NADA: A Unified Congestion Control Scheme for Real-Time Media

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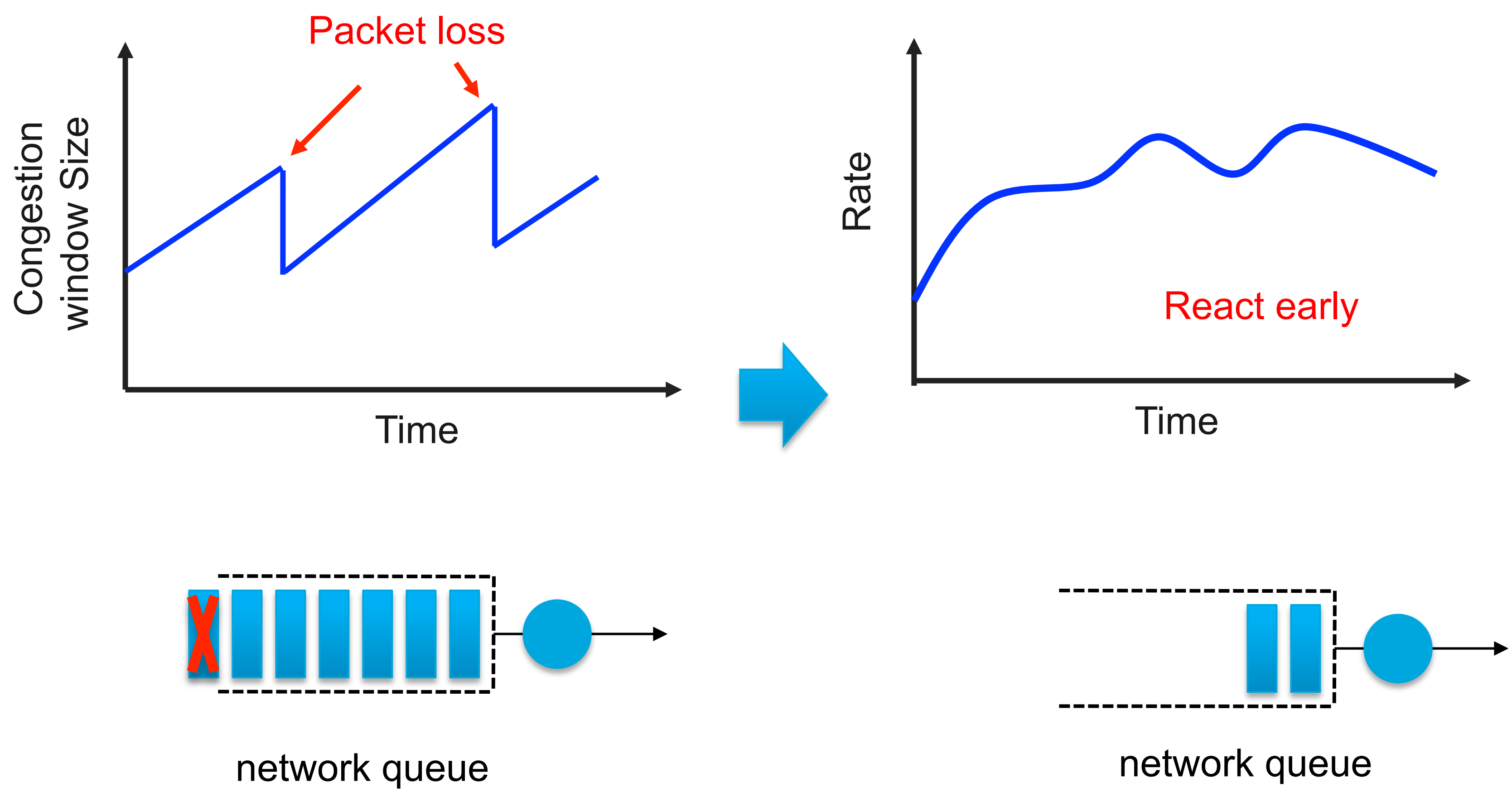
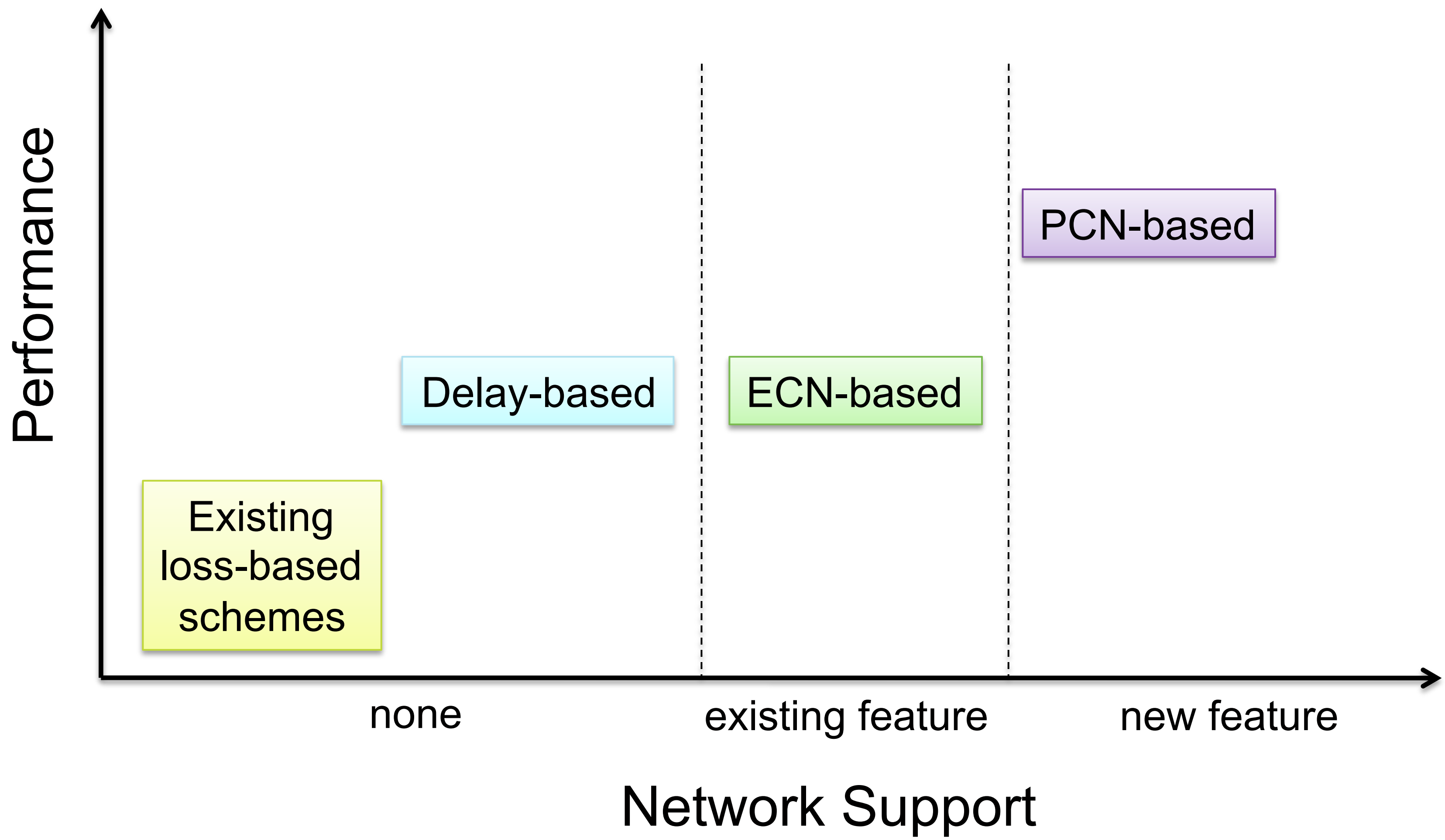
Agenda

