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Low Latency Low Loss Streaming using In-Network Coding and Caching

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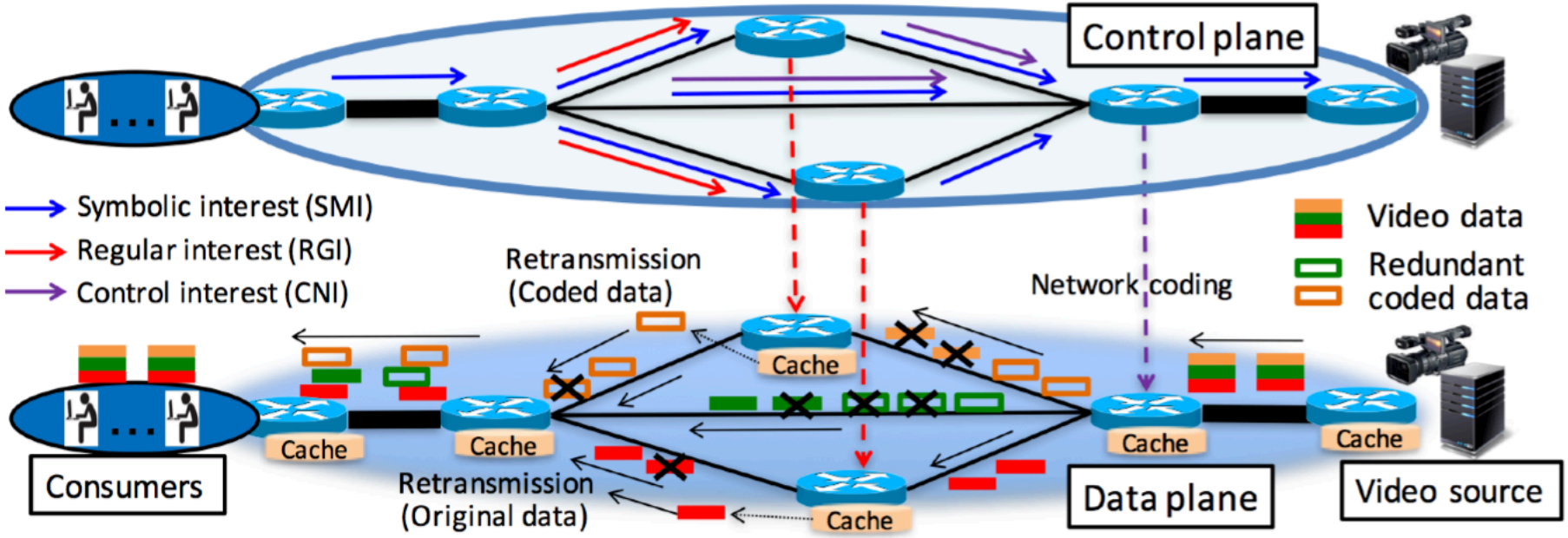
Motivation

- Target
  - UHD-level (4K/8K) delay-sensitive video streaming
- Requirements
  - Low latency (about 150ms) for interactive communication
    - ITU-T recommendation G.114
  - Low packet loss to maintain high QoE
  - Efficient packet delivery to support a large number of receivers
- Proposal
  - L4C2 (Low Latency Low Loss streaming using In-network Coding and Caching)

L4C2: Basic Idea

- Leveraging CCN/NDN features
  - Name-based data requests/forwarding, including multicast and multipath
- Enabling adaptive hop-by-hop data forwarding within an acceptable end-to-end delay
  - In-network coding (RLNC)/caching for efficient data recovery
  - Data recovery within an estimated acceptable link delay (not end-to-end delay)
  - Data recovery based on a measured data loss rate
- Newly defined Symbolic Interest (SMI) and Control Interest (CNI)
  - SMI: stream request including layer information
  - CNI: RTT measurement, notify redundancy level, switch to RGI

