Rate-Adaptive Merging as a Technique for Efficient Resource Utilization in Video-on-Demand Servers[1]

Ashok Narayanan, Prithwish Basu, and T.D.C. Little
Multimedia Communications Laboratory
Department of Electrical and Computer Engineering
Boston University, Boston, Massachusetts 02215, USA
(617) 353-9877, (617) 353-6440 fax
tdcl@bu.edu

Technologies such as IP multicast have enabled distribution of data to multiple receivers with efficient end-to-end resource utilization. However, in order to provide full interactivity in a conventional video-on-demand scenario, each user must be allocated a separate unicast channel, resulting in lower channel utilization.

To improve resource utilization, the concept of "virtual channels" has been suggested by Venkatesh and Little [1]. Under this model each user has a virtual channel, and one or more virtual channels are mapped to one physical channel. If two users are watching the same movie, they will be occupying two virtual channels. However, if they are at the same point in the movie, their virtual channels can be mapped onto a single physical channel, thereby releasing the resources associated with the other physical channel.

Rate-adaptive merging has been suggested as a technique to reconcile the temporal skew between two virtual channels playing the same movie by Golubchik et al. [2]. If user A has been viewing movie M for time T, and user B has been viewing the same movie for time T', then (assuming $T' < T$), we can speed up the playout of user B by a factor F, such that both users A and B will be at the same point in the movie, at time $(T - T')/(F - 1)$. Their virtual channels can then be merged onto one physical channel and the other physical channel can be released. If one of the users interacts (e.g., pause, fast-forward), the corresponding virtual channel must be "promoted" by allocating it an additional physical channel. In this manner, we can provide the functionality of interactive video-on-demand while improving resource utilization. This technique is especially suited to content libraries with skewed content popularity distributions.

[1]Presented at the 4th Intl. Conf. on Multimedia Computing and Systems, Ottawa, Canada, June 1997. This work is supported in part by the National Science Foundation under Grant No. NCR-9523958, EMC Corporation, and Hewlett-Packard.

Currently, on a 10 Mb/s Ethernet LAN, one can obtain between 4 and 6 streams of 1.5 Mb/s MPEG-1 video/audio. In this low bandwidth scenario, saving even 1 physical channel results in a 16 to 25% improvement in resource utilization. For high-usage, high-bandwidth channels, we argue that the large number of users operating in a constrained-content universe will allow us to apply merging techniques frequently, and will thereby allow frequent release of physical channels.

Here, we demonstrate that a video server can perform service aggregation via rate-adaptive merging without causing perceptible degradation in QoS. We demonstrate rate-adaptive merging using a video server which distributes streaming MPEG video/audio to multiple clients. Our studies have shown that speedup by a factor of 1.06 does not cause significant perceptible QoS degradation. Specific cases are demonstrated where the server accelerates the playout of one client, then switches this virtual channel onto the physical channel of the other client at the appropriate time.

In future work, we plan to experiment with other approaches to channel merging including content insertion [4]. Currently, this mechanism is being integrated into an application to serve news and educational video on demand [3] via the Web.

References

[1] D. Venkatesh, T.D.C. Little, "Dynamic Service Aggregation for Efficient Use of Resources in Interactive Video Delivery," *Lecture Notes in Computer Science, Vol. 1018, (Proc. of the 5th International Workshop on Network and Operating System Support for Digital Audio and Video),* T.D.C. Little, R. Gusella, Eds., Springer-Verlag, November 1995, pp. 113-116.

[2] L. Golubchik, J.C.S. Lui and R.R. Muntz, "Adaptive Piggybacking: a Novel Technique For Data Sharing in Video-On-Demand Storage Servers," *Multimedia Systems* Vol 4, 1996, pp. 140-155.

[3] G. Ahanger and T.D.C. Little, "A System for Customized News Delivery from Video Archives," To appear in *Proc. Intl. Conf. on Multimedia Computing and Systems,* June 1997, Ottawa, CA.

[4] R. Krishnan and T.D.C. Little, "Service Aggregation Through a Novel Rate Adaptation Technique Using a Single Storage Format,"*Proc. 7th Intl. Workshop on Network and Operating System Support for Digital Audio and Video*, St. Louis, MO, 1997.