LAN Systems

Bus topology LANs

Design problems: not only MAC algorithm, not only collision domain management, but at the Physical level the signal balancing problem (signal adjustment):

- Signal must be strong enough to meet receiver's minimum signal strength requirements
- Give adequate signal to noise ratio
- Not so strong that it overloads transmitter
- Must satisfy these for all combinations of sending and receiving station on bus
- Usual to divide network into small segments
- Link segments with amplifiers or repeaters (operate at the physical level)

Used Transmission Media

-Twisted pair

Not practical in shared bus at higher data rates

-Baseband coaxial cable

Used by ‘pure’ Ethernet

-Broadband coaxial cable

Included in 802.3 specification but no longer made (ex.: 10Broad36)

-Optical fiber

Expensive

Difficulty with availability

Not often used, eventually as link segments

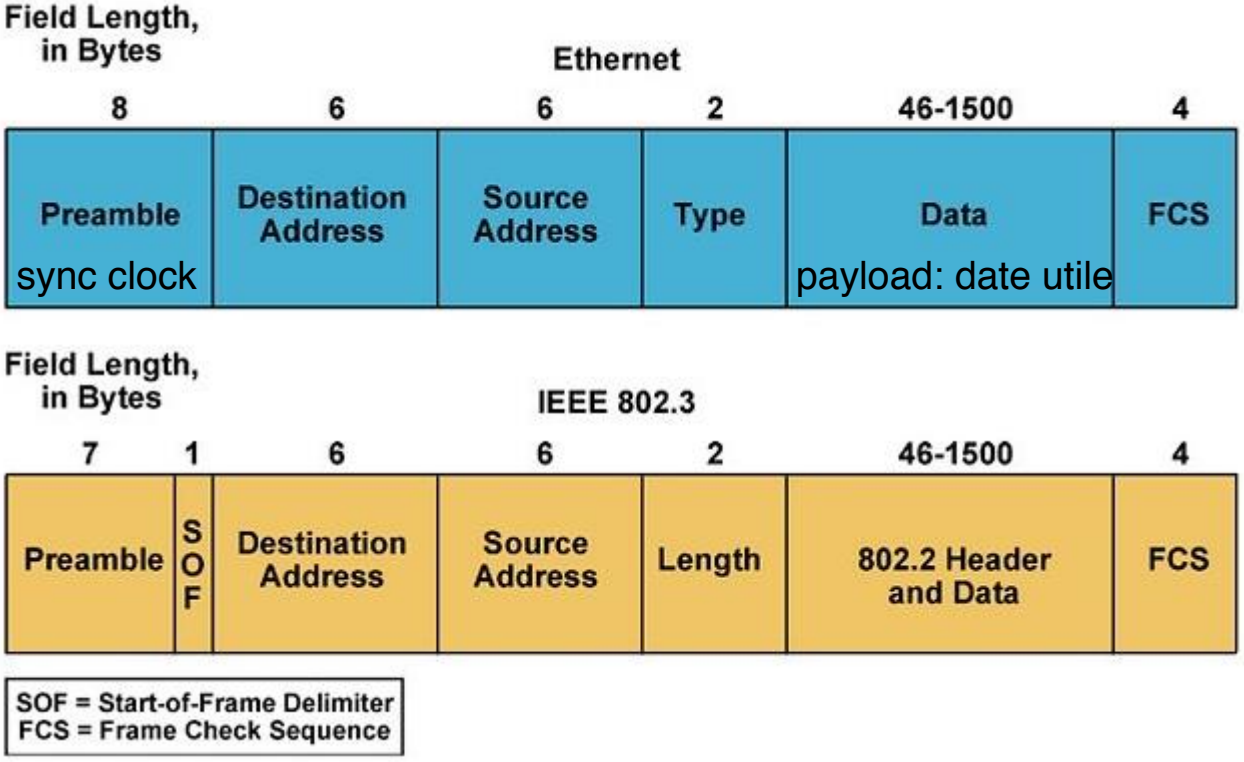
Conclusion: Few new installations, no perspectives, not allowing FD switched links

Replaced by **star based twisted pair and optical fiber**.

