# Nomadic Communications

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Course Home Page
www.disi.unitn.it/locigno/didattica/NC/

## 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 Alessandro, etc.
- ...

The web site is work in progress and updated frequently (that's at least my intention)
Please don't blame ME if you did't read the last news ☺



## Program

- **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

## Program

- **WLAN**
  - 802.11 Standard
  - 802.11b MAC/PHY
  - 802.11g/a/h
  - QoS and Differentiation enhancement: 802.11e
  - Mesh networks: 802.11s
  - Other extensions: 802.11f/n/p/...
- **802.16**
  - Midway between WLAN and Cellular Networks
  - Wireless Local Loop



## Program

- **Ad-Hoc Networks**
  - Stand-Alone WLANs
  - Routing and multi-hop in Ad-Hoc networks
  - Sensor and Actuator Networks
- **Personal Area Networks and WSNs**
  - Bluetooth
  - 802.15 (ZigBee)



## Laboratories

- Intended to be **experimental** labs
  - Hands on the material (hardware/software)
  - Configuration of devices
  - **Measurements** and results interpretation
- Centered on 802.11
  - We have material and experience
  - Devices are easy to configure and use
  - They are not meant to cover all the course material
  - They are not meant to give you **notions** but a working methodology

## Laboratories

- We have four different experiments
  - Configuring APs and measuring throughput performances
  - Identifying and Authenticating Users with Radius
  - Ad-Hoc Networking: setup and management, throughput, interference
  - Channel-level security: WEP and WPA2, identifying weak points and cracking (if possible) the security
- Labs are on Monday (15.30-18.30) and start on March 3 (Lab Week 1 – LW1), we will have 8 LW
- Each experiment will be repeated twice (LW1/2, LW3/4, ...) because you are too many to do it them all together
- You have to group up in 2-4 students to run the experiments and write the reports
  - Groups must be defined before LW1 and are STABLE until the end of the course
  - Groups are **ASSIGNED** to odd/even weeks and will stay maintain their assignment



## Laboratories

- How to define groups:
  - talk to each other, find common interests and "presumed" exam dates (it is better, not mandatory, but better, if groups take the exam together)
  - group up in 3 (best number) or 2 or 4, "singles" are not accepted, one of the aims of the labs is also to teach you to work together
  - within **Thursday Feb. 28, 12 noon**, send an e-mail to Alessandro and me with the names and e-mail addresses of the group components
  - assignment to LW will be both posted on the course site and replied via e-mail within Friday 29, 7.00 PM



## Laboratories

- We have reserved addition hours of the mobile lab on Wednesday 14.30-18.30 to allow finishing experiments and measurements, Alessandro will give details on its use and rules to follow
- Lab reports are **mandatory**
- Each report is evaluated on a scale 0-4 and all together sum up to roughly 50% of the exam evaluation, though not in an "algebric" sense, e.g:
  - all 3 in lab reports does not mean that you have a strict upper bound of 26
  - all 4 does not mean that you will surely pass the exam
- If reports are delivered within 2 weeks from the lab day, i.e., before the next lab, then Alessandro will have a look at them and advise if additional work/refinement is suggested, otherwise they go directly to me for evaluation
  - Alessandro advices are not an evaluation, just suggestions on improvements ... so don't come to me and say "but Alessandro said it was O.K.", that's not true by definition.

## Laboratories

- The focus is on experimental science
  - Devise an experiment, find interesting "measures" and define them
  - Set it up, explain it carefully so that it is replicable – a fundamental property of science!!
  - Take data and measurements
  - Check them quickly and immediately, so that if there are problems additional data can be collected
  - Present results carefully, in a readable way
  - Give an interpretation of the results based on the theoretical knowledge you have



## ...Copyright





## Why Nomadic

- Cellular Networks widely diffused
  - Expensive
  - Omnipresent
  - Still voice/small terminal oriented
- 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

### Wireless Network

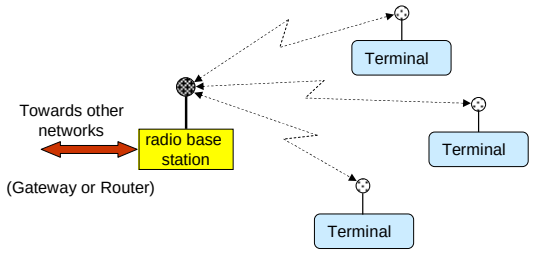
(sub)net where the access is on a tetherless channel, can be your cordless at home!

### 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

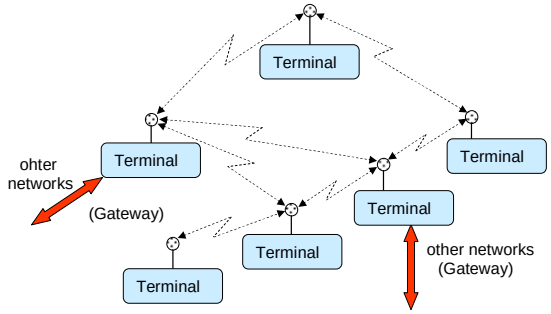


## Wireless Network with a Fixed Point of Access

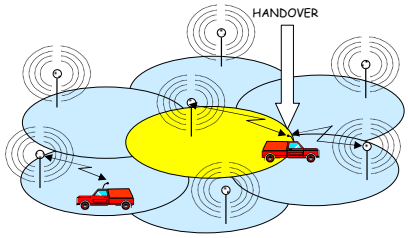





## Ad-Hoc Self Configuring Wireless Network



## 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??)
- Warchalking is not sustainable (at least for HotSpots and professional support)



## Access Protocol Rehearsal

what you *already know* but don't *remember*
what you *should know* but are not *aware*
☺

## Classification of LAN MAC protocols

- 3 types
  - Contention or Randoma 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)
  - Ropology, Resilience, Network dimension, Number of Stations, ....



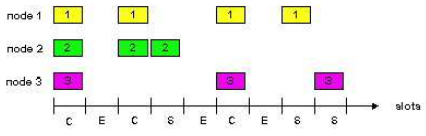
## Random Access Protocols

- A node in transmit a packet
  - At line speed R
  - without coordination with others
- If more than one node transmit at the same time..... ⇒ 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

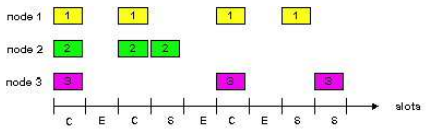
- Time is divided in equl length slots
- Nodes transmit at the beginning of the slot only
- In case of collision retransmit either with probability p or after a random delay till success




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

## Slotted Aloha: homework

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

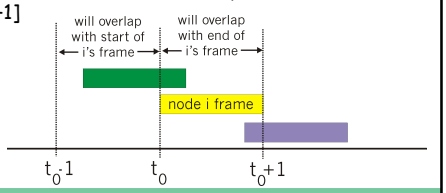



Success (S), Collision (C), Empty (E) slots



## ALOHA

- 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!!

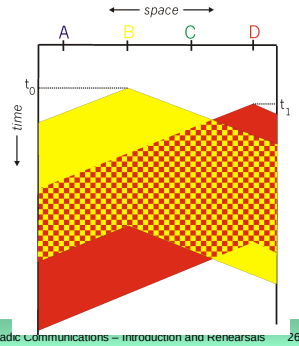
## CSMA: Carrier Sense Multiple Access

- 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

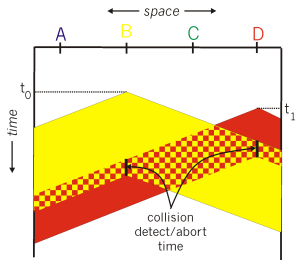





## CSMA/CD (Collision Detection)

- 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 ration 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

## Architecturea & Protocols

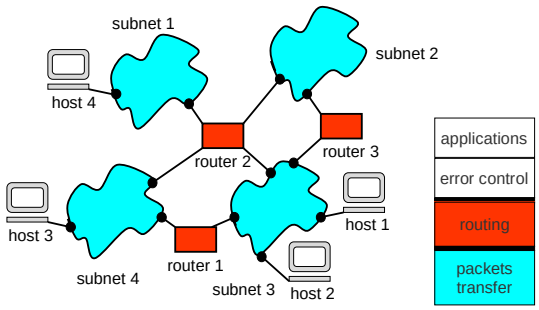
- ITU-T & ISO definition:
  - **Communication**: information transfer following predefined conventions
- Communication require cooperation
- An abstract description of communication among two or more users requires a
  **reference model**
- The highest level abstraction of a reference model defines a
  **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)



## Protocols

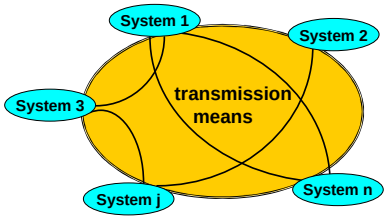
- In other words:
  - Semantics
    - Algorithms
  - Syntax
    - Formats
  - Timing
    - State machines and sequential diagrams

## ISO/OSI reference model

- (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

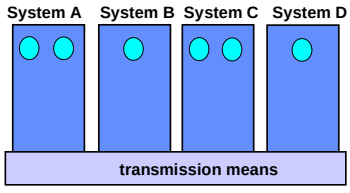


## OSI Reference Model



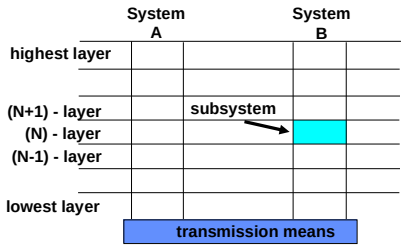



## OSI Reference Model




application processes

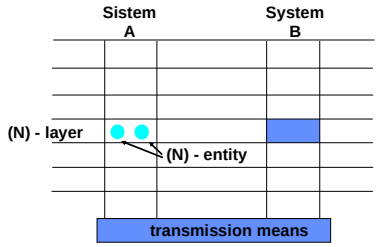
## Layers






## Entities

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



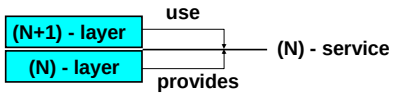



## Layering

- Each Layer (N)
  - Provides services to the upper layer (N+1)
  - using
    - (N-1) Services
    - Own functions
- Identify:
  - service providers
  - service users
  - SAP (Service Access Points)

## Services

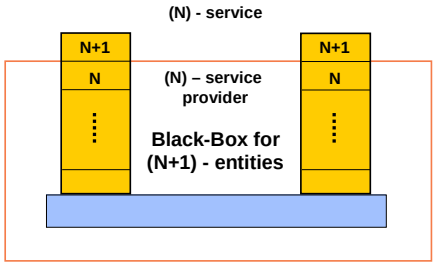
- N-layer users –(N+1) – entities– cooperate and communicate using the (N)-service provided by the (N)-service provider




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

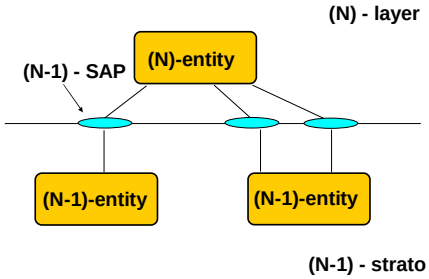


## Services



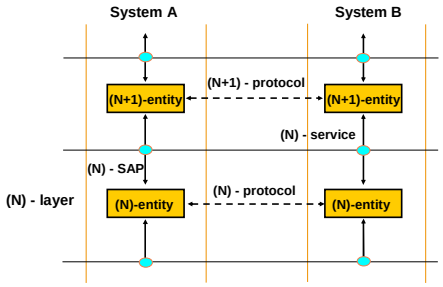



## SAPs



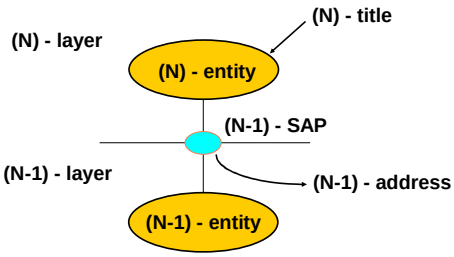

In Internet we have many different names for SAPs, from sockets to buffer to simply c-functions non formally named (e.g., the "ethernet" interface of Linux kernels

## Protocols





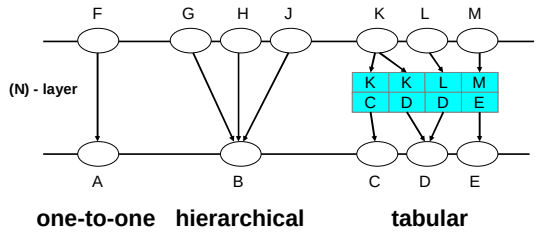

## Indirizzi



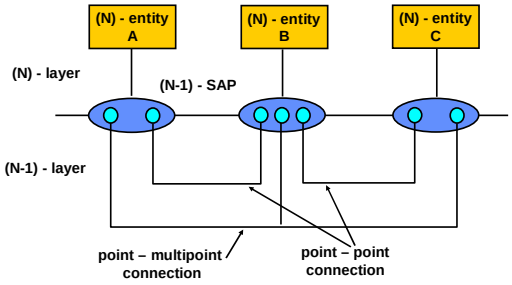

In TCP/IP addresses are named "port", "protocol", depending on the layers.
Notice the differences/similarities with IP-addresses



## Mapping Types



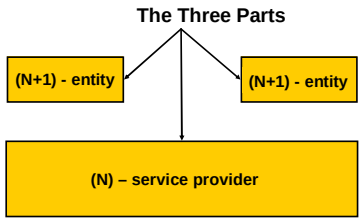
## Connections






## Agreements

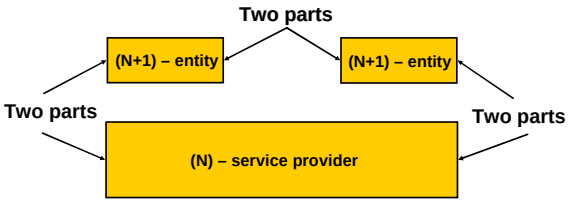
**Three parts agreement:**
**connection oriented communications**





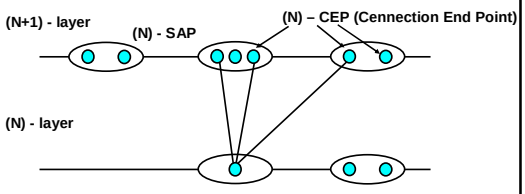

## Agreements

**Two parts agreement:**
**connectionless communications**



## Connections

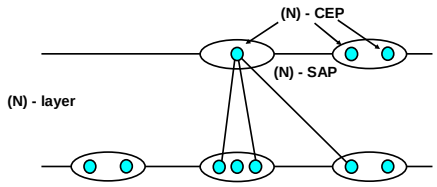
- Multiplexing (N) – connections onto a (N-1) – connection





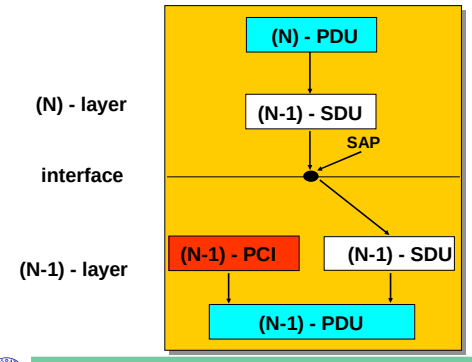

## Connections

- (N) – connection splitting onto multiple (N-1) – connections






## PDU Formation

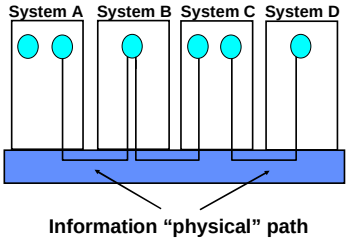


## PDU Formation

- 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

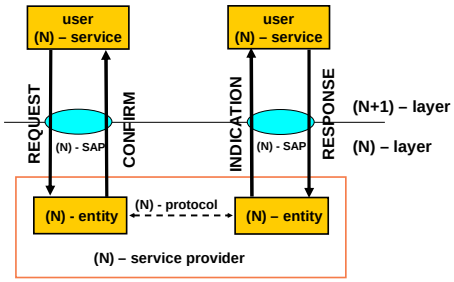


## Information Transfer



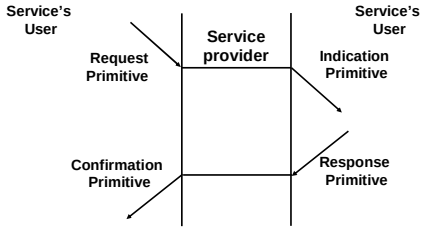



## Primitives




## Primitives' Use

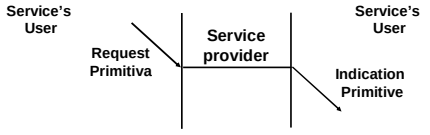
### Confirmed Service






## Primitives' Use

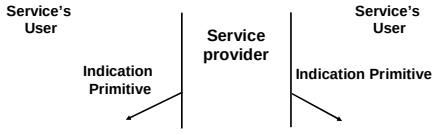
### Un-Confirmed Service






## Primitives' Use

### 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)



## LAN Protocols

- 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.)**
  - ...