CI0121 Computer Networks

Network categories and

## Interconnecting devices

Profesores ECCI

Categories of networks

- Personal Area Networks (PANs)

- Local Area Networks (LANs)

  - Storage Area Networks (SANs)

- Metropolitan Area Networks (MANs)

- Wide Area Networks (WANs)

Alternative classifications

- Telecommunication networks:
  - Access networks
  - Backbone networks
  - Data centers

- Internet structure:
  - Local ISP
  - Regional ISP
  - Backbone ISP

- Corporate networks:
  - Department networks
  - Building or campus networks
  - Enterprise-wide networks

- Internet structure (ISP classification):
  - Tier 1
  - Tier 2
  - Tier 3
  - Tier 4
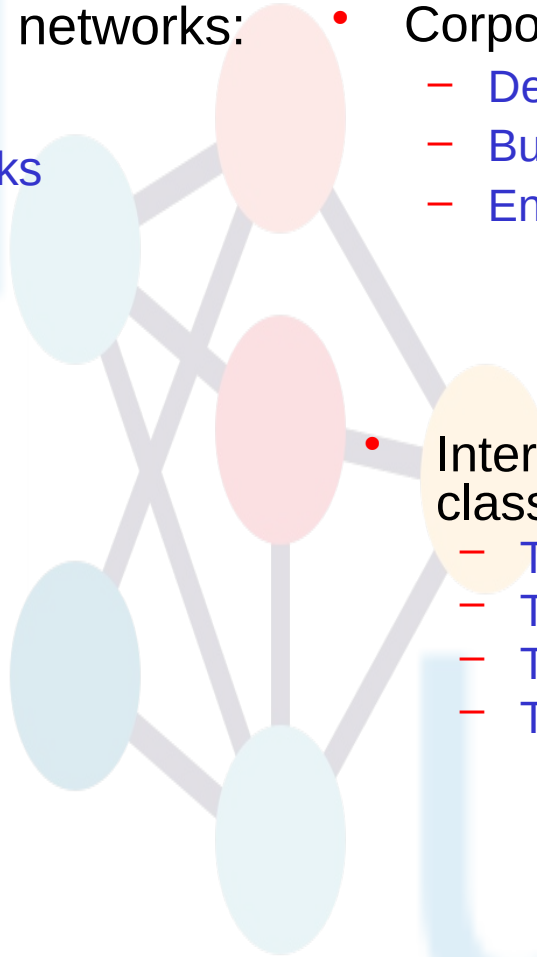
Differences among categories

- Geographical area of coverage
- Data transmission rates
- Ownership
- Government regulation
- Data routing
- Type of information transmitted
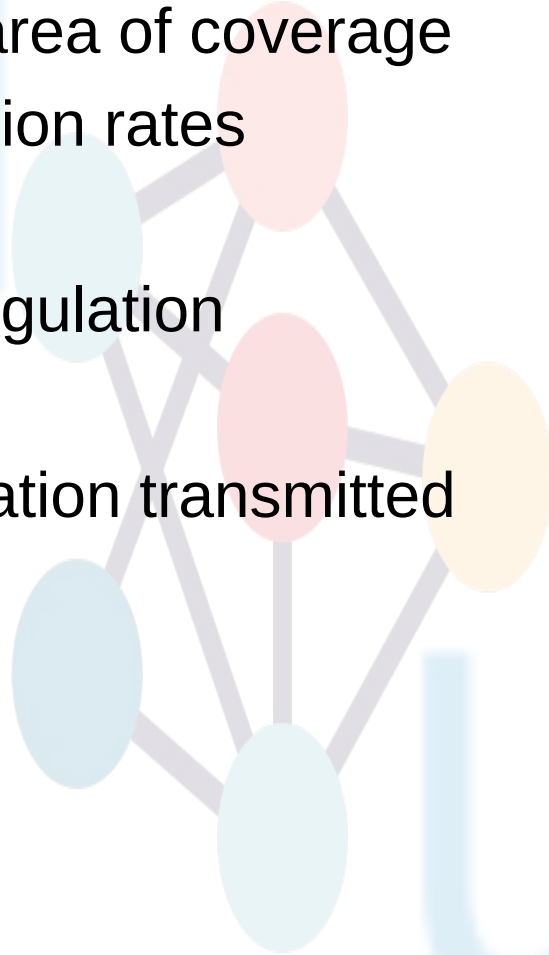
Geographic Area

| Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	Local area network
1 km	Campus	Local area network
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	Wide area network
10,000 km	Planet	The Internet

Data transmission rate

PANs: 100 Kbps – 2 Mbps

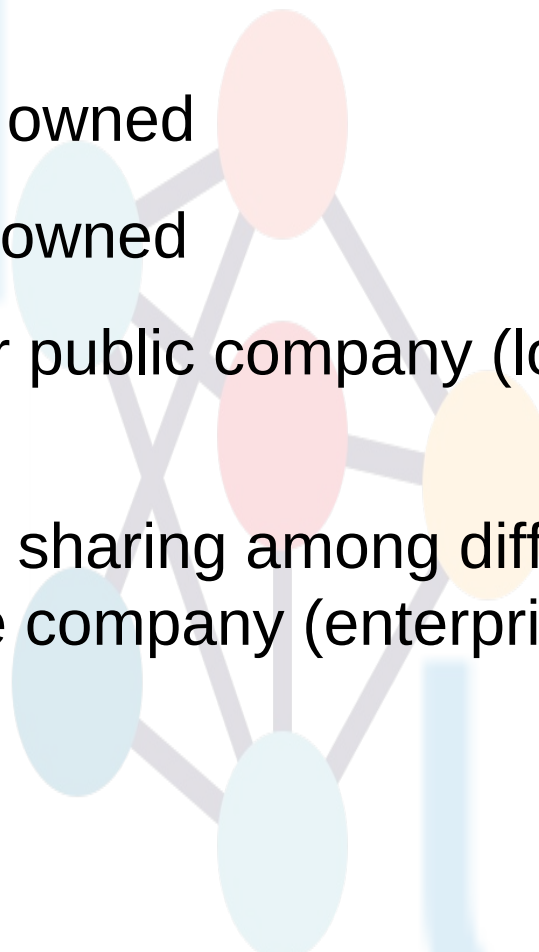LANs: 1 – 1000 Mbps

MANs: 10 – 40 Gbps

WANs: Tbps
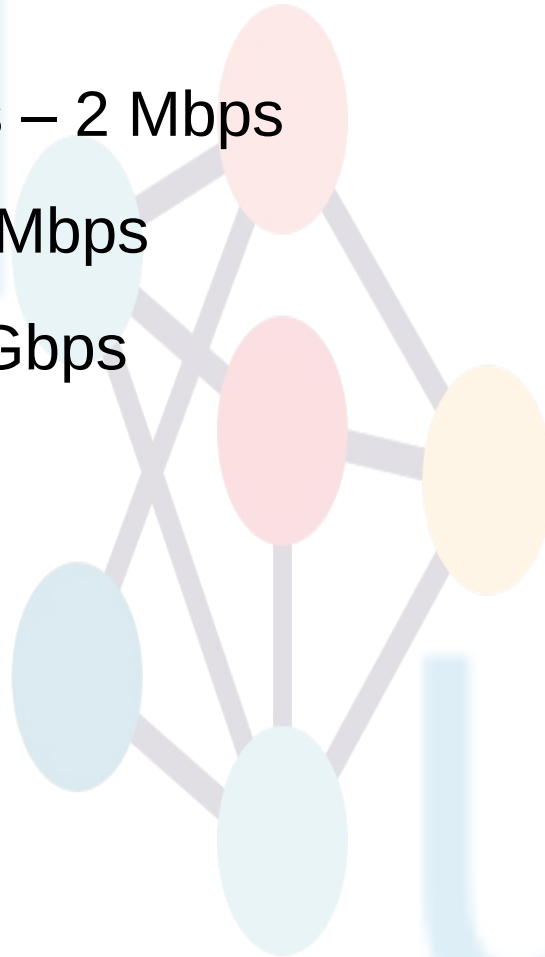
Ownership

PANs: privately owned

LANs: privately owned

MANs: private or public company (local telephone company)

