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ROUTING PROTOCOL FOR WIRELESS MESH NETWORK-A SURVEY

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Abstract

Wireless Mesh Network (WMNs) have developed to give better administration's to fixed and portable clients because of self-organizing, self-optimizing and fault tolerant abilities. Routing is the most challenging issue in the wireless mesh network. The routing protocols are categorized into three parts named as proactive, reactive and hybrid. In this paper the wide range of protocols that falls under each category are mentioned like CGSR, TORA, LCMP vice versa along with some metrics like ETX, WCETT and many more which are used for path selection and route optimization has been reviewed.

1. Introduction

Wireless Mesh Network (WMNs) is been developed for giving better administrations to fixed & portable clients because of self-organizing, self-optimizing and fault tolerant abilities. The routing is the biggest challenging issue in WMNs because of the dynamic characteristic of it. The routing protocols majorly subcategorized in three classifications, for example, proactive, reactive and hybrid conventions. In a proactive convention, hubs find courses just when correspondence is needed in between a source and goal hub. These sorts of conventions diminish the control traffic on the system however these need additional opportunity to build up the course at the season of correspondence. Proactive directing methodologies are additionally called table driven methodologies. For proactive directing methodologies, each hub keeps up and finds the course with each hub in the system paying little respect to whether the course is required or not.

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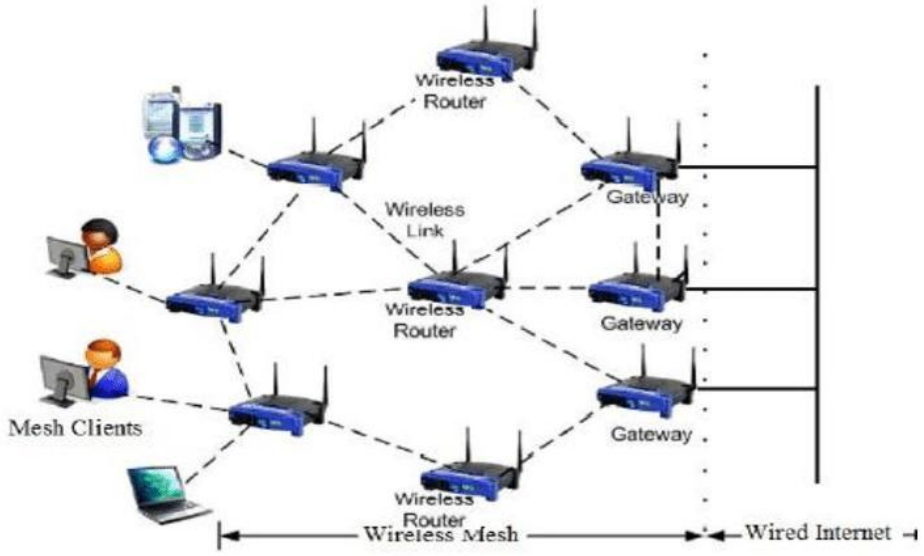

Figure 1.1. WMNS architecture.

These methodologies figure the courses with each other hub, by trading the steering tables intermittently. The proactive steering approaches higher the traffic control and needed more data transfer capacity when contrasted with receptive directing methodologies. The proactive conventions don't have to find the course at the season of correspondence. The courses will dependably be accessible. The half and half steering convention is the mix of both on-interest and table-driven methodologies and pulls benefits from the both systems.

In WMNs, hubs are included of work switches and work customers. Each hub works as a host as well as the switch, sending parcels for the benefit of different hubs that may not be inside direct remote transmission scope of their goals. A WMN is progressively self-sorted out and self-arranged, with the hubs in the system naturally setting up furthermore, keeping up work availability among them (making, basically, a specially appointed system). This highlight conveys numerous favorable circumstances to WMNs, for example, low straightforward cost, simple system upkeep and strength. Figure 1.1 shows the basic structure of WMNs.

Routing Protocol

Routing Protocols searches routes for packet transmission and deliver packets to destination suggested by source. They use routing algorithms to search the optimal path for data communication between the nodes in a network. From many years researches actively proposed work related to various aspects of these routing protocols.

Protocols can be divided into three categories as given below-

- Proactive Protocols (Table Driven).
- Reactive Protocols (On-Demand).
- Hybrid Protocols.

