Security and Project 3

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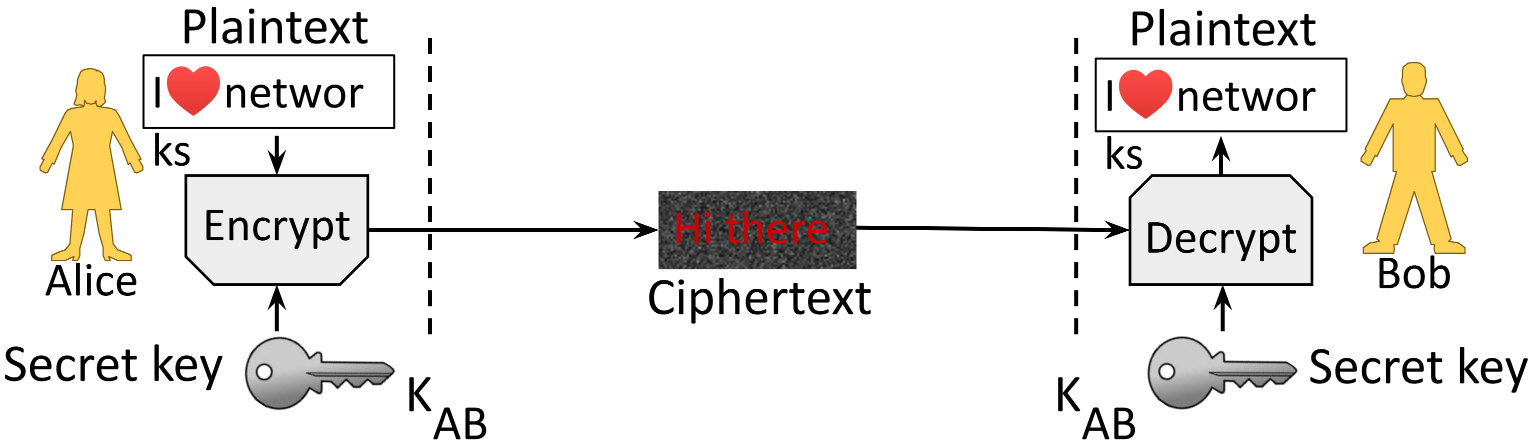
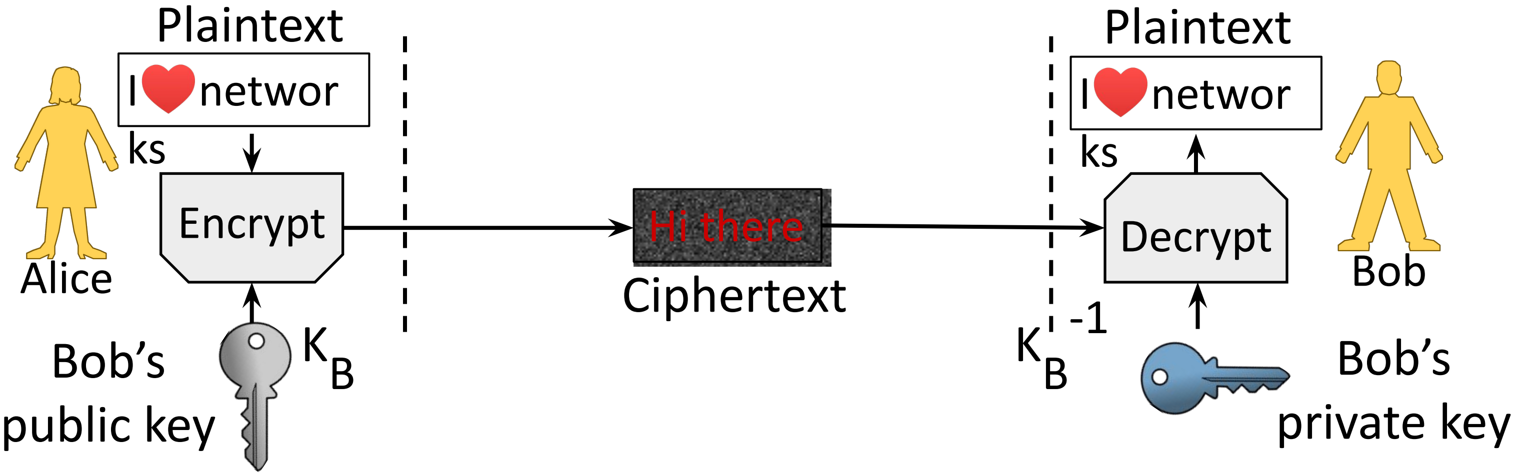
Symmetric (Secret Key) Encryption

