Network Wiring & Devices

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Network Wiring

- Half/full duplex Ethernet
- Network Wiring
- Autonegotiation
- Structured wiring
- Optics

- Your questions please!

Copper Ethernet media

- Coax (10 Mbit/sec)
  - now obsolete
- Twisted pair
  - Uses pair 1-2, 3-6, 4-5, 7-8
  - 10 Mbit/sec (10BASE-T)
  - 100 Mbit/sec
  - 1000 Mbit/sec ('gigabit ethernet')
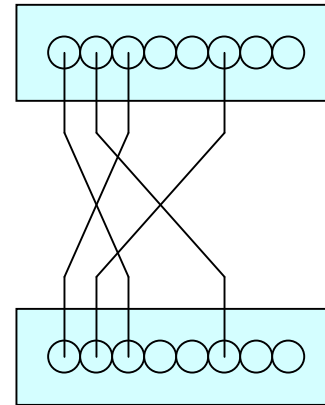 - (10.000 Mbit/sec)

A few words on 10BASE-T

- Available everywhere today
- Uses pair 1-2, 3-6
    - Unshielded twisted pairs
    - Often miswired
- Typically half-duplex
    - Full duplex possible
- Max length 100 meters!

10BASE-T cables
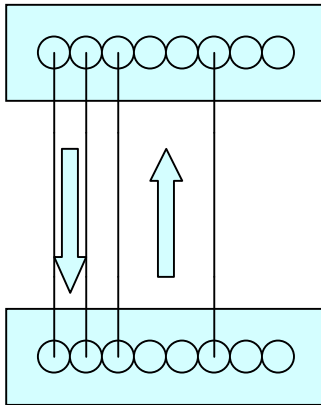
Normal cable
Used from host to hub

Crossover cable
Used hub to hub
or host to host

Newer devices often have built-in automatic crossovers

100 Mbit copper networks

- 3 standards:
    - 100BASE-TX <<-- Winner
    - 100BASE-T4 <<-- Loser
    - 100VG-Anylan <<-- Loser
- Don't buy anything but 100BASE-TX!
    - Fortunately, these days, other stuff is nearly extinct on flea-bay

100BASE-TX

- Requires Category 5 ('CAT5') cabling
  - No more, no less
- 100BASE-TX runs on 2 wire pairs
  - 1-2, 3-6, like 10BASE-T
- Cheap today
  - Built-in in PC chipset
  - Has replaced 10BASE-T equipment

Faster: Gigabit Ethernet

- 1000 Mbit/sec, 1000BASE-T
- Still works on CAT5 cabling, tight fit
- Uses all 4 wire pairs
  - In both directions
- About to get cheap and common
  - $15 network card
  - Being integrated in PC chipset (replacing 100BASE-TX)
- Automatic crossover additional new feature

Still faster: 10 Gigabit Ethernet

- 10 Gigabit originally only on fiber
- 10 Gigabit on copper currently being under development by IEEE 802.3 standards committee
  - Close to Shannon Limit
  - Standard is IEEE 802.3an - IEEE voting process completed

Half/Full duplex

- Ethernet is CSMA/CD
  - Carrier Sense Multiple Access/Collision Detection
- Without Full Duplex, only one station transmitting at any time
- With Full Duplex, packets can be sent in both directions simultaniously

Half duplex

- Listen before you transmit
- Listen while you transmit
- If there is a collision, both transmitters will:
  - Jam
  - Backoff (exponentially, randomly)
  - Re-try sending the packet
  - Minimal packet size: 64 bytes
- Collisions are harmless!
  - Actually help scale / stabilize an ethernet network

Full duplex

- Allows transmission/reception simultaneously
  - Impossible on older coax media
  - Easy to implement on twisted pair/fiber media
- No collisions
- More bandwidth available

Link pulses

- 10BASE-T sends link pulses when idle
  - used to test integrity of link (why?)
  - link light
- 100BASE-T uses faster link pulses
  - Automatic detection between 10 and 100 possible
- Manual setting of half/full duplex
 - Settings must match

Autonegotiation

- Method to automatically select 'best' transmission method between link partners
- Link pulse now becomes pulse train
- Automatically sets speed, duplex etc

Autonegotiation (2)

