ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

NS2-SIMULATED OPERATION AND PERFORMANCE ANALYSIS OF WSN BASED SMART GRID

Vaibav Sharma*[1] & Satish Kumar[2]
*[1&2]Amity School of Engineering & Technology, Amity University Uttar Pradesh, Lucknow Campus, India

ABSTRACT

Designing Wireless Sensor Network to monitor parameters like packet interval, packet delivery, latency, end-to-end delay of data packets and throughput. Network simulator tool has been employed to analyse the performance of ad-hoc routing protocols using the above simulation parameters to evaluate the performance and latency of the WSNs in order to establish their suitability for a typical set of monitoring and supervision functionalities required by urban scale Smart Grids applications. The software used is Network Simulator 2.35 which employs Xgraph and TCL. Wireless sensor network can be used to collect data and send control information to the device in distributed manner for the last mile two-way communication which makes it a promising option for the smart grid communication. The aim of this paper is to concluded that WSNs perform better with comparatively low speed communication which makes it suitable for smart grid applications like AMI, distributed automation, distributed energy resources and storage, electric transportation, distribution grid management according to the communication requirements of the smart grid.

Keywords: *Wireless Sensor Networks, Smart Grid, Network Simulator, Performance Analysis, Monitoring.*

I. INTRODUCTION

Wireless Sensor Networks are efficient and more affordable because of their low-cost which is why it is widely being used to monitor remote facilities using applications such as SCADA. The traditional power grid shows signs of inefficiency which gave way to the idea and implementation of Smart Grid. In comparison to the one-way communication in conventional power grid, the Smart Grid offers two-way communication which also acts as a two-way flow of information as well as electricity which forms the foundation of revolutionizing energy distribution, generation and delivery.

Conventional power grids lack effective communication, diagnostics and fault monitoring. Latency is a great setback when it comes to monitoring and control of grid to avoid potential blackout from cascading effect.

We focus on simulation of ad-hoc wireless network to evaluate the performance and latency of WSNs in order to establish suitability for a typical set of monitoring and supervision functionalities required by urban scale Smart Grids application. NS2 (Network Simulator 2.35 all in one) is used here for the sake of simulation purposes which includes packages like Xgraph and NAM(Network Animator) which use trace files to plot the output and help is drawing conclusions from the comparative study after implementing the required protocol for the Wireless Sensor Network.

II. NETWORK SIMULATION MODEL (NS2)

NS2 simulator deals with transport layer protocols, routing protocols, different types of queues, link layer mechanisms. This simulator gives the essence of dealing with practical network structure components such as routers, switches, bridges, wired and wireless nodes. Once simulation is complete, NS2 produces trace files which keeps the record of every event in the simulation line by line. NS2 consists of C++ programming language, Tcl and Object Tcl interface allowing user to put inputs in the simulation script of the network model.

TABLE I
SMART GRID FUNCTIONALITIES AND COMMUNICATIONS NEEDS

Application	Bandwidth	Latency
AMI	10-100 kbps/node, 500 kbps for backhaul	2-15 sec
Demand Response	14kbps- 100 kbps per node/device	500 ms - several minutes
Wide Area Situational Awareness	600-1500 kbps	20 ms-200 ms
Distribution Energy Resources and Storage	9.6-56 kbps	20 ms-15 sec
Electric Transportation	9.6-56 kbps, 100 kbps is a good target	2 sec-5 min
Distribution Grid Management	9.6-100 kbps	100 ms-2 sec

III. EVALUATION OF WSNs FOR VARIOUS PROTOCOLS

Performance Metrics used for evaluation of routing protocols are [9, 10, 11, 12]:

Packet Delivery Ratio

Measures the percentage of total number of data packets received out of total number of data packets sent.

Routing Over Head

The total number of routing packets transmitted during simulation. Routing overhead is important as it measures the scalability of a protocol, the degree to which it will function in congested or low bandwidth environments.

End-to-End Delay of Data Packets

This metric measures the average time it takes to route a data packet from the source node to the destination node. The lower the end-to-end delay the better the application performance. If the value of end-to-end delay is high, then it means the protocol performance is not good due to the network congestion.

TABLE II
SIMULATION PARAMETERS

Simulation Dimension	500*500
Number of Nodes	Vary according to experiment
Propagation	Two Ray Ground
Routing queue	Drop tail
Mac protocol	802.15.4
Antenna	Omni Directional
Traffic type	cbr

