Design and Simulation of Wireless Network using NS-2

Almargni Ezreik, Abdalla Gheryani

***Abstract*—** The main goal of this paper is to learn how to use simulation for designing and studying wireless networks. In order to achieve the defined thesis task, analyze literature sources related to wireless communication networks. Briefly describe the basic wireless networks categories. Analyze wireless LAN networks and briefly describe their components and technologies. Explain the Wi-Fi technology. Analyze literature sources related to wireless networks simulators. Analyze the Network simulator ns-2 and give its detailed description. Present a brief comparison of ns-2 simulator with other open source network simulators. Specify the configuration for the simple wireless network and create corresponding model by using ns-2 simulator. Demonstrate selected characteristics of the specified network configuration using the simulation model.

***Keywords*—** MAN, NS2, PAN, WAN, WIRELESS.

I. Introduction

WIRELESS network is a computer network that is wireless, and it is commonly associated with a telecommunications network whose interconnections between nodes are implemented without the use of wires. Wireless telecommunications networks are generally implemented with some type of remote data transmission system that uses electromagnetic waves, such as radio waves, for the carrier and this implementation usually takes place at the physical level or "layer" of the network.

The reasons for using wireless network are cost-effectiveness of network deployment, and its applicability to environments where wiring is not possible or it is preferable solution compared with wired networks.

When designing wireless networks and/or studying their behavior under various conditions, software simulation tools are often used.

In this paper the software tool Network Simulator (Version 2), widely known as ns-2, is described and used for the simulation of selected illustrative examples of wireless networks.

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II. WIRELESS NETWORKS DEFINED

Wireless network is described as a network of devices which communicate by using wireless technologies [1]. Webster dictionary referees to a wireless as a concept of "relating to data communications using radio waves; operating by means of transmitted electromagnetic waves". Wireless communication is used as a term for transmission of information from one place to another without using cables. This may be one-way communication as in broadcasting systems (such as radio and TV), or two-way communication (e.g. mobile phones).

In telecommunications, Wireless communication is the transfer of information without the use of wires. [2]

Wireless network refers to any type of computer network that is wireless, and is commonly associated with a telecommunications network whose interconnections between nodes are implemented without the use of wires. [3]

Nowadays, there are many reasons for companies to consider the usage wireless networking technologies. The reasons that speak in favor are the practical use and benefit of wireless network for its user, cost-effectiveness of deployments of a network, environment where wiring of building in not possible or it is preferable solution for building the network. Wireless network enables people to communicate and access applications and information without wires. This provides benefit in form of a freedom of movement and the ability to extend applications to different parts of a building, city, or nearly anywhere in the world.

Many types of wireless communication systems exist, but a distinguishing attribute of a wireless network is that communication takes place between computer devices. These devices include personal digital assistants (PDAs), laptops, personal computers (PCs), servers, and printers. Computer devices have a means of interfacing with a particular type of network.

Wireless networks transfer data, such as e-mail messages and files, but advancements in the performance of wireless networks is enabling support for video and voice communications as well.

III. CATEGORIES OF WIRELESS NETWORK

Wireless networks can be classified into diverse categories depending on classification criteria (e.g. size of the physical area that they are capable of covering and domain of their use) [4]. The following types of wireless networks satisfy diverse user requirements:

- Wireless Personal-Area Network (PAN)
- Wireless Local-Area Network (LAN)
- Wireless Metropolitan-Area Network (MAN)
- Wireless Wide-Area Network (WAN)

IV. NS-2 SIMULATOR

Network Simulator (Version 2), widely known as ns-2, is simply a discrete event driven network simulation tool for studying the dynamic nature of communication networks. It is an open source solution implemented in C++ and Otcl programming languages. ns-2 provides a highly modular platform for wired and wireless simulations supporting different network element, protocol (e.g., routing algorithms, TCP, UDP, and FTP), traffic, and routing types. In general, ns-2 provides users with a way of specifying network protocols and simulating their corresponding behaviors. Result of the simulation is provided within a trace file that contains all occurred events.

