IEEE802.3 Medium Access Control

- Random Access
  - Stations access medium randomly
- Contention
  - Stations content for time on medium

CSMA

- Propagation time is much less than transmission time
- All stations know that a transmission has started almost immediately
- First listen for clear medium (carrier sense)
- If medium idle, transmit
- If two stations start at the same instant, collision
- Wait reasonable time (round trip plus ACK contention)
- No ACK then retransmit
- Max utilization depends on propagation time (medium length) and frame length
  - Longer frame and shorter propagation gives better utilization

If Busy?

- If medium is idle, transmit
- If busy, listen for idle then transmit immediately

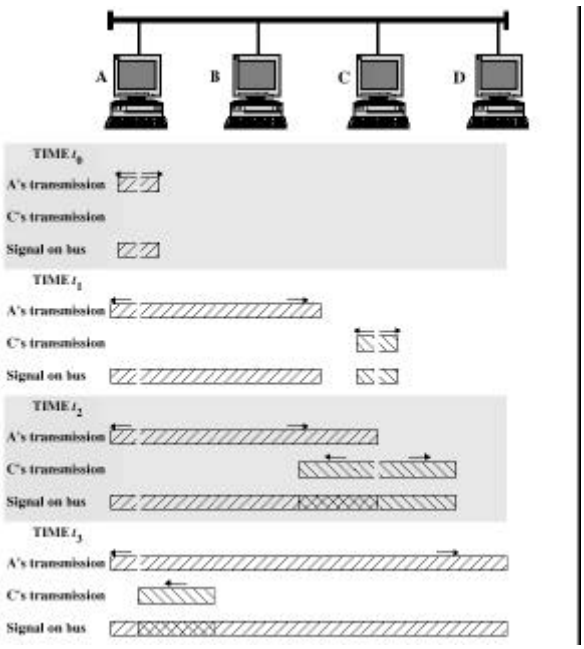
- If two stations are waiting, collision

CSMA/CD

- With CSMA, collision occupies medium for duration of transmission
- Stations listen whilst transmitting

- If medium idle, transmit
- If busy, listen for idle, then transmit
- If collision detected, jam then cease transmission
- After jam, wait random time then start again
  - Binary exponential back off

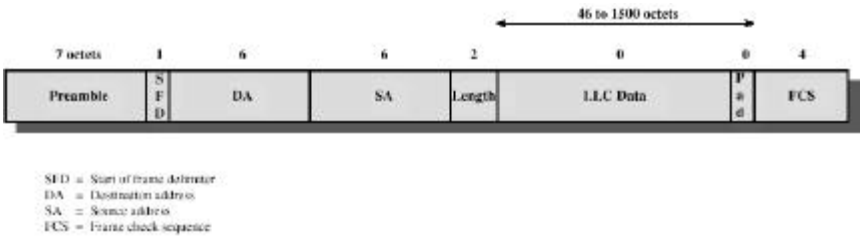
CSMA/CD Operation



Collision Detection

- On baseband bus, collision produces much higher signal voltage than signal
- Collision detected if cable signal greater than single station signal
- Signal attenuated over distance
- Limit distance to 500m (10Base5) or 200m (10Base2)
- For twisted pair (star-topology) activity on more than one port is collision
- Special collision presence signal

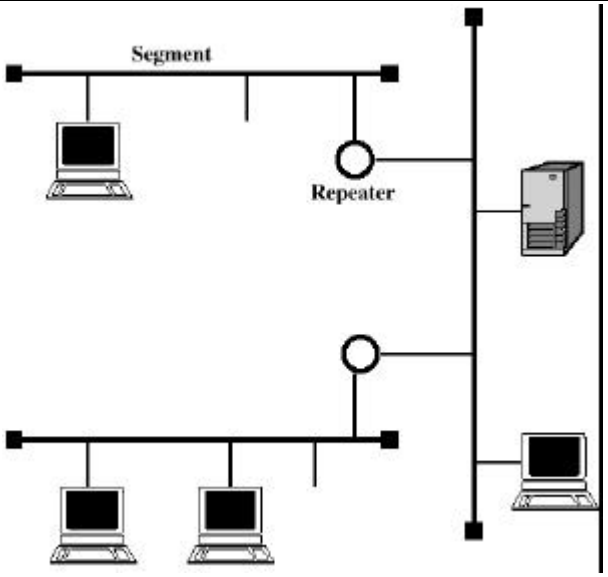
IEEE 802.3 Frame Format



Repeaters

- Transmits in both directions
- Joins two segments of cable
- No buffering
- No logical isolation of segments
- If two stations on different segments send at the same time, packets will collide
- Only one path of segments and repeaters between any two stations

