A comparative Study of two Ad Hoc Network Simulators

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Abstract. Simulation is a valuable tool to verify and evaluate the performance of mobile Ad Hoc networks. The most commonly used Ad Hoc network simulators are ns2, GloMoSim and Opnet. Particularly, GloMoSim is a popular simulator tested in many previous works. Consequently, it is considered as a trustable simulator. In last few years, a new simulator called NCTUns is appeared. The performance of this simulator I s not yet justified. However, it seems to have many advantages, such as the easiness of use and its realistic applications. The objective of this study is to evaluate NCTUns while comparing it to GloMoSim. The comparison is done in terms of simulation results and execution time, according to different scenarios.

1 Introduction

Discrete-event simulation is among the most commonly used techniques to evaluate protocols and architectures for Mobile Ad hoc networks (MANETs) [8]. A consequent work is done in MANET group of the IETF [1] in order to standardize some routing protocols of these networks. These works are based on simulations using the standard 802.11 of the IEEE [16]. The models on which network simulators are based should be “as close as possible” to the reality so that simulations results, imitating the behavior of real network, prove to be meaningful.

Nowadays, the popularity of the existing network simulators [2, 3, 14, 15] and in particular that of Ad Hoc networks varies from one simulator to another. Besides, every simulator is based on its own methodology and models to simulate a real network. A simulator using simple models generates few events in simulation execution. Therefore, the simulation time is reduced allowing the passage to large scale or "scalability" i.e. to simulate networks whose size can reach 10.000 nodes. However, the obtained accuracy is not satisfactory. A simulator using complex models generates too many events in simulation execution. So, the simulation is expensive in terms of resources occupation. This is why the passage to the large scale always requires more than one processor. However, simulation results are more accurate.

NCTUns (National Chiao Tung University network simulator) [2] is a new network simulator. It seems to have many advantages such as the easiness of use and its realistic applications. How can we evaluate this simulator? Does it have any drawbacks? In particular, is it possible to get scalable simulation of Ad Hoc networks with bounded inaccuracies ? Our study consists in evaluating NCTUns 2.0 while comparing it to a famous simulator that was tested in many previous works. This simulator is GloMoSim 2.0 (Global Mobile information system Simulator) [3]. The next two sections of this paper will describe the features and the capacities of the two simulators NCTUns and GloMoSims. In the last section, the paper will present a comparison of these simulators in terms of simulation results and execution time, according to different scenarios.

2 NCTUns

NCTUns is a network simulator and emulator able to simulate various protocols used in both wired and wireless IP networks. It is developed by Prof. S.Y. Wang in NCTU of taiwan [2]. It is a tool that provides a graphical user interface (GUI) written in C++. NCTUns was first released on November 18, 2002. Its last edition was on August 27, 2006. This work used NCTUns 2.0 that was released on February 16, 2005. NCTUns is not as popular as GloMoSim. However, it presents several advantages:

- It provides an easy-to-use GUI environment.
- It directly uses the real-life Linux's TCP/IP protocol stack to generate simulation results and can use a real-life existing UNIX application program as a traffic generator program.
- It supports concurrent simulations due to its distributed architecture.

Through the simulations achieved with this simulator, several shortcomings were noted:

- The connection through dispatcher with the simulation server is not stable. Indeed, it is frequent that the coordinator becomes busy. In this case, it notifies its state to the dispatcher. This last will not be able to select the appropriate simulation machine (apparition of the message "no idle server"). Therefore it is necessary to start again the coordinator, the dispatcher and the client.
- The programming is not supported by NCTUns. So, simulation parameters are set only by the graphical user interface. Consequently, the manipulation of protocol modules of every node has to be done manually, node by node, or all the nodes at the same time.
- To run simulation, it is necessary to use the graphical user interface. Thus, simulation running will be very slow especially when the network simulated contains many nodes.

3 GloMoSim

GloMoSim [3] is a scalable simulation environment for wireless and wired network systems, developed by PCL (Parallel Calculation Laboratory) of UCLA (University of California in Los Angeles). It uses PARSEC [13] (Parallel Simulation Environment for Complex systems) that is a C-based simulation language for sequential and parallel execution of discrete-event simulation models. PARSEC introduces the notions of entities (autonomous blocks that can be executed simultaneously) and messages between these entities. This is very useful for the simulations of nodes exchanging information between themselves. It allows the simulation scalability to simulate networks with a hundred thousand nodes.

