UNIVERSIDAD DE MÁLAGA

Executive Overview

TITLE: D2.2.6-WiFi performance comparison in the CARLINK::UMA scenarios

SUMMARY: This deliverable summarizes all the results obtained during the real tests performed at UMA using one-hop communications in the adhoc operation mode of the IEEE 802.11b/g standard. We consider static as well as dynamic experiments in order to study the impact of mobility when using the WiFi standard.

GOALS:

1. Description of the WiFi hardware equipment at UMA
2. Summarizes the performance analysis and evaluation using this equipment considering:
   - One-hop communications
   - Ad-hoc operation mode (car-to-car)
   - Dynamic and static MEUs

CONCLUSIONS:

1. Although the IEEE 802.11b/g standard was not designed for vehicular networks, the test reveals that it can be a feasible option under certain conditions. In static tests, we have transmitted data being the cars separated up to 100 meters. We have also transmitted files while cars are traveling across an urban and a highway scenario with a maximum velocity of 90 Km/h, being the cars separated up to 50 m. In general, since the obtained download values are always lower than 1MB/s, it is not advisable to transfer high amounts of data.

D2.2.6-WiFi performance comparison in the CARLINK::UMA scenarios

CARLINK::UMA

March 28, 2008

1 Introduction

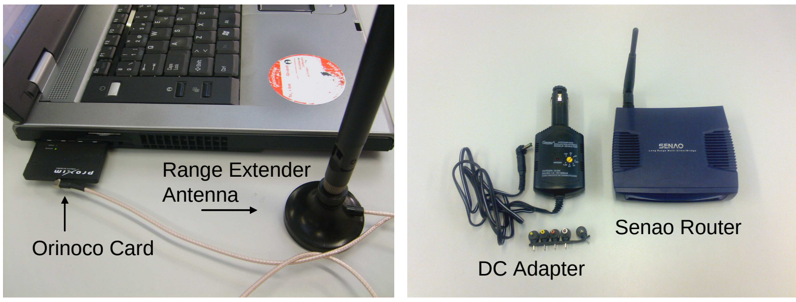
The aim of the CARLINK project is to develop an intelligent wireless traffic service platform for communicating cars. The platform is divided in three different parts (please, consult [2] for more details): the Traffic Service Central Unit (TSCU), the Traffic Service Base Stations (TSBS) and the Mobile End Users (MEUs). The TSCU and MEUs interchange information while the TSBSs act as bidirectional data transceivers. However, under special conditions (when transmitting critical car to car data between two MEUs), it is necessary to establish a direct communication among cars. The scope of the developed work in UMA is focused on the study of P2P communication among MEUs. Different wireless technologies have been considered by the consortium [1], and the WLAN (IEEE 802.11) has been our selected choice (see [3]).

In the deliverables D2.2.1 [5], D2.2.2 [6], D2.2.4 [7] and D2.2.5 [8], we measured the performance of the equippment used at UMA in different scenarios (considering both static and dynamic tests and covering different places as parking, urban or highways itineraries). In this deliverable, we summarize and make a comparison among all the previous results.

This deliverable is associated to the Work Package 2 (*Wireless Traffic Service Platform*) in the task 2.2 (*Platform Definition*). The structure of the deliverable is as follows: Section 2 presents all the hardware used for the ad-hoc communications. Section 3 describes the experiments and makes a comparison among the different results (divided in static and dynamic tests). Finally, in Section 4 the technical conclusions are discused.

2 WiFi Hardware

This section presents all the WiFi equipment used in the experiments. We propose two alternatives: a wireless card (Proxim Orinoco [1]) and a wireless router (Senao NCB-3220 [2]). The Orinoco card is connected to the laptop by means of a PCMCIA slot, while the Senao router and the laptop are connected using an ethernet cable. Figure 1 shows the devices and Table 1 outlines their main characteristics.



