Analysis of Reactive Routing Protocols for Mobile Ad-Hoc Networks

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---ABSTRACT---
A MANET is an autonomous collection of mobile users (nodes) that communicate over relatively bandwidth-constrained wireless links. The infrastructure less and the dynamic nature of these networks demands new set of networking strategies to be implemented in order to provide efficient end-to-end communication. MANETs employ the traditional TCP/IP structure to provide end-to-end communication between nodes. However, due to their mobility and the limited resource in wireless networks, each layer in the TCP/IP model require redefinition or modifications to function efficiently in MANETs. Routing in the MANETs is a challenging task and has received a tremendous amount of attention from researches. This has led to development of many different routing protocols for MANETs, which are classified in two basic categories: reactive routing and proactive routing protocols. This paper compares and analyze reactive routing protocols on the basis of various properties.

Keywords: MANETs, Routing protocols, Ad-hoc.

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1. INTRODUCTION

A mobile wireless network is the infrastructureless mobile network, commonly known as an ad-hoc network. Infrastructureless networks have no fixed routers; all nodes are capable of movement and can be connected dynamically in an arbitrary manner. Nodes of these networks function as routers which discover and maintain routes to other nodes in the network. Example applications of ad-hoc networks are emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain. In ad-hoc networks if two mobile nodes are within each other's transmission range, they can communicate with each other directly. Otherwise, the nodes in between have to forward the packets for them. In such a case, every mobile node has to function as a router to forward the packets for others.

However, wireless networks have special limitations and properties such as limited bandwidth, highly dynamic topology, link interference, limited range of links, and broadcast. Wireless ad-hoc networks are traditionally used in battlefield communications, law enforcement, disaster recovery, and emergency search and rescue. Recently, wireless ad-hoc networks have been extensively used in civilian forums such as electronic classrooms, convention centers, construction sites, and special events.

Routing (and forwarding) is a core problem in networks for delivering data from one node to another. Traditional routing protocols used in hardwired networks, such as distance vector protocols (e.g. RIP) and link state protocols (e.g., OSPF) cannot be applied in the MANET directly for the following reasons:

- There may be uni-directional links between nodes.
- There is more than one eligible path between two nodes.
- The consumption of bandwidth and power supply incurred by periodic routing information updates is considerable.

- The routing fabrics converge slowly in contrast to rapid topology change.

There have been several routing protocols proposed for wireless ad-hoc networks. They can be divided into the following basic categories:

- Proactive routing protocols (DSDV, WRP, OLSR, WRP, CGSR, FSR, GSR)
- Reactive routing protocols (DSR, SSR, AODV, TORA, LAR, ABR, LMR)

There have also been several articles written which compare the performance and characteristics of different protocols [4, 5, 8, 9]. Among them, three articles [4, 5, 9] compare a few (up to four) protocols based on the simulation of the compared protocols .The OLSR is the most widely used link state protocol, while AODV is the most popular distance vector protocol. General analysis of link state routing and distance vector routing in MANET respectively are provides in [1] and [2] respectively. In [3] compared two on demand routing protocols DSR and AODV. They consider various performance metrics like packet delivery fraction, average end to end delay of data packets, normalized routing load, normalized MAC load. In [8] provides an overview of eight different routing protocols by presenting their characteristics and functionality and then provided a qualitative comparison and discussion of their respective merits and drawbacks.

Result of above study is: so far researchers in ad-hoc networking have generally studied the on demand routing protocols, there comparison with table driven routing protocols and comparison of some of reactive routing protocols based on the simulation of the compared protocols. This paper gives outline of the all reactive routing protocols, their properties and there comparison on the bases of their properties.

2. REACTIVE ROUTING PROTOCOLS

These take a lazy approach to routing. 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. This section discusses on-demand routing protocols

2.1 Dynamic Source Routing Protocol (DSR)

The key feature of this protocol is that is a pure on demand protocol, i.e. it does not employ any periodic exchange of packets. DSR does even employ beacon packets like some other on demand protocols. Consequently, DSR applies on demand schemes for both route discovery and route maintenance. This makes the routing overhead traffic scales to the actual needed size automatically, which is considered as the main advantage of DSR. On the other hand, DSR employs source routing, so that each data packet contains the full path it should traverse to its destination. Source routing is some time considered as a disadvantage of DSR.

