A Survey on Approaches and Issues of Multicast Routing in Wireless Mesh Networks

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Abstract— Wireless Mesh Network (WMN) is a multiradio multihop network that is emerged as prime technology for the next generation wireless networks. Because of their vantages over other wireless networks, WMN gains rapid progress and renders numerous applications. WMN delivers reliable and efficient services for a large variety of applications on local, personnel and campus environments. Multicasting is one of the major communication technologies primarily designed for bandwidth conservation and an efficient way of transferring data to a group of receivers in wireless mesh networks. Despite of the recent advances there are severa issues and factors that should be considered while designing an effective multicast routing protocol for WMN. This paper presents a survey based on the multicast protocols and the issues that are related to multicast routing in wireless mesh networks like Resource Management, Control overhead, Load Balancing, Routing Metrics, Quality of Services, Security, etc.

Index Terms— Wireless Mesh Networks, Multicast, Routing Protocol, Security, Multiradio.

I. INTRODUCTION

Wireless mesh network is a multiradio multihop network and one of the emerging technologies that are developed to provide solutions to the retreats caused by the wireless adhoc networks. WMN offer high bandwidth, low cost design, all time connectivity features to the wireless network. The main components of WMN include the mesh routers, mesh clients and the gateways where the mesh routers are stationary and form the wireless mesh backbone, which in turn provides the multihop connectivity for the mobile mesh clients to communicate with each other or to the Internet through the access points.

The mesh clients can be mobile or stationary and can form a particular wireless network like adhoc networks, LAN etc. The multihop connectivity of the mesh network provides reliable delivery of information to the proper destination through the intermediate nodes on the course of transmission, even if the specified hosts fails to forward the packets. This explains the major characteristics of wireless mesh networks. WMN are dynamically self-organized, self healing and reliable networks that maintain continuous connectivity among the nodes. These distinguished characteristics of the wireless mesh networks make WMN highly reliable and fault tolerant networks.

The main features of the wireless mesh networks can be listed below [2]:

- Flexible network architecture, ease of deployment and configuration, capability to provide fault tolerant services, low cost and scalability.
- Mobility features are dependent on the node (clients) type.
- Routers are having less mobility and clients are either stationary or mobile.
- Power consumption constraints: the mesh routers do not have any power constraints rather the clients are required to have power efficient protocols.
- Compatible and interoperable with the other existing wireless networks.
- Mesh routers have multiple radios and non overlapping channels which can be assigned to these radios.
- Able to integrate the functionality of heterogeneous networks, including both wired and wireless networks which provide multiple access types.

Figure 1 explains the architecture and communication between the components of WMN.

Numerous applications in WMN are deployed using multicasting which is feasible in the day to day life, like webcasting, distance learning, online games, and video conferencing. [3].

The rest of the paper is organized as follows: Section II discusses about the multicast technology, classification of multicasting protocols and applications of multicasting. Section III discusses about issues related works with multicasting in wireless mesh networks. Section IV discusses about the related works on multicasting in WMN. And as we proceed further we conclude with the related works, the factors that must be taken into consideration on designing the multicast protocols and the performance comparison of various protocols.
II. MULTICASTING IN WIRELESS MESH NETWORKS

Multicasting is a bandwidth conserving technology that helps to reduce the traffic by delivering the appropriate message or information to a group of receivers that can be anywhere or in any network. In the network environment, the host joins the multicast group by informing its local router that it wants to join the multicast group and the router in turn informs other multicast routers and thus a multicast tree is created using the multicast routing protocol.

The multicast router sends queries periodically to the network to make sure that any of the nodes are connected to it and is a member of the multicast group created. Several protocols [4], [5], [6], [7], [8], [9], [10] have been proposed to provide multicast services in networks during recent years. Multicast protocols can be classified as various categories based on their behavior, dependability on other protocols and the topology created by these protocols.

These protocols were mainly purposed for mesh based mobile networks and it has been reckoned that these protocols focuses on the connection between the network elements and also uses various metrics for the selection of paths. But it has been noticed that the usage of traditional unicast metrics for selecting the path of data transfer creates stacks of problems including the selection of lossy links for forwarding the packets etc.

