# *The IEEE 802.11 standard*

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PLANETE

IN'Tech

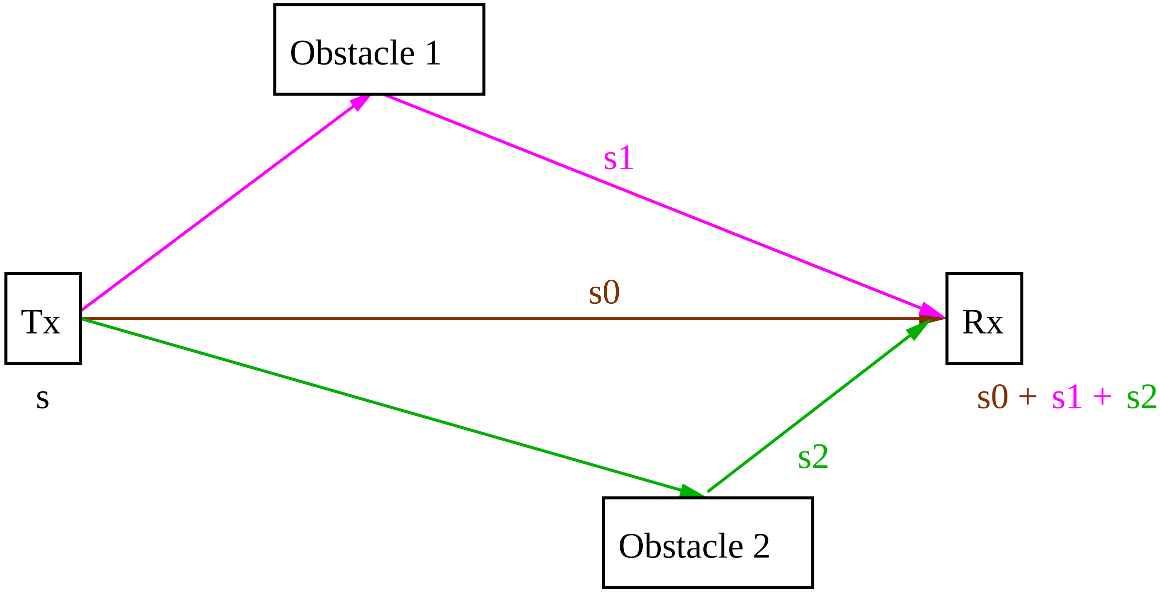
IN'Tech, May 31st, 2002

# *Outline*

- **WLANs vs. Wired LANs**
- History
- Working modes
- MAC sub-layer
- The PHY layer (1997)
- The PHY Extensions (1999)
- Security

# WLANs vs. Wired LANs

- No wires → Mobility
- Scarse bandwidth (?)
- Multipath, pathloss, interference / noise → BER



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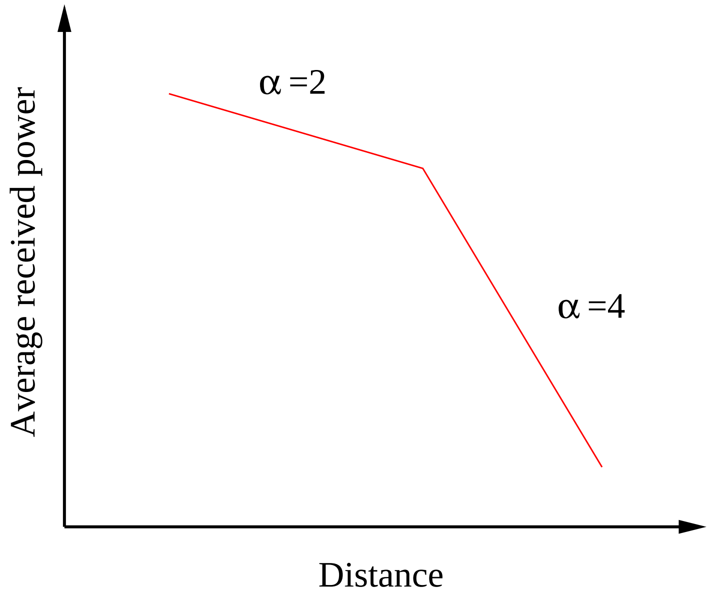
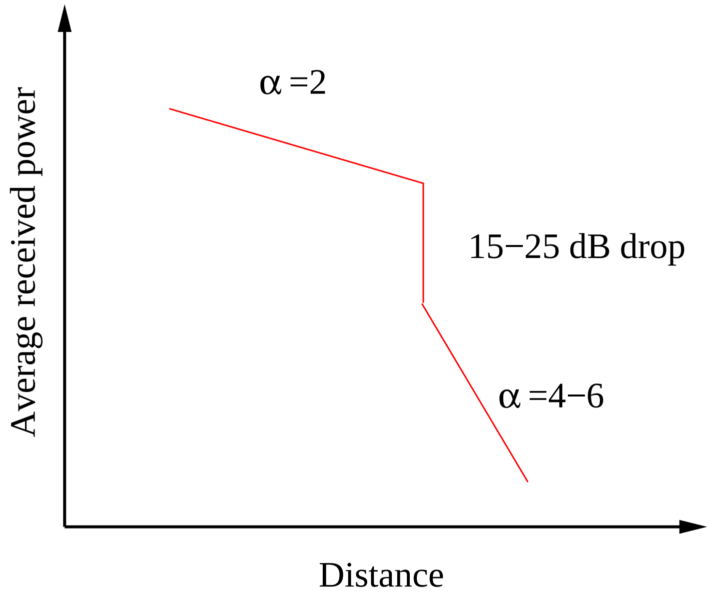
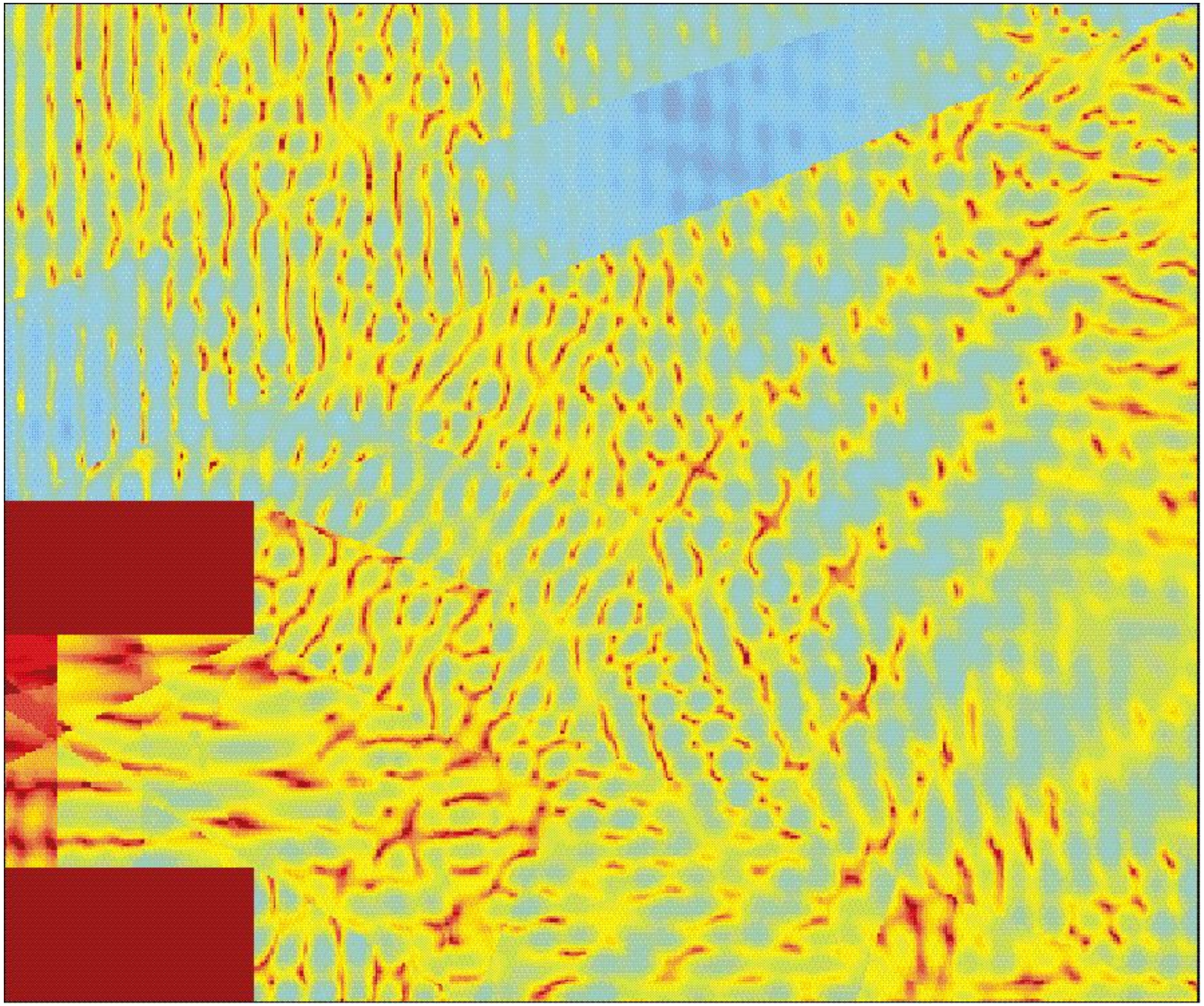
**LOS**



**No LOS**



# WLANs vs. Wired LANs

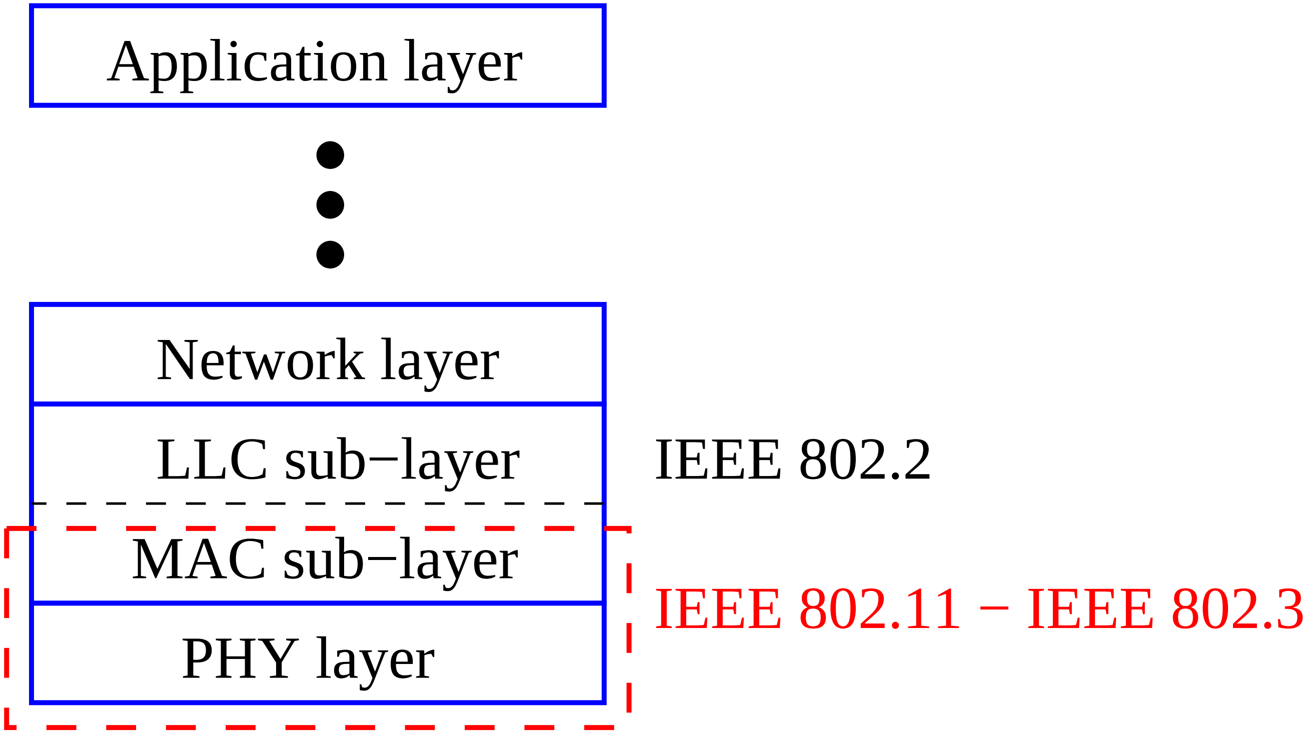


# *WLANs vs. Wired LANs*

- No wires → Mobility
- The hidden node problem
- Scarse bandwidth (?)
- Multipath, pathloss, interference / noise → BER
- Protection / Privacy

