Computer Networks
COL 334/672

To Packet Switch or Not

Slides adapted from K&R book

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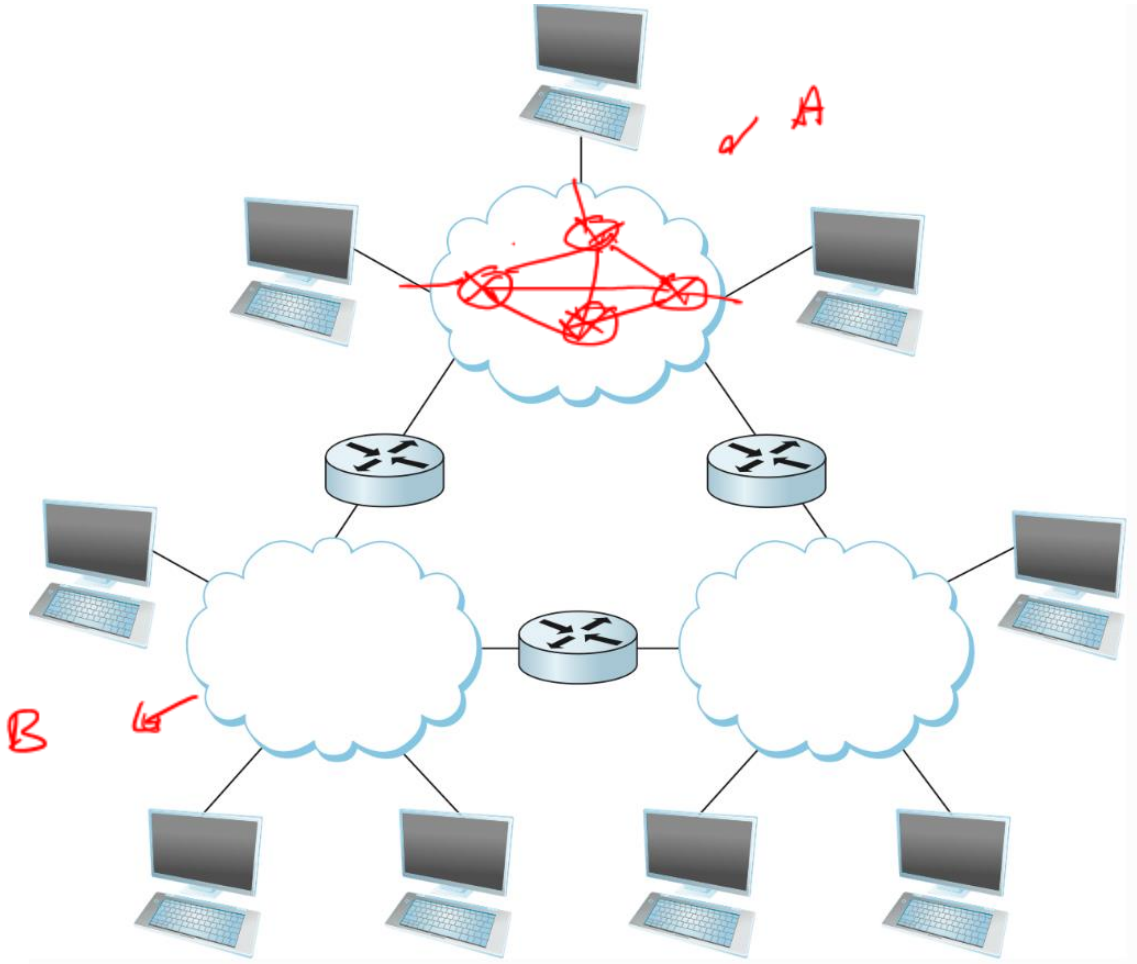
Recap: Building Internet from First Principles

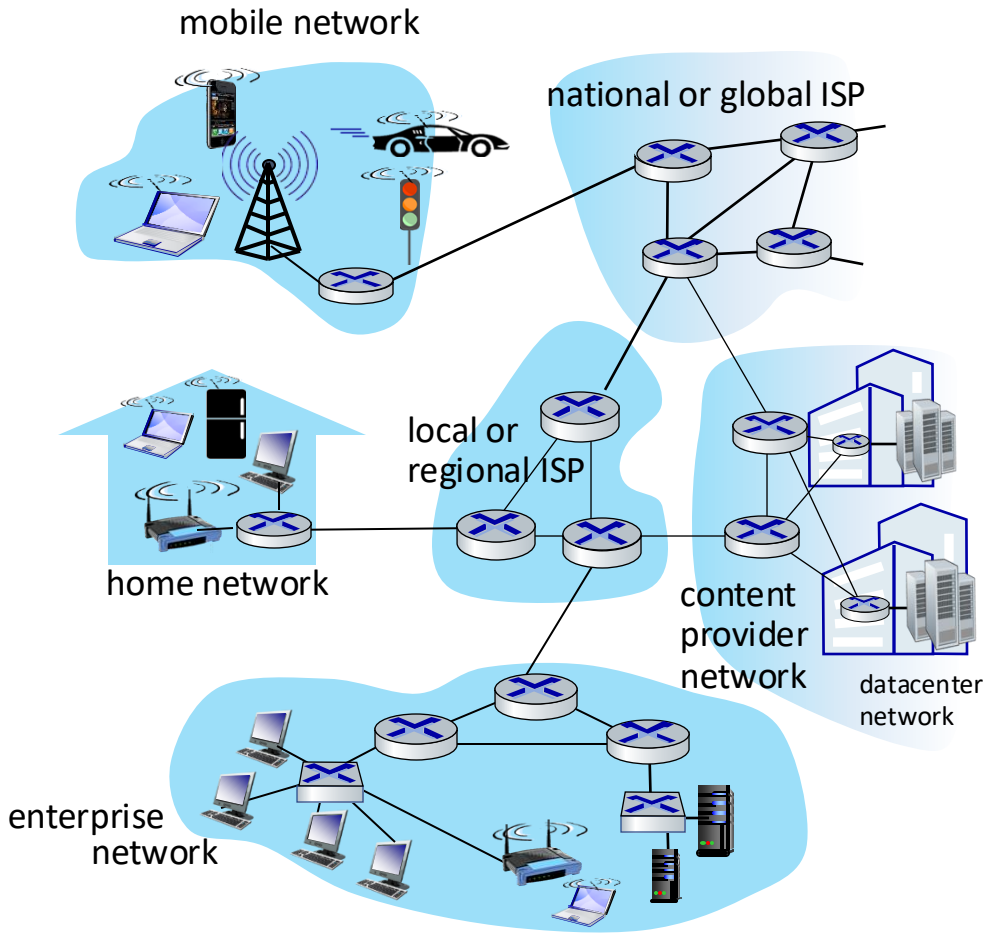
- Building blocks
  - Physical medium aka links
  - Switches or routers
- Network: collection of devices, switches, links managed by an organization
- Internet: network of networks



