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QUALITY OF SERVICE ENHANCEMENT IN JAMMED WIRELESS LOCAL AREA NETWORKS

BY

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Abstract. In a crowded Wireless Local Area Network (WLAN) there are many stations that have data to transmit, trying to access the same wireless channel into the same time. The situation gets worse when a jamming source disturbs the transmission on that wireless channel. With the Media Access Control (MAC) frame fragmentation feature enabled the bit error rate diminishes, but this comes with increased media access delay and decreased throughput. The Quality of Service (QoS) could be enhanced when a modified Binary Exponential Back-off (BEB) algorithm is involved in MAC sublayer.

Key words: WLAN; jamming source; MAC frame fragmentation; QoS; modified BEB algorithm.

1. Introduction

The WLAN network performances decrease with increasing the handled traffic. The bigger number of traffic flows trying to access the wireless channel, the higher collision rate value and the number of retransmission attempts. In addition to this, the presence of a jamming source leads to a rising number of corrupted packets in the receiver ports, and they need to be retransmitted until the error-free information is delivered to destination. The fragmentation of MAC frames allows the retransmission of the corrupted fragments only,

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yielding a smaller global bit error rate, with the price of a bigger global media access delay and a smaller global throughput (Diaconu, 2012). The QoS enhancement is needed in such cases, and a possible solution comes from a modified BEB algorithm.

The IEEE 802.11e standard introduces a new MAC coordination function, called Hybrid Coordination Function – Enhanced Distributed Channel Access (HCF–EDCA), which includes four back-off entities, associated to four Access Categories (ACs) (Diaconu *et al.*, 2011). Each back-off entity independently competes for gaining a transmission opportunity (TXOP) using an adapted form of the BEB algorithm described in the original IEEE 802.11 standard (802.11-2012, Standard). Thus, after a successful transmission finalization, the Contention Window (CW[AC]) parameter of a back-off entity is reset to its minimum CWmin[AC] value, leading to a higher probability of collision between the following transmission and the other back-off entities transmissions.

Resetting the CW[AC] parameters to higher than CWmin[AC] values has the capability to decrease the number of transmissions collision and the media access delays, and to increase the throughput. The modified back-off algorithm described in this paper, called BEB α-decrease (BEBαd) (Diaconu, 2013), implements the CW[AC] parameter reset, after the successful finalization of a transmission, by multiplying its current value with an α factor in (0, 1] interval, with a resulting value higher or equal to CWmin[AC].

2. Simulation and Results

2.1. Simulation Model

The OPNET Modeler network simulator is used to generate the results. The simulation model given in Fig. 1 includes a WLAN which operates on 2,401…2,423 MHz channel and a jamming source with the parameters given in Table 1.

The WLAN includes a multiple-of-four number (4 to 44) of fixed workstations and a wireless Ethernet router configured as an access point, connected through an Ethernet 100BaseT link to an Ethernet LAN.

The Ethernet LAN includes a multiple-of-two number (2 to 22) of workstations, two servers, and a switch. All the wired links between nodes are 100BaseT.

Each WLAN workstation initiates a single bidirectional application, with a random start time uniformly distributed between 1 s and 2 s, and a stop time equals to the end of simulation. Four applications are configured, using different User Priorities (UPs): voice (UP=6), videoconference (UP=5), http (UP=3), and ftp (UP=2). Each type of traffic belongs to four different ACs: AC_VO, AC_VI, AC_BE, and AC_BK respectively.

The voice or the videoconference traffic runs between a WLAN workstation and an Ethernet workstation, while the http or the ftp traffic runs between a WLAN workstation and an Ethernet http or ftp server. Each application gets 25% of total available band.

