

Digital Communications over Packet-Switched Networks

(ECE 446 – Lecture #4)

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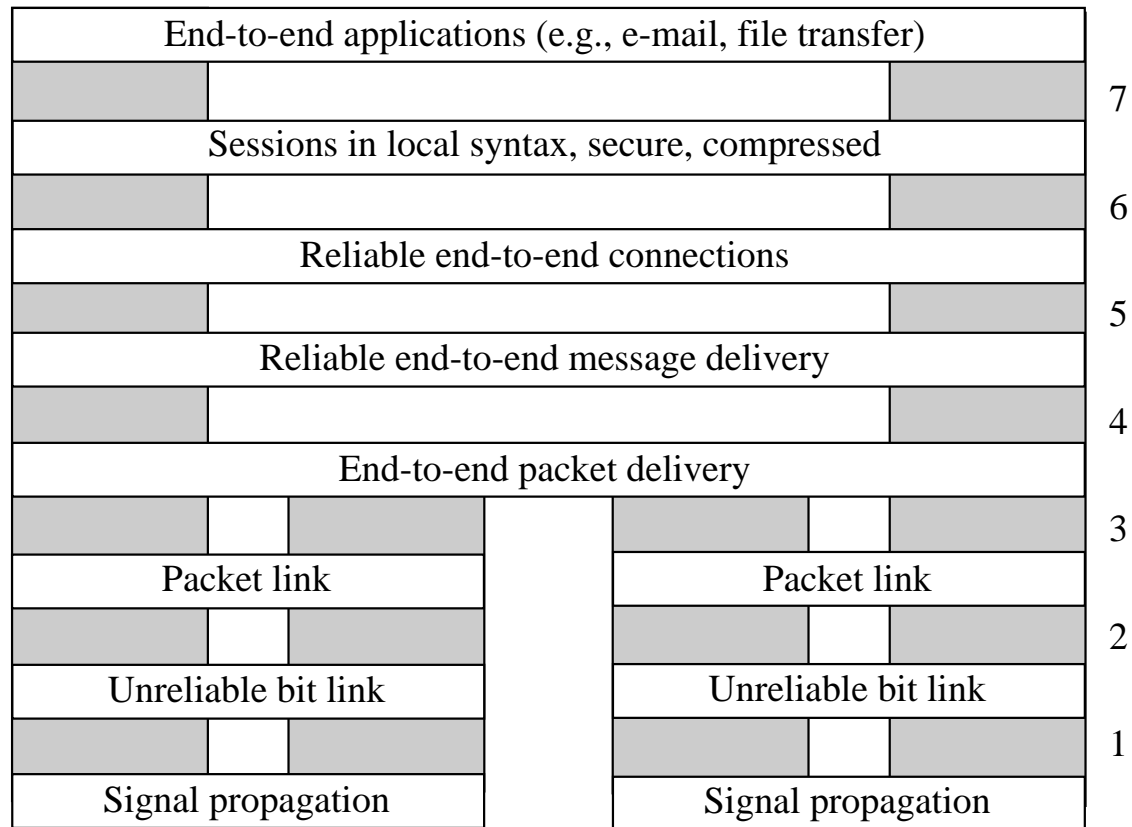
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Outline

- Last time: Network Mechanisms and Layered Architectures.
 - Error Control, Retransmissions, Flow/Congestion Control, Layers.
- Today: the OSI and IP models.

The Open Systems Interconnection Reference Model

Today our goal is to dissect the OSI network architecture:

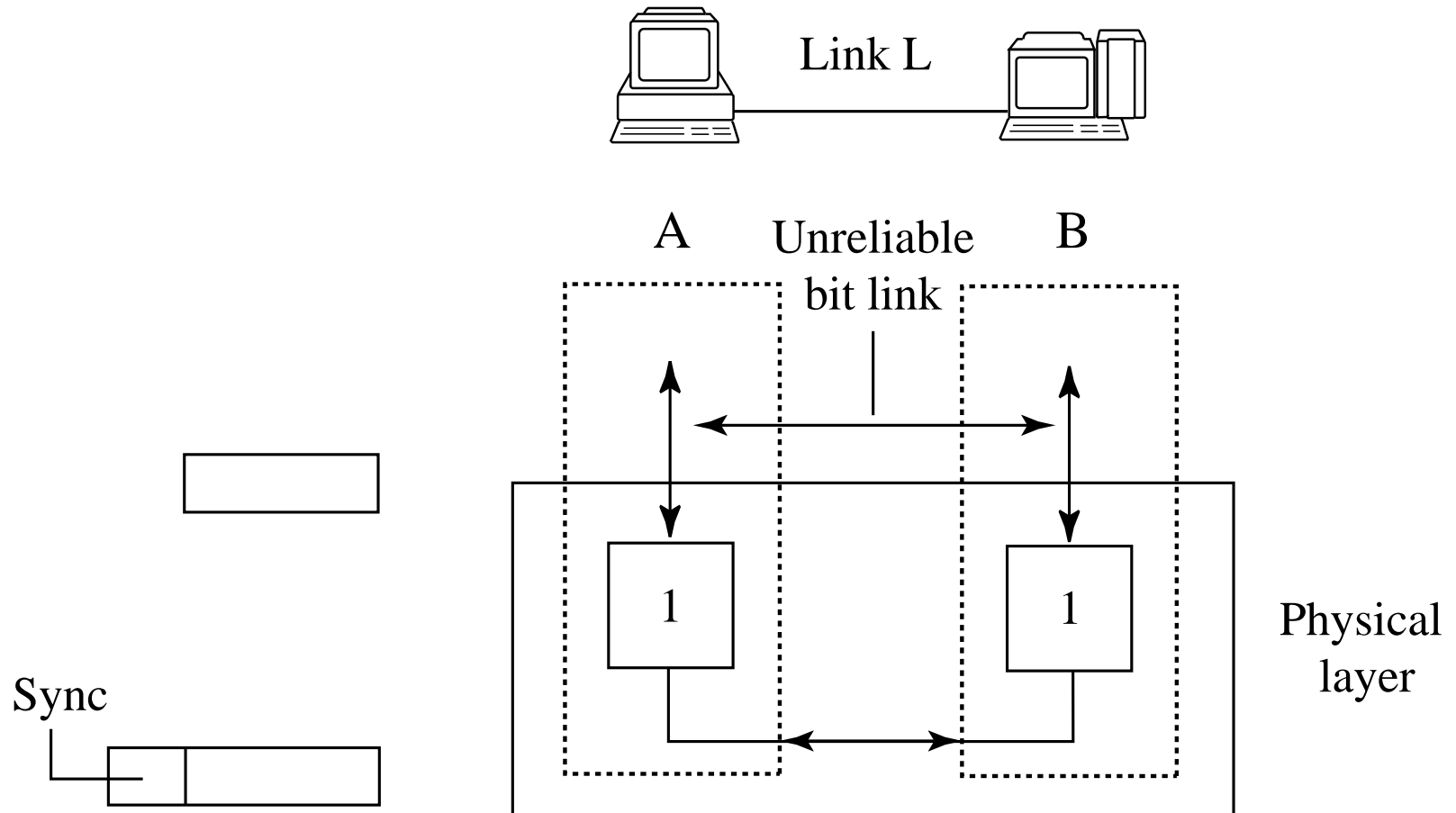


Layer 1: Physical Layer

- Link: direct connection between tx and rx over some medium.
- Information sent from tx to rx: modulated electromagnetic waves.
- Tx: transform bits into signals (modulator in ECE 467).
- Rx: transform signals into bits (demodulator in ECE 467).
- Synchronization needed between tx and rx for successful communication.

Communication is unreliable because of noise and sync errors...

Abstraction: Unreliable Bit Link



Layer 2: Data Link Layer

- Direct link connections:
 - No contention for access to the medium.
 - Example: a piece of cable connecting two computers directly.
 - Example: two radios using a reserved frequency band.
- Shared medium:
 - Nodes compete to gain access to the medium.
 - Example: an Ethernet (local area network).
 - Example: multiple radios sharing unregulated spectral bands.