This Class: Structure of Internet

last-mile ISP

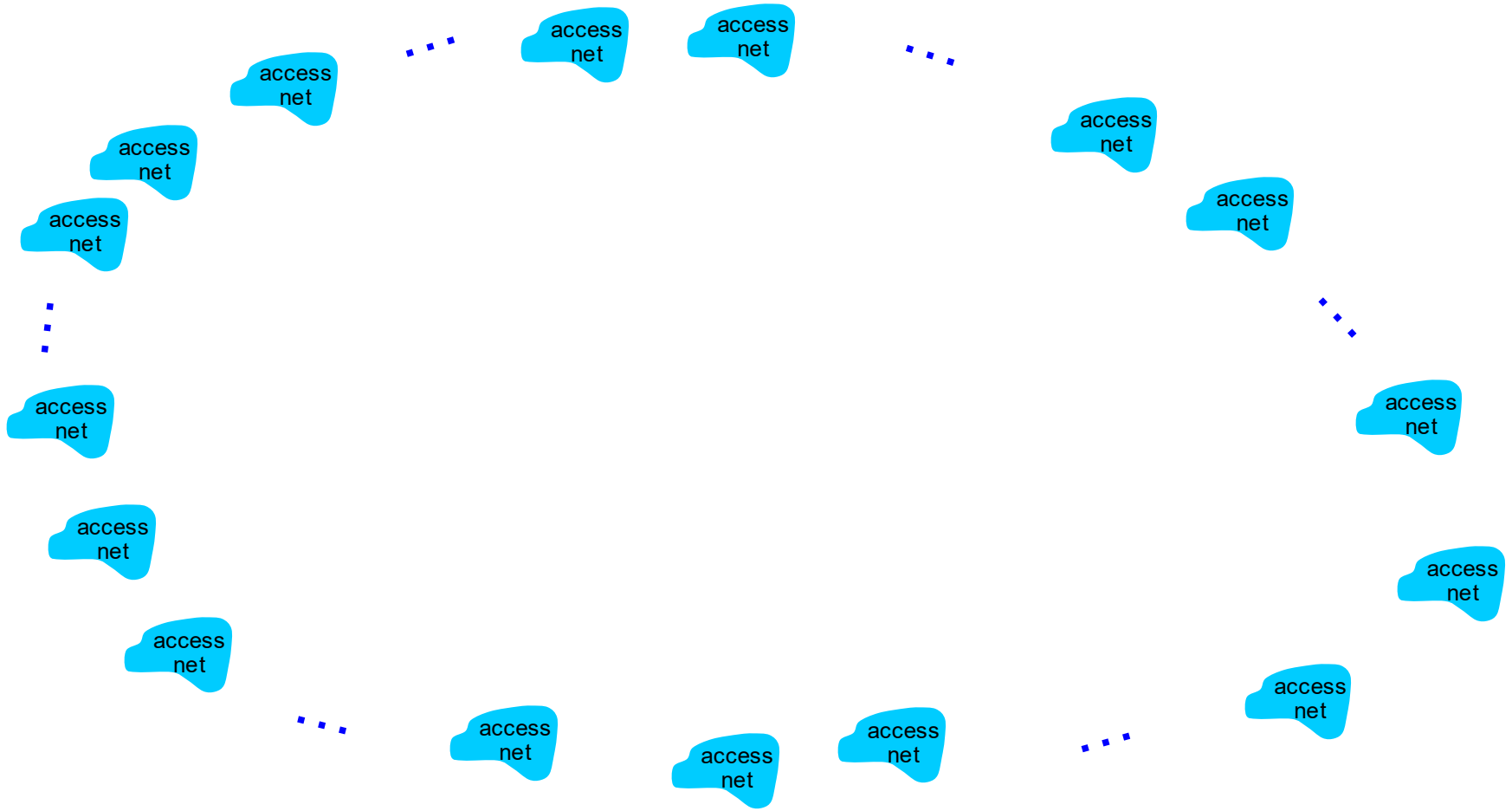
- hosts connect to Internet via access Internet Service Providers (ISPs)
- access ISPs in turn must be interconnected
  - so that *any* two hosts *(anywhere!)* can send packets to each other
- resulting network of networks is very complex
  - evolution driven by economics, national policies



Let's take a stepwise approach to describe current Internet structure

Internet structure: a "network of networks"

Question: given *millions* of access ISPs, how to connect them together?



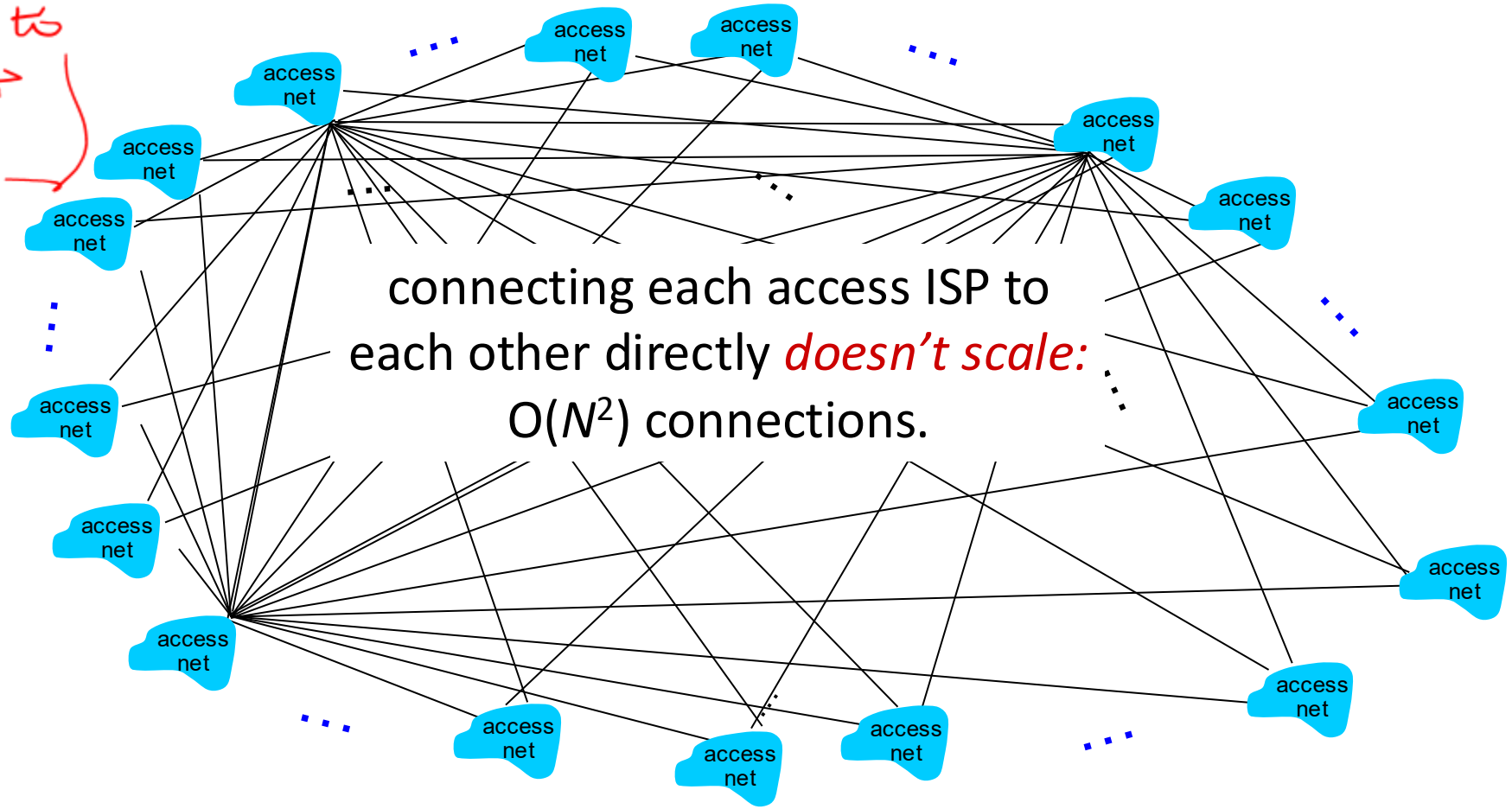
Internet structure: a "network of networks"

Question: given *millions* of access ISPs, how to connect them together?

