CS144
An Introduction to Computer Networks

Congestion
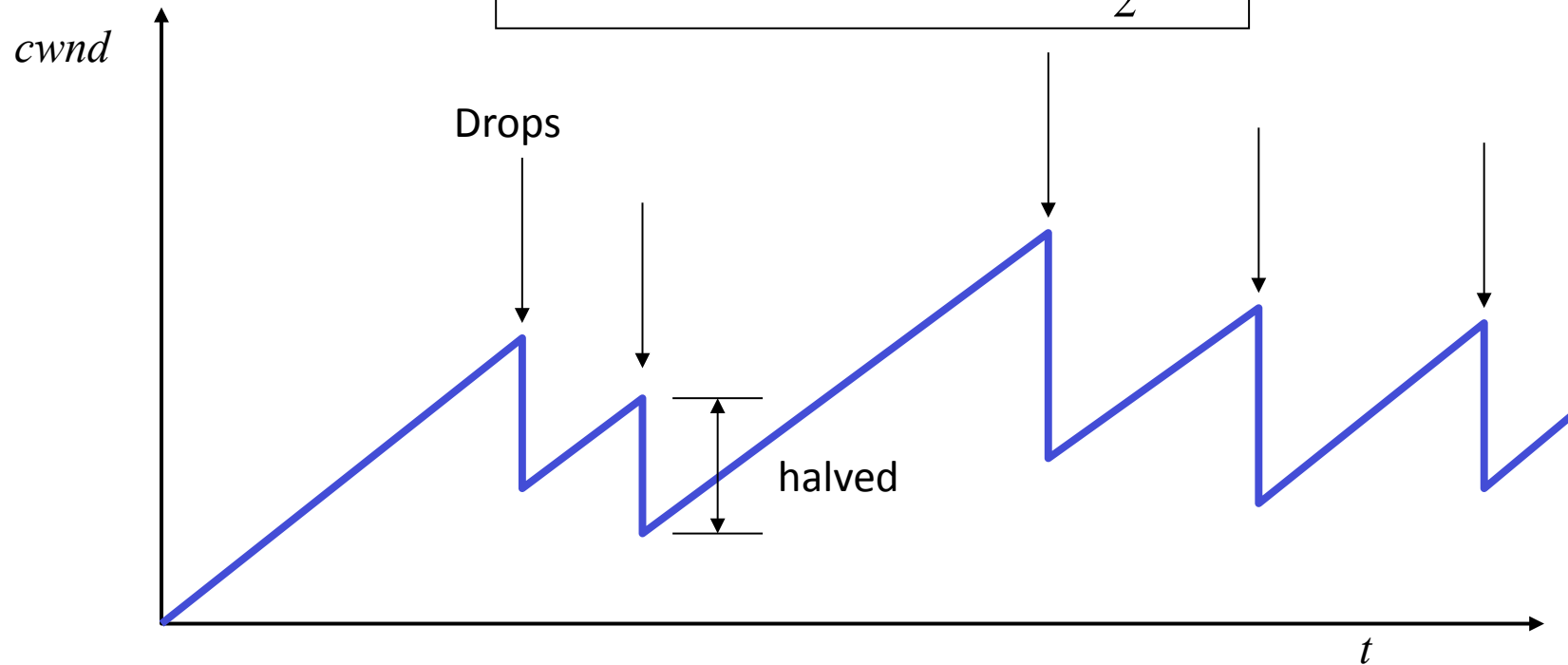
AIMD with a single flow

Nick McKeown

Professor of Electrical Engineering
and Computer Science, Stanford University

AIMD

Additive Increase, Multiplicative Decrease

