Performance Analysis and Comparison of Different Routing Protocols in MANET

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Abstract
Mobile Ad-Hoc Network (MANET) is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. Most of the proposed MANET protocols do not address security issues. In MANETs routing algorithm is necessary to find specific routes between source and destination. The primary goal of any ad-hoc network routing protocol is to meet the challenges of the dynamically changing topology and establish an efficient route between any two nodes with minimum routing overhead and bandwidth consumption. The existing routing security is not enough for routing protocols. An ad-hoc network environment introduces new challenges that are not present in fixed networks. A several protocols are introduced for improving the routing mechanism to find route between any source and destination host across the network. In this paper present a logical survey on routing protocols and compare the performance of the following protocols such as AODV, DSR, DSDV and OLSR.

Keywords:
MANET, AODV, DSR, OLSR and DSDV

1. Introduction

Wireless networking is an emerging technology that allows users to access information and services electronically, regardless of their geographic position. Wireless networks have become increasingly popular in the computing industry. The applications of the ad-hoc network are vast [9]. Mobile Ad hoc Network is a self organized network because it is an infrastructure less feature of networks. Mobile ad-hoc network is a collection of nodes. Each node can connect by wireless communication links, without any fixed station such as base station. In mobile ad-hoc network each node can act as a router and connectivity is achieved in the form of a multihop graph between the nodes [8].

The nodes in MANET themselves are responsible for dynamically discovering other nodes to communicate. It is a self-configuring network of mobile nodes connected by wireless links the union of which forms an arbitrary topology. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably.

A routing is a core problem in network for sending data from one node to another. Wireless Ad-Hoc networks are also called Mobile Ad-Hoc multi-hop wireless networks is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure or centralized administration. Mobile Ad-Hoc Networks (MANETs) are characterized by a dynamic, multi-hop, rapid changing topology [1, 2]. Such networks are aimed to provide communication capabilities to areas where limited or no communication infrastructures exist. MANETs can also be deployed to allow the communication devices to form a dynamic and temporary network among them.

It is used in areas of Sensor networks for environmental monitoring, Rescue operations in remote areas, Remote construction sites, and Personal area Networking, Emergency operations, Military environments, Civilian environments. The scopes of the ad-hoc network are also associated with Dynamic topology changes, Bandwidth-constrained, Energy constrained operation, Limited physical security, Mobility-induced packet losses, Limited wireless transmission range, Broadcast nature of the wireless medium, Hidden terminal problem, Packet losses due to transmission errors attention due to many potential military and civilian applications [9]. A MANET uses multi-hop routing instead of a static network infrastructure to provide network connectivity. Several routing protocols have been proposed for mobile Ad-Hoc networks. In this paper we present a number of ways of classification or categorization of these routing protocols and the performance comparison of an AODV, DSR, OLSR and DSDV routing protocols [2].

2. MANET ROUTING PROTOCOL

MANET protocols are used to create routes between multiple nodes in mobile ad-hoc networks. IETF (Internet Engineering Task Force) MANET working group is responsible to analyze the problems in the ad-hoc networks and to observe their performance [7, 9]. There

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are different criteria for designing and classifying routing protocols for wireless ad-hoc networks. The MANET protocols are classified into two huge groups, namely Proactive (Table-Driven) and Reactive (On-Demand) routing protocol [1, 2].

Proactive (Table-Driven) routing protocol: - In proactive routing protocols, consistent and up-to-date routing information to all nodes is maintained at each node.

Reactive (On-Demand) routing protocol: - This type of protocols find route on demand by flooding the network with Route Request packets.

2.1 Proactive (Table-Driven) Routing Protocol

The proactive routing protocols are maintaining routes to all nodes, including nodes to which no packets are sent. They react to topology changes, even if no traffic is affected by the change. They are based on either link-state or distance vector principles, or required periodic control messages to maintain routes to every node in the network [3]. Each node in the network has one or more tables that contain the latest information of the routes to any node in the network. Each row has the next hop for the reaching a node or subnet and the cost of this route. Various table-driven protocols differ in the way the information about a change in topology is propagated through all nodes in the network. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables. The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth. Examples of such schemes are the conventional routing schemes, Destination Sequenced Distance Vector (DSDV) [2].

2.2 Reactive (On-Demand) Routing Protocol

In On-Demand routing protocols, 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. Once a Route has been established, it is maintained until either the destination becomes inaccessible (along every path from the source), or until the route is no longer used, or expired [6]. Reactive routing protocols don't maintain routing information or routing activity at the network nodes if there is no communication. They do not maintain or constantly update their route tables with the latest route topology. The route discovery usually occurs by flooding the route request packets throughout the network. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad-hoc on-demand distance vector routing (AODV) [1, 2, and 6].