Proactive Protocols (Table Driven)

In Proactive protocols, each node repeatedly updates the route to other nodes presents in the network. The routing information traversed into entire networks to maintain route-table. With this, if the route is made previously, transmission is done without delay. Whenever the network topology changes, node spread a message to the entire network to maintain current and updated routing information. However, for highly active networks, these protocols need a notable quantity of resources to keep routing data up to date and well-founded. There are multiple protocols that fall under the proactive categories which have been mentioned below-

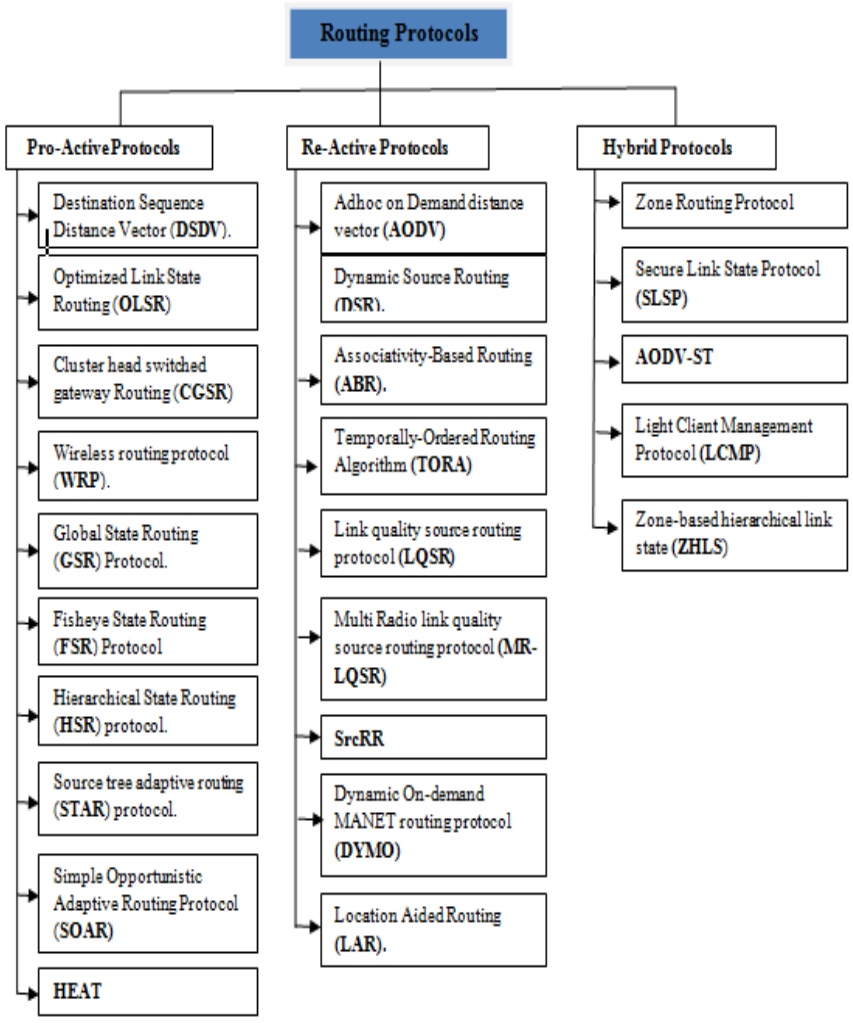

Figure 1.2. Routing protocol along with its categories.

Perkins et.al. [1] proposed Destination-Sequence-distance Vector Routing Protocol (DSDV), where each node has information about other nodes life, information of its neighbors, and periodically incremented. This protocol is adapted from RIP (Routing Information Protocol) with adding a sequence number to the route table entry. With this, it can prevent loops in the routing table. In DSDV, routing table updates packets are of two types-

Full dump which carries all the available routing information. Its packets are transmitted often if the nodes are encountered with occasional movement.

Incremental update packets only have the information which is changed from the time of latest full dump was sent out by the node. These packets use fewer resources of the networks than the full dump does.

T. Clausen et.al shows in his paper that OLSR (Optimized Link State Routing) protocol which is an optimized version of a Link State Protocol [2]. OLSR creates a link with only a subset of neighbors which reduces the size of control packets as well as allows only selected nodes named as multi-point relays (MPR) to retransmit broadcast messages, which minimize the retransmission of flooding messages. OLSR control messages are of two types:

Hello messages: Get information of link status & the host's neighbors Topology Control (TC) messages: Broadcast's information of neighbor, MRP hosts can only forward these messages.

Chiang CC suggested an algorithm named CGSR (Cluster-Head Switched Gateway Routing) where nodes are maintained in different groups called Cluster and select a head node named as Cluster-Head. Nodes which lie in the communication area of Cluster-Head are in there Cluster [3]. Communication between different cluster-nodes done by nodes named as gateway nodes. The Global State Routing (GSR) algorithm was proposed in [4].

A. Iwata et al. proposed a protocol named Fisheye State Routing (FSR) Protocol in which each node have a topology table which is maintained with the updated information received from its neighbors [5]. In this each update message doesn't have information belongs to all nodes rather than it exchanges information to closer nodes and nodes gets accurate information about neighbors.

