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Reti di Elaboratori

Corso di Laurea in Informatica
Università degli Studi di Roma "La Sapienza"
Canale A-L

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Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

- end systems, access networks, links

1.3 Network core

- circuit switching, packet switching, network structure

1.4 Delay, loss and throughput in packet-switched networks

1.5 Protocol layers, service models

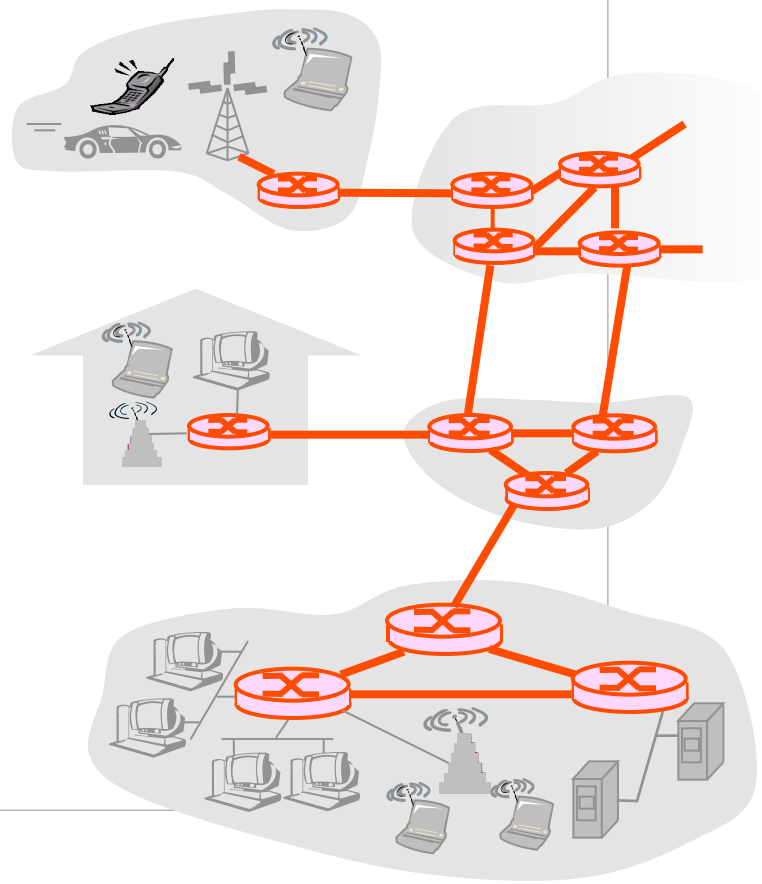
1.6 Networks under attack: security

1.7 History

The Network Core

Impossibile visualizzare l'immagine. La memoria del computer potrebbe essere insufficiente per aprire l'immagine oppure l'immagine potrebbe essere danneggiata. Riavviare il computer e aprire di nuovo il file. Se viene visualizzata di nuovo la x rossa, potrebbe essere necessario eliminare l'immagine e inserirla di nuovo.

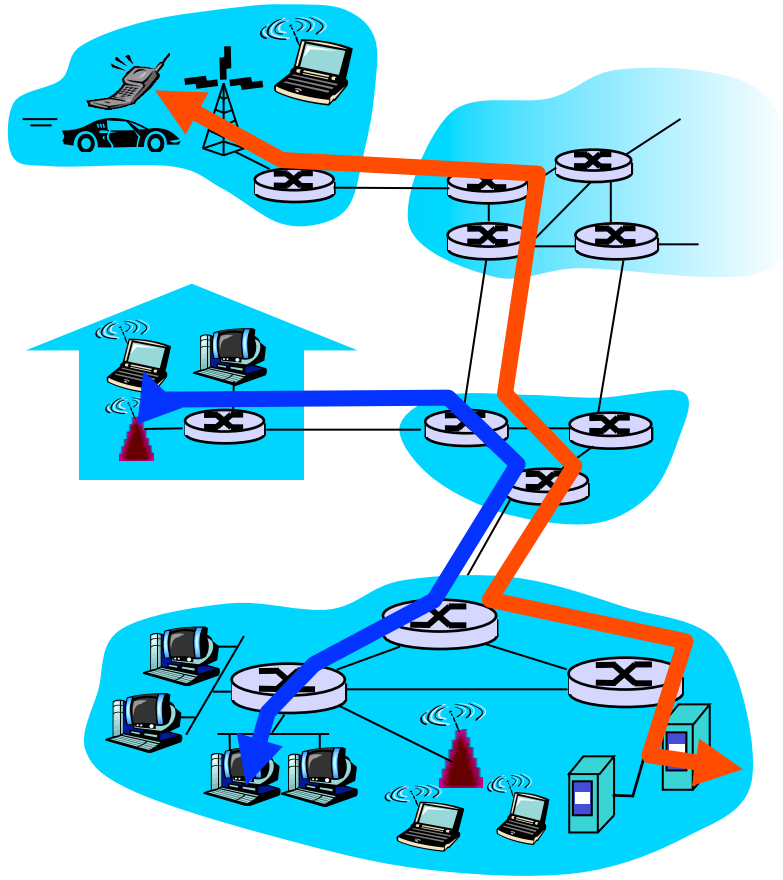
- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete "chunks"



Network Core: Circuit Switching

End-end resources reserved for "call"

- link bandwidth, switch capacity
- dedicated resources: no sharing
- circuit-like (guaranteed) performance
- call setup required



Network Core: Circuit Switching

network resources (e.g., bandwidth) divided into "pieces"

- pieces allocated to calls
- resource piece *idle* if not used by owning call *(no sharing)*

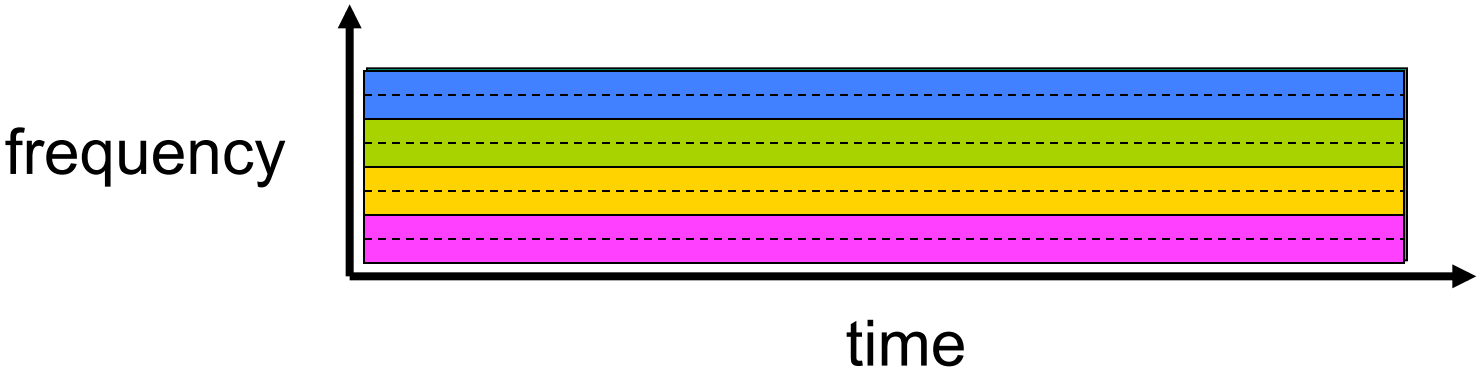
- dividing link bandwidth into "pieces"
  - frequency division
  - time division