(a) (b)

Figure 1: WiFi hardware used in UMA. We handle two alternatives: a wireless card connected to a range extender antenna (a) and a wireless router together with a DC Adapter for connecting it to the car lighter (b)

Table 1: Main device characteristics

	Senao router NCB-3220	Orinoco Wireless Card
Standards	802.11a/b/g	802.11a/b/g
Operation Mode	Point to Point / Point to Multipoint	Point to Point / Point to Multipoint
Max Nominal Output Power	26 dBm	14 dBm
Antenna gain	2dBi	7dBi
DC output	N/A	12 V

Both devices support the 802.11b/g wireless standards in the ad-hoc operation mode. On the one hand, for increasing the signal range offered by the Orinoco card, we use a range extender antenna which is fixed to the car surface with its magnetic base. On the other hand, the Senao router reaches a higher nominal output power which allows to obtain a wider coverage area. Another advantage of the router is the possibility of creating a private network connecting several laptops to it. The only drawback of using the router with respect to the card is the necessity of an external energy supply by means of a DC adapter connected to the car lighter.

3 Experiments

This section describes all the experiments performed. All the communications have used the ad-hoc operation mode of the IEEE 802.11b/g standard. Only two MEUs (cars) are considered in the experiments. The goal is to measure the real performance in the communications using this protocol under different conditions. This way, the results can be useful to determine under what conditions is advisable to use this protocol (i.e. distance, speed, size of data for transmitting, etc.). We use an ad-hoc application developed in UMA (Finding and Sharing Files FSF [9]) for transferring files between the MEUs. According to the mobility of the MEUs, we divide the test in two categories:

[1] http://www.proxim.com
[2] http://www.senao.com

- **Static tests**: The MEUs are placed in fixed positions. The scenario is a parking where there are no presence of obstacles between cars (line-of-sight environment). This tests have been performed using both the Orinoco card and the Senao router. Section 3.1 is dedicated to describe them.
- **Dynamic tests**: The MEUs traveling across a predefined itinerary. Specifically, we have selected an urban and a highway scenario. The results are shown in Section 3.2.

3.1 Static tests

As we commented previously, these tests consist of placing two cars in fixed positions while they are sharing files. We consider three different distances for carrying out the experiments (see Figure 2a). The selected scenario is a parking, being the cars in a line-of-sight environment. Figure 2b illustrates a snapshot during the experiments.

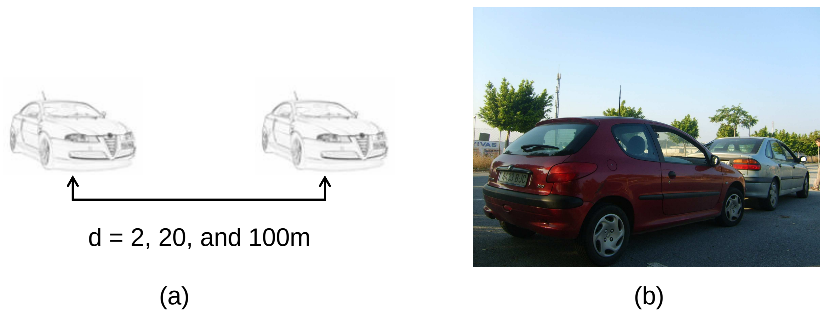


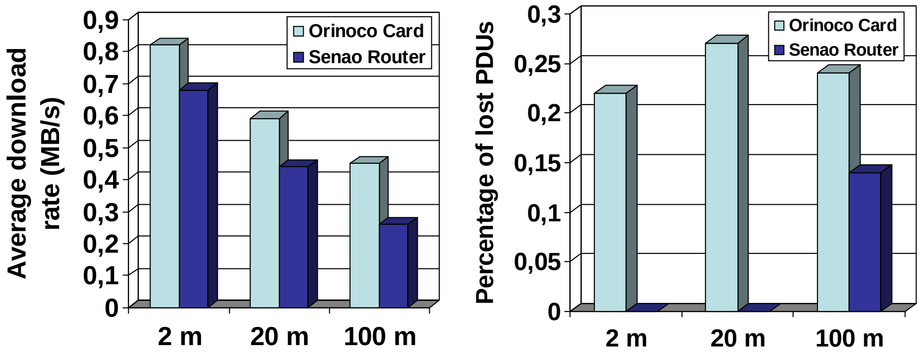
Figure 2: Static tests: two cars interchange files in fixed positions. (a) We consider three different distances: 2, 20 and 100 meters. (b) A capture of the cars during the experiments

