Estimation of Signal Coverage and Localization in Wi-Fi Networkswith AODV and OLSR

Kazy Noor E Alam Siddiquee[1], Karl Andersson[2*], Francisco Javier Moreno Arrebola[3], Zainal Abedin[1], and Mohammad Shahadat Hossain[4]
[1]*Department of Computer Science and Engineering, University of Science and Technology Chittagong Foy′s Lake, Chittagong, Bangladesh*
{knas11, jakcse99}@gmail.com
[2]*Pervasive and Mobile Computing Laboratory, Luleå University of Technology SE-931 87 Skellefteå, Sweden*
karl.andersson@ltu.se
[3]*HeidelbergCement, Spain*
c3021ma@gmail.com
[4]*Department of Computer Science and Engineering, University of Chittagong-4331, Bangladesh*
hossain_ms@cu.ac.bd

Abstract

For estimation of signal coverage and localization, path loss is the major component for link budget of any communication system. Instead of traditional Doppler shift or Doppler spread techniques, the path loss has been chosen for IEEE 802.11 (Wi-Fi) signals of 2.5 and 5 GHz to measure the signal coverage and localization in this research. A Wi-Fi system was deployed in a MANET (Mobile Ad-hoc NETwork), involving both mobile and stationary nodes. The Adhoc network was also assessed in a routing environment under AODV and OLSR protocols. The proposal was evaluated using the OPNET Modeler simulation environment.

Keywords: i-voting, signal coverage, localization, distributed scalable wireless networks, MANET, routing protocols, AODV, OLSR.

1 Introduction

Current world is being run by wireless technology. This fastest growing technology is gradually assembling people in this world with wide range of applications and hence, dependencies on wireless technologies are rising sharp. But, major challenges those affect its users are the loss of signals or poor signal coverage, weak localization, poor routing and many more like these. This research has identified these issues as its research goals and in a MANET using a Wi-Fi communication network of 2.5 GHz signal has been configured for an online Internet voting system [1].

Wi-Fi is a widely used wireless technology with a variance of its uses and its applicability having a standard of IEEE 802.11. Users prefer generally its valuable characteristics, such as low cost, flexibility, mobility and availability. It is commonly propagated at 2.4 GHz UHF and 5.8 GHz SHF ISM radio bands with a maximum of 54 Mbps speed in any network [2]. Therefore, Wi-Fi was the primary consideration for the wireless network of the MANET in this paper.

Signal Coverage in a wireless network is a major concern. For stable network coverage of the wireless area, path loss plays an important role in link budget which is the evaluation of both attained gains and

Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications (JoWUA), 9:3 (Sept. 2018), pp. 11-24
*Corresponding author: Pervasive and Mobile Computing Laboratory, Luleå University of Technology, Forskargatan 1, Campus Skellefteå, A building, Skellefteå, Sweden, tel: +46-(0)910-585364

losses from transmitting end to receiving end of a signal in a specific medium of a communication system [3]. Therefore, the term path loss is a dependent variable to the distance value of the signal from the transmitter and the receiver of the Wi-Fi network. The coverage of the signal depends on some parameters named as i. carrier frequency, ii. antenna height of both transmitter and receiver, iii terrain contour and iv. building concentration. Besides, there is a variable in the path loss equation, termed as attenuation and in this paper, bricks wall, wooden structure, metallic structure and electric fields [2][3].

Localization of any node in a wireless network field is another challenging issue. The target node needs to discover wireless nodes within its transmission and receiving range so that it can obtain measuring vectors to read wireless nodes. Nodes are not getting any signals from static nodes like single mounted camera capturing images [4] or any stagnant single devices providing continuous signals; rather, the system is depending on a wireless network. Therefore, the status and behavior of the signal strength of transmitting and receiving signals are another main focus of this research. For getting the behavioral status of the signal the uncertainty as a function as the Received Signal Strength (RSS) is calculated for different attenuation values [5] [6].

Since the MANET is going to be used by greater number of users, assessment of the performance is necessary. Routing protocols should be assessed considering some routing overheads such as congestion control, delays, network load balancing, energy of nodes, media accessing, throughput and heterogeneous configurations. In such a case, some parameters should be given focus. However, the deployment of ad hoc wireless nodes, accompanied by lower density (1 to 5 nodes) network as well as with the use of traditional protocols are inefficient to overcome the technical bottlenecks [7] [8]. For both lower and higher density of nodes (in figure 1 and figure 2), analysis of performances of routing protocols has special significances not only for routing parameters but also for various attacks and vulnerabilities [9] [10] [1]. This article also investigates the efficiency aspects of the different routing protocols (OLSR and AODV) to be used in the MANET under Zigbee. The performance is assessed by taking account of five parameters including Packet Dropped, Network Load, End to End delay, Throughput and Media Access Delay.

In the OPNET Simulator environment, 10 and 20 nodes are considered for configuring MANET.

The application field of this article is an online Internet voting (i-voting) system (see Figure 3) which have already been mentioned in our previous research [1]. Some fixed nodes termed as servers are the target nodes and users are the mobile wireless nodes considered here. The wireless network is configured in a building structure or the debris. The network coverage is computed through signal ranging with attenuation factors under some constraints. Collapsed brick structures, wooden structures, metallic structure and electrical fields are taken in to accounts as such constraints. At the same time, localization of wireless nodes are also studied so that the uncertainty function will discover the required localized range with values of received signal strength. As both ranging of signal and localization are directly depending on the behavior of the network, some parameters such as end-to-end delay, media access delay, network load, packet loss and throughput of the wireless network under routing protocols (AODV and OLSR) in a specific topology have been investigated.

