Simulation-Based Comparative Study of On Demand Routing Protocols for MANET

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Abstract- ***If the cable replacement feature of WLANs (Wireless LAN) is the core factor of its popularity, so is the non-existence of any prior infrastructure for MANET (Mobile Ad-hoc Network). The wireless links in an Ad-hoc network are highly error prone and can go down frequently because of node mobility, interference, channel fading, and the lack of infrastructure. Several routing protocols have been proposed for a typical MANET. We have selected two routing protocols (DSR & TORA) to analyze their relative performance as both of them fall in the category of on demand MANET routing protocols. We use quantitative performance metrics for our analysis; comparing relative results in simulation section. Our simulation results indicate that DSR shows overall better performance as it has less overhead control packets thus yielding more throughput. The performance also depends upon the size of the network. Furthermore, we use OPNET MANET Tool to simulate our hypothetical MANET.***

***Keywords**: DSR, TORA, MANET, OPNET*

I. INTRODUCTION

Mobile Ad-hoc Network (MANET) is an especial kind of network where all the nodes configure themselves. Nodes themselves can act like a router. The topology may also change frequently. Each user of the node has the freedom to move while communicating. One node can take packet from other node and transmit it to its neighboring node. This kind of network works in a standalone fashion. Fig 1 shows a typical ad-hoc network. Unlike wired network in ad-hoc network there are many challenges and issues which are very important for the deployment. For example, control message management, dynamic and fast adaptation, speed, power, frequency of updates or network overhead, scalability, security, routing etc. As nodes are mobile and they may disappear anytime, maintaining routing in such network is the most challenging part.

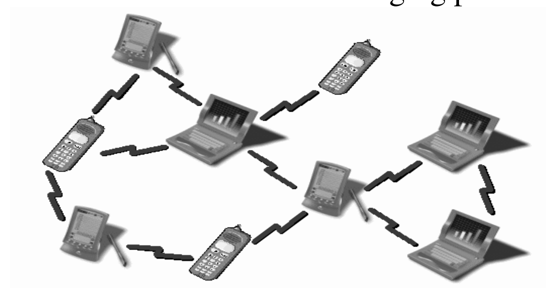

Fig.1: Ad hoc network example

There are numerous routing protocols that have been proposed for such kind of network. MANET is classified into three types based on routing protocols which are as follows:

Table Driven Routing Protocols: In Table-driven routing protocols, each node maintains one or more tables containing routing information to every other node in the network. All the nodes update these tables so that a consistent and up-to-date network is maintained. When the network topology changes, the nodes propagate update messages to the entire network. The main disadvantage of proactive routing protocol is that all the nodes in the network always maintain an updated table.

On-Demand Routing Protocols: These protocols take a lazy approach to routing. In contrast to table-driven routing protocols, all up-to-date routes are not maintained at every node; instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. The route remains valid till the destination is reachable or until the route is no longer needed. Unlike Table driven, reactive or on-demand routing protocols do not main an updated table. DSR and TORA both are two typical examples of on-demand routing protocol.

Hybrid: This is the mixture of both of the above types. The rest of the paper is organized as follows: a short description of the protocols is discussed in section II and section III respectively. In section IV, we describe related work while section V gives brief introduction of OPNET-MANET tools. Simulation model and result analysis are discussed in section VI and VII respectively. Section VIII carries concluding remarks.

II. DYNAMIC SOURCE ROUTING PROTOCOL

There are two basic parts of DSR protocol: route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node wants to send a packet to a particular node, it first checks the cache whether there is an entry for that. If yes then it uses that path to transmit the packet. Also it attaches its source address on the packet. If there is no entry in the cache or the entry is expired (due to long time unused), the sender broadcasts a route request packet to all its neighbors asking for a path to the destination. Until the route is discovered, the sender host will be waiting and during this time it can do other things like sending other packets or forwarding other packets. When the route request packet arrives to any other nodes, they check whether they know the destination asked (may be from neighbor or from their caches). If they have route information, they send back a route reply packet to the destination. Otherwise they broadcast the same route request packet. Once the route is discovered, the sender will send its required packets using the discovered route as well as insert an entry in the cache for future use. Also the node keeps the age information of the entry to recognize whether the cache is fresh or not. When any intermediate node receives a data packet, it first sees whether the packet is sent to itself or not. If it is the destination, it receives that. Or it forwards the packet using the path attached on the packet.

