Recent Advances in 100 Mbps LAN Technologies

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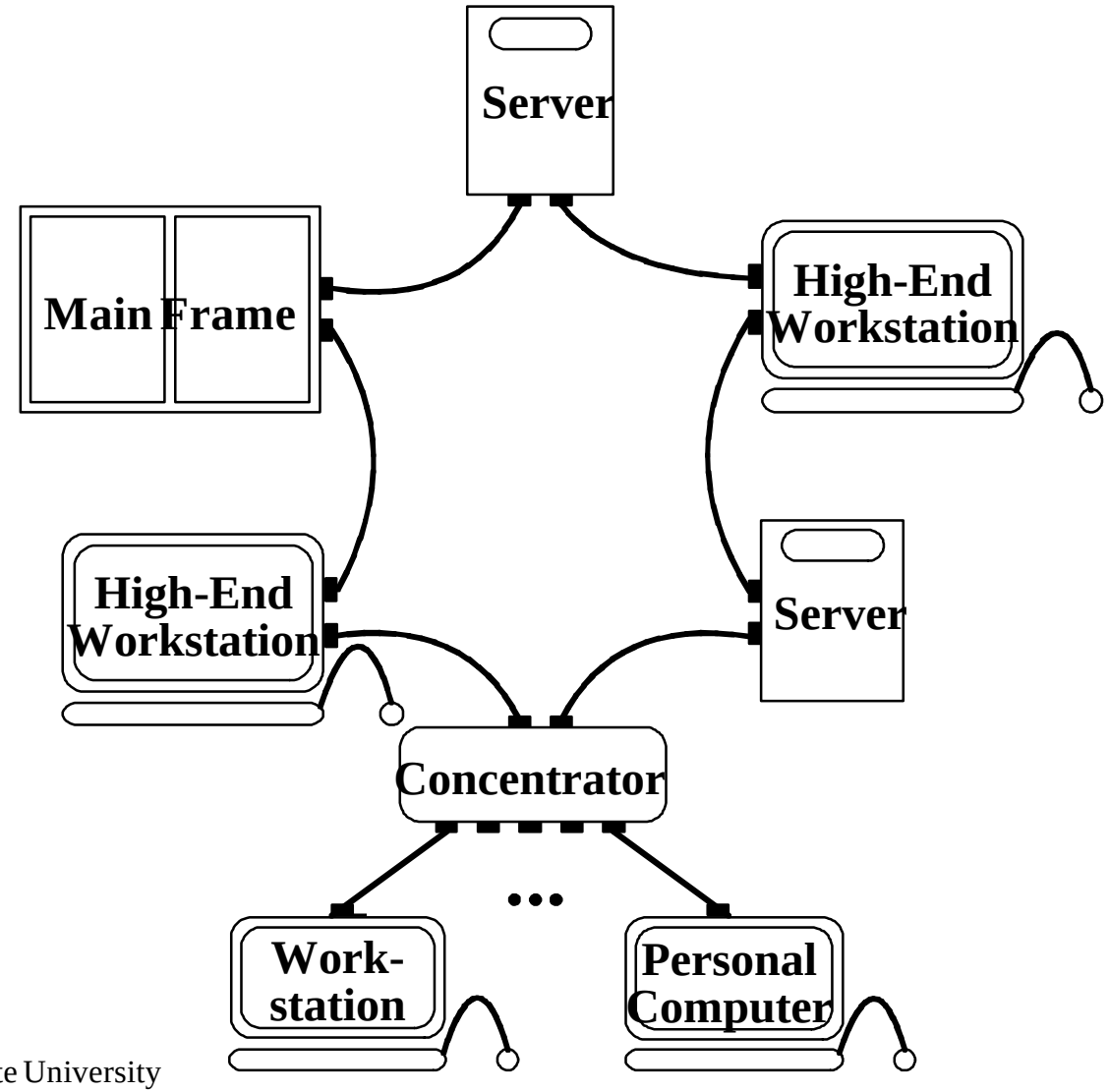
- FDDI, Copper FDDI
- 10 Mbps Ethernet
- IEEE 802.3 Notation: 10BASE5
- Repeater, hub, bridge, router
- 100 Mbps Ethernet
- 100VG-AnyLAN
- Switched, full duplex LANs, Virtual LANs

FDDI

- Fiber Distributed Data Interface
- ANSI Standard for 100 Mbps over Fiber and twisted pair
- Timed token access
- Up to 500 stations on a single FDDI network
- Inter-node links of up to 2km on multimode fiber, 60+ km on single mode fiber, Longer SONET links, 100 m on UTP.
- Round-trip signal path limited to 200 km $\Rightarrow$ 100 km cable.
- Maximum frame size is 4500 bytes.
- Eight priority levels
- Synchronous (guaranteed access delay) and asynchronous traffic
- Arranged as single- or dual-ring logical topology

