



The Ethernet Evolution

The 180 Degree Turn



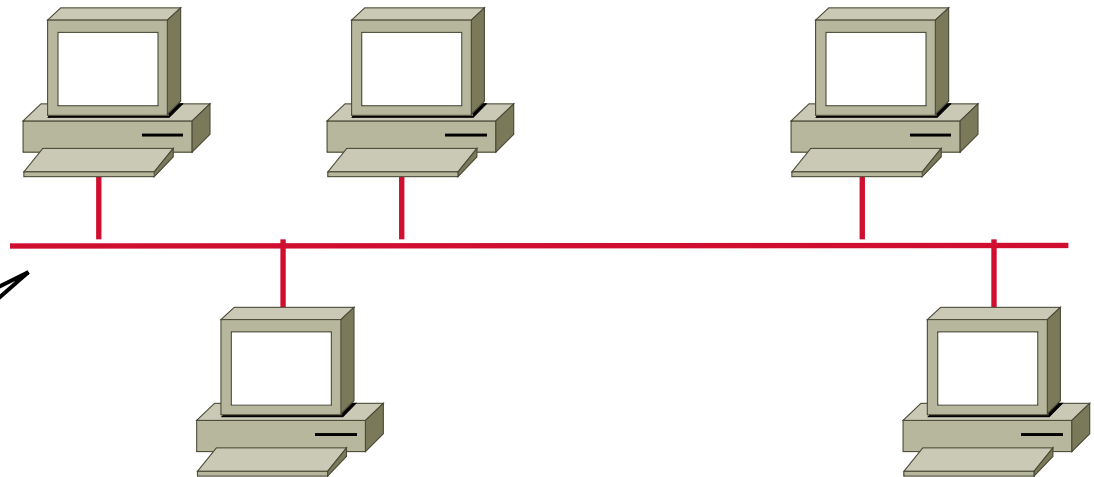
“Use common sense in routing cable. Avoid wrapping coax around sources of strong electric or magnetic fields. Do not wrap the cable around flourescent light ballasts or cyclotrons, for example.”





History: Initial Idea

- Shared media → CSMA/CD as access algorithm
- COAX Cables
- Half duplex communication
- Low latency → No networking nodes (except repeaters)
- One collision domain and also one broadcast domain

