A Survey, Study and Review on Performance Improvements in P2P Content Distribution Network

M.Anandaraj
Associate Professor, Department of Information Technology, PSNA CET, Tamilnadu, India.

G. Muthupandi
Assistant Professor, Department of Information Technology, PSNA CET, Tamilnadu, India.

P.Sivakumar
Assistant Professor, Department of Information Technology, PSNA CET, Tamilnadu, India.

Abstract – Today, the majority of Internet applications rely on point-to-point transmission. The utilization of point-to-multipoint transmission has traditionally been limited to local area network applications. Over the past few years the internet has seen a rise in the number of new applications that rely on multicast transmission. Multicast IP conservers bandwidth by forcing the network to do packet replication only when necessary, and offers an attractive to unicast transmission for the delivery of network ticker tapes, live stock quotes, multiparty video conferencing and shared whiteboard applications (among others). It is important to note that the application for IP multicast are not only solely limited to the Internet. Multicast IP can also pay an important role in large distributed commercial networks. Recently, network coding has been applied to the reliable multicast in networks and also in content distribution network , where intermediate nodes between the source and the receivers of an end-to-end communication session are not only capable of relaying and replicating data messages, but also of coding incoming messages to produce coded outgoing ones. The basic idea behind network coding is the summation of incoming information traffic through simple XOR. It can be used to improve throughput, reduce the number of transmission, better network management, less BER, minimum delay, less resource consumption. Recent studies have shown that network coding is beneficial for peer to peer content distribution, since it eliminates the need for content reconciliation, and is highly resilient to peer failures. This paper aims to explore the basics of network coding and use of network coding in P2P content distribution.

Index Terms – Network Coding, P2P network, Multicast, Contend Distribution Network.

1. INTRODUCTION

P2P paradigm has established itself to be an effective, scalable and robust networking application to provide services for content sharing and also for personal communications. Unlike traditional client-server model,

P2P network combines the resource from all peers together and contributes to all peers. In General, the P2P content distribution networks can be categorized into four different types based on topology and degree of decentralization: those are (1) decentralized unstructured network, (2) decentralized structured network, (3) partially decentralized network, and (4) centralized network. In decentralized unstructured network, such as Gnutella [2] and Freenet [3], all peers act as both server and client equally and the overlay networks are formed by peers. In case of decentralized structured network, like Chord [4] and CAN [5], each peer in the network performs as both server and client simultaneously, but the overlay network is specifically controlled by a distributed hash table (DHT) [6]. The partially decentralized network has some super-peers that play a more significant role than others peers in the network. FastTrack [7] and Brocade [8] are few of this type.

Central server coordinates the interaction between peers in the network in case of the Centralized network, such as Napster [9] and BitTorrent [1]. This system is described by two attributes: centralized index and distributed download. The central server in this network only provides the directory service. The file transfer is performed by distributed peers. In this architecture, resource management is easy and resource discovery are efficient. When any peer requests the central server for certain resources, the server just look up its resource directory and then return the information about resource location immediately to that peer.

Applying network coding in P2P content distribution is new and popularly known research area in recent years. This paper's main objective is to describe the basics of P2P model for content distribution mechanisms and also analyze and explore the opportunity to implement network coding in content distribution network. This paper describes a survey of existing results with respect to practical applications of random network coding in peer-to-peer networks.

2. PEER-TO-PEER NETWORK

Peer-to-Peer (P2P) networks have been one of the most promising platforms to realize the potential of network coding, since end hosts at the edge of the Internet have abundant computational resources with modern processors. This chapter describes the application world of network coding in P2P networks with a focus on two important applications: content distribution and multimedia streaming. For each application, the possible design space of P2P systems with network coding has been explored and an intuitive explanation for the advantages of using the network coding technique has been provided. P2P content distribution has become increasingly popular in current-generation content distribution protocols. The basic idea in P2P content distribution protocols is surprisingly simple. Consider a single server distributing a file to a large number of end hosts (peers) over the Internet. Instead of uploading the file to every individual peer, the server first divides the file into r data blocks, and then distributes these data blocks in an efficient manner by letting participating peers exchange them with one another. The essential advantage of P2P content distribution is to dramatically reduce the file downloading time for each peer. Intuitively, as participating peers contribute their own upload bandwidth to serve one another, the collective upload bandwidth in the system is significantly increased, leading to a much faster file distribution process and also reduction in time delay. Content Distribution systems offer a efficient method of distributing contents such as multimedia content and software to a large number of users.