- 'Parallel detection' for devices w/o autonegotiation
  - 10BASE-T and 100BASE-TX only
  - Only HDX
- Autonegotiation mandatory for gigabit ethernet
- Technology is mature now
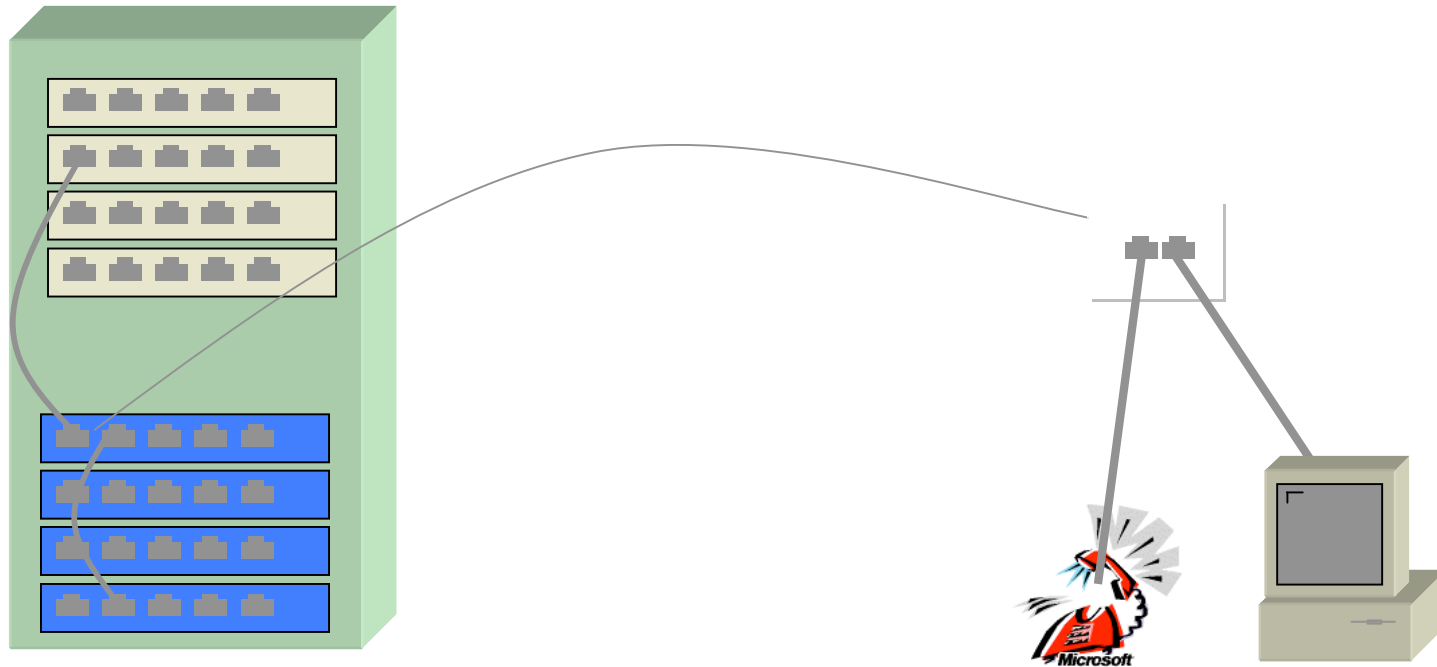 - Early chips had serious issues, so be aware

Autonegotiation failure mode

| 100Mbit FDX | Autonegotiation |
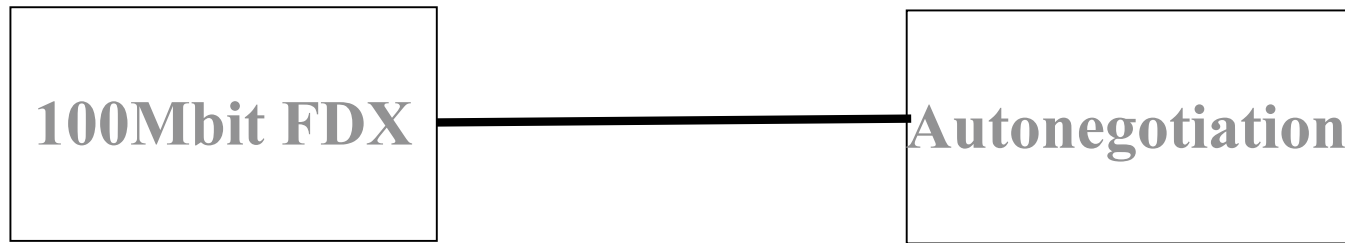
- One end set to fixed 100Mbit, Full-Duplex
- Other end uses autonegotiation

- What happens?

Structured wiring

"Everything over the same wiring"

Wire Types

- Category 3: 10 Mbps
- Category 4: 16 Mbps (for token ring)
- Category 5: 100 Mbps / 1000 Mbps
  - Cat5e: tighter tolerances
  - Cat6: Allows even higher bandwiths
- Shielded or unshielded
- Advice: use Cat 5, Cat 5e or Cat6 UTP (unshielded twisted pair)
- Category 7 and higher marketing hype
  - Not official IEEE spec

Structured wiring pitfalls

- High installation cost
  - so install enough the first time
- Use materials that are qualified for Cat 5e or higher
- Get guarantee from installer

- (IP Telephony?)

Fiber optics

- Long-haul connections within buildings
  - Remember: copper = 100m max!
  - Interconnects between structured wiring wiring cabinets

- Must use fiber between buildings
  - Cable length restrictions
  - Lightning protection

Fiber optics (2)

- Multi mode: short hauls
- Single mode: long hauls

- Different fiber diameters
- Different connector types
  - ST, SC, VF45
  - Many others these days

Fiber optics (3)

- 10BaseF for 10Mbps ethernet
- 100BaseFX for 100Mbps fast ethernet
- 1000BaseSX for gigabit ethernet
- Advice: run more fibers than you need, but don't terminate them (yet)

Power Over Ethernet

- Allows to power device over ethernet cable
  - No power plug or *wall wart*
  - Uses 'unused' wire pairs
- Convenient for places where power is difficult
  - Wireless access points
  - IP telephones
- IEEE 802.3af standard
  - Be aware of pre-standard (incompatible) equipment

Hubs, Switches and Routers

How do they work?

