Transport Layer

→ Understand Principles of Transport Layer

→ Building Reliable Protocols from first principles

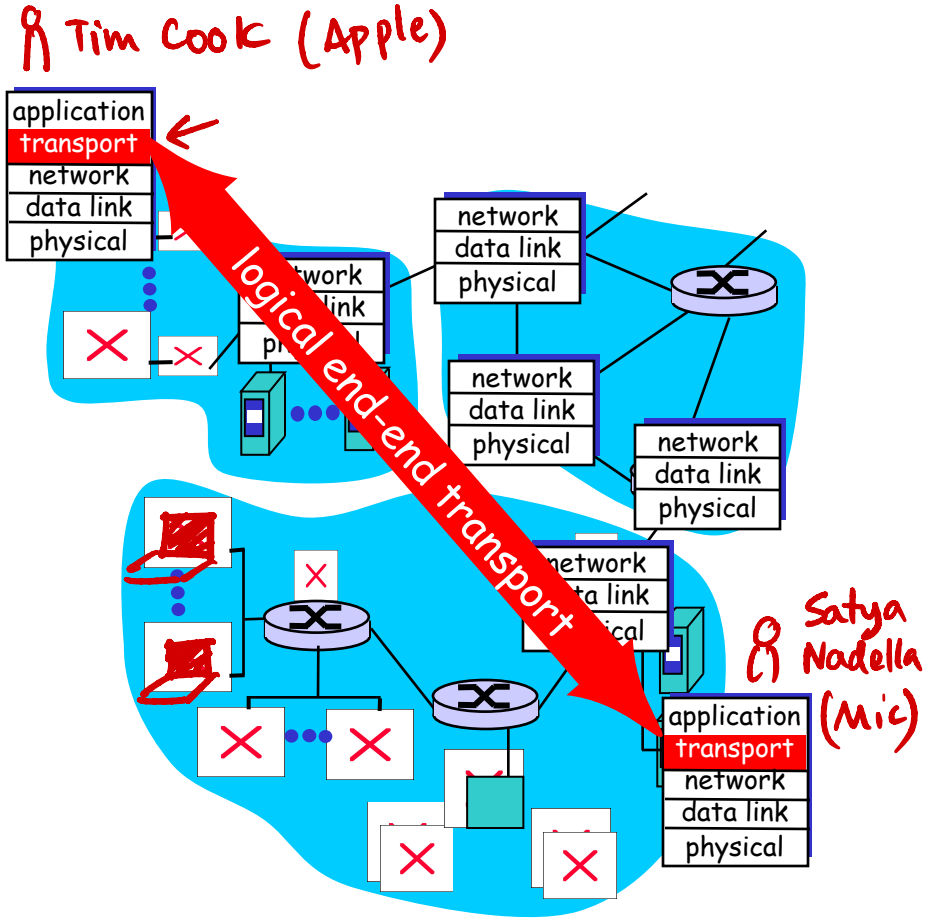
→ Case Studies < TCP
UDP

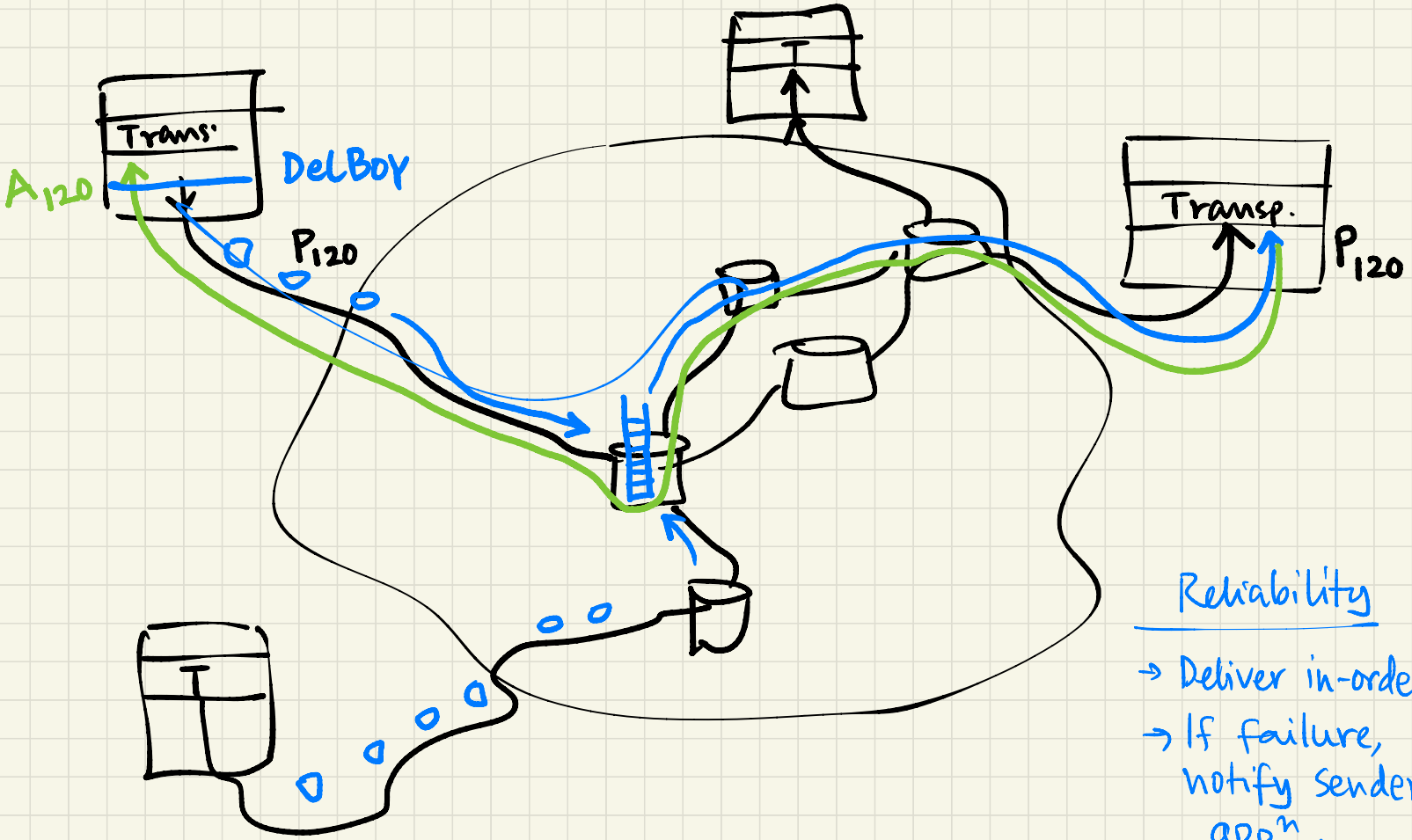
Transport Layer

- Understand Principles of Transport Layer
  - End to end
    - E2E Bandwidth estimation
  - Notion of reliability
    - Reliable over unreliable channel
    - Error detection / correction
  - Reliable concensus
  - State machine
- Building Reliable Protocols from first principles
- Case Studies < TCP, UDP

Transport services and protocols

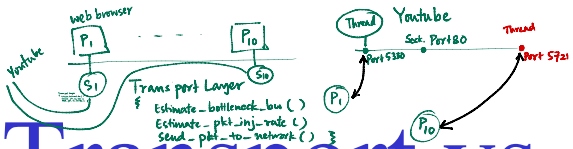
- provide *logical communication* between app processes running on different hosts
- transport protocols run in end systems
  - sender: breaks app messages into segments, passes to network layer
  - receiver: reassembles segments into messages, passes to app layer
- more than one transport protocol available to apps
  - Internet: TCP and UDP



