NADA: A Unified Congestion Control Scheme for Low-Latency Interactive Video

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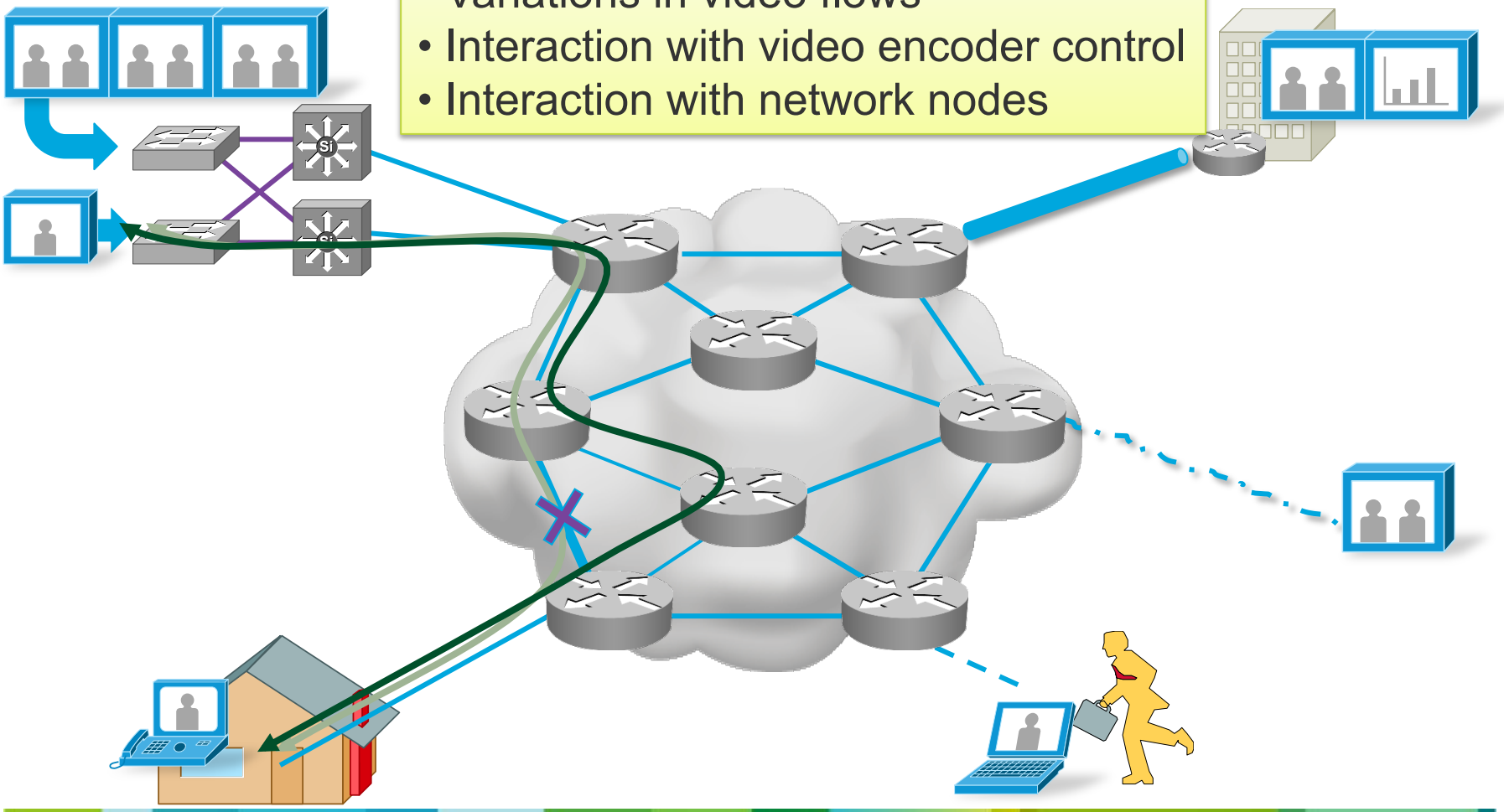
Outline

- Motivation & Related work
- Design goals of NADA
- The NADA system
  - Network congestion signals
  - Receiver behavior
  - Sender operations
- Highlight of results

Challenges of Low-Latency Interactive Video

- Loss- and delay- sensitive
- Variations in video flows
- Interaction with video encoder control
- Interaction with network nodes



Related Work

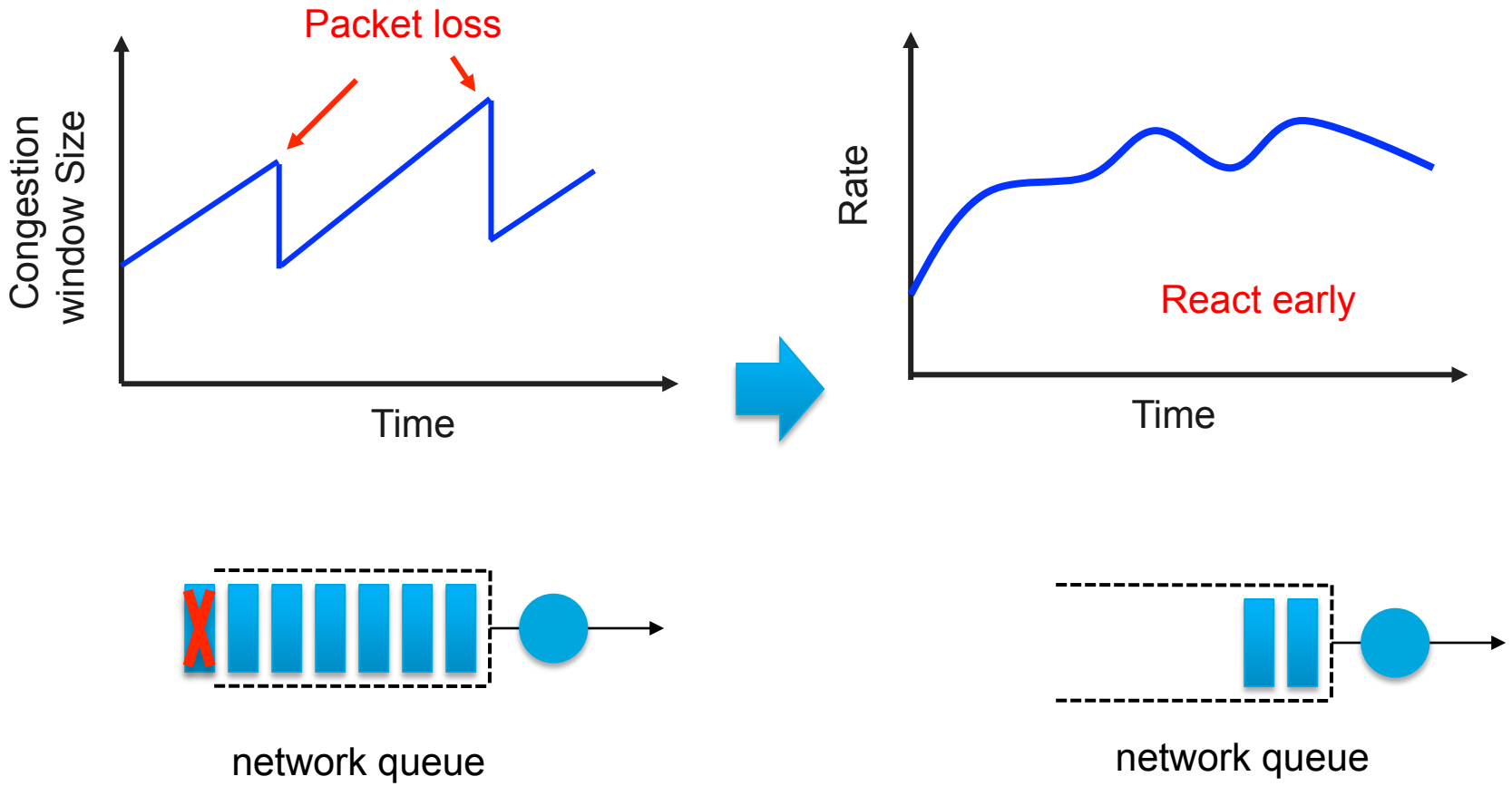
- Earlier Attempts:

  TCP-Friendly Rate Control (TFRC) *[Floyd and Fall, 1999]*

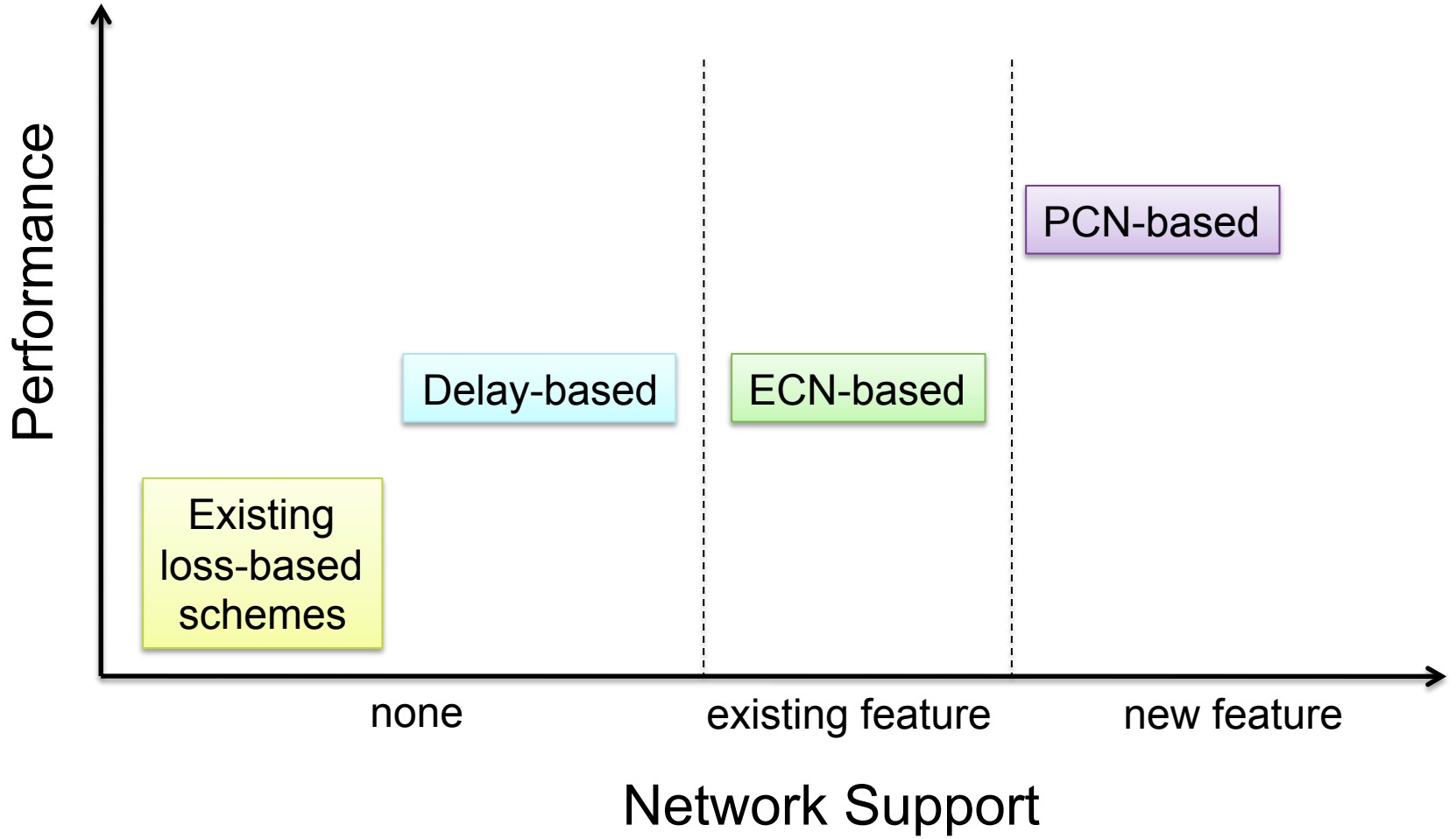
  Media-Friendly Slowly Responsive Congestion Control
  [Wang, Banjeree, and Jamin, 2004]
  [Yan et al., 2006]

- Proposed Solutions in IETF RMCAT WG
  [Lundin, Holmer, and Alvestrand, 2013]
  [O'Hanlon and Karlberg 2013]

