AN OVERVIEW OF FAULT TOLERANT ROUTING PROTOCOLS IN MANET

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***Abstract*— Mobile Ad Hoc networks (MANET) consist of a collection of wireless nodes and exchange data among themselves dynamically. The network topology changes frequently due to mobility, disconnections, failures of nodes and network partitioning. Moreover the mobile nodes which are basically resource constrained, exhibit various kinds of faulty behaviors that may be transient or permanent due to the hardware or software problems. In such a situation, the faulty node may not forward packets and the situation becomes worse. Hence fault tolerance is an important design issue to construct a reliable mobile ad hoc network. Due to the presence of faulty nodes, the performance of routing degrades and the reason for the faulty nodes has to be identified to address routing by exploring network redundancies.**

***Index Terms* — ACO, Fault tolerance, Link failure, Multipath routing, Node failure, QoS.**

I. INTRODUCTION

MANET is a re-configurable wireless network and does not have a fixed infrastructure. They are self-created and self-organized. These networks are characterized by dynamic topology, high node mobility, low channel bandwidth and limited battery power [Ran 11]. These characteristics have paved a new way for designing and operating the routing protocols.

A. Important characteristics of MANET:

The nodes in MANET can join or leave the network anytime, making the network topology dynamic in nature and hence links in a route may be temporarily unavailable and making the route invalid. The overhead involved in finding alternate routes may be high, and delay in packet delivery may be found. Multipath routing addresses this problem by providing more than one route to a destination node. Source and intermediate nodes can use these routes as primary and backup routes.

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The fundamental problem is how to deliver the packets among the mobile nodes effectively, is the main objective of ad hoc routing protocols.

B. Fault Tolerance:

Fault tolerance approach is used to prevent the malfunctioning node, which would otherwise affect the overall task of the network. Fault tolerance is the ability to react to the unpredicted hardware and software failures [Mah 13].

Reasons for fault:

- Communication Failure
- Nodes leaving the Network
- Attacks of various types
- Compromised nodes behaving in non-cooperative manner
- Selfish nodes behaving in non-cooperative manner
- Altruistic nodes becoming selfish after sometime
- Critical Section Problems and Mutual Exclusion (unable to enter that region)
- Signal interference and packet loss.

C. Routing Protocol:

The existing MANET routing protocols according to [Joh 11] has been classified into two categories: (i) Unipath routing protocols, and (ii) Multipath routing protocols.

i) Unipath Routing Protocols:

In unipath routing protocol, a unique path is being used to transmit a message between the sender and receiver. Unipath routing protocols has been classified as either table based or demand based. Table-based protocols are used to store information about the routes from one node in the network to the other nodes by means of routing table. Easy to implement but due to the frequent movement and dynamic nature of A*d hoc n*etworks, maintaining the routing information in these tables is a very challenging task. On the other hand, On-demand based routing protocols, overcomes the above problems, and makes routing more scalable for dynamic and large networks. On-demand based routing protocols compute the routes only when a need arises. On-demand based routing protocols, consists of i) *route discovery* phase in which a route is found between two nodes ii) followed by a *route maintenance* phase in which a broken link in a route is repaired, or a new route is found.

ISSN: 2278 – 1323

ii) Multipath Routing Protocols:

Due to the continuous changing infrastructure in MANET, the routes that were once considered to be the "best" may no longer remain as the "best" at a later time. Therefore, the routes are to be continuously re-computed.

Multipath routing protocols have the advantage of the inherent redundancy i) which helps to find multiple routes from a source node to a destination node, ii) also increases the reliability during the transmission of information, and iii) also ensures that at least one of the paths will be able to successfully deliver the packet. This further ensures its success as a fault-tolerant routing algorithm which provides route resilience when there are route failures in the network. However, multipath routing faces unnecessary overhead when duplicate packets are sent through different routes.

The rest of the paper is organized as follows. Section 2 deals with the Review of literature, Section 3 provides the mechanism related to Fault tolerance and routing protocol, and Section 4 deals with the Conclusion.

II. REVIEW OF LITERATURE

Rana E. Ahmed [Ran 11] proposed a new fault-tolerant routing protocol (extension of Dynamic Source Routing - DSR) that attempts to find two routing paths, if exists from the source node to the destination node. This method produced low-overhead in terms of control messages and the message sizes.

Disadvantage is RREP (Route Reply) message has more information (for both primary and secondary paths) to carry, while basic DSR carries information about primary path only.

When compared to the classical DSR protocol, the proposed method achieved an output with higher packet delivery ratio, higher network throughput, and less control message overhead.

[Jay 12] proposed an energy efficient multipath fault tolerant routing protocol to improve the reliability of data routing in Mobile ad hoc networks. This multipath routing protocol modified the route discovery and route maintenance mechanisms of DSR and Ad hoc On-Demand Distance Vector (AODV) protocols to improve the performance of a network in terms of delay, reliability, overhead reduction, energy efficiency and network throughput.