Circuit Switching: FDM and TDM

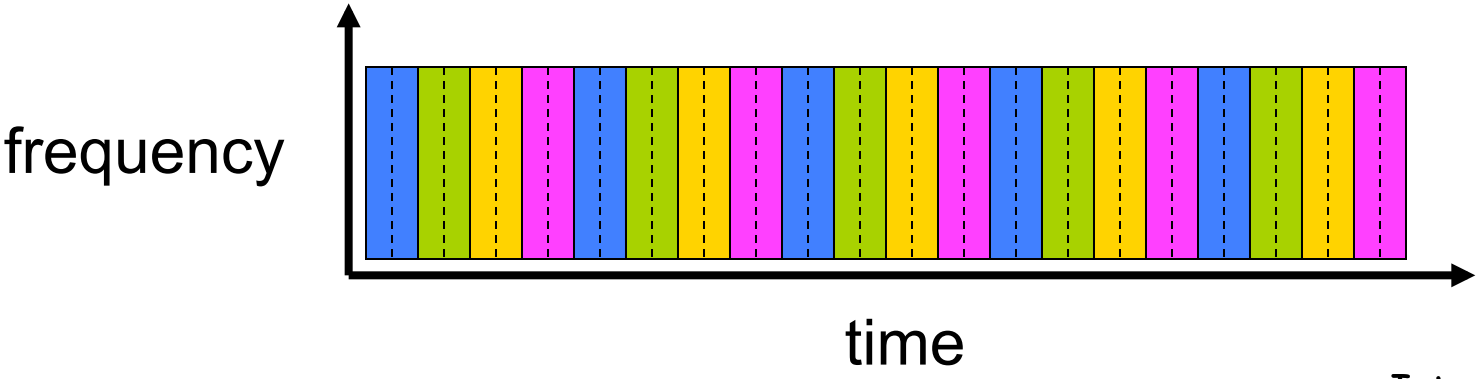
Example:

4 users

FDM



TDM



Numerical example

- How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?
  - All links are 1.536 Mbps
  - Each link uses TDM with 24 slots/sec
  - 500 msec to establish end-to-end circuit

Let's work it out!

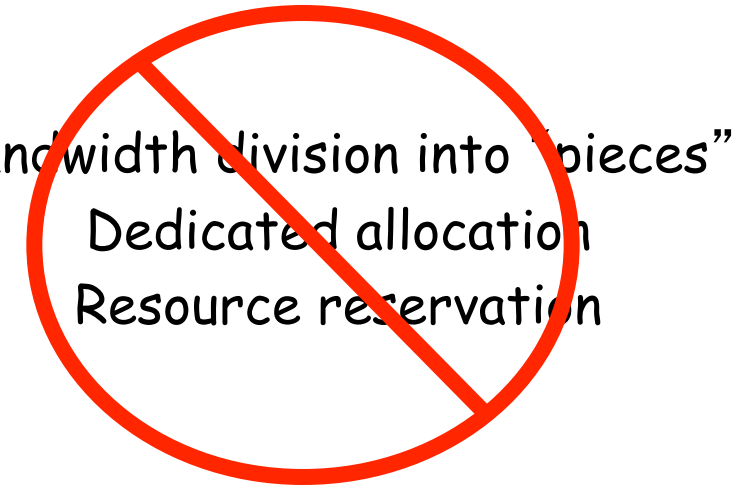
..Numerical example

- Each circuit has a transmission rate of (1,536Mbps)/24=64Kbps
- 640000/64000=10s
- Plus the circuit establishment→10,5s

Network Core: Packet Switching

each end-end data stream divided into *packets*

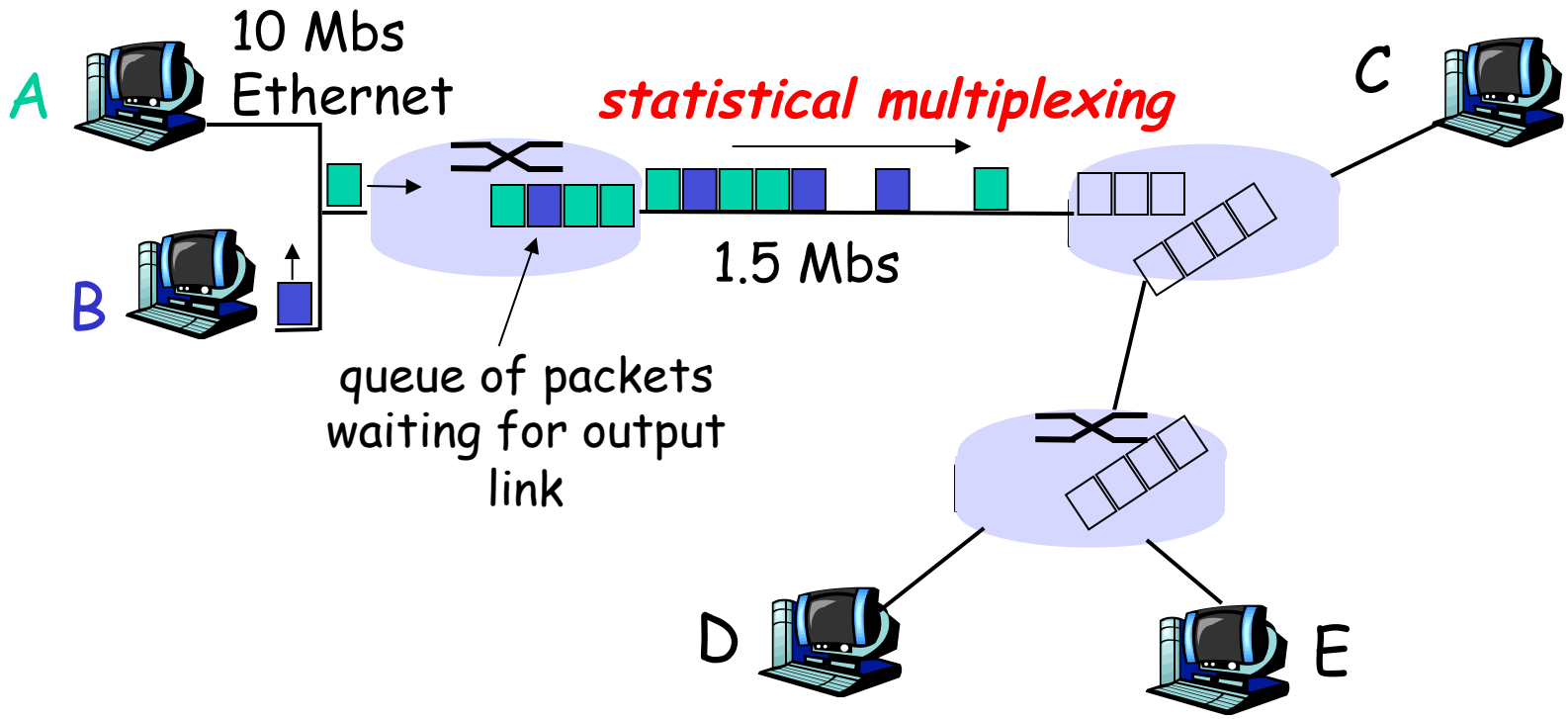
- user A, B packets *share* network resources
- each packet uses full link bandwidth
- resources used *as needed*



resource contention:

- aggregate resource demand can exceed amount available
- congestion: packets queue, wait for link use
- store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding

Packet Switching: Statistical Multiplexing



Sequence of A & B packets does not have fixed pattern

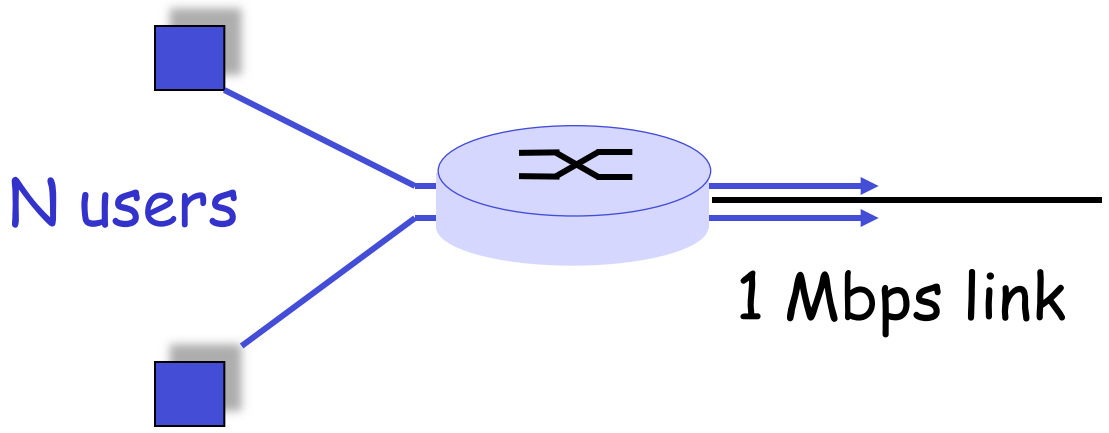
➡ ***statistical multiplexing***.

