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Reliable Multicasting Protocols in Ad-hoc Networks- Simulated Analysis of Impact of Mobility Speed and Number of Senders

Shikha[1], Vijender Kaushik [2]

Deptt. of Computer Science, Mewar University, Mewar[1]

IMT, Ghaziabad[2]

Abstract: This paper identifies the impact of change in mobility speed and number of senders during multicasting in ad-hoc network. The various protocols like AMRIS, MAODV, ODMRP, CAMP, AMRoute supports the multicasting in ad-hoc network. The analysis of these protocols helps in finding out the pro and cons of these protocols. By way of such a comparative analysis of ad-hoc multicast protocols, the paper tries to fill the current gap in their appropriate understanding with regard to their strength as well as weaknesses and suitability in different environments. It also facilitates in selecting a correct and mainly apposite multicasting protocol in particular circumstances and thus put in efforts to efficiency by research in this area. This paper identifies the area of improvement for future examination in these protocols for better efficiency in terms of delivery ratio and the network traffic. The various open challenges in reliable multicasting are discussed in this paper.

Index Terms: Ad-hoc Network, QoS, MANET, AMRoute, AMRIS, ODMRP, CAMP, MAODV, Flooding.

I. INTRODUCTION

In group-oriented applications, multicasting is better alternative of sending by means of several uni-casts for broadcasting data to many nodes in group. It is efficient in view of lesser processing power and bandwidth consumption, reduced transmission cost, minimum forwarding and routing handling cost, less delivery delay. Now days, wireless network is commonly used by the people than wired network due to advancement in Bluetooth technology and handy devices like mobile, tablets, i-pads. People are widely using ad-hoc networks for the sharing of information, playing multiplayer online games, chats and many more as ad-hoc networks do not have issue of address management. Mobile ad-hoc network (MANET) applications include battlefield area as well as disaster aid situations.

The uncontrollable and irregular deviation in network topology make reliable multicasting a challenging task in ad-hoc networks [1] [9]. The challenges of reliable multicasting also include the constraint of inadequate battery backup, device memory and bandwidth in MANET, which adds the problems. The multicast protocols like DVMRP, MOSPF**,** CBT and PIM are used in the fixed networks for the multicasting but they can't be applied directly for ad hoc networks as multicast trees are fragile and need to be reconfigured as network topology changes. Keeping in view all such issues, various multicast protocols have been proposed [11] [17]. All these protocols aim towards a common goal of efficient and reliable multicasting. However, the problem in these protocols is that multicast packet delivery paths become fragile with respect to mobility when they try to be optimal in reducing the transmission cost; on the other hand these are not optimal if made to be resilient to mobility. Efforts continue towards an optimized multicast for ad hoc network [2].

The rest of the paper organizes as follows: Section II express the characteristic and challenges of reliable multicasting. Section III expresses the open issues of ad hoc networks for future work and consideration. Section 4 illustrates the available techniques of ad hoc multicasting protocols. Section V brings out various network scenarios and further comparison and analysis of the widely used protocols, viz. AMRIS [3], MAODV[4], ODMRP[6], CAMP[7], AMRoute [13] and flooding in such network scenarios. The methodical study is based on the impact of change of mobility speed, number of senders on network reliability. Observations and concluding remarks discussed in Section VI.

II. RELIABLE MULTICASTING

The term reliability differs with the framework of different applications. For all applications, reliability means an assurance of the final delivery of all the multicast data packets to the entire destinations. It represents the first level of reliability. For various applications, it also guarantees delivered data packets to be error free along with minimal use of bandwidth and power. The second level of the reliability is to preserve the order (partial or total) between data packets. Maintaining the order is crucial for the real-time applications, which requires that all packets be received to every receiver in accurately that order.

The various issues of the reliable multicasting include detection of loss of packet and initiating the process of recovery from such loss. However, depending upon the protocol, any of the sender or the receivers may be responsible for packet loss detection and loss recovery initiation.

Achieving the second level of the reliable multicasting is difficult due to unhindered mobility of nodes in ad-hoc network. Any receiver can be detached from the network for a random amount of time. However, buffers can be used for retransmission of packets to nodes having small time disconnections. But it increases the overhead and computational complexity of the protocol. In MANET, there is constraint of limited size buffer / memory and inadequate battery back-up. The objective of high packet delivery ratio is considered more practical in MANET.

