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Research Article

QoS Multicasting in MANET

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Abstract

We surveyed majority of QoS multicast solutions for MANETs published during last ten years for resource estimations, multicast tree/mesh administration and multicast routing (including design principles and conceptual operations). MANETs are widely used for supporting multimedia services that necessitate predictable QoS from networks. In multicast routing, packets need to be multiplexed for reaching multiple destinations, conserving bandwidth and network resources. Hence, QoS support in form of multicasting needs to be identified for multipoint to multipoint communication. We have also outline the new areas for future research in QoS Multicast.

Keywords: *QoS, manet, multicast, unicast, ad hoc network.*

1. Introduction

In multicasting, data is transmitted to a group of nodes recognized by one unique address (D. P Agrawal *et al*, 2003). Tree and mesh are two structures for multicast distributions. Tree based multicast protocols can be source-rooted or core-routed. Source-rooted tree-based multicast is not suitable for dynamic networks. Mesh structure is more robust and its redundant paths result in higher availability. QoS routing, Admission control, resource reservation, estimation and preemption are necessary elements required for QoS multicast. It is not required to organize these elements into a fixed sequence.
Unicast routing protocol sends information packets to a single destination from a single source. Due to replication of packets at sender node, one separate copy is provided to each receiver node creating redundant data packets. This leads to consumption of excess of bandwidth of bandwidth. Proactive, reactive and hybrid routing are the three categories of unicast routing applicable for mobile distributed networks. Proactive unicast routing is widely used in Internet backbone but is unable to find any place in MANETs.

Unicast addresses are used by connection-oriented protocol. Multicast routing protocol delivers information to a group of destinations simultaneously, using best strategy to deliver messages over each link of the network only once. When links to destinations split, copies of messages are created. Multicast routing is used to support group-oriented services. Mesh-based multicast routing protocols use quite a few routes to arrive at destination while only one path is sufficient for tree-based protocols. Fig 1. shows Unicast and Multicast processes.

Dynamic environment of MANETs make it difficult for centralized multicast routing schemes to accurately predict resource information and relative tree/mesh based calculations. Hence, distributed approach is the most preferred one. Geographical location of nodes, signal range, connectivity, mobility and relative location between nodes are the parameters responsible for the development of clusters. Multicast tree/mesh between clusters is build by reactive protocols in mobile ad hoc networks. Mesh based distribution mechanism provide alternative paths for packets along with provision of relaying node to forward it regardless of parent from which it was received. In tree based multicast distribution mechanism, each node is linked with one parent to forward the packets.

There are several design factors vital for Multicast Routing Protocol (MRP). Fig 2. Shows relation between different components of multicast routing protocol. Scalability depends on network size and group size. It is recommended that scalability should be supported by higher layers such as Transportation and Application. The system implements a feedback approach for users on cost parameter for different QoS requirements and applications. Multicast services are chosen when user is concerned for bandwidth savings, neglecting deployment and management cost.

2. Related work

This section lists reviews and surveys on multicasting in ad hoc networks. Routing protocols were classified into tree/mesh, stateless, hybrid and flooding protocols (O. Tariq *et al*, 2005). In their work, (X. Chen *et al*, 2003) described On demand multicast protocols like Forwarding Group Multicast Protocol (FGMP) and Core-Assisted Mesh Protocol. (T.A. Dewan *et al*, 2005) explain AODV,

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ODMRP and other multicast protocols. (Carlos de Morais *et al*, 2003) compared multicast protocols on several performance metrics. (Carlos de Morais *et al*, 2003; Z.C. Huang *et al*, 2002) classified protocols on basis of route creation like tree-based, mesh-based, stateless, multicast and hybrid approaches.