Table 2 shows the tests parameterization. We consider three different file dimensions (1 MB, 5 MB, and 10 MB, filled with random dummy content). All the transferences work under the IEEE 802.11b/g MAC layer standard using the FSF application. The transport protocol used by FSF (VDTP [4]) needs to split the file in chunks of configurable size (25 KB in our case). Finally, for each configuration (distance between cars and file size) and equipped hardware (Orinoco card or Senao router), each file is transferred 30 times.

Table 2: Static tests parameterization

Speed of the devices	0Km/h (static tests)
Wireless Ad hoc Application	FSF [9]
MAC Layer Standard	IEEE 802.11b/g
File sizes	1 MB 5 MB 10 MB
Distances	2 m 20 m 100 m
Chunk size	25 KB
Number of trials	30
Equipped network hardware	Orinoco Card & Senao router NCB-3220

Figure 3 summarizes the most significative results. Specifically, the average download rate and the percentage of losing packets depending on the distance between cars. It is clear to observe the fall in the download rates when we increase the distance. Comparing both equipped hardware, the Orinoco card presents higher rate values than the Senao router. This difference is more evident when the cars are separated by 100 m. However, using the Senao router the probability of losing PDUs is lower. In fact, up to 20 m, none PDU was lost. The Orinoco card presents probabilities between 0,22% and 0,27%. These values, lower than 1%,do not influence much in the download speed, but we have to keep in mind the conditions of this experiment (the cars are stopped and there is a line of sight between them). If we consider cars in movement and the appearance of obstacles, the percentage of lost packets can increase notoriously, penalizing the download rate (FSF penalizes the download with a timeout of 2 seconds when a packet is lost).



(a) (b)

Figure 3: Average download rates (a) and percentage of lost PDUs (b) depending on: the distance between cars and the equipped hardware. The Orinoco card presents higher download rates, but the drawback of a higher probability of losing packets

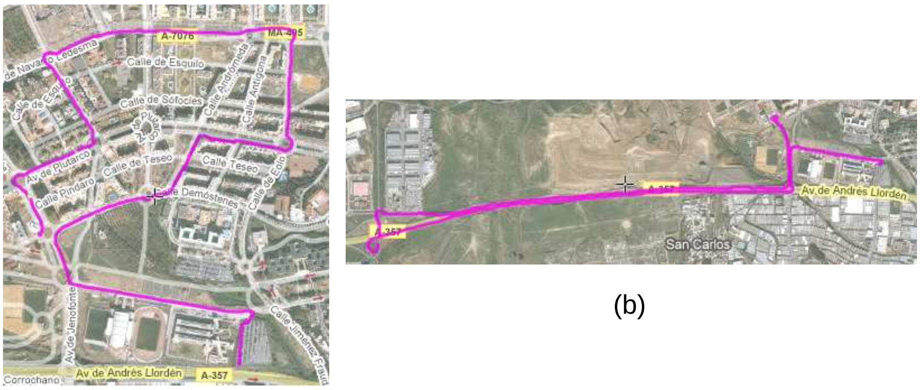
3.2 Dynamic tests

In the previous section, MEUs were placed in fixed positions. Now, the cars are traveling across a predefined itinerary. We have selected two different scenarios for the tests: Urban scenario (Figure 4a) and Highway scenario (Figure 4b).