Currently, GloMoSim supports protocols for a purely wireless network.

GloMoSim is considered as a popular simulator because many searchers tested it. On the other hand, it presents some drawbacks. For example: the updates of GloMoSim are not regular. The last update was in 2003. Moreover, GloMoSim is being designed using the parallel discrete-event simulation capability provided by PARSEC [3]. However, the last version of GloMoSim supports only one sequential simulation.

4 A comparative Study

4.1. Introduction

The scenarios achieved in this section are more and more complex. We first start with testing the following features: transmission range, access to the radio medium and routing. Finally, we essentially test scalability. Common parameters for all scenarios are fixed in the following table:

Table 1. Scenarios parameters

Parameter	Value
PROPAGATION-PATHLOSS	Two Ray Ground
MAC layer	IEEE 802.11b, DCF
Routing protocol	AODV
Transport layer	UDP
Traffic	CBR, 200 pkts/s
Packet size	512 bytes
Rate of radio medium	11 Mbits/s
Transmission range	250 m

4.2. Transmission Range

NCTUns set the transmission range simply by modifying the parameter "Transmission Range". Whereas GloMoSim [4] determines the transmission range by setting the following parameters :

- Set the propagation pathloss model, which is “*Two Ray Ground*” in our case (PROPAGATION-PATHLOSS parameter).

- Fix the received power of the destination antenna (RADIO-RX-THRESHOLD parameter).
- Calculate the transmitted power (RADIO-TX-POWER parameter) according to the selected propagation pathloss model, whose expression is given by :

$$P_r = P_t \frac{h^2{}_t h^2{}_r}{d^4} G_t G_r \quad (1)$$

where, P_r and P_t are RADIO-RX-THRESHOLD and RADIO-TX-POWER parameter; d is the transmission range; G_t and G_r ($G_t = G_r = 0.0$ dBm = default value in GloMoSim configuration file) denote radio antenna gain for transmission and radio antenna gain for reception; h_t and h_r (both fixed to 1.5 m) represent radio antenna height for transmission and radio antenna height for reception.

To verify that the transmission range is exactly 250 m for both simulators, we conduct the following simulation: a topology containing two nodes (N_1 and N_2). N_1 sends to N_2 CBR traffic. The traffic begins at 1s and ends at 250s, the simulation lasts 300s. N_1 is stable, while N_2 moves with a speed equal to 1m/s. The initial distance between N_1 and N_2 is 50 m. While moving, the distance between the two nodes increases, so N_2 leaves the transmission range of N_1. As a result, at a definite time, N_2 does not receive the packets sent by N_1 anymore. Therefore, the total number of packets received becomes constant. If we measure the distance (N_1, N_2) at this time, its value should be equal or close to 250 m.

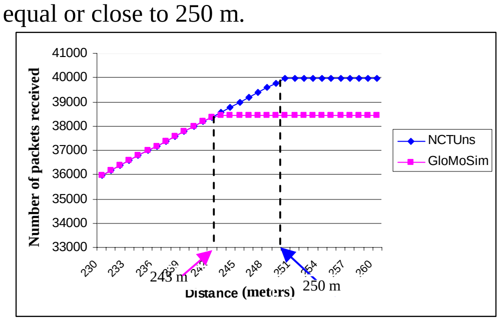

Figure .1. Number of packets received by the mobile N2 according distance (N1, N2)

Simulation results: Figure1 shows that the transmission range of NCTUns is exactly 250 m. While that of GloMoSim is different from 250 m. Moreover, the number of packets received with NCTUns is higher than that received with GloMoSim (38439 packages for GloMoSim and 39977 packages for NCTUns).This can be due to many factors such as the calculation of noise and interferences, which is different for the two simulators. Figure1 also shows that the modelling of the physical layer is simplified. Indeed, when the transmission range has a fixed value (250 m), two mobiles can communicate only if the distance that separates them is shorter than or exactly equal to 250m. However, in real life, the source node can succeed in sending packets even if the distance which separates it from the destination node exceeds 250 m. This phenomenon can be explained by the following phenomena: The computations of interference and noise factors prove that transmitted power is stronger than noise and interferences. That is why; communication between the two nodes is still possible.

