

# COMPSCI 314 S1 C

## Data Communications Fundamentals

Lecture Slides, Set #3

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27 March 2006

## What sort of a student are you?

- “C” student: attends most lectures, reads the textbook only when it seems necessary to do homework, learns terminology and basic concepts.
- “B” student: pays attention during lectures, reads textbook carefully *before* the lecture on that topic, completes homework, develops a competent understanding of the material emphasized in homework and lectures.
- “A” student: asks and answers their own questions, using outside sources if necessary; develops a critical and appreciative understanding of the textbook and the lecturer; works creatively with what they have learned.

314 S1C 06: Set 3

27 Mar 06

Page 2

## Critical and Appreciative Views

- “I think networks, as taught in COMPSCI 314, are a boring and bewildering mess of detail. Where are the underlying scientific concepts?”
- “I want to learn how to set up and administer a network for a small office – or for a large corporation!”
- “I want to learn enough to get hired as a network administrator when I graduate.”
- What is your current view of this class? Can you develop a view that will motivate you to be an “A” student?

314 S1C 06: Set 3

27 Mar 06

Page 3

## Layers in a Communication System

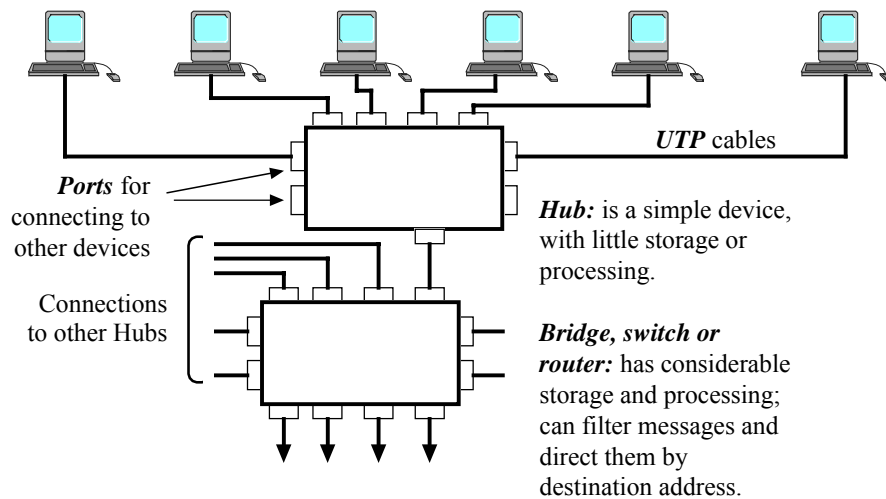
1. **Physical**: Transmit bits from one place to another.
  2. **Link**: Assemble bits into bytes and messages, check for reliable transmission. (The “MAC” sublayer is below the “LLC” sublayer.)
  3. **Network**: Send messages between nodes on different links.
  4. **Transport**: Handle lost packets, broken links, network independence.
  5. **Session**: Handle extended connections.
  6. **Presentation**: Resolve differences between data representation in different computers.
  7. **Application**: Interact with a human.
- These are the seven layers of the “Open Systems Interconnection” (OSI) communications model.  
(Compare with Figure 1.38?)
  - We concentrate on levels 1 through 4 in COMPSCI 314.

314 S1C 06: Set 3

27 Mar 06

Page 4

## A user connection into a network



314 S1C 06: Set 3

27 Mar 06

Page 5

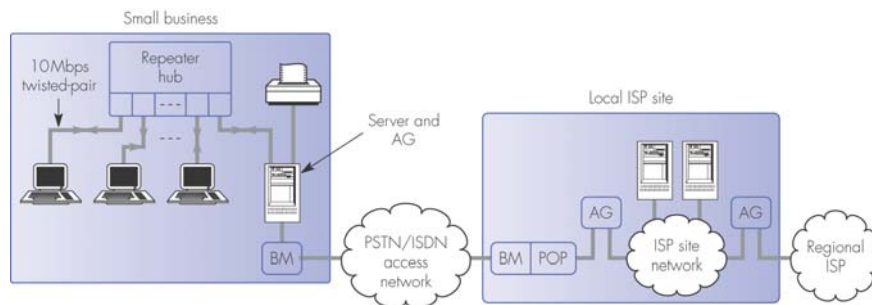
## Many Types of Connections!

- Additional wire length may be needed on a LAN segment – use **repeaters** (also called signal regenerators).
- Additional stations may be needed on a LAN – use **hubs** or **switches**.
- A network may have to be subdivided to reduce contention, or to allow more stations – use **bridges**.
- Two or more networks may have to be connected together – use **routers** (if the networks use the same Network layer protocol) or **gateways** (if the networks use different protocol stacks).
- Warning: terminology is **not** standardised.
- Some equipment manufacturers and vendors use the term “router” for what others call a “bridge”.
- To add to the confusion... we have **repeater hubs**, **bridging hubs**, and **switching hubs**.

