Nomadic Communications

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http://disi.unitn.it/locigno/index.php/teaching-duties/nomadic-communications

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What do you find on the web site

- Exam Rules
- Exam Details … should be on ESSE3, but …
- Generic (useful) information
- Teaching Material: normally posted at least the day before the lesson
- Additional Material and links
- Laboratories groups, rules, description and hints
- News, Bulletin, How to find and meet me and Francesco, etc.

- …

The web site is work in progress (well as of today working badly, but improving)
and updated frequently (that's at least my intention)
Please don't blame ME if you did't read the last news ☺

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- **Why "Nomadic"**
  - Mobile vs. nomadic
  - Cellular vs. HotSpot
  - Local wireless communications
- **Some rehearsal**
  - Access Control Protocols
  - Protocols and architectures
  - Services and primitives
  - IEEE 802 project
  - Nomadic communications positioning

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- **WLAN**
  - 802.11 Standard
  - 802.11 MAC
  - 802.11b/g/a/h/n/ac PHY
  - QoS and Differentiation enhancement: 802.11e
  - Mesh networks: 802.11s & other protocols
  - Other extensions: 802.11f/p/ad/ad/...

- **Ad-Hoc Networks**
  - Stand-Alone WLANs
  - Routing and multi-hop in Ad-Hoc networks
- **Vehicular Networks**
  Problems and scenarios
  - Specific issues
  - 802.11p and WAVE

Laboratories

- Intended to be **experimental** labs
  - Hands on the material (hardware/software)
  - Configuration of devices
  - **Protocols (MAC) manipulation/design** and results interpretation
- Centered on 802.11 (b/g at 2.4GHz)
  - They are not meant to cover all the course material
  - We have bought the OpenWWF enabled boards to play with
  - They are not meant to give you **notions** but a **working methodology**
- **More on Labs Later**

Why Nomadic

- Cellular Networks widely diffused
  - Expensive
  - Omnipresent (or nearly so…)
- The Internet *while around* requires
  - Different (faster/cheaper) network
  - Don’t need to use it while *moving*
  - Want to have it “*around*” but not necessarily *everywhere*

A Fundamental Difference

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Wireless Network

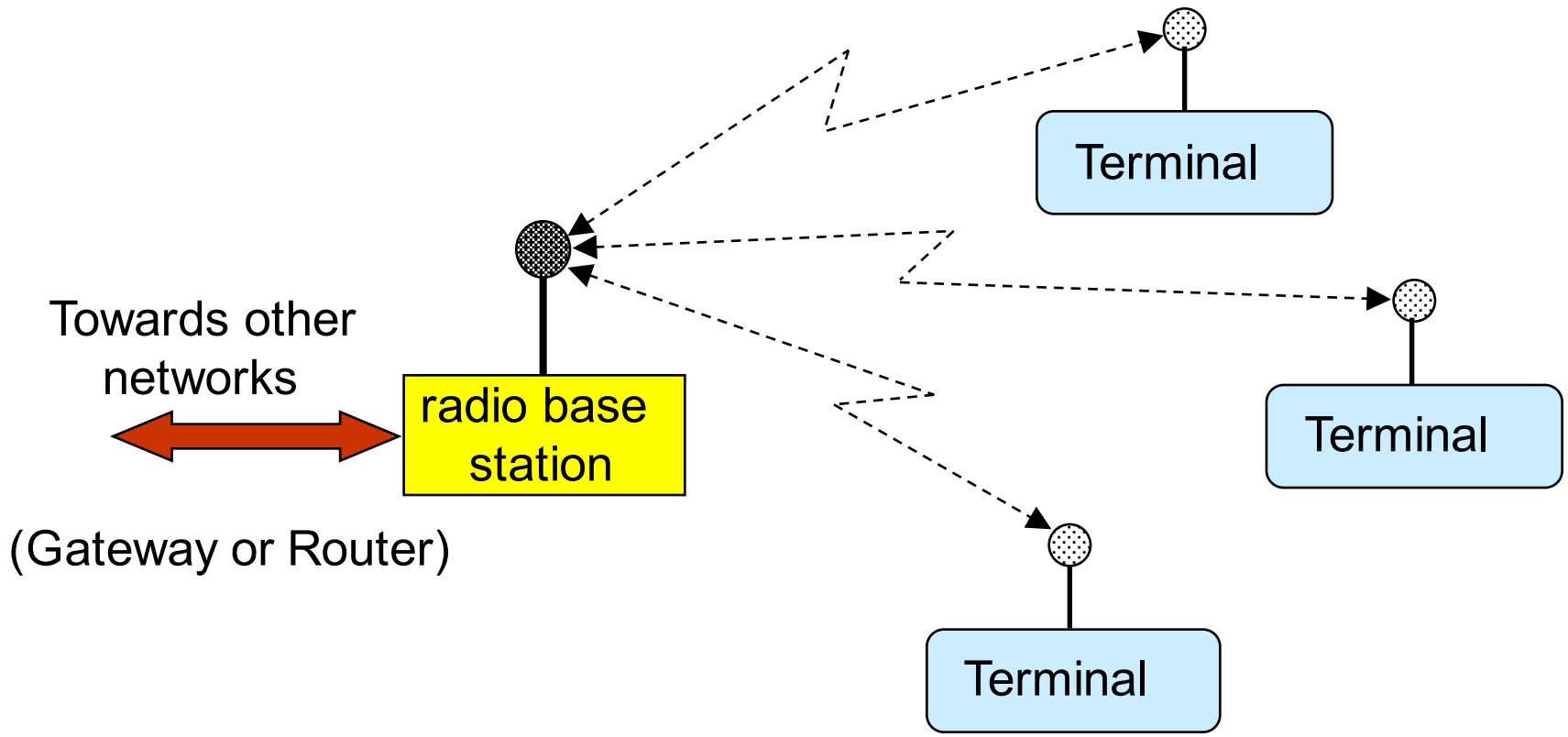
(sub)net where the access is on a

tetherless channel, can be your cordless at home!

Cellular Network

a global network where the topological coverage is obtained with a set of adjacent or overlapping areas called *cells.* The mobile terminal (user) can move from one cell to the other keeping the communication seamlessly active

