Performance Analysis of OLSR Protocol in Mobile Ad Hoc Networks

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Abstract—Optimized Link State Routing Protocol (OLSR) is an efficient routing protocol used for various ad hoc networks application. It employs the Multipoint Relay (MPR) technique to reduce network overhead traffic. A mobility model's main goal is to realistically simulate the movement behaviors of actual users. However, the high mobility and mobility model is the major design issues for an efficient and effective routing algorithm for real Mobile Ad hoc Networks (MANETs). Therefore, this research paper aims to analyze and evaluate the performance of the OLSR protocol concerning various random and group mobility models. Two simulation scenarios were conducted over four mobility models, specifically the Random Waypoint (RWP), Random Direction (RD), Nomadic Community (NC), and the Reference Point Group Model (RPGM) consider a low as well as high random range mobility of the nodes. Moreover, BonnMotion Software and Network simulator NS-3 used to implement the simulation scenarios. Further, the performance of the OLSR protocol analyzed and evaluated based on latency, routing overhead, and packet loss ratio metrics. According to the results, the OLSR protocol provides the best performance over the RWP model in a low mobility environment, whereas the Nomadic mobility model is suitable for OLSR protocol in a high mobility environment.

Keywords—olsr routing protocol, random mobility, group mobility, bonnmotion software, network simulation

1 Introduction

Advancements in ad hoc networks are being driven with the growing use of wireless networks[1]. Search and rescue operations, Learning environment, military operations, Internet of thing (IoT), and forest fire surveillance are all examples of major Ad hoc network applications that require a high level of QoS [2–6]. MANET is a network of wireless self-organized nodes powered by battery and built-in in situations where other forms of communication are impractical to deploy. MANET allows for rapid communication system deployment without the need for any central management, as in other wireless or sensor communication networks [7–8].

Generally, all nodes in MANET can perform as a router to receive and forward the packets. Further, all nodes are mobile so their behavior is unpredictable, due to that routing is becoming hard to manage. The routing process is the main challenge in MANET for data transmission from sender to the receiver nodes. Typically, the routing protocol is use to route the data between mobile nodes from one node to another efficiently. Moreover, these protocols are categorized into three different types [9–10]. The first one is a proactive routing protocol and also noted a table-driven protocol, Optimized Link State Routing Protocol(OLSR) is a well-known protocol with proactive nature [11]. The second one is reactive routing protocol and called on-demand protocols, and the last one is a hybrid routing protocol. However, the overall performance of ad hoc networks is influenced by mobility models like the Random Waypoint (RWP) [12], Random Direction (RD) [13], Nomadic Community [14], and Reference Point Group Mobility Model (RPGM) [15]. The change in the direction and speed of nodes depend on the type of mobility models used in the network.

This paper aims to analysis the performance of the OLSR routing protocol over four various mobility models and two different degrees of mobility. The network simulation tool NS-3 was used to run two simulation scenarios and BoonMotion software used to generate the motion file. This paper has two important contributions; 1) the performance of OLSR analyzed and evaluated under two different random mobility model and two different group mobility models, including one of the most important models like Nomadic Community model, which not cover by other studies; and 2) mobile nodes move at random range of speed instead of fixed speed.

2 Related work

Mobility models and OLSR protocol's behavior in ad hoc networks plays an important role to achieve the best QoS and enhance network performance. In the last years, several research studies have been conducted in order analyze and evaluate the performance of routing protocol under different mobility models, but very few attempts have been found in nomadic mobility models and considering the random range speed of nodes.

The performance of multicasting routing algorithms analyzed on MANET under varying mobility models and node density, but this study does not consider a nomadic mobility model [1]. Another study focused on analyzing OLSR performance in MANET consider RWP as well as Graph-Based Model (GBM). However, this study does not consider a random range of speed [16]. Author in [17] analyzed the performance of the OLSR protocol in ad hoc network under RWP and Manet_Down_left model. However, this study does not consider group mobility models. Authors in [18] investigate the impact of random mobility pattern on the OLSR performance in MANET with respect to network metrics. Tables 1 summarize the related work.