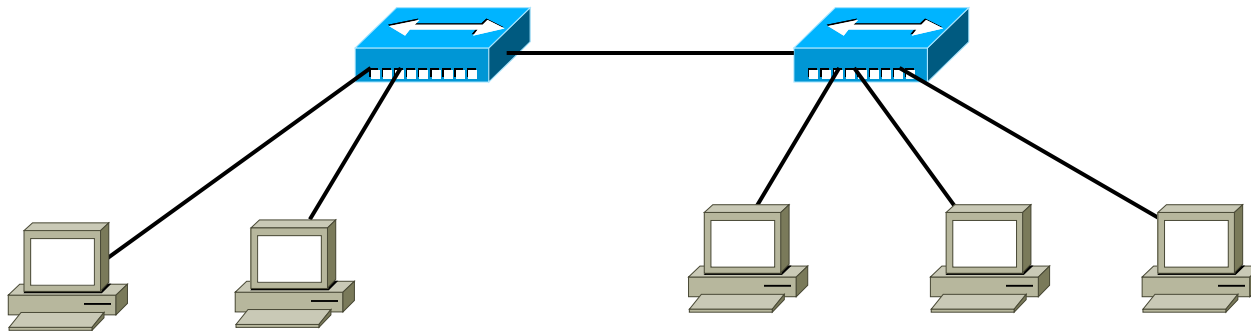


10 Mbit/s shared
by 5 hosts → 2
Mbit/s each !!!

History: Multiport Repeaters



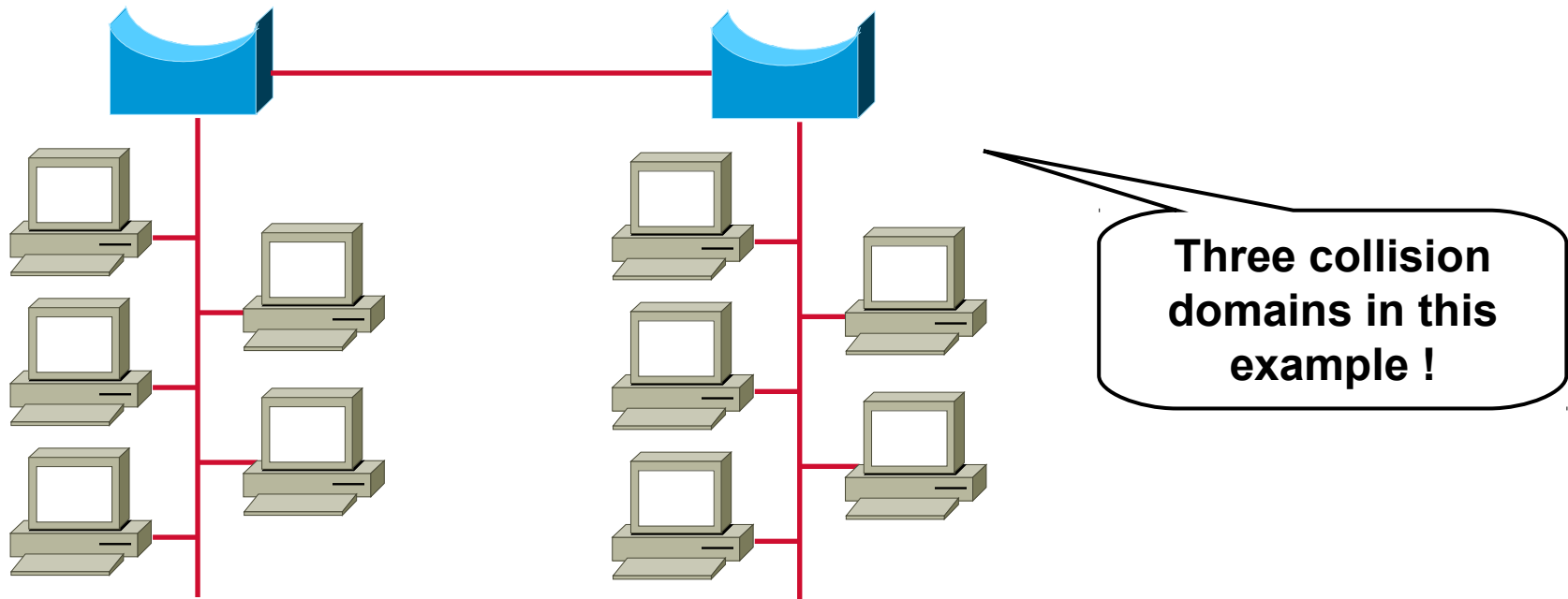
- Demand for structured cabling (voice-grade twisted-pair)
 - ◆ 10BaseT (Cat3, Cat4, ...)
- Multiport repeater ("Hub") created
- Still one collision domain ("CSMA/CD in a box")





History: Bridges

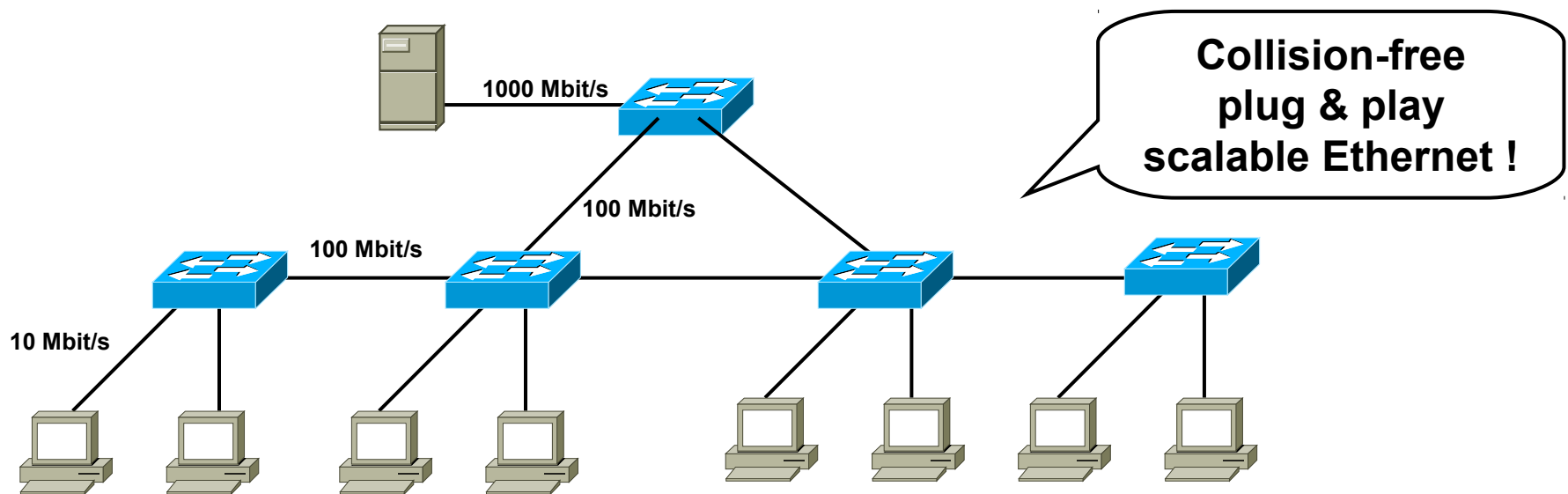
- Store and forwarding according destination MAC address
- Separated collision domains
- Improved network performance
- Still one broadcast domain



History: Switches



- Switch = Multiport Bridges with HW acceleration
- **Full duplex** → **Collision-free Ethernet** → No CSMA/CD necessary anymore
- **Different data rates** at the same time supported
 - ◆ Autonegotiation
- VLAN splits LAN into several broadcast domains





- No collisions → no distance limitations !
- Gigabit Ethernet becomes **WAN technology** !
 - ◆ Over 100 km link span already
- Combine several links to "**Etherchannels**"
 - ◆ Link Aggregation Control Protocol (**LACP**, IEEE 802.3ad)
 - ◆ Cisco proprietary: Port Aggregation Protocol (**PAgP**)
 - ◆ HP: **Mesh** (like L2-routing over 5-8 hops)



Note: Spanning Tree regards this as one logical link!
=> Load balancing!

