CS2105

AY22/23 Sem 2

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01. Introduction

- **Network Edge** - Hosts (Clients and servers)
- **Access Networks** - Wired and wireless communication links
- **Network Core** - Network of interconnected routers

Network Core

Packet-Switching

- Host breaks messages into packets of L bits
- Transmits packets into access network at transmission rate R (aka Link bandwidth, capacity)

$$\text{Packet Transmission Delay} = \frac{\text{Packet Size (bits)}}{\text{Transmission Rate (bits/sec)}}$$

- **Store and Forward** - Entire packet must arrive at router before being transmitted to next link

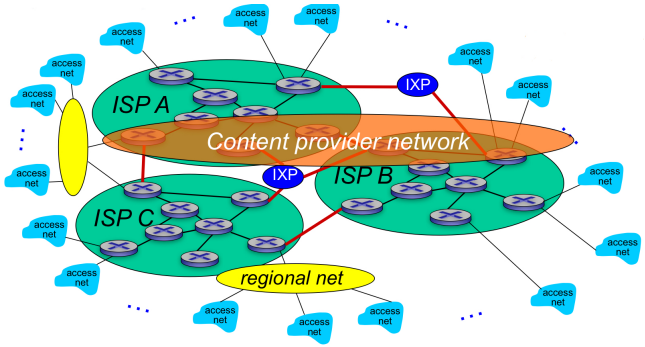
Key Functions of Network Core

- **Routing** - Determines source-destination routes taken by packets (How we get the hashtable)
- **Forwarding** - Move packets from router's input to correct router output

Circuit Switching

- Resources reserved for call between source and destination
- Pros: Betrer performance
- Cons: More resources

Internet Structure



- End systems connect to Internet via **Access Internet Service Providers (ISPs)**
- ISPs connect to larger global ISPs (usually competitors)
- Large ISPs connect via **peering links** or **internet exchange points (IXP)**
- **IXP** - Physical place with routers from different ISPs
- **Regional Networks** - Smallers ISPs
- **Content Provider Networks** - Provide content close to end users

Loss, Delay, and Throughput

Packet Loss

- If Arrival Rate $>$ Transmission Rate, packets will queue and can be dropped if queue fills up
- Solutions: Lost packets can be retransmitted

Packet Delay

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

- **Nodal Processing** - (d_{proc}) Check for bit errors and determine output link
- **Queueing Delay** - (d_{queue}) Time at queue waiting for transmission
- **Transmission Delay** - (d_{trans}) Time to load packet onto link
  - $d_{\text{trans}} = \frac{L}{R}$ where L is packet length and R is link bandwidth
- **Propagation Delay** - (d_{prop}) Time for 1 bit to reach end of link
  - $d_{\text{prop}} = \frac{d}{s}$ where d is length of link and s is propagation speed

Throughput

- Rate at which bits transferred between hosts
  - Different from transmission rate (Theoretical upper bound)
- Average: Rate over long period of time
- Instantaneous: Rate at given point in time

Protocol Layers and Service Models

- **Protocol** - Defines format, order of messages sent and received, and actions taken on message transmission
- Networks are complex with many components. How can we organize its structure?
- **Layering** - Each layer implements a service by doing something within layer and relying on services provided by layer below it
  - Explicit structure allows us to make sense of complex components
  - Easy maintenance (Like OOP, change in 1 layer should not affect others)

Internet Protocol Stack

1. Application
2. Transport
3. Network
4. Link
5. Physical