- Alice and Bob have the same secret key, K_{AB}
    - Anyone with the secret key can encrypt/decrypt



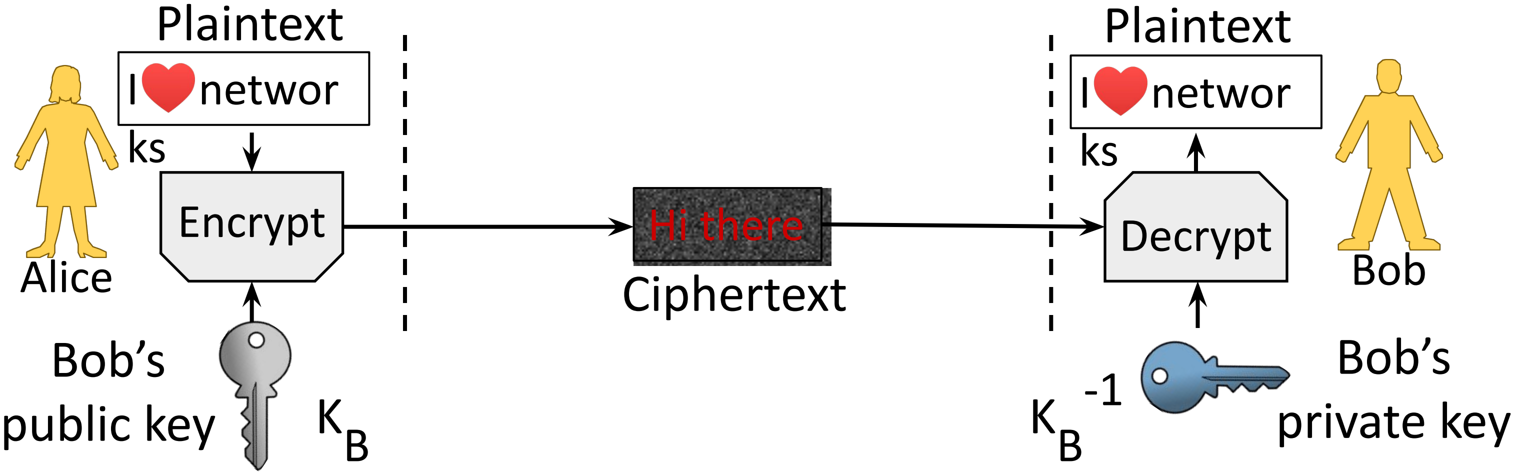
Public Key (Asymmetric) Encryption

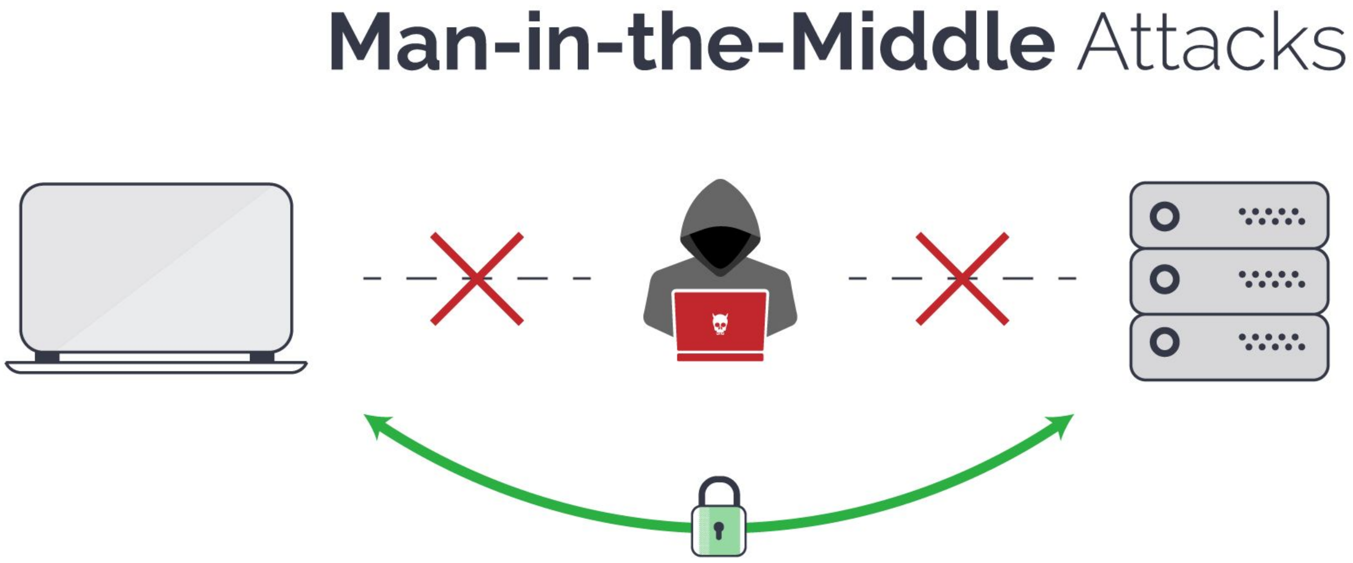
- Alice and Bob have public/private key pairs (K_B / K_B^{-1})
  - Public keys are well-known, private keys are secret



Public Key Encryption (2)

- Alice encrypts w/ Bob's pubkey K_B; anyone can send
- Bob decrypts w/ his private key K_B^{-1}; only he can