Wireless Network with a Fixed PoA



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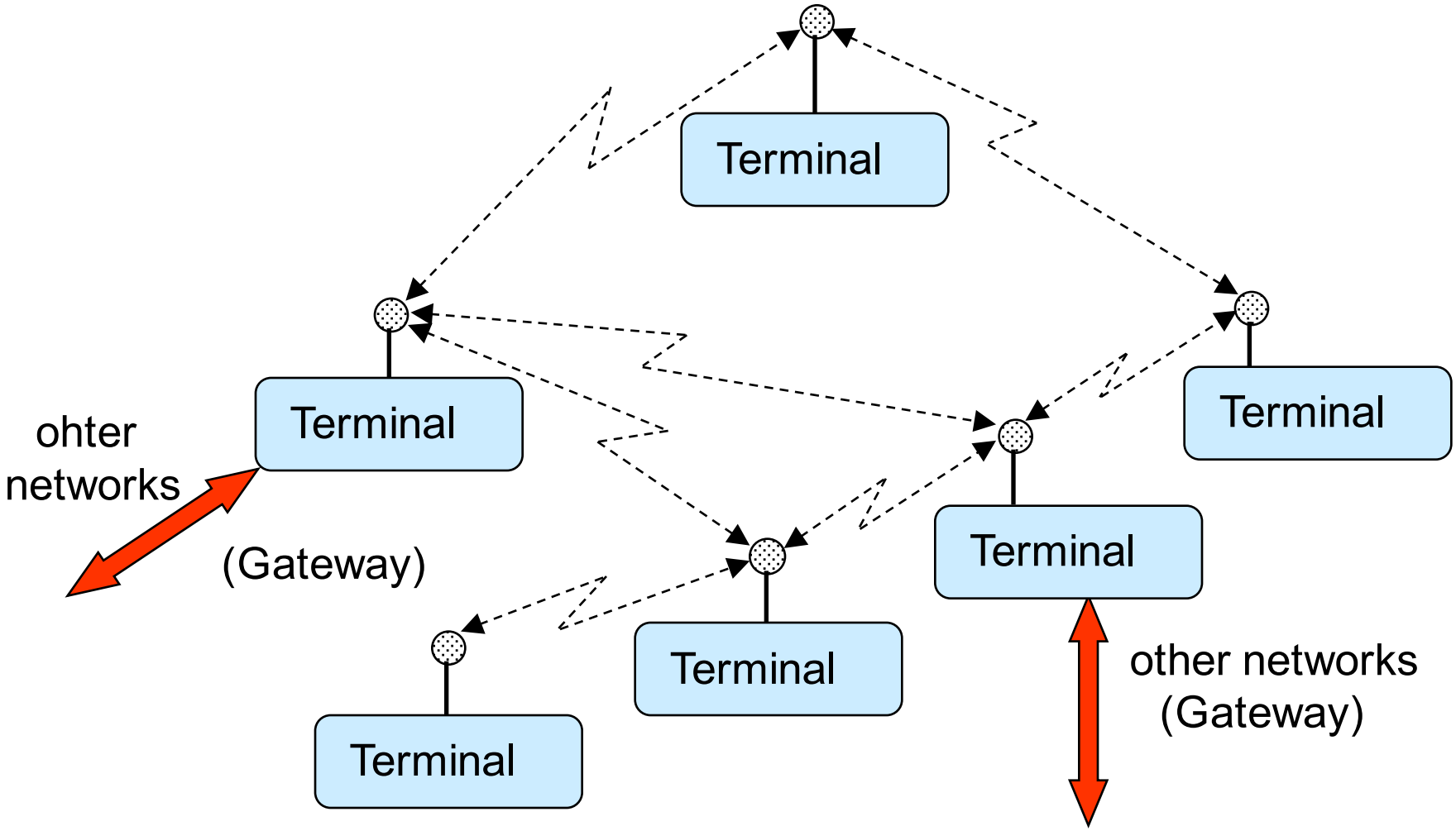
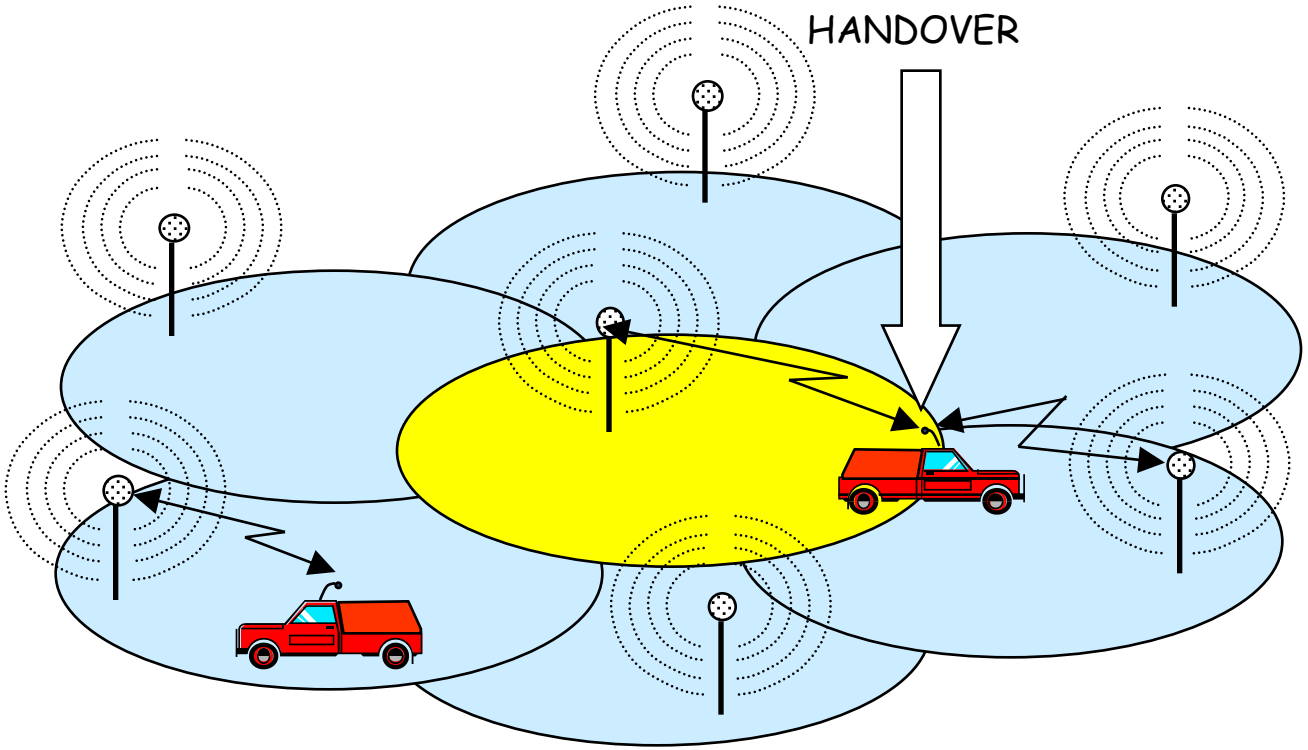


Cellular Network



Wireless Local Access

- Nomadic communications are characterized by a first (second, third ...) wireless hop, then a connection to the global network
- Short range radio
- Normally shared medium
- Generally Best-Effort
- Need for authentication, identification, authorization (or not??)
- Open Access is not sustainable (at least for HotSpots and professional support) and often barely legal

Access Protocol Rehearsal

what you *already know* but don't *remember*

what you *should know* but are not *aware of*

☺

Classification of LAN MAC

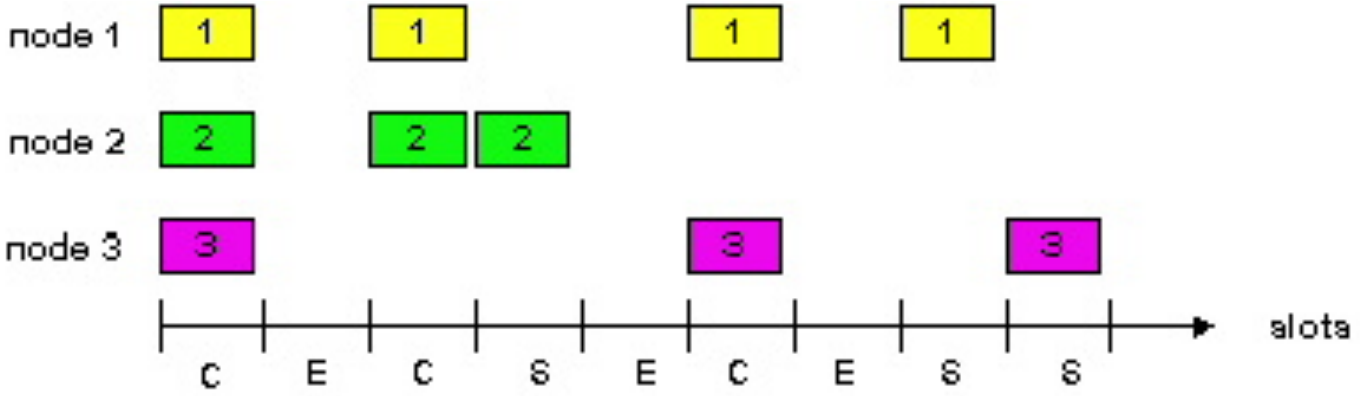
- 3 types
  - Contention or Random Access (Aloha, CSMA/CD, Ethernet)
  - Ordered Access (Token Ring, Token Bus, FDDI)
  - Slotted with reservation (DQDB, Res-Aloha)
- Evaluation/Performance Parameters
  - Throughput (capacity and carried traffic)
  - Fairness
  - Delay (access, propagation, delivery)
  - Topology, Resilience, Network dimension, Number of Stations, ...

Random Access Protocols

- A node in transmit a packet
  - At line speed R
  - without coordination with others
- If more than one node transmit at the same time..... ..... $\Rightarrow$ collision
- Random Access (or contention based) MAC protocols specify:
  - How to randomize the initial access
  - How to recognize a collision
  - How to retransmit the packet after a collision

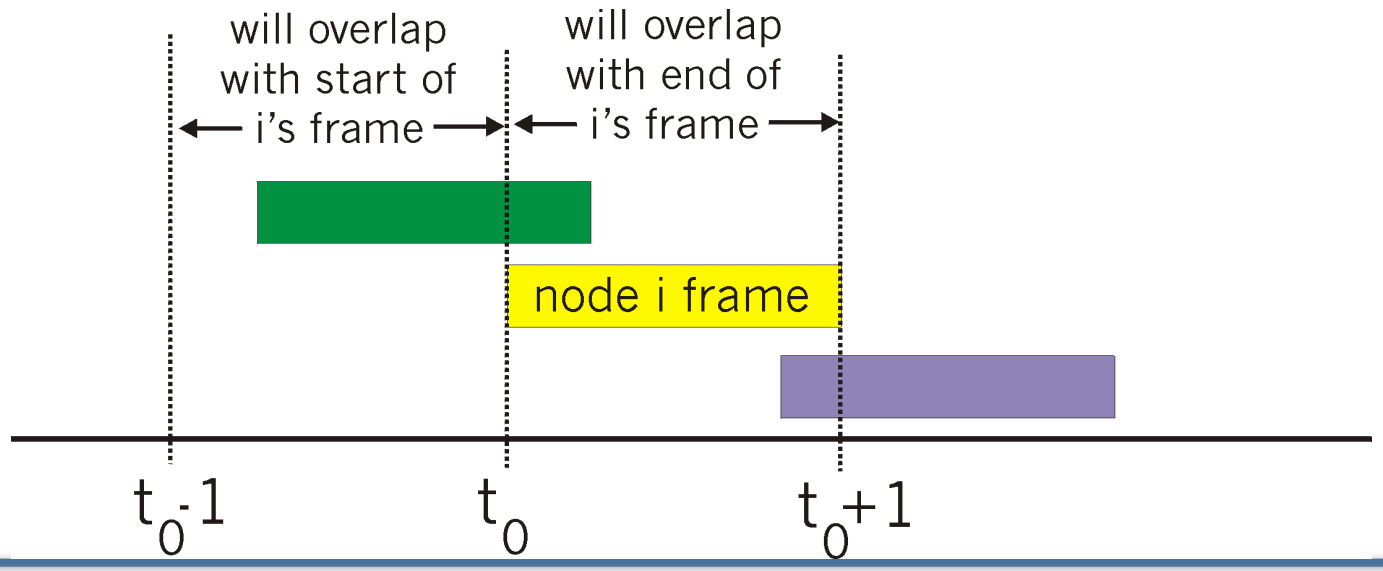
Slotted Aloha

- Time is divided in equal length slots
- Nodes transmit at the beginning of the slot only
- In case of collision retransmit either with probability p in the next slot or after a random delay of n slots until success



