TINA-based Multicast Connection Management

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Abstract

Lots of multimedia applications require multicasting where data from a sender must be duplicated and delivered to multiple destinations. The examples of the multi-party communication service are virtual classroom, video conferencing, tele-medical and VoD(video on demand). In many circumstances, the group members are all potential senders, the number of group members can be large and changed dynamically. Therefore, the future integrated services network must provide efficient resource management for multicasting. Construction and maintaining multicast tree is very important and difficult problem in multicast communication. We suggest a hierarchical network management function to construct and maintain a multicast tree for solving this problem. The hierarchical management concept is well defined in TINA, and it is very effective to solve multicast tree problem.

In this paper, we propose a management architecture model for multicast environment based on TINA. Although five functional areas, FCAPS, are depicted in TINA, we focus on the connection management of point-to-multipoint connection in this paper.

1. Introduction

The goal of network management is to organize and highlight relevant information of the network including protocols, addressing, data flow, statistics, and especially anomalies. This allows people without in-depth knowledge of a network's configuration to monitor its operation, easily identify problems when abnormal events occur, and solve problems based on the availability and presentation of relevant information.

The management of multicast is somewhat similar to the management of unicast. The key difference is that multicast traffic is destinated for multiple receivers. This difference necessarily affects the types of questions asked by network managers. With multicast, this level of abstraction carries additional importance because of the added complexity associated with delivering a packet to multiple receivers. Instead of managing/monitoring connectivity between pairs of users, multicast deals with potentially very large groups of users. And instead of managing/monitoring a single point-to-point path, multicast deals with links organized into a tree.

The ideal suite of multicast management tools and strategies likely do not exist today. Why has multicast-specific network management received so little attention? The basic answer is that much of the effort being devoted to multicast is focused on developing multicast protocols, maintaining reasonable quality connectivity in the Multicast

Backbone(MBone), and providing connectivity to end users in networks. As multicast begins to mature as major Internet services, such as tele-education, CSCW and VoD, more attention will be given to the efficient management.

A set of tools has developed for the MBone. But they tend to have limited functionality, and are difficult to use. TMN & TINA, which provide well defined network management architecture, don't consider the management of multicasting communication seriously. All management function in TMN & TINA are focused on the point-to-point communication. Therefore, network management architecture to manage point-to-multipoint call is strongly required nowadays.

2. Multicast Connection Management

2.1 Connection Object Models in TINA

The overall connection object model of TINA is described in network resource architecture(NRA)[1]. Connection management architecture(CMA) structure is based on the TINA network modeling concepts. It is divided into a number of conceptual levels, that work together to transform service layer communication requirements into constructs that can be implemented in the resource layer. Each level has its own set of environmental and organizational concepts, connection concepts, detailed information models and computational objects.

These conceptual levels are defined as service, communication, connectivity, layer network and subnetwork level. Connection management in TINA involves management of connectivity resources, such as stream binding, stream flow connection(SFC), network flow connection(NFC), trail, tandem connection and subnetwork connection(SNC). These connectivity resource concepts are associated with the conceptual levels. Service session uses stream binding, communication session uses SFC, connectivity session uses NFC, layer network uses trail or tandem connection, and subnetwork uses SNC.

As NRA functional requirements of the above connection resource, for each of the connectivity resource type except link, the following capabilities

<Table.1> Connection object models in TINA

Level	Connection concept	type of connection
Service	stream binding	multipoint-to-multipoint
Communication	SFC (stream flow connection)	point-to-point unidirectional
		point-to-multipoint unidirectional
Connectivity	NFC (network flow connection)	point-to-point bidirectional
		point-to-multipoint unidirectional
Layer network	trail, tandem connection	point-to-point bidirectional
		point-to-multipoint unidirectional
Subnetwork	SNC (subnetwork connection)	point-to-point bidirectional
		point-to-multipoint unidirectional
	Link	point-to-point

are offered :

- Establishment(i.e., creation) and release(i.e., deletion)
- Addition of branch to a point-multipoint connectivity resource
- Modification of the traffic and/or QoS parameters
- Activation and deactivation of specific branches in point-to-multipoint configuration.

These TINA NRA functions indicate that all connectivity resources except link can support point-to-multipoint connection for multicasting, and all conceptual sessions can be used for point-to-multipoint connection.