4.3. Media Access method

The Media Access method that we adopt for NCTUns and GloMoSim is CSMA/CA with RTS/CTS mechanism. The goal of the following scenario is to create a competition on the medium access. This scenario consists in placing four equidistant nodes of 50 m (Figure.2). N1 and N3 send CBR traffic simultaneously to N2 and N4.

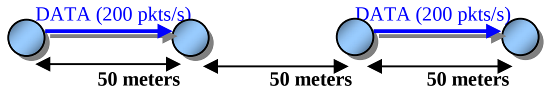

Figure.2. Testing the Media Access method

Simulation results: According to simulation results obtained by the two simulators, no packet is received by N_2 and N_4. This can be due to synchronization in the transmission of the "RTS messages": Before broadcasting its “RTS message”, each of N_1 and N_3 waits for some time. If the two times of waiting are always equal, there will be a collision between the “RTS messages " of N_1 and N_3, until the end of the traffic. So, no “CTS packet” is sent by N_1 and N_3, thereafter no data left the MAC layer and no packet is received by N_2 and N_4. To confirm this, we repeat the same scenario with the two simulators but this time we modify the beginning time of CBR traffic: N_2 begins transmitting 0.003s after the transmission beginning time of N_1. Simulation results show that all the packets sent by N1 and N3 are delivered to their destinations N2 and N4. So, effectively there was synchronization in sending "RTS packet". This scenario showed that each of NCTUns and GloMoSim simulators presents a common drawback that is the choice of the same SEED number for each node N_1 and N_3: Each mobile has his own SEED number. This number is created using a simulation SEED number, which is fixed when configuring simulation. Using its SEED number, each node generates a random number which is used in "Backoff" mechanism to calculate the retransmission time of “RTS message”. Thus, retransmission times of “RTS message” should be different for each node. Therefore the simultaneous retransmission problem is due to the choice of the same SEED number for each node. This problem concerns the two simulators NCTUns and GloMoSim.

4.4. Performance of routing

In our comparison, we achieved two scenarios. The first scenario is to test multi-hop routing when the topology is static. The second scenario is to compare the network behavior with the two simulators when the topology is dynamic. In the first scenario, we have four nodes (N_1, N_2, N_3, N_4). N_1 sends CBR traffic to N_4 that is at three hops of N_1 (Figure .3).

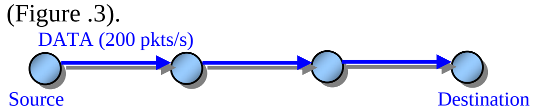

Figure . 3. Scenario 1 for Performance of routing

Simulation results: Let’s define PDR (packet delivery ratio) as the number of data packets received by the CBR destinations over the number of data packets originated from the CBR sources in the network. The simulation results show that with the two simulators, the PDR is equal to one. Indeed, N_1 receives an acknowledgment on its frame before sending the following frame (inter-arrival frame is 5ms and the acknowledgment frame arrives to N1 after 0.3ms).

In the second scenario, we consider a topology containing 13 nodes (Figure 4). N_1 sends CBR traffic to N_6. The mobility concerns only nodes N_4 and N_7. Their movement involves the failure of some links but there is always a path between the source and the destination. The aim of this scenario is to compare the network behavior with the two simulators when topology is dynamic.

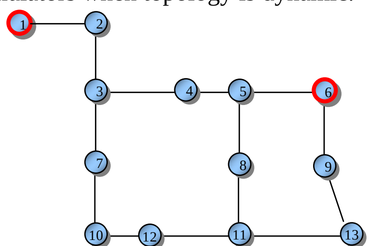

Figure.4. Scenario 2 for Performance of routing

<u>Simulation results</u>: Simulation results obtained by the two simulators show some differences in the delays of the network reconfiguration. Indeed, with NCTUns, destination node (N_6) remains one time 1.57s and another time0.7s, without receiving any packet. These delays are not acceptable. However, delays obtained by GloMoSim simulator are acceptable. They do not exceed ten milliseconds. This problem is due to the tardiness in the RREQ (Route REQuest) diffusion. Besides, the implementation of the AODV protocol by NCTUns includes some anomalies.

