Multicast Delivery Based on Unicast and Subnet Multicast

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***Abstract*—In spite of the numerous works recently made, IP multicasting has not been widely deployed in the public Internet. We present a realistic alternative scheme for IP multicasting, which is based on the unicast transport from a remote sender to a local subnet and the multicast forwarding to receivers within the subnet.**

***Index Terms*—Feeder, IP multicast, subnet multicast.**

I. INTRODUCTION

FOR one-to-many multicast applications, it is agreed that IP multicasting [1]–[3] is more efficient than the replicated one-to-one unicast transports. Nevertheless, IP multicasting has not been widely deployed in the public Internet. One of the main reasons is that many ISPs still have much concern for implosion of multicast traffic into the networks. In particular, a large amount of investment on the existing network is required for the multicast deployment including multicast-capable routers and software. In fact, it does not seem that IP multicasting will be widely deployed in the near future.

We propose a realistic transport scheme as a short-term solution for Internet multicast applications, which can easily be deployed without the legacy IP multicasting technologies [2]. The proposed scheme is designed on the recognition that the multicast users are mainly distributed in the private enterprise subnetworks, which is typically based on IEEE 802 LAN [4], [5], and that the multicast forwarding can be easily achieved within a subnetwork, compared to the WANs.

II. DATA DELIVERY BASED ON THE UNICAST AND SUBNET MULTICAST

In the unicast-only networks, the application sender has to send a data stream to each of the receivers by multiple unicast connections, as shown in Fig. 1(a). It is well known that these replicated transmissions induce inefficiency in terms of the network resource utilization and management overhead at the sender [1].

In the framework of the unicast and subnet multicast proposed in this letter, only a single IP host for each subnet receives the application data stream from the remote sender by unicast. Such a receiver is called the feeder for the concerned application data stream. The other receivers in the subnet will receive the application data stream from the feeder, not the remote sender, as illustrated in Fig. 1(b).

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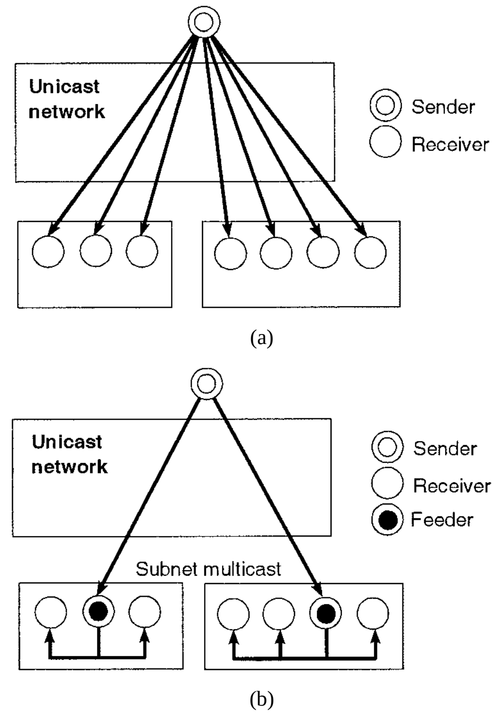

Fig. 1. Unicast only and the proposed scheme. (a) Unicast only. (b) Unicast and subnet multicast.

III. SUBNET MULTICAST TRANSPORT

In the proposed subnet multicast, the receiver that has first requested the application stream becomes a feeder for the corresponding sender. The feeder forwards the application data stream from the remote sender to the other receivers located in the same subnetwork. For the subnet multicast transmissions, a feeder must be configured and announced to the other receivers in the subnet.

For the configuration and maintenance of a feeder, three kinds of control messages are employed: 1) feeder solicitation (FS); 2) feeder announcement (FA); and 3) feeder release (FR). Those messages are summarized in Table I. All the control messages are delivered within the subnetwork via a well-known multicast address such as 224.0.0.x/24 or 224.0.1.x/24. Note that those addresses are reserved by IANA [6] for the multicast delivery of control messages in the subnetwork.

The application data stream will be forwarded from the feeder to the other receivers by local multicast. A multicast IP address is required for the delivery of the application data to the receivers. For the scoping of the multicast traffic to the subnet, it is recommended to use one of the 239/8 addresses and to set the TTL (time to live) of the corresponding IP packets as "1."

