Week 3: Connectivity, losses, latency, and geolocation

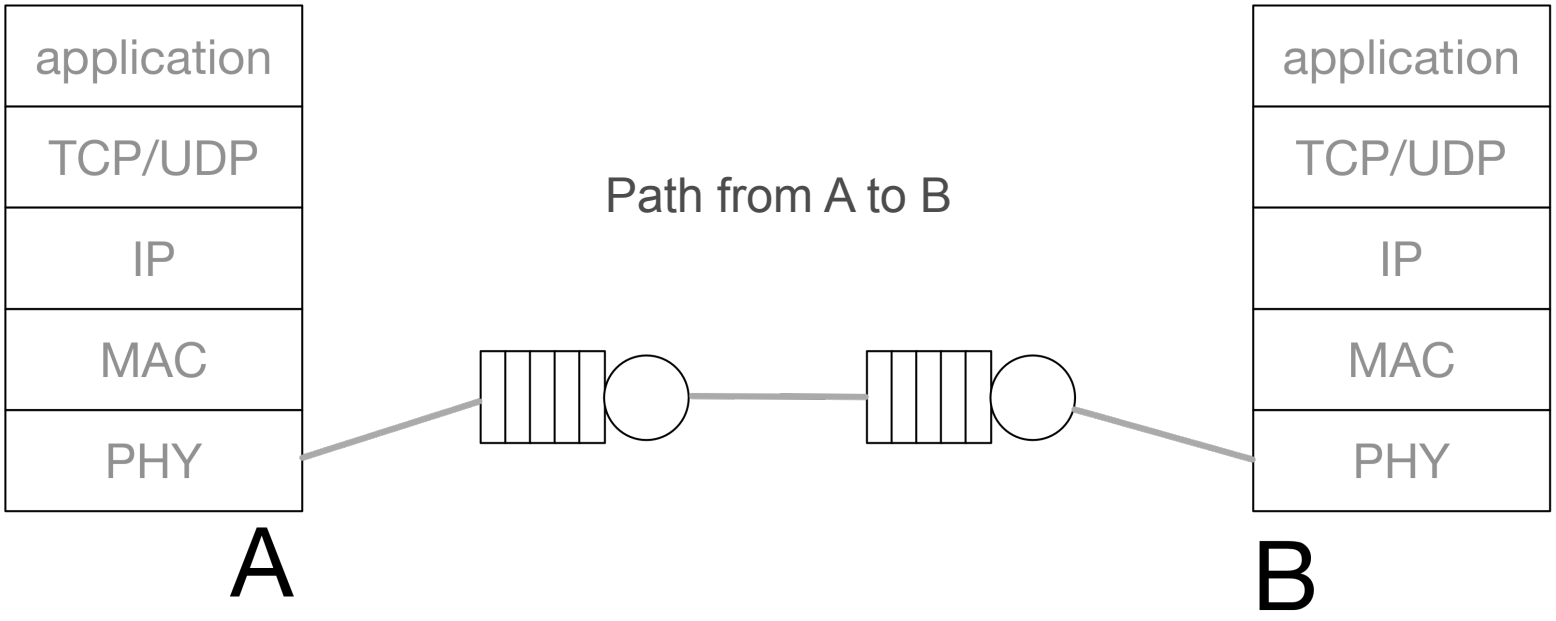
1. Introduction - Ping
2. Connectivity
3. Losses
4. **Latency**
   A. Introduction
   B. **Components**
   C. Clocks
   D. Tools
5. Geolocation
6. Conclusion