As ad-hoc network is very promiscuous, anytime any link might fail. So route maintenance process monitors and notifies the nodes if there is any failure in the path. And accordingly the nodes change the entries of their route cache. In Appendix section, Fig.6 shows the flow of DSR algorithm.

III. TEMPORARY ORDERED ROUTING PROTOCOL

TORA (Temporary Ordered Routing Algorithm) is an adaptive and efficient routing algorithm primarily designed for Mobile Ad Hoc Networks (MANETs). It comes under the category of on-demand MANET routing protocol (with source-initiated feature). TORA is a fairly complicated protocol but what makes it unique and prominent is its main feature of propagation of control messages only around the point of failure when a link failure occurs. On the contrary, other protocols need to re-initiate a route discovery when a link fails. TORA would be able to patch itself up around the point of failure. This feature allows TORA to scale up to larger networks but has higher overhead for smaller networks. Moreover, in its enhanced version, it stores the time value since a link failure. The protocol algorithm has three distinct phases i.e. route creation, route maintenance and route erasure. In route creation, routes are created mostly in reactive mode. Initially, all nodes are disconnected. The protocol then forms a DAG (Directed Acyclic Graph). The criterion of adding node is based on a metric called "height". The node j is added with the node i, which is already member of the DAG if $h_i > h_j$. The metric "height" consists of five arguments all of which define the "height" of the node [3]. The source sends QRY packet indicating the destination node. The QRY packet propagates until it reaches a node whose neighbor is the specified destination which then transmits a UPD (update) packet [3]. All is done locally. i.e. the nodes know only their neighbors and not all members of the network. *In route maintenance*, route is maintained only for nodes with non-null height. On link failure, if a node is not connected to any node with height smaller than its own, all of its links are reversed based on link reversal algorithm. This is how routes are adapted according to topological changes. This feature adds extra overhead even if that path is not required for data transmission. For this reason, TORA is also considered member of Table-Driven MANET protocols family. *Route is erased* on the reception of CLR packet from a source in route erasure phase. A node, on receiving CLR packet, sets its own height and heights of all its neighbors to NULL and broadcasts CLR packet. This way, route erasure is performed. Finally Fig.7 highlights the steps of route creation, maintenance and erasure in flowchart form.

Comparison: Both DSR and TORA create routes when required. But DSR has more overhead on account of assigning cache to each node. In DSR, nodes can be globally aware of other nodes but TORA adopts local policy rule thus minimizing overhead during route creation. On the other hand, there is no adaptive change in route paths in DSR compared to TORA which inherits this feature. This feature, of course, reduces route discovery time but also a lot of bandwidth is wasted in control messages exchange for route adaptation even when it is unwanted. This imposes a significant burden for the network when topological change rate is very high thus degrading protocol performance. This may result in less throughput of the network. The performance of both protocols is degraded with the increase in the number of nodes [6].

IV. RELATED WORK

All MANET nodes take significant overhead to work any routing algorithm properly. The amount of overhead depends on the type of routing algorithm. The study of [16] shows that scalability of the network (directly related with overhead) largely depends on the traffic pattern. By intelligently playing with traffic pattern, one can easily increase the scalability with minimal overhead. On the contrary, there are situations where DSR is almost to implement for ad hoc networks. e.g. we cannot use DSR where resources are scarce and routing is based on source because in that case, each datagram (in case IPv6) must carry source address [17]. Finally, the performance comparison of [18] shows the dominance in terms of better performance of DSR over TORA, ADSR and DSDV routing algorithm.

