Switching, Layering & Measurement

Lecture 2

http://www.cs.rutgers.edu/~sn624/352-F24

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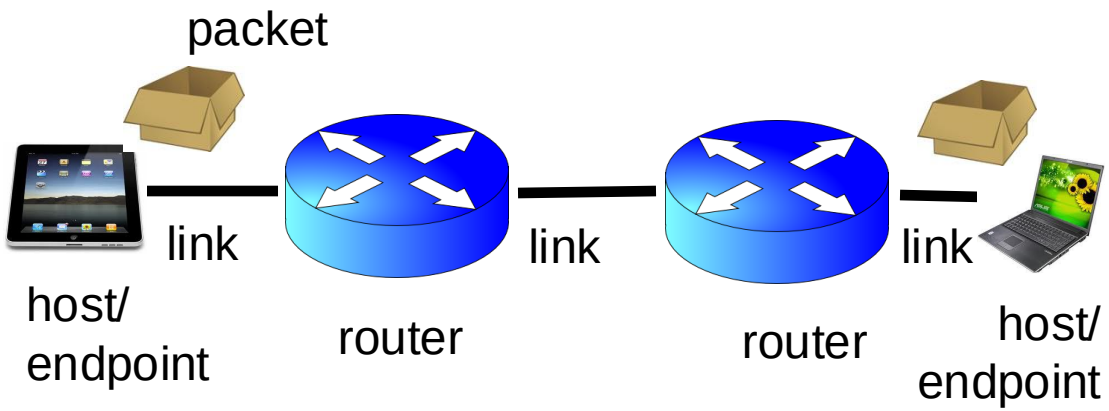
Review of definitions



- Endpoint or Host: Machine running user application
- Packet: a unit of data transmission (ex: 1500 bytes)
- Link: a physical communication channel between two or more machines
- Router: A machine that processes packets moving them from one link to another towards a destination
- Network: Collection of interconnected machines
- Address: a unique name given to a machine (more later)

Today’s lecture

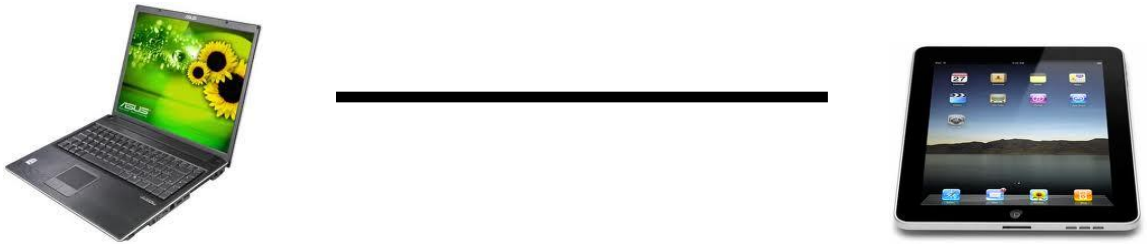
- Dive a bit deeper into how Internet communication works
  - Links: how does communication work physically?
  - Routers: how do they move data between links?
  - Endpoints: how is networking organized at endpoints?

- Understand how to measure the Internet

How do machines talk?

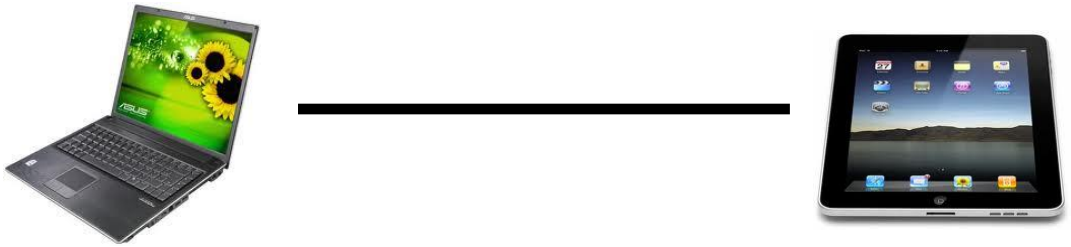
How do machines communicate?

- With 1s and 0s
  - Digital computers deal with 1s and 0s
- How do we transmit 1s and 0s in a network?



