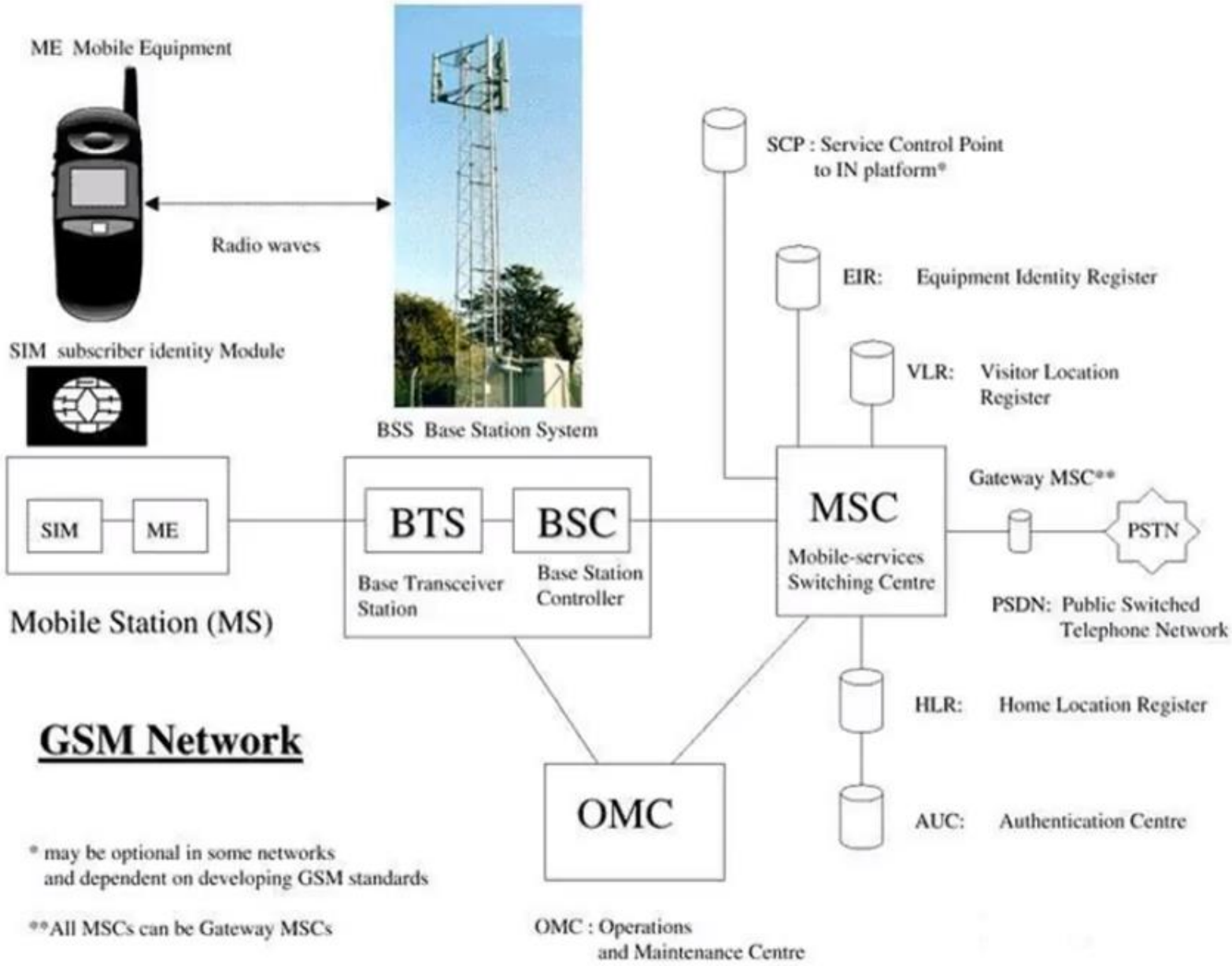
GSM
Global System for Mobile Communication

Hany El-Ghaish


ME Mobile Equipment
Radio waves
SIM subscriber identity Module
BSS Base Station System
SCP : Service Control Point
to IN platform*
EIR: Equipment Identity Register
VLR: Visitor Location
Register
Gateway MSC**
SIM
ME
BTS
BSC
Base Transceiver
Station
Base Station
Controller
MSC
Mobile-services
Switching Centre
PSTN
PSDN: Public Switched
Telephone Network
Mobile Station (MS)
HLR: Home Location Register
OMC
AUC: Authentication Centre
GSM Network
* may be optional in some networks
and dependent on developing GSM standards
**All MSCs can be Gateway MSCs
OMC : Operations
and Maintenance Centre

GSM NETWORK ARCHITECTURE

- Geographic network areas

The GSM service area is the collection of PLMNs in which you can use one mobile station.

GSM SERVICE AREA

GSM NETWORK ARCHITECTURE

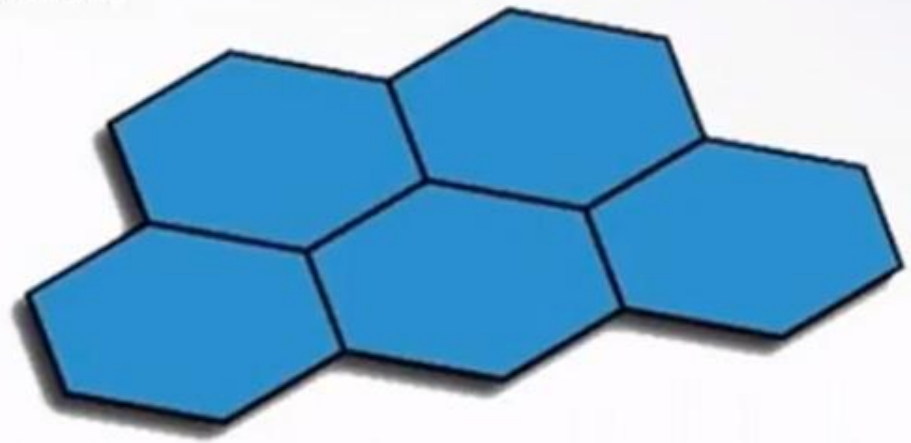
An MSC/VLR service area is made up of several LA's and is covered by one MSC.

SERVICE AREA

GSM NETWORK ARCHITECTURE

A Location Area (LA) is a group of cells. It is:

- The largest area in which a mobile station may roam without updating location
- Served by one or more BSCs, but only one MSC
- The area within which paging messages are sent out to all mobile subscribers



LOCATION AREA

IDENTITY NUMBERS

The Location Area Identity (LAI):

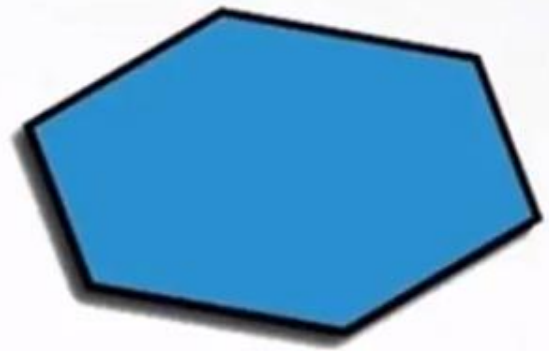
- Determines the need for location updating
- Is the area in which a mobile station is paged
- Consists of three parts

SWEDEN: 240 - 01 - 65412

GSM NETWORK ARCHITECTURE

- Cell

A cell is the smallest radio coverage area in the network.