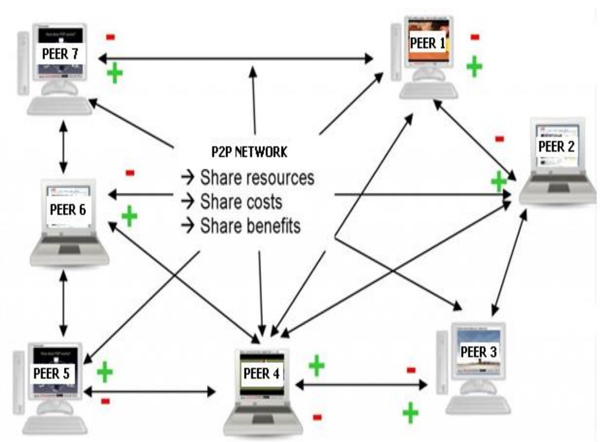

Figure 1. P2P network with seven peers

P2P content distribution creates overlay networks with end nodes having similar interest, in order to enhance the scalability and flexibility to network dynamics.P2PCD is a combination of a both distributed storage function, a propagation function of contents among peers, and a request routing module. BitTorrent is an example of such P2PCDs. Gkantsidis and Rodriguez introduced a network coding based content sharing system, such as Avalanche. In this system, and original large scale content is divided into n native packets and before distributing out those native packets, each peer encodes them using simple mathematical operation. As a result, the original content can be reconstructed from any n linearly, independent coded data.

3. IDEA BEHIND NETWORK CODING

Network coding is promising alternative to the traditional store and forward routing. It allows the intermediate node in the network to encode several received packets into a single coded packet and forward it to its neighboring peers. Network coding can be used in both wire and wireless network. It is applied to overlay network in case of wired network. In wireless network, it can be used in multihop wireless network. Its applications are categorized into throughput enhancement, improving the robustness of the network, network tomography and network security [10].

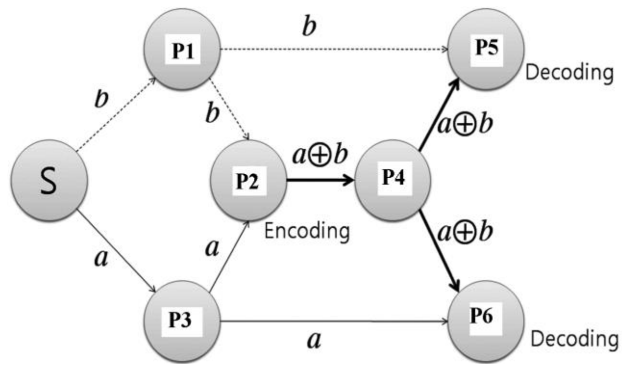

Figure 2. Network Coding

The Figure 2 shows the mechanism behind network coding mechanism. There are six peers download the large scale content from server. Instead of downloading the all original content from server, peers collaborate with each other by using network coding mechanisms. Performance enhancement can be achieved with Network coding for existing systems and new systems can be developed based on NC are two broad classification network coding application. In my research I concentrate more on throughput/capacity enhancement using network coding in P2P content distribution network. Packet transmission through a network using linear network coding are viewed a symbol in GF(q) and mathematical operations(XOR operations) of those are defined in GF(q). Packets generated at source node are called to as native packets and packets produced at the intermediate are called as coded packets.

Unlucky combination problem occur when we make use of random linear network coding. Downloader-Initiated Random Linear Network Coding [11] (DRLNC) used to solve the above said problem in Peer-to-Peer File sharing system. Upload complete is the performance metric, have been taken into consideration to analyze the proposed system. Upload complete means “how many rounds does the network take for all the peers to obtain the whole information”. In this scheme, all the peers need to share their buffer map (what are all the packets they have in their buffer) to their neighbors frequently. It is unnecessary of wasting bandwidth.

The chunked network coding system, which is called as Swifter [12], is a pull-based P2P content distribution system. It is made up of five different components namely neighbor manager, segment scheduler, an encoding and decoding module, a dependence checker, and a buffer-map manager. It is proposed in the year 2008 [13]. Improved version of this system was introduced in 2011 and it is referred to as I-swifter. Besides the basic components of Swifter, I-swifter include additionally two more components called as requests reducer – restrict the unnecessary request transmission from any peer to the serving peer, and an encoding vectors reducer - eliminates the transmission of encoding vectors. We need not to have Request reducer module and also unlucky combination problem can be resolved if the intelligent packet selection will be implemented properly.