III. CHALLENGES IN AD-HOC NETWORK- A FUTURE SCOPE

The various challenges in multicasting in ad-hoc network crop up due to unhindered mobility of nodes. It has been observed that nodes are unhindered due to absence of restraint on speed and route of movement. As a resultant, each node conduct is autonomous of other nodes and makes a grand possibility of recurrent / transitory network partitions. Various issues with such ad-hoc networks like MANET are as follows:

Issue of Optimal usage of limited Power

How efficiently the insufficient and limited battery power be utilized? This issue relates with the low complexity and high packet delivery reliability of the multicasting protocol. Since the devices in Ad-hoc network have restricted battery backup, multicasting protocol with low computing complexity and high packet deliver ratio is favorable for the major applications. Power can be preserved by reducing the routing overhead and use of cache memory.

Network Size /Scalability Issue

What should be the maximum network size for a multicasting protocol? This issue relates to the number of nodes in the ad-hoc network versus performance of a multicast protocol. The performance of the multicast protocol will change with the increase in nodes network. The issues of reliability and computation power may increase with increase in nodes. Mobility, transmission overhead and delivery delay concerns in MANET adds constraints to the issue of scalability. The impact of groups' size is studied later in this paper.

Allocation of Address and Auto-Configuration Issue

What address configuration is used in MANET? This issue relates with mobility of the node, dynamic address configuration, address auto-configuration, and uniqueness of address. In MANET a temporary network is created. Due to presence of unhindered mobility of nodes, any node can join or leave the network at any time. Scalability may raise the performance and robustness issue with multicast protocol.

Quality of service (QoS) Issue

Whether MANET provides assurance of QoS in data flow for the Real time applications? This issue relates to reserving bandwidth, delivery delay, loss of packets, jitter delay, creation of loops, power consumption, throughput etc. The impact of mobility speed, numbers of senders, multicast group size, varying network traffic load on network etc. are the QoS issues which are studied later in this paper.

Applications for multicast over MANETs

Whether all applications supported by MANET? MANET applications also include battlefield area, disaster aid situations, online gaming or conversations in a classroom or conference. Transmission overhead, power limitation and routing, delivery delay may add constraints to various applications of MANET.

Security related Issue

Is MANET secure from the active and passive attacks? The security issues relates with the maintenance of authentication, confidentiality, Integrity, access control, availability and non repudiation. Since an adversary can easily enter in the network and send the malicious packets, mobility in MANET increases the security issues.

IV. MANET MULTICASTING PROTOCOLS

In view of the absence of fixed infrastructure, ad-hoc networks are characterized as infrastructure-less. There is no dissimilarity between host and router, as all nodes, including mobile hosts, are required to compute, maintain, and store routing information. The various open challenges are discussed in previous section. These problems make the use of Flooding as multicasting technique not a suitable choice in terms of usage of bandwidth, security and quality of service issues. Flooding increases the traffic and decline the overall performance. The various multicasting protocols are grouped on the basis of the manner of building routes in a MANET group.

Tree-Based Techniques

This technique builds a route with grouping of a variety of multicast trees of source and receiver pair from source to receiver. For every source to destination, there is existence of only one route between them. The plus of this technique is high data forwarding effectiveness and little operating cost. The high mobility in network decreases competence and reliability in terms of delivery of packet of this technique.

The absence of alternate paths results in low robustness due to unpredictable change of topology due to mobility. Source or shared tree based approach is used for creation of routing paths. In source based technique, individual shortest multicast path is formed from each sender to receiver node. The mobility in MANET amplifies the traffic overhead for this method.

Single distributed tree is mutual amongst all the sender nodes in shared tree method. A rendezvous point (RP) for group is there. Senders' node drive packets to RP and various receivers join at RP. There is less delay in the source based approach, whereas traffic load is skewed in the later approach. AMRIS [3], MAODV [4], LAM [5], LGT [14] protocols are based on this technique.

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Mesh-Based Techniques

There exist multiple routes linking source and destination node in this technique. Accessibility of numerous routes put in robustness from varies of topology due to mobility in MANET. This method is superior than the tree based practice in terms of high performance, increases in delivery of packets and delays to be less.

However, the maintenance of multiple routes and accessibility to them and forwarding the packet results in high cost than tree based techniques. Also, the ease of use of numerous routes shall outcome in the receiving of duplicate data packets at the destination node which domino effect in enhance of network traffic and load. On-Demand Multicast Routing Protocol (ODMRP) [6] [10], Core-Assisted Mesh Protocol (CAMP) [7], Forwarding Group Multicast Protocol (FGMP*)* [8] are based on this technique..

Stateless Multicast

As already discussed in the mesh based techniques, mobility in the MANET lead to origins the overhead in preserving the itinerary and forming novel routes due to recurrent topology alterations.

There is overhead in uphold tree and mesh in tree based method and mesh based method respectively. The stateless multicast procedure diminishes this overhead by explicitly release the list of destinations in data packet header by sender node.