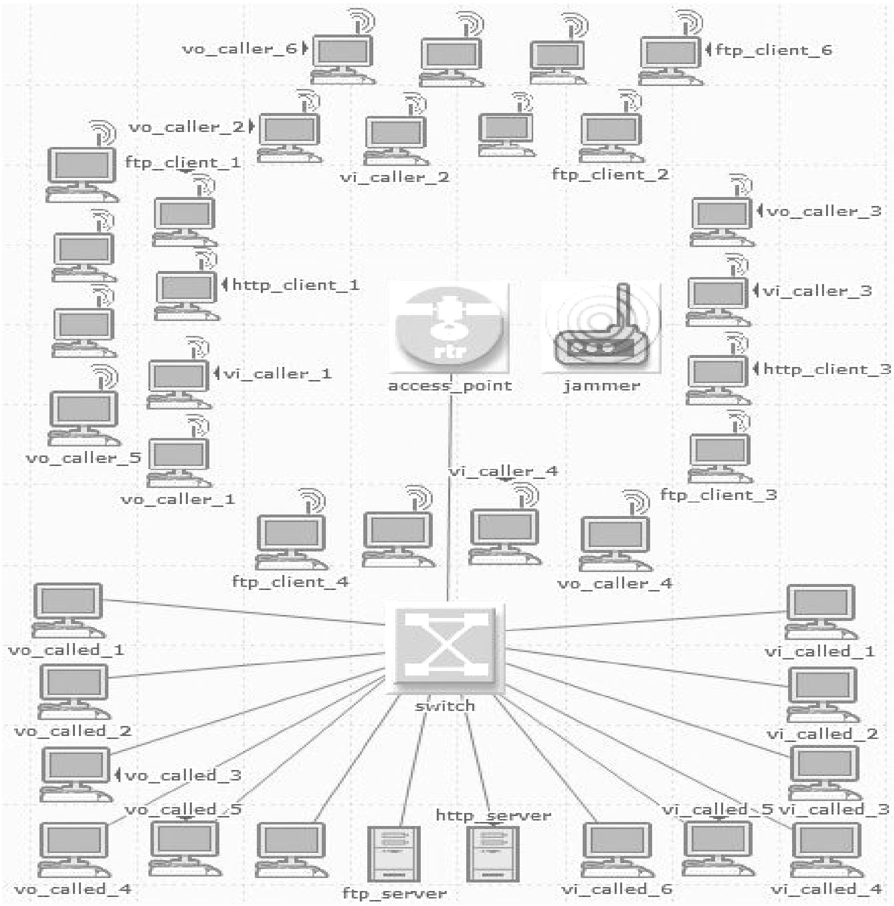

Fig. 1 – **S**imulation model.

Table 1
Jamming Source Parameters

Lower frequency of jammed bandwidth, [MHz]	2401
Jammed bandwidth width, [MHz]	22
Jamming source packets inter-arrival time	Exponential (0.01 s)
Jamming source packets length	Exponential (256 b)
Jamming source start time, [s]	0
Jamming source stop time	End of simulation
Jamming source transmission power, [W]	100

All 802.11g WLAN devices have the physical layer (PHY) parameters

given in Table 2, except for the Access Point (AP) which has a 1024 Kb buffer length. The EDCA parameters in MAC sublayer for all devices are given in Table 3, except for the AP which has AIFSN[AC_VO]=1, and AIFSN[AC_VI]=1.

Table 2
802.11g Devices Parameters

Transmission rate, [Mbps]	54
Channel bandwidth, [MHz]	2,401…2,423
Transmission power, [W]	0.005
Packet receiving power threshold, [dBm]	–95
SRC limit	7
LRC limit	4
Buffer length, [Kb]	256
MAC frame fragmentation threshold, [b]	1,024

Table 3
EDCA Parameters

AC	CWmin[AC]	CWmax[AC]	AIFSN[AC]	TXOPlimit[AC]
AC_BK	15	1,023	7	1 MSDU
AC_BE	15	1,023	3	1 MSDU
AC_VI, [ms]	7	15	2	3.008
AC_VO, [ms]	3	7	2	1.504

The best performances of the BEBαd back-off algorithm were obtained for α = 0.8, and the statistics used to compare the performances of BEB and BEB0.8d back-off algorithms are: global bit error rate in AP's receiving port, global retransmission attempts, throughput, and media access delay. Every simulation runs between 0 s and 120 s, and it is 30 times repeated using different seed parameters. The mean results are displayed using a time average function. The simulated scenarios include 28, 36, and 44 active WLAN workstations.

