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The Survey of Classification Methods Using Wireless Mesh Networks

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Abstract: WMNs are one of the insufficient commonly applied types of Mobile Ad-hoc NETworks (MANETs); several companies offer WMNs for broadband Internet access and for spreading the attention of wireless local area networks. Several particularities differentiate WMNs from MANETs. Principal, in WMNs, most of the circulation originates or terminates at the gateways (nodes connected to the wired infrastructure/Internet). Additional, in most requests, WMN nodes incline to be neatly distinguished as either stationary nodes or mobile nodes (utilizing the coverage afforded by the stationary nodes). Routing Protocol is an important typical of mesh topology network. The strengths and fault of routing protocols are reflected directly in WMN's characteristics. Numerous compensations of WMNs over competing skills are directly enabled by the routing protocols. WMNs necessitate routing procedures that provide suppleness to work with different topologies, low latency for route (re-) discovery, low control traffic overhead, scalability with respect to mobility and network dimension, moveable user support, efficient delivery, QoS support, multicast which is significant for emergency response cases and more desirable one multipath. This paper reviews on various types of routing protocols that are used in wireless mesh networks. An evaluation of properties and proposed classification of WMN routing protocols. Also authors tried to make an evaluation of different structures of selected routing metrics and characteristics of selected routing protocols.

Keywords: Wireless Mesh Networks, MANET, Routing Protocols, Quality of Service and Characteristics in WMNs.

I. INTRODUCTION

A mesh networks are unstructured networks. Henceforth routing protocols have to explanation for movement, dynamic changes in topology and unreliability of the medium. WMN nodes communicate with each other and they establish routes to non-neighbouring nodes. Routing protocols are responsible for discovery, establishing and maintaining such routes. The hidden list of route optimization contains the smallest number of hops, interference, delay, error rates, power consumption; the maximum data rates and route stability; use of multiple roots to the same gateway, use of multiple gateways [1].

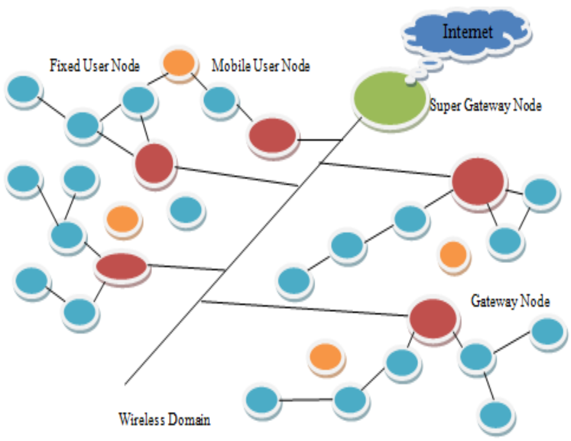

Fig 1. General Wireless Mesh Topology[1]

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WMNs are a relatively new wireless multi-hop technology that has much in common with the mobile ad hoc networks. WMN is a set of wireless nodes that can interconnect with each other, promoting both others's packets. Like in MANETs, each node is both a host and a wireless router. Clients can connect to the WMN routers using common networking interfaces [2].

In most proposed applications, the WMN provides connectivity to an infrastructure network, typically connected to the Internet. We will call the nodes providing Internet connectivity gateways.

There are four types of links presented in Fig. 2. Except for the intra-mesh links (that have to be wireless), all other links can be either wireless or wired. The same or different technologies can be used for the four link types. The link choice usually represents a trade-off between the cost/complexity and the performance of the WMN.

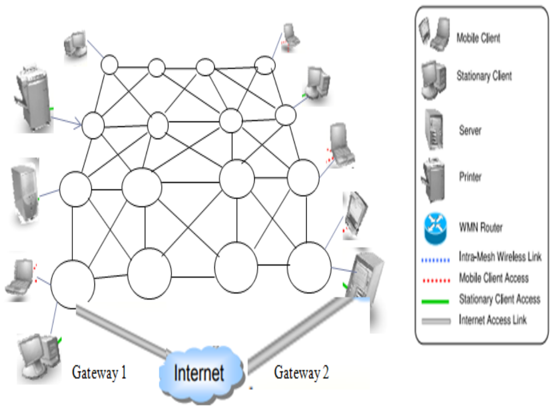

Fig 2. A wireless mesh network connecting several stationary and mobile clients to the Internet [3].

