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Refining Location-Aided Routing (LAR) through Proactive Algorithm

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Abstract: One of the weaknesses in Location-Aided Routing (LAR) is the delay due to partial flooding of data packets throughout the ad hoc network during route discovery. Systematic literature review indicates that very little or no studies conducted to seek a solution to this routing weakness in LAR. This study proposes introduction of periodic updates of location information among the nodes as a solution to minimizing latency. Proactive-LAR (P-LAR) eliminates partial flooding, thus reducing latency while advancing routing performance of traditional LAR. As a research scope, this study uses Angle of Arrival (AoA), Time of Arrival (ToA), Time Difference of Arrival (TDoA) and the expected distance of nodes and the direction of movement as the only location information details. Moreover, the simulation on OMNET ++ is limited to the initial expected zone of LAR Scheme 1. Simulation of the modified LAR Scheme 1 algorithm indicates that inclusion of proactivity as an algorithmic aspect of LAR augments general data packets throughput, latency, packets delivery ratio while minimizing the number of packets dropped. Nodes mobility in simulation was considered stationary. The simulation results—as analyzed through RapidMiner, suggest that proactive algorithmic element in LAR routing algorithm can potentially minimize partial flooding thus improving routing performance while minimizing routing overheads such as jitter and delay.

Key Terms; Mobile Ad Hoc Networks (MANETs), Flooding, Proactivity, Latency, Location -Aided Routing (LAR)

1. Introduction

A Mobile Ad Hoc Network (MANETs) is a type of wireless network that relies on IEEE Wifi standards 802.11a/b/g/n/ac/ax. A key feature of MANETs is their flexibility and the ability of the network nodes/devices to either join or leave the network at will [1]. They are composed of wireless host devices whose transmission is broadcast to any other device or node within its range. Devices out of range are reachable through hopping from along the nearest nodes. However, such flexibility comes with its challenges. Studies have established that autonomous mobility within a MANET introduce security weaknesses. Because MANETs operate without a centralized operation, it is very hard to guarantee security relative to other networks such as ethernet or fiber [2].

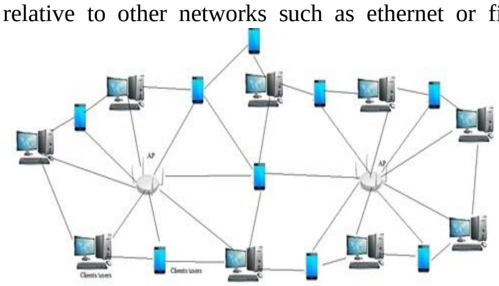

Figure 1: Example of Mobile Ad Hoc Network (MANET)

In figure 1, for example, the radio signal relay is characterized by multihopping as it is propagated from one neighboring node to another. Multihopping, however, introduces regular and unplanned network breakages and shutdowns. High mobility in MANETs results into constrain on the available resources such power and bandwidth. Besides these shortcomings, MANETs, unlike the infrastructure dependent networks, can be deployed instantly to every situation that may arise. Such networks are used to create connectivity responses for the “purpose” of a particular scenario [3]. Scenarios differ, and so do the required MANETs. For instance, a MANET formed to respond to a rescue mission is different from a MANET created for a military operation.

Other Applications of MANETs include community wireless, distributed and collaborative computing, mesh networks and multi-hop cellular networks. Constant devices movements within a MANET introduces high level dynamism the topology of the network. Although MANETs are flexible and dynamic, they experience certain shortcomings [4]. For instance, relative to other networks, MANETs experience high data packets drop rates, traffic collisions and higher signal-to-noise ratio. Other MANETs shortcomings include hidden and exposed terminals and difficulty in their modelling approaches.

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Routing protocols in MANETs are designed to respond to the network flexibility and topological dynamism introduced by the autonomous nature of network nodes. Because MANETs allow high nodes mobility and autonomy to either join or leave a network, the designed routing protocols are designed to be flexible and responsive enough to support such network dynamism. Consequently, MANET routing protocols are classified based on various criteria. Within the routing protocols, there are algorithmic rules that set out how a data packet should be moved from the source node to the destination. Routing parameters compose a key feature in MANETs routing [5].

Each of the routing protocols in MANETs has strengths and weaknesses. Among the most studied routing protocols is Location-Aided Routing (LAR). While it outperforms various proactive, reactive and hybrid routing, it experiences delay and higher consumption of power due to partial flooding. To solve this problem, this study proses introduction of proactive algorithmic element into conventional LAR Scheme 1 to combat partial flooding. The hypothesis is that proactivity will minimize the need for partial flooding of data packets during route discovery and data transmission process.