WANs: resource sharing among different companies or owned by one company (enterprise network)
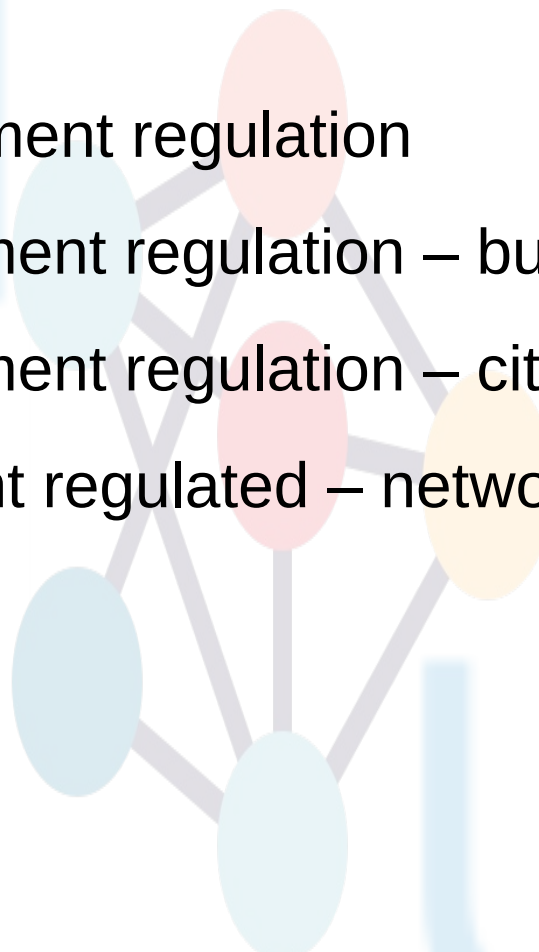
Government regulations

PANs: no government regulation

LANs: no government regulation – building policy

MANs: no government regulation – city regulations

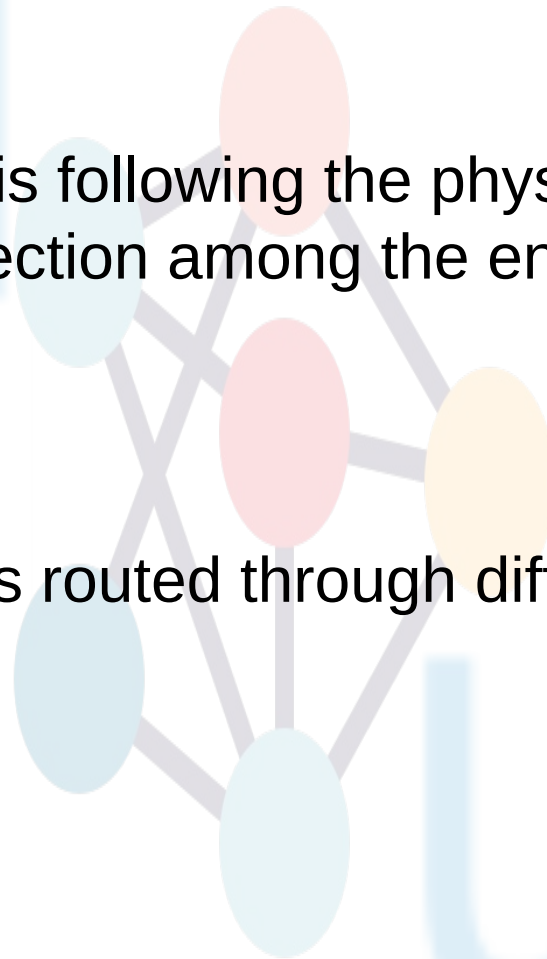WANs: government regulated – networks among states

Data routing

PANs:

LANs:

MANs:

Data is following the physical connection among the end nodes

WANs:

Data is routed through different links
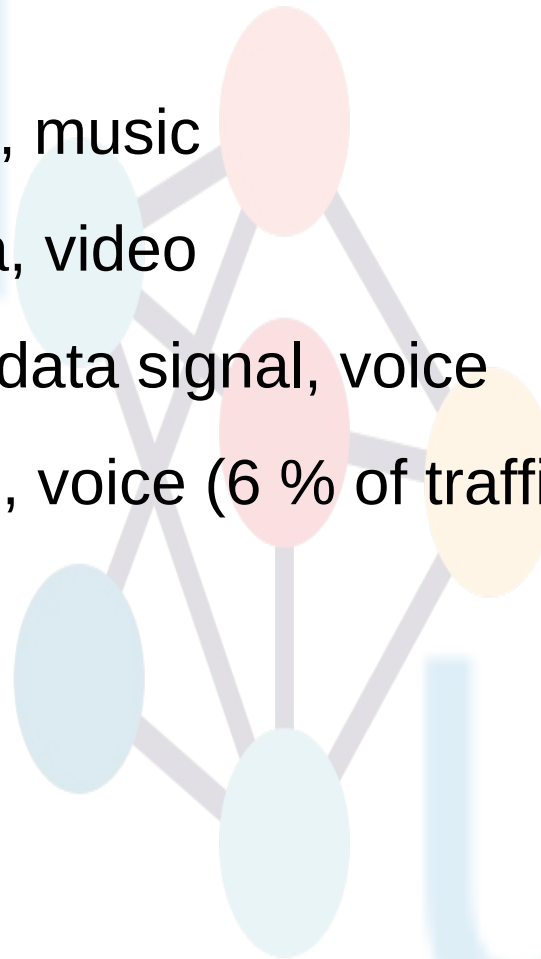
Transmitted information

PANs: voice, data, music

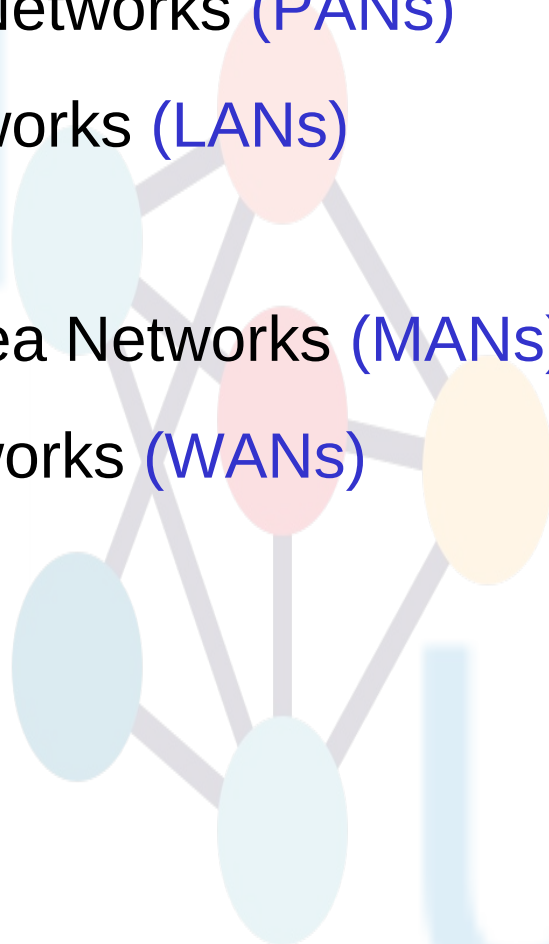LANs: mostly data, video

MANs: majority of data signal, voice

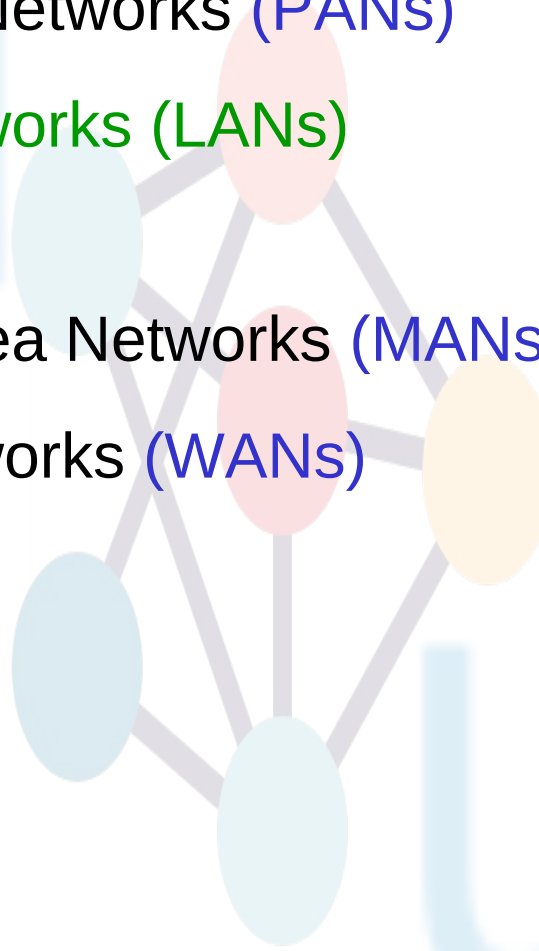WANs: data, video, voice (6 % of traffic in 2003)

