Study of different CSMA/CA IEEE 802.11-based implementations

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Abstract

In this work we present a model for the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol according to IEEE 802.11 standard, approved in June 1997, for Wireless Local Area Networks. The model has been developed using the simulation tool SES/Workbench. Our purpose is to analyze the access protocol performance in terms of available throughput, access delay and packet dropping. The evaluation has been done to make a comparison between the three physical specifications standardized: InfraRed (IR), Direct Spread Spectrum Sequence (DSSS), and Frequency Hopping Spread Spectrum (FHSS). In this work, we also have compared CSMA/CA performance versus CSMA/CD used in wired LANs that are based on IEEE802.3 standard.

The results show different behavior for each implementation, due basically to the physical parameters specified for all three implementation. Using ideal propagation delay conditions, DSSS physical implementation shows the best throughput results while introducing more realistic conditions the results are not so clear.

Introduction

In the last years a great growth deployment and acceptation of mobile communications has been produced, in the particular field of Wireless Local Area Networks (WLANs). WLANs allow connectivity and access to traditional wired LANs, as WLANs can be seen as an extension of wired LANs but with the flexibility and mobility that characterizes wireless systems. The last release of IEEE 802.11, approved in June 1997, has been definitive for the introduction and development of WLAN systems in the mass-market. This standard specifies the physical and MAC layers following OSI (Open Systems Interconnection) architecture.

In this extended abstract we briefly present the simulation details and some of results obtained. Finally we present some of the conclusions.

IEEE 802.11 MAC Layer

As IEEE 802.3 standard, the MAC layer defined by IEEE 802.11 standard is the lower part of the link layer and is placed between the dependent sublayer of the physical layer and LLC sublayer of the link layer. The MAC architecture is composed by two basic coordination functions: Punctual Coordination Function (PCF) and Distributed Coordination (DCF). Each of these functions defines an operation mode for the stations that want to access the wireless medium.

Coordination Function is defined as the function that determines, within a Basic Services Set (BSS), when a station is enabled to transmit and/or receive Protocol data Units at MAC level (MPDUs) through the wireless channel.

DCF is a basic and compulsory mode for all stations and is located at lower part of MAC architecture. The DCF functionality is based on random techniques and is used by asynchronous traffic that does not require a severe bounded time. The IEEE 802.11 standard specifies the CSMA/CA access algorithm for this level.

PCF is located over DCF and the access algorithm for this level is based on circular polling from an access point, that is, deterministic access. This mechanism allows transmission of traffic that does not tolerate random and unbounded delays or contention free asynchronous traffic.

Two coordination modes operates in the same network over a structure called the superframe: during the first part of the superframe, the network operates under DCF mode allowing random access. When the contention period finishes then the access point, called central coordinator, takes the medium and a contention free period begins.

In this paper we analyze the Distributed Coordination Function according to IEEE 802.11 standard, that is, CSMA/CA access algorithm.

CSMA/CA Simulation Details

IEEE 802.11 standard offers three different physical layer implementations, each of them corresponds to a kind of technology that has been commonly used to implement WLAN systems. The MAC layer is exactly the same for each implementation, which defines the exact operation of the CSMA/CA protocol. In figure 1 we present a flow diagram of the CSMA/CA simulation used to study its performance.

Using the same CSMA/CA protocol model, IEEE 802.11 standard specifies different numerical values for each physical parameter involved in the implementation of the access protocol. The parameters involved are shown in the following table, jointly to the numerical values standardized by IEEE 802.11 document:

Parameter	DSSS	FHSS	IR
Slot time	20 µs	50 µs	6 µs
SIFS	10 µs	28 µs	7 µs
DIFS	50 µs	128 µs	19 µs
ACCAtime	≤ 15 µs	27 µs	5 µs
$MSDU_{max}$ size	2312 b	2312 b	2312 b
RxTxArTime	10 µs	19 µs	0 µs
Phy preamble	192 b	122 b	92-112 b

Other parameters that are related to the MAC protocol implementation are not changed to do the comparison with exactly the same conditions.
We have used the simulation model based on the SES/Workbench software package, where only the numerical values have been changed depending on the physical level chosen. In figure 2 we present the simulation model done for the CSMA/CA.

