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# Reliable Multicast using Opportunistic Feeding and Inter-batch Coding

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***Abstract***

*In modern wireless networks, multicast is a very important technique to improve network performance, including throughput, delay, energy efficiency, loss monitoring, etc. The quality of wireless links in wireless networks is affected by many factors like collisions, fading, packet loss problem and noise. Multicast techniques and reliable multicast protocol are used to resolve these negative factors and improve throughput and reduce delay in lossy wireless networks. Point-to-multipoint data transmission over wireless IP networks occurs in multicast technology. Bandwidth of network saved and load on the network is reduced with the use of multicast technique. In this paper, the four key techniques named as LP-based opportunistic routing structure, opportunistic feeding, fast batch moving and inter-batch coding, are reviewed.*

***Keywords:*** *Multicast, opportunistic feeding,LP-based opportunistic routing structure,opportunistic feeding, fast batch moving, inter-batch coding.*

## 1. Introduction

In advanced wireless communication techniques, wireless networks have applications in various fields named as Interactive TV programs, video/audio conference, military commands, broadcast audio/video, multi-receiver data file transfer and control systems, distance education and smart transportation systems. In all of above these applications, reliable multicast is an advanced method developed to spread information from a single source to multiple destinations and also improve its performance in wireless environment, including throughput, delay, energy efficiency, etc. In the ideal wireless network model, the wireless transmission links are loss-free, however in real wireless networks, the wireless transmission links are not loss-free because the quality of wireless links is affected by many factors named as fading, collisions or noise etc. [1]. Cooperation between nodes in lossy wireless networks is improving the multicast performance. When a destination node is not more able to receive a packet from its direct source node than other neighboring nodes that have successfully received can properly feed the packet to that destination node. Both forwarder-cooperation and destination cooperation is present in a reliable multicast protocol. Code-Pipe improves the multicast throughput and achieves coordination between nodes as well, by using both inter-batch and intra-batch coding techniques. It is mostlyused in multimedia conferencing, real-time data transmission, Multi-player games, High-speed www, Video-conferencing, Video-on-demand, and data duplication. The purpose of this paper is to find out the network throughput, cumulative sum, and end to end delay, etc. in wireless networks. In multicast network, a source node generates messages and multiple receivers who are present in the network collecting these messages. In this paper, Section 2 describes the information related to unicast, broadcast, and multicast methods. Section 3 presents system model, protocol overview and brief description of four key techniques and process of joining and

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leaving the network. Section 4 provides simulation parameters and results, which describes the information related to simulation parameters, their setup values, resultant values and their simulation graphs. Finally, Section 5 concludes this paper.

## 2. Background

Early communications fall into two modes: unicast and broadcast. In unicast, point-to-point communications are occurring between a source host and a destination host. In broadcast, point-to-multipoint communications is occurring between a source host and all destination hosts on the single subnet. By using broadcast method, most of the network bandwidth is a waste because the information is delivered to all hosts, except some predefined hosts that need the information. By using unicast method, a separate copy of information is sent to each host use a high amount of network bandwidth and also adds to the burden of the source host. In multicast group, multicast provides a best and effective service to deliver data packets to a particular set of receiver hosts on the network. By using multicast, the source host or a multicast source sends only a single copy of data packets to the particular address of the multicast group. Those hosts can only receive the data, which are present in the multicast group, but those hosts out of the multicast group cannot receive any same data packets. So, the conventional unicast and broadcast methods cannot effectively satisfy the advance requirements of wireless network. In this section, subsection 2.1 describes the working scenario of the system model and briefly describes four key techniques and subsection 2.2 describes the process of joining and leaving the nodes in the network step by step.

### 2.1 About System Model

To achieve high throughput and less delay in lossy wireless environment, opportunistic routing allows any intermediate node is participating in forwarding the packet that overhears a packet transmission and also closer to the destination. In the multicast, data are broken up into batches like b1; b2; b3. . . . ., each batch contains K connate packets. During transmission, a node creates a coded packet. Coded packets have broadcasted it to destination nodes. If it is independent from previous data packets, then this new one packet is entered into its buffer.

