AN ANALYSIS OF NETWORK CODING AND BANDWIDTH SATISFIED MULTICAST ROUTING PROTOCOL IN MANET

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***Abstract*:** Multicast is an efficient strategy for transmitting information and data to several recipients at the same time. The prior quality-of-service (QoS) routing/multicasting protocols in mobile ad-hoc networks decided the bandwidth-fulfilled routes for QoS applications. But, they are affected by two bandwidth-infringement issues, such as, the hidden route problem (HRP) and the hidden multicast route problem (HMRP). HRP may come up if a new flow is allowed and just the bandwidth consumption of the hosts present in the neighborhood of the route is computed. In a similar manner, HMRP may come up if a number of flows are allowed simultaneously. The bandwidth consumption of two-hop neighbors being not considered is the cause behind the introduction of the two issues. Network coding is a mechanism that is evolving and presently used in wireless networks for improving the network throughput and other performances. In this survey, the fundamental concept of the coding conditions to find a coding host is reviewed. Then the bandwidth consumption of a coding host is estimated under the contention-based wireless networks with a random access technique. In addition, this research work analyzed a Bandwidth-Satisfied and Coding-aware Multicast Routing Protocol (BCMRP) aimed to build a bandwidth-satisfied multicast tree for real-time multicast service in MANETs, with the goal of minimizing the overall bandwidth consumption of all the forwarders present in the multicast tree. The bandwidth-satisfied and coding-aware multicast routing protocol (BCMRP) offers a greater admission ratio and lesser bandwidth consumption exploiting the benefits of network coding.

IndexTerms - Mobile ad-hoc networks (MANET), Quality-of-Service (QoS), bandwidth-satisfied, multicast routing, coding-aware, network coding.

1. INTRODUCTION

Mobile ad-hoc networks (MANETs) are evolving quickly in the form of a novel technology recently, which have gained the attention of researchers due to its probable applications in different fields, such as last mile broadband Internet access. Mobile ad-hoc networks comprises of wireless hosts, which communicate with one another, with a stable infrastructure absent [1]. Owing to considerations like radio power constraints, power consumption, and channel usage, a mobile host may not be capable of directly communicating with other hosts in a single-hop fashion. A multi-hop scenario happens, where the packets transmitted by the source host are re-sent by various intermediate hosts prior to getting to the destination host. Ad-hoc wireless networks are composed of mobile nodes that are interconnected by multi hop communication paths. Dissimilar to the traditional wireless networks, ad-hoc networks do not have stable network infrastructure or administrative support [2]. Owing to bandwidth limitations and dynamic topology of mobile ad-hoc networks, providing support to Quality of Service (QoS) is an intrinsically complex, hard challenge and very significant research challenge.

An extensive range of applications that involve one-to-many, many to-many, and many-to-one type communication could take advantage from the effective bandwidth usage of multicast. Multicasting, a one-to-many communication, is inspired by the rising significance of real-time and multimedia applications [3]. Multicasting is a suitable technique for sharing information in a network as it can deliver the messages from the source to a pool of destinations with less resource simultaneously. The provisioning of a quality-of-service (QoS) assurance is very essential in developing future wireless networks [4], owing to the considerable improvement in real-time and multimedia applications with QoS demands.

Multicast routing is an efficient means of communicating among a number of hosts in a network. In the case of multicast communication, a single source node transmits a message or information to a set of receivers at the same time, and transmits it just once, even when it has to be sent to a huge number of receivers [5]. Multicasting protocols attempt to reduce the consumption of network resources by benefitting from the fact that few segments of the paths from the source to the destinations could be shared by a number of destinations. The much large the path gets shared, the lower will be the overall bandwidth consumption [6]. For resource-constrained wireless network, multicast communication takes full advantage of wireless broadcast and has been extensively used in multimedia applications with various quality of-service (QoS) needs.

