Interest Shaping Congestion Control for CCN

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Agenda

Key points on CCN architecture

Traffic control in CCN

HoBHIS: Hop-by-hop Interest Shaping Mechanism

Explicit Rate feedback

Performance analysis

Conclusion and future work

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Key points on CCN architecture

- Two packet types:
  - Interests (Requests) & Chunks (Data)
- Base rule:
  - One Interest retrieves at most one Chunk
- Content location
  - Anywhere in the network thanks to extensive *caching capabilities*
- Node architecture
  - Assumptions that supports the content-based schemes

Traffic control in CCN

- Source is not identified
- Content might be cached
- Congestion manifests by the overflow of the *transmission buffer* associated to an output interface and therefore by the loss of data chunks
  - *Transmission buffer* is separated from *Content Store*

Hop-by-hop Interest Shaping mechanism (HoBHIS)

- Anticipate the drop of data Chunks due to buffer overflow
  - Unlike TCP that starts to react only after the drop of one segment
- Congestion avoidance
  - *Monitoring* of the current transmission queue size
  - *Control* the transmission queue around *some threshold*
- Control Interest rate to adjust the Chunk rate

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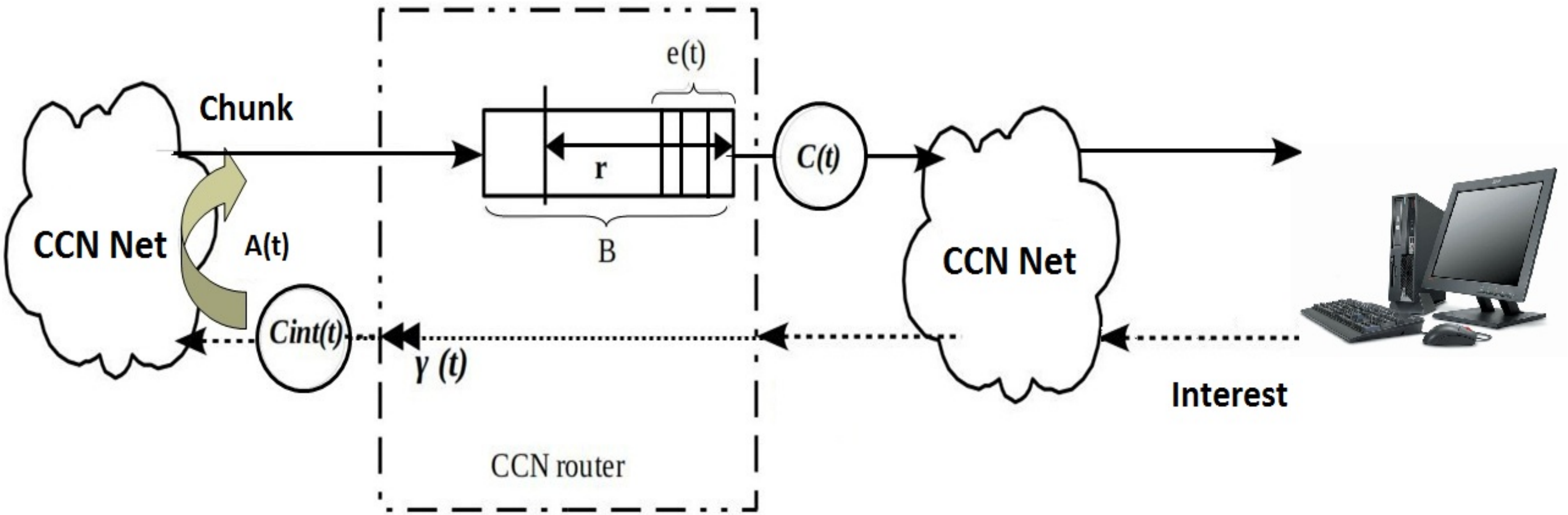
Main advantages of HoBHIS

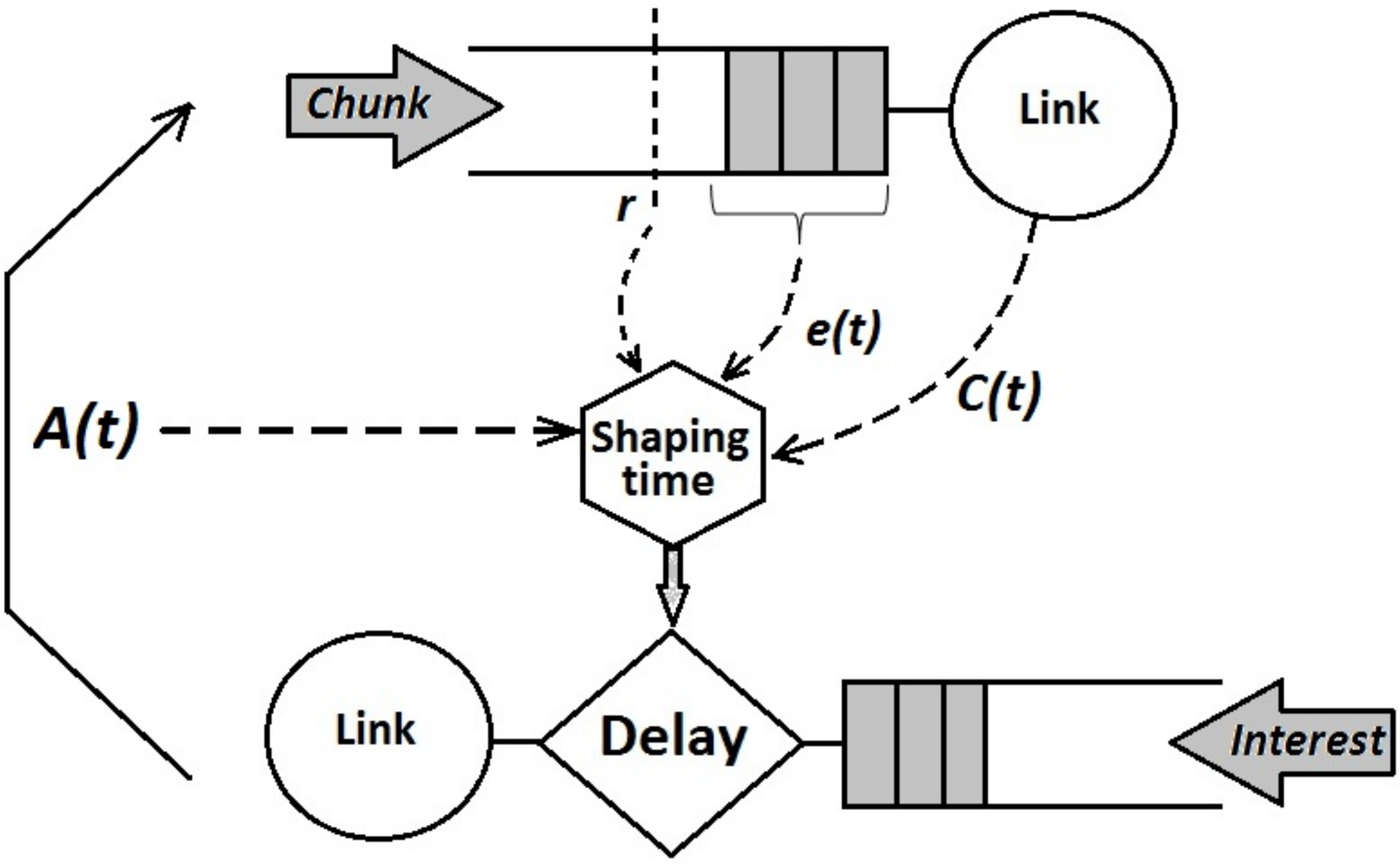
- Distributed in each CCN node
- *Hop-by-hop* control scheme provides a feedback information more quickly
- The algorithm is proactive
  - Using Interest packets rather than the data chunks
- Differentiation is feasible

Single router model (I)



