# Wireless Communications

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# Swiss Alps

**Today, we can all be in touch with the digital resources we need, no matter where we may find ourselves.**

# Wireless communication include

| | | | |
|---|---|---|---|
| Radio engineering | Wireless network | Smart antenna | Link design, ARQ_ACK |
| Satellites | OFDMA | MIMO | Security |

# There are few TYPES OF SERVICEs

❑ **Broadcast:**

- the information sent in one direction the same for all users

❑ **Paging:**

- the user could receive information, but cannot transmit

❑ **Cellular telephony**

- the information flow is bi-directional.

  A user can transmit and receive information at the same time

❑ **Trucking radio:**

- used by police departments
- fire departments
- taxis and similar service

❑ **Cordless telephony**

❑ **Wireless Local Area Network (WLAN)**

❑ **Personal area network**

❑ **Satellite cellular communications**

# Requirements for the Service engineering market

| | Require Data rates | Data rates |
|---|---|---|
| Sensor Network | Bit/sec-1kbit/s | |
| Speech communications | 5kbit/s-64kbit/s | 10 Kbit/s-32kbit/s |
| Elementary data services | 10-100 Kbit/s (internet) | 50kbit/s laptop |
| Communication between computer peripherals | | 1 Mbit/s |
| High speed data service WLAN, internet | 0.5-Mbit/s-100 Mbit/s | |
| Personal Area Network (10m), streaming video, DVD player or TV, wireless USB | 100 Mbit/s | |

| Type of service | Range | Users |
|---|---|---|
| Body area networks | 1 m | 1 |
| Personal area networks | 10 m | 10 |
| Wireless Local Area Networks | 100-300 m | 100-300 |
| Cellular systems<br>Microcells<br>macro cells | <br>R=500<br>R=10-30 km | 5-50 |
| Fixed wireless access services | 100-n*10 km | |

