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Review on Performance Issues of Routing Protocols of Mobile Ad-hoc Networks

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Abstract: ***The 1990s have seen a rapid growth of research interests in mobile ad hoc networking. The infrastructureless 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. This, along with the diverse application of these networks in many different scenarios such as battlefield and disaster recovery, have seen MANETs being researched by many different organization and institutes. 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. One interesting research area in MANET is routing. 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, and each author of each proposed protocol argues that the strategy proposed provides an improvement over a number of different strategies considered in the literature for a given network scenario. Therefore, it is quite difficult to provide protocols which may prove best under a number of different network scenarios, such as increasing node density and traffic. In this paper, we provide an overview of a Manet Protocols and it also includes wide range of performance issues in routing protocols so as to improve its Performances in various environment.***

Keywords: mobile ad-hoc network, MANET protocol, delay, network load, retransmission attempt, throughput, DSR, GRP, OLSR.

I. Introduction

A Mobile Ad hoc Network (MANET) is a collection of mobile nodes (MNs) that cooperatively communicate with each other without any pre-established infrastruc-tures such as a centralized access point. These nodes may be computers or Devices such as laptops, PDAs, mobile phones, pocket pc with wireless connectivity are commonly used. Due to the fact that MNs change their physical location by moving around, the network topology may change unpredictably. This causes changes of link status between each MN and its neighboring. Thus, MNs which join and/or leave the communication range of MN in the network will surely change its relationship with its neighbors by detection of a new link breakages and/or link additions. In the same way, the change of the all routes printed by this MN is also based on the relationship. This change of routes is made with an overhead traffic in the process of maintenance routes assured by the implemented routing protocol in a MANET. For resume, the performance of a MANET is closely related to the capability of the routing protocols to adapt them-selves to unpredictable changes of topology network and link status [23,24]. One of the most important aspects of the communication process is the design of routing protocols used to establish and maintain multi-hop routes to allow data communication between nodes. Several researches have been done in this area, and many multi-hop routing protocols have been developed. There are three main categories of MANET routing protocols: Proactive (table-driven), Reactive (on-demand) and Hybrid. Proactive protocols build their routing tables continuously by broadcasting periodic routing updates through the net-work; reactive protocols build their routing tables on demand and have no prior knowledge of the route they will take to get to a particular node. Hybrid protocols create reactive routing zones interconnected by proactive routing links and usually adapt their routing strategy to the amount of mobility in the network. In this paper, we present a new quantitative measure of performance issues in MANET. This paper is organized as follows. Section 2 gives an overview of the wireless networks. Section3, presents the objective of this research. Section 4 explains properties of mobile adhoc network. Section5 Includes the classification of Manet Routing Protocol. Section6 explains the limitations of Manet. In Section7 presents performance metrics for evaluating performance of routing protocols. The last section concludes and presents some future works.

II. Wireless Networks

Recently wireless networks are getting more and more admiration due to their ease of utilization, its mobility,simplicity, affordable and cost saving installation. Consumer/user is no more dependent on wires where he/she is, easy to move and

enjoy being connected to the network. As user wants wireless connectivity that enable users to communicate and transfer data with each other without any wired medium irrespective of their geographic position. Therefore all nodes are operating as routers and need to be capable to discover and maintain routes to every other node in the network and to propagate packets accordingly. One of the immense features of wireless network that makes it captivating and distinguishable among the conventional wired networks is mobility. These features provide user the ability to move liberally, while being connected to the network. Wireless networks comparatively easy to install and could be configured according to the need of the users. These can range from small number of users to large full infrastructure networks where the number of users is in thousands. MANETs are efficiently and quickly deployed and be a contemptible network solution. MANET (Taruna and Purohit, 2011) is an autonomous system of mobile nodes moving at any time in random dynamic topology, these mobile nodes are self organized and deployed with routing capabilities, communicate over wireless links in the form of peerto- peer and multi-hop forwarding connectivity independent of centralized authority.

III. Research Objective

The basic purpose of this research is to evaluate and examine the routing protocols in mobile ad hoc network. The presentation of routing protocols evaluated carefully by analyzing the various performance issues in mobile adhoc network on the basis of metrics i.e. both *qualitative* and *quantitative*. These metrics are used to measure the suitability and performance of the different protocols. These issues help in removing the limitations of MANET.

