A Hierarchical Meshed System for VOD Streaming Services on P2P Network

Presented by wdchiang

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Introduction

- *A VOD* (Video-on-Demand) service allows clients to access video at arbitrary time, and provides not only the normal playback functions but also the VCR-like functions.
- In traditional client-server model, the high bandwidth requirement and long duration easily makes the streaming server become the system bottleneck as the popularity increases.

Introduction

- Two important solutions:
  - *IP multicast*

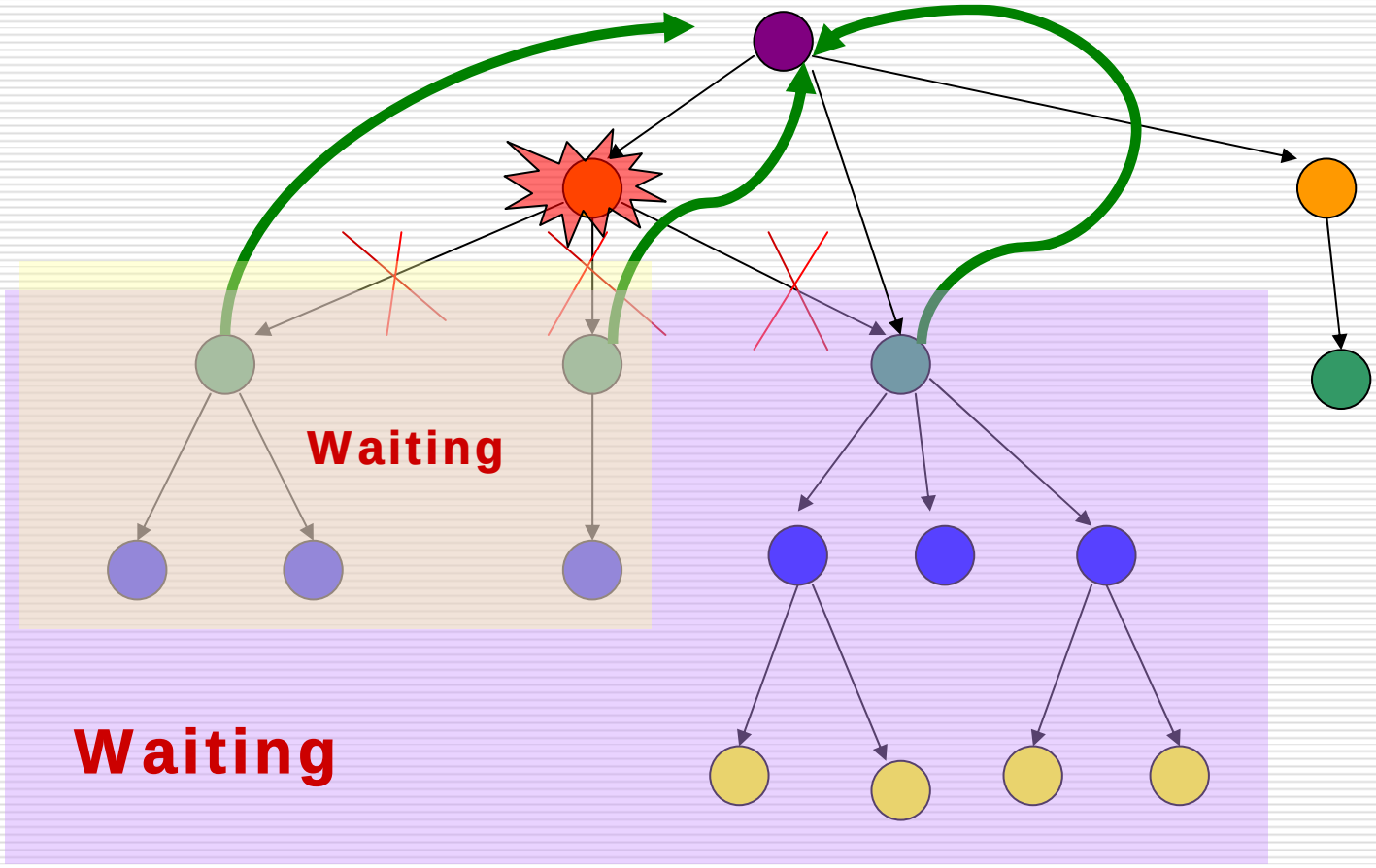
    It has not widely deployed because it is complicated to maintain every flow state and there exist some problems of scalability and group dynamics.
  - *ALM (Application Layer Multicast)*

    It has been proposed to replace IP multicast because of its low cost and easy deployment.

