QoS Aware Multicast Routing in Mobile Ad Hoc Networks: A Contemporary Affirmation of Benchmarking Models

K. Seshadri Ramana, Dr. A.A. Chari

Abstract— **The contemporary research work is focussed on developing applications based on Mobile Ad hoc Networks (MANET) for a rapid wireless infrastuctureless communication either for personal or public requirements. Mobile Ad hoc Networks with large network size and highly dynamic real-time traffic for collaborative data sharing and computation ina VOIP, VoD, or P2P based communication require routing strategies to be designed in terms of different types of data, applications and MANET specific environmental challenges of node mobility, multiple users accessing shared resources, data transfer using multiple hops, and with limitations of link breakages, packet transmission delays, losses etc. All these constraints require an optimized and inflexible utilization of available resources of bandwidth and power. The multimedia transmissions are with additional challenges as it is characterized with rapid real time changes in the traffic and for recognizing the changing traffic patterns efficient strategies are needed for the routing and in guaranteeing Quality of Services. The devising of strategies of QoS specific multicast protocols today is faced with mostly mobile ad-hoc networks topology specific challenges. Several strategies have been proposed for the routing problem and for the multimedia data specific routing in mobile ad-hoc networks where compared to other approaches the multicasting strategy in group systems communication offers superior, higher capacity, reliable communication, with efficient usage of bandwidth and power, has better error control, security while limiting the costs, delays and packet losses overhead. To provide a better overview of the various multicasting strategies we have in this paper discussed various literature approved QoS multicast routing protocols with a taxonomy where the different protocols are classified according to different parameters and discuss the complexities associated with the current research activities. The review covers several benchmark QoS multicasting routing protocols and their performances based on service attributes like ratio of packet loss, jitter, delay, etc. with finally comparing their performances.**

Index Terms— **Quality of service (QoS), Multicast routing protocols, Mobile ad hoc network (MANET).**

I. INTRODUCTION

Mobile Ad hoc networks is a wireless networking of mobile devices for communicate rapidly without any infrastructure, where there are no base stations or fixed routers for a centralized control over the nodes and the data routed. Route the traffic by acting as a sender, and receiver.

K. Seshadri Ramana, Research Scholar, Rayalaseema University, Kurnool-518002, A.P., India.

Dr. A.A. Chari, Emeritus Professor, Dept of OR&SQC, Rayalaseema University, Kurnool-518002, A.P., India.

The autonomous MANET network is a highly dynamic environment based on an open architecture. The examples of applications of Mobile adhoc networks are, business communication networking in specific areas and in disaster or defence mechanisms for emergency operations. The users may join in real time and communicate in multi-hops using the nodes in the MANET topology. The rapid global exposure to various kinds of information, implosion in exchange of digital information, advances in cloud based data access, and increasing demand for multimedia content have created numerous challenges of communication in MANETs. The research challenges are devising routing strategies for MANETs offering efficient services with QoS. The challenges are due to the MANETs environment such as the volatility related to node density and node mobility. The MANET operations performed do not have fixed infrastructure or central coordination and constraints of device mobility and changing node patterns make routing decisions very difficult. In this context the routing efficiency achievable is determined based on the bandwidth, energy, security and QoS. The provisioning of quality of service in MANETs systems has further very high QoS standards set for the transmission of high quality multimedia content and real time streaming data. In this context multicast routing protocols gain importance over the other available approaches. For a MANET settings there exist numerous and varied types of applications, however QoS delivery in MANET is a current research area whose development is surrounded with many impediments in areas of services with content based on multimedia or streaming data. Our study evaluates different protocols based on measures such as the packet drop rate, the overhead introduced by the routing protocol, end-to-end packet delays, network throughput, ability to scale, etc.

The paper organization below is as; classification of the multicast routing protocols is covered in Section 2; description of Quality of Service in MANETs and QoS provisioning by different protocols is covered in Section 3; a description of the protocols of QoS multicast routing is covered in Section 4; description in Section 5 gives a detailed account of various QoS multicast routing protocols; in Section 6 the paper is concluded.

II. THE TAXONOMY OF MULTICAST ROUTING PROTOCOLS

Multicasting supports multipoint communication and the multicast based protocol development is increasing with growing demand for applications of high quality multimedia content communication.

A multicast consists of many nodes which send packets to many receivers. The model has two components where the first component is called the multicast group management whereas the second component is known as the multicast routing protocols. The first component multicast group management has to take care of transmitting the multicast grouping starting at local router in the direction of the subnets which have direct connections where retransmitting of the multicast groups is not considered either within the routers else over the networks existing in the intermediary [1]. The second component multicast routing protocol determines the suitable multicasting paths of delivery towards all the receivers. The MANET topology undergoes changes recurrently and in this context multicasting and multicast routing protocol aim to provide information broadcasting competently especially for multimedia communication in terms of the bandwidth available where the transmission of data packets in multicast groups has packet forwarding starting at the sender and ending with every receiver of the group [2]. In this context multicast based protocol design is an important strategy in MANETs where network hosts implement tasks using a group based working approach.

The research for devising protocols for Ad-hoc networks based on multicast routing has given in recent time many different routing protocols. The protocols for multicast routing in MANET may be classified into two types [3], the first type is the application independence-based multicast routing protocols, and the second type is the application dependence-based multicast routing protocols.