Table 1. Summarize of related work

Ref.	Year	Random Mobility	Group Mobility	QoS Metrics	Nomadic Mobility	Random Rang of Speed
Ref. [1]	2019	√	√	√	x	x
Ref. [16]	2019	√	x	√	x	x
Ref. [17]	2017	√	x	√	x	x
Ref. [18]	2019	√	x	√	x	x
Our work		√	√	√	√	√

3 Mobility models

Mobility of node is a vital factor in the development of a stable route, scalable, and reliable routing protocol on ad hoc networks. Therefore, it has a major influence on overall network performance and should taken into consideration while studying such networks [25]. Further, mobility models depict the movement pattern of mobile nodes as well as changes in their position, and speed over time. The degree of mobility of nodes is determined by the remarkable rate at which their speed and direction vary [26]. Figure 1 Illustrated category of some mobility models in MANETs.

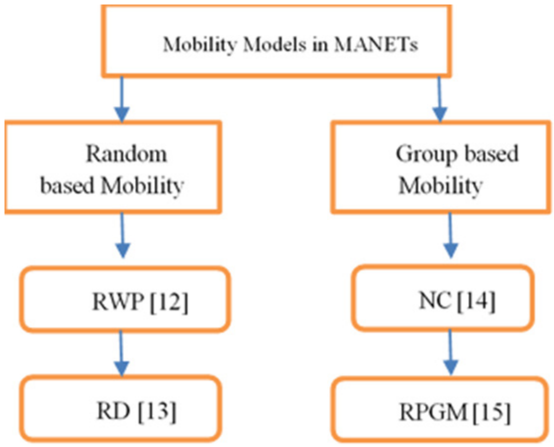

Fig. 1. Category of some mobility models in MANETs

3.1 RWP

In the RWP mobility model, each network node chooses a random direction position and then start moves at a random speed towards it. Once the node arrives at its final destination, it comes to a complete stop for the duration specified by the pause time argument. After the pause period has elapsed, the node selects a random destination direction and repeats the procedure until the simulation complete [12]. Figure 2. depicts node movement using RWP.

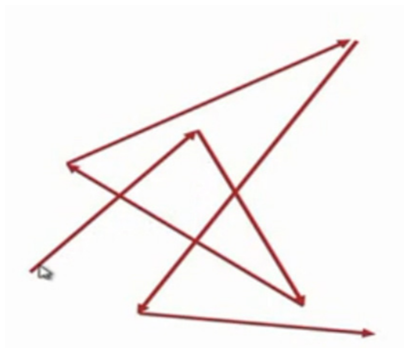

Fig. 2. Node movement using RWP

3.2 RD

Nodes are required to move to the edge of the simulation zone before changing speed and direction in this model. The RD has density waves in the simulation space. Furthermore, like the RWP, all nodes move in a random direction. Initially, a mobile node goes to the simulation area's edge in that direction. The mobile node pauses for a certain length of time when the simulation edges is reached before selecting a new angular direction and proceeding with the operation [13]. Figure 3 show node movement with RD.

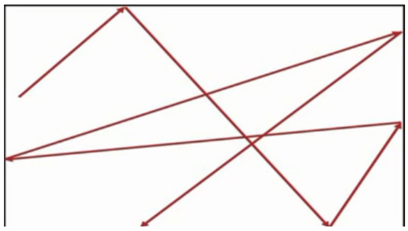

Fig. 3. Node movement using RD

3.3 NC

This model belongs to the correlated or group-dependent mobility model category, which portrays group movement scenarios in which several nodes move together based on a single reference point. According to the leader's mobility decisions, the entire group moves at random from one place to another. This versatile pattern is used in mobile communications for military applications, conferences, and class visits to museums [14]. Figure 4 present an example of node movement using NC.