But, the multicast routing protocols in from the hidden route problem (HRP) and the hidden multicast route problem (HMRP) that may result in bandwidth infringement of the requested flow and the current flows. The HRP and HMRP results if the forwarders just consider their neighbors, but not all of their cs-neighbors, during the construction of the tree [7]. To yield a QoS-satisfied multicast, it must be ensured that the forwarders, along with their cs-neighbors, have adequate residual bandwidth. The multicast routing issue with several QoS constraints that may involve the delay, bandwidth and packet loss measurements is explained, and a network model for examining the ad-hoc network QoS multicast routing problem is accomplished in the worst case scenario [8]. The multi-constrained QoS-based multicast routing algorithm has been shown to be NP-hard problem [9]. As the global information is required for these algorithms, the global information is hard to attain in MANETs also.

Along with meeting QoS demands, a multicast routing protocol also needs to get the multicast routes, which can reduce the bandwidth consumption of the flow requested, such that the resource usage of wireless networks can be enhanced by including multicast applications to the maximum extent possible[10], [11]. In the last few years, network coding has emerged to be a novel methodology used to unicast/multicast routing protocols for minimizing the bandwidth consumptions. Moreover, as the broadcast nature of a wireless channel renders the network coding to be beneficial in terms of bandwidth consumption, a rising interest is seen to use network coding to wireless networks [12].By making use of network coding, a forwarder can act as a coding host that can have coding chances to send the coded packets that are encoded from packets, which belong to various traffic flows, minimizing its bandwidth consumption.

Network coding is a method where the relay nodes combine packets utilizing a mathematical operation that minimizes the number of packets transmitted [13]. It is a coding conception that is a hugely effective transmission approach that has brought about a fundamental change in the way of delivering the data packets in communication networks. Dissimilar to conventional store-and-forward packet delivery approaches, network coding realizes store, code, and forward technique, where every node stores the incoming data packets in its buffer, mixes the information in various data packets when coding condition shows up, and the coded packets is sent [14]. It is revealed that network coding lets the communication to attain a greater throughput. Network coding was first introduced for wired networks to resolve the bottleneck and to maximize the throughput. But, the broadcast nature of wireless networks and the versatility of the links render the network coding to be more interesting in wireless networks [15].

At last, this research work introduces a survey on bandwidth-conscious multicast routing algorithm that attempt to minimize the bandwidth consumption for attaining a better network performance by reducing the number of forwarders in a tree. This research work described about a bandwidth-satisfied and coding-aware multicast routing protocol (BCMRP). By considering the residual bandwidth of the carrier-sense neighbors of the forwarders, this protocol can meet the bandwidth demands of the requested flow and other flows that are ongoing. As a result of taking the coding chances in multicast tree construction into construction, this multicast protocol can minimize the overall bandwidth consumption.

The overall organization of the research mechanism is provided as below: This section introduces about the Mobile ad-hoc networks (MANETs), Multicast routing, Network coding. Section 2 explains about the different associated research mechanisms along with their operational procedure. Section 3 provides the performance assessment of the recent techniques on the basis of simulation results. At last in section 4, the conclusion of the review work is provided.

2. LITERATURE REVIEW

This section discusses about the different approaches used in multicast protocol and also evaluates the advantages and drawbacks of all these methodologies.

Mnaouer et al (2007) introduced an optimized, polymorphic, hybrid multicast routing protocol for MANET. This novel polymorphic protocol tries to take advantage from the high efficacy of proactive behavior (in terms of rapid response to transmission requests) and the less network traffic overhead of the reactive behavior, when staying power, mobility, and vicinity-density (in terms of the number of neighbor nodes per specific region around a mobile node) conscious. The newly introduced protocol is dependent on the principle of adaptability and multi behavioral modes of operations. It is capable of changing behavior in various conditions with the aim of improving few metrics such as increasing battery life, minimizing communication delays, enhancing the deliverability, etc.

