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Performance Analysis Of Network Coding Using OPNET

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Abstract: Network coding is a useful technique for improvingnetwork throughput and reducing communication delays. This paperprovides a detailed study of network coding and its characteristics and proposes a better model based on the performance results. Analysis is performed using the OPNET simulator interfaced with the MATLAB. Furthermore, we also implement linear-information-flow algorithm in order to analyzethe performance of the proposed network model where the performance criterion is based on the maximum data flow rate.

Keywords: Network coding; OPNET; Modeling and simulation.

I. INTRODUCTION

In this age of a rapid shift to the information technology, computer communication is playing a vital role for providing facilities to common users and e-business applications. During last few years, the development and evaluation process of technologies is growing rapidly for providing an efficient and effective use of these technologies in order to provide a reliable, faster, and secure communication of data. However, in order to make it convenient and effective, developers need to make communication technologies to be fully applicable in order to be implemented and used in order to meet the demands of the modern business applications (Tenenbaum, 2002).

In this paper, we provide a detailed study and analysis of network coding techniques that improve network throughput and robustness. For this purposewe propose a network model that is implemented using the OPNET simulator (Guo *et al*. 2007). Furthermore, based on our experimental results, we also provide a comparative analysis of simple and network coding models based where the performance criteria are based on throughput and communication delays.

The analysis of network coding schemes is not a new topic, in (Pinto 2010), the author has provided a formal analysis of the characteristics of network coding using a combination of OPNET (Guo, *et al*., 2007) and MTLAB (Fehnker *et al.,* 2006). The author has considered a point-to-point communication in order to experiment network throughput. However, in this work (mostly based on the master thesis (Qureshi, 2012), we consider multi-point communication models for our analysis. Additionally, we also consider network delay as a performance criterion along with the throughput. We use OPNET (Guo, *et al.* 2007) as an analysis tool and the interface is provided using MATLAB (Fehnker *et al.* 2006).

The rest of the paper is organized as follows: Section II gives a detailed overview of network coding along with the proposed network model. Section III presents simulation results and also provides a comparative analysis basedon the performance results. Finally, Section IV concludes the work with a discussion and gives suggestions for the future work.

2. MATERIAL AND METHODS

A. Network Coding (NC)

Network coding (NC) is a new concept to design a communication model that guarantees faster video streaming, and allows a reliable transfer of data with minimum communication delays. Network coding consumes low processing power and widely improves network throughput and performance (Yuan, *et al.* 2011).

Under network coding scheme, the transmission of data from source to a particular destination may involve a number of intermediate nodes (relay nodes) and a routing algorithm. The routing algorithm used in network coding is store-and-forward method (Cypher, *et al.*, 1996). The main contribution of relay (intermediate)nodes is to receive signals from the sending node and to translate them into a format understood by the destination (Zhang, *et al*., 2006).

In order to understand the working of network coding, let us consider a network scenario (see Fig.1) where a sender *s1*is sending data to the receiver *t1*, and sender *s2*sendsdata to receiver *t2*over a network of directed links all with the same data rate i.e., 1 Gbps. The scenario contains two streams of information both of which having the same bandwidth represented respectively as *r1* and *r2*. In a case, if data is transmitted

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from *s1* to *t1* and from *s2* to *t2* and a bottleneck is found in the middle of the link,then it is required that the data be transmitted first to *t1* and then to*t2*. However, in the same case if a network coding technique is used then the bottleneck is overcome with the central **(Fig.1).**