IV. Classification

An ad-hoc routing protocol is a convention that controls how nodes decide which way to route packets in MANETs. Routing Protocols[19,20] can be classified into three categories as shown in the figure 1: Reactive (On-demand), Proactive (Table-driven) or Hybrid. The table-driven ad hoc routing approach is similar to the connectionless approach of forwarding packets, with no regard to when and how frequently such routes are desired. This is not the case, however, for on-demand routing protocols. When a node using an on-demand protocol[1,2] desires a route to a new destination, it will have to wait until such a route can be discovered. On the other hand, because routing information is constantly propagated and maintained in table-driven routing protocols, a route to every other node in the ad hoc network is always available, regardless of whether it is needed or not.

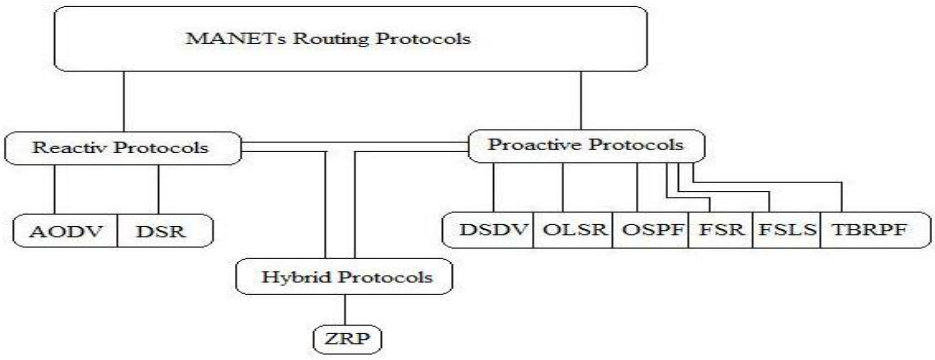

Figure 1. Classification of Routing Protocols.

4.1 Proactive or Table-Driven Routing Protocol

Proactive routing protocols[19,20] rely on the periodic collection and exchange of topology information by all the nodes to its neighboring nodes. Proactive or Table Driven.Routing protocols perform route discoveries automatically & periodically without any request from the nodes. It builds up a routing table for each node which contains information on how to reach every other node and to maintain the consistency the algorithm tries to keep updating its routing table periodically. Each node shares this table with its neighbor nodes. Therefore, routes are discovered for every mobile node of the network, without any requests from the nodes. Each node has to maintain one or more tables to store routing information, & response to changes in network topology by broadcasting & propagating. Examples: DSDV (Destination-Sequenced Distance-Vector Routing), WRP (Wireless Routing Protocol) and OLSR[5,17] (The Optimized.

Link State Routing Protocol). The main disadvantages of Proactive Routing protocols are:

- Wastage of bandwidth due to unnecessary advertising of routing information.
- Maintaining a routing table for each node and advertising of this table leads to overhead, which consumes more bandwidth.
- Regular update of its routing tables uses up battery power.
- Slow reaction on restructuring and failures.
- Many redundant route entries to the specific destination needlessly take place in the routing tables.

4.2 Reactive or On-Demand Routing Protocols

Reactive routing protocols[19,20] have been introduced to prevent the periodic routing information exchange as in Proactive routing protocols, which consumes an essential amount of the available network resources. In reactive routing protocols, when a node requires a route to a destination, it initiates a route discovery process. Reactive protocols perform route discovery and path establishment by using specialized sets of control packets such as RREQ (Route Request), RREP (Route Reply) and RERR (Route Error). When a node wants to communicate with any other node in the network it sends a RREQ packet to its neighboring nodes and if the neighboring node is the required destination it replies with a RREP packet to the source thus acknowledging the RREQ packet from source. If there is an error in a link it sends a RERR to its source. On-demand routing protocols were designed with the aim of reducing control overhead, thus increasing bandwidth and conserving power at the mobile stations. These protocols limit the amount of bandwidth consumed by maintaining routes to only those destinations for which a source has data traffic. Examples: AODV (Ad-hoc On Demand Distance Vector Routing), DSR[12] (Dynamic Source Routing), and DYMO (Dynamic MANET On Demand). The main disadvantages of Reactive Routing protocols are:

- High latency time is required in finding the route to the destination,
- Flooding to can lead to network clogging.
- RREP, RREQ & RERR messages leads to Control overhead.

