Survey on QoS for Multi-Path Routing Protocols in Mobile Ad-Hoc Networks

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***Abstract*—Mobile Ad hoc Network is a self-configuring network of mobile devices. These devices (nodes) are free to move independently in any direction and will therefore change its links to other devices frequently. Because of multi-hop routing requirements MANET nodes need to act as both host as well as router at a time and perform all the routing and state maintenance operations. Routing has always been one of the key challenges in Mobile Ad Hoc Networks and the challenge become more difficult when the network size increases. This paper gives the survey of multi-path routing protocols for Mobile Ad-Hoc networks. Also future work is suggested where different Quality of service parameters for routing protocols is suggested.**

***Index Terms*—Mobile Ad-Hoc network, routing protocol.**

I. Introduction

Mobile Ad Hoc Network (MANET) [1] has many applications in today's world. It can be used for forming a network at campuses, offices etc. Mainly Mobile Ad Hoc Networks are useful in the areas where network infrastructure is not available. A few examples include: military soldiers in the field; sensors scattered throughout a city for biological detection; an infrastructure less network of notebook computers in a conference or campus setting; rare animal tracking; space exploration; undersea operations; temporary offices such as campaign headquarters and emergency and rescue operations.

Compared with the other communication networks MANET have following characteristics: network autonomy, dynamic topology, bandwidth limitations, mutative link capacity, energy limitation and distributed control etc. [2]. MANET is a self-configuring network of mobile devices. These devices (nodes) are free to move independently in any direction and will therefore change its links to other devices frequently. That is why the Network topology for MANET is Dynamic. Routing messages in MANET is a crucial issue due to the dynamic topology characteristic of MANET.

MANET nodes have limited bandwidth that means there transmission range is limited. A Source node or host can directly communicate with other node if the other node is in transmission range of the source node. Since these nodes can directly communicate with one another, they are called as neighbors in the network. Communications between non-neighboring nodes require multi-hop routing protocol [3]. Because of multi-hop routing requirements, MANET nodes need to act as both host as well as router at a time and perform all the routing and state maintenance operations [4]. This means that all routing decisions to forward message/s towards the destination/s need to be taken at intermediate nodes. Routing has always been one of the key challenges in Mobile Ad Hoc Networks and the challenge become more difficult when the network size increases [5].

Many routing protocols have been proposed for Ad Hoc Networks [3]. The routing protocols mainly are either table-driven (Proactive) or on-demand (reactive) routing protocols. Many hybrid protocols having combination of functionality of both proactive as well as reactive routing protocol are also proposed. The proactive routing protocols periodically update the routing tables. When there is a request to forward message the routes are available in the routing table. On the contrary reactive routing search the route when there is a request for it. In the route search operation the reactive routing protocols, find multiple paths for the same source-destination pair. One out of these multiple paths is selected to forward message/s.

This paper focuses on the idea of finding multiple paths (Multi-path) and prioritizing them according to different Quality of Service parameters. The idea here is to allocate paths to applications according to their need of Quality of Service. In addition to this, the study also targets to evaluate the performances of different on-demand routing protocols based on variety of Quality of Service parameters.

The organization of the rest of the paper is as follows. Section 2 presents brief history and concept of MANET. Section 3 presents the discussion about routing protocols in MANET. Section 4 briefs about the related work and in section 5 present future work in this area.

II. Manet History And Concepts

The history of ad hoc networks can be traced back to1972 and the DoD-sponsored Packet Radio Network (PRNET), which evolved into the Survivable Adaptive Radio Networks (SURAN) program in the early 1980s. The goal of these programs was to provide packet-switched networking to mobile battlefield elements in an infrastructure less, hostile environment (soldiers, tanks, aircraft, etc., forming the nodes in the network).

The PRNET used a combination of ALOHA and CSMA approaches for medium access, and a kind of distance vector routing. SURAN significantly improved upon the radios (making them smaller, cheaper, and power-thrifty), scalability of algorithms, and resilience to electronic attacks. The routing protocols were based on hierarchical link-state

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and were highly scalable.

