Mobile Ad hoc Networking (MANET): Routing Protocol Evaluation Considerations

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Abstract: ***Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. Nodes in mobile ad-hoc network are free to move and organize themselves in an arbitrary fashion. Each user is free to roam about while communication with others. However, the fact that there is no central Infrastructure and that the devices can move randomly gives rise to various kind of problems, such as routing and security. There are several familiar routing protocols like table driven, on- demand, hybrid routing protocols which have been proposed for providing communication among all the nodes in the network. This paper presents Qualitative and Quantitative metrics that can be used to evaluate a routing protocol.***

Keywords: MANET, Qualitative, Quantitative, Wireless**.**

1. Introduction

Wireless cellular systems have been in use since 1980s. We have seen their evolutions to first, second and third generation's wireless systems. Wireless systems operate with the aid of a centralized supporting structure such as an access point. These access points assist the wireless users to keep connected with the wireless system, when they roam from one place to the other. The presence of a fixed supporting structure limits the adaptability of wireless systems. In other words, the technology cannot work effectively in places where there is no fixed infrastructure. Future generation wireless systems will require easy and quick deployment of wireless networks. This quick network deployment is not possible with the existing structure of current wireless systems. Recent advancements such as Bluetooth introduced a new type of wireless systems known as mobile ad-hoc networks. Mobile ad-hoc networks or "short live" networks operate in the absence of fixed infrastructure. They offer quick and easy network deployment in situations where it is not possible otherwise. Ad-hoc is a Latin word, which means "for this or for this only." Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. Nodes in mobile ad-hoc network are free to move and organize themselves in an arbitrary fashion. Each user is free to roam about while communication with others. The path between each pair of the users may have multiple links and the radio between them can be heterogeneous. This allows an association of various links to be a part of the same network. [2]

A mobile ad-hoc network is a collection of mobile nodes forming an ad-hoc network without the assistance of any centralized structures. These networks introduced a new art of network establishment and can be well suited for an environment where either the infrastructure is lost or where deploy an infrastructure is not very cost effective

The popular IEEE 802.11 "WI-FI" protocol is capable of providing ad-hoc network facilities at low level, when no access point is available. However in this case, the nodes are limited to send and receive information but do not route anything across the network. Mobile ad-hoc networks can operate in a standalone fashion or could possibly be connected to a larger network such as the Internet. [2]

Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality. Typical application examples include a disaster recovery or a military operation. Not bound to specific situations, these networks may equally show better performance in other places. As an example, we can imagine a group of peoples with laptops, in a business meeting at a place where no network services is present. They can easily network their machines by forming an ad-hoc network. This is one of the many examples where these networks may possibly be used.

2. Classification of Routing Protocols

In Topology based approach, routing protocols are classified into three categories, based on the time at which the routes are discovered and updated.

a. Proactive Routing Protocol (Table Driven)
b. Reactive Routing Protocol (On-Demand)
c. Hybrid Routing Protocol

The Proactive routing approaches designed for ad hoc networks are derived from the traditional routing protocols. These protocols are sometimes referred to as table-driven protocols since the routing information is maintained in tables. Proactive approaches have the advantage that routes are available the moment they are needed. However, the primary disadvantage of these protocols is that the control overhead can be significant in large networks or in networks with rapidly moving nodes. Proactive routing protocol includes Destination-Sequenced Distance-Vector (DSDV) protocol, Wireless Routing Protocol (WRP), Optimized Link

State Routing Protocol (OLSR) etc. Reactive routing approaches take a departure from traditional Internet routing approaches by not continuously maintaining a route between all pairs of network nodes. Instead, routes are only discovered when they are actually needed. When a source node needs to send data packets to some destination, it checks its route table to determine whether it has a route. If no route exists, it performs a route discovery procedure to find a path to the destination. Hence, route discovery becomes on-demand. The drawback to reactive approaches is the introduction of route acquisition latency. That is, when a route is needed by a source node, there is some finite latency while the route is discovered. In contrast, with a proactive approach, routes are typically available the moment they are needed. Hence, there is no delay to begin the data session. Reactive routing protocol includes Dynamic Source Routing (DSR) protocol, Ad hoc on-demand Distance Vector (AODV) protocol, Ad hoc On-demand Multiple Distance Vector (AOM DV) protocol etc. Hybrid protocols seek to combine the Proactive and Reactive approaches. An example of such a protocol is the Zone Routing Protocol (ZRP).

3. Evaluation Criteria of Routing Protocol

Routing protocols for MANETs should be evaluated on both qualitative and quantitative metrics. Qualitative metrics describe desirable protocols' attributes that make them efficient for use in the ad hoc wireless environment. Quantitative metrics include statistical data, which provide the tools to assess the performance of the routing protocols.

