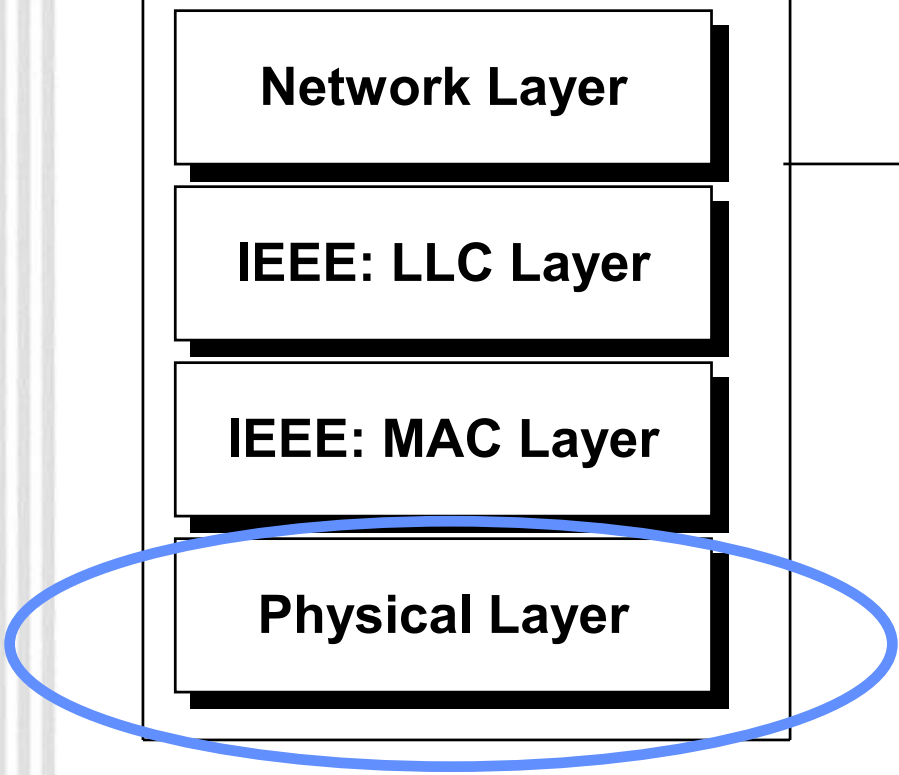
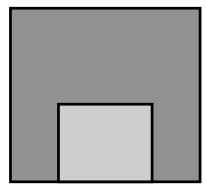
Module contents

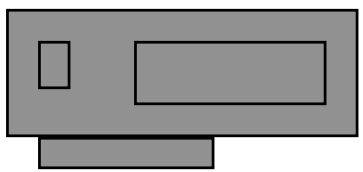
- ★ **Technologies overview**
- ★ Spread Spectrum
  - ★ Direct Sequence
  - ★ Frequency Hopping
- ★ Modulation
  - ★ DBPSK/DQPSK
  - ★ CCK

OSI Reference Model: Phy



- ★ Network Oper. System
  - ★ Network Layer
  - ★ Guarantees delivery data
- ★ Drivers
  - ★ LLC Layer
  - ★ send/receive data
- ★ LAN Controller
  - ★ MAC Layer
  - ★ data into/out frame
- ★ MODEM
  - ★ Physical Layer
  - ★ frame into/out phy frame

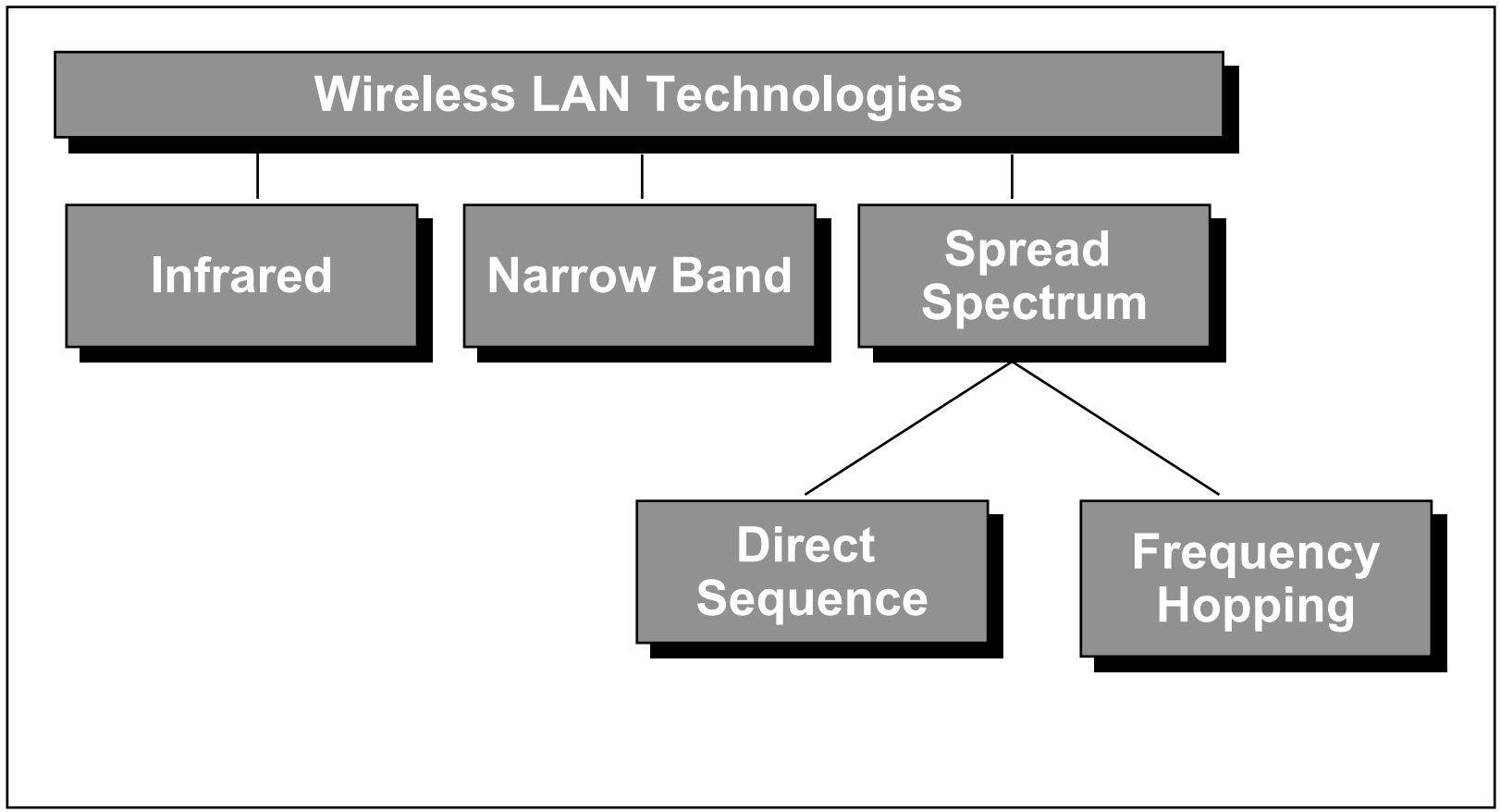




AVAYA communication

Wireless LAN technologies

(overview)



