Requirements for Scalable Adaptive Multicast Framework in Non-GIG Networks

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Abstract

The Scalable Adaptive Multicast (SAM) Research Group is chartered to explore and research techniques which improve multicast performance with respect to dimensions such as number of groups, dynamics of group membership, dynamics of the network topology, and network
resource constraints. This document describes requirements for SAM framework, especially for non-GIG environment.

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Changes:

Changes from draft-muramoto-irtf-sam-generic-require-00.txt:

* Added a discussion on harmonization (4.7) inspired by the e-mail by Jun Lei and Yuji Imai.
1. Introduction

IP Multicast [IETF] [2236] [2235] [DEER] [DEE2] [MBONE] has achieved great engineering success. Various protocols, SSM [3569], PIM [2362], MSDP [FARI] and MBGP [2858] will provide firm basements for distribution of live contents like TV programs broadcasting all over the Internet. And bulk content delivery could be achieved by standardized RMT protocols [RMT].

On the other hand, it is possible to improve multicast performance with respect to dimensions such as number of groups, dynamics of group membership, dynamics of the network topology, and network resource constraints. Alternative technologies such as end-system multicast [ESM], [YOID], [NICE], [ALMI], [TAG], [DTO], [CAN], [BAYEUX], [XCID] and overlay multicast [SCX], [OVERCAST], [RMX], [MSN], [OMNI], [AKAMAI], [IBEAM] have been demonstrated to achieve such improvement. But these mechanisms have not been integrated into a unified architecture and operational design.

SAM (Scalable Adaptive Multicast) research group [SAM] is chartered to explore and research such techniques. This document describes requirements for SAM framework, especially for non-GIG environment.

2. What is SAM

The Scalable Adaptive Multicast (SAM) Research Group is chartered to explore and research techniques which improve multicast performance with respect to dimensions such as number of groups, dynamics of group membership, dynamics of the network topology, and network resource constraints. The RG will investigate approaches based on application layer multicast (ALM), overlay multicast (OM), and native IP multicast, as well as hybrid approaches. A key design consideration is the placement of multicast state information along
the multicast path, including packet headers, end hosts, and network nodes, where placement may be determined adaptively.

3. non-GIG requirement for SAM framework

The Global Information Grid (GIG) [GIG] is a large and complex undertaking that is intended to integrate virtually all of the information systems, services, and applications in the US Department of Defense (DoD) into one seamless, reliable, and secure network.

But in this document, we enumerate requirement for SAM framework which is NOT specific to GIG.

This section describes the non-GIG requirements.

3.1 Multicast capability

SAM framework must support point to multipoint communication and may support multipoint to multipoint communication. Native IP multicast can support one to many bulk data transfer and broadcasting. SAM framework provides compliment and integrated method of one to many and many to many communication.

3.2 Minimizing the infrastructure support and fastening the service-connectivity cycle

To start up a networking, it is quite important to minimize the change to existing network infrastructure [MOSSDAV]. Native IP multicast requires infrastructure support and it sometimes cause difficulty to evolve because initial proposals always looks very ambitions and it is very hard for multiple organizations (i.e. carriers, ISPs) to negotiate and to agree to deploy something at the same time. User initiate start up function and incremental deployment function is quite important for SAM-RG to design the SAM framework.

3.3 Scalability problems

SAM framework should support various scalabilities. This section enumerates the scalability problems.

3.3.1 Fast routing convergence

Multicast distribution tree must be maintained even if the unicast routing path is changed. The convergence period should be short. This requirement is common among Native IP multicast, ALM, OM and the future hybrid SAM solutions. The SAM framework should be able to rapidly adapt to changes in network topology even if there is a
large number of multicast groups, even if group membership is highly dynamic and even if lots of group members are moving. To state this requirement in a more quantifiable way, multicast routing should converge for 95% of the affected groups within 1 second, say, after convergence of unicast routing (to minimize outages of VoIP conference, e-meetings etc.)

3.3.2 Dynamic topology change

Multicast forwarding functions (i.e. router or receiver) are not always settled in fixed locations. Mobile [NEMO] and MANET [MANET] situation might be assumed. In such a situation, the router location and link topology are dynamically changed. Multicast distribution tree must be maintained in such case too.

3.3.3 Number of group

The number of group all over the Internet would be quite large. We should assume millions of human group communication and multiple sensors (i.e. machine to machine) networks all over the world. That is, the SAM framework should be scalable in that it should be able to support a very large number of multicast groups (since the network will need to support very large numbers of groups for VoIP conference calls, for videoconferences, e-meetings and other applications).

3.3.4 Dynamic management of group membership

Many communications would be generated at the same time all over the world. And it is necessary to assume frequent change of group membership for the management mechanism.

3.4 Adaptivity for real-time communication

In the real-time group communication over the best effort network, adaptation mechanism is necessary. This section describes describe the requirement for real-time group communication.

3.4.1 Latency (Delay sensitivity)

The end to end delay of the conversation over the network should be shorten. The delivery path of the multipoint communication should be optimized to shorten the total transmission delay.

Multicast packets should follow "close to optimal" routes from a source to a destination. To state this in a more quantifiable and measurable way, the end-to-end delay from a source, \( s \), to a destination, \( d \), in a multicast transmission should be no more than 50 msec (say) longer than the end-to-end delay of a unicast transmission.
from s to d. (Need to have good end-to-end delay to support full-duplex, real-time VoIP communications.)