2. Routing in MANETs

Nowadays, there are a myriad of MANETs routing protocols designed for maximization of resources utilization. Various MANETs routing protocols are proposed to minimize overheads while maintaining optimal performance—data packets transmission among nodes. For instance, in figure 2, some routing protocols are designed to minimize power consumption, bandwidth, handle link failure and respond to the overall dynamism within the network [6]. Routing in MANETs are classified based on various strategies. Because MANETs do not depend on any fixed infrastructure, every mobile device/node operates as both a transmitter and a router. For this reason, each node in a MANET can receive, store, update, maintain and transmit data packets. Generally, routing is one of the most challenging tasks in a MANET [7].

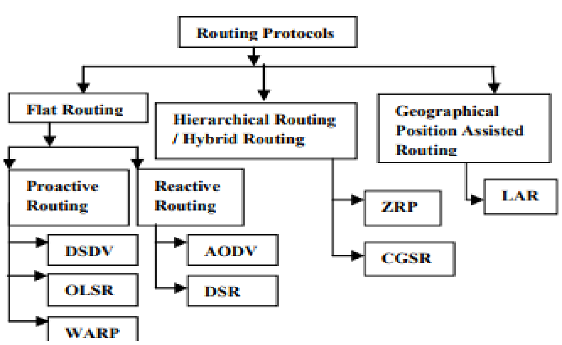

Figure 2: Routing Classification in MANETs (7)

Network engineers and administrators of MANETs have to contend with the management of limited resources while designing routing in MANETs. Network specialists have to put into consideration all the downfalls of MANETs in regard to power utilization and unplanned link failures [8]. In MANETs, the process of route discovery and their associated maintenance is paramount in network designs and developments. Routing in MANETs should exhibit certain characteristics [9]. For example, an effective routing protocol should be able to avoid signal loops while maintaining an acceptable level of quality in signal. Moreover, routing in MANETs should be able to optimize utilization of the available power, bandwidth and memory. Because MANETs are created for response in specific cases or scenarios, MANETs routing adaptability is critical. Adaptability in MANETs requires a routing protocol to be able to fully and equally distribute the network signal among the nodes [10].

Reliability of connectivity is also a trait that should be reflected in MANETs routing. All these qualities ensure reliability and stability of the network. In general, MANETs' routing protocols possess and exhibit abilities such as tolerance to faults and failures, implement ability and simplicity [11]. In addition, routing in MANETs should be able to exhibit reliability and scalability. Routing protocols in MANETs are expected to be dynamic enough to offer sufficient distribution signal in a format that allows effective and easy implementation and maintenance. Classification of routing protocols in MANETs is important. Mainly, MANETs routing protocols can be grouped based on their responses to route discovery requests—routing strategy, or based on topological/structural description of the network. Grouping of MANETs routing protocols based on routing strategy yields proactive and reactive classes [12], [13], [14].

Proactive routing protocols depend on network topological routing tables to initiate route discovery processes. Oppositely, reactive protocols rely on the source nodes to initiate route discovery requests. In proactive routing, there is constant updates of routing tables. For this reason, one of the key shortcomings in proactive routing protocols is the increased overhead in the form of power [15]. Constant updates of routing tables make proactive protocols consume more transmission power in comparison to reactive routing protocol. However, proactive routing protocols can transmit data packets faster than the reactive routing protocols. Faster data packets transmission can increase the general data throughput [16]. The trade off, however, is the higher consumption of power. Reactive routing protocols initiate route discovery process only when requested to do so [17].

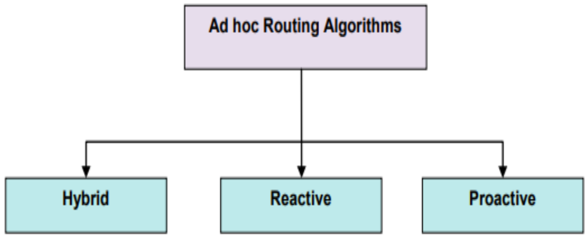

Figure 3: Classification of Routing in MANETs based on Topological Structure [18]

Consequently, the dormant nature reactive protocols conserve power but may experience slower data transmission rates. Proactive routing protocols include Destination Sequenced Distance Vector (DSDV) protocol, Distance vector (DV) protocol and Fisheye State Routing (FSR) protocol. Reactive routing includes Dynamic Source Routing (DSR) and *Ad-hoc* On-demand Distance Vector (AODV) routing [18]. When routing features of proactive and reactive routing are combined, a hybrid routing is produced. An example of a hybrid routing is the Zone Routing Protocol (ZRP). In ZRP the interior zones use proactive routing while the exterior zones as determined by the zonal radius use reactive routing.

