Resource Optimization in Video-On-Demand Networks

Jeong-dong Ryoo and Shivendra S. Panwar
ryoo@photon.poly.edu, panwar@kanchi.poly.edu

Department of Electrical Engineering
Polytechnic University
Five Metrotech Center, Brooklyn, NY 11201

Summary

It is widely considered that *Video-On-Demand* (VOD) will become an important residential service as a substitute for current home entertainment and information services. VOD services offer instant access to a video library of educational and entertainment programs, as well as communication services. Developing this new information delivery infrastructure requires considerable planning and effort. Considering the initial cost in early deployment stage, *Hybrid Fiber/Coax* (HFC) transport architecture is regarded as a good option for the delivery of interactive broadband service. Given that broadband coaxial cable has been installed over 93 percent of the homes in the United States, it has been provided cable operators with the opportunity to play a important role in interactive broadband service. Migration from current broadcast video service to real-time interactive video service needs a change of the cable network structure.

In this paper, we address the problem of designing a cost-minimized network for VOD services satisfying given customer demands and *Grade-Of-Service* (GOS) requirements. GOS is expressed as an acceptable level of blocking for customer requests. Request blocking arises when there is not enough bandwidth in the network, or the required video file cannot be retrieved from the video server. The latter results from a situation when the video server reaches the limit on the number of requests that can be supported simultaneously, or the requested video file is not available.

Our logical multimedia network topology is constructed as illustrated in the figure. Each node of the tree consists of a potential site for a video server. The leaves of the tree represent a cluster of users. Video files are assumed to be allocated hierarchically. That is, according to the given demand characteristics of video files, the video files are distributed among various levels. For example, the most demanded video file should be placed in the lowest level.

The objective of the design is to minimize the overall costs, which are composed of the costs of video servers and link bandwidths.

$$J^* = min\{\sum_{i,j} B(c_{ij})Y_{ij} + \sum_{l,k,s,m} V_{lk}(s,m)X_{lk}\}$$

Link cost, $B(c_{ij})$, is the cost of link capacity c_{ij}, connecting locations i and j. V_{lk} represents the cost of a video server that is placed at location k, in level l, with service capacity s (i.e.

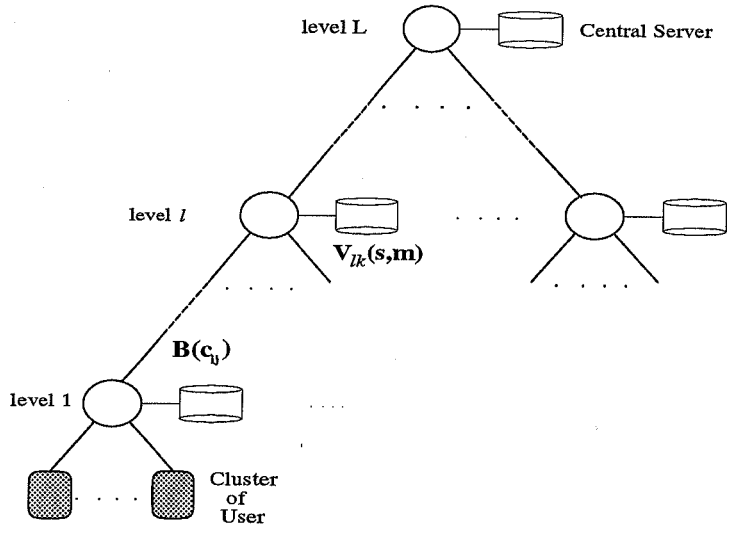

Figure 1: Logical network topology for VOD

the maximum number of simultaneous requests that can be handled), and storage capacity m. Y_{ij} and X_{lk} are indicator functions, indicating the presence or absence of a link or a server. Several constraints are imposed, such as the maximum blocking probability on all the clusters of users.

We present an assumed cost function for video server and link. With those cost components, a nonlinear lagrangean relaxation problem is formulated under the blocking probability constraint. We then provide a solution that can optimize the network cost by means of the selection of nodes in which video servers will be placed, the service and storage capacities of these video servers, and the allocation of the link capacities that meet traffic requirements.