In the early 1990s, a spate of new developments signaled a new phase in ad hoc networking. Notebook computers became popular, as did open-source software, and viable communications equipment based on RF and infrared. The concept of commercial (non-military) ad hoc networking had arrived. Other novel non-military possibilities were suggested and interest grew.

At around the same time, the DoD continued from where it left off, funding programs such as the Global Mobile Information Systems (GloMo), and the Near-term Digital Radio (NTDR). The goal of GloMo was to provide office-environment Ethernet-type multimedia connectivity anytime, anywhere, in handheld devices. Channel access approaches were now in the CSMA/CA and TDMA molds, and several novel routing and topology control schemes were developed. The NTDR used clustering and link-state routing, and self-organized into a two-tier ad hoc network.

Spurred by the growing interest in ad hoc networking, a number of standards activities and commercial standards evolved in the mid to late **'90s.** Within the IETF, the Mobile Ad Hoc Networking (MANET) working group was born, and sought to standardize routing protocols for ad hoc networks. The development of routing within the MANET working group and the larger community forked into reactive (routes on-demand) and proactive (routes ready-to-use) routing protocols. The 802.11 subcommittee standardized a medium access protocol that was based on collision avoidance and tolerated hidden terminals, making it usable, if not optimal, for building mobile ad hoc network prototypes out of notebooks and 802.11 PCMCIA cards. HIPERLAN and Bluetooth were some other standards that addressed and benefited ad hoc networking [6].

A Mobile Ad hoc network is a collection of autonomous nodes that can dynamically form network anywhere and anytime without using any pre-existing infrastructure. The nodes of MANET can move randomly and often act as router at the same time. Due to this there are different types of traffic in MANET.

- Nodes can directly communicate if inside the transmission range, these are called neighbors in the network.
- Nodes can indirectly communicate with the help of intermediate nodes (work as router) if outside the transmission range, these are called as non neighbors in the network.

MANET has the following features:

1) *Autonomous terminal:* - In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router. In other words, besides the basic processing ability as a host, the mobile nodes can also perform switching functions as a router. So usually endpoints and switches are indistinguishable in MANET.

2) *Distributed operation:* - Since there is no background network for the central control of the network operations, the control, and management of the network is distributed among the terminals. The nodes involved in a MANET should collaborate amongst themselves and each node acts as a relay as needed, to implement functions e.g. security and routing.

3) *Multi-hop routing:* - Basic types of ad hoc routing algorithms can be single-hop and multi-hop, based on different link layer attributes and routing protocols. Single hop MANET is simpler than multi-hop in terms of structure and implementation, with the cost of lesser functionality and applicability. When delivering data packets from a source to its destination out of the direct wireless transmission range, the packets should be forwarded via one or more intermediate nodes.

4) *Dynamic network topology:* - Since the nodes are mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time. MANET should adapt to the traffic and propagation conditions as well as the mobility patterns of the mobile network nodes. The mobile nodes in the network dynamically establish routing among themselves as they move about, forming their own network on the fly. Moreover, a user in the MANET may not only operate within the ad hoc network, but may require access to a public fixed network (e.g. Internet).

5) *Fluctuating link capacity:* - The nature of high bit error rates of wireless connection might be more profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subject to noise, fading, and interference, and has less bandwidth than a wired network. In some scenarios, the path between any pair of users can traverse multiple wireless links and the link themselves can be heterogeneous.

6) *Light-weight terminals:* - In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions.

III. MANET Routing Protocols

Because of uncertain movements of nodes in MANET the network topology is dynamic. As these moving nodes form the routes of MANET. These nodes work as a source, a destination or a router (forwarding node) at times. This makes the routing a vital issue in MANET. Many routing protocols are proposed for ad hoc networks. The routing protocols for ad hoc networks are divided into two categories depending on the time when the routes are formed. In first category the routes exists before there is a need for it. The protocols used are Table-Driven (Proactive) routing protocols. In the second category the routes are searched when there is need for it. The protocols used are On-Demand (Reactive) routing protocols.