TORA faces a severe security problem because route discovery is done in cooperative manner in this protocol. Hence, many malicious nodes may add to the routes. Using security technique of [19] measures confidence level for a particular node and hence gives better security to TORA. It is interesting to not that designing TORA in a hierarchical fashion greatly reduces control messages across the network [20]. Moreover, one of the results of [8] is to achieve higher throughput using TORA under certain circumstances by route discovery time.

V. OPNET-MANET TOOLS

OPNET is a network simulation tool for modeling, simulating and analyzing the performance of Communication Networks, Distributed Systems, Computer systems and Applications. It provides a variety of toolbox to design, simulate and analyze a network topology. We use MANET Toolbox to simulate our hypothetical Ad hoc network.

We used MANET_Station, RXGroup and Mobility configuration in our simulation model. MANET_station can be used to set routing algorithm, traffic generation parameter. Moreover, we can also set parameters specific to routing algorithm.

VI. SIMULATION MODEL

A. *Traffic Modeling*

We use 50 wireless devices in each scenario. For a single scenario, all devices have the same setting meaning hereby that traffic parameters, protocol specification distance settings etc. remain same for each device. We use a constant file size of 1000 byte (FTP traffic) and it remains the same throughout the whole simulation. We keep changing Inter Arrival Time to increase or decrease data rate. For analysis purpose, we increase traffic load by decreasing Inter-Arrival Time (IAT) as data rate is inversely proportional to IAT.

B. *Performance Matrices*

There are a number of metrics using which one can compare between these two protocols. We use the following typical metrics for our simulation design and analysis purpose.

Delay (sec) represents end-to-end delay

Data dropped (Kbps) total data dropped until retry limit.

Throughput (bps) represents the total number of bits forwarded to higher layers per second.

Media access delay the time a node takes to access media (link) to start its transmission. For each packet, the delay is recorded when the packet is sent to the physical layer for the first time.

VII. ANALYSIS

As mentioned earlier in section 3, it is known that TORA tries to minimize communication overhead by localization. This reduces end-to-end delay to a great extent as shown in Fig 2. The large delay in case of DSR is due to the storage of entire route both in route replies and data sent.

Similarly, media access delay is also less in case of TORA as depicted in Fig 3. Because of less overhead to maintain communication, DSR uses large caches and as the network grows, it becomes difficult for the nodes to have access to the media which results in large media access delay.

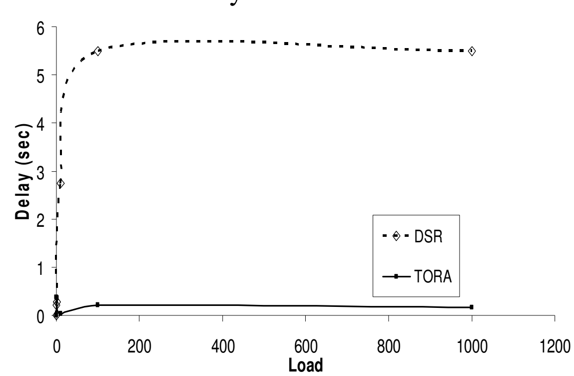

Fig.2: End-to-End delay versus Load in kBps.

While TORA reduces communication overhead, it increases unnecessary overhead due to its route adaptation feature in response to topological changes. This deteriorates overall performance of the network by decreasing throughput. We can see in Fig 4 more decreasing trend of TORA throughput. On the other hand, DSR performs better in this regard as it has no such adaptive route update. Furthermore, as TORA is implicitly table driven, it transmits a lot of control packets to update the routing information as soon as there is a change in topology. So DSR has better throughput compared to TORA.