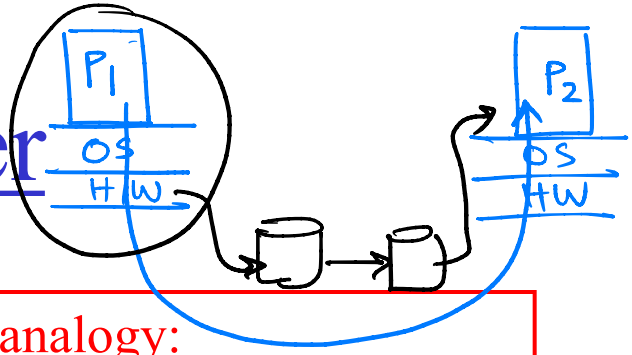


Reliability

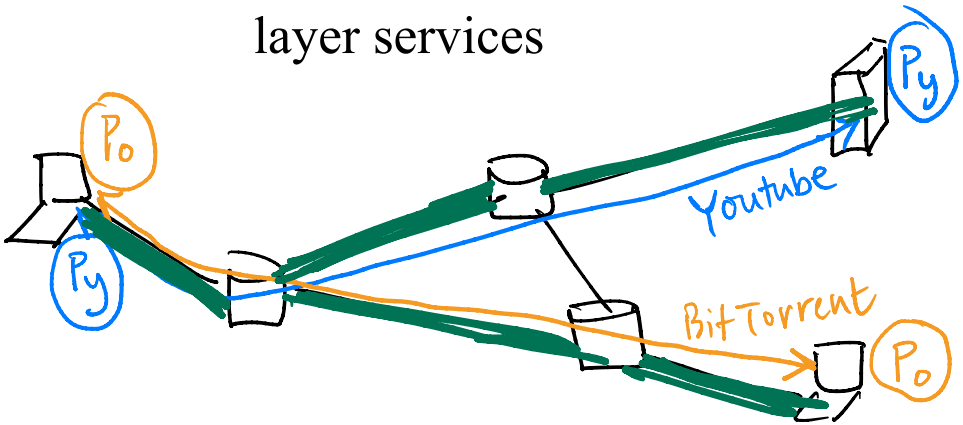
- → Deliver in-order
- → If failure, notify sender app^{n}.



Transport vs. network layer



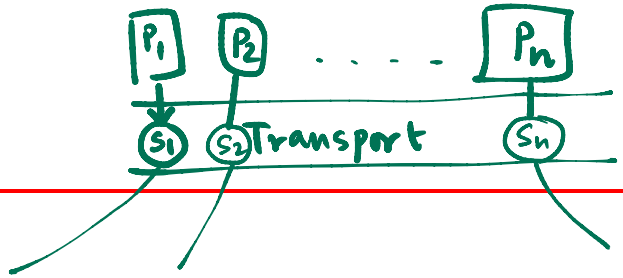
- *network layer:* logical communication between hosts
- *transport layer:* logical communication between processes
  - relies on, enhances, network layer services



