IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 15, Issue 4 (Nov. - Dec. 2013), PP 88-92
www.iosrjournals.org

A comparative analysis on qos multicast routing protocols in MANETs

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Abstract: *Simultaneous transmission of data from one sender to multiple receivers is called multicasting. Several widely used applications require multicasting at least at the logical level. Examples include audio video teleconferencing, real time video streaming and the maintenance of distributed databases. In many cases it is advantageous to implement multicasting at the level of the routing algorithm (other approaches would be one-to-all unicast or the implementation of multicasting at the application layer). In this paper we are presenting a comparative analysis on various multicast routing protocols in adhoc networks.*
Keywords: *multicasting, multicast protocols,dynamic core, performance evaluation,Qos Parameters*

I. INTRODUCTION

Mobile Adhoc Networks (MANETs) are a class of wireless communication networks without a fixed infra-structure.The MANET concept has basically evolved to tackle the disaster situations like tsunami, earthquake, terrorist activities, battlefields, land slides, etc.Later, the concept has been extended to include applications such as online education, gaming, business, etc. Several applications in MANETs need group communication to manage the situations. The MANET nodes do not provide reliable services and QoS (QualityofService) guarantees as compared to other wireless networks such as WiFi, WiMAX, GSM and CDMA.The main sources of unreliability in MANETs are due to limited battery capacity, limited memory and processing power, varying channel conditions, less stability under unpredictable and high mobility of nodes.The QoS parameters to be guaranteed for multimedia group commu- nication are bandwidth, delay, packetloss, jitters and bandwidth-delay product.Here we discuss some of the important multicast routing protocols.

II. MULTICAST ROUTING MECHANISM IN MANETS

Multicast routing mechanisms are categorized based on topol- ogy and services within a topology.The basis of topological classification includes: (a)Mesh (b)Tree (c)Zone,and (d) Others. Multicast routing mechanisms can be further classified based on the services they provide by mainly focusing on reliability (Rel),bandwidth (BW), delay(Del)andbandwidth- delay (BD) product.Examples of mesh based multicast routing include On-Demand Multicast Routing Protocol (ODMRP) (Su etal.,2002; Leetetal.,1999), Enhanced ODMRP (EODMRP) (Oh etal.,2008; Hu etal., 2009), Resilient ODMRP (RODMRP) (Xu etal.,2009; Pathirana, 2007), Forward Group Multicast Protocol(FGMP) (Chiangetal., 1998), link stability based multicast routing in MANETs(LSMRM) (Biradaretal.,2010), Agent-driven back bone Ring-based Reliable Multicast routing in mobile Adhoc networks (RRMRA) (Biradarand Manvi,2011a), Reliable Neighbor based Multipath Multicastrouting in MANETs (MMRNS) (BiradarandManvi, 2011b), Team Oriented Multicast (TOM) protocol(Yunjungetal.,2003; Egbogahetal.,2008), Delay-Guaranteed Multicast Routing in multi-rate MANETs (DG-ODMRP) (Chen etal.,2009), QoS-Aware Mesh construction to enhance multicast routing in mobile adhoc Networks(QAMNet).

III. RELATED WORK

A.*Adaptive demand-driven multicast routing (ADMR)[1]*:

Jetcheva and Johnson propose ADMR, an on-demand multicast routing algorithm with almost no periodic components within its system. ADMR dynamically maintains the multicast routing state for active groups of nodes. The protocol uses source-based forwarding trees and continuously monitors the traffic pattern of the source. This allows ADMR to detect broken links in a tree as well as to identify the sources which stopped sending data packets. The sender node will transmit ''keep-alive'' messages to maintain the forwarding tree. When the source wants to terminate the route, it stops sending the ''keep-alive'' messages, and the tree expires. Similarly, the receiver nodes need to keep alive their respective branches by sending downstream passive ACK messages. If these messages are stopped, ADMR ''prunes'' the specific branches of the forwarding tree. Multicast data packets are forwarded from the sender to the multicast receivers using MAC layer multicast transmissions along the path of shortest delay.

B.Dynamic core based multicast routing (DCMP)[2] **:**

DCMP is a source-initiated multicast protocol proposed by Das et al. DCMP has been designed from the ground up as a multicast protocol, without relying on existing unicast protocols. DCMP classifies the sources into active, core active, and passive as shown in Fig. 30. Active sources use the traditional technique of flooding the network with JoinReq control packets at regular intervals. Nodes which desire to join the multicast group as a destination, reply with a JoinReply packet along the reverse path to the source. Passive nodes do not participate in the creation of the multicast routes themselves. Instead, a subset of the active nodes, the core active nodes form a shared mesh through which the passive sources transmit their data packets.

C.AMRoute: ad hoc multicast routing protocol [3]:

Xie et al. propose AMRoute which aims to avoid the high control packet overhead associated with the maintenance of multicast trees in ad hoc networks with highly mobile nodes. It does not support guarantees for minimal bandwidth and packet latency; the main design objectives are robustness and scalability. A conventional unicast routing protocol is used to keep track of the network dynamics. AMRoute is independent of the underlying unicast protocol, which can be chosen according to the specific network requirements. Thus, AMRoute is only concerned with the dynamics of the multicast groups.