In TDM each host gets same slot in revolving TDM frame.

Packet switching versus circuit switching

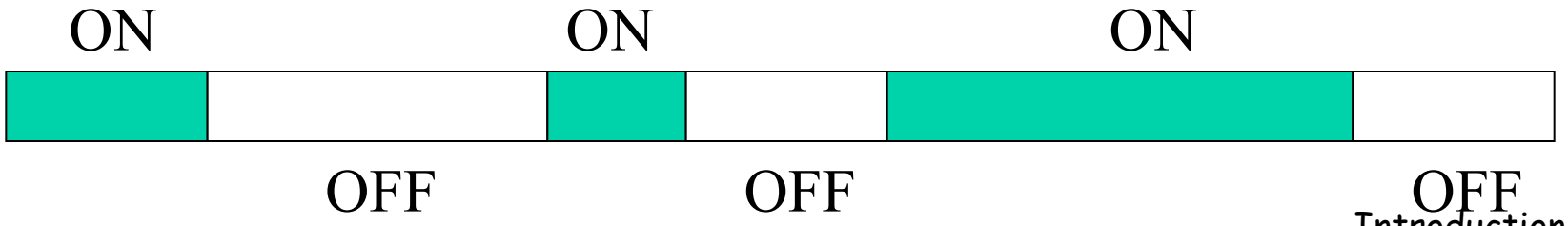
Packet switching allows more users to use network!

- 1 Mbit link
- each user:
  - 100 kbps when "active"
  - active 10% of time
- circuit-switching:
  - 10 users
- packet switching:
  - with 35 users, probability > 10 active less than .0004



Source types

- Constant Bit Rate (e.g. encoded voice without silence suppression→ voice packets have fixed size and are trasmitted periodically. Required bit rate: 64Kbps)
- Variable Bit Rate (e.g. Video encoding, voice with silence suppression, file downloading etc.)
  - The bit rate varies with time
  - Source behavior characterized by min/max transmission rate, and average bit rate. Source burstiness = max bit rate/ average bit rate.
  - Example: CBR ON/OFF



Packet switching versus circuit switching

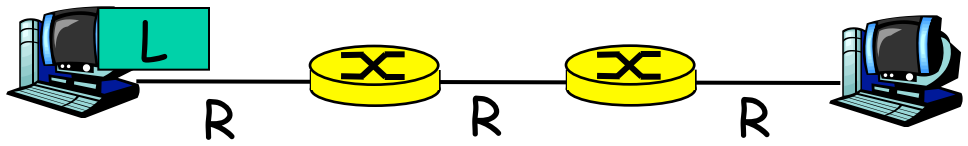
Is packet switching a "slam dunk winner?"

- Great for bursty data
  - resource sharing
  - simpler, no call setup
- Excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control

Packet switching

- Perche' dividere I messaggi trasmessi dall'applicazione in pacchetti di dimensione limitata.
  - Nelle prossime slides pro e contro….

Packet-switching: store-and-forward



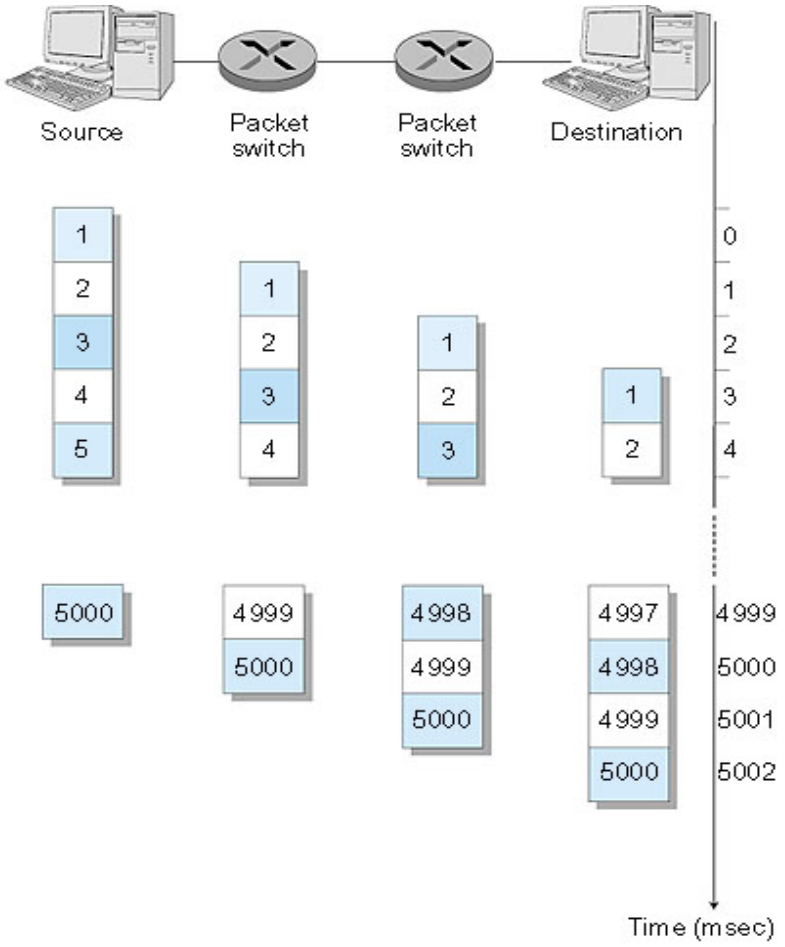
- Takes L/R seconds to transmit (push out) packet of L bits on to link or R bps
- Entire packet must arrive at router before it can be transmitted on next link: *store and forward*
- delay = 3L/R

Example:

- L = 7.5 Mbit
- R = 1.5 Mbps
- delay = 15 sec

(only transmission delay considered here)

Packet Switching: Message Segmenting



Now break up the message into 5000 packets

- Each packet 1,500 bits
- 1 msec to transmit packet on one link
- *pipelining:* each link works in parallel
- Delay reduced from 15 sec to 5.002 sec

Message switching iff dim pacchetti= dim. messaggio originale applicativo

See packet-switching vs. message switching (no segmentation) and the effect of queueing delay through the Java applets on the Kurose-Ross website.

Effect of packet sizes

Packet format

- A longer packet (more data transmitted in a single packet) leads to a lower overhead
- Longer packets result in a higher chance to be corrupted (critical especially for wireless transmission)
- When a packet is corrupted all the data are lost and need to be retransmitted
- Longer packets might decrease the paralellism of transmission

