Goals and Metrics

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Goal

- Enable <u>Efficient</u>, <u>Robust</u> and <u>Scalable</u> Communication
  - Efficient in terms of delay, cost etc
  - Robust towards failures or errors
  - Scalable with more users and data

Means

- Technology Development (Hardware)
  - Faster/Cheaper/Energy-efficient Routers, Links and Hosts
- Protocols (Software): Implement many of the required functionality to support communication
  - Provide reliability
  - Route packets
  - Share physical media etc
  - Each protocol tries to achieve a specific goal

Protocol

- Defines format and rules for exchange of messages
  - What to send: Format
  - When to send & How to act : Rules
- E.g. TCP, IP, CSMA/CD (Ethernet)

Challenges

- Tradeoff
  - Cost vs delay vs Energy
  - Need to strike the right balance based on usage scenario
- System Failure
  - Nodes can die; Links corrupt packets; Processing can duplicate or reorder packets
- Backward compatibility
  - Newer versions of protocol should support older devices

Popular Metrics

- Capture performance of protocols (determines whether goals are being met or not)
  - Eg. Throughput, Latency, Energy-consumption
- Example:
  - Throughput vs Number of Nodes in the system
  - Throughput vs Energy consumption
  - Loss Rate/Delay vs Number of Hops

Throughput

- Also called Bandwidth or Data-Rate
  - Measured in Mbps, Kbps (less often in MBps, KBps)

Latency/Delay

- Delay experienced by a packet/message from source to destination (one way delay)
- Round Trip Time (RTT): source-destination-source
- Measured in us (micro-second), ms, s
- Made up of
  - Processing, Transmission, Propagation and Queuing

Latency/Delay

- Processing: Time to inspect the packet
  - Examine headers, check for errors
- Queuing: waiting time in a queue
- Transmission: size (of packet or message)/bandwidth
- Propagation: distance/speed of light
  - 2.3* 10^8 ms/s in cable; 2 * 10^8 m/s in fiber; 3* 10^8 m/s in vacuum
- Latency = processing + queuing + transmission +propogation

Loss

- Causes: limited storage space at switches, corruption of packet

- Often measured as a probability
  - Eg. 0.1 or 10% loss (on average one out of every 10 packets are lost)

Summary

- Understood the goal of computer networks
- Goal reached through design of hardware and protocols
  - Challenges to overcome
- Performance metrics
  - Throughput, latency and loss