What About Gigabit Hubs?

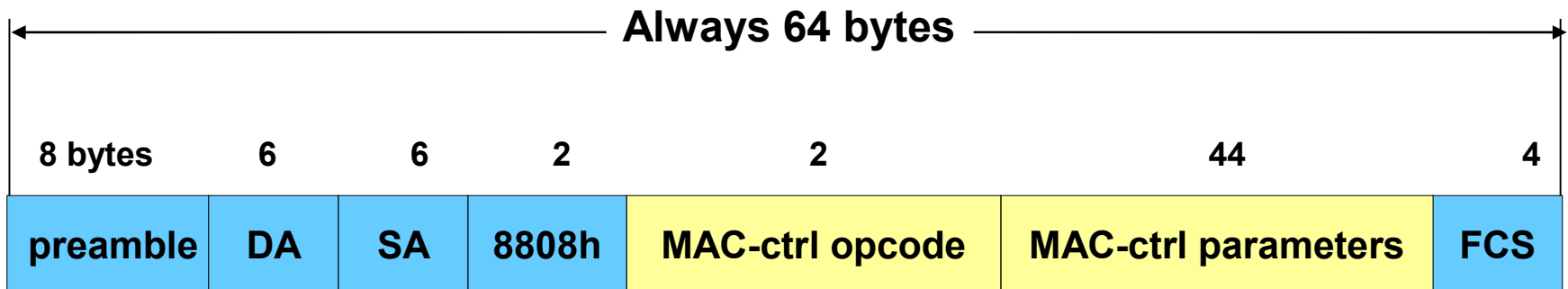


- **Would limit network diameter to 20-25 meters (Gigabit Ethernet)**
- **Solutions**
 - ◆ **Frame Bursting**
 - ◆ **Carrier Extension**
- **No GE-Hubs available on the market today → forget it!**
- **No CSMA/CD defined for 10GE (!)**

MAC Control Frames

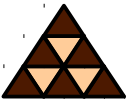


- Additional functionality easily integrated
- Currently only **Pause-Frame** supported

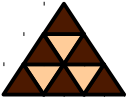


MAC-ctrl opcode Defines function of control frame

MAC-ctrl parameters control parameter data (always filled up to 44 bytes)

