Experimental Evaluation on Impacts of Timers on Diverse Movement Patterns for Mobile Ad HOC Networks

Daniel Godfrey Majengo, Ki-Il Kim, Bong Soo Roh, Jae-Hyun Ham

Abstract: Background/Objectives: Due to mobility nature of nodes in mobile ad hoc networks, topology changes are observed frequently, that it affects the performance metric of the routing protocol. Therefore, designing a mechanism for fast reactivity to these network changes could improve the performance of mobile networks.

Methods/Statistical analysis: Several factors like, local link connectivity, local link failure and the rate at which topology changes are highly impacted by the mobility behavior of the communicating mobile nodes. We present a comparative analysis of tuning refresh timers of a proactive Optimized Link State Routing protocol (OLSR) when mobile are moving under at different mobility patterns.

Findings: Routing protocol in mobile ad hoc network is highly impacted by the mobility behavior of the communicating nodes. In addition to that, the impact of setting the rate at which the refresh messages are being broadcasted in a network varies depending on the mobility behavior of communicating mobile nodes. We observed the impact of tuning HELLO intervals on the performance of optimized link state routing protocol on mobile nodes moving under different mobility models. From our observation, we learn that the settings of HELLO interval on a network of mobile nodes have different impacts depending on the mobility behavior of mobile nodes and node density.

Improvements/Applications: The dynamic timer for refreshment of topology information can improve the performance of routing protocol. In addition, application-specific mobility model is required for routing protocol.

Keywords: mobile ad hoc networks, mobility model, refresh timer, performance evaluation, dynamic timer

I. INTRODUCTION

Mobile Ad hoc Network (MANET) is a type of wireless network that works in a self-organizing system without the presence of any pre-configured central infrastructure. In MANET, nodes communicate in a multi-hop way, whereby a number of intermediate host nodes forward the packets they received from the source node to make them reach the destination node. In order for nodes to communicate through multiple-hops, an individual node needs to discover neighbor nodes that it can communicate with directly. However, due to the limitation in communication range, not all nodes can communicate directly to each other hence required to discover nearby nodes that they can use as routers to relay packets to far destinations.

In MANET, a node discovers its neighbors by periodically broadcasting special messages called HELLO, in order to establish and confirm network adjacency. The rate at which these HELLO messages are being broadcasted account for the correctness of topology information and routes construction. A number of studies have been done to observe the impacts of using different HELLO intervals on network performance. Using OLSR protocol which is detailed explained in ITF RFC 3626[1], authors in [2] and [3] investigated the impact of tuning refresh intervals on network performance and suggested that, when network mobility is high, broadcasting HELLO messages in small intervals could improve the overall performance since it allows quick reactivity to topology changes. Using small HELLO intervals in high mobility conditions were proved to increase overall network throughput but it came at the cost of an increased routing overhead.

Traditional MANET routing protocols use static time intervals to send HELLO messages. These pre-configured static timers do not allow routing protocols to respond according to rapidly changing network conditions. For that reason, using static timers to periodically broadcast neighbor discovery messages might not give the best routing performance at all times. Using static could negatively affect network performance due to problems like, late detection of link changes when conditions are too mobile or unnecessary routing overhead when conditions are less mobile or completely static. In research results [4] and [5], authors proposed similar schemes to dynamically adjust HELLO message`s intervals depending on the rate of link change. The author in [6] suggested a scheme that controls HELLO intervals depending on Link Change Rate (LCR) parameter. In addition to that, the scheme controls the minimal protocol overhead by limiting HELLO interval when a certain number of neighbor nodes is already being discovered.

In this paper, we focus our research on observing the impact of tuning HELLO

Revised Manuscript Received on May 22, 2019.

Daniel Godfrey Majengo, Department of Computer Science and Engineering, Chungnam National University, 99 Daehak-ro Yuseong-gu, Daejeon, 34314, Korea.

