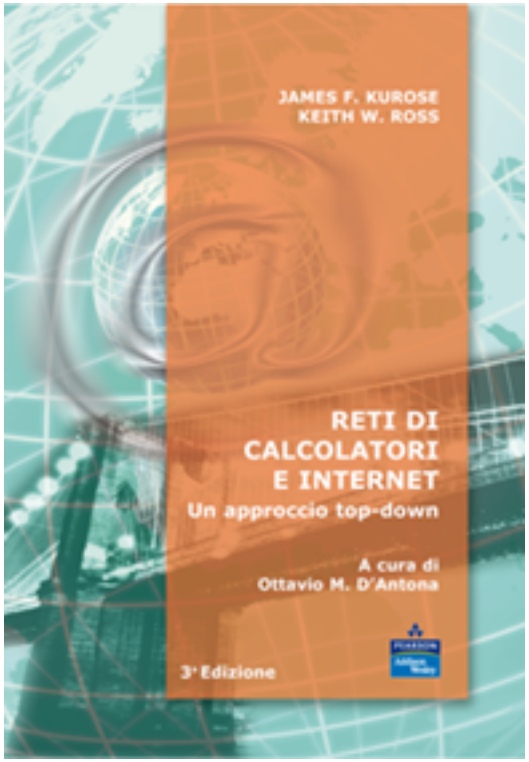
Reti di calcolatori: introduzione (Capitolo 1 Kurose-Ross)

Marco Roccetti

22 febbraio 2023

(Capitolo 1 Kurose-Ross)



Reti di calcolatori e Internet:
Un approccio top-down

3ª edizione
Jim Kurose, Keith Ross
Pearson Education Italia
©2005

Part I: Introduction

Chapter goal:

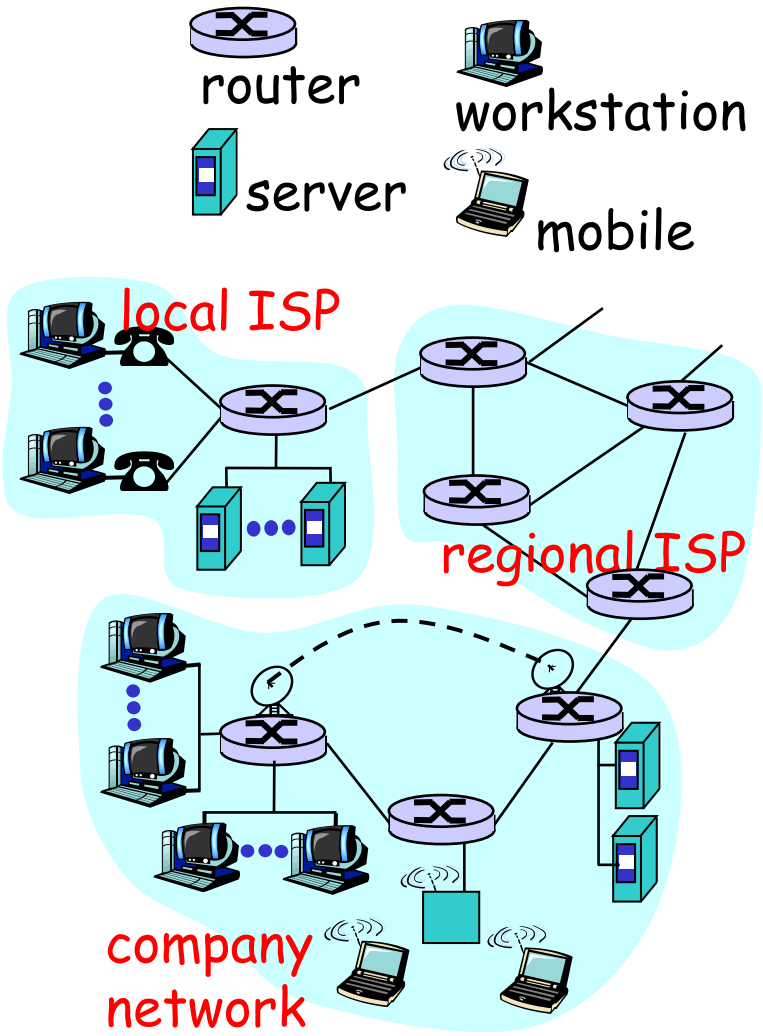
- get context, overview, "feel" of networking
- more depth, detail *later* in course
- approach:
  - descriptive
  - use Internet as example

Overview:

- what's the Internet
- what's a protocol?
- network edge
- network core
- access net, physical media
- performance: loss, delay
- protocol layers, service models
- backbones, NAPs, ISPs
- history
- ATM network

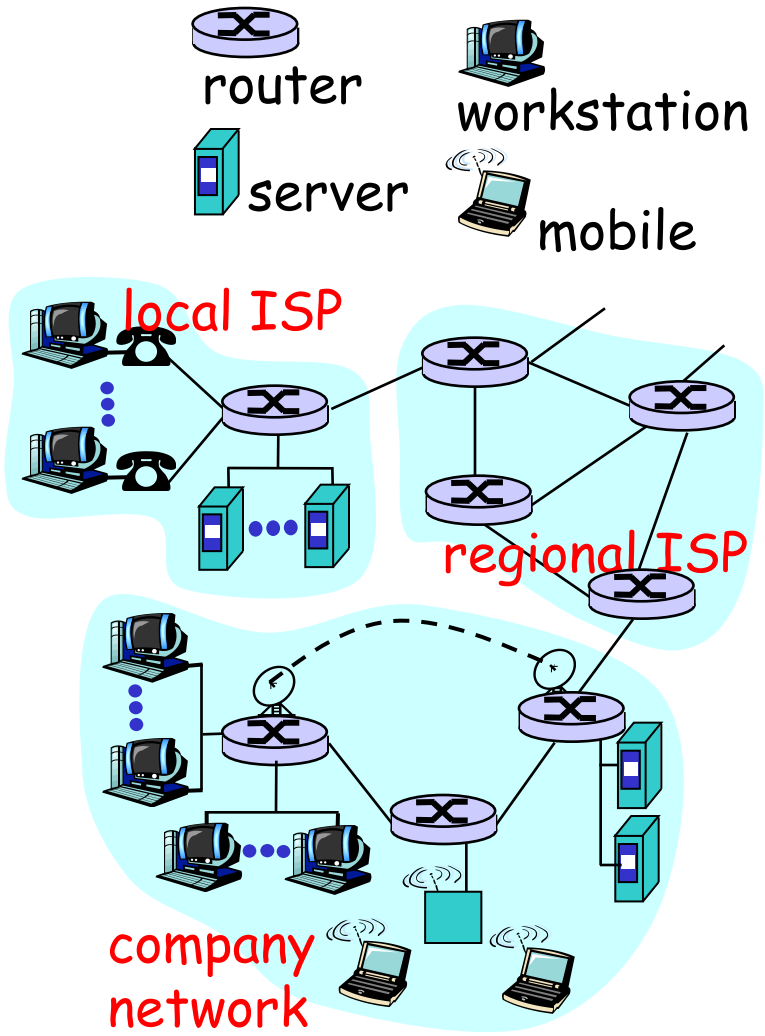
What's the Internet: "nuts and bolts" view