# Principles and Attributes of Radio Engineering

POWER

MODULATION

LINK DESIGN

ANTENNA TECHNOLOGY

PROPAGATION

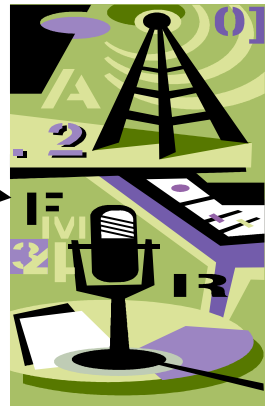
# Attributes

Wireless Link design

verizon wireless

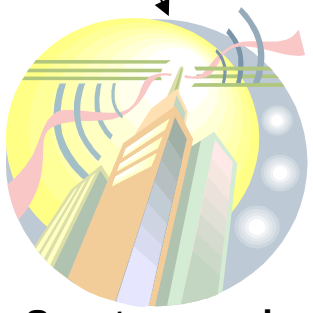
Service

Wireless infrastructure



Regulator & compatibility requirements


Radio Engineering



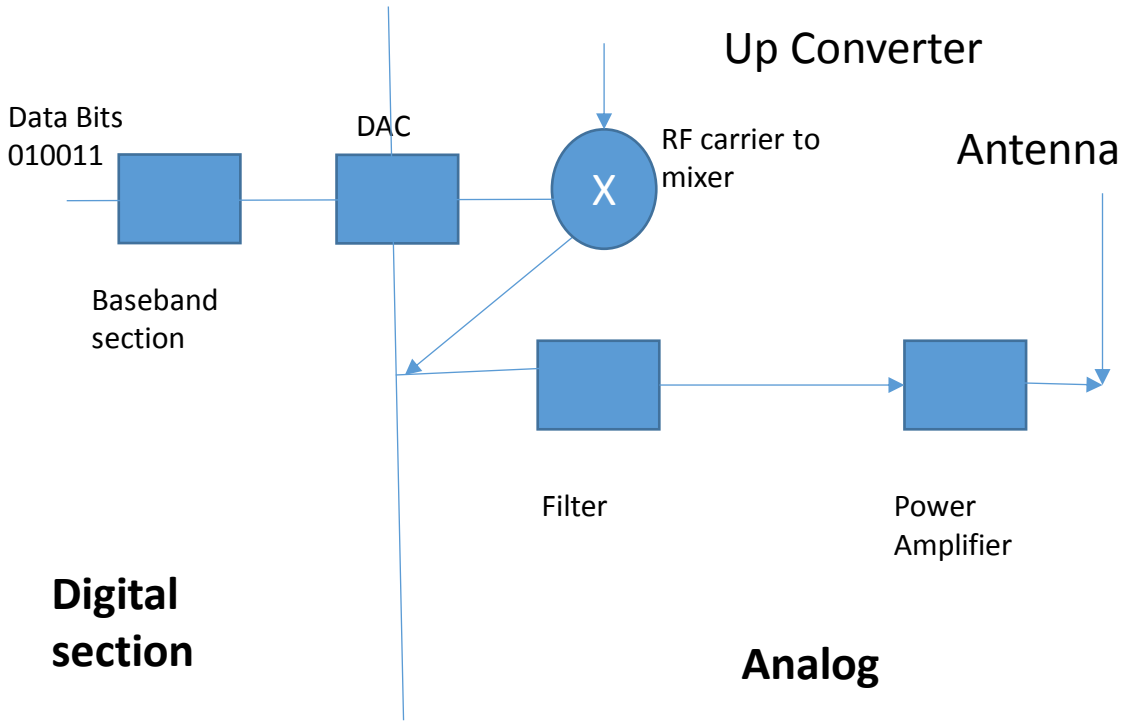
Spectrum and frequency allocation

Networking

User Device

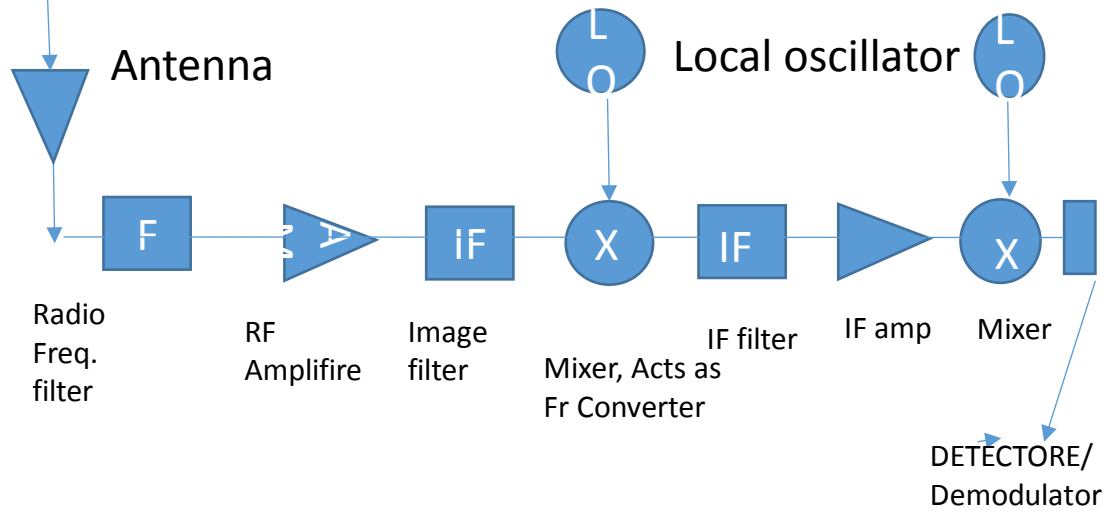
# Radio Frequency Engineering

- **Typical Modern Wireless Transmitter Block**



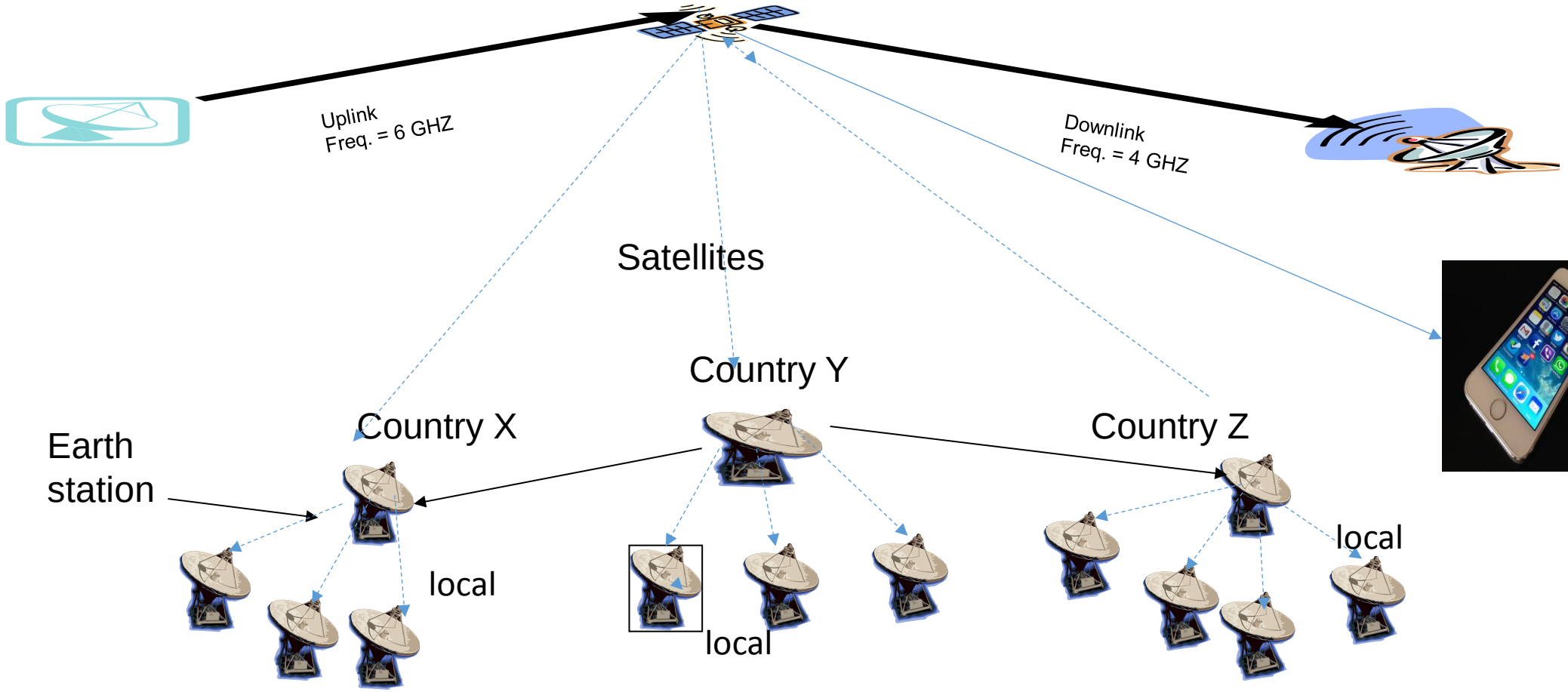

- **Super Heterodyne Radio Receiver**

Channel:010011



# Satellites

- Satellites used in communications.
- It has as transmitter as reciever.

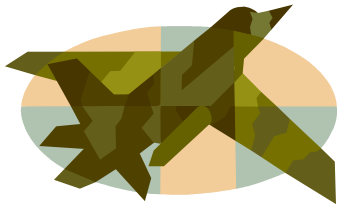



Partitioning of source-to-destination Radio link for purpose of end-to-end Link design

# Satellites are used for a large number of purposes

## Different Purposes

- Civilian Earth observation satellites
- Communications Satellites
- Navigation Satellites
- Weather Satellites
- Military
- Research satellites



# Satellites are used for a large number of purposes

| <100 MHZ | Citizens band pages, analog phone |
|---|---|
| 100-800 MHZ | Broadcast TV, radio |
| 400-500 MHZ | Cell systems |
| 800-1000 MHZ | 2G cell systems |
| 1.8-2.0 GHZ | The main frequency band for cellar communications |
| 2.4-2.5 GHZ | WLANs and personal area networking |
| 3.3-3.8 GHZ | Wireless fixed systems |
| 4.8-5.8 GHZ | WLAN can be found, used for fixed wireless |
| 11-15 GHZ | Most popular Satellite TV service |
| 11-15 GHZ | Uplink |
| 11.7-12.2 GHZ | Down link |

# Frequency band designation

| Band designation | VHF | UHF | L | S | C | X | KU | K | KA | V | W | mm | mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency range, GHZ | 0.1-0.3 | 0.3-1.0 | 1.0-2.0 | 2.0-4.0 | 4.0-8.0 | 8.0-12.0 | 12.0-18.0 | 18.0-27.0 | 27.0-40.0 | 40.0--75 | 75-110 | 110-300 | 300-3000 |

# Satellites Communications

- LEO (Low Earth Orbit)
  - Phone service to remote areas
  - Iridium (#66)
  - Global Star systems
  - Cascade System
- MEO (Medium Earth Orbit)
  - Large coverage Area

- GEO (Geostationary orbit)
  - Provide microwave radio relay technology for communication cables;
  - Communications for ships, vehicles,
  - TV broadcasting
  - Radio broadcasting
  - Weather forecasting

- HEO (High Earth Orbit)

  provide continues service to a very large foot print,

  monitor compliance with the nuclear test ban agreements,

  satellite service in the Polar Regions

❑ **Geostationary orbit well established for communications**

- A circle at an altitude of =35786 km
- A single Geostationary provide communications
- to areas > 1/3 of the Earth.
- The Geostationary satellites placed 120 degree apart
- The Satellite velocity in this orbit V=3075 (m/sec);

❑ **Disadvantages:**

- Propagation delays = 250 ms from transmitter to receiver
- Sun is a strong source of noise.

# Satellite Classification

| | LEO | MEO | GEO |
|---|---|---|---|
| **Circle around the Earth at Altitudes between** | **200 and 900 miles 321 and 1,448 km** | **1,500 and 10,000 miles 2,413 to 16,090 km-20 000 km** | **of 22,282 miles 35,860 km** |
| **Travel Speed (St velocity)** | **17,000 miles 27,359 km/hour** | **constant** | **3075 (m/s)** |
| **Travel time around the Earth**<br><br>**Connection with Satellite** | **90 min**<br><br>**10-15 min** | **12 hours**<br><br>**1.5-2. hours** | Stationed at an altitude 63,333 miles=101,925 km<br>**All the time** |
| **# of Satellites** | **225** | **27** | **3-4** |
| **Latency** | **20-40 ms (downlink, uplink)** | **50-100 ms (round trip)** | **250 ms** |
| **DW Data Rates**<br>**UP Data Rates** | **400 Kbps**<br>**2 way: 500 Kbps** | | |

# Orbits and Launching Methods

- Satellites (spacecraft) which orbit the Earth follow the same lows that govern the motion of the planets around the sun.

❑ Johannes Kepler (1571-1630):

- Derives 3 lows, describing planetary motion.

❑ Sir Isaac Newton (1642-1727) develop the theory

❑ of gravitation.

❑ Kepler's laws apply quite generally to any two bodies in space which interact through gravitation.

- The more massive of the two bodies is referred to as primary,
- the other, the secondary, or satellite.

# Konstantin Eduardovich Tsiolkovsky

**Konstantin Eduardovich Tsiolkovsky (1857-1935)**

was a Russian and Soviet Union rocket scientist and pioneer of the astronautic theory, of Russian and Polish descent.

Along with his followers,

The German Hermann Oberth and

The American Robert H. Goddard,

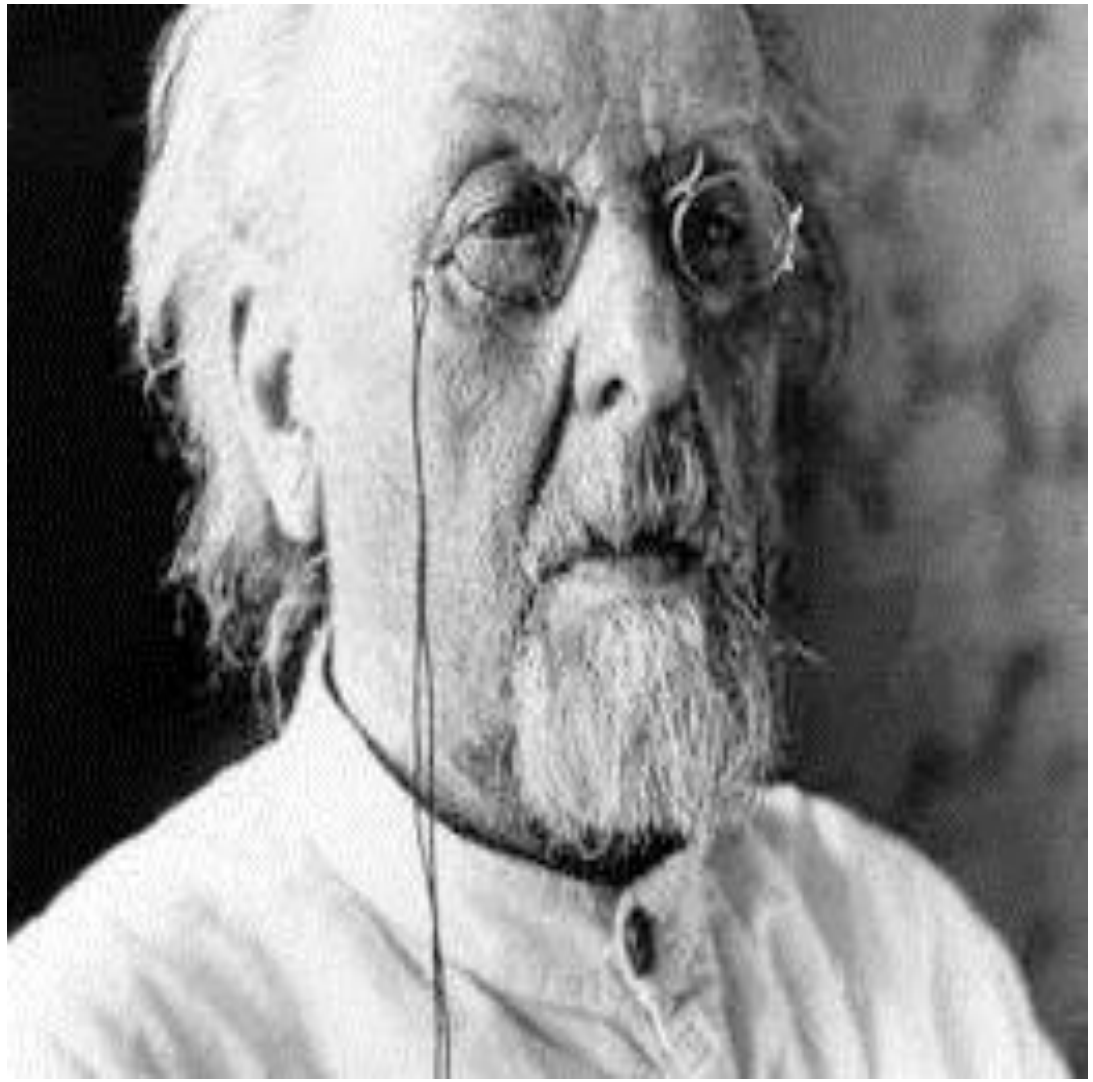
he is considered to be one of the founding fathers of rocketry and astronautics.

