

# Le reti dei calcolatori

Slides are mainly taken from

- *W.R. Stevens “Unix Network Programming” Prentice Hall, 1999*
- *Peterson – Davie “Computer Networks: A system approach” Morgan Kaufmann 2000*
- *Andrew Tanenbaum and David Wetherall, “Computer Networks”*
- *William Stallings “Operating Systems: Internals and Design Principles”, 8/E (Chapter 5).*

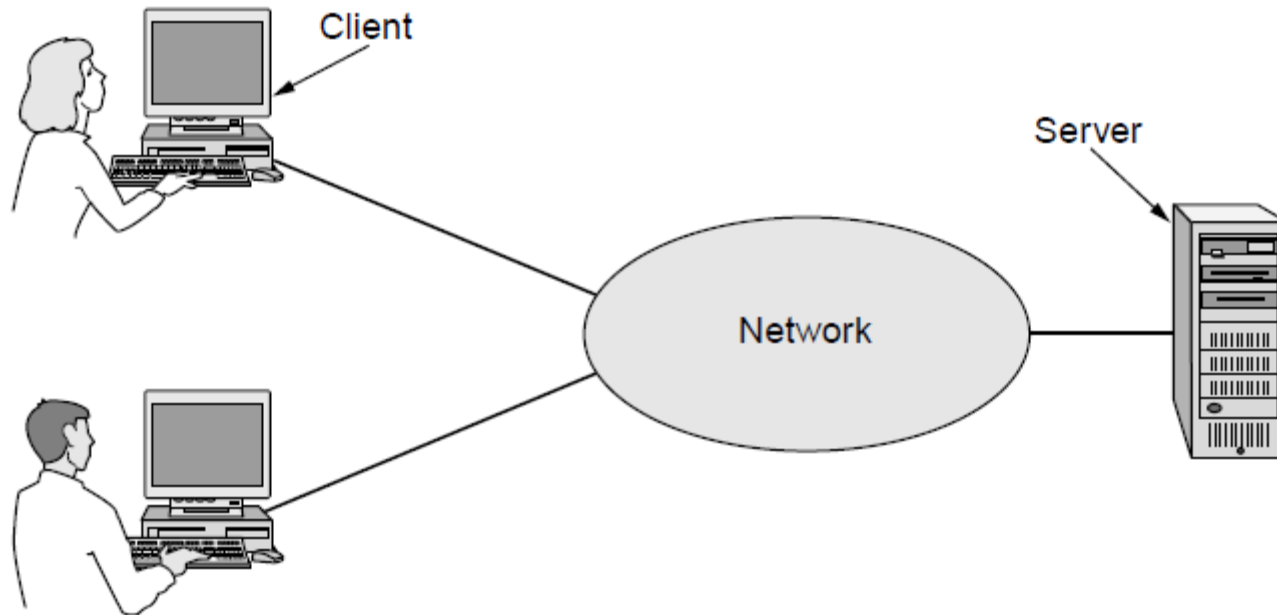
*Sistemi di Calcolo 2*

*Instructor: Riccardo Lazzeretti*

*Special thanks to: Daniele Cono D’Elia, Leonardo Aniello, Roberto Baldoni*

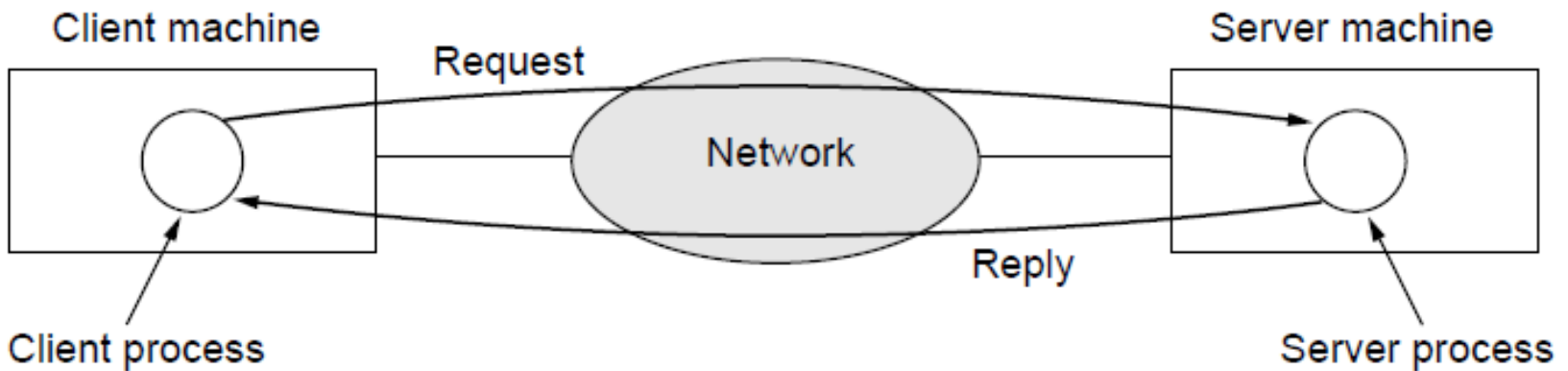
# Architettura di Internet

# Business Applications (1)

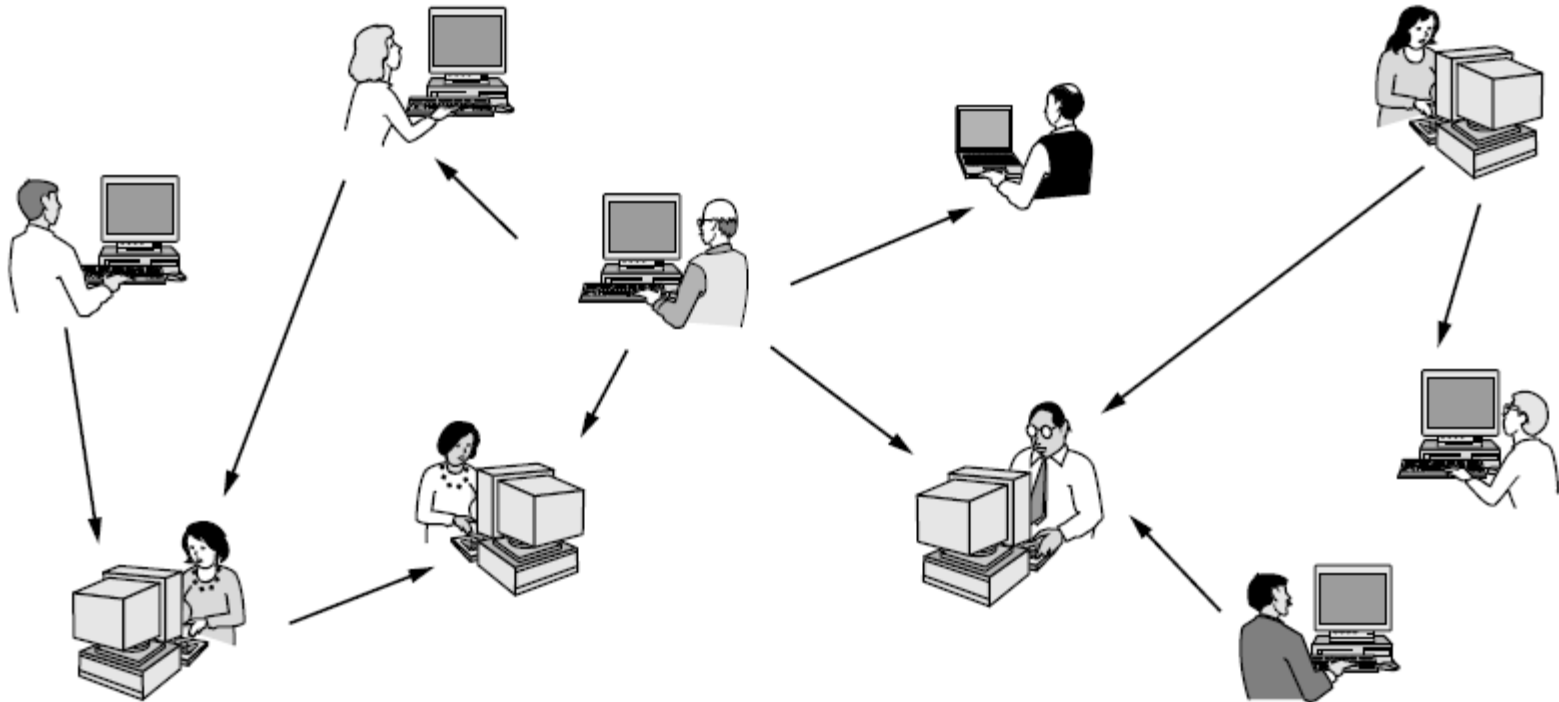


# Business Applications (2)

The client-server model involves requests and replies



# Home Applications

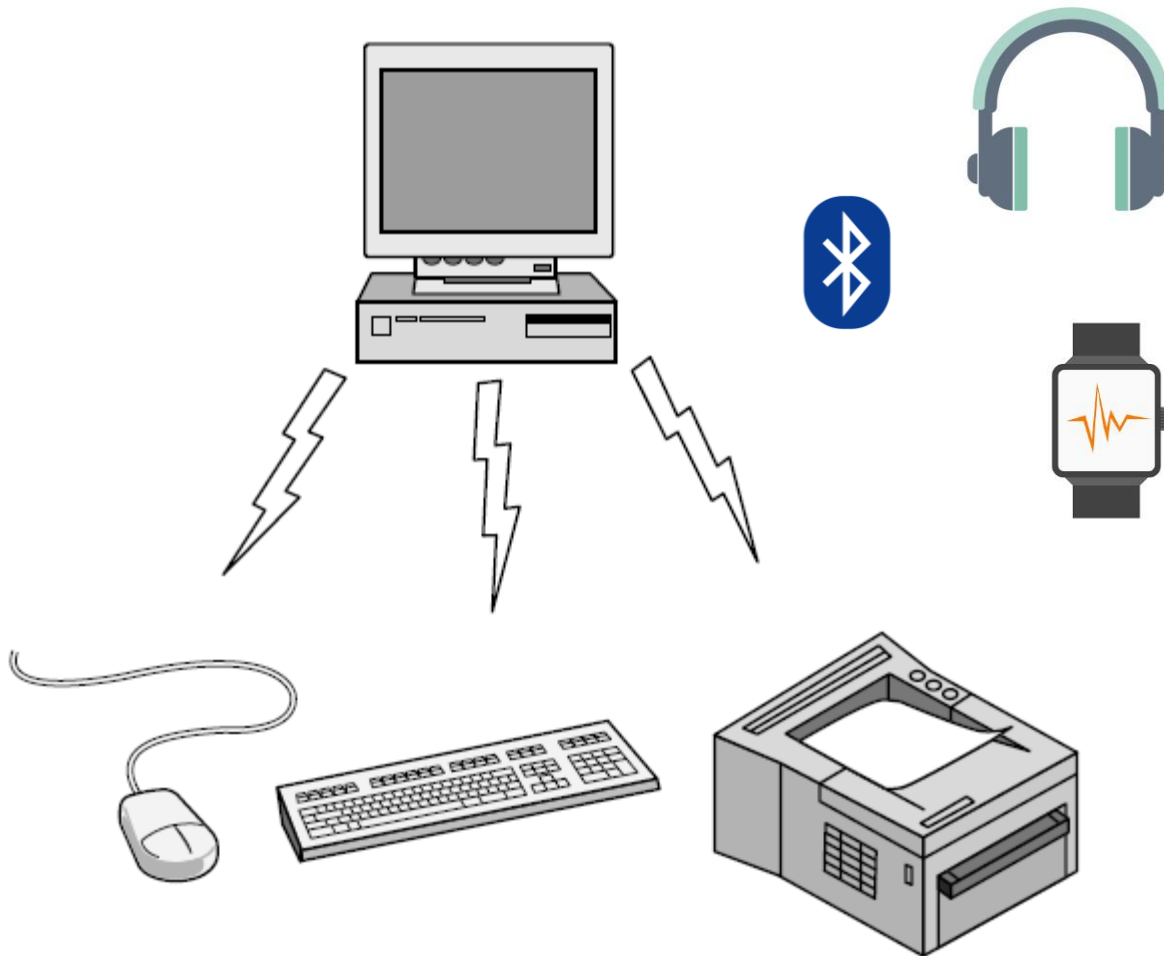


In a peer-to-peer system there are no fixed clients and servers.

# Network classification by scale

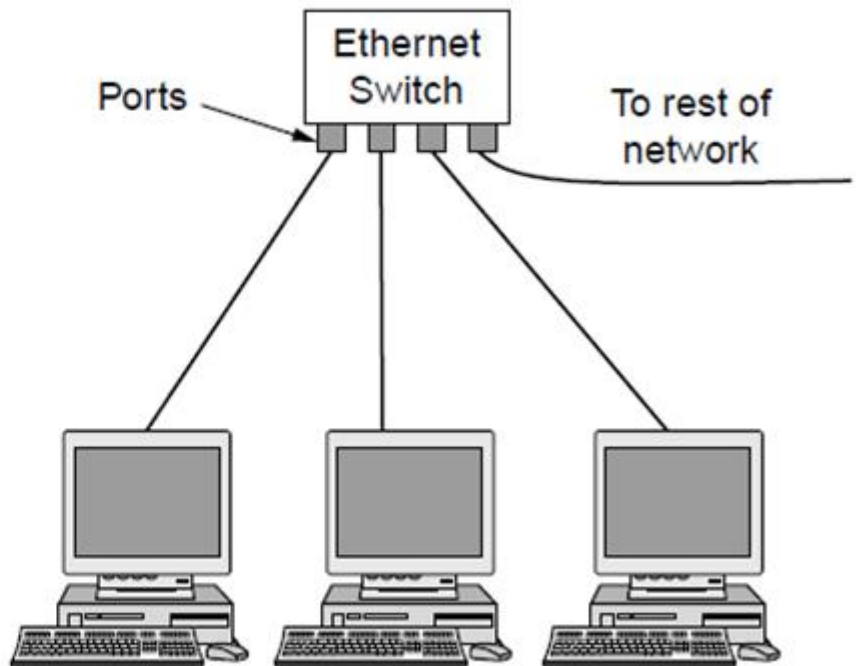
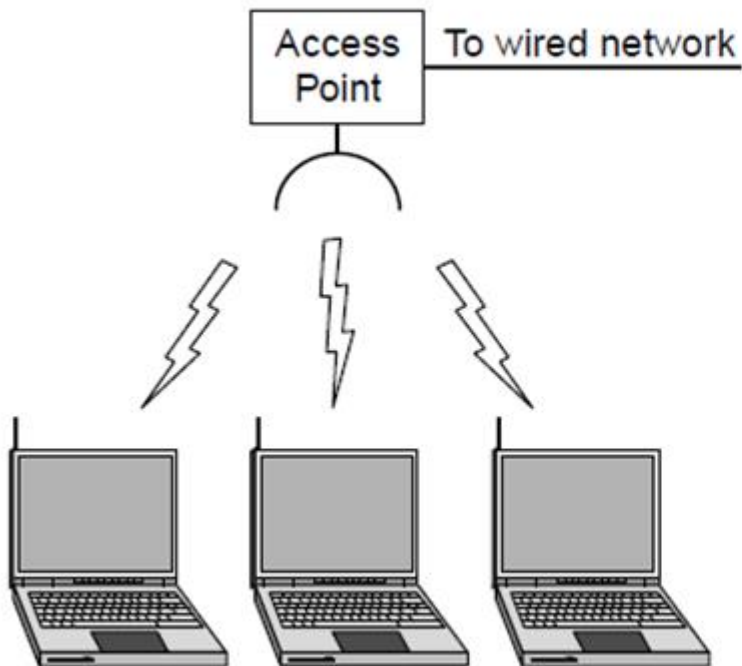
Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

# Personal Area Network



# Local Area Networks

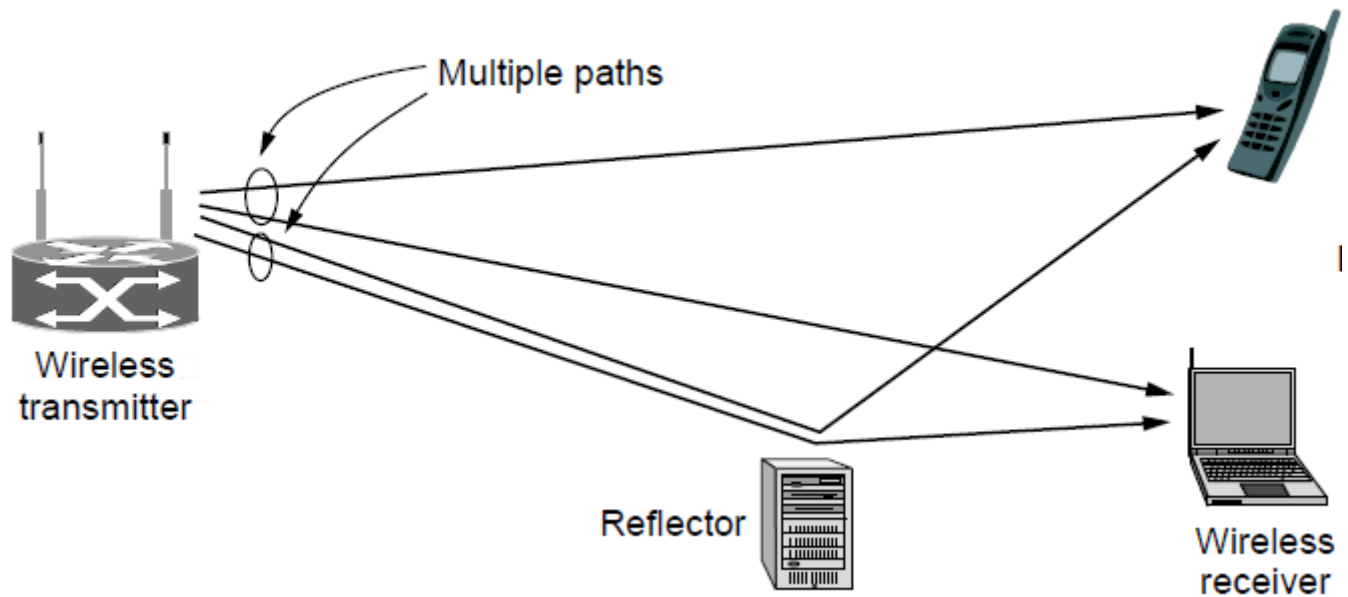
Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.