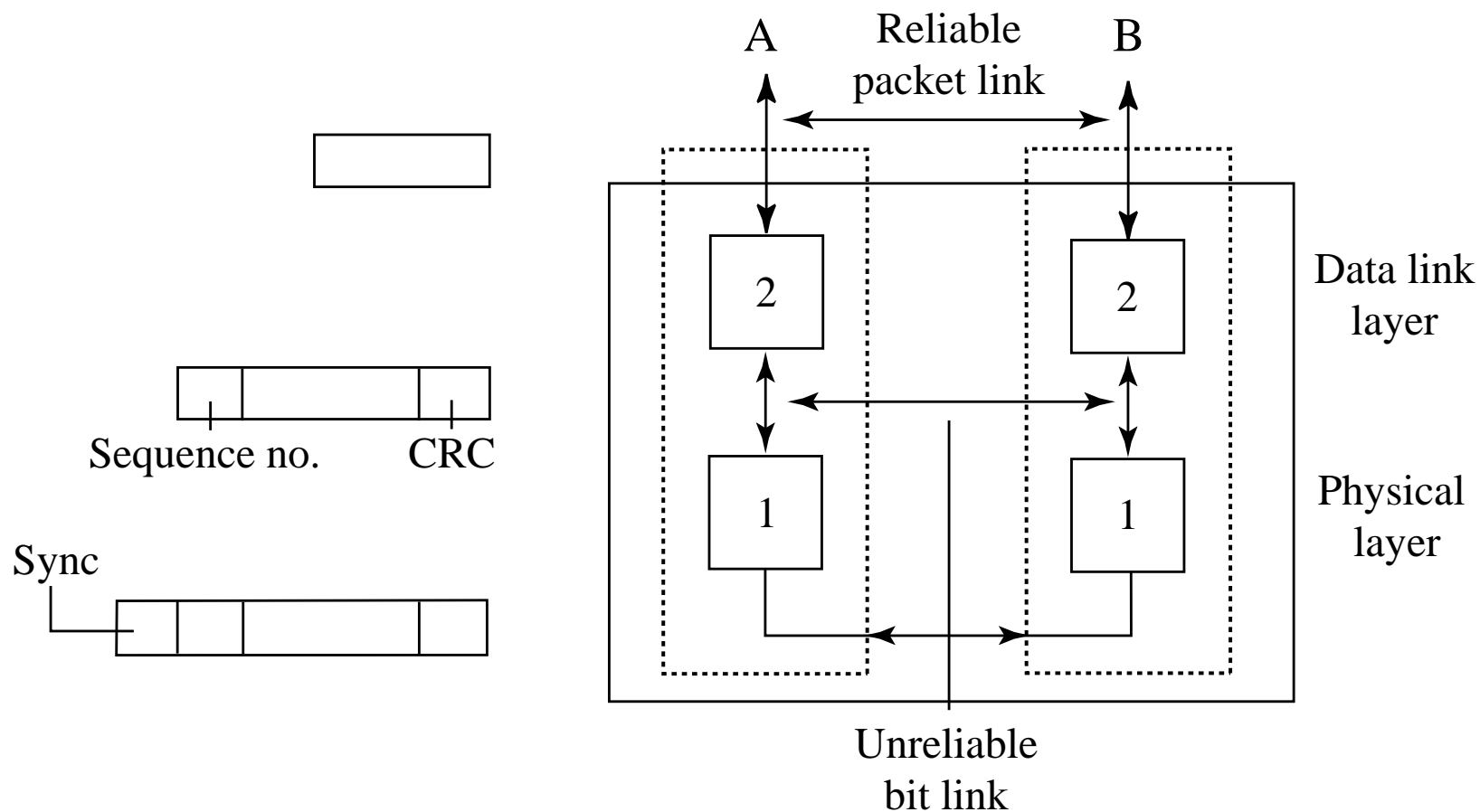
The link layer takes a different form in each of these cases...

Layer 2: Data Link Layer – Direct Links

- Retransmission of corrupted packets, link level error detection/correction.
- Adds sequence number and CRC bits.
- Typically implemented in hardware (at the network interface card).
- Nesting of header information for each layer, encapsulation/decapsulation.
- End-to-end (good for rare errors, e.g., optical) vs. hop-by-hop (good for bad links, e.g., wireless) error control.

Protocols turn unreliable links (from layer 1) into reliable ones...