MANETs routing can also be classified as either geographical, multicast, power-aware, hierarchical or flat based on the topological/structural makeup of a network. Most of the routing protocols in MANETs fall under the flat routing because all proactive and reactive routing protocols are included. Hierarchical routing is made up of hybrid Cluster Switch Gateway Routing (CGSR) and Zone Routing Protocol (ZRP). Geographical routing is composed of Location-Aided Routing (LAR) and Greedy Perimeter Stateless Routing (GPSR)—refer to figures 2 and 3.

3. Related Work

There is plenty of studies attempting to improve the current MANETs routing protocols. Many of the available studies examine various methods and approaches to minimize routing overheads. Comparatively, however, existing studies on LAR mainly concentrate on performance analysis relative to other routing protocols. Consequently, there is very little or no improvement proposal studies conducted on LAR. For example, study [19] attempts to compare overall performance between LAR and the Ad-hoc on-demand distance vector (AODV).

Some of the parameters used in comparative studies include throughput, delay, jitter and drop rates. Simulations in such studies are carried out under varied number of nodes and area. Study [19] analyzes the performance of LAR in as a routing protocol for a Vehicle Ad Hoc Networks (VANETs). The performance analysis in the study uses LAR to simulate vehicular movements in a city. While [20] attempts to propose a new version of LAR--Energy Efficient Location Aided Routing (EELAR) Protocol, it is not clear how the proposed algorithm saves energy. The study compares the performance of EELAR with AODV, LAR, and DSR.

Additionally, the measure of control packet overhead as an overhead is not clear enough to allow such comparison. According to [20], cluster routing can improve routing LAR. The Cluster Based Location-Aided Routing Protocol for MANET (C-LAR), outperforms the traditional LAR because it introduces scalability and effectiveness. According to the simulation results, C-LAR outperforms traditional LAR on routing overhead, delay and packets collision.

However, the paper does not show how the modified algorithm alters the technical performance of the traditional LAR in different circumstance. Other studies concentrate on general performance of LAR without algorithmic modification or performance comparisons. For instance, studies, [21], [22] analyze routing general performance of LAR. Major differences in generalized LAR routing performance studies include variations in simulators, parameters and situations.

4. Location-Aided Routing (LAR)

Proposed by [23], Location-Aided Routing (LAR) seeks to improve reactive routing protocols such the Dynamic Source Routing (DSR) and Ad Hoc On Demand Distance Vector Routing (AODV). Because both AODV and DSR do not use location information in their route discovery, they are likely to suffer from added overheads in form of latency. This is so because during route discovery, AODV and DSR initiate the process for the first time without prior route information. Oppositely, proactive routing protocols have less latency because of constant updates of routing information.

Another key common feature between AODV and DSR is the flooding of data packets during route discovery process. Proposition of LAR is that utilization of location information improves the performance of such reactive protocols. Although flooding as design feature is maintained in LAR, introduction of location information as an algorithmic feature helps in the reduction of latency and the overall packets throughput. For example, figure 4 represents the concept of flooding in either AODV or DSR. Assuming that node S is the sender, it broadcasts a route discovery request to all of its neighbors [23].

If a neighboring node does not recognize the routing information in the route request packet, it discards the it. Otherwise, it forwards to the next neighbor. Every node makes the decision either to forward or drop a route discovery packet by comparing the intended destination information with their identifiers. However, sequence numbers are used to avoid redundancy. Therefore, a node is expected to conduct route request forwarding once.

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In figure 4, sender node S broadcasts a route request message to nodes A, B, and C. But since node A has no neighbors apart from S, it discards the message. Nodes B and C forward the request message to E and F respectively. Similarly, node E discards the message because it is the dead end. However, nodes B and C forwards the message to node F. However, node F retains the message that is received first while discarding the other message that comes second. Eventually, node F forwards the rout request to destination node D.

Node D then sends a reply to source node S based on the route through which it received the request message—request message retains the nodal routing information as moves from the source/sender node S to destination node D.