The main benefit of WMNs in judgment to out-dated broadband Internet access technologies is the dramatically reduced initial investment and deployment time. The main advantage in comparison to fixed wireless metropolitan area networks is the market coverage (especially in areas with significant obstructions - trees, high-rise buildings) and reliability (multiple available routes can avoid failed nodes and poor links). Furthermore, some implementations allow for mobile user access, while the current IEEE WMAN standard only allows stationary users (although work for mobility extensions is underway) [4].

Routing is a fundamental characteristic of WMNs. The routing protocol's strengths and weaknesses are reflected directly in the WMN's characteristics. Several advantages of WMNs over competing technologies are directly enabled by the routing protocol:

○ Reliability: It would be able to re-route fast universally failed mesh nodes and fragmented links; upon the disappointment of a gateway, it should be able to redistribute the orphaned clients among neighbouring gateways. For this property, fast reconfiguration and support of multiple gateways is essential.
○ Mobile user connectivity: To ensure seamless mobile user connectivity, the routing protocol should enable fast hand-offs.
○ Scalability/Efficiency: Uncertainty, the routing procedure has a high over-head; it will be unbearable to scale the WMN to a large amount of nodes.
○ QoS: In addition to support from the medium access control (MAC) layer and the forwarding engine, selecting the "best" routes for different traffic classes is an essential ingredient for QoS support.

II. LITERATURE REVIEW

G. Akilarasu et al., 2017 [5] proposed owing to the growth in several applications, Wireless Mesh Networks were emerging as a vital technology for future wireless networks. Wormhole attack was one of the major security threats, which can disturb majority of routing communications, even when placed strategically. Therefore, a technique that can find wormhole-free routes in the network is required. In order to achieve this, developed a Monitoring Technique for Wormhole-Free Routing and DoS Attack Defence in WMNs. Initially, finite state model was applied where the node keeps the information about its sender and neighbourhood receiver. Then, wormhole-aware secure routing was implemented to find wormhole free routes in the network. Finally, the priority mechanism was applied where the data packets are transmitted based on their priority. Based on the finite state model and priority mechanism, the malicious or wormhole nodes in the network are removed.

Zhang Wei-wei et al., 2017 [6] described a Wireless Mesh Networks consists of wireless mesh routers and terminals connected by wireless multi-hop communication. It can be divided into three network types, including terminal mesh networks, infrastructure mesh networks, and hybrid mesh networks according to the network topology and the node function. For infrastructure mesh networks, the network throughput will determine the number of terminals which can access the network. How to effectively use multiple orthogonal channels and multiple interfaces to increase the throughput of WMNs and decrease the radio link transmission interference is of great significance. Firstly, the characteristics of WMN are studied. According to these characteristics in WMNs, the interfaces in mesh router node are classified to two types: one is Data Backhaul Interface, and another is Internal Traffic Transfer Interface (TI). In view of this approach implemented a channel assignment scheme based on group management. Secondly, the routing protocols of WMN were studied, and a new routing protocol based on AODV and multi-channel was proposed to increase the network throughput by taking advantage of multiple orthogonal channels.

Mohammad Tariq Meeran et al., 2017 [7] focused on proposing approaches for the improvement of Voice over Internet Protocol (VoIP) service quality in Wireless Mesh Network (WMN). While WMNs have self-healing, self-forming and dynamic topology features, they still pose challenges for the implementation of multimedia applications, such as voice, in various scenarios. The research had been conducted using a network simulator and experiments conducted on three main scenarios with mesh nodes in no-mobility, partial mobility and full mobility deployments. The experiments consider the IEEE 802.11n/g/e/s standards; G.711, G.726 and G.729 voice codecs; and AODV-reactive, OLSR-proactive and HWMP hybrid routing protocols. The measurement and evaluation is based on the Mean Opinion Score (MOS) rating-scale defined by ITU-T standard and supported by the delay, jitter and packet loss metrics. The proposed approaches identify the integration choices and inclusion of supportive mesh nodes in order to improve VoIP quality. The analysis of the results show that our proposed approaches improve the VoIP quality in terms of 5 point MOS rating-scale by 0.2 in no mobility, 2.2 in partial mobility and 0.9 in full mobility scenarios.