2.3 Single-Path vs. Multi-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 multi-path routing results in a higher throughput. Third, multi-path networks are fault tolerant when dynamic routing is used, and some routing protocols, such as OSPF (Open Shortest Path First), can balance the load of network traffic across multiple paths with the same metric value [2, 6, 10].

2.4 Proactive vs. Source Initiated

A proactive (Table-Driven) routing protocols are maintaining up-to-date information of both source and destination nodes. It is not only maintained a single node's information, it can maintain information of each and every nodes across the network. The changes in network topology are then propagated in the entire network by means of updates. Some protocols are used to discover routes when they have demands for data transmission between any source nodes to any destination nodes in network, such protocol as DSDV(.Destination Sequenced Distance Vector) routing protocol. These processes are called initiated on-demand routing. Examples include DSR (Dynamic Source Routing) and AODV (Ad-hoc On Demand Distance Vector) routing protocols [2].

3. AD-HOC on Demand Vector Protocol (AODV)

Ad-hoc on demand vector (AODV) is a routing algorithm used in ad-hoc networks. AODV adapts a very different mechanism to maintain routing information. It uses traditional routing tables. One entry per destination is allowed. This is in contrast to DSR, which can maintain multiple route cache entries for each destination. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers. An important feature of AODV is the maintenance of timer-based states in each node, regarding utilization of individual routing table entries. It is loop-free, self-starting, and scales to large numbers of mobile nodes. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets [1, 2, 6, and 9]. Whenever a node needs to find a route to another node it broadcasts a Route Request (RREQ) message to all its neighbors. The RREQ message is flooded through the network until it reaches the destination or a node with a fresh route to the destination. On its way through the network, the RREQ message initiates creation of temporary route table entries for the reverse route in the nodes it passes. If the destination, or a route to it, is found, the route is made available by unicasting a Route Reply (RREP) message back to the source along the temporary reverse path of the received RREQ message. On its way back to the source, the RREP message initiates creation of routing table entries for the destination in intermediate nodes. Routing table entries expire after a certain time-out period [3, 7]. The recent specification of AODV includes an optimization technique to control the RREQ flood in the route discovery process. It uses an expanding ring search initially to discover routes to an unknown destination. In the expanding ring search, increasingly larger neighborhoods are searched to find the destination. The search is controlled by the TTL field in the IP header of the RREQ packets. If the route to a previously known destination is needed, the prior hop-wise distance is used to optimize the search [5, 6, and 14].

4. Dynamic Source Routing (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks and is based on a method known as source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache [1]. The data packets carry the source route in the packet header. DSR is on demand, which reduces the bandwidth use especially in situations where the mobility is low. It is a simple and efficient routing protocol for use in ad-hoc networks. It has two important phases, route discovery and route maintenance [2, 5]. When a node in the ad-hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving a RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed so far. The RREP routes are itself back to the source by traversing this path backwards. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source, if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. Several additional optimizations have been proposed such as,

***Salvaging*:** An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source route.

***Gratuitous route repair*:** A source node receiving a RERR packet piggybacks the RERR in the following RREQ. This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes.

***Promiscuous listening*:** When a node overhears a packet not addressed to it, it checks if the packet could be routed via itself to gain a shorter route.

If so, the node sends a *gratuitous* RREP to the source of the route with this new, better route. Aside from this, promiscuous listening helps a node to learn different routes without directly participating in the routing process [5, 6].

5. OPTIMIZED LINK STATE ROUTING PROTOCOL (OLSR)

Optimized Link State Routing (OLSR) protocol is developed for mobile ad-hoc networks. It operates as a table-driven, proactive protocol, that is, it exchanges topology information with other nodes of the network regularly. OLSR is an optimization version of a pure link state protocol in which the topological changes cause the flooding of the topological information to all available hosts in the network. OLSR may optimize the reactivity to topological changes by reducing the maximum time interval for periodic control message transmission. Furthermore, as OLSR continuously maintains routes to all destinations in the network, the protocol is beneficial for traffic patterns where a large subset of nodes are communicating with another large subset of nodes, and where the [source, destination] pairs are changing over time.

OLSR protocol is well suited for the application which does not allow the long delays in the transmission of the data packets. The best working environment for OLSR protocol is a dense network, where the most communication is concentrated between a large numbers of nodes. OLSR reduce the control overhead forcing the MPR to propagate the updates of the link state, also the efficiency is gained compared to classical link state protocol when the selected MPR (Multi Point Relays) set is as small as possible. But the drawback of this is that it must maintain the routing table for all the possible routes, so there is no difference in small networks, but when the number of the mobile hosts increase, then the overhead from the control messages is also increasing. This constrains the scalability of the OLSR protocol. The OLSR protocol work most efficiently in the dense networks.

