ADVANCED METHODS OF NETWORK SIMULATIONS WITH OPNET MODELER

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Abstract: This paper presents advanced methods for network simulations using the OPNET simulation tool. This is one of the most widespread simulation tools for network simulations, appropriate for both for teaching and the researching of new devices and protocols. The basic package is indented for simulating communication networks and the developments of protocols and devices. There are also additional specific modules, such as a module assigned to the simulation of wireless networks, an ACE module for analyze of applications, 3DNV module for visualizing networks on virtual terrain and the "System in the loop" module for simulating networks with real communication equipment in the loop, in real-time.

Key words: simulation tools, communications, teaching, networks, modeling, OPNET

1. INTRODUCTION

Over the last few years, network simulations tools have become an indispensable help in the process of constructing and upgrading communication networks. OPNET offers varied simulation tools for many solutions:

- Application performance management (ACE, ACE Live, OPNET Load scalar, OPNET Commander, SLA Commander)
- Network operations (IT and SP Sential, IT and SP Netcop)
- Capability management (IT and SP Guru Network Planner, IT and SP Guru SystemPlanner)
- Network R&D (OPNET Modeler, OPNET Modeler Wireless suite, OPNET Modeler Wireless suite for Defance)

The OPNET Modeler is one of the most advanced tools from among OPNET products palette, together with additional modules, such as Wireless for defense, 3D network visualizer (3DNV), Application Characterization Environment (ACE) and system in the loop (SITL) modules allow advanced simulation methods for wired and wireless communication networks. They also represent an indispensible tool for teaching and researching new communications devices and protocols.

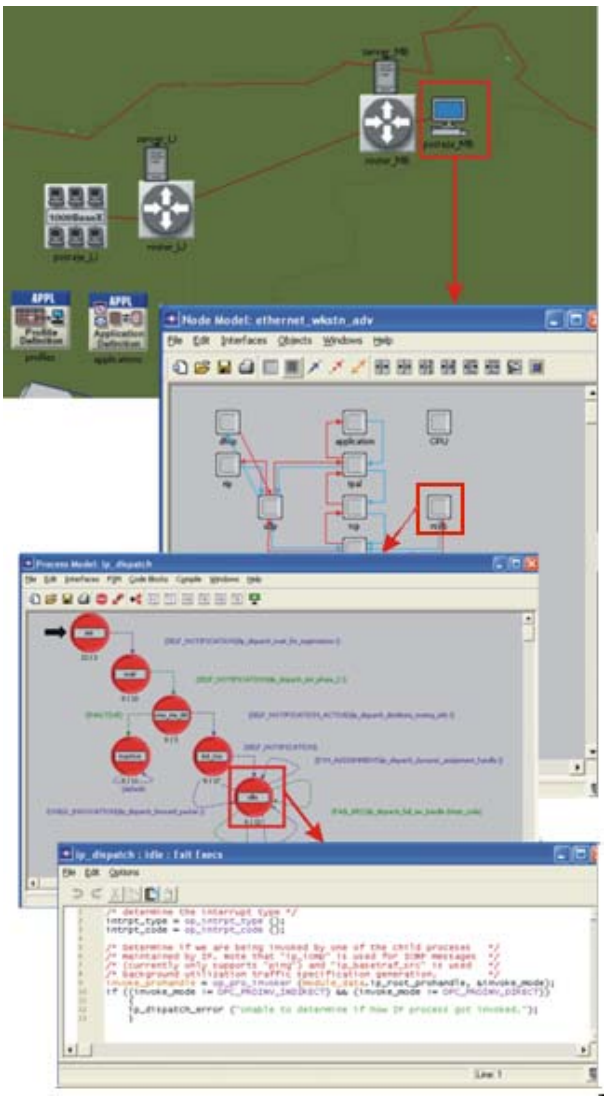
2. OPNET MODELER FOR TEACHING AND RESEARCH PURPOSES

Although OPNET was created for specific University program, its products are also available a simulations tools for nonprofit purposes such are teaching and academic research. There are presently about 20,000 students and professors around the world using these products. Numerous text books and accompanying lab examples are also available. Two options exist when using the OPNET University program [1]:

- Full-featured software OPNET Modeler, which includes an extensive model-library with around 800 protocols and vendor device models. These models are also supported by source code and provide technical support at discount prices.
- The second option is the free OPNET IT Guru Academic edition, which provides a feature set for use at networking levels (without any possibilities of modeling new process and protocols, as with the OPNET Modeler). IT GURU academic edition provides solution testing for different protocols and network technologies: studying various wired and wireless routing protocols, visualizing TCP/IP mechanisms and variations, understanding LAN/WAN/MAN network architectures, designing reliable wireless networks, and implementing efficient network security.

