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Comparison of Multicast Algorithms over Wireless Network

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Abstract— Multicast communication is a technique of passing information over large networks and it saves a lot of cost and resources. In this paper, the performances of three multicast algorithms used in wireless communication are compared based on their bandwidth utilization efficient multicast namely, the Improved Network Coding Algorithm (INCA) formulated as mixed Integer linear programming, the Network Coding Algorithm (NCA) formulated as linear program and the Multicast Incremental power algorithm (MIPA). Simulation was carried out and the results showed that the INCA with two performance metrics of loss and delay achieved reduction in the average cost of bandwidth used during multicast. For example when 60 randomly generated nodes were used multicasting to various groups of receivers, there was a reduction in the average cost of bandwidth used during multicast by 78% and 17% when compared to MIPA and NCA.

Index Terms— MIPA, NCA, INCA, Multicast in wireless network and Bandwidth Utilization.

I. Introduction

Multicasting in wireless networks has been intensively studied by using several heuristics algorithms. Multicast as a means of communication is an essential part of many next generation networks and there are limited network layer that support multicast in the Internet today. According to [1], multicasting is the transmission of messages in a group of nodes which is recognized by one and unique address. Multicast services allow one source to send information to a large number of receivers and it finds application in many areas such as audio conferencing, video conferencing, video-on-demand etc. [2, 3].

Multicasting over wireless networks is important but at the same time is a challenging goal in the field of wireless communication networks. It requires numerous issues to be addressed such as bandwidth, topology, loss of packets, delay, routing, reliability, security and quality of service, before it can be fully deployed [4]. Figure 1 shows the basic concept of multicasting.

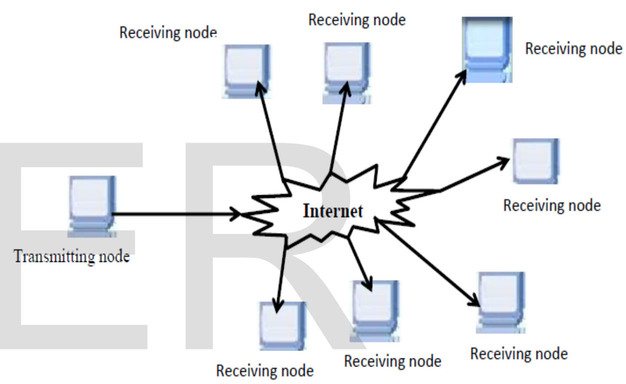

Figure 1.1: Basic Multicasting Concept [5]

In order to avoid sending several copies of the same message through the same link, multicast routing is used and this can be achieved by using a tree connecting the receivers to the same source. The problem of finding node transmission cost such that the total cost is minimized as an optimization problem is referred to as minimum cost multicast [6].

Two models are usually associated with multicast; the node-based model and link based model. The node based model is mostly used during multicasting because single transmission can be heard by several nodes rather than using a link based model where a node transmits separately to each of its neighbors resulting in increased cost of operation [7].

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The aim of this paper is to compare the performance of some few multicast algorithms namely, Multicast incremental power algorithm, Network coding Algorithm and the Improved Network Coding Algorithm for cost efficient multicast over wireless networks. The NCA and MIPA were proposed by [8] and [9] while, the INCA was proposed by [10]

This paper is divided into various sections, section I covers the introduction, section II deals with the review of related work. In section III, Multicast network model is logically presented and section IV presents few algorithms for Multicasting. Section V discusses and presents the simulation results, and finally section VI concludes the paper.

II. Review of Related Work

[11] examined low complexity distributed algorithm for computing minimum-Depth multicast trees in wireless networks. The algorithm was aimed at approaching only two wireless multicast problems with multicast tree while keeping forwarding nodes as low as possible and to obtained a multicast mesh for stability for various source to checkmate robustness to link failures and mobility. [12]worked on a cost delay shortest path algorithm for multicast tree stability in a dynamic networks environment under heavy traffic as the traffic changes. The algorithm attempts to balance the difference between the QoS parameters such as delay and cost. [13] studied the performances of Multicast Incremental Power algorithm (MIPA) and Network Coding Algorithm (NCA) for minimum cost of multicast over wireless network. Simulation results shows that the NCA outperformed the MIPA for cost efficient multicast over coded packet wireless networks. [10] improved the performance of the NCA by considering two key performance metrics namely packet delay and packet rejection aimed at minimizing the cost of average cost of bandwidth used during multicast over wireless network. Simulation result shows that with two performance metrics, the average cost of bandwidth was minimized by a reasonable amount.

III. Multicast Network Model

A network model is a clear description of how a set of network layers interact with each other within the network.