3.1 Qualitative Metrics include:

(a) Loop freedom: According to Bellman-Ford algorithm in wireless environment with limited bandwidth, interference from neighboring nodes transmissions and a high probability of packet collision, it is essential to prevent a packet from looping in and thus consuming both processing time and bandwidth

(b) On demand routing behavior: Due to bandwidth limitations in the wireless network, on demand or reactive based routing minimizes the dissemination of control packets in the network, increases the available bandwidth for user data and conserves the energy resources on the mobile nodes. Reactive routing protocols introduce a medium to high latency.

(c) Proactive behavior: This behavior is preferable when low latency is main concern and where bandwidth and energy resources permit such behavior. Mobile nodes in vehicular platforms do not face energy limitations.

(d) Security: The wireless environments along with the nature of routing protocols in MANET which require

(e) Unidirectional link support: Nodes in the wireless environment may be able to communicate only through unidirectional links. It is preferable that routing protocols are able to support both unidirectional and bidirectional links.

(f)Sleep mode: In general, nodes in a MANET use batteries for their energy source. The protocol should be able to operate, even though some nodes are in "sleep mode" for short periods, without any adverse consequences in the protocol's performance.

Therefore, a routing protocol for MANETs should keep a balance between latency and routing overhead, energy consumption, and node participation in the routing process, and should employ security mechanisms. For high speed wireless communications, low latency and high packet delivery ratio are more important than low routing overhead[3].In tactical communications, user data will be destined, in many cases, to a group of other users in network, making multicasting an important attribute of routing protocol in those networks.

3.2 Quantitative Metrics Includes

(a)End to end throughput and delay: These metrics can be used to measure the effectiveness of the routing protocol. Design flaws that increase delay and minimize data throughput can be revealed by these metrics.

(b)Route acquisition time: it indicates how much time does a protocol need to discover a route? This is a main concern in reactive routing protocols, as the longer the time is, the higher the latency is in the network.

(c)Out-of-order delivery: The percentage of packets that are delivered out of order may affect the performance of higher-layer protocols such as TCP, which prefers in-order data delivery of packets.

(d)Efficiency: Additional metrics can be used to measure the efficiency of the protocol. One can use them to measure the portion of the available bandwidth that is used by the protocol for route discovery and maintenance. Another measurement calculates the packet delivery ratio over the total number of packets transmitted and the energy consumption of the protocol for performing its task.

All the above quantitative metrics should be based on the some network attributes, such as network density, mobility, data density, bandwidth, energy resources, transmission and receiving power, antenna types, etc.

It is useful to track several ratios that highlight the internal efficiency of a protocol in doing its job. Following are such points:

(a)Average number of data bits transmitted/data bit delivered- This can be thought of as a measure of the bit efficiency of delivering data within the network. Indirectly, it also gives the average hop count taken by data packets.

(b)Average number of control bits transmitted/data bit delivered--This measures the bit efficiency of the protocol in expending control overhead to delivery data. This should include not only the bits in the routing control packets, but also the bits in the header of the data packets.

(c)Average number of control and data packets transmitted/data packet delivered--Rather than measuring pure algorithmic efficiency in terms of bit count, this measure tries to capture a protocol's channel access efficiency, as the cost of channel access is high in contention-based link layers.

Also, we must consider the networking context in which a protocol's performance is measured. Essential parameters that should be varied include:

1. Network size--Measured in the number of nodes
2. Network connectivity--The average degree of a node (i.e. the average number of neighbors of a node)
3. Topological rate of change--The speed with which a network's topology is changing
4. Link capacity--Effective link speed measured in bits/second, after accounting for losses due to multiple access, coding, framing, etc.
5. Fraction of unidirectional links--How effectively does a protocol perform as a function of the presence of unidirectional links?
6. Traffic patterns--How effective is a protocol in adapting to non-uniform or busty traffic patterns?
7. Mobility--When, and under what circumstances, is temporal and spatial topological correlation relevant to the performance of a routing protocol? In these cases, what is the most appropriate model for simulating node mobility in a MANET?
8. Fraction and frequency of sleeping nodes--How does a protocol perform in the presence of sleeping and awakening nodes?

A MANET protocol should function effectively over a wide range of networking contexts--from small, collaborative, ad hoc groups to larger mobile, multi hop networks. The preceding discussion of characteristics and evaluation metrics somewhat differentiate MANETs from traditional, hardwired, multi hop networks. [4]

4. Conclusion

In summary, the networking opportunities for MANETs are intriguing and the engineering tradeoffs are many and challenging. In order to answer "how the goodness of a protocol should be measured?" Here in this paper we presented an outline of protocol evaluation issues that highlight performance metrics that can help promote meaningful comparisons and assessments of protocol performance. It should be recognized that a routing protocol tends to be well-suited for particular network contexts. The attributes and performance of a protocol can typically be expressed qualitatively or quantitatively.

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