Otherwise, input is discarded when it arrives. A transmission from a source node can be successfully received by a destination node only within its transmission range otherwise not.

In this the following four key techniques are used to improve multicast throughput, cumulative sum, and delay etc.

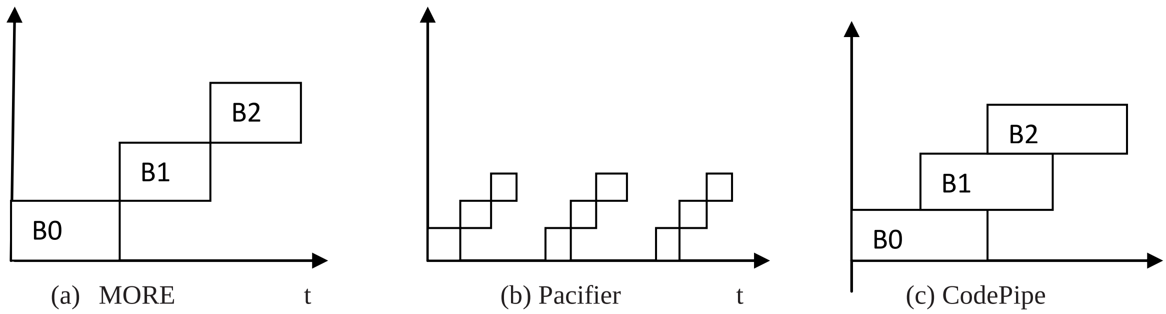
**(1) LP-based opportunistic routing structure**: ORS finds out the transmission rate of eachnode in the structure [4], [5]. To fulfill a desirable throughput, ORS boosts the forwarding set of each transmitter.

**(2) Opportunistic feeding:** By re-executing the linear programming, ORS is updated eachand every time. Destination can act as a cooperative source or feeder because it will feed and accelerate the received current batch at another destination node (host).

**(3) Fast batch moving:** ORS selects all destinations as cooperative sources and havethe capability to decoding of the current batch of all destination nodes. The batch window is also used to control the maximum numbers of batches that are allowed to coexist in the network. The original source node can start to send coded packets of the next batch and forms as a pipeline. Throughput is improved due to pipeline scheme.

**(4) Inter-batch coding:** Advantage of the fast batch moving scheme is the multiple batchesof data are coexisting in the network. It applies a great opportunity for inter-batch coding that could reduce the delay and enhance the throughput. Dynamic networks are those where nodes randomly join and leave the network with respect to time. In MORE, delay is high because batches are sending one after another. In Pacifier, delay is less than MORE but cause contention problem because batches are broken into packets and send simultaneously. In Code Pipe, delay and contention problem is reduced because batches are disseminated in pipeline manner and not broken into packets, shown in Fig 1.




(a) MORE (b) Pacifier (c) CodePipe

**Figure 1. Comparison of Different Batch Moving Schemes**

### 2.2 System Methodology

In real-time applications of multicast, where the membership status is not stable, like live TV service, cell phone or laptop users can join or leave at any time. Let us consider a network consisting of stationary nodes, but with dynamic member status, i.e., a destination node can join and leave the network at any time. Dynamic multicast membership is the global approach by sending all update messages to the original source(s) nodes. Upon receiving a message, so immediately updates the ORS according to the current network topology. When such updates are frequent, the resulting ORS update operations would impose a high burden at the source 's'. To overcome this problem, make the ORS update only when an ACK packet is received from a destination. As a result, the nodes that join the network cannot receive any packets as a destination or contribute to the multicast as a forwarder, during the period between two sequential ORS updates. Mechanism of inter-batch coding is shown in Fig 2.
Assume three metrics in protocol design:

(1) Destination throughput
(2) Response time or end to end delay
(3) Energy efficiency

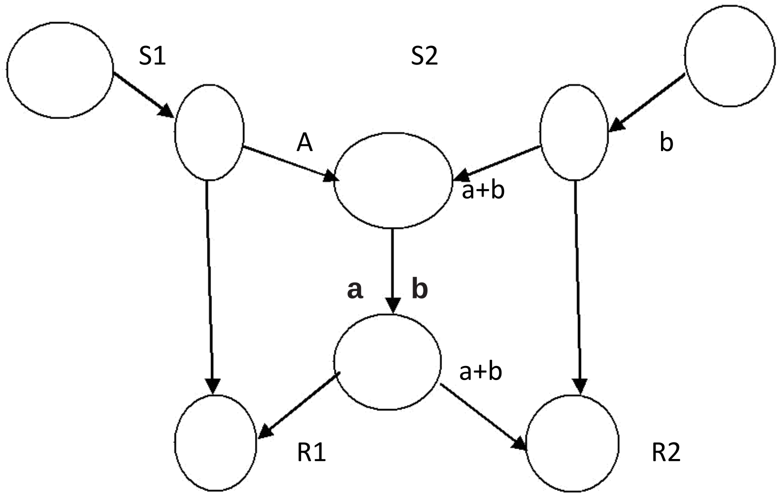



**Figure 2. An Illustrated Example of Inter-batch Coding**

To handle these problems like that:

(1) Any joining node achieves maximum throughput without degrading the performance of other destinations,

(2) Any leaving node minimizes the performance degradation.

**2.2.1 Participation of a node in the network:** First, consider the case that a node x joins thenetwork as a destination. The joining process contains five steps are shown in Fig. 3.

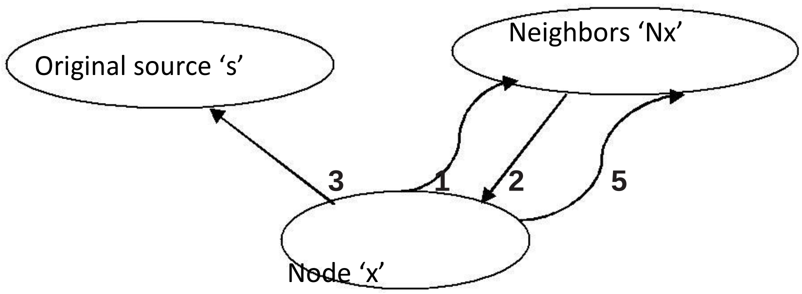



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**Figure 3. The Process of Joining the Network**

Step 1 (Broadcasting probe packets): When a node x joins the network, it starts to discover a neighbor by discovering the process by broadcasting probe packets. This is shown by arrow (1) in Fig. 3.
Step 2 (Return node information): After receiving such type of probe packets, any neighboring node Nx estimates the quality of links. After estimation, it returns the result as well as other related information to node x, which includes its membership status as well. This is shown by arrow (2) in Fig. 3.
Step 3 (Inform the original source): After collecting the information returned by its neighbors, node, 'x' immediately reports the participatory event with all its related link quality information to the original source 's', so the next construction of global ORS is based on an updated network topology. This is shown by arrow (3) in Fig. 3.
Step 4 (Local Optimization): Node x joins the multicast, via a local optimization to maximize its throughput while the performance of other destinations should be stabled,

 

shown in Fig. 3.

Step 5 (Inform the Result): After following all these steps the updated flow of each link are obtained. So, node, 'x' always sends the updated ORS to its neighbors. This is shown by arrow (5) in Fig. 3.

**2.2.2 The Departure of a Node in the Network:** When any destination x leaves the network, adopt alocal approach to optimize the data dissemination after its leaving. The corresponding process is illustrated in Fig. 4 and the details of each step are elaborated as follows.

