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NetCodCCN: a Network Coding approach for Content-Centric Networks

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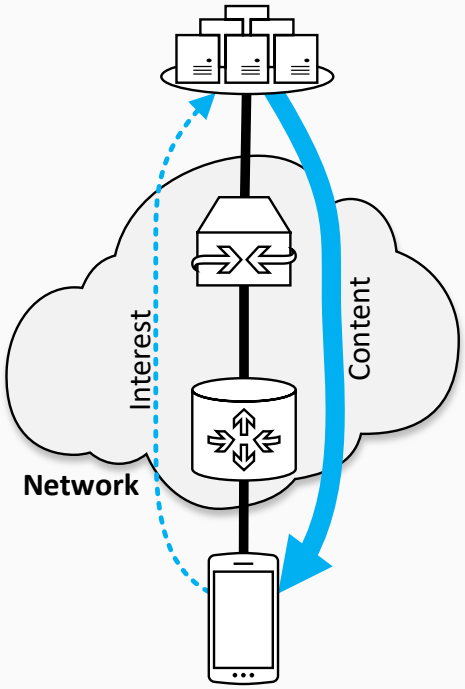
Introduction

CCN in a nutshell

1. Clients send Interest messages that contain the **name** of the content
2. Interest messages are routed based on their name
3. A node that holds a copy of the requested content replies to an Interest with a Content message

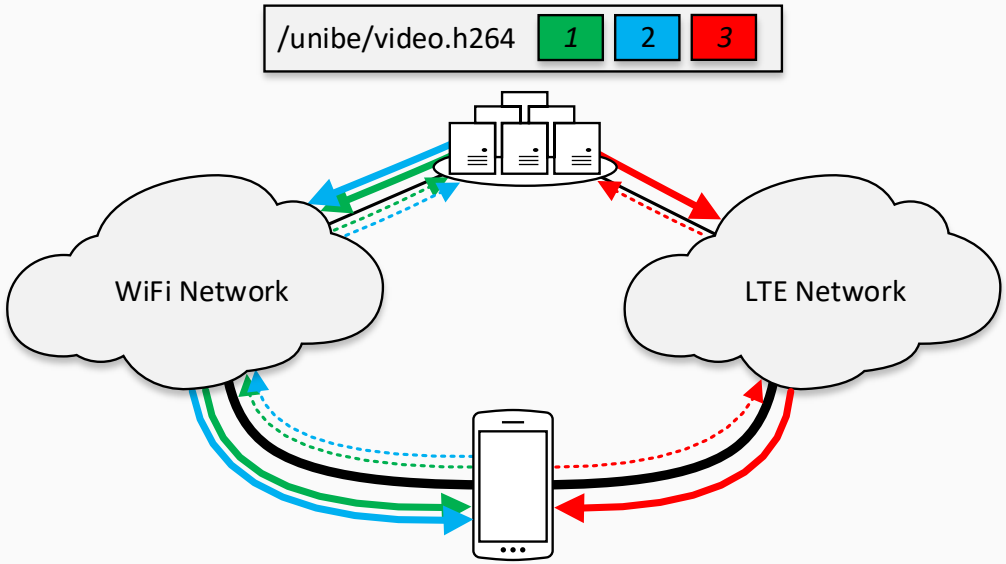


CCN: Handling large file request

The different segments that compose a large file can be requested in parallel over different interfaces.

Interests of the figure:

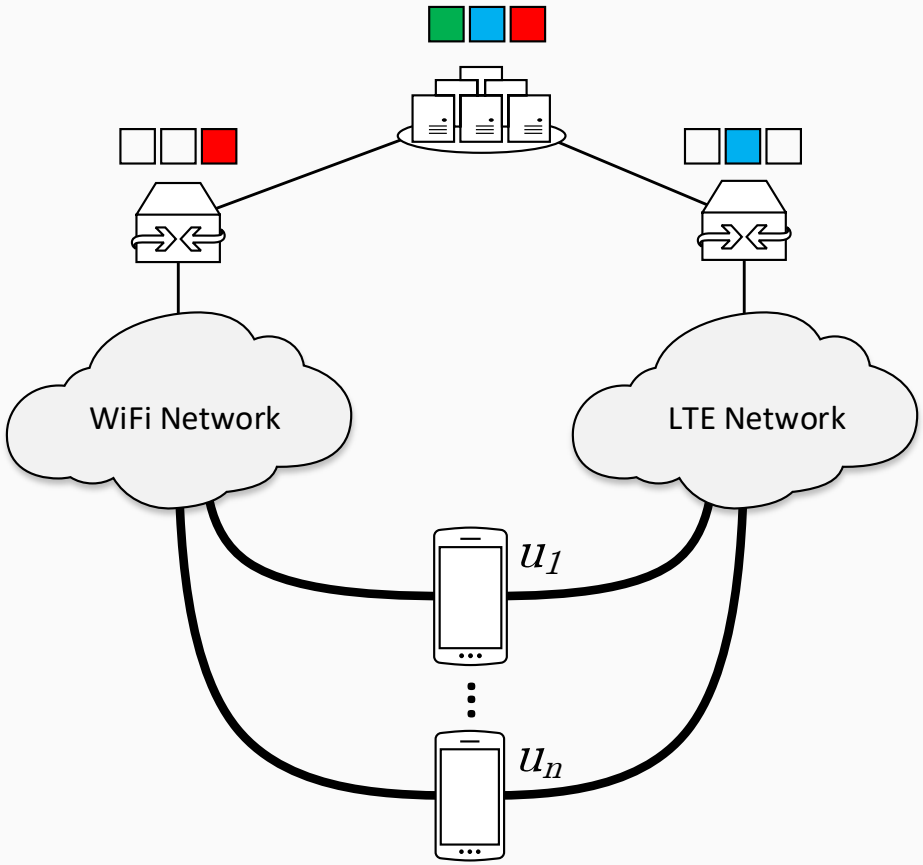
- `/unibe/video.h264/1`
- `/unibe/video.h264/2`
- `/unibe/video.h264/3`