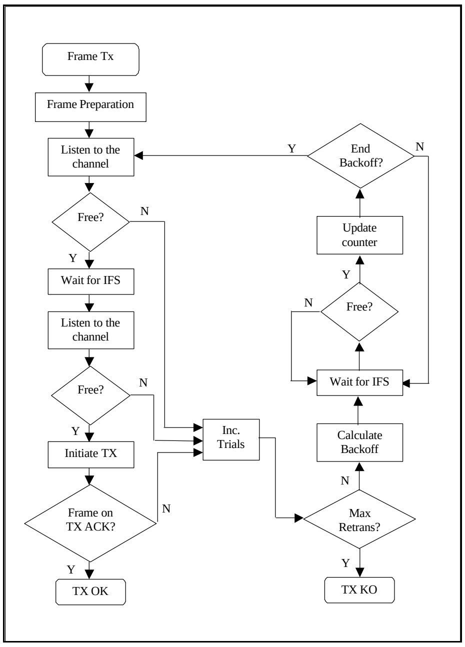

Fig. 1: Flow diagram of the CSMA/CA protocol

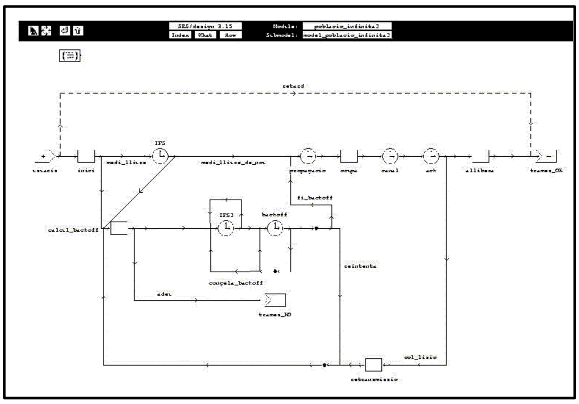

Fig. 2: Simulation model for the CSMA/CA

The detailed explanation of the simulation model is done in the full paper.

Some of the Results Obtained

In this section we present some of the results obtained in terms of throughput and access delay. We have offered traffic in two ways: following Poisson arrivals from an infinite population, and from 10-100 finite population models.
Another important parameter that strongly affects the access protocol performance is the propagation delay. To compare a wide range of situations we have set different values for this parameter, ranging from ideal propagation delay (null) to a propagation delay equivalent to one slot time, depending on the physical implementation layer.
The first sets of results shown in this extended abstract (fig. 3,4) are the throughput performance for Poisson arrivals with null propagation delay. We can observe that DSSS physical layer provides the best throughput values for almost all offered loads. In second place, but a noticeable distance appears FHSS, which is quite similar to the IR implementation. We also present the results obtained for the access delay using DSSS layer.

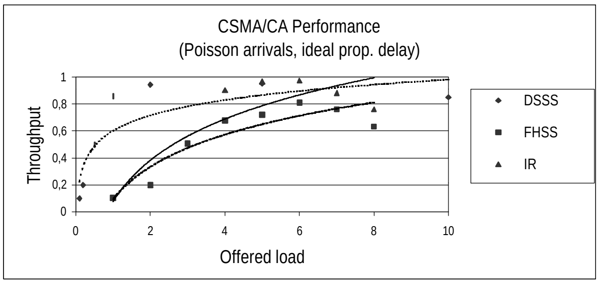

Fig. 3: System performance for infinite population and ideal propagation delay.

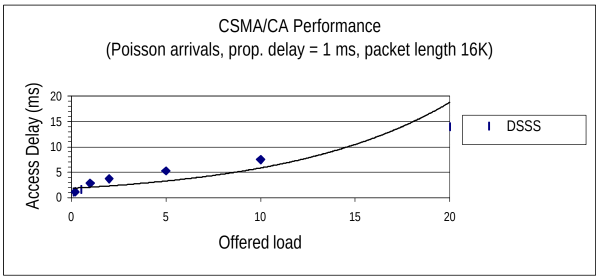

Fig. 4: System performance for infinite population.

If we fix the offered load from a finite pool of 100 users, and set a propagation delay at a half slot time value, we obtain the throughput evolution shown in figure 5. Then the differences observed between the three physical implementations of the IEEE802.11 have changed. The propagation delay equals the DSSS and FHSS throughput, while IR physical implementation is reduced to a less than the 60%.

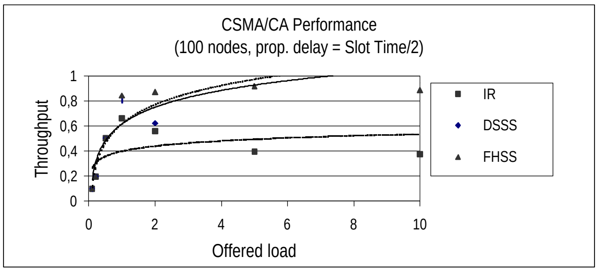

Fig. 5: Finite population case with non-ideal propagation delay conditions

We have also studied the access delay of the CSMA/CA protocol and we have compared its performance with the CSMA/CD, but due to the lack of space we can not include it in this abstract.

Conclusions

In this work we have studied different performance parameters of the CSMA/CA protocol. One of the most important conclusions is that not all three physical implementations do have at all the same performance due to the different values standardized by the IEEE 802.11. Moreover, introducing different delay propagation values, we obtain also different performance results that are completely different from the results obtained using ideal propagation conditions.

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