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MULTICAST ROUTING IN MOBILE AD HOC NETWORKS: ISSUES AND TECHNIQUES

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ABSTRACT

Mobile Ad hoc Network is a self-organised, infrastructure less network with mobile nodes. Nodes may be a source, router or a destination. The mobile nodes form a network via radio links. This type of network is very useful in military, rescue environment and also situation which needs infrastructure less networks. There are many challenges and characteristics in MANET such as mobility, bandwidth and power constraints, limited security, dynamic network topology and error-prone shared radio channel. Research in MANET includes enormous area such as routing, security and improving Qos, etc., Routing is an important operation in any network system. A routing protocol is needed whenever a packet transmits to a destination.

The routing protocols for wired network are not directly suitable for wireless network because its limitations and properties. A lot of routing protocols proposed for routing in mobile ad hoc network because of its dynamic multi hop nature. Bandwidth consumption is an important issue in wireless networks as many users are sharing the same wireless channel. Multicasting is the transmission of data grams to a group of hosts identified by a single destination address. It provides efficient communications among a group of nodes, while reduce bandwidth consumption of many applications such as videoconferencing, replicated databases, information distribution, resource discovery, sharing of text and images, distributed gaming etc. In recent years, various multicast routing protocols proposed with different features. This paper exhibits the exiting issues and techniques in designing protocol for multicast routing in MANET.

KEYWORDS: Issues, MANET, Multicast Routing, Protocol, Techniques

1. INTRODUCTION

The development of wireless communication technology includes two basic wireless network models [1]. The fixed backbone wireless model consists of large number of fixed Mobile Nodes (MNs). The communication between fixed node and MNs occurs via wireless medium. This requires a fixed permanent infrastructure. Another model, a Mobile Ad-hoc NET work (MANET) is a self-organizing collection of MNs that temporary and dynamic wireless network on shared wireless channel without any fixed infrastructure and centralized control.

The communication can be a single-hop if the receipt is within sender's range else it may be multi-hop. In MANET, the MN operates not only as a host but also router to forward the packet for other MNs in the network who may not be within the transmission range of each other. Each node participates in an ad-hoc routing protocol that allows itself to discover multi-hop paths through network to any other node. The Multicast Routing Protocol designed for fixed networks may fail to cope with node movement and dynamic topology, because of the mobility and protocol overheads. If a

conventional multicast routing protocol is used in wireless mobile networks several problems appear because those protocols are designed for static hosts, so when they construct the multicast delivery tree it expects permanent locations. Table 1 compares between wired and wireless multicast protocols based on many important aspects.

Table 1: Comparison of Wired Multicast and Wireless Multicast [8]

Issues	Wired Multicast	Wireless Multicast
Types of Links	Fixed broadcast links in LANs	unidirectional links of varying performance and point-to-point links in cellular and PCs
Bandwidth	Plentiful	Limited and variables
Topology	Fixed	Fixed in infrastructure based and Dynamic in Ad Hoc Networks
Loss packets	Infrequent < 1%	Frequent and varied (1%-30% based on links)
Membership changes	When users leave or join a group	Also when a user moves to another location
Routing	Fixed routing structure	Routing structure changes due to used or node mobility
Security	Less complexity	More complex in infrastructure networks and very complex in infrastructure less as Ad Hoc
Quality of Service	Possible use of a transport layer protocol	More complex due to wireless links and user mobility which makes it unwanted in such environment

MULTICAST over wireless networks is a well demanding service since it adds efficiency to the network when utilizing group communication [2]. However, in wireless networks multicasting faces several challenges, due to the networks Bandwidth (BW) limits, host mobility, and network delay. The market demand of multimedia and real time application adds challenges to the wireless network and therefore the network architecture must be reliable and provides continuous connectivity. The Multicast routing problem is how to arrange for routers to deliver one copy of a packet to every other sub-network to which group members are attached, across an arbitrary topology of routers and sub networks. Many researchers have adopted multicasting for their solution of Group Communication Applications (GCA). There are many applications such as audio/video distribution which can tolerate loss of data but many other applications cannot In mobile ad hoc networks, there are three basic categories of multicast algorithms [3]. A naive approach is to simply flood the network. Every node floods the receiving message to its neighbours. The proactive approach pre computes the paths to all destinations and stores the information's in routing table. The routing information is periodically distributed throughout the network. The final approach is reactive or query-response approach. The paths are created to the hosts on demand. Once query reaches the destinations, the response phase starts and establishes the path. Multicast routing protocols are mainly divided based on i) topology - Tree-based and Mesh-based and Hybrid ii) how routing information acquired and maintained (Proactive and Reactive, Hybrid).