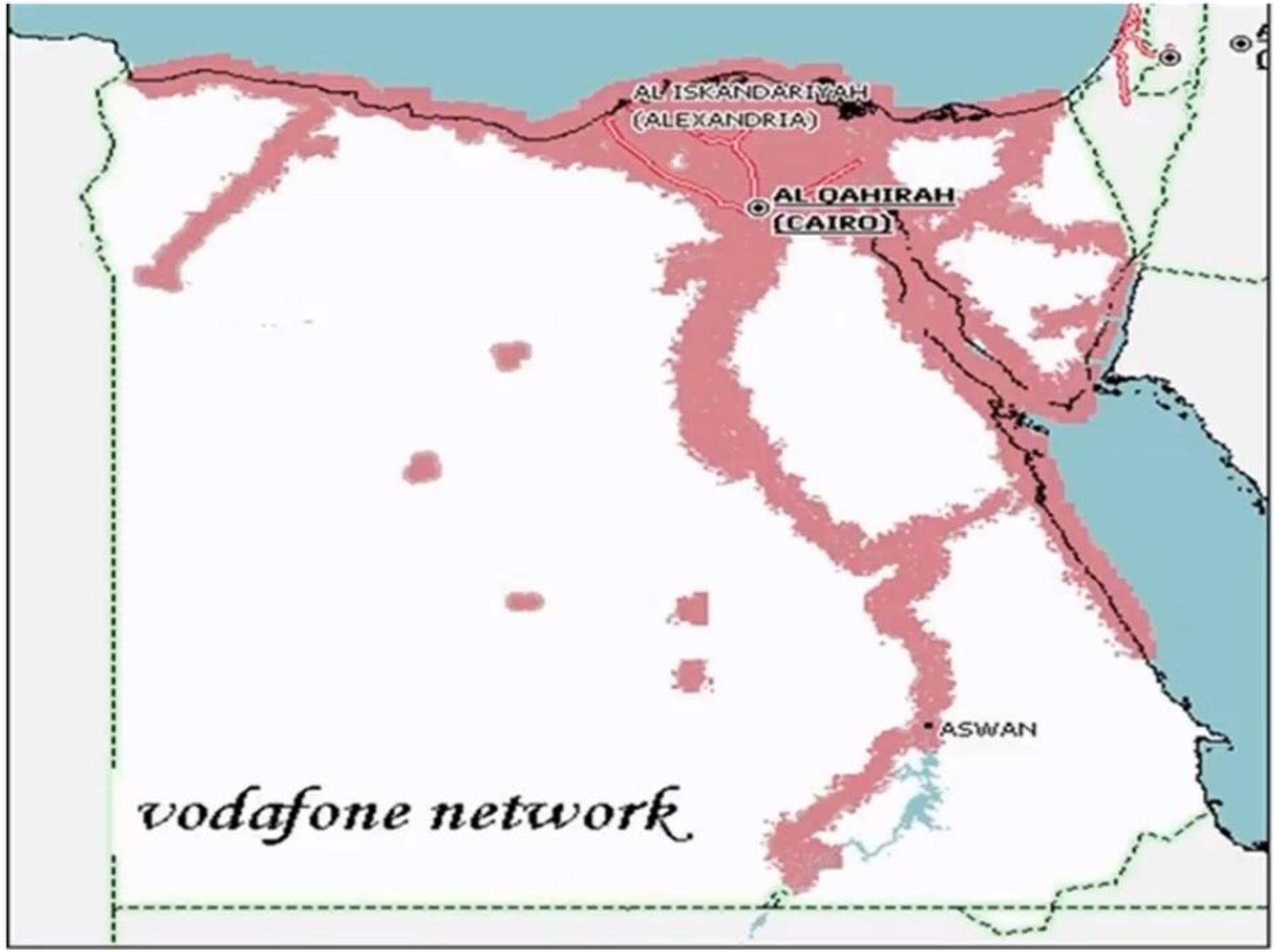


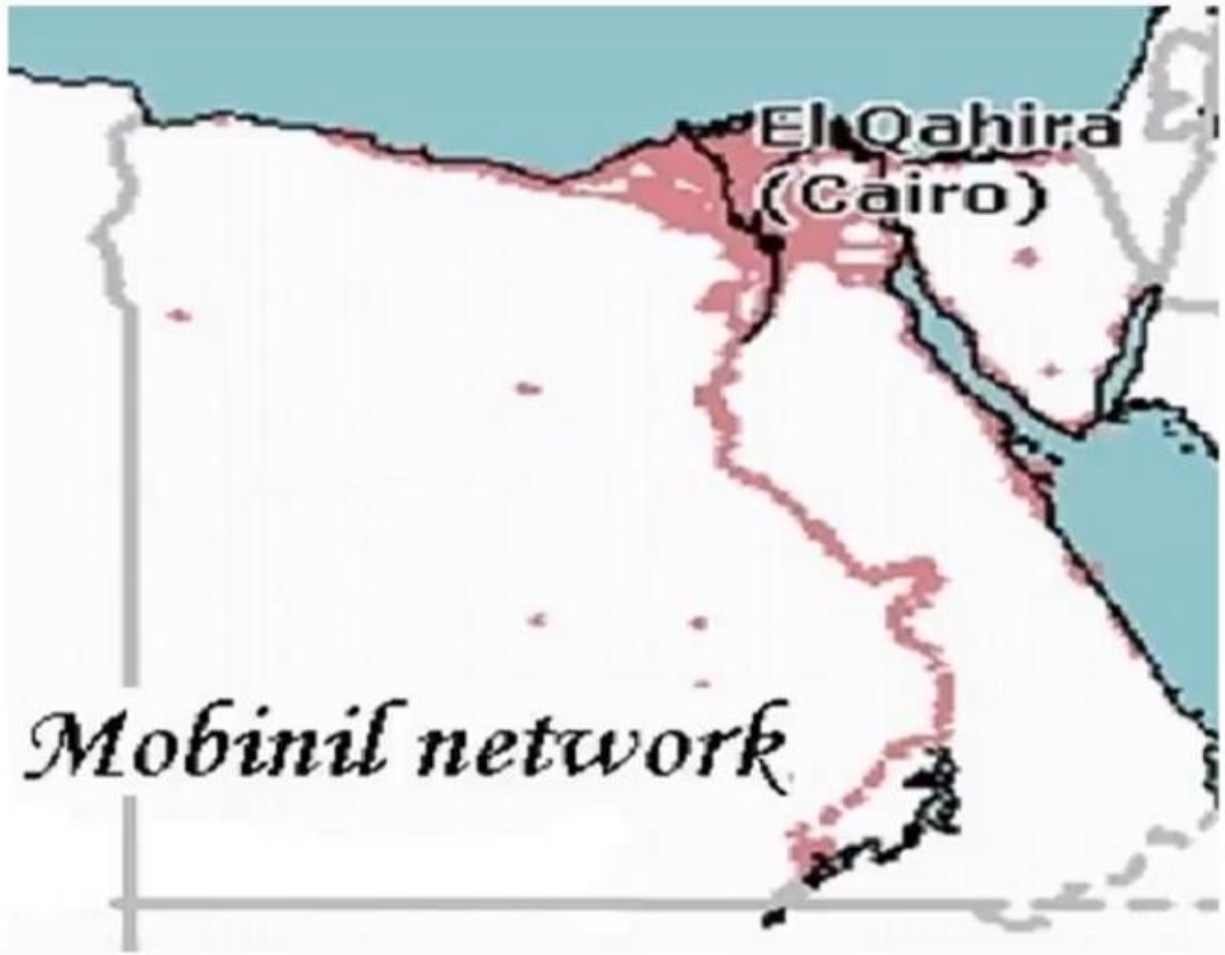
CELL

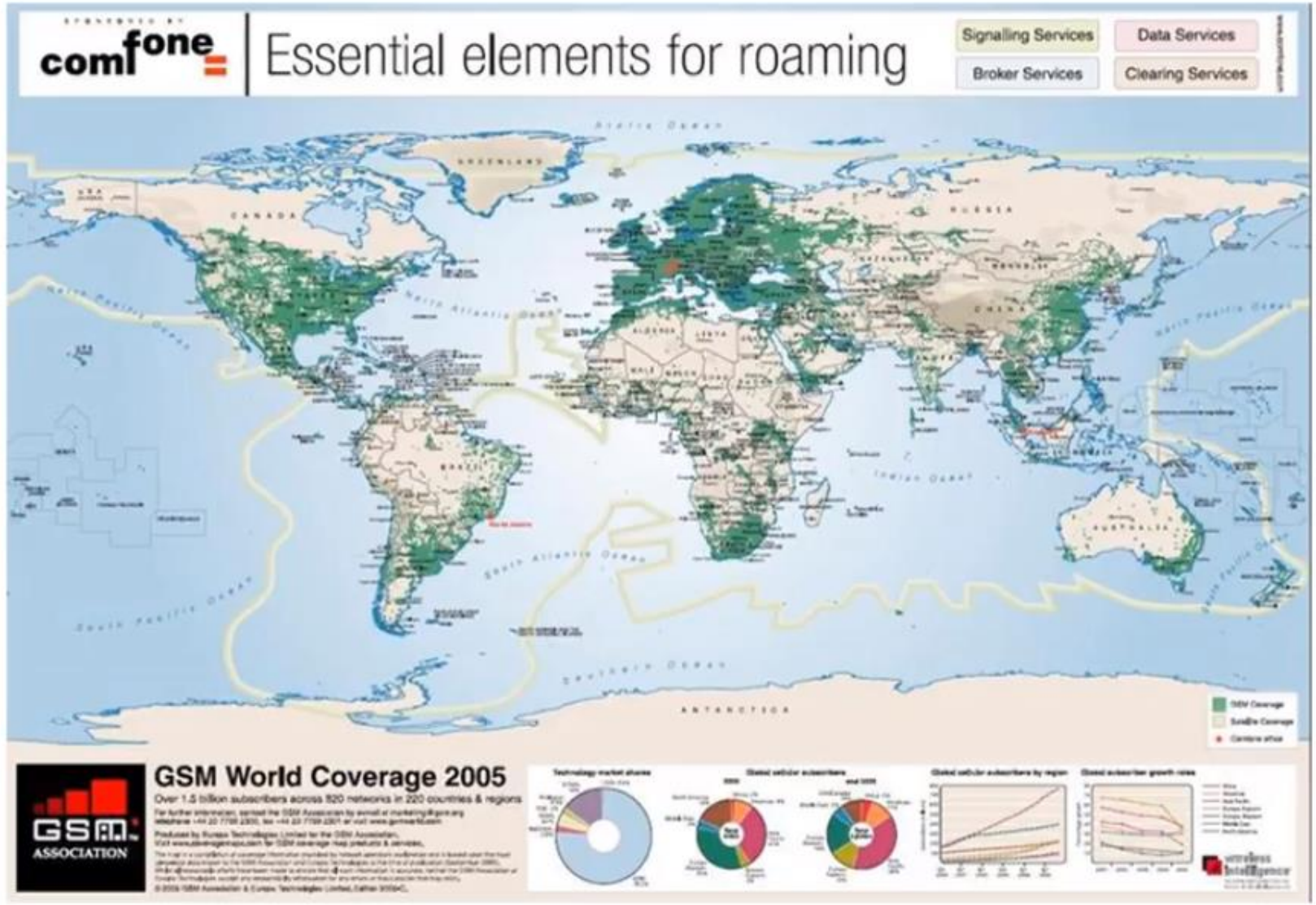
IDENTITY NUMBERS

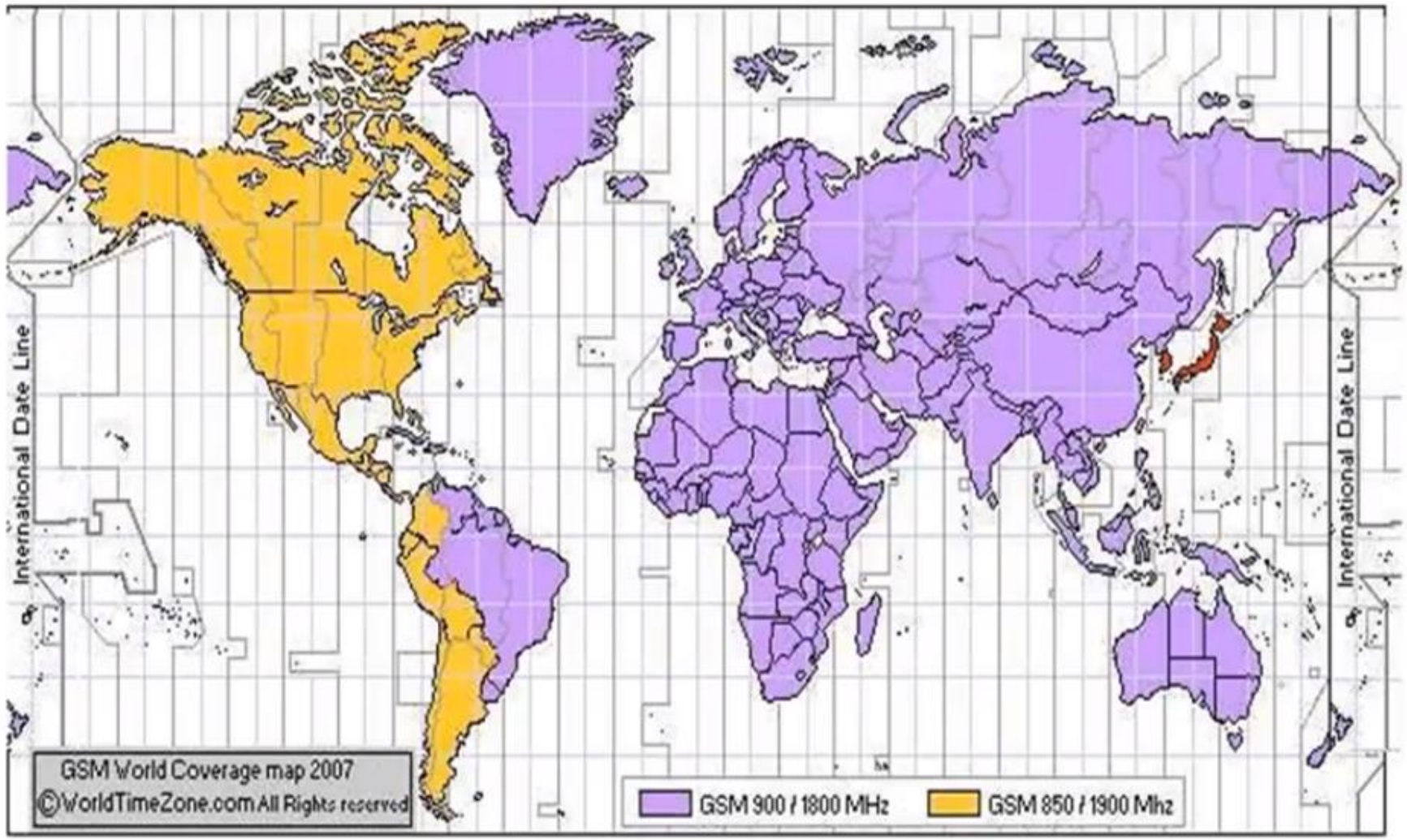
The CGI is used to identify cells within the GSM network.

GERMANY: 262 - 02 - 4867 - 6832


AL ISKANDARIYAH
(ALEXANDRIA)
AL QAHIRAH
(CAIRO)
ASWAN
vodafone network

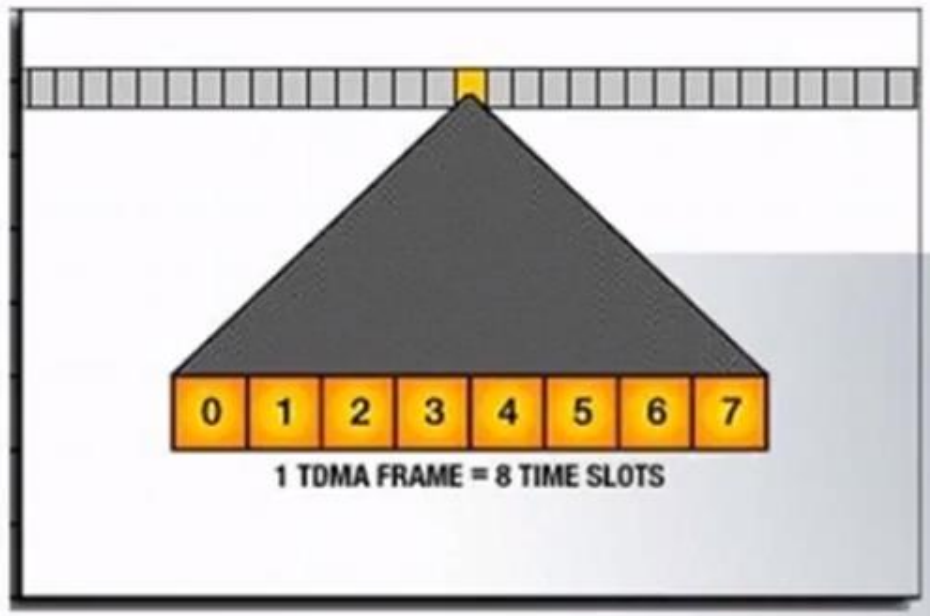

El Qahira
(Cairo)
Mobinil network


comfone
Essential elements for roaming
Signalling Services
Data Services
Broker Services
Clearing Services
GSM World Coverage 2005
Over 1.5 billion subscribers across 520 networks in 220 countries & regions
GSM ASSOCIATION


International Date Line
International Date Line
GSM World Coverage map 2007
©WorldTimeZone.com All Rights reserved
GSM 900 / 1800 MHz
GSM 850 / 1900 Mhz

