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Multipath QOS Routing for Mobile Adhoc Networks - A review

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ABSTRACT

Mobile Ad-hoc networks (MANET) are a collection of wireless nodes which do not have any infrastructure unlike cellular networks which are infra-structured (i.e. base-stations are present). MANET consists of nodes (mobiles or laptops) that can act both as routers or hosts. The nodes communicate through radio waves. Range of each node is limited. If a receiver does not lie in senders range then the intermediate nodes act as routers. Routing refers to sending the data from source to destination by first finding a route and then maintaining a route fulfilling QoS requirements. This paper provides glimpses on multipath routing. Multipath routing allows the establishment of multiple paths between a single source and single destination node. It is typically proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing. Load balancing is of especial importance in MANETs because of the limited bandwidth between the nodes. It is very well known that in the mobile ad hoc network paradigm (MANET), routing is a challenging task, not only because of the dynamic topology caused by mobility, but also because of the limitations in bandwidth, range and power. From the review, it is observed that multipath routing minimizes the consequences of security attacks deriving from collaborating malicious nodes in MANET, by maximizing the number of nodes that an adversary must compromise in order to take control of the communication.

Keywords: MANET; QOS; Route Discovery; Route Maintenance.

1.0 Introduction

Mobile ad hoc networks (MANETs) composed of a collection of wireless mobile nodes which dynamically exchange data among themselves without the reliance on a fixed base station or a wired backbone

network (Fig. 1). MANET nodes are typically distinguished by their limited power, processing, and memory resources as well as high degree of mobility. In such networks, the wireless mobile nodes may dynamically enter the network as well as leave the network. Due to the limited transmission range of wireless network nodes, multiple hops are usually needed for a node to exchange information with any other node in the network. Thus routing is a crucial issue to the design of a MANET.

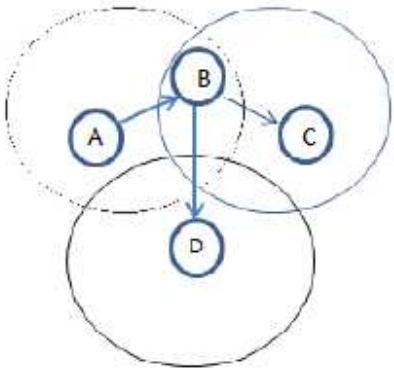

Fig. 1 Typical illustration of a MANET

Routing protocols in conventional wired networks are generally based upon either distance vector or link state routing algorithms. Both of these algorithms require periodic routing advertisements to be broadcast by each router. In distance vector routing [Hedric, 1988], each router broadcasts to all of its neighboring routers its view of the distance to all other nodes; the neighboring routers then compute the shortest path to each node. In link-state routing [Moy, 1991], each router broadcasts to its neighboring nodes its view of the status of each of its adjacent links; the neighboring routers then compute the shortest distance to each node based upon the complete topology of the network. These conventional routing algorithms are clearly not efficient for the type of dynamic changes which may occur in an ad-hoc network. In conventional networks, routers do not generally move around and only rarely leave or join the network.

The typical problems encountered in designing single path protocols for a mobile wireless environment also arise in designing multipath protocols [V. Jayalakshmi1 and Ramesh Kumar, 2012]. Mobility makes it difficult or impossible to maintain a global view of the network. Mobility also has implications in terms of caching policies. If cached information at intermediate nodes is frequently out of date, caching can degrade routing performance because detecting inaccurate routing. Information is not instantaneous. In addition to the dynamic topology, unreliable and range limited

wireless transmission makes resiliency a requirement rather than an enhancement in a routing solution. Since mobile transmitters are likely to be battery powered, routing protocols need to minimize the communication for coordinating network nodes. At the protocol level, the design of multipath routing needs to consider failure models, characteristics of redundant routes, coordinating nodes to construct routes, mechanisms for locating mobile destination and intermediate forwarding nodes, and failure recovery.

