A Survey on QOS Improvement in Wireless Mesh Network

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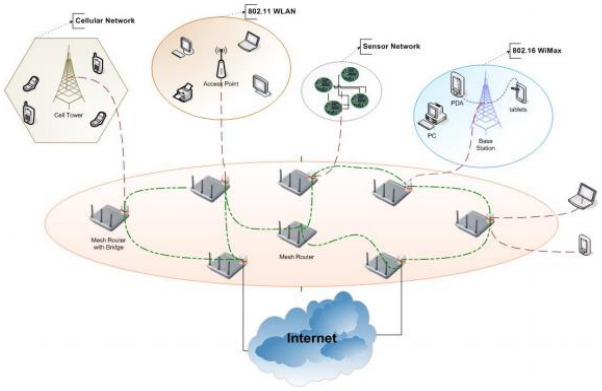
Abstract*: Wireless mesh Network (WMN) is rapidly catching momentum in developing countries like India for providing seamless internet services and for disaster time emergency networking. QOS is one of the hurdles for acceptance of WMN because as more people start using the network for internet services, latency, session drops, and packet loss are noticed. Many solutions for improving QOS in terms of placement of components, QOS based routing, cross layer optimizations, MAC layer scheduling etc. are proposed to improve the QOS. In this work, we review all these solutions and problems in these solutions for large scale acceptance of WMN.

Keywords: (WMN), QOS, WMN, MAC, Wireless

I. INTRODUCTION

Wireless Mesh Network (WMN) is emerging as a promising technology for providing internet services in cities and urban area with minimal infrastructure cost and fast deployment. WMNs are multi-hop infrastructure based wireless networks that are interconnected by a set of relatively stationary wired gateways connected to the Internet. The routers that relay traffic and the client may or may not be mobile. Most of the traffic in a WMN flows from the client to the gateways.



WMN consists of following types of nodes:
WMN Clients: These are the end-user devices like PDAs, laptops, smart phones, etc., that can access the network for using applications like email, web surfing, VoIP, and alike. These devices are assumed to have limited power, mobility, having none or limited routing capabilities, and may or may not be always connected to the network. Mobile Ad-hoc Networks (MANETs) can be assumed to be a special case of WMNs that are formed purely by WMN clients. WMN Routers: These network elements are primarily responsible for routing traffic in the network. Traffic does not originate or terminate at a router. The routers are characterized by limited mobility and relatively high reliability. Compared with a conventional wireless router, a wireless mesh router can achieve the same coverage with much lower transmission power consumption through multi-hop communications. Additionally, the Medium Access Control (MAC) protocol in a mesh router supports multiple-channels and multiple interfaces to enable scalability in a multi-hop mesh environment. WMN Gateways: This is a router which has direct access to the wired infrastructure (i.e. Internet). Most of the client nodes on a WMN, communicate with the wired infrastructure for information delivered over the World Wide Web (WWW), emails, audio and video. Since they have multiple interfaces (wired and wireless), the gateways are typically more expensive, both to install and operate. Typically, they are fewer in number and their placement has a significant impact on the performance of the network.

Since the WMN is a wireless infrastructure, typical problems of wireless network like congestion, collision occur in the network and affects the Quality of Service (QOS) of the network. Frequent session drops, session unavailability, low speed are the typical problems that irritate WMN users. Many solutions for ensuring QOS have been proposed and in this survey work we categorize them to different groups and analyze the disadvantages. The objective of this survey is to identify open areas for QOS improvement in Wireless mesh network.

II. SURVEY

We categorize the existing works on QOS improvement as below

1. MAC Layer optimization
2. Optimized Routing Protocols
3. Optimized Gateway Placement
4. Optimized Router Placement
5. Cross Layer Protocols

2.1 MAC Layer Optimization

In [1], S-TDMA based MAC was proposed for wireless mesh network in which continuous power control is done to reduce the noise interference and rate allocation is done to increase the capacity. This solution relies on conflict free scheduling, to increase the throughput by avoiding collisions, but the solution does not address delay due to conflict free scheduling, Mesh Routers and Mesh client have to wait in turn for time schedule and as delay increases buffer overflow occurs in routers and QOS is affected. So it is not a scalable solution.

In [2], solution based on increasing the contention window size to lower the collision is proposed. By reducing the collision throughput can be increased. A spatial extension of the TXOP (transmission opportunity) concept called 'express forwarding' to clear

Revised Version Manuscript Received on April 06, 2016.

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multi-hop flows sooner, and a new mechanism called 'express re-transmission' to reduce collisions on retransmission were also proposed.

In [3], use of smart antenna to do directional transmission and link scheduling algorithm to activate the links in such a way to increase the network capacity was proposed. But this is not a scalable approach as new routers are deployed to existing network; placement becomes a difficult operation and has to place without interfering within the path of another router. Also the use of smart antenna will increase cost of Routers.

In [4], STDMA (spatial-TDMA) based scheduling was done at MAC layer with admission control. Admission control ensures clients have a minimum guarantee of bandwidth and maximum delay. It works for VOIP services, but it is not profitable to apply this solution as clients will switch to a different operator if strict admission control is enforced.

