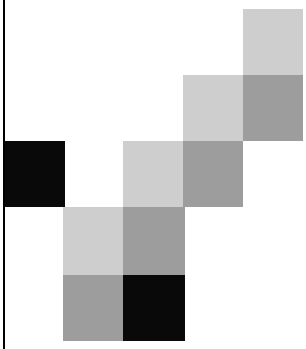


IEEE 802

Tanvir Rahman
CSC 412

IEEE Standards 802 for LANS and MANS

- 802.1 Introduction, Interface primitives
- 802.2 Logical Link Control (LLC)
- 802.3 CSMA/CD – Ethernet
- 802.4 Token Bus
- 802.5 Token Ring
- 802.6 Distributed Queue Dual Bus
- Bridges from 802.x to 802.y

2

IEEE 802.2

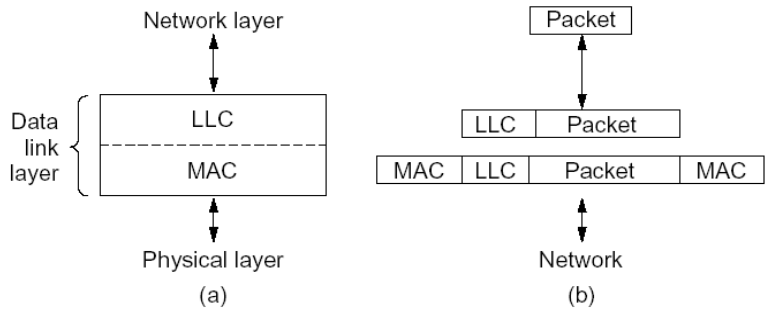


Fig. 4-33. (a) Position of LLC. (b) Protocol formats.

3

802.2: Logical Link Control

- The 802 LAN's only provide for a best-effort datagram service.
  - This is enough for IP packets, (no guarantees are required or expected) which are simply inserted into the data part of 802 frames.
- For other situations, LLC is defined by IEEE.
- It provides 3 services:
  - unreliable datagram service,
  - acknowledged datagram service
  - reliable connection oriented service
- The LLC header is based on the older HDLC protocol.

4

IEEE 802.3: Ethernet

- Data link layer provides:
  - Data encapsulation / decapsulation entity
    - Establishes CSMA/CD frame
    - Source and destination address
    - Calculates an error detection field for the transmitting site and uses the field to calculate an error detection indicator at the receiving site.
  - Transmit / receive media access management entity
    - Transmit frame into physical layer and receives frame from physical layer
    - Buffers the frame
    - Provides for collision avoidance on transmit side
    - Provides for collision handling at transmit side

5

IEEE 802.3: Standards

- Cabling Schemes
- Ethernet uses 1 persistent CSMA/CD, with Manchester encoding. (at 20 Mbaud).
- Xerox, Dec, Intel created standard for 10Mbps

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.

802.3: Cabling

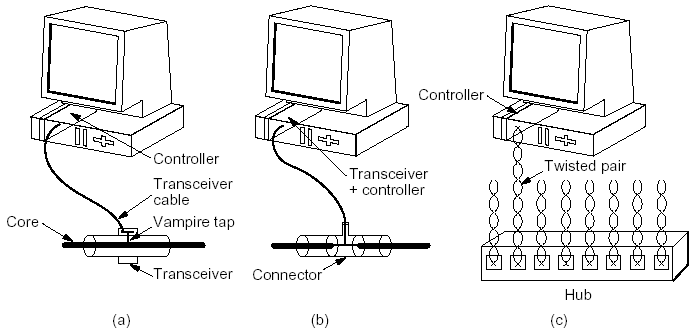


Fig. 4-18. Three kinds of 802.3 cabling. (a) 10Base5. (b) 10Base2. (c) 10Base-T.

