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A Review on QoS Multicast Routing Protocols for MANETs & Internet

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Abstract-Multicasting is a technique used for distributing data packets from one or more sources to a set of receivers on interconnected networks. Currently developing network applications bring specific quality of service (QoS) requirements like bounded delay, minimum bandwidth, and maximum data loss rate. Providing the required quality of service addresses routing and resource reservation concepts. In this study, a literature survey is carried out on traditional and QoS multicast routing protocols, and the need for QoS routing protocols is investigated. Multicasting can minimize the link bandwidth consumption and reduce the communication cost by sending the same data to multiple participants. Multicast service is critical for applications that need collaboration of team of users. Multicasting in MANETs and internet becomes a hot research area due to the increasing popularity of group communication applications such as video conferencing and interactive television. Recently, multimedia and group-oriented computing gains more popularity for users of ad hoc networks. In this paper we are presenting an overview of set of the most recent QoS multicast routing protocols that have been proposed in order to provide the researchers with a clear view of what has been done in this field and how modified protocols can be designed using these protocols.

Index terms-MANETs, Multicasting, QoS, Routing.

I. INTRODUCTION

Multicasting is a technique proposed to distribute datagrams to a set of interested receivers on interconnected networks. The growing Internet has brought many new and challenging network applications such as teleconferencing interactive gaming, distance learning, Internet telephony, real-time multimedia playing, distributed computing, and distributed database applications. The common point of these applications is that all involve interactions among multiple users forming a group. In contrast to the traditional one-to-one communication (unicast), these applications may be costly and infeasible to implement unless some underlying network protocols are designed.

The need for the multicast applications brings a need for efficient data transfer between many users belonging to the same multicast communication group.

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The data to be carried between end hosts must follow the most efficient path and it must be delivered to the correct set of users; that is, data must be routed correctly and efficiently. Some routing protocols are proposed to meet these conditions.

Traditional multicast routing protocols consider only best-effort traffic. The development of high-speed networks opens a new research field, which is to provide quality of service (QoS) for multicast applications. Timely and satisfactory information delivery over a decentralized and shared network is challenging and complicated. A network that is originally designed for best-effort traffic such as the Internet makes things even worse. To ensure the quality of data delivery in terms of delay, capacity, or loss, some kind of network resource reservation is required. Although a resource reservation protocol addresses the problem of reserving resources on a multicast tree, a routing protocol is necessary to construct a feasible multicast tree that covers all multicast group members and provides the required resources.

With the rapid advancement in wireless communication and availability of mobile computing devices a conceptual shift happen in mobile computing and a lot of applications that can work anywhere and anytime is emerged. There are to variations of wireless mobile communication. The first one is known as infrastructure wireless networks, where the mobile node communicates with a base station that is located within its transmission range (one hop away from the base station). The second one is infrastructure less wireless network which is known as mobile Ad hoc networks.Mobile Ad hoc Networks (MANETs) are collections of mobile nodes that communicate with each other over wireless links in the absence of any infrastructure or centralized administration. Each mobile node acts as a host generating flow, being the receiver of flows from other mobile nodes, or as a router and responsible for forwarding flows to other mobile nodes [1] .

The paper is organized a follows: in section 2 QoS multicast routing protocols are discussed. In section 3 a summary for this paper is presented.

II. QUALITY OF SERVICE MULTICAST ROUTING PROTOCOLS

In the introduction we revised the basics of multicasting, multicast protocols for internet and MANETs, their need and challenges faced by multicast routing protocols. In this section we present various multicast routing protocols designed for providing the facility of Quality of service.

A. QGMRP (QoS Guaranteed Multicast Routing Protocol)

QGMRP (QoS Guaranteed Multicast Routing Protocol) [12] constructs a multicast tree that optimizes end-to-end delay, inter-receiver jitter, available bandwidth, and packet loss probability. QGMRP can operate on any

underlying unicast routing protocol, reduce tree construction overhead, and support dynamic membership.
New member forwards rqst along the shortest unicast path to the SOURCE. Each router checks QoS parameters and either forwards rqst or sends back rjct. A node which receives an rjct branches out. The source sends back an rply/rjct, and the (sub) optimal path among feasible paths will be selected by the new router.