Introduction

- Most ALM studies hang over from the IP multicast and adopt the *tree-based* topology.
- The Challenges of the tree-based topology:
  - The heterogeneities of the peers
    - The different capacities lead to *bandwidth-leak*.
    - With different capacities, the dynamics produce a large number of reconstructing topology messages and the long latency of the reconstructing peers.
  - Hard to provide the VCR-like functions
    - It is necessary to maintain the whole topology and deal with high dynamics.

Introduction



Introduction

- This paper proposes a hierarchical meshed system for VOD streaming services, called **HMVOD**.
- HMVOD well arranges peers' various properties to enhance the system capacity, and meanwhile satisfies the VCR-like functions.

System Model

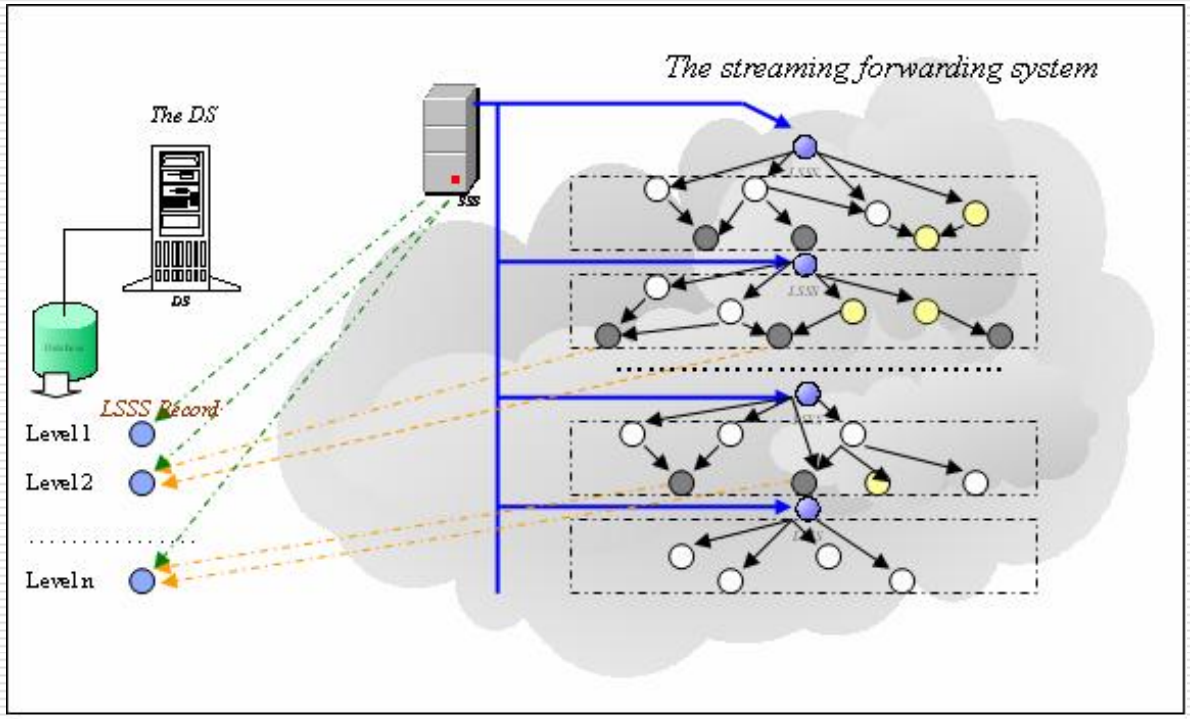
- Main Components
  - An *SSS* (the Source Streaming Server)
    - Storing the whole streaming frames
    - The playback rate is defined as ***R*** frames/second
  - A *DS* (the Directory Server)
    - Maintaining the rough information of the system
    - Introducing a virtual level conception
      - Boundary: Level start time ~ Level start time + cache length