Dual-Ring of Trees Topology

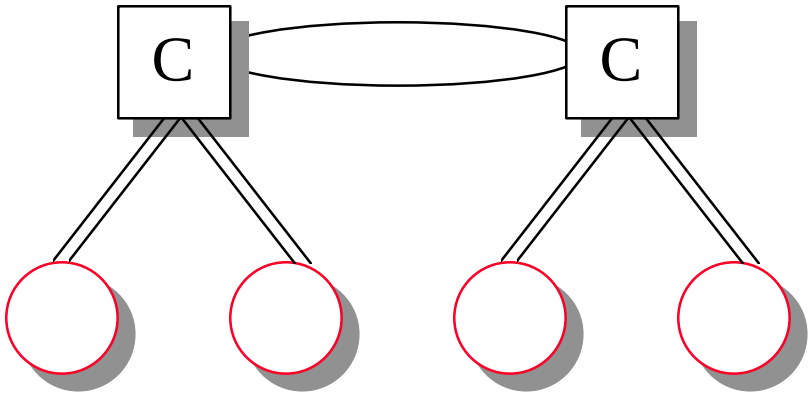


Timed Token Access

- Two classes of traffic: Synchronous, Asynchronous
- Asynchronous: Timed token access
- Stations agree on a target token rotation time (TTRT)
- Stations monitor token rotation time (TRT)
- A station can transmit TTRT-TRT
  =Token Holding Time (THT)
- Complete the frame if THT expires in the middle of a frame
- Release the token at the end of frame transmission
- If TRT>TTRT, Increment late count (LC)
- Reinitialize the ring if LC = 2
- Synchronous: ith station can transmit SAi (pre-allocated)

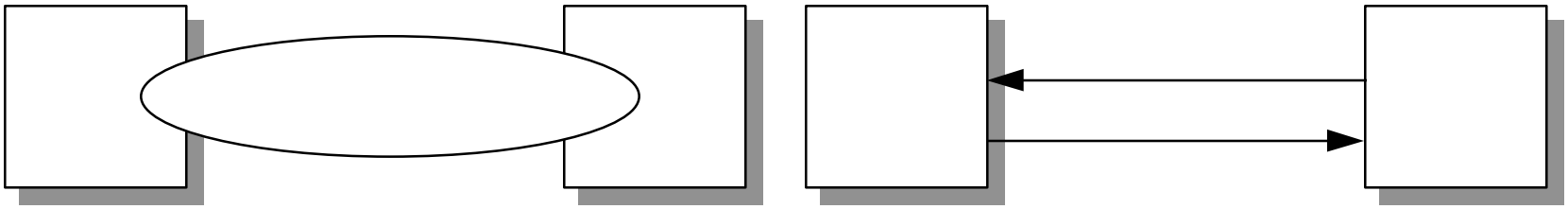
TP-PMD

- Twisted-Pair Physical Media Dependent
  = Copper FDDI or CDDI
- Allows 100 m over Cat-5 unshielded twisted pair (UTP)
  - **Cat-3**: 15 MHz Voice grade
  - **Cat-4**: 20 MHz
  - **Cat-5**: 100 MHz data grade
- Uses scrambling and 3-level encoding



Full Duplex FDDI

- The stations transmit and receive simultaneously.
- Works only on a 2-station ring.
- 200 Mbps.
- Network starts in ring mode.
- After detecting a two node ring using SMT frames, the stations negotiate and enter full duplex mode
- On error, stations enter the ring mode.
- Patented and licensed by Digital.



CSMA/CD

- Aloha at University of Hawaii:
  Transmit whenever you like
  Worst case utilization = 1/(2e) =18%
- Slotted Aloha: Fixed size transmission slots
  Worst case utilization = 1/e = 37%

- CSMA: Carrier Sense Multiple Access
  Listen before you transmit
- CSMA/CD: CSMA with Collision Detection
  Listen while transmitting. Stop if you hear someone else

Ethernet Media Access Protocol

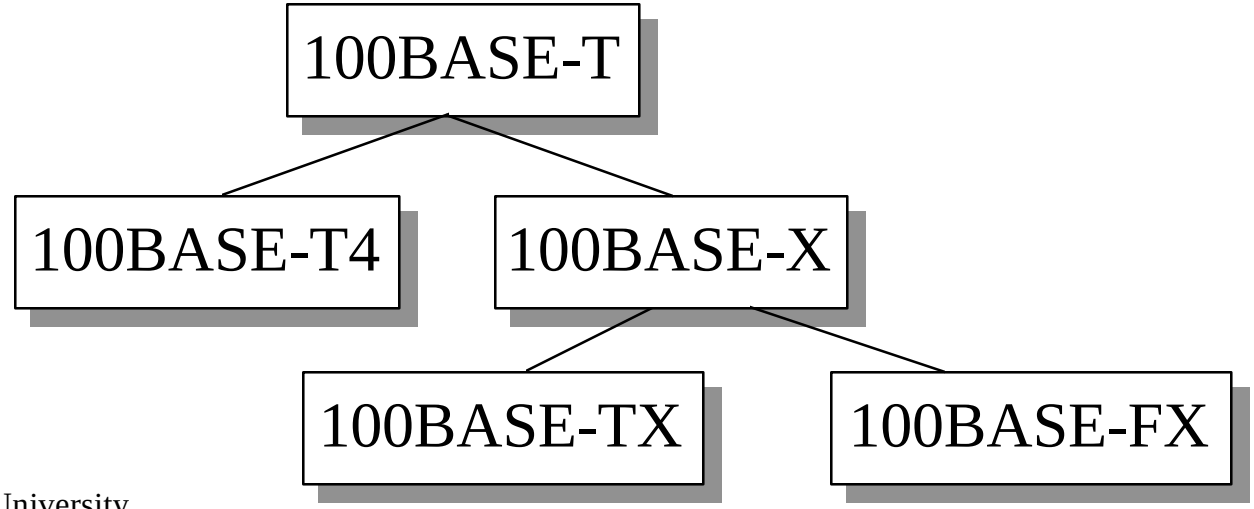
- If the medium is idle, transmit
- If the medium is busy, wait until idle and then transmit immediately.
- If a collision is detected while transmitting,
  - Transmit a jam signal for one slot (= 51.2 μs = 64 byte times)
  - Wait for a random time and reattempt (up to 16 times)
  - Random time = Uniform$[0,2^{\max(k,10)}]$ slots
- Collision detected by monitoring the voltage
  High voltage ⇒ two or more transmitters ⇒ Collision
  ⇒ Length of the cable is limited to 2.5 km