III. ISSUES IN MULTICASTING

A. Resource Management

Resource management [11] is a major issue that must considered in efficient multicasting. During the deployment of the operational network, the bandwidth provided to each of the node of the network may be different, but according to the application to which the nodes are provisioned they may or may not need much bandwidth sufficiency. In order to help from the nodes from a particular outage, the work load between the channels of nodes should be reduced by controlling its input traffic. The fair flow value can be found out by evaluating some bound values which achieves maximum or minimum flow between the nodes. The algorithm based on the max/min bound value performs wee and good compared to other algorithms based on analytical bound value.

B. Control Overhead

Control overhead is a basic criterion on which highly reliable networks are made up and operated. The optimization of control overhead during the design phase of a network gives high throughput and performance for the network. Controlling of overhead is a matter of concern in multicast networks. For the minimal overhead on demand routing protocols such as ODMRP [13] can be best fit since they provide creation of mesh networks based on the need of the nodes that wants to join the group and thus the overhead can be balanced to a great extend.

Since WMN are multiradio multihop networks the packets that are transmitted through various links and through various frequencies that are basically known as the radios. Each node can have several radios associated with it. These frequencies can matter a lot depending up on the type of packets that are transmitted through the mesh networks. The overhead mainly increases when each node sends the control packets that are send occasionally, when each node joins and leaves the group. The multicast protocol that is designed should consider a mechanism to avoid the extra overhead created due to the frequent sending of the control packets.

C. Load Balancing

Load balancing [14] is a dandier issue in multicast networks since the packets are send through a group of routers to a group of receivers. The unbalanced load present in the network can cause several types of clogging like, gateway and channel overloading. Gateway overloading occurs mainly because of the data aggregation that occurs at the gateway and channel overloading due to the increased number of packets in the channels and the data overhead. The center overloading occurs mainly due to the static nature of networks, presence of nodes on the shortest path of the network, and the multihop
relying mechanism. These are the major constraints that are to be considered in designing of an effective multicast protocol since load balancing plays a crucial role on improving the network utilization and the performance; it also helps to avoid the hotspots that are present in the network.

D. Creating Multiple Channels and Making them available among Existing Nodes

Several standards are used by the wireless mesh networks like 802.11a/b/g/n. The frequency bands are divided in to numerous channels in the physical layer. The number of channels [12] used by each standard varies from each other. Two channels of a particular standard are said to be non overlapping if they are separated by means of several other channels say four for two. In single channel wireless network each channel is associated with single radio interface and is assigned a common channel and this channel is shared among the nodes for the communication. Apart from the usual networks the wireless mesh networks are equipped with multiple radios and thus the capacity of the network is not limited.

The radios in WMN can be allocated with non overlapping channels and helps in sending the data simultaneously over the network. The multicast routing algorithms should take into consideration the channel diversity among the nodes along the path of a network, since the main routing issue that is addressed include which nodes are present on the routing path and which channel to be used on a particular path. Channel assignment to a particular channel can be static, dynamic and hybrid, and it is a major factor that should be considered at the time of designing multicast algorithms.

E. Routing Metrics

The routing metrics are the best criterion that is used to judge the rating or the performance of a particular multicast algorithm and a multicast protocol. There are several kind of routing metrics are used in the wireless mesh networks like Expected Transmission Count(ETX), Expected Transmission Time(ETT), Weighted Cumulative Expected Transmission Time(WCETT), Packet Pair(P), Multicast ETX(METX) etc. Each routing metric measures particular criteria including the number of packets transmitted, packet transmission time etc.

Several papers deal about the comparative study about different routing metrics [16]. Basically in unicast network hop count is used as a routing metric, which cannot be a suitable metric for multicast network. When hop count is used as the routing metric the channels or the paths with the least link quality can be used, therefore for multicast protocols that considers link quality as the routing metric is useful. So the unicast routing metric should be upgraded to higher level metrics as ETX is upgraded to SPP, which is a multicast level routing metric.