CCN: Non-optimal cases

Case1: Multi-cast
Clients must coordinate
Interest forwarding

Case 2: Multi-source
Client must know the location of the segments



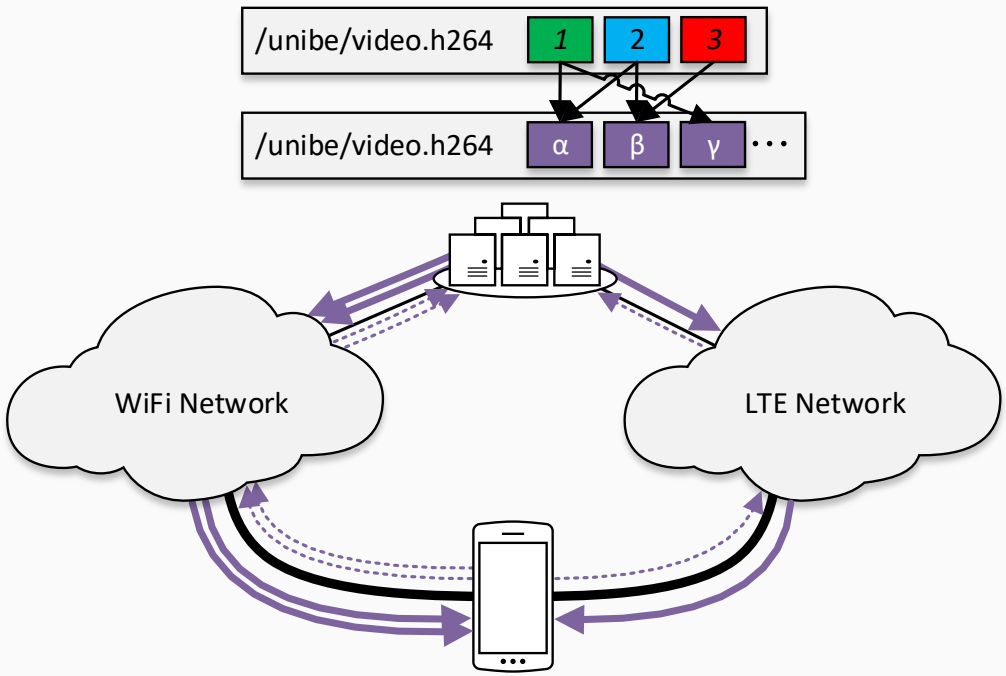
NC enabled CCN

Sources and routers perform coding operations on the segments.

Clients request coded segments, instead of specific segments.

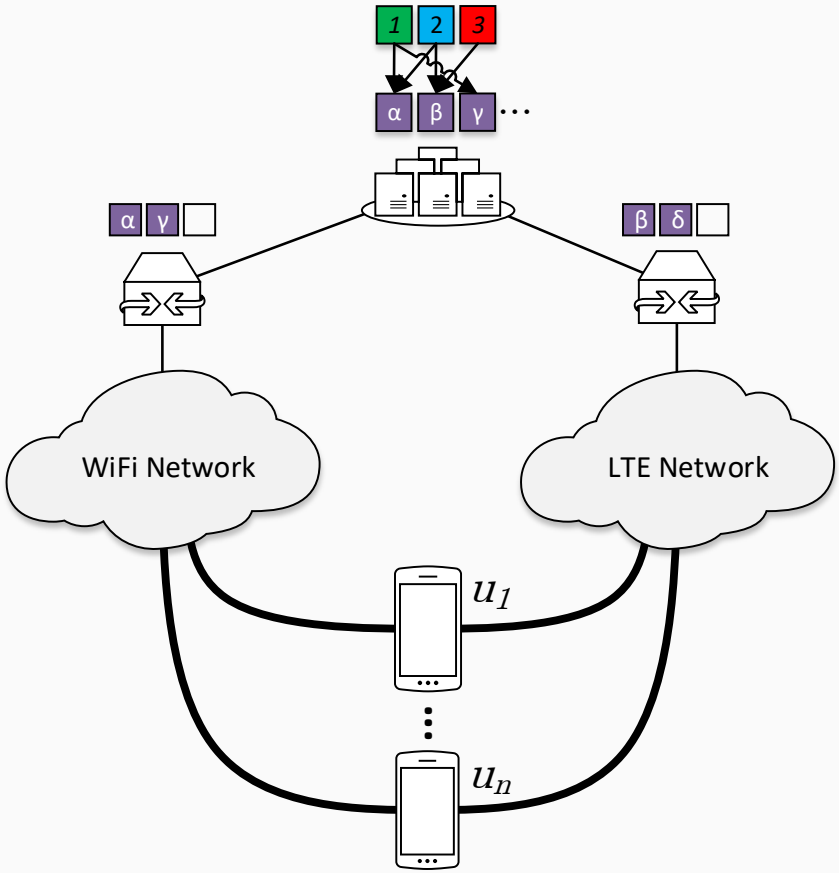
Interests of the figure:

- `/unibe/video.h264`
- `/unibe/video.h264`
- `/unibe/video.h264`



Benefits of NC enabled CCN

- Multi-cast, Multi-source issues alleviated
- Improved error resiliency
- Better throughput in networks with bottlenecks



NC enabled CCN: Name matching issues

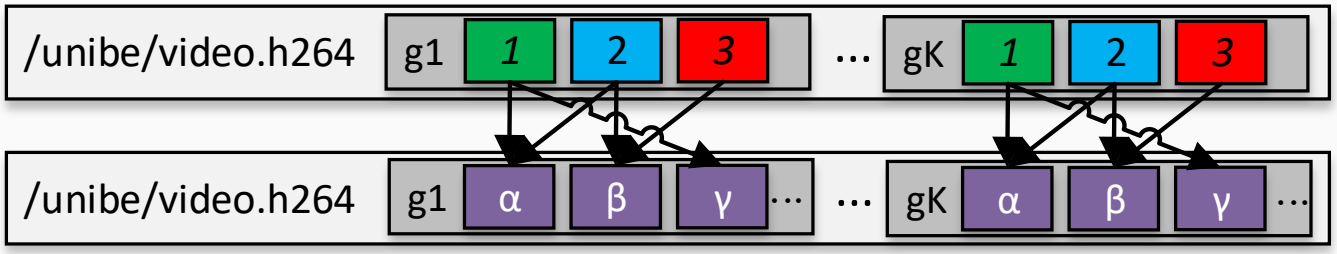
Multiple Interests for different coded segments will carry the same name

- **Interest aggregation issue**
  Interests for different coded segments are aggregated in the routers
- **Caching issue**
  The cache replies to all the Interests for different coded segments with the same segment

NetCodCCN

NetCodCCN: Content segmentation and naming

Content segmentation



Interest name

/unibe/video.h264/ g1

file name

generation id

Segment name

/unibe/video.h264/ g1 / 110

file name

generation id

NC header

NetCodCCN: Name matching

The **Interest aggregation issue** is solved by allowing the nodes to forward an Interest to its neighbor(s) only if if:

- The number σ_{fwd} of forwarded Interests is less than or equal to the number σ^{f}_{pend} of pending Interests on the face f where the Interest arrived

$$\sigma_{fwd} \leq \sigma^{f}_{pend}$$

NetCodCCN: Name matching

The **caching issue** is solved by allowing nodes to reply to an Interest with a cached coded segment only if:

- **Case 1:** The generation is decoded, or
- **Case 2:** The number L of segments stored in the CS is larger than the number σ^{f}_{sent} of segments sent through the face f where the Interest arrived

$$L > \sigma^{f}_{sent}$$

Implementation & Evaluation

Implementation & Evaluation

CCN codebase

- CCNx version 0.8.2

Network Simulation

- ns3 DCE (Direct Code Execution)

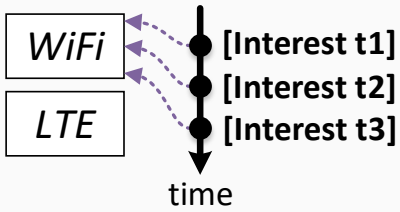
Metric

- Normalized delivery delay: $d = \Delta t_{measured} / \Delta t_{min}$

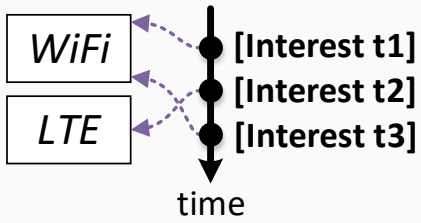
Implementation & Evaluation

Interest forwarding strategies

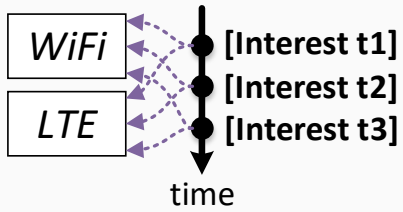
Default (DS)
Fastest face



Load Sharing (LS)
Distribute load over all faces

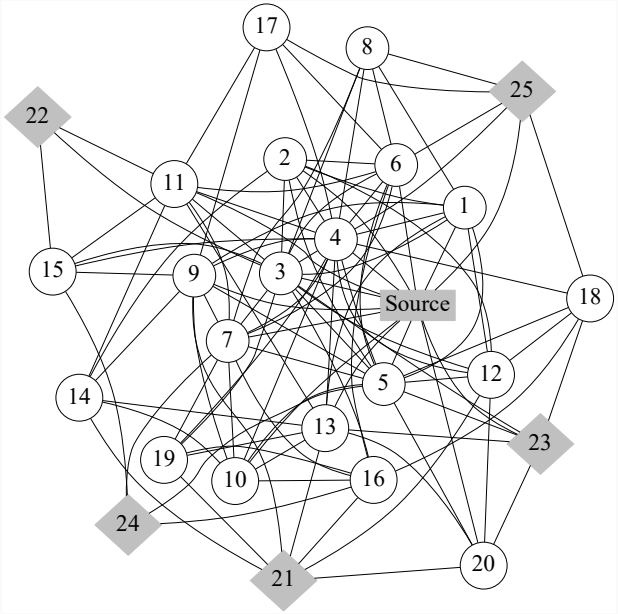


Parallel (PS)
All available faces



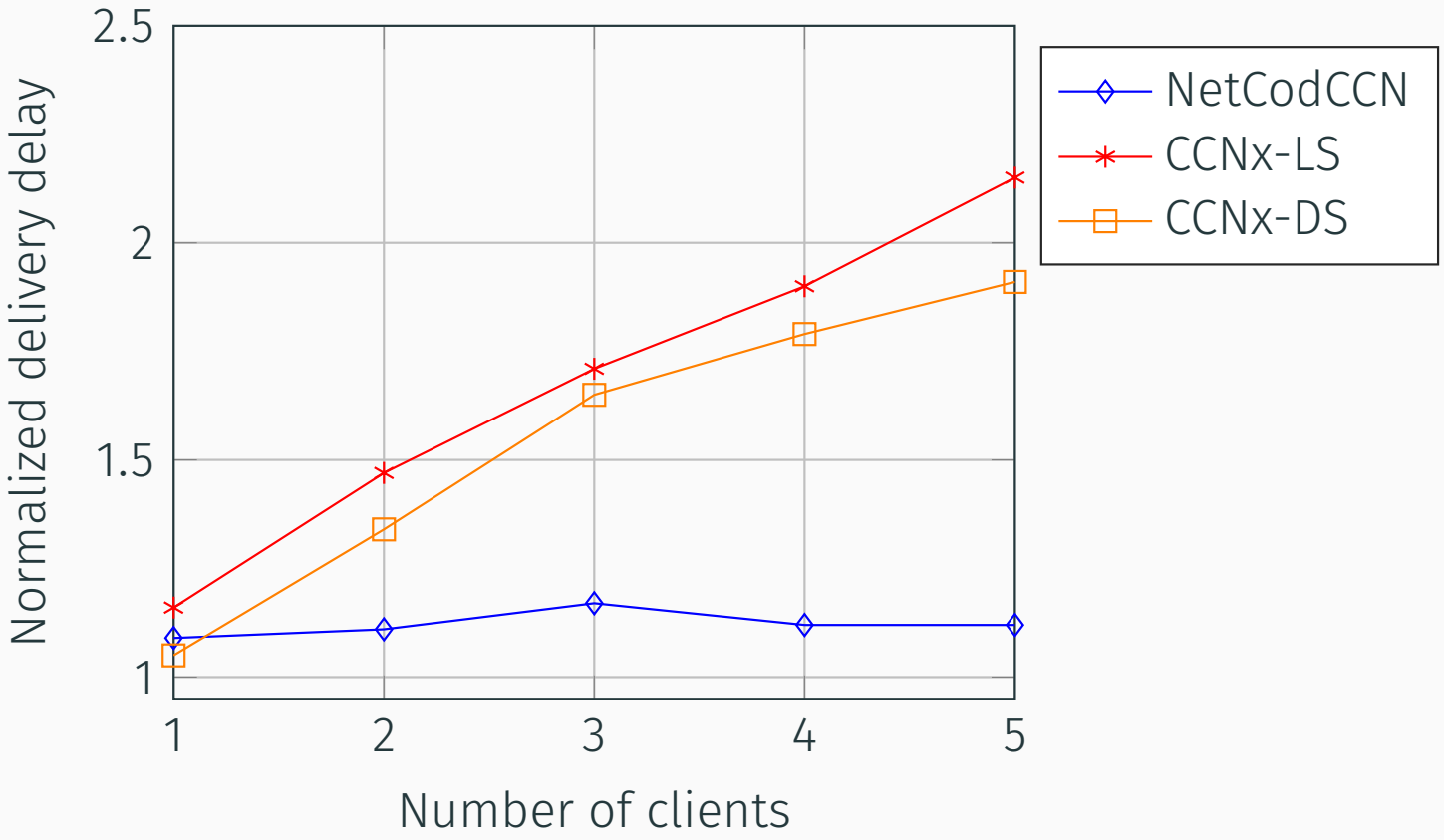
Evaluation: Set up

- Topology: random from PlanetLab
- Link capacity: 12Mbps
- Generation size: 100 segments
- Segment payload size: 5kB