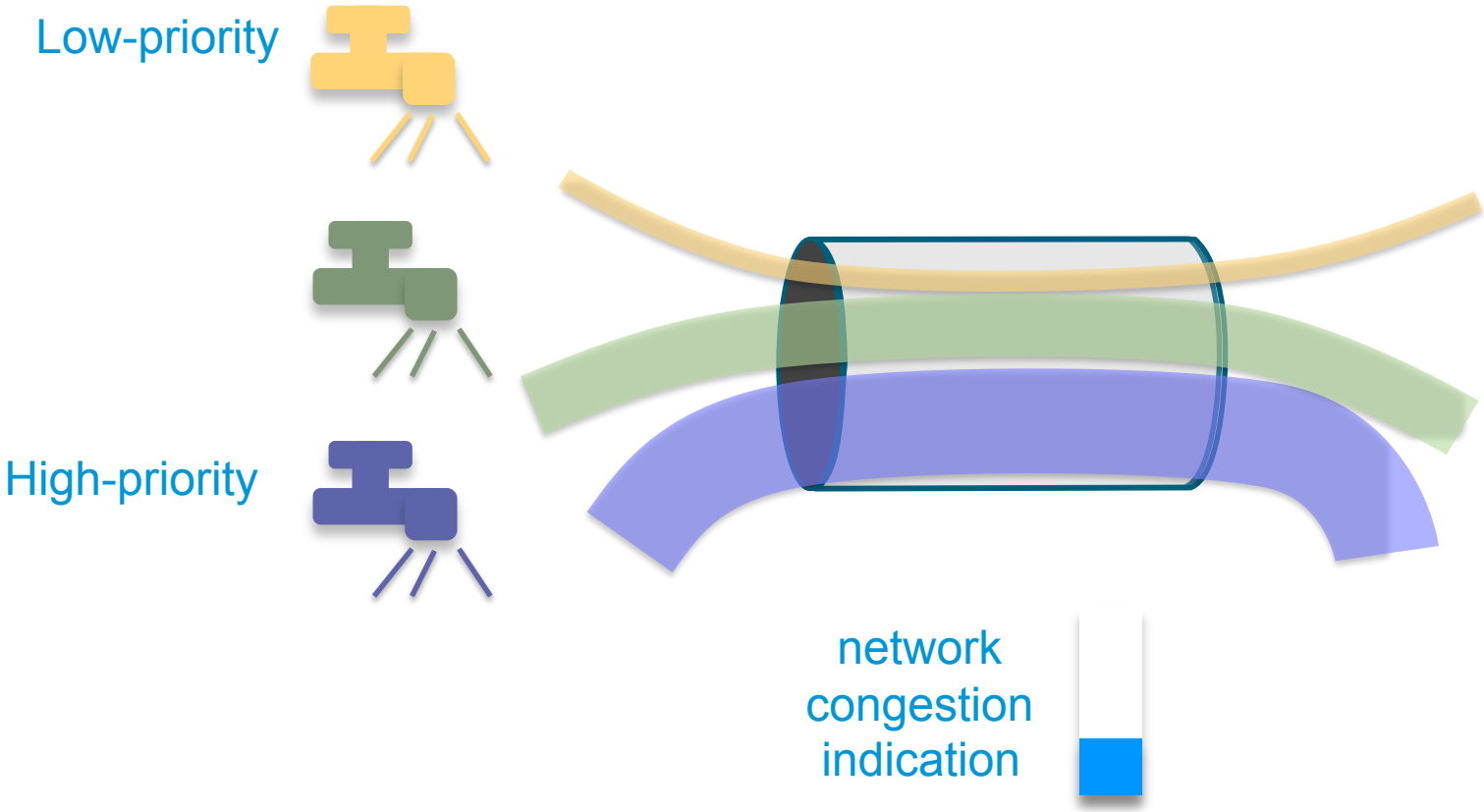
Design Goal of NADA #1: Limit Self-Inflicted Delay



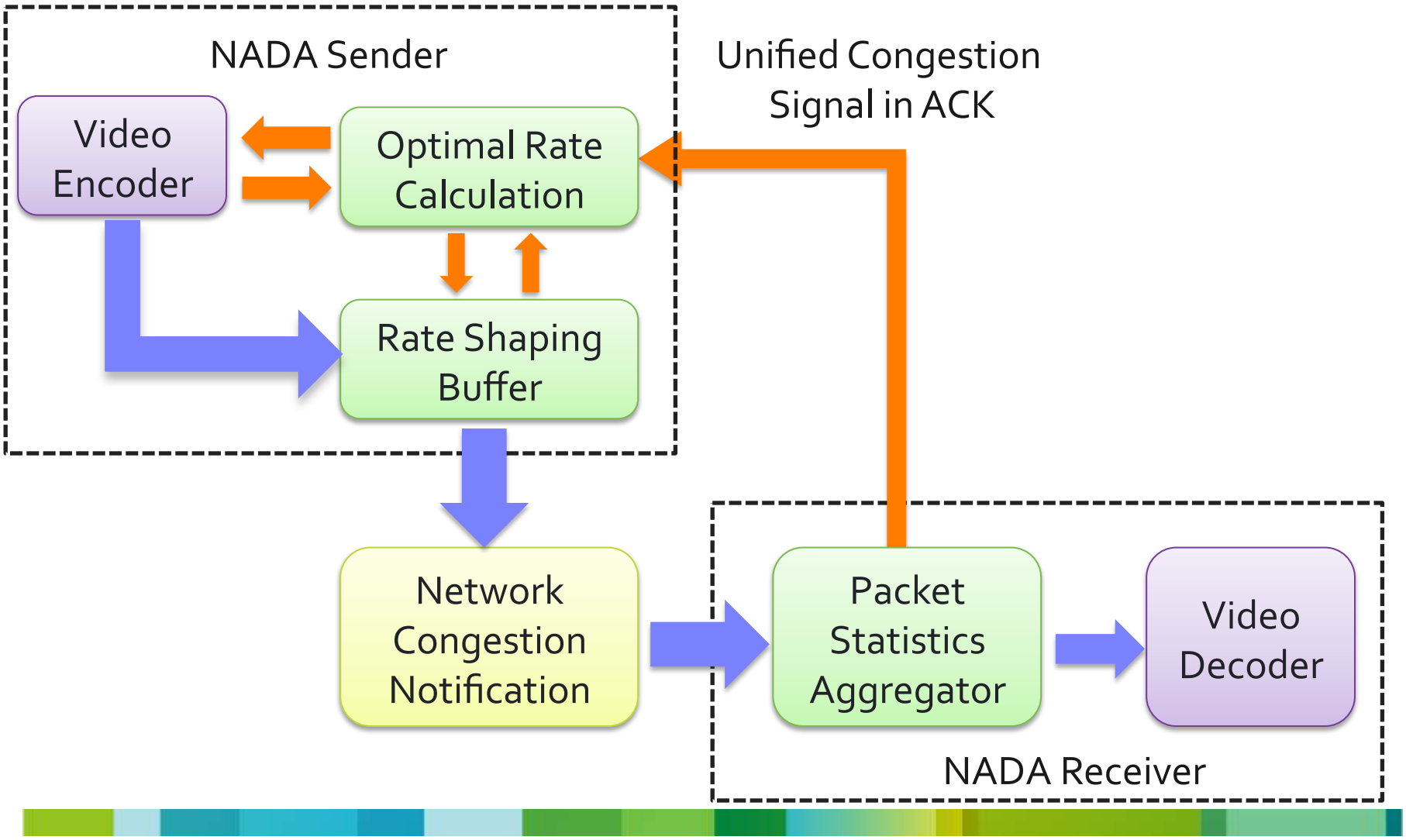
Design Goal of NADA #2: Leverage A Suite of Feedback Mechanisms



