# *IEEE802.11a standard performance in mobile environment*

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*Abstract* – **In this paper we reflect evaluation of Wireless Local Area Network (WLAN) standard in a vehicular environment. WLAN based on the IEEE802.11a standard in wireless user community is widespread and well known to ensure wireless communication. This standard can be used indoor environment for stationary and slowly move users. Despite this fact we analysed this wireless communication standard to understand basic performance and suitability for Intelligent Transportation Systems (ITS) providing a ubiquitous mobile INTERNET access. A wireless vehicular communication tests in real scenario usually require a large number of vehicles and testers for proper results. To derive an experimental result we used simulation/emulation tool such as National Chiao Tung University- network simulator (NCTUns).**

***Keywords-WLAN, IEEE802.11a, NCTUns, mobile environment***

## I. INTRODUCTION

In the recent years an inestimable effort has been made to ensure the ubiquity of the Internet. Communication systems like Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMax), and Global System for Mobile (GSM) / Universal Mobile Telecommunications System (UMTS) provide wireless Internet access for a variety of mobile applications. Mobile Internet based on wireless communication standards is becoming more developed technology to increase an ability of creating high throughput and low cost networks for the user in-motion.

Providing ITS with stable wireless INTERNET connection is an attractive research field of industries and academics. The potency to exchange information wireless V2X is a major backbone of powerful Intelligent Transport Systems (ITS). ITS wireless vehicular communication systems are divided in three research areas such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-person (V2P) communication. The aim of these efforts is mainly to increase drivers and passenger comfort providing ubiquitous wireless access to the INTERNET, road safety and transport efficiency. Using such communication technology driver and pedestrian can quickly access a useful and/or emergent traffic or entertainment information on the roads for free or at low cost. For this reason, stable and reliable wireless communication has become a very important technology for developing ITS.

However, the main task of the researcher is to choose and develop the best option of providing wireless communication and make it applicable to mobile environments. Result from such effort is an international standard, IEEE802.11p with raw data rate up to 27 Mega bits per second (Mbps). This standard can provide a short message communication to improve safety on the road and traffic flow, but it does not have the capacity to provide the comfort of the passengers and drivers with appropriate INTERNET access. In this case, a new initiative is offered to develop wireless network solutions with low costs, wide accessible and high capacity of data exchange.

Users are not static in vehicular environment; they change velocity, amount and location. In this research we propose to evaluate the IEEE802.11 wireless standards unsuitable condition. We made analyse to apply wireless networking standard like IEEE 802.11a for providing wireless networking connection in a vehicular environment.

A wireless vehicular communication tests in real scenario usually require a large number of vehicles and testers for deriving proper results. For conducting such outdoor test many vehicles, communication devices need to be provided and many testers need to be involved. Give such problems to perform outdoor testing in our research, we use integrated simulation platform NCTUns version 6.0 to evaluate wireless technology, namely IEEE802.11a. To obtain results, we analysed the performance of the technology in one of communication solution vehicle to infrastructure scenario.

This paper is divided in follow sections: After the introduction of the problem in Section 1, Section 2 provides some information about the related works. Then, in Section 3 we describe the main future of the IEEE802.11a standard. After test description and demonstrating the simulation results in Section 4, in Section 5 we summarize this paper.

## II. RELATED WORKS

Previous works that we have analysed in this research principally authors use of NCTUns software support as advantage of easy modelling and simulating of various vehicular environments, also specific research is made for vehicular networking, V2X communications, IEEE802.11 in-motion and others. Mostly they are made to improve the safety and keep driver aware of condition and situation on the road [1, 6, 9-13].

Many researches are made to describe, test and estimate performance of WLAN access points using in static scenarios, such as restaurants, offices, public places and different indoor locations. In a vehicular environment or high traffic condition more research is directed to use a navigation system based on Global Positioning System (GPS) which can provide only location and time information. But only same researches have the main goal to derive a permanent connection to the INTERNET.