In Table-Driven protocols the MANET nodes exchange information with other nodes to capture the information about the network. This helps them understand the entire topology of the network. Using this information they compute the routs for all source-destination pairs. The routes will be ready to use whenever there is a need of communication. For storing this information the nodes need to maintain one or many tables (routing tables or state information tables). Due to uncertain mobility of mobile nodes the information stored in these tables at node may become stale or ineffective very often. To overcome this problem the nodes periodically exchange routing information

available to them [3]. This periodic information exchange causes additional traffic in the network, which may lead to congestion. Also as the MANET node use battery power for functioning; this additional control traffic processing will increase power consumption.

On-Demand routing protocols has altogether a different strategy. In on-Demand routing protocols the routes between source and destination are searched when there is a need for communication. If a node S (source) has some message/s to send to another node D (destination) then S starts route search. Once the route/s between S and D is/are found the communication starts [3]. Means there is no need for maintaining any state or routing information (i.e. no tables required).

The comparison between the two types of MANET routing protocol goes as follows. The Table-Driven routing protocols always have communication routes ready. In Contrast to this the On-Demand routing protocol start the route search when there is demand for it. But the route maintenance cost and control traffic overhead involved in Table-Driven protocols is too much, which makes the reactive routing protocols more popular. Many On-Demand routing protocols for MANET are proposed in [2], [3], [7], [8], [11- 15].

The basic idea of On-Demand routing protocol is to search route when it is required. Due to the mobility characteristic of MANET nodes and Dynamic Topology of the network, there are always multiple routes available between the source-destination pair. The reactive routing mechanism suggests using the route that is considered best according to the required Quality of Service for the transmission, as in [3] hop count, is the parameter for selecting a route. Once the best route out of searched route is chosen, the other routes are not given any considerations. But maintaining information about these additional routes will be more advantageous [2-3], [8]. These additional routes can be used as backup paths in the events of link failures.

IV. Related Work

This section briefs about the research work on the idea of multi-path routing in Mobile Ad hoc networks.

Ronghua Shi and Yongyan Deng in [2] have suggested a latency forecasting mechanism for reducing the Latency of Ad Hoc On-Demand Distance Vector (AODV) routing protocol. At the time of route discovery, the source node sends route request packet to the destination. The route request packet carries the value of latency forecasting of the route (calculated at the originator). Intermediate nodes calculate the latency forecast of themselves after receiving the route request packet. We can get new path latency forecasts by accumulating the latency forecasts of nodes to the old latency forecast of the route, and then the new value is added into the packet and transmitted to the next node. According to the route request packet it has received, the destination node returns a route reply packet with the final value of latency forecast of the route; after receiving several replies, the source chooses the route, which has lowest latency forecast of the route. Authors have given emphasize on only two parameters i.e. latency and packet loss rate for choosing route; also load spreading or load balancing is not considered. Only delay sensitive applications kept in consideration.

Hua-Wen Tsai et al in [3] proposed an on-demand routing protocol with backtracking. Here they have given a concept of checkpoints, which have discovered multiple routes at the time of route discovery. In the event of route failure the node, which knows that there is no path to the destination sends an error message back to the source. On the route, back to the source any checkpoint node, which receives the error message, uses alternate or backup path to forward actual message to the original destination. The error message will not be sent to the source. The routes initially are chosen based on hop count. Authors have not used load spreading which could have proved significant increase in transmission speed and reduced power consumption.

Another extension to AODV protocol is proposed in [7] by Pradeep Macharla et al. While searching a route the source provide details of Quality of Service to be followed during communication. Only those nodes which can provide, the required Quality of Service forward the route request. Again, the Quality of Service parameters used here is latency or delay. The proposed protocol AODV-D ensures that delay does not exceed a maximum value for Mobile Ad Hoc Network.