If packet received OK: $W \leftarrow W + \dfrac{1}{W}$

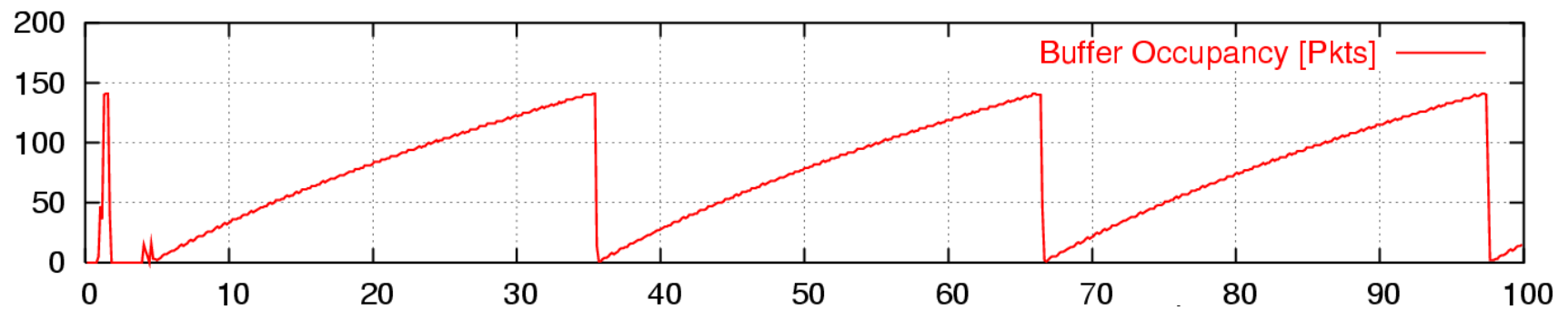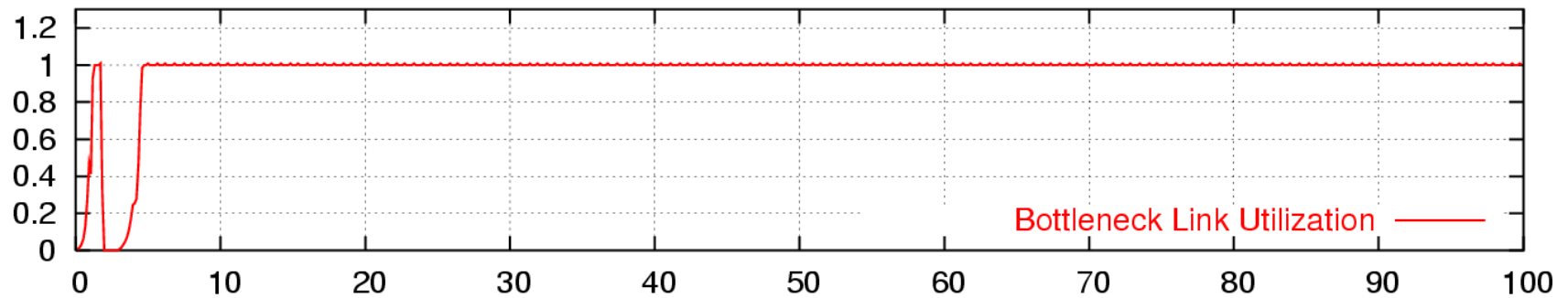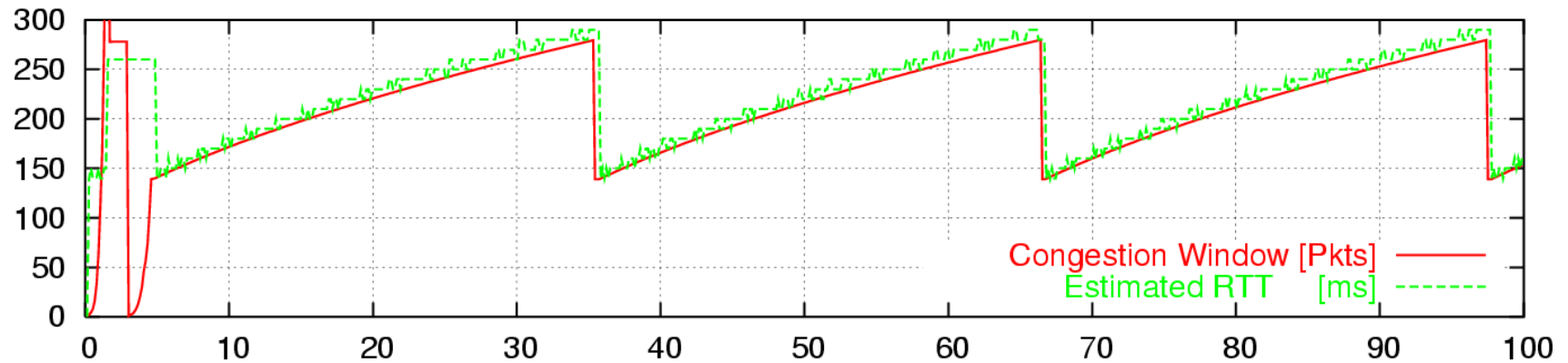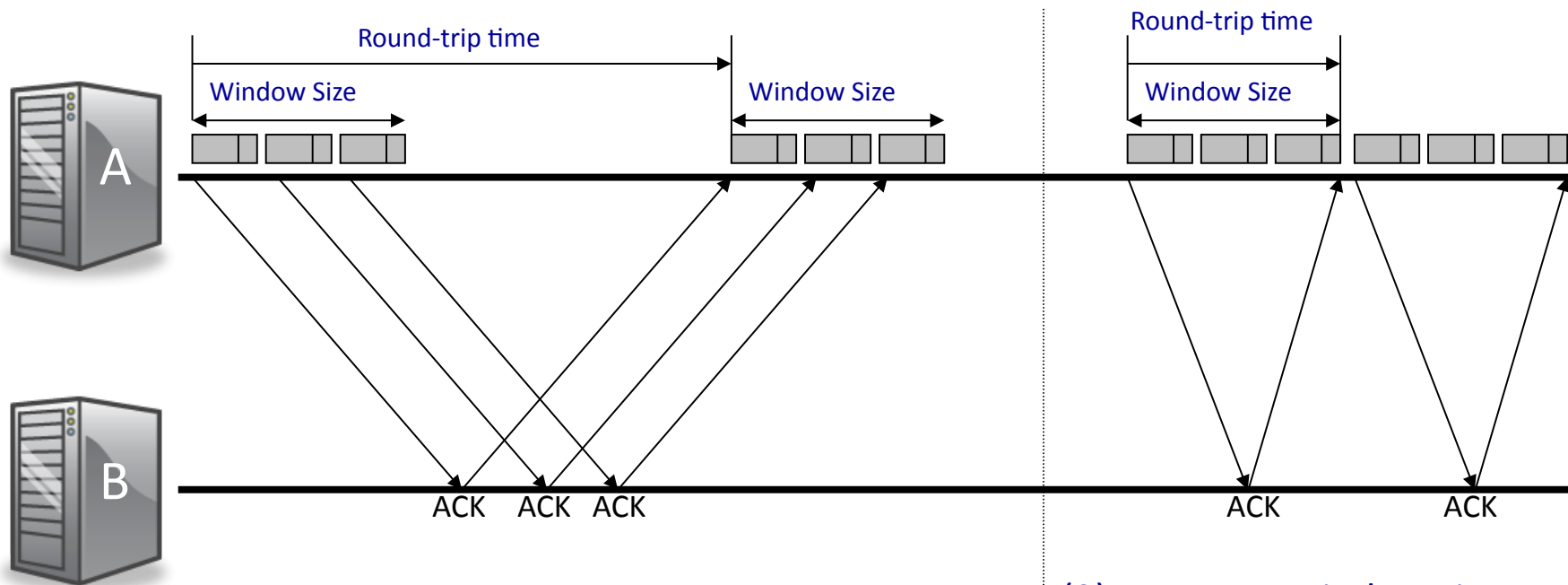If a packet is dropped: $W \leftarrow \dfrac{W}{2}$