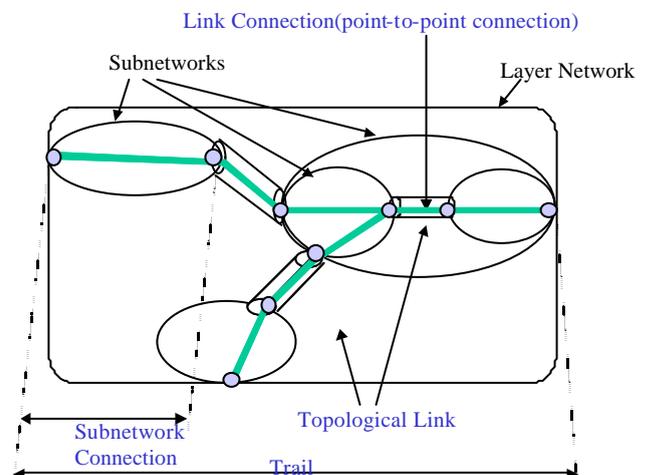## 2.2 Link Object Model in TINA

The connection concepts in TINA conceptual level support point-to-multipoint connection, but link supports only point-to-point connection. To determine whether this approach is reasonable to support point-to-multipoint communication, we look over the link connection object model in TINA.

A layer network is decomposed into subnetworks that are interconnected by topological links among them. In general, a link represents a topological relationship between two subnetworks, and the potential connectivity between the subnetworks. In the TINA network resource information model (NRIM), the concept of a link is more specific, and is called as topological link. A topological link represents a group of transport resources (called link connections) that transport information between the subnetwork. Further, a topological link is configured using exactly one trail in the underlying server layer network.

Each subnetwork may be further decomposed into smaller subnetworks interconnected by topological links until the desired level of detail is obtained. This decomposition will generally be done until when the subnetwork is equivalent to a single network element, such as a switch or a digital cross-connect.

Therefore, even if the link supports only point-to-point connections, the network (or subnetwork) can support point-to-multipoint connection for multicasting. If point-to-multipoint connection is required in layer network, a point-to-multipoint connection is established in a view of layer network because trail or tandem connection which used layer network can support point-to-multipoint connection. This trail or tandem connection is decomposed into subnetwork connections which are interconnected by link connections among them.

It should be noted that subnetwork connections may be either a point-to-point or a point-to-multipoint connection. Links connect only between connection termination points of these subnetwork connections. Addition of a branch to a point-to-multipoint connection is provided within subnetwork(i.e., switch).

(Figure.1) Link object model in TINA

2.3 Multicast Connection Management

In the TINA connection management architecture, the connection is handled by the connection management computational object(CO). COs communication session, connectivity session, layer network, and subnetwork create or delete connections on demands. Conceptual groupings and associated objects are listed as follows :

(i) Communication session related objects : Communication Session Manager Factory(CSMF), Communication Session Manager(CSM), Terminal Communication Session Manager(TCSM)

(ii) Connectivity session related objects : Connection Coordinator Factory (CCF), Connection Coordinator (CC), Flow Connection Controller (FCC)

(iii) Layer network related objects : Layer Network Coordinator(LNC), Trail Manager(TM), Tandem Connection Manager(TCM), Terminal Layer Adapter(TLA)

(iv) Subnetwork related objects : Connection Performer(CP).

Because all connections, which are handled by these COs except link, support point-to-multipoint connection, every COs which manage connection at each conceptual level must be able to handle the information of point-to-multipoint connection. Every CO must be designed and implemented to process point-to-multipoint object model.

NFC which represents a end-to-end connection in physical network is managed by CC and FCC in connectivity session. Since the connectivity layer network can be composed of different technologies, such as ATM, Frame Relay, and N-ISDN, the connection information in connectivity layer must be independent of network technology. As a result, the point-to-multipoint connection information which is managed by connectivity layer must be an abstract information which is independent of network technology by same reason.

A layer network represents a particular networking technology, such as ATM, Frame Relay, and N-ISDN. A LNC can act on behalf of the layer network to setup end-to-end connections across the network technology, independent of connectivity provider domains and subnetworks. Therefore the point-to-multipoint connection information, which is managed by the layer network is dependent on network technology.

3. Multicast Tree Management

3.1 Multicast tree: source-rooted tree vs. shared tree

Constructing and maintaining multicast tree is very complicated and difficult problem in multicast communication. Since bandwidth is a scare resource in networks, one of the major goals of IP-based or ATM-based multicasting research works is to improve bandwidth efficiency in multicasting. The minimization of resource usage for a single message multicasting over the given network is the goal.