III. APPLICATION INDEPENDENCE-BASED *MULTICAST ROUTING PROTOCOL*

The multicast application independent routing protocols preserve link state for routing purposes in MANETs. The protocols may be classified as three types of protocols based on the factor of topology, the mechanism used for initialization, and dependent on the maintenance scheme used.

A. TOPOLOGY BASED MULTICAST ROUTING PROTOCOL

The multicast protocols based on topology are protocols which for finding paths to members in a group use several routing techniques. The protocols may be categorized based on the strategy used in route discovery and the architecture used for routing. The classification divides the protocols as of three types, tree-based, mesh-based, and hybrid design based multicast protocols of routing.

The tree-based scheme of multicast protocols builds the multicast trees by depicting a tree root as a source node where the ends of tree branches are depicted as destinations. The model has a single path created from a source connecting to the destination, and all paths created from a source towards destination are combined to create a multicast based tree structure. The protocols packet forwarding mechanism has least number of copies in a packet sent from source towards branches, with high efficiency, using very less bandwidth and incurring low overhead. The multicast tree is formed by the combination of every path initiating at the source and ending at the destination. In the tree formation two types of trees are used, the trees which are source-based and the shared trees. A source is maintaining only one multicast tree in a source-based trees approach, whereas all sources share only one tree in a group in the shared trees based approach. The protocols devised based on a multicast routing using tree-based strategy are, the MAODV (Multicast Ad hoc On-demand Distance Vector protocol) approach, the ADMR (Adaptive Demand-driven Multicast Routing protocol) method, the AMRoute (Ad hoc Multicast Routing) approach, and the AMRIS (Ad hoc Multicast Routing protocol utilizing Increasing id-numbers) [3] method. However with nodes becoming increasingly mobile the routing protocols devised with Tree-based mechanism are unable to forward huge amount of data with lesser bandwidth due to the breakdowns in mobile node connections. Also if the network comprises of several sources for maintaining the tree which is shared among all of these many sources causes inefficiency in the tree-based mechanism as again the total tree has to be configured, leading to failure of finding an optimal path, and maintenance several number of trees leads to overhead due to storage including control options additionally.

A mesh-based design of multicast protocols uses in packet distribution a mesh type structure of network nodes formed by connecting sender nodes with receiver nodes. The protocols with mesh based setting are extremely dynamic where paths redundant between the source and destinations are used to achieve greater efficiency compared to the tree structure protocols. However the maintenance of the mesh structure needs further control messages additionally causing wasteful power usage and higher overhead incurred because of the network together with the control mechanisms. The different multicast protocols based on a mesh structure for routing in MANETs [3] are, the CQMP (Mesh-based Multicast Routing Protocol with Consolidated Query Packets) approach, the method known as E-ODMRP (Enhanced On-Demand Multicast Routing Protocol)approach, the BODS (Bandwidth Optimized and Delay Sensitive) approach, etc.

The Hybrid based protocols for multicast routing are based on a strategy where the benefits of tree structure based mechanism are integrated with that of the mesh structure based mechanisms where efficiency as well as the requirements of robustness [4] is effectively handled. In case of node mobility the trees created by the hybrid based protocols would be however non-optimal. An example for a routing protocol based on hybrid multicast mechanism is the approach in [3] called the EHMRP (Efficient Hybrid Multicast Routing Protocol).

B. INITIALIZATION BASED MULTICAST ROUTING PROTOCOL

The initialization based multicast routing protocols are based on the mechanism used for developing the structure for routing. The routing process is done with a tree structure or a mesh structure the mechanism used in developing the structure for routing is the basis for classifying the multicast protocols which is of two types. The first type of classification is, a sender initiated built routing structure, and the second type is a receiver initiated built routing structure.

A sender initialization routing protocol is based on a sender sent packet being recognized by the receiver. The sender performs two operations in the data routing process which are, to maintain information of the network state related to every receiver, and the obtained receiver's feedback is further processed in the routing process. A receiver initialization routing protocol makes the receiver in charge of for the detection of the errors in transmitting the data and the loss in the packets occurring. The loss of packets is determined by a receiver on detecting in the packets which are received based on a sequential gap in the packet numbers. The strategy in a receiver initiated protocol is based on the size of the senders where the packet is unicast within the structure of the routing and every receiver in the structure sent a flood of the packets. So if we consider the criteria of scalability the Receiver initiated strategy achieves greater efficiency in contrast to a strategy based on Sender initiation.

C. MAINTENANCE-MECHANISM BASED MULTICAST ROUTING PROTOCOL

The multicast protocols for routing based on mechanism used in the maintenance of the routes are of two types, a soft state implementation method, and a hard state implementation method. A soft state implementation method can be adapted to wireless ad-hoc networks characterized by high node mobility where an update mechanism in the method has the multicasting group flooded regularly with control packets to maintain the route and achieves reliability by overcoming route disconnections though with considerably greater network overhead. A hard state implementation method has reconfiguration of the links which are destroyed with two different mechanisms, a reactive mechanism which in case of connections breaking sends control packets and reconfigures the routes, and a proactive mechanism which acts before the connections breaking performs periodic reconfiguration in the routes which achieves with lesser network overhead greater efficiency.

D. APPLICATION DEPENDENCE-BASED MULTICAST ROUTING PROTOCOL

The protocols for multicast routing based on application dependence developed for implementing applications of a special type are called Application dependence-based multicast routing protocols which are grouped as four types based on, network coding based protocols, energy-efficient protocols, the reliability protocols, and the QoS protocols.