F. Guaranteed Quality of Service

This issue is mainly related with the multimedia services which require higher bandwidth. The multicast protocol should define all the requirements that should be considered in applications like mobile TV and also the audio and video conferencing. The requirements that are related with these applications include jitter, delay, packet loss and throughput.

The multicast applications should provide highly robust an reliable services [15] in order to achieve the intensive throughput through the network. Even though the multicast protocols helps in bandwidth management, the limited bandwidth and the shared nature of the wireless medium is a great constraint to design and define effective multicast algorithms.

G. Security in Multicasting

Security [13] is a significant fact that has to be taken in to prior validation since the receiver nodes who wants to join the multicast group sends JOINQUERY message so that they can include themselves in multicasting. These nodes can behave like attacker nodes which can perform several kinds of attacks including drop only attacks, wormhole attacks, and metric manipulation attacks. As a result of these attacks the metrics that are used to find the link quality are changed by the attacker nodes to advertise wrong values, packets are dropped etc. the multicast protocols should be designed such a way that the impact of the attacker nodes can be easily found out and particular nodes can be isolated. The up gradation of the multicast protocol ODMRP, by adding security features makes the S-ODMRP, a secure multicast routing protocol.

IV. PERFORMANCE ANALYSIS OF VARIOUS APPROACHES ON MULTICASTING IN WMN


The paper purports a framework for the efficient management of the bandwidth in wireless mesh networks for multicasting. The framework integrates the advantages of both shortest path trees (SPT) and the minimum cost tree (MCT) algorithms. The bandwidth in wireless mesh network is a bare resource which is used by various wireless nodes which are close to each other. The problem concerning this is that many times some nodes may dominate the channel capacity and the bandwidth may not be efficiently available to other nodes. It is a major factor of concern. The proposed Multicast Framework for Bandwidth Management in WMN (MFBW) gives the theme of how the bandwidth can be effectively managed between various wireless nodes.

The framework was designed to provide multicasting in such a way that the bandwidth of the network is saved by utilizing both SPT and MCT. By decreasing the number of forwarding nodes in the multicast tree using the above algorithms, bandwidth can be conserved as less number of nodes are using the bandwidth. The paper supports the SPT metrics for the networks that support dynamic topology.

The main phases include route discovery, multicast routing tree construction, and node identification. The paper gives an amend idea about how the bandwidth is conserved and preserved in the network and also explains about the implementation of QoS features as a future work.

B. Efficient Multicast Algorithms for Multichannel Wireless Mesh Networks[12]

The paper addresses about the designing of a multicast protocol for the WMN that employs the characteristics like high throughput and the allocation of available channel to the nodes rather than the overlapping channels. The major idea
introduced is a Level Channel Assignment algorithm and Multichannel Multicast algorithm to improve the throughput of the network and also designs a new backbone for the mesh networks namely tree-mesh which partitions the mesh routers into different levels based on the breadth first search(BFS) and later assigns the channels to different interfaces.

WMN considers throughput optimization as the prior value of concern rather than other wireless networks and opts for tree based protocols; to avoid the extra overhead caused by the fully organized mesh based multicast protocols. The use of partially overlapping channels also increases the throughput to an optimized level. The system model considers set of gateways, mesh routers and physical links among the neighboring nodes.

The simulations show that the purported technique outperforms the other single channel multicast algorithms, and obtains higher throughput, shorter delay and can be implemented in a distributed manner.