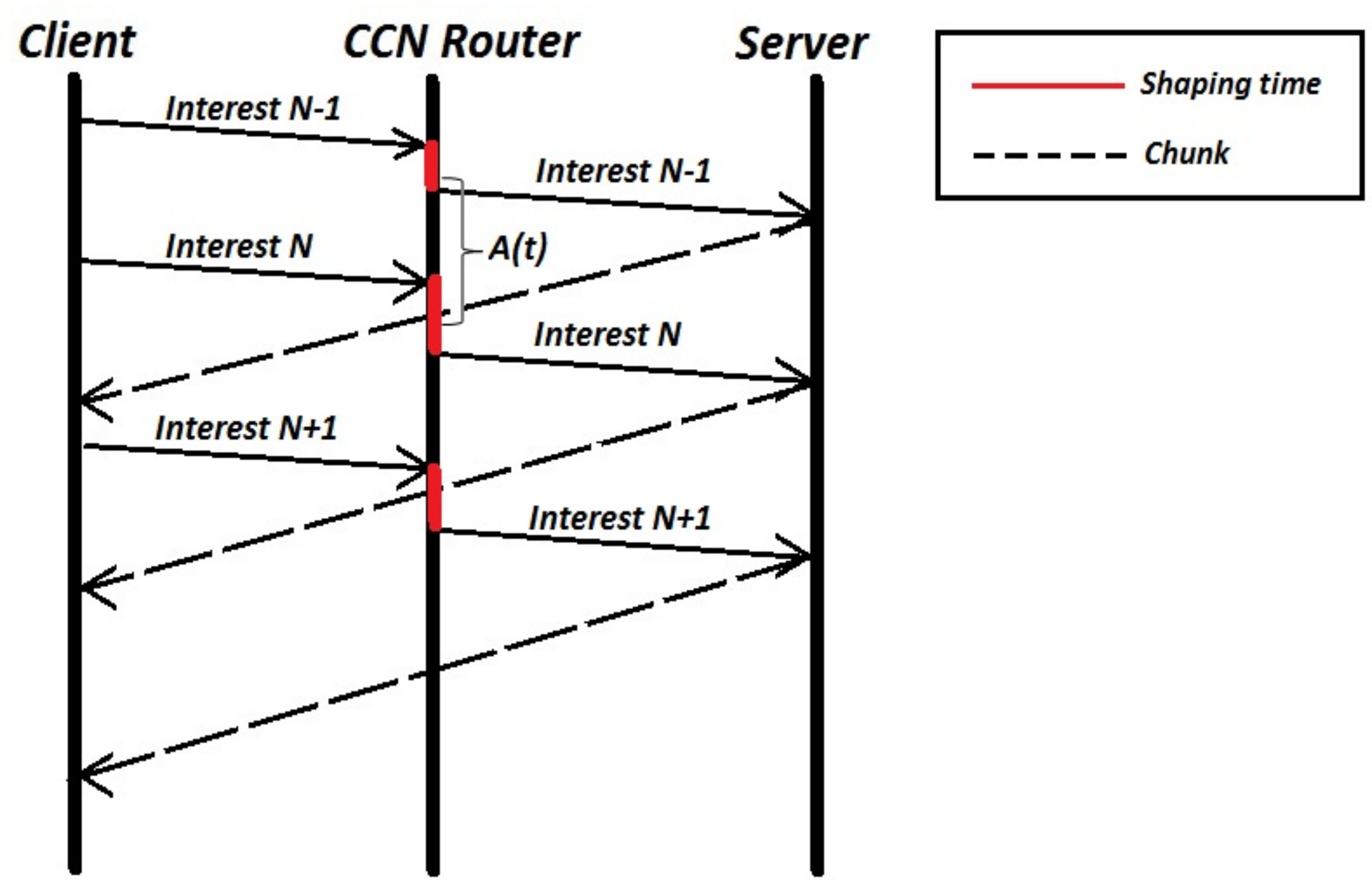
Simple Model of a CCN Router

Single router model (II)



Description of the system

Single router model (III)



Packet exchange process under shaping

Shaping rate

- Conversation is a stream of Interest/Chunk pairs
- The *data rate* is upper bounded by the *Interest sending rate*
- The shaping rate γ(t) is computed as follows:

$$\gamma(t) = C(t) + h.\frac{r - e(t)}{A^{*}(t)}$$

where ***C(t)*** is available capacity at time *t*;

h is a design parameter;

r is the queue threshold;

e(t) is the queue size at time t;

A*(t) is the delay from the Interest to related Chunk (*Response Delay*).

Multi-conversation

- Total utilization of available buffer capacity
- We need to divide the available buffer capacity between all active conversations at time *t*

$$\gamma_i(t) = C(t) + h.\frac{\frac{r * e_i(t)}{e(t)} - e_i(t)}{A^*(t)}$$

- *We allow each conversation to get* $r' = r * \frac{e_i(t)}{e(t)}$ *of the total buffer capacity*

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Convergence properties of *HoBHIS*

- According to the *algorithm definition*, the average queue size shall converge to a queue threshold *r*
- According to the *analytical model*
  - The queue converges to *r* as expected
  - The queue size for each conversation converges to r'_i and for global queue size we have

$$r = \sum_{i=1}^{F} r_i'$$

where F is number of conversations

Multicast (I)

- Interest aggregation
  - In the case of multiple Interests asking for the same content, only one copy will be sent to the network
- Shaping rate computation
  - How should we adjust the shaping rate formula?
  - Congestion avoidance

Multicast (II)

- Using the smallest capacity to calculate the shaping rate:

$$\gamma(t) = \min\{C_1, \ldots, C_j\} + h.\frac{r - \min\{e_1(t), \ldots, e_j(t)\}}{A^*(t)}$$

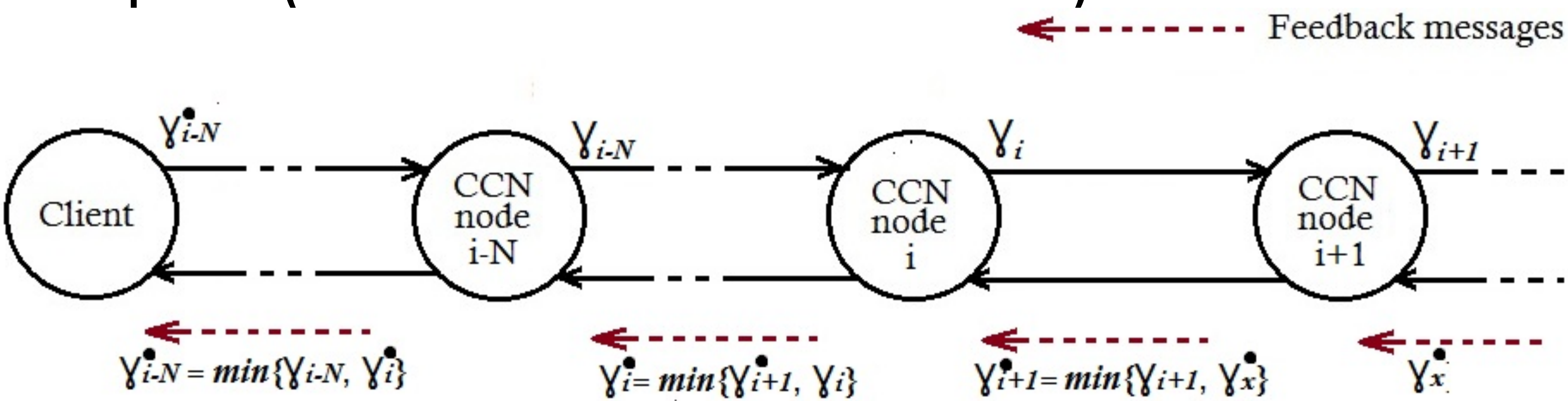
- Absence of packet loss due to buffer overflow
- The queue corresponding to an output interface with the smallest capacity is converging to the objective *r*.

