An Improved Algorithm for Efficient Bandwidth usage During Video Conferencing

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Abstract:- **Video conferencing is one of the fundamental methods of supporting group communication, where participants see and hear each other during conferences or meetings. However, one of the problems that hinder this group interaction over the Internet is high rate of bandwidth consumption, channel congestion, and packets delay, as well as rejection and loss of packets over the Internet. In this paper an Improved Network Coding Algorithm (INCA) was developed and implemented in order to establish by how much bandwidth consumption during video conferencing over wireless network was minimized. Simulation results showed that the INCA with three parameters significantly minimized bandwidth consumption. For example the INCA with three parameters minimized the consumption of bandwidth by 1.1362Mb/s, 0.8498Mb/s and 0.4301Mb/s for ten participants when 20, 50 and 60 nodes are generated at random as compared with the benchmark algorithm. Similarly, Simulation results also showed that the INCA with three parameters minimized average bandwidth consumption by 11.1%, 12.7% and 16.3% when compared with the INCA using only two parameters for 20, 50 and 60 nodes generated at random during video conferencing.**

Key words: Video conferencing, INCA, Performance metrics, Bandwidth consumption and wireless network.

I. INTRODUCTION

The increased demand to incorporate video data into telecommunications services for conferences, meetings, business transactions and home games, have made digital video technology a necessity [1]. Telecommunication technology has enhanced human lives in many multimedia applications such as in electronic learning, video conferencing, electronic library, online shopping, video on demand and so on [2]. Face-to-face interactions at meetings are the best meaningful decision making technique, but it is sometimes difficult to assemble participants at the same time in a single place [3].

Video conferencing applications are key multicasting alternatives for group meetings and for costs savings as well [4]. Video conferencing has been a method of supporting group communication which allows transmission and routing of packets to multiple destinations using fewer resources. This method is the processing of source information and routing it to a set of receivers; r_1, r_2,…r_n nodes [5, 6]. The method is essentially a televised telephone call, in which both audio and visual signals are transmitted both ways.

These signals are transmitted via the Internet and processed into readable format by equipment called a codec. Video conferencing has the following components: display, cameras, microphones, amplifiers, speakers, echo cancellers, networks, user interface, cables, peripheral equipment and codec.

Data applications tend to be very demanding in the utilization of network bandwidth during video conferencing. Congested queues are the primary contributors to packet delay and loss in a packet network. The bandwidth required to send the video is higher than the required bandwidth for receiving the video [7]. Webcam video is used primarily for video conferencing. The streaming video file feature is a video that is encoded and streamed to other meeting participants as shared content during a meeting [8].

Electronic learning over the Internet is also taking the center stage to replace classroom training and instructional meetings, where a presenter and the participants can demonstrate physical equipment and processes in real-time, addressing questions as they arise [9]. A good example of video conferencing concept is shown in Figure 1. Participants listen to one another from different part of the world and share ideas. in this concept, only one person talk at a time while the other once are listening and they can as well give their individual contribution.

Figure 1: Video Conferencing Concept [10]

Audio signals in a videoconference are not transmitted simultaneously with the video signals. A study was carried out to develop an improved multicast algorithm for interpreting the cost of bandwidth within the channel during multicast over wireless network by considering three performance metrics [11]. The study revealed that, the cost of bandwidth within the channel was under estimated if less metrics were collectively used. However, since packet congestion was not considered, its impact on the cost of bandwidth was not taken care of. The research focused only on three key performance metrics (delay, rejection and loss of packets) that degraded the quality of signals (audio and video) during video conferencing [12]. The study revealed that the performance metrics degraded the quality of signals and caused lip synchronization during video conferencing. However, there were other performance metrics that affect the quality of video and audio signals during multimedia applications which were not considered.
Multi-party video conferencing aimed at achieving optimal bandwidth sharing by investigating two cross swarm bandwidth sharing scenarios was also studied by [13]. In the study, the sharing scenario was in two fold as thus: swarms were independent and peers from different swarms shared the same pools. Also, swarms were cooperative and peers in an abundant bandwidth swarm could share their bandwidths with peers in a limited bandwidth swarm.
The challenges of video multicast over Wireless Local Area Networks (WLANs) studied by [14] investigated problems due to varying channel conditions and limited bandwidth. The conducted and experimental study of the packet loss behavior of the IEEE 802.11b protocol revealed that error control in video multicast over wireless networks could be tackled by the use of forward error correction (FEC) to handle losses.
The performance of two multicast algorithms over wireless network was studied by [15]. In the study, they observed that, the performance of Network Coding Algorithm (NCA) and the Multicast Incremental Power Algorithm (MIPA) in which the simulation results showed that the NCA performed better than MIPA in terms of cost effectiveness and efficiency of multicast. However, their research was not directed to a particular multimedia platform. A pertinent review of some multicast algorithms over wireless networks with a view of identifying areas for further research was also studied by [16].