In RLNC, all the available packets at the coding nodes are combined to produce the coded packets. Then the coded packets will be transmitted to the neighboring nodes in the network along with coding vector. Coding vectors contains the information about performed coding operation at the coding node. If more number of packets is combined, then coding will become dense. The computational complexity of performing both encoding and decoding is high in this type of coding. If less number of packets is combined, then the density of the coding vector decreases, it will become sparse. This decreases the computational complexity of both encoding and decoding of the packet. If the number of packets to be combined is not selected carefully, it can increase the amount of linear dependent packets created in the coding node. There is a trade off between the numbers packets to be combined and computation complexity of encoding and decoding operation. Instead of using a random selection of packets for performing encoding operation, priority may be given to the packets that are needed by the most receivers in the network [14]. In this case maximum throughput can be achieved with less number of transmissions.

The following questions are raised when RLNC is used for content distribution: at which nodes network coding need to be performed and how can one make use of most of the network capacity like buffering, CPU etc. at a minimal cost in terms of network coding resources? A minimal set of nodes needs to be identified in the network to perform the coding operation is the possible solution to the above asked questions. NC requires additional cost such as communication overhead, transmission delay and also consumes public resources like buffer, computation resource. It is necessary to perform the coding operation is kept minimized to realize the benefits of NC in content distribution network [15]. Specifically, the behavior of some encoding nodes in the network needs to be restricted [16]. Figure 3 shows generation of coded packets in network coding mechanisms.

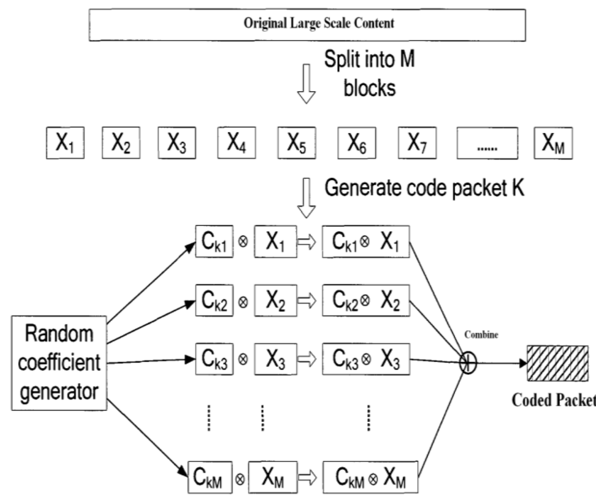

Figure 3. Generation of Coded Packets

4. TRADITIONAL NETWORK CODING PROCEDURES

Nodes in the network store the incoming data within their buffer. After receiving more than one original or linearly coded packet from other nodes, receiving node selects the linear coefficients in finite field GF(2^s) in a random manner and combines the received packet. The combined packet will be forwarded to other nodes in the network. Encoding vector will be sent within the same packet. It is used to perform the decoding operation at receiver. Once node receives enough linearly independent packets, it can decode the original set of packet.

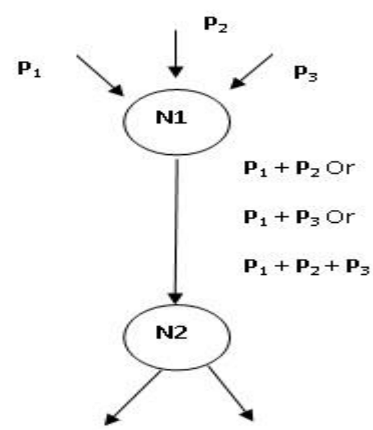

Figure. 4. Traditional network coding

All packets related to same source vectors P_1, P_2, …., P_n are said to be in the same generations. Here the n represents the size of the generation. All packets belong to the same generation are tagged with same generation number. One byte is enough to represent this information in each packet.

In the figure 4 Node N1 has three data blocks in its buffer namely P_1, P_2 and P_3. It has different choices to generate the coded packets. They are $P_1 + P_2$, $P_1 + P_3$ and $P_1 + P_2 + P_3$. In this + symbol represents the simple XOR operation.

