COMP 3331/9331: Computer Networks and Applications

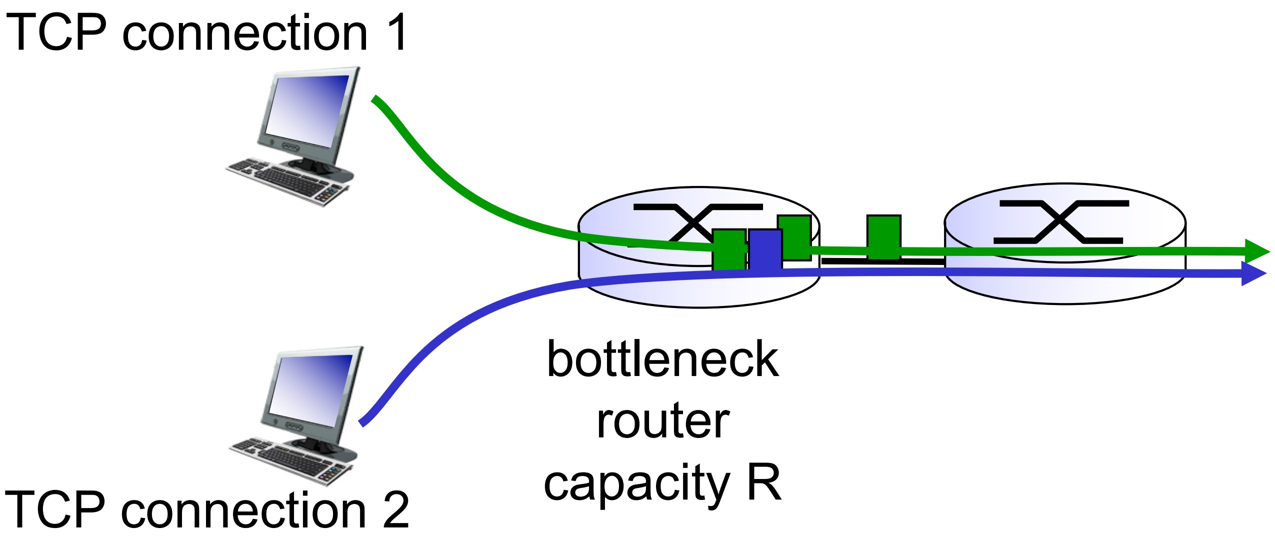
Week 7

TCP Fairness (Transport Layer)

Reading Guide: Chapter 3, Sections: 3.7

TCP Fairness

fairness goal: if K TCP sessions share same bottleneck link of bandwidth R, each should have average rate of R/K



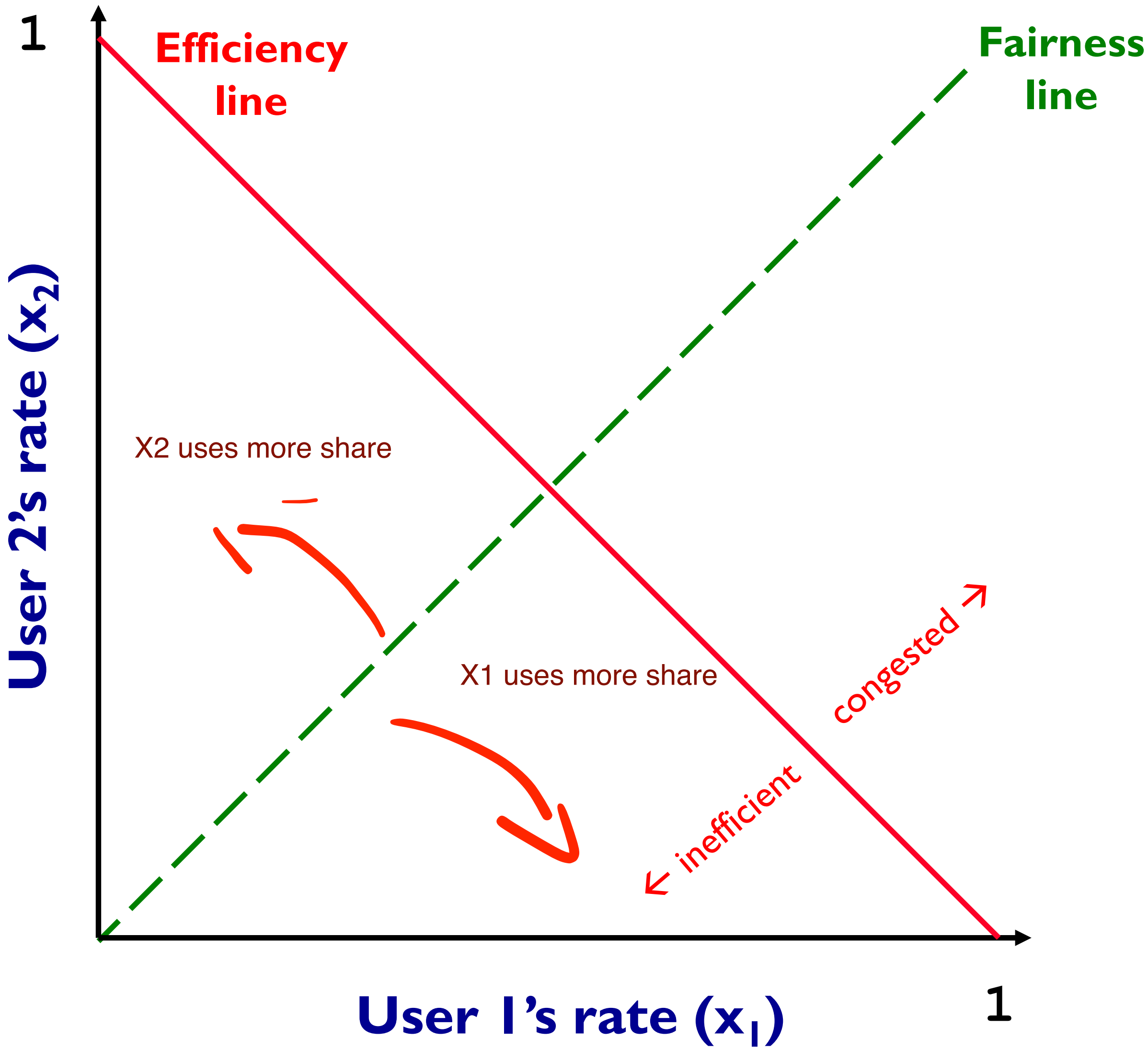
Why AIMD?

