Lecture 2: Internet Design Philosophy

CS 234 / NetSys 210: Advanced Computer Networks

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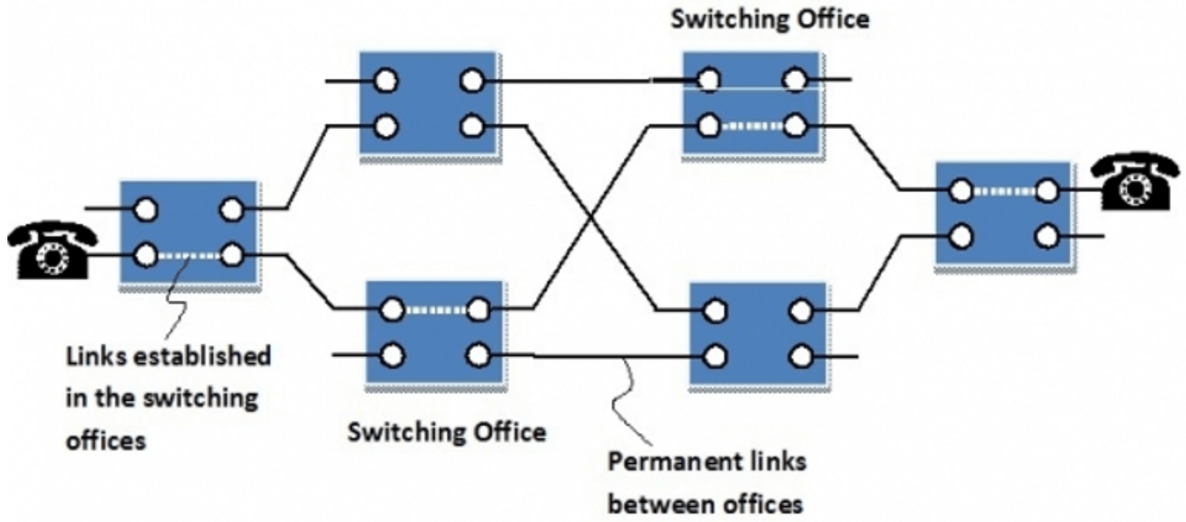
Parts of this lecture were adapted from MIT 6.02 Fall 2012 Lecture #23 A Brief History of the Internet

Key Topics

- What motivations shaped the Internet?
- Which of the design goals helped in Internet's success?
- What important goals did they miss?

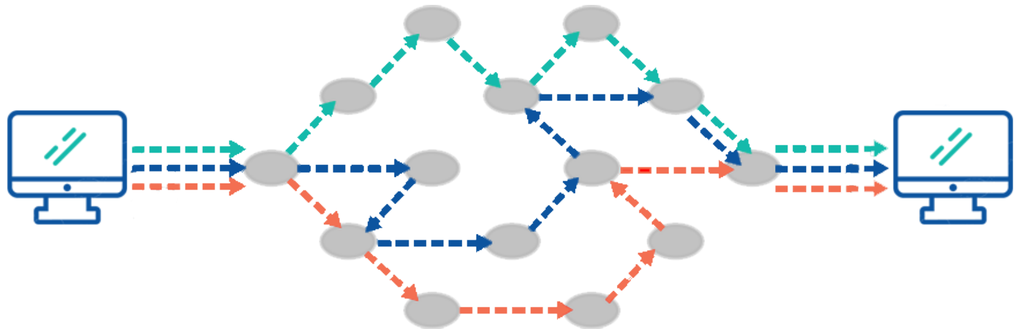
Before the Internet: Circuit-Switched Telephone network

- Reserve the path in advance
- All data follows the reserved path
- Bandwidth wastage!



Packet Switching

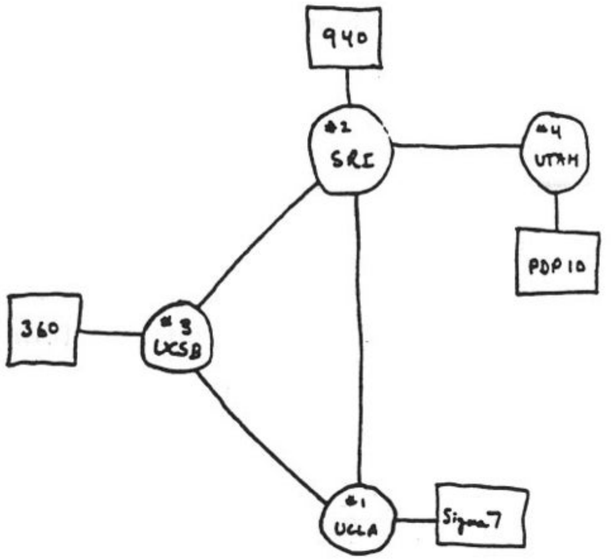
- The idea was introduced in the 1960s
- Packets travel independently
- No dedicated physical path or reservations
- Store and forward at intermediate points
- Better multiplexing
- No bandwidth wastage!