Emmanouil Dimogerontakis et al., 2017 [8] defined Citizens develop Wireless Mesh Networks (WMN) in many areas as an alternative or their only way for local interconnection and access to the Internet. This access was often achieved through the use of several shared web proxy gateways. These network infrastructures consist of heterogeneous technologies and combine diverse routing protocols. Network-aware state of-art proxy selection schemes for WMNs do not work in this heterogeneous environment. They developed a client-side gateway selection mechanism that optimizes the client-gateway selection, agnostic to underlying infrastructure and protocols, requiring no modification of proxies nor the underlying network. The choice is sensitive to network congestion and proxy load, without requiring a minimum number of participating nodes. Extended Vivaldi network coordinates are used to estimate client-proxy network performance. The load of each proxy is estimated passively by collecting the Time-to-First-Byte of HTTP requests, and shared across clients. Developed was evaluated experimentally with clients and proxies deployed in guifi.net, the largest community wireless network in the world. The selection mechanism avoids proxies with heavy load and slow internal network paths, with overhead linear to the number of clients and proxies.

Deepak C Karia et al., 2016 [9] defined has been rapid growth in the area of wireless communication by Wireless Mesh Networks where routing metric is the key metric to find the optimized route in WMNs. For obtaining optimal performance, integrating multiple performance metrics into a routing protocol is effective, as single metric will not be able to satisfy the thorough requirement of WMNs. They proposed a new routing metric for Multiple Metric Cost (MMC), WMNs, incorporating three metrics: Residual energy 2) Available Bandwidth and 3) Expected Transmission Count (ETX). MMC results in a better throughput.

Yousif Ali Saadi et al., 2016 [10] defined a WMNs might be the most important wireless network in the future as a key technology. However, WMNs has not met our expectations. Thereby, several researches focused on this field to specify the issues that needs to be solved. Based on the researches, one of the most important factors in WMNs is the routing protocol and how it makes it more efficient to transmit the data over the nodes. They aimed to enhance a routing protocol for WMNs to improve the performance of data transmission and receive better energy save while transmitting the data. The Directional Hierarchical Ad hoc On Demand Distance Vector (DH-AODV) routing protocol has been

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selected in this research which is an improvement of Ad hoc On Demand Distance Vector (AODV) routing protocol in case of route breakage and network quality. DH-AODV is efficient routing protocol for WMNs and performing well, but they have not considered a mechanism to find new node when link fails and the next node is unreachable. To handle this problem, DH-AODV will be modified by using Local Route Repair (LRR) in order to achieve better energy save while transmitting data and less End to-End (E2E) delay

Table 1: Related Work using various techniques used and Performance parameters used in existing work

Author Name	Year	Technique Use	Parameter
G. Akilarasu	2017	Wormhole Free Routes, DoS	Delivery Ratio
Zhang Wei-wei	2017	AODV	Delay
Mohammad Tariq Meeran	2017	Voice over Internet Protocol (VoIP)	proxy delay or 1Mb per strategy
Emmanouil Dimogerontakis	2017	Proxy Selection	Latency(ms), Absolute Error(ms)
Deepak C Karia	2016	SOAR, AOMDV, OLSR	Residual energy
Yousif Ali Saadi	2016	Demand Distance Vector and Local Route Repair	Better energy, less End to End (E2E) delay.

I. CHARACTERISTICS OF WIRELESS MESH NETWORK

Though, there are also important differences among WMNs and overall MANETs:

• Gateways: Most WMNs are designed to provide connectivity to a distribution system (usually connected to the Internet). Therefore, they have specialized nodes (the gateways) that provide connectivity to the distribution system. [11]

• Traffic pattern: In WMNs, most of the traffic is expected to flow between the clients and the Internet (via the gateways). In general MANETs, the common assumption is that any node is equally likely to be the source or the destination of a traffic flow.

• Mobility: In greatest WMNs, nodes fit to two separate categories: either stationary or mobile, capable of roaming in the coverage area provided by the stationary nodes. In MANETs, it is often assumed that all nodes have homogeneous mobility characteristics.