4.3 Hybrid Routing Protocols

Hybrid protocols[19,20] combine the features of reactive and proactive protocols. These protocols have the advantage of both proactive and reactive routing protocols to balance the delay which was the disadvantage of Table driven protocols and control overhead (in terms of control packages). Main feature of Hybrid Routing protocol is that the routing is proactive for short distances and reactive for long distances. The common disadvantage of hybrid routing protocols is that the nodes have to maintain high level topological information which leads to more memory and power consumption. Examples: ZRP (Zone Routing Protocol), CEDAR (Core
Extraction Distributed Ad Hoc Routing). The main disadvantages of Hybrid Routing Protocols are:

- Large overlapping of routes.
- Longer delay if route not found immediately.
- Core nodes movement affects the performance of the protocol
- In case of CEDAR the route establishment and computation is relied on core nodes.

TABLE1. Summary of Wireless Adhoc's Routing Protocol Classification

Properties	Proactive	Reactive	Hybrid
Network organization	Flat Hierarchical	Flat	Flat Hierarchical
Topology dissemination	Periodical	On-demand	Both
Route Latency	Always available	Available when needed	Both
Communication overhead	High	Low	Medium

V. Properties Of Ad Hoc Routing Protocols

The desirable properties of ad hoc routing protocols are discussed below [1]:

A. Distributed Operation

Here each node maintains a set of values in its routing table. As ad-hoc networks are self-dependent and autonomous systems, they demand for a routing protocol that may be able to maintain the required criterion.

B. Quality of Service Support

Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support.

C. Efficient Bandwidth Utilization

The available network bandwidth will be consumed by control traffic as routing protocols incurs excessive control traffic. This may affect communication performance of the network as the bandwidth of the wireless network is moderately limited; reduction of control overhead becomes an important design factor.

D. Manageable Resource:

In a cellular network, reduction in the number of active mobile nodes reduces the amount of signal interference and channel contentions where as the ad hoc mobile nodes transmit their messages via other nodes toward their intended destinations i.e. a decrease in the number of mobile users can also degrade performance of networks. Unlike cellular networks, the ad hoc network performance deeply impacts the lifetime of mobile nodes. Therefore, as the number of available nodes decreases, it may be further noted that the network may also be partitioned into smaller networks and to prolong the lifetime of each node, ad hoc routing protocols should consider power consumption.

E. Optimization of metrics

The bandwidth and battery power are important metrics in ad hoc networks besides end-to-end throughput and delay, the widely used performance metrics in wired and wireless networks. Though the existing metrics influence the design of routing protocols, the designer must optimize the following metrics:

- Maximum end-to-end throughput.
- Minimum end-to-end delay.
- Minimum total power (battery capacity).
- Minimum overhead (bandwidth).
- Load balancing (least congested path).
- Shortest path/minimum number of hops.

F. Freedom from loops

Sometimes, a fraction of packets start revolving around the network because of temporary loops. Since, looping of packets can cause a considerable overhead in terms of bandwidth and power consumption. Therefore, it is desirable for routing to have acyclic route i.e. may not have loops.

G. Security

The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behaviour of the routing protocol we need some sort of security measures. Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network.

VI. Limitations Of Routing In Manets

There are lots of challenges when designing MANETs. While developing and implementing for MANETs bearing in mind installation, operation and maintenance should be offered. Numeral
issues which in fact have an effect on the design, implementation and performance of MANETs are: routing, transport layer protocol, multi-casting, security, medium access scheme, quality of service (Qos), self organization, pricing scheme, scalability & deployment considerations,Transmission range limitation, band width of the protocol, rate of errors, Vulnerable to interferences and dynamic nature of frequent topological changes. Routes between a source and a destination may potentially contain an ordered series of intermediate nodes that act as the routers. The multiple hops communication paradigm has three main performance advantages compared with single hop communication solution:

1) *Adaptability*. While maintaining a multiple hop data forwarding network, packets can be routed around obstructions captured by enemies, which is very crucial for the battlefield scenario.

2) *Spatial reuse*. Packet forwarding over multiple hops via small radii-transmissions exploited spatial reuse, by allowing multiple concurrent packet transmissions in different regions of the network and maximize throughput.