QGMRP has a distributed algorithm working in either unicast routing (UR) or fork routing (FR) modes [12]. The former fits the case in which each node or link has enough resources to guarantee the desired QoS requirement. The latter searches for multiple feasible paths, and selects an optimal or a near-optimal path for connecting a new member to the existing multicast group. The path searching process changes between UR and FR modes when the searching path in use does not satisfy the QoS constraints [12].

The algorithm control messages of QGMRP are defined as follows:

i. *rqst*: When a new host wants to join a multicast group, an *rqst* message is sent from this candidate to the source of the multicast group.

ii. *rply*: If the QoS requirements of the candidate are accepted, an acceptance reply must be sent downstream towards the new member. This message can possibly accumulate some link or node metrics, such as delay and delay jitter, and the bottleneck bandwidth of the path it traverses. This data storage can then be used to select an optimal (or near-optimal) path.

iii. *rjct*: If the QoS requirements of the candidate cannot be satisfied by the network, a rejection message is sent back to the new member by some node rejecting the joining request. This message can enable the immediate downstream neighbor of the rejecting node to enter the *FR* mode.

Merits

1. One of the important advantage of is that it reduces the overhead.
2. Secondly its simplicity make it more useful as the procedure or algorithm it uses work on three messages which are multicast throughout the process.
3. No need for global information.
4. Dynamic group membership is provided.

Demerits

1. Branching out seems very difficult.
2. This protocol doesnot provide the feature of scalability.

B. QoSMIC

QoSMIC (Quality of Service Sensitive Multicast Internet Protocol) [10,15] is an Internet multicast routing protocol supporting QoS-based routing, which removes the unnecessary overhead of *a priori decisions* (such as core selection, or source router selection). QoSMIC tries to use resources in an efficient manner. Additionally, the protocol has satisfied some of the user requirements, like robustness, flexibility, and scalability.

Protocols older than QoSMIC used to provide usually a single path based on static information. Their performances were sometimes based on the initial core selection process, and most importantly, they were not designed to support applications with demanding QoS requirements [10].

The main change that QoSMIC provides is having choices for routing [15]. QoSMIC searches for multiple paths and collects QoS routing information along each path. A new node that wishes to join a multicast tree selects the path that suits its QoS needs according to the information gathered for all choices. QoSMIC operates using a *greedy* routing heuristic, and, according to this heuristic, the protocol finds routers that are already in the tree and close to the new entering router [15].

The search phase has two mechanisms, namely *local search* and *multicast tree search*. Local search is the same as the search procedure of YAM (Yet another Multicast) [3]; the joining router tries to connect the tree through a bounded broadcast in its neighborhood. Multicast tree search mechanism reduces control overhead; in-tree routers run a distributed algorithm to select candidates[10].In local search, the new router attempts to identify in-tree routers by flooding a *Bidding Request (BID-REQ)* message to the routers around itself, as in the procedure proposed in YAM [3].

Merits

1. Coreless routing.
2. Better end-to-end delay for variable network load.
3. The complexity is less than "only local search.

Demerits

1. Success ratio, candidate selection & global network info, any problem can be solved at Manager.

C. QMRP

QMRP (QoS-aware Multicast Routing Protocol) [4] tries to achieve scalability by reducing the communication overhead of constructing a multicast tree. QMRP can switch between single-path routing and multi-path routing to maintain a reasonably high success rate. Heuristic solutions to the NP-complete Steiner tree problem cause excessive overhead , require global network information management, and do not handle dynamic multicast group membership. Hence, those heuristic solutions cannot be said to be practical for the Internet applications.Also, QMRP is against relying on flooding. QoSMIC alleviates flooding, but it has the disadvantage of using an extra global control element (the Manager router) [15, 4].

In QMRP, a new member joining a multicast group obtains the address of the core of the tree by inquiring the Session Directory Protocol [11]. Then, the new member starts routing process by sending a *REQUEST* message to the core along the unicast path. There are two defined searching modes: *Single-path mode* and *multiple-path mode*. The routing process begins with the single-path mode, and only the known unicast routing path traversed by the REQUEST is considered[4].

Merits

1. Simple, becomes SPR if every node has the resources.
2. Loop-free trees (break message to select only the best path).
3. No need for global information.

