An Overlay Multicast Scheme for Distributed Interactive Applications

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Abstract

Recently broadcasts on the Internet, Internet movie theaters and the growing stream of service-oriented Internet services have increased. The bottleneck created to enhance network performance to meet the needs of service users has also increased, while accommodating the needs of the system for the performance of multimedia server capacity cannot meet the server specifications. To provide Distributed Interactive Applications (DIAs) such as IPTV, Teleconferencing and NetGames service in a real environment it is required to have a large amount of system resource and network bandwidth. Our analysis results show that proposed scheme can reduce the network overhead for the multicast routing tree construction and uses minimal bandwidth for data delivery.

1. Introduction

For the past few decades Internet services have changed from conventional text-based services to multimedia-based services. The improvement of PC and infrastructure like network devices makes radical changes possible. Under such circumstance, TV broadcasting service over the Internet is regarded as one of the most promising service.

To provide scalable routing stream service over IPTV through internet, several approaches have been studied. IP multicast has been proposed to support efficient inter-group data exchange over the Internet [1,2,3]. It is very useful to reduce required bandwidth and to provide minimum network stress when attempting to support a large number of clients.

Overlay multicast has been introduced for IP multicast still has some drawbacks to deploy over the Internet [4,5,6,7]. Supporting IPTV on the Internet without changes of existing infrastructure requires combination of a suitable overlay multicast scheme with a good routing scheme.

The problem of multi-users dissatisfaction while receiving service in web-based broadcasting due to service waiting time which needs a counter-plan for tree construction change when hosts experience frequent breakdowns is addressed. Besides, the relative transmission delay experienced in a stream multi-user servicing must also be taken into reduction action. It is, sometimes, unfair when in a system of stream multi-user service we have clients over utilizing the service while others suffer from missing the service or a user faced to starve for better service waiting time and hence a need for modest service.

In this paper, we propose adaptive processing for scalable routing stream service scheme which is suitable to provide TV broadcasting service over the internet. In proposed scheme, each host participating in data relay uses a little amount of shared buffer for support overlay multicast. It also builds up data delivery tree based on bandwidth and delay for lessening the network bottleneck problem at IPTV server. In addition, proposed scheme could offer easy implementation and management because it is designed based on existing internet routing model.

Dealing with the increase in join request users number in overlay multicast group and to create the transformation tree in the proposed algorithm and compare the results with the traditional TBCP and the HMTP algorithms have been the main performance evaluation goals. To do so, the simulation environment is generated with a network topology using GT-ITM Transit-Stub way a Transit area class at high level and a Stub area class at low level. Between them, a connection of random nodes is made. There are 1,000 overlay hosts included around Transit and Stub area. For HD stream service, it is needed to have about 25Mbps bandwidth with a base of 100Mbps. For modeling the scenario, we use Network Simulator version 2 (NS-2).

In section 2, the related research work will be discussed. The details of the concepts of multicasting with overlay multicasting are underlined in section 3. The adaptive processing for scalable routing stream service in overlay protocol technique is detailed in section 4 where section 5 talks about the simulation environment, results, and analysis of the results. In section 6 has the conclusion and discussion in detail.

2. Related Research work

2.1 Routing algorithms for Multicasting service

Multicasting is the process of sending messages from a source to defined group nodes that are numerically large in size. Multicast Routing is the process of determining a message path from a source to multiple destinations in a network. The algorithm is responsible for finding a suitable path tree from a source to destinations. Thus, the routing algorithms are the heart of routing software.

In the graph theory, finding a suitable path is finding a good tree for routing from the graph. Routing algorithms can be grouped into two major classes: Shortest Path Tree (SPT) routing algorithm and Minimum Spanning Tree (MST) routing algorithm.

SPT and MST Routing algorithms can be classified as a static routing based on the timing of tree construction. Static algorithms do their routing decision is made in advance, off-line, and downloaded to interworking nodes. Since it finds best route, we generally use the static routing when the status of network is not changing frequently.

Because updating network status information requires serious overhead, internet uses dynamic routing rather than static routing. Dynamic algorithms change their routing decisions based on measurements or estimates of the current traffic and topology [8, 9].