Multipath routing allows the establishment of multiple paths between a single source and single destination node. Multipath routing is typically proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing. Load balancing is generally of especial importance in MANETs because of the limited bandwidth between the nodes. Traditional circuit switched telephone networks used a type of multipath routing called alternate path routing. In alternate path routing, each source node and destination node have a set of paths (or multipaths) which consist of a primary path and one or more alternate paths. Alternate path routing was proposed in order to decrease the call blocking probability and increase overall network utilization.

2.0 Background Information on Multipath Routing

Mobile ad hoc networks are characterized by a dynamic topology, limited channel bandwidth and limited power at the nodes. Because of these characteristics, paths connecting source nodes with destinations may be very unstable and go down at any time, making communication over ad hoc networks difficult. On the other hand, since all nodes in an ad hoc network can be connected dynamically in an arbitrary manner, it is usually possible to establish more than one path between a source and a destination. When this property of ad hoc networks is used in the routing process, we are in need of multipath routing.

2.1 Requirements for Multipath Routing in Ad Hoc Networks

When a routing protocol is needed for the purpose of using data transport in mobile ad hoc networks, certain properties are required. The prescribed requirements are listed below [S.Vijayaragavan et al., 2009]:

- The routing protocol must provide multiple paths to destinations.

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• The routing protocol must provide loop-free paths to destinations.

• The routing protocol must provide node-disjoint paths to destinations, because (in this case) this is the strongest measure of path independence.

• The multiple paths need to be used simultaneously for data transport, the data packets are need to arrive at more or less simultaneously at the destination, so the multiple paths must not be backup routes, used only when the first route fails.

Multipath routing was addressed in data networks which are likely to support connection-oriented service with QoS. For example, Asynchronous Transfer Mode (ATM) [ATM forum] networks use a signaling protocol, PNNI, in order to set up multiple paths between a source node and a destination node. The primary (or optimal) path was used until it either fails or becomes over-utilized, then alternate paths are tried. Using a crankback process, the alternate routes are attempted until a connection is completed.

There are several issues such as (i) Unpredictability of environment (ii) Unreliability of wireless medium (iii) Resource-constrained nodes (iv) Dynamic topology to consider when deploying MANETs. As a result of these issues, MANETs are prone to several types of faults including, (i) Transmission errors (ii) Node failures (iii) Link failures (iv) Route breakages

(v) Congested nodes or links

Routing protocols for MANETs must be dealt with these issues to be effective. Routing protocols are generally employed to find and maintain routes between source and destination nodes. There are two main classes of ad hoc routing protocols, namely, are table-based and on-demand protocols [Perkins and Royer, 1999; Johnson and Maltz, 1996]. It is observed from the literature that (i) in table-based protocols [Murthy et al., 1996; Perkins and Bhagwat, 1994], each node maintains a routing table containing routes to all nodes in the network and (ii) in on-demand protocols [Perkins and Royer, 1999; Johnson and Maltz, 19963], nodes only compute routes when they are needed. On-demand protocols contains, the following two main phases.

1. **Route discovery** is the process of finding a route between two nodes (Fig. 2)
2. **Route maintenance** is the process of repairing a broken route or finding a new route in the presence of a route failure (Fig. 3). Fig. 4 shows a typical route failure in MANET.