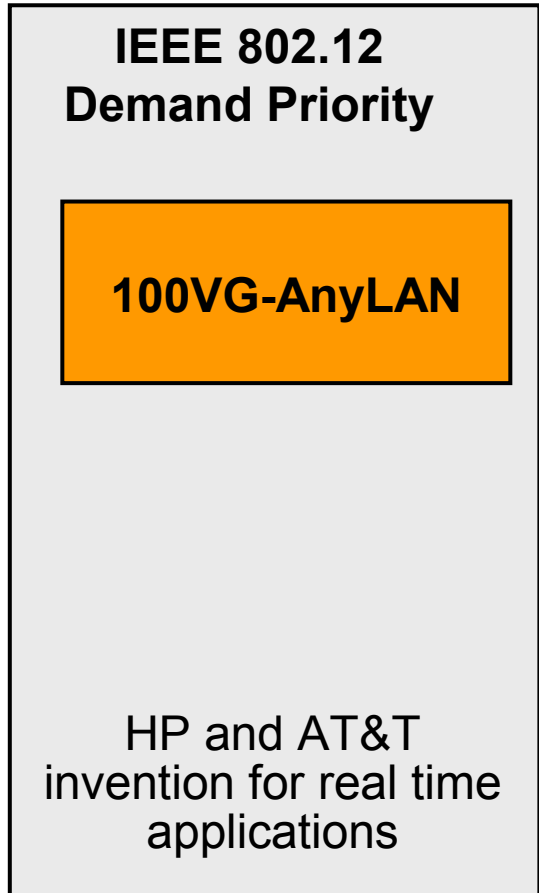
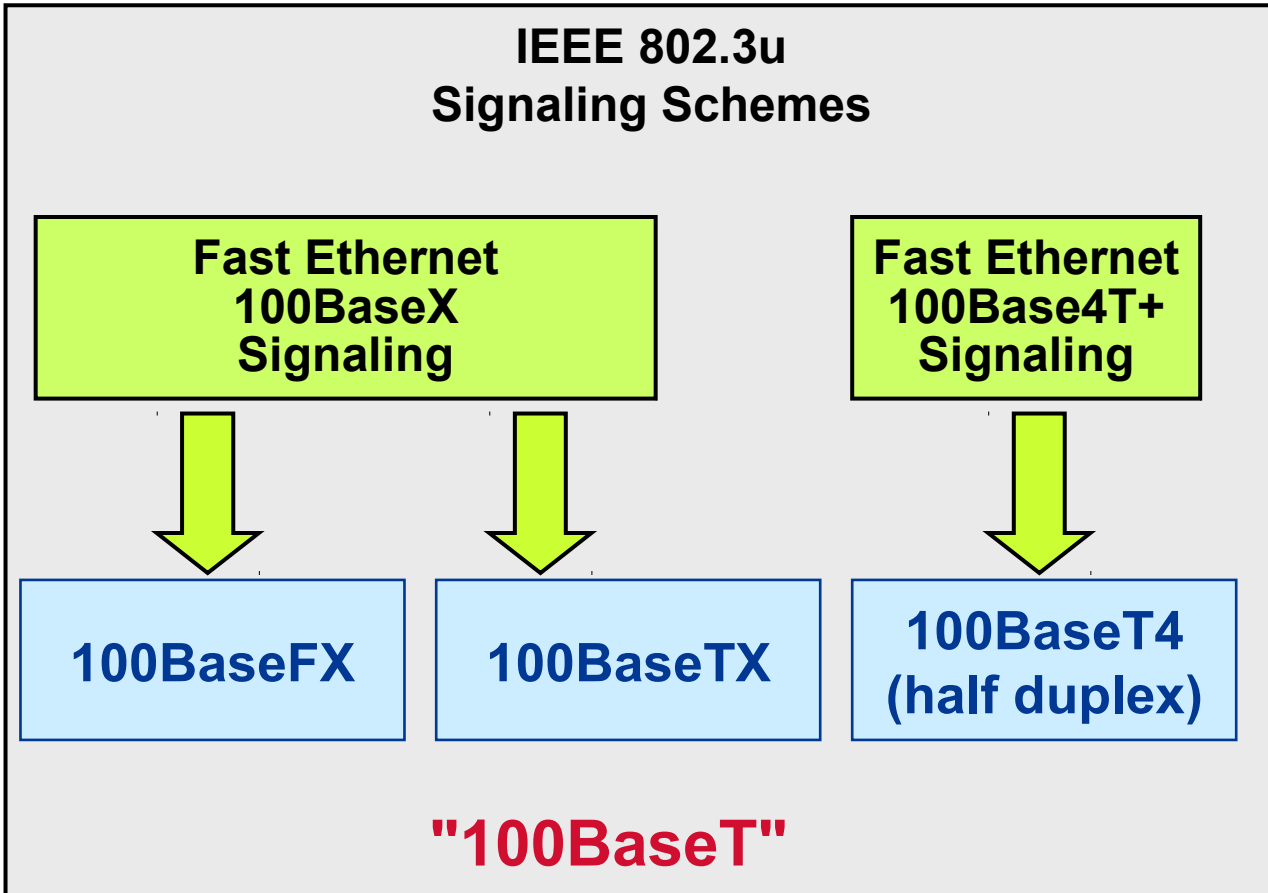


- Enables each two Ethernet devices to exchange information about their capabilities
 - ◆ Signal rate, CSMA/CD, half- or full-duplex
- Using **Link-Integrity-Test-Pulse-Sequence**
 - ◆ Normal-Link-Pulse (NLP) technique is used in 10BaseT to check the link state (green LED)
 - ◆ 10 Mbit/s LAN devices send every 16.8 ms a 100ns lasting NLP, no signal on the wire means disconnected