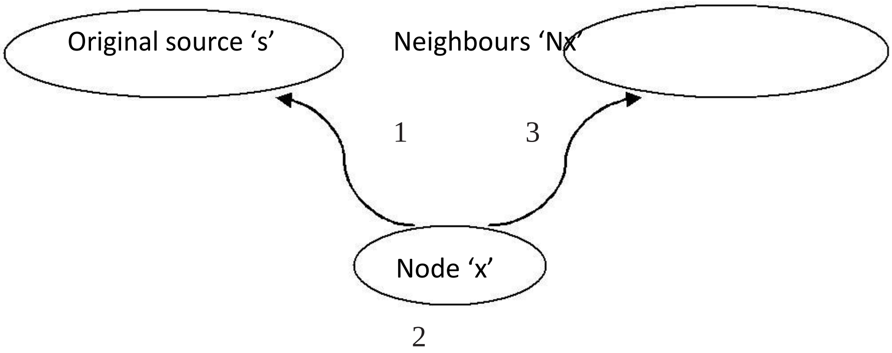


**Figure 4. The Process of Leaving the Network**

Step 1 (Inform the original source): When a destination x decides to leave the network, to inform the original source (s) of the departure event, it first sends a message such that it will be excluded in the next global ORS construction. This is shown by arrow (1) in Fig. 4.

Step 2 (Local Optimization): Node x always determines its neighbor'sactivitiesafter its departure. Since node x may act as a forwarder. Its departure would decrease the throughput at the corresponding destinations. Thus, the objective of local optimization is to minimize such type of performance degradation. This is shown in Fig. 4.

Step 3 (Inform the results): Finally, node, 'x' removes itself from destination set and sends the results of local optimization to its neighbors. To follow all the above steps, the node, then leaves the network. This is shown by arrow (3) in Fig. 4.

## 3. Related Work

Douglas S. J. *et al.* [1] described the expected transmission count metric (ETX), which finds high-throughput paths for multi-hop wireless networks. Sanjit Biswas *et al*. [2] described Ex-OR, an integrated routing and MAC protocol that increases the throughput of large unicast transfers in multi-hop wireless networks. ExOR is also increasing a connection's throughput than traditional routing. R. Ahlswede *et al.* [3] introduced a new class of problems called network information flow and it is inspired by computer network applications. This model subsumes all previously studied models along the same line. Bandwidth is saving by using network coding. Szymon Chachulski *et al.* [4] described opportunistic routing technique because it achieves high throughput in the lossy wireless links. The name of an opportunistic routing protocol is Ex-OR. This paper presents MORE, a MAC-independent opportunistic routing protocol. MORE mixes packets randomly before forwarding them. Dimitrios Koutsonikolas *et al.* [5] described Pacifier, a new high-throughput, reliable multicast protocol for WMNs. Pacifier integrates four building blocks which support high-throughput, reliable multicast routing in WMNs, name as, tree-based opportunistic routing, intra-flow network coding, source rate limiting, and round-robin batching. Sachin Katti *et al.* [6] described the bridge theory and also practical issues suffering the integration of network coding in the current network stack. Sudipta Sengupta *et al.* [7] described that COPE improves the throughput of unicast traffic in wireless multi-hop networks. It exploits the broadcast nature of the wireless medium through opportunistic network coding. In this throughput improvement obtained by COPE-type network coding in wireless networks. Yang Qin *et al*. [9] investigate the network throughput in ad hoc wireless networks under a cluster-based hierarchical routing scheme. Such hierarchical routing protocols can reduce the routing overhead. This paper provides a theoretical computation on the throughput of the ad hoc wireless networks under one hierarchical structure, i.e., cluster-based. Kazunori Yamamoto *et al*. [10] describe the performance of flow control schemes for reliable multicast under several retransmission approaches in terms of scalability. The schemes are a rate-based flow control scheme for NAK-based retransmission approaches and a window-based flow control scheme for ACK-based retransmission approaches. Chien-Chia Chen *et al.* [11] studies the performance of pipeline network coding for multicast stream distribution in high loss rate scenarios.

