Proxy Caching Mechanisms with Video Quality Adjustment

Masahiro Sasabe
Graduate School of Engineering Science
Osaka University
E-mail : m-sasabe@ics.es.osaka-u.ac.jp

Background

- Growth of computing power
- Proliferation of the Internet
- Distributed multimedia applications

Increasing of video streaming services over the Internet

High-quality and low-delay video streaming service is required

Technique for low-delay data delivery

- Proxy mechanisms
  - Widely used in WWW systems
  - Reduce network load

Applying to the video transfer

Problems

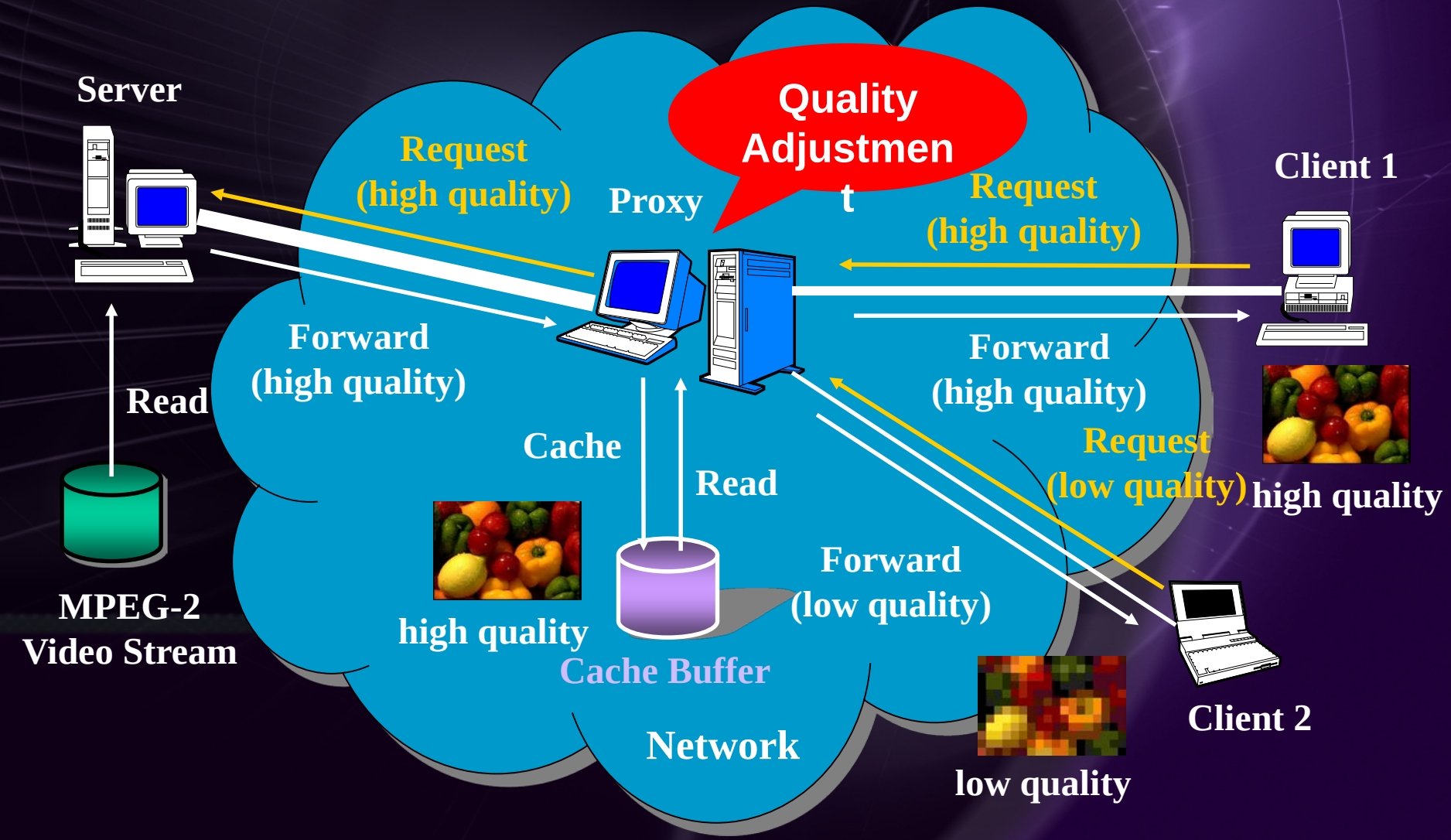
- A current proxy system only handles files whereas a single video stream is very large
- Client requests on the video quality considerably differ due to heterogeneity in the available bandwidth