The following research questions were identified:

a. What is the optimal distance measurement for wireless nodes for getting a minimum coverage and localization of Wi-Fi signal?

b. What is the required protocol under a topology for some network conditions (parameters) for the optimal performance of the wireless network?

The remaining of the article is organized as follows: Section 2 presents the related work, while Section 3 details the methodology and simulation scenarios. Finally, the analysis of the results and our conclusion are presented in Sections 4 and 5, respectively.

Figure 1: MANET in the architecture.

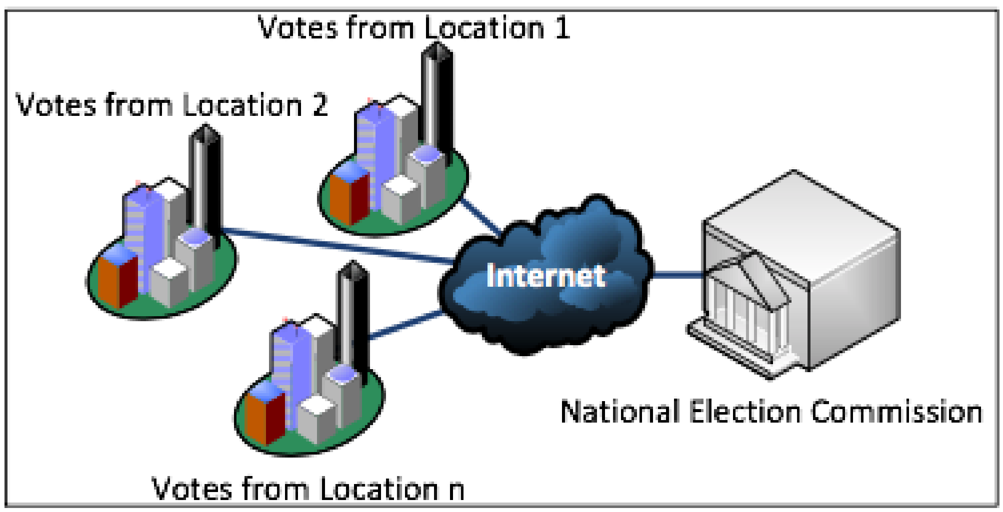

Figure 2: National i-voting system at a glance.

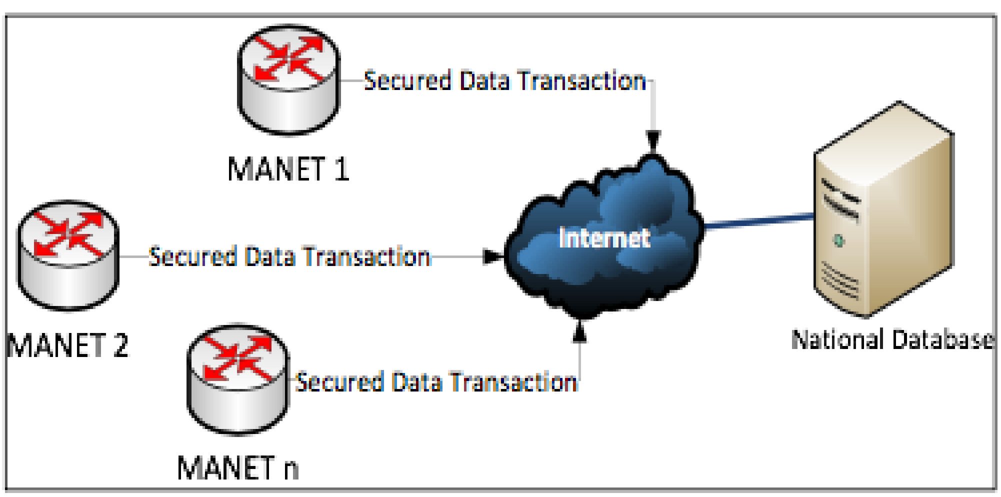

Figure 3: Context network architecture diagram of the system [1].

2 Related Work

Signal Coverage and Localization

Models that predicts wireless signal coverage under link budget have been developed over years. There are many path loss models which use signal strength measurements to predict path loss and these models provide efficient and reliable coverage area [2][11]. Link budget is an accounting evaluation from attained gains and losses from transmitting end to receiving end of a signal in a specific medium of a communication system [12]. So the right choice of path loss model is important to estimate path loss correctly considering the effects of environment. Wireless LAN basically works in indoor environments. The indoor environment suffers from various obstructions like reflection, diffraction, absorption losses and losses because of floors and walls [13]. Several indoor path loss models were established to predict signal strength [2][12]. They are divided into three categories: Deterministic, Empirical and semi empirical [14] [15] [16]. The deterministic models presented in have high computational complexity because they are used in complex indoor environment. Empirical models are found from a specific environment through huge calculation and statistical analysis that apply parameters like received signal strength, frequency, antenna heights, and terrain profiles [17][18] [19] There are some basic empirical models for indoor environments [11] [3]:

a. Okumura model
b. Okumura-Hata path loss model
c. Cost-231 Hata model

The Okumura model is the most widely used empirical model based on enormous measurements and tests and was built from the data taken in Tokyo, Japan. It operates between the frequency range from 150MHz to 1920 MHz and this range can be extended upto 300 MHz. Okumura have done numerous field tests with different frequencies, transmitter height, transmitter power and finally made the decision that signal strength decreases at a much higher rate than free space loss. This model acts as a base for Okumura-Hata model.