- Design goals
- Network congestion signals
- Receiver behavior
- Sender operations
- Highlight of results

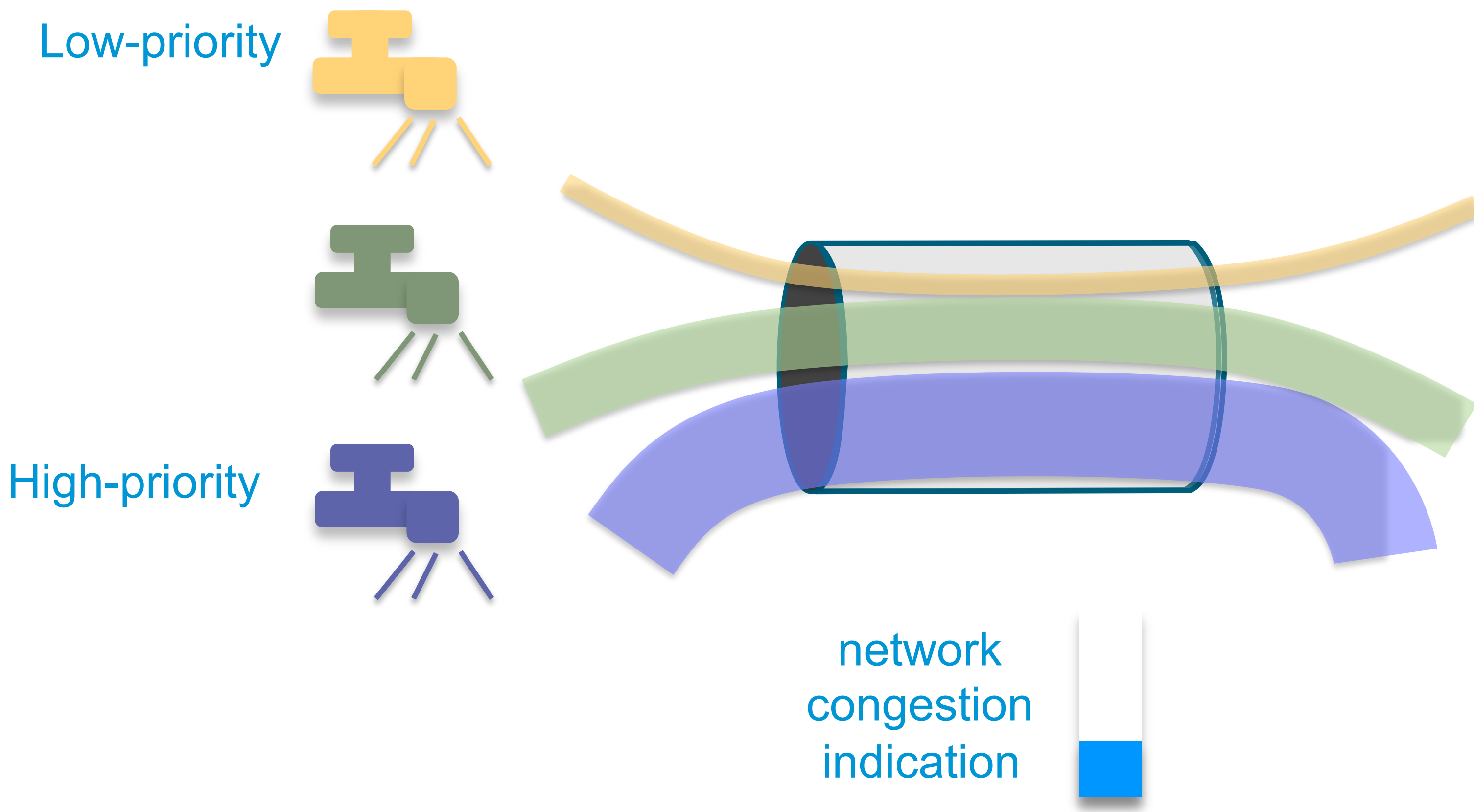
Design Goal #1:
Limit Self-Inflicted Delay



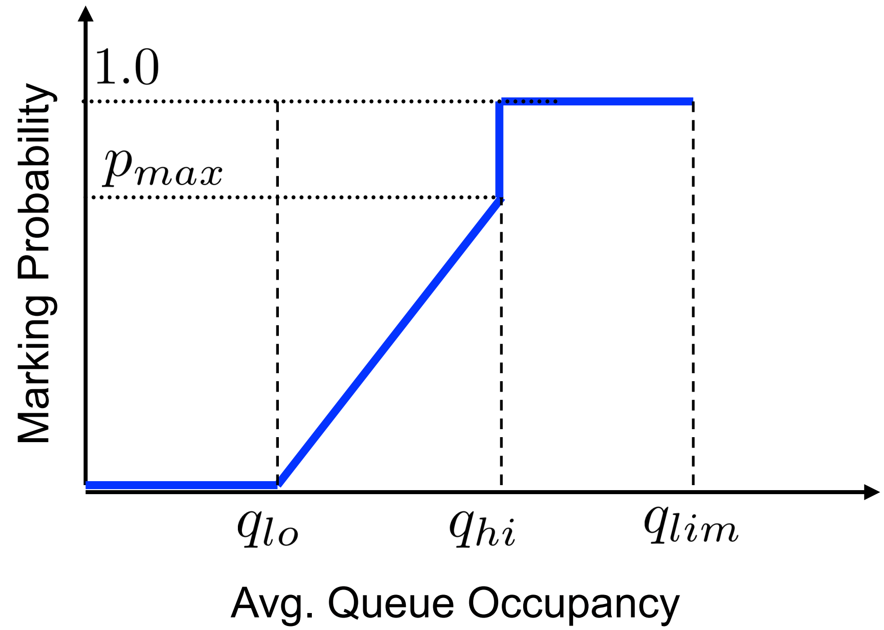
Design Goal #2:
Leverage A Suite of Feedback Mechanisms