Abstraction: Reliable Packet Delivery over Links



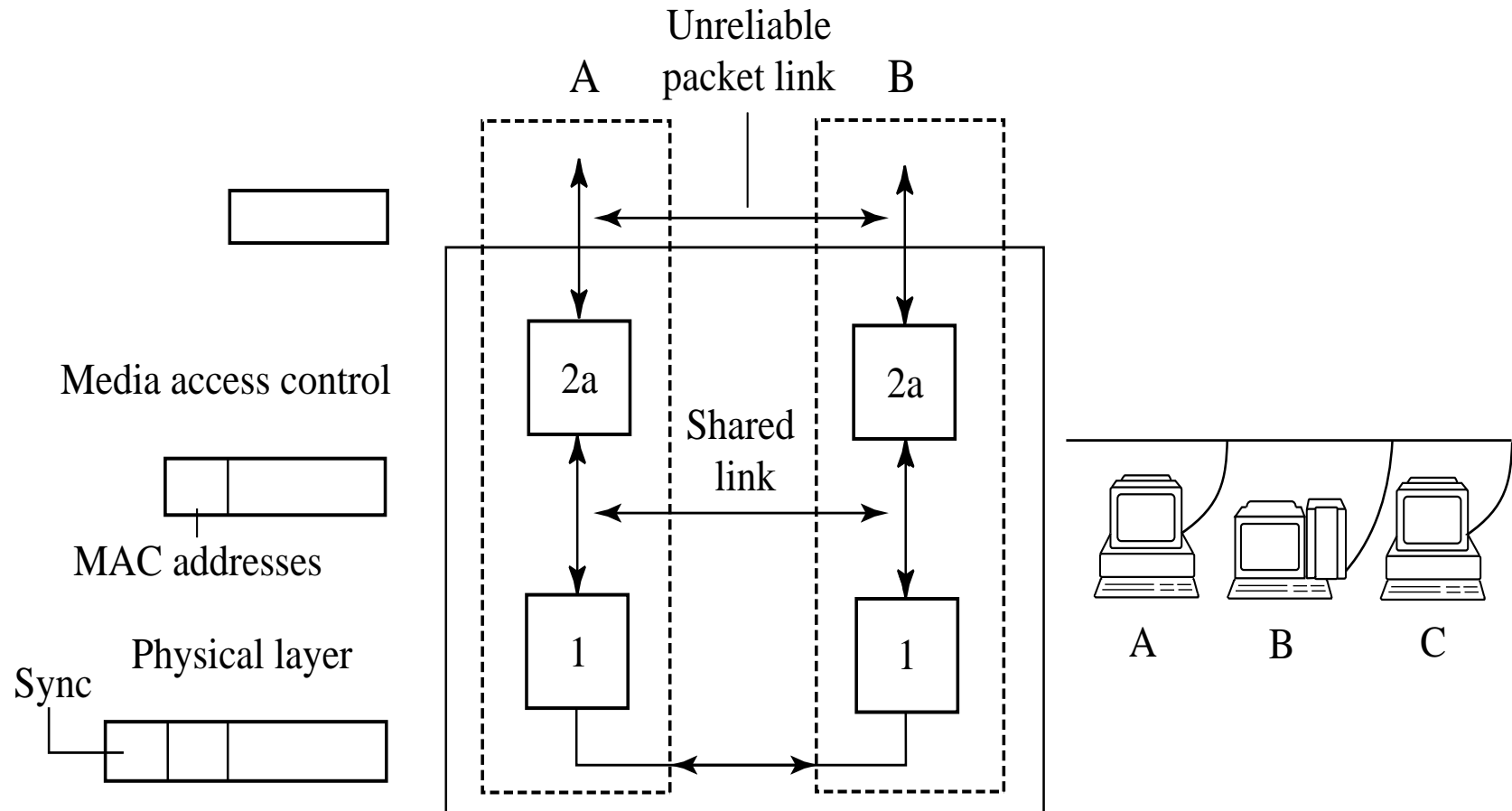
Layer 2: Data Link Layer – Shared Medium

Sublayer 2a: Media Access Control.

- MAC protocol: set of rules to regulate access to the shared medium.
- Addressing/identifier mechanism needed – who is this packet for?
- Also used to provide/deny access to a network – if MAC address unknown, packets from that host are discarded.
- Unreliable because collisions can occur, if so packets arrive garbled.

A MAC protocol manufactures a link where there is none...

Abstraction: Unreliable Packet Link



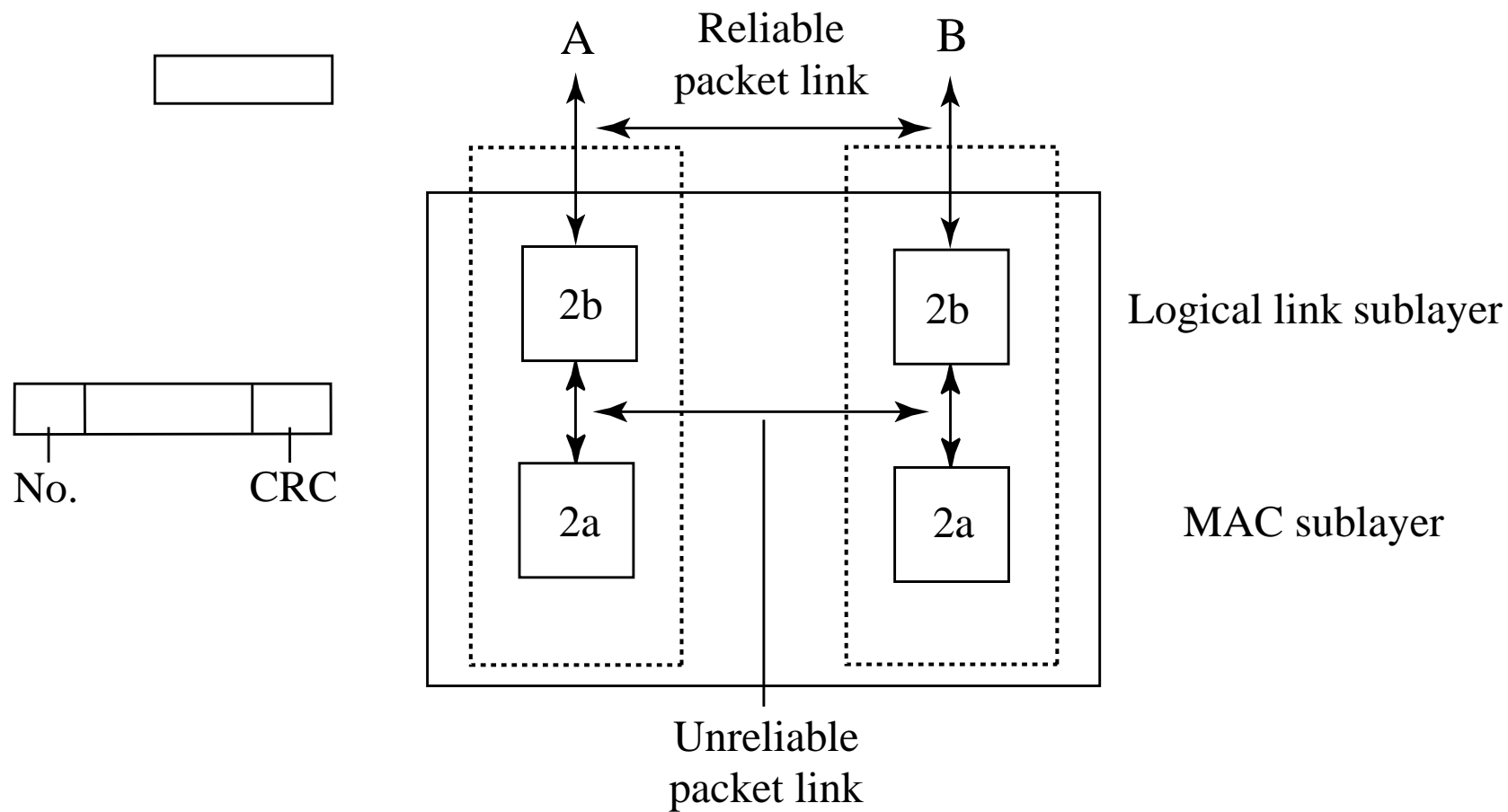
Layer 2: Data Link Layer – Shared Medium

