

# 3D Visualization of UMTS/WLAN Integration Using OPNET Modeler

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## ABSTRACT

The primary design goal for this project is to interwork WLAN with UMTS and visualizing in 3D network, so that it can be utilized as an alternate radio access network for defense system. Simulations and modeling have become a very important part of the process when designing communication networks. Only a real network, with real hardware will provide real results. General Dynamics C4 Systems has been working collaboratively multiple routing protocol interaction. 3D Network Visualizer (3DNV) functionality lets you create three-dimensional animations based on topology information, node relationships, performance statistics, and terrain data. The OPNET Modeler is one of the most powerful simulation tools regarding communications. It is especially useful on R&D (research and development) areas for developers of communication devices and protocols. The network model must have a terrain database specified. The nodes to be animated must be mapped to specific shapes (called entities in 3DNV) using a 3DNV mapping library. Furthermore, a 3D visualization of the entire network has been developed, representing both real and simulated nodes, including effects on their communications. The other purpose of this paper is to evaluate different integration solutions and mobility schemes that provide best service and performance by using OPNET as simulation tool.

**Keywords:** 3DNV; HLA; TIREM

## 1. Introduction

The simulation model is designed in OPNET™ Modeler 14.5. The simulation parameters were selected to accurately model an interworked WLAN-UMTS system supporting a “hot spot.”

Animation with 3DNV requires a network model with a terrain database and nodes mapped to 3DNV entities with loop implementation.

A successful network in the loop implementation provides several benefits in the area of testing real networks. Test bed networks may be scaled up to any size. The effects of network performance may then be tested and monitored by varying inputs within the simulated environment, e.g., weather effects, bandwidth limitations, nodal outages, etc.

Furthermore, a network in the loop implementation provides the opportunity to perform system level verification and validation of the simulation using the real portion of the network. Network in the loop provides the ability to monitor the communication effects graphically on the entire effective network, both real and simulated, via a real-time two and three-dimensional visualization tool from almost any point in the network.

## 2. Basic Interworking Operation

To facilitate integration of a WLAN network into a UMTS network four levels of coupling are proposed [1-3]. The first level is open coupling where the UMTS and the WLAN networks make use of two separated access and transport networks while having a common billing. Note that the UMTS and the WLAN networks maintain separate authentication mechanisms.

The second level is loose coupling which enables the use of common authentication mechanisms by providing a link between the authentication, authorization and accounting (AAA) server in the WLAN network and the Home Location Register (HLR) in the UMTS network.

The third level is tight coupling where the WLAN AP is connected as an RNC to the UMTS SGSN to support the handover between WLAN and UMTS networks.

The fourth level is very tight coupling where the WLAN AP is connected to the RNC using the same interface used by a Node B to connect to an RNC.

The latter two coupling schemes are not considered in this paper as they require major modifications in the protocol stacks of the WLAN AP, the UMTS RNC, and/or the UMTS SGSN for such coupling schemes to

work. Furthermore, the integration architectures outlined in this subsection only highlight the generic network structure and do not specify the solution details.

**Figure 1** describes the basic network design of integrated WLAN-UMTS.

### OPNET Module ACE

OPNET is designed modularly. One of modules, used in this study case, is ACE (Application Characterization Environment) [4]. ACE is a tool for the 3D visualization, analysis and prediction of traffic in network applications. It helps us with the activity analysis of existing, and the development of new applications. This module allows the importing of captured traffic by sniffer and analysis for the following intentions:

- Diagnosing application problems;
- Predicting application behavior.

### 3. OPNET 3D Network Visualizer

OPNET 3D Network Visualizer (3DNV™) provides a powerful solution for understanding and visually analyzing mobile networking issues such as terrain masking, propagation loss, interference, and ad hoc routing. 3DNV

enables three-dimensional displays of OPNET network simulations that incorporate topology, node relationships, and performance statistics overlaid on realistically rendered terrain [5,6]. This allows Defense organizations to visualize:

- Link connectivity;
- Terrain masking and other propagation impairments
- Ad hoc routing performance;
- Aerial or space-based relays;
- Mobile network performance.

HLA (High-Level Architecture) is a protocol that allows two or more programs to exchange data and run in time-step together. The 3DNV network uses the same terrain database in Modeler and the 3D Network Visualizer [7].

The network model uses an elevation map of the Monterey region. A matching terrain database must be specified. We specified here a terrain database in Open Flight format, which is the preferred type for 3DNV. Before you can view 3D animation of a network model, you must configure the model to work with 3DNV.