What are the differences?

Packet headers

Ether	IP	TCP	Data

Edst	Esrc	T

	IPsrc	IPdst
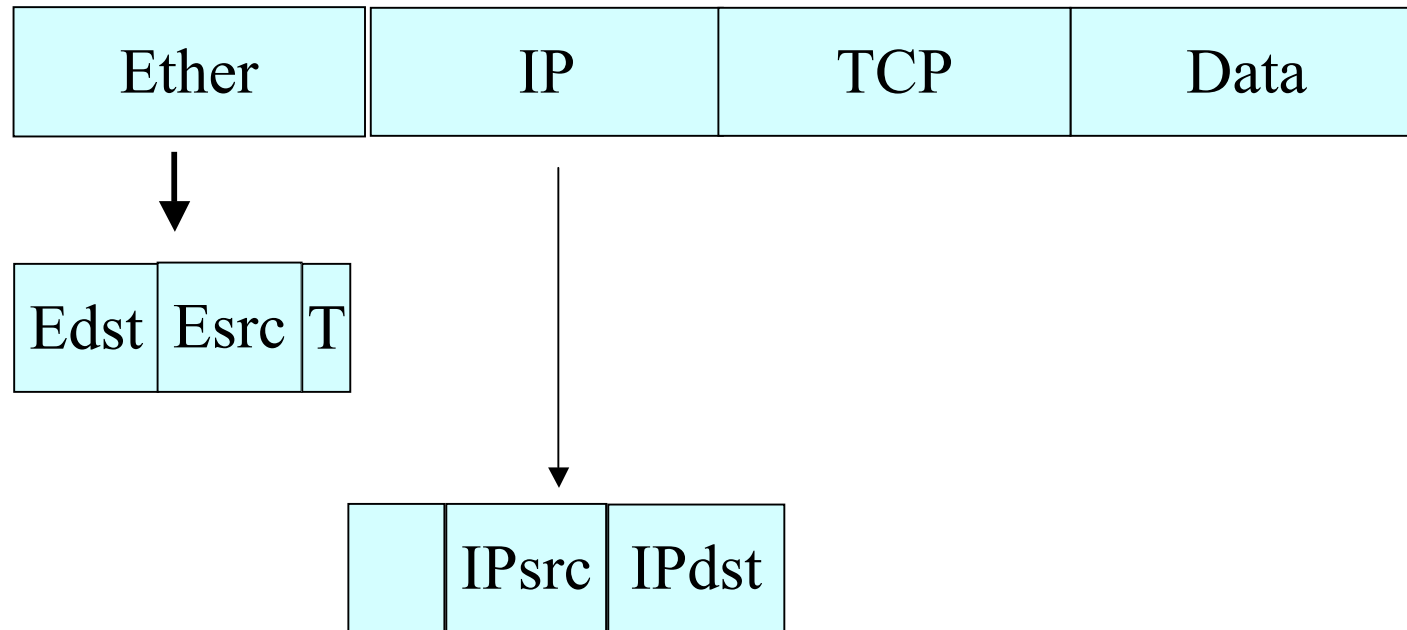
Network devices may use {ether, IP} headers to do it's job
(sometimes in twisted ways)

Types of ethernet addresses

- Typically one interrupt per packet received
  - Interrupts cost a lot of CPU performance!
- Use ethernet addresses to be able to filter packets in ethernet receiver hardware
- First 3 bytes (actually, only 22 bits) assigned by IEEE
  - Organisational Unique Identifier
- 3 types of addresses:
  - Unicast, Multicast, Broadcast

Ethernet address types

- Last 2 bits of 1st byte gives type:
  - **00:**01:02:03:04:05
    0000 00**00**: unicast (single host)
  - **01:**01:02:03:04:05
    0000 00**01**: multicast (group of hosts)
  - **ff:ff:ff:ff:ff:ff**: broadcast (all hosts)
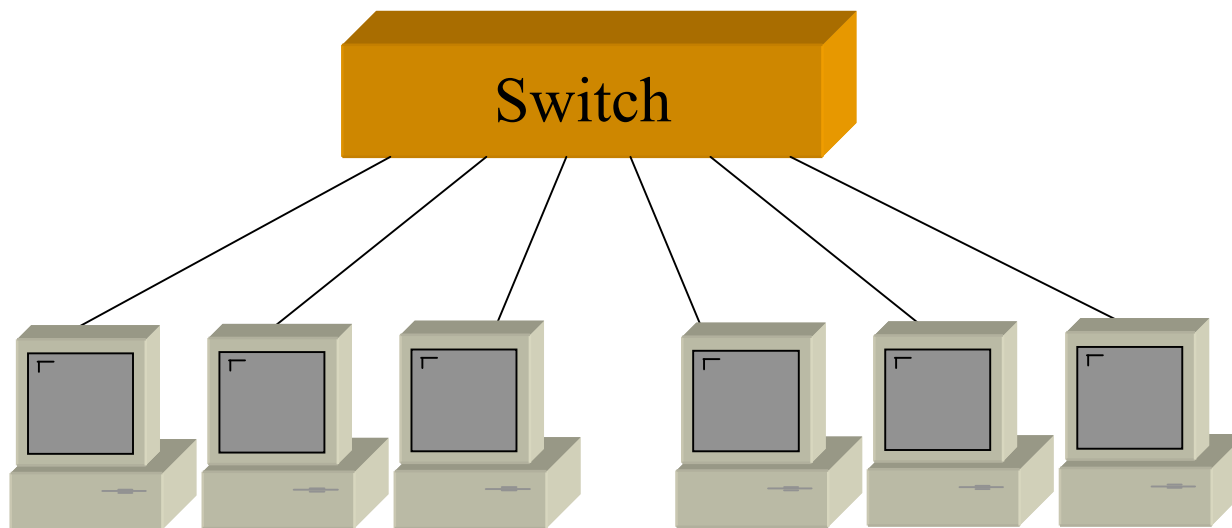   - Special case of multicast

