Introduction to Ethernet

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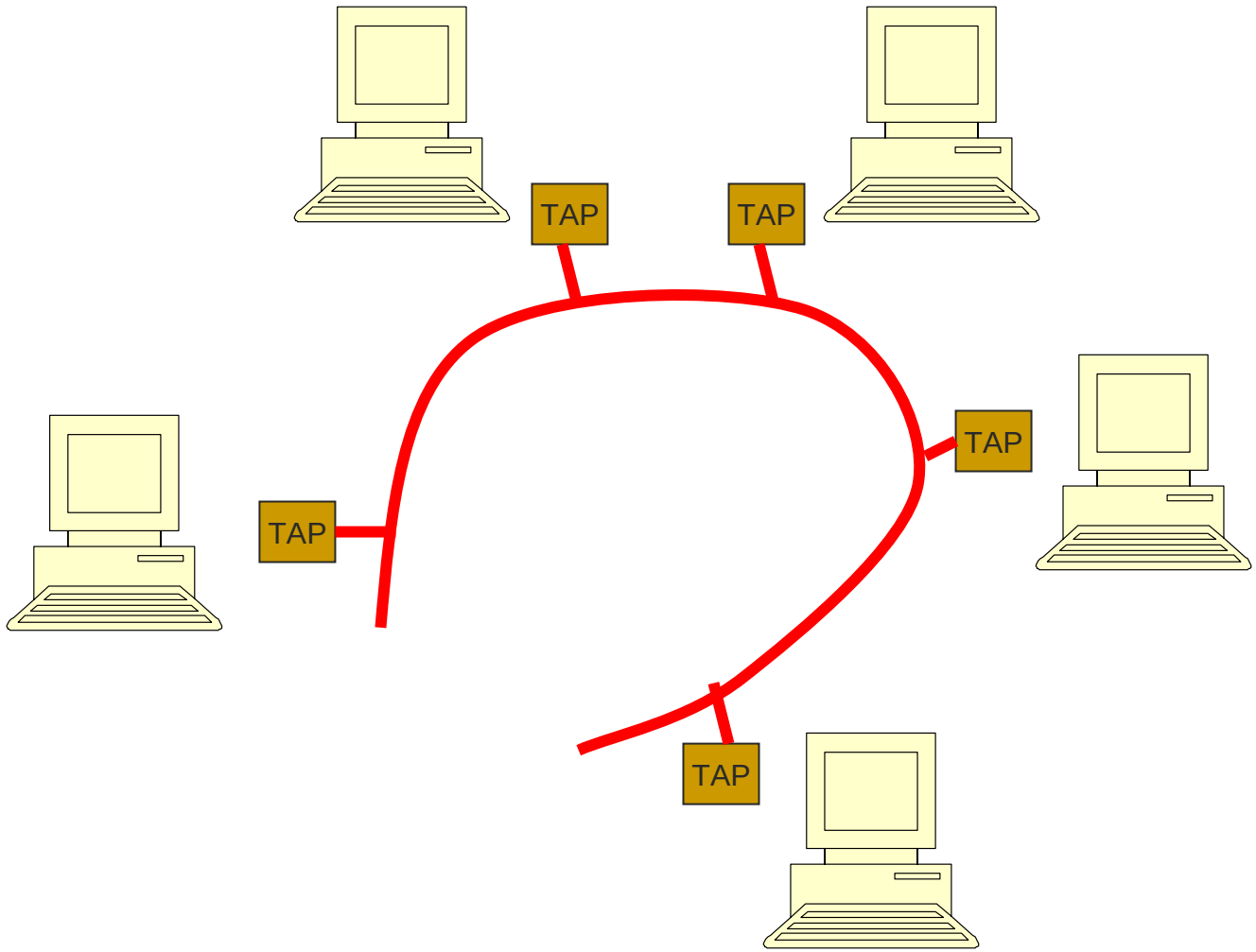
What is Ethernet?