AVAYA communication

Wireless LAN technologies

(Infrared)

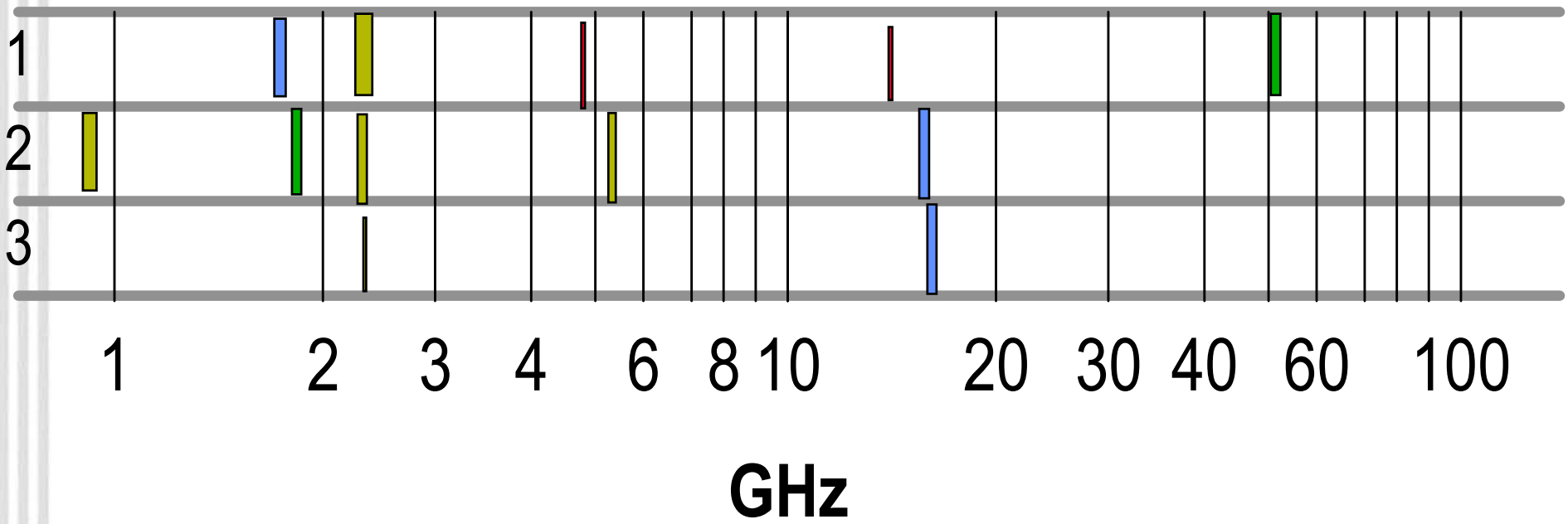
- ★ low power infrared light as the carrier
- ★ No license required
- ★ Very restricted mobility, limited coverage
- ★ high data rate (10 Mbps, 16 Mbps)
- ★ Line-of-Sight Infrared
  - ★ no objects in the path between two stations
- ★ Diffuse Infrared
  - ★ uses reflections to set-up wireless link

Wireless LAN technologies

(Narrow Band)

- ★ Dedicated band (18 GHz)
  - ★ License required
- ★ ISM band (915 MHz, 2.4 GHz, 5.8 GHz)
  - ★ unlicensed (special modulation)
  - ★ extremely low output power i.e. limited coverage
  - ★ high data rate (up to 10 Mbps) on short distance
- ★ Europe - DECT band (1.8 GHz)
  - ★ based on voice standard

ISM Frequency Allocations Worldwide



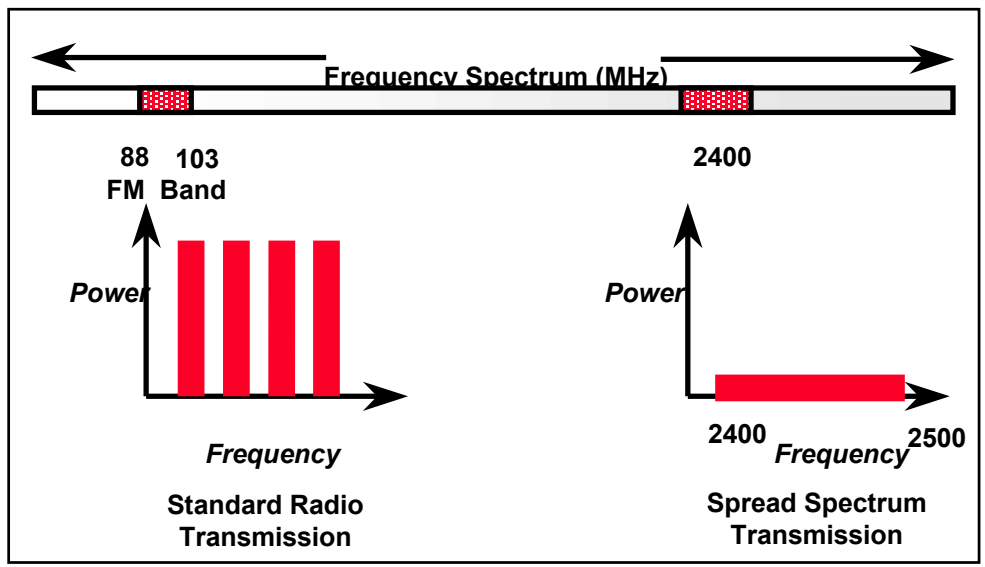
- **915 MHz only in the Americas (region 2)**
- **2.4 GHz for global availability (region 1,2,3)**

AVAYA communication

Wireless LAN technologies

(Spread Spectrum)

- ★ Unlicensed usage (ISM band)
- ★ No line of sight requirement (indoor)
- ★ High link reliability
- ★ Built-in transmission security
- ★ Two techniques used:
  - ★ Direct Sequence
  - ★ Frequency Hopping



