Internetworking

Common Types of relays:

Layer 1: **Repeaters** copy individual bits between cable segments

Layer 2: **Bridges** store/forward frames between LAN's

Layer 3: **Gateways(routers)** store/forward packets between dissimilar networks

Layer 4: **Protocol Converters** provide interfacing in higher layers.

Internetworking Requirements

1. provide connections between networks.
2. provide routing and delivery of messages on different networks.
3. provide accounting service and topology/status information.
4. Resolve network differences:
   - Address schemes.
   - maximum packet sizes.
   - network access mechanisms
   - time-outs.
   - error recovery
   - status reporting
   - routing techniques.
   - user access control
   - connection, connectionless

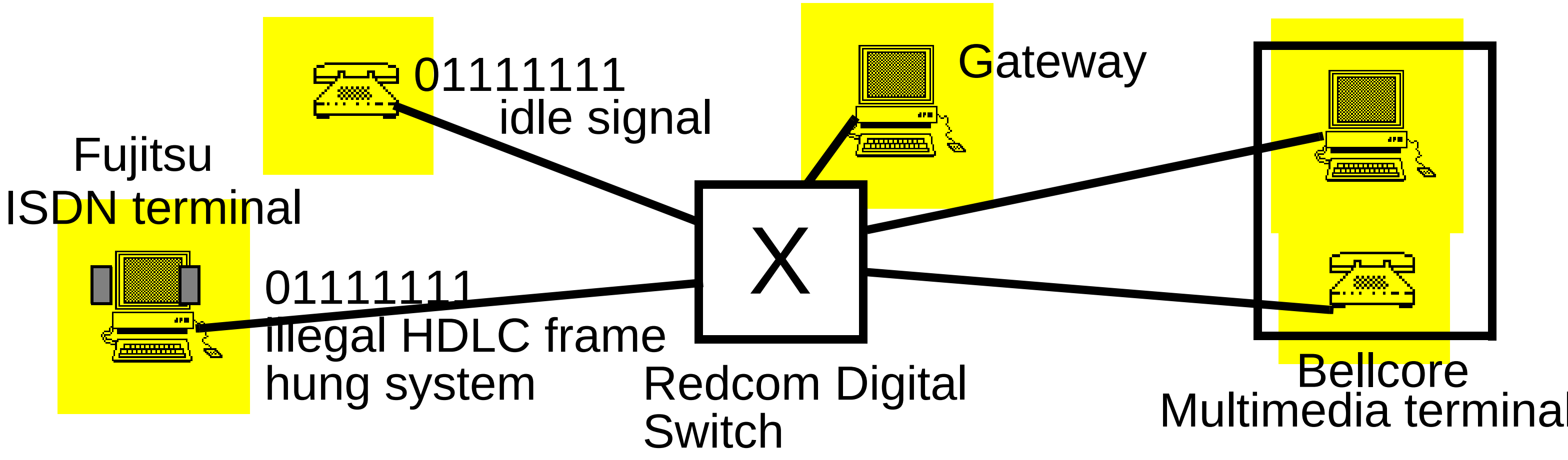
Protocol Mismatch Problems

Hard Protocol Mismatch

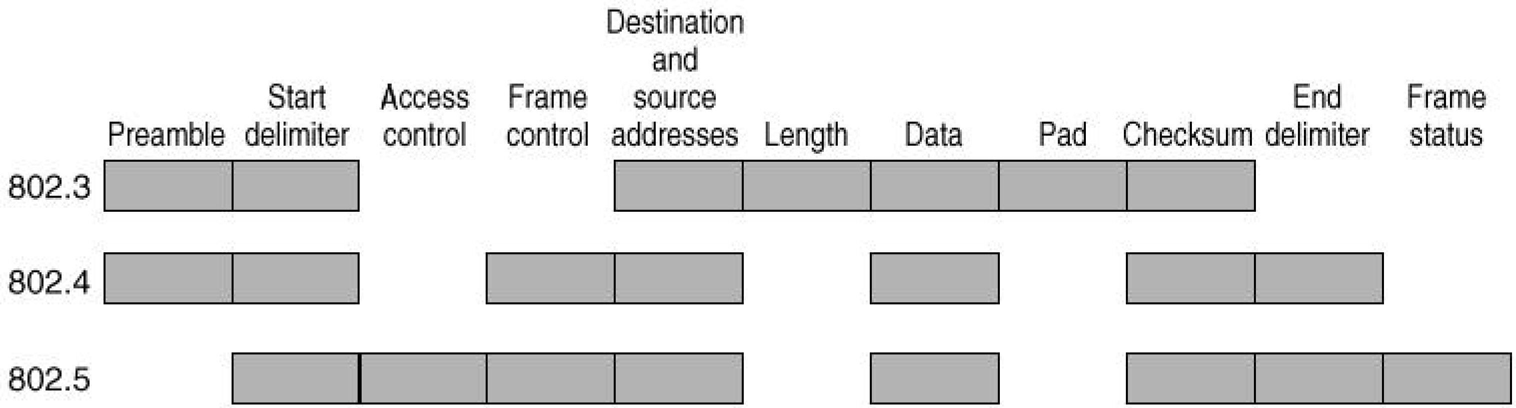
can not be resolved,
need higher layer solution
e.g.
idle signal incompatible between
Digital SW and HDLC,
frame size difference among 802 standards,
old T1 and ISDN.

Soft Protocol Mismatch

can be resolved by using
common subset of functionality
performance may degrade
e.g.
speed difference→use buffer,
timer difference,
no equivalent A, C bits in 802.3,
priority.



Frame Format Mismatch in 802



The gray box indicates the standard contains this specific field.

Protocol Mismatch among 802 Standards

Source LAN \ Destination LAN	802.3 (CSMA/CD)	802.4 (Token bus)	802.5 (Token ring)
802.3		1, 4	1, 2, 4, 8
802.4	1, 5, 8, 9, 10	9	1, 2, 3, 8, 9, 10
802.5	1, 2, 5, 6, 7, 10	1, 2, 3, 6, 7	6, 7