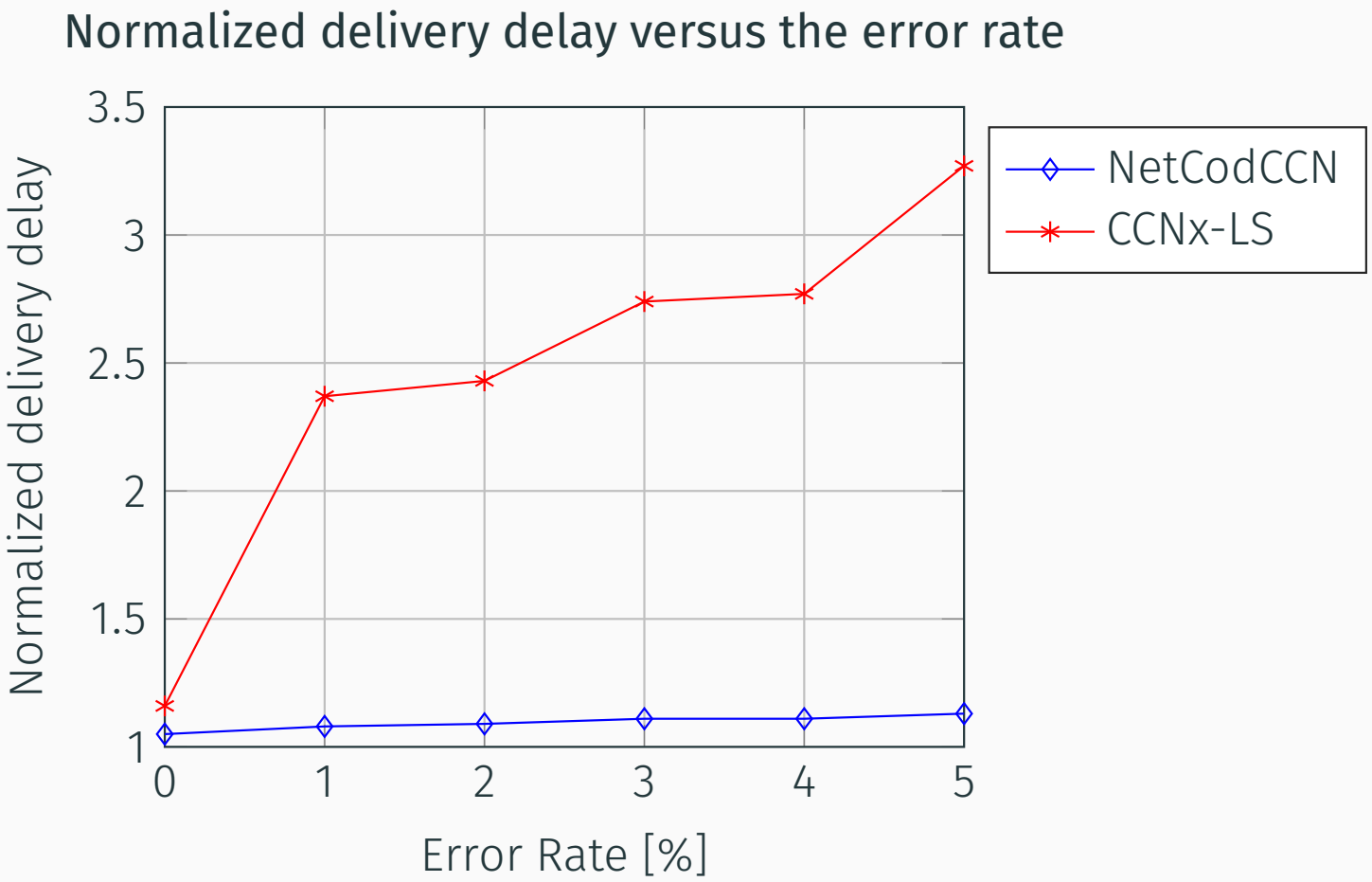


Evaluation: Number of clients

Normalized delivery delay versus the number of clients in the network



Evaluation: Error rate



Conclusion

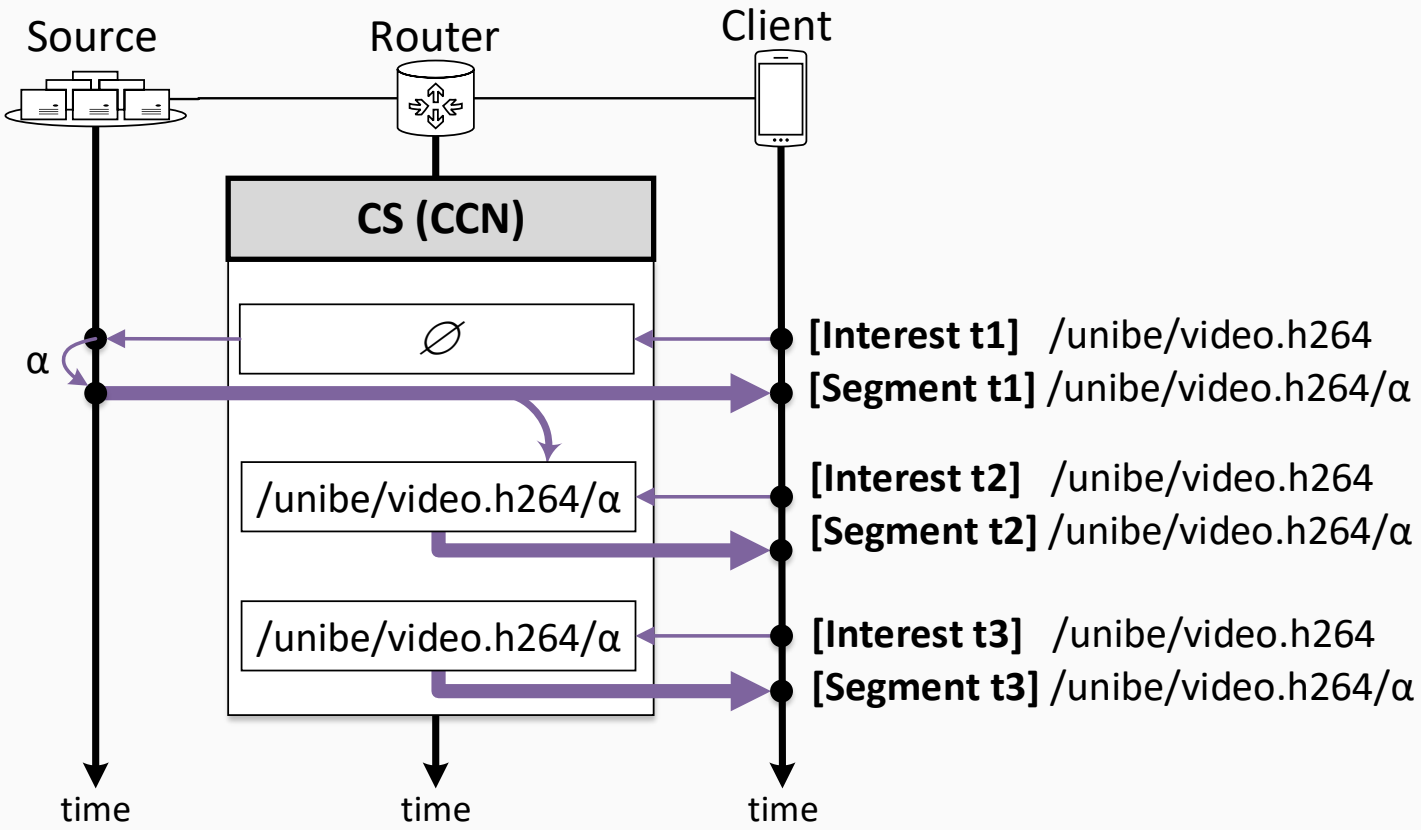
Conclusion

- Network Coding can improve content retrieval in CCN, in