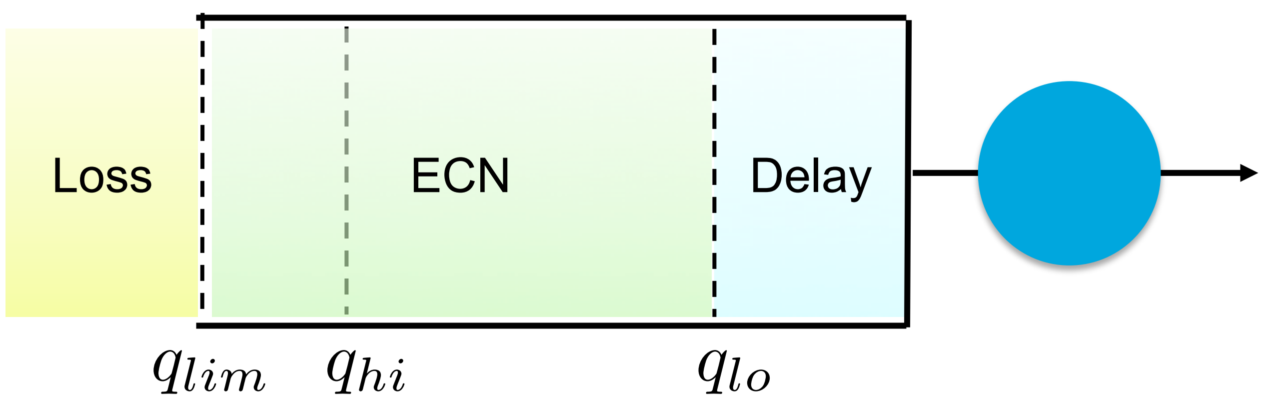


Design Goal #3: Weighted Bandwidth Sharing



Congestion Signals At the Network Node





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

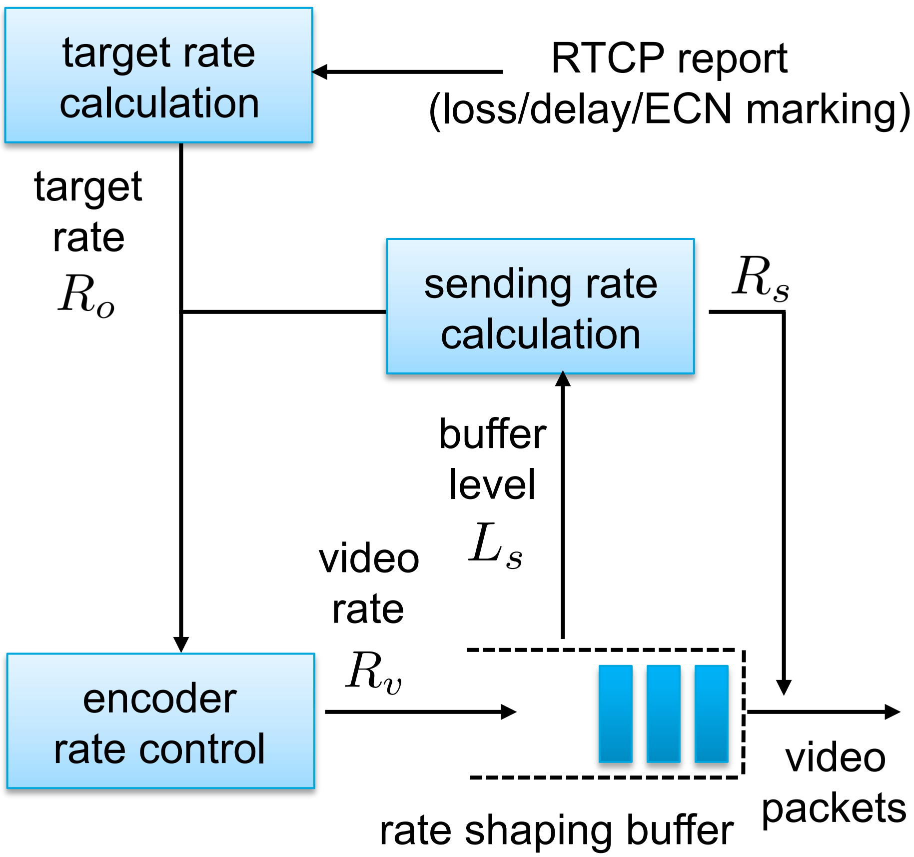
Virtual delay of loss

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

- Exponential smoothing:

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

Sender Operation



- Linear prediction:

$$\hat{x} = x_n + \frac{(x_n - x_{n-1})}{\delta}\tau_o$$

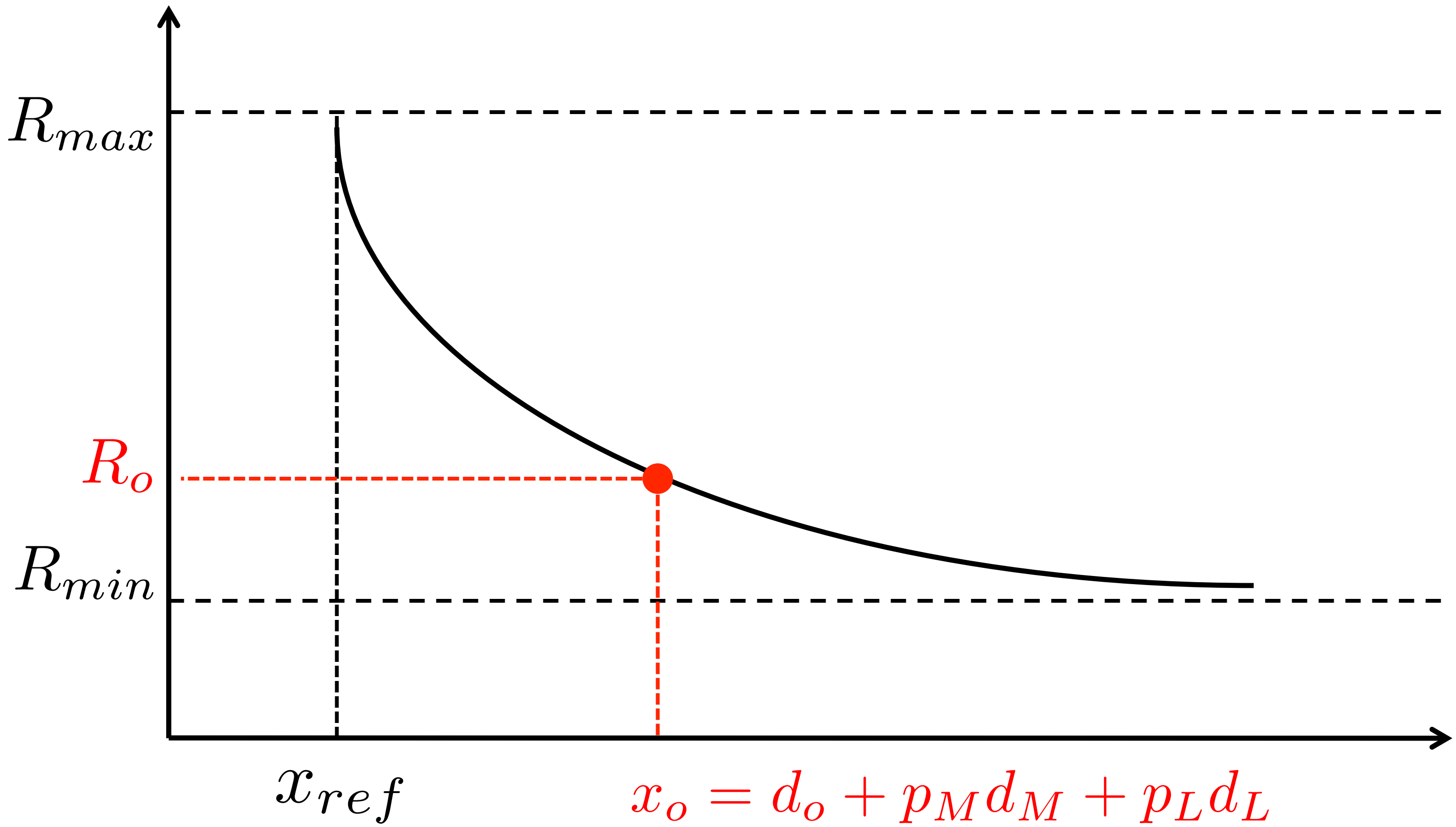
- Calculate target rate:

$$R_o = R_{min} + w(R_{max} - R_{min})\frac{x_{ref}}{\hat{x}_n}$$

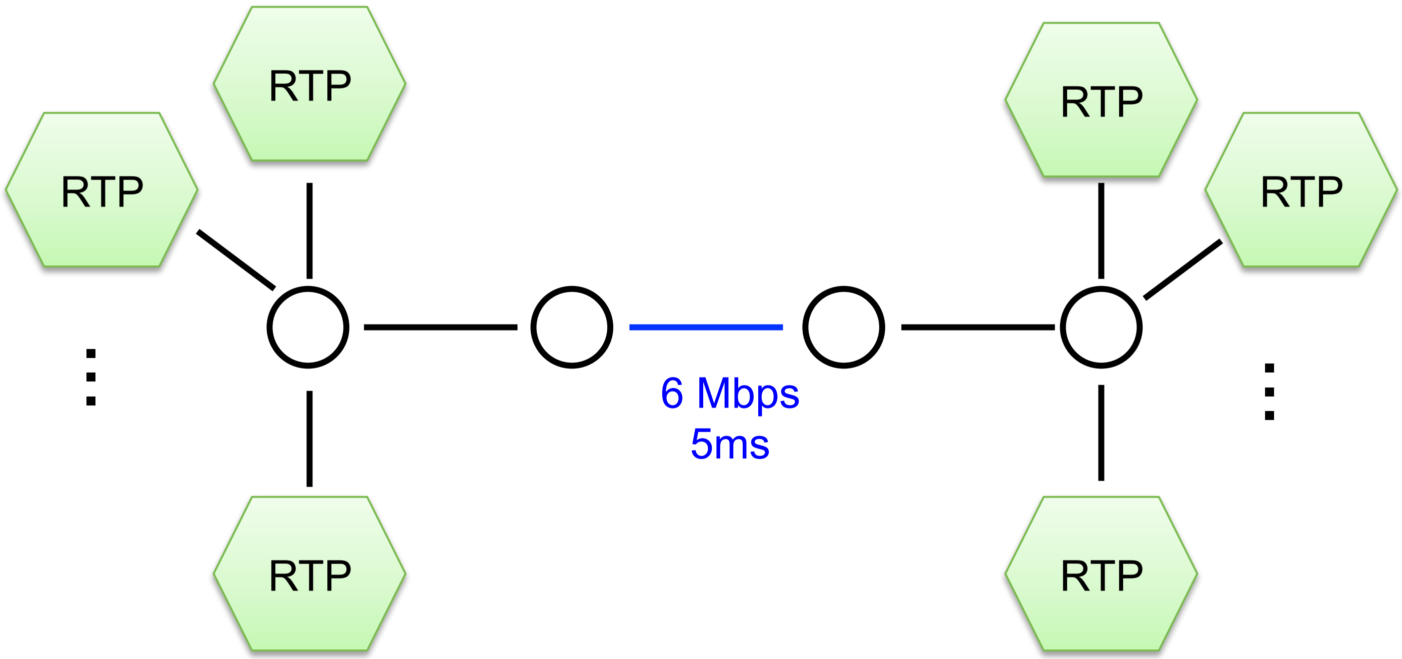
- Adjust for sending buffer:

$$R_s = R_o + \beta\frac{L_s}{\tau_v}$$

Result at Equilibrium

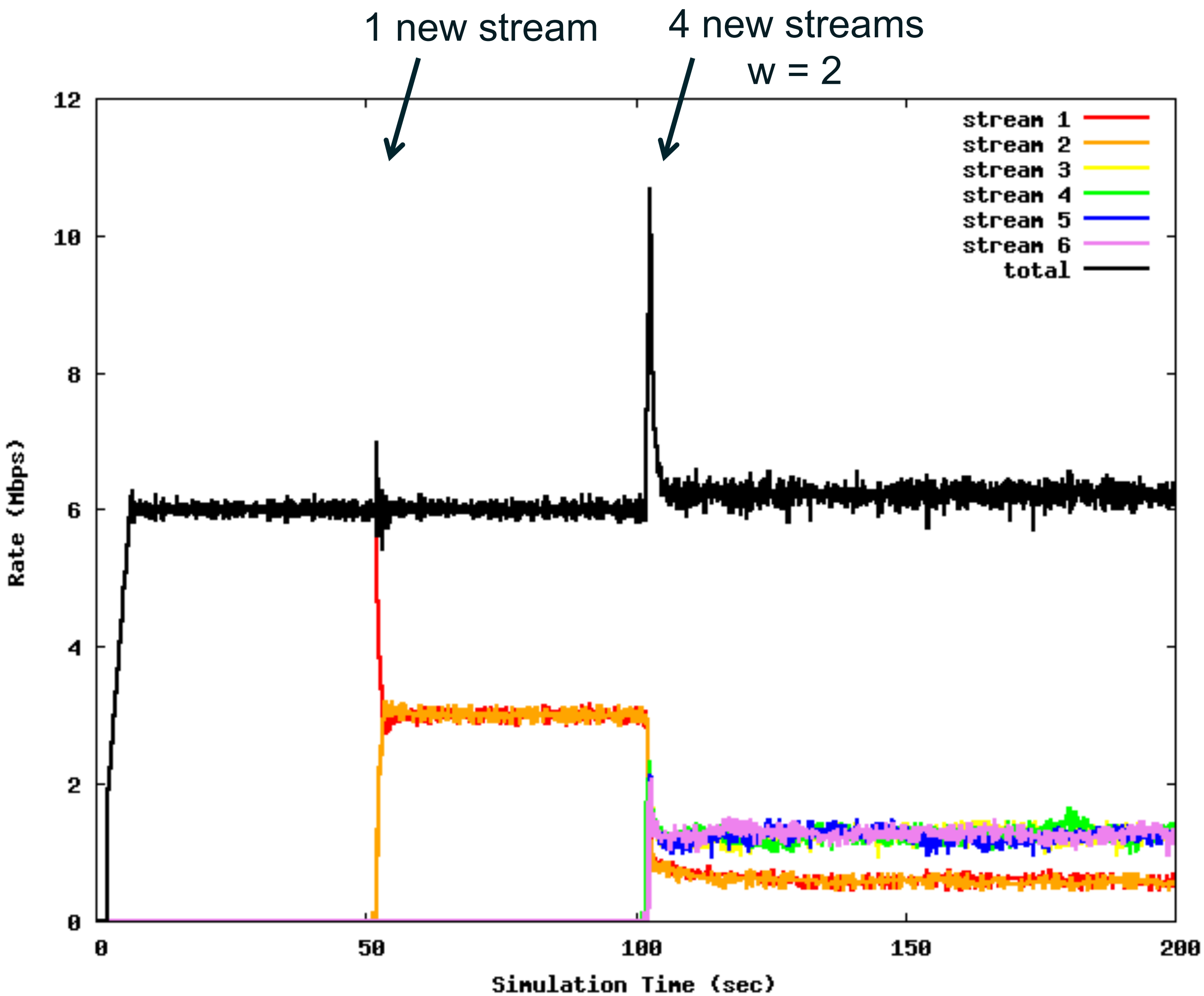


Simulation Setup

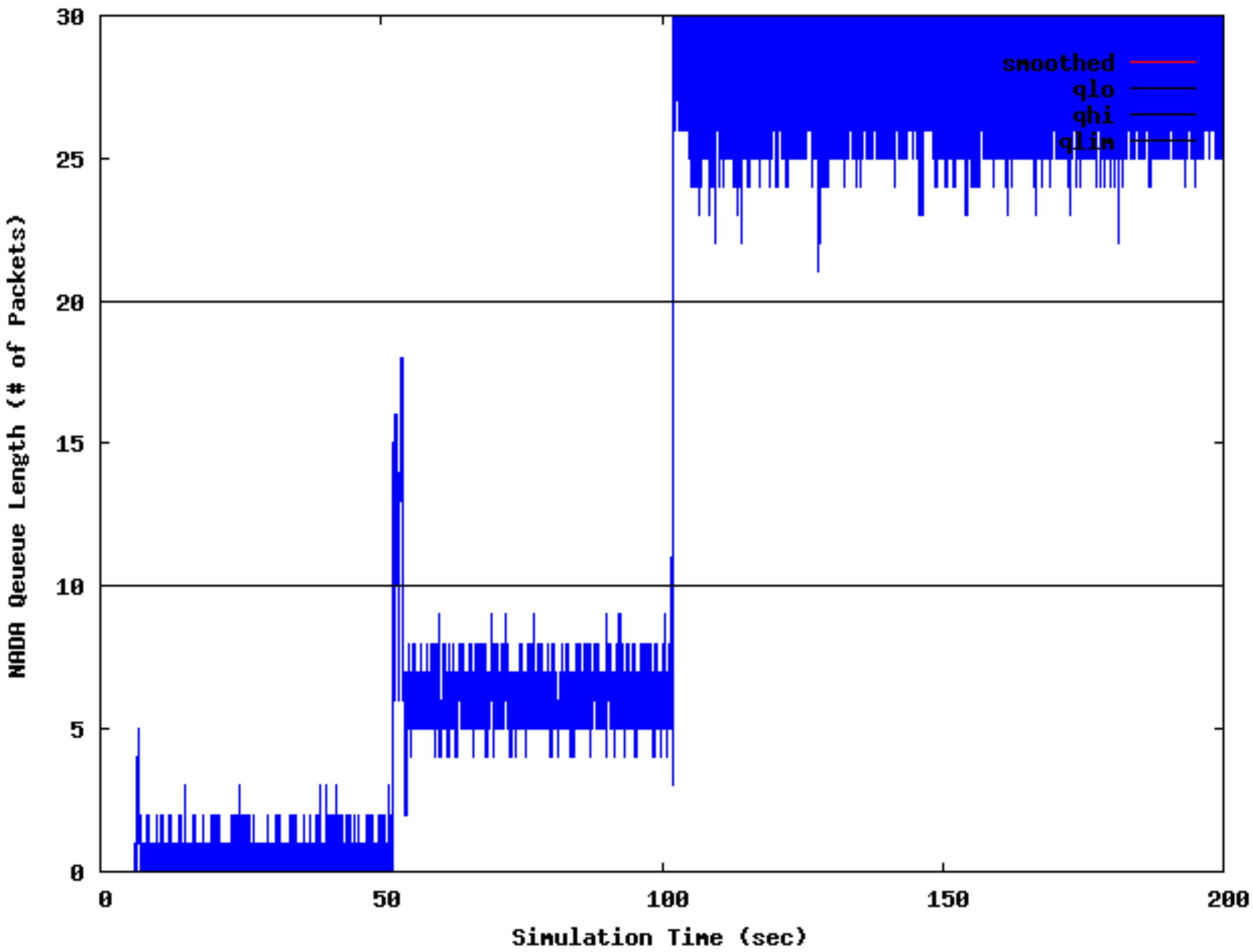


- Six competing streams
- Comparison of three modes: w/o ECN, ECN-based, and PCN-based.