Distance vector is the most popular dynamic routing and it is used in the internet. In the internet, each router maintains a distance vector table which contains the best distance to each destination. The table is updated by exchanging the distance vector table with its neighbors and by using new delay with its neighbors. It can update routing based on current status of network with its neighbors and this updated information eventually propagates to all routers in the network. This method takes time to adjust all routers, but generates minimum overhead.

In IP multicast, routers play key roles in building and managing multicast tree by performing operations such as group creation, member joining and member leaving using multicast protocols. Protocols operated by routers are DVMRP (Distance Vector Multicast Routing Protocol), PIM-SM/DM (Protocol Independent Multicast Sparse Mode/Dense Mode) and MOSPF (Multicast Open Shortest Path First). In IP multicast, Distance Vector Multicast Routing and Core Based Tree, are adopted to get optimal path [10, 11]. Distance Vector Multicast Routing uses pruning and Reverse Path Flooding methods to build a shortest path routing tree. In the core-base tree algorithm, a single spanning tree per group is computed using a shortest path routing algorithm, with the core near the middle of the group.

2.2 Overlay Multicast Scheme for IPTV Service

Overlay multicast has been targeted to be alternative scheme to IP multicast where data packets transmission can relay between group members.

IPTV-based overlay streaming service systems commonly face the problems oriented from IP addresses. Group communication method using overlay multicasting doesn’t take influence from network configuration. In addition, we can have a network expansion, change, and maintenance at application level where we can deal with error, congestion, and flow controls of stream.

Among the proposed schemes include the one that suggests to build a new overlay multicast tree called BASE (Bandwidth aware overlay multicast architecture) as described eloquently by Kim in [12].

The earlier proposed BASE uses available bandwidth metric instead of hop counts or delays in order to construct and reconstruct overlay multicast trees. BASE reduces packet loss probability by locating group member with more available bandwidth a upper level so that packet loss seldom happens at upper position. In addition, BASE, to immediately resolve both network and node congestions, especially at a varied traffic load, it dynamically designate proper number of children.

Scalability problem of the need for maintaining large multicast groups’ state information has made a real multicast not yet being actually deployed in current networks.

The effort to achieve scalability in a new approach has been in designing application level controllable overlay multicast where constructions of overlay multicast trees consisting of only group members at application layer have been done so that the overlay multicast trees can be flexibly handled.

In a new overlay multicast protocol (Nemo) founded by Birrer et al in [13] a design for a high resilience from the ground up has been done. Nemo achieves high connectivity and delivery ratio under highly stressful conditions, all at significantly low costs. Reliable overlay multicast architecture (ROMA) designed by Kwon et al in [14] prevents influence of congestion at the nodes. It addresses the deployment issues for TCP performance degradation on group member which should establish multiple connections, but duplicated forwarding makes link utilization worse than original overlay multicast because several packets should be additionally delivered.

The applicability of all the mentioned schemes and others not mentioned is mainly in dealing with a light traffic load. A better overlay multicast tree is needed to proposed scheme. In that connection, Propose mechanism is needed to prevent packet loss so that higher packet delivery ratio can be achieved.

A mechanism is proposed by use minimum amount of traffic overhead to get routing information in trees and it is very simple to calculate optimal route compared with conventional scheme in overlay protocol.

3. The Proposed NWP Scheme in the Adaptive processing Overlay multicasting

IPTV server generally has high capacity system resources to support many users. But, they have limited network bandwidth and processing powers to support certain number of users. This limitation is the main reason that unicasting is not working and multicasting is required to support many users for IPTV service. To support overlay multicast, each client receives the stream from its parent and forwarding the stream to its children. They also have limited network bandwidth and processing powers to support certain number of children and it defines the degree of each node.

To provide overlay multicast for IPTV service, SPT routing algorithm can be used to build up the overlay multicast tree. This will be reasonable and provide best tree for multicasting when all the members of the group are known in advance and joined together. But, it is not usual, because any node can join for service at any moment. When a client wants to join the specific IPTV service session, a new multicast tree must be built to relay the stream. Thus, this scheme will generate large overhead.

In this mechanism, the root host which is a broadcasting provider has to manage the configuration of all the clients and their conditions. The child host which is the stream broadcasting receiver has to get the receiver's stream broadcasting service and if the child host has allowance in out-degree it has to operate media relay as a member of the potential parent list and it will have to serve other users in the system.