The effects of some key performance metrics on the quality of signal during video conferencing was studied by [10]. The paper was aimed at determining the effects of loss, delay and rejection of packets on the quality of signal during video conferencing. The study reveals that these metrics degrades video quality, freezes video and causes lip synchronization during group discussion. But there effect on bandwidth consumption during video conferencing was not taken into consideration.
The studies carried out so far have not been done on determination of effect of delay, rejection and loss of packets on bandwidth consumption during video conferencing over a wireless network, and hence the motivation of this research. The significant finding of this research shows that the effect of the outlined performance metrics (delay, rejection and loss of packets) leads to poor bandwidth utilization and more energy consumption during multimedia application services. This paper focuses only on the findings of the effect of these performance metrics on bandwidth consumption in order to develop INCA to achieve an efficient bandwidth usage during video conferencing. Bandwidth and energy consumption over wireless networks are factors that need to be addressed in order to achieve cost efficient multicast.
To carry out this research, the focus was on a network where nodes were generated at random involving ten participants. The cost of bandwidth when multicasting to different groups of receivers, namely: 2, 3, 4, 5, 6, 7, 8, 9 and 10 were obtained for different numbers of nodes generated at random.
The remainder of the paper is organized as follows. Section II, deals with the network model and the methodology adopted for this research. Section III, presents the mathematical model of the INCA with two- and three-parameter conditions. Sections IV cover the simulation results and sections V concludes and summarizes the paper.

II. NETWORK MODEL

A static network with one source node is considered at a time of sending messages to all participants in a random network topology within the wireless multicast group. Figure 2 shows a graphical representation of a network and how the network layers interact with each other. The nodes are referred to routers in real time video conferencing.

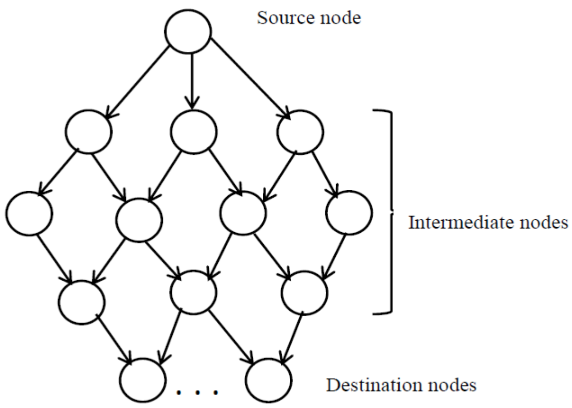

Figure 2: A multicast network Model [11].

The discussion is centered on video conferencing over wireless network, where participants are located at different places and are linked together through the Internet. The methodology that was adopted in this research is itemized as follows:

i. Determination of key performance metrics that affect bandwidth consumption of a wireless network during video conferencing.
ii. Using two and three performance metrics to improve the performance of network coding algorithm
iii. Formulation of the problem as mixed integer linear programming with delay, rejection and loss of packets as the constraints.
iv. Validation of the performance of an INCA with only two performance metrics and INCA with three performance metrics considered.

III. MATHEMATICAL MODEL

Let $M \subset V$ be a set of nodes involved in a group communication and M is called multicast group with each node $v \in M$ as a group member. Packets originating from a source node v_S have to be delivered to a set of receivers nodes M$\{v_S\}$. Each node *v* is assigned a cost $\gamma(v)$ and a delay $\delta(v)$ which are assumed to be nonnegative integers. For a node i of the network, the cost of bandwidth required to reach another node j is given by equation (1) as in [17]

$$y_{ij} = c_{ij} \qquad (1)$$

where

C_{ij} is the cost of bandwidth used and y_{ij} is the distance from the source node to destination nodes.

A vertex *s* is designated as the source and a set of D $\{d_1, d_2, ...d_n\}$ vertex is designated as the destinations. A structure is called the multicast tree (T) if all the source and destination nodes are all members of the multicast tree [18].

For a given network graph G, denoted by (V_G, E_G), where V_G is the set of nodes in the network and E_G is the set of edges which connect the nodes of V_G. The set Vm is divided into three subsets V_S, V_D and V_I related by [19] as:

$$V_M = V_S \cup V_D \qquad (2)$$

where V_M V_I, V_S and V_D are the multicast group, source node, intermediate node and destination node within the network.