2.2 Ad-hoc On-Demand Distance-Vector Routing Protocol (AODV)

The key feature of this protocol is that applying a distributed routing scheme. In contrast to the source routing applied by DSR, AODV depends on storing the next hops of a path as entries in the intermediate nodes, which is considered as an advantage. However this may require additional resources form the intermediate nodes, which is the negative side of AODV.

2.3 *Location Aided Routing Protocol (LAR)*

The most important feature of this protocol is limiting the area of flooding the route request packets in the network. It uses the location information to predict the current location of the destination nodes. LAR assumes the availability of a global positioning system infrastructure (GPS). According to the performance study in LAR schemes introduce less routing overhead than that introduced by the pure flooding scheme. However, it is considered as a two sided solution, as more recourses are required, namely, GPS.

2.4 Associatively-Based Routing Protocol (ABR)

This protocol has two unique features. First, it uses periodic beacon packets not just to detect the availability of a link, but also to measure the associatively with its neighbor through this link, namely, the stability of the link. This criterion is used for the route selection process. Second, it applies a route maintenance mechanism which is initialized as a local one but can expand to a global one if the local scale is not enough to solve the problem.

Every node in the network expects to periodically receive beacon packets for a neighbor. It keeps a count of the received packets. This count can be used to measure the stability of the link between the two nodes. Consequently, the links in the network are classified as either stable or unstable. This classification is used in the route selection process.

2.5 Signal Stability-Based Adaptive Routing Protocol (SSR)

The key feature of this protocol is making the routing decision based on the signal strength of the links. SSR measures the signal strength of the periodically exchanged beacons between nodes in the network. These measurements are used to classify the links as either stable or unstable. SSA tries to find a completely stable paths form the beginning, a process that if succeeded to find a path, it will be a very positive side of SSA. On the other hand if this process fails to find a path it may start the procedure form the beginning allowing paths with unstable link, which means additional effort to find a path.

SSA consists of two protocols which are working together, viz. the forwarding protocol (FP) and the dynamic routing protocol (DRP). When a source wants to send data packets to a destination, the FP checks the routing table (RT) of the source node to find any route to this destination. If it has a route the packets are directly forwarded, if not the FP initiates a route request packet to find a route.

2.6 Light-weight mobile routing (LMR)

The LMR protocol is another on-demand routing protocol, which uses a flooding technique to determine its routes. The nodes in LMR maintain multiple routes to each required destination. This increases the reliability of the protocol by allowing nodes to select the next available route to a particular destination without initiating a route discovery procedure. Another advantage of this protocol is that each node only maintains routing information to their neighbours. This means avoids extra delays and storage overheads associated with maintaining complete routes. However, LMR may produce temporary invalid routes, which introduces extra delays in determining a correct loop.

2.7 Temporally ordered routing algorithm (TORA)

The TORA routing protocol is based on the LMR protocol. It uses similar link reversal and route repair procedure as in LMR, and also the creation of a DAGs, which is similar to the query/ reply process used in LMR. Therefore, it also has the same benefits as LMR. The advantage of TORA is that it has reduced the far-reaching control messages to a set of neighbouring nodes, where the topology change has occurred. Another advantage of TORA is that it also supports multicasting, however this is not incorporated into its basic operation. TORA can be used in conjunction with lightweight adaptive multicast algorithm (LAM) to provide multicasting. The disadvantage of TORA is that the algorithm may also produce temporary invalid routes as in LMR.

2.8 Cluster-based routing protocol (CBRP)

Unlike the on-demand routing protocols described so far. In CBRP the nodes are organized in a hierarchy. As most hierarchical protocols described in the previous section, the nodes in CBRP or grouped into clusters. Each cluster has a cluster-head, which coordinates the data transmission within the cluster and to other clusters. The advantage of CBRP is that only cluster heads exchange routing information, therefore the number of control overhead transmitted through the network is far less than the traditional flooding methods. However, as in any other hierarchical routing protocol, there are overheads associated with cluster formation and maintenance. The protocol also suffers from temporary routing loops. This is because some nodes may carry inconsistent topology information due to long propagation delay.

