Design of Network-adaptive Extended Video Services for Access Grid

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1. Background

With the advent of Gbps-range Research and Engineering networks, it is now possible to accommodate the increasing demand toward high-quality immersive media services. To better assist the advanced collaboration environment, AG (Access Grid) needs to support high-quality videos with large displays. However, current AGTk 2.1.x only offers low-resolution VIC-based video (around 300Kbps CIF sized image) with the existing Video {Producer, Consumer} Services [1]. To address this problem, since year 2003, we've been working on high-quality video extensions for AG to include support for DV (digital video) and HDV (high-definition digital video) video. Based on our past experience, we are now designing an extended version of video services for high-quality video support.

2. Problems

VIC-based video services of current AGTk 2.1.x have following weak points. First, it shares a single multicast address among all participants and all video streams are transmitted to this shared multicast address [2]. Though it intends (and allows) simple video interface, it is impossible to isolate video streams from selected senders. Regardless of the network bandwidth limitation of each AG node, the amount of consumed bandwidth depends on the number of video stream. If AG nodes use high-quality video (e.g., 30Mbps DV), this easily leads to too big bandwidth. Thus, it is desirable to allow flexible multicast address allocation. Second, we also need to accommodate selected set of open-source video delivery applications. Especially, applications such as DVTS and VideoLAN are supporting RTP/UDP/IP-based streaming. Thus, it is important to prepare unified interface for versatile video applications. Finally, since AG nodes are not aware of whether receivers are getting video with good quality or not, it is very difficult to pinpoint the point of trouble when there is quality problem with AG. Thus, it would be very useful if we can arrange AG nodes to aware of both network and system status of all involved AG nodes.

3. Proposed Architecture

In order to address the above issues, we are now designing ExtendedVideo{Producer, Consumer}Services and Monitoring Service like <figure 1>. ExtendedVideoProducerSerivce is an interfacing module to support versatile video formats. This service has the role to allocate multicast address, obtained from venue server, to its own video tool and announce its video session description periodically via announcement-only multicast (similar to SAP [3]). On the other hands, ExtendedVideoConsumerService just listens to the announced video session descriptions via announcement-only multicast. Monitoring Service is the component that estimates system and network resource and assist to better rich media service on heterogeneous network environment. In this Monitoring Service, both active and passive measurement agents are used to estimate system and network metrics efficiently. The proposed Venue Client includes Monitoring Service to be managed by Service Manger. The Monitoring service has active monitoring agent and passive monitoring agent. The active monitoring agent measures network condition and the passive monitoring agent measure video data traffic and system condition. Based on hybrid monitoring result, we can select suitable sending rate to improve AG performance.

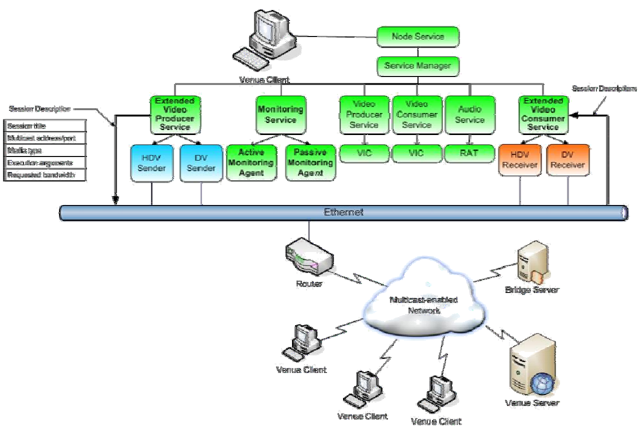

Figure 1. Network-adaptive extended video services

3.1. Flexible Multicast Address Allocation

Flexible multicast address allocation is essential to support versatile video tools. To isolate video streams from video senders, video senders should have a unique multicast address. Furthermore, for the purpose of making groups of specific video source like <figure 2>, the proposed approach supports group-multicast addressing. For example, if a video application is capable of identify each stream among many streams sharing a common address (like VIC), it allocates (and shares) a group multicast address. If a video application has to get a unique multicast address per each stream, it allocates a unique multicast address. This approach makes the extended video services independent so that participants can selectively receive video streams by joining the selected multicast address groups. The advantage of group-multicast addressing is that Network Service of Venue Server can apply the quality-controllable policy to each video group. For this, Venue Server allocates a pool of multicast addresses flexibly.

