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IEEE 802.11 MAC FRAME FRAGMENTATION PERFORMANCES IN JAMMED ENVIRONMENTS

BY

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Abstract. IEEE 802.11 Wireless Local Area Network (WLAN) is one of the most popular Internet access technologies. As wireless channels are unreliable, information transmission errors are inevitable. IEEE 802.11 standard has introduced an optional error reducing mechanism for the cases where channel characteristics limit reception reliability for longer frames. This is called *Medium Access Control* (MAC) sublayer frame fragmentation/defragmentation. OPNET Modeler network simulation tool was used to evaluate the performances of this feature in jammed environments.

Key words: IEEE 802.11 WLAN; MAC sublayer; frame fragmentation.

1. Introduction

IEEE 802.11 has become the most widely accepted WLAN standard. Portable devices such as laptops, tablets, mobile phones have 802.11 chipsets built in as standard. Furthermore, wireless infrastructure equipment such as access points is relatively inexpensive.

The IEEE 802.11 standard includes MAC (a component of layer-2 in International Standardization Organization/ Open System Interconnection

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(ISO/OSI) protocol stack) and physical (PHY) (layer-1 in ISO/OSI protocol stack) specifications only.

2. Background

In the presence of Radio Frequency (RF) interferences, MAC Service Data Units (MSDUs) received from the Logical Link Control (LLC) sublayer, with sizes over a certain threshold, may be fragmented and sent as a sequence of smaller MAC Protocol Data Units (MPDUs). Fig. 1 shows the fragmentation of an MSDU and the encapsulation of MPDUs.

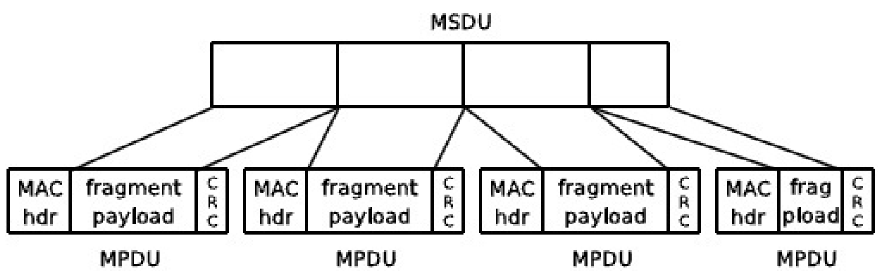

Fig. 1 – Fragmentation of an MSDU into multiple MPDUs.

Each MPDU includes a header, a payload and a Cyclic Redundancy Check (CRC) field.

The receiving node is responsible for recombining the MPDUs into a MSDU, this process being called *defragmentation*.

Only MPDUs with a unicast receiver address could be fragmented. Broadcast/multicast frames could not be fragmented even if their length exceeds the fragmentation threshold.

Each MPDU is sent independently and acknowledged separately as shown in Fig. 2, where Short Inter-Frame Space (SIFS), PCF Inter-Frame Space (PIFS), and DCF Inter-Frame Space (DIFS) are PHY-dependent parameters for MAC coordination functions.

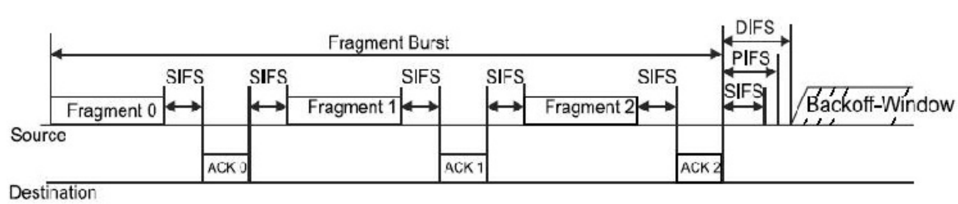

Fig. 2 – MSDU fragmentation and acknowledgements.

Any individual MPDU lost in transmission may be retransmitted rather than the whole MSDU. The transmission of an MSDU is successful if all of the MPDUs (or any retransmissions) have been transmitted successfully.

An Automatic Repeat Request (ARQ) mechanism is used for error control. IEEE 802.11 standard implements a send and wait, positive acknowledgment ARQ of each MPDU. An Acknowledgment Timeout (AckTimeout) is set for each MPDU. The MPDU is retransmitted if the acknowledgment timeout expires. If the maximum number of retransmission attempts of an MPDU is reached, the transmission of the entire MSDU is aborted and the remaining MPDUs in the sequence are discarded.