AVAYA communication

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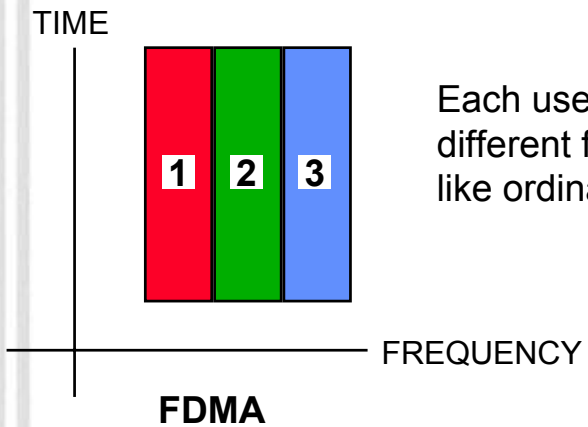
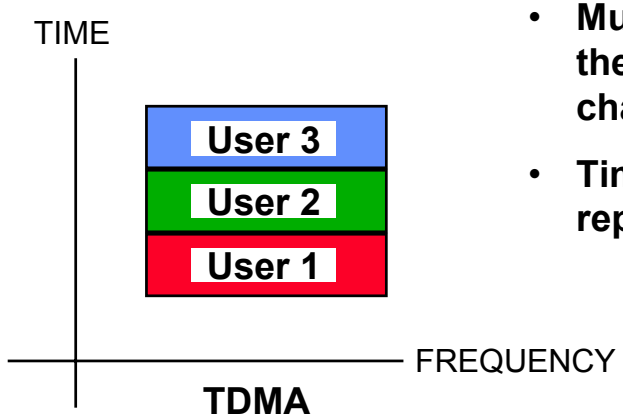
Multiple Access Methods

Multiple users share the available spectrum



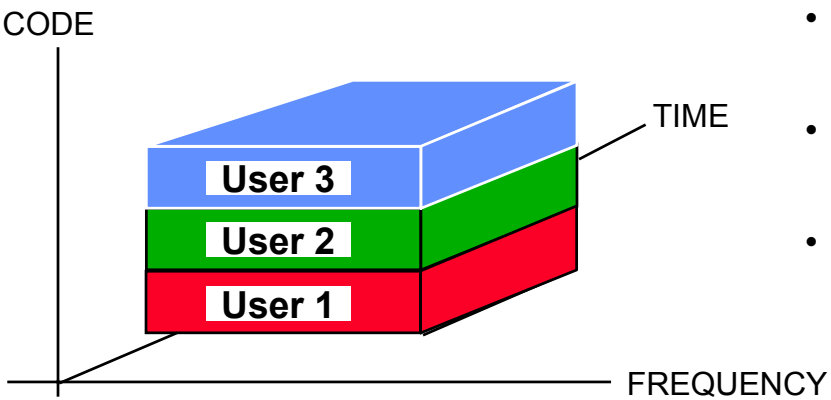
FDMA

Each user assigned a different frequency - like ordinary radio



TDMA

- **Multiple users share the same frequency channel sequentially**
- **Time slot sequence repeats over and over**



CDMA
also known as "Spread Spectrum"

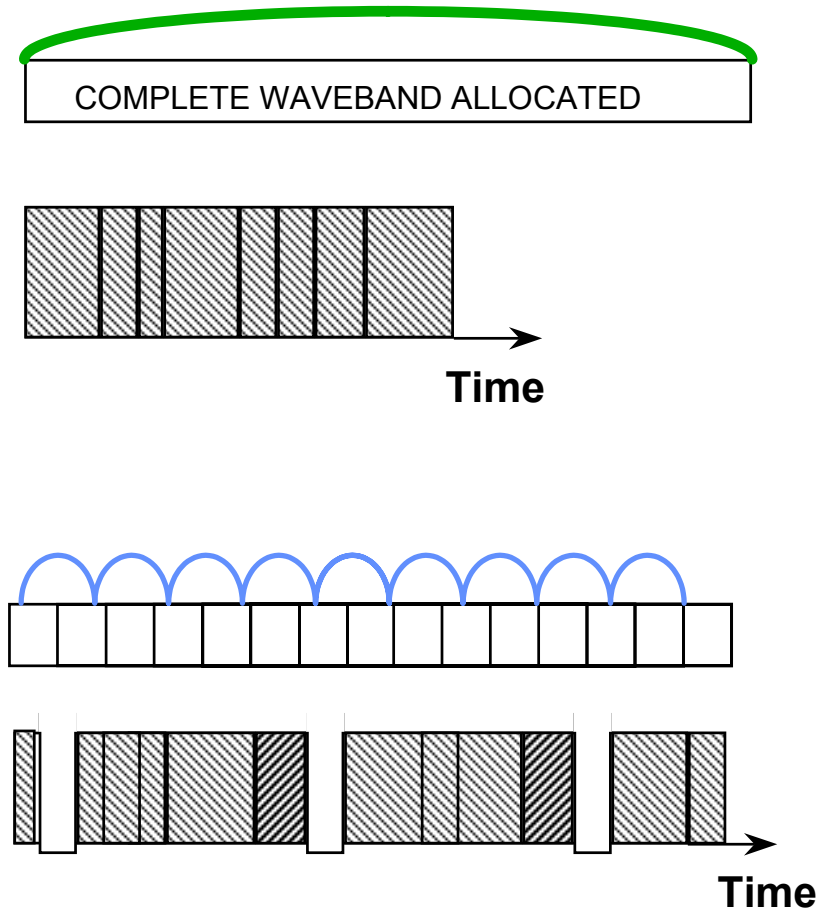
- **Channel is "spread" over wide frequency band**
- **Many users share the same frequency band at the same time**
- **Each user is assigned a unique "code" to identify and separate them**

AVAYA communication

Spread Spectrum Technologies

DS vs. FH

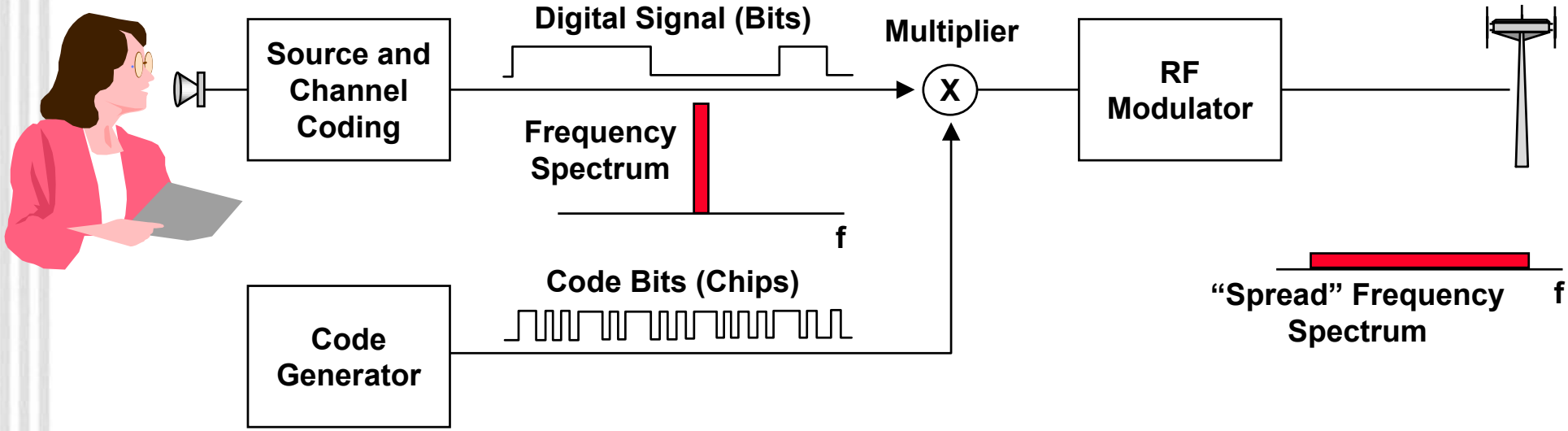
- ★ Direct Sequence
  - ★ Each symbol is transmitted over multiple frequencies at the same time
  - ★ Very efficient (no overhead)
  - ★ Higher speed than FH at comparable distances
  - ★ System capacity (multiple channels) higher than FH
- ★ Frequency Hopping
  - ★ Sequential use of multiple frequencies
  - ★ Hop sequence and rate will vary
  - ★ “End hop waste time”



