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Influence of Suppleness in Multi hop Wireless Network Topology Reconfiguration

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Abstract. In Mobile Ad Hoc Networks (MANETs) a highly dynamic topology and the presence of transient links are the major challenges for maintaining connectivity and performing efficiently when subjected to varying network conditions. Links between nodes are created and broken, as the nodes move within the network. The node mobility not only affects the source and/or destination, but also intermediate nodes. Thus topology reconfiguration mainly depends on the movement pattern of participating nodes at a moment. In order to better understand this environment, this paper inspects several network parameters including node density, velocity of nodes, and transmission power of nodes, as well as mobility parameters for different speed and pause times. The results reveal several properties that should be considered in the design of topology reconfiguration of MANET.

Keywords: MANET, topologyreconfiguration, mobility.

1. Introduction

Mobile Ad-hoc Network (MANET) is a kind of temporary network comprising of mobile nodes with wireless transceivers, which enables self-organizing of mobile nodes into temporary ad hoc topologies. Minimal configuration, rapid deployment and the lack of a central governing authority make mobile ad hoc networks suitable for emergency situations like natural disasters, emergency medical circumstances etc. Future advances in technology will allow us to form small ad hoc networks on campuses, during conferences and even in our own homes.

In MANET, each mobile node (MN) serves as a router, and may move at random and dynamically connected to form a network depending on their positions and transmission range. The topology of the ad hoc network depends on the transmission power of the nodes and the location of the MNs, which may change with time. Thus it is important to predict the mobility of nodes to keep the topology always connected or to reconfigure the topology as per the current status of the network.

Unlike fixed network, MANET topology depends on uncontrollable factors such as node mobility, weather, interference, noise as well as controllable factors such as transmission power, directional antennas and multi-channel communications [2]. However, the node velocity and density are often invariable parameters in ad hoc environment.

The mobility of limited power nodes with different speed often causes changes in the ad hoc network structure. In sparse networks with low node densities, movement of mobile hosts in contrasting patterns causes network partitioning. [4]Whereas in dense networks higher connectivity among the nodes will exist due to the higher node degrees. As MANET cannot be regarded as a reliable communication system when it partitions [5], reconfiguring the topology of the network is essential.

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In order to reconfigure the nodes in ad hoc networks, knowing the impact of speed, density and pause time are most important. Thus this paper inspects the correlation between node density, velocity of nodes, pause time and their transmission power. Besides, it demonstrates the effect of them in topology reconfiguration.

2. MANET Topology

The topology of a multi-hop wireless network is generally represented by a graph G = (V, E), where V is the set of nodes u and E is the set of links (u,v) in the network. In MANET, the network topology is formed based on the nodes transmission ranges and routes of node movement. Since node position and link between them are dynamic in adhoc networks, maintaining connectivity between the mobile nodes is a very big challenge in the mobile environment.

The topology of the ad hoc network depends on the transmission power of the nodes and the location of the MNs, which may change with time. The presence of wireless communication and mobility make an ad hoc network unlike a traditional wired network, and requires the routing protocols used in ad hoc network based on new and different principles.

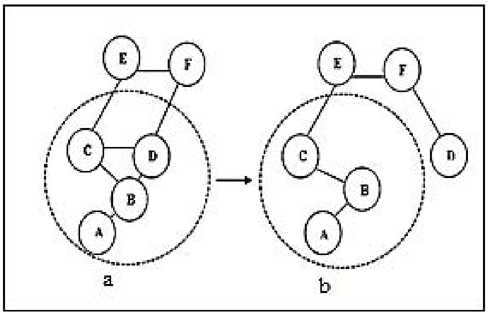

Fig. 1: Topology change in ad hoc networks

In Fig1.Mobile nodes A, B, C, D, E, and F constitute an ad hoc network. The dotted circles represent the radio range of node A. The topology of the network is initially as in (a), when node D moves out of the radio range of A, the network topology changes to the one in (b).The topology will be regarded as quality one only if it maintains connectivity between the participating nodes in an energy efficient method and being robust to mobility.

2.1. Impact of mobility

In mobile ad hoc networks (MANETs), node mobility induces the network topology to change randomly and rapidly at unpredictable times. Hence, the networktopology is vulnerable to frequent link failure and network partitioning, which could incur extensive routing overhead, excessive transmission delay and packet loss among mobile nodes. [5]The mobility models describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time. Mobility models can be categorized into several classes based on their specific mobility characteristics.

For some mobility models, the movement of a mobile node is likely to be affected by its movement history. This type of mobility model is referred as mobility model with temporal dependency. In some mobility scenarios, the mobile nodes tend to travel in a correlated manner. Such models are referred as mobility models with spatial dependency. Another class is the mobility model with geographic restriction, where the movement of nodes is bounded by streets, freeways or obstacles.