CSMA/CD PHY Standards

- **10BASE5:** 10 Mb/s over coaxial cable (ThickWire)
- **10BROAD36:** 10 Mb/s over broadband cable, 3600 m max segments
- **1BASE5:** 1 Mb/s over 2 pairs of UTP
- **10BASE2:** 10 Mb/s over thin RG58 coaxial cable (ThinWire), 185 m max segments
- **10BASE-T:** 10 Mb/s over 2 pairs of UTP
- **10BASE-FL:** 10 Mb/s fiber optic point-to-point link
- **10BASE-FB:** 10 Mb/s fiber optic backbone (between repeaters). Also, known as synchronous Ethernet.
- **10BASE-FP:** 10 Mb/s fiber optic passive star + segments
- **10BASE-F:** 10BASE-FL, 10BASE-FB, or 10BASE-FP

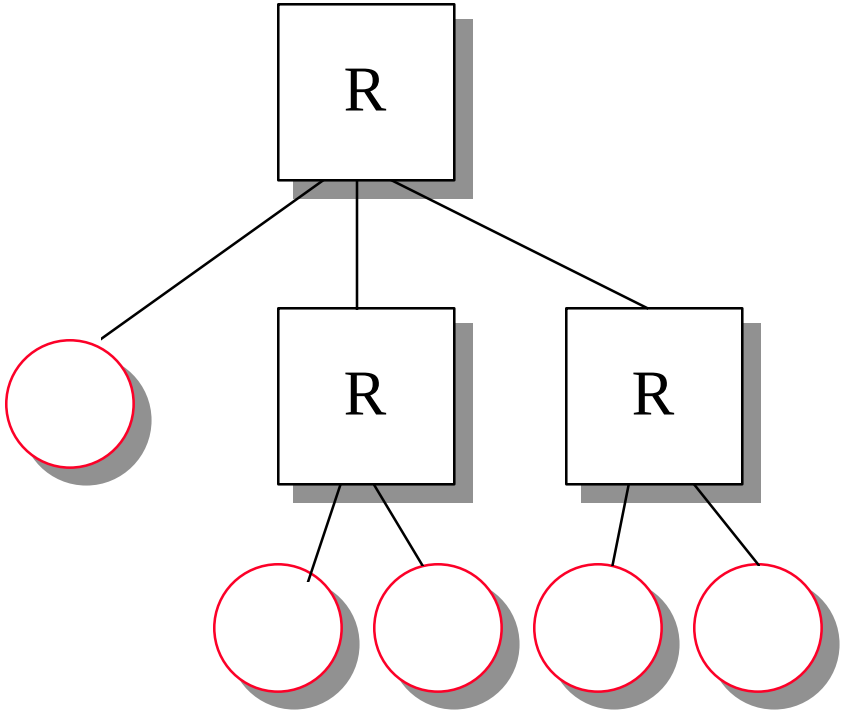
Fast Ethernet Standards

- **100BASE-T4:** 100 Mb/s over 4 pairs of CAT-3, 4, 5 UTP
- **100BASE-TX:** 100 Mb/s over 2 pairs of CAT-5 UTP or STP
- **100BASE-FX:** 100 Mbps CSMA/CD over 2 optical fiber
- **100BASE-X:** 100BASE-TX or 100BASE-FX
- **100BASE-T:** 100BASE-T4, 100BASE-TX, or 100BASE-FX



10BASE-T

- Collision detected by the hub.
- Activity on two or more channels ⇒ Collision
  Collision presence (CP) transmitted by hub to all stations
  Collision window = 2X One-way delay between farthest stations