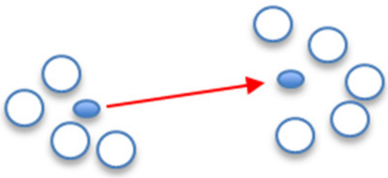

Fig. 4. Node movement using NC

3.4 RPGM

Nodes are split into groups in this group model. Every group does have a leader who oversees the movement of the group's mobile nodes. The direction and speed of each group member were calculated at each instant based on the speed and direction of the leader node at that time. This model depicts the movement of soldiers in a battalion or tourists following tour guides [15]. Node movement using RPGM is shown in Figure 5.

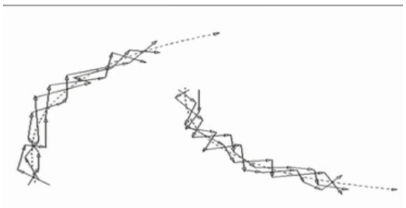

Fig. 5. Node movement using RPGM

4 OLSR

OLSR is a proactive routing algorithm that regularly communicates topology data between nodes in the network. Every network nodes selects a group of its neighbor's nodes to act as Multipoint relays (MPR). OLSR intend to operate in isolation from other protocols in the network. Furthermore, OLSR does not do any calculations based on the connection layer that is behind it [19]. It adopted for ad hoc network families such as MANET, VANET [20], and FANET [21].

Only MPRs are in charge of forwarding control traffic that is meant for dissemination throughout the whole network in OLSR. As shown in Figure 6. MPRs provide an effective and reliable mechanism to broadcasting control messages by decreasing the number of required transmissions. Further, it has a specific responsibility when it comes to announcing link state information in the networks [22]. It is used in route computation to construct a route between two nodes in the network, starting at one source node and ending at another destination node in the network.

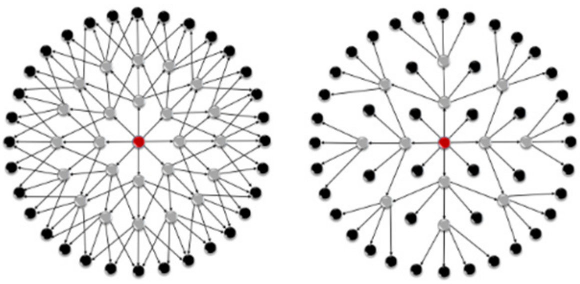

Fig. 6. Optimizing flooding of control traffic in OLSR using MPR

Hello Messages and Topology Control Massages (TC) are the two types of control messages utilized in OLSR. Hello Messages enable every node in the network to be aware of link-state and neighbors within two hops [20].This information is utilized by each node to determine the multi-point relay (MPR) nodes that it will use for communication. Every node in the network broadcasts controls messages known as topology control messages to maintain a database required for packet routing. Different nodes broadcast TC messages regularly to create their MPR selector set. OLSR is optimized regularly by sending TC messages reactively and decreasing the maximum periodic time interval [23].

OLSR does not require a centralized administrative system to handle the routing process. Since there is no latency in discovering a route in the routing table, having routes available in the routing table may be advantageous for some network applications. Furthermore, OLSR is best suitable in the highly-dense network due to the MPR technique [24]. On the other hand, there are no facilities in the OLSR standard for sensing link quality. Due to periodic intervals of updating of the routing table, usage of bandwidth gets increased. Furthermore, finding MPR becomes a more difficult job sometimes.

5 Simulation experiments

5.1 Network simulation and motion software

The performance of OLSR is investigated under varying mobility models and the degree of the node's mobility. The simulation will be carried out using powerful network simulator NS-3 [27]. Moreover, BonnMotion [28] software will be used to create and analyzes mobility models Scenarios. The general parameter setting used in all simulation scenarios presented in Table 2. The process of the simulation is depict in Figure 7.