- Segmentation of video data
- Video quality adjustment in the proxy

Research Targets

- Proposal of proxy caching mechanisms with video quality adjustment
  - Low-delay video streaming service while meeting user's demand
    - Data retrieval with consideration on client's request
    - Prefetching data that clients are going to require in the future
  - Reduce required cache buffer size
    - Segmentation of video data for retrieval, caching and forwarding
    - Replacement of cached data with consideration of size, quality and re-usability of data

Video streaming system using proxy cache with video quality adjustment

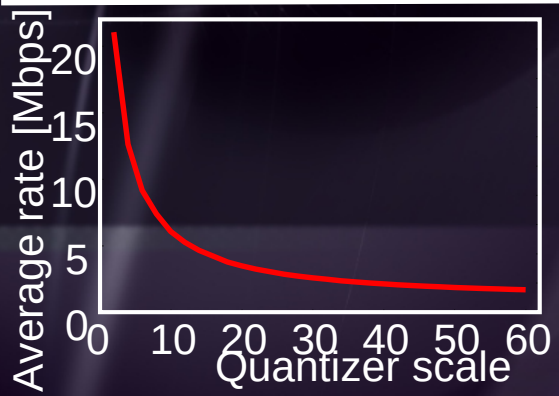


Assumptions on our proposed mechanisms

- MPEG-2 video
- Unit of data for retrieval, caching and forwarding
  - GoP (Group of Pictures)
- A client periodically requests the proxy to send a GoP with user's demand
- Rate control for sending video data
  - TFRC (TCP Friendly Rate Control)
- Available Bandwidth → Video quality

  ||| TFRC rate

  ||| Reciprocal of a quantizer scale



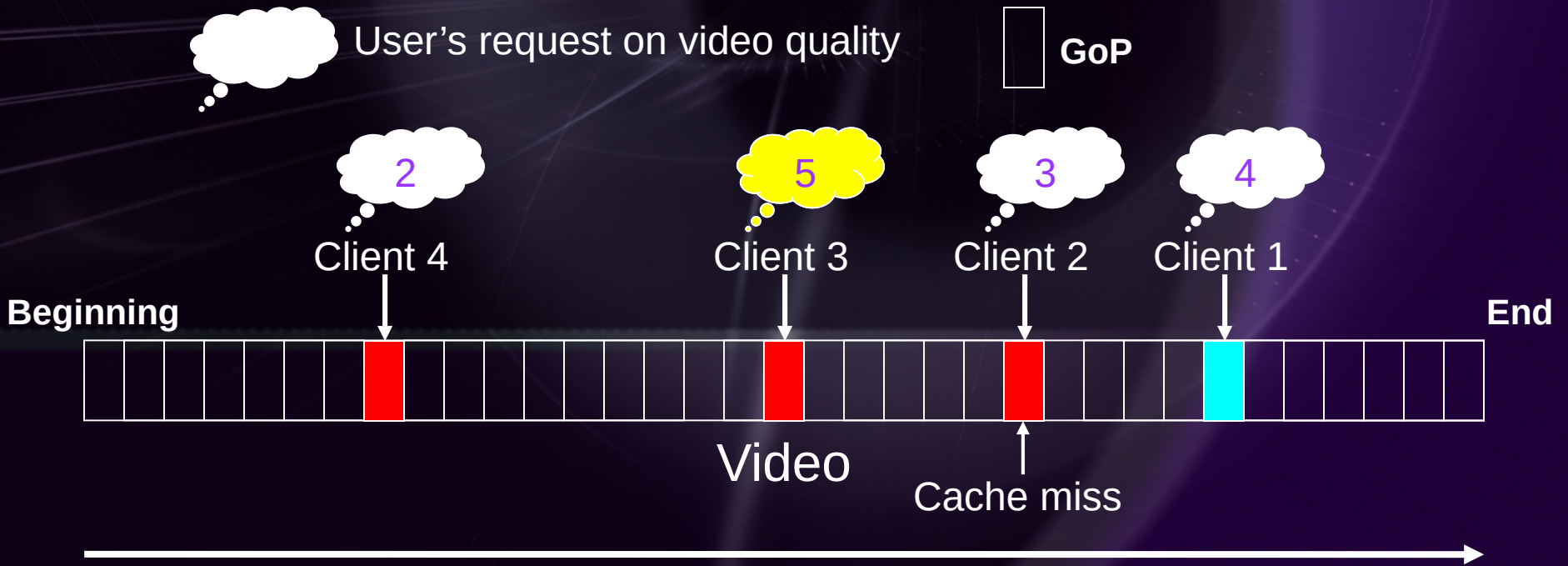
- Quality adjustment is performed by re-quantization filter

