# 네트워크 혼잡상태에 동적 적응을 위한 계층적 멀티캐스트

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A Hierarchical Multicast for Dynamic Adaptation to Network Congestion Status

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## 요 약

멀티캐스트 응용에서 네트워크 혼잡상태에 동적 적응을 위한 방법으로 SARLM이 있다. 이 방법에서는 혼잡이 발생하면 혼잡지역의 전송률 감소로 인하여 비혼잡 지역에서 가용 대역폭의 낭비가 발생한다. 본 논문에서는, 네트워크 혼잡에 동적 적응을 위한 계층적 멀티캐스트를 제안한다. 제안한 방법에서는 지역마다 대표자를 선택하여 혼잡상태일 때, 전송률 감소를 방지하기 위하여 멀티캐스트 송신자로부터 전송된 패킷을 혼잡지역 대표자에게 유니캐스트로 계층적 전송하고, 혼잡지역 대표자는 지역 수신자들에게 멀티캐스트로 전송한다. 실험결과, 제안 기법이 혼잡상태에서 수신자들의 전송률을 향상시키고 가용 대역폭을 보다 더 효율적으로 이용함을 알 수 있었다.

## ABSTRACT

There is SARLM scheme for dynamic adaptation to network congestion status which arises from multicast applications. However, in this scheme, when congestion occurs in a local, the waste of available bandwidth occurs in non-congestion local because of reducing of transmission rate in congestion local. In this paper, we propose a hierarchical multicast for dynamic adaptation to network congestion. In proposed scheme, we select a representative in each local. while congestion status, It receives packet from multicast sender and hierarchically transmits packet to the representative in congestion status by unicast for preventing decrease of transmission rate and the representative in congestion local transmits packet to the receivers in local by multicast. In experimental results, it was known that the proposed scheme could improve transmission rate of receivers in congestion status and more efficiently used available bandwidth.

## 키워드

Hierarchical Transmission, Representative, Unicast, Multicast

## Ⅰ. Introduction

There are many applications using IP multicast has been proposed that such as internet broadcast, videoconferencing by development of internet[1-4]. Multicast transmission is an efficiently transmit for applications that use fixed network. There is a SARLM scheme for dynamic adaptation to network congestion which arises from multicast video conference[5-9]. The SARLM is a representative scheme of using multicast. In this scheme, the sender first codes the video sequence into multiple data streams by using scalable source codec with FEC and then sends each stream as a separate multicast group.

In the meantime, the receivers dynamically estimate the

available bandwidth using packet pair approach followed by join or leave groups independently according to their network condition. Moreover, the receivers send sparse feedbacks containing statistical information about the receivers' network status. According to the analysis of feedback messages, the sender dynamically adapts to network status which arises from multicast applications[5,8,9]. But, in this scheme, when congestion occurs, the waste of available bandwidth of non-congestion local occurs because of reducing of transmission rate in non-congestion local caused by reducing of transmission rate in congestion local.

In this paper, to solve such a problem, we propose a hierarchical multicast for dynamic adaptation to network congestion. So we can be efficiently use available bandwidth though dynamic adaptation to network congestion. In proposed scheme, we select a representative in each local. Each representative is the first receiver that joins in the local multicast group. It performs two roles: First, hierarchical transmission that hierarchically transmits duplicative packets during congestion by unicast such as overlay multicast. Second, it merges feedback messages of local receivers and hierarchically transmits to the sender. When the estimated loss rate of local is higher than congestion threshold, the receivers drop from current multicast group and join local multicast group. Each representative in congestion status becomes sender of local multicast group. the representative in non-congestion status transmits duplicated packets by unicast to the sender of local multicast group. After the sender received packet, transmits packet to the receivers of local by multicast.

The rest of the paper is organized as follows: In section 2, we briefly present review these two schemes that were proposed earlier. Our proposed scheme is presented in section 3. In section 4, we compare the transmission rate. Finally we conclude in section 5.

## Ⅱ. Related Work

### 2.1 SARLM(Sender Adaptive & Receiver-driven Layered Multicast)

The SARLM is a representative scheme of using multicast. In this scheme, the sender first codes the video sequence into multiple data streams by using scalable source codec with FEC and then sends each stream as a separate multicast group. For sender adaptive & receiver- driven layered multicast, the main challenges on the receiver side are how to estimate the varying network status, how to send feedback to avoid so-called feedback implosion[5-9].