Explicit rate feedback

- *Client's behaviour* is dictated by an *explicit rate* value
- Continuous Interest sending
- *Client rate* is aligned to the *rate of bottleneck*
- Bottleneck link is effectively used
- Keeping the Chunks arriving all the time
- Designed *to avoid the Interest losses*

Explicit rate feedback

- *“Signaling” packets* are generated every *A(t)*
- Feedback messages are *updated* by the routers along the path
- *Explicit rate* is a *minimum* shaping rate of the path (or *maximum* allowed rate)



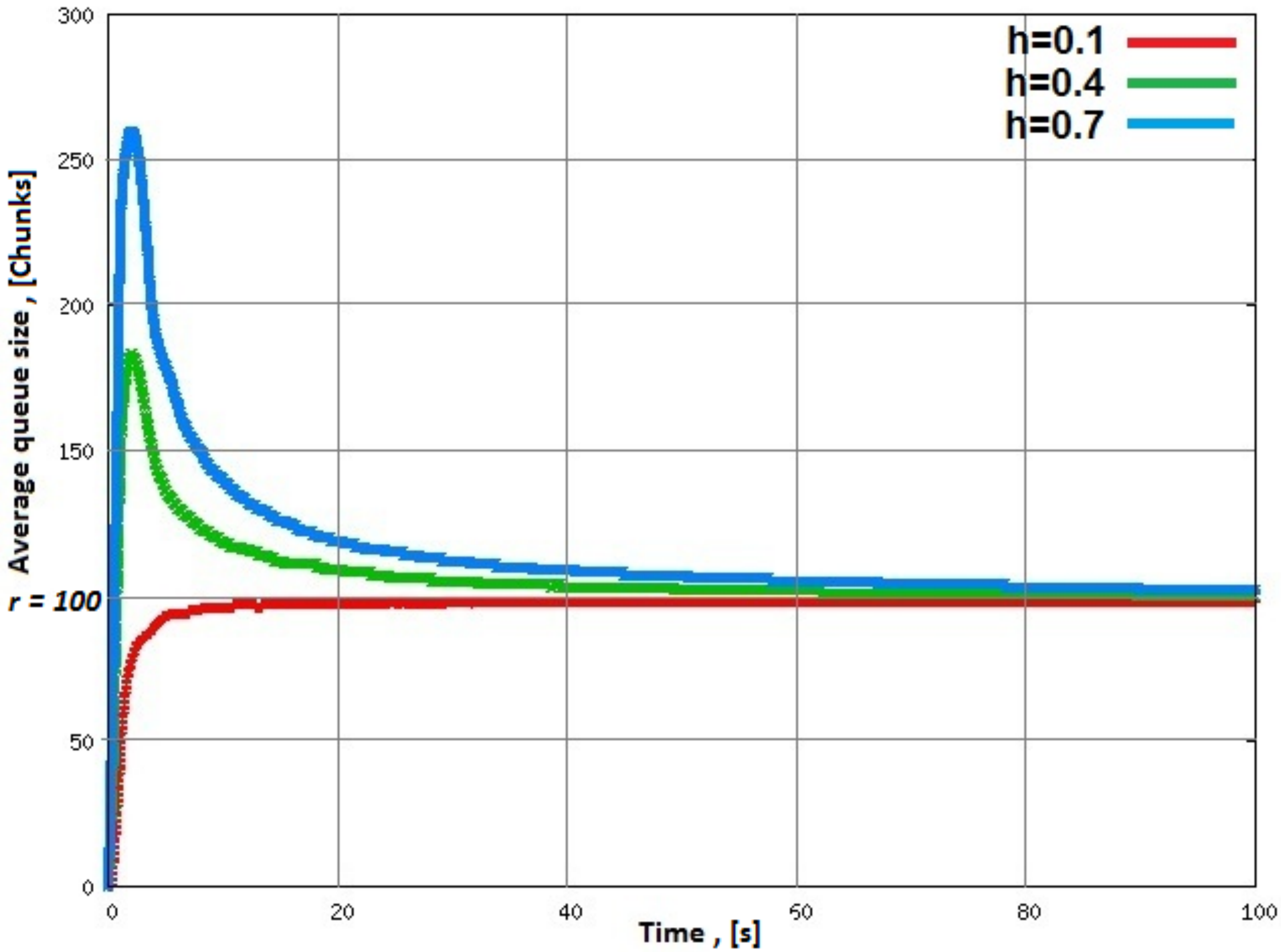
Performance analysis

- Network simulator 2 (NS2)
- First Implementation of HoBHIS in NS2
- Single router model:
  - Single conversation scenario
  - Multi-conversation scenario. Buffer sharing
- Network model
  - Multi-nodes and Multi-conversations
- Multicast
- Explicit rate feedback

Simulation Configuration
Single router model

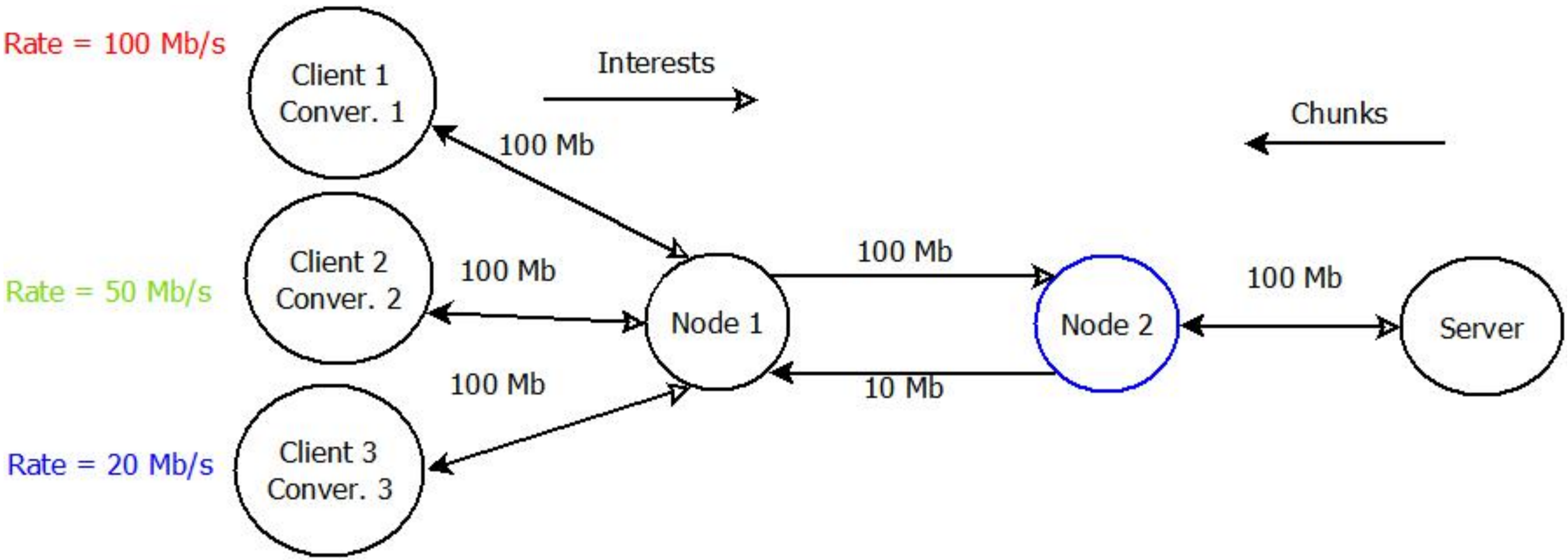
- Interest packet size = 500 bytes
- Chunk packet size = 1500 bytes
- r=100 Chunks
- B = 500 Chunks
- h = 0.1; 0.4 and 0.7
- A(t) is :
  – a random value uniformly distributed in [0;1]
  – generated for every packet