Categories of networks

- Personal Area Networks (PANs)

- Local Area Networks (LANs)

  – Ethernet

- Metropolitan Area Networks (MANs)

- Wide Area Networks (WANs)

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Local area networks

- Typically, based on a shared medium
  - broadcasting at layer 1 or layer 2
- Relatively small distance   (few kilometres, at most)
- Simple topologies

- High *total* bandwidth

- Limited number of nodes

- Low delay and error rate (mostly in wired environments)

- Broadcast facility supported

 - i.e., part of the layer 2 service

Standardizing LANs: IEEE 802

- Working Groups and Study Groups
  - 802.1 Higher Layer LAN Protocols Working Group
    - Try to unify some issues for all LANs: management, addressing, bridges
  - 802.2 Logical Link Control working Group
    - Issues in connecting to the network layer
  - 802.3 Ethernet Working Group
  - 802.4 Token bus Working Group
  - 802.5 Token ring Working Group
  - 802.11 Wireless LAN Working Group
    - 11a, 11b, 11e, 11g
  - 802.15 Wireless Personal Area Network (WPAN) Working Group
    - e.g. BlueTooth, ...
  - 802.16 Broadband Wireless Access Working Group
    - wireless MAN
  - 802.17 Resilient Packet Ring Working Group
  - 802.18 Radio Regulatory TAG
  - 802.19 Coexistence TAG
  - 802.20 Mobile Broadband Wireless Access (MBWA) Working Group
  - Link Security Executive Committee Study Group

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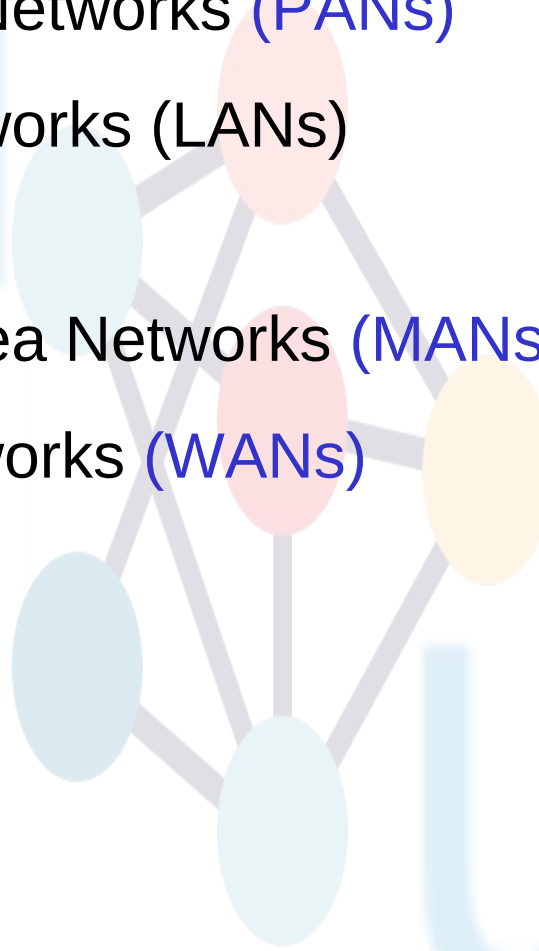
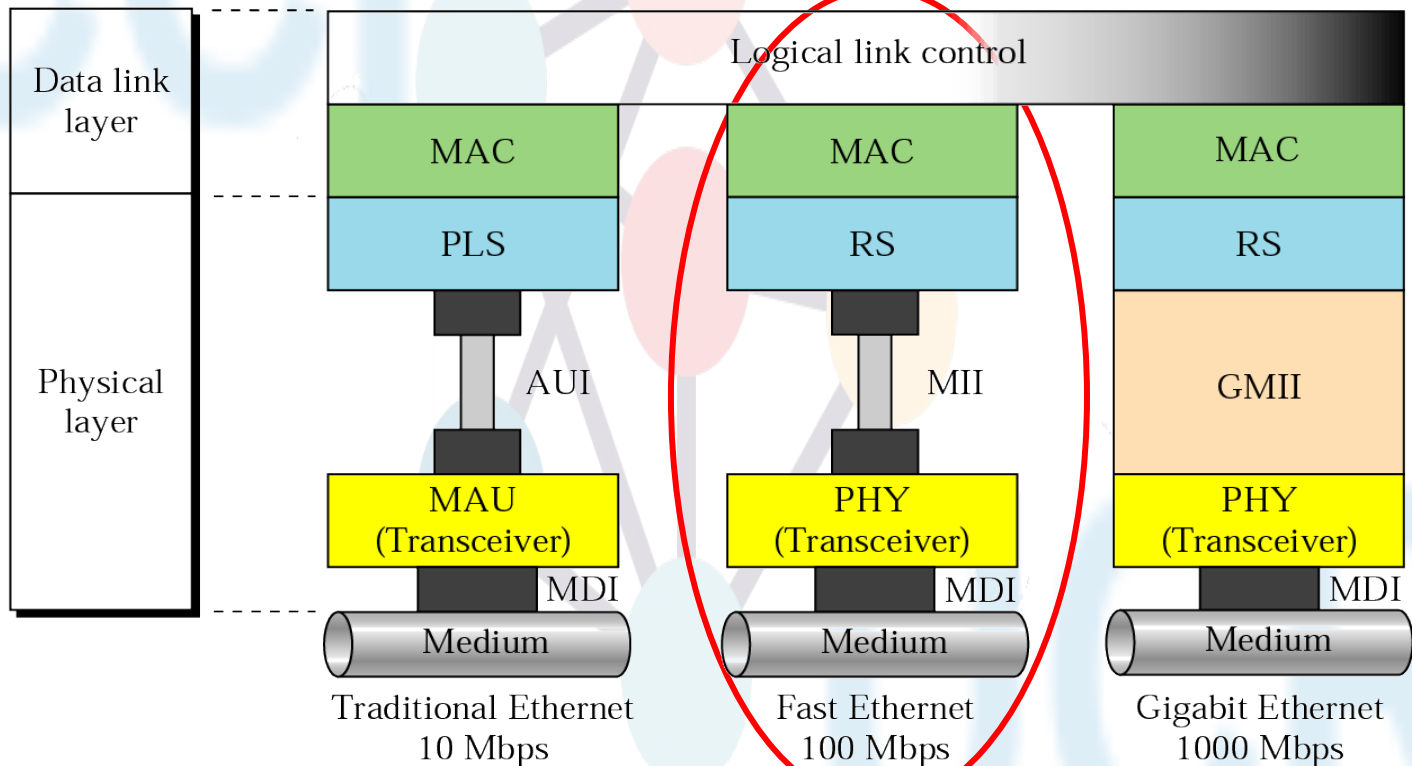# The most widely used standard: Ethernet

Why Ethernet?

- It is simple
- Low cost
  - upgrading from one version to another is very easy and costs increase only 2 folds while speed increases 10 times
- According to Nortel 95 % off all LAN nodes are Ethernet!
- Standard for both LANs and WANs
- Wireless LAN standard
- Total area network standard?