Typical values for fragmentation threshold range between 256 and 2,048 bytes. Fragmentation could be activated in the AP only, but better results could be obtained when all the WLAN devices use this feature.

3. Simulation and Results

3.1. Simulation Model

OPNET Modeler network simulator was used to evaluate the performances of the MAC frame fragmentation/defragmentation mechanism in jammed environments. The simulation model shown in Fig. 3 is deployed in a 300×300 m^2 area, and consists in an 802.11 WLAN subnet connected to an 802.3 (Ethernet) LAN subnet.

WLAN subnet is composed from ten workstations and an access point (AP), and LAN subnet includes ten workstations connected to a switch. The AP is connected to the Ethernet switch *via* an 100 Mb/s link. A wireless jamming source is located close to the AP.

WLAN workstations and AP use 802.11g parameters for PHY layer, the data rate being set to 54 Mb/s. Communication in WLAN are set to use Channel 1 (2,401…2,423 MHz), similar to the frequency band corrupted by the jamming source which generates an 1,024 bytes jamming packet every 0.1 s.

WLAN subnet clients initiate a voice-type application with LAN subnet clients, which reply accordingly. Ten pairs of distinct clients were defined, each one handling the same kind of traffic in both directions. The application generates a constant flow of 4,096 bytes/s, and the Type of Service (ToS) field in Internet Protocol version 4 (IPv4) packet header is set to 0 (Best Effort).

Application start time was set to 0 s and the simulation stop time was set to 10 min. Three scenarios were analysed: no fragmentation, fragmentation with an 1,024 bytes threshold, and fragmentation with a 512 bytes threshold. When activated, fragmentation feature was enabled in all WLAN devices.

Six statistics were generated: two for local AP's radio receiver: bit error rate and throughput, two for global WLAN: retransmission attempts and media access delay, and two for global voice application: packet end-to-end delay and packet delay variation. All of these statistics were displayed using a time average function.

