4

THE MEDIUM ACCESS SUBLAYER

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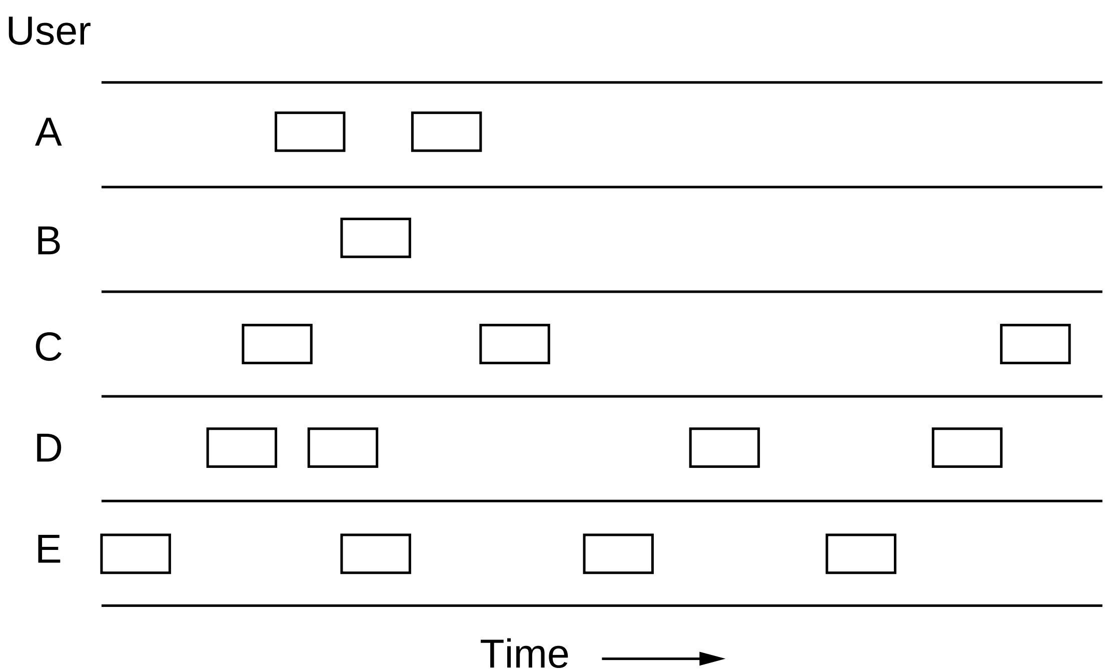

Fig. 4-1. In pure ALOHA, frames are transmitted at completely arbitrary times.

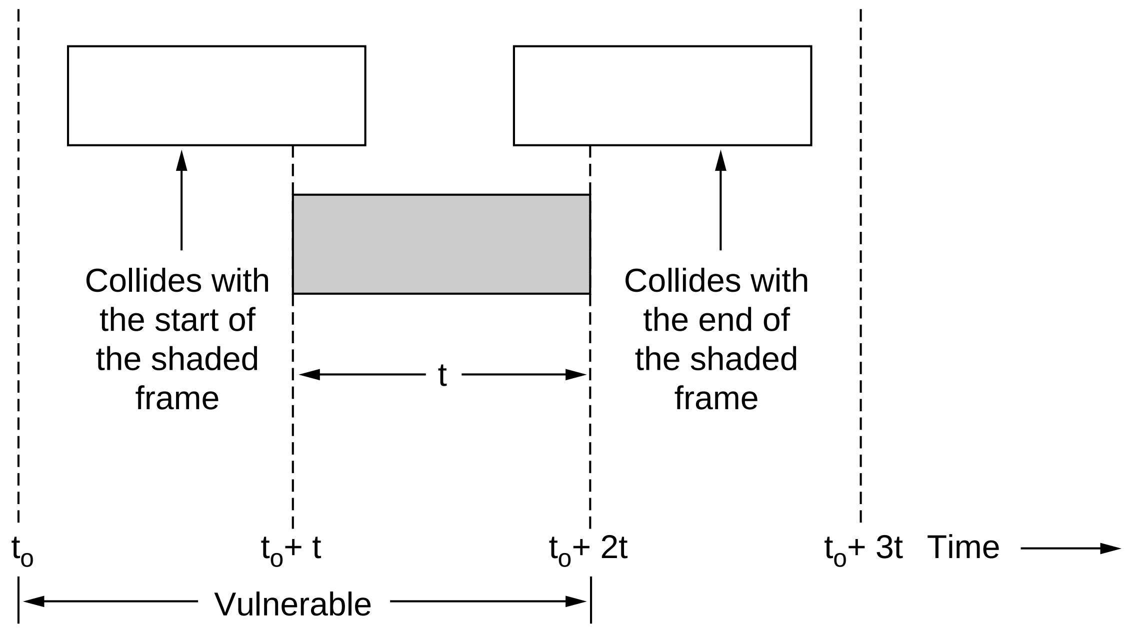

Fig. 4-2. Vulnerable period for the shaded frame.

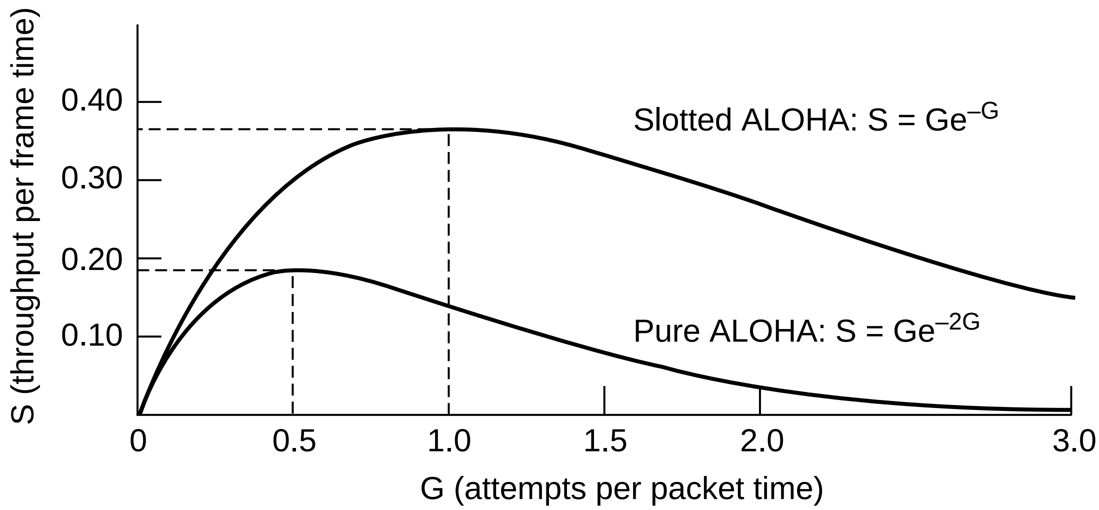

Fig. 4-3. Throughput versus offered traffic for ALOHA systems.

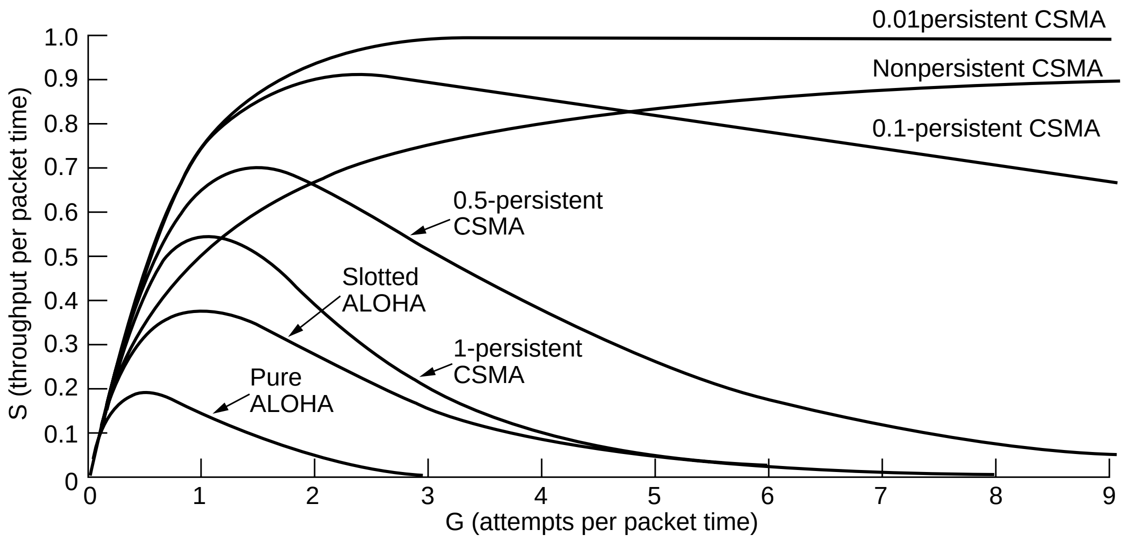

Fig. 4-4. Comparison of the channel utilization versus load for various random access protocols.

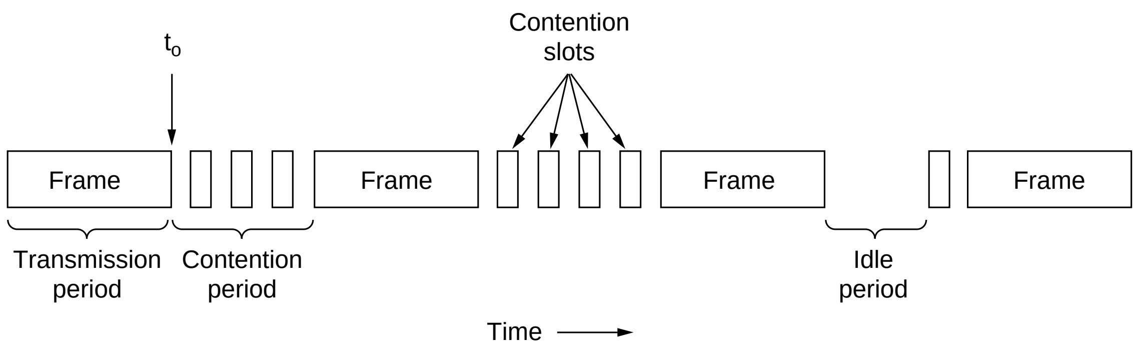

Fig. 4-5. CSMA/CD can be in one of three states: contention, transmission, or idle.

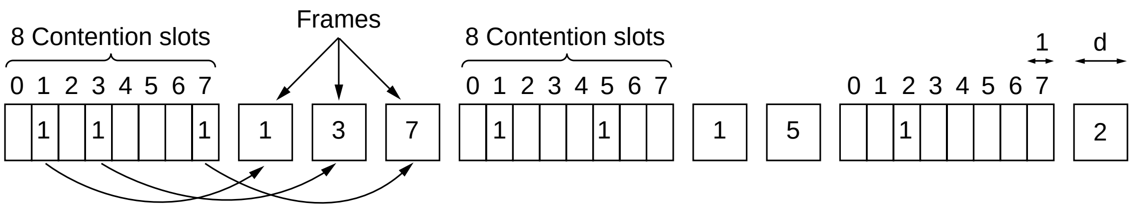

Fig. 4-6. The basic bit-map protocol.

