



Computer Networks

COL 334/672

To Packet Switch or Not

Slides adapted from K&R book

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Sem 1, 2024-25

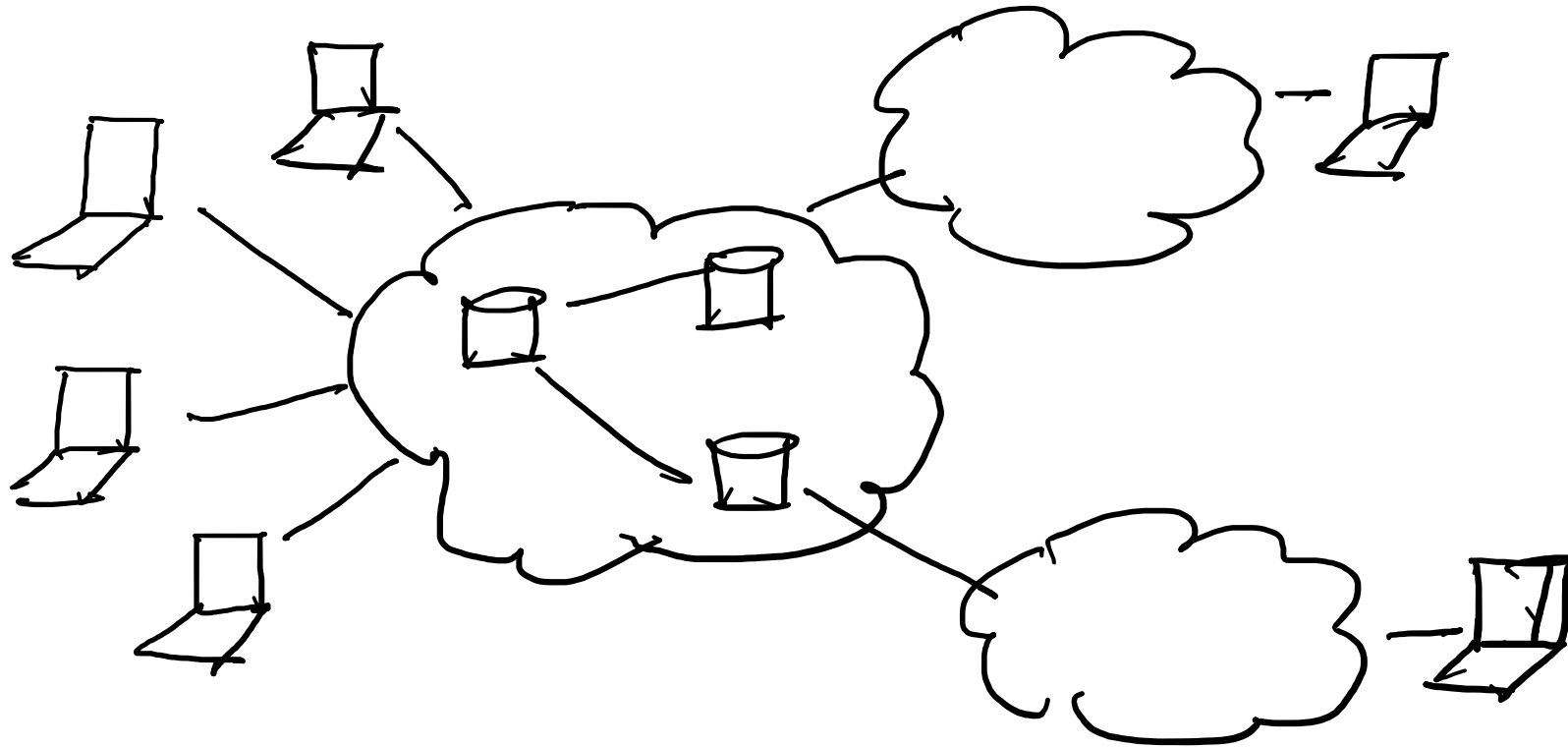
Recap

- How to send data over the Internet?
- Need protocols for distributed networks

① link data transmission

② Addressing / Routing

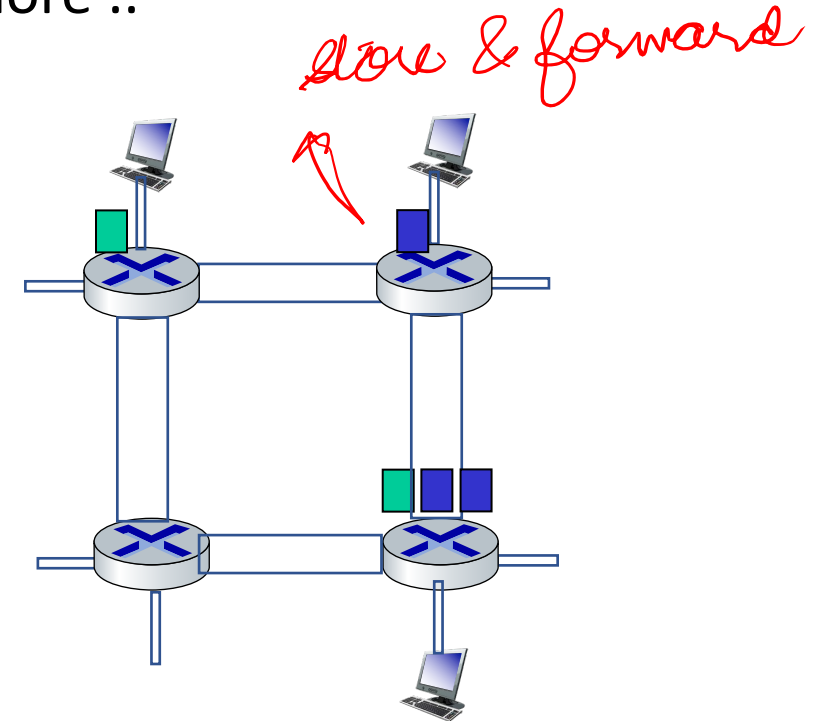