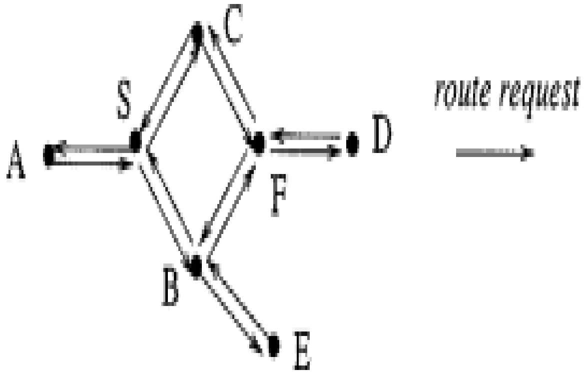

Figure 4: Example of Flooding in either AODV or DSR

If the destination node fails to receive the request message either due to link error, a timer is used to determine when a resend is needed. The main purpose of LAR is to diminish the number of nodes that receive the routing packet. By doing so, it creates a partial flooding. Utilization of location information by the LAR in route discovery is intended to introduce elimination of certain nodes that are not within either the expected or request zones—refer to figures 5 and 6.

Location information can be obtained through Global Positioning System (GPS). The key assumption of LAR is that the source node knows the maximum mobility speed of the destination node. In figure 5, the expected zone is the area determined by multiplying the speed of the destination node and the time between the request messages. The results from the speed and the time difference offers the radius of the expected area.

Assuming that the destination node S has a maximum speed V, at time t_0 (previous time), then at time t_1, the expected zone is the area determined by radius $v(t_1-t_0)$. Although comparative simulation studies suggest that LAR outperforms normal flooding algorithms such as AODV and DSR, it still experiences latency due to partial flooding. In other words, LAR uses minimized flooding in its routing despite introduction of location information. The presence of partial flooding retains some level of latency.

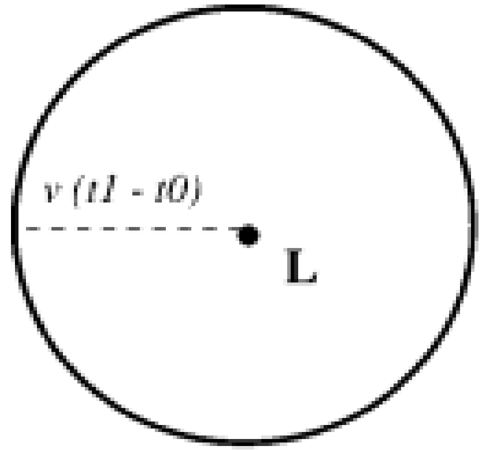

Figure 5: Expected zone at t_1

With inclusion of more routing information of the destination node, the expected zone reduces in size, hence reducing the amount of route request time. For example, if the source node S knows that direction of movement of destination node S is north, the expected zone in figure 5 can be reduced into half. Figure 6 represents reduction of the expected zone by half. More detailed workings of LAR can be found in paper [23]. However, LAR relies on two principles in its routing. That is, the expected zone and the request zone. The purpose of this paper is not to explain LAR in details but rather to offer an alternative to partial flooding.

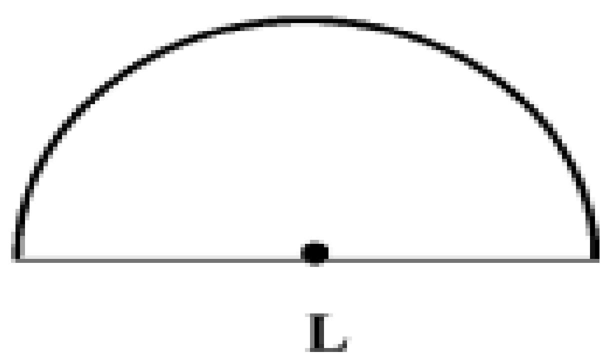

Figure 6: Expected zone reduced by half

5. Proactive Location-Aided (P-LAR)

Conventional LAR uses partial flooding of the expected and request zones based on location information of the destination node. Methods used in determining both the expected and request zones has been described in the previous sections of this article—refer to figures 5 and 6.

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Figure 7 (a) demonstrates partial flooding on the expected and request zones in LAR Scheme 1. In figure 7 (a), source node S is outside the request zone.

The expected zone is defined by (Xd, Yd) coordinates and radius R. The Request zone is the rectangular area defined by A, B, C, S. Because node J—defined by (Xj,Yj) coordinates, is outside the request zone, it does not receive request messages broadcasted by source node S. In figure 7 (b), the source node S—defined by (Xs,Ys) coordinates, is within the request zone. As noted earlier, radius R is determined through multiplication of estimated nodal speed v with the difference between prior time t_0 and the current time t_1; (t_1-t_0).