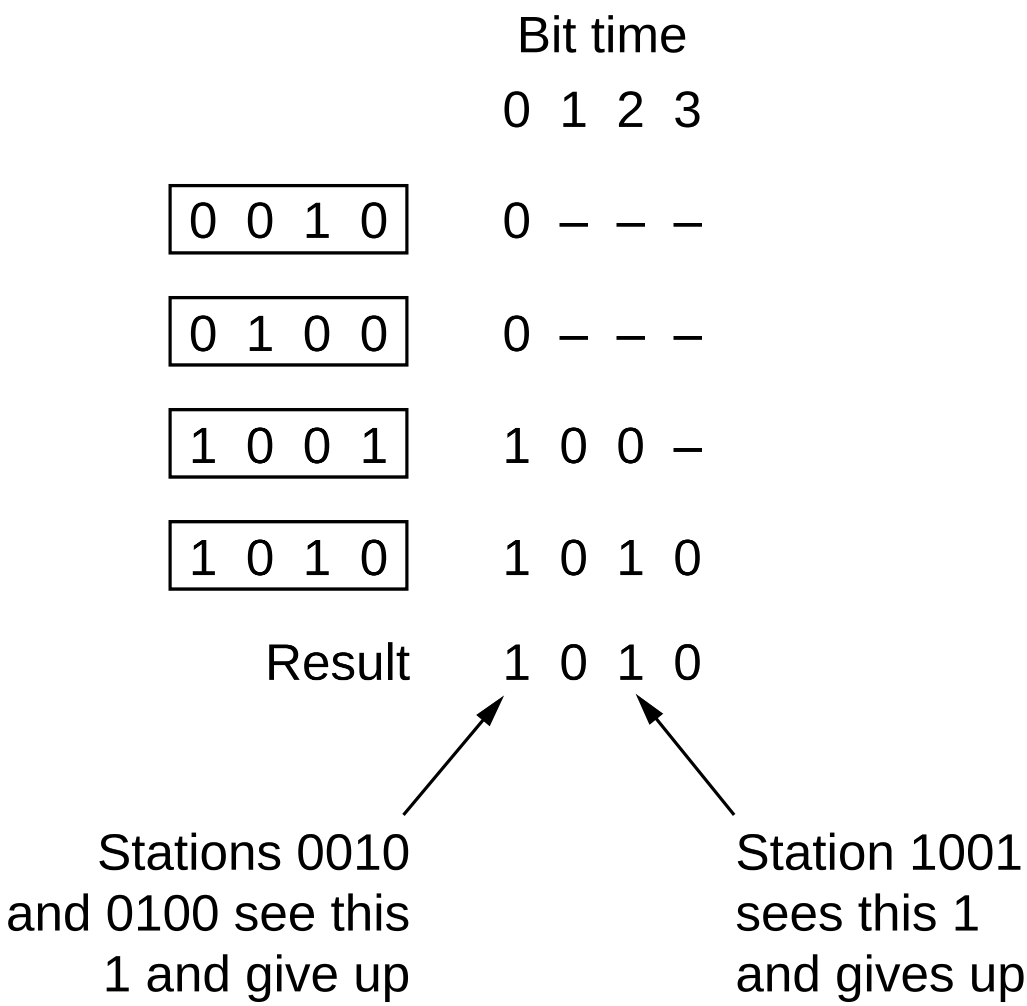

Fig. 4-7. The binary countdown protocol. A dash indicates silence.

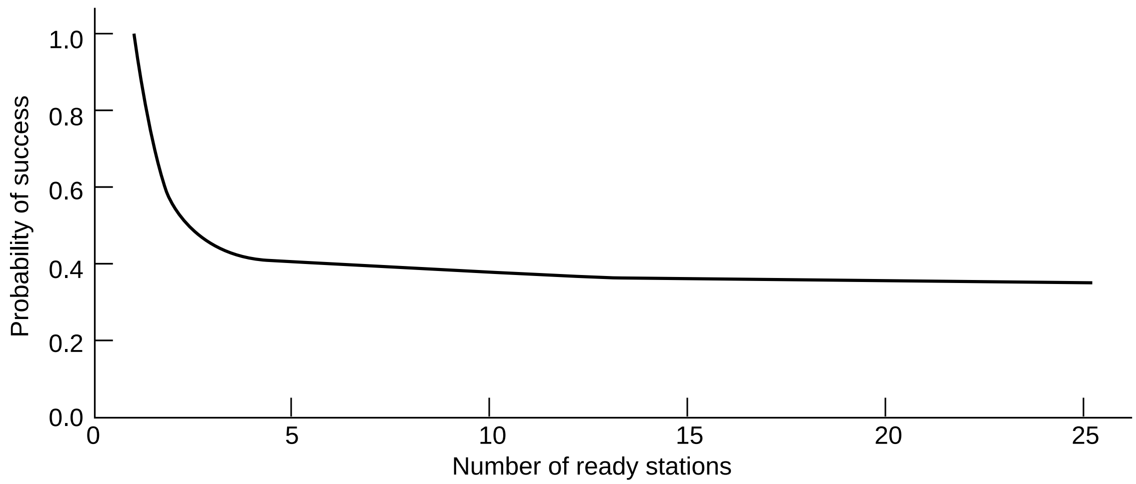

Fig. 4-8. Acquisition probability for a symmetric contention channel.

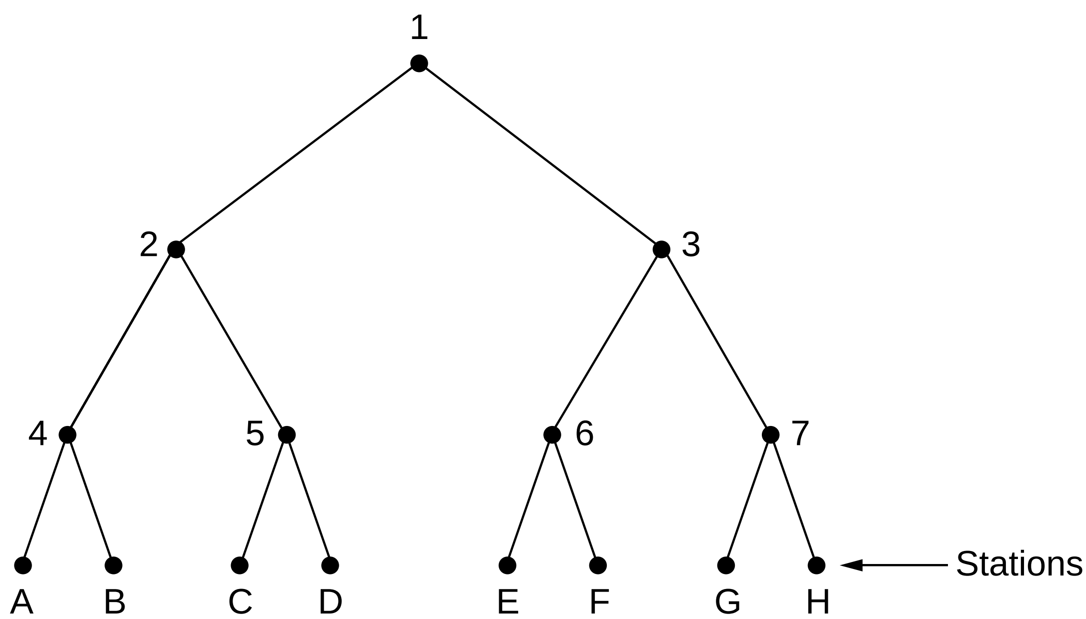

Fig. 4-9. The tree for eight stations.

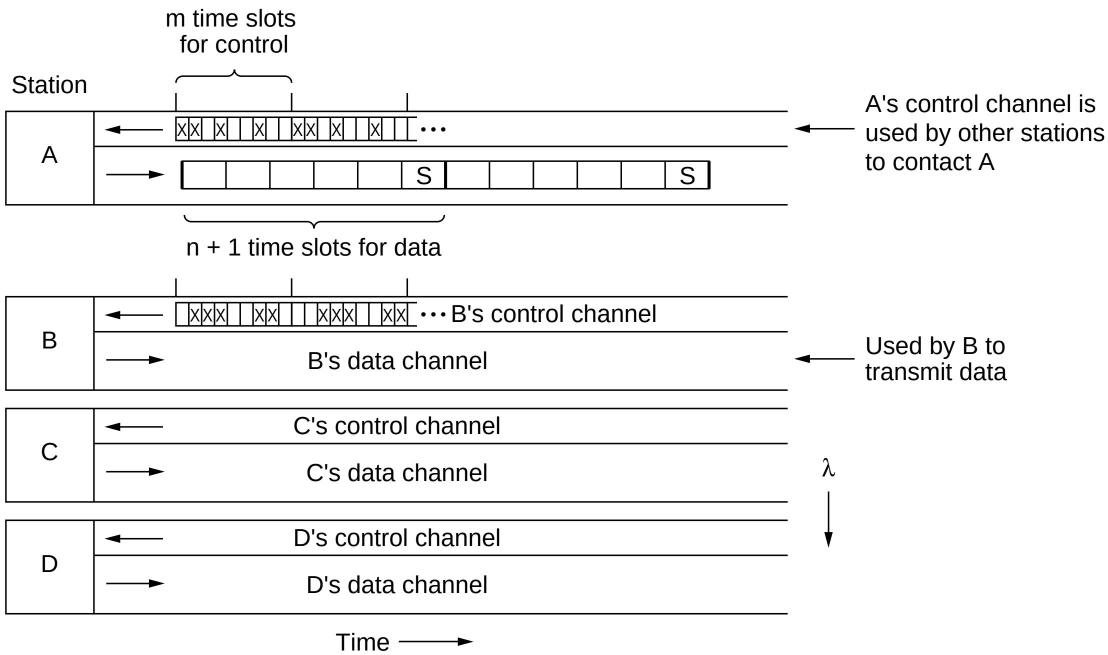

Fig. 4-10. Wavelength division multiple access.

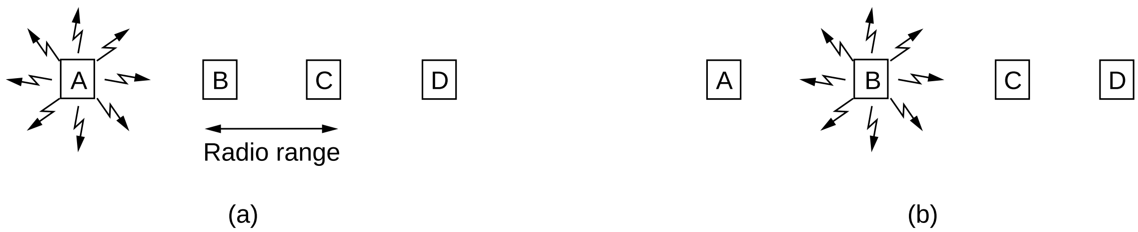

Fig. 4-11. A wireless LAN. (a) *A* transmitting. (b) *B* transmitting.