(S. Papavassiliou *et al*, 2002) classified the multicast protocols as proactive and reactive, tree and non-tree approaches . It has not included QoS multicast in ad hoc networks. (Aaron Striegel *et al*, 2002) presented multicast "life cycle" model covering all events in different phases. (D. Perkins *et al*, 2002; C.S.R. Murthy *et al*, 2006) identified all necessary components required for QoS solutions. (L. Hanzo-II *et al*, 2007) surveyed MANET QoS routing solutions covering metrics, resources and constraints. Main focus area was routing metrics and constraints. (L. Junhai *et al*, 2009) surveyed multicast routing protocols and classified them into two categories: application independent and application dependent routing. (A.A. Hashim *et al*, 2008) provide review of nine protocols and presented a short description, advantages and disadvantages of these protocols. QoS multicast routing protocols were reviewed (M. Masoudifar *et al*, 2009) to study their behavior. (S.F. Hwang et al, 2011; M.A. Sophn *et al*, 2007) propose cluster based multicast routing scheme. (H. Hernandez *et al*, 2009) introduced protocols for static conditions of node. (Lusheng ji et al, 2003) proposed an explicit multicast routing protocol named as Differential Destination Multicast (DDM) for MANET. (X. Xiang *et al*, 2006) proposed an efficient and robust geographical multicast protocol for MANET. In this paper, we have studied most of QoS multicast protocols and compared their behavior also.

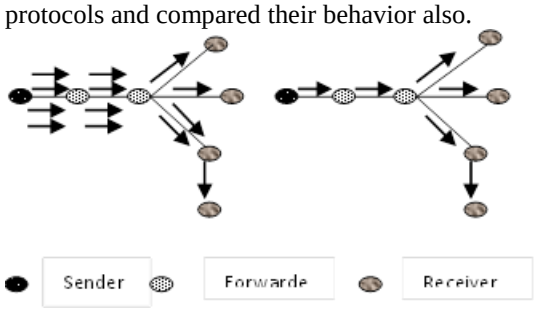

Fig 1 (a) Unicast process (b) Multicast process

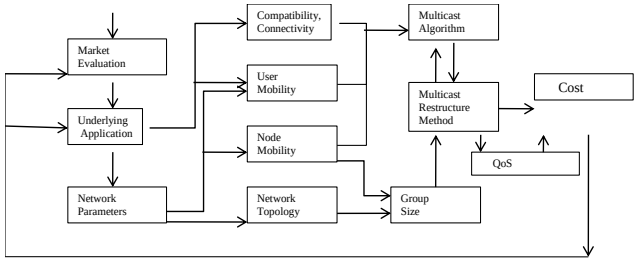

Fig 2. Relation between Design factors for Multicast Routing Protocol (MRP)

3. QoS Multicast mechanisms

Existing multicast routing protocols also exploit the classification methods used for unicast routing protocols. For example, reactive routing and proactive routing. We have summarized the characteristics of QoS multicast protocols included in our survey in Fig 3. Routing scheme, multicast distribution, tree/mesh initiation, reservation type, QoS constraints, MAC sub-layer and resource estimation form the comparison criteria for QoS Multicast Protocols.

This defines the nature of routing decision to be taken among all nodes either centrally or distributive. In central scheme, it is the responsibility of source to compute multicast tree/mesh topology and share it with other nodes. In distributed scheme, participation of all nodes in routing process (request-reply) is must. When source floods route requests, intermediate nodes take decision to forward/discard it. 'Route reply' is forwarded to the source, through intermediate nodes. On basis of construction of distribution path among group members, multicast routing approaches can be classified into tree based multicast routing, mesh based multicast routing, core based multicast routing and group forwarding based multicast. Tree based multicast routing protocols can be divided into source-rooted and core-rooted schemes.

Multiple QoS Constraints

Bandwidth, delay, probability of packet loss, jitter, life-time and link reliability are some of QoS metrics for Multicast protocols. For a particular routing solution, it may happen that QoS metrics and QoS constraints differ. Example- For fulfilling bandwidth requirement of an application, stability metric could be utilized for route selection.

The Constructed Metric Technique constructs an Accumulated Constructed Metric as a function of other metrics such as bandwidth and delay. This is done to prioritize various path segments for routing protocols. Independent Metric Technique uses an Evaluation Function, which is function of some parameter such as cost, bandwidth, delay, jitter, stability etc. This technique consists of two phases. Phase I selects all paths satisfying QoS constraints. Phase II selects the best path for building tree/mesh by application of man evaluation function based on other metrics.