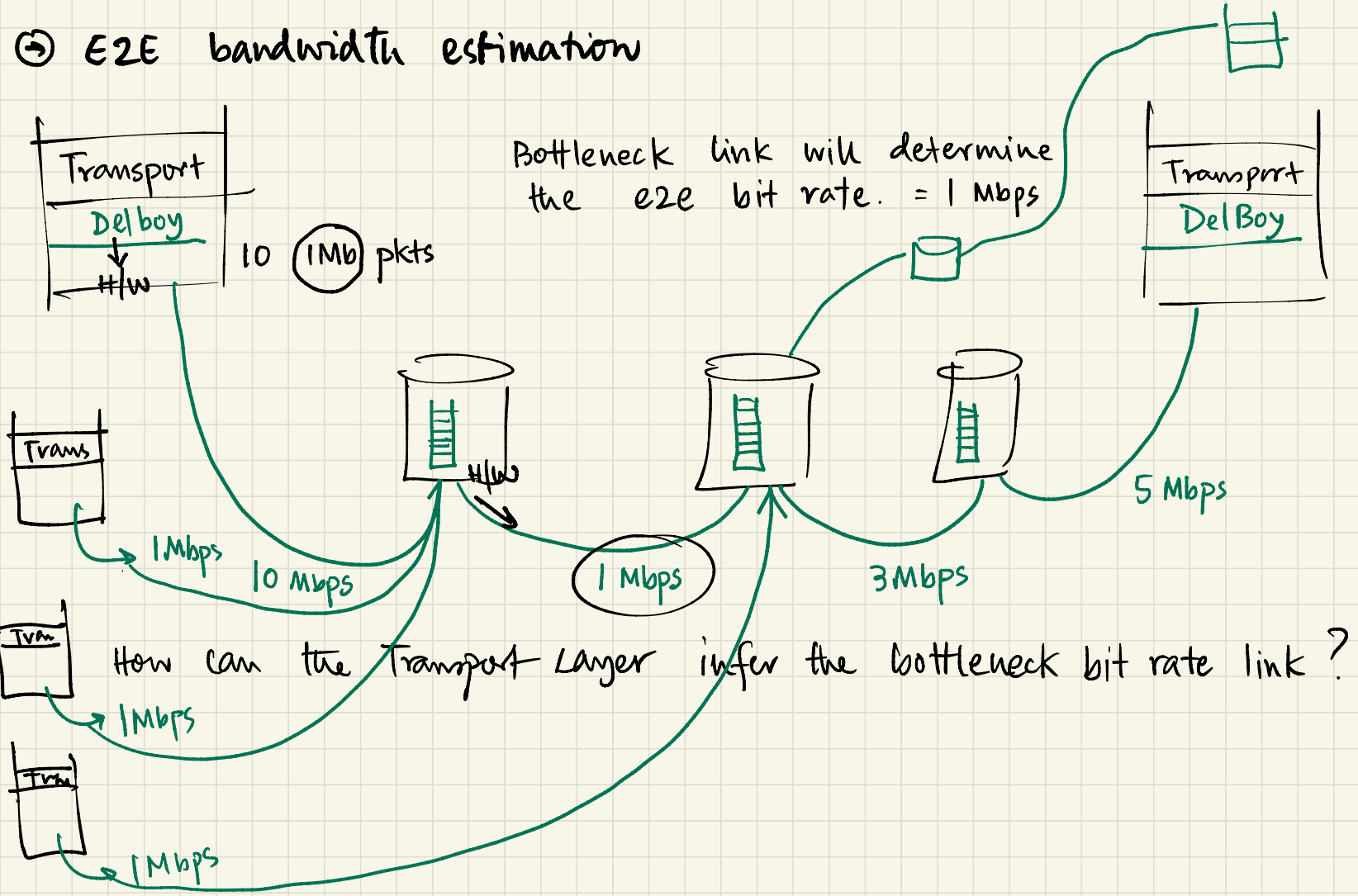
Household analogy:

12 kids sending letters to 12 kids

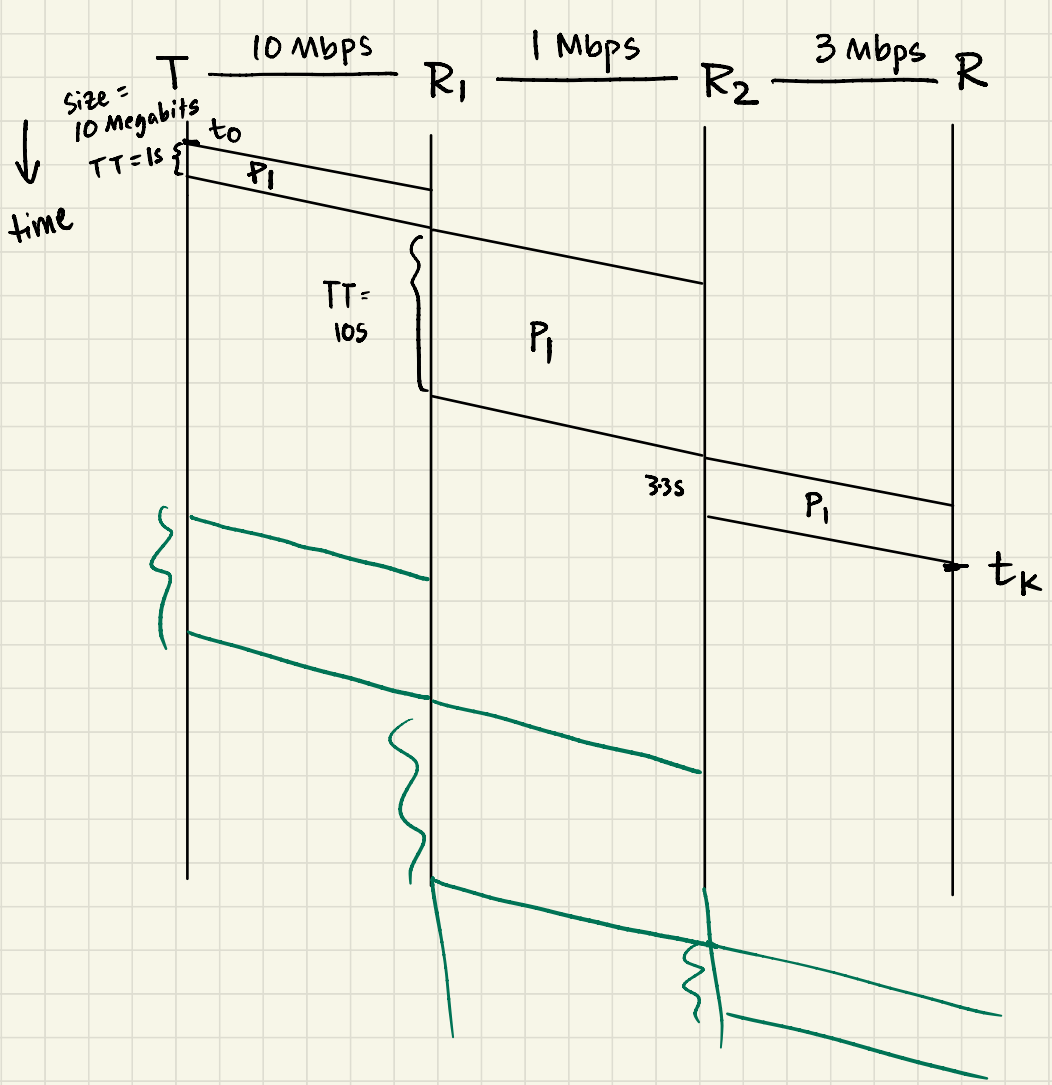
- processes = kids
- app messages = letters in envelopes
- hosts = houses
- transport protocol = Ann to Bill
- network-layer protocol = postal service



