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Effect of Random Mobility Models Pattern in Mobile Ad hoc Networks

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ABSTRACT
A mobile ad hoc network (MANET) is a network consisting of a set of wireless mobile nodes that communicate with each other without centralized control or established infrastructure. The mobility model represents the moving behavior of each mobile node (MN) in the MANET that should be realistic. It is a crucial part in the performance evaluation of MANET. In this paper, we have studied the effects of various random mobility models on the performance of AODV. For experimental purposes, we have considered three mobility scenarios: RandomWaypoint, Random Walk with Reflections and Random Walk with Wrapping. Experimental results illustrate that performance of the routing protocol varies across different parameters like number of nodes, packet delivery ratio and end to end delay.

Key words:
Ad hoc Network, performance evaluation, mobility models, Routing Protocol, AODV

Introduction
A mobile ad hoc network (MANET), is a network comprising wireless mobile nodes (MNs) that communicate with each other without centralized control or established infrastructure. MNs that are within each other's radio range can communicate directly, while distance MNs rely on their neighboring MNs to forward packets. Each MN acts as either a host or router. In MANET environment, MNs are free to join or leave the network at any point of time, resulting in a highly dynamic network environment compared to wired network.
Mobility models define nodes' movement pattern in ad hoc networks. Since, MANETs are currently not deployed on a large scale and due to the inherent randomness of mobility models, research in evaluating the performance of routing protocols on various mobility models are simulation based. Therefore in most of the cases performance analysis is carried out using various popular simulators like ns-2[5], GloMoSim [6], Qualnet [7] or Opnet [8]. In this paper, the performance of MANET using AODV routing protocol is evaluated by comparing different mobility models like Random Waypoint mobility and Random Walk with wrapping mobility model. [1] AODV (Ad hoc On-demand Distance Vector) [2] is a dynamic, self –starting, multi-hop on-demand routing protocol for mobile wireless ad hoc networks. AODV discovers paths without source routing and maintains table instance of route cache. This is loop free and uses destination sequence numbers. In AODV a node informs its neighbors about its own existence by constantly sending ``hello messages" at a defined interval. This enables all nodes to know the status about their neighbors,
i.e. if they gone down or moved out of reach. To resolve a route to another node in the network AODV floods its neighbors with a route request (RREQ). The receiving node checks if it has a route to the specified node. If a route exists then the receiving node replies to the requesting by sending a route reply (RREP). If on the other hand a route does not exist the receiving node sends a RREQ itself to try to find a route for the requesting node. If the original node does not receive an answer within a time-limit the node can deduce that the sought nodes are unreachable. To be sure that the route still exists, the sender has to keep the route alive by periodically sending packets. All nodes along the route are responsible for the upstream links which means that a broken link will be discovered by the closest node. This node signal the broken link by sending an error message (RERR) downstream so that the using nodes can start to search for a new route.

Related work

In [3] the authors have shown that the mobility model used can significantly impact the performance of ad hoc routing protocols, including the packet delivery ratio, the control overhead and the data packet delay.
A framework to evaluate the impact of different mobility models on the performance of MANET routing protocols is provided in [11]. Various protocol independent metrics are provided to capture interesting mobility characteristics like spatial and temporal dependence and geographic restrictions. In addition, a rich set of parameterized

mobility models is introduced including Random Waypoint, Group Mobility, Freeway and Manhattan models. It is shown that the performance of various protocols like DSR, AODV and DSDV vary with the mobility models used.
The performance of two on demand routing protocols for mobile ad hoc networks DSR and AODV are compared in [13]. It is shown that even though DSR and AODV share similar on demand behavior, the differences in the protocol mechanics can lead to significant performance differentials. Here the difference in the performance is analyzed using varying network load, random waypoint mobility model and network size.
Various protocols like DSDV, AODV, DSR and TORA are compared in [12]. The performance parameters considered for analyzing are mobility rate, network load and network size. It is shown that DSR generates less routing load then AODV and also AODV suffers from end to end delays while TORA has high routing overhead. DSDV packet delivery fraction is very low for high mobility scenarios.
Hong et al[14] introduced a mobility model called the mobility Vector Model and compared the performance of the routing protocols DSR, AODV and FSR using mobility model along with other mobility models like Random Walk, RPGM and the Random Waypoint Model. The metrics measured were Link Up/Down rate and Packet Delivery Ratio with variations of average speed and transmission range respectively.
Hence, it is important to use the mobility models that accurately represent the intended scenarios in which the protocol is likely to be utilized. In this way, the performance of the protocol can be more accurately predicted.

Mobility models

The Mobility model is designed to describe the movement pattern of MNs, and how their speeds and directions are changed over the time. Currently there are two types of Mobility models used in the simulation study of MANET: traces base model and synthetic base model [4]. The traces base model obtains deterministic data from the real system. This mobility model is still in its early stage of research, therefore it is not recommended to be used. The synthetic base model is the imaginative model that used statistics. The movement of each MN to its destination has a pattern that can be described by a statistical model that expresses the movement behavior in the real environment.