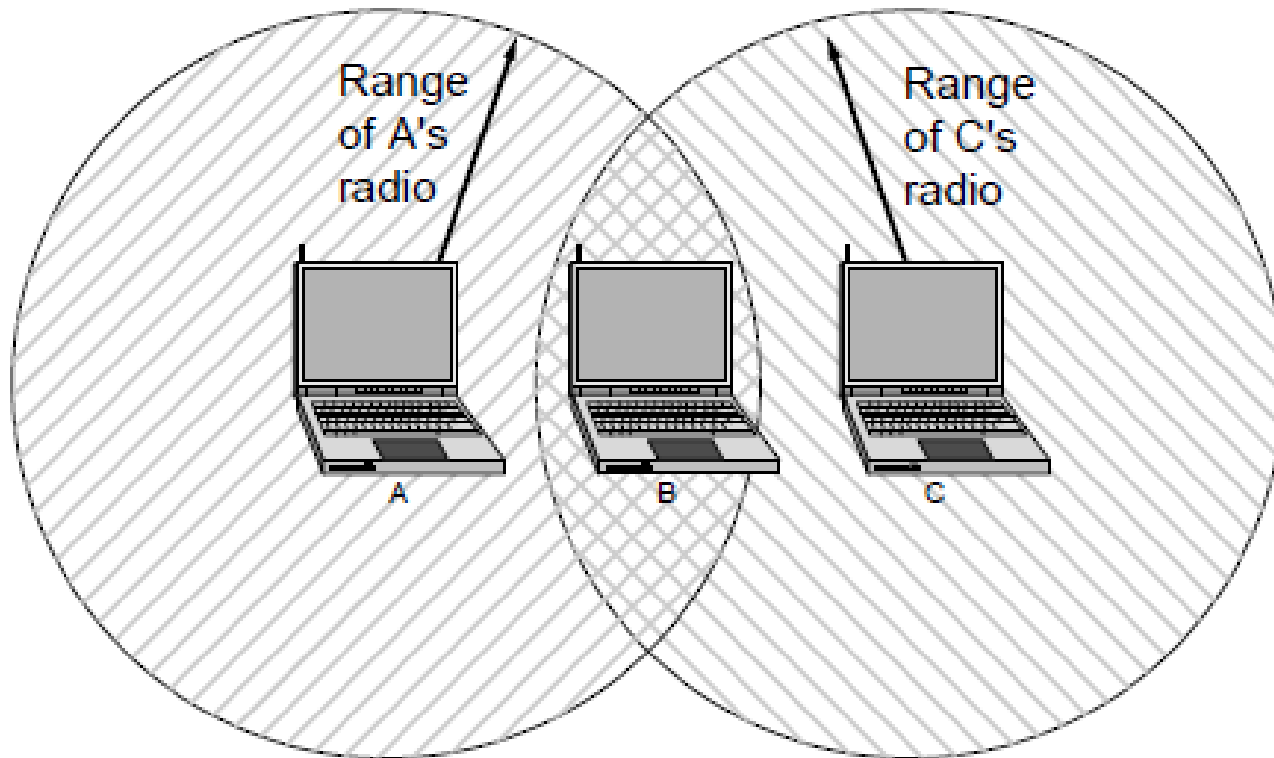


# Wireless LANs: 802.11 (2)

Multipath fading

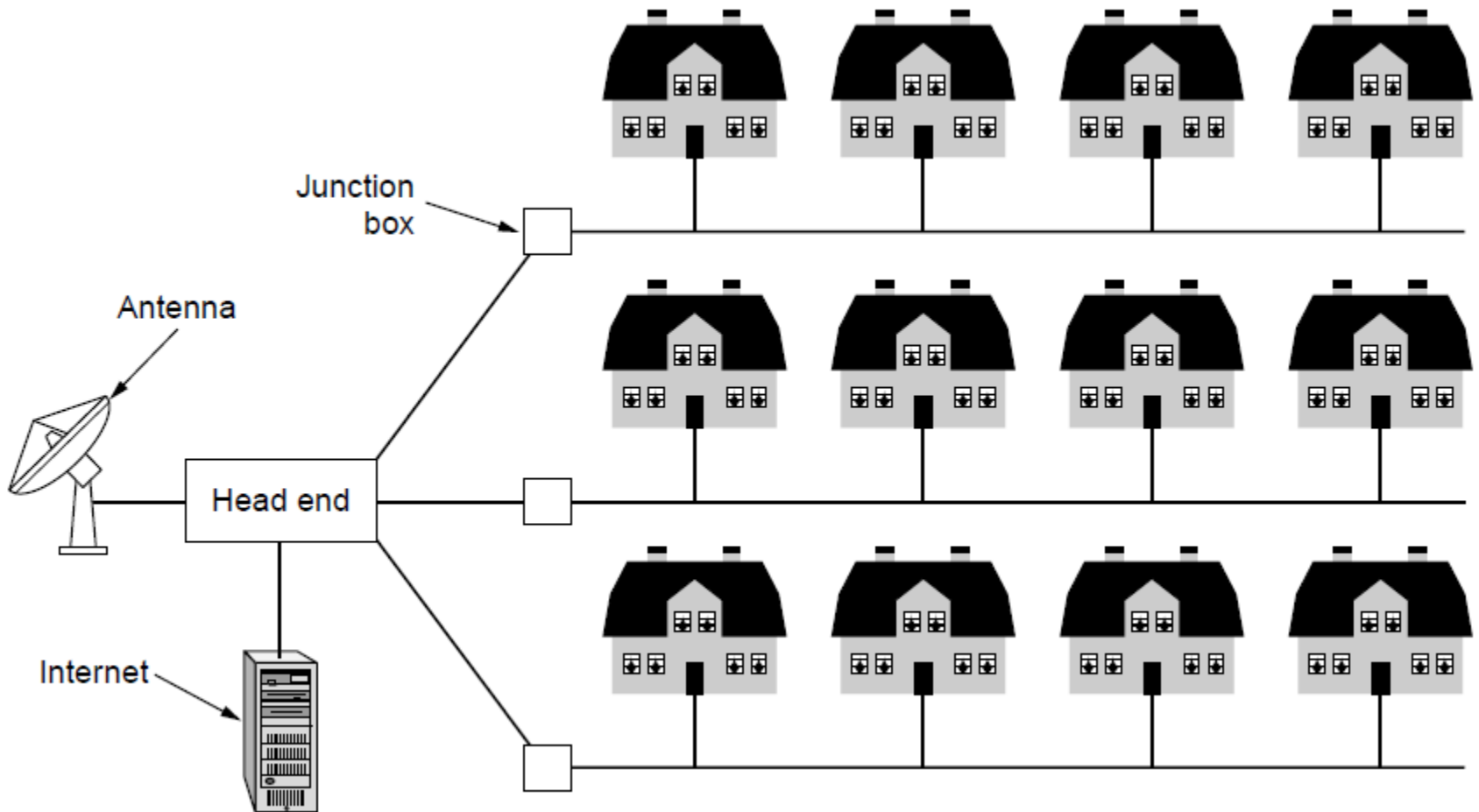


# Wireless LANs: 802.11 (3)



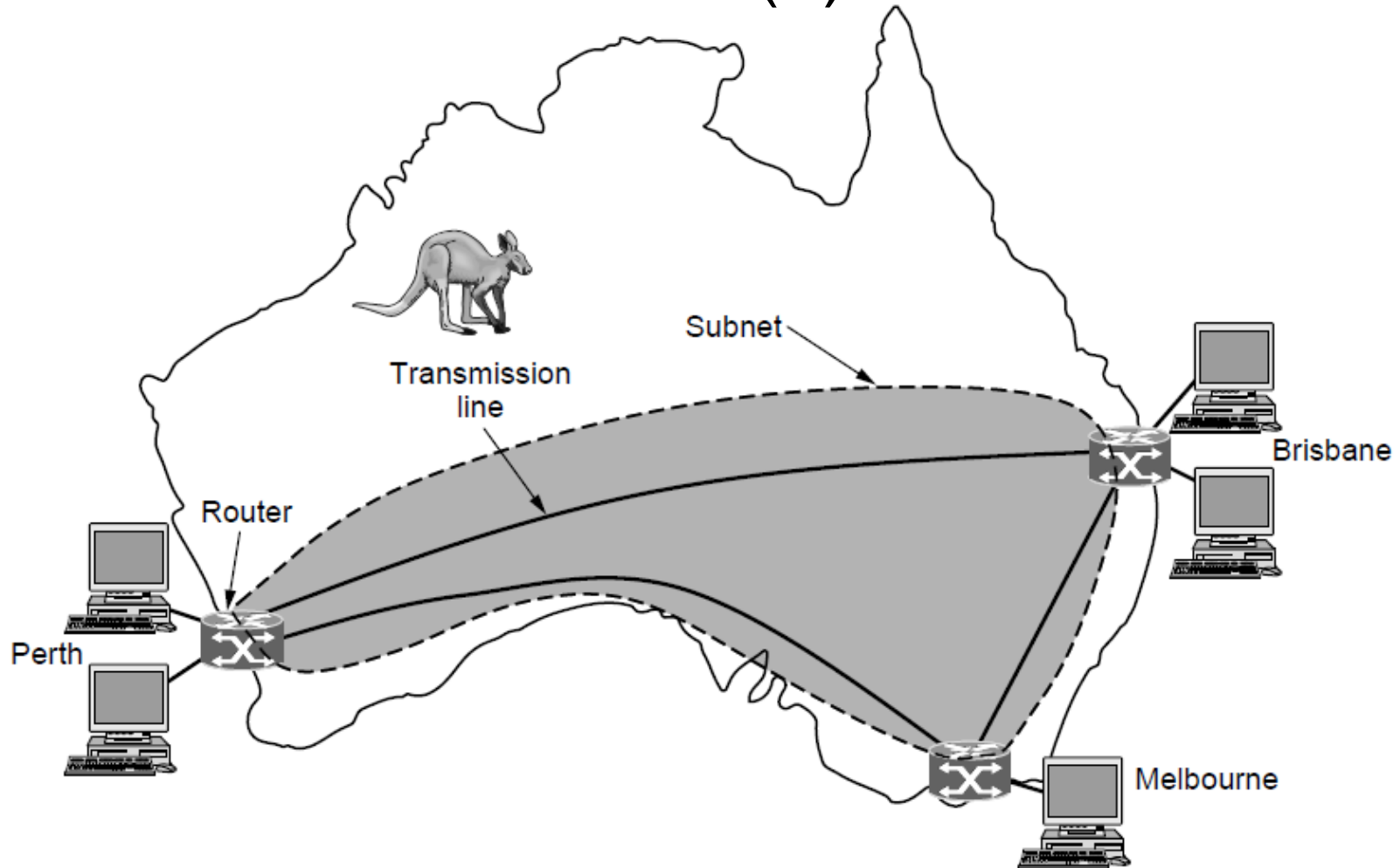
The range of a single radio may not cover the entire system.

# Metropolitan Area Networks



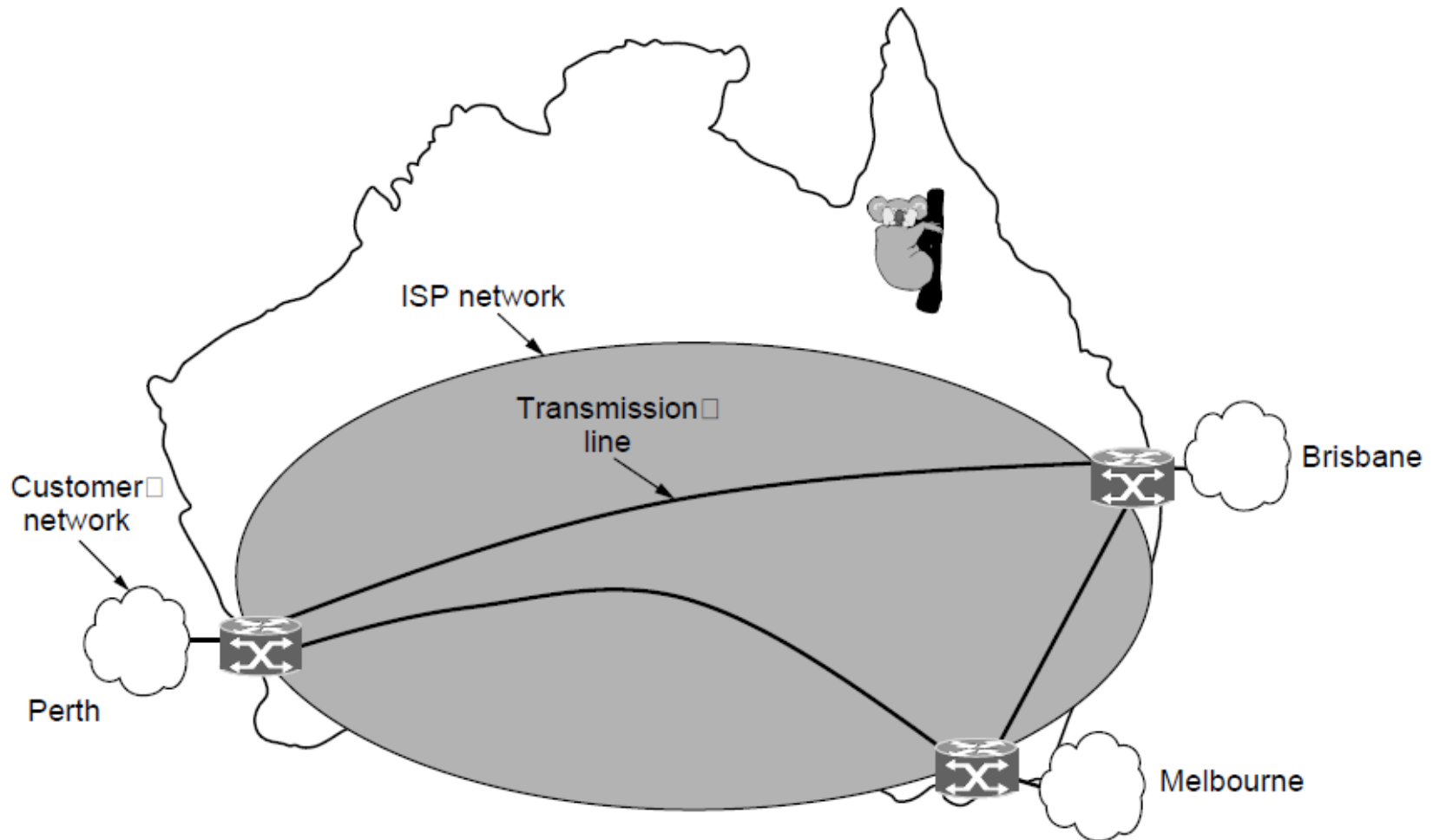
A metropolitan area network based on cable TV.

# Wide Area Networks (1)



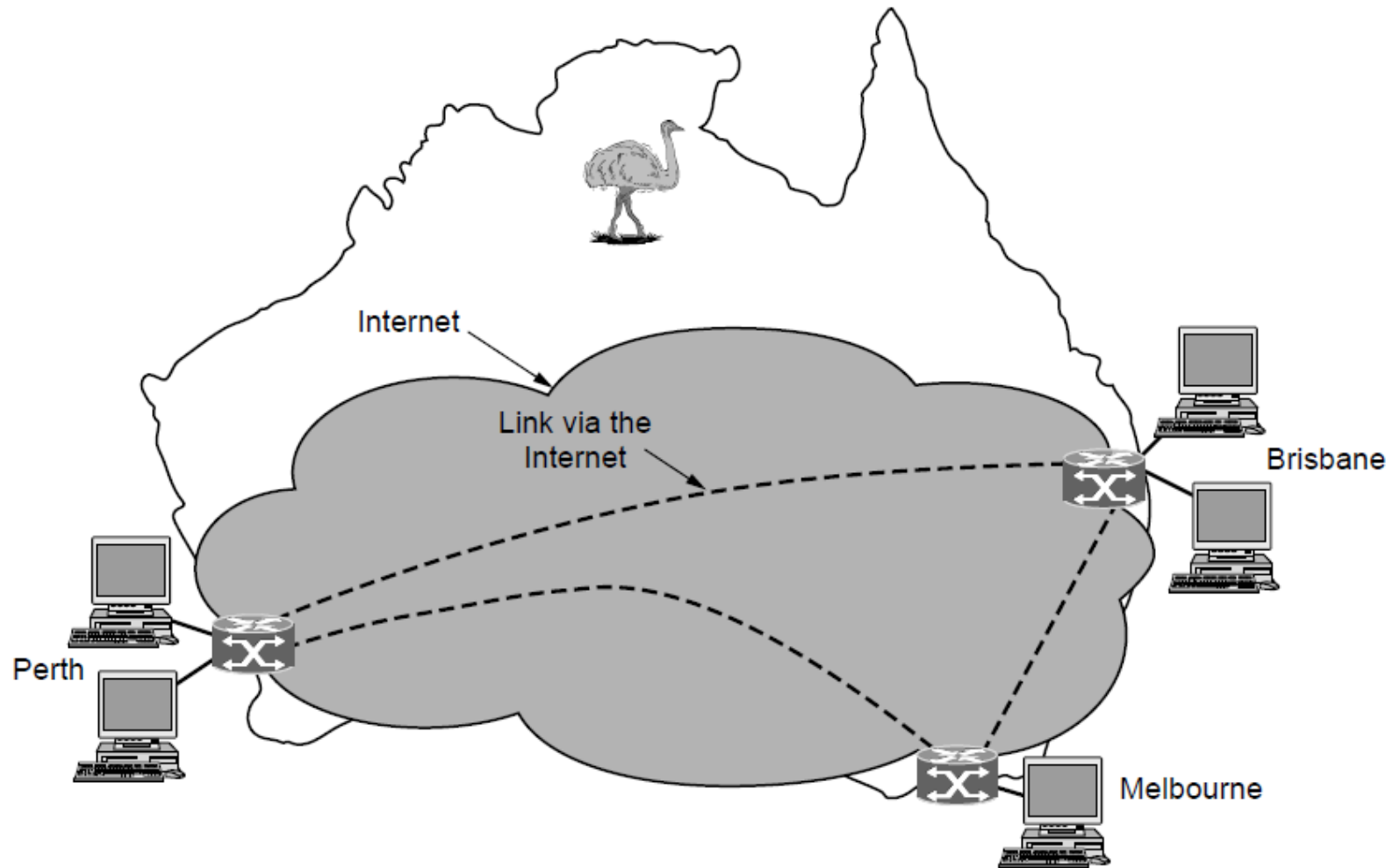
WAN that connects three branch offices in Australia