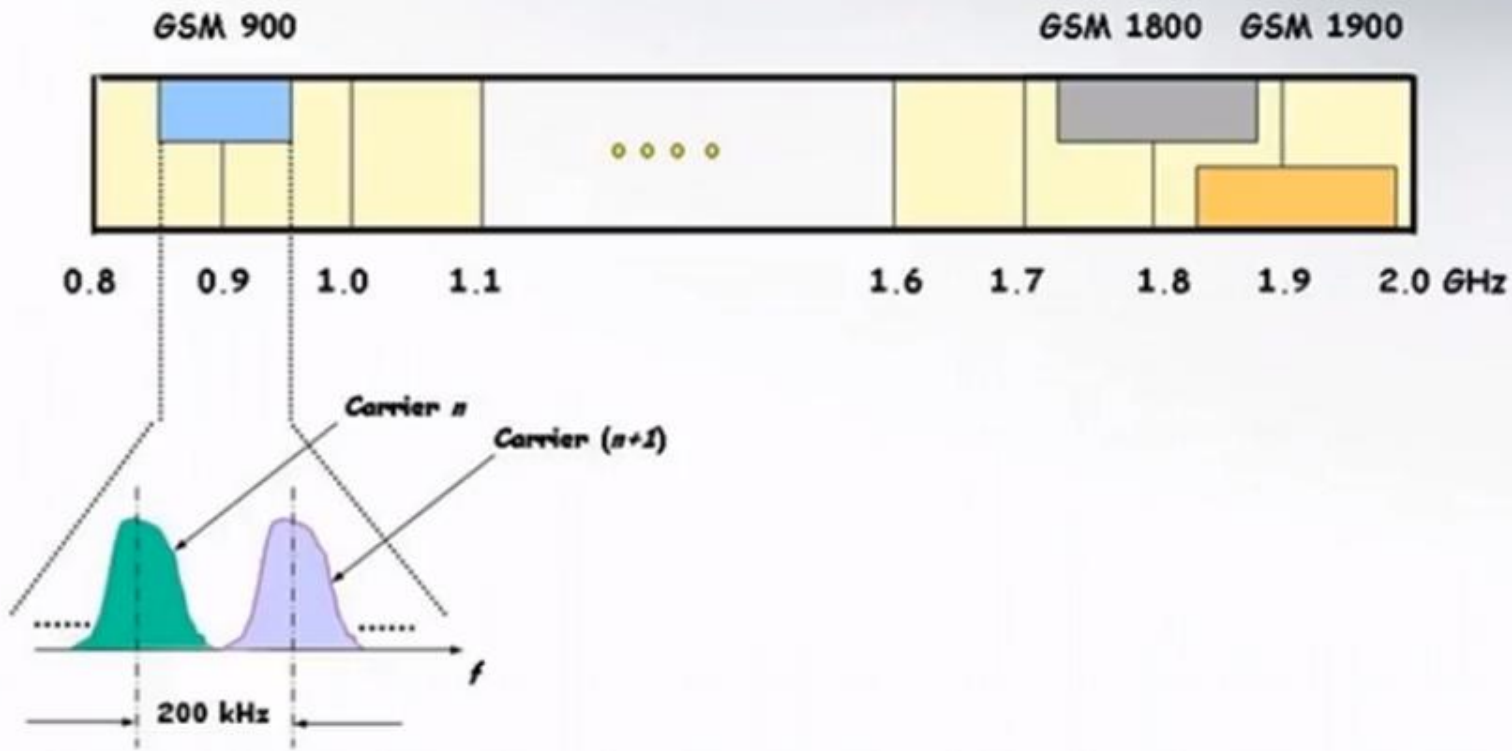
CH 3

AIR INTERFACE



AIR INTERFACE

- GSM bands



AIR INTERFACE

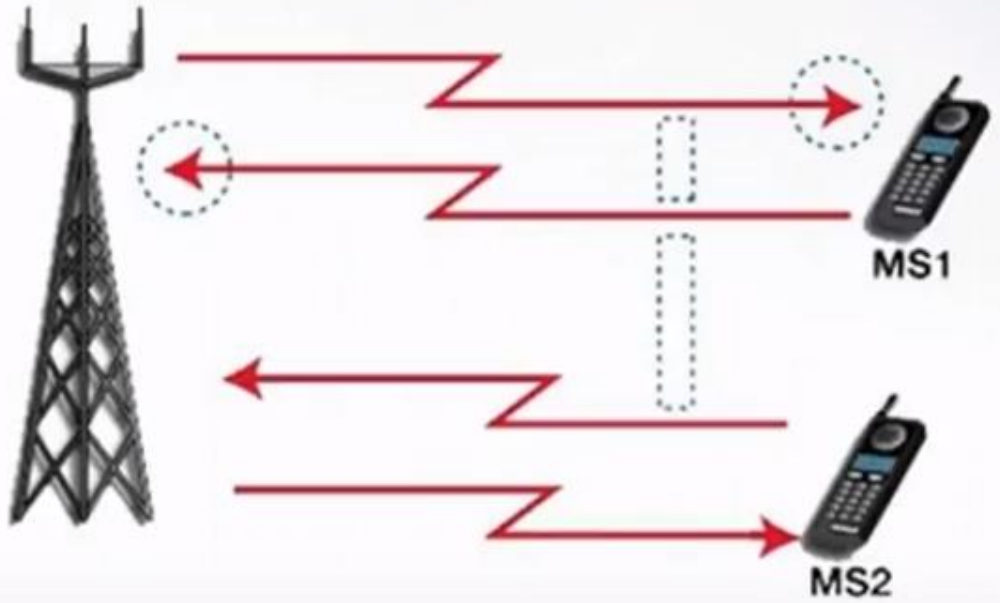
- GSM Frequency Bands

System	P-GSM 900	E-GSM 900	GSM(DCS) 1800	GSM(PCS) 1900
Uplink (MS → BS) Downlink(BS→ MS)	890 - 915 MHz 935 - 960 MHz	880 - 915 MHz 925 - 960 MHz	1710 - 1785 MHz 1805 - 1880 MHz	1850 - 1910 MHz 1930 - 1990 MHz
Wavelength	≅ 33 cm	≅ 33 cm	≅ 17 cm	≅ 16 cm
Bandwidth	25 MHz	35 MHz	75 MHz	60 MHz
Duplex distance	45 MHz	45 MHz	95 MHz	80 MHz
Carrier separation	200 kHz	200 kHz	200 kHz	200 kHz
No. of carriers	124	174	374	299
Channel rate	270.8 kbps	270.8 kbps	270.8 kbps	270.8 kbps

AIR INTERFACE

Uplink and downlink

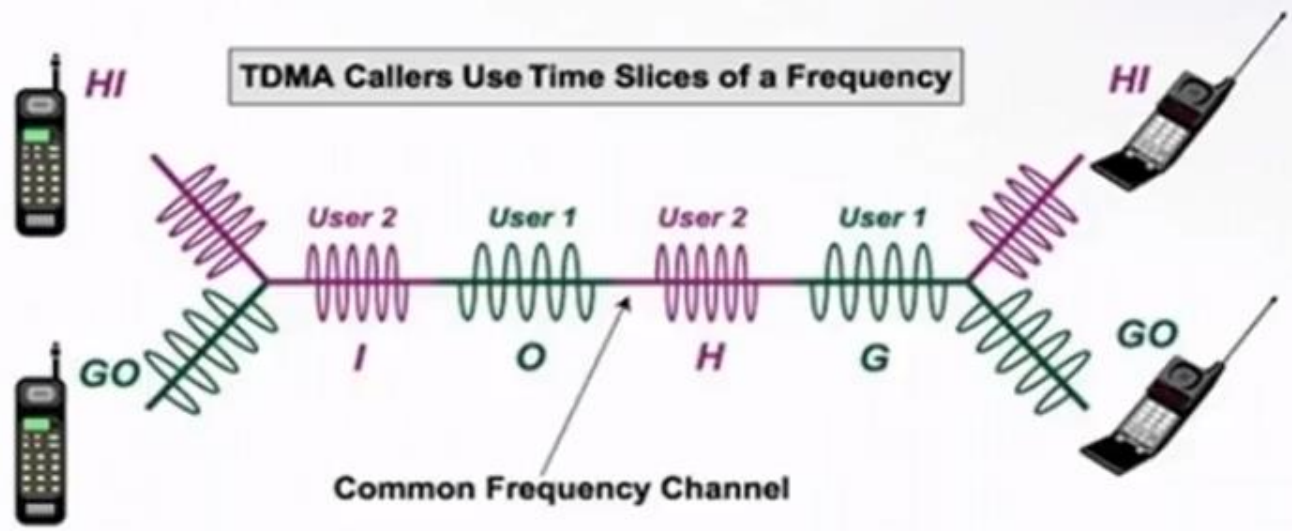
Two carriers make up the radio channel required for communication between the Mobile Station (MS) and Base Transceiver Station (BTS).



AIR INTERFACE

For digital systems:

- Time Division Multiple Access (TDMA) is the GSM standard



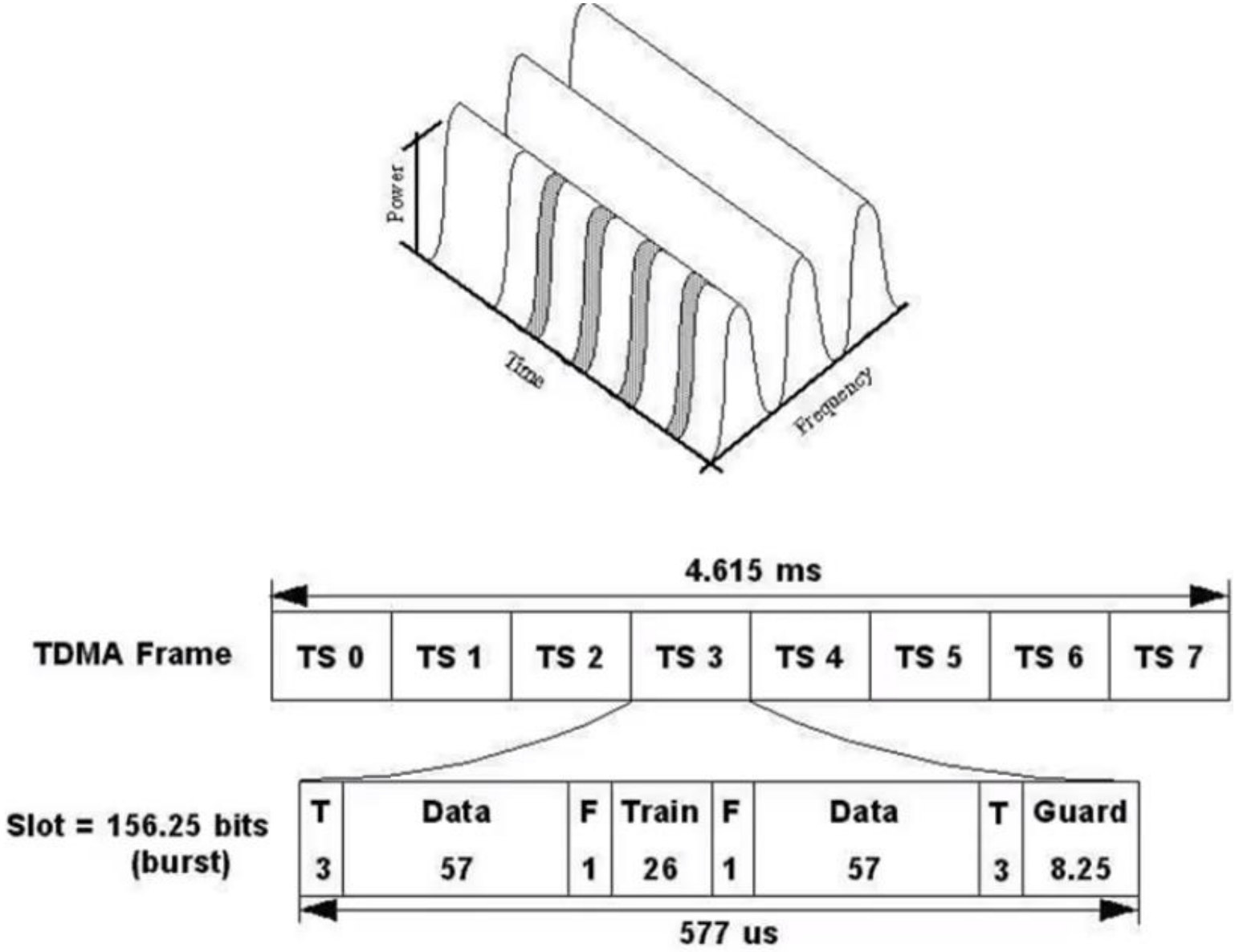
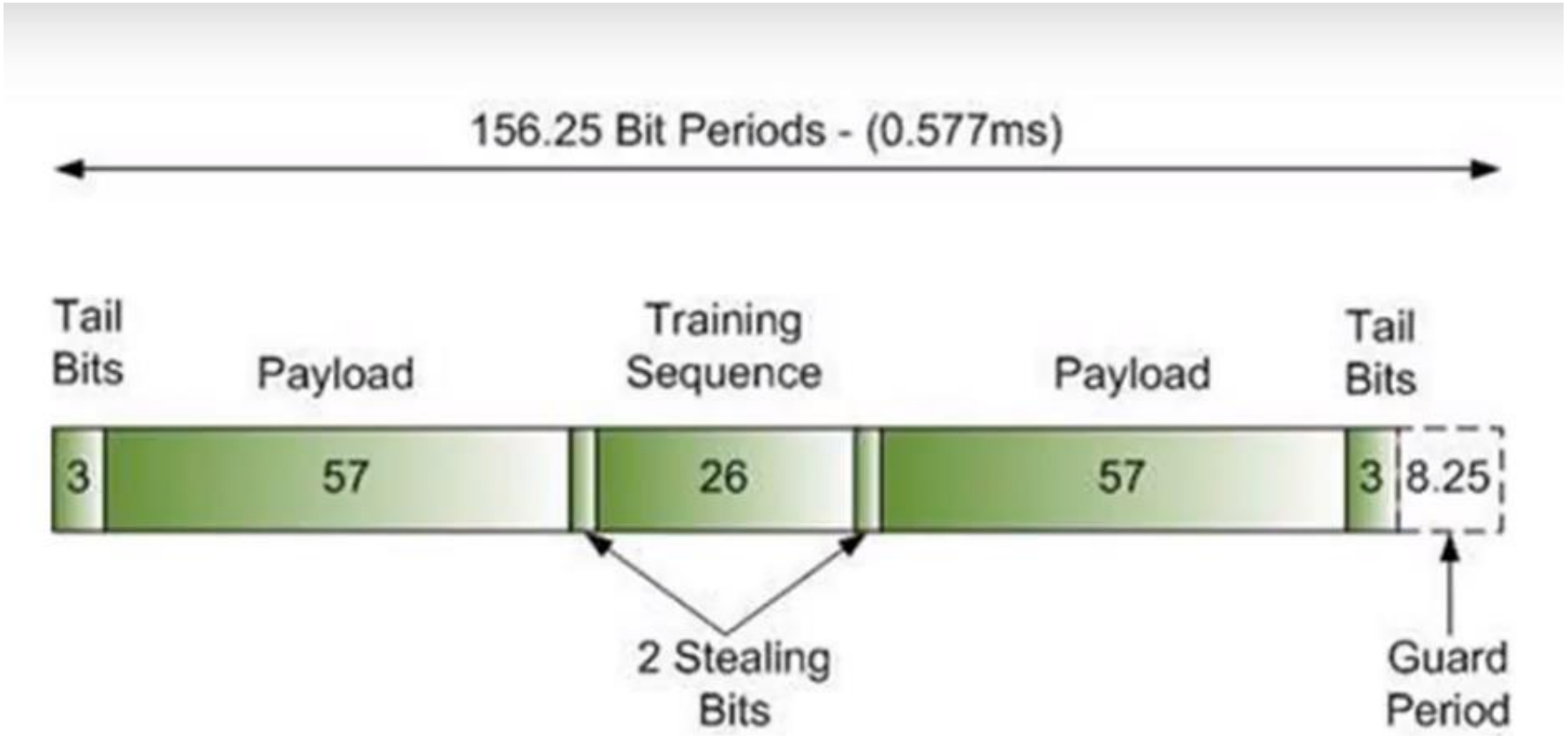


Figure 1 GSM RF Channel


156.25 Bit Periods - (0.577ms)
Tail Bits
Payload
Training Sequence
Payload
Tail Bits
3
57
26
57
3
8.25
2 Stealing Bits
Guard Period

AIR INTERFACE

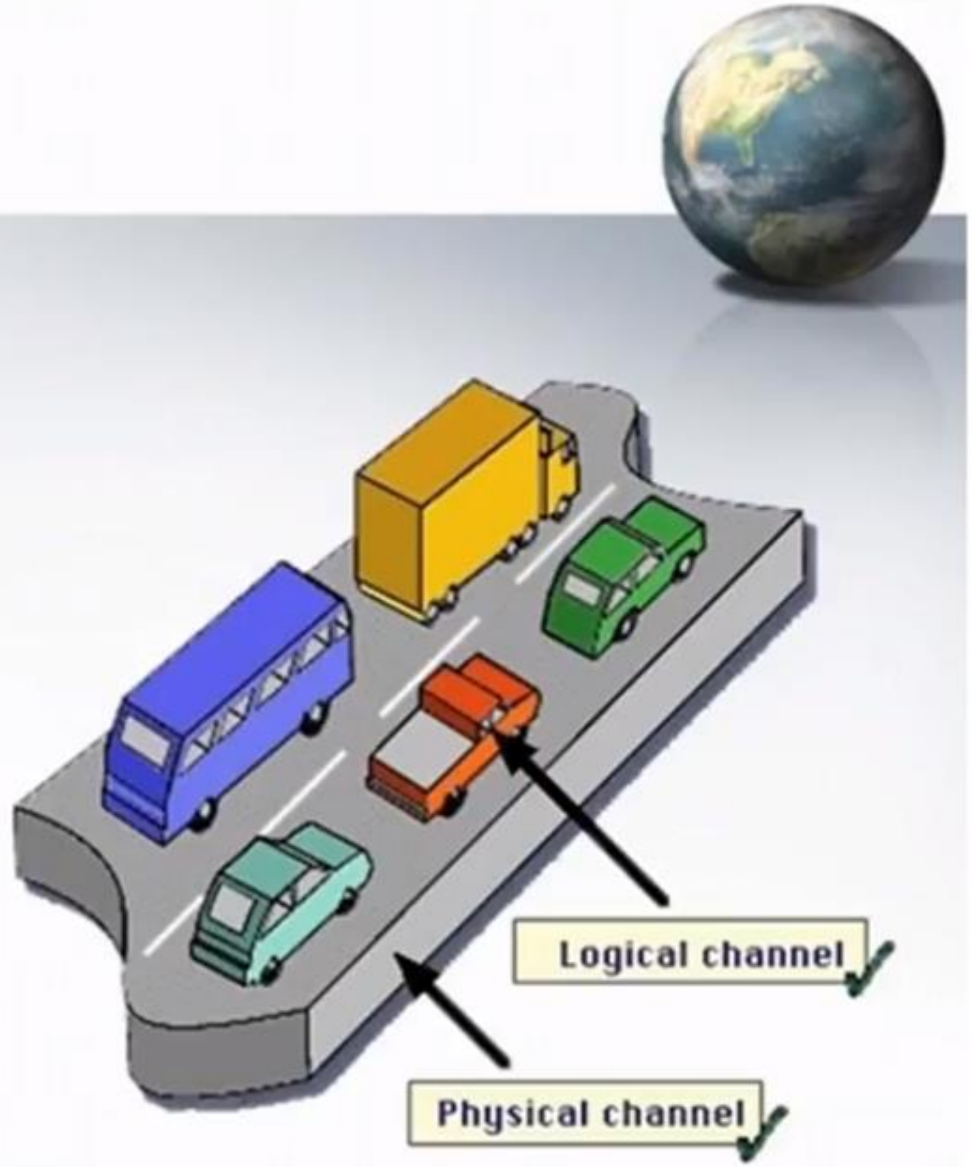
- TDMA frame structure
  - -Bit rate of the radio carrier is 270.833 Kbps
  - -Bit duration =1/270.833=3.69 μsec
  - -One time slot =148 bits+8.25 guard bits=156.25 bits
  - -Time slot duration =156.25x3.69 μsec= 0.577 msec
  - -Frame duration=0.557x8= 4.615 msec

AIR INTERFACE

- TDMA frame structure
  - -Bit rate of the radio carrier is 270.833 Kbps
  - -Bit duration =1/270.833=3.69 μsec
  - -One time slot =148 bits+8.25 guard bits=156.25 bits
  - -Time slot duration =156.25x3.69 μsec= 0.577 msec
  - -Frame duration=0.557x8= 4.615 msec