Multicast applications vary in users' requirements using a number of dimensions [5]: Nu*mber of senders, Group organization and receiver scalability, Data reliability, Congestion control, Group management and Ordering.* Number of senders may be single sender or multiple senders. 1-to-N multicast applications do not need any human interface. Examples of applications modelled as one-to-many GCA are: scheduled audio/video distribution, push media, file

distribution, caching, and monitoring of stock prices. M-to-N multicast applications need direct human involvement. Examples of many-to-many GCA are: Multimedia conferencing, synchronized resources, concurrent processing, collaboration, distance learning, chat groups, and multiplayer games. Characteristics of multicast routing protocols differ depends on number of senders and number of receivers. Level of scalability may be small, medium and large. In unicast transmission, the data reliability is very simple to achieve but in multicast transmission, data reliability is semi or weak. Multicast congestion control is important to maintain same speed for all receivers. Group management includes group reliability and group membership maintenance. Ordering concentrates on how the packets are delivered to receivers.

The packets are in same order as they are generated or no ordering. In this paper, multicast routing techniques and challenges are discussed. The rest of the paper is organized as follows: Section II shows some of the issues while designing the multicast routing protocols. Section III describes technologies for multicasting in MANETs. Conclusion is in Section IV.

II. ISSUES IN MULTICASTING

Multicast routing protocol design comprises several design issues. They are: Scalability, Dynamic topology structure, Limited bandwidth, Control overhead, Quality of Service, Dependency on the unicast protocol, Resource management, Congestion control, Energy aware resource utilization, Mobility Prediction, Link Stability, Multisource Multicasting, Reliable Multicasting, Security in Multicasting and Load balancing[7].

Scalability

This issue is not only related to multicast in MANETs but also with the ad-hoc itself. A multicast routing protocol is scalable with respect to some constraints posed by MANETs.

Address Configuration

In ad-hoc environments, a different addressing approach may be required. Special care must be taken so that other groups do not reuse a multicast address used by a group at the same time. Node movement and network partitioning makes this task of synchronizing multicast addresses in a MANET really difficult.

Traffic Control

Both source and core-based approaches concentrate traffic on a single node. In stateless multicast group membership is controlled by the source, which leads to the vulnerability of multicast protocols for MANETs. Still need to be investigated is how to efficiently distribute traffic from a central node to other member nodes for MANETs.

Multicast Service Support

The multicast protocol defines conditions for joining/leaving groups, multicast participants should be able to join or leave groups at will. On the other hand, service providers can be convinced to support multicast protocols.

Power Control

For power-constrained wireless networks, a crucial issue in routing and multicasting is to conserve as much power as possible while still achieving good throughput performance.

Resource Management

Resource management 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. The work load between the channels of nodes should be reduced by controlling its input traffic.

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. 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.

Load Balancing

Load balancing is a greater 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 channel overloading. 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.

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 reliable services in order to achieve the intensive throughput through the network.

Security in Multicasting

Security 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.

Link Stability and Mobility Prediction

Designing a routing protocol is very tedious work because of its dynamic topology nature, the link between nodes are unstable. The probability of link stability is one of important issue. Mobility prediction estimates the expiration time interval which is more useful for stable link estimation.

Multiple Sources

A multicast group may contain multiple sources due to different kinds of services or applications simultaneously provided by the networks. Each single source multicast routing protocol induces a lot of overhead and thus wastes tremendous network resources in multi-source multicast environments. Multiple source routing is essential for load balancing and offering quality of service. Other benefits of multiple source routing include: the reduction of computing time that routers' CPUs require, high resilience to path breaks, high call acceptance ratio (in voice applications) and better security.

Reliable Multicast Routing

In ad-hoc environments, every link is wireless and every node is mobile. Those features make data loss easy as well as multicasting inefficient and unreliable. Reliable multicast routing protocol becomes a very challenging research problem for MANETs. The design of reliable multicasting depends on the following three decisions: (1) by whom errors are detected; (2) how error messages are signalled and (3) how missing packets are retransmitted.