- millions of connected computing devices: *hosts, end-systems*
  - pc's workstations, servers
  - PDA's phones, toasters
  - running *network apps*
- *communication links*
  - fiber, copper, radio, satellite
- *routers:* forward packets (chunks) of data thru network



What's the Internet: "nuts and bolts" view

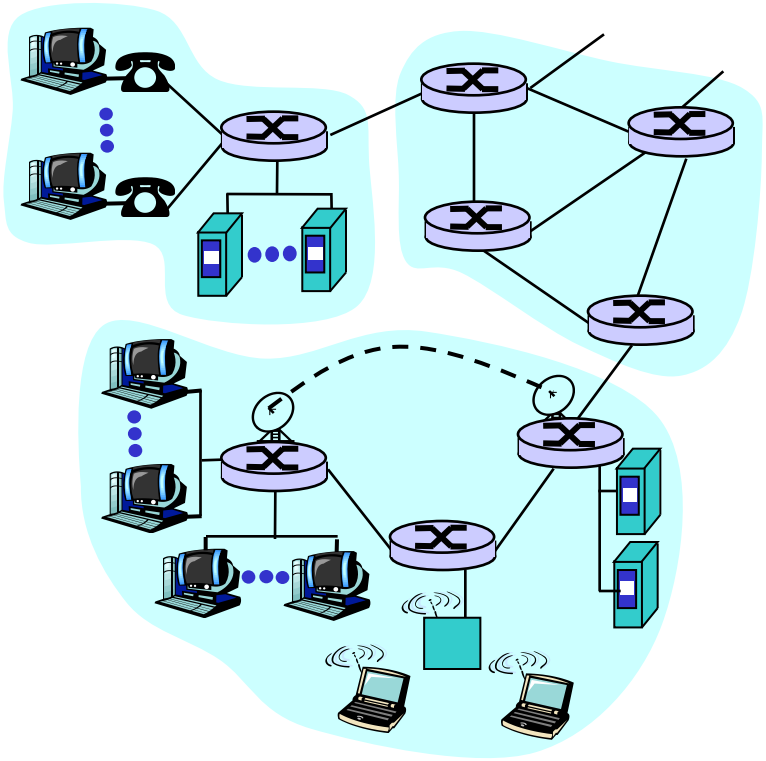
- *protocols*: control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP
- *Internet*: "network of networks"
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- communication *infrastructure* enables distributed applications:
  - WWW, email, games, e-commerce, database., voting,
  - more?
- communication services provided:
  - connectionless
  - connection-oriented
- cyberspace [Gibson]:

  "a consensual hallucination experienced daily by billions of operators, in every nation, ..."



What's a protocol?

human protocols:

- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

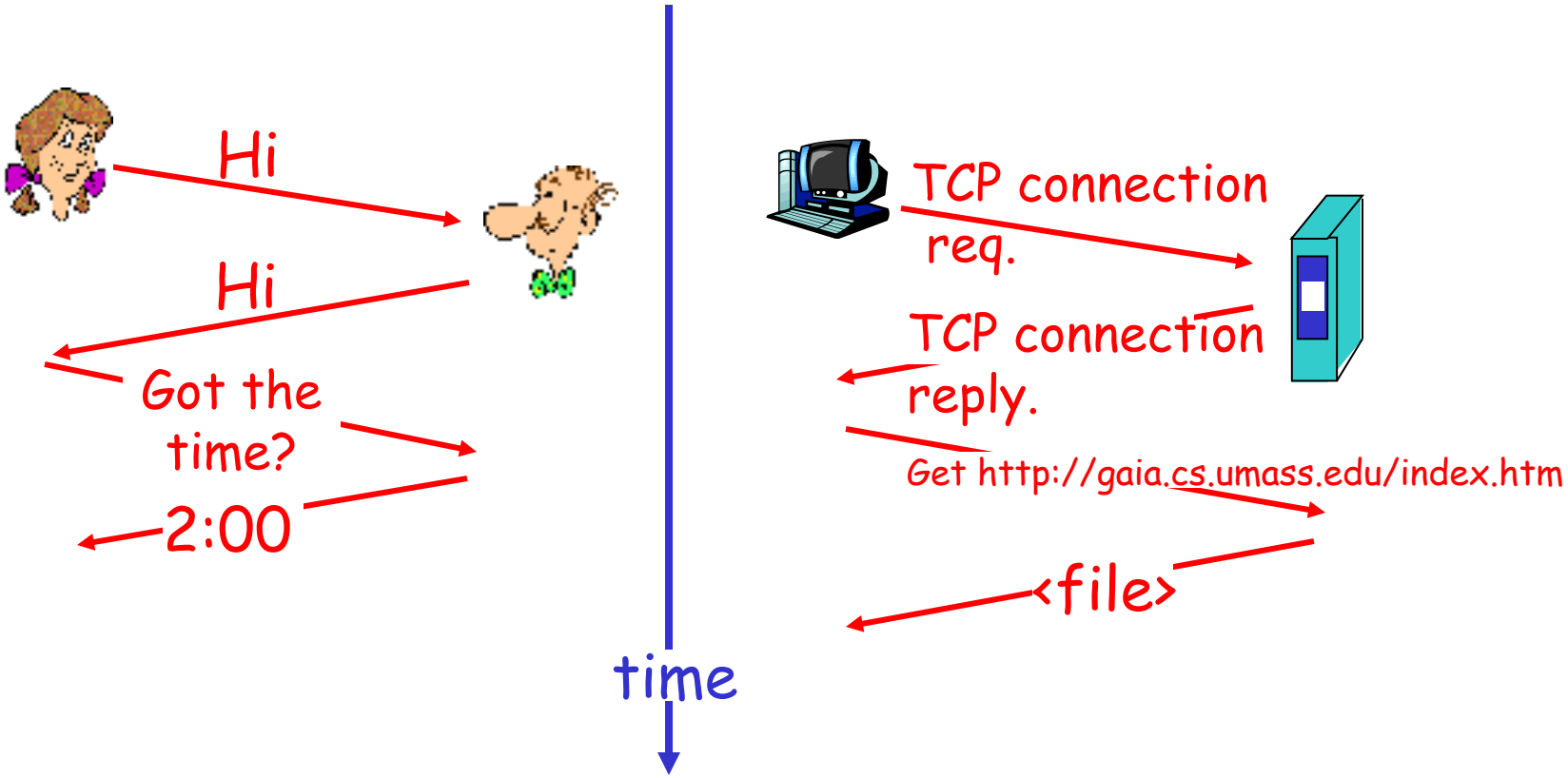
network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