His works later inspired leading Soviet rocket engineers such as

Sergey Korolyov and

Valentin Glushko and

contributed to the success of the Soviet space program.



# Frequency Planning

- To facilitate the frequency Planning, the world is divided into 3 Regions:
- Region 1:

  Europe, Africa, Russia and

  Mongolia
- Region 2: North and South

  America, and Greenland
- Region 3: Asia, Australia,

  South- West Pacific

- At These Regions frequency Bands are allocated to various Satellite Services.
- Although a given service may be allocated different frequency bands in different regions.
- Some of the services provided by Satellites are:
  - Fixed Satellite service (FSS)
  - Broadcasting Satellite Service (BSS)
  - Mobile satellite Service (MSS)
  - Navigation Satellite Service (NSS)
  - Meteorological Satellite Service (MetSS)

# Example of Utilization different operational frequencies by Universal Mobile Telecommunications system (UMTS)

| 1650 MHZTDD | 1700 MHZ | 1750 MHZ | 1800 MHZ | 1850 MHZ | 1900 MHZ | 1950 MHZ | 2000 MHZ | 2050 MHZ | 2100 | 2150 | 2200 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **B1** | | | | 1880 TDD | 1920 TDD | 1920 M | 1980 M wired | | TDD 2010 2025 | 2110 BS | 2170 BS Wired |
| **B2** | 1710 MS Wired | | 1785 MS | 1805 BS Wired | 1880 BS | | | | | | |
| **B3** | | | | 1850 MS Wired | 1910 TDD | 1930 BS Wired | 1990 BS | | | | |
| **B4** | | 1710 MS Wired | 1785 MS | 1805 BS Wired | 1880 TDD | 1920 TDD | 1980 MS | 2010-2025 TDD | | 2110 BS | 2160 BS Wired |
| **B5** | 1710 | | | | | 1930 | 1990 BS | | | 2110 BS | 2160 BS |
| **B6** | 1710 | 1770 | | 1850 | 1910 | 1930 | 1990 | | | 2110 BS | 2170 BS |

# Radio Channel (electromagnetic spectrum)
# Unguided Transmission techniques

| ELF<br>Extremely Low Freq | SLF<br>Super Low Freq | ULF<br>Ultra Low Fr | VLF<br>Very Low Freq | LF<br>Low Fr | MF<br>Medium Fr | HF<br>High Freq | VHF<br>Very High Freq | UHF<br>Ultra High Freq | SHF<br>Super Low Freq | EHF<br>Extreamly High freq | THF<br>Tremadly High Freq |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-300<br>HZ | 3-300<br>HZ | 300-10^3 HZ | 10^4<br>HZ | 10^5<br>HZ | 300-3<br>MHZ | 3-30<br>MHZ | 30 MHZ-300 MHZ | 300 MHZ-3GHZ | 3-30 GHZ | 30-300 GGZ | 300 GiGa HZ 3 Tera HZ |

# Antenna introduction Basics

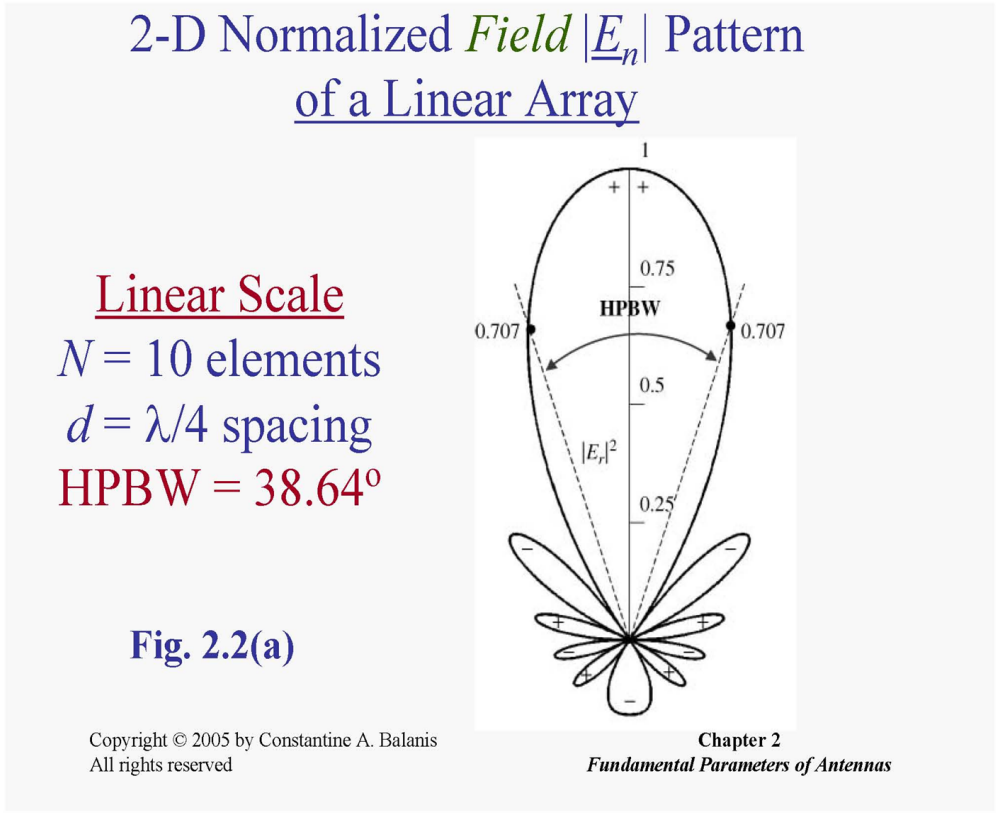
- Different types of antennas are used

  in wireless telecommunications.
- Wire antennas
- Aperture antennas
- Micro strip antennas
- Array antennas
- Reflector antennas
- Lens antennas
- Between free space and guided device

# Parameters of Antenna

- **Radiation Pattern (Amplitude and Phase) Gain, Hz/m**
- **Directivity**
- **Efficiency**
- **Impedance**
- **Current distribution**
- **Polarization**
- **Radiation intensity**
- **Radiation efficiency**
- **Electromagnetic wave Propagation**
- **EXH fields**
- **Beam forming (Beam efficiency)P tr/P res**
- **Total Radiated Power Density**
- **Reflected Power**