STAR (Source tree adaptive routing protocol) was proposed in [6]. In this proposed protocol each router shares information about nodes which are in a route to the destination, with their neighbors. Each node has information about its neighbor links and the source tree of its neighbor nodes. With this, it makes a graph which is used to generate routers source tree. STAR supports both ORA and LORA process to update routing information. With ORA, updates change only when source tree change. With LORA a router node of STAR transmits modifications on its source tree to its immediate only when-

- All paths to destinations losses.
- Finds a new destination.

Rozner E. came up with a new protocol named as SOAR (Simple Opportunistic Adaptive Routing Protocol) in which every node regularly computes and spread link quality based on ETX (Expected transmission count metric). Using this data sender selects defaults path with a list of nodes eligible for transmitting data and broadcast data packets with this information [7]. Nodes available on forwarding list hold the packet and set forwarding timers to the destination, whereas nodes which are not in the broadcasting list, discard the packets. Node's close to the destination forwards the packet earlier because it uses small timers.

Singh Amar et al. proposed PB3C (Parallel-Big Bang Big Crunch) optimization algorithm [8]. It is a multi-population algorithm. With the parallel searching feature, this improves search and optimization capability of BB-BC. The search starts with independently in parallel groups, the best of each group (local best) communicates with global best. With this, it avoids local minima problem with BB-BC. It produced a better minimum, better average, and better Maximum MSE than many algorithms. This algorithm has been successfully applied for routing in WMN.

Amar et al. proposed P3PGA (Parallel-Three Parent Genetic Algorithm) [9]. This algorithm is the extension of Genetic algorithm. The algorithm is used to find out the optimum cost route in WMNs. To find a cost-effective and optimal route this algorithm creates an adjacency matrix for all nodes which is having neighbor's node information. Using the adjacency matrix, a set of the population is evaluated. Each population has its own optimal routes. After that from the local optimal cost route of each of the population, the globally optimal path is derived. After the routes are evaluated, the nodes construct routing tables and transmission starts.

Reactive Protocols (On-Demand)

In Re-active Protocols, the node starts to search for a route in entire the network only when it requires sending a packet to the destination node. When a source starts transmitting packets till destination, it chooses the route-discovery procedure to search for a path. The route-discovery gets

completed, once all the possible conditions examined. After the route is being formed, it is maintained by the route maintenance process. In Reactive Protocols, nodes maintained the routes to active the destination. The author proposed AODV (Adhoc on Demand distance vector) which is the most popular routing protocol, where routes are created on-demand and only active routes are maintained [10]. With this, it has a reduced routing overhead, but because of the on-demand route setup, initial latency introduced as well. AODV follows request-reply techniques to find routes. AODV uses the sequence numbers in order to overcome routing loops. The source starts transmission by broadcasting the RREQ packet (Which has elaborates source and destination IP address). Then the packet received by the immediate node and it will check for valid route till the destination. If the route is valid then RREQ, rebroadcasted routes otherwise route error RERR will be sent to the source.

Johnson, D. B. et al. proposed [11] DSR (Dynamic Source Routing), which requires every node to maintain a route cache. If a node is having a packet to transmits, the source will examine their routes available in cache for the valid route till destination. Here nodes can have multiple paths to the destination. When destination doesn't occur in the cache, a route discovery process comes in place and a route request is generated by the source to transmit packets till destination. Whereas if the path already exist in the cache, a packet which is to be sent, is having a copy of route and packet follows that route to reach the destination. If route cache is having route information, but that route is no longer valid, the process of route maintenances comes in place [12]. Nodes will process the route-request packet when it does not process the packet in past as well cache doesn't have its address.

A Route Reply is processed by the destination when a particular node knows about the route to the destination.

Toh, C.K. et al. proposed ABR (Associatively-Based Routing) protocol, which is having an advantage like free from loops, deadlock, and duplicates packet [13]. The objective of ABR is to look for routes with longer lives in a network. It has three phases- (a) Route Discovery (b) Route Reconstruction (RRC) (c) Route Deletion.

In the route-discovery phase, the source node broadcasts the message to finds a path to reach till destination. A node cannot requests further after it's done once. After receiving the message request, neighbor nodes attach address and associatively with the packet. Destination selects the cost-effective and optimal route by the associatively attached with each the path. When different paths have a similar overall degree of association stability, route with least hops is selected. After selection of the path, the destination node transmits a reply back message to the source with the path. The nodes come on the path of reply packet, checked their route as a valid route. Other than that all routes become inactive. The source node initiates a route delete (RD) broadcast whenever a path is no longer needed.