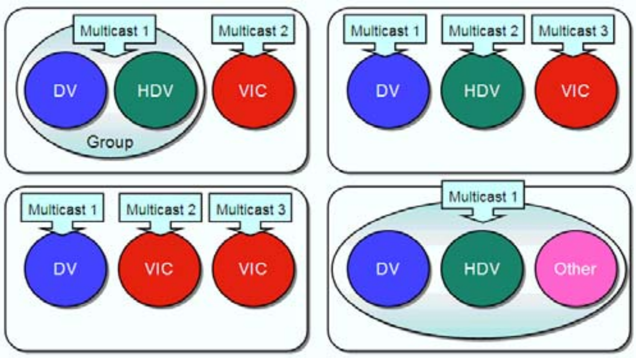

Figure 2. Examples of flexible multicast address allocation

Venue Server issues two multicast address, a announcement-only multicast address and video multicast address. Using this announcement-only multicast address, all AG nodes are aware of the video multicast addresses. For this, we need to modify multicast address allocation in Venue Server in order to allocate both announcement-only multicast address and video multicast address for each video stream. ExtendedVideoProducerService takes both multicast addresses from Venue Server and runs SAP server to announce video sessions. SAP server opens announcement-only multicast channel and

ExtendedVideoConsumerService gets the announcement-only multicast address from Venue Server and receives video session description by announcement channel. Then the nodes selectively decide to join the video streams considering their bandwidth and computational budget.

3.2. Versatile Video Format Support

By extending the existing video producer and consumer services tied heavily with outdated VIC, we have enabled high-quality video support with AGTK 2.1.x. There are the major components of proposed enhancement: ExtendedVideo{Producer, Consumer} Services. The proposed system uses both video applications such as DVTS and VideoLAN in order to delivery DV and HDV, respectively. DVTS (Digital Video Transport System) gets DV stream from DV camera via IEEE1394 interface and transports DV stream encapsulated by RTP/UDP/IP [4]. VideoLAN is open source project to target multimedia streaming on a high-bandwidth network. VideoLAN supports any types of camera (HDV, DV camera, and etc.) and sends video streams, transcoded by MPEG2-TS, to the destination [5]. Video delivery in transcoding mode can reduce bandwidth demand down to 3Mbps for both DV/HDV delivery with additional 1~2 sec delay.

The capability of a node regarding its video format capability (e.g., DV[1]/HDV[2] support) needs to be pre-configured. Video session description contains session title, multicast address, media type, execution command and requested bandwidth.

3.3. Network-adaptive Video Transmission

Network adaptive transmission is required to provide and maintain high-quality video service over time-varying and heterogeneous networks. This feature enables users on the poor network to use high-quality video service of AG. The MonitoringService is the key component in order to provide network-adaptive video transmission. This service measures network metrics (delay, jitter, loss and available bandwidth) on network and pinpoints the cause of performance degradation to disturb normal AG operating. In addition, as supporting network estimation feedback, MonitoringService assists to deliver the quality-controlled video suitable for network status.

[1] DV (digital video): 30Mbps 720x480 DV-encoded video

[2] HDV (high-definition digital video): 19.2Mbps MPEG-2-encoded 1280x720 30progressive