Sublayer 2b: Logical Link Control.

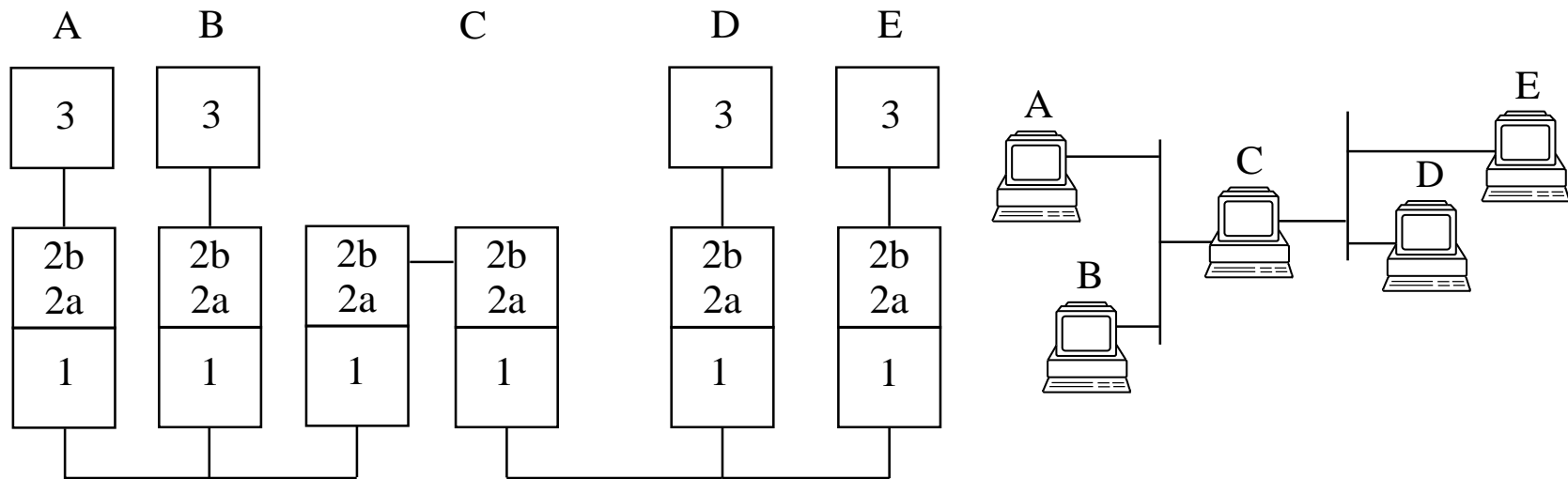
- The MAC sublayer is unreliable, must be cleaned up.
- LLC: error detection and retransmissions (similar to DL for links).

Sublayers 2a (MAC) and 2b (LLC) \equiv data link in a multiple access setup.