The feature of the proposed model, technically, consists of the stream user path establishment by a client's broadcasting service request. For distribution system's configuration, proper settings for sensitive delay real-time broadcasting model have to be met. The model has also an overlay multicast base client relay transmission for media relay function for other clients. Considering the fact that web-based broadcasting provider capability decreases the performance limit using PPL management, the protocol tries to reduce the broadcasting service waiting time and it inhibits the reception of good quality and it is designed to include many hosts to stream multi-user tree using PPL management which is simple and powerful middle node position policy for stream service.

Fig. 1 shows a web-based overlay multicasting of stream application in a multi-user scenario can be represented in a simplified IPTV broadcasting.

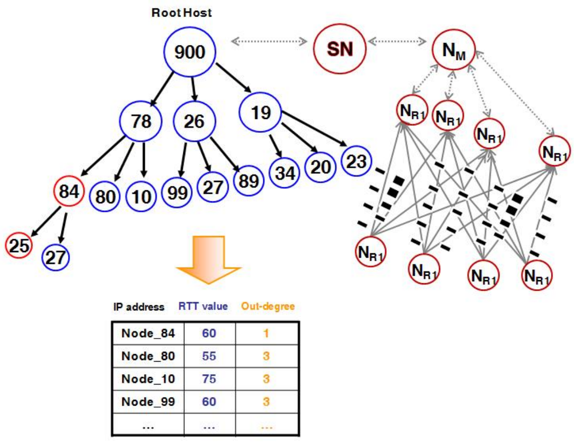

Fig. 1. Schematic diagram showing the Overlay multicasting for web-based broadcasting with a new host join constituent.

In the presence of a single join request in the protocol, first a root host within out-degree limit is registered to a PPL. A new host sends a join request to the root host with already some existing hosts. A response, including the PPL, is sent from the root host to the new requesting host where then the new host estimates the corresponding RTTs to all proposed potential parents. Consequently, the new host selects its best potential parent and it sends a respective control message to the root host which is used to update the PPL.

The latency product oriented max-heap-form overlay construction scheme intends to reduce the incurred induced packet loss and hence improve the packet delivery ratio by imposing integrated metric values, Node Worth Point(NWP), acting as node IDs for the nodes positioning, in such away that the higher NWPed nodes logically take upper-to-down and alternating left-to-right positions. The reason for the upper-to-down placement is to make sure that the higher metric valued serve the lower ones so that the packet loss causing nodes do not recursively influence the lower children nodes. On the other side, the logical alternating left-to-right approach is for the sake for ensuring load balancing throughout the overlay tree.

The combination of the preferred latency from the newcomer to an expected parent, L_p, and the proposal of the best latency available from the newcomer to a proposed parent, L_b, is of equal importance for consideration while constructing and reconstructing an overlay multicast tree with an aim of reducing induced packet loss to the end users. The strongest points that the protocol has, include its nature of handling concurrent stream multi user requests and its capability in tree transforming based on the hosts performances. Therefore, the novel proposed scheme in this work aims at building a max-heap form of an overlay tree where the major key of nodes' positioning is a value, NWP, determined by a function of integrated metrics of L_p, L_b.

$$NWP = \frac{(1-\alpha)(L_b - L_p)}{L_p}$$

There is an updated list of a few best rtt's registered at the SN which maintain the best Lb values that will be used to offer the new members wanting to join so that the later can use the values to compare with their L_p values. A source node (SN) starts with an rtt to itself registered as 0 and SN stores rtt's of only a few members with remaining out-degree(s) with a consideration that non-fixed out-degree restriction applies.

4. Adaptive Processing for Reduce the Control Packet in Overlay Protocol Technique

In most mechanisms proposed for building a overlay multicast tree, the process of building a multicast tree for data transmission is the process of determining the most appropriate parent node of the host which calls for member joining or member rejoining operation to the multicast group.

We want to reduce the control packets which are required to build a multicast tree. Since this overhead occurs whenever a new node joins for serves, it is critical when the size of group is large. In this section, we evaluate two conventional methods as following.

Let's define a graph with n nodes as $G_n = (V_n , E_n)$, where V_n is a set of n vertices and E_n is a set of n edges. It is a connected graph with n = $|V|$ nodes in multicast group. If a new node wants to join the group, one of following routing algorithms can be applied to build a new routing tree T_n.