3. OPNET MODELER

The OPNET Modeler is one of the most powerful simulation tools regarding communications. It is especially useful R&D (research and development) areas for developers of communication devices and protocols. Planners and communication network operators have the possibility to use this tool for network efficiency analyze, optimization, growth analysis, etc. The OPNET Modeler comprises a series of hierarchical user interfaces, which are shown in Figure 1.



⇒ **The project editor** is the main user interface. It allows for graphical representations of communication network topology with components from comprehensive library of devices and models, defining communication links, configuring models' parameters, defining, editing and running simulations, scenarios, checking and comparing results etc.

⇒ **The node editor** enables the editing of these network device models that consist of process modules linked by signal and data paths. Each of these process modules can generate, send, receive and process packets from other modules. The standard model contains visualization of communication devices with all protocol layers (from application to the physical layer), according to the ISO/OSI communication model.

⇒ **The process editor** is intended for process modeling with the help of a FSM (Finite State Machine). Using this editor we can approach supported specifications at any level (even regarding details), which relate to communication protocols, data sources, applications, algorithms, queues etc. Every state in the process model includes **C/C++ code**, supported by an expanded functions library, intended for programming communication protocols.

Figure 1: Formation of basic network model (project editor), details using workstation model (node editor) and process coded level (process editor)

There are different possibilities for simulation results' visualization. One of them is shown in Figure 2, where the numerical labels represent:

1) choosing statistics for visualization in the right-window,
2) choosing types of graph showing (individually or more statistics on the same graph),
3) choosing the numerical operation or chosen statistics (average value, logarithmic scale, distributions)
4) displaying a graph in the independent-window.

4. ADVANCED SIMULATION METHODS

The OPNET Modeler Wireless package for wireless network modeling. Wireless links are simulated by using an open-concept called a transceiver pipeline. The transceiver pipeline enables delay computations during the spreading of radio waves, closing radio links, consideration of an aerial's emissive diagram, background noise, modulation effects, interference, bit-error rate, forward error corrections, etc. A very important task of the transceiver pipeline is also consideration of these effects caused by field influences over the modeled terrain, such as fading, diffraction, reflections, atmospheric absorption etc. These are considered by propagation models such as Free Space, Longley-Rice, and the most sophisticated TIREM. The virtual field is modeled in the form of Digital Terrain Elevation Data (DTED) maps. It is possible to simulate various wireless's communication technologies such as MANET, 802.11, 3G/4G, Ultra Wide Band, WiMAX, Bluetooth, ZigBee etc.

The ACE (Application Characterization Environment) package allows virtualization, analyze and prediction of any network applications' problems. It also helps us with analysis during the phase of developing new applications. This module allows the importing of real traffic, and analysis of captured traffic. It allows diagnostics for properties such as information concerning blockages, and delays in networks. The user interface of this module is shown in Figure 3.

