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Optimization of Dynamic Source Routing Protocol Considering the Mobility Effect of Nodes in Cache parameter using OPNET

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Abstract

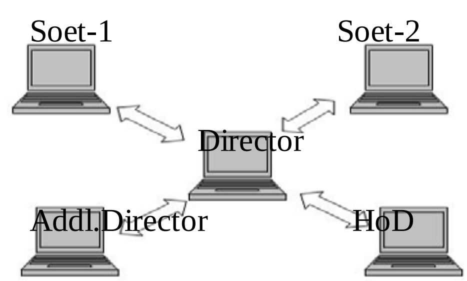
In this paper we propose a method of improving the performance of Dynamic Source Routing (DSR) protocol. In DSR, as well as other on-demand routing protocols, every established path is considered as temporary to reflect the mobility effect, therefore, once a path is established, it is associated with an expiration time. After the route expiration time the path is deleted from the route cache of the nodes. In practice the mobility of nodes are not equal all the time and we propose to treat paths differently according to their stationary, rather than deleting them after every route expiration time to improve performance. By simulation we show that this method improves the performance of DSR.

Keywords: DSR, MANET, On-Demand Routing Protocol, Route Cache Management.

1. Introduction

Two or more mobile devices that have networking capabilities and wireless communications are said to establish a MANET. The mobile device should be within their radio ranges. A destination mobile device that is out of radio range from the source mobile device, an intermediate mobile device that is within radio range with the destination mobile device can forward the packets from the source mobile device to the destination destination mobile device.

According to [1], it is proposed an ad hoc wireless network to be self-organizing and adaptive. This suggests that, the MANET can be formed and be reformed without any system administration. The MANET can be represented in various forms, which can be standalone, mobile, or networked. An mobile device has the capability to detect the availability of other mobile device within the radio perimeter, this enable a routing handshake to be established which gives room for communication and sharing of information among the mobile device. The MANET does not require any fixed router or fixed radio base stations to make connection. The MANET that has two or more mobile devices that is of the same type is said to set up homogeneous mobile device network as can been seen in figure 1 below.



Heterogeneity comes into MANET due to the kinds of mobile devices that made up the MANET. Heterogeneity has some effect in mobile devices communication performance and the design of the communication protocols according to [1]. It shows that, these mobile devices have differences in terms of their size, memory, computational power, and battery capacity. Mobile devices features allow some mobile device to act as a server while others can act as a client. Examples take a scenario of different types of MDs for School of Engineering and Technology (SoET) campus where Director have Pocket PC, Additional Director have laptop, Faculty members haves cellular phones etc. MANET that is set up by different types of mobile devices is said to be heterogeneous mobile device network, as can be seen below in figure 2.

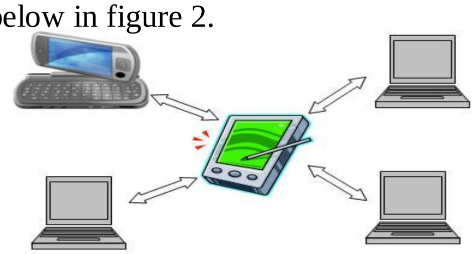


Figure 2: Heterogeneous Mobile Device Network Of SoET

Mobile Device Movement.

When in MANET, MD are always moving. This movement can be initiated either by the source node, destination node, or the intermediate node. These MD movements allow the network to take different shape. Due to change in the Topology the movement of these mobile devices affects directly the routed information i.e. routing table of each MD require to update dynamically.

Among all other challenges in launching MANET, routing is the most crucial as there is no supporting infrastructure. Depending upon the mechanism and functionalities MANET routing protocols can be classified into three categories: *table-driven* or proactive, *on-demand* or reactive and *hybrid* routing protocols. Among the table driven routing protocols Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm [22], Wireless Routing Protocol (WRP) [15], Global State Routing (GSR) [11], Fisheye State Routing (FSR) [12], Hierarchical State Routing (HSR) [12], Zone-based Hierarchical Link State Routing Protocol (ZHLS) [13] are popular. Among on-demand routing protocols Cluster Based Routing protocol (CBRP) [4], Ad-hoc On-demand Distance Vector Routing (AODV) [5], Temporally Ordered Routing Algorithm (TORA) [5], Dynamic Source Routing Protocol (DSR) [1] are famous and there are also some other routing protocols which are utilizing different mechanisms for better performance and to support more features. Among all on-demand routing protocols DSR is straight forward, simple, and recently a lot of modifications and improvements are going on in this protocol. Some are introducing security and power issues [7] and many other concepts. Therefore we are closely examining the protocol and its performance under various working conditions using simulation techniques. We also propose a modification for the DSR protocol to enhance its performance. The following reviews the basic operation of DSR and its main features.