Ki-Il Kim, Corresponding author, Department of Computer Science and Engineering, Chungnam National University, 99 Daehak-ro Yuseong-gu Daejeon, 34314, Korea.

BongSoo Roh, Jae-Hyun Ham, The 2nd R&D Institute, Agency for Defense Development, Daejeon, 34186, Korea.

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

intervals on a network of mobile nodes moving under different mobility pattern. In our studies, we used the two commonly applied mobility models, Gauss Markov and the Random Walk model. Our studies involve the use of a link state proactive routing protocol OLSR, which discovers and propagates routing information using two different message types. Routing information discovery is achieved through HELLO messages, while the propagation of these pieces of information is achieved through flooded Topology Control (TC) messages. In OLSR protocol, TC messages are generated and flooded through the network by special type of nodes called multipoint relays (MPRs). OLSR also use several state hold timers which are specified in the OLSR specification as the NEIGHBOR_HOLD timer and REFRESH_INTERVAL to check for validity of stored information. We perform a thorough performance evaluation of the OLSR protocol by observing the impact of tuning HELLO intervals of mobile nodes moving under two different mobility models at different node`s speed and density. We present the performance evaluation of the OLSR protocol in terms of packet delivery ratio.

The remainder of this article is organized as follows. In section 2, we present a brief introduction to the OLSR protocol. In section 3, is an introduction to mobility models used during our studies. In section 4, simulation results and analysis is given. Finally, in section 5 we make a conclusion and briefly explain about our future studies.

II. OPTIMIZED LINK STATE ROUTING

OLSR routing protocol is a kind of a classical link state routing optimized for mobile ad hoc networks and operates as a table driven proactive protocol. In OLSR protocol, a node periodically exchanges topology information with other available nodes of the network in order to discover and update routes to all destinations in the network. OLSR protocol optimization is based on the usage of the special selected nodes called multipoint relays to flood link state advertisement messages described as TC messages.

A node implementing OLSR protocol uses HELLO messages to both announce its self and to discover other nodes in its communication range. A node broadcasts HELLO messages periodically to sense a set of available links to its neighbors and from it, to select a set of nodes to use as its relay nodes (MPRs) when sending data packets.

A number of researches have been done regarding the impact of tuning parameters of OLSR protocol. In [7], an author presented an analysis of the parameter Route Change Latency (RCL) and how it is affected by different routing protocol parameters of OLSR protocol. In [8], the author presented an analysis on optimum settings of state hold timer as to avoid highest overall packet loss. In the literature [9], the author studied the impact of using various HELLO interval and Link Change Rate (LCR) parameter on overall network throughput. The author presented a scheme that took into consideration the number of nodes which already existed in a node`s routing table when estimating as to reduce the effect of an increased routing overhead.

In OLSR protocol, a node uses periodic static timer (soft state) approach to update its information base which consists of various sets like link set, neighbor set, MPR set, MPR selector set, Topology information Base as to ensure consistency of routes to all possible destinations in a network. In OLSR, the soft state timers can be categorized into message generation timers and state maintenance timers. Table 1 shows a brief explanation of some of the most relevant timers and their default values as defined in OLSR RFC.

Table 1 Timer values in OLSR protocol

Type	Timer Name	Description
		Default value
Message generation timers	HELLO_INTERVAL	Announcement and neighbor discovery
		2 seconds
	TC_INTERVAL	Dissemination of topology information
		5 seconds
State maintenance timers	REFRESH_INTERVAL	Time during which, each node must be advertised at least once
		2 seconds
	NEIGHBOR_ HOLD_TIME	Valid time for information received from previous HELLO message
		3*REFRESH_INTERVAL

III. DESCRIPTION OF MOBILITY MODELS

In mobile ad hoc networks, movement behavior of mobile nodes depends on the node mobility model applied. Mobility model decides how the movement (speed and direction) of a mobile user changes over the time. Network performance of a mobile ad hoc network protocol is highly affected by the nature of mobility patterns. Change in mobility behavior of mobile nodes could drastically affect the performance results of a particular routing protocol [10]. Mobility model used by communicating mobile nodes account for important factors which affect network performance like network connectivity, average route lifetime and average hop count [11].