Single conversation scenario



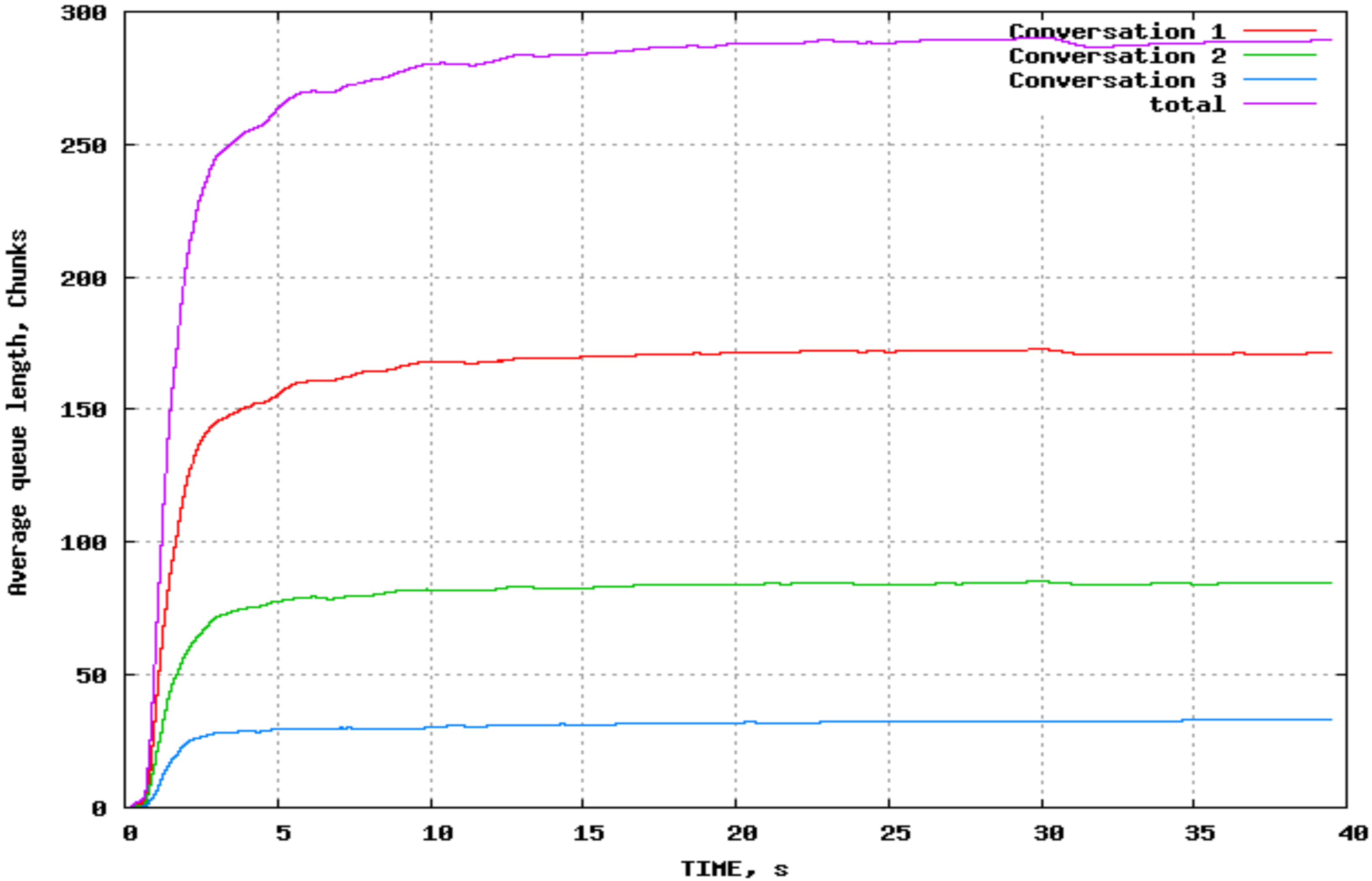
Transmission Queue convergence

Multi-conversation scenario (I)



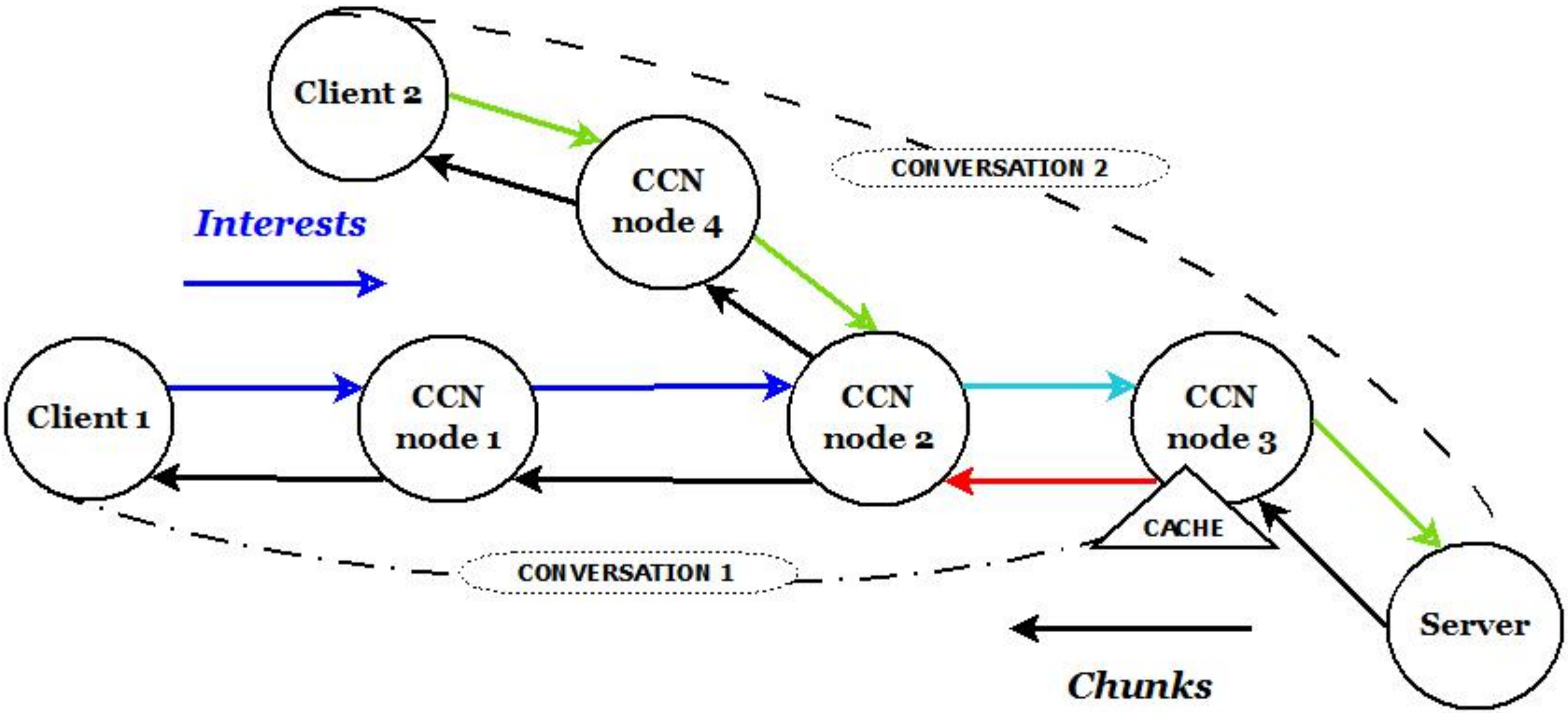
Simulation topology for multi-conversation scenario

Multi-conversation scenario (II)



Transmission Queue convergence (r = 300 Chunks)

Network of nodes (I)