# WLANs vs. Wired LANs

# *WLANs vs. Wired LANs*



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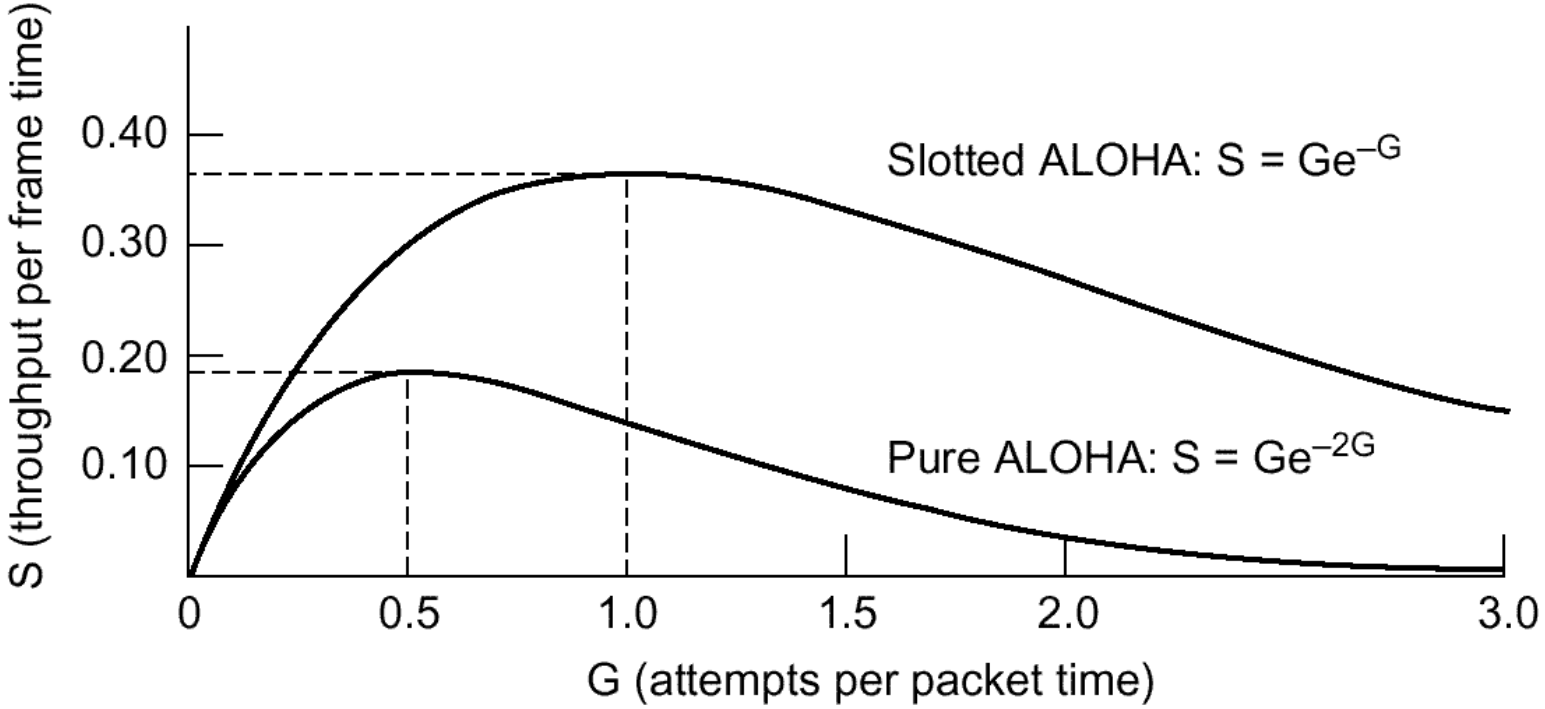
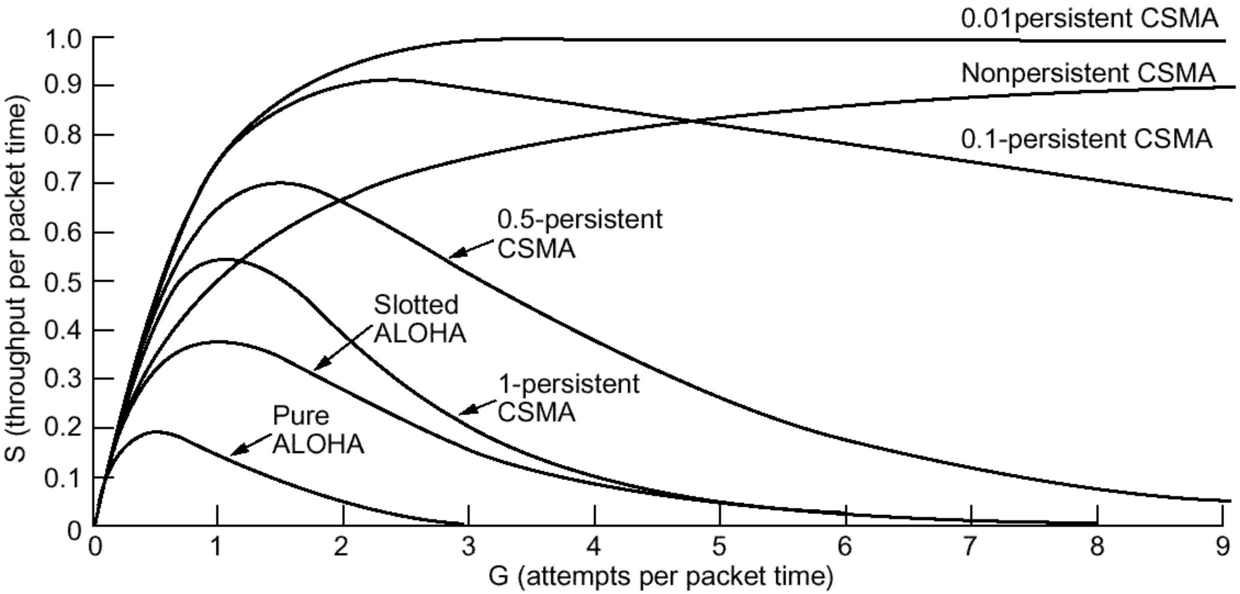
# History

- 1970s: ALOHA
- 1972: Slotted ALOHA



# History

- 1970s: ALOHA
- 1972: Slotted ALOHA
- 1975: Carrier Sense Multiple Access (CSMA)
  - non persistent
  - p-persistent



# ***History***

- 1970s: ALOHA
- 1972: Slotted ALOHA
- 1975: Carrier Sense Multiple Access (CSMA)
  - non persistent
  - p-persistent
- CSMA with collision detections (CD): Ethernet (1976)
- CSMA w/ coll. avoidance (CA): **IEEE 802.11 (1997)**

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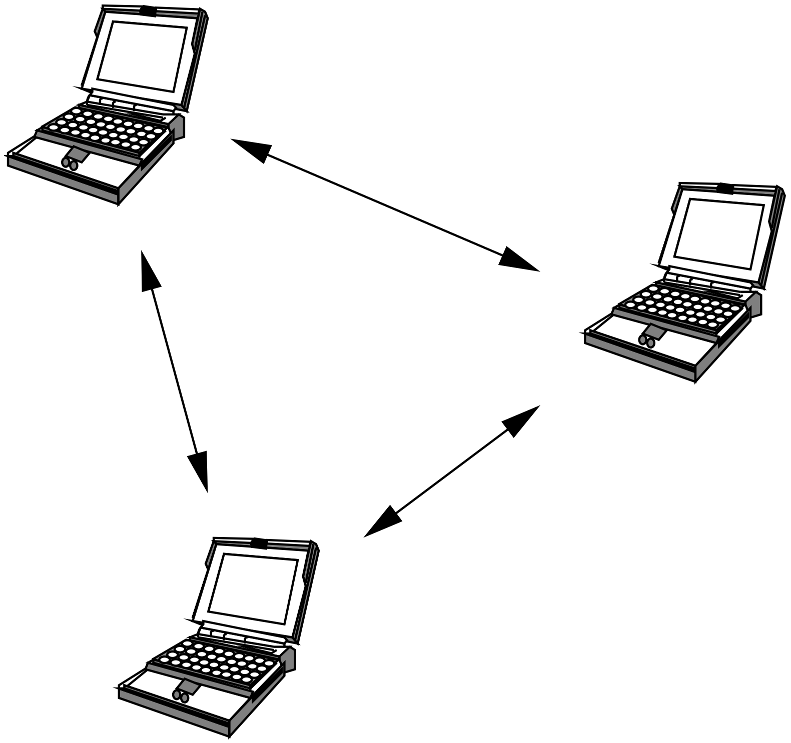
# *Working modes*

- Ad-hoc mode vs. Infrastructure mode (IS)
- Independent BSS (IBSS), Basic Service Set (BSS), Extended Service Set (ESS)