10Mbps CSMA/CD based LANs – IEEE 802.3 standard

MAC frame long enough to detect collision prior to transmission end
Standard 802.3 establish minimum length for the frame of 512bits, or 64bytes
Frame also upper bounded for transmission reasons
Minimum size for the Data field, if not allowed use padding (filling with *pad* char)
6 bytes for each address field: MAC address (physical address, burnt on each station network interface)

Ethernet and 802.3 frame format



10Mbps Specification (Ethernet based LANs – IEEE 802.3 standard)

Specification:

<data rate><Signaling method><Max segment length>

Example: 10Base2, 10Broad36

All implement Ethernet based CSMA/CD MAC algorithm.

Problems here: the **Round Trip Collision Delay** value, implying limitations for data format (minimum length for the frame of 512bits, or 64bytes), and maximum distance between stations (depends on link segment media).

	10BASE5	10BASE2	10BASE-T	10BASE-FP
Transmission Medium	Coaxial cable (50 Ω)	Coaxial cable (50 Ω)	Unshielded twisted pair	850-nm optical fiber pair
Signaling Technique	Baseband (Manchester)	Baseband (Manchester)	Baseband (Manchester)	Manchester/ on-off
Topology	Bus	Bus	Star	Star
Maximum Segment Length (m)	500	185	100	500
Nodes per Segment	100	30	—	33
Cable Diameter (mm)	10	5	0.4–0.6	62.5/125 μm

On baseband bus, collision produces much higher signal voltage than active signal

Collision detected if cable signal greater than single station signal; station detecting collision will generate a burst jam signal (jabber control)

Signal attenuated over distance => limits distance to 500m (10Base5) or 200m (10Base2)

Collision domain – given by the set of stations sensing collision when simultaneous transmissions; for 10Mbps standard it is allowed a number of 516 bits onto the shared medium

For higher speeds (i.e. Ethernet at 100Mbps) is kept the same minimum length, obtained by splitting the collision domain; use of hubs or switches instead of repeaters (they do not propagate the collision signal)

10BaseF (802.3 standard for fiber optic)

States use of fiber optics links (a pair of fibers, one for each direction) for CSMA/CD network at 10Mbps.

3 standard specifications:

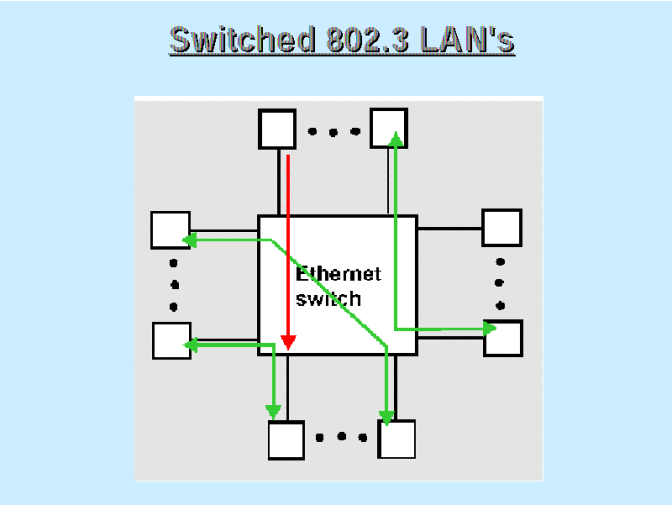
10BaseFP- passive star topology (33 stations connected to a central passive optical splitter device, up to 1km segment length between two stations)

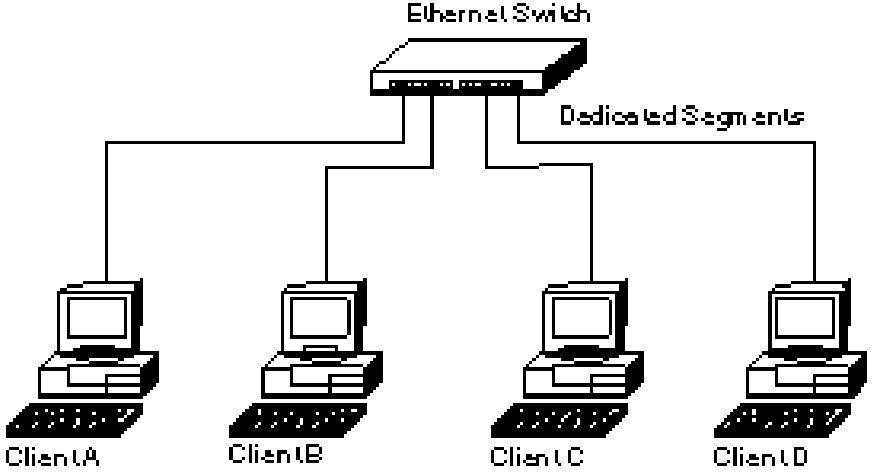
10BaseFL- point-to-point link, connecting stations & repeaters up to 2km

