Hop-by-hop Adaptive Video Streaming in Content Centric Network

Zhengyang Liu, Yiran Wei

Beijing University of Posts and Telecommunications, China

Background

- Background:
  - Content-Centric Networking (CCN)

    Future network proposals

    Focuses on content retrieval with content-based addressing

    Universal caching design
  - Adaptive video streaming (DASH)

    Dynamically adjust the bitrates for video services
  - Scalable video coding (SVC)

    Encode video into base and enhancement layer content

    Support progressive transmission

Aim

- Problems for DASH over CCN:
  - Bitrate oscillations
  - Network congestions

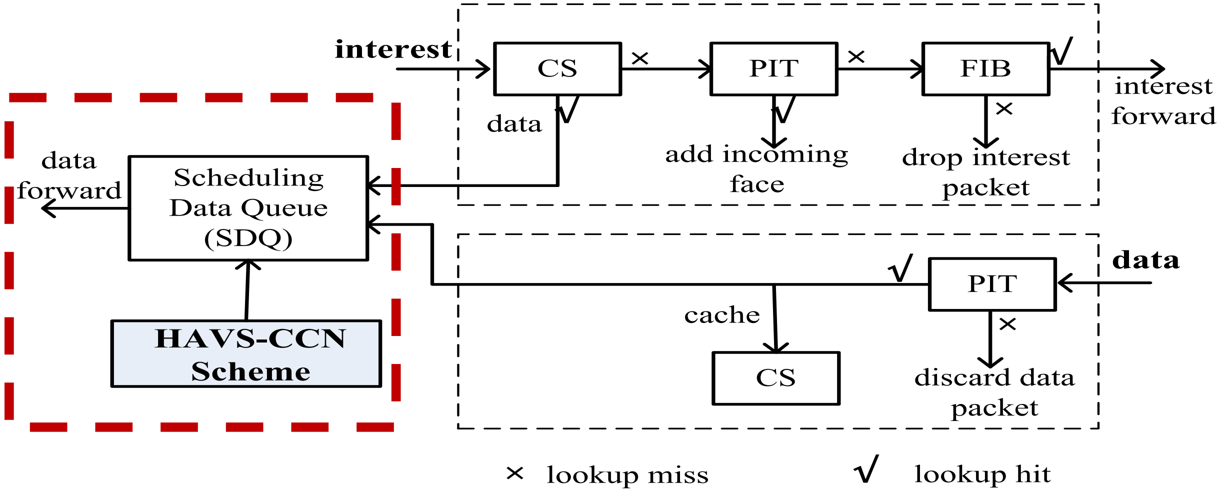
We propose a hop-by-hop adaptive video streaming scheme (HAVS-CCN)

- Solved by:
  - Adjust the video quality hop-by-hop
  - A flow control for data packets, directly

SYSTEM MODEL

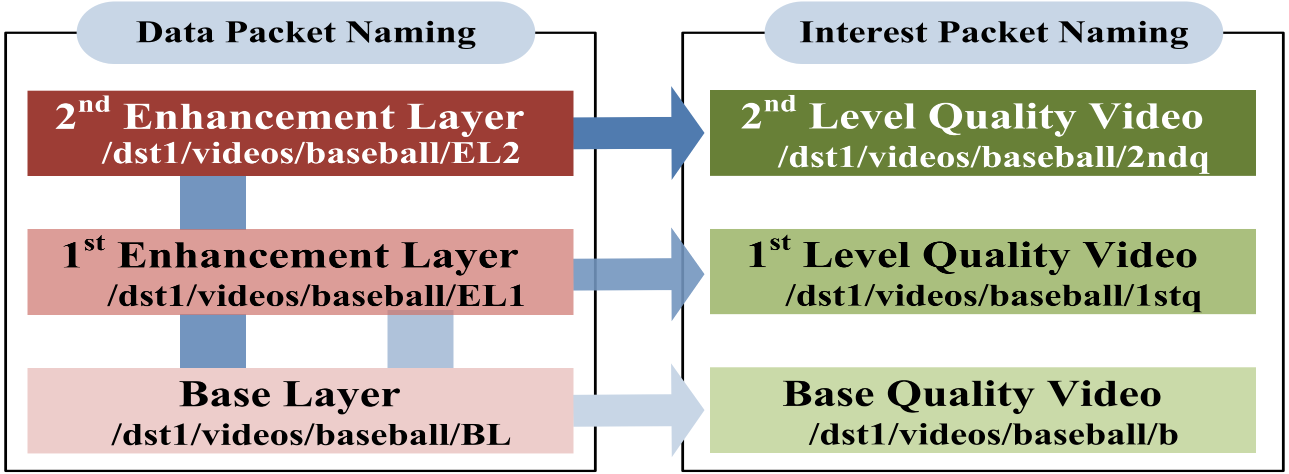
System model

- Improved CCN router design
  - Scheduling Data Queue (SDQ)
  - Schedule the outbound data flow for each interface