- Some rate adjustment options: Every RTT, we can
  - Multiplicative increase or decrease: CWND→ a*CWND
  - Additive increase or decrease: CWND→ CWND + b

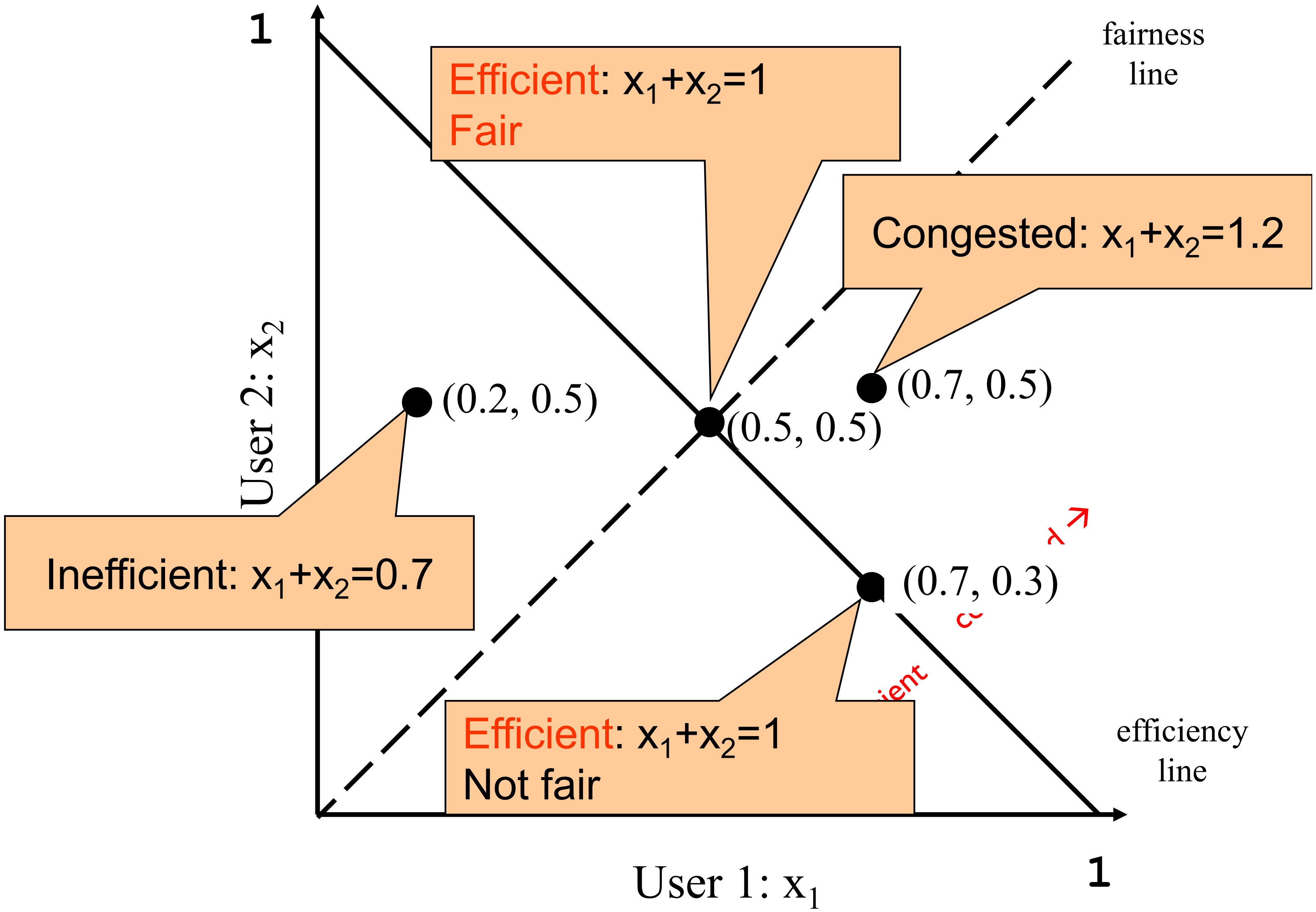
- Four alternatives:
  - AIAD: gentle increase, gentle decrease
  - AIMD: gentle increase, drastic decrease
  - MIAD: drastic increase, gentle decrease
  - MIMD: drastic increase and decrease

Simple Model of Congestion Control

- Two users
  - rates x_1 and x_2
- Congestion when $x_1+x_2 > 1$
- Unused capacity when $x_1+x_2 < 1$
- Fair when $x_1 = x_2$

