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Analytical Performance Comparison of Different Routing Protocols in Mobile Ad hoc Wireless Networks

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Abstract

Mobile Ad-Hoc Networks (MANETs) are becoming increasingly popular as more and more mobile devices find their way to the public, besides “traditional” uses such as military battlefields and disaster situations they are being used more and more in every-day situations. With this increased usage comes the need for making the networks secure as well as efficient, something that is not easily done as many of the demands of network security conflicts with the demands on mobile networks due to the nature of the mobile devices (e.g. low power consumption, low processing load).In MANETs 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. Thus, routing is a basic operation for the MANET. Because traditional routing protocols cannot be directly applied in the MANET, a lot of routing protocols for unicast, multicast, and broadcast transmission have been proposed since the advent of the MANETs. This paper gives a complete analysis of routing protocols in the MANETs.

Keywords: *Manet, Routing Protocols, DSDV.*

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a temporary wireless network composed of mobile nodes, in which an infrastructure is absent. There are no dedicated routers, servers, access points and cables. Because of its speedy and convenient deployment, robustness, and low cost, a MANET can find its applications in the following areas:

(1) Military use (e.g. a network in the battlefield)

(2) Search and rescue

(3) Vehicle-to-vehicle communication in intelligent transportation.

(4) Temporary networks in meeting rooms, airports, etc.

(5) Personal Area Networks connecting cell phones, laptops, smart watches, and other wearable computers.

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. 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:

(1) There may be uni-directional links between nodes.

(2) There is more than one eligible path between two nodes.

(3) The consumption of bandwidth and power supply incurred by periodic routing information updates is considerable.

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(4) The routing fabrics converge slowly in contrast to rapid topology change.

Most research effort has been put in the routing protocols since the advent of the MANET. They can be divided into the following basic categories:

1. Proactive routing protocols (DSDV, WRP, OLSR, WRP, CGSR, FSR, GSR)
2. Reactive routing protocols (DSR, SSR, AODV, TORA)

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, normalize MAC load. The experiments were conducted using various sets: varying mobility and number of different number of sources, varying offered load. They used different sets: varying mobility and number of sources, varying offered load. They used different sets consisting of different number of mobile nodes. It was observed that DSR outperforms AODV in less stressful situations. In [4] 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. Each protocol has definite advantages and disadvantages and has certain situations for which it is well suited. The paper categories the protocols as table driven and on-demand routing protocols. The various examples of table driven routing protocols are: DSDV, CGSR, and WRP. In this approach routes are maintained in the forms of a table, consisting of only one entry for each of rout. These table entries have to be constantly updated irrespective of whether the route is in use or not. As a result of this sometimes it might lead to immerse routing overhead. On the other hand the on-demand routing protocols: AODV, DSR, TORA, A BR, SSR do not have to maintain all the routes, a route discovery is initiated only when a particular node require a route to a particular destination. The exact mechanism differs for different protocols. [6] Provides a through study of protocols for Manets. The paper provided a study of unicast and multicast routing protocols along with broadcast algorithm for Manets. It describes the relative strength sand drawbacks of various routing protocols.

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 proactive routing protocols. This paper provides outline of the all proactive routing protocols, reactive routing protocols, their properties and there comparison on the bases of these properties.

II. PROACTIVE ROUTING PROTOCOLS

These are also called table driven routing protocols. In proactive protocols nodes continuously search for routing information within a network, so that when a route is needed, the route is already known. There are mainly four protocols under this category:

A. Destination-Sequenced Distance Vector Routing(DSDV)

DSDV is based on the classical Bellman-Ford routing algorithm. Each node maintains a list of all destinations and number of hops to each destination. Each entry is marked with a sequence number. It uses full dump or incremental packets to reduce network traffic generated by route updates. The broadcast of route update is delayed by settling time. The only improvement made here is avoidance of routing loops in a mobile network of routers. With this improvement, routing information can always be readily available, regardless of whether the source node requires route or not.

B. Wireless Routing Protocol (WRP)

WRP belongs to the class of path-finding algorithm with the exception of avoiding the count-to-infinity problem by forcing each node to perform consistency check of predecessor information reported by all its neighbours. The novel part of this protocol is it achieves loop freedom. Each node maintains 4 tables: Distance table, Routing table, Link cost table & Message retransmission list table. Link changes are

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propagated using update messages sent between neighboring nodes. Hello messages are periodically exchanged between neighbors. This protocol avoids count-to-infinity problem by forcing each node to check predecessor information.

