DIPARTIMENTO DI INFORMATICA
Via Salaria 113 - 00198, Roma

SAPIENZA
UNIVERSITÀ DI ROMA

Reti di Elaboratori

Corso di Laurea in Informatica
Università degli Studi di Roma "La Sapienza"
Canale A-L
Prof.ssa Chiara Petrioli

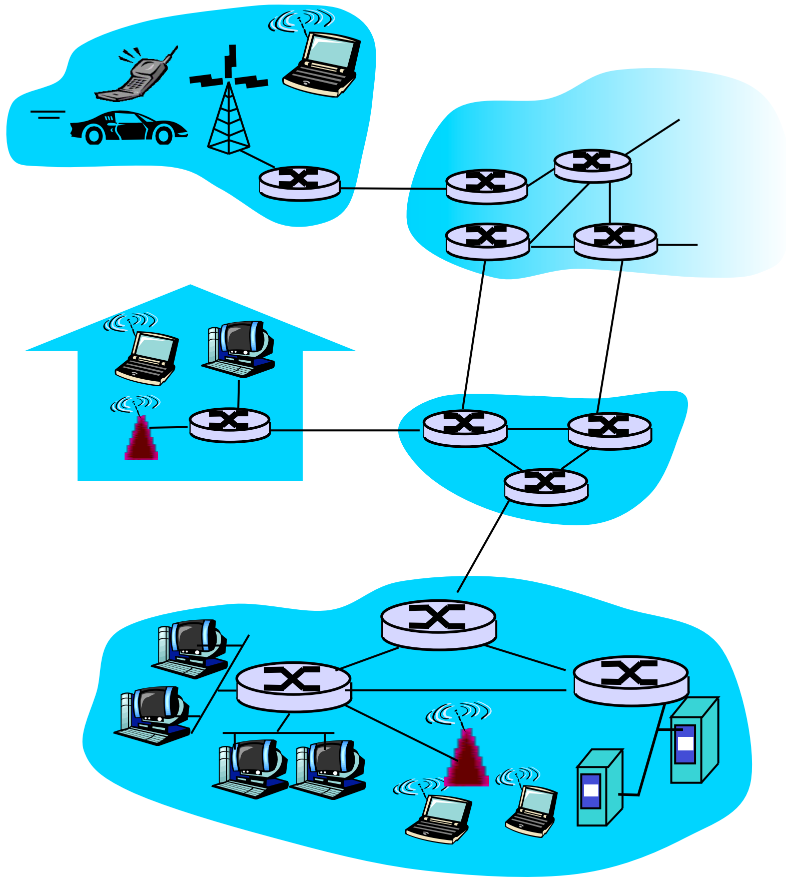
Parte di queste slide sono state prese dal materiale associato al libro *Computer Networking: A Top Down Approach* , 5th edition.

Thanks also to Antonio Capone, Politecnico di Milano, Giuseppe Bianchi and Francesco LoPresti, Un. di Roma Tor Vergata

Chapter 1: roadmap

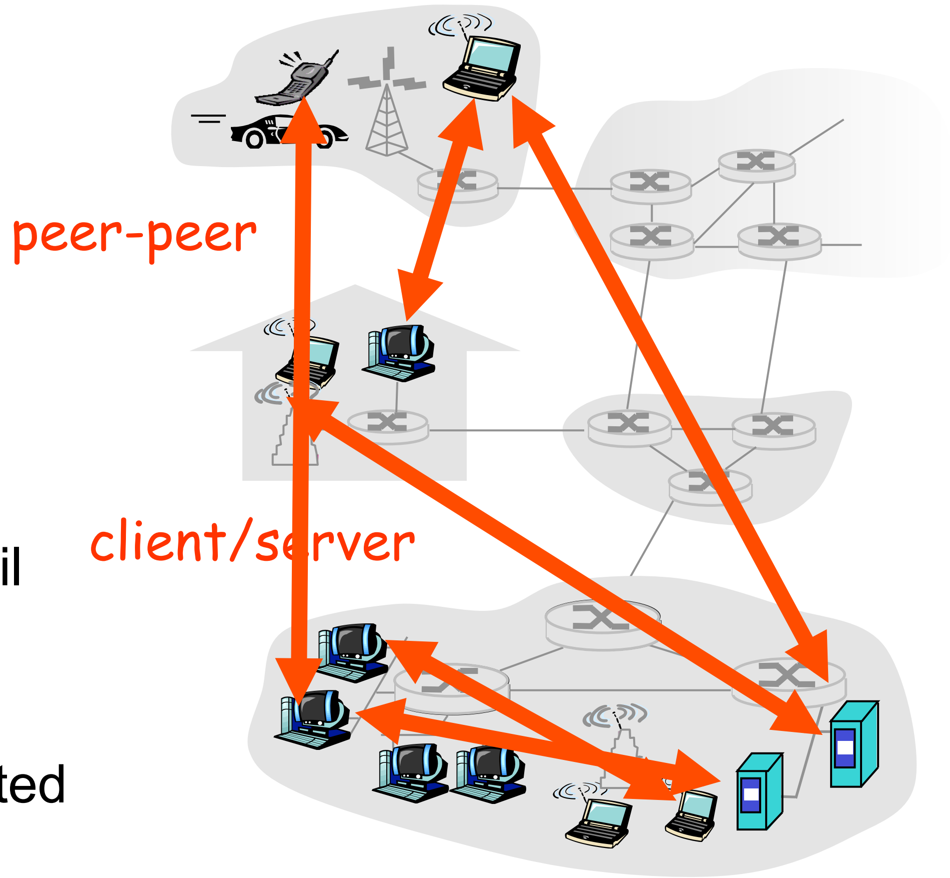
A closer look at network structure:

- 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



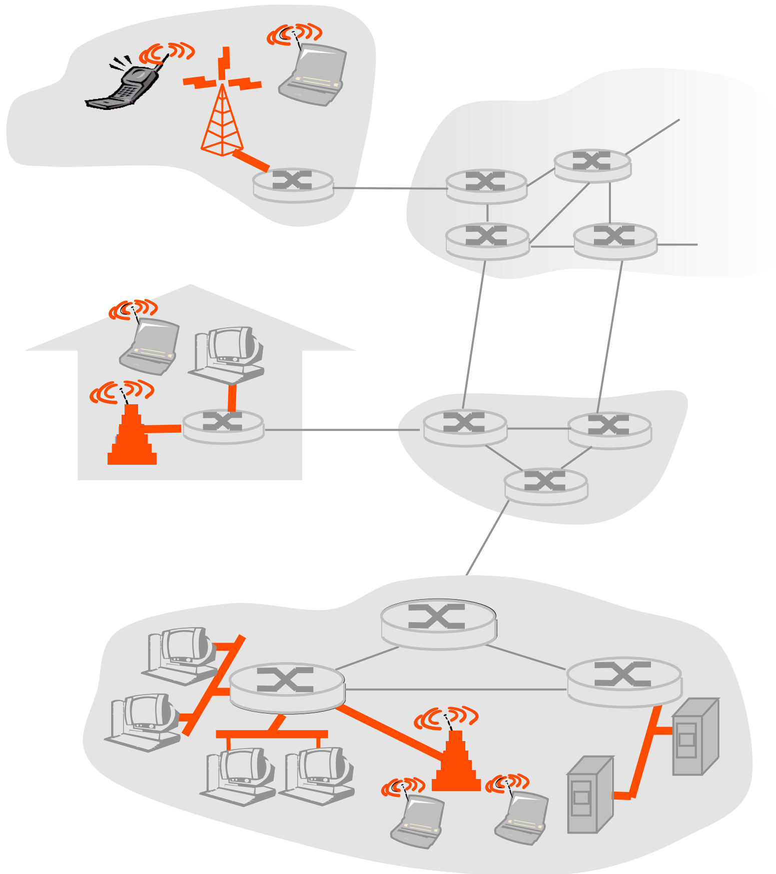
Access networks and physical media

Q: How to connect end systems to edge router?

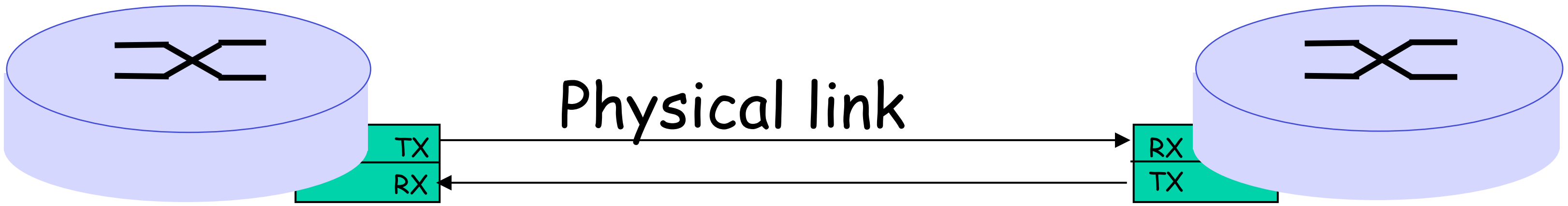
- residential access nets
- institutional access networks (school, company)
- mobile access networks

Keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?
- reliable/unreliable (bit error rates)

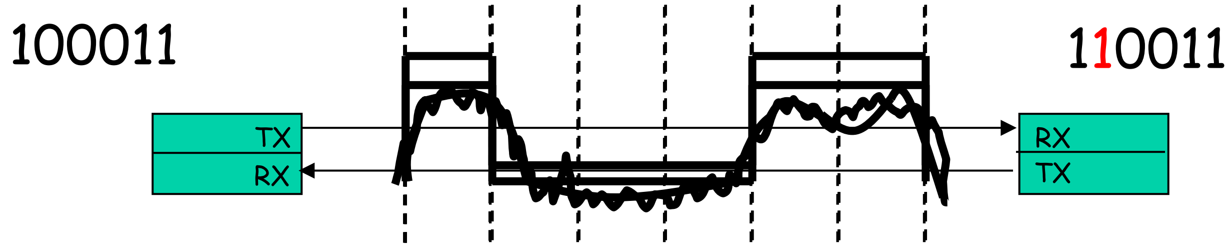


Transmission across a physical link



- 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



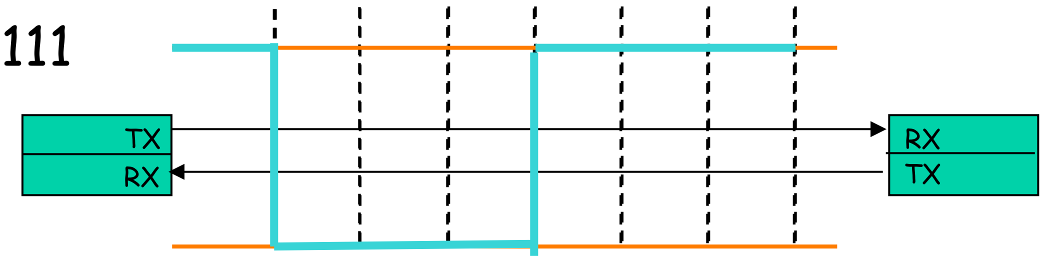
- Bit sequence modulates a suitable waveform which is sent across the link
  - How and which depends on the medium
- As the signal travels it experiences
  - Attenuation (absorption)
  - Distortion (limited bandwidth (frequency))
  - Noise (interference, thermal noise)
  - Influenced by medium, bit rate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

1000111

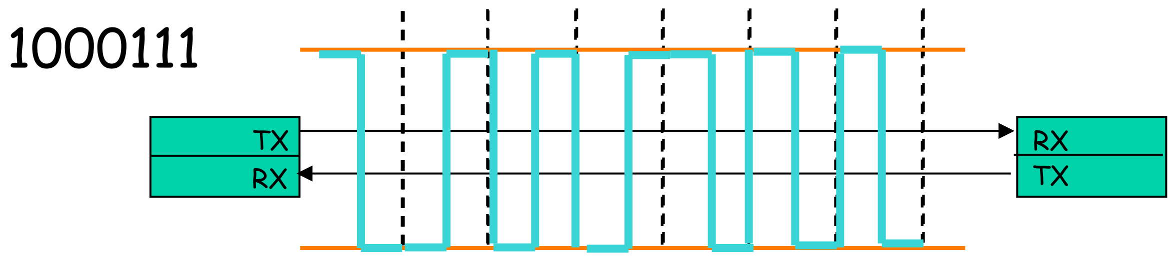


Problemi di sincronizzazione del ricevitore (nessuna transizione nel caso di sequenze di zeri o di uni)→ NRZ 5B6B o 4B5B

Codifica Manchester

- Codifica Manchester

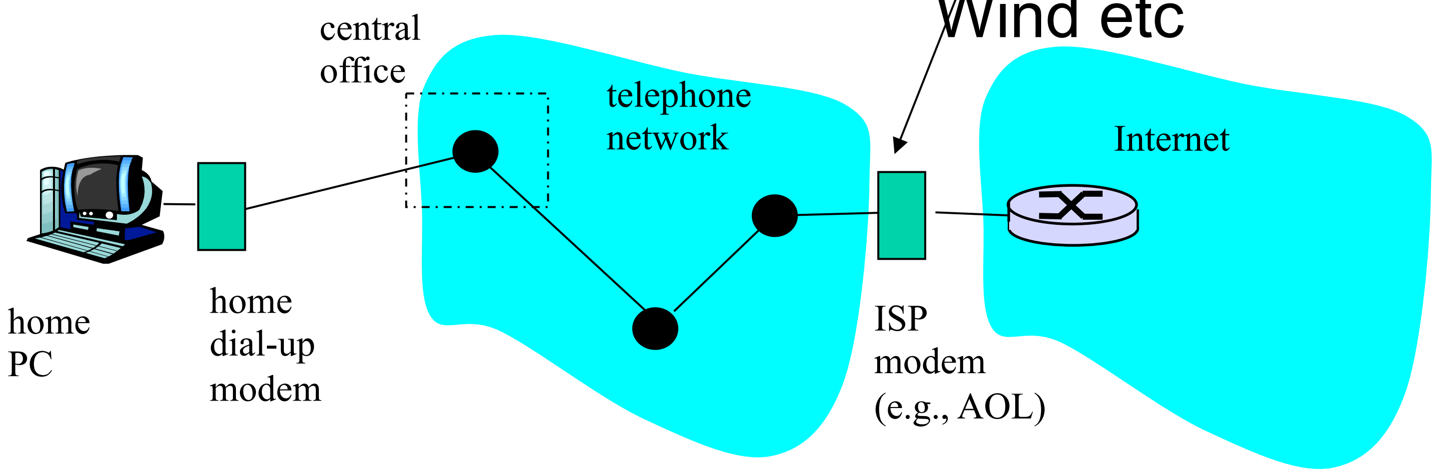
Una transizione basso-alto (codifica dello zero) o alto-basso (codifica del valore uno) in corrispondenza di ogni bit



Usato in Ethernet 10Mbps e Token Ring

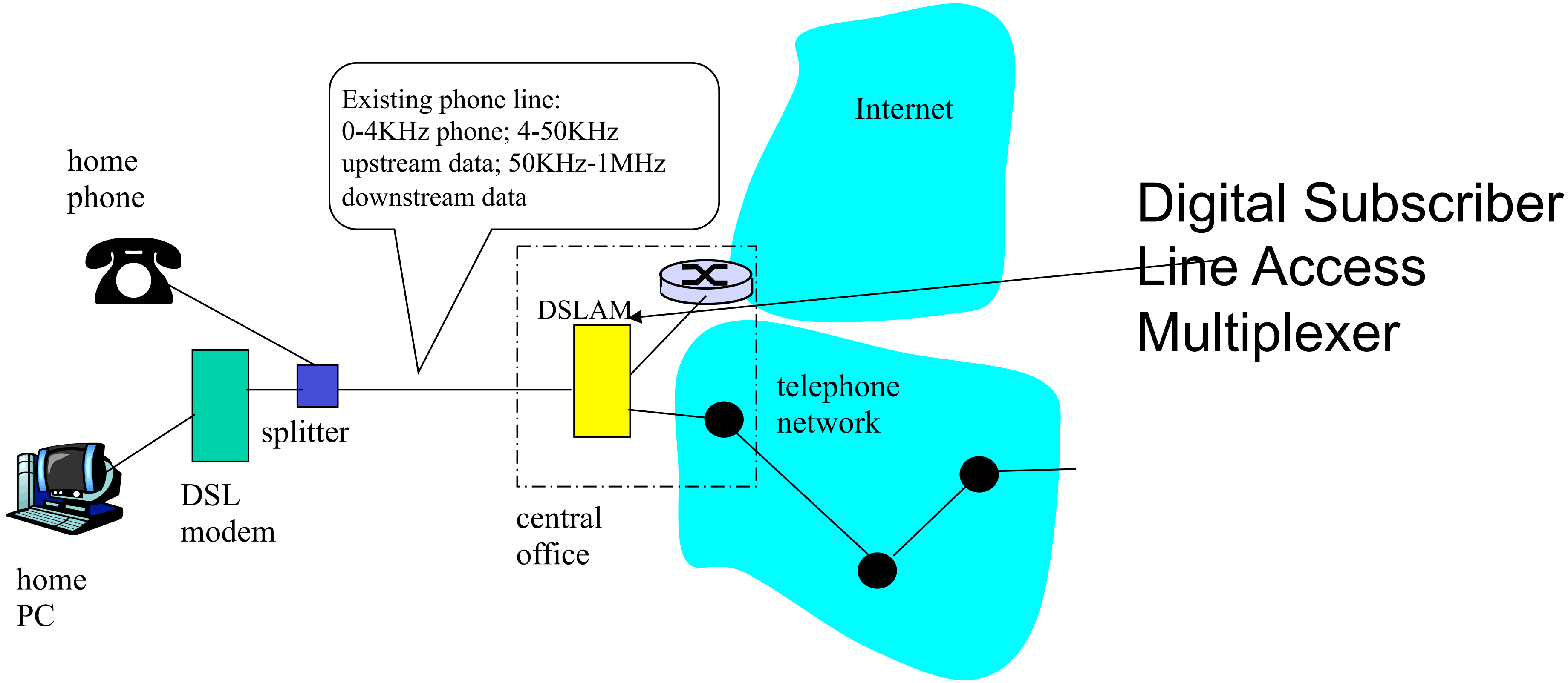
Dial-up Modem

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)

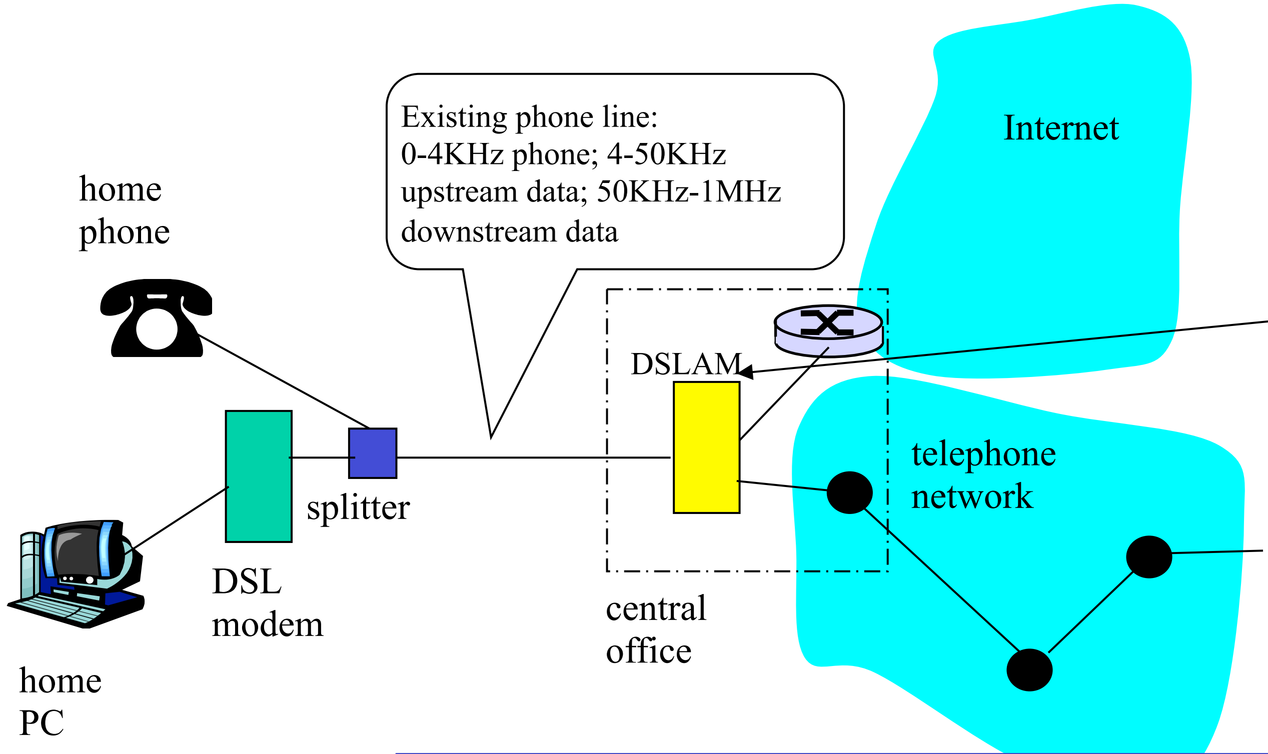


- Also uses existing telephone infrastruture
- up to 1 Mbps upstream (typically < 256 kbps)
- up to 8 Mbps downstream (typically < 1 Mbps)
- dedicated physical line to telephone central office