2.2. Simulation Results

The global bit error rate in AP's receiving port is shown in Fig. 2, where the BEB0.8d algorithm outperforms the BEB algorithm in all scenarios.

The global retransmission attempts are shown in Fig. 3, where the BEB0.8d algorithm outperforms the BEB algorithm in all scenarios.

The throughput of every HCF–EDCA AC is shown in Figs. 4,…,7, where the BEB0.8d algorithm outperforms the BEB algorithm in all scenarios.

The media access delay of every HCF–EDCA AC is shown in Figs. 8,…,11. For the AC_VO and AC_VI traffic, the BEB0.8d algorithm outperforms the BEB algorithm in all scenarios. For the AC_BE and AC_BK traffic, when the number of stations is smaller (28 or 36), the BEB algorithm outperforms the BEB0.8d algorithm, but if the number of stations gets higher, the situation is reversed.

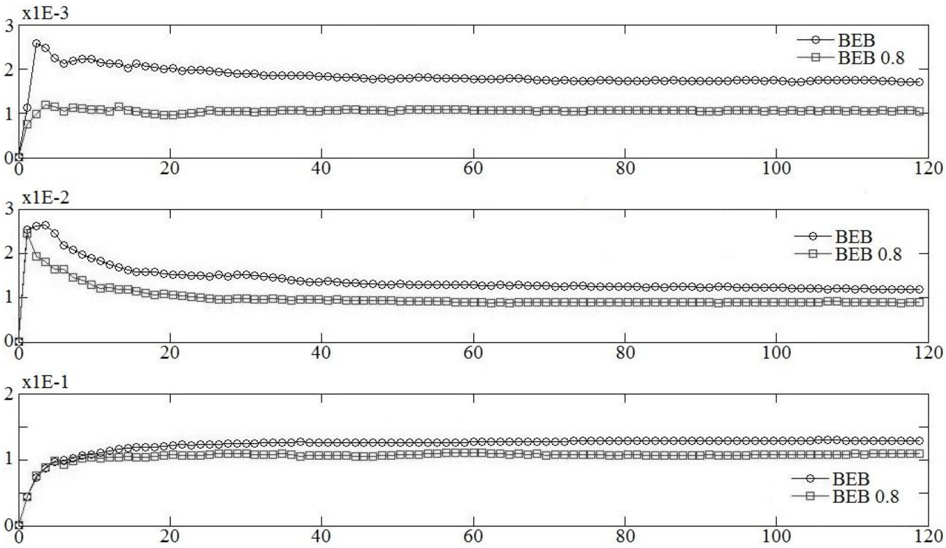

Fig. 2 – Global bit error rate in AP’s receiving port (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

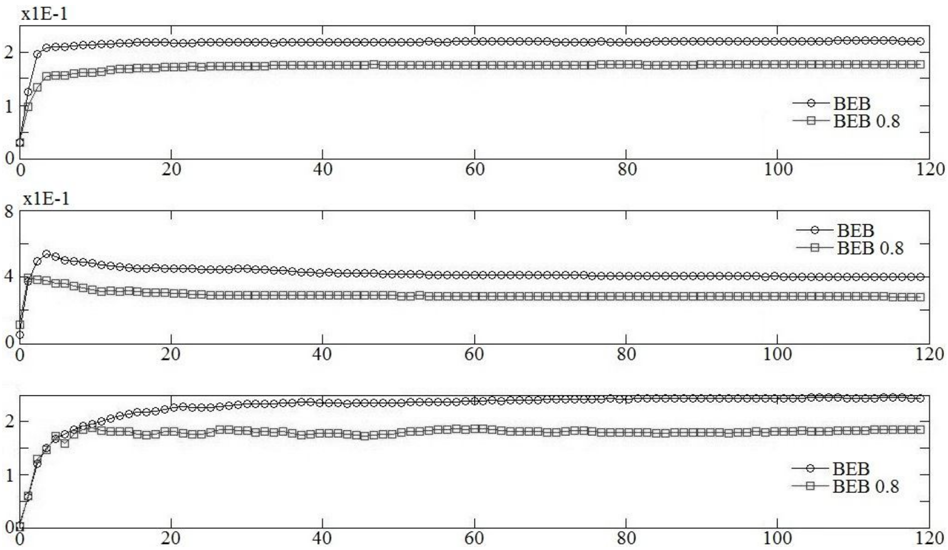

Fig. 3 – Global retransmission attempts, [packets] (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