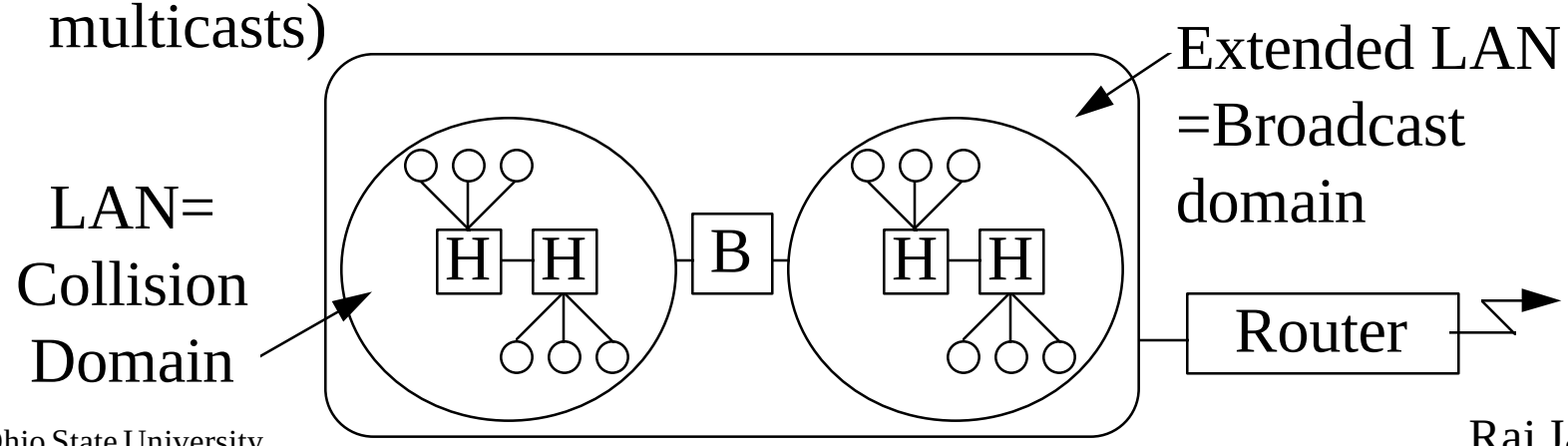


Hub Functions

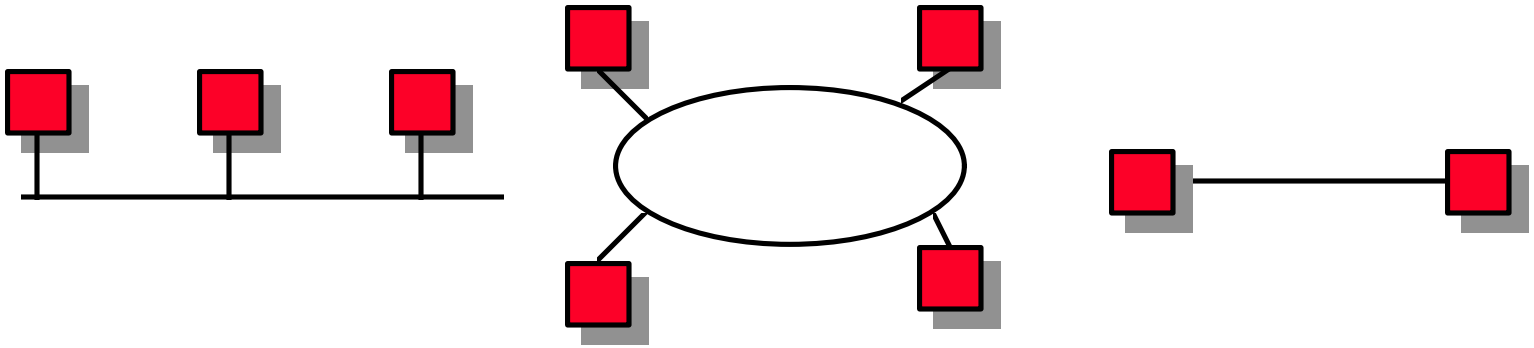
- Signal Restoration (timing and amplitude)
- Data forwarding
- Collision detection (by monitoring receive ports)
- Jam signal propagation to all ports
- Fault detection and recover: autopartition and restore

Interconnection Devices

- **Repeater**: PHY device that restores data and collision signals
- **Hub:** Multiport repeater + collision detection, notification and signal broadcast
- **Bridge:** Datalink layer device connecting two or more collision domains
- **Router:** Network layer device (does propagate MAC multicasts)



Distance-Bandwidth Tradeoff



- Efficiency = Maximum throughput/Media bandwidth
- Efficiency is a decreasing function of α

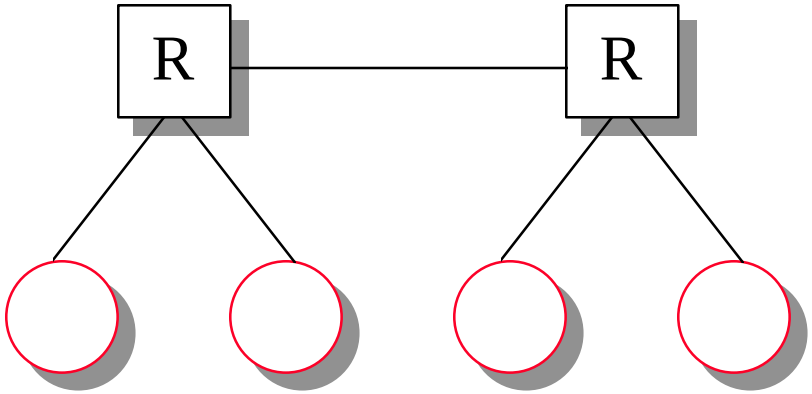
  = Propagation delay /Transmission time

  = (Distance/Speed of light)/(Transmission size/Bits/sec)

  = Distance × Bits/sec/(Speed of light)(Transmission size)
- Bit rate-distance-transmission size tradeoff.
- **Options for 100 Mbps**: Change the protocol, Increase the min/max frame size by 10, *decrease the distance by 10*