Multicast should not artificially concentrate traffic on certain nodes or certain links (think rendez-vous points) since this can introduce unnecessary queuing delays and unnecessary packet loss in addition to unnecessarily long network paths and unnecessarily large end-to-end latencies.

3.4.2 Data rate control & Congestion avoidance

In SAM framework, overlay such approach as ALM or OM might be taken. In such a situation, multiple delivery path might share a physical network link. The mechanisms to fairly share the bandwidth and to avoid congestion would be necessary.

3.4.3 Redundancy path

In SAM framework, the receiver might take a part of forwarder. The membership of the forwarding path might be unexpectedly changed without relationship to the membership of real-time group communication. The management mechanism should take care about such situations.

3.5 Capability for non streaming application

There exist strong requirement of the collaboration over the Internet. This section enumerates requirement for non streaming application.

3.5.1 Interactive application

Internet game and collaboration tools like white board or remote presentation are the representatives of interactive applications. Such application might exchanges bursty or intermittent traffic between participants. Both of latency and reliability might be the most important for those applications.

3.5.2 File transfer

 Sharing file between participants are required in multipoint group communications. Casual file sharing like instant message should be achieved easily in SAM framework.

3.5.3 Data collection

Data collection from remote sensor is required. Bi-directional distribution tree in SAM framework might be used for such purpose.
4 Interoperability of existing methods

Application layer multicast (ALM), overlay multicast (OM), and native IP multicast are separately developed. Harmonizing of those technologies might be one of the requirements for SAM framework. This section explains each technology and harmonization briefly.

4.1 ALM

Application layer multicast generates distribution tree between terminals. Logical group management function or the joining algorithm automatically calculates optimal path for all participations.

4.2 OM

Overlay multicast connects each individual multicast enable network by unicast tunneling. Addressing space of multicast group can be maintained by transform function. As ALM, logical group management function calculates optimal path between networks.

4.3 Selfish routing

Many research points out problems of selfish routing in overlay approach [TAON], [SROU], [CMP], [ITOL], [PAA], [EEA]. The logical group management function optimize their own performance goals not considering system-wide criteria. It means traffic cannot be controlled by the network operator.

4.4 Native IP multicast

Native IP multicast manages receivers in the distributed method. Edge router aggregates tree construction request and routing algorithm finds source and generates distribution tree between edge routers. Trees are constructed from leaf (i.e. edge router) to root (i.e. the source) based on the unicast routing information. Network operator can imagine the tree construction and control it. It means trees and traffic can be managed by the network operator.

4.5 Cooperation with Network TE in overlay approach

Network traffic could be controlled by the network operator to keep network healthy and grown up effectively. Overlay approaches have problem about selfish routing and bandwidth consuming. But SAM framework should provide the chance to traffic engineering while forming distribution tree or transmitting real-time streaming.

4.6 eXplicit Multi-Unicast (Xcast)
eXplicit Multi-Unicast (Xcast) is a new multicast scheme with complementary scaling properties: Xcast supports a very large number of small multicast sessions. Xcast achieves this by explicitly encoding the list of destinations in the data packets, instead of using a multicast group address. Therefore, the data packets has knowledge about distribution tree. It might mean Xcast packet could give the network operator the chance to estimate the traffic trend and to increase the bandwidth properly.

4.7 Brief consideration on harmonization

4.7.1 One does not fit all

The requirements that has been described above includes many things. It is difficult to fill everything with one mechanism. An above-mentioned individual mechanism doesn’t meet all demands at the same time either. Those are not mandatory rather than we have to choose subset of them depends on real-applications we would use.

4.7.2 Assumed requirement for harmonization

A part of mechanism requires a fixed-point (e.g. a rendezvous point or a group management function) on the Internet, and a part of mechanism needs the router support or the relay servers when forwarding packets. They try to deploy their own mechanism independently. We can assume that a specific network service operator introduce the specific fixed point, the router support, or the relay servers for specific service which they want to introduce (e.g. for video conferencing, a group management for XCAST, and for TV broadcasting, relay servers for an OM). The SAM framework might have to include the interconnectivity of such state-of-the-art methods.

5. Security consideration

5.1 Unexpected utilization of resources

Some overlay approach try to use the unused resource on the Internet. They try to make efficient and robust path using other person’s resources. But in real time communication, resource might be used heavily and continuously. It sometimes suffer the resource owner unexpectedly. Unexpected resource use could be avoided in SAM framework.

5.2 Authorization of group membership

Native IP multicast aggregates receiver join request at the edge router and the edge router need not manage individual receiver in normal case. It provides receiver initiated multipoint communication. But it also give the chance to malicious receiver to be a black hole
sink for all multicast group. Authorization of group membership should be supported in SAM framework.

5.3 Mechanism to limit denial of service attack

Multi-point overlay approach essentially has the function to duplicate packet and forward to multipoint. The mechanism to limit denial of service attack should be thought while designing SAM framework.

5.4 Encryption and key distribution

It should be possible for a source to protect streaming content from viewing by intermediate nodes that are not part of the group. Point to multipoint association and key distribution mechanism should be carefully designed.

15. Informative References


[OVERCAST]  

[RMX]  

[MSN]  

[OMNI]  

[AKAMAI]  

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