## 4. Simulation Setup Parameters and Results

### 4.1 About ns2

**NS** stands for **network simulator. Ns-1**, **NS-2** and **NS-3** are the name for a series ofdiscrete event network simulators. The goal to create an open simulation environment for networking research. It should be the need of modern networking research. In 1996-97, NS-version 2 (NS-2) was started by Steve McCanne. Use of Tcl was replaced by Object TcL (OTcl). OTcl is an object-oriented Tcl. The core of NS-2 is written in C++ and simulation scripts are written in the OTcl language. OTcl is an extension of the Tcl scripting language. Ns2 is used in this for simulation purpose.

### 4.2 Simulation Parameters

In this paper, a wireless network is design using the reliable multicast technique. Two Ray Ground propagation model and 802.11 MAC type are used. Droptail interface queue type and link layer type is used. In this design, omnidirectional antenna model and DSDV routing protocol are used. In this design 100 nodes are set up.

**Table 1. Description of Setup Parameters**

| Sr. no. | Parameters | Setup values |
|---|---|---|
| 1. | Channel Type | Wireless |
| 2. | Propagation | Two Ray Ground Model |
| 3. | MAC Type | 802.11 |
| 4. | Interface Queue type | Queue/ Droptail/ priqueue |
| 5. | Link Layer Type | LL |
| 6. | Antenna Model | Omniantenna |
| 7. | Routing Protocol | DSDV |
| 8. | Simulation Time | 150 |
| 9. | Antenna Height | 1.5 |
| 10. | Distance Covered | 550 |

 

### 4.3 Simulation Results

In this design 100 numbers of nodes are present. The numbers of sending nodes are 100 but receiving nodes are 2. The numbers of generating packets are 7248 and numbers of sending packets are 7237 and number of forward packets are 5121. The number of dropped packets is 21 and the numbers of lost packets are 13. The minimal size of packet is 32 and maximal size of packet is 1220. Maximum Delay occurs in this is 28.162, minimum delay occur in this is 0.0041 and the average delay occur in this is 0.25 s.The reliable multicast distribution tree is worked out in the ns2 simulation by using tcl script to follow out the multicast routing strategy. Sender transfers data to all the nodes in the multicast group.The multicast routing protocols can be work at every node in the network. All nodes are bonded to the multicast protocol agents.

**Table 2. Description of resulted parameters**

| Sr. no. | Parameters | Resulted values |
|---|---|---|
| 1. | Number of Mobile nodes | 100 |
| 2. | Number of sending nodes | 100 |
| 3. | Number of receiving nodes | 2 |
| 4. | Number of generated packets | 7248 |
| 5. | Number of sent packets | 7237 |
| 6. | Number of forward packets | 5121 |
| 7. | Number of drop packets | 21 |
| 8. | Number of lost packets | 13 |
| 9. | Minimal packet size | 32 |
| 10. | Maximal packet size | 1220 |
| 11. | Max. Delay | 28.162 |
| 12. | Min. Delay | 0.0041 |
| 13. | Average Delay | 0.25 |