In [4] Hao Ma et al used reliable routing another Quality of Service of routes. The work mainly focuses on choosing reliable routes among the available routes. In Mobile Ad Hoc Network, the unpredictable movements of nodes cause route failures very often. This degrades the network performance very rapidly. Authors have proposed A Reliable Routing Algorithm (RRA), which uses Fuzzy Petri Net to compute most reliable route. The idea can extended further for choosing multiple paths to serve as backup path for the initial route also load spreading can be more useful.

AntHocNet: a hybrid algorithm; based on a specific self-organizing behavior of ant colonies, the shortest path discovery, and on the related framework of ant colony optimization is proposed in [8]. Reactive ant agents discover multiple routes during discovery phase and proactive ant agents maintain the routes during maintenance phase. The routing overhead due to proactive ants for maintaining the routes can be reduced as if there are multiple routes available, no need of utilizing resources in finding routes when there is no demand for it.

Yuh-Shyan Chen and Chao-Yu Chiang worked on power consumption issue. In [10] they proposed A Power-Life Extension Routing Protocol Using a Round Robin Scheme. They proposed a mechanism for using multiple paths in round robin fashion to distribute power consumption evenly among the nodes. In [11] Mahesh K. Marina and Samir R. Das developed a multi path extension of AODV. This extension is based on the principle of disjoint ness of alternate paths and loop freedom in paths. Authors in [12] have given one more protocol where all the traffic is destined to a same node i.e. gateway. The source and the other intermediate nodes in the network are mobile and the destination is fixed. This is just another type of network, which we think cannot be treated as MANET.

The multi-hop AODV-2T suggested in [14] is an extension to AODV where the backup routes are constructed and

applied as the power level of nodes on the route crosses the 2 thresholds. When the battery power of a particular node goes below some, value i.e. first Threshold it is a trigger for node to recover a backup route at right time. Second threshold switch the traffic from first route to backup route.

In there paper [15] authors have suggested an idea of recovery of a failed route. Here a number of intermediate nodes on a route are selected as a waypoints and the route is divided into segments by the waypoints. When a route fails instead of discarding the completely original route and discovering a new route from the source to the destination, only the two-waypoint nodes of the broken segment have to find a new segment.

V. Future Work

From the literature survey we can propose following future work in the area of multi-path routing protocols in Mobile Ad-Hoc Networks. In literature survey, we have found that the researchers have worked on one Quality of Service parameter at a time in their research. In general, the Quality of Service parameters considered in earlier research are hop count and latency as par our knowledge.

The minimum number of hop count does not guarantee optimal forwarding path. Because even if a minimum hop count route has less number of forwarding nodes but the nodes may be overloaded or congested. They may be running out of battery power. Another parameter considered is latency. These routes guarantee about less delay but does not guarantee about route reliability.

It is required to focus all the Quality of Service issues extensively. The study and evaluation of protocols' performances when more than one QoS parameters are also needed. This will be helpful in choosing protocols as par application requirements. QoS parameters such as minimum bandwidth utilization, maximum delay variance (jitter), and most importantly path reliability long with hop count and low latency need to be extensively explored

For multiple route discoveries Ant Colony Optimization and Fuzzy Petri Net techniques can be used. The Fuzzy Petri Net mechanism can also be used for route selection.

Once multiple routes are discovered the next important issue is optimal route selection. The routes can be prioritized according to what quality of service they can provide to applications. Also a load balancing/spreading among different routes can be done. This will help in reducing power consumption.

VI. Conclusion

This paper has provided analysis of different protocols for Mobile Ad Hoc Network. In this paper we have suggested future scope in the area of multi-path routing protocols in MANET where the main focus will be on using multiple paths for message/s forwarding. Also future work in the area of different quality of service parameters for route selection is suggested. Another important future work suggested is to focus on less power consumption to increase the node life time.

This paper intends to give route choices to applications as par their Quality of service requirements.

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