Fast Ethernet

- Same access method (CSMA/CD) as in Ethernet
- Same frame sizes (64 B to 1518 B) as in Ethernet
- Ten times faster. Ten times shorter.
- Extent = 2.5 km (10 Mbps) 205 m (100 Mbps)

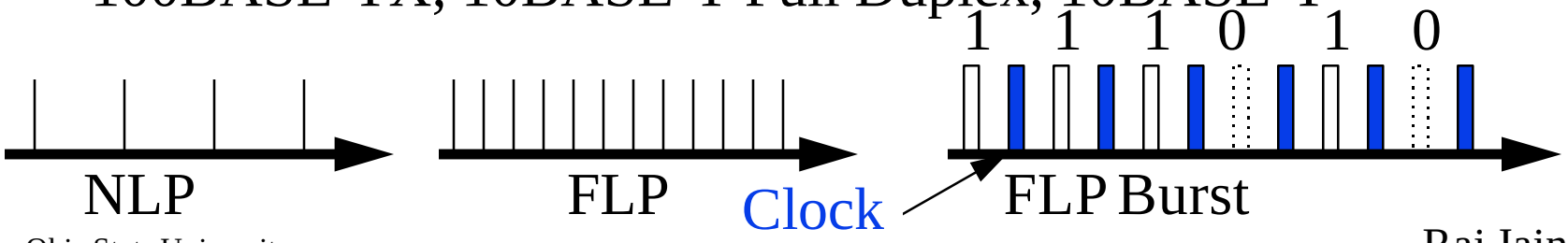


Ethernet vs Fast Ethernet

	Ethernet	Fast Ethernet
Speed	10 Mbps	100 Mbps
MAC	CSMA/CD	CSMA/CD
Network Diameter	2.5 km	205 m
Topology	Bus, Star	Star
Cable	Coax, UTP, Fiber	UTP, Fiber
Standard	802.3	802.3
Cost	X	2X

Autonegotiation: Nway Protocol

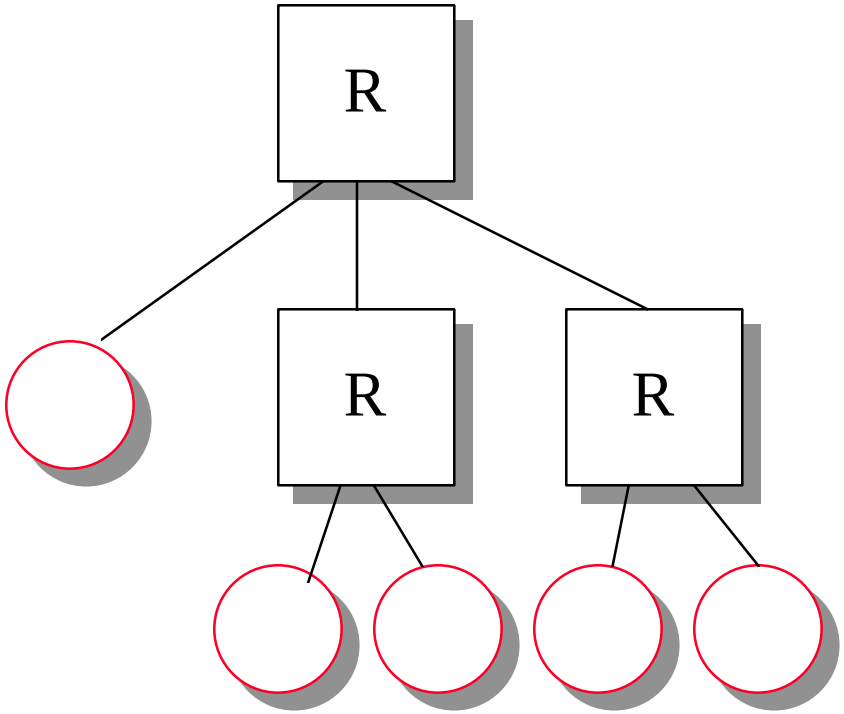
- Allows selection of 10 Mbps, 100 Mbps, full duplex modes
- Modified 10BASE-T link integrity pulse test
- Integrity test allowed devices to advertise abilities and ack common modes of operation
- On power-on transmit a burst of 10BASE-T pulses containing "link codeword"
- Normal link pulse (NLP) ⇒ 10BASE-T
- Fast link pulse (FLP) ⇒ 100BASE-T
- Priority Order: 100BASE-TX Full Duplex, 100BASE-T4, 100BASE-TX, 10BASE-T Full Duplex, 10BASE-T



100VG-AnyLAN: Key Features

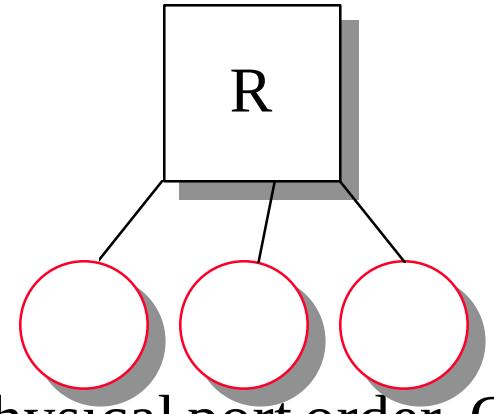
- IEEE 802.12 standard. Also known as 100BASE-VG.
- **AnyLAN**:
  ⇒ Supports both Ethernet and token ring frame formats
  - Only one format in any LAN
  - Allows 10BASE-T and Token ring wiring infrastructure
  - 2.5 km network diameter
  - Can use LLC Type 1 or 2
  - Allows little-endian and big-endian bit order