Encoding and
Decoding problem

Physical transmission on a single link



Physical signaling (light, AC voltages, etc.) are often analog

Convert bits to signals through modulation of the physical characteristics of signals: encoding

Convert signals back to digital by decoding physical signals

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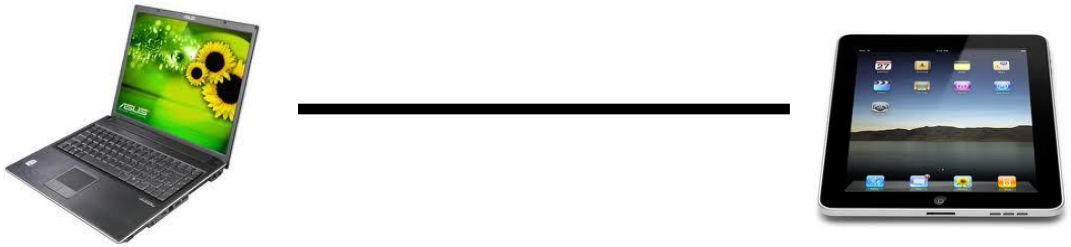

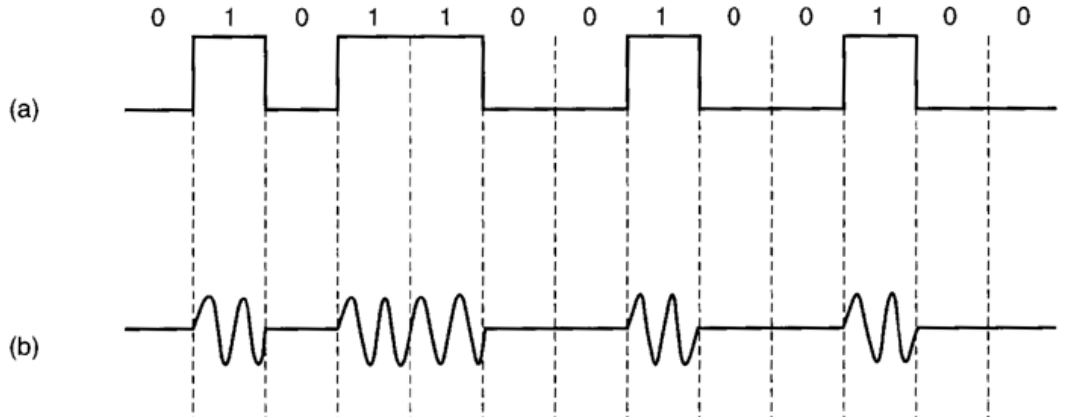

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Fig. 2-18. (a) A binary signal. (b) Amplitude modulation. (c) Frequency modulation. (d) Phase modulation.

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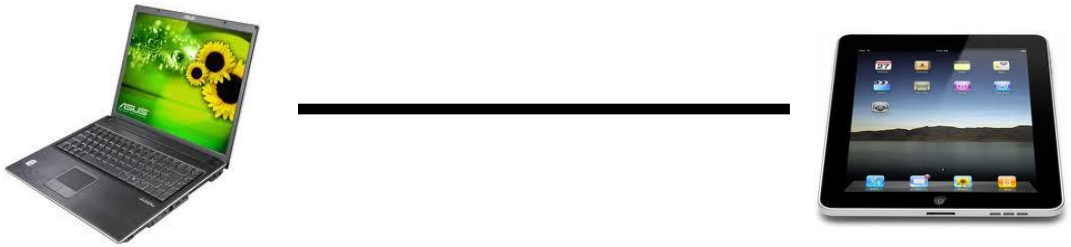

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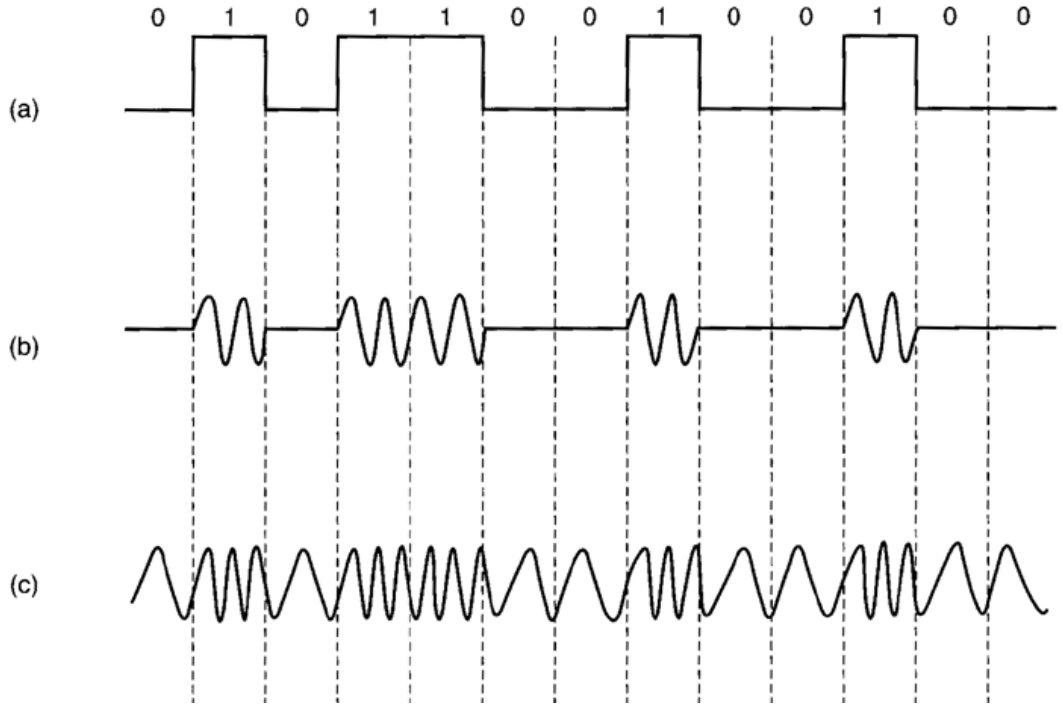

