(DEMO) WTTool: A Visual Web-based Topology Generator and 5G Network Simulator with ns-3

Nicholas Accurso*, Samir Si-Mohammed†, Diptangshu De*, and Filippo Malandra*
* Department of Electrical Engineering, University at Buffalo
† ICube Laboratory, University of Strasbourg

***Abstract*—In this work, we provide a web-based application designed to aid researchers in the study of wireless network performance. This application provides several key features. The graphical user interface allows users to create realistic topologies through the use of real geographical data. Our application allows for the sharing of network topologies among researchers, improving the reproducibility of results. The network simulator, ns-3, is built into the platform providing users with a simple, seamless method to generate realistic results. The visualization of these results as a heatmap allows users to better understand and predict the performance of their network, allowing them to change its configuration to meet specific requirements before the actual deployment. Altogether, this application contains tools for each step of wireless network research: from network design, to result generation and visualization.**

***Index Terms*—Internet of Things, Cellular IoT, Network Generation, Wireless Networks, Simulation.**

I. Introduction

Cellular infrastructures have long been used to facilitate communication between people, and more recently between machines through massive Machine Type Communication (mMTC). There are three primary ways in which researchers can study cellular networks: Mathematical modeling, gathering data from real networks (experimentation), and simulation. Mathematical modeling, while convenient and arbitrarily scalable, suffers from a lack of realism since it is nearly impossible to consider the many diverse and complex variables in such a system. Gathering data from real networks is without a doubt the most realistic of the three approaches, but suffers from inaccessibility due to the difficulty in obtaining or setting up such experiments. Simulation strikes a balance between these other approaches in the sense that simulation can be reasonably realistic while also being accessible and scalable.

It is essential when conducting simulation studies on wireless networks that the simulation itself be as realistic as possible though. Typically, the locations of nodes in a simulation are either completely random or predetermined in some unrealistic manner (for example nodes are placed perfectly along a grid). In real life, the locations of nodes rather tend to align with the geography of the surrounding area. For example, in a smart city scenario, nodes will tend to be clustered along roads and by large buildings. By taking this into account, a simulation can become much more realistic [1].

Once this network topology has been designed with a geographically-based distribution of nodes, the simulation itself needs to be conducted using a simulator such as ns-3. ns-3 is a C++-based discrete-event simulator that has been developed to provide an open and extensible network simulation platform for networking research and education. Due to its strong documentation and the important set of network technologies it supports, it has become one of the most used simulators in the network community. However, one of the main drawbacks to a broader adoption of ns-3 is its interactive usability. Indeed, it requires network expertise and knowledge in C++ programming to design experiments and to exploit the results.

In this work, we combine our two existing platforms - Wireless Topology Tool (WTTool) [2] and StackNet [3]. WTTool is a web-based platform designed to help researchers design, create, and visualize cellular network topologies. The user interface for topology generation is overlaid upon the Google Maps Application Programming Interface (API), allowing the user to create realistic network topologies themselves. WTTool also supports the sharing of network topologies among users as well as the spacial visualization of network performance as a heatmap. However, the main limitation of WTTool is that there is no built-in network simulation, requiring the user to export topologies and run simulations themselves. StackNet (which is based on SIFRAN [4]) is a no-code tool that allows users to run ns-3 simulations and visualize results without having to write a single line of code, but does not consider geographical data. Together, these two applications form one single application that can aid the wireless networks research community in each step of the research process - from network design, to result generation and visualization.

II. Application Features

In this section, we describe the three main features of the application: creating topologies, conducting simulations, and visualizing results.

A. Creating Topologies

The first step of conducting a study on a wireless network is designing the network itself. Upon logging into the application, the user is met with the dashboard shown in Fig. 1. In this dashboard, the user can specify the area in which they want their topology by manipulating the yellow polygon over the top of the Google Maps API. After specifying this area of interest, the user can begin adding nodes. There are two types of nodes supported in this application - eNodeBs and User Equipments (UEs). For each of these, there are two methods a user can employ to place the nodes. First, the user can manually use the

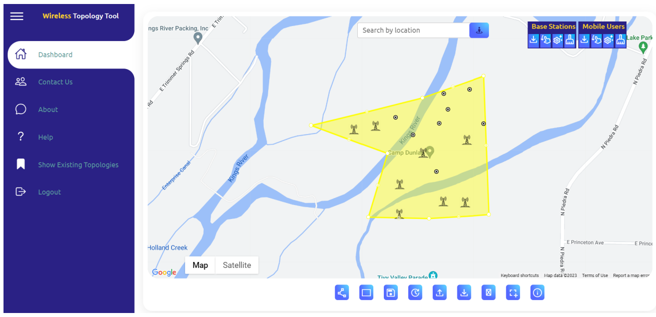

Fig. 1. The WTTool user interface

mouse to place individual nodes. Second, the user can place n nodes randomly over the area of interest.