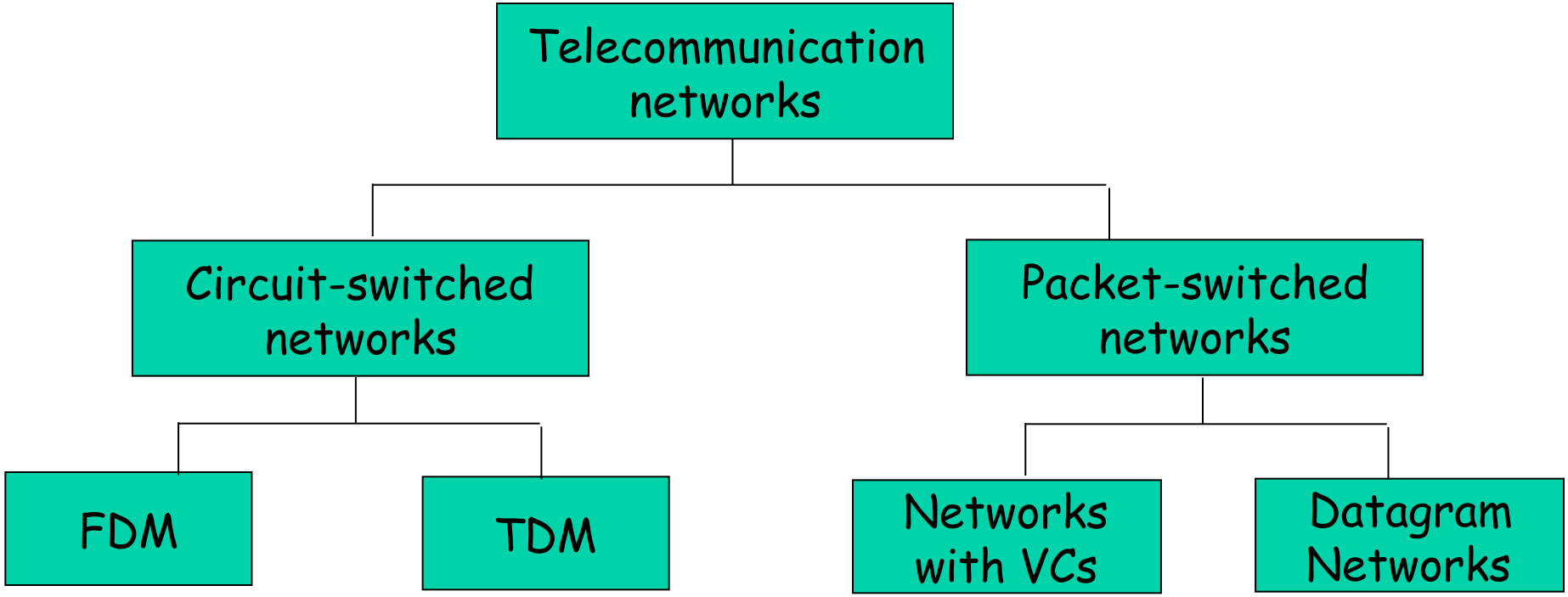
Packet-switched networks: forwarding

- *Goal:* move packets through routers from source to destination
  - we' ll study several path selection (i.e. routing)algorithms (chapter 4)
- datagram network:
  - *destination address* in packet determines next hop
  - routes may change during session
  - analogy: driving, asking directions
- virtual circuit network:
  - each packet carries tag (virtual circuit ID), tag determines next hop
  - fixed path determined at *call setup time*, remains fixed thru call; VC share network resources
  - *routers maintain per-call state (the link on which a packet with a VC tag arriving to a given inbound link has to be forwarded and its VC tag on the next hop)*
  - Virtual circuit number changes from hop to hop. Each router has to map incoming interface, incoming VC # in outgoing interface, outgoing VC #
    - Why? (what would be the size of the VC number field and the complexity of the VC number assignment in case the same VC # had to be used over the whole path??)

Internet L3 protocol: IP

MPLS

Network Taxonomy



- Datagram network is *not* either connection-oriented or connectionless.
- Internet provides both connection-oriented (TCP) and connectionless services (UDP) to apps.

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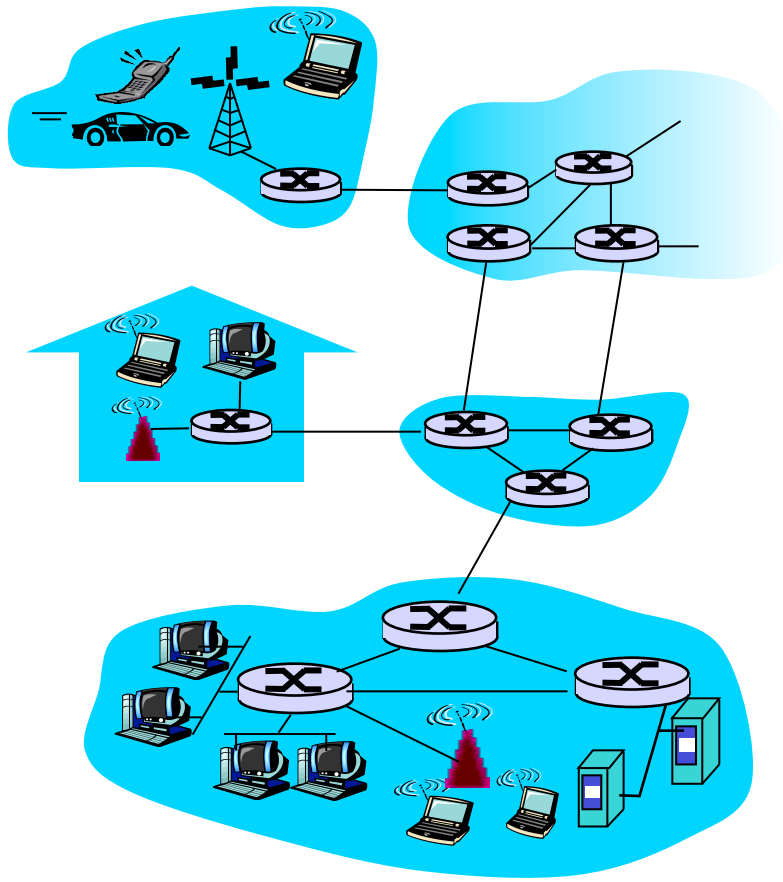
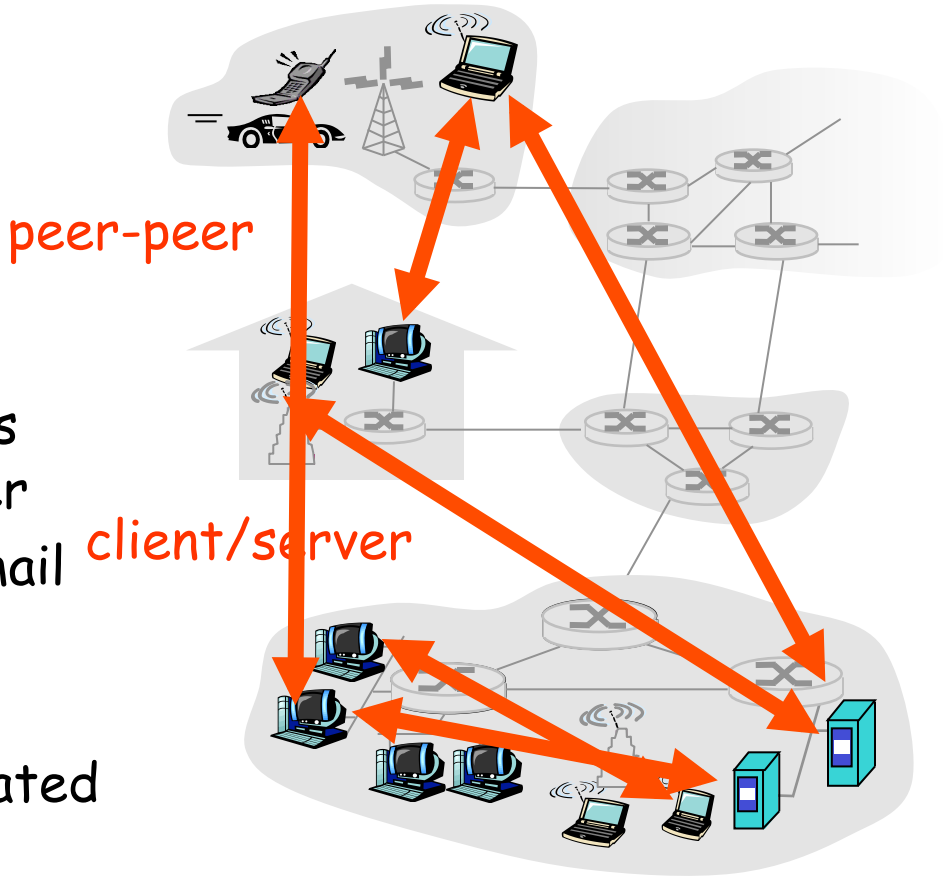
A closer look at network structure:

- network edge:
  applications and hosts
- access networks, physical media:
  wired, wireless communication links
- network core:
  - interconnected routers
  - network of networks



The network edge:

- end systems (hosts):
  - run application programs
  - e.g. Web, email
  - at "edge of network"
- client/server model
  - client host requests, receives service from always-on server
  - e.g. Web browser/server; email client/server
- peer-peer model:
  - minimal (or no) use of dedicated servers
  - e.g. Skype, BitTorrent



