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Routing protocols for Wireless Mesh Networks: A comparative study

B. Nandini*[1], Prof. Suresh Pabboju[2], Dr.G.Narasimha[3]

[1]Asst. Prof., Dept of CSE, TU, NZB.
[2]Prof. Suresh Pabboju, Head, Dept of CSE, CBIT, HYD.
[3]Assoc. Prof., Dept of CSE, JNTUH, HYD.
[*]Corresponding author Mobile: 919441862510, Fax: 08421 222212

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Abstract

A wireless mesh network (WMN) is a particular type of mobile ad hoc network (MANET), which aims to provide high bandwidth access for a large number of users. Shared nature of the wireless medium, static nodes and diversity of multiple paths between source and destination nodes makes designing of routing protocols makes a challenging task for wireless mesh networks when throughput, delay and protocols overhead taken into consideration. In this paper we present common metrics considered in routing protocol design and complete comparative analysis between some of the most deployed routing protocols in the wireless mesh networks along with simulation results for throughput, overhead and overall delay.

Keywords: *Wireless Mesh Networks, Routing, Routing Metrics*

Introduction

A wireless mesh networks (WMNs) comprises a number of devices with the ability to communicate via radio. Wireless links are formed between nodes within range of each other. These links are self-forming, Self-organizing and self-healing. The mesh network architecture is composed of three different network elements: network gateways, access points (mesh routers), mobile nodes (mesh clients) [1]. Network gateway element allows access to the wired infrastructure, possibly the Internet or other local networks. Normally to reach the present day requirements more than one gateway can be deployed in wireless mesh networks. Access points (APs) form the network backbone spanning over wide areas as shown in fig 1. APs are easy to deploy, Low cost and flexible. Users connect to the APs using wired or wireless links. APs are assumed to be static, with a low failure probability, and no power constraints. This mesh of APs provides communication between mobile nodes and network gateways. Mesh clients are end-user devices, such as laptops, cell phones and PDAs with varying degrees of mobility. Mesh clients access internet through mesh routers. According to their position and transmission capabilities they can communicate directly with the mesh gateway. In WMN, Only gateway nodes physically connected to the broadband router.

The WMNs provide support for applications that are not possible with other existing wireless networks such as cellular networks, sensor networks, and ad-hoc networks etc. WMNs are capable of providing attractive services in a wide range of application scenarios, such as broadband home, enterprise, community networking and disaster management.

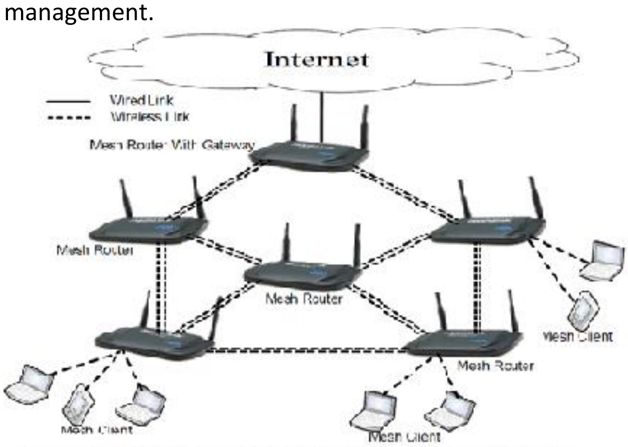

Fig. scenario of wireless mesh network with gateway, router and mobile nodes

Traffic in WMNs is expected to high in volume and predominantly between IGWs and the MRs, which places higher demand on certain paths connecting gateways and routers [2]. The design of WMNs need focus on aspects including multi-path routing, load balancing, proper traffic distribution policy, scalability among others. Because of few common features among WMNs and MANETs, routing protocols developed for MANETs are also applicable for WMNs. Some of the commonly used routing protocols in WMNs are [3] Destination-Sequenced Distance-Vector Routing (DSDV), Dynamic Source Routing (DSR), Ad Hoc on-Demand Distance Vector Routing (AODV), Zonal Routing Protocol (ZRP) [4].

The remainder of the paper is organized as follows: Section 2 identifies basic characteristics of WMNs. Classification of routing protocols is given in section 3. Section 4 compares different protocols which are suitable for WMNs. Results are shown in section 5. Conclusion and future work given in section 6.