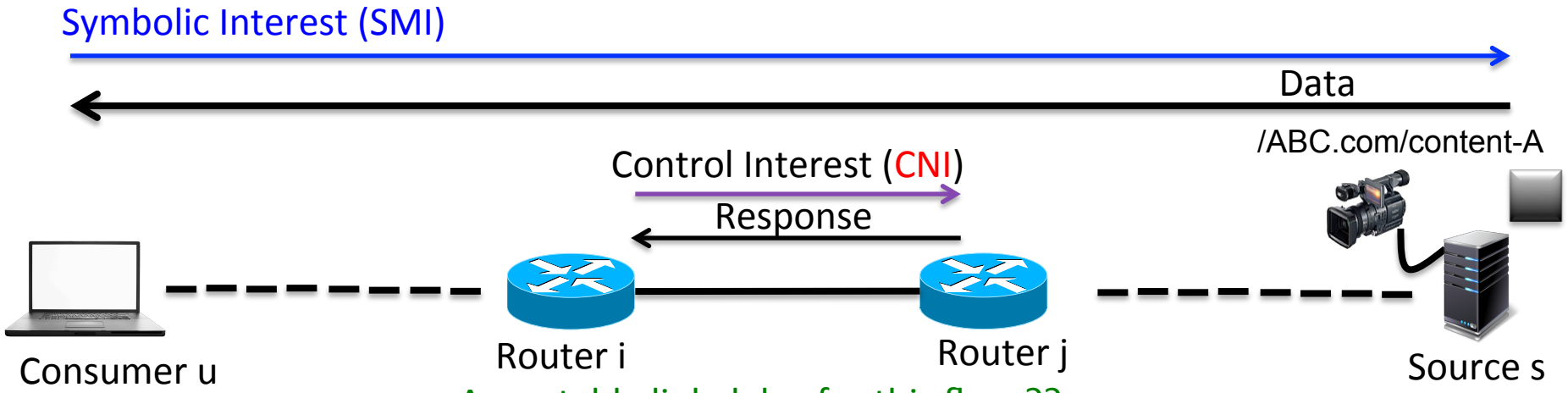
L4C2: System Architecture



- **Three types of interest messages**:
  - (1) **SMI**, (2) **RGI** (retransmission request), and (3) **CNI**.
- **Network Coding**:
  - Applied for each coding group which consists of the k different original/coded data packets
    - Encoding vectors are randomly selected from GF(2^8)
    - k is set to a constant value considering the waiting time to recover lost data

L4C2: Estimating Link Conditions

- Data loss rate
  - Calculated from Seq-num and NC-params (k) stated in Data header
- Acceptable link delay
  - Router knows the acceptable e2e delay (e.g. 150ms) when receiving Data.
  - Router *i* retrieves $D_{(s,j)}$ using CNI
  - Router *i* informed $D_{(u,i)}$ when receiving CNI

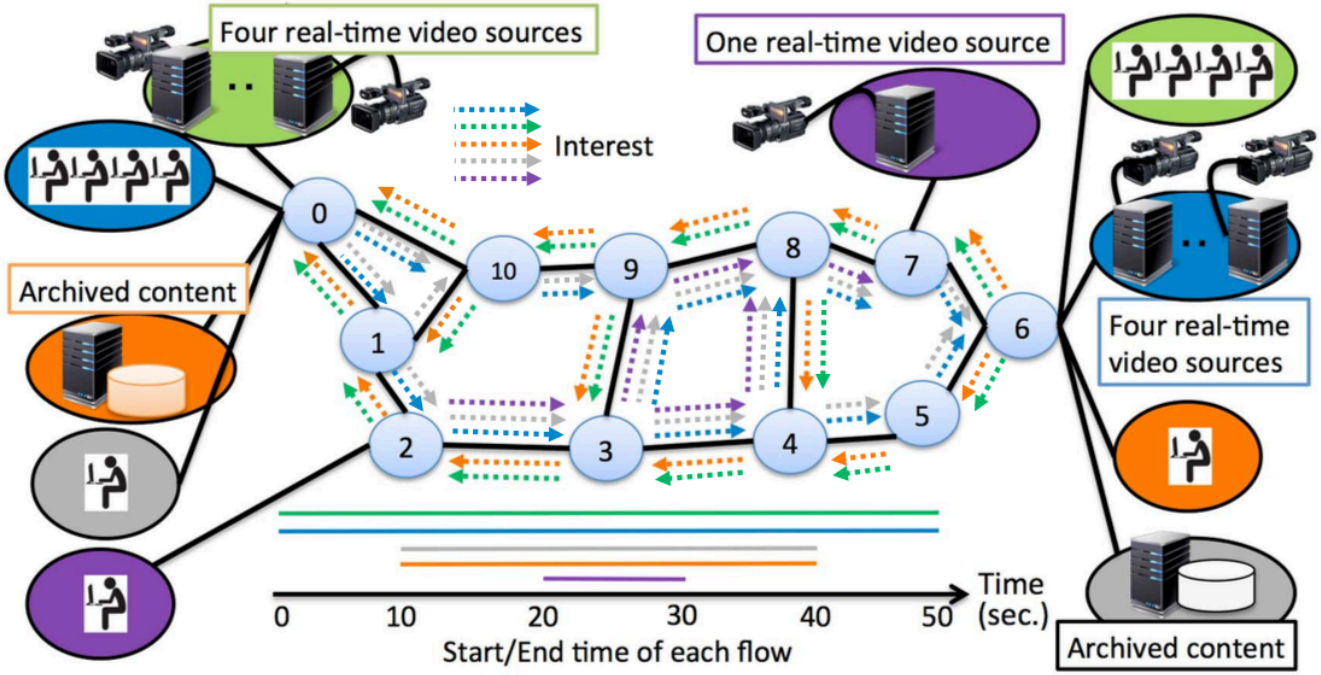


Acceptable link delay for this flow ??

$$D_{l(i,j)}^{MaxAlw} = D_f^{allow} - (D_{(u,i)}^{min} + D_{(s,j)}^{min})$$
$$D_{l(i,j)}^{MinAlw} = D_f^{allow} - (D_{(u,i)}^{max} + D_{(s,j)}^{max})$$