3. ANALYSIS OF REACTIVE ROUTING PROTOCOLS

Various reactive routing protocols are analyzed and compared on the basis of following properties :

- *Full/Limited/Local Broadcast*

Some protocols uses a full network broadcast, which means, a message is intended for every node in the network, and needs to be retransmitted by intermediate nodes. There is no routing protocol that always issues full broadcasts except: ABR, DSR, CBRP. On the other hand, there is a local broadcast, which is intended for any node within the senders reach, but which is not retransmitted at all. TORA use local broadcasts. Many protocols prefer limited broadcast: LAR, LMR, SSR, AODV. In between there are limited broadcasts, in which the maximum hop count (time to live) is limited as desired.

- *Route Selection Strategy*

The route selection strategy is an important aspect of a routing protocol. Signal Strength method is used by ABR and SSR to route packets along the connection with the best signal strength. Link Stability method is used to route packets along the connections that appear most stable over a period of time. It is used by Flow oriented routing protocol (FORP). Shortest Path method is used by many protocols like TORA, AODV, DSR, CBRP, LAR, LMR.

- *Single path vs. multiple paths*

Some routing protocols will find a single route from a source to a destination, which results in simple protocol and saves storage. It is used by AODV, ABR, CBRP, SSR. Other routing protocols will find multiple routes which have the advantages of easy recovery from a route failure and being more reliable and robust. Moreover, the source can select the best one among multiple available routes. It is used by LMR, TORA, DSR, LAR.

- *Complexity of Routing Protocols*

Complexity is defined in the form of storage, time and Communication complexity for different Routing protocols. Storage Complexity measures the order of the table size used by the protocols. Communication Complexity gives the no of messages needed to perform an operation when an update occurs.

Time Complexity of ABR is order of network diameter O(d), of TORA, AODV, DSR, LMR is twice of order of network diameter O(2d), SSR is order of sum of network diameter + diameter of the directed path of the RREP O(d+P) and LAR is twice order of diameter of the nodes in the localized region O(2S).

Storage complexity of TORA is order of multiple of no of maximum desired destinations and average no of adjacent nodes O(D*A), SSR is (D+A), DSR and AODV is order of number of communication pairs O(E), and of ABR is O(D-A).

Communication Complexity of CBRP, TORA, LMR is O(2* number of affected nodes (A)), AODV, DSR order of twice number of nodes in the network O(2N), ABR,SSA is O(number of affected nodes (A) + ¼ number of nodes forming the route reply path(R)) and LMR is O(2*¼ number of nodes in the localized region(M)).

- *Other properties*

All reactive protocols are loop free except TORA and LMR. Critical nodes are those nodes which are having more and special responsibilities than other (i.e. clusturhead in CBRP). Only CBRP have critical nodes. Regarding structure, in a flat structure, all nodes in a network are at the same level and have the same routing functionality. Flat routing is simple and efficient for small networks. The problem is that when a network becomes large, the volume of routing information will be large and it will take a long time for routing information to arrive at remote nodes.

For large networks, hierarchical (cluster-based) routing may be used to solve the above problems. In hierarchical routing the nodes in the network are dynamically organized into partitions called clusters, then the clusters are aggregated again into larger partitions called super clusters and so on. Organizing a network into clusters help maintain a relatively stable network topology. Only CBRP uses the hierarchical structure other uses the flat.

4. CONCLUSION

This paper gives the overview of reactive routing protocols for MANETs. By looking at performance metrics and characteristics of all categories of reactive routing protocols, it is found that all reactive routing protocols have flat routing structure except in case of CBRP, which uses the hierarchical structure. Route is determined when needed and traffic volume control is lower than global routing and can be further improved using GPS e..g. LAR. Storage, communication and time complexity depends on the number of nodes, routes and diameter of network. Further, network scalability depends on the level of traffic and the levels of multihoping which may be upto few hundred nodes but point-to point may scale higher.

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