DSR in brief: In DSR, to send a packet to a destination, the source inserts a routing path with the packet. The path contains the node information following which the packet is transmitted. Each mobile host participating in the ad hoc network maintains a route cache in which it caches source routes that it has learned. When one host sends a packet to another, the sender first checks its route cache for a source route to the destination. If the route is found, the sender uses that route entry to transmit the packet. If no route entry is found, the sender may attempt to discover one using the route discovery mechanism. Until the route is discovered, the sender host will be waiting and during this time it can do other operations like sending or forwarding other packets. Once the route is discovered, the sender sends its required packets using the new learned route. Finally the packet of interest is received by the destination. The sender updates its route caches too for that particular destination for future use.

When a sender does not know the path to a node to which it wants to send a packet, it generates a route request packet and broadcasts to its neighbors. The neighbors get the packet and give route information either if they have that in their cache or if the destination is their neighbor. Otherwise they again re-broadcast the same packet to their non recipient neighbors. Finally, when this packet reaches to the destination, it replies a route reply packet through the reverse path the packet traveled. When this packet comes back to the originator, it updates its routing cache and start sending packets using this newly discovered path. If the originator receives multiple route reply packets, it keeps the shortest one. Also it stores the current time along with the cache entry in order to keep track of how old the path is. Since topology of an ad-hoc network might change frequently, a path is not used for a long time. Therefore, a cache expiration time is enforced after which the entry is deleted. A route maintenance agent periodically checks all links and updates the route cache of a node. It also checks whether there is any routing error while transmitting packets. If there is any route error due to a sudden link failure, this entity immediately informs the sender about the link failure. Sender then deletes the route entry and broadcasts a route request packet. Sometimes optimization is possible in route cache. As for example, node A has a path information in route cache for node B and the path length is x. Now if A gets another packet whose source or destination is B and path length is x' where x > x', A immediately can remove the old path by the new one. The studies in [1][2] describe the detailed algorithm and operation of DSR. In section 2 we discuss related work, while in section 3 the proposed stationary effect is presented. Section 4 describes the simulation model and the performance results are discussed in section 5. Finally section 6 states the main conclusions.

2. Related Work

A lot of researches have been done in different routing techniques both in wired and wireless networks. In fact the efficiency of the network and internet is depending upon the performance of routing algorithms. Therefore many research works analyzed the performance of routing protocols intensively last few decades. On the other hand ad-hoc network is a very new area. Though it has a very demanding and rising future, it is deployed in limited scopes. Since all the nodes in an ad -hoc network work as routers, routing algorithms have become more crucial for deploying such network. Recently many ad-hoc routing techniques have been proposed. Therefore performance improvement and measurement of MANET routing algorithm become a hot research topic. Some researches measure the overhead and performance of reactive routing protocols. Authors of [16] present a mathematical and simulation based measurement of overhead in DSR Link failure is common in MANET due to the mobility. Every link failure will increase the average packet delivery latency because packets are to wait for the path to be re-established or retransmitted from the originator. In [6] authors have introduced a directional antenna to transmit packets over a long distance when there is a link failure due to the disappearance of a node. They simulated and showed a positive effect of this proposal using the DSR protocol. Routing overhead and route discovery delay should reduce to increase the performance of routing protocol. In DSR keeping route cache up to date with the topology change is very difficult. If the