In this scheme, For efficient scalable video transmission, each receiver is estimated the available bandwidth by Receiver Based Packet Pair. The SARLM is composed of an adaptive layered video sender, layered or scalable video receivers, and multicast-capable routers. In addition, it uses a feedback analysis system to avoid feedback implosion. The sender first codes the video sequence onto multiple data streams and then sends each stream as a separate multicast group. Each receiver dynamically monitors the varying network condition, estimates available bandwidth, and decides whether to join a higher layer, stay at or leave the current layer. The sender periodically multicast a feedback request to all receivers, and the sender adjusts the sending rate and parity check level for each multicast group based on all feedback messages.

### 2.2 Overcast

Overcast is an application-level multicast system that can be incrementally deployed using Internet infrastructure[10]. Also it is easily implemented on the overlay network, and can efficiently use the bandwidth such as IP multicast. Overlay multicast use a end host that is not a router and presented on the internet. A sender send a packet to the end host by unicast. Overcast is single source multicast system. This contrasts with IP multicast, which allows any member of a multicast group to send packets to all other members of the group. Figure 1 shows topology of Overcast. In figure, a Source (S), two Overcast nodes (O), a router, and a number of links. The links are labeled with bandwidth in Mbps.
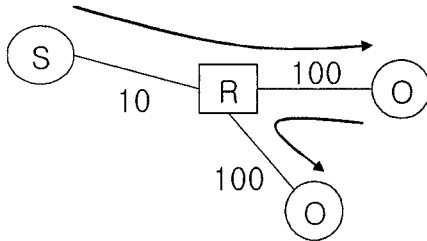
그림 1. Overcast 토폴로지
Fig. 1. Topology of Overcast

There are three ways of organizing the root and the Overcast nodes into a distribution root. The organization shows optimizer bandwidth by using the constrained link only once.

## III. Hierarchical Multicast

In proposed scheme, according to the network status of receivers, it puts properly use to multicast and hierarchical transmission such as overlay multicast. When the multicast session is started, all receivers join multicast group and it receives packet from the multicast group. If average loss rate of all receivers is not higher than congestion threshold, the sender transmits packet to each multicast group, and all receivers receive packet from current multicast group. If congestion occurs in a local, the loss rate of receivers in congestion status is increasing. Therefore, the loss rate of receivers is higher than congestion threshold. At this time, they are dropping from current multicast group and then join local multicast group. Also the representatives set up hierarchical transmission path through control information. The representatives in congestion status become sender of local multicast group and request packet to the representative in non-congestion status. According to request, the representative in non-congestion status transmits packet to the sender of local multicast group by unicast. And then it transmits packet that received packets from the representative in non-congestion to all receivers in the local network by multicast. As a result, we can prevent to the waste of available bandwidth of non-congestion local

occurs because of reducing of transmission rate in non-congestion local caused by reducing of transmission rate in congestion local. The representative use control information that is composed through information of local receiver to communication with each other.

### 3.1 Control information

Table 1 shows structure of control information that is used for communication of representatives. the control information is updated by 30 seconds for avoiding information implosion. In table, On, Oi, Od, Ol, Or, is described as follow.

Specially, the representative uses Od to select unicast sender in congestion status. And Oi is decided through estimated Od.

표 1. 제어정보 구조
Table 1. Structure of control information

| $O_n$ | $O_i$ | $O_d$ | $L_l$ | $L_r$ |
|---|---|---|---|---|
| · $O_n$ : ID of representative. | | | | |
| · $O_i$ : Information of hierarchical transmission path. | | | | |
| · $O_d$ : Information of delay time. | | | | |
| · $L_l$ : Loss rate of local. | | | | |
| · $L_r$ : Transmission rate of local. | | | | |

### 3.2 Representative selection

In this paper, we select a representative in each local. Each representative is the first receiver to join in the local multicast group. It performs two roles: First, hierarchical transmission that transmits duplicated packet to the sender of local multicast group during congestion by unicast. Second, transmits feedback message of local receivers to sender of current multicast group. The second role is described in figure 2. Figure 2 shows feedback message process of representative. In figure, after the representative received the feedback message from all receivers in local network, then calculates local transmission rate, and then hierarchically transmits feedback message to the sender for avoiding feedback implosion.
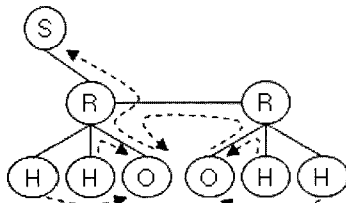
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그림 2. 피드백 메시지 처리
Fig. 2. Process of feedback message