ISSN 2348 – 8034
Impact Factor- 5.070

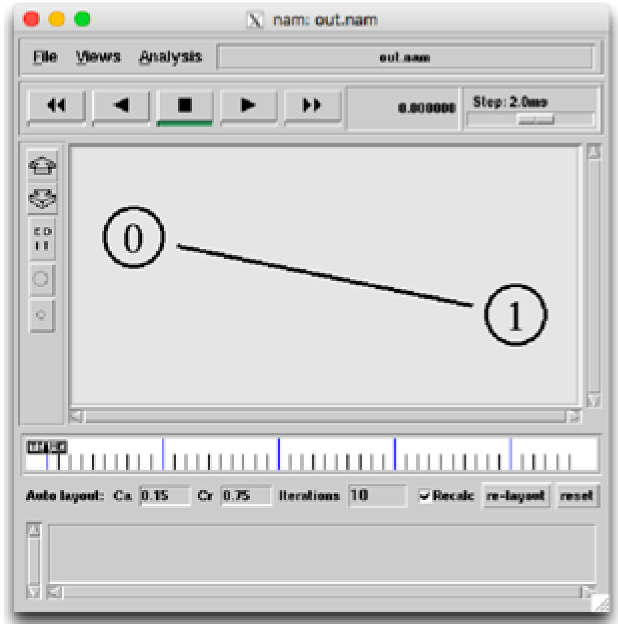

Figure 1 NAM Window

When we create sensor nodes in NS2, an energy model needs to be defined which is the energy each node has at the beginning of simulation. The components required for creating an energy model includes initialEnergy, txPower, rxPower and idlePower. The initialEnergy represents the level of energy in the node at the beginning of simulation, txPower and rxPower represents the energy consumed for transmitting and receiving the packets. And the most important component the energy model of a sensor node must contain is called the "sensePower". It denotes the energy consumed by a sensor node during the sensing operation.

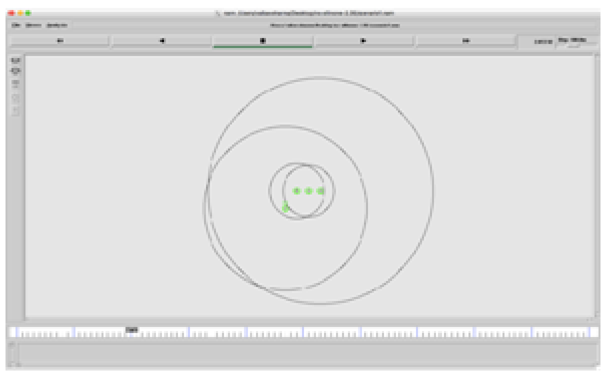

Figure 2. WSN Simulation

The simulation of a sample wireless sensor network with three nodes and a sink node is shown in action. This simulation was done on network animator using the trace file made using TCL script. Here, the interaction between various nodes is shown. The event schedulers, traffic pattern, network components are implemented in C++ and can be merged to Tcl script. Core structure of network is built on C++ code and Tcl is on the top of it to make the simulation handling much easier to carry out.

Variation of latency is presented with different packet inter-arrival time in the Figure- 3. Actually packet interval was introduced to simulate the variation of network speed and to observe the characteristics of it with applying different ad-hoc routing protocols. It can be observed that when packet inter-arrival time is 0.02s (that means the system speed is about 100 kbps) all of the routing protocols showed high latency as high as around 0.2 s for AOMDV except DSR which showed as low as 8 ms. As the packet arrival time increases all of the routing protocols showed lowered latency for the same system.

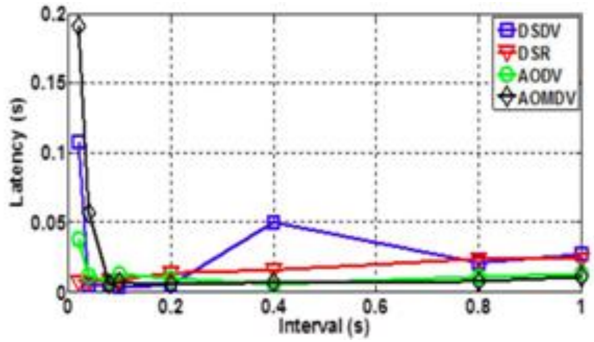

Figure 3. Packet interval vs. latency for 25 grid connected nodes

That means when the system generates less traffic it can perform better. The packet delivery ratio is presented in the figure 3 and it can be observed that the system's packet delivery ratio is best for DSR with varying traffic generation rate which is around 90%.

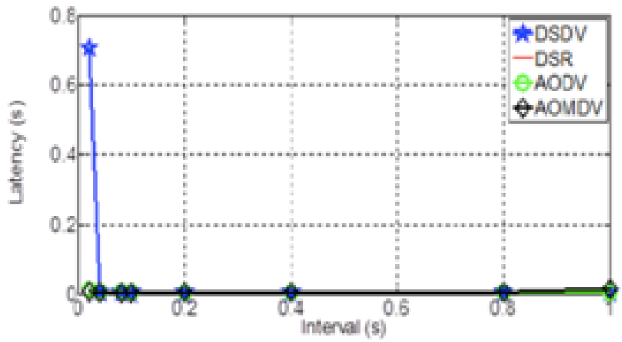

Figure 4. Packet interval vs. latency for 9 grid connected nodes

It also observed that Packet delivery ratio and latency improved much for smaller networks as evident from the figures available for 16 and 9 nodes network. Such as for a WSN with 9 nodes shows 100% packet delivery ratio and latency of 4 ms which evident from figure 5.2 and 5.1 respectively.