Demerits

1. Only bandwidth and local state maintenance.

D. S-QMRP

S-QMRP (Scalable QoS Multicast Routing Protocol, also called SoMR) has appeared in [6] and has been published later in [7]. It is a scalable, stateless QoS Internet multicast routing protocol that shares the same idea with QMRP, but eliminates the temporary state usage for join requests. QMRP initiates a new search tree for each new member to connect the multicast tree, and the initiated search tree grows towards the existing multicast tree.

On the contrary, S-QMRP eliminates the search tree, and the multicast tree grows toward new members. The protocol stores no routing state other than the multicast tree. In addition, it also allows aggregation of join requests, in such a way that a single tree branch may grow towards more than one new member. S-QMRP uses an early-warning (EW) mechanism,takes the additive delay requirement into account , and identifies the most suitable point to search for additional paths in order to increase success probability [6].

S-QMRP has mainly two phases. In the first phase, a *JOIN* message is sent from a new member to the root of the multicast tree along the unicast routing path, and again the *JOIN* message keeps the information of its path and the accumulated delay on the path it traverses. If the message reaches an in-tree node, and if the sum of the accumulated delay collected on the message and the in-tree delay from the root to this in-tree node does not violate the delay requirement, the path traversed by the *JOIN* message is considered to be *feasible*. In that case, the in-tree node, which is the receiver of the *JOIN* message, sends a *CONSTRUCTION* message back along the same path to the new member [6].

Merits

1. This protocol is loop-free protocol.
2. Concurrent joins are supported.

Demerits

1. Branching starts around the source, so everytime source will be checked it increases the complexity.

E. **QoS -MAODV**

QoS-MAODV is a tree-based multicast routing protocol based on MAODV protocol. Similar to MAODV [8,9], and AODV [5], it creates the routes on-demand and makes the shared trees. Route discovery is based on a route request and route reply cycle. To provide quality of service, we added extensions to these messages during the route discovery process.

In QoS-MAODV protocol, we use admission control to prevent intermediate nodes from being overload. If there is no available bandwidth, the intermediate node will reject Rreqs of newsessions.When an intermediate node receives a QoS-Rreq, and has enough available bandwidth, it accepts the Rreq.

A. Data Forwarding: For each multicast group, the tree contains the members of two distinct classes of nodes, the nodes joined the multicast tree (source or destination nodes), and the nodes not joined the multicast group but are forwarding the multicast group packets towards other nodes in the tree. Both classes must reserve the required bandwidth for the multicast packets.

B. Message Types: QoS-MAODV protocol uses six different message types for creation of QoS multicast tree. These messages are: Route request (Rreq), Route reply (Rrep) ,Multicast activation (Mact) ,Group hello (Grph) ,Hello ,QoS-lost. All of these messages are also used in MAODV protocol except QoS-lost. QoS-lost message informs the other nodes that the reserved bandwidth is no longer available. The format of these messages remains as specified in except that we add some flags and extensions for bandwidth and state of reservation especially for Hello message. In our protocol, the Grph and Hello messages are also responsible for update the bandwidth reservations in the nodes. Therefore, the nodes which do not receive these packets in certain time will release the reserved bandwidth or change the state of reservation.

C. *Control Tables:* MAODV keeps a routing table for multicast routes and a multicast group leader table to optimize the routing. Similarly, QoS-MAODV has these two tables. In addition a node may also keep these following tables:

Bandwidth reservation table : It is used to keep bandwidth reservation information for different groups.

Neighbors table : This table keeps information of neighbors such as neighbor address, amount of reserved bandwidth in neighbor node, state of the reservation, amount of consumed bandwidth in neighbor, state of neighbor, and time stamp.

·Multicast Consumed bandwidth: It keeps required information for calculation of consumed bandwidth in each node.

D. *QoS-MAODV Mechanism:* When a multicast source requires a route to a multicast group, it broadcast a Rreq message with the bandwidth field set to the required bandwidth, join flag set to true, and destination address set to the multicast group address. A member of multicast tree with a current route to the destination and enough amount of available bandwidth responds to the request with a Rrep message. A node receiving Rreq message with a quality of service extension will rebroadcast themessage only if it can able to meet the service requirement. Each node accepting the Rreq message will reserve the required bandwidth as allocated state. Allocated state is not a real reservation; it is a notification of acceptance for the node itself and its neighbors. It updates its tables and records the sequence number and next hop information for the source node. This information is used to send the Rrep message back to the source[14].