System model

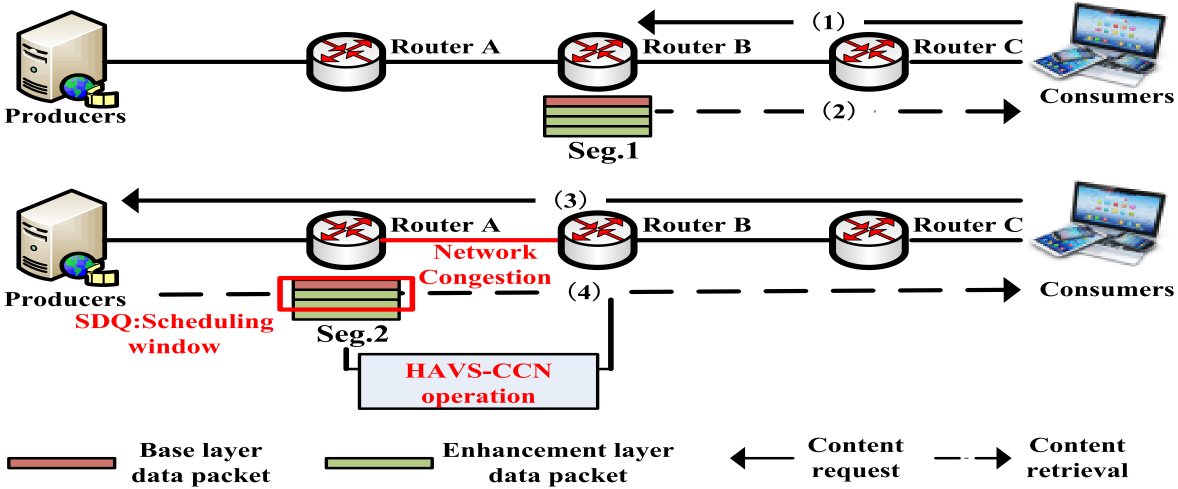
- Scalable Video Segmentation and Naming



CCN nodes can directly drop the some enhancement layer packets to guarantee smooth playback.

Building HAVS-CCN

HAVS-CCN overview



1. Set a scheduling window

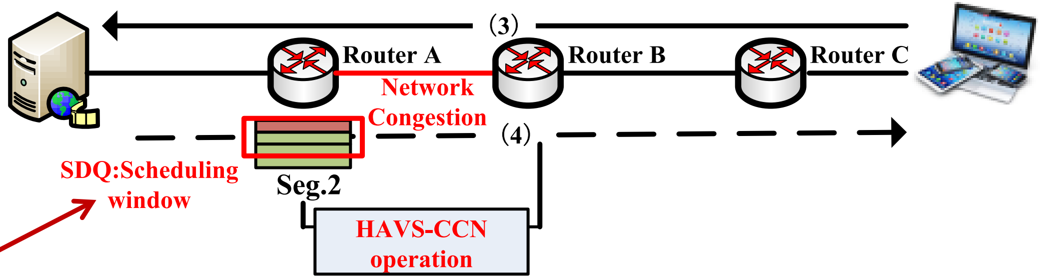
2. Compute priority for SVC data packet

3. Hop-by-hop operation

Description of scheme (1)

- Set a scheduling window to limit the video transmission rate
  - Scheduling Data Queue (SDQ)
  - Schedule the outbound data flow for each interface

$$wnd_{scheduling}(k) = delay \cdot \alpha \cdot BW_{out}(k)$$



Scheduling window to make flow control

Description of scheme (2)

- Priority of each SVC content data packet

Type-based priority

$$w_t(p_{i,seg,type}) = \frac{1}{\eta_{type}}$$

$$\eta_{type} = \begin{cases} 1, & type = base\ layer \\ i+1, & type = i^{th}\ enhancement\ layer \end{cases}$$