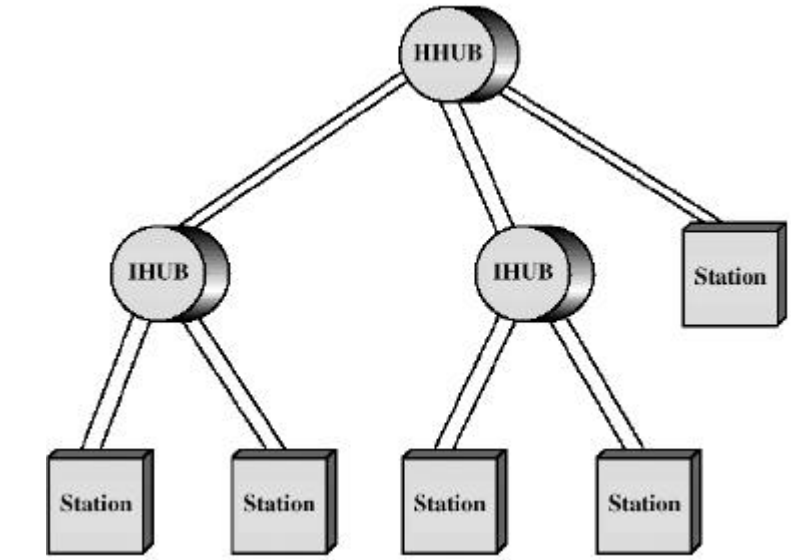
Baseband Configuration



Star LANs

- Use unshielded twisted pair wire (telephone)
  - Minimal installation cost
    - May already be an installed base
    - All locations in building covered by existing installation
- Attach to a central active hub
- Two links
  - Transmit and receive
- Hub repeats incoming signal on all outgoing lines
- Link lengths limited to about 100m
  - Fiber optic - up to 500m
- Logical bus - with collisions

Two Level Star Topology



Hubs and Switches

- Shared medium hub
  - Central hub
  - Hub retransmits incoming signal to all outgoing lines
  - Only one station can transmit at a time
  - With a 10Mbps LAN, total capacity is 10Mbps
- Switched LAN hub
  - Hub acts as switch
  - Incoming frame switches to appropriate outgoing line
  - Unused lines can also be used to switch other traffic
  - With two pairs of lines in use, overall capacity is now 20Mbps

Wireless LANs

- Mobility
- Flexibility
- Hard to wire areas
- Reduced cost of wireless systems
- Improved performance of wireless systems

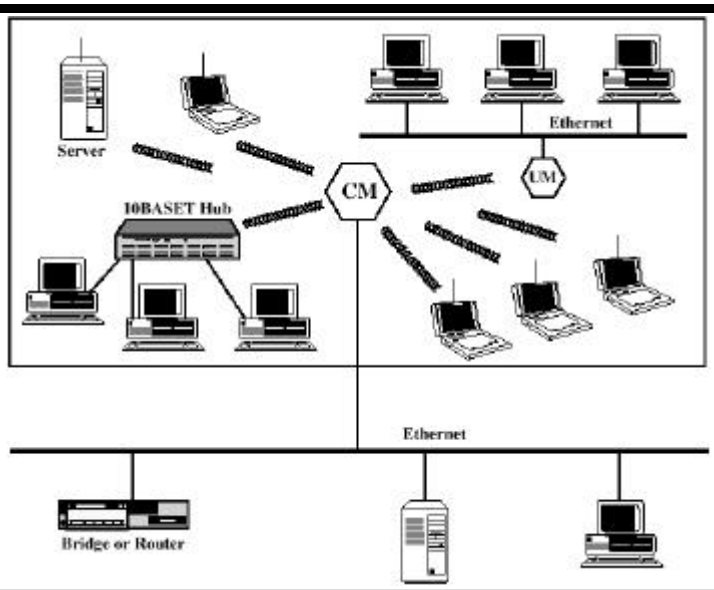
Wireless LAN Applications

- LAN Extension
- Cross building interconnection
- Nomadic access
- Ad hoc networks