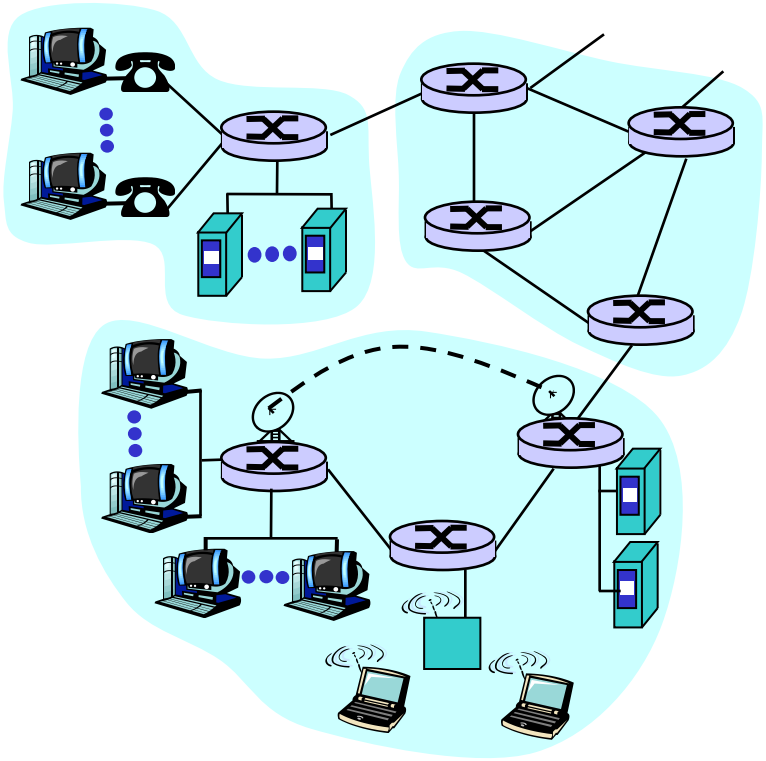
a human protocol and a computer network protocol:



Q: Other human protocol?

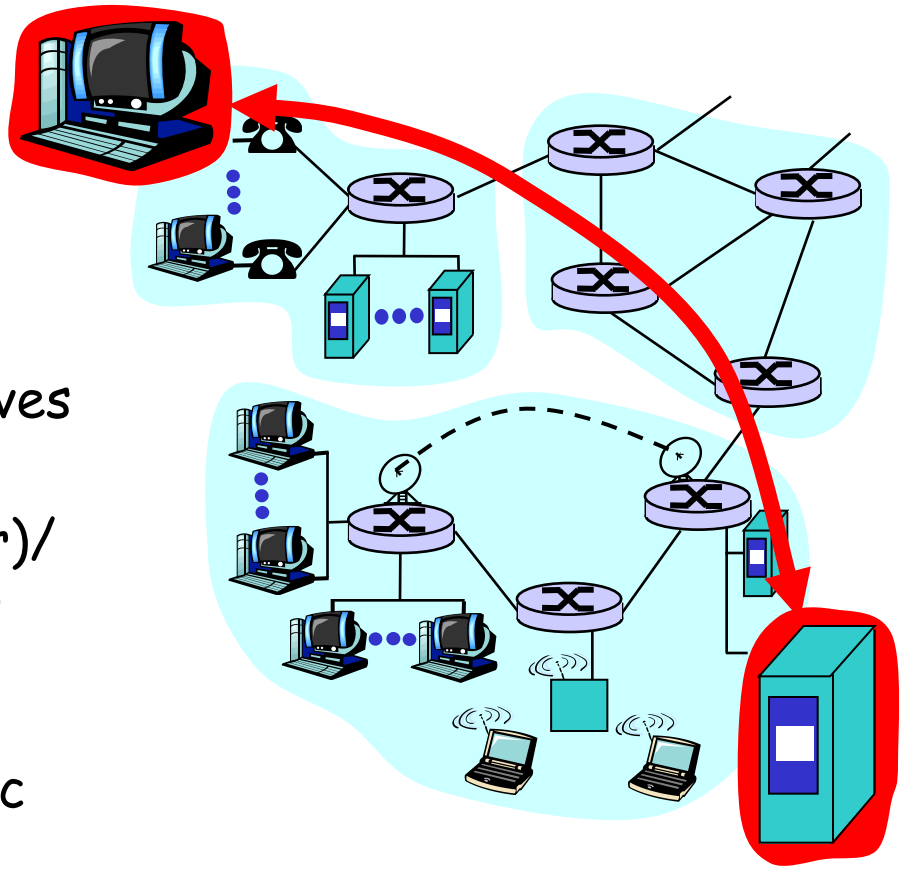
A closer look at network structure:

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



The network edge:

- end systems (hosts):
  - run application programs
  - e.g., WWW, email
  - at "edge of network"
- client/server model
  - client host requests, receives service from server
  - e.g., WWW client (browser)/ server; email client/server
- peer-peer model:
  - host interaction symmetric
  - e.g.: teleconferencing



Network edge: connection-oriented service

Goal: data transfer between end sys.

- *handshaking:* setup (prepare for) data transfer ahead of time
  - Hello, hello back human protocol
  - *set up "state"* in two communicating hosts
- TCP - Transmission Control Protocol
  - Internet's connection-oriented service

TCP service [RFC 793]

- *reliable, in-order* byte-stream data transfer
  - loss: acknowledgements and retransmissions
- *flow control:*
  - sender won't overwhelm receiver
- *congestion control:*
  - senders "slow down sending rate" when network congested

Network edge: connectionless service

Goal: data transfer between end systems

- same as before!