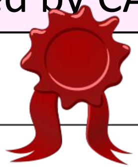
How can we trust a public key?

Certificates

- A certificate binds pubkey to identity, e.g., domain
  - Distributes public keys when signed by a party you trust
  - Commonly in a format called X.509

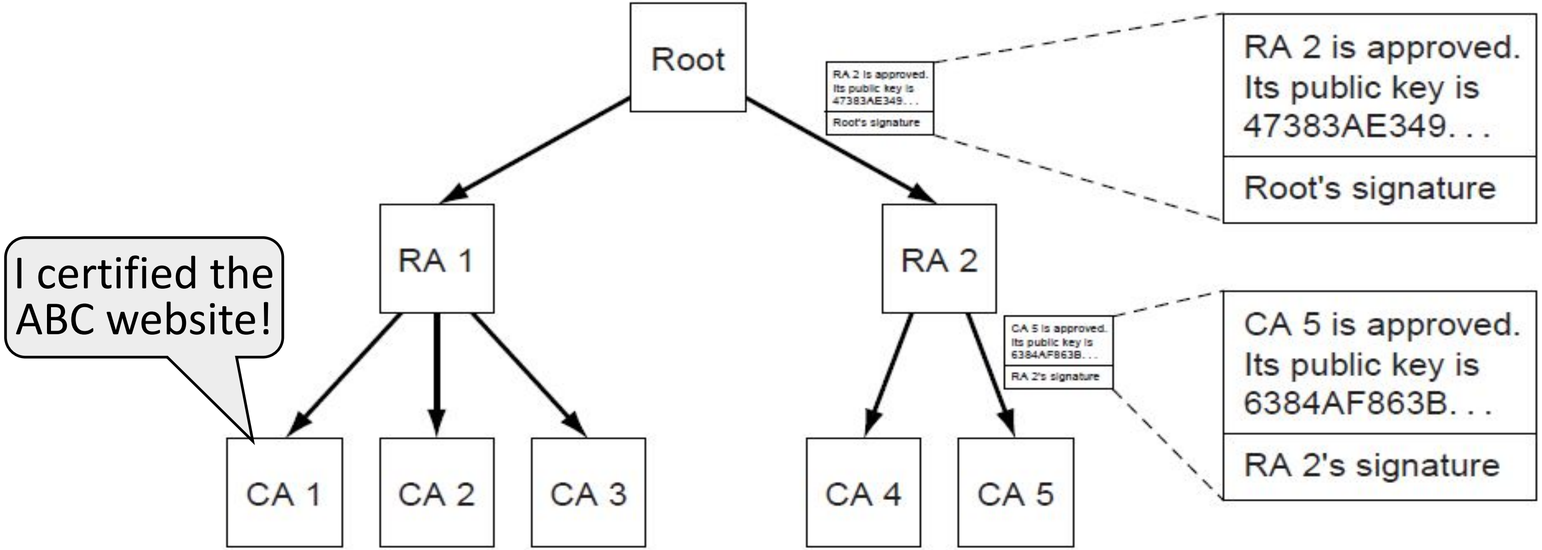
I hereby certify that the public key
19836A8B03030CF83737E3837837FC3s87092827262643FFA82710382828282A
belongs to
Robert John Smith
12345 University Avenue
Berkeley, CA 94702
Birthday: July 4, 1958
Email: bob@superdupernet.com