NS is a REAL simulator developed by UCB (University of Carolina Berkley) in 1989. An earlier version of simulator ns-1 (version 1) was developed by Floyd and McCanne. ns-2 (version 2) was developed at LBNL (Lawrence Berkeley National Laboratory) under VINT project (Virtual Internet Test bed) by LBL [8], PARC [9], UCB [9], and USC/ISI (University of Southern Carolina/ Information Sciences Institute) [10]. It is currently maintained at USC/ISI, with input from K. Fall, S. Floyd et al. NS-3, a newest version of ns written in C++ and Python came as a replacement for ns-2 in 2006. ns-3 is not an extension of ns-2, but a new simulator that does not support the ns-2 APIs. Also, ns-3 does not support all NS-2 functionality; some models are still being ported from ns-2.

Totally changed API and missing functionality in ns-3 are only some of aspects that favor the use of ns-2. The real advantage of ns-2 over ns-3 is its popularity. Its user base is greater than 1000 institutions and 10000 users.

NS-2 size in terms of line of codes is above 200k written in C++ and TCL and 350 page manual. ns-2 is portable tool that works on most UNIX and Windows like operative systems. Ii it supported on Linux (Ubuntu, Fedora etc.), FreeBSD, SunOS/Solaris, HP/SGI, and Windows 95/98/NT/ME/2000/XP.

V. PROGRAMMING LANGUAGES IN NS-2

The reason for having two programming languages stems from the aim to have an easy to use, yet fast and powerful simulator. Object-oriented C++ forms an efficient class hierarchy core of ns-2 that takes care of handling packets, headers and algorithms. Object Tcl, or OTcl, is also an object-oriented programming language utilized in ns-2 for network scenario creation, allowing fast modifications to scenario scripts. Simulation scenario contains network nodes, applications, topology and connections between the nodes. OTcl and C++ interact with each other through Tcl/C++ interface called TclCI as depicted in figure 3.1.

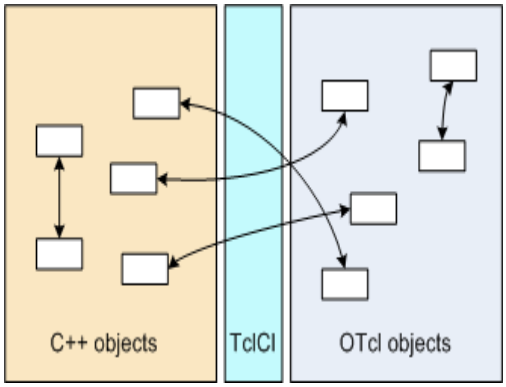

Fig. 3.1 C++ and OTcl Communication

Tcl/Otcl is a language with very simple syntaxes that allows easy integration with other languages. Tcl was created by John Ousterhout. The characteristics of these languages are [11]:

- It allows a fast development.
- It provides a graphic interface.
- It is compatible with many platforms.
- It is flexible for integration.
- It is a scripting language.

OTcl in ns-2 enables full control over simulation setup, configuration, and occasional actions (e.g. creating new TCP flows). It is a language that compromise between speed and abstraction level offered to the user. OTcl enables simulation scenarios of slightly varying parameters or configuration, where the main goal is to quickly explore a number of scenarios (change the model and re-run). Iteration time is an important aspect in OTcl [11].

C++ object oriented language is used for byte manipulation, packet processing and algorithm implementation. It is important to notice that detailed protocol simulations require the use of systems programming language. With C++ fast execution is enabled, so the Run time speed is important aspects in ns-2. Modularity of ns-2 is observed trough the Class hierarchy core of ns-2 written in C++. Modularity of simulation elements results in a compact simulation model, ns-2 does not waste resources of the platform in vain. Compact design of elements opens up new space for the scalability of the elements of a simulation scenario.

VI. SIMULATION EXPERIMENT DESIGN

A.Simulation Scenario

Wireless network performance depends mainly on the end to end throughput and average delay. Different applications place different requirements on the network. Real time applications such as voice over IP are highly sensitive to delay but function satisfactorily with little bandwidth. At the other hand data transfer applications like FTP are insensitive to delay but require as much bandwidth as possible.

In this section we are going to present simulation scenario aimed at simulating the network performance through network throughput, packet drop rate and average packets end to end delay.

Within the scenario we have stated clearly the layout and configuration of our network and the simulation experiment setup.

B. NETWORK LAYOUT

In our scenario we have two buildings of Computer department (professors' office and students' office) covered by the wireless network.

The wireless network consists of two Access Points separated from each other approximately 200 meters. Access Point 1 is for professors' office, Access Point 2 is for students' office, and there are five nodes that are connected directly to the access points.