  ⇒ Simple speed-matching bridges
- Priorities: Normal and High ⇒ Multimedia
- Multi-level Configuration



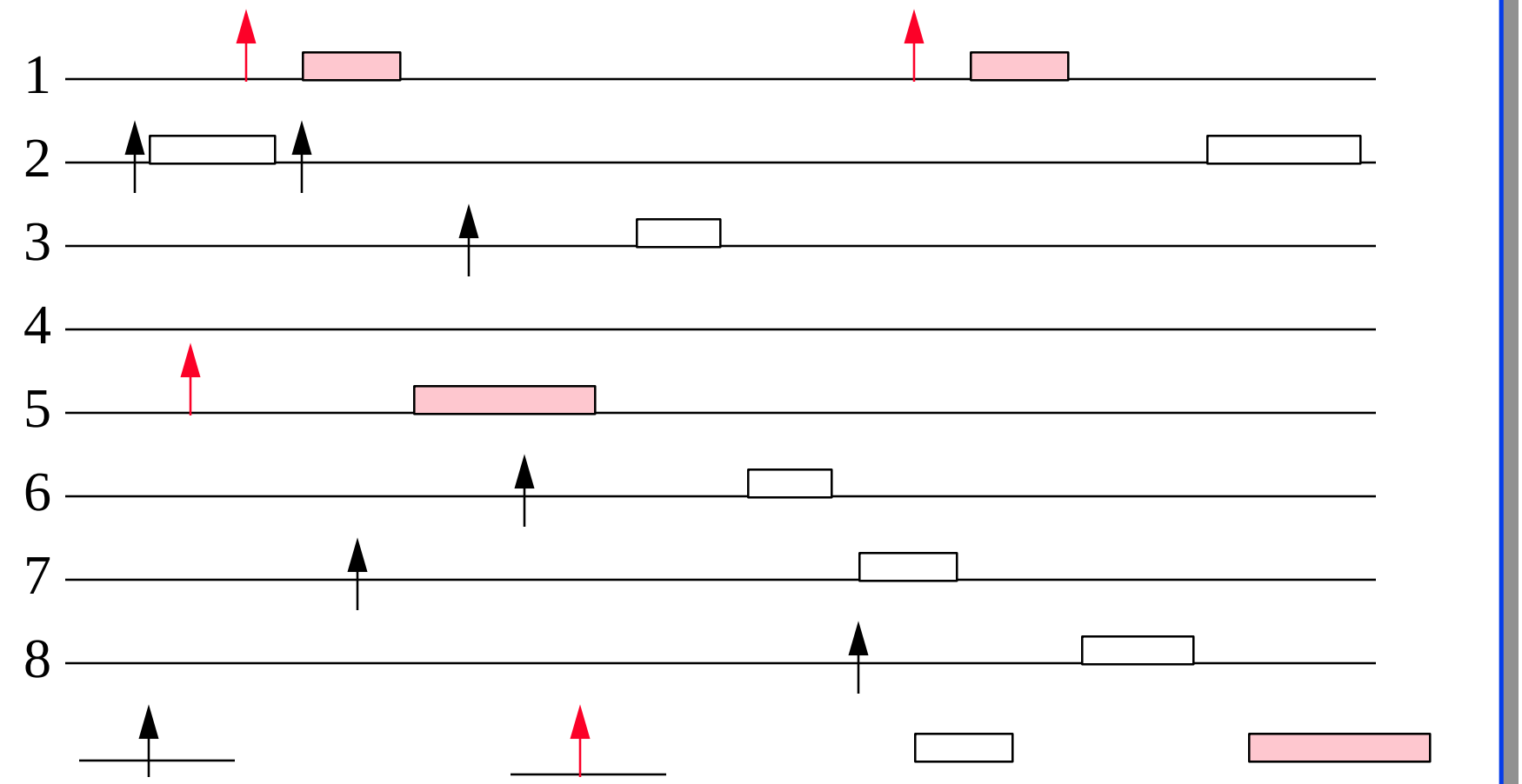
- Store-and-forwarding repeaters.
  Repeaters monitor destination address.
- **Privacy**: Unicast packets not delivered to other end-nodes.
- All repeaters and promiscuous nodes hear all traffic.
- End-nodes can be in private mode or promiscuous mode
- Uses centralized "demand priority protocol"