### 3.3 Transmission mechanism

As another role, the representative becomes a sender of local multicast group and hierarchical transmission in congestion status. Figure 3 shows mechanism of hierarchical multicast.
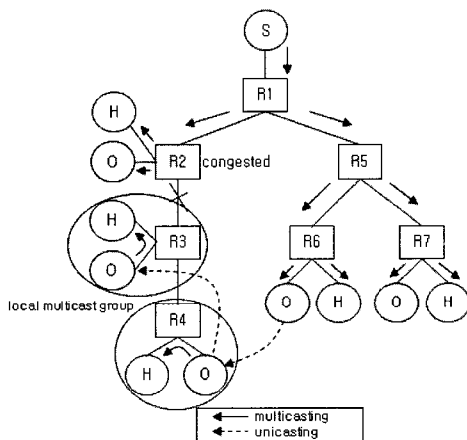


그림 3. 계층적 멀티캐스트 메커니즘
Fig. 3. Mechanism of hierarchical multicast

In figure 3, the solid lines represent multicast tree, the solid arrows represent multicasting, and the dotted lines represent the hierarchical transmission, the sender(S), end hosts(H), the representative(O), the routers(R), and the sender linked with R1. The R1 linked with two routers(R2, R5). For the first time, the sender transmits packet by multicast. And all receivers receive packet from multicast group. When congestion is occurring in R2, the transmission rate is gradually reducing in R3, R4 and the loss rate in R3 and R4 is gradually increasing cased by packet loss. At this time, nevertheless, there is not congestion status, the waste of available bandwidth occurs in R3 and R4. Also the

transmission rate of R5 and its lower nodes(R6, R7) on the multicast tree is a few reduced because of the sender dynamically adjusts transmission rate to loss rate of packet.

To solve this problem, we use hierarchical multicast. While congestion status, if the loss rate of receivers in R3 and R4 are higher than congestion threshold, they stop to receive packet and drop from current multicast group and join local multicast group. Each representative in R3 and R4 becomes the sender of local multicast group in each local. The sender in R4 requests packet to the representative in R6(assume : It has a least delay time that estimated from R4 to R6 and R7, hierarchical transmission path : R6->R4->R3). The sender in R4 received packet from the representative in R6 by unicast and transmits packet by multicast to local multicast group. All receivers in R4 receive packet from local multicast group. Also, the sender in R4 transmits packet to the sender in R3 by unicast and the sender in R3 transmits packet to local multicast group by multicast.
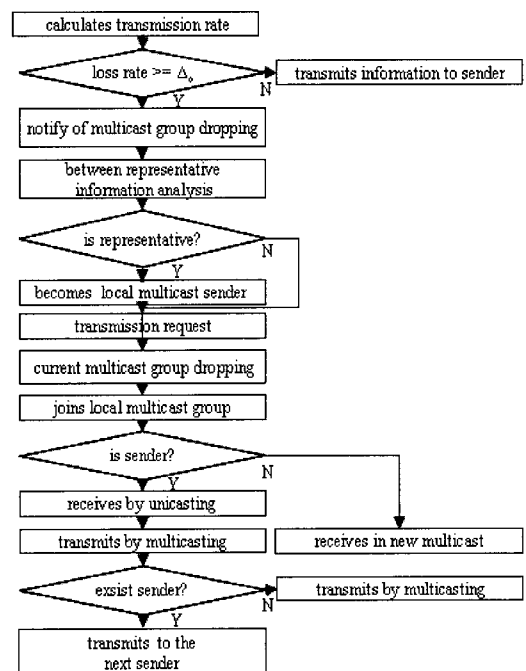


그림 4. 제안 메커니즘의 흐름
Fig. 4. Flow of proposed mechanism

Therefore, the receivers in R3 and R4 in congestion status do not effect on the transmission rate of original multicast group through hierarchical multicast. They can safely receive packet by high transmission rate and it can prevent that the waste of available bandwidth of receivers in R3, R4 and R6, R7. We represented the flow of proposed mechanism in figure 5.

## IV. Experiment

### 4.1 Experimental environment

In this section, we implement our proposed scheme and algorithms. We use seven personal systems and four routers for experiment. The bandwidth of local network is 100Mbps. All nodes are joined at same multicast group and can be connected to each other by mesh. The receivers receive multicast packets via R2 on the multicast tree. Figure 5 shows that topology for experiment.