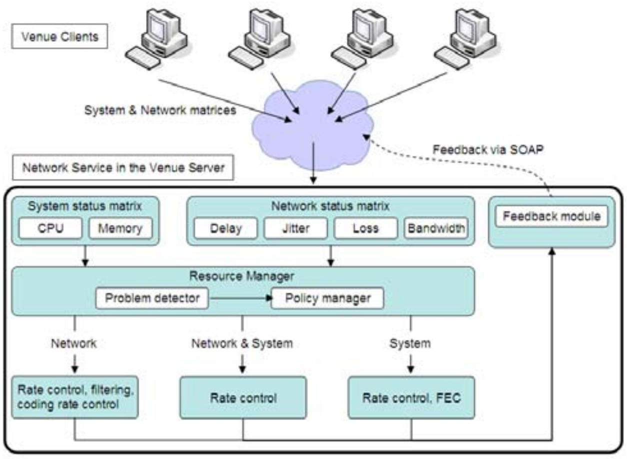

Figure 3. Hybrid monitoring scheme for AG

The proposed system employs hybrid monitoring scheme as the method of MonitoringService. The hybrid monitoring scheme performs both active monitoring and passive monitoring. The active monitoring module measures network characteristics such as delay, jitter and loss by using packet probing over multicast network. On the other side, the passive monitoring module estimates the quality of video by analyzing RTCP packets of multi-party real-time media application and takes the system metric like the rate of both CPU and memory utilization. The MonitoringService collects the measurement information from both monitoring modules and forward report packets to the hybrid monitoring server. In the proposed system, Network Service in Venue Server undertakes to perform the function of hybrid monitoring server. <Figure 3> shows the basic concept of Network Service as the hybrid monitoring server. Measurement reports from participants in the same Venue are stored in the system status matrix and the network status matrix, respectively. Resource manager is the core component which pinpoints the cause of performance degradation to disturb normal AG conferencing and decide a solution to the problems based on policy. If the problem results from one or two AG nodes, resource manager enforces the simple policy: notifying the corresponding nodes of the problems and let the user to control the quality of video suitable for network status manually. However, for the case of the deterioration of the network state on the whole, the resource manager performs complicated policy to harmonize the quality of video on all participated nodes with the current network state. Resource manager makes a reasonable induction to decide problems between end-node system and network from system and network state matrix. Resource manager chooses the adaptive play-out schemes such as FEC (Forward Error Control) and rate control according to the problem reason.

Original active and passive monitoring scheme have limitations. The active monitoring approach should send probe packets periodically to measure the multicast network. To raising measuring accuracy, this scheme must increase the frequency to send probe packets on multicast IP network. However, this work probably degrades network performance by packet flooding. On the other hands, passive monitoring needs the high procession cost to capturer RTCP packers while never consumes additional bandwidth. The proposed hybrid monitoring scheme can measure multicast-enabled network characteristics accurately with less probing frequency. This is because passive monitoring provides roughly network metrics and active monitoring can estimate the network state based on passive monitoring report.

<Figure 4> describes the process flow of Monitoring Service on AG. After measuring system and network status, MonitoringServices reports the estimation result to Monitoring Server on Venue Server. Monitoring Server transfers the data to Network Service, and Network Service orders that Event Service notifies network status to Event Client. Then, Event Client lets ExtendedVideo{Producer, Consumer}Service to obtain the control command from Network Service via SOAP call. ExtendedVideo{Producer, Consumer}Service takes the control command and transfers that command to video application via inter-process call. In order to support network-adaptive video delivery on video application, we should make glue-code to support adaptive scheme such as FEC, filtering and rate control for the video tool.

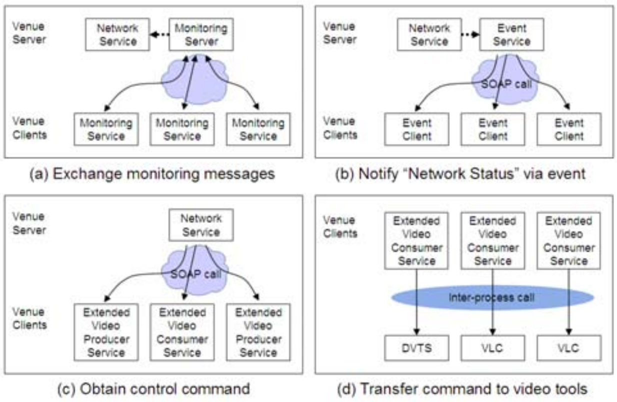

Figure 4. Process flow of the monitoring service

4. Remaining Issues

To make the proposed design flexible and robust on the AG, we will consider the following issues.

- NAT and firewall issue to process high-quality media packets

- Enabling Quick Bridge Server to support flexible multicast address allocation scheme
- Non-conflicted multicast address allocation scheme
- Lip synchronization between video and audio
- Media security
- IPv6 support

5. Conclusion

In this paper, the proposed design enables Access Grid to employ various video formats with flexible multicast address allocation and to deploy proposed system over heterogeneous network. We expect to enhance Access Grid with high-quality video. However, DV/HDV transmission requires much bandwidth, so that the proposed design has the disadvantage that many participants cannot use high-quality video service simultaneously. Therefore high-performance and compact codec is indispensable to deploy the proposed design.

6. References

[1] Access Grid, http://www.accessgrid.org/.

[2] SangWoo Han, DongHoon Yi, and JongWon Kim, "Video Quality Enhancement of Access Grid System employing DV transmission", in Proc. of KICS Fall Conference, November 2003.

[3] Handley, M., Perkins, C. and E. Whelan, "Session Announcement Protocol", RFC 2974, October 2000.

[4] DVTS, http://www.sfc.wide.ad.jp/DVTS/.

[5] VideoLAN, http://www.videolan.org/.