There is no Such Thing as TCP: TCP Congestion Control

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Background

- RFC 793 – Original TCP RFC
- RFC 2001 – Close language to class
- RFC 5681 – More up-to-date RFC 2001
- Vint Cerf is here Friday
- http://dl.acm.org/citation.cfm?id=52356 – Van Jacobson, Congestion Avoidance and Control
- Linux: `man tcp`

The Learning TCP Problem

- Slide's versions
- Book's version
- RFC versions
- Research paper versions
- Version in your head
- Then, there's the multiple real-world implementations

Learn Exact Versions of TCP

- Tahoe
- Reno
- New Reno
- Vegas
- That's the goal here unfortunately

As always, experimenting on your own with a real implementation is the **only way you will learn anything valuable**.

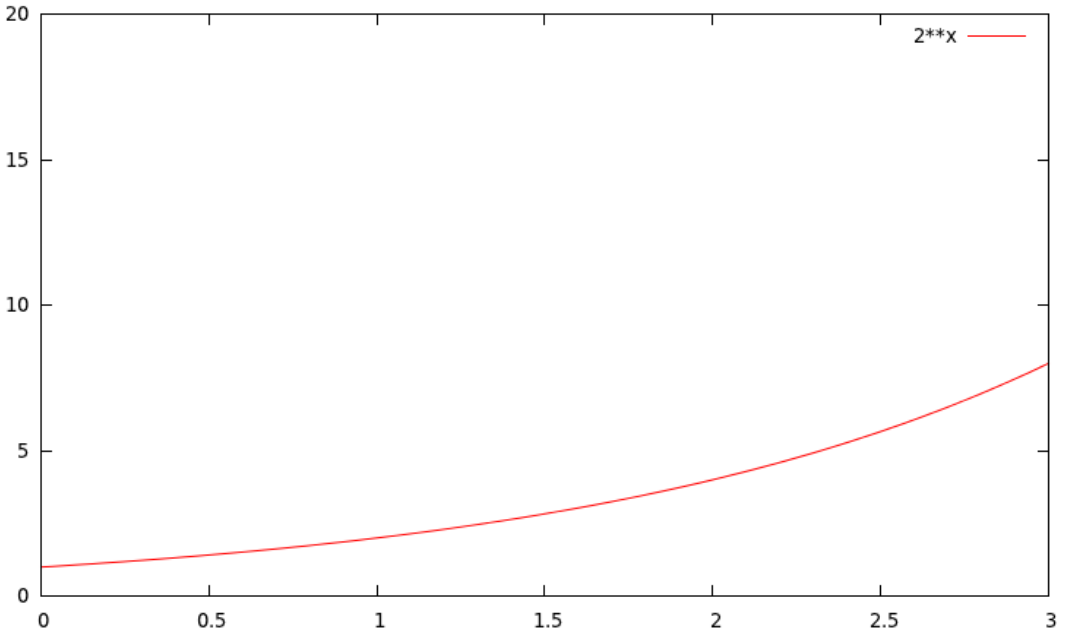
So, we're making
you implement your own.

Problem: Avoid congestion with no central coordination, no knowledge from peers, and no direct network feedback.

All you see are, essentially, ACKs.

New Connection: Slow Start [Tahoe]

- Intuition: Don't flood, but quickly optimize
- Start really small: 1 SMSS
- Grow really fast: exponentially
- Occurs: beginning of TCP, after timeout