Demand Priority Protocol



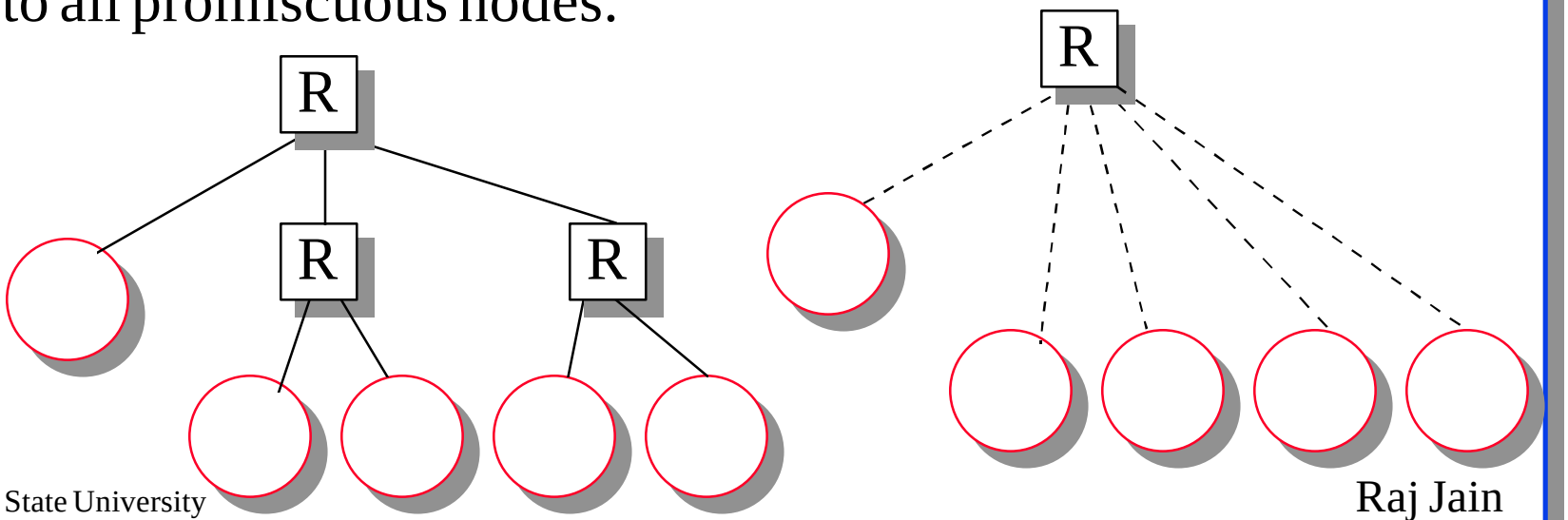
- Round-robin in physical port order. One packet per grant
- Two Priorities: Normal and High
  - Higher priority requests preempt normal priority *round*
  - Higher priority requests served after current normal priority packet *finishes*. No preemption.
  - After 200ms to 300 ms, normal priority request becomes higher priority. No starvation.
  - Repeaters remember the next-node to poll

Demand Priority Example



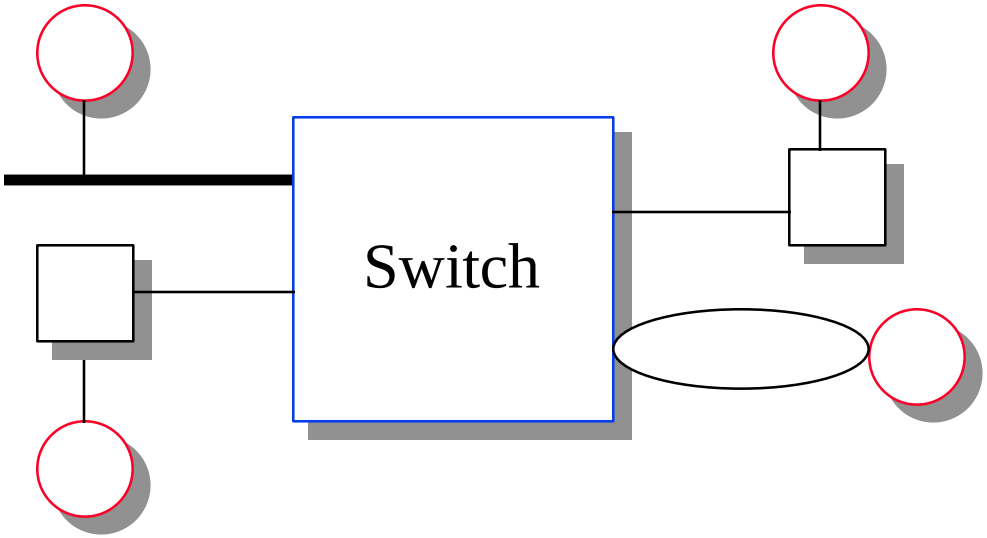
Cascaded Networks

- Repeaters send request upwards.
- Root grants requests to repeaters.
- Repeater keeps privilege for one round-robin cycle.
- Network acts like a large single-repeater network.
- Packets to attached nodes are sent directly to that node.
- All packets are always forwarded to all other repeaters and to all promiscuous nodes.