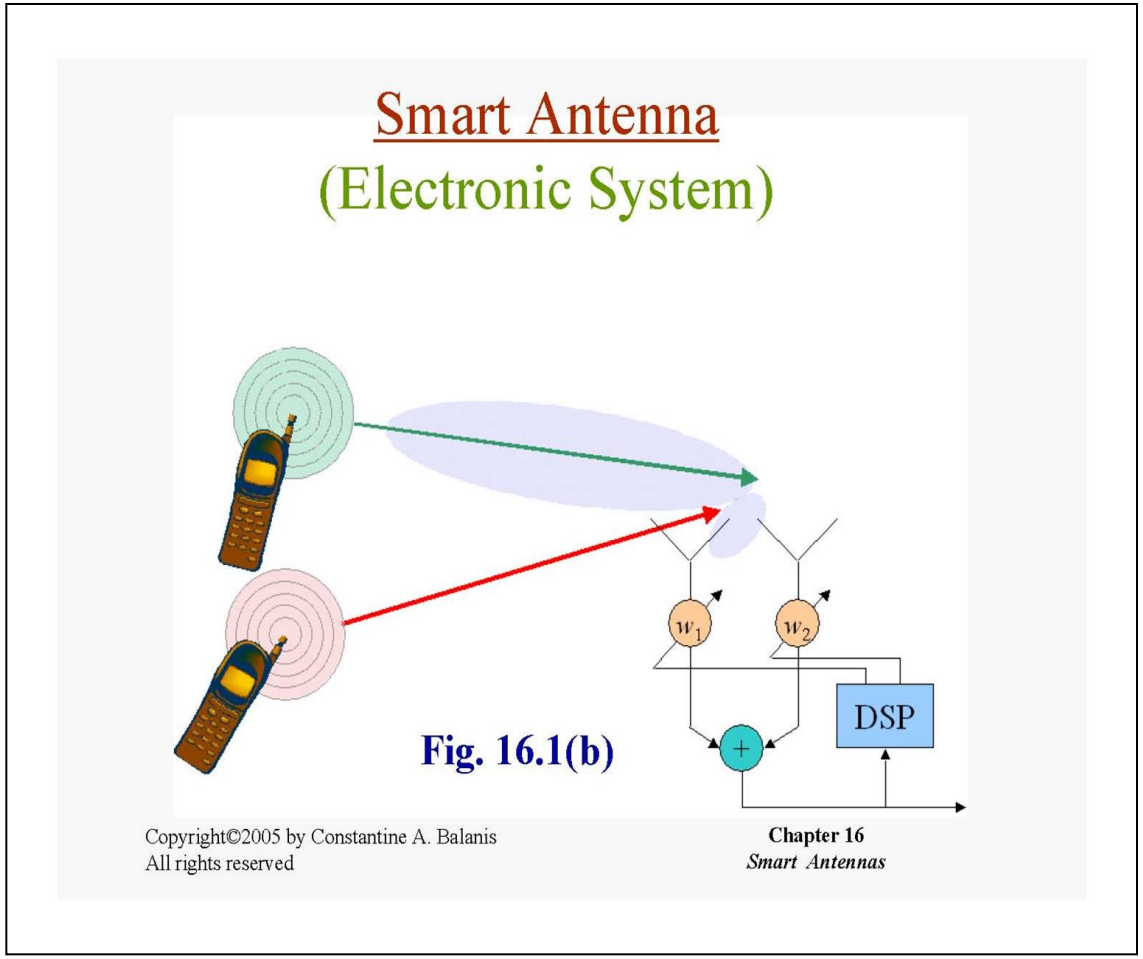
# Normalized field pattern of a Linear Array



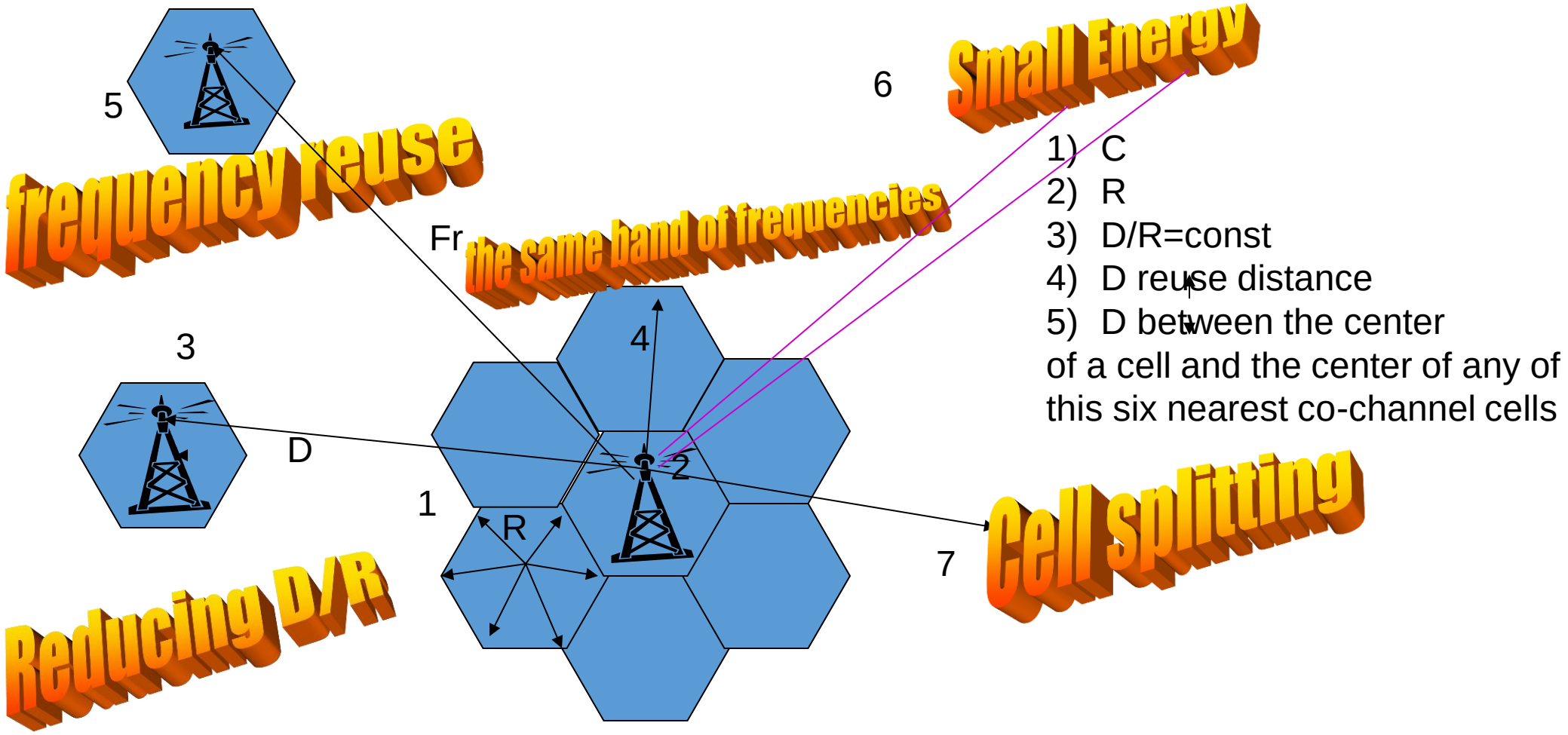

- Power density S=1/2*ExH
- Radiation intensity U(O,Fi)*R^2
- Radiated power P=Int S*ds
- P=IntU(O,Fi)domega
- U=P/4Pi
- Directive gain D(O,FI)=U max/U avg
- Ddb=10log(D)
- Directivity vs Beam Width
- Ddb=10log(D)
- G=er*D G db=10*log(G)
- Pa=Ae*S

# Smart Antenna

- SIR<SNR;
- Smart antennas more directional than omnidirectional antennas
- Smart antennas are able to focus their energy toward the intended users
- (base stations can be placed further apart)
- Smart antenna systems is security
- Smart antenna beam forming is computationally intensive, which means that smart antenna base stations must be equipped with the very powerful digital signal processing
- Smart antennas have sensor necessary for human ear.
- (Humans the ears transducers that convert acoustic waves into electrochemical impulse, antenna elements convert electromagnetic waves to electrical impulse)