Our goal is to show the performance of IEEE802.11a in a mobile environment. Similar research [11] evaluates realistic urban scenario to observe the performance of the WLAN at very low speeds. They varied the modulation scheme and analysed the throughput. Gained results of research have implications for multimedia and other real-time applications that will use vehicle-to-roadside connectivity.

The idea of using IEEE802.11a standard in vehicular scenario is quite unusual. In our research we try to prove main features of IEEE802.11a because this technology can be much more accessible and easier to implement.

The main task of this research is to review IEEE802.11a standard points using in a vehicular environment. We are interested in real road situations to test IEEE802.11a standard using NCTUns simulation software. We have to observe the advantages of using WLAN between other systems, for example Wireless Access in Vehicular Environments (WAVE). Also, we are showing the possibility of using standard IEEE 802.11a in road situations instead of others and IEEE 802.11p. The most important advantage that has the standard IEEE 802.11a is that it is very outspread and popular, and it is possible to use almost any device to connect to the access point using through this standard. This standard is using lots of existing infrastructure.

We make several experiments using this standard and test the throughput by changing the speed of vehicles and traffic from non-busy too busy. Results are evaluated and calculated as the goodput of the standard. In our research we use goodput as the application level throughput, i.e. the number of useful information bits, sent from sources of information through the network to a certain destination, per unit of time. This useful information is an amount of data which exclude protocol overhead bits as well as retransmitted data packets. If a file is transferred, the goodput that the user experiences correspond to the file size in bits divided by the file transfer time. The goodput is lower than the throughput, which generally is lower than network access connection speed (the channel capacity or bandwidth).

## III. IEEE 802.11A STANDARD FEATURES

The IEEE802.11a standard operates in 5 GHz band and the signal is modulated with 52-subcarrier orthogonal frequency-division multiplexing (OFDM) using different digital modulation schemas where each of subcarriers can be BPSK, QPSK and QAM. The one channel bandwidth of the modulated signal is 20 MHz with an occupied bandwidth of 16.6 MHz. According mentioned digital modulation schemas the raw data rate can be modified up to 54 Mbps, but more realistically achievable throughput is around the 20 Mbps. IEEE802.11a originally had 12/13 non-overlapping channels, 12 that can be used indoor and 4/5 of the 12 that can be used in outdoor point to point configurations. Recently many countries allowed operation in the 5.47 to 5.725 GHz band. IEEE802.11h standard provides an additional 11 channels to the IEEE802.11a standard 12 non-overlapping channels enabling significant overall wireless network capacity enabling the possibility of 23+ channels. Most enterprise class Access Points has dual band capability and at the same time this allows to use two different standards [2, 3, 5].

Advantages that are more referable in Intelligent Transportation Systems are popularity, ease to use and a low systems price. The new standard IEEE802.11p is now suited especially for vehicular environment required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure in the licensed ITS band of 5.9 GHz. It has a twice less maximum data rate than IEEE802.11a – 27 Mbps although its working range is up to 1000 meters. This standard is made to provide with short messages and broadcasting information, unlike in our case we are trying to provide mobile users with a stable connection to the INTERNET [4, 7, 8, 13].

## IV. TESTS DESCRIPTION AND EXPERIMENTAL RESULTS

First we draw our topology, which is going to be as simple vehicular network scenarios. We created simulation scenarios where one mobile user passes access point. At different velocities a mobile user runs through the access point's operating area. Our topology will consist of the host, IEEE802.11a access point and IEEE802.11a (infrastructure mode) user.

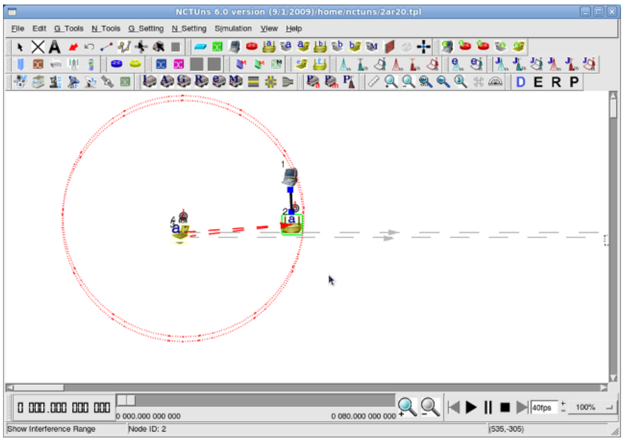

Figure 1. Example of simulation scenario.