TABLE I
MESSAGES FOR SUBNET MULTICAST TRANSPORT

	for	by	dst	contains
FS	C	R	224.0.{0,1}.x	SA
FA	C	F	224.0.{0,1}.x	SA, FA, MA
FR	C	F	224.0.{0,1}.x	SA, FA, MA
DF	D	F	239.x.x.x	DS

C: Control; D: Data delivery; R: Receiver; F: Feeder; DS: Data stream; SA: Source addr.; FA: Feeder addr.; MA: Multicast addr. used for forwarding.

Note that those 239/8 addresses are used for the administratively scoped IP multicasting [7].

A. Configuration of a Feeder

Each receiver that wants to receive a stream sends an FS message to the subnet, and checks whether a feeder for the stream already exists in the subnet. The FS message includes the information on the IP address of the remote sender (see Table I). If there is no response for some time (i.e., there is no feeder in the subnet, and thus the receiver cannot hear any FA message), then the receiver becomes a feeder for the stream. The new feeder will receive the application data from the remote sender by unicast and listen to an FS message from the other hosts in the subnet. If a feeder already exists in the subnet, it responds with an FA message, as described in the next section.

B. Multicast Forwarding of Data by the Feeder

If there is no other receiver, the feeder does not need to forward the application data stream. When another receiver appears in the subnet, the feeder begins to forward the data into the subnet over the multicast address such as 239/8. The detailed procedures for the feeder maintenance and data forwarding are described below.

When a new receiver sends an FS message in the subnet, the feeder responds with an FA message. The FA message contains the information on the multicast address for the data forwarding (i.e., 239/8) as well as the IP addresses of the remote sender and the feeder (see Table I). The feeder will assign one of the 239/8 addresses as the data forwarding address. When a receiver, not the feeder, receives the FA message from the feeder, it keeps the announced multicast forwarding address to receive the application data stream. If one or more other receivers are detected in the subnet, then the feeder begins the multicast forwarding of the application data to the subnet. The destination address of the forwarded IP data packets will be set to the multicast forwarding address such as 239/8, and the TTL (time to live) value is set to "1" for restricting the propagation to the subnet only.

During the data forwarding, the feeder continues to check whether there still exist the receivers in the subnet. If not, the feeder will not forward the data any more. For this purpose, each receiver sends a periodic FS message over a pre-specified FS time interval. To do this, each receiver keeps the FS timer. In response to an FS message, the feeder sends an FA message to the receivers. If any FS message has not arrived during a pre-specified time interval, the feeder stops forwarding of the application data.

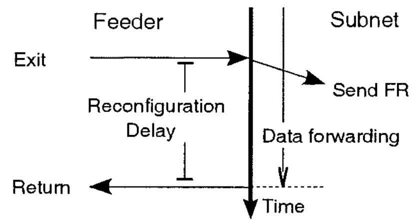

Fig. 2. Data forwarding during feeder reconfiguration.

TABLE II
PERFORMANCE COMPARISON IN TERMS OF THE TRAFFIC AMOUNT GENERATED

	At Sender	In a Subnet	Network Requirement for the net
Unicast	$\propto R$	$\propto R$	None
Multicast	$= 1$	$= 1$	MRP & MR
Proposed	$\propto S$	≤ 2	None

R: No. of receiver; S: No. of subnet; MRP: Multicast routing protocol; MR: Multicast-capable router

C. Reconfiguration of a New Feeder

If the current feeder releases the connection to the remote sender, then a new feeder is elected among the receivers in the subnet. To do this, the current feeder first sends an FR message to the receivers in the subnet and then continues to forward the data over the *Reconfiguration Delay* time interval, which is set to the FR time (described below) plus the time duration that was taken for the current feeder to establish a connection to the remote sender. This is done to reduce the data losses possibly occurred during the feeder reconfiguration. Fig. 2 illustrates the data forwarding during the feeder reconfiguration.

When the FR message is received, each receiver activates the FR timer. One of the receivers will send the FA message, after its FR timer expires. The receiver becomes the new feeder, and joins the remote sender by unicast so as to receive the data stream. The other receivers, not the new feeder, will cancel their FR timers, and receive the application data from the new feeder.

IV. PERFORMANCE ANALYSIS

To evaluate the proposed unicast and subnet multicast scheme, the amount of data traffic generated is compared for the unicast, multicast and the proposed scheme, which is summarized in Table II.