Success (S), Collision (C), Empty (E) slots

- Simpler, no slots no synchronization
- Transmission at any time, retransmission too, only random delay possible after collisions
- Collision probability is increased
  - yellow packet collides with other packets in $[t_0-1, t_0+1]$



Comments

- Simple protocols
- Throughput is very limited due to collisions
  - with Poisson arrival hypotheses the maximum efficiency is
    - 18% ALOHA
    - 37% SLOTTED ALOHA
  - With other traffic may be larger/smaller
- Unstable protocols (throughput goes to zero at high loads)!!!
- At low loads access delay is close to zero
- Access delay is not guaranteed nor bounded!!

Aloha: homework

- Compute collision probability and throughput in case of Poisson Arrivals
  - Compare with collision probability and throughput of Aloha and explain differences
- Compare the p-retransmission policy with the delayed retransmission one
  - are they equal? in what conditions?

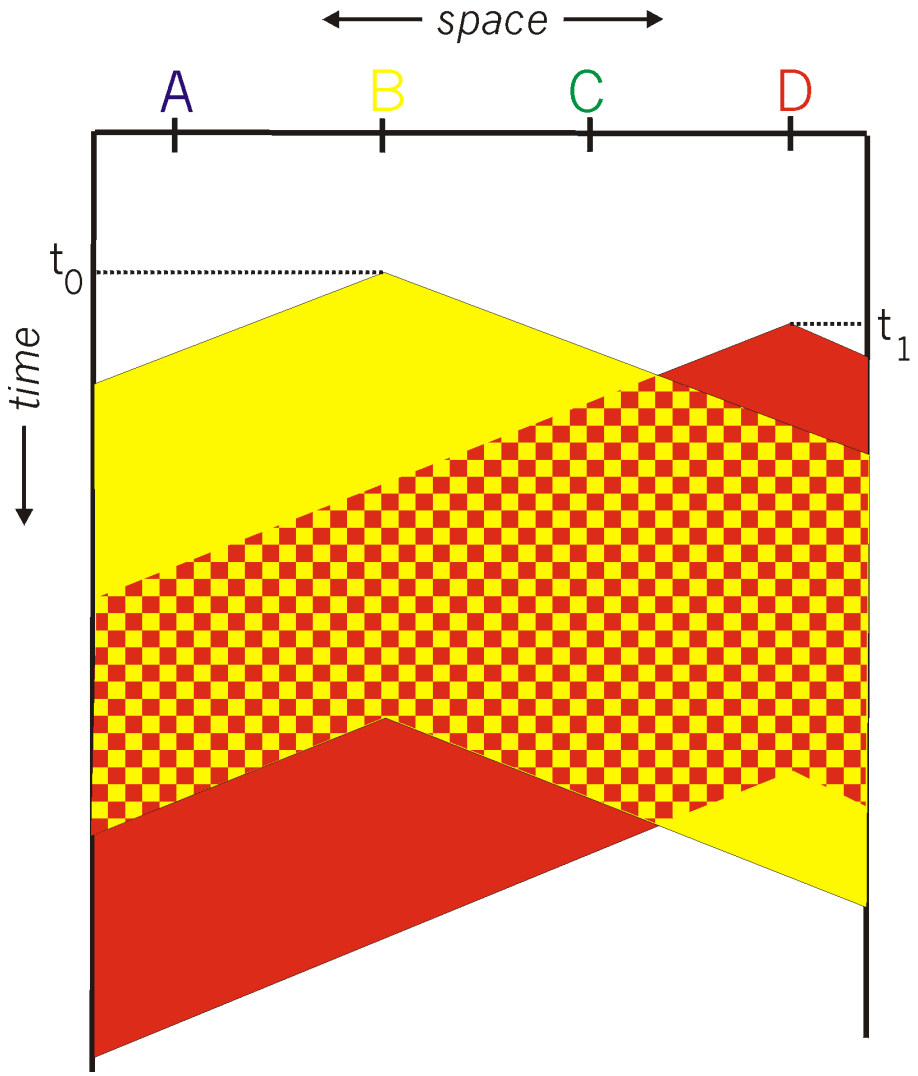
- The homework can be done in 2 or 3, this can be the occasion to start forming groups for labs
  - Homworks are part of the program … don't blame me if you cannot answer brilliantly about them at the oral

CSMA: Carrier Sense Multiple Access

- Conceived to increase throughput
- Stations listen to the channel before transmitting
  - If channel is free: Transmit Packet
  - If channel is occupied delay transmission
    - 1- persistent CSMA: Immediate transmission on free channel
    - 0-persistent CSMA: Retry after a long random delay
    - p-persistent CSMA:
      - With probability p behaves as 1-persistent
      - With probability (1-p) behaves as 0-persistent

CSMA: collisions???

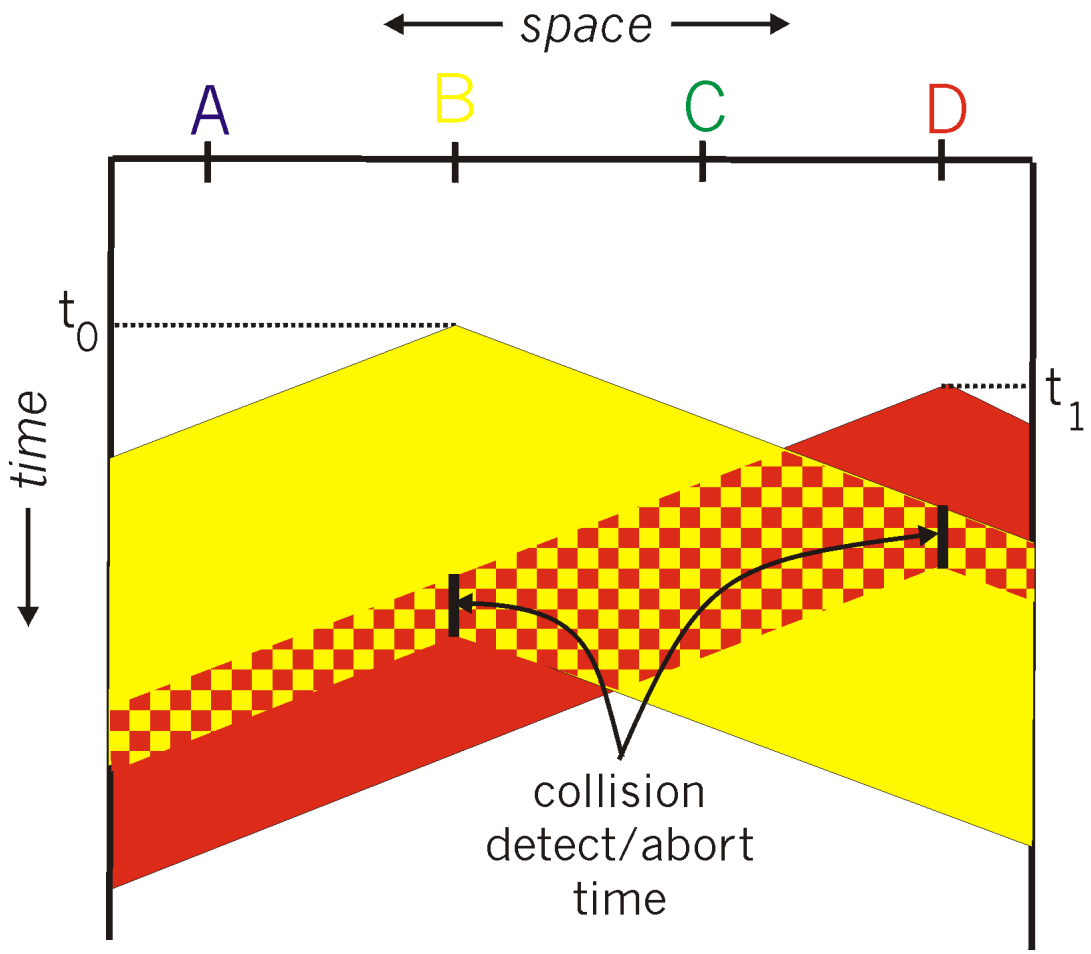
- May happen due to propagation delay
- Transmission time is entirely wasted
- Distance between stations plays a fundamental role in the collision probability