Data retrieval

- Cache hit
  - The proxy adjusts cached GoP to the request and transmits it to the client
- Cache miss
  - Server-Proxy bandwidth is sufficient
    - Data retrieval with consideration on current and future demands
  - Server-Proxy bandwidth is insufficient
    - Data retrieval with consideration on trade-off between quality and delay

Data retrieval
- Sufficient bandwidth -

- Considering clients that are going to require the GoP in the future, the proxy retrieves the GoP of maximum quality among their demands



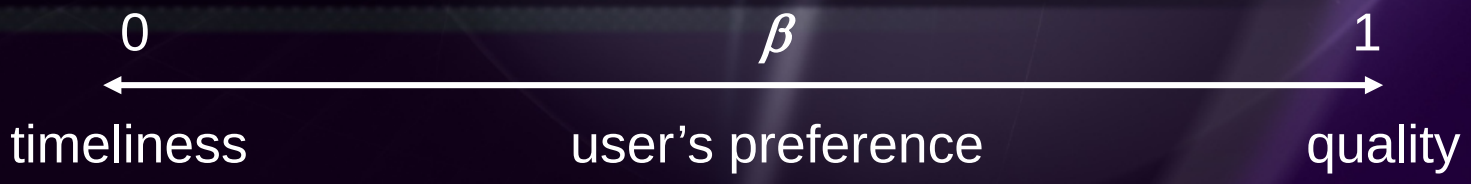
Data retrieval
- Insufficient bandwidth -

- Trade-off between quality and delay

Which does the user give priority to, quality or timeliness?

Introducing a parameter β

β is defined as the ratio of the acceptable quality to the demand



Data retrieval
- Insufficient bandwidth -

- Control based on β

$$\frac{\text{Quality of cached GoP}}{\text{Quality of the client's request}} \geq \beta$$

Yes ➡ The proxy sends the cached GoP

No ⬇

$$\frac{\text{Quality of the GoP which the proxy can retrieve from the server}}{\text{Quality of the client's request}} \geq \beta$$