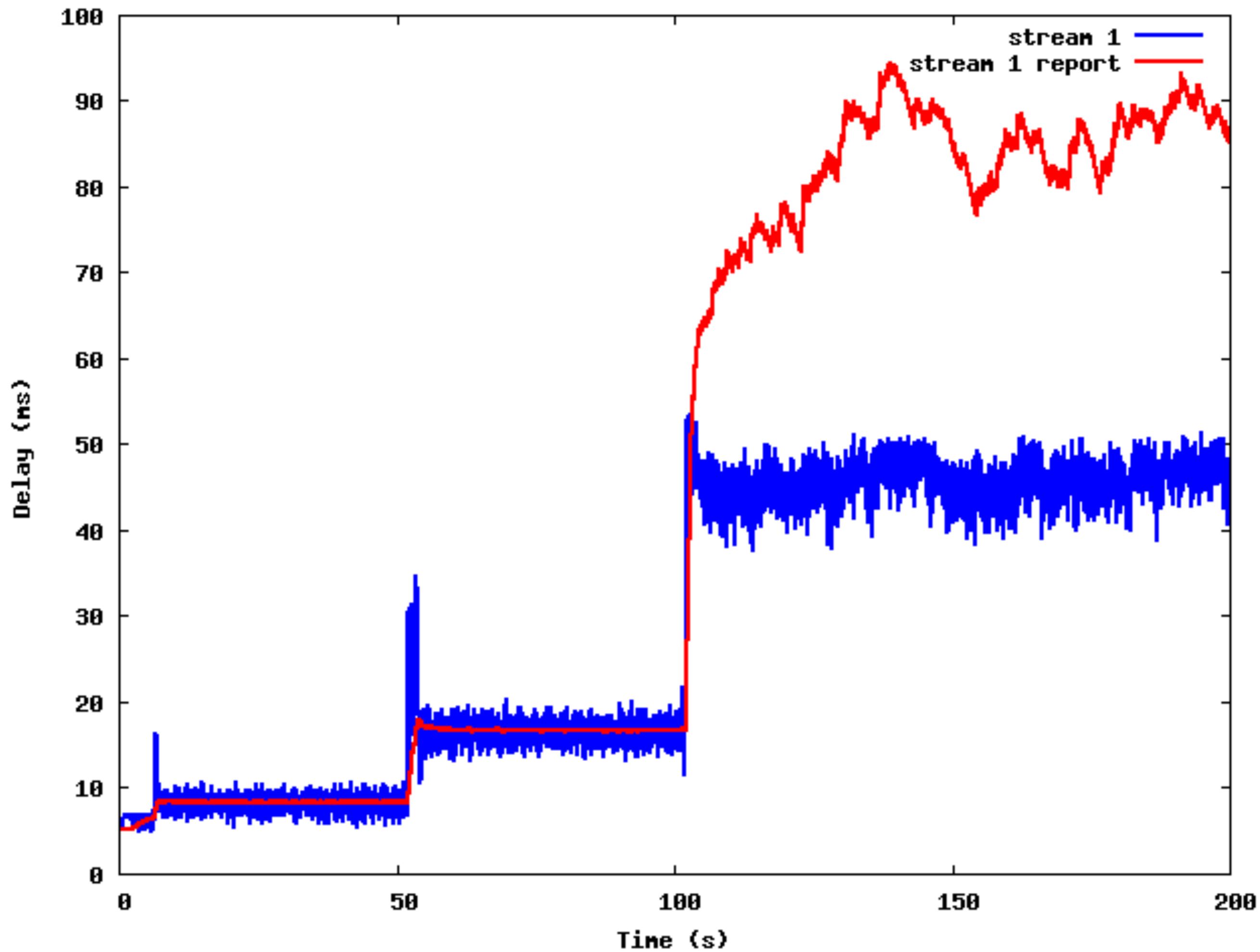
Without ECN: Per-Stream Rate



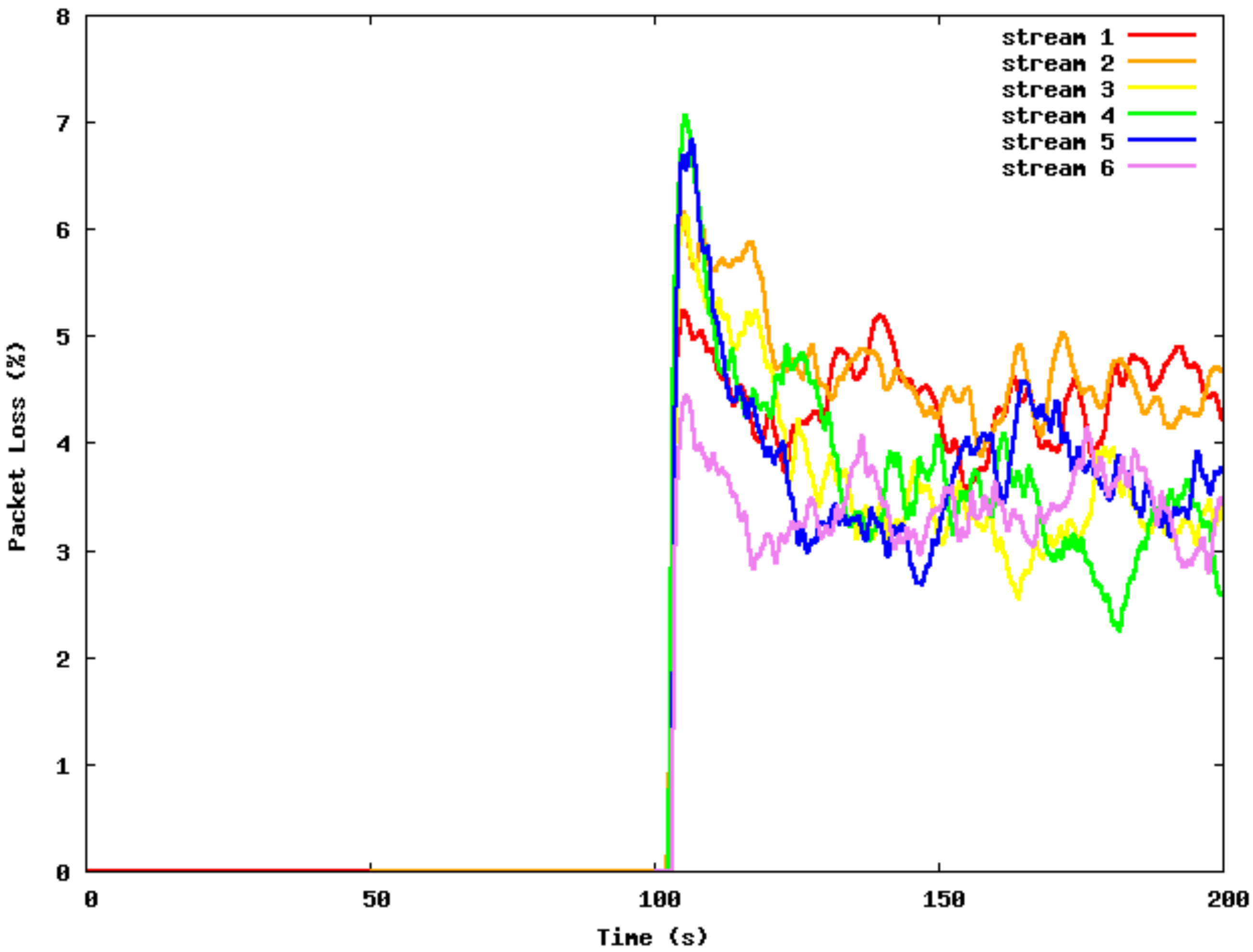
Without ECN: Bottleneck Queue Length



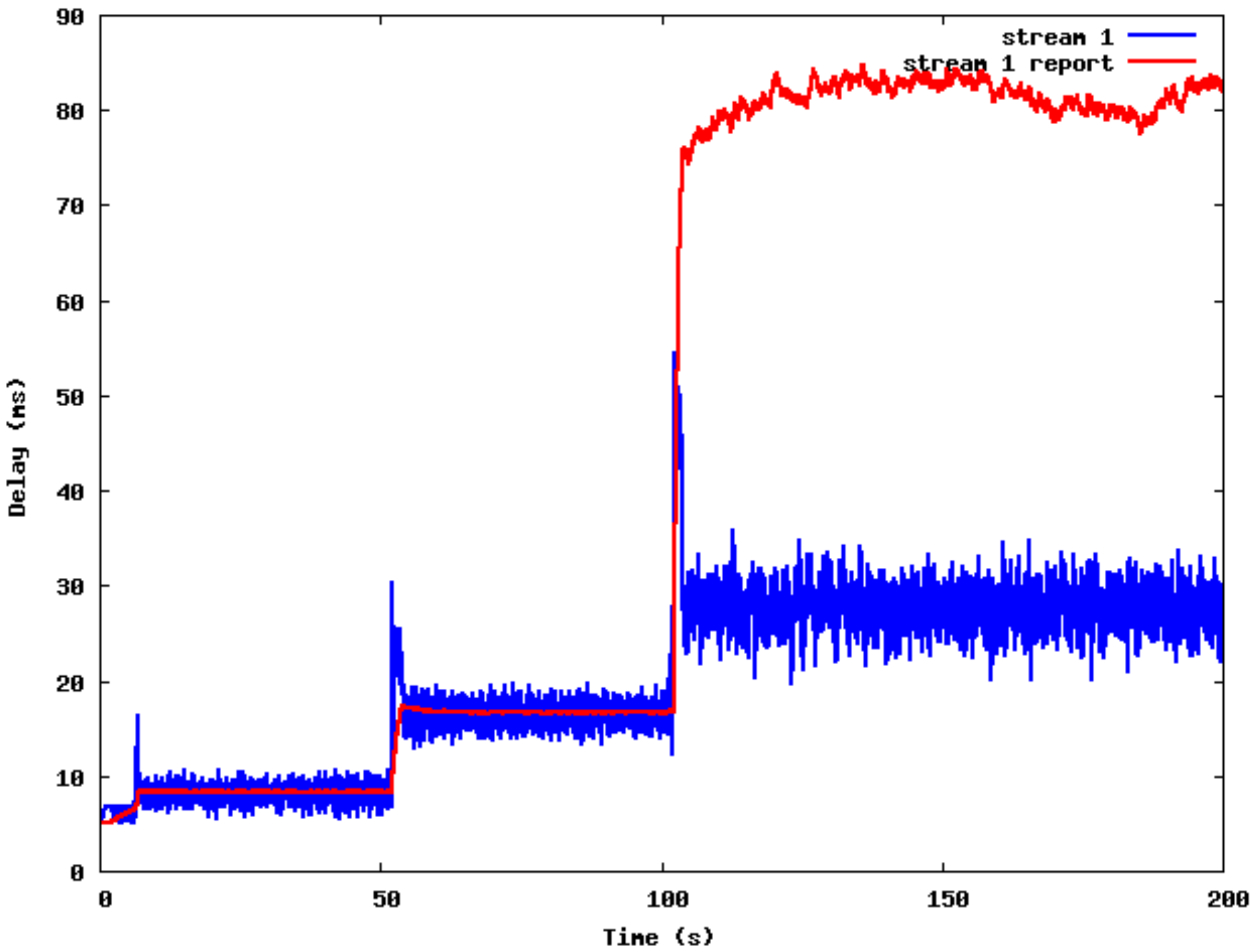
Without ECN: Congestion Signal



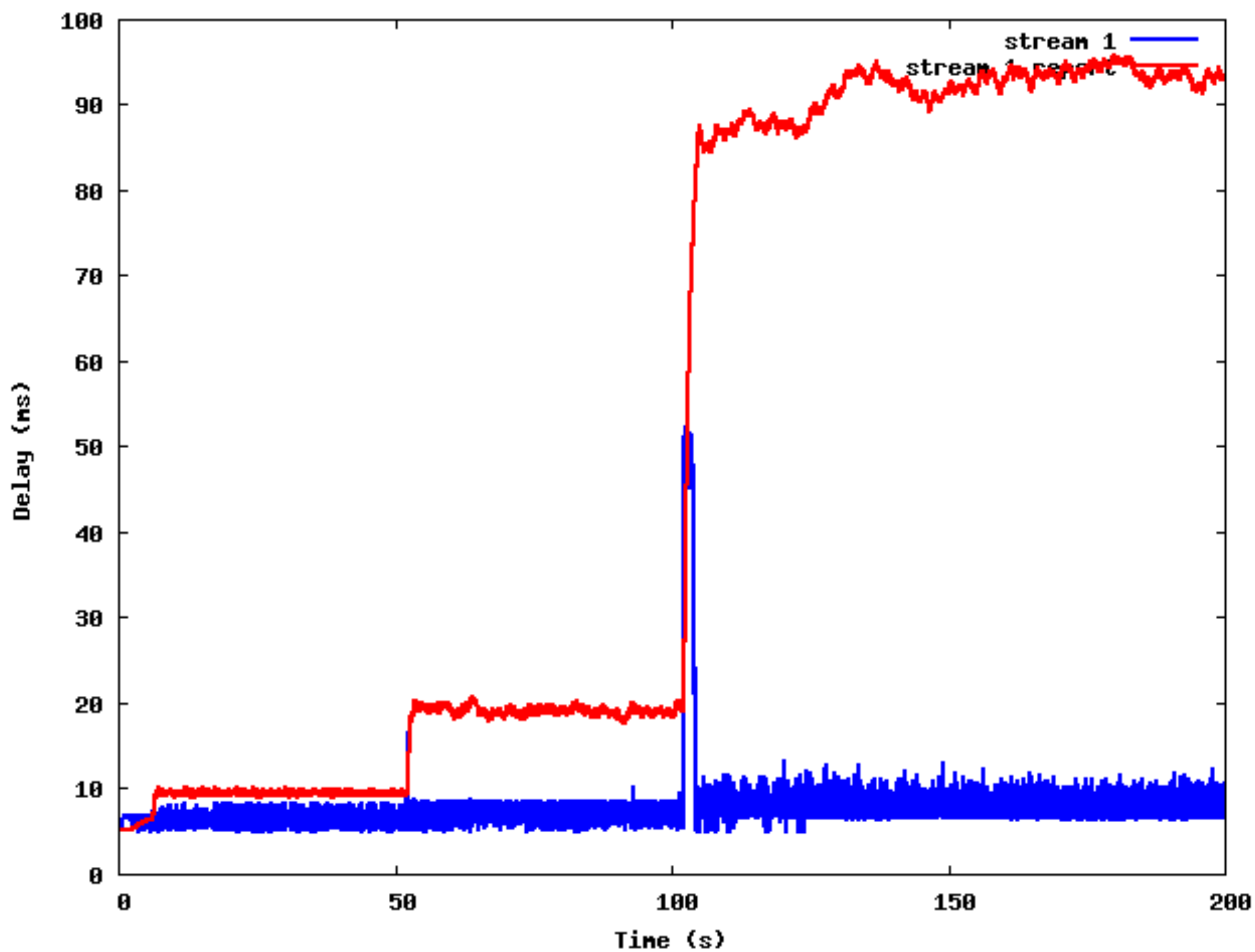