The Okumura-Hata model is also known as Hata model. It is formulated from the graphical path loss data provided by Okumura. It operates in the rage of 150Mz to 1500MHz and is only applicable for microcell planning.

The Cost-231 Hata model is the extended vesion of Okumura-Hata model and it mainly works for higher range of frequencies like 1500MHz-2000MHz for predcting path loss in mobile wireless system.

There are also mathematical models of indoor propagation environments [11] [20] including the Log distance path loss model, the Log normal shadowing model, and the Two ray model.

Log distance path loss model expresses the path loss as a function of distance by the use of path loss exponent. Path loss exponent expresses at which rate path loss increases with distance while the close reference distance is estimated through measurement. Path loss exponent depends on particular environment ranging from 1.2 to 8. As the value of path loss exponent decreases, signal loss also decreases.

Log normal shadowing takes into account in different levels of clutter on the propagation path. As a result the measured signal is different from the one measured in log distance path loss model.

The two ray model does not depend on measurements, instead it depends on indoor environments to predict signal propagation within the building. It basically predicts path loss when the received signal is composed of line of sight component and multipath component formed by a single ground reflection.

MANETs

The MANET is in use with various routing protocols. Panchard [8] highlighted the role of WSN on agricultural activities (such as irrigation and plantation) for small land owners and farmers. In this approach, data was collected by conducting survey while the system was designed and implemented by using a decision support tool. Shiravale and Bhagat [7][8] configured a WSN by using a master-slave (point to point) system with short hop addressing scheme of IPv6. Here, the network was built on the single topology with limited application of protocols also [21]. In other works, WSNs have been utilized in irrigation purposes [22][23][24][25] and natural disasters [26][27][28].

MANETs are usually configured with both the proactive and reactive routing protocols such as AODV, DSR and OLSR [29][30].

In case of routing problems, most research works found reactive routing protocol to be dominant over proactive routing protocols and AODV performs better than those of others [7]. This protocol uses traditional routing table and for each destination there is a single entry in the routing cache.

The i-voting system which is the research focus of this article, was not initiated with the term 'Internet' at first. Rather a proposed system has been mentioned in the works [10] and [1]. Major threats have been pointed out and security experts expressed their concerns on 'protection', 'electronic ballot', 'safety of voters', 'safety of data transactions', 'confidentiality of votes', 'accountability', 'online voting from remote places', 'accuracy', 'transparency' and 'verifiability of elections' [10] [1].

3 Methodology, Scenario, and Simulation Environment

For effective coverage of Wi-Fi signals in the debris, the following ISM frequency bands have been used: 5 GHz, 2.4 GHz, and 900 MHz. The path loss model has been adopted. The values obtained from the echo signals are run through in a simulated environment with different attenuation factors under certain constraints such as bricks wall, wooden structure, metallic structure and electric fields to achieve the required function of the path loss.

For localizing a set of nodes treated as target nodes have been deployed. Some mobile nodes (users) are also been set in the building area for reading these nodes. Hence, target nodes obtains some measured vectors and the behavior of Received Signal Strength (RSS) known as the uncertainty function [31][11].

Later on, the network is assessed under some parameters such as end-to-end delay, media access delay, network load, packet loss and throughput using a proactive routing protocol, OLSR and a reactive routing protocol, AODV under a MANET in Zigbee environment.

Signal Ranging

The path loss (PL_{Deb}) contains a relation with the distance d (Euclidean distance) according to the following equation [11]:

$$d = 10^{(\frac{PL_{Deb}}{\alpha})} \tag{1}$$

α is the attenuation related with the distance multiple of 10 having an index of path loss/loss factor for

1. brick walls
2. wooden structure
3. metallic structure and
4. electric fields

The value of X_g is considered as zero (0) for all possible losses considering Brick walls, wooden collapsed structure, metallic structure and electric fields are considered as 2, 3, 6 and 5.

Therefore, the modified path loss model is derived from the following equation:

$$PL(d)[dB] = PL(d_0) + 10 * \alpha * log_{10}\frac{d}{d_0} + X_0 \tag{2}$$

$$X_g = p * AF + FaF \tag{3}$$

AF is the attenuation factor for brick walls, wooden structures, metal structures, or electric fields, while FaF incorporates all fading factors including slow or fast.

Localization

The Received Signal Strength (RSS) or the received power is directly related to the distance [11].

$$RSS \propto \frac{1}{distance^2} \tag{4}$$

Again considering Eq. 3

The value of X_g is considered as zero (0) again.

Performance of the MANET

As Reactive routing protocols AODV, and as Proactive routing protocols OLSR are considered as these are the optimal protocol in mentioned parameters of this network.

The simulation is performed both in 10 and 20 nodes densities for three topologies with a duration of 600 (sec). Each node is given an IP in IPv4 scheme. The area is considered as 1000 x 1000 (m) for MANET as larger field is considered for installation and deployment of this topology. A 100 x 100 (m) area is considered for both single hop star and mesh topology.

