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Routing Flow in Network Coding

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***Abstract*- Network coding is a new area of networking, in which data is processed inside the network to increase throughput, to balance traffic load and to save bandwidth of a network.Network Coding performs well in lossy wireless networks in both multicast and broadcast scenarios. Even in wireless networks with low density of nodes network coding performs well using its multi-copy packet transmission scheme. The problem of minimizing the number of coding nodes is caused by network coding overhead and is proved to be NP-hard.To resolve this issue, this paper proposes Central based Network Coding Node Selection (CNCNS) that is the heuristic and distributed mechanism to minimize the number of network coding (NC) nodes without compromising the achievable network throughput.Central based network coding algorithms is then proposed for the cases where a central node is aware of the full network**

statistics and where each node knows the local statistics from its neighbor, respectively. The simulation results show that in the centralized scenario the maximum profit from network coding comes by adding only a few network coding nodes. A similar result is obtained with the algorithm based on local statistics, which moreover performs very close to the centralized solution. These results show that the proper selection of the network coding nodes is crucial for minimizing the transmission delay

***Index Terms*- Network coding Node, Centrality, Degree, Weight, ThroughPut**

I. INTRODUCTION

The max-flow min-cut theorem can't be established in the multicast communication scenario under the traditional routing Random Linear Network coding (RLNC) which is coding over routing for multicasting from several sources over a network in [2]. RNC has two attractive features: First, it can be constructed distributively, thereby facilitating application of network coding in largescale networks it achieves max-flow capacity with a probability that rapidly approaches 1 as the size of the associated finite field increases. Random property of RLNC makes it possible robust, distributed transmission of coded packets without communication with neighbors and higher decoding success probability. Network coding means that bits in information flows do not have to be delivered as commodities; they can be mixed however we wish, as long as the receiving hosts have received sufficient "evidence" or "clues" to reconstruct the original packets from the sending host. Not only network coding is remarkable in improvement of throughput performance, but also according to network coding has other advantages such as minimizing energy, consumption, minimizing delay through reduction of transmission number.

II. LITERATURE REVEIW

2.1.1 Related Work

Ahlswede *et al.* [1] showed that with network coding, as symbol size approaches infinity, a source can multicast information at a rate approaching the smallest minimum cut between the source and any receiver. Li *et al.* showed that linear coding with finite symbol size is sufficient for multicast. Koetter and Médard presented an algebraic framework for network coding that extended previous results to arbitrary networks and robust networking, and proved the achievability with time-invariant solutions of the min-cut max-flow bound for networks with delay and cycles.Concurrent independent work by Sanders *et al.* and Jaggi *et al.* considered single-source multicast on acyclic delay-free graphs, showing a similar bound on field size by different means, and giving centralized deterministic and randomized polynomial-time algorithms for finding network coding solutions over a subgraph consisting of flow solutions to each receiver.

2.1.2 Traditional and Network Coding approach

Network coding is much easier to deploy than multicast techniques, for a similar throughput when the number of trees to manage is large, and for a much better throughput when the number of tree is small. Of course, there are also many other interesting features offered by network coding (dynamicity, robustness, ...) which have been already largely promoted in the literature.

Multicast:

By Multicast, we mean here that several multicast trees can be set up between one source and all of its terminal, and the traffic is split appropriately among the chosen trees to reach the best possible throughput.The optimal throughput in G1 is 8/3=2:666, using 5 trees. The original data are hence sliced.

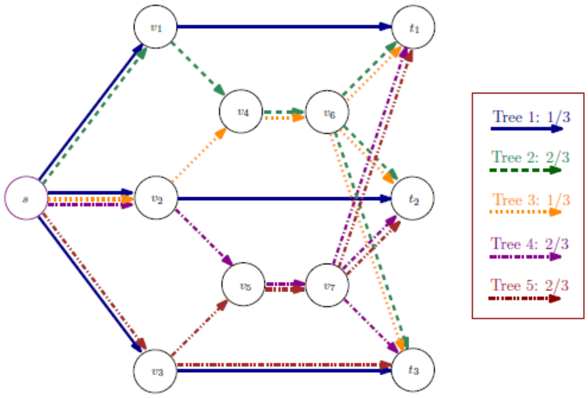

Figure 1: Multicast Routing

Network Coding:
We use the result of to compute the throughput achieved using network coding and multicast forwarding. Solving independently the sequence of maximum flow problems allows to obtain the value of the network coding throughput. The result obtained for a small graph G1 is depicted. The instance has one source, three terminals, all arcs have a capacity of 1, except the arc (s; v2) of capacity 2. three streams a,b and c (each one representing a volume of 1) are sent by the source node s. The node v2, v4 and v5 perform That stream a and b are coded together, resulting in a stream of volume 1). As a result,the terminal nodes receive each three different coded or uncoded streams, from which they can all decode the original streams a, b and c: the optimal network coding throughput is hence 3.

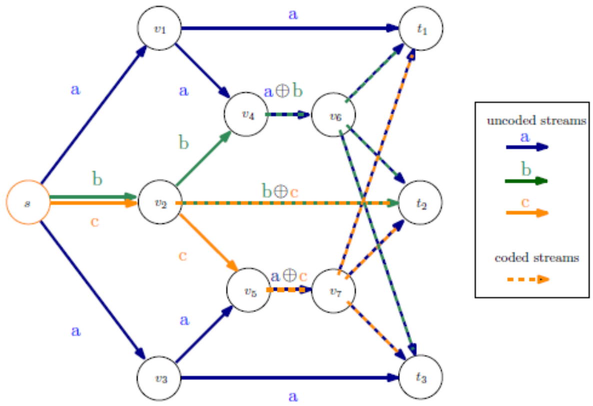

Figure 2:Multicast Routing by Network Coding Approach

2.1.3 Network Coding Scheme

Network Coding is a recent research area in information theory . It dramatically changes the traditional processing and transportation style. For example, in the traditional computer networks, information packets are transmitted from the source through intermediate nodes in a store-and-forward manner. There is no extra processing except replication. With network coding, the operations such as xor or linear combinations between two or more different packets are allowed to join different information flows, and the original binary could be recombined or extracted later in the receivers. In the other words, it is not necessary to keep data streams independently in the communication networks.

2.1.4 Identification of Network Coding Node

Types of nodes are defined as follows.

Definition 1: One node is called coding node if it satisfies:

1) The node has two incoming edge in the combination max flow;
2) The node has at least one outgoing edge belonging to overlap edge.

Definition 2: The overlap edge is the edge used in two or more max-flows.
Definition 3: One node u is called a multicast node if the sum of incoming flow is less than the sum of outgoing flow.
Definition 4: One node is called a forward node if the sum of incoming flow is equal to the sum of outgoing flow Node 4 is the coding node as it satisfies the both property in Definition 3. The two incoming edge is 1, 4_i and 2_i, 4_i and the outgoing overlap edge is 4_i, 7_i. Note that node 4 is also a multicast node because the incoming flow value is less than the outgoing flow value. Node 6 is not a coding node even though there are two incoming edges however the only outgoing edge 6_i, 9_i is not an overlap edge. Node 7 is a multicast node because incoming flow is 2 and outgoing flow is 4 (2 to node 9 and 2 to node 10). The nodes 1, 2, 3, 5, 6, 8 are all forward nodes.

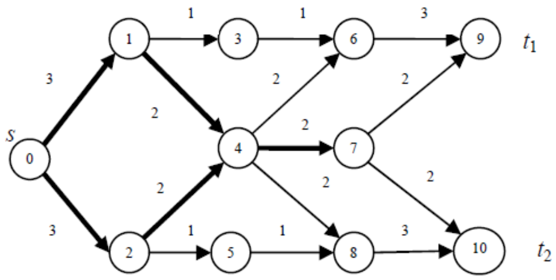

Figure 3:Combined Max flow from source s to destinations t1 and t2.

2.2 Network Coding Technique

The coding scheme could be constructed by coding at the coding node and multicast at the multicast node. After the node types are identified, the following rules are applied to route packets.
Rule 1: Forward nodes simply forward packets following the max flow scheme.
Rule 2: Applied the network coding at coding nodes and transfer the encoded packets through the overlap edges.
Rule 3: Multicast node replicated some of the incoming packets and broadcast them to the outgoing edges, in which flow terminate at different sinks.
There are 5 packets a1a5 being transferred simultaneously from s to both sink node t1 and t2. For clarify, only xor is used for coding here. ai xor aj (i,j=1..5, ij) is represented as (aiaj) in the graph. Coding node 4 encodes a2 xor a4 and a3 xor a5 then send them along the overlap edge to node 7. As node 4 is also a multicast node, the packets a2 and a3 are sent to both nodes 6 and 8. Node 7 is a multicast node, and the encoded packets are sent to both sink nodes 9 and 10. All the other nodes transmit the packets under a certain link are following the combined max-flow scheme

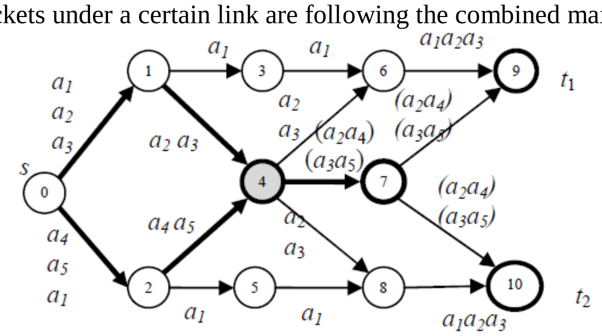

Figure 4:An Example of XOR Coding

2.2.1 Linear Network Coding and Random Network Coding

Random Linear Network Coding is a variant of Network Coding. Random Linear Network Coding works well over Wireless Networks to improve performance of multimedia transmission. In RLNC, the node combines number of packets (each Packet of length L exactly) it has received or created into one or several outgoing packets of L exactly, that's why it is called Linear. It is called Random because nodes draw coefficients (these coefficients are sent to the destination in the packet header) at random from a finite field to form[3]. Random Linear combinations. In RLNC, outgoing packets are linear combinations of the original packets, where addition and multiplication are performed over the field F2s.An encoded packet carries information about several original packets .

2.3 Node Selection Algorithm

The problem of the optimal selection of the NC nodes is known to be an NP-hard problem. We focus here on a greedy approach that searches at each step the optimal placement for a Novel network coding node, assuming that all other NC nodes are known. The candidate nodes for turning into NC mode are only the SF intermediate nodes. The algorithm iteratively examines all nodes backwards from clients to servers and finally outputs the subset of nodes that should implement network coding.
We now consider two different cases with (1) a centralized solution with global knowledge of the network and (2) a solution where all the nodes only have a local view of the network. The Algorithm 1 is used in both cases to compute the innovative rates, whose computation stops before reaching the server in the second scenario.
1) Global information: A fully centralized algorithm is devised to accurately determine the number of duplicate packets received by each client node (see Algorithm
2) Global information about the network is used to compute the innovative rate at each client. This leads to the selection of *K* NC nodes by iteratively computing the change that would maximize the increment in innovative rate at the clients. The value of *K* can be determined based on the maximum number of nodes that the network can support or the delay that the transmitted data can tolerate.

3) Local information: The centralized approach above is probably unrealistic in large networks because it requires that a hypernode is aware of the network status and is able to track all packet replications. We therefore propose to distribute the node selection algorithm to address a scenario where each node only has a local view of the network. An algorithm similar to the centralized solution is applied in each node's neighbourhood in order to compute the benefit of replacing a SF node by a NC node.

This data are successively forwarded to the ancestor nodes.

The above procedure is repeated till the servers are reached. Note that, in a fully distributed scenario, each node independently decides whether it should be replaced by a NC node and the decision is taken by comparing the estimated benefit with a predetermined threshold value. In our implementation the decision is, however, centralized. Thus, each node independently computes centrality gain that arises if it turns into a NC node. These gains are sent to a central node that eventually decides about the location of the NC nodes.

The algorithm used for selecting K network coding nodes by using Centrality illustrated in Proposed Work

III. CENTRAL NODE SELECTION ALGORITHM

It provides a practical way of approximating the minimum number of NC nodes required for achieving network capacity.

To select network coding node in a distributed manner without central information, we define an area which is the set of nodes with a concentrator node as the center and its neighbor nodes.

In network, there are concentrated nodes which are more connected and communicated with its neighbors than other nodes. These nodes have more incoming traffic and opportunity to transmit traffic into network. It means if these nodes turn into Network Coding node, it can more generate innovative packets and transmit packets to receivers with improving the network throughput. A centrality is a tendency to be these concentrated nodes. To estimate the centrality of network node, we define a node traffic flow and sum of bandwidth link.The node degree represents the number of flow which is traffic connection passing through the node from source to receiver(s). And the sum of link bandwidth connected to the other node is represented by strength and traffic flow is represented by degree.

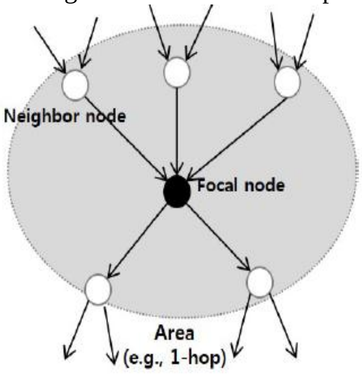

Figure 5 A simple Example

As shown in Figure 5, there is a focal node which can be any node in the network. In the area, the focal node is connected to its neighbor nodes within the same hop distance.

Degree of focal node i(d_{in}(i)) is given by:

$$d_{in}(i)=\sum_{j=1}^{N} x_{ji} \qquad d_{out}(j)=\sum_{j=1}^{N} X_{ji}$$

where i,j ε {1, 2, … , N} is the number of network nodes, i is the focal node and j represents neighbor nodes in the network. If there is traffic connection between node j and i node , X_{ij} is 1 or not 0. When node i sends messages to node j, d_{in}(i) is the input degree of the node i. Otherwise node i sends messages to node j , d_{out}(j) is the output degree of the node i.

3.1 The CNCNS Algorithm

Algorithm:CNCNS

Input: $d_{in,}$ $d_{out,}S_{in,}S_{out,}W_{ij,}W_{ji}$

Ouput:Centrality of the node which is the network Coding node

Step1:Initialize the Number of Network Coding Node=1

Step2:for i=1; Traverse all network coding nodes to compute the centrality of node i C(i).by using equations 1 to 5.

Step3:for j=1;Traverse all neighbor nodes to compute the centrality of node j i.e.C(j) which are neighbor nodes of i

Step 4:Send Centrality of j i.e. C(j) to node i;

Step 5:End for

Step 6:Select network Coding node which has maximum of centrality i.e. C(i).

Step 7:If network Coding node is not node i then

Step 8:Send message to Network Coding node notification to node j

Step 9:Else Turn node i to network coding node.

Step 10:end if
Step 11:end for.
$S_{in}(i)= \sum_{j=1}^{N} W_{ji}, S_{out(j)}=\sum_{j=1}^{N} W_{ji}$ ……………………………….Equation(2)

where i is the focal node, j represents neighbor nodes in the network. If there is traffic connection between node i and node j, W_{ij} is the value of link bandwidth between node i and node j or not 0. Thus, $S_{in}(i)$ is a sum of input strength of the node i and j. $S_{out(j)}$ is a sum of output strength of the node i. Based on node degree and strength, we compute input centrality and output centrality. Input centrality and
output centrality of node C_{in} and C_{out} is given by:
$C_{in}=d_{in}(i)\times(S_{in}(i)/D_{in}(i))=d_{in}(i)^{1-\alpha}\times S_{in}(i)^{\alpha}$..Equation(3)
$C_{out}=d_{out}(i)\times(S_{out}(i)/D_{out}(i))= d_{out}(i)^{1-\alpha}\times S_{out}(i)^{\alpha}$ ...………..Equation(4)
where α is a positive weighted parameter that can control
between node degree and strength. If this parameter is
between 0 and 0.5, then a degree of node is powerful value,
whereas if it is between 0.5 and 1, a strength is powerful value.
In this paper, we set this value to 0.5 arbitrarily.
Finally, centrality of node is given by:
$C(i)=C_{out}(i)\times(C_{in}(i)/C_{out}(i))^{\beta}$
$= C_{out}(i)^{1-\beta}\times C_{in}(i)^{\beta}$
where β is a positive weighted parameter to control between packet transmission rate and packet innovativeness.
For example, if this parameter is between 0 and 0.5, output centrality is more powerful than input centrality. This means if this node turns into NC node, the volume of output traffic from node i to neighbors is larger and this increase the packet transmission rate. Whereas if it is between 0.5 and 1, input centrality is more powerful than output centrality. This means if this node turns into Network Coding node, the packet innovativeness of node i is higher and this increase the decoding probability at the receiver. Thus this parameter is an indicator to control weight between packet transmission rate and packet innovativeness.
To select NC nodes, CNCNS is composed of following procedures as shown in Alg.1. **(i) Compute centrality**: to begin with, CNCNS initializes the number of NC node in each area (N_c) (=1) which can be decided by network administrator. Based on computed degree and weight using equation (1)-(2), focal node computes the centrality itself using equation (3)-(4).
And connected neighbor nodes to focal node compute its centrality. **(ii) Compare the centrality of focal node and its neighbor nodes**: next, the focal node is one of all network node at a time and neighbor nodes are connected to focal node in a one hop area. To compare the centralities of focal node
and connected neighbor nodes, focal node collects the centrality of neighbor nodes. And then, as much as , focal node decides the NC node(s) which has the maximum value in the area. If selected NC node is the one of the neighbor nodes, focal node makes it known. Otherwise, focal node operates NC node.Above overall procedures of CNCNS iteratively operate to accustom the variable network status, thus NC nodes are dynamically changed by centrality.
CNCNS objects to select the NC node individually in the defined as an area. Thus CNCNS can be adopted in network without constraint on network environment i.e., the number of network nodes, links, receivers, etc. In the area, NC node is chose as much as the prescribed NC node number(s). Areas are overlapped each other, thus occasionally more than one node work NC operation in the area.