II. CLASSIFICATION IN ROUTING PROTOCOLS

Routing protocols for WMNs are mostly based on protocols designed for mobile ad hoc networks. These can be classified in the three categories: [12]

A. Pro-active Routing Protocol

Proactive routing protocols maintain a table for each node representing the entire network topology which is regularly updated in order to maintain the freshness of routing information. At any given time, any node knows how to reach another noe of the network. This approach minimizes the route discovery delay at the cost of exchanging data periodically, which consumes network bandwidth. Proactive protocols are favoured for small systems because of low routing, table lookups. Destination Sequenced Distance Vector (DSDV), Optimized Link State Routing (OLSR), Topology dissemination Based on Reverse-Path Forwarding (TBRPF), Open Shortest Path First – MANET (OSPF-MANET), Fish-eye State Routing (FSR) are some of proactive routing protocols.[13]

1 .DSDV (Destination Sequenced Distance Vector)[14]

Destination Sequenced Distance Vector Destination Sequence Distance Vector (DSDV) protocol is based on Bellman – Ford routing algorithm where each node maintains a routing table that contains the shortest path to every possible destination in the network and number of hops to the destination as shown in Fig.3.The sequence numbers allows the node to distinguish stale routes from new ones and avoid routing loops. A new broadcast route contains --Destination Address --Number of hops to reach the destination --Sequence number of the information about the destination and a new sequence number unique to broadcast.

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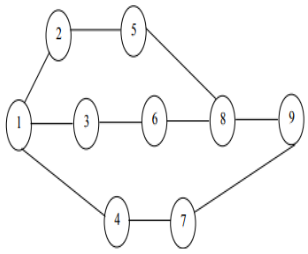

Fig 3. DSDV Routing Protocol in Network

2. OLSR (Optimized Link State Routing)

Optimized Link State Routing (OLSR) is a proactive routing protocol [7]. Each node broadcasts its link state information to all other nodes in the network. OLSR operation mainly consists of updating and maintaining information in 1- hop, 2 – hop neighbor table and routing table. OLSR uses hello messages for link state information. Multi Point Relays (MPR) is important aspect of the OLSR protocol. An MPR for a node N is a subset of neighbours of N which broadcast packets during the flooding process, instead of every neighbor of N flooding the network. When a node propagates a message, all of its neighbours are receive message. Only MPR which have not seen the message before again propagates the message. Therefore flooding overhead can be reduced. OLSR uses three kinds of Control messages: Hello Messages, Topology control (TC) messages and Multiple Interface Declaration messages. HELLO messages are transmitted to all neighbours. These messages are used for neighbor sensing and MPR calculation. TC messages are the link state signaling done by OLSR. This messaging is optimized in several ways using MPRs. MID - Multiple Interface Declaration messages are transmitted by nodes running OLSR on more than one interface. These messages list all IP addresses used by a node.[15]

B. Re-active Routing Protocol

In reactive routing protocols, nodes are not aware of the network topology. Routing table is constructed on-demand. They find routes by flooding network with route requests. This leads to higher latency due to the fact that the route has to be discovered, however it minimizes control traffic overhead. Usually, reactive routing protocols are better suited in networks with low node density and static traffic patterns. Since the traffic patterns are static, the first request encompasses the route discovery, while the subsequent use the previous discovery to route the traffic. On the other hand, proactive protocols are more efficient in dense networks with bursts traffic due to the continuous exchange of topology information, reducing route discovery delay. Reactive protocols are preferred for high mobility networks. Dynamic Source Routing (DSR), Ad hoc On-Demand Vector (AODV) and some other extensions derived from AODV are reactive routing protocols.

1. AODV (Ad-hoc on demand distance vector)

The AODV protocol belongs to the most popular protocols because they employ simple mechanisms of the type “question - reply” to define routing paths. For this purpose, three types of packets are used: Route Request (RREQ), Route Reply (RREP) and Route Error (RERR). The source node sends RREQ packets when a necessity to send packets arises and then intermediate nodes, provided they know the route, send a RREQ packet further on towards the destination node, whereas when intermediate nodes do not know the route, they reply with a RERR packet. This process is then repeated until the packet reaches the destination node (the node sends then a RREP packet). In the case when the node receives RREQ packets from different routes, then the route along which the packet has reached the node as first is selected [16].