314 S1C 06: Set 3

27 Mar 06

Page 6



**Figure 3.5** Access to the Internet for a small business.  
AG = access gateway; IG = interior gateway;  
ISP = internet service provider; BM = broadband modem;  
POP = point of presence.

What OSI level(s) are handled by each of these devices?

314 S1C 06: Set 3

27 Mar 06

Page 7

## Layer Activity of Connectors

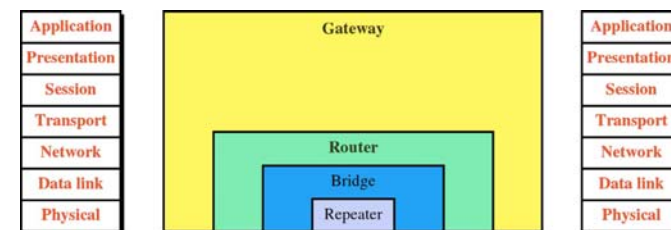
**Repeater** – active only at the Physical layer.

**Hub, Bridge** – most active at the Link layer (usually MAC).

**Router** – links separate but similar LANs ( $\Rightarrow$  Network layer).

**Gateway** – provides “translation” service between incompatible LANs or applications  $\Rightarrow$  active in all layers.

NOTE: each of these devices also operates in all layers **below** the one in which it is most active.



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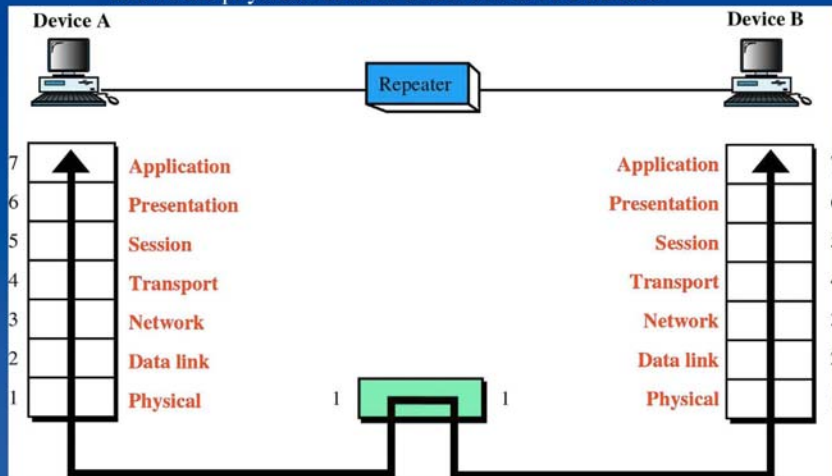
314 S1C 06: Set 3

27 Mar 06

Page 8

## 6.1 Internetworking Devices: Repeater

- an electronic device which regenerates ("cleans up") incoming signals
- allows the physical reach of a network to be extended



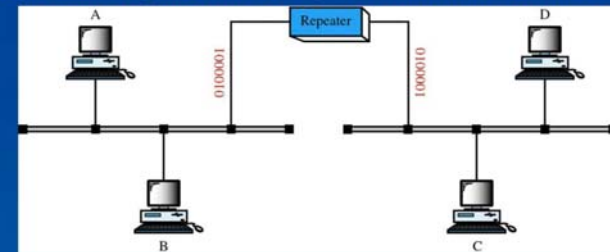
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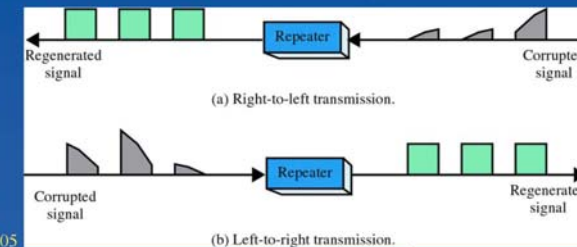
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## Internetworking Devices: Repeater (cont.)