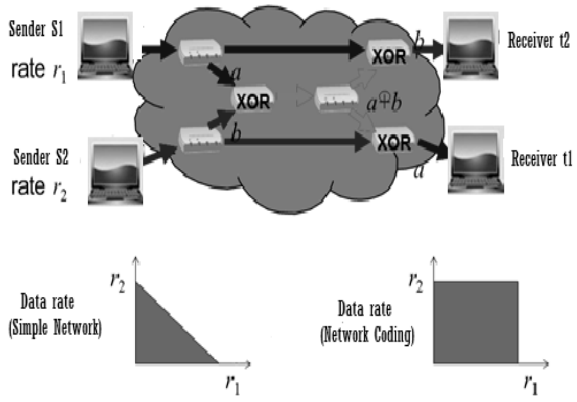


Fig. 1 Network coding scenario

router that can send data both to*t1* and to *t2* at the same time. The network coding scheme handles bottlenecks by superimpose data coming from multiple senders, adding them up bit by bit, taking their Exclusive-OR, and finally sending data to the bottleneck link. Under network coding scheme, Exclusive-OR is calculated at the bottleneck link. The trick is to disambiguate the combined stream at the receivers using additional information.

B. Network coding implementation methodology and performance analysis

In order to evaluate the performance analysis of network coding and non-network coding communication models, we use the OPNET simulator (Guo, *et al*. 2007). However, in case of the implementation of network coding model the interfacedescription is provided using MATLAB (Fehnker, *et al.* 2006).The implementation process is shown below:

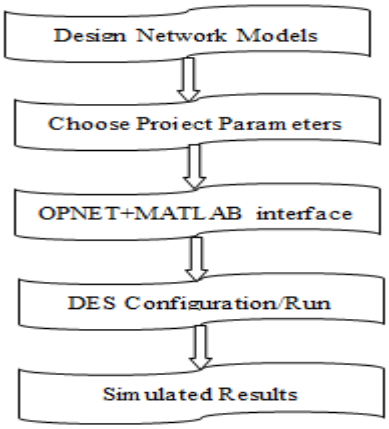


Fig. 2. Communication models implementation methodology

The network model is based on source, destination, and intermediary nodes, network switches which connect the nodes, and directed links. The project parameters include throughput, delay, and HTTP, FTP (Holzmann, 1991), and email for analyzing the network traffic.As mentioned earlier, network models are designed using OPNET where the interface is provided using MATLAB. Here our focus is on the integration of MATLAB with OPNET, with which we can calculate the desired finite fields in a way to generate the global or local coding vector in the modeled network. Once the network models are developed and project parameters are assigned, simulation experiments are performed using Discrete Event Simulation (DES) (Salah *et al.* 2006).

3. RESULTS AND DISCUSSION

We develop two network models: simple and a model implemented using network coding technique. Furthermore, based on our experimental results, we compare the performance results of both the models where the performance criteria are the network throughput and communication delay. **(Fig. 3)** shows the network model implemented using OPNET. For our analysis, we consider two network servers: http-ftp and email, five intermediary nodes that forward data from sender to the receiver, three client nodes and two network switches. Furthermore, the communication involves user profiles and applications that are running on client and server nodes. The main goal is to check the performance (based on bandwidth and delay) of two network models (simple and network coding) to analyze the traffic status throughout these models in order to analyze the performance differences between them.

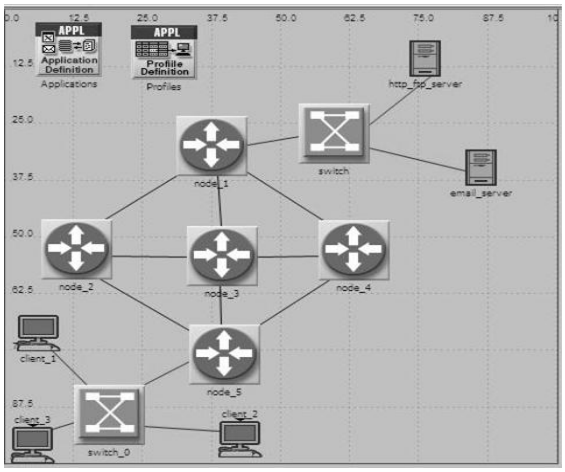


Fig. 3: Network model implemented using OPNET

(Fig. 4), shows the coding process produced by the OPNET simulator. Each row in Fig. 4, defines current simulation time, process ID, coding value at the output interface,andpacket value which is a combination and multiplication of coding value at output.