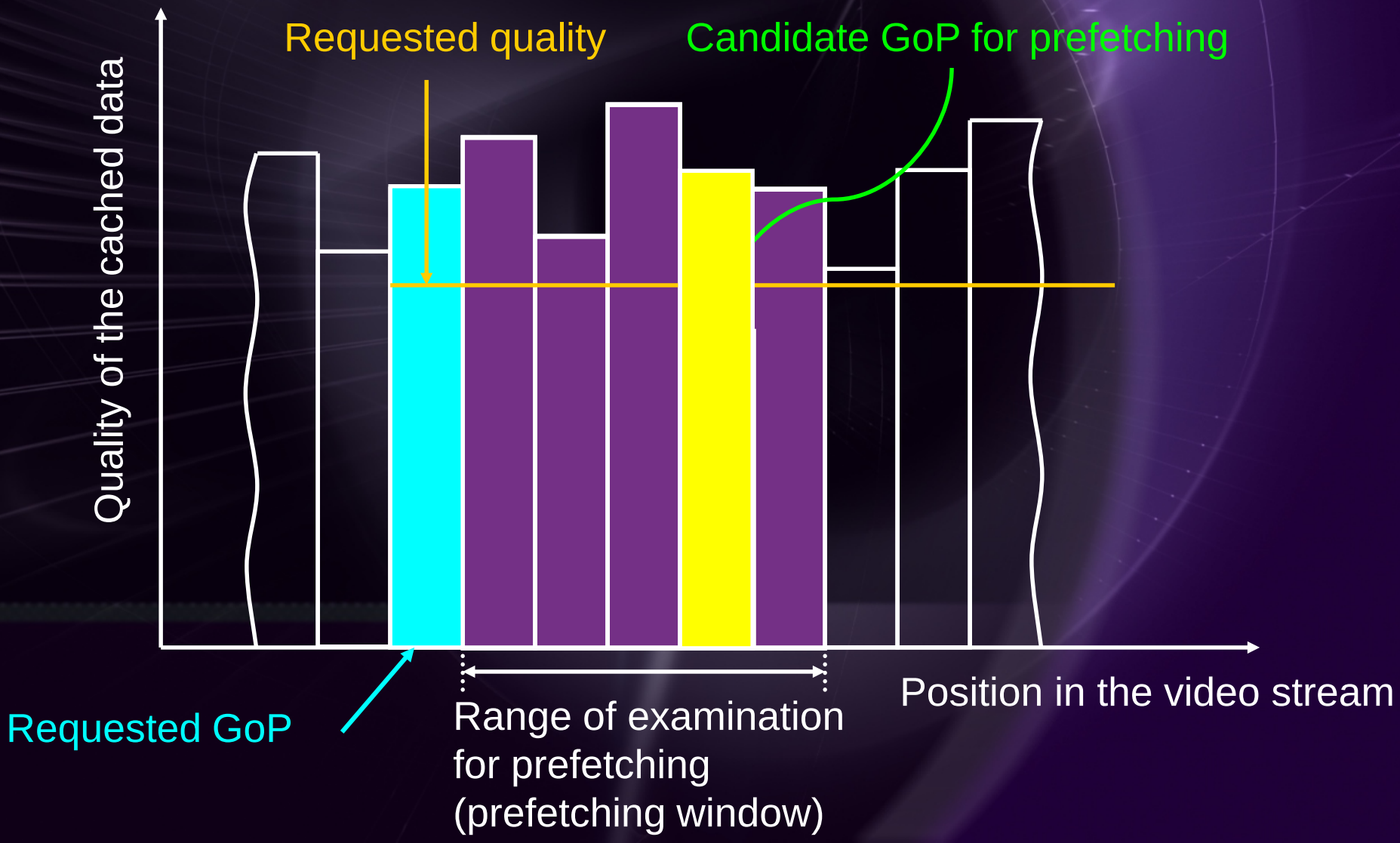
Yes ➡ The proxy retrieves the GoP from the server

No ⬇

$$\frac{\text{Quality of the GoP which the proxy can provide}}{\text{Quality of the client's request}} < \beta$$