Aceves &Mendez (2011) studied about a framework for integrated routing in MANETs through PRIME to create meshes, which are activated and deactivated by the existence or absence of interest in different destination nodes and groups and restricts much of the signaling overhead within areas of interest (enclaves) in these meshes. The routes created in PRIME are revealed to be independent of permanent loops. Experimental results dependent on elaborate simulations reveal that PRIME achieves identical or better data delivery and end-to-end delays compared to conventional unicast and multicast routing approaches for MANETs (AODV, OLSR, ODMRP). The experiments also demonstrate the signaling in PRIME.

Chen et al (2018) built a multicast tree, which is a delay-aware multicast protocol used for real-time applications in multi rate MANETs. With the aim of increasing the network potential, the newly introduced multicast protocol tries to reduce the sum of the overall transmission time of the forwarders and the overall blocking time of the blocked hosts, by considering the neighboring information of the forwarders and correctly adjusting the data rates of the forwarders. Simulation results reveal that the novel delay estimation approach offers more accuracy, in comparison with earlier works.

Xiang et al (2010) introduced a new Robust and Scalable Geographic Multicast Protocol (RSGM). Various virtual architectures are utilized in the protocol without having to maintain the state information for more reliable and scalable membership management and packet forwarding in the existence of high network dynamics owing to inconstant wireless channels and node movements. Particularly, scalable and effective group membership management is carried out by means of a virtual-zone-based structure, and the location service for group members is combined with the membership management. Both the control messages and data packets are then forwarded along effective tree-like paths, however it is not needed to explicitly form and actively preserve a tree structure.

Chen et al (2017) studied about a multicast routing protocol, which builds several multicast trees and uses the network coding for lossy MANETs, where every multicast tree can meet a predetermined percentage of the bandwidth needs. The newly introduced protocol can minimize the overall bandwidth consumption when rendering bandwidth ensures a requested flow and ongoing flows. Due to the usage of network coding, no repetitive packet is created, and a scheduling algorithm for distribution of packets amongst the multicast trees is not required. Simulation outcomes reveal that the performance of the new protocol is much better than the earlier multicast routing protocols in terms of the receipt ratio, the admission ratio, and the overall bandwidth consumption.

Shankar & Ilavarasan (2014) introduced an effective Zone based Geographical Multicast Routing (ZGMR) protocol for attaining a resourceful and scalable group communication in a dynamic network topology. It uses a stateless unicast routing protocol for transmitting the data packets separately to all multicast members. This research work establishes the virtual zone based structure utilizing a group of multiple zone members and consists of the link duration depending on greedy selection for the implementation of the scalable group membership management. It includes two metrics like distance and link duration to choose the data forwarding nodes, and adapts the tree structure to deal with the dynamic network topology. Therefore, the sender node knows the location information accurately and chooses the highly adaptive forwarding node with longer duration.

Dahal & Ray (2016) analysed an Enhanced Multicast Routing Protocol (EMRP) for MANET. It is dependent on MAODV. The proposed EMRP functions in two stages: (i) Route Discovery and Multicast Tree Formation (ii) Multicast Tree Maintenance. EMRP chooses the path depending on node lifespan and hop count to the destination node. A technique is utilized for reducing the route discovery during link breakage. A node makes use of two hop neighbor information for repairing the link. The new protocol is then compared with previous ones. It is observed from the simulation results that the newly introduced EMRP offers greater throughput.

Hu & Zheng (2011) demonstrated an efficient packet selection algorithm, known as Weight Pick, for boosting the efficacy of a network coding based retransmission protocol to be used for mobile communication networks. Dissimilar to the earlier packet selection algorithms, Weight Pick presents the concept of dynamic combination number for carrying out network coding. On the basis of this concept, a base station dynamically decides the number of packets integrated or encoded in a retransmitted packet depending on the ongoing packet receiving status and the combination number for every retransmitted packet can be dissimilar. Simulation results reveal that Weight Pick can considerably enhance the retransmission performance in comparison with the available packet selection algorithms in terms of packet loss ratio and the number of packets transmitted.