Host and access point is connected by point-to-point links, but mobile user is connected to the access point by wireless link. A packet transfer is possible when all users and access point are in one subnet and IP addresses are generated. For tests mobile user runs through the access point's operating range where data transfer is possible, in our case that is 400 meters. Velocity of moving user is considered as the vehicle will be 20, 50, 70, 100 kilometres per hour (kmph).

The wireless link data rate is 54Mbps as a maximum of standard IEEE802.11a. Our test's results will be evaluated by sending UDP packets from user to host through the access point node. During the tests we increased the number of mobile users and the same time still having only one access point which will have to process incoming packets. The size of the transmitted packets is 1500 Bytes long. The host receives these packets gathering information about the performance of WLAN.

Each of mobile user node and host send and receive generated packets. We use different commands rtg/stg for receiving and sending UDP packets. Using these generators increase packet loss ratio because packets sending option aren't regulated accordingly. This protocol doesn't wait for delivery confirmation and just send next packets. Sent and received packet count is different and our measurements we rely only on receiving packet volume.

A small shortage of NCTUns modelling is that it does not have a Data Rate Adaption Algorithm. Therefore, the throughput will not be impacted by the distance between access points and other as long as the user is in the access point's operating area.

We started the tests by simplest topology with only one user. Moving speed was changing from 20 kmph up to 90 kmph. As we assumed from the theoretical approach difference between sent and received an amount of data is quite large. The main reason for that is specified of stg. As we are measuring from receiving packets in our case the big data loss is not so important. Figure 2 shows the difference between sending and received packets in time, which is necessary to run through the access point's operating area. Our subject is one user moving with speed 20 kmph.

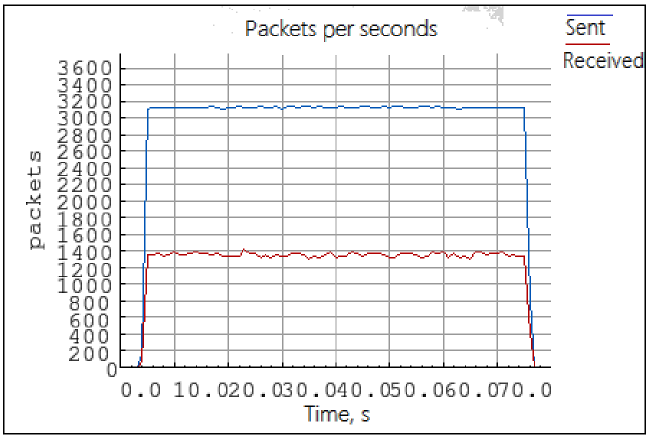


Figure 2. Number of sent and received packets in amount of time.

We tested topology with one user moving with 20, 50, 70 and 90 kmph. We see that peak number of received packets is similar in all simulations. Main value that is changing is time which user spends in the access point's operational area, where it can send packets.

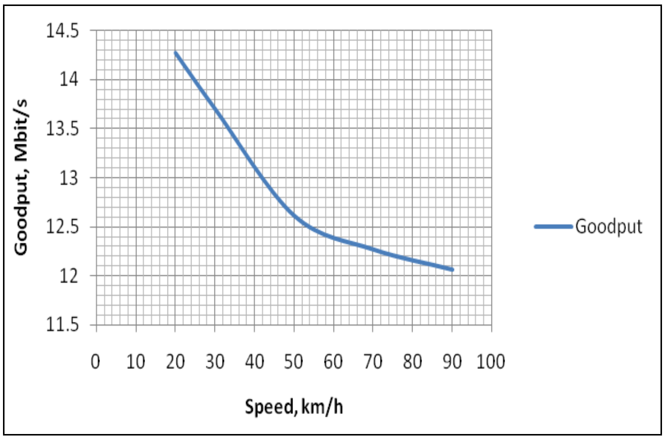


Figure 3. Goodput with one user

As faster the mobile user moves in the access point's operating area, the slower it should reach the peak of the possible number of packets to send. In our simulations we see that it takes two seconds to reach the peak point of the packet volume. The reason of goodput decreasing that using higher velocity mobile user spends less time in access operating area. Figure 3 shows the unstable packet sending process for each of the six users when they are moving at speed 20 kmph.