# Wide Area Networks (2)



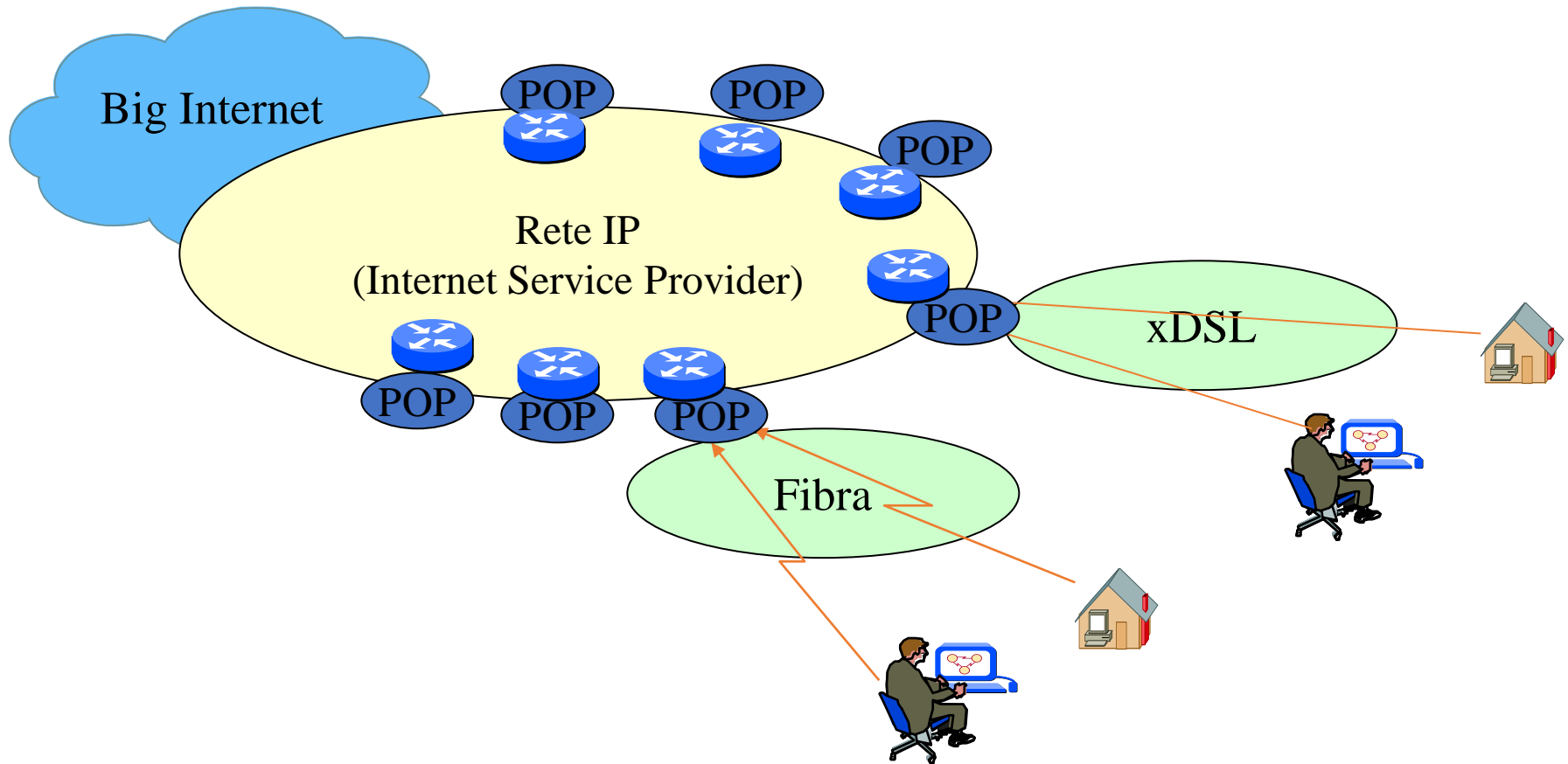
WAN using an ISP network.

# Wide Area Networks (3)

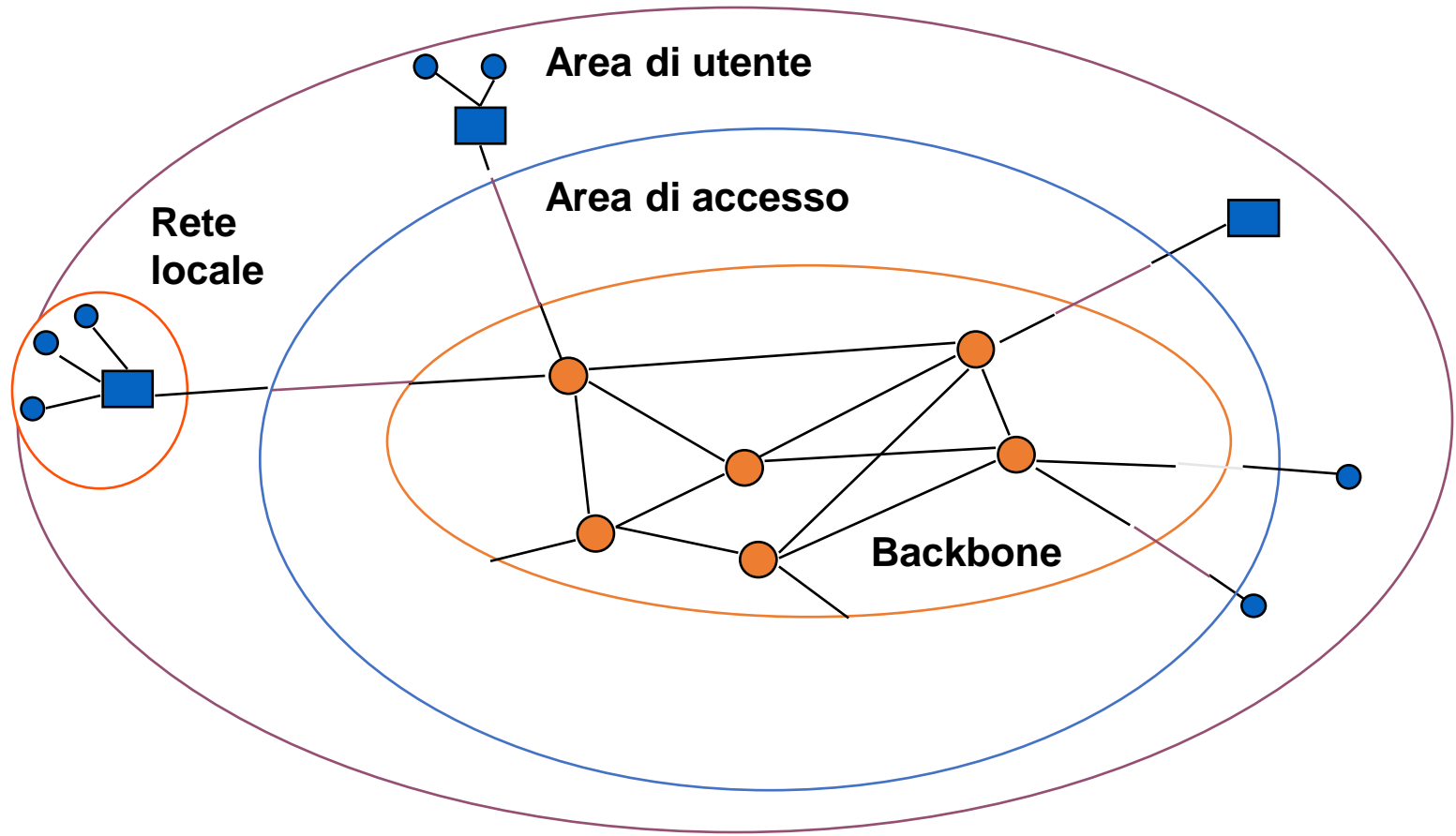


WAN using a virtual private network.

# Internet Service Providers



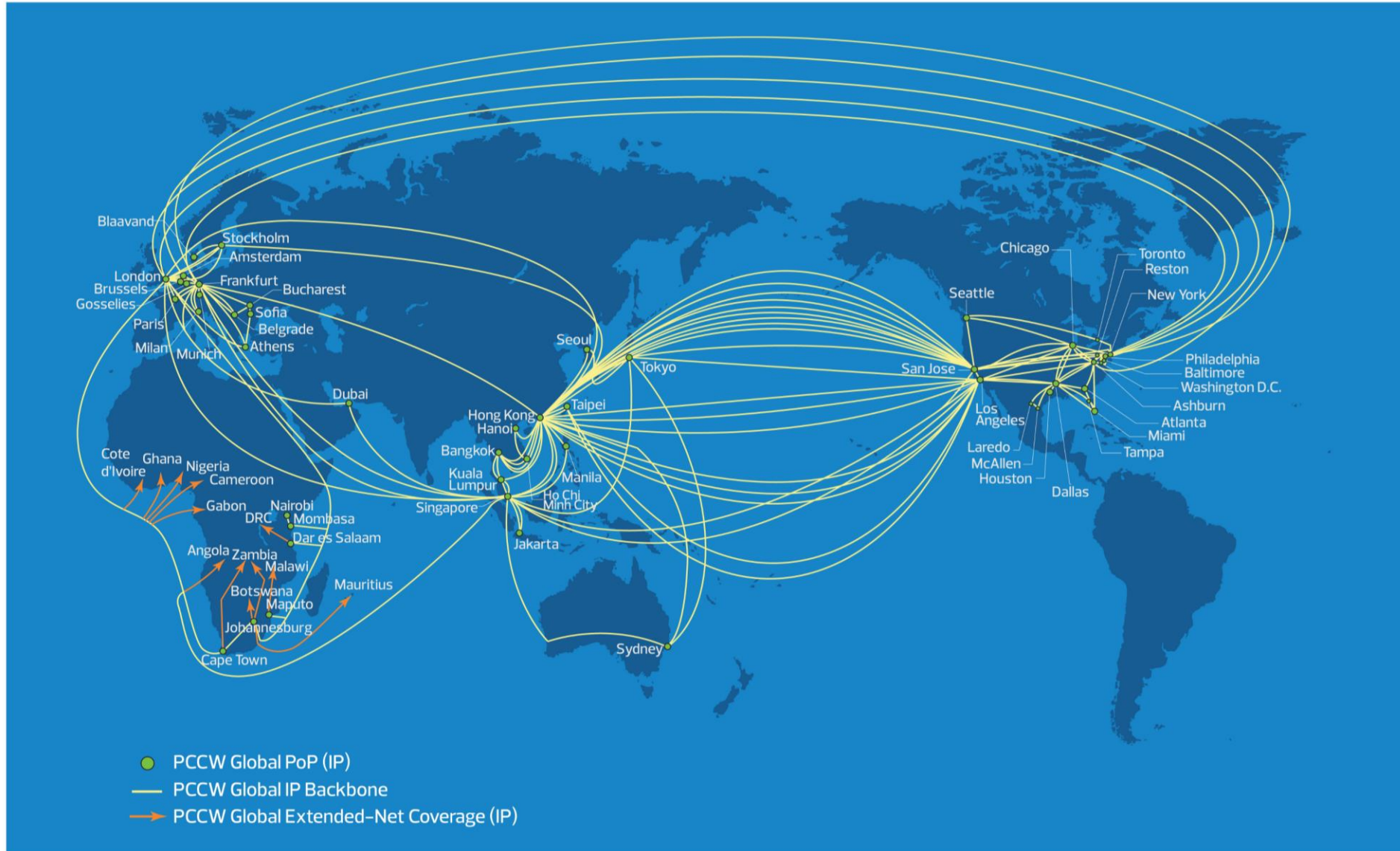
# Rete geografica per trasmissione dati



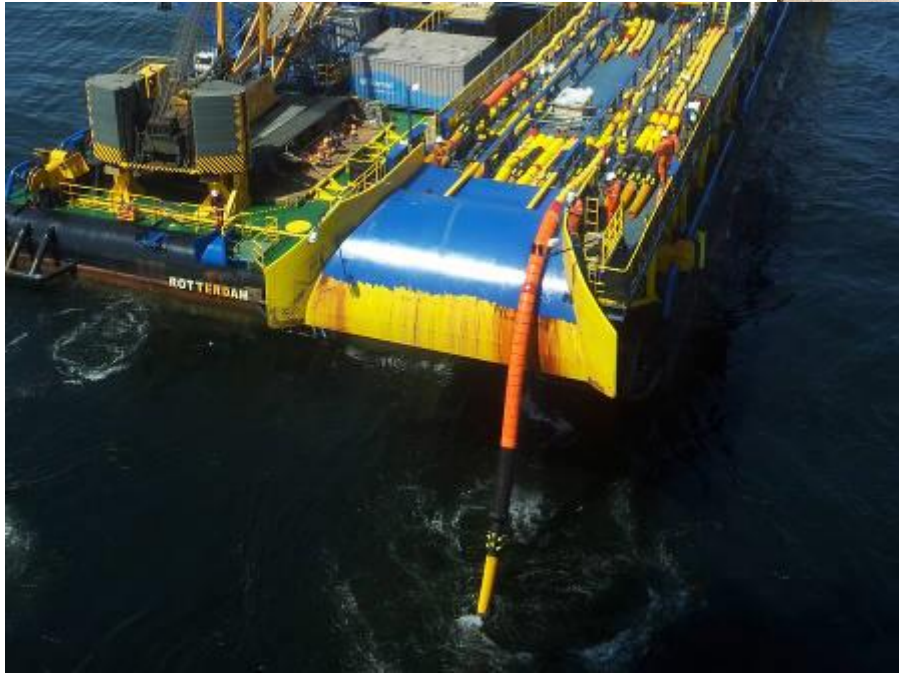
- = terminale di utente
- = unità di accesso
- = nodo del sottosistema di comunicazione