It is important to find the optimal multicast trees for the given set of participants. The cost of the multicast tree used for multicasting is very important, especially for broadband applications like a video-conference application. Minimizing the bandwidth consumption makes efficient use of the available resources, and increases the number of connections that can be handled simultaneously.

Multicasting trees are classified as source-rooted tree (SRT) and shared tree (ST). Distance vector multicasting routing protocol (DVMRP) or protocol independent multicast - dense mode (PIM-DM) are typical examples which use source-rooted tree type.

Source-rooted tree is constructed from each source to its multicast group members by finding the shortest path. Therefore each source node uses separated source-rooted tree, and it is suitable to point-to-multipoint communication. However, it is possible to construct multipoint-to-multipoint communication by using multiple source-rooted point-to-multipoint tree in overlap.

Shared tree type use only one tree regardless of the number of source and group member. Core based tree(CBT) is a typical example of the shared tree, and consists of a shared tree which centers around core among group members. Each multicast group has only one shared tree. Tree management information of shared tree is smaller than the source rooted tree, and link utilization is high. But, because all source use the same shared tree, traff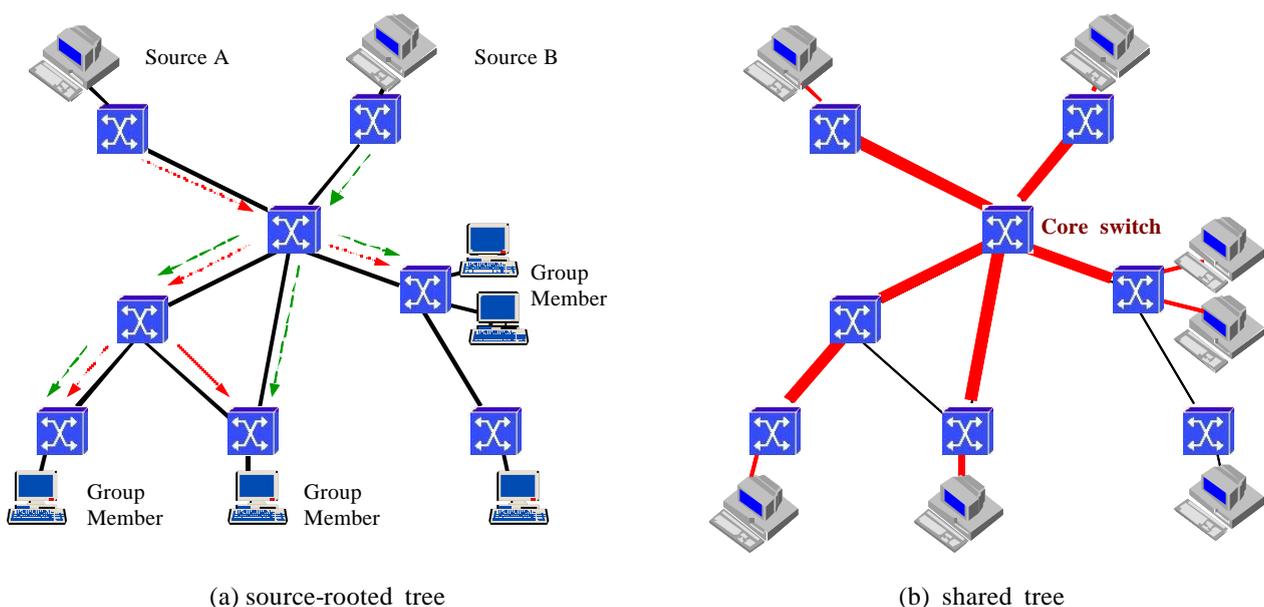ic is concentrated to links of core tree. And source and group member may not be connected by the optimal shortest path.

3.2 Considerations in multicast tree

Recent studies suggest that shared trees (STs) are very scalable in terms of bandwidth consumption, network resources, join latency, membership management complexity and operating system overhead. The choice of multicast tree affects almost all of the above metrics.

But shared tree is usually based on multipoint-to-multipoint connection. Although stream bindings are described by the service level information models which support multipoint-to-multipoint connection, the service level is a client of the connection management architecture which is not part of the TINA network resource architecture. Connections which are described in TINA connection management architecture don't support multipoint-to-multipoint concept.