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link failure information is broadcasted by a node, the whole network will be flooded with these overhead packets. The study in [9] proposes several methods of keeping the route cache up-to-date which might adapt to frequent topology changes. They propose three techniques for improving cache correctness. Those are wider
rror notification, time based route expiry and negative cache. The authors in [10] propose modifications of DSR which compromise the on-demand characteristic of the protocol. In DSR, after a timeout the cache entry will expire to reflect the mobility. But in reality MANET's behavior is uncertain. So instead of this idea the authors propose to modify the original DSR protocol a little closer to reactive routing. Where, they propose after a link failure there should be a mechanism which will propagate the failure information to all the nodes in the network. Authors in [8] introduce some issues to minimize the delay for routing for on-demand routing protocol in ad -hoc network. They propose a way of optimizing the Time -to-Live (TTL) of route cache. A good caching mechanism can reduce the overhead of DSR and can improve the performance of the protocol. The work in [3] proposes an adaptive link timeout mechanism. They show an appropriate timeout mechanism for link cache which reduces the routing overhead significantly. Stale cache has a very bad impact on performance where the cache size is critical especially in MANET nodes. The authors of [18] propose a timer -based stale link expiry mechanism where they show that their proposed link cache strategy achieves significant performance improvement. We think that research which relates the cache management to the mobility behavior especially the stationary effect of nodes would have an important role in on-demand routing protocol.

3. Proposed Improvement in Cache Management

To keep the route cache up to date and fresh, a route expiration time is maintained in every node's cache which also reflects the transient and mobility behavior of MANET. In reality it is obvious that not all the nodes are all the time equally mobilizing. Some nodes might be kept in some fixed places; some sensor devices might be fixed to a particular place for several hours or days. So we could treat such path/route as stable until any nodes in the path changes its location. For stable paths, it is not required to remove the corresponding route cache entry. In some cases all the nodes might arrive to stable state, which might lead the ad-hoc network to a stable network. So why do we use costly routing protocol which is suitable for highly mobile network to a network which is almost stable? Therefore, we introduce this concept in DSR caching policy. All nodes are required to send their movement information (for how long those nodes are stable) with route reply packet while route discovery. May be the nodes will know this information by Global Positioning System (GPS) technology. Therefore the originator could decide whether that path is stable or not.

Let us consider an example in fig1 and fig2. There is a path from node A to E (ABCDE). Among all the nodes, B, C, D and E are stable for a minimum duration of time. Therefore the path BCDE is considered as stable. Let B's cache table contains an entry for path BCDE. As path BCDE is stable B can avoid nullifying its cache entry for path BCDE after the periodic cache expiration time.

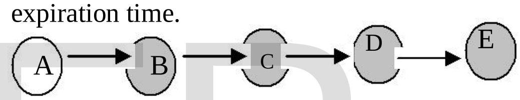

Fig3: Stationary effect of nodes and Route cache table of A and B

If D changes its location and another node F appears in place of D. The path should no longer be stable. But this path will remain in the cache table of B. When B sends packet again using this route, the intermediate nodes in this case C will send a link error message back to B. Then B will nullify the entry and generate a route request packet for new path. New route and cache table might be like fig4:

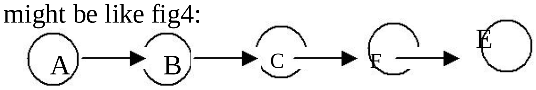

Fig4: Movement of nodes from a stable path and Route cache table of A and B

4. Simulation Model

In order to evaluate the performance of our proposed improvement in DSR we use OPNET Modeller 14.5 to implement a packet level simulation for different scenarios. We consider different circumstances to focus the appropriate performance matrices. Sometimes we vary the number of nodes in the network, other times we

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vary the pause time or mobility keeping the number of nodes constant. We create a scenario of School of Engineering and Technology, Vikram University, Ujjain of 1000 by 1000 meter where mobile terminals can move, appear and disappear in promiscuous mode. The range of the radio frequency of the nodes we consider is 50 meter, and the cache expiration time is set at 100 sec. Every node may work as a sender, a receiver and even as a router. Nodes send packets in an exponential distribution with mean of 4 packets per sec and can process (forward) data in the same distribution with mean of 125 packets per sec. The queuing discipline used is First in First out (FIFO) with infinite buffer size. For simplicity we consider a maximum path length of 15 where end-to-end acknowledgements are required. During movement in the specified area one node or a group of nodes may be isolated. In that case the network will split. Therefore if any node sends a route request packet for a destination which is not in its segment, it will timeout and cannot transmit data packet to that destination. Eventually the isolated nodes will discover that they are split from the big network. During movement of nodes any link may be dropped due to a node disappearance. Then all the packets in the buffer of the node will be dropped. At the same time the cache entry of the involved nodes are updated accordingly.