AVAYA communication

Spread Spectrum Technologies

Direct Sequence transmitter



★ Spreading: Information signal (I.e. a "symbol") is multiplied by a unique, high rate digital code which stretches (spreads) its bandwidth before transmission.

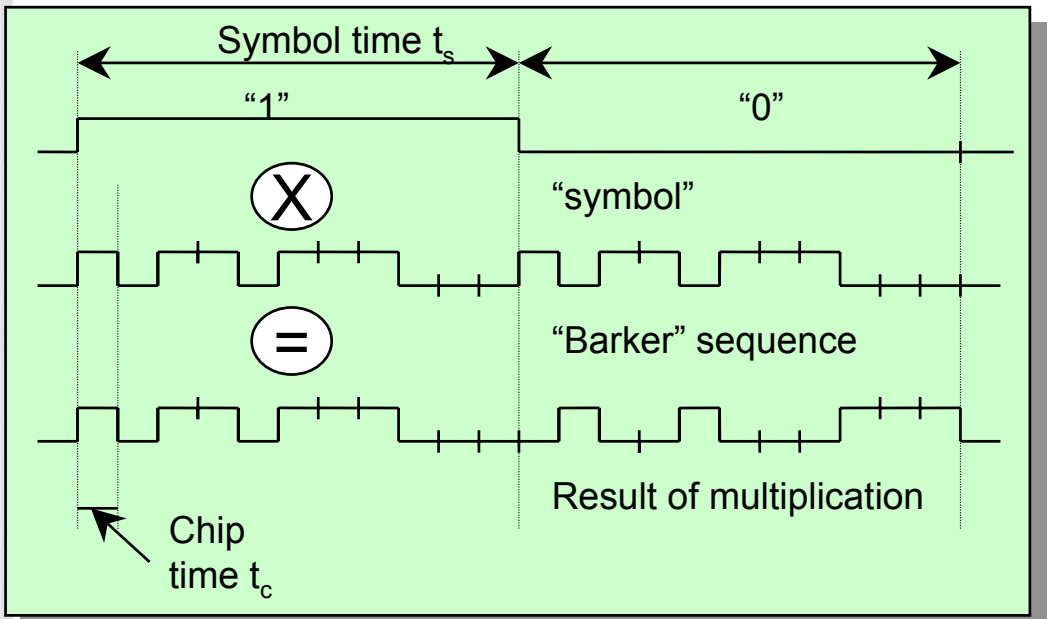
★ Code bits are called "Chips".

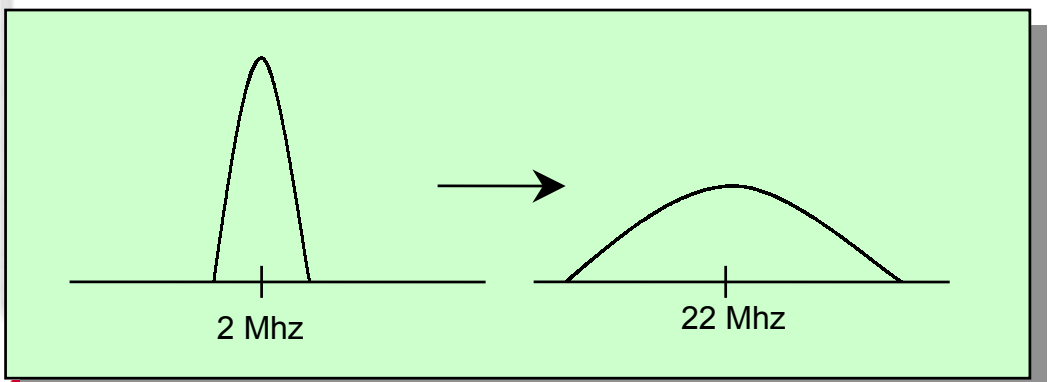
★ Sequence is called "Barker Code"

AVAYA communication

Spread Spectrum Technologies

What happens during "spreading"



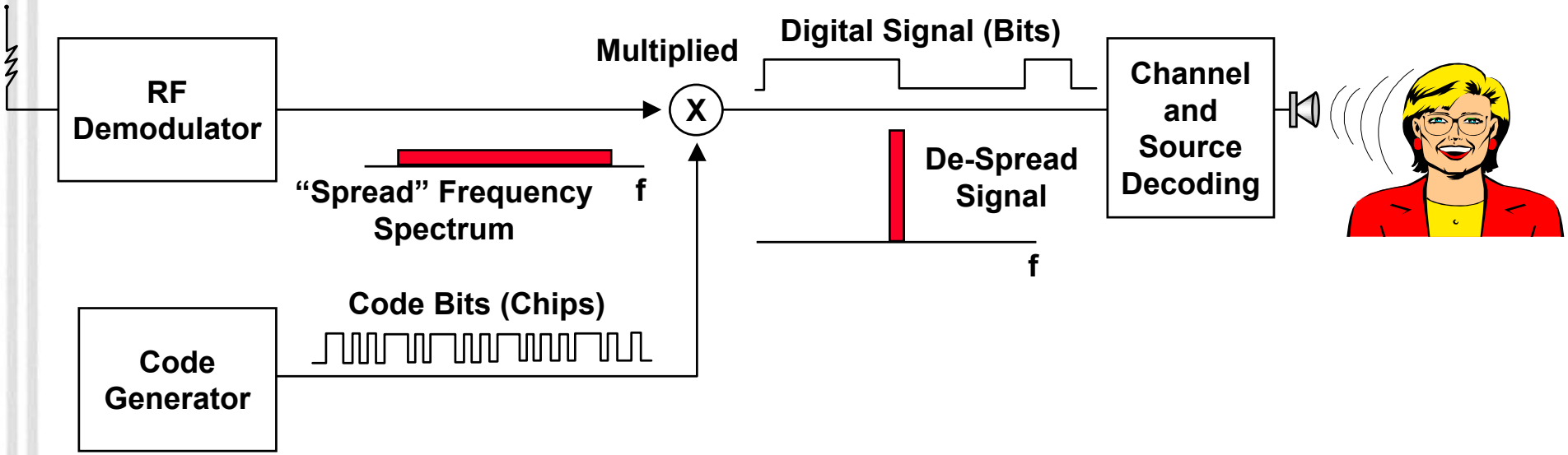


- ★ Due to the multiplication of a symbol with Barker code, the "rate-of-change" increases with a factor 11
- ★ This means that cycle rate increases from 1 MHz to 11 MHz
- ★ In terms of spectrum this means that after RF modulation the signal is spread from 2 MHz bandwidth to 22 MHz bandwidth