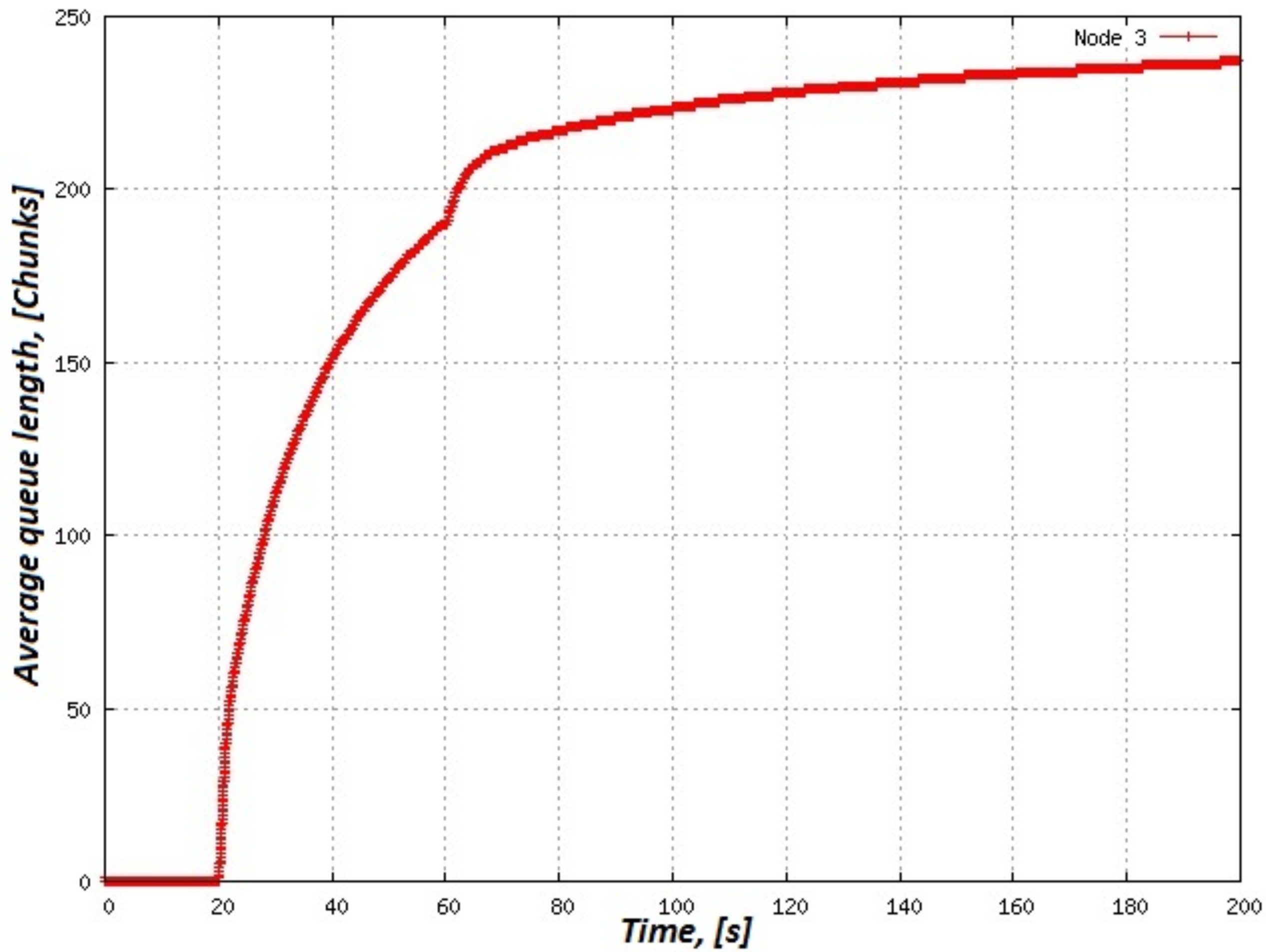


Network topology

Network of nodes (II)
Configuration

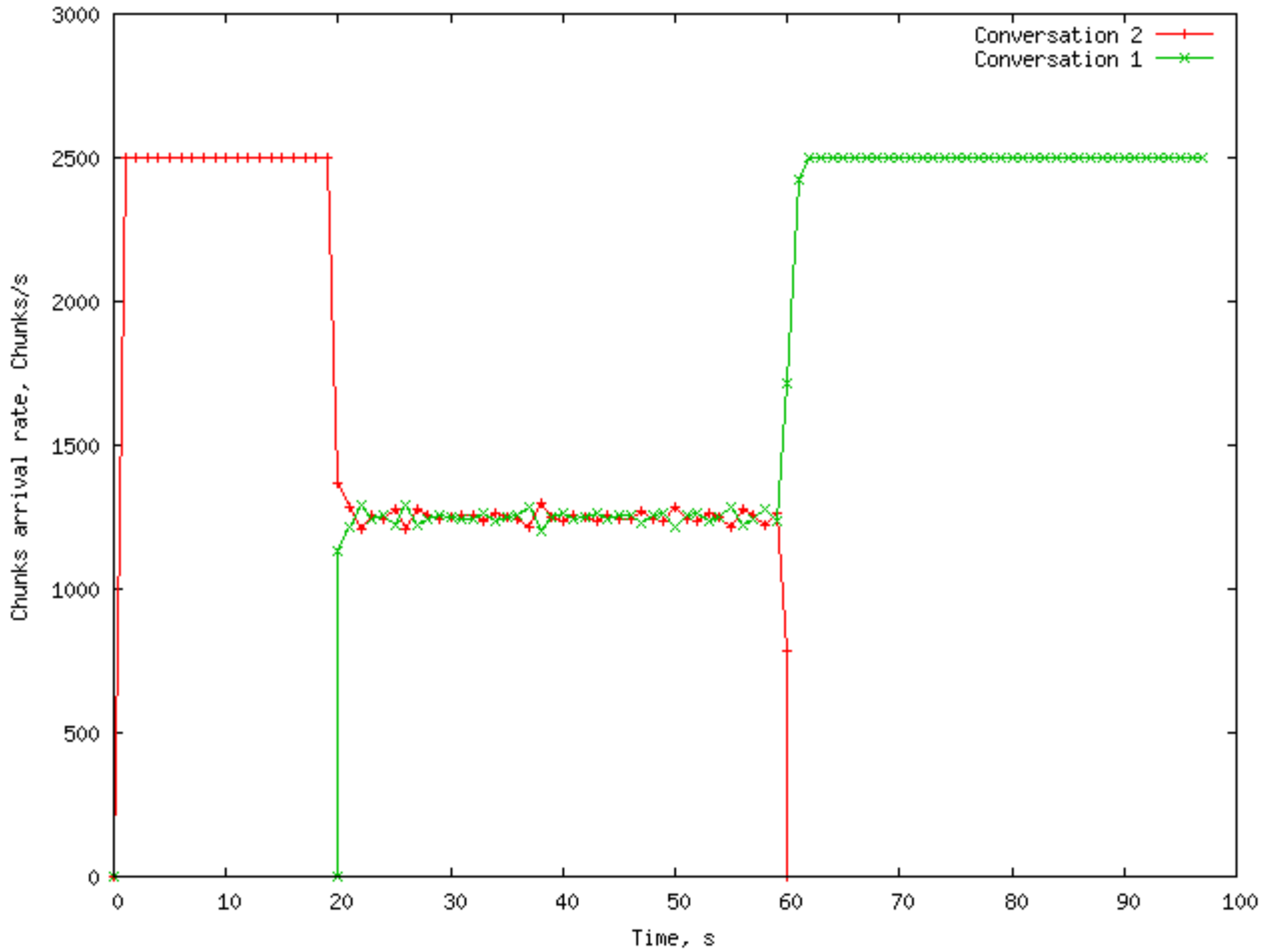
- 2 conversations
  - Conversation 2 starts before 1
  - Conversation 2 stops before the ending of 1
  - Data for conversation 1 is in the cache of node 3
- h=0.7
- r=250 Chunks
- B=500 Chunks
- We are interested in
  - The buffer state for node 3
  - The rate of each conversation over time