Ethernet hub

Hub
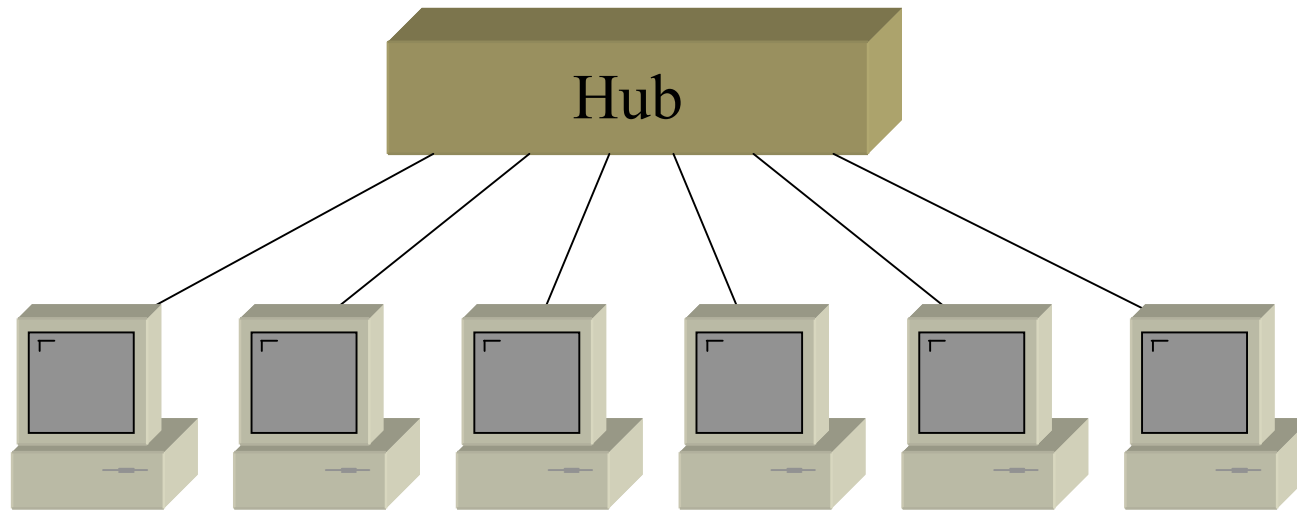
Ethernet hub (2)

- Hub is layer 1 device
- Hub does not filter packets
- Whole hub is one collision domain
  - Hence cannot do full duplex
- Daisychaining of hubs limited
- Cheap
- Nearly extinct

- Doesn't exist for Gigabit Ethernet

Ethernet Switch

Switch

Ethernet Switch (2)

- Formally, a switch is just a bridge
- Switch looks at ethernet headers (layer 2)
  - ethernet to ethernet only
- Learns what addresses are connected to which ports
- If destination of packet known, the packet is only sent to the destination port

Ethernet Switch (3)