[Raj 12] attempted to reduce the route breakages and congestion losses. The Ad hoc On-demand Multipath Distance Vector (AOMDV) protocol is used as a base for the multipath routing. More nodes are enabled for recovering a dropped packet. Proactively detects node level and link level congestion and performs congestion control using the fault-tolerant multiple paths.

The proposed protocol achieves better throughput, packet delivery ratio with reduced delay, and packet drop energy.

[Raj 12] presented an Improved Fault Tolerant Multipath Routing (IFTMR) protocol to reduce time delay in mobile ad-hoc networks. The strength of the path through which data or packets are transmitted and the power level of nodes are examined. The proposed method aimed in reducing the time delay.

[Poo 13] suggested Enhancement of Multipath Routing Protocol for Route Recovery (EMPRR) in MANET, which provides multipath discovery, efficient utilization of bandwidth and controlled traffic load route recovery at the time of failure. The proposed protocol overcomes the problem of stale routes in multipath routing protocols and significant improvement in packet delivery ratio and reduced end to end delay**.**

[Man 13] designed a new AODVEBR (Ad hoc on demand distance vector Energy based routing protocol) which optimizes AODV by creating a new route for routing the data packets in the active communication of the network. The proposed protocol efficiently managed the energy weakness node and delivered the packets to destination with minimum number of packets dropped. Reduced the control overhead and efficiently utilized the existing control packets and routing table.

[Nil 14] proposed a Node disjoint minimum interference multi-path (ND-MIM) routing protocol for MANETs, based on AODV protocol. Goal was to determine all node-disjoint routes from source to destination with minimum routing overhead by taking into account the energy and distance of intermediate nodes in the path. When the route is broken, the data is transmitted continuously through next shortest route.

[Sud 10] presented a fault tolerant routing algorithm (FTAR), based on the idea of searching the natural ants, applied the (Ant Colony Optimization) ACO on the set of paths obtained by the source routing algorithm. The ants worked on the paths which are already at the disposal of the source node. This algorithm achieved high packet delivery ratio and throughput.

[Roi 05] developed Octopus, a fault tolerant and efficient position-based routing protocol. This protocol achieved fault tolerance through redundancy and low location update overhead obtained by using a novel aggregation technique, whereby a single packet updates the location of many nodes and thus reduced the overhead.

III. MECHANISM

i) Fault Tolerance: - [Mah 13]

The topology changes rapidly due to the high mobility of nodes and hence reliability on the transmission of message is an important concern in MANET. Therefore strategies should be considered to deliver the packets even in the presence of node failures/link failures in adversarial environment. Fault tolerance is used to enhance system reliability and the areas where fault tolerance is needed are as follows:

1) Fault tolerance in Node Failures

Every node in the network can communicate directly with other nodes in the network, if it is a single hop, or uses the middle node as a router to pass the information to the next node in case of multi hop, provided if they are within the transmission range. A node failure can take place if the nodes are not within the transmission range. To get rid out from the

problem of node failure, many algorithms and protocols have been suggested by different authors.

2) Fault tolerance in Link failures and Network Failure

In MANET, Fault tolerance in Link failure and Network failure occurs, due to the fully or partially failed components in the network because of malfunction otherwise natural disaster. If a node moves away from the cluster, link failure will occur and in order to continue effectively many approaches have been proposed.

3) Fault tolerance in Transmission Power and Energy

Transmission power and energy are the important issues in Mobile Ad Hoc Networks. Battery is mostly used to send and receive messages, also used for the route selection, discovery and to repair the failures in the link of the network. If the battery gets drain, then failure occurs. To have constant working, many authors had presented their contribution towards it.

ii) Routing Protocols:

The nodes in MANETs can communicate directly with other nodes if they are within the transmission range and makes use of router otherwise. Thus the node can act as both host and router. In MANET, since the nodes are joining and leaving the network, the continuously changing infrastructure, imposes problems in routing.

The different types of error that can occur in MANET are as follows:

1. Transmission error
2. Node failures
3. Link failures
4. Route breakages
5. Packet loss due to congested nodes/links

According to [Raj 12], Fault tolerant routing protocols have been classified into 2 types.

1. Proactive : They provide protection proactively (before the fault occurs) by:

- Suitably selecting optimum paths with least possibility of Faults.
- By caching important data
- By using erasure codes or redundant data.

2. Reactive: They provide protection proactively (after the fault occurs) by:

- Using Retransmission techniques
- Using Effective Route maintenance techniques
- Using Alternate path techniques.

Multipath routing protocols can be used for achieving fault tolerance in which proactive or reactive techniques can be used.

Dynamic Source Routing (DSR) [Dhe 13]:

DSR is a reactive protocol that is based on source route approach. The protocol is uses Link state algorithm in which the source initiates route discovery on demand basis. Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the cache are continually updated as new routes are learned. Records the entire path from source to destination into the routing table and selects the shortest path.

Ad hoc On demand Distance Vector (AODV) [Dhe 13]:

AODV is a reactive routing protocol. It minimizes the number of broadcasts by casting routes based on demand. Every mobile node functions as a specialized router. Routing tables are maintained in the intermediate nodes, with routing information being fetched as request is made on demand.

