Wireless

Wireless

- Wireless networking evolved dramatically over the last 10 years. We have:
  - Mobile telephony (W-CDMA, GSM, LTE (Long Term Evolution Standard, 3GPP (3th Generation Partnership Project) Release 10)
  - WiFi (wireless fidelity)
  - Bluetooth
  - etc (infrared devices, remote control)

Wireless

- **Characteristic problem**: How can the different stations which are transmitting be differentiated, and how can they together share a communication medium?
- The problem is even harder when stations move in or out a certain region (mobile). Think of:
  - Using the internet on the auto-bahn
  - Using the internet at a hotspot

Wireless

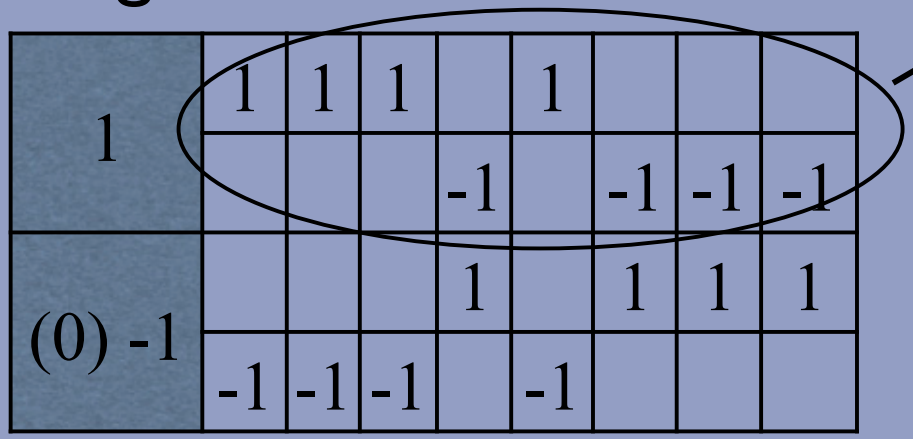
- Hotspots in cities in the US are partly created by using “old fashioned” telephone booths!
  - Have coverage and already connected to a network.
- Characteristic problem solved by several techniques.

1 CDMA

- Code Division Multiple Access
- Used in cellular networks and hotspots.
- Assumption: The transmitting frequency is much higher than the bit rate.
- The quotient of “transmitting freq” over “bit rate” is called the “chip rate”.

CDMA

- Each bit can therefore be represented by a sequence of signals, say M.
- PSK (phase shift keying) followed by PM (phase modulation)
- E.g. M = 8



CDMA

Now, each bit to be transmitted is encoded by:
For $1 \leq m \leq M$: $Z_{i,m} = d_i \, c_m$

So, if $d_1 \, d_2 \, d_3 = 1 \; 0 \; 1$ $(1 \; -1 \; 1)$, then the transmitted signal is:

1	1	1		1							1		1	1	1	1	1	1		1			
			-1		-1	-1	-1	-1	-1	-1		-1							-1		-1	-1	-1

CDMA

The receiving station performs:

$$d_i = \frac{1}{M} \sum_{m=1}^{M} Z_{i,m} \cdot c_m$$

Thereby recovering the original signals (b d_i)

Example:

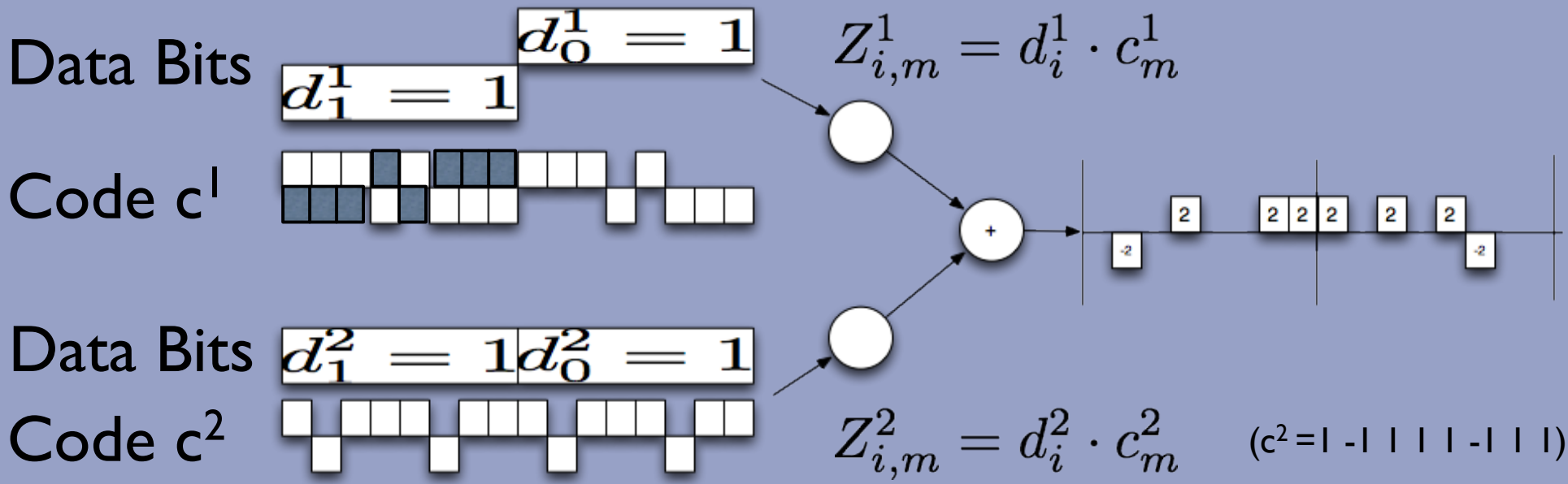
$$d_2 = \frac{1}{8} \sum_{m=1}^{8} Z_{2,m} \cdot c_m$$

