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# NCTUns 5.0 Network Simulator for Advanced Wireless Vehicular Network Researches

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## Abstract

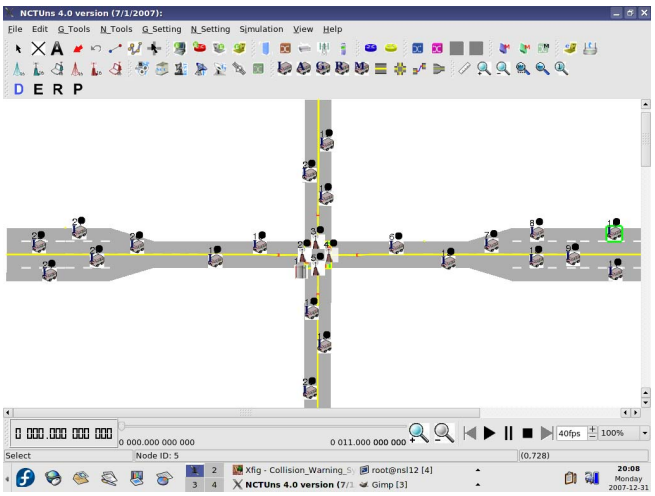
*NCTUns is a high-fidelity network simulator and emulator. By using a novel kernel re-entering simulation methodology, it provides many unique advantages over traditional network simulators and emulators. For this reason, since its public release on November 1, 2002, as of February 2, 2009, more than 13,838 people from 130 countries in the world have registered at its web site to download it and these numbers are still fast increasing.*

*NCTUns is open-source and runs on Linux. It can simulate many different types of networks. In this paper, we will present its supports for wireless vehicular network researches. In particular, it supports IEEE 802.11(p)/1609 standards, which are proposed for wireless vehicular networks. More information about this tool is available at its web site at (http://NSL.csie.nctu.edu.tw/nctuns.html).*

## 1. Introduction

Since Intelligent Transportation Systems (ITS) has shown the world its great potential to improve the quality of transportation, intelligent transportation technologies have grabbed the attention from the industry and the academia. Among several intelligent transportation technologies, wireless communications is one of them to provide drivers/passengers with safer and efficient driving/traveling experience. By the support of wireless communications technologies, many kinds of information can be exchanged among vehicles or between vehicles and roadside base stations. Accordingly, many sorts of ITS applications, such as collision warning, driving guidance, electronic toll collection, etc., can be realized in vehicular environments.

The IEEE 802.11(p)/1609 standards [1] have been proposed as a communication technology to support ITS applications in vehicular environments. ITS applications based on this new technology must be thoroughly tested and evaluated before being deployed on the roads. This means that many experiments under different parameters settings, configurations, scenarios, and conditions must be performed to verify the feasibility and effectiveness of an application




and the used networking technology in the real-life environment. According to the results obtained from experiments, the designs of the application and the used networking technology might need to be revised many times before acceptable performances can be achieved.

A field trial of wireless vehicular communication research usually involves a large number of vehicles and people (drivers and computer operators) for generating meaningful results. Conducting such field trials is very costly because many vehicles need to be rented (or purchased), many communication equipment need to be purchased, and many experimenters need to be employed for conducting the field trials. Sometimes, during a field trial with a specifically-designed high-speed scenario, the experimenters may even face potential dangers such as collisions with vehicles or pedestrians. Besides, it is very difficult to accurately control and repeat a field trial on the roads, which is bad for debugging the problems and improving the performances of a new protocol or application. Given these problems, it is highly desirable to use software simulation to perform indoor function testing and performance evaluations prior to conducting field trials.

In this paper, we introduce a software network simulator, called NCTUns [2], that satisfies the requirements for wire-

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less vehicular network researches. NCTUns is an integrated network and traffic simulator, which has the abilities to simulate wireless communication protocols and vehicular movements on road networks. In terms of these abilities, NCTUns has been selected by WiVec 2008 as a demonstration [3] and been published as a book chapter [4]. Besides, several researches have been conducted based on NCTUns and the results have been or will be published [5]–[7]. In the next section, we will only and briefly present some of the NCTUns' features that are useful for conducting wireless vehicular network researches. To obtain more information about NCTUns, we refer the readers to its web site at (http://NSL.csie.nctu.edu.tw/nctuns.html).

## 2. Supports for Wireless Vehicular Network Researches

To clearly introduce the NCTUns' abilities to support wireless vehicular network researches, we classify them into four aspects according to their specific functionality: Graphical User Interface (GUI), Simulation Engine (SE), Protocol Module (PM), and Car/Signal Agent (CA/SA). Each aspect will be described below respectively.

- NCTUns has a highly-integrated and professional GUI environment. This GUI can help a user (1) draw road network topologies or import them from existing road map files, (2) configure the communication protocols used on each vehicle, (3) deploy a large volume of vehicles on the road network, (4) specify vehicular properties applied on each vehicle, (5) plot network performance graphs, (6) play back the animations of vehicular movement and network packet transfer, etc. All these operations can be easily and intuitively done with the GUI.
- The NCTUns' SE directly uses the real-life Linux's TCP/IP protocol stack to generate high-fidelity simulation results. Besides, it can use any real-life existing or developing UNIX application program as a traffic generator program during simulation. This feature enables a researcher to test the functionality and performance of a developing application under simulated network environments and then directly deploy it to the real-life networks without any modification.
- NCTUns can simulate various wireless communication protocols that could be used in vehicular networks to provide communication servirces, such as IEEE 802.11(a), GPRS, DVB-RCS, IEEE 802.16(e) (also known as mobile WiMax), IEEE 802.11(p)/1609 [1] (also known as WAVE), etc. In particular, the emerging WAVE standards originated from the need for ITS applications. Accordingly, the support of WAVE will be very useful to future wireless vehicular network researches. Besides, a researcher is free to modify protocols already supported by NCTUns or add new ones into it.
- The CA controls the vehicular movement during simulation while the SA controls the signal status during simulation. A researcher is free to add any customized control logic into the CA or the SA. This provides high flexibility to satisfy various research needs. Conclusions

## 3. Conclusion

In this paper, we first motivate the needs of using software network simulator to conduct vehicular network researches and then introduce NCTUns that satisfies the needs. Due to the paper length limitation, we only and briefly introduce the significant features of NCTUns that support wireless vehicular network researches. More information about this tool is available in its web site at (http://NSL.csie.nctu.edu.tw/nctuns.html).

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