ARPANET

- 1967: Connect computers at key research sites across the US using telephone lines

- Interface Message Processors (IMP) ARPA contract to BBN



Courtesy: Alex McKenzie

The first message on the Internet...

- Kleinrock's group at UCLA tried to log on to SRI computer
- His recollection of the event…

"We set up a telephone connection between us and the guys at SRI...

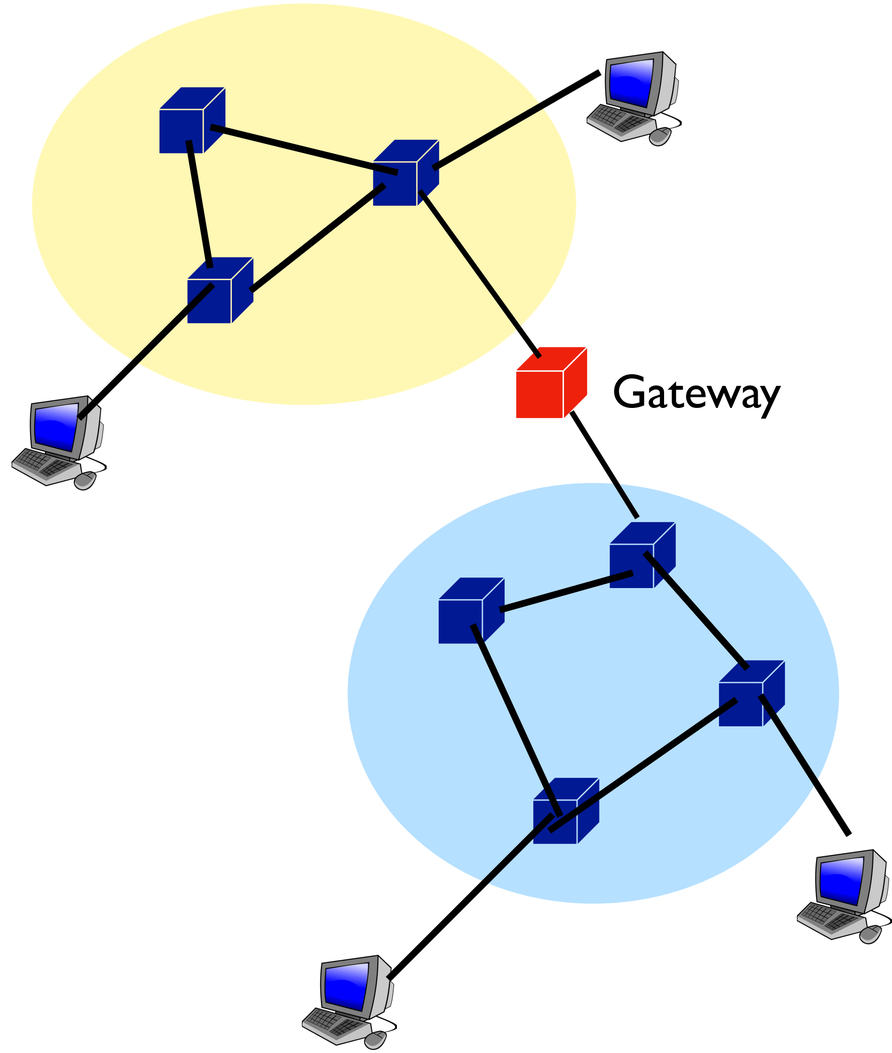
We typed the L and we asked on the phone..
"Do you see the L?"
"Yes, we see the L," came the response

We typed the O, and we asked…"Do you see the O?"
"Yes, we see the O."

Then we typed the G…
and the (SRI) system crashed!"