- a repeater *does not* filter frames, e.g. A's Frame to B also received by C & D



- a repeater copies and "refreshes" incoming bits – it *does not amplify* the signal



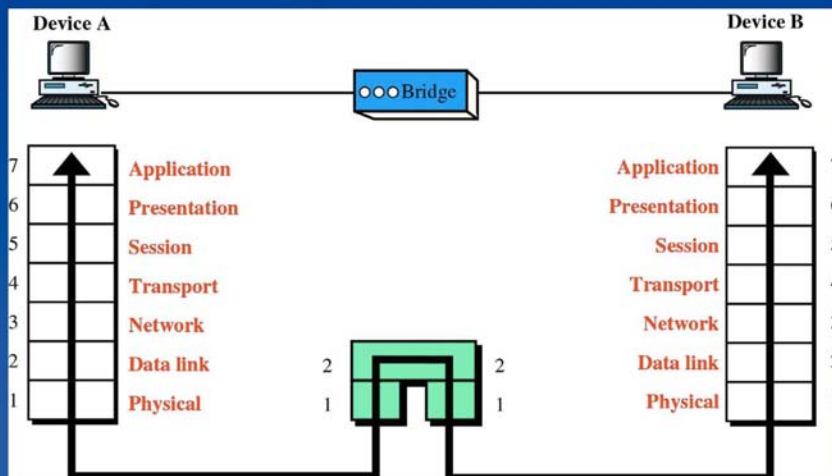
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(b) Left-to-right transmission.

4

## 6.2 Internetworking Devices: Bridge

- operates in both the Physical and Datalink layers
- a bridge knows the physical addresses of the connected nodes



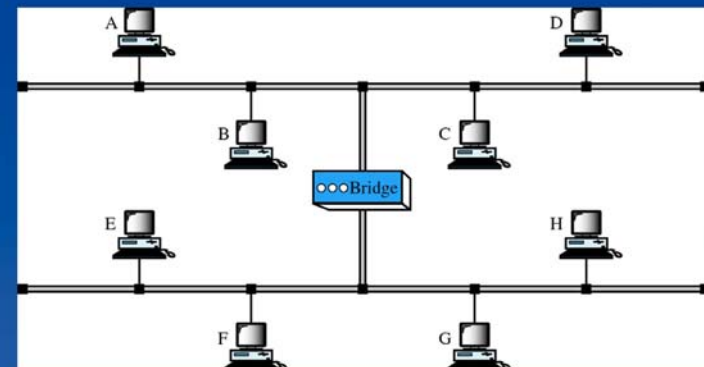
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5

## Internetworking Devices: Bridge (cont.)

- a bridge can divide a large network into smaller segments, or relay Frames between 2 originally unconnected LANs:



- unlike a repeater, a bridge contains logic which allows it to keep traffic for each segment separate  $\Rightarrow$  *bridge can filter traffic*
- helps in controlling traffic congestion, isolating problems, security...

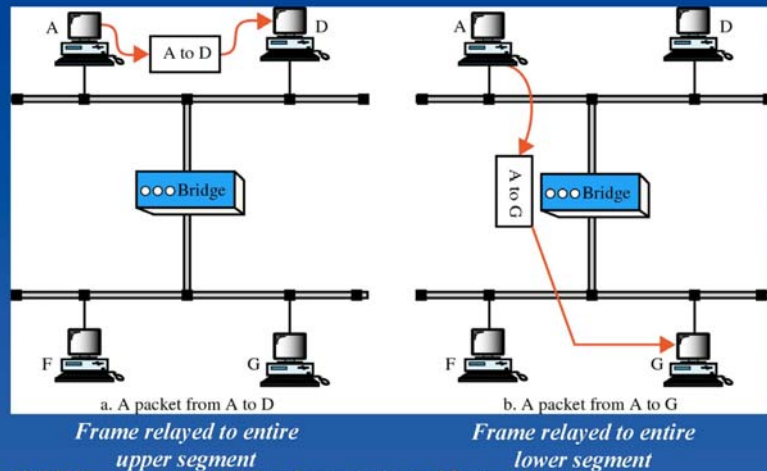
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6

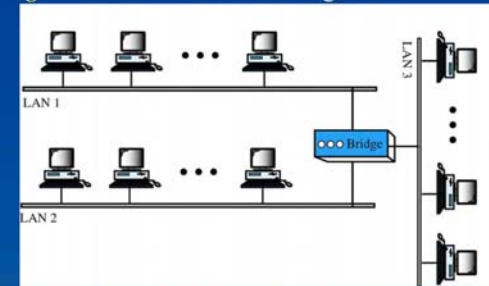
## Internetworking Devices: Bridge traffic filtering

- when a Frame arrives, the bridge not only regenerates the signal but also checks the destination address, and only forwards the Frame to the segment to which this address belongs:



## Internetworking Devices: Bridge types

- simple bridge** – links 2 segments; node addresses entered manually in bridge table
- multi-port bridge** – connects more than 2 segments:



- transparent bridge** (also called a **learning bridge**) – builds its tables of addresses automatically as it relays Frames (by noting the source address in each Frame)
  - if more than one bridge connects 2 LANs, a loop could be formed in the bridges' forwarding tables  $\Rightarrow$  Frames could circulate forever
  - transparent bridges learn the topology and build a loop-free **spanning tree**
- source routing bridge** – each sender learns the topology (using *Discovery Frames*) and decides the **exact path** of segments and bridges each of its Frames will take