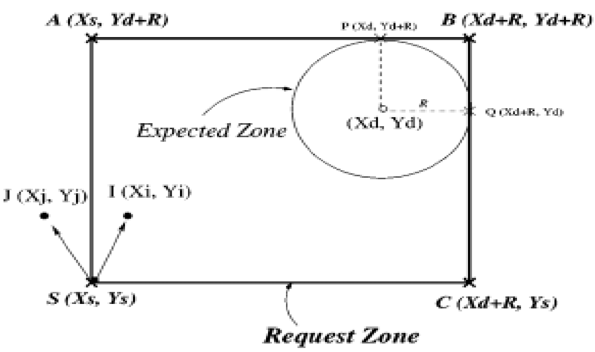

Figure 7: Expected Zone with and without the Source Node S

In this study, we propose introduction of proactivity in LAR route discovery process. The argument is that constant update of location information among network nodes are will eliminate the need for partial flooding. Topological routing tables are used to store three key location information of the nodes within the transmission range.

The two-location information are the Angle of Arrival (AoA), the distance from the source node and the expected direction of movement. In the new proactive LAR (P-LAR), the source node receives constant updates of location information of all nodes within a request zone. Proactivity within the source nodes speeds up route discovery process because of the updated location information in the network topological routing tables.

Position = initial position+ initial velocity * time + 1/2 * acceleration * (time)^2.

x = position

x0 = preliminary position

v0 = preliminary velocity

t = time

a = acceleration

Although proactivity may increase other routing overhead such as power, latency is greatly reduced. Minimization of latency results into better general data packet throughput. Augmenting general data packets throughput increases the performance of a MANET network. Better performance improves the general performance of MANETs. Because MANETs are used in areas whose infrastructure is damaged or missing altogether, reliable performance is vital. In our proposal, the location information of the destination node is composed of the Angle of Arrival (AoA) and the distance from the source node. These two parameters calculable based on the coordinates of the nodes.

Assume, for example, that in figure 7, the coordinates subset of destination node D is (x_0, y_0) at time t_0. Due to its movement at time t_1, the coordinates subset for the destination node D is (x_1, y_1). Therefore, the distance covered due to the movement of the node is;

$$d = \sqrt{(x_1-x_0)^2+(y_1-y_0)^2} \qquad (1)$$

Else, if the movement speed of destination node D is a constant v, then the distance d is determinable based on the following formulae;

$$d = v\,(t_1-t_0) \qquad (2)$$

$$d = x_0 + v_0 t + a*t2/2 \qquad (3)$$

Similarly, the Angle of Arrival (AoA) is determined based on the following formula;

$$\theta = \tan^{-1}\left(\frac{(y1 - y0)}{((x1 - x0))}\right) \qquad (4)$$

The above location information is included in the algorithm below and run on C++ based simulator. It is critical to note, however, that the code snippet included below is only a representation of a single modular function to enable proactivity in LAR. The code below was only tested in OMNET++ simulator. For simplicity purposes, integer is used for both the distance and the angle of arrival (AoA).

Due to proactivity, the following nodes formula— (5), must be applicable to maintain continuousness of the location updates.

V_n is the nth node during the proactivity process.

N is the number of nodes in the network.

Therefore, to assure constant location information update;

$$\sum n = 1NVn = 0 \quad (5)$$

Rendering of the code on OmNET++;

```
network P-LAR
{
    parameters:
        int numHosts;
       int nodeDist;
      int  AoA;
        @display (nodeDist, AoA);
        @display("bgb=650,450");
        @\displaystyle\sum\limits_{n=1}^N V_n = 0;
    submodules:
        visualizer:    <default("IntegratedCanvasVisualizer")>
like IIntegratedVisualizer if hasVisualizer() {
            parameters:
                @display("p=100,300;is=s");
        }
        configurator: Ipv4NetworkConfigurator {
            parameters:
                @display("p=100,100;is=s");
        }
        radioMedium: UnitDiskRadioMedium {
            parameters:
                @display("p=100,200;is=s");
        }
        host[numHosts]: AdhocHost {
            parameters:
                @display("r=,,#707070;p=300,200");
        }
}
```

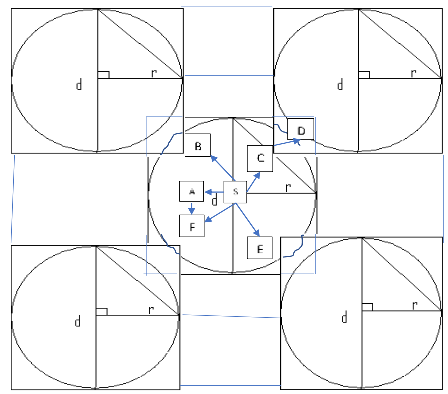

Figure 8: A theorical representation of initial routing instance in the P-LAR

Reference Source Node s Actions:

-Physical location information is included in the topological routing table of node s

-Physical information includes the Angle of Arrival (AoA) and the relative distance of the destination node s and the

-Relative distance and the AoA is used to determine the presence of the destination node in the request zone as defined by radius r in figure 8.