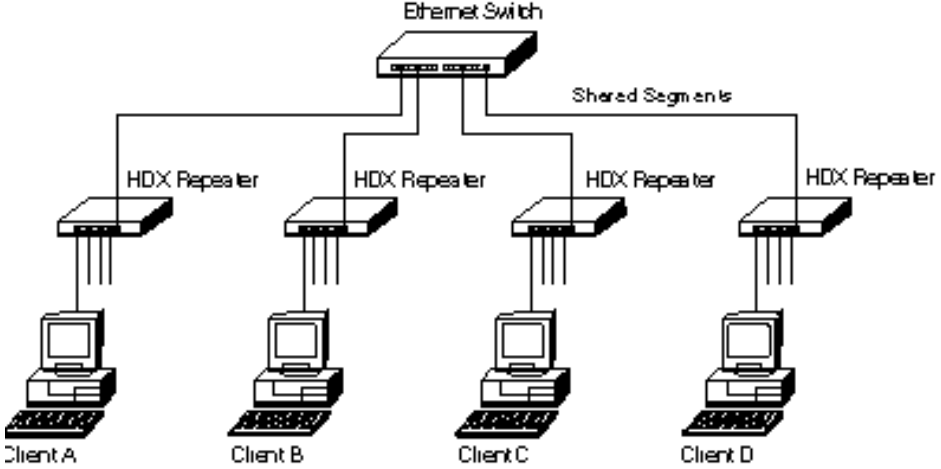
10BaseFB- backbone connecting repeaters up to 2km, using synchronous transmission (allows more repeaters cascading)

Switched Ethernet

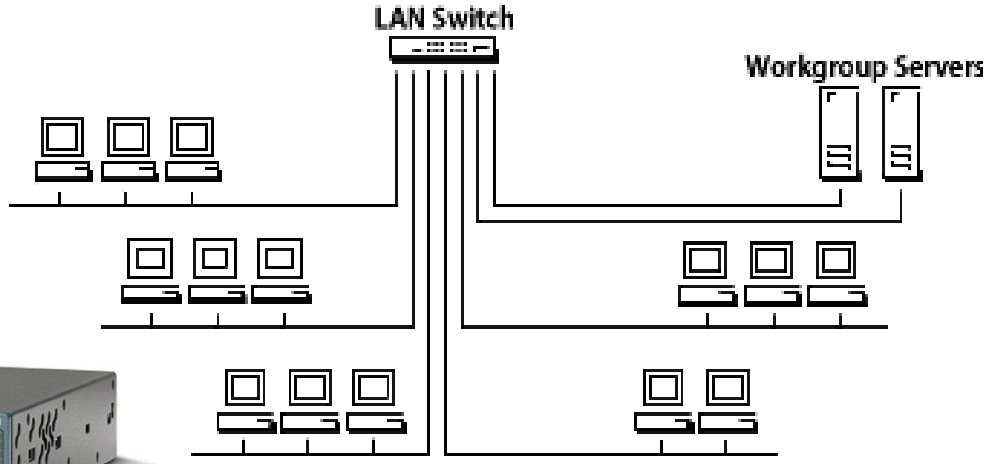
Use of *switches instead of hubs*, to join smaller LAN segments together; the switch filters and forwards the packets, in accordance with any packet protocol.
Fully Star topology.







May have dedicated segments (one per station) or shared segments (use of repeaters)



Switch device: ideal for implementing virtual LANs (for workgroup purposes)

Hubs vs. Switches

Hub: multi-port repeater, acts at Physical level

Switch: multi-port bridge, acts at Data Link level

Shared medium hub

Central hub retransmitting incoming signal to all outgoing lines

Only one station can transmit at a time

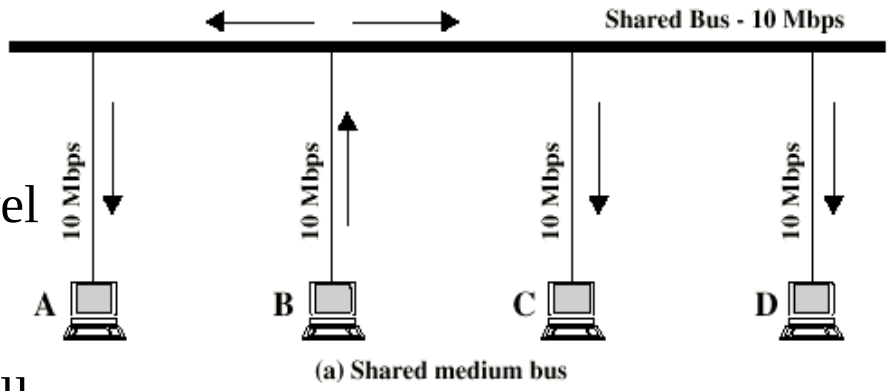
With a 10Mbps LAN, total capacity is 10Mbps