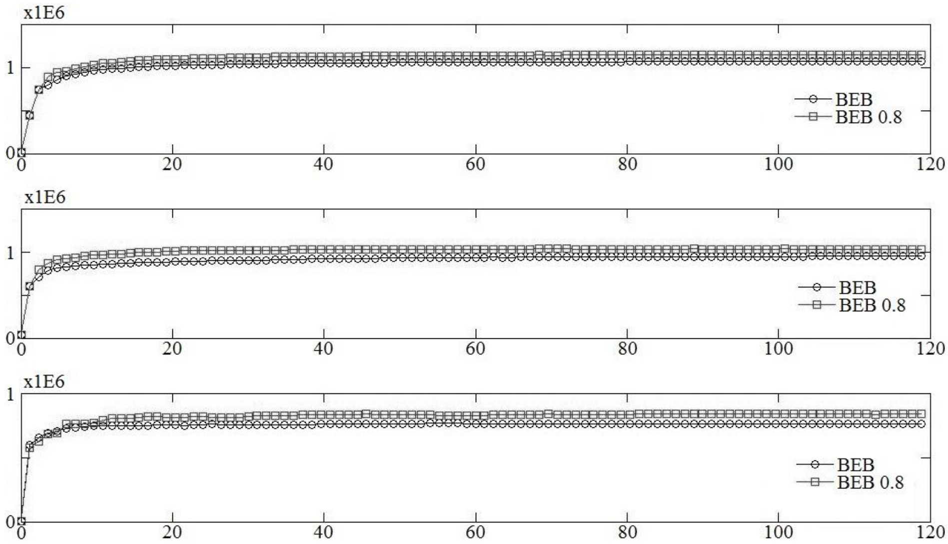

Fig. 4 – Throughput, [bps], for AC_VO traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

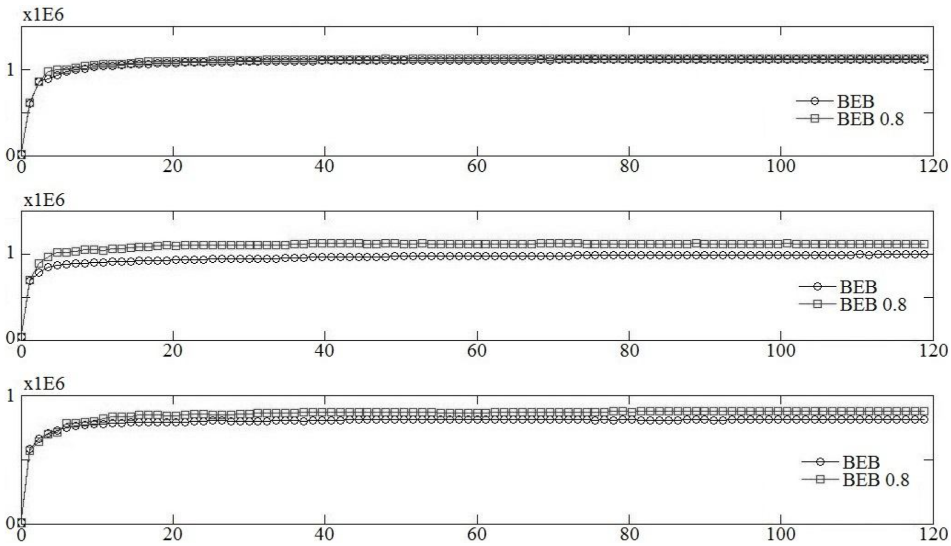

Fig. 5 – Throughput, [bps], for AC_VI traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