-If the request zone does not cover the topological distance and AoA, the destination node is outside the request zone, hence removal of the information from the network topological routing table.

- Route dismissal from the network topological routing table is initiated through equation 5

- Else, a network topological route discovery message is relayed to the source node

-Otherwise, the data packet with the physical location information of node as identified in network topological routing table, is successfully delivered to the appropriate destination

6. Evaluation of Performance of P-LAR

Because this study was designed to gauge the effects of proactivity inclusion in LAR, OMNET++ was used to simulate the LAR Scheme 1 and the proposed new Proactive LAR Scheme 1—P-LAR. Results on basic scalar parameters—network throughout, packets drop rate, latency, and the data packets successfully received, were analyzed on RapidMiner to produce graphical illustrations. It is important to emphasize that the graphs presented herein are summaries of three iterations of simulations.

As noted above, location information included in the performance evaluation was limited to the distance of the source node, Angle of Arrival (AoA), and the general estimation of direction of the destination node. Simulation model required 10,100 and 1000 nodes for test runs. However, the graphs included in this study are summaries of average results of these three test runs. Table 1 describes the summary of parameters, variables and their associated metric indicators. Simulation environment is largely derived from []. All packets transmission is assumed to occur at Transmission Control Protocol/Internet Protocol (TCP/IP) layer of network.

Table 1: Parameters, Variables and Indicators

Parameters	Parameter Value	Simulation Variables	Variable Indicators/Values
Packet size	1,500 bytes	Network Throughput	Quantity of data packets
Nodes	10,100,1000	Drop Rate	Amount of Data Packets dropped/lost in an iteration
Simulation Time	100 seconds	Network Latency	Transmission time in seconds
Number of iterations	3	Data Received	Amount of data packets received by destination node

Each test run duration was 100 seconds. The area of movement was confined to 500m X 500 m. Uniform distribution of the coordinates was used to determine variable x and y. Initial assumption is that nodes do not move while subsequent assumption is that all nodes move at a constant average speed of *v*. General direction of the nodes movement is determinable through Global Positioning System (GPS). Another simulation assumption is that the location error is negligible. Since all nodes are assumed stationary during the simulation event:

time $t_0=t_1$; therefore, time difference = 0;

also; velocity $v_0=v_1$, therefore, distance d = 0;

Network throughput (PT) is key this study because it represents the overall performance of the proposed P-LAR compared to LAR Scheme 1. This study measures network throughput as the key basic scalar parameter in the simulation because it the only performance metric that can be influenced by variations in latency, packet loss, network congestion, and jitter. However, this study derives simulation parameters from the latter four metrics to simulate latency, packets delivery ratio and the number of packets dropped.

Figure 9 represents the simulation results for data packets throughput (PT) or network throughput (NT) simulation results between the conventional LAR Scheme 1 and the proposed Proactive LAR Scheme 1 (P-LAR). Data packets throughput in this simulation refers to the quantity of data successfully sent and successfully received within a specified period of time.

It can also refer at the rate at which packets are successfully received at the destination node. That is, the result of dividing the number of the packets received (PR) at the destination node with the number of packets successfully transmitted (PT) at the source node. In this simulation, the units used in measuring this quantity are expressed in Megabits per second (Mbps). The following formula was used to calculate network throughput:

$$NT = \frac{PR}{PT} \qquad (6)$$

Figure 9 represents the general average trend of data packet throughput of three simulations runs—10,100 and 1000 nodes. Clearly, there is a general variation in the network throughput between the Proactive LAR (P-LAR) and the traditional LAR Scheme 1. However, at around 90th second, P-LAR drops sharply relative to LAR Scheme 1. At around 95th second, P-LAR rises to supersede Network throughput of LAR Scheme 1.

Although the performance of P-LAR looks steadily better than conventional LAR Scheme 1, the variation in ultimate data packets throughput can be phenomenal after long period of time. Because this study is only concerned demonstrating fundamental effects of inclusion of proactive algorithmic elements in LAR Scheme 1, further studies can be conducted to derive the appropriate extrapolation formula that can be used in determining the variations in network throughput at $t_0 \ldots t_n$. The general overall of p-LAR is represented by the dotted line.