Random Waypoint Mobility model

The random way point mobility model is simple and is widely used to evaluate the performance of MANETs. The random way point mobility model contains pause time between changes in direction and/or speed [9, 10].
Once a Mobile Node begins to move, it stays in one location for a specified pause time. After the specified pause time is elapsed, the MN randomly selects the next destination in the simulation area and chooses a speed uniformly distributed between the minimum speed and maximum speed and travels with a speed *v* whose value is uniformly chosen in the interval (0, V_{max}). V_{max} is some parameter that can be set to reflect the degree of mobility. Then, the MN continues its journey toward the newly selected destination at the chosen speed. As soon as the MN arrives at the destination, it stays again for the indicated pause time before repeating the process. Fig 1 shows a traveling pattern of a mobile node using the random waypoint mobility model starting at a randomly chosen point or position.

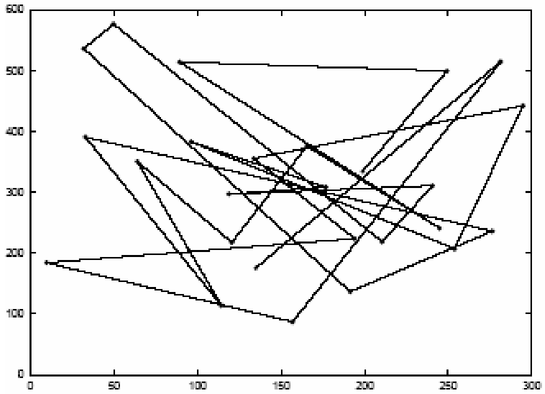

Fig 1. Traveling Pattern of a MN using Random Waypoint MobilityModel

Random Walk with Wrapping Mobility model

This model is similar to the random waypoint, but at a trip transition instant, a node picks direction, trip duration and numeric speed. The node moves in the given direction with the given numeric speed for the given numeric speed for the given trip duration. If on a trip, the node hits the boundary of the domain, it is wrapped around into the domain. The steady state version of this model is such thatnode position is uniformly distributed on the domain, the node speed has the same distribution as at a trip transitioninstant. [15]

Random Walk with Reflection Mobility model

The difference between this model and random walk with Wrapping is that whenever a node hits the boundary of the domain, it is not wrapped around, but reflected into the domain itself [15].

Simulation Environment

Simulation Setup

The MANET network simulations are implemented using the Scenario Generation tool and NS-2 simulator. The mobility models are computed using scenario generating programs, whose results are imported into the NS-2 simulation models. Each node is then assigned a particulartrajectory. The simulation period for each scenario is 900seconds and the simulated mobility network area is 800 mx 500 m rectangle. Simulation runs are made with the number of nodes varying from 5 to 25. In each simulationscenario, the nodes are initially located at the center of thesimulation region. The nodes start moving after the first 10seconds of simulated time. The MAC layer protocol IEEE
802.11 is used in all simulations with the data rate 11 Mbps. The transmission range is 250m. The application used to generate is CBR traffic and IP is used as Network layer protocol. The performance evaluation, as well as thedesign and development of routing protocols for MANETs, requires additional parameters which is addressed in RFC developed by Internet Engineering Task Force (IETF). Mobility scenario generator Scenario Generation tool produces the different mobility patterns following Random Waypoint, Random Walk-Reflections and Random Walk-Wrapping according to the format required by the *ns-2.*The movement was controlled as per the specifications of the respective models. If a node crosses the boundary of the area it is re-inserted at the beginning position in a randomly chosen lane.

4.2 Mobility Metrics

We have selected the Packet Delivery Ratio, Average end-to-end delay and Protocol Control Overhead as a metrics during the simulation in order to evaluate the performanceof the different protocols:
Packet Delivery Ratio: This is the number of packets sentfrom the source to the number of received at the destination.
Average end-to-end delay: This is the average time delay for data packets from the source node to the destination node.
Protocol Control Overhead: This is the ratio of the number of protocol control packets transmitted to the number of data packets received.

Results and analysis

We investigated the effect of mobility on relative rankingsof protocol performance.

Effect on the Performance

Random Way Point mobility pattern was generated using the Scenario Generation tool, which is a support the format of ns-2 distribution. The nodes are configured witha constant pause interval of 100 seconds. The speed is a uniform random variable, with a maximum value changing in each simulation run. The Fig 1 shows the Packet Delivery Ratio with Random Way Point mobility model. Itis observed that the mobility models drastically affect protocol performance.

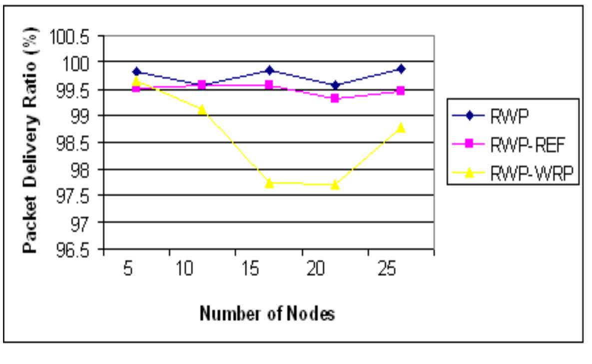

Fig 2.Packet Delivery Ratio vs. Number of nodes

We investigated the effect of mobility on relative performance of protocols. We observe that Random Waypoint seems to produce the highest throughput. But the throughput of Random Walk-Reflections and Random Walk-Wrapping drastically falls over a period of time. Random Walk-Reflections shows moderate packet delivery ratio.

