Wireless Ad Hoc Network Simulation in Cloud Environment

Wireless Ad Hoc Network Simulation in Cloud Environment

Leonid Djinevski, Sonja Filiposka, Igor Mishkovski and Dimitar Trajanov

Abstract - In this paper we present the utilization of cloud computing environment for fast network simulation of wireless ad hoc networks in 3D terrains. Considering 3D terrains involves larger amounts of data, thus the network simulation requires more compute intensive calculations. In this paper we evaluate the usage of cloud computing environment for network terrain aware simulation in order to optimally utilize the available hardware resources. Our experimental results show that there in not a significant decrease of performance when migration to a private cloud environment.

Keywords – Ad hoc, HPC, cloud computing, network simulation.

I. INTRODUCTION

Cloud Computing is becoming one of the most popular fileds in IT, finding applications in many diverse areas [1]. Cloud resource providers are offering many services to their customers, thus the capabilities of a given cloud solution is ambiguis to determine regarding performance. In this paper, we are focusing on the computational performance of the cloud environment.

Network simulators are tools used by researchers for testing new scenarios and protocols in a controlled and reproducible environment. That is, the user can to represent various topologies, simulate network traffic using different protocols, visualize the network and measure the performances. The drawback with these tools is their scaling, thus the execution time for a given simulation of medium to large networks, can take up few hours up to few days, or even weeks. Therefor waiting so much time makes the network simulators unsuitable for investigating protocols. In order to accelerate the simulation process, turning to high performance computing is the best choise, after optimizing the sequential implementation.

We have presented a 3D terrain aware extension [3] of the NS-2 network simulator [4] that enables simulation of wireless ad hoc networks, considering the terrain details. Additionally, we developed parallel implementation of the extension for GPU execution [5]. We have further optimized the performance of the extension [6] by introducing Triangular Irregular Network (TIN) terrain representation [7] [8]. Also, in [9] we have analysed the performance impact of the GPU memory configurations and proposed an approach for obtaining optimal performance. Parallel message-passing implementation for distributed execution was also developed in [10]. In this paper we are interested in the overall execution time of the network simulation running on a cloud instance of OpenStack [2]. Additionally, we present the results of migrating the network simulation execution of NS-2 on private cloud. Additionaly we compare the obtained results with on-premise execution of the same network simulator and under the same simulation scenarios.

The rest of the paper is organized as follows. In Section II we present a small introduction to network simulators and our extension of the NS-2 simulator for wireless ad hoc simulation. In Section III we present the migration of the simulator to the grid environment. The testing methodology is disrobed in Section IV, followed by the obtained results in Section V that show the impact of the extension of the NS-2 simulator on the time duration of the simulations. We conclude our findings in Section VI.

Leonid Djinevski is with Faculty of Information and Communication Technologies, FON University, Av. Vojvodina 5, 1000 Skopje, Macedonia, E-mail: {leonid.djinevski}@fon.edu.mk.

Sonja Filiposka, Igor Mishkovski and Dimitar Trajanov are with Faculty of Comuputer Science and Engineering, Ss Cyril and Methodius University, St. Rugjer Boshkovikj 16, 1000 Skopje, Macedonia, E-mail: {sonja.filiposka, igor.mishkovski, dimitar.trajanov}@finki.mk.

II. NETWORK SIMULATION

The NS-2 network simulator is considered to be a de facto standard simulator in the research community especially because of the existence of large number of implemented protocols. Although there is a NS-3 [11] version of the network simulator, which goal is to improve NS-2 by building the architecture from scratch, users still report problems with wireless ad hoc scenarios. The major issue that is reported is the very long simulation time, especially when using Ad hoc On-Demand Distance Vector (AODV) routing protocol. In a nutshell NS-3 is not yet mature enough to be as popular and verified as NS-2 which is still active. Regarding our terrain extension for the NS-2 network simulator which is not OTcl based, it can be easily ported to NS-3 network simulator.

The NS-2 network simulator contains two models (free-space and ground reflection) for wireless radio propagation when evaluating wireless ah hoc network performance. These propagation model are usually utilized by simulation modelers [12], however they are not terrain aware. By considering the terrain, the network simulation is made closer to real-life scenarios. In this paper, we are utilizing the Durkin's algorithm [3], which includes terrain details represented by TIN data.