Since using SPT generate new shortest path for join operation, the structure of current tree can be changed from previous tree in the middle of data delivery. If the routing tree is changed in the middle of delivery, it will be very difficult to prevent packet loss. Thus, we need to provide a mechanism to recover lost packets and it is a very complicate procedure and requires many retransmissions.

SCT algorithm does not change the tree T_{n-1} to build a new tree T_n. It finds a parent node from the tree T_{n-1} and adds the new node. The new node will be attached to a parent node which offers the shortest path from the tree T_{n-1}. It also requires three steps to build tree T_n. same as SPT.

In the first step, it gathers delay information and this delay is

$D_{1sct,n} = 3d(s,n) + \sum_{i=1}^{n-1} 2d(i,n)$, where d(i , j) is a time delay sending a packet from node i to node j. This procedure requires $N_{1sct,n} = 2n+1$ packets passing to get delay between the nodes based on round trip delay.

In the second step, new routing tree T_n is built by finding a parent node which has shortest path to the new node through current tree T_{n-1}. Since the source node knows the distance to all nodes in T_n , it is easy to find by add and compare operation. It will take a time $D_{2sct,n}$ that has time complexity of O(n).

In the third step, the tree information needs to be transferred to the new node and its parent node. Since the new tree T_n is built by attaching the new node to a parent node in the tree T_{n-1}, new routing only need to setup between them. This third step requires $N_{3sct,n} = 2$ packets passing and. this will take $D_{3sct,n} = d(s,i) + d(s,n)$

Thus, the time delay $D_{SCT,n}$ to build multicast tree T_n is

$$D_{SCT,n} = D_{1sct,n} + D_{2sct,n} + D_{3sct,n}$$
$$= 3d(s,n) + \sum_{i=1}^{n-1} 2d(i,n) + D_{2sct,n} +$$
$$d(s,i) + d(s,n)$$

And the number of message $N_{SCT,n}$, which is required to prepare routing in the all multicast nodes, is

$$N_{SCT,n} = N_{1sct,n} + N_{3sct,n} = 2n + 3$$

5. Simulation Setup, Results and Inference

5.1 Simulation Setup

Simulation intends to provide a criterion for Adaptive processing overlay multicasting for provide TV broadcasting service with an increase in join request hosts number in an overlay multicast group, and creating a transformation of a tree in the proposed protocol's algorithm and compare the results with the traditional TBCP and HMTP algorithms. The simulation environment was created with GT-ITM transit-stub model made up two connected classes to high level transit area and to low level stub area. Random connections were allocated to make up to 1,000 hosts.

5.2 Simulation Results and Inference

There is, of course, a trade off between adopting this newly designed scheme and sticking to the already available traditional schemes. The comparison simulations of the NWP based mechanism with the schemes like HMTP and TBCP gave the results of HMTP and TBCP systems and the NWP based overlay constructed for the packet loss ratios. It can be clearly seen that the proposed NWP mechanism leads to less packet than its counterparts.

The discrepancy, in favor of the NWP based latency product max-heap overlay, increases for the best as the Group size increases. Depending on the group size, the maximum number of Concurrent users can be monitored by comparing the performance of the proposed model with the other recent systems. The reduction in the group size of the reduced initial waiting time can be achieved from the resulting values. A very small group size will provide a faster response time. Therefore, without waiting for buffering, the user can conveniently receive TV broadcasting services.

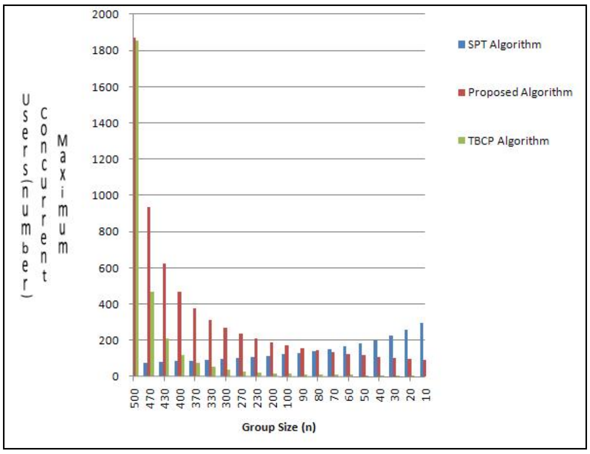

Fig. 2. ***Maximum Concurrent users vs. Group Size***

It is again, clear that the Propose mechanism fits better than the other mechanisms, especially for growing group of overlay multicasting.