$$d_2 = \frac{1}{8}(Z_{2,1} \cdot c_1 + Z_{2,2} \cdot c_2 + \ldots + Z_{2,8} \cdot c_8)$$

$$d_2 = \frac{1}{8}(-1 \cdot 1 + -1 \cdot 1 + -1 \cdot 1 + 1 \cdot -1 + -1 \cdot 1 + 1 \cdot -1 + 1 \cdot -1 + 1 \cdot -1) = \frac{1}{8}(-8) = -1$$

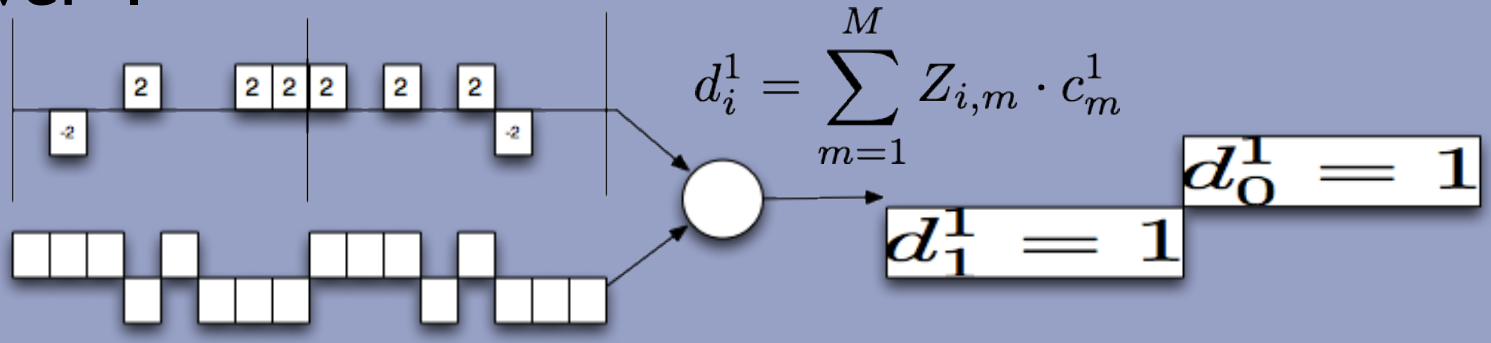
CDMA

For just one transmitter this seems very stupid. However, when there are several stations transmitting, who move in and out of an area. Then each station is assigned its own code:



CDMA

Receiver 1



$$\frac{1 \cdot 0 + 1 \cdot -2 + 1 \cdot 0 + -1 \cdot 2 + 1 \cdot 0 + -1 \cdot 0 + -1 \cdot 2 + -1 \cdot 2}{8} = \frac{-8}{8} = -1$$

Receiver 2 is similar, but then code c^2 is used.

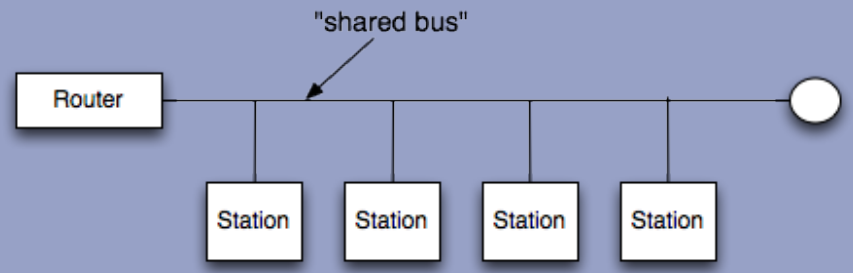
So, the trick is to find the right code so that this works!!!