particular in multi-source, multi-client scenarios.
- NetCodCCN addresses the issues that network coding introduces to the original CCN.
- NetCodCCN can be further improved by optimizing the caching and the Interest forwarding strategies.

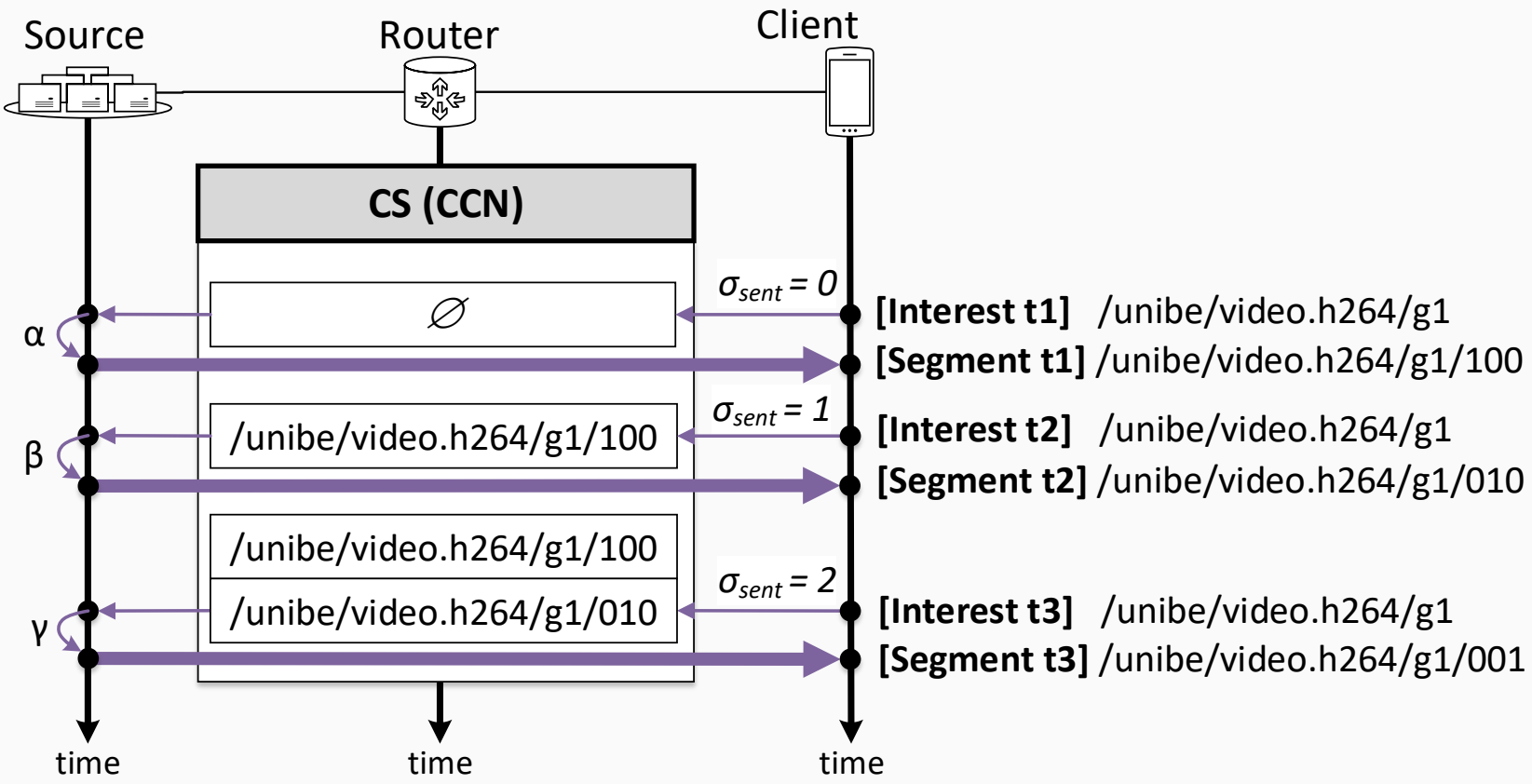
Questions?