AVAYA communication

Spread Spectrum Technologies

Direct Sequence receiver



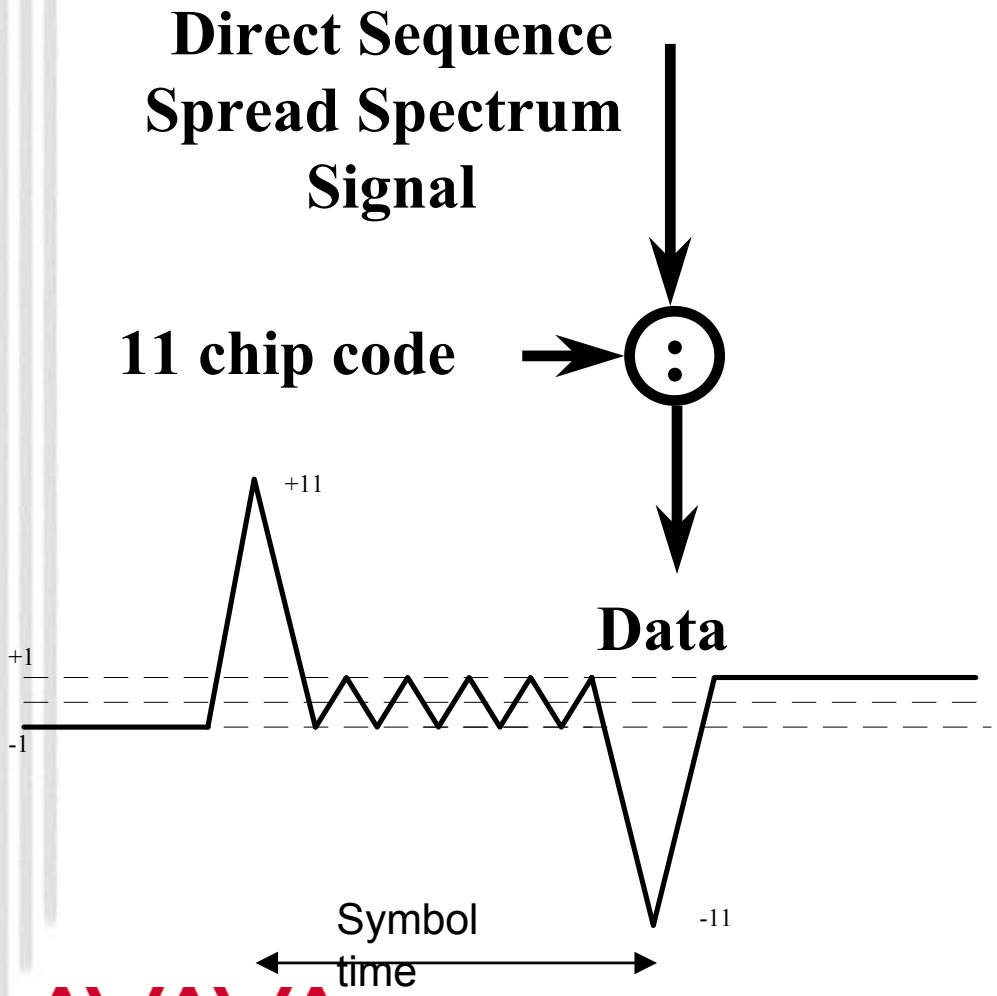
★ At the receiver, the spread signal is multiplied again by a synchronized replica of the same code, and is "de-spread" and recovered

★ The outcome of the process is the original "symbol"

AVAYA communication

Spread Spectrum Technologies

De-spreading

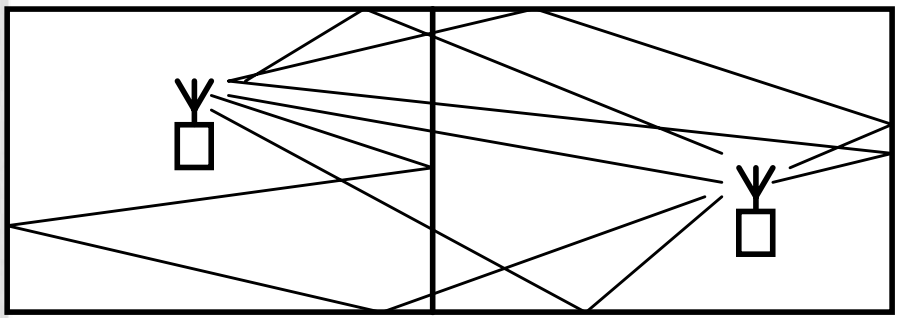


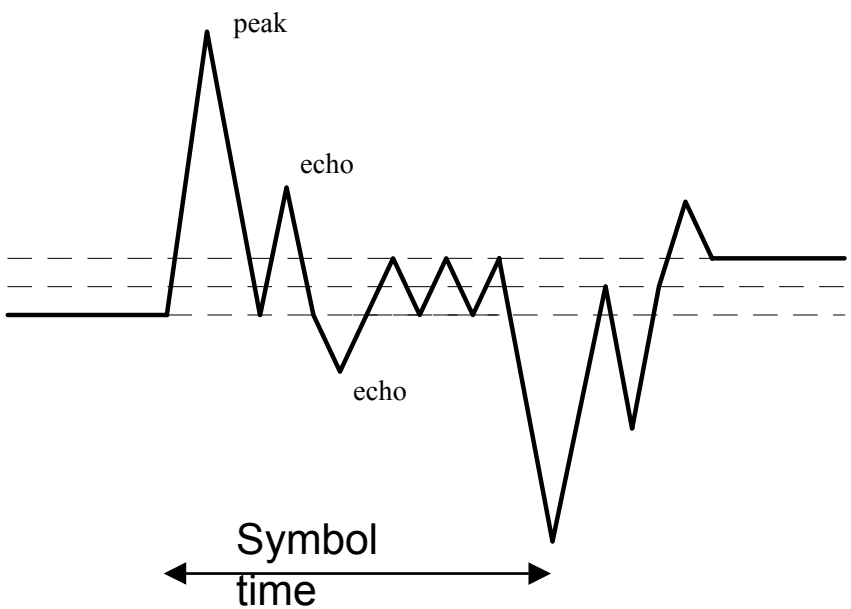
- ★ When the incoming signal is de-spread, it results in either a positive (+) or a negative (-) "spike"
- ★ These "spikes" arrive at intervals equal to the symbol time
- ★ A positive spike represents a "1" symbol, a negative spike represents a "0" symbol