IBSS

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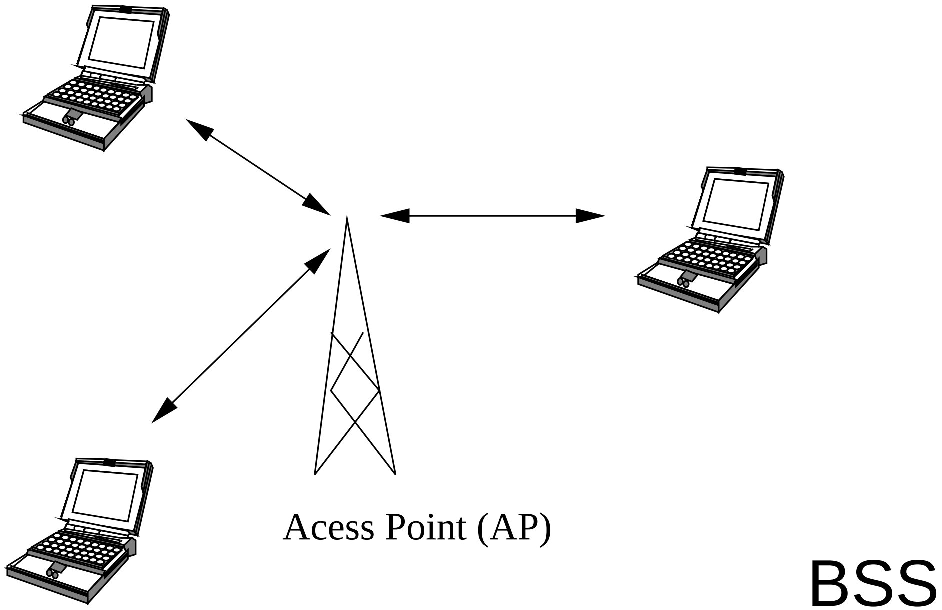

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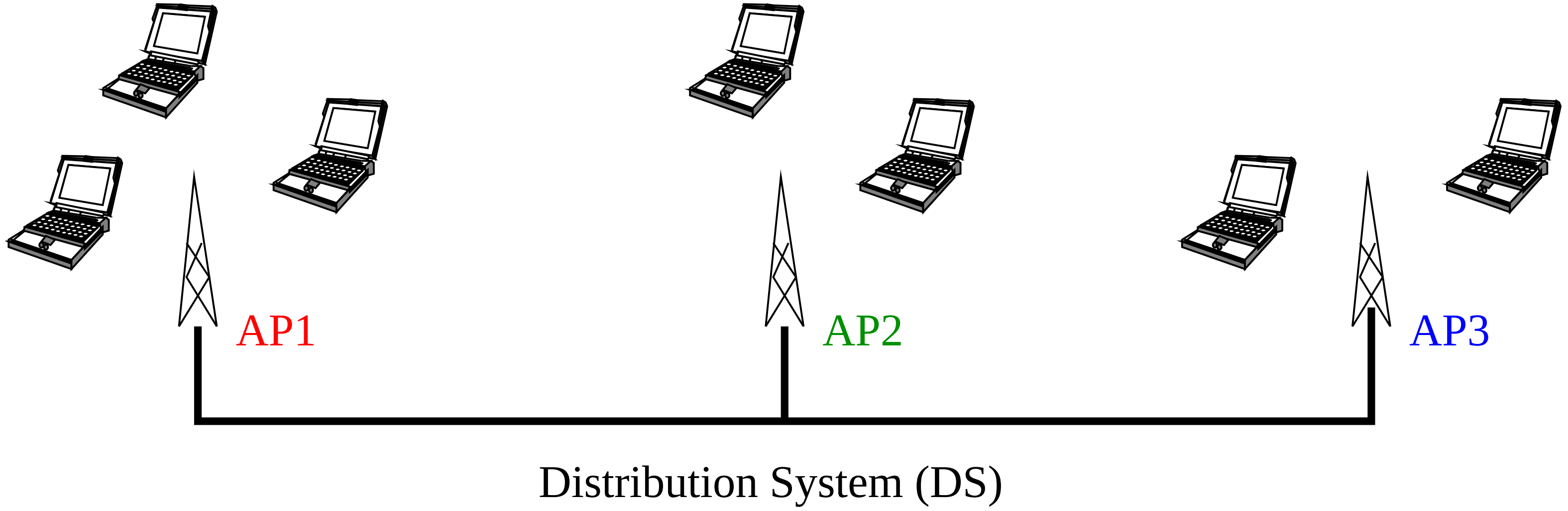

ESS

- Handoff on the MAC sub-layer

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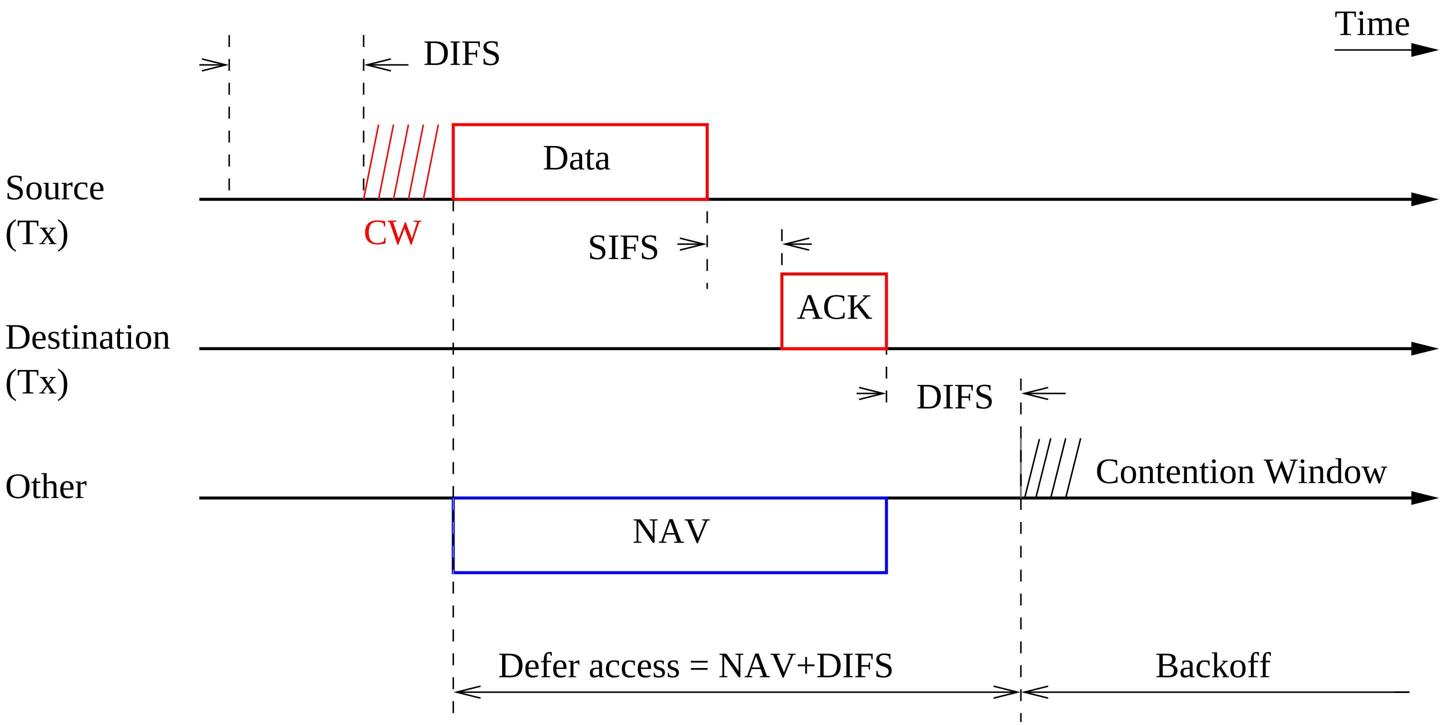
# ***MAC sub-layer***

DCF: Distributed Coordination Function (ad-hoc, IS modes)

PCF: Polling Coordination Function (in IS mode, optional)

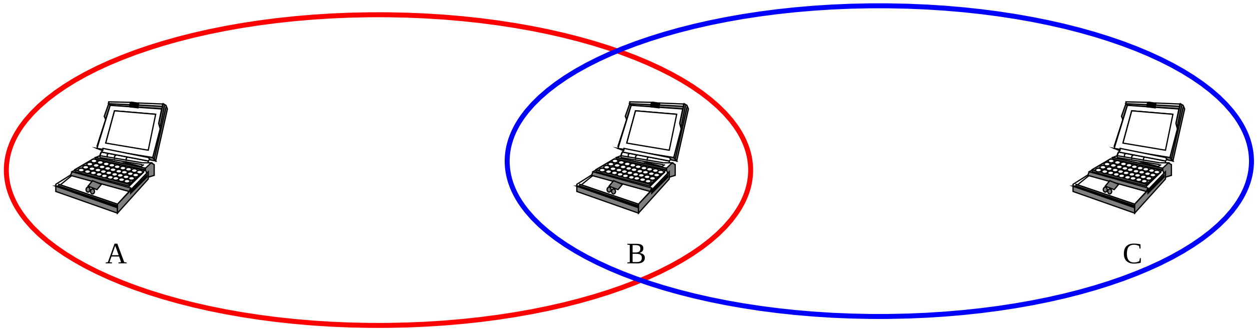
# MAC sub-layer

DCF: Distributed Coordination Function (ad-hoc, IS modes)
- Basic machanism ($pktsize < RTSthreshold$)



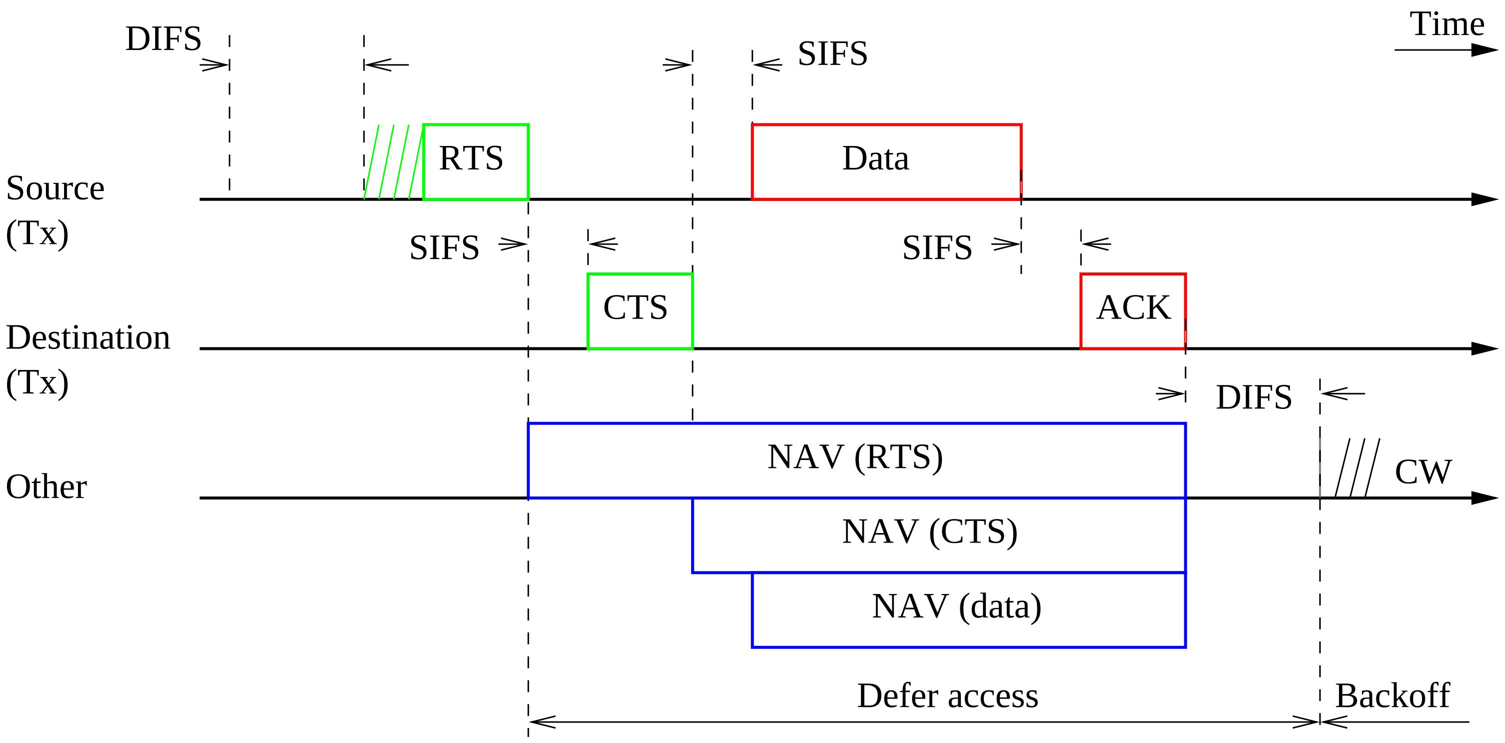
# *MAC sub-layer*

DCF: Distributed Coordination Function (ad-hoc, IS modes)
- The hidden node problem