- UDP - User Datagram Protocol [RFC 768]: Internet's connectionless service
  - unreliable data transfer
  - no flow control
  - no congestion control

App's using TCP:

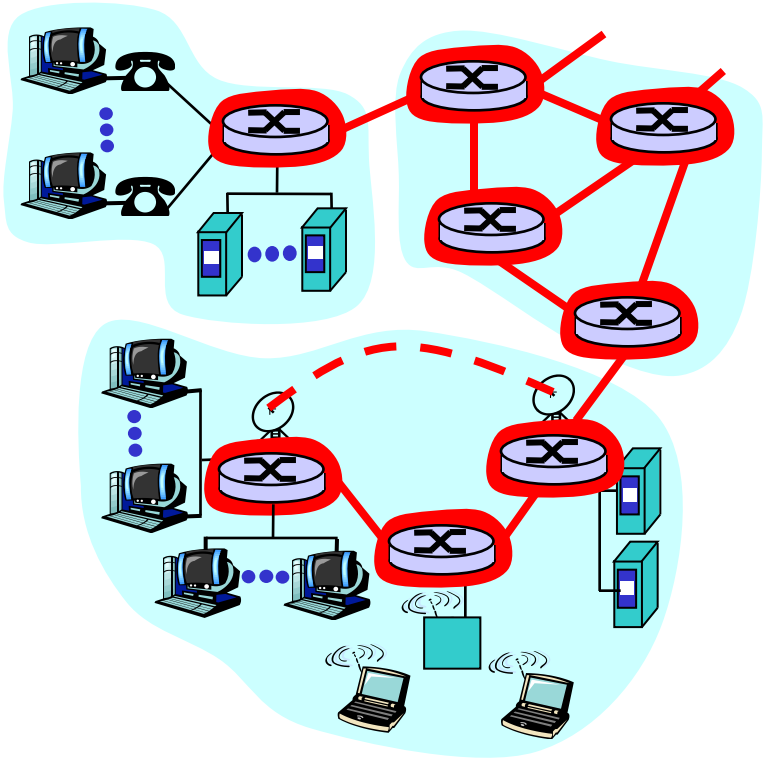
- HTTP (WWW), FTP (file transfer), Telnet (remote login), SMTP (email)

App's using UDP:

- streaming media, teleconferencing, Internet telephony, gaming

The Network Core

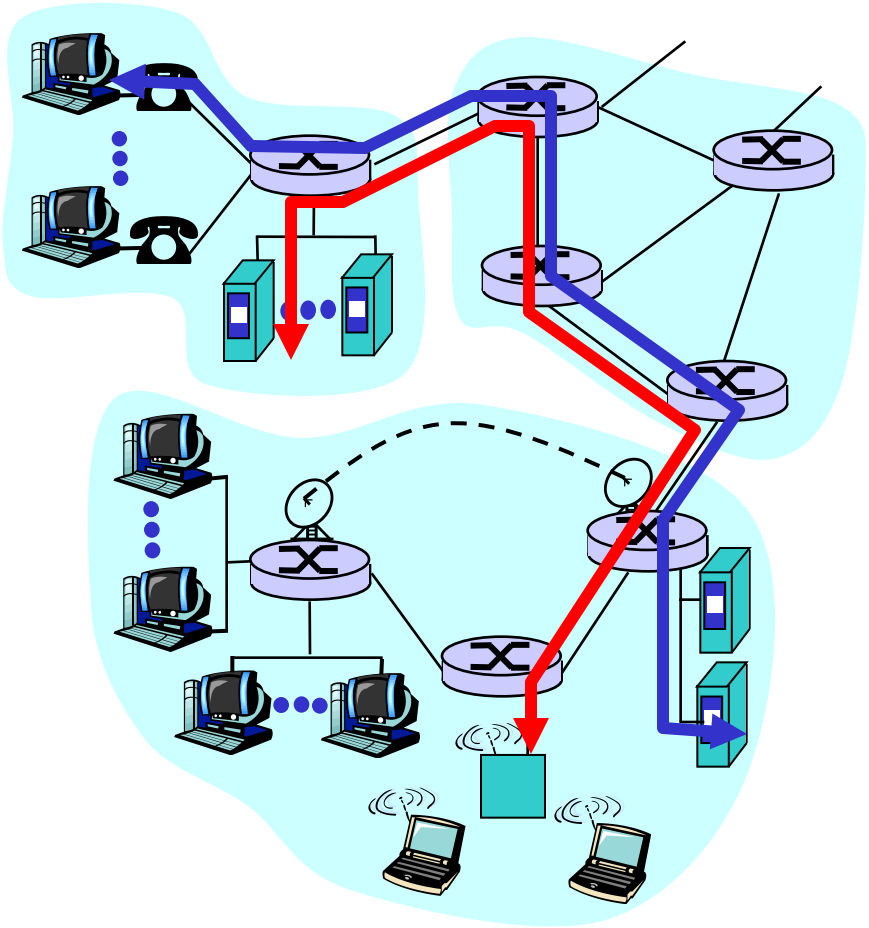
- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete "chunks"



Network Core: Circuit Switching

End-end resources reserved for "call"

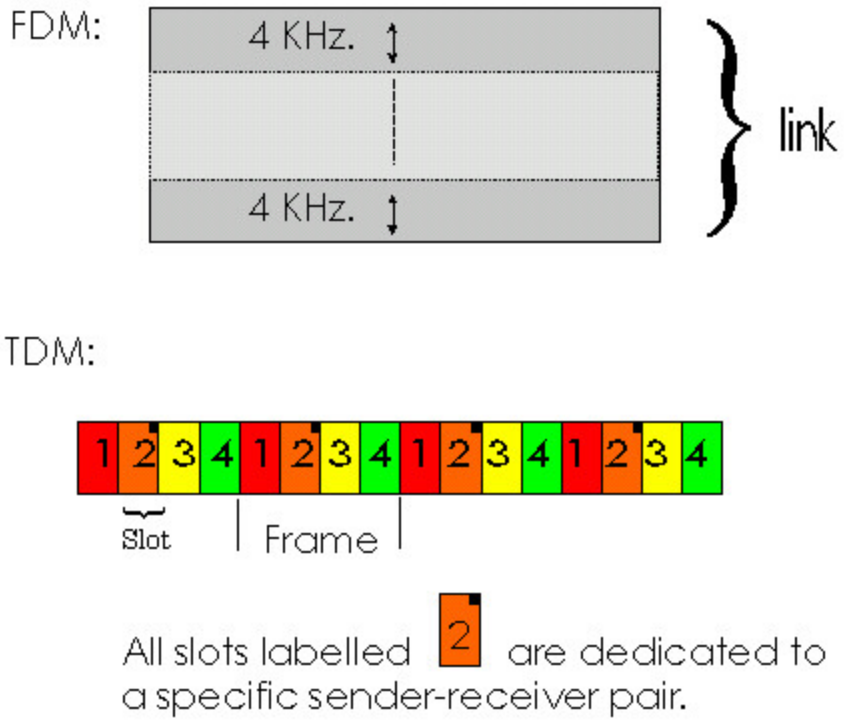
- link bandwidth, switch capacity
- dedicated resources: no sharing
- circuit-like (guaranteed) performance
- call setup required