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## How Transparent Bridges Learn

- A bridge maintains a **forwarding database**, or **routing directory**, so that it can properly route the frames it receives.
- Initially the database is empty.
  - CREATE TABLE database (address INTEGER, port INTEGER);**
- When a bridge receives a frame it looks for the correct port:
  - SELECT port FROM database WHERE database.address=DA;**
  - Of course we don't use a relational database system!
  - A hash table will do the trick.
- If no match is found in the database, then the bridge broadcasts the frame on all its other ports ("flooding").
- This bridge may have learned something!
  - INSERT INTO database VALUES (SA, IN-PORT);**

## What Happens When a Machine is Moved?

- The forwarding database should be changed whenever machines and bridges are powered up or down, moved around, links are broken, etc.
- Whenever a hash table entry is updated, its **inactivity timer** is reset to some fixed value  $T \approx 3$  minutes.
- The bridge purges all records that have been inactive for more than  $T$  minutes.

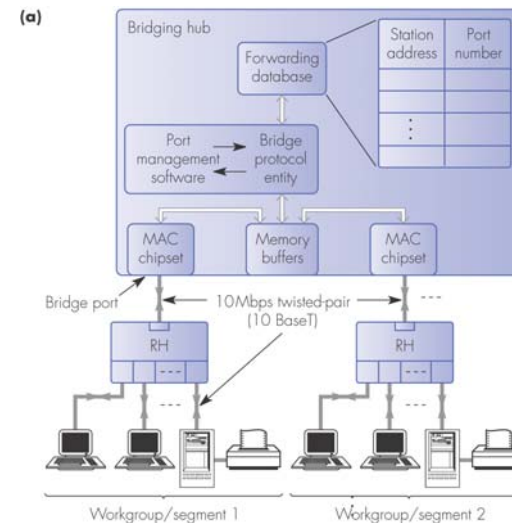


## Routing Procedure for a Transparent Bridge

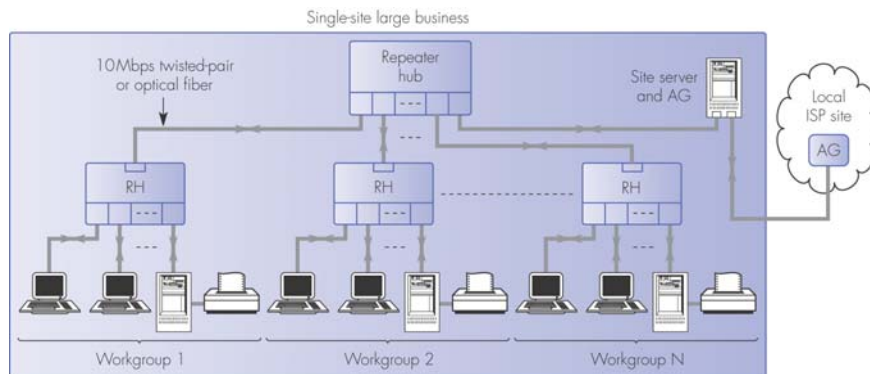
1. If the destination and source ports are the same, discard the frame.
2. If the destination and source ports are different, forward the frame.
3. If the destination port is unknown, use flooding.

### Problems:

1. This doesn't scale. Imagine a network with 1000 bridges, 1001 segments, and 10000 nodes. There will be  $(10000)(1000) = 10$  million flood frames!
2. What if there are redundant links (= loops)?
  - Should use IEEE 802.1d (minimum spanning tree).
3. What about stations that rarely send frames, *e.g.* printers?
  - Should statically configure these addresses to avoid repeated floods.

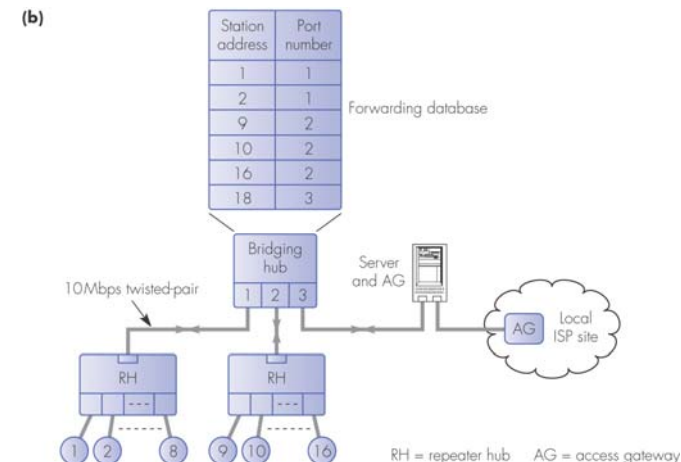


**Figure 3.7** Transparent bridging hub schematic: (a) general topology. (Why might this be preferable to using repeaters?)