- Each port is a separate collision domain
  - no daisychain limit
- Can do full duplex
- Often one host per port
  - high performance
- Security features
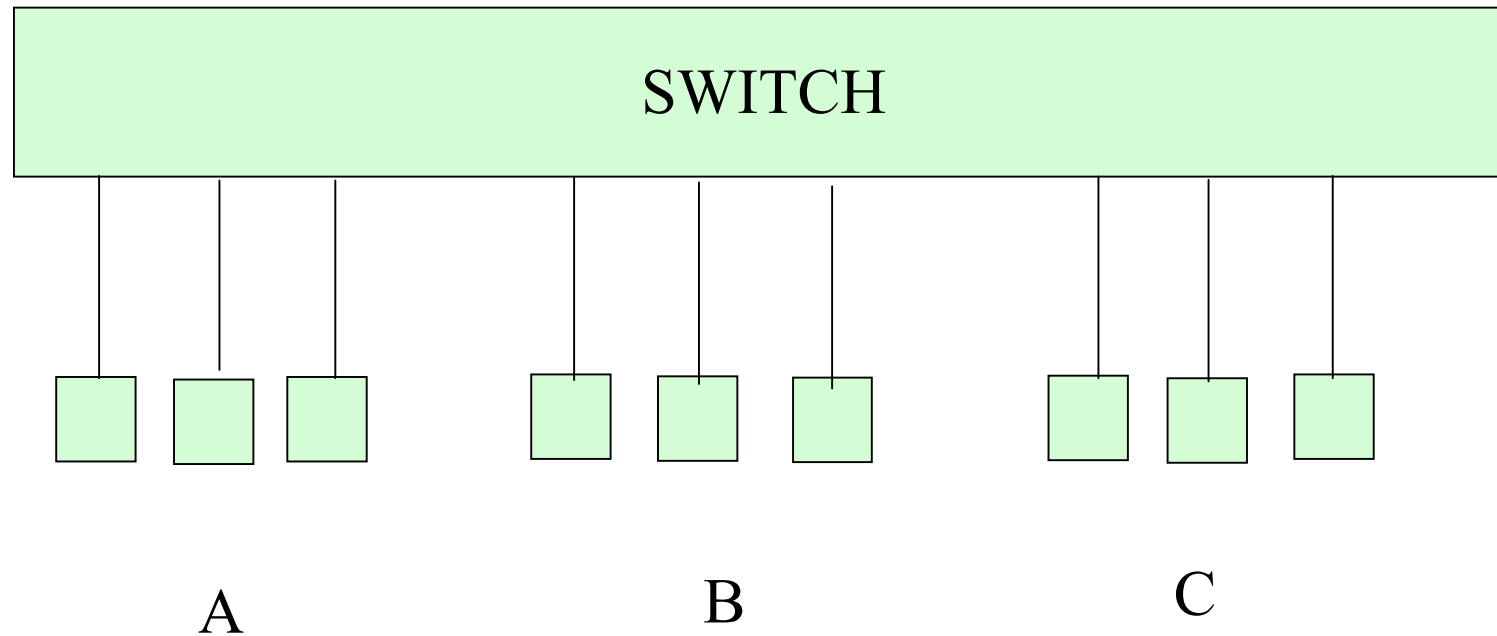
- Dualspeed 'hub' includes switch
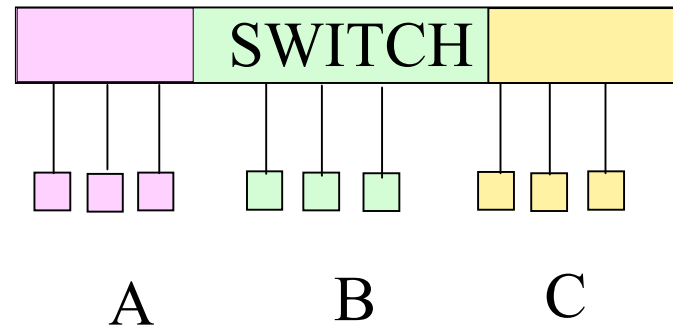
Router
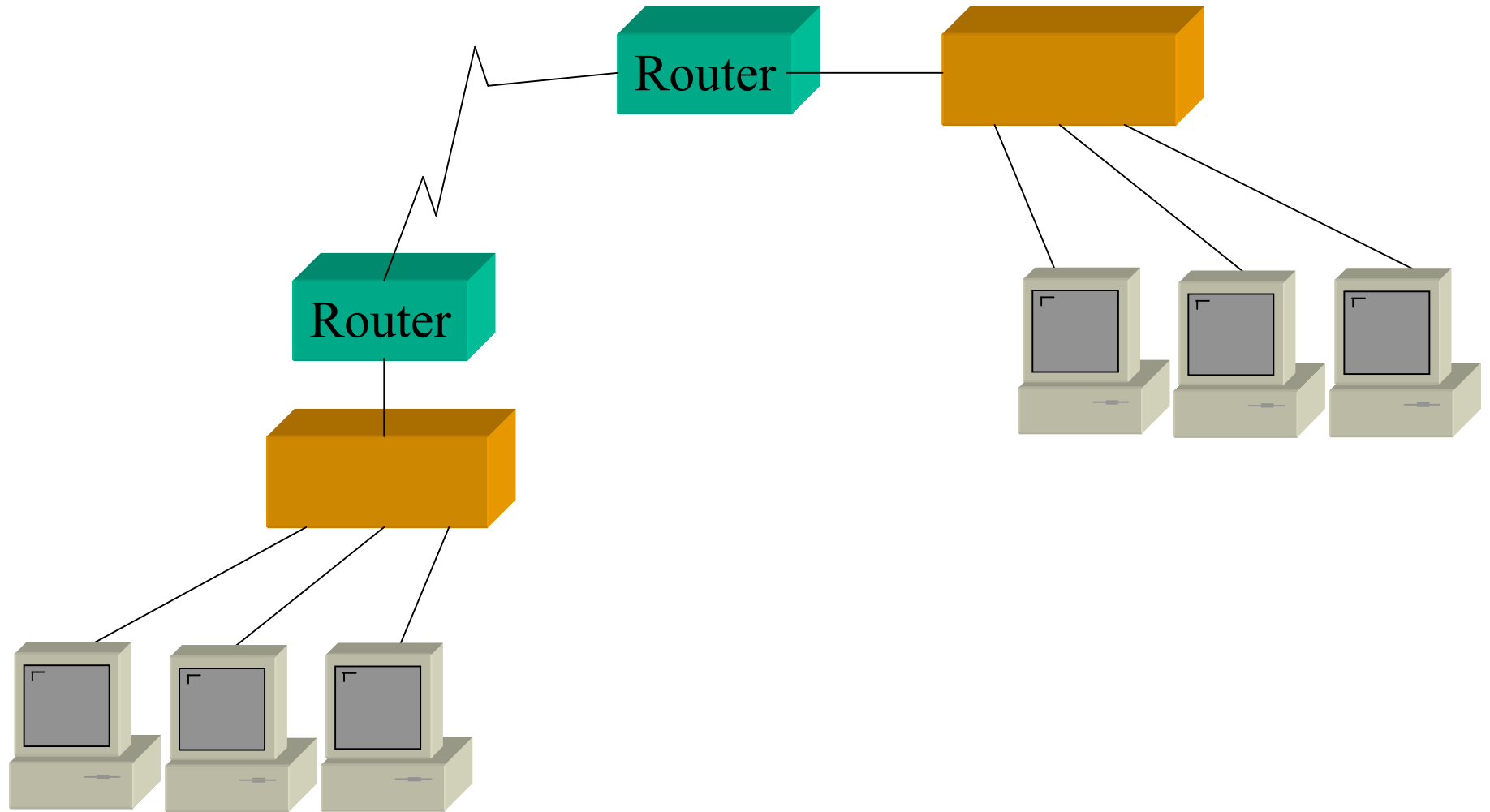
Router (2)