System Model

- Main Components
  - *Peers*
    - Outgoing bandwidth, cache size
  - *LSSS* (Logical Source Streaming Servers)
    - Stored in the database of the DS
    - Virtually existing in the HMVOD
    - Playing the role of the source server of each virtual level

System Model

- Architecture

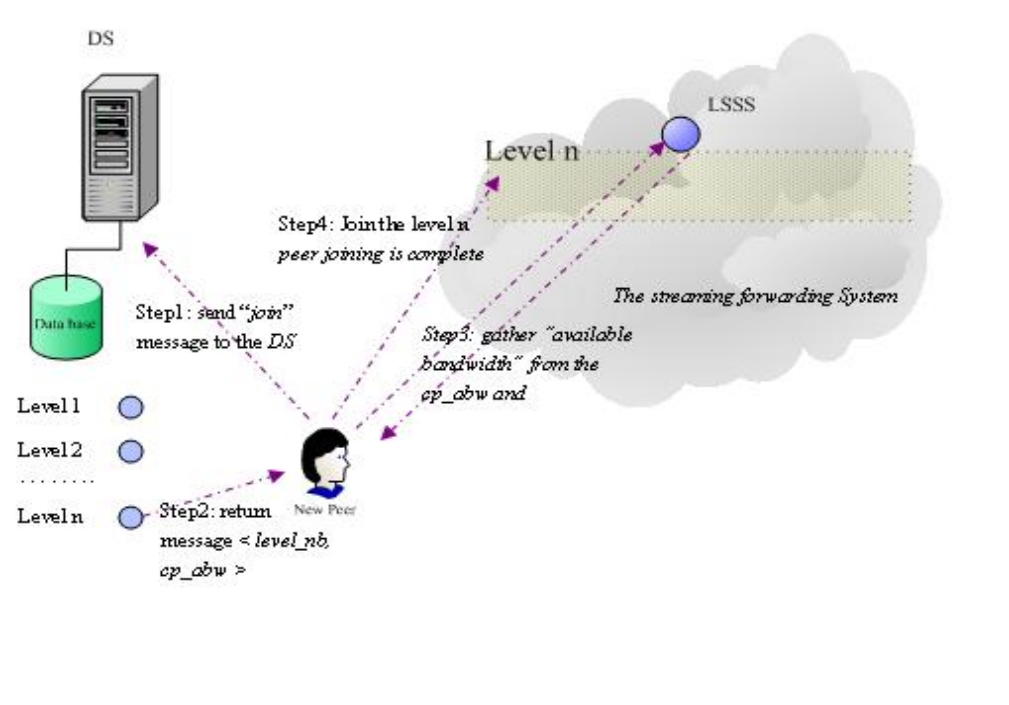


System Model

- Operations
  - Peer Joining
  - Peer Departure
  - Peer Joining with VCR-like Functions
    - Peers start and end playing the video at specific time points
    - Replay function

System Model

- Peer Joining
  - A peer is joining a level



System Model

- Peer Joining
  - An example of a peer's gathering bandwidth.
    - Suppose <peer number, outgoing bandwidth> as follows:

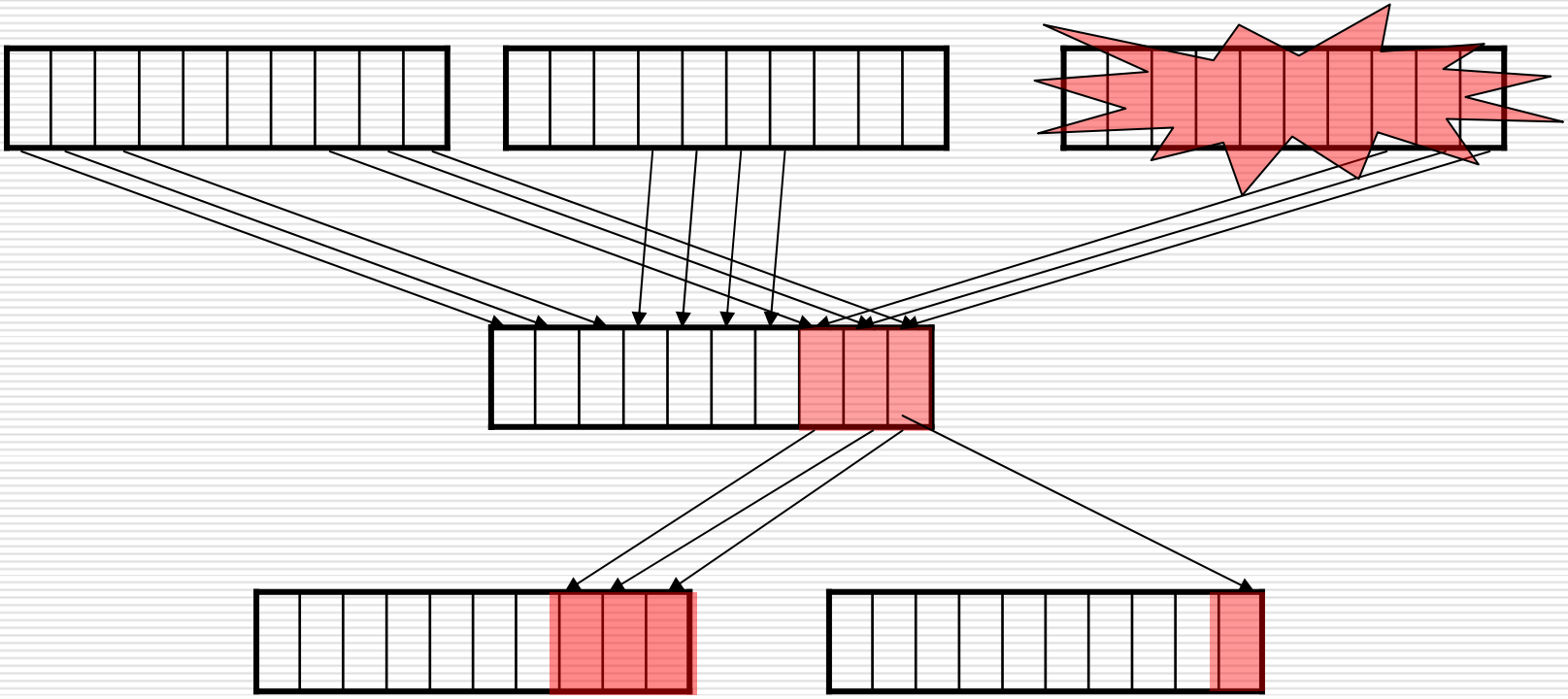
      < Peer1, 0.4R> 、< Peer2, 0.6R> 、< Peer3, 0.9R> 、
      < Peer4, 1.2R> 、< Peer5, 1.7R>
    - At first, get the "minimum rate" which these peers could provide. In this case, the minimum rate is 0.4R of Peer1. And then request to each peer for 0.4R bandwidth until that the sum of bandwidth is 1.0R. So, we get 0.4R from Peer1, Peer2, and 0.2R from Peer3.

System Model

- Peer Departure
  - Recovery the lost bandwidth
    - Actively Leaving
      - The leaving peer actively sends a *release* message to its upper peers and the DS to let off bandwidth.
      - It tells its children to get new bandwidth source.
    - Breaking Down for Unknown Reasons
      - The children directly asks for bandwidth from the DS.

System Model

- Peer Departure



System Model

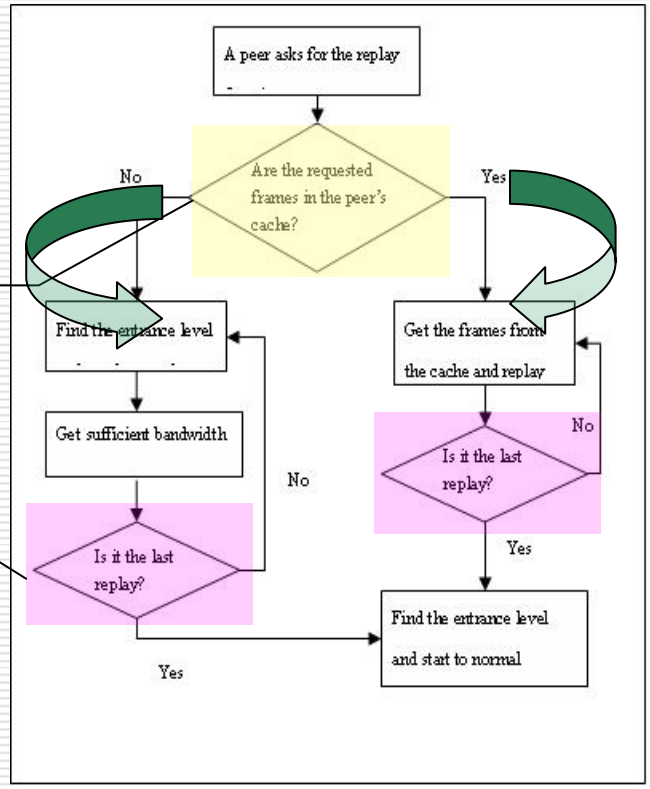
- The VCR-like Functions
  - A peer start and end playing the video at specific time points
    - The DS would arrange the peer into proper level according to the level boundary.
    - The peer gather bandwidth from the LSSS of that level.