**Figure 3.6** Access to the Internet for a single-site large business using repeater hubs only. RH = repeater hub (repeats each frame onto all ports); AG = access gateway; IG = interior gateway.

Can you see any security issues here?



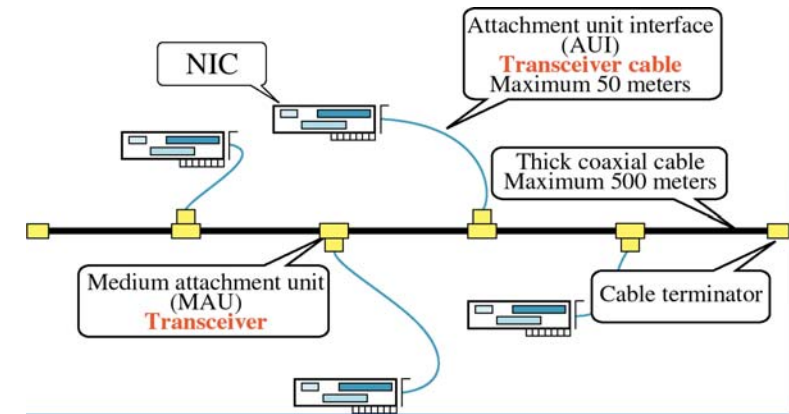
**Figure 3.7** Transparent bridging hub schematic: (b) multiport bridge example. (Is the routing table correct?)

## Switching Hubs versus Bridging Hubs

- Most bridges handle just one frame at a time (half-duplex).
- Some switches can handle “wire-speed” frames on all ports simultaneously, even if the frames are minimum-length.
- Switches may have more ports than bridges, e.g. 16 vs. 4.
  - Cisco: A bridge is a “[d]evice that connects and passes packets between two network segments that use the same communications protocol. Bridges operate at the data link layer (Layer 2) of the OSI reference model. In general, a bridge filters, forwards, or floods an incoming frame based on the MAC address of that frame. See also [relay](#).”
- According to your textbook, switches route any-to-any, whereas a bridge will discard frames that would be routed to the same link.
- Read the specification sheets!

## Review: 10Base5 “Thick Ethernet”

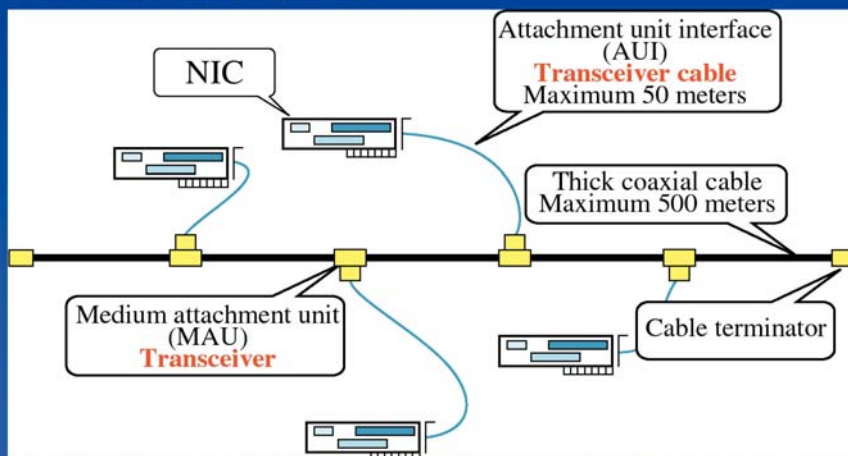
- 10 Mbps, Baseband (digital encoding), maximum channel length = 500 metres, 0.5” diameter coax.



Source: Dr. Gabriel-Miro Muntean, <http://www.eeng.dcu.ie/~ee210/>  
27 Mar 06 Page 22

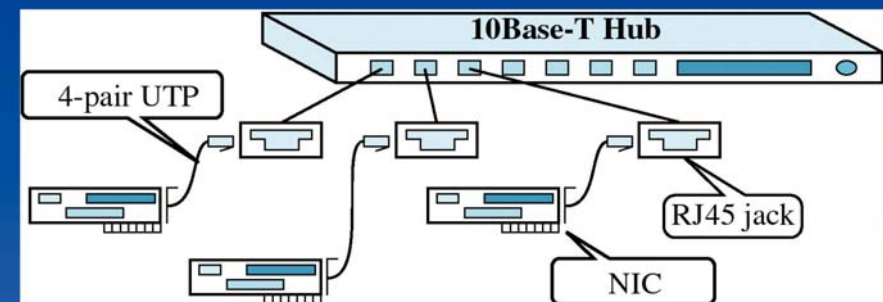
### Datalink layer: Ethernet Implementations (1)