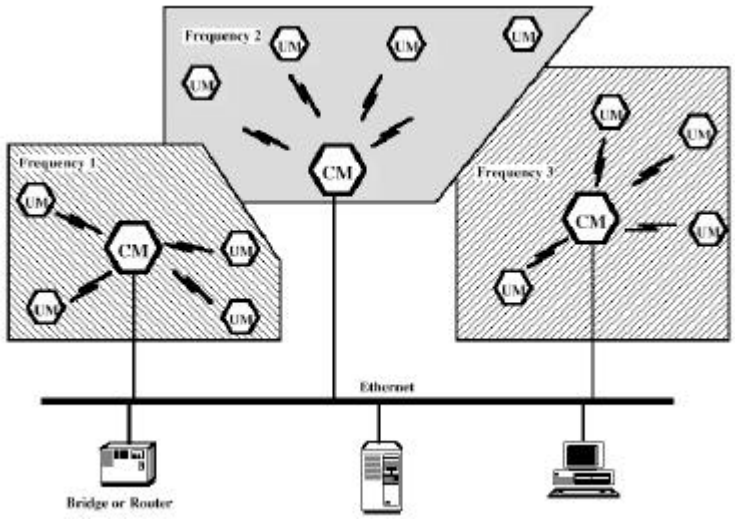
LAN Extension

- Buildings with large open areas
  - Manufacturing plants
  - Warehouses
- Historical buildings
- Small offices
- May be mixed with fixed wiring system

Single Cell Wireless LAN



Multi Cell Wireless LAN



Cross Building Interconnection

- Point to point wireless link between buildings
- Typically connecting bridges or routers
- Used where cable connection not possible
  - e.g. across a street

Nomadic Access

- Mobile data terminal
  - e.g. laptop
- Transfer of data from laptop to server
- Campus or cluster of buildings

Bridges

- Ability to expand beyond single LAN
- Provide interconnection to other LANs/WANs
- Use Bridge or router
- Bridge is simpler
  - Connects similar LANs
  - Identical protocols for physical and link layers
  - Minimal processing
- Router more general purpose
  - Interconnect various LANs and WANs
  - see later

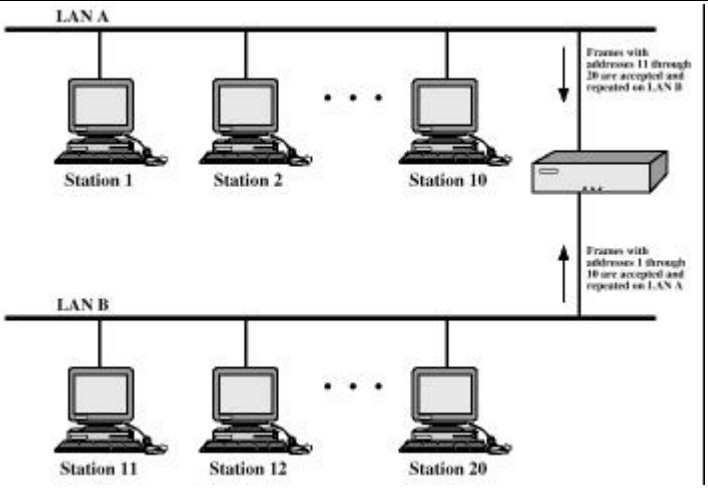
Why Bridge?