➡ The proxy retrieves the GoP of the acceptable quality from the server

Prefetching mechanism



Replacement Algorithm

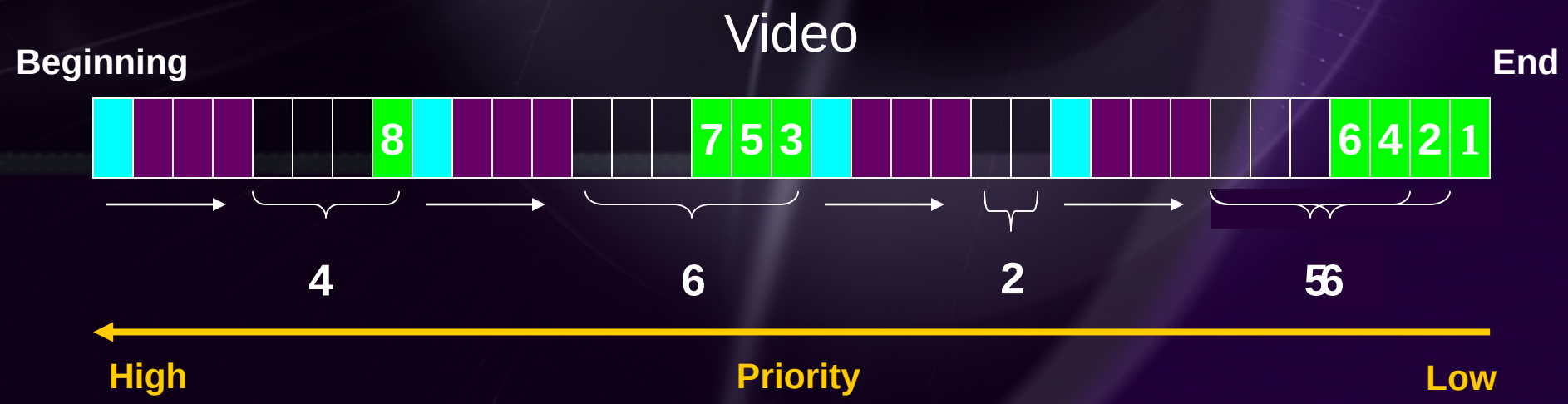
1. Choose a candidate GoP for replacement
2. Try the quality adjustment to decrease the size of the candidate
3. Eject the candidate from the cache