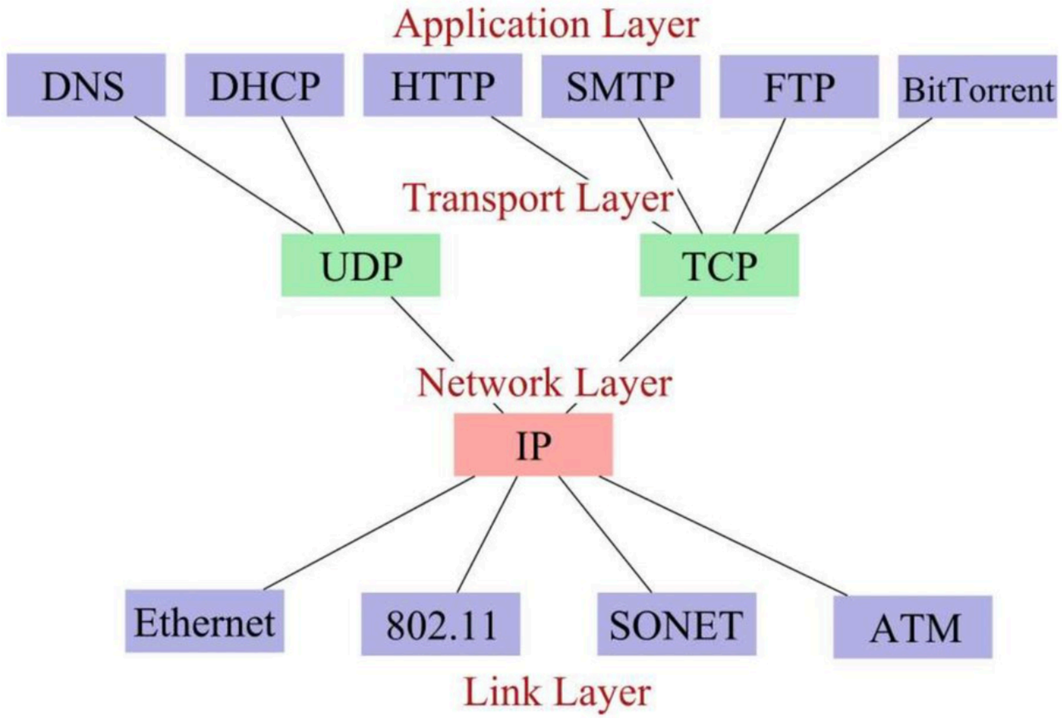
A new Problem

- Many different packet-switching networks
- Only nodes on the same network could communicate
- Solution: Gateways!
- Gateways would "translate" between networks
    - We now think of it as all routers supporting IP
- Bob Kahn & Vint Cerf imagined there would be only a few networks and thus only a few gateways.
    - PS: They were a little wrong about that!



DARPA Goals: Fundamental Goal

- "Develop an effective technique for multiplexed utilization of existing interconnected networks"
    - Need interoperability between heterogeneous networks
- Packet switching
- Layered architecture: Divide tasks into pieces and solve each in a different layer



Secondary Goals

- Survivability in the Face of Failure
    - Fate-sharing with state information only at the end host
    - IP layer: best effort packet delivery
- Support multiple types of service
    - TCP datagram can support most services.
        - It is good enough for almost every application (though optimal for nothing!)

Secondary Goals

- Must accommodate a variety of networks
- Must permit distributed management of its resources
- Must be cost effective
- Must permit host attachment with a low level of effort
- Resources used in the internet architecture must be accountable

Discussion

1. What aspects of the Internet architecture contributed towards its success?

What contributed towards the Internet's success?

- Layered architecture

- Datagrams and end-to-end principle (more details in next class!)

Discussion

1. What aspects of the Internet architecture contributed towards its success?

2. What are some design goals that were completely overlooked or not given enough weightage during Internet design which are very relevant in today's world?
How would the Internet design change if these were among the core goals?