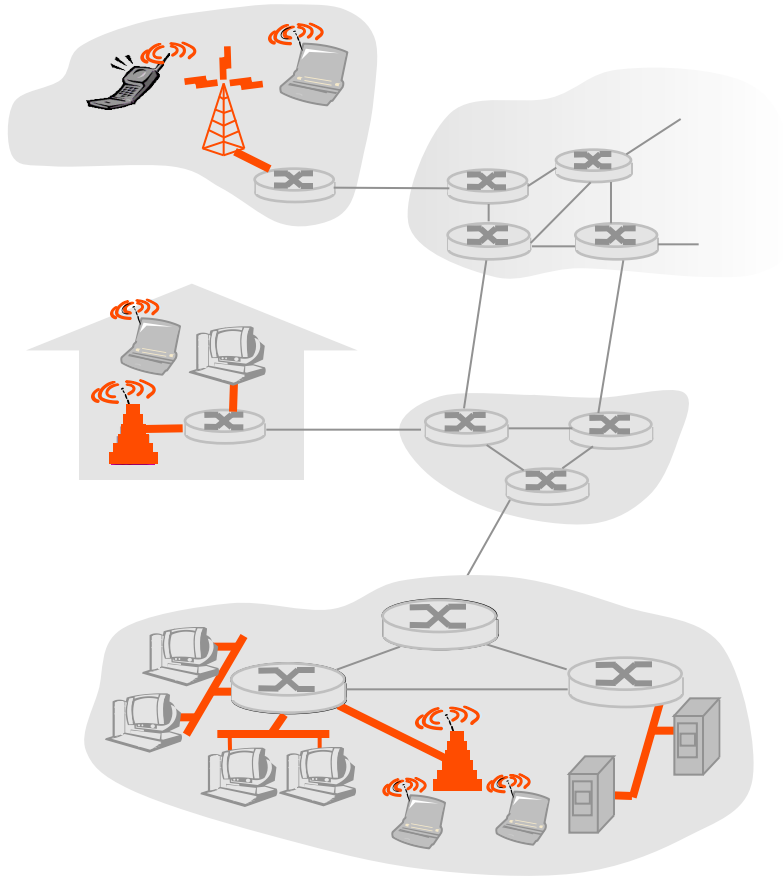
Access networks and physical media

Q: How to connect end systems to edge router?

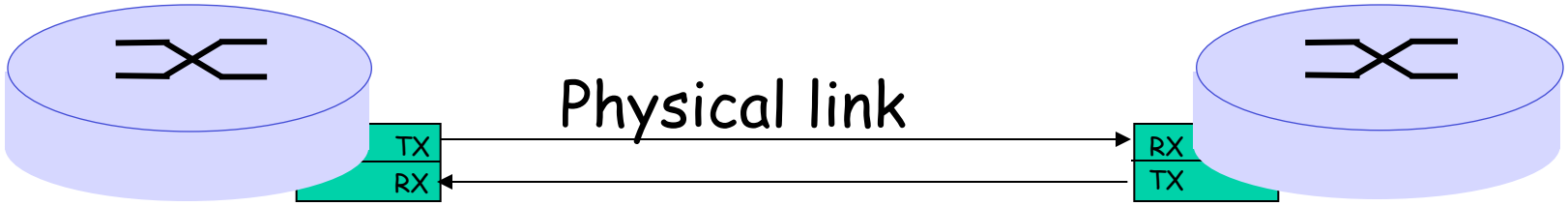
- residential access nets
- institutional access networks (school, company)
- mobile access networks

Keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?

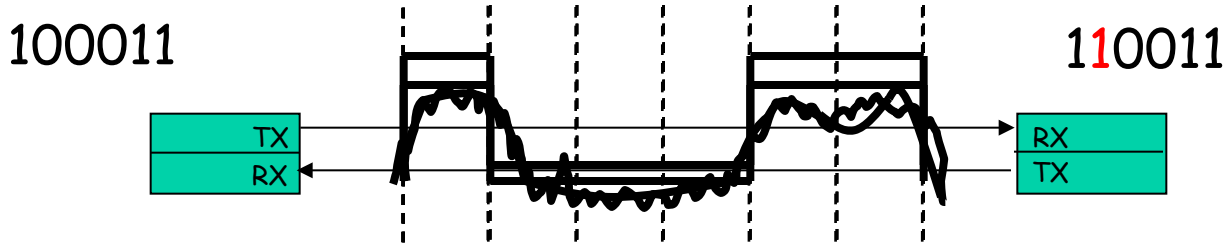


Transmission across a physical link



- Bits: propagate between transmitter and receiver
- physical link: what lies between transmitter & receiver
- guided media:
  - signals propagate in solid media: copper, fiber, coax
- unguided media:
  - signals propagate freely, e.g., radio

Transmission across a physical link

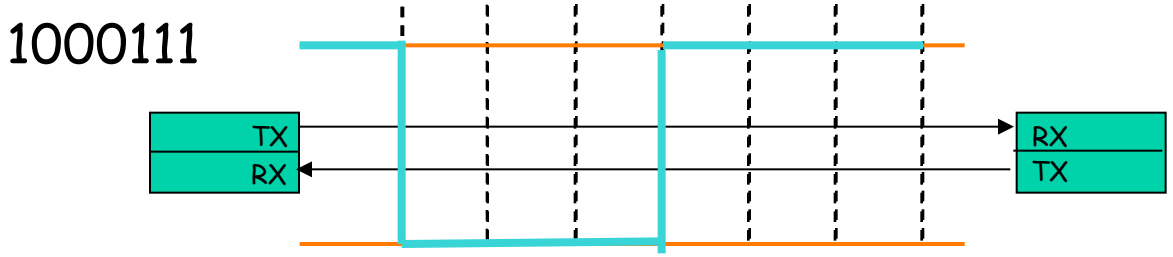


- Bit sequence modulates a suitable waveform which is sent across the link
  - How and which depends on the medium
- As the signal travels it experiences
  - Attenuation (absorption)
  - Distortion (limited bandwidth (frequency))
  - Noise (interference, thermal noise)
  - Influenced by medium, bit rate and distance
- Received sequence may be incorrect!!!

Codifica NRZ

- Codifica NRZ (Non Return to Zero)

Ogni bit ha associato un valore stabile per la sua intera durata (1: High; 0: Low)

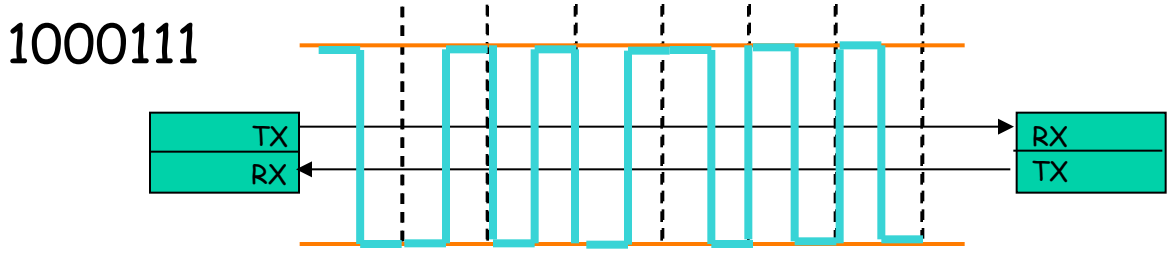


Problemi di sincronizzazione del ricevitore (nessuna transizione nel caso di sequenze di zeri o di uni)→ NRZ 5B6B o 4B5B