Tao et al (2011) introduced a protocol that is based on network coding and simple XOR to avoid the drawbacks in On-Demand Multicast Routing (ODMRP) protocol. The results of NS2 (Network Simulator version 2)simulation have shown that the enhanced protocol can minimize the consumption on the control packets, the number of packet forwarding and conserves energy.

Fanous & Ephremides (2010) suggested a protocol that uses the Network-level cooperation, in contrary to the conventional physical layer cooperative protocols; and moreover, it makes use of random linear network coding at the relay node. The traffic is supposed to be bursty and the relay node then forwards its packets during the idle time periods of the source that permits for better usage of channel resources. The results reveal that collaboration results in greater stable throughput rates compared to traditional retransmission policies. In addition, the usage of random linear network coding at the relay can improve the stable throughput more with rising network coding field size or incrementing the number of packets over which encoding is carried out.

Tan et al (2013) suggested a Partial Network Coding based Real-time Multicast (PNCRM) approach for assisting real time multicast services in Mobile Ad-hoc Networks (MANETs). PNCRM integrates the partial network coding along with the creation of mesh. It can not just decrease the delay in an efficient manner, but also considerably improves the over all throughput performance. Simulation results indicate that, in an extensive range of scenarios with different number of receivers and/or high mobility, PNCRM performs better than PUMA or conventional network coding based real-time multicast protocols considerably in terms of packet delivery ratio and end-to-end delay.

Cao et al (2013) introduced a random network coding algorithm for mitigating this drawback. Network simulation results with OPNET reveals that the novel protocol efficiently increases the network survivable cycle in fixed network size scenarios. The performance of network delay and throughput also increased to a specific degree.

Chen et al (2018) introduced and explained about the coding conditions to find a coding host. Then the bandwidth consumption of a coding host is estimated under the contention-based wireless networks using a random access scheme. At last, a bandwidth-satisfied and coding-aware multicast routing protocol (BCMRP) is proposed. By considering the residual bandwidth of the carrier-sense neighbors of the forwarders into consideration, the newly introduced protocol can meet the bandwidth demands of the requested flow and other ongoing flows. As a result of taking the coding chances in multicast tree construction into account, the new multicast protocol can minimize the overall bandwidth consumption. The simulation results indicate that BCMRP performs better than the earlier multicast routing protocols in receiving ratio, admission ratio, and overall bandwidth consumption.

3. COMPARISON ANALYSIS

Table 1. Comparative analysis on various techniques of multicast protocol

Author name	Method	Advantages	Disadvantages
Mnaouer et al (2007)	An Optimized Polymorphic Hybrid Multicast Routing (OPHMR)	(i) It has rapid response to transmission response. (ii) It also increases the battery life, minimizes the communication delays, and enhances the deliverability.	Requires improvement in packet delivery ratio and end to end delay performance.
Aceves &Mendez (2011)	Protocol for Routing in Interest- defined Mesh Enclaves (PRIME)	(i) It has greater packet delivery ratio and lesser communication overhead. (ii) It offers good performance for huge networks.	There is a probability for packet losses owing to load congestion.
Chen et al (2018)	Delay sensitive multicast protocol	This multicast protocol can meet the delay demands of the requested flow and ongoing flows, while preventing HRP/HMRP.	The process is time consuming and also requires more energy for transmission.