### 4.4 Simulation Graphs

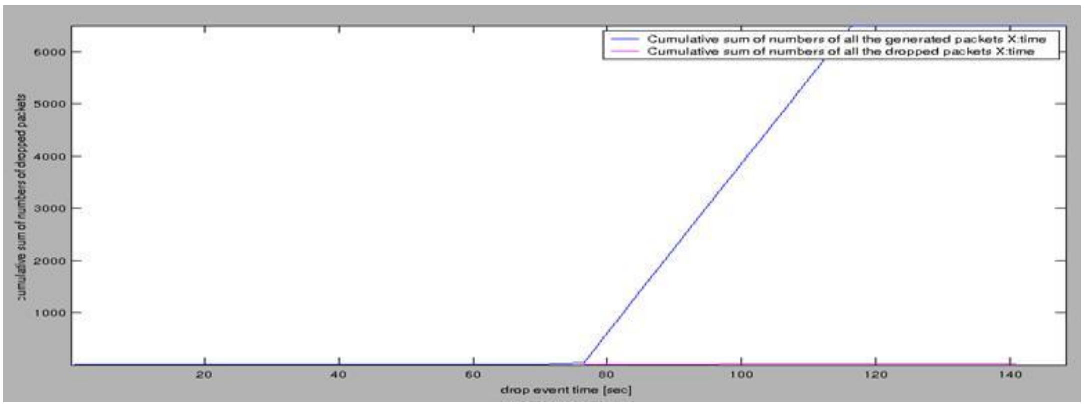


**Figure 5. Cumulative Sum of Number of all the Generated Packets and Dropped Packets**

 

Figure 5 shows Cumulative sum of the number of all the generated packets is more than droppedpackets in multicast mechanism but opposite in unicast mechanism. Amount of dropped packets is less; it means the outcoming packets are approximately equal to the incoming packets. In this number of generated packets are increased and dropped packets are low.

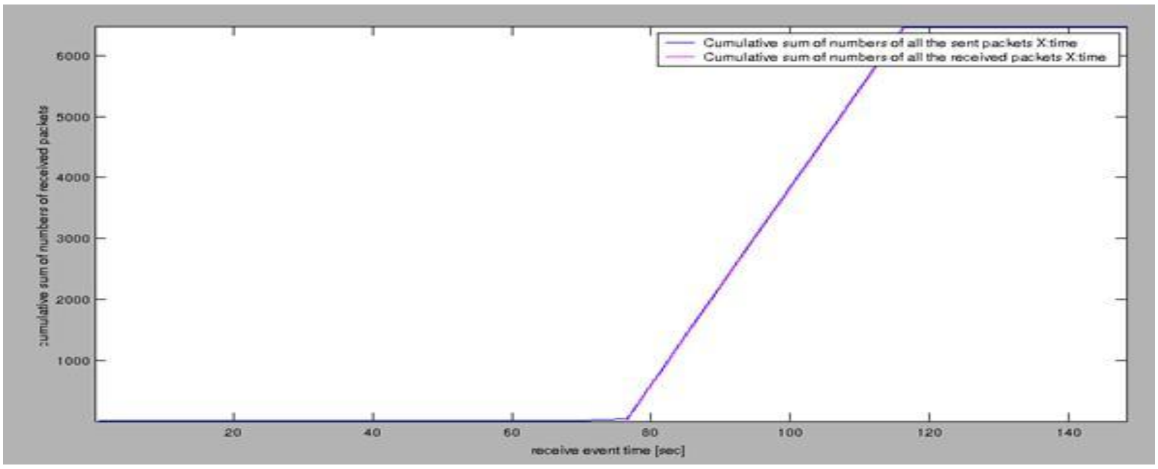


**Figure 6. Cumulative Sum of Number of all the Sent Packets and Received Packets**

The Cumulative sum of the number of all the received packets is nearly equal to the sent packets using multicast mechanism is shown in Figure 6. If the numbers of dropped packets are less than received packets are equal to the sent packets.

