Estimation of Network Partition Problem in Mobile Ad hoc Network

Varaprasad Golla
B.M.S.College of Engineering
Bangalore, India
varaprasad555555@yahoo.co.in

ABSTRACT: *A node cannot communicate with others due to the network partition. The network partition can occur when the nodes are separated by themselves as groups with a critical link/ node fails. In this paper, I proposed a new routing model for mobile ad hoc networks to detect the critical link and network partition. In order to predict the network partition/critical link, the proposed model uses the information like the node location and node signal strength. The proposed model has been simulated using NS-*2.334 *with the help of 100 nodes. It has been compared with the reference-point-group-mobility model and reference-velocity-group-mobility model in terms of node density, size of network partition and number of active nodes participating in the network. The simulation results are proved that the proposed model has reduced the average number of network partition sizes. It increases the average number of active nodes participating in the network.*

Keywords: Network Partition, Location Aware, Signal Strength, Throughput, Energy

Received: 19 August 2013, Revised 25 September 2013, Accepted 30 September 2013

1. Introduction

Mobile Ad hoc Networks(MANETs) are formed by the mobile nodes without having the fixed infrastructure. In the MANET, each node performs as a host as well as router to forward the packets. The mobile devices(laptops, PDAs, sim-computers) are used to transmit the data from one node to another. These devices forward the data packets independently in the network. The mobile node is adjustable based on the local conditions[1]. The nodes can move from one location to another location. The nodes are transmitted data packets through the wireless links in the MANET. The nodes frequently change their locations from time to time over the network[2]. The network may be partitioned due to the node mobility, node failure, link failure, shortage of battery power or physical damage of the node. The network will divide into a number of partitions. Once the network is partitioned, it is difficult to communicate with other nodes. The network partition will reduce the quality of service and also makes the service unable to the end-users over the network. In the MANET, each node may not be communicated with other nodes if the node density is low and the node is out of coverage[3]. Some of the projects[4]-[5] attempted to improve the communication systems without network partition problems. Park et al.[6] proposed a Temporally Ordered Routing(TORA) for MANETs, which is an efficient routing protocol. The aim of this protocol is to detect the network partition before it occurs. It forwards the data packets based on the nodes, which are more reachable towards the destination. The remainder of this paper is as follows: section 2 discusses some of the related projects, its advantages and disadvantages. The proposed model and its design steps are presented in the section 3. Section 4 presents the simulation environments. The simulation results are presented in the section 5. Finally, section 6 presents the conclusion of the proposed work and further research work.

2. Related Projects

In this section, I am discussing some of the existing projects on the network partition. Several researchers are worked to reduce the network partition. Most of them have failed to predict the network partition and to increase the network throughput. Here, I will classify the network partition into pre-partition model and post-partition model. The pre-partition models are gateway routing and fast recovery. The gateway routing is used to detect the network partition early and recovery [7]. The post-partition model is used in the system before the network partition occurs. In [8-9], the authors tried to enhance the data transmission between the nodes over the network. The main advantage of this model is that every node knows the network partition before it occurs. At the same time, it has some drawbacks: every node must know the positioning system, which leads more costly and burden. We can find several control message packets over the network due to the exchange of the node mobility. Hong et al. [10] developed a Reference Point Group Mobility (RPGM) model to present the behavior of the mobility of group nodes. RPGM model identifies a logical-reference server, whose movement is followed by the other members. The location of the reference-server and its members are presented by two levels of displacement vectors such as group motion and random motion. The group-motion vector provides the location of the reference server while random-motion vector, adds it to the group-motion vector to give the position of nodes. RPGM model generates the topology of the ad-hoc network with the group-based node mobility for simulation purposes. But for mobility or partition prediction purposes, it has 2 disadvantages as follows: lacks of prior knowledge about the mobility groups make RPGM model inapplicable for run-time partition predictions. Secondly, RPGM model represents the nodes by their physical coordinates.