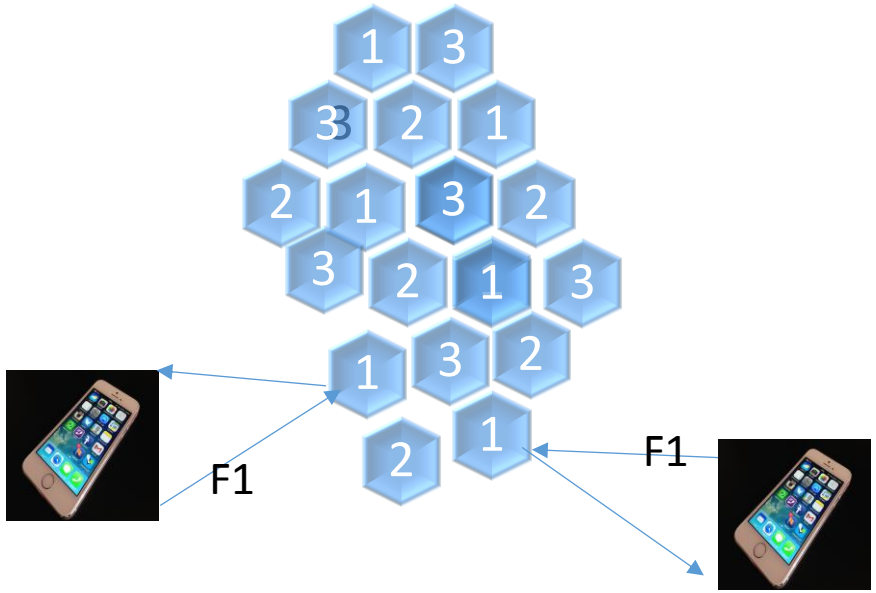


# Cellular model networking



# Frequency Reuse

**The concept of Frequency Reuse is at the heart of cellular concept**



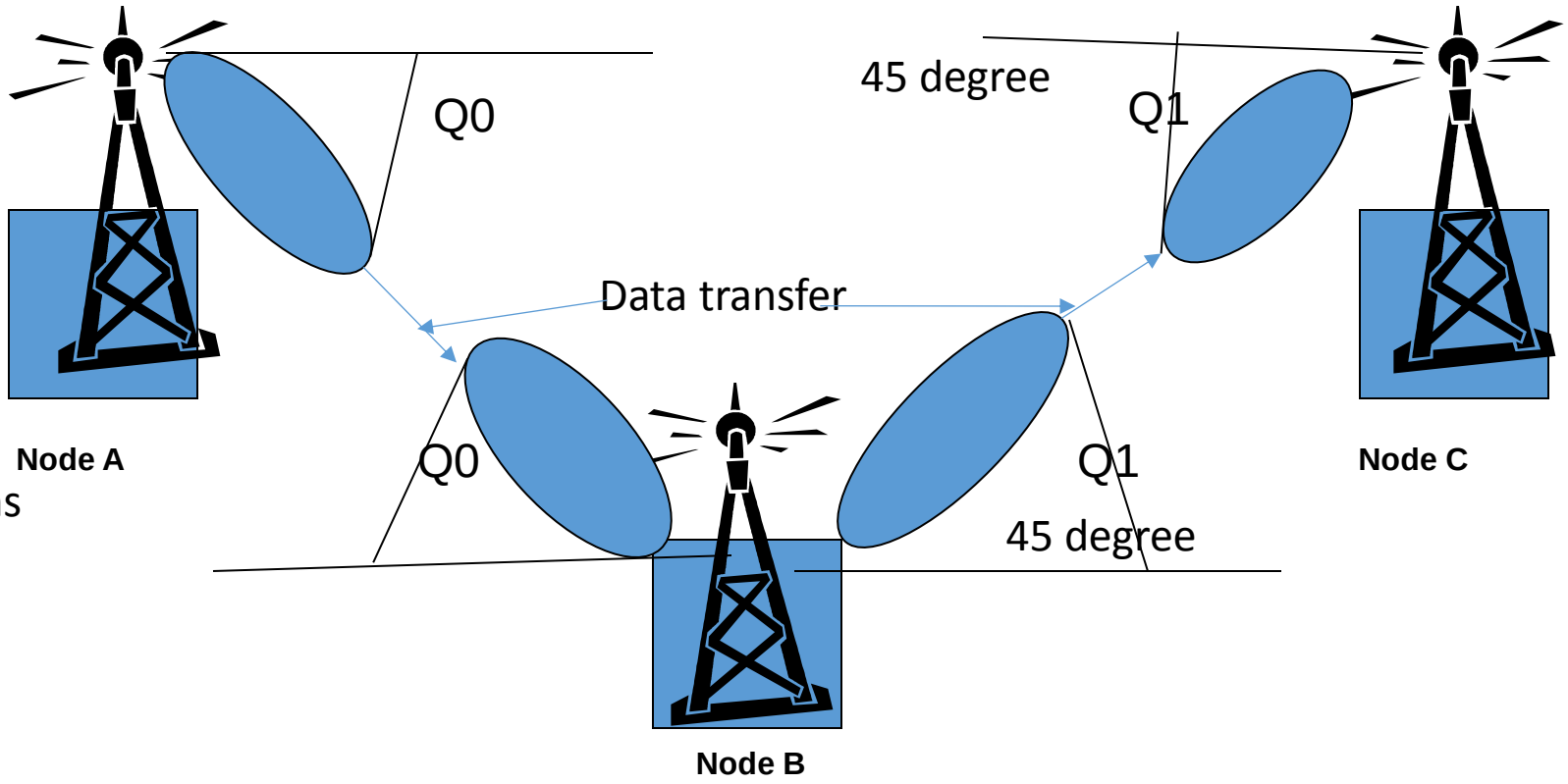

## Frequency reuse

- ❑ Signal from a single phone can stay confined to the cell and not cause any interference with any other cells.
- ❑ The same Frequency can be used in other cells at the same time
- ❑ Cellular phones has special codes associated with them
- ❑ This codes are used to identify:
  - the phone,
  - the phone's owner,
  - and the carrier or service provider (AT&T, Verizon, T-Mobile)
  - SIM card (the user phone #)

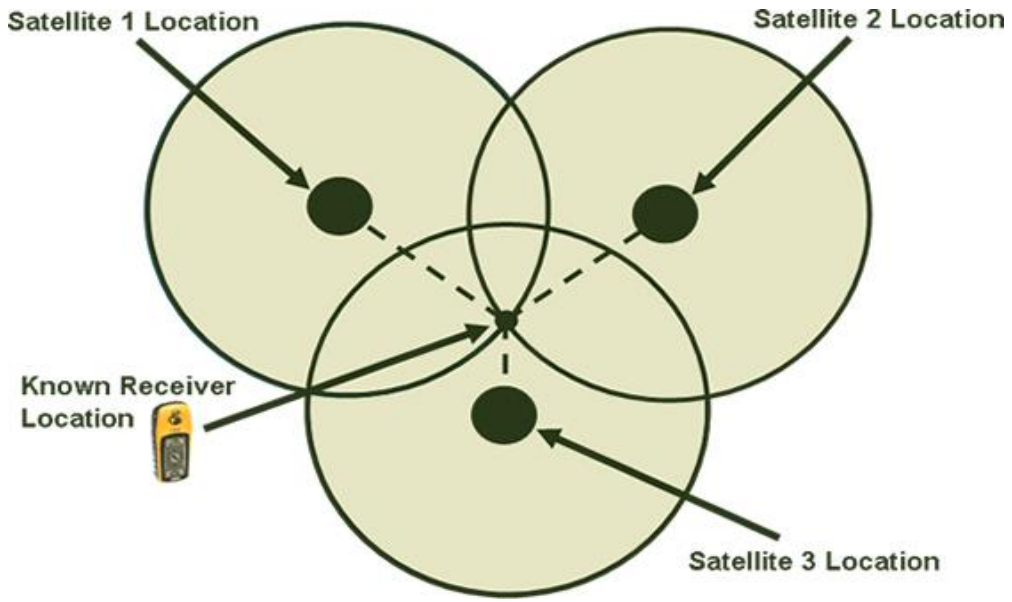
# The Wireless Network

The main criteria in a link design is the selection of operational frequency

Satellite communication network Utilize radio link for interconnections



# Link Designed in consideration that




- ❑ Each Satellite Transmits the unique digital code Sequence of 1s and 0s, precisely timed by atomic clock,
- ❑ Digital code picked up by the GPS receiver antenna and matched with the same code sequence generated inside the receiver

❑Satellite related

❑A constellation of Satellites

(#=27 on orbit=20 000km)

- Transmit signals on microwave signals

❑A control segment which maintains GPS (Global Positioning System)