4 Analysis of Results and Discussion

Signal Ranging

Path loss for brick walls and collapsed brick walls are least compared to other constraints (wooden structure, metallic structure and electric fields) in Figure 4. With the rise of the distance, attenuation of wooden structure, metallic structure and electric fields rises more compared to that of brick walls.

Localization

When α = 2, there is less immediate change of attenuation and the limit stays from 0 to 60 for all four constraints in Figure 5.

When α = 5, the rise of sharp changes are rapid compared to that of brick walls (α = 2) in Figure 6.

When, α = 6, the rapid change of attenuation continues compared to that of α = 2 in Figure 7.

Therefore, brick walls are more feasible compared to wooden, metallic or electric field structure for wireless nodes to be localized and a better received signal strength.

Performance of MANETs

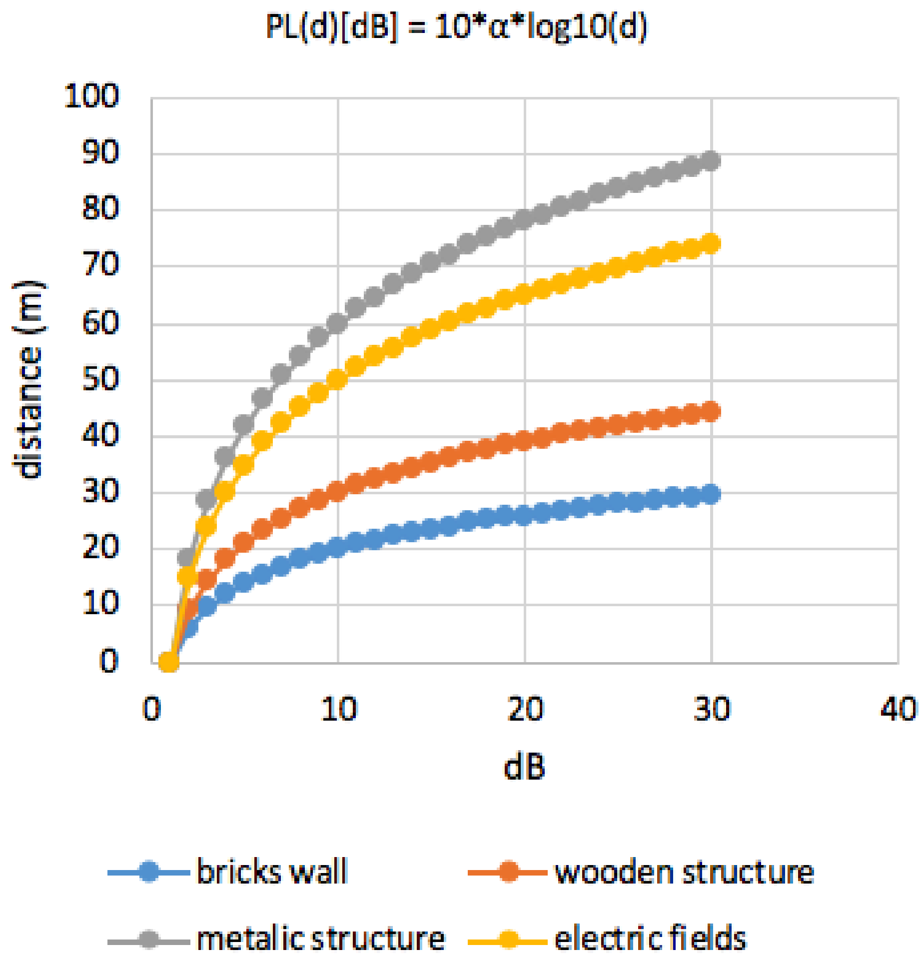

Figure 4: Path Loss for signal ranging under constraints.

End-to-end Delay
The end-to-end delay is defined as follows:

Average end-to-end Delay = $\sum(Tdrp--Tssp)/NoP$

where $Tdrp$ = Time of Destination received packets, $Tssp$ = Time of Source sent packets, and NoP = Number of packets.

In both 10 and 20 node environment, OLSR performs better whereas AODV minimizes broadcasts required through creation of routes (on demand).

AODV maintains sequences for each destinations which prevent routing loops and that should made AODV faster than any other protocols.

But the scenario says that OLSR is the fastest of all for its proactive nature where it computes all possible routes to all nodes and save it in its rout cache.