III. TECHNOLOGIES IN MULTICAST ROUTING

Network Encoding

The advent of the notion of coding at the packet level, commonly called network coding, changes many aspects of networking. Given a network with capacity constraints on links, one problem of designing multicast routing protocols is to maximum the multicast throughput between a source node and a set of receivers. The main advantage of using network coding can be seen in multicast scenarios. Network coding enables better resource utilization and achieves the max-flow which is the theoretical upper bound of network resource utilization, by allowing a network node, such as a router to encode its received data before forwarding it. Each node implementing the network coding function, receives information from all the input links, encodes it and sends the encoded information to all output links. The coded network lends itself, for multicast connections, to a cost optimization which not only outperforms traditional routing tree-based approaches, but also lends itself to a distributed implementation and to a dynamic implementation when changing conditions, such as mobility. Under a simplified layered model of MANETs, the minimum energy multicast problem in MANETs is solvable as a linear program, assuming network coding.

Overlay-Based Multicasting

In most protocols [4], both group members and non-members on a tree/mesh link must maintain the multicast states to forward data packets. Thus, multicast protocols must detect and restore link failure, which can be a result of migrations by non-group members as well as group members. As a result, many control messages are issued to repair broken links. To provide data forwarding without involvement of non-group members and to constrain the protocol states on group members, overlay multicast protocols for MANETs enhance the packet delivery ratio by reducing the number of reconfigurations caused by non-group members' unexpected migration in a tree or mesh structure. The advantages of overlay multicast come at the cost of low efficiency of packet delivery and long delay. However, when constructing the virtual infrastructure, it is very hard to prevent different unicast tunnels from sharing physical links, which results in redundant traffic on the physical links. Overlay multicast based on heterogeneous forwarding (OMHF)is an example for overlay multicast routing protocols for MANETs.

Backbone-Based Multicasting

In these protocols [4], the state information is limited within the virtual backbone only. The adaptive backbone protocols consist of core nodes which will forward the multicast data packets themselves. Maintenance and forwarding of the membership are done only within the local group. Other backbone-based protocols use the concept of dominating set to create the backbone. Every node in the network is just hop away from a core or it is a core itself.

Stateless Multicasting

This type of protocols [4] do not need additional any information. This assumes the existence of unicast protocols. The forwarding states are included in packet header and no protocol state is maintained at any nodes except for the source node. From the information included in the packet headers, any intermediate node knows how to forward or duplicate the packet. Although packing routing information together with data traffic will enlarge data packet size, it reduces the total number of control packets generated by the protocol. Beside, when the group is idle, there is no control overhead. Differential Destination Multicast (DDM) is a stateless multicast routing algorithm suitable for small groups.

IV. CONCLUSIONS

Multicast is a key technology for future wireless networks. The above sections discussed about the issues of designing a multicast routing in MANET and the new technologies available for multicast routing listed in Table 2. As mentioned earlier, research in the area of multicast over MANETs is far from exhaustive. Much of the effort so far has been on devising routing protocols to support effective and efficient communication between nodes that are part of a multicast group. It is really difficult to design a multicast routing protocol considering all the above mentioned issues. The design space of multicast routing algorithms suitable for Ad hoc Networks in simulation includes a set of variables: endpoint mobility patterns, Ad Hoc Network mobility dynamics, multicast group dynamics and coverage as well as traffic patterns. The conclusion is that a mobile host carries only one multicast mechanism at a time which corresponds to the type of network host is currently part of. This approach raises several research aspects and one single protocol cannot address all problems. Still the researchers have open way to design a multicast routing protocol which resolves more issues.

Table 2: List of Issues and Techniques with Example Protocol in Multicast Routing in MANET

Issue	One of the Technique Used	Example Protocol
Control overhead	Mesh creation	ODMRP
Security	Adding security features	S-ODMRP
Link Stability	Genetic Algorithms	LLMR
Multiple Sources	Clustering	CMMR
Increasing Packet Delivery Ratio	Overlay-based multicasting	OMHF
Control Overhead	Stateless multicasting (small group)	DDM
Maximize throughput and energy efficiency	Network coding	COPE
Quality of Service	Fuzzy Logic, Genetic Algorithms	MCEDAR

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