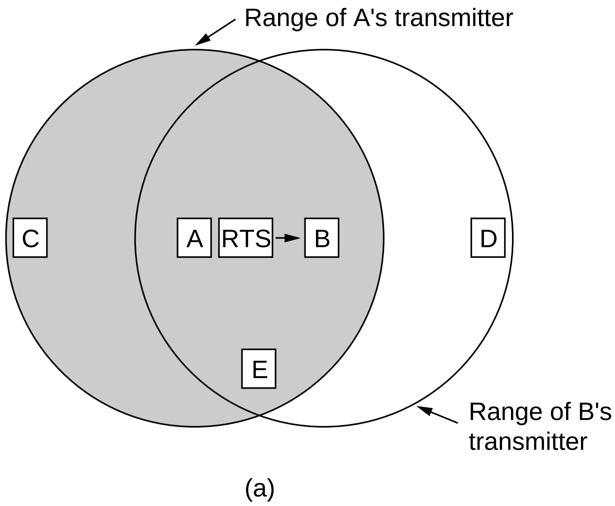

Fig. 4-12. The MACA protocol. (a) *A* sending an RTS to *B*. (b) *B* responding with a CTS to *A*.

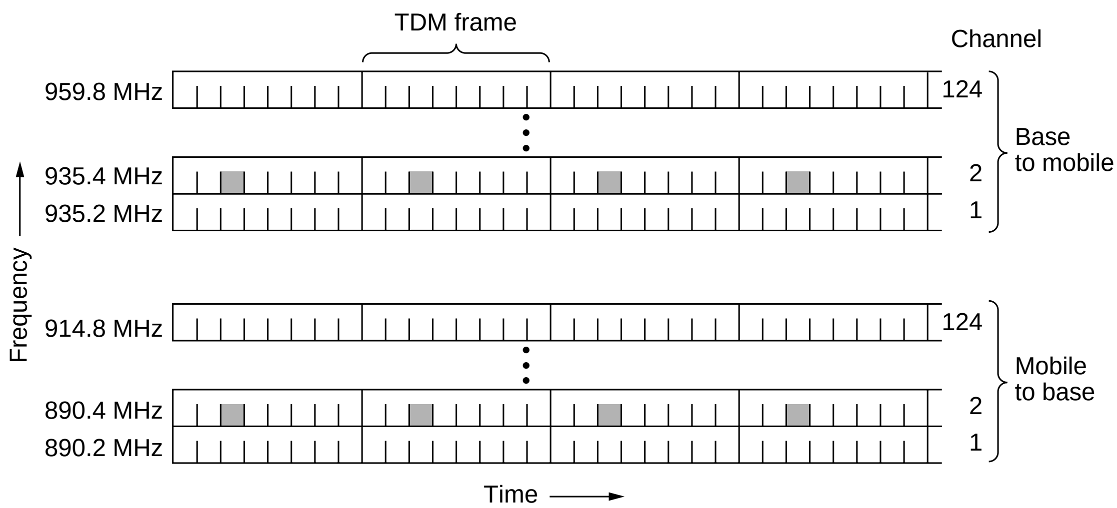

Fig. 4-13. GSM uses 124 frequency channels, each of which use an eight-slot TDM system.

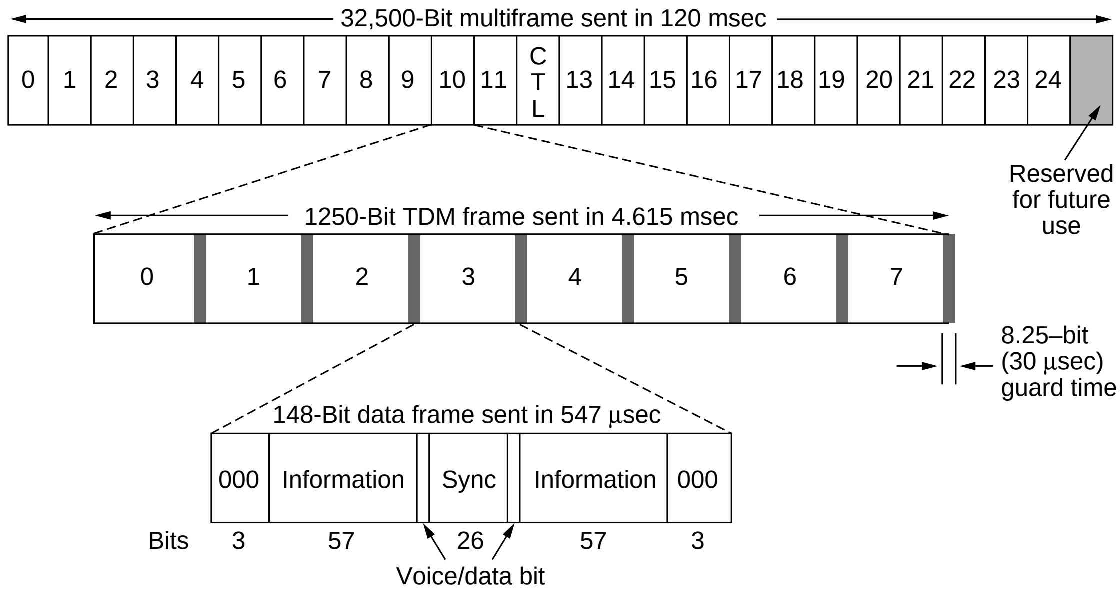

Fig. 4-14. A portion of the GSM framing structure.

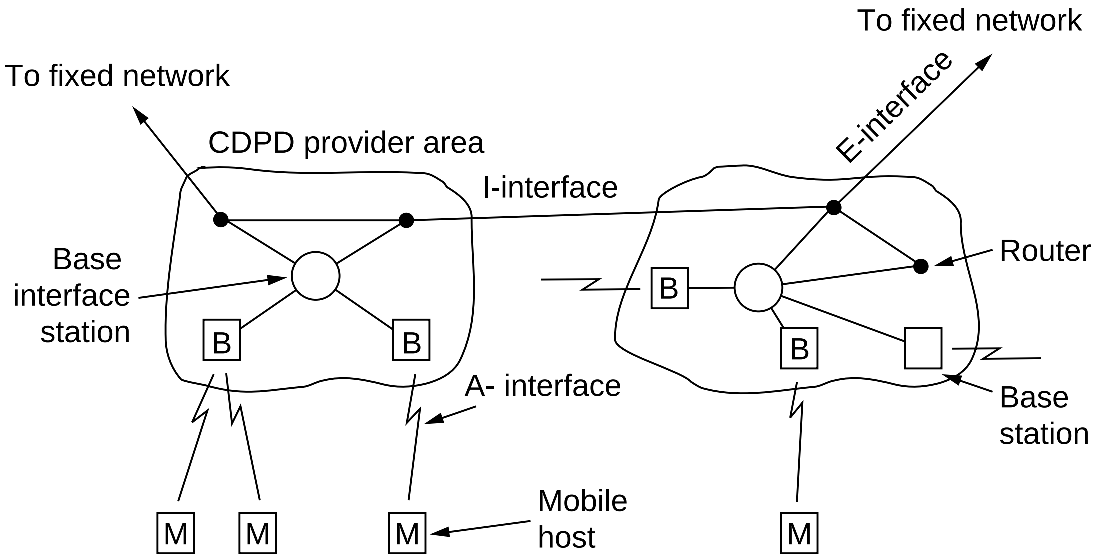

Fig. 4-15. An example CDPD system.

A: 0 0 0 1 1 0 1 1	A: (–1 –1 –1 +1 +1 –1 +1 +1)
B: 0 0 1 0 1 1 1 0	B: (–1 –1 +1 –1 +1 +1 +1 –1)
C: 0 1 0 1 1 1 0 0	C: (–1 +1 –1 +1 +1 +1 –1 –1)
D: 0 1 0 0 0 0 1 0	D: (–1 +1 –1 –1 –1 –1 +1 –1)
(a)	(b)

Six examples:

– – 1 –	$\mathbf{C}$	S_1 = (–1 +1 –1 +1 +1 +1 –1 –1)
– 1 1 –	$\mathbf{B} + \mathbf{C}$	S_2 = (–2 0 0 0 +2 +2 0 –2)
1 0 – –	$\mathbf{A} + \overline{\mathbf{B}}$	S_3 = (0 0 –2 +2 0 –2 0 +2)
1 0 1 –	$\mathbf{A} + \overline{\mathbf{B}} + \mathbf{C}$	S_4 = (–1 +1 –3 +3 –1 –1 –1 +1)
1 1 1 1	$\mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D}$	S_5 = (–4 0 –2 0 +2 0 +2 –2)
1 1 0 1	$\mathbf{A} + \mathbf{B} + \overline{\mathbf{C}} + \mathbf{D}$	S_6 = (–2 –2 0 –2 0 –2 +4 0)

(c)

$S_1 \bullet C$ = (1 +1 +1 +1 +1 +1 +1 +1)/8 = 1
$S_2 \bullet C$ = (2 +0 +0 +0 +2 +2 +0 +2)/8 = 1
$S_3 \bullet C$ = (0 +0 +2 +2 +0 –2 +0 –2)/8 = 0
$S_4 \bullet C$ = (1 +1 +3 +3 +1 –1 +1 –1)/8 = 1
$S_5 \bullet C$ = (4 +0 +2 +0 +2 +0 –2 +2)/8 = 1
$S_6 \bullet C$ = (2 –2 +0 –2 +0 –2 –4 +0)/8 = –1

(d)

Fig. 4-16. (a) Binary chip sequences for four stations. (b) Bipolar chip sequences. (c) Six examples of transmissions. (d) Recovery of station C’s signal.

Name	Cable	Max. segment	Nodes/seg.	Advantages
10Base5	Thick coax	500 m	100	Good for backbones
10Base2	Thin coax	200 m	30	Cheapest system
10Base-T	Twisted pair	100 m	1024	Easy maintenance
10Base-F	Fiber optics	2000 m	1024	Best between buildings

Fig. 4-17. The most common kinds of baseband 802.3 LANs.

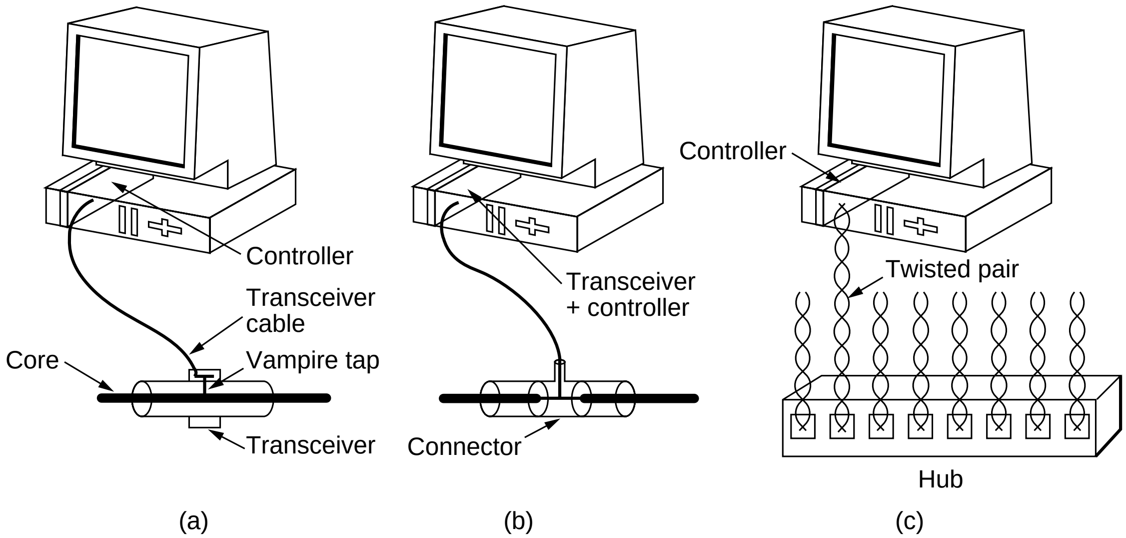

Fig. 4-18. Three kinds of 802.3 cabling. (a) 10Base5. (b) 10Base2. (c) 10Base-T.