Reference Velocity Group Mobility (RVGM) model was proposed by Wang et at [11]. Here, each group uses average velocity instead of the position. A member in the group determines its velocity by considering random-motion vector and its group velocity, so that it can be regarded as a time deviator of displacement-based group mobility in the RPGM model. The velocity of the RVGM model provides a distinct membership in a velocity coordinate space, which can be utilized to predict a group partition and mobility pattern. It uses centralized server for communications. It worked based on the reference-point-group-mobility model. Each node sends its location and speed to the central server. The server executes sequential clustering algorithm to all group the nodes. The server knows the group velocity and its location. It can inform the nodes of further partition. Here, the nodes are grouped based on the location and speed [12]. Kejun Wu et al [13] proposed a Multi-Group Coordination Mobility (MGCM) model to evaluate the performance of the military ad hoc network. In MGCM model, the speed of each node in the group is determined by the leader of the group, neighbors and random velocity. Mobility of the leader of each group is determined by the leader of the reference group, other leaders and random velocity. MGCM model work outs the mobility problem caused by the most random mobility models. Goyal et al.[14] proposed a model for MANETs to detect the critical link over the network. It uses the location-based system to identify the nodes. All the nodes are known their neighbors and periodically update their neighbors with current location. It uses the dept-fist-search tree algorithm to compute the critical links. Drawback of this model is that every node must compute the dept-fist-search tree with itself(as a root) to detect the network partition. This model increases the overheads over the network [15]. Killijian et al[16] tried to avoid the network partition problem. It briefly described about the failure anticipator, movement planner and environment evaluator. These components rely on the sensing equipments and huge amount of information exchanged.

3. Proposed Model

The proposed model detects the critical link and network partition over the network with the help of node location and signal strength. In this work, I use 2 updates namely, regular and trigger. The regular update is updated by the node for every 60 sec. The regular update contains the information like neighbor node ID, neighbor location and neighbor signal strength. The trigger update is used only when node moves at high speed and the signal strength of the node goes below threshold value.

3.1 Network Model

The network is presented by $G\text{H} \approx \langle V,E \rangle$, where V is the node and E represents link between 2 nodes. In proposed model, each node updates its position, mobility and signal strength to its neighbors over the network. The proposed model uses 2 cases to identify the critical link and to route the data packets from the source to destination.

3.1.1 Case1: Identifying critical paths

A critical-path-test packet dynamically allows any node in the network to discover a path to any host, whether directly reachable within the wireless transmission range or reachable through one or more intermediate hops through others. An intended node initiates a critical-path-test packet by broadcasting it to over the network, which may be received by the nodes within the wireless transmission range. If the critical path-test packet finds a path, then it is referred as non-critical path.

When node has path, it sends the message via non-critical path over the network. In case, if an intended node receives the critical-path message packet, then it sends warning message to all neighbors over the network. The node calculates the path breaking probability as follows:

$$P_b = \frac{Link\ (t)}{T_r(t)} \quad (1)$$

Here, $Link\ (t)$ is distance between 2 nodes at time t. $T_r(t)$ is transmission range of the node i. $Link\ (t)$ is defined as follows:

$$Link\ (t) = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (2)$$

$$\text{Reachability} = \frac{\text{No.of reachable nodes}}{\text{Total no.of of nodes}} \quad (3)$$

$$Gain = \frac{A}{B} \quad (4)$$

A = Number of nodes are reachable within a broadcast packet.

B = Total number of broadcast packets.

This method is to avoid breakdown usually for short-term due to the limitations from the neighbors. The nodes with critical links may not adjust their trajectories beyond a limit resulting in its failure. It potential partitions are of large sizes, it would be preferable to maintain them fixed as extensive as possible.

3.1.2 Case 2: Signal strength

Every node calculates the signal strength as follows: $i\ (R_i - d_{ij})\ /\ M$, where d_{ij} is the current distance between the nodes i and j at time t. M is the average mobility and R_i is the transmission range of the node i.

