

# CS144

## An Introduction to Computer Networks

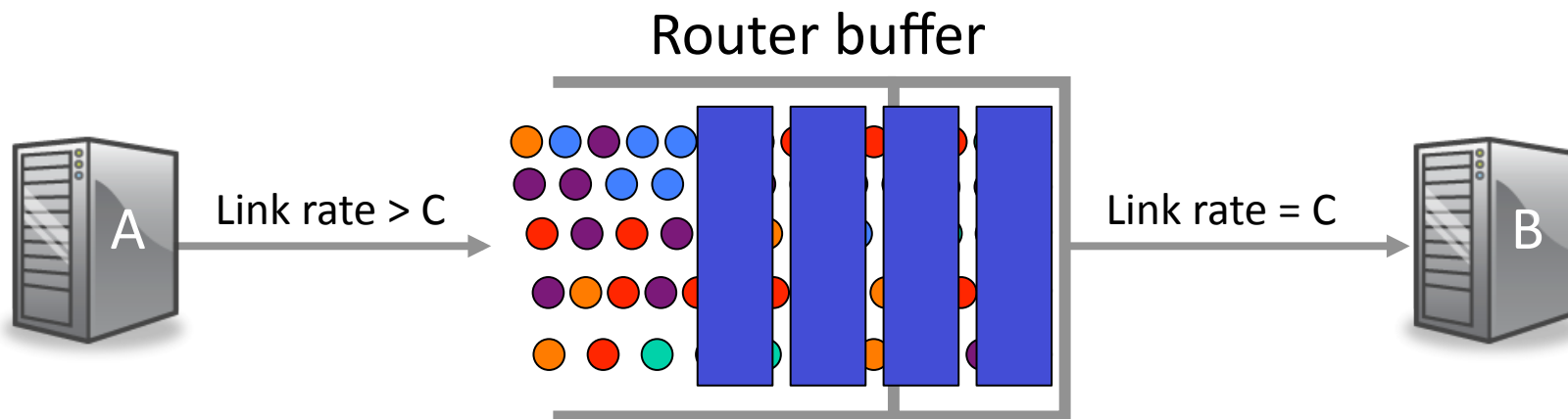
### Congestion