# MAC sub-layer

DCF: Distributed Coordination Function (ad-hoc, IS modes)
- RTS/CTS mechanism ($pktsize \geq RTSthreshold$)



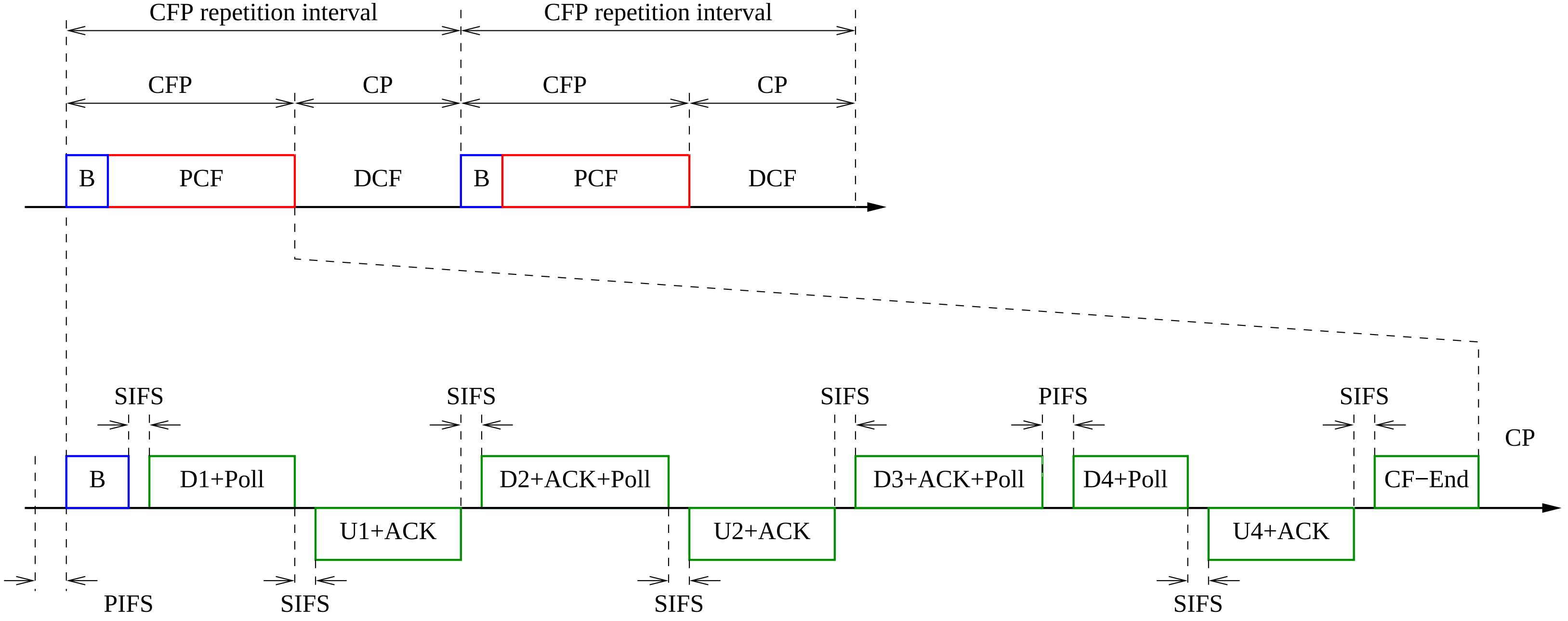
# *MAC sub-layer*

DCF: Distributed Coordination Function (ad-hoc, IS modes)
- Fairness ? ... depends on scenario
- QoS ? ... not yet ... wait for 802.11e

# MAC sub-layer

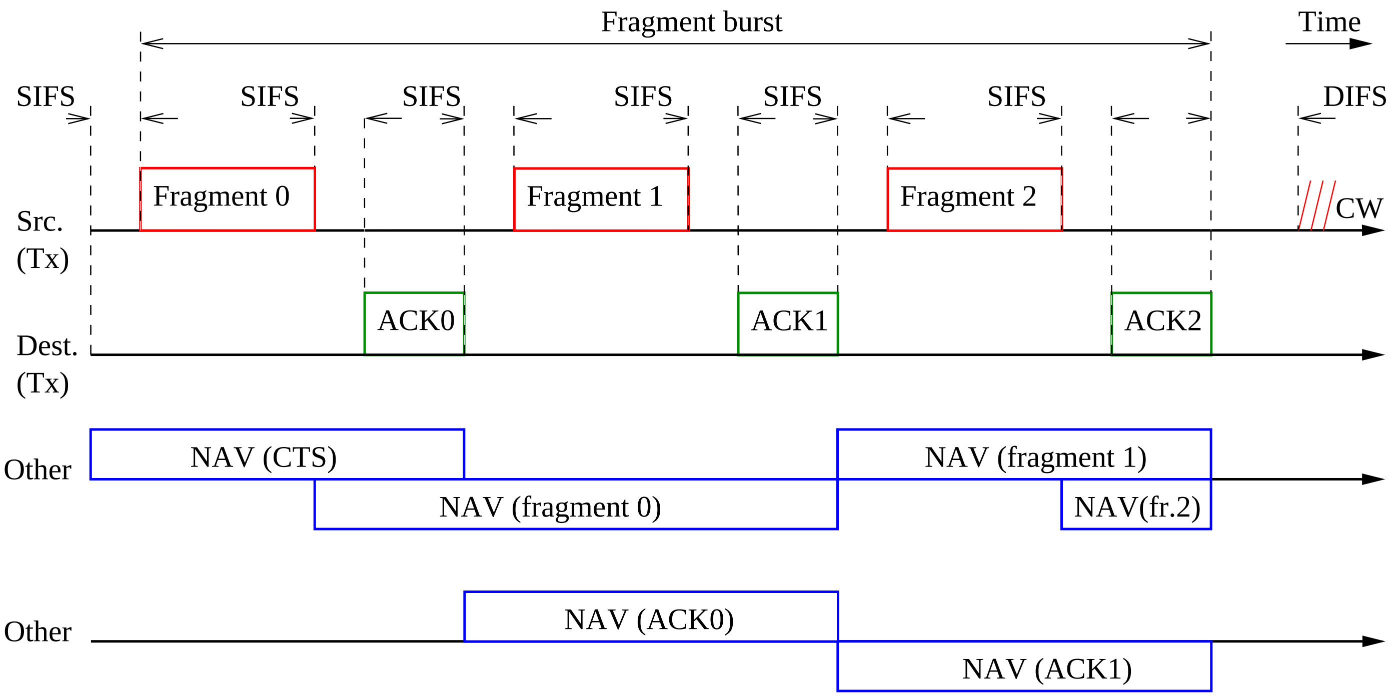
DCF: Distributed Coordination Function (ad-hoc, IS modes)

PCF: Polling Coordination Function (in IS mode, optional)



# MAC sub-layer

## Packet fragmentation



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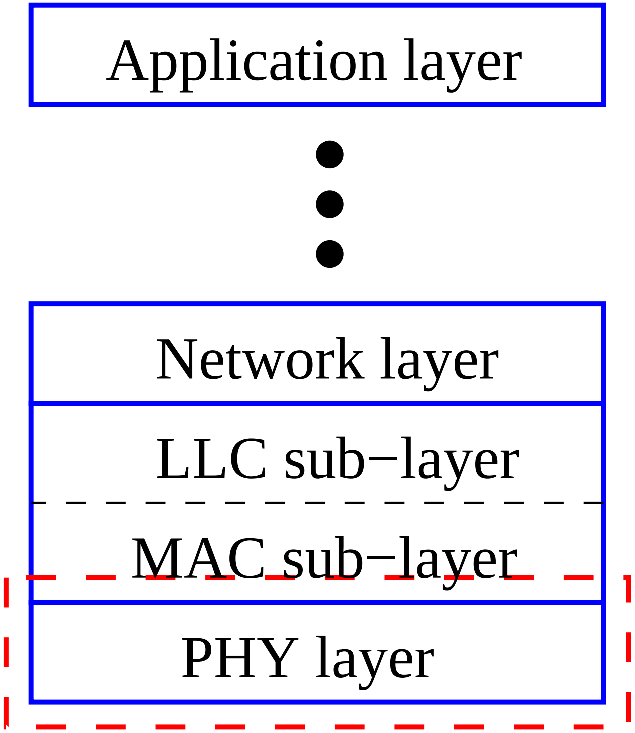
# *The PHY layer (1997)*