1) Connect to K-nearest neighbors

2) Star topology

3) Connect to 3 random networks



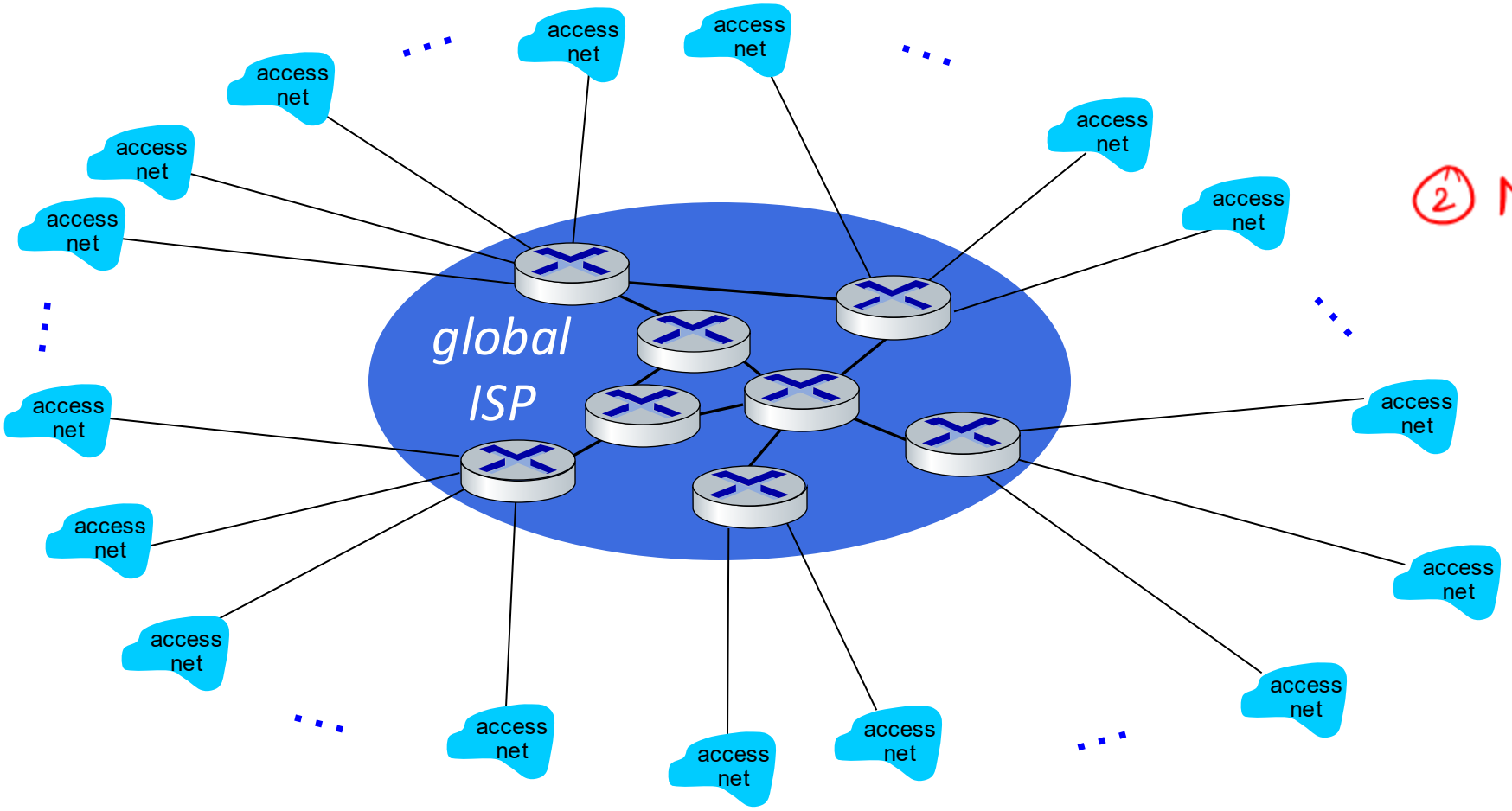
Internet structure: a "network of networks"

Option: connect each access ISP to one global transit ISP?

Customer and provider ISPs have economic agreement.

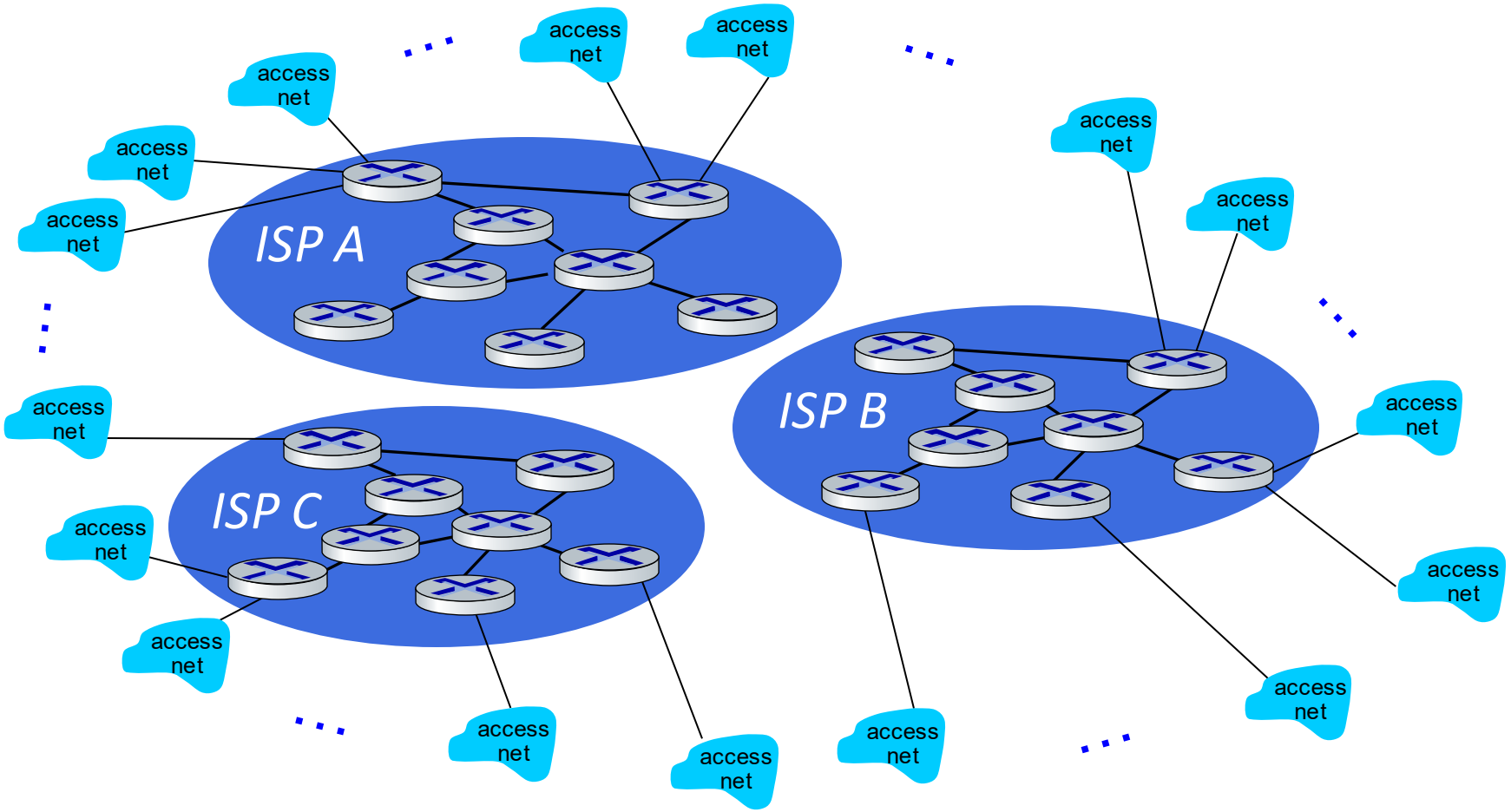
① Single point of failure

② Monopoly



Internet structure: a "network of networks"