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)

Digital Subscriber Line (DSL)



Digital Subscriber Line Access Multiplexer

- Also uses exi
- up to 1 Mbps
- up to 8 Mbps
- dedicated phy

Speed significantly increased in the last few years
- **technologies more robust to interference;**
- **lower distance from DSM modem to DSLAM**

is expected to raise speed to 1Gbps by 2016)

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

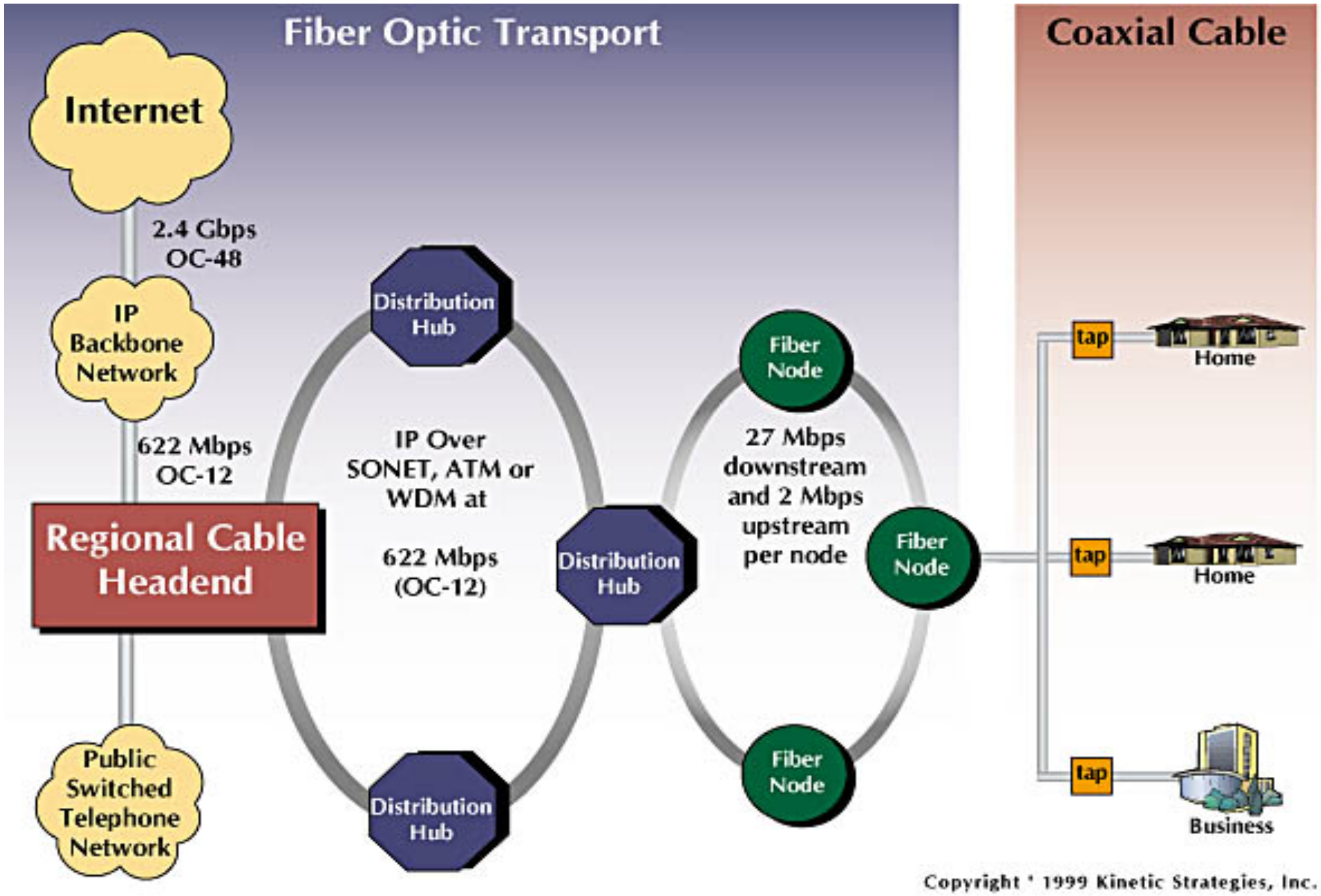
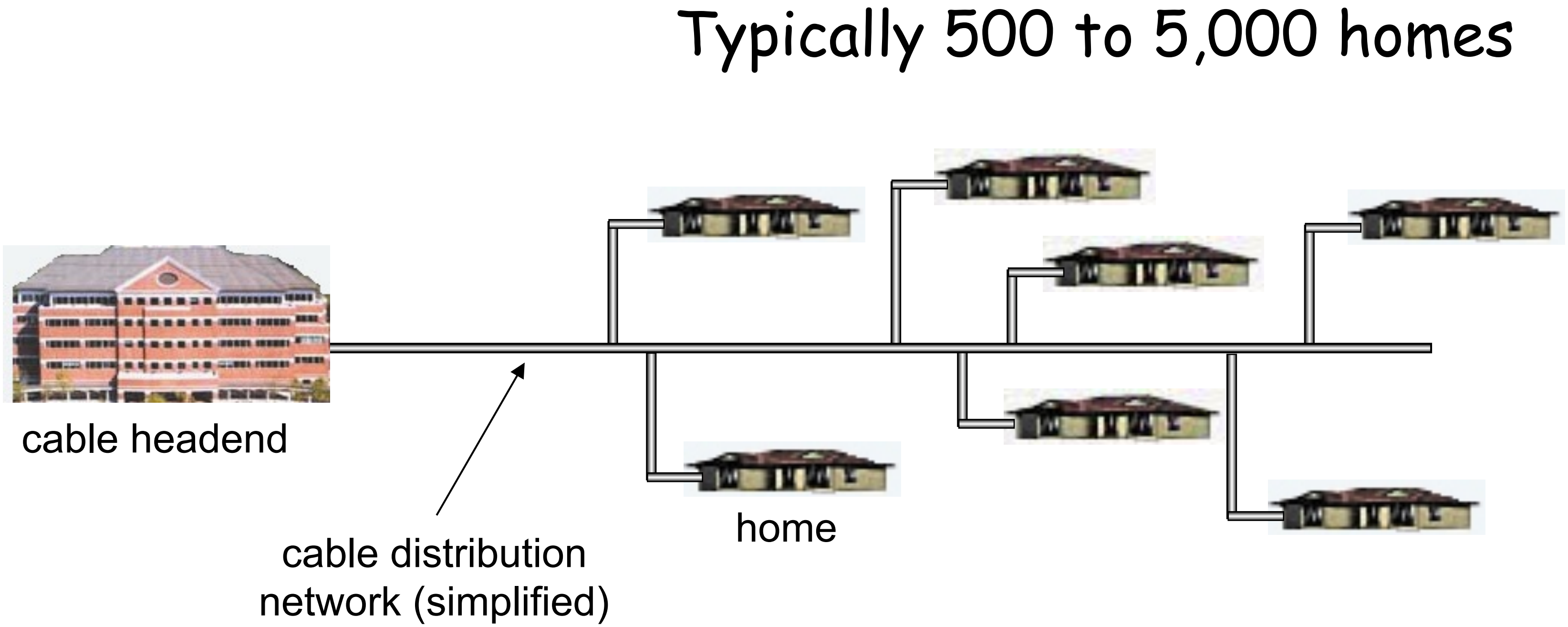
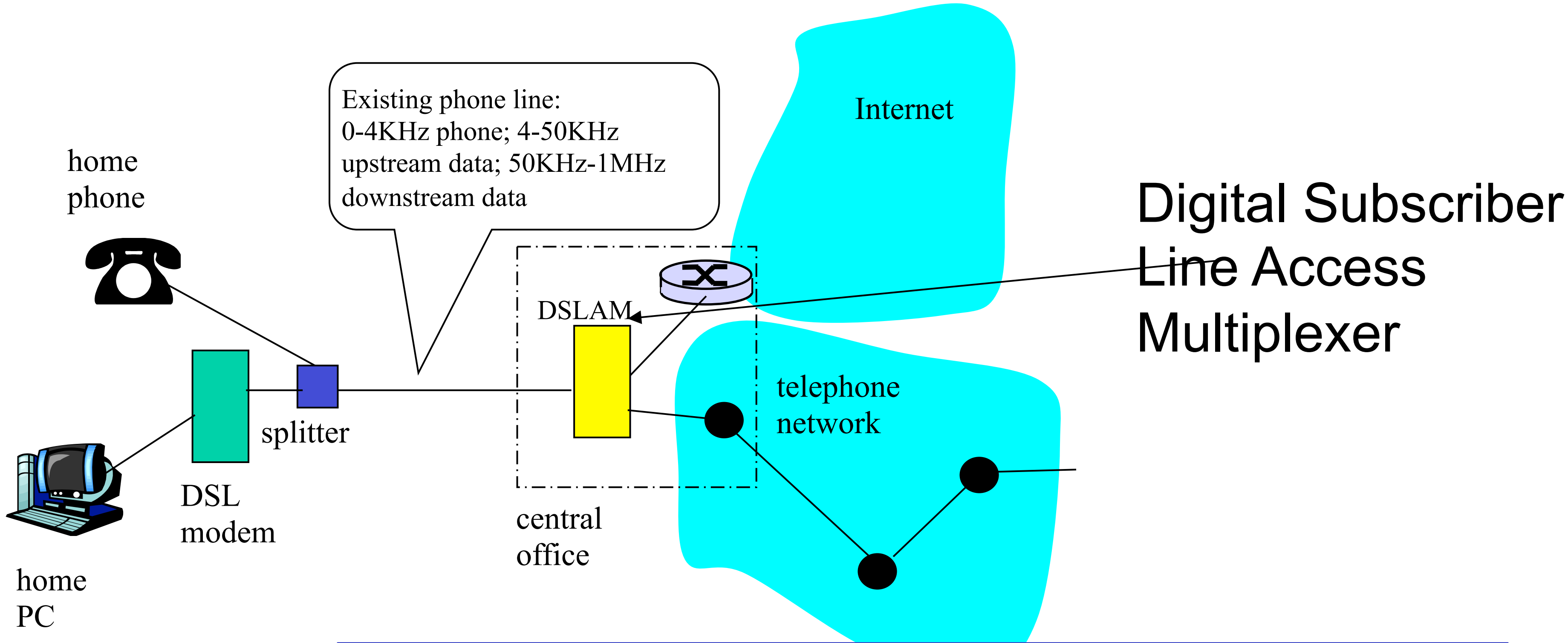


Diagram: http://www.cabledatacomnews.com/cmic/diagram.html

Cable Network Architecture: Overview



Digital Subscriber Line (DSL)

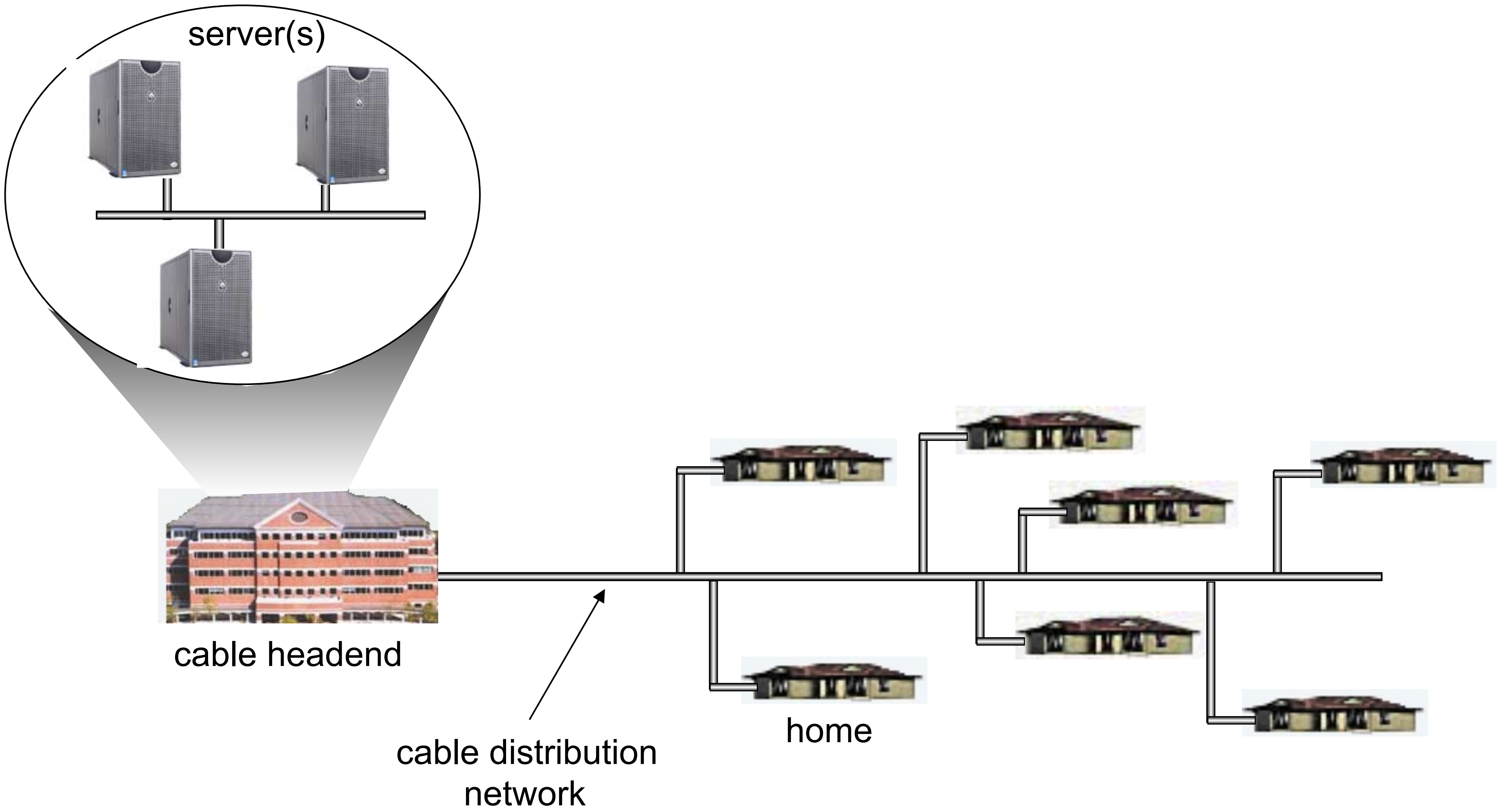


- Also uses exi
- up to 1 Mbps
- up to 8 Mbps
- dedicated phy

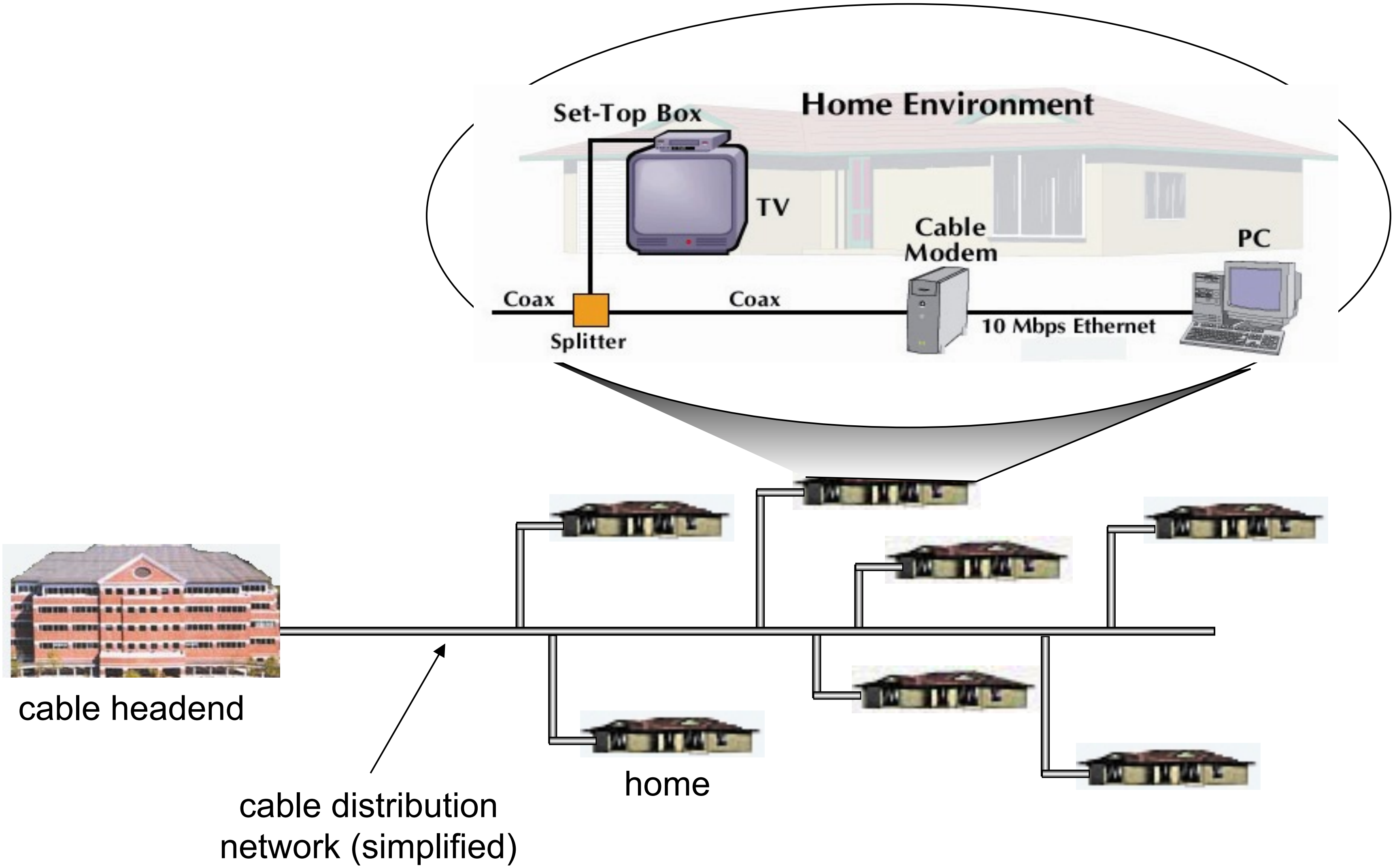
Speed significantly increased in the last few years
- **technologies more robust to interference;**
- **lower distance from DSM modem to DSLAM**

is expected to raise speed to 1Gbps by 2016)