Three generations of Ethernet

AUI: Attachment Unit Interface
MAC: Media Access Control
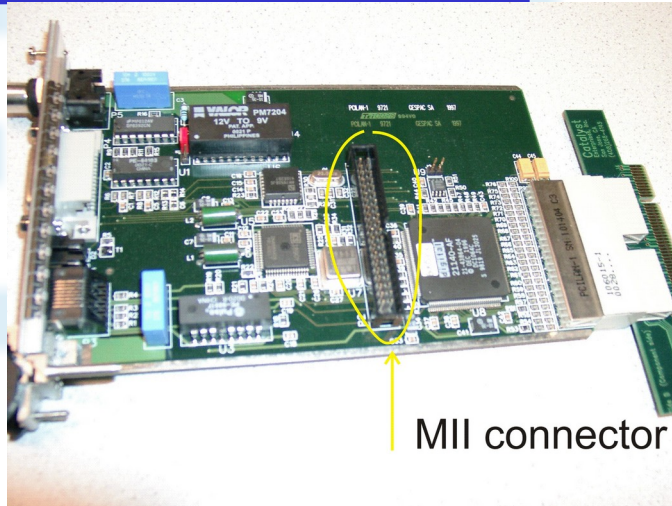MAU: Medium Attachment Unit

MDI: Medium-Dependent Interface
MII: Medium-Independent Interface
GMII: Gigabit Medium-Independent Interface

PHY: Physical Layer Entity
PLS: Physical Layer Signaling
RS: Reconciliation Signaling

Ethernet protocol only in the lowest 2 layers

Data link layer	Logical link control		
	MAC	MAC	MAC
	PLS	RS	RS
Physical layer	AUI	MII	GMII
	MAU (Transceiver)	PHY (Transceiver)	PHY (Transceiver)
	MDI	MDI	MDI
	Medium	Medium	Medium

Traditional Ethernet
10 Mbps

Fast Ethernet
100 Mbps

Gigabit Ethernet
1000 Mbps

Ethernet NIC with MII connector
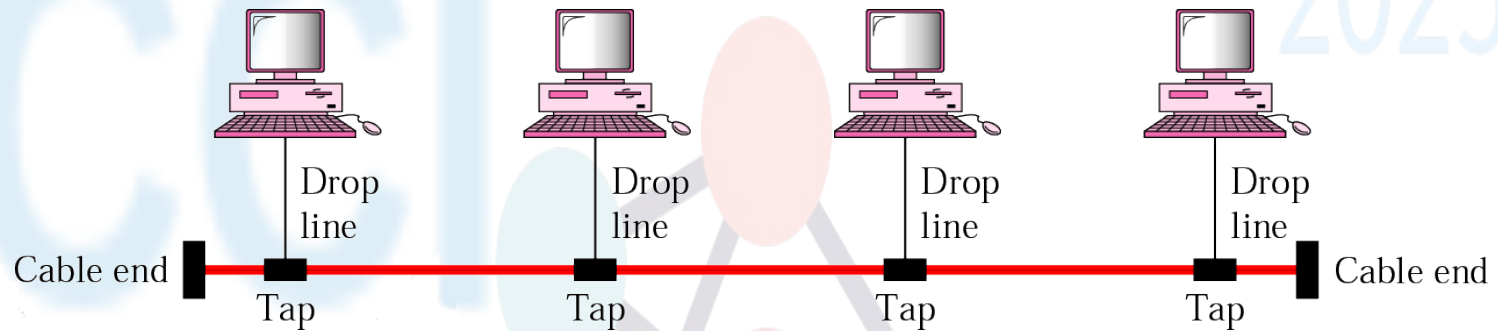
MII connector

Network Interface Card
with the MII connector

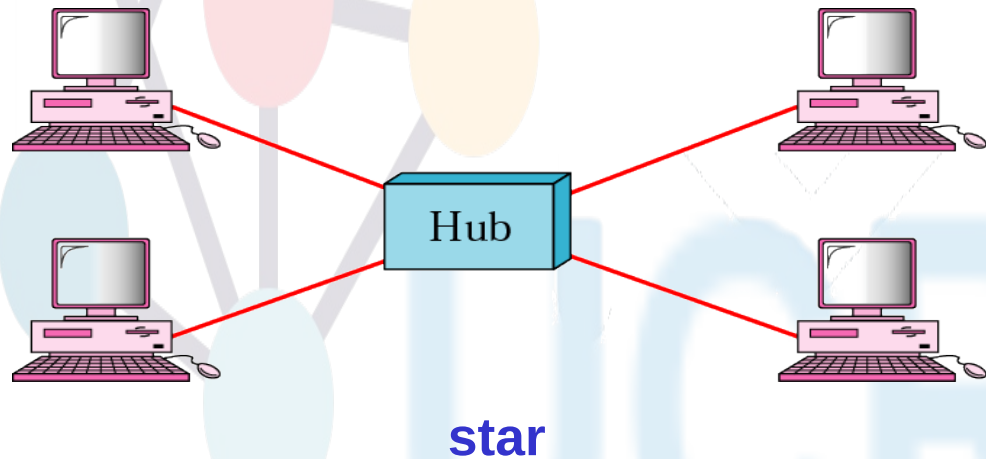Physical Layer Device
attached to the NIC with
the MII connector

Optical MII transceiver
- Physical Layer Device -
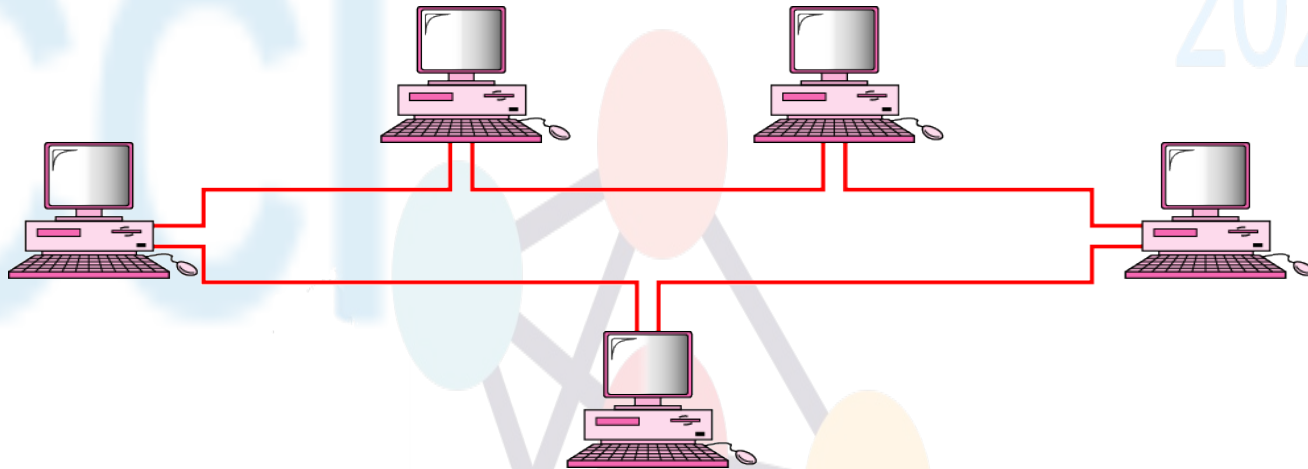
Ethernet topologies

Drop line
Drop line
Drop line
Drop line

Cable end — Tap — Tap — Tap — Tap — Cable end

bus

shared medium
- broadcast -

span limited by
collision domain!

Hub

star

Token ring

- Each node waits for the token to send data
- Token is mostly exchanged in the Round-Robin fashion
- Nodes get equal chance to transmit
- Introducing priorities is possible

Categories of networks

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STOP

Interconnecting devices

- How to get more users attached to a LAN?

- How to extend a single LAN?

- How to connect different LANs?
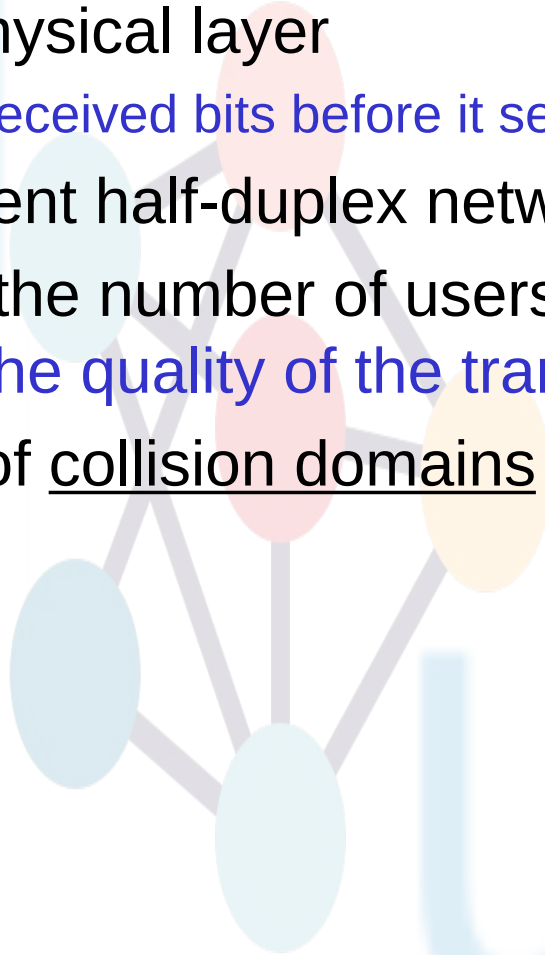
Interconnecting devices (cnt'd)