802.3: Frame Format

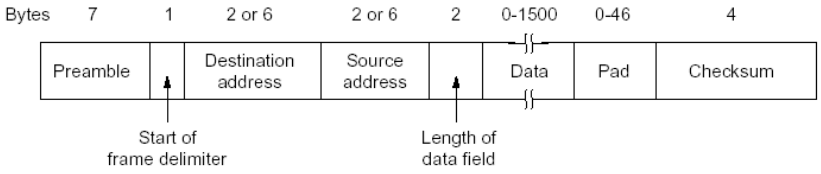


Fig. 4-21. The 802.3 frame format.

Manchester Coding

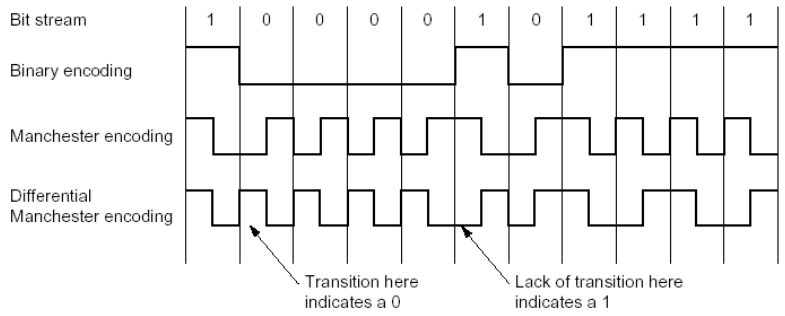
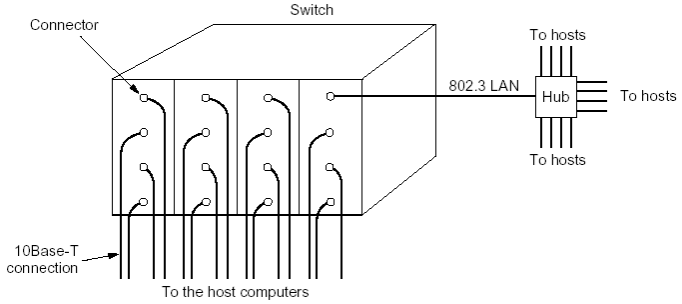


Fig. 4-20. (a) Binary encoding. (b) Manchester encoding. (c) Differential Manchester encoding.

802.3: Frame Format

- Preamble: Square wave (7 bytes of 10101010) to facilitate synchronization (5.6 μsec).
- Start of Frame: 10101011
- Address: 6 bytes. Higher order bit set to 1 for multicast. (????). All bits set to 1 for broadcast.
- Length: Enables transparency. Small frames not suitable, may get confused with aborted frames.
  - May cause collisions to go undetected if frame size is so small that transmit time < 2τ.
- Pad: Permits data field to be set to minimum size.

Switched 802.3: LAN



- Interconnects hubs at high speed without changing adapter cards at workstations
- Hubs may interconnect at 100Mbps or higher (backplane usually 1Gbps)
- Collision domain restricted to single port on switch.

11

IEEE 802.4: Token Bus

- 802.3 most widely used office LAN
- Many businesses concerned about potential for unbounded delay on Ethernet.
- General Motors drove new standard based on passing a "token."
- Token bus supporters concerned about reliability of token ring so supported token bus: an arbitrary linear or tree topology.

12

Binary Exponential Backoff

- After a collision, time is slotted (length of 2500m roundtrip propagation) to 512 bit-times or 51.2μs.
- After collision i, each station picks a random number 0,1,2,...,2^i-1and skips that many slots (for i=1...10).
  - For larger i, number of slots frozen at 1023.
  - After 16 collisions, controller reports failure to LLC
  - Random interval grows exponentially with number of collisions.
  - Tradeoff between prob. of re-collision and delay.