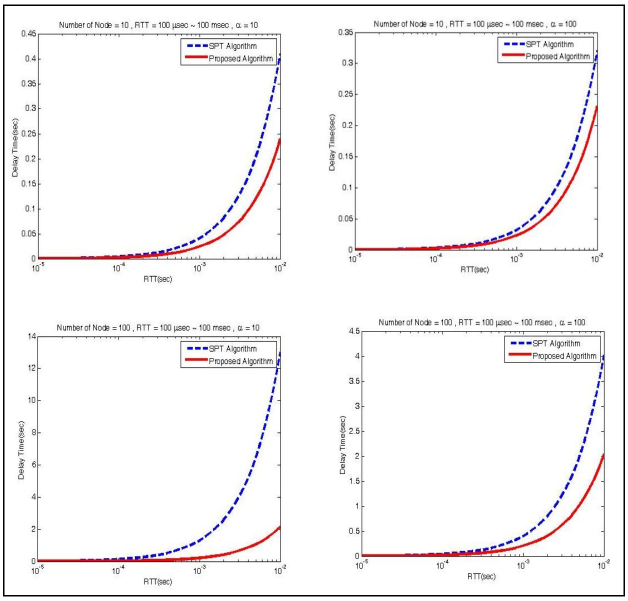

Fig. 3. ***Delays to prepare routing in all multicast nodes***

Fig. 3 shows the time delays to prepare routing in all multicast nodes when the number of nodes grows from 10 to 100. The value of α changes from 10 to 100. The amount delay grows fast as the number of nodes increase when the SPT scheme or the Proposed scheme is applied.

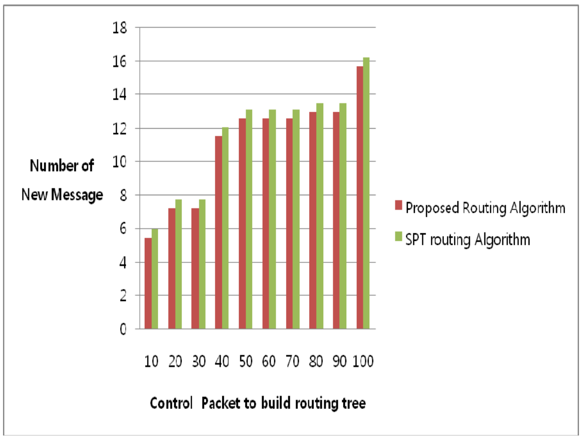

Fig. 4. Control packet to build routing tree

Fig. 4 shows the number of new packets to prepare routing in the all multicast nodes when the number of nodes grows from 10 to 100. We wanted to reduce these new packets, because those will be an unnecessary burden to network.

6. Conclusion and Discussion

Traditional routing algorithms could be applied to overlay multicast. However, they are not efficient for overlay multicast providing IPTV service. Characteristics of some mechanisms are as follow requires new algorithm. First, overlay multicast for IPTV service is built in the application layer. They use IP layer services, but they don't have topology information of network,. Second, the members of multicasting group are not predefined. It is natural that the multicast groups are made by the joining operations of members.

We proposed a NWP scheme which can be used to build an overlay multicast routing tree for IPTV service.

Instead of just considering a general delay metric, the newly proposed NWP, latency products based architecture adapts the available bandwidth metric, the delay metric, the relative rtt metric with respect to a suggested/preferred/proposed rtt, the best delay metric as suggested by the source root to individual members. This makes NWP to enhance the performance by evenly loading the tree and recursively distributing the members with closer N`WP on each branch of the network and, hence, reducing the possibility of path congestion or group members congestion by making each group member independently check the congestion situation, considers its position with respect to the source root and other members, and then dynamically adjusts its own variables according to varied traffic environments and its position to quickly reach the source node in case of failure. The results of performance evaluation show that proposed scheme provides better performance than existing scheme from the viewpoint of the time delays to prepare routing in all multicast nodes and the amount of total network traffic.

More research is needed to identify a policy to follow, a real field test environment with a topology of more hosts and much bigger group sizes, and adding of mechanism for robust maintenance and link repair are needed to improve the system.

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