In core based tree(CBT) every data packet is sent

(a) source-rooted tree   (b) shared tree

(Figure. 2) Source-rooted tree vs. shared tree

to the core node and forwarded from the core node to group members using core tree. All source node sends data packet only to the core node; the multicasting to group members is the role of core node. But this type of connection concept is not supported in TINA.

Therefore a direct application of the shared tree to TINA is very difficult, and as a result source rooted tree (SRT) is more suitable.

Even if source rooted tree is selected, construction and management of a tree is very difficult and complex. Difficulties which happen in tree construction are as follows: (1) Managing information about group members require so much resource and it is hard to be performed by all network nodes. It causes a scalability problem. (2) Construction of tree by exchanges of messages between network node (switch) requires the network node to have a function to process the messages of core selection. And this massages are overhead. (3) Since there is no node responsible to construct a tree, we can't have confidence that constructed tree is correct. At the worst, a loop can be found.

3.3 Hierarchical multicast tree management

We propose a hierarchical multicast tree management architecture for constructing the source-rooted tree for multicasting. A large network is partitioned to subnetworks by layering and partitioning concept. The subnetwork is viewed as a logical node to upper-layer network. A tree is constructed among logical nodes (subnetwork) by the network management system (NMS) of upper-layer network. In this scheme upper-layer network management system doesn't require the concrete information of its subnetwork; the upper-layer
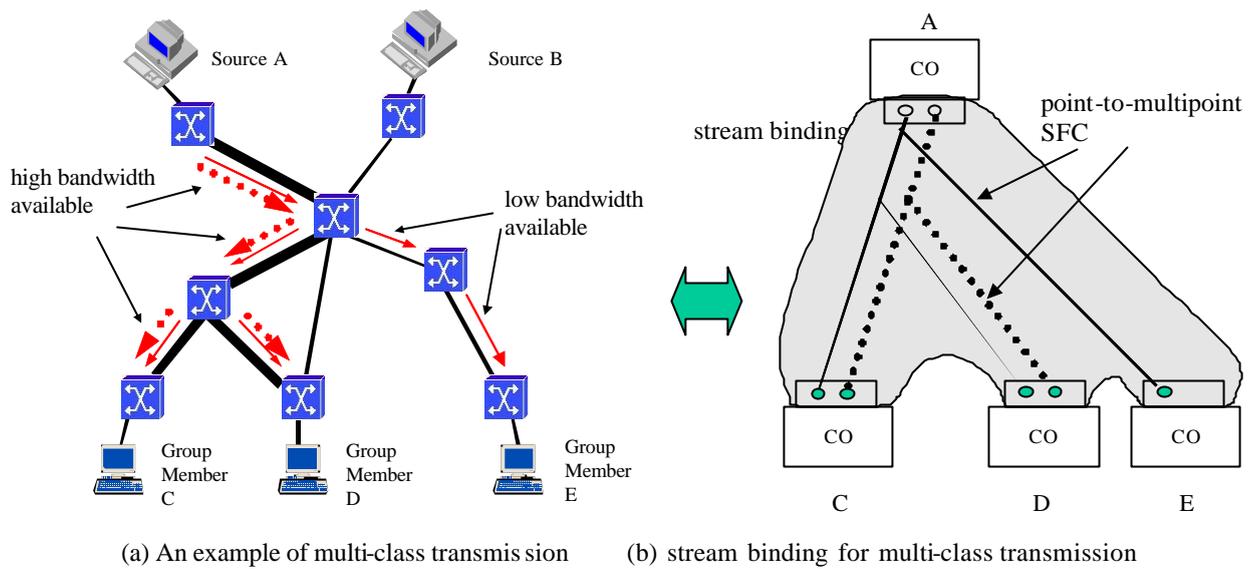
network management system handles its subnetworks as logical nodes, and only needs abstract information.

The tree constructed by a network management system is optimal, because the network management system always has the latest information of its subnetwork to be managed. Therefore, the determination by the network management system is always correct.