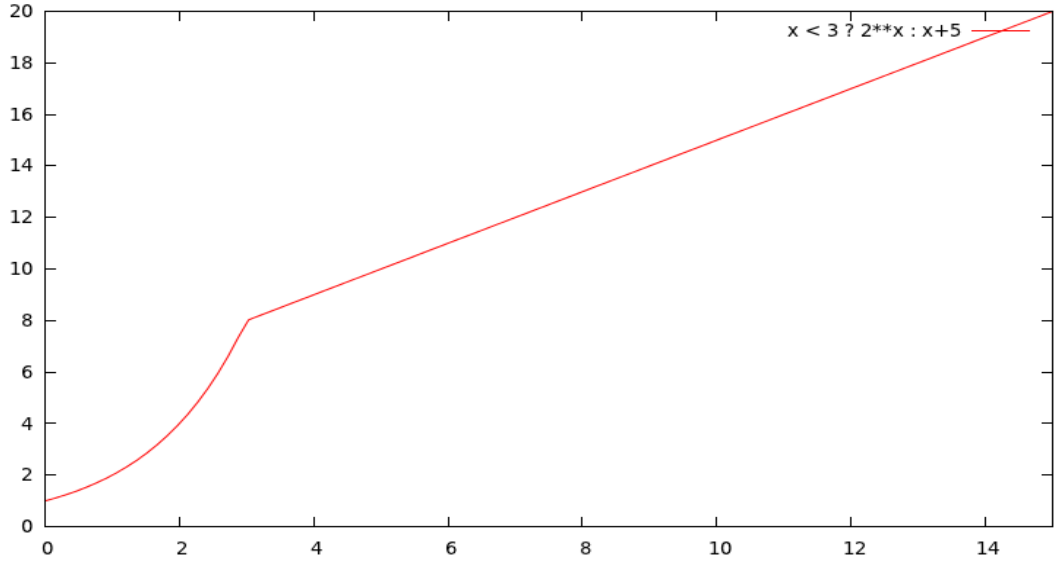
ssthresh

- cwnd – congestion window
  - Governs data transmission (with rwnd)
  - SMSS == sender maximum segment size
  - On segment ACK, `cwnd += SMSS`
- ssthresh – slow start threshold
  - Use slow start when `cwnd < ssthresh`
  - Use congestion avoidance when `cwnd > ssthresh`

Typically, ssthresh starts at 65535 bytes.

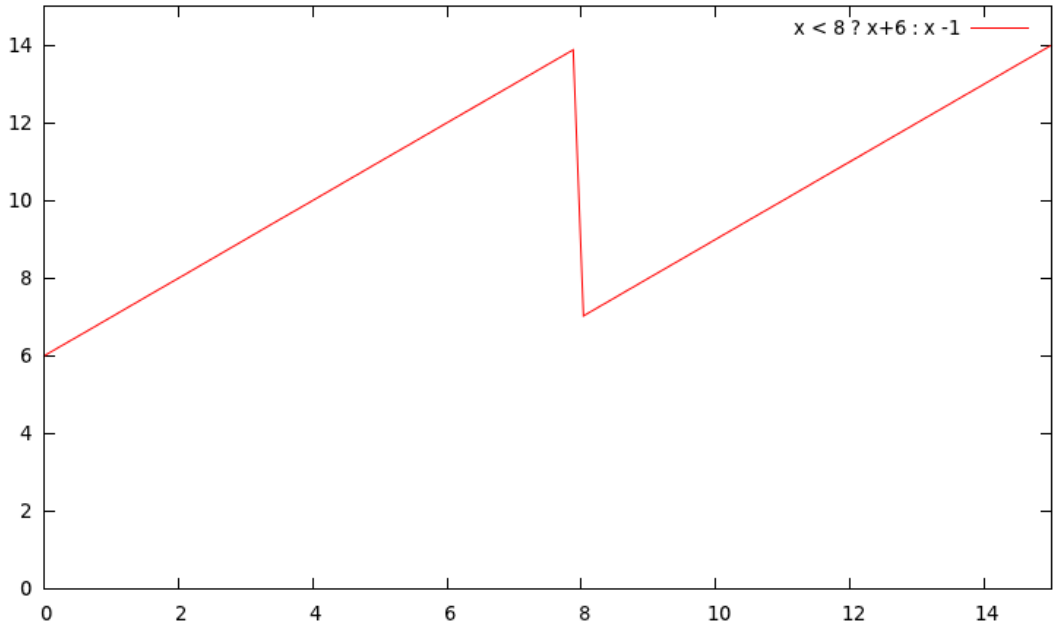
CA: Additive Increase

- On ACK: `cwnd += SMSS*SMSS/cwnd`
- Takes over when `cwnd > ssthresh`
- `ssthresh = min(cwnd,rwnd) / 2` when congestion
- If congestion is a timeout, `cwnd = SMSS`



CA: Multiplicative Decrease

- Appears depending on congestion control
  - Most likely [Reno]: 3 Duplicate ACKs
- On a timeout, set `cwnd = cwnd / 2`



Fast Retransmit [Tahoe]

- Receiver sends duplicate ACKs
- Immediately on out-of-order segment
- Sender receives >= 3 duplicate ACKs
- Immediately retransmit segment
  - `cwnd = SMSS`
  - Slow start
- [Reno] Fast Recovery until non-duplicate ACK