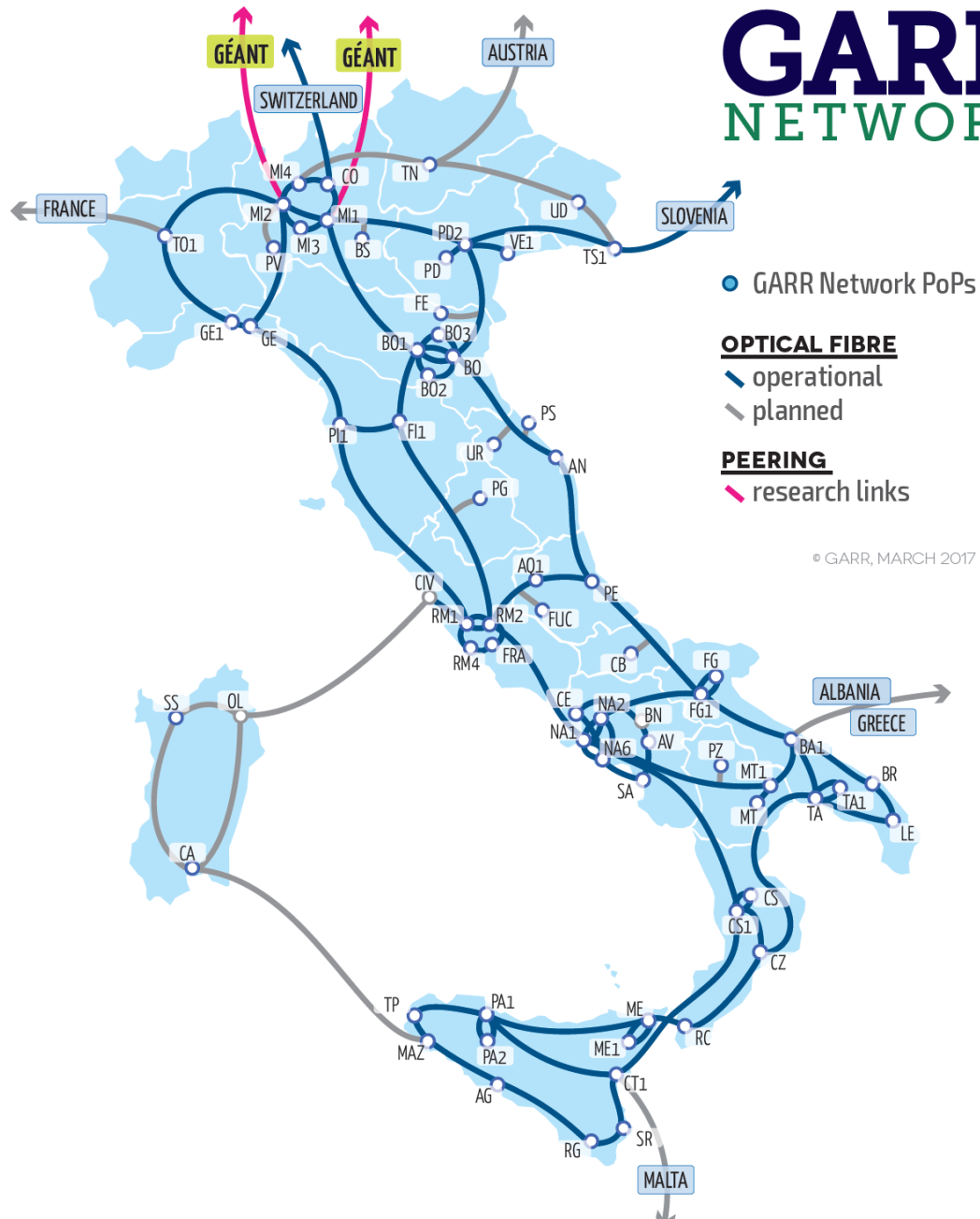
# Global IP Backbone







# GARR NETWORK





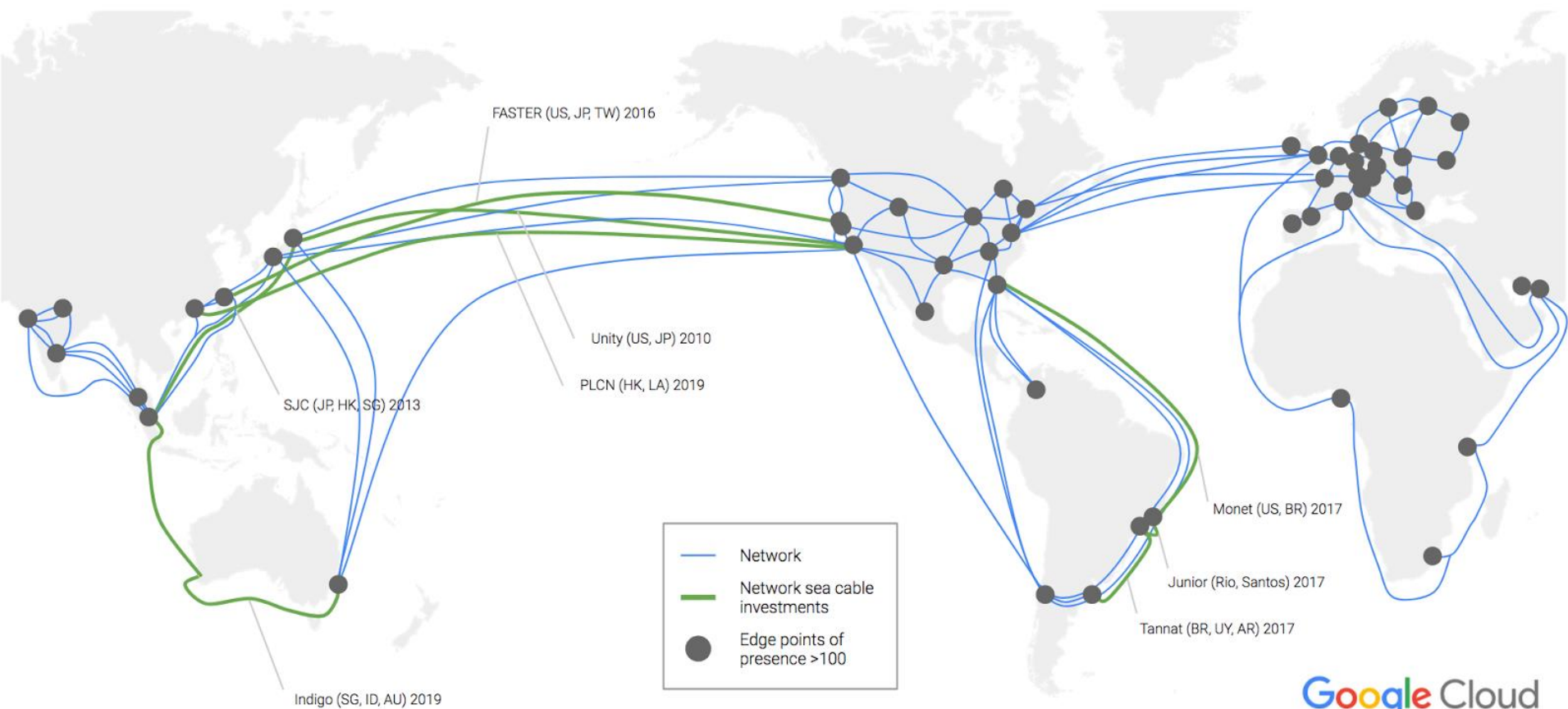
# Google



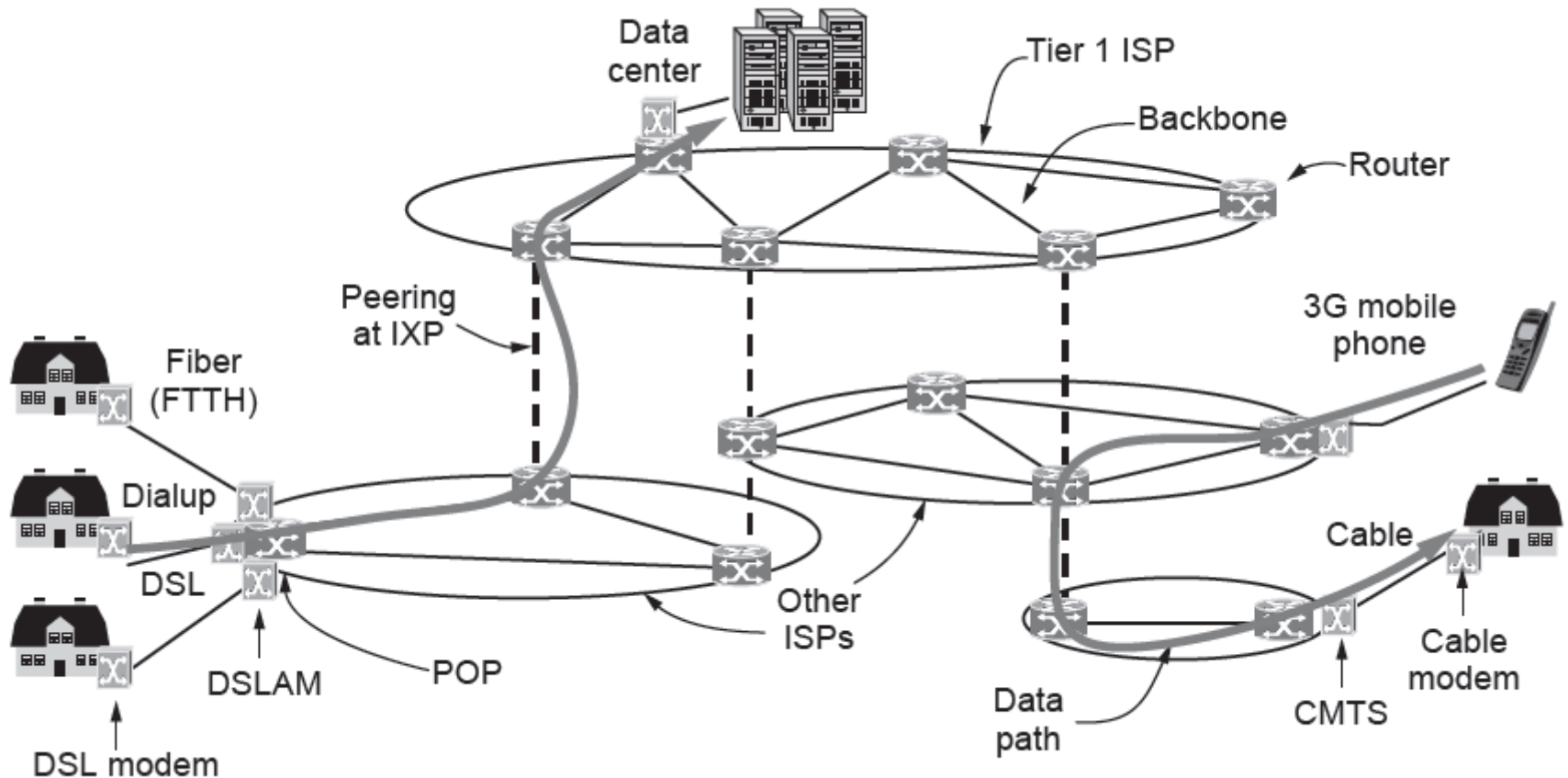
The company has essentially two huge networks: the one that connects users to Google services (Search, Gmail, YouTube, etc.) and another (internal) that connects Google data centers to each other.

Google is in control of scheduling internal traffic (bursty), but it faces difficulties in traffic engineering.

Often Google has to move many petabytes of data (indexes of the entire web, millions of backup copies of user Gmail) from one place to another.

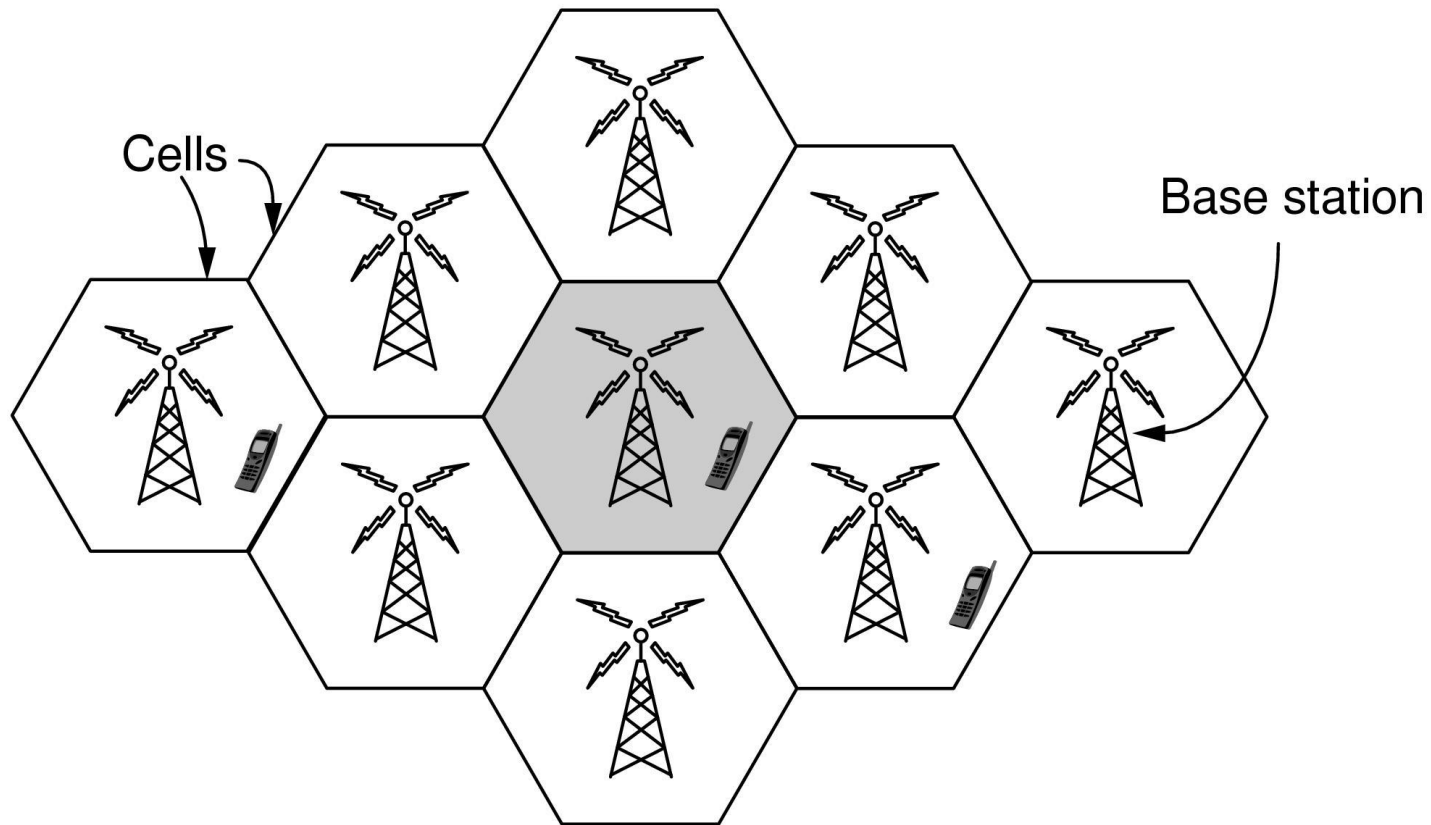


# Architecture of the Internet



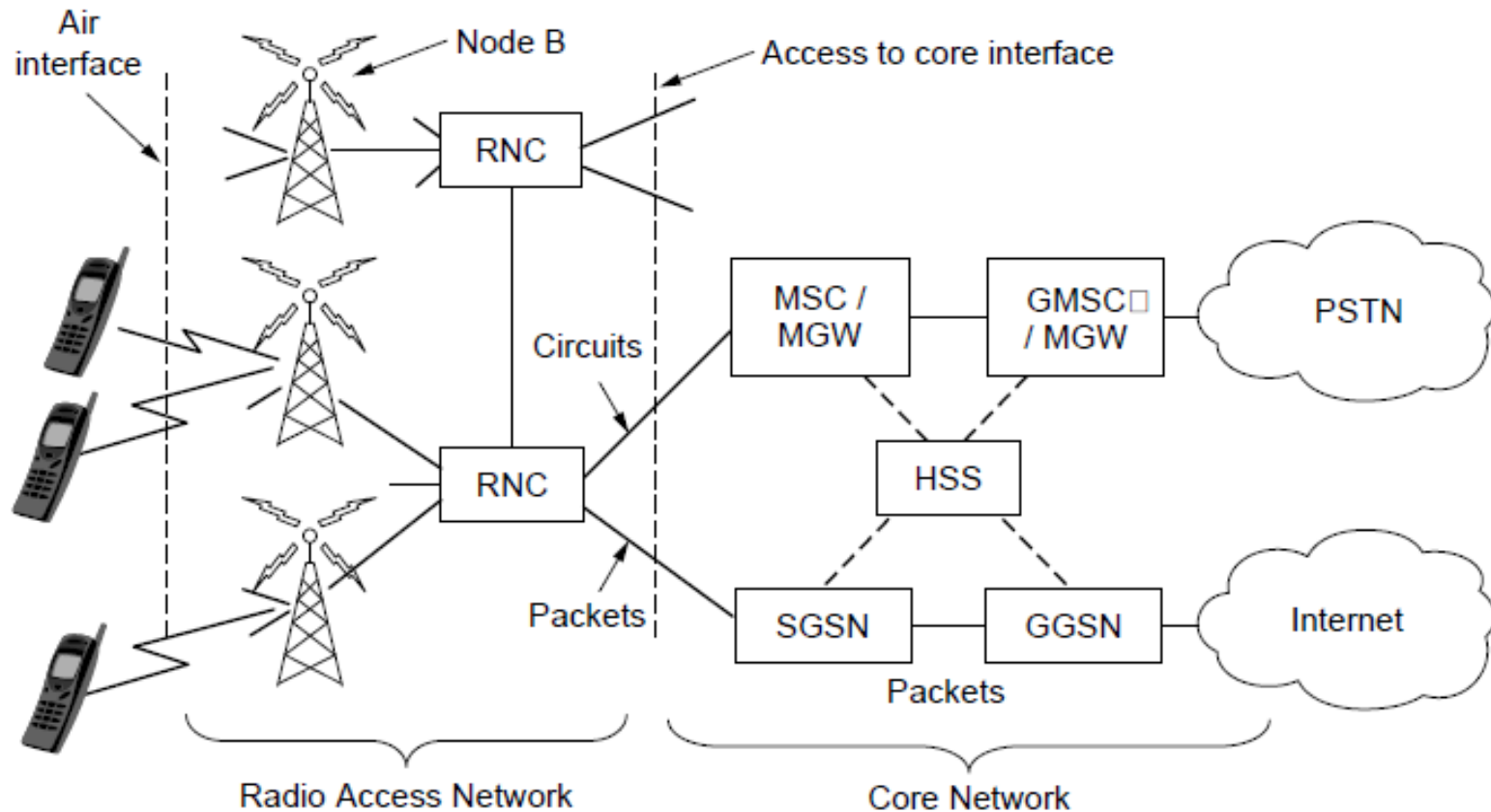
Overview of the Internet architecture

# Third-Generation Mobile Phone Networks (1)



Cellular design of mobile phone networks

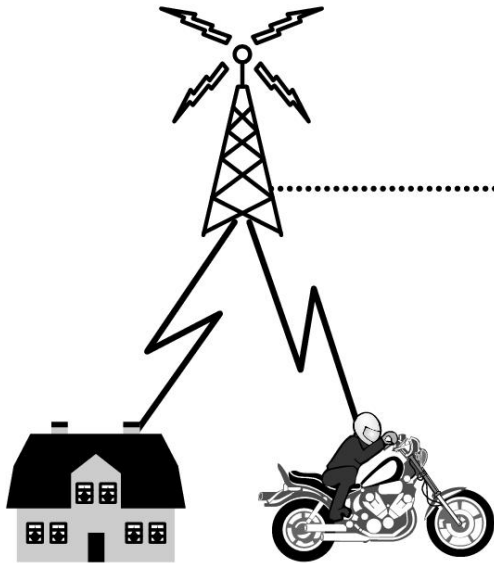
# Third-Generation Mobile Phone Networks (2)



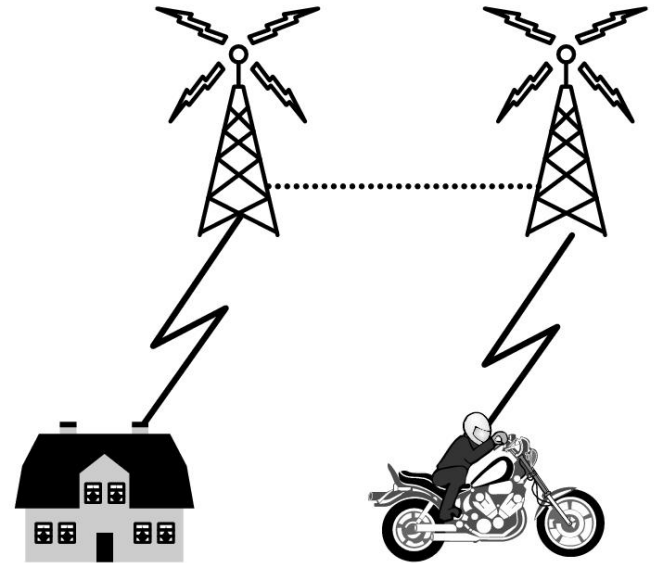
Architecture of the UMTS 3G mobile phone network.