End-to-end accounting

Cox Internet Lawsuit Alleges Overstated Internet Speeds

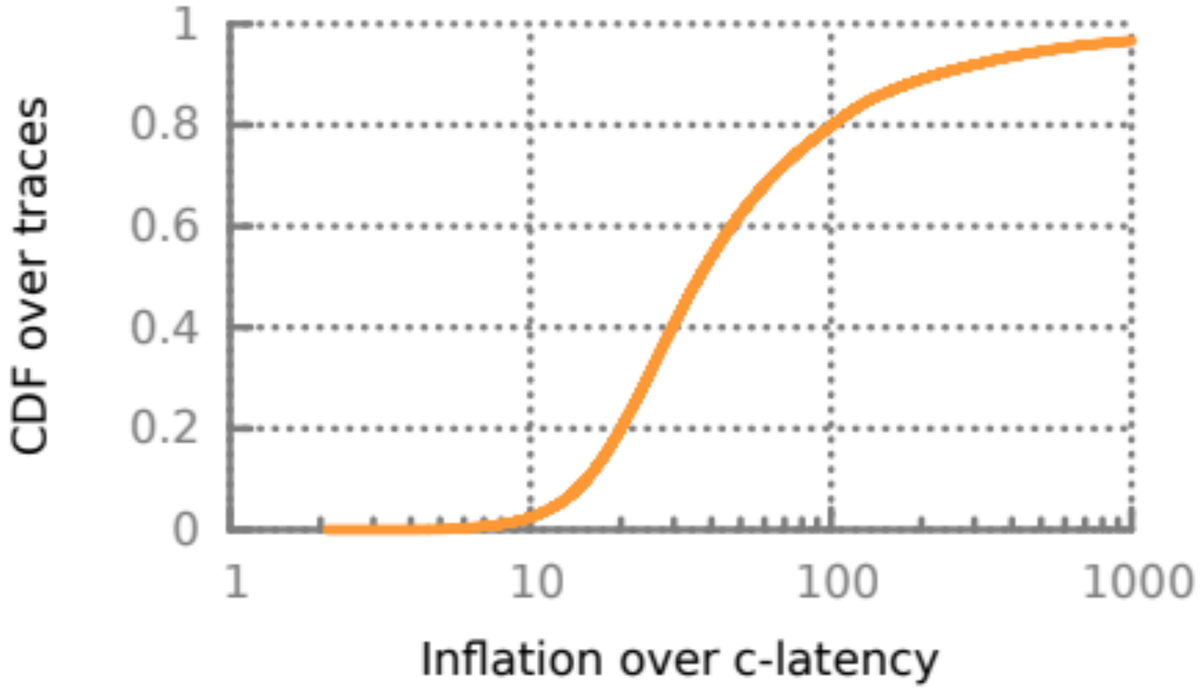
Time Warner to Pay $18.8M to Settle Lawsuit Over Internet Speeds

Southern California prosecutors said Thursday that Time Warner Cable will pay $18.8 million to settle claims it provided slow internet service to over 170,000 customers who paid for faster internet speed.

FTC Sues Frontier Communications for Misrepresenting Internet Speeds

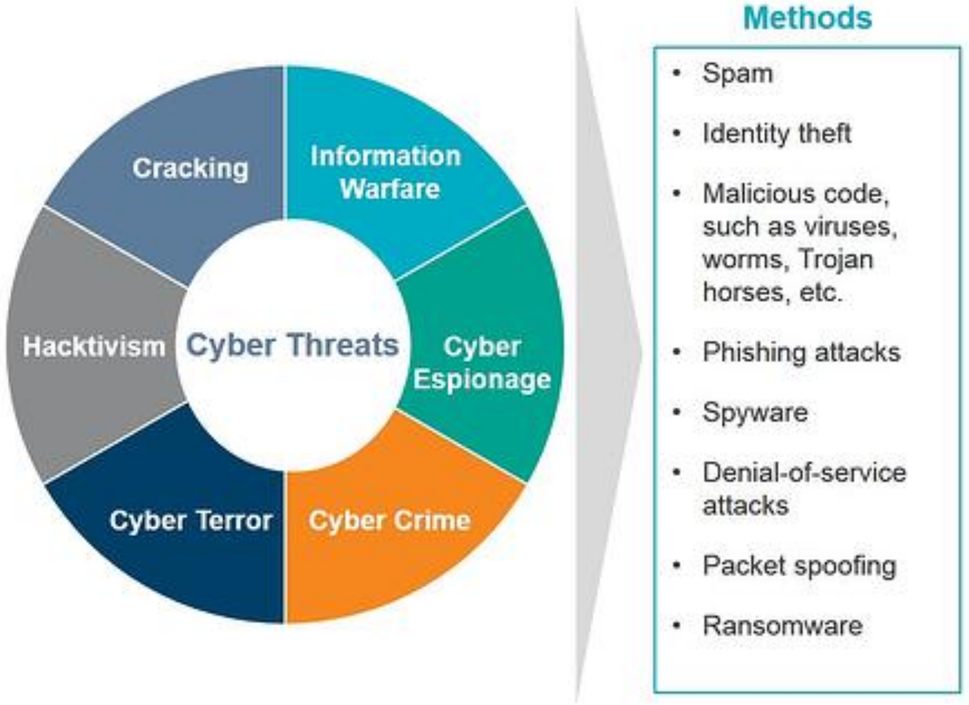
Company failed to deliver DSL Internet speeds for which consumers paid and were promised