Abstraction: Reliable Packet Delivery over Links



Bridges: Links Joining Different Shared Media



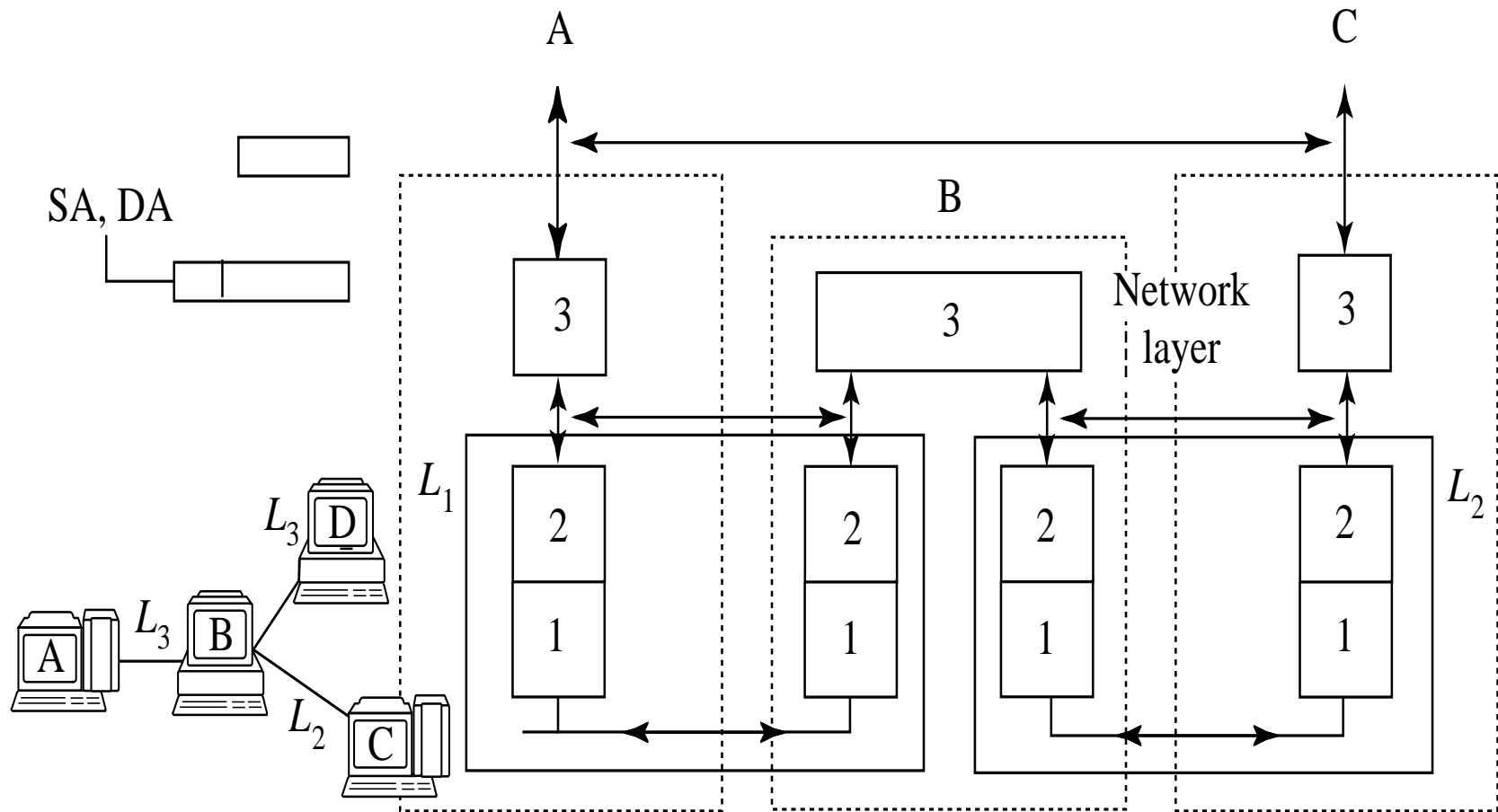
- A bridge enables two different Ethernets to act as a single one.
- LLC Function: decide which packets must go across the bridge, fast.