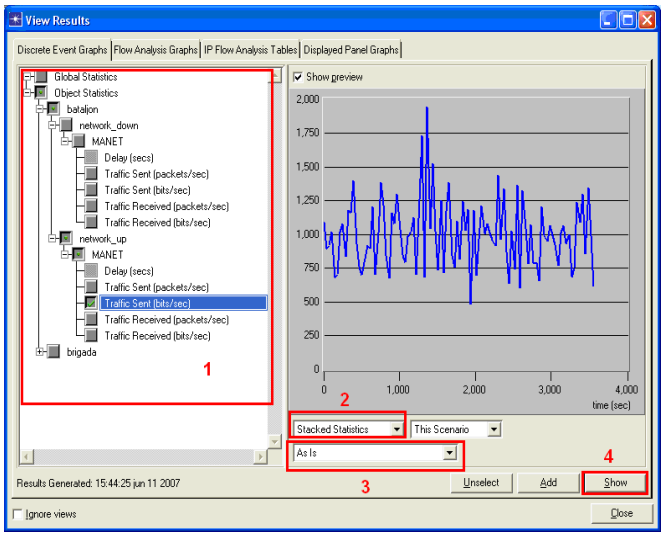


Figure 2: Window "View Results" with simulation results

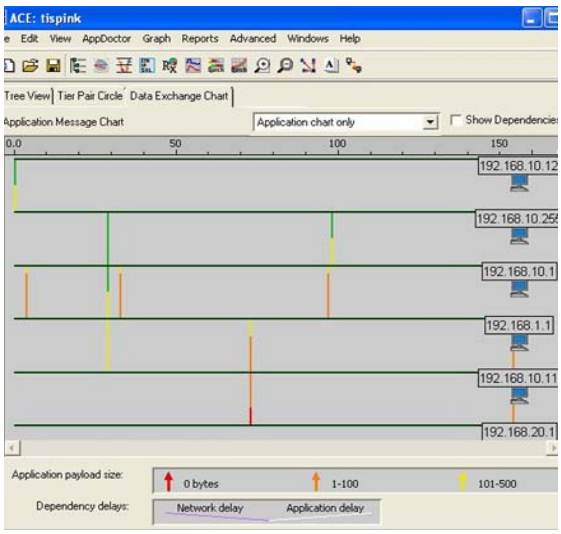


Figure 3: Packet flow analysis with ACE module.

The 3DNV module, shown in Figure 4, in combination with OPNET Modeler, enables the playing of simulated mobile network's 3D animations. Every communication device in the OPNET Modeler can be illustrated by 3D models, in 3DNV environment, by vehicles, soldiers, planes, helicopters, satellites, etc. This tool enables the interactive direction regarding viewpoints of observation 3D scenes similar to video game consoles.

The System-in-the-loop - SITL module adds to the OPNET Modeler the ability to simulate in real time, with real communication equipment in the simulation loop. The module of SITL is suitable for

- studying how simulated network's impact on real network and vice-verse,
- using OPNET simulator as a traffic generator for loading a real network,
- testing of new protocols and device prototypes,
- scalability testing by adding virtual (simulated) devices to a real network etc.

Simulated network can have an influence on real network through parameters, as are packet-loss packages, delays, jitter, packet doubling on receiver side, etc.

External-devices are connected to the simulation loop over SITL gateways, which are bridges between communication simulation environment and host computer Ethernet interfaces as one of the typical configurations [1]:

- Real-Sim-Real: Real network with real network over simulated network. An example is shown in Figure 5.
- Sim-Real-Sim: Simulated network with simulated network over real network.
- Sim-Real: Simulated network with real network.

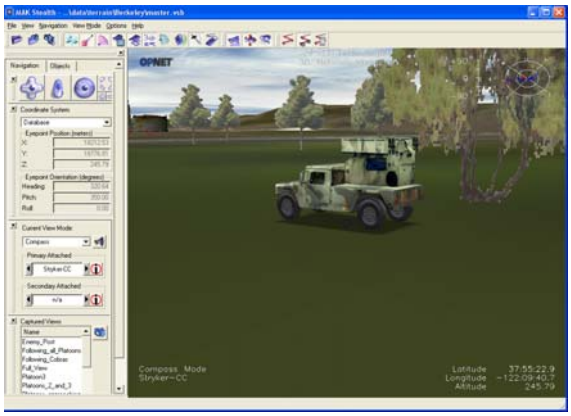


Figure 4:3D visualization of communications unit on virtual field

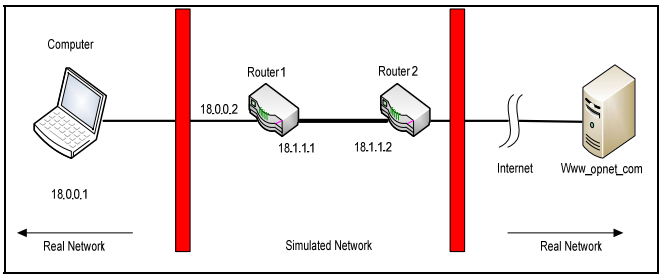


Figure 5:Use case for "Real-Sim-Real" SITL simulation

5. CONCLUSION

From the rich experiences gained from using the OPNET Modeler over the last few years, we can claim, that the OPNET Modeler is an appropriate tool for use in communication research activities [3, 7, 8] and teaching objectives for under-graduate [5, 6] and post-graduate [2, 4] programes.

6. REFERENCES

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