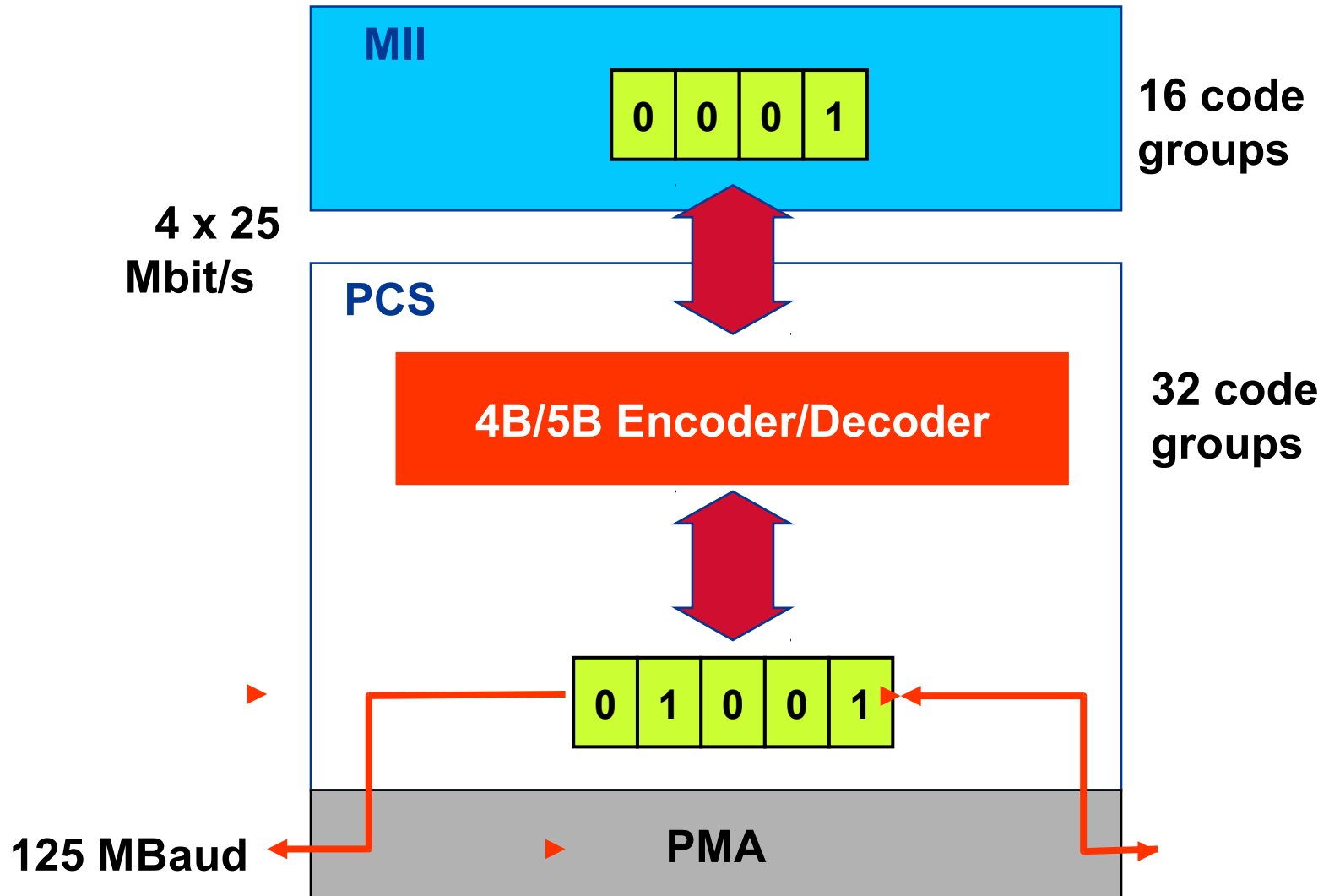


- **Modern Ethernet NICs send bursts of Fast-Link-Pulses (FLP) consisting of 17-33 NLPs for Autonegotiation signalling**
- **Each representing a 16 bit word**
 - ◆ **GE sends several "pages"**