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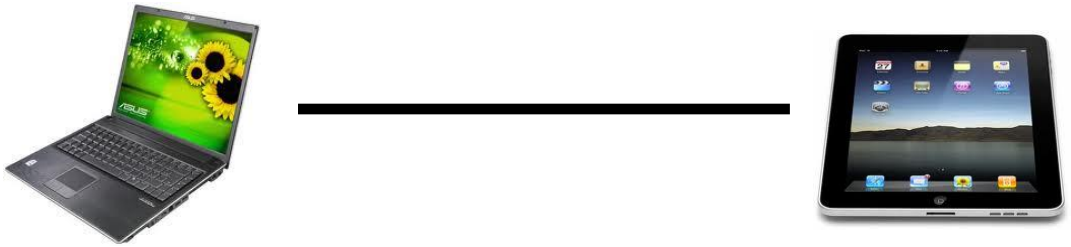

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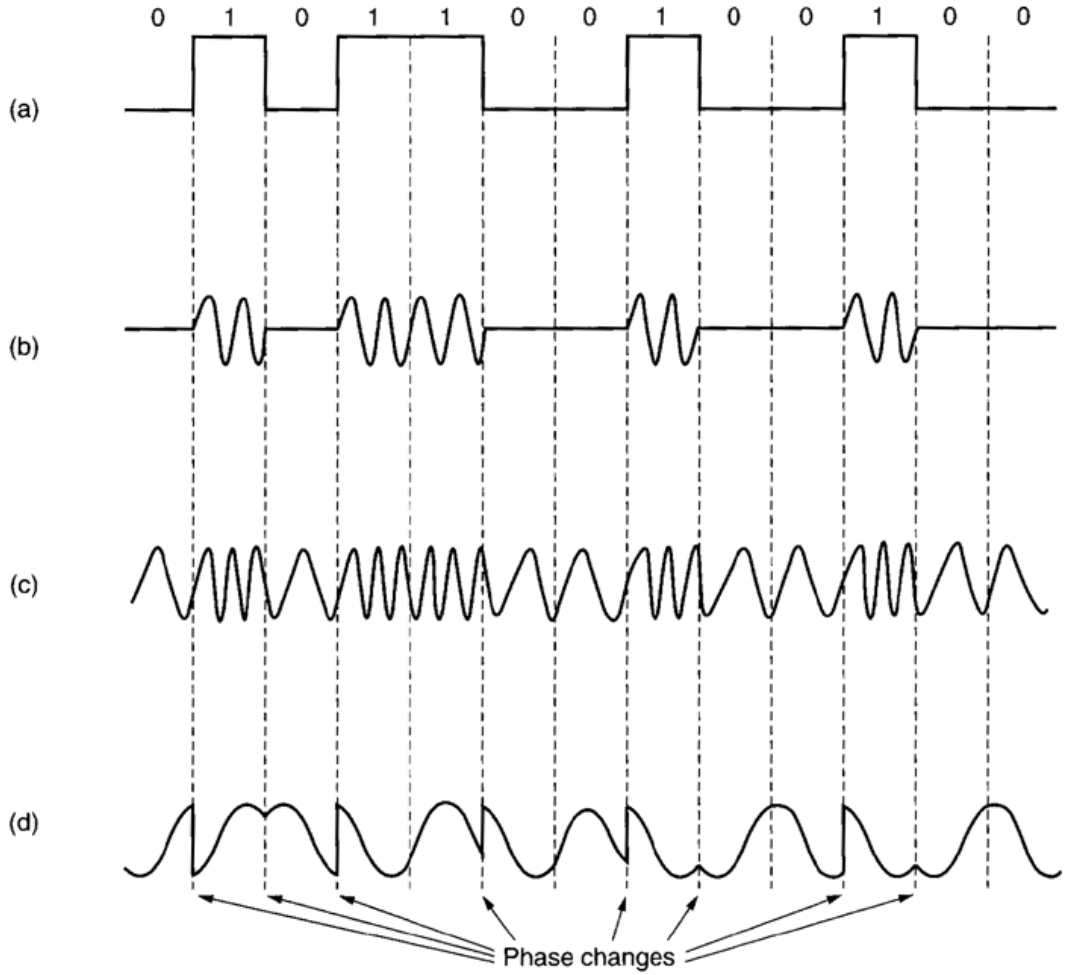