- Local area transport protocol
- Layer 2 of the OSI stack
- Zero/minimal configuration
- Low-cost, high performance
- Best-effort delivery

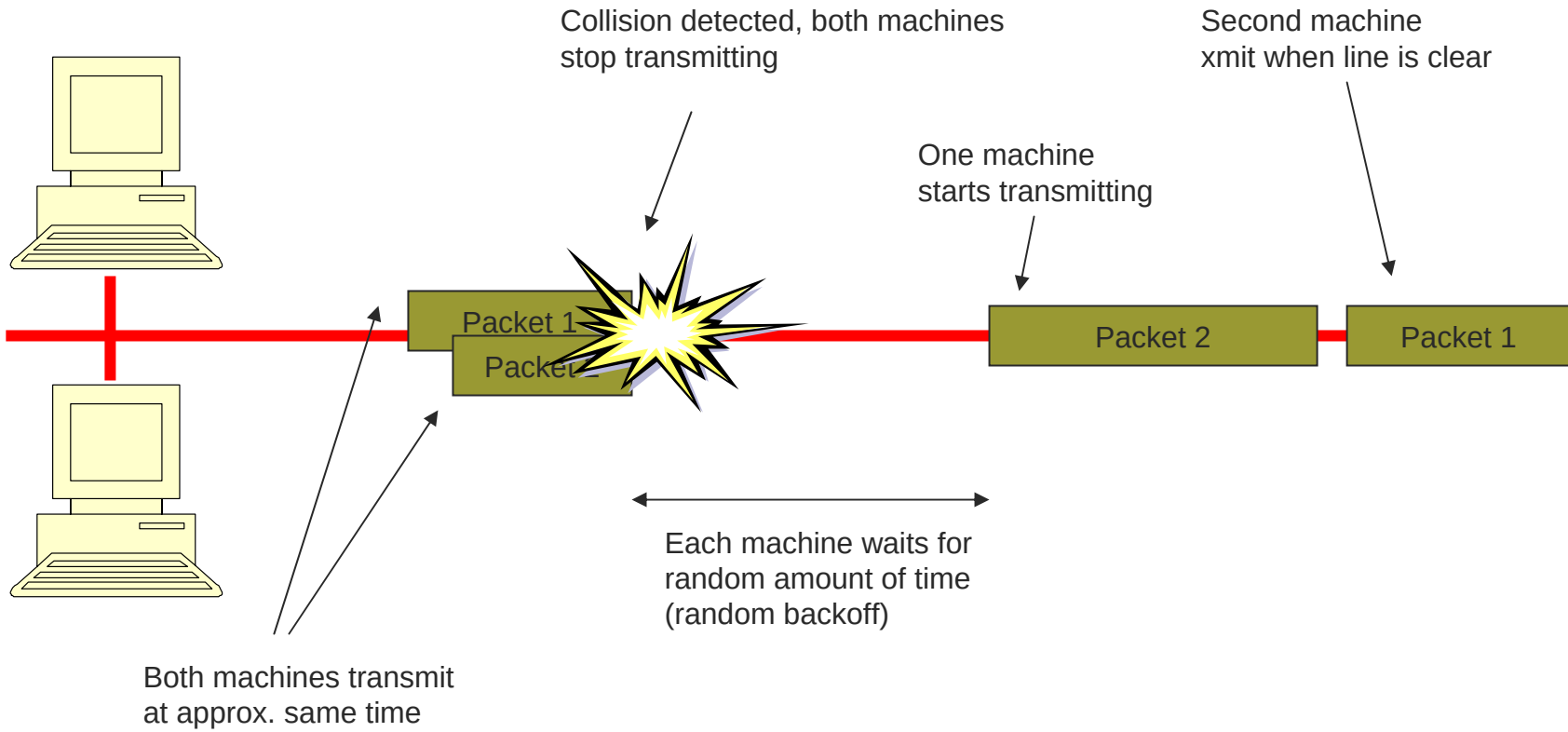
Original – Shared Wire



History of Ethernet

- Important to understand historical configuration to know how modern ethernet works
  - Modern bridges are still required to act as if all traffic was sent over a single shared wire
- Original configuration was a shared wire
- All communication is half-duplex
- Need some form of arbitration
- Early competitor was TokenRing