⊕ E2E bandwidth estimation



How can the Transport Layer infer the bottleneck bit rate link ?



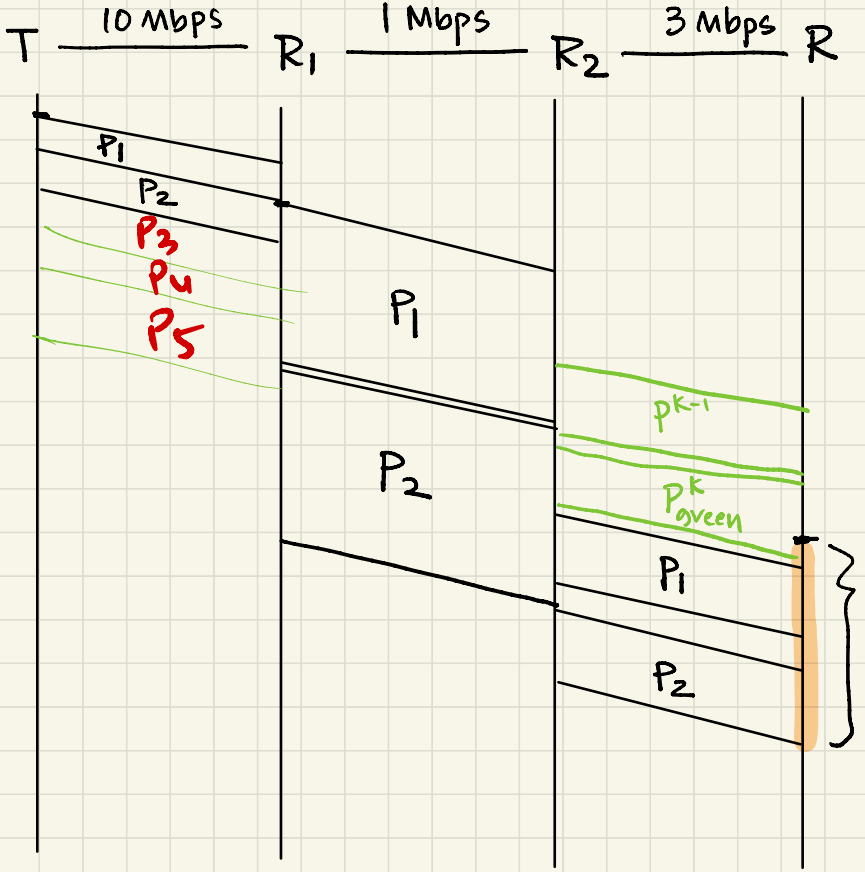
$t_K - t_0$ = time taken to reach destⁿ..

