TCP modeling

- Given the congestion behavior of TCP can we predict what type of performance we should get?
- What are the important factors
  - Loss rate
    - Affects how often window is reduced
  - RTT
    - Affects increase rate and relates BW to window
  - RTO
    - Affects performance during loss recovery
  - MSS
    - Affects increase rate

TCP modeling

- Some additional assumptions
  - Fixed RTT
  - No delayed ACKs
- In steady state, TCP losses packet each time window reaches W packets
  - Window drops to W/2 packets
  - Each RTT window increases by 1 packetW/2 * RTT before next loss

TCP continues to be an active topic of research

- Networks are heterogeneous
- TCP meltdown problem (outside the scope of this class)
  - Tunneling is currently en vogue
  - Nesting congestion control algorithms can be EXTREMELY bad
  - Answer:
    - Disable CC for all but one of the nested flows
- Bufferbloat problem
  - Huge buffers were popular for a minute… TCP doesn't care about queues/buffers, it cares about how many packets it can safely have in flight. Bad mix

Evolution of transport layer functionality

TCP, UDP: principal transport protocols for 40 years

different “flavors” of TCP developed, for specific scenarios:

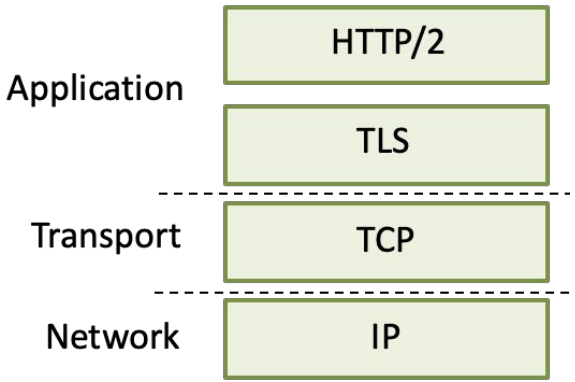
Scenario	Challenges
Long, fat pipes (large data transfers)	Many packets “in flight”; loss shuts down pipeline
Wireless networks	Loss due to noisy wireless links, mobility; TCP treat this as congestion loss
Long-delay links	Extremely long RTTs
Data center networks	Latency sensitive
Background traffic flows	Low priority, “background” TCP flows

moving transport–layer functions to application layer, on top of UDP

- HTTP/3: QUIC

QUIC: Quick UDP Internet Connections

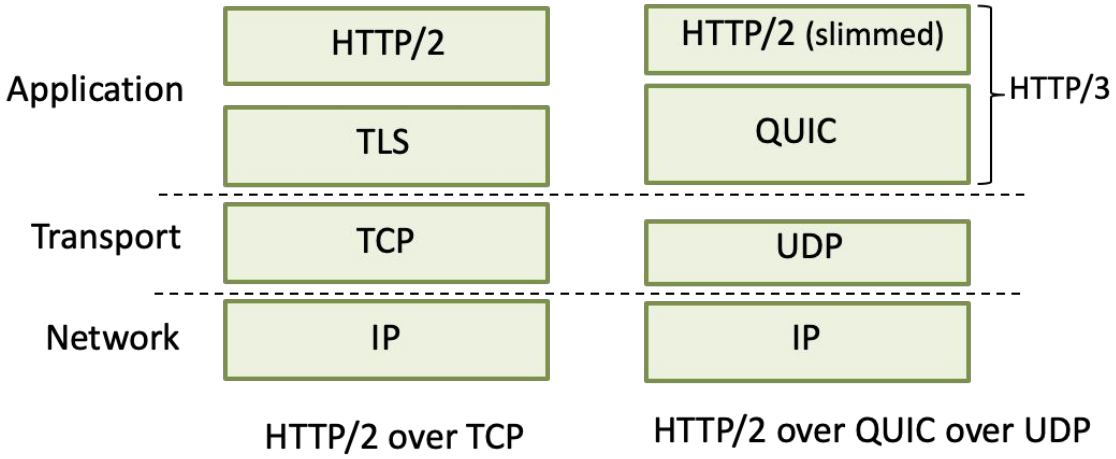
- application-layer protocol, on top of UDP
  - increase performance of HTTP
  - deployed on many Google servers, apps (Chrome, YouTube)



HTTP/2 over TCP

QUIC: Quick UDP Internet Connections

- application-layer protocol, on top of UDP
  - increase performance of HTTP
  - deployed on many Google servers, apps (Chrome, YouTube)