In the unicast transport, the traffic amount is proportional to the number of receivers. In IP multicasting, the traffic amount is fixed to one unit, regardless of the number of receivers. In the proposed scheme, the traffic amount at the sender depends on the number of subnets containing one or more receivers. The traffic amount generated in the subnet can be reduced to one (for the subnet with only the feeder) or two units (for the subnet with the feeder and the other receivers).

We have measured the amount of traffic generated in a subnet for the unicast-only scheme and the proposed scheme. The test application stream generates the traffic by the average rate of 0.5 Mbps. Each receiver in the subnet joins the stream by a time interval of 20 s.

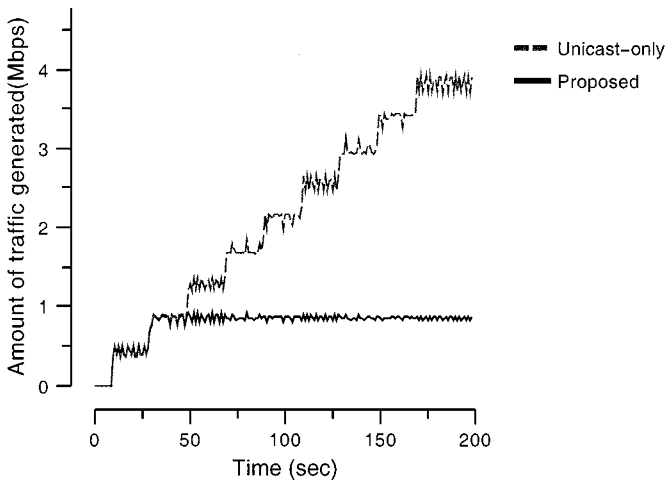

Fig. 3. Comparison of traffic amount.

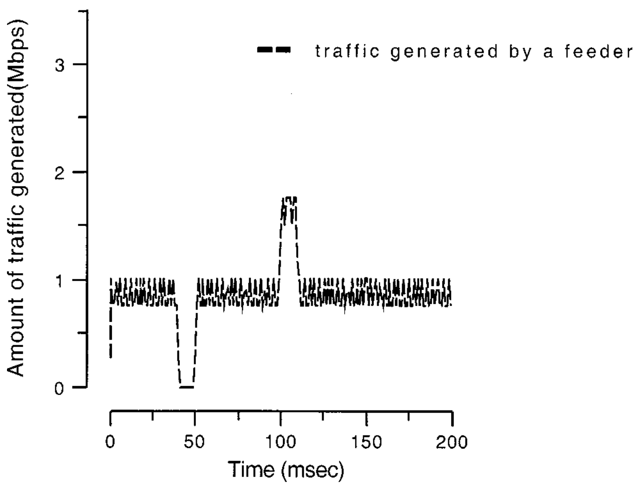

Fig. 4. Traffic discontinuity during the feeder reconfiguration.

Fig. 3 plots the traffic generated in the subnet over 200 s. From the figure, the traffic by the unicast-only scheme is proportional to the number of receivers, while the proposed scheme shows a uniform traffic pattern.

Fig. 4 shows the traffic generated by the feeder(s), when the feeder reconfigurations occur. In the figure, the feeder reconfigurations occur at the time 50, 100, and 150 ms. For the first reconfiguration at 50 ms, the connection setup time interval of a new feeder is longer than the Reconfiguration Delay. We can see that the traffic stream is shortly disconnected and some data losses occur. At the 100 ms, the connection time of a new feeder is shorter than the Reconfiguration Delay, and thus two feeders generate the same traffic over a short-time period. For the third reconfiguration at 150 ms, the connection setup of the new feeder occurs exactly after the Reconfiguration Delay, hence neither loss nor duplication.

We see that the proposed scheme provides the nearly same performance as the conventional IP multicasting in terms of traffic amount generated in the subnet environment. In particular, the proposed scheme does not require any modification of the network infrastructure, and thus it can easily be deployed in the network.

V. Conclusions

In this letter, we propose a scheme for the rapid deployment of Internet multicast applications. The proposed scheme is currently being implemented and tested on the Unix machines with FreeBSD 4.1 [8]. It is noted that the proposed unicast and subnet multicast scheme does not depend on any IP multicasting technologies and thus can easily be deployed in the network. Recognizing that the IP multicasting still have much concern for the wide deployment, the proposed scheme can be used as an alternative short-term solution for Internet multicasting services.

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