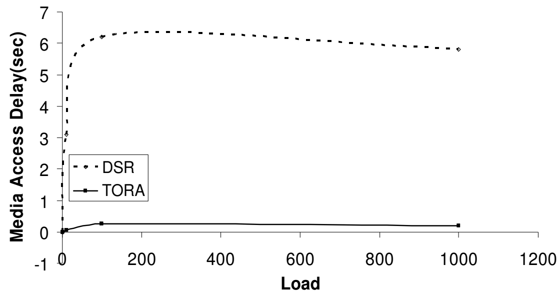

Fig.3: Media Access Delay versus Load in kBps

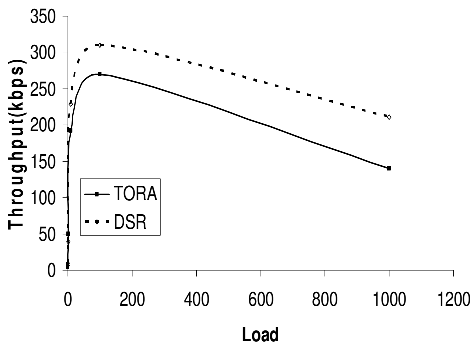

Fig.4: Throughput versus Load in kBps

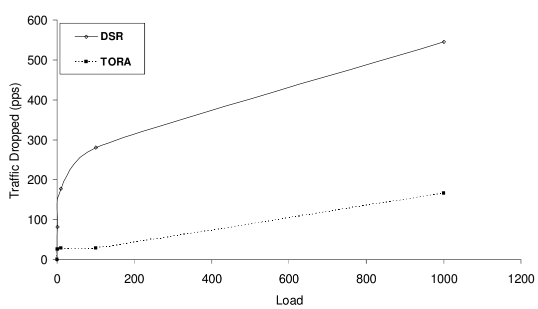

Fig.5: Dropped data versus Load in kBps

TORA decides about shortest path on local basis. Therefore out of the available paths, the shortest one is chosen whereas DSR maintains one shortest path. Therefore if there is a change in topology due to the mobility, the sender sends a Route Query packet to its neighbors and keeps those packets waiting in the queue. Consequently queue overflows and more packets are dropped. It can be observed from Fig.5.

VIII. CONCLUSION

We have analyzed the performance of two on demand routing protocols, DSR and TORA. As far as simplicity is concerned, DSR is simpler and also it gives better performance in terms of throughput while TORA produces less throughput due to extra overhead for path establishment and for upgrading the path in an adaptive fashion. On the other hand, TORA minimizes communication overhead by localization in route creation process, which results in less delay and media access delay. Absence of this feature in DSR causes a larger end-to-end and media access delay.

In this comparative study, we did not focus on the queuing disciplines used in the network (Instead we used OPNET default discipline). Furthermore, we did not check the network performance for real time traffic. The effect of increasing number of nodes on the network performance was also not analyzed. Therefore, we intend to focus on these three issues in our future work.

