International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 11, Issue 03 (March 2015), PP.70-78

Comparative Analysis and Secure ALM P2P Overlay Multicasting of Various Multicast Routing Techniques

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Abstract:- *Multicasting is the delivery of a message or information to a group of destination computers simultaneously in a single transmission from the source. The copies of the messages are automatically created in other network elements like routers but only when the topology of the network requires it. Multicast is implemented most commonly in IP multicast which is further could be employed in internet protocol applications of streaming media. In the IP multicast the implementation of the multicast concept occurs at the IP routing level where routers create optimal distribution paths for datagram sent to a multicast destination address. At the Data Link Layer, multicast describes one-to-many distribution such as Ethernet multicast addressing, Asynchronous Transfer Mode (ATM) point-to-multipoint virtual circuits (P2MP) multicast. In this paper we have compared various multicasting mechanisms. The comparison is done on the basis of various factors like complexity, overhead, maintenance, etc. The mechanisms that are part of the paper are a secure ALM P2P multicasting technique for large scale networks using face recognition, IP multicasting techniques and the overlay multicasting techniques. The comparison of these multicasting techniques will help us to design and Implement a Secure Application-Level Multicasting (SALM) P2P Overlay Multicasting for large Scale Network. The main objective of the paper is to discuss all the three above mentioned multicasting phenomenon's and compare them on the basis of certain criterion so as carved out the best of all which can be further used for designing a secure multicasting technique which can take the best features of all combined together so as to get effective and efficient technique for multicasting the throughput of the network by effective and efficient delivery of the information to all the members of the group. The certain findings can be carved out of the comparison can help us to create a multicasting technique with less incurring of delays so that information can be delivered in limited time span and multicast path length so that efficient paths should be used so as to enhance performance in multicasting. Moreover in this paper we will study & investigate other issues that degrades the performance of Multicasting Techniques for large Scale Network and later we will come to know through the comparison that which technique performs well in these harsh environment and give effective results.*

Keywords: - *Multicasting, Application Level Multicasting, IP Multicasting, Overlay Multicasting*

I. INTRODUCTION

Multicast technology today days is driving the interest of Internet Service Providers (ISP) and users from around the world. It is used in IP networks to send information to multiple receivers simultaneously. It is possible to have a single or multiple senders in multicast technologies. It supports a variety of applications, such as web caching and live streaming, which were not possible with uni-cast technology in which data can only be sent from one sender to one receiver. Multicast on the other hand enables the transfer of data between one sender and many receivers as well as transfer from many senders to many receivers. [1] The concept of multicasting was started when there was a need for group communication in which one member could send data to all other members at same time to work more efficiently in a shorter period of time. First multicast applications allow the sender to send a single copy of the data to the router and switches, then these in turn make several copies of the data to send them to all the group members. This kind of application has many benefits such as it saving a significant amount of bandwidth usage on the network because the server is only sending a single copy of the data to the router, rather than sending a copy to each individual member.

This feature of multicast technology decreases the computational load on the server and enables the network to perform more efficiently.

1) Importance of Multicasting

Today the whole world is interlinked through the internet. There are many applications through which we can communicate and share data with each other, for instance through multimedia applications and social networking websites. Everything that is happening around the world is available online and various activities taking place in countries around the world are tracked and posted online in a matter of minutes. Let's consider the example of the most common video streaming website at this time, YouTube. People upload their videos on this website for various reasons such as communicating with others, providing useful information to world, sharing their resources, expressing themselves and much more [2]. With the increase in multimedia content available on the web every day, one- to-many and many-tomany traffic on the internet is also on the rise.

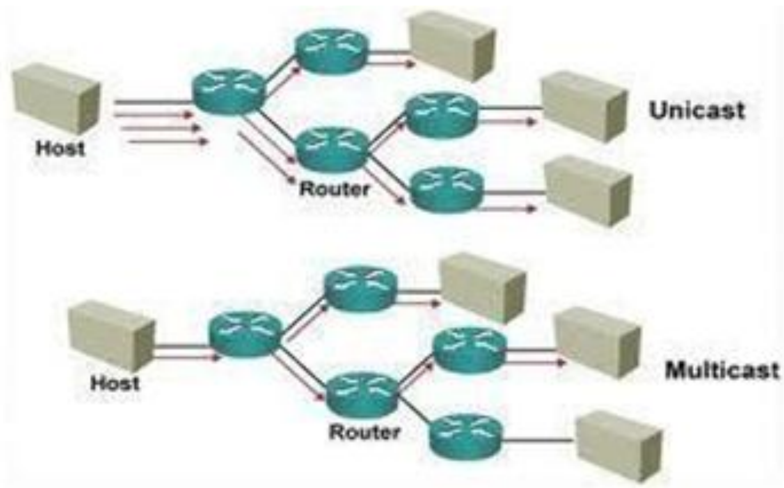

Fig.1: Scenario Representing Uni-casting and Multicasting

As more and more users started connecting to such websites every day, the need for advanced technology which could implement the concept of group communication in efficient way became evident. Implementation of multicast technologies has not only fulfilled this need but has also helped in widespread use of audio/video conferencing in many applications with limited use of network resources. All this would not have been possible without the deployment of multicast technologies.

2) Advantages of Multicasting

Multicast has greatly helped Internet service providers (ISP) and the content providers. As it is an efficient method of group communication and delivering data from one sender to multiple receivers. In case the server receives a request for the same data from multiple users, it only has to send one data stream to the router and switches; these routers and switches themselves can make copies of the data and distribute amongst the users. Imagine how much of a computational load is decreased on the server as compared to unicast technologies in which server has to send as many copies of data individually as the number of users requesting the data. Unlike unicast technology therefore, multicast also decreases the bandwidth utilization on the network and reduces the response time for requests made by users. Furthermore, the ISP also gets assistance in tackling the problem of congestion on the network when there were so many requests that the pipelines are overwhelmed. It is possible for the network to go down as well due to low bandwidth or higher than manageable computational load on the server [4]. Therefore, development of multicast has not only increased the life of the server, but also decreased the cost of maintenance of the server.

- **One to Many**

IP multicast is a technique for one-to-many communication over an IP infrastructure in a network. The destination nodes send join and leave messages, for example in the case of Internet television when the user changes TV channel. IP multicast scales to a larger receiver population by not requiring prior knowledge of whom or how many receivers there are. Multicast uses network infrastructure efficiently by requiring the source to send a packet only once, even if it needs to be delivered to a large number of receivers. The nodes in the network take care of replicating the packet to reach multiple receivers only when necessary [3].

- **Many to Many**

Many-to-many multicast routing can be extensively applied in computer or communication networks supporting various continuous multimedia applications. The paper focuses on the case where all users share a common communication channel while each user is both a sender and a receiver of messages in multicasting as well as an end user. In this case, the multicast tree appears as a terminal Steiner tree (TeST). The problem of finding a TeST with a qualityof-service (QoS) optimization is frequently NP-hard. However, we discover that it is a good idea to find a many-to-many multicast tree with QoS optimization under a fixed topology. In this paper, we are concerned with three kinds of QoS optimization objectives of multicast tree, that is, the minimum cost, minimum diameter, and maximum reliability. All of three optimization problems are distributed into two types, the centralized and decentralized version [7]. This paper uses the dynamic programming method to devise an exact algorithm, respectively, for the centralized and decentralized versions of each optimization problem.

1.3 Applications of Multicasting

Now, let us discuss the kind of applications that require multicasting. Multicasting can be linked to all the applications that require broadcasting. Broadcasting which is carried out in a reliable, controlled, secured and efficient manner is referred to as multicasting. This is so because in multicasting, the sender has complete control over the data to be sent to the desired users. There is no doubt that multicast can be used in any application in which same kind of data is requested many users. So multicasting is an excellent method of transmission for such things as video conferencing, software distribution, stock quote streaming [12], satellite television broadcasting, internet radio broadcasting etc [5]. So it is clear that multicasting is mostly and widely used for multimedia applications. Apart from the above mentioned applications, other widely used applications that employ multicast technology are Microsoft Windows Media Player, RealPlayer, Apple QuickTime, Cisco's IP/TV and Apple's MacTV have multicast capabilities. Using such applications millions of users around the world are connected to each other through the sharing of their resources.

II. MULTICASTING TECHNIQUES

The various multicasting techniques we are going to discuss here consist of:

- IP Multicasting.
- ALM Multicasting
- Overlay Multicasting.

1) IP Multicasting

Multicast is a communication pattern in which a source (Sender) sends some data to all the interested members (Host) of a certain group. There are certain protocols which we need to know for better understanding of the complete structural design of the multicast network. In a typical multicast network (One-to-many) there is a source which is connected to a router which need to know its RP addresses and on the receivers side the RP collects the information from those host's which are interested in receiving data from the sender. The host is also connected to RP via router [6]. RP connects the sender and receiver for transmission of data in the form of packets and it keeps a track of the number of hosts entering and leaving the network. The range of Addresses between 224.0.0.0 – 224.0.0.225 is inclusively reserved for the use of routing protocols and other low level topology discovery or maintenance protocol. Multicast routers should not forward any multicast datagram with destination address in this range.

Whenever some host is interested in receiving data from a source, it needs to know the multicast group addresses using MSDP. The host then passes on information to the first-hop router using the IGMP. Then the router passes the information to the RP which contains information about all the available sources for that particular group. After receiving transmission of data from the source RP duplicates the data and pass the copies to all the interested receivers using the MFIB [8].

1.1 Multicast Addressing

An IP multicast group is identified by a class D address. The size of the Class D multicast address space is therefore 2^{28}or 268,435,456 multicast groups [31]. The first four bits of the address are fixed and rest 28 bits vary. So, all multicast addresses always begin with "1110".

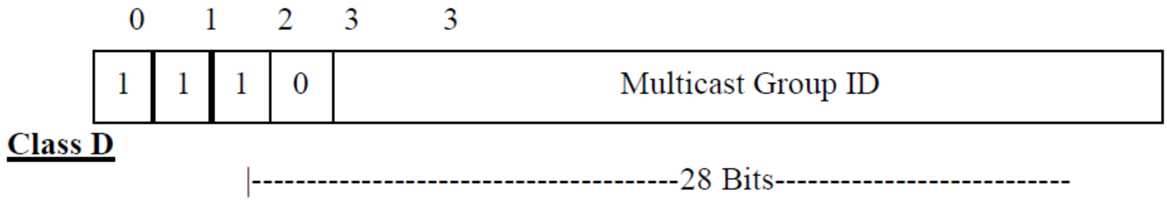

Fig2: Multicast Addressing

1.2 Multicast Address Types

Multicast groups are identified by the IP addresses in range 224.0.0.0 – 239.255.255.255. There are some special and reserved addresses out of above given range which are used for different purposes [11].

224.0.0.1 All systems on this subnet
224.0.0.2 All routers on this subnet
224.0.1.1 NTP (Network time Protocol)
224.0.0.9 RIP-2 (Routing Protocol)

a. The range of Addresses between 224.0.0.0 – 224.0.0.225 is inclusively reserved for the use of routing protocols and other low level topology discovery or maintenance protocol. Multicast routers should not forward any multicast datagram with destination address in this range.

b. The range of Addresses between 224.0.1.0 – 238.255.255.255 is used internet wide for all the transmissions.

c. The range of Addresses between 239.0.0.0 – 239.255.255.255 is used for the administrative purposes.

2) ALM Multicasting

In recent times, the deployment of network-layer multicast (IP Multicast) has not been widely adopted by most commercial ISP's because of the high cost of implementation involved in the deployment of routers, and thus large parts of the Internet are still incapable of using multicast applications. Application layer multicast protocols do not change the network infrastructure, instead they implement multicast forwarding functionality exclusively at endhosts using ALM. Simply it can be defined as the implementation of multicasting as the application service instead of network service.

P2P Multicast: In p2p multicast end-hosts (peers) handles all the basic functionality of the system like group membership, routing and addressing. Two terms p2p multicasting and application level multicasting have been used together in various algorithms, such as orchard. In which the ALM is implemented in the p2p networks decentralized structured environment to share the video stream [9]. Earlier p2p technology was used only for offline file sharing but with the advancements brought about with time and the increase in demand for video streaming and multimedia sharing applications, it started being used online as well [31]. A stream of video can be divided into several sub-streams and spanning trees are formed with each sub-stream to deliver data. In the orchard algorithm, p2p multicasting using the application level multicasting has proved to be very successful as it has solved two major problems that were encountered during the data sharing in p2p networks. First problem deals with free riding as peers are not ready to donate their resources (uploading), but regardless they want to be able to download data. Another problem is with the peers joining and leaving the network at a very high rate. Further p2p multicast can also be referred as end system multicast (ESM) in which the end host is both downloading and uploading the data to other end host at the same time.

3) Overlay Multicasting

The overlay multicasting being a broad concept but is very efficient and gained attention as one of the mechanisms to overcome the barriers of deployment to the router level solutions for various networks issues. The overlay solutions for multicasting consists of content distribution and content sharing are extensively studied in recent times. There are a number of overlay application-layer multicast approaches which have been proposed over the last few years and the amendments are still going on for better performances. In the overlay multicast the hosts participating in a multicast session form an overlay network which only utilizes unicasts among pairs of hosts for the data dissemination and also the hosts in overlay multicast handle group management, tree construction and routing, exclusively, without any support from Internet routers [10]. The advantages of overlays comprises of its adaptive features, ease of deployment and flexibility. The overlays mainly impose a performance penalty over router-level alternatives as the data packet forwarding mainly occurs at the end hosts. Also the overlay multicast consumes more network bandwidth and also increases latency over IP multicast, so little attention has been paid to precisely justify this overlay performance penalty. Moreover there is no work on characterizing overlays multicast tree structure and such characterization is important to gain insight into overlay properties and their causes at both the application layer and the underlying network layer so as to tackle various network related issues. There is also importance in comparing different overlay multicast strategies s0 as to determine how to meet the goals of target applications. The overlay networks have recently emerged as available solution to the various challenging problems which includes routing, multicasting, peer-to-peer services and content distribution. The application-level overlays do incur performance degradation over router level solutions. The recent studies in overlays illustrate that the mean number of hops and mean per-hop delay between parent and its child hosts in overlay trees gradually decreases as the level of the host in the overlay tree increases and the overlay host distribution, internet topology and overlay multicast routing strategies characteristics are recognized as three primary causes of the observed phenomenon [14].

III. RESTORABILITY AND DESIGNING ISSUES

Various issues that are incorporated during the designing of a multicast routing are discussed in this section. These issues should be considered prior to working on a multicast routing phenomenon. Such issues can degrade the performance metrics during the multicast routing so this part of paper will elaborate such issues.

1) Restorability: The restorability mainly occurs due to two reasons: link failure and node failure. As we all know that in wireless scenario node failure is a common issue. The nodes can lead to failure mainly due to restriction on power that a node possesses. So whenever nodes run out of power that results in restoration. Similarly when a node in a network fails it results in the failure of the link between the failed node and the other nodes of the network that again leads to the restoration [13]. So mainly in restoration the routing table of the each node which are participating the network is updated and the obsolete routes to all the other nodes in the network are removed.

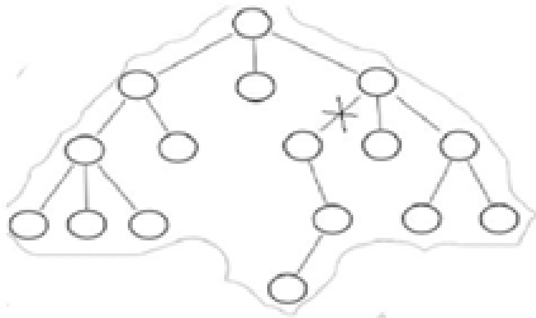

Fig 3: Link Failure and Node

Though restoration incurs a lot of bandwidth consumption it is necessary to restore for effective communication. So while designing a multicast routing protocol these problems should be kept in mind as they can degrade the performance of the protocol.

2) Design Issues: The following are some of the performance issues that degrade the performance in the multicast routing:

- **Overhead**

The routing protocols especially in multicasting incurs heavy overloads as they carry information about the all the member in the multicast group. This led to the higher consumption of available bandwidth and processing power and hence results in the inefficiency in the performance of the protocol.

- **Bandwidth**

As we all know the bandwidth in the wireless networks are very limited. A lot of the bandwidth gets wasted in the restoration that occurs mainly due to link or node failure and resulting in the degradation of the performance.

- **Delay**

In wireless medium the chances of collision are vibrant. There is no presence of central arbitrator than can monitor the communicating nodes. So at the same time more than one node can initiate the communication that results in collision which further results in subsequent delays.

- **Looping**

Looping occurs only when there are more than one path available between source and destination during a communication. The looping can result in performance degradation when source tries to send data to destination using second path when he comes to know that the first path is down. But meanwhile first path becomes active again and source gets acknowledgement from first path.

- **Data Loss**

As in wireless medium there is no arbitrator than can monitor the communicating nodes. So at the same time more than one node can initiate the communication that results in collision which further results in loss of data.

- **Stress or Load**

The over stress over a link or over a communicating network having limited bandwidth can result in degradation of performance. If there is limited bandwidth but the load is more than it will slow down all the process occurring over the network.

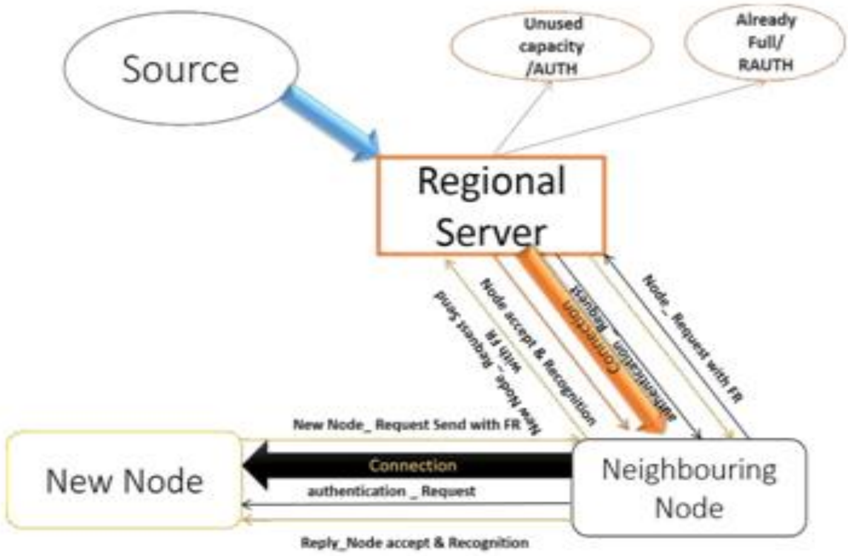

Fig 4: Block diagram Multicasting Network with Face Detection and Recognition

Architecture: The structure of P2P overlay network architecture is different from the client server architecture. It has more of distributed architecture as peers are present in random locations and there is no fixed pattern use of face recognition. A secure ALM Simulator design with Emgu CV library is a cross platform .Net wrapper to the OpenCV image processing library. Allowing OpenCV functions to be called from .NET compatible languages such as C#, VB, VC++, IronPython etc. The wrapper can be compiled by Visual Studio, Xamarin Studio and Unity, it can run on Windows, Linux, Mac OS X, iOS. Its architecture can be described in five layer model with network communication layer at the bottom. It keeps a track of all the peers in the network and describes the network characteristics. Above networking layer is the Overlay nodes management layer which tracks all the existing and new peers, manage them and provide the routing algorithms for optimization

IV. PERFORMANCE METRICS

In this section we will discuss various performance metrics on the basis of which the IP multicasting, ALM Multicasting and the overlay multicasting is to be compared. The result will display which multicasting technique produces the best when measured against these metrics:

1. Multicast Efficiency

The multicast efficiency will measure which of the all the three multicasting techniques would multicast more efficiently to all the members of the multicast group.

2. Ease of Deployment

The ease of development will tell which of the above mentioned multicasting technique is easy to implement according to the environment around. As discussed in Section III there are lot of performance factors that can affect the performance. So in such environment the technique which can v deployed easily will be shown by this metric [15].

3. Complexity and Overhead

More Complex a technique would be more it would be difficult to implement it mainly in the wireless environment. Similarly if there is more overhead than it degrades the performance straight away.

4. Maintenance

This metric will measure which of the above technique is easy to maintain. The more easily a technique could be maintained more easily it can give efficient performance results.

5. Adaptability

There are lot of factors in the wireless medium on which entire communication relies. Sometimes there could be heavy traffic so a technique should be highly adaptive so that it can adapt according to the current situation of the network and yet been able to produce better results.

6. Robustness

The wireless medium is full of uncertainties. The time where a communication is going well next moment the network can lead to some failure. So the technique used for the multicasting should be reliable enough so as it can take it out of such failures. So this metric will tell us out of these three techniques which perform the best.

7. Data packet Forwarding

The data packet forwarding will tell where in each of the above mentioned techniques the data packet forwarding will take place. It is another important metric as it will tell which multicast technique uses less time to wrap or un-wrap the data packets and hence influences the performance.

V. RESULT

The result shows the behavior of the multicast routing techniques on the basis of the performance metrics. The table shows that how the three techniques differ from each other on the metrics discussed earlier:

Performance Metrics	IP Multicasting	ALM	OM
1.Multicast Efficiency	High	Low	Medium
2.Ease of Deployment	Difficult	Easier	Medium
3.Complexity & Overhead	Low	High	Medium
4.Maintenance	High	Low	Low
5.Adaptability	Low	High	High
6.Robustness	High	Low	High
7.Data Packet Forwarding	At Routers	End Hosts	End Hosts

Tab. 1: Comparison of Multicasting Techniques

We have conducted preliminary simulations to examine large scale multicast tree formation using this technique. A 4000-kilometer wide square-shaped area was assumed to approximate the size of Punjab. The area was divided into K regions, and a regional server was placed in a random location in each region. One of the regional servers was picked as the multicast source. Then a total of N host locations were randomly generated. We assumed that at the beginning of multicast only the regional servers were present, and then the hosts joined one by one. We limited the egress capacity for each server to 2Kstreams, and for each participating host to five streams. Therefore in these simulations the nodal degree of a user host in the overlay network would be six or less. We also calculated the initial set up time for each host, based on the round trip delay of the messages they must send to the root, their regional server and their parent candidates until a viable parent is found.

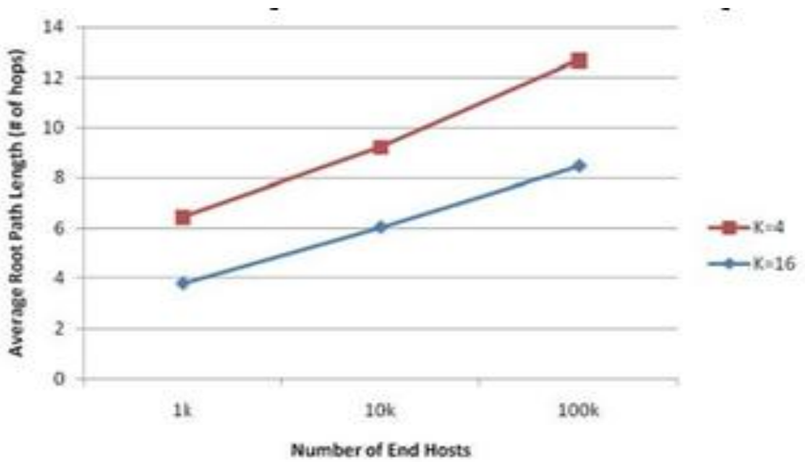

Fig 5: Average multicast path length for different core and network sizes

Simulations were run for K= 4 (sparse-core) and 16 (dense-core), each in N= 1000, 10000 and 100000 hosts. In all cases, a new host was able to find a parent with available capacity. The initial setup delay was between 26.9 to90 milliseconds in different scenarios. The average label length (which indicates the average root path length – indicating the data path delay) decreased almost by 35% when number of servers quadrupled, but increased with the number of users. Figure 3 shows the results of average root path length (in hops) for different scenarios. The strict maximum nodal degree protects each host against being overloaded by its child nodes. Next, we simulated node drop or failure in these scenarios. For each scenario (sparse- or dense-core, N=10000,10000 or 100000) we failed nodes one by one, and had downstream nodes apply our algorithm to find new parents and reconnect to the multicast tree. Tree repairs were first done locally, i.e. by connecting to a backup parent in the same region as the node seeking a new parent.

However there is a special case where all other end-nodes in the region are in the child tree of the node seeking a new parent. Obviously, a node cannot choose a parent form its own child tree because that would partition the multicast tree. In such case, after a number of unsuccessful reconnection attempts within the region (10 in our simulations), the parent-seeking node will have to connect to another regional server. Accordingly, as long as at least two regional servers are up and running, a node can always recover from the failure of its parent. In our simulation, we assumed that regional servers did not fail (e.g. stand-by servers were available at each location).

As mentioned, a key approach to simplify the operation of the algorithm was based on the decision that the regional server need not maintain a topology map of the nodes under its domain and will not check for loops when sending lists of potential backup parents to end-nodes. In this approach the regional server randomly selects Knodes (10 in our simulations) that still have capacity, and send them as potential backup parents to each node. This list will be updated periodically. In our simulations, without loss of generality, we assumed that the regional server generated a new random list per node in every period, and that the new list would be entirely independent of the old list. This approach allows further saving on the regional server memory because it does not have to maintain tables of current backup parent nodes for each node. However it could pose a potential problem: that a potential backup parent node could be allocated to many nodes, and upon a failure that affects all of them, it may not have enough capacity to accommodate them all. This problem is resolved by the fact that the selection of backup parent node must be acknowledged, therefore once the potential backup parent node runs out of capacity, it will refuse any further requests, and the parent-seeing nodes will move to the next potential parent on their list. As mentioned before, loop-checking is also performed by each parent-seeking node based on the hierarchical addresses. If none of the parents in the list have enough capacity or are eligible parents, the parent-seeking node contacts the regional server for a new list, which adds to the restoration delay.

Therefore, it was important to find out how many times on average a node will have to contact the regional server. We expected the multiple connection attempt incidents to be small, for two reasons: First, the egress capacity for each node was limited to five; therefore a node failure would affect at most five downstream nodes who would be seeking new parents. If the regional server creates the parents list in a genuinely random manner, the probability of five nodes receiving similar backup parent (with insufficient egress capacity) out of hundreds of potential candidates would be small. The probability of multiple connection attempts would increase for the nodes in the higher layers of the tree, because they have more child nodes (that are ineligible as backup parent).However the number of nodes decreases as we move higher in the tree; therefore the probability of such incidents remain small; and our simulation results confirmed it. Figure 5 shows the distribution of the number of connection attempts for different nodal failure ratios from 10% of all nodes to 90% of all nodes, in a sparse-core 1000-node scenario. For a scenario in which 10% of all nodes failed, only 8% of nodes had to attempt more than once to reconnect, and no node had to attempt more than twice. As failure ratio increased, the possibility of multiple attempts increased too. However even for a failure ratio of 50%, no node had to attempt more than five times, and over 60% of nodes reconnected in the first attempt. At failure ratio of 70% or higher in this scenario, some nodes had to connect to another regional server.

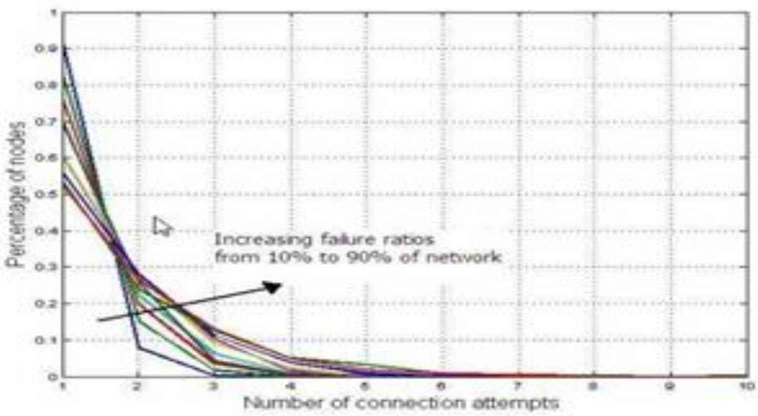

Fig 6: Distribution of Connection Attempts

Our results indicate that in large scale ALM networks, a lightweight simple algorithm could still guarantee robustness against failure without a need for resource-intensive preprocessing of nodes for initial or post-failure parent assignment. In particular, random selection of parents from a pool of local candidates seems to be a viable possibility. We have not yet established a clear trend in our simulation results regarding the restoration performance based on the number of regional server (sparse or dense). However more simulations based on larger networks are being conducted for this purpose.

VI. CONCLUSION

Multicast enables the transfer of secure data between one sender and many receivers as well as transfer from many senders to many receivers as we have discussed the various techniques in the multicasting. We come to know that multicast efficiency in IP multicasting is high as compared to the ALM and the Overlay multicasting with face detection. The deployment of ALM is easier than overlay and IP multicasting. From the above discussion we come to know that the complexity of IP multicasting is lower than its counterparts and also possess low overheads whereas ALM and Overlay multicasting requires less maintenance. The comparison shows that the ALM and the OM are highly adaptive to the networks conditions whereas the IP multicasting is less adaptive to the situations. OM and IP multicasting are highly robust in nature as compared to the ALM and in IP multicast the data packet forwarding are done at router whereas in its counterparts it is done at the end hosts. So this paper on whole discusses various techniques that are part of multicasting and using this study one can easily design a multicast routing protocol that keeps in mind all the metrics that results in degradation of performance and also those factors that can massively endeavor the efficiency in performance of the protocol.

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