Media Access Delay

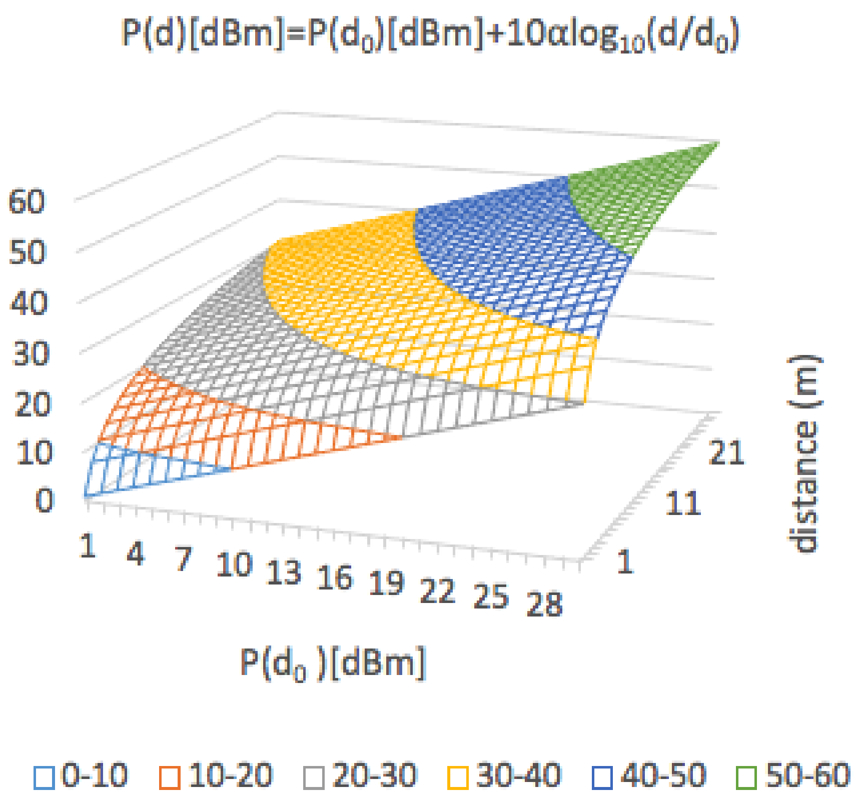

Figure 5: Path Loss for localization when $\alpha = 2$.

OLSR performs better with both 10 and. AODV uses the traditional routing table (one entry per destination in the route cache and does not create any loop in the network). But OLSR outperforms all having the least media access delay due to its proactive nature.

Network Load

In both 10 and 20 node environment, OLSR has less network load than AODV. AODV uses traditional routing table. OLSR has more network load than reactive routing protocols.

Throughput

In both 10 and 20 node environment, OLSR performs best. Because of its proactive nature, OLSR sends Topology Control (TC) packets along with Hello packets to all nodes for discovering of routes. After discovering of all nodes in symmetric or asymmetric nature, the transferring of messages become more stable which results better throughput than that of other protocols. But, in a highly dense nodes network, the result may fall.

Throughput = Pbytes/T

Pbytes = Size of the Received packet

T = Time

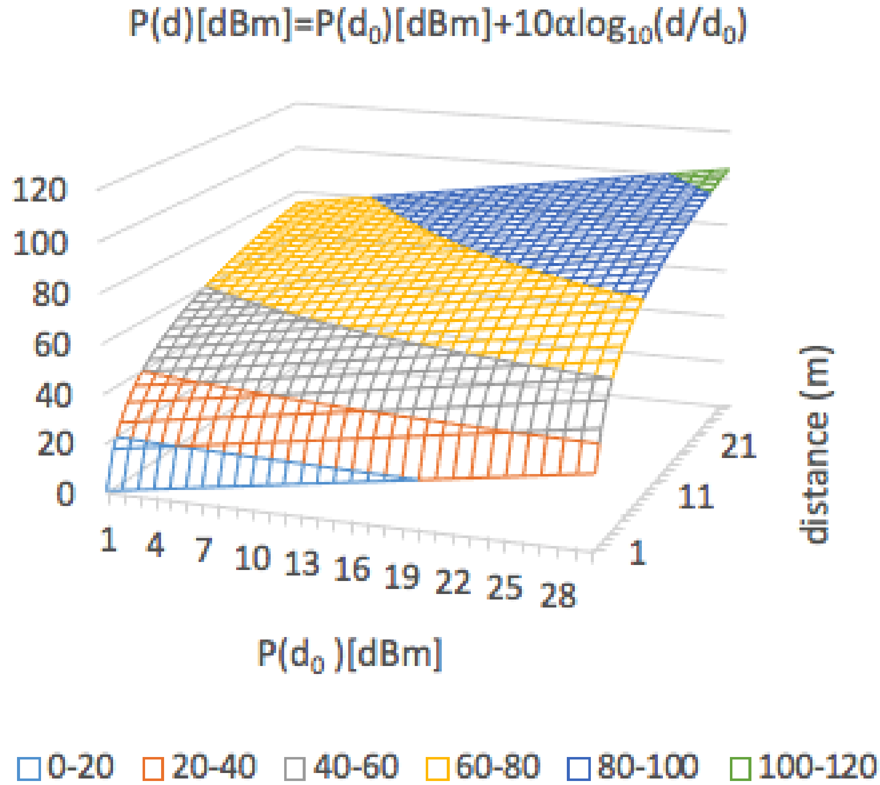

Figure 6: Path Loss for localization when $\alpha = 5$.

Packet Drop

In both 10 and 20 node environment, AODV performs optimal. As AODV is loop free and can self-start, route maintenance and discovery are efficiently handled. It can establish unicast route with less memory utilization and hence, with minimum network utilization, it does not create overhead to the network. After getting a link failed, AODV instantly notifies all nodes and AODV uses destination sequence number for optimal routing. Therefore, packet drops are less than any other protocols in the network. Packet delivery can be further assessed from the following equation:

PDF = NPr/NPs

PDF = Packet delivery fraction

NPr = Number of packets received

NPs = Number of packets sent

Under Zigbee protocol, the MANET has greater sustainability on Network load tolerances (in Table 1 and Table 2) as it has multiple links to communicate to other nodes.