Signed by CA



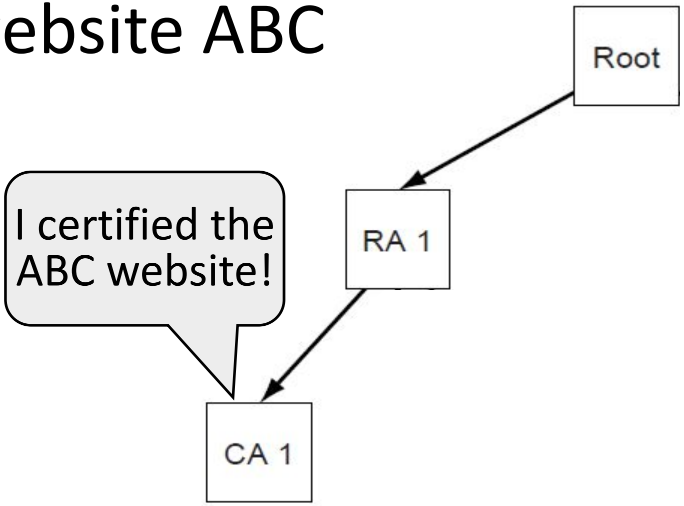
PKI (Public Key Infrastructure)

- Adds hierarchy to certificates to let parties issue
  - Issuing parties are called CAs (Certificate Authorities)



PKI (2)

- Need public key of PKI root and trust in servers on path to verify a public key of website ABC
  - Browser has Root's public key
  - {RA1's key is X} signed Root
  - {CA1's key is Y} signed RA1
  - {ABC's key Z} signed CA1



PKI (3)

- Browser/OS has public keys of the trusted roots of PKI
  - >100 root certificates!
  - That's a problem …
  - Inspect your web browser

Certificate for wikipedia.org issued by DigiCert

PKI (4)

- Real-world complication:
  - Public keys may be compromised
  - Certificates must then be revoked
- PKI includes a CRL (Certificate Revocation List)
  - Browsers use to weed out bad keys

Certificate

www.google.com | GTS CA 1C3 | GTS Root R1 | **GlobalSign Root CA**

Subject Name

Country	BE
Organization	GlobalSign nv-sa
Organizational Unit	Root CA
Common Name	GlobalSign Root CA

Issuer Name

Country	BE
Organization	GlobalSign nv-sa
Organizational Unit	Root CA
Common Name	GlobalSign Root CA