Requested GoP by a client

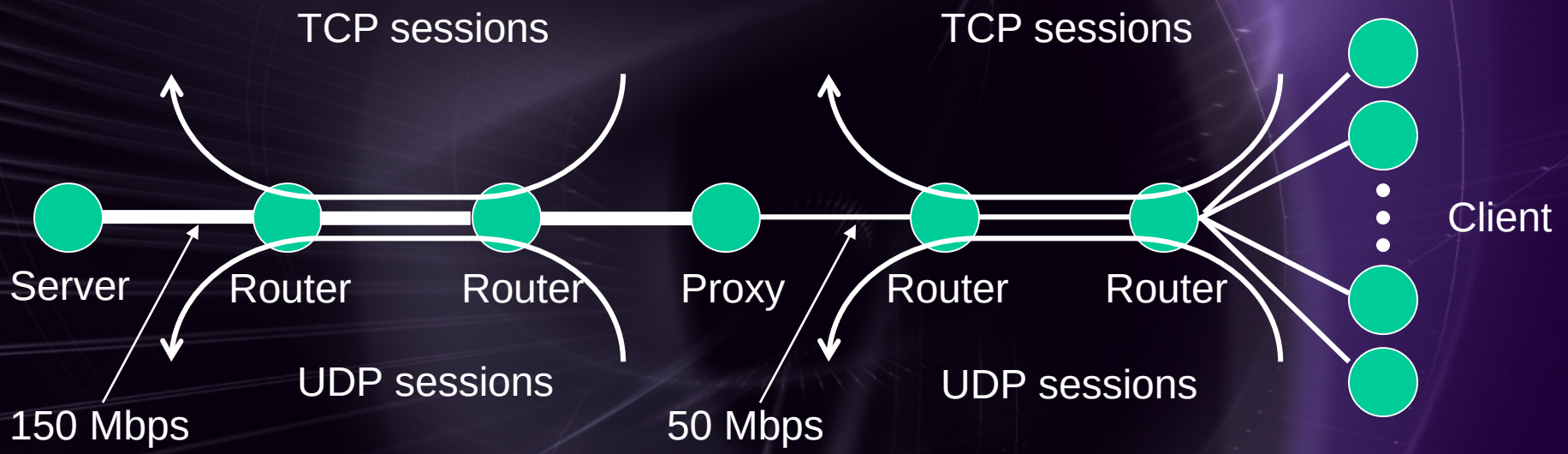
GoP in the prefetching window

No priority

Candidate GoP for replacement



Simulation model

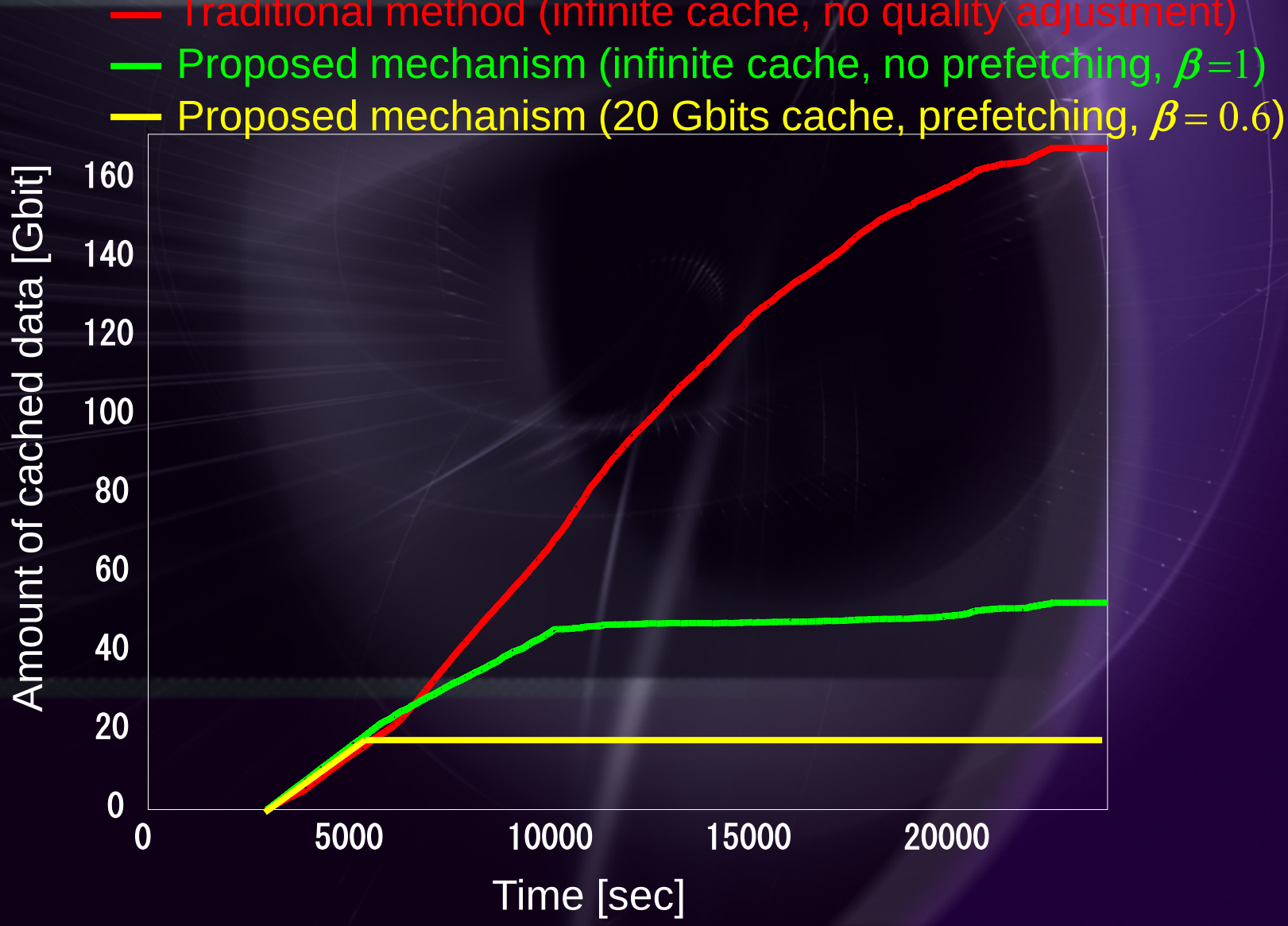


- Video stream is two hours long
- 10 clients watch the same video stream from the beginning to the end without interactions
- The inter-arrival time between two successive client participations follows the exponential distribution whose average is 1,800 seconds