Codifica Manchester

- Codifica Manchester

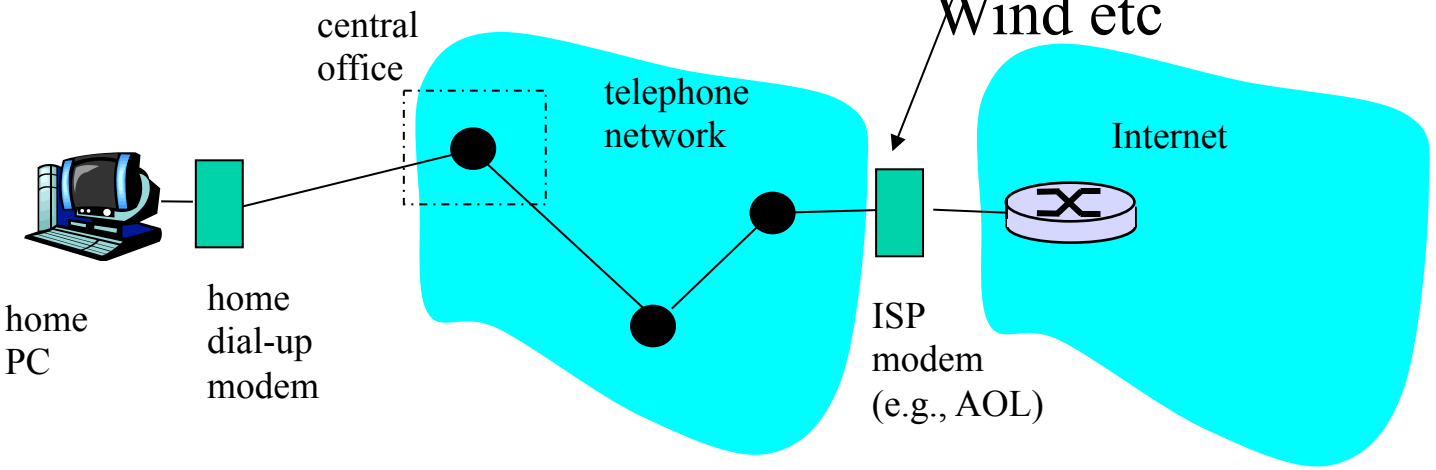
Una transizione basso-alto (codifica dello zero) o alto-basso (codifica del valore uno) in corrispondenza di ogni bit



Usato in Ethernet 10Mbps e Token Ring

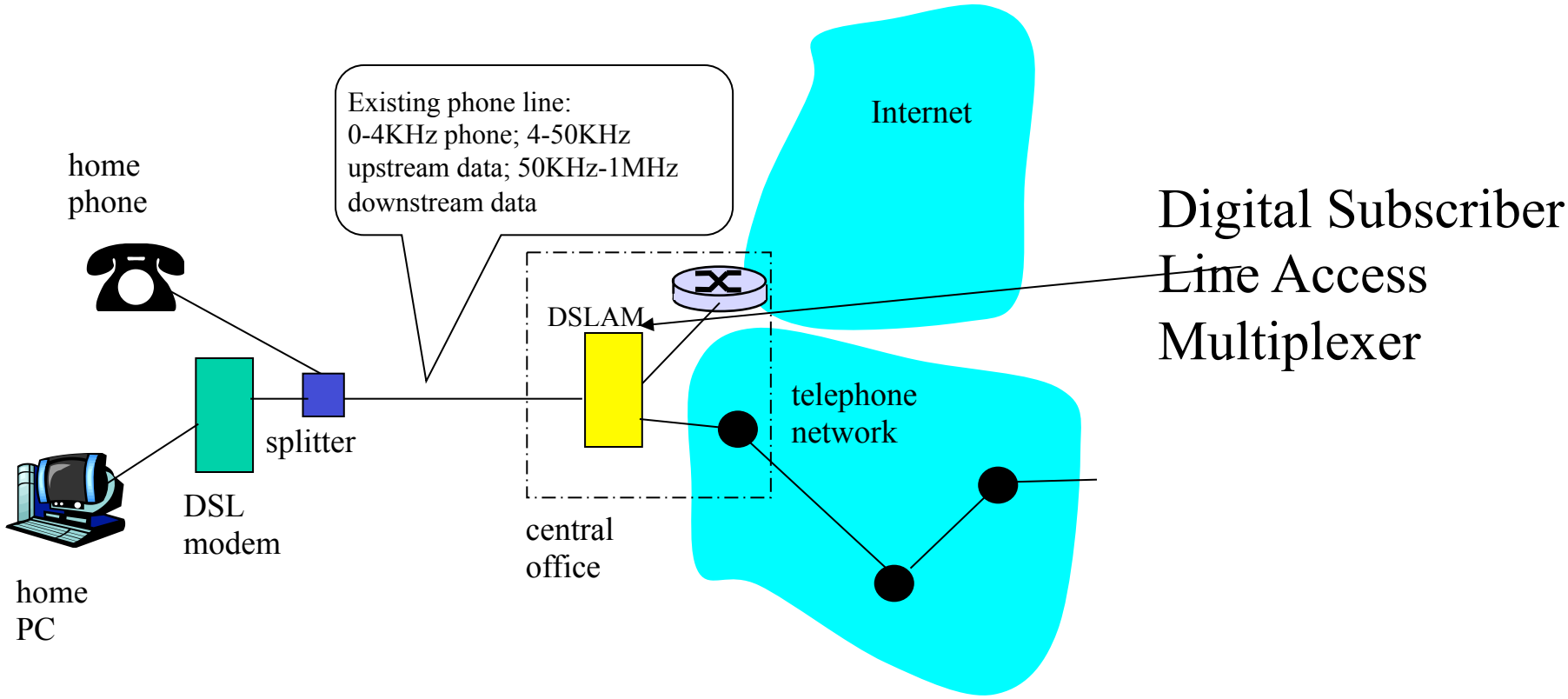
Dial-up Modem

ISP=Internet Service Provider
Es. Telecom, Tiscali, Fastweb, Wind etc



- Uses existing telephony infrastructure
  - Home is connected to central office
- up to 56Kbps direct access to router (often less)
- Can't surf and phone at same time: not "always on"

Digital Subscriber Line (DSL)



- Also uses existing telephone infrastruture
- up to 1 Mbps upstream (today typically < 256 kbps)
- up to 8 Mbps downstream (today typically < 1 Mbps)
- dedicated physical line to telephone central office

ADSL loops extender

- An **ADSL loop extender** or **ADSL repeater** is a device placed midway between the subscriber and central office by the telephone company to extend the distance and increase the channel capacity of their DSL connection.
- In some cases, service can now be established as far as 10 miles from the Central Office (factor of 2 improvement)

Residential access: cable modems

- Does not use telephone infrastructure
  - Instead uses cable TV infrastructure
- HFC: hybrid fiber coax
  - asymmetric: up to 30Mbps downstream, 2 Mbps upstream
- network of cable and fiber attaches homes to ISP router
  - homes share access to router
  - unlike DSL, which has dedicated access