Validity

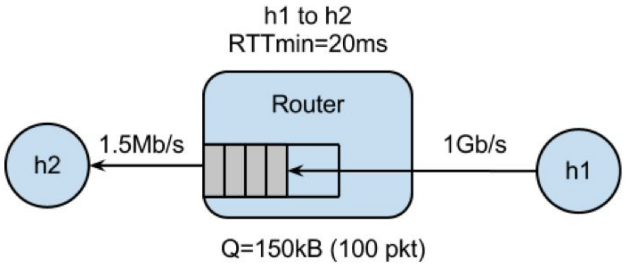
Not Before	Tue, 01 Sep 1998 12:00:00 GMT
Not After	Fri, 28 Jan 2028 12:00:00 GMT

Bufferbloat

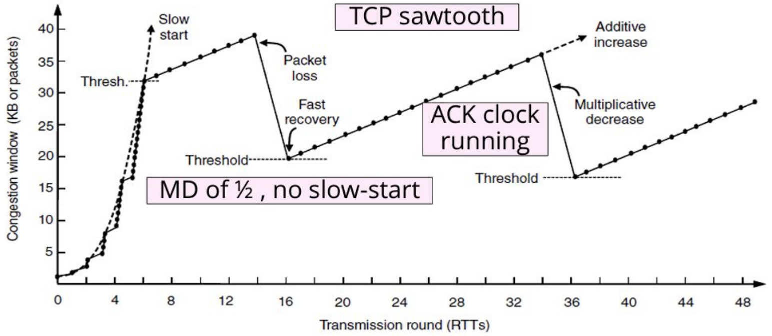
“Bufferbloat is a cause of high latency in packet-switched networks caused by excess buffering of packets” – Wikipedia

Bufferbloat – Cause

- Host doesn’t know the bandwidth of the bottleneck link.
- TCP relies solely on packet losses to guide how fast to send.
  - It keeps sending faster and faster until a packet drops.
- With a queue, this can fill up the queue pretty quickly.



TCP Reno



Bufferbloat – Problem

- Suppose h1 knows to send at 1.5 Mb/s, what's the RTT when the queue is full?
  - …when it's not full?
- TCP at the end of the day will operate at the bottleneck bandwidth, but is it necessary to fill up the queue?

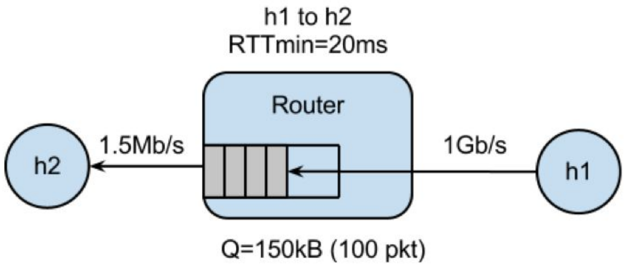
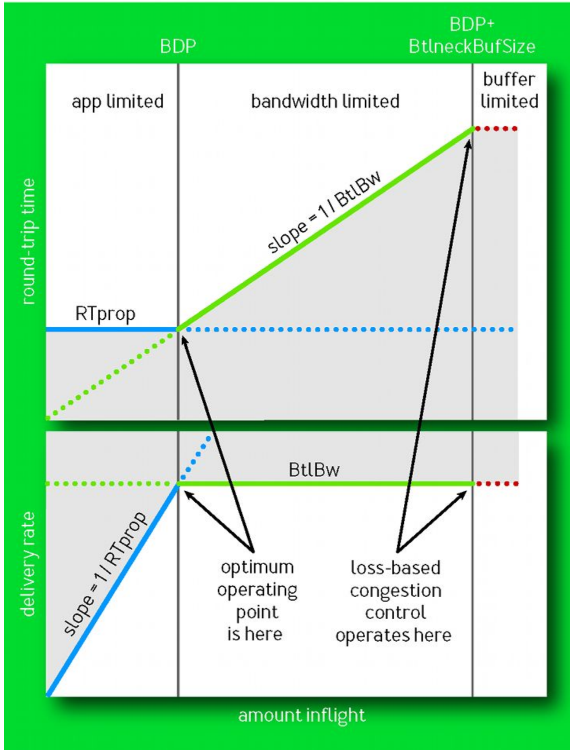