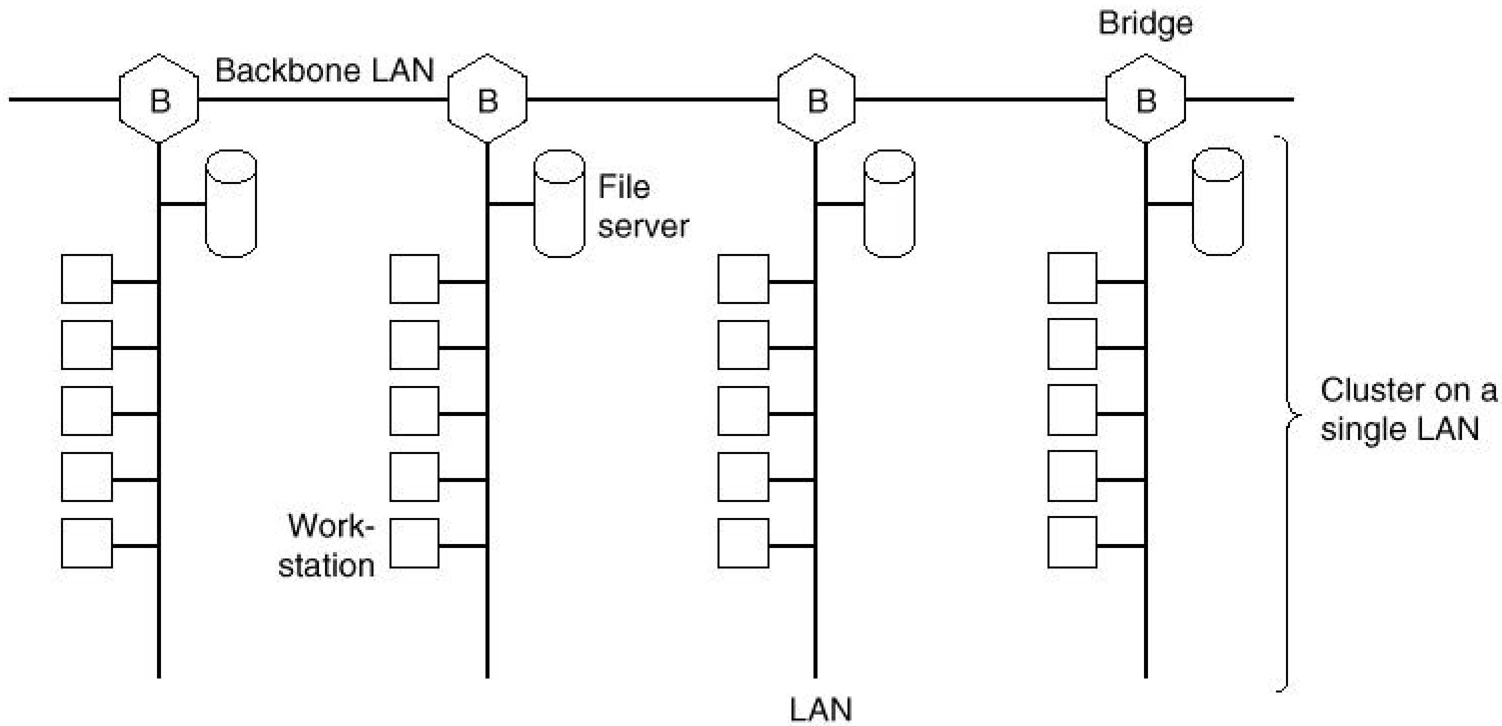
Actions:

1. Reformat the frame and compute new checksum
2. Reverse the bit order.
3. Copy the priority, meaningful or not.
4. Generate a ficticious priority.
5. Discard priority.
6. Drain the ring (somehow).
7. Set A and C bits (by lying).
8. Worry about congestion (fast LAN to slow LAN).
9. Worry about token handoff ACK being delayed or impossible.
10. Panic if frame is too long for destination LAN.

Parameters assumed:

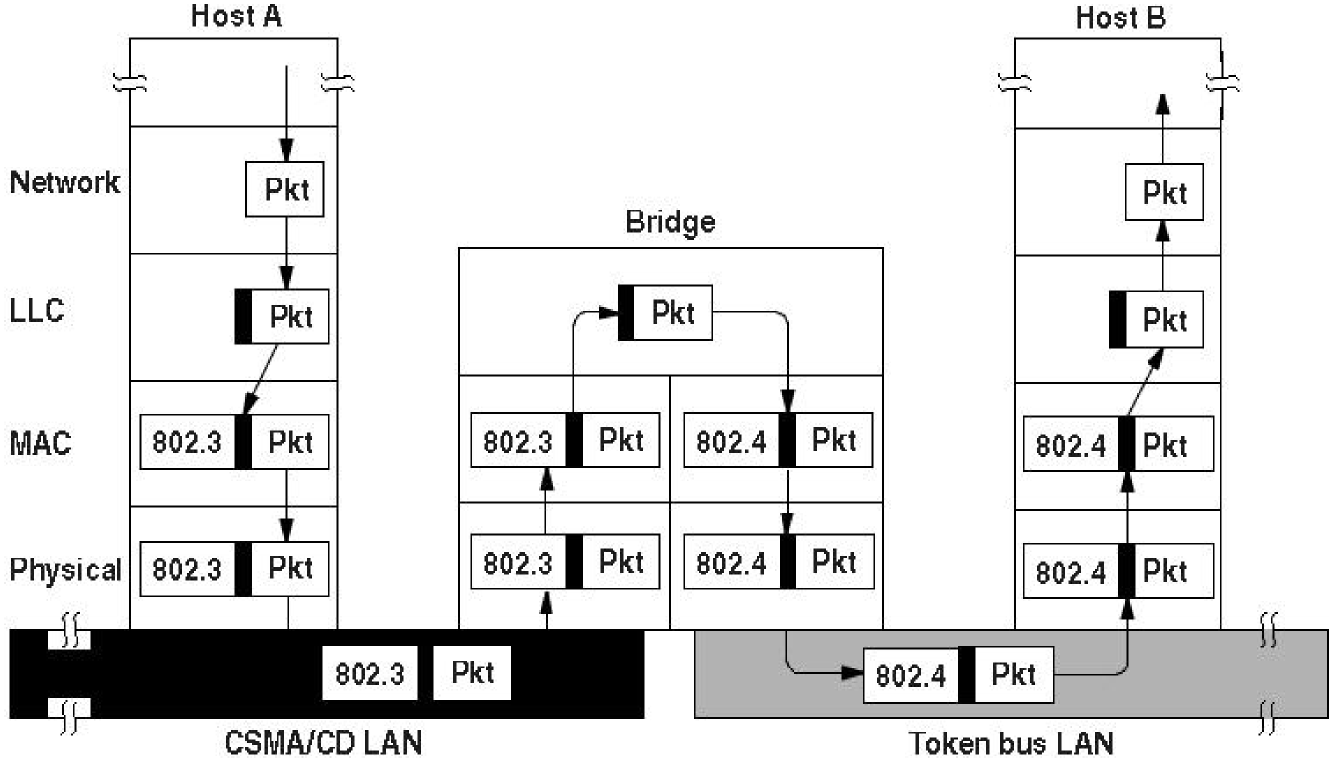
802.3:	1500-byte frames,	10 Mbps (minus collisions)
802.4:	8191-byte frames	10 Mbps
802.5:	5000-byte frames	4 Mbps

Why we use bridge?

