**Video Streaming Service**

- Considerable amount of video traffic
  - Causes network congestion
  - Longer transfer delay and higher packet loss probability
- Proxy cache server

- Heterogeneity in clients
  - Available bandwidth: ADSL, FTTH, Dial-up
  - End-system performance: PC, PDA, Pocket PC
- Video quality adjustment

**Proxy Caching Mechanisms Considering on Video Characteristics**

- Divide video data into blocks
  - Efficient use of a cache buffer and bandwidth
- Block Provisioning Mechanism
  - Provide blocks to clients considering network and cache condition for continuous and high-quality video distribution
- Block Prefetching Mechanism
  - Prefetch blocks of the appropriate quality to avoid future cache misses
- Cache Replacement Mechanism
  - Replace cached blocks with a newly retrieved block for efficient use of a cache buffer

**Basic Behavior**

- Provide block with caching
  1. Read out block
  2. Quality adjustment, transfer
- Provide block by retrieving
  1. Locate an appropriate server
  2. Retrieve a block, cache
  3. Quality adjustment, transfer

- Establishing sessions
  - Provide block by retrieving

**Block Provisioning Mechanism**

- A proxy adopts the fastest way that can provide the client with a block of higher level of quality
  1. Read out and send a cached block, or
  2. Use a block being received, or
  3. Wait for the preceding request for the same block to be served, or
  4. Newly retrieve a block from the other server

**Block Prefetching Mechanism**

- A proxy retrieves the block preparing for the future cache miss
  - Caching condition
    - Range of examination for prefetching (Prefetching window P)
    - Being sent to client
    - Prefetch
    - Cached block
    - Lower quality block or uncached block
  - Block Number
Cache Replacement Mechanism
- Cached blocks are replaced with a new block
  - Candidates are chosen considering their importance
    - Blocks reside at the head are important
    - Blocks being sent to clients and their followings are important
    - Marked blocks are important since they will be needed soon
  - A candidate is first reduced its quality (if possible) and then removed from the cache

Sharing Information among Proxies
- A proxy has two tables
  - Cache Table
    - To maintain information of locally cached blocks
    - Consists of block number, bit rate (quality), marker
  - Remote Table
    - To maintain information of blocks cached at the other servers
    - Consists of estimated one-way delay, throughput, quality of offerable blocks
- RTSP messages are exchanged to update tables
  - QUERY: inquires quality of cached blocks at the other server
    Range of blocks to inquire is limited by inquiry window
  - REPLY: answers quality of cached blocks
    Those blocks in inquiry window are marked not to be replaced

Video Quality Adjustment Mechanism
- Frame dropping filter
  - Buffer a series of frames of one second
  - The interdependency of video frame (I, P, B frame) is considered
  - Frames are prioritized for well-balanced discarding
    E.g. 15 fps numbers indicate the order of discarding

Configuration of Experimental System
- Video stream detail
  - 1 Mbps, 30 fps
  - 50 blocks (1 block = 300 VOP)
  - After 260 seconds, the link capacity is changed to 700 kbps
- Setting of proxy
  - Inquiry window: 5
  - Prefetching window: 0
  - Cache buffer: 50 Mbytes

Outline of Implemented System
- Video Server
  - Darwin Streaming Server
  - RealOne Player
  - QuickTime Player
- Proxy
  - Cooperation Process
  - Frame drop
  - Video quality adjustment
  - TFRC
  - Bandwidth estimation
  - RTCP/UDP
  - RTP/UDP
  - RTSP/TCP

Reception Rate Variation at Proxy 2
- Time [sec]
  - 0
  - 500
  - 1000
  - 1500
  - 2000
  - 2500
  - Reception rate [kbps]
    - 0
    - 200
    - 300
    - 400
  - Link capacity is changed
  - To accomplish a continuous video-playout, proxy 2 retrieves the block applied video quality adjustment by proxy 1
Conclusion and Future Work

- **Conclusion**
  - Our implemented system can provide users with a continuous and high quality video streaming service

- **Future work**
  - Additional experiments
  - Considering user interactions such as pauses, fast-forwarding, and rewinding