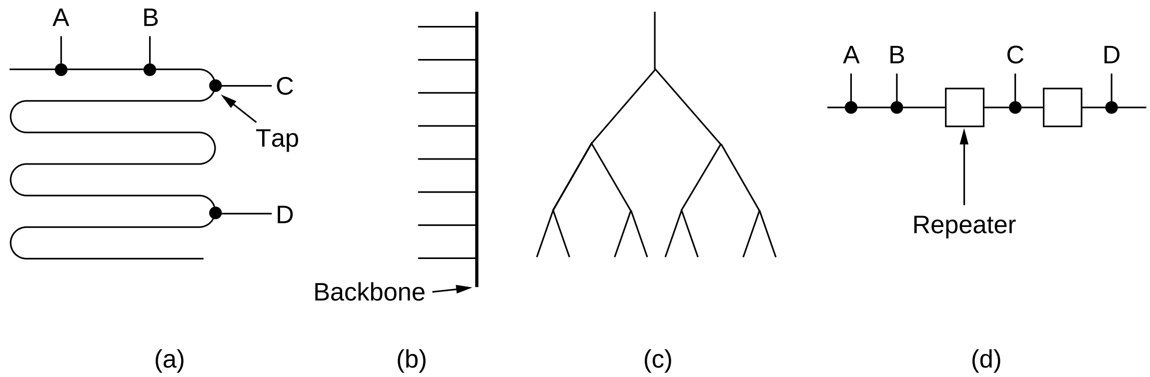

Fig. 4-19. Cable topologies. (a) Linear. (b) Spine. (c) Tree. (d) Segmented.

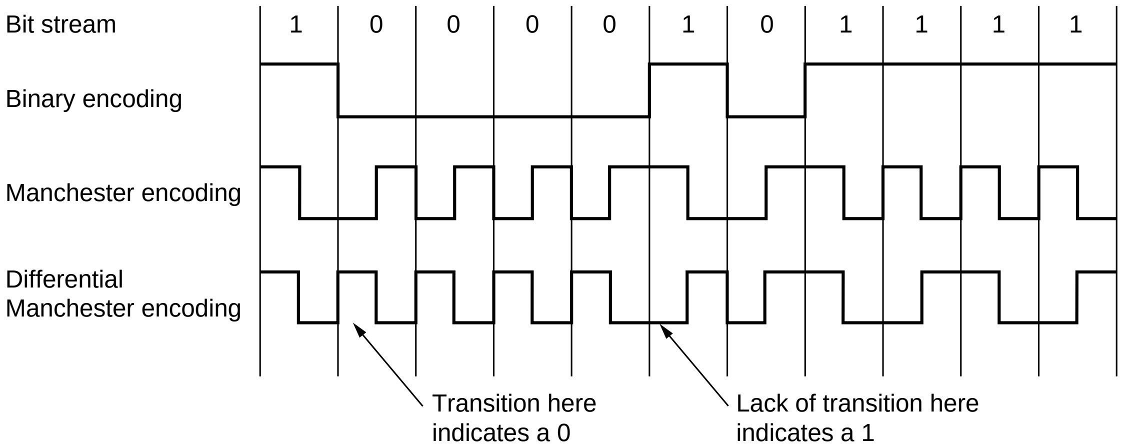

Fig. 4-20. (a) Binary encoding. (b) Manchester encoding. (c) Differential Manchester encoding.

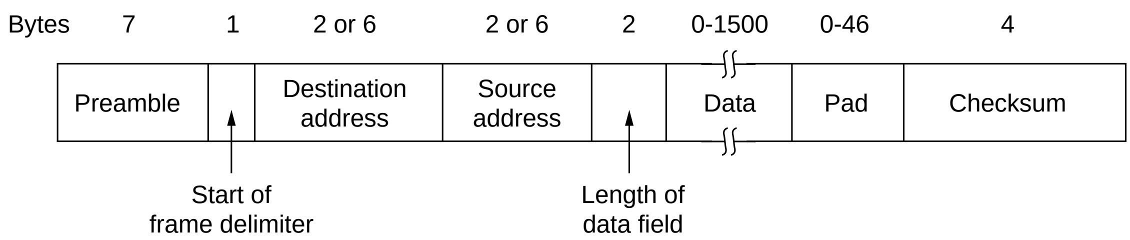

Fig. 4-21. The 802.3 frame format.

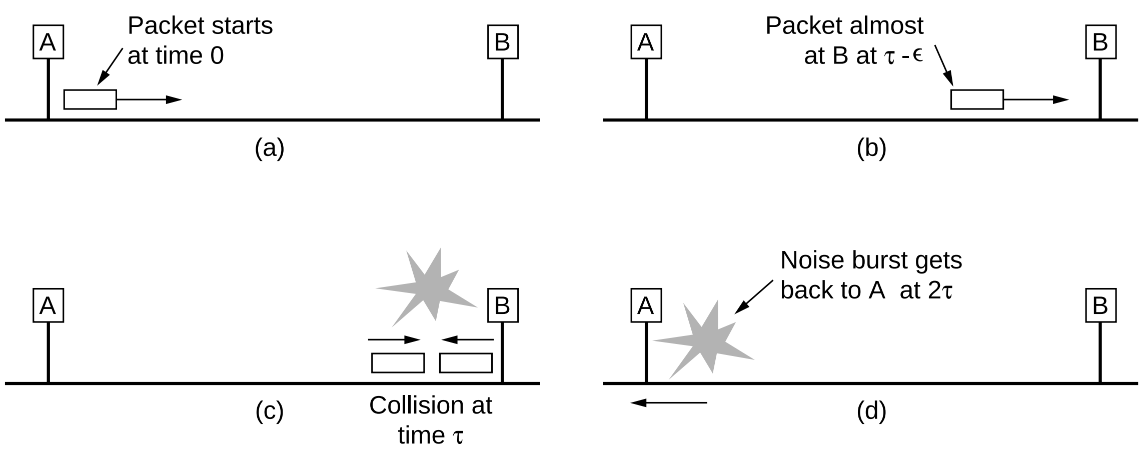

Fig. 4-22. Collision detection can take as long as 2τ.

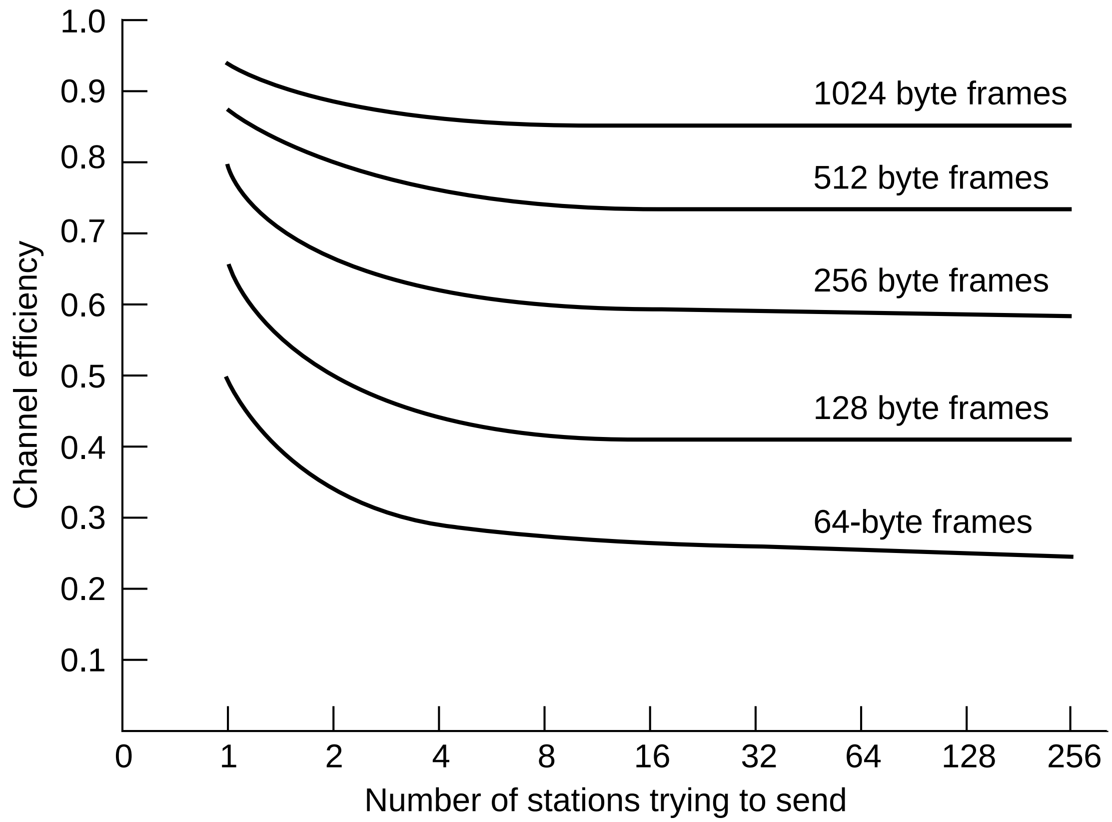

Fig. 4-23. Efficiency of 802.3 at 10 Mbps with 512-bit slot times.

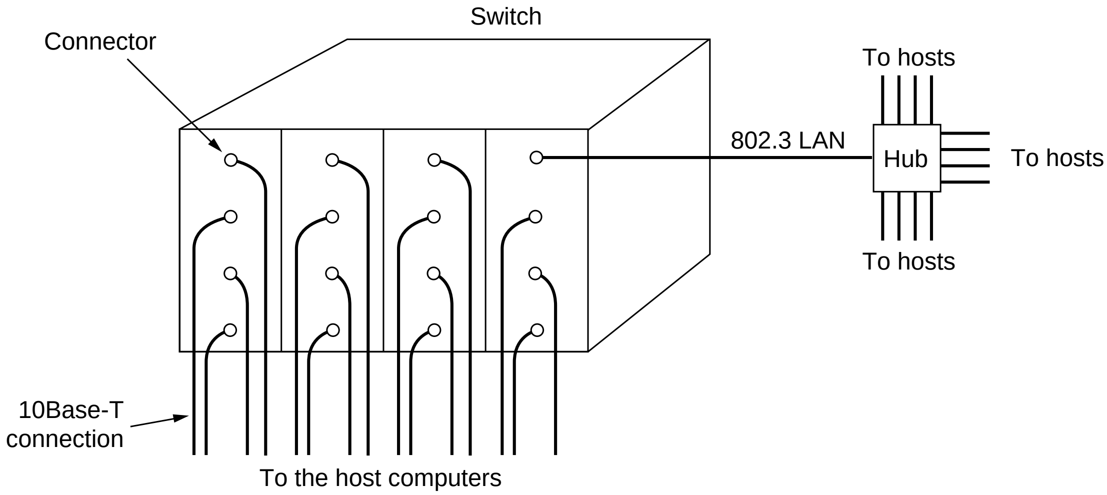

Fig. 4-24. A switched 802.3 LAN.