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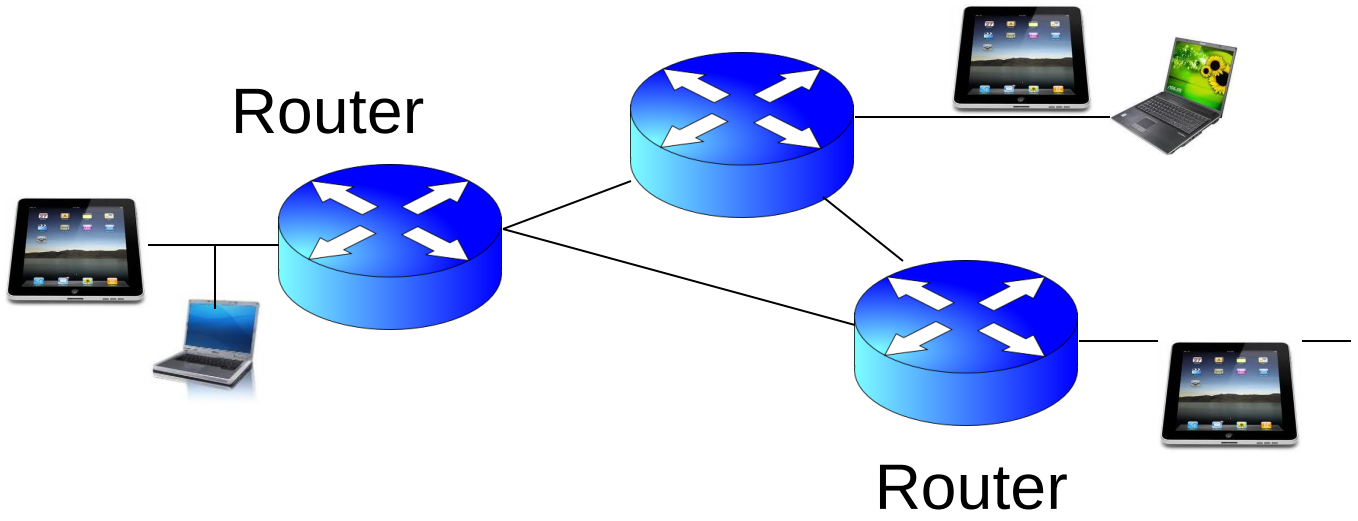
Routers and Multi-link networks



- Routers need a way to move data across links
- We use the term switching to denote physically moving data from one link to another
- There are different possibilities to switch data across links

Switching methods

Host applications transfer data containing many messages.