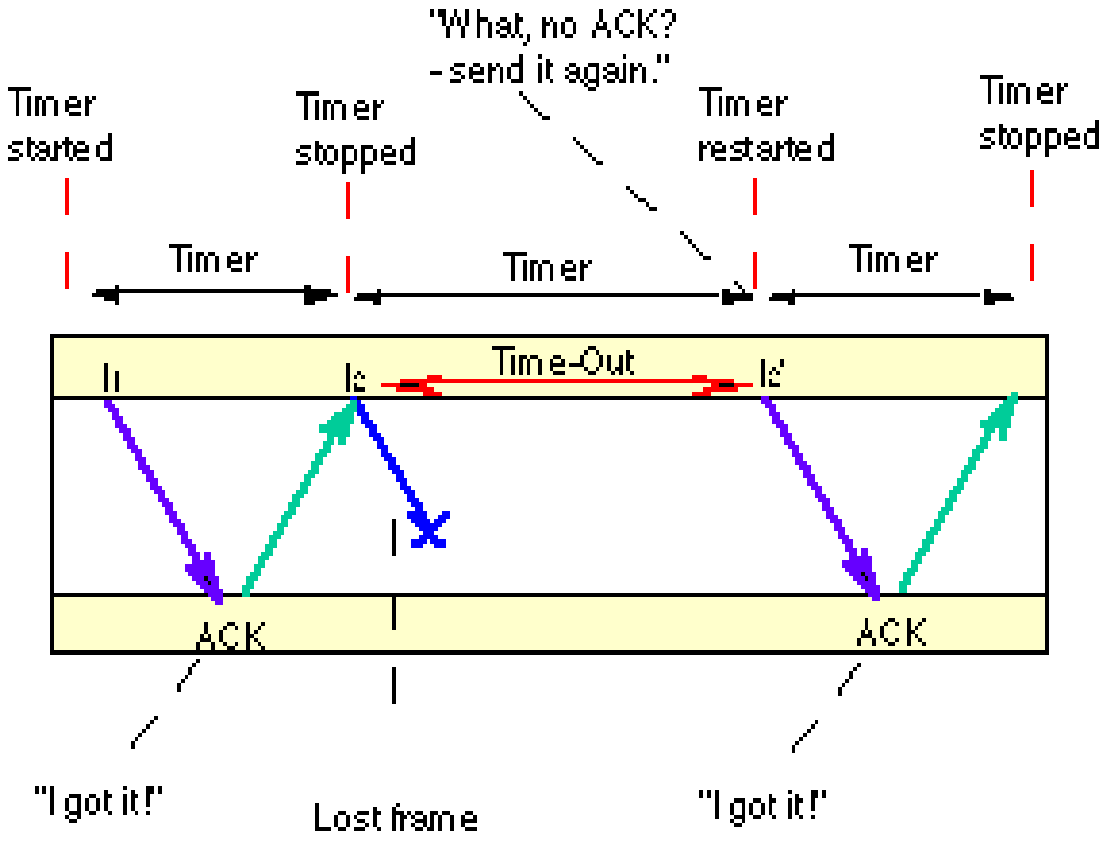
❑through the ground monitor stations and satellite upload facilities

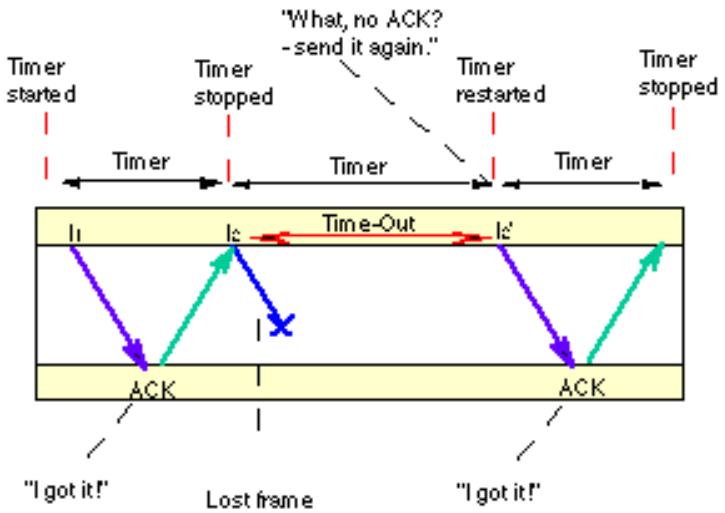
- The user receivers the both:

civil and military

# “Stop and wait ARQ”

- In our project we need to develop a Stop and Wait ARQ protocol over the UDP socket. For this we used programming language Java.
- Stop and Wait ARQ is the simplest kind of automatic repeat-request (ARQ) method.
- Sender sends one frame
- Get ACK (acknowledgement)signal






```
package server;
import java.io.*;
import java.net.*;
public class server {
        public static void main()
        throws Exception {

}
int port;
int maxQueue;
InetAddress localAddress;

String clientSentence;
Socket.getInput

String capitalizedSentence;
ServerSocket welcomeSocket = new
ServerSocket (1045);
while (true)
}
```

## Link (Cisco)
## Command Prompt

- ❑ To get information about your current:
  - IP-address
  - Ipconfig/all:
- ❑ Show all information about your networking
  - Subnet Mask;
  - Default Gateway;
  - Tracert /d:
- ❑ Show your track
  - without DNS
  - without: /d
- ❑ Show all hops on the way to DNS server

❑ **Wireless LAN adapter Wi-Fi:**

Media State . . . . . : Media disconnected

- Connection-specific DNS Suffix . :
- Tunnel adapter isatap.home:
- Media State . . . . . : Media disconnected
- Connection-specific DNS Suffix . : home
- Tunnel adapter Local Area Connection* 15:
- Connection-specific DNS Suffix . :
- IPv6 Address. . . . . : 2001:0:9d38:6ab8:2049:3278:b593:e330
- Our IP Link-local IPv6 Address . . . . . : fe80::2049:3278:b593:e330%9
- Default Gateway . . . . . : ::
- 
- C:\Users\Lyubov>
- 
.
.

# WIRELESS NETWORK Key elements

Key elements to comprise the Internet:

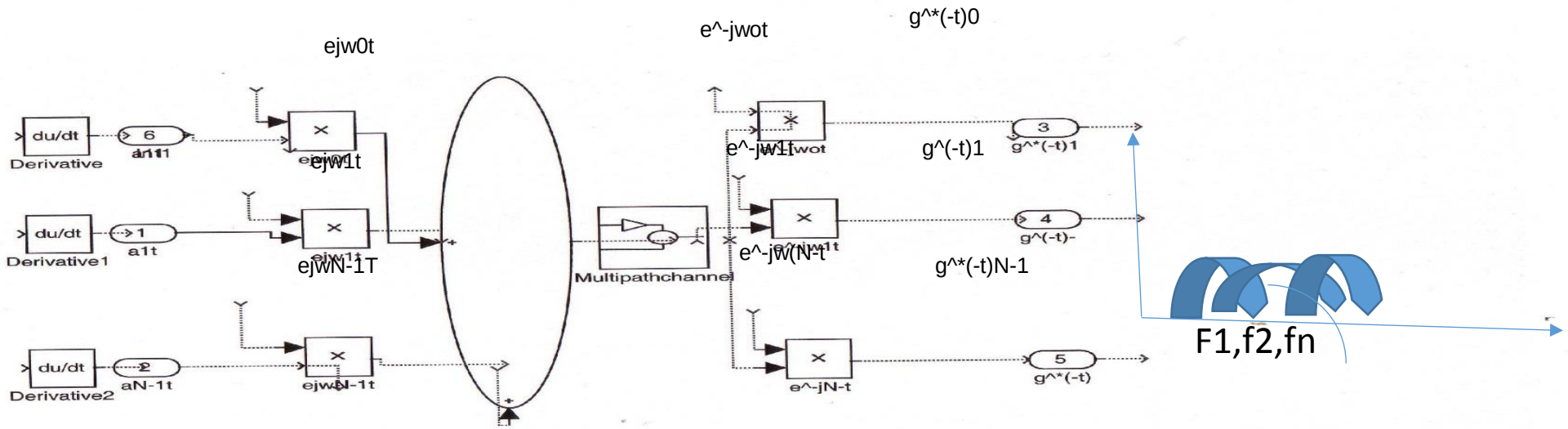
- ❑ The purpose of the Internet, of course is to interconnect end systems (hosts)
- ❑ Pc work stations:
  - servers
  - Mainframes
- ❑ Networks are connected by routers
- ❑ Each router attaches to two or more networks
- ❑ A host may send data to another host anywhere on the Internet.
- ❑ The source host breaks the data to be sent into a sequence of packets:
  - called IP datagrams or IP packets

- **Windows [Version 6.3.9600]**
- **(c) 2013 Microsoft Corporation. All rights reserved.**
- **C:\Users\Lyubov>ipconfig**
- **Windows IP Configuration**
- **Wireless LAN adapter Local Area Connection* 12:**
- **Media State . . . . . : Media disconnected**
- **Connection-specific DNS Suffix . :**
- **Ethernet adapter Bluetooth Network Connection:**
- **Media State . . . . . : Media disconnected**
- **Connection-specific DNS Suffix . :**
- **Ethernet adapter Ethernet:**
- **Connection-specific DNS Suffix . : home**
- **Link-local IPv6 Address . . . . . : fe80::849a:ff79:15a5:6f83%4**
- **IPv4 Address. . . . . : 192.168.1.3**
- **Subnet Mask . . . . . : 255.255.255.0**
- **Default Gateway . . . . . : 192.168.1.1**

# Multiple Access Technique

- Multiple Access scheme must be able to optimize the following parameters:
- Satellite Radiated Power
- RF spectrum
- Connectivity
- Adaptability to traffic different types and network
- Economics
- Ground Station complexity
- Secrecy for some applications

# OFDMA




Orthogonality: integral (-infinity, infinity)xp(t)*xq(t)*dt=0 (p not =q)