A Network coding based multicast routing protocols compared to the earlier methods of routing, has every node which receives the data first encoding it and then forwards it using the network coding functionality which provides distinct benefits over the earlier devised approaches of efficient resource consumption, higher computational efficiency and the dynamics of the network are ensured robustness.

An Energy-efficient multicast routing protocol design is based on maximizing the network efficiency by improving the nodes lifetime in the network. In MANETs energy management with protocols that are energy efficient in the multicast routing are necessary to achieve efficiency in a node consumed battery stored energy supplies and preventing their energy from draining quickly is critical for the node functioning, for the network being continuous and avoiding possible interruptions or total partition in the network.

A Reliable multicast routing protocol is based on the strategy of sequentially sending data packets simultaneously to several recipients reliably. These protocols are of four types, Sender initiated based methods, the Receiver-initiated strategies, the Ring-based approaches, and the Tree-based methods. The strategy of reliable multicast routing is for improving the packet delivery ratio with decreasing the transmission delays, and packet delivery losses. The protocols design handles the various constrains of MANETs such as, the dynamically environmental changes in the channels, the problems of nodes being highly mobile, and the complications associated with the links in the wireless mobile networks, etc. which leads to the routes becoming stale and causing subsequent data losses. These constraints which make the multicasting approach totally ineffective and unproductive are overcome with reliable multicast routing protocol.

A QoS-based multicast routing protocol offers application particular parameters of QoS for certain applications. In Section 4 the detailed description of the protocols is provided.

IV. QUALITY OF SERVICE IN MANET

The service requirements followed in a network for data transmission between two locations describes Quality of Service (QoS) [5]. The characteristics inherent to MANETs make data forwarding and adhering to service requirements very difficult. Also the communication in data specific applications is vastly different with that of multimedia communication, where services VOD or VOIP has mostly traffic with requirements of higher bandwidth, with more delay sensitivity and higher throughput, where stringent conditions are laid regarding packet losses. In order to meet the various specifications in the service such as delay start, higher bandwidth, lesser packet loss, jitter etc. the functions as well as features for every layer in the architecture of the MANET must be clearly described. Though there are considerable number of studies describing the layer specific architecture functionalities in the network, these are inadequate for achieving efficient communication, and a lot more work is necessary specifically for assuring of QoS specific services for mobile adhoc networks. The strategies for classifying the literature of QoS based mobile systems [6] are of two types, the layered methodology, and the cross-layered methodology.

A. LAYERED APPROACH

The QoS based mobile data systems with a Layered QoS approach has data forwarded using any specific layer. These layers are the, the MAC layer, a network layer, and the transport layer or application layer where this approach is performed. At any specific layer the general procedure followed is, process of rate control, routing process, scheduling process, and the admission control policy.

In a MAC layer implementation of QoS based MANET communication the protocol uses in the transmission process, admission control as well as scheduling mechanisms and based on the factors of fairness, stability, and rate of packet loss, enhances the performance of transmitting the data. In a network layer based implementation of QoS services in MANETs the emphasis of the most of the studies performed are based on routing with QoS which satisfies the QoS flow necessities by using routes having adequate resources. In a transport layer based implementation of QoS services in MANETs the most important function is that of congestion control where a main protocol is TCP protocol. This TCP protocol devised for wire based networking in case of wireless networks is ineffective. When there is packet loss the protocol decreases the rate of transmission and a high rate of bit error in wireless channels decreases the performance. This ability to distinguish between loss of packets because of congestion and that due to errors in the channel must be included in designing a transport layer protocol in wireless networks [6]. In an application layer based implementation of the QoS services in MANETs comprises of the criteria of scalability in video coding, feature of transcoding, characteristic of source coding, transmission with adaptiveness, and the rate control. Here a context-aware rate of transmission with coding is applied adaptively in terms of network settings, content based on video, user specific choices, etc. Also in the mobile settings the use of the abstract layer with a middleware has the data processed at low-level differentiated from that of high-level computing. Here every layer of the network is required to be QoS aware, and a combination of all will provide the end-user total QoS solutions. However if we apply for QoS provisioning with a traditional layer which is devised for wire based networking the efficiency fails in MANETs [7].

B. CROSS-LAYERED APPROACH

A cross-layer design combines the mechanisms at multiple layers in the network architecture for an optimized performance. In multimedia applications of wireless networks this combined strategy of designing multiple protocols of several layers offers improvement in the performance [6] in terms of quality aspect of the video and the utilization of the power. This strategy of combining various layers design for instance may include, the strategy of including at the physical layer both coding and modulation, applying near MAC layer scheduling process and control admission, implementing near network layer the routing procedure, near the transport layer the application of congestion control and rate control, or applying near the application layer the source coding mechanism, shaping the traffic, process scheduling, and with rate control. The studies in this area of cross-layer based strategies are mostly an implementation of physical and MAC layer combined adaptation and optimization. The various design strategies which adapt the strategy of cross-layer technique have been mostly application layer designs. However the designs which have been researched considering the complete protocol stack have been very few [7].

