

# ADEUS: Tool for Rapid Acceleration of Network Simulation in OMNeT++

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**Abstract**—There is lot of accessible mobile devices on the market nowadays, which caused significant rise of mobile networks. There are two main types of mobile networks, infrastructure and ad-hoc. This paper is focused on mobile ad-hoc networks also known as MANET, which are easy to build, and do not rely on fixed infrastructure. On the other side, simulation of MANET is really difficult and it is really important to properly design test and simulation scenario. There are various well known simulation environments over there, but this paper aims at OMNeT++[5]. The main contribution of this paper is to introduce ADEUS, support tool used to simplify creation and reduce the time needed to set up OMNeT++ simulation environment, for simulation of public key infrastructure, further referred as PKI, in MANET. ADEUS is graphical add-on for OMNeT++, with simple but powerful user interface.

**Keywords:** *MANET, Ad-Hoc, MiXiM, OMNeT, simulation, ADEUS, PKI*

## I. INTRODUCTION

As a result of significant advances in mobile computing and wireless communication technology, mobile devices have gained sufficient communication, computation and memory resources to be interconnected. Mobile Ad-Hoc networks differentiate themselves from existing networks by the fact that they rely on no fixed infrastructure. Another important characteristic of MANET is the same level of functionality which preserves homogeneity inside the network and protects it before the single point of failure and denial of service attacks.

MANETs are the most flexible networks nowadays, but there is still some important fact which prevents MANETs from spreading across the world.

First of all we need to answer the few questions. Do we prefer functionality, like in case of fully self-configured design, or security with added layer of PKI infrastructure?

The public key infrastructure security is merely based on the security of certificate/attribute authority private key and on the trust relationship between the nodes in network and authorities. Nowadays we can differ between authorities based MANET, which use some kind of online or offline authorities responsible for configuration of the client before the network is created and fully self-organized MANET which do not use any form of online or offline authority. In the fully self-organized networks users have to manage their own repositories of trusted or untrusted peers. Each of these

concepts has their own advantages and disadvantages. To be sure to say, which one and in what conditions is better, we need to properly simulate both concepts.

There are various network simulators, which contain modules used for MANET simulation, but they really lack the powerful and clean user interface. Therefore specialist for concrete simulation tool is needed and a lot of time to program and setup our test scenario. One of these simulators is OMNeT++, powerful network simulator environment which contains only small set of wizards, used for basic network setup. OMNeT++ is really powerful tool, but practically unusable for advanced tasks, without deeper programming skills in C# or Java and really good understanding of how OMNeT++ works.

These facts have inspired us to create simple but powerful enough user interface add-on used for simulation of MANET and various ways of PKI implementation in MANET. This way even beginner is able to use pre-programmed modules for simulation of PKI, MANET and various network attacks.

## II. RELATED WORK

Before we opt for OMNeT++, we have analysed some of the well-known network simulators. We have to choose between Network Simulator 2[3], Network Simulator 3[4] and OMNeT++. All of these simulators are accessible for academic purposes for free.

Network Simulator 2 or NS-2 is an older simulator developed in 1996, written in C++ and used mainly on UNIX based operating systems. Simulations are defined using OTCL (Object Tool Command Language).

Network Simulator 3 or NS-3 is a newer discrete event network simulator developed in 2008, with better support for distributed simulation. Its kernel is written in C++ and simulations can be defined in C++ or in Python languages. It runs on various Linux distributions.

OMNeT++ is a discrete event simulation environment with flexible architecture, which consists of modules programmed in C++. These modules are further assembled into larger components and models using high level language NED. OMNeT++ has extensive GUI support and can be embedded into existing applications. In contrary to previous simulators OMNeT++ can run on various operating systems like Linux, UNIX, Mac OS X, Windows 2000 or better.