FIGURE 1: DELIVERY RATE AND ROUND-TRIP TIME VS. INFLIGHT



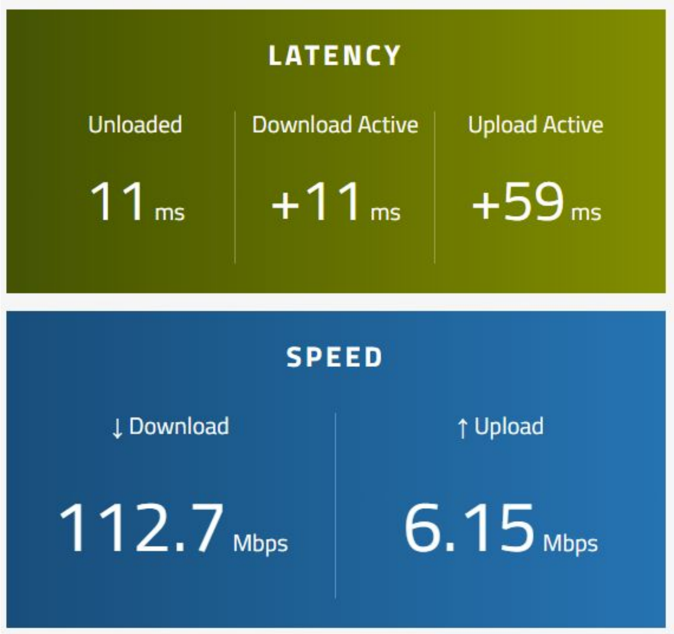
A motivational example…

Not all “speedtests” capture bufferbloat… took a long time for the networking community to realize it was a problem!

- A regular “ping” test, used to measure RTT in practice, won’t fill the buffers!

Let’s as a class try it out:

- https://www.waveform.com/tools/bufferbloat
  - Loaded latency vs. unloaded latency
  - How big is the difference?



Real-world Initiatives

Active Queue Management (AQM)

- Goal is to use better queue management techniques
- Leverage ECN to give fast feedback without causing loss
    - Unfortunately hard to deploy ECN CC “fairly” with existing CC algos (Reno, Cubic)
    - It works so much more responsively (aka better) it tends to takeover throughput from legacy TCP!

L4S “Low-latency, low-loss, scalable throughput” initiative at IETF

- One solution is to mandate a split at bottlenecks, two queues with independent behavior
- Required in latest cable modem standards

One AQM Technique: FQ_CODEL

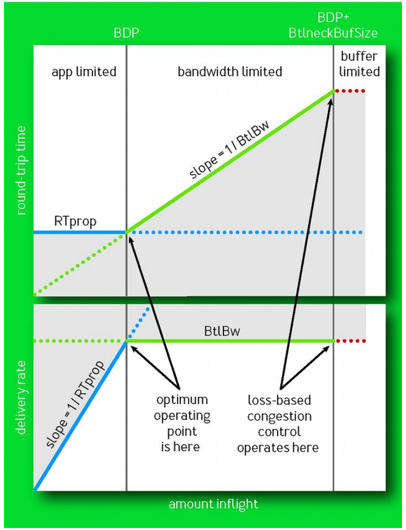
💡 **FQ == "Fair Queue"**
CoDel == "Controlled Delay"

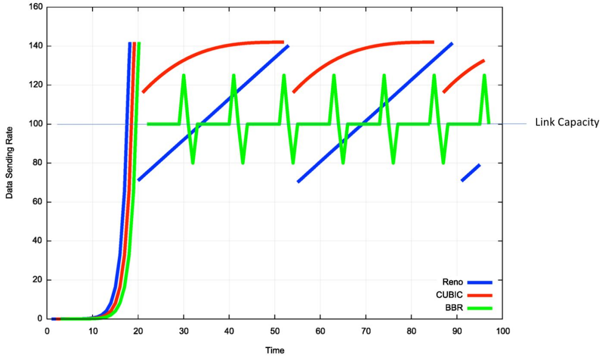
- Initiatives to add *flow-independent* queues to bottleneck routers…
  - like L4S to an extreme…
  - Each flow gets its own queue, and it's the router's job to make them all fair!
  - Attempts to estimate bottleneck and not queue any more than necessary to fill the pipe
    - Similar big idea to BBR
- Available in all modern Linux distros (kernel > 3.16)
  - Default in some
- Default in OpenWRT
  - Used as the basis for some commercial routers too (SpaceX Starlink is a prominent example)
- Relatively resource intensive though, so not feasible on "core" routers yet