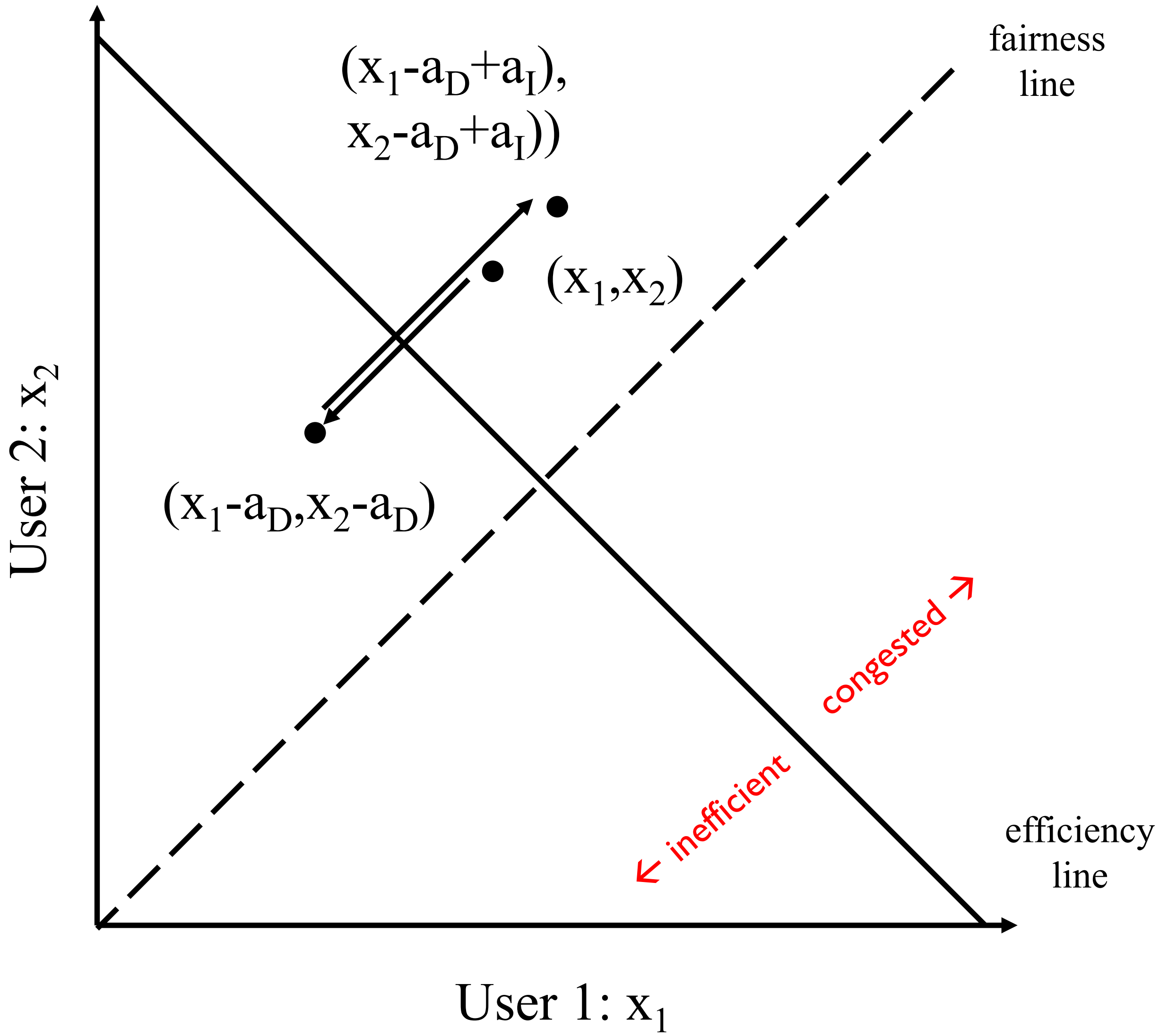


Example

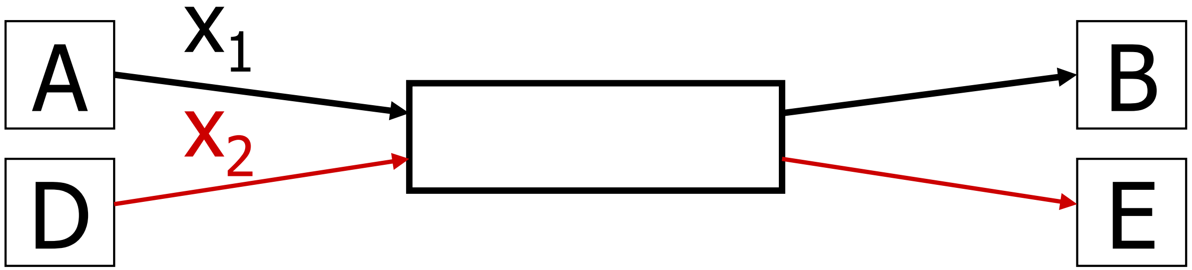

1
fairness line
Efficient: $x_1+x_2=1$
Fair
Congested: $x_1+x_2=1.2$
(0.2, 0.5)
(0.5, 0.5)
(0.7, 0.5)
(0.7, 0.3)
User 2: x_2
Inefficient: $x_1+x_2=0.7$
Efficient: $x_1+x_2=1$
Not fair
efficiency line
User 1: x_1
1