CSMA/CD (Collision Detection)

- CSMA/CD Builds on top of CSMA
  - Try to understand when a collision occurs and stop transmission
  - Wasted time is reduced
- Collision detection:
  - Easy on wired LANs: Simple power measurement with threshold comparison between transmitted and received power
  - Practically impossible in WLANs
    - Half Duplex
    - Power fluctuation/Power attenuation

CSMA/CD collision detection



CSMA/CD: Performances

- The fundamental parameter is end to end propagation delay
  - More precisely what counts is the ratio between the (average) packet transmission time and the e-t-e propagation delay
- Performances are optimal for small, slow (in terms of transmission speed) LANs with large packet dimension
- There is a minimum packet size required to identify collisions

CSMA/CD: Performances

- The 1-persistent behavior is normally preferred for the low access delay at low loads
- The protocol is instable, just like any contention based protocol without “corrections”
  - Exponential backoff on transmissions to induce stability
  - Dimension and No. of stations limits adapted to backoff
- It’s not easy to introduce traffic differentiation and priority
- **This is Ethernet !!**

Protocols and Architectures

understand the “world” we’re moving in

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- ITU-T & ISO definition:
  - **Communication**: information transfer following predefined conventions
- Communication require cooperation
- An abstract description of communication among two or more users requires a

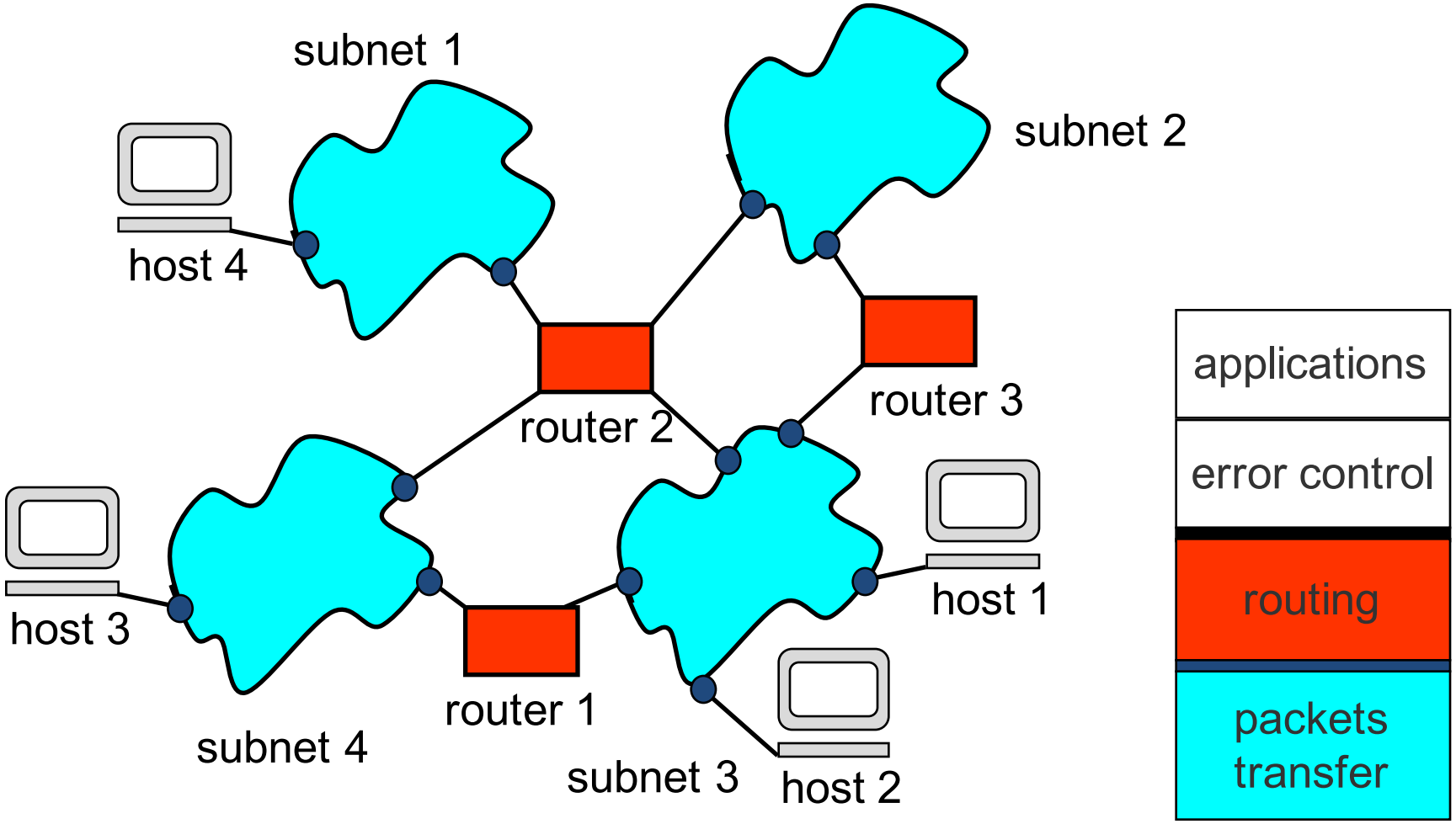
  reference model
- The highest level abstraction of a reference model defines a

  network architecture

Network (Protocol) Architecture

- A network architecture defines the *objects* and *entities* used to describe:
  - The communication process
  - Relationships among these objects/entities
  - Functions required for communication
  - Organization modes of these functions
- Modern communication architectures are layered
  - Easier design
  - Easier management
  - Easier standardization and grater modularity
  - Function separation

Function separation: Internet



Protocols

- ITU-T & ISO definition (once again!)
  - formal description of the procedures adopted to ensure communication among two or more objects **at the same hierarchical level**
- Protocol definition (design):
  - Semantic
    - **The ensemble** of commands and responses
  - Syntax
    - **The structure** of commands and responses
  - Timing
    - **Temporal sequences** of commands and responses (procedures)

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- In other words:
  - Semantics
    - Algorithms
  - Syntax
    - Formats
  - Timing
    - State machines and sequential diagrams