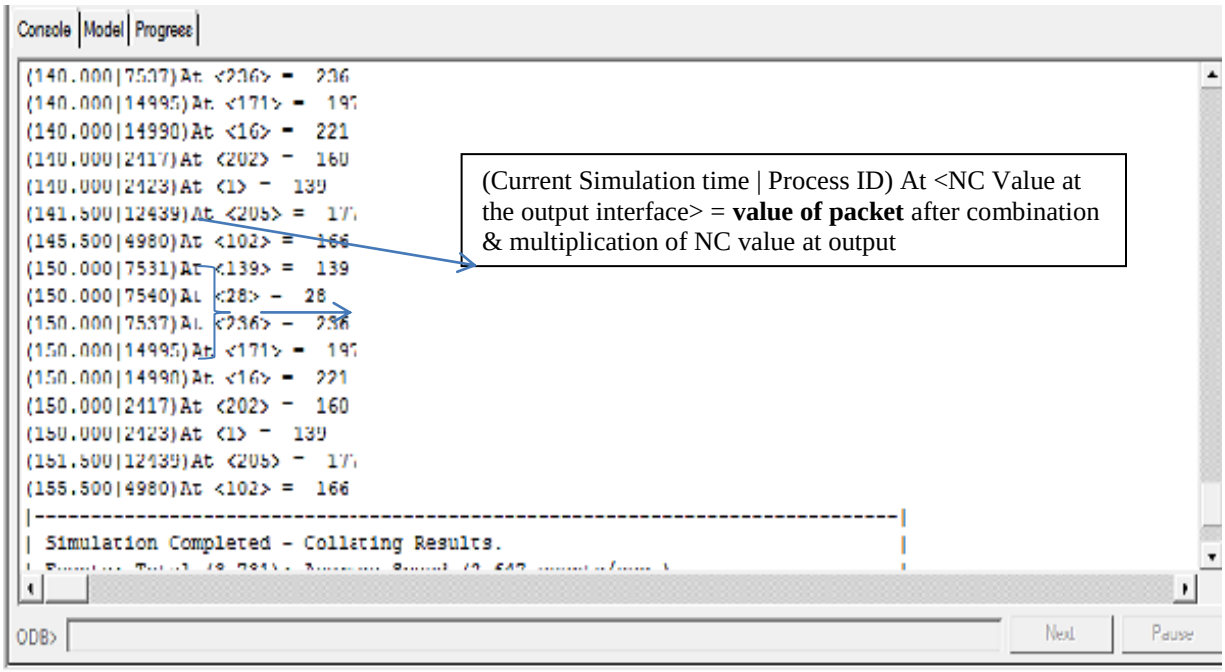


Fig. 4: Network coding process

Fig. 5 shows the packet flow within the network and the timeouts. In **(Fig. 5),** blue arrows represent data packets flowing from node *R1* to other nodes with varying data rates. The initial node (*R1*) receives data from a single interface and sends the date packets immediately to other nodes. Similarly, nodes*R2* and *R4* also receive packets from the single the interface, i.e., *R1* in the case of Fig. 5. On the other hand, node *R3* is different than *R1*, *R2* and *R4* in a way that it first receives packets from node *R1* (flow in blue) and later from nodes *R2* and *R4*; therefore, a timeout must be defined so that packets can be streamlined, added, and sent to *R5*. A similar processtakes place at node *R5*. In network coding scheme each packet flow is divided

