EECS 563 Spring 2024

Review Test 1

Drivers

- CPU ↑
- Link Rates ↑
- # Users ↑

} Value of Net ↑

- Economic
- Policy

Network Elements

- Hosts (edge)
- Packet switches (core)
- Links
- Networks
- Internet is a network of networks

Issues in Networking

- Sharing
- Distributed Network Elements (NE)
- Protocols
- Privacy and Security
- Survivability/Resilience
- Routing
- Resource Allocation
- Imperfect Knowledge
- "Real time"
- Cooperation among competing entities (network of networks)

Transmission

- Physical transmission of information
- Multiplexing
  - TDM, TDMA, TDD
  - FDM, FDMA, FDD
  - Uplink/downlink
  - Statistical multiplexing

Data plane

- Circuit switching: reserves dedicated recourses for duration of "session/call"
- Packet Switching
- Datagram packet switching
- Virtual Circuit Packet Switching

Trade-offs and attributes

- Structure of a packet switch
- Output port queueing
- Forwarding vs routing

Control plane

- The control plane is responsible for managing and controlling network devices and protocols.
- Routing
- Session/Call set-up

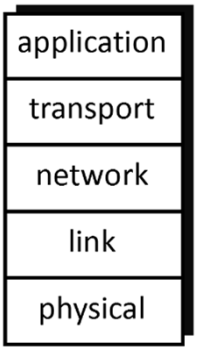
Layered, Architectures and Standards

- Edge device
- Access networks
- Core NEs
- Structure
  - Access ISPs
  - Regional ISPs
  - Tier 1 ISPs
  - Tier 1 ISPs connected via IXPs

Layered, Architectures and Standards

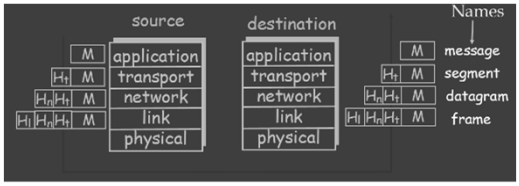
- Layers provide a way to
  - Describe networks
  - Organize functionality
  - Enable flexibility
- Internet Architecture
  - PHY, Link, Network, Transport, Application

Functions of each layer



Layered, Architectures and Standards

- Role of packet headers
  - Add headers as data goes from upper-to-lower layers
  - Consume headers as data goes from lower-to-upper layers



- Role of encapsulation
- Common Protocol Functions

Layered, Architectures and Standards

- Internet design choices
  - Service model-Best effort
  - Layered architecture
  - Mechanisms
    - Routing
    - End-to-end reliability
    - Naming/addressing

Layered, Architectures and Standards

- Standards
  - Process
  - IETF
    - RFC
  - IEEE
  - ITU
  - The good and bad of standards

Metrics, Network Traffic, Performance

- Impairments
  - Delay-Bandwidth Product
    - # bits in RTT
    - # packets in RTT
    - LAN, MAN, WAN, Satellite, Deep Space
  - Bit Errors
    - Random
    - Bursty
  - Packet loss
    - Bit errors
    - Congestion
- Applications
  - Elastic
  - Loss-tolerant
  - Minimum throughput
  - Bursty
  - "Real time"
    - CBR in→ Variable on received
    - Jitter buffer
    - Delay budget

Metrics, Network Traffic, Performance

- Metrics
  - Response Time
  - Throughput
  - Normalized Throughput = S
  - S_{Max}
  - Utilization
  - Channel Efficiency
  - Loss/blocking
  - Reliability
  - Fairness
- Metrics (continued)
  - BER=Probability bit error
  - Time between errors

Metrics, Network Traffic, Performance

- Network Performance Guarantees
  - QoS
  - CoS

Metrics, Network Traffic, Performance

- M/M/1

Probability of k in system=P[K=k] = $\rho^k(1-\rho)$

Probability of system busy = utilization= ρ

Probability of system empty = $1-\rho$

$$Average\ Number\ in\ System = E[K] = \frac{\rho}{1-\rho}$$

$$\text{Variance of } Number\ in\ System = \text{Var}[K] = \frac{\rho}{(1-\rho)^2}$$

$$\text{Average Delay} = E[D] = \frac{E[T_H]}{1-\rho} = \frac{E[L]/R_{out}}{1-\rho} = \frac{1}{\mu-\lambda}$$

- M/M/1/S

$$P[K=k] = \frac{(1-\rho)\rho^k}{1-\rho^{S+1}} \text{ for } k \le S$$

$$P[K=k] = 0 \text{ for } k > S$$

$$P_{Blocking} = P[K=S] = \frac{(1-\rho)\rho^S}{1-\rho^{S+1}}$$

Table to be provided on test and Excel spreadsheet provided on class web site see http://www.ittc.ku.edu/~frost/EECS_563/M-M-1-K-Blocking%20cal.xls

- M/M/S/S

$$P[K=k] = \frac{\frac{\rho^k}{k!}}{\sum_{n=0}^{S}\frac{\rho^n}{n!}}$$

$$P[K=k] = 0 \text{ for } k > S$$

$$P_{Blocking} = P[K=S] = \frac{\frac{\rho^S}{S!}}{\sum_{n=0}^{S}\frac{\rho^n}{n!}}$$

Erlang B blocking Formula

Tabulated and there are web calculators see:

http://www.erlang.com/calculator/index.htm

http://www.ittc.ku.edu/~frost/EECS_563/LOCAL/erlang-table.pdf

Load = $\rho = R_{in}/R_{out} = \lambda E[T_H] = \lambda E[L]/R_{out} = \lambda/\mu$

Metrics, Network Traffic, Performance

- Insights from performance analysis
  - Delay increase exponentially as load→1
  - The variance of the delay increase exponentially as load→1
  - Aggerating traffic to share resources provides better performance compared to portioning resources

At the conclusion of this class the students are expected to:

- Understand the basics of multiplexing
- Understand the layered structure of protocols
- Understand the importance of standards and who sets them
- Understand the basics of network protocols, including,
  - Statistical multiplexing
  - Circuit switching/Datagram packet switching/virtual circuit switching
- Explain performance metrics
- Understand the nature of network traffic
- Perform basic analytic performance and design trade-off studies
- Be fluent in the language of communication networks, i.e., understand the meaning of networking terms and abbreviations
- Use network analysis tools, e.g., traceroute and ping