A. Durkin's algorithm for wireless radio propagation

In this subsection we present the Durkin's algorithm, which makes use of diffraction and shadowing effects. The classical Fresnel solution is used for obtaining the diffraction loss, which is described by the following equations (1), (2) and (3):

$$G_d(dB) = 20\log|F(v)|. \quad (1)$$

$$v = h\sqrt{\frac{2(d_1+d_2)}{\lambda d_1 d_2}}. \quad (2)$$

where *F(v)* is the Fresnel integral, which is a function of the Fresnel-Kirchoff diffraction parameter *v* defined in (2). The approximation of (1) is given by:

$$\begin{aligned} &G_d(dB) = 0, && v \le -1 \\ &G_d(dB) = 20\log(0.5 - 0.62v), && -1 \le v \le 0 \\ &G_d(dB) = 20\log(0.5 * e^{-0.95v}), && 0 \le v \le 1 \\ &G_d(dB) = 20\log(0.4 - 0.62v), && 1 \le v \le 2.4 \\ &G_d(dB) = 20\log(\frac{0.225}{v}), && v > 2.4 \end{aligned} \quad (3)$$

Based on the conditions: if there is Line Of Sight (LOS), whether first Fresnel zone clearance is achieved or there is inadequate first Fresnel zone clearance, the durkin's algorithm using the diffraction parameter *v* can determine the path loss of for a given transmitter/receiver (TR) pair [13][14].

III. NETWORK SIMULATION IN CLOUD INFRASTRUCTURE

Cloud computing is currently very popular and growing field, which offers many services, providing an optimal utilization of information technology resources. Thus, many educational and research institutions are adopting cloud computing in order to rationalize the why they manage resources [15]. The organization of the convencional and cloud computing system, that are running our NS-2 network simulation application is presented in figures 1 and 2.

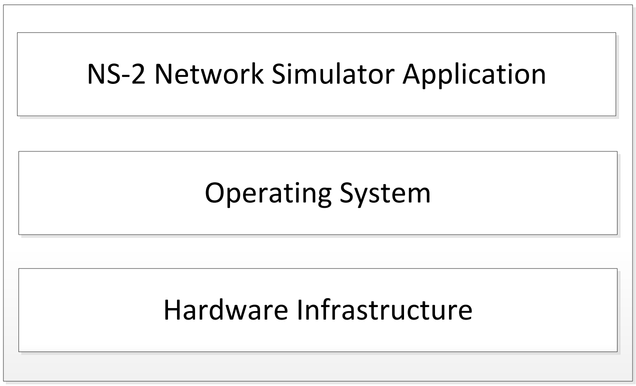

Fig. 1. Conventional computing environment

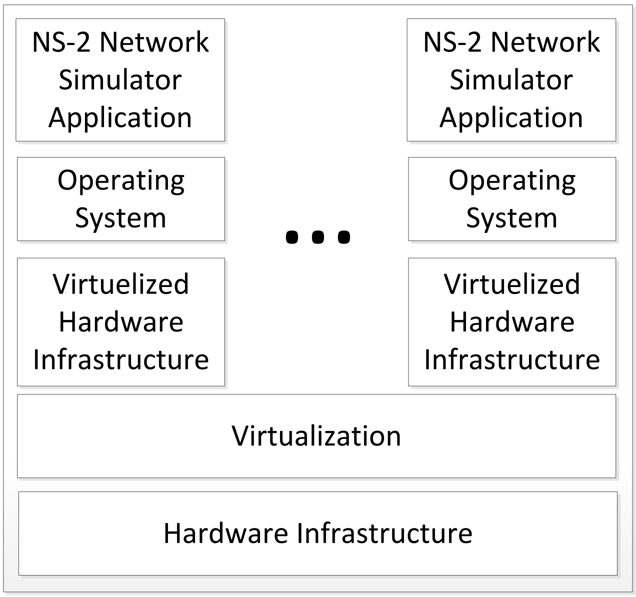

Fig. 2. Cloud computing environment

The presented cloud computing environment, implements a private cloud solution which utilizes the available on-premise hardware resources. Although this cloud configuration has its advantages, regarding our computational requirements, it lacks scalability and elasticity [16], which is the case with public clouds. In this paper we are analyzing the migration of our 3D terrain aware extension for NS-2 network simulator on the private cloud environment.

IV. TESTING METHODOLOGY

The used technology is described in this section. Our experiments were conducted on: cloud computiong environment and on-premise environment. The hardware infrastructure is consisted of Intel(R) Xeon(R) CPU X5647 @ 2.93GHz with 4 cores and 8GB RAM. The operating system is running Scientific Linux distribution. The cloud environment uses the same hardware infrastructure and the same operating system as the first environment. OpenStack cloud solution software is deployed, and KVM hypervisor is used for instantiating virtual machines in the cloud.