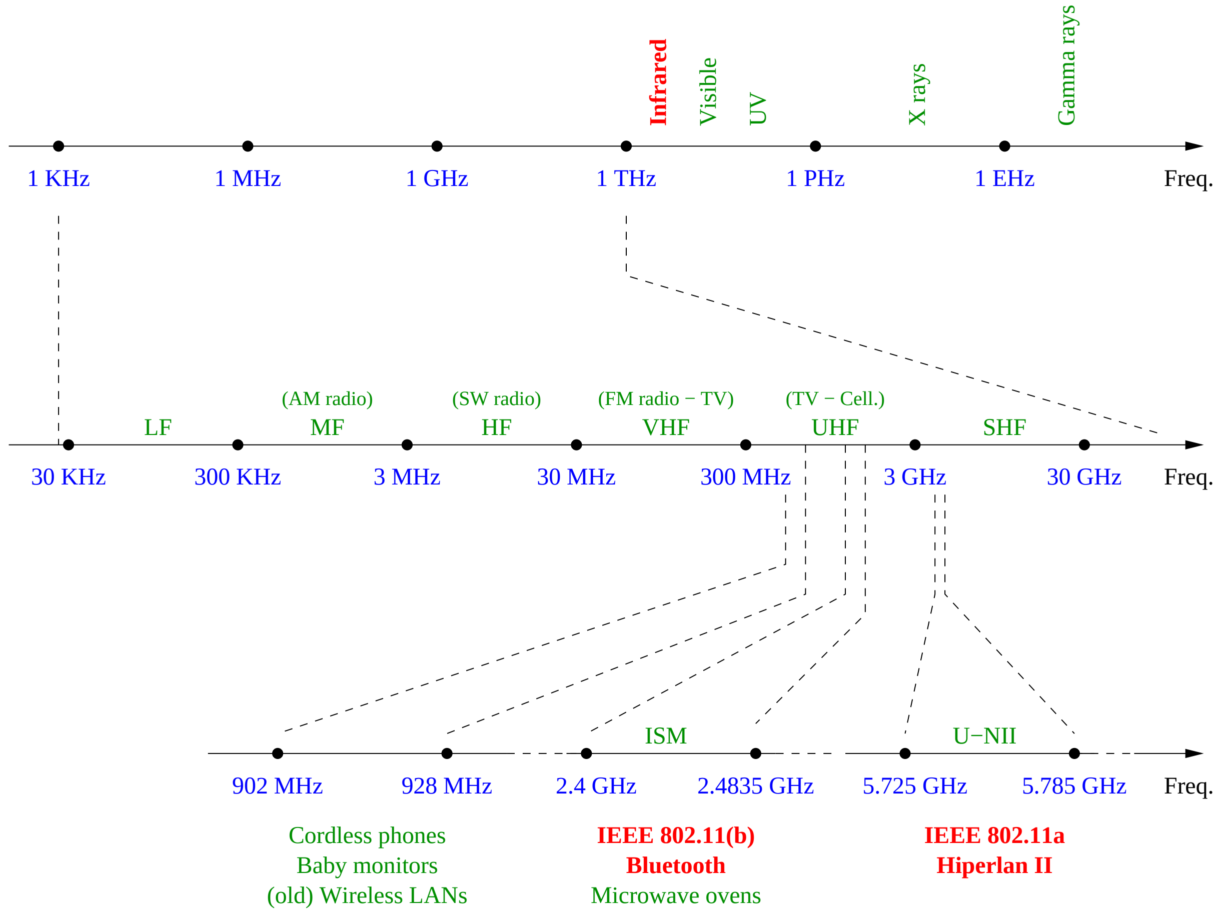


3 PHY types:

- − DSSS (most products)
- − FHSS (less products)
- − IR (unknown products)

# *The PHY layer (1997)*

## the EM spectrum allocation

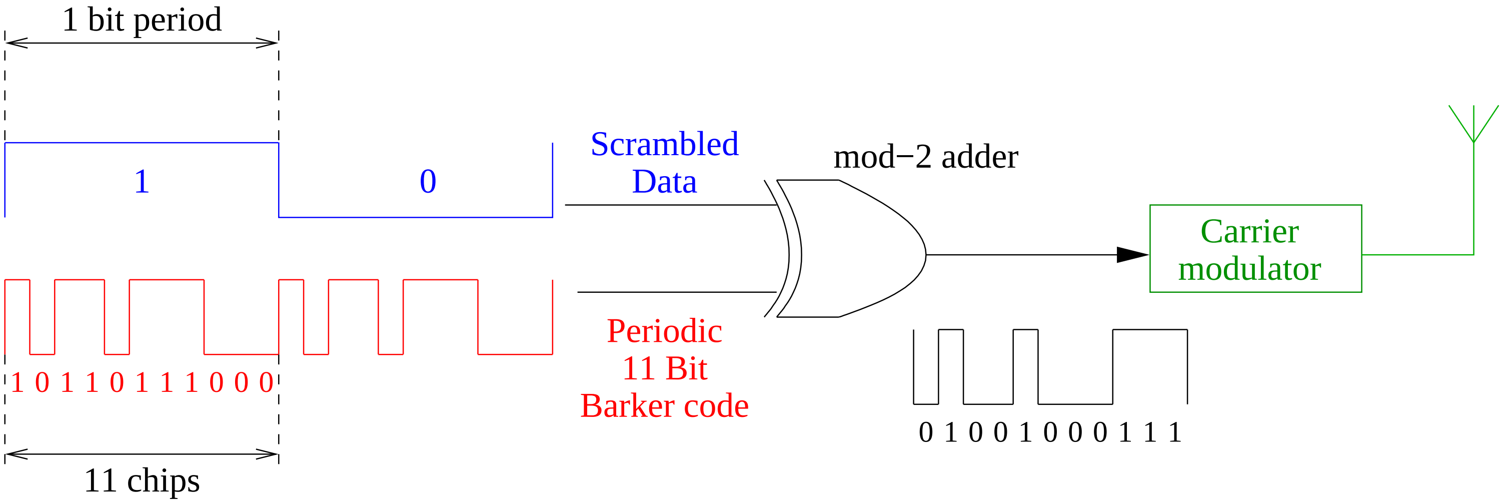


# *The PHY layer (1997)*

- **DSSS (Direct Sequence Spread Spectrum)**
- FHSS (Freq. Hopping Spread Spectrum)
- IR (Infra Red)

# *The PHY layer (1997)*

## DSSS: principle

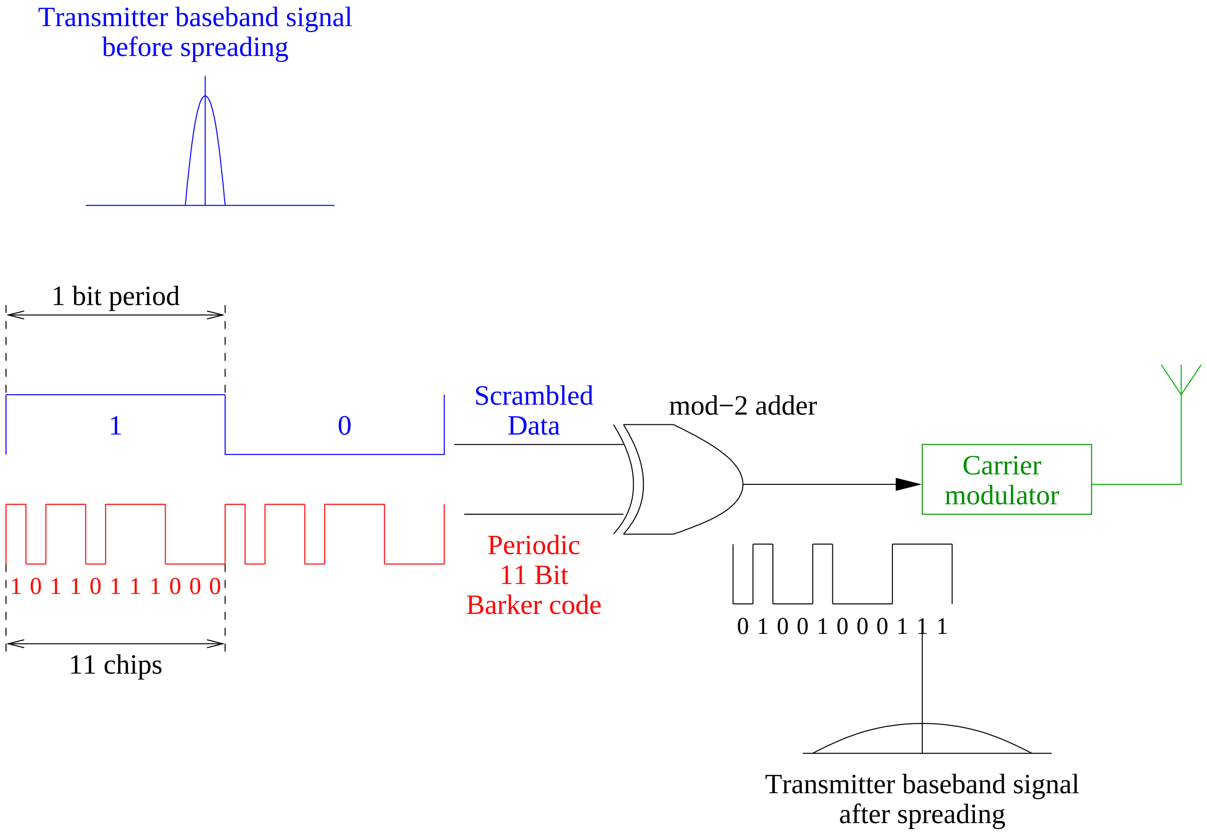


## Note:

- single code (11-chips)
- multiple access ? ... no
- security ? ... no

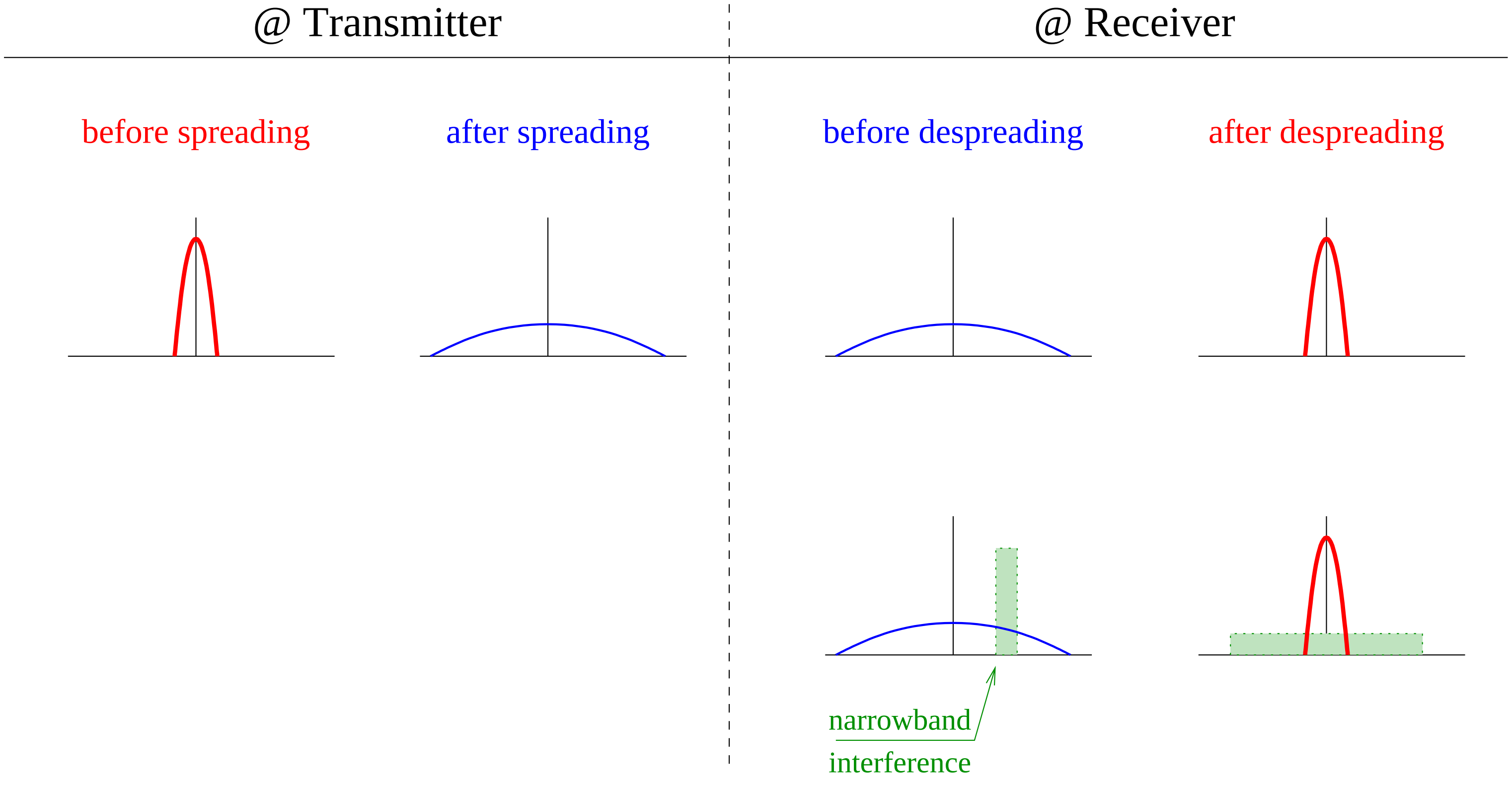
# The PHY layer (1997)