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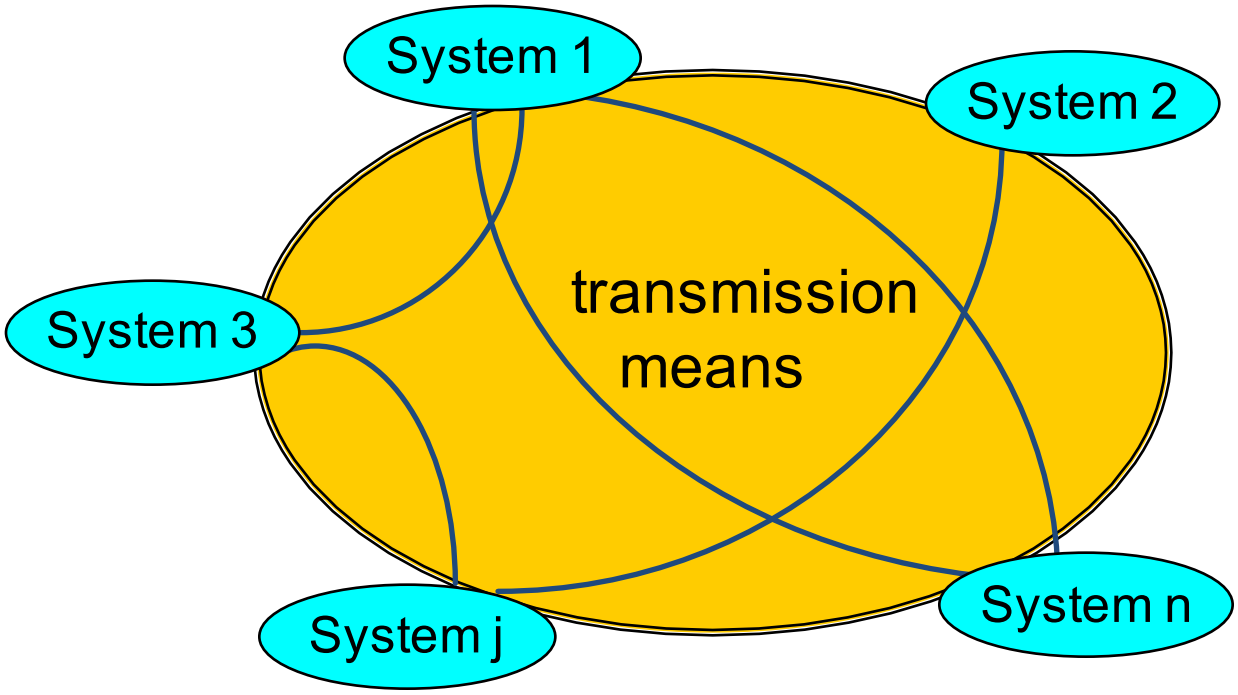
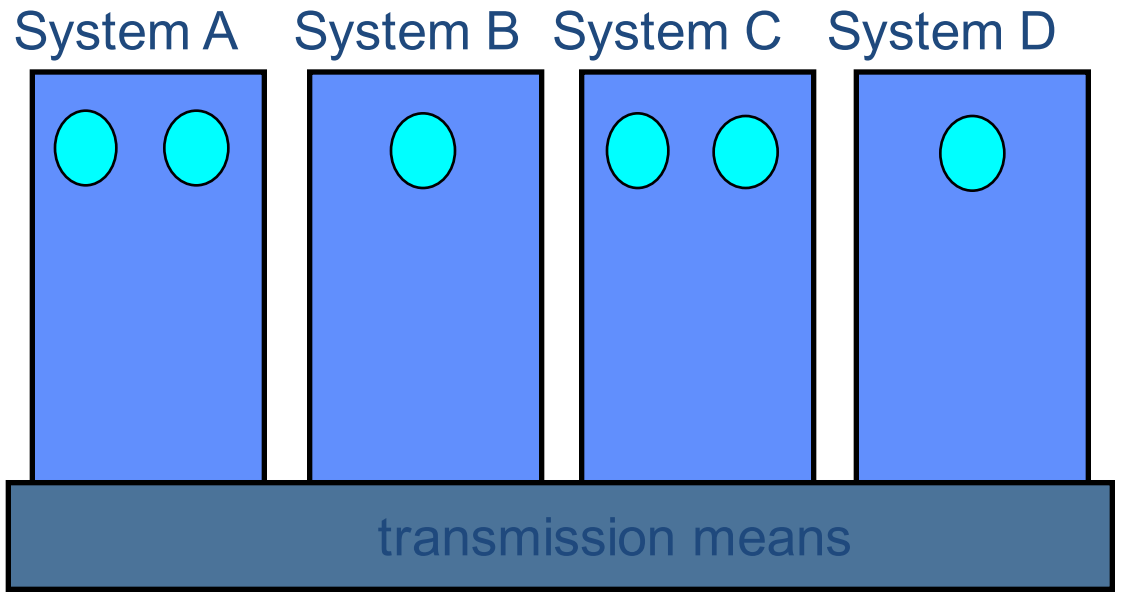
- (Open System Interconnection) is today the basis (sometimes disregarded for ignorance and sometimes questioned for philosophy) for any protocol design, from the physical layer to the application layer ... to overlay structures such as web-services and peer-to-peer systems

- We are talking about **principles**, not the detailed functionalities and not even the detailed layers, objects, entities