2.2. Random waypoint model

In order to test the effects of mobility, a random way point model, the most commonly used mobility model in research group is used. In this model at every instant, a node randomly chooses a destination and moves towards it with a velocity chosen randomly from a uniform distribution [0, V_{max}], where V_{max} is the maximum allowable velocity for every mobile node. After reaching the destination, the node stops for a duration defined by the 'pause time' parameter. After this duration, it again chooses a random destination and repeats the whole process until the simulation ends. [4]In the Random Waypoint model, velocity (V) and pause time (T) are the two key parameters that determine the mobility behaviour of nodes. Figure2 shows an example travelling pattern of a MN usingtheRandom Waypoint Mobility Model starting at a randomly chosen point.

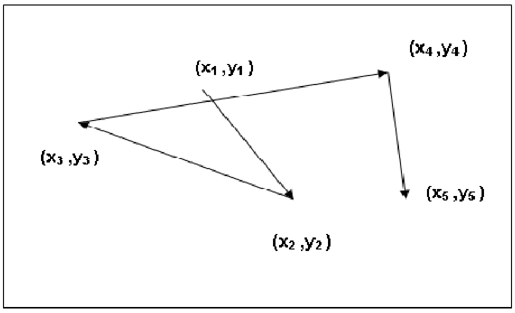

Fig. 2: Movement pattern of a MN using Random Waypoint Model

3. TopologyControl and Reconfiguration

Whenever the link between the nodes in MANET changes due to the mobility of participating nodes - routing gets affected, congestion may occur, data transfer rate varies and thus affects the reliability, security, and quality of service of the network. The physical structure of the system gets changed, leading to dead lock and thereby affecting the robustness. The overall system reliability will thus become a problem.

Topology control plays a vital role in solving such problems, it computes and preserves connected topology among the network nodes. It changes the current topology in response to changes in link capacities and load demands of various nodes. As a part it involves topology reconfiguration scheme to break and set up links to create a new topology, so that when the links or nodes fail, fault-tolerant operation and rapid service reconfiguration can be achieved. In general reconfiguration is the ability of recovery, self-healing and survivability in the failure and unsafe environment. Dynamic topology reconfiguration can be achieved by controlling the velocity as well the direction of movement of nodes without increasing its transmission power which is scarce in mobile nodes.

4. Simulation Environment, Results and Analysis

The authors used the Random Waypoint mobility model with minimum and maximum speeds of 10 ms^{-1} and 70 ms^{-1} respectively and the pause time is set to 20s to 100s. Nodes are uniformly distributed and CBR (Constant Bit Rate) traffic with data packets of size 512 bytes are transmitted at an arrival rate of 10 packets per second. Our simulation settings and parameters are summarized in Table 1.

Table. 1: Simulation Parameters

Parameters	Values
No. of mobile Nodes	10,20, 30, 40, 50
Transmission Power (W)	0.02,0.04,0.06,0.08,0.1
Area (m^2)	1000
Speed (m /sec)	10,20,30,40,50,60,70
Pause Time (sec)	20, 40, 60, 80, 100.
Traffic Source	CBR
Routing protocol	AODV
Application	FTP
Node density(N)	(N-1)

Figure 3 shows the capriciousness of average rate of successful message delivery over a communication channel due to the randomness of the participating nodes.

Figure 4reveals that the increase in node density increases the additional transceivers in the network and hence the end-to-end delay decreases.