II. CSMA/CD

Carrier Sensed Multiple Access / Collision Detection

Developed as part of the IEEE 802 standard for Ethernet & Fast Ethernet LANs (802.3).

The shared medium in the early versions of the Internet were the COAX cable.



CSMA/CD

- Random Access: each station can send arbitrarily (However, the configuration is much more stationary in contrast to CDMA)
- Based on ALOHA technique for radio transmission:
  - Station sends a frame, then waits for acknowledgement (round trip propagation delay + fix time increment)
  - If multiple senders are active at the same time, then collision & receiver discards frames.
    - Leads to 17-37% efficiency rate of the medium.

CSMA/CD

1. If medium is idle ("carrier sensed"), then transmit. (CSMA)
2. If medium is busy, then listen until medium is idle, then retransmit. (CSMA)
3. If collision is detected during transmission, then send jamming signal to all stations and stop transmission. (CSMA/CD)
4. Wait random amount of time and go to 1. (CSMA/CD)

CSMA/CD Randomisation

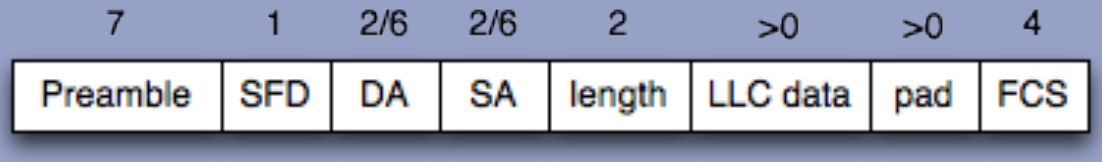
- After a collision, the time is divided in a number of time slots, based on the length of the worst case round trip propagation time.

Binary Exponential Backoff

- After first collision (jamming), each station waits 0 or 1 time slot.
- After 2 collisions, each station waits 0,1,2 or 3 time slots.
- After 3 collisions, each station waits, 0,1,2,3,4,...,7 time slots, etc (0,1,...,2^i-1).
- After 10 collisions randomisation is frozen on 1024 slots
- After 16 collisions, failure reported.

CSMA

The frame format of CSMA is based on the MAC (Media Access Control) format



- Preamble: 0101101... meant for syncing of clocks
- SFD: Start Frame Delimiter: 10101011
- DA/SA: Destination/Source address (the MAC address)
- length: length of the LLC field
- LLC: Logic Link Control data.
- pad: padding
- FCS: CRC-32 of all fields except preamble, SFD & FCS

IEEE 802

- Differentiates between:
  - Physical layer
  - Media Access Control
  - Logical Link Control
    - Unacknowledged connection less service
    - Connection mode servies
    - Acknowledged connection less services

III. CSMA/CA

- CA: Collision Avoidance

IEEE	Freq Range	Data Rate
802.11b	2.4-2.485 GHz	≤11 Mbps
802.11a	5.1-5.8 GHz	≤54 Mbps
802.11g	2.4-2.485 GHz	≤54 Mbps

WiFi is based on CSMA/CA

Main difference with, say Ethernet is Collision Avoidance vs Collision Detection.

CSMA/CA

- Reasons for CA vs CD
  - In order to detect collisions, senders must also be able to receive at the same time. Because of signal weakness, it is very costly to build hardware.
  - Because of senders shielded off, not all collisions can be detected.

CSMA/CA

- So, for WiFi:
  - As soon as a sender starts transmitting a frame, it will send the whole frame.
  - So, collisions will have to be avoided at all costs.