System Model

- The VCR-like Functions
  - Replay Function

Are the requested frames in the peer's cache?

Is it the last replay?



Simulation

- Performance Indicator
  - The server suffers loads:
    - Multiple of the playback rate, called *mpr*
    - The mpr intends that the outgoing bandwidth from the server divides by the playback rate of the video.
    - In client-server model, the mpr equals to the number of the clients.

Simulation

- The Outgoing bandwidth Distribution in 2006's Taiwan

Outgoing bandwidth	Percentage
64kb/s	58%
128kb/s	21%
256kb/s	8%
384kb/s	7%
> 512kb/s	6%

Simulation

- The Server Load in 128, 256kb/s Playback Rate
  - In the Normal Playback Mode

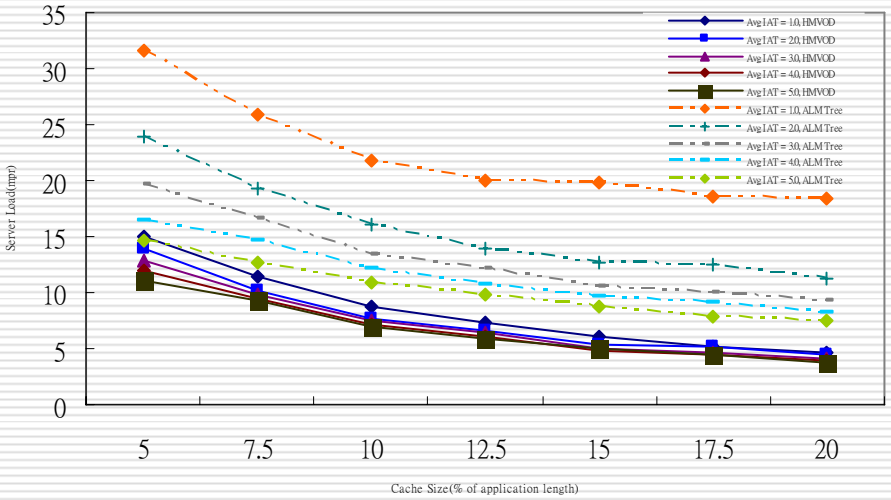


Fig. 4: Server Load in 128kb/s playback rate

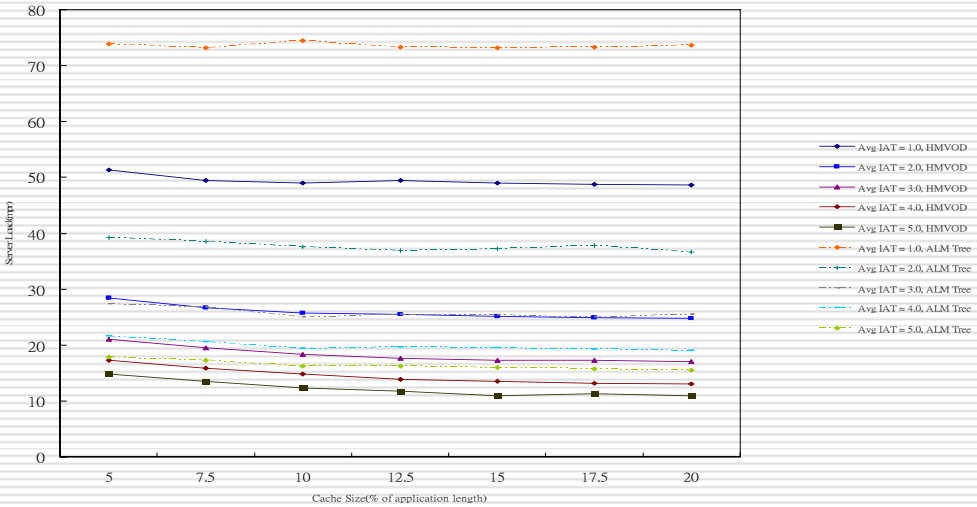


Fig.5: Server Load in 256kb/s playback rate

Simulation

- The Server Load in 128, 256kb/s Playback Rate
  - In the VCR-like Playback Mode