Without ECN: Packet Loss Ratio



With ECN: Congestion Signal



With PCN: Congestion Signal

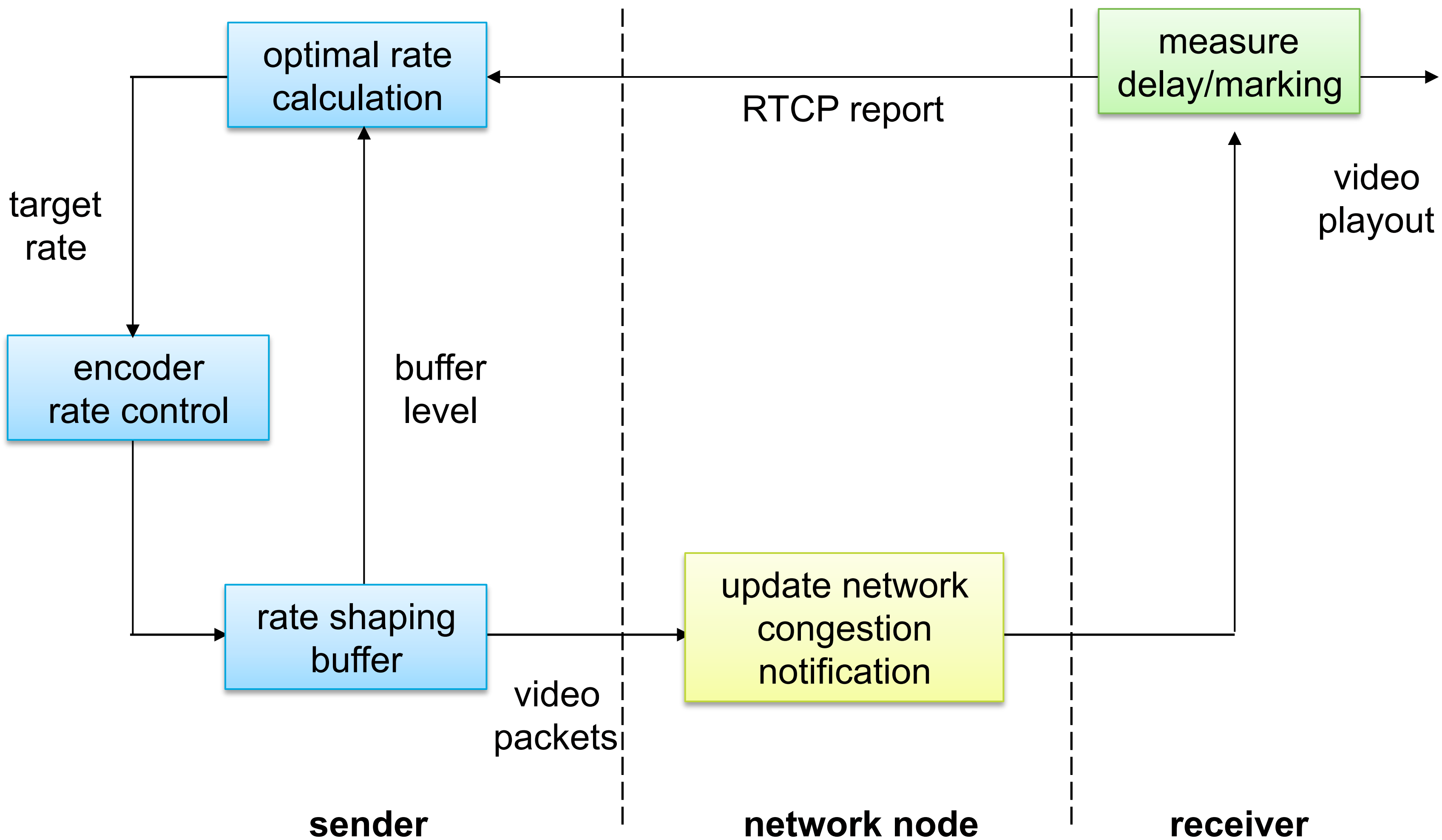


Key Benefits of NADA

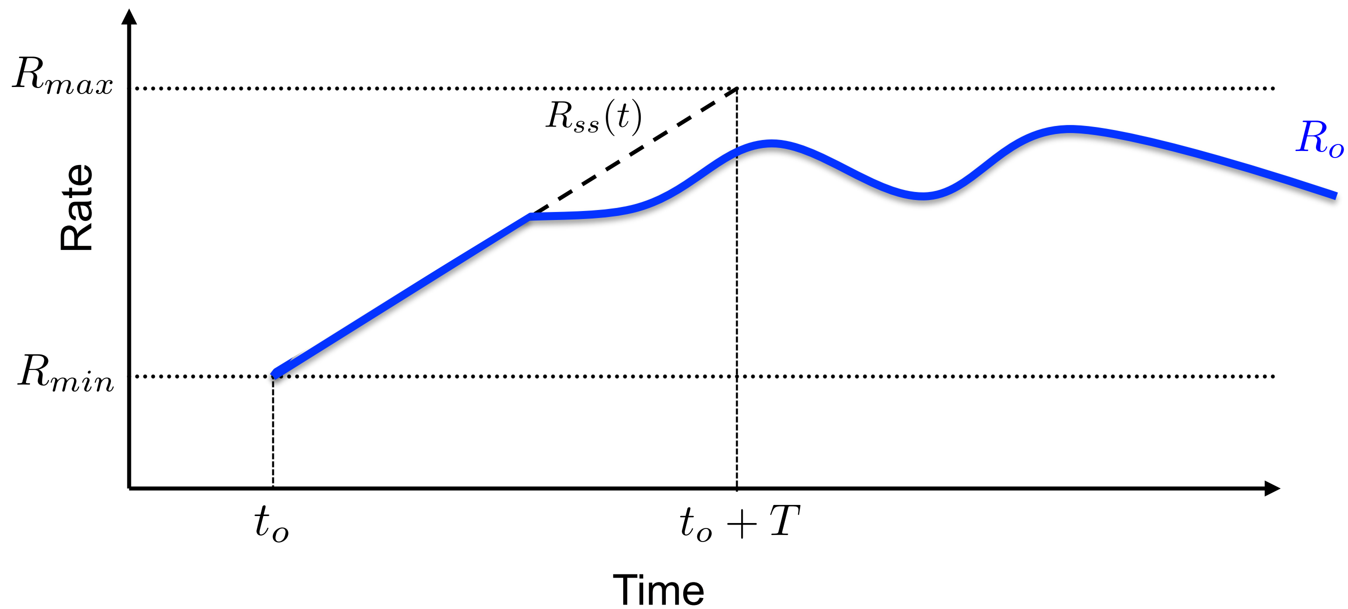
- Fast rate adaptation
- Weighted bandwidth sharing
- Graceful transition within a range of congestion signals: delay, loss, ECN/PCN markings
- In case of PCN: zero standing queue

Backup Slides

System Overview



Slow-Start Rate



start time

$$R_{ss}(t) = R_{min} + \frac{t - t_o}{T}(R_{max} - R_{min})$$

time horizon