D.Energy efficient multicast routing [4]:

Li et al. focus on developing an energy efficient multicast routing protocol. By assigning the transmission power of each node as a weight, the network graph is transformed to a new graph with weights between edges. The minimum energy multicast (MEM) problem is to find the multicast tree whose total energy cost is minimized. The problem now reduces to the directed Steiner tree (DST) problem.

E.QoS multicast routing protocol for clustering mobile ad hoc networks (QMRPCAH) [5] :

Layuan and Chunlin present a QoS aware multicast protocol for MANETs with clustering. The proposed QMRPCAH protocol allows a node to maintain only local multicast information and a summary of other clusters; it does not require knowledge of the global network. The protocol supports soft QoS without any hard guarantees. There may exist transient periods of time without the required QoS, for instance during periods of congestion, link breakage or packet loss.

F.QoS multicast routing using multiple paths/trees [6] :

Wu and Jia propose a routing protocol using multiple parallel paths or trees to ensure the bandwidth requirement of a connection. The protocol is distributed and uses standard route discovery and route reply techniques. The QoS requirements include a bandwidth requirement for a route and a delay bound represented by the number of hops from source to destination. Similar to other on demand protocols,

G.Genetic algorithms for group multicast [7]:

Randaccio and Atzori propose a genetic algorithm (GA) based approach to the problem of finding multicast trees which optimize bandwidth and delay parameters. The algorithm is initialized by building a population of multicast trees in isolation by combining unicast paths between the source and destination pairs. The unicast paths follow the shortest path in terms of hops, calculated using Dijkstra's algorithm. From this initial population, the GA algorithm generates various (possibly sub-optimal) combinations and selects them for fitness. The fitness function used by the GA is based on the weighted average of transmission delay and network resource utilization.

H.Fireworks [8] :

Law et al. propose a 2-tier multicast/ broadcast routing protocol, Fireworks, which adapts itself based on network topology and group density. At appropriate times, it resorts to broadcast instead of multicast. Sensor nodes are grouped together with local group leaders or cohort leaders corresponding to areas of high group member affinity. These cohort leaders establish a sparse multicast tree between themselves and the source node while they broadcast messages within the local group members
within their own cohort. The 2-tier hierarchical structure comprises of the upper tier formed the source and cohort leaders (see Fig. 32). The lower tier consists of the members
in the cohort. The authors use a new metric termed as cohesiveness which maintains the affinity of group members within a node's k-hop radius.

I.Probabilistic predictive multicast algorithm (PPMA) [9] :

The Probabilistic Predictive Multicast Algorithm (PPMA) proposed by Pompili and Vittucci improves the robustness and reliability of multicast trees in the event of link and/or node failures. The algorithm defines a new way to quantify the suitability of a link, the probabilistic link cost which is comprised of three terms: energy, distance and lifetime. Using this new metric, the multicast trees can be computed in the centralized or distributed manner. In the centralized approach, the algorithm simply substitutes the new metric for the other metrics traditionally used in the centralized Bellman-Form algorithm (such as hop count).

J.Hierarchical multicast techniques and scalability [10]:

Gui and Mohapatra introduce a framework for hierarchical multicasting in MANET. The proposed approaches include a domain-based and an overlay-driven. In the domain-based scheme, a large multicast group of nodes is divided into sub-groups. Each sub-group is assigned as a sub-root, chosen based on topological optimality. The sub-root uses its own lower-level multicast protocol to create its tree and deliver packets to nodes within its sub-group. The source nodes of each group and sub-roots form a special sub-group for upper level multicast which is used by the source node to deliver packets to the sub-roots.

K.Application layer multicast algorithm (ALMA) [11]:

Ge et al. propose an application-layer receiver-driven overlay multicast protocol. As the ALMA protocol operates at the application level, it can be used in conjunction with any routing protocol.

ALMA creates a tree of logical links between the group members. If node mobility or congestion makes it necessary, the tree can be dynamically reconfigured. Each edge of the logical multicast tree represents a logical link – a path at the network layer (see Fig. 33). The members of the the group can choose to allow zero, one or more children. A new member joins the group by sending join messages to multiple existing members.

L.QoS aware multicast routing[12]:

Sun and Li describe a series of QoS extensions to the AODV protocol. The approach uses the delay, bandwidth and packet-loss characteristics of MAODV with no additional signaling. It also incorporates multicast routing capability with the existing unicast. A source node sends a QoS route request, RREQ, which is forwarded by intermediate nodes until it reaches the destination. The destination sends back the RREP packet with a delay time corresponding to a predefined node traversal time (NTT). Intermediate nodes add their own NTTs to the delay value and update their routing tables. Routes with the minimum delay are selected for data transmissions. A similar technique is applied for the bandwidth requirement where source nodes indicate their bandwidth requirements and intermediate nodes compare their available bandwidth before forwarding the packet.