Cable Network Architecture: Overview

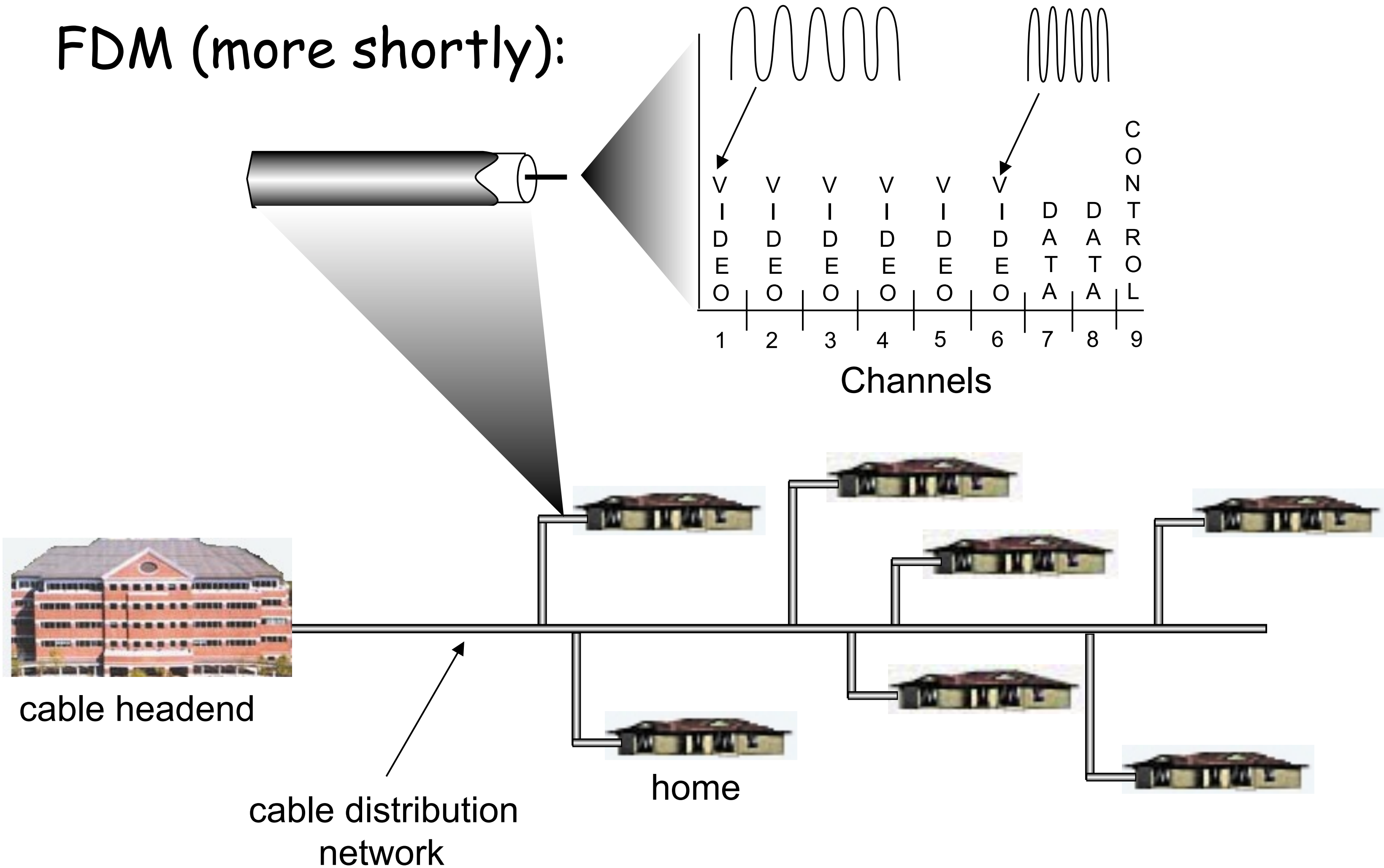


Cable Network Architecture: Overview

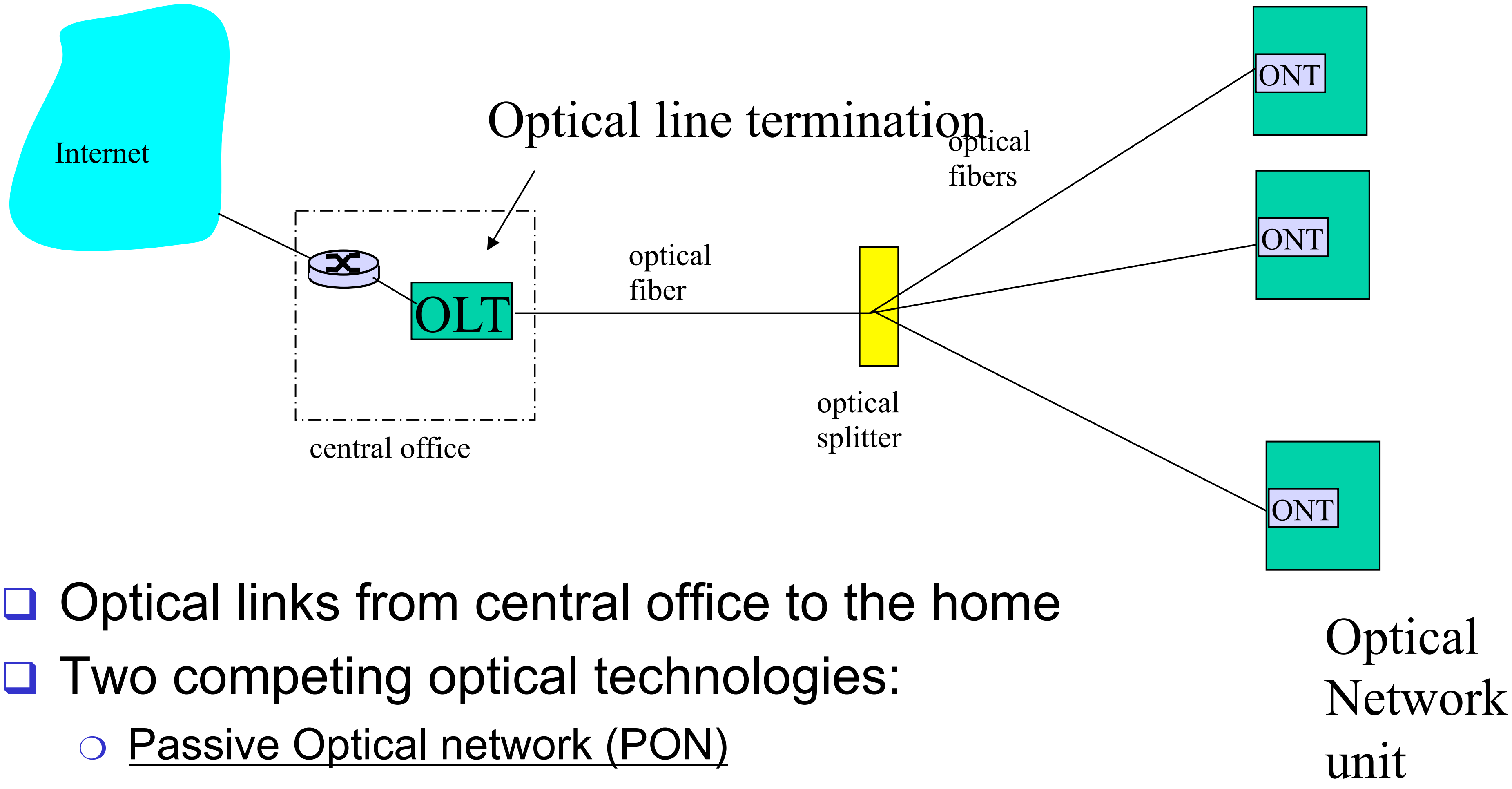


Cable Network Architecture: Overview

FDM (more shortly):

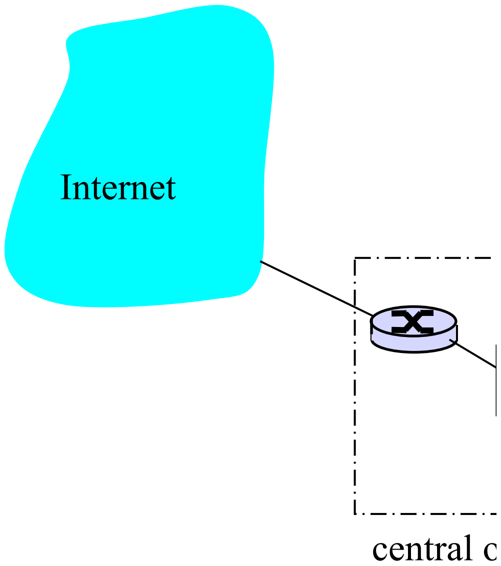


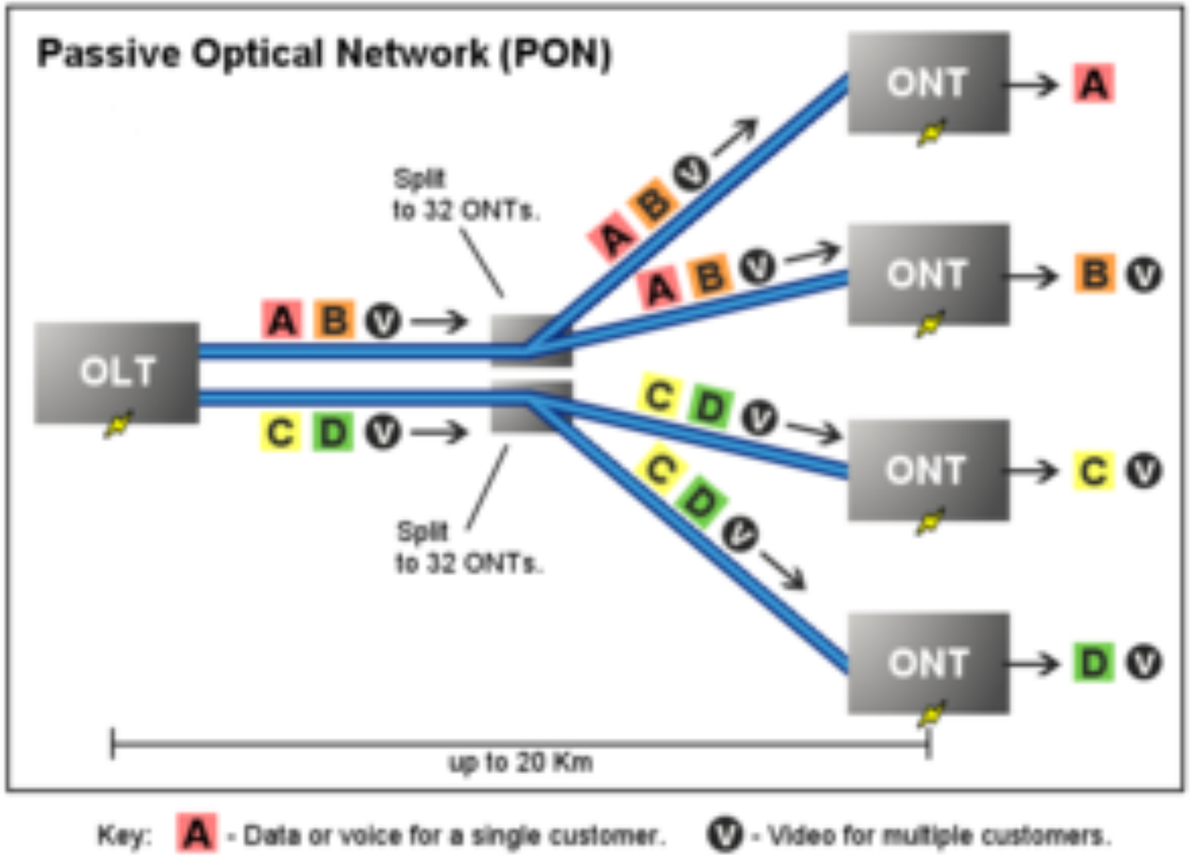
Fiber to the Home



- Optical links from central office to the home
- Two competing optical technologies:
  - Passive Optical network (PON)
  - Active Optical Network (PAN)
- Much higher Internet rates; fiber also carries television and phone services

Fiber to the Home



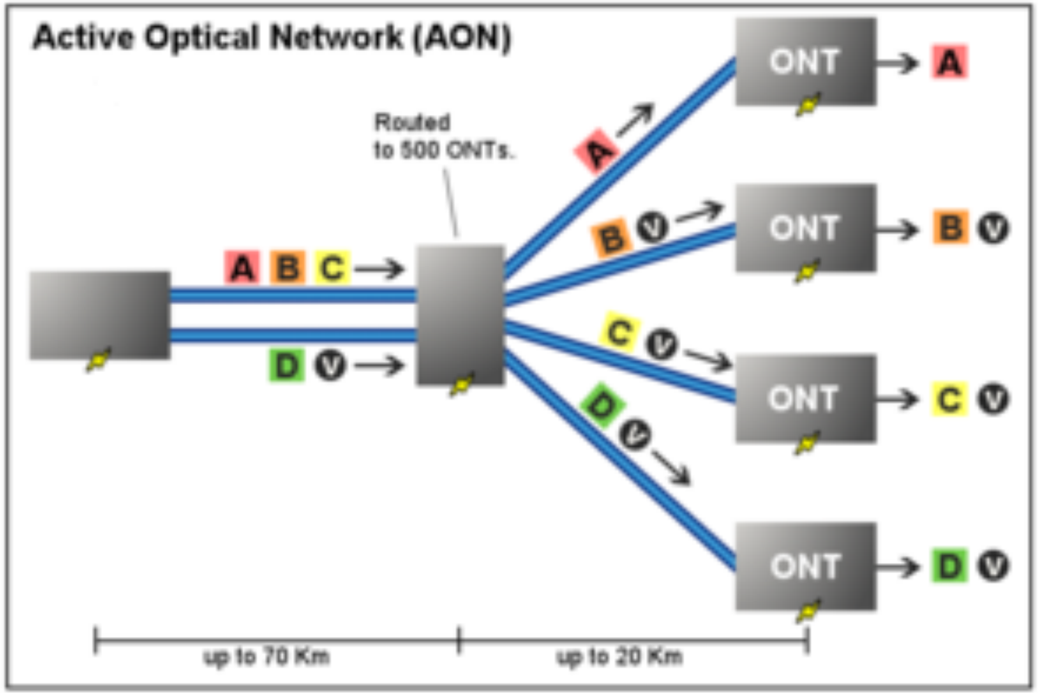


- Optical links fro
- Two competing
  - Passive Optical network (PON)
  - Active Optical Network (PAN)
- Much higher Internet rates; fiber also carries television and phone services

cal
Network
unit

Active Optical Networks

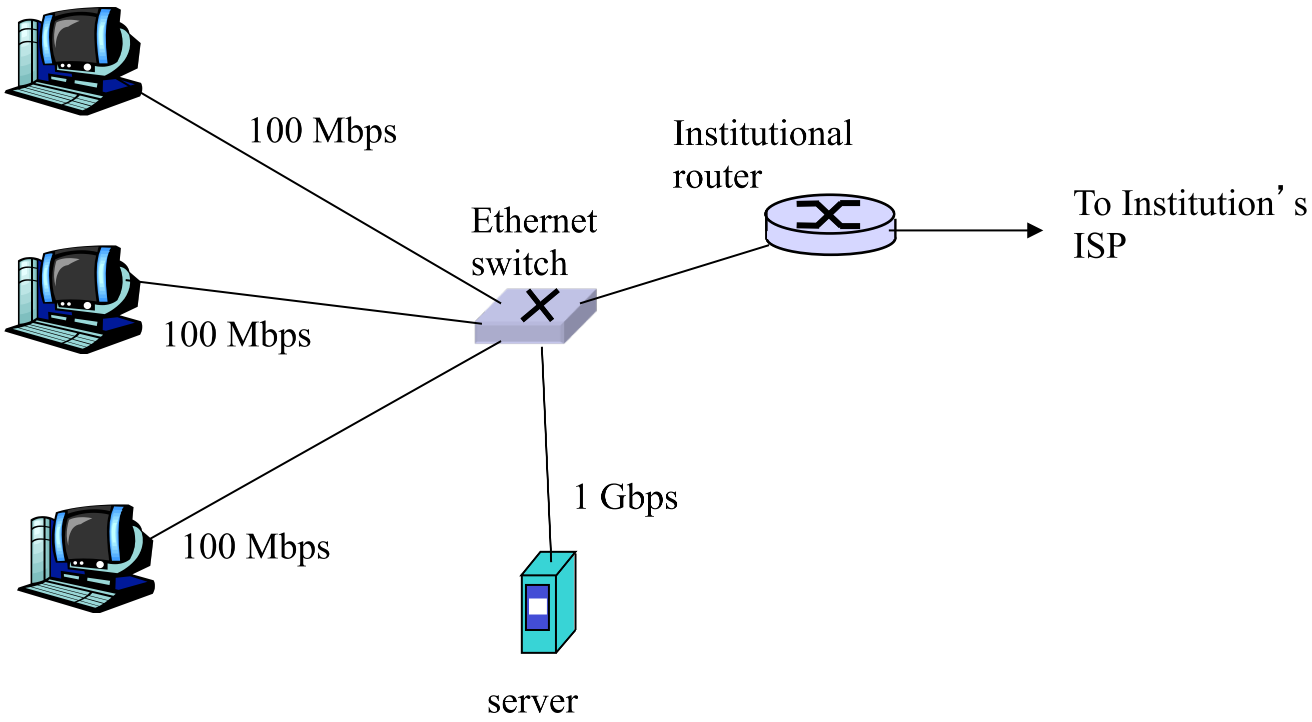
- An active optical system uses electrically powered switching equipment, such as a router or a switch aggregator, to manage signal distribution and direct signals to specific customers.
- In such a system, a customer may have a dedicated fiber running to his or her house.



Active vs Passive Optical Networks

- Passive optical networks, or PONs, have some distinct advantages.
  - They're efficient, in that each fiber optic strand can serve up to 32 users
  - PONs have a low building cost relative to active optical networks along with lower maintenance costs. In active optical networks one aggregator is required every 48 subscribers.
- Passive optical networks also have some disadvantages.
  - They have less range than an active optical network.
  - PONs also make it difficult to isolate a failure when they occur.
  - Because the bandwidth in a PON is not dedicated to individual subscribers, data transmission speed may slow down during peak usage times.

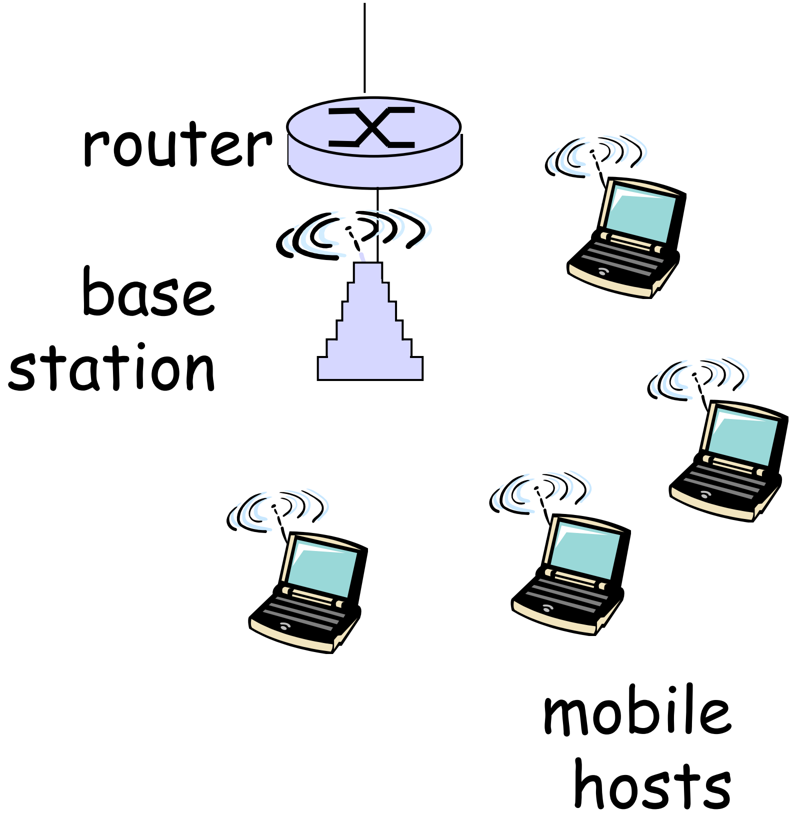
Ethernet Internet access



- Typically used in companies, universities, etc
- 10 Mbs, 100Mbps, 1Gbps, 10Gbps Ethernet
- Today, end systems typically connect into Ethernet switch