(a) (b)

Figure 4: A snapshot during the Urban (a) and Highway (b) itineraries

Figure 5 illustrates the GPS tracking of both scenarios. On the one hand, the urban scenario covers an area of 4 Km approximately. In this itinerary, we have avoided the presence of traffic lights in order to keep the car in movement during all the travel (to avoid static conditions similar to the experiments performed in Section 3.1). On the other hand, the length of the highway itinerary is 12 Km approximately. Both scenarios are placed in Malaga, close to UMA.



(a) (b)

Figure 5: GPS tracking for the urban scenario (a) and the highway scenario (b)

The parameterization of the tests is shown in Table 3. We have tried to keep the cars close to each other (with a maximum distance of 50 meters between them). Only a file with 1 MB size (filled with random dummy content) is transmitted during 4 (highway) and 9 (urban) trials, because of the low data rates obtained. We made the decision of using only the Senao router for these experiments. Although the Orinoco card obtained better download rates in the static tests (see Figure 3 for more details), it also presented a higher probability of losing packets. In these experiments, we can expect a higher difference in the number of packet lost between both hardwares because of the hardness in the environment conditions (mobile devices, appearance of obstacles, etc.). The rest of parameters are the same as in the static tests.

Table 3: Dynamic tests parameterization

Maximum speed of the devices	90 Km/h (highway) 50 Km/h (urban)
Traveled distance	4 Km (urban) 12 Km (highway)
Wireless Ad hoc Application	FSF [9]
MAC Layer Standard	IEEE 802.11b/g
File size	1 MB
Maximum distance between vehicles	50 m (approximately)
Chunk size	25 KB
Number of trials	4 (highway) 9 (urban)
Equipped network hardware	Senao router NCB-3220

The results in terms of download rates are shown in Figure 6. On the one hand, in the Urban scenario the rates are included between 0,07 MB/s and 0,65 MB/s. The environment conditions in this scenario can be very variable: the distance between the cars and the speed is not constant, and the appearance of obstacles (other cars, people, street elements) is frequent. In these conditions, two consecutive transferences can produce very different rates (e.g. the fourth and fifth trial). On the other hand, the Highway scenario presents the lowest download rates. The average rate is 0,012 MB/s, being necessary at least 76 seconds for transmitting a 1 MB file, so it is not advisable to transfer larger amounts of data under these conditions.

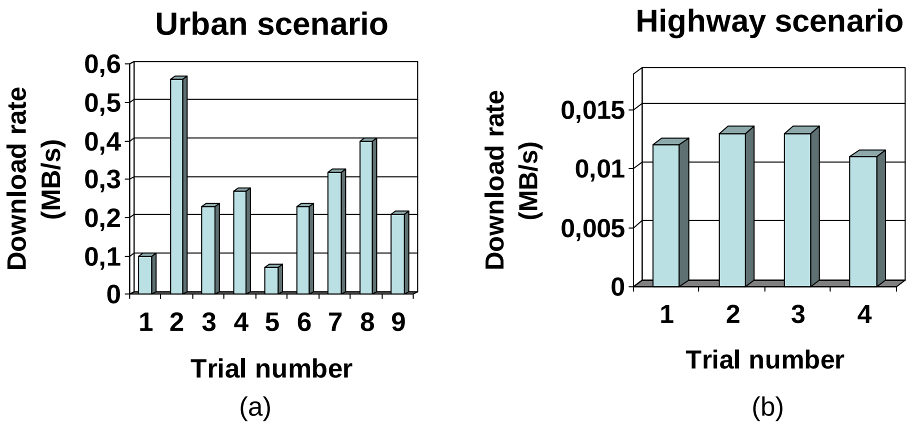


Figure 6: Download rates obtained in the Urban (a) and Highway (b) scenario. In the urban scenario each transference can produce a very different rate because of the variability in the environment conditions. In the highway scenario, the high mobility of the devices produces the lowest data rate

The resulting percentage of lost packets in both scenarios is shown in Figure 7. Just like before, the urban scenario presents a high oscillation in the values (between 0% and 14,63%). In the first and fifth trial, the highest values are reached. In the highway scenario, these values are more homogeneous, which always exceed the 1%. The highest percentage value is also reached in this scenario (specifically in the fourth trial).