AVAYA communication

Spread Spectrum Technologies

Direct Sequence receiver - effect of echoes





- ★ Echoes may arrive at the receiver, fluctuations can be noticed at positions other than at the symbol time boundaries
- ★ These fluctuations are ignored as the receiver will only interpret the spike at the synchronization points (separated from each other by the symbol time)

AVAYA communication

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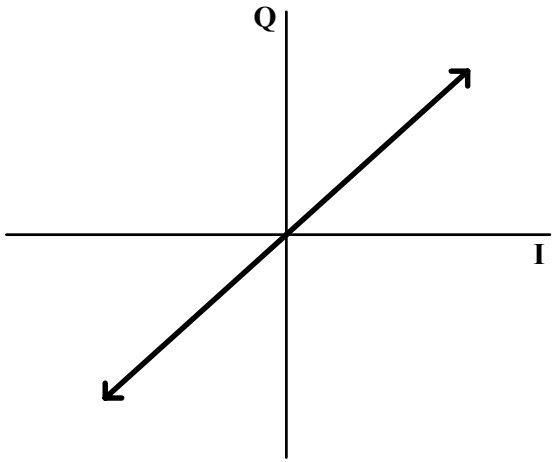
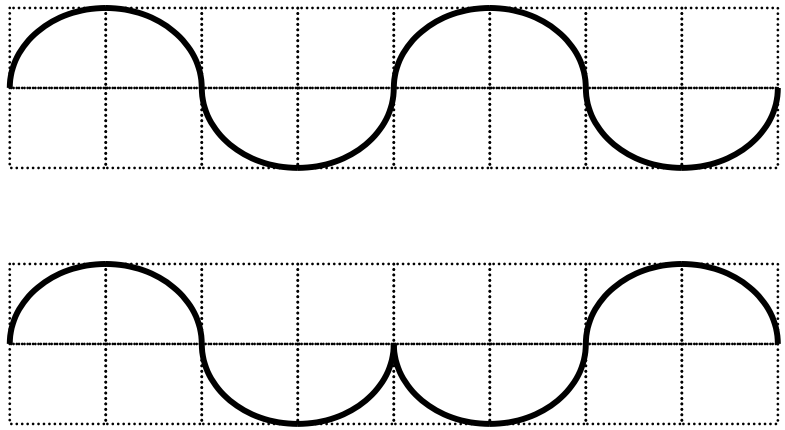
  - ★ **CCK**

Modulation

DBPSK (Differential Binary Phase Shift Keying)



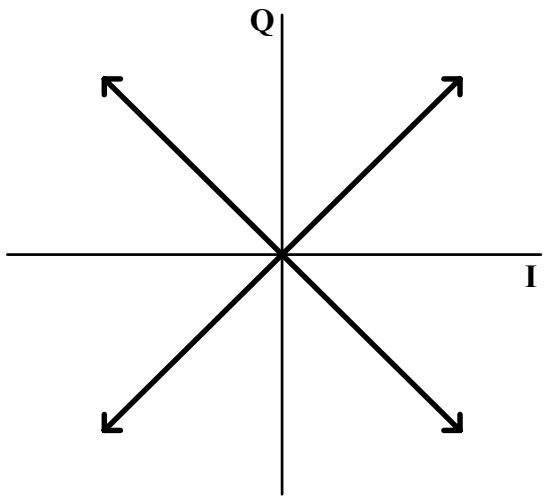


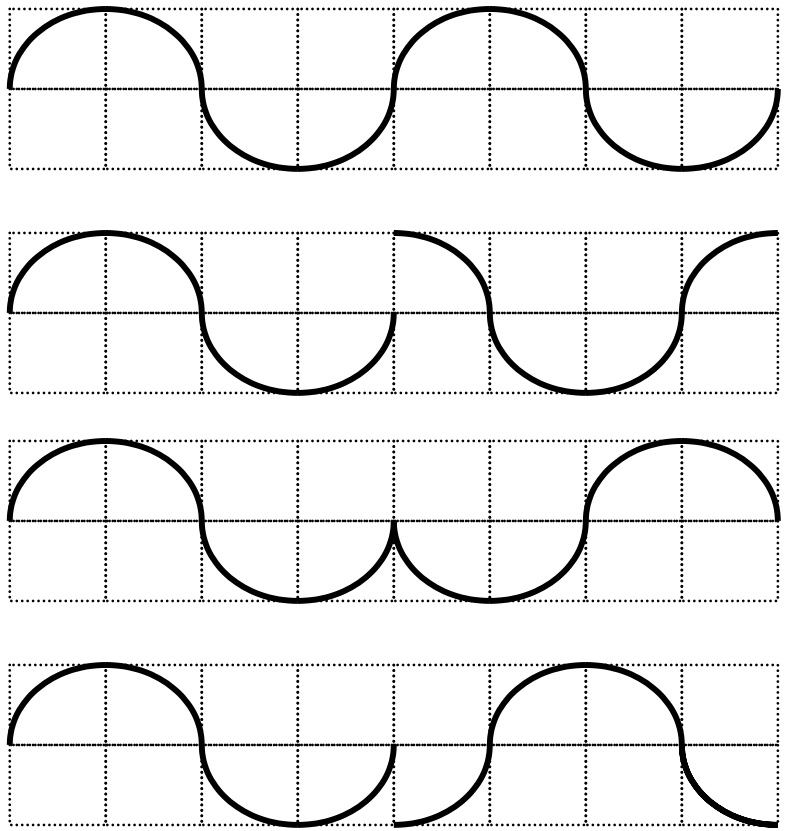
Bit Input	Phase Change (+jω)
0	0
1	π

Table 1, 1 Mb/s DBPSK Encoding Table.