- repeater
- hub
- bridge
- switch
- router
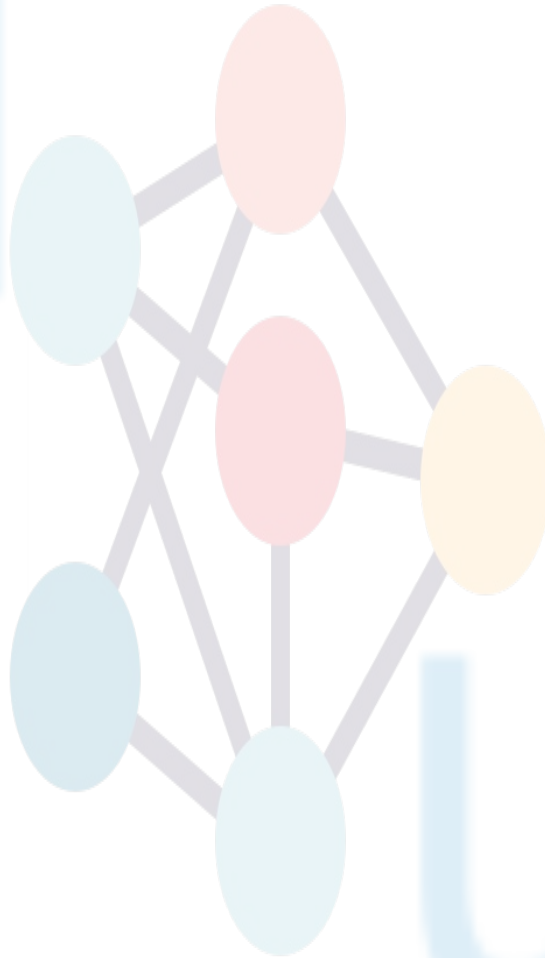
Repeater

- works at the Physical layer
  - Regenerates received bits before it sends them out
- connects different half-duplex network segments
- either extends the number of users or the total span (by improving the quality of the transmitted signal)
- no separation of <u>collision domains</u>

Hub

- multi-port repeater (physical hardware device)
- provides physical star topology
- no intelligence
- no separations of collision domains
  - all the hosts compete for the shared bandwidth
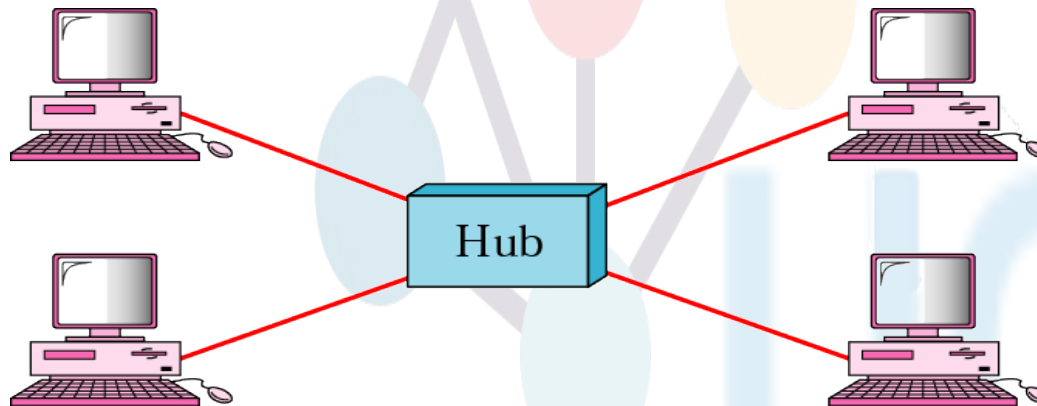
Bridge

- works at layer 2 (requires software)
- connects two networks of the same type
  - LAN to LAN (example: WLAN to Fast Ethernet)
- forwards data (1 packet @ the time) depending on the destination address in the data packet (not the IP address, but the physical (MAC) address that is unique for every Network Interface Card (NIC))
- all computers are in the same <u>sub-network</u>
- packet filtering
- separates collision domains – larger network spans
- a stand alone device or a PC with the special NIC and the accompanied software

Bridge (cnt'd)

a. Without bridging

b. With bridging

Domain

a. Without bridging

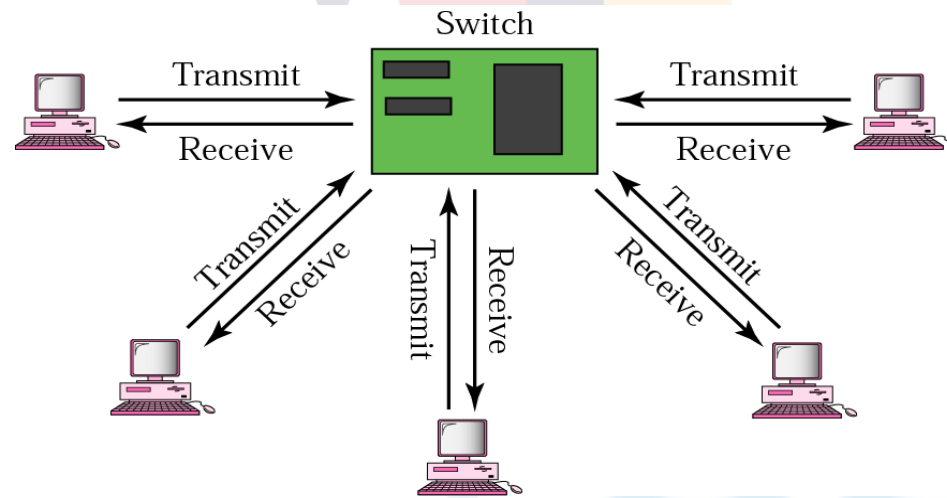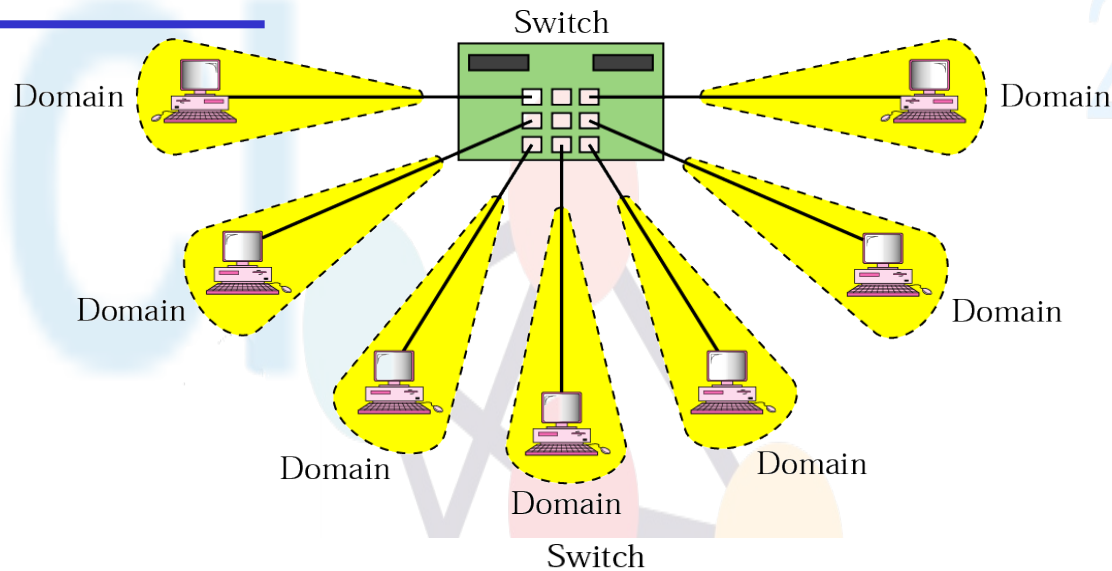Domain   Domain