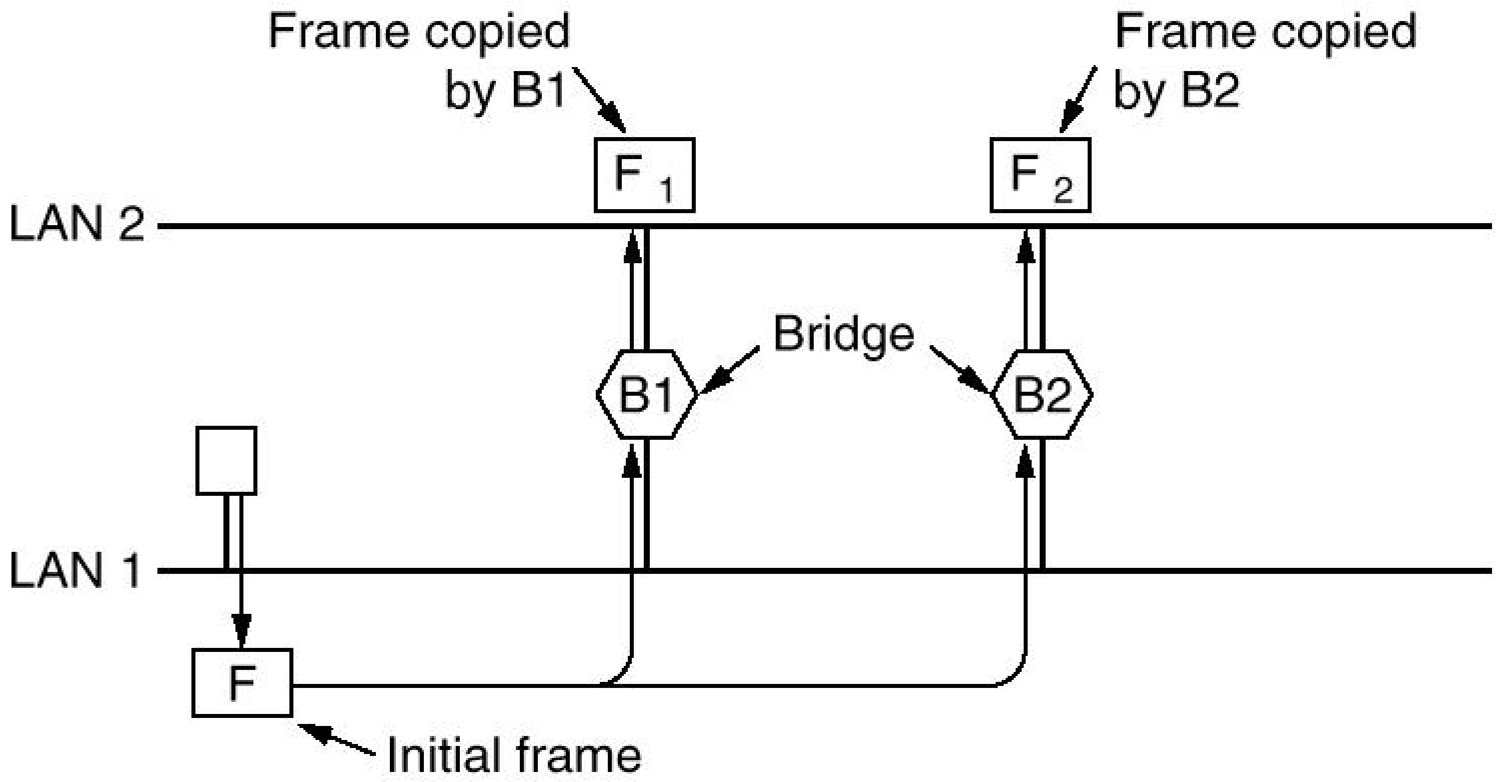


- reliability. Shield problematic LANs from others.
- performance. Bridges can isolate traffic, not relay unnecessary traffic.
- security. Not forward sensitive frames outside certain LAN.
- geography. Increase total distance, allow > 2.5km for 802.3.

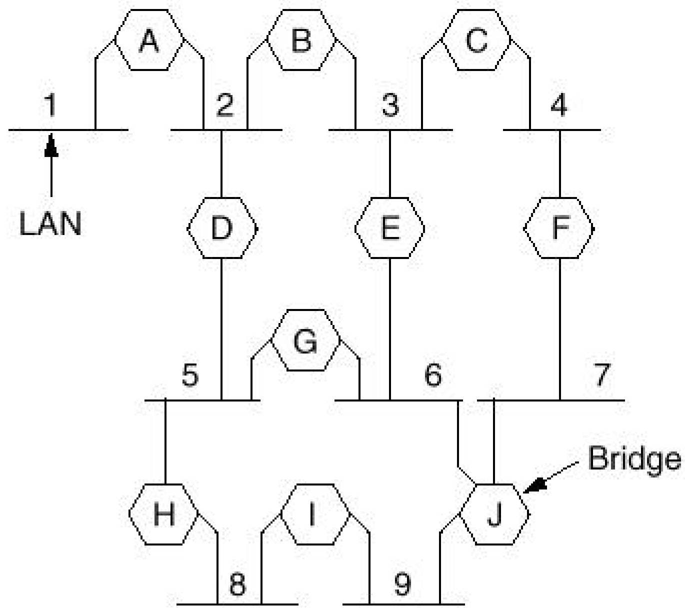
802.3 to 802.4 LAN Bridge



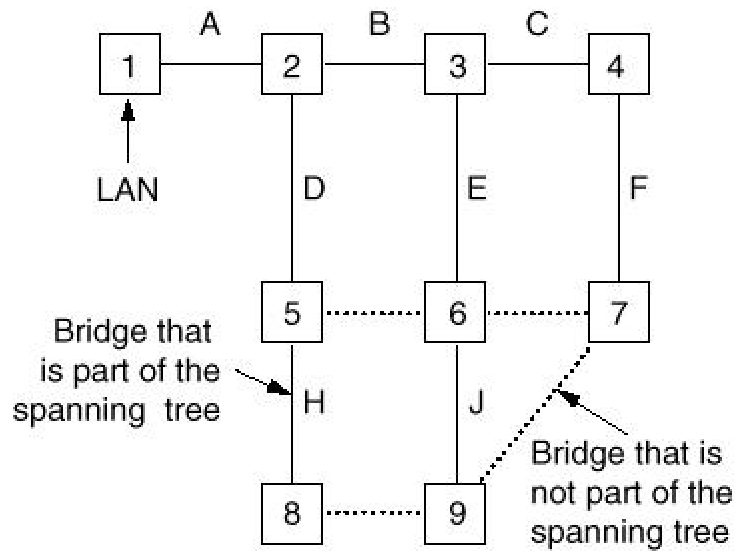
Looping problem with redundant bridges



Spanning Tree Approach



(a)



(b)

Spanning Tree Bridge

How to avoid looping of messages? $\rightarrow$ form a **spanning tree** among bridges.

Every bridge is assigned a ID.

There is a special group MAC address - “all bridges on this internetwork”