Once the topology has been created, the user can save their topology to our database either publicly or privately. If the user elects to save their topology publicly, it will be available to all users on the application. If the user saves it privately, it will only be available to other users if selected by the topology owner. This ability to directly share topologies is aimed to encourage the sharing of data among research groups and enhance the reproducibility of results.

B. Simulating Topologies

If a user has access to a topology, they are able to simulate it using StackNet. The technologies we currently support for simulation are Wi-Fi and 5G. The simulation interface allows the user to enter any parameters relevant to the simulation, such as traffic generation rate, bandwidth, and simulation time. Upon submitting the simulation form, these parameters are automatically passed to ns-3, which is running in parallel on the same host as the web application. ns-3 subsequently executes a simulation of the network with the provided parameters. The simulation results, computed in ns-3, are then retrieved by the web application, analyzed, and transmitted back to the user.

C. Visualizing Results

Finally, the user can visualize their simulation results on a heatmap. Such an illustration is shown in Fig. 2, which shows the Free Space Path Loss (FSPL) from various traffic lights in the city of Montreal to their nearest base station (it is important to note that the scale used in this visualization is entirely dynamic, meaning any quantifiable performance indicator can be plotted in this way). Such a visualization is very useful when studying a wireless network, as it emphasizes the importance of node locations on the generated results. For example, poor network performance can often be attributed to a high density of nodes or a significant distance between transmitter and receiver.

III. Description of Demonstration

In our demonstration, we plan to take attendees through a full workflow of our application. First, we will create a network from scratch, emphasizing the importance of basing the distribution of nodes on the surrounding geography. Next, we will show and discuss how the topology is stored and shared among users, emphasizing how our application facilitates the reproduction of results. After this, we will conduct a short simulation of the network we have just created, highlighting the various parameters a user can manipulate. Finally, we will show the results of the simulation as a heatmap. Particularly, we will discuss how the results vary over space in relation to the surroundings, demonstrating the importance of geographical consideration when conducting simulation studies.

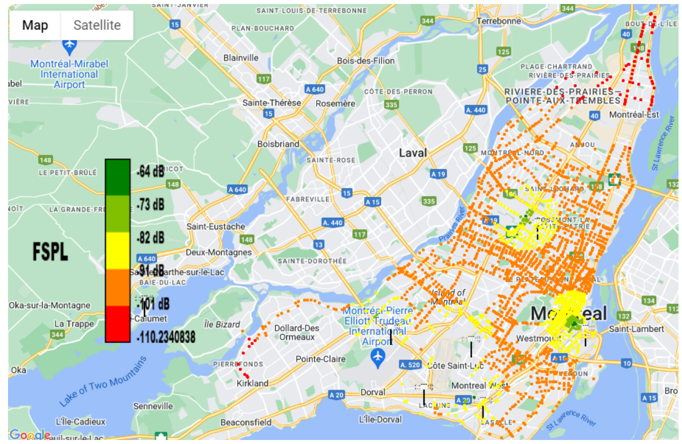

Fig. 2. Example of heatmap visualization, illustrating the Free Space Path Loss (FSPL) from traffic lights in Montreal to the nearest base station

IV. Conclusion

In this work, we have presented a single web application that is designed to aid the wireless networks research community in the design, execution, and visualization of wireless network simulation. The front end of the application provides a user interface over the top of the Google Maps API, leveraging the use of real geographical data to design more realistic networks. In the backend, network simulations using ns-3 can be executed without the user writing a single line of code. Finally, these results can be displayed back in the front end as a heatmap, allowing for spatial visualization of the network performance. In the future, we plan to add more technologies that can be simulated, for example, LoRa and Sigfox. We also plan to improve the customization of network topologies, adding per-node attributes to facilitate the design and simulation of large-scale heterogeneous networks.

References

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