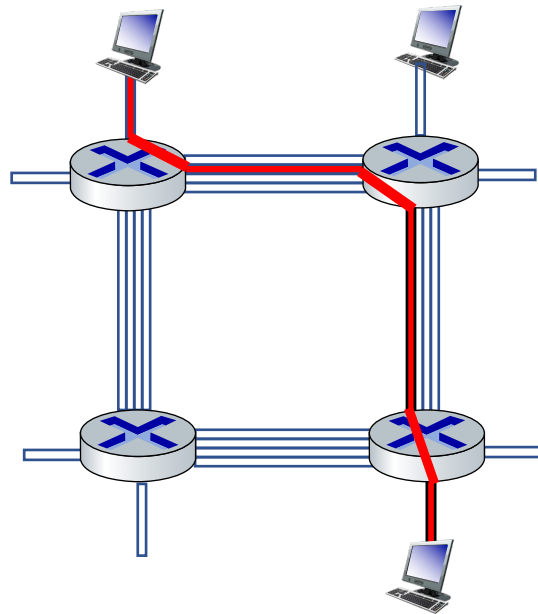
③ Multiplexing



Recap

"Bursty"

- How to send data over the Internet?
- Need protocols for distributed networks
- Two communication paradigms:
 - Circuit switching – resource reservation,
 - Packet switching – on-demand
- **This class:** *in statistical multiplexing* which option did the Internet chose and more ..