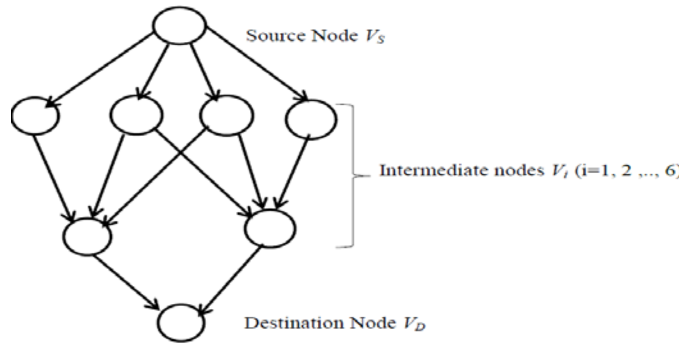

Figure 2: Multicast network Model [10]

The nodes in set V can be of the following three types (source node, intermediate nodes and destination nodes) and they are all called the nodes of the multicast group V_m. In other to improve the utilization of the network, the random linear network coding is assumed to be used in the multicast flows, and network coding allows the flows of a multicast session to share network capacity by coding them together [14]

IV. Algorithms for Multicasting

Three algorithms have been considered for multicast wireless networks in this work. These algorithms are, the existing Multicast Incrementing Power Algorithm formulated as an optimization problem to minimize the cost of multicast tree. Secondly, the Network Coding Algorithm formulated as a linear program and lastly, the Improved Network Coding Algorithm formulated as mixed integer linear programming framework.

a). The Multicast Incremental Power Algorithm: the algorithm was proposed by [9] and it can be used to compute the cost of energy consumption for both broadcast and multicast tree in wireless networks. Minimum cost tree algorithms are heuristic algorithms aimed at minimizing the overall cost of the tree and they are based on the minimum Steiner tree problems, which is NP-complete [14]. NP-complete problems are classes of problems that are widely believed that it is impossible to solve effectively using a specific algorithm.

b). Network Coding Algorithm: this algorithm was proposed by [8] and it is used for solving multicast problems by reducing it to polynomial time solvable optimization problem. The algorithm employs the used of network coding approach for real time multicast network and it has been developed within the framework of linear program.

c). The Improved Network Coding Algorithm: the INCA was proposed by [10] and this is an extension of the work carried out by [13] were the NCA can be improved by collectively considering two key performance metrics namely packet delay and packet loss. The multicast problem was formulated as mixed integer linear programming framework.

V. Simulation Results and Discussion

Simulations were carried out for 60, 70, 80 and 90 randomly generated nodes multicasting to groups of receivers using the same simulation pattern in order to agree with the results presented by [13] and the cost of multicast were obtained and presented.

Table 1: Cost of multicast for 60 randomly generated nodes

No. of receivers	Cost of Bandwidth		
	(MIPA)	(NCA)	(INCA)
2	8.6830	2.2322	1.8676
3	15.448	2.7653	2.5694
4	11.676	1.6617	1.4818
5	17.524	5.0950	4.7344
6	18.807	6.6742	4.2993
7	17.746	5.1722	3.7835
8	24.285	6.1766	5.9203

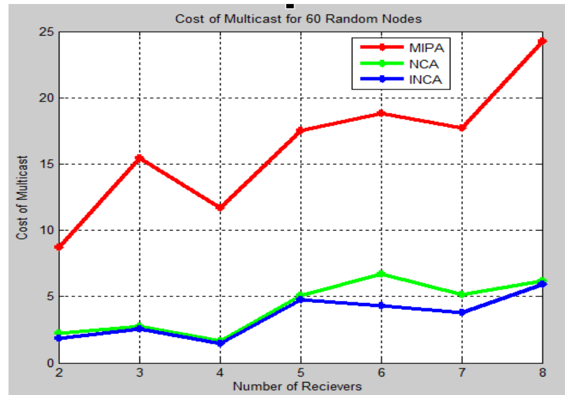

Figure 3: Performance results for 60 randomly generated nodes multicasting to group of receivers.

In Figure 3, the simulation results presented by INCA outperformed the results presented by MIPA and NCA. For instance, the cost of multicast when there are seven receivers yielded 17.745, 5.1722 and 3.7835 for MIPA, NCA and INCA respectively. Similar results are observed for two, three, four, five, six and eight group of receivers.