C. Cluster head Gateway Switch Routing Protocol (CGSR)

Under CGSR mobile nodes are grouped into clusters and each cluster has a cluster head. A cluster head can control a group of ad hoc hosts and clustering provides framework for network separation (among clusters), channel access, routing and also bandwidth allocation. It uses DSDV as the underlying routing algorithm and each node maintains a cluster member table and a routing table. However, for CGSR, some nodes, such as cluster heads and gateway nodes have some special over head that's why these nodes are called critical nodes. The network reliability may also be affected due to single points of failure of these critical nodes.

D. Optimized Link State Routing (OLSR)

Optimized link state routing is a proactive routing protocol. In which each node periodically broadcasts its routing table allowing each node to build a global view of the network topology. The periodic nature of the protocol creates a large amount of overhead. In order to reduce overhead it limits the number of mobile nodes that can forward network wide traffic and for this purpose it uses multi point relays (MPRs) which is responsible for forwarding routing messages and optimization for controlled flooding and operation.

E. Global state routing (GSR)

The GSR protocol is based on the traditional Link State algorithm. However, GSR has improved the way information is disseminated in Link State algorithm by restricting the update messages between intermediate nodes only. In GSR, each node maintains a link state table based on the up-to-date information received from neighbouring nodes, and periodically exchanges its link state information with neighbouring nodes only. This has significantly reduced the number of control message transmitted through the network. However, the size of update messages is relatively large, and as the size of the network grows they will get even larger. Therefore, a considerable amount of bandwidth is consumed by these update messages.

F. Fisheye state routing (FSR)

The FSR protocol is the descendent of GSR. FSR reduces the size of the update messages in GSR by updating the network information for nearby nodes at a higher frequency than for the remote nodes, which lie outside the fisheye scope. This makes FSR more scalable to large networks than the protocols described so far in this section. However, scalability comes at the price of reduced accuracy. This is because as mobility increases the routes to remote destination become less accurate. This can be overcome by making the frequency at which updates are sent to remote destinations proportional to the level of mobility.

III. REATIVE 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

A. 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.

B. 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.

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C. 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.

The studies of LAR focuses on the way the protocols forward the route request packets and not the way it maintain the routing information or it reconfigures the broken paths.

D. Associatively-based routing protocol (ABR)

This protocol has two unique features. First, it uses periodic beacon packets not 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.

E. 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. SSA 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.

F. 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 neighbors. 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.

G. 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 neighboring 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.

H. 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.

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IV. ANALYSIS OF MANETS ROUTING PROTOCOLS

This section evaluates all MANETs routing protocols on the basis of there properties:

A. Full/limited/local broadcast

There is a full network broadcast, which means, a message is intended for every node in the network, and needs to be retransmitted by intermediate nodes. 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. In between there are limited broadcasts, in which the maximum hop count (time to live) is limited as desired. There is no routing protocol, that always issues full broadcasts, but there are some, that may use full broadcasts: DSDV, CGSR, ABR, DSR, CBRP. Many protocols prefer a limited broadcast: FSR, LAR, LMR, SSR, AODV. And also there are protocols, which use only local broadcasts: GSR, OLSR, WRP, TORA.

B. Route selection strategy

The route selection strategy is an important aspect of a routing protocol. I describe the main representatives and the protocols, which use them. Signal Strength: Route packets along the connection with the best signal strength ABR, SSR. Link Stability: Route packets along the connections that appear most stable over a period of time. It is used by DSDV. Shortest Path: Select a shortest path according to some metric. This is used by many protocols: FSR, GSR, OLSR, WRP, CGSR, TORA, AODV, DSR, CBRP, LAR, LMR.

C. Periodic vs. Event driven

Periodical update protocols disseminate routing information periodically. Periodical updates will simplify protocols and maintain network stability, and most importantly, enable (new) nodes to learn about the topology and the state of the network. .This is used by protocols GSR, FSR, CGSR. In an event-driven update protocol, when events occur, (such as when a link fails or a new link appears), an update packet will be broadcast and the up-to-date status can be disseminated over the network soon (use in all reactive routing protocols). The problem might be that if the topology of networks changes rapidly, a lot of update packets will be generated and disseminated over the network which will use a lot of precious bandwidth, and furthermore. That's why it used with periodic update in DSDV, WRP, OLSR.