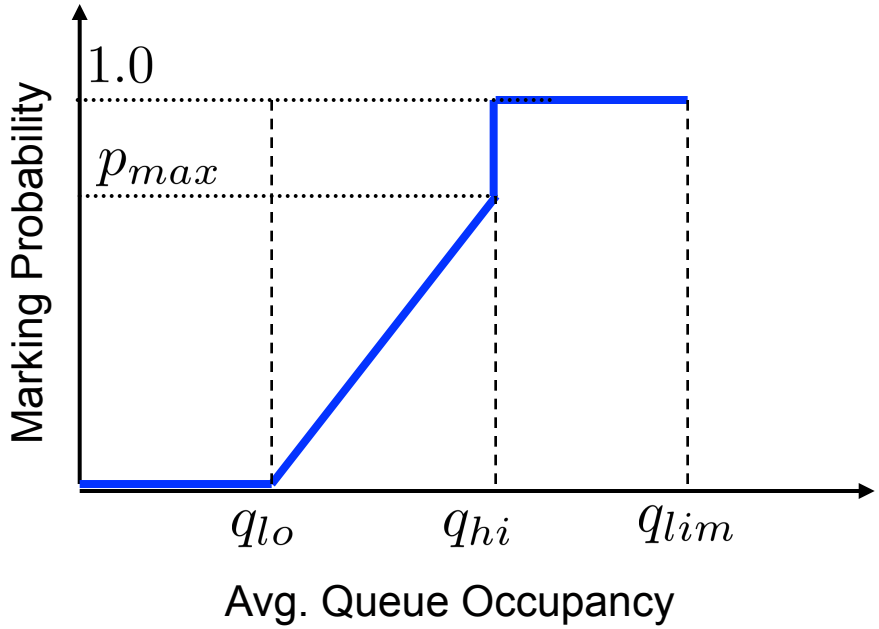
Design Goal of NADA #3: Weighted Bandwidth Sharing

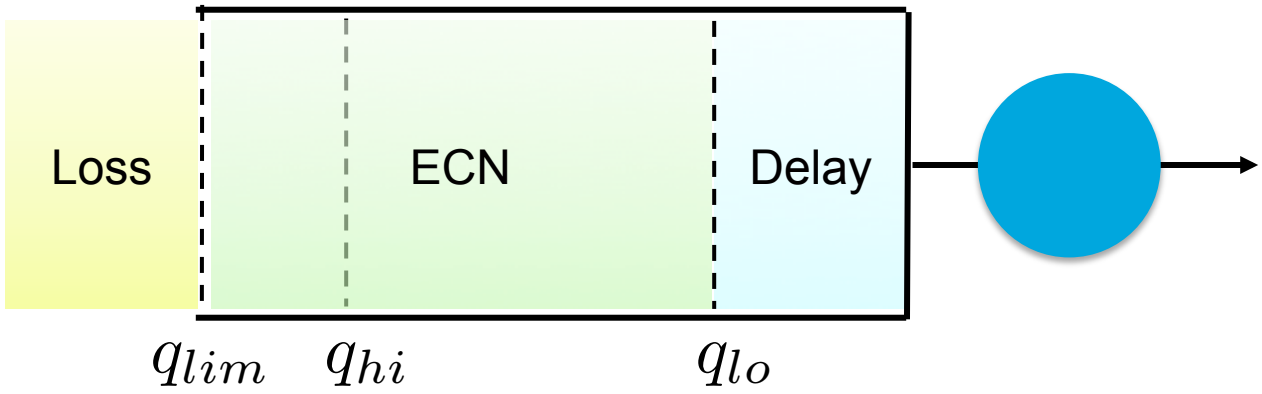


Architecture Overview



Congestion Signals At the Network Node





NADA Receiver Behavior

- Obtain per-packet observations:

$$d_n = t_{r,n} - t_{s,n}$$

$$\mathbf{1}_M := \begin{cases} 0, & \text{no marking} \\ 1, & \text{w/ marking} \end{cases}$$

$$\mathbf{1}_L := \begin{cases} 0, & \text{no loss} \\ 1, & \text{w/ loss} \end{cases}$$

- Calculate equivalent delay:

Virtual delay of marking

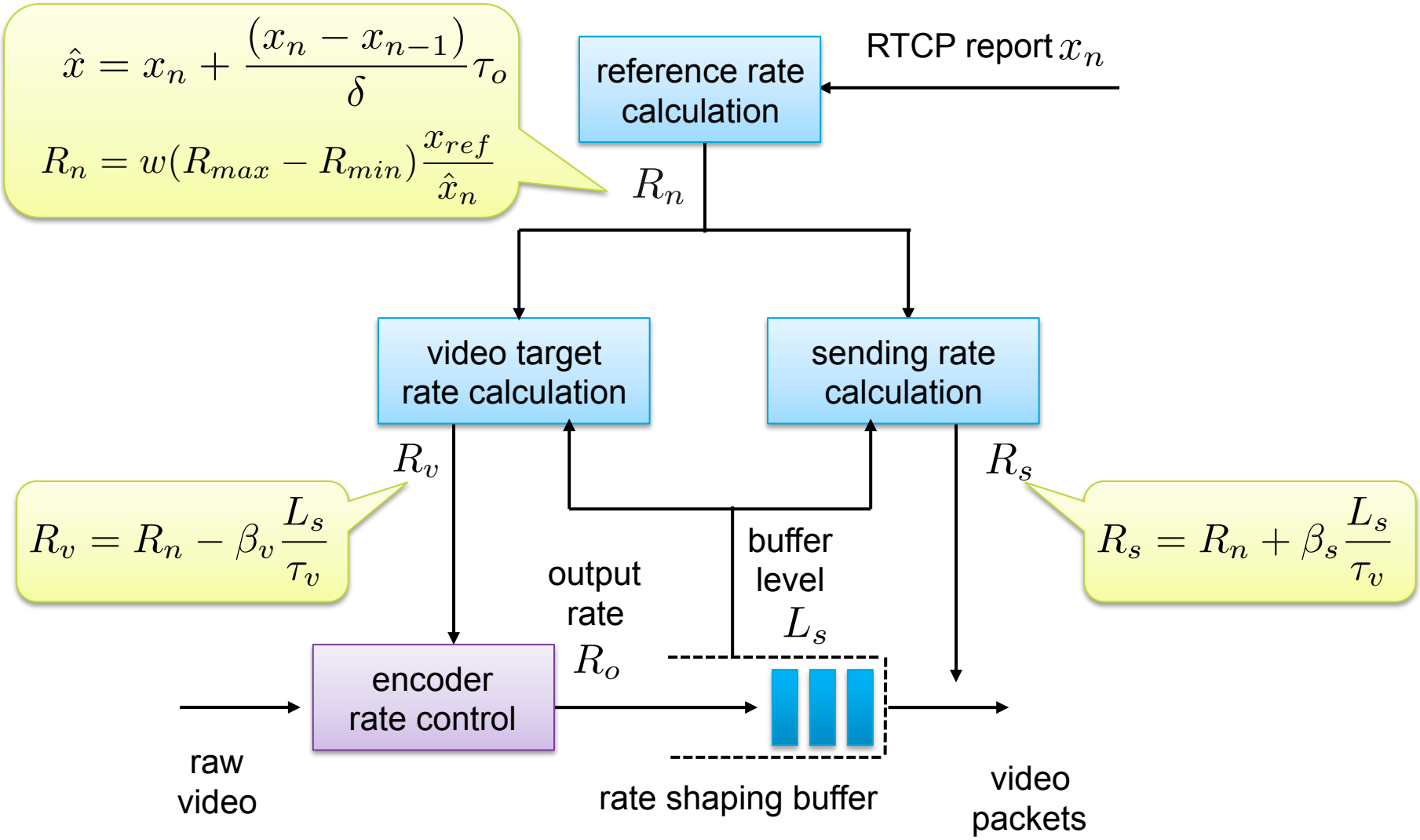
Virtual delay of loss

$$\tilde{d}_n = d_n + \mathbf{1}_M d_M + \mathbf{1}_L d_L$$

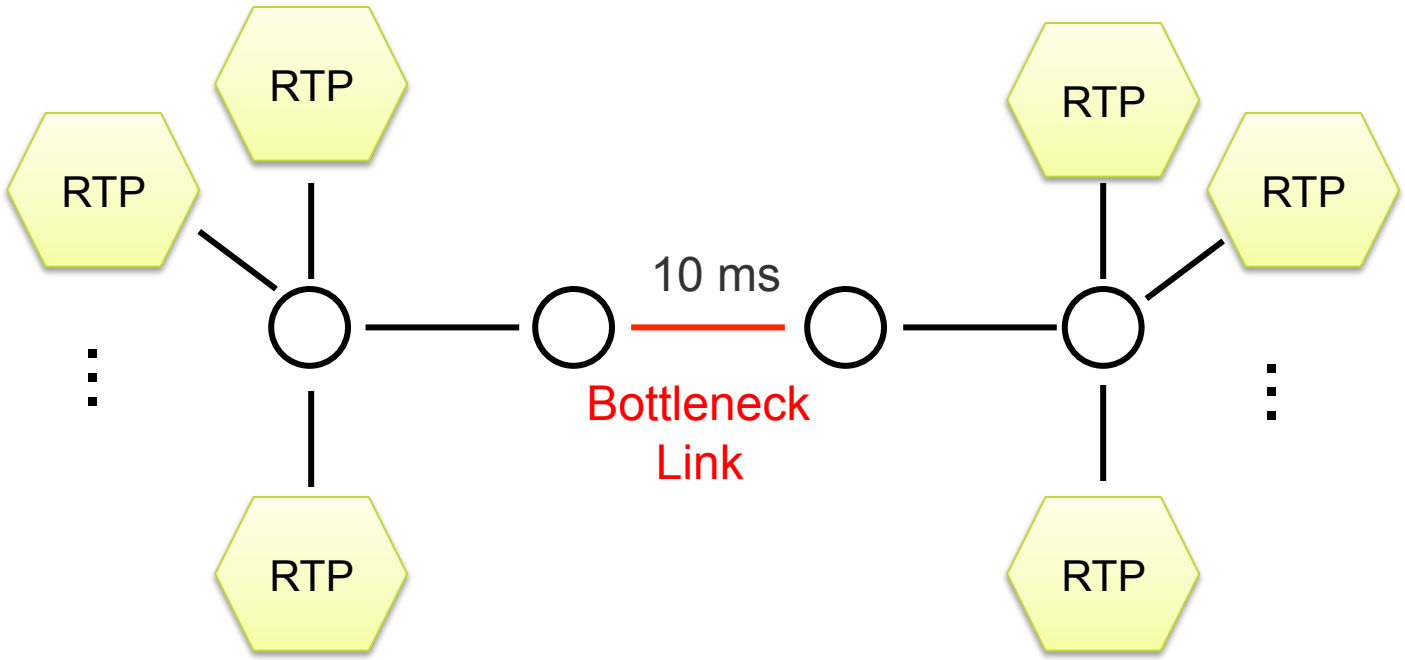
- Exponential smoothing:

$$x_n = (1-\alpha)x_{n-1} + \alpha\tilde{d}_n$$

NADA Sender Behavior



Simulation Scenarios

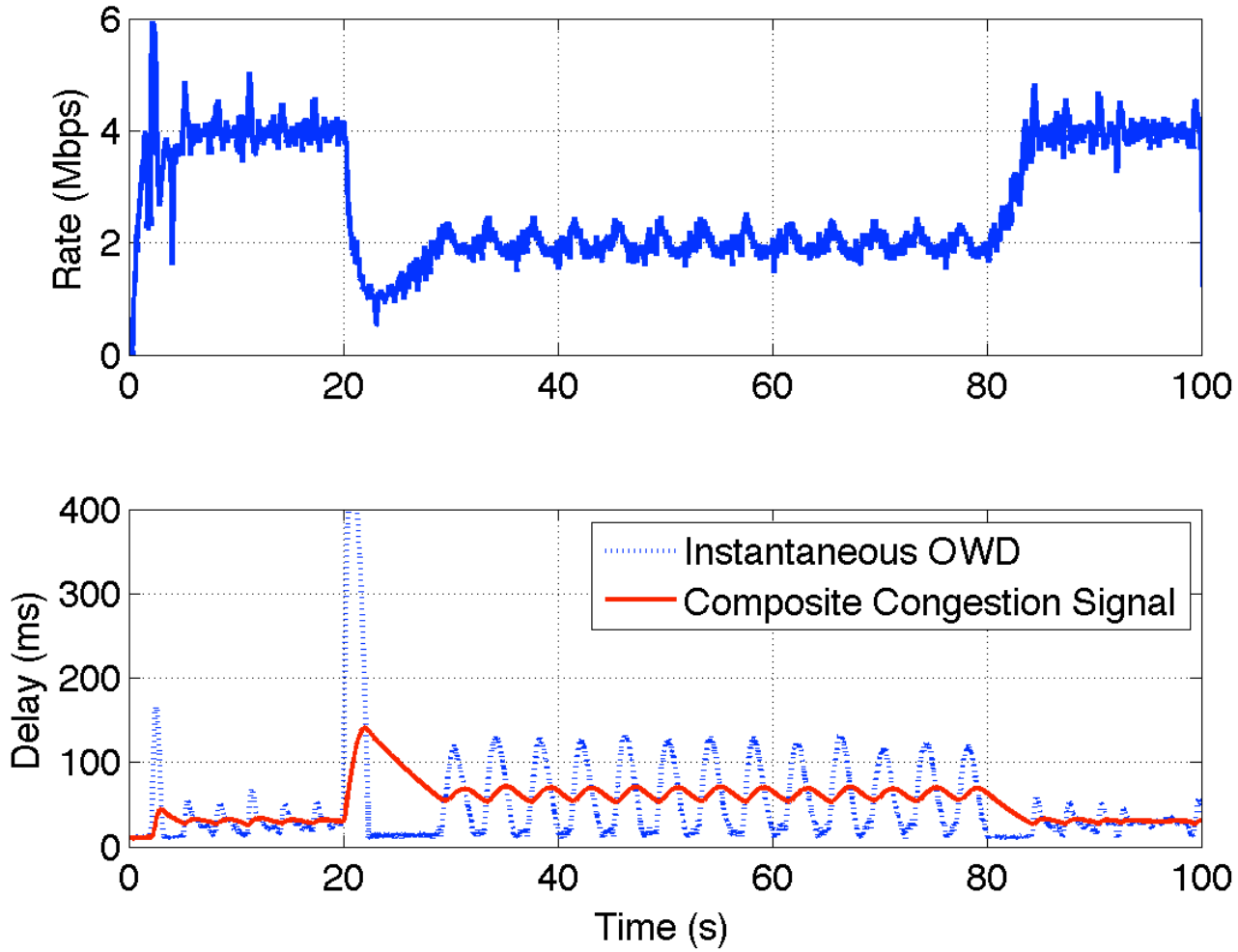


- Single NADA stream with time-varying link capacity
- Multiple competing NADA streams with different weights of priority
- Multiple NADA streams competing against TCP

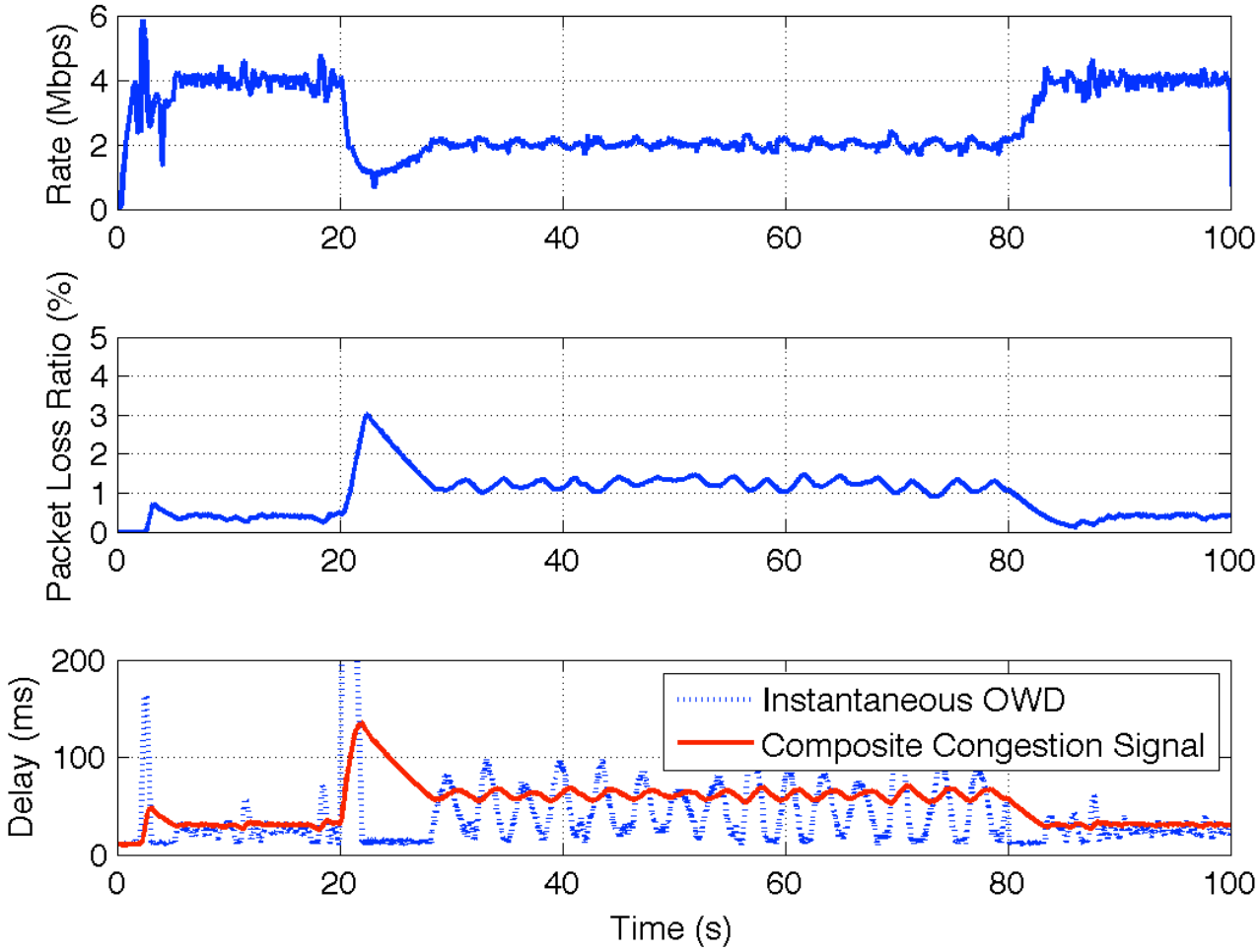
A Suite of Queue Management Schemes

- DropTail: Queue-based dropping
- RED: Queue-based random dropping
- CoDel: Delay-based deterministic dropping
- PIE: Delay-based random dropping
- PCN: Virtual-queue-based random marking