Wireless access networks

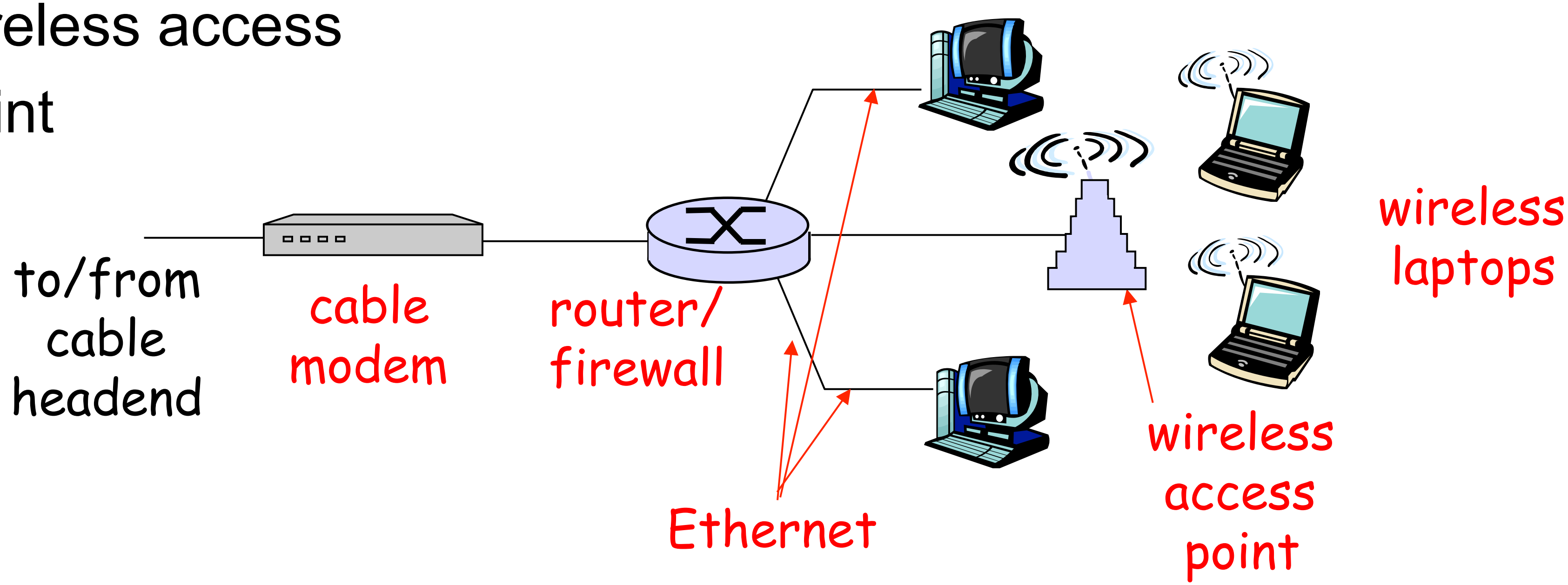
- shared *wireless* access network connects end system to router
  - via base station aka "access point"
- wireless LANs:
  - 802.11b/g (WiFi): 11 or 54 Mbps
- wider-area wireless access
  - provided by telco operator
  - ~1Mbps over cellular system (EVDO, HSDPA), several tens Mbps LTE
  - WiMAX (10's Mbps) over wide area
  - Next to come: 5G systems



Home networks

Typical home network components:

- DSL or cable modem
- router/firewall/NAT
- Ethernet
- wireless access point

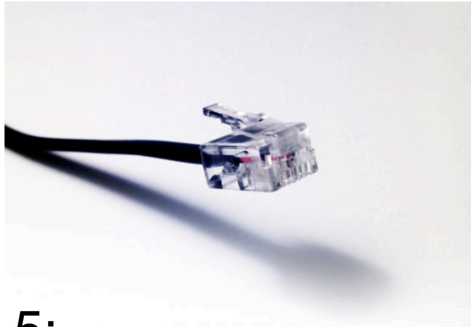


Physical Media

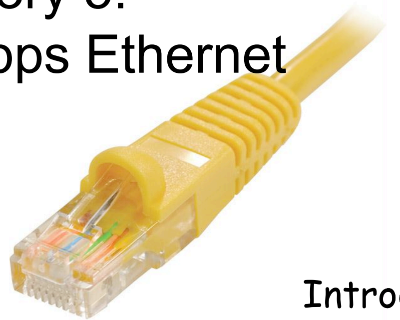
- Bit: propagates between transmitter/rcvr pairs
- physical link: what lies between transmitter & receiver
- guided media:
  - signals propagate in solid media: copper, fiber, coax
- unguided media:
  - signals propagate freely, e.g., radio

Twisted Pair (TP)

- two insulated copper wires
  - Category 3: traditional phone wires, 10 Mbps Ethernet



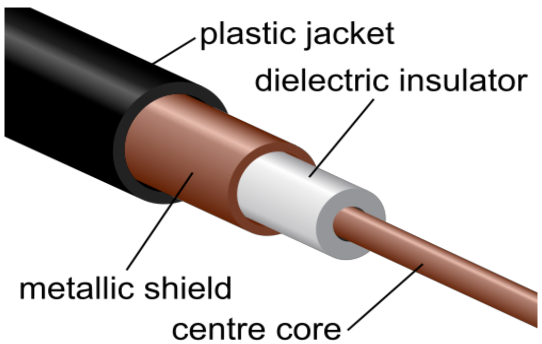
  - Category 5: 100Mbps Ethernet



Physical Media: coax, fiber

Coaxial cable:

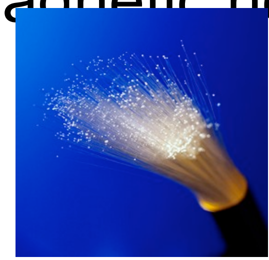
- two concentric copper conductors
- bidirectional
- baseband:
  - single channel on cable
  - legacy Ethernet
- broadband:
  - multiple channels on cable
  - HFC



http://commons.wikimedia.org/wiki/File:Coaxial_cable_cutaway.svg

Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gps, but experimented up to tens of terabps)
- low error rate: repeaters spaced far apart ; immune to electromagnetic noise



http://www.macmynd.com/storage/misc-pics/fiber_optic_cable.jpg

Physical media: radio

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

Radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., Wifi)
  - 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 3G cellular: ~ 1 Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude
    - (500 Km dalla superficie terrestre, servono costellazioni di satelliti)

Physical media performance evolution (update: 2014) –On the move

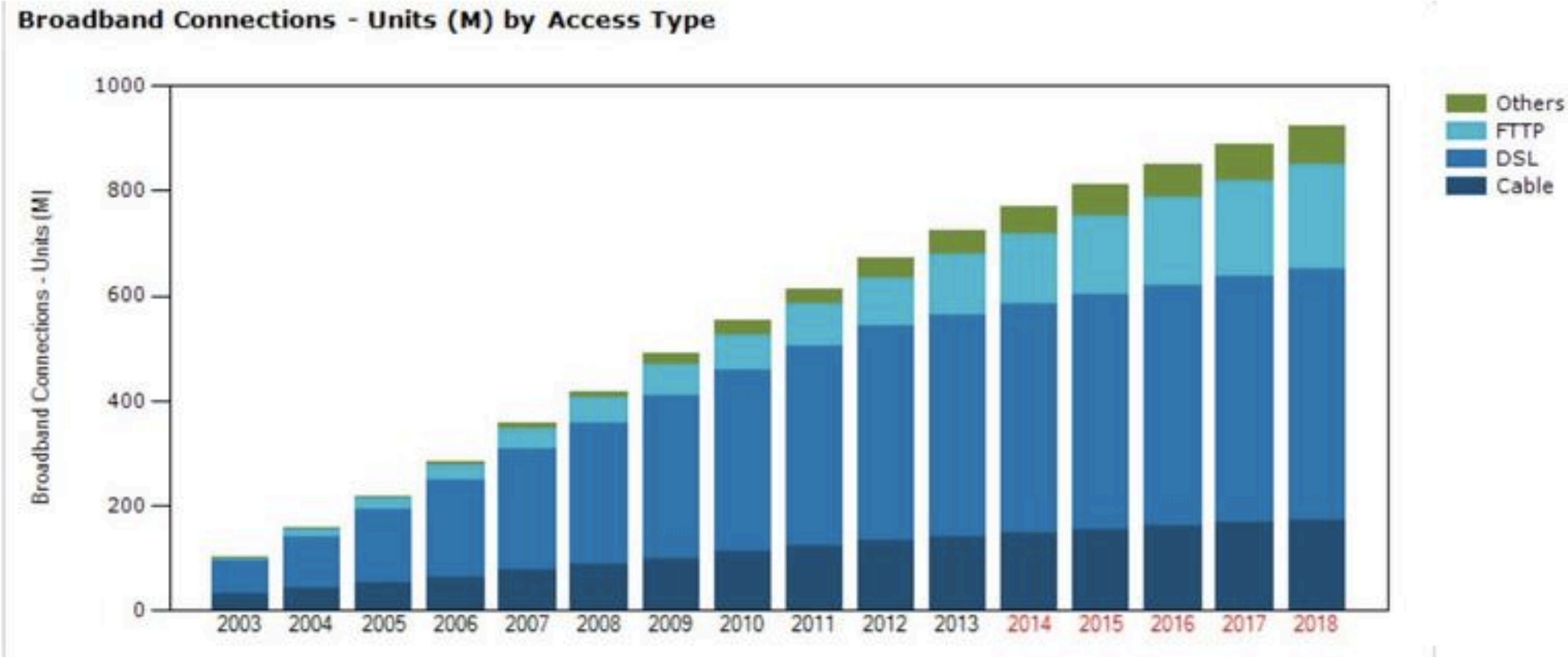
Generation		Technology	Maximum Download Speed	Typical Download Speed
2G	G	GPRS	0.1Mbit/s	<0.1Mbit/s
	E	EDGE	0.3Mbit/s	0.1Mbit/s
3G	3G	3G (Basic)	0.3Mbit/s	0.1Mbit/s
	H	HSPA	7.2Mbit/s	1.5Mbit/s
	H+	HSPA+	21Mbit/s	4Mbit/s
	H+	DC-HSPA+	42Mbit/s	8Mbit/s
4G	4G LTE	LTE	100Mbit/s	15Mbit/s

Physical media performance evolution (update: 2014) –Access technologies

WiFi, Ethernet, Fiber to the "home", DSL…Maximum current speeds or technologies tested to enter the market within a couple of years

- DSL (G.Net technology) 1Gbps
  - By 2016
  - Combined with fiber; access to broadband network within 50m to reach such speeds
- Ethernet: 1-10Gbps
- WiFi (Samsung tehnology). Up to 1Gbps to come
- Fiber
  - Technologies tested up to few tens of terabps
  - 1Gbps per home more than enough (current threshold per user satisfaction >10Mbps)
- Cellular systems evolution
  - Tens of Mbps

Physical media performance evolution (update: 2014)—different types of media

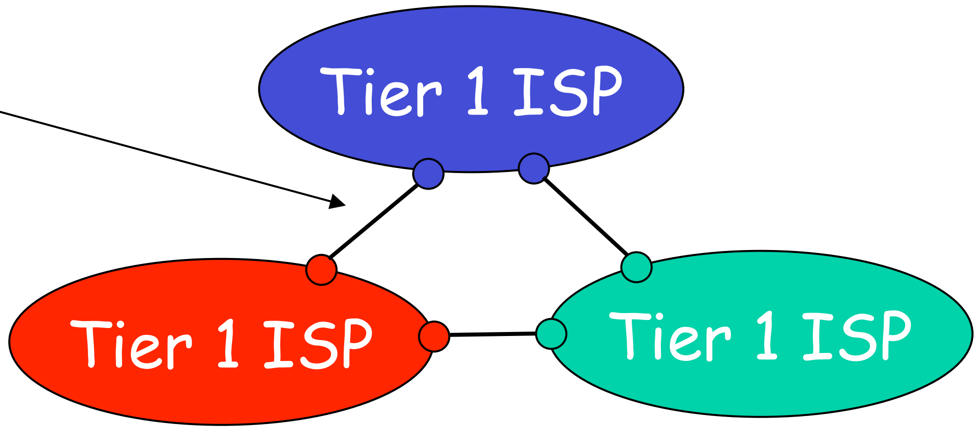


DSL is the most widely used broadband connection technology, and it's growing, but fiber-optic links are growing faster.

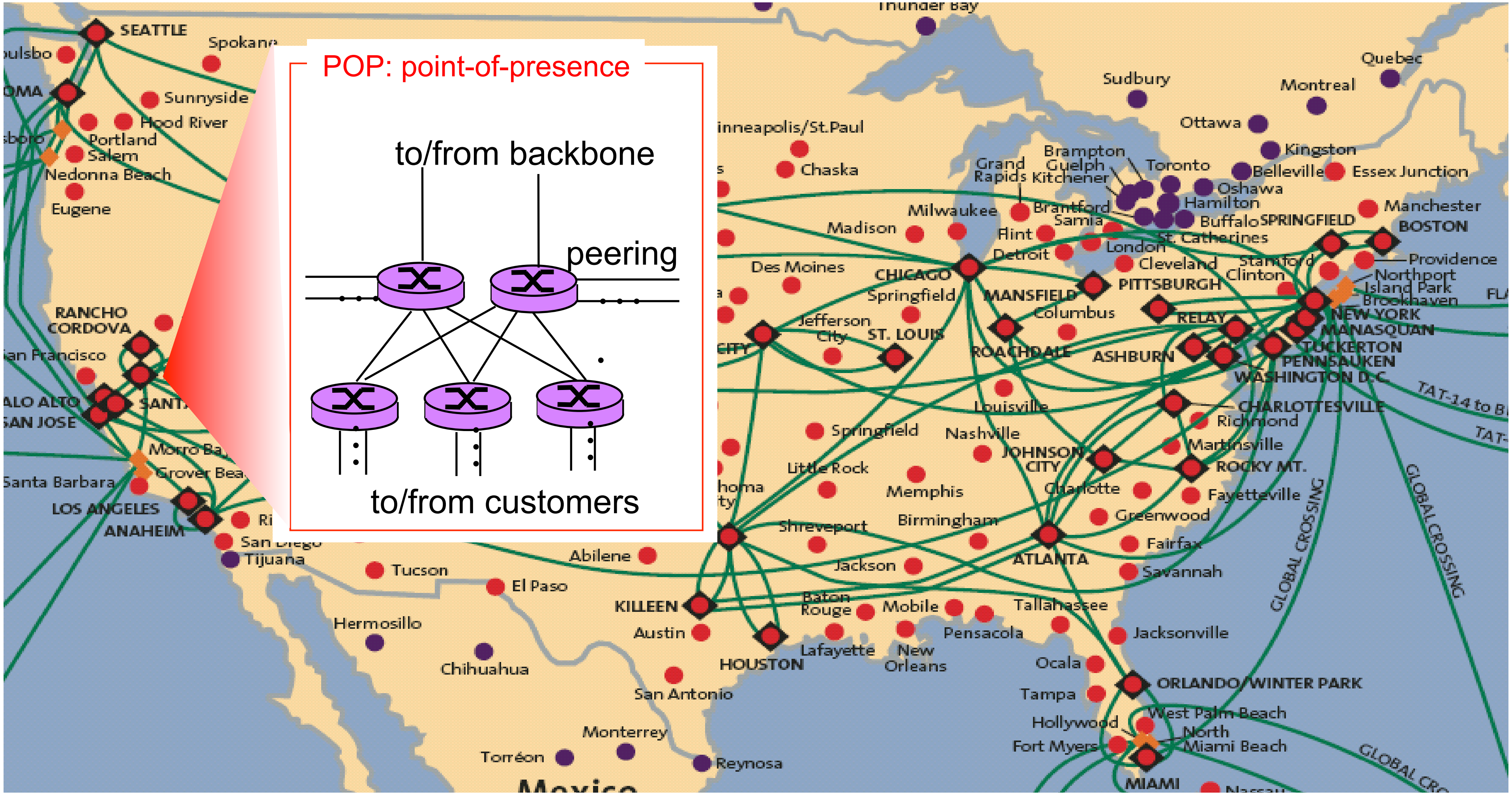
Internet structure: network of networks

- roughly hierarchical
- at center: "tier-1" ISPs (e.g., Verizon, Sprint, AT&T, Cable and Wireless), national/international coverage
  - treat each other as equals

Tier-1 providers interconnect (peer) privately



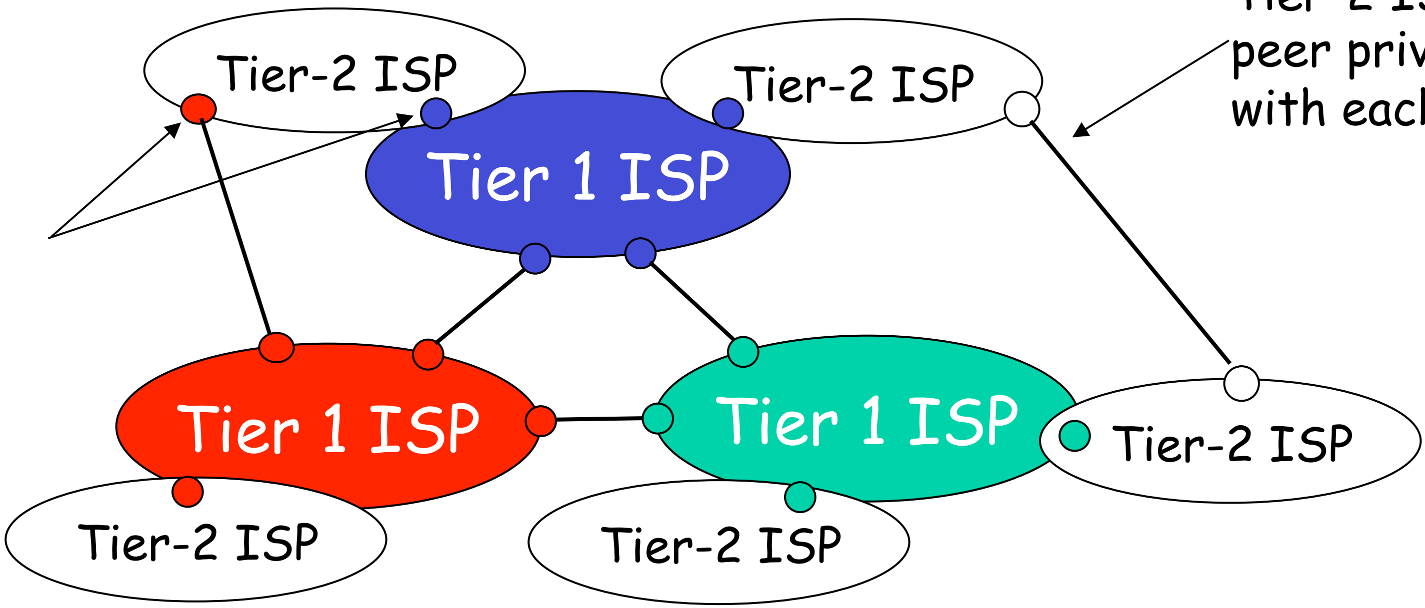
Tier-1 ISP: e.g., Sprint



Internet structure: network of networks

- "Tier-2" ISPs: smaller (often regional) ISPs
  - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

Tier-2 ISP pays tier-1 ISP for connectivity to rest of Internet
- tier-2 ISP is *customer* of tier-1 provider

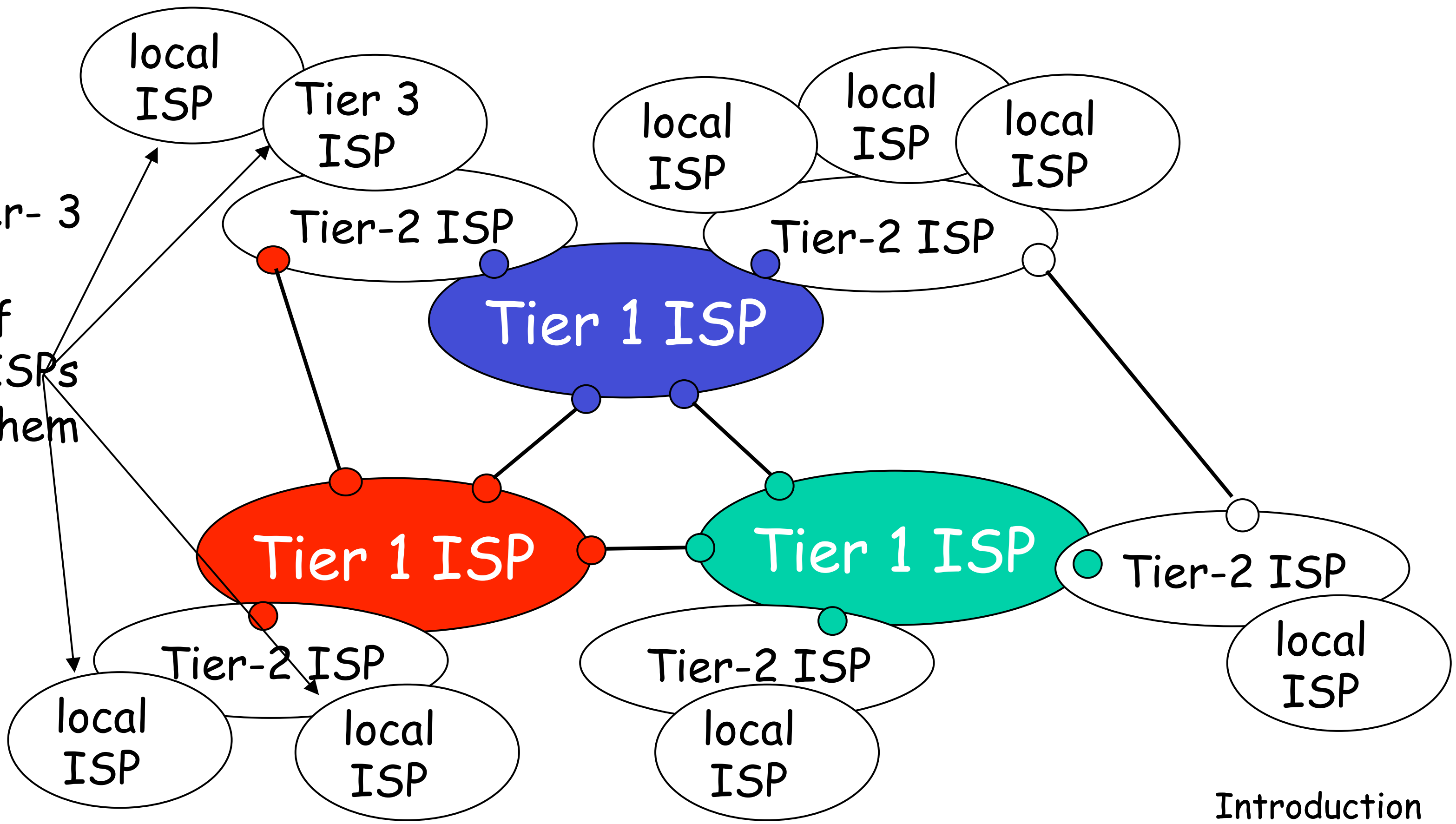


Tier-2 ISPs also peer privately with each other.