Collision Detection



Collision Detection

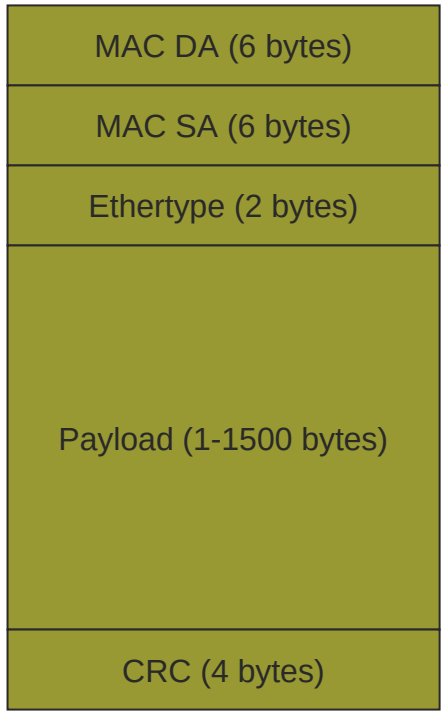
- Ethernet wire arbitration is by collision detection
  - Listen to see if line is clear
  - Wait X amount of time after last transmitter is heard
  - Start transmitting
  - Use electrical detection to determine if another station transmitting at same time
  - If collision is detected, wait semi-random amount of time and transmit packet again
- End stations keep trying until they succeed

Addressing

- Original ethernet is inherently broadcast
  - All stations receive all traffic
  - Stations use addressing to separate out their own traffic
  - Traffic for other stations is discarded
- Each device has a unique 48-bit MAC address assigned by manufacturer
  - IEEE hands out blocks of addresses so that MAC addresses are globally unique
- Some special unique addresses exist
  - Broadcast address is all ‘1’s
  - Multicast address is MAC DA bit 40 equal to 1

Packet Format

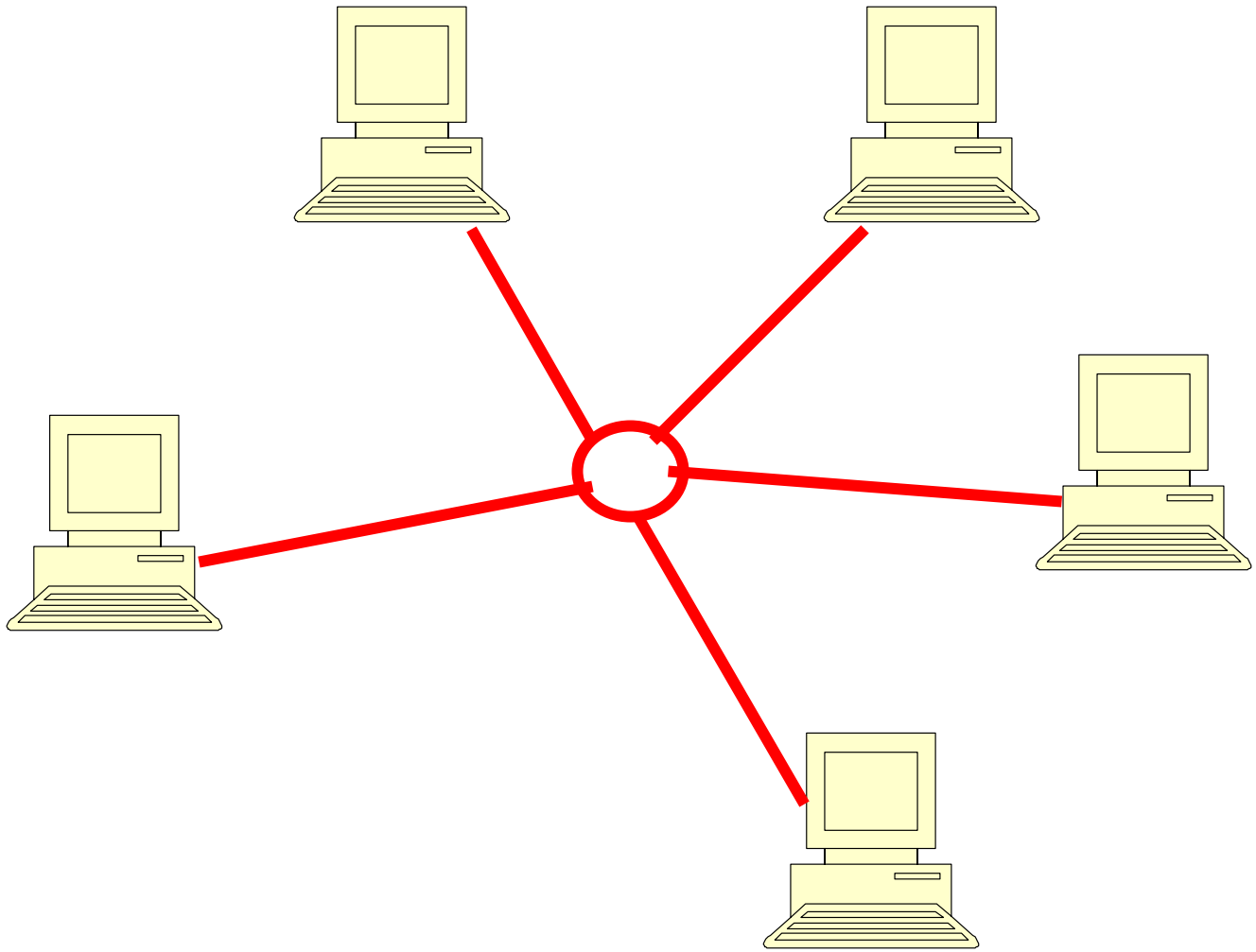
- Simple packet format
- Contains destination address and source address
- Destination address may be broadcast/multicast address
- Source address is always address of sender
- Minimum packet size is 64 bytes
- Max size is 1518 bytes, but longer packets are possible (jumbo frames)