Characteristics of Routing

WMN is a combination of both wired and wireless infrastructure. The "first generation" of WMNs used wired routing protocols (for example RIP, OSPF) [5] and protocols developed for MANETs are also used. However, the characteristics and requirements of WMNs are considerably different than those of general MANETS. WMNs exhibit unique characteristics that differentiate them from other wireless and wired technologies [6]. Therefore, existing routing protocols must be revisited in order to consider their adaptability to WMNs. The main differences relating to routing are:

- Network topology: WMNs have fixed wireless backbone. With in the backbone multi-hop communication similar to MANETs is performed. But node mobility in the backbone infrastructure is not frequent.
- Traffic pattern: In WMNs, data transmission is primarily between the mobile nodes and the gateway, where as in MANETS traffic can flow between any pair of nodes.
- Inter-path interference: Communication between two wireless nodes can have an effect on the transmissions of all neighboring nodes, leading to the well-known problems of hidden and exposed terminals.
- Link capacity: Due to the very nature of wireless communications WMNs are sensitive to surrounding interference.
- Channel diversity: WMNs can benefit from the possibility of introducing channel diversity in the routing process, which is not possible in other wireless networks due to node mobility or energy constraints. This technique can significantly reduce inter-nodes interference and increase the overall throughput.

Classification of Routing Protocols

WMN routing protocol design can be classified into several categories based on:

- The routing topology: Routing protocols can be designed either as a flat routing protocol or as a hierarchical routing protocol based on routing topology.
- The use of a routing backbone**:** Based on the use of routing backbones routing protocols classified into:
  a. Tree-based backbone routing: Link layer will form a tree topology
  b. Mesh-based backboneless routing: Network layer will follow a backboneless mesh routing approach.
  c. Hybrid topology routing: This is dynamic backbone topology.
- The routing information maintenance approach**:** routing protocols can be designed on the basis of the routing information maintenance approach as Proactive (or table-driven) routing protocols, reactive (or on-demand) routing protocols, and hybrid routing protocols.

Proactive protocol is characterized by continuous availability of information with reduced latency, but creates high overhead in the network due to flooding. In contrast Reactive protocol finds path on-demand resulting less overhead and increased latency. Hybrid protocol blends both Proactive and Reactive protocols, thus making it suitable for large networks. Table 1 further elucidates this comparison [7].

Every routing decision is made based on routing metric. This plays very important role in the performance of a routing protocol. Routing metric is the routing parameter, weight, or value that is associated with a link or path. Most commonly used routing metric for WMNs are [8]:

- Hop count: Number of hops between the source and the destination. It is the simplest routing metric and is an additive routing metric.
- Expected Transmission Count (ETX): It calculates the number of retransmissions needed to successfully transmit a packet over a link.
- Expected Transmission Time (ETT): This metric is an enhancement of ETX. ETX does not consider link data rates.
- Energy Consumption: A node energy level can be considered as a routing metric if some nodes are energy-constrained and their involvement in the routing process can lead to path failure if they suffer from energy depletion [6]. Because of static topology, it is not a big problem in WMNs
- Path availability/reliability: This estimates the percentage of time a path is available. Node mobility can be captured with this. In WMNs wireless backbone is fixed, so this is mainly useful in MANETs.

Comparison of Routing Protocols

Protocols used for MANETs can also be used for WMNs but needs some modification due to fixed wireless backbone. Accordingly few protocols that are suitable in this aspect are discussed. A comparison is made between the routing protocols based on routing protocol properties. Table 2 provides this comparison.

- Destination-Sequenced Distance-Vector Routing (DSDV) [9]: It is a table-driven routing scheme based on the Bellman–Ford algorithm. DSDV requires a regular update of its routing tables. DSDV is not suitable for highly dynamic networks.
- Dynamic Source Routing (DSR) [10]: It uses source routing instead of relying on the routing table at each intermediate device. It has two major phases, which are Route Discovery and Route Maintenance. It is an on-demand protocol designed to restrict the bandwidth consumed by control packets.
- Ad Hoc on-Demand Distance Vector Routing (AODV) [11]: It uses an on-demand protocol. It builds routes between nodes only as desired by source nodes. AODV builds routes using a route request / route reply query cycle. An important feature of AODV is the maintenance of timer-based states in each node, regarding utilization of individual routing table entries.
- Zonal Routing Protocol (ZRP) [4]: ZRP employs a table-driven routing approach within a zone (local) and on-demand approach beyond the zone (outside). Every node uses proactive approach within a k-hop routing zone and employs a reactive routing approach beyond the routing zone.