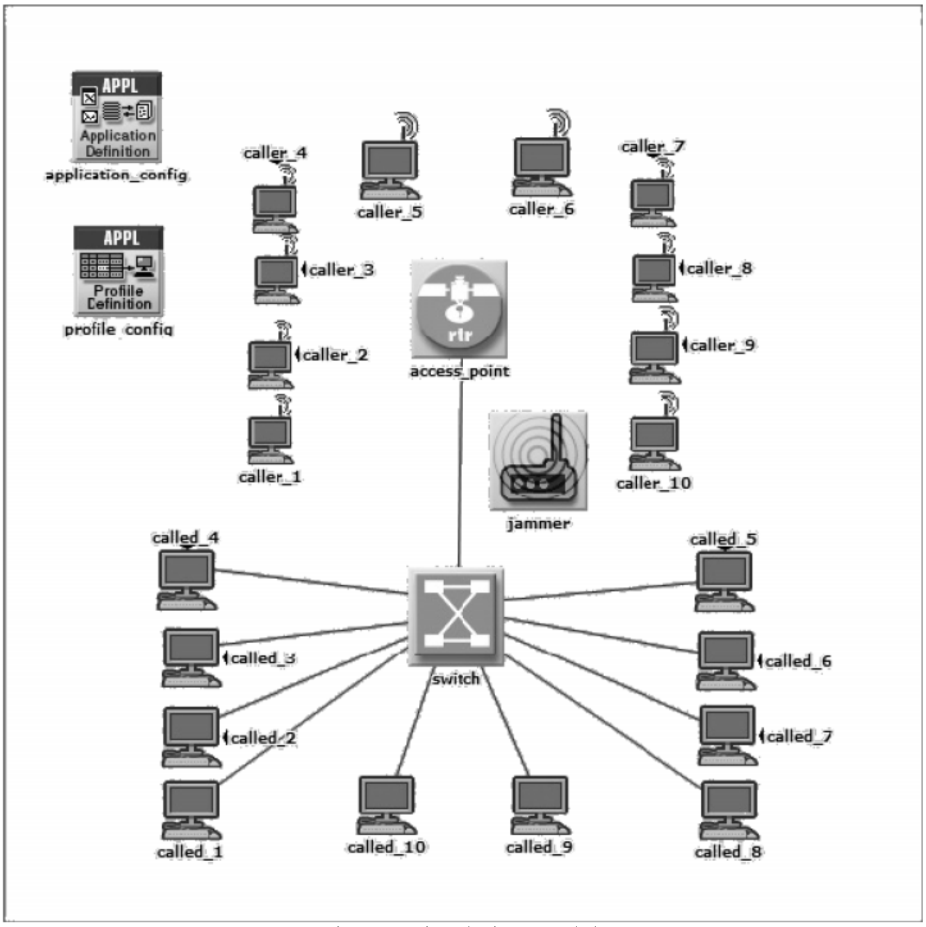

Fig. 3 – Simulation model.

3.2. Simulation Results

With fragmentation activated, only individual corrupted fragments should to be retransmitted instead of a whole corrupted MAC frame.

According to Figs. 4 and 5, the local bit error rate in AP's radio receiver diminishes and the local throughput in AP's radio receiver grows when the fragmentation threshold decreases.

According to Figs. 6 and 7, the number of global retransmission attempts in WLAN diminishes when the fragmentation threshold decreases, while the global WLAN media access delay diminishes when the fragmentation threshold increases.

Packet end-to-end delay and packet delay variation are two important quality of service parameters for voice application. According to Figs. 8 and 9, the global packet end-to-end delay and the global packet delay variation diminish when the fragmentation threshold increases.

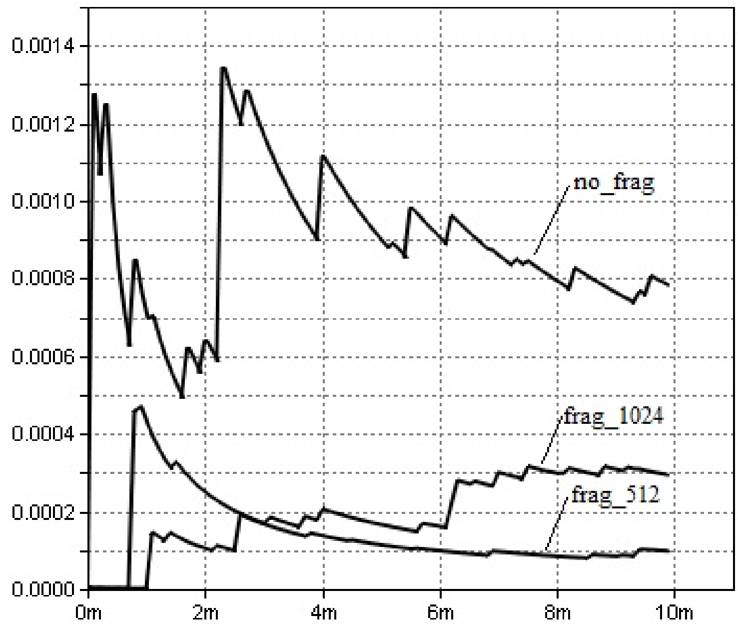

Fig. 4 – Local bit error rate in AP's radio receiver *vs*. time, [min].

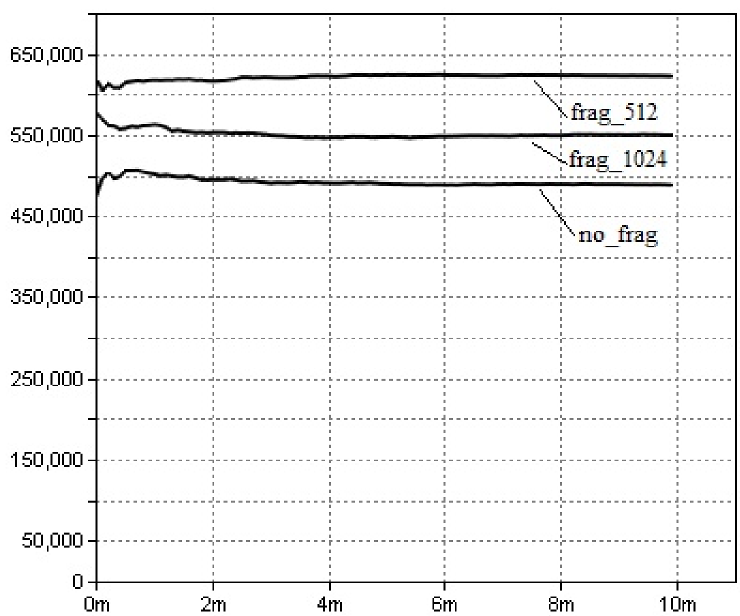

Fig. 5 – Local throughput in AP's radio receiver, [bits/s], *vs*. time, [min].