2.2 Optimized Routing Protocol

In [5], the routing protocol in WMN is adapted to choose the relay nodes in the path on estimation of wireless link quality and bandwidth. But without any control on the rate of transfer, this approach is not useful as a path found efficient based on link quality and bandwidth can later be congested due to a variable rate of usage from clients.

In [6], Weighted Contention and Interference routing Metric (WCIM) is proposed. Based on interference, bandwidth available, the quality of the link, etc. a metric is calculated for each node. Routing is done in such a way next node with the highest value of the metric is caused as a relay node in the route. The problem with these approaches is that it requires frequent exchange of information between nodes to calculate the metric and also it is not end to end decision. When end to end is considered there may be a better path with more WCIM value than the current chosen path and solution converges in local minima.

In [7], routing based on opportunistic method is proposed. Every node overhearing other nodes in wireless medium can assist in routing in case of failure. But this method has many practical difficulties in deciding the cooperation and also increases the network communication overhead.

2.3. Optimized Gateway Placement

In [8], the controller is placed optimally in the network using Particle Swarm optimization technique for maximizing the flaws in network found out by using a Ford Fulkerson algorithm. But this method requires frequent movement of controller based on traffic observation over a period of time.

In [9] wireless mesh network is clustered based on the degree/number of WMRs connections, while ensuring Delay, Relay load and Cluster size constraints.

In [10], proposed a genetic algorithm based solution for gateway placement. This solution optimized variation of MR-IG- hop counts (VAR-MRIG-Hop) among MRs to insure that the Gateway's are placed in the appropriate positions. But during loading, the solution cannot maintain QOS.

2.4. Optimized Router Placement

In [11], a heuristic solution, called PRACA (Placement, Routing and Channel Assignment) was proposed to find the optimal position for the router in the Mesh Network. The solution jointly considers and routing, channel assignment and placement get the optimal solution for placement. By this way it tries to eliminate interference and improve QOS.

In [12], solution for placement of multi rate routers in mesh network was considered. It presented a heuristic placement algorithm called The IL Search which takes into account both multiple transmission rates and co-channel interference. The IL Search consists of two components: (1) Coverage MR determination which greedily exploits the capability of each selected MR to cover mesh clients (MCs); and (2) Relay MR determination that incrementally chooses the additional MRs for traffic relaying through the local search.

In [13], the nearest cell association algorithm was proposed to reassign users to routers in different times and a greedy search to find optimal positions for the router. They proved QOS is improved due to switching users between routers in this way.

2.5. Cross Layer Protocols

In [14], cross layer mixed bias algorithm was proposed. The cross-layering will provide information on the link-quality and distance between nodes. Link quality will be provided from the physical layer while distance can be provided in many ways. The distance could be computed by the number of hops between two points, by measuring the delay or by using real life coordinates if the nodes are equipped with Global Positioning Systems (GPS). In this paper author used the number of hops. A portion of the scheduling resources will be biased according to a set of heuristics that penalize nodes for various "bad behaviors" such as distance from the gateway, overuse of traffic, poor link quality and so on. Each heuristic will be assigned a different proportion of the network resources which will be determined experimentally. Another portion of the resources will be left for absolute fairness in order to ensure that none of the links are starving and that some minimum level of service is maintained. Then the collective system will be optimized to produce high throughput fair scheduling for wireless mesh networks.

In [15], two cross layer routing were proposed a loosely coupled cross-layer scheme and a tightly coupled cross-layer scheme. In the loosely coupled cross-layer scheme, routing is computed first and then the information of routing is used for link layer scheduling; in the tightly coupled scheme, routing and link scheduling are solved in one optimization model. The two cross-layer schemes involve interference modeling in multihop wireless networks with Omni directional antenna. A sufficient condition of conflict-free transmission is established, which can be transformed to polynomial-sized linear constraints, and a linear program based on the sufficient condition is developed.

In [16], the authors proposed a new routing metric for wireless mesh network CAETT (Congestion Avoidance Expected Transmission Time). With the queue's utilization rate and the transmit situation of control frames in 802.11 protocol's MAC layer, a

reasonable path is chosen in terms of the channel competition status, link data frame delivery rate and the node's queue utilization rate.

III. OPEN ISSUES

From the survey we notice that each solution tries to achieve maximum QOS by reducing interference, parallel data rate, smart antenna, network component placements etc. One of the most important points noticed in all the solution suffers from scalability issues and gateway can get overloaded soon with internet service requests. To reduce the overload on the gateway, multi gateway is suggested, but still there is a scalability problem. To solve this problem only way is to use the cooperation of Mesh clients. With no previous work, cooperation of mesh clients in the WMN is considered. Mesh Clients can cooperate in WMN by sharing their bandwidth to access internet traffic, mutually assist to reduce congestion, etc. If these solutions are implemented in WMN, it can scale up to increased user base.

IV. CONCLUSION AND ENHANCEMENTS

The paper summarizes the current works in the QOS improvement in wireless mesh network from different perceptions of MAC Layer optimization, Optimized Routing Protocols, Optimized Gateway Placement, Optimized Router Placement and Cross Layer Protocols. We identified the open areas for further work on QOS improvement in WMN.

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