Domain   Domain

Bridge

b. With bridging

Switch

- basically a multi-port bridge
- provides a better network performance
  - forwards more than a single packet at a time
- separates collision domains – larger total network span
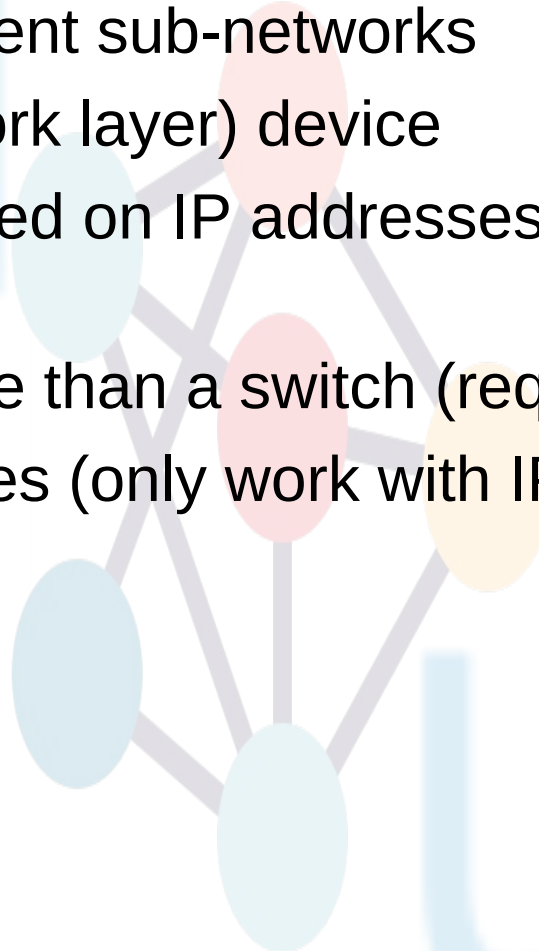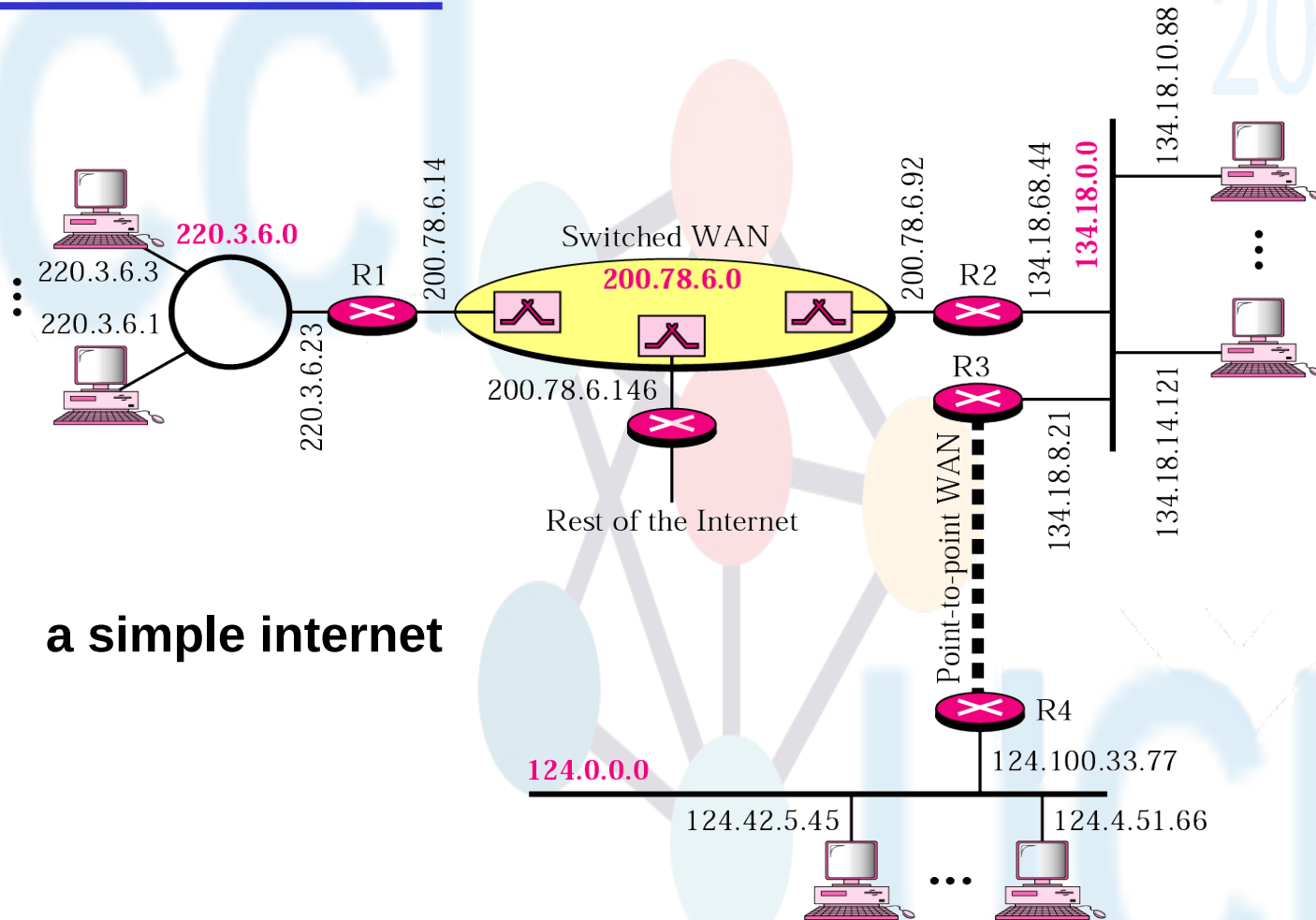- bandwidth not shared
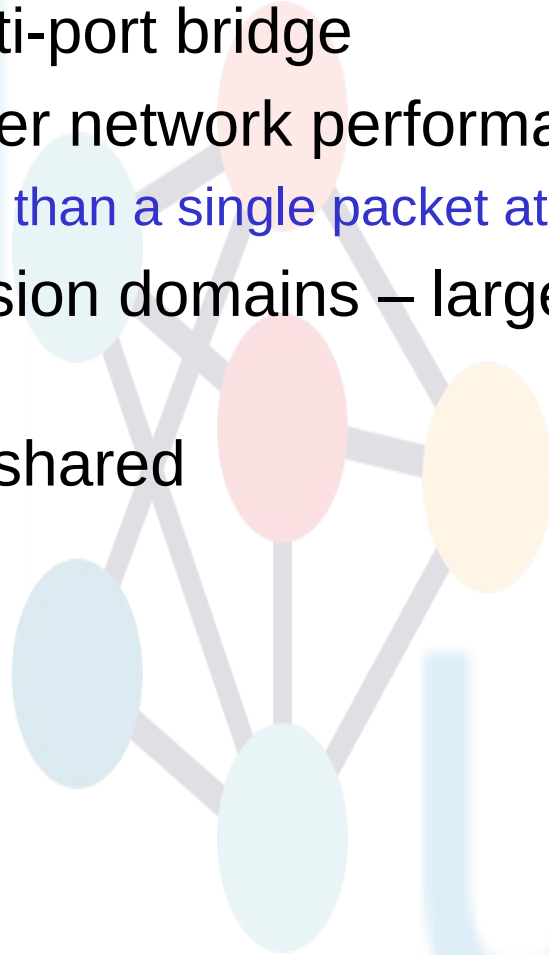
Switch (cnt'd)

Router

- connects different sub-networks
- Layer 3 (Network layer) device
- forwarding based on IP addresses not on MAC addresses
- more expensive than a switch (requires CPU)
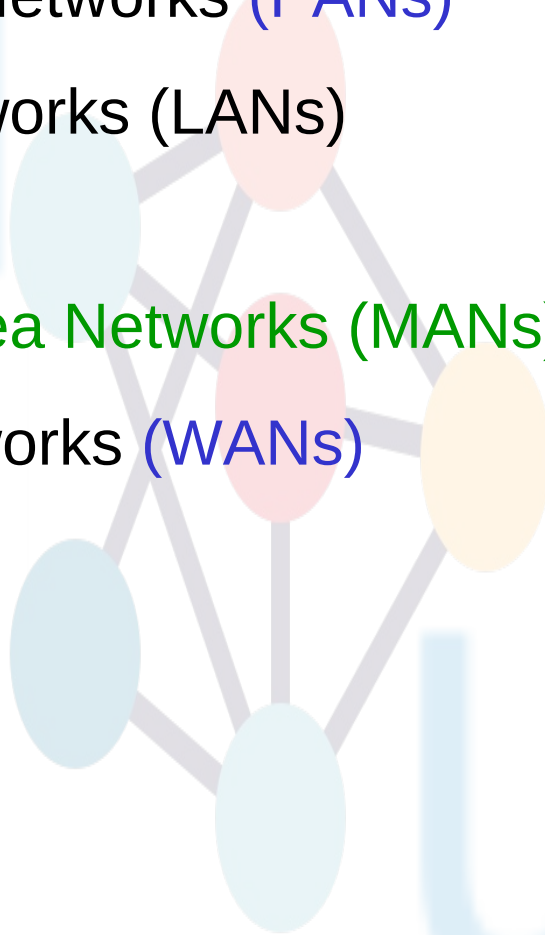- Layer 3 switches (only work with IP packets)