On average, P-LAR successfully transmits some 1665 data packets per second (1665.17/sec) while traditional LAR successfully transmits some 1643 data packets per second (1643.28/sec.). The variance in transmission success (DT) is (1665.179-1643.28)/sec.

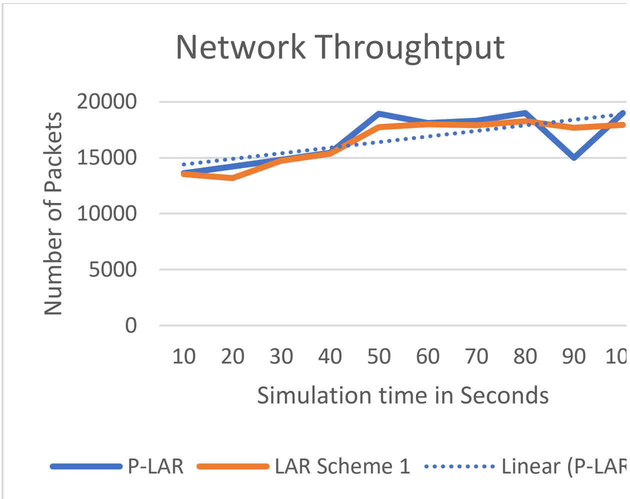

Figure 9: Network Throughput of LAR Scheme 1 and P-LAR

After simulating the network throughput, this study examined variations in the number of data packets lost/dropped. It should be noted that the rate of data loss affects the general final network throughput. Therefore, it is only reasonable that P-LAR outperform the traditional LAR Scheme 1. The rate of data packets (PL) droppage or loss is calculated by dividing the number of data packets successfully transmitted (PT) at source node with the data packets successfully received (PR) at the destination. The following formula was used in determining the rate of data droppage during the simulation period:

$$PL = \frac{PT}{PR} \qquad (7)$$

After simulation run, the graphical representation shows that, as expected, inclusion of proactive algorithmic elements in LAR Scheme 1, lowers the number of packets lost during route discovery and data packets transmission. In figure 10, the proactive LAR steadily and consistently experienced lower data packets drop rates. As the P-LAR trend line indicates, the proactive algorithmic routing element lowers the packets drop rates.

However, up to around 30^{th} second, P-LAR and the conventional LAR Scheme 1 experience virtually similar levels of data packets drop rates. After the 30^{th} second point the proactive enhanced consistently outperforms the traditional LAR Scheme 1. On average, P-LAR drops some 240 data packets per second (240.81/sec.) while traditional LAR Scheme 1 drops some 268 per second (268/sec.). The differential drop rate (DD) per second is approximately (240-268)/sec.

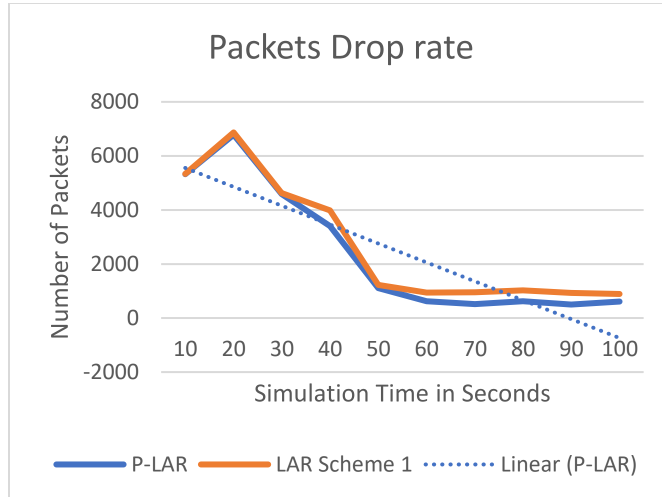

Figure 10: Data Packets Drop rate

Another performance parameter evaluated in this study is latency. Network latency (NL) is the measure of the amount of time a data packets takes to successfully move from the source node to the destination node. Latency in this study is the measure of the round trip taken by a data packet from the source node to destination node and back. Usually, maximum latency is determined by dividing the desired size of the packet size (DP) with the with maximum network throughput (NT). The following formula is used to determine latency:

$$NL = \frac{DP}{NT} \qquad (8)$$

Figure 11 represents latency results of both the P-LAR and the traditional LAR Scheme 1. The graph indicates that, as expected, the overall latency of P-LAR is relatively lower throughout the simulation instances. The results are consistent with the rest of measured basic scalar parameters. Lower latency in P-LAR means that a data packet takes less time for a roundtrip during route discovery and packet transmission.