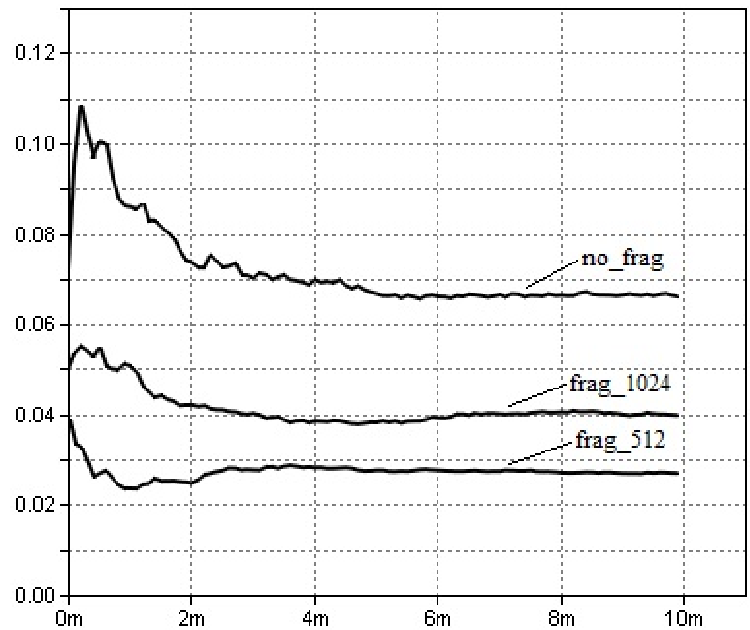

Fig. 6 – Global retransmission attempts in WLAN, [packets/s], *vs*. time. [min.].

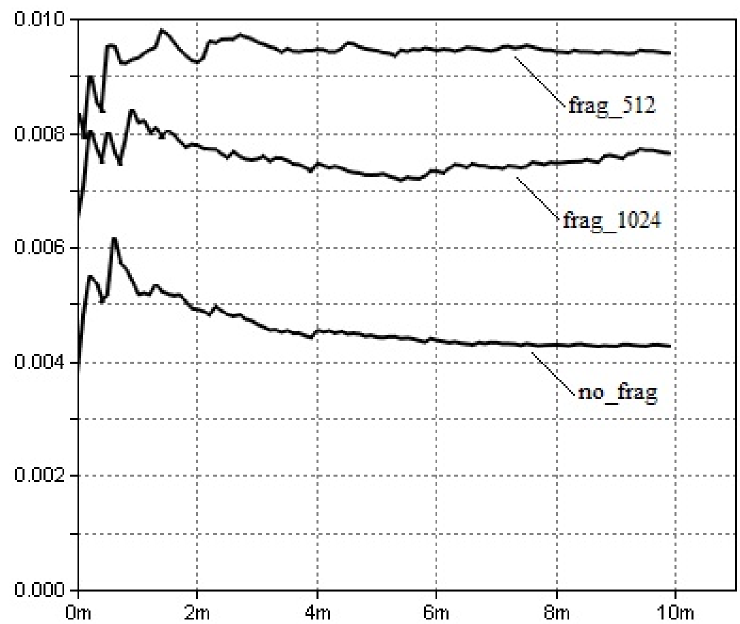

Fig. 7 – Global media access delay in WLAN, [s], *vs*. time, [min.].