13

IEEE 802.4: Token Bus

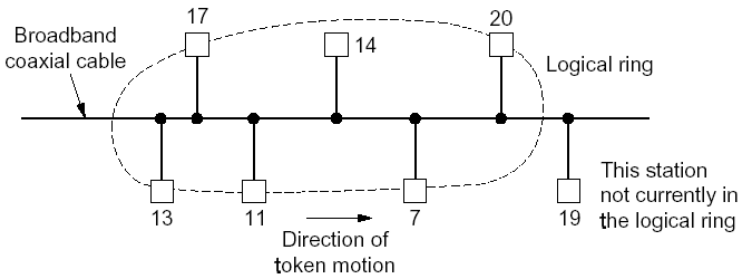


Fig. 4-25. A token bus.

14

Token Bus (continued)

- Stations uniquely numbered highest to lowest and token passes accordingly.
  - Physical location not important
- Broadcast domain so everyone "hears."
- 75Ω cable with speeds of 1/5/10Mbps possible.
- Four priority classes for traffic: 6, 4, 3, 0
  - Significant advantage over Ethernet
  - Example: 50 stations on 10Mbps network with 3.33Mbps dedicated to priority 6 traffic. Implies each station gets $(3.333)(10^6)/50 \cong 67$kbps guaranteed for priority 6. Enough to support voice.

IEEE 802.5: Token Ring

- Station gets token, sends frame, removes frame from ring (as bits propagate around the ring and return), then regenerates token and goes to listen mode.
- Max frame size in practice is 2000 bytes
- If no traffic to send, station simply passes token along.
- Under heavy load channel utilization approaches 100%.
- Virtually all installations use star-wired hubs.

IEEE 802.5: Token Ring

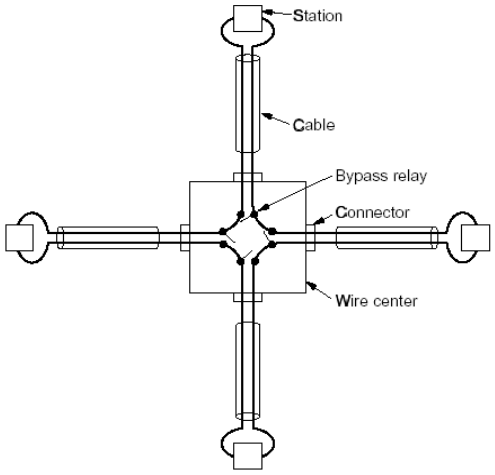


Fig. 4-29. Four stations connected via a wire center.

17

Comparison among Ethernet, Token Bus, and Token Ring

Ethernet	Token Bus	Token Ring
802.3	802.4	802.5
Broadcast	Broadcast	Store-and-forward
Simple and robust protocol	Protocol not as simple as Ethernet	Protocol is somewhat complex
Low delays at low load	Finite delays at low load	Finite delays at low load
Delays increase exponentially at high load	Delays at high load are high, but are predictable.	Delays at high load are high, but are predictable.
No priorities	Priorities handled	Priorities handled

18

Repeaters

- Signals suffer from attenuation
- Repeaters: electrical devices that amplify signal
  - can extend cables with repeaters
  - does not know about frames
  - copies bits
  - will forward noise
- Cannot arbitrarily extend LAN with repeaters
  - noise is amplified
  - relation between distance between stations and min frame size
- E.g. 802.3 species no more than 4 repeaters

19

Bridges

- Similar to repeaters
  - Can connect LAN segments by copying
- Know frame structure
  - Can detect invalid frames/noise
  - Only forwards valid frames
- Know locations of computers on its segments
  - Only forwards frames if they must go to other segment
  - Intelligent forwarding (filtering)
  - Segment bandwidth according to requirements
- Interconnect different IEEE LANS (802.3, 802.4, 802.5)
  - Span greater distance than single LAN segment.