cwnd

Drops

halved

t

Animation

Animation at:

http://guido.appenzeller.net/anims/

Single Flow Dynamics

Sending rate for a single flow

Round-trip time

Window Size

Round-trip time

Window Size

Window Size

A

B

ACK   ACK   ACK

ACK

ACK
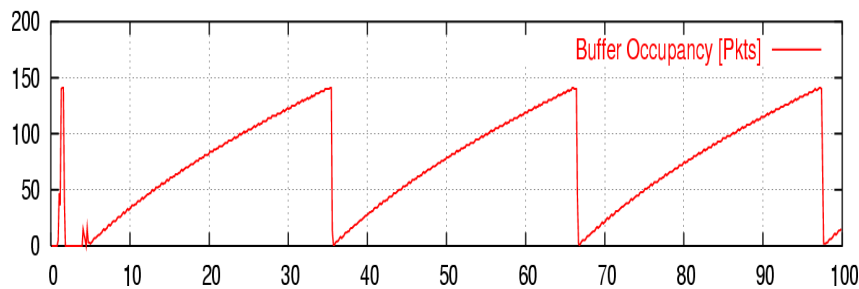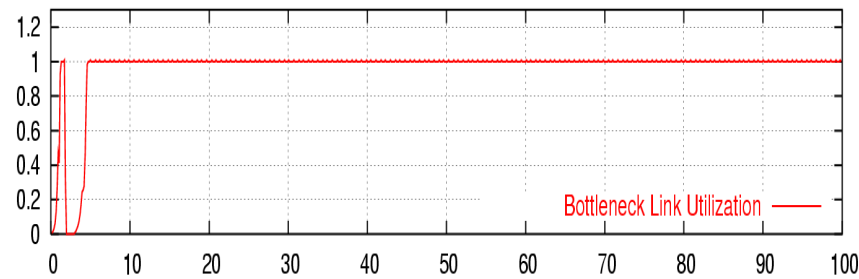
(1) R x RTT > Window size, W