Packet-switching versus circuit switching

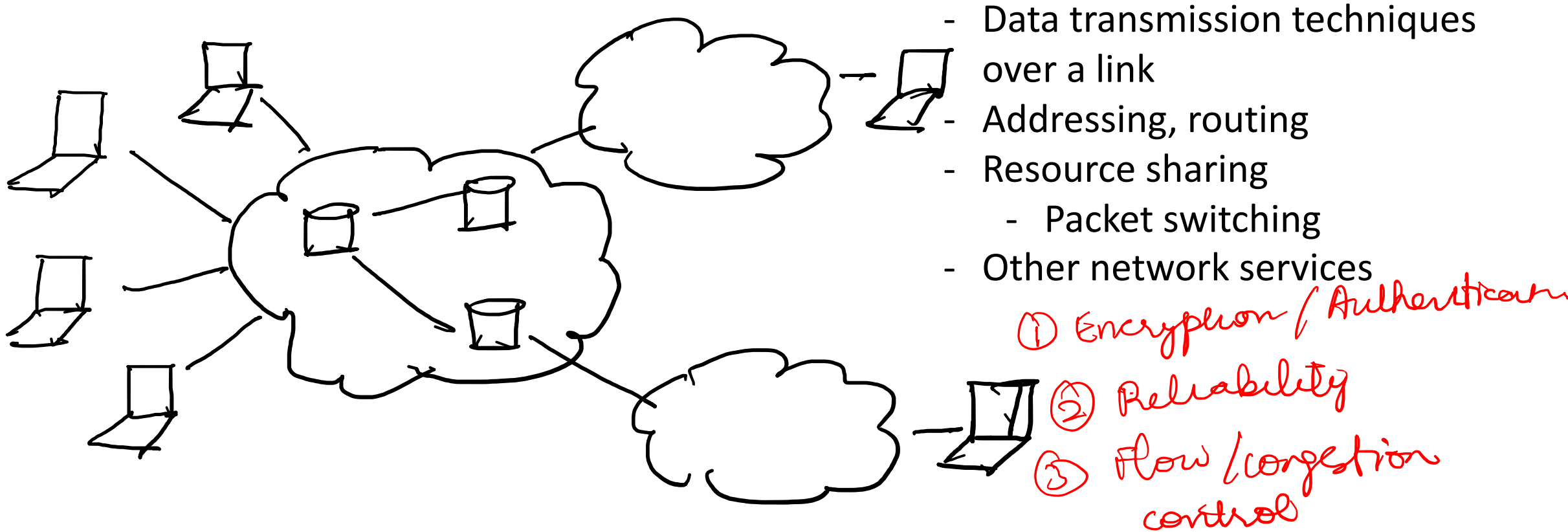
Internet uses packet switching

- Great for “bursty” data – sometimes has data to send, but at other times not
 - Efficient resource sharing (why?)
 - Simpler*, no call setup unlike circuit switching
- however, does not provide any performance guarantee, **best-effort** delivery
 - protocols needed for reliable data transfer, congestion control
 - Implication on router design

→ state in routers
→ what if the link goes down

10 Gbps
store & forward → router buffer
 10^9 packets per second → 10^{-9} s

How To Send Data over Distributed Network?



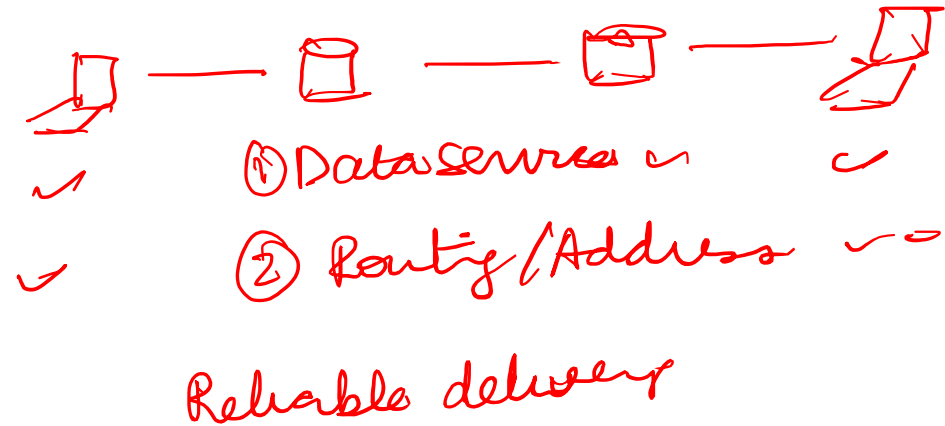
Other Network Services

① Data transmission

- Reliable delivery
- Congestion control
- In-order delivery
- Encryption
- Authentication
- ...

How to implement them?

→ Where to implement them?