This multicasting procedure is mainly appropriate for the small sized groups. No complex direction-finding is requisite. Basic direction-finding protocol further sends the packet to all receivers. However, in huge sized groups this method raises operating cost due to enlarge in list of destinations addresses. Differential Destination Multicast (DDM) protocol [15] uses this procedure.

Hybrid Approaches

Hybrid procedures are based on a mixture of both the tree based and the mesh based approaches, and these also come across a point out in the study on the subject matter [12]. The focus of this procedure is to capture benefit of the pros of the mesh (i.e. robustness) based methods and tree (i.e. low overhead) based methods to achieve superior performance. This planned method is added extra reliability than tree based approach and diminishes the network traffic and load. AMRoute[13], MCEDAR[16] multicasting protocols uses this scheme.

The comparative position of different multicast protocols (i.e. Flooding, ODMRP, CAMP, AMRoute, AMRIS, MAODV) under various parameters is shown in Table1:

Table - 1 : Comparative position of different Multicast protocols

Sr. No.	Parameters / Protocols	Flooding	ODMRP	CAMP	AMRoute	AMRIS	MAODV
1	Multicast technique	Mesh	Mesh	Mesh	Hybrid	Tree	Tree
2	Loop Free	Yes	Yes	Yes	No	Yes	Yes
3	Dependency on Unicast protocol	No	No	Yes	Yes	No	Yes
4	Requirement of periodic Messages	No	Yes	Yes	Yes	Yes	Yes
5	Requirement of Control Packet Flooding	No	Yes	No	Yes	Yes	Yes
6	Acquirement / maintenance of Routing Information	Reactive	Reactive	Proactive	Proactive	Proactive	Reactive
7	Scalability support	Fair	Negligible	Good	Fair	Fair	Fair
8	Drawbacks	Increased traffic load	Scability increase overhead	High control overhead	Formation of loops / increased congestion	Packet collision due to periodicity and beacon size	Low packet delivery in high mobility

V. SIMULATED ANALYSIS OF MULTICAST PROTOCOLS

The Multicast protocols are analyzed simulated in special Network setting like change in Mobility speed, change in Number of senders. The results are evaluate in terms of packet delivery ratio, data overhead, control overhead and traffic overhead. The details of presentation metrics is as follows:

Performance Metrics for the protocols

The presentation metrics discussed for the various multicast direction-finding protocol costing in MANET are as follows:

- **Packet delivery ratio**: It evaluates the consistency and effectiveness of the protocol in terms of packet delivery to the destination node. It can be calculated by finding out the ratio of number of packets truthfully arrived to the number of packets supposedly reached at the destination.
- **Number of data packets transmitted per data packet delivered**: it evaluates the number of data packet send out by the protocol. It correspond to the data overhead of the protocol. In uni-cast protocols its value is one or more than one, while in case of multicast it may be less than one as a single transmission may distribute to multiple locations.
- **Number of control bytes transmitted per data bytes delivered**: It evaluates the competence with regard to utilization of control packets in ensuring the data reaches to destination node.
- **Number of control and data packets transmitted per data packet delivered**: it is a measure of traffic overhead. It represents how efficiently the channel is accessed.

SIMULATION BASED SETUP AND ANALYSIS

The analysis of different ad-hoc multicasting protocols was performed on the simulator named NS2. It supports the simulation based analysis of multi-hop wireless network at Mac layer and physical layer. In the experiment, 50 wireless network nodes were created in a simulated environment with a roaming range of 1000x1000. Simulation duration was about 1000sec. The

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mobility of nodes in simulation environment was kept diverse from 1m/s to 20m/s. All nodes become the member of the only one multicast group in the beginning and remain the member of the same group only during the simulation environment. Node placement was done randomly. The nodes mobility was also chosen randomly i.e. nodes can change direction randomly. The non mobility time, also called pause time, is varied to change the relative speed of mobile. The node transmission power range was kept at 250 meter. The numbers of senders are 5.

Mobility Speed

The mobility speed varies from 0 to 20 m/s. Sender nodes are 5.

Packet Delivery Ratio

When nodes are not moving, all the protocols have the packet delivery ratio to be 1 except the AMRIS as shown in Fig1. The reason is the packet collision due to beacons frames sent by nodes in AMRIS.

The performance of the ODMRP is remarkable in high mobility situations due to minimal data loss along with availability of redundant routes in a mesh topology. Flooding gives best results but increase traffic. CAMP gives poor packet delivery ratio in dynamic situation due to non availability of redundant paths for the far-away nodes. The reason of poor performance of MAODV is non creation of alternate routes instantly. AMRoute gives worst performance due to conception of loops.