C. QOS MULTICAST ROUTING PROTOCOLS

The multicast protocols for delivering the data are typically devised for throughput maximization, or a hop based end-to-end delay averages minimization. A routing process for a Quality of Service based multicasting in a particular route must meet specifications of QoS like, the bandwidth, delay start, etc. Here the results of a few protocols for quality of service may be inefficient dependent on constraints of resources, or computational overhead [3] involved. In this context the design of a QoS multicast protocol must involve the QoS metrics like, bandwidth, delay, cost, and packet loss rate. A few examples of protocols for QoS multicast routing in MANETs [3] are, the Multicast Core Extraction for Distributed Ad-hoc Routing (MCEDAR) approach, Ad-hoc QoS for Multicast (AQM) method, and the QoS Multicast Routing Protocol in Clustering mobile Ad-Hoc network (QMRPCAH) approach.

A definition for classifying the multicast QoS routing protocols in mobile ad-hoc networks is based on the factors of, i) the routing protocol interaction-based with scheme of QoS provisioning, ii) the routing protocol interaction-based with MAC protocol, and iii) the routing information updating mechanism-based.

All the QoS protocols which are routing protocols interaction-based with the QoS providing mechanisms may be additionally categorized into two types, a coupled QoS protocol based technique has dependency on the routing protocol entirely in providing and assuring quality of service and, and a decoupled QoS protocols based technique provides QoS with a scheme independent of any specific routing protocol, and assures guaranteed QoS with all protocols rather than only a few type of protocols.

All the QoS protocols which are routing protocols interaction-based with the MAC protocol may be additionally divided into two types which in providing QoS, independent QoS protocols have the network layer independent of the MAC layer and the dependent QoS protocol which has the network layer supported by the MAC layer.

All the QoS protocols which are updating mechanism-based on the routing information are additionally categorized into, table-driven QoS protocols which forwards the packets supported by a route table maintained by every node, the on-demand QoS protocols which has route discovery on the fly by the source nodes, and hybrid protocol which has provisioning of QoS based on the scheme of a table-driven protocols and that of the on-demand protocols merged together.

V. REVIEW OF BENCHMARKING QOS MULTICAST ROUTING PROTOCOLS

The existing literature studies have produced several important multicast protocols for QoS routing in MANETs discussed in the following section.

A. LANTERN TREE-BASED QOS MULTICAST PROTOCOL [8]

The approach Lantern Tree-Based QoS Multicast Protocol with respect to the availability of the bandwidth provides QoS. This approach applies near MAC layer a mechanism of CDMA-over-TDMA channel which has the available bandwidth measured in terms of the total free slots.

In every link the free bandwidth space available is measured by determining the time slots free between a node and neighbour nodes based on the information of the local link state gathered by the nodes. Here apathy exploration procedure initiating at the source node and ending at several destination nodes is used to determine the connecting lantern paths and by consequently combining all the routes a unique structure called Lantern tree is created where the bandwidth present connecting two neighbouring nodes in a two-hop path is the bandwidth required. A Lantern-tree strategy is used to creating a multicast tree between two nodes when a single unipath of a tree section is unable to offer the bandwidth necessary in situations demanding higher bandwidth. The creation and usage of multiple sub-paths among the nodes pairs and the total bandwidth offered by the multiple sub-paths connecting the two nodes meets the bandwidth requirement that is efficiently utilized in the network. The examples of Lantern tree-based QoS multicast protocols are, the approach ODMRP [9] and the MAODV [9] method. The assessment of these protocols performance is based on factors of like, tree creation success ratio, the overhead incurred, the throughput, and the delay averages considering several hosts in terms of mobility speed and the requirement for bandwidth. The experiments simulated with increasing speed of mobility demonstrate stability in the success ratio which however has simultaneous increase in delay as well in the overhead.

B. QOS MULTICAST ROUTING USING MULTIPLE PATHS/TREES [10]

A Multiple Parallel Paths/Trees (MPT) approach is an on-demand QoS based multicast protocol similar to the LTM approach which creates parallel paths or trees in multiple numbers between nodes for connections with assured bandwidth. A strategy is used based on the assumption of a MAC sub-layer here using a CDMA-over TDMA channel and that any node is capable of calculating the link specific free time slots. Based on this strategy three approaches of multicast routing are devised: the SPTM (shortest path tree based multiple paths) approach, the LCTM (least cost tree based multiple paths) method, and the MLCT (multiple least cost trees) approach .Here realization of the necessary bandwidth and delay minimization is the objective primarily of the algorithms. This strategy applied in the SPTM and the LCTM approaches creates between every node pair as per necessity multiple numbers of paths and with the MLCT approach similarly creates multiple trees connecting a source node and the destinations nodes. The minimization of the delay is achieved by path selection based on lesser hops and considering minimization of the costviability of the network is also achieved. The computation of the cost incurred from network is equivalent to the bandwidth times by the total number of hops or links within a tree. Here paths or the trees of multiple numbers are used in a parallel manner for improving the protocols utilization of the network resources .For all the above approaches we observe no increase in the cost of the network in terms of the distribution in the traffic, however because of maintenance of the tree there is increase in the overhead.