- Router works on IP header (layer 3)
- Can use almost any underlying media
  - LAN or WAN
- Can have several ports
- Useful for long distance connections (backbone)
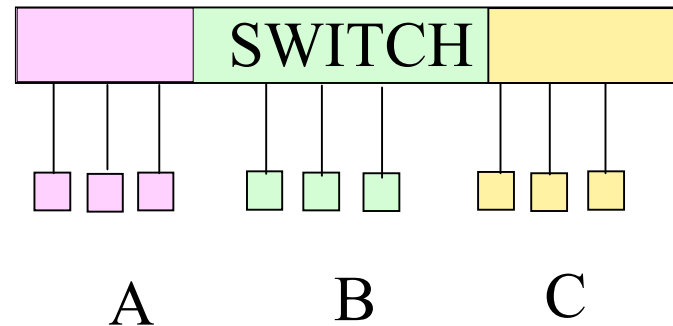- Must be configured
  - IP addresses etc.

VLANs

A, B, C can be customerA, customerB, customerC
or sales, administration, engineering, …
They all share the same network!

Splitting up switches

- VLANs allow you to split up the network in smaller network (and divide the switch in smaller parts)
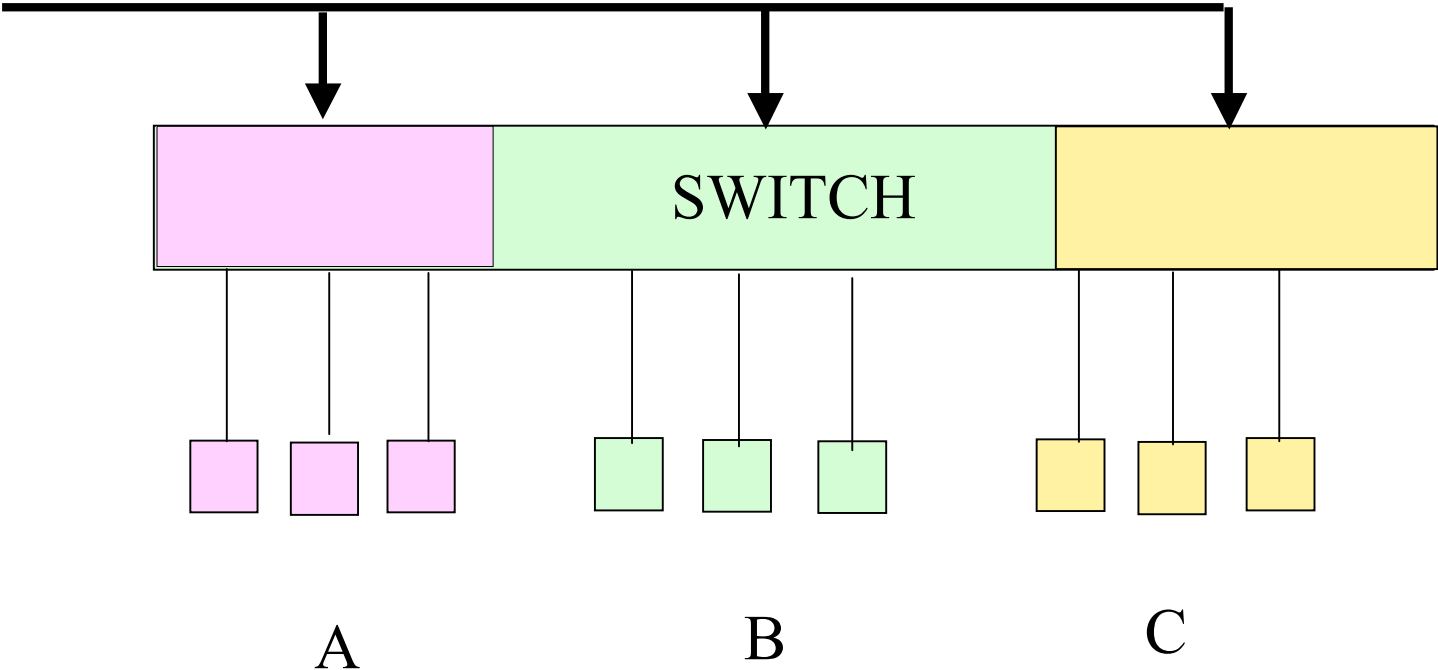- VLANs identified by a number - vlan 1234
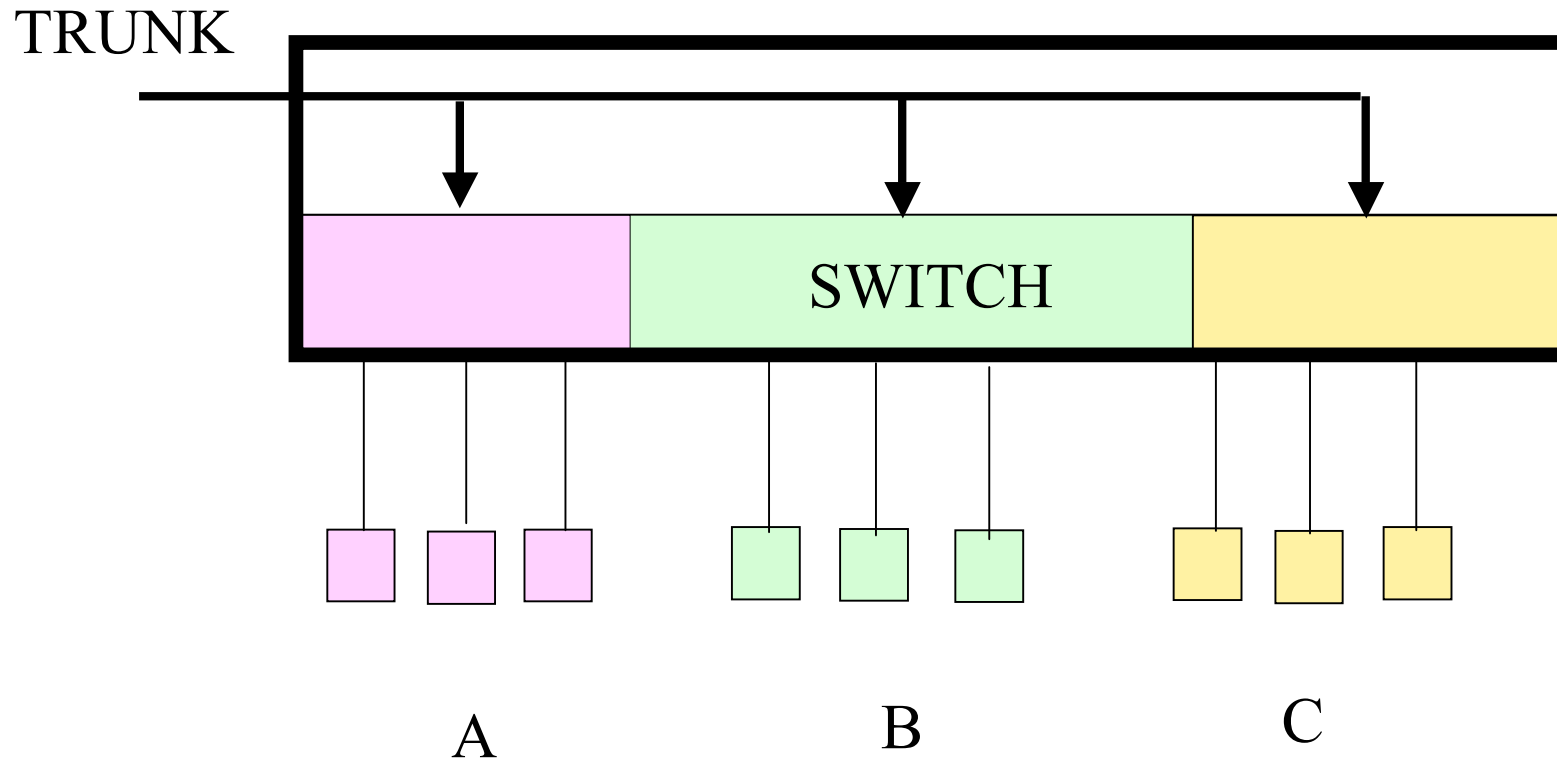
Splitting up switches (2)