A message could be a single web page, chat message

(1) Circuit Switching

(2) Message Switching

(3) Packet Switching

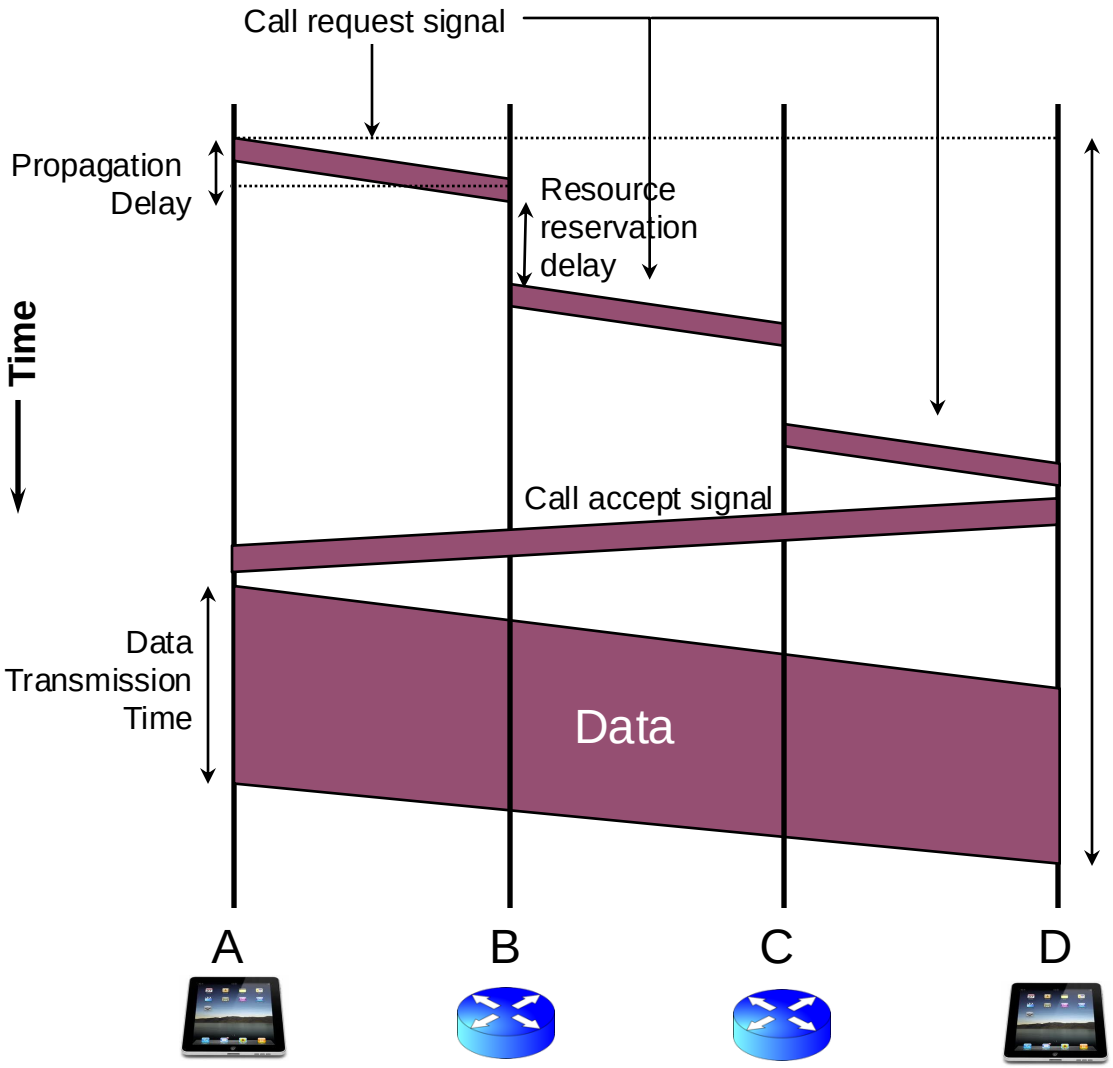
Circuit switching

- Provides service by setting up the full path of connected links from the origin to the destination

- Example: Telephone network

Dedicated path with
dedicated resources

Circuit switching



1. Setup: Control message sets up a path from origin to destination
2. Accept signal informs source that data transmission may proceed
3. Data transmission begins
4. Entire path remains allocated to the transmission (whether used or not)
5. When transmission is complete, source releases the circuit

Message switching

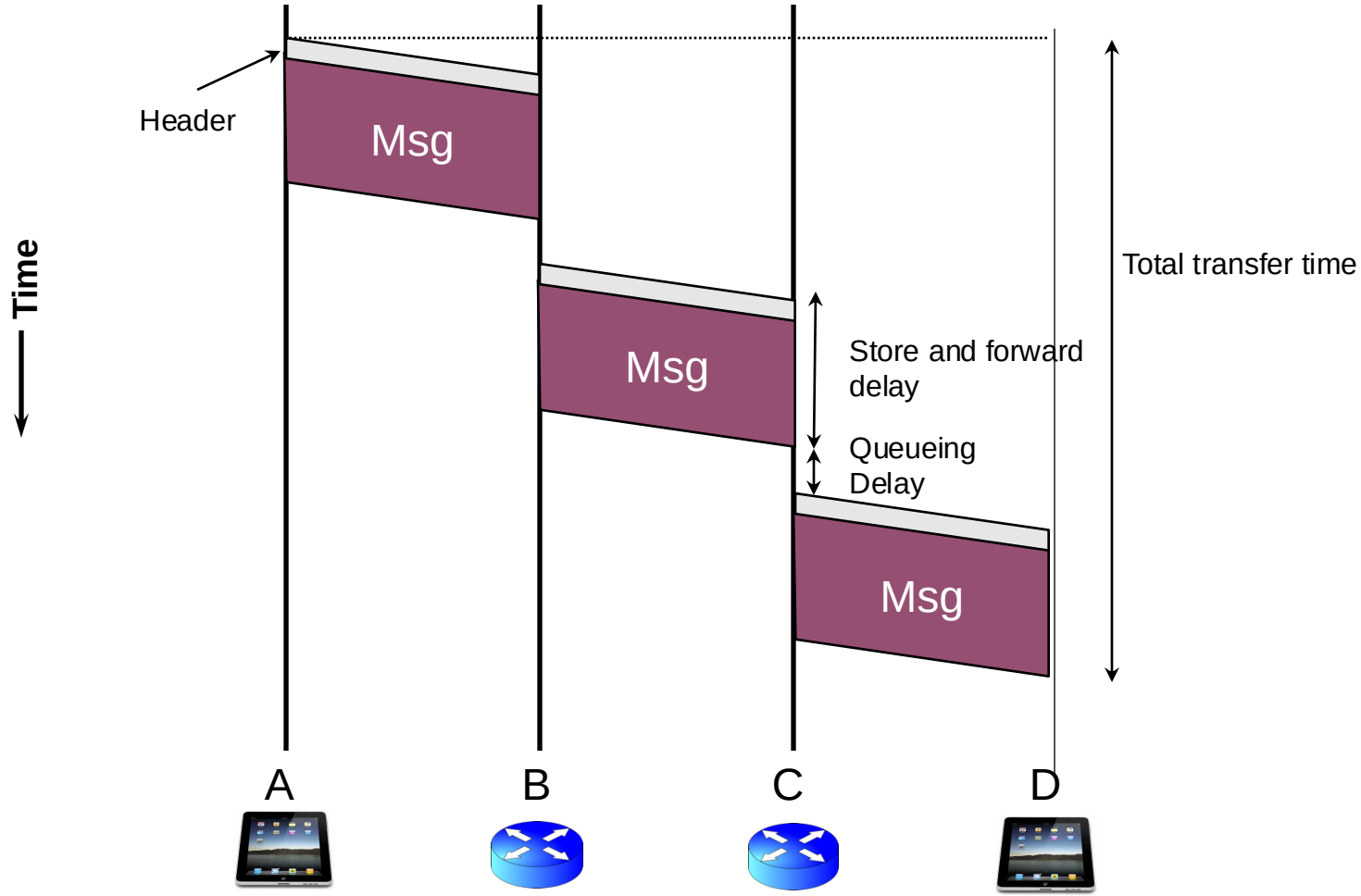
- Each message is addressed to a destination