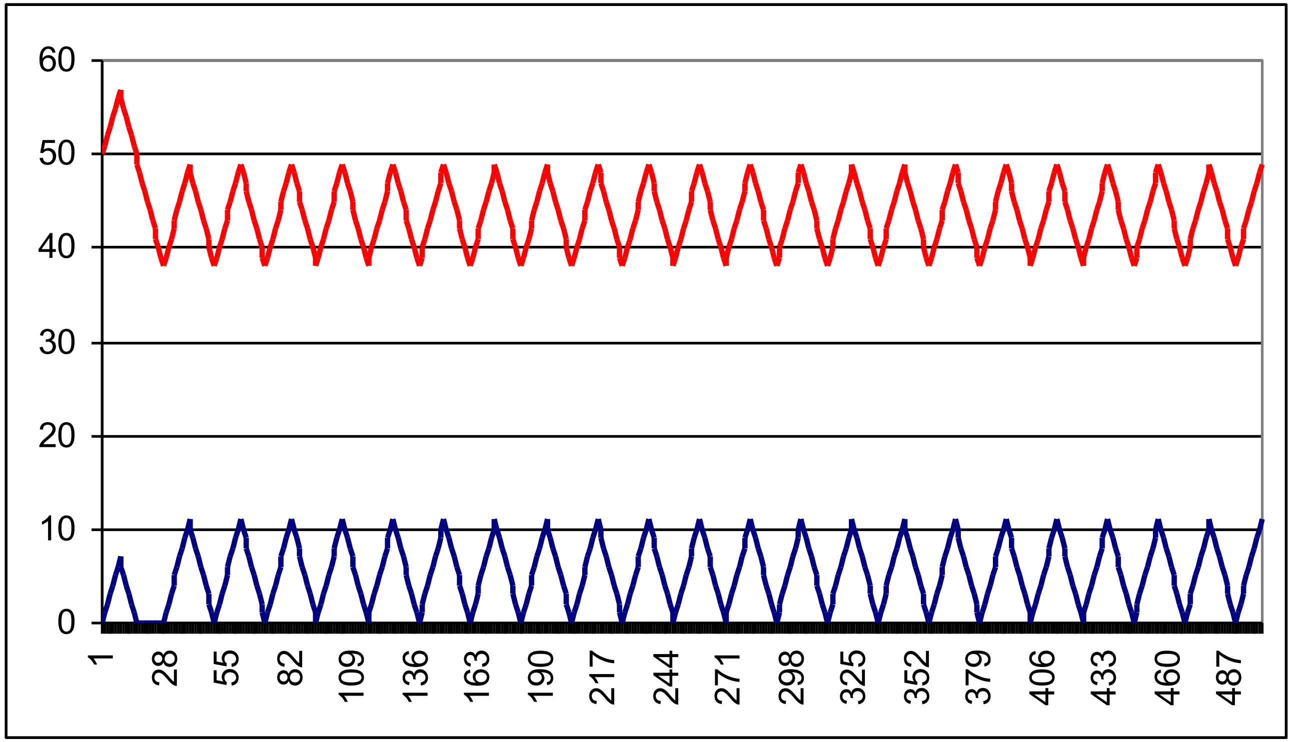
AIAD

- Increase: $x + a_I$
- Decrease: $x - a_D$
- Does not converge to fairness



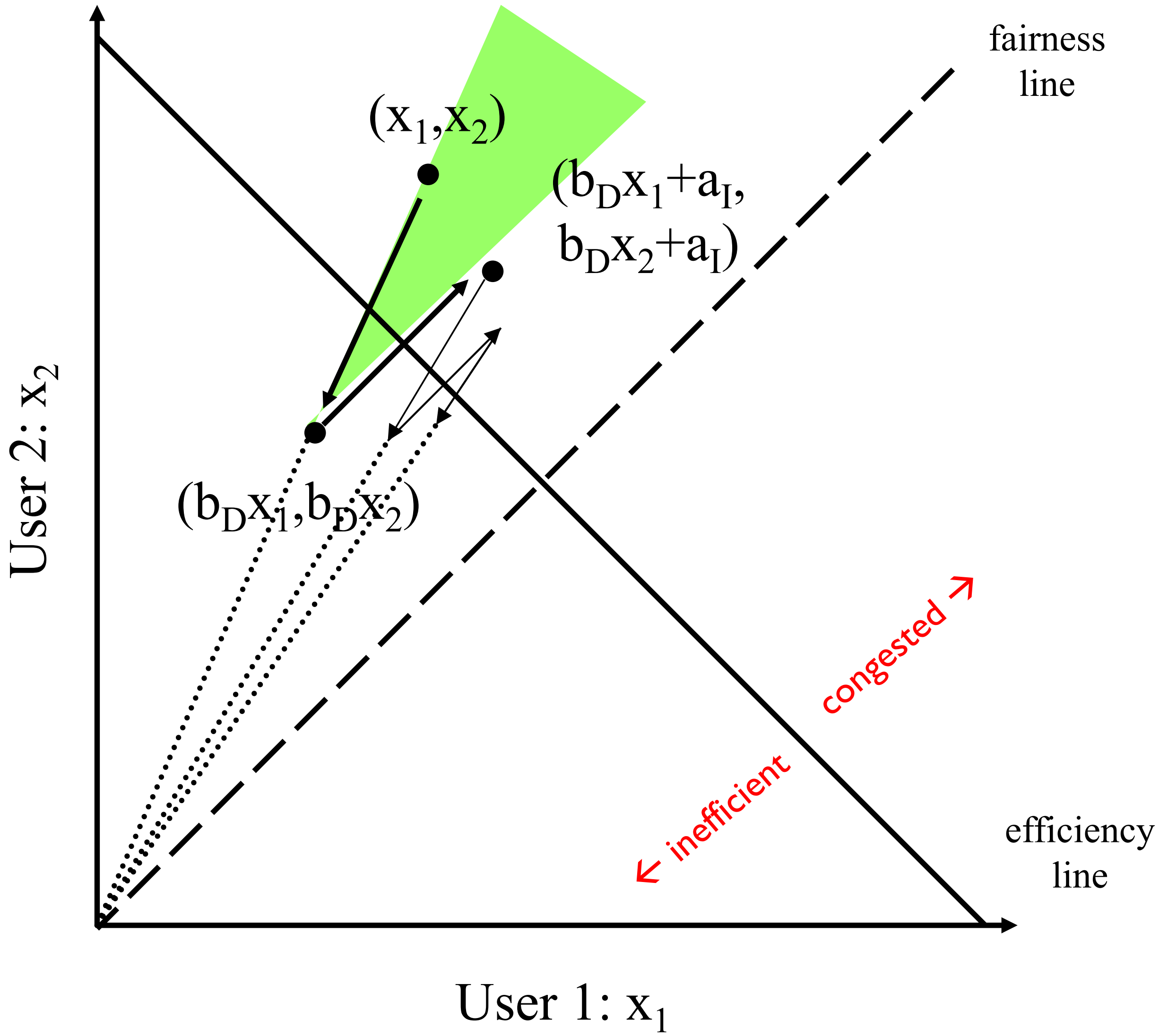
AIAD Sharing Dynamics



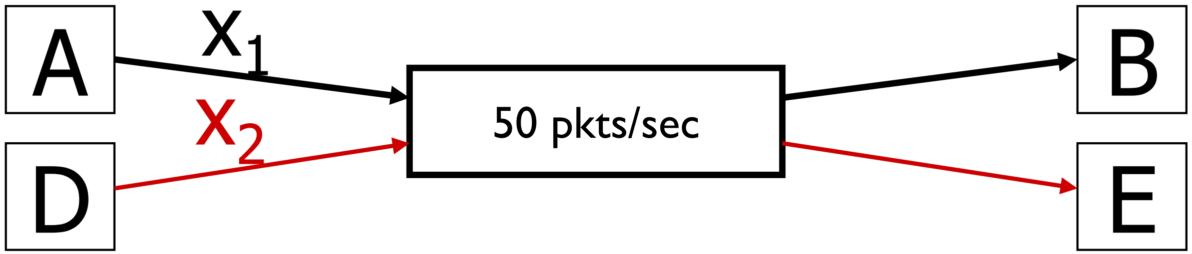


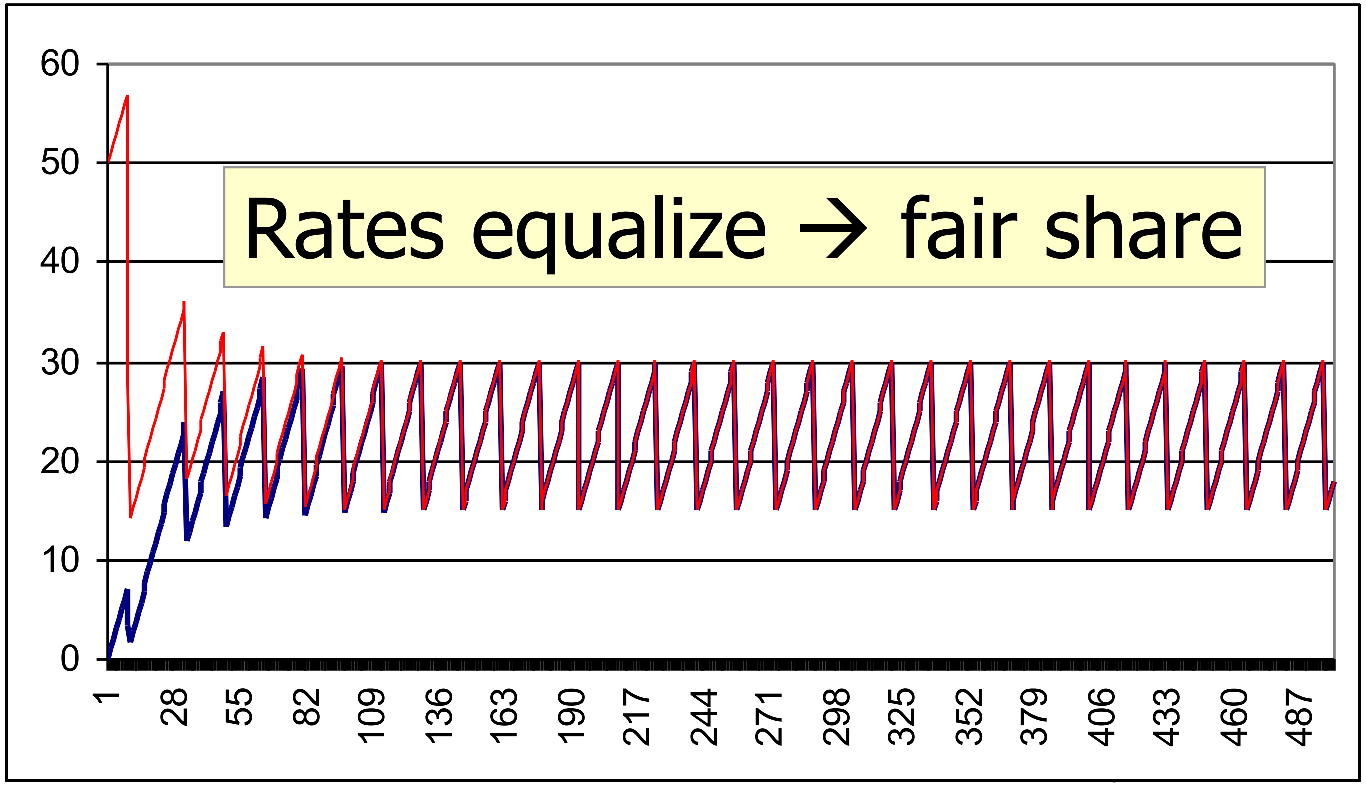
AIMD

- Increase: $x+a_I$