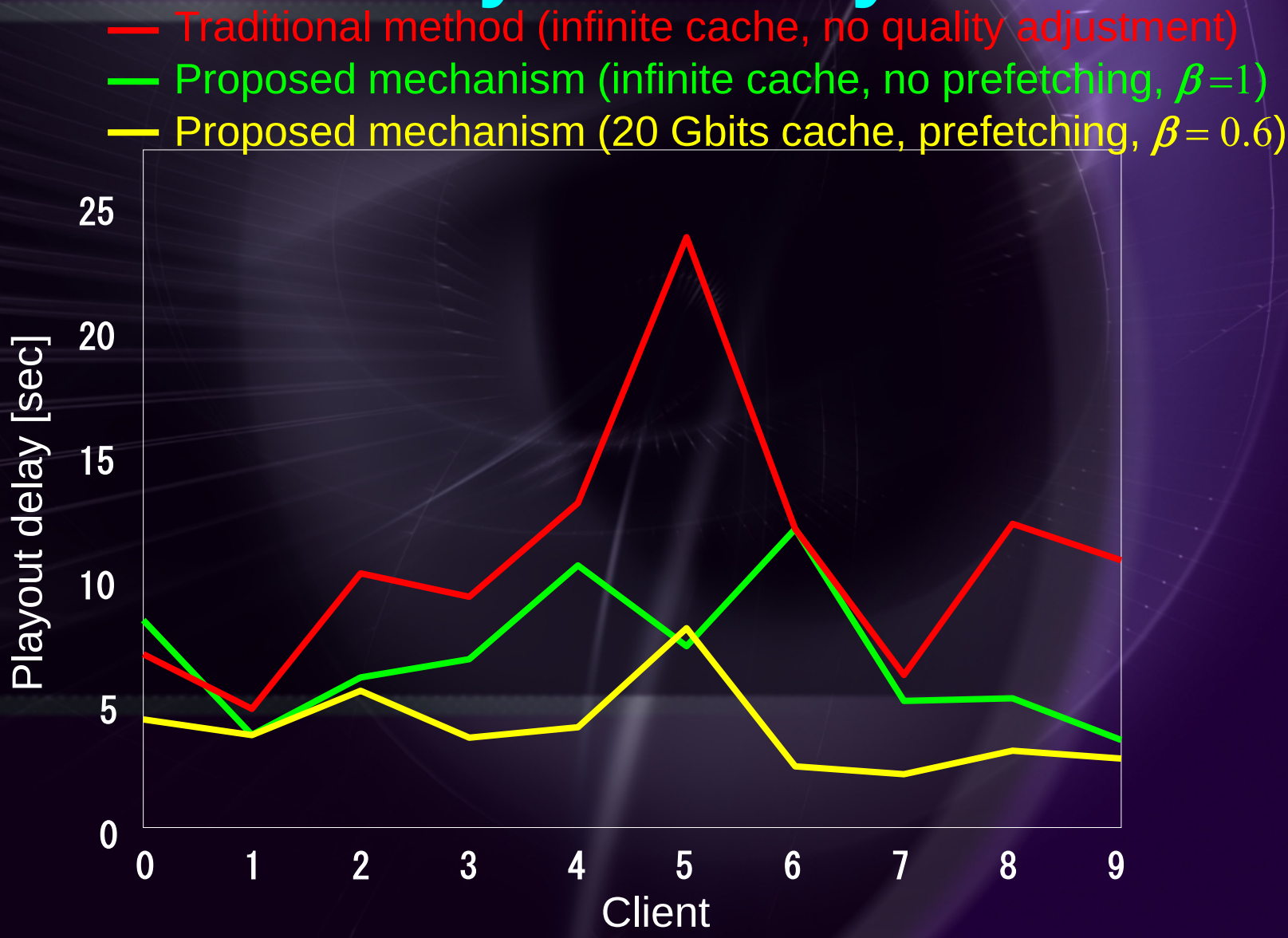
Evaluation criteria

- Required cache buffer size
  - Amount of cached data
- Playout delay
  - Maximum jitter
- Degree of satisfaction on delivered video
  - The average ratio of the delivered video quality to the demand