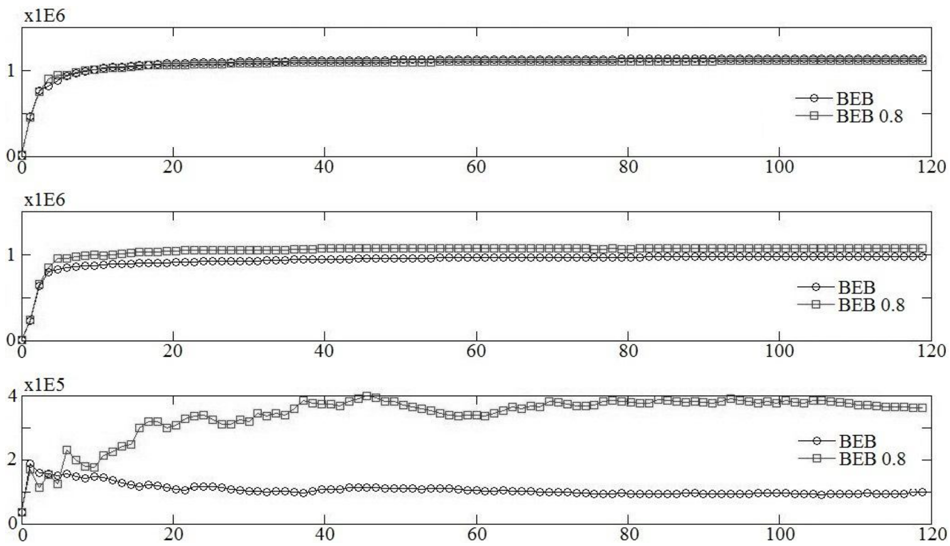

Fig. 6 – Throughput, [bps], for AC_BE traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

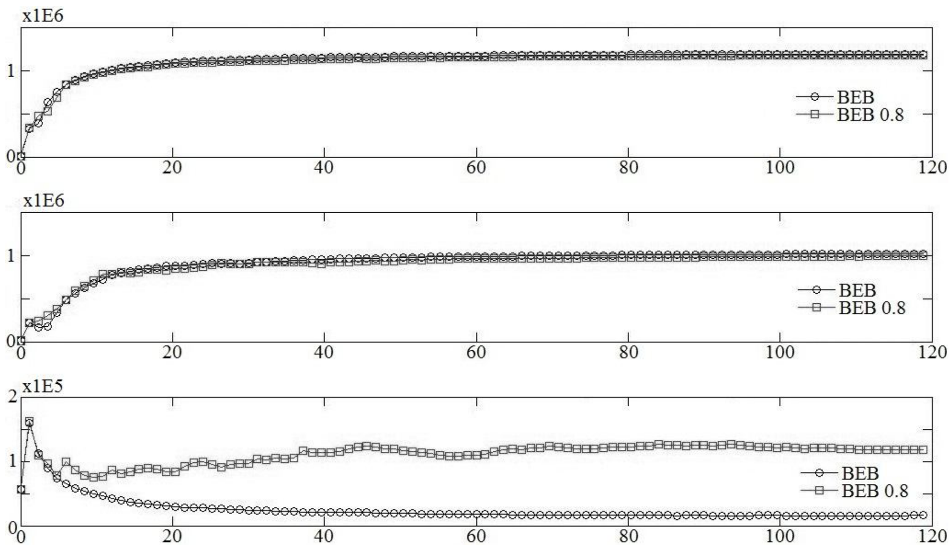

Fig. 7 – Throughput, [bps], for AC_BK traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

