Week 4: Bandwidth

1. **Introduction**
2. Definitions of bandwidth metrics
3. End-to-end measurement approaches
4. Flooding
5. Advanced probing
6. Conclusion

Bandwidth captures network speed

- Bandwidth
  - Data rate of network link or path
- Why measure bandwidth?
  - Main commercial metric (e.g., in SLA)
  - Important for many applications
    - ✓ TCP congestion control
    - ✓ Video streaming
    - ✓ File transfer

Nominal physical link capacity

- Definition
  - Theoretical maximum transmission rate a link can support

Examples of physical capacities

- Local networks
  - 100BaseTX Ethernet: 100 Mbps
  - WiFi 802.11g: 54 Mbps; 802.11n: 130 ~ 150 Mbps (max 600 Mbps)
- Residential access (downstream)
  - ADSL2+: 24 Mbps
  - Cable: 30 Mbps
- Backbone links
  - OC-192: 10 Gbps
  - OC-768: 40 Gbps

Physical versus IP link capacity

- IP-layer capacity < nominal capacity
  - Coding schemes
  - Framing bits, overhead
  - Medium access control

Example: 100BaseTX Ethernet

- Nominal capacity = 100 Mbps

Preamble	Start of frame delimiter	Destination MAC	Source MAC	Ethertype	Payload	Frame Check Sequence	Inter-packet gap
7 octets	1 octet	6 octets	6 octets	2 octets	1500 octets	4 octets	12 octets

- IP capacity (assuming max-size packets)
  - 1500 * 100 Mbps = 97.5 Mbps

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Focus of this week

- Measurements at the IP layer and above
  - IP layer capacity
  - End-to-end capacity of a TCP connection

Outline of this week

- Definitions of bandwidth metrics and some limitations
- Bandwidth measurement approaches
- Measuring end-to-end bandwidth with flooding
  - Example flooding tools: iperf, Speedtest
- Advanced probing methods
  - Packet pair
  - Size delay
  - Self-induced congestion
- Conclusion