As previously shown, a number of studies have been done to explore the impacts of tuning refresh intervals on network performance. To the best of our knowledge, these previous studies have investigated the impact of tuning refresh interval on different mobility models, however they did not present the performance of the routing protocol in terms of very important performance parameter like packet delivery ratio. In this research, we focus on observing changes in network performance when HELLO intervals of mobile nodes are being altered at different network conditions like mobility patterns, node speed and varied node density.

3.1. *Gauss Markov model*

Mobile nodes moving under the impact of Gauss

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

Markov model have some temporal dependency behavior, which means the current velocity of a mobile node may be changed to some degree depending on its previous velocity. In this model, the settings of a tuning parameter (**α**) determine the variation of the degree of randomness in mobility pattern. Depending on the settings of **α** which ranges from 0 to 1, different levels of randomness can be obtained. Total random values can be obtained when setting **α**=0 while linear motion is obtained when **α**=1. A mobile node moving under Gauss Markov model calculates its next destination after a time interval ***t*** according to its current velocity and location. Under the Gauss Markov model, a mobile node is kept away from reaching over the boundaries of the simulation area by forcing its direction to flip by 180 degrees [12].

3.2. Random Walk model

In this model, a mobile node chooses a random velocity to move from its current location to a new destination with zero pausing time. When moving towards a chosen destination, a mobile node choose the new velocity (speed and direction) from the predefined ranges, $[V_{min}, V_{max}]$ and $[0,2\pi]$, respectively after a fixed time interval ***t*** or a fixed traveled distance ***d***. If a mobile node move according to the above rules and reaches the end of the simulation field, it is bounced back to the field at an angle of θ (t) or π - θ(t). In the Random Walk model, previous mobility information of a mobile node does not have any effect on the current movement of a mobile node, which makes it have strong randomness in movement behavior.

IV. PERFORMANCE EVALUATION

In this section we investigate changes in packet delivery ratio of OLSR protocol at different HELLO intervals. In each simulation scenario, other parameters were fixed as to be able to observe the impact of one parameter (HELLO_INTERVAL).

4.1. Simulation Environment

Simulations of OLSR protocol under two different mobility models was conducted on a network simulator ns-2 version 2.35 [13]. We investigated how packet delivery ratio changes with respect to changes in HELLO intervals when mobile nodes are moving at varied speed and node density under two different mobility models. Gauss Markov and Random Walk mobility models are two completely different mobility models that we chose to evaluate the performance of the OLSR routing protocol. The reason for choosing these models was, we wanted to observe how tuning HELLO intervals on a completely random model would be affected compared to a model with some degree of temporal dependency characters.

The network dimensions are 820m x 820m and mobile nodes wireless transmission range is 250m. We considered different values of node density and varied it from 10 and 30 for low and high node density respectively. For both models we considered the uniform speed of mobile nodes,i.e (Vmin=Vmax =V). In Random Walk model, mobile nodes chose new direction to travel after every 5 seconds and for Gauss Markov model, nodes updated their speed and location after every 5 seconds as well. Node speed Vmax for both Random Walk model and Gauss Markov were gradually increased at different values of 5,10,15,20,25,30 m/s. The simulation parameters are summarized in Tables 2 and 3 below.

