Simulation Study of 802.11e in the Presence of Hidden Terminals – a Star Topology Case

Katarzyna Kosek[1], Marek Natkaniec[1], Luca Vollero[2], Andrzej R. Pach[1], *Members, IEEE*
[1] *AGH-UST, Poland;* [2] *CINI, Italy*

***Abstract*— This paper explains the problem of hidden terminals and gives a short overview of the most known solutions minimizing their impact on IEEE 802.11 network performance. Additionally, the paper presents a preliminary simulation study of one of the possible wireless scenarios (i.e., a star topology) based on the IEEE 802.11e standard. The scenario consists of five stations communicating with each other, from which, four are hidden. The degrading impact of the presence of the hidden nodes on the observed delay and throughput are presented as well.**

Index Terms—ad-hoc, hidden terminals, IEEE 802.11e, simulations

I. Introduction

Wireless networks are one of the most dynamically evolving technologies in which assuring QoS support remains an unsolved problem. QoS is crucial, most of all for bandwidth consuming and delay sensitive services such as VoIP or multimedia streaming. The challenge is even more complicated if we look at ad hoc networks, for which topology and traffic load change unpredictably. An additional difficulty appears when hidden nodes are present within such a network. Their presence causes meaningful unfairness in granting medium access which is the main topic of the study presented in this paper.

II. Hidden Station Problem Overview

One of the general disadvantages of wireless stations is their half-duplex nature which prevents the simultaneous transmission and reception of data. As a consequence of such operation, the CSMA/CA procedure cannot detect hidden stations.

The most known solution minimizing the negative impact of hidden nodes on the performance of IEEE 802.11 standard based environments is the four way handshake mechanism. It takes advantages of sending the RTS and CTS frames while granting medium access. The most important improvement of this mechanism is MACAW where five different frame types are exchanged among the stations.

In the literature one can also find several alternative solutions. From the simplest ones, such as boosting the transmission power of the wireless terminals or changing stations positions, to more complicated ones, such as busy tone signals protocols (e.g., BTMA, DBTMA) or separate and common control channel protocols (e.g., DCA, MAC-SCC, JMAC) [5].

This work has been carried carried out under the UE-funded NoE CONTENT project no. 038423

III. Simulation Study

A preliminary simulation study was performed with the use of ns2 and the TKN 802.11e EDCA model [4] which was improved for the purpose of this research. The changes made mostly affect the RTS/CTS mechanism.

The list of simulation assumptions was as follows: nodes – fixed and wireless sending CBR background traffic of the same priority, transmission power – 0.282W, transmission range – 250m, carrier sensing range – 262.5 m, routing protocol – DSDV, wireless standard – IEEE 802.11b [2] with the IEEE 802.11e [1] enhancement.

The scenario topology, in which five stations form a star, is shown in Figure 1. Four nodes are hidden from each other and, therefore, may start their transmissions at the same time causing collisions.

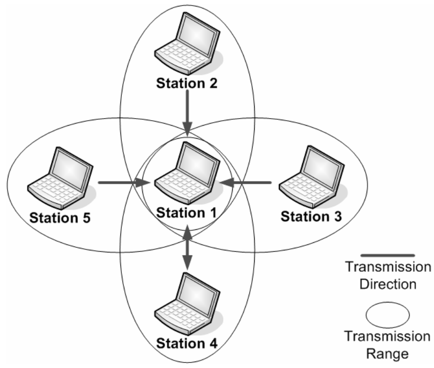

Figure 1. Star topology

Figure 2 and Figure 4 correspond to the situation in which the RTS/CTS mechanism was disabled. Figure 2 shows the observed throughput as a function of the offered load. It can be easily noticed that Station 1 was given meaningful priority over others. Its throughput was over seven times higher than the throughput of the hidden nodes, even though, all the generated traffic had the same priority. In Figure 4, in which the mean packet delay is shown, the same unfairness appears.

Figure 3 and Figure 5 show what happens when the RTS/CTS mechanism is enabled. Once again Station 1 takes priority over the hidden ones, however, its throughput decreases by about 100 KB/s in comparison to the previous simulations. Moreover, also the throughput of the hidden nodes rises by about 10 KB/s each. Furthermore, in Figure 5 we see that the mean packet delay of Station 1 starts to increase unacceptably at a smaller offered load. Therefore, if we consider fairness in granting medium access, the situation with disabled RTS/CTS is always worse.