This hierarchical tree management reduces multicast tree construction load at each switch, and is efficient in scalability. It includes quality of service (QoS) guarantee scheme by bandwidth management. Implementation of this hierarchical tree management is possible by using the network management function of TINA.
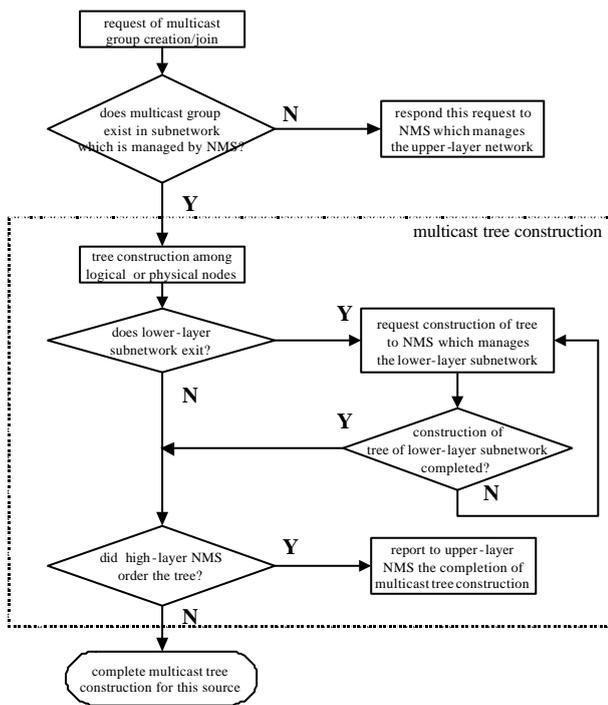
As we explained before, TINA connection management architecture has layering and partitioning concept such as communication session, connectivity session, layer network, and subnetwork. The NML-CP, TCM, TM and FCC can construct a source-rooted tree following the procedure as described above.

FCC constructs tree among layer network which is viewed as a logical node, then order LNC to construct tree within the layer network which managed by LNC. LNC constructs tree among logical node at layer network level, and order NML-CP to construct tree at subnetwork level. NML-CP constructs tree among nodes (EML-CP) and order EML-CP to make point-to-multipoint or point-to-point link. Finally, EML-CP which manages a network element (NE) change attributes of the connection MO to make a point-to-multipoint or a point-to-point link in the network element.

(a) An example of multi-class transmission   (b) stream binding for multi-class transmission

(Figure.4) Multi-class transmission and stream binding

(Figure.3) Hierarchical multicast tree construction

4. Multi-class transmission and stream binding

In multicast communication environment, group members are distributed over the wide area, and the installed link capacity or usable capacity may have a disagreement. The required bandwidths in each group members can be different to each other.

For example in figure 2 (a), suppose that source node A and the receiver nodes (C, D and E nodes) construct a multicast group for a multimedia application such as video conferencing, and subnetwork for group member C and D has good network environment. Installed link has enough capacity, high bandwidth is available. But group member E has bad network condition to communicate a multimedia application which requires broad bandwidth, while the available bandwidth is not enough.

How can we satisfy the different bandwidth requirement of each node C, D and E ? If we adjust a traffic bandwidth which is send from the source A to satisfy group member C and D, node E can't join this multicast group because links to E node don't accept such high bandwidth traffic. On the other hand, if we adjust a traffic bandwidth which is sent from source A to satisfy group member C, all group member can join multicast group. But this approach does not satisfy the request of node C and D which expect high quality image or video. To solve these problem, multi-class

transmission is suggested. In this scheme, the image data is disassembled to multi-class and transmitted along the separated multicast tree.

TINA can easily support this multi-class transmission mechanism by using stream binding concept. A stream binding is a modeling concept which represents a collection of stream flows that have been grouped together for some purpose at the application level. Figure 2 (b) represents mapping of multi-class transmission and stream binding. Base layer (a solid line) and enhanced layer (a dotted line) are used as different class point-to-multipoint SFCs. A stream binding maps to two point-to-multipoint SFCs.

5. Conclusion

In this paper, we proposed a management architecture model for multicasting based on TINA. We are especially interested in the connection management part of multicasting management.

We inspected connection object models of TINA connection management architecture to evaluate whether they can be used to support point-to-point connection or point-to-multipoint connection. As the analyzed result, we concluded that the connection object model of TINA has no problem to be used in the construction of multicast tree, without big change. Then we proposed a multicast management scheme using TINA. The source-rooted tree is more suitable for TINA connection management architecture than shared tree such as core-based tree.

To provide multicast tree construction and management, we proposed a hierarchical multicast tree management architecture. Management for group member information is only performed by the network management system which is in charge of the subnetwork, and the abstracted tree information

of subnetwork is provided to the upper layer network. This concept matches well for the hierarchical connection management architecture of TINA. We explained that the stream binding, which is a modeling concept to represent a collection of stream flows supports well multi-class transmission scheme for multicast.

As further studies, we will elaborate our concepts and implement the various components of connection management for multicasting, and evaluate multicasting operation.

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