Table 2 Simulation parameters

Parameter	Value
Map size	820m x 820m
Simulation time	100 sec
The number of nodes	10 and 30
Source and destinations	3 sources and 3 receiver
Transmission range	250m
MAC protocol	802.1lb
Traffic model	Constant Bit Rate (CBR)
Size of packet	512 bytes
Packet sending rate	5 packets/sec

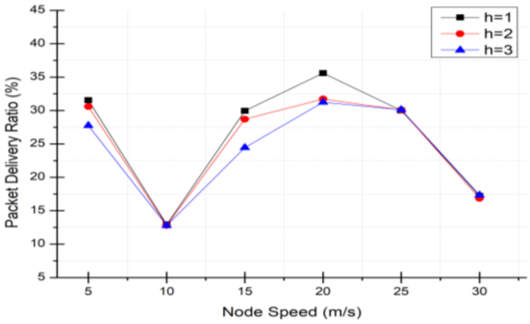
Table 3 Mobility models parameters

Model	Parameter settings
Random Walk model	Velocity = 5, 10,15,20,25 and 30 m/s
	Random movements after every 5seconds
Gauss Markov model	Randomness tuning parameter (α)= 0.5
	Update frequency (t) = 5 seconds
	Velocity =5, 10,15,20,25 and 30 m/s
	Average direction = 0~360 degrees (random)

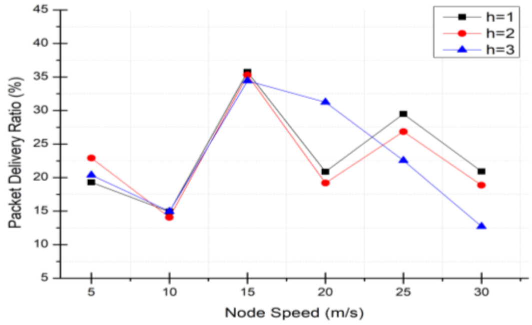
4.2. Simulation Results

Simulation results from Figure 1(a) and 1(b) show the how the packet delivery ratio of OLSR protocol when nodes move under the impact of Gauss Markov for 10 and 30 nodes respectively. While in 2(a) and 2(b) is for Random Walk model. Performance on each model is different from the other based on its mobility characters. As expected, Gauss Markov model is more stable under high mobility conditions than Random Walk model which drops in packet delivery rate as node speed increases. This is due the fact that, compared to Gauss Markov model, in Random Walk model nodes are subject to frequently change their direction without considering the previous information. However, in both models at low node density (10 nodes), higher rates of packet delivery is reached when the network is most reactive (HELLO is 1second). At higher mobility (25 m/s and above), Random Walk model is affected more by changes in HELLO intervals. However, As the number of nodes in network increases(30 nodes), changes in HELLO intervals does not seem to react as predicted. Lower HELLO intervals gave a small increase in delivery rates in Random Walk model but in Gauss Markov model, using small HELLO interval is not guaranteed to give higher packet delivery rates unless mobility is high (25m/s above).