Modulation

DQPSK (Differential Quadrature Phase Shift Keying)





Dibit pattern (d0,d1) d0 is first in time	Phase Change (+jα)
00	0
01	π/2
11	π
10	3π/2 (-π/2)

Table 1, 2 Mb/s DQPSK Encoding Table

AVAYA communication

CCK

Turbo 11 Mb approach

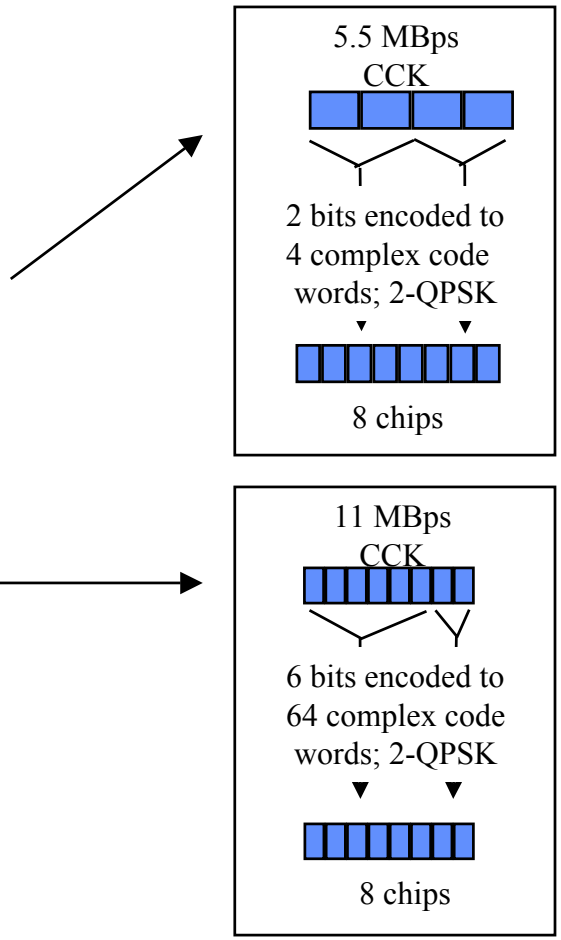
CCK = Complementary Code Keying

- ★ IEEE 802.11 standard for high speed
- ★ 11 and 5.5 Mbps data rates
- ★ Outstanding high multi-path performance
- ★ Outstanding low-SNR performance
- ★ Seamless interoperability with existing DS
- ★ Maintains QPSK chips at 11 MHz chip rate
- ★ Maintains 3 frequency channels
- ★ FCC and MKK regulations satisfied

CCK

How it works

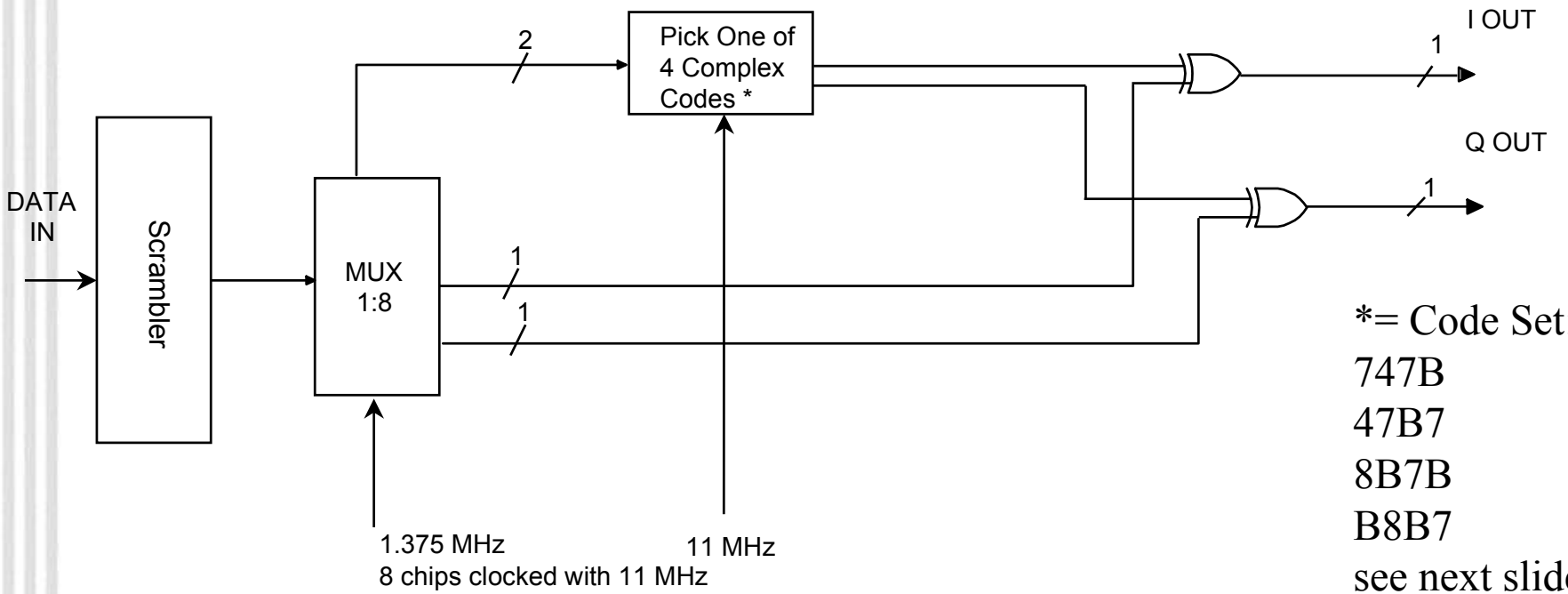
- ★ Data bits are encoded to a symbol which is transmitted in the form of 8 chips
- ★ For Data-Rate = Medium Encoding means:
  - ★ mapping 2 data bits to I or Q channel (in-Phase, Quaternary Phase)
  - ★ mapping 2 data bits to one of 4 Complex Codewords
- ★ For Data-Rate = High Encoding means:
  - ★ mapping 2 data bits to I or Q channel (in-Phase, Quaternary Phase)
  - ★ mapping 6 data bits to one of 64 Complex Codewords
- ★ Codewords are complex complementary codes selected from a code set