Switched LAN hub

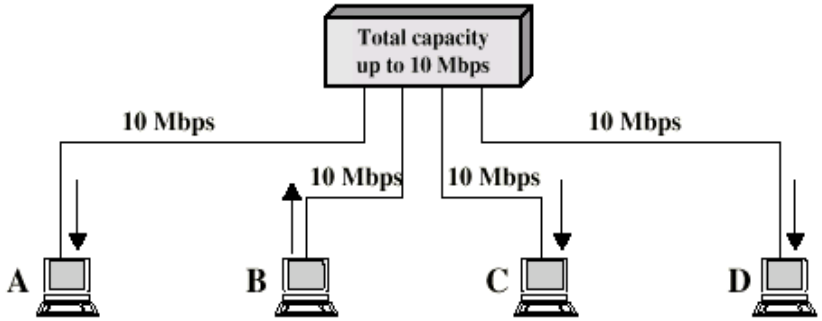
Hub acts as switch, incoming frame switched to appropriate outgoing line

Unused lines can also be used to switch other traffic

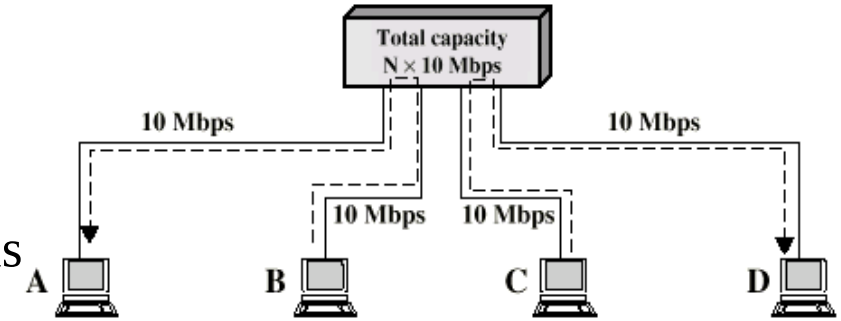
With two pairs of lines in use, overall capacity is now multiple of line speed (20Mbps)



(a) Shared medium bus



(b) Shared medium hub



(c) Switching hub

Switched Hubs

No change to software or hardware of devices

Each device has dedicated capacity

Scales well

Two major categories:

-Store and forward switch

Accept input, buffer it briefly, then output

-Cut through switch

Take advantage of the destination address being at the start of the frame

Begin repeating incoming frame onto output line **as soon as address recognized**

May propagate some bad frames

Switch General Problem: simultaneous transmissions to same destination:

Let first one through

Use of buffers associated with switch's ports

100Mbps specification (Fast Ethernet)

Providing low-cost Ethernet compatible LAN @ 100Mbps. Using 10Mbps legacy, development of 10/100Mbps NIC cards and devices. General specification in 100BaseX standard.

Different approaches:

100BaseT4

use of existing UTP Cat.3 networks (possible due to the signaling frequency of 25MHz), or Cat.5

achieve full-duplex 100Mbps transmissions using 4 UTP pairs, three used for data transmissions at 33,3Mbps and one for collision control

use of a ternary signaling scheme (8B6T- use of 27 symbols), allowing to transmit on three wires of a number of 4bits during a clock period

100BaseX (IEEE 802.13 standard)

Use of 100Mbps unidirectional data rate, so need for 2 pairs (Tx and Rx)

Two approaches, for different physical media:

100BaseTX for TP Cat.5 (UTP or STP) TP: twisted pair

100BaseFX for multi-mode fiber

Use of MLT-3 encoding scheme for 100BaseTX and of 4B/5B-NRZI for fiber based (as FDDI)