C. AD HOC QOS MULTICAST ROUTING PROTOCOL [11]

The approach Ad hoc QoS Multicast Routing Protocol (AQM) has a resource reservation based QoS multicast sessions provisioning in terms of the service class requests. For the devised approach considering bandwidth necessary and delay bound factors, the QoS classes are of four types called, QoS high-quality voice class, CD-quality audio QoS class, the video conference QoS class, and the high-quality video class for QoS. This approach applies a strategy based on a hybrid technique for maintenance of the routing tables and based on information of every node's resource status collected beforehand performs the operations of checking and replying to session related requests. In terms of the requirements the protocol has the availability of QoS tracked in each node's neighbourhood and this node status is made available during starting of a session. For joining a session a node has to follow the steps of request-reply-reserve to make sure both the QoS related information update, as well as the selection of a likely route.

A node's present bandwidth utilization is informed to the nodes neighbours from time to time in maintaining the neighbourhood with broadcast of hello packets. To evaluate every one of the four service classes in terms of changing nodes, the grade metrics such as member and session satisfaction are used. However the periodic broadcasting of these hello messages for starting a multicast session, or in some other process results in resources wastage and also introduces loops, incurring significant mobile network overhead and impacting the support to QoS.

D. FRAMEWORK FOR QOS MULTICAST APPLICATIONS [12]

The Framework for QoS Multicast Applications (FQM) approach is based on the strategy of using a cross layer framework for handling wide ranging different traffics incorporating various components with the routing protocol. To create multicast session based on various QoS requirements the protocol uses a hybrid strategy for services differentiation and integration. Here initially the provisioning of the IntServ by a forward node to each source node has the request for QoS route accepted. Then on receiving the other sources sent packets of data the forward node runs DiffServ if it possesses additional bandwidth. These services of multicast may be categorized as two different classes, which are the, BE (best effort) class, and the RT (real time) class. Here the modules such as shaper, the priority queue module, and the module for rate control within the node classifier are involved in traffic management and for packet admission or rejection. By performing regular estimations every node determines the bandwidth available for changing rate consequently of the BE traffic and achieving low delay in the RT traffic. Regulation of the output rate of the traffic shaper is performed with an AIMD (additive increase multiplicative decrease) rate control algorithm in the Traffic rate controller. Here an assumption of the MAC sub-layer using IEEE 802.11 is the basis for the FQM strategy. Also a technique of passive listening for available bandwidth measurement based on the idle or busy status of the radio channels is used in the FQM approach. An assessment of the approach performance is based on RT and BE traffic considering separately mobility speed in terms of traffic rates that are constant and also variable with parameters of packet delivery ratio, the control overhead, average delay, jitter, and throughput.

E. ON-DEMAND QOS MULTICAST ROUTING AND RESERVATION FOR MANETS [13]

The approach On-Demand QoS Multicast Routing and Reservation for MANETs (ODQMM) protocol is motivated from the MAODV approach and attempts to implement in the unicast protocols or the protocols of multicast routing a strategic integration with bandwidth reservation. A requirement for QoS reservation of bandwidth is implemented in the Protocol, using a fixed filter (FF) style of reservation, and a shared-bandwidth filter (SB) type of reservation. A FF based reservation style has every source not enabled for resources sharing by the other sender and so it is appropriate for implementations of streaming video. A SB based reservation style has one reservation shared with all the senders in a session, which makes it appropriate for various implementations of audio conferencing, etc. This total reserved bandwidth with SB may be given as: max(BW1, BW2, . . . ,BWn). A best effort manner may be used to send the data in case the data is insensitive to the parameters of QoS. This newer ODQMM approach attempts to enhance the process of the MAODV where the MAODV messages collection is added with the QoS Error as well as the Keep Alive control messages. The bandwidth reservation strategy is executed in case of finding a suitable path by the approach based on the strategy of reservation service integrated in it with the routing protocol.

The bandwidth information is obtained from an underlying layer such as TDMA network. Here the routing requires huge storage and communication in case of maintaining multiple numbers of tables by every node consisting of the topology information of the network along with the reservation information of the bandwidth.

F. QOS MULTICAST ROUTING FOR CLUSTERING MANETS [14]

The QoS Multicast Routing for Clustering MANETs (QMRPCAH) design is an ad hoc network cluster based multicast protocol with QoS awareness where the quality of service is a soft QoS support without assurances. Here the strategy of the protocol QMRPCAH has the information of the local multicast maintained by a node including the information of the remaining clusters where the global network knowledge is not needed. Here the strategy of the approach has the routing tables of the intra-cluster network maintained and updated by every node whereas the routing tables of the inter-cluster are maintained by every bridge node. A mobile node for subscribing to a new domain uses remote technique of subscription to join a local multicast tree. A path best suitable is chosen using programming techniques of a discrete dynamic approach based on the factors of delay and hop count. Here links disturbing the bandwidth constraints are deleted using an algorithmic strategy of flooding based on the receiver-initiated selection. An assessment of the performance of the QMRPCAH approach is based on the metrics of delay, bandwidth, jitter, and the packet loss in terms of variance in the delay, mobility, the size of the network. The outcomes of the simulated experiments show achievement of improved control overhead including higher delivery ratio particularly for huge size multicast groups.

G. QOS MULTICAST ROUTING BASED ON BANDWIDTH ESTIMATION IN MANET [15]

The approach QoS Multicasting Routing Based on Bandwidth Estimation in MANET (E-QMR) offers QoS multicasting with a technique of cross-layer framework and calculates for every node the available bandwidth using an improved MAC layer based on IEEE 802.11. This strategy is an improvement over the QMR approach [16] and the information obtained from the MAC layer related to the bandwidth decides the network layer admission control decisions. The QMR approach is an on-demand and mesh based protocol, where the members in a multicast group may be connected with QoS paths using a functionality of bandwidth reservation.