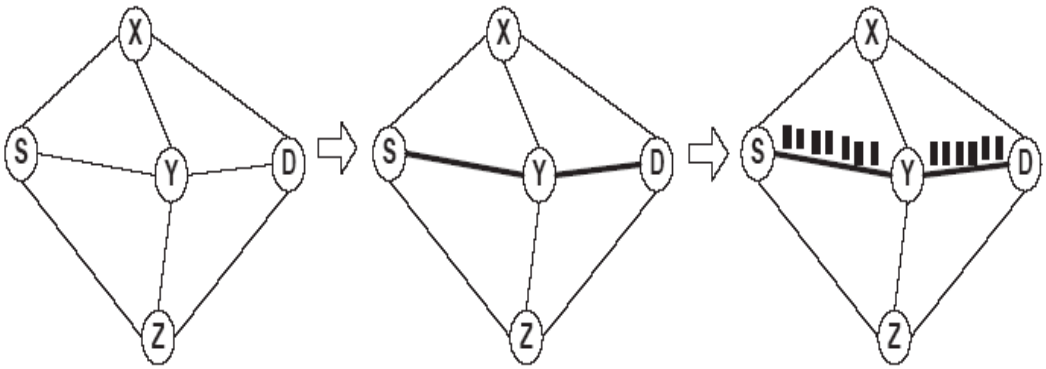

Fig. 2 Typical example of route discovery in an ad hoc network

(http://ahvaz.ist.unomaha.edu/azad/temp/multipath/04-mueller-multipath-sensor-adhoc-source-routing-challenges.pdf)

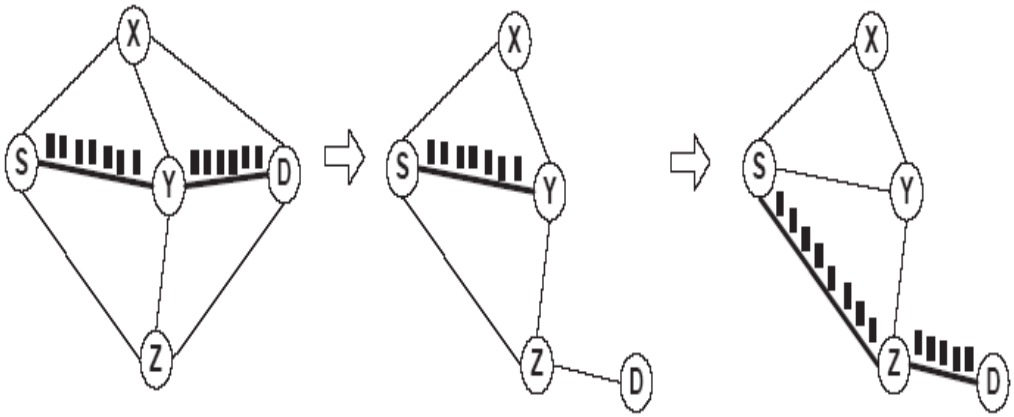

Fig. 3 Typical example of route maintenance in an ad hoc network

(http://ahvaz.ist.unomaha.edu/azad/temp/multipath/04-mueller-multipath-sensor-adhoc-source-routing-challenges.pdf)

Dynamic Source Routing (DSR) is an on-demand routing protocol for ad hoc networks. In DSR, the source includes the full route in the packets' header. The

intermediate nodes use this to forward packets towards the destination and maintain a route cache containing routes to other nodes.