Park V.D. et al. [14], along with his team proposed TORA (Temporally Ordered Routing Algorithm) which is highly flexible, scalable and an efficient protocol. It provides the number of routes for transmitting data from source to destination. For creating a route, source node firstly broadcast a QRY packet along with destination address. Every node in the network is having height with respect to a different destination. These heights are allocated to links depends on the direction towards a destination. At the time of route creation and route maintenance process, with the help of height metric node generates a directed cyclic graph (DAG). Route maintenance process requires if any of the links in DAG is broken. This protocol is having a good sense of dealing with link failure, whenever any link is broke down; protocol reverses the links to re-position the DAG for searching an alternate path. Each link reversal sequence looks for the secondary routes to get the destination.

Ko Y.B. et al. Introduces Location-aided routing (LAR) [15] which works with information related to the location by flooding on particular part of the network, which is likely to have the route till destination. With this feature, it enhances efficiency level by reducing control overhead. LAR uses the GPS (Global Positioning System) to bounds the search area during the process of route discovery. There are two zones in LAR-Expected Zone where the destination is expected to be present based on past location. Request Zone is a zone where path-finding packets are permitted to be generated.

Hybrid Protocols

Hybrid protocols combine proactive and reactive protocols. These algorithms reduce the control overhead of proactive routing protocols and

reduce delay in route discovery process presented in reactive routing protocols. These protocols use distance-vector for more precise metrics to get the best optimal paths in the network. And also declare routing information whenever the change occurs in the topology of the network.

Haas Z. J. et al. proposed [16] ZRP (Zone Routing Protocol) where networks divided into two overlapping zones. Intra-zone (Pro-active uses this) and Inter-zone (Re-active uses this). If both source and destinations are in same routing zone, source transmitted packets straight to the destination whereas if both of them are in different zone ZRP begin, route discovery process of re-active by finding the paths. Majorly it aims to find loop-free routes with reduced transmission.

Different from other hierarchical protocol, ZHLS [17] divides the network into two non-overlapping zones with no zone-head. Two Topological structures, (a) Node Level which defines how nodes presented in zones are connected physically and (b) Zone Level Topology defines how the zones are connected to each other.

Two LSP's (Link State Packets), the Node LSP where a node is having information about the neighbor node and participates presents inside the zone and the Zone LSP which are having the zone information and also participates information globally. Each node has its unique zone-id & node-id, based on which the packet is transmitted (with the help of zone-id it transmits till the correct zone than inside that zone, routes are described by node-id).

The author proposed ADOV-Spanning Tree Protocol [18] which uses the ADOV functionalities for Intra-mesh traffic and Spanning trees for communication. AODV-Spanning Tree Protocol actively maintains the spanning trees, having gateways as root in WMN's. It reduces route discovery latency to achieve lightweight & soft state route maintenance. It uses a proactive approach to discover routes between most-used nodes or routing between more than one network (relay-gateway) and reactive approach for routes between less used nodes or Internal routing (relay-to-relay).

Wehbi B et al. [19], proposed LCMP (Light Client Management Protocol) which achieves on-demand path setup and helps in client's mobility by new light mechanisms. This protocol works with two routing table for maintaining

process information, the first table maintains detail about mesh clients falls under its local area and a second table stores information on the remote-clients and mesh-routers which associates to them.

Routing Metrics Used in WMN's Protocol

In WMN's routing, for path selection as well as for the route optimization, matrices play a key role. As defined in the literature, ETX termed as "expected no of transmission nodes" which are required at the time of transmitting the information from source node to destination node. To calculate ETX, each node spreads an inquiry packet which is having the number of received inquiries from every neighbor. The Route EXT sum up all the ETX links which come in between the route. With the help of source routing and ETX/ETT metrics, the Local on-Demand Link State (LOLS) [20] protocol executes route-discovery process. WCETT was proposed [21] to minimize the number of nodes on the route of a flow that transmits information on the same channel. It is a combination of end-to-end delay and channel diversity. The MR-LQSR (Multi-Radio Link Quality Source Routing Protocol) [22] follows LQSR to works over multiple channels and interfaces with the help of the WCETT metric. ETT tackles the problem of low performance presented in ETX by considering the differences in link transmission rates. ETT adjusts ETX to different PHY rates and data-packet sizes.

Conclusion

Here we discussed the recent protocol used in routing in WMN's with their working. The subcategories of these routing protocols have been discussed with some details of them. The paper presents some of the most used metrics for finding cost-effective and optimizes routes. As a future work, some new metrics can be introduced and can be applied to these protocols especially in hybrid protocols, to make a cost-effective, as well as most, optimizes route. Moreover, the challenges faced in WMNs can be surveyed and these metrics can be used to solve those issues.

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