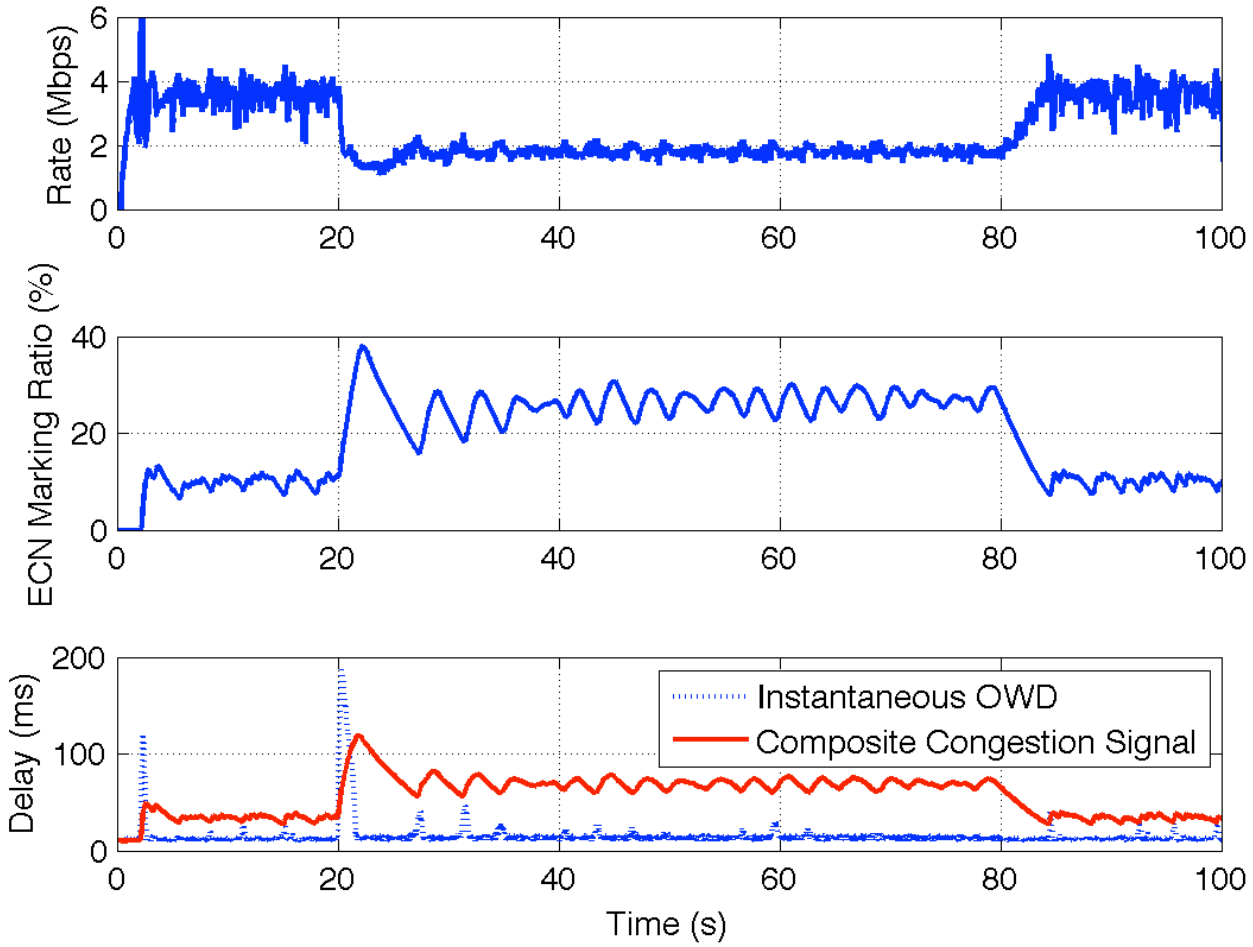
Time-Varying Link: NADA+DropTail



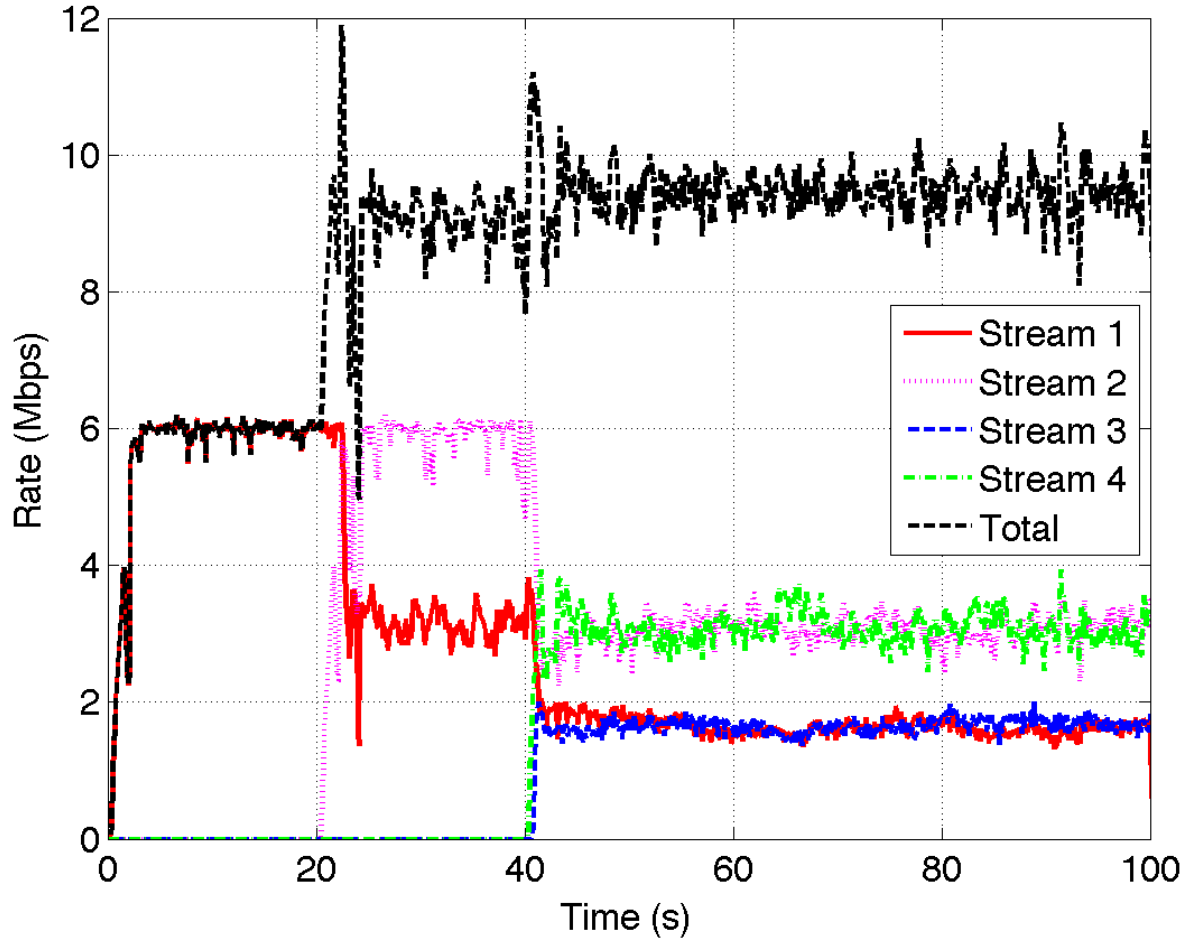
Time-Varying Link: NADA+RED



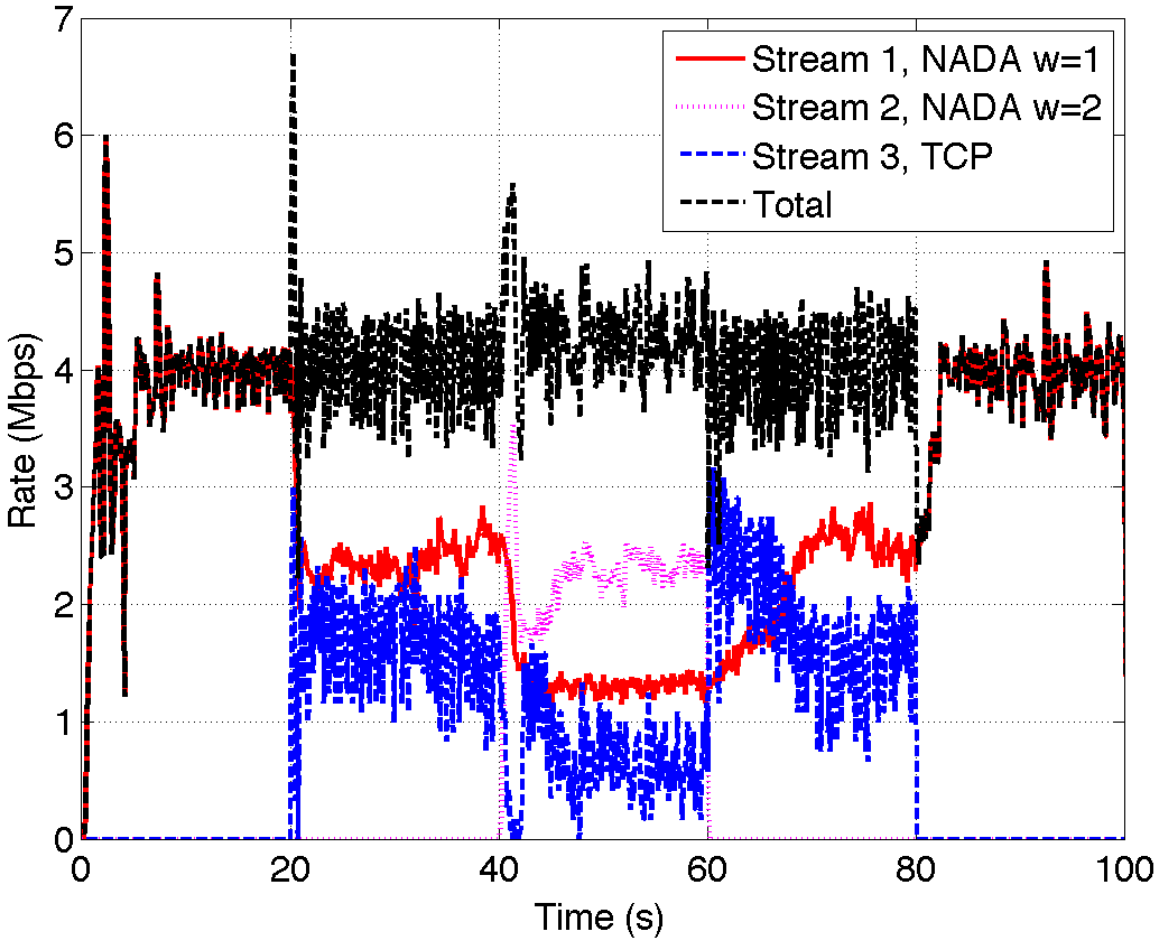
Time-Varying Link: NADA+PCN



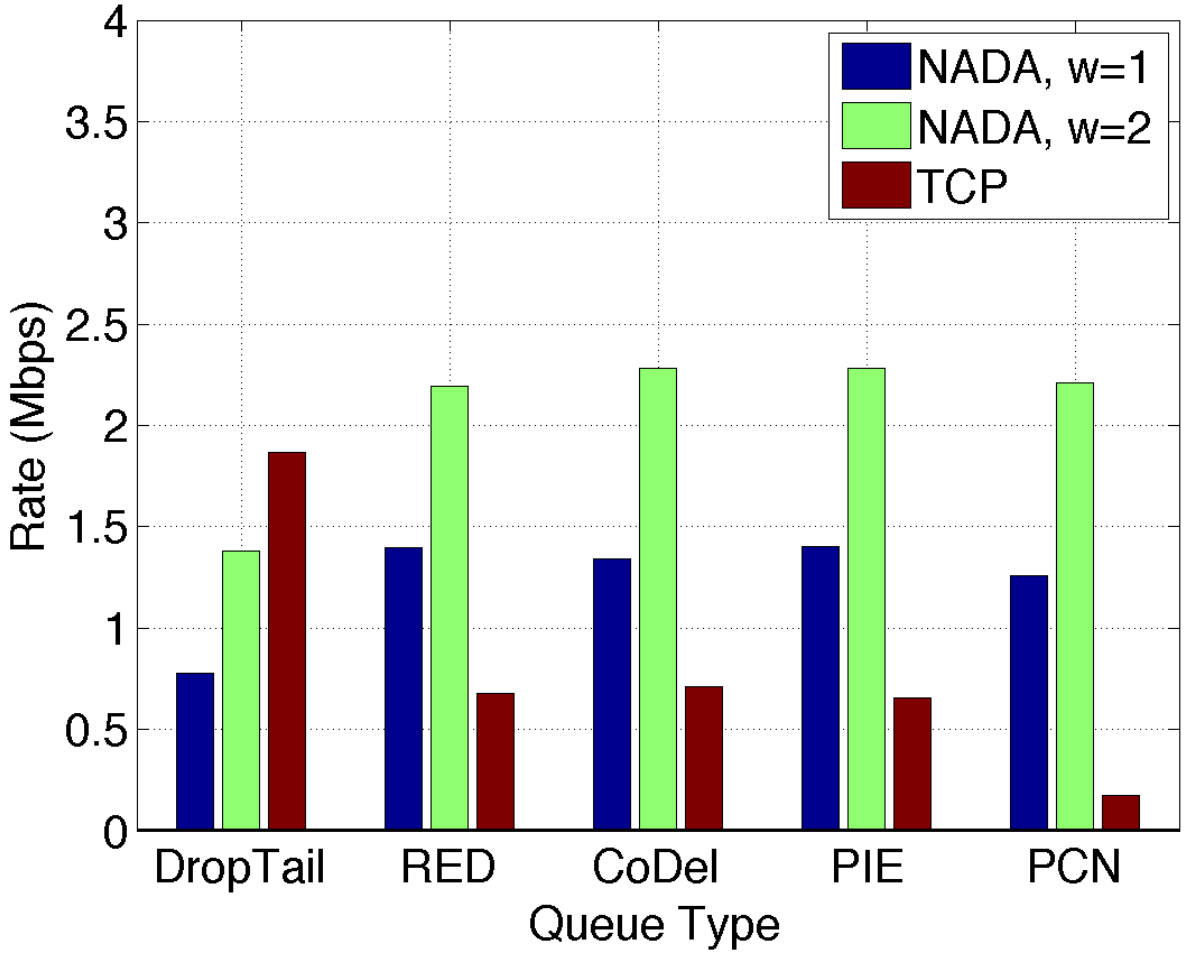
Multiple Competing NADA Streams



NADA Competing against TCP: w/ RED



NADA Competing against TCP: Different Queue Types



Conclusions & Future Work

- Key benefits of NADA:
  - Fast and stable rate adaptation
  - Graceful transition across a range of congestion signals and AQM schemes
  - Zero standing queue with PCN
  - Weighted bandwidth sharing
- Ongoing work:
  - Testbed implementation and evaluation
  - Integration of proactive error protection