6. DESTINATION-SEQUENCED DISTANCE-VECTORS ROUTING (DSDV)

DSDV is a hop-by-hop distance vector routing protocol. It is proactive; each network node maintains a routing table that contains the next-hop for, and number of hops to, all reachable destinations. Periodical broadcasts of routing updates attempt to keep the routing table completely updated at all times [3]. To maintain the consistency of routing tables in a dynamically varying topology, each station periodically transmits updates, and transmits updates immediately when significant new information is available.

Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently [10]. Routing information is advertised by broadcasting or multicasting the packets which are transmitted periodically and incrementally as topological changes are detected – for instance, when stations move within the network [4].

To guarantee loop-freedom DSDV uses a concept of sequence numbers to indicate the freshness of a route. A route R is considered more favorable than R' if R has a greater sequence number or, if the routes have the same sequence number, R has lower hop-count. The sequence number for a route is set by the destination node and increased by one for every new originating route advertisement. When a node along a path detects a broken route to a destination D, it advertises its route to D with an infinite hop-count and a sequence number increased by one. Route loops can occur when incorrect routing information is present in the network after a change in the network topology, e.g., a broken link. In this context the use of sequence numbers adapts DSDV to a dynamic network topology such as in an ad-hoc network [2, 3, and 10].

DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, DSDV is not suitable for highly dynamic networks. (As in all distance-vector protocols, this does not perturb traffic in regions of the network that are not concerned by the topology change.) [10].

7. COMPARISION

It is difficult for the quantitative comparison of the most of the ad-hoc routing protocols due to the fact that simulations have been done independent of one another using different metrics and using different simulators. This paper does the realistic comparison of a various routing protocols, such as DSDV, AODV, OLSR and DSR. The significant observation is, simulation results agree with expected results based on theoretical analysis. As expected, reactive routing protocol AODV performance is the best considering its ability to maintain connection by periodic exchange of information, which is required for TCP, based traffic. AODV performs predictably [18]. Delivered virtually all packets at low node mobility, and failing to converge as node mobility increases. Meanwhile DSR was very good at all mobility rates and movement speeds and DSDV performs almost as well as DSR, but still requires the transmission of many routing overhead packets [1]. At higher rates of node mobility it's actually more expensive than DSR. Compared the On-Demand (DSR and AODV) and Table-Driven (DSDV) routing protocols by varying the number of nodes and measured the metrics like end-end delay, dropped packets, As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. Hence for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DSDV's performance is superior [2].

Considered both OLSR and AODV performed very reliably and established quick connection between nodes without any further delay. With regards to overall performance, AODV and OLSR performed pretty well showing average performance throughout the simulation which is equivalent to result generated by other researchers [ref]. However, AODV showed better efficiency to deal with high congestion and it scaled better by successfully delivering packets over heavily trafficked network compared to OLSR [2, 17, and 19].

8. CONCLUSION

In this article we provide descriptions of several routing schemes proposed for ad hoc mobile networks. We also

provide a classification of these schemes according to the routing strategy (i.e., table-
driven and on-demand). We have presented a comparison of these two categories of routing protocols, highlighting their features, differences, and characteristics. Finally, we have identified possible applications and challenges facing ad-hoc mobile wireless networks. While it is not clear that any

Table: 1 Comparision between DSDV, DSR, AODV, OLSR

Protocol Property	DSDV	DSR	AODV	OLSR
Multi-Cost Routes	NO	YES	NO	YES
Distributed	YES	YES	YES	YES
Unidirectional Link	NO	YES	NO	YES
Multicast	NO	NO	YES	YES
Periodic Broadcast	YES	NO	YES	YES
QoS Support	NO	NO	NO	YES
Routes Information Maintained in	Route Table	Route Cache	Route Table	Route Table
Reactive	NO	YES	YES	NO
Provide Loop-Free Routers	YES	YES	YES	YES
Route Optimization	YES	YES	YES	YES
Scalability	YES	YES	YES	YES
Route Reconfigurati on	Sequen ce Numbe r Adopts	Erase Route Notify Source	Erase Route Notify Source	Link State Announce ment
Proactive	YES	NO	NO	YES
Routing Philosophy	FLAT	FLAT	FLAT	FLAT

Particular algorithm or class of algorithm is the best for all scenarios; each protocol has definite advantages and disadvantages, and is well suited for certain situations. The field of ad-hoc mobile networks is rapidly growing and changing, and while there are still many challenges that need to be met, it is likely that such networks will see widespread use within the next few years.

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