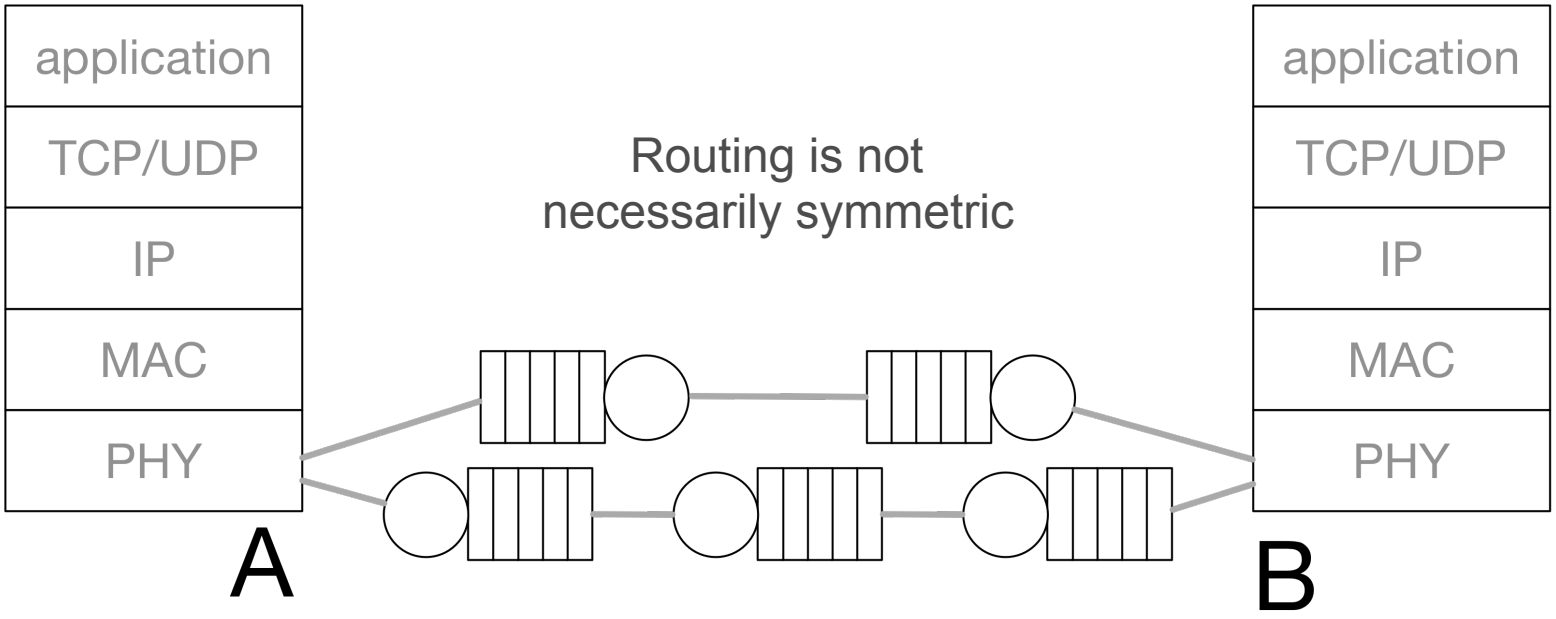


A

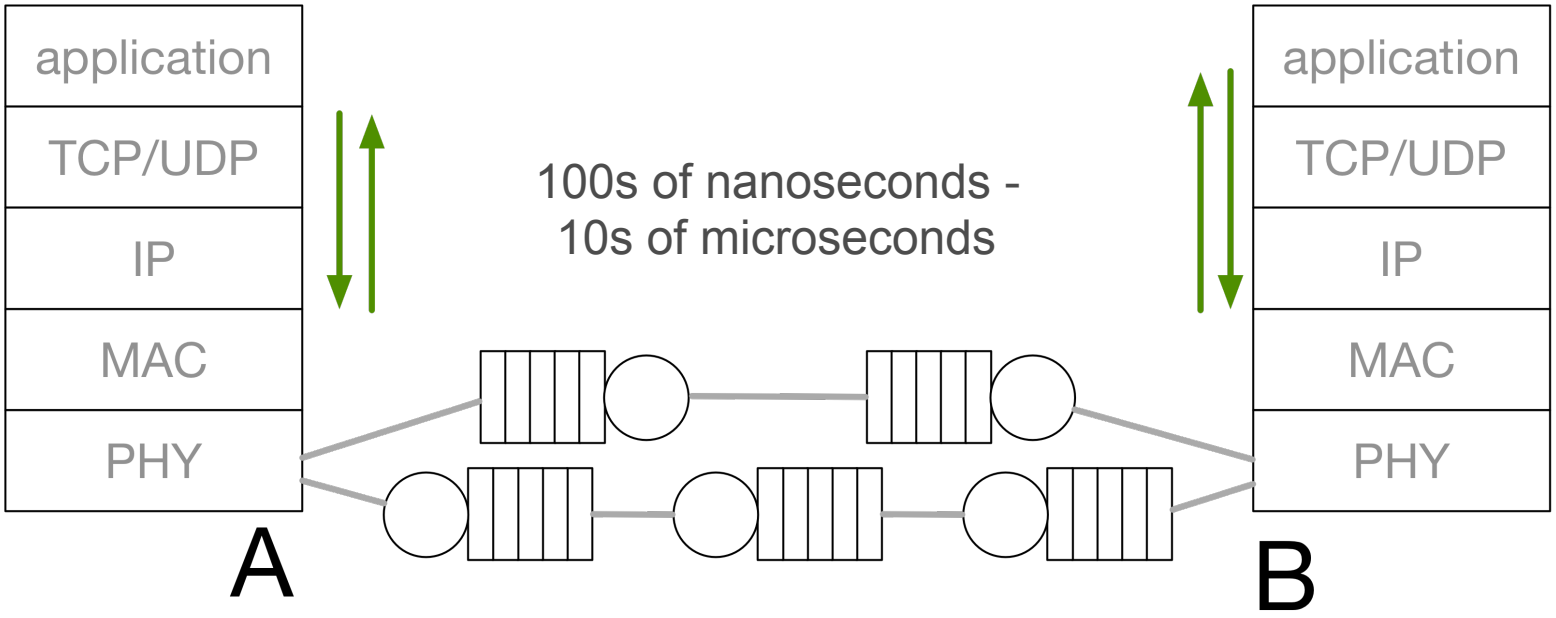
ICMP at this layer


application
TCP/UDP
IP
MAC
PHY
A
application
TCP/UDP
IP
MAC
PHY
B

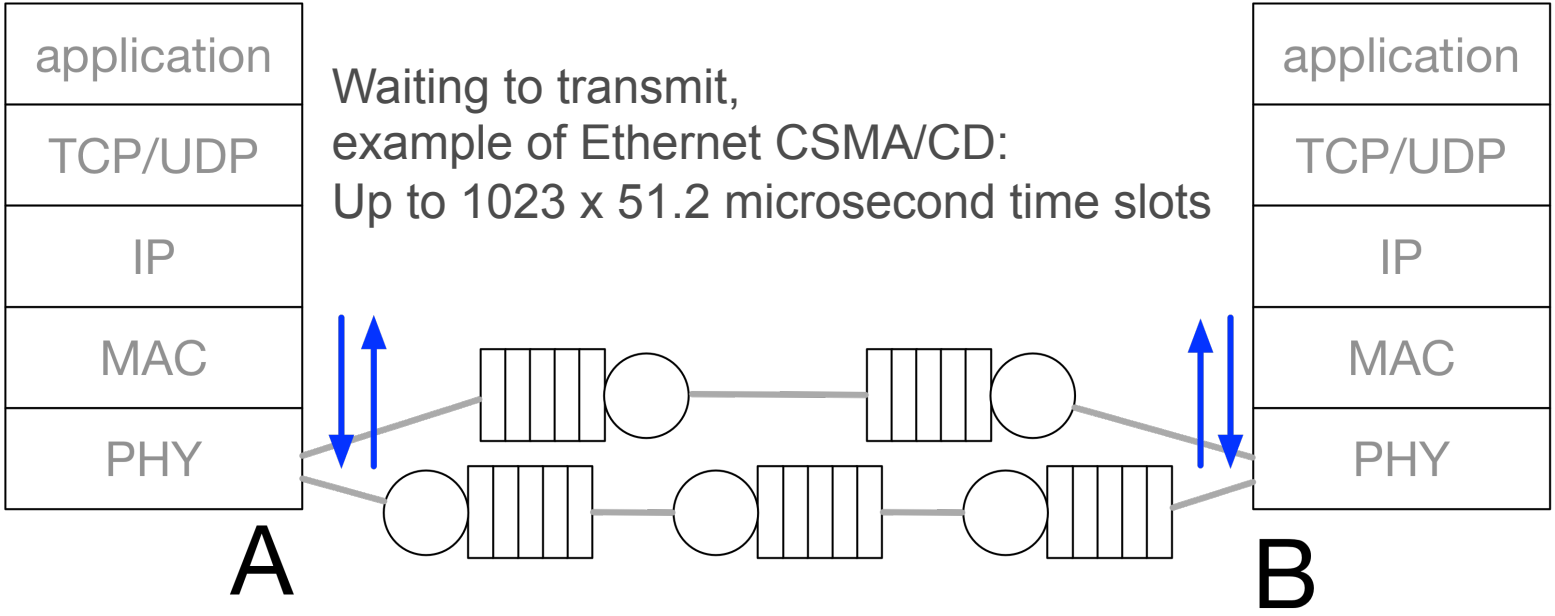