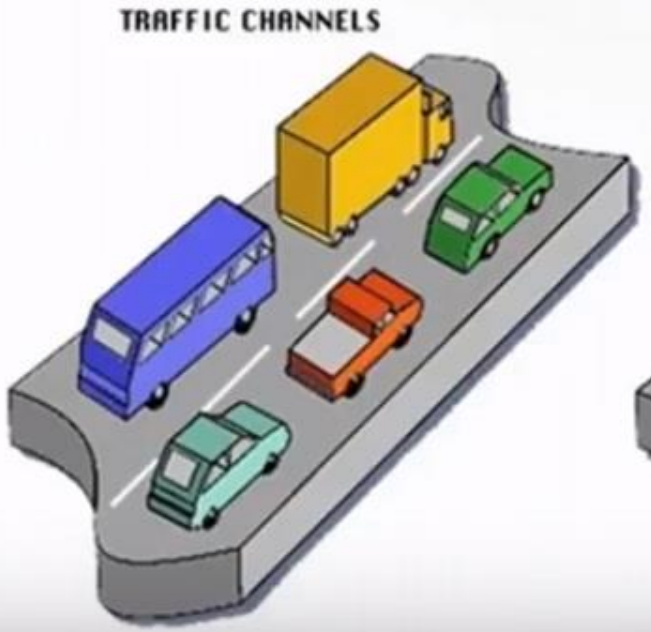
AIR INTERFACE

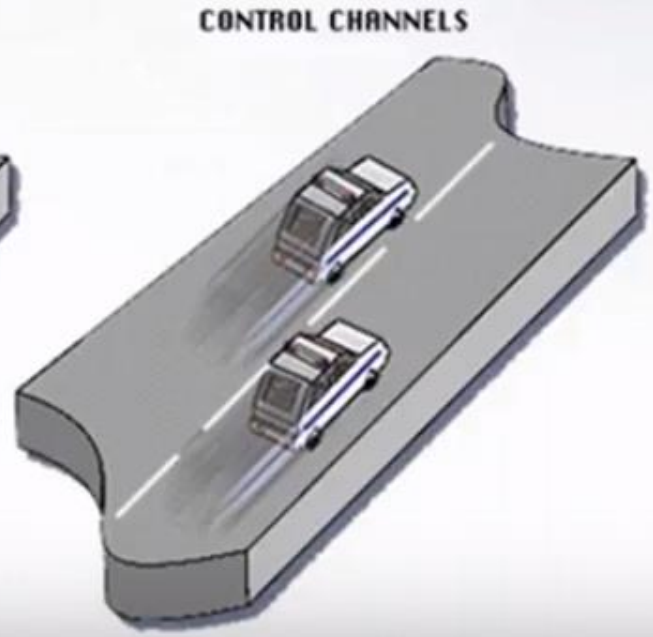
- Types of channels
  1. Physical channels
  2. Logic channels



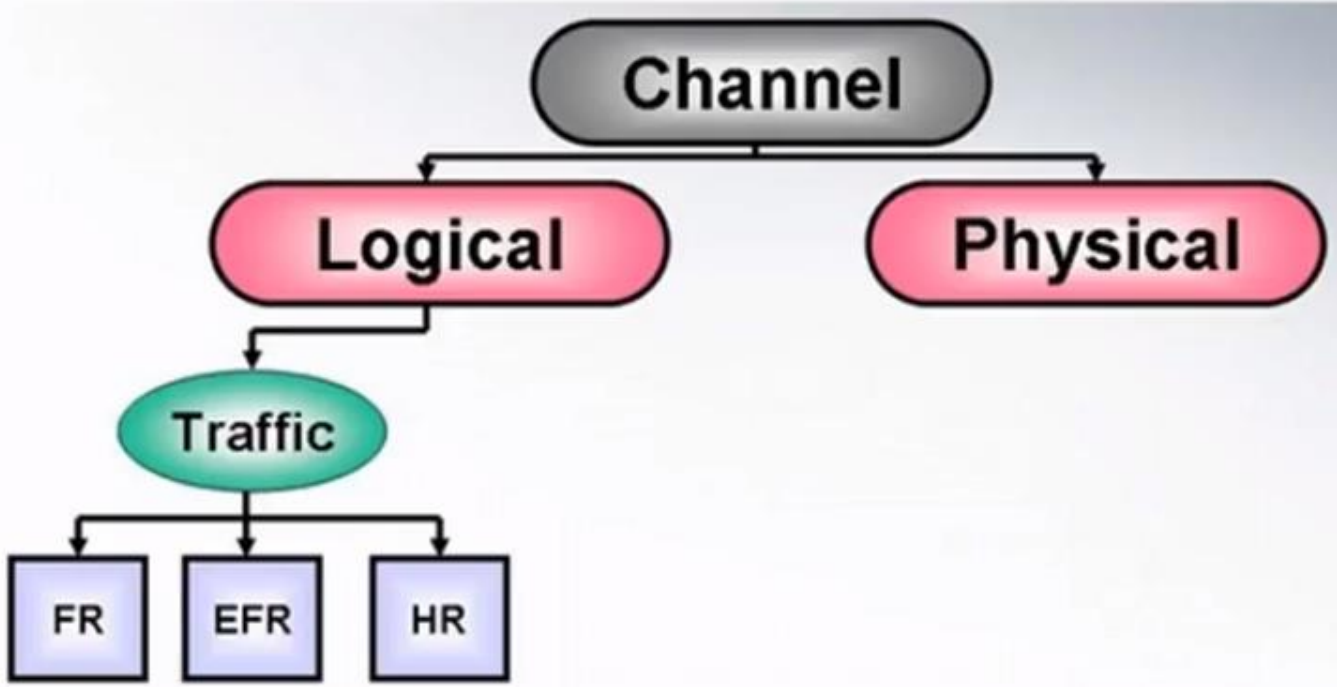
AIR INTERFACE

- Types of logic channels
  1. Traffic channels
  2. Control channels



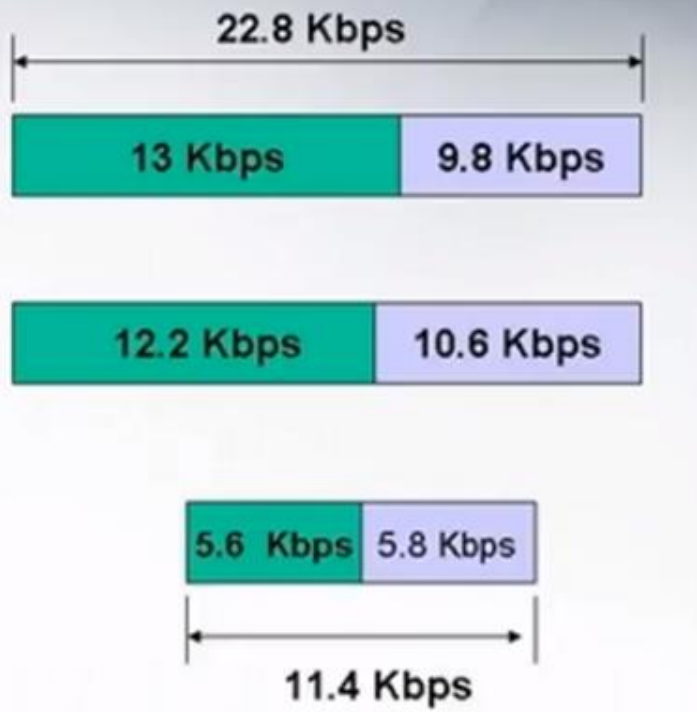


AIR INTERFACE



AIR INTERFACE

- Types of Traffic channels
  1. Full rate
     - 13 Kbps data rate
  2. Enhanced full rate
     - 12.2 Kbps data rate
  3. Half rate
     - increase network capacity