- Header: metadata that denotes how to process a message
  - Typically includes a destination address
- The message “hops” from node to node through a network while allocating only one link at a time
- (Compare to circuit switching, where all links are reserved at the same time, regardless of use.)
- Analogy: Postal service

Message switching

- When the entire message is received at a router, the next step and link in its journey are selected (routing)
- If this selected link is busy, the message waits in a queue until the link becomes free
- Store and forward switching
  - Router waits for all bits of a message to arrive on incoming link before sending the first bit of the message on the outgoing link
  - Alternative: cut–through switching sends bits as they arrive

Message Switching

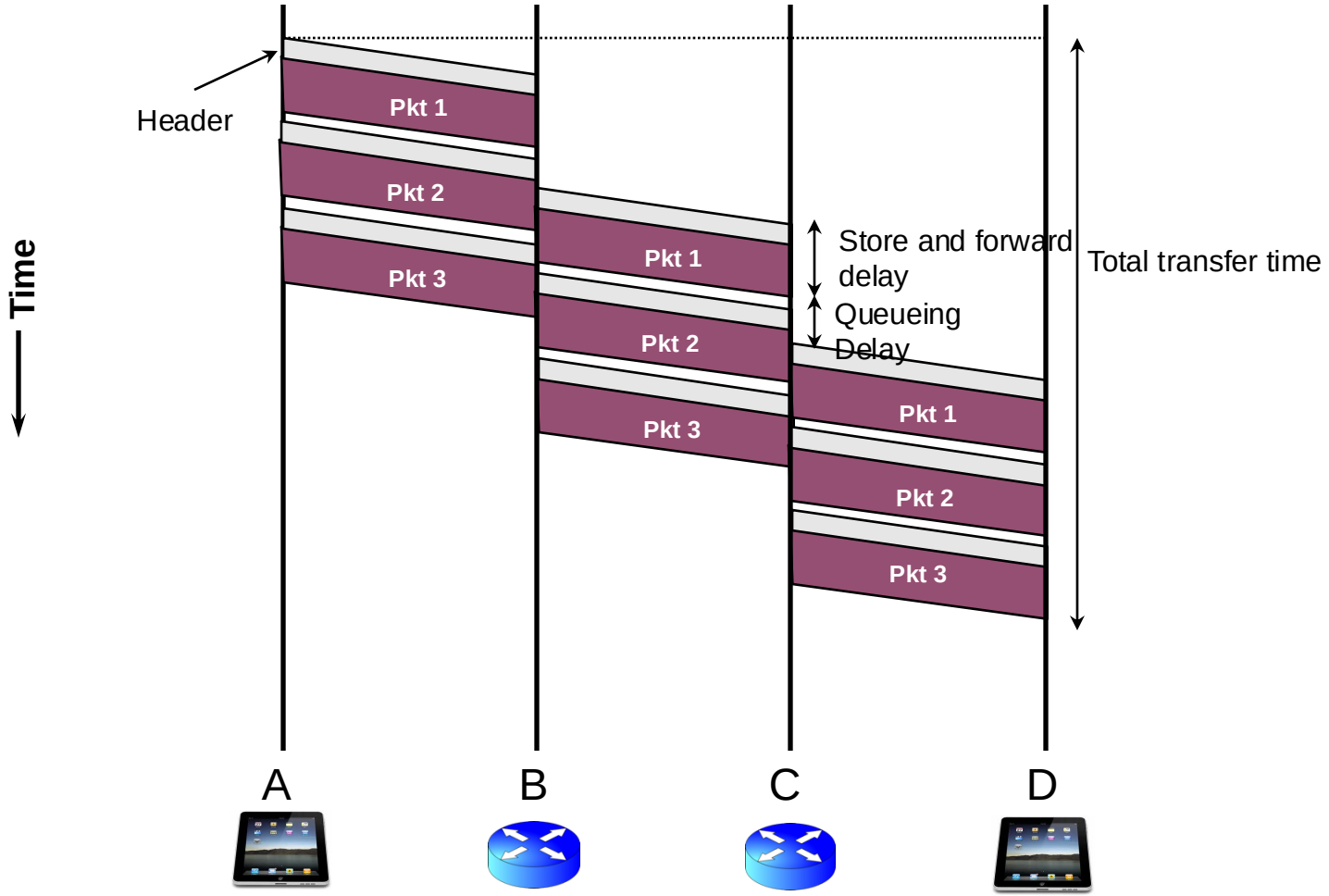


Packet switching

- Messages are split into smaller pieces called packets
  - Packets have a maximum length
  - Packets are numbered and addressed
  - Packets are sent through the network one at a time