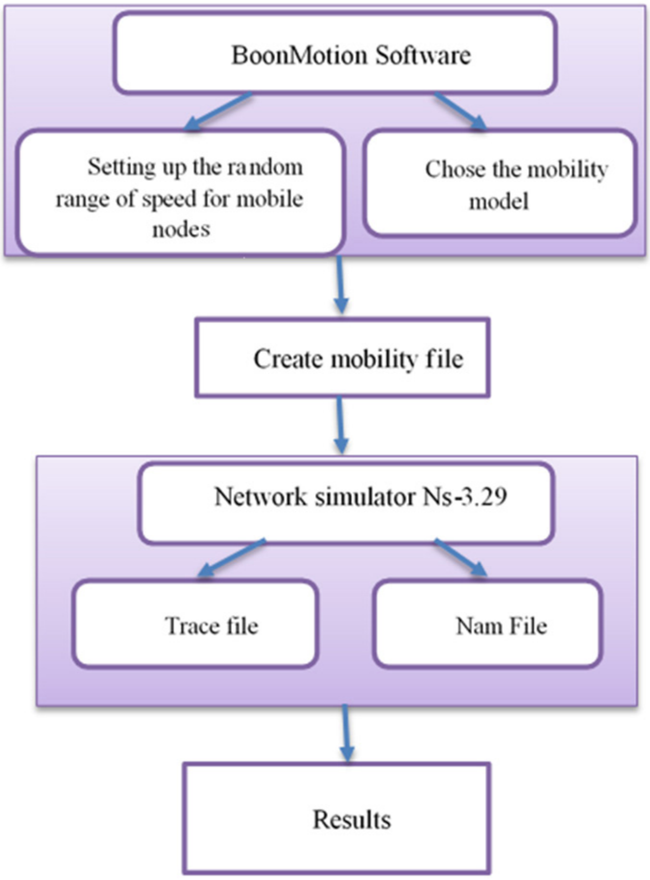

Fig. 7. The full process of simulation

Table 2. General setting for simulation parameters

Parameter	Value
Simulation area	900*900 m2
Simulation time	100 sec
Channel type	Wireless
MAC standard	IEEE 802.11
Routing protocol	OLSR
Transport protocol	UDP
Packet size	512 Byte

5.2 Simulation scenarios

Two scenarios used in the simulation to analyze the OLSR performance over MANET. In the first scenario, the OLSR protocol simulated over four different mobility models with low random range (min, max) speed of the node. Table 3 presents the parameters of the first simulation scenario. The objective of this scenario is to compare and analyze the performance of OLSR with low node mobility and different mobility models.

Table 3. Parameter setting for first scenario

Parameter	Value
Node mobility range	(1–5) (5–10) (10–15) (15–20) (20–25)
Mobility model	RWP, RD, NC, RPGM
Number of traffic	4
Number of nodes	50

In the second scenario, the OLSR protocol simulated with High range speed (Min, MAX) of Node mobility over four mobility models. Table 4 presents the parameters of the second simulation scenario. The objective of this scenario is study the impact of various mobility pattern with high mobility degrees on the performance of OLSR.

Table 4. Parameter setting for second scenario

Parameter	Value
Node mobility range	(30–40) (40–50) (50–60) (60–70) (70–80)
Mobility model	RWP, RD, NC, RPGM
Number of traffic	4
Number of nodes	50

6 Results

6.1 Simulation results of OLSR in first scenario

The time it takes for a data packet to reach its destination is known as latency. It measured by the second. Figure 8 depicts the Latency analysis of OLSR Protocol under four mobility models with low mobility of nodes. Simulation results indicate that the packet latency is increased for OLSR protocols when node mobility is increased under the various mobility models. Furthermore, it can be observed that the OLSR protocol over the RWP model has a comparatively lower latency. Packet latency for OLSR protocol over RD model is higher than nomadic and RPGM models at node mobility 25m/s.