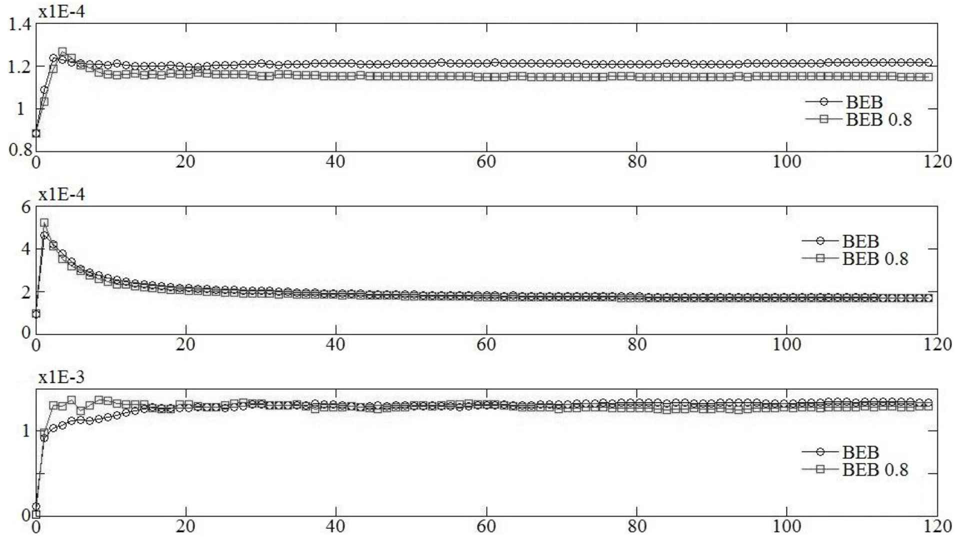

Fig. 8 – Media access delay, [s], for AC_VO traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

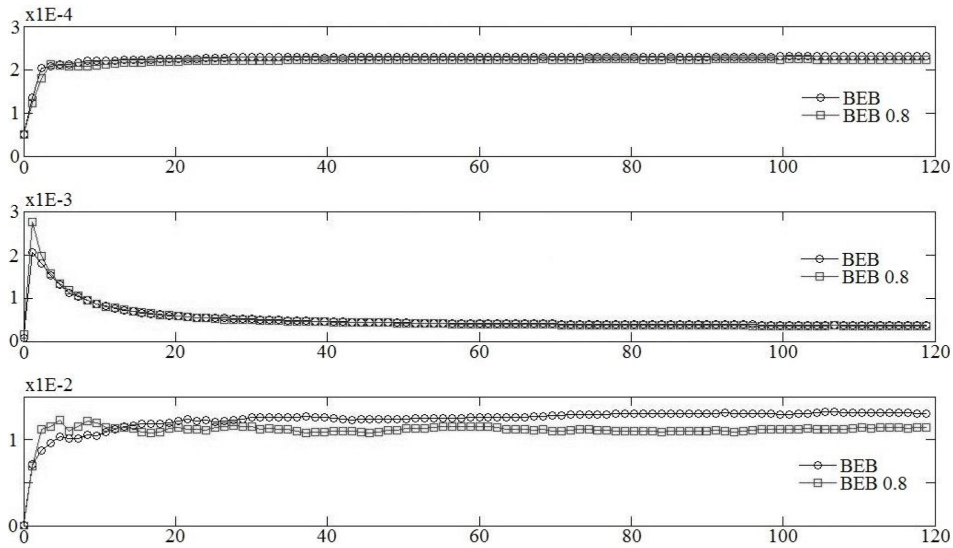

Fig. 9 – Media access delay, [s], for AC_VI traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