Orthogonal Carriers S(t)=RE {SUM xk*Ae^j2pi*k*f0*t} T=1/f0

# The perspectives of development of Wireless Communications utilizing MIMO technology

- Increasing the bandwidth and increasing the quality of service

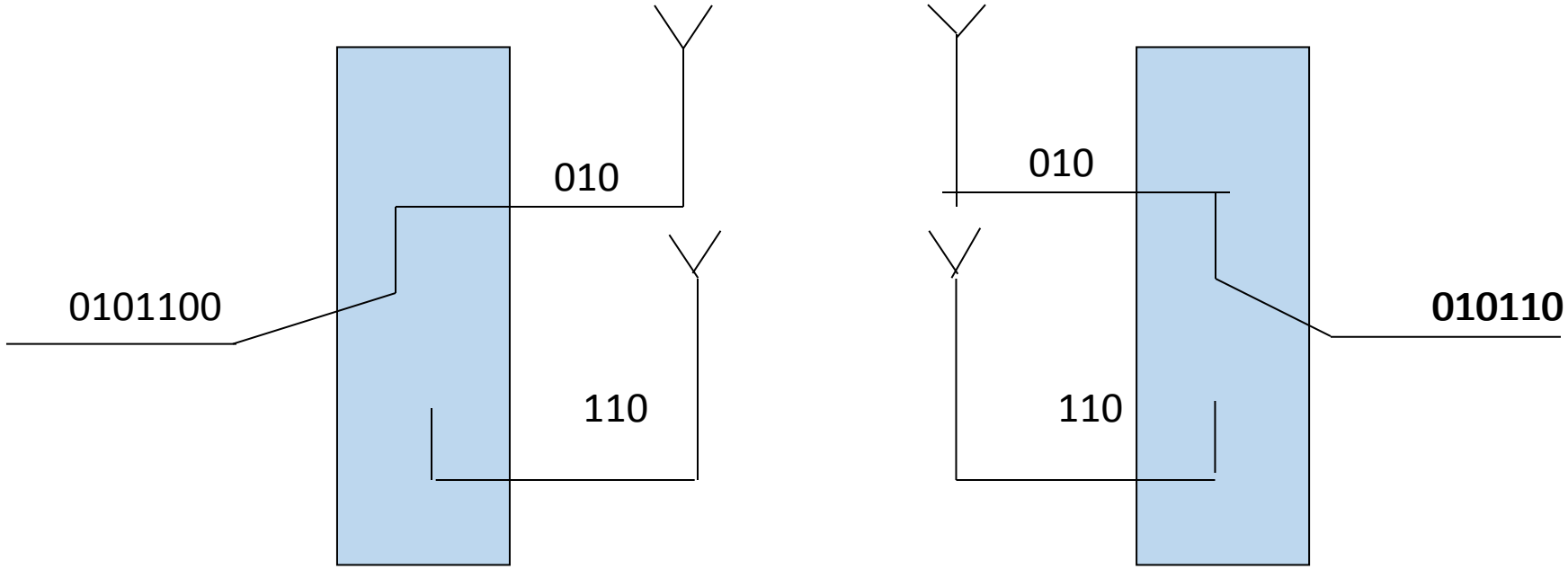
  at new system LTE-> directly connected with the development of MIMO technology;
- MIMO technology allow decrease the # of errors, without the decreasing the speed of data;
- The history of MIMO very short (the first patent registered at 1985).

# MIMO Technology was used:

- for the first time at UMTS for high speed technology when transforming the IP at downlink to increase the Vmax of date from 10.8 Mit/sec to 20 Mbit/sec
- shorten time frame (Tint=2msec)
- multi code
- adaptive Modulation and code
- shorten HARQ (N channel with Stop And Wait Protocol)
- antenna MIMO
- perspective Receiver UMTS

# Space Time Coding STC
# C mimo=Mfglog2(1+S/N)

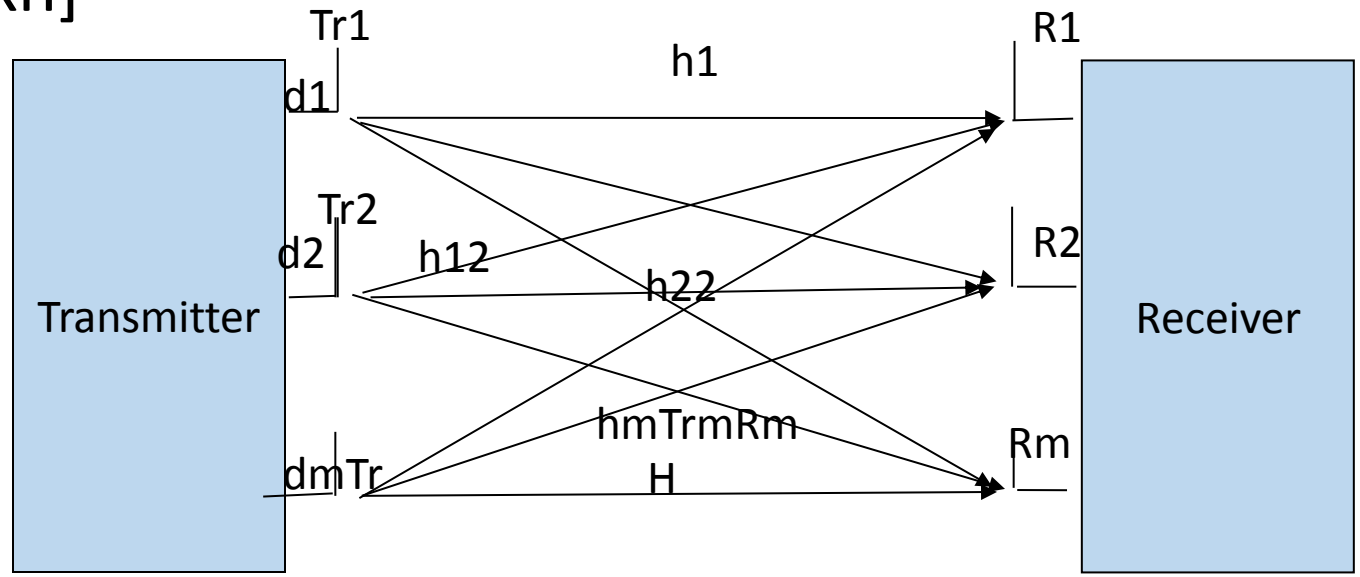
Example: 2 antenna




The technology MIMO can be considered not as the technology-> as the method of forming the channel;
The goal of this MIMO technology is to increase the peak speed of transferring the date and decrease the interference.

# MIMO

- H=[nxn]