In case of Zigbee network (in Table 1) AODV for its reactive nature starts up with less delay, network load and packets dropped. But the average performance in terms of delay is not better than OLSR. OLSR, for its proactive nature results an optimal delay and throughput in Zigbee environment.

AODV and OLSR are again assessed in the environment of NS3 exclusively to watch their performance and adaptability in a scalable network. With 10, 20 and 400 nodes, in a 100 sec simulation time and a constant bit rate traffic the two protocols were evaluated and the following results were obtained (Table 2).

Here, in Table 2 it is clear that OLSR is faster than AODV as it has less delay in transmission of

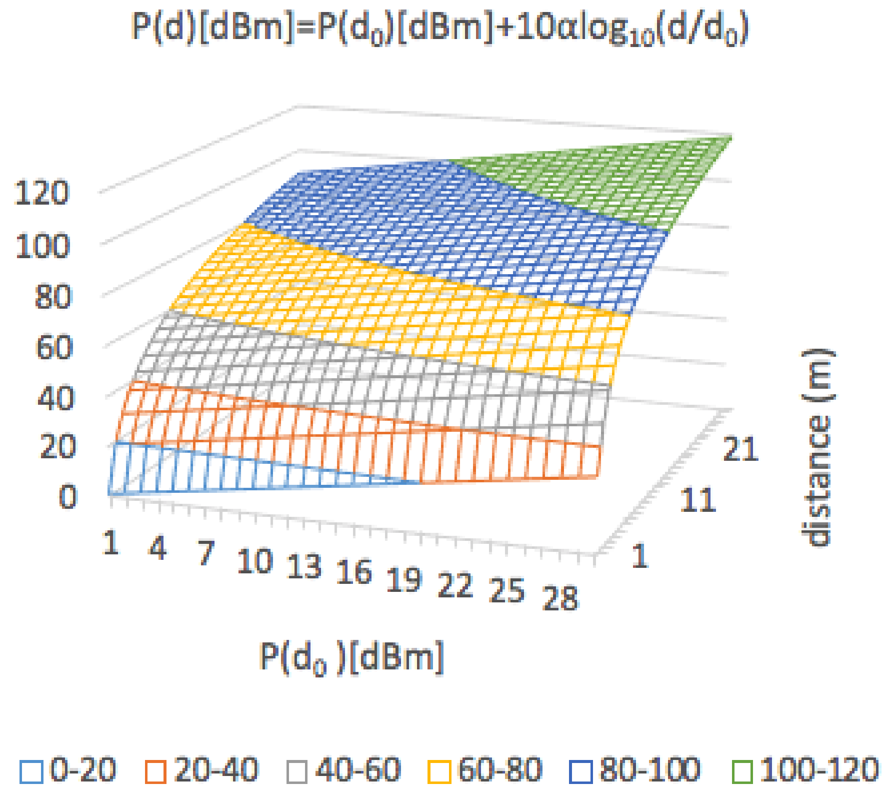

Figure 7: Path Loss for localization when $\alpha = 6$.

Table 1: Results for different parameters

Parameter	AODV	OLSR
Throughput	120.378	180.315
End-to-End Delay	0.0119	0.0138
Network Load	146.124	176.87
Media Access Delay	0.00079	0.00092
Packet Dropped	1.16	1

Table 2: Results for different speeds

Speed (m/s)	AODV	OLSR
10	100%	100%
20	100%	100%
40	97.92%	96.46%

data. As a reactive routing protocol, AODV consumes more time than OLSR. But, after the first routing caching by nature of reactive routing, AODV is more reliable in re-routing of data and it is reliable than OLSR (from Table 1 and Table 2). Hence, AODV is more adaptable to scalable network where performance of the network varies with the growth of nodes and other parameters of the network.

5 Conclusion and Future Work

Under the debris, wireless nodes are deployed as fixed (targets) or mobile nodes (users). Several constraints such as brick walls, wooden, metal structures or electric fields played major role for this research of finding signal strengths and pass losses for both signal ranging and localization. But, still mapping against each constraints have not yet been done due to time constraints. The research plan has been set for future works. We have drawn a strong scenario with Zigbee environment under several topologies. However, only the scenario of MANET has been included in this article. As proactive routing protocol OLSR and GRP dominate in end to end delay, media access delay and in handling of throughput. Reactive protocols perform better in packet drops and handling of networks loads. AODV performs better in packets dropped and in more scenarios than those of OLSR. In terms of the five parameters mentioned in earlier sections the protocol AODV has better result in three topologies with different parameters.

Acknowledgment

This study was supported by the Swedish Research Council under grant 2014-4251.

References

[1] K. N. E. A. Siddiquee, K. Andersson, F. F. Khan, and M. S. Hossain, "A scalable and secure MANET for an i-voting system," *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, vol. 8, no. 3, pp. 1–17, September 2017.

[2] F. Adib and D. Katabi, "See through walls with Wi-Fi!" *ACM SIGCOMM Computer Communication Review*, vol. 43, no. 4, pp. 75–86, October 2013.

[3] S. D. Chitte, S. Dasgupta, and Z. Ding, "Distance estimation from received signal strength under log-normal shadowing: Bias and variance," *IEEE Signal Processing Letters*, vol. 16, no. 3, pp. 216–218, March 2009.