D. Single path vs. Multiple path

There are several criteria for comparing single-path routing and multi-path routing in ad hoc networks. First, the overhead of route discovery in multi-path routing is much more than that of single-path routing. On the other hand, the frequency of route discovery is much less in a network which uses multi-path routing, since the system can still operate even if one or a few of the multiple paths between a source and a destination fail. Second, it is commonly believed that using multipath routing results in a higher throughput. The reason is that all nodes are assumed to have (and limited) capacity (bandwidth and processing power). Since multi-path routing distributes the load better, the overall throughput would be higher, may cause too much fluctuation of routes .Single path routing used in WRP, DSDV, OLSR, GSR, FSR, AODV, ABR, CBRP, SSA and multiple paths routing in CGSR, LMR,TORA, DSR, LAR, .

E. 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 OLSR,DSDV,GSR, FSR,CGSR,ABR is order of network diameter O(d) and of WRP is order of height of routing tree, of TORA, AODV, DSR, LMR is twice of order of network diameter O(2d), of SSR is order of sum of network diameter + diameter of the directed path of the RREP O(d+P) and of LAR is twice order of diameter of the nodes in the localized region O(2S)..

Storage complexity of OLSR, GSR is order of Number of nodes in the network into average no of adjacent nodes O(N*A), of DSDV is order of No of nodes affected by topological change O(X) of FSR is O(N), of CGSR is order of Number of nodes in the network divided by Average no of nodes in a cluster O(N/M) and of WRP is O(X*A) Storage complexity of TORA is order of multiple of no of maximum desired destinations and average no of adjacent nodes O(D*A), of SSA is (D+A), of DSR and AODV is order of number of communication pairs O(E), and of ABR is O(D-A).

Communication Complexity of CGSR, WRP, FSR, GSR, DSDV is order of number of nodes in the network O(N) and of OLSR is O(N*N), of CBRP, TORA, LMR is O(2* number of affected nodes(A')), of AODV, DSR order of twice number of nodes in the network O(2N), of ABR,SSA is O(number of affected nodes (A') + ¼number of nodes forming the

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route reply path(R)) and of LMR is O(2*¼number of nodes in the localized region(M)).

F. Loop free or not

It is also an important characteristic of routing protocols which define that protocol provides a single path to a destination. WRP, DSDV, DSR, AODV, LAR, SSR, ABR, CBRP protocols are loop free others are not.

G. Critical nodes

These are those nodes which are having more and special responsibilities than other (i.e. cluster-head in CGRP). CGRP, CBRP are having critical nodes others are not.

H. Number of routing table

This characteristic defines the number of routing tables that are maintained for routing purpose. DSDV, CGSR maintains 2, WRP maintains 4, GSR, FSR maintains 3 and a list and OLSR maintains 3(Routing, neighbor and topology table) routing tables.

I. Flat structure vs. Hierarchical 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, than the clusters are aggregated again into larger partitions called super clusters and so on.

In case of reactive routing protocols only CBRP uses the hierarchical structure other uses the flat and in case of proactive routing protocols both flat and hierarchical routing structures are available.

V. CONCLUSION

This paper gives the overview of routing protocols for MANETs. By looking at performance metrics and characteristics of all categories of routing protocols, a number of conclusions can be made for proactive routing protocols. First, in case of proactive routing both flat and hierarchical routing structures are available, but in case of reactive routing protocols only CBRP uses the hierarchical structure other uses the flat. Second, In case of proactive routing protocols route is always available and traffic volume control is high (i.e. as in OLSR by using TBPRF hello messages) but in case of reactive routing protocols route is determined when needed and traffic volume control is lower than global routing and further improved using GPS e..g. LAR.
Third, in case of proactive routing protocols storage volume requirement is high and usually update occur at fixed interval but in case of reactive routing protocols storage volume requirement is depend on the number of routes kept or require and usually update not required, however some nodes may require periodic beacon e.g., ABR . Fourth, in case proactive routing protocols only small routes are predetermined and hence delay is high. Fifth, in case of proactive routing protocols: they are having scalability upto 100 nodes except OLSR, but in case of reactive routing protocols: they are having scalability up-to few hundred nodes. Point-to-point may scale higher. Also depends on the level of traffic and the levels of multi-hopping.

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