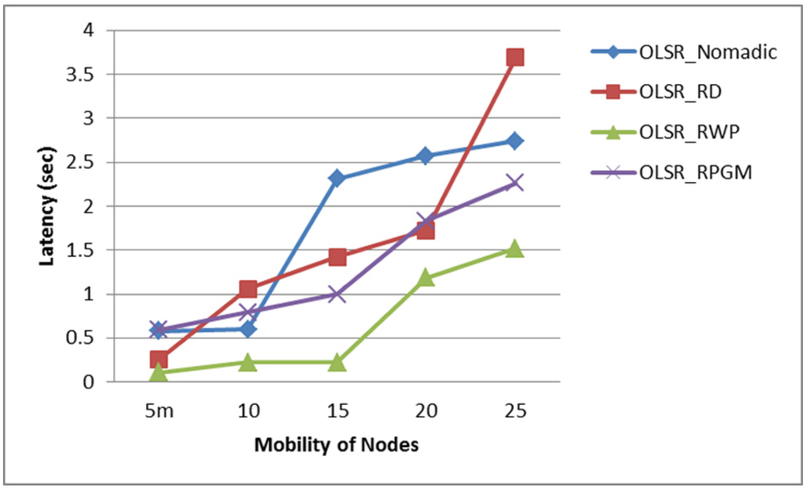

Fig. 8. Latency analysis of OLSR under four mobility models with low degree of mobility

The ratio of routing control packets to data packets carried through a network is known as overhead. Furthermore, it determines the quantity of how many control packets being required by the protocol to transmit data packets successfully to their destinations. Figure 9 represents the overhead analysis of OLSR Protocol under various mobility models with low node mobility. The findings reveal that the OLSR protocol overall mobility models have low overhead for low mobility. However, as node mobility increases, an increase in overhead costs is noted. The OLSR protocol on RPGM models performs much better than other mobility models, while the OLSR protocol generates relatively higher overhead costs on the RD.

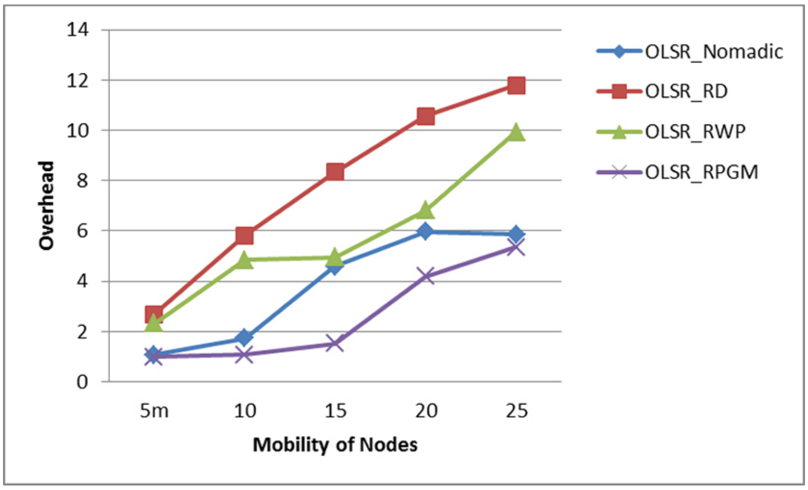

Fig. 9. Overhead analysis of OLSR under four mobility models with low degree of mobility

Packet Loss Ratio (PLR) is defined as the ratio of data packet loss before reach to destination nodes and the data packets send for those destinations. Whenever the loss ratio is reduced, the routing protocol's performance improves. Figure 10 represents the PLR analysis of OLSR Protocol under four mobility models with low mobility of nodes. From the Figure 5, it is clear that at low mobility of nodes, OLSR protocol over RWP and nomadic models outperforms RD and RPGM in terms of the PLR. Neverthe-less, as the node mobility increases, OLSR overall compared to mobility models grad-ually increases PLR. The OLSR protocol over the RWP model performs much better in terms of PLR due to low packet losses.

