

Goals and Metrics

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Goal

- Enable Efficient, Robust and Scalable 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 + propagation

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