Transmission Buffer Status



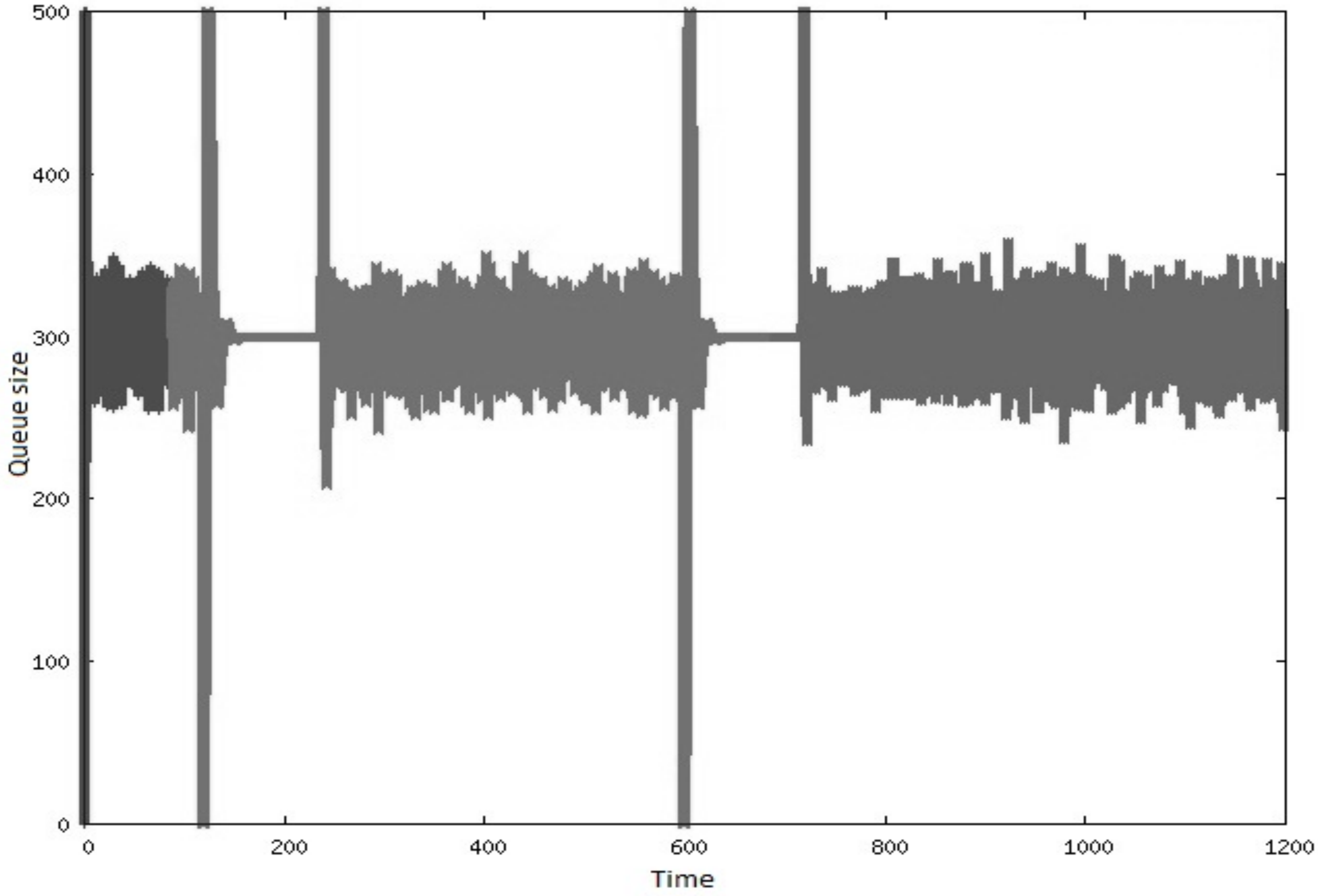
Queue state of node 3 for network scenario (r=250 Chunks)

Chunk rates for each conversation



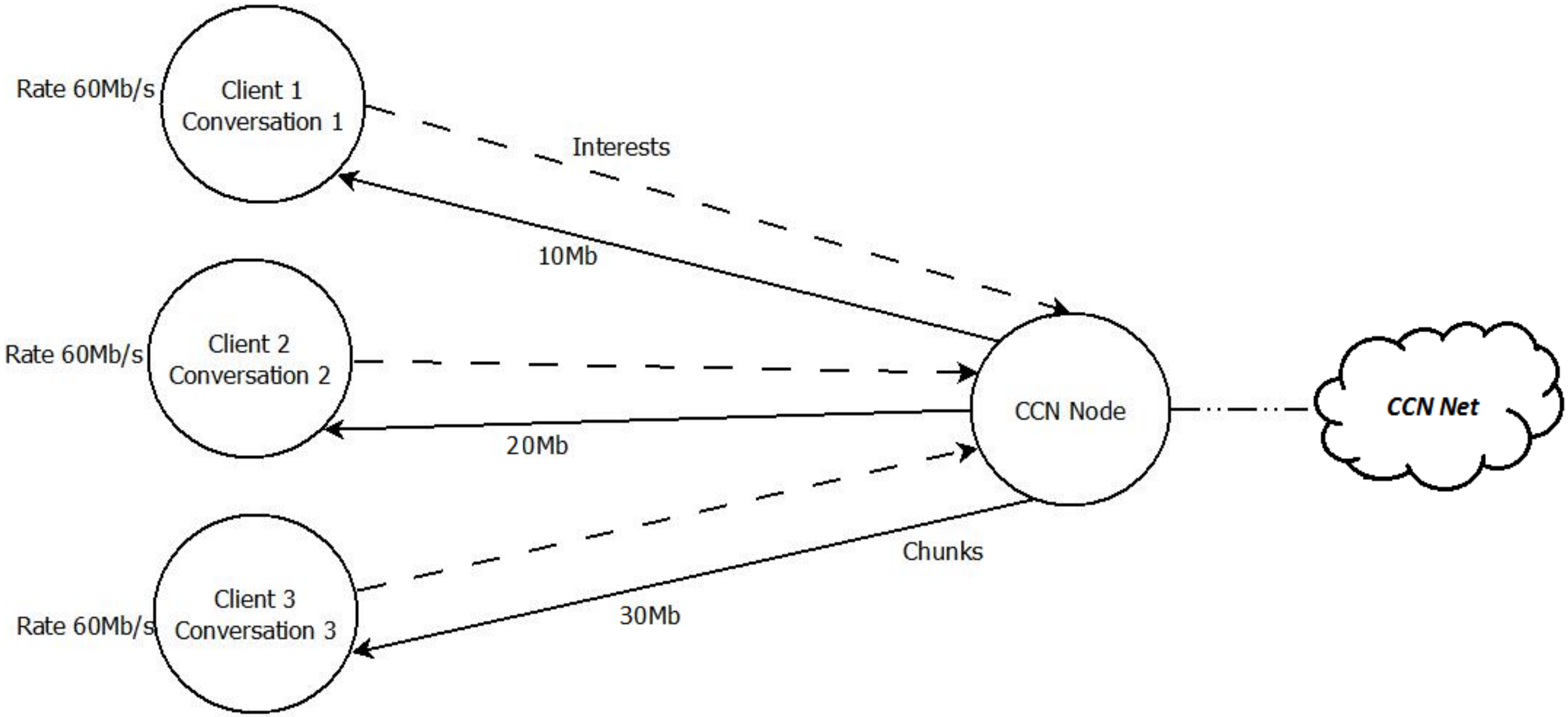
Chunk rates for network scenario

Response delay variations



Queue size as the function of time; 2 bursts of A(t)