Internet structure: network of networks

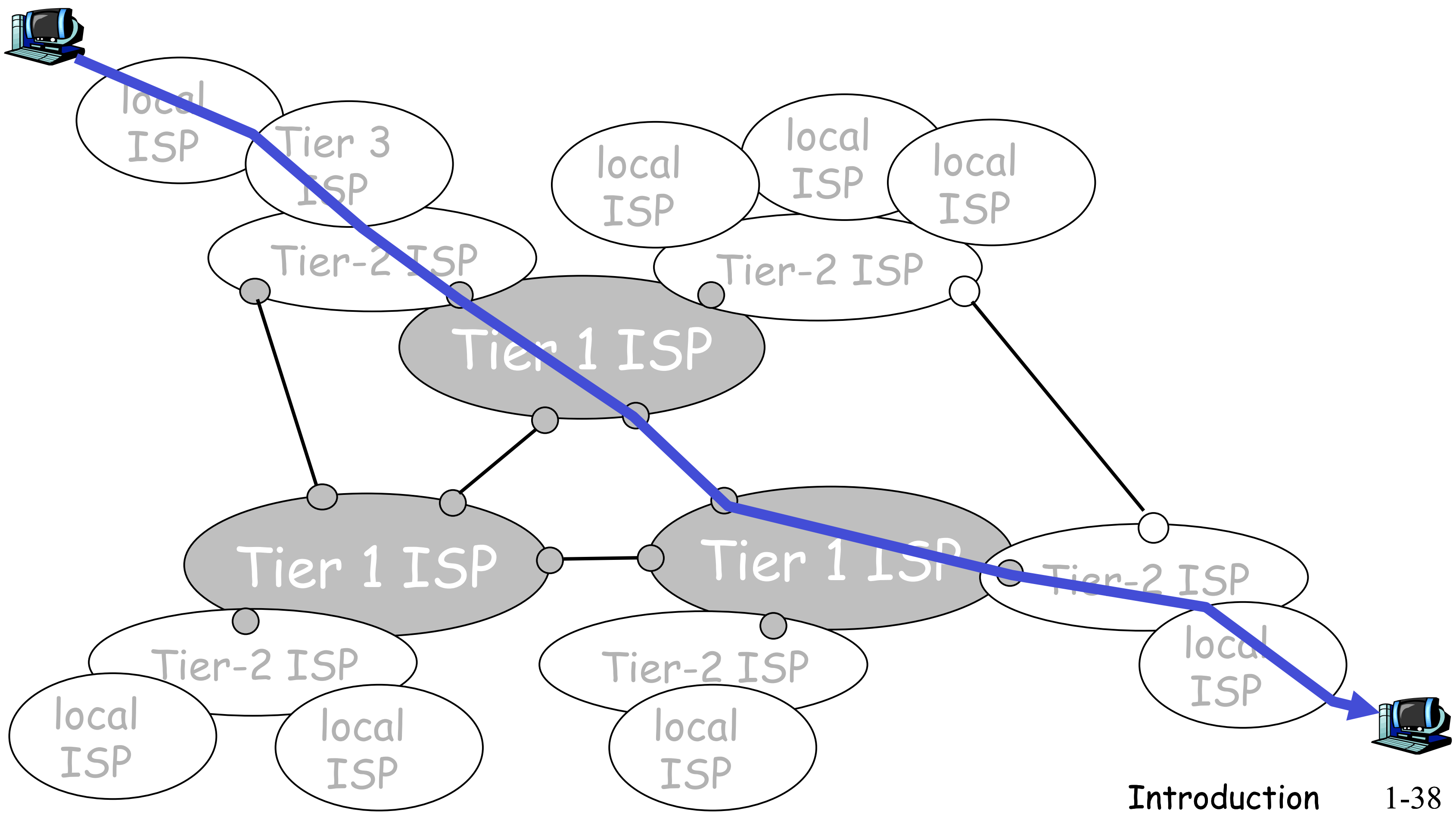
- "Tier-3" ISPs and local ISPs
  - last hop ("access") network (closest to end systems)

Local and tier- 3 ISPs are *customers* of higher tier ISPs connecting them to rest of Internet



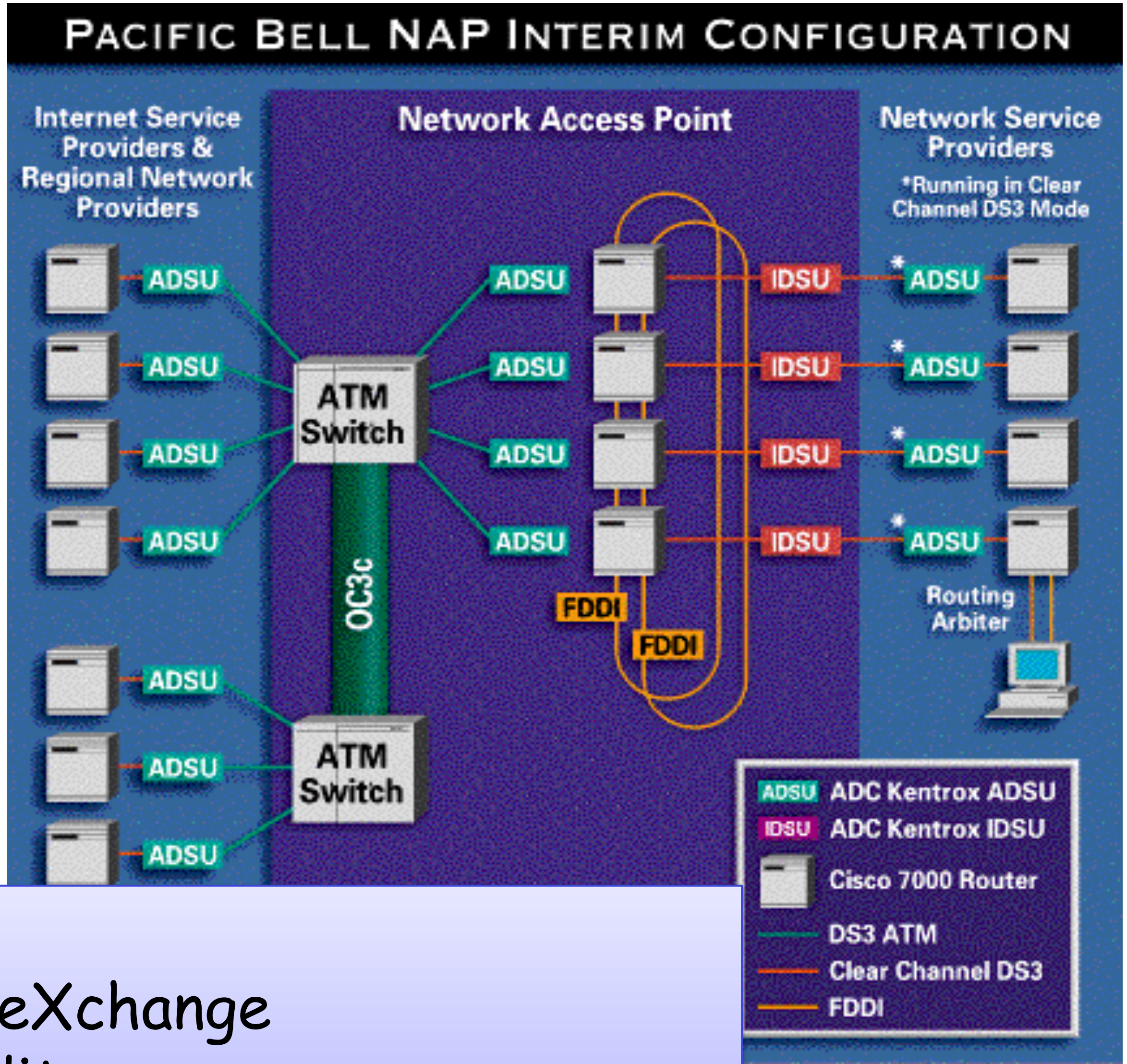
Internet structure: network of networks

- a packet passes through many networks!



A NAP: just another router...?

Pacific Bell S. Francisco NAP



In Italia:
- MIX Milan Internet eXchange
- NaMeX Nautilus Mediterranean Exchange Point

Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

1.3 Network core

1.4 Network access and physical media

1.5 Internet structure and ISPs

1.6 Delay & loss in packet-switched networks

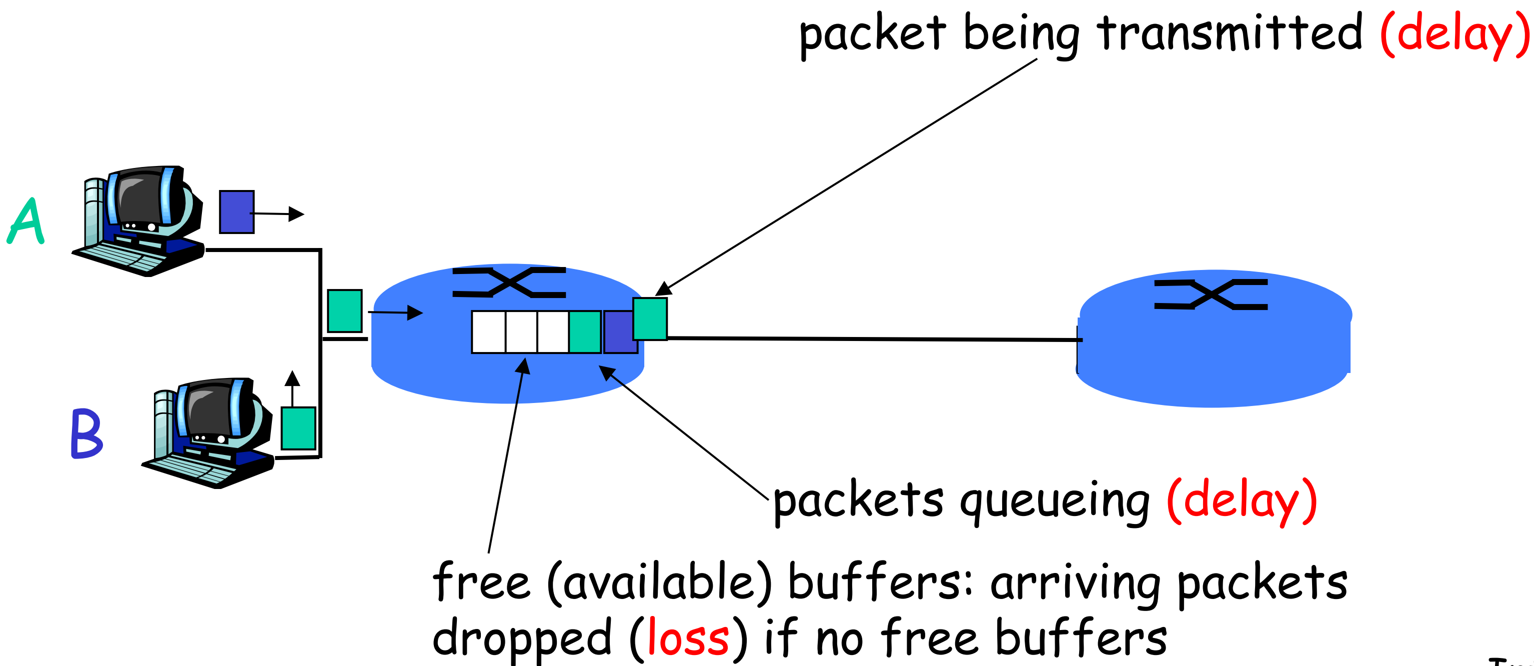
1.7 Protocol layers, service models

1.8 History

How do loss and delay occur?

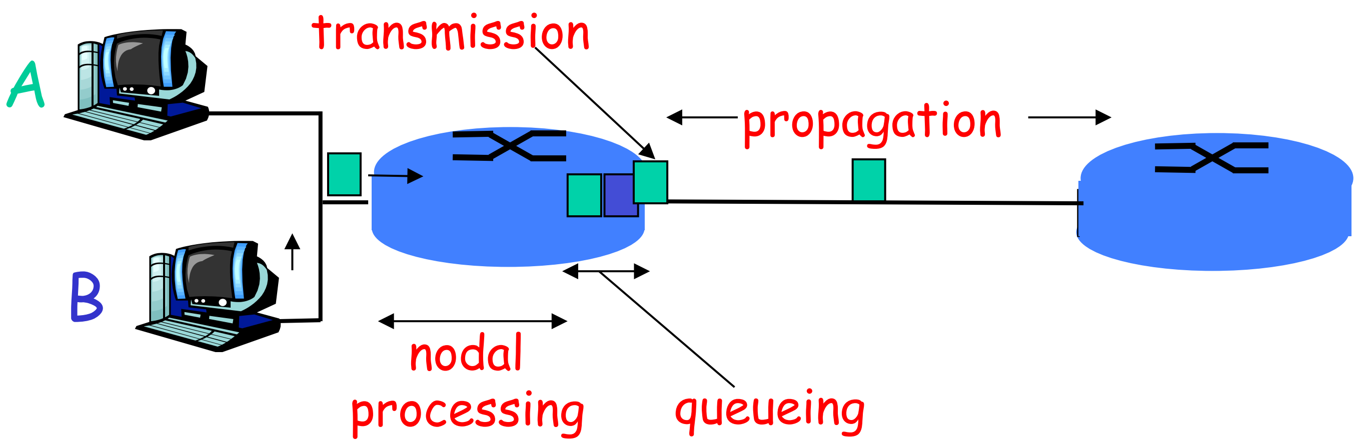
packets *queue* in router buffers

- packet arrival rate to link exceeds output link capacity
- packets queue, wait for turn



Four sources of packet delay

- 1. nodal processing:
  - check bit errors
  - determine output link
- 2. queueing
  - time waiting at output link for transmission
  - depends on congestion level of router



Delay in packet-switched networks

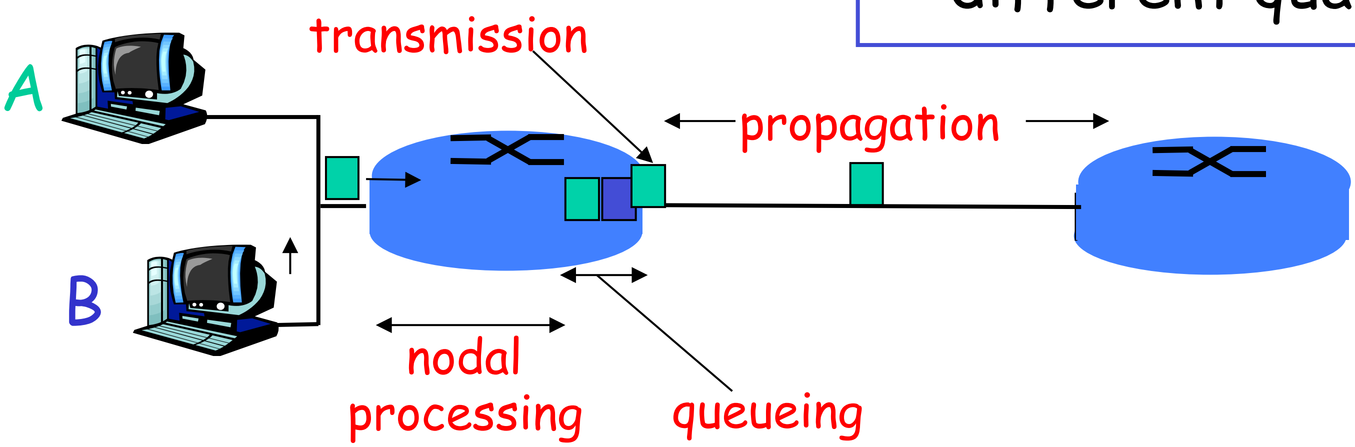
3. Transmission delay:

- R=link bandwidth (bps)
- L=packet length (bits)
- time to send bits into link = L/R

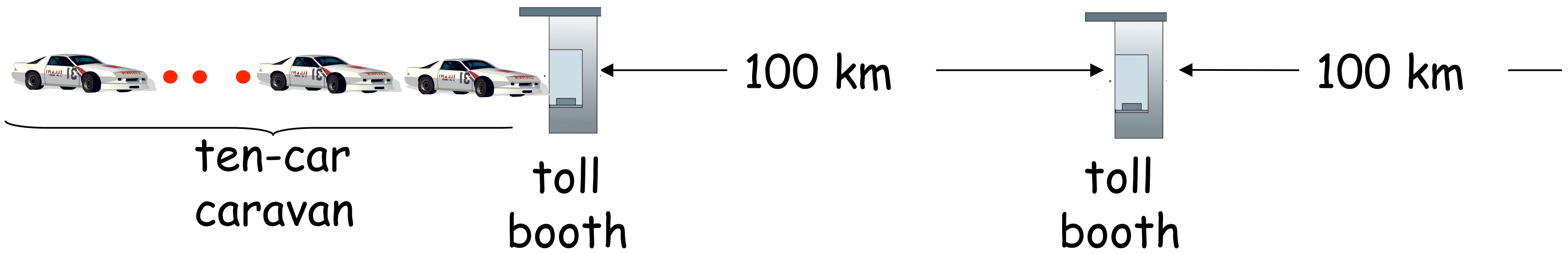
4. Propagation delay:

- d = length of physical link
- s = propagation speed in medium (~2×10^8 m/sec)
- propagation delay = d/s

Note: s and R are *very* different quantities!

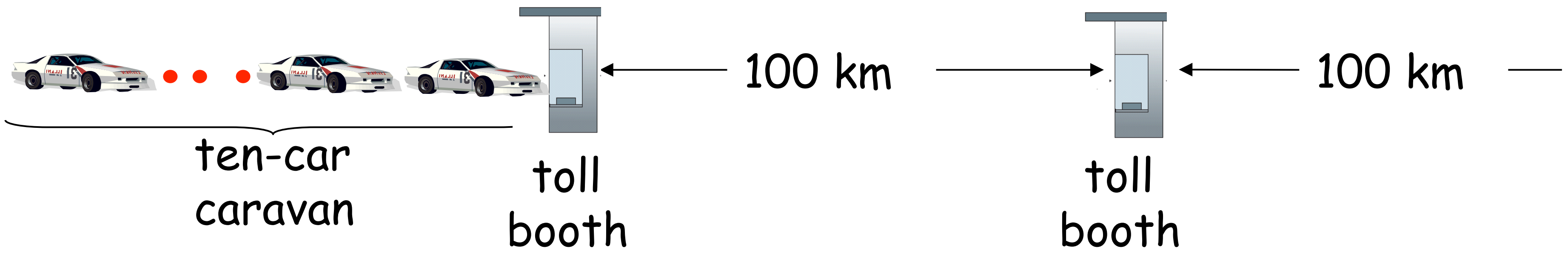


Caravan analogy



- cars "propagate" at 100 km/hr
- toll booth takes 12 sec to service car (transmission time)
- car~bit; caravan ~ packet
- Q: How long until caravan is lined up before 2nd toll booth?
- Time to "push" entire caravan through toll booth onto highway = 12*10 = 120 sec
- Time for last car to propagate from 1st to 2nd toll both: 100km/(100km/hr)= 1 hr
- A: 62 minutes

Caravan analogy (more)



- Cars now "propagate" at 1000 km/hr
- Toll booth now takes 1 min to service a car
- Q: Will cars arrive to 2nd booth before all cars serviced at 1st booth?

