A MULTICAST ROUTING SCHEME FOR FINDING TWO NODE DISJOINT PATHS IN A NETWORK

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ABSTRACT

Currently researchers are using the application-layer multicast (ALM) for multicasting, where the multicast-related functionalities are handled by end-hosts. While in IP-multicast, multicast-related functionalities are handled by network routers. We know that application-layer multicast has advantage over IP-multicast. We are presenting here a new multicast routing scheme for ALM which always has two node disjoint path in the network. Two node disjoint paths ensure the secure transmission of data between any two nodes in the network. In this proposed scheme node failure is also taken into consideration. We describe this scheme in detail with required network. The network construction algorithm is also given in detail. Graph theoretic explanation is also given for insuring that there exist two node-disjoint paths in the network.

KEYWORDS: *Node Disjoint Path, Node Failure, Multicasting Scheme, Routing Algorithm.*

I. INTRODUCTION

Some applications such as multi-party games, video conferencing, and software distribution are required point to multipoint communication. The IP- multicast [1], relies on network-layer multicast routing protocol, packet duplication, and forwarding functionality at network routers, is an efficient way for transmission media streams to multiple receivers. Unfortunately, IP multicast has not deployed. This can be explained by the facts that:

- IP multicast faces scalability problem with the number of groups.
- IP multicast has limited support for higher level functionalities such as multi-party games and reliable data delivery.
- Internet service providers are reluctant to replace their existing routers.

As a result, researchers have turned to application-layer multicast (ALM) for fast deployment. Researchers are attempting the application layer for the multicast-related functionalities to the end-hosts. This is so-called application-layer multicast (ALM). For example take, Source *S* needs to deliver data to recipients *H*1 to *H*3. Routers *R*1 to *R*5 replicate and forward data packets along the physical links formed by the spanning tree rooted at source S. The cast of each link is also labeled on particular link.

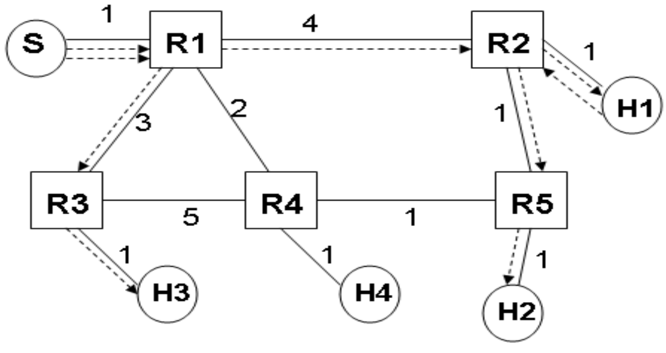

Fig-1.1: Packet flows in application-level multicast

We show an example of ALM delivery mechanism in Fig-1.1. Here source *S* establishes unicast connections with *H*1 and *H*3, while *H*1 in turn delivers data to *H*2 via unicast. Multicast is hence achieved via piece-wise unicast connections. End-hosts are responsible for replicating and forwarding multicast packets.

In this way, the spanning tree of ALM forms an overlay topology which consists of only end-hosts and unicast connections between end-hosts. In this way ALM can implement multicast network to consist of end-hosts only. Implementing multicast functionalities in ALM many issues associated with IP multicast are comes with a number of strengths [5]:

- *Absence of multicast routers* — ALM is built on an overlay without the need of multicast routers.
- *Leverage to existing unicast protocols* — since the connections are based on unicast, the existing functionalities of unicast protocols; can be directly applied in ALM.

II. MULTICASTING

Multicasting stands for data transmission from one source to many destinations. In multicasting group management is necessary. Some applications, such as widely-separated processes work together in groups, for example, a group of processes implementing a distributed database system. Each router computes a spanning tree to know which host belongs to that group. They forward the information to their neighbors and this way the information propagates in the subnet. When a process sends a multicast packet to a group, the first router examines its spanning tree and sends it, removing all reaming links that do not lead to hosts that are members of the group [4]. With the help of multicasting data can be sent to a group of users, situated in different places.

III. PROPOSED NETWORK

In this network we always have at least two paths in between any two nodes that we selected. Main feature of this network is that these two paths are having no node common; so these two paths do not have dependency over each other. That's why they are called node disjoint path and such type of network that is formed is called node disjoint path network**.** This property of this network facilitates us that if in between any two nodes we have single link or node failure, then we have surety that we are having one more path ready for the data transmission and it will not be affected by the first path failure. Due to this failure, the working of the given network would not be affected.

Another advantage is the simplicity of this network. This network can be easily formed as well as can be easily programmed; hence this algorithm can be easily implemented over the entire network.

3.1. Algorithm to Construct Network

Algorithm of the formation of this network is very simple and is described as:

- Every new node is allowed to be connected to only two nodes.
- Nodes are attached to each other by comparing their degrees. The new node will be connected to those two nodes which are having the least degrees so as to confirmation of the efficient network. Degree of a node can be understood as the number of nodes connected to that node.
- If a new node finds the degree of the many nodes to be same then it will be connected to the recently connected nodes.

3.2. Limitation of this Network

Apart from all its attractive features this network has some limitations too. These are:

- This network is designed for less degree of nodes (max four) and less links between nodes. That's why for any two nodes the paths may have more number of hops than a network which has nodes of higher degree.
- The another limitation of this network that after the single link failure the second path that we have in between the two nodes may not be of that cost as of the first one. It is possible that the second path that we are having is of more cost than the first one.

IV. CONSTRUCTION OF NETWORK

Firstly we consider one node is present there. Now 2nd node comes and attached to first. 3rd node attached to 1st and 2nd node. As the 3rd node is a new node hence it is allowed to get connected to the two nodes only. Hence it will get connect to them and the network formed with these three is shown below.

Here we see that degree of the 1st, 2nd and the 3rd node is two.

Fig-4.1-One node, 2 nodes and 3 nodes in the network

Now when the 4th node comes, then it sees the degrees of the nodes it found that the degree of all the nodes are equal to the two hence it can get attached to recently added two nodes; node three and node two.

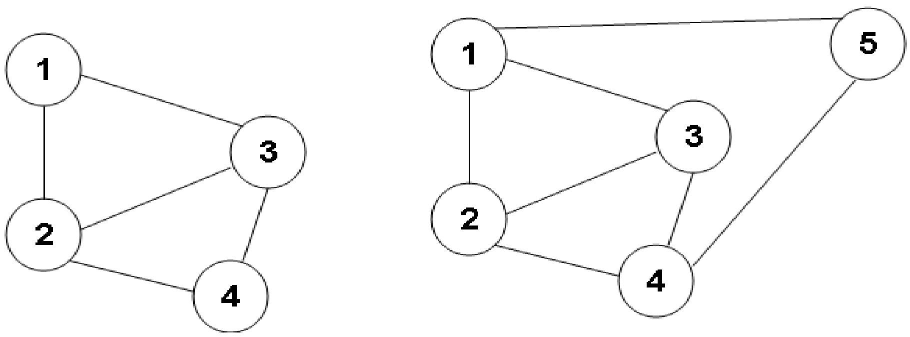

Fig-4.2- four node network and five node network

Now when the 5th node comes, it checks the degree of the nodes and it found that the degree of the node1 is two, degree of the node2 & node3 is 3 and degree of the node4 is two. Since node five is connected to only two nodes which have least degree in the network. Hence node five decided to connect with the node4 and the node1.

Again when the 6th node comes, it sees that the degree of the node1, node2, node3, node4 is 3 and the degree of the node5 is two. It compares the degrees of all the nodes and found the degree of node5 is two and the degree of all other node is equal to three. Hence it decides to connect with the node5 and the node4.

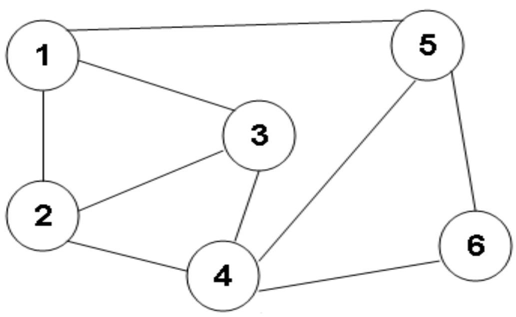

Fig-4.3- Six node network

Continuing this whole process we find that we can form this network very easily and can have as many nodes as we want in this network. The below shown network is for the 12 nodes only and we can extend it by following the above procedure.

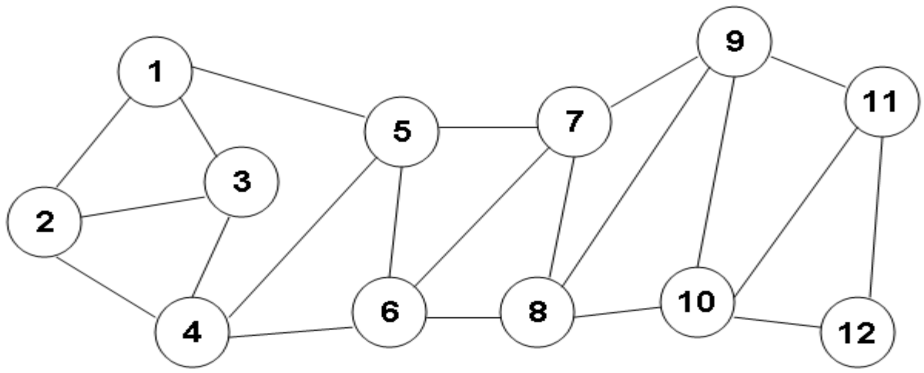

Fig.4.4. An Efficient Network Formation

V. NETWORK RELIABILITY

It is well known that a communication network failure can have an extremely crippling effect on today's society. In future, as more application employ multicast routing, a strong need will emerge for algorithm that can be employed by network reliability.

The network constructed in such a way that there always exists an additional path for protection; and when node fail occurs network is reconstructed for restoration. So this scheme is very much useful for multicast routing.

The network is constructed as discussed in previous section. Here we are showing the network for 16 nodes (0 to 15) as shown in the figure below.

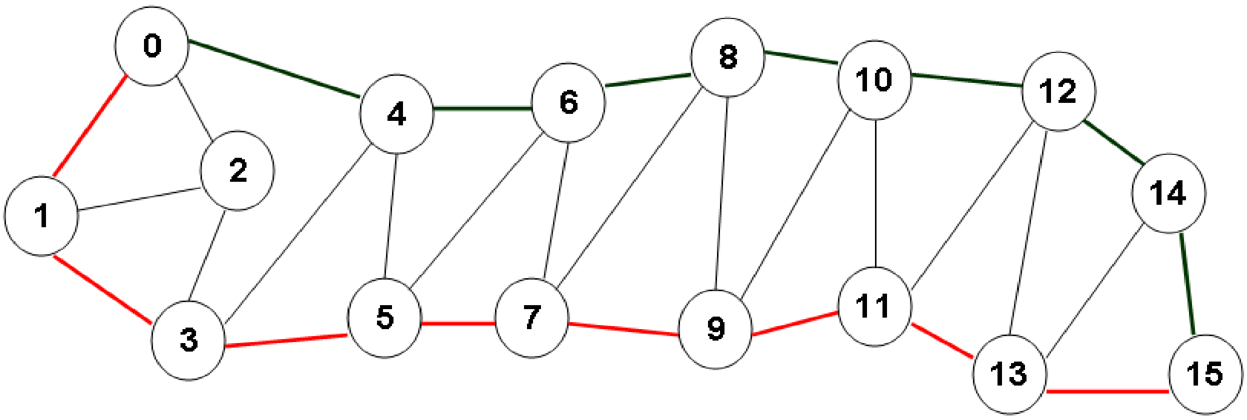

Fig 5.1-Network having 16-nodes only

5.1 Reliability for Single Node failure

The above network figure shows the 16 nodes only and we can connect any number of nodes by this way. And this network always has two node disjoint paths between any pair of nodes.

For example paths between node0 to node15 are

Path1: 0->4->6->8->10->12->14->15

Path2: 0->1->3->5->7->9->11->13->15

These two paths are node disjoint path. If node 6 got fail due to any reason then path1 is break and data can not reach to destination node by path1 then data will send through path2. This shows that this network having facility to send data from alternative path. If source-node or destination-node is fail then we can not be send/received data.

5.2 Network Reconstruction:

The network also has facility to reconstruction of the network. When any node is fail in the network. We remove all links connected to that node. As for node6 fail links between 4->6, 5->6, 7->6and 6->8 are removed in reconstructed network. And we connect the first hop nodes of failure node in a ring form with the help of some new link formation. We know that if a ring is form between a group of nodes then it is confirm that there we be defiantly two node disjoint path between any pair of nodes in the group.

Here some new links are formed to connect all nodes in the ring. As in node 6 failure case we form 4->8 a new link. When this new link is formed the first hop nodes of node6 are connected in the ring form; like in figure node4, node5, node7 and node8 are connected in ring form. If we analyze then we get that the all first hop nodes of failure node are form only one new link between minimum node number to maximum node number. As in figure first hop nodes are node4, node5 node7, node8; so node4 (min) and node8 (max) form a link 4->8. Now this network again starts to provide the facility of two paths between any pair of nodes present in the network.

Now paths between node0 to node15 are

Path1: 0->4->8->10->12->14->15

Path2: 0->1->3->5->7->9->11->13->15

Now here both paths are also node disjoint path. Data can be send by any path but Path1 have less cost (may be equal) to Path2 cost.

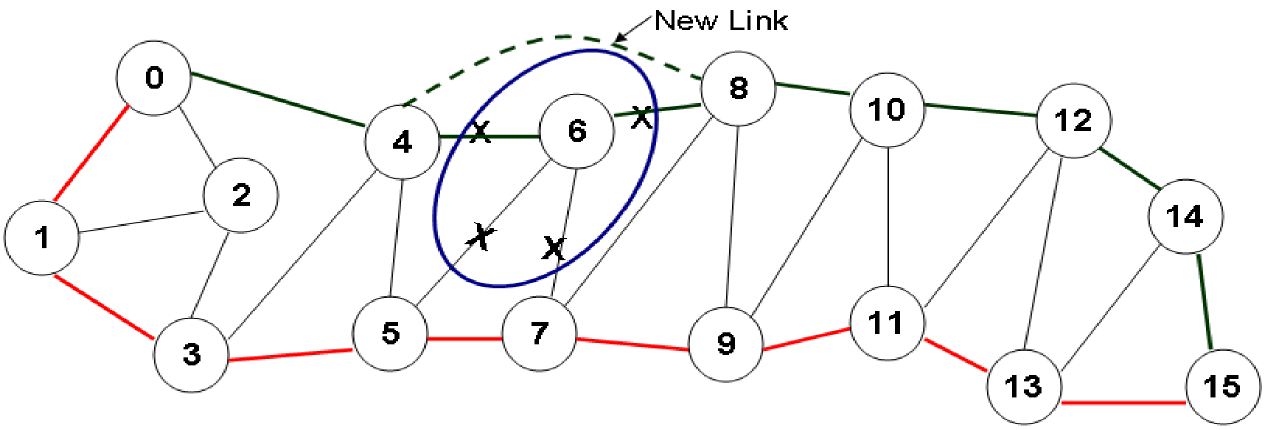

Fig 5.2- Node-6 fails and generation of new link

VI. Average Degree of Network

In this network a node can have maximum degree four. That means a node can connect maximum four nodes and maximum of four links. If we analyze previous constructed network (above 5 nodes networks) then we get some results-

- Node1, node2, node3 have degree three.
- Last node connected in the network has degree two.
- Second last node connected in the network has degree three.
- Except from node1, node2, node3, last node and second last node all nodes has its maximum degree four.

On the basis of above discussed point we can calculate the average degree of the network.

$$\text{Average degree of network} = \frac{\sum_{n=1}^{n=N} (\text{degree of node n})}{\text{total number of nodes}}$$

Where n is node number. If we calculate average degree of different network then we get different results these results are plotted on graphical form as shown below. The average degree of network will be tends to four.

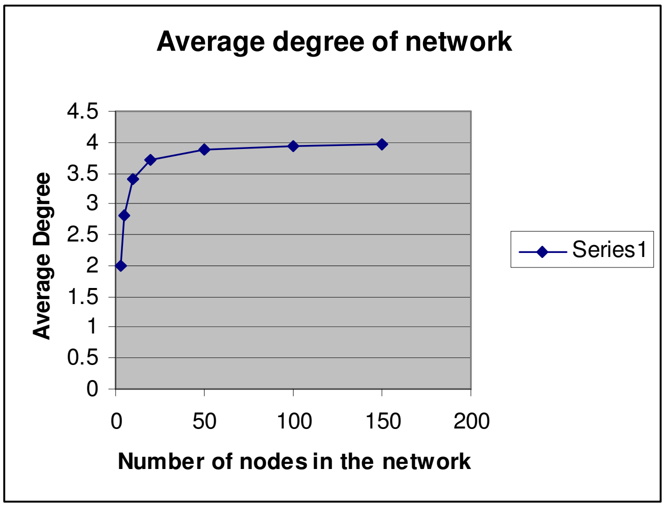

Fig-6.1. average degree of network verses network size

From the above plot it is clear that the average degree of node is approaches to four as the number of nodes is increases in the network.

VII. COMPLEXITY OF NETWORK

We can define complexity of network in terms of average number of steps/ number of hops required to find path between any pair of nodes in the network. This is calculated for all pair of nodes and it includes both paths finding steps.

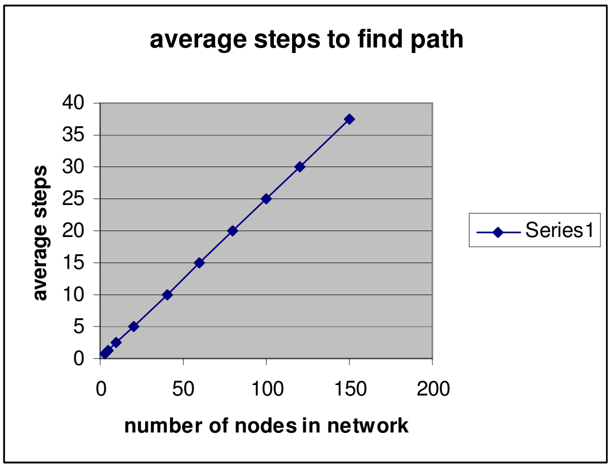

Fig.7.1. average to find paths verses network size

Now from the above figure it is clear that if the network size is increases then number of steps to find path in that network is increases linearly. This shows the steps/ numbers of hops are increases with the increase in user number in this scheme.

If the network size is large then this scheme will take more time to reach the destination node from source node. But if we find the steps to find path between any two selected nodes in any network then it will take same number of steps for these selected two nodes in any size of network.

Number of steps are increases as the number of nodes increases only for newly joined nodes where as the previous nodes have same steps for same combination.

VIII. GRAPH THEORETIC EXPLANATION

Let an undirected graph G = (V,E) represent a communication network, where a set of nodes V and a set of links E correspond to switching nodes and communication links, respectively. Let

$r(v,v') = v_1, v_2, ..., v_k$ where $v = v_1$ and $v' = v_k$ denote a path between nodes v and v'. If $v \neq v'$ then it is called a path. If there are r paths between v and v', then these paths are distinguished by denoted as $r_{sp}(v,v') = v_1^{sp}, v_2^{sp}, ..., v_k^{sp} (1 \leq sp \leq r)$. We say that two paths $r_{sp}(v,v')$ and $r_{ss}(v,v')(sp \neq ss)$ are node-disjoint if these paths do not have common nodes except node v and v'. We also say that an undirected graph G = $(V,$ E) is biconnected (form a ring) if there exists a pair of node-disjoint paths between every pair of nodes in G [2].

Now, we formalize Problem of two node-disjoint paths as follows:

[Problem] Given a biconnected undirected graph $G = (V, E)$ and an arbitrary node $v_d \in V$ (we call it a destination node), find two paths $r_1(v, v_d)$ and $r_2(v, v_d)$ between any node $v(\in V, v \neq v_d)$ and v_d, which satisfy the following two conditions.

Condition 1: $r_1(v, v_d)$ and $r_2(v, v_d)$ are node-disjoint paths.

Condition 2: Let $r_1(v, v_d) = v_1^1, v_2^1, ..., v_k^1$ where $v_1^1 = v$ and $v_1^1 = v_d$. Then, given an arbitrary node $v_j^1 (1 \leq j \leq k)$ on $r_1(v, v_d)$ the terminal sub-path $v_j^1, v_{j+1}^1, ..., v_k^1$ is $r_1(v_j^1, v_d)$. The similar condition holds for $r_2(v, v_d)$.

We call $r_1(v, v_d) = v_1^1, v_2^1, ..., v_k^1$ a shortest path of v and $r_2(v, v_d) = v_1^2, v_2^2, ..., v_k^2$ 2nd shortest path of v. If Problem is solved for any $v_d \in V$, we have two node-disjoint paths between every pair of nodes in an undirected graph. Condition 2 is included mainly in consideration for the minimization the size of paths; insuring there is no looping in the paths**.**

Example-

We will show an example of that problem. We are given an undirected graph $G_1 = (V_1, E_1)$ and a node $v_6 \in V_1$ as v_d in Fig.8.1.

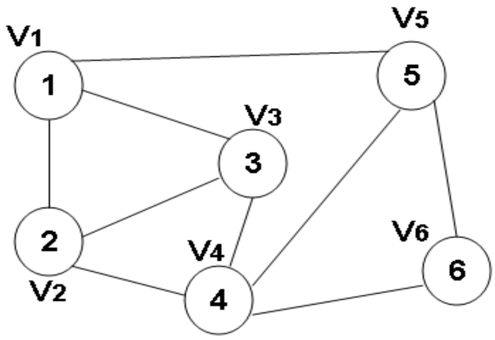

Fig.8.1. An undirected graph $G_1 = (V_1, E_1)$

The following forward and backward paths of any node: $v(\in V, v \neq v_6)$ satisfy Condition D and Condition S of Problem. The forward paths (shortest path or path1) and backward paths (2nd shortest path or path2) are

Path1: $r_1(v_1, v_2) = v_1 -> v_2$

Path2: $r_2(v_1, v_2) = v_1 -> v_3 -> v_2$

Path1: $r_1(v_1, v_3) = v_1 -> v_3$

Path2: $r_2(v_1, v_3) = v_1 -> v_2 -> v_3$

Path1: $r_1(v_1, v_4) = v_1 -> v_2 -> v_4$

Path2: $r_2(v_1, v_4) = v_1 -> v_3 -> v_4$

Path1: $r_1(v_1, v_5) = v_1 -> v_5$

Path2: $r_2(v_1, v_5) = v_1 -> v_2 -> v_4 -> v_5$

Path1: $r_1(v_1, v_6) = v_1 -> v_5 -> v_6$

Path2: $r_2(v_1, v_6) = v_1 -> v_2 -> v_4 -> v_6$

Here we can see that for any $v_j \in r_1(v, v_d)$ also satisfy $v_j \notin r_2(v, v_d)(v_j \neq v \; or \; v_d)$. So we can say that $r_1(v, v_d)$ and $r_2(v, v_d)$ are node disjoint paths for all pair of nodes.

We can say that our proposed scheme always have two node-disjoint paths between any pair of nodes present in the network. It can easily handles' any failure in the network.

IX. CONCLUSION

In this proposed scheme there are two node disjoint paths are always available. Our proposed network has facility to reconstruct the network after any node failure. With the help of this network all the ALM related functionality can be implemented over this network effectively. Its algorithm is very simple and with the help of this algorithm we can construct a network which has any numbers of nodes. This scheme has reliability for any node failure in the network; which makes it very versatile usefulness in the communication network.

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