Xiang et al (2010)	Robust and Scalable Geographic Multicast Protocol	The stateless virtual-tree-based structures considerably minimizes the tree management overhead, assists in more effective transmissions, and renders the transmissions to be more reliable to dynamics.	It is not effective for huge networks.
Chen et al (2017)	Multiple Multicast Trees	It minimizes the overall bandwidth consumption while providing bandwidth guarantees to a requested flow and ongoing flows.	The process is time consuming and requires improvement with regard to performance.
Shankar & Ilavarasan (2014)	Zone based Geographic Multicast Routing Protocol	The group membership maintenance and multicast data transmission successfully carry out their tasks with the help of the accurate location information, which minimizes the routing overhead and access delay.	Lesser temporary link disconnection rate.
Dahal & Ray (2016)	Enhanced Multicast Routing Protocol (EMRP) based on MADOV	This approach renders a greater throughput value.	Has to enhance performance in terms of mobility.
Hu & Zheng (2011)	Weight pick algorithm.	It yields an effective transmission of packets.	The prior transmission will not be done again if any error is observed during the transmission process.
Tao et al (2011)	A simple XOR to prevent the deficiencies in ODMRP protocol (NX-ODMRP)	It minimizes the number of transponders and energy consumption.	Requires enhancement in performance and energy consumption.
Fanous & Ephremides (2010)	Network-level Cooperation – Random Linear Network Coding	It offers a maximum stable throughput rate and in addition, greater throughput gain can be achieved by making use of random linear network coding at the relay.	Requires improvement in the energy efficacy.
Tan et al (2013)	Partial Network Coding based Real-time Multicast (PNCRM)	It minimizes delay efficiently and enhances the throughput value with lesser latency and low overhead.	Requires improvement in performance for multiple multicast networks.
Cao et al (2013)	Random Network Coding	It increases the throughput value and efficacy of the network.	The failure of transmission packets have to be reduced.
Chen et al (2018)	Bandwidth-Satisfied and Coding-Aware Multicast Protocol (BCMRP)	It prevents HRP/HMRP, and meets the bandwidth demands for the requested flow and ongoing flows.	(i) It will function under the conditions that a host can act as a coding host defined, Based on the packet categories received/Over heard by every host. (ii) Process takes time consuming.

4. PERFORMANCE EVALUATION

This section analyses the performance of different methods such as, ODMRP, PNCRM and BCMRP in terms of packet delivery, bandwidth consumption and throughput value for differential number of nodes. During the simulation, the data rate was fixed to 11 Mbps and the transmission power was fixed to 0.0316 W [28]. A host is a transmission neighbor of another host when the signal-to interference- plus-noise ratio (SINR) values of the packets obtained from the latter exceeds 11 dB. The simulation examined the impacts of bandwidth fulfillment and the coding-aware multicast tree over the performance of BCMRP.

4.1 Bandwidth consumption

Bandwidth is defined to be a range within a band of frequencies or wavelengths. Bandwidth also refers to the amount of data, which can be transmitted in a given amount of time. In this, the comparison between the range of bandwidth for different techniques such as ODMRP, PNCRM and BCMRP.

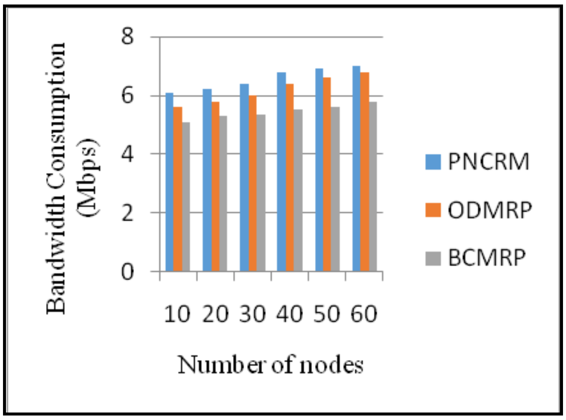

Figure1. Comparison of various techniques on bandwidth consumption in mbps

Figure1. Illustrates the comparison made on different methodologies on bandwidth consumption in mbps. The bandwidth consumption of PNCRM comes to 6.9mbps, ODMRP comes to 6.6mbps and BCMRP has 5.6 mbps at node 50. It can be seen from this analysis that the bandwidth consumption is low for the technique BCMRP in comparison with other two approaches.

4.2 Packet delivery Ratio

Packet delivery ratio is defined to be the ratio of data packets obtained by the destinations to those created by the sources. In mathematical terms, it can be defined as: PDR= S1÷ S2 Where, S1 refers to the sum of data packets received by every destination and S2 stands for the sum of data packets created by every source.