	100BASE-TX		100BASE-FX	100BASE-T4
Transmission Medium	2 pair, STP	2 pair, Category 5 UTP	2 optical fibers	4 pair, Category 3, 4, or 5 UTP
Signaling Technique	MLT-3	MLT-3	4B5B, NRZI	8B6T, NRZ
Data Rate	100 Mbps	100 Mbps	100 Mbps	100 Mbps
Maximum Segment Length	100 m	100 m	100 m	100 m
Network Span	200 m	200 m	400 m	200 m

Gigabit Ethernet (1000BaseX)

Developed by IEEE High-Speed Study Group

How to convey Ethernet packets @ Giga

Keeping backward compatibility

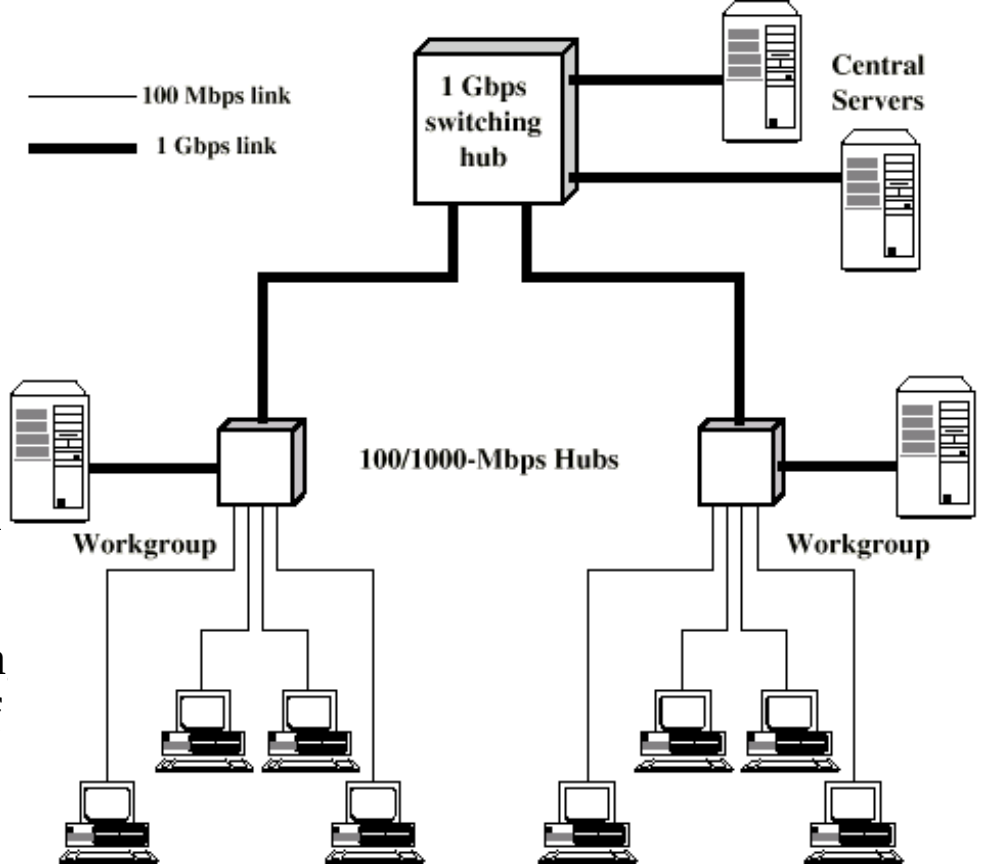
Differences vs 100Mbps at MAC level:

-***Carrier extension***, so the frame length of a transmission being longer than the propagation time at 1Gbps (principle of CSMA/CD)

Now transmission at least 4096 bit-times lon (512 bit-times for 10/100, min. frame length of 64octets)

-Frame bursting

Multiple short frames transmitted consecutively, without CSMA/CD control; avoids the overhead of carrier extension when a single station has a number of small frames ready to send.



Gigabit Ethernet - Physical specifications: Signaling - 8B/10B

Different approaches:

1000BaseSX

Short wavelength light, multimode fiber; duplex links @ 200-400m length

1000BaseLX

Long wavelength light, Multi or single mode fiber; duplex links @ 500 – 5000m length

1000BaseCX

Use of copper jumpers < 25m made from shielded twisted pair; cluster of stations, close situated

1000BaseT

4 pairs, cat 5 UTP

10Gigabit Ethernet (10GBaseX)

Why?