Let $S_{ij}(t)$ is the signal strength value at time t and is defined as follows:

$$S_{ij}(t) = S_{ij}(t) - S_{ij}(t - \theta t) \quad (5)$$

Here, $S_{ij}(t)$ is the present signal strength value of the node i received by the node j. The $S_{ij}(t - \theta t)$ is the previous signal strength value at time $(t - \theta t)$, where θt is a sample interval. The $S'_{ij}(t)$ is changing rate of the signal strength and is defined as follows:

$$S'_{ij}(t) = S_{ij}(t)\ /\ \theta t \quad (6)$$

Each node maintains the signal strength table and routing table to forward the data from one node to another. In Figure 1, the node 1 has message to transmit to the node 6. First, it finds a path based on the signal strength (Table 1, the values are taken from the Figure 1). Each node sends the beacon signal to all neighbors for every 60 sec. All the nodes receive and store it in their tables. Each node measures the signal strength by using the device driver interface. The routing table contains the source address, destination address and residual battery capacity of the node. By using hello packet, every node collects the neighbor locations, neighbor speeds and signal strength values over the network. The format of the hello packet is shown in Table 2.

Destination node	Next node
2	-
3	-
4	2
5	2
6	3

Table 1. Routing table at node 1

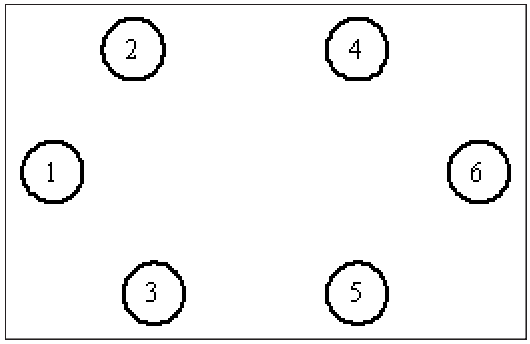

Figure 1. Structure of the MANET

Since the criteria for becoming non-critical node is the neighbor count, all nodes in the network have to monitor their neighbor nodes periodically. Every node sends a broadcast packet with time-to-live filed so that the broadcast packet is heard by neighbor nodes only, which in terns send acknowledgement. This way every node keeps the up-to-date information.

SNo	Node -ID	Location	Speed

Table 2. Hello packet

4. Simulation Model and Results

In this section, I will explain some of the parameters, which are used in the simulation. Then, I will present the simulation results and will compare the performance of all 3 models.

Parameters	**Value**
Simulator	NS-2.334
Topology area	1,000 m × 1,000 m
Simulation time	5,00 sec
Traffic type	CBR
Packet size	512 bytes
Hello_packet_interval	1 sec
Node mobility	0-20 m/ sec
Frequency	2.4 Ghz
Channel capacity	2 Mbps
Transmission power	600 mW
Receiving power	300 mW
Mobility	Random waypoint model
Transmission range	150 m
Battery voltage	5 V
Initial energy of nodes	7 J
Pause time	1 sec
Weak node	2.2 V
Threshold value(θ)	3.5 V

Table 3. Simulation parameters

4.1. Simulation Environment

The simulation environment has shown in Table 3. Here, I have used Network Simulator(NS-2.334) to test the performance of 3 routing algorithms. The proposed model simulated in area of 1,000 m × 1,000 m with 100 mobile nodes and used the random waypoint mobility model. The mobile speed of each node was varied from 0-20 m/sec and the transmission range of each node was 250 m. We used Constant Bit Rate(CBR) traffic over the networks and the data packet size fixed with 512 bytes. The data transmission rate was set to 2 Mbps. Total simulation time was conducted for 500 sec. The source and destination nodes were randomly chosen. Each node was randomly assigned an initial energy. In this work, I used node density, size of network partition and number of active nodes participating in the network to test the performance.