[4] K. N. E. A. Siddiquee, D. Sarma, A. Nandi, S. Akhter, S. Hossain, K. Andersson, and M. S. Hossain, "Performance analysis of a surveillance system to detect and track vehicles using haar cascaded classifiers and optical flow method," in *Proc. of the 2017 12th IEEE Conference on Industrial Electronics and Applications (ICIEA'17), Siem Reap, Cambodia*. IEEE, June 2017, pp. 258–263.

[5] A. Ali, A. Ikpehai, B. Adebisi, and L. Mihaylova, "Location prediction optimisation in wsns using kriging interpolation," *IET Wireless Sensor Systems*, vol. 6, no. 3, pp. 74–81, June 2016.

[6] A. Basere and I. Kostanic, "Cell coverage area estimation from receive signal level (RSL) measurements," in *Proc. of the 2016 World Congress on Engineering and Computer Science (WCECS'16), San Francisco, California, USA*. IAENG, October 2016.

[7] F. F. Khan, T. Samira, A. Jana, and K. N. E. A. Siddiquee, "Performance of agro-sensors: Assessment of optimality in routing protocols of MANET in wireless sensor networks," in *Proc. of the 2016 International Conference on Intelligent Control Power and Instrumentation (ICICPI'16), Kolkata, India*. IEEE, October 2016, pp. 98–102.

[8] K. N. E. A. Siddiquee, F. F. Khan, K. Andersson, and M. S. Hossain, "Optimal dynamic routing protocols for agro-sensor communication in MANETs," in *Proc. of the 5th IEEE CCNC International Workshop on Security and Cognitive Informatics for Homeland Defense (SeCIHD'17), Las Vegas, Nevada, USA*. IEEE, January 2017.

[9] P. Joshi, "Security issues in routing protocols in MANETs at network layer," *Procedia Computer Science*, vol. 3, pp. 954–960, 2011.

[10] K. N. E. A. Siddiquee, *The challenges of I-voting and its remedy*. CRC Press, October 2016.

[11] W. Stutzman and G. Thiele, *Antenna Theory and Design*. John Wiley & Sons, Inc., 1981.

[12] E. A. Kadir and A. P. Hu, "A power processing circuit for indoor Wi-Fi energy harvesting for ultra-low power wireless sensors," *Applied Sciences*, vol. 7, no. 8, p. 827, August 2017.

[13] P. Atanasov and Z. Kiss'ovski, "Optimization of path loss models based on signal level measurements in 4G lte network in sofia," *Bulgarian Journal of Physics*, vol. 44, no. 2, pp. 145–154, 2017.

[14] G. Chandrasekaran, T. Vu, A. Varshavsky, M. Gruteser, R. P. Martin, J. Yang, and Y. Chen, "Vehicular speed estimation using received signal strength from mobile phones," in *Proc. of the 12th ACM international conference on Ubiquitous computing (UbiComp'10), Copenhagen, Denmark*. ACM, September 2010, pp. 237–240.

[15] F. Heereman, W.Joseph, E. Tanghe, D. Plets, L. Verloock, and L. Martens, "Path loss model and prediction of range, power and throughput for 802.11n in large conference rooms," *AEU - International Journal of Electronics and Communications*, vol. 66, no. 7, pp. 561–568, July 2012.

[16] S. Frattasi and F. D. Rosa, *Mobile Positioning and Tracking: From Conventional to Cooperative Techniques, Second Edition*. John Wiley & Sons Ltd, July 2017.

[17] S. I. Popoola, A. A. Atayero, O. D. Arausi, and V. O. Matthews, "Path loss dataset for modeling radio wave propagation in smart campus environment," *Data in Brief*, vol. 17, pp. 1062–1073, April 2018.

[18] R. Ludwig and J. Taylor, "Voyager telecommunications, descanso design and performance summary series, article 4," https://descanso.jpl.nasa.gov/DPSummary/Descanso4--Voyager_ed.pdf [Online; accessed on September 10, 2018, March 2002.

[19] C. Tepedelenlioglu, A. Abdi, G. B. Giannakis, and M. Kaveh, "Estimation of doppler spread and signal strength in mobile communications with applications to handoff and adaptive transmission," *Wireless Communications and Mobile Computing*, vol. 1, no. 2, pp. 221–242, March 2001.

[20] C. K. Toh, *Wireless ATM and Ad-Hoc Networks: Protocols and Architectures*. Kluwer Academic Publishers, 1997.

[21] S. Thombre, R. Islam, K. Andersson, and M. S. Hossain, "Performance analysis of an IP based protocol stack for WSNs," in *Proc. of the 2016 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS'16), San Francisco, California, USA*. IEEE, April 2016.

[22] Z. Abedin, S. Paul, S. Akhter, K. N. E. A. Siddiquee, M. S. Hossain, and K. Andersson, "Selection of energy efficient routing protocol for irrigation enabled by wireless sensor network," in *Proc. of 2017 IEEE 42nd Conference on Local Computer Networks Workshops (LCN Workshops'17), Singapore*. IEEE, October 2017, pp. 75–81.

[23] S. Thombre, R. U. Islam, K. Andersson, and M. Hossain, "IP based WSNs: Performance analysis using simulations and experiments," *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*, vol. 7, no. 3, pp. 53–76, September 2016.