Performance



Inflation in fetch time of 1.9 million HTTP fetches of only the HTML of the landing pages of popular Web sites
[Why is the Internet so Slow? PAM'17]

Security and Privacy



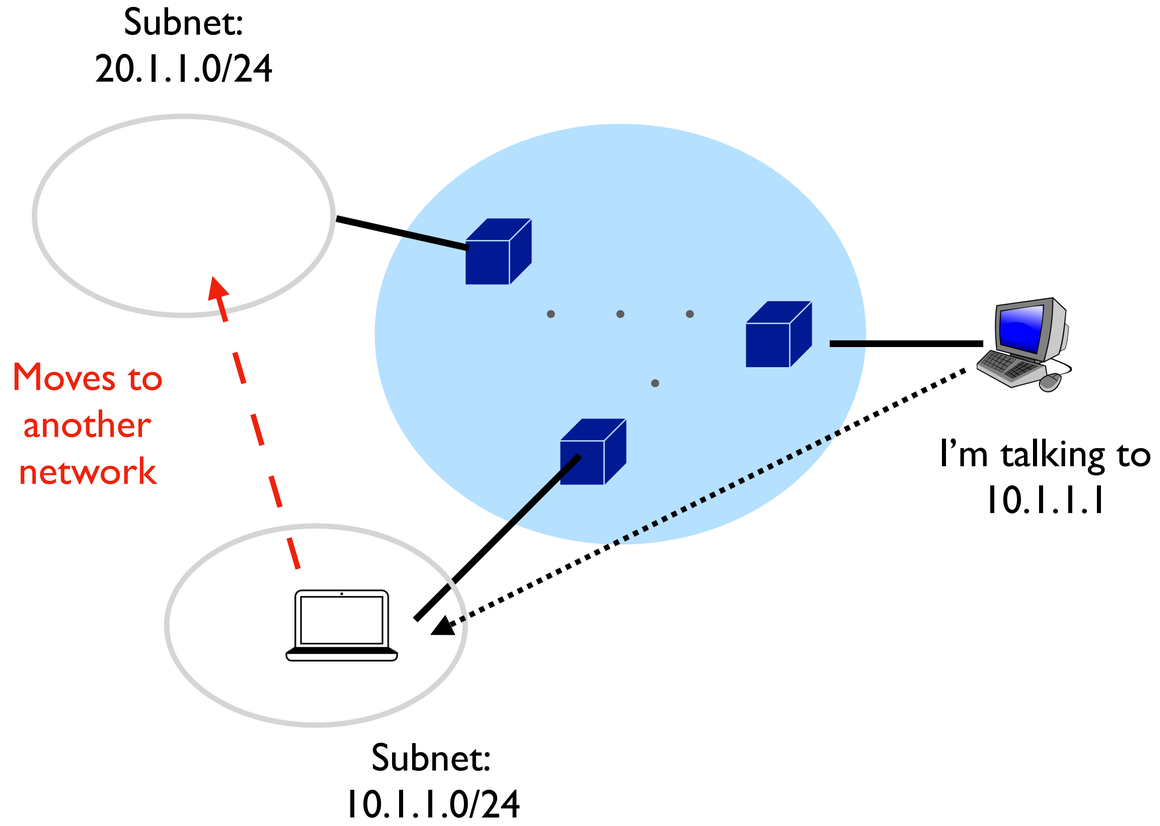
The Cost of Cybercrimes

Internet crime victim losses in 2020:	**$4.2 billion**
The average cost of a ransomware attack:	**$1.85 million**
Global cybercrime damages per second:	**$190,000**
The average cost of cybercrime for organizations:	**$13 million**