4.2 Node Density

In this scenario, 100 nodes are spread within the defined area. The node mobility varies from 1 to 10 m/sec, 5 source nodes transmit the data at the rate of 5 pkts/sec. Figure 2 shows the packet loss versus node density. Here, it is clearly shown that at low density, the number of packet loss is more in the both RPGM and RPGM models, whereas in the proposed model, the packet loss is very low. In the both models of RPGM and RPGM, there is less chance of having alternative paths due to the limited number of nodes. As the node density increases, for example at 60, there are more possible routes for same destination node resulting in decrease of the number of packet loss at 181 for RPGM model and 163 with RVGM model whereas the proposed model with 91. In proposed model, the packet loss has come down drastically.

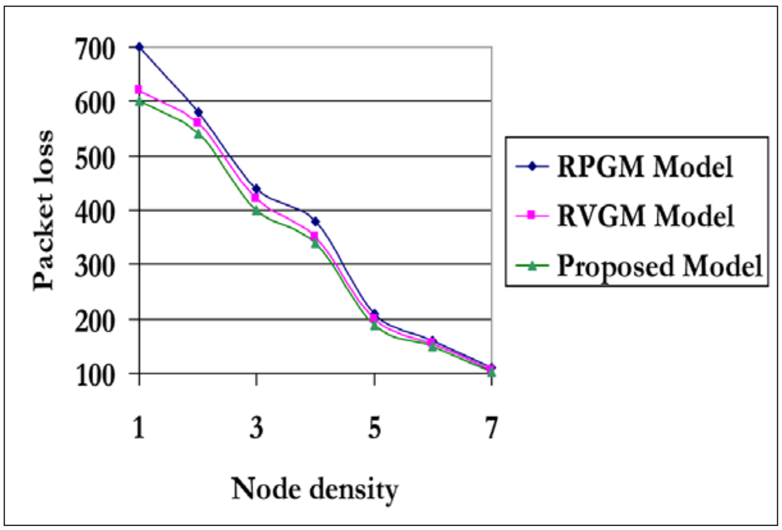

Figure 2. Node density versus packet loss

4.3 Size of Network Partition

Here, it has considered 25 nodes and the number of data packets sends between 0-80 packets/sec and each node travels constantly with 2 m/sec. The experimental setup has executed 20 times with different arrival rate of the packets in a given topology. Figure 3 shows the problem of network partition size for dissimilar node densities. In all situations, the occurrence of partition, e.g., separated nodes and partitions of 5 nodes is general. For low node density, these small sizes of the network partition are dominated. For large node density, the occurrence of very large network partition becomes more frequent and leads to a large standard deviation for the size of the network partition if the system uses RPGM and RVGM models. The results that the average sized partitions are rarely leads to the conclusion. If a node is not located inside a small partition, there is a high probability that it is located in a large partition. Detecting a node whether is in a small network partition with relatively low communication overhead by calculating k-hop neighborhood.

4.4. Number of Active Nodes

In this setup, it has considered 100 nodes deploying within the defined area and node mobility varies from 0-30 m/sec. In fact, the simulation executed 25 times with the different speeds in a given topology. The number of active nodes participating in the network against the simulation time is shown in fig.4. It is shown that if the threshold value (2.5 volts) is small, then the number of active nodes participating in the network in the proposed model is 173(120 for RPGM model and 161 for RVGM model). In the proposed model, new routes start before the node battery gets drained-out completely.