Admission Control

Admission control can be done at source, receiver or at intermediate node. When the decision lies with intermediate nodes, each node on path checks for availability of sufficient resources to meet QoS requirement for forwarding route request. When the receiver is entitled to make decisions, it simply compares the quality of probe packets with known QoS requirements. On satisfactory results, it accepts session; otherwise, session is rejected. Finally, receiver sends its decision to the source. For admission control, source builds a multicast tree and computes QoS satisfied paths to all destinations. This multicast structure is informed to all involved nodes.

Resource Reservation/ Release

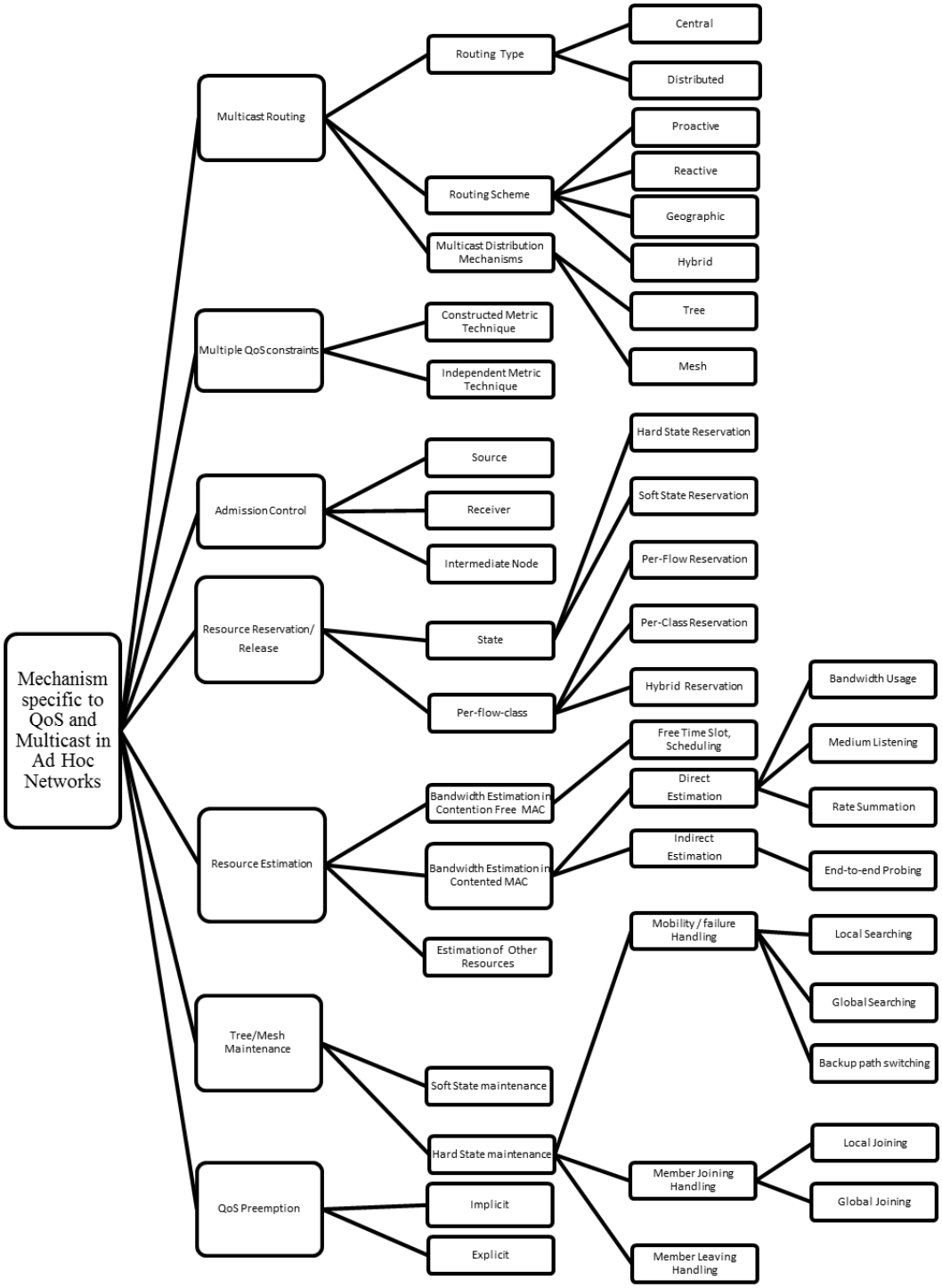

Fig 3 Classification of mechanism specific to QoS and Multicast in Ad Hoc Networks

Resources need to be reserved to achieve a certain limit of QoS requirements. Implicit resource reservation mechanism treats a system as black box. When a new source or receiver needs to be admitted, end-to-end probing is done to determine the acceptability of resulting QoS. In explicit resource reservation, resources are associated to a particular node or a multicast group.