(2) R x RTT = Window size, W
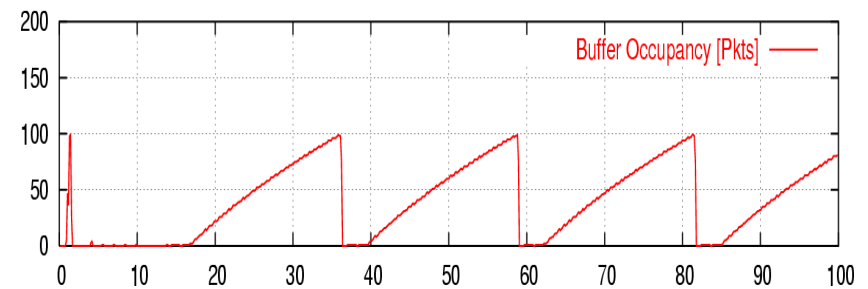
$$R = \frac{W}{RTT}$$

Sending rate for single flow

Window size

W_{max}

$\dfrac{W_{max}}{2}$

t

RTT

$R = \dfrac{W}{RTT}$

Router buffer

A   Link rate > C   Link rate = C   B
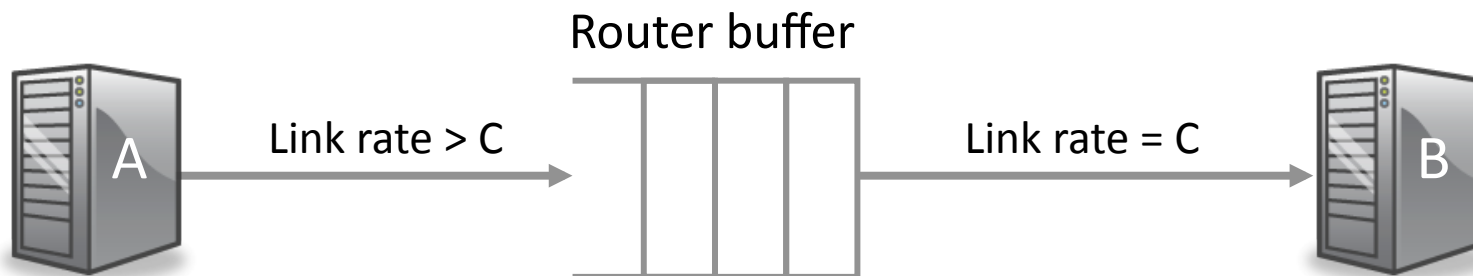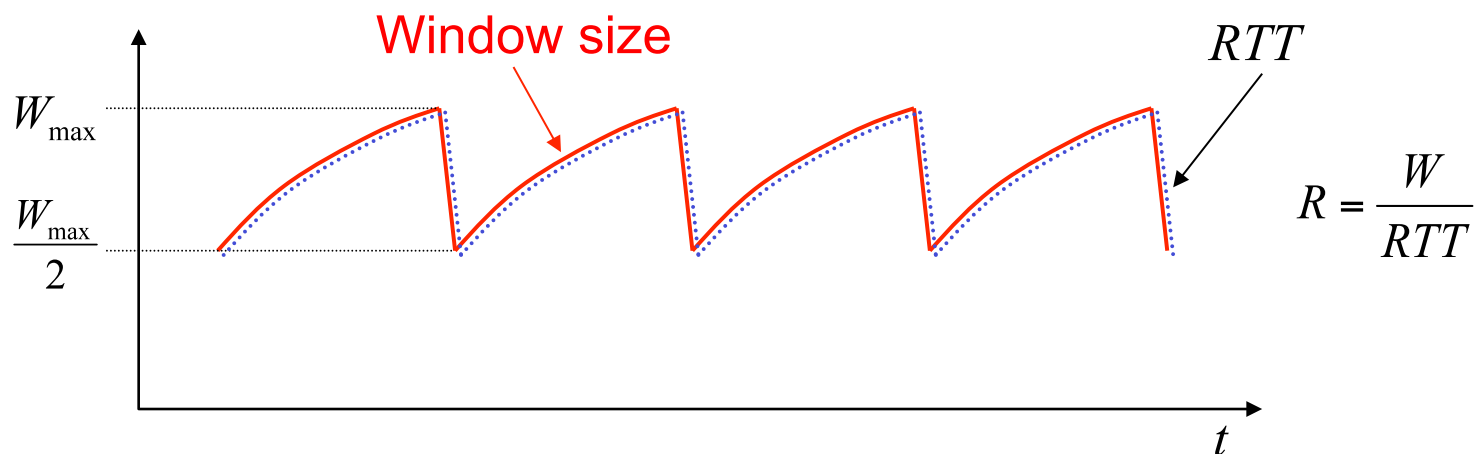
How big should the buffer be?