Multicast scenario

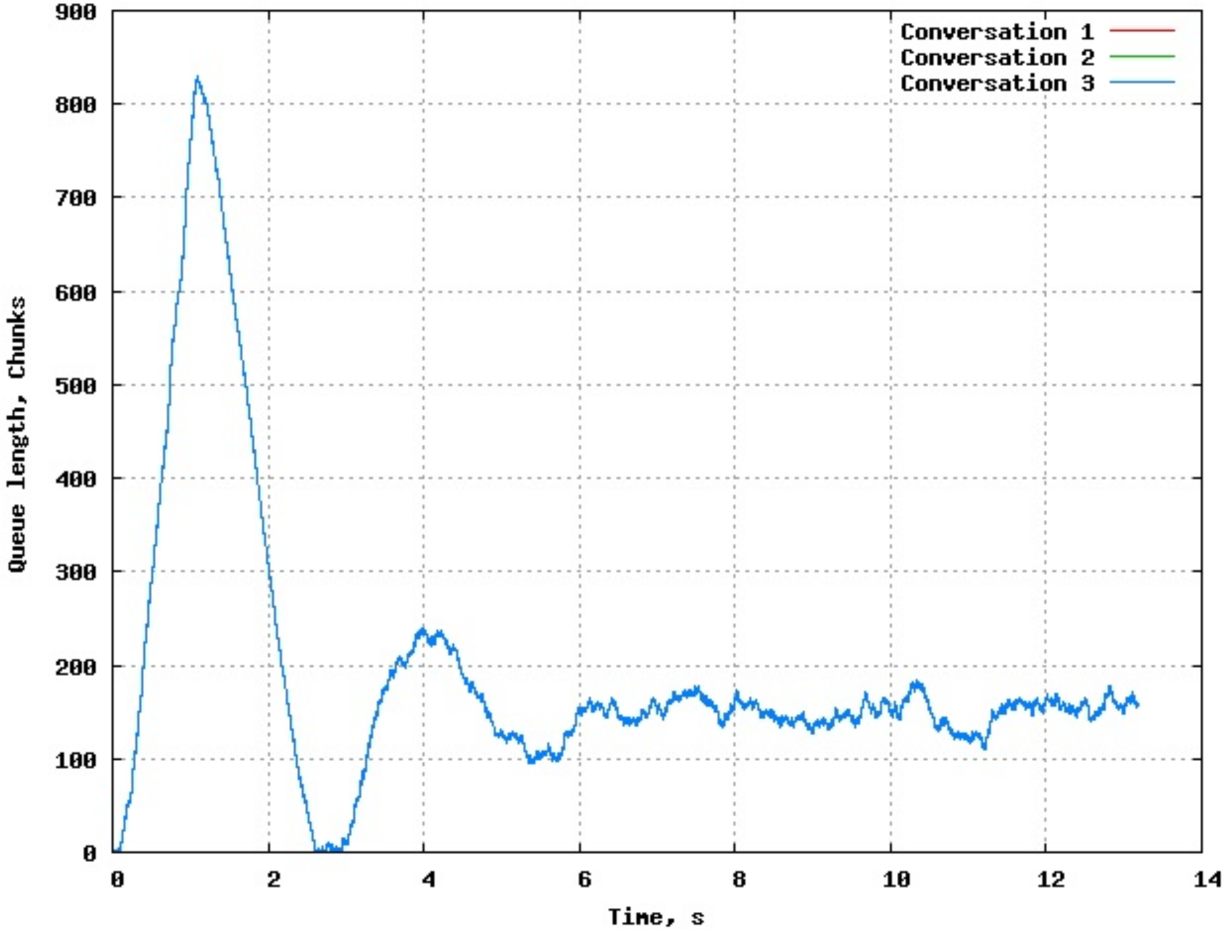


Network topology for multicast scenario

Multicast Configuration

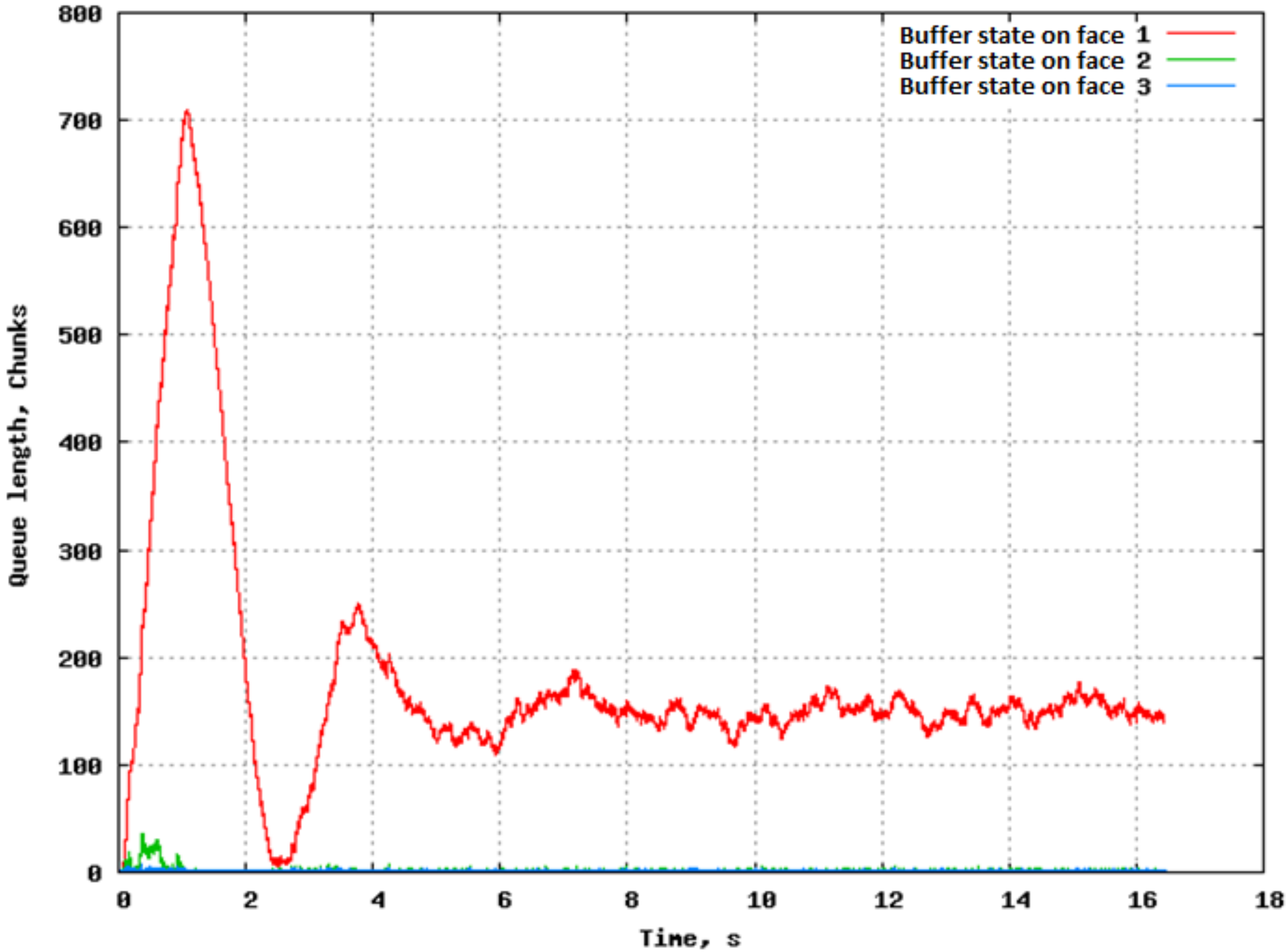
- Three clients are asking for the same content
- Two scenarios:
  - The Clients have the same rates (60Mb/s) and the same link capacities (10Mb)
  - The Client have the same rates (60Mb/s) but different link capacities (10Mb, 20Mb, 30Mb)
- r = 150 Chunks

Multicast
Same rates/same bandwidths



Queue length for multicast scenario (r = 150 Chunks) have exactly the same value

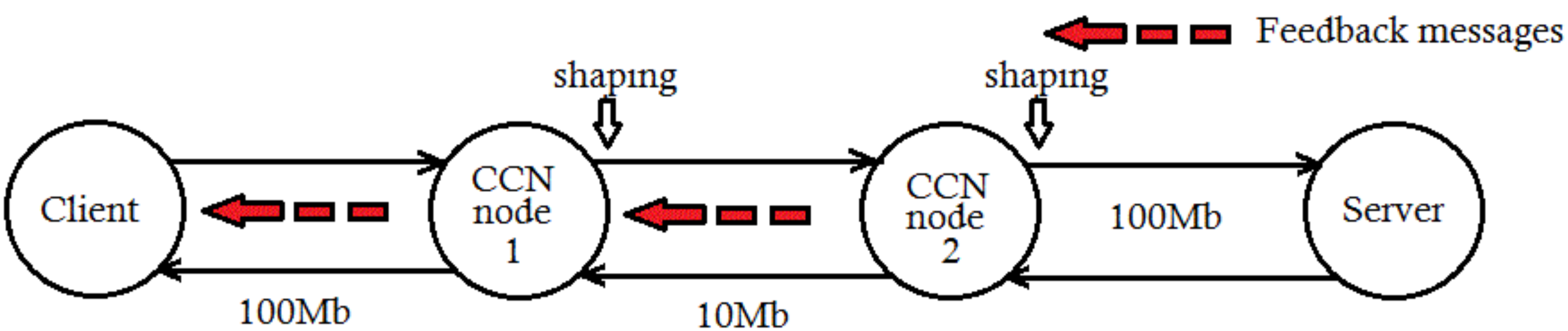
Multicast
Same rates/different bandwidths