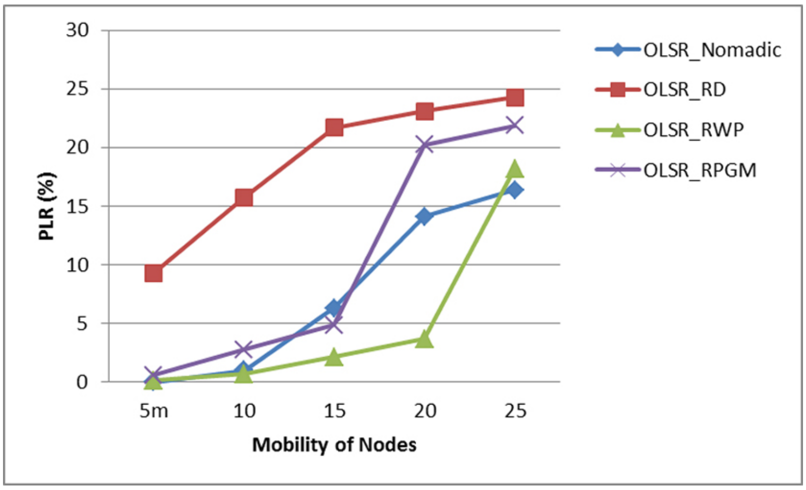

Fig. 10. PLR analysis of OLSR under four mobility models with low degree of mobility

6.2 Simulation results of OLSR in second scenario

Figure 11 represents the Latency analysis of OLSR Protocol under four mobility models with low mobility of nodes. From figure 6, it can be observe that the latency of OLSR protocols over RD models significantly increases with the high mobility of nodes. But at the other hand, OLSR protocols latency over nomadic and RWP models slightly affected by increasing in the mobility of nodes. Hence, it provides an efficient and reliable data routing in the network. Real-time applications like VoIP prefer routing protocol with lower latency.

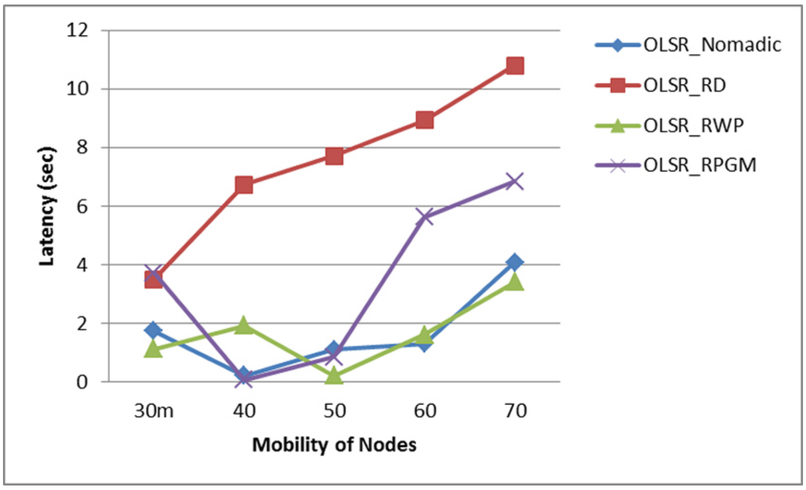

Fig. 11. Latency analysis of OLSR under four mobility models with high degree of mobility

Figure 12 represents the overhead analysis of OLSR Protocol under four mobility models with the high mobility of nodes. Simulation results indicate that the overhead of OLSR protocol over nomadic, RWP, and RPGM is slightly affected by the high mobility. In contrast, the OLSR protocol has high overhead when run over the RD mobility model. Additionally, it can be observed that the nomadic mobility model is the best choice for OLSR protocol in High mobility environments due to the lower overhead.

