.e. the round trip time (RTT). In addition, we also measure the number of successful ICMP exchanges. Note that the amount of data sent in each ICMP requires the partition of the messages, therefore a single packet lost in the process translates into a failed operation. In order to look at the transition from a non-saturated to a saturated medium, we collected 50000 measurements with each computer starting with a light ICMP payload (5000 Bytes) and increased it in steps of 5000 Bytes until we found the payload where most of the ICMP exchanges required more than 90% of the TDMA round to complete the operation (30000 Bytes). ICMPs that took longer than the 90%

of the round to complete were considered failed and the RTT disregarded.

IV. Preliminary results

Analysis of the RTT data, Figure 1, shows that even in light loads the synchronisation has a positive impact on the RTT of the wireless transmissions. Namely, with a payload of 5000 Bytes the RTT of synchronised exchanges can be significantly lower (10500us) than the unsynchronised (15260 us), with a similar trend in the 10000 and 15000 Byte payloads. When the medium approaches saturation, this value is not as pronounced, since operations either finish on the limit of the 90% of the round or are disregarded. In addition to that, the standard deviation (depicted in the error bars) is much higher on the unsynchronised experiments. This is expected, since only nodes that are transmitting close together have higher interference. Nodes transmitting far from other transmissions, have lower interference and thus behave similarly to synchronised traffic.

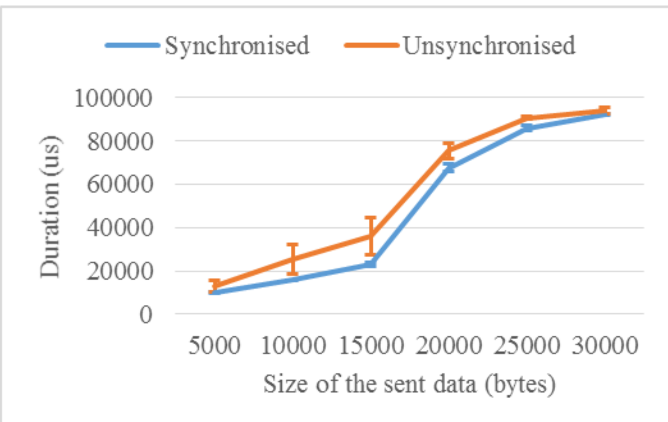

Figure 1 – Comparison of the average roundtrip time of synchronised and unsynchronised traffic for 4 computers. The unsynchronised traffic shows a larger roundtrip time for the tested data size values.

The number of successful ICMP exchanges on the other hand, Figure 2, are very similar to both tests under light traffic conditions. This is expected, since under light traffic the CSMA/CA mechanism with its random backoff is enough to avoid collisions, and thus lost packets. However, once we start approaching the saturation point, the synchronised traffic is shown to significantly improve the reliability of the communications. Namely, when the payload is 25000 Bytes, the unsynchronised ICMP failures can be as high as 80% while the synchronised failures are limited to 63%. Similarly, with a payload of 30000 Bytes, which corresponds to an almost completely saturated medium, we measured for one unsynchronised node a percentage of 91% failures with the remaining three around 70%. In the same conditions two of the synchronised nodes measured 67% failures and the other two only 61%.

V. Conclusion

In this paper we presented our preliminary results on the impact of synchronisation of wireless transmissions in a TDMA round. Results showed that independently of the traffic conditions, synchronising transmissions has a positive impact on the round-trip time measured by the nodes. Moreover, when the medium becomes saturated, the impact of synchronisation on the failure rate of ICMP operations is significant, with a maximum of 67% failures for the synchronised nodes, and a maximum of 91% of failures for the unsynchronised nodes.

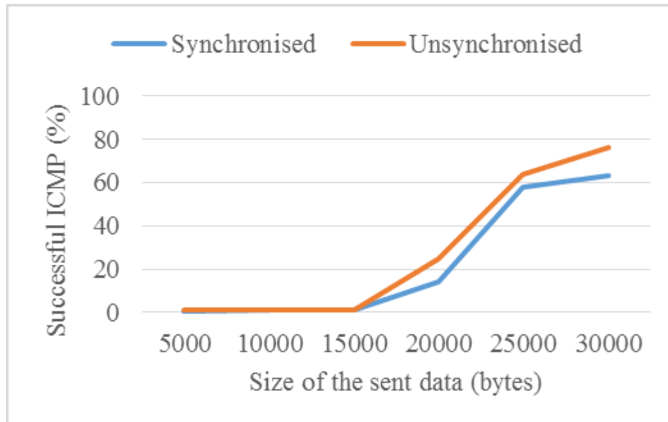

Figure 2 – Comparison of the average ratio of failed ICMP operations by the 4 computers. When the amount of traffic is small the number of losses is negligible. Then, when the amount of traffic increases, using synchronised traffic shows a positive impact on the number of the delivered packets.

References

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