-increase in Internet and intranet traffic

-increase in the connection speed of each end-station

-increase of bandwidth-intensive applications

Allows the construction of MANs and WAN

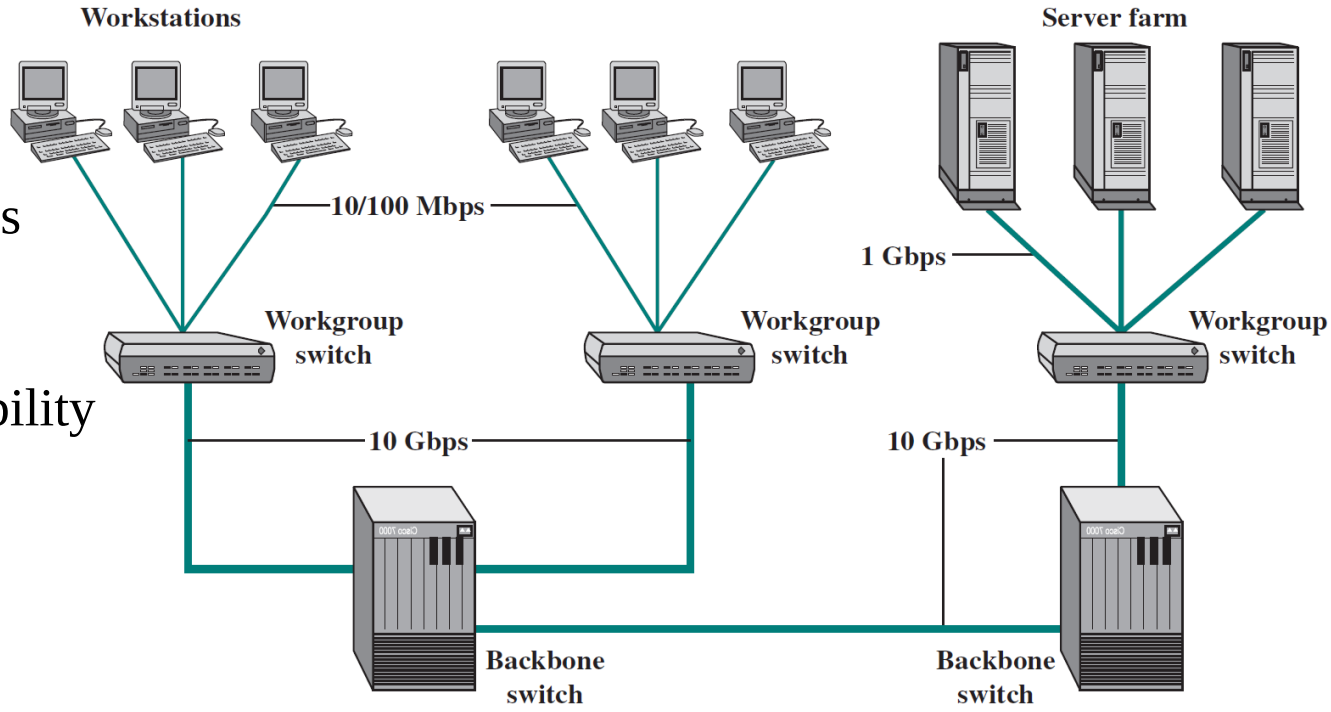
Combining IP and Ethernet offers quality of service and traffic-policing capabilities

Range:

-from 300m to 40 km

-standard optical interfaces

Keeps backward compatibility



10Gigabit Ethernet

Different approaches:

10GBASE-S (short)

multimode fiber with distances up to 300 m
10GBASE-SR and10GBASE-SW versions

10GBASE-L (long)

single-mode fiber with distances up to 10 km
10GBASE-LR and 10GBASE-LW versions

10GBASE-E (extended):

single-mode fiber with distances up to 40 km
10GBASE-ER and 10GBASE-EW versions

10GBASE-LX4:

single-mode or multimode with distances up to 10 km
uses wavelength division multiplexing (WDM) to multiplex the bit stream across four light waves.

100Gigabit Ethernet (100GBaseX)

Ethernet is the preferred carrier for bridging wireless technologies, such as Wi-Fi and WiMAX, into local networks.

Where?

Data center/Internet media providers

-to support the growth of Internet multimedia content and Web applications

Metro-video/service providers

-video on demand services

• **Enterprise LANs**

-converge networks (voice/video/data) and unified communications

-most enterprises still rely on 1-Gbps or a mix of 1-Gbps and 10-Gbps Ethernet,

-adoption of 100-Gbps Ethernet - slow.

