

Thematic-Based Group Communication

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INTRODUCTION

In the network level computer group-communication (one-to-many) technology, IP-multicast contributes significant roles in enhancing the physical network scalability by replicating identical packets at routers. However, since its initial proposal the IP-multicast has not been widely enabled due to the slow pace of its deployment. Hence, the *application-level multicast (ALM)* concept emerged to solve this deployment issue by shifting the multicast support from routers to end-systems.

The article reviews the most important facts of the Application-Level Multicast and its proposed models. Furthermore, the article describes a novel concept of modeling relative density of members called *bunched mode* and a proposed host-end multicast transport protocol called *shortest tunnel first (STF)*. The bunched mode is based on the *thematic multicast concept (TMC)*, which means that it is a typical multicast scenario where there are a lot of interested hosts in certain institutes and these institutes are relatively far from each other.

The developed analysis tool *NetSim* and the implementation of the *TMC* called *PardedeCAST* are also presented as the tools of this research.

APPLICATION LEVEL MULTICAST

Currently there is a fast increasing need for scalable and efficient group communication technology. The multicast is theoretically optimal for such purposes. It can be realized in the Data-link Level, IP level and Transport/Application level (Hosszú, 2005). However, the IP Multicast has a slow deployment; it has been implemented in the most operating systems (OS) and

routers, but not widely enabled. That is why the end-host based multicast is emerging, in which each member host duplicates and forwards packets. It's simply shifting the multicast support from routers to end systems, see Figure 1. That solution is called *application-level multicast (ALM)*.

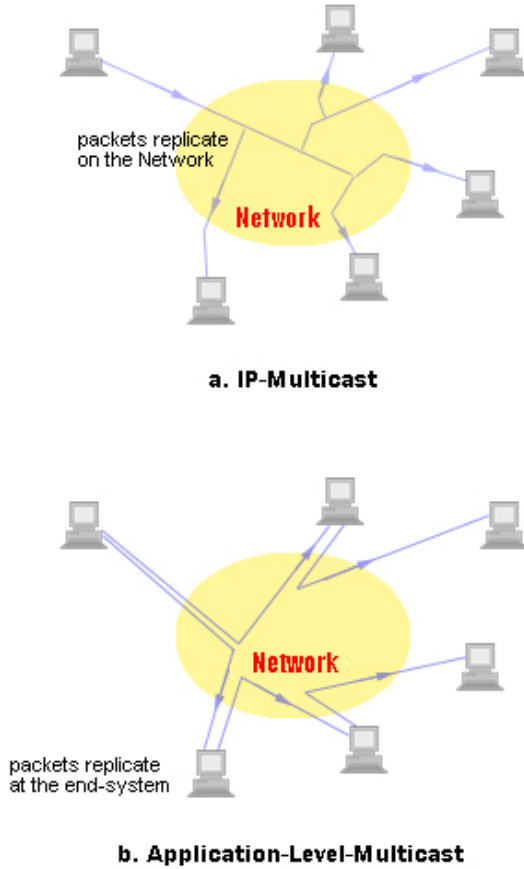
As we can see from Figure 1, ALM is easy to deploy, however less efficient comparing to IP-multicast. It can be understood since as a tradeoff, ALM faces the latency problems. Therefore, several ALM models are proposed. ALM model encompasses ALM routing algorithm, ALM protocol, ALM topology, and so forth.

For designing an ALM model, the metric or goodness of the generic ALM model must be recognized. The goodness of the ALM system can be measured by some parameters, such as *control overhead*, *robustness of the overlay*, *stress*, and *stretch*.

Control overhead means the ratio of the necessary control messages sent by the clients to each other and the amount of the data traffic on the ALM system. In other word, the control overhead is a metric to examine the scalability of the overlay to large groups. Each member on the overlay exchanges refresh messages with all its peers on the overlay. Those messages build the control overheads at different routers, different links and different members of the multicast group. For efficient use of network resources, the control overhead should be low (Banerjee et al., 2002).

Robustness of the overlay of the ALM protocols is measured by quantifying the extent of the disruption in data delivery when various members fail, and the time it takes for the protocol to restore delivery to the other members. Since hosts are potentially less stable than routers, it is important for ALM protocols to decrease the effect of host failures.

Figure 1. IP-multicast and application-level-multicast



Stress means the number of identical packages sent through a certain link. In the case of IP-multicast, the stress is 1, but in the case of the ALM the stress is possibly higher than 1. The total amount of the necessary network resources of an ALM system can be measured by the following expression:

$$\sum_{i=1}^L d_i \cdot s_i,$$

where L is the number of active links in the data or control message transmission, d_i is the propagation delay of the link, and s_i is the stress of the link.

Stretch measures the ratio of length of the path from the sender to the receiver in the case of the ALM and path length in the case of the pure unicast (one-to-one) transmission for each receiver. For the IP-multicast

the stretch equals to 1 for every receiver, for ALM the stretch is possibly higher than 1.

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APPLICATION LEVEL MULTICAST MODELS

Many ALM protocols have been proposed. They are categorized based on the similarity of their characteristics, which are grouped as an ALM model or solution. In the following, those various models are listed.

The special model of the ALM is the *host multicast*, which is a hybrid approach. Its goal is to reach a ubiquitous multicast. One of its design requirements is that it should be deployable on the current Internet, which means that the installation of user-space program is done at end hosts and there is no support required from OS, routers or servers to enable multicast services. The client applications can create a virtual network called *overlay network* (shortly *overlay*) on the top of the Internet. However, the hybrid approach has another design requirement, which is the compatibility with IP Multicast to the furthest extent. For that reason, it should use the IP Multicast where available, keep IP Multicast service model and provide incentive to the future deployment.

Another model of the ALM is the *mesh-based protocol*. This solution creates a mesh for the control plane at first with a redundant topology of the connections between members. After creating the mesh, the algorithm starts to construct a multicast tree. Such protocols are the *Narada* (Chu et al., 2000), or the *Gossamer* (Chawathe, 2000).

The opposite of the mesh-based model is the *tree-based protocols*, where the multicast delivery tree is formed first and then each member discovers some others that are not neighboring members and creates control links to these hosts. This solution is suitable for data transferring applications, which need high bandwidth, but not efficient for real-time purposes. Such protocols are the *Yoid* (Francis, 2000) and the *host multicast tree protocol* (HMTP) from Zhang et al. (2002).

Ad-Hoc Multicast

The communication over the wireless networks also enhances the importance of the ALM. The reason is because that in the case of mobile devices the importance of the *ad-hoc networks* is increasing. Ad-hoc is

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