Now let find the impact of theses delays on the PDR: Figure.5 shows that the PDR at time 20s is greater than 1, which is false because PDR is always equal or shorter than one. This problem is due to the fallacy of the trace file of NCTUns.

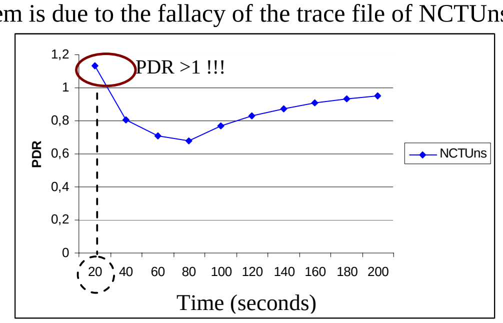

Figure.5. Packet Delivery Ratio

Indeed, after parsing the trace file of NCTUns containing all the packets received by the MAC layer, we found that 13.13 % of these packets are duplicated. Thus, they are delivered to their destinations more than one time. We constructed a new trace file, which use the first one and eliminate the duplicated packets in order to recalculate the correct values of PDR. Figure 6 plots the correct PDRs obtained by NCTUns and those obtained by GloMoSim according to time. This figure shows that the PDRs obtained by NCTUns are superior to those obtained by GloMoSim. This implies that the total number of packets received with NCTUns is superior to that with GloMoSim. This difference in the total number of packet received is due to the fact that NCTUns neglects some factors such as noise and interference. It is also due to the difference between the transmissions ranges (the transmission range of GloMoSim is lower to that of NCTUns).

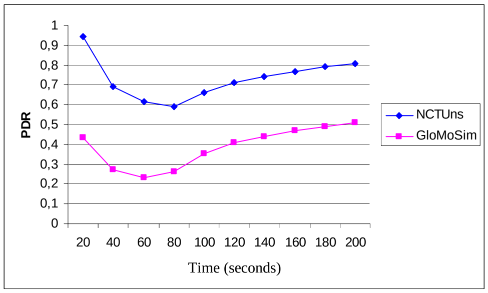

Figure.6. Packet Delivery Ratio (After correction)

4.5. Scalability, simulation speed and other factors

In this section, we are going to consider a typical scenario [7] : a rectangular topology (1000 m, 500 m), containing 50 nodes of which 10 sources and 10 sinks. All nodes are mobile according RWM model. We did a set of simulations of this scenario. In every simulation (which must be done one time with NCTUns and another time with GloMoSim), we changed one of the factors of the simulation environment. These factors are: mobility, traffic load, number of sources and transmission range.

Simulation results: The simulation results that we obtained with the two simulators showed some similarity in the global behavior of the network but differed in simulation speed and the delivery packet ratio.

Transmission range: Figure 7 shows that there is a direct relation between the PDR and the transmission range; i.e. the larger the transmission range, the higher the PDR. This is due to the increase in the number of neighbors which decreases the number of lost packets. As was shown in section above, the transmission ranges of NCTUns and GloMoSim are not equal (243 m with GloMoSim and 250 m with NCTUns). Therefore, according to Figure 7 (the smaller the transmission range the smaller the PDR), all PDR collected from NCTUns will be superior to those collected by GloMoSim. This is going to be confirmed in the results that follow.