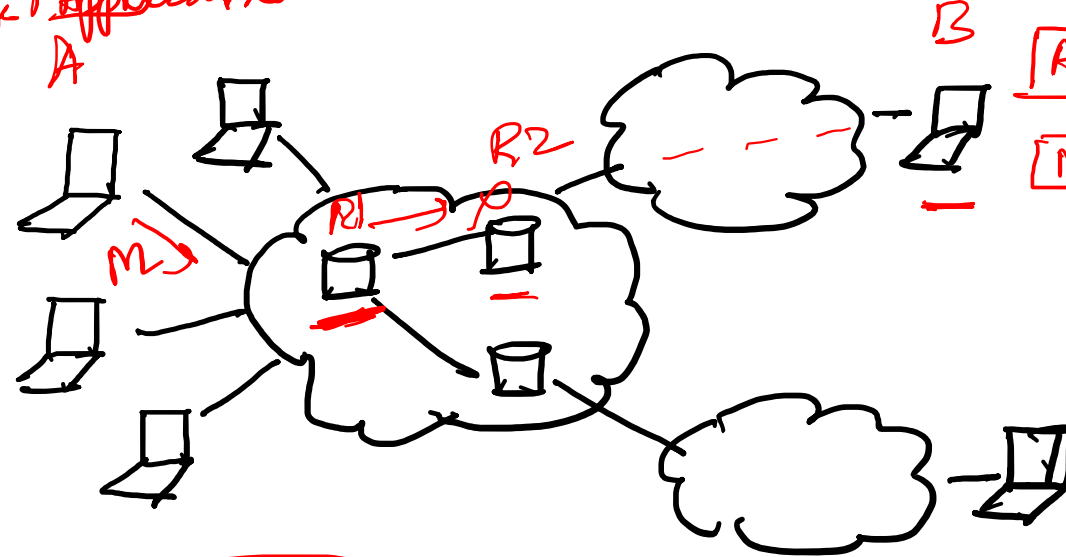
Where to implement reliability?

~~Network~~ Application A

~~Network~~

Application

Application
↕
Network



① Bit error
Why do we need to
implement reliability?

② Packet drops

③ hard failures

↳ link goes down

④ Security reasons

In-network support

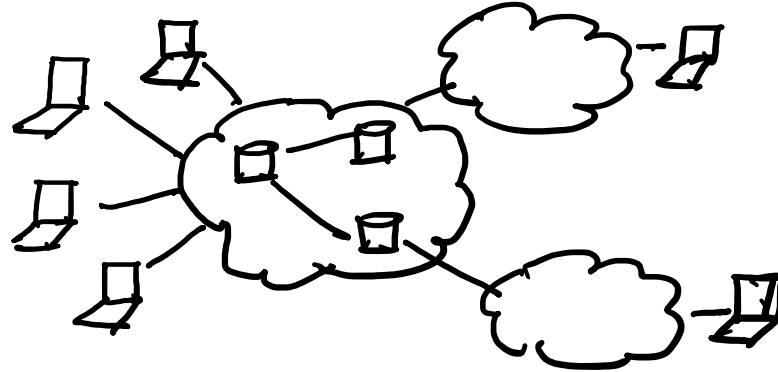
- Routers cache the packet and resend if it is not acknowledged
- Needs extra memory and compute in routers

End-host support only

- End-host send acknowledgement
- Reduced performance*

Where to Implement Network Services?

Two different paradigms



In-network support

- Network with rich functionality that covers most requirements
- Network with multiple “lanes”?
 - CISC-like
 - Modular network

End-system support only

- As little functionality as possible in the network
- Most functionality at the end points
- Also called **end-to-end principle**
 - Dumb network, intelligent end-points
 - Saltzer, Reed, Clark (1981)

Which option did the Internet designers chose?

End-to-end principle

Why End-to-End Principle?

- Need end-to-end correctness anyways
- Not everyone needs it
 - Diminishing returns from in-network functionality
 - Cost-effective
- Not everyone has it
 - All networks are not capable of providing functionalities
- Flexibility of implementation

Are there exceptions?

Any limitations?

Summary

- How to send data across distributed networks?
- Requirement 1: Cost-effective resource sharing
 - Use packet switching
 - Implications on other network services and network equipment design
- Requirement 2: Common network services
 - Where to implement those?
 - End-to-end design principle
- Next: How does Internet architecture look like?