A. Testing data and scenarios

Several sets of scenarios were defined as typical real-life scenarios for the evaluating of ad hoc wireless network performances. Two experiments are performed, consisted of series of test cases. For both of the experiments, we are running the same 3D terrain aware extension for radio propagation for the NS-2 network simulator, in orde to obtain fair results. The latest message-passing implementation [10] is used in order to utilize the available parallel resources.

In the first experiment we are interested in the execution time of the NS-2 network simulator using the on-premese environment. We evaluate the influence on the execution performance by varing the terrain resolution (2,000, 4,000, 6,000, 8,000, 1,0000 and 12,000 triangles) of a given hill-like TIN-based terrain of Rhode Island, USA obtained from webGIS [17] and the different mobility scenarios of node velocity (1, 2 and 5m/s).

For the second experiment, we are ivestigating the execution time of the NS-2 network simulator using the cloud environment. The applied input parameters (different terrain details and node velocity) are the same as the first experiment.

Our expectarion regarding the performance is that the network simulation in the cloud computing environment will run slower than the network simulation in the conventional computing environment.

V. Results

This section presents the results that show the performance of wireless network simulation in conventional and cloud computing.

Figure 3 depicts the inverse execution time for different terrain details. With larger terrain details, smaller inverse time is achieved. It is also easy to notice that for bigger velocities, the inverse time is higher, which is expected.

Figure 4 presents the obtained results from the second experiment. The results show very similar values of the inverse time, for which there is no significant difference.

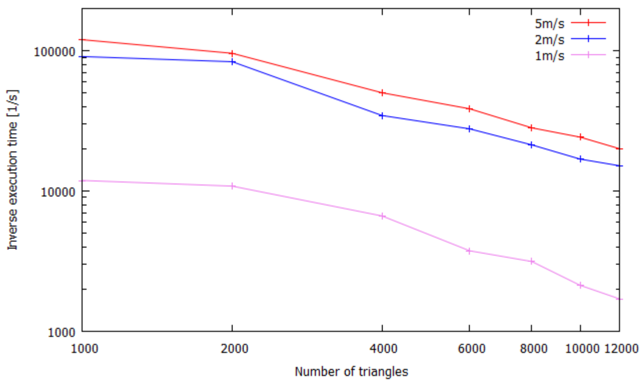

Fig. 3. Inverse execution time for conventional computing environment

In order to determine the trendline of the cloud computing environment compared to the conventional environment, we normalized the results with the inverse time of the conventional environment which is depicted in Figure 5.

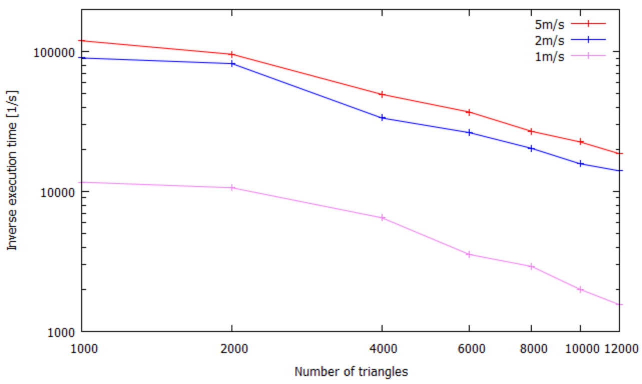

Fig. 4. Inverse execution time for cloud computing environment

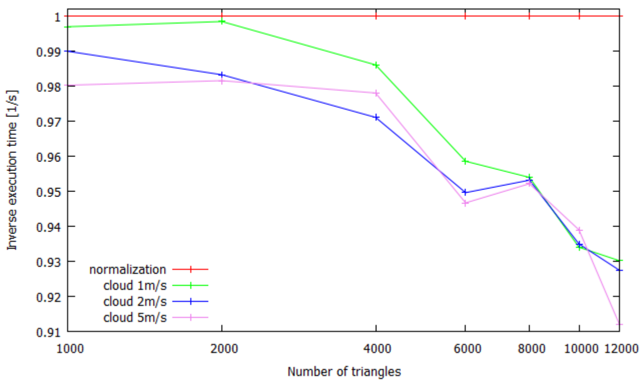

Fig. 5. Relative speedup of the cloud computing environment normalized over the

Our expectation that running the NS-2 network simulator on the cloud is slower than the conventional environment. The results for the cloud network simulation with node velocity of 2m/s, are discrepant for derrain resolution of 4000, 6000, and 8000 triangles. However, the difference from the other simulation scenarios of 1m/s and 5m/s are not significant.

