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Nov 2nd, 10:45 AM - 11:00 AM

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# Modeling a Interworking WiMax LAN and MANET using OPNET Software

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**Abstract.** Recent research has been made for the convergence of WiMAX Networks (WiMAXN) and mobile ad hoc systems in order to achieve the MANET requirement for guaranteed 100 Mbps for heavy traffic convergence. The WiMN access point can be enhanced to either incorporate or supplant the transmission and packet data capabilities in the MANET. For this research OPNET Modeler has been used to design, implement, and test a network system level simulation environment to allow researcher to study the issues for interworking the infrastructure-based MANET technologies into WiMAXN systems. The specific contribution of this research was to augment the current OPNET model library using the standard MAC protocol will not incorporate the MANET, so by modifying the MAC PLC on MANET technologies and the Mobility protocol in WiMAXN the access to the network and reliability will increase.

**Keywords**: MANET, OPNET, WiMAXN, MAC PLC

## 1 Introduction

Communications technology is the enabler to network operations when all elements are networked in a reliable, robust infrastructure, providing secure and wireless connectivity even when mobile. This infrastructure is a necessary condition for the existence of network operations. The infrastructure will also serves as a driver for the effective development of those operations [1]. The deployment of cell-phone technology and e-commerce has demonstrated that the existence of the infrastructure will generate new behaviors that develop the technology. The development of low-cost commercial off-the-shelf technology can serve as a key technology driver to realizing the WiMAX-MANET systems.

### 1.1 Background

Ad hoc networking is in critical interest to the especially emergency services for many years. Mobile ad-hoc networks (MANET) have been of specific interest. Recently ad-hoc networking in the context of wireless broadband networks has come to the forefront in importance. A number of specialised military wave forms have been developed in attempts to address this need [2]. In the commercial world, wireless broadband networking has been dominated by technologies such as IEEE 802.11 2, Wi-Fi 3 and 3G cellular. The introduction of IEEE 802.16e-2005 [3][9][13] (802.16e) to meet mobility requirements for wireless broadband should enable very strong growth in this market. The WiMAX Forum (WiMAX) promotes and certifies compatibility and interoperability for 802.16-based products. A number of products are being accommodated with the IEEE 802.16-2004 [4] (802.16d) standard for fixed wireless broadband access have already been certified by WiMAX and 802.16e-certified products for mobile wireless broadband access should be available in 2007. Due to the high cost of developing and maintaining sole use military communications equipment and waveforms. 802.16 has been assessed by the community as promising in this regard [5], [6]. But a key limitation of the waveform is its current inability to support MANET and mesh networking topologies. Particularly in the emergency services context, it is important to draw a clear distinction between MANET and wireless mesh networking since their meanings are often a source of confusion. The key difference is the dynamics of the network nodes, and emergency services nodes tend to have higher dynamics. MANET always supports mobile nodes (high dynamics), whereas a mesh network may not. MANET networks must deal with mobility and

quickly evolving network topologies. They must automatically configure themselves without centralized control. This presents additional challenges to the networking problem. In mesh networks every node has the ability to be a router or switch. Through the ability to forward or route traffic between nodes, a fully connected network is formed wirelessly.Other networking concerns exist for the application of WiMAX in guaranteed service networks. The 802.16e standard only allows for subscriber mobility. WiMAX base stations in close proximity with each other can require the ability to exchange control traffic over a land line channel. If the base stations themselves are in motion, a wired connection is not possible. [16][17] The need to accommodate a constantly changing mobile topography further complicates the required communications. Multi-hop Relay (MMR). This group is working to define a Relay Station (RS) within the 802.16 standard to extend the coverage of an 802.16 BS to 802.16 Subscriber Stations (SS) and Mobile Stations (MS) that may be out of range or disadvantaged.

## 2  Methodology

To develop a simulation model for both MANET and WiMAX, the authors examined and studied the topologies of the MANET and WiMAX, and the applications that are required for network access and to be generated during the simulation.
To verify the correctness of the developed simulation models, we planned to compare simulation results with the live packet traces obtained from the research published in IEEE. To simplify the analysis process, we first created a small network model into two scenarios (the first scenario is on MANET only), (second scenario is on WiMAX only) and the third scenario is combining both scenarios examine and validate the implementation of individual scenarios models. We compared simulation results with live packet traces obtained from the network in OPNET Modeler. The simulation models of individual networks were developed using the OPNET Modeler [2] network simulation software. The packet traces from the network were collected and analyzed using DES and NetDoc which are separate modules to the simulation packet (OPNET). Once all networking models were verified and tested, we deployed them into the simulation model and combined them to get a difference.