Residential access: cable modems

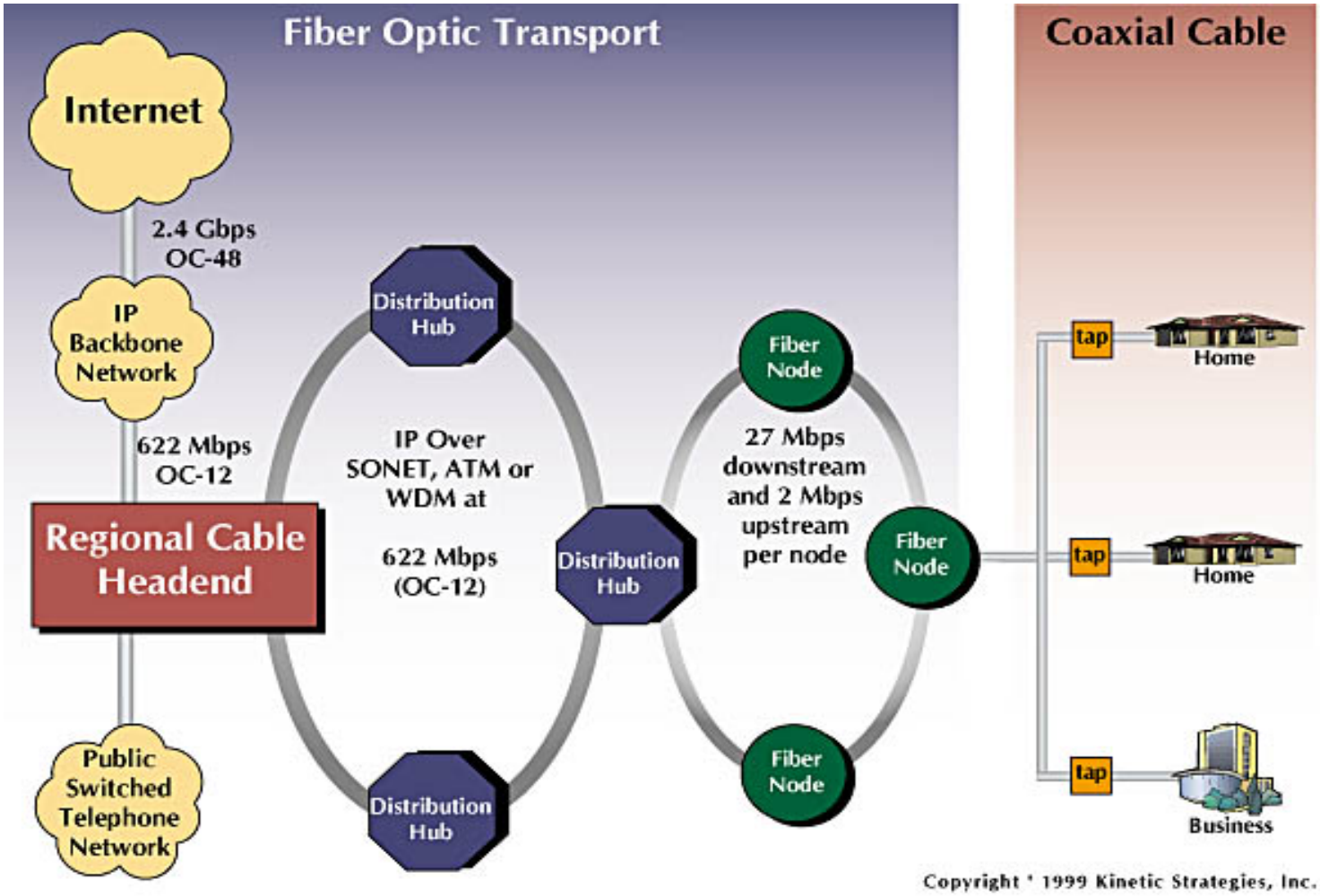
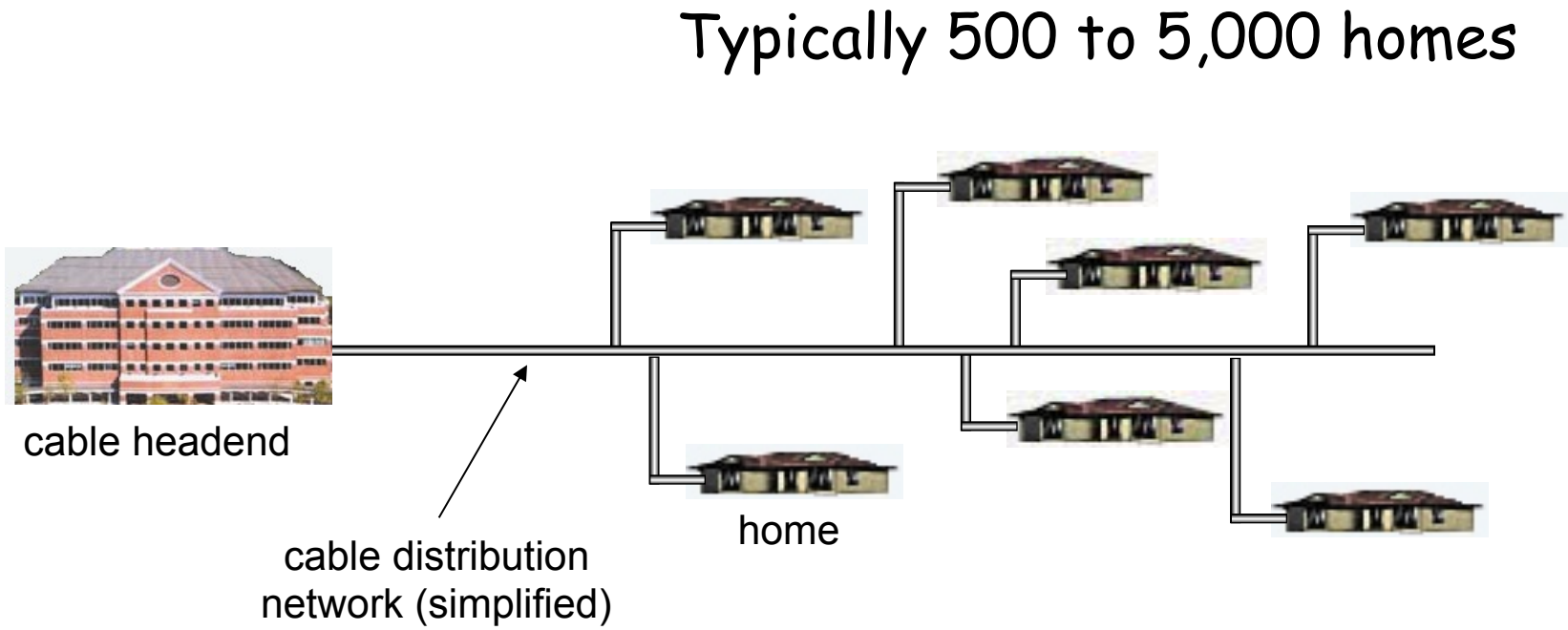


Diagram: http://www.cabledatacomnews.com/cmic/diagram.html

Cable Network Architecture: Overview



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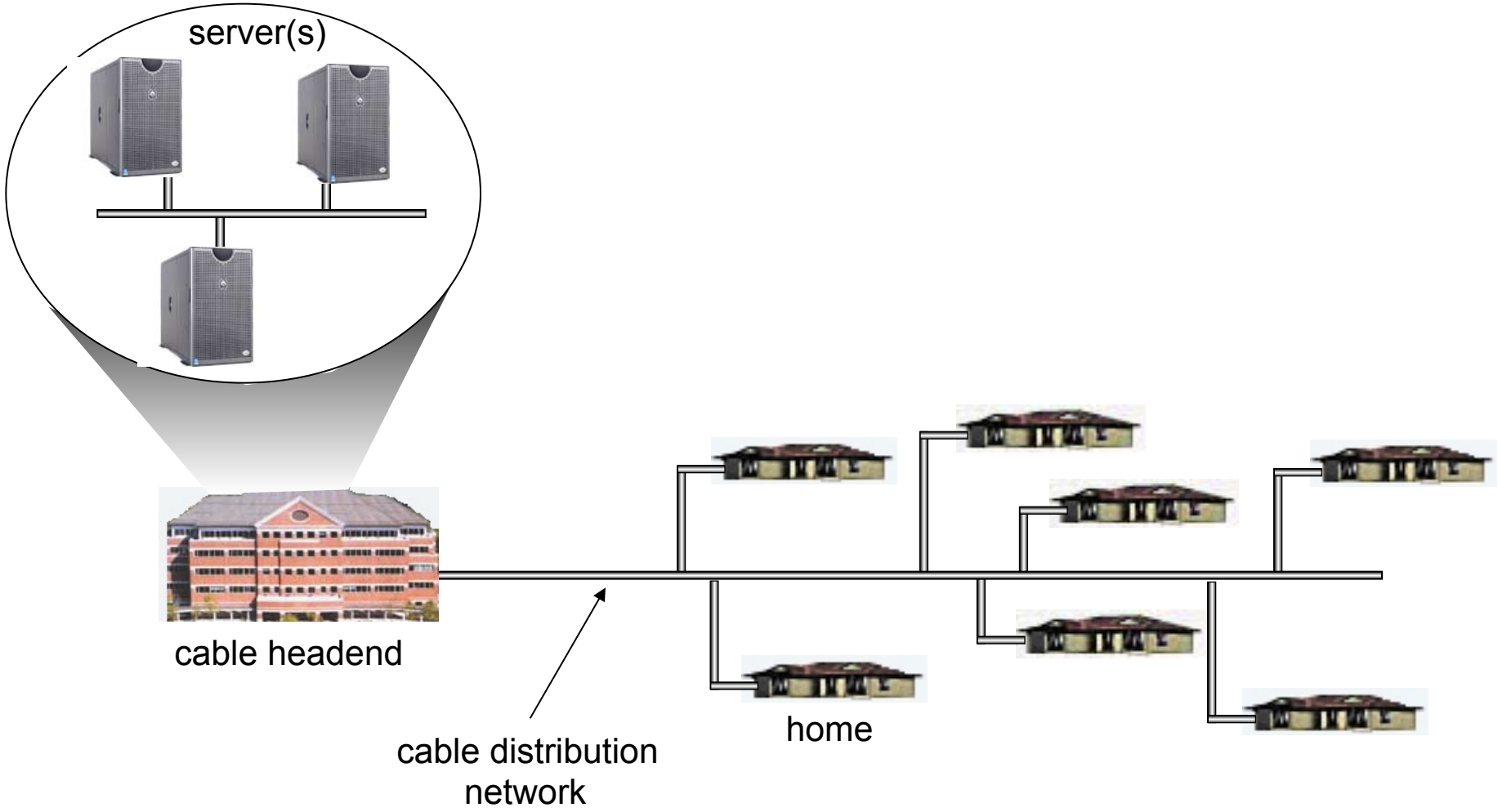