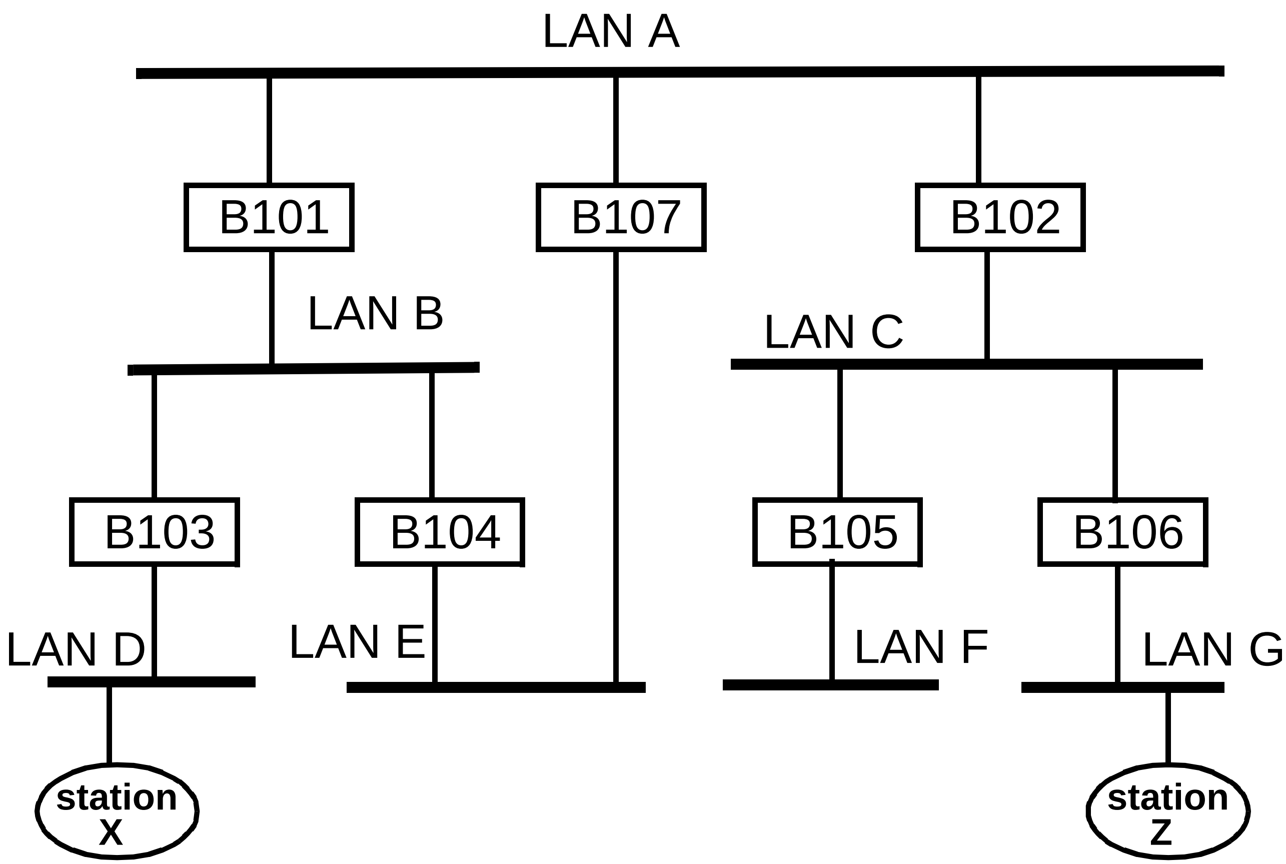
Each port of the bridge is uniquely identified (by the LAN ID it connects to).

Spanning Tree algorithm:

1. Elects the root bridge of the spanning tree. (distributed voting problem)
2. Determine the root port on all other bridges.
   root port is the port of a bridge that pointed to the root bridge (with the lowest root path cost, RPC)
3. Select the designated bridge with the lowest RPC and lowest bridge ID on each LAN.