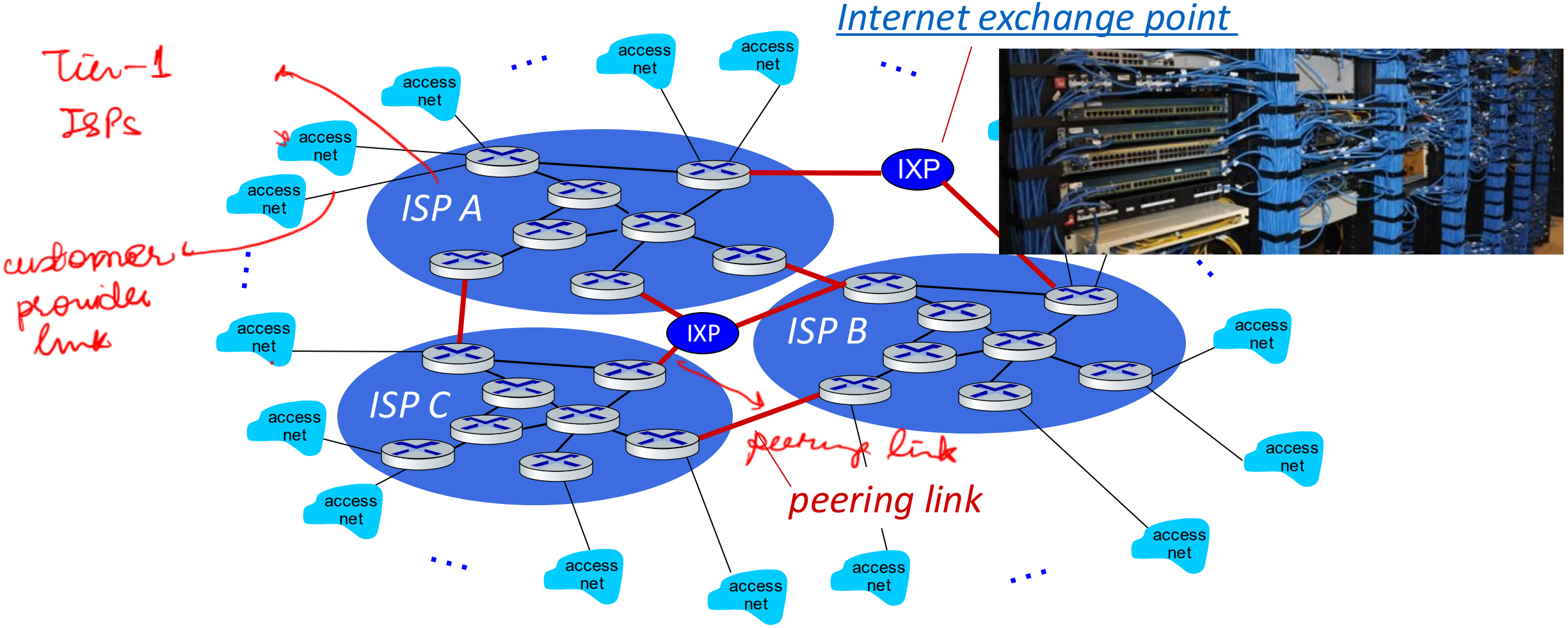
But if one global ISP is viable business, there will be competitors ….



NIXI : National Internet Exchange of India

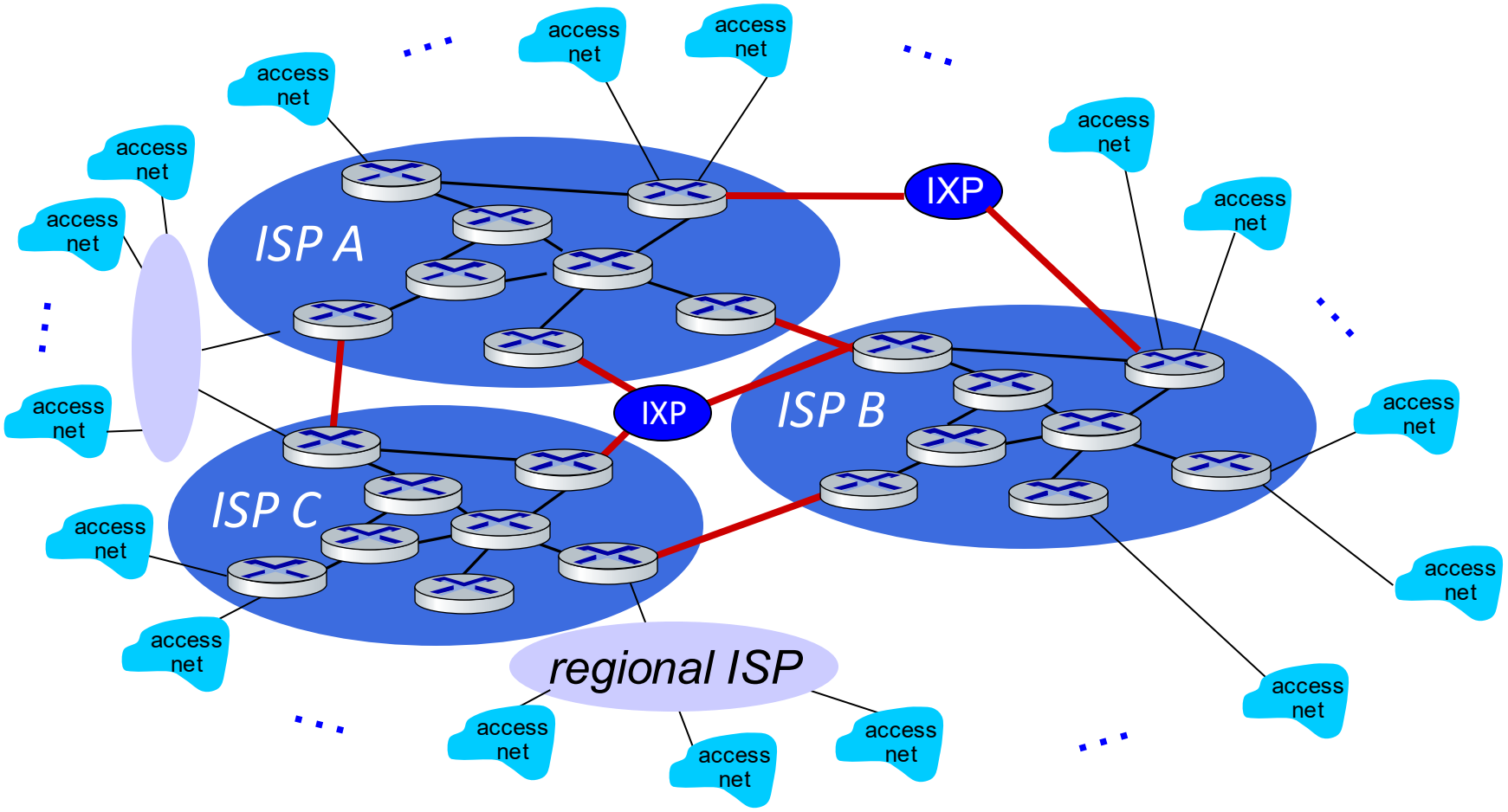
Internet structure: a "network of networks"