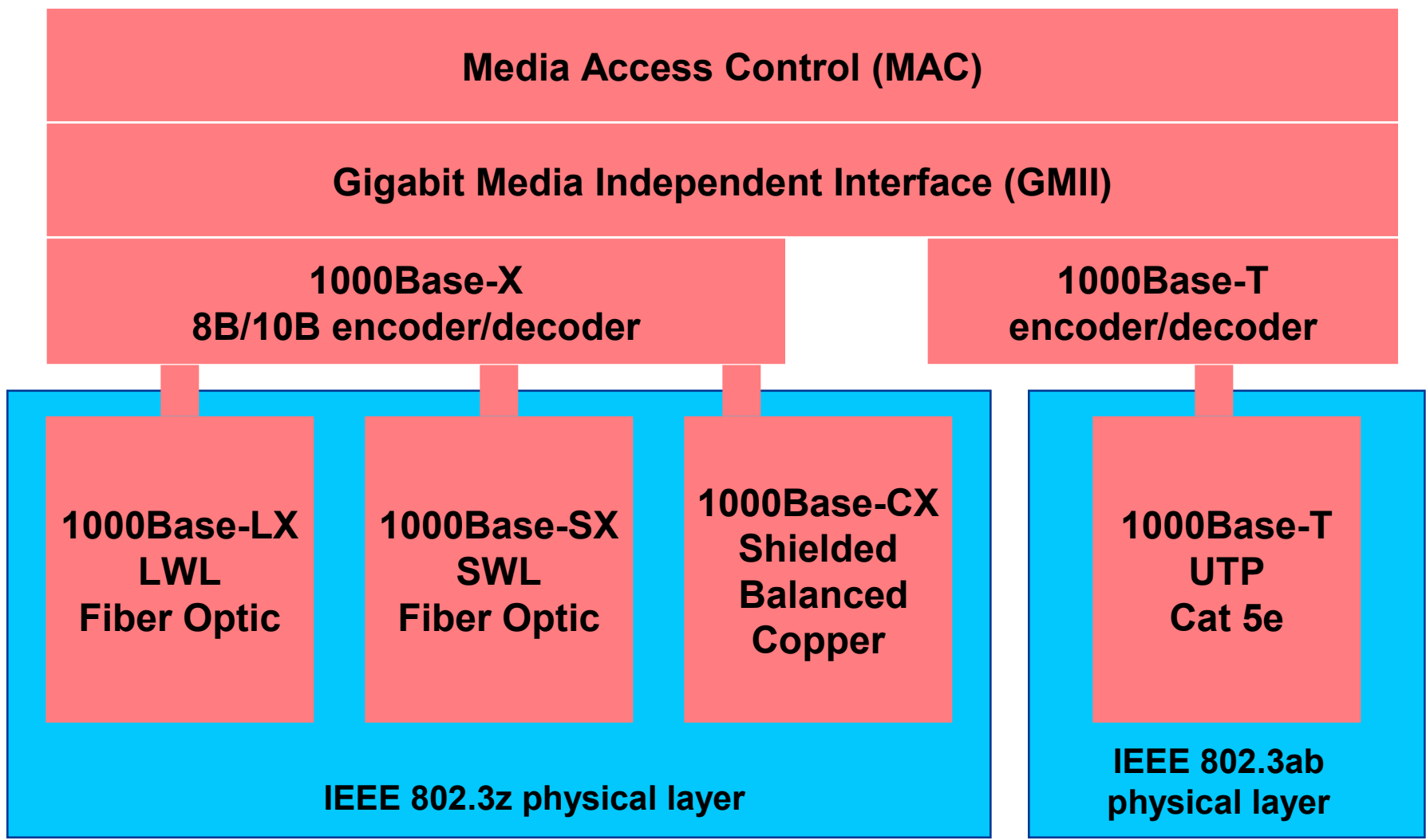
100 Mbit Ethernet Overview



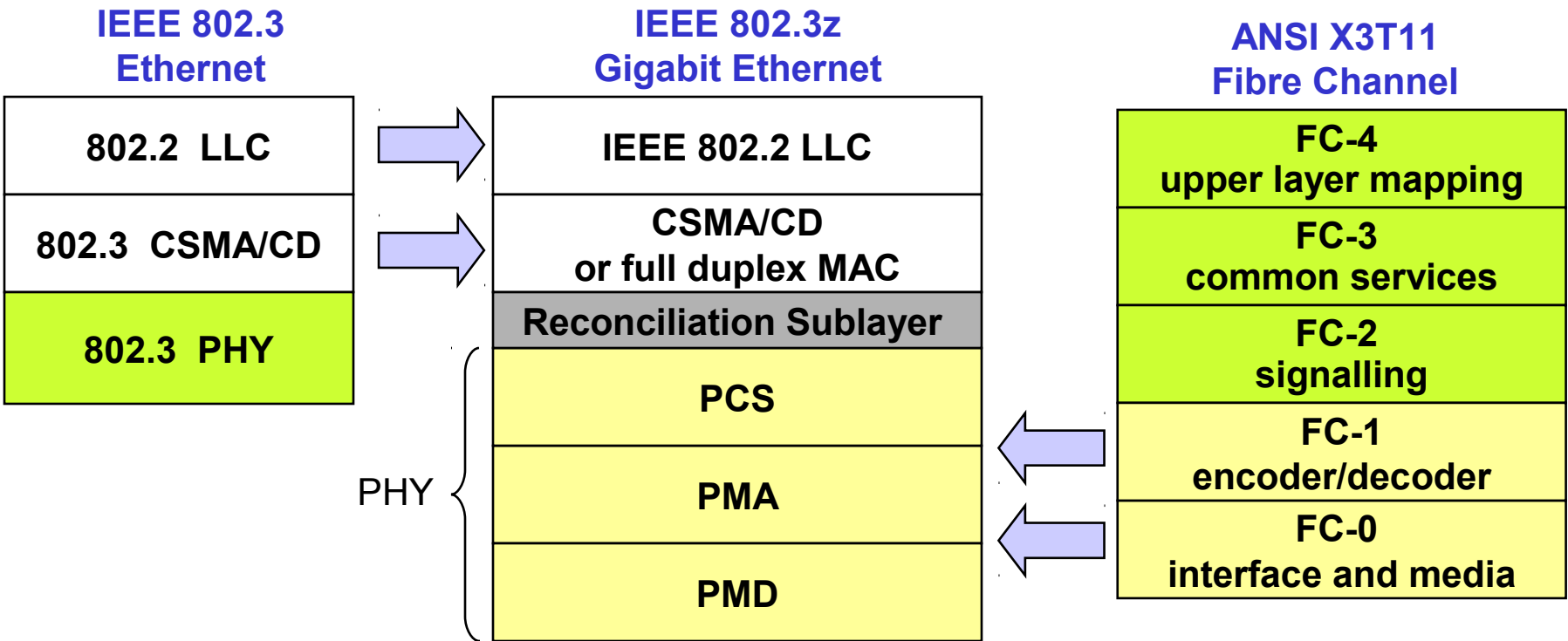
4B/5B Coding



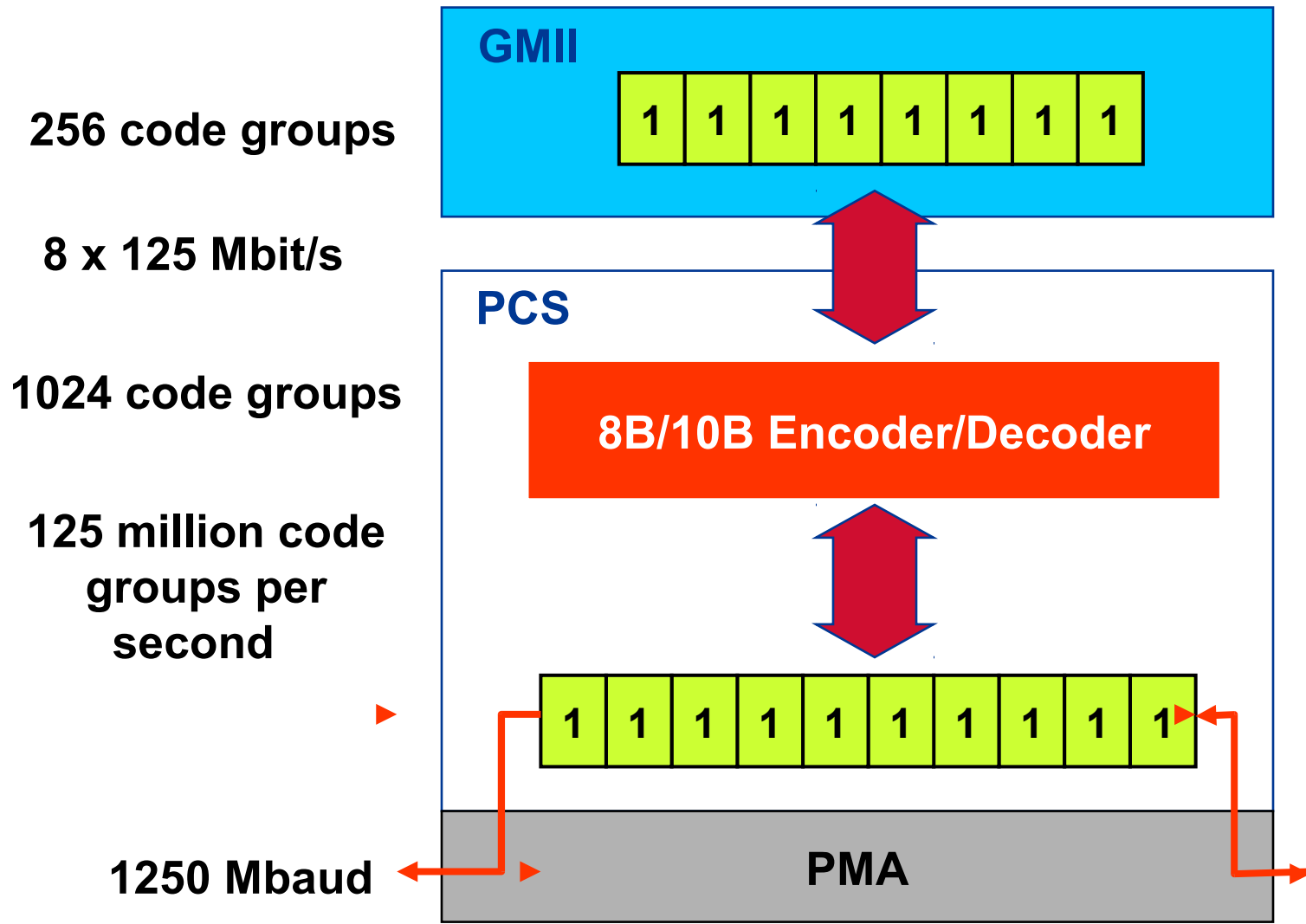
Gigabit Ethernet



GE Signaling



GE 8B/10B Coding



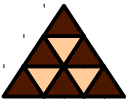
Only used by 1000BaseX



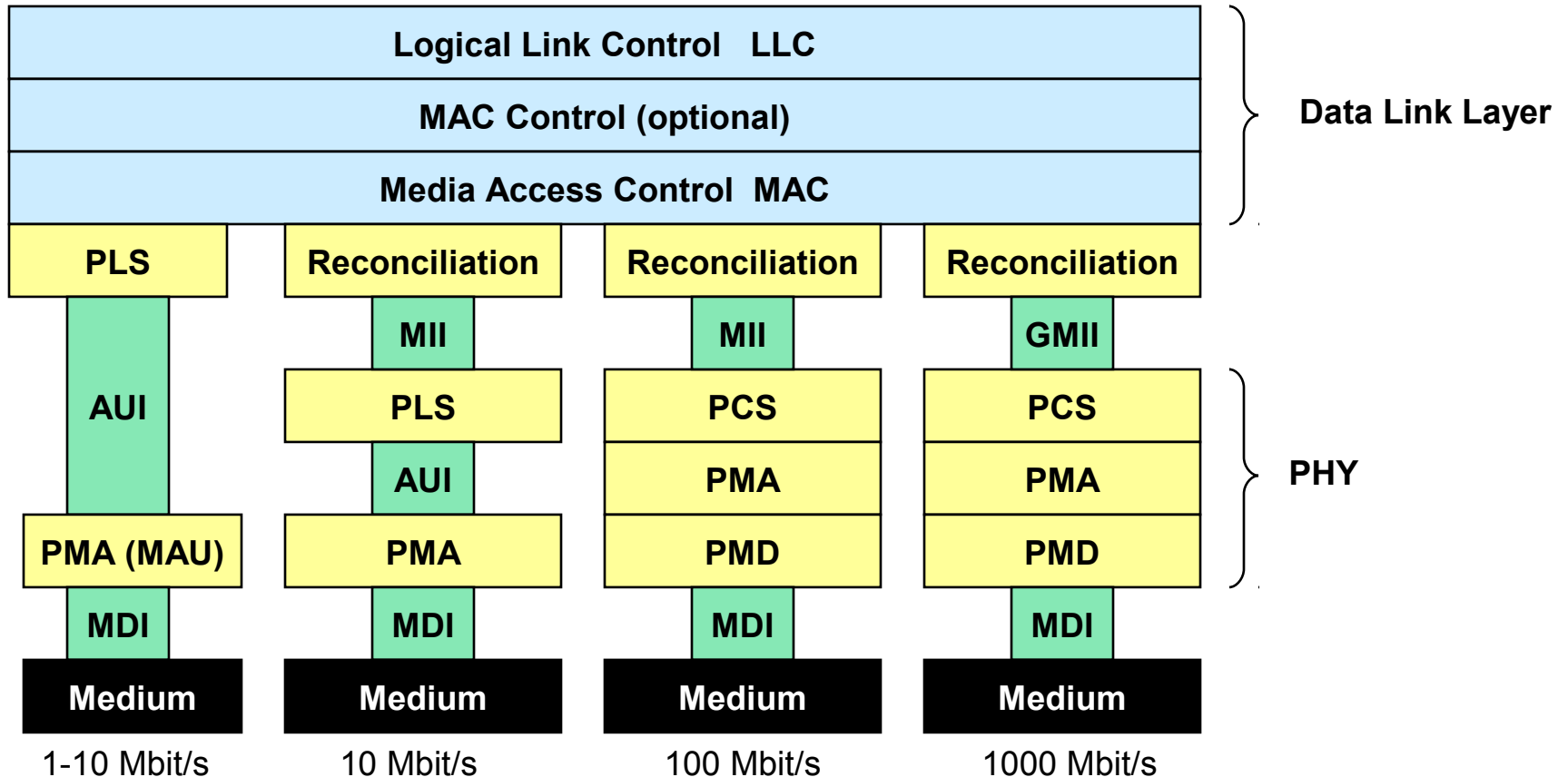
- **Two different wavelengths supported**
- **Full duplex only**
 - ◆ **1000Base-SX: short wave, 850 nm MMF**
 - ◆ **1000Base-LX: long wave, 1300 nm MMF or SMF**
- **1000Base-CX:**
 - ◆ **Twinax Cable (high quality 150 Ohm balanced shielded copper cable)**
 - ◆ **About 25 m distance limit, DB-9 or the newer HSSDC connector**



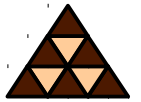
- **Defined by 802.3ab task force**
- **UTP**
 - ◆ **Uses all 4 line pairs simultaneously for duplex transmission! (echo cancellation)**
 - ◆ **5 level PAM coding**