Bufferbloat aware transport: BBR

- Different type of solution than AQM
  - Operates only on end hosts
- Developed at Google in 2016 for YouTube traffic.
- Uses a model instead of loss to formulate how fast to send
  - Probe RTT and latency and predict the bottleneck bandwidth.

FIGURE 1: **DELIVERY RATE AND ROUND-TRIP TIME VS. INFLIGHT**



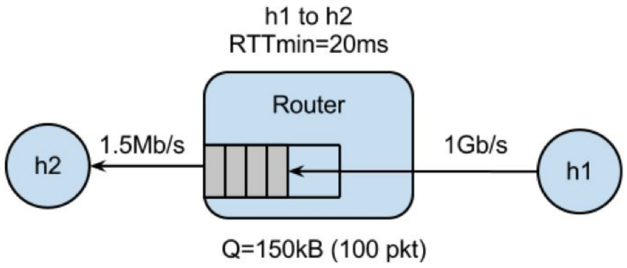


Project 3 – Goal

- Simulate bufferbloat problem.
- See the worse performance when queue size is larger
- See the difference between TCP Reno and TCP BBR.

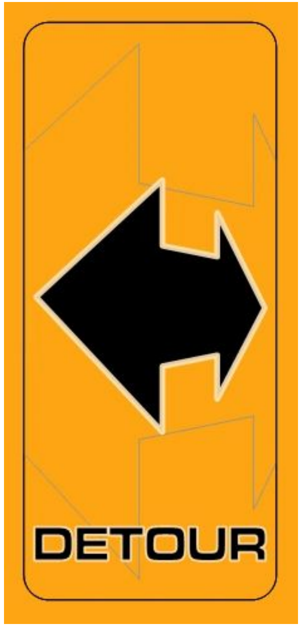
Experiment Setup

- Long-lived TCP flow from h1 to h2
  - Simulate background traffic
- Back-to-back ping from h1 to h2
  - Measure RTT
- Spawn a webserver on h1 and periodically fetch a page
  - Simulate more important load
  - Measure time
- Plot time series of RTT and number of queued packets.



- Run the experiment with
  - Q=20 and Q=100
  - Reno and BBR
  - 4 experiments total

Detour – Hypothesize



In groups of 3-4,...

- In your own words, what is bufferbloat problem?
- For each of the 4 experiments (Q=20 or 100; and with Reno or BBR),
  - How do the webpage fetch time compare?
- How would plot between queue size and time look like for TCP Reno?

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	Q=20	Q=100
Reno	<;=;>	
	<;=;>	<;=;>
BBR	<;=;>	

Setup

- Use Mininet VM (same as Project 2)
- Get the starter code and install dependencies

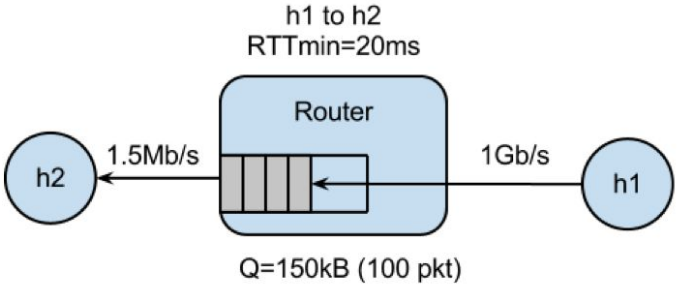
```
cd ~

wget
https://courses.cs.washington.edu/courses/cse461/22wi/projects/project3/resources/project3.zip

unzip project3.zip

sudo apt-get update

sudo apt install python3-pip

sudo python3 -m pip install mininet matplotlib
```