Network Core: Circuit Switching

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

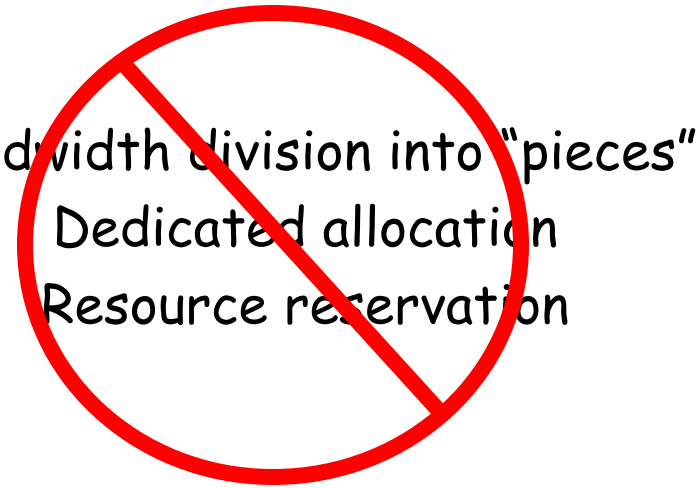
- pieces allocated to calls
- resource piece *idle* if not used by owning call *(no sharing)*
- dividing link bandwidth into "pieces"
  - frequency division
  - time division



Network Core: Packet Switching

each end-end data stream divided into *packets*

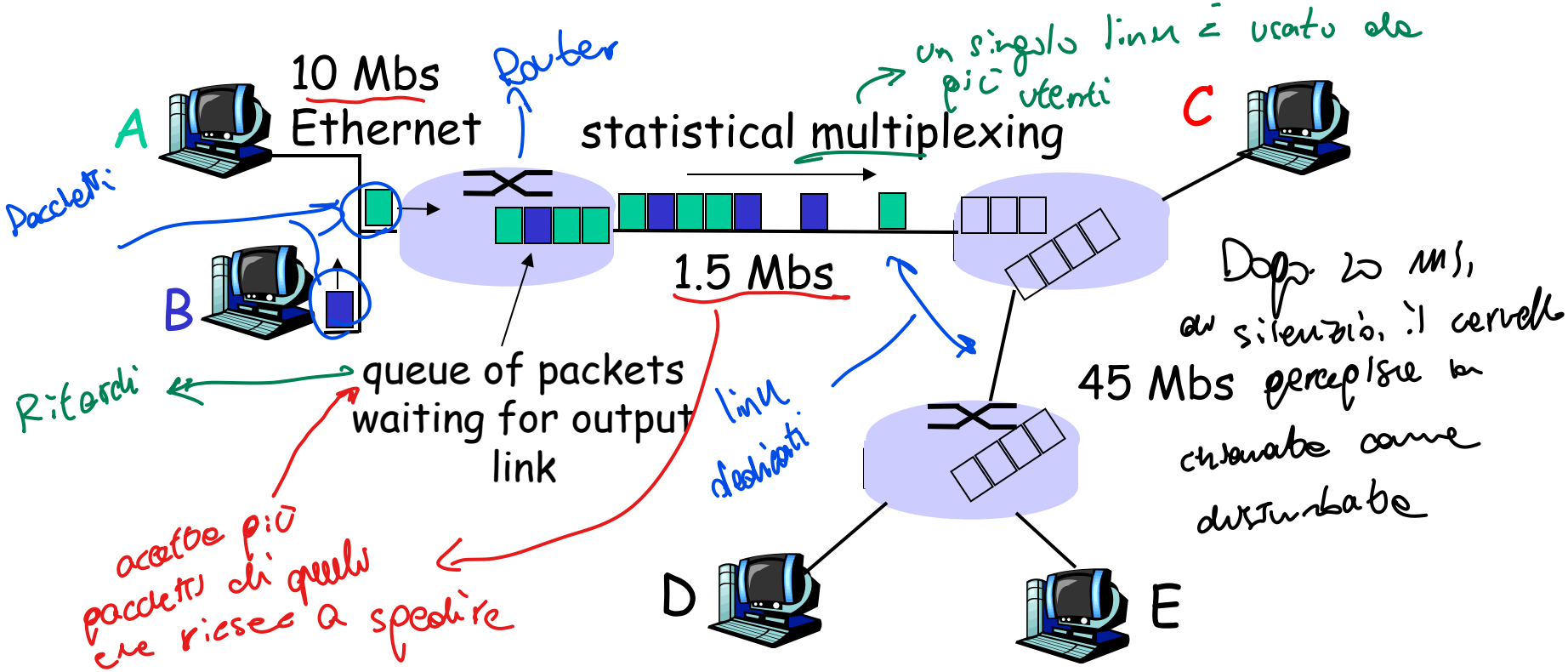
- user A, B packets *share* network resources
- each packet uses full link bandwidth
- resources used *as needed*,



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
  - transmit over link
  - wait turn at next link