- Decrease: $x*b_D$
- Converges to fairness

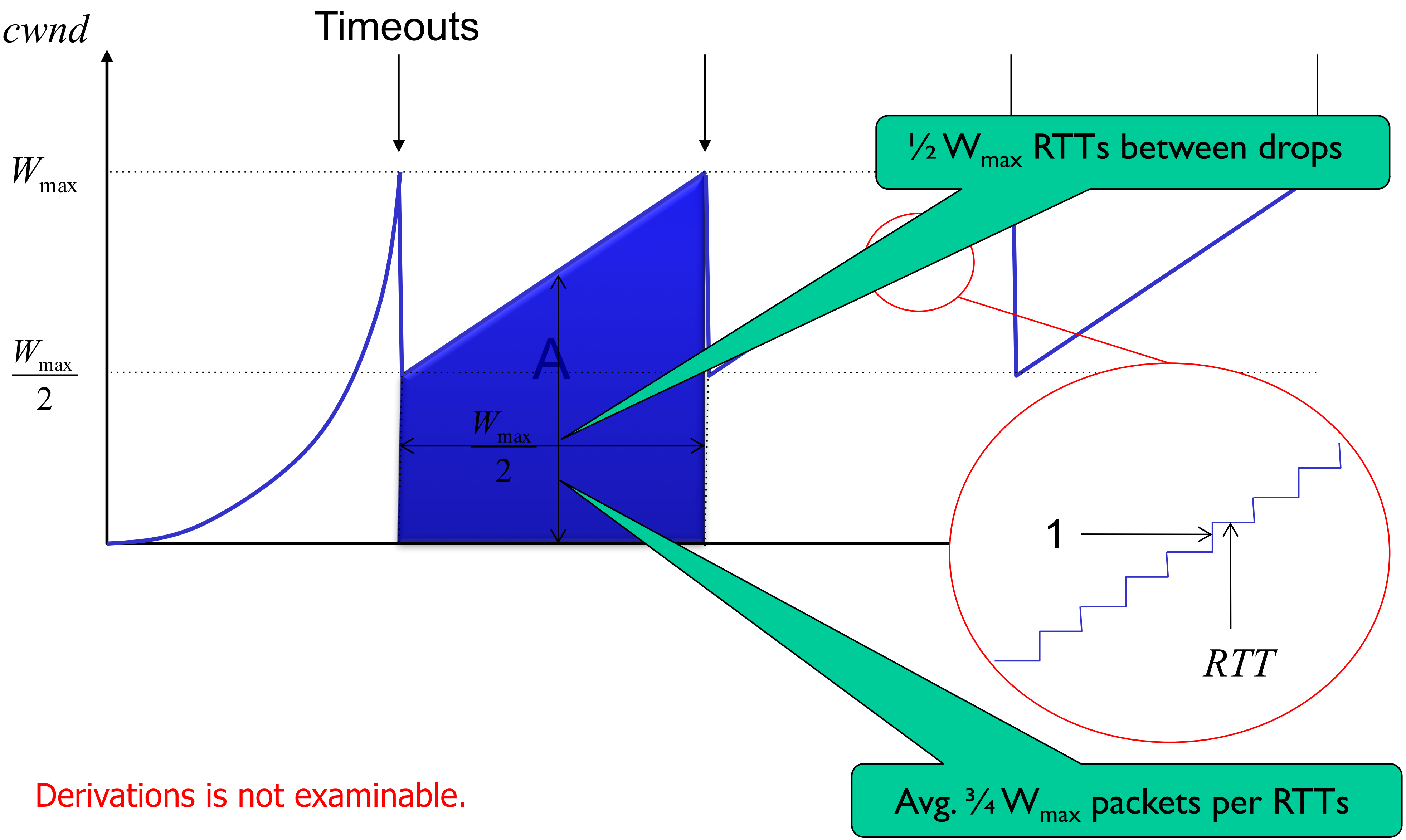


AIMD Sharing Dynamics



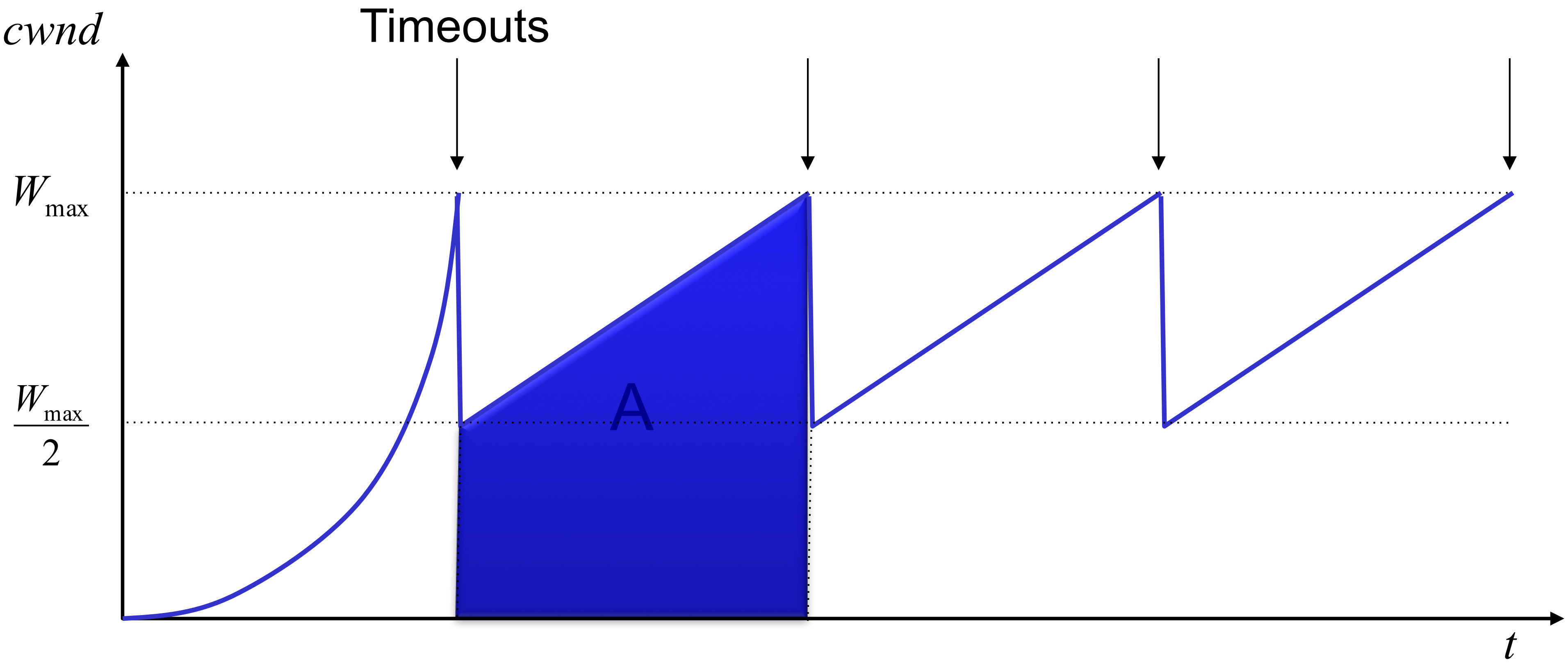


A Simple Model for TCP Throughput



Derivations is not examinable.

A Simple Model for TCP Throughput



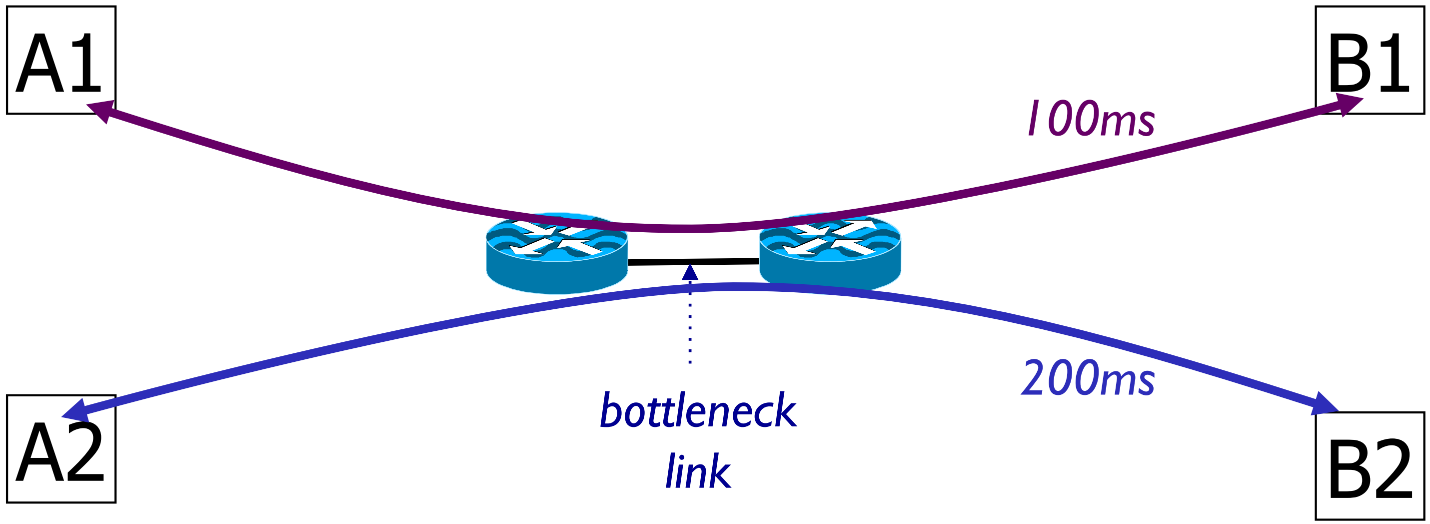
$$\text{Packet drop rate, } p = 1/A, \text{ where } A = \frac{3}{8} W_{\max}^2$$

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

Implications (1): Different RTTs

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

- Flows get throughput inversely proportional to RTT
- TCP unfair in the face of heterogeneous RTTs!



Implications (2): Loss not due to congestion?

- TCP will confuse corruption with congestion
- Flow will cut its rate
  - Throughput ~ 1/sqrt(p) where p is loss prob.
  - Applies even for non-congestion losses!

Implications: (3) How do short flows fare?