**10Base5:** 10 Mbps, Baseband (digital encoding), maximum channel length = 500 metres (also called “Thick Ethernet”)



### Datalink layer: Ethernet Implementations (3)

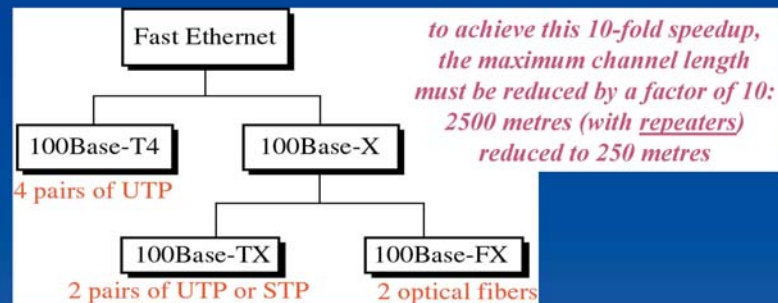
**10BaseT:** 10 Mbps, Baseband (digital encoding), twisted pair wiring, maximum length hub-to-node = 100 metres



*logically still a bus topology, although physical topology is a star*

## Datalink layer: Ethernet Implementations (5)

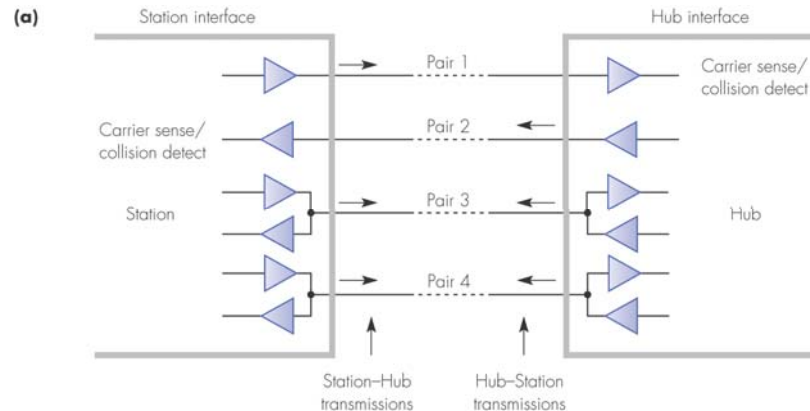
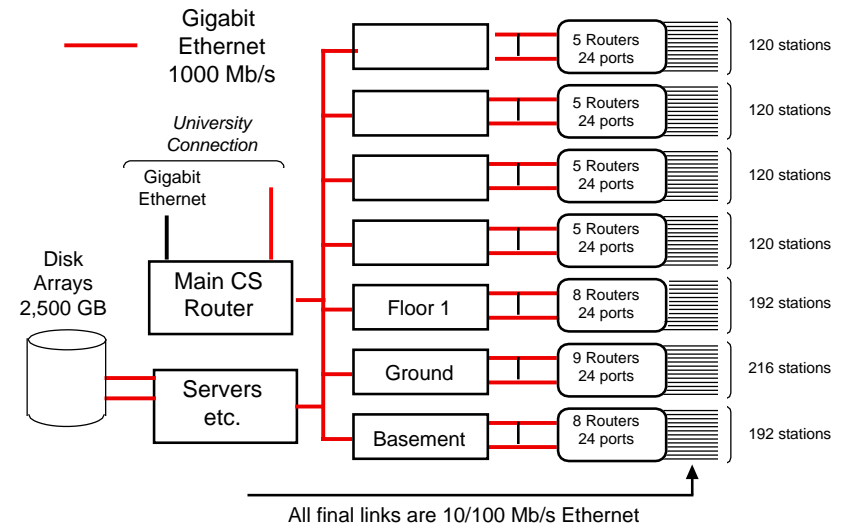
### Fast Ethernet: increase channel bandwidth to 100 Mbps



### Gigabit Ethernet: increase channel bandwidth to 1000 Mbps = 1 Gbps

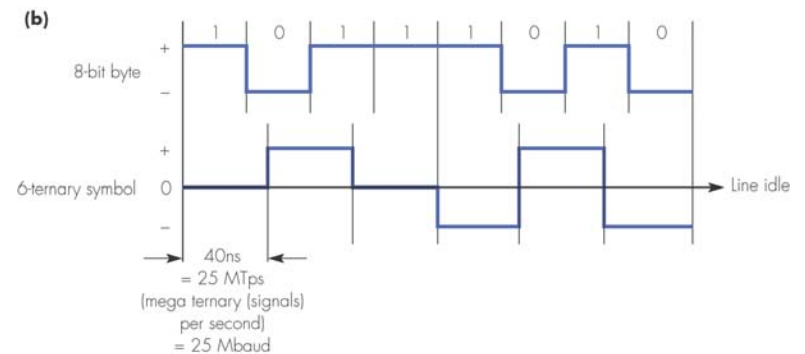
- mainly intended for use with optical fibres
- maximum channel length reduced to 25 metres
- usually for backbone connection between Fast Ethernet networks

## Simple view of Computer Science Network, 2003



**Figure 3.9** 100Base4T: (a) use of wire pairs.

Why is this relevant information?