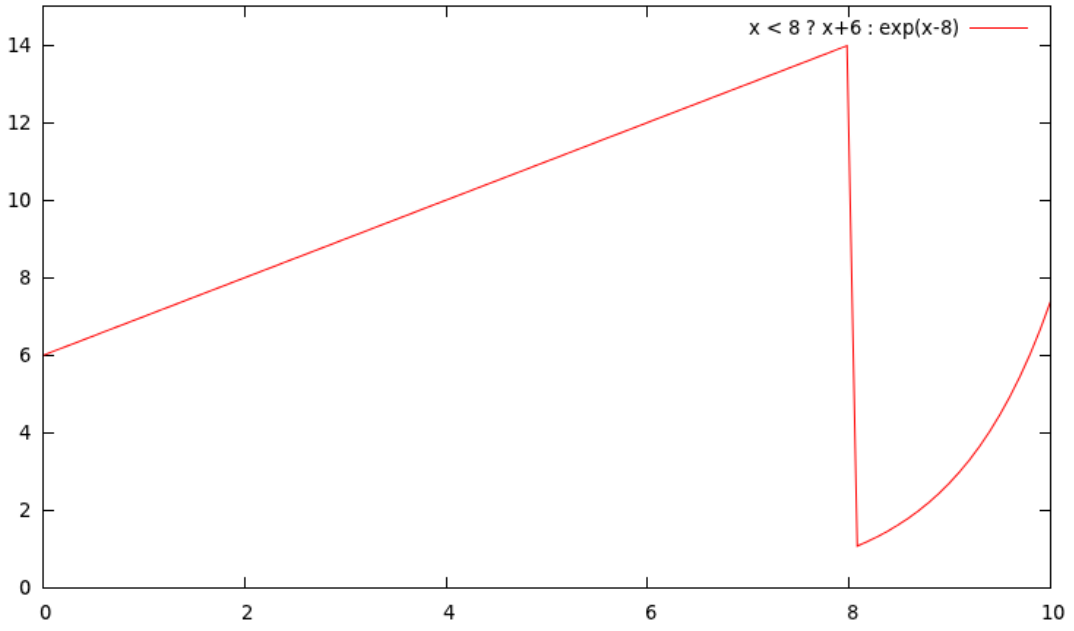
Fast Recovery [Reno, New Reno]

- `ssthresh = cwnd / 2`
- `cwnd = ssthresh [+ 3*SMSS] (in RFC)`
- Each time another duplicate ACK arrives,
  - `cwnd += SMSS`
  - Transmit new segment if allowed [New Reno]
- When ACK for new data arrives
  - `cwnd = ssthresh`
- If timeout again, slow start with `cwnd = SMSS`

Timeout Events [Tahoe, Reno]

Both treat these the same: drop to slow start

```
ssthresh = cwnd / 2
cwnd = SMSS
```



Experimenting on Your Own

- `getsockopt()` – on a TCP socket
- Transfer large amounts of data
- Check out `TCP_INFO`
- Returns a `struct tcp_info;`

/usr/include/netinet/tcp.h

```
struct tcp_info

  u_int8_ttcpi_state;
  u_int8_ttcpi_ca_state;
  u_int8_ttcpi_retransmits;
  u_int8_ttcpi_probes;
  u_int8_ttcpi_backoff;
  u_int8_ttcpi_options;
  u_int8_ttcpi_snd_wscale : 4, tcpi_rcv_wscale : 4;

  u_int32_t  tcpi_rto;
  u_int32_t  tcpi_ato;
  u_int32_t  tcpi_snd_mss;
  u_int32_t  tcpi_rcv_mss;

  u_int32_t  tcpi_unacked;
  u_int32_t  tcpi_sacked;
  u_int32_t  tcpi_lost;
  u_int32_t  tcpi_retrans;
  u_int32_t  tcpi_fackets;

/* Times. */
  u_int32_t  tcpi_last_data_sent;
  u_int32_t  tcpi_last_ack_sent; /* Not remembered,
sorry.  */
  u_int32_t  tcpi_last_data_recv;
  u_int32_t  tcpi_last_ack_recv;

  /* Metrics. */
  u_int32_t  tcpi_pmtu;
  u_int32_t  tcpi_rcv_ssthresh;
  u_int32_t  tcpi_rtt;
  u_int32_t  tcpi_rttvar;
  u_int32_t  tcpi_snd_ssthresh;
  u_int32_t  tcpi_snd_cwnd;
  u_int32_t  tcpi_advmss;
  u_int32_t  tcpi_reordering;

  u_int32_t  tcpi_rcv_rtt;
  u_int32_t  tcpi_rcv_space;

  u_int32_t  tcpi_total_retrans;
};
```

Cheating TCP: Foul Play

- What happens with two TCP streams, one from each host, on a 10 Mbps link?

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- Name them host A and host B. What if host A opens 10 TCP streams? Host B keeps only 1 TCP stream?

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- What happens with two TCP streams, one from each host, on a 10 Mbps link?
- Name them host A and host B. What if host A opens 10 TCP streams? Host B keeps only 1 TCP stream?
- Fair sharing across streams...
- No notion of logical peers

P2P Research: Bandwidth Trading

- UVA limited dorm links in dorm rooms
- We had high-speed WiFi between us
- What if we all colluded?
- Merging many TCP flows out-of-band :-)
- Fun senior thesis project
- P2P Bandwidth Trading (economics+CS)

LPTHW EC [10 Points]

Due November 19

Email Wolf

Fork me on GitHub

GitHub:

Git it, got it, good.

git clone git://github.com/theonewolf/15-441-Recitation-Sessions.git