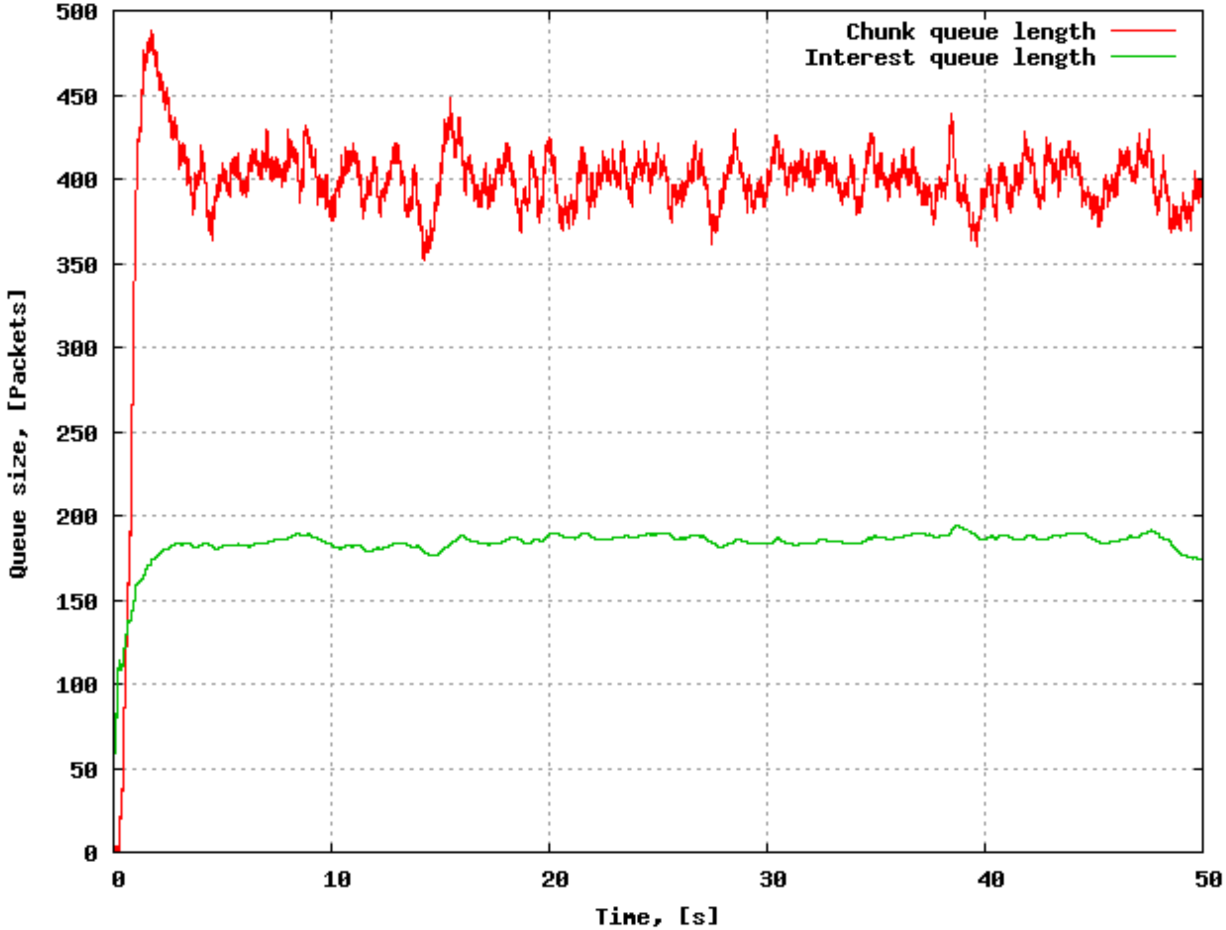
Queue length for multicast scenario (r = 150 Chunks),
C1>C2>C3

Explicit rate feedback

- HoBHIS is used by each CCN node
- Feedback messages are generated every A(t)
- Signal packets carry the minimum shaping rate of the path



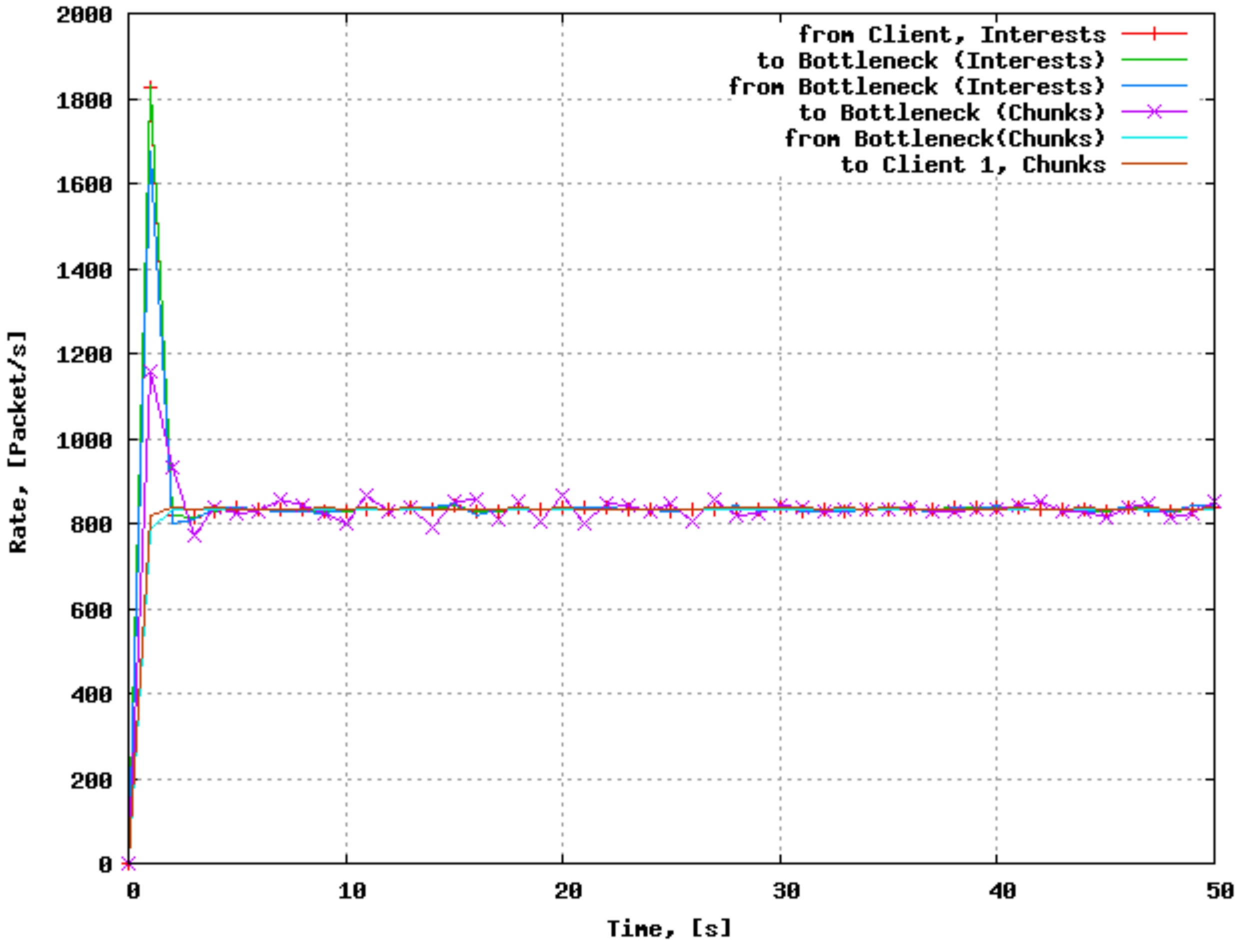
Explicit rate feedback
Buffer state



Interests and Chunks queue lengths

Explicit rate feedback

Rates



Interest and Chunk rates along the path

Conclusion

- First contribution based on Interest Shaping to address Congestion Control in CCN
- We propose a model for a CCN router
- We have introduced a hop-by-hop Interest shaping congestion control mechanism for CCN (HoBHIS)
  - It allows to control the network congestion state locally in each router
  - It is based on continuous queue monitoring
- We have proposed an explicit rate feedback mechanism to avoid the losses of Interests
- We have explored their performance
  - We demonstrated the convergence property of our algorithm
  - We have provided a performance analysis based on various scenarios using our NS2 simulation environment
  - We have shown that our mechanisms perform as designed

Future work

- Future work will extend the analysis and design of HoBHIS
- In order to favor important content, differentiation will be considered
- Explore the complexity and scalability of our algorithm
- Study more complex scenarios

Thank you

for

your attention

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