*AIMD with multiple flows*

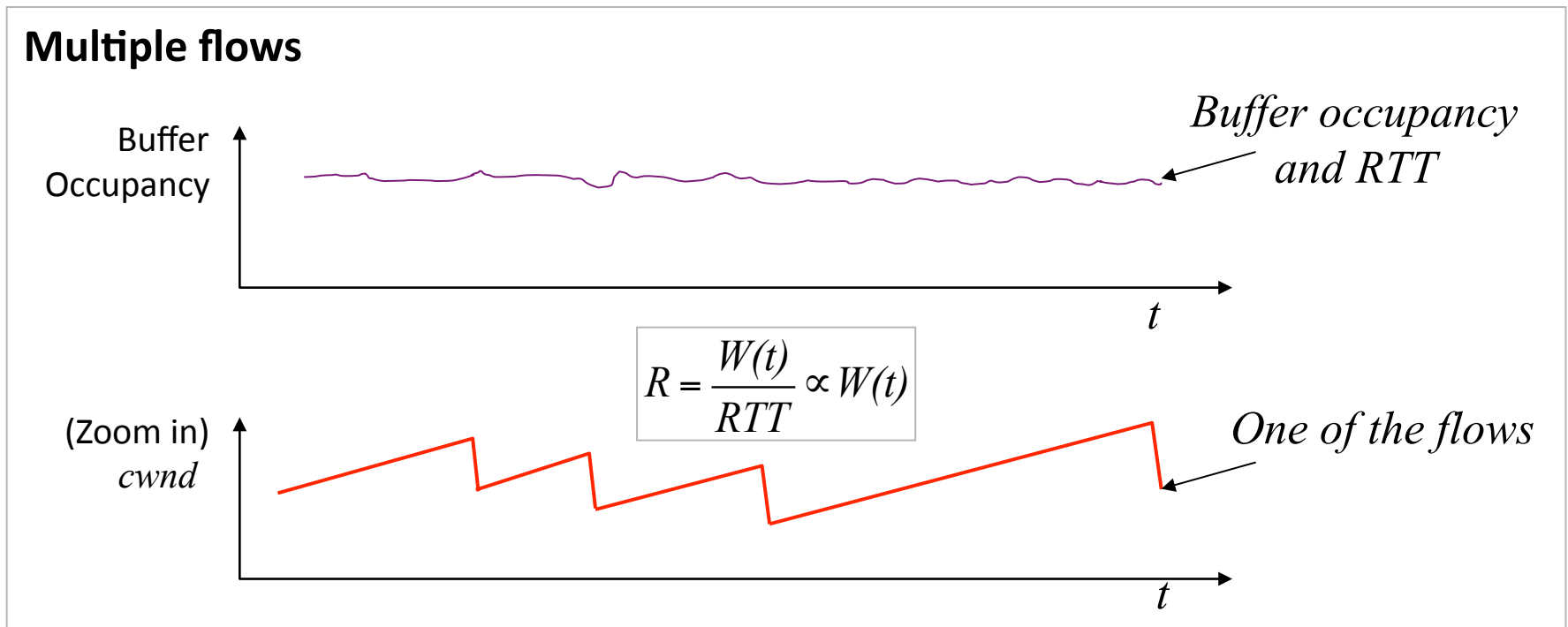
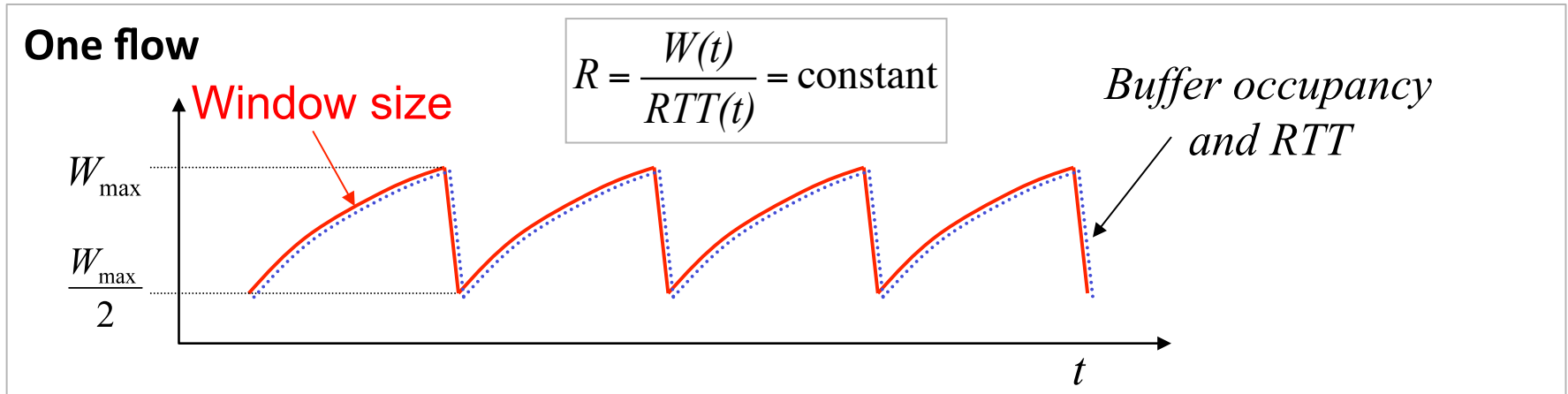