The traditional network coding mechanism performs the following:

- Each node stores the incoming data into its buffer until either receives more than one packet or prefixed time elapse. The former is called as synchronous network coding and later is called as asynchronous network coding.
- After receiving more than one packet or prefixed time elapse, each node generate the coded packet by combining those received packets using random linear combination and send it out to other nodes in the network**.**
- After receiving the coded packets from other nodes, each node decides whether to store packet or drop it. If the packet is useful one, then it will be stored into its buffer. There are two possible packets each node may get from others, one is innovative packet and another one is non innovative packets. The packet is called as innovative for that node if it is used to increase the current rank of its matrix. The packet is called as non innovative for that node if it is not used to increase the rank its matrix. It means that the packet has redundant information and it should be dropped.
- The matrix maintained by each node needs to be updated for the reception of each random linear combination of source packets.
- Each node has to check whether the matrix has full rank (r) or a sub matrix with full rank ($s<r$) exists or not for the each reception of coded packets.
- If the matrix or sub matrix of any node has full rank, then by using the Gaussain elimination method, node can decode all or partial number of packets.

5. PERFORMANCE IMPROVEMENT IN P2P NETWORK BY USING NETWORK CODING

In this section, we provide the performances comparison of P2P content distribution networks with and without network coding mechanisms. We start explain it by describing the challenge encountered by conventional P2P file sharing networks that network coding mechanism try to solve. The conventional P2P content distribution network achieves the ideal efficiency when all downloading peers download packets from the source node and later on share with those from each other in a cooperative manner. Consider a network with one source node and ten downloading nodes (N1 to N10). The original data is divided into ten packets (d1 to d10). In practice any such network, total uploads always equal to total download. Hence, when there are ten downloading nodes try to acquire those ten packets, the total download is 10X10 = 100 packets. In peer to peer network, the burden of providing these 100 packets download will be shared by all nodes to offer ten packets of upload, and remaining ten nodes upload nine packets each.

In this case, the nodes have to avoid downloading the same packets from the same peers to achieve this perfect load balancing. Therefore, the most of the traditional P2P content distribution, they download packet which is owned by few nodes in the network. These packets are called as rarest packet [17]. This mechanism requires the downloading node need to know which packets all other nodes in the network currently have. Since the size of the P2P network is large in practice, it is not possible for all nodes to know about this information. Therefore, nodes in conventional P2P network knows only about limited number of other peer nodes in the network [18]. The overall efficiency of the system will be less desirable with compare to the previous one. Even node knows about the packet availability of other nodes in a traditional P2P network, it has its own limitations. For example, there are two packets that are the rarest and there are other two nodes attempt to download these packets, there is no guarantee that each of these two nodes would pick different rarest packet to download [19]. The application of network coding mechanism in a P2P network is an attempt to resolve this problem in the conventional content distribution.

6. CONCLUSION

In this study, we explained the basics idea behind network coding techniques and its applications in several areas of communication networks. We also described about P2P network and different variant of that network. Applying network coding in the area of P2P network is relatively new area of research in communication network that requires tools from different disciplines such as algebra, graph theory and combinatorial. This paper explores the opportunity of implementing the idea of network coding in P2P CDN network. There is no central coordinator in P2P network model so each peer doesn’t have global topological information. In this case implementing data scheduling is very difficult. NC can make this easier and make all packets are equally important. This technique has been implemented successfully in several commercial products, called Avalanche developed by Microsoft. It follows basic principles of topology management technique adopted in BitTorrent. Here, randomized network coding is employed for content distribution. They used this to distribute the software patch file to their customers. Further improvement is needed in traditional network coding technique as described in the previous section. Especially, which node in the network has to perform the coding operation and which flows need to be combined are open problem. These are NP complete problem. To solve this problem, one may make use of any soft computing techniques.