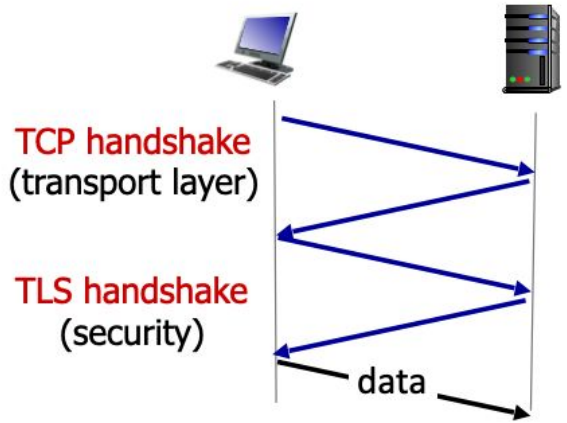


QUIC: Quick UDP Internet Connections

- adopts approaches from TCP for connection establishment, error control, congestion control
- error and congestion control: “Readers familiar with TCP’s loss detection and congestion control will find algorithms here that parallel well-known TCP ones.” [from QUIC specification]
- connection establishment: reliability, congestion control, authentication, encryption, state established in one RTT

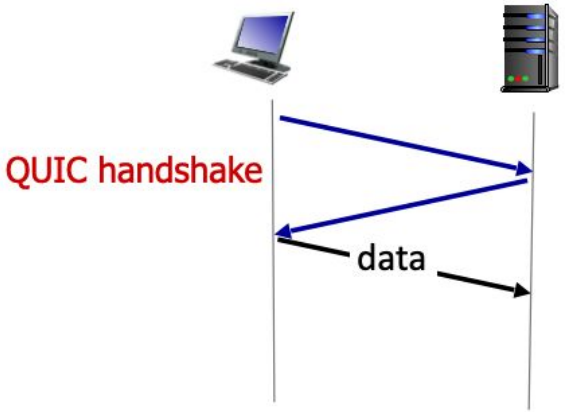
- multiple application-level “streams” multiplexed over single QUIC connection
  - separate reliable data transfer, security
  - common congestion control

QUIC connection establishment



TCP (reliability, congestion control state)
+ TLS (authentication, crypto state)

- 2 serial handshakes



QUIC: reliability, congestion control, authentication, crypto state

- 1 handshake

QUIC: streams: parallelism, no HOL blocking

Transport wrap up

- Muxing data streams to applications
- TCP vs UDP
  - Properties, pros and cons of each
- Reliable data transfer
- Fairness (max-min)
- Flow control
- Congestion control
- Congestion avoidance (TCP AIMD)

DNS

Leaving the transport layer for application layer

- DNS uses UDP or TCP
- Special protocol - not simply an application, it’s a fundamental network protocol for making the Internet operate
- www.hawaii.edu ->
  - web3x-vip-www00.its.hawaii.edu ->
    - 128.171.133.5

DNS

- The Internet has one global system for:
  - Addressing hosts IP
    (by design)

  - Naming hosts DNS
    By accident, an afterthought

DNS

- The Internet has one global system for:
  - Addressing hosts IP
    (by design)
    - Numerical addresses appreciated by routers
    - Provide little (if any) information about location

  - Naming hosts DNS
    By accident, an afterthought
    - Naming appreciated by humans
    - Hierarchical, related to host location

Using Internet services can be divided into four logical steps

1. A person has name of entity she wants to access	www.hawaii.edu
2. She invokes an application to perform the task	Chrome
3. The application invokes DNS to resolve the name into an IP address	128.171.133.5
4. The application invokes transport protocol to establish an app-to-app connection	

The DNS system is a distributed database which enables to resolve a name into an IP address

www.hawaii.edu

128.171.133.5

In practice, names can be mapped to more than one IP

www.hawaii.edu	128.171.133.5
www.netflix.com	52.18.41.127
	34.248.59.175
	52.209.236.203
www.pschmitt.net	185.199.111.153
	185.199.110.153
	185.199.109.153
	185.199.108.153

In practice, names can be mapped to more than one IP

na

Why is this a good thing?

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In practice, names can be mapped to more than one IP

Why is this a good thing?
Load balancing
Reduce latency by picking nearby servers
Tailored content based on requester's location/identity

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In practice, IPs can be mapped by more than one name

www.hawaii.edu	128.171.133.5
ee449.pschmitt.net	128.171.216.7
salmo-trutta.pschmitt.net	128.171.216.7