- Reliability
- Performance
- Security
- Geography

Functions of a Bridge

- Read all frames transmitted on one LAN and accept those address to any station on the other LAN
- Using MAC protocol for second LAN, retransmit each frame
- Do the same the other way round

Bridge Operation



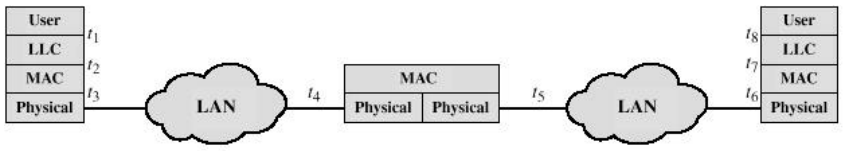
Bridge Design Aspects

- No modification to content or format of frame
- No encapsulation
- Exact bitwise copy of frame
- Minimal buffering to meet peak demand
- Contains routing and address intelligence
  - Must be able to tell which frames to pass
  - May be more than one bridge to cross
- May connect more than two LANs
- Bridging is transparent to stations
  - Appears to all stations on multiple LANs as if they are on one single LAN

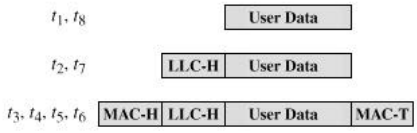
Bridge Protocol Architecture

- IEEE 802.1D
- MAC level
  - Station address is at this level
- Bridge does not need LLC layer
  - It is relaying MAC frames
- Can pass frame over external comms system
  - e.g. WAN link
  - Capture frame
  - Encapsulate it
  - Forward it across link
  - Remove encapsulation and forward over LAN link

Connection of Two LANs



(a) Architecture

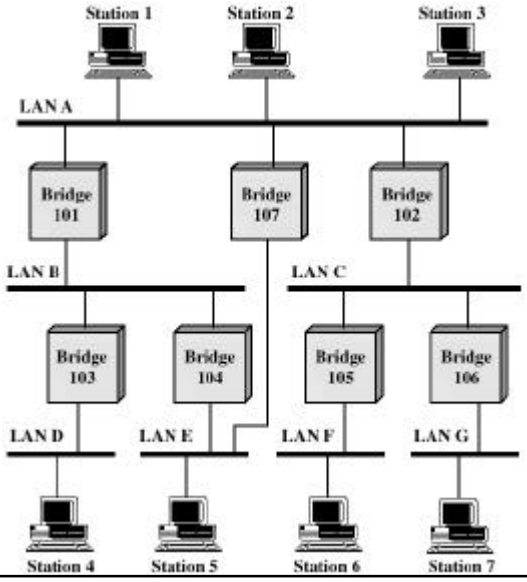


(b) Operation

Fixed Routing

- Complex large LANs need alternative routes
  - Load balancing
  - Fault tolerance
- Bridge must decide whether to forward frame
- Bridge must decide which LAN to forward frame on
- Routing selected for each source-destination pair of LANs
  - Done in configuration
  - Usually least hop route
  - Only changed when topology changes

Multiple LANs



Spanning Tree

- Bridge automatically develops routing table
- Automatically update in response to changes
- Frame forwarding
- Address learning
- Loop resolution

Frame forwarding

- Maintain forwarding database for each port
  - List station addresses reached through each port
- For a frame arriving on port X:
  - Search forwarding database to see if MAC address is listed for any port except X
  - If address not found, forward to all ports except X
  - If address listed for port Y, check port Y for blocking or forwarding state
    - Blocking prevents port from receiving or transmitting
  - If not blocked, transmit frame through port Y

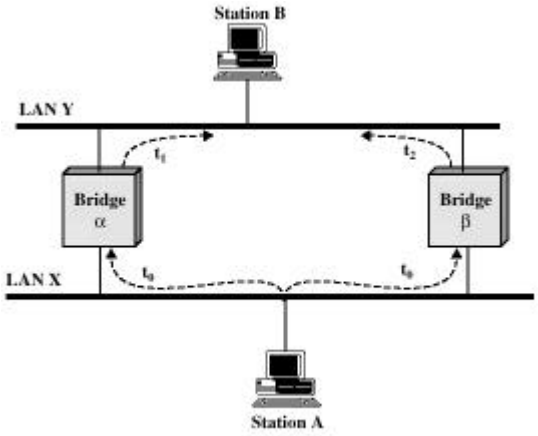
Address Learning

- Can preload forwarding database
- Can be learned
- When frame arrives at port X, it has come form the LAN attached to port X
- Use the source address to update forwarding database for port X to include that address
- Timer on each entry in database
- Each time frame arrives, source address checked against forwarding database