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APPENDIX

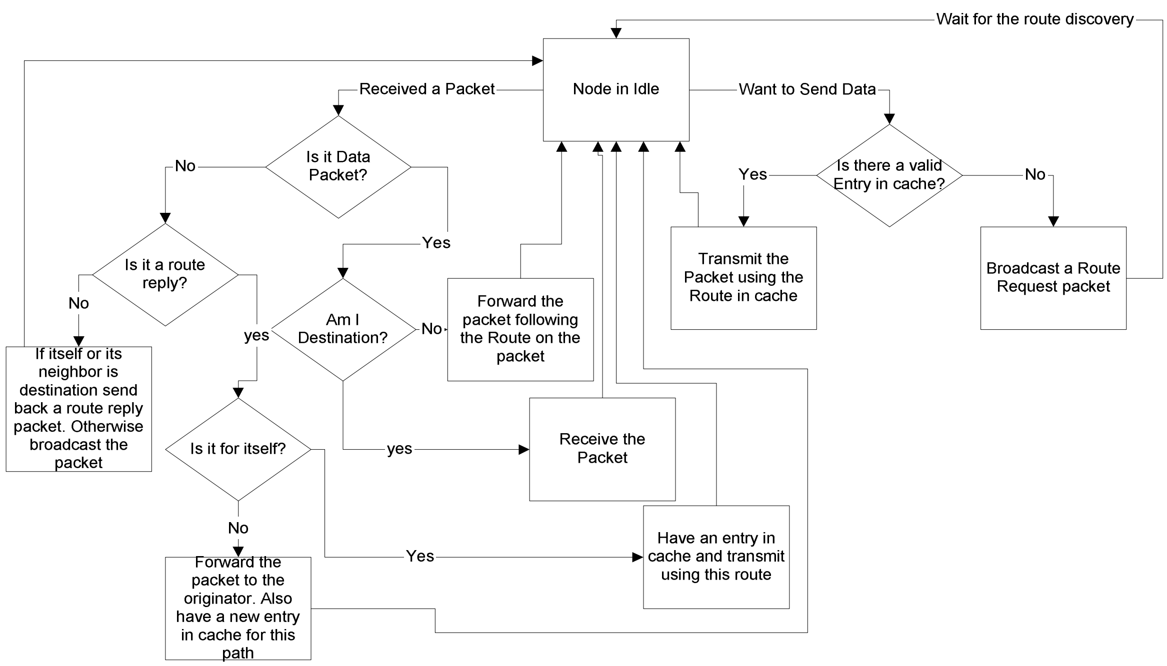

Fig.6: DSR Flowchart

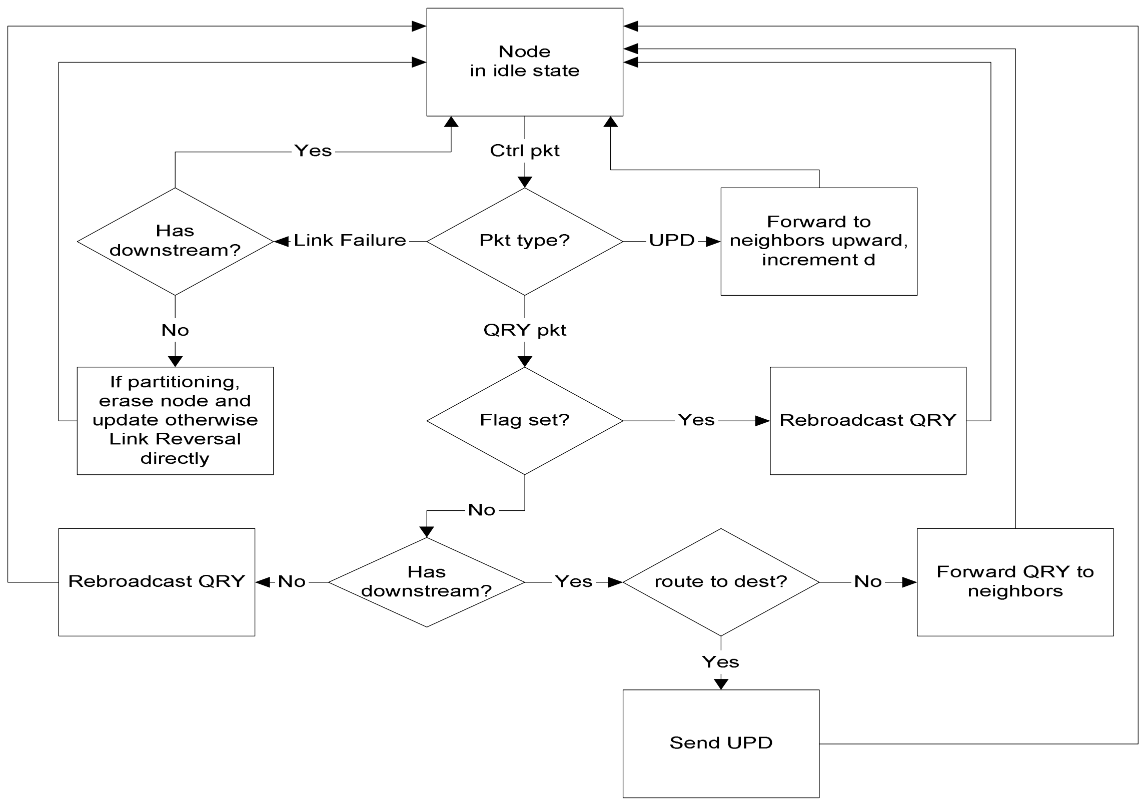

Fig.7: TORA Routing Flowchart

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