Reservation mechanism may be categorized into three types: per-flow reservation (IntServ), per-class reservation (DiffServ) and hybrid reservation (IntServ over DiffServ). In the per-flow reservation method, resources are reserved for certain flows or sources. In the per class reservation, there is no flow reservation and reservation is implicit. Hybrid reservation partitions bandwidth into fixed reservation for accepted sources and shared reservation for others.

Resource Estimation

Routing protocols estimate resources like bandwidth, delay, buffer, power etc. Resource estimation mechanism for bandwidth can be divided into two categories: 1)

Estimation of bandwidth in contention-free MAC. 2) Estimation of bandwidth in contented MAC, (Direct Estimation/Indirect Estimation). The Code Division Multiple Access (CDMA) employs spread-spectrum technology. CDMA can be overlaid on top of Time Division Multiple Access (TDMA). The direct

The capacity is calculated as the difference between the raw rate and the total of rate of flows through the nodes. Indirect estimation uses end-to-end probing from source to receiver or from source to intermediate nodes to introduce the priority of packets. Receiver accepts only those transmissions, where difference between the quality of probe packets and required QoS is within an accepted threshold.

Mechanisms used for estimation of resources other than bandwidth, mainly focus lies on parameters at the path level like-delay, route stability, power level, buffer level, streaming resolution and streaming continuity etc.

Tree/Mesh maintenance

Soft state maintenance technique demands periodic refresh of tree/mesh by the source or receiver at regular time interval of few seconds. Every link break is automatically repaired at beginning of refresh interval. Hard state maintenance mechanism requires additional technique to handle link break and joining/leaving of nodes using "Hello" packet. In mesh structures, packets are sent through primary and alternative paths. Hence, they are more robust and do not require any additional support until both primary and alternative links break down. However, when receiver node leaves the multicast group, the associated resource must be released and corresponding routing table is updated.

QoS Preemption

The preemption techniques are of two types: implicit and explicit preemption. Periodic admission control and resource reservation result into implicit preemption. QoS violation may be detected and recovered through explicit reservation. Network metrics for constructing routing path form the basis for protocol classification. Mostly, the "hop-number" is used as a metric. Mobile applications demand use of appropriate QoS metrics for packet routing and forwarding. Metrics, such as bandwidth, delay, jitter, packet loss and cost are used for routing path construction.

4. Other approaches

Some other protocols for MANET multicasting are Overlay-based multicasting, backbone-based multicasting and Stateless multicasting etc. For avoiding the explosion of state information, overlay based multicasting keeps protocol states within the group members. In backbone based multicasting, only the virtual backbone keeps state information. Stateless multicasting avoids maintaining any state in forwarding nodes.

Dynamic core based multicast routing protocol (DCMP) (S. K. Das *et al*, 2002) dynamically classifies source nodes into active sources, core active sources and passive sources. Periodic route refreshment is performed by active nodes. Reliable Adaptive Lightweight Multicast Protocol (RALM) (K. Tang *et al*, 2003) takes care of reliability and congestion related issues of multicasting protocols in MANET.

Conclusion

The multicast services in an ad hoc environment demands full proof security infrastructure covering authentication, access control, data integrity and group confidentiality. The issues which deserve further exploration are quality of service, power control, multiple sources, address configuration, multicast service support, traffic control and reliability. Future works in the design of multicasting protocols should focus on reducing the overall control overhead to support scalability. Future protocols should try to take an application viewpoint when designing admission control and preemption mechanisms. Interconnecting wired network multicast with ad hoc based multicast still needs to be made functional by development of multicast gateway. New routing protocols need to be developed for multiple source multicasting, reducing wastage of network resources for multicast group in network running different kinds of applications/services simultaneously.

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