$= 14.3\,s$

$10 = a + b + c$

what is $\min\{a, b, c\}$

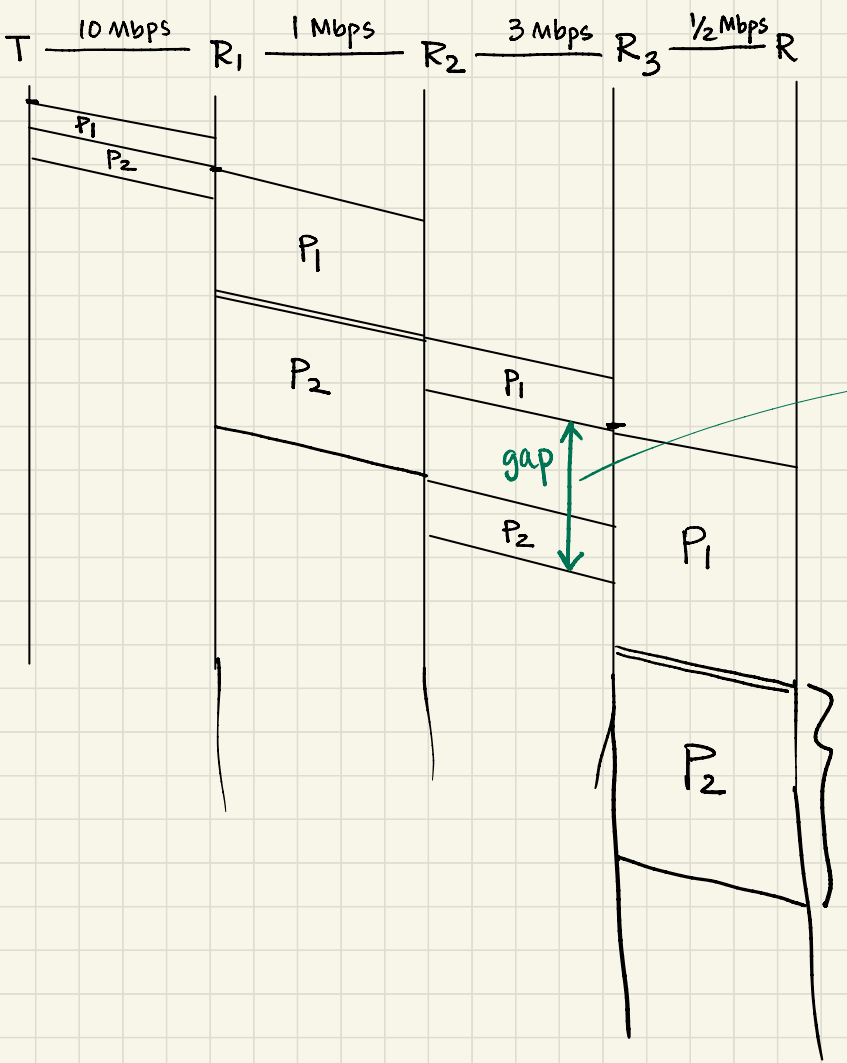
Packet pair based bottleneck bitrate estimation



this duration is a f^n of

$$\frac{\text{Packet size}}{\text{Bottleneck bit rate}}.$$

Packet pair based bottleneck bitrate estimation



This gap will never decrease if all subsequent queues are empty and the previous link is the network's bottleneck. Function of ½ Mbps. However, if the bottleneck comes later, then the gap will increase to exactly reflect that bottleneck.

Internet transport-layer protocols

- reliable, in-order delivery (TCP)
  - congestion control
  - flow control
  - connection setup
- unreliable, unordered delivery: UDP
  - no-frills extension of "best-effort" IP
- services not available:
  - delay guarantees
  - bandwidth guarantees