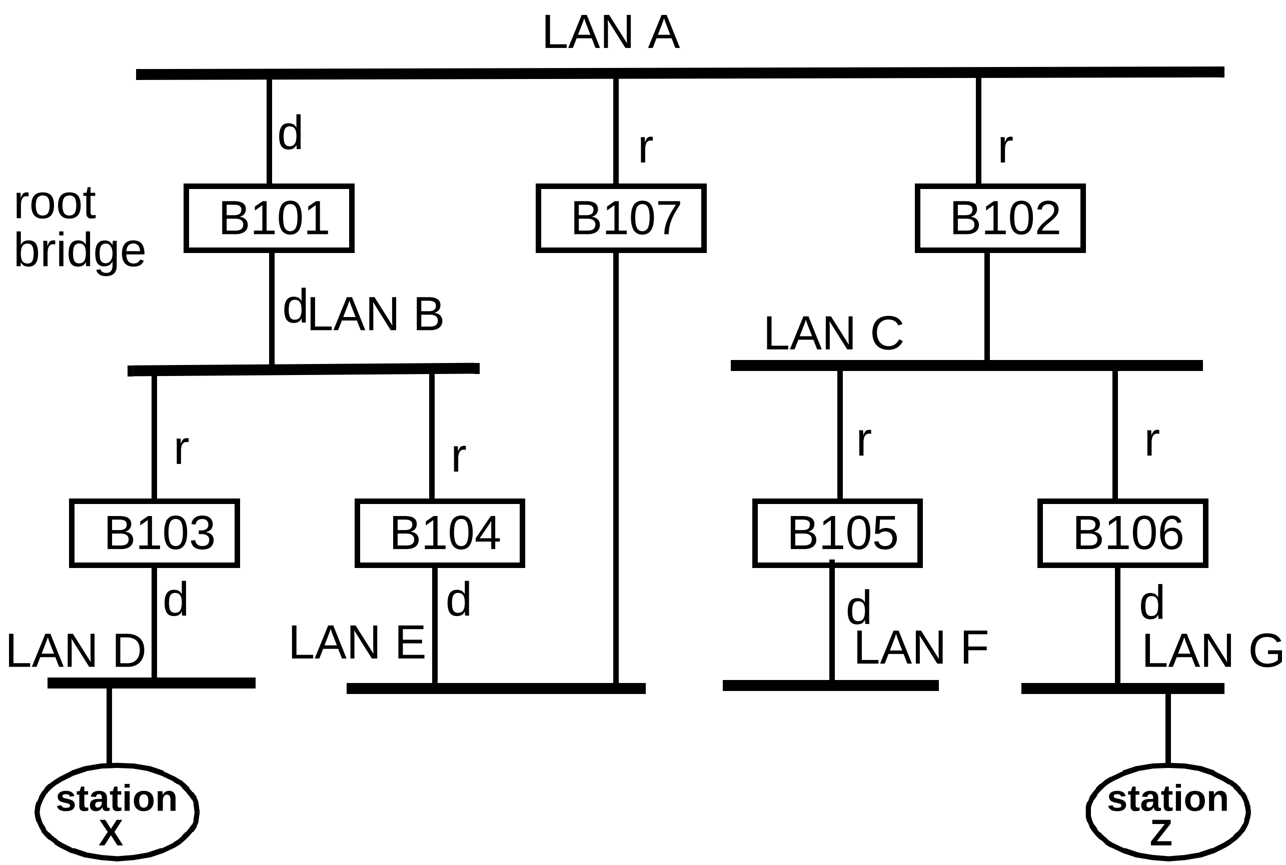
Exercise on Spanning Tree Bridge

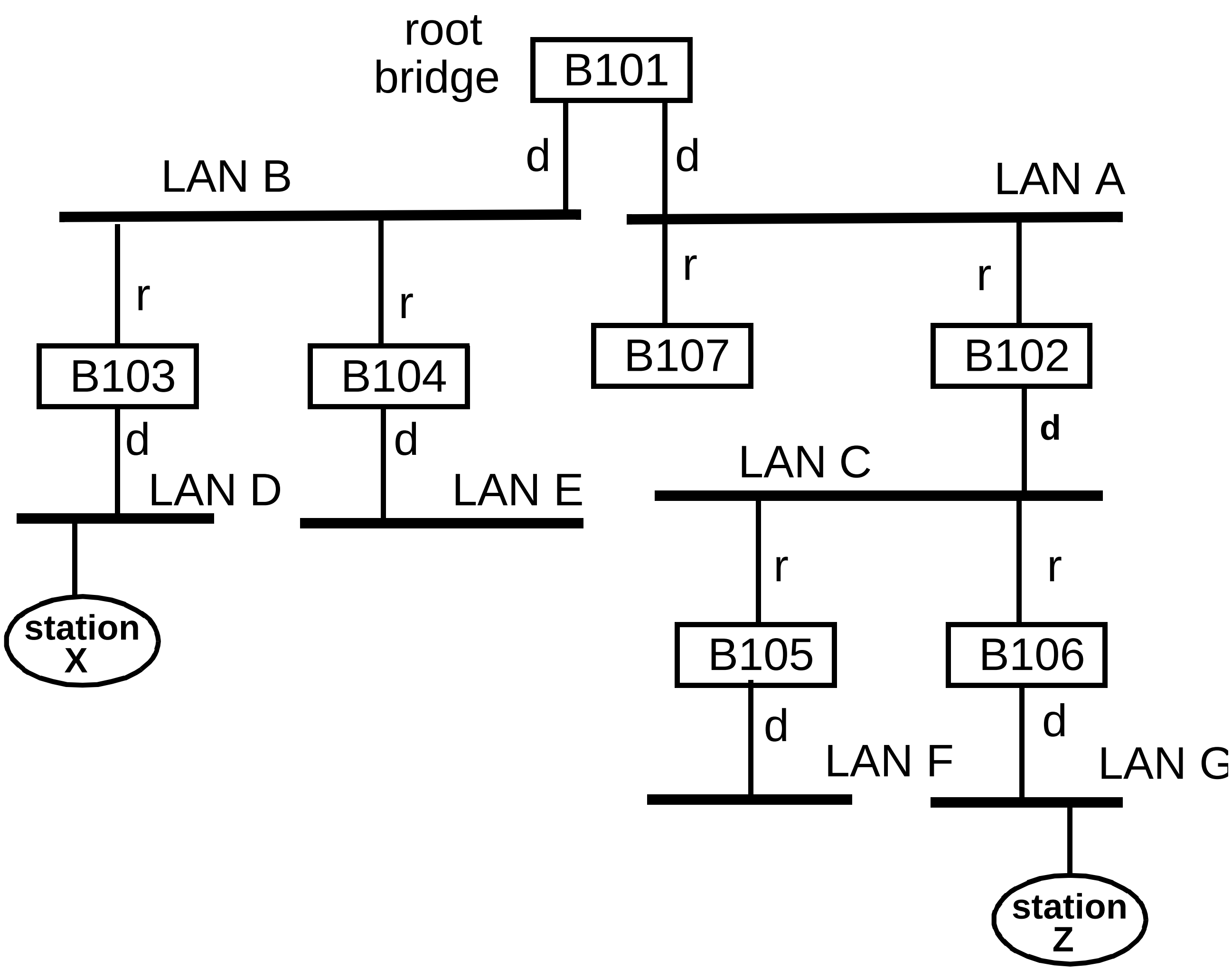
For the topology below Use hop count as cost, and choose low ID bridge to break



tie.

a) Find the spanning tree.




root
bridge
B101
d
d
LAN B
LAN A
r
r
r
r
B103
B104
B107
B102
d
d
d
LAN D
LAN E
LAN C
station
X
r
r
B105
B106
d
d
LAN F
LAN G
station
Z

Source Routing Bridges 802.5

The host machine of the source is responsible to identify the non-local msg and compute the exact path to the destination.

If a host does not have enough topology information, it broadcasts the *discovery* frame and the optimal path is encoded in the acknowledge message coming back.

The path is encoded in (bridge ID, LAN ID, bridge ID, LAN ID,....) form and attached to the header of a non-local msg.

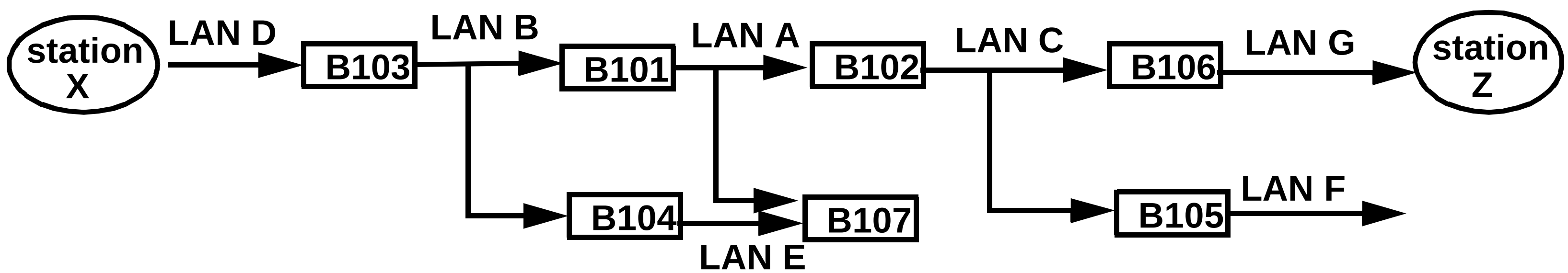
Four Routing Directives

- Null—No routing (with the same LAN).
- Nonbroadcast—Using the above path encoded form, follow a specific path to destination.
- All-route broadcast—frame will deliver by all possible routes to destination.
- Single-route broadcast—using spanning tree algorithm, frame only deliver one copy to each LAN.

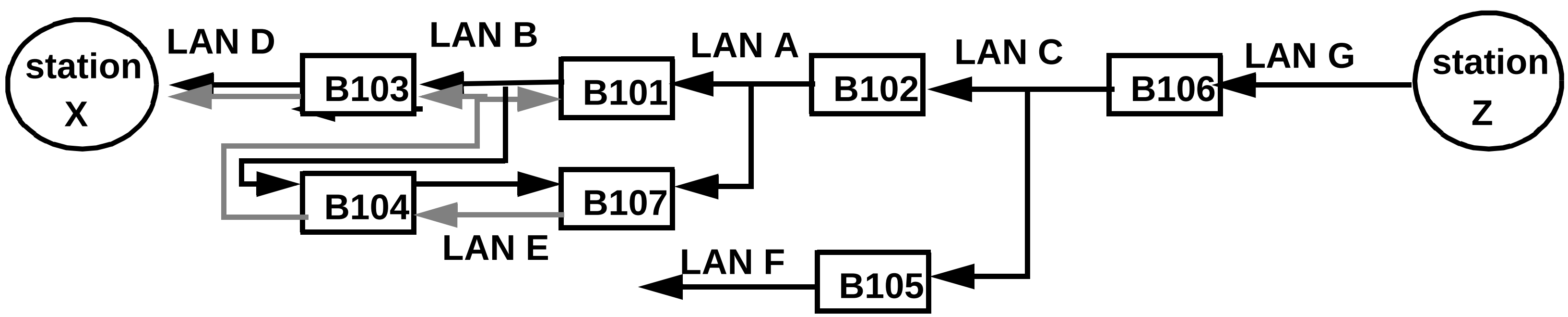
Route Discovery Example

For station X attached to LAN D to discover the route to station Z attached to LAN G using the single-route broadcast and all-route broadcast response, how many messages will be generated?