Additionally, the following conditions for access are presumed:

1) Each user (professor or student) can access the Internet by using Secret key, which registered to one of the Access points.
2) Purpose of using two access points is to separate accessing load.

The network layout is depicted in Figure 4.1.

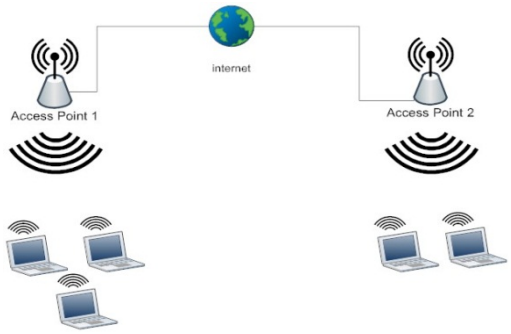

Fig. 4.1 Layout of the Wireless Network

C. DETERMINING the THROUGHPUT, PACKET DROP RATE and AVERAGE PACKETS END to END DELAY

The nodes in our scenario use IEEE 802.11 standards (CSMA/CA) to communicate with each other. We are going to use the simulation for:

- Determining the throughput for each node; ns-2 should calculate the bytes received by each node.
- Determining the packet loses; ns-2 should calculate the bytes that are transmitted and not receive by any node.

Determining the average packets end to end delay; ns-2 should calculate the difference time of the last packet received and the number of all packets received.

VII. SIMULATION RESULT

As already mentioned, wireless simulators provide full control to researchers in investigating traffic flow behavior, but do not always reflect real-world scenarios. Therefore, in this chapter we will present results of simulation obtained by using ns-2 simulator where the experiment setup is aimed primarily at demonstration of ns-2 features and illustrations of some basic performance for simulated network.

The results of our simulation from ns-2 trace files are shown in subsequent sections.

A. NAM OUTPUT

The Nam class outputs at runtime in our simulation setup (Figures 5.1, 5.2 and 5.3) show two networks consisting of two wireless access points (Access Point_1 corresponds to node 0 and Access Point_2 to node 3) and five nodes (node_1, node_2, node_4, node_5 and node_6) that are connected to these access points and the traffic of packets between nodes.

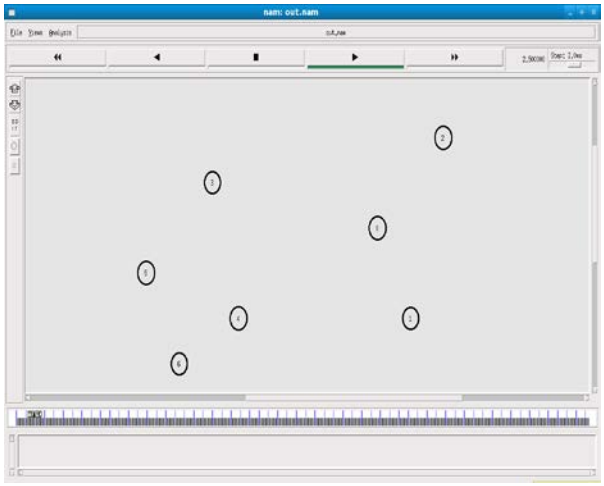

Fig. 5.1 Nam output showing nodes of two wireless networks

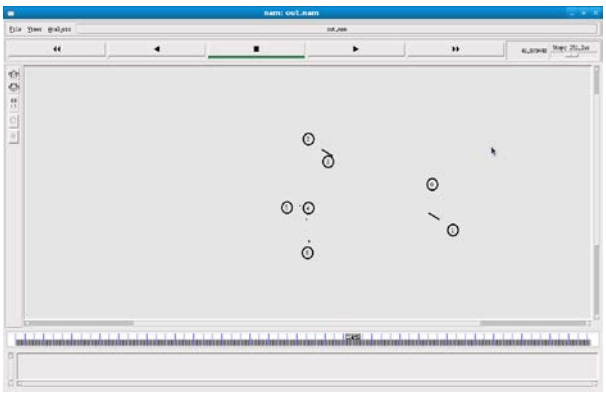

Fig. 5.2 Nam output - Transmission packets between nodes

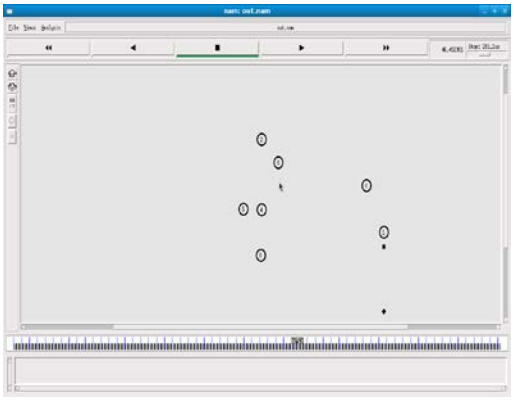

Fig. 5.3 Nam output - Node_2 is moving away from Access Point_1 and the packets are dropped