Layer 3: Network Layer

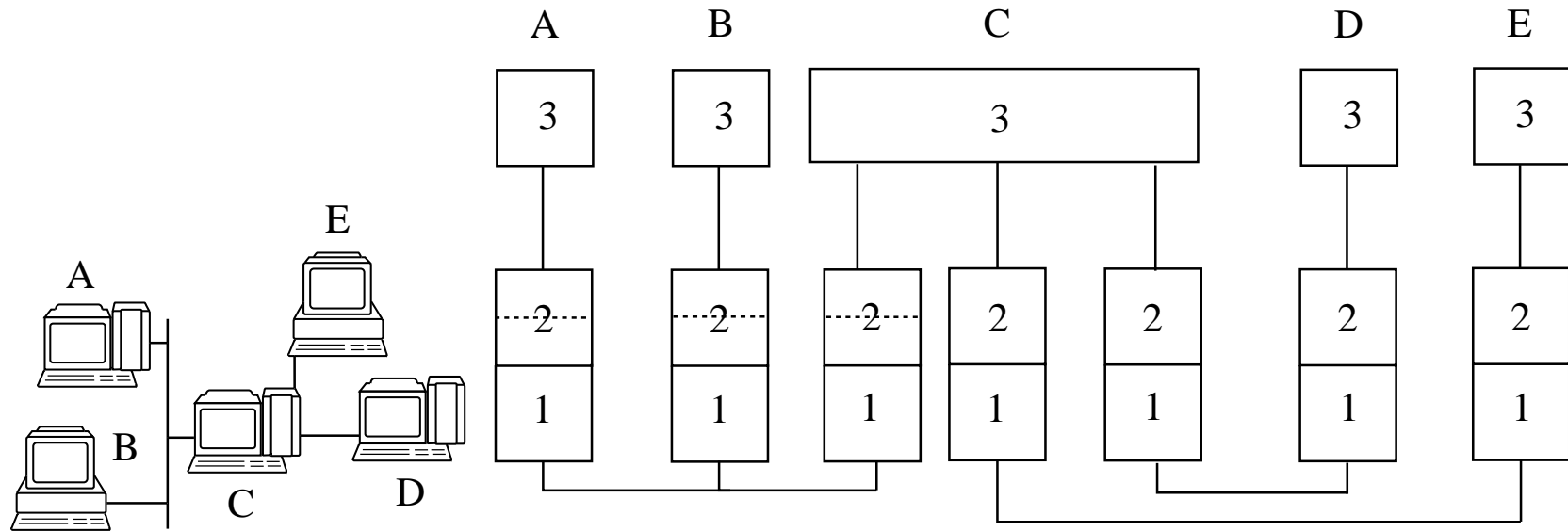
- Layer 2 provides a set of links – must allow for multihopping.
- In a network of links, must decide on where to send received packets.
- Need *routing* information: destination address, source, route, ...

Routing is the main function provided by the network layer.

Abstraction: Routes



Routers



- C is a router.
- Link C-E carries traffic from $A \rightarrow E$ and $B \rightarrow E$ – multiplexed by C.
- Addressing information used to demux.

Layer 4: Transport

- Network layer provides reliable delivery of packets between nodes.
- Delivery of packets between ports.
- Fragmentation, sequencing and reassembly of messages.
- Flow control – care to avoid overloading the network.
- Connection oriented or connectionless.

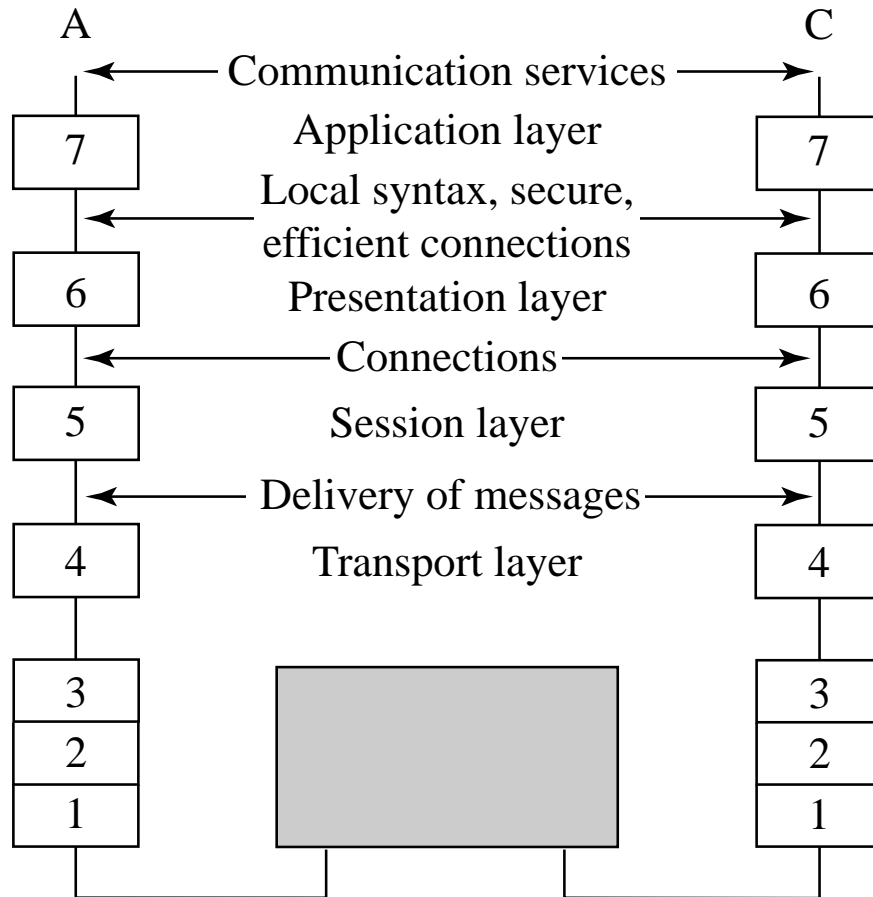
The transport layer implements reliable data *streams* on top of packets.