But if one global ISP is viable business, there will be competitors …. who will want to be connected



Internet structure: a "network of networks"

… and regional networks may arise to connect access nets to ISPs



Internet structure: a "network of networks"

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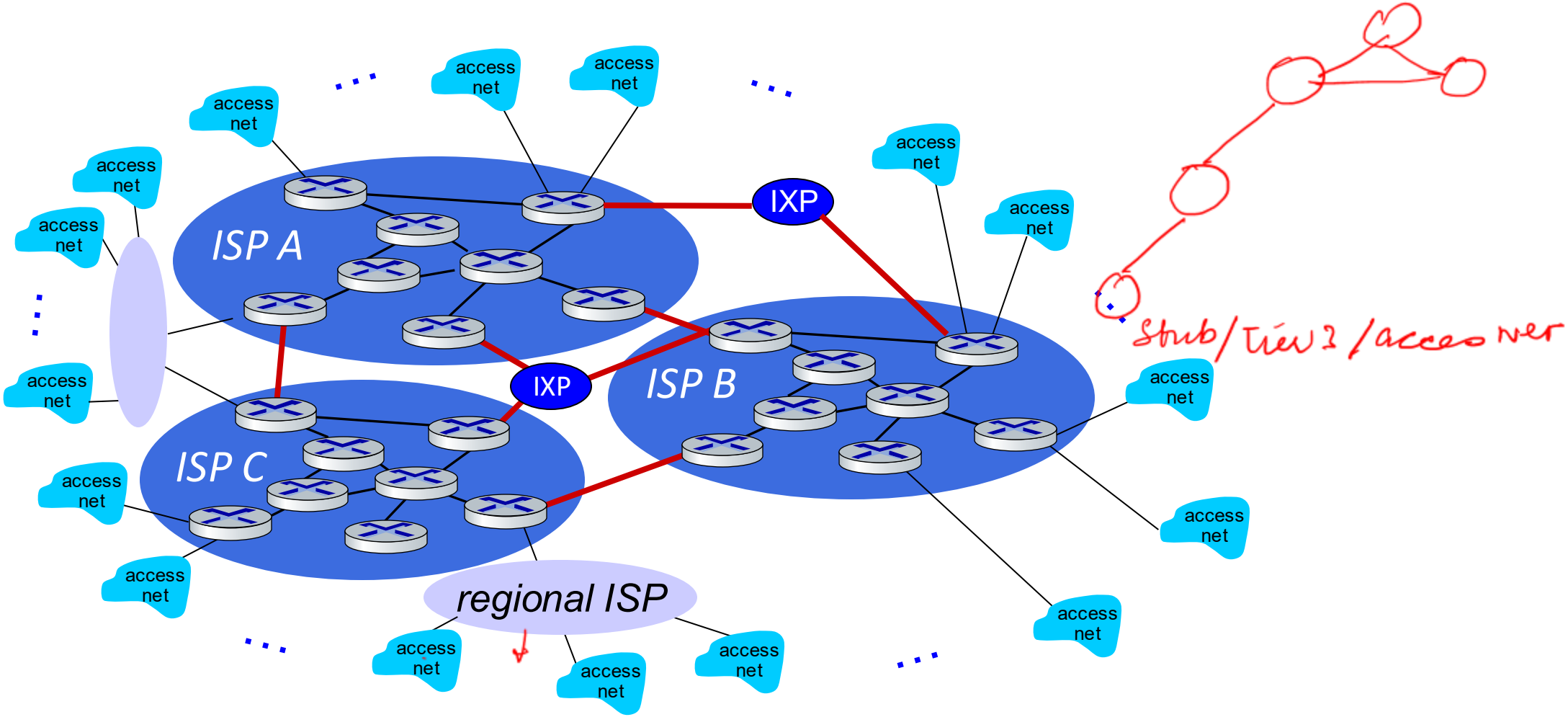
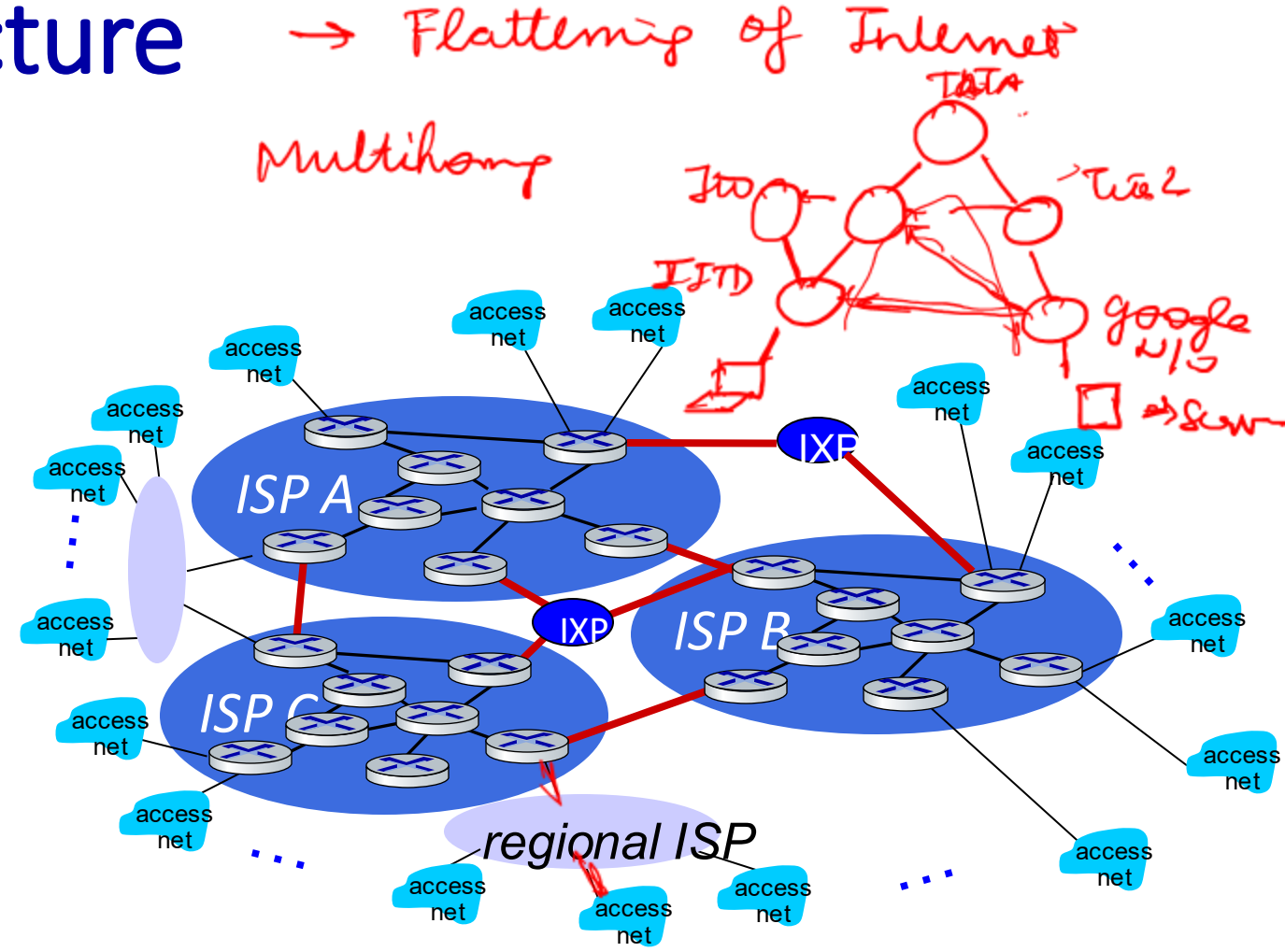


