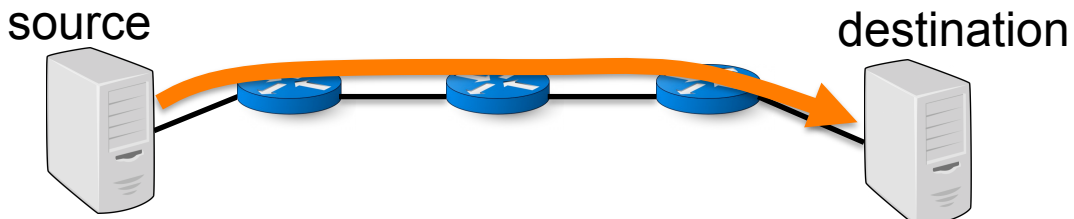
Week 4: Bandwidth

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

Bulk transfer capacity (BTC)

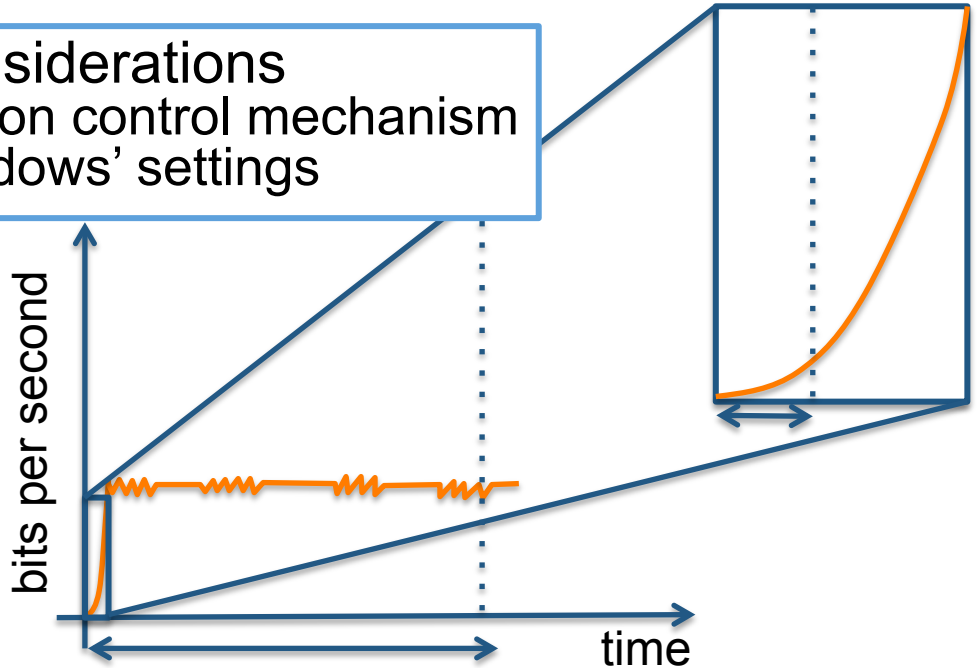
- Basic method
  - Send as much data as possible over a single TCP connection from source to destination



  - BTC = $\frac{\text{data size (in bits)}}{\text{transfer time}}$

Consideration: Transfer size

Other considerations
- Congestion control mechanism
- TCP windows' settings

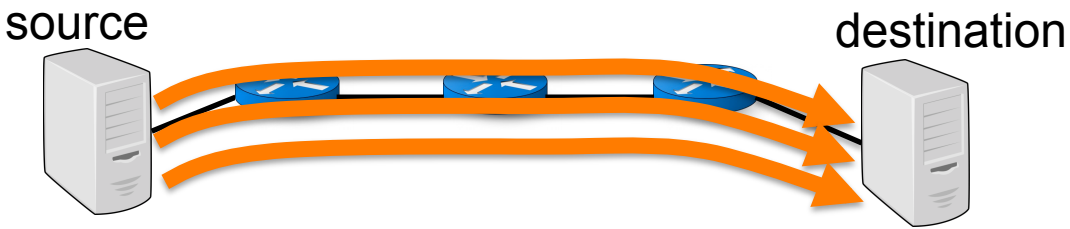


Too small mainly measures slow start

Too large creates unnecessary overhead

Available bandwidth

- Basic method
  - Send as much data as possible from source and measure rate at destination
    - ✓ Over multiple TCP connections or UDP



  - A = $\frac{\text{data size (in bits)}}{\text{transfer time}}$

Considerations

- TCP versus UDP
  - UDP not biased by congestion/flow control
  - Flooding with UDP may create too much congestion and bias results
  - Multiple TCP connections reduces bias
- Multi-threaded TCP
  - How many threads?
  - Which size transfers?
- UDP
  - How to pick sending rate?

Measure path capacity with flooding

- Hard to measure capacity with a single measurement
- Solution: estimate from multiple measurements
  - Maximum available bandwidth over time approximates path capacity

Picture credits

- Slides 2 & 4:
  - **Server Linux box clip art** by OCAL, www.clker.com (public domain)
  - **Router clip art** by OCAL, www.clker.com (public domain)