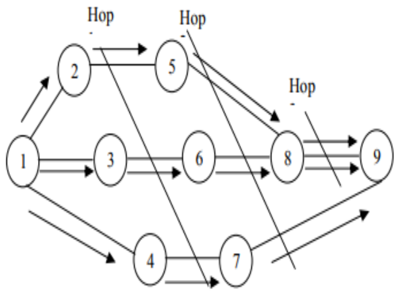

Fig 4 (i). Broadcast Route Request from source node 1 to destination node 9

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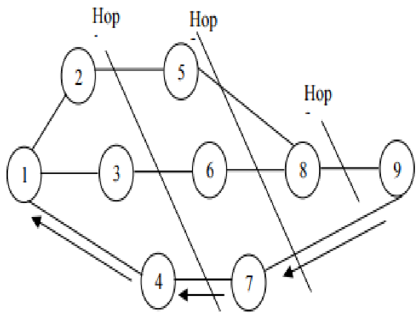

Fig 4(ii) Route Reply from destination node 9 to source node 1

2. DSR (Dynamic Source Routing Algorithm)

Dynamic Source Routing Algorithm (DSR) [17]. DSR is one of the most commonly used routing protocol in WMN networks and belongs to the group of unicast reactive protocols. The protocol uses source routing, which results in the knowledge of the whole of the destination routing path by any packet. The operation of the protocol occurs in the two consecutive stages: the route discovery phase and the route maintenance phase. The first, initiated by the source node, involves sending broadcast packets that include the destination address, the source address and a unique id to neighbouring nodes. If the packet is received by a node that is not a destination node, this node adds its address to the header and then forwards the packet according to the same scheme. Thus, a packet that has reached its destination has in its header information on the end-to-end connection path. On the basis of information carried in the header, intermediate nodes collect information on routing paths. In the second phase, nodes supervise updated information on stored routes by generating error packets (RERR) forwarded towards the source node. When such a packet is received, a given router is removed from the database and further process proceeds in line with the phase one described earlier.

C. Hybrid Protocol

Hybrid routing protocols are mixed design of two approaches mentioned above. The protocols typically use a proactive approach to keep routes to neighbourhood nodes (nodes within the vicinity of the source). But for the nodes beyond the vicinity area the protocol behaves like a reactive one. Alternatively, multiple algorithms can be used simultaneously, if WMN is segmented into clusters. Within each cluster a proactive algorithm is used, whereas between clusters a reactive algorithm is used. The challenge is to choose a point, a point from which the protocol should change from practive to reactive.

1. Zone Based Routing Protocol

Zone Based Routing Protocol (ZRP) is a hybrid protocol, which take advantage of best of proactive and reactive protocols. A node’s local neighbourhood is known as a routing zone [18]. A node’s routing zone is defined as the set of nodes whose minimum distance in hops form the node is no greater than the zone radius. To construct a routing zone, the node has to identify all its neighbours first which are one hop away and can be reached directly. The neighbor discovery process is managed by the Neighbor Discovery Protocol (NDP). ZRP uses two routing methods: Intra Zone Routing Protocol (IARP) and Inter Zone Routing Protocol (IERP).The IARP is responsible for maintaining routes to all destinations in the routing zone proactively. The IERP is responsible for discovering and maintaining the routes to nodes beyond the routing zone reactively [19, 20].

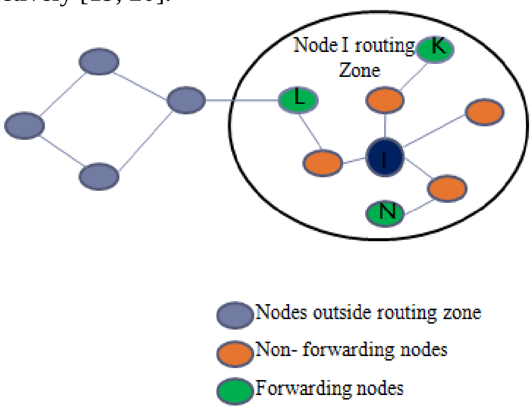

Fig 5. Zone Routing Protocol

V.CONCLUSION

Wireless mesh networks are becoming increasingly popular as they have significant advantages over competing technologies. In this paper, we introduce a new routing protocol specifically designed for those networks. The design of the proposed routing protocol takes advantage of the particularities of WMNs, only maintaining routing trees to and from the gateways. In addition, the article includes another division of routing protocols grouped within the following categories; Hop Count Based Routing Protocols, Link Level Based Routing Protocols and End-To-End QoS Routing. It is worthwhile to notice that the above three categories are by no means exhaustive and, as a result, only some selected protocols are presented due to the complexity of this many-faceted problem. During the selection process of protocols, the popularity and common use of protocols were decisive in their inclusion.

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