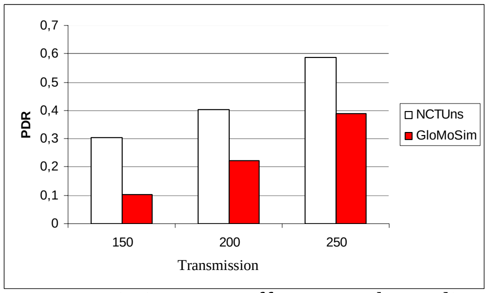

Figure 7.Transmission range effect on Packet Delivery Ratio

PDR Variation according to throughput, number of sources and mobility: The PDR decreases when the traffic load increases because the number of collisions increases. Figure.8.a shows that GloMoSim confirms this result while NCTUns provides non-logical values. This is due to the fallacy implementation of the routing protocol. Figure .8.b shows that the PDR decreases when the number of sources increases. Indeed, when the number of sources increases, the number of lost packets increases. This can be explained by the collision phenomena, congestion and competition for obtaining the access to the medium. Figure .8.c also shows that the mobility is an important factor that damages the performance of the network in terms of delivered packets. This is due to the losses of the packets during the phase of reconfiguration of the network.

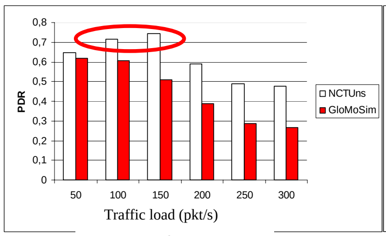

Figure 8.a

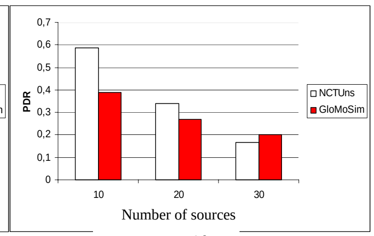

Figure 8.b

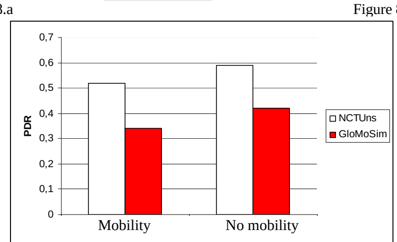

Figure 8.c

Figure 8. PDR Variation according to throughput, number of sources and mobility

*Simulation speed and scalability: S*imulations were achieved on a machine that has the following features: CPU: Pentium 4 of frequency 1.70GHz and RAM: 256 MB. Figure .9 shows that simulation time of NCTUns is distinctly superior to that of GloMoSim. It is quite logical because NCTUns can not be independent of graphical user interface when executing simulations. On the other hand, simulation time with NCTUns grows quickly as soon as we increase the number of sources, the mobility or the throughput (Figure .9.c). Thus, we can confirm that NCTUns has a weak scalability power while GloMoSim has a strong scalability power.

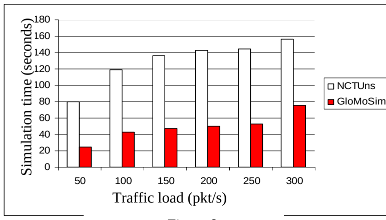

Figure 9.a

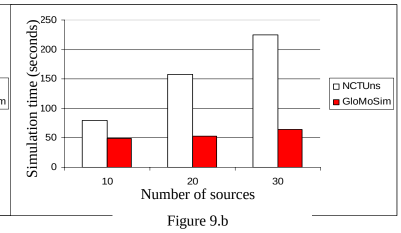

Figure 9.b

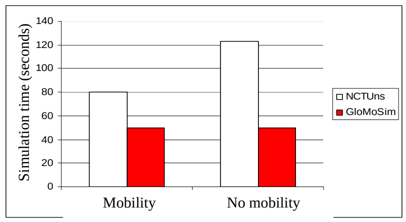

Figure 9.c

Figure 9. Simulation speed Variation according to throughput, number of sources and mobility

5 Conclusion

The objective of this paper was to evaluate NCTUns while comparing it to GloMoSim and theoretical results. GloMoSim was chosen because it is considered popular and has been tested by several researchers. Our comparative study showed that despite the advantages provided by NCTUns like the easiness of use and the conviviality of its interfaces, it presents several drawbacks. These drawbacks are essentially related to the fallacy implementation of its rooting protocol and the simplification of some of its models, what explains the inaccuracy in its results. Moreover, some trace files of NCTUns are false. Finally, NCTUns is not scalable comparing it to GloMoSim which has a strong scalability power. However, GloMoS was found to share some fallacies with NCTUns despite of its popularity.

Further studies are urgently recommended to develop more accurate and reliable simulation devices.

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