Here the QMR strategy is based on an assumption of a constant availability of bandwidth equivalent to the bandwidth of raw channel and the mechanism of control admission assures multicasting QoS routing with the schemes of hybrid fix-reservation bandwidth and with shared-reservation bandwidth. The changes in the state of the channel are constantly monitored by every node where on detecting busy state related to transmission, receiving, or carrier channel sensing changing to an idle state a count is initiated, whereas the counting is stopped on detecting state of the channel change from idle state to busy state. This composition of the idle time comprises of many idle periods for a time interval which if denoted as t, and by adding all of the idle time intervals the node has the total idle time computed. The available bandwidth (BWavail) is calculated as is the product of γ and BW where γ denotes ideal ratio(ratio of ideal time with each time period t) and BW denotes the raw channel bandwidth where the product is represented as $BWavail = \gamma * BW$. The BW allocated to older paths is freed and reallocated to newer paths in updating the forward nodes (FNs) regularly in the QMR strategy in the process of handling the mobility impacts. The performance assessment of the E-QMR approach is done in terms of average delivery ratio, the control overhead, and the average latency considering changing nodes mobility. The results of the simulated experiments indicate the ratio of packet delivery is efficient while the overhead as well as the latency are decreased.

H. MESH-BASED QOS AWARE MULTICAST ROUTING PROTOCOL [17]

An approach based on bandwidth assurances called “QoS Aware Multicast Routing Protocol (QMRP)” for MANET applications is mesh based design which has a source create a multicast mesh with the Route Request packet broadcast.

A receiver node on receiving a RouteRequest packet updates its cache of RouteRequest and broadcasts a Route Reply packet. A receiver node when it first receiving a RouteReply packet uses QMRP-with which it gives response to the received request and does not wait for the remaining requests. Else the receiver on first receiving node uses QMRP-w with which it wait still the completion of a time interval before giving a response and a route best of all the routes determined upto that time is selected. The best route chosen is dependent on the Forwarding count as well as the non-Forwarding count where greaterimportanceis given to a route associated with a high forwarding count value. In this approach every node regularly updates bandwidth related information by sending Hello message. At every node the residual bandwidth is calculated from the raw channel bandwidth difference with total consumed bandwidth and the ratio of this difference obtained with the value of the associated weight factor gives the residual bandwidth. Near every node the Maximum bandwidth is in terms of the hop number that is added to the

RouteReply packet. The route has On-demand maintenance and periodic maintenance. In case of failure of links in a node the mechanism of On-demand maintenance is used for decreasing the control overhead. In the other case the source node uses Periodic maintenance initiated by the source node involves only the mesh nodes and the neighbouring nodes. The performance assessment of the QMRP approach is in terms of, the ratio of packet delivery, and the ratio of control overhead considering changing speeds of mobile nodes, and the quantity of multicast senders. The requests accepted is with a bandwidth reservation technique which meets the requirements of the bandwidth measured at several speeds of mobility with lesser ratio of control overhead. The approach QMRP does not have wait time at the receiver, has no maintenance periodically, and compared to other types of configurations offers a better performance.

I. QUALITY OF SERVICE SUPPORT FOR ODMRP [18]

The approach Quality of Service Support for ODMRP (QoS-ODMRP) is an extension of the ODMRP which supports QoS based on the calculation of the bandwidth available and also the bandwidth required. Here the bandwidth requirement in case of a new flow is determined based on the flow related information related to the available and the consumed bandwidth.

In a flow the Bandwidth available and Bandwidth consumed values are compared by the admission control for accepting or rejecting the flow. A session is executed formulticasting using several node states as, “explored”, “registered” and “reserved”. A node on receiving a JOIN-REQUEST packet where the bandwidth available is greater than the bandwidth consumed the request is rebroadcasted and a entry newly is added in the table of reservation with status updated to as “explored”. A node on receiving a JOIN-REPLY packet it is broadcasted to a node upstream and the status updated to “registered”. A node on receiving data packet has its status “registered” changed to that of “reserved”. The performance assessment of the QoS-ODMRP approach with factors of packet delivery ratio and parameter of traffic admission ratio in terms of speed of mobile nodes in a simulated environment demonstrates compared to ODMRP a decreased overhead, proficient utilization of the bandwidth and overall enhancement in the network functioning.