Merits

1. QoS-MAODV extends existing Multicast Ad hoc On-demand Distance Vector Routing (MAODV) protocol by using admission control and bandwidth reservation in each node.
2. It is the integration of unicast and multicast into a unified framework.
3. The protocol is also free from loops.

Demerits

1. Poor packet delivery under mobility.
2. Congestion along links in the tree.

F. PIM-SM(QOS Aware)

Protocol Independent Multicast-Sparse Mode (PIM-SM) routes multicast packets to multicast groups, and is designed to efficiently establish distribution trees across wide area networks (WANs). PIM-SM is called "protocol independent" because it can use the route information that any routing protocol enters into the multicast Routing Information Base (RIB), or, as it is known in Windows terminology, the multicast view. Examples of these routing protocols include unicast protocols such as the Routing Information Protocol (RIP) and Open Shortest Path First (OSPF), but multicast protocols that populate the routing tables—such as the Distance Vector Multicast Routing Protocol (DVMRP)—can also be used. *Sparse mode* means that the protocol is designed for situations where multicast groups are thinly populated across a large region. Sparse-mode protocols can operate in LAN environments, but they are most efficient over WANs[16].

PIM relies on an underlying topology-gathering protocol to populate a routing table with routes.This routing table is called the MRIB or Multicast Routing Information Base. The routes in this table may be taken directly from the unicast routing table, or it may be different and provided by a separate routing protocol such as MBGP. Regardless of how it is created, the primary role of the MRIB in the PIM protocol is to provide the next hop router along a multicast-capable path to each destination subnet. The MRIB is used to determine the next hop neighbor to which any PIM Join/Prune message is sent. Data flows along the reverse path of the Join messages. Thus, in contrast to the unicast RIB which specifies the next hop that a data packet would take to get to some subnet, the MRIB gives reverse-path information, and indicates the path that a multicast data packet would take from its origin subnet to the router that has the MRIB. Like all multicast routing protocols that implement the service model from RFC 1112, PIM-SM must be able to route data packets from sources to receivers without either the sources or receivers knowing a-priori of the existence of the others. This is essentially done in three phases, although as senders and receivers may come and go at anytime, all three phases may occur simultaneously[2].

PIM-SM was designed to support the following goals:

1. Maintain the traditional IP multicast service model of receiver-initiated multicast group membership.
2. Leave the host model unchanged. PIM-SM is a router-to-router protocol, which means that the hosts don't have to be upgraded, but that PIM-SM-enabled routers must be deployed in the network.
3. Support both shared and source distribution trees.
4. Maintain independence from any specific unicast routing protocol.
5. Use soft-state mechanisms to adapt to changing network conditions and multicast group dynamics.

Merits

1. Unlike other sparse mode protocols, it doesn't limit us to receiving multicast traffic only via shared tree.
2. By joining the shortest path trees, it gain the advantage of an optimal distribution tree without suffering from the overhead and in efficiencies associated with other protocols such that PIM-DM, DVMRP.

Demerits

1. Concentration of traffic around Routing Protocol.
2. Sub-optimal trees increase Latency.

III. CONCLUSION

Many currently developing applications involve one-to-many communications, and, therefore, multicast is crucial due to its ability of delivering point to point or multipoint-to-multipoint data in an efficient and scalable way. The novel applications start to have emerging user requirements, and satisfying the requirements addresses the problem of QoS multicast routing protocol design to manage network resources.However, any change in the availability of resources causes the final connection to fail, and to solve this problem together with the over-reservation challenge, QoS-guaranteed routing protocols are designed. QoS-guaranteed multicast routing protocols must be able to maintain network resources for the QoS applications, must avoid overuse of resources, and they must be immune to dynamic changes in network conditions. Multicast routing can efficiently utilize the resources by sending the same information to all destinations simultaneously. The design of QoS multicast routing protocols are varies according to the goal and the requirement and based on the assumptions and properties of the network and application area. QoS multicasting routing protocols different from each others in the way to maintain the network state, constructing the links to the multicast group, how to join and leave the group and the QoS constrains supported. Also, the design of the protocol is influenced by the wishes of the multicast members which have to balance between supporting QoS and utilization of the resources.

In this paper we have offered a survey of the QoS multicast routing protocols. We have stated the advantages and disadvantages of each protocol to provide and identify new areas to be covered in future research.

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