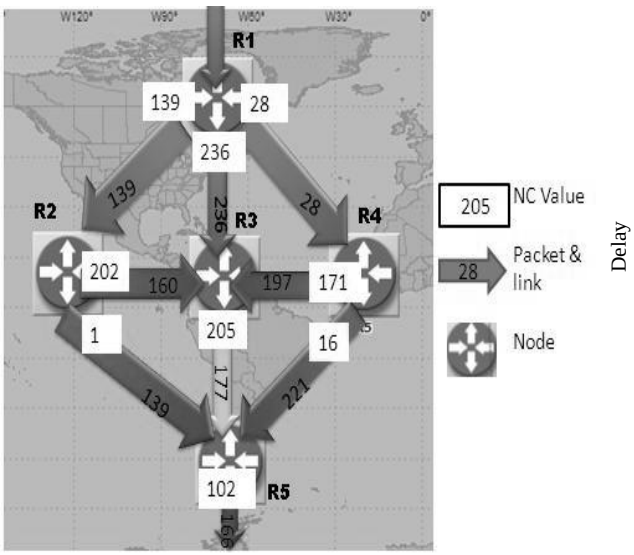


Fig. 5: Network coding and packet values

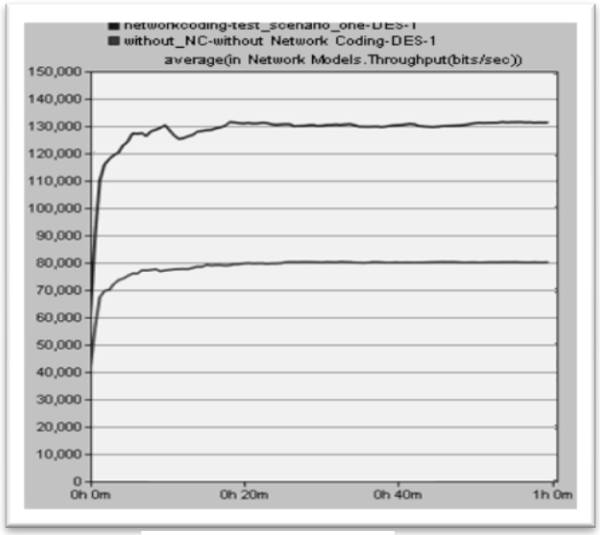


Fig. 6: Simulation results: average throughput

Fig. 5: Network coding and packet valueinto time steps, blue arrows occur at time step one, red at time step two, green at time step three, and purple at time step four. A simple way to find how the network would respond to link failures is simply to define the timeouts in the pretended interface with an infinite value such as 100. **(Fig.6)**

shows the simulation results that are based on the average throughput. The blue and red lines respectively show the average throughput values for network coding and non-network coding schemes. Simulation results show that the network models implemented with network coding scheme are far better than simple network models in terms of average throughput under the same timing parameters. Similarly, **(Fig. 7),** shows a comparative analysis for both network models (simple, network coding). The results are based on the average communication delay. The simulation experiments prove that the network coding reduces communication delaysmpared to simple networks.

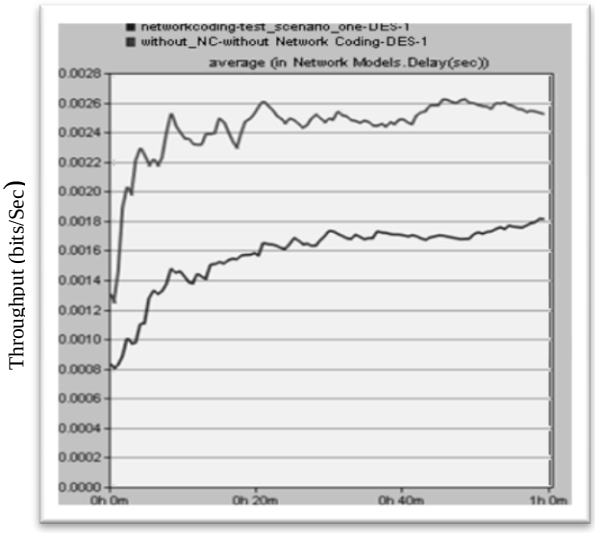


Fig. 7: Simulation results: average dela

4. CONCLUSION

In this paper, we presented comparative analysis of the performance between simple and network coding models. The analysis is performed using the OPNET simulator where the interface is provided using the MATLAB. The performance parameters considered in this paper are the throughput and communication delays. The simulation results proved that the network models implemented using network coding scheme perform better than simple networks in terms on increasing throughput and reduced communication delays.

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