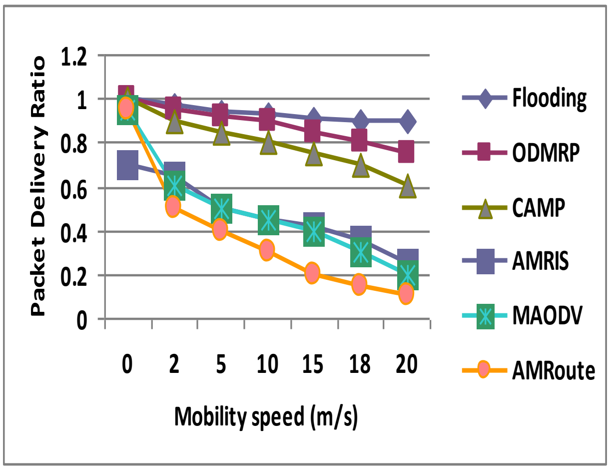

Fig1-Packet Delivery ratio performance in mobility speed

The Number of data transmissions per data delivery to destinations (Packet transmission ratio-Data Overhead).

Creation of loops in AMRoute is responsible for maximum injection of data packets as shown in Fig2. The analysis shows that protocols like ODMRP and CAMP which use mesh based technique inject more packets in comparison to AMRIS, MAODV, which is tree based protocol. The output of flooding and OMRDV is almost same due to establishment of various redundant routes in OMRDV.

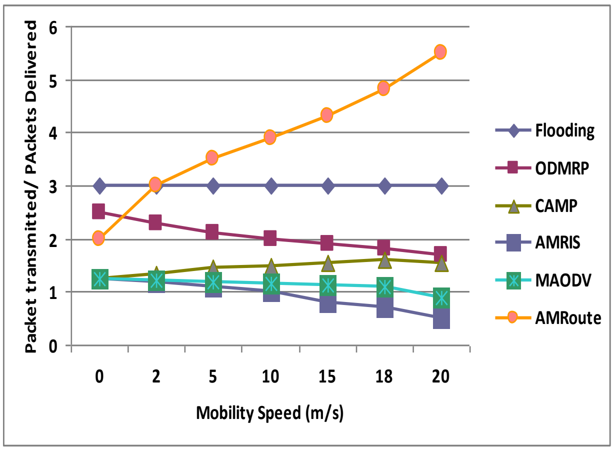

Fig2- Data overhead in mobility speed

The control byte overhead per data byte delivered

The result shows that control overhead in flooding do not increase with mobility. The reason is flooding do not send control frames, only data packet header performs the controlling activity. .

Flooding and AMRIS has least control overhead as shown in fig3. AMRIS has low control overhead vis-à-vis other multicast schemes as there is less transmission of data packets. WRP causes larger control overhead in CAMP, in case of high mobility vis-à-vis ODMRP. Overhead is relatively constant in ODMRP as there is no trigger of updates by mobility. Creation of loops in AMRoute is responsible for maximum injection of data packets as well as maximum control overhead. MAODV has less control overhead than ODMRP.

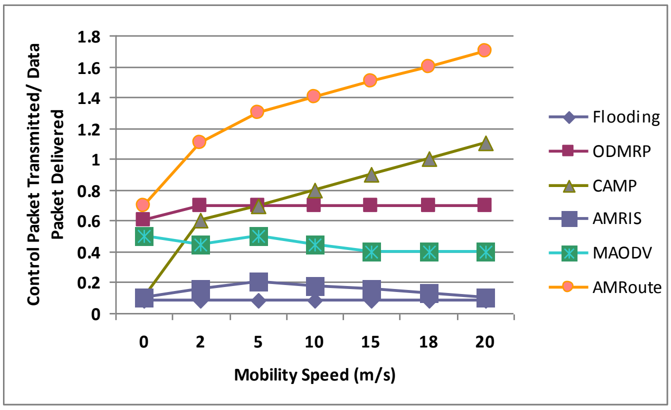

Fig3- Control overhead in mobility speed

The number of all packets transmitted per data packet delivered

It is observed that AMRIS has the least packet transmissions on account of tree usage, whereas AMRoute has the largest value due to loops.

ODMRP injects more packets than CAMP and MAODV due to presence of redundant paths as shown in fig4. Piggybacking technique in CAMP helps in reducing the number of control packets which is responsible for better channel access than ODMRP.