- 50% of flows have < 1500B to send; 80% < 100KB

- Implication (1): short flows never leave slow start!
  - short flows never attain their fair share

- Implication (2): too few packets to trigger dupACKs
  - Isolated loss may lead to timeouts
  - At typical timeout values of ~500ms, might severely impact latency

Implications: (4) TCP fills up queues → long delays

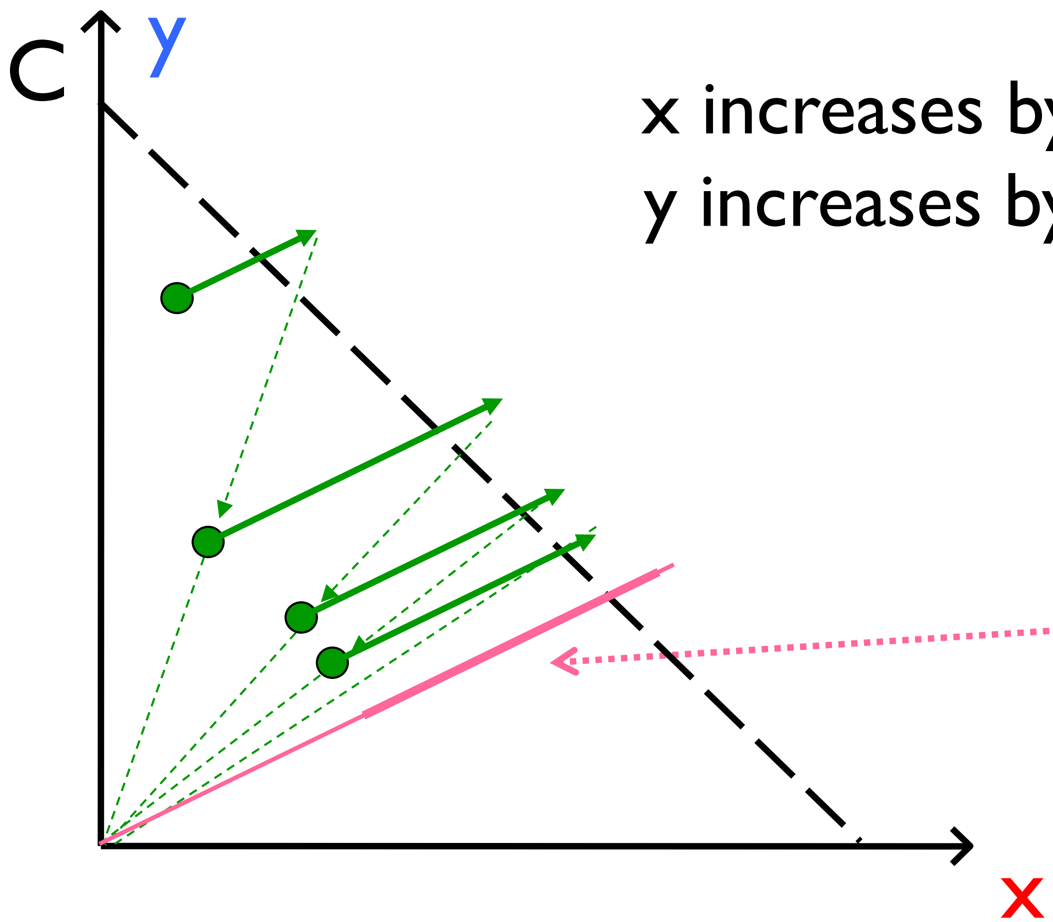
- A flow deliberately overshoots capacity, until it experiences a drop

- Means that delays are large for *everyone*
  - Consider a flow transferring a 10GB file sharing a bottleneck link with 10 flows transferring 100B

Implications: (5) Cheating

- Three easy ways to cheat
  - Increasing CWND faster than +1 MSS per RTT

Increasing CWND Faster



x increases by 2 per RTT

y increases by 1 per RTT

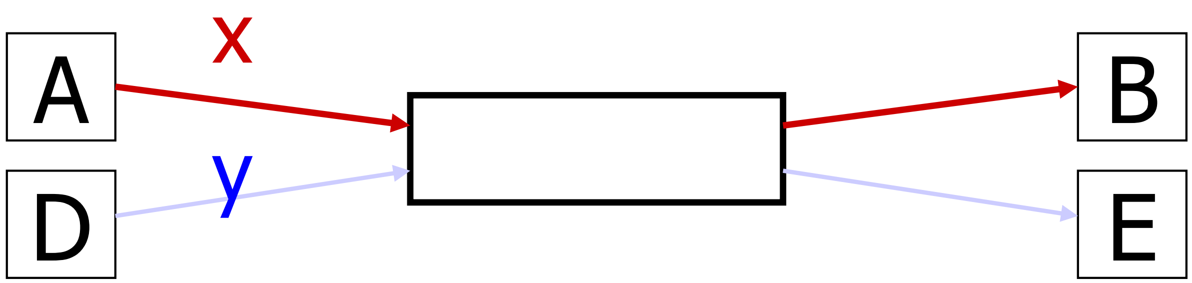
Limit rates:

$x = 2y$

Implications: (5) Cheating

- Three easy ways to cheat
  - Increasing CWND faster than +1 MSS per RTT
  - Opening many connections

Open Many Connections



Assume

- A starts 10 connections to B
- D starts 1 connection to E
- Each connection gets about the same throughput

Then A gets 10 times more throughput than D

Implications: (5) Cheating

- Three easy ways to cheat
  - Increasing CWND faster than +1 MSS per RTT
  - Opening many connections
  - Using large initial CWND

- Why hasn't the Internet suffered a congestion collapse yet?

Robustness?

ISP functions

Transport Layer: Summary

- principles behind transport layer services:
  - multiplexing, demultiplexing
  - reliable data transfer
  - flow control
  - congestion control
- instantiation, implementation in the Internet
  - UDP
  - TCP

next:

- leaving the network "edge" (application, transport layers)
- into the network "core"