- You can set the VLAN per port
- This is a configuration thing and hence can be changed dynamically - flexible!
- Network port can be member of multiple VLANs
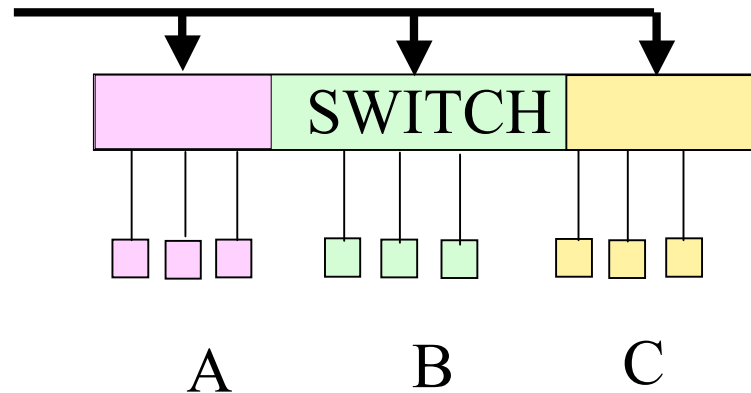
VLAN trunks

TRUNK

SWITCH

A   B   C

VLAN trunks
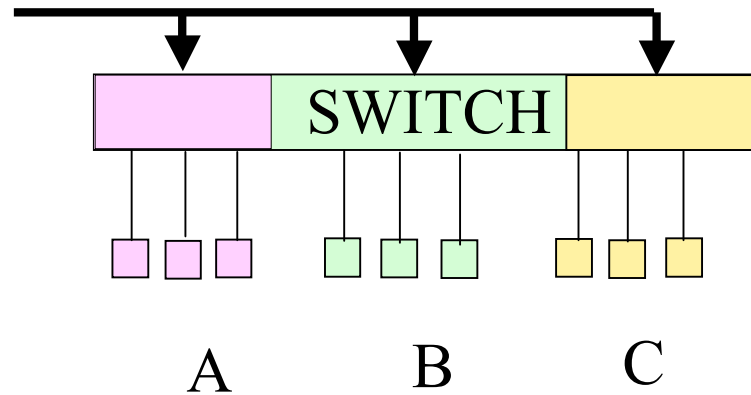

TRUNK

SWITCH

A   B   C

All VLANs reachable from the same single ethernet port

VLAN trunks

- A VLAN trunk connects to multiple isolated VLANs over the same single interface

- VLANs are differentiated by an extra VLAN tag field in the packet
  - Access port: regular ethernet
  - Trunk port: access to multiple VLANs, with tags

VLAN trunks

- Multiple trunking protocols exist:
  - IEEE 802.1Q (open standard)
  - Cisco ISL (proprietary)

802.1Q packet format

Edst	Esrc	Etype IP	IP	TCP	Data

Edst	Esrc	Etype VLAN	VLAN tag	Etype IP	IP	TCP	Data
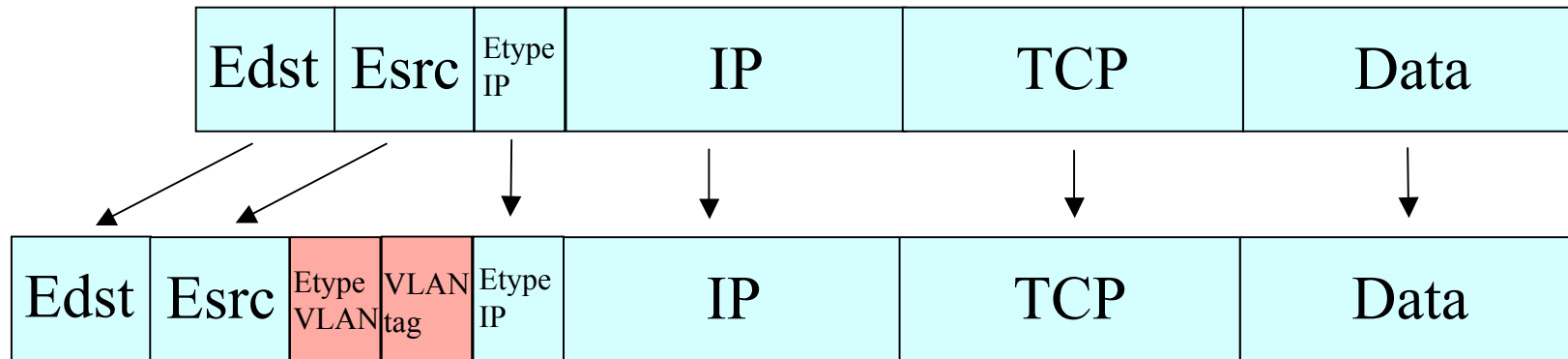
VLAN Ethernet type, and VLAN tag are added
VLAN tag = 1 - 4094
VLAN tag includes priority field

Ethernet packet size for VLANs

- Max ethernet packet size is 1514 bytes
    - 1500 bytes MTU, 14 bytes ethernet header
- Trunking adds 4 bytes
    - But trunking must be transparent!
    - But max ethernet packet size is still 1514 bytes

Ethernet packet size for VLANs (2)

- Solution:
  IEEE discovered that 99.9% devices would support 1514 + 4 = 1518 bytes

- IEEE 802.3ab says that packets may be 1518 bytes
  - But additional bytes may only be VLAN tags

- See FreeBSD VLAN_MTU,
  "mini jumbograms"