Single-route broadcast: requires 7 messages. Each LAN is delivered one message.

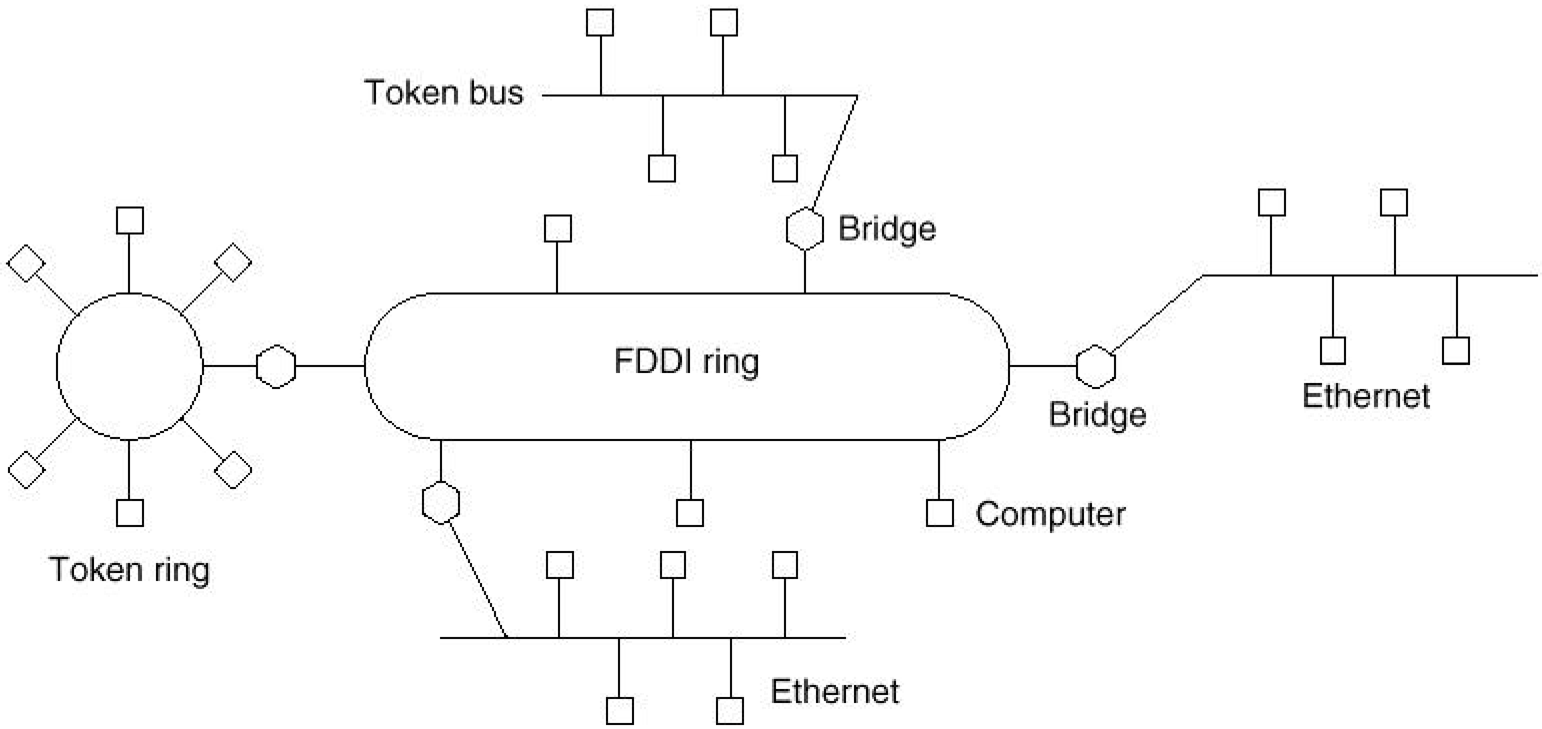


All-route broadcast response: requires 10 messages.



FDDI: Fiber Distributed Data Interface

- 100Mbps, 200km, 1K stations, error rate=4×10^{-9}. Often used as a backbone network.
- MA protocol like 802.5 but releases token right after data is sent (multiple token mode).
- The synchronous frames generated by a master station every 125μsec.



FDDI/Token Ring Comparison

	FDDI	802.5 Token Ring
Data Rate	100 Mbits/sec	4 or 16 Mbits/sec
Media	Fiber (multi-mode)	Twisted (shield) pair
Encoding	4B/5B–80% efficient +-10% DC offset	Manchester-50% efficient No DC offset
Clocking	Distributed receive & transmit clocks	Centralized active ring monitor
Max. Frame Size	4500 Bytes	No Limit
Frame Format	FC Frame Control differentiate token & frame	Has AC–Access Control field
Priority Handling	Uses station priority	Uses ring (ppp&rrr bits)
Priority Levels	Sync & Optional 8 levels	8 levels
Transmission Process	Byte level manipulation Requires half duplex	Bit level manipulation Requires full duplex
Token Transfer	early token release	single token mode