 - **4 levels encode 2 bits + extra level used for Forward Error Correction (FEC)**
 - ◆ **Signal rate: $4 \times 125 \text{ Mbaud} = 4 \times 250 \text{ Mbit/s}$ data rate**
 - **Cat. 5 links, max 100 m; all 4pairs, cable must conform to the requirements of ANSI/TIA/EIA-568-A**
 - ◆ **Only 1 CSMA/CD repeater allowed in a collision domain**



Several Physical Media Supported



AUI Attachment Unit Interface, **PLS** Physical Layer Signaling, **MDI** Medium Dependent Interface
PCS Physical Coding Sublayer, **MII** Media Independent Interface, **GMII** Gigabit Media Independent Interface, **PMA** Physical Medium Attachment, **MAU** Medium Attachment Unit, **PMD** Physical Medium Dependent



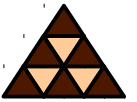
- **Only optical support**
 - ◆ 850nm (MM) / 1310nm /1550 nm (SM only)
 - ◆ No copper PHY anymore !
- **Different implementations at the moment – standardization not finished!**
- **8B/10B (IBM), SONET/SDH support, ...**
- **XAUI ("Zowie") instead of GMII**



- **GE and 10GE use synchronous physical sublayer !!!**
- **Recommendation: Don't use GE over copper wires**
 - ◆ **Radiation/EMI**
 - ◆ **Grounding problems**
 - ◆ **High BER**
 - ◆ **Thick cable bundles (especially Cat-7)**



- **Ethernet evolved in the opposite direction:**
 - ◆ Collision free
 - ◆ WAN qualified
 - ◆ Switched
- **Several coding styles → Complex PHY architecture**
- **Plug & play through autonegotiation**
- **Much simpler than ATM but no BISDN solution – might change!**



- **Why tends high-speed Ethernet to synchronous PHY?**
- **Can I attach a 100 Mbit/s port to a 1000 Mbit/s port via fiber?**
- **What is the idea of Etherchannels?
(Maximum bit rate, difference to multiple parallel links)**