3-tier Internet Architecture

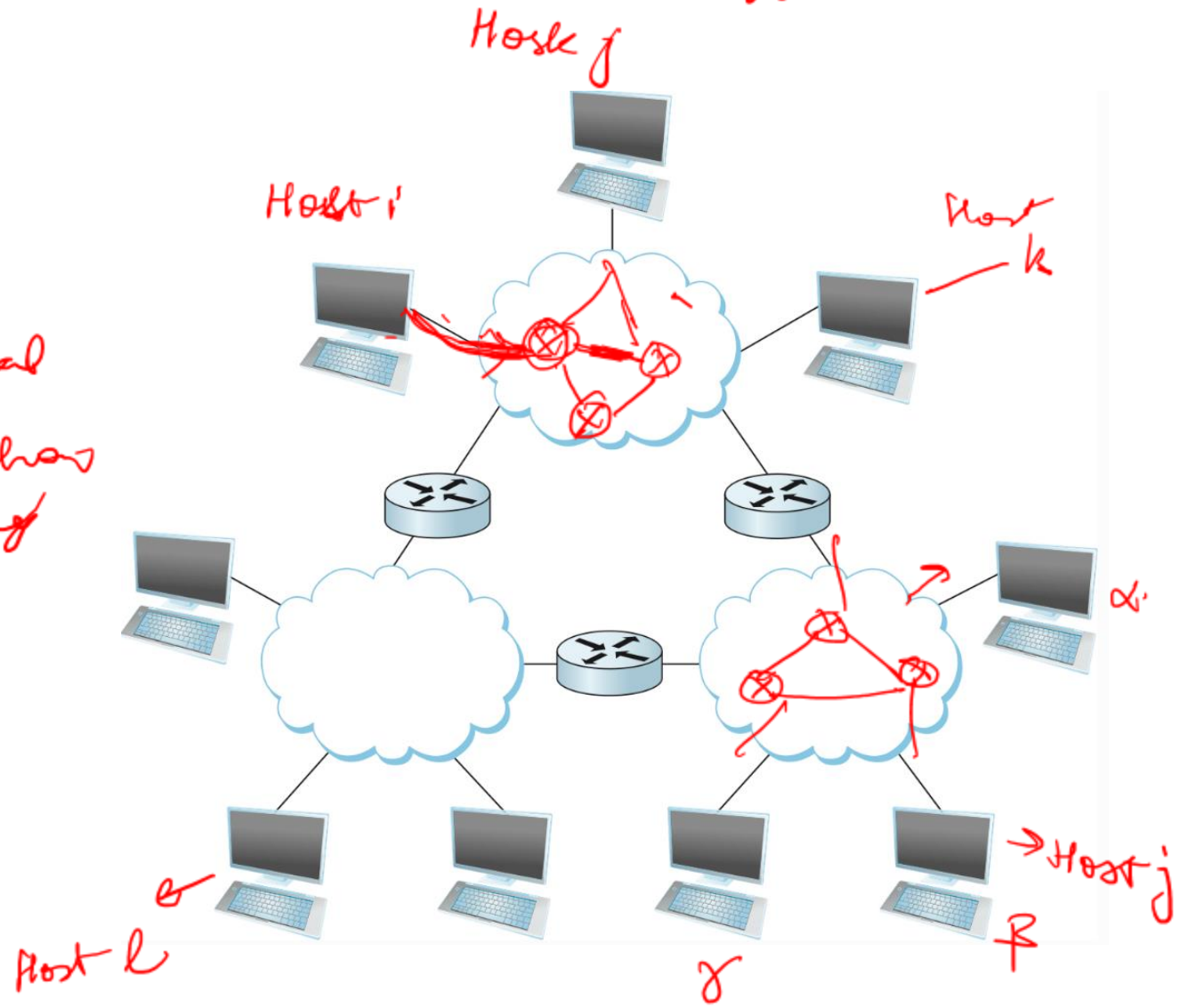
- Tier-1 ISP
  - Global reach
  - Don't pay for transit
  - E.g., TATA Communications, AT&T
- Tier-2 ISP
  - Customer for some networks
  - Providers or peers for others
  - E.g., ?
- Tier-3 ISP
  - Only act as customers
  - E.g., ?



Is it that neat?

How to send data over the Internet?

- What are the different functional elements that need to be implemented?
- **Key implication of a decentralized design:**
  - Networks need to agree on certain rules aka protocol



What's a network protocol?

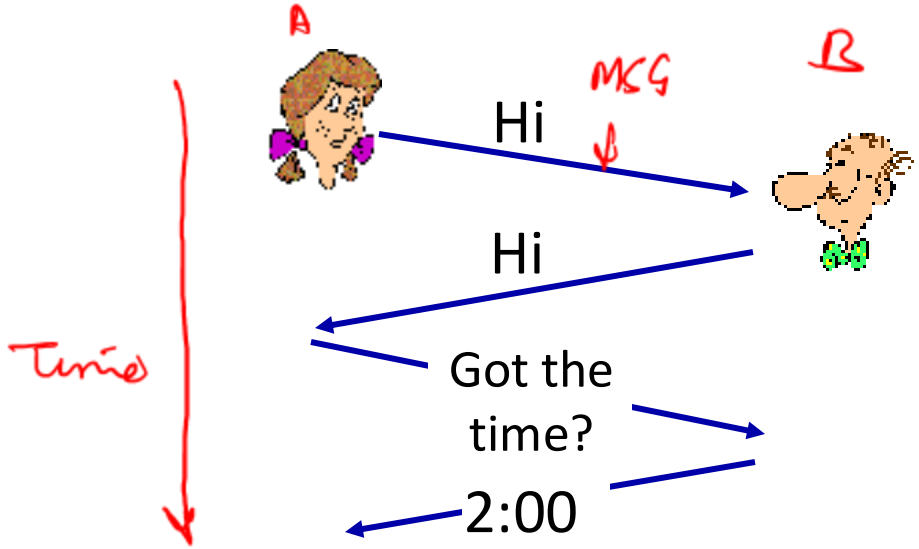
Network protocols:

Rules for:

… specific messages sent

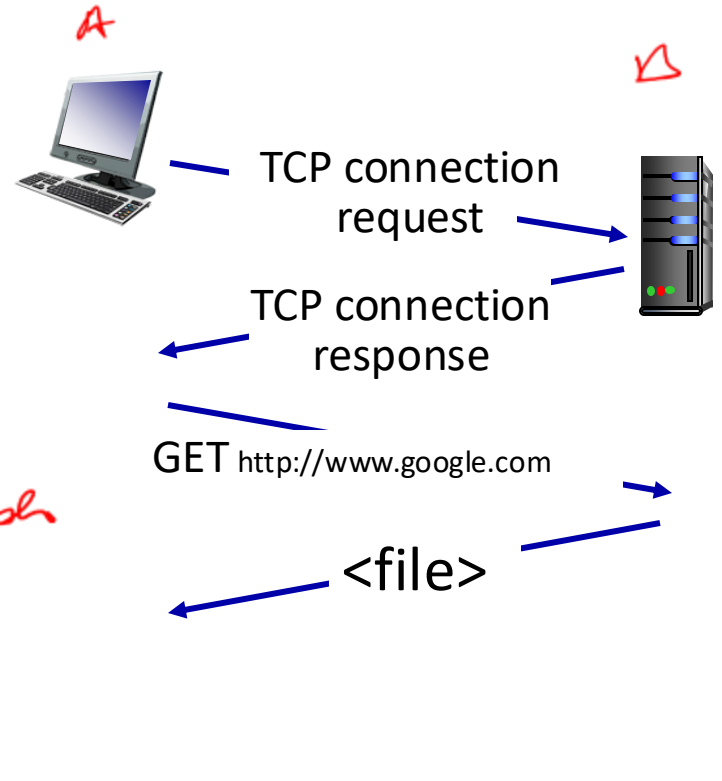
… specific actions taken when message received, or other events

… similar to human protocols but designed for machines



Protocols define the format, order of messages sent and received among network entities, and actions taken on message transmission, receipt

- Request For Comments (RFCs) specifying the protocols
- Standardization bodies: IETF, IAB etc.

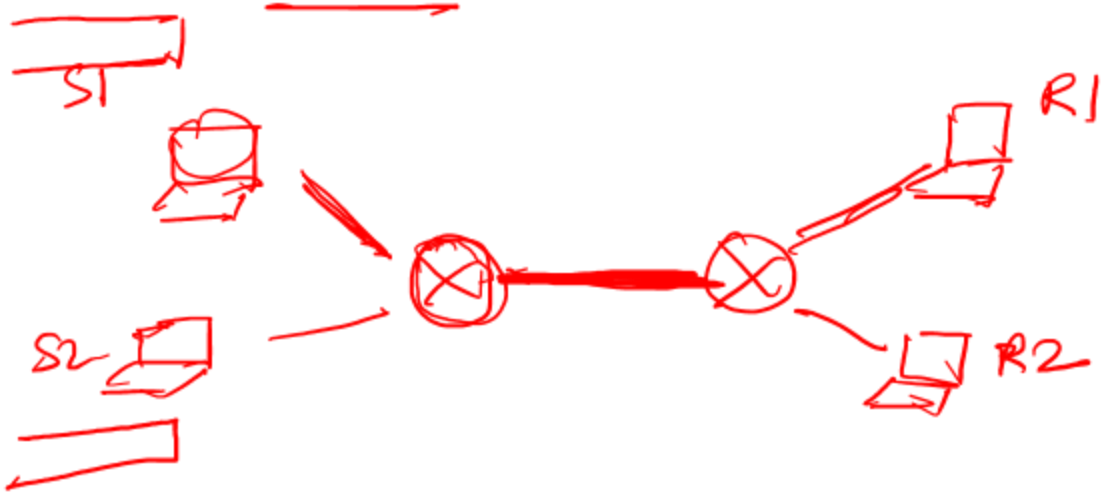


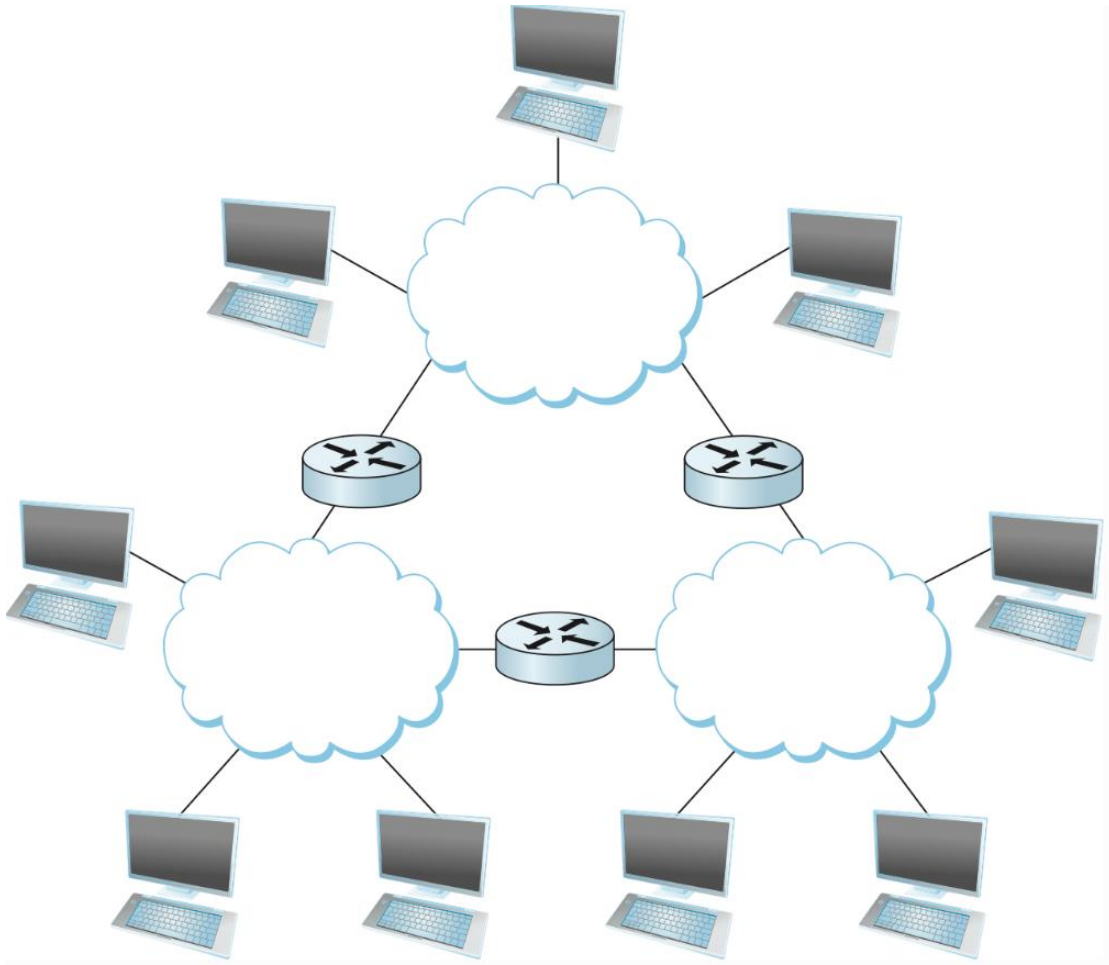
How to send data over the Internet?

- What are the different functional elements that need to be implemented?