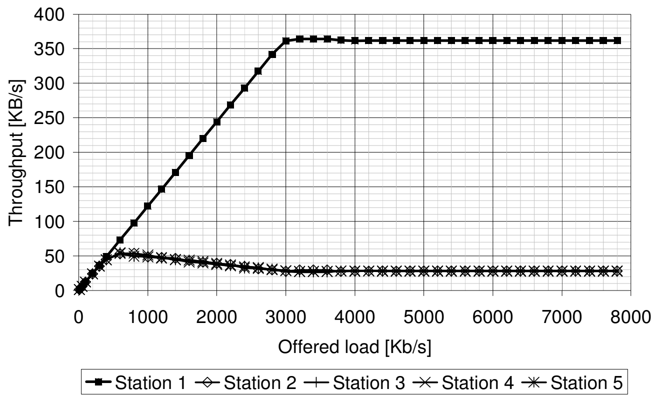

Figure 2. Throughput vs offered load, RTS/CTS disabled

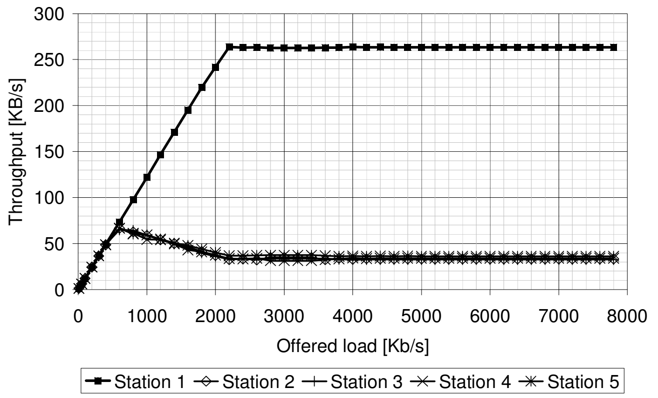

Figure 3. Throughput vs offered load, RTS/CTS enabled

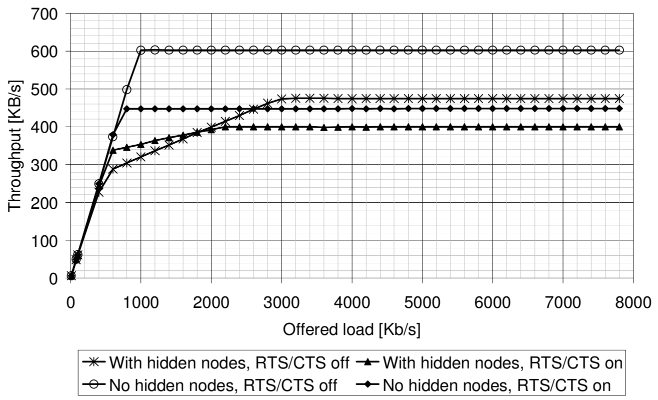

Figure 6. Overall throughput vs offered load, star topology with and without hidden nodes comparison

Figure 6 is a comparison of two different star scenarios. The first scenario was the same as shown in Figure 1. The second one was almost the same with the only difference being that the nodes were close enough to eliminate hidden stations. All simulations were performed with both enabled and disabled RTS/CTS. As can be seen, the exchange of the RTS/CTS frames always results in an overall throughput reduction for the second scenario. When hidden stations appear, the RTS/CTS mechanism causes an overall throughput increase for an offered load of less than 2 Mb/s. The situation changes when the load is higher. Such operation may be explained by the fact that the RTS and CTS frames were sent with the basic

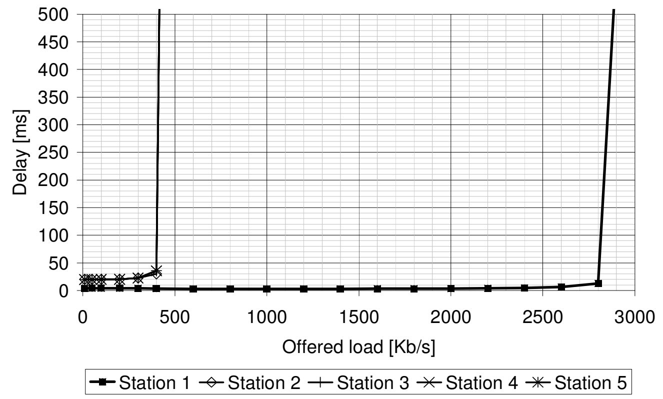

Figure 4. Mean packet delay vs offered load, RTS/CTS disabled

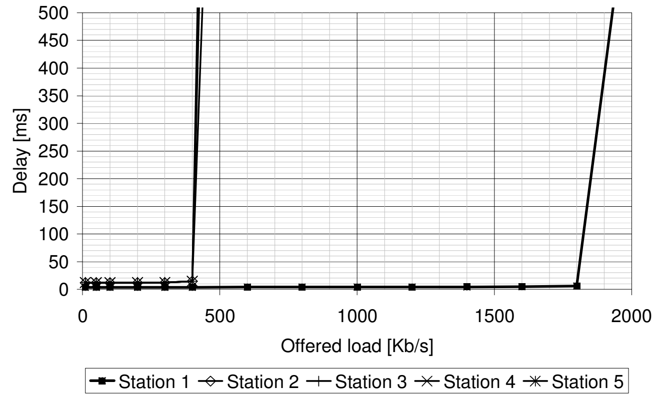

Figure 5. Mean packet delay vs offered load, RTS/CTS enabled

rate of 2Mb/s. Therefore, if the load was high enough, the gain of using the RTS/CTS mechanism to eliminate collisions was smaller than the impact of the increasing queuing drops of Station 1.

IV. Conclusions an d Future Research

The main conclusion from the presented study is that the RTS/CTS mechanism does not always bring the desired results. Additionally, even in only one hop communication it does not eliminate the degrading impact of the hidden stations.

Future steps to be taken are as follows: improving the ns2 simulator (especially the TKN EDCA model), making additional tests of different scenarios with hidden nodes (with changing priorities considering unfairness), and performing mathematical analysis. Furthermore, a novel MAC mechanism eliminating, or at least minimizing, the degrading impact of the hidden nodes in the multi-hop ad hoc environments will be proposed.

References

[1] IEEE 802.11e, *MAC Enhancements for Quality of Service*, 2005

[2] IEEE std. 802.11b, *Higher-speed PHY extension in the 2.4 GHz band*, 1999

[3] http://www.isi.edu/nsnam/ns/

[4] http://www.tkn.tu-berlin.de/research/802.11e_ns2

[5] H. Zhai, J. Wang, X. Chen and Y. Fang, *Medium Access Control in Mobile Ad Hoc Networks: Challenges and Solutions*, Wireless Communications and Mobile Computing, vol. 6, pp. 151-170, March 2006