Ethernet Today

- Modern network topologies bear little resemblance to original ethernet
- Half-duplex operation nearly dead
- Networks are now bridged and/or routed
- However, *original semantics are retained*:
  - Zero configuration by end stations
  - An endstation can broadcast to all other stations

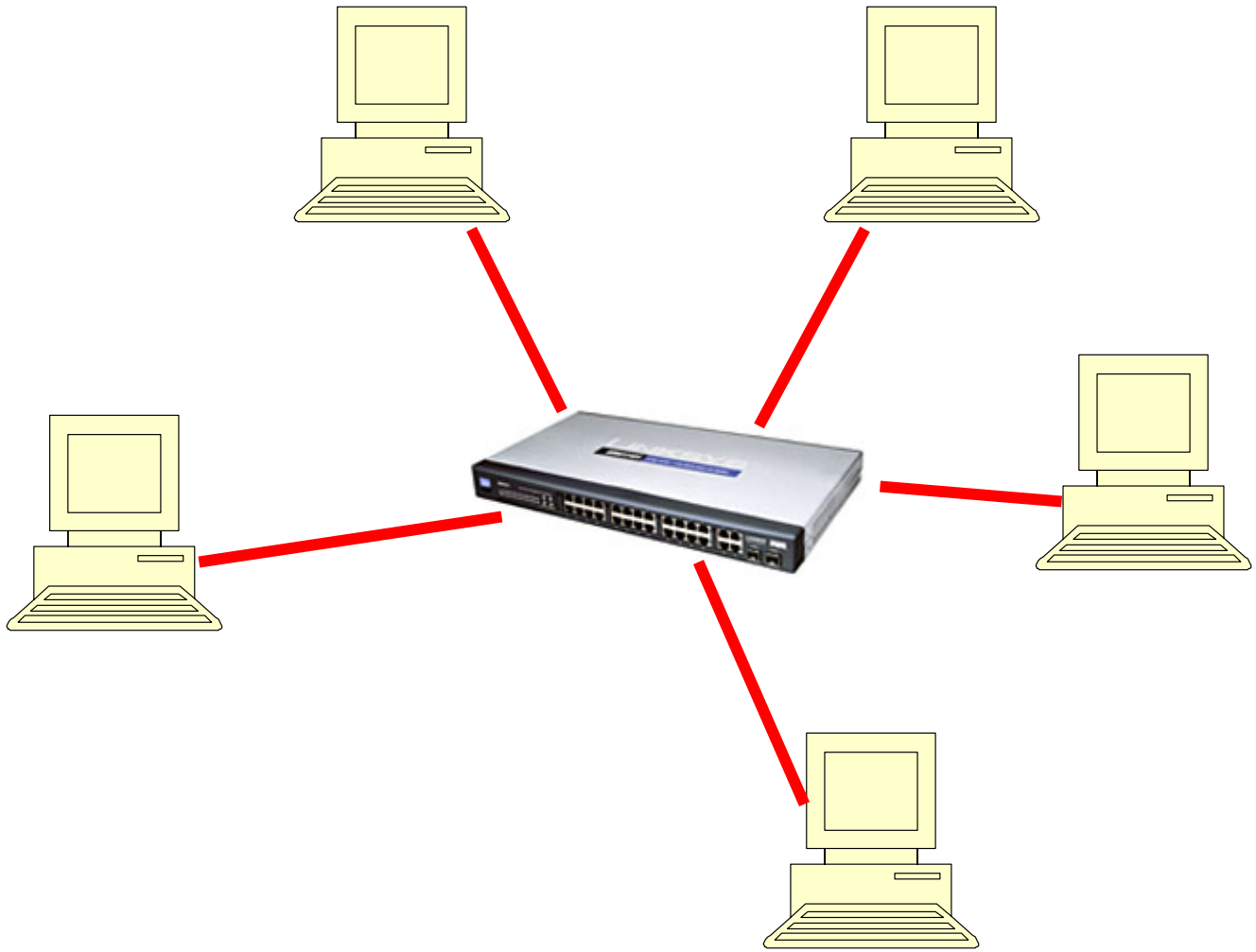
Hub Network



First Generation - Hubs

- Ethernet networks move from original 1 Mb networks over coaxial wire to 10 Mb networks running over twisted-pair wire
- Topology goes from ring to hub-and-spoke
- Device at the center is called a “hub”
  - Original hubs are analog devices which broadcast received signals to all receivers
  - All ports must run at the same speed
  - Hubs become more complex over time
  - Logically network still looks like a wire – all stations receive every packet