AVAYA communication

CCK

Operating at medium speed



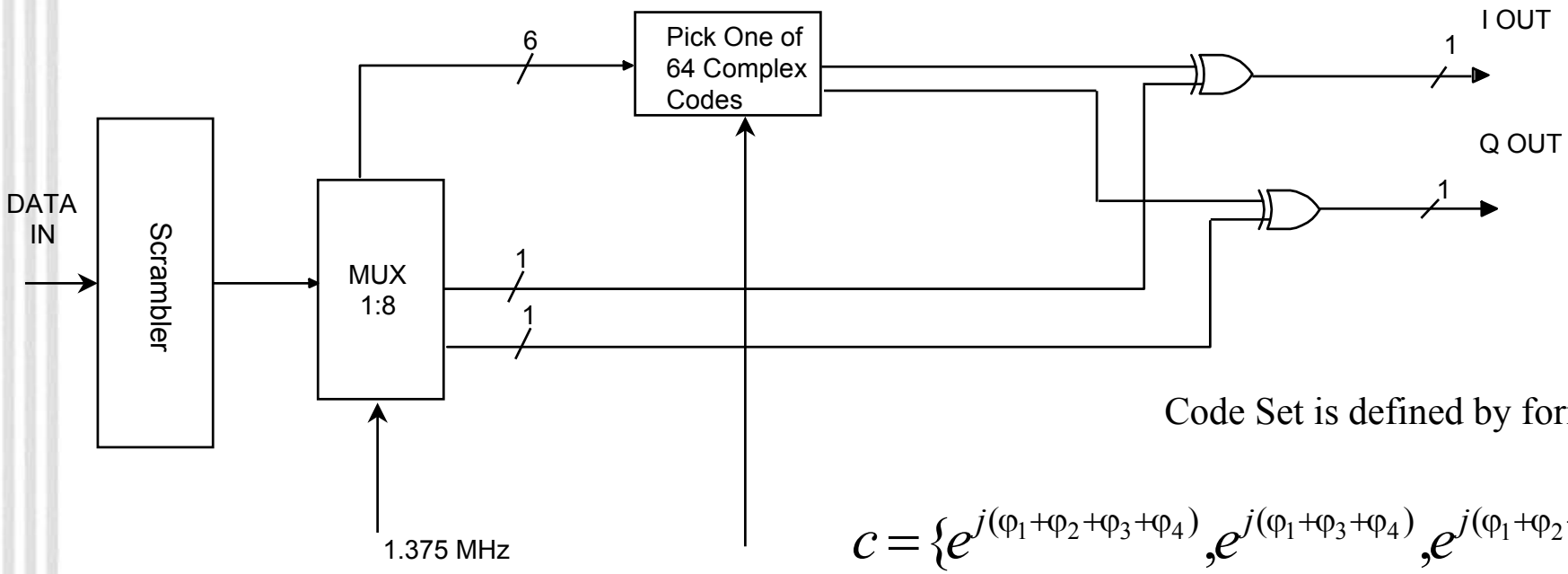
*= Code Set:
747B
47B7
8B7B
B8B7
see next slide

Data Rate = 4 bits/symbol * 1.375 MSps = 5.5 MBps

AVAYA communication

CCK

How it works



Code Set is defined by formula:

$$c = \{e^{j(\varphi_1+\varphi_2+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_3+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_4)},$$
$$-e^{j(\varphi_1+\varphi_4)}, e^{j(\varphi_1+\varphi_2+\varphi_3)}, e^{j(\varphi_1+\varphi_3)}, -e^{j(\varphi_1+\varphi_2)}, e^{j\varphi_1}\}$$

Data Rate = 8 bits/symbol * 1.375 MSps = 11 Mbps

AVAYA communication

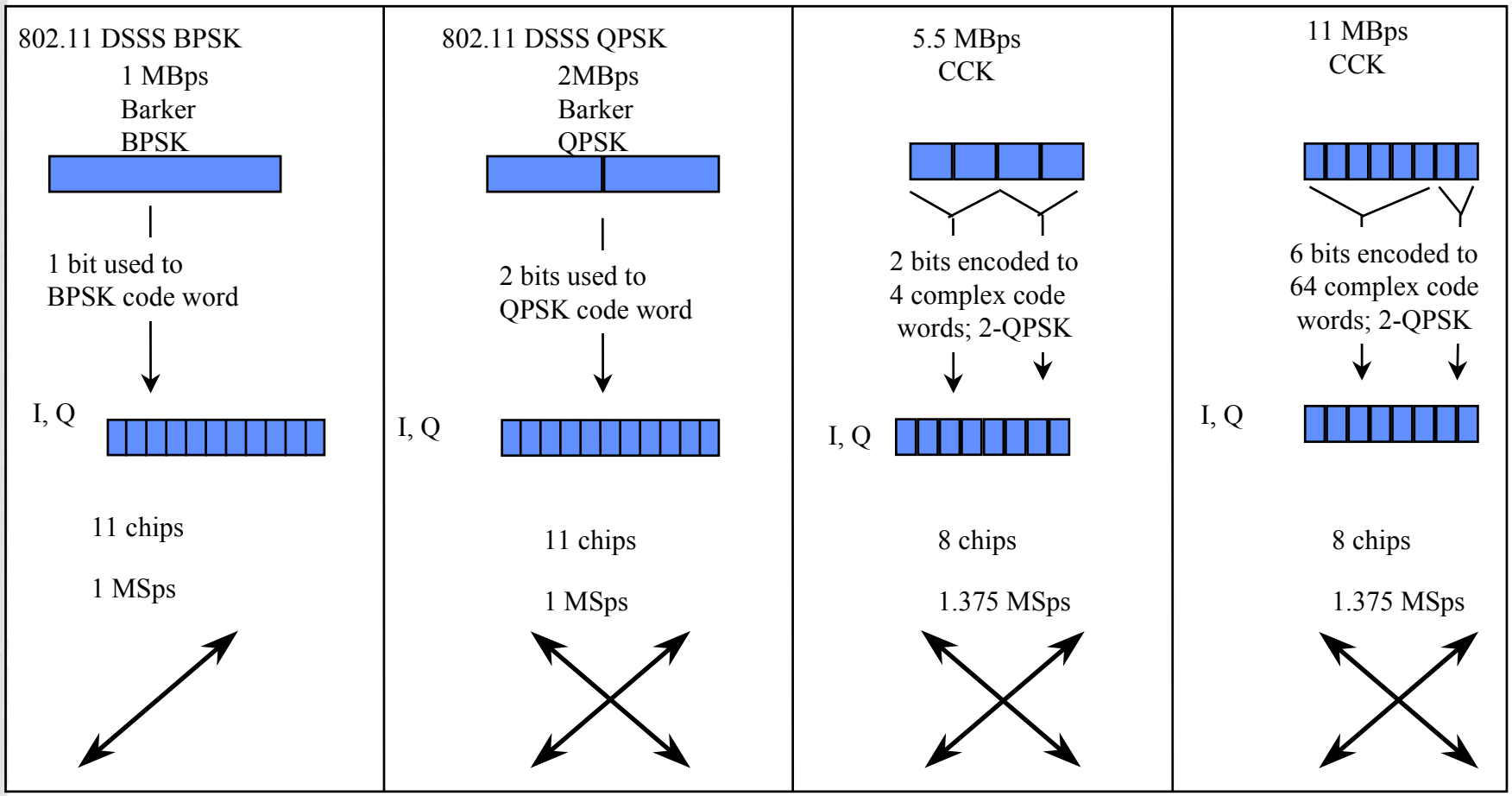
CCK

Data rates and symbol rates

- Bit-rates:
  - The 11 chips Barker sequence in Standard DSSS carries one symbol clocked at 1MHz, which results in a symbol rate of 1Msymbol/sec.
  - The 8 chips sequence in CCK clocked at 1 MHz, results in a symbol rate of 1.375 Msymbol/sec (I.e. 11/8)
  - At date rate = medium, 4 data bits are mapped on one symbol, which results in 5.5 Mbps (I.e. 1.375 * 4)
  - At date rate = high, 8 data bits are mapped on one symbol, which results in 11 Mbps (I.e. 1.375 * 8)

CCK

From DSSS BPSK to 11 Mbps CCK



AVAYA communication

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