AIR INTERFACE

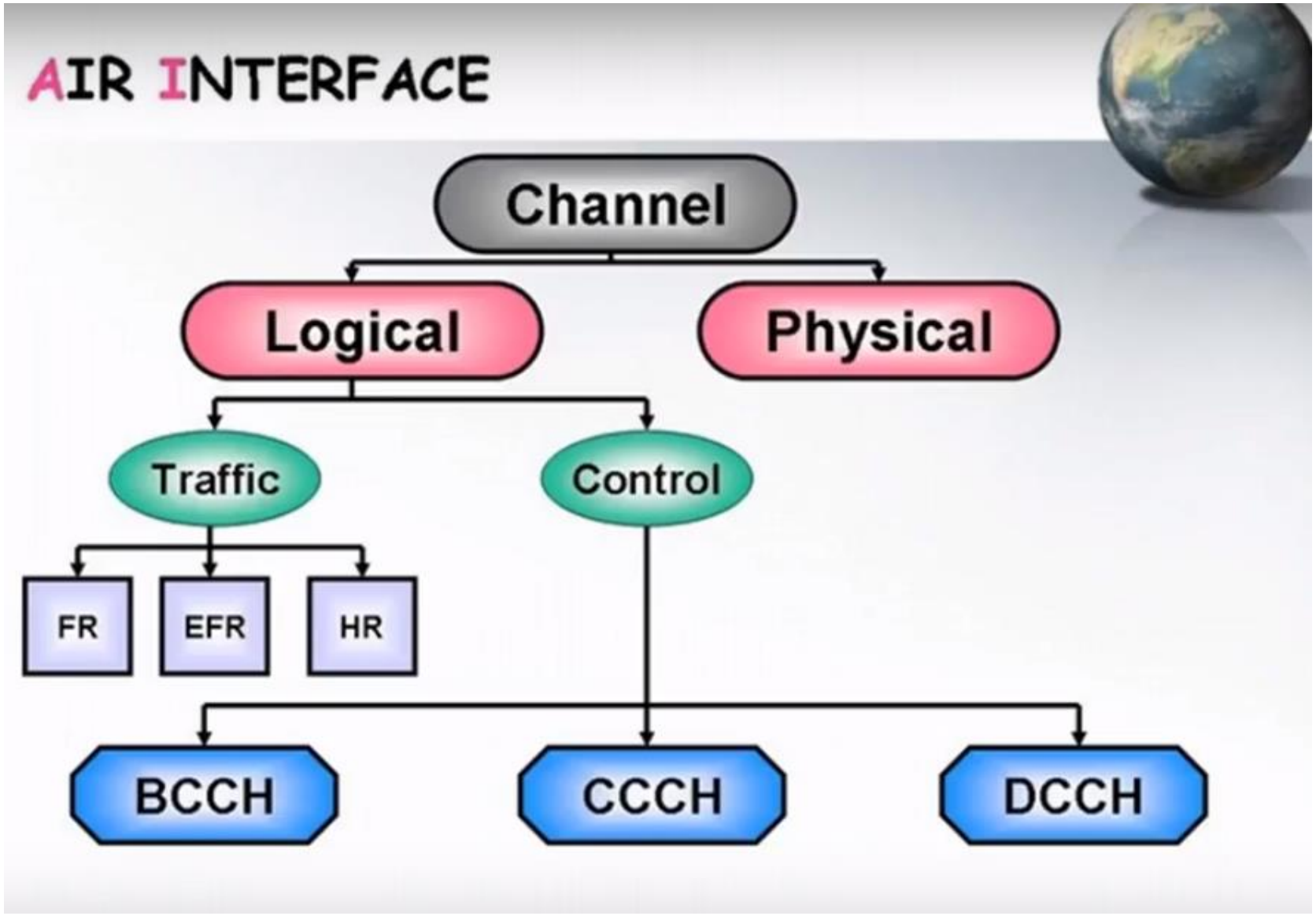
- Types of control channels

- Broadcast control channel

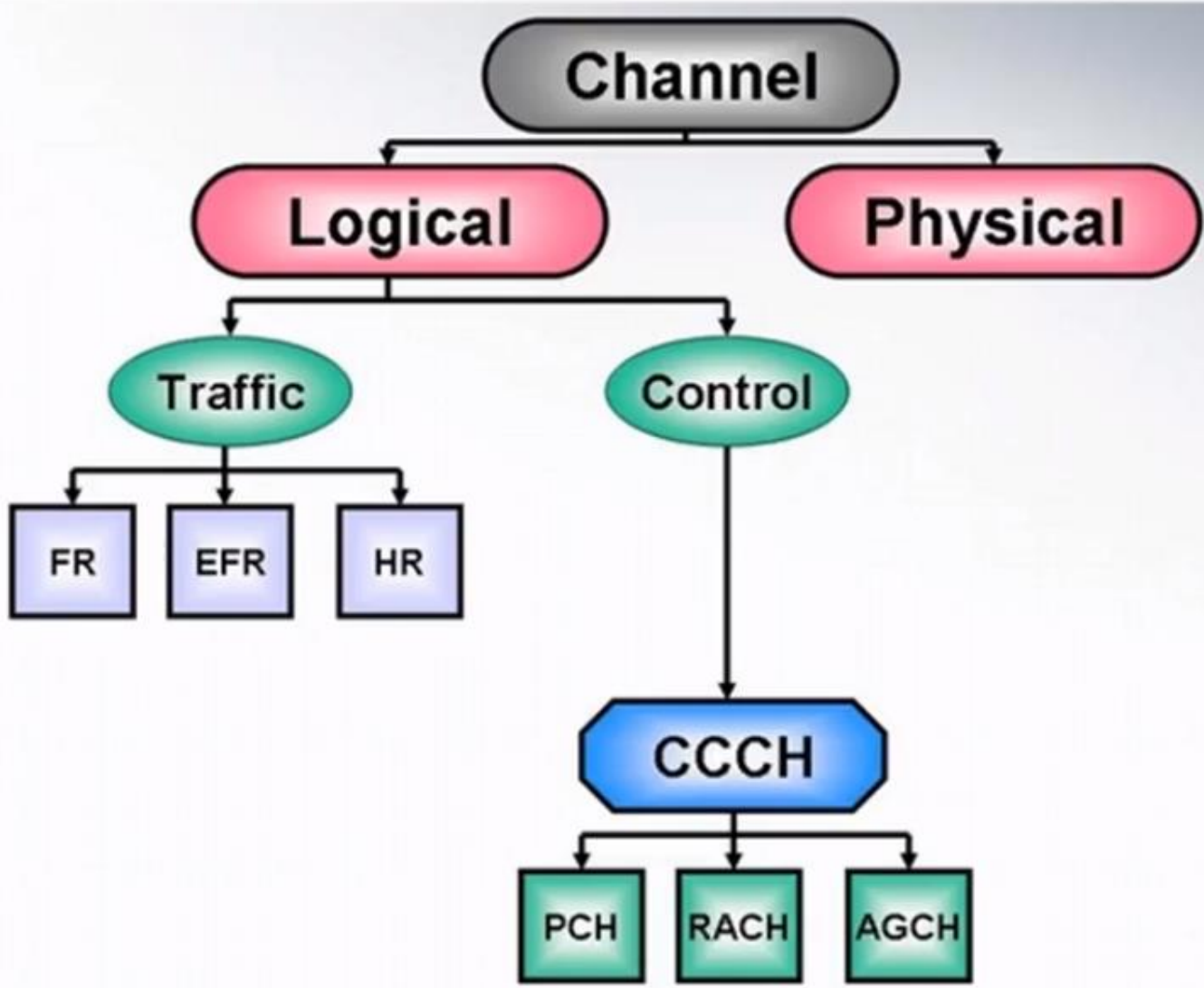
- Common control channel

- Dedicated control channel

AIR INTERFACE



AIR INTERFACE



ENG_TRCT

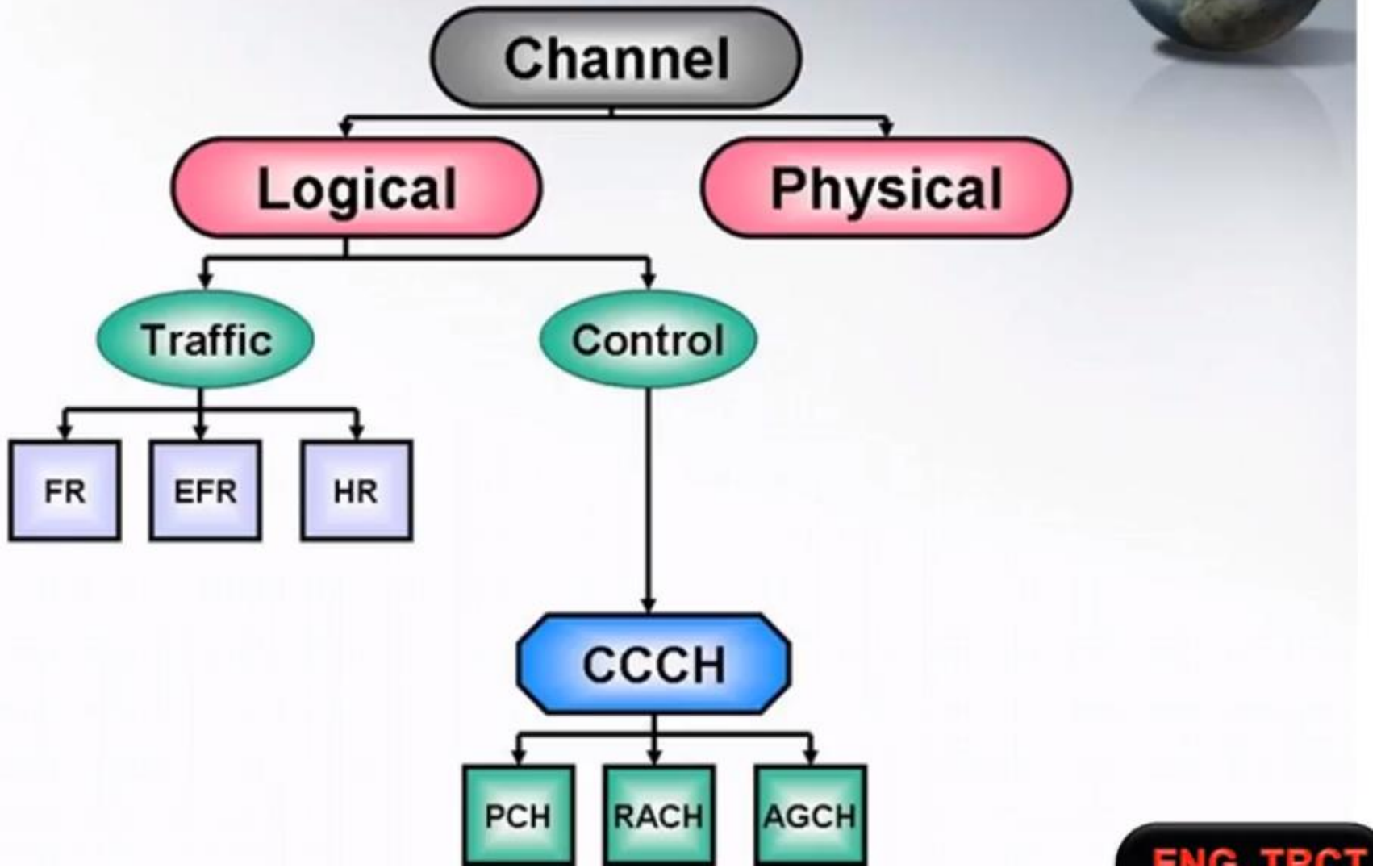
AIR INTERFACE

The Broadcast Channels (BCHs)