Bridged Network



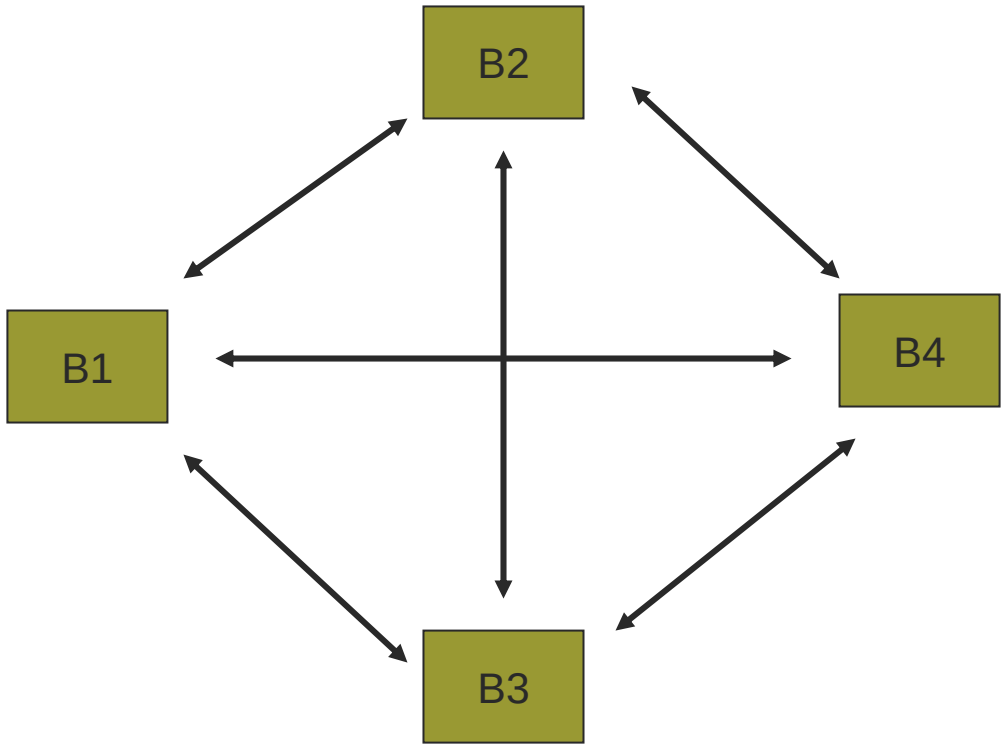
Switching Hubs

- New device, called “switching hub”, evolves from hubs
  - Sometimes called a “switch”, although term is ambiguous
  - Fully buffers packets
  - Operates full duplex (can receive and transmit at same time)
  - Remembers addresses and sends traffic only to those ports
  - No configuration (usually)
  - Different ports can run at different speeds
- Limitations
  - No loops are allowed in topology
  - No redundancy
  - Ports can be oversubscribed
  - No priority in packets which are dropped