IV. CONCLUSION

Network simulator tool has been employed to analyze the performance of ad-hoc routing protocols using the above simulation parameters. It can be concluded that WSNs perform better with comparatively low speed communication (2kbps~100kbps) which makes it suitable for smart grid applications like AMI, distributed automation, distributed energy resources and storage, electric transportation, distribution grid management according to the communication requirements of the smart grid as indicated by the Table-I [3]. And necessary routing protocol can be DSR ad-hoc routing protocol to operate WSN better. It is also observed that WSNs meet the latency (700ms~4ms) requirement of the smart grid communication for time critical applications but they work better for short range communication (30m~90m). Wireless sensor network can be used to collect data and sending control information to the device in distributed manner for the last mile two-way communication which makes it a promising option for the smart grid communication. In future the performance of the WSNs can be analysed with hardware implementation in a real smart grid environment as Florida International University has state of the art smart grid test bed facility. The performance of WSN then can be compared with that of the existing wired communication infrastructure. WSNs can also be implemented for operation monitoring of the smart grid and control of smart capacitor bank that can monitor and control capacitor banks remotely, Volt/VAR Control, Substation circuit breaker trip coil status and control, State Estimation, Fault Detection/Isolation.

REFERENCES

1. *V. C. Gungor and M. K. Korkmaz, "Wireless Link-Quality Estimation in Smart Grid Environments" , Hindawi Publishing Corporation, International Journal of Distributed Sensor Networks, vol.2012, Article ID 214068,10pages, doi:10.1155/2012/214068.*
2. *Woon, W.T.H.; Wan, T.C.; "Performance Evaluation of IEEE 802.15.4 Ad Hoc Wireless Sensor Networks: Simulation Approach," Systems, Man and Cybernetics, 2006. SMC '06. IEEE International Conference on , vol.2, no., pp.1443-1448, 8-11 Oct. 2006, doi: 10.1109/ICSMC.2006.384920*
3. *Melike Erol-Kantarci and Hussein T. Mouftah," Wireless Sensor Networks for Cost-Efficient Residential Energy Management in the Smart Grid", IEEE Transactions on Smart Grid, vol. 2, no. 2,pp. 314- 325, June 2011*
4. *Security Model Using NS2 "International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 4 Issue 1 May 2014.*
5. *Spector, A. Z. 1989. Achieving application requirements. In Distributed Systems, S. Mullender.*
6. *Bi Jun-lei, Chen Jing. Research on Routing Protocols for Wireless Sensor Networks, Computer Knowledge and Technology [J] 2007.6: 1578-1579*
7. *J. J. Conti, P. D. Holtberg, J. A. Beamon, A. M. Schaal, G. E.Sweetnam, and A. S. Kydes, Annual energy outlook with projections to 2035, report of U.S. Energy Information Administration (EIA), Apr. 2010 [Online]. Available: http://www.eia.doe.gov*
8. *Zhao Chen-chen, Yang Zhen. Analysis for routing protocols of wireless sensor network, Guangdong Communication Technology [J],2006.7 :30-36*
9. *Liu Lintao Yang Ping, Routing Protocols Simulation Based on NS2, Ship Electronic Engineering [J],2008.4 Vo.l 28 No. 4:132-134*
10. *HUANG Wei, SONG Liang-tu, WU Min-min, etal. Application of wireless sensor networks for agricultural and Related Issues [J], Automation & Instrumentation,2008.6:52-54,82*
11. *R. Aleliunas, R. Karp, R. Lipton, L. Lovasz, and C. Rackoff. Random walks, universal traversal sequences, and the complexity of maze prob- lems. In 20th Annual Symposium on Foundations of Computer Science, pages 218–223, 1979.*
12. *P. Papadimitratos and Z. Haas. Secure Routing for Mobile Ad hoc Networks. In Proceedings of the SCS Commnication Networks and Distributed Systems Modeling and Simulation Conference (CNDS), pages 193–204, 2002.*
13. *O. Erdene-Ochir, M. Minier, F. Valois, and A. Kountouris. Toward resilient routing in wireless sensor networks: Gradient-based routing in focus. In Proceedings of the 2010 Fourth International Conference on Sensor Technologies and Applications, SENSORCOMM '10, pages 478–483, 2010.*
14. *D. Liu and P. Ning. Multilevel tesla: Broadcast authentication for distributed sensor networks. ACM*
15. *Transactions in Embedded Computing Systems (TECS), 3:800–836, 2004.*
16. *C. Schurgers and M. Srivastava. Energy efficient routing in wireless sensor networks. In Proceedings of MILCOM 2001, pages 357–361, 2001.*