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# Network Tomography Integrated Probe Tested Network Coding in Wireless Networks

**Mayank Kumar Goyal, Satya Prakash Ghrera, Jai Prakash Gupta**

***Abstract*****: *This paper depicts a collective structure for carrying system tomography on topologies with different sources & numerous destinations, exclusive of expecting topology to be well-known. We present a novel different source dynamic estimation technique utilizing a semi-randomized probe testing plan and packet entry arrange estimations which don't require exact synchronization between the hosts. In past tomography work, the connection between wrong inference of topology set & % loss probability on every link has been utilized to derive the hidden topology. Conversely, our principle thought behind utilizing Network coding is to present relationships among probe packets in a topology subordinate way and furthermore create calculations that exploit these connections to surmise the system topology from end host perceptions. Primer reenactments outline the execution advantages of this methodology. Specifically, without packet loss, we can deterministically surmise the topology, with not very many tests; within the sight of packet loss, we can quickly derive topology, even at little loss rates.***

***Index Terms*****: *Broadcasting, Broadcast Storm Problem, Flooding, MANET, Network Coding, Redundancy, Topology.***

## I. INTRODUCTION

The Wireless medium is creating numerous fortuities for nodes to get packets when they are not the anticipated beneficiary. MANET is such a sort of specially appointed Network. Message broadcasting is a basic function in wireless Ad-hoc network in which a node passes on a message to all neighbors thus causing redundant broadcast which is called as Broadcast storm Problem in which every node will be obligated to re-broadcast the data packet every time it gets the data packet thus causing redundancy. In this way, the no. of forwarding nodes is utilized as the cost criterion for propagation.

Routers mix (i.e., Network Code) packets from diverse sources to boost the information content of each transmission by XORing two or more packets. This design is embedded in the hypothesis of network coding. Prior work on network coding focuses on multicast traffic.

In Figure 1, Bits $m_1$ and $m_2$ need to be transferred to both receivers $R_1$ and $R_2$. Every link transmits only a bit. Message $m_1$ and $m_2$ can be received either on the right or on the left side.XOR (i.e. Apply network coding) in the middle link and both sides get $m_1$ and $m_2$. Table 1 clearly demonstrates this. Intermediate nodes will further send packets which are XORed of previous received bits [2].

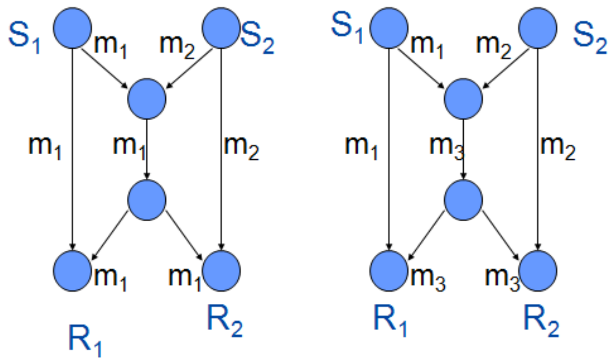


**Figure 1 Butterfly Network; Source S1 and S2 multicast m1 and m2 to both receivers**

**Table 1**

**XOR operation between $m_1$ and $m_2$**

| $m_2$ | $m_1$ | $m_3 = m_2 \oplus m_1$ | $m_2 = m_3 \oplus m_1$ | $m_1 = m_3 \oplus m_2$ |
|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 |

Utilizing numerous source with regards to arrange tomography, it is conceivable to recognize fragments inside a system shared by the ways associating numerous sources & destinations. This data might be valuable for recognizing likely blockages. Sharing insights between sources may likewise be helpful to improve the utilization of system assets while exchanging vast sums of information. Also, sometimes it is conceivable to combine data gathered from different sources to get a more exact and refined system portrayal.

[1], [2] proposes the basic idea of network coding in the context of network tomography. Active techniques & passive techniques have been proposed in [11] [12] [13] respectively.

The dominant part of experiment in system tomography has spun on probing from solitary source. Derivation and portrayal of system properties utilizing active end-to-end dimensions to finish estimations is one of its naive testing issue. Since the hosts are dispersed over the system, it isn't handy to expect that they can be absolutely synchronized [9][10].

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This paper centers around the numerous source, different destination arrange tomography issue of portraying the topology and execution on connections interfacing a gathering of sources and destinations

In the first place, the general system tomography issue can be decayed into a lot of little parts, each including only 2 sources & 2 destination [7][8].

We would then be able to concentrate on this unique case and produce results that are effortlessly stretched out to increasingly broad different source, numerous destination systems.

Next, we recognize a division of conceivable 2 sources, 2 destination topology. A tale various source testing calculation is then exhibited for deciding the model request of an obscure 2 source, 2 destination topology. An adaptable choice theoretic system is produced empowering the joint portrayal of topology & inside execution. The adequacy and precision of the examining calculation & factual structure are assessed via reproduction.

## II. RELATED WORK

The primary knowledge in using system coding for topology revelation is that when we do neighborhood XOR tasks, the perceptions seen toward the end-has depend on the system topology. Within the sight of packet losses, only one effectively received packet for each system way is adequate, without the need to gather packet loss insights. This property empowers quick disclosure of the basic topology. Also, these thoughts can be additionally joined with qualities of packet loss designs for very lossy systems. On the off chance that a couple of hubs have a critical cover of packet loss and achievement designs, at that point they ought to have a common parent. Thus, by grouping such hubs, one can construe the topology for a binary tree arrangement. The rightness of this thought was thoroughly settled in [5] and this structure was stretched out to progressively broad trees. The thoughts were then stretched out to unicast networks by [6], [14]. At long last, tomographic approaches for gathering the connection qualities [15] [16] can be joined with topology derivation.

Since the XOR activities are neighborhood, the moderate hubs don't have to forward insights or network data. Additionally, the moderate hubs don't need to uncover any data since they simply forward straight bundle blends, and henceforth there are no issues of security which may make strategies that utilization hub character labels less alluring[2][3].

The Network coding approach takes into account fast topology disclosure, for example utilizing not very many probes[4][6]. We along these lines trust that in foundations where the Network coding functionalities are as of now sent, the cost saving advantage exchange off of our proposed methodology for topology derivation is very alluring.

Kruskal's algorithm finds the minimum cost spanning tree of graph by adding edges 1-by-1.

**Kruskal's algorithm:**

```
enqueue edges of G in a queue in increasing order of cost.
T = ϕ ;
While (queue is not empty){
  dequeue an edge e;
  if(e does not create a cycle with edges in T)
     add e to T;
}
return T;
```

Prim's algorithm finds a minimum cost spanning tree by selecting edges from the graph one-by-one as follows:

**Prim's algorithm:**

```
G=(V, E)
Let 'T' be the tree having only the initiating vertex 'x';
While(T has <  I V I vertices)
{
     Look for a minimum cost edge connecting 'T' to 'G-T'
     append it to T;
}
```

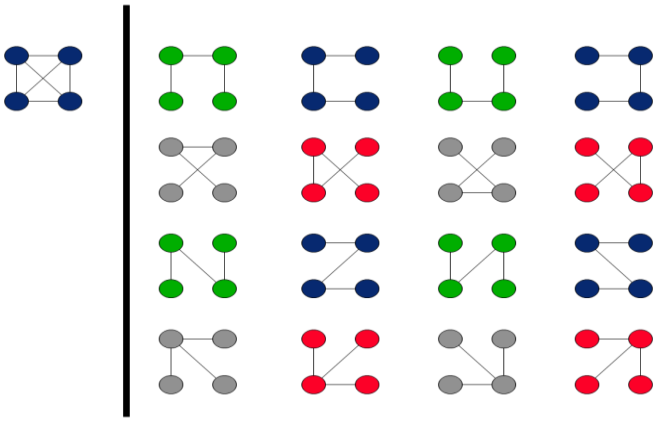

**Figure 2: Illustration for finding all possible set of spanning tree for a graph**

Figure 2 illustrates for finding all possible set of spanning tree for a given graph. For given graph in Figure 2, there are 16 possible set of spanning tree.

## III. PROPOSED ALGORITHM AND RESULTS

Consider Fig. 3 with 7 leaves (1,2,3,4,10,11,12) and 5 intermediate nodes (5,6,7,8,9).

Assume that nodes 1, 10 act as sources $S_1$, $S_2$ and send probes $p_1$ = [10], $p_2$ = [01] respectively. All other leaves act as receivers.

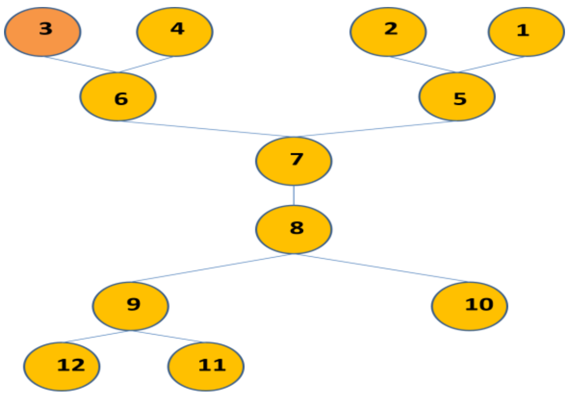


**Figure 3: Illustration using tree with 7 leaves nodes and 5 intermediate nodes**

Consider a tree chart G = (V;E) with x= | V | hubs. A tree with m hubs has precisely x-1 edges, and there exists precisely one way that associates any two vertices. For straightforwardness, we will confine our thoughtfulness regarding calculations that gather the topology of binary trees. These are trees with two kind of vertices: leaf vertices, that have degree 1, & intermediate vertices that have maximum degree 3.

We expect that the system can be spoken to as an undirected tree, as in each edge can be utilized in either heading, and the association between any two vertices is corresponding. Our calculations continue in cycles, where in every emphasis an alternate arrangement of leaves go about as sources and as beneficiaries of probe packets. The essential thought is that every emphasis progressively isolates the leaves in the system into groups, and uncovers how the groups are associated with one another.

Consider at a specific emphasis the sources S1 and S2. Amid this cycle, precisely 1 probe packet will be sent from each source towards every single other leave in the system. Each Probe packet will cross the undirected connections in a source to recipients heading. Regardless at every emphasis the leaves of the system will be separated into a few additional segments. When a part has 2 or less leave nodes, & because we have binary tree, we can assure of its topological structure. Note that deducing the binary tree topology with no mistake requires 2 probe packets through the tree. Additionally take note of that since each connection will be crossed precisely once at every cycle by a valuable probe packet.

Review that in the lossless case, at a given cycle, since there exist just a single probe packet produced by each source, the probe packet can at most meet at one transitional hub as depicted in the past segment.

In any case, when the connections are lossy, we have to send more than one probe packets. This issue is viably made by the way that we manage undirected diagrams, where a connection might be crossed in inverse ways by probe packets amid a similar cycle.

**BSP-NC-ALGORITHM:**

**Iteration 1:** Consider the set **SET** which comprise of **all leaf nodes**.

1. **Two leaf nodes** start working as **sources $S_1$, $S_2$**; sending **probes $P_1$, $P_2$** respectively. All other leaves **S - {$S_1$; $S_2$} act as receivers.**

2. **Partition SET** (into **$SET_1$ U $SET_2$ U $SET_3$** ) as follows.

   a. **$SET_1$ contains $S_1$ and all receivers that receive $p_1$.**

   b. **$SET_2$ contains $S_2$ and all receivers that receive $p_2$.**

   c. **$SET_3$ contains all receivers that receive $p_3 = p1 \oplus p2$.**

3. If **$SET_3 \neq \phi$**, replace the original graph with the three sets $SET_1$, $SET_2$, $SET_3$.

4. If **$SET_3 = \phi$**,, replace the original graph with two sets $SET_1$, $SET_2$, connected through a single edge.

**Iteration i:**

1. Consider any 1 previously identified $SET_i$ and repeat.

2. As done earlier, two leaves in $SET_i$ act as sources $S_1$ and $S_2$ and all remaining nodes in $SET_i$ act as receivers.

3. Node $A_i$ that connects $SET_i$ to the network will act as an aggregate receiver; whatever packet is received by $A_i$ will be multicasted and received by all leaves in SET that are not in $SET_i$

4. Repeat the exact same procedure as in iteration 1 to reveal the structure of $SET_i$. Connect the component to the network depending on what packet is received by $A_i$.

5. Remove vertices of degree two this way and so on.

Figure 4 illustrates the working of BSP-NC-ALGO.

**Illustration of BSP-NC-ALGO**

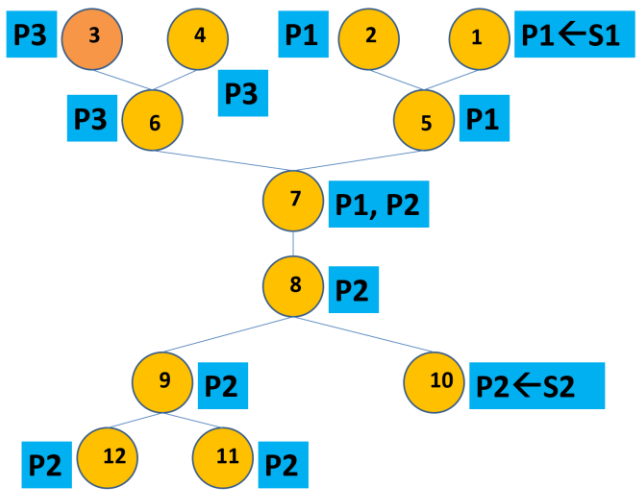


**Figure 4: Illustration of BSP-NC-ALGO**

**$SET_1$ = {1, 2};** leaf nodes having packet $p_1$ and source $S_1$

**$SET_2$ = {10,11,12} ;** leaf nodes having packet $p_2$ & source $S_2$

**$SET_3$ = {3, 4} ;** leaf nodes having packet $p_3$

We would now be able to stretch out BSP-NC-ALGO 1 in order to work over lossy systems. The main distinction is that, in every emphasis, we send M rather than 1 probe packet from every one of the sources.

Plot between % loss Probability 'P on every link and % wrong inference of topology SET has been represented for iteration i =1 & 2 with different values of Probe messages (M=1,2,4 & 8) in Figures (5-14) which clearly says that with increasing value of iteration "i" and probe messages "M", Topology with network coding is inferred is at it best.

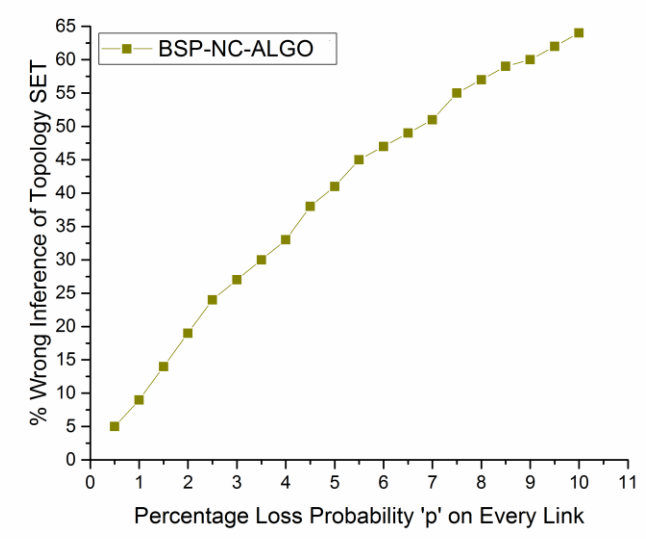


**Figure 5: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=1; M=1)**

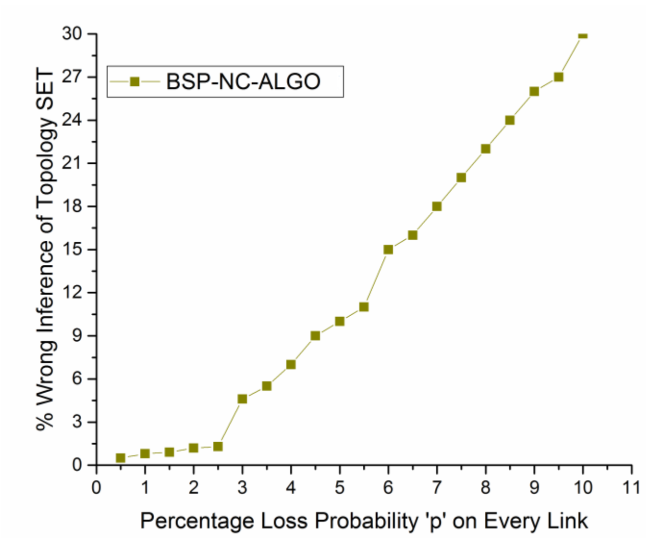


**Figure 6: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=1; M=1)**

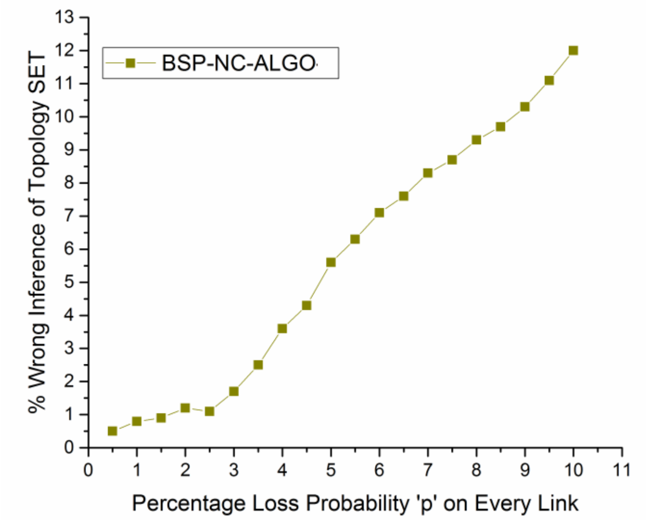


**Figure 7: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=1; M=4)**

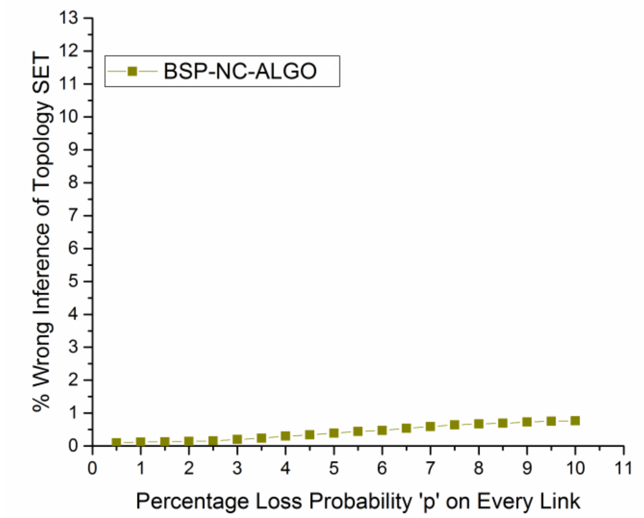


**Figure 8: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=1; M=8)**

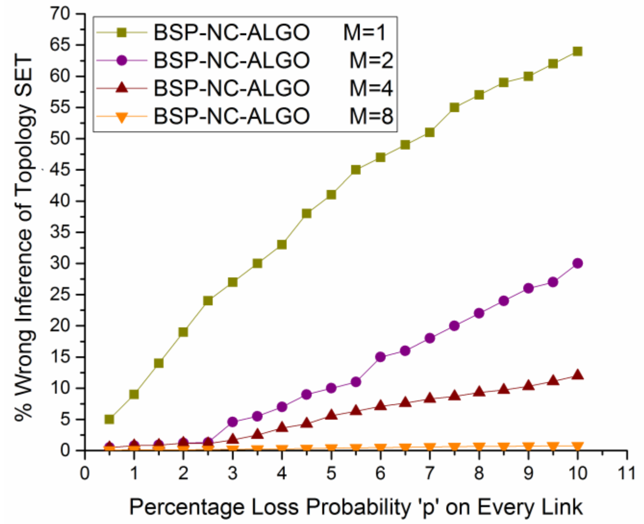


**Figure 9: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=1; M=1, 2, 4, 8)**

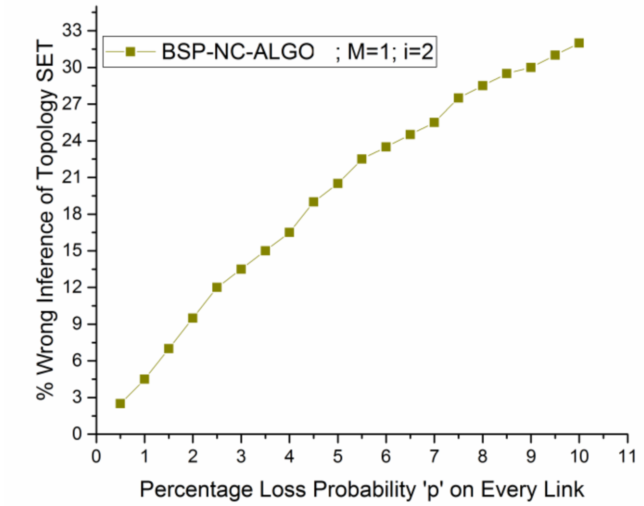


**Figure 10: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=2; M=1)**



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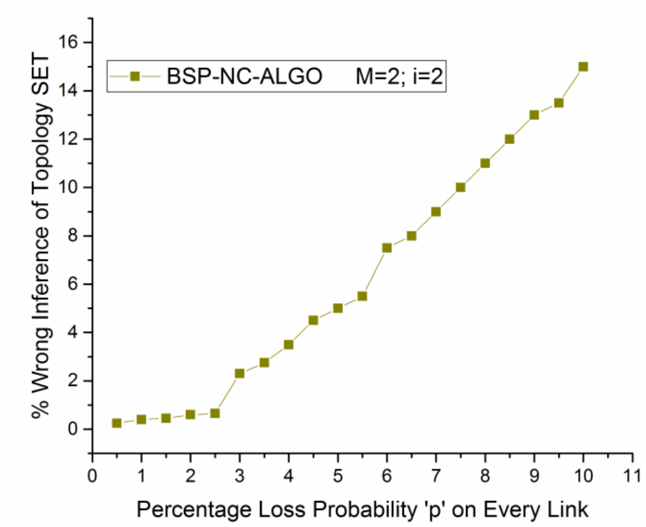


**Figure 11: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=2; M=2)**

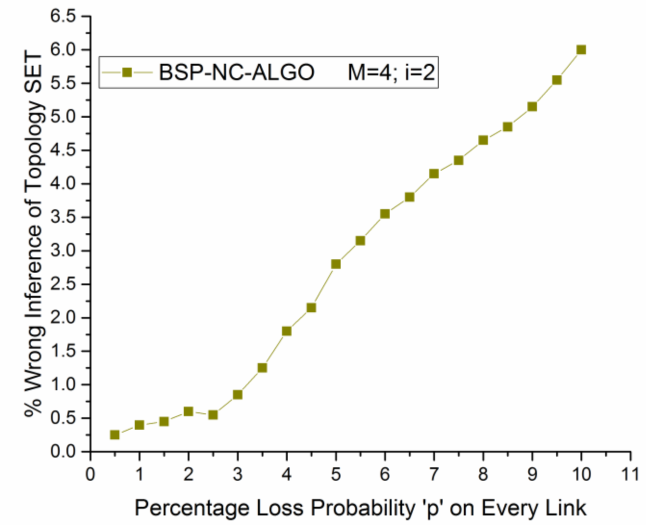


**Figure 12: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=2; M=4)**

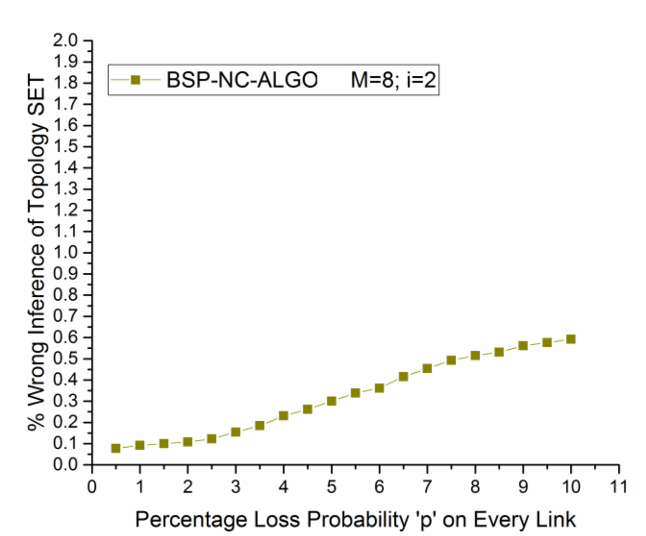


**Figure 13: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=2; M=8)**

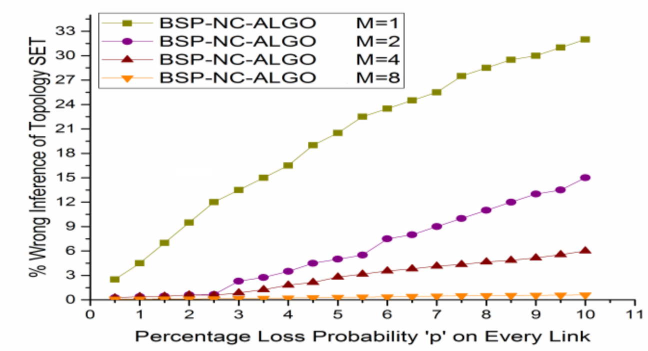


**Figure 14: Plot between % Wrong Inference of Topology SET & % Loss Probability 'p' on Every Link (i=2; M=1, 2, 4, 8)**

## IV. CONCLUSION

Making association between topology surmising & NC (Network Coding), this perception is in certainty not astonishing: by joining the approaching data streams, the moderate hubs naturally uncover data about the network structure. The primer thoughts exhibited are right now being stretched out in a few directions. The displayed calculations don't completely misuse the data from lossy estimations: to do as such, we require calculations that abuse both the connection presented by connection misfortunes and Network coding. Another heading we are investigating is expanding the calculations proposed in this paper to discretionary system topologies. At long last, we are investigating the utilization of uninvolved estimations to surmise the topology in circumstances where network coding is as of now deployed. SET Partition concept when integrated with Network Coding approach distinguishes and comprises nodes based on the fact of bundles of different network coded reduces the No. of Forwarding nodes for retransmission in contrast to actual no. of nodes as structure of topology is inferred.

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