application
TCP/UDP
IP
MAC
PHY
A
Path from A to B
application
TCP/UDP
IP
MAC
PHY
B


application
TCP/UDP
IP
MAC
PHY
Routing is not
necessarily symmetric
application
TCP/UDP
IP
MAC
PHY
A
B

Processing delay

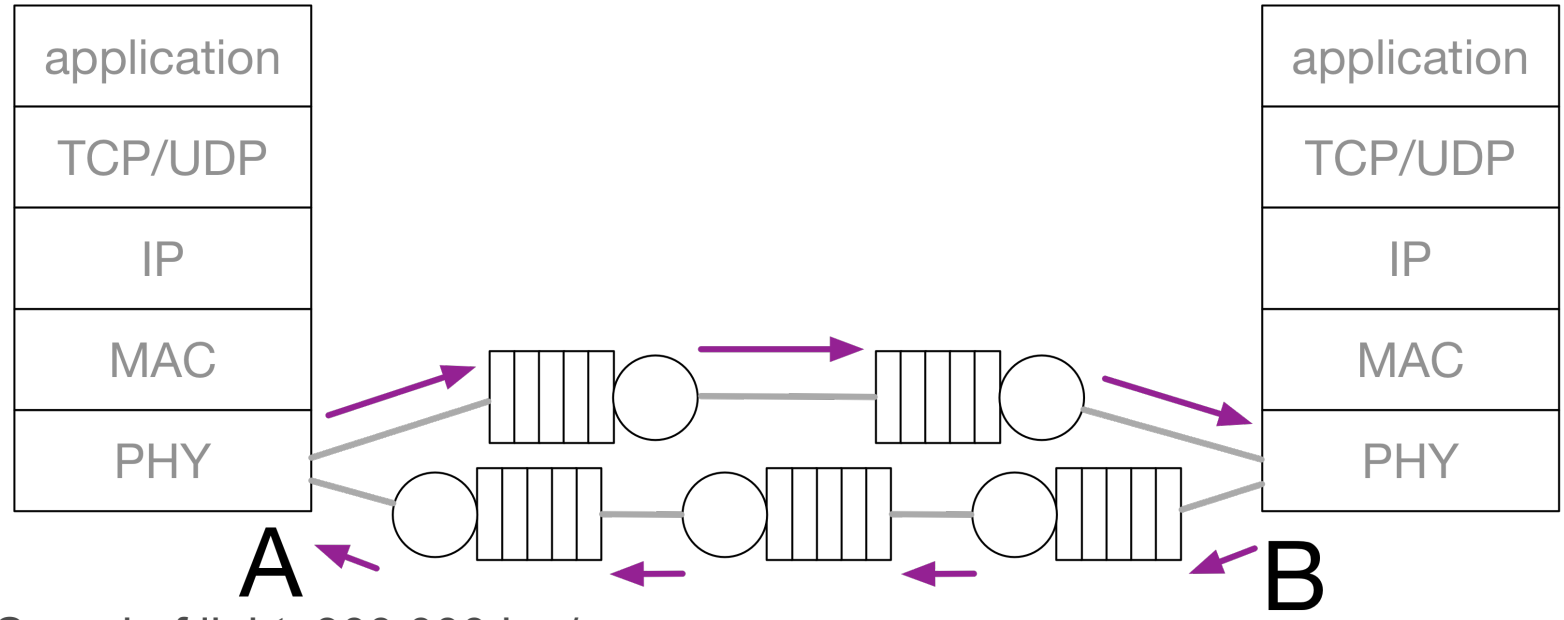


Transmission delay



Transmitting:
9216 bytes jumbo Ethernet frame: 74 microseconds at 1 Gbps
1526 byte Ethernet frame: 1.2 milliseconds at 10 Mbps