B. THE NETWORK THROUGHPUT

In this subsection we are showing the simulation results illustrating the network throughput. We will compare throughput of nodes to see how nodes affect each other as a result of different emitting times of the nodes. Figure 5.4 and figure 5.5 show the relation between throughput and transmission rate. Here, the X axis represents the time of simulation and Y axis represents the throughput.

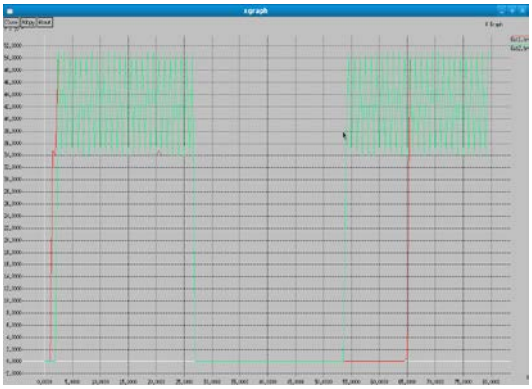

Fig. 5.4 Throughput for two nodes (Node_1 is red line and Node_2 is green line)

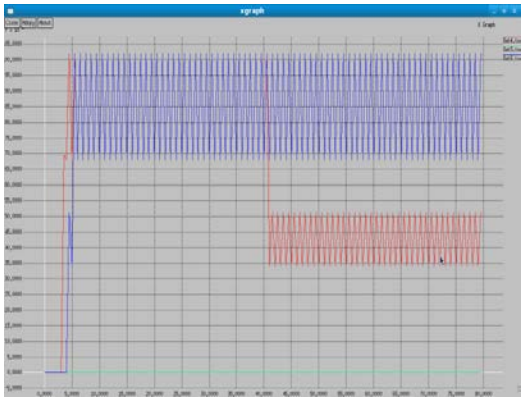

Fig. 5.5 Throughput for three nodes (Node_4 is a red line, Node_5 is a green line and Node_6 is a blue line)

V.II PACKET DROP RATE

Packet drop occurs when one or more packets of data travelling across a computer network fail to reach their destination.

Figure 5.6 and Figure 5.7 show the relation between drop packets and transmission rate. Here *X* axis represents the simulation time and *Y* axis represents to number of dropped packets.

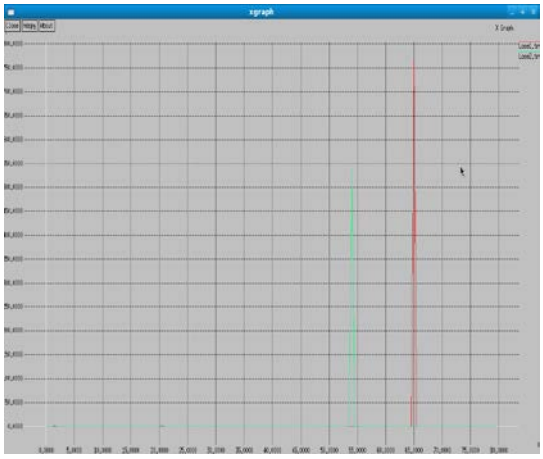

Fig. 5.6 Packet drop for two nodes
(Node_1 is a red line and Node_2 is a green line)

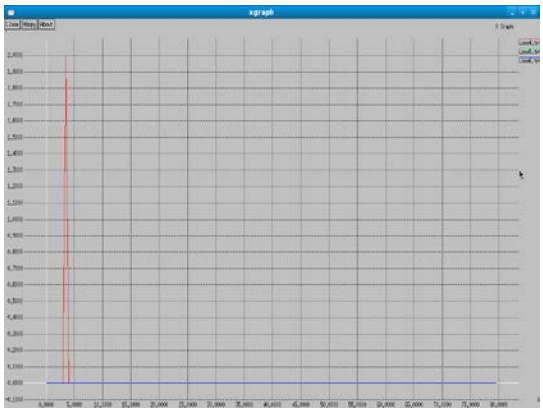

Fig. 5.7 Packet drop for three nodes
(Node_4 is a red line, Node_5 is a green line and Node_6 is a blue line)

V.IIIAVERAGE PACKETS END to END DELAY

Packet delay is the difference in end-to-end delay between selected packets in a flow with any lost packets being ignored.