After we have analysed these simulators we were able to create list of advantages and disadvantages:

- NS-2
  - o Advantages
    - Stability
    - Good support, with lot of modules and add-ons
    - Supports lot of network protocols
  - o Disadvantages
    - Older kernel architecture
    - Do not support distributed simulation
    - No GUI
- NS-3
  - o Advantages
    - Modular core
    - Software integration
    - Virtualization and test bed integration
  - o Disadvantages
    - New concept, not so stable core
    - The lack of protocols support, which were supported in NS-2
- OMNeT++
  - o Advantages
    - Comes with lot of support tools
    - GUI used for designing network modules with help of NED language
    - Tool for generating documentation
    - Data gathered during simulation are saved for further post processing and analysis
  - o Disadvantages
    - Only few modules usable for MANET
    - Lot of possibilities causing hard times while creating simulation project.

As we have stated before OMNeT++ is built from modules which communicate by exchanging of the messages. The simple simulated network consists of several modules which can be nested into compound module. Those compound modules can be further interconnected via gateways and channels to create simulation model. This is possible thanks to NED language. To be able to simulate MANET we need another important component, namely OMNeT++ simulation models. There are various extensions suitable for MANET simulation, e.g. INET Framework and MiXiM – Mixed simulator.

INET Framework is an open-source communication networks simulation package for the OMNeT++ simulation environment, which contains models for several wired and wireless networking protocols, e.g. IP, TCP, UDP, PPP, Ethernet, MPLS and many others. INET Framework also includes support for mobile and wireless simulations.

MiXiM is modelling framework created for wireless networks, which supports wireless sensor networks, body area networks, ad-hoc networks or vehicular network. The MiXiM concentrates on lower layer of the protocol stack, so we are able to specify strict conditions. The MiXiM was created as a merge of several earlier OMNeT++ frameworks.

After we have analysed both of the frameworks, we have chosen MiXiM which has outstanding MANET support and a lot of pre-configured modules and variables.

As we have stated before, MiXiM contains various models, which can be divided into five groups:

- Models of environment – these models are used to specify characteristics of the environment in which nodes are located, e.g. physical obstacles, which could affect communication between nodes.
- Mobility and connectivity – nodes can affect other nodes while travelling through the network. This module is responsible for managing and reporting of these events.
- Collision and communication – mobility highly affects nodes communication. This module is responsible for processing of messages from other nodes, based on the node's position.
- Testing support – compares results of simulation with pre-defined states and contains databases of possible solutions.
- Protocols library – contains all of the supported protocols.

Besides the models, MiXiM contains also modules, needed for proper simulation, which our tools are interacting with:

- Module World
  - o This module is responsible for settings the testing area environment, like dimensions, 2D or 3D environment.
- Module Object Manager
  - o This module is responsible for managing and applying of virtual obstacles into our testing area. These obstacles can prevent spreading of signal to neighbours' nodes.
- Module Connection Manager
  - o This module is responsible for managing communication and connections between nodes. This module registers position of each node and interacts with ObjectManager. Moreover it is responsible for applying of environment specifics like

spread of the signal or frequency spectrum. MiXiM support use of various Connection Managers in the same simulation. This way we can simulate 802.11a and 802.11g network in one simulation.

- Module Node
  - o Module Node is one of the most complex MiXiM modules and represents our mobile nodes. With the help of this module we are able to define various nodes characteristics like communication speed, transmit power, nodes position and lot of others.

These modules needs to be configured for proper network simulation in omnetpp.ini, config.xml or in various users defined files. The main contribution of our tool ADEUS is to configure this file in the name of user, with the help of graphical user interface and preconfigured wizards.

### III. ADEUS OVERVIEW

ADEUS is tool designed to simplify the preparation of network simulations in the OMNeT++ environment and further analysis of simulation results. Our goal is to minimize hand editing of OMNeT++ configuration files, which is really hard and time consuming task for the average user.