**Nick McKeown**

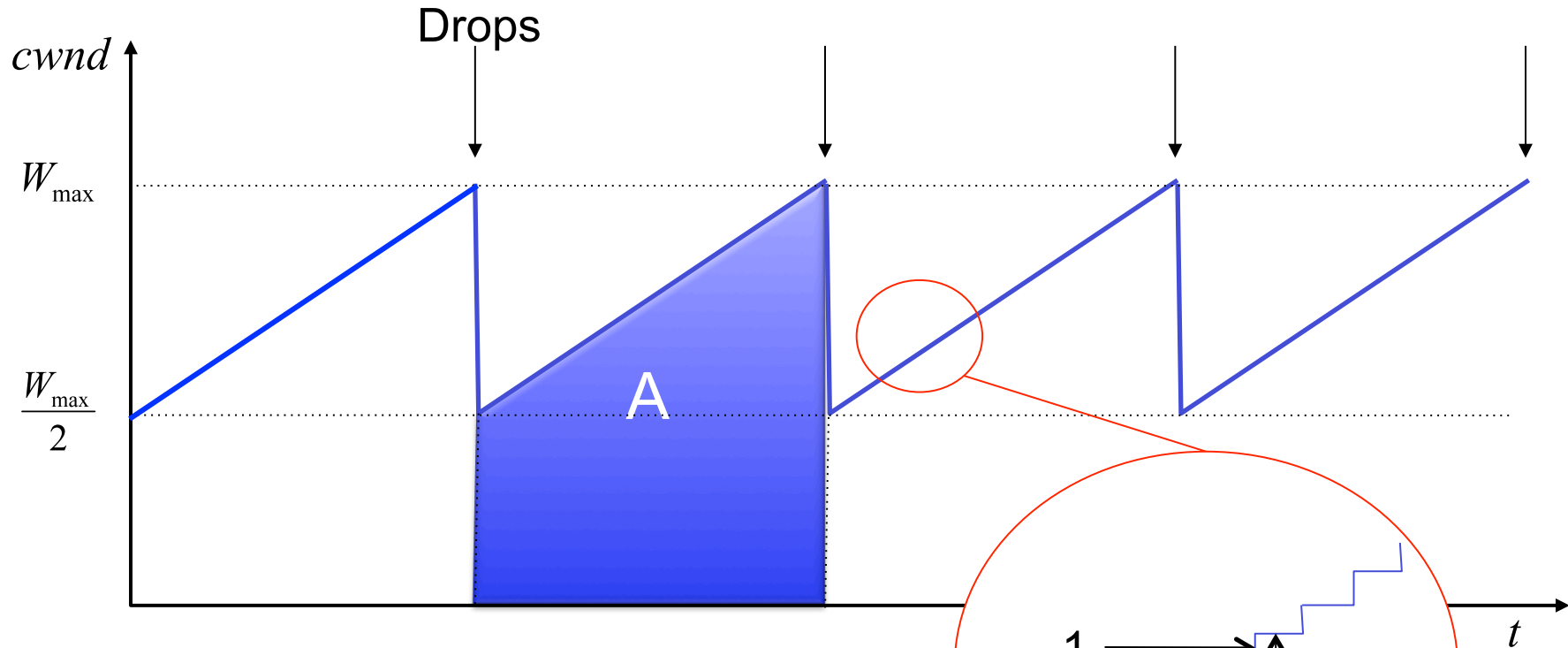
Professor of Electrical Engineering  
and Computer Science, Stanford University



# One flow vs multiple flows



# Simple geometric intuition



Packet drop rate,  $p = 1 / A$ , where  $A = \frac{3}{8} W_{\max}^2$

$$\text{Throughput, } R = \frac{A}{\left(\frac{W_{\max}}{2}\right) RTT} = \sqrt{\frac{3}{2}} \frac{1}{RTT \sqrt{p}}$$

# Interpreting the rate equation

$$R = \sqrt{\frac{3}{2}} \frac{1}{RTT \sqrt{p}}$$

1.  $RTT \rightarrow 0 \Rightarrow R \rightarrow \infty$  ?

2.  $p \rightarrow 0 \Rightarrow R \rightarrow \infty$  ?

# Observations for multiple flows

1. Window expands/contracts according to AIMD.
2. ...to probe how many bytes the pipe can hold.
3. Bottleneck will contain packets from many flows.
4. The sending rate varies with window size.
5. AIMD is very sensitive to loss rate.
6. AIMD penalizes flows with long RTTs.

<end>