Backup Slides

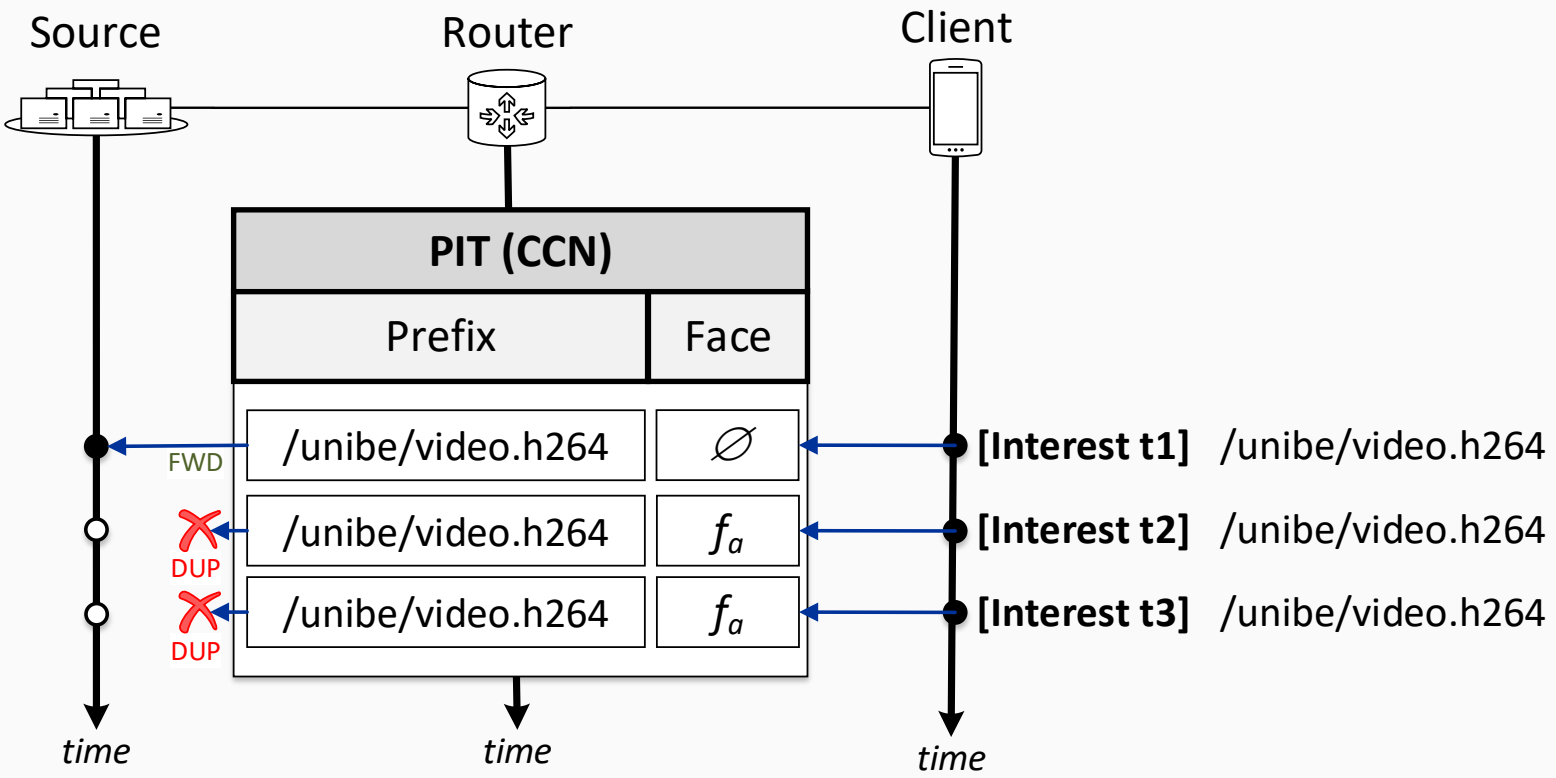
NC + CCN: Name matching issue (CS)



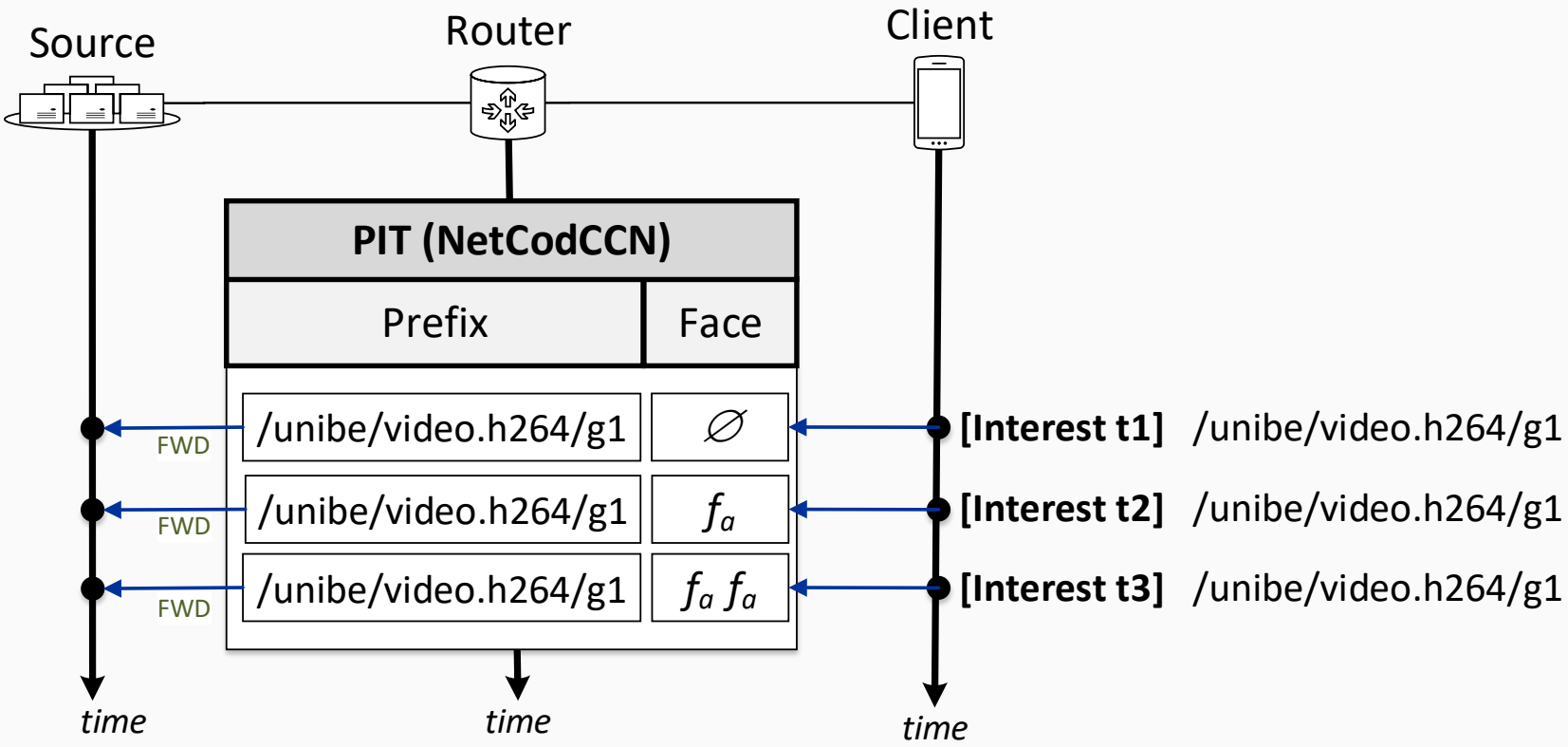
NetCodCCN: Name matching (CS)



NC + CCN: Name matching issue (PIT)