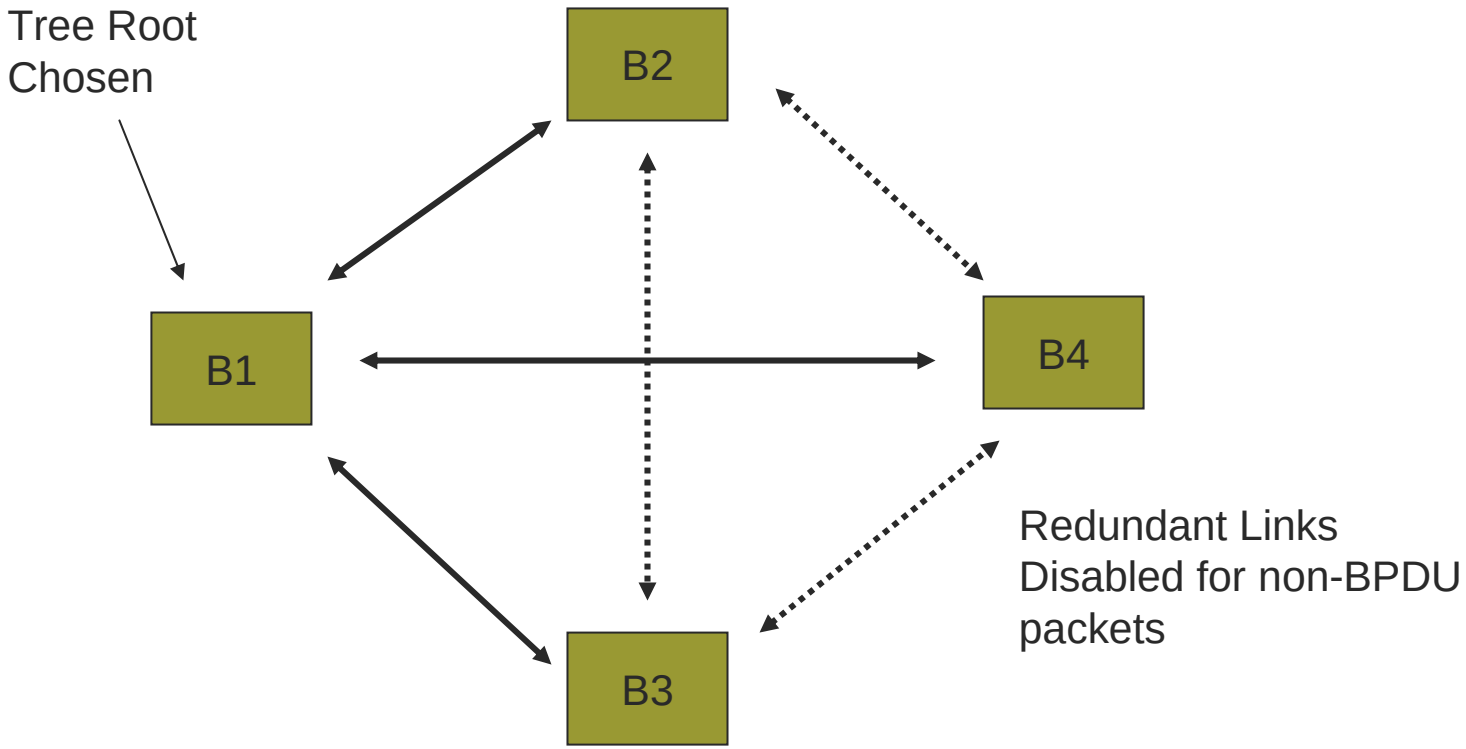
Bridges

- Bridges evolve from switching hubs
- “Smart” devices capable of being configured
- IEEE 802.1D specifies operation of bridges
- Can have loops in topology, allowing for redundancy
- Protocol detects loop ports and cuts off links
  - Inter-bridge packets are called “BPDUs” (Bridge Protocol Data Units)
- Protocol called “spanning tree” (STP)
- Newer version is Rapid Spanning Tree (RSTP)

Spanning Tree Operation



Spanning Tree Operation



Summary

- Bridged networks still obey semantics of original Ethernet
- Connections between two bridged networks must be done by a router, at layer 3
- Complex devices may combine bridging and routing in one box, but operations are logically distinct

Protocol - GMII

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Introduction

- Ethernet MACs use a variety of electrical protocols to communicate with PHY devices
- 1G MACs commonly use GMII interface
- GMII stands for “Gigabit Media-Independent Interface”