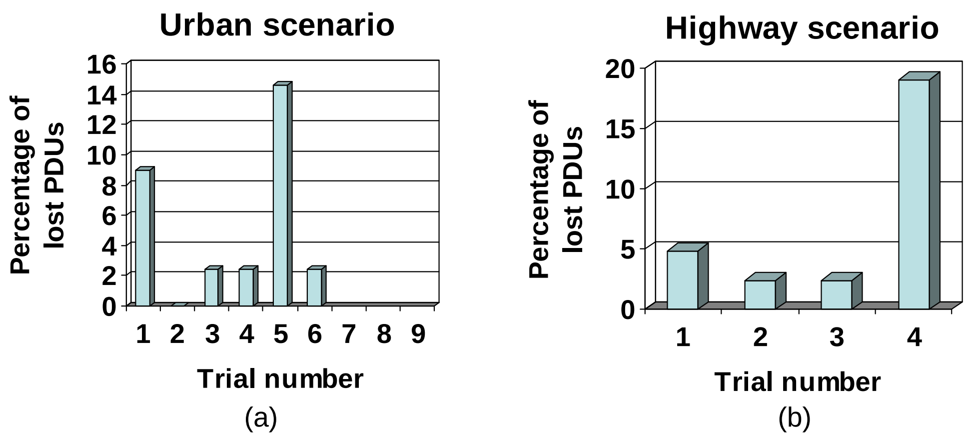


Figure 7: Percentage of lost packets during the different trials in both scenarios. (a) In the urban itinerary these values oscillate because of the variability in the environment conditions, existing trials where none packet is lost. (b) The highway scenario presents the transmission with the highest percentage of lost packets (19,04 %)

4 Conclusions

We are interested in measuring the real performance of the IEEE 802.11b/g under different conditions. The deliverables D2.2.1 [5] and D2.2.2 [6] present the static tests where MEUs are placed in fixed positions (considering different distances between them). We have considered different network hardware in different distances. The results revealed that the WiFi router had lower percentage of losing PDUs then the Orinoco card. Therefore, we used the Senao router in the dynamic experiments presented in D2.2.4 [7] and D2.2.5 [8] where MEUs travel across an urban and a highway scenario respectively. This deliverable summarizes all these experiments.

In the static tests, we have transmitted files between two cars separated up to 100 meters (in a line-of-sight environment). The obtained average rate values are between 0,26 MB/s and 0,82 MB/s. The Orinoco card presents the advantage of a higher download speeds, while the percentage of lost packets is lower using the Senao Router.

The dynamic tests presented harder conditions because of the high mobility of the cars, appearing obstacles and signal interferences. The Senao router have been the selected hardware in order to avoid a high percentage of lost packets (each time a packet is lost, the download time is penalized two seconds). In the urban scenario, the variability in the environment conditions (distance between MEUs, speed variation, appearance of other cars between them, etc.) produces that two consecutive transferences obtain very different download rates. Being the MEUs separated up to 50 m and moving at a maximum speed of 50 Km/h, the download rates were between 0,07 MB/s and 0,56 MB/s. In the highway scenario, because of the high speeds (up to 90 Km/h), the download rates were very low. In fact, at least 72 seconds were necessary for transmitting 1 MB file. In this case, the download rates were between 0,012 MB/s and 0,014 MB/s. The IEEE 802.11b/g standard was not designed for vehicular networks, but it can be a feasible option for transmitting car-to-car data if the MEUs are not moving at very high speeds ($\leq$ 90 Km/h), being separated by short distances ($\leq$ 100 m).

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