- Pipelining: different parts of a message concurrently transmitted over different links
  - Provides higher utilization of link resources

Packet switching



The Internet uses store-and-forward packet switching.

Comparisons across switching tech

- Circuit switching incurs an initial delay in setting up the resources along the path
  - Packet (and message) switching can start transmitting data right away
- Packet switching doesn't reserve resources for the conversation
  - While circuit switching does. Needs admission control
  - Packet switching makes resource reservation decisions per packet
- Fewer or no guarantees ➔ easier to build
  - Telephone networks are more reliable but harder to build

Comparisons across switching tech

(1) **Total Delay to transfer a message**

Short Bursty Messages:

Packet < Circuit

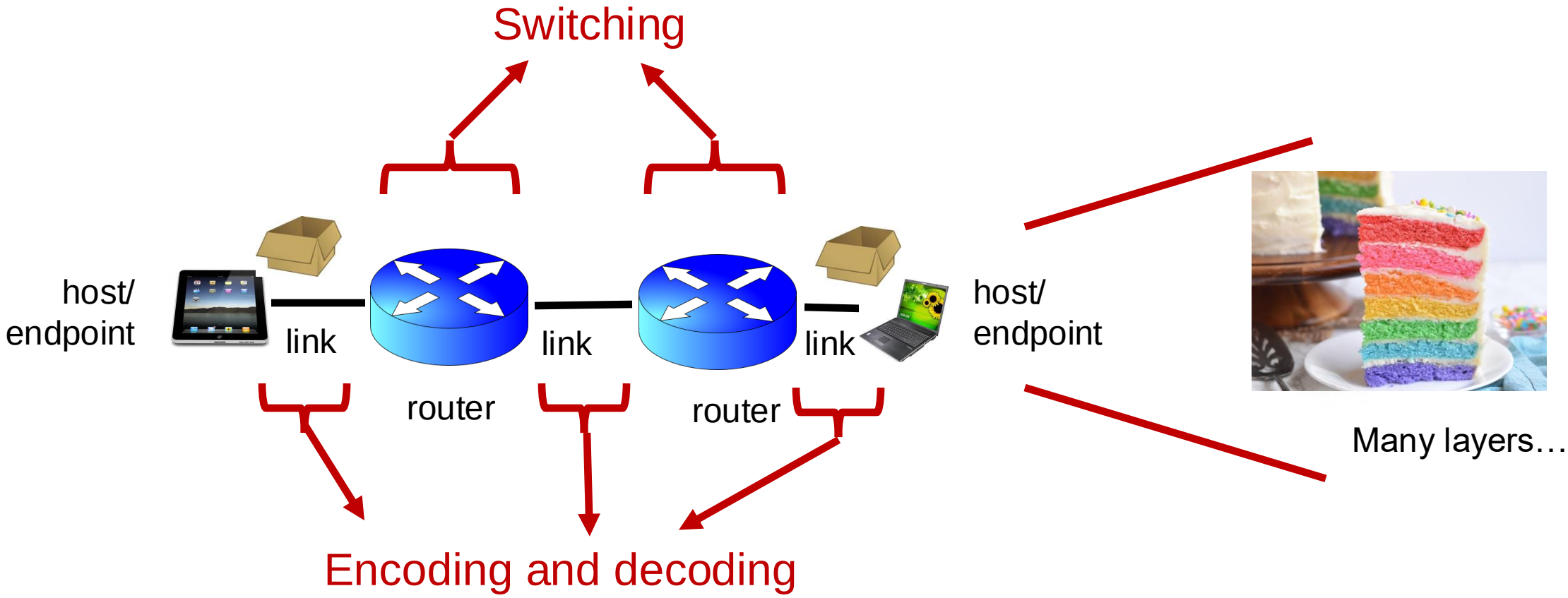
Long Continuous Messages:

Circuit < Packet

(2) Header overhead (wastage, or what % of bits on the wire is metadata?)