Source: FBI, Sophos, Cybersecurity Ventures, Accenture

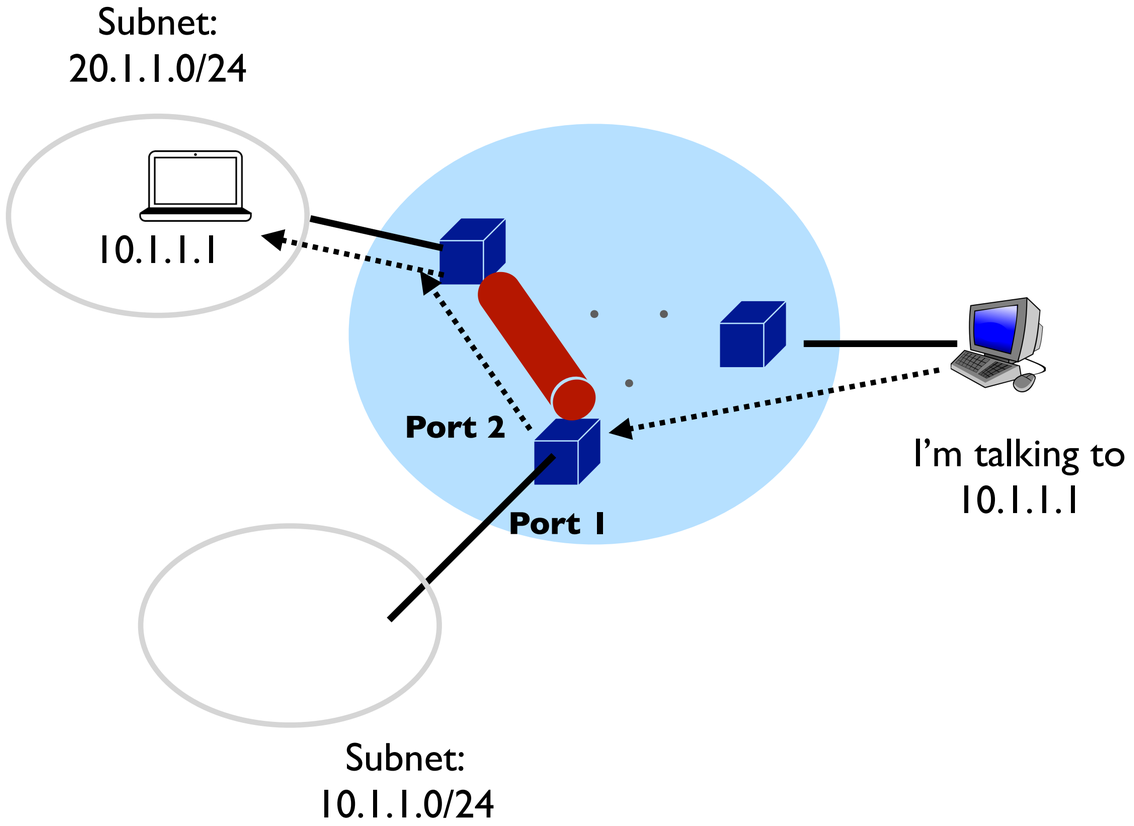
Mobility

- What are some options?
  - Maintain the IP address in new network
    - Packet drops
  - Renew the IP address
    - Loses application continuity
  - Inject the host address in routing at the new location
    - Routing convergence, scalability, and stability stability concerns



Solution: Mobile IP

- Tunneling
  - Virtual pipe for the packets available between a tunnel entry and an endpoint



Destination	Forwarding
10.1.1.0/24	Port 1
10.1.1.1/32	Port 2, Add MPLS tunnel header

Overlooked Design Goals

- End-to-end accounting
- Performance
- Security
- Mobility

Some interesting comments from students

- “Debates surrounding net neutrality, the idea that all internet traffic should be treated equally by network providers, continue to pose challenges to the architecture.” - Maganth Seetharaman
- “To facilitate data communication between distributed ML models, a protocol specifically designed for this purpose is crucial. In the context of federal learning, uploading training data requires careful consideration of factors such as data quality, reliability, and efficiency. While TCP is excessively expensive for this purpose, IP is not reliable enough to meet the requirements.” - Yurun Song
- “With the rise of IoT devices and the anticipated explosion of number of IoT devices in the coming decades, a highly efficient and reliable protocol is necessary for these devices.” - Rahima Jahan Mitu
- “Most datagrams are a part of some sequence of packets instead of isolated blocks. The middleware of the network should deal with the sequence of the packets instead of isolated blocks.” - Jiahao Song

Next Class: End-to-End Principle

Thanks!