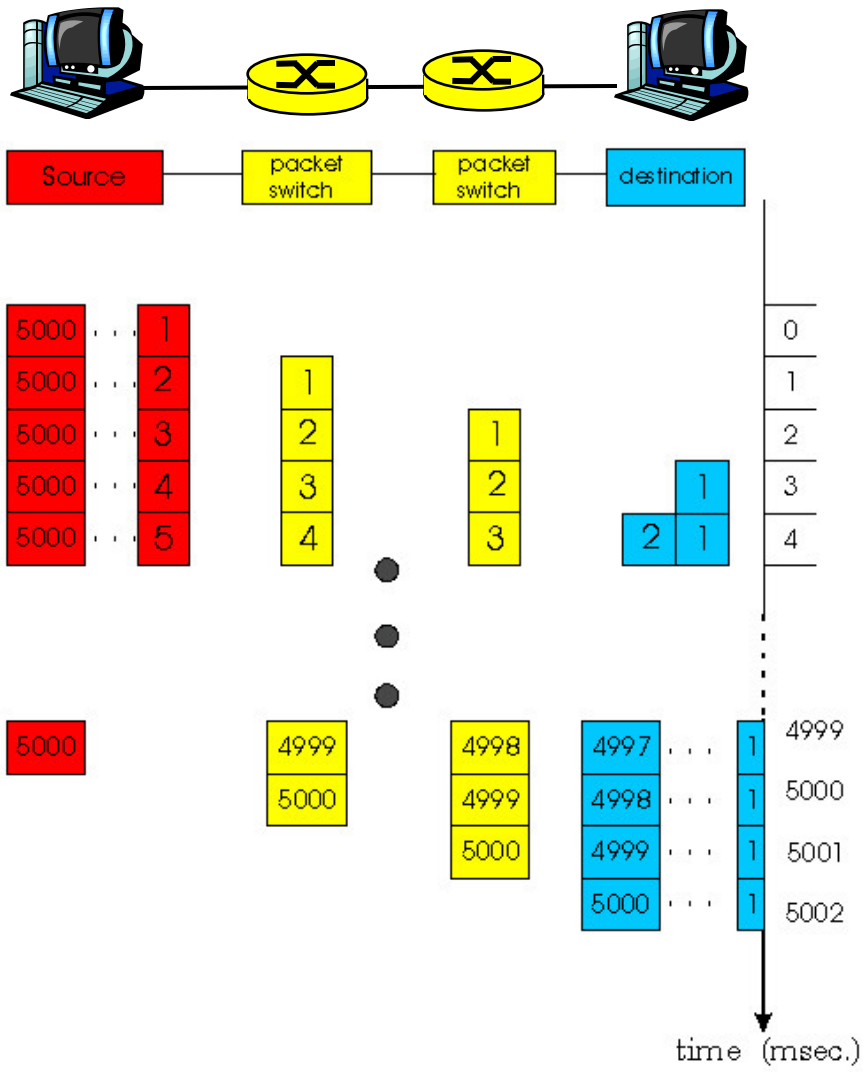
Network Core: Packet Switching



Packet-switching versus circuit switching: human restaurant analogy

- other human analogies?

Network Core: Packet Switching



Packet-switching:

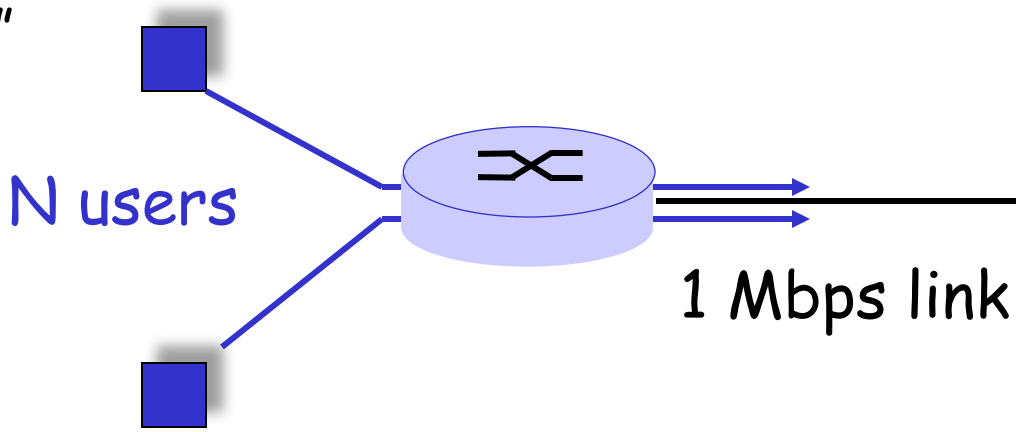
store and forward behavior

Delays augments with the number of hops, as each packet has to be completely received before it is transmitted!!

Packet switching versus circuit switching

Packet switching allows more users to use network!

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



Packet switching versus circuit switching

Is packet switching a "slam dunk winner?"

- Great for bursty data
  - resource sharing
  - no call setup
- Excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control
- Q: How to provide circuit-like behavior?
  - bandwidth guarantees needed for audio/video apps

  still an unsolved problem (chapter 6)

Packet-switched networks: routing

- *Goal:* move packets among routers from source to destination
  - we'll study several path selection algorithms (chapter 4)
- datagram network:
  - *destination address* 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
  - routers maintain per-call state

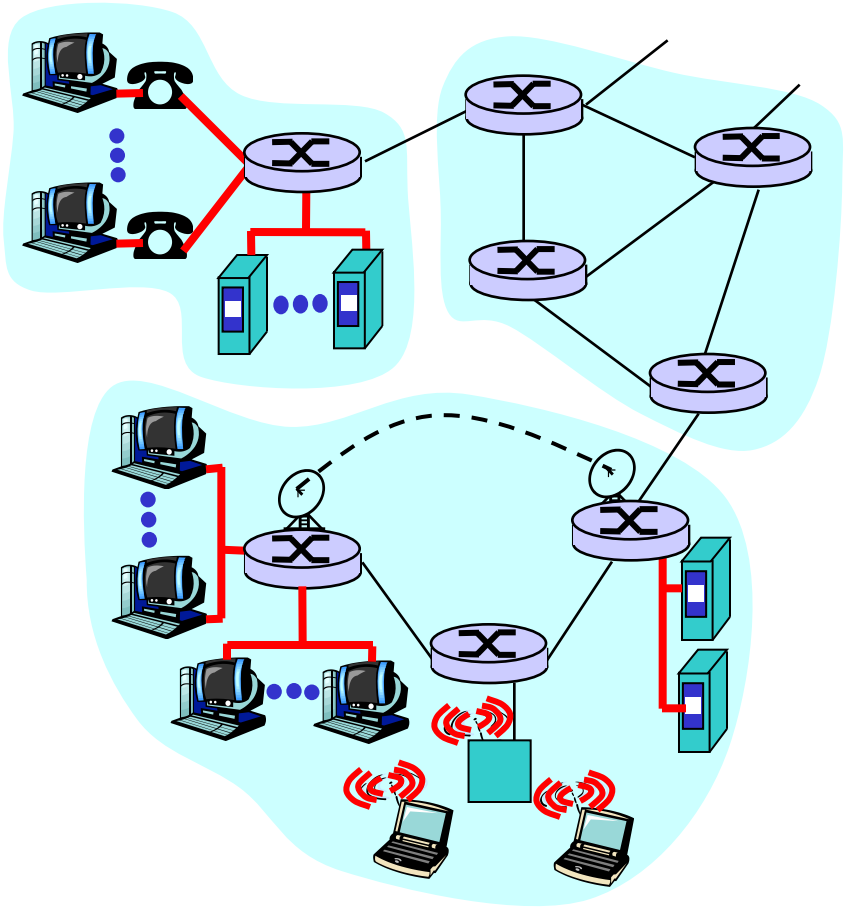
Access networks and physical media

Q: How to connect end systems to edge router?