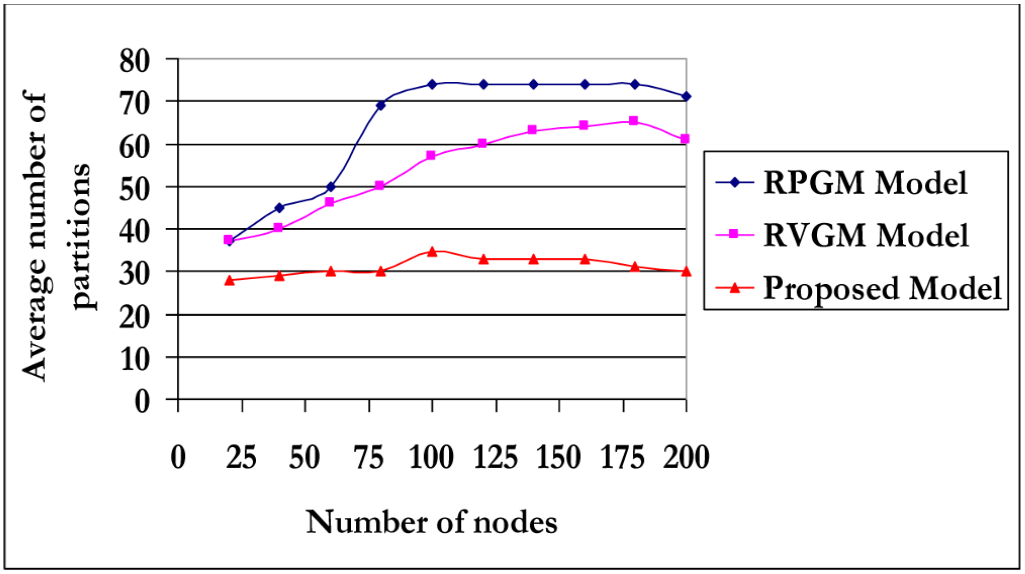

Figure 3. Average number of partitions

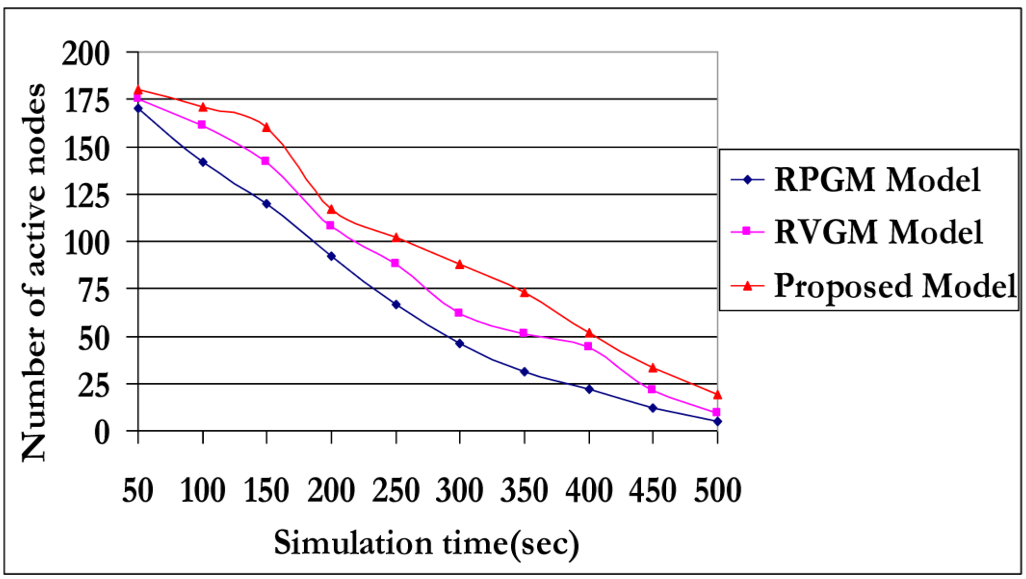

Figure 4. Number of active nodes

5. Conclusion

In this paper, I have discussed the network partition problem. The proposed system used the node location and signal strength to predict the network partition and critical link. The proposed model simulated using NS-2.334 with the help of 100 mobile nodes. It has compared with the reference-point-group-mobility model and reference-velocity-group-mobility model in terms of node densities, size of partitions and number of active nodes participating in the network. The simulation results are shown that the proposed model has increased the average number of nodes. If the node density is 60, then the number of packet loss is more (181) for RPGM model and 163 with RVGM model, whereas the proposed model with 91. If the remaining battery of the node is 2.5 V, then the number of active nodes participating in the network in the proposed model is 173, whereas in RPGM model with 120 and 161 for RVGM model.