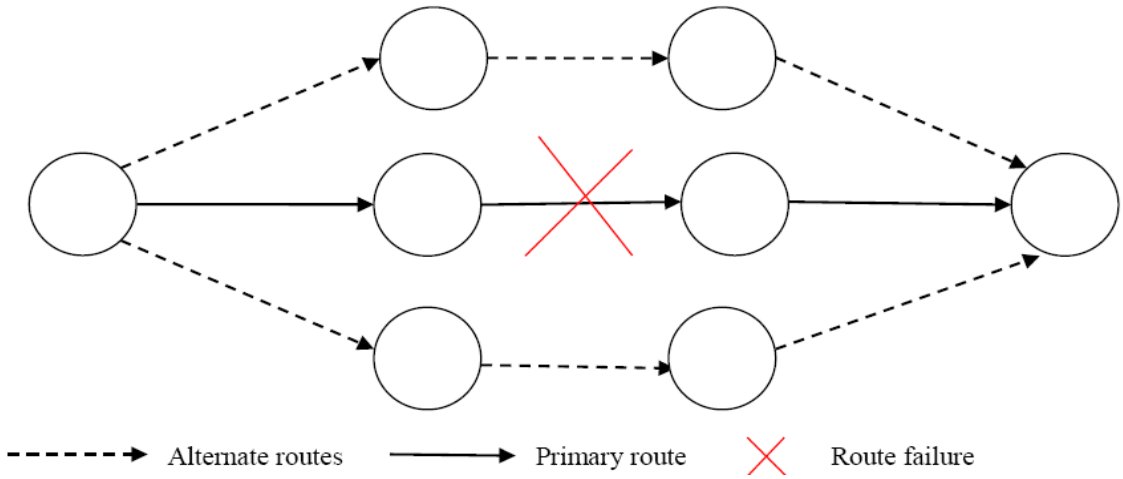

Fig. 4 Typical route failure in MANET [Pooja and Ajay, 2013]

3.0 Multipath Routing in MANETs

Multiple paths can provide load balancing, fault-tolerance, and higher aggregate bandwidth. Load balancing can be achieved by spreading the traffic along multiple routes. This can alleviate congestion and bottlenecks. From a fault tolerance perspective, multipath routing can provide route resilience. Multipath routing consists of three components: route discovery, route maintenance, and traffic allocation. A number of QoS routing protocols have been proposed. These protocols can be classified into proactive (table driven) and reactive (on-demand) protocols. In table driven protocols all the nodes maintain their tables and these tables are updated from time to time. In reactive protocols the route is established only when data is to be send. Table 1 presents relative comparison of various protocols. Multipath routing can be used to support a variety of applications such as support reliability (fault tolerance), energy conservation, minimization of end-to-end delay, and satisfying bandwidth requirements.

Table 1 Relative comparison of various protocols

Protocol	QAMR[Venkata Krishna et al., 2012]	NCPR[Xin et al., 2013]	MP-QMRB[Ali et al., 2011]	Q-AOMDV[Chunxue et al., 2013]
	It is based on ant colony optimization (ACO). It is used to solve the problem of bandwidth allocation in MANET. FANTs (forward ants) and BANTs (backward ants) are the ant like agents which are used to measure parameters like next hop availability (NHA), delay and bandwidth.	neighbor coverage-based probabilistic rebroadcast for reducing routing overhead in mobile Ad-hoc networks	a multipath QoS mobile routing backbones protocol. It has been proposed to enhance load balancing in MANET. Protocol ensures that the available bandwidth in the network is utilized efficiently by distributing traffic evenly which ensures better load balancing and congestion control. This is motivated by QMRB-AODV.	Ad-hoc on demand multipath routing which provides QoS support. For route discovery process in Q-AOMDV, RREQ message includes hop-count, time and bandwidth also to select the primary path in all the available paths. RERR message also contain these parameters.
QoS Metrices	Delay/bandwidth	Routing overhead	Bandwidth	Bandwidth, hop count, end to end delay
Base protocol	ACO	AODV	QMRB-AOMDV	AOMDV
Multiple route support	Yes	Yes	Yes	Yes
Routing overhead	Higher than AODV	---	----	Less than AOMDV at high speeds
Loop free	Yes	Yes	Yes	Yes
End to end delay	Higher than AODV	---	Less than AOMDV	Less than AOMDV

4.0 Summary and concluding remarks

These protocols use several QoS metrics like bandwidth, delay, routing overhead, hop count. QAMR is an ant colony optimization based protocol. NCPR uses AODV as a base protocol. MP-QMRB uses QMRB-AOMDV as base protocol. Q-AOMDV has AOMDV as the base protocol. From the review, it is noted that application of multipath routing to support application constraints such as reliability, load-balancing, energy-conservation, and Quality-of-Service (QoS) are to be given importance. It would be desirable to develop a multipath protocol that can provide delay bounds or guarantees, which are required by some real-time applications. Using multipath routing to provide adaptive QoS using source coding is also a promising technique that can be expanded upon for applications other than video.

The proposed routing protocol should possess the following advantages:

- Reduces packet drops
- Controlled traffic load at the time of route failure
- • Provide optimal routes
- • Utilize bandwidth efficiently
- • Loop-free
- • Reduce stale routes problem

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