# Third-Generation Mobile Phone Networks (3)



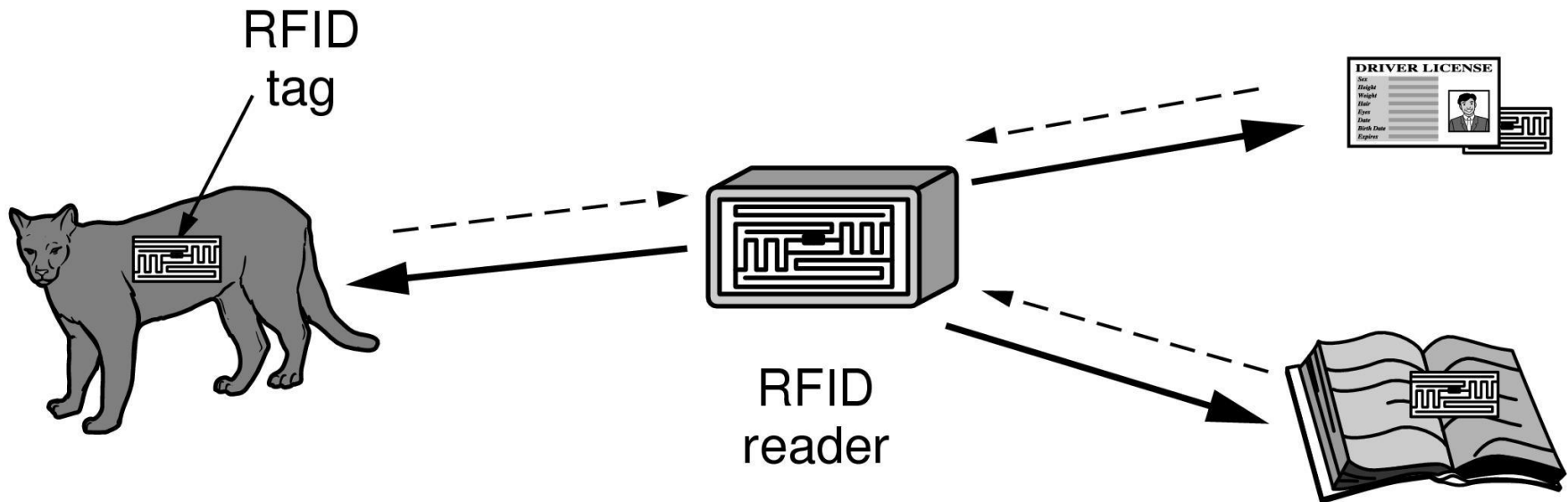
(a)



(b)

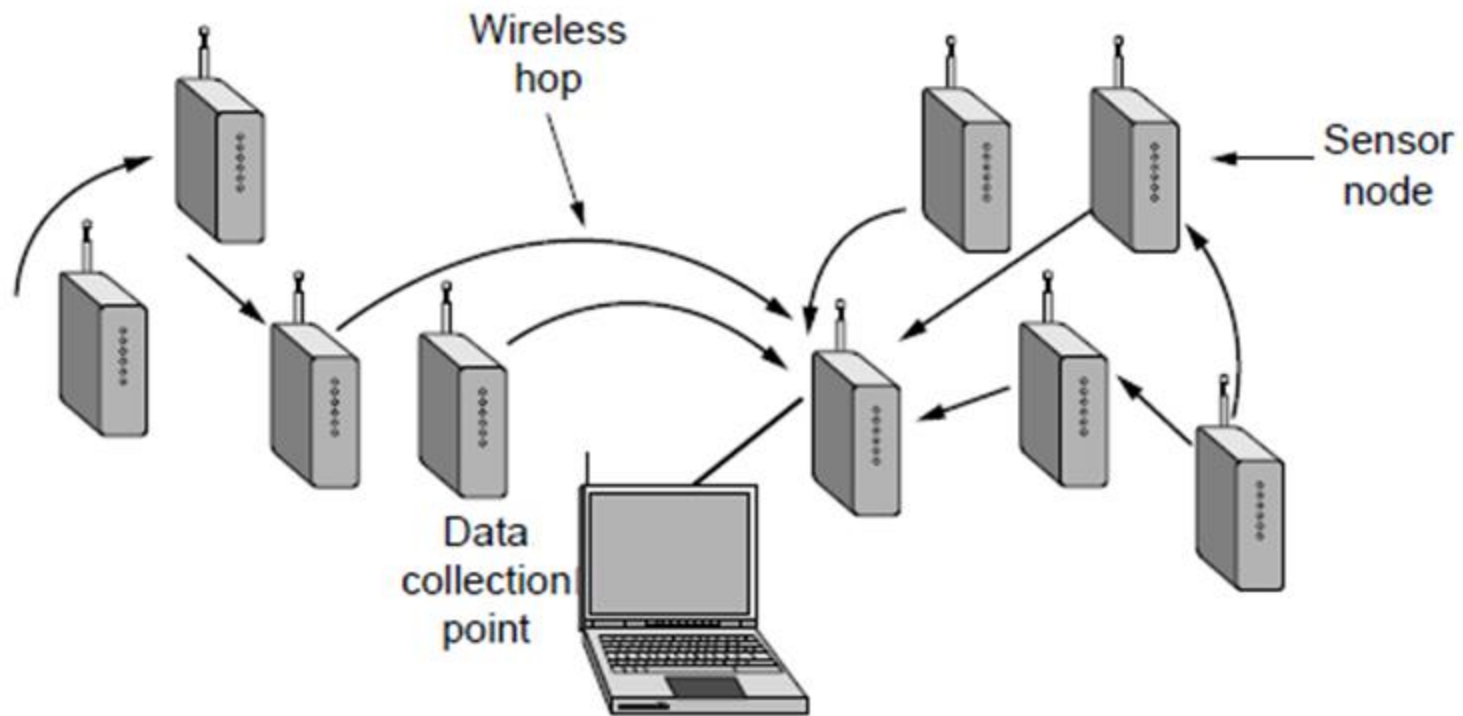
Mobile phone handover (a) before, (b) after.

# RFID and Sensor Networks (1)



RFID used to network everyday objects.

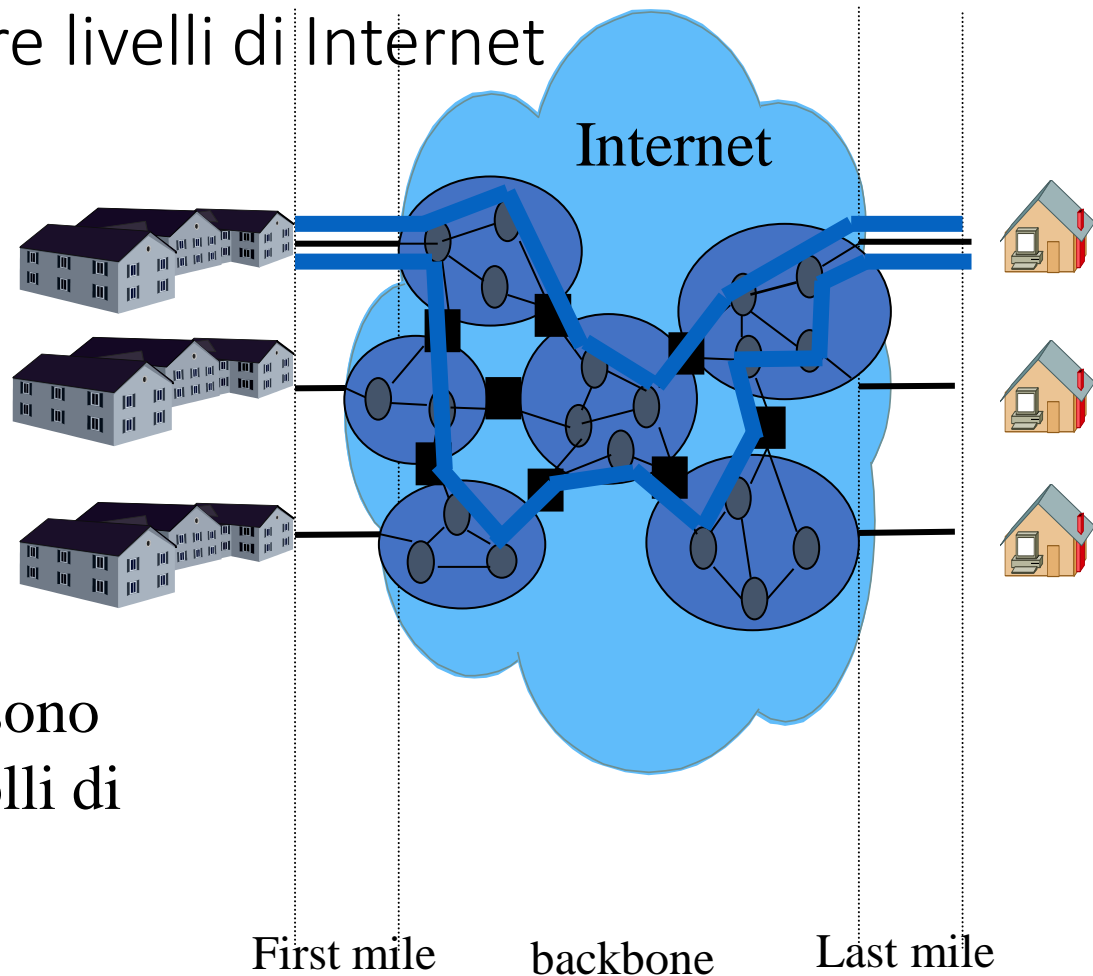
# RFID and Sensor Networks (2)



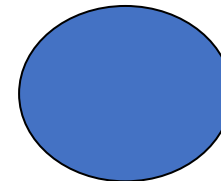
Multihop topology of a sensor network

# Architettura a tre livelli di Internet

Le tre zone sono  
potenziali colli di  
bottiglia



■ Neutral/Network access point



ISP o NSP

# Architettura a tre livelli di Internet

Eliminare colli di bottiglia (soluzioni hardware)

- first mile, last mile -> aumentare la banda che connette al provider
- Backbone -> dipende dal miglioramento delle infrastrutture di rete dei singoli ISP (non controllabile dagli utenti finali)

Eliminare il collo di bottiglia di backbone (soluzione software)

- Content Delivery Networks.
- Caching di pagine vicino a dove risiede l'utente completamente trasparente all'utente (e.g. AKAMAI). In questo modo si spera che l'utente possa accedervi con larga banda

Nota: idea di soluzione simile a quella della gerarchia di caching delle memorie nei processori

# Akamai's Global Platform

## ■ Akamai's Internet Platform

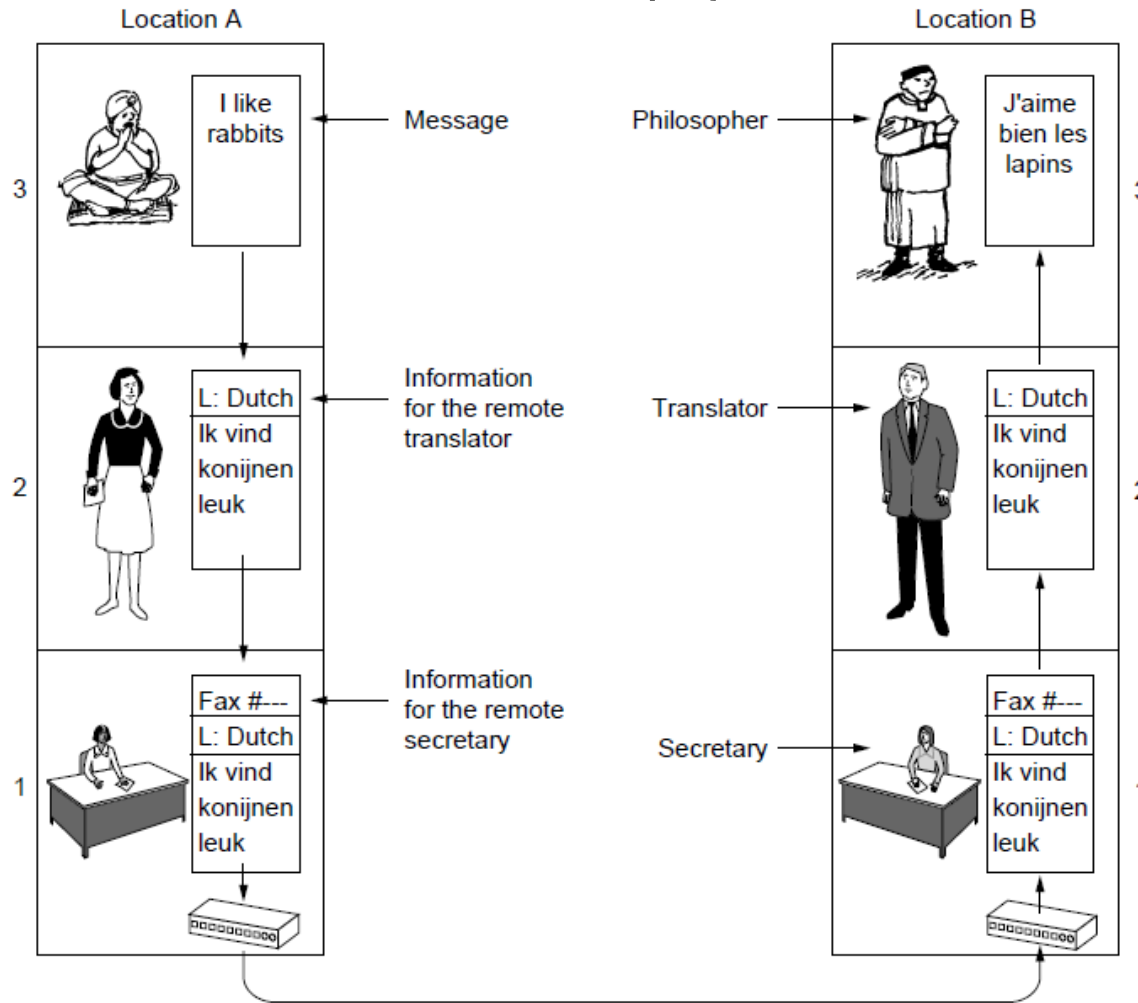
- 100,000+ servers
- 72 countries
- 1,500+ locations
- 1,000 networks

## ■ Ginormous Daily Traffic

- Carries 15-30% of the world's web traffic on any given day
- More than 1 trillion requests
- More than 30 petabytes
- 10 million+ concurrent video streams

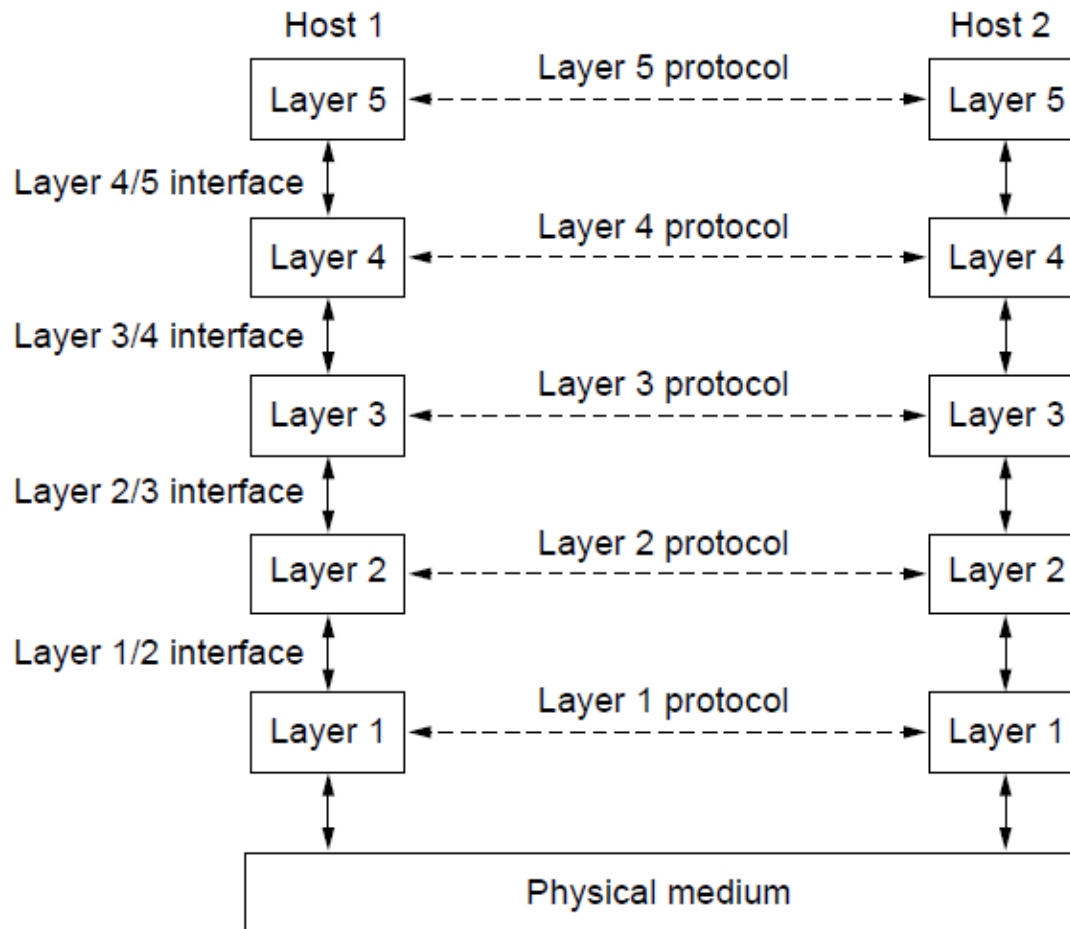


# Protocol Hierarchies (1)



The philosopher-translator-secretary architecture

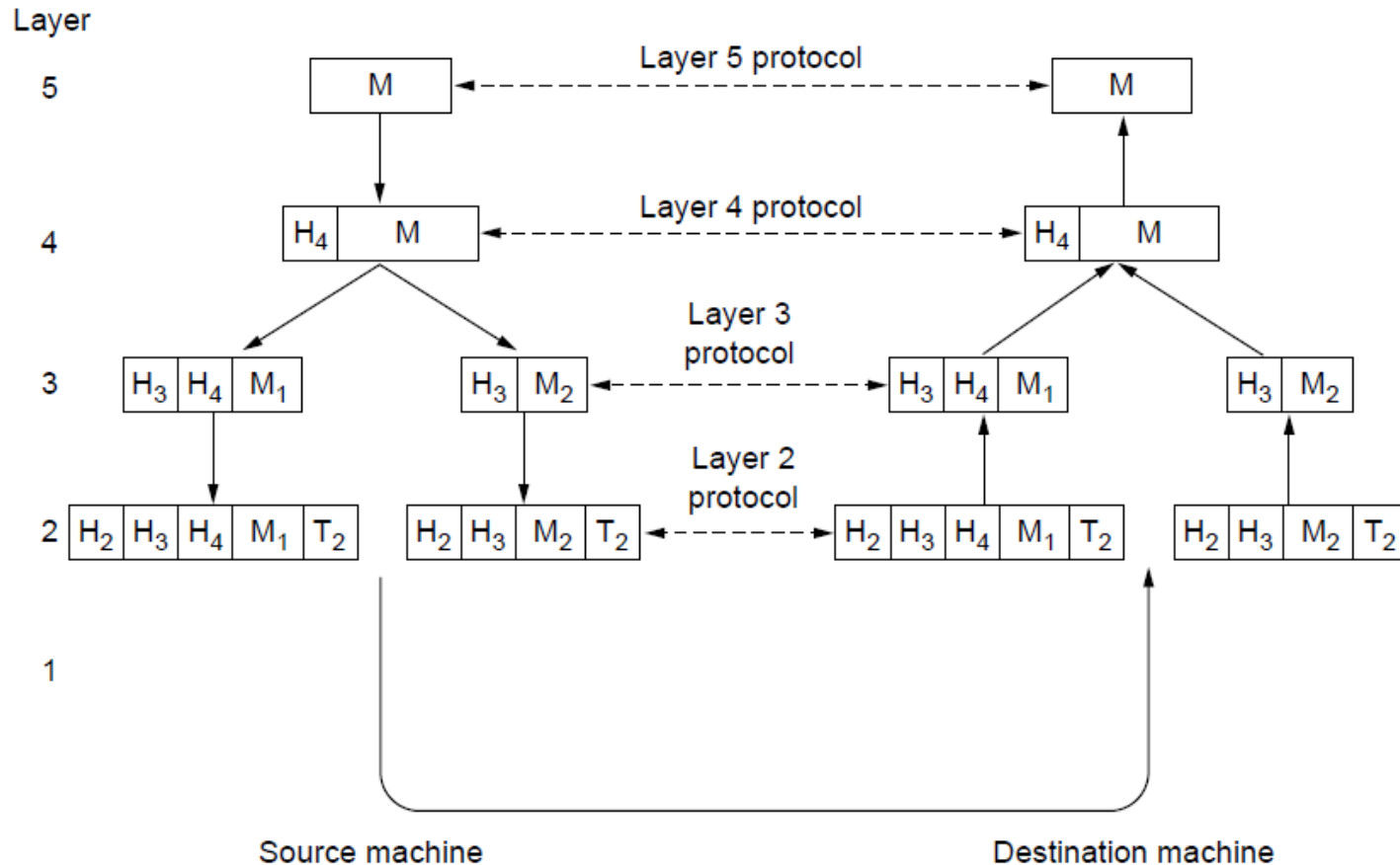
# Protocol Hierarchies (2)



Layers, protocols, and interfaces.