IV. CONCLUSION

CNCNS improves the network throughput with the minimizing the number of coding nodes. Since CNCNS operates under distributed manner, it is simple while not requiring centralized information of network. Through the control indicator, CNCNS is useful for enhancing a performance of the network throughput and the network reliability

REFERENCES

[1] R. Ahlswede, N. Cai, S.-Y. R. Li, and R. W. Yeung, “Networkinformation flow,” IEEE Trans. Inf. Theory, vol. 46, no. 4, pp. 1204– 1216, Jul. 2000.
[2] T. Ho, M. Medard, J. Shi, M. Effros, and D. R. Karger, “On randomized network coding,” in Proc. 41st Allerton Annual Conf. Communication, Control, and Computing, Monticello, IL, Oct. 2003.
[3] T. Ho, M. Medard, R. Koetter, D. R. Karger, M. Effros, S. Jun, and B.Leong, “A random linear network coding approach to multicast,” IEEETrans. Inf. Theory, vol. 52, no. 10, pp. 4413–4430, Oct. 2006.
[4] P. A. Chou, Y. Wu, and K. Jain, “Practical network coding,” in Proc. 41st Allerton Conf. Communication, Control, and Computing, Monticello,IL, Oct. 2003.
[5] P. A. Chou and Y. Wu, "Network Coding for the Internet and Wireless Networks," Signal Processing Magazine, IEEE , vol.24, no.5, pp.77,85, Sept. 2007
[6] A.E. Kamal, A. Ramamoorthy, L. Long and L. Shizheng, "Overlay Protection Against Link Failures Using Network Coding," Networking, IEEE/ACM Transactions on , vol.19, no.4, pp.1071,1084, Aug. 2011
[7] N. Cleju, N. Thomos, and P. Frossard, “Network coding node placement for delay minimization in streaming overlays,” in Proc. Int. Conf.Communications (ICC’10), Cape Town, South Africa, May 2010.

[8] M. Langberg, A. Sprintson, and J. Bruck, "The encoding complexity of network coding," Information Theory, 2005. ISIT 2005. Proceedings. International Symposium on , vol., no., pp.1987,1991, 4-9 Sept. 2005

[9] J. Thibault and M. Hajiaghayi, “Minimizing network coding nodes for multicast”, IEEE Trans. Inf. Theory, vol, no, pp, 2009

[10] M. Kim, M. Medard, V. Aggarwal, U.-M. O'Reilly, W. Kim, C.W. Ahn and M. Effros, "Evolutionary Approaches To Minimizing Network Coding Resources," INFOCOM 2007. 26th IEEE International Conference on Computer Communications. IEEE , vol., no., pp.1991,1999, 6-12 May 2007

[11] Centrality-Based Network Coding Node Selection Mechanism for Improving Network Throughput,ISBN-978-89-968650-3-2,Feb 2014

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