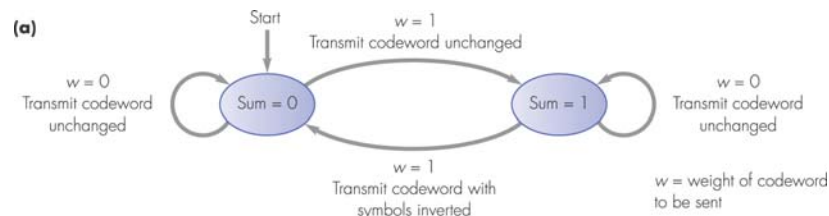


**Figure 3.9** 100Base4T: (b) 8B6T encoding.

What are the desirable properties of this code?

Have you learned anything interesting about coding theory from this example?

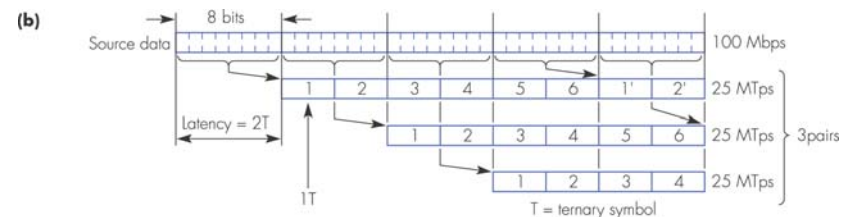
Might coding theory ever be relevant to you again?



**Figure 3.10** 100Base4T transmission detail: (a) DC balance transmission rules.

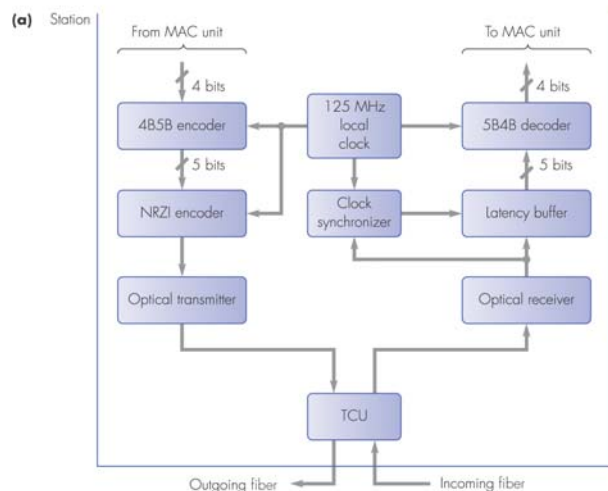
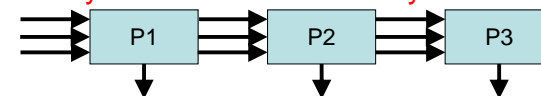
Can you “hand-execute” this finite state machine?

Isn’t this a clever way to ensure DC balance?



**Figure 3.10** 100Base4T transmission detail: (b) 8B6T encoding sequence.

Your textbook says “This means that the sequence of symbols received on each pair can be decoded independently. Also the frame can be processed immediately after the last symbol is received.” Do you understand this?



**Figure 3.12** 100BaseFX: (a) physical interface schematic.

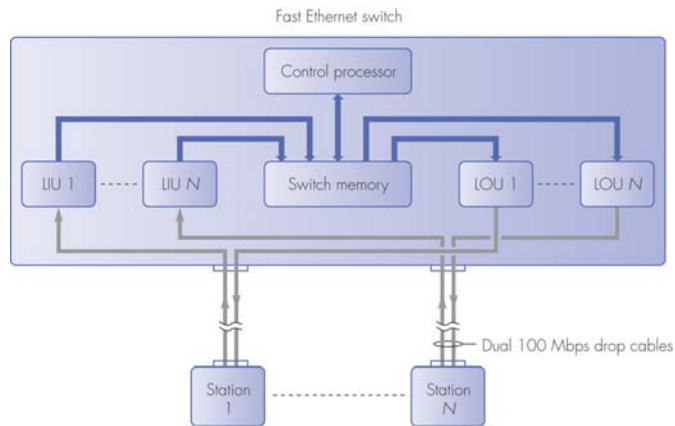
Do you understand how the clock signal is retrieved? Do you remember what NRZI means?