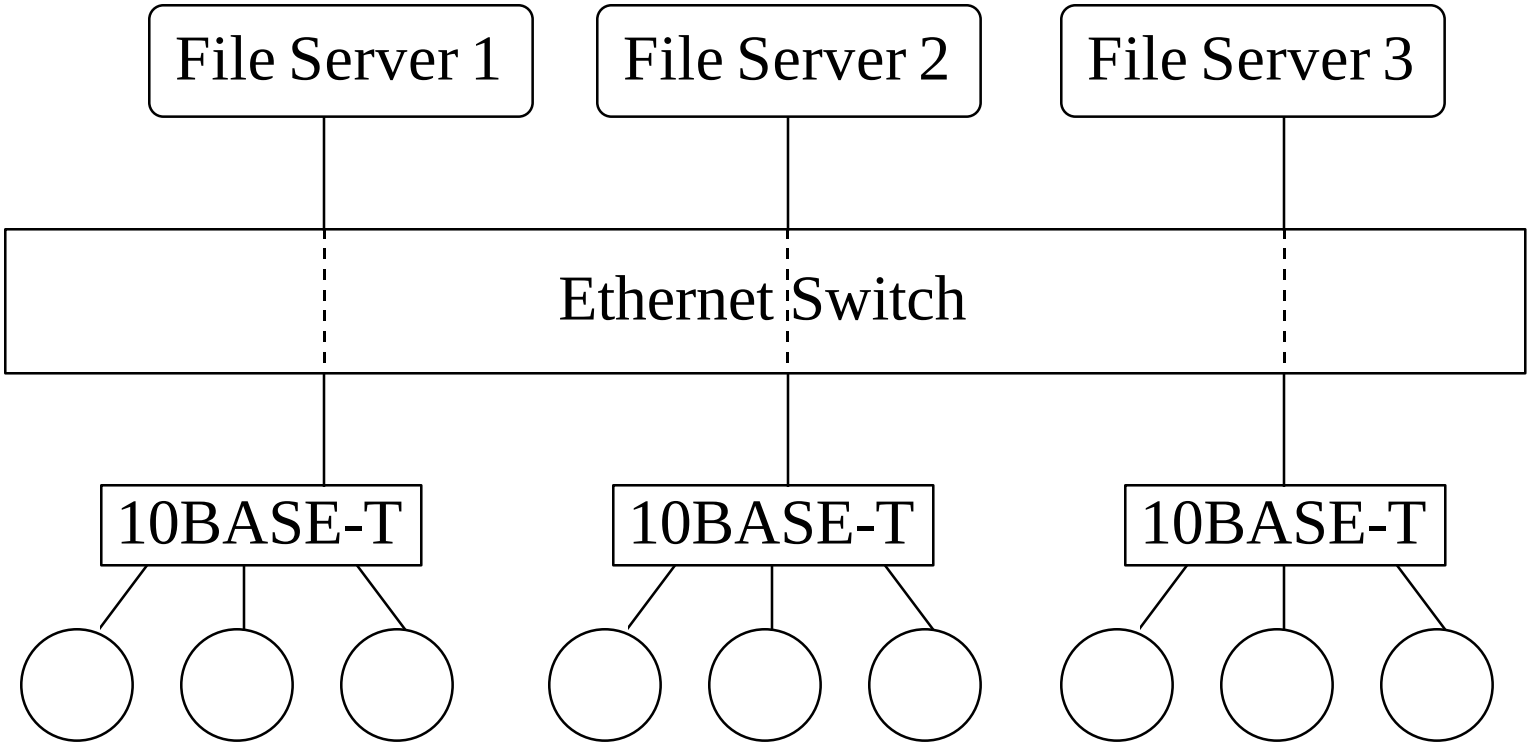


Switched LANs

- LANs connected to a switch
- Switch = Multiport bridge
- Many simultaneous flows possible
- 10 Mbps dedicated per node possible.
- 20 Mbps dedicated possible with full-duplex links
- Virtual LANs possible



Virtual LANs



LANs: Summary

	100VG-AnyLAN	100BASE-T4	100BASE-TX	TP-PMD	10BASE-T
Cat-5 Links	200	100	100	190	100+
Network Diameter	2,000m	250m	250m	N/A	2,500m
Cat-3 Links	100m	100m	Not supported	Not supported	100m
# of pairs	4 (2 on STP)	4	2	2	2,4
10/100 support	Yes	Yes	Yes	N/A	N/A
Cost	1.5X	1.5X	1.5X	5X	X
Standard	802.12	802.3u	802.3u	TP-PMD	802.3i

Acronyms

- AUI Attachment Unit Interface
- Cat-3 Category 3 Cable
- Cat-4 Category 4 Cable
- Cat-5 Category 5 Cable
- CRC Cyclic Redundancy Check
- DTE Data Terminal Equipment
- FCS Frame Check Sequence
- FDDI Fiber Distributed Data Interface
- FEXT Far-end Crosstalk
- FIFO First-in first out
- FOIRL Fiber Optic Inter-Repeater Link

- FLP Fast Link Pulse
- FOMAU Fiber Optic Medium Attachment Unit
- FOMDI Fiber Optic Media Dependent Interface
- FOPMA Fiber Optic Physical Medium Attachment
- HH Header Hub
- IH Intermediate Hub
- IPG Inter-packet Gap
- IRL Inter-Repeater Link
- LAN Local Area Network
- LLC Logical Link Control
- MAC Medium Access Control
- MAU Medium Attachment Unit
- MDI Medium Dependent Interface

- MIB — Management Interface Base
- MII — Media independent interface
- NEXT — Near-end Crosstalk
- NLP — Normal Link Pulse
- NRZI — Non-return to Zero and invert on ones
- PCS — Physical Coding sublayer
- PHY — Physical Layer Device Sublayer
- PLS — Physical signaling sublayer
- PMA — Physical Medium Attachment
- PMD — Physical Medium Dependent
- PMI — Physical Medium Independent
- SSD — Start of Stream Delimiter
- SFD — Start of Frame Delimiter

- STP Shielded Twisted Pair
- UTP Unshielded Twisted Pair

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