References

[1] Merlinda Drini, Tarek Saadawi. (2008). Modeling Wireless Channel for Adhoc Network Routing Protocol. *In*: Proceedings of ISCC, p. 549-555.

[2] Bheemalingaiah, M. *el al*. (2009). Power aware Node-Disjoint Multipath Source Routing with Low Overhead in Mobile Adhoc Network. *International Journal of Mobile Network Design and Innovation*, 3 (1) 33-45.

[3] Fuad Alnajjar, Tarek Saadawi. (2009). Social stratification Probabilistic Routing Algorithm in Delay-Tolerant Networks.*In*: Proceedings WASA, p. 579–591.

[4] Varaprasad, G., RSD. Wahidabanu. (2009). Signal Stability Routing Algorithm for Mobile Ad hoc Networks. *International Journal of Wireless Networks and Communication*, 1 (2) 119-126.

[5] Hahner, J., Dudkowski, D., Marron, P. J., Rothermel, K. (2007). Quantifying Network Partitioning in Mobile Ad Hoc Networks. *In*: Proceedings of IEEE MDM', p174-181.

[6] Vincent D. Park, Scott Corson, M. (1997). A Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks. Proceedings of IEEE INFOCOM, p. 1405-1413.

[7] Raghunathan, *S. el al*. (2000). Gateway Routing: a Cluster Based Mechanism for Recovery From Mobile Host Partitioning in Cellular Networks. *In*: Proceedings of IEEE ASSET, p. 135–139

[8] Varaprasad, G. (2011). Lifetime Enhancement Routing Algorithm for Mobile Ad hoc Networks. *IET Communications*, 5 (1) 119-125.

[9] Samarth H. Shah, Kai Chen, Klara Nahrstedt. (2002).Cross-Layer Design for Data Accessibility in Mobile Ad hoc Networks. *Journal of Wireless Personal Communications*, 21 (1) 49-75.

[10] Varaprasad, G., Venkataram, P. (2007).The Analysis of Secure Routing in Mobile Ad Hoc Network. *In*: Proceedings of IEEE *Conference on Computational Intelligence and Multimedia Applications*, p.393-397.

[11] Wang, K. H., Li, B. (2002). Group Mobility and Partition Prediction in Wireless Ad-hoc Networks, *In*: Proceedings of IEEE International Conference on Communications, p. 1017-1021.

[12] Varaprasad, G., Wahidabanu, R. S. D., Venkataram, P. (2007). New Power Aware Routing Algorithm for MANETs Using Gateway Node. *In*: Proceedings of IEEE International Conference on Parallel and Distributed Systems, p. 1-4 .

[13] Kejun Wu *el al.* (2006). A Multi-Group Coordination Mobility Model for Ad Hoc Networks. *In*: Proceedings of IEEE MILCOM, p. 1-5.

[14] Goyal, D., Caffery, J. Jr. (2002).Partitioning Avoidance in Mobile Ad Hoc Networks Using Network Survivability Concepts. *In*: Proceedings of IEEE International Symposium on Computers and Communications, p. 553-555.

[15] Shiva Murthy G., Souza, R. J. D. *el al*. (2012). Digital Signature Based Secure Node Disjoint Multipath Routing Protocol for Wireless Sensor Networks. *IEEE Sensor Journal*, 12 (10) 2941-2949.

[16] Killijian, M., Riviere, N., Roy, M. (2007). Experimental Evaluation of Resilience for Ubiquitous Mobile Systems. *In*: Proceedings of IEEE Workshop on Ubiquitous Systems. Evaluation, p. 283–287.