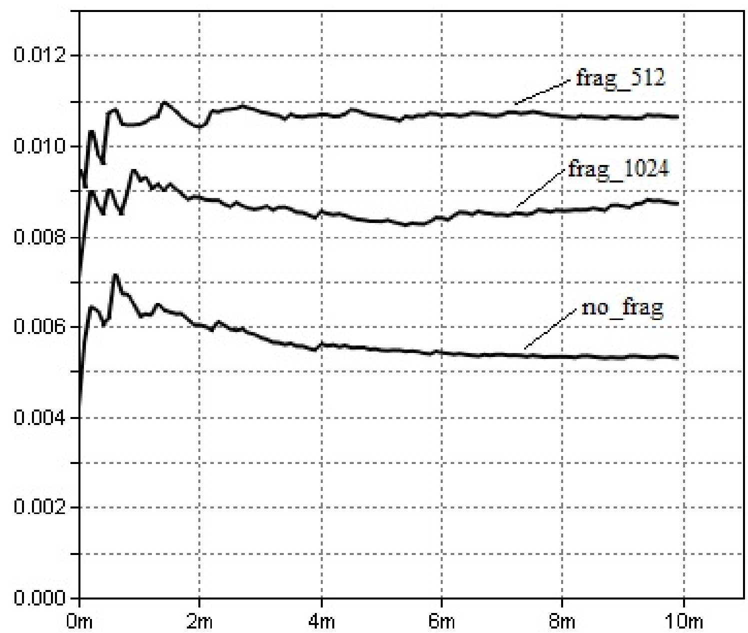

Fig. 8 – Global packet end-to-end delay in voice application, [s], *vs*. time, [min.].

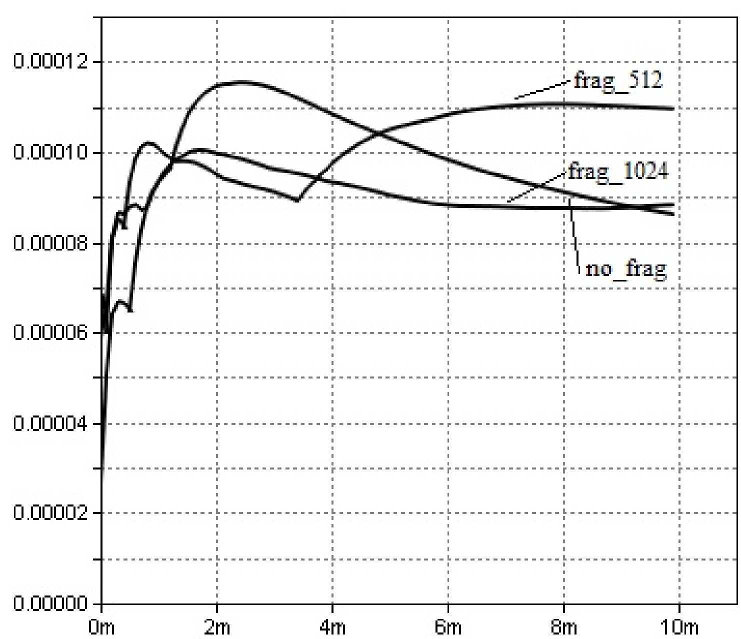

Fig. 9 – Global packet delay variation in voice application, [s], *vs*. time [min.].

4. Conclusions

Fragmentation mechanism is able to improve the performances of the IEEE 802.11 WLAN in the presence of RF interference.

The advantages of decreasing the fragmentation threshold are the following: local bit error rate diminishes in AP's radio receiver, local throughput grows in AP's radio receiver, and global retransmission attempts in WLAN diminish.

The advantages of increasing the fragmentation threshold are the following: global media access delay in WLAN diminishes, global packet end-to-end delay diminishes in voice application, and global packet delay variation diminishes in voice application.

Therefore, attention should be paid on finding an optimal value for the fragmentation threshold size, in order to maximize the advantages while minimizing the drawbacks.

REFERENCES

* * * IEEE 802.11 Standard, http://standards.ieee.org, 2007.
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PERFORMANȚELE FRAGMENTĂRII CADRELOR MAC IEEE 802.11
ÎN MEDII BRUIATE

(Rezumat)

Rețeaua de arie locală wireless IEEE 802.11 constituie una din cele mai populare tehnologii de acces la Internet. Deoarece canalele wireless sunt vulnerabile, apariția erorilor de transmisie a informației este inevitabilă. Standardul IEEE 802.11 a introdus un mecanism opțional de diminuare a erorilor, destinat situațiilor în care carateristicile canalului afectează calitatea recepției cadrelor de lungime mai mare. Acesta este denumit *fragmentarea/defragmentarea cadrelor nivelului de control al accesului la mediu*. Pentru evaluarea performanțelor operării acestei facilități în medii bruiate a fost utilizat simulatorul de rețele OPNET Modeler.