Ad hoc Multipath On demand Distance Vector (AOMDV) [Pun 12]:

AOMDV employs multiple loop free and Link disjoint path. In AOMDV only disjoint nodes are considered in all the paths, thereby achieving path disjoint.

Robust Fault Tolerant Protocol (RFTA) [Jay 12]:

Used AOMDV as a base and tried to improve the fault tolerance and achieved efficient routing in MANET.

Multipath routing protocols has the ability to find node-disjoint, link-disjoint, or non-disjoint routes. Node-disjoint routes have no nodes or links in common. Link-disjoint routes have no links in common but have many nodes in common. Non-disjoint routes can have both nodes and links in common.

Position Based Routing Protocol [Roi 05]:

The node in the position based routing protocol can determine its physical location. The location of each node is stored at some other nodes, which act as a location servers for that node. When a node wishes to send packets to another node, issues location queries to discover the target's location and then forward packets to that location. Reliability is measured as the success rate of location queries.

Ant Colony Optimization (ACO) [Ani 09]:

A probabilistic technique searching for optimal path in the graph based on behavior of ants seeking a path between their colony and food source.

Each ant moves at random and pheromone is deposited on path. More pheromone on path increases probability of path being followed and the shortest path is discovered via pheromone trails. ACO algorithms are the part of swarm intelligence that is made up of simple individuals, co-operate through self- organization.

Congestion [Raj 12]:

Congestion in MANET happens due to limited resources. Dynamic topology and wireless channels leads to interference and fading during packet transmission. Packet losses and bandwidth degradation are caused due to congestion and thus time and energy is wasted during its recovery. Congestion can be prevented using congestion-aware protocol through bypassing the affected links.

The multipath routing is more effective when compared to single path routing since it provides load balancing, fault-tolerance and high aggregated bandwidth. Table 1 and Table 2 provides a summary of various fault tolerant routing protocols by considering the objectives, parameters used, routing protocol and simulator used.

ISSN: 2278 – 1323

Table 1: Fault tolerance in Node Failure, Link Failure and Network Failure

S.No	Algorithm	Objective	Routing Protocol	Performance Metrics	Simulator used
1	Multipath fault tolerant routing protocol in MANET	To improve packet delivery ratio and reduction in end-to-end delay	Robust Fault Tolerant (RFTA) Protocol	Throughput, end-to-end delay, Routing loads	NS2
2	A Fault Tolerant Congestion Aware Routing Protocol for Mobile Ad hoc Networks	To reduce route breakages and congestion losses	AOMDV (Ad hoc on demand multi path distance vector) routing protocol as a base	Throughput, Delivery ratio, packet drop and end-to-end delay.	NS2
3	Time Delay Reduction in MANETs using Improved Fault Tolerant Routing Protocol	To reduce time delay	FTMR (Fault tolerant multipath routing) protocol as base and used IFTMR	Delay, Throughput and Packet drop	-
4	Enhancement of multipath routing protocol for route recovery in MANET	To provide multipath discovery, efficient utilization of bandwidth, controlled load route recovery	Multipath routing protocol as base	Average end-to-end delay, Average packet delivery ratio, average throughput, Routing overhead and drop	NS2
5	A low overhead fault tolerant routing algorithm for mobile as hoc networks: A scheme and its simulation analysis	To achieve high packet delivery ratio and throughput	Fault tolerant Routing algorithm (FTAR)	Packet delivery ratio, Throughput and overhead incurred	GloMoSim

Table 2: Fault tolerance in Transmission Power and Energy

S.No	Algorithm	Objective	Routing Protocol	Performance Metrics	Simulator used
1	A Fault-Tolerant Routing Protocol for Mobile Ad Hoc Networks	To have Low overhead (Terms of Number of sizes and control messages)	Dynamic Source Routing (DSR) as base.	Packet Delivery Ratio (PDR), Overhead in terms of control message sent in a session and Network throughput.	GloMoSim
2	A highly adaptive fault tolerant routing protocol for energy constrained mobile ad hoc networks	To deliver more packets with minimum routing overhead when nodes are in high mobility.	AODV(Ad hoc on-demand distance vector)-Energy Based Routing Protocol	Average end-to-end delay, packet delivery ratio, Average route acquisition delay, Throughput, Routing load.	NS2
3	An improved multipath AODV protocol based on minimum interference	To consider energy and distance of intermediate nodes in the path	Use Node disjoint Interference multipath routing protocol based on AODV	-	-

IV.CONCLUSION

Having gone through the related works, each seems to provide good results on Fault tolerant routing protocols in certain aspects, by considering various parameters such as throughput, End-to-end delay, Routing loads, Delivery ratio, packet drop and energy consumption. Moreover other parameters such as bandwidth, jitter, distance, dwell time etc., can also be considered in fault tolerant routing protocols to make more effective.

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ISSN: 2278 – 1323