OSI Reference Model

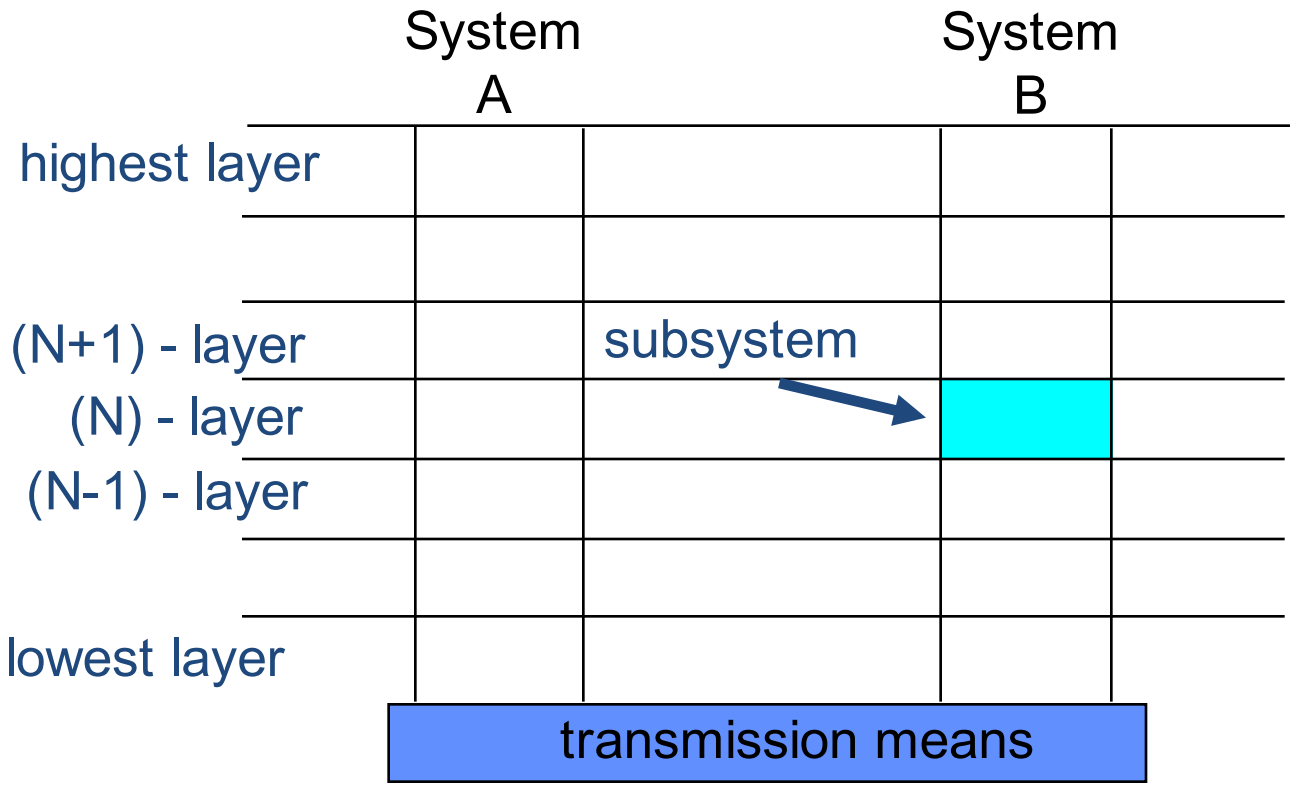


OSI Reference Model

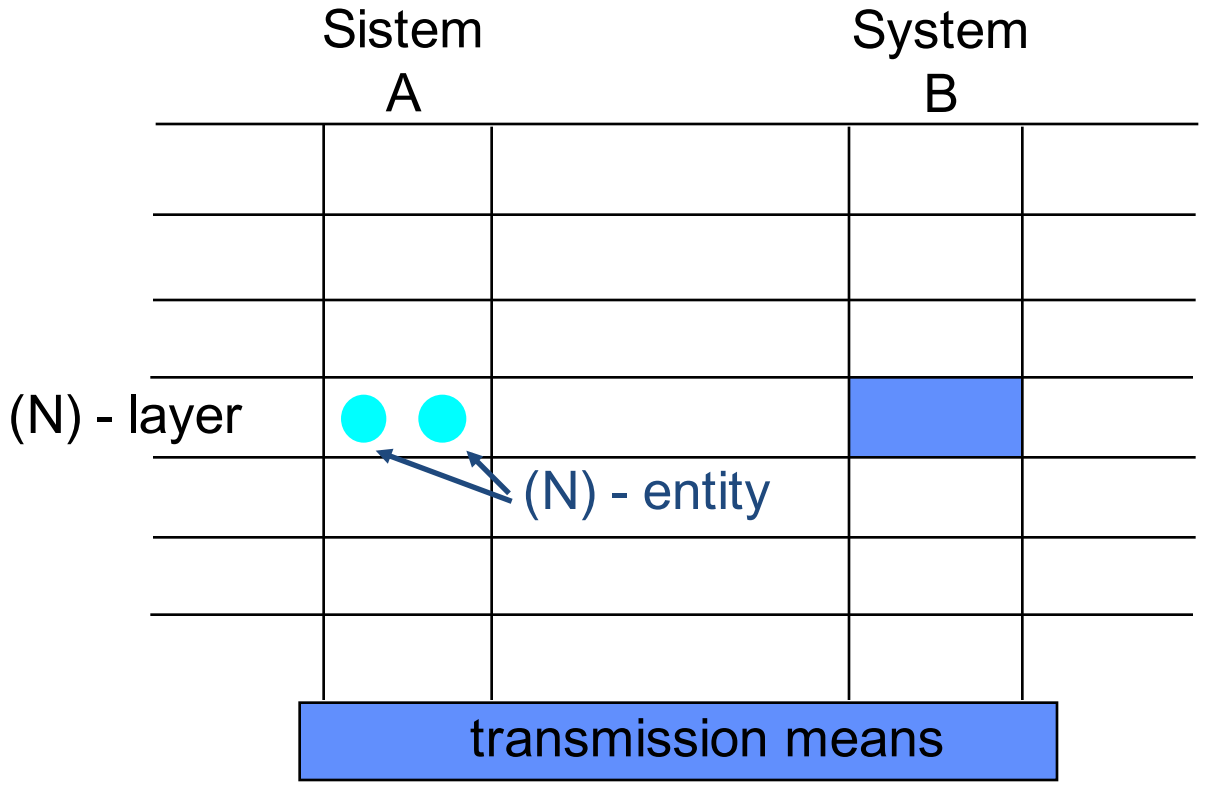


application processes

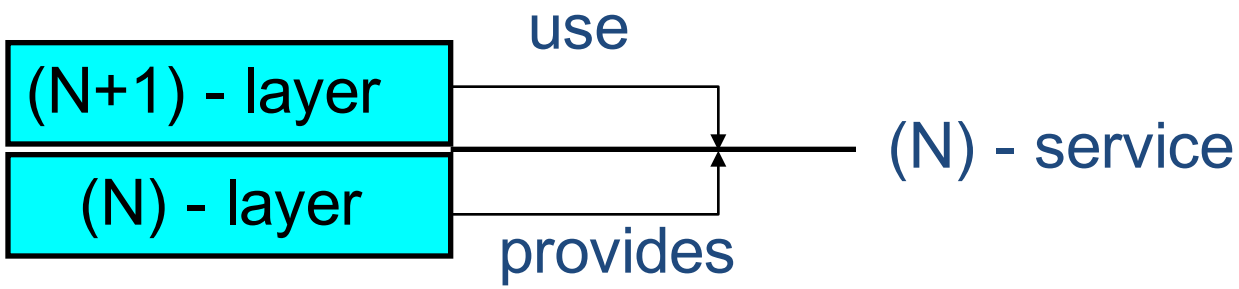
Layers


System A
System B
highest layer
(N+1) - layer
subsystem
(N) - layer
(N-1) - layer
lowest layer
transmission means

- Active elements in a sub-systems
- Fulfill layer operations
- Interact with peer entities

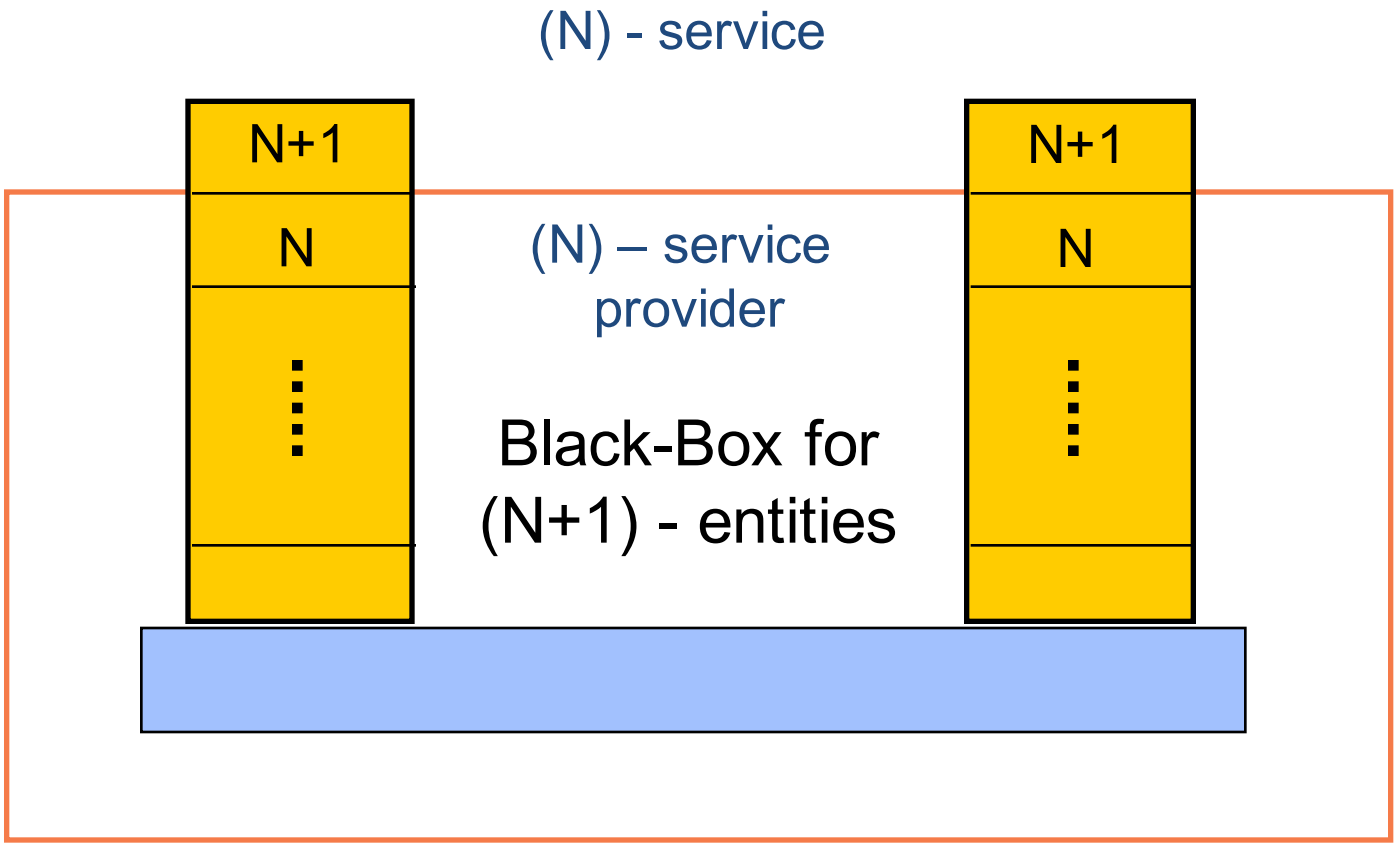


- N-layer users –(N+1) – entities– cooperate and communicate using the (N)-service provided by the (N)-service provider

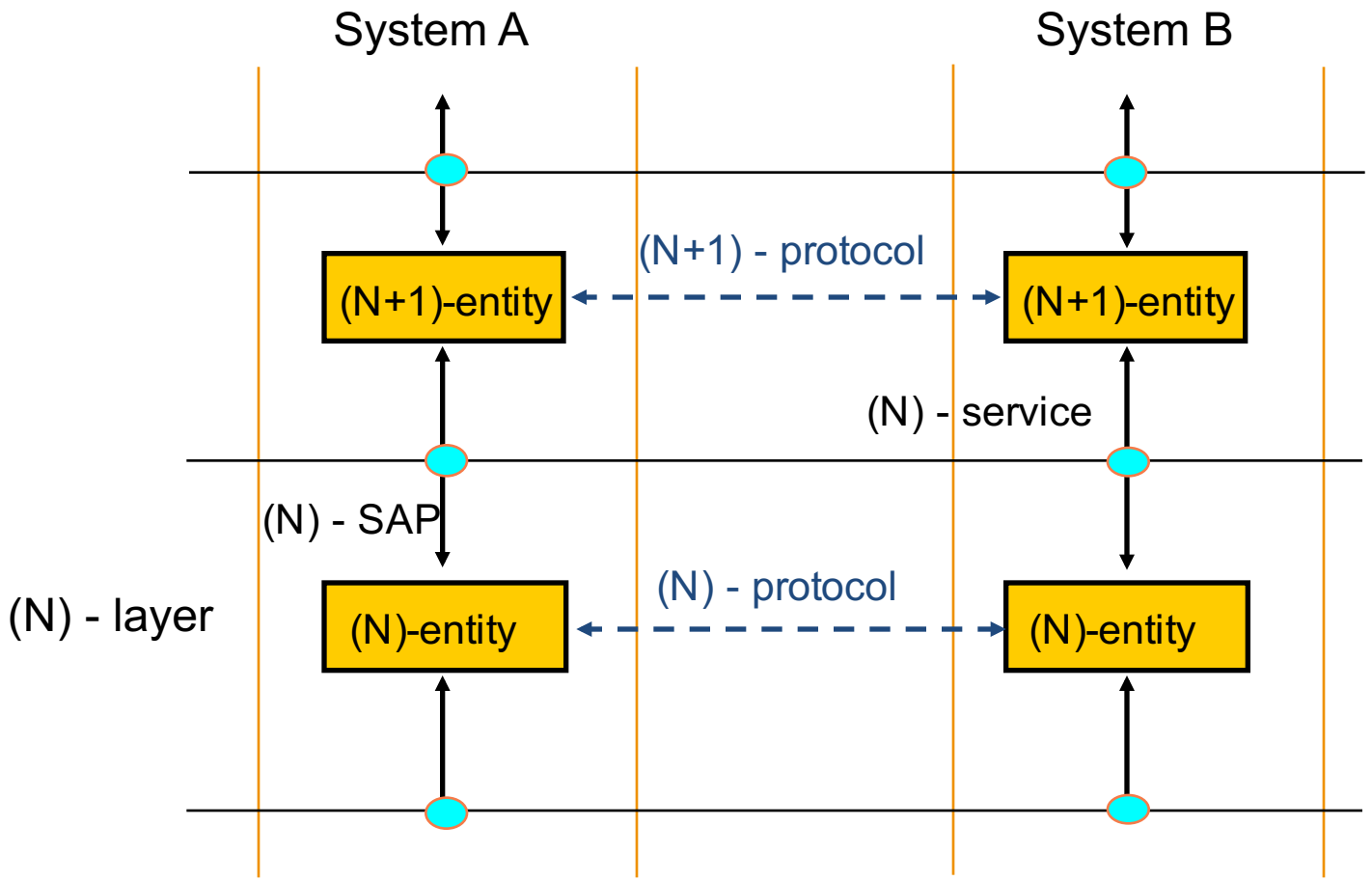


- In TCP/IP this are the “socket” between application layer protocols and TCP/UDP

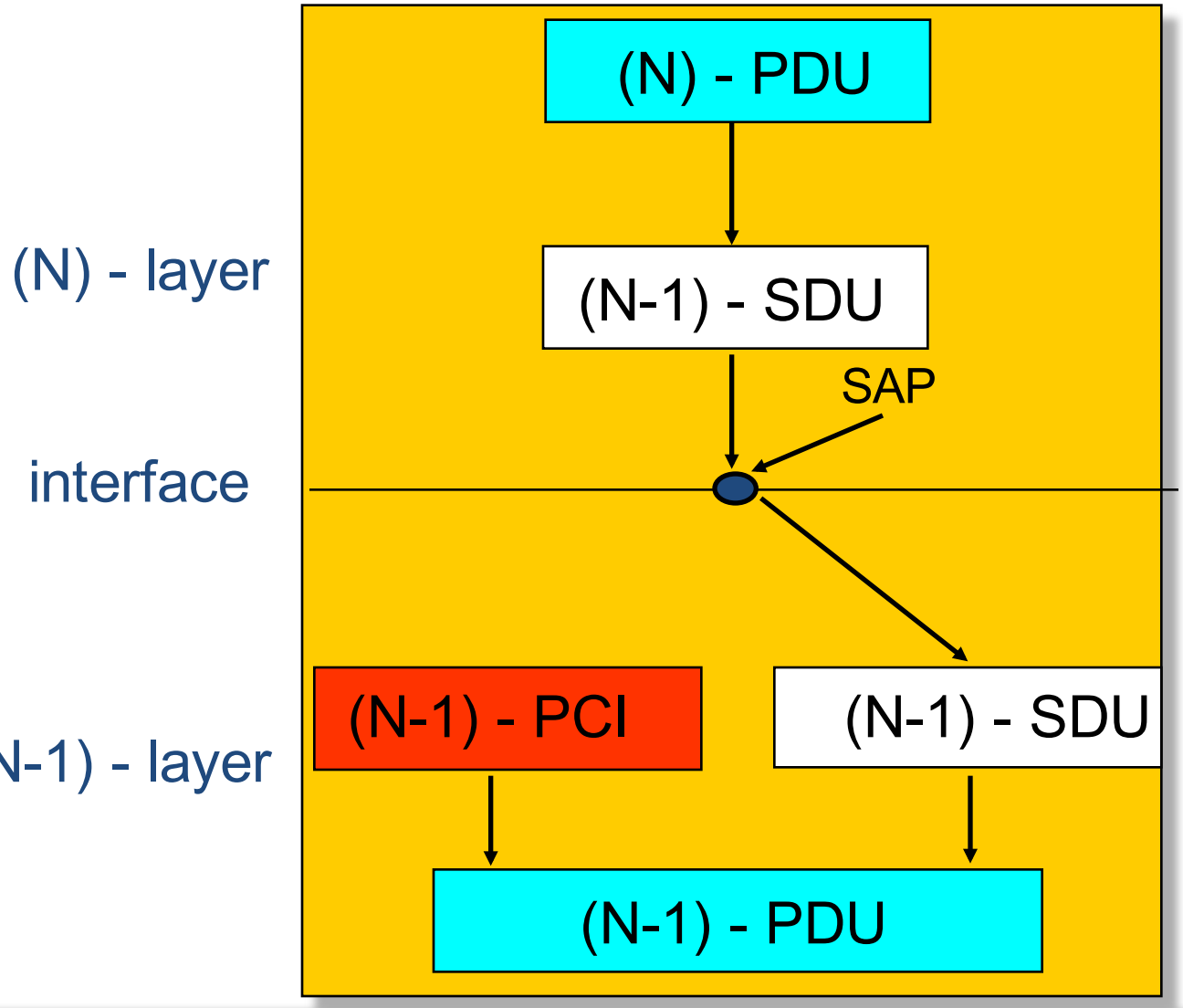
Services


(N) - service
N+1
N
N+1
N
(N) – service provider
Black-Box for (N+1) - entities

Protocols


System A
System B
(N+1) - protocol
(N+1)-entity
(N+1)-entity
(N) - service
(N) - SAP
(N) - layer
(N) - protocol
(N)-entity
(N)-entity

PDU Formation

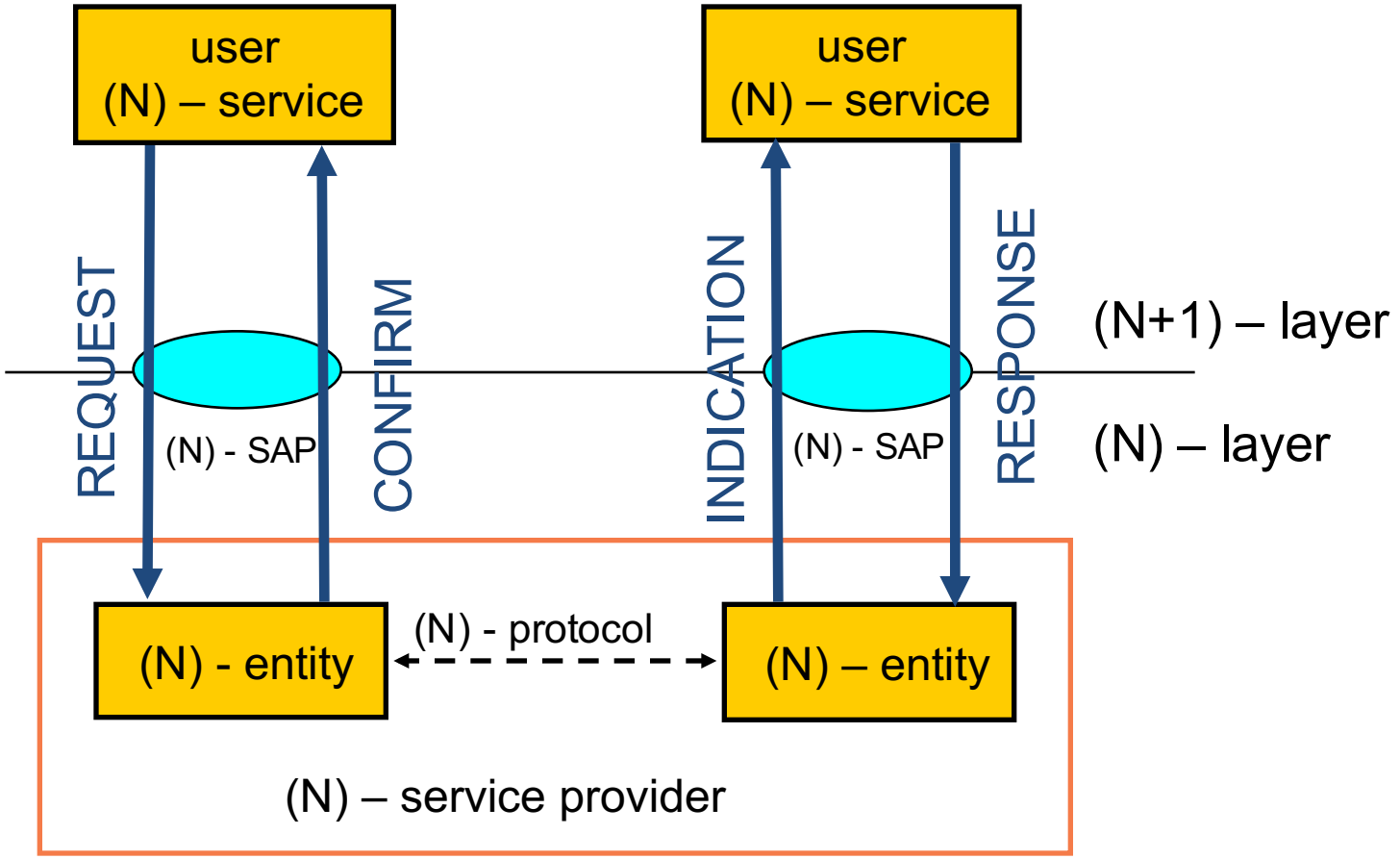


PDU Formation

- Data Units can be
  - segmented
  - concatenated
- Segmentation may follow two “paths”
  - Building more (N) - PDUs from one (N) – SDU
  - Generating more (N-1) - SDUs from one (N) - PDU
- Similarly for concatenation

- Often both processes are called segmentation for the sake of brevity

Primitives


user
(N) – service
user
(N) – service
REQUEST
CONFIRM
INDICATION
RESPONSE
(N+1) – layer
(N) - SAP
(N) - SAP
(N) – layer
(N) - entity
(N) - protocol
(N) – entity
(N) – service provider

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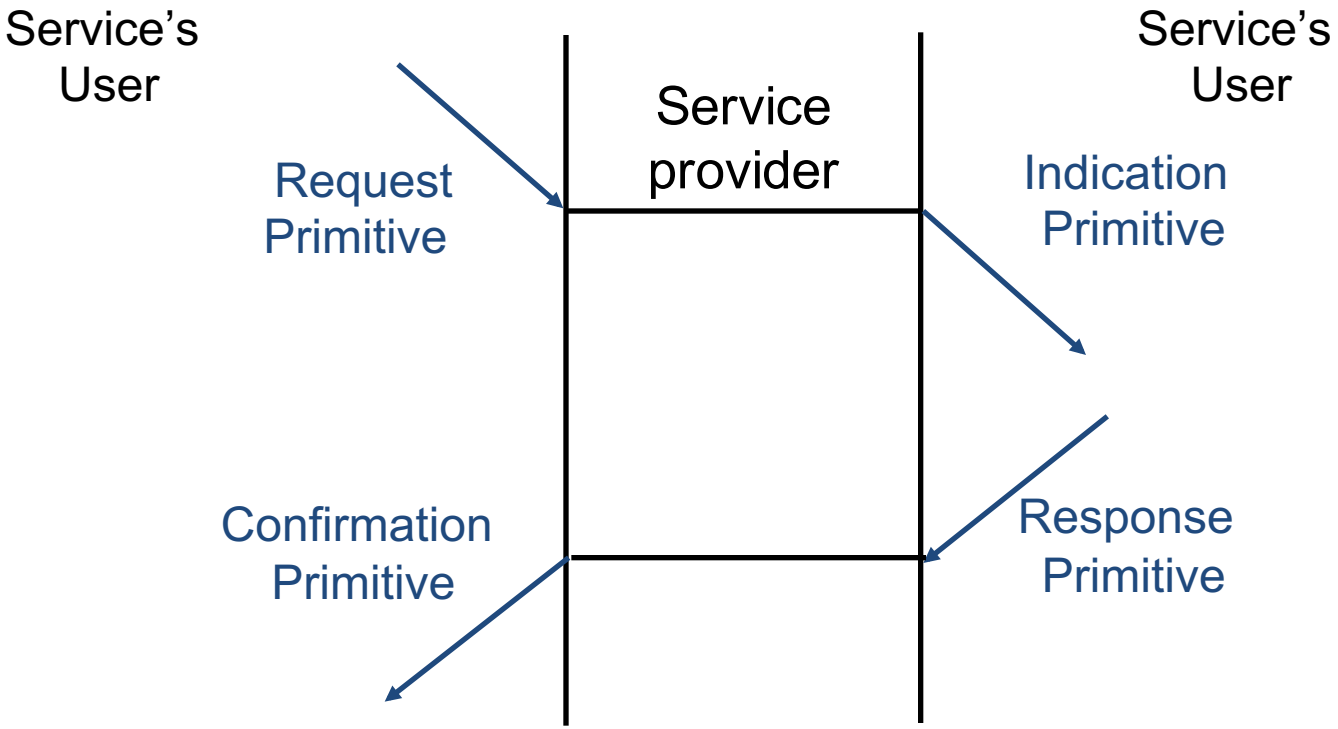
Confirmed Service



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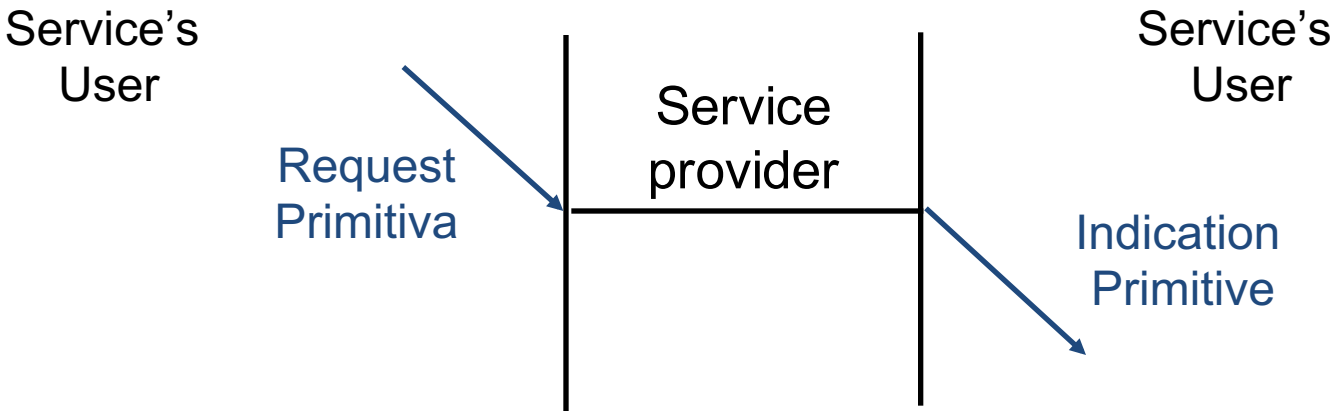
Un-Confirmed Service



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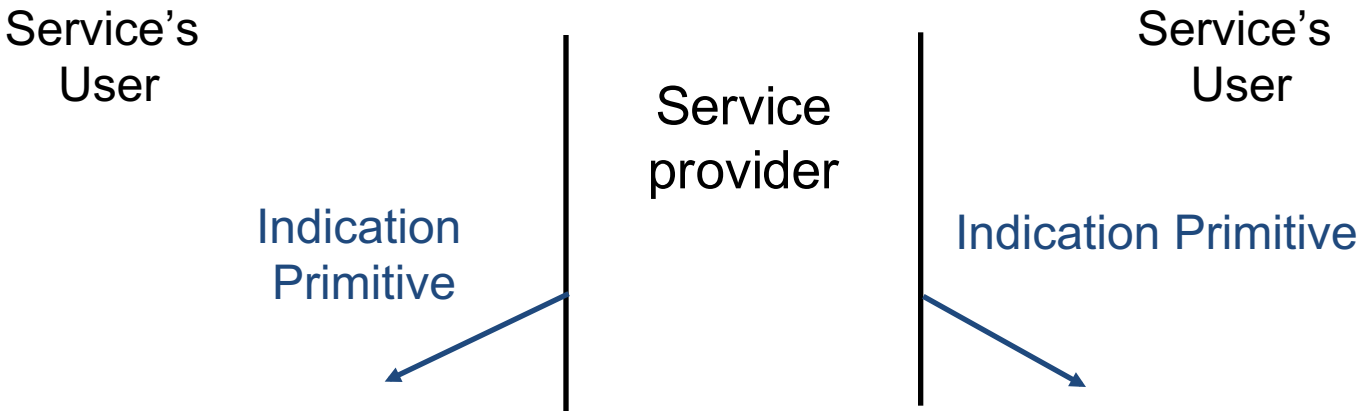
Service Provider Initiated



Nomadic Communications
&
WLANs

characterized by LAN-like wireless access

typically use Internet upper layers

requires some means to handle portability and (sometimes) local mobility

LAN Protocols

- Standardization process started in the ’80s by IEEE 802 project:
  - ✓ 802.1: LAN *Internetworking*
  - ✓ 802.2: LLC Sublayer
  - ✓ 802.3: CSMA/CD: *Ethernet* is a small (1-bit in the header) variation of 802.3
  - ✓ 802.4: *Token Bus*
  - ✓ 802.5: *Token Ring*
  - ✓ 802.6: DQDB (for MANs)

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- Work is still going on in many technical committees and new committees are founded every year (or close to):
  - ✓ 802.7: Broadband Technical Advisory Group
  - ✓ 802.8: Fiber-Optic Technical Advisory Group
  - ✓ 802.9: Integrated Data and Voice Networks
  - ✓ 802.10: Network Security
  - ✓ **802.11: Wireless Networks (/a/b/g/h/f/s/n/p/…)**
  - ✓ 802.12: 100base VG
  - ✓ 802.13: 100base X
  - ✓ **802.15: Personal Area Networks (.1 [Bluetooth] … .4 (ZigBee))**
  - ✓ **802.16: Wireless MAN (WiMax & Co.)**
  - ✓ …