(b)			
Data symbols		Control symbols	
4-bit data group	5-bit symbol		
0000	----- 11110	IDLE	----- 11111
0001	----- 01001	J	----- 11000
0010	----- 10100	K	----- 10001
0011	----- 10101	T	----- 01101
0100	----- 01010	R	----- 00111
0101	----- 01011	S	----- 11001
0110	----- 01110	QUIET	----- 00000
0111	----- 01111	HALT	----- 00100
1000	----- 10010		
1001	----- 10011		
1010	----- 10110		
1011	----- 10111		
1100	----- 11010		
1101	----- 11011		
1110	----- 11100		
1111	----- 11101		

**Figure 3.12** 100BaseFX: (b) 4B/5B codes.

Which 5-bit codes were not chosen for this code, and why?

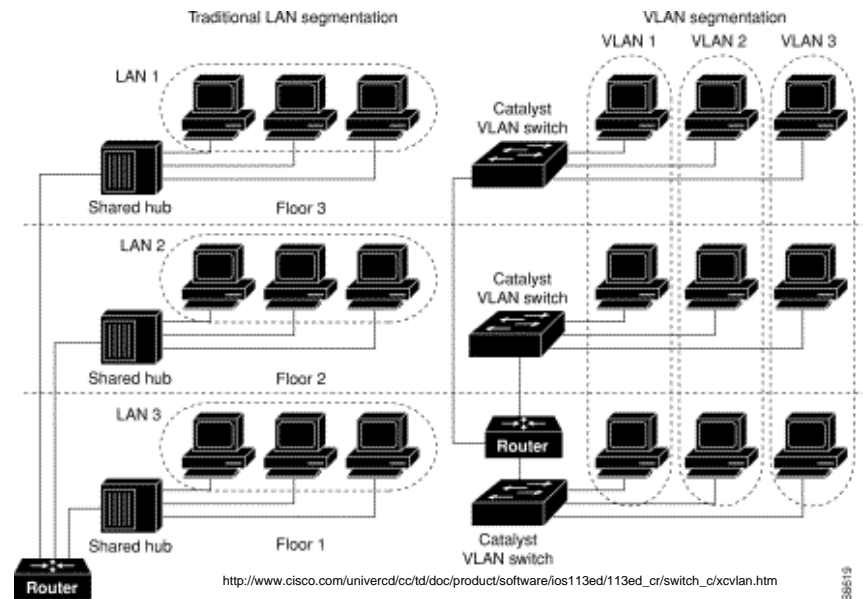




**Figure 3.13** Fast Ethernet switch schematic. LIU = Line Input Unit; LOU = Line Output Unit.

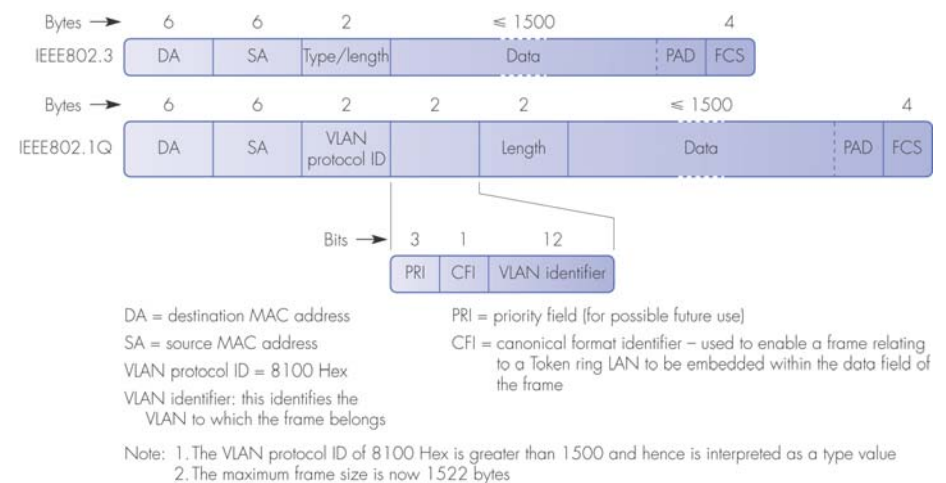
Is this a trivial diagram?

## LANs versus VLANs



## Advantages of VLANs over LANs

- Scalability
  - Broadcasts (e.g. floods) and multicasts stay within a VLAN
- Security
  - High-security users can be put on the same physical link. Their VLAN traffic doesn't go outside the link, but they can still communicate with other users, servers and printers on the local network.
- Network management
  - Low-security users can be put on any low-security link. They can be organised into workgroups depending on their job description, rather than by their physical location.
  - When a user is moved to a new physical address, they can use their old VLAN address.



**Figure 3.15** IEEE802.1Q frame format and field descriptions.

Will a 802.3 repeater or bridge correctly handle 802.1Q frames?