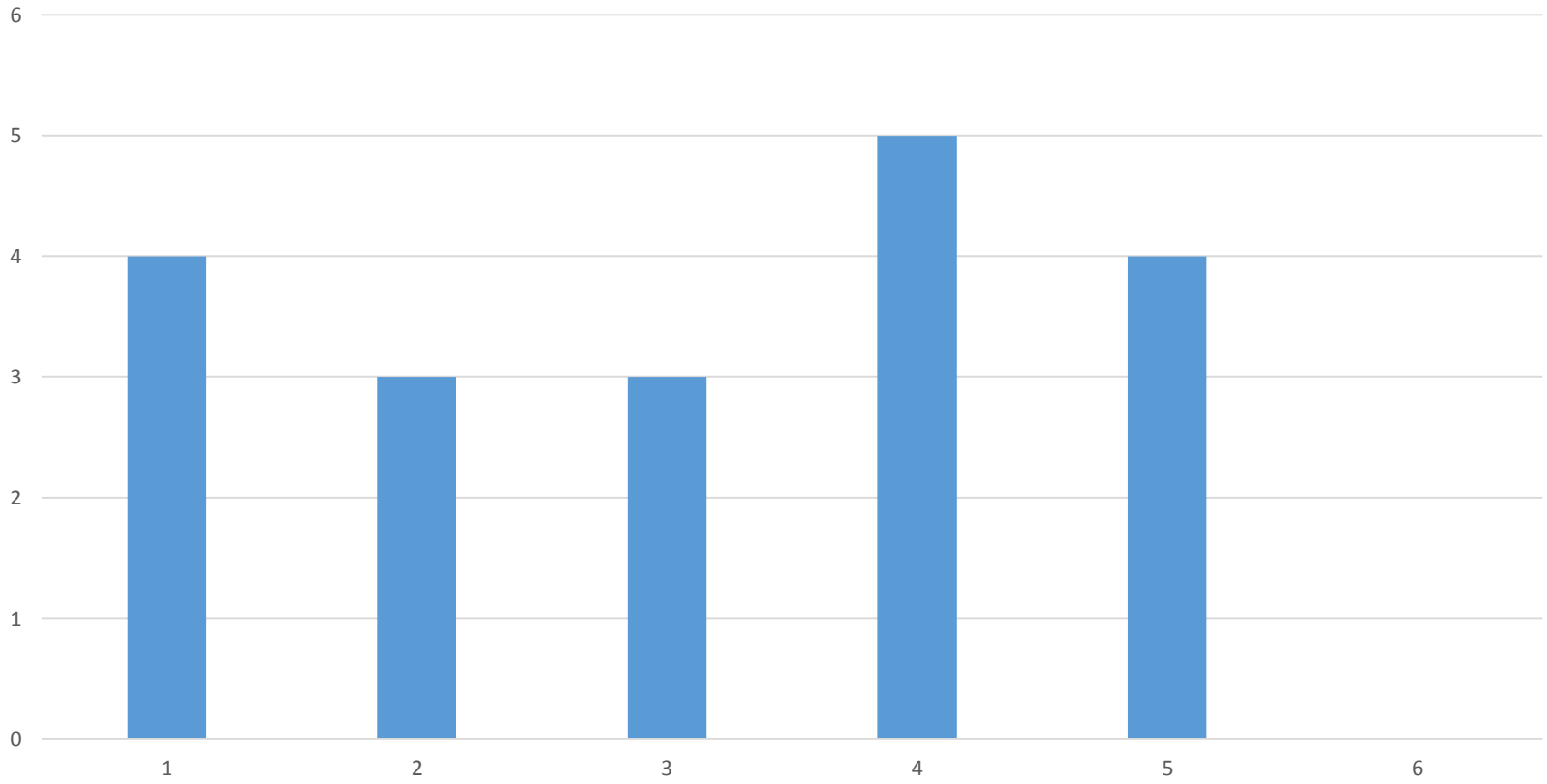



H the model of the communications line The equation MIMO: R=Ht+n

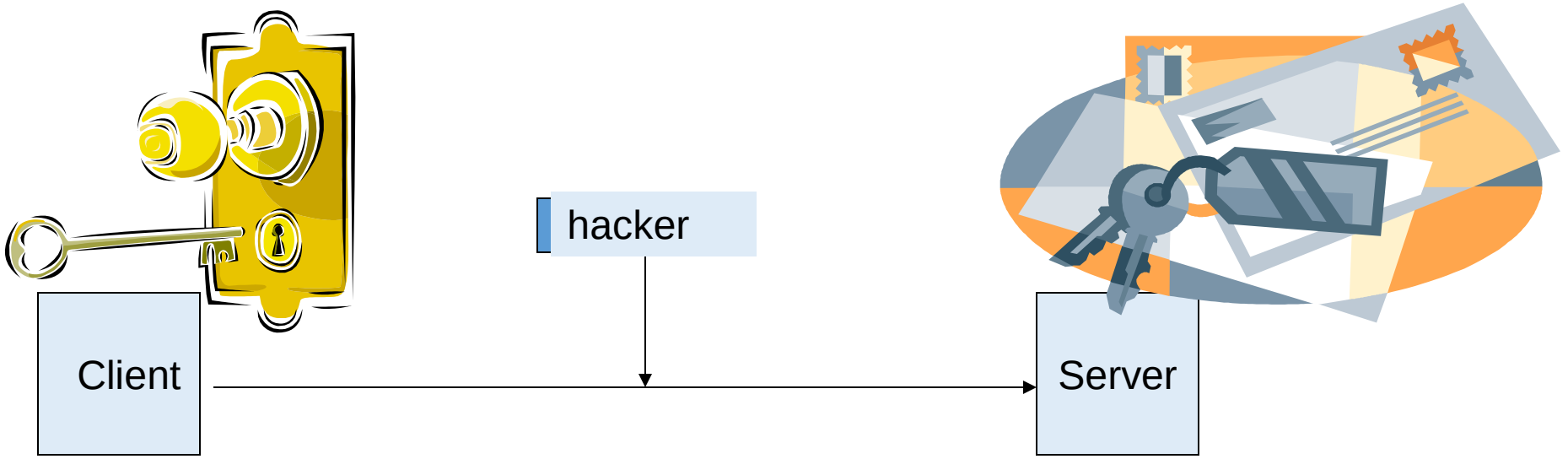
# Antenna MIMO technology

- **Multipath Input/Multipath Output->(MIMO)**
- **The technology MIMO give us a possibility:**
- **to make the Channels robust to the Noise Signals**
- **decrease the amount of bits with an error, without Decreasing the speed of the transforming the date.**
- **Entering HARQ in Multi transforming of the Signal.**
- **The worthy of such method is using of multi antennas**

# Spectral Efficiency
# UMTS; 802.16; CDMA; LTE



# Security



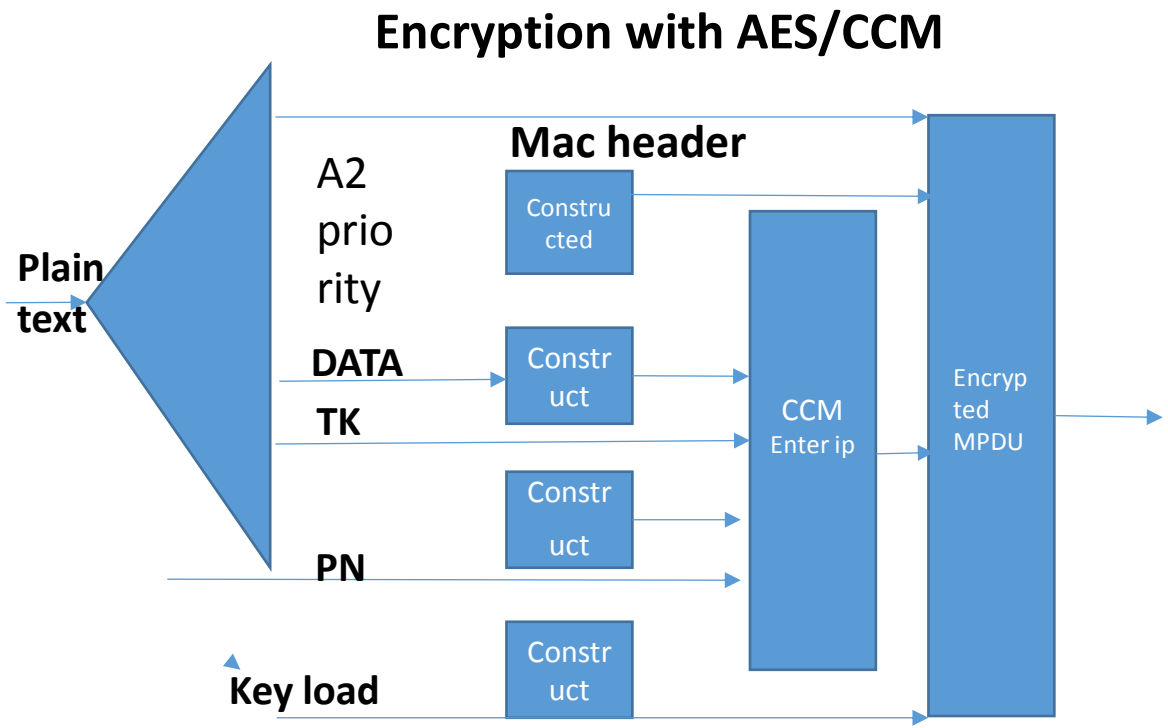

| **Security methods:** | **Not effective methods** |
|---|---|
| a) Hidden SSID; | a) Hackers sent empty row; |
| b) Filter Mac. | b) Build tables with physical addresses, which allowed clients to connect with the main point, based on its physical addresses. |

# Types of security

- WEP security
- TKIP (Temporal Key Integrity Protocol)
- Cisco MIC
- Cisco Leap (Lightweight Extensible Authentication Protocol)
- Wi-Fi WPA
- 802 IX FOR WEP

| WEP | 802.1x EAP | WPA | 802.11i/WPA 2 |
|---|---|---|---|
| Simple encryption | Improvement encryption | Standard encryption | Powerful encryption |
| Static open<br>The keys<br>No authentication | Dynamic keys Authentication | Strong Authentication | Management the dynamic keys, Authentication |
| WEP+ MAC filters | | | |

# Extensible Authentication Protocol




## Extensible Authentication protocol

- **EAP- is a frame work for performing authentication in a situation where the three-party model with supplicant, and authentication server applies**
- **The main upgrade from in going from WPA to WPA2/802.11i is the change from TKIP to advanced encryption standards (AES).**
- **AES is used in the counter with CBC-MAC protocol, where CBC_MAC stands for the cipher-block chaining message authentication code.**
- **Use of AES/CCM is shown at the picture**
- **AAD-additional authentication data**
- **TK transient key**
- **And PN is packet number**

# Security:

❑Negative side:

- too simple password passwords not encipher; “Welcome” for hackers

❑No “welcome” for hackers

- Command prompt:
- Switch # configure terminal
- Enter config command, one per line
- Switch (config) #banner login%, Enter TEXT message.
- After user Access Verification the password saved and the hackers cannot enter you config.
- Telnet:
- Ipconfig:
- Crypto key generate rsa for security required the size [512], better_ 1024; banner

# Security

each client has
a key code to reach the point

- 802.11i AES,WEP;
- 802.11i suggests WPA 2;no
- 802.11 open WEP key

Crypto key generate rsa for security required the size [512], better_ 1024