We set up that congestion is occurred in R2 by other traffics. We observed that the transmission rate of two nodes for 1000 seconds. At the first time, the sender transmits packet by IP multicast. In congestion status, if the loss rate of the receivers in R3 is higher than congestion threshold, we set up for the representative in R4 can transmit packet to it in R3 by unicast.
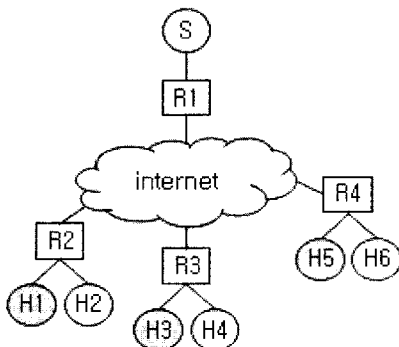


그림 5. 실험을 위한 토폴로지
Fig. 5. Topology for experiment

### 4.2 Experimental results

The result of experiment is represented in figure 6, figure 7. In the figures, the dotted line is represented the transmission rate of SARLM, and the solid line is represented the proposed scheme. In figure 6, the transmission rate of R3 is represented that the compare the SARLM and proposed scheme.
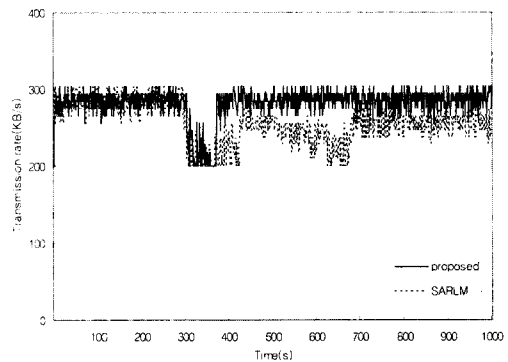


그림 6. 전송률 비교(R3)
Fig. 6. Comparison of transmission rate(R3)

In figure 6, the transmission rate of the SARLM in R3 is gradually reduced in about 300 seconds by congestion of R2. After 300 seconds, it was known that the transmission rate of SARLM is very unstable and the receivers received packet through relatively lower transmission rate. But, in proposed scheme, when congestion occurs, all receivers drop from current multicast group and join local multicast group. The representative in R3 receives packets by unicast from the representative in R4. All receivers in R3 receive packet from the representative(the sender of local multicast group) in R3 on local multicast group. Therefore, the transmission rate of the proposed scheme is safely estimated.

Figure 7 shows transmission rate that compare SARLM and proposed scheme in R4. Nevertheless, all receivers in R4 do not experience the congestion, the transmission rate is reduced by congestion in R2. Because the transmission rate of receivers in R2 has an effect on the original multicast group. But, in proposed scheme, while congestion status, the receivers in R2, R3 drop from current multicast group, and

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join local multicast group for do not effect on the original multicast group. So the receivers in R4 could safely receive packet and the representative in R4 could transmit received packet to the representative in R3.
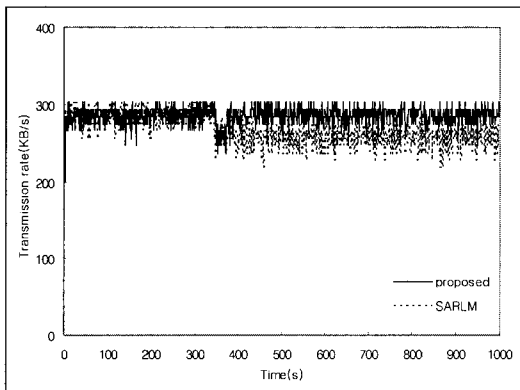


그림 7. 전송률 비교(R4)
Fig. 7. Comparison of transmission rate(R4)

Therefore, it was known that the proposed scheme more efficiently used available bandwidth, could prevent the waste of available bandwidth in R3.

## V. Conclusions and Future Work

There are many schemes using IP multicast. In these schemes, the transmission rate is dynamically adapted according to network status of the receivers. When the congestion is occurring in a local, it effect on itself and receivers of its lower layer on the multicast tree. Therefore, the waste of available bandwidth can be occurred in the lower multicast tree. In this paper, we proposed a hierarchical multicast for dynamic adaptation to network congestion. We used two types of transmission. First, if there is no congestion, the receivers receive packet from only the multicast group. Otherwise, the loss rate of receivers is higher than congestion threshold in congestion status, the receivers dropped from current multicast group for do not effect on the multicast group and join local multicast group. The representative in congestion local

hierarchical receives from the representative in non-congestion local by unicast. Also, it transmits the received packet to the receivers in local multicast group by multicast.

In experimental results, the proposed scheme could improve transmission rate of the receivers in congestion status. It more efficiently used available bandwidth. In the near future, we will study the overlay multicast that has robust transmission path.

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