[24] M. Abedin, A. Chowdhury, M. S. Hossain, K. Andersson, and R. Karim, "An interoperable IP based WSN for smart irrigation systems," in *Proc. of the 14th Annual IEEE Consumer Communications & Networking Conference (CCNC'17), Las Vegas, Nevada, USA*. IEEE, January 2017.

[25] R. U. Islam, M. S. Hossain, and K. Andersson, "A novel anomaly detection algorithm for sensor data under uncertainty," *Soft Computing*, vol. 22, no. 5, pp. 1623—-1639, March 2018.

[26] R. U. Islam, K. Andersson, and M. S. Hossain, "Heterogeneous wireless sensor networks using CoAP and SMS to predict natural disasters," in *Proc. of the 2017 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS'17), Atlanta, Georgia, USA*. IEEE, May 2017, pp. 30–35.

[27] K. Andersson and M. S. Hossain, "Smart risk assessment systems using belief rule based expert systems and WSN technologies," in *Proc. of the 2014 4th International Conference on Wireless Communications, Vehicular Technology, Information Theory and Aerospace & Electronic Systems (VITAE'14), Aalborg, Denmark*, May 2014.

[28] K. Andersson and M. S. Hossain, "Heterogeneous wireless sensor networks for flood prediction decision support systems," in *Proc. of the 2015 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS'15), Hong Kong, China*. IEEE, April–May 2015, pp. 133–137.

[29] V. V. Mandhare and R. C. Thool, "Comparing the performance of proactive and reactive routing protocol in mobile ad-hoc network," in *Proc. of the 2015 International Conference on Industrial Instrumentation and Control (ICIC'15), Pune, India*. IEEE, May 2015, pp. 394–399.

[30] A. Khosravi and Y. S. Kavian, "Challenging issues of average consensus algorithms in wireless sensor networks," *IET Wireless Sensor Systems*, vol. 6, no. 3, pp. 60–66, June 2016.

[31] C. D. Loggers, "The basics of signal attenuation," https://www.dataloggerinc.com/resource-article/basics-signal-attenuation/, [Online; accessed on September 10, 2018].

Author Biographies

Kazy Noor E Alam Siddiquee was born in Chittagong, Bangladesh and is currently serving as an Assistant Professor in the Department of Computer Science and Engineering of University of Science and Technology Chittagong. He has completed his BSc in Computer Science and Technology from University of Science and Technology Chittagong and completed his MSc. in Computer Science and Engineering from United International University. His research field surrounds computer visions and wireless ad-hoc networks. He has applied computational intelligences in e-Governance, Surveillance & security and Food Bank in perspective of concurrent problems in the third world countries, such as Bangladesh.

Karl Andersson (Senior Member of IEEE) has a M.Sc. degree in Computer Science and Technology from Royal Institute of Technology, Stockholm, Sweden and a Ph.D. degree in Mobile Systems from at Luleå University of Technology, Sweden. After being a postdoctoral research fellow at the Internet Real-time Laboratory at Columbia University, New York, USA and a JSPS Fellow with National Institute of Information and Communications Technology, Tokyo, Japan, he is now Associate Professor of Pervasive and Mobile Computing at Luleå University of Technology, Sweden. His research interests include Mobile Computing, the Internet of Things, Cloud Technologies, and Information Security.

Francisco Javier Moreno Arrebola is the international coordinator and co-founder of Fab Lab Chittagong and is an experienced engineer in several areas. As Mechanical Engineer, in 2005 he founded "Ingenieros y Consultores", his own company to develop technical projects for mechanical machines. In 2009, he won the Spanish National Award of Health and Safety for companies over 50 workers in Cía General de Canteras, and published a safety article "La visita de trabajo como herramienta de prevención" and performed several speeches in safety workshops and the National Congress of Aggregate Manufacturers. During his international career in Italcementi Group, he worked during 10 years in several companies and especially, as Operations Manager and with the background of his degree in Industrial Organization and MBA he succeeded to achieve outstanding results in cost reduction and production performance. It is worth to mention his experience as I+D+I Lab Manager where he developed several innovative products of ready-mix. Francisco Javier Moreno Arrebola has achieved his Mechanical Engineering degree from Universidad Politécnica, University of Málaga, Málaga (Spain) and Organizacional Engineering degree from ETS Ingenieros Industriales, University of Málaga, Málaga (Spain). He has also achieved the MBA degree from Escuela Superior de Estudios de Empresa (ESESA), Málaga (Spain).

Zainal Abedin received his B.Sc. degree in Computer Science and Engineering from Chittagong University of Engineering and Technology (CUET), Bangladesh and is currently ppursuing his M.Sc from the same university. He is currently with the Faculty of Science, Engineering and Technology of USTC, Bangladesh as an assistant professor. His current research interests include image processing, WSNs, signal processing, and machine learning.

Mohammad Shahadat Hossain is a Professor of Computer Science and Engineering at the Chittagong University (CU), Bangladesh. He did both his MPhil and PhD in Computation from the University of Manchester Institute of Science and Technology (UMIST), UK in 1999 and 2002 respectively. His current research areas include e-government, the modeling of risks and uncertainties using evolutionary computing techniques. Investigation of pragmatic software development tools and methods, for information systems in general and for expert systems in particular are also his areas of research.