Results

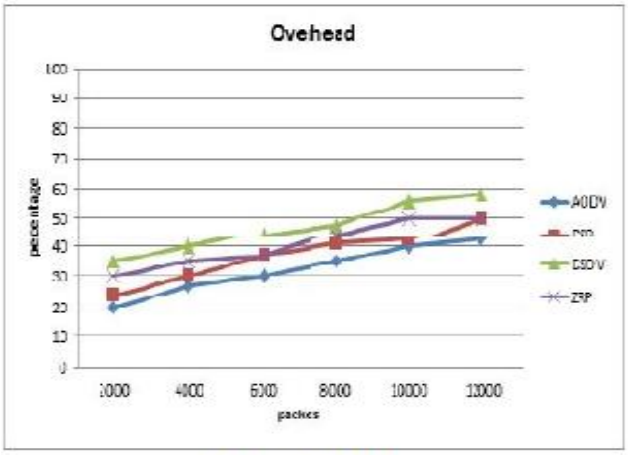

Fig. 2 : Result 1 (overhead)

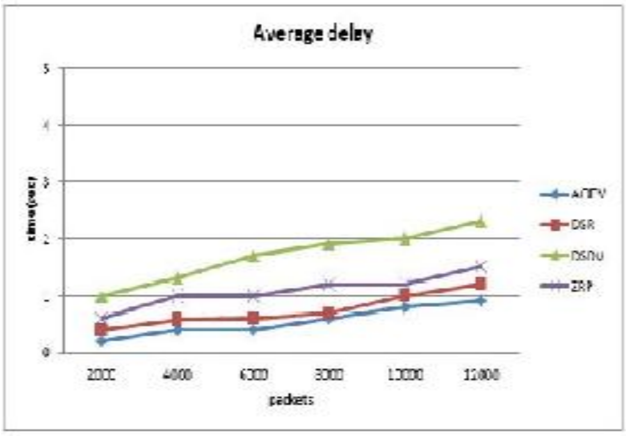

Fig. 3 : Result 2 (Average delay)

This section gives simulation results of overhead (Fig 2.), average delay (Fig 3.), and throughput (Fig 4). AODV routing protocol is performing good in all aspects. Poor performance is given by DSDV routing protocol. DSR and ZRP protocols are there in between AODV and DSDV.

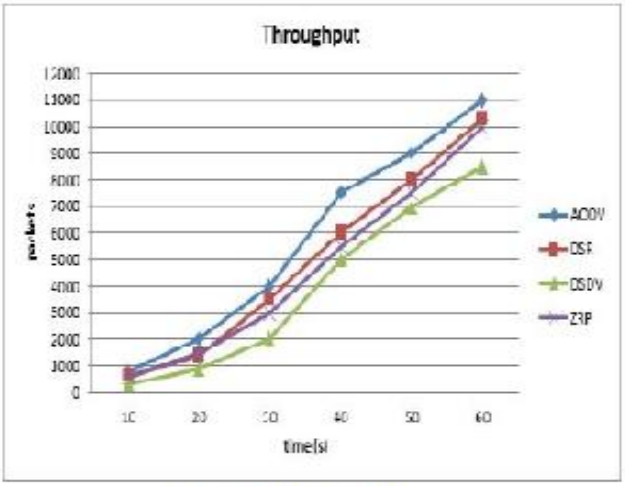

Fig 4 : Result 3(Throughput)

Conclusion and Future Work

In this paper we have presented a complete analysis and comparison of routing protocols for WMNs for throughput, delay and overhead. Still the main area of improvement is to provide Quality of services (QoS) to real time and non real time data applications by providing fair routing and scheduling algorithms for aggregate demands for multiple source and destination pairs.

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