FDDI with two CounterRotating Rings

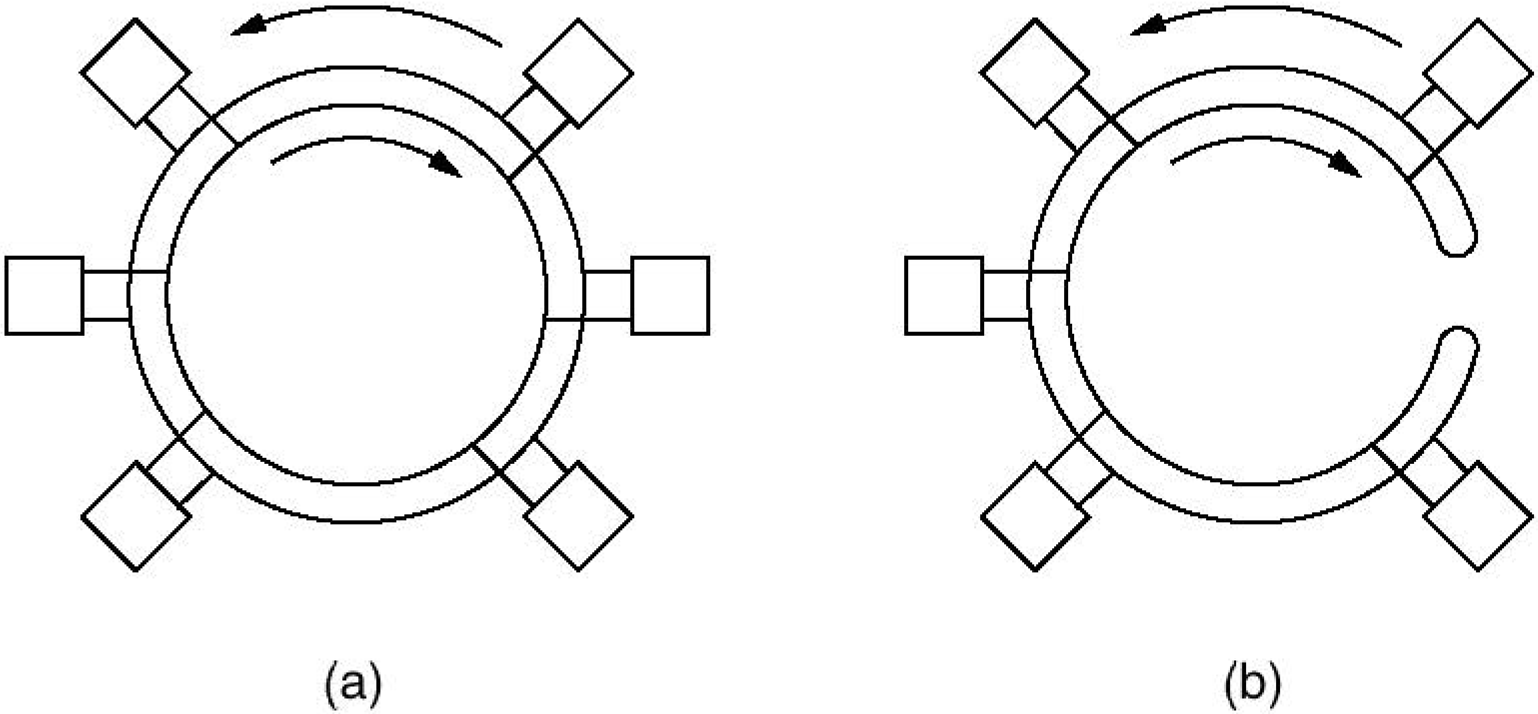
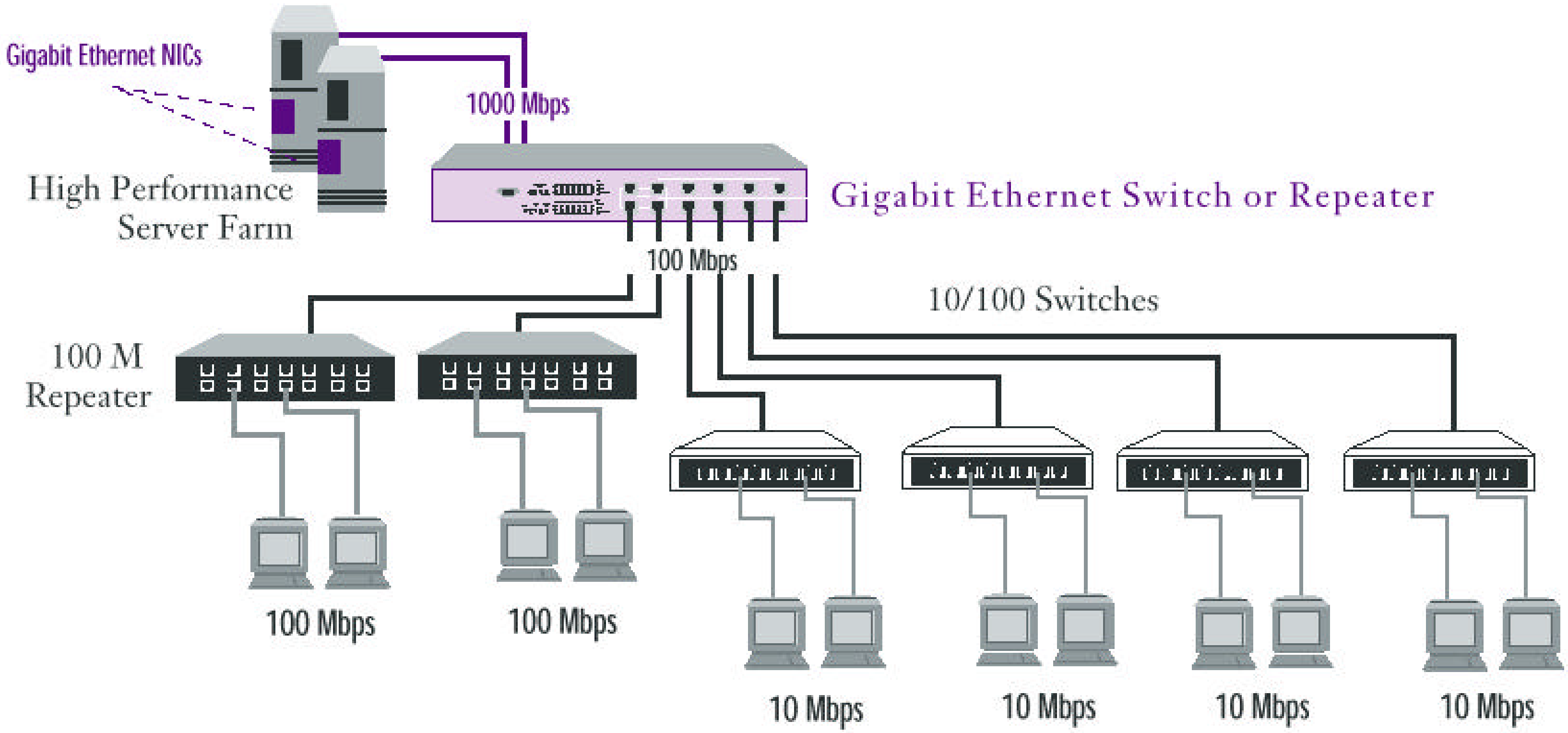


Fig. 4-45. (a) FDDI consists of two counterrotating rings. (b) In the event of failure of both rings at one point, the two rings can be joined together to form a single long ring.

