Demo: Rapid Cellular Network Simulation Framework for Automotive Scenarios (RACE Framework)

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***Abstract*—Testing new communication concepts in automotive scenarios using field tests is expensive and consumes a lot of time. Several simulation frameworks and tools exist to deal with these constraints of scalability and time. However, all of them require profound background knowledge for building such a custom scenario. This crucial and necessary procedure is often time consuming and error-prone. The RACE framework presented in this demo, aims to solves these problems for the simulation of cellular LTE networks. RACE is intuitive and based upon real life cellular network infrastructure data as well as a realistic vehicular traffic simulation.**

I. Introduction

There exist many software simulators which try to simulate cellular Long Term Evolution (LTE) networks. SimuLTE [1] for example is a tool that enables the well known Omnet++ [2] network simulator to process LTE scenarios. Omnet++ itself only offers basic movement concepts for the simulation of mobility like random walk or constant speed movement, but no real vehicle traffic. To overcome this insufficiency, the Veins simulation framework [3] connects Omnet++ together with the traffic simulator Simulation of Urban MObility [4] (SUMO). Thereby, wireless communication simulations with realistic traffic conditions can be conducted. VeinsLTE [5] is an extension of the Veins simulation framework which integrates SimuLTE into Veins and thus achieves the task of simulating LTE networks under the needed vehicular traffic conditions.
However, SimuLTE, upon which the other simulators rely, has one particular insufficiency. The simulation of the LTE X2-handover procedure has not been implemented in SimuLTE. The result is that LTE simulation scenarios of SimuLTE can only be based upon the connection of mobile nodes to one single cell tower. In reality moving vehicles constantly change between different cell towers along their routes; but such scenarios cannot be simulated with SimuLTE.
Besides Omnet++ there exists the very popular Network Simulator 3 (ns3) [6]. The simulation of LTE is enabled for it through the LENA project [7]. LENA itself implements the X2-handover procedure which capacitates the simulation of automotive scenarios. As ns3 is also capable of using SUMO mobility traces, the required toolset to simulate realistic real life automotive scenarios is given. Nevertheless, the generation of a cellular scenario in ns3 requires profound background knowledge and costs a lot of time. To receive detailed information about cellular network infrastructure is very difficult. The presented RACE framework aims to close this gap. RACE is easy to use, with an intuitive graphical user interface, and it generates realistic scenarios quickly. The framework relies on information about real life cellular network infrastructure. This data set is provided by the Canadian organisation of Innovation, Science and Economic Development (ISED) [1]. It covers the whole infrastructure of the Canadian network providers (e.g. Telus, Rogers and Bell).

II. Scenario Creation

The most novel feature provided by the RACE framework is its capability to generate and test different real world scenarios quickly. Other simulation frameworks often provide just a single example scenario which is not easy to adapt to personal needs. Profound background knowledge has to be acquired first. RACE however lets one quickly generate a custom scenario. After the user has selected the required scenario constraints the framework itself performs all the remaining steps. In the end, it provides the files that can directly be used to simulate the configured network conditions within ns3. The necessary steps are explained in the following:
1.) First the user has to specify the area of his custom scenario by providing the name of the nearest city (e.g. Toronto). The framework will then only show data in an area of 200x200km around this city. Besides the area, one can also specify which cellular providers (a single or a multitude, e.g. Telus, Rogers or Bell) one would like to consider available in the scenario.
2.) Based upon this preselection, the user can then further specify his particular scenario by defining the actual vehicular traffic in a map view (see Fig. 1 and Fig. 2). This is achieved by specifying the start and end point of each track and the

[1] http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h_00010.html

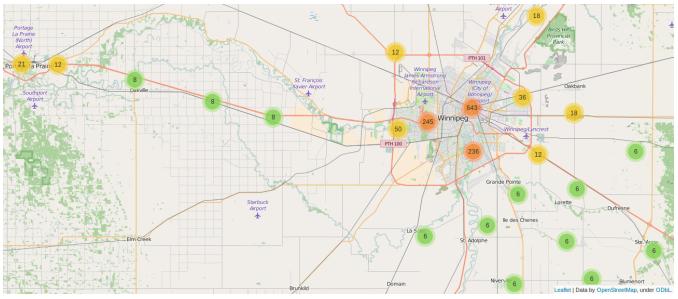

Fig. 1. Overview of the LTE infrastructure of provider TELUS Communications Inc. for the city of Winnipeg.