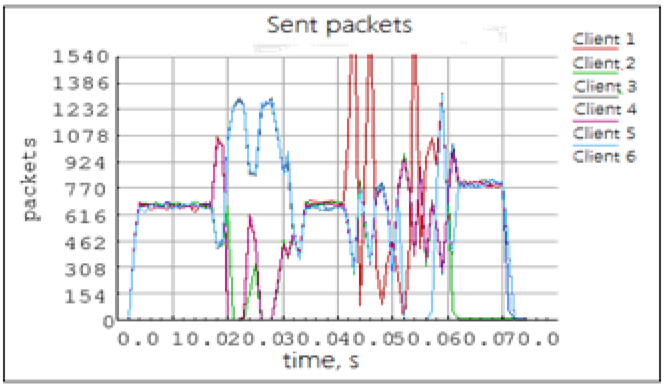


Figure 3. Sent packets

In Figure 4, we can see that by increasing moving speed from 20 kmph up to 90 kmph our goodput is decreasing from 14.3 Mbps to 12.1 Mbps. We have to point out that now only one user is connected. As we know that our data rate is 54 Mbps there is visible decreasing of the data rate in this simulation scenario. When we added more users to the simulation scenario goodput decreased even more, so we can see that number of users is also important for WLAN performance. In Figure 4, we see goodput depending on number of active mobile users at different velocities up to 90 kmph. We have to point out that goodput is what host can provide receiving data packets, but this volume is splited for each active user. For simulation we derive that amount of data what host can process is divided for each user.

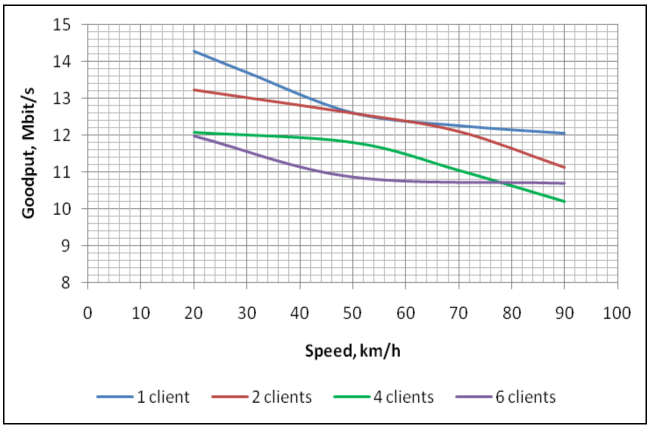


Figure 4. Goodput depending on number of users

In our tests when we tried to increase the number of active users we found out that it is hard to provide data throughput for more than five users at the same time. When we try to add sixth and more users to the subnet access point data flow became unstable. At the same time users could send packets, but it can do only periodically with gaps between sending sessions. Also, this large volume of sending sessions causes some small gaps in traffic when no packets were received from none of the others.

## CONCLUSION

From our test results we can see that it is possible to use IEEE802.11a standard in vehicular environments to provide stable wireless internet connection with average goodput over 10 Mbps with a condition that one access point holds not more than five users. If number of users increases it is still possible to send broadcasts information and shorter messages about traffic, safety or advertisement.

Simulation results showed that goodput is not so related to the velocity of the user and the network is until stable even if it is moving with 90 kmph and more. When more than six users are trying to access WLAN resources and they are moving from different sides and with different velocities, still some of the users can get required data rate, but in just some cases.

The main observation that moving with greater velocities leaves less time in the access point's operating area decreasing useful connection possibilities.

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