Table 2: Cost of multicast for 70 randomly generated nodes

No. of receivers	Cost of Bandwidth		
	(MIPA)	(NCA)	(INCA)
2	10.829	2.1989	1.3733
3	11.587	2.4378	1.6463
4	15.077	3.9606	2.6533
5	13.199	6.5154	4.4382
6	19.635	5.8008	3.5805
7	24.390	7.5415	5.9904
8	27.253	7.3358	5.4878

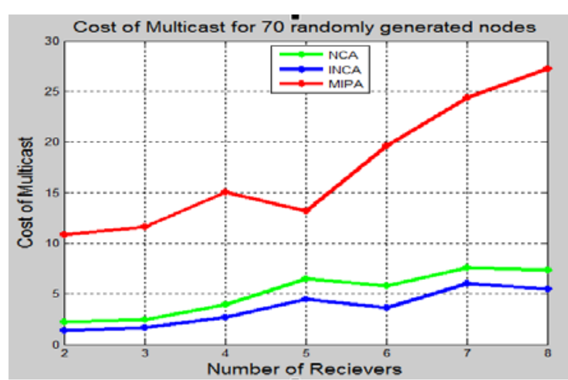

Figure 4: Performance results for 70 randomly generated nodes multicasting to group of receivers.

It can observe from Figure 4 that the cost of bandwidth depends largely on the performance of the multicast algorithms developed and the performance metrics considered. For example, in all the sets of randomly generated nodes, the INCA recorded the lowest consumption of bandwidth when compared with NCA and MIPA. The results presented showed that the INCA with loss and delay of packets achieved a reduction in the average cost of bandwidth by 79.4% and 29.7% for 70 randomly generated nodes multicasting to various groups of receivers.

Table 3: Cost of multicast for 80 randomly generated nodes

No. of receivers	Cost of Bandwidth		
	(MIPA)	(NCA)	(INCA)
2	9.4747	1.7148	1.2911
3	10.7794	2.2160	1.4136
4	15.8787	3.7686	3.1239
5	16.7105	4.6060	3.6566
6	19.8834	5.7069	4.4924
7	22.0798	7.2867	4.7107
8	27.2535	7.8046	5.5230

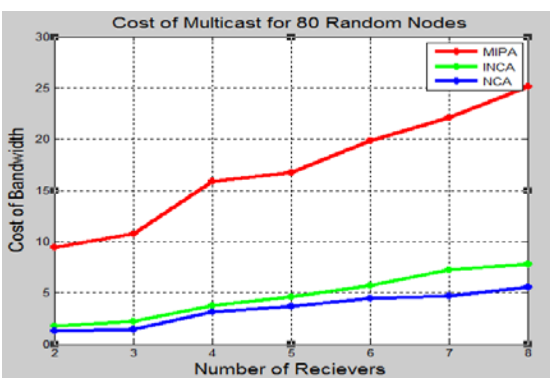

Figure 5: Performance results for 80 randomly generated nodes multicasting to group of receivers.

It can be observed that the cost of bandwidth during multicast increases as the number of receivers increases for all the numbers of randomly generated nodes. The INCA achieved a reasonable reduction in the average cost of bandwidth during Multicast when compared with NCA and MIPA. For example, when 70 randomly generated nodes were used with the multicast network multicasting to different groups of receivers, the INCA with delay and loss of packets achieved a reduction in the average cost of bandwidth used during multicast by 80% and 26.8% when compared with MIPA and NCA. Similar results with different percentage of lessening in the average cost of bandwidth are also observed in Figures 5 and 6 for 80 and 90 randomly generated nodes.

Table 3: Cost of multicast for 90 randomly generated nodes

No. of receivers	Cost of Band width		
	(MIPA)	(NCA)	(INCA)
2	10.6185	1.5485	1.0738
3	15.7079	2.4472	2.1387
4	16.7604	3.0309	2.8710
5	13.1769	4.6266	4.4886
6	14.4519	5.9491	2.6338
7	17.9528	4.9986	4.7146
8	18.2964	6.5523	5.1668

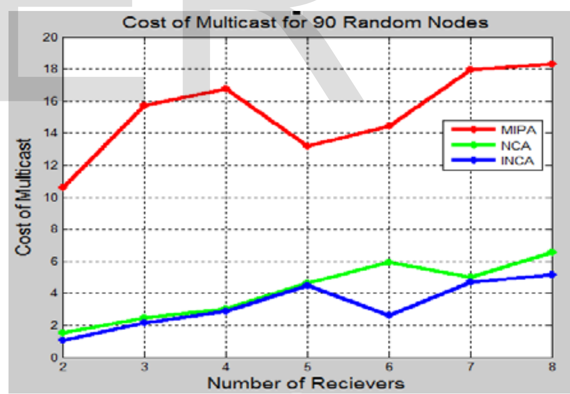

Figure 6: Performance results for 90 randomly generated nodes multicasting to group of receivers.

VI. Conclusion

In this paper, bandwidth has been considered as cost to determine the performances of the three multicast algorithms over wireless networks. Network coding techniques has been considered as a promising approach for substantial improvement in minimizing the cost (bandwidth and energy) of multicast over wireless networks. Simulation results reveal that the INCA performed better in terms of minimizing the average cost of bandwidth when compared to both NCA and MIPA. The implementation of some of these algorithms in real time is a step forward toward achieving reliable cost effective multicast.

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