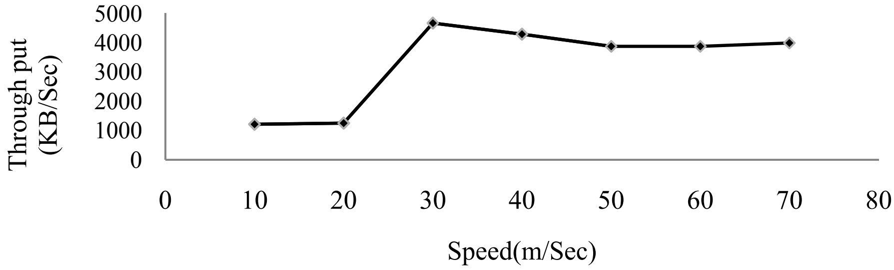

Fig. 3: Speed Vs throughput

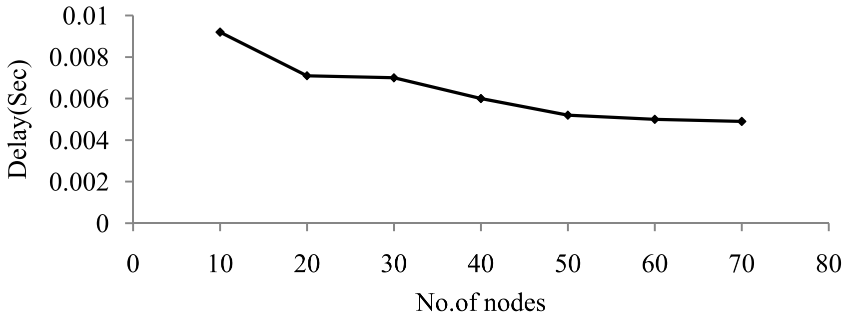

Fig. 4: Number of nodes Vs Delay

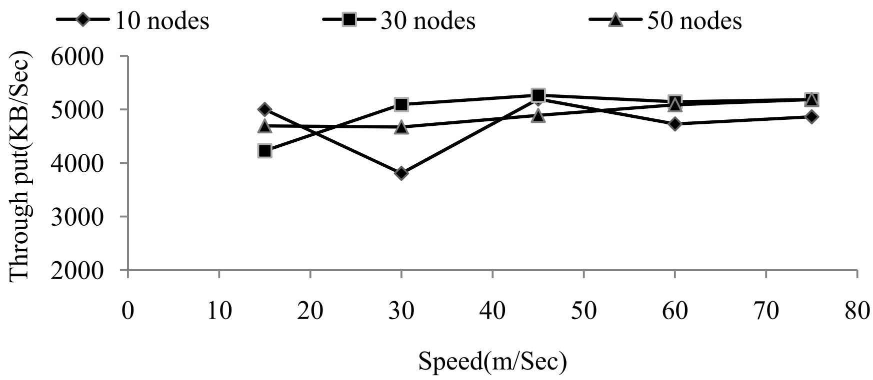

Fig. 5: Speed Vs Throughput

Figure 5 reveals that increase in node density won't ensure connection among the nodes in an ad hoc network; this is due to the presence of critical nodes whose presence or absence affects the network topology and thus the overall performance of the network.

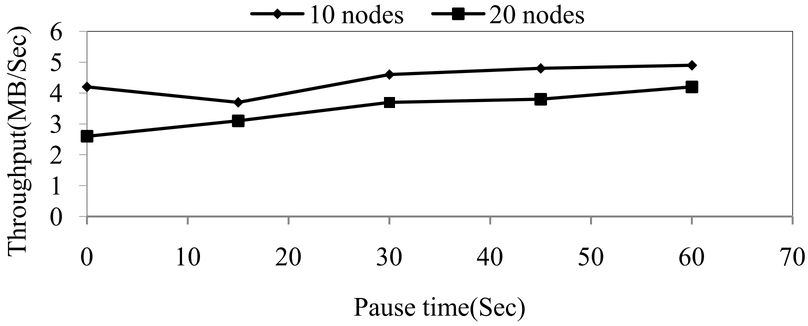

Fig. 6: Pause Time Vs Throughput

Figure6 shows that when the pause time T is long, the topology of ad hoc network becomes relatively stable. On the other hand, if the node moves fast (i.e., is large) and the pause time T is small, the topology is expected to be highly dynamic.

As the pause time decreases, the mobility increases, which increases the probability of link failures and hence the end-to-end delay increases. The probability of link failures increases as the pause time decreases.

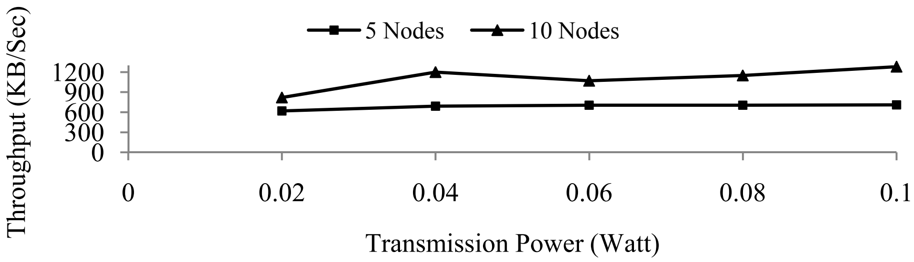

Fig. 7: Transmission power Vs Throughput

Figure7 shows that when all the nodes are travelling in uniform speed, once the connection is established among them i.e. the nodes are set to be within the range of each other, further increase in transmission power makes no use. Thus it shows that Dynamic topology reconfiguration can be achieved by controlling the velocity as well the direction of movement of nodes without increasing its transmission power which is scarce in mobile nodes.

5. Conclusion

In this paper, authors have analyzed the factors that affect the topology reconfiguration in mobile ad hoc networks. The study shows that even the increase in node density increases the number of paths for data traversing to the destination, the relative movement of nodes and failure of them may affect the topology of MANETs.

On one hand, the connectivity maintenance of ad hoc networks is at most important; on the other hand, ad hoc networks are inherently vulnerable to topology changes. Consequently, reconfiguration mechanisms that conserve the power consumption of nodes are indispensable for ad hoc networks. The idiosyncrasy of ad hoc networks poses both challenges and opportunities for these mechanisms.

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