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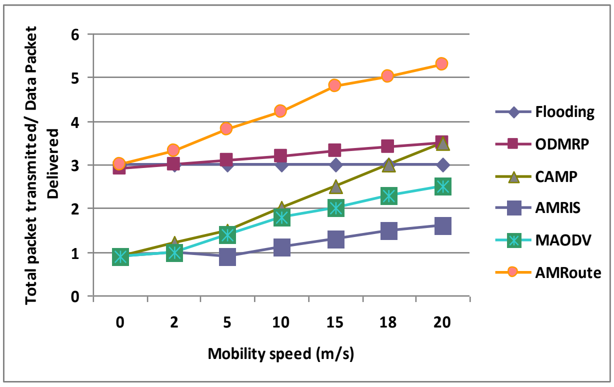

Fig4- Traffic overhead in mobility speed

Number of Senders

The number of sender nodes varied from 1 to 20.

Packet Delivery Ratio

The result shows that ODMRP do not support scalability. The reason is route request is sent by senders periodically in ODMRP. Increase in number of senders means increase in traffic. Packet delivery ratio decreases with increase in number of senders due to congestion. Packet delivery ratio in Flooding decreases with increase in number of senders due to traffic congestion and collision. CAMP gives better results than tree based protocol i.e. AMRoute, AMRIS, and MAODV as shown in fig5. Increase in number of sources helps increase redundant paths in a mesh

The performance of AMRIS and AMRoute is not affected by increase in the number of senders on account of a shared tree being used in multicast session.

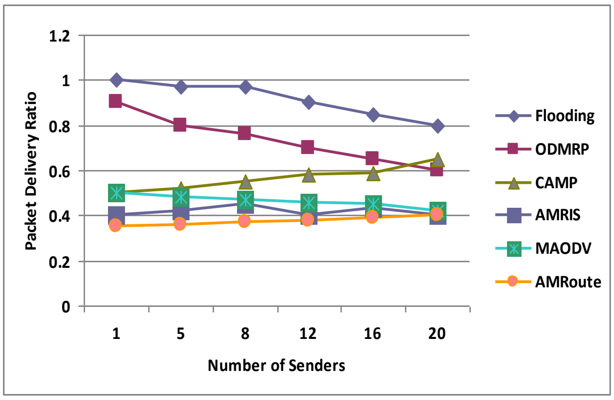

Fig5-Packet Delivery ratio performance in number of senders

The Control Overhead per data byte delivered.

The results show that AMRoute has maximum control overhead due to loops creation. For CAMP, Flooding, AMRIS, and MAODV, control overhead has minor effect of increase in number of senders. They retain a stable value for control overhead as shown in fig6.

In ODMRP, control overhead increases with increase in number of senders. The reason is in ODMRP every source node sends route request periodically to the network and increase control overhead. ODMRP is not proficient for the network having larger multicast sources in terms of associated overhead.

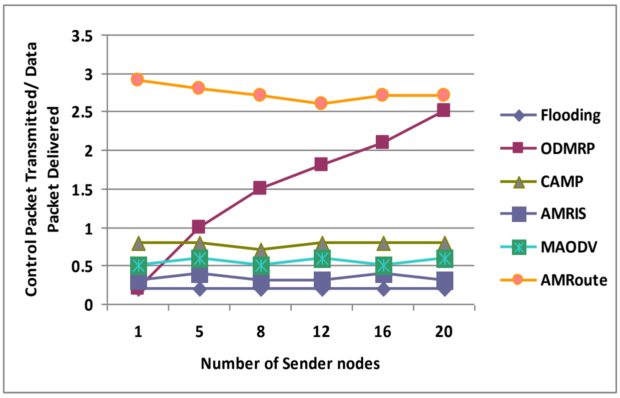

Fig6- Control overhead in number of senders

VI. Conclusion

It is observed that effectiveness of different protocols fluctuate with the underlying application environments. The various open issues of reliable multicasting for the further study and analysis are discussed in this paper. The study and simulated examination of various ad-hoc network multicast protocols under change in mobility speed and number of senders are measured with respect to deliver ratio, data overhead, control overhead and traffic overhead. The analysis in the paper bring out that normally, mesh based protocols perform better than tree-based protocols in a mobile situation, where multiple path add to the robustness to mobility.

ODMRP is better performed with respect to packet delivery ratio under high mobility requirements circumstances; also, there is need for the enhancement of protocol in terms of scalability.

Although AMRoute supports the scalability but the creation of loops degrades its performance, it necessitates for the suitable management and solution of loops. In the network scenarios; high mobility, and greater number of senders; AMRoute is most inefficient protocol. AMRIS increases the network traffic due to transmission of beacons. It is significant to research on size and transmission rate of beacons in terms of the management of network traffic. With regard to CAMP and MAODV suitable research work is required to improve data delivery ratio.

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