Figure 5.8 and Figure 5.9 show the relation between delay of the packets and transmission rate. X axis represents the simulation time and Y axis represents to average delay packets.

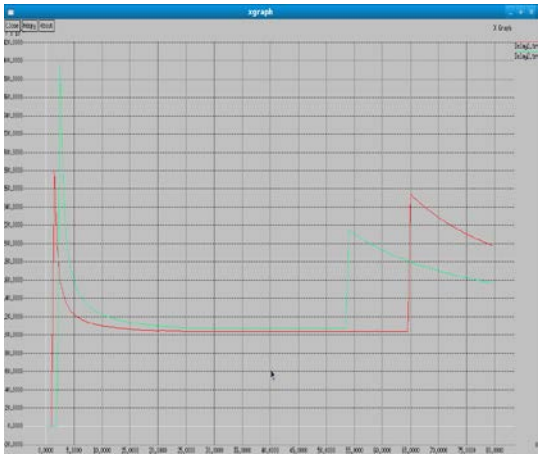

Fig. 5.8 Delay for two nodes
(Node_1 is a red line and Node_2 is a green line)

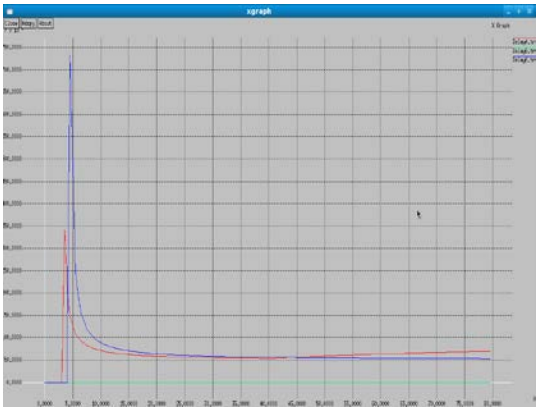

Fig. 5.9 Delay for three nodes
(Node_4 is a red line, Node_5 is a green line and Node_6 is a blue line)

VIII. Conclusion

Wireless network is a computer network that is wireless, and it is commonly associated with a telecommunications network whose interconnections between nodes are implemented without the use of wires. Wireless telecommunications networks are generally implemented with some type of remote data transmission system that uses electromagnetic waves, such as radio waves, for the carrier and this implementation usually takes place at the physical level or "*layer*" of the network.

The reasons for using wireless network are cost-effectiveness of network deployment and applicability to environments where wiring is not possible or it is preferable solution compared with wired networks.

When designing wireless networks and/or studying their behavior under various conditions, software simulation tools are often used.

In this master thesis the software tool *Network Simulator (Version 2)*, widely known as ns-2, is described and used for the simulation of selected illustrative examples of wireless networks.

Network Simulator (Version 2) is a discrete event driven network simulation tool for studying the dynamic nature of communication networks**.** ns-2 provides a highly modular platform for wired and wireless simulations supporting different network elements, protocols, traffic and routing types. In general, ns-2 provides users with a way of specifying network protocols and simulating their behavior. The results of the simulation are stored in a trace file that records data about all events that occurred during the simulation process.

In the master thesis we have used ns-2 to simulate the end user performance of the wireless network consisting of two APs and five nodes for variable throughput and transmission rate for the nodes.

The simulation results in following conclusions about network behavior:

- For variable throughput and transmission rate for the nodes of Access point_1 and Access point_2, the performance of network remains constant and there is high fluctuation for single node.
- Another comparative study between packet drop rate and transmission rate for the nodes of Access point_1 and Access point_2 shows that the performances of the observed networks differ and there is high fluctuation for single node in 3 node network.
- Third important feature of performance study is average packets end to end delay and transmission rate for the nodes of Access point_1 and Access point_2. The performance of the whole network is finding to be transient initially, but it comes to a stable state after a certain amount of time.

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