P-LAR experiences average latency of 5.64E-03 seconds, while traditional LAR Scheme 1 experiences 6.36E-03 seconds of latency. The latency variation is (5.64E-03-6.36E-03) seconds. Although the -7.20E-04 seconds in latency variation may not seem as a big difference, it can greatly influence the overall performance of the network over a longer period of time. Moreover, such small difference in latency can cause a huge difference when transmitting large sizes of data packets.

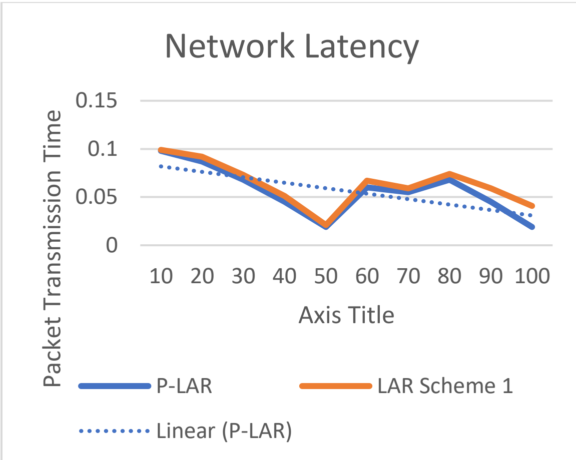

Figure 11: Network Latency

Average data packets received successfully (APR) measures the quantity of data packets effectively transmitted from source node to the destination node in a given period of time. APR is calculated by dividing the number of data packets successfully transmitted with time (T) taken to transmit the packets. The following formula is used in determining the average data packets transmitted:

$$APR = \frac{PR}{T} \qquad (9)$$

Similar to other three basic scalar performance parameters, the quantity of average data packets received is relatively better in P-LAR than the conventional LAR Scheme 1. This result is in line with network throughput, packets drop rate and latency.

Because the network throughput in P-LAR is relatively higher than conventional LAR Scheme 1, it means that it experiences less packet loss, better latency and higher average data packets transmission. Figure 12 represents the graphical representation of the performance of P-LAR and the conventional LAR. The average data packets successfully received variant is (1167 - 1101.11) packets. This translates to transmission of more 66 data packets by the P-LAR compared to traditional LAR Scheme 1. However, the difference in average data packets received seem to congregate after the 100th second.

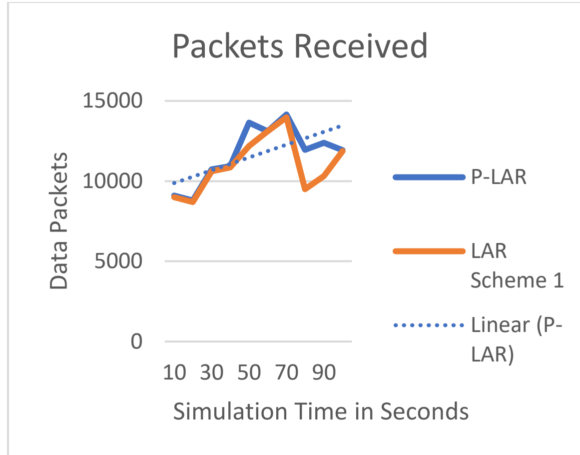

Figure 12: Data Packets Received

7. Conclusion

This study examines routing performance effects of proactive algorithmic feature in conventional LAR Scheme 1. The proposed version of LAR Scheme 1 is called Proactive LAR Scheme 1 (P-LAR). The simulation was carried out on OMNET++ while data analysis was done on RapidMiner. Simulation results of the new algorithm (P-LAR) suggest that inclusion of the proactive algorithmic element augments the performance on network throughput, while minimizing packet loss and latency. Besides the proactive algorithmic element enhances the amount of average data packets reception. This performance variation is attributable to the ability of proactivity routing algorithm to reduce the size of the request zone, hence minimized flooding during route discovery process.

Because this study focused on elementary scalar parameters, we recommend that further studies be carried to gauge the routing performance effects of proactive algorithm on jitter and power consumption. Moreover, it is important to extend this research to include the LAR Scheme 2. We also recommend examination of the effects of proactive algorithm on routing performance other location-aided protocols such as the Greedy Perimeter Stateless Routing (GPSR).

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