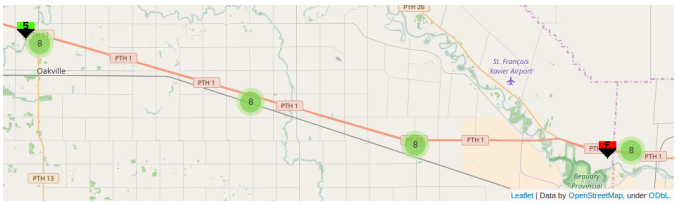

Fig. 2. Example highway scenario for the Trans Canada Highway near Winnipeg. The start and end of the route are selected through markers.

amount of vehicles to drive on it. The user can also remove already set data if he wants to change some parameters. With this feature the RACE framework can also be used to quickly generate customized traffic scenarios which are then simulated by SUMO. RACE even offers the possibility to simulate the movement of trains. 3.) If the user is satisfied with his scenario, he can save the different specified routes in a record file. This file is then further processed by RACE. The framework simulates the traffic and selects the nearest cell towers along the route. An example scenario for the Trans Canada Highway near Winnipeg, Manitoba is shown in Fig. 2.

The RACE framework provides amongst others, the following parameters for simulation of LTE: Height and GPS position of the cell towers, transmission direction (azimuth and vertical angle), transmission power, transmission bandwidth and gain of each antenna.

Each scenario is initially configured based on the data set provided by the ISED to resemble reality. All the parameters however are customisable to simulate different network conditions in the scenario itself. A possible scenario e.g. is the outage of one of the cell towers.

A plot of the radio environment map for the Winnipeg highway scenario is shown in Fig. 3. The map shows the Signal to Noise Ratio (SINR) of the antennas related to each other. In this scenario all antennas have the same transmission power.

III. Demonstration Setup

The provided demonstration at NetSys 2017 will give the audience the possibility to make themselves familiar with the RACE framework. Beginning with the creation of custom traffic situations, you will be guided through the different processing steps involved in RACE. The generated scenarios will then be simulated and visualized within ns3. After the initial

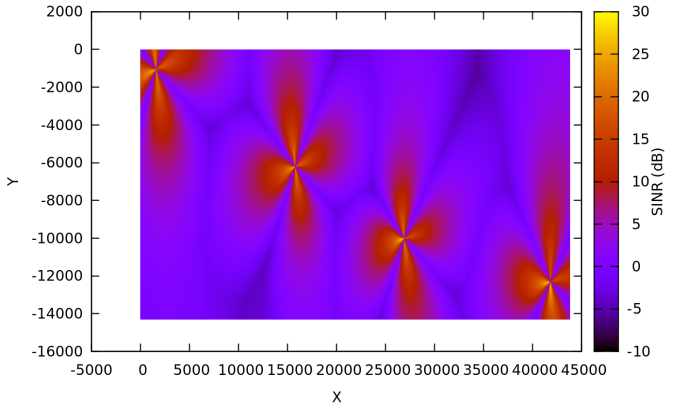

Fig. 3. Radio Environment Map plot of the example highway scenario.

creation of the scenario with RACE, the further customisation possibilities, amongst others, will be explained. Thereafter, the audience can try to modify their initial scenarios regarding the following parameters:

1) Position, transmission power and availability of cell towers to simulate changes in the infrastructure
2) Number of participating vehicles in the scenario

Then the changed scenario will be simulated and visualized to show the influence of each of the modified parameters once again. The framework itself will be made publicly available on GitHub [2] for personal use and adaptation after the conference.

IV. Conclusion

In this paper, a rapid prototyping framework (RACE) has been presented to simulate cellular LTE networks in automotive communication scenarios. It relieves the user of acquiring profound background knowledge about the underlying simulation tools (the LENA LTE package for the network simulator ns3 and the traffic simulator SUMO). RACE relies on real data about the cellular network infrastructure of Canada. It enables the possibility to generate custom traffic simulation scenarios which could also be used for other purposes.

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