M.Ad hoc QoS multicasting (AQM) [13]:

Bur and Ersoy propose the AQM protocol which tracks QoS availability within the neighborhood of every node based on the requirements and announces it during the session initiation. In order to join a session, the nodes go through a request reply-reserve procedure that ensures the QoS information is updated and a possible route is selected. A session is initiated by the initiator (MCN_INIT) node by broadcasting a session initiation packet (SES_INIT).

This packet consists of the identity number and QoS class of the new session while also setting the bandwidth and hop count rules for the session. Active sessions are maintained in a table (TBL_SESSION) at each node. A membership table (TBL_MEMBER) maintains the status of predecessor nodes. The session information is maintained with periodic session updates keeping track of changes in the QoS conditions and node connectivity.

N.Content based multicast (CBM) [14]:

Zhou and Singh present a multicast model for a scenario where nodes are interested in obtaining information about specific threats and resources. These threats and resources are a time t and distance d away from the current location of the node. Nodes generate information about the movement, intensity and location of threats. This information is multicast
through the network using a sensor-push receiver-pull approach. Here, sensors push the information into the network while receivers pull the relevant information. The network is divided into geographic regions and a sensor detecting a threat broadcasts it into one of these small regions. Individual receivers then pull threat warnings from nodes that lie in the direction of travel.

O.Differential destination multicast (DDM) [15]:

In the DDM algorithm, proposed by Ji and Corson the source node of a multicast transmission encodes all the destination addresses within each data packet header in an in-band fashion. With this approach, no fixed multicast tree is created, the routing will be soft-state, similar to state routing algorithms such as DSR. This allows a lower control overhead, as there is no need for extra packets to maintain multicast forwarding state. Control overhead only occurs when there is actual data to send.

P.Robust multicasting in ad hoc networks using trees
(ROMANT) [16]:

The ROMANT algorithm proposed by Vaishampayan et al. uses a receiver-initiated group joining scheme which does not require any underlying unicast routing protocol or the pre-assignment of cores to groups. The cores of the groups are determined as follows. When a receiver joins a group, it checks if it has ever received a core announcement for that group. If it did, the node joins the group as a non-core node. Otherwise, the node considers itself to be the core of the group and starts sending core announcement packets with a core ID. If several receivers join the group simultaneously, the one with the highest ID becomes the group core.

Q.Epidemic-based reliable and adaptive multicast for
mobile ad hoc networks (EraMobile) [17]:

Ozkasap et al. propose a reliable and adaptive multicast protocol based on bio-inspired epidemic methods. Epidemic methods are stateless, thus they are a good match for the rapidly changing, non-deterministic structure of MANETs. The algorithms takes advantage of the broadcast nature of the wireless medium to send gossip messages locally within a multicast group to neighboring nodes. The traditional approach in gossip based protocols is to select a random node from a predefined list before unicasting the gossip message to the node. In EraMobile, the node gossips with a random subset of one-hop neighbors, constantly changing with node mobility and changes in the local node density.

IV. COMPARISION AND ANALYSIS

1.The most important factor of comparision is whether the multicast happens at the network layer or somewhere else. Most protocols position the implementation of the multicast at the network layer. ALMA [11] implements it at the pplication layer (more exactly, at what the ISO model would call the session layer – but in our current 4-layer networking hierarchy would be the lowest sublayer of the application layer with multiple applications being able to be built on top of it).

2.Most multicast protocols are based on the receiver subscribing to the transmissions of a specific sender. An interesting exception is CBM [14], which performs multicast based on the content rather than the source of the messages. Almost all the protocols are based on building a multicast tree, although there are some exceptions. CBM [14] does not build a tree due to its radically different distribution model.

3. Differential destination multicast (DDM) [15] performs an on-demand, soft state based multicasting without constructing an explicit tree. Finally, EraMobile [17] replaces the multicast tree with a stateless approach based on epidemic algorithms.

4. Another question is whether the algorithm is considering the state of the underlying network in the choice of the routing tree. There is an overall group of protocols whose approach is to select a core of the network. These nodes will serve as forwarding nodes (for instance, as the nonleaf nodes of the multicast tree). Naturally, the nodes in the core will be nodes with more resources (although other criteria might also be considered – for instance, the fact that the core must extend in all geographic areas of the network). From the protocols reviewed, core based protocols are DCMP [2], AMRoute [3] (‘‘logical core’’), Fireworks [8] (‘‘cohort leaders’’), and ROMANT [16]. The latter is an example of those protocols where the choice of the core is not based on resources (being simply based on the highest id). Other protocols do not establish a core but consider the available resources of the nodes on a case-by-case basis: energy efficient multicast routing [4] and PPMA [9] where energy is part of the probabilistic link cost.

V. CONCLUSION AND FURTHER WORK

Most protocols use a distributed implementation, with the only exception being the genetic algorithm based approach.So, there is a question whether the protocol considers QoS features such as minimal bandwidth of the multicast. QoS assurance almost always conflicts with resource conservation, as nodes with move advantageous locations or higher bandwidth will tend to become overloaded. From the surveyed protocols, the ones considering QoS are: QMRPCAH [5] (soft Qos), QoS multicast routing using multiple paths/trees [6], QoS aware multicast routing [12], AQM [13]. My future work includes designing a better qos performance routing lgorithm.

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