3) *Energy consumption efficiency*. Packet forwarding via multiple small radii transmissions as opposed to a single large radius transmission improved the throughput per unit energy

VII. Performance Issues

To judge the quality of a protocol one needs to test them on the basis of metrics i.e. both *qualitative* and *quantitative*. These metrics are used to measure the suitability and performance of the different protocols. The metrics should be chosen carefully and should be i*ndependent* of any routing protocol. The following is a list of all desirable ***qualitative*** properties of MANET routing protocols:-

i) Loop-Freedom: - It is very important for the network to achieve loop freedom i.e. to be able to
avoid loop formation in the network. Loop-freedom might not be an important in terms of quantitative measure but it is very important in terms of quantitative measure. A worst case scenario can be a small fraction of packets moving in the network again and again for infinite/very long time periods blocking the network routes and increasing traffic.

ii) Demand-Based Operation: - The routing algorithm should be flexible and should be able to
cope with new, ever-changing network structure and node locations. It should be able to adapt to the ununiform traffic distribution inside the network. It should be able to maintain routing between all nodes at all times. It should be able choose the routes with the least traffic density for routing of packets to their density.

iii) ***Proactive Operation: -*** In certain cases the additional overhead that the demand-based operation incurs may be very high and thus render the protocol unacceptable. It is the drawback of demand-based routing. In these cases proactive routing is used. But in case proactive routing we need a higher bandwidth and energy resources.

iv) Security: - A MANET routing protocol is vulnerable to many forms of attack. They are more
prone to security replay transmission, do spoofing threats than other general wired networks because the network structure is not strictly defined. Also a number of nodes keep on getting added as well as deleted from the network making it very easy

for a malicious node to enter a network. Then it will be relatively easy for that node to snoop on network traffic, redirect traffic and flood the entire network. Security is very important to stop any kind of disruption of the network.

v) "Sleep" Period Operation: - This concept should be used to conserve energy or when the network is inactive. In such a case the nodes of the MANET stop transmitting and/or receiving for arbitrary periods of time until the network traffic is high enough to warrant the need of these particular nodes. A routing protocol must be able to accommodate such kinds of sleep-periods without any adverse consequences on the network.

vi) Unidirectional Link Support: - Usually in case of design of routing algorithms, bidirectional links are used as not all algorithms are capable of performing over unidirectional links. Still, it so happens that sometimes unidirectional links may also appear in the wireless network. Mostly, a sufficient number of duplex links are present so that the use of unidirectional links is limited. But, sometimes we face situations where the only form of bidirectional connection in between two ad-hoc regions is provided by two unidirectional links pointing in opposite directions. In these cases the ability to make use of them is extremely valuable. Some essential parameters that should be varied are as follows:

1) Network Size – Measured in the number of nodes.
2) Network Connectivity – The average degree of a node (i.e. the average number of neighbours of a node).
3) Topological Rate of Change – The speed with which a networks's topology is changing.
4) Link Capacity – Effective link measured in bits/second after accounting for losses due to multiple access, coding, framing etc.
5) Fraction of Unidirectional Links – Check how effectively a protocol performs as a function of the presence of unidirectional links.
6) Traffic Patterns – Check how effective is a protocol in adapting to non-uniform or bursty traffic patterns?
7) Mobility – Test that when and under what circumstances, is temporal and spatial topological
correlation relevant to the performance of a routing protocol. In these cases check, what is the most appropriate model for simulating node mobility in a MANET.
8) Fraction and Frequency of Sleeping Nodes – Check how does a protocol perform in the presence of sleeping and awakening nodes [1].

A MANET protocol should be able function effectively over a wide range of networking contexts i.e. from small, collaborative, ad hoc group to larger mobile, multihop networks. The wireless networking environment is one of scarcity rather than abundance, wherein bandwidth is relatively limited, and energy may be as well.[1]. Thus the protocols should be designed so as to be able to handle all the issues. A lot of experimental work has been going on towards the development of more efficient MANET protocols. Rather than try and design new protocols, people are trying to improve the already existing ones in order to be able to provide more efficient routing in MANET.

VIII. Conclusion

Mobile ad hoc network is decentralised, self-organised, "anytime, anywhere" network and provide cheap communications. Mobile Ad-Hoc Networks has the ability to deploy a network where as traditional network infrastructure environment cannot possibly be deployed. In this paper author discussed classification of routing protocols, highlighting their characteristics and provides various performance issues so as to overcome the limitations of MANET. In this paper we analyze various factors that affect their routing performance. There are still many challenges facing wireless ad hoc networks regarding their performances in different scenarios but besides this each protocol has their own merits and demerits and is well suited for certain situations,Because of there advantages, wireless ad hoc networks are becoming more and more prevalent in the world.

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