•**Internet exchanges/ISP core routing:**

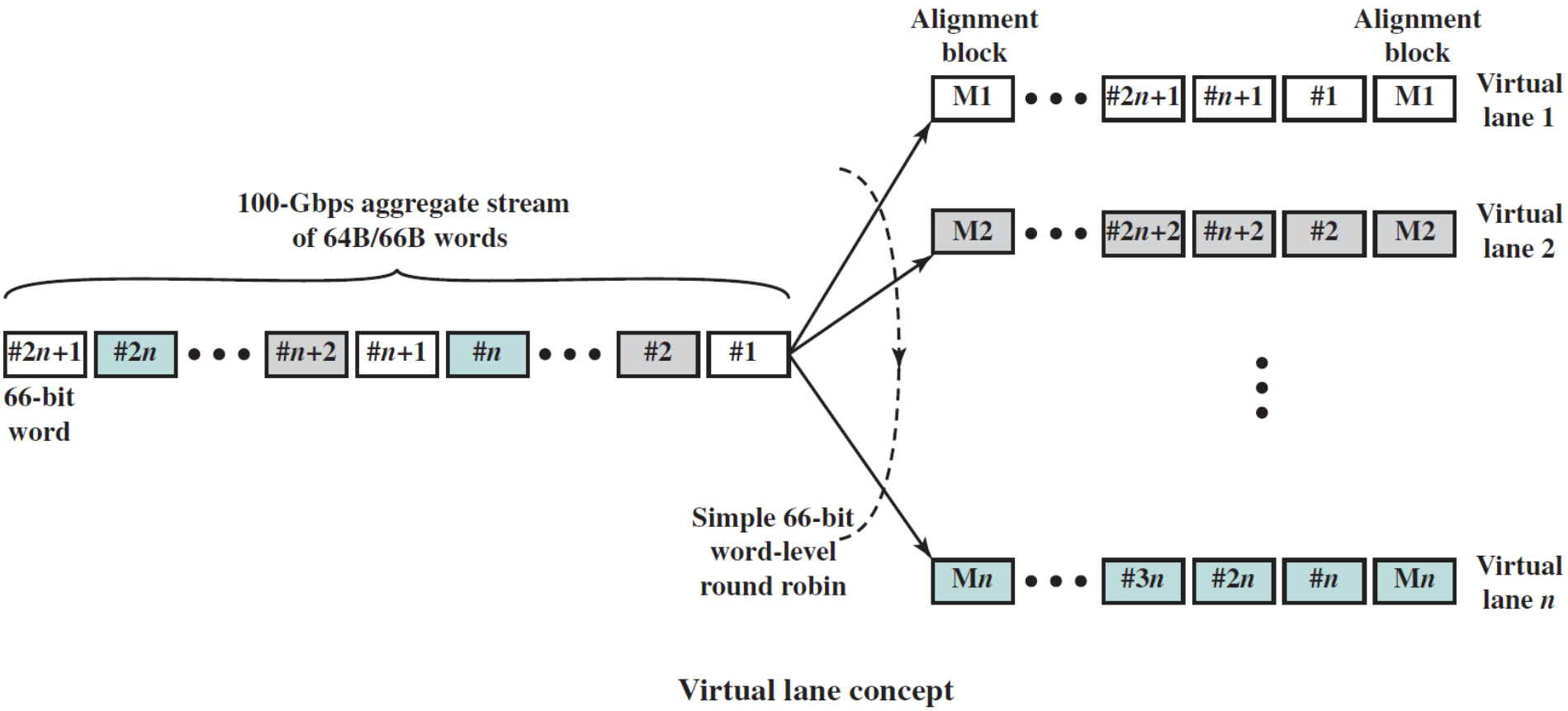
-massive amount of traffic

IEEE 802.3 working group: IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet Task Force

-Keeps backward compatibility

New concepts: multilane distribution and virtual lanes

- **multilane distribution**:
  - -physical links implemented as multiple parallel channels
  - -separate physical wires **or** wavelength division multiplexing over a single optical fiber link