Fig. 6: Server Load in VCR function, 128kbps streaming

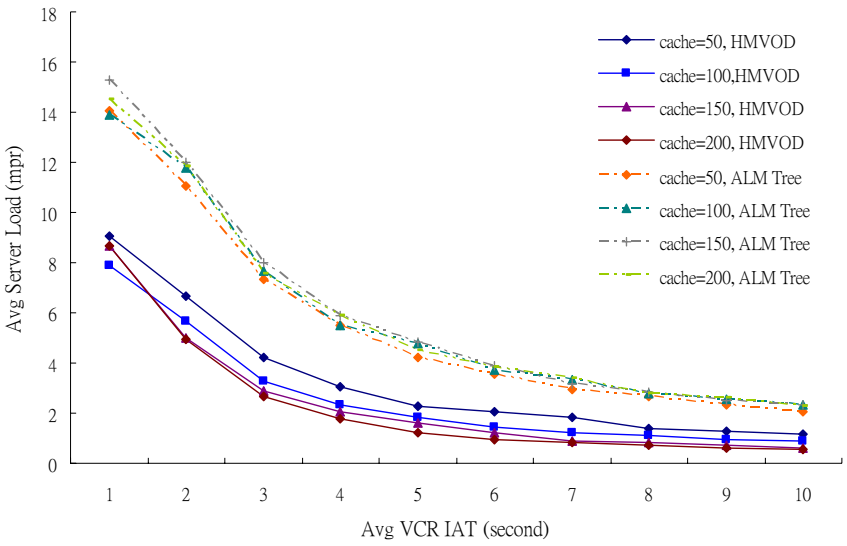
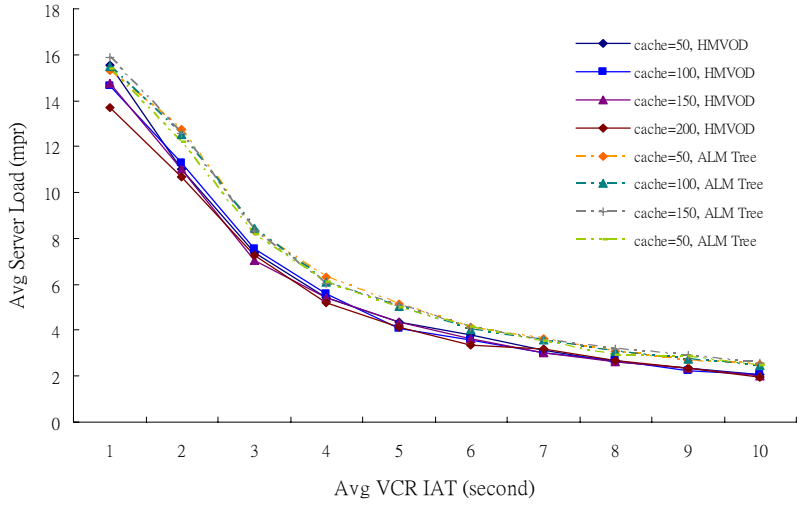


Fig. 7: Server Load in VCR function, 256kbps streaming



Simulation

- Results
  - When the cache size increases, the server load would degrade if the bandwidth resource is enough.
  - HMVOD has more capacity to suffer the flash crowds than the ALM tree both in the normal and the VCR-like playback mode.
  - In the VCR-like playback mode, the performance in HMVOD would be close to the ALM tree if the bandwidth resource exhausted.

Conclusions

- By adopting the mesh topology, HMVOD makes the bandwidth resource employ more efficiency.
- The hierarchical architecture let bandwidth resource easy to manage as well as provide the VCR-like functions.
- In our simulation, HMVOD has more outstanding performance to lighten the server load than the ALM tree system.