J. AD-HOC MESH-BASED ON-DEMAND MULTICAST ROUTING PROTOCOL WITH QOS SUPPORT [19]

The approach Ad-hoc Mesh-based On-demand Multicast Routing Protocol with QoS Support (AMOMQ) is based on, a dynamic refreshing procedure to forward the group members, and a mechanism of correctly calculating the bandwidths available and that which is necessary is reserved in the active route end-to-end to support of the QoS. Here in the approach the scalable factor is increased with control overhead reduction. The route optimization efficiency is achieved in the AMOMQ approach with two different techniques. The first method is applied where the nodes are not supporting the requirements of QoS, and as a result RREQ packet is not considered. The second technique is applied over each intermediate node by comparing the bandwidth available with every node and the bandwidth necessary in terms of the position of the node and the role of neighbour node’s like sender node, or the intermediate node, or the receiver, etc.) For a session and performs bandwidth calculation as, Required BW = Breq$*$ (1 + n), with n depicting the total number of forwarding neighbours count and the intermediate node’s neighbour counter the senders and however not members belonging to the forwarding neighbours group. The present node utilized bandwidth for data forwarded to specific group members is denoted by Breq. Also the control mechanism for the admission procedure has every node active in the routing inspecting the bandwidth available with its one-hop neighbour nodes where the reserved or the updated reserved bandwidth is only used with nodes on the route end-to-end, and not for the neighbouring nodes in the route. A periodic broadcast of “Hello” packet, maintains the information of the neighbourhood at every node as B available related to originator whereas the information of the traffic in terms of the neighbour set. Next a session of multicasting implements several node states like “explored”, “registered” and “reserved” based on metrics of performance like, RREQ Control Packet Load, the Packet Delivery Ratio, and the End-to-End delay. The experiment outcomes show the performance of the protocol is good for traffic which is over loaded implying that improvement in QoS is achievable.

K. IMPROVED QOS ON-DEMAND MULTICAST ROUTING PROTOCOL [20]

The protocol called Improved QoS On-Demand Multicast Routing Protocol (IQoS-ODMRP) based on the node mobility and the reservation strategy of bandwidth enhances the performance of the QoS-ODMRP [18] protocol. In this strategy the main feature is an application feedback based bandwidth reduction mechanism used by the source node in case due to bandwidth insufficiency a request for an application for acceptance is not possible. Another main characteristic is that according to the mobility speed related delays the timer's value is changed by the protocol. Here related to the mobility in the nodes there is also adjustments in the time interval in which the HELLO packets are sent, changes in the time interval in which the JOIN-REQUEST packet is sent, and in the reservation timeout for saving a reservation entry in the table of bandwidth reservation. Indentifying the nodes the protocol uses the techniques of mobility speed and the GPS. Also various web service solutions may be used in case GPS is not available to collect the positions of the nodes. Based on the quantity of the packets of JOIN-REPLY being received at source together with the timeouts occurrences quantity, we may find the mobility speed of the nodes, with adjustment of the timers we may find the high’s or low’s in the network and with the correct adjustment of the timers the ratio of packet delivery may be improved leading to a delay reduction.

The simulations experiments of the IQoS-ODMRP protocol are done using the performance assessment metrics like, packet delivery ratio, and the end-to-end delay in terms of variations in the mobility of the nodes. The experiment outcomes demonstrate good improvement in the packet delivery ratio and the factor of end-to-end delay is reduced.

L. ADAPTIVE MULTICAST ROUTING PROTOCOL [21]

A mesh protocol called, Adaptive Multicast Routing Protocol (AMul) offers an improved QoS based on both reactive as well as receiver initiated multicast routing in wireless networks. The design objective is based on minimizing the queuing delay per packet thus achieving decline in the total networks end-to-end delay. An adaptation of the PUMA [9] protocol the design of AMul removes the requirement of the unicast protocol and the requirement of the multicast groups to be pre-assigned a special node known as cores. A network node in the devised protocol should calculate the average remaining queue and using a MAP (Multicast Announcement Packet) the calculated information must be forwarded to the remaining nodes. Here the functionality of MAP is the nodes are able to send to the remaining network nodes notifications related to it joining a group, of leaving a group, of maintaining the group, of the election of core nodes, and for sources which exist to the multicast group externally determine the routes. In the network routing table is created by each node with the Maps technique based on which a mesh is made for routing the data packets between the senders and receivers. In the table used for entering the routing information the entries are organized in a descending order of the average remaining queue size. The calculation of the average remaining queue size of the node by it is done in terms of the Exponential Weighted Moving Average (EWMA) as: new avg = ((1 −α) ∗ old avg) +(α ∗ rem queue size). Here the queue size is calculated as the difference of the max queue size from the cur queue size, the new avg denotes average remaining queue size whose calculation is performed near the node during the coming of every packet, and for a previous iteration Old avg denotes the average remaining queue size where the α value might be static and on the other hand may be dynamic also. The experimental evaluation of the protocol is done using performance metrics like, the average end-to-end delay, the control overhead, and with the total overhead which are in terms of variable numbers of the receivers. The protocol AMulhas overall reduction in end-to-end delay with minimal network control overhead.

M. QUALITY OF SERVICE TO AD HOC MULTICAST ENABLED NETWORK [22]

The protocol QoS to Ad hoc Multicast Enabled Networks (QAMNET) adapts a multicast mesh topology model ODMRP to offer low delay with necessary throughput in multicast real-time flows. The approach presents the techniques differentiation of service (traffic class RT and BE),distributed resource probing, a control admission strategy, and rate control addictiveness in non-real-time traffic dependent on the feedback from the MAC layer. A scheme to regulate the mobile nodes and the variations in the bandwidth is also incorporated in QAMNET approach. The available node-based bandwidth is measured from the RT flows threshold rate difference with the present RT traffic rate in the same way as the SWAN based calculation [23]. The dynamic pattern changes occurring in traffic directly impacts the threshold rate increasing the complexity of its accurate assessment [23]. The regulation of the BE traffic is performed with a MAC layer back-off delay based algorithm AIMD (Additive Increase Multiplicative Decrease) in QAMNet. A probing mechanism included in the multicast routing in QAMNet offers stability in the routing together with control messages reduction. Near the shaper the regulation of the BE traffic has the RT packets average delay controlled. The simulated experiments of the approach are performed in MANETs with multicast routingand real-time data packets which demonstrates delay reduction and decrease in the rate of packet losses considering the entire mobile nodes range.