An example

a simple internet

Categories of networks

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- Local Area Networks (LANs)

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# Metropolitan Area Networks

- Three components
  - the access network for end-users
    - at the end-user you may find a LAN again...
  - connect to long-haul access points
  - specifically serve enterprises
    - e.g. file storage, disparate locations
- Requirements
  - diverse access technology
    - xDSL, cable, telephony, fiber
  - diverse managerial domains
    - home/enterprise equipment, PTT, cable company, leased lines
  - locally: fast, reliable and fair
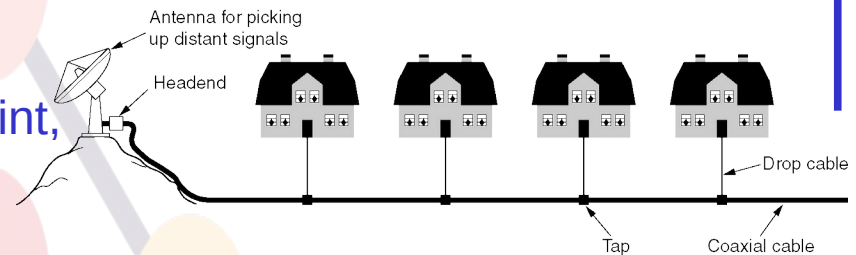   - similar technologies as LAN, if possible

MANs (cnt'd)

Public city network
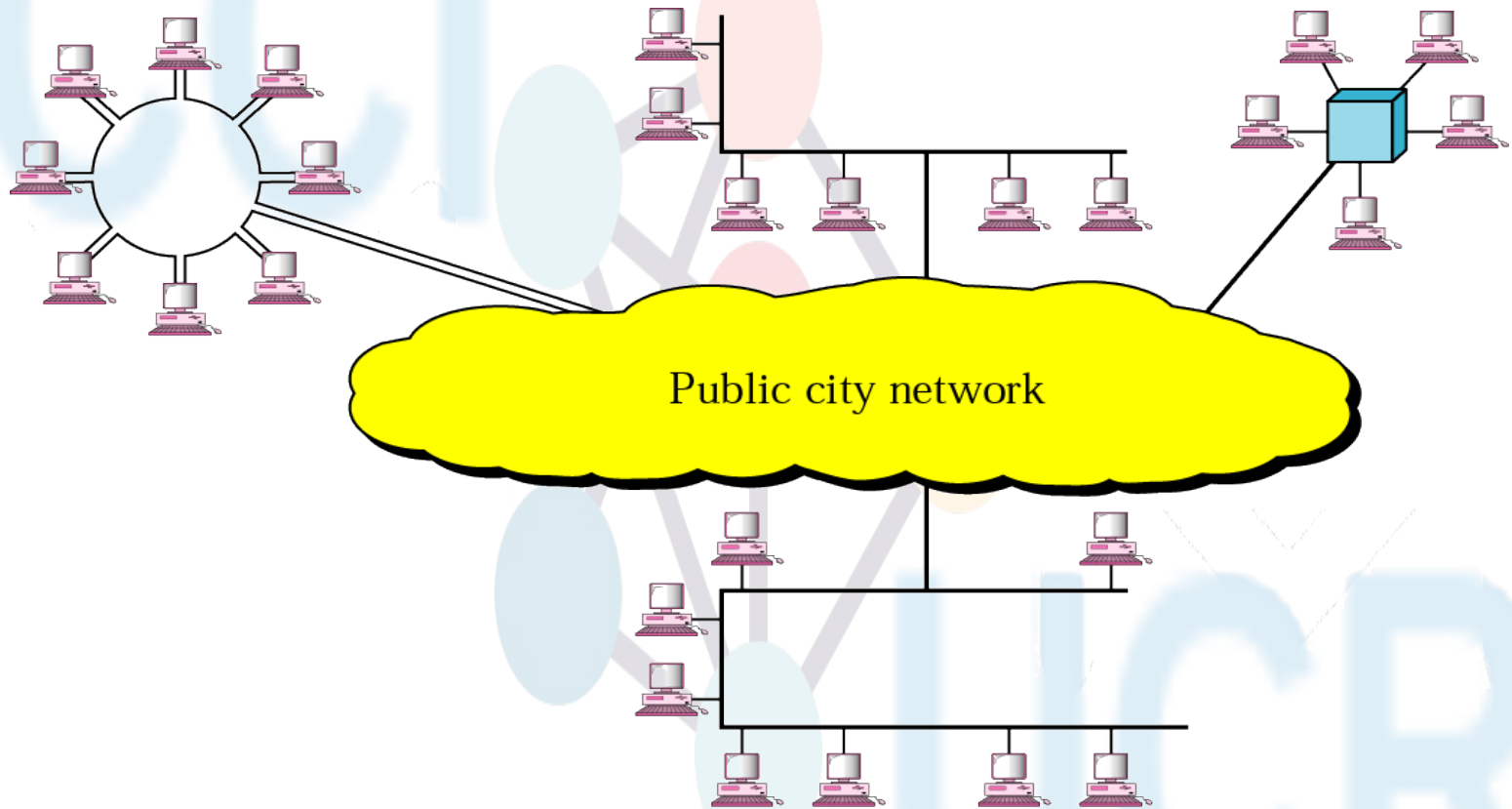
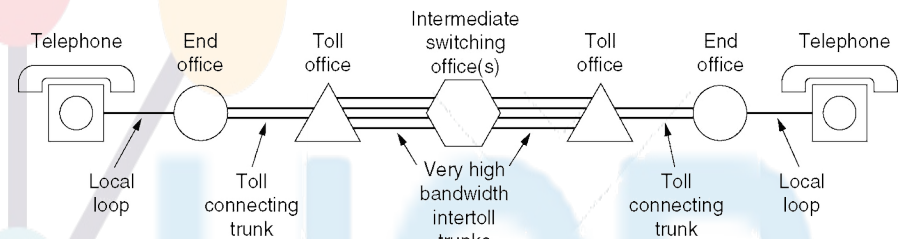# MANs: examples

- Regular, special purpose networks
  - cable TV: just broadcasting and multiplexing of *signals* across the same physical medium
  - telephony: full duplex, point to point, connection oriented
  - electricity

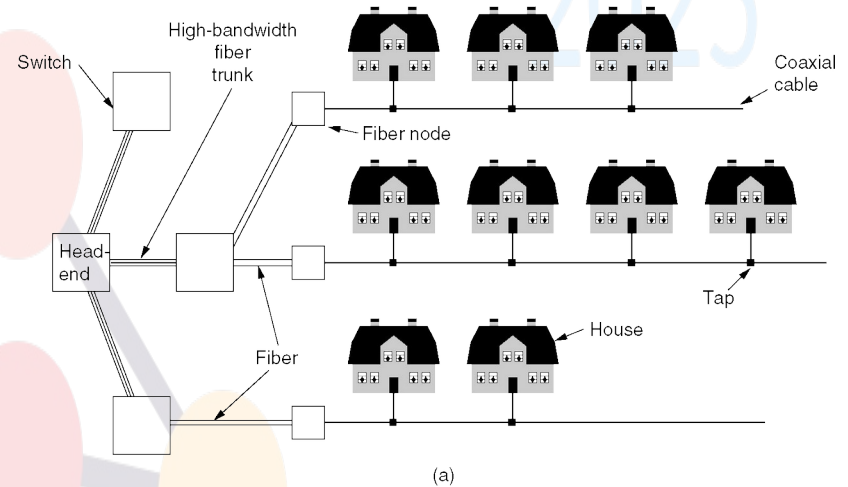- General data communication
  - re-use existing infrastructure

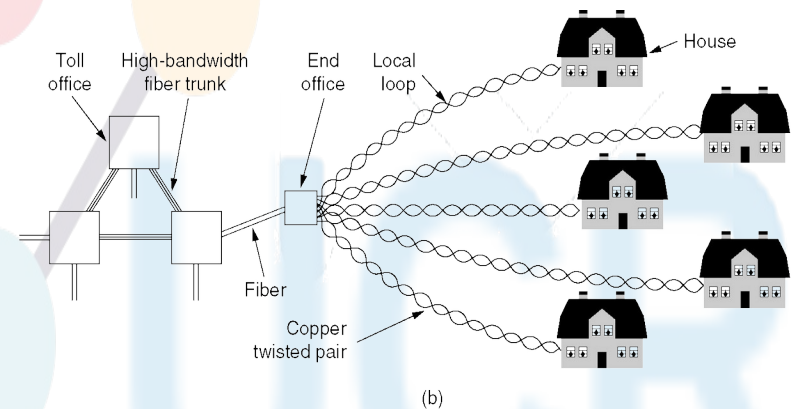# Cable and telephony

- ## Cable TV
  - need to add two-way communication
  - sharing of cable segments