The optimization objectives are usually defined in terms of minimizing the cost of a multicast tree, and the cost in question is the bandwidth used, delay, rejection and loss of packets serve as the constraints. the INCA was the extension of the research work carried out by [15] where delay, loss and rejection of packets are considered as key performance parameters. The INCA was implemented in visual studio 2010 installed along with relevant compilers of C-programming language. Interested readers should refer to the work of [11] for detailed information on the Improved Network Coding Algorithm (INCA). The problem is formulated as mixed integer linear programming with an objective function stated by as:

$$\forall (i.j) \in V, i \neq j \text{; Min (q)} = \sum_{(i,j)\in V}^{n} c_{ij} \qquad (3)$$

when subjected to:

$$\delta(p) \leq 400, \; \forall (i.j) \in V, i \neq j \qquad (4)$$

$$\rho(l) \leq 4; \; i = \text{Source}, \; i \neq j \;\; \forall (i,j) \in V \qquad (5)$$

$$p(r) \leq 8; \; i = \text{Source}, i = \text{Source}, \; \forall (i,j) \in V \qquad (6)$$

The constraints in equations 4, 5 and 6 mean that the value of delay, rejection and loss of packets should be less than and equal to 400ms, 4 decibel and 8 decibels. The source node is not equal to destination for all the nodes of the multicast group. The choice of 400ms is prompted to allow maximum flow of packets during video conferencing, to ensure efficient packet delivery and to take care of large variations in end to end delay in order to agree with existing values of [20] for validation purpose.

The value of packet loss was chosen to be 4 decibels which is equal to 5.7% of highest nodes generated at random to avoid complete retransmission of packet which requires additional cost of bandwidth [21]. The value of rejected or dropped packets was assumed to be 8 decibel which represent 11.42% to avoid complete buffer occupancy of packets and possible overflow [6].

IV. SIMULATION RESULTS

In the simulation, the bandwidth consumption results during video conferencing for different number of nodes generated at random was presented. The cost of bandwidth consumed for different groups of participant were also obtained. Tables 1, 2 and 3 show the simulation results for bandwidth consumption during video conferencing when 20, 50 and 60 nodes were generated at random. The cost of bandwidth consumption to 2, 3, 4, 5, 6, 7, 8, 9 and 10 participants were also obtained.

Table 1: Bandwidth Consumption for 20 Nodes Generated at Random

Number of participants	Cost of bandwidth consumption in Mbps	
	INCA with two parameters	INCA with three parameters
2	0.3405	0.1571
3	1.5047	1.4453
4	1.6769	1.5297
5	2.2611	1.2306
6	3.2449	2.4076
7	4.9350	4.3894
8	5.5823	5.4192
9	6.2030	5.9324
10	8.4356	7.2994

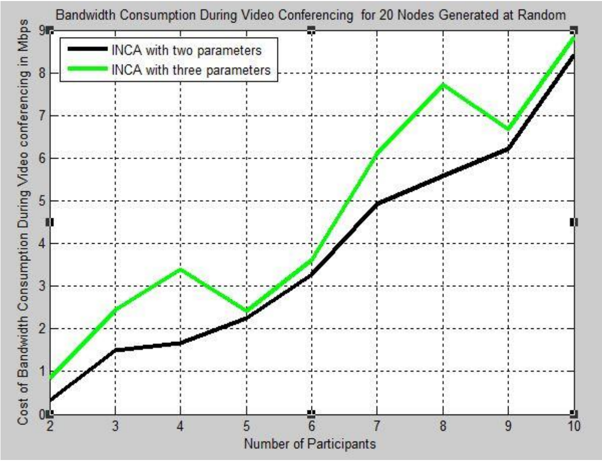

Figure 3: Bandwidth Consumption during Video Conferencing for 20 Nodes Generated at Random

From Figure 3, the consumption of bandwidth during video conferencing was minimized by 12.7% when INCA of three performance metrics was compared with INCA of two metrics as shown in Table 2. Figure 4 shows a graph of the bandwidth consumption during video conferencing minimized to 11.1% when INCA with three performance metrics was compared to the INCA with only two performance metrics.