① Circuit Switch
② Packet Switch

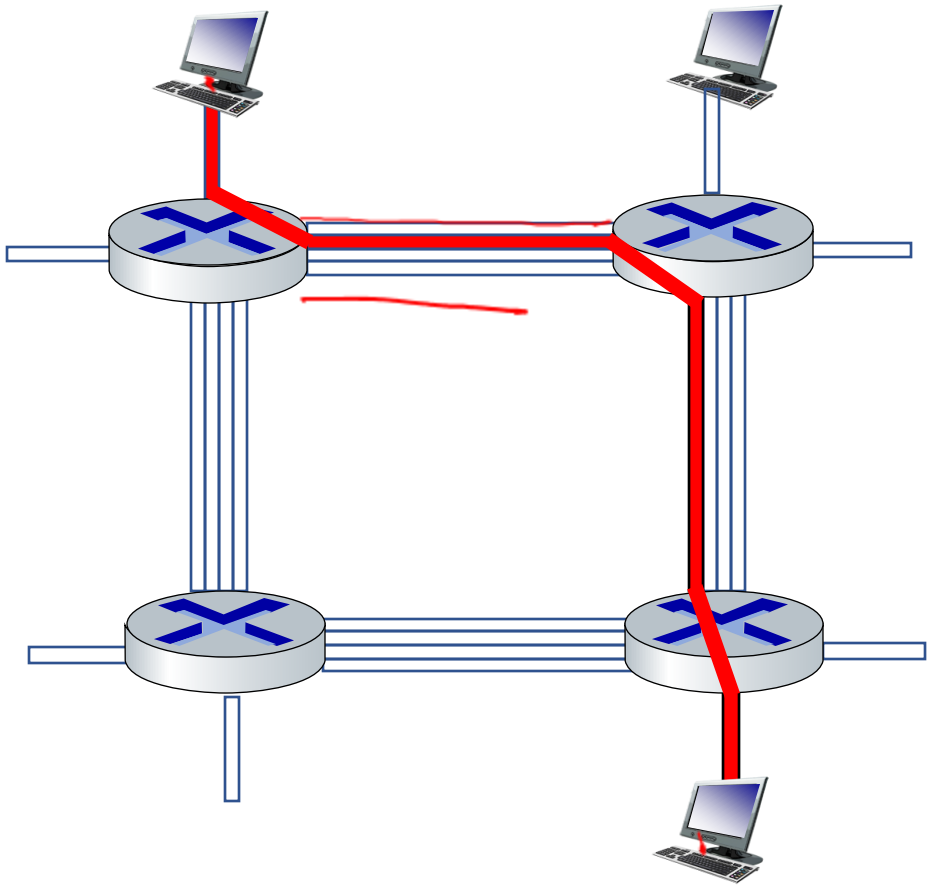
- How to do resource sharing?





Circuit Switching

- End-end resources allocated to, reserved for "call" between source and destination
- in diagram, each link has four circuits.
  - Signalling for resource reservation
  - call gets 2nd circuit in top link and 1st circuit in right link.
- dedicated resources: no sharing
  - circuit-like (guaranteed) performance



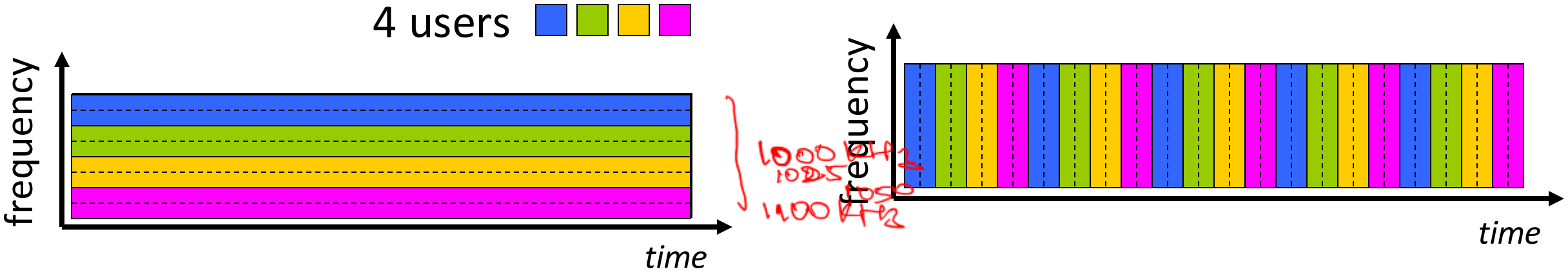
Mechanisms for circuit switching

Frequency Division Multiplexing (FDM)

- optical, electromagnetic frequencies divided into (narrow) frequency bands
- each call allocated its own band, can transmit at max rate of that narrow band

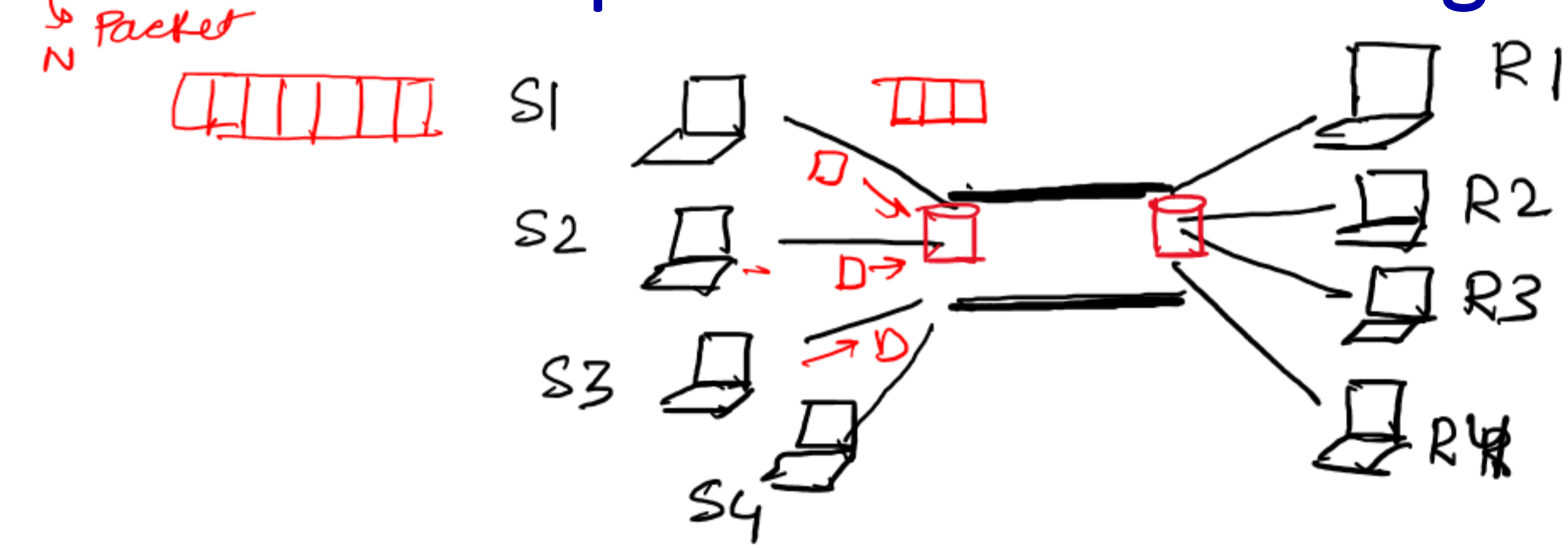
Time Division Multiplexing (TDM)

- time divided into slots
- each call allocated periodic slot(s), can transmit at maximum rate of (wider) frequency band (only) during its time slot(s)



Alternate option: Packet switching

(Statistical Multiplexing)



- Divide the data into packets of size L bits
- Each packet is transmitted at link bandwidth
- Store and forward approach