Popularity-based priority

$$w_p(p_{i,seg,type}, k) = \frac{\eta_{i,k}}{SDQ_k}$$

- A data packet with higher type-based priority and higher popularity-based priority will have preference to be transmitted

Overall priority: $w(p_{i,seg,type}, k) = w_t(p_{i,seg,type}) \cdot w_p(p_{i,seg,type}, k)$

Description of scheme (3)

- The aim of the HAVS-CCN is to transmit high priority data packets first when the link capacity is limited

Objective:

$$maximize f = \sum_{i,seg,type} c_{i,seg,type} \cdot e^{w(p_{i,seg,type},k)}$$

Subject to:

$$\begin{aligned} \sum c_{i,seg,type} \cdot p_{size}(type) &= wnd_{scheduling}(k) \\ c_{i,seg,type} &\in \{0,1\} \\ c_{i,seg,type} &\neq 0, type = base \end{aligned}$$

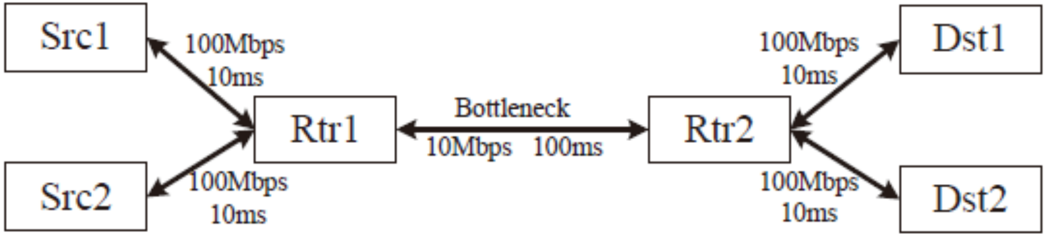
Algorithm 1 HAVS-CCN Priority Transmission Algorithm

```
procedure OnWindowEmpty(interface)
    TxQueue ← SDQ[interface].
    if sizeof(TxQueue) > wnd_scheduling then
        c_{i,seg,type} ← Solver(p_{i,seg,type}, w_{i,seg,type,k})
        TxQueue ← {p_{i,seg,type} | c_{i,seg,type} ≠ 0}
    end if
    Send(TxQueue).
end procedure
```

Simulation

Small scale simulation

- 6-node topology
- Demonstrate the real-time response of HAVS-CCN when the available bandwidth changes.

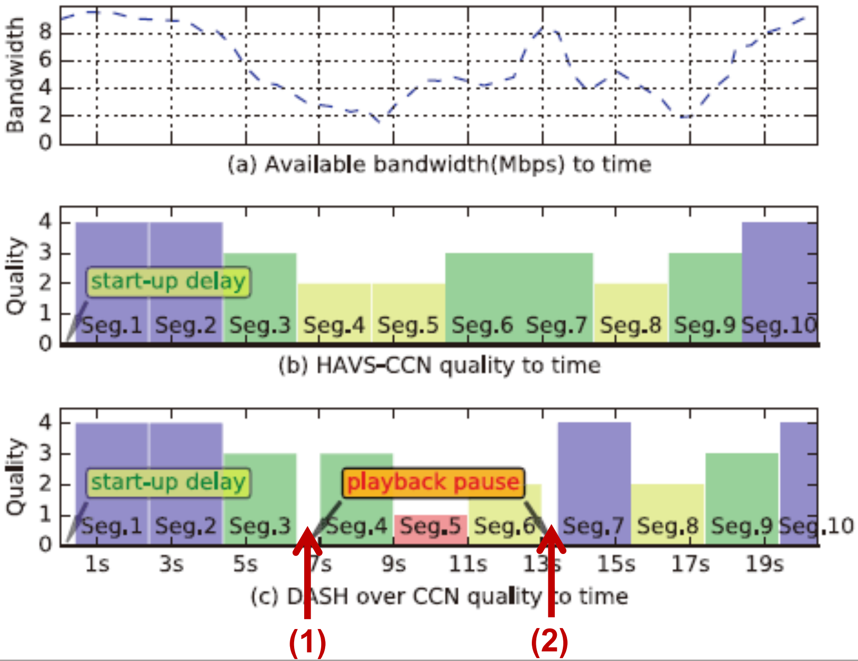


- Video source: SVC encoded video from University Klagenfurt [1]
- The demo video has 500 frames which are encoded into 11 segments. Each segments have a base layer and 3 enhancement layers.