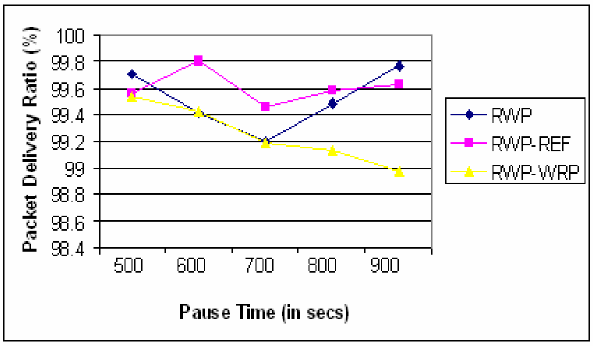

Fig 3. Packet Delivery Ratio vs. Pause Time

The delay on Random waypoint is less as compared with two other models

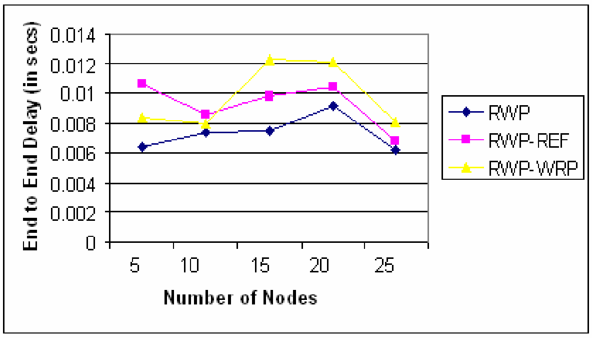

Fig 4. End-to-End Delay vs. Number of nodes

Effect on the Delay

The delay on Random waypoint is less as compared with other two models.

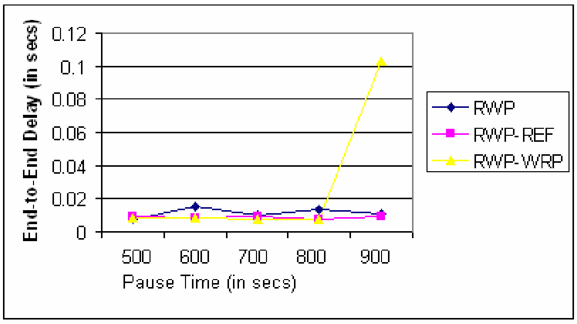

Fig 5. End-to-End Delay vs. Pause Time

We observed that Random Walk with wrapping achieve the highest delay with node density as well as mobility. The relative rankings of protocols may vary with themobility model used.

Effect on the Routing Overhead

The effect on the routing overhead is very less with Random Walk model with wrapping. But the other two models suffer a lot from routing overhead packets.

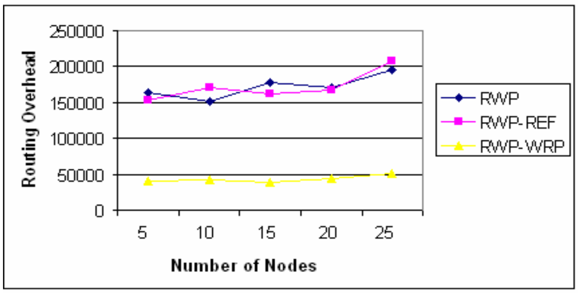

Fig 6. Routing Overhead vs. Number of nodes

We also observed that Random Walk with wrapping achieve the lowest routing overhead with node density as well as mobility.

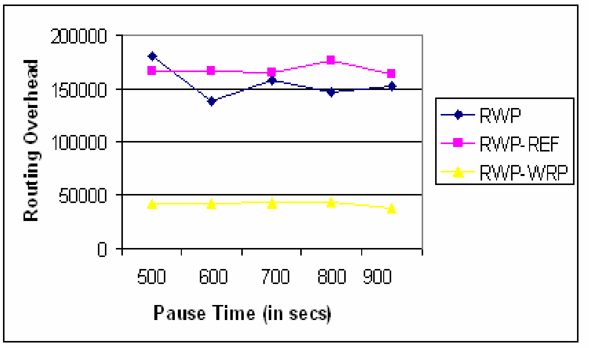

Fig 7. Routing Overhead vs. Pause Time

Conclusion

In this paper we calculate packet delivery ratio, end to end delay and routing overhead to evaluate the performance of a routing protocol. Empirical results illustrate that the performance of a routing protocol varies widely across different mobility models.

With reference to the performance, we observe that the Random Waypoint produces the highest throughput. But the throughput of the Random Walk with Reflection and Random Walk with wrapping drastically falls over a period of time and also Random walk with Reflection shows moderate packet delivery ratio.

We observe that Random Walk with Wrapping has the highest delay with node density as well as mobility.

Also the effect of the routing overhead is very less with Random Walk model with Wrapping. But the other two models suffer a lot from routing overhead packets.

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