## DSSS: principle



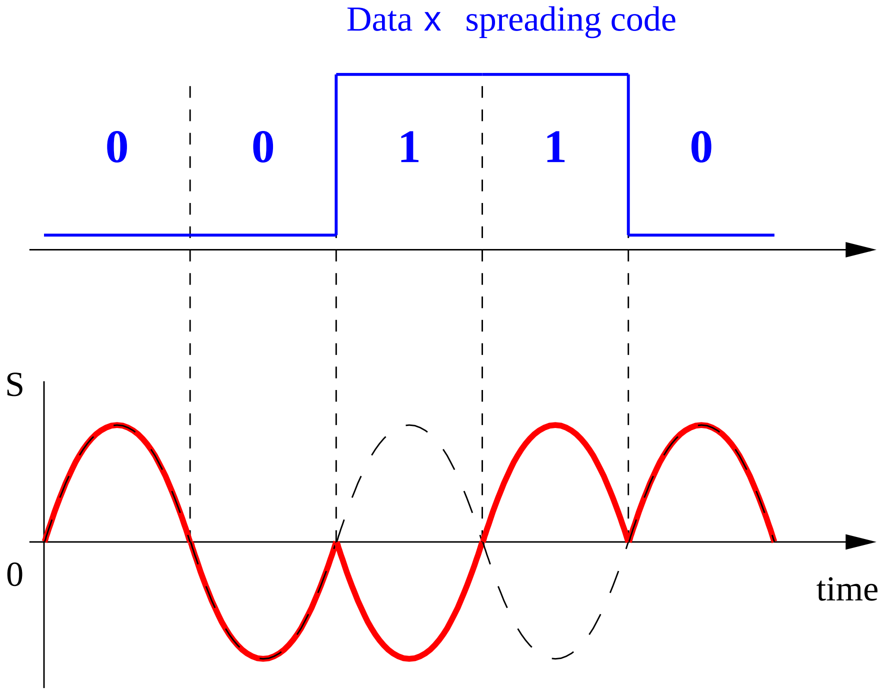
# The PHY layer (1997)

## DSSS: principle



# *The PHY layer (1997)*

PSK (Phase Shift Keying)

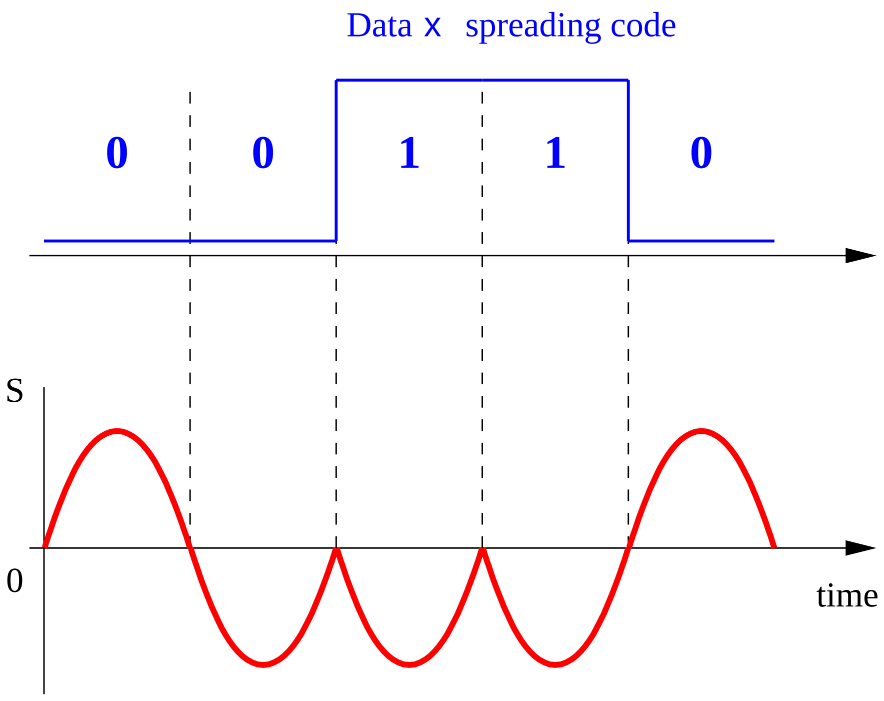


S(t) = A sin ( 2πω t + φ(t))

φ = 0

# *The PHY layer (1997)*

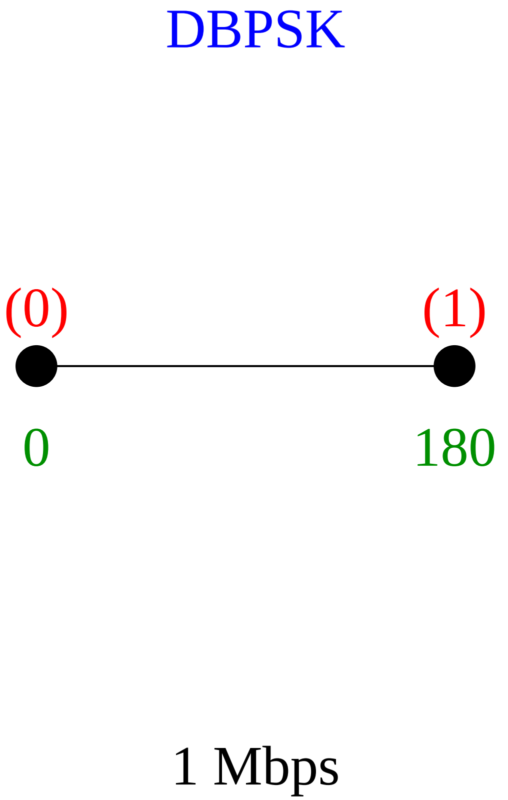
DPSK (Differential PSK):
no reference signal needed

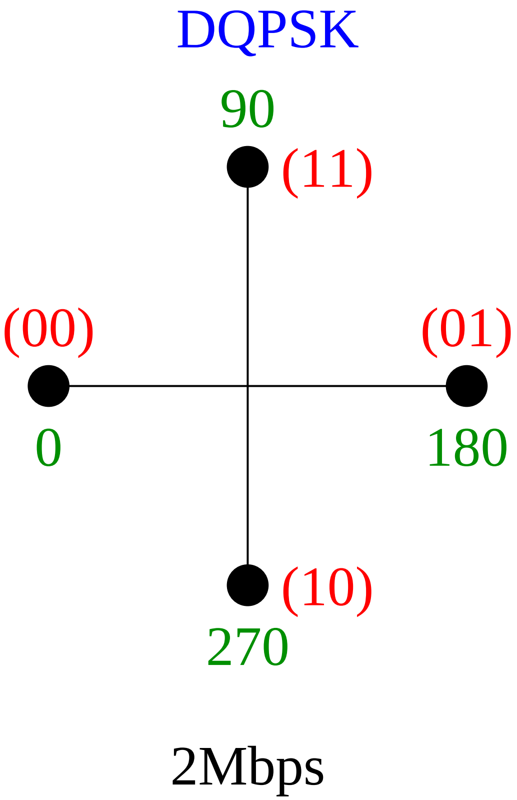


S(t) = A sin ( 2πω t + φ(t))