Propagation delay



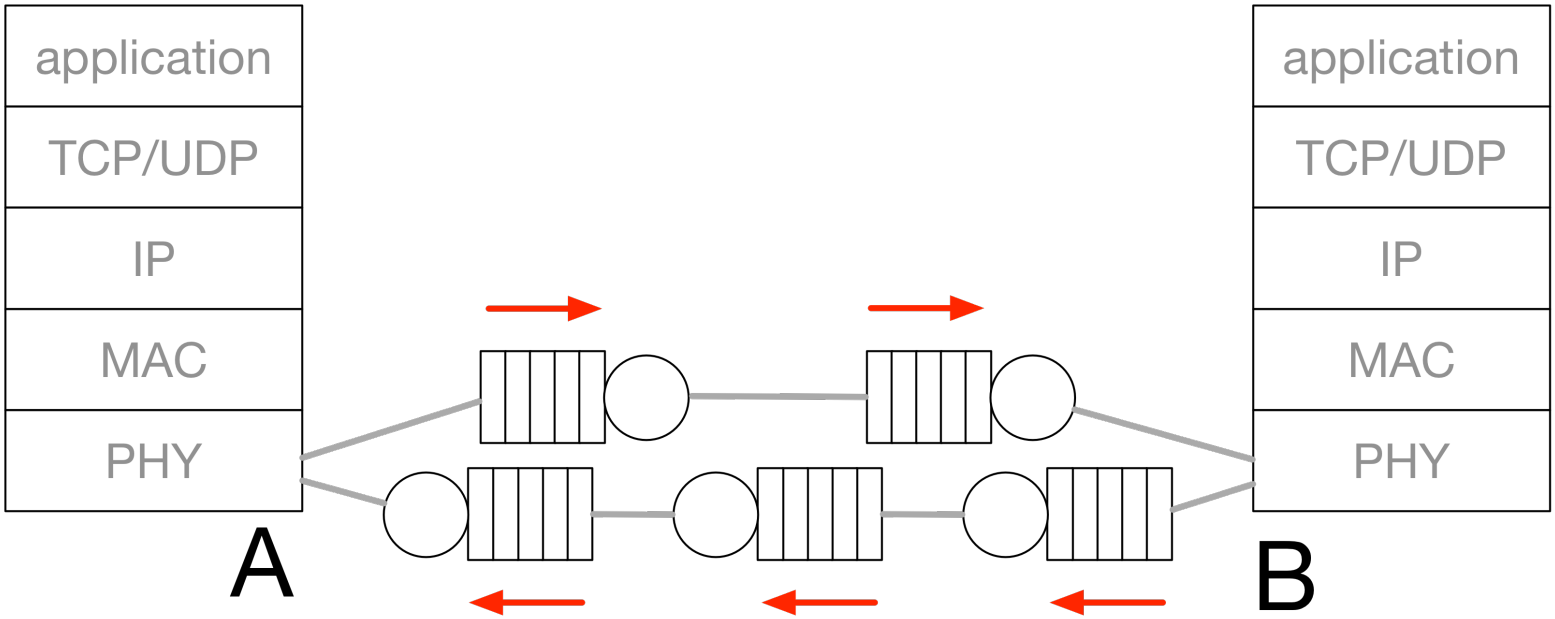
Speed of light: 300,000 km/sec

- To geostationary satellite and back: 240 milliseconds

Optical fiber at 2/3 speed of light

- Milliseconds within country
- 100 milliseconds halfway around the world

Queueing delay



- Unloaded network: queueuing delay almost zero
- Large buffers: 250 milliseconds not unusual,
  up to six seconds observed ("bufferbloat")

Latency components

- Processing
  - Hundreds of nanoseconds to tens of microseconds
- Transmission
  - Tens or hundreds of microseconds, plus milliseconds for CSMA/CD backoff
- Propagation
  - A fraction of a millisecond to a couple of hundred milliseconds (one way)
- Queueing
  - Up to several seconds due to "bufferbloat"
  - Ideally, no more than a couple of milliseconds