- Yes! After 7 min, 1st car at 2nd booth and 3 cars still at 1st booth.
- 1st bit of packet can arrive at 2nd router before packet is fully transmitted at 1st router!
    - See Ethernet applet at AWL Web site

Nodal delay

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

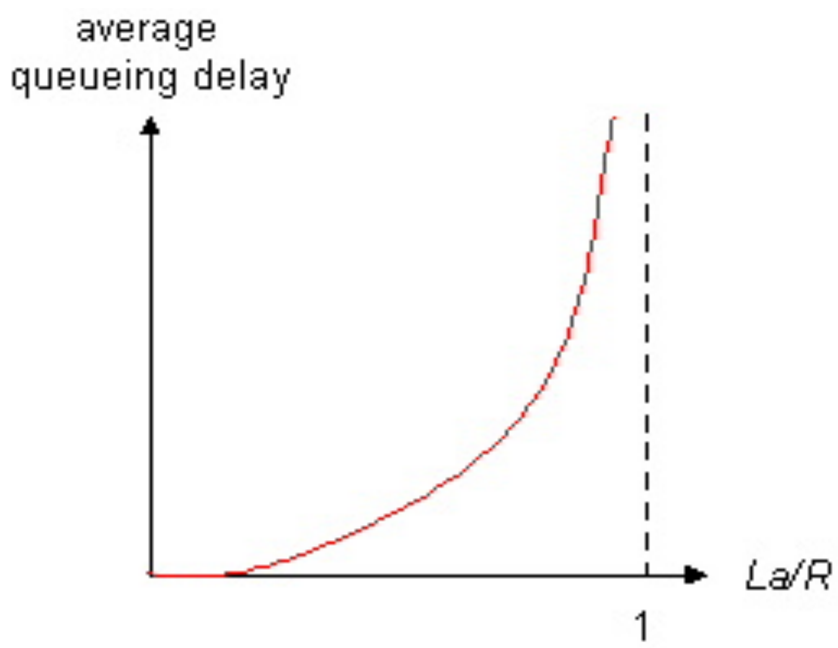
- d_{proc} = processing delay
  - typically a few microsecs or less
- d_{queue} = queuing delay
  - depends on congestion
- d_{trans} = transmission delay
  - = L/R, significant for low-speed links
- d_{prop} = propagation delay
  - a few microsecs to hundreds of msecs

Delay for each hop!!!

Queueing delay (revisited)

- R=link bandwidth (bps)
- L=packet length (bits)
- a=average packet arrival rate

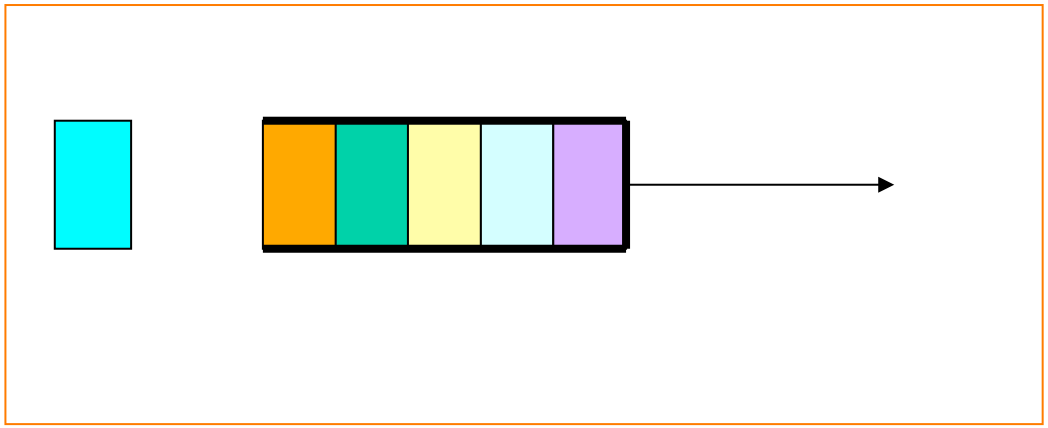
traffic intensity = La/R

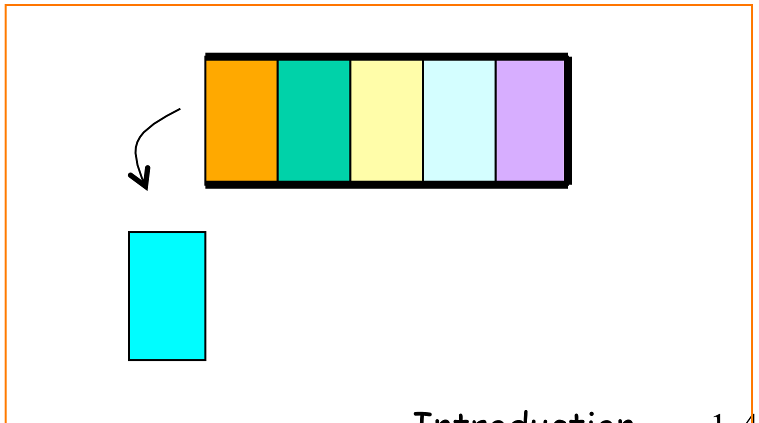


- La/R ~ 0: average queueing delay small
- La/R -> 1: delays become large
- La/R > 1: more "work" arriving than can be serviced, average delay infinite!

Packet loss

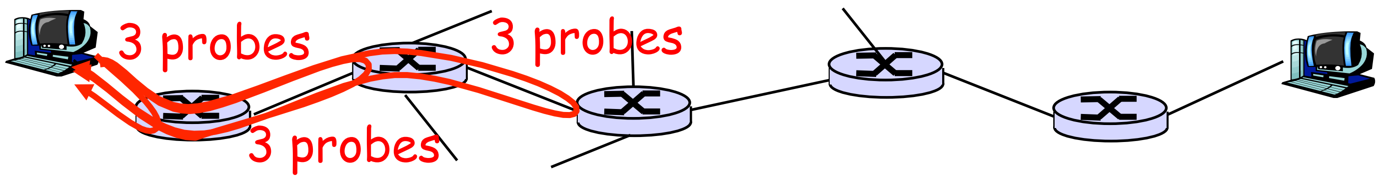
- queue (→buffer) preceding link in buffer has finite capacity
- when packet arrives to full queue, packet is dropped (→lost)
- lost packet may be retransmitted by previous node, by source end system, or not retransmitted at all





"Real" Internet delays and routes

- What do "real" Internet delay & loss look like?
- Trace route program: provides delay measurement from source to router along end-end Internet path towards destination. For all *i:*
  - sends three packets that will reach router *i* on path towards destination
  - router *i* will return packets to sender
  - sender times interval between transmission and reply.



"Real" Internet delays and routes

traceroute: gaia.cs.umass.edu to www.eurecom.fr

Three delay measements from gaia.cs.umass.edu to cs-gw.cs.umass.edu

1 cs-gw (128.119.240.254) 1 ms 1 ms 2 ms
2 border1-rt-fa5-1-0.gw.umass.edu (128.119.3.145) 1 ms 1 ms 2 ms
3 cht-vbns.gw.umass.edu (128.119.3.130) 6 ms 5 ms 5 ms
4 jn1-at1-0-0-19.wor.vbns.net (204.147.132.129) 16 ms 11 ms 13 ms
5 jn1-so7-0-0-0.wae.vbns.net (204.147.136.136) 21 ms 18 ms 18 ms
6 abilene-vbns.abilene.ucaid.edu (198.32.11.9) 22 ms 18 ms 22 ms
7 nycm-wash.abilene.ucaid.edu (198.32.8.46) 22 ms 22 ms 22 ms
8 62.40.103.253 (62.40.103.253) 104 ms 109 ms 106 ms
9 de2-1.de1.de.geant.net (62.40.96.129) 109 ms 102 ms 104 ms
10 de.fr1.fr.geant.net (62.40.96.50) 113 ms 121 ms 114 ms
11 renater-gw.fr1.fr.geant.net (62.40.103.54) 112 ms 114 ms 112 ms
12 nio-n2.cssi.renater.fr (193.51.206.13) 111 ms 114 ms 116 ms
13 nice.cssi.renater.fr (195.220.98.102) 123 ms 125 ms 124 ms
14 r3t2-nice.cssi.renater.fr (195.220.98.110) 126 ms 126 ms 124 ms
15 eurecom-valbonne.r3t2.ft.net (193.48.50.54) 135 ms 128 ms 133 ms
16 194.214.211.25 (194.214.211.25) 126 ms 128 ms 126 ms
17 * * *
18 * * *
19 fantasia.eurecom.fr (193.55.113.142) 132 ms 128 ms 136 ms

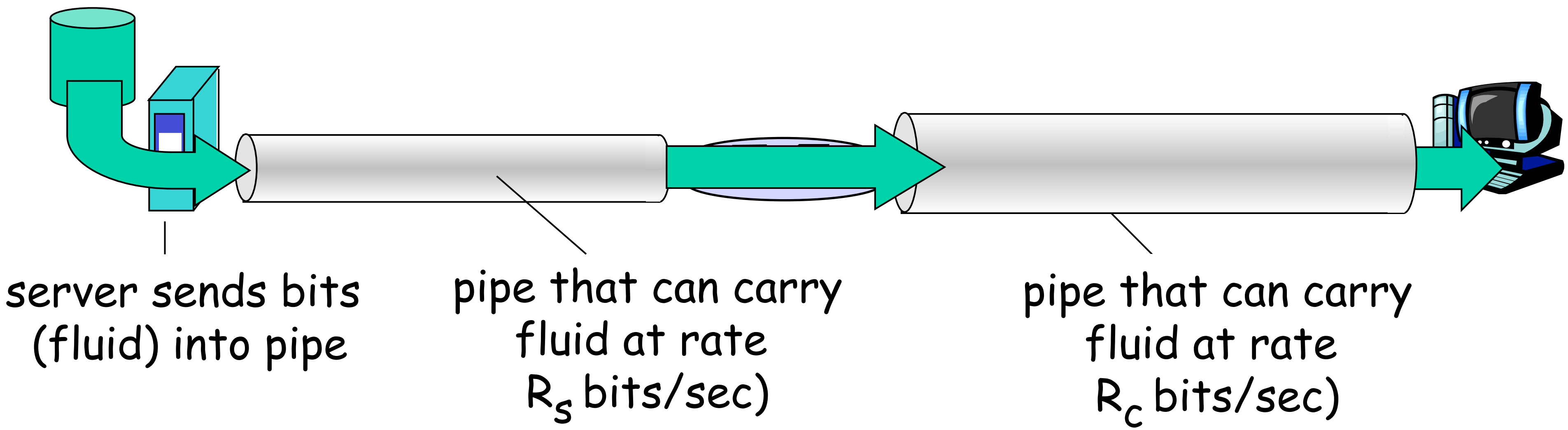
trans-oceanic link

* means no reponse (probe lost, router not replying)

Name and address of router, round trip delays (3 samples)

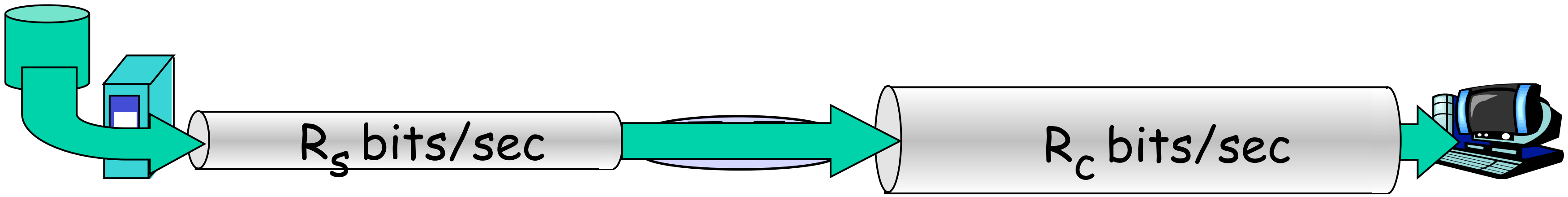
Throughput

- *throughput:* rate (bits/time unit) at which bits transferred between sender/receiver
  - *instantaneous:* rate at given point in time
  - *average:* rate over longer period of time

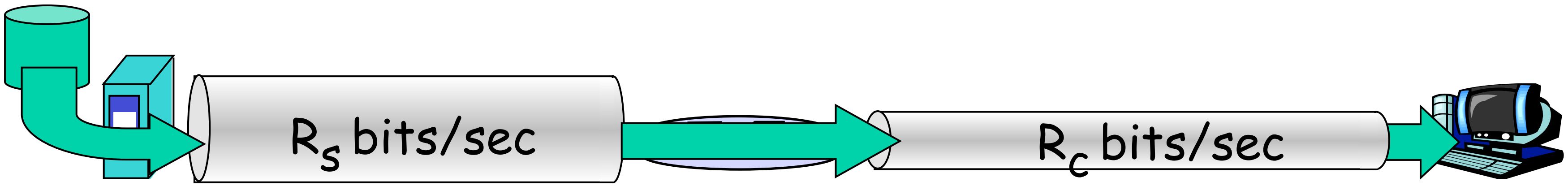


Throughput (more)

- $R_s < R_c$ What is average end-end throughput?



- $R_s > R_c$ What is average end-end throughput?

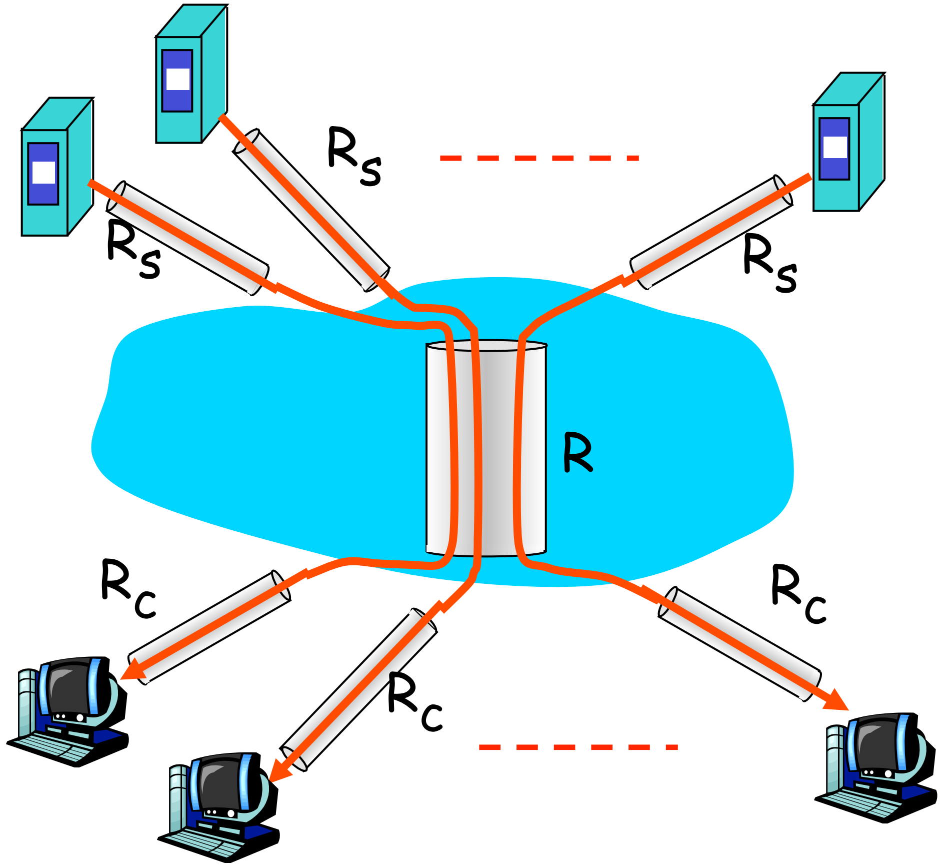


bottleneck link

link on end-end path that constrains end-end throughput

Throughput: Internet scenario

- per-connection end-end throughput: $\min(R_c, R_s, R/10)$
- in practice: R_c or R_s is often bottleneck



10 connections (fairly) share backbone bottleneck link R bits/sec

Chapter 1: roadmap

Protocol "Layers"

Networks are complex!

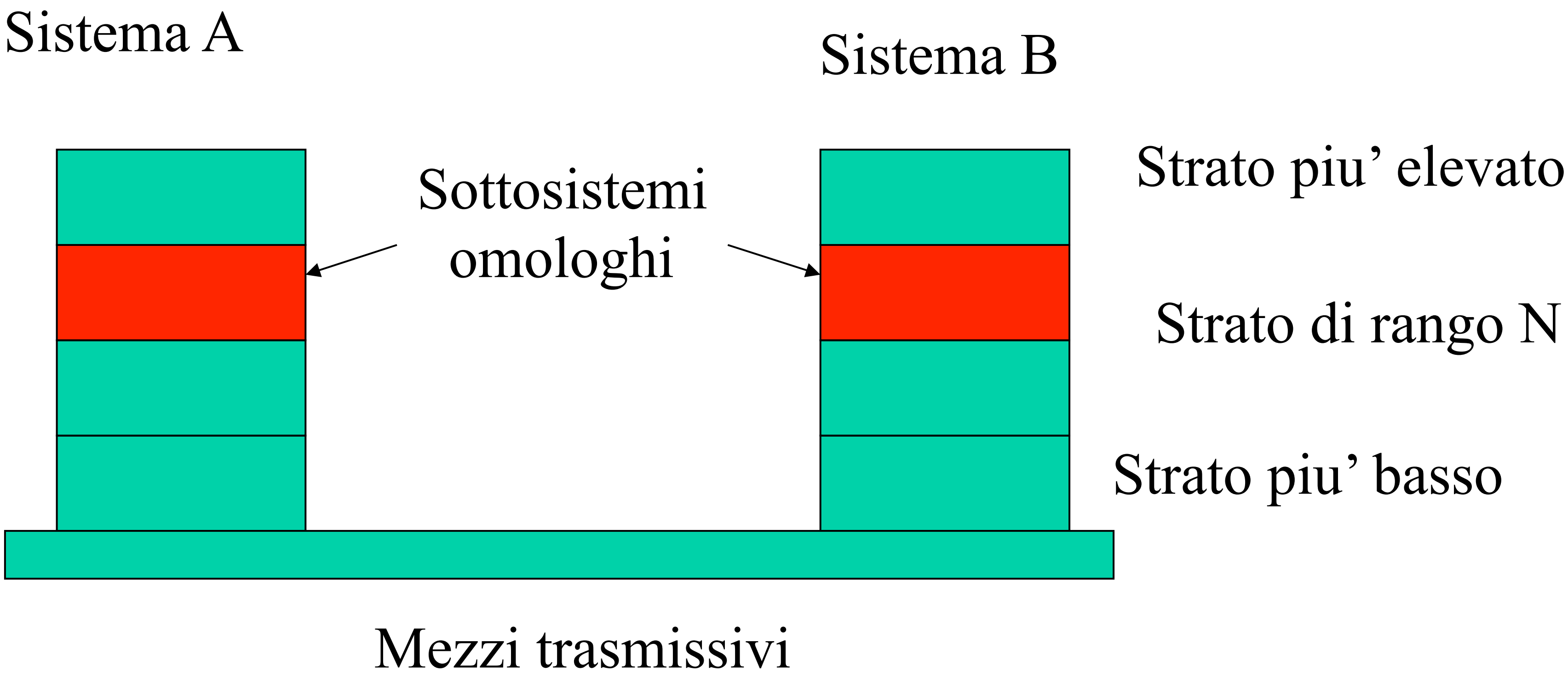
- many "pieces":
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

Question:

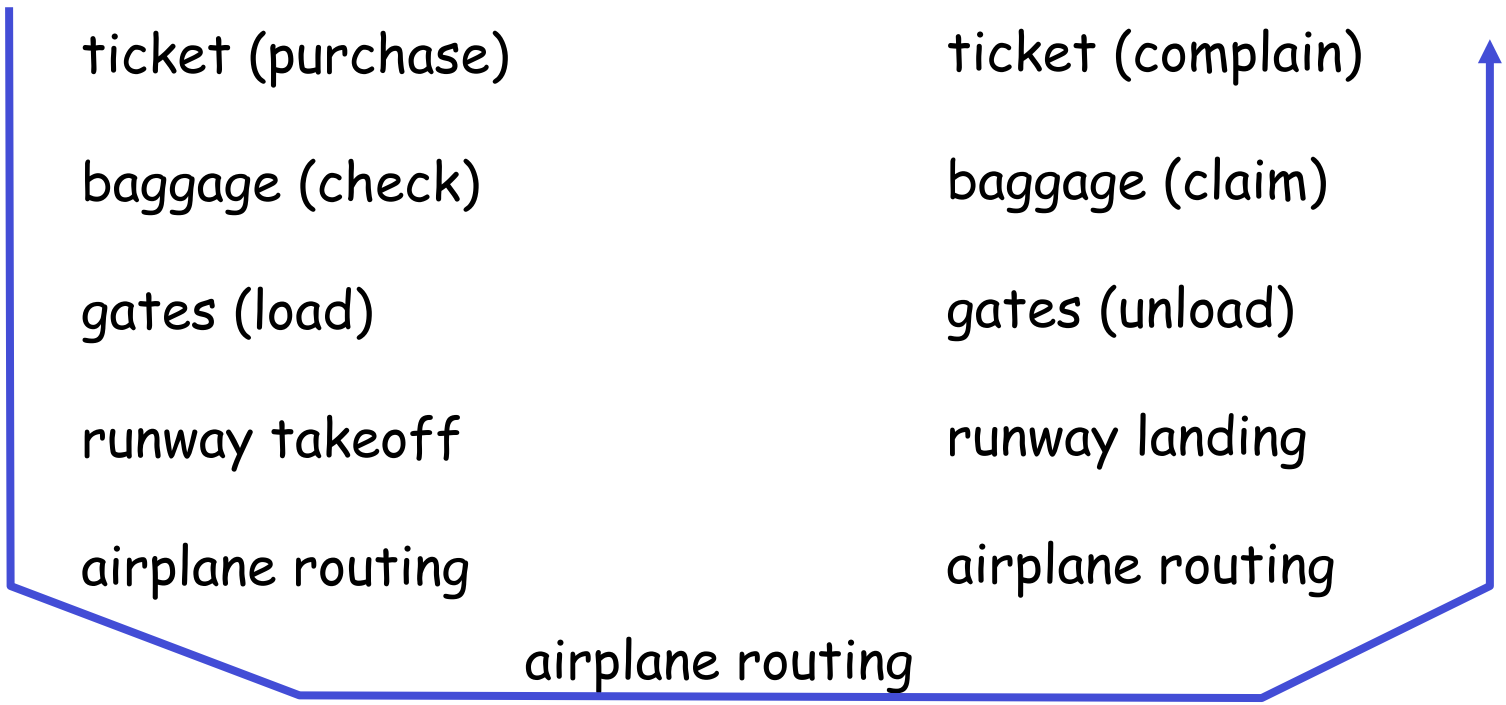
Is there any hope of *organizing* structure of network?

