Notes – Lecture 4 → TCP

Lecture → Streamed / Recorded

TCP → Modern CC A

CCA → Congestion Control Algorithm

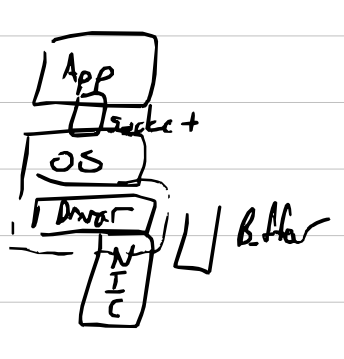
Challenge → How much data to send?

Client Server

How fast? CWND → Max data in flight

Sender Perspective Transmit Rate

Buffer ↓

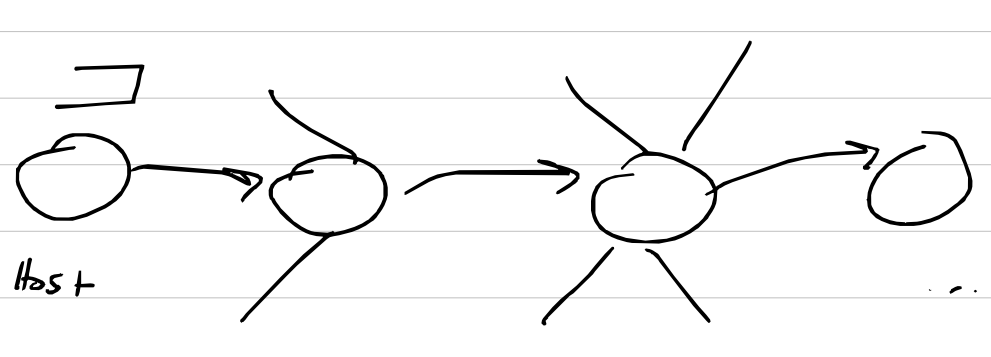


socket → write
Max buffer size

User vs. kernel
Space Recap

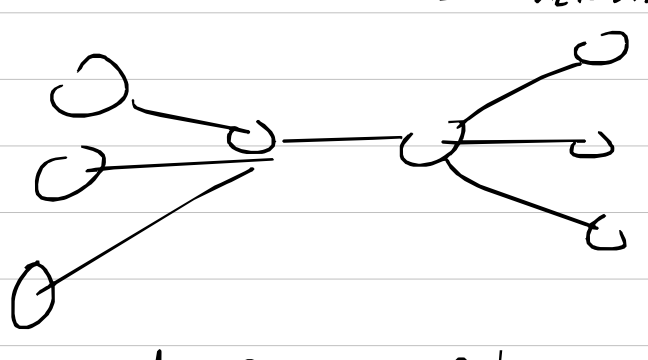
Host Limitation → Transmit Rate
Link Speed

Problem: Network → Distributed



Cross Traffic
Flows Varying Duration
RTT

TCP → Reliability How can I fairly use the network?



AIMD Probe up slowly
React quickly

Link Utilization 0 → 1

Only user

0-100%

Two users → 50%
Three users → 33%
"safe"

Probe slowly → Probe slow as you get your fair share

?? → Ramp up CUBIC, BBR → Diff strategies

Evolution TCP

TCP Tens, hundreds, kb/s single Mb/s

T1 → 1.544 Mb/s

193 kB/sec
bytes

~128
127.48 pkts/sec
full MTU
802.3 Ethernet

Not a lot

Ethernet 10 Mb/s
Maybe fast Eth 100 Mb/s

T1 link 1.544 Mb/s

Recall CWND SSThresh

TCP ... OK

TCP New Reno Fast Retransmit → Slide
Fast Recovery → Diagram

TCP + City

RTO vs. Fast R/T
Slow Start → Trigger fast R/T?

→ New Reno Reactive

TCP Vegas
Variations in delay

window if Delay ↑ Congestion ↑
∴ Decrease CWND
Delay ↓ or Steady
∴ Increase CWND

What is up / down EWMA
α
$1-\alpha$

Hysteresis Ignore → Significant change

How much to change?
Variable delay?

? Minimum RTT on network

Rules Ack
Time / #
windows
Mac 2

SACK → Option

CUBIC
Linux

BBR
Google

CUBIC
Old school TCP New Reno

AI one per full cwnd

BDP 1 Gb/s → 20ms

High Speed TCP FAST
Westwood

BIC Binary search
Midpoint last loss
and last min

Wiggle room → Your fair share
Grow speedy
Slow as you converge

Convex ∪
Concave ∩
Looks like a curve

Slower than linear to start?

Convex / concave
Cubic function

Slow start
Start low
Exp growth

Ignore → Initial growth/start → Sep Discussion

Loss → BIC

↳ Apply β to CWND

W_{max} = CWND
CWND = CWND * β
W_{min} = CWND

$$Jump = \frac{W_{max} - W_{min}}{2}$$

If Jump > S_{max}
CWND += S_{max}
else
CWND += Jump
end if

Repeat that ladder up if OK on a CWND delivery

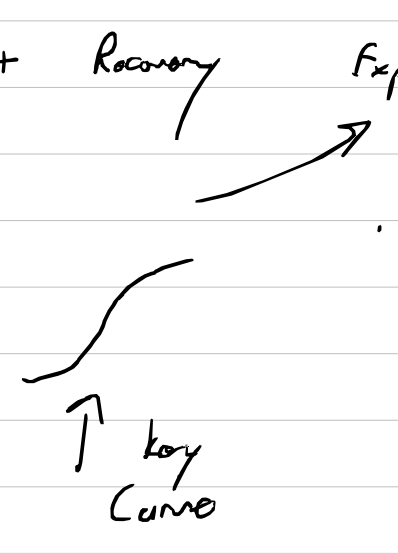
Compare until S_{min}

Too Aggressive

$$W(t) = C(t-k)^3 + W_{max}$$

Same β reduction

Fast Recovery Exp growth to SSThresh



C → Parameter
t from last window reduction
k time period to W_{max}

$$k = \sqrt[3]{\frac{W_{max}\,\beta}{C}}$$

Presumption W_{max} is not a bad indicator and does have some stability

CUBIC dial back BIC lower scale

CUBIC losses → wireless

BBR → Estimate BDP Vegas-like

RT_{prop} Min RTT

Btl BW Bottleneck Bandwidth

If low data RT_{prop} dominates
Data is great Btl BW

Early signal → figure 1

CUBIC W_{max}

Departure times Tx

Estimate Btl BW → Probe / test upwards to get the "true" value

Dilemma Time / Env / Conditions vary

How nice should one be?

Who should be nice?

Scheduler interactions

RAN → Brief Overview early