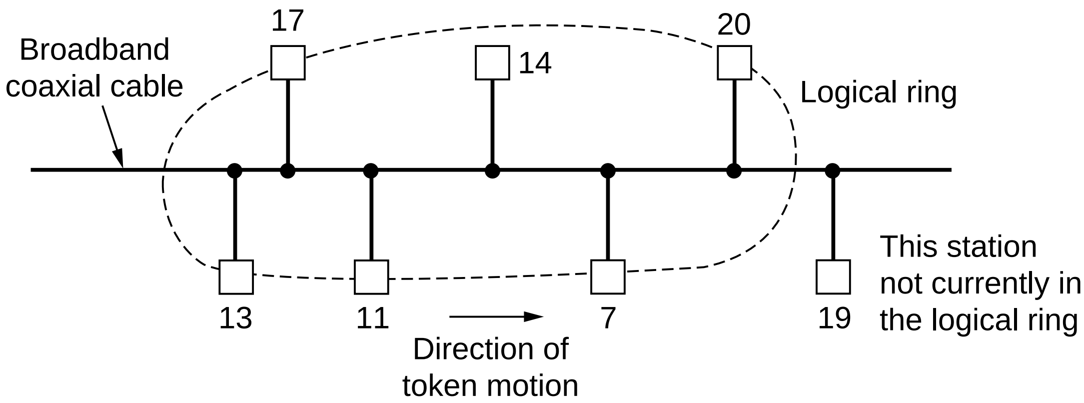

Fig. 4-25. A token bus.

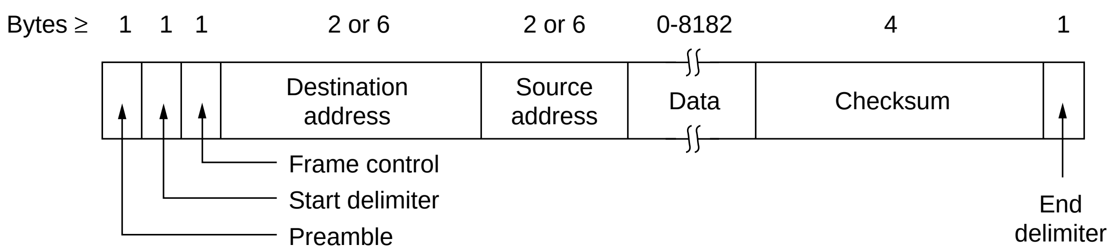

Fig. 4-26. The 802.4 frame format.

Frame control field	Name	Meaning
00000000	Claim_token	Claim token during ring initialization
00000001	Solicit_successor_1	Allow stations to enter the ring
00000010	Solicit_successor_2	Allow stations to enter the ring
00000011	Who_follows	Recover from lost token
00000100	Resolve_contention	Used when multiple stations want to enter
00001000	Token	Pass the token
00001100	Set_successor	Allow station to leave the ring

Fig. 4-27. The token bus control frames.

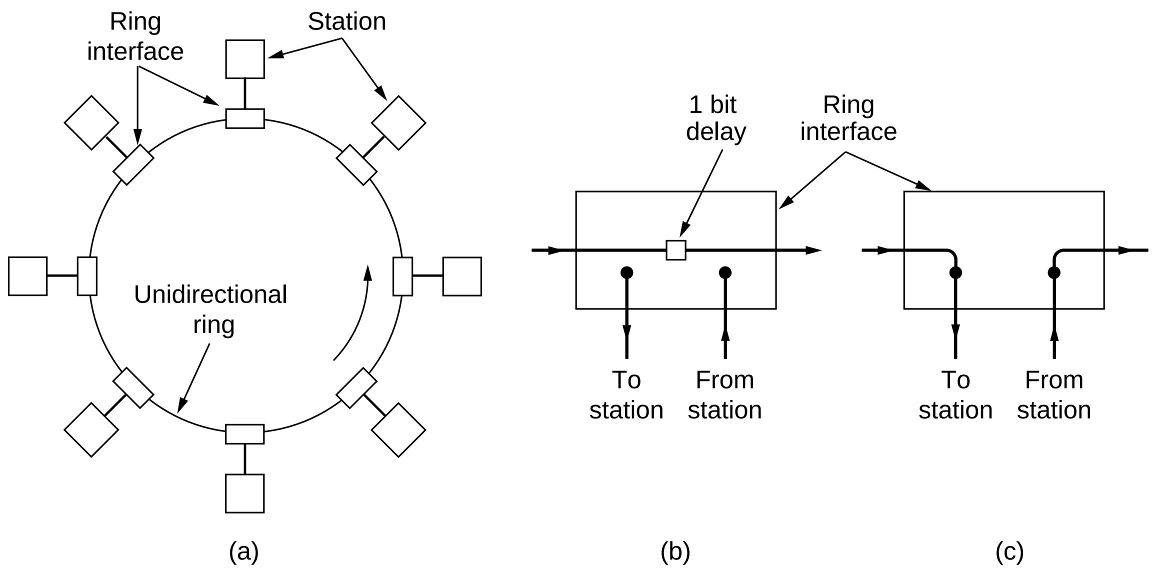

Fig. 4-28. (a) A ring network. (b) Listen mode. (c) Transmit mode.

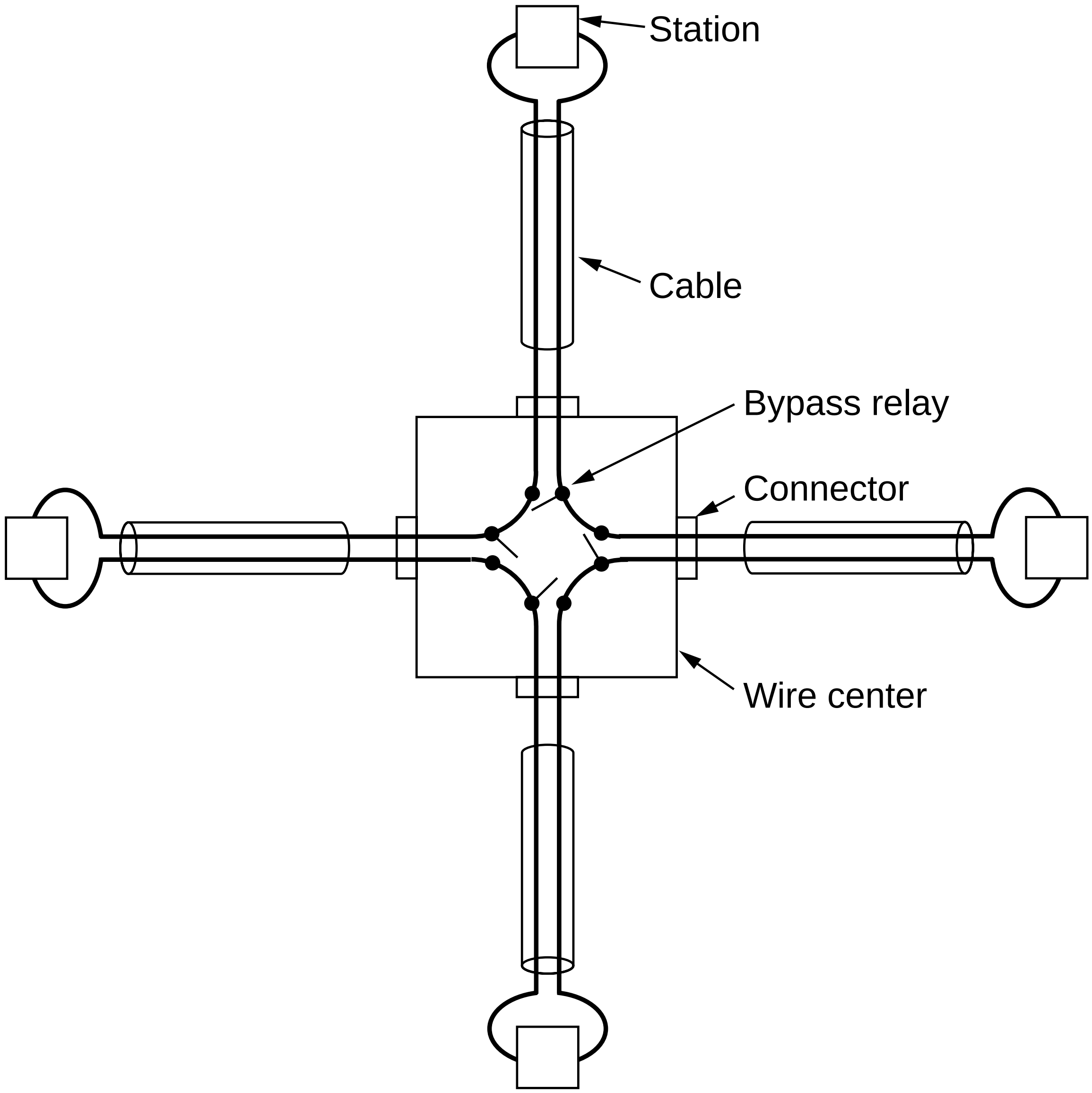

Fig. 4-29. Four stations connected via a wire center.

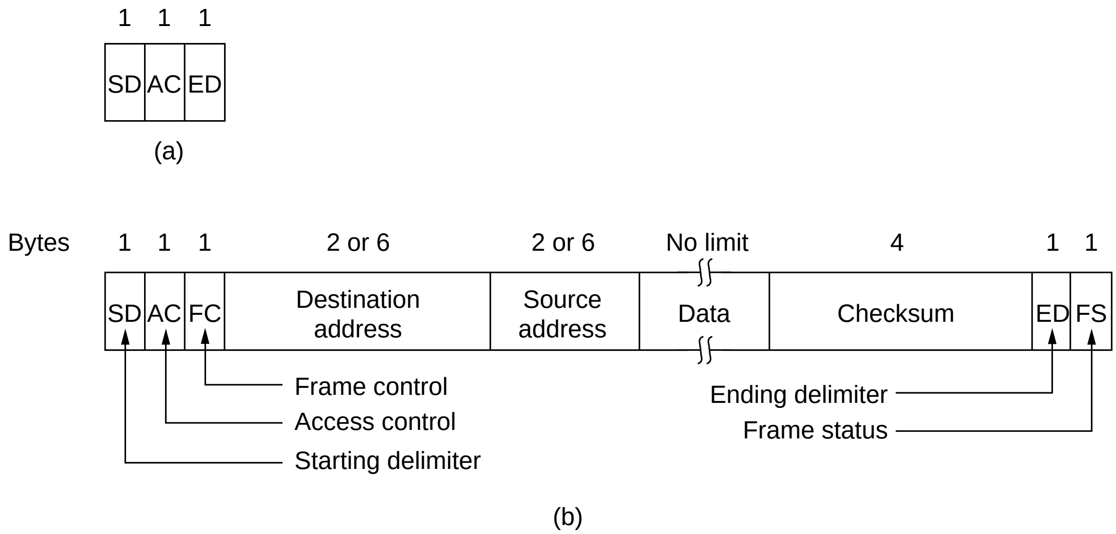

Fig. 4-30. (a) Token format. (b) Data frame format.

Control field	Name	Meaning
00000000	Duplicate address test	Test if two stations have the same address
00000010	Beacon	Used to locate breaks in the ring
00000011	Claim token	Attempt to become monitor
00000100	Purge	Reinitialize the ring
00000101	Active monitor present	Issued periodically by the monitor
00000110	Standby monitor present	Announces the presence of potential monitors

Fig. 4-31. Token ring control frames.