N. HIERARCHICAL QOS MULTICAST ROUTING PROTOCOL [24]

The hierarchical communication protocol called Hierarchical QoS multicast Routing Protocol (HQMRP) provides routing in mobile networks using QoS based routes with flexibility as well as scalability. Here every local node has to keep the local information of the multicast routing along with or only the information of the remaining clusters (or domains) in summary instead of the information of the global states of the ad-hoc network. The arrangement of the network is of several levels based on a “full-mesh” scheme in which a domain is depicted using the domains border routers depicted with domain of higher level. In the formation of trees of shared multicast and for maintaining them, both the procedures are coordinated using a domain controller mechanism. Here to the tree new hosts are connected in terms of the QoS end-to-end constraints using a unique mechanism of reverse flooding proposed in the protocol. The tables created for routing are decreased in their size to attain scalability using a mechanism of topology aggregation. The network has in its each controller an array known as Tree Routers (multicast) which stores addresses associated with each and everyon-tree router inside its domain including the controller addresses of the sub-domains having on-tree routers. The HQMRP approach is evaluated using a metric for measuring performance called success ratio based on the specifications of the avg. node delay and the avg. delay. Here this protocol based on the hierarchical structure and the topology aggregation mechanism provides the necessary scalable factor in the model. The protocol is strong in terms of the network link breakage as every possible path is flooded with messages and the conditions forwarded use various pruning techniques to resize the flooded messages.

O. POSITION-BASED QOS MULTICAST ROUTING PROTOCOL [25]

A scalable QoS routing protocol PBQMRP supporting multicasting without limitations in the total number of members and the size of the network is termed as Position-Based QoS Multicast Routing Protocol which is also lightweight in performance. The model is devised based on a mechanism of virtual clustering and this approach has a network partitioned as various hexagonal cells where a cell symbolizes a powerful node.

The strategy removes among the cells the existing duplicates of the packets and thus the number of nodes participating in total is decreased. The nodes related information of their positions is used to collect the subscribers information and for finding routes which adhere to the QoS specific constraints. For advancing the forwarding efficiency together with the protocols scalability the approach for the multicast members uses a hierarchical construction. Here for a protocol in its process several stages are involved like, network construction, network maintenance, location service, multicast group partitioning, data transmission and routing discovery with maintenance. The stage of network construction divides the entire network into numerous cells hexagonally. A cell identity (Cell−ID) is given to every hexagonal cell where every node belongs to one cell only to which it's the member. The selection of the cell size is such that in a certain cell inside it in between every prevailing node a transmission based on 1-hop is supported. For every cell the information of all the nodes prevailing in the cell is maintained until a node belonging to this cell links with a new cell. This information is maintained by an elected Cell Leader (CL) node and when a CL node failure occurs or else exits the cell it is replaced by a node called Cell Leader Backup (CLB) present for every cell. The Network maintenance phase has various actions performed such as ,the periodic election tasks ,the task of backup confirmation with backup nodes, the mobile nodes intra-cell and inter-cell movement control and the regulation of the empty cells in the network. The location information is also used in the communication process. Within a certain cell the communication among all the nodes is achieved using 1-hop communication (cell broadcast) only. Whereas among the neighbouring cells it is mostly a 3-hop communication accomplished with the CL node information of the nodes kept in the cell along with neighbouring CLs location information. In the phase of multicast group members partition strategy is based on an enhancement in the efficiency of delivering the packets of multicast to the members in the multicasting. In the phase of the hierarchical multicasting the applied strategy reduces the route discovery packets size which results in a decreasedoverheadand rate of packet delivery may be enhanced in its efficiency as data packets received by nodes residing in a particular area is with only one data broadcast. Here by means of the coordinators a sparse multicast tree is built by the source where in every sub-group a lower multicast tree is built by every coordinator along with the local members. The performance assessment of the PBQMRP approach is performed with varying node mobility speeds, varying sizes of the area of the network, and varying densities of the multicast group in terms of the protocol throughput. The results of the simulated experiments performed demonstrate the PBQMRP protocol in contrast to ODMRP gives a packet delivery ratio considerable higher with lesser overhead.

VI. CONCLUSION

We have given in this review a discussion in detail with classification of the different type's multicast routing protocols. We have covered the different strategies for QoS provisioning in the mobile ad-hoc networks with a proper description. Our paper gives information in detail of a number of QoS multicast routing protocols with respect to their attributes and parameters for performance assessment. In this review we find many patterns among the frequently faced constraints in a multicast QoS routing scenario in MANETs. From the assessment of the many different approaches we have determined all of these strategies are devised based on only one QoS constraint of bandwidth and only some of them consider delay, jitter including some added parameters as QoS constraints. Also some algorithms consider service classification as an important constraint in multimedia based environments. These types of patterns are not observed if we take into account protocols classification based on an evaluation of their performances and the existing performance evaluations do not cover all the diverse different types of parameters prevailing. We infer that almost all the approaches have ignored the factor of scalability. In this context for overcoming these challenges the research direction henceforth should be for devising applications and protocols of QoS multicast routing for the multimedia services in MANETs.

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