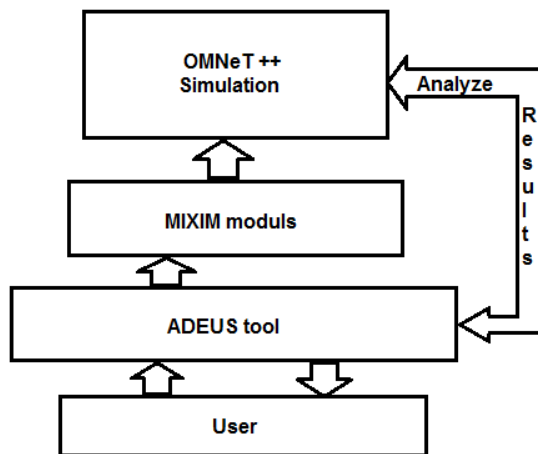


Figure 1: Architecture simulation with ADEUS tool

As we can see on Figure 1, ADEUS is used as an interface between the user and MiXiM simulation modules, responsible for setting up the simulation parameters and presenting of simulation results.

ADEUS has the following main features:

- Setting up the simulation environment
- Adding or removing modules used in simulation based on the user input. These can be preconfigured C++ modules contained in MiXiM installation or downloaded from foreign repositories.

- Adding or removing of NED files into simulation, or editing NED files which are responsible for nodes interconnection and graphical representation.
- Editing any of the user defined parameters, one by one or at once based on key property.
- Management of project files which contains all of the required configuration files. Project can be imported or exported.
- Controlling of OMNeT++ simulation engine. Before the simulation can start, all required configuration files are sent to OMNeT++ and after that simulation starts. When the simulation is complete all results are sent back to ADEUS for further analysis.
- ADEUS can be used for further analysis of simulation results, with help of OMNeT++ included tools or any external tool which can parse xml files.
- Preparing the simulation tasks for parallel simulation on many hosts. ADEUS provides function which can help us to make decision whether is our project suitable for parallel simulation.

For minimal MANET simulation, we have to setup following parameters:

- Amount of nodes.
- Mobility characteristics of nodes, like minimum, average, maximum speed and the direction of node movement.
- Nodes radio characteristics, like maximum distance for communication
- Node category – reserved parameter used for simulation of various attacks on PKI in MANET's
- The length of simulation
- Various environment characteristics, like importing files with geographic data, like kml or gpx files for visualization of simulation on public maps portals like maps.google.com

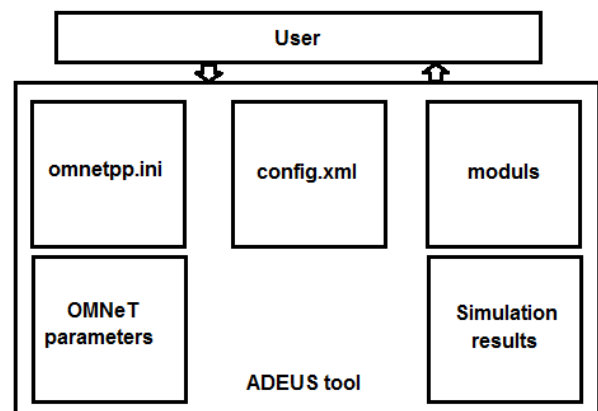


Figure 2: How ADEUS in interacting with the OMNeT++

Figure 2 shows simple diagram about how ADEUS is interacting with OMNeT++. As we can see ADEUS transparently manages all of the configuration files, simulation modules and the results of simulation, too.

The main motivations for developing ADEUS are:

- Reducing the time needed for preparation of the simulation. With help of graphical user interface, wizards and predefined patterns for simulation of PKI in MANET's, ADEUS can save us a lot of time.
- Simplicity – with help of ADEUS we can greatly simplify the process of setting our testing environment. Users, who know what to setup, can find it without the knowledge of OMNeT++ internal architecture.
- Cross platform compatibility - ADEUS is developed in JAVA. This way our projects can be moved together with OMNeT++ between various supported platforms, like UNIX, Linux, Windows.
- Support – ADEUS comes with comprehensive manual and sourceforge.net hosted forum.