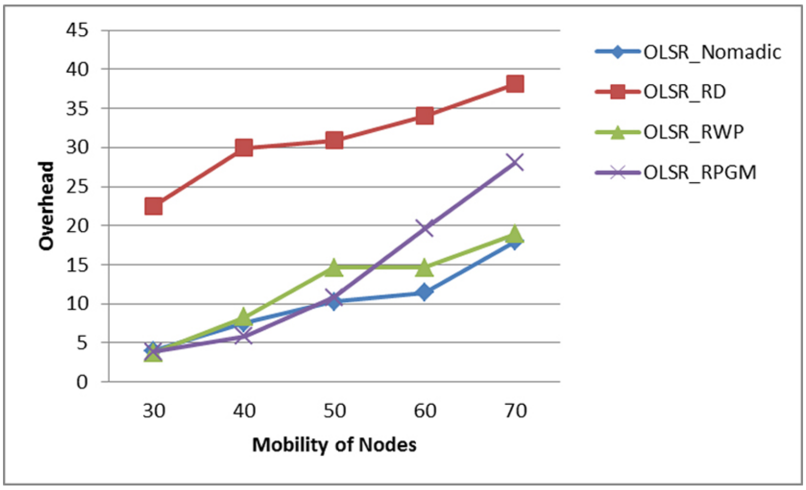

Fig. 12. Overhead analysis of OLSR under four mobility models with high degree of mobility

Figure 13 represents the performance analysis of OLSR routing protocols in terms of the PLR under four different mobility models with the mobility of node 30, 40, 50, 60, and 70 m/sec respectively. From figure 6, it is observed that OLSR under RWP and RPGM model has a lower PLR at node mobility 30, 40, and 50 m/s. But with the increases of mobility after 50 m/sec, the PLR of OLSR over the RWP model increase. Further, OLSR protocol over RD and Nomadic models has shown a poor performance with higher PLR.

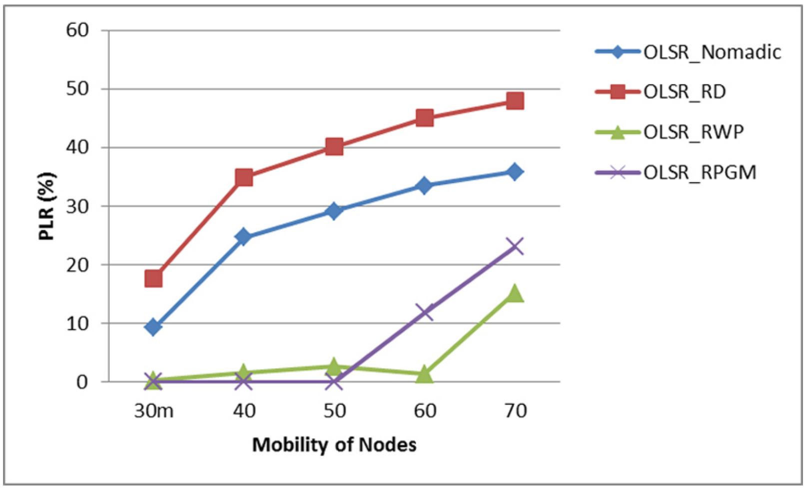

Fig. 13. PLR analysis of OLSR under four mobility models with high degree of mobility

7 Conclusion and future direction

Ad hoc networks are gaining research attention in the last decade due to their widespread use in various applications. This paper analyzed the performance of OLSR routing protocols under Nomadic, RD, RWP, and RPGM mobility models in MANET. Extensive simulation findings demonstrate that the node mobility pattern has a significant influence on the overall performance of the OLSR. Therefore, it can be observe that an increase in node mobility from low to high degree leads to degradation of OLSR performance in the network. However, the performance degradation varies for different mobility models. Based on the result analysis, the OLSR protocol under Nomadic and RWP has low latency performance at low and high node mobility. The performance of the RPGM model provides a minimum overhead of OLSR protocol when there is an increase in ode mobility.

In the future, we intend to study 3D mobility models to determine the Routing protocol best suited to flying ad hoc networks (FANETs).

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