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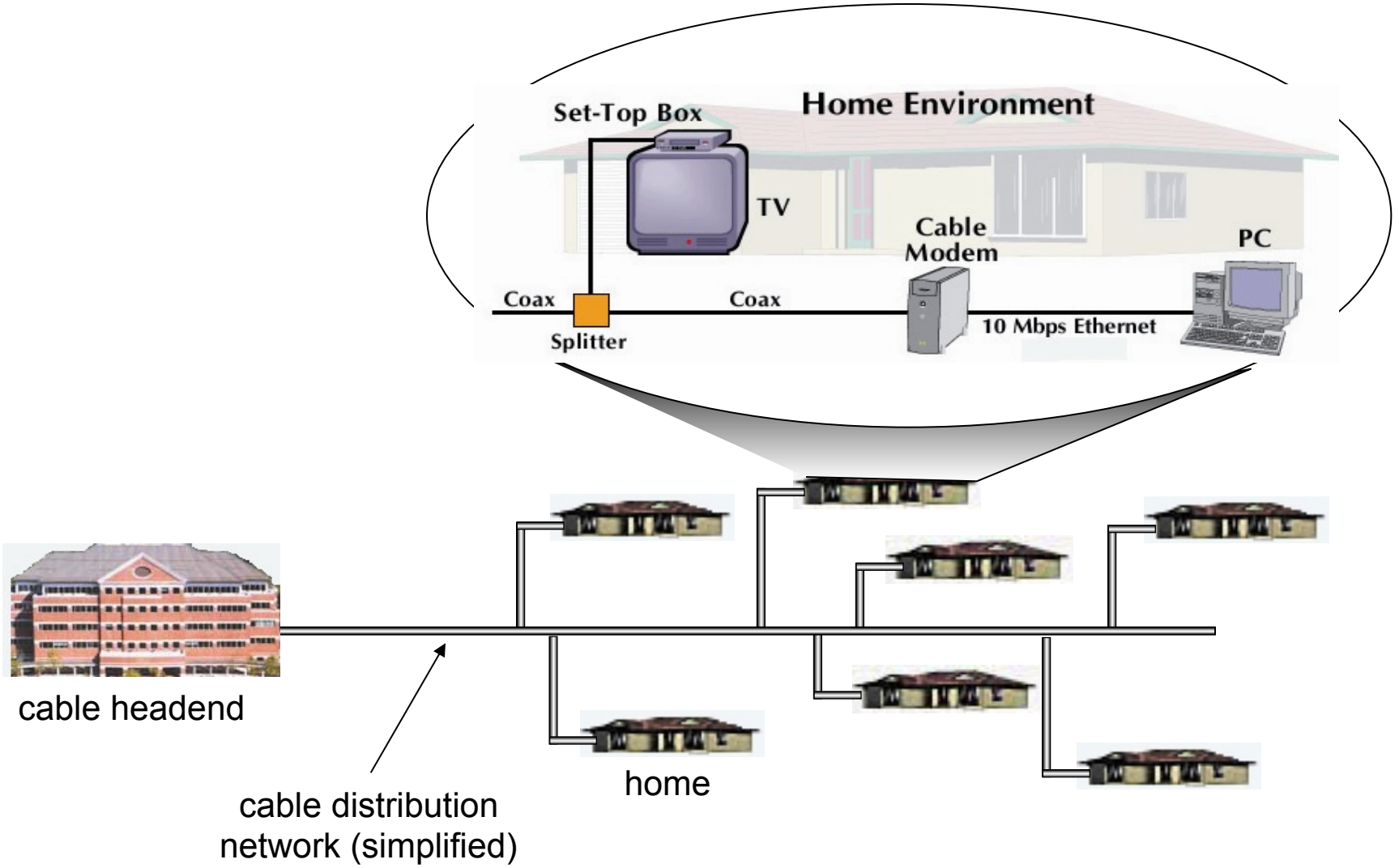

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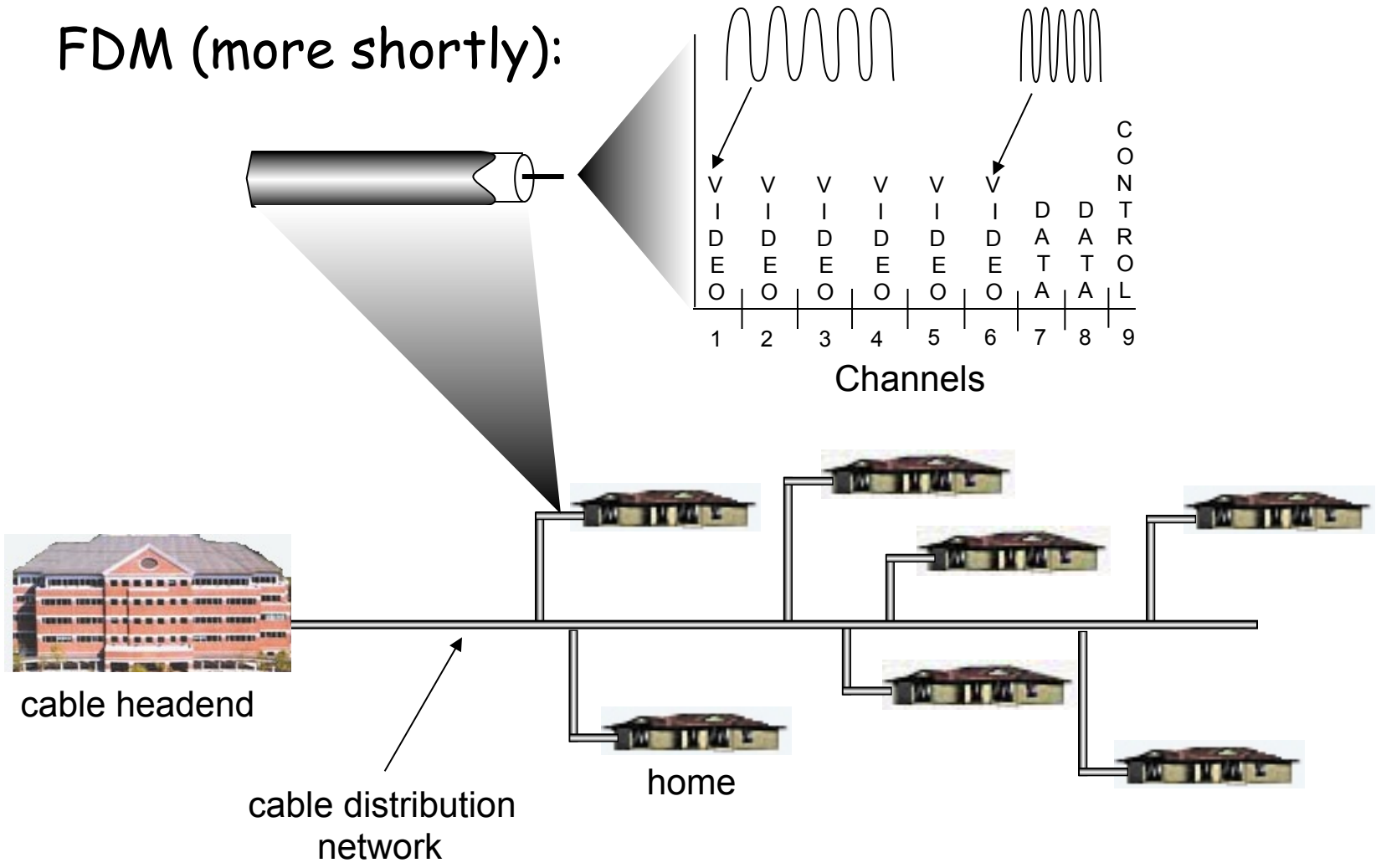

FINE SECONDA LEZIONE