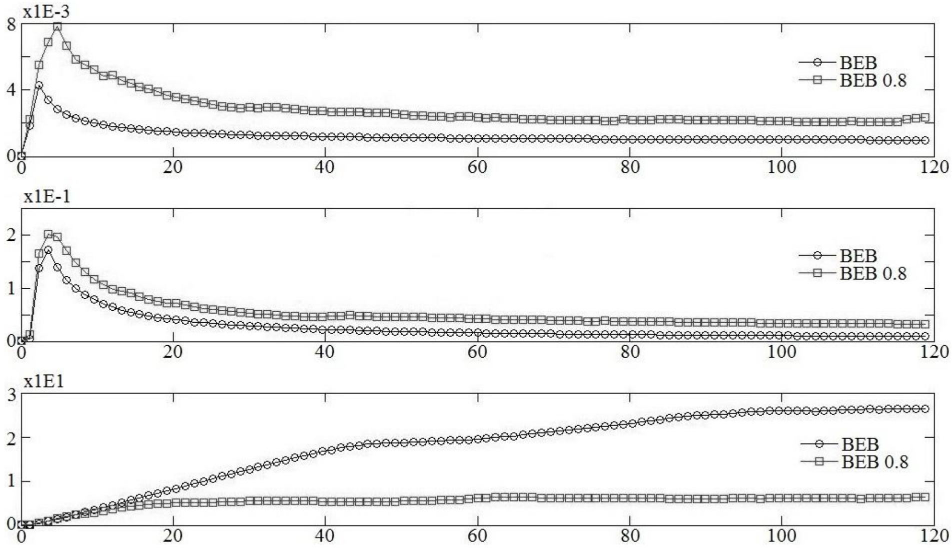

Fig. 10 – Media access delay, [s], for AC_BE traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

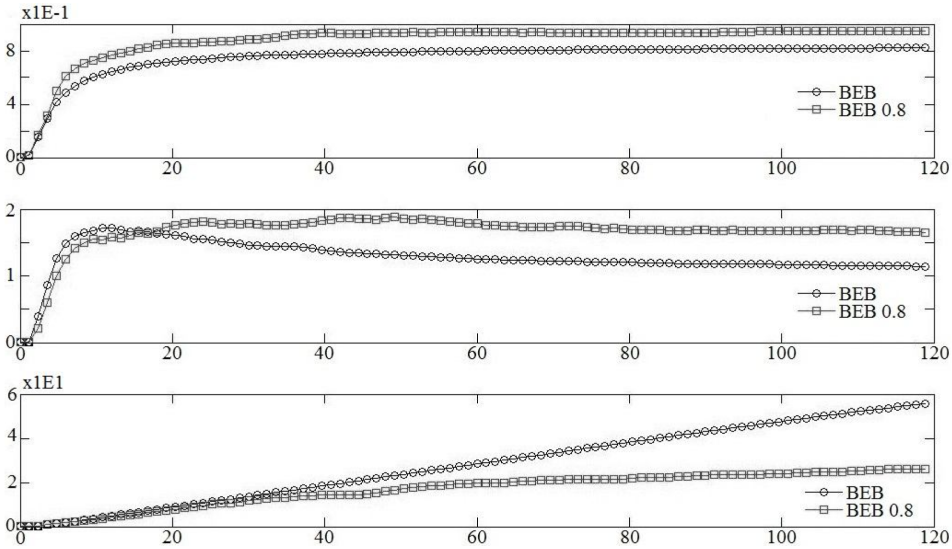

Fig. 11 – Media access delay, [s], for AC_BK traffic (28 stations – up, 36 stations – middle, 44 stations – down) *vs*. time, [s].

3. Conclusion

A modified BEB algorithm (BEBαd) could improve the QoS in a jammed WLAN. With MAC frames fragmentation feature enabled, the reset of the CW[AC] parameter after a successful finalization of a transmission, by multiplying its current values with an α = 0.8 factor has the capability to decrease the retransmission attempts and the media access delays, and to increase the throughput. The higher number of active stations the better QoS for every access category.

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CREŞTEREA CALITĂȚII SERVICIILOR ÎN REȚELE WLAN BRUIATE

(Rezumat)

Într-o rețea WLAN aglomerată, există numeroase stații care au de transmis informații, încercând să acceseze canalul „wireless” simultan. Situația se înrăutățeşte atunci când există şi o sursă de bruiaj a canalului de comunicații. Activând opțiunea de fragmentare a cadrelor MAC, rata de eronare a biților scade, cu prețul creşterii întârzierii de acces la mediu şi a scăderii „throughput”-ului. Calitatea serviciilor poate fi îmbunătățită prin utilizarea la nivelul MAC a unui algoritm modificat de „back-off”-ului binar exponențial.