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

Keep in mind:

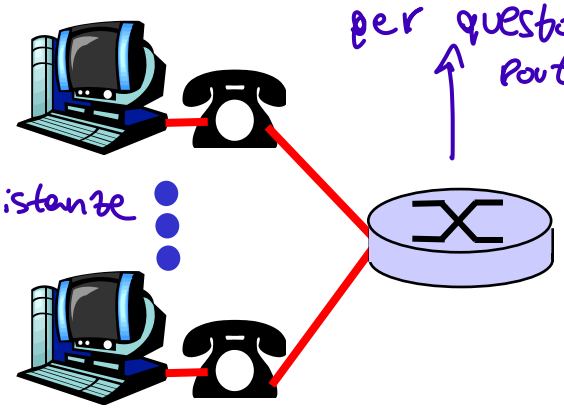
- bandwidth (bits per second) of access network?
- shared or dedicated?



Residential access: point to point access

anni '80

- Dialup via modem (analogico), portava i pacchetti
  - up to 56Kbps direct access to router (conceptually)
- ISDN: intergrated services digital network: 128Kbps all-digital connect to router
- ADSL: asymmetric digital subscriber line
  - up to 1 Mbps home-to-router
  - up to 8 Mbps router-to-home
  - ADSL deployment: fino a 50 Mbps?
  - Always-on, point-to-point



Come si fa col modem da 64k a 100 mega?

Come un processore DSP all'interno del modem

Voce dall'analogico al digitale

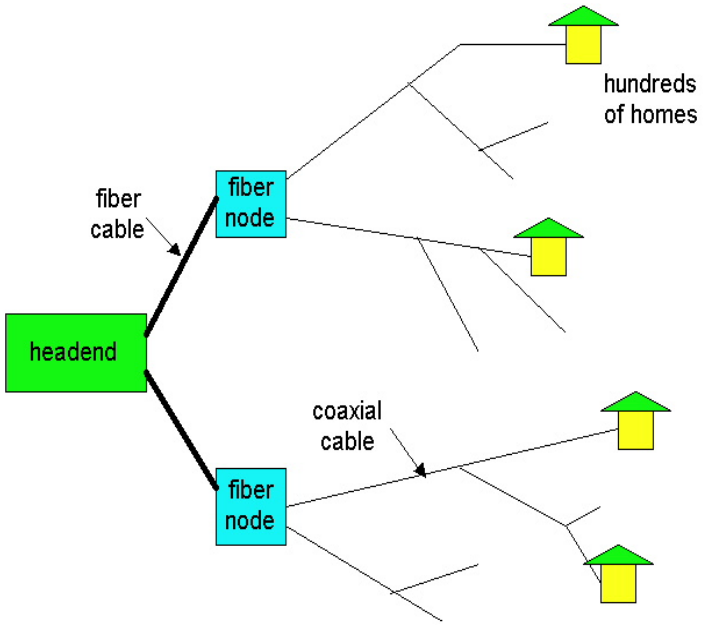
la voce viene campionata e trasformata in bit

campionamento: che vengono spediti

non si perde se il numero di campioni è pari a 2·frequenza

Residential access: cable modems

- HFC: hybrid fiber coax
  - asymmetric: up to 10Mbps upstream, 1 Mbps downstream
- network of cable and fiber attaches homes to ISP router
  - shared access to router among home
  - issues: congestion, dimensioning
- deployment: available via cable companies, e.g., MediaOne



Ret: local: tipo Ethernet

Institutional access: local area networks

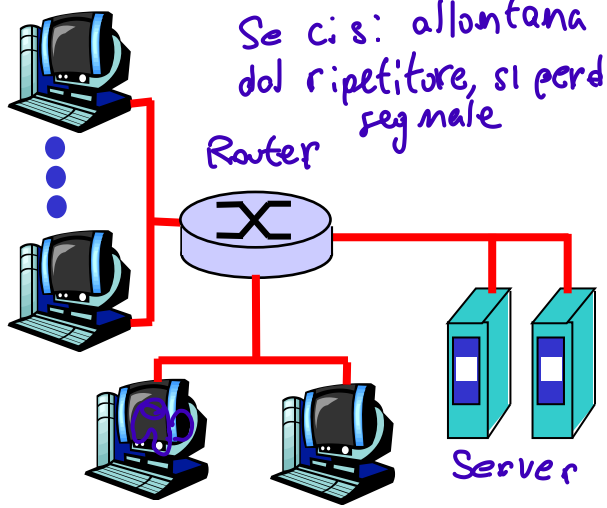
MAN = metropolitan area network

- company/univ local area network (LAN) connects end system to edge router
- Ethernet:
  - shared or dedicated cable connects end systems and router
  - 10 Mbs, 100Mbps, Gigabit Ethernet
- deployment: institutions, home LANs soon
- LANs: chapter 5