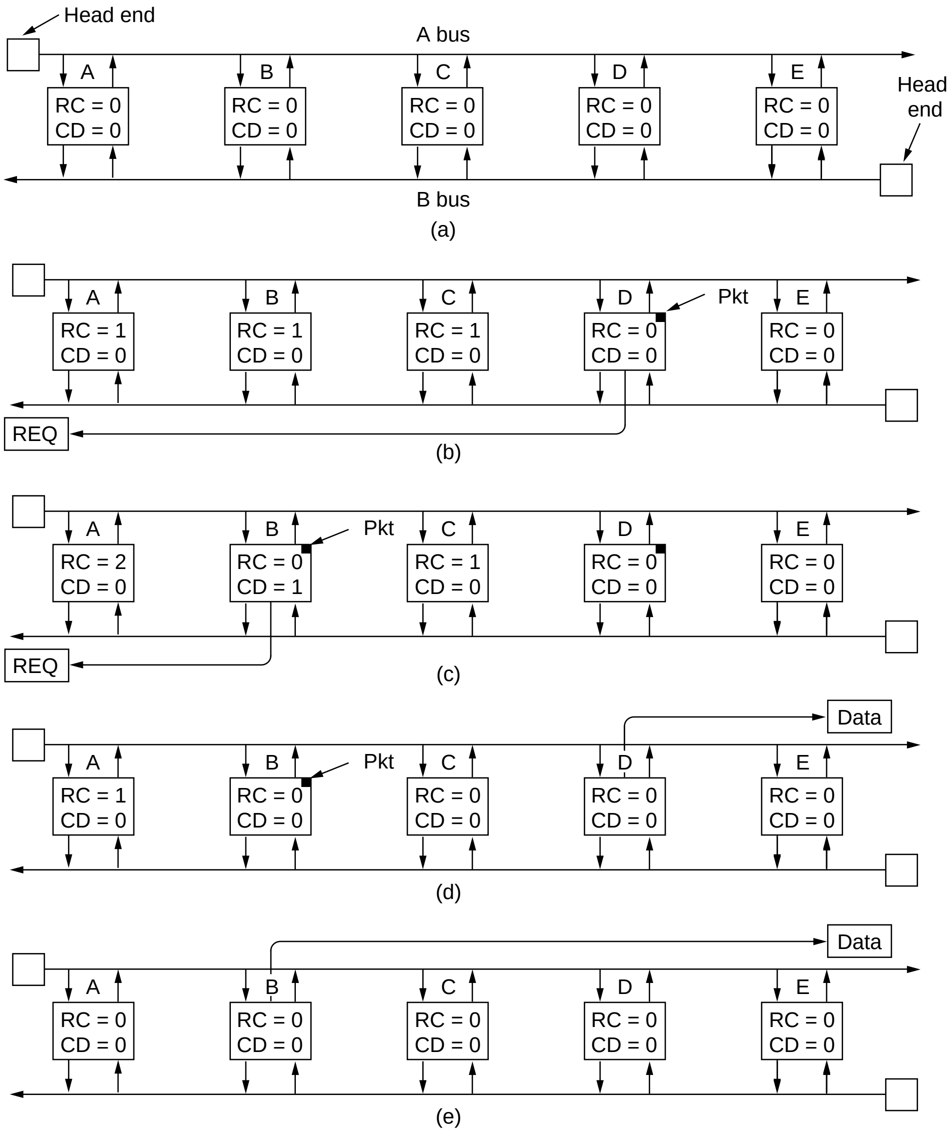

Fig. 4-32. (a) Initially the MAN is idle. (b) After *D* makes a request. (c) After *B* makes a request. (d) After *D* transmits. (e) After *B* transmits.

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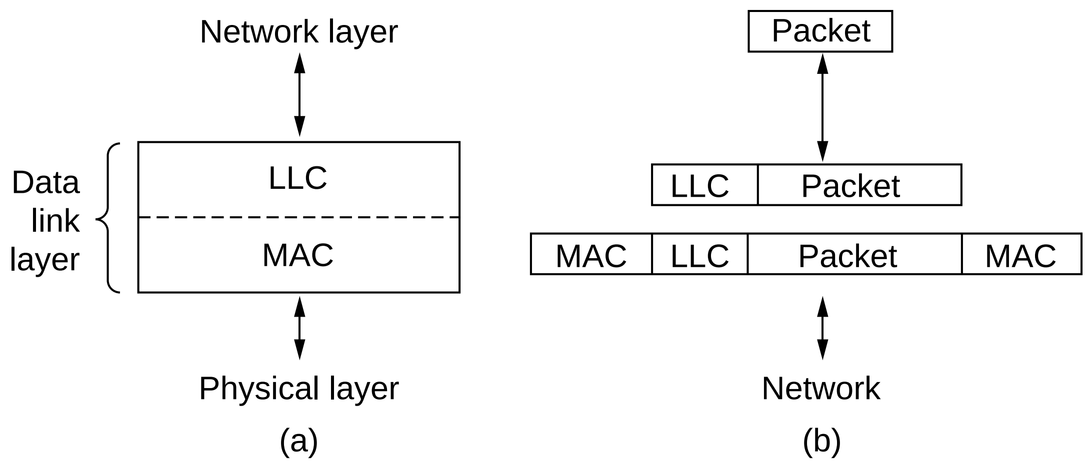

Fig. 4-33. (a) Position of LLC. (b) Protocol formats.

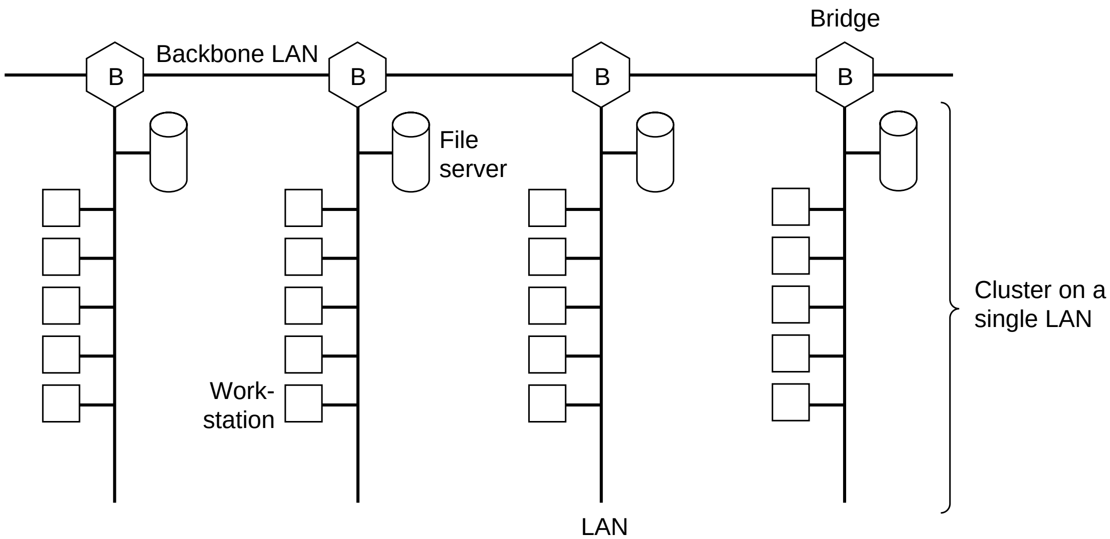

Fig. 4-34. Multiple LANs connected by a backbone to handle a total load higher than the capacity of a single LAN.

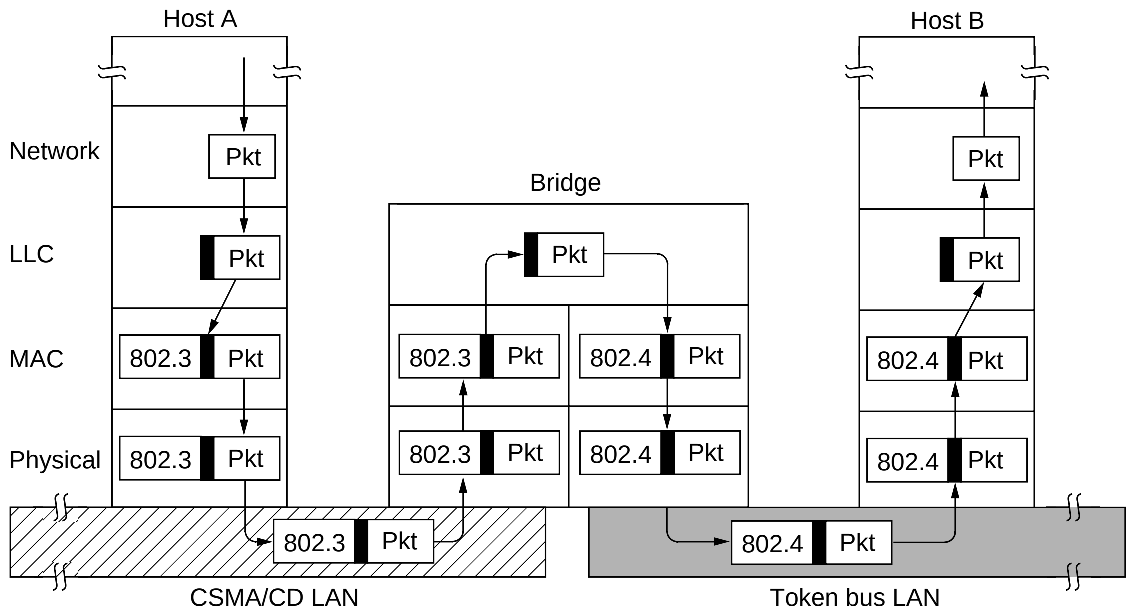

Fig. 4-35. Operation of a LAN bridge from 802.3 to 802.4.

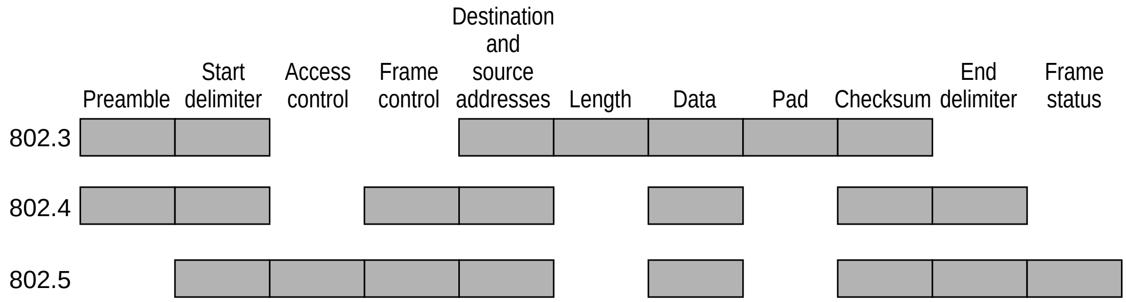

Fig. 4-36. The IEEE 802 frame formats.

Source LAN	Destination LAN: 802.3 (CSMA/CD)	802.4 (Token bus)	802.4 (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

Fig. 4-37. Problems encountered in building bridges from 802.x to 802.y.