# *The PHY layer (1997)*

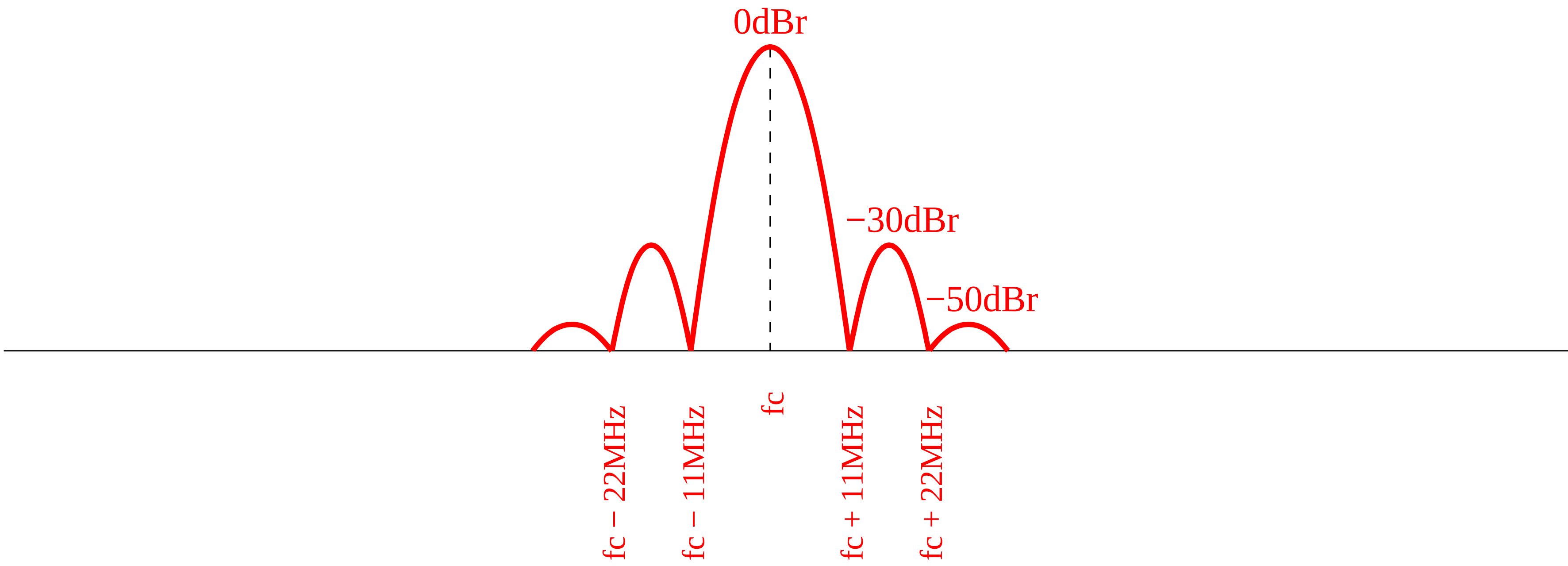
DSSS: modulation





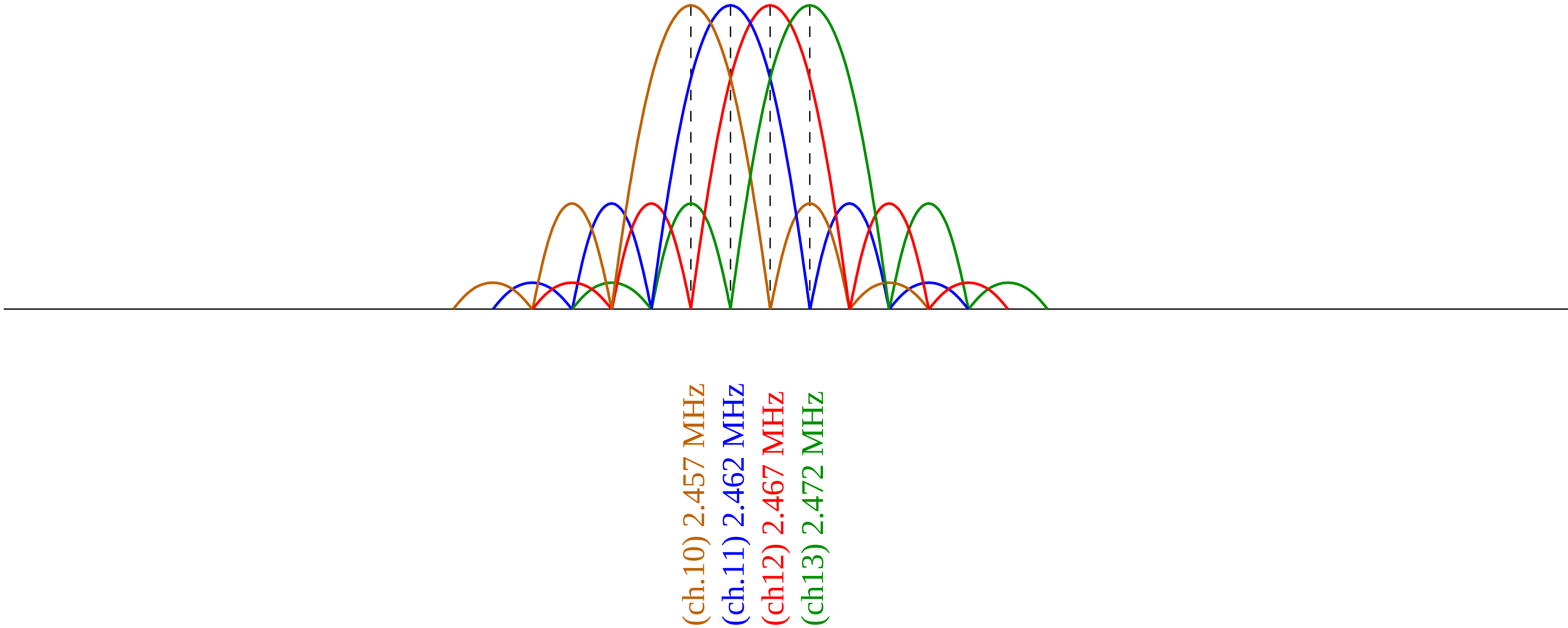
# *The PHY layer (1997)*

DSSS: Spectrum @ modulator output



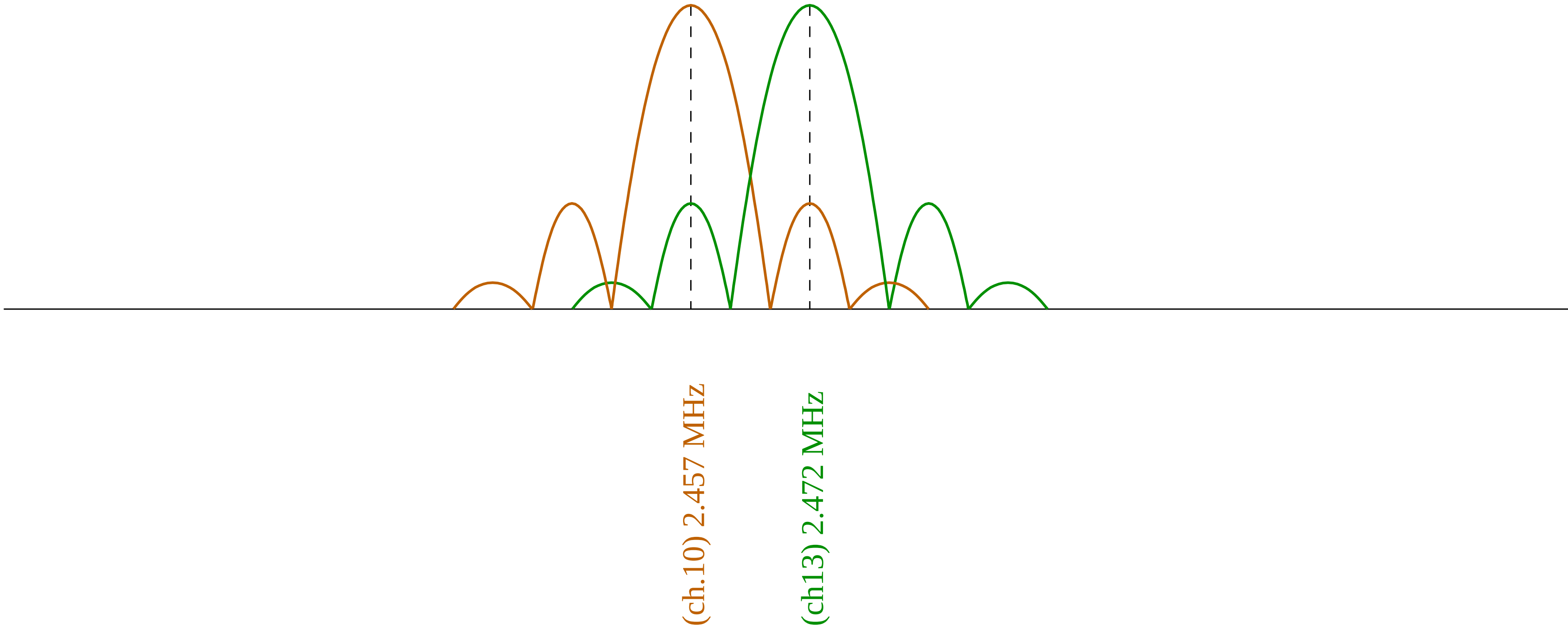
# *The PHY layer (1997)*

in France (few months ago): allowed channels



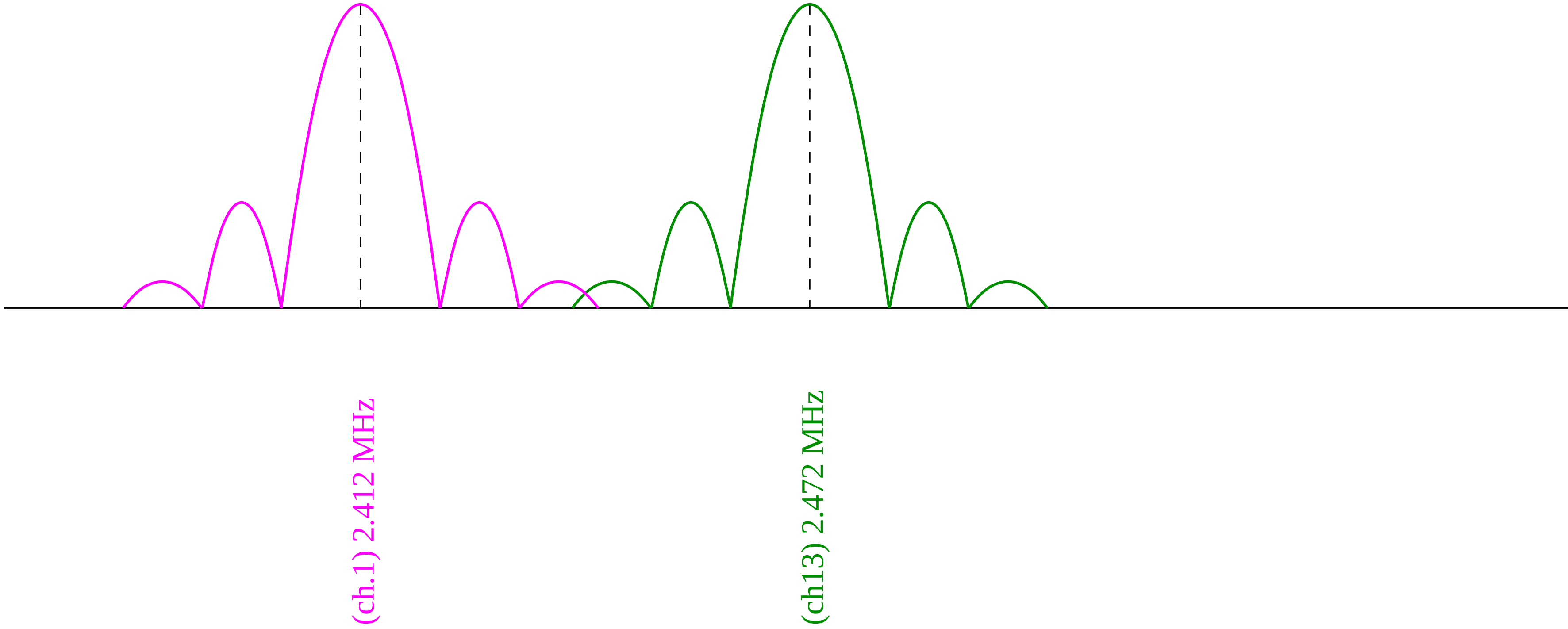
# *The PHY layer (1997)*

in France (few months ago): maximum channel separation



# *The PHY layer (1997)*

in Europe



# *The PHY layer (1997)*

Transmission power

| | GSM | $\mu$ wave<br>oven | IEEE<br>802.11 |
|---|---|---|---|
| Typical | 100 mW - 600 mW | 0.2mW/$cm^2$ | 6.3 mW |
| Regulations | | 1-5 mW/$cm^2$<br>@ 5cm | 100 mW<br>(Eur.) |

# *The PHY layer (1997)*

- DSSS (Direct Sequence Spread Spectrum)
- **FHSS (Frequency Hopping Spread Spectrum)**
- IR (Infra Red)

# The PHY layer (1997)

FHSS

- Modulation: GFSK
  binary 0/1: $F_c \pm f_d$ (for 1 Mbps)
  00, 01, 10, 11: $F_c \pm 2f_d$ (for 2 Mbps)
- $F_c$ sequence = $F_x(i) = [b(i) + x]mod(35) + 48$ (France)
  $b(i)$: tables
  $x$: 3 sets
- Fast-FH vs. Slow-FH: min 2.5 hops/s
- Bluetooth interference ?... YES

# *The PHY layer (1997)*

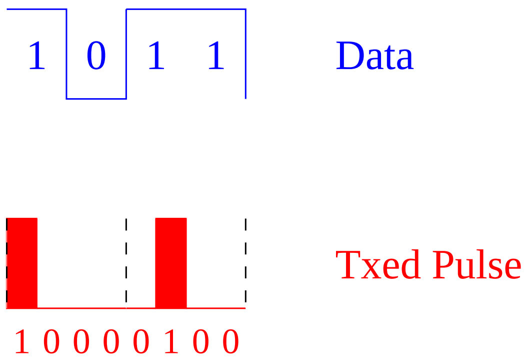
- DSSS (Direct Sequence Spread Spectrum)
- FHSS (Freq. Hopping Spread Spectrum)
- **IR (Infra Red)**

# ***The PHY layer (1997)***

Infra Red (IR)
Pulse Position Modulation (PPM)

- 1 Mbps: 4 data bits → 16-PPM symbol
- 2 Mbps: 2 data bits → 4-PPM symbol

| Data bits | 4−PPM symbol |
|---|---|
| 00 | 0001 |
| 01 | 0010 |
| 10 | 0100 |
| 11 | 1000 |



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# *PHY Extensions (1999)*

IEEE 802.11b: 2.4 GHz. 1Mbps, 2Mbps, 5.5Mbps 11 Mbps.