Table 2: Bandwidth Consumption for 50 Nodes Generated at Random

Number of Participants	Cost of bandwidth consumption in Mbps	
	INCA with two parameters	INCA with three parameters
2	0.7506	0.2555
3	1.6129	1.0598
4	2.0116	1.6066
5	2.8540	2.8184
6	4.3289	4.3147
7	5.9323	5.0145
8	6.4192	6.2312
9	6.9220	6.0914
10	7.8556	7.0058

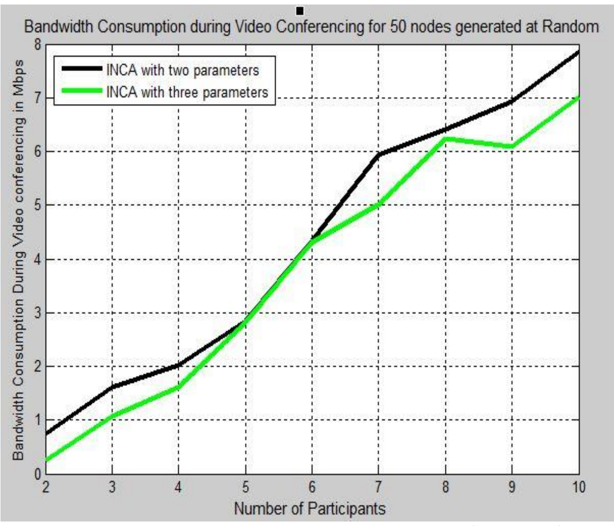

Figure 4: Bandwidth Consumption during Video Conferencing for 50 Nodes Generated at Random

Table 3: Bandwidth Consumption for 60 Nodes Generated at Random

Number of participants	Cost of bandwidth consumption in Mbps	
	INCA with two parameter	INCA with three parameters
2	1.8676	1.0772
3	2.5694	1.1341
4	1.4818	1.2087
5	4.7344	4.2347
6	4.2993	4.1223
7	3.7835	3.1230
8	5.9203	5.8159
9	6.2568	5.3186
10	6.9860	6.5559

As shown in Figure 5, the INCA which has three parameters minimized the rate of bandwidth consumption to 16.3% when compared with the INCA having two parameters.

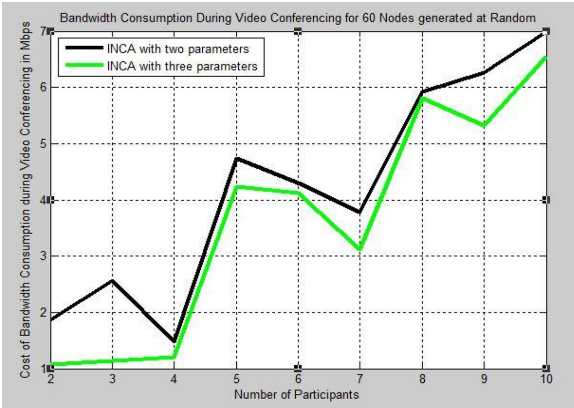

Figure 5: Bandwidth Consumption during Video Conferencing for 60 Nodes Generated at Random

V. RESULTS AND DISCUSSIONS

From the simulation results obtained, the Improved Network Coding Algorithm with three performance parameters significantly achieved a reduction in bandwidth consumption during video conferencing over wireless network. As shown in Tables 1, 2 and 3, the INCA with three performance metrics was benchmark with the INCA with two performance metrics. For example the bandwidth consumption for the INCA with two parameters during video conferencing to groups of seven participants is 4.3894Mb/s, 5.0145Mb/s and 3.1230Mb/s for 20, 50 and 60 nodes generated at random. Similarly, for the INCA with three parameters, the consumption of bandwidth for seven participants using the same number of nodes generated at random are 4.9350Mb/s, 5.9329Mb/s and 3.7835Mb/s. It is evident from the simulation results that the consumption of bandwidth to groups of seven participants when the INCA with three parameters achieved a reduction in the consumption of bandwidth by 0.5456Mb/s, 0.9184Mb/s and 0.6605Mb/s for 20, 50 and 60 nodes generated at random when benchmark with the INCA with two parameters.

Using Figures 3, 4 and 5, as an example, there is a clear difference between the simulation results obtained for the INCA with two and three parameters. The decrease in the consumption of bandwidth was expressed in percentages for 20, 50 and 60 nodes generated at random. The consumption of bandwidth was minimized by 12.7%, 11.1% and 16.3% when the INCA with two parameters was compared with the one of three parameters**.** The significant contribution of this research to the existing body of knowledge is that as more performance metrics affecting the consumption of bandwidth during video conferencing are considered, the amount of bandwidth consumed decreases. This is evident from the simulation results obtained from Tables 1, 2 and 3.

VI. CONCLUSION

The implementation of this research in real time will go a long way to encourage group discussion over wireless networks. This will save a lot of resources and time as the world has become a global village.

Further work should consider the implementation of this algorithm in a real time situation so as to encourage other multimedia applications such as e-learning, distance education, group oriented mobile commerce, software enhancement and online shopping.

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