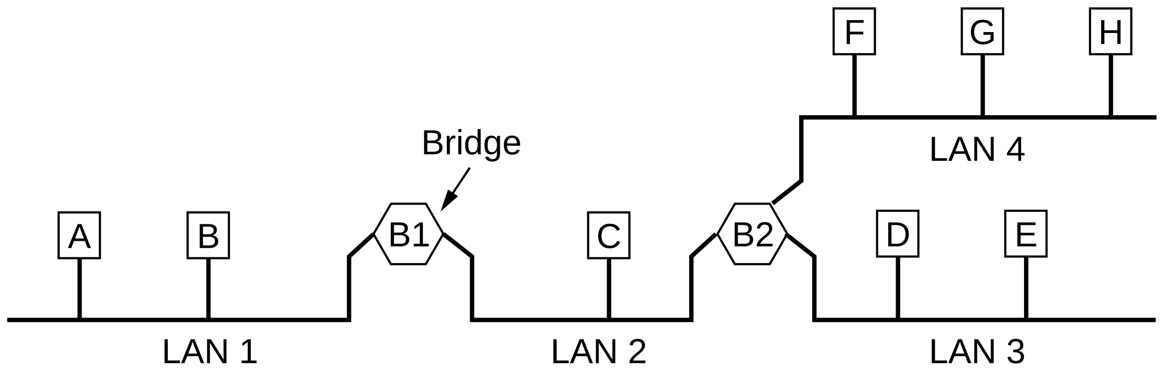

Fig. 4-38. A configuration with four LANs and two bridges.

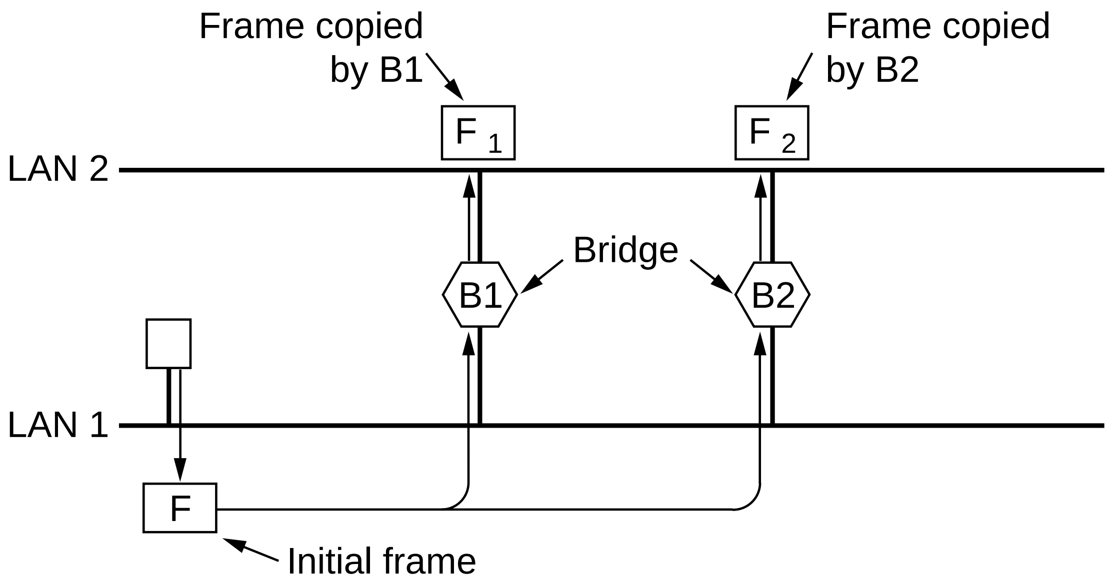

Fig. 4-39. Two parallel transparent bridges.

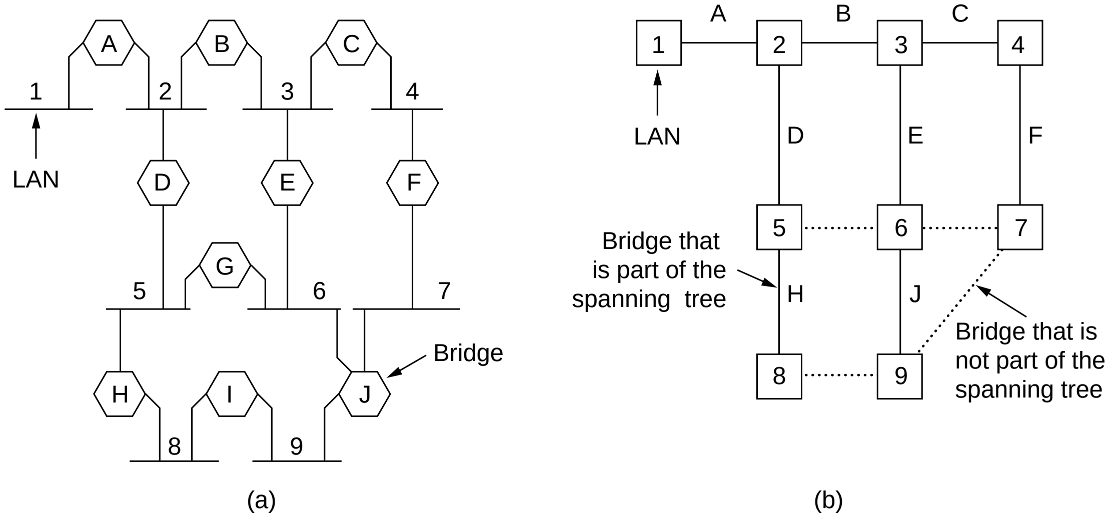

Fig. 4-40. (a) Interconnected LANs. (b) A spanning tree covering the LANs. The dotted lines are not part of the spanning tree.

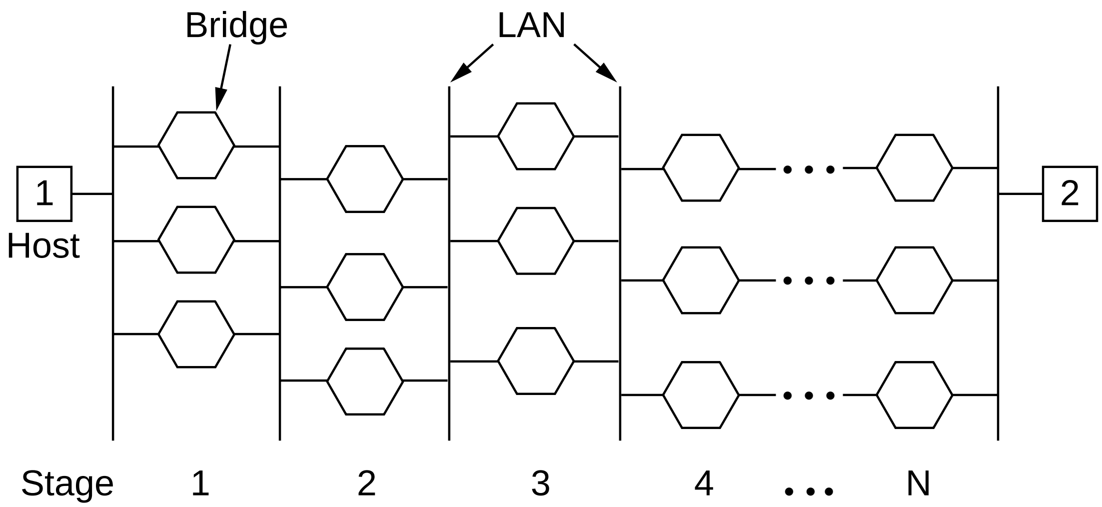

Fig. 4-41. A series of LANs connected by triple bridges.

Issue	Transparent bridge	Source routing bridge
Orientation	Connectionless	Connection-oriented
Transparency	Fully transparent	Not transparent
Configuration	Automatic	Manual
Routing	Suboptimal	Optimal
Locating	Backward learning	Discovery frames
Failures	Handled by the bridges	Handled by the hosts
Complexity	In the bridges	In the hosts

Fig. 4-42. Comparison of transparent and source routing bridges.

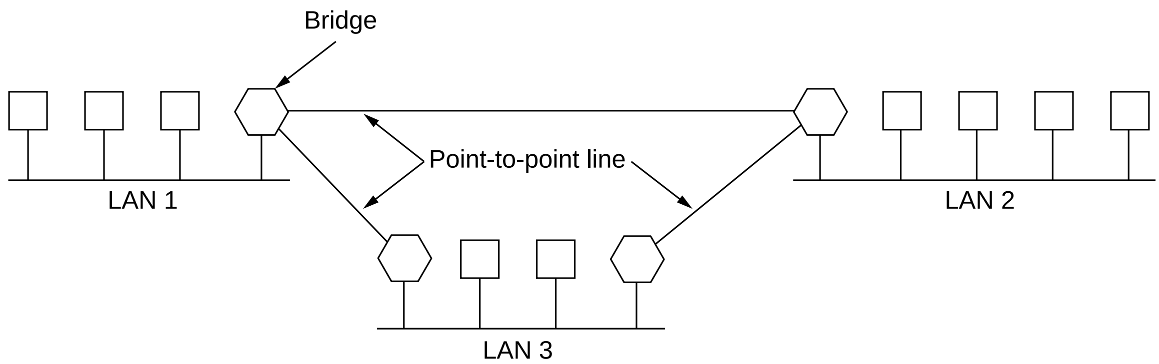

Fig. 4-43. Remote bridges can be used to interconnect distant LANs.

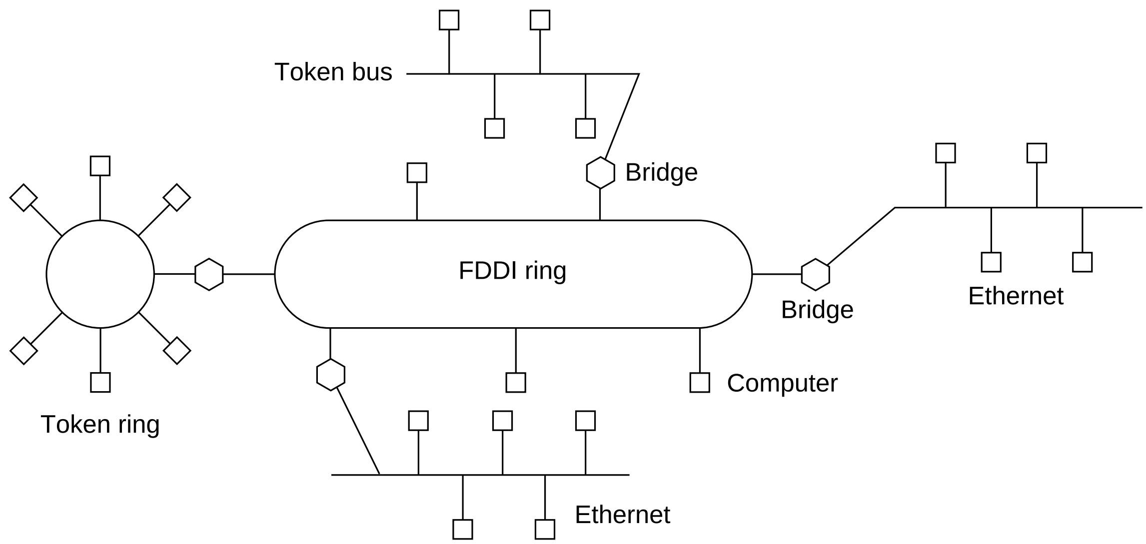

Fig. 4-44. An FDDI ring being used as a backbone to connect LANs and computers.