Virtual lane concept

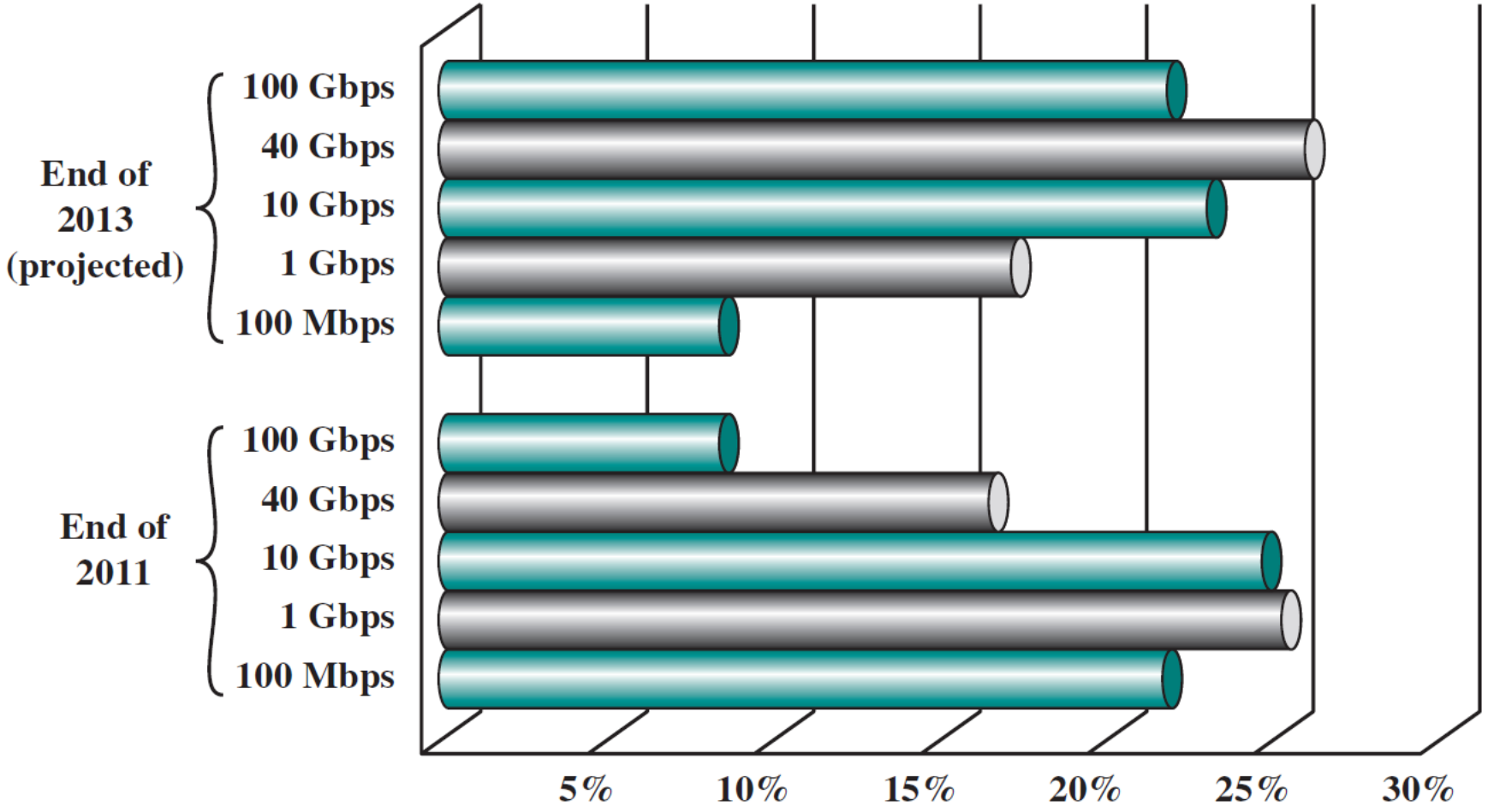
Media Options for 40-Gbps and 100-Gbps Ethernet

	40 Gbps	100 Gbps
1m backplane	40GBASE-KR4	
10 m copper	40GBASE-CR4	1000GBASE-CR10
100 m multimode fiber	40GBASE-SR4	1000GBASE-SR10
10 km single-mode fiber	40GBASE-LR4	1000GBASE-LR4
40 km single-mode fiber		1000GBASE-ER4

Naming nomenclature:

Copper: K = backplane; C = cable assembly
Optical: S = short reach (100 m); L = long reach (10 km); E = extended long reach (40 km)
Coding scheme: R = 64B/66B block coding
Final number: number of lanes (copper wires or fiber wavelengths)

From 100Mbps to 100Gbps Ethernet usage



Data Center Study—Percentage of Ethernet Links by Speed