20

Bridge Example

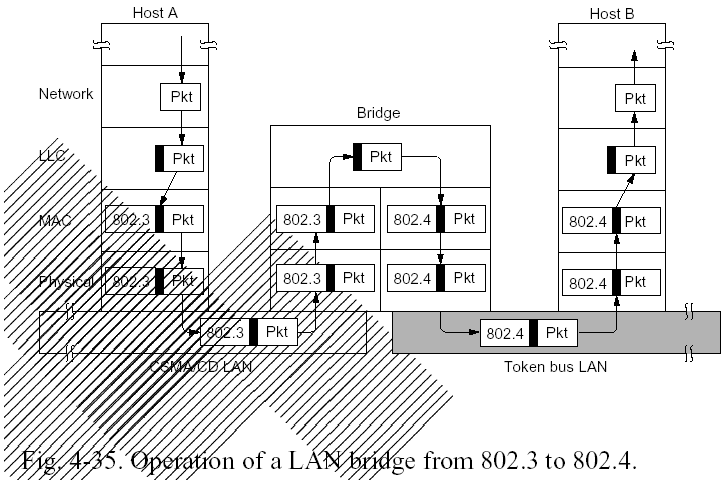


Fig. 4-35. Operation of a LAN bridge from 802.3 to 802.4.

Bridges

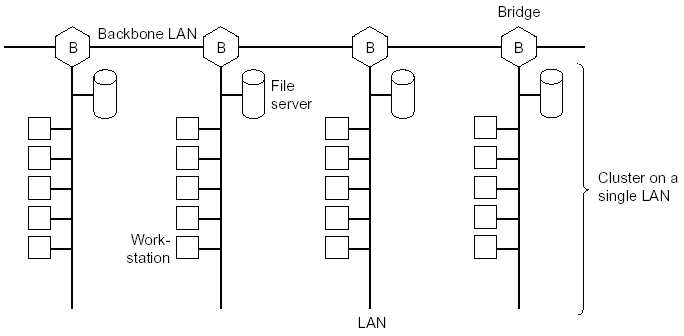


Fig. 4-34. Multiple LANs connected by a backbone to handle a total load higher than the capacity of a single LAN.

Bridge Challenges

- Each LAN type has unique frame format
- Two LANs may have different effective speeds
  - destination may be overloaded
- Two/more input LANs may feed one output LAN
- Compatibility with higher-layer timers (Acks, etc.)
- Max frame lengths are different
  - Not possible to segment in this layer.
  - Frames larger than max are discarded.
- How to handle priorities from 802.x to Ethernet

23

Destination LAN

Source 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.

24

Frame Formats

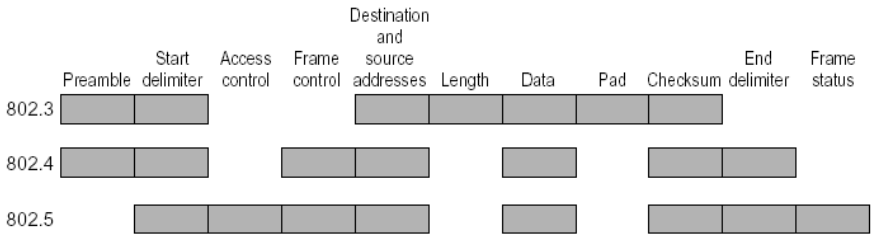


Fig. 4-36. The IEEE 802 frame formats.

Transparent Bridge

- A plug-and-play bridge.
- Operates in promiscuous mode
  - Accepts every valid frame arriving at its inputs
  - Decides whether to discard or forward frames
  - Forwarding decision is made by looking up the destination address of the frame in a big (hash) table inside the bridge.
- Initially the hash tables are empty.
  - The destination LAN of an incoming packet is not known.
  - Flooding is used to learn the destination LAN.

Transparent Bridge (Continued)

- Bridges also learns the requesting host address and its corresponding LAN.
  - Thus it sets its table accordingly, this is called backward learning.
- Hash table entries are marked with the last time that the entry is made or confirmed.
  - Periodically all entries, older than a few minutes are purged.
- To increase reliability, some sites use two or more bridges in parallel between two LAN's. This creates loops in the topology, giving all kinds of problems: double arriving packets or long circulating packets.