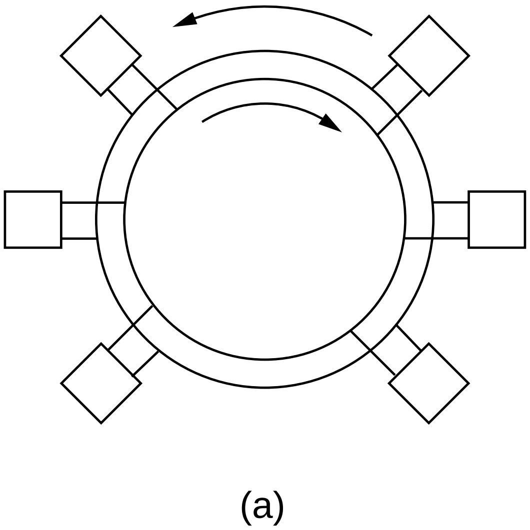

Fig. 4-45. (a) FDDI consists of two counterrotating rings. (b) In the event of failure of both rings at one point, the two rings can be joined together to form a single long ring.

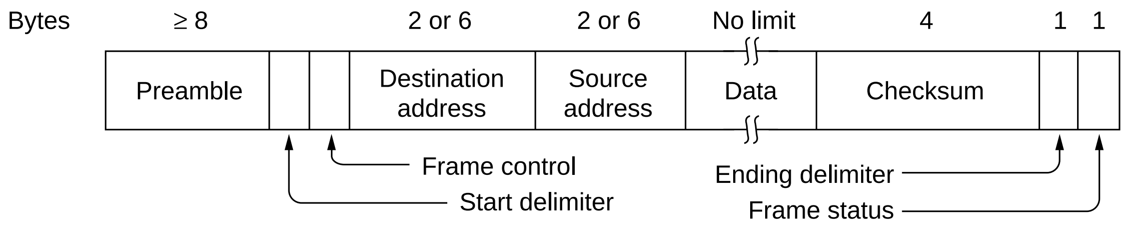

Fig. 4-46. FDDI frame format.

Name	Cable	Max. segment	Advantages
100Base-T4	Twisted pair	100 m	Uses category 3 UTP
100Base-TX	Twisted pair	100 m	Full duplex at 100 Mbps
100Base-F	Fiber optics	2000 m	Full duplex at 100 Mbps; long runs

Fig. 4-47. Fast Ethernet cabling.

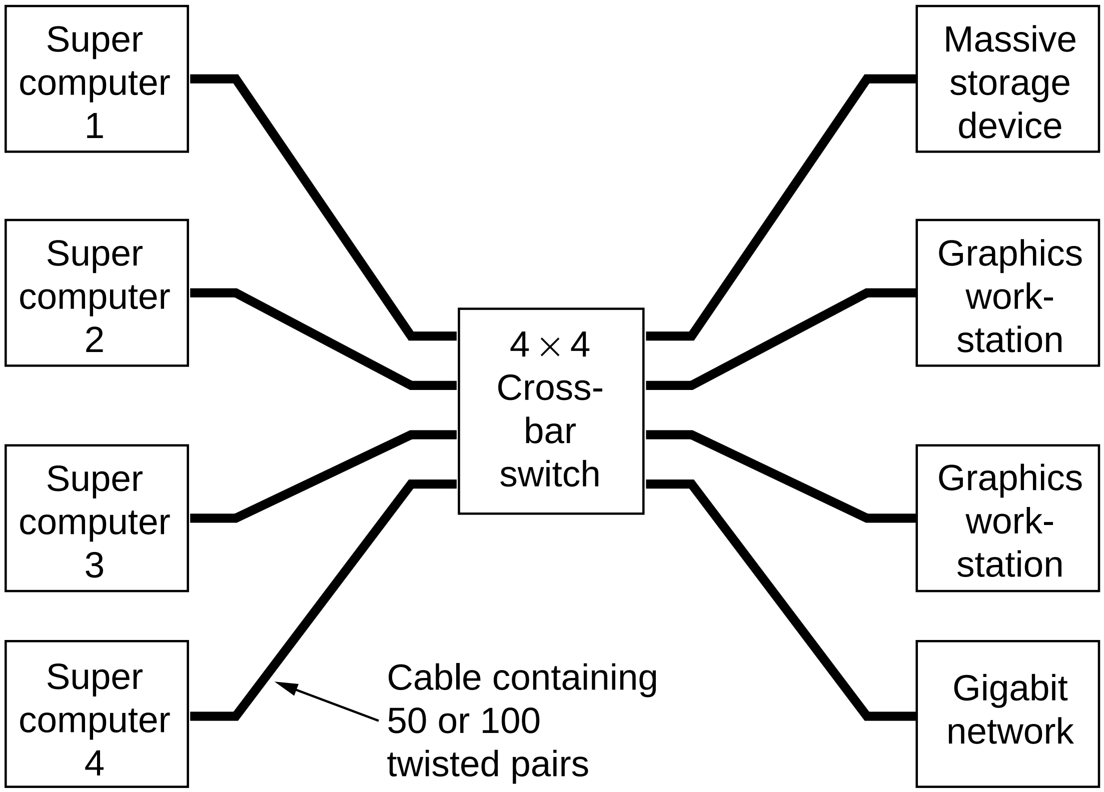

Fig. 4-48. HIPPI using a crossbar switch.

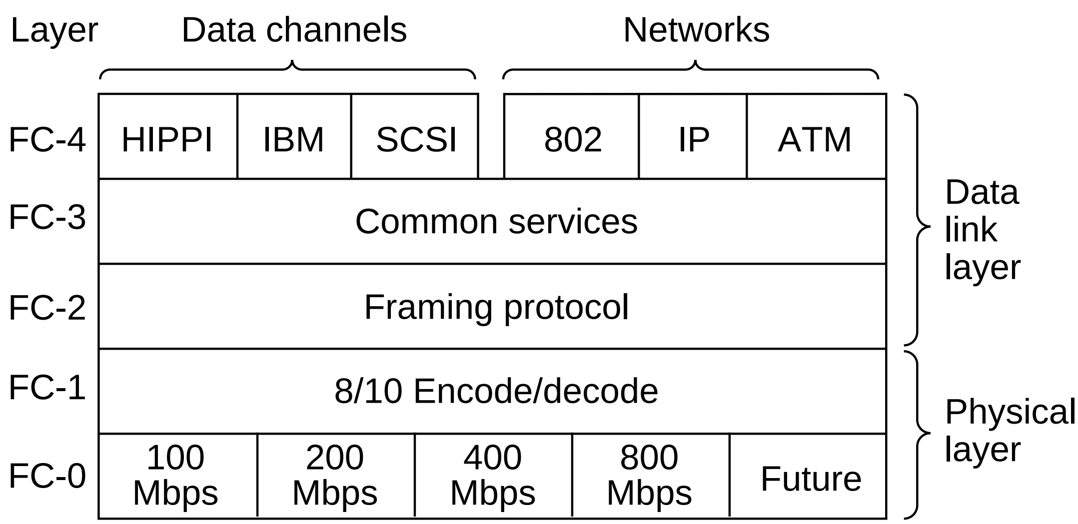

Fig. 4-49. The fibre channel protocol layers.

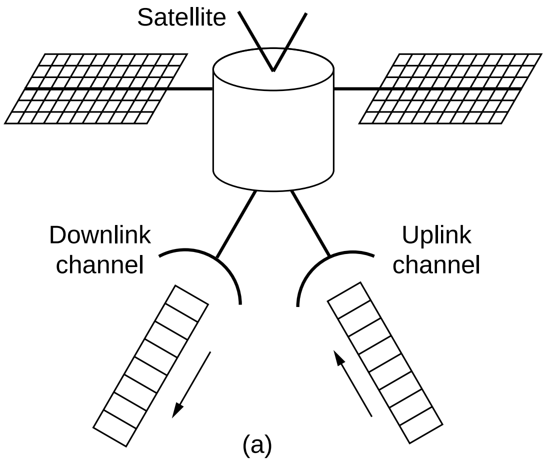

Fig. 4-50. (a) A standard ALOHA system. (b) Adding a second uplink channel.

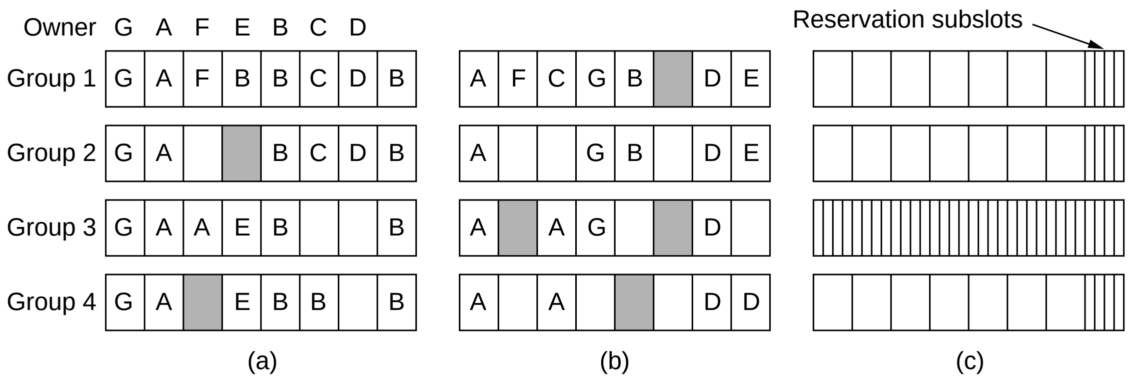

Fig. 4-51. Reservation schemes. (a) Binder. (b) Crowther. (c) Roberts. The shaded boxes indicate collisions. For each of the three schemes, four consecutive groups of slots are shown.

Method	Description
FDM	Dedicate a frequency band to each station
TDM	Dedicate a time slot to each station
Pure ALOHA	Unsynchronized transmission at any instant
Slotted ALOHA	Random transmission in well-defined time slots
1-persistent CSMA	Standard carrier sense multiple access
Nonpersistent CSMA	Random delay when channel is sensed busy
P-persistent CSMA	CSMA, but with a probability of p of persisting
CSMA/CD	CSMA, but abort on detecting a collision
Bit map	Round robin scheduling using a bit map
Binary countdown	Highest numbered ready station goes next
Tree walk	Reduced contention by selective enabling
Wavelength division	A dynamic FDM scheme for fiber
MACA, MACAW	Wireless LAN protocols
GSM	FDM plus TDM for cellular radio
CDPD	Packet radio within an AMPS channel
CDMA	Everybody speak at once but in a different language
Ethernet	CSMA/CD with binary exponential backoff
Token bus	Logical ring on a physical bus
Token ring	Capture the token to send a frame
DQDB	Distributed queuing on a two-bus MAN
FDDI	Fiber-optic token ring
HIPPI	Crossbar using 50-100 twisted pairs
Fibre channel	Crossbar using fiber optics
SPADE	FDM with dynamic channel allocation
ACTS	TDM with centralized slot allocation
Binder	TDM with ALOHA when slot owner is not interested
Crowther	ALOHA with slot owner getting to keep it
Roberts	Channel time reserved in advance by ALOHA

Fig. 4-52. Channel allocation methods and systems for a common channel.