Spanning Tree Algorithm

- Address learning works for tree layout
  - i.e. no closed loops
- For any connected graph there is a spanning tree that maintains connectivity but contains no closed loops
- Each bridge assigned unique identifier
- Exchange between bridges to establish spanning tree

Loop of Bridges



LAN Generations

- First
  - CSMA/CD and token ring
  - Terminal to host and client server
  - Moderate data rates
- Second
  - FDDI
  - Backbone
  - High performance workstations
- Third
  - ATM
  - Aggregate throughput and real time support for multimedia applications

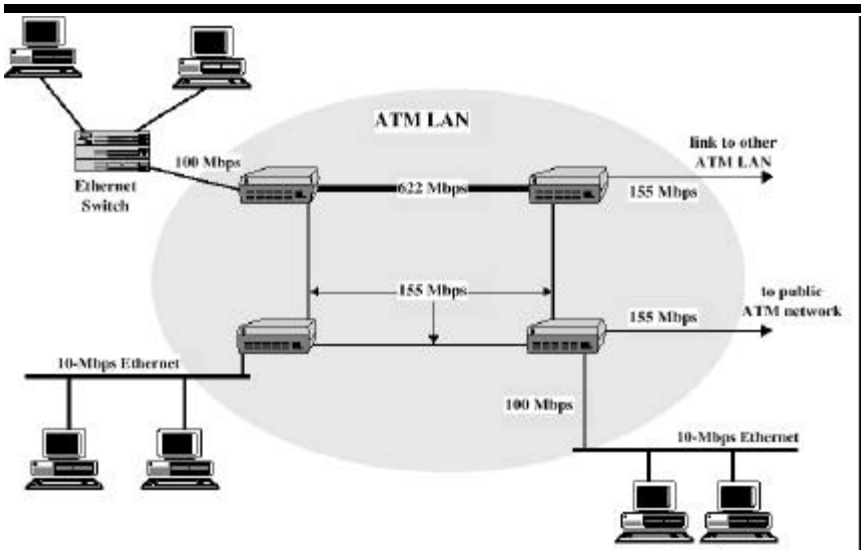
Third Generation LANs

- Support for multiple guaranteed classes of service
  - Live video may need 2Mbps
  - File transfer can use background class
- Scalable throughput
  - Both aggregate and per host
- Facilitate LAN/WAN internetworking

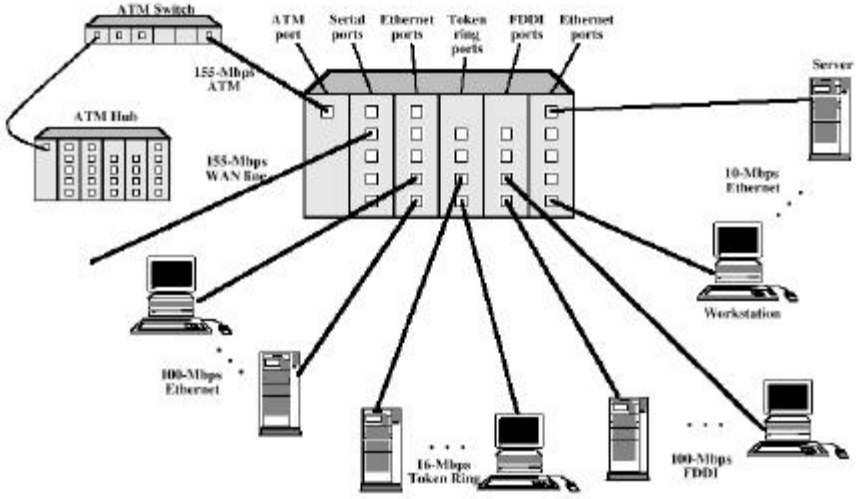
ATM LANs

- Asynchronous Transfer Mode
- Virtual paths and virtual channels
- Preconfigured or switched
- Gateway to ATM WAN
- Backbone ATM switch
  - Single ATM switch or local network of ATM switches
- Workgroup ATM
  - End systems connected directly to ATM switch
- Mixed system

Example ATM LAN



ATM LAN HUB



Compatibility

- Interaction between end system on ATM and end system on legacy LAN
- Interaction between stations on legacy LANs of same type
- Interaction between stations on legacy LANs of different types