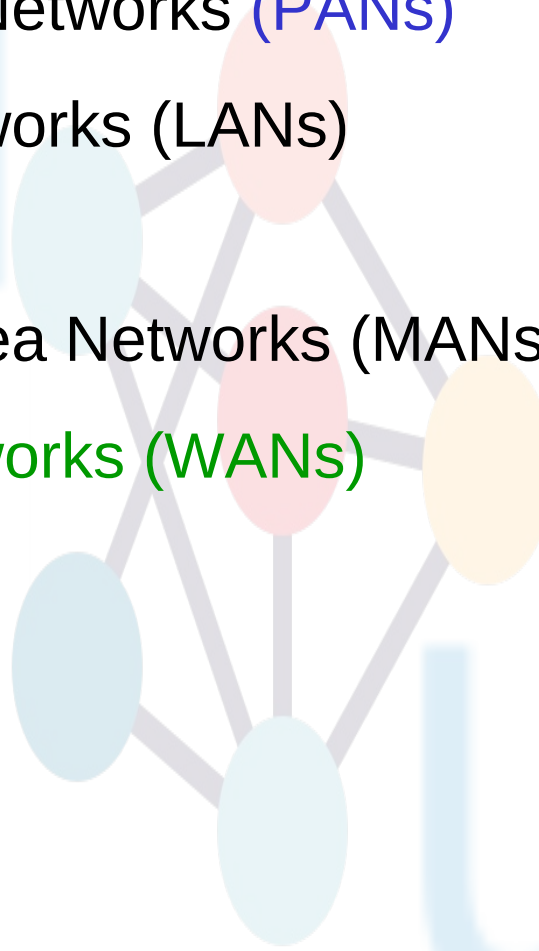- ## Telephone
  - low bandwidth UTP

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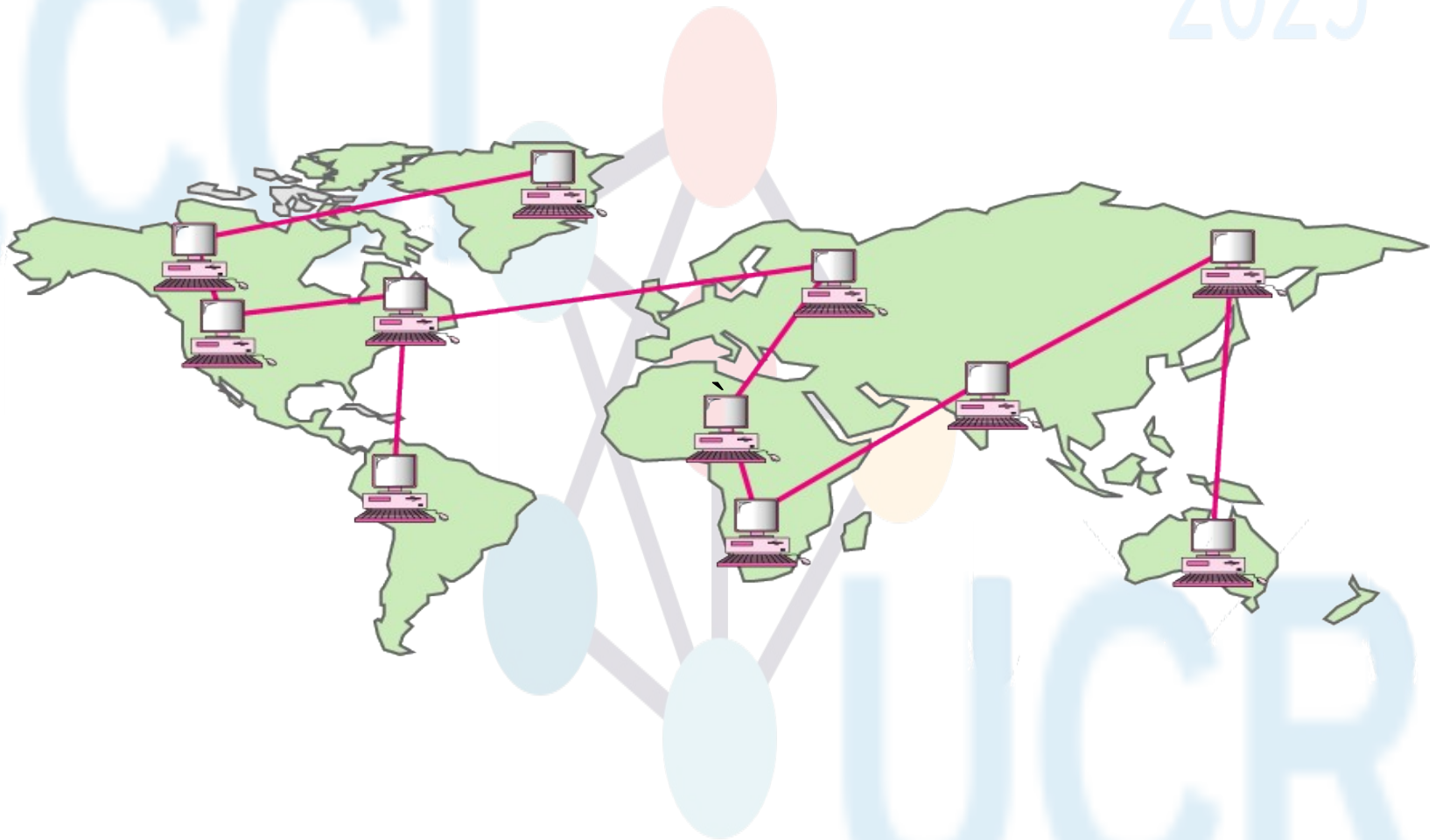
- Wide Area Networks (WANs)

Wide Area Networks

- <u>Long-range</u> geographical distribution
- Separation of *local net* and *subnet*
  - different management
  - subnet: just transport – wires, switches, routers (no hosts!)
- Path-oriented transport through the subnet
- **Note**: subnet properties will affect WAN services

Subnet   Router

Host

LAN
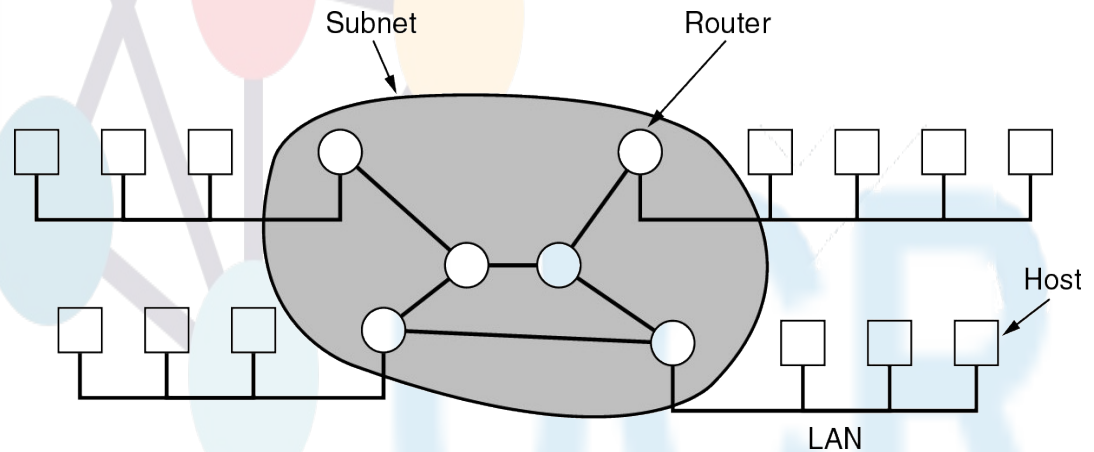
WANs (cnt'd)

Home networks

- Special requirements
  - diverse hardware and interconnect
    - Information, Communication, Entertainment, Control
  - must work, reliable, foolproof
  - low cost
  - much streaming, rather than bursty traffic
    - high capacity
    - does not work well with Ethernet
  - evolutionary path
    - equipment is there for years to stay
  - safe, secure, privacy protection

Connecting everything: the Internet

Network Access Point

serves to tie all the Internet Service Providers together

AT&T
Bell South
WorldCom