Fast Ethernet

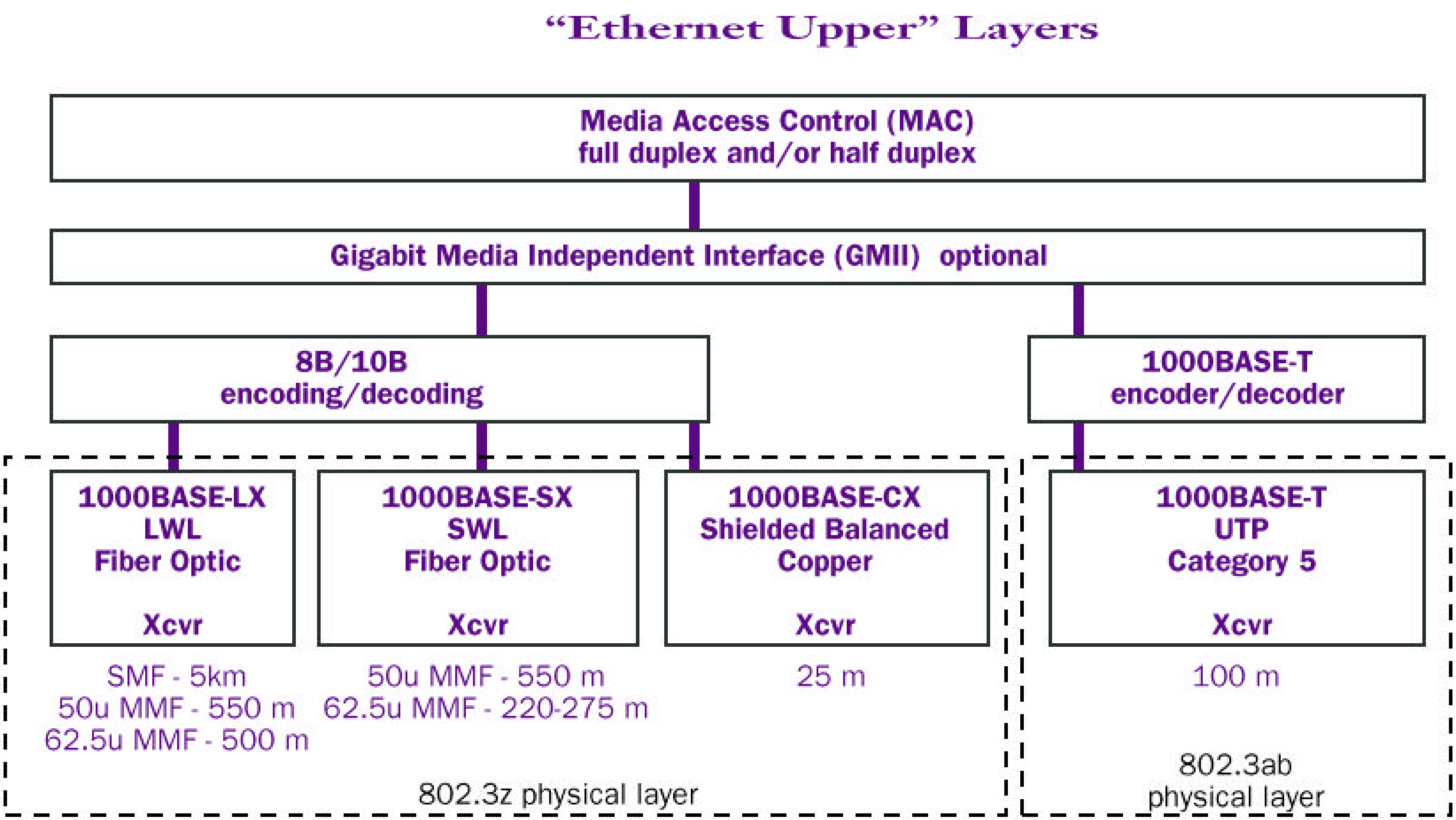
Name	Cable	Max. Segment	Advantages	Disadvantage	Clock Rate
100Base-T4	Twisted pair	100 m	Uses category 3 UTP	4 pairs upstream only 33.3Mbps	25 MHz
100Base-TX	Twisted pair	100 m	Full duplex at 100Mbps	2 pairs	125 MHz
100Base-F	Fiber optics	2000m	Full duplex at100Mbps; long runs	expensive two strands multimode fiber	125 MHz?

Gigabit Ethernet



- http://www.gigabit-ethernet.org/technology/whitepapers/index.html

Gigabit Ethernet Function Elements



Network Backbone Connection Prices

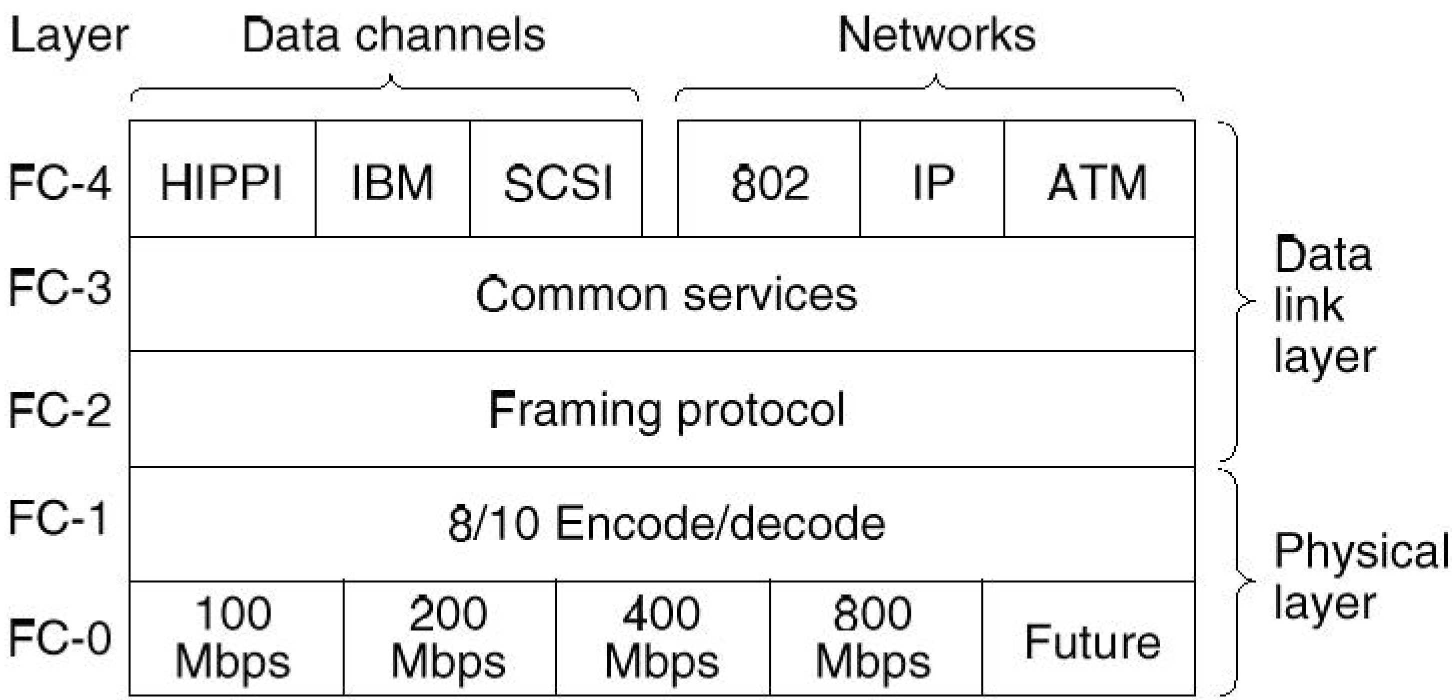
Technology	Equipment Type	1996 Equipment Price/Port	1999 Equipment Price/Port	Change %
Shared Fast Ethernet	Hub	$137	$85	-39%
Switched Fast Ethernet	Switch	$785	$390	-50%
Shared FDDI	Concentrator	$835	$650	-22%
Switched FDDI	Switch	$4000	$1860	-54%
ATM 622 Mbps Estimate (multimode fiber)	Switch	$6600	$4800	-27%
Shared Gigabit Ethernet IEEE goal (multimode fiber)	Hub	N.A.	$470 to $700 ** (2x to 3x Fast Ethernet MM)	
Switched Gigabit Ethernet IEEE goal (multimode fiber)	Switch	N.A.	$1070 to $1610 ** (2x to 3x Fast Ethernet MM)	

Source: Dell'Oro Group

** Estimates based on Dell'Oro Group info and IEEE goals

Fibre Channel

- Use in Mainframe, super computers.



- Recently it was used in Storage Area Network (SAN) for connecting Storage devices and servers.

Homework #7

For the topology in Figure 11.9,

a) Find the spanning tree.

b) For station X attached to LAN D to discover the route to station Z attached to LAN G using the single-route broadcast and all-route broadcast response, how many messages will be generated?

Problems 32 and 41, pp.338.