Or at least our discussion of networks?

Layering


Sistema A
Sistema B
Sottosistemi
omologhi
Strato piu' elevato
Strato di rango N
Strato piu' basso
Mezzi trasmissivi

Organization of air travel



- a series of steps

Organization of air travel: a different view

ticket (purchase)	ticket (complain)
baggage (check)	baggage (claim)
gates (load)	gates (unload)
runway takeoff	runway landing
airplane routing	airplane routing
airplane routing	

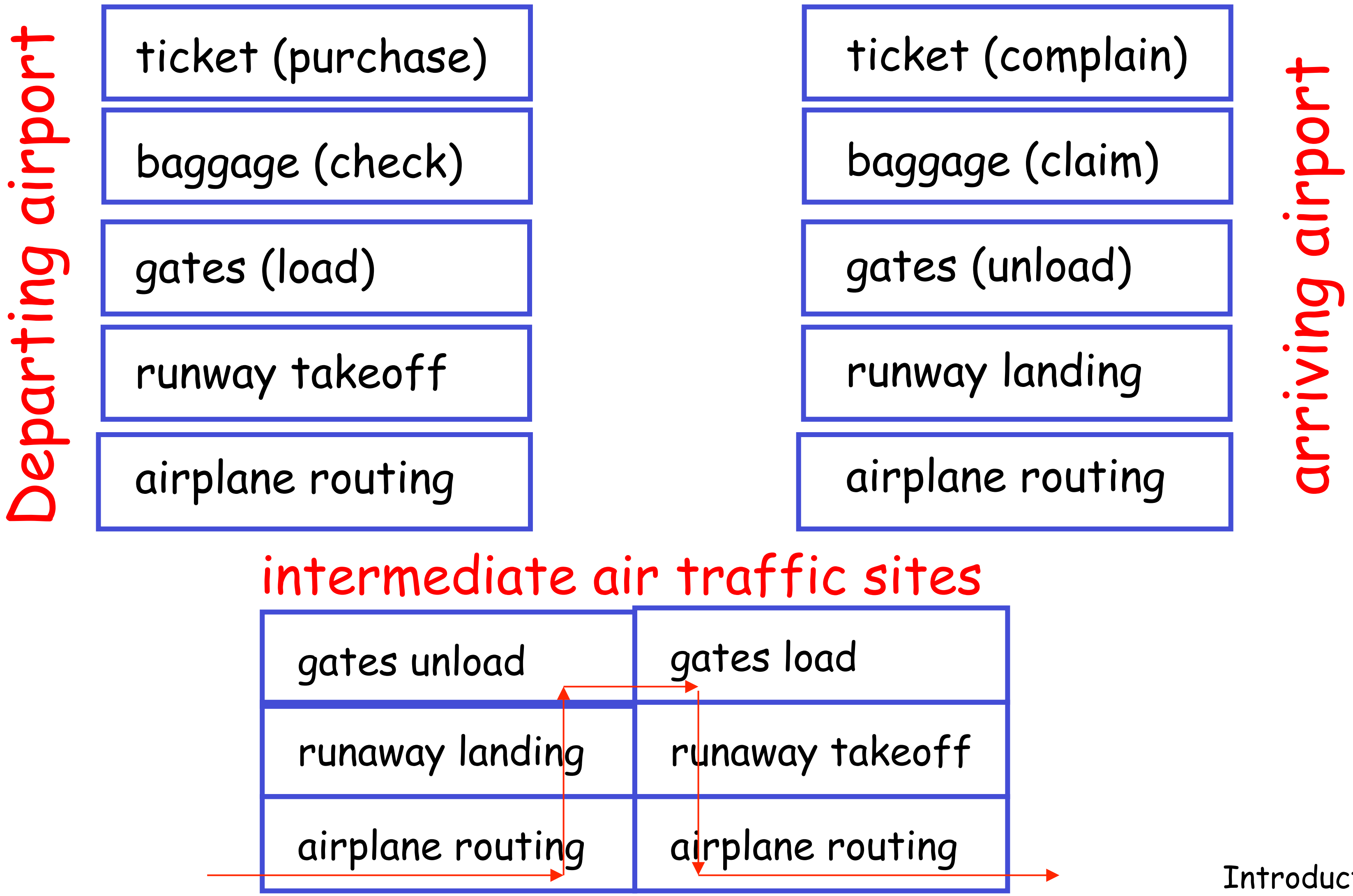
Layers: each layer implements a service

- via its own internal-layer actions
- relying on services provided by layer below

Layered air travel: services

Counter-to-counter delivery of person+bags
baggage-claim-to-baggage-claim delivery
people transfer: loading gate to arrival gate
runway-to-runway delivery of plane
airplane routing from source to destination

Distributed implementation of layer functionality



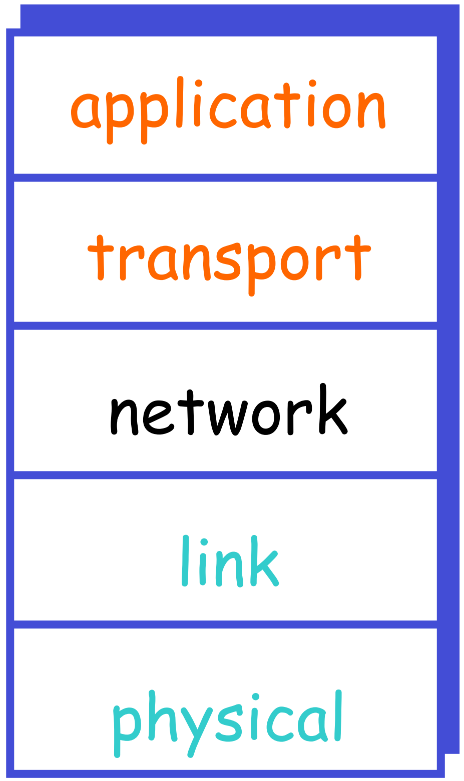
Why layering?

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered reference model for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system (I.e. if baggage check and claim procedures changed due to Sept 11th or if the boarding rules change, boarding people by age)
- layering considered harmful?

Internet protocol stack

- application: supporting network applications
  - FTP, SMTP, HTTP
- transport: host-host data transfer
  - TCP, UDP
- network: routing of datagrams from source to destination
  - IP, routing protocols
- link: data transfer between neighboring network elements
  - PPP, Ethernet, WiFi
- physical: bits “on the wire”

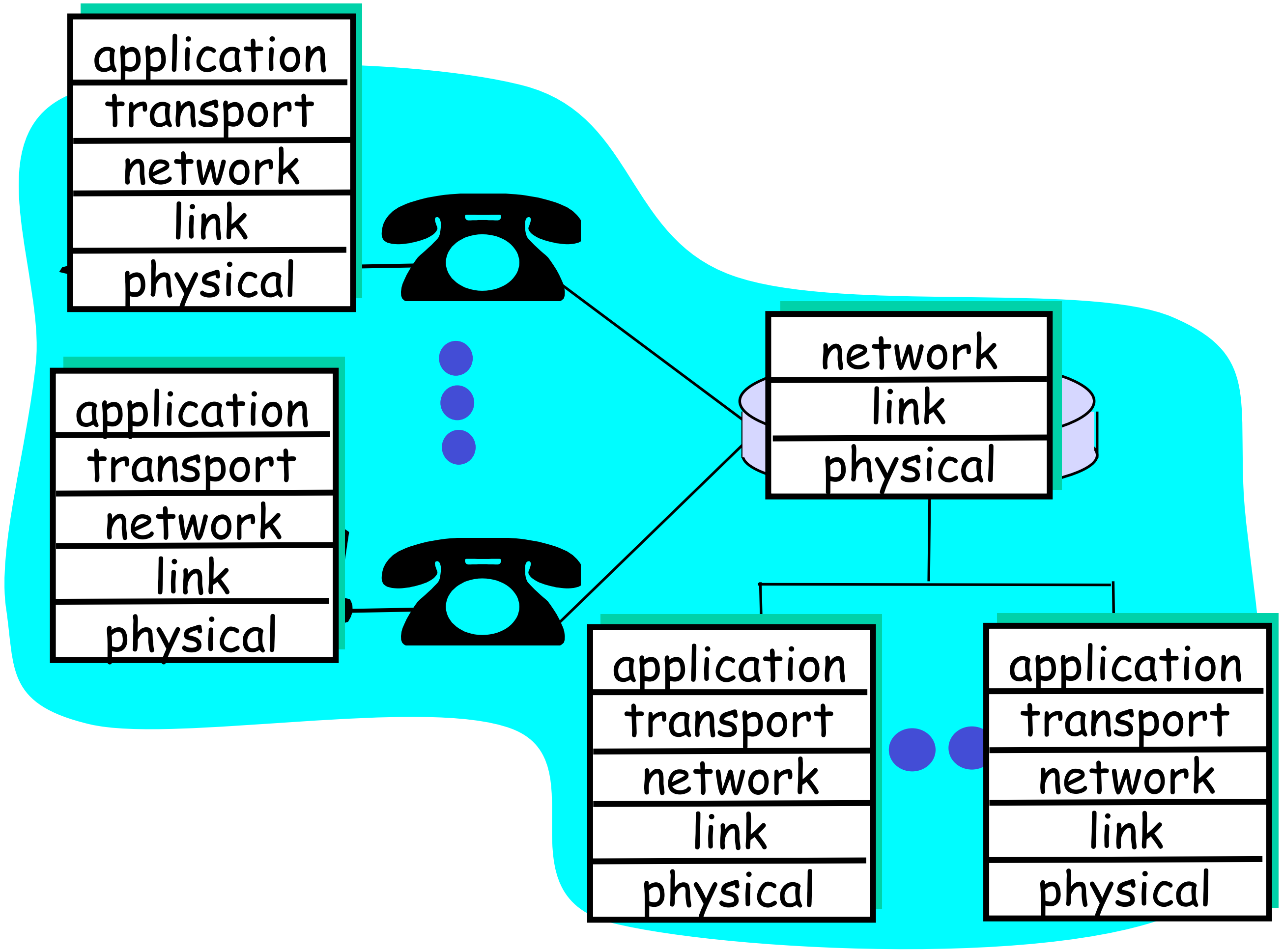


Typically in HW

Typically SW

Layering: logical communication

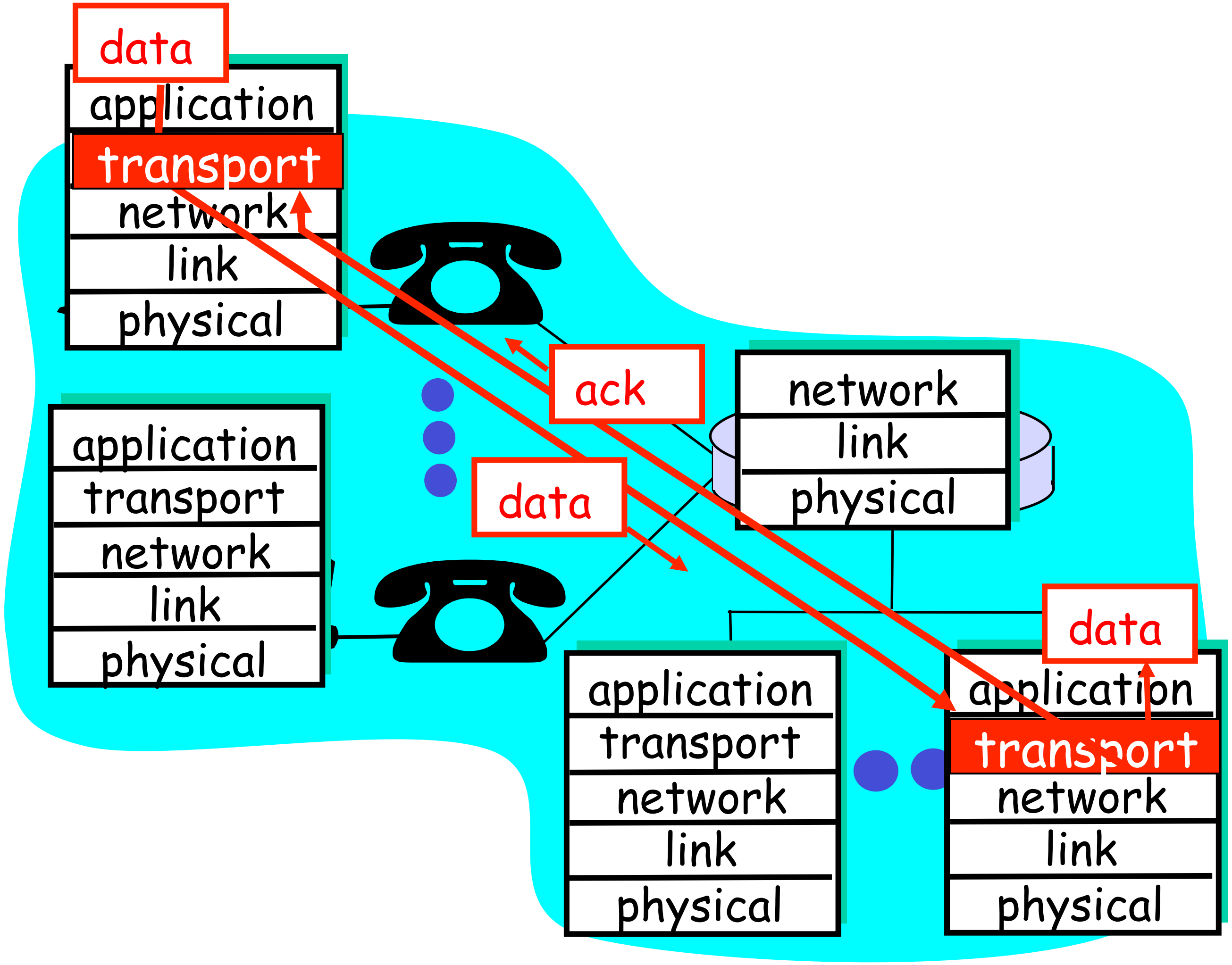
Each layer:
- distributed
- "entities" implement layer functions at each node
- entities perform actions, exchange messages with peers



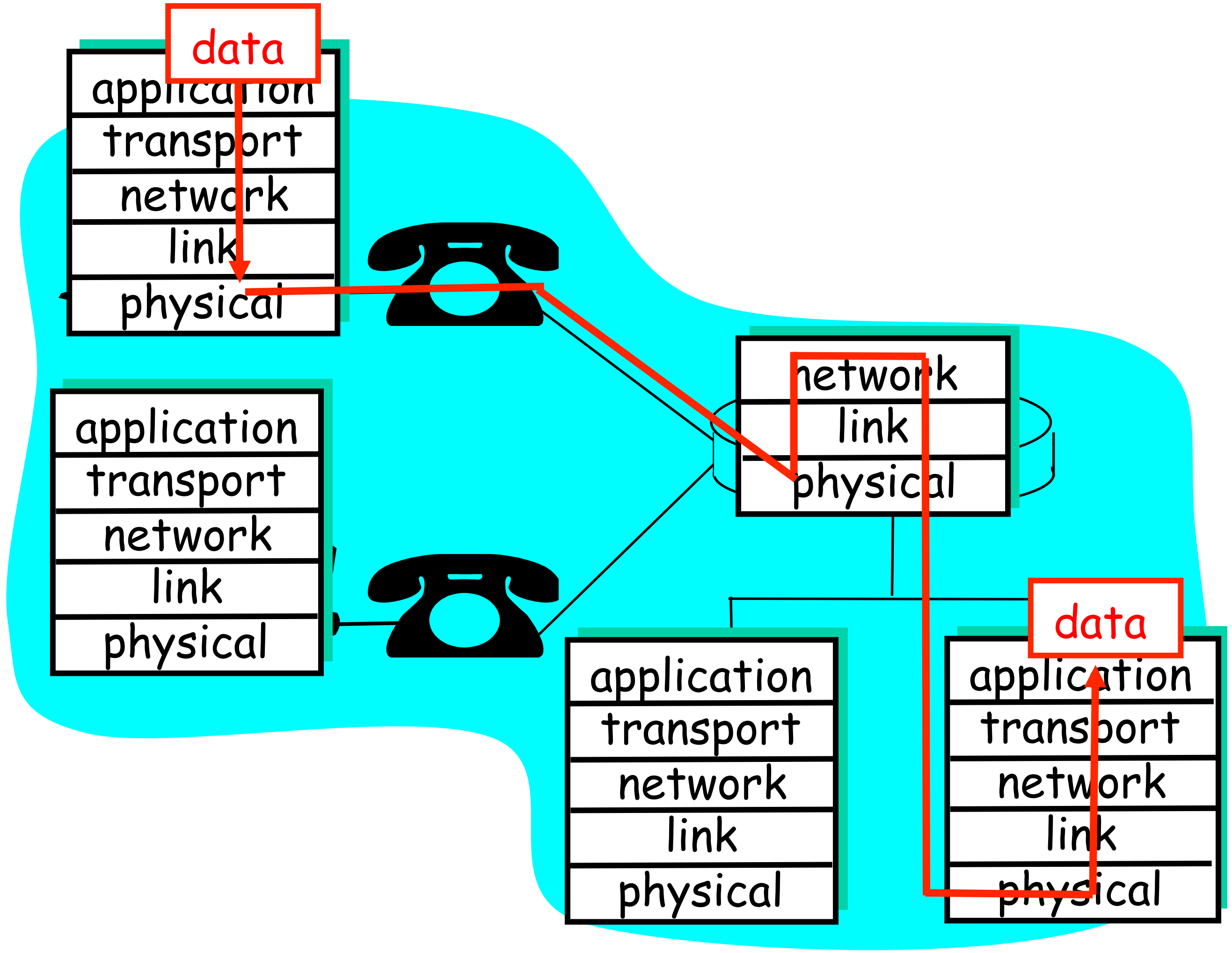
Layering: *logical* communication

E.g.: transport

- take data from app
- add addressing, reliability check info to form “datagram”
- send datagram to peer
- wait for peer to ack receipt
- analogy: post office



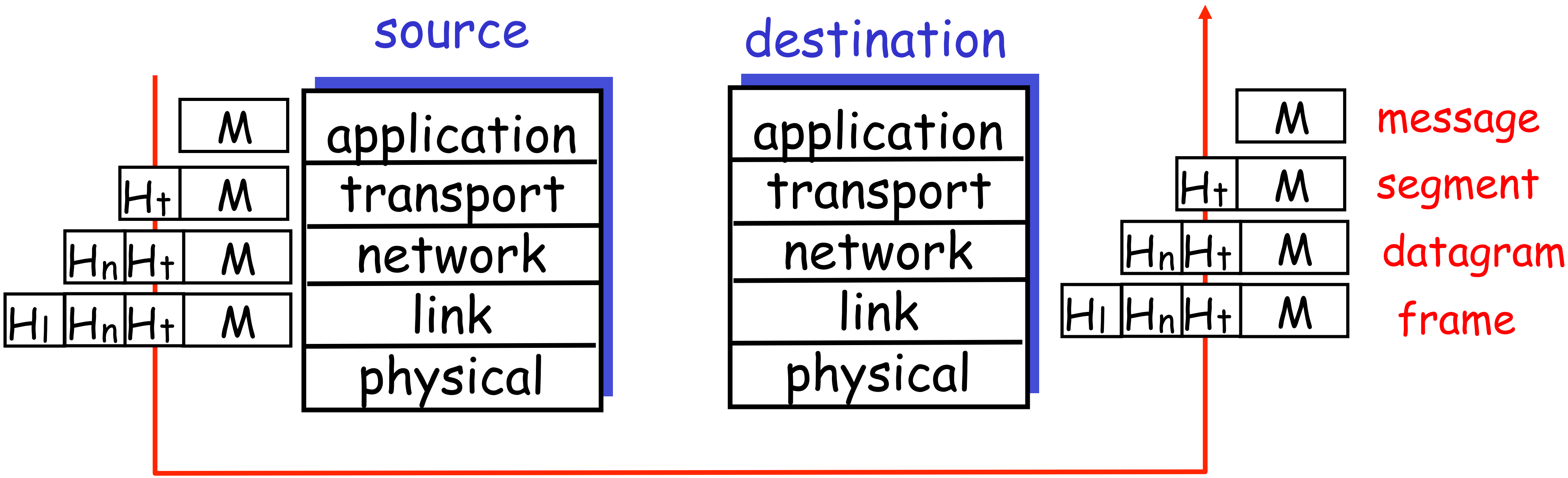
Layering: physical communication



Protocol layering and data

Each layer takes data from above

- adds header information to create new data unit
- passes new data unit to layer below



Layering: pros

- Vantaggi della stratificazione
  - Modularita'
    - Semplicita' di design
    - Possibilita' di modificare un modulo in modo trasparente se le interfacce con gli altri livelli rimangono le stesse
    - Possibilita' per ciascun costruttore di adottare la propria implementazione di un livello purche' requisiti su interfacce soddisfatti
  - Gestione dell'eterogeneita'
    - Possibili moduli 'diversi' per realizzare lo stesso insieme di funzioni, che riflettano l'eterogeneita' dei sistemi coinvolti (e.g. diverse tecnologie trasmissive, LAN, collegamenti punto-punto, ATM etc.)
    - Moduli distinti possibili/necessari anche se le reti adottassero tutte la stessa tecnologia di rete perche' ad esempio le applicazioni possono avere requisiti diversi (es. UDP e TCP). All'inizio TCP ed IP erano integrati. Perche' adesso sono su due livelli distinti?