Buffer size, $B = RTT \times C$

Buffer size, $B < RTT \times C$

Congestion Window [Pkts]
Estimated RTT   [ms]

Bottleneck Link Utilization

Buffer Occupancy [Pkts]
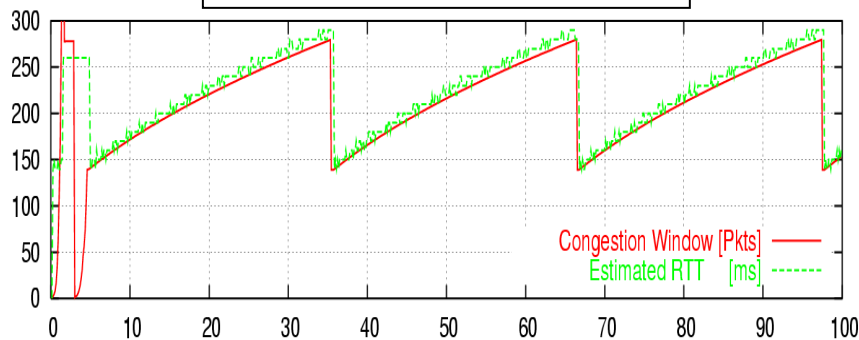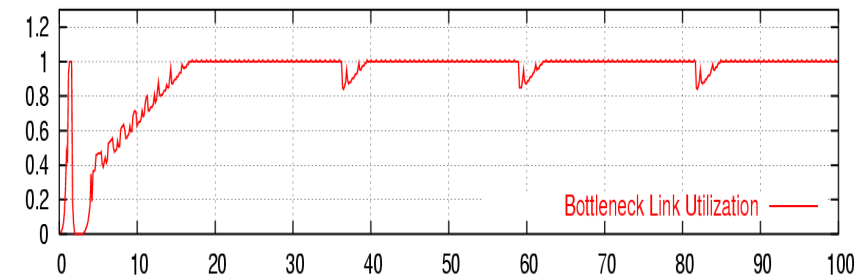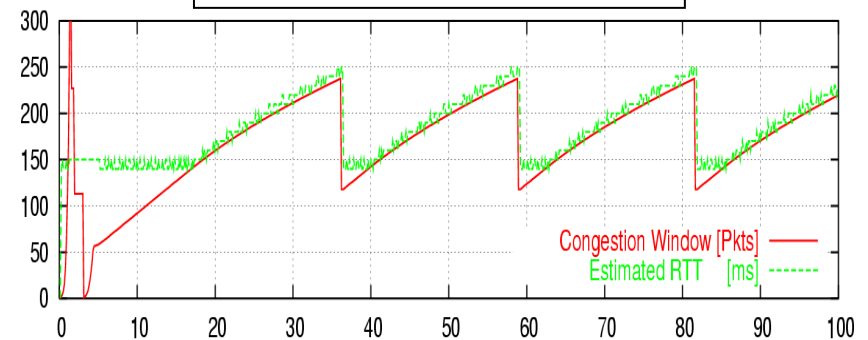
Observations for single flow

1. Window expands/contracts according to AIMD.

2. …to probe how many bytes the pipe can hold.

3. The sawtooth is the stable operating point.

4. The sending rate is constant.

5. …if we have sufficient buffers (RTT x C).

<end>