We want to highlight the effect of node stationary where some nodes are not changing their locations after their pause time to reflect the real scenario. For simplicity in our simulation we consider that a node will change its position after the specified pausing time with a probability of 0.3. We consider a node is stable if it has not changed its location for last 30 sec. Nodes may get this mobility information using GPS technology as mentioned earlier. A path containing all the nodes stable is referred to as a stable path which will remain in the cache unless any node in that path moves. If a node moves from a stable path, the originator wouldn't aware unless it sends a packet using that path. Therefore, a stale path might exist in the cache. But it will automatically be removed if it is not used for a long time because we assume the cache replacement mechanism used is Least Recently Used (LRU).

The gathered performance results are averaged over several simulation replications where the number of data or control packets sent is random in each simulation run. Therefore we do not compare by number of packets sent or received. Instead we take the ratio of control and data packets. We also take the ratio of packet drop and total packet sent which will depict the effect of mobility. To depict the stationary effect we take the ratio of data received and sent too. Furthermore, different pausing time figures (30 sec to 300 sec) for different number of nodes in the same location is used. The number of nodesconsidered is 10, 15, 20, 25, 30, or 35. The duration of the simulation is 10 minutes.

5. Result and Analysis

The more the number of nodes increases in the network, the more data is sent and the more control packets are required. But when we use the advantage of stationary effect of the nodes, we get better performance that is less number of control packets are required in case of improved cache management (St effect). Fig5 depicts this.

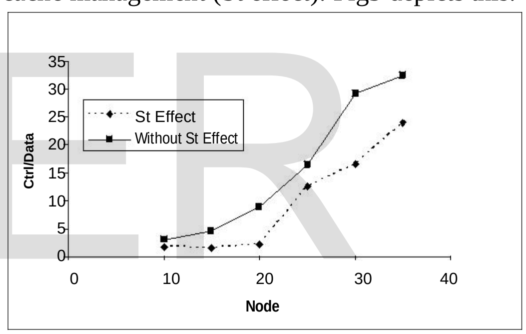

Fig5: Ratio of Control Packet to data packet sent

Fig4 shows the mobility effect, where we see in general that, the more the pausing time, the less the mobility and the less the drop is. When the number of nodes increases the density of nodes increases and distance between nodes decreases therefore, packet drop decreases. Within the same figure we also notice that improved cache management has less packet drop.

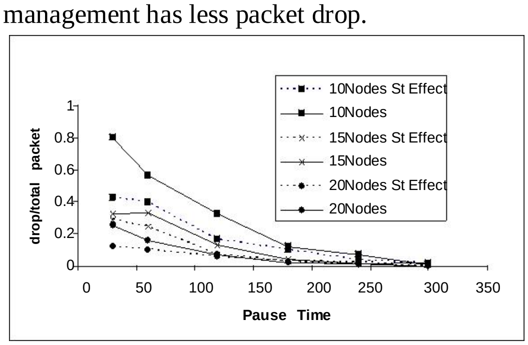

Fig6: Effect of Pausing Time in Packet Drop

How many packets are received among all the sent packets is also another measurement evaluating a routing protocol. In our simulation model we did packet by packet simulation and when the number of nodes within the network increases, the node movement and packet drop increases also there are lots of data packets in the network so the ratio decreases. Fig5 depicts this. It also shows that in case of improved cache management (St Effect), we have better receive/sent ratio.

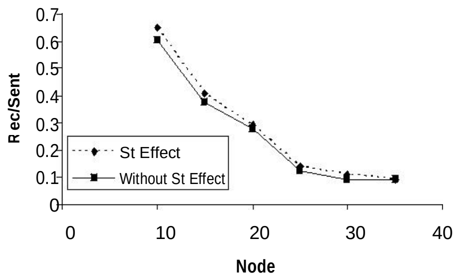

Fig7: Effect of Number of Nodes in Packet Drop

6. Conclusion

The performance of DSR algorithm is depending upon how the network is connected. If the nodes are denser, the connectivity is stronger and the overhead is less but due to the node mobility their might be lot of packets drop. We keep number of nodes constant and vary pausing time and find better performance in denser network. We also vary the number of nodes keeping pausing time constant which shows the mobility effect on the overhead of the DSR. We notice that, our proposed improved cache management in DSR gives better performance in all the cases. The same concept can be introduced in case of other MANET routing protocols.

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