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication*

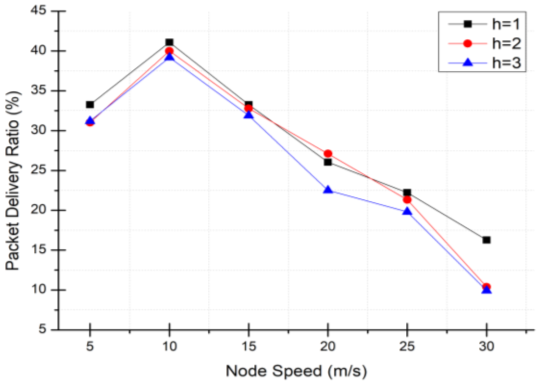


(a) 10 nodes

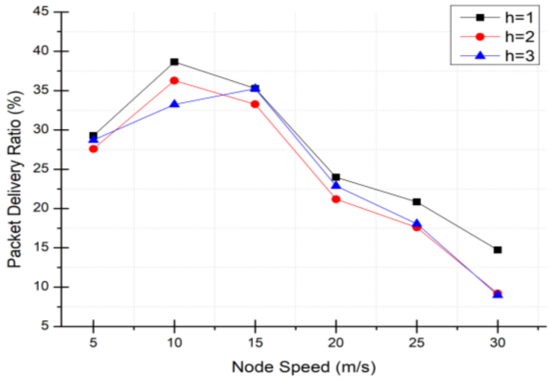


(b) 30 nodes

Figure 1. Packet delivery ratio for Gauss Markov model



(a) 10 nodes



(b) 30 nodes

Figure 2. Packet delivery ratio for Random Walk model

V. CONCLUSION

In this paper, we perform an evaluation of OLSR protocol performance at different HELLO intervals values on different networks of mobile nodes moving under different mobility models (Gauss Markov and Random Walk). From our observations, we learn that different mobility models give different performance results. In addition to that, settings of different HELLO intervals on a network of mobile nodes have different impacts depending on the mobility behavior of mobile nodes. For more mobility models with a high degree of randomness, using small HELLO intervals could increase the overall routing performance in terms of packet delivery ratio. However, for mobility models with less degree of randomness like Gauss Markov, using small HELLO intervals could give better results when mobility is only high and in high node density environment.

From these results, we suggest that, when designing a dynamic timer mechanism, the mobility behavior of mobile nodes should be taken into account. In addition to that, the number of nodes in a network should also be considered when designing a dynamic timer mechanism. In the future, we will evaluate the impacts of setting other timers of OLSR protocol like TC_INTERVAL, NEIGHBOR_HOLD_TIMER under various dynamic network conditions and observe the impact they have on network connectivity, average route lifetime and average route discovery latency.

ACKNOWLEDGMENT

This work has been supported by the Small-scale Mobile Ad-hoc Network with Bio-networking Technology Project of Agency for Defense Development(UD170097ED).

REFERENCES

1. Clausen T,Jacquet P. Optimized link state routing protocol (OLSR). IETF RFC 3626. 2003.
2. Huang Y, Bhatti S, Parker D. Tuning olsr.Paper presented at the proceedings of the International Symposium on InPersonal,Indoor and Mobile Radio Communications. 2006;1-5.
3. Bose PA, Nandi S. Impacts of refresh interval parameters on m-olsr performance for wireless mesh networks. Paper Presented at the proceedings of IEEE Region 10 Conference. 2009;1-5.
4. Huang Y, Bhatti S, Handurukande S.Autonomic tuning of routing for manets. Paper presented at the proceedings of Network Operations and Management Symposium. 2008; 314-20.
5. Cons NH, Kasahara S, Takahashi Y. Dynamic hello/timeout timer adjustment in routing protocols for reducing overhead in manets. Computer Communications. 2010;33(15): 1864-78.
6. Raphael E, Martin P. Adaptive hello for the neighborhood discovery. Paper presented at the proceedings of Local Computer Networks. 2012;470-78.
7. Gomez C, Garcia D, Paradells J. Improving performance of a real ad-hoc network by tuning olsr parameters. Paper presented at the proceedings ofthe Symposium on Computers and Communications.2005;16-21.
8. Jovel F, McCartney J, Teller PJ, Ruiz E, McGarry MP. Neighbor discovery message hold times for manets. Computer Communications. 2017;(112); 38-46.
9. Park NU, Kim GH, Cho YZ. Impact of hello interval and link change ratio on throughput in manets. Paper presented at the proceedings of International Conference on Ubiquitous and Future Networks. 2017; 610-12.
10. Tracy C, Boleng J, Davies V. A survey of mobility models for ad-hoc network research. Wireless Communications and Mobile Computing. 2002;2(5):483-502.
11. Natarajan M. Impact of the Gauss-Markov mobility model on network connectivity, lifetime and hop count of routes for mobile ad-hoc networks. Journal of Networks.2010;5(5): 509-16.
12. Vinayagam PS. Impact of random mobility models on olsr. International Journal of Wireless and Mobile Networks. 2014; 6(6):87-100.
13. NS3, Network Simulator 3, http://www.nsnam.org.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication