Wireless Mesh and Vehicular Networks

http://disi.unitn.it/locigno/teaching-duties/wmvn

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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
- Projects

- ...

The web site is also used as bulletin board for last day (not minute) information

- **Short Range Communications & 802.11**
  - Cellular vs. Other Wireless
  - Local wireless communications
- **Some rehearsal**
  - Wireless Access Control Protocols
  - IEEE 802 project
  - Wireless Mesh Networks
  - Vehicular Networks

- **WLAN (WiFi & Beyond)**
  - 802.11 Standard
  - 802.11 (modern) MAC
  - 802.11b/g/a/h/n/ac PHY
  - ....

- **Mesh & Community Networks**
  - Stand-Alone WLANs
  - Routing and multi-hop in mesh networks
    - OLSR & not only
  - Alternative Internets
  - Community Networks

- **Vehicular Networks**
  Problems and scenarios
  - Specific issues
  - 802.11p and WAVE

Exams

- **Written + Oral**
  - A standard exam, with a written part with open questions and exercises (probably 2 hours) followed immediately or the day after by an oral discussing the written exam and covering parts of the program not touched in the written part
- **Project + Discussion**
  - A project (experiments, simulation, research) on either Mesh or Vehicular Networks substituting the written part
  - An oral discussion of your project plus some questions on the first part of the project ... i.e., if you do a project on Mesh Networks the vehicular part is part or your personal culture, but it is not part of the oral and vice-versa

Projects

- Intended to be **hands-on work** labs
  - Experiments, Simulations or theory with a research flavor
  - Can be pure / visionary research or application oriented
  - Can go from PHY/MAC (e.g., simulations/experiments with full duplex radio) to applications (e.g., P2P streaming on Meshes or cooperative driving protocols)
- Choose one of the “majors” (Meshes / Vehicular)
  - We’ll do some introductory lessons on these to let you select your choice early in the course
- Discuss with us to select a specific topic
- Do the project

UNIVERSITY OF TRENTO
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Wireless Network

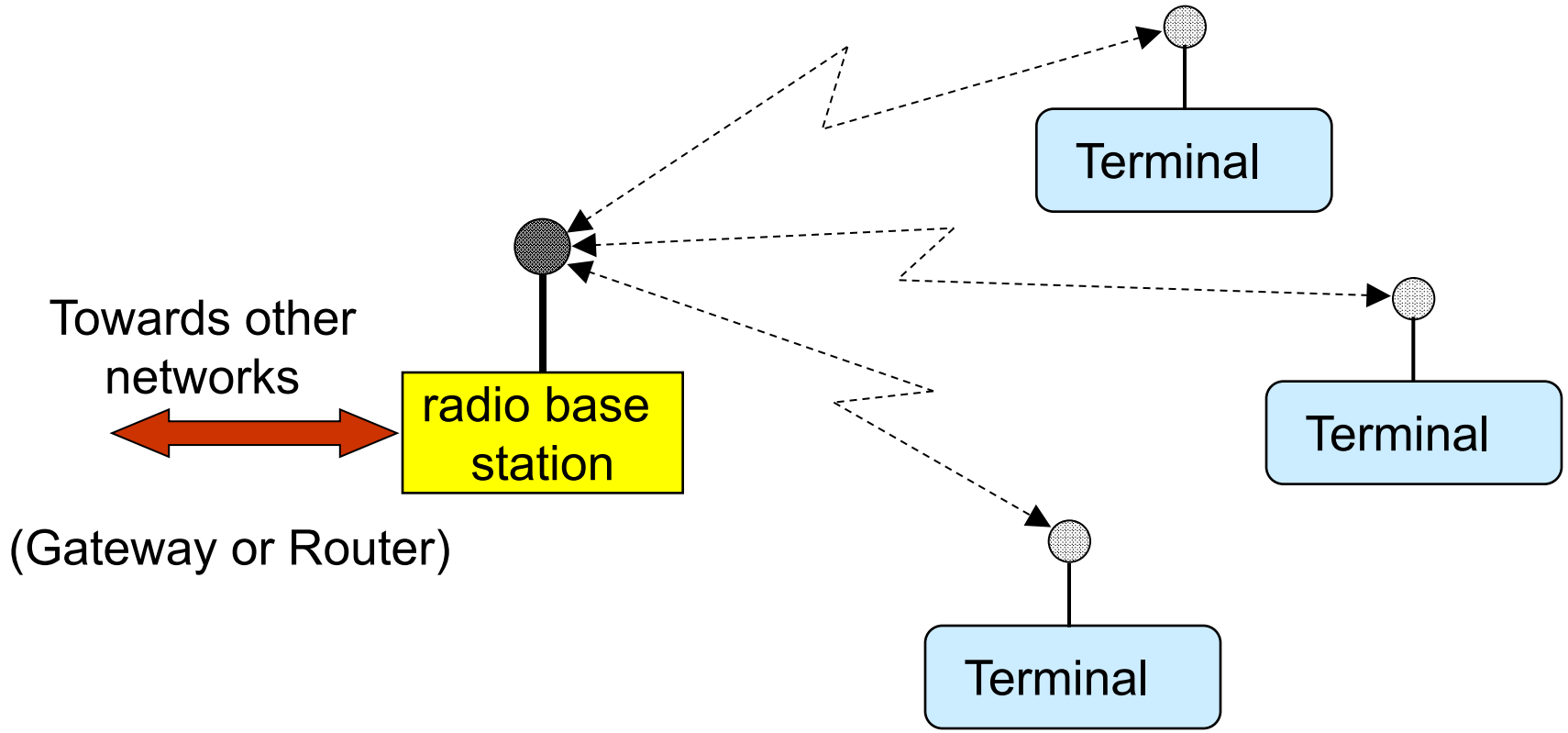
(sub)net where the access is on a

tetherless channel, can be your cordless at home!

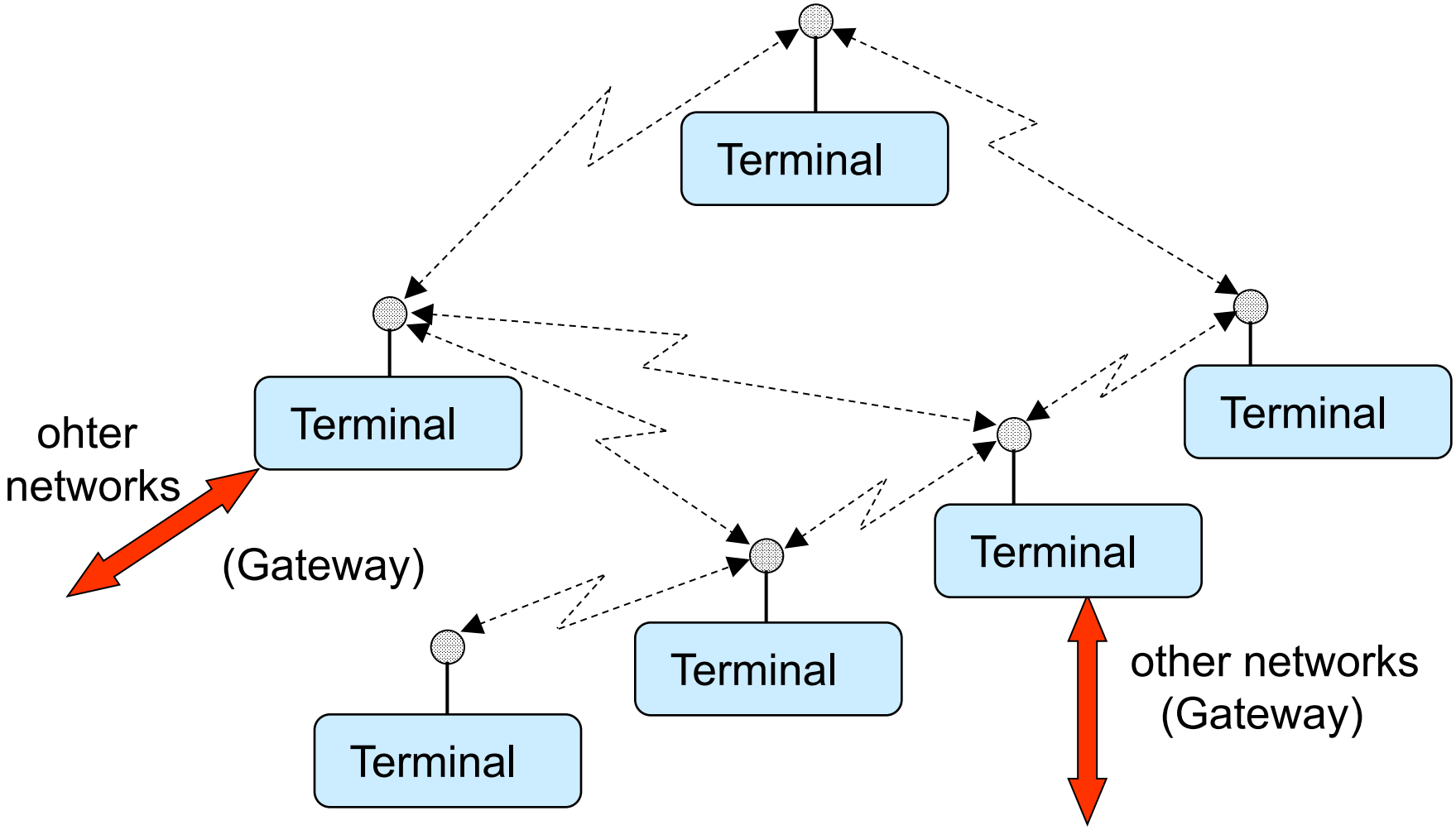
Cellular Network

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

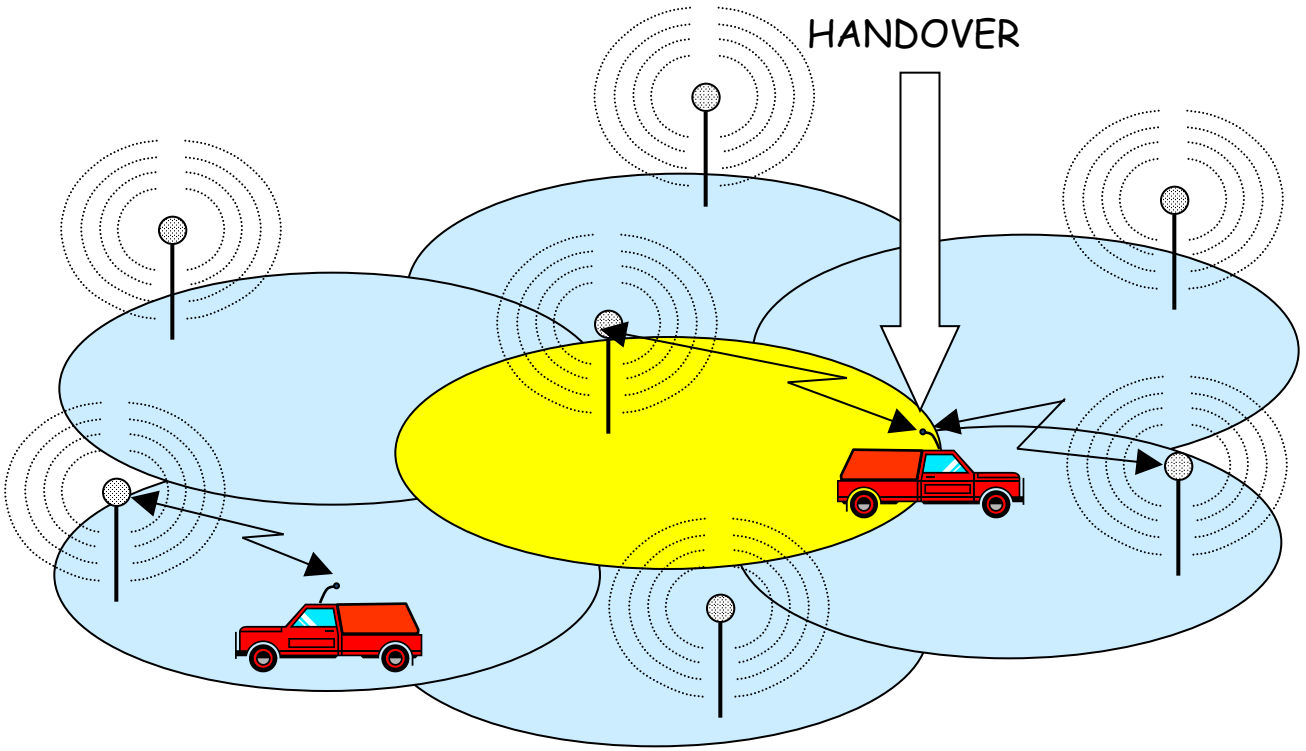
Wireless Network with a Fixed PoA



Ad-Hoc Wireless Network



Cellular Network



Wireless LANs

- Short range radio
  - 50-250 m for access
  - 100m to 20km & more for p-t-p links
  - Max 100mW (EU)
- Normally shared medium & ISM bands (2.4, 5 GHz)
- Standard WiFi & Beyond (our interest)
- Cheap & Accessible
  - Allows building autonomous & independent (from the Internet & telco) networks
- Flexible
  - Suport anything from IoT to Community backbones to V2V for cooperative driving

Access Protocol Rehearsal

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

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

☺

Classification of LAN MAC

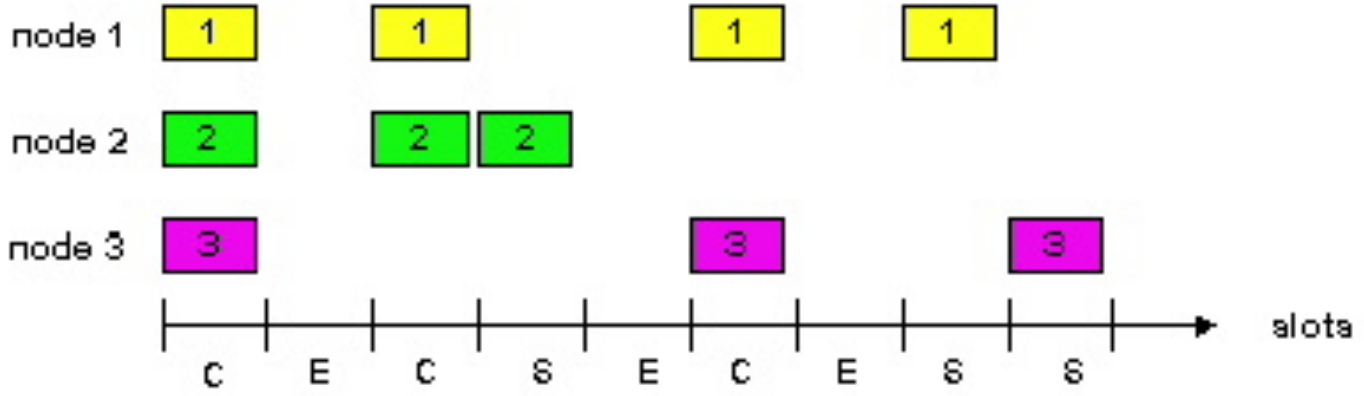
- 3 types
  - Contention or Random Access (Aloha, CSMA/CD, Ethernet)
  - Ordered Access (Token Ring, Token Bus, FDDI)
  - Slotted with reservation (DQDB, Res-Aloha)
- Evaluation/Performance Parameters
  - Throughput (capacity and carried traffic)
  - Fairness
  - Delay (access, propagation, delivery)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

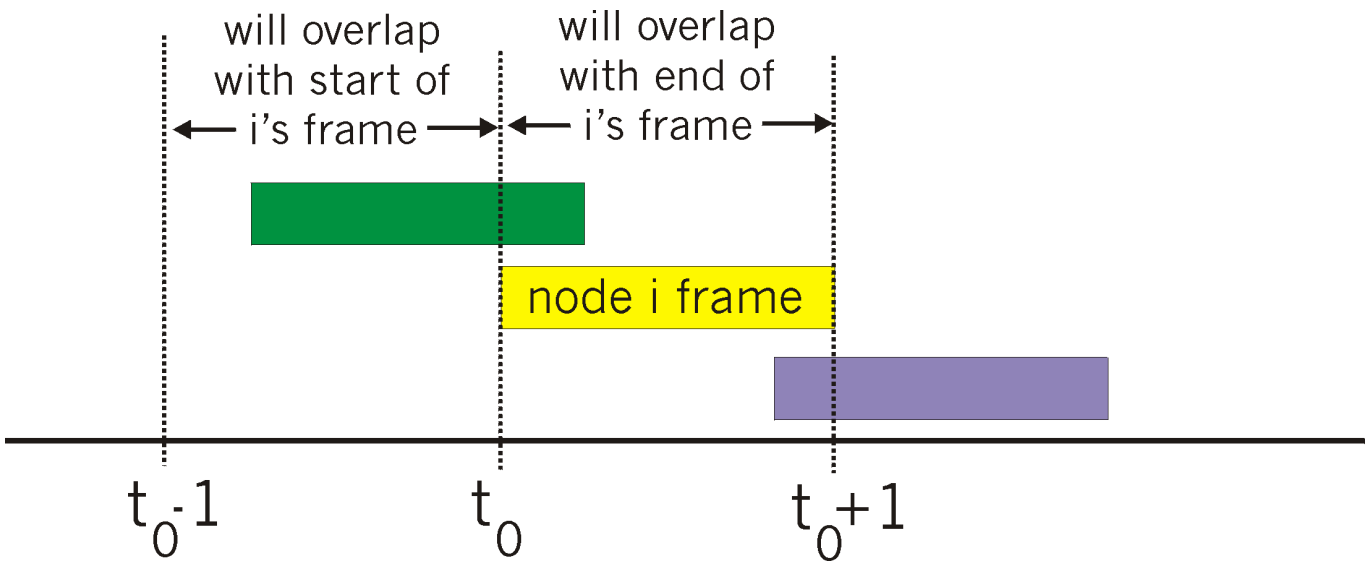
Slotted Aloha

- 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

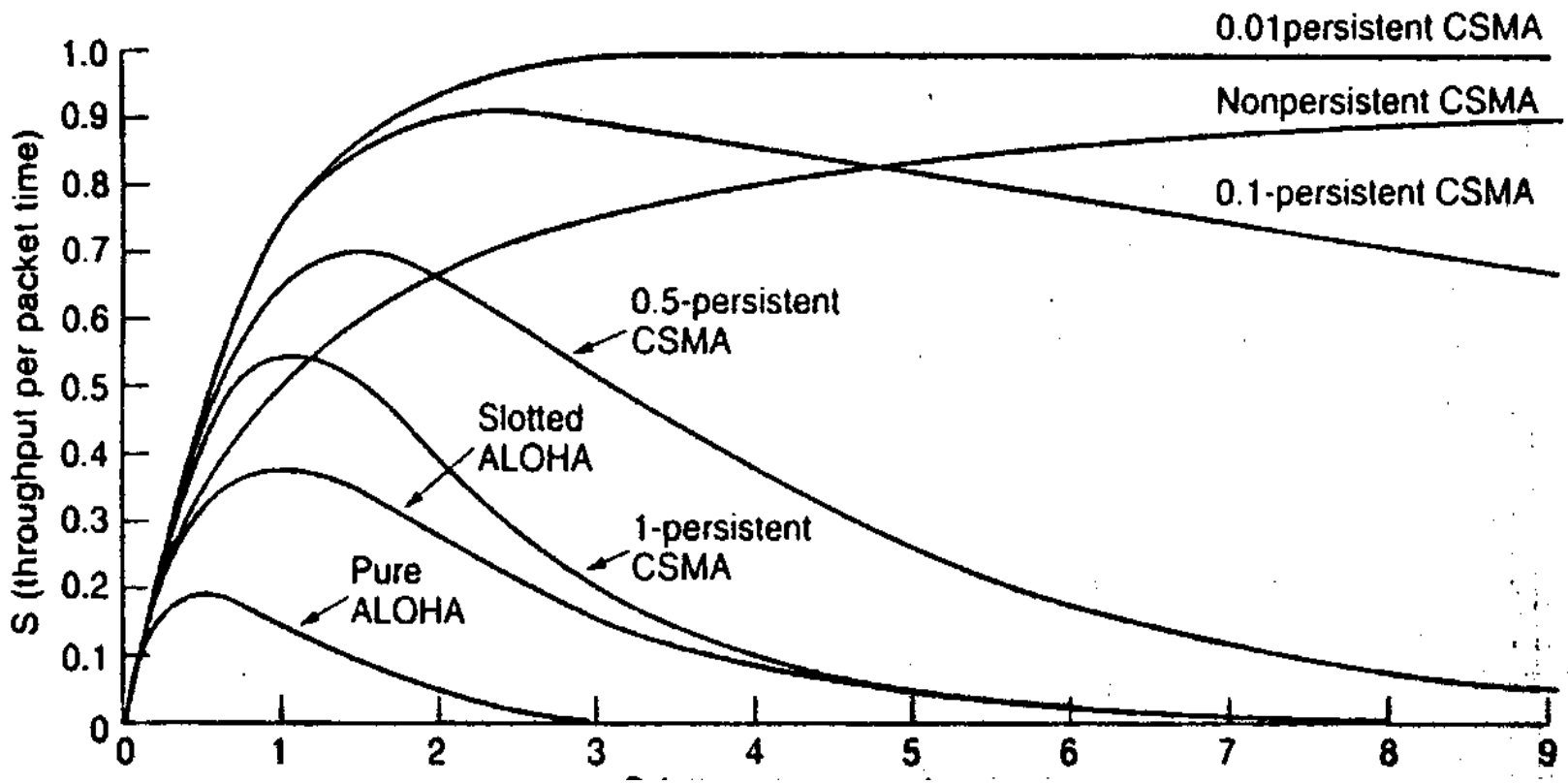
- Compute collision probability and throughput in case of Poisson Arrivals
  - Compare with collision probability and throughput of Aloha and explain differences
- Compare the p-retransmission policy with the delayed retransmission one
  - are they equal? in what conditions?

- The homework can be done in 2 or 3, this can be the occasion to start forming groups for labs
  - Homeworks 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:
    - 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

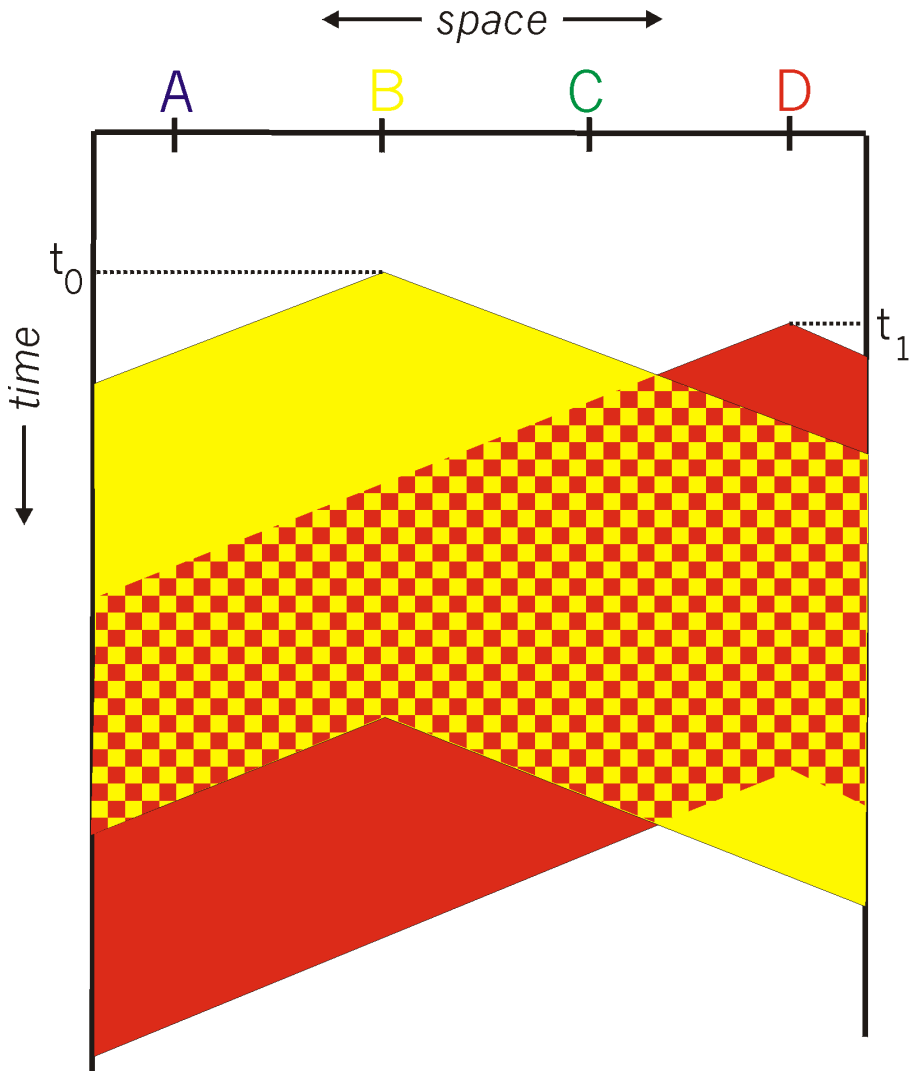
Aloha & CSMA performance



(reproduced from: A. Tanenbaum, Computer Networks)

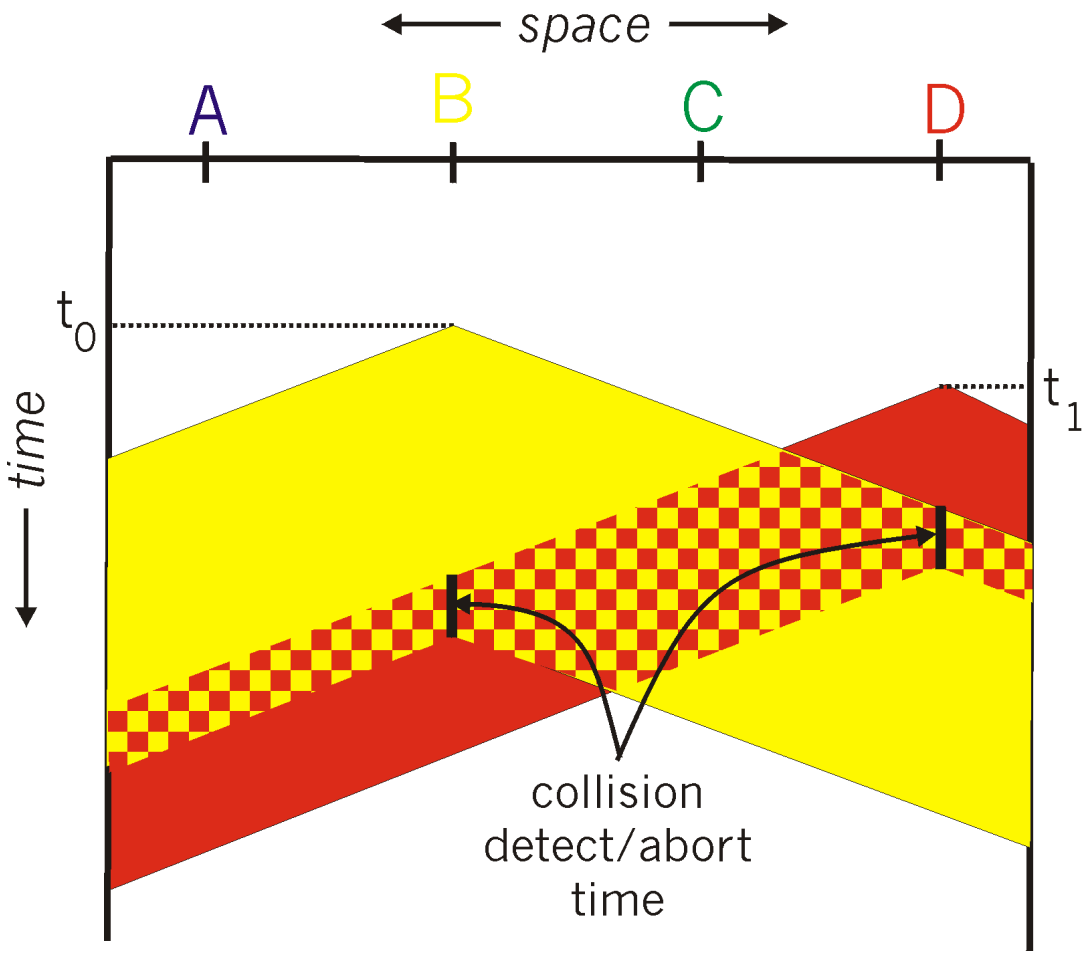
CSMA: collisions

- May happen due to propagation delay or simply because 2 stations start to transmit together when the channel becomes free (think 1-persistent)
- Transmission time is entirely wasted



- 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
  - Up to now impossible in traditional WLANs
    - Half Duplex
    - Power fluctuation/Power attenuation
  - Full Duplex Radio available in labs since a few years
    - Yet CD seems to be of little help (why?)

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

Local Area Networks
&
WLANs

The networks we address use LAN-like technologies all derived from IEEE 802 project

- 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)

- 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/ac/ax/…)**
  - ✓ 802.12: 100base VG
  - ✓ 802.13: 100base X
  - ✓ **802.15: Personal Area Networks (.1 [Bluetooth] … .4 (ZigBee))**
  - ✓ **802.16: Wireless MAN (WiMax & Co.)**
  - ✓ …