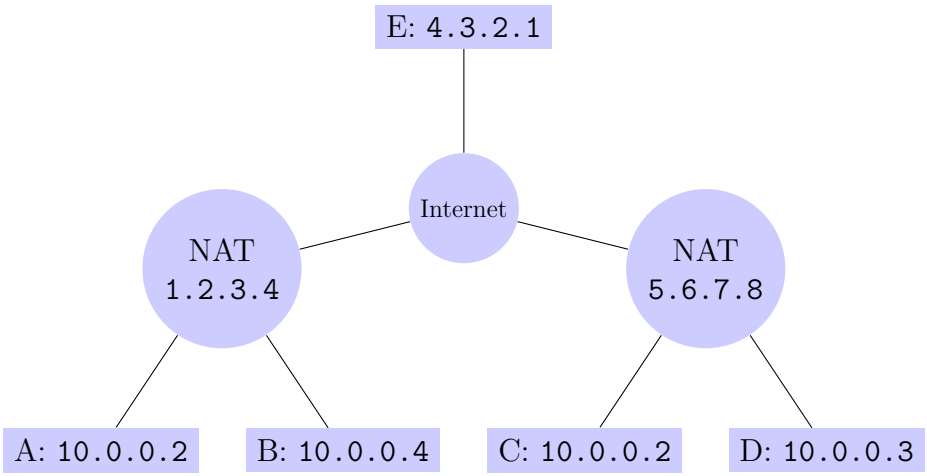
1. Consider the following network topology where some residential hosts connect to the Internet via NAT devices:



   (a) Host A has an active SSH connection (Port 22) to Host E. Give a plausible value for the (source address, destination address, source port, destination port) 4-tuple for packets in this connection as they exit Host A's computer. Indicate what elements of the tuple would be assigned at connection time (pick whatever value you want for these *ephermeral* ports).

   (b) What is a plausible value for the (source address, destination address, source port, destination port) 4-tuple for packets for the connection in (a) when they arrive at Host E? Again, indicate what elements would be assigned at connection time.

   (c) Suppose Host D wishes to serve web pages (on port 80) to the Internet. What must happen in order for devices on the Internet to access the server on Host D?

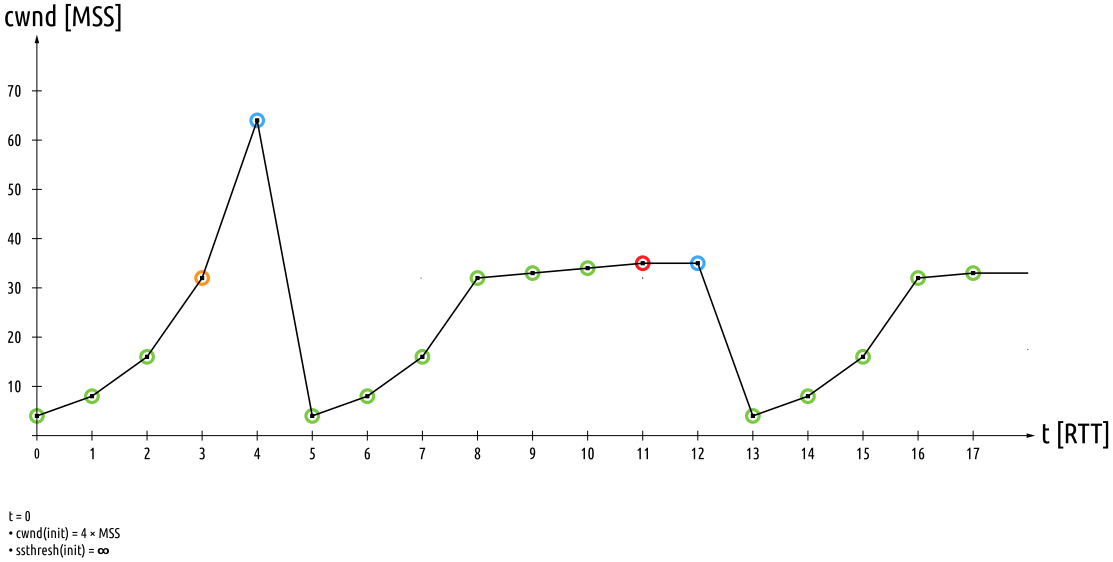
   (d) Host B attempts to connect Host D (i.e. by sending a packet to D). List out how the (source address, destination address, source port, destination port) 4-tuple evolves as it traverses the network from B to D. Indicate what elements would be assigned at connection time.

   (e) Host A and Host C have the same IP address. Is this an issue? Explain why it is or isn't.

2. Show that to achieve a steady-state throughput of 10 Gbps, a TCP session with a Round-Trip-Time (RTT) of 100 ms and a Maximum-Segment-Size (MSS) of

1500 bytes can tolerate a packet loss probability of less than 2×10^{-10}. What would the tolerable loss be for a 100 Gbps connection?

3. Consider the following plot of CWND size over the duration of a TCP connection. Note that in this computer's implementation of TCP the initial CWND is 4.



   (a) What has occurred during the events marked by blue circles?

   (b) What has occurred during the event marked by the red circle?

   (c) What range(s) of times correspond to slow-start?

   (d) What is `ssthresh` at t=5?

   (e) What is `ssthresh` at t=13?

4. It is interesting to consider the consequences if TCP's behaviour was a bit different. Describe the consequences if the following were true:

   (a) TCP slow-start increased CWND by 1 each RTT

   (b) TCP does not reset the CWND to 1 after a timeout

   (c) TCP resets CWND to 1 after a duplicate ACK

5. TCP has a few problems areas

(a) Why are non-congestion losses bad for TCP? Give examples of how non-congestion losses might arise.

(b) Give two reasons why short flows are inefficient for TCP. What kind of Internet activity can result in many short flows?

6. Delay-based TCP (e.g., TCP BBR) uses latency instead of packet loss to estimate congestion and throttle window sizes accordingly. Explain why connection latency (i.e., RTT) is a suitable proxy for congestion?