## 3  Implementation and Testing of WiMAX - MANET

The implementation will be composed of simulation tool extensions to the implementations of the IEEE 802.16-2004 or IEEE 802.16-2005 MAC specifications. This approach supports backward compatibility with existing 802.16 and WiMAX compliant SS and MS.
The implementation of the network is focused on two additions to the general MAC compatibilities: the Frame Scheduler (FS) and the Topology Control Manager (TCM). Figure 1 shows a high- level architecture of a sample 802.16-2004 MAC protocol. Modules are for mutually transmit (Tx) and receive (Rx) in the data plane, with a
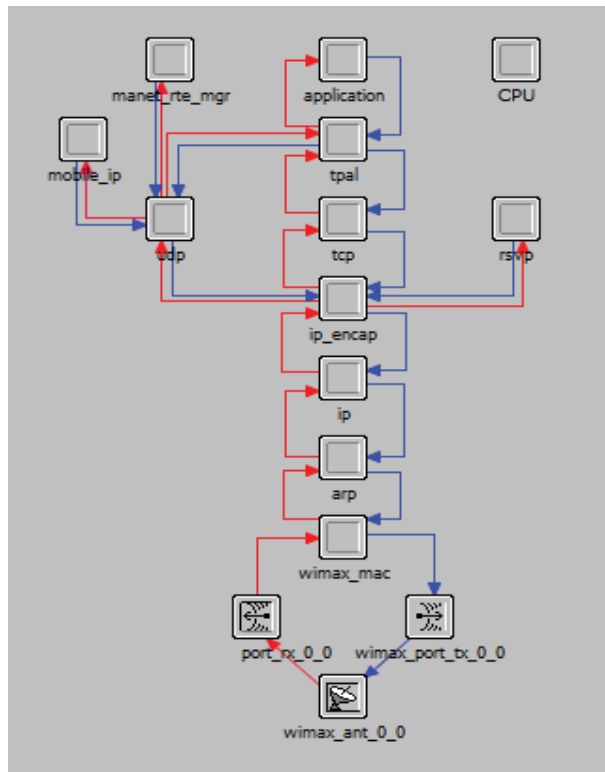
**Fig. 1.** MAC architecture modified according to the 802.16-2004

separate module for the control plane. Enabling the new frame scheduler to handle both PMP mode and mesh mode requires modification of two modules in the Tx and Rx chains to handle the proper construction and scheduling for both the transmission and reception of MANET-enabled 802.16 MAC frames. The control plane requires the addition of a TCM module that interacts directly with the normal Control Plane functions of the MAC and uses the existing data plane for custom messaging between peer TCM. This allows topology information to be disseminated across the META- MANET so topology decisions can be made at the layer that contains the appropriate link layer data and information. The TCM is responsible for interacting with Layer 3 such that the appropriate decisions for routing can be made.

The implementation process involves several phases. The first phase is the development of a small portion of the FS that allows multiple MPs to communicate directly with one another in a static configuration. In the second phase of development, the FS must support dynamic (ad-hoc) topology control as multiple nodes enter or leave the MANET The third phase of the design process involves the implementation of the TCM to handle the interaction of multiple MANET subnets and MANET Mac acceptance b. The primary goal of initial testing is to demonstrate y WiMAX MAC protocol by developing a simple scenario with several MP nodes with a single SS node. This will demonstrate that a MANET network comprised of multiple MP nodes can be formed, and that those MP nodes can maintain interoperability with standard SS nodes operating in PMP mode. For this research, the MAC modified OPNET module will be in the first phase of the design process. To evaluate the WiMAX-MANET protocol in a test-bench setting, each station will use a directional antenna that can be adjusted to make or break physical layer connections, thus influencing the network topology. In Figure 2, is the network design that was simulated for WiMAX where each MP is represented by MPx,
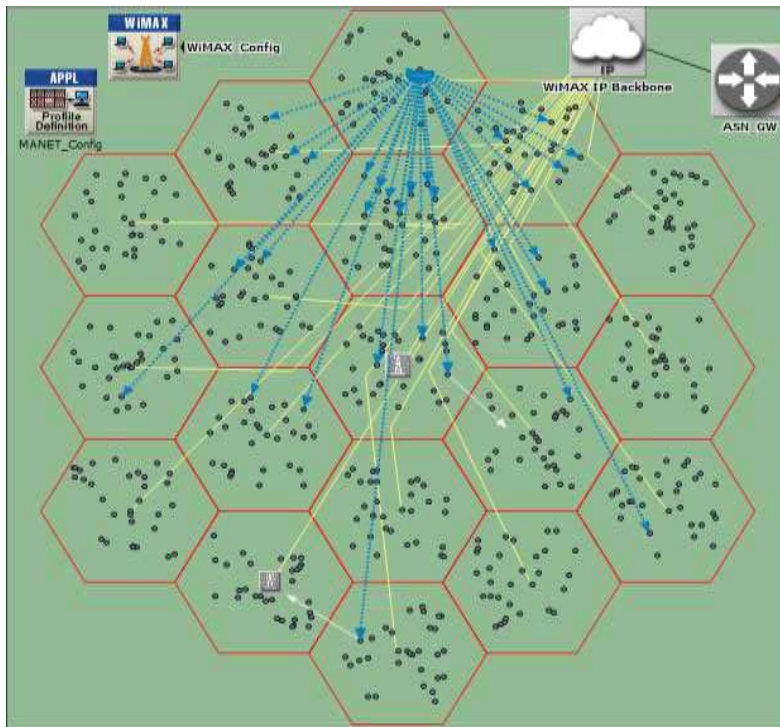
**Fig. 2.** WiMAX – MANET network design (and simulated)