Simulation result
- Amount of cached data -

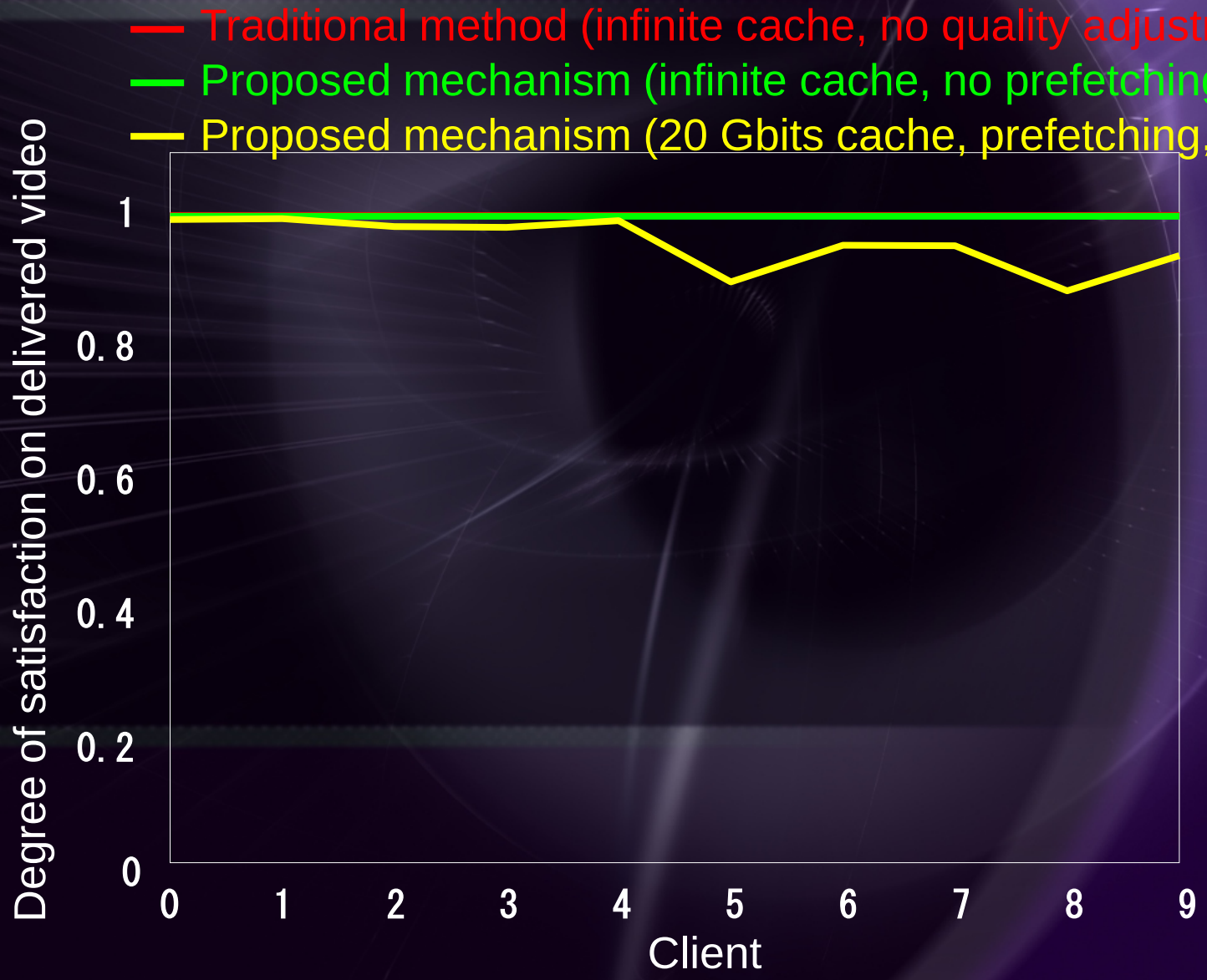


Simulation result
- Playout delay -



Simulation result

- Degree of satisfaction on delivered video -



Conclusion

- Conclusions
  - We proposed proxy caching mechanisms with video quality adjustment
  - Simulation results show that our system can accomplish a low-delay video streaming service while meeting user's demand and available bandwidth
- Future works
  - Reducing playout delay
  - Considering interactions such as rewinding, pausing and fast-forwarding