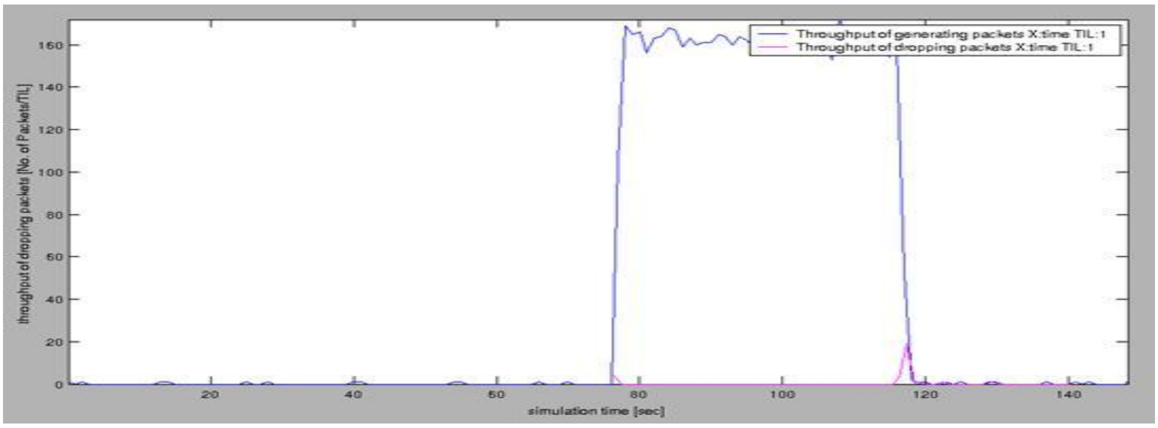


**Figure 7. Throughput of Generating Packets and Dropping Packets**

Throughput of Generating packets is more than throughput of Dropping Packets using multicast mechanism is shown in figure 7; means loss of data is very less. The throughputs of the dropping packets are less and the throughputs of the generating packets are high.

 

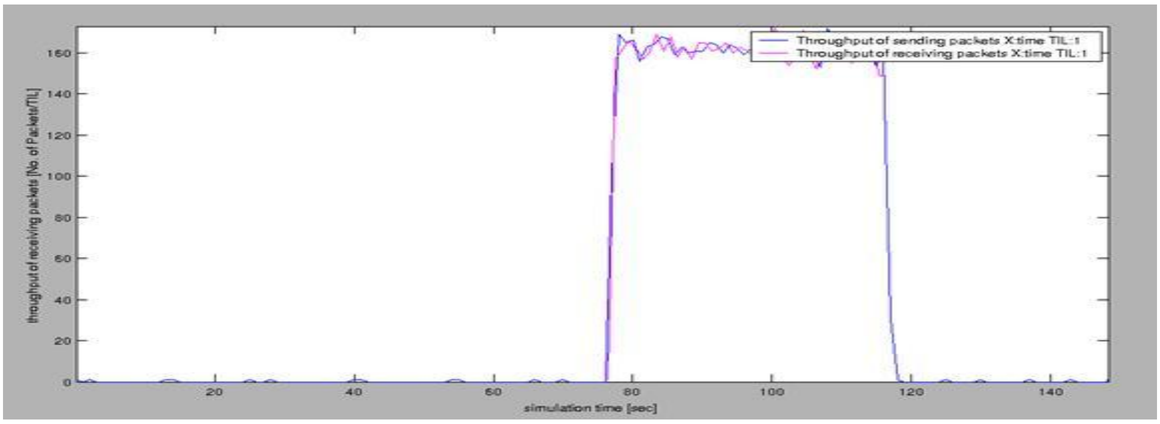


**Figure 8. Throughput of Sending packets and Receiving Packets**

The throughput of receiving packets is nearly equal to the sending Packets in multicast mechanism, shown in figure 8. If the numbers of dropping packets are less then, the receiving packets are approximately equal to the sending packets.