REFERENCES

[1] "Bittorrent," http://www.bittorrent.com/.
[2] "Gnutella," http://www.gnutelliums.com/.
[3] "Freenet," http://www.freenetproject.org/.
[4] I. Stoica, R. Morris, D. Karger, M. F. Kaashoek, and H. Balakrishnan. "Chord: a scalable peerto-peer lookup service for Internet applications," In Proc. ACM SIGCOMM, Aug. 2001, pp. 149-160.
[5] S. Ratnasamy, P. Francis, M. Handley, R. Karp, and S. Shenker, "A scalable content-addressablenetwork," in Proc. ACM SIGCOMM, Aug. 2001, pp. 161-172.
[6] Hari Balakrishnan, M. Frans Kaashoek, David Karger, Robert Morris, and Ion Stoica, "Looking updata in P2P systems," Communications of the ACM, vol. 46, no. 2, pp. 43-48, February 2003.
[7] FastTrack, http://developer.berlios.de/projects/gift-fasttrack/.
[8] Ben Y. Zhao, Yitao Duan, Ling Huang, Anthony D. Joseph and John D. Kubiatowicz, "Brocade: landmark routing on overlay networks," in Proc. First International Workshop on Peer-to-Peer Systems (IPTPS), March 2002, pp. 34-44.
[9] "Napster protocol specification," March 2001, http://opennap.sourceforge.net/napster.txt.
[10] Invited survey paper – Survey of Network coding and its applications Takahiro MATSUDA, Taku Noguchi, and Tetsuya TAKINE – IEICE TRANS. CMMUN., VOL E94-B, No3 March 2011.
[11] Downloader-Initiated Random Linear Network Coding for Peer-to-Peer File Sharing Nan Wang, Member, IEEE, and Nirwan Ansari, Fellow, IEEE IEEE SYSTEMS JOURNAL, VOL. 5, NO. 1, MARCH 2011.
[12] I-Swifter: Improving chunked network coding for peer-to-peer content distribution Jinbiao Xu · XinWang · Jin Zhao · Azman Osman Lim - 16 July 2011- Springer Science+Business Media, LLC 2011.
[13] Xu J, Zhao J, Wang X, Xue X (2008) Swifter: Chunked network coding for peer-to-peer content distribution. In: Proc. IEEE int. conf. on commun., May
[14] J. Le, C. S. Lui, and D. Chiu, "DCAR: distributed coding-aware routing in wireless networks," IEEE Trans. Mobile Comput., vol. 9, pp. 596–608, 2010.
[15] Huanlai Xing, Rong Qu "A compact genetic algorithm for the network coding based resource minimization problem", Applied Intelligence June 2012, Volume 36, Issue 4, pp 809-823.
[16] L. F. Xie, P. H. J. Chong, S. C. Liew, Y. L. Guan, "CEO: Consistency of Encoding and Overhearing in Network Coding-Aware Routing", IEEE WIRELESS COMMUNICATIONS, 2012.
[17] A. Legout, G. Urvoy-Keller, and P. Michiardi, "Rarest first and choke algorithms are enough," in Proc. 6th ACM SIGCOMM Internet Measurement Conf., IMC, Oct. 2006, pp. 203–216.
[18] A. Angelin Jayanthi, M. Anandaraj, Dr.P.Ganeshkumar, "An Efficient Framework for Network Code Based Content Distribution in P2P Network" Proceedings of International Conference on Communication and Signal Processing, April 3-5, 2014, India. Pp 1403 – 1407.
[19] M.Anandaraj, P.Ganeshkumar, K.P. Vijayakumar, K. Selvaraj, "An Efficient Framework for Large Scale Multimedia Content Distribution in P2P Network: I2NC", Volume 2015, International journal of scientific world 2015.

Authors

M.Anandaraj received his B.E. degree in Computer Science and Engineering from Madurai Kamaraj University (India) in 2003, his M.E. degree in Computer and Communication from Anna University Chennai (India) in 2007, and doing Ph.D. degree in Information and Communication Engineering at Anna University, Chennai. He has been working as an Associate Professor in the Department of Information Technology at PSNA College of Engineering and Technology, India since June 2003. His research interests include computer networks, particularly in network optimization, multicast algorithm design, network game theory and network coding.

G.Muthupandi received his B.E. degree in Electronics and Communication Engineering from Madurai Kamaraj University (India) in 2001, his M.E. degree in Computer and Communication from Anna University Chennai (India) in 2007, and doing Ph.D. degree in Information and Communication Engineering at Anna University, Chennai. He has been working as an Assistant Professor in the Department of Information Technology at PSNA College of Engineering and Technology, India since May 2008. His research interests include Image and Signal Processing.

P. Sivakumar received his B.E. degree in Computer Science Engineering from Anna University (India) in 2009, his M.E. degree in Computer and Communication from Anna University, Trichy (India) in 2011, and doing Ph.D. degree in Information and Communication Engineering at Anna University, Chennai. He has been working as an Assistant Professor in the Department of Information Technology at PSNA College of Engineering and Technology, India since January 2012. His research interests include Soft Computing and Artificial Neural Networks.