Starter Code

- run.sh
  - Run the entire experiment
    - Run bufferbloat.py on q=20 and q=100
    - Generate latency and queue length graphs
- bufferbloat.py
  - Complete the TODOs
    - Setup the mininet topology and the experiment
    - Write shell commands to do the measurements

Long-lived TCP Flow

- Starter code sets up iperf server on h2
- Goal: start iperf client on h1, connect to h2
  - Should be “long-lasting”, i.e. for time specified by --time parameter
- How do I connect to a certain IP or make the connection long-lasting?
  - man pages are your friend!
  - type `man iperf` in a Linux terminal

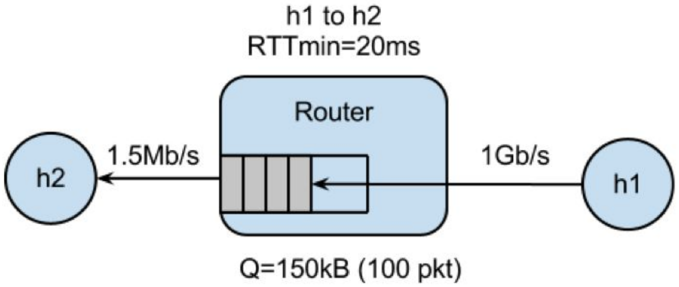


Ping Train

- Goal: Start “ping train” between h1 and h2
  - Pings should occur at 10 per second interval
  - Should run for entire experiment

- How do I specify the ping interval and how long the ping train runs?
  - man pages are your friend!
  - type `man ping` in a Linux terminal

- Write the RTTs recorded from `ping` to {args.dir}/ping.txt
  - See starter code comments for more detail

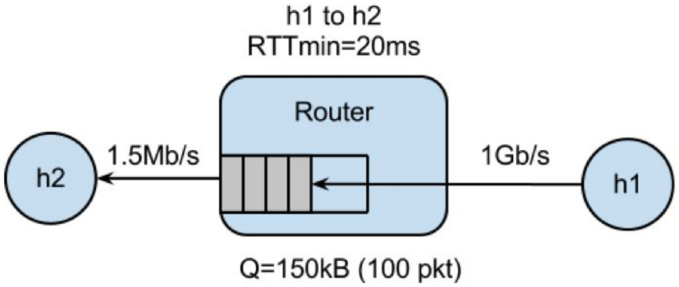


Download Webpage with curl

- Starter code spawns webserver on h1

- Goal: Use `curl` to measure fetch time to download webpage from h1
  - Starter code has hint on formatting curl command
  - Make sure `curl` doesn't output an error
    - Errors report very small latency

- No need to plot fetch times; just need to report average fetch time for each experiment.

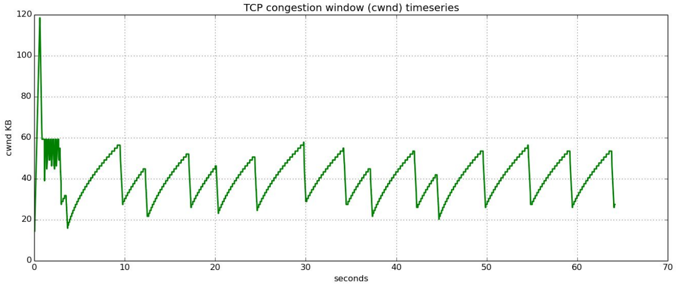


Plotting

- Starter code contains scripts for plotting, `plot_queue.py`, `plot_ping.py`
  - Expects queue occupancy in $dir/q.txt, ping latency in $dir/ping.txt
  - Plots are useful for debugging!

- Part 3, run same experiments with TCP BBR instead of TCP Reno
  - How do you expect the graph outputs to differ?

Q = 20



Q = 100