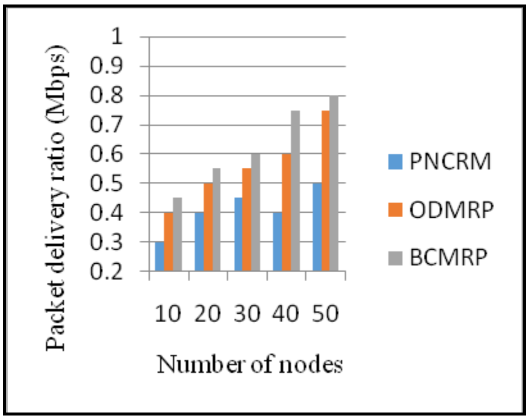

Figure2. Comparison of various techniques on Packet Delivery Ratio in mbps

Figure2. Illustrates the comparison analysis made on different methodologies in term of Packet Delivery Ratio with regard to the number of nodes. The technique BCMRP provides a higher Packet Delivery Ratio in comparison with the earlier ODMRP, PNCRM protocols. It is quite evident from the figure 2. the BCMRP offers greater Packet Delivery Ratio in comparison with all other two techniques.

4.3 Throughput

Network throughput represents the typical ratio of packet delivery made successful over a message channel. Throughput is generally measured in bits per second (bit/s or bps), and at times in data packets per second (p/s or pps) or data packets per time slot.

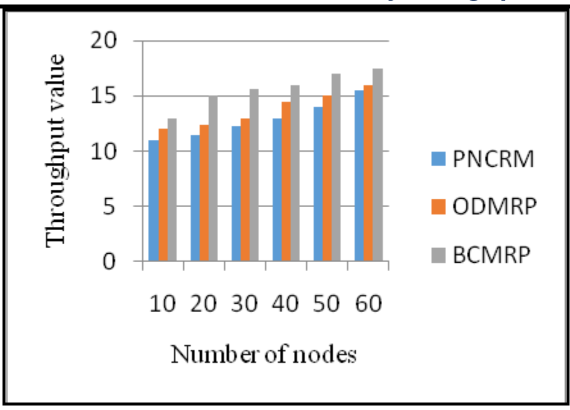

Figure3. Comparison of various techniques on throughput value (b/s)

Figure 3. Illustrates the comparison analysis made on different methodologies in terms of throughput value with regard to number of nodes. The technique PNCRM achieves a throughput value to be 14bits/second, ODMRP has a throughput value as 15 bits/second and BCMRP achieves a throughput value as 17bits/second with the node value 50. It is quite evident from the figure 3. that BCMRP offers a greater throughput value in comparison with all other two techniques.

5. CONCLUSION

In this research work, with the aim of effectively making the best use of wireless resources and yield QoS guarantees for real-time multicast services in lossy MANETs, a bandwidth-satisfied multicast protocol with network coding has been evaluated. Many of the earlier routing/ multicasting protocols for MANETs (with ideal links) were affected by two bandwidth violation issues, i.e., the HRP/HMRP, as a result of not considering the resource consumption of the two-hop neighbors of forwarders. Moreover, for lossy MANETs, duplicate packets were transmitted on several routes to improve the reliability that consumed additional bandwidth. In this research, recently introduced network coding mechanism named Bandwidth-Satisfied and Coding-aware Multicast Routing Protocol (BCMRP) is targeted at constructing a bandwidth-satisfied multicast tree for real-time multicast service in MANETs, with the goal of minimizing the overall bandwidth consumption of all of the forwarders in the multicast tree. This newly introduced multicast protocol can prevent the HRP/ HMRP when rendering the bandwidth guarantees to a requested flow and ongoing flows. The simulation results indicate that the newly introduced BCMRP satisfies the bandwidth demands and offers a greater admission ratio and lesser bandwidth consumption by making use the benefits of network coding.

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