VI. Conclusion

In this paper we analyzed the migration of NS-2 network simulation tool, using our terrain aware extension for wireless radio propagation, over a private OpenStack cloud computing solution. The performance of the network simulaton were observed, while focusing on the influence of different terrain details and node velocity over the overal duration of the simulation execution time.

The obtained results show that for both of the experiments, the duration of the simulation exectution time is influenced by the node velocity. By increasing the terrain details, the execution time is impacted in a positive trend.

The comparison of the cloud computing experiment normalized by the convencional computing experiment proves our expectation that the network simulation runs slower in the cloud.

Having investigated our the private cloud solution for NS-2 network simulation, as future work we are planning to migrate our terrain aware extension to a public multi-tenant cloud environment and analyze possible influences on the overall network simulation execution time.

REFERENCES

[1] Armbrust, M., et al., *"A view of cloud computing"*, Communications of the ACM, Vol.53, No. 4, 2010, pp. 50-58.

[2] Openstack cloud software, (retrieved September 2013), http://openstack.org.

[3] Filiposka, S., Trajanov, D., *"Terrain-aware three-dimensional radiopropagation model extension for ns-2"*, Simulation Vol. 87, No. (1-2), January 2011, pp. 7-23, DOI: 10.1177/0037549710374607.

[4] NS-2, network simulator, (retrieved November 2010), http://www.isi.edu/nsnam/ns/.

[5] Djinevski, L., Filiposka, S., Trajanov, D., Mishkovski, I., *"Accelerating wireless network simulation in 3D terrain using GPUs"*, Tech. Rep. SoCD:16-11, University Ss Cyril and Methodius, Skopje, Macedonia, Faculty of Information Sciences and Computer Engineering (June 2012).

[6] Vuckovik, M., Trajanov, D., Filiposka, S., *"Durkins propagation model based on triangular irregular network terrain"*, In: ICT Innovations 2010, pp. 333-341. Springer (2011).

[7] Unit 39-the tin model, (retrieved November 2011), http://www.geog.ubc.ca/courses/klink/gis.notes/ncgia/u39.html.

[8] Zeiler, M., *"Modeling our world, environmental systems research institute"*. Inc. Redlands, California 1999.

[9] Djinevski, L., Filiposka, S., Mishkovski, I., Trajanov, D., *"GPU performance impact of the Durkin's radio propagation algorithm"*, 21 Telecommunications Forum (TELFOR), IEEE Proceedings, 26 - 28 November, Belgrade, Srebia, 2013.

[10] Djinevski, L., Filiposka, S., Trajanov, D., Mishkovski, I., *"Message-passing terrain aware wireless network simulation"*, Tech. Rep. SoCD:11-13, University Ss Cyril and Methodius, Skopje, Macedonia, Faculty of Information Sciences and Computer Engineering, September 2013.

[11] Stojanova, S., Djinevski, L, Mishkovski, I, Filiposka, S, Trajanov, D, *"Micro-benchmarking NS-2 and NS-3 Network Simulators Using Terrain Aware Radio Propagation Extension"*, 3nd International Conference on Internet Society Technology and Management (ICIST 2013), Conference Proceedings, pp. 81-84, Kopaonik, Serbia, March 2013.

[12] Rappaport, T. S., *"Wireless Communications: Principles and Practice"*, Prentice Hall, New York, 2002.

[13] Edwards, R., Durkin, J., *"Computer Prediction of Service Area for VHF Mobile Radio Networks"*, Proceedings of the IEEE, Vol. 116, No. 9, pp. 1493-1500, 1969.

[14] Rappaport, T. S., *"Wireless Communications: Principles and Practice"*, Prentice Hall, New York, 2002.

[15] Sultan, N., *"Cloud computing for education: A new dawn?"*, International Journal of Information Management Vol. 30, No. 2, 2010, pp. 109-116.

[16] Shtern, M., Simmons, B., Smit, M., and Litoiu, M., *"An architecture for overlaying private clouds on public providers"*, in 8th Int. Conf. on Network and Service Management, CNSM 2012, Las Vegas, USA, 2012.

[17] webGIS, Geopraphic Information System Resource, (retrieved September 2013), http://www.webgis.com/.