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Analysis of Performance of Core Based Tree and Centralized Mode of Multicasting Routing Protocol

Ijtaba Saleem Khan, Abhinandan Tripathi and Anwar Ahamed Shaikh

Abstract- In recent years online gaming where multiple players from different location participate through internet in same session. Multicasting is very suitable in such environment. Multicasting is a key concept for modern communication. A message is sent from a source host to a group of destination hosts. Communication link is used as a path to receivers. Multicasting uses several multicast routing protocols for forwarding messages from source host to destination hosts. In recent years packet radio has gained much popularity for host to host communication. Power constraints and scarce bandwidth are the major challenges for routing protocols. We performed the comparative study and analysis of the Reactive and Proactive routing strategies for wired ad hoc networks. In this paper we are showing the comparison between the Core Based Tree and Centralized routing strategies.

Index Terms- Multicast routing, ad hoc network, RP, CBT, CM

I. Introduction

Multicasting is a highly demanded service now a days. Most of the major ISP provides the multicast [12] features. Applications such as online multiplayer gaming, news, audio/video conferencing and so on are used in our day to day life. Earlier in unicasting multiple copies were forwarded one by one to a group of multiple users. In unicasting the bandwidth and delay were the major concern because there was limited bandwidth and delay was there between first and last receiver of message. Steve Deering [4] introduced the concept of multicasting in the late 80s. Later in 1992 IETF (Internet Engineering Task Force) did audiocast which is a widescale test. Multicast added to internet without any change to basic model of network. It uses a new type of address known as host group address. One common situation where multicast is used is distributed conference. In distributed conferencing a set of hosts joins the real time distribution of audio and video. Figure 1 is showing the example of multiple unicast and multicast.

Problem with Unicast

Anything which is neither multicast nor broadcast is unicast. When one sends a packet and there is only one sender and one recipient process, this is unicast. TCP is a unicast oriented protocol. Unicast is supported by UDP also. Unicast was enough for data transmission on internet for many years.

In 1993 when BSD 4.4 releases, multicast first implemented.

In today's technology if a web page is shared to different peoples on internet, can be done through unicast. However if we want to send audio/video which uses a huge amount of bandwidth relative to web applications, we are having two options either every recipient is connected through unicasting or to use broadcast. Unicasting is not affordable because sending audio/video requires a huge amount of bandwidth for a single connection, so for hundred or more it will be much more and network and sending computer would collapse. Broadcast is a solution if we are interested to send all hosts on a LAN but if we want to send a group of host on one LAN and a group of host on other LAN, the best

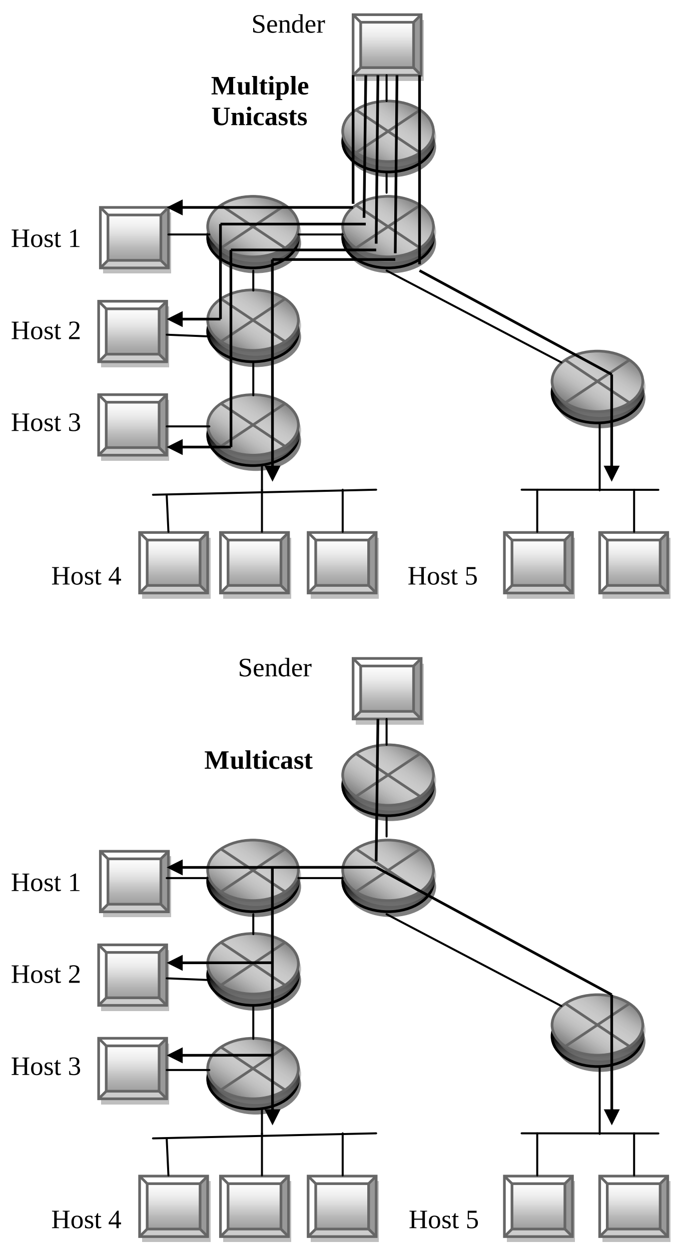

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Figure: 1 Multiple Unicasts vs Multicast comparison solution will be one in which we want to send packets to a certain specified address. All interested hosts to join the conference must notice that destination address of packet, read that address while traversing the network and send them for demultiplexing to IP layer. These packets are IP packets, are routed at kernel level. The routing algorithm tells the kernel where to route or not to route them.

II. Routing Protocols – An Overview

Ad-hoc [1] On Demand Distance Vector Routing (AODV) [2,3] can be used for scalability study of various communication methods such as unicast, multicast, and broadcast. Routes for unicasting and broadcasting are discovered by route discovery mechanism of broadcast. AODV provides broadcast data delivery using source IP address and IP header's Identification field to uniquely identify the packet. Every node maintains two routing tables in AODV first one as Route Table and another as Multicast Route Table. Route discovery in AODV is done as route request/reply cycle. When a route for a particular destination is needed by certain node Route Request is broadcasted. Any node having this route as current route to that particular destination, unicast Route Reply back to the source node. Every node maintains a table as Route Table for these route information. Route Table keeps the information obtained through these Route request and Route reply messages with other routing information. Primary objective of AODV is not only the unicasting, broadcasting, and multicasting, but also minimizing the broadcast of control packet as well as link breakage information is dissemination to the neighboring nodes that uses that link. AODV provides an on-demand route discovery that is when any node requires a route to any particular destination. Node asking for route discovery does not have a pre-recorded route. In the network, each node maintains two separate counters: broadcast ID and sequence number. The freshness of routes is ensured by the sequence number to the node. Each Route Request is uniquely identified by the IP address of source node and broadcast ID together. A node first updates its route table after receiving Route Request message. Updation for sequence number and next hop is done for the source node. This is known as reverse route entry and is used to relay a Route Reply back to the source. A node that responds the Route Request can have the fresh route to destination or destination itself. Nodes fulfilling the above requirements send a Route Reply message back to source. Route Reply receiving nodes increment the Hope Count by one. Route Table updates this entry for destination node and establishes the forward path to the destination. Route Reply is then unicasted towards recorded next hope to the source node. This forward path is established till the Route Reply reaches the source node. Once the Route Reply reaches the source node a route is established from source node to destination node to send data packets. For ad-hoc networks, multicast routing protocol is an extension of AODV. This protocol is known as MAODV[11]. A tree is created with the nodes joining the group. Tree connects group members as well as non routers which are non group members. These routers exist to connect the group members in the tree. Dynamic group membership is there in multicast routing protocol. Routers along with group members are members of the tree. There is a unique address to identify every multicast group and the freshness of group condition is traced by group sequence number. As we have discussed in AODV any interested node to join any particular group broadcasts a Route Request message. Node having fresh enough routes to that multicast group can give a response by Route Reply message. To become member of such a group which does not exist, node sending message to such groups becomes the leader of group and responsible to maintain that group. Periodically group hello messages are broadcasted to check the tree structure's connectivity. QoS multicast routing protocol are reviewed long in current scenario. Power consumption and energy efficiency are the major concerns in quality of service for multicast routing protocols. QoS extensions to MAODV use the bandwidth, delay and packet loss as characteristic of MAODV. A QoS Route Request is send by the source node. Intermediate nodes forward this Request until it reaches the destination. Destination node forwards the Route Reply by adding a delay time known as predefined node traversal time (NTT). These NTTs are added by all intermediate nodes to the delay values and there routing table is updated. For data transmission minimum delay route is selected. For bandwidth requirements similar techniques are used. One more protocol for managing the group is IGMP. This protocol tells the host's membership information of group to multicast routers. The multicast tree is build using vertices and edges depending on minimum cost or smallest path. The tree can be defined mathematically as G(V,E) where V denote the vertices and E represent the edges of the tree.

III. Taxonomy of Multicast Routing Protocols

Multicast routing protocols can be classified on various issues into different categories. For instance one can classify them as sparse and dense mode protocol. PIM is one of the protocols which can operate as PIM-SM and PIM-DM. Another way to classify the multicast routing protocol is how the connectivity is initiated and maintained. Two methods in this category are source initiated and receiver initiated connectivity. In source initiated approach source initiates the multicast group formation and a tree is constructed per sender. In source initiated protocol periodically join request is polled, Packet receivers of this join message if they are willing to join responds with reply packets. In receiver initiated approach a join message is flooded by the receiver and a path towards the multicast group is searched. One common technique used in receiver initiated approach is that every group has a node known as rendezvous point to accept join requests. This rendezvous point is also known as the core. The shortest path connection from core to every member of the group is maintained. Multicast routing protocols can also be divided as reactive and proactive protocols. Reactive protocols are on demand protocols, this on demand approach is the best suited mesh or tree network is created whereas due to dynamic variation in topology table driven protocol is used for Manets. Multicast routing protocols further classified as mesh and tree based topology [5]. In tree based protocol only one route from source to destination is available whereas in mesh based protocols there exist more than one path for source destination pair. Tree based topology can be further classified as shared tree [13] and source based shortest path tree.

In shortest path tree a minimum cost spanning tree is maintained using Dijikstra's algorithm or any other minimum spanning tree algorithm whereas in shared tree a core is selected and data from source is first send to core later it forwards destination by appropriate route. When the group members are densely distributed, shortest path tree is used to minimize the delay. In shared trees resource utilization is much better than shortest path trees. Figure 2 is showing the classification of routing protocols for wired network.

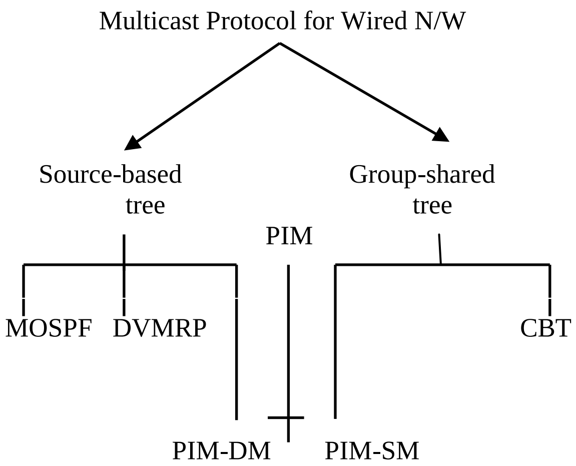

Figure: 2 Classifications of Wired Multicast Protocols

IV. MULTICASTING PROTOCOL FOR WIRED NETWORK

Distance Vector Multicast Routing Protocol (DVMRP)

Distance vector Multicast Routing protocol [6] is originally driven from Routing Information Protocol. The difference between RIP and DVMRP is that RIP takes the information of next hop and forwards the unicast packets towards the destination whereas DVMRP takes the information of previous hop and makes delivery tree back to the source. Now DVMRP constructs its delivery based on Reverse Path Multicasting. The first packet send from source to destination is flooded across internetwork. Branches which are not coming from any group member are truncated by the use of "prune" message. If a new host joins that pruned branch then a new type of message called "graft" message quickly backs that branch. Prune messages are forwarded hop by hop whereas the graft message are sent one hop back until they reach a node which is available on that multicast delivery tree. DVMRP floods the packets periodically. If there are more than one router present in a subnetwork the one close to the source is elected as incharge to forward multicast messages. Multicast messages are simply discarded by other routers. If the two routers have the same distance from the source then the router having lowest IP address is elected.

Multicast Extensions to OSPF (MOSPF)

MOSPF[7], an extension of OSPF uses group membership obtained from IGMP and also obtains the unicast routing information from OSPF. For each (source, group) pair MOSPF builds a multicast forwarding tree. MOSPF supports hierarchical routing in which all host are partitioned into autonomous systems. To distribute unicast routing information within an AS, Interior Gateway Protocol is used. AS is further divided into OSPF area, based on the address range. With the help of these areas border routers can identify every router in that area. Area in OSPF is similar to IP network subnetting. Routing in OSPF can be intra-area routing or inter-area routing as it is limited to single OSPF or multiple OSPF. Intra-area routing runs within a single OSPF area, supporting multicast in which sender and receiver are in the same OSPF area of an autonomous systems. Inter-domain routing is used when the sender and the receiver are in different Autonomous Systems. MOSPF uses area border router (ABR) to support inter-domain routing. These ABR works as inter-area multicast forwarders.

Protocol-Independent Multicast (PIM)

Protocol Independent Multicast (PIM)[5] is independent of any particular unicast routing protocol providing scalable multicast routing across the internet. It is developed by Inter Domain Multicast Routing working group of the IETF. Basically PIM have two variations as PIM Dense-Mode (PIM-DM) [9] and PIM Sparse-Mode (PIM-SM) [10]. PIM-DM is a source based multicast routing protocol whereas PIM-SM is core based multicast routing protocol. PIM-DM is suitable for that area where group members are frequently available, densely populated and plentiful bandwidth is available. PIM-SM is suitable when the group members are widely distributed across the globe and bandwidth is limited. It must be noticed that sparse mode does not mean that group members are distributed sparsely but the groups are sparsely present across the internet. In the next two sections these two protocols are reviewed.

Protocol Independent Multicast- Dense Mode (PIM-DM)

PIM-DM is very much similar to Distance Vector Multicast Routing protocol. PIM-DM also uses RPM algorithms to construct delivery tree. It builds source based multicast tree. Although unicast routing protocols are used to find the path back to the source node, PIM-DM is independent of the mechanism used by unicast routing protocols. DVMRP and MOSPF are different as RIP-like exchange message is used by DVMRP and OSPF link state database is used by MOSPF. Another difference between DVMRP and PIM-DM is that in DVMRP child nodes in delivery tree obtain the forwarded multicast messages while in PIM-DM all downstream interfaces obtain the forwarded multicast messages until it receives prune messages. So PIM-DM also needs mechanism to deal with duplicate messages. PIM-DM is chosen because it eliminates routing protocol dependencies and also the overhead at each router due to calculation of child interface. A previously pruned branch can be active by sending graft messages as in DVMRP.

Protocol Independent Multicast-Sparse Mode (PIM-SM)

PIM-SM can use both the approaches core based tree and source rooted tree for multicasting. In PIM-SM to receive multicast messages of multicast groups routers explicitly announce their will while in dense-mode all routers receive the multicast messages unless the prune message is sent. The other difference is that a "rendezvous point" (RP) or the "core" that is employed in PIM-SM. Any receiver interested in multicast packets has to join a multicast tree explicitly. Some rendezvous points are selected for each group. One of the RP is selected as primary RP.

All packets destined for any multicast group are forwarded by this RP. A designated router (DR) is selected for every multicast domain. Multicast group membership messages are handled by this DR.

V. Routing Strategies

Core Based Tree (CBT) Multicast Routing Protocol

Core based Tree[8,10] is sparse mode, protocol independent shared tree protocol. CBT is rooted at Core routers. One more router in every domain is present known as Designated Router. Multicast Group Membership messages are handled by these DRs.

Finding Core Router

In the CBT domain a set of routers are configured as candidate core routers. Candidate core messages are exchanged using these routers. One of the router among these is elected as Boot Strap Router. This Boot Strap router selection is priority based. If equal priority is there then router having highest IP is selected. Now candidate core messages by the other core routers is unicasted to the Boot Strap Router as a keepalive in every 60 seconds. A candidate core set is assembled using these candidate core messages. Now using boot strap messages this candidate core set is advertised to all CBT routers in that domain. To join a group using IGMP router runs a hash algorithm against candidate core set. This gives the correct core router for that group.

Finding The Designated Router

Designated Routers are elected using the HELLO messages on a multi access network. CBT DR concept is same as MOSPF DRs and DVMRP Designated Forwarders. RPF is not used by CBT for checking the forwarding of packets. When there are multiple paths towards the core then DRs are especially important for preventing loops. CBT interfaces are configured using preference values between 0 and 255. A HALLO message carries these values. Routers having preference values between 1 and 254 are eligible to become DR. The lower number gets higher preference that is a preference value with 5 is more eligible with preference value 10. CBT router having preference value 0 is selected as DR as shown in figure 3.

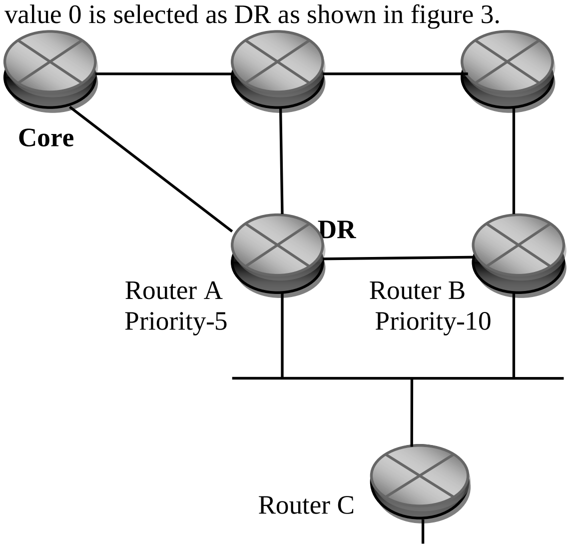

Figure: 3 CBT electing designated router (DR)

Working of CBT

The location of Core can be anywhere in the network, one Core can be used as root for many group trees. Links leading to interested receivers are included in CBT. Any host is interested to join any particular group may join using IGMP membership report message. Using explicit join, CBT router forwards packet for a particular group. This router graft itself from the multicast tree of that group. Now router first checks the core for that particular group in its routing table and a JOIN_ REQUEST message towards the core is forwarded. These JOIN_REQUEST messages are examined by the next hop routers for the group and core addresses. If router is an on tree router or a core router a JOIN_ACK message to the originator of JOIN_REQUEST is sent. It indicates that Originator now successfully joined. If the router is neither in group tree nor the core, must join the tree also. Router consulting its own routing table for core identification and a JOIN_REQUEST message is forwarded upstream. If the JOIN_ACK is not received within 7.5 seconds this transient join state is deleted and unsuccessful join is considered. Two interfaces are present, upstream towards the core is called as parent interface and downstream towards the group member is child interface. When tree is created using JOIN_ACK, an ECHO_REQUEST is sent every 60 seconds by the child router to its parent router. Only the originating child routers address is present in this ECHO_REQUEST message. An ECHO_REPLY message is responded by the parent listing those groups for which messages are forwarded. A timeout period of 70 seconds is there for ECHO_REPLY after that parent router is declared as unreachable. Likewise if a group is not listed in the past 90 seconds this is also declared as invalid. Two messages are now sent as QUIT_NOTIFICATION upstream towards parent router and FLUSH_TREE downstream for listing all invalid group addresses. This FLUSH_TREE is further sends towards the downstream and so on till all branches of tree having routers

Routers are deleted. QUIT_NOTIFICATION message is also used for pruning. For checking of a particular group that there are no attached members, a router uses IGMP leave group messages. By checking it, router forwards QUIT_NOTIFICATION message to its parent router. This message contains that group address to be pruned. If there are no group members attached to this parent router and no child interfaces are present then this parent router also forwards the QUIT_NOTIFICATION message upstream. This continues until a core or an active on tree router is obtained.

Centralized Multicast (CM)

All major multicast routing schemes assumes that the routers participate in data movement and control algorithm both. For example if we see the DVMRP approach we will find that multicast routers forwards packets and also participate in DVMRP protocol. Similar requirements are with the CBT and PIM. By involving in both data forwarding and control algorithm, complexity of router is substantially increased. For multicast forwarding router needs to support complex routing and if flow and reservation protocol are also be there it will make the task much more difficult. We will take the approach that not only decouples data movement and control but special control elements that centralize the control. A two level hierarchy as shown in figure 4 is used to arrange the control elements. This two level controls the multicast routing within autonomous system and between autonomous systems. Autonomous systems (ASs) are also called as domains. Control element in each domain is called a gateway and the other one linking these gateways is called as root controllers. Figure 4 is showing the gateways and root controllers. Our approach is to centralize the control, because of this it is called as Centralized Multicast or CM [14].

In CM, Each domain is having a well known gateway. Host interested to join a particular multicast group determine the IP address of the gateway. Host may discover the group IP address in variety of ways. Host can get the address using session discovery or a centralized server.

Working of CM

When a new sender comes in the contact of gateway, it grafts the sender if a multicast tree exist otherwise creates a new tree with only node as sender. Grafting is done as a shortest path tree from sender to the existing tree by sending ADD messages. These messages are forwarded using appropriate routers. If creates the tree with only one node then no computation of shortest path is done. This working is if groups are present within domain.

If the group span across different domains the new sender first contacts the gateway present in that domain. Now This particular gateway contacts with the nearest root controller. Now two cases arise whether the root controller knows that particular gateway or it does not know the presence of that gateway. If the root controller knows the group it forwards the JOIN message to that gateway of domain. Group is created by this gateway for admission control. Gateway replies with an OK message to root controller. On receiving the OK message from gateway, root controller grafts the sender. If the root controller does not know the existing group, either group is not present or it is present and not known by root controller. In both cases root controller waits for a certain period. This period is state exchange period to know about the group. A new group is created by the root controller if the group does not exist. And information is forwarded to other root controllers. If the group is existing then root controller grafts that sender in the tree present. In CM the tree within the domain can be source specific shortest path tree or bidirectional shared tree whereas in inter domain multicasting a shared tree is used.

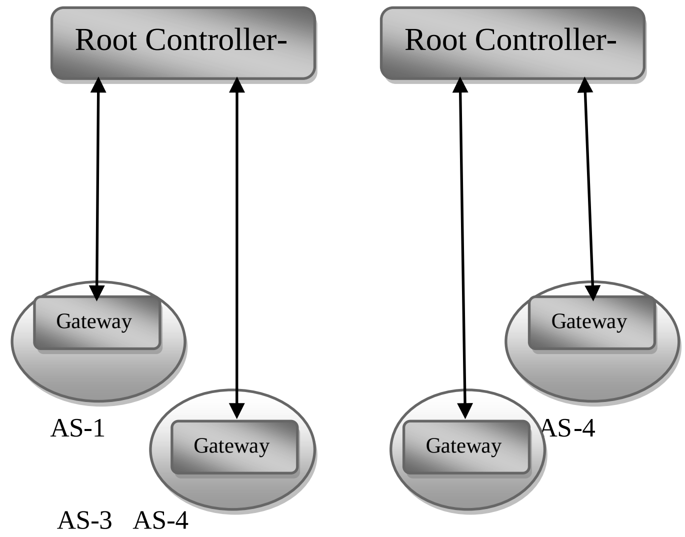

Figure: 4 Gateways and root Controllers

In CBT a JOIN message is forwarded from a router to the core. This message goes through different intermediate routers in the shared tree to that particular node. In CM the JOIN message is first forwarded to the gateway which sends the ADD message to the appropriate routers. The path associated with these ADD messages is same as the path associated with the shared tree constructed in CBT. So the CM will take additional messages between the sender and the gateway. So there is an increased overhead in Centralized Multicast with respect to CBT.

VI. EXPERIMENTAL RESULT

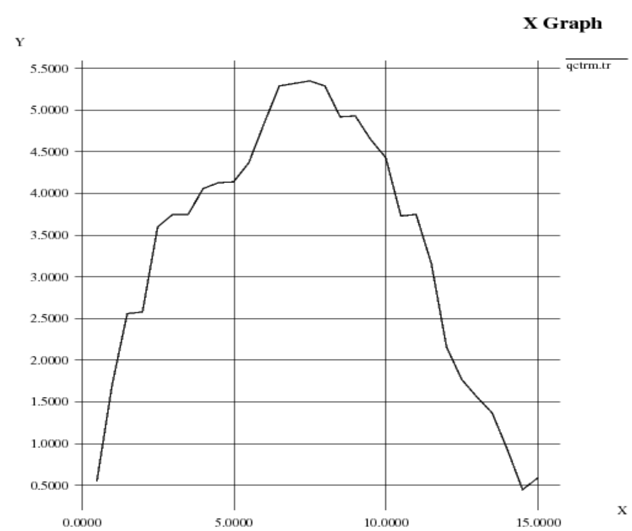

Figure: 5 Graph for QoS of Centralized mode showing time interval on x-axis and quality of service on y-axis.

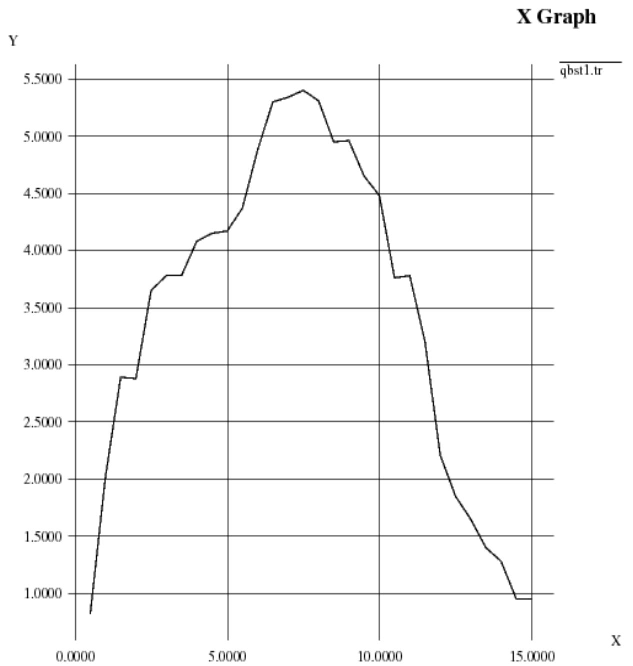

Figure: 6 Graph for QoS of CBT mode showing time interval on x-axis and quality of service on y-axis.

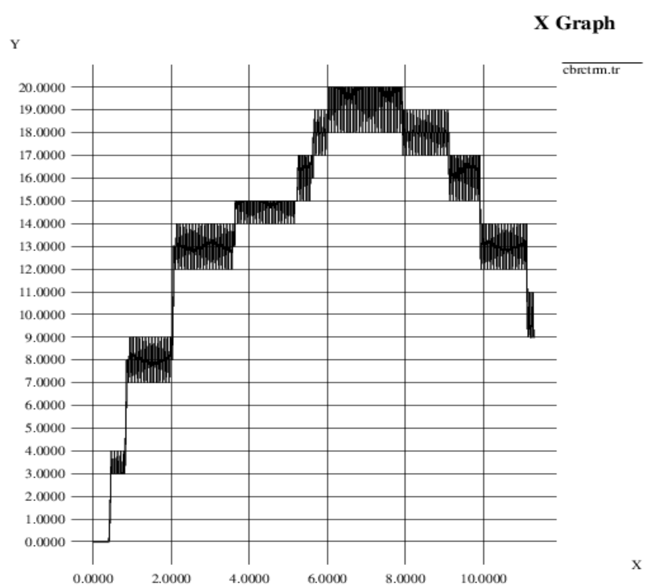

Figure: 7 Performance of Centralized mode showing time interval on x-axis and number of packets on y-axis

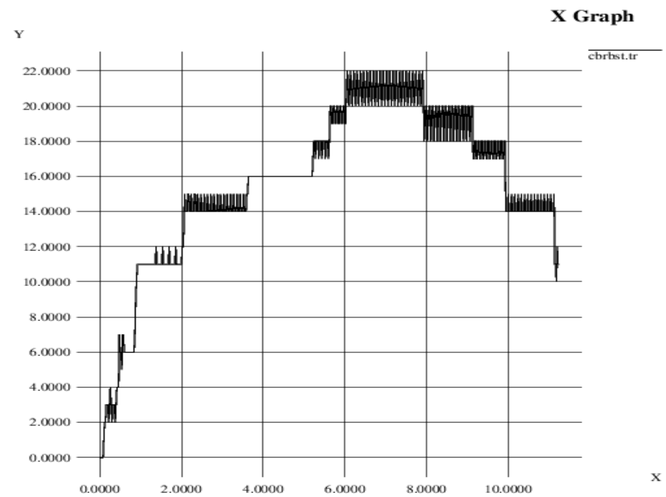

Figure: 7 Performance of CBT mode showing time interval on x-axis and number of packets on y-axis

VII. CONCLUSION

In this paper I have implemented the Centralized mode and CBT mode of routing protocol. NS-2 simulator is used to integrate the module using tool command language. Packet delivery ratio metrics is used to measure the performances. I have made the performance comparison of Centralized mode and CBT mode. The result indicates that the performance of CBT mode protocol is better than the centralized mode protocol.

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AUTHORS

First Author – Ijtaba Saleem Khan, Email: ijtaba007khan@gmail.com
Second Author – Abhinandan Tripathi, Email: abhinandan2787@gmail.com
Third Author – Anwar Ahamed Shaikh, Email: anwar.nizami@gmail.com