[1] C. Kreuzberger et.al, "A scalable video coding dataset and toolchain for dynamic adaptive streaming over http," in MMSys 2015

Small scale simulation

- The aim of the HAVS-CCN is to transmit high priority data packets first when the link capacity is limited

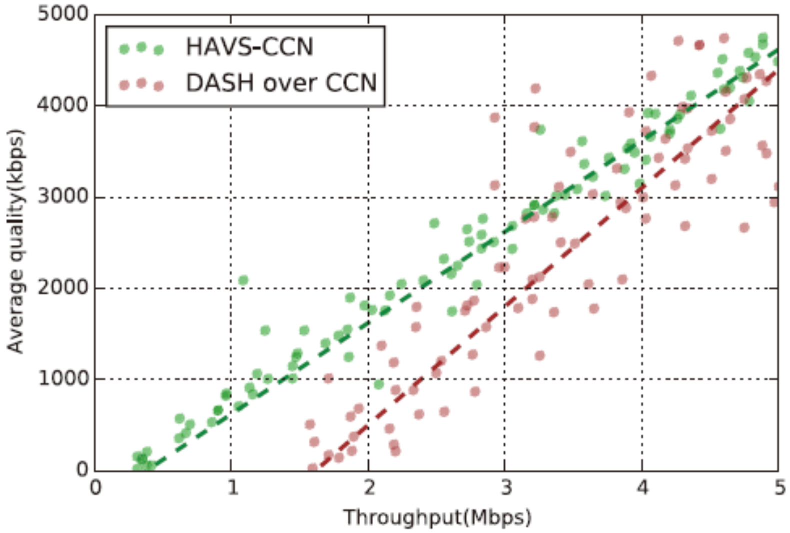


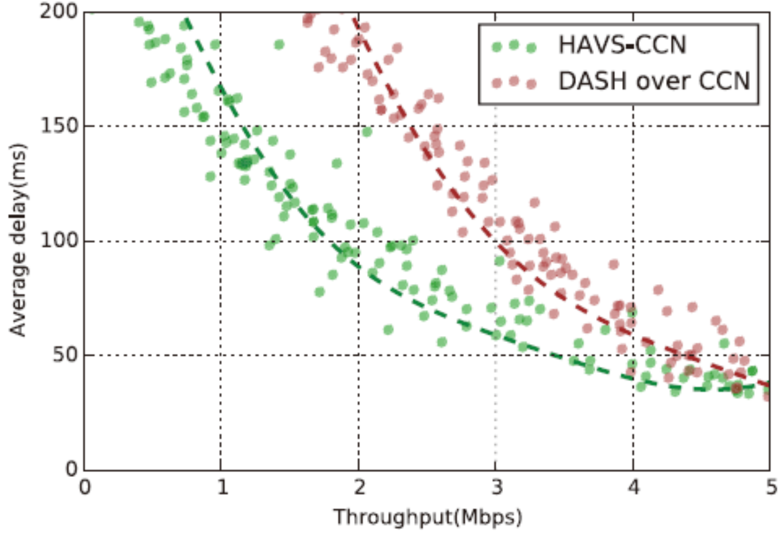
HAVS-CCN reduce playback pause:

1. when the link encounters a varying pressure from *Src2*
2. *when bandwidth overestimation, can directly drop some enhancement layer packets*

Large scale simulation

- Realistic topology: Rockfuel's AT&T topology [1], including 192 nodes classified into clients, gateways and backbones





Metrics: average quality and average delay

[1] N. Spring, R. Mahajan, and D. Wetherall, "Measuring isp topologies with rocketfuel," in *ACM SIGCOMM Computer Communication Review*

Conclusion

- We introduce a hop-by-hop solution which achieves:
  - reduce the negative effect of inaccurate bitrate predication
  - provide flow controls at router level
- Novelty:
  - An novel add-on, SDQ component, queues data packets for each interface.
  - The video quality can be adjusted directly along the data packet transmission path

Future work

- Mathematically analyze the priority weights setting for SVC packets

Questions, discussion…

- Thank you very much for your kind attention!

- Contact:
  - E-mail: zhengyang-liu@hotmail.com
  - yiranwei314@gmail.com