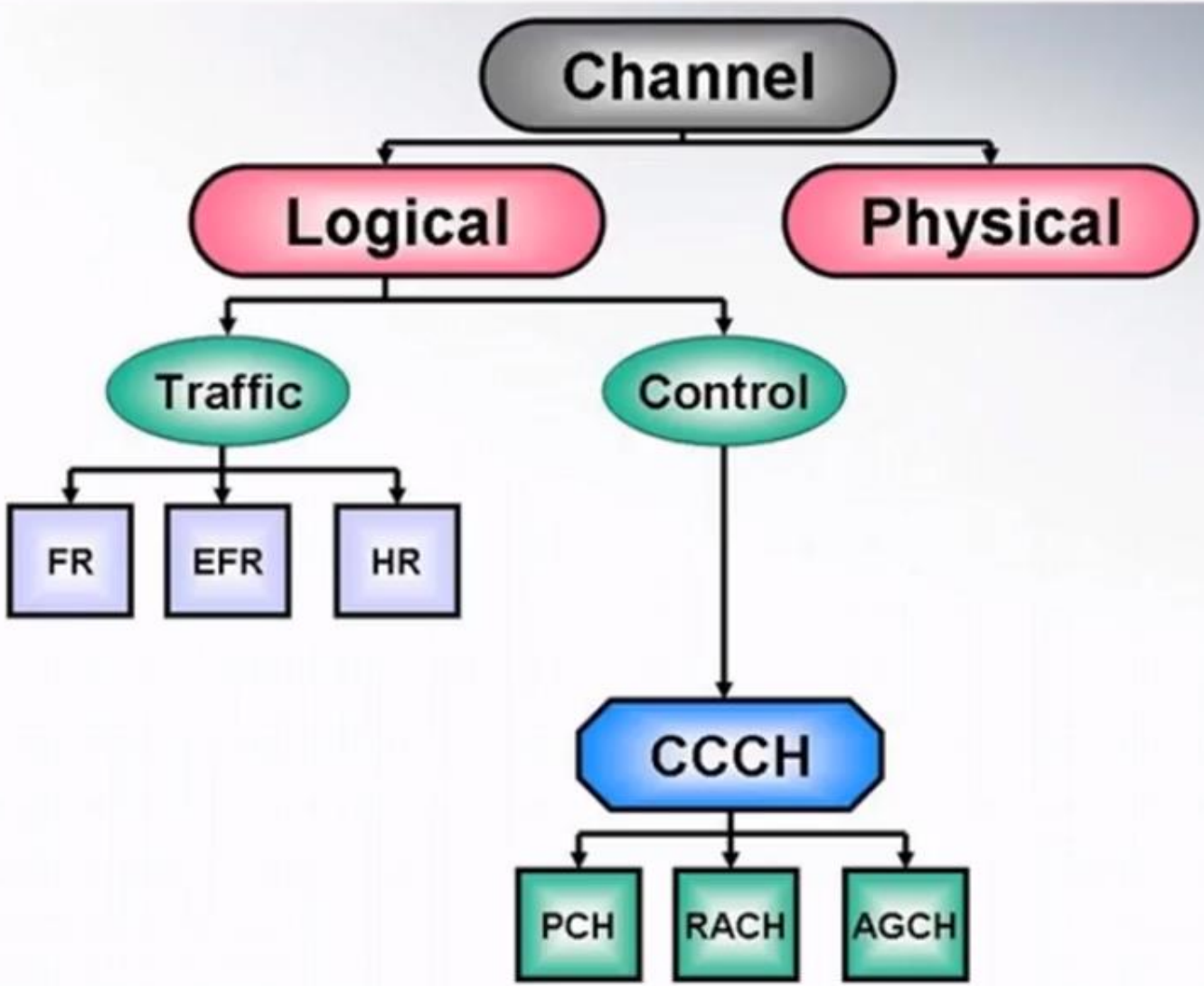
- Is transmitted by BS all the time.
- Monitored by MSs periodically (every 30 sec).
- All BCHs are downlink.

Logical channel	Function	BTS	MS
Frequency Correction Channel (FCCH)	Supply MS with reference freq.	•Transmits a carrier frequency.	• Identifies BCCH carrier • synchronizes with the frequency.
Synch. Channel (SCH)	For TDMA frame synchronization .	•Transmits frame number and BSIC.	•Synchronizes with frame structure.
Broadcast Control Channel (BCCH)	·Carries parameters needed to identify and access network. ·It is transmitted at constant power at all times and checked by all MSs.	• Broadcasts cell information such as –LAI, –maximum output power needed	•Receives LAI •May update •MS sets its output power level.

AIR INTERFACE

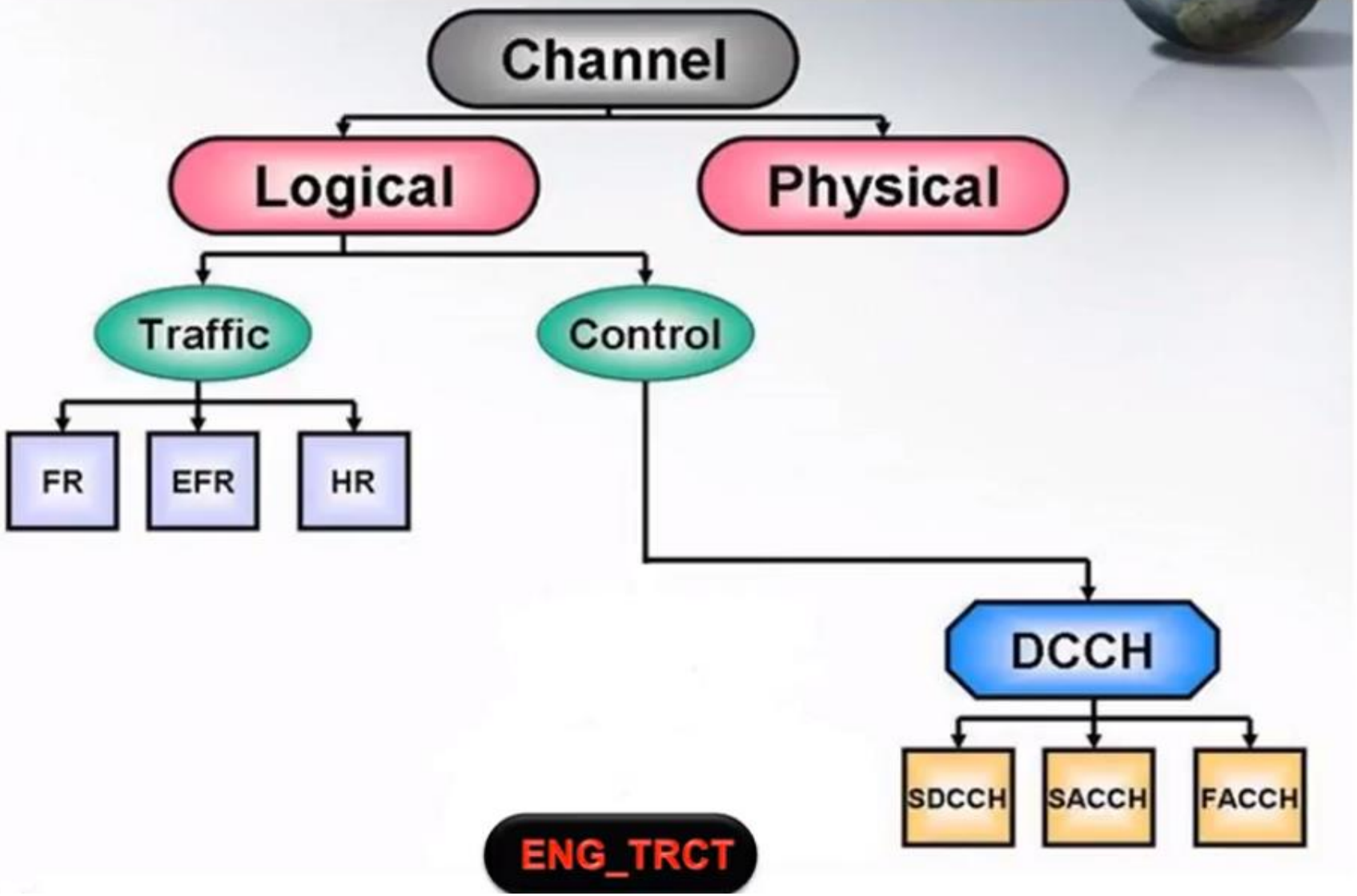


AIR INTERFACE



ENG TRCT

AIR INTERFACE