(W:reles) LAN

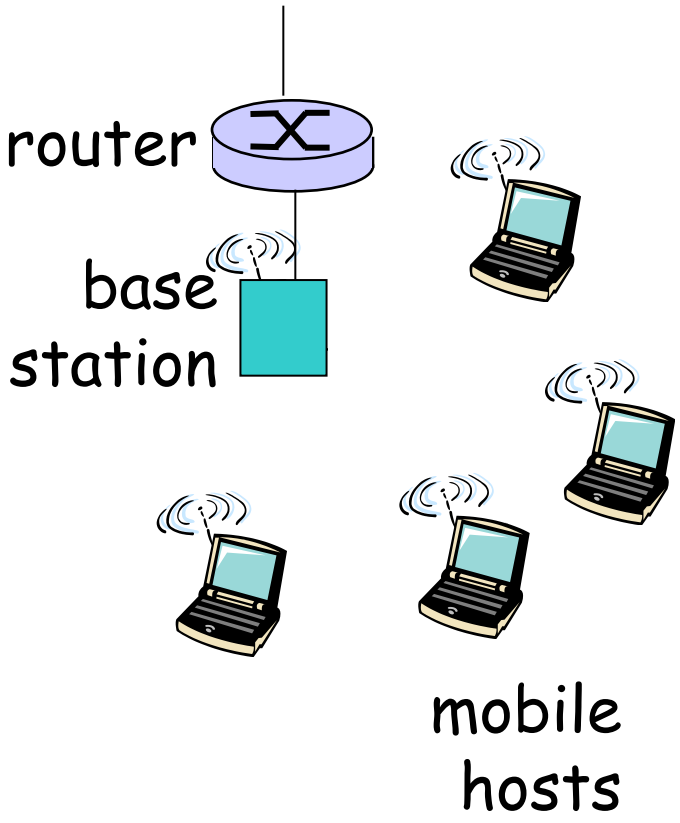
Tecniche simili a quelle dei cellulari

Se ci si allontana troppo dal ripetitore, si perde il segnale



Wireless access networks

- shared *wireless* access network connects end system to router
- wireless LANs:
  - radio spectrum replaces wire
  - e.g., Wi-Fi > 11 Mbps
- wider-area wireless access
  - 3G: wireless access to ISP router via cellular network



Physical Media

- physical link: transmitted data bit propagates across link
- guided media:
  - signals propagate in solid media: copper, fiber, coax → cavo coassiale
- unguided media:
  - signals propagate freely e.g., radio, satellite or terrestrial

Twisted Pair (TP)

- two insulated copper wires
  - Category 3: traditional phone wires, 10 Mbps ethernet
  - Category 5 TP: 100Mbps ethernet
  - < 100 meters → maggiore isolamento elettromagnetico

Physical Media: coax, fiber

Coaxial cable:

- wire (signal carrier) within a wire (shield)
  - baseband: single channel on cable
  - broadband: multiple channel on cable
- bidirectional
- common use in 10Mbs Ethernet

Fiber optic cable:

- glass fiber carrying light pulses
- high-speed operation:
  - 100Mbps Ethernet
  - high-speed point-to-point transmission (e.g., 5 Gps)
- low error rate

se la luce è molto collimata si ha maggiore banda (vetro di maggior qualità)

Physical media: radio

- signal carried in electromagnetic spectrum
- no physical "wire"
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

Radio link types:

- microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., waveLAN)
  - 2Mbps, 11Mbps, 45Mbps
- wide-area (e.g., cellular)
  - e.g. 3G, 100's Kbps
- satellite
  - up to 50Mbps channel (or multiple smaller channels)
  - 270 Msec end-end delay
  - geosynchronous versus LEOS

ISP e backbone

INTERNET SERVICE PROVIDER

- ISP 3 livelli (o tier)
- Alta capacita' da 622 Mbps a 10 Gbps
- ISP-1 o di backbone (decine):
  - Sono collegati a tutti gli altri ISP-1
  - Sono collegati a numerosi ISP-2 e reti clienti
  - Sono internazionali, come copertura
- ISP-2(decine): distrettuale o nazionale, si collega solo a ISP-1
- ISP di accesso (centinaia), livello inferiore cui si collegano utenti e fornitori di contenuto

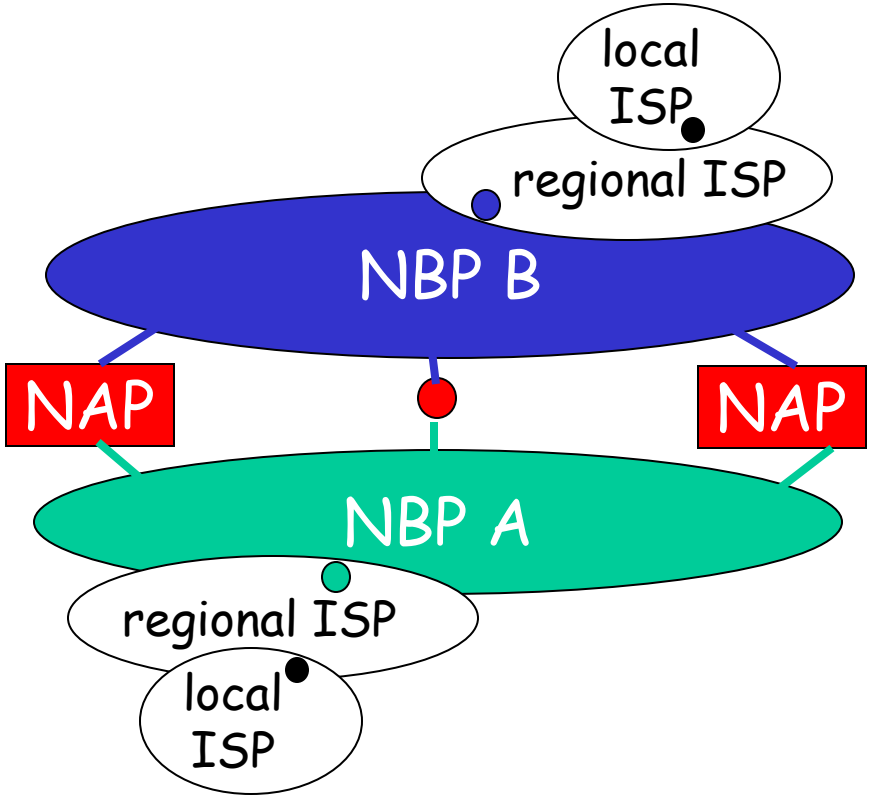
- ISP 1 internaz.
- ISP 2 nazion.
- ISP utenti

POP e NAP:

- POP
  - Point of Presence
  - Punto in cui un ISP si collega ad altri in peering
  - Uno o piu' router a cui collegare i router di altri ISP o reti clienti
  - peering
- NAP Network Acc. Point
  - Ad alta velocita' affittati da terze parti (telcom)
  - ISP-1 si collegano tra loro con POP, ISP-2 convergono su NAP

Internet structure: network of networks

- roughly hierarchical
- national/international backbone providers (NBPs)
  - e.g. BBN/GTE, Sprint, AT&T, IBM, UUNet
  - interconnect (peer) with each other privately, or at public Network Access Point (NAPs)
- regional ISPs
  - connect into NBPs
- local ISP, company
  - connect into regional ISPs



National Backbone Provider

PoP

e.g. BBN/GTE US backbone network