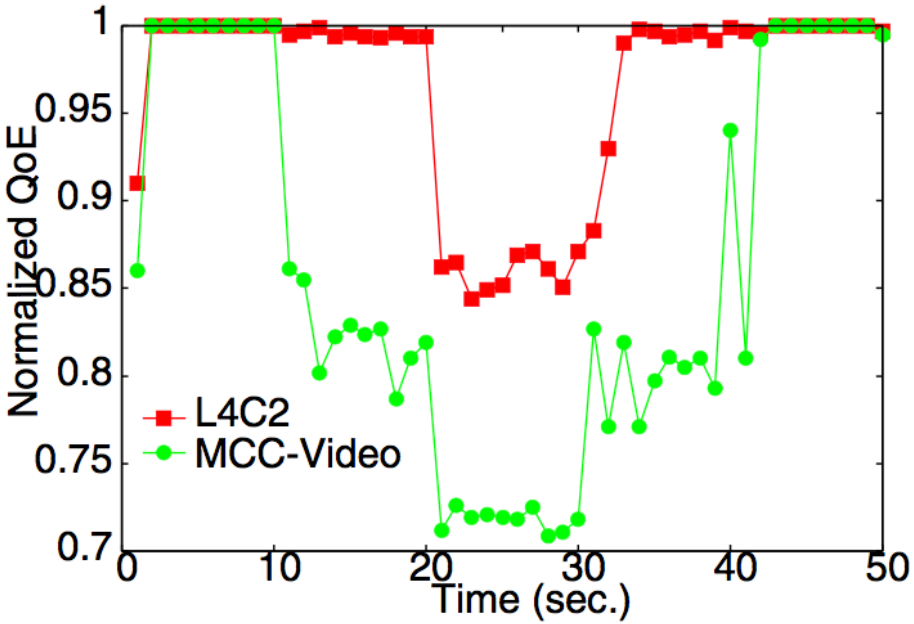
Simulation

- Parameters
  - Real-time video rate (total 35Mbps): 20/10/5 Mbps
  - Interest/Data packet size: 120/1024 bytes
  - Acceptable E2E delay: 150ms
- Scenario
  - Investigate user's QoE, using an existing QoE model
  - Comparison with state-of-the art for multipath data retrieval in CCN.

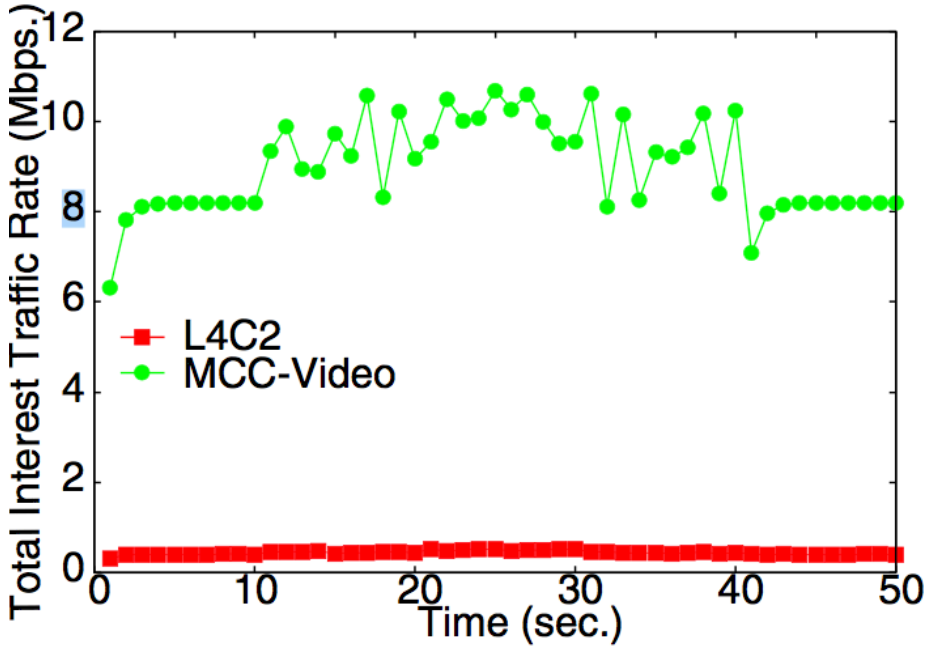


LinkBW/Queue/Delay:
100Mbps/100pkt/5ms

Results



(a) Normalized QoE of real-time video streaming flows



(b) Interest traffic rate at link (9,8)

[MCC-Video] G. Carofiglio, et al, "Optimal multipath congestion control and request forwarding in information-centric networks," Proc. IEEE ICNP 2013.

Potential Work in NWCRG

- (Describe common research challenges)
- Describe a baseline scenario for NC for ICN/CCN
- Discuss about in-network coding, including;
  - Clarify problem statement and introduce recent work
  - Compare with RLNC and other codes
  - Investigate block coding vs. sliding window coding approaches