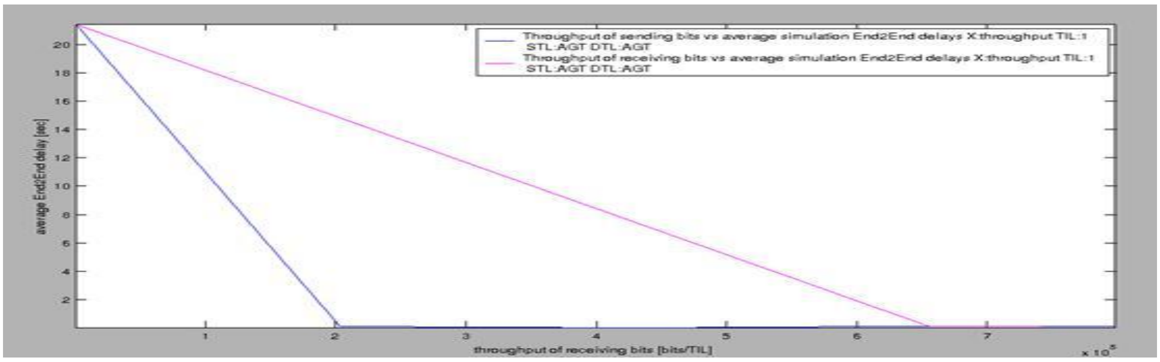


**Figure 9. Throughput of Sending or Receiving Bits vs Average End to End Delays**

Figure 9 shows a comparison between throughput by sending and receiving bits with average simulation end to end delay. By using multicast mechanism the average end to end delay is decreased with respect to sending and receiving bits.

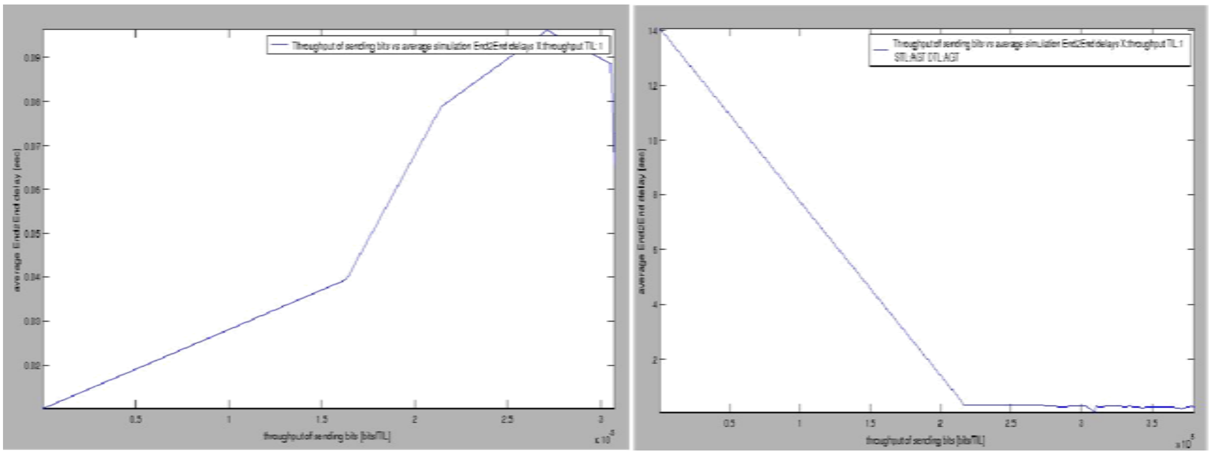

**Figure 10. End to End Delay of Unicasting and Multicasting**

End to End Delay of Unicasting is larger than End to End Delay of Multicasting, shown in Figure 10. When the delay is decrease than the performance of the network is increased. The main motive of this paper is to reduce delay and increased throughput.

## 5. Conclusion

This paper proposed a reliable multicast protocol in lossy wireless networks that rely on four key techniques LP-based opportunistic routing structure, fast batch moving, opportunistic feeding and inter-batch coding. Using these entire four techniques throughput, cumulative sum and end to end delay are improved. Through local optimization, the nodes that join the network can acquire services by a quick packet feeding from their neighbors. On the other hand, unnecessary packet transmissions can be avoided when nodes leaves the network. We performed a simulation analysis in ns2 which reveals that the current technique is much better than incest mechanism. In Unicasting, the End to End Delay was very high, but by using reliable multicasting, End to End Delay is kept very low.

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