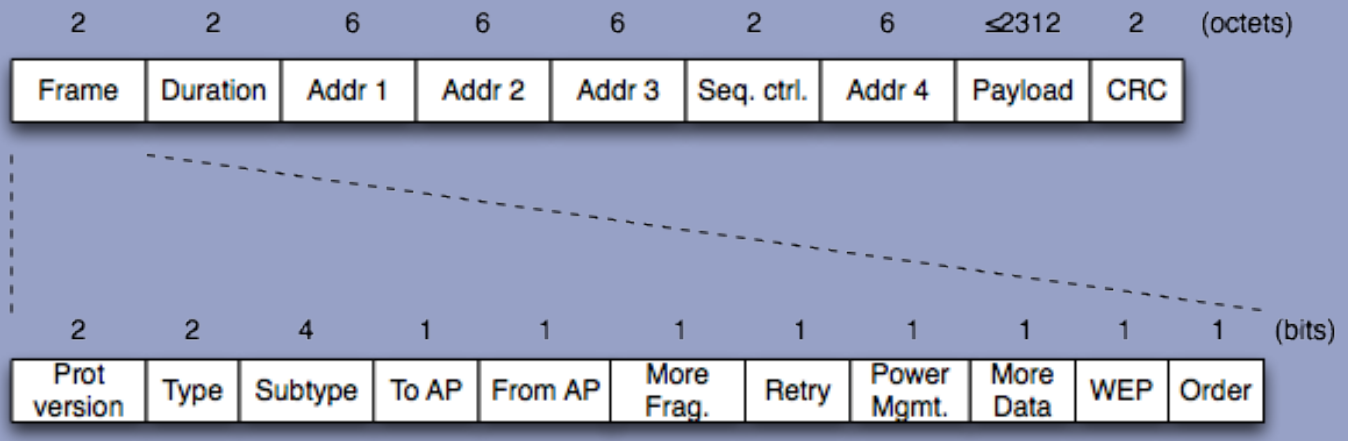
CSMA/CA

- Based on: Short InterFrame Spacing (SIFS)
- Stop and Wait ARQ
  - When the destination station receives a frame & it passes CRC, then it waits a short time (SIFS), before it sends an ACK frame.
  - If sender does not receive ACK, then it will do a retransmit.

CSMA/CA

1. If station senses channel to be idle then:
    1. Wait a short period of time: Distributed Interframe Space (DIFS)
    2. Transmit frame
2. If channel is not idle:
    1. Choose a randome backoff value count down this value.
    2. If counter reaches 0, then transmit & wait for ACK.
3. If ACK is received, then goto 1, otherwise goto 2 (with larger count down value)

WiFi Frame Format



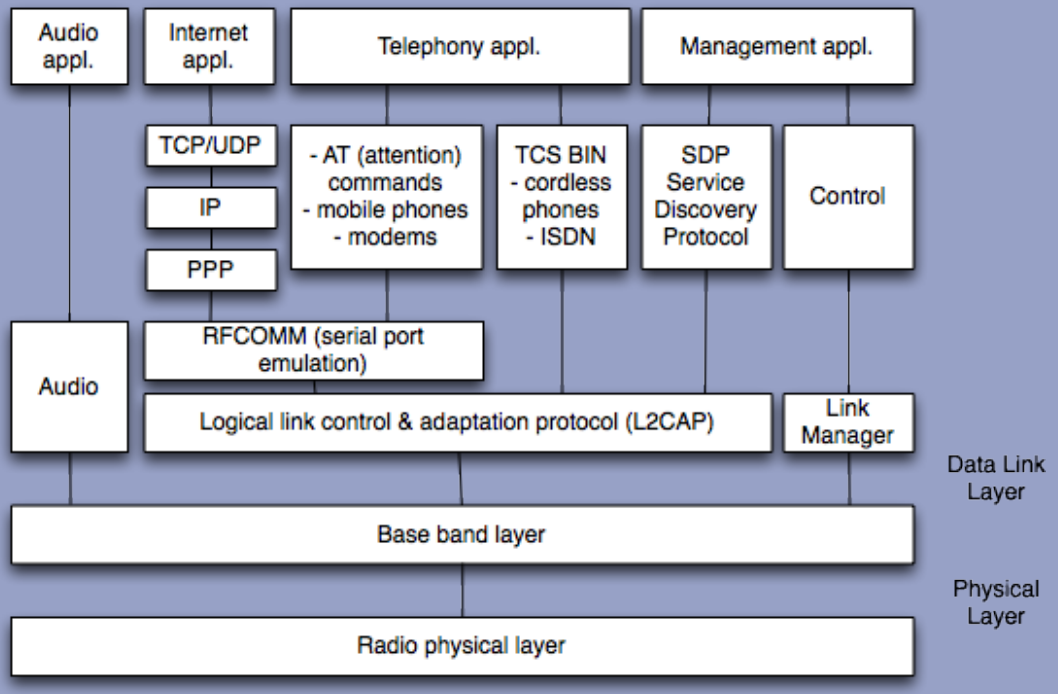
(AP = Access Point)

Based on 802.3, but clearly different in number of addresses.

WiFi Frame Format

- Address 1: MAC address of receiving station.
- Address 2: MAC address of transmitting station.
- Address 3: MAC address of router interface to other subnets.
- Address 4: For *ad hoc* networks.

IV. Bluetooth



- RFCOMM: Radio freq communication
- TCS BIN: Telephony control protocol specification (binary)

Bluetooth

- Industrial standard!! So a whole range of application profiles are also part of the standard.
- Based on short range radio transmission arranged in WPAN (Wireless Personal Area Networks)