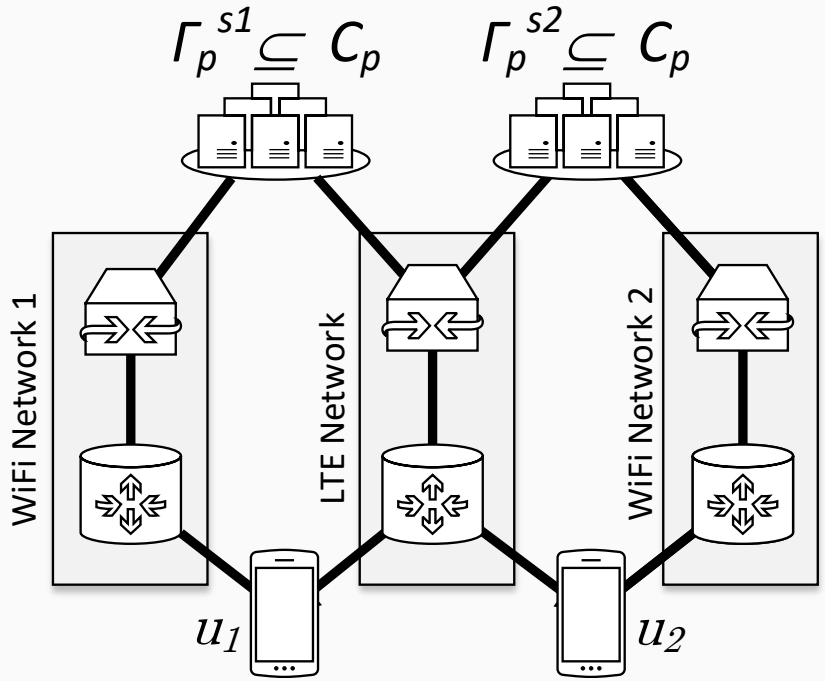


NetCodCCN: Name matching (PIT)



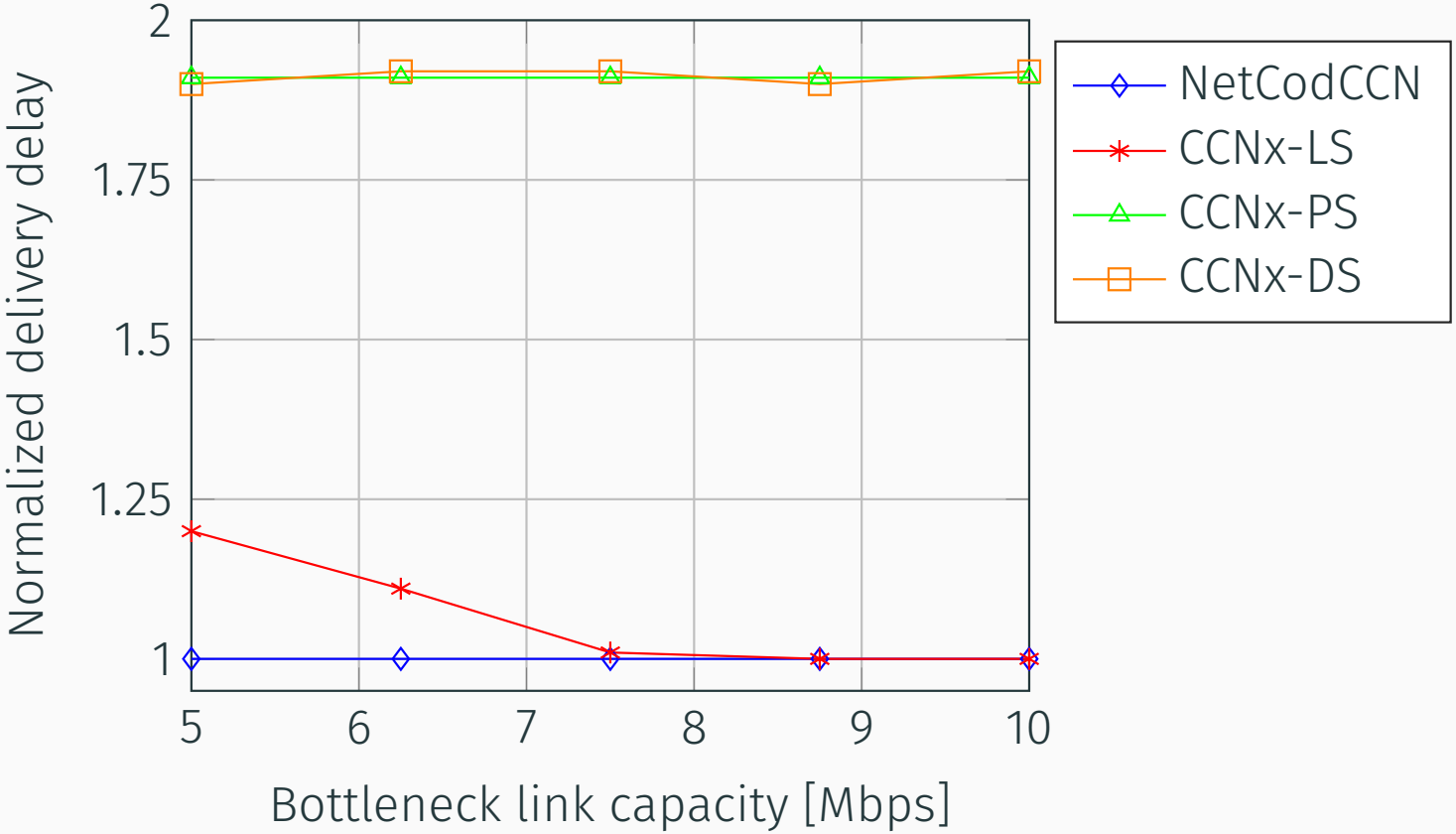
Evaluation/Butterfly topology/Set up

- Link Capacity: 5Mbps
- Generation size: 100 segments
- Segment payload size: 5kB