Layering: cons

- Svantaggi della stratificazione
  - A volte modularita' inficia efficienza
  - A volte necessario scambio di informazioni tra livelli non adiacenti non rispettando principio della stratificazione

Chapter 1: roadmap

1.1 What *is* the Internet?

1.2 Network edge

1.3 Network core

1.4 Network access and physical media

1.5 ISPs and Internet backbones

1.6 Delay & loss in packet-switched networks

1.7 Internet structure and ISPs

1.8 History

Internet History

1961-1972: Early packet-switching principles

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching (MIT)
- 1964: Baran - packet-switching in military nets
- Davies at the National Physical Laboratory, UK was also developing ideas on packet switching
- 1967: ARPAnet conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational

Packet switches dubbed Interface Message Processors (IMP)

- 1972:
  - ARPAnet demonstrated publicly by Robert Kahn
  - NCP (Network Control Protocol) first host-host protocol
  - first e-mail program
  - ARPAnet has 15 nodes

- Leonard Kleinrock with first IMP

Kleinrock's students:
Vinton Cerf
John Postel…

Network measurement center UCLA

Internet History

1972-1980: Internetworking, new and proprietary nets

- 1970: ALOHAnet satellite network in Hawaii (Abramson)
- 1973: Metcalfe's PhD thesis proposes Ethernet
- 1974: Cerf and Kahn - architecture for interconnecting networks
- late70's: proprietary architectures, e.g. IBM SNA (Schwartz)
- late 70's: switching fixed length packets (ATM precursor)
- 1979: ARPAnet has 200 nodes

Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
- best effort service model
- stateless routers
- decentralized control

define today's Internet architecture

Internet History

1980-1990: new protocols, a proliferation of networks

- 1983: deployment of TCP/IP
- 1982: SMTP e-mail protocol defined
- 1983: DNS defined for name-to-IP-address translation
- 1985: FTP protocol defined
- 1988: TCP congestion control

- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

Internet History

1990, 2000's: commercialization, the Web, new apps

- Early 1990's: ARPAnet decommissioned
- 1991: NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- early 1990s: Web
  - hypertext [Bush 1945, Nelson 1960's]
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
  - late 1990's: commercialization of the Web

Late 1990's – 2000's:

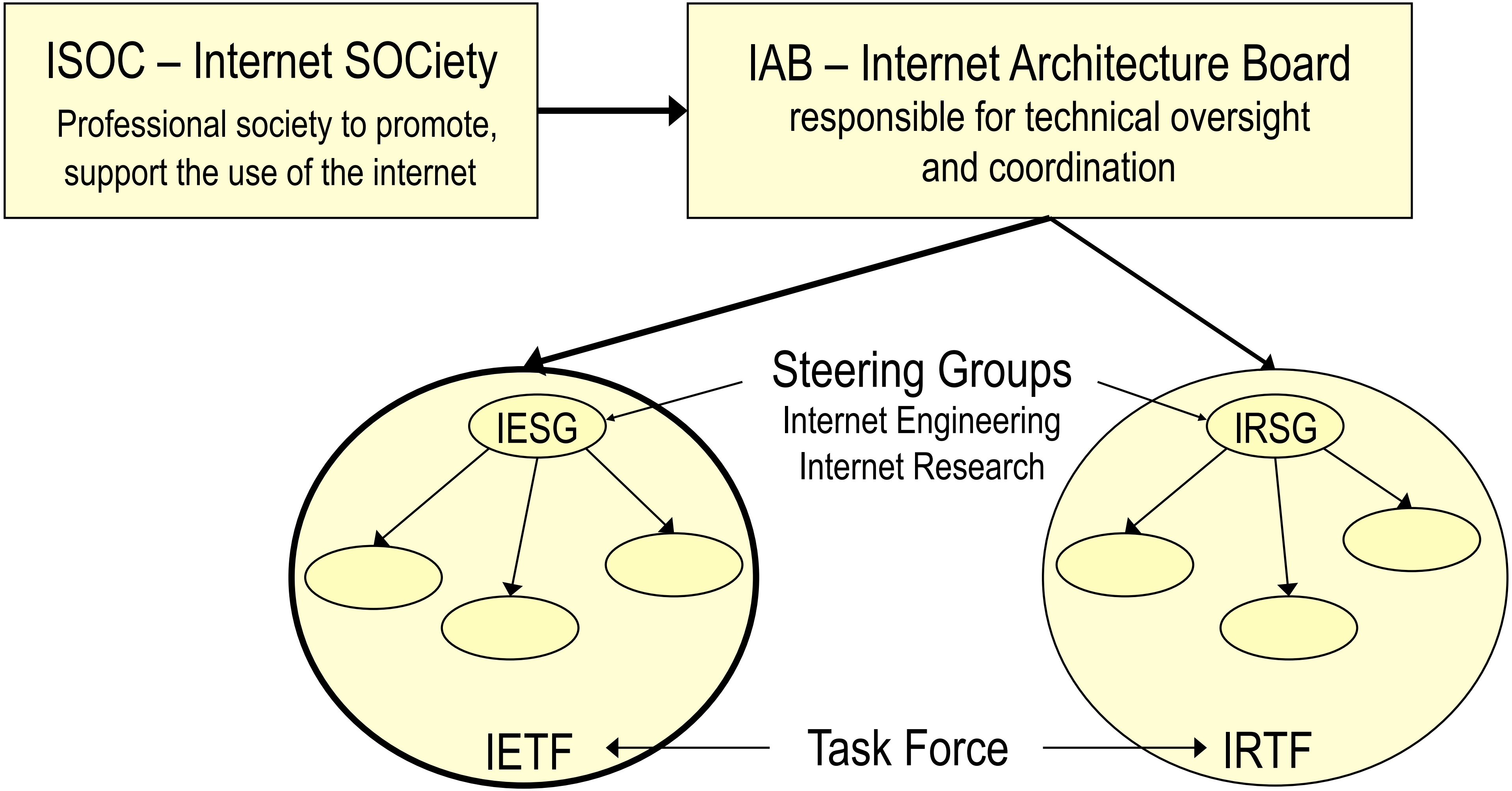
- more killer apps: instant messaging, peer2peer file sharing (e.g., Naptser)
- network security to forefront
- est. 50 million host, 100 million+ users
- backbone links running at Gbps

Significant late developments: P2P,broadband access, wireless Internet, Mobile access, change of traffic (multimedia, on line gaming)

A short digression: where is Internet standardized? Who controls the Internet?

- No single administrative organization
- IETF - Internet Engineering Task Force (since 86)
  - Developement of current protocols and specifications for standardization.
    - International community, open to everyone
    - Most of the work via mailing lists
    - Meets three times/year
  - organized in areas and working groups
    - Dynamically activated & deactivated on need
    - group coordination: IESG (Internet Engineering Steering Group). Area directors are members of the IESG. Responsible for the actions associated with entry into and movement along the Internet "standards track," including final approval of specifications as Internet Standards.
- Industry also preemptively determine standards

Technical Bodies Structure

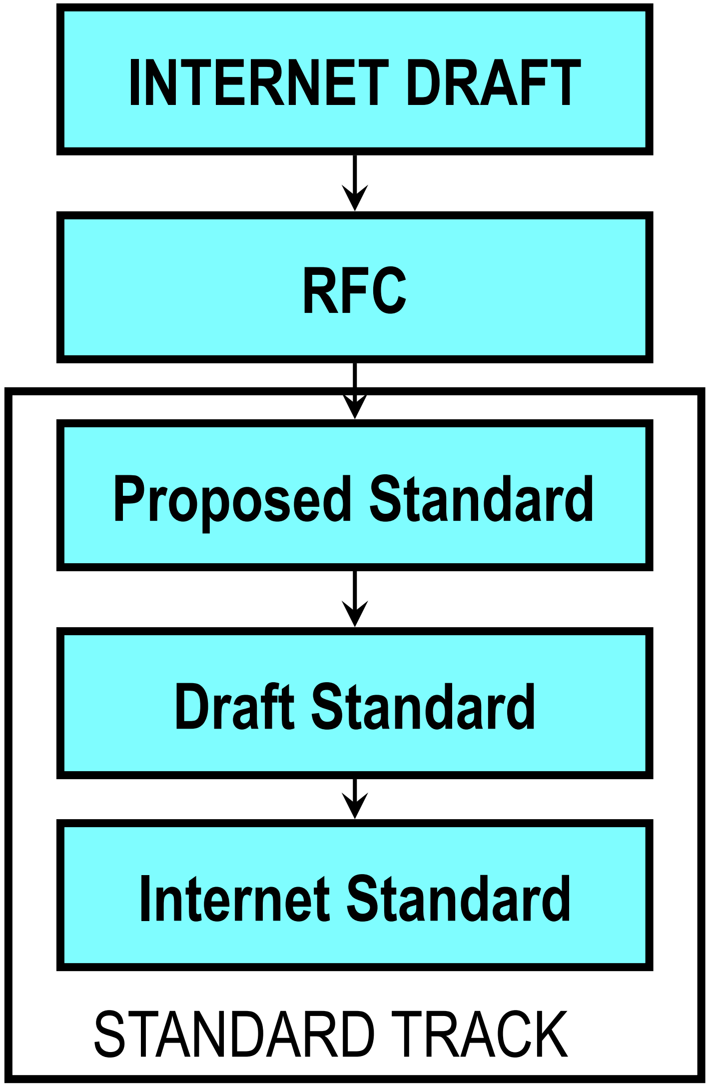


IETF credo

We reject kings, presidents and voting.
We believe in rough consensus
and running code

David Clark (MIT), 1992

Internet Standard Process



Draft version for information review and comments. 6 months lifetime

Official Internet publication: never expires

Entry level - protocol specification should be stable technically

At least 2 independent & interoperable implementations testing all spec. fcts

Have had significant field use and clear community interest in production use

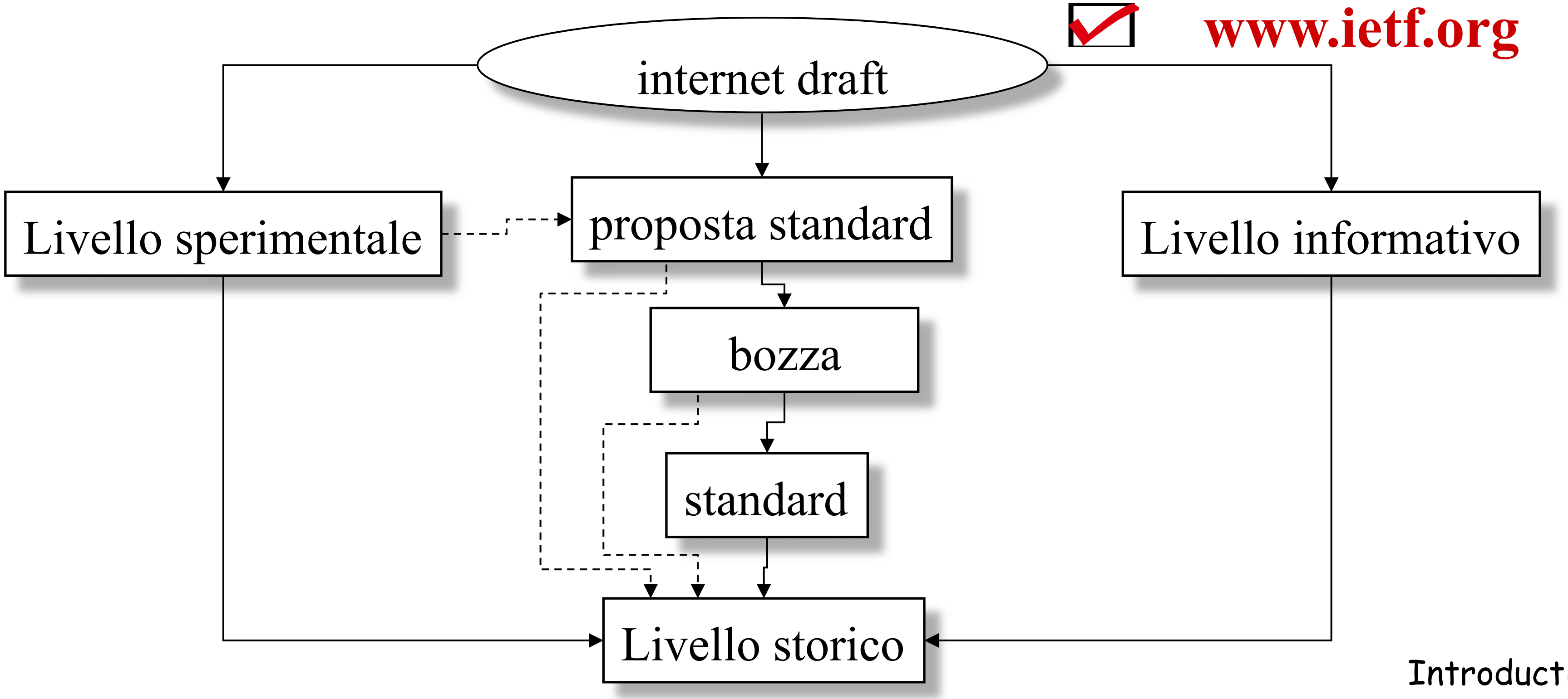
Non-Standard Track (the most common track!!)

- Specifications may not be intended to be an Internet standard
- Three labels
  - Informational
  - Experimental
  - Historic

Gli standard di Internet

- Gli standard di Internet sono documenti pubblici denominati RFC (Request For Comments)
- L'organismo che coordina la stesura degli RFC è l'IETF (Internet Engineering Task Force)

www.ietf.org



Internet Documents

- RFC - Request For Comments
  - RFC3000 in Nov 2000
  - Updated RFCs published with new numbers
  - Not all describe protocols
  - Not all used!
- BCP - Best Current Practice
- FYI - For Your Information
  - RFC subseries: FYI = no protocol specs (es. RFC1718: the Tao of the Internet)
- STD - STanDard
  - official Internet Standard

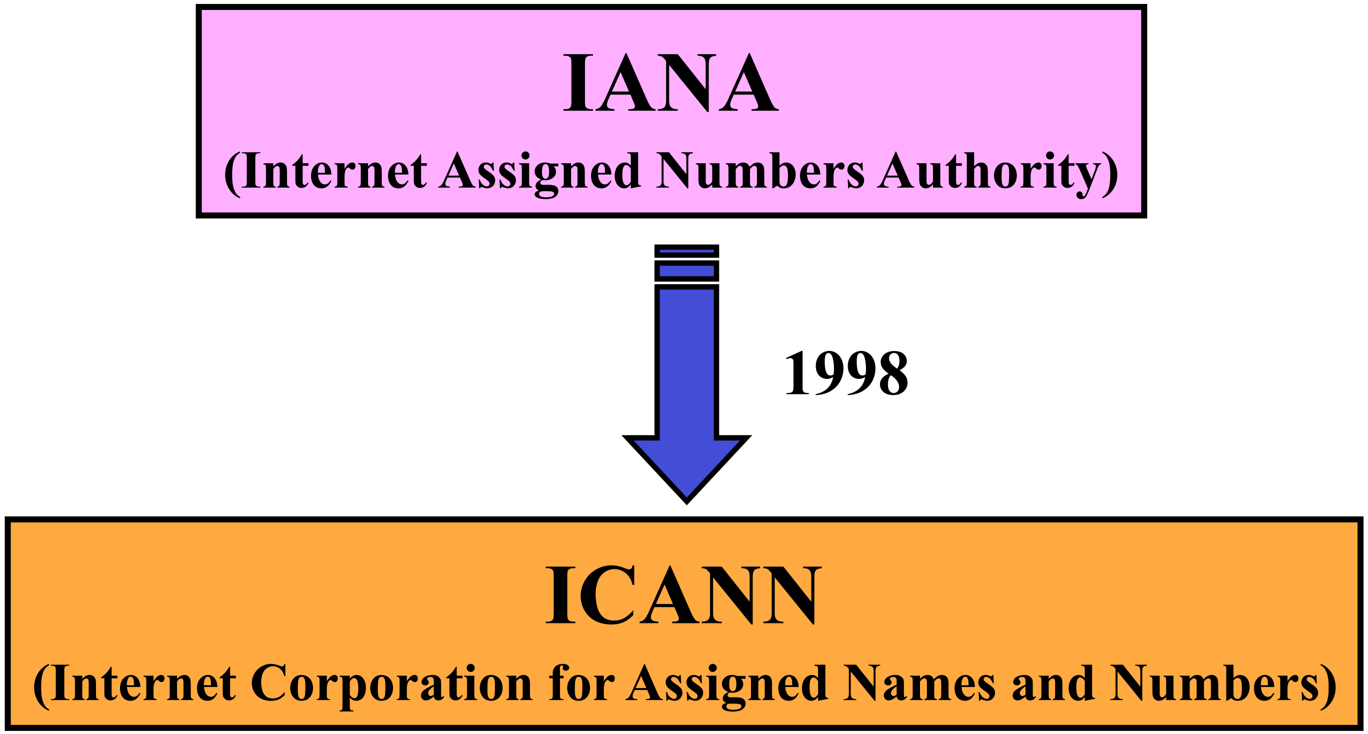
Important Documents

all RFCs from ftp://ds.internic.net/rfc
RFCs + IDs + WG: http://www.ietf.org

- RFC2300 (STD0001): Internet Official Protocol Standards (standardization process description)
- RFC1340 (STD0002): Assigned Numbers
- RFC1122 + RFC1123 (STD0003) Requirement for Internet hosts - communication layer (1122), Application and support (1123) (description of the TCP/IP architecture)

Indirizzi e nomi

- Gli indirizzi IP sono assegnati su base globale
- Internet fa uso anche di nomi simbolici che sono anch'essi assegnati su base globale



Internet and Intranets

- Internet is an interconnection of public networks based on the TCP/IP technology
  - everyone establishing a connection with an Internet Service Provider can access it
- The TCP/IP technology is used more and more often as the technology to build private networks (Intranets)
  - access controlled and restricted
  - may not have any Internet access
  - since nodes of the Intranets cannot be accessed from the outside world local addresses are used (and the same address can be re-used in different Intranets)

Introduction: Summary

Covered a "ton" of material!

- Internet overview
- what's a protocol?
- network edge, core, access network
  - packet-switching versus circuit-switching
- Internet/ISP structure
- performance: loss, delay
- layering and service models
- history

You now have:

- context, overview, "feel" of networking
- more depth, detail *to follow!*