# Protocol Hierarchies (3)



Example information flow supporting virtual communication in layer 5.

# The OSI Reference Model

Principles for the seven layers

- Layers created for different abstractions
- Each layer performs well-defined function
- Function of layer chosen with definition of international standard protocols in mind
- Minimize information flow across interfaces between boundaries
- Number of layers optimum

# Il modello di comunicazione OSI

## ESEMPIO DI PROFILO DEI PROTOCOLLI PER IL PIANO UTENTE (commutazione di pacchetto)



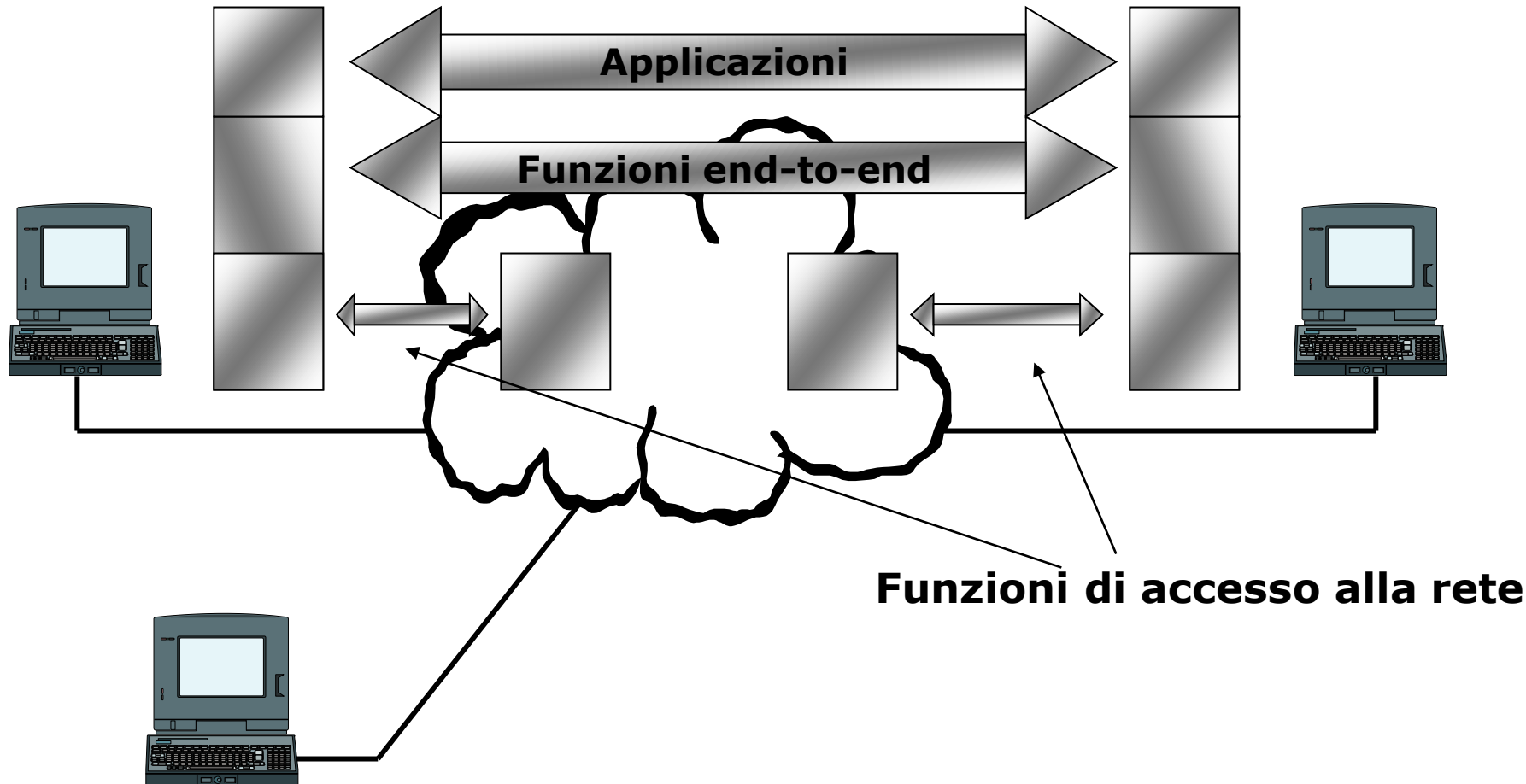
## ESEMPIO DI PROFILO DEI PROTOCOLLI PER IL PIANO UTENTE (commutazione di circuito)



# Critique of the OSI Model and Protocols

- Bad timing.
- Bad technology.
- Bad implementations.
- Bad politics.

# Rete geografica di calcolatori



# Struttura a tre livelli di una rete di calcolatori

**Area Applicativa**

**Interoperabilità trasporto dell'informazione**

**Infrastruttura di trasporto dell'informazione**

# Struttura a tre livelli di una rete di calcolatori

**Area Applicativa**

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**Interoperabilità trasporto dell'informazione**

**TRASPORTO**

**RETE**

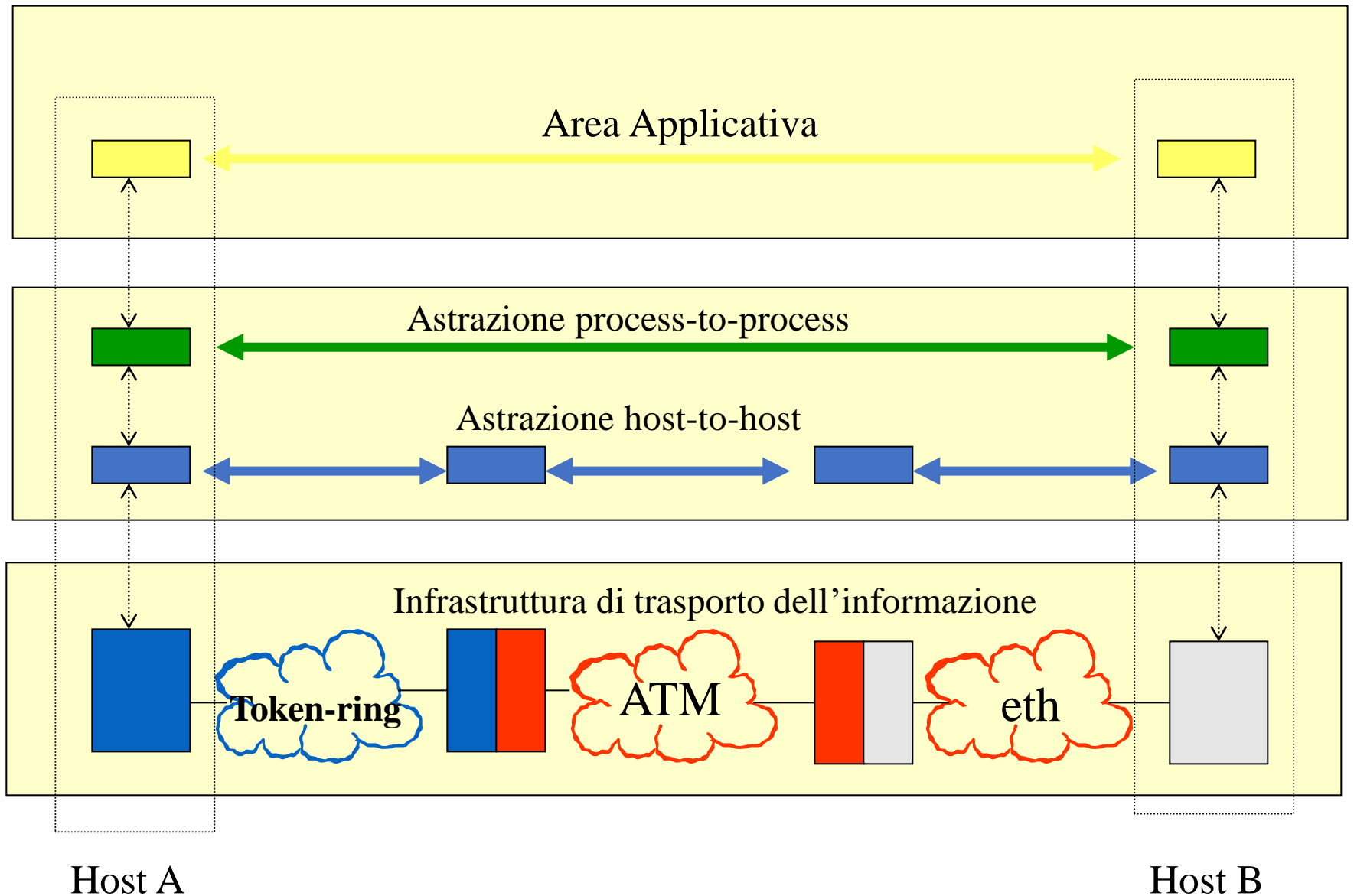
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**Infrastruttura di trasporto dell'informazione**

**LINK**

**FISICO**

# Rete geografica di calcolatori





# Esempi di problematiche comuni: Indirizzamento

**Area Applicativa**

**Indirizzamento DNS “www.uniroma1.it”**



**Interoperabilità trasporto  
dell'informazione**

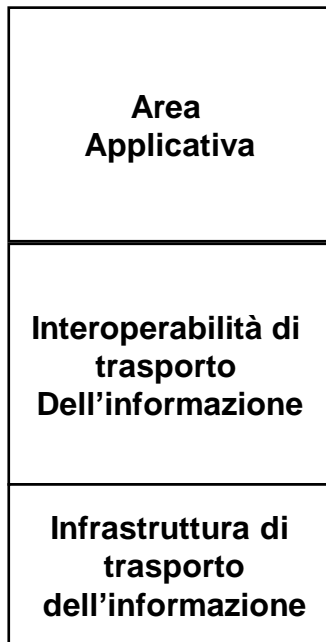
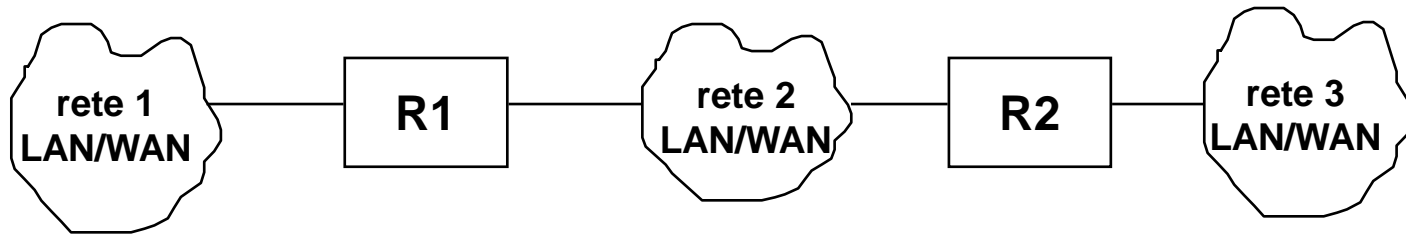
**Indirizzamento IP “151.100.16.1”**



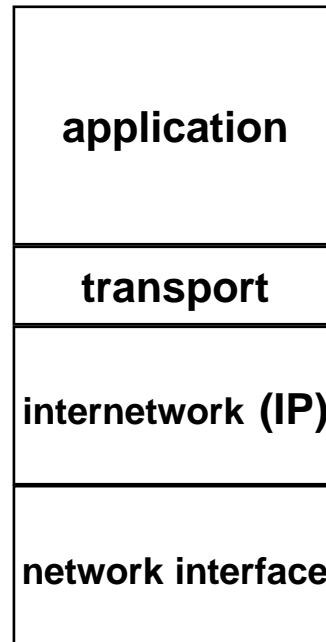
**Infrastruttura di trasporto  
dell'informazione**

**Indirizzamento MAC “ABC123578ABB”**

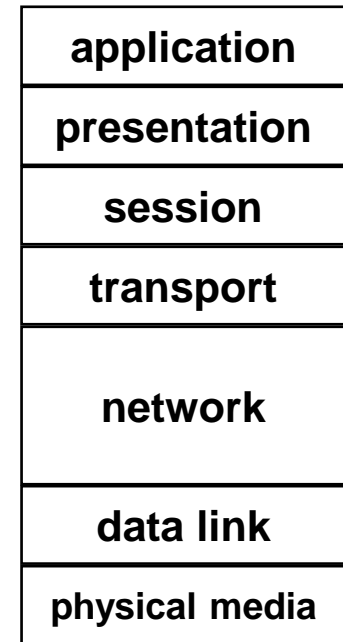
# Interoperabilità Trasporto dell'informazione: Internet



**Struttura a  
tre livelli**

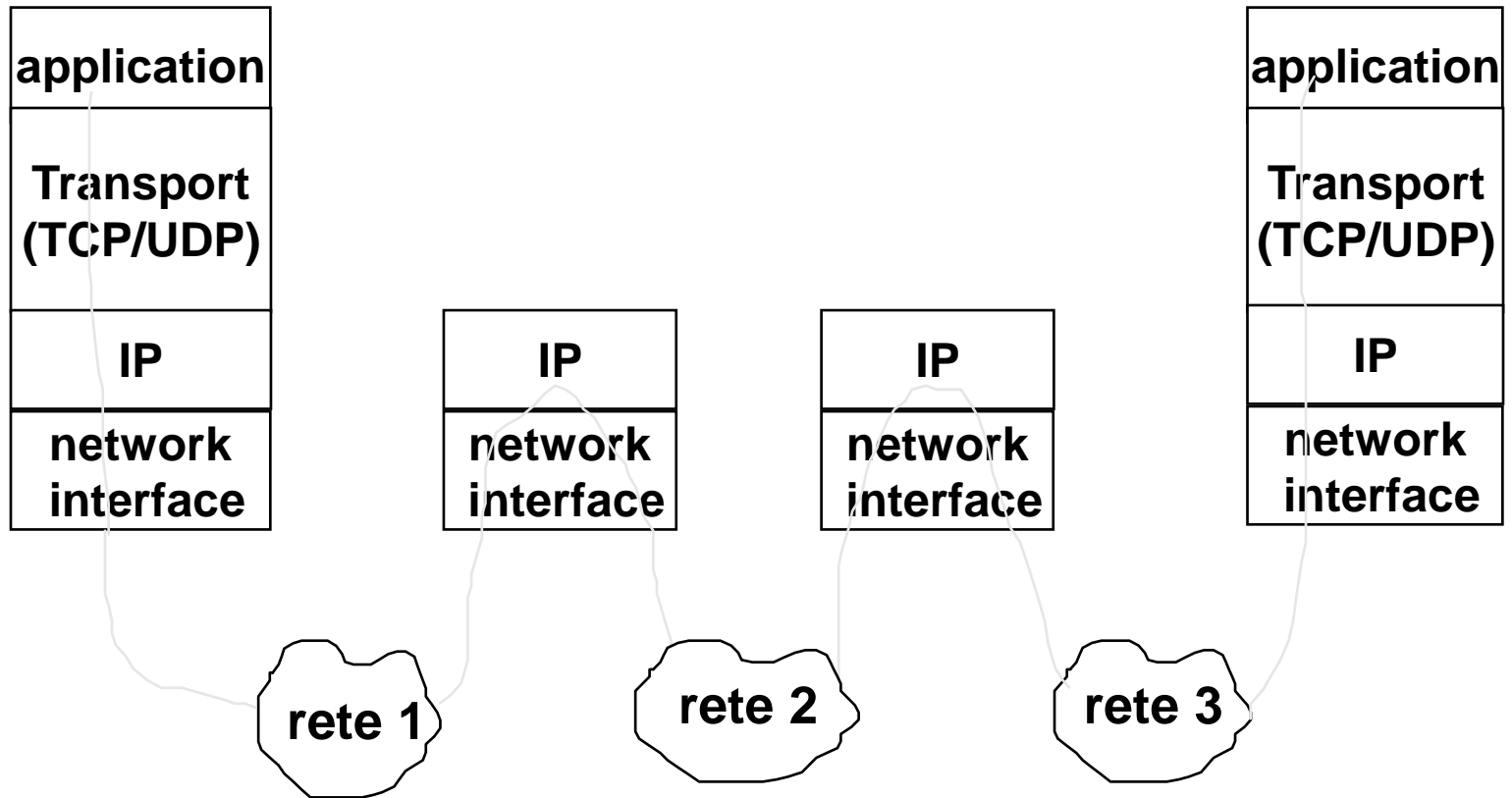


**Internet**



**OSI**

## L'ARCHITETTURA TCP/IP E LA RETE INTERNET

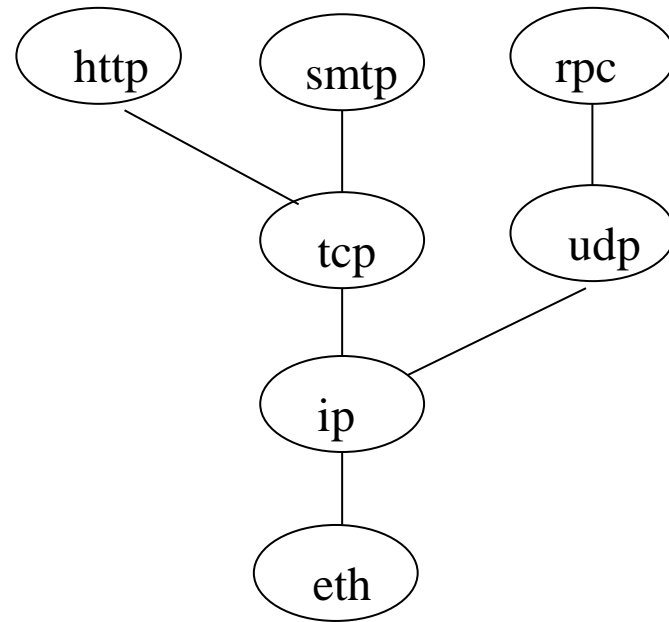


## Protocol Stack: esempi

http= hyper text transfer protocol

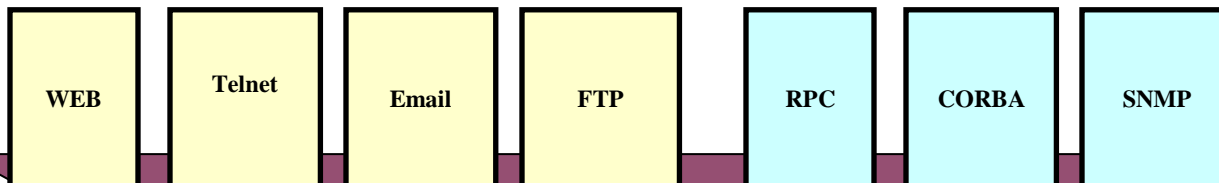
smtp= simple mail transfer protocol

Rpc= remote procedure call



Applicazioni di base

Supporto per interoperabilità applicativa



Area delle applicazioni

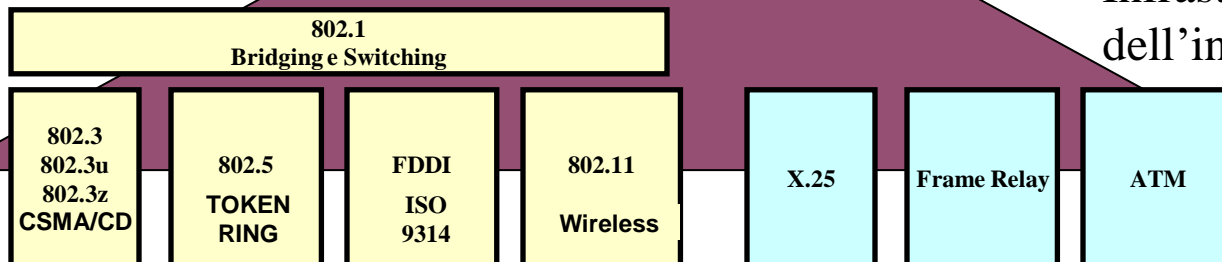
Interoperabilità di trasporto dell'informazione