### Table 1
**Summary of Multicast Approaches**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Nature of Topology/ Initialization approach</th>
<th>Performance metrics</th>
<th>Routing Metrics</th>
<th>Throughput(T)/ PDR/Protocol Overhead</th>
<th>Advantages</th>
<th>Issues not addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient Multicast Algorithms for Multichannel Wireless Mesh Networks [12].</td>
<td>Tree Mesh topology, Source Initiated</td>
<td>Transmission rate, Throughput, Delay</td>
<td>Hop count, Interference Range</td>
<td>T- 20 (T/no of sec) PDR- 225 (T/no of sec)</td>
<td>Better throughput. Shorter delay Distributed nature.</td>
<td>Interference is reduced to smaller level, Geographical information is needed.</td>
</tr>
<tr>
<td>Secure High-Throughput Multicast Routing in Wireless Mesh Networks [13].</td>
<td>Source Initiated, Multicast tree topology</td>
<td>Security, Throughput</td>
<td>ETX, SPP</td>
<td>PDR- 0.8 (p/sec) Overhead- 0.9 (p/sec)</td>
<td>High throughput. Security level is high</td>
<td>Single accusation at single time. Detection based on threshold value</td>
</tr>
<tr>
<td>A QoS Aware Multicast Algorithm for Wireless Mesh Networks [17].</td>
<td>Tree based topology, Source Initiated</td>
<td>QoS, Throughput, delay</td>
<td>Interface Queue Length</td>
<td>T- 25% more PDR- 20 (p/sec)</td>
<td>High throughput. Lower delay.</td>
<td>Doesn’t discuss about multichannel requirements. Multicast metrics are not addressed.</td>
</tr>
</tbody>
</table>

**C. Secure High-Throughput Multicast Routing in Wireless Mesh Networks [13]**

The paper explicates about the employment of metrics like SPP for the measurement of quality of the links in the total network and to render high throughput for the application in WMN. Success Probability Product (SPP) is the advanced multicast metric formulated on the basis of the unicast metric ETX. Attacks like wormhole attacks, metric manipulation attacks, resource consumption attacks, and mesh structure attacks will be present in WMN and are analyzed on the basis of the proposed algorithm and protocol is made secure in order to preclude the network from these defined attacks.

ODMRP protocol is used to extend scenario and simulation and also for enabling secure high throughput in the WMN. ODMRP is up rated to S-ODMRP by adding RSA signatures and certificates to the protocol. The algorithm explained in the paper creates a mesh based multicast tree for the efficient transmission of the packets using link quality metric and also prevents the attacks that are reckoned to occur in the network using the weighted flood suppression and accusation mechanism. The throughput of the network is increased by using the technique explained with the use of upgraded multicast metrics.
Practical issues regarding implementation of the specific method deals with three exceptional values including threshold, timer and duration which are matter of great concern. The paper mentions the attack detection based on the comparison with the threshold value, and doesn’t mention about the occurrence of attack when the threshold value is less also the accusation of multiple nodes are not included.

**D. A QoS Aware Multicast Algorithm for Wireless Mesh Networks [17]**

The paper proposes a new hybrid multicast algorithm mainly Gateway- cluster based Load balancing Multicasting algorithm (GLBM), which relays on the main challenge of QoS in multicasting by avoiding uneven traffic load.

The suggested algorithm divides the multicast session into three main steps, where first step shows how a node starts a multicast session, step2 deals with how multicast receivers join the multicast group and the third step explains the way in which each receiver leaves the multicast group and how the group is maintained in the network.

The algorithm provides a comparative study about the best load count and the best hop count, where the load count is obtained from the load status present at each node along with the node id.

The proposed algorithm has a lower jitter or delay characteristic on comparison with the other existing multicast protocols for mobile networks. The explanation about the multicast routing metric that can increase performance of the entire network is a matter of concern in WMN and is discussed as the future work.

The different approaches that are described above gives a comparison between the topology and the initialization approach of each protocol that are used in the mesh networks and as we can see the ODMRP protocol along with the security features gives better performance for the ODMRP protocol, increased throughput, high packet delivery ration and provides reliability to the multicast routing in wireless mesh networks.

**V. CONCLUSION**

Multicasting in wireless mesh networks is a better choice for major real-time applications like video/audio conferencing, webcasting, home management and entertainment. It allows the usage of multiple channels for the transmission of data to various networks especially to group of receivers which are located in various networks. Various crucial factors affect the proper functioning of efficient multicast protocols in WMN, thus causing degraded value of throughput. The metrics should be chosen carefully for the multicast networks which increase the throughput to an optimized level. The development of a multicast protocol that achieves efficiency and meets all the existing issues is challenging area of research.

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