27

Spanning Tree Bridges

- Spanning tree algorithm:
  - Choose bridge with lowest serial number as root
    - This is done by having each one broadcast its serial number, installed by the factory and unique worldwide.
    - The one with the lowest serial number becomes the root.
  - Then a tree of shortest paths from the root to every LAN is constructed.
  - Uses distributed algorithm to build spanning tree
  - It may happen that not all (ports of) the bridges are present, in order to remove loops.
  - This algorithm continues to run periodically, to automatically detect topology changes or failures in bridges.

28

Spanning Tree Bridges

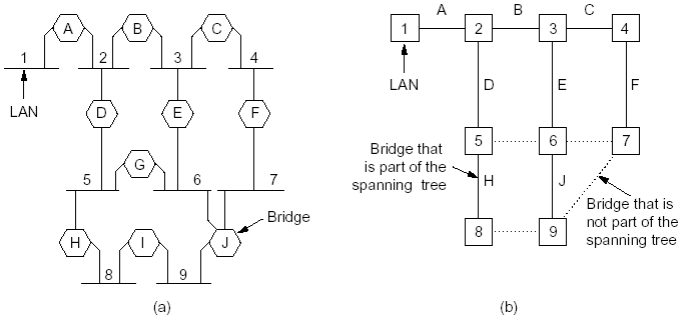


Fig. 4-40. (a) Interconnected LANs. (b) A spanning tree covering the LANs. The dotted lines are not part of the spanning tree.

Source Routing Bridges

- In standards CSMA/CD and Token Bus supporters like transparent bridge. Token Ring people liked source routing bridges.
  - Connectionless vs. connection-oriented in the LAN
  - Concern about waste of bandwidth from TR people.
- Source routing:
  - Set high order bit of source addr to 1 if dest off-LAN.
  - Insert into the frame (Routing Information Field) the entire route from source to dest... L1,B1,L2,B2,L3
  - SR bridge scans the list until it finds LAN on which frame arrived.

Source Routing

- Source routing (Continued):
  - If next field is its own bridge number, then forwards to next LAN...otherwise discards frame.
  - NOTE depends on every terminal being able to find a good path to every other terminal in the interconnected LAN network.
  - To get routes, source broadcasts a discovery frame that is forwarded by every bridge in the network. Every destination terminal responds and bridges insert their numbers into the response. Source generally picks the route contained in the quickest response.

31

Ex.: Discovery Frame Explosion

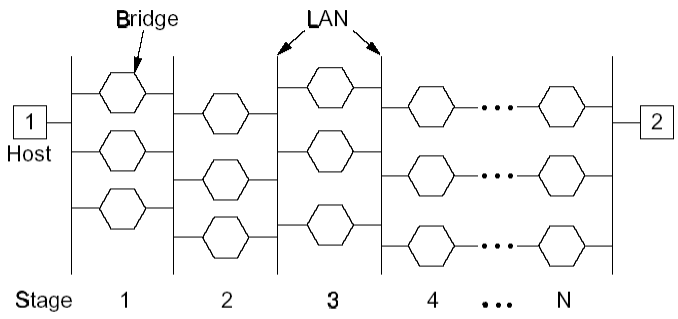


Fig. 4-41. A series of LANs connected by triple bridges.

32

Transparent vs. Source Routing

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.

33

High Speed LANS

- FDDI (Fiber Distributed Data Interface):
  - a high-performance fiber optic token ring LAN running at 100 Mbps over distances up to 200 km with up to 1000 stations connected.
  - A common use for it is as a **backbone** to connect copper LAN's.
- Fast Ethernet was approved as 802.u by IEEE in 1995.
  - The basic idea was simple: keep all the old packet formats, interface and procedural rules
  - Just reduce the bit time from 100 ns to 10 ns, to reach 100 Mbps

34