Layers 5-7: Session/Presentation/Application

- Session layer: management of connections.
 - Start, stop, add synchronization information, fault tolerance, ...
- Presentation layer: syntax conversions.
 - Different machines/applications use different syntax to represent data.
 - Presentation layer takes care of translations.
 - Encryption and data compression.
- Application layer: ftp, telnet, rpc, email, WWW, streaming media, ...

Not really network layers, more like software engineering principles...

Functions

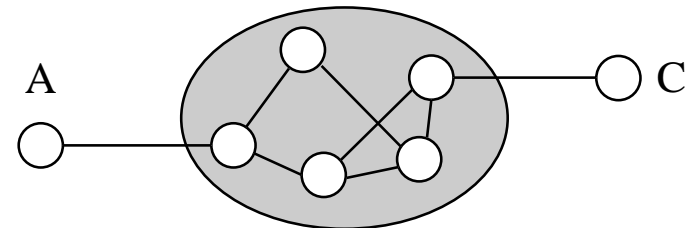


Commonly used applications

Encryption; compression;
syntax conversion

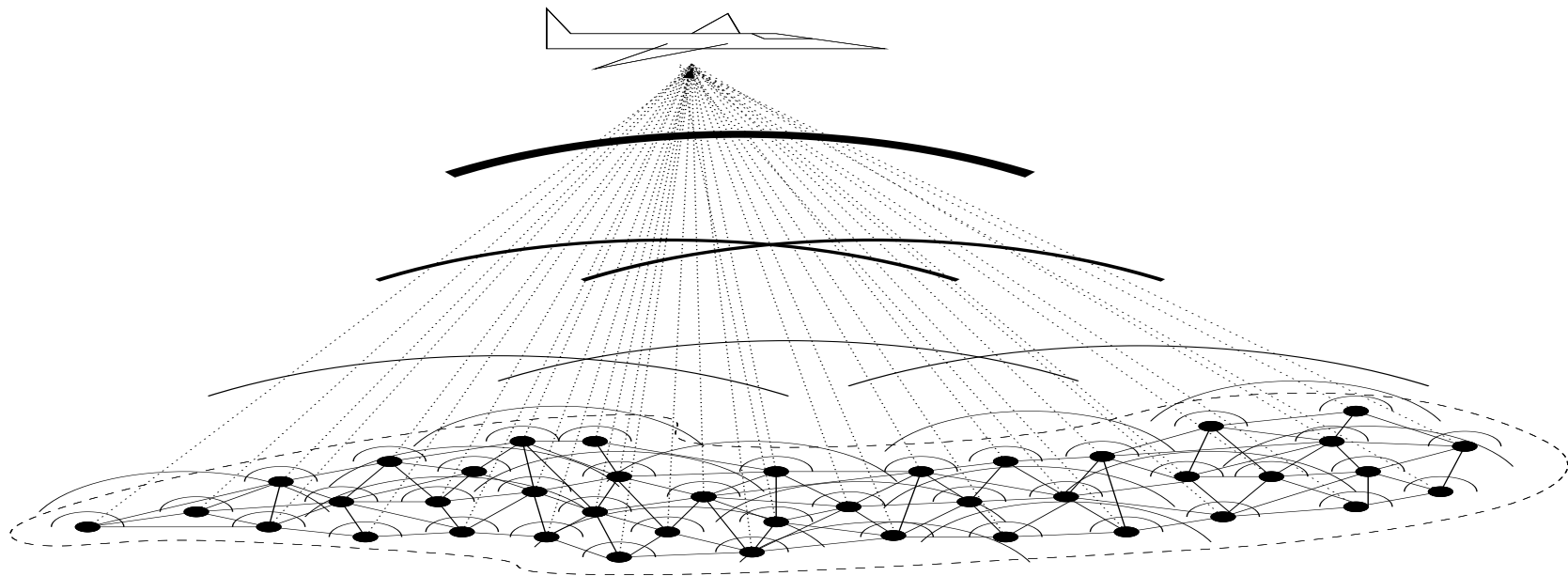
Supervision of connection

Segmentation/reassembly; flow
control; end-to-end error control



Seems so natural... yet links/layers could be bad ideas

What if you don't have enough power to create a link?...



This is the PhD thesis topic of one of your TAs... (An-swol).

What Next

- Complete reading section 3.1, start browsing the rest of chapter 3.
- Homework #2 assigned (due on 9/20).
- Solutions to homework #1 distributed later today.

Credits: all but the last figure in these slides are from our textbook.