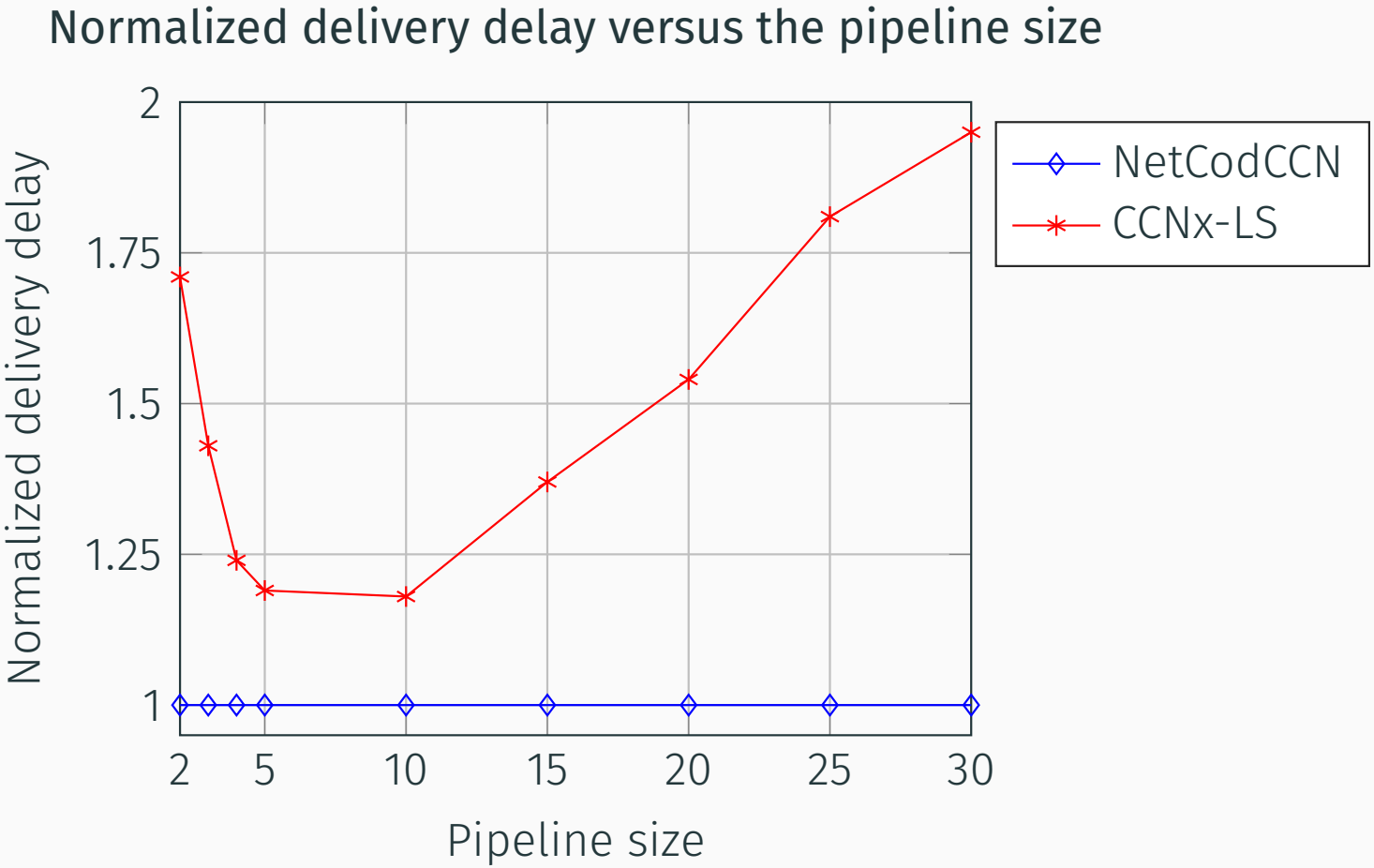


Evaluation/Butterfly topology/Results

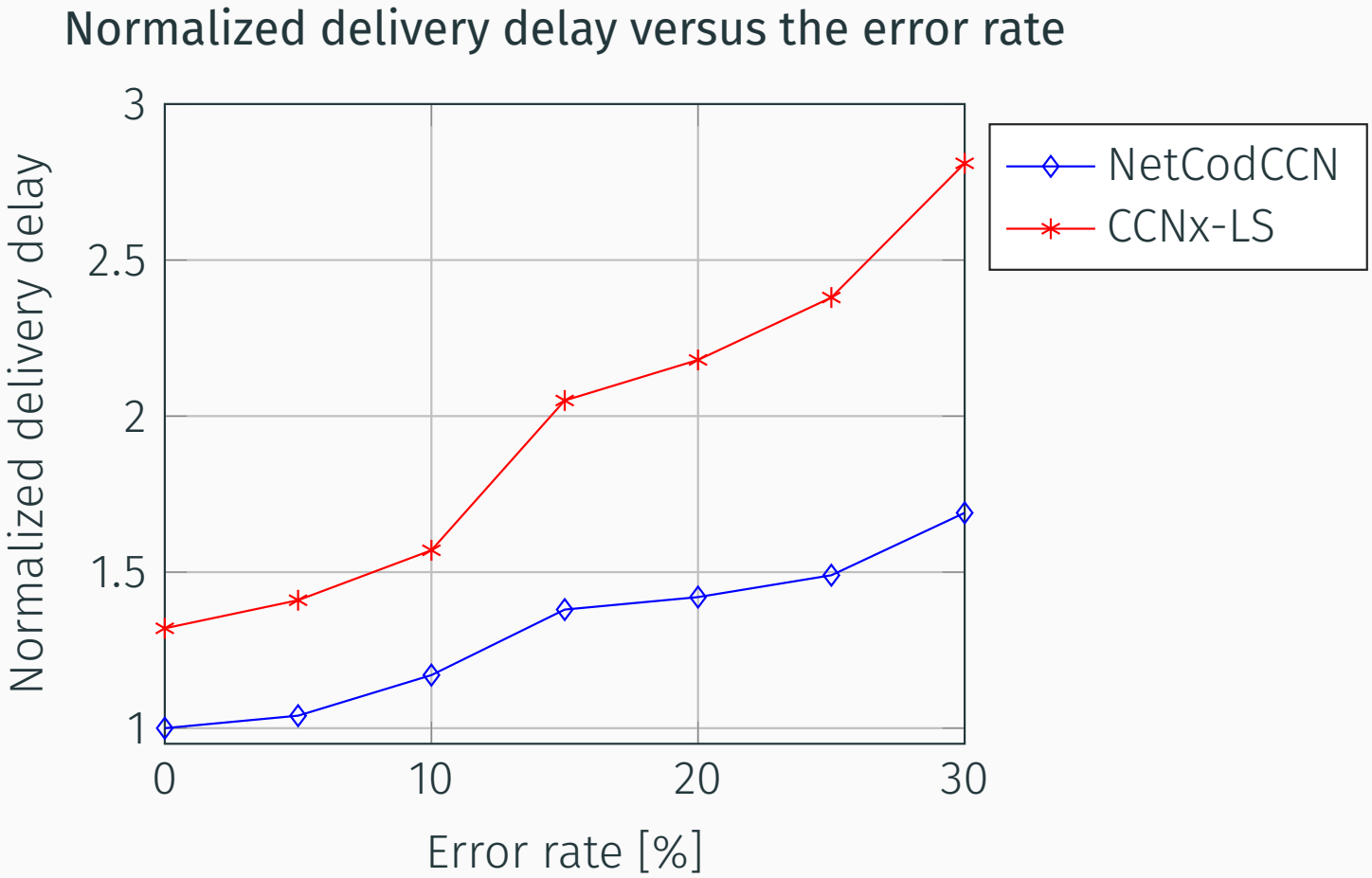
Normalized delivery delay versus the capacity of the bottleneck link



Evaluation/Butterfly topology/Results



Evaluation/Butterfly topology/Results



Normalized delivery delay versus the source content duplication probability