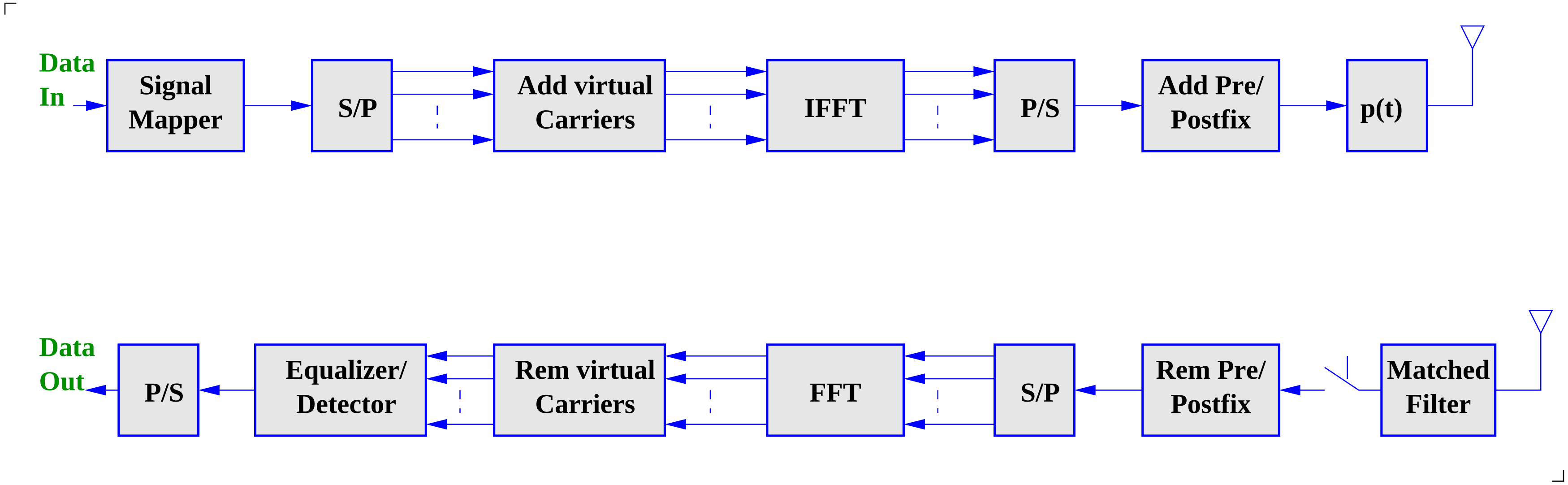
- High Rate DSSS
- Modulation: (backward compatible)DBPSK, DQPSK Complementary Code Keying (CCK) + DQPSK, (opt.) Packet Binary Convolutional Coding (PBCC) + (BPSK,QPSK)
- Currently the most widely used one

# *PHY Extensions (1999)*

IEEE 802.11a: 5.7 GHz, 6 Mbps → 54 Mbps!!

- OFDM (Orthogonal Frequency Division Multiplexing)
  - Principle:
    High-rate data is devided into several lower rate binary signals.
    Each low-rate signal modulates a different sub-carrier (48)
    Sub-carrier sets are orthogonal.
  - Modulation: BPSK, QPSK, 16QAM and 64QAM
- FEC: Convolutional encoding needed (Viterbi)
- Close to Hiperlan 2 specs.
- “coming soon”

# *PHY Extensions (1999)*



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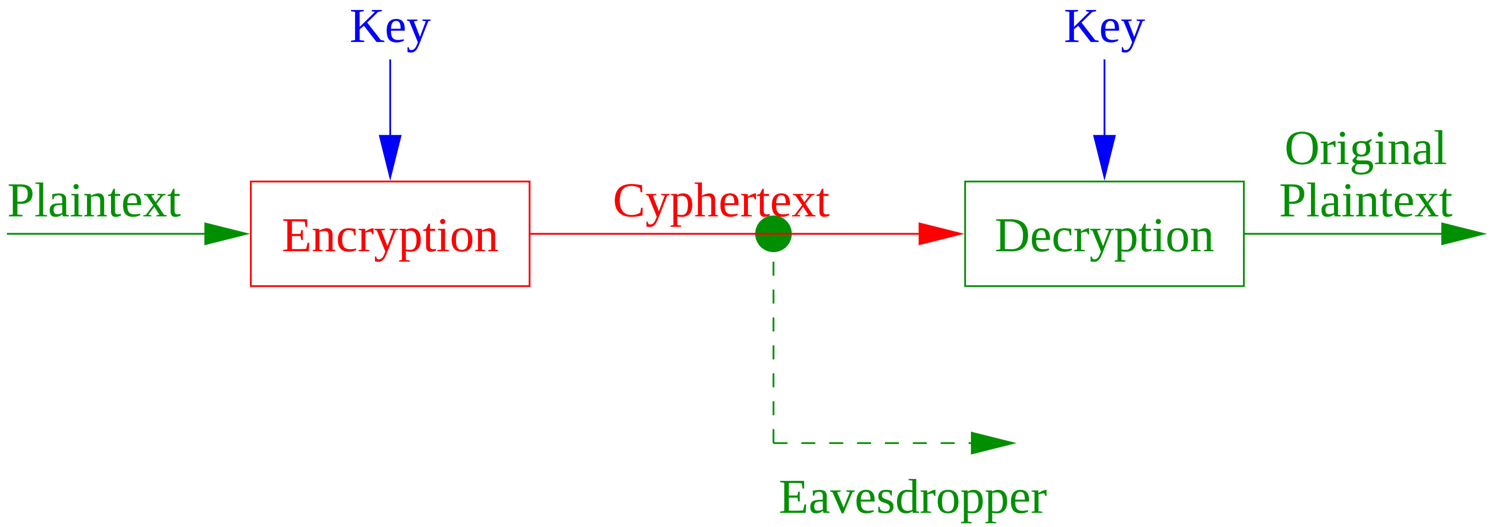
# ***Security***

## WEP (Wired Equivalent Privacy)



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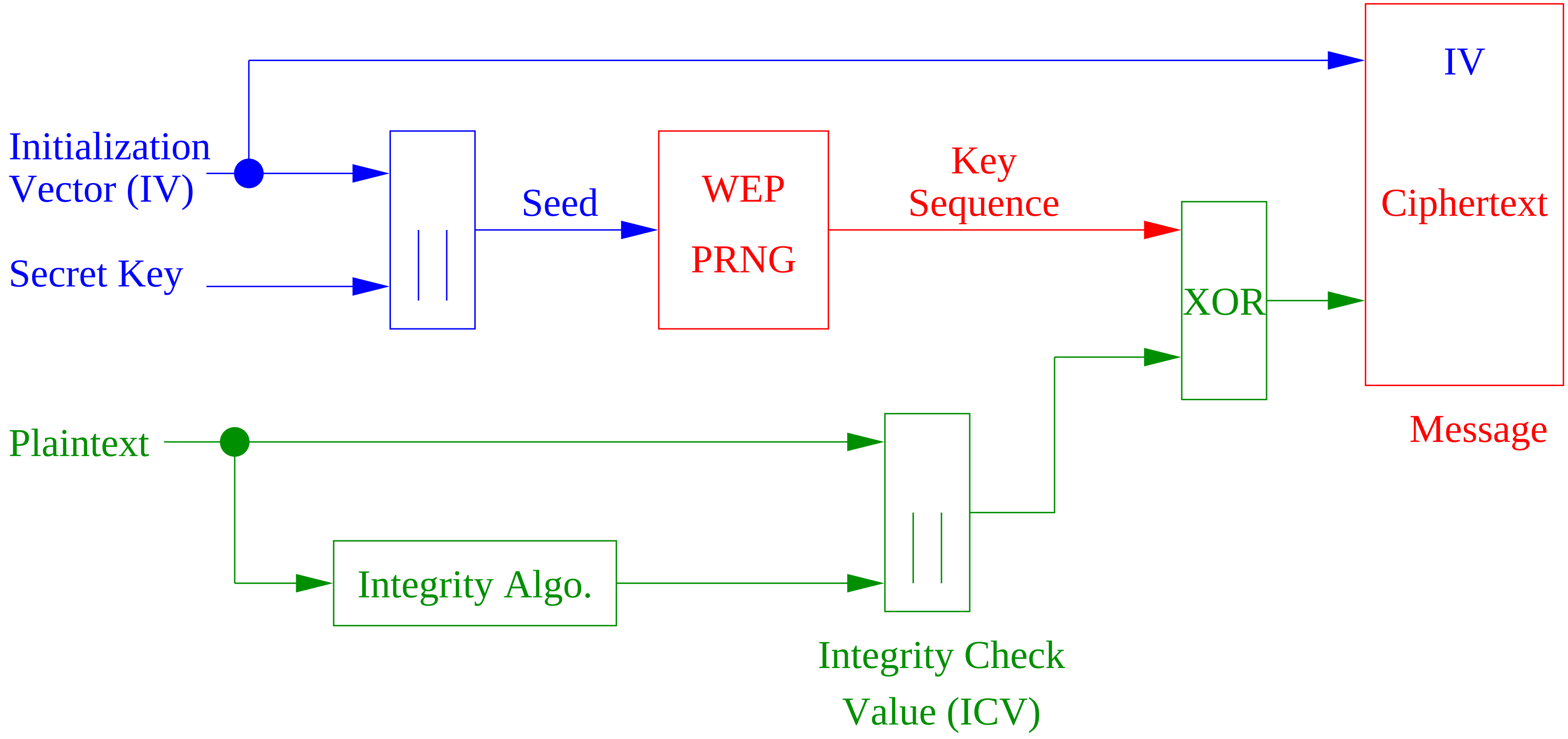

# ***Security***

WEP (Wired Equivalent Privacy)

- default keys / established keys
- 40-128 bit key
- Algorithm: RC4 (symmetric stream cypher)
- Cracking tools: WEPcrack, AirSnort:
  if “100MB-1GB of data can be gathered” then one “can guess the encryption password in less than a second”!!

Access control table ? ... inefficient
Network ID ? ... inefficient

# Conclusion

- it works!
- looks just like ethernet to higher layers
- no QoS support... yet.
- limited security management.

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