Studies on Pragmatic Reliable Multcast

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Background and Purposes

Various type of communication via the Internet has been requested, according to increase of user, growing scale and diversity of utilization. In addition to the typical Internet application such as e-mail and WWW, requirements for realization of one to many and many to many communication are requested , for example a push application of data delivery for movie or music, a distance learning application via video chat, interactive virtual reality and interactive gaming via the Internet are needed.

Recently, the technology of IP multicast on the Internet provides capability for one to many or many to many data delivery. But it can not provide reliable data delivery but provide best effort packet transmission. Reliable multicast is one of technologies which provide such reliability to one to many or many to many communication on the Internet like unicast reliable protocol, TCP.

It is difficult to develop a single commonly accepted technical solution because demands for reliable multicast is various, such as reliability of packet delivery, ordering, timeliness, session management issues, security, accounting, friendliness of TCP, needs for support of asymmetry network like satellite network, etc. Then Reliable Multicast Transport group of IETF has concluded that they should take the "building-block" approach to standardize reliable multicast protocols. It recommend they should develop certain common components to multiple protocols as "building-block" and utilize those for specific protocol merging with its protocol core modules.

In this paper , we make general problems of reliable multicast protocol clear and make detail problem concrete and find solutions and develop the took kit for reliable multicast protocols. Through these work ,we expected to make reliable multicast practicable.

General problems of reliable multicast

Multicast application has various demands. For example the application which treat real time stream such as video or audio requires low delay and has strict limits on timing jitter. On the other hand the date delivery application such as server replication between many sites request absolute reliability rather than tight timing requests. Because of these diversity of demands, it is difficult to standardize a common protocol designed satisfy all needs for reliable multicast.

Feedback implosion is the most typical problem of which all reliable multicast protocols must avoid. A packet sent by sender is delivered to receivers along the distribution tree which multicast routing protocol has made beforehand. But packets from receiver such as acknowledgement packet or negative acknowledgement packet will be delivered via the reverse path to the sender and cause implosion over loading to the network elements around the sender.

All protocol must implement the function of congestion avoidance that will be deployed to the widespread Internet. Therefore reliable multicast protocols must avoid all congestion that may arise at any link constructing the distribution tree. The behavior of congestion control must be TCP-friendly.

Multicast applications have peculiar security problems that impact to its deployment in the Internet. For example, multicast router does not manage membership list of receivers. It forward multicast packet to the link from which any receiver requested. So charged contents must be sent as encrypted data for fairness of accounting. But currently, Such feasible method is not found to establish security association dynamically with mulitcast sender and receivers every time receiver join or leave the session. We must recognize those and present practical solution.

To extract concrete problems and requirement to improve protocols

We had two types of experiment below to extract the concrete problems and requirement to improve the protocol.

- Experiment to make a file transfer application practical
  First, We listed up detail requirement for newspaper delivery to a million of receivers via autonomous domain in which all flow share a link and TCP friendly congestion control is needed.

- Experiment to make real time streaming application practical, such as MP3 audio data delivery and video stream of DV format.

  In the MP3 audio experiment, we use Netwave wireless Lan system as a practical link with natural packet loss. We observed 2% packet loss and noisy play while IP

multicast delivery trial and 12% packet loss and clear play with reliable multicast recovery.

For the digital video experiment, we selected DV format video stream, which use only intra frame DCT and VLC compression technique at the fixed ratio compression and easy to thin frame out. In order to find out feasible utilization of real time video stream, we tested with various condition such as frame drop rate, prebuffer size, sender window space, receiver NAK back off parameters, etc.

Through these experiments, several problems had arisen and we found feasible solution of them. Remarkable ones are listed below.

- Application may have a few type of multicast session which request different reliability.
- Where to deploy translators in an acknowledge base reliable multicast application.
- Necessity of Application Level Framing especially for real time applications, which needs cooperative behavior between transport protocol and application.
- Inspiration for three type of design of ALF model.
- Relationship between packet loss rate of the network, network resource needed for the protocol and feasible application requirement.
- Combination of the solutions to guarantee the reliability.

Proposal of tool kit

To solve these problem arisen those experiments effectively, I propose the tool kit of reliable multicast transport protocols and applications named MRMT (Muramoto Reliable Multicast Toolkit). MRMT consist of two part below.

- A-kit
  A-kit is a software library, which enforce the suitable design method such as ALF to programmer easily. I designed three type of ALF model listed below and implemented some of those and applied to MP3 delivery application to confirm the efficiency. Because application need not handle timestamping, buffering and miscellaneous setting of sockets with MRMT a-kit ALF extension of PGM, program code was reduced 60%.
  - real time ADU model
  - name space sharing model
  - ADU window model

- P-kit
  P-kit is a function library, which is used to implement a reliable multicast transport protocol. P-kit consists of function block such as blocking, byte ordering, checksumming, inactivity control, sequence number, negative acknowledgement, segmentation, rate flow control, time, etc. In this paper, I show the design of end host protocol stack of PGM.

Future work

I present three subject below to progress study on reliable multicast and to deploy it.

- Experiment of adaptive reliable multicast application under the network condition with general traffic.
- Development of RPC like reliable multicast tool kit to generate sender program, receiver program and traffic specification for DiffServ bandwidth broker or RSVP from a description of program logic and formal description of timeliness requirement.
- Design and implementation of large scale reliable multicast application with peculiar requirement such as synchronicity, causality ordering.