If typical messages are larger than typical packets:

Packet > Message

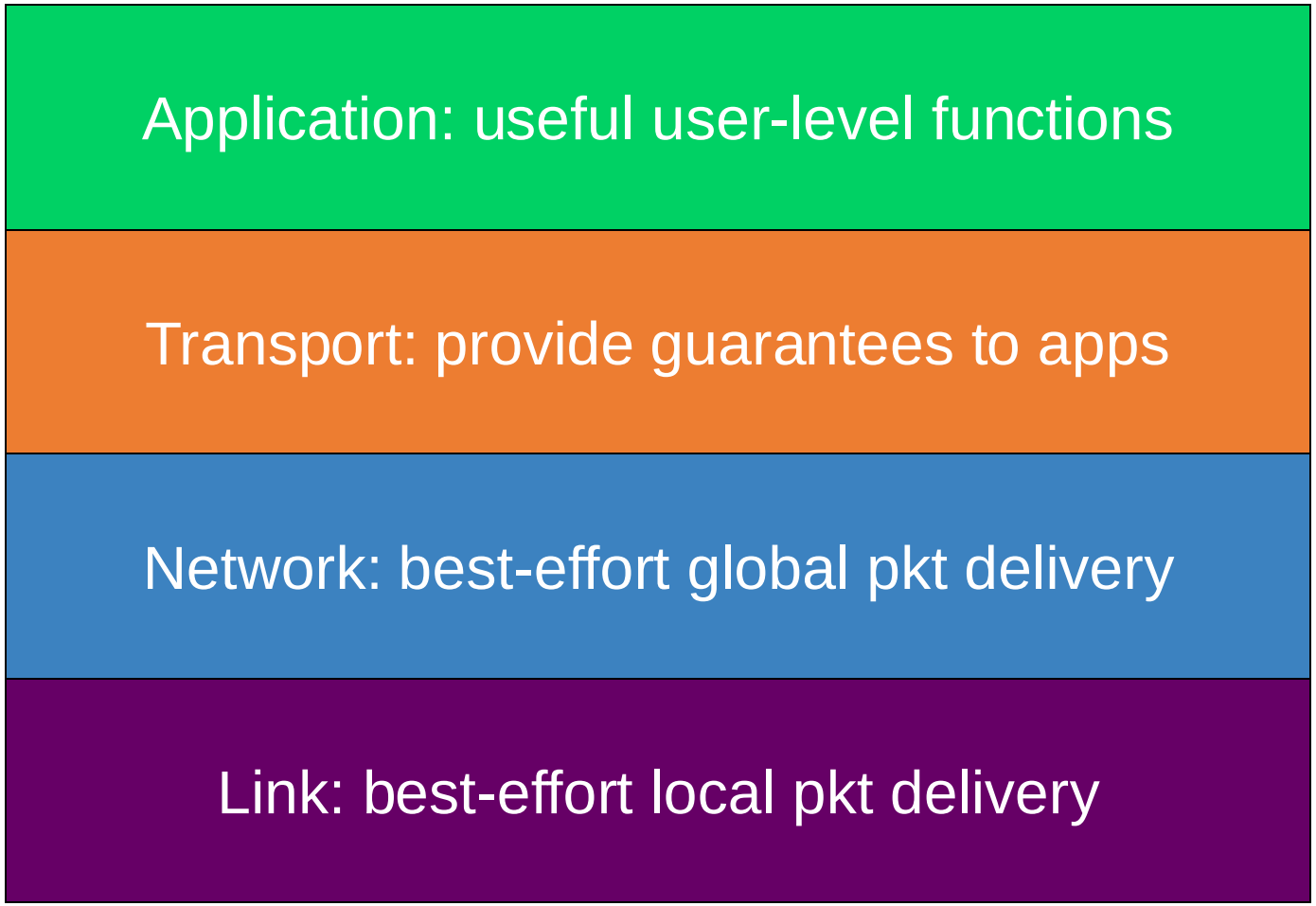

Switching
host/
endpoint
link
link
link
router
router
host/
endpoint
Encoding and decoding
Many layers…

Layering and Protocols

Solving the problems of communication

- Communication over the Internet is a complex problem
  - Application (e.g., web)
  - Guarantees (e.g., reliability)
  - Data movement across the Internet (routing)
  - Link concerns (encoding/decoding, medium access control)
- We solve complex problems by breaking them into simpler ones!
- Layering simplifies understanding, testing, and maintaining
- It is easy to improve or replace solutions at one layer without affecting others

Software/hardware organization at hosts



Communication functions broken up and “stacked”

Each layer depends on the one below it.

Each layer supports the one above it.

The interfaces between layers are well-defined and standardized.

Internet software and hardware are arranged in layers.

Layering provides modularity

Each layer: well-defined function & interfaces to layers above & below it.

Functionality is implemented in protocols.