#### IV. PRELIMINARY RESULTS

The main goal of ADEUS is ability to reduce the time needed for preparing of MANET simulation. We have made series of tests targeted on simulation of PKI infrastructure in MANET. Our tests consist of measurements of time needed for setting up testing environment.

Testing environment has following parameters:

- Testing area dimension: 1200x800m
- Area land character: super elevation max. 100m
- Number of nodes: 98
- Nodes movements characteristics: random direction of movement (Random waypoint model)
- Node activity: 25% idle
- Maximum speed: 78km/h
- Communication distance: 200m
- MAC layer protocol: IEEE802.11
- Traffic pattern: random
- Simulation time: 350 secs.
- Probability of node failure: 2%

Besides this basic set of characteristics, we have included some of our testing modules used for simulating PKI and various attacks in MANET. With help of ADEUS we were able to define following parameters:

- Four categories of nodes: endpoint nodes, routing nodes, backbone nodes, PKI node.
- Define rules for communication between these nodes.

- Setup various attacks, like Sybil attack and Denial of Service attacks.

We have made two series of tests. The first series of tests was passed by users, who have used OMNeT++ for the first time, but have good knowledge of MANET. Figure 3 represents the results. As we can see we have measured time required for proper simulation setup. The X axis represents the number of required parameter to be setup. The Y axis represents the time required for proper setup. We can clearly see that even the beginner user can work effectively with help of ADEUS. In some cases, time reduction can represent as much as 80%. Generally, the more parameters need to be setup, the more time can ADEUS save.

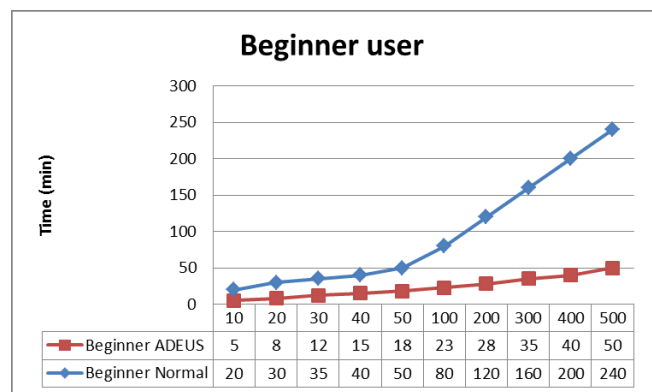


Figure 3: Graph represent's the amount of time required for applying required settings.

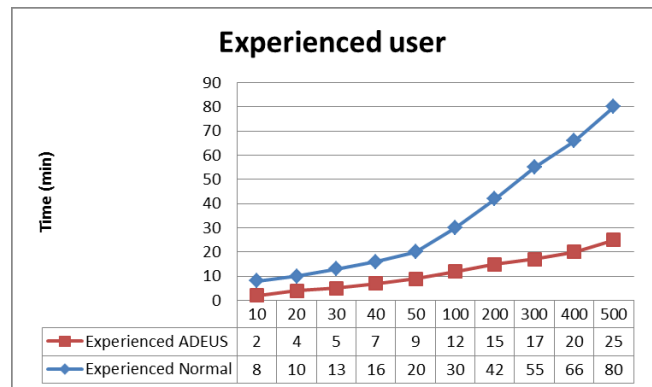


Figure 4. Graph represent's the amount of time required for applying required settings

Another series of tests was done with experienced users, which use OMNeT++ as their primary simulation environment. Even in this case, we can see great reduction

of time needed for proper simulation setup. In case of advanced simulation there are 500 or more parameters to be setup, which take about 80 minutes for experienced users. This is not so much as in case of beginners, but this time can be reduced to 25 minutes with help of ADEUS, which is more than 70% improvement.

## V. CONCLUSION

As we can see, ADEUS can greatly reduce the time needed for first simulation environment setup. This is possible thanks to its simplicity and our precompiled modules used for basic MANET and advanced PKI simulations.

This way we can fully concentrate on results of simulations and their analysis. Another advantage is possibility to quickly edit simulations according to our needs.

## ACKNOWLEDGMENTS

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