- Full details available in IEEE 802.3 specification

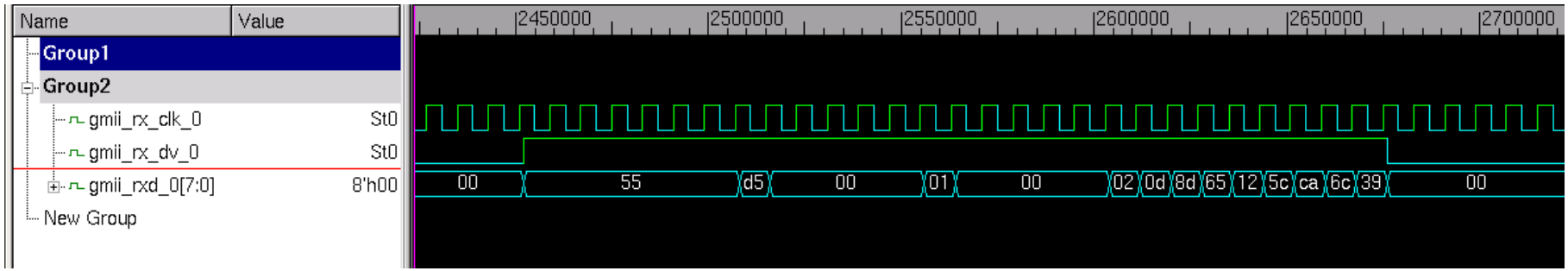
GMII Signals

- GMII provides source-synchronous clocking
- 10 control signals + 1 clock in each direction, 22 signals total
- TX: TX_CLK, TX_EN, TX_ER, TXD[7:0]
- RX: RX_CLK, RX_DV, RX_ER, RXD[7:0]
- GMII Sends one byte per clock, TX_EN and RX_DV encapsulate the packet

Preamble

- Ethernet sends a preamble for all packets
- Originally used to synchronize the receiver's PLL prior to arrival of packet data
- Consists of 7 bytes of 0x55 followed by one byte of 0xD5
- 0xD5 byte is called Start of Frame Delimiter (SFD)

GMII Waveform



The above waveform shows a sample packet reception. RX_DV is asserted for the entire time the packet is transmitted, and the low to high transition on RX_DV indicates start of transmission.

The preamble of 7 x 55 followed by D5 is visible, and the first byte of the DA immediately follows (DA=0000_00000001 for this packet). Note that this packet is an illegally short packet (24 bytes) so that it fits on the screen.