There are two basic requirements:

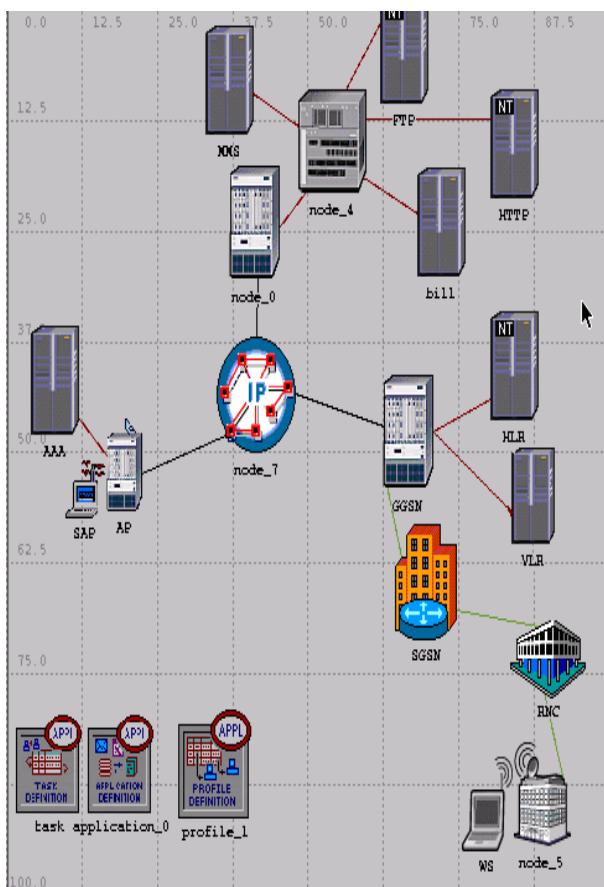
- The network model must have a terrain database specified.
- The nodes to be animated must be mapped to specific shapes (called entities in 3DNV) using a 3DNV mapping library.

Modeler Wireless Suite for Defense utilizes Digital Terrain Elevation Data (DTED) and Digital Elevation Map (DEM) raw data sources for propagation calculations and rendering of elevation maps.

The Modeler Wireless Suite for Defense also includes the Terrain Integrated Rough Earth Model (TIREM) that computes accurate propagation losses due to terrain effects, such as diffraction and absorption, within wireless network simulations. TIREM is the de facto United States DoD standard algorithm for signal propagation modeling. The Modeler Wireless Suite for Defense supports TIREM v4 (available exclusively through OPNET) along with TIREM v3. TIREM v4 operates significantly faster than v3 with added precision.

OPNET also provides an optional Multi-Federate Logger for 3DNV capability. The Multi-Federate Logger for 3DNV captures and saves information passed between OPNET Modeler and 3DNV during simulation runtime and is used to review results visually post-simulation [8,9]. The addition of 3DNV Mapping is shown in **Figure 2**.

The 3DNV module, shown in **Figure 2**, 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



**Figure 1.** Basic network design.

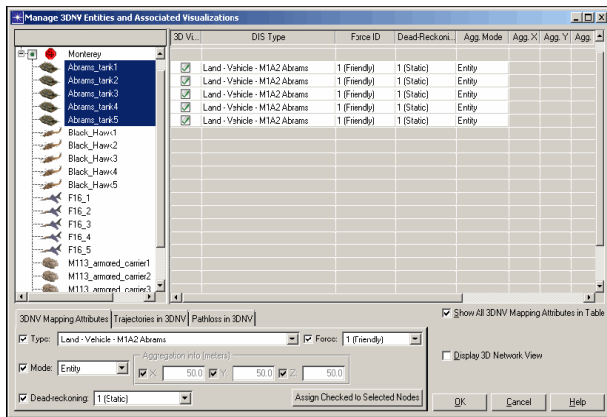


Figure 2. Object with 3D NV mapping attribute added.

the interactive direction regarding viewpoints of observation 3D scenes similar to video game consoles. The **Figure 3** shows 3D Visualization of communications unit on virtual field.

### 3.1. Viewing 3D Animation in Planning Mode

To obtain network model that is configured for 3D animation, 3D NV is used to examine the Placement of nodes in the surrounding terrain and to visualize movement along trajectories. The mode in which you view animations of the GUI workspace is called *planning mode*. Planning mode shown in **Figure 4** visualize node placement and movement from the workspace, without running a simulation. Planning mode is also useful for visualizing the trajectories of mobile nodes.

In networks model, we will need to set the time range and step size to useful values. In this network, however, the start and stop times have been preset to match the duration of the mobile node trajectories. The time step needs some adjustment, however.

Set the time controller for a smaller time step, to produce smoother-looking animation. The elevation lines are based on the same 'Monterey' terrain database as is currently shown in the OPNET 3D Network Visualizer. The tmm\_data\_directory preference is set to that same database so that the simulation uses matching terrain elevation information.

### 3.2. Viewing 3D Animation in Simulation Mode

In addition to viewing node movement and terrain in 3D NV, we can visualize simulation results while a simulation is running. This is called simulation mode. The simulation is shown in **Figure 5**.

In simulation mode, we can view the following types of simulation data in 3D NV:

- Packet transmission and reception statistics
- Membership of nodes in specific receiver groups
- Successful and failed transmissions.

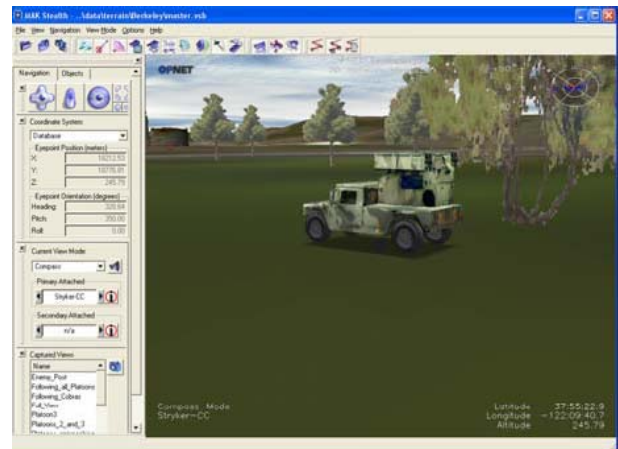


Figure 3. 3D Visualization of communications unit on virtual field.

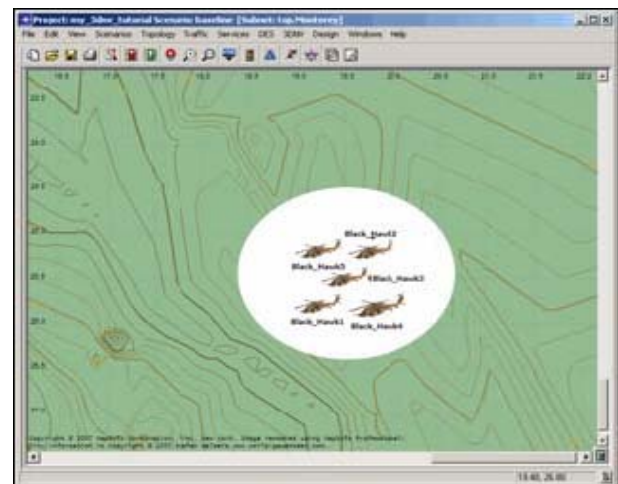


Figure 4. Modeler network design.

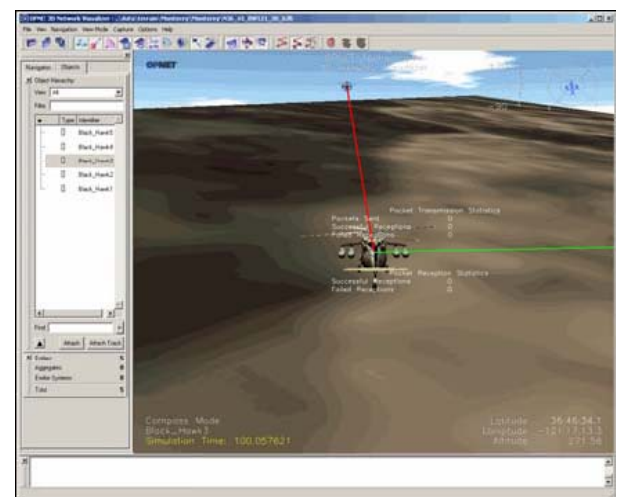


Figure 5. Visualization showing simulation data.

Simulation mode lets you view a 3D animation showing data generated by a simulation as the simulation runs.

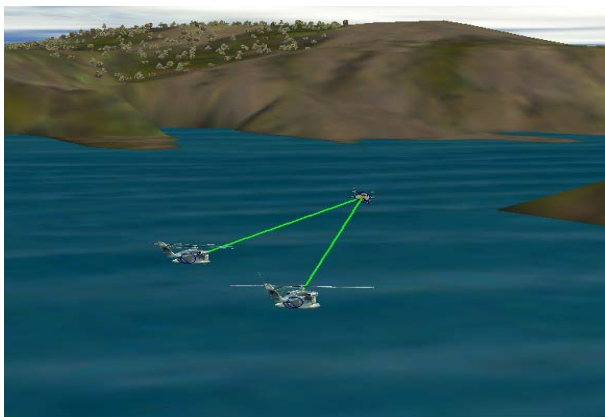


#### 4. Defense Network Simulation

The OPNET Modeler Wireless Suite for Defense supports the unique R&D requirements of the defense community, including research and development of network protocols and architectures crucial to Network-Centric Warfare implementations. Three-dimensional displays of network simulations incorporate topology, node relationships, and performance statistics, overlaid on a realistically rendered terrain. Modeler Wireless Suite for Defense enables analysis and prediction of communications effects in the theater of operations.

**Figures 6(a) and (b)** show the Wireless Communications (WC) in Navy and Defense respectively using 3D Network.

The suite is used by the world's largest defense organizations and contractors to accelerate the R&D of network protocols, devices, and architectures including MANET protocol development, JTRS/Bowman Radio design, and WIN-T/FCS architecture studies. Defense

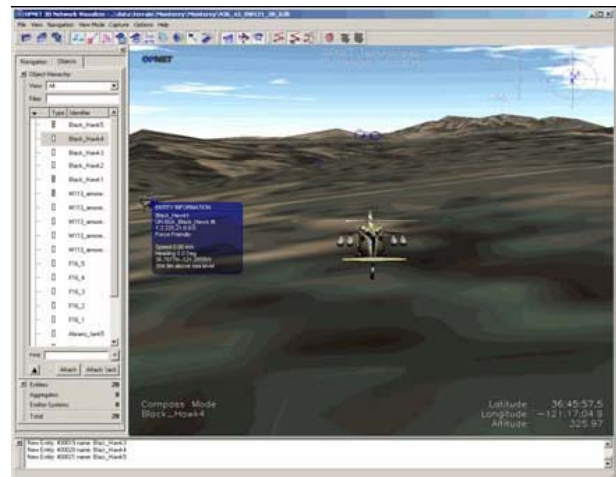


(a)



(b)

**Figure 6. (a) WC in Navy using 3D Network; (b) WC in Defense using 3D Network.**



**Figure 7. Playing module in Terrain map.**

network planners and architects can analyze end-to-end behavior, tune network performance, and develop custom protocols to optimally support the war fighter.

#### 5. Simulation Result

This paper presents an interwork of WLAN/UMTS network by showing entire network into a 3D visualized. The effects of network performance may then be tested and monitored by varying inputs within the simulated environment, e.g., weather effects, bandwidth limitations, nodal outages, etc. Using the 3D simulation view with MAK Stealth 3DNV, we run with menu selection Edit → Start → 3DNV Visualize. We load suitable terrain and then we can review any simulation in 3D mode, and thus we can view all the information about statistics [10]. An entire network of 3D visualization is in **Figure 7**, where we can see one of the units (in this case a helicopter), and the data for node statistics around it. It also enable replaying of simulations records in 2D by OPNET Modeler or in 3D mode using external MAK Stealth 3DNV program.

#### 6. Conclusions

This paper presents one segment of this widely established project, namely methodologies regarding wireless 3D network simulations the-real time using real communication equipment within the simulation's loop. OPNET introduces the module System-In-The-Loop SITL [6,7], which works in the context of the OPNET Modeler simulations package. It allows for the exchanging of packets between simulated and the real environment (3D NV) and represents the latest large innovation in the area of communication simulations. In this paper we connect real devices (tactical computers installed with C2IS applications used by the Slovenian army) with a simulated environment containing simulated wireless tactical radios

on a virtual terrain. The virtual terrain is modeled using Digital Terrain Elevation Data (DTED) maps, which can be used in different radio wave propagation models. This paper presents these simulation methodologies supported by examples.

For this Research, the network visualization tool was executed on several of the OPNET simulation machines, although it could have been run on any Windows machine in the simulated or real network. This allows for one or many to observe the 3D visualization representation of the entire effective network (real and simulated) from anywhere in the network.

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