and the PMP SS node is represented by SS1. SS1 is a Subscriber to MP1, and MP1 serves both as a base station and a mesh point, providing a gateway to the remainder of the MANET network. Laptops are connected to nodes via Ethernet switches to emulate end users and to generate application layer traffic. Since the primary goal of this experiment is to simply form a MANET network, the routing and topology functions will remain at Layer 3.
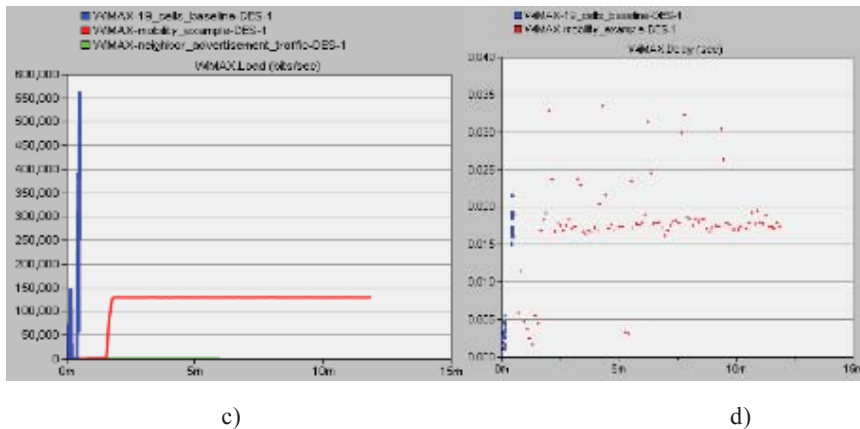


a)



b)

c)                                                    d)
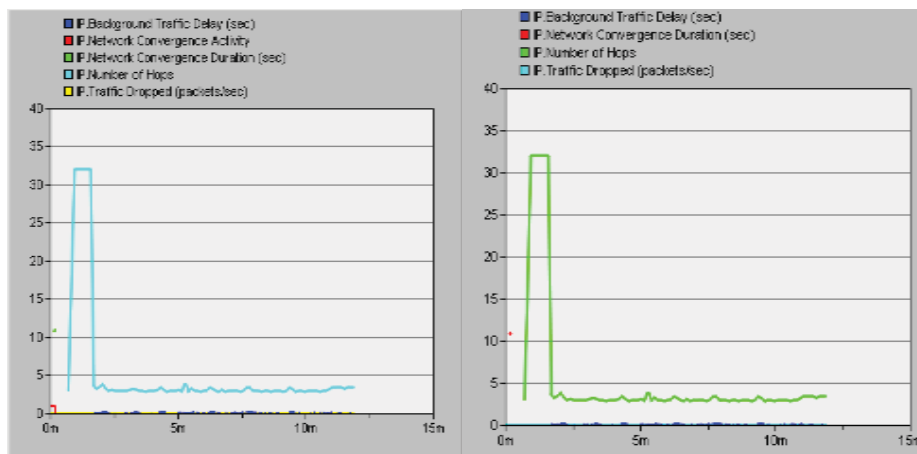
**Fig. 3.** a) MANET IP traffic, b) MANET background traffic, c) WiMAX cell traffic and d) WiMAX mobility Traffic

The changes in the topology will closely resemble the behavior of a MANET network. As presented on Fig 3 a, the number of hops is high as soon as an Mobile device enters a new cell, and the amount of background traffic delay is increased after first 10 meters due to the MAC address and new topology, as well as on WiMAX network the network delay starts with minimum 0.00001517 sec to max delay 0.00189 seconds. It us successfully demonstrated that applications running over the MANET network will validate the initial phase of design for the MAC extensions. As the implementation process continues, testing will likely continue in other methods, such as in the emulation of larger-scale networks. To continue this emulation, To determine scalability and to fully test the TCM, the emulation of multiple MPs and SS nodes will be done virtually on one or more computing platforms.

## 4   Summary and Conclusions

The 802.16 suite of standards has been identified as having significant potential to support MANET networks to adapt to any wireless network and to serve network-enabled high-mobility operations. A key shortcoming to the commercial standard is the lack of support for mobile ad- hoc and mesh networking topologies. We have analysed the MAC protocol suite as per IEEE standards and are implemented to set a new extension that enables MANET capabilities. These capabilities will support commercial needs by providing mesh operation for highly mobile nodes while retaining backward compatibility and interoperability.

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