**TCP/IP**

Process-to-process

Host-to-host

Infrastruttura di trasporto dell'informazione



Reti Locali

Backbone

# Basi di TCP/IP

# Il protocollo IP

- IP e' una grande coperta che nasconde ai protocolli sovrastanti tutte le disomogeneità della infrastruttura di trasporto dell'informazione
- Per far questo necessità di due funzionalità di base:
  - Indirizzamento di rete (indirizzi omogenei a dispetto della rete fisica sottostante)
  - Instradamento dei pacchetti (Routing) (capacità di inviare pacchetti da un host ad un altro utilizzando gli indirizzi definiti al punto precedente)

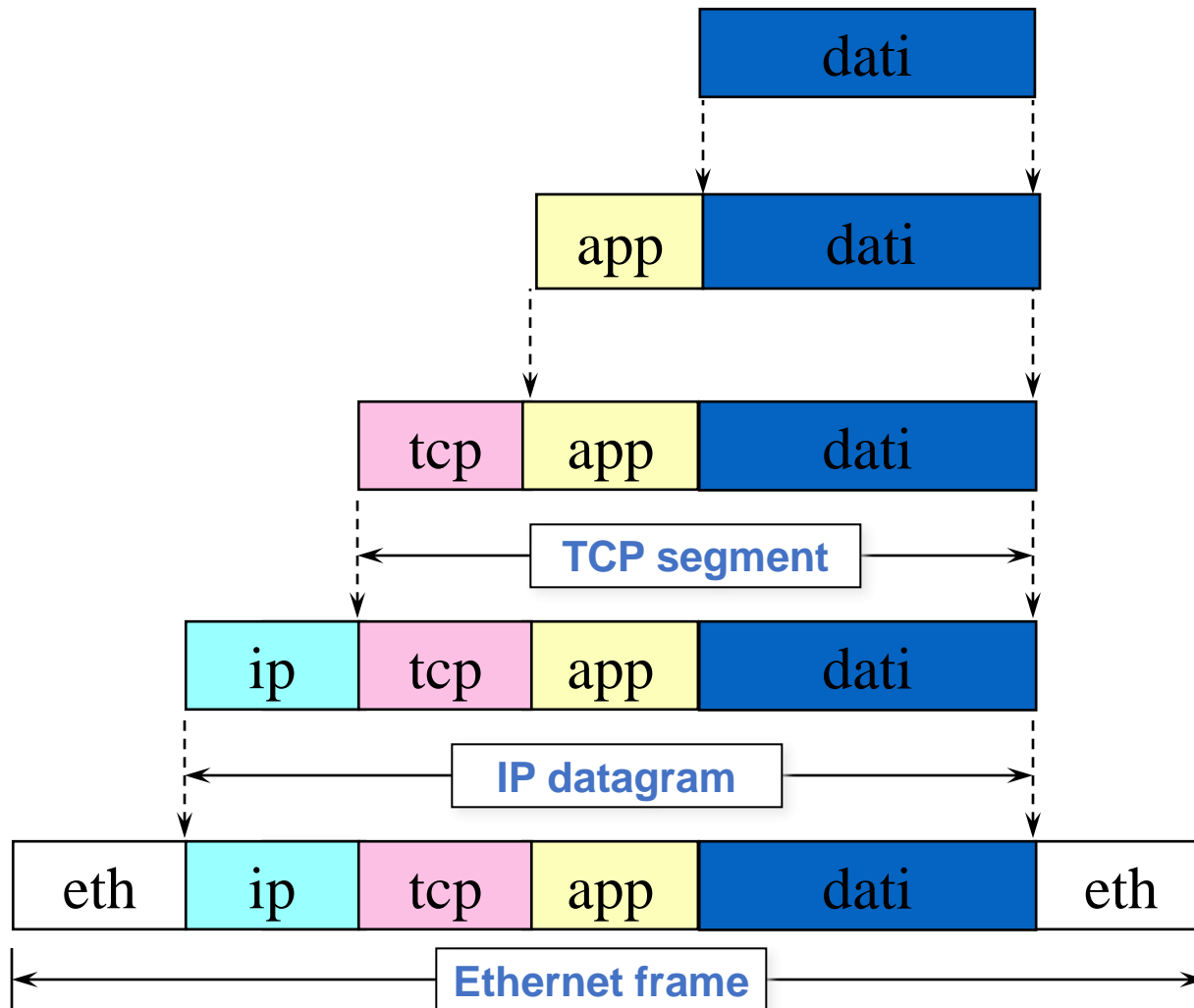
## Proprietà di IP

- Senza connessione (datagram based)
- Consegna Best effort
  - I pacchetti possono perdersi
  - I pacchetti possono essere consegnati non in sequenza
  - I pacchetti possono essere duplicati
  - I pacchetti possono subire ritardi arbitrari

## Servizi di compatibilità con l'hardware sottostante

- Frammentazione e riassemblaggio
- Corrispondenza con gli indirizzi dei livelli sottostanti (ARP)

# Il protocollo IP





# Il protocollo IP

## *In Trasmissione, IP*

- riceve il segmento dati dal livello di trasporto

Segmento dati

- inserisce header e crea datagram

IP

Segmento dati

- applica l'algoritmo di routing
- invia i dati verso l'opportuna interfaccia di rete

## *In Ricezione, IP*

- consegna il segmento al protocollo di trasporto individuato

Segmento dati

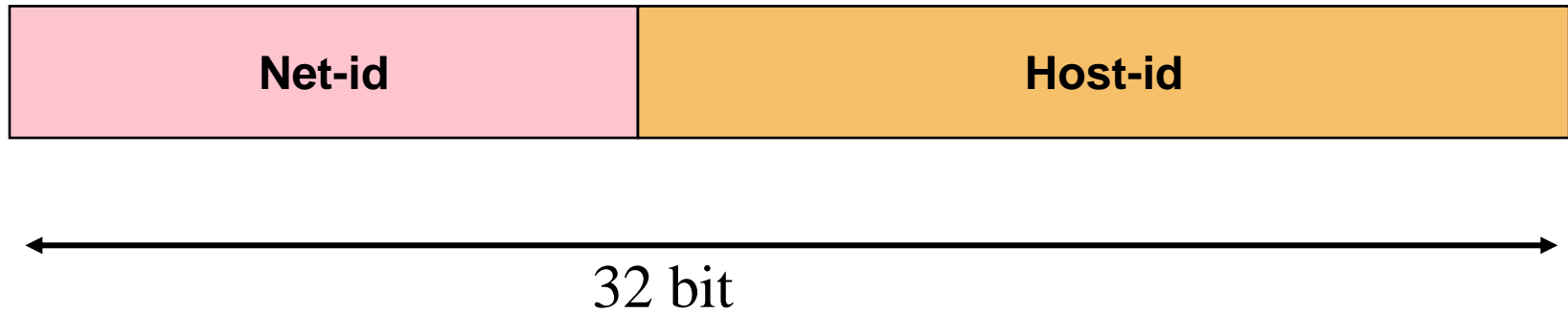
- se sono dati locali, individua il protocollo di trasporto, elimina l'intestazione

IP

Segmento dati

- verifica la validità del datagram e l'indirizzo IP
- riceve i dati dalla interfaccia di rete

# Indirizzamento



# Classi di indirizzi

**Classe A** (0.0.0.0 - 127.255.255.255)

127.0.0.0 riservato



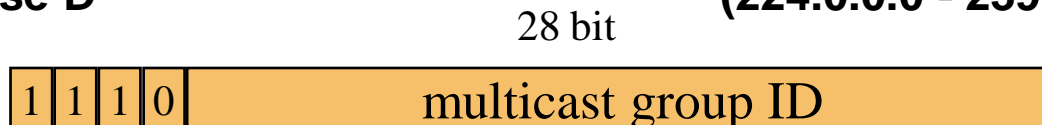
**Classe B** (128.0.0.0 - 191.255.255.255)



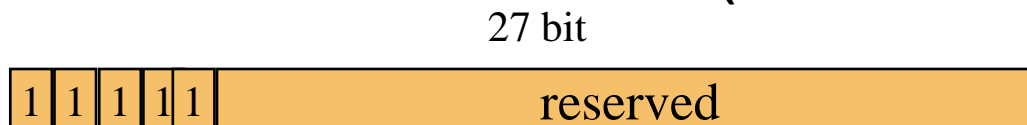
**Classe C** (192.0.0.0 - 223.255.255.255)



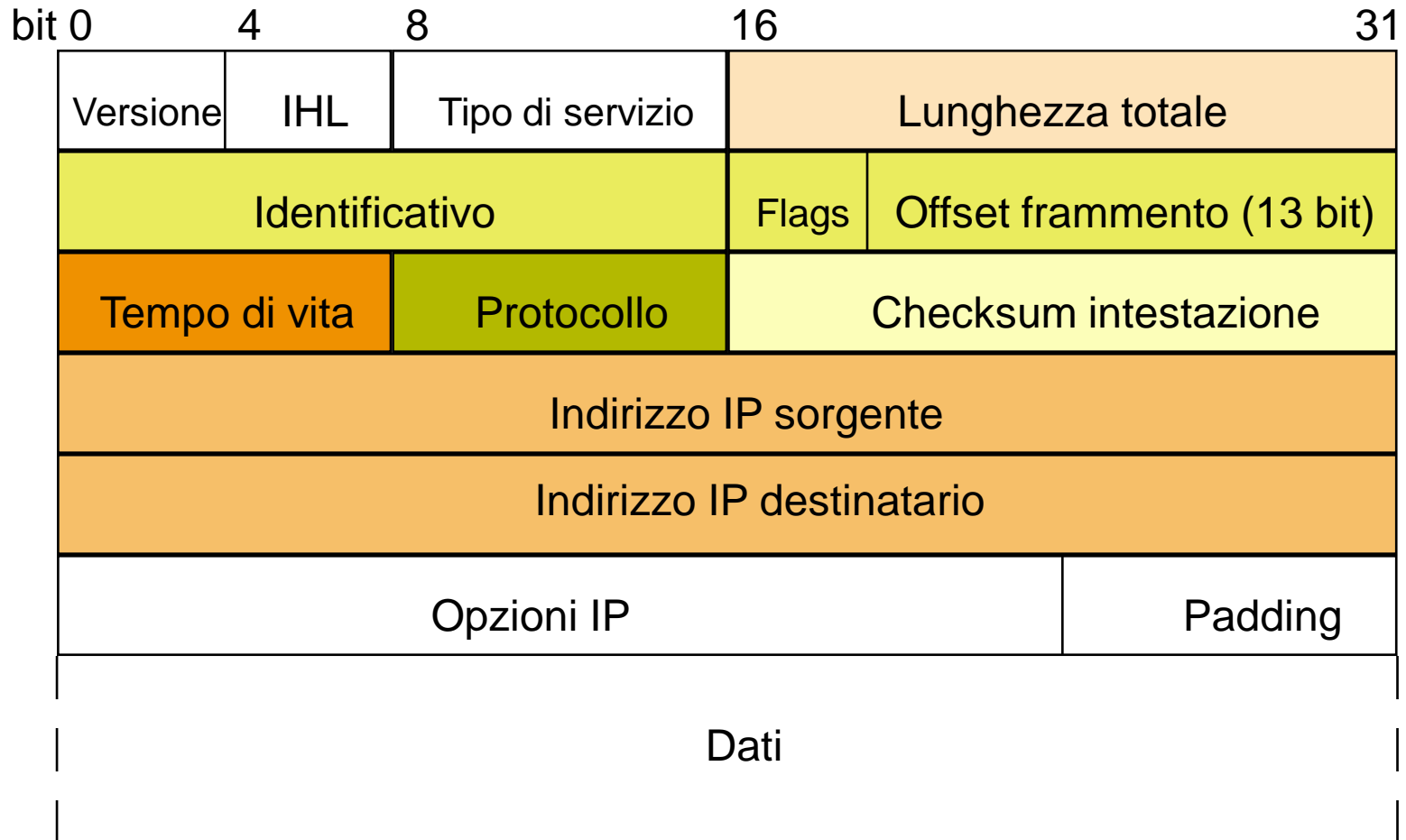
**Classe D** (224.0.0.0 - 239.255.255.255)



**Classe E** (240.0.0.0 - 255.255.255.254)



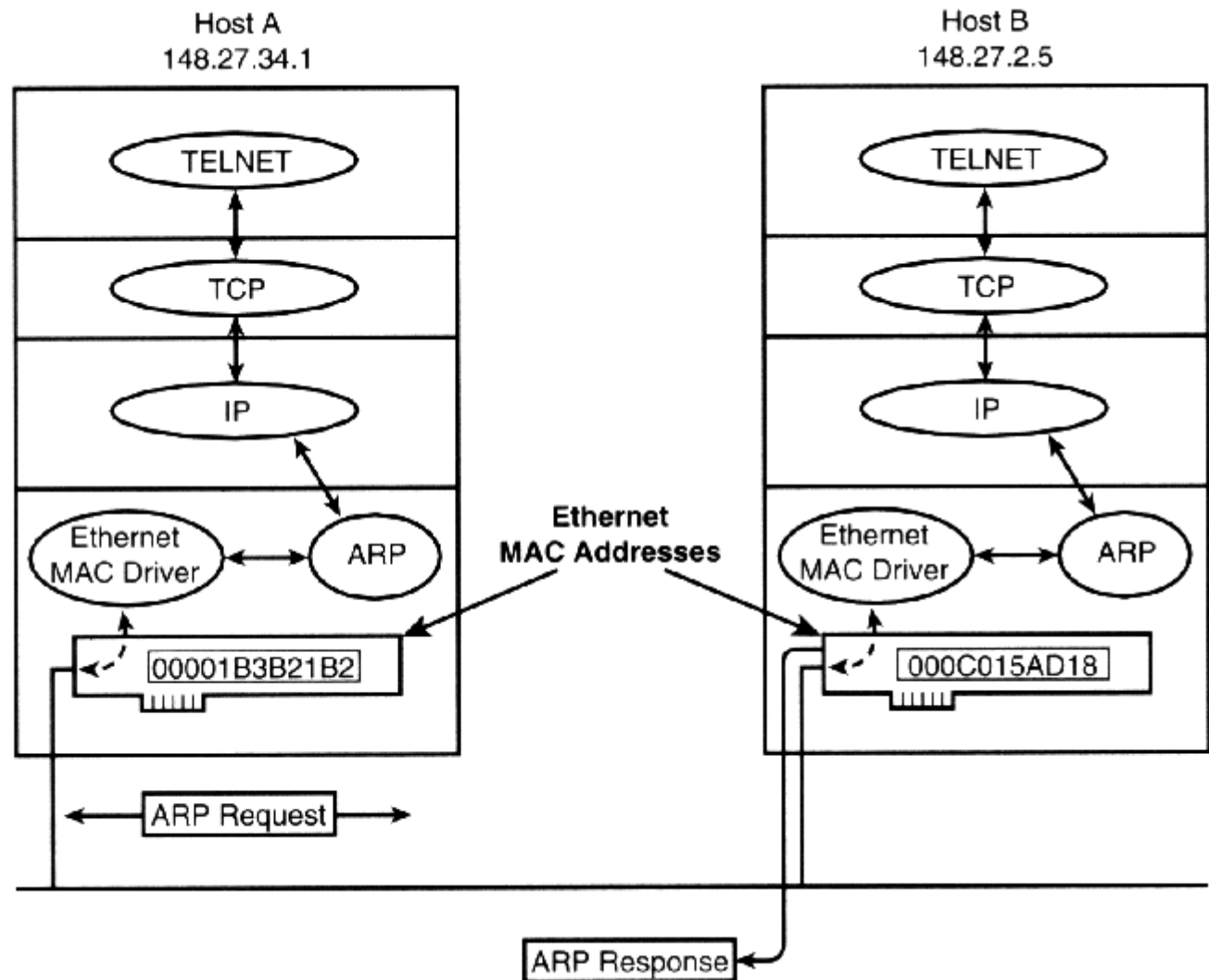
# Il protocollo IP



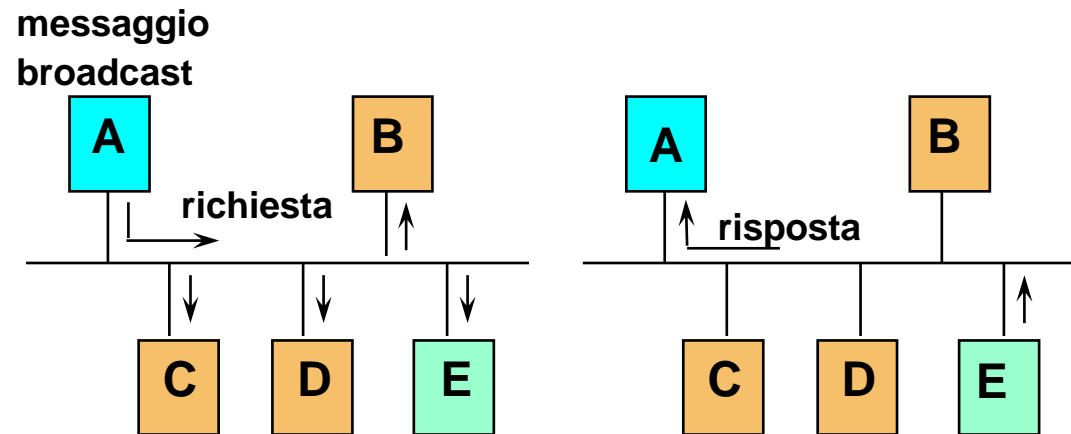
# Address Resolution Protocol: ARP

**FIGURE 4.9.**

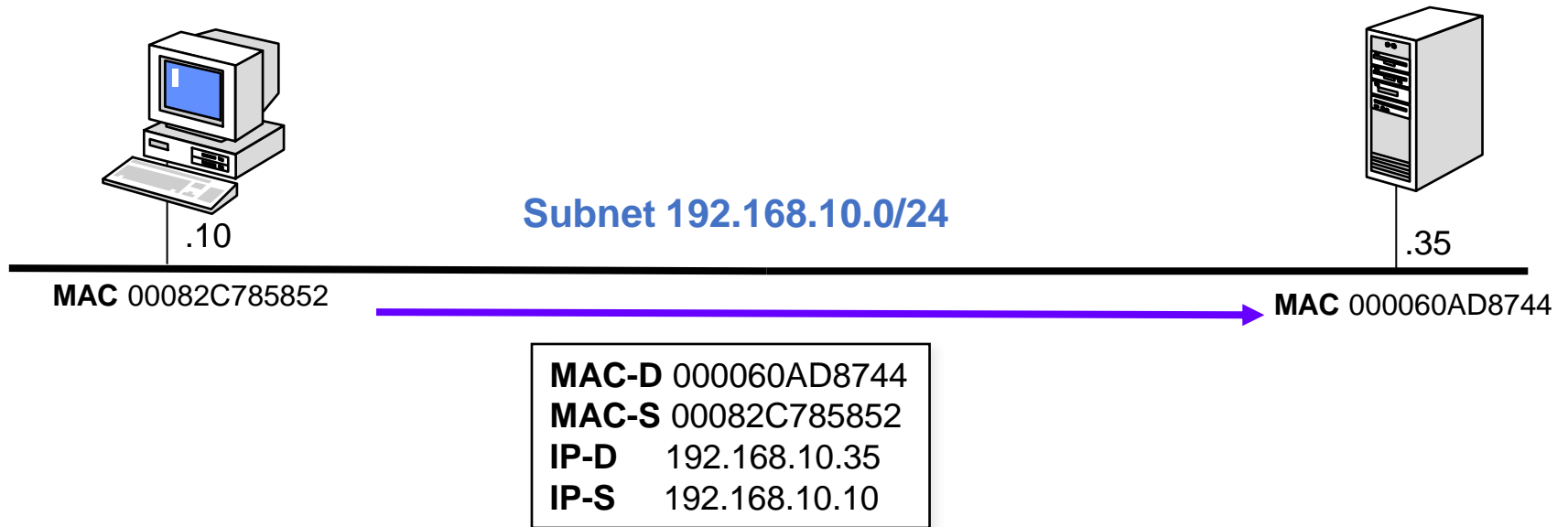
*Resolution of an IP address into its MAC address using ARP.*



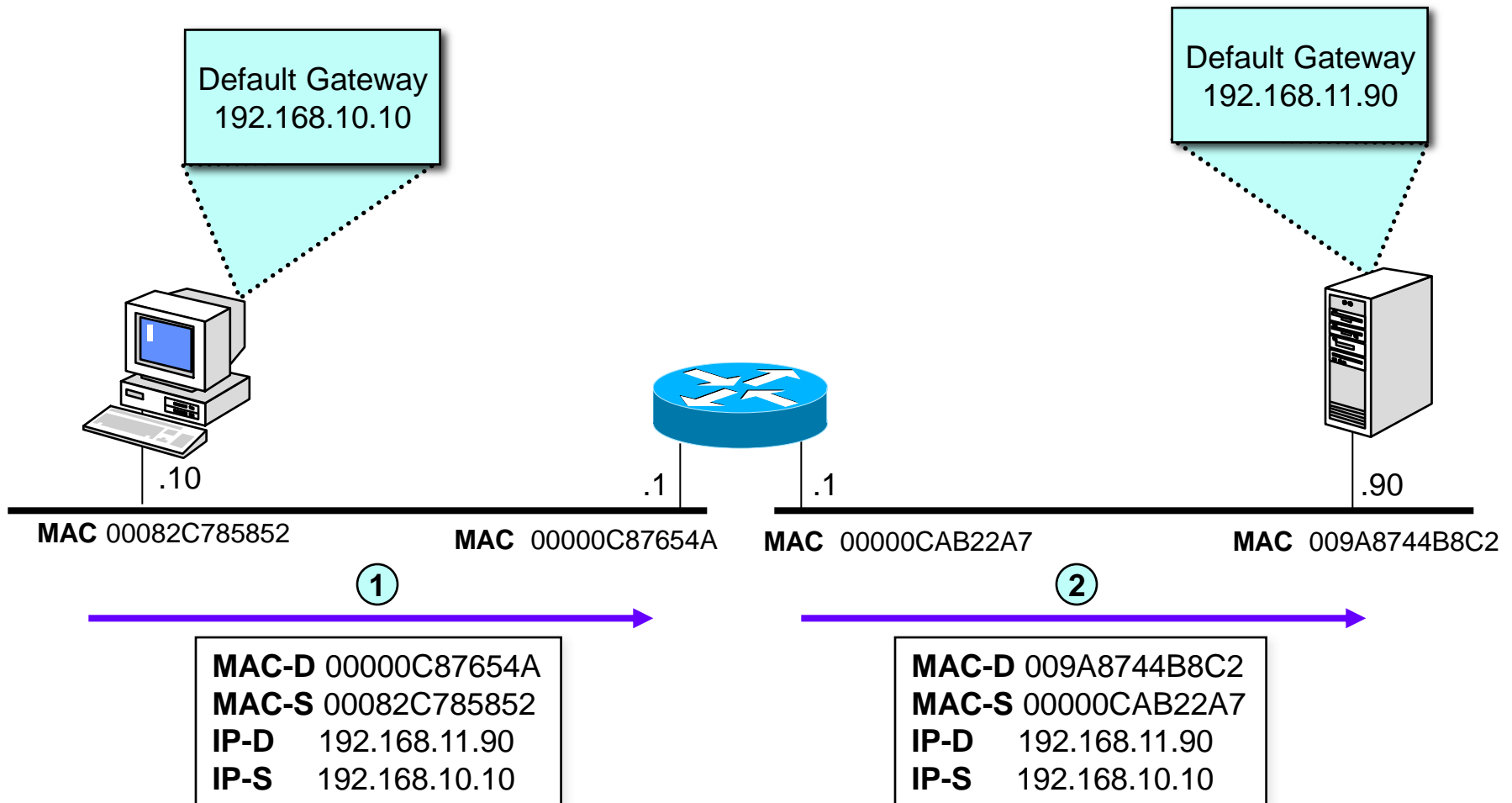
# Address Resolution Protocol: ARP



# Forwarding diretto: esempio

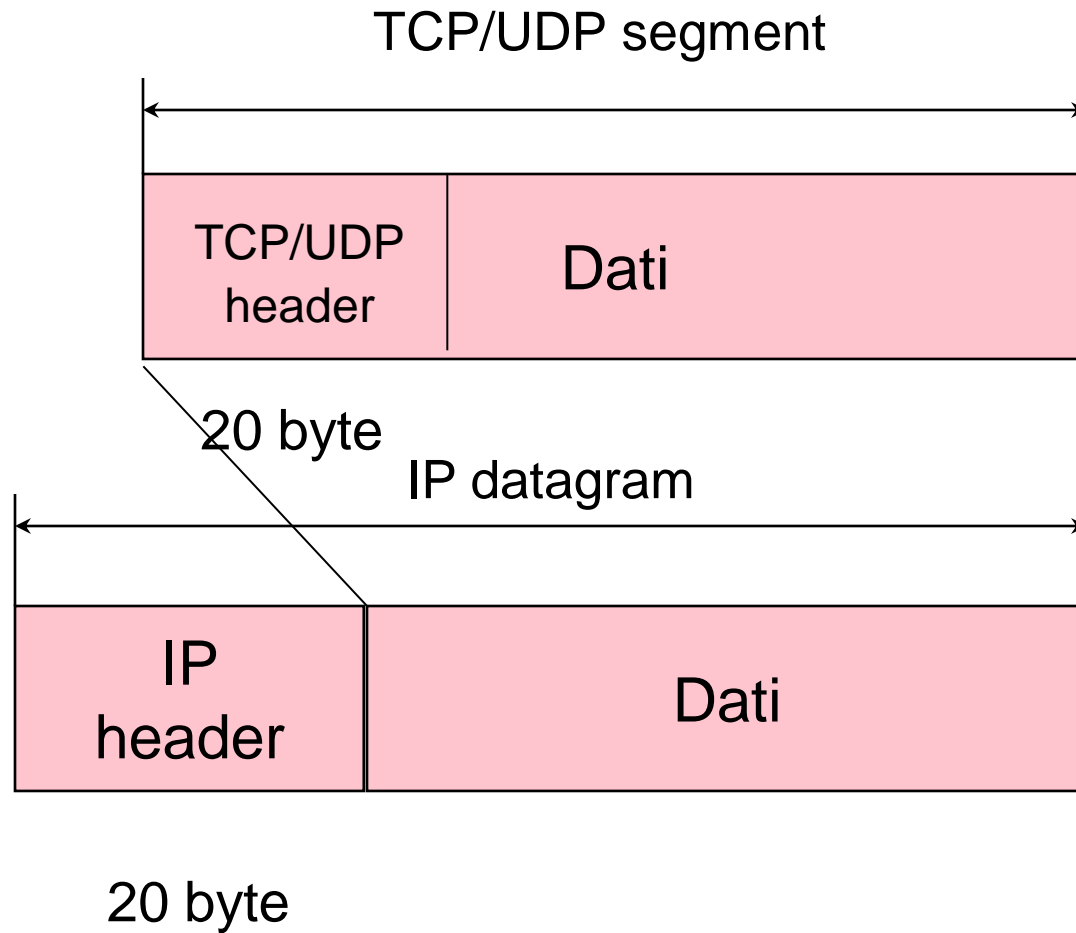


# Forwarding indiretto: esempio





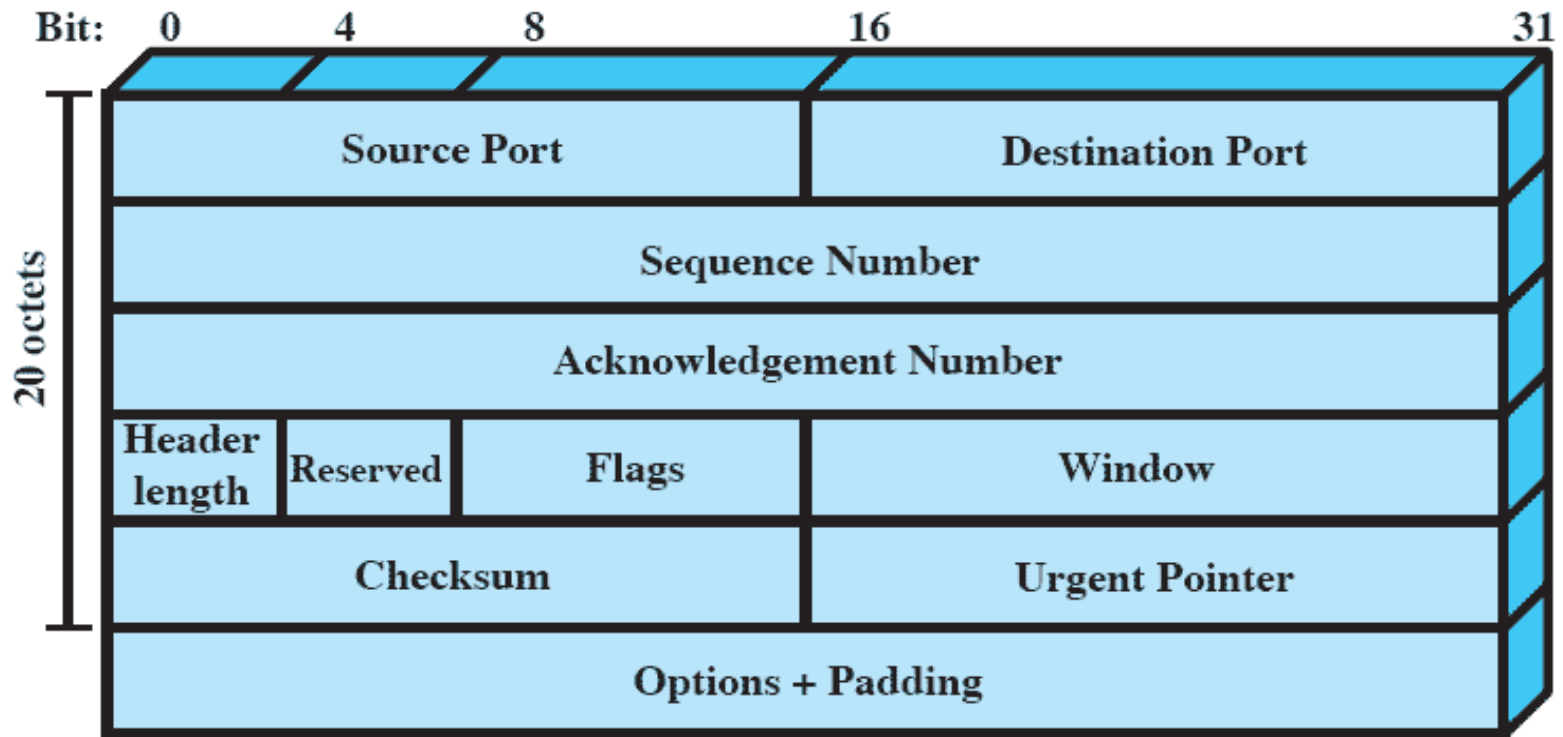
# Strato di Trasporto



# Strato di Trasporto

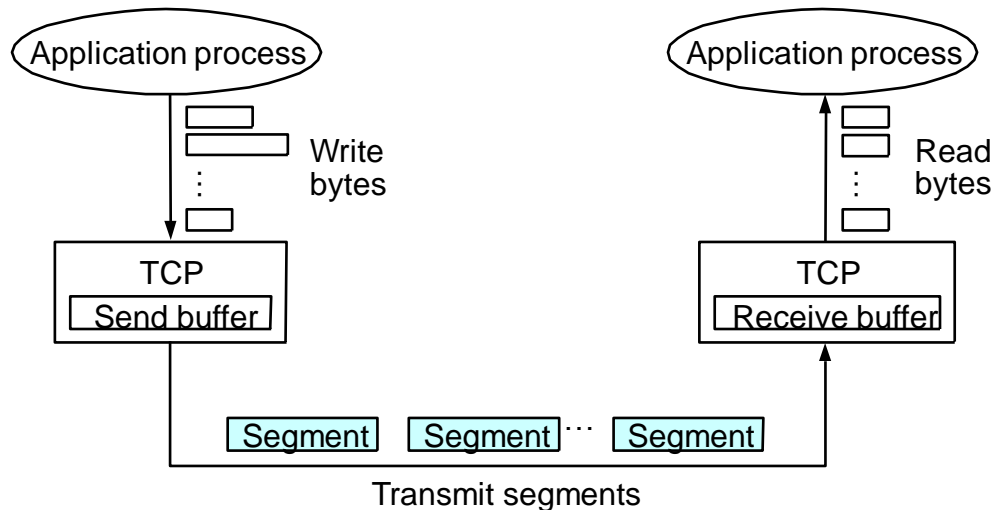


# TCP header

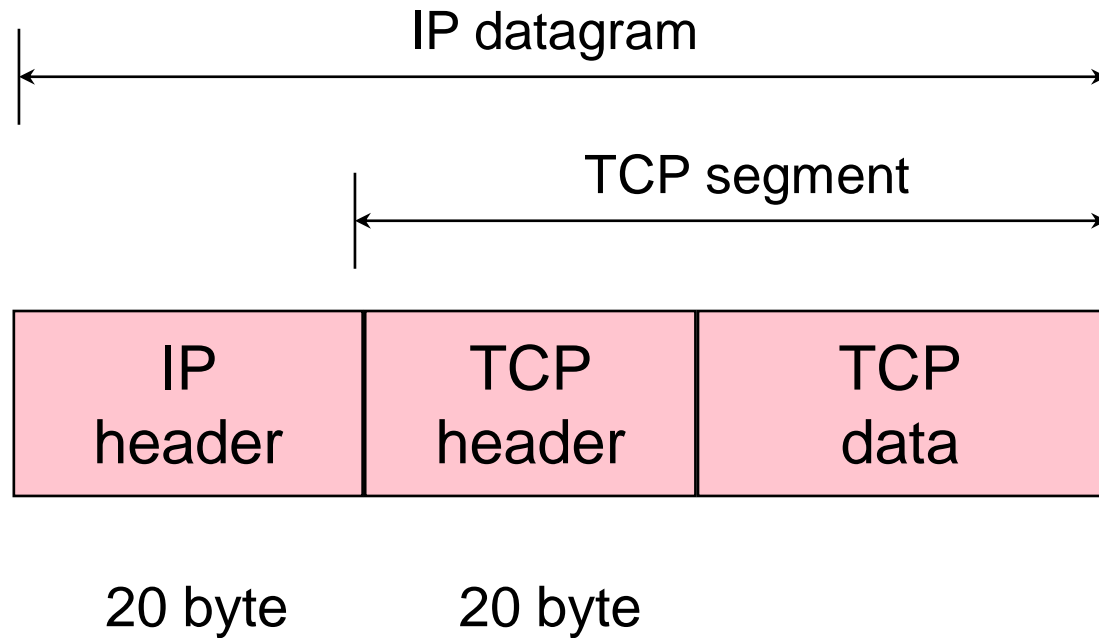


# TCP Overview

- Connection-oriented
- Byte-stream
  - app writes bytes
  - TCP sends *segments*
  - app reads bytes
- Full duplex
- Flow control: keep sender from overrunning receiver
- Congestion control: keep sender from overrunning network



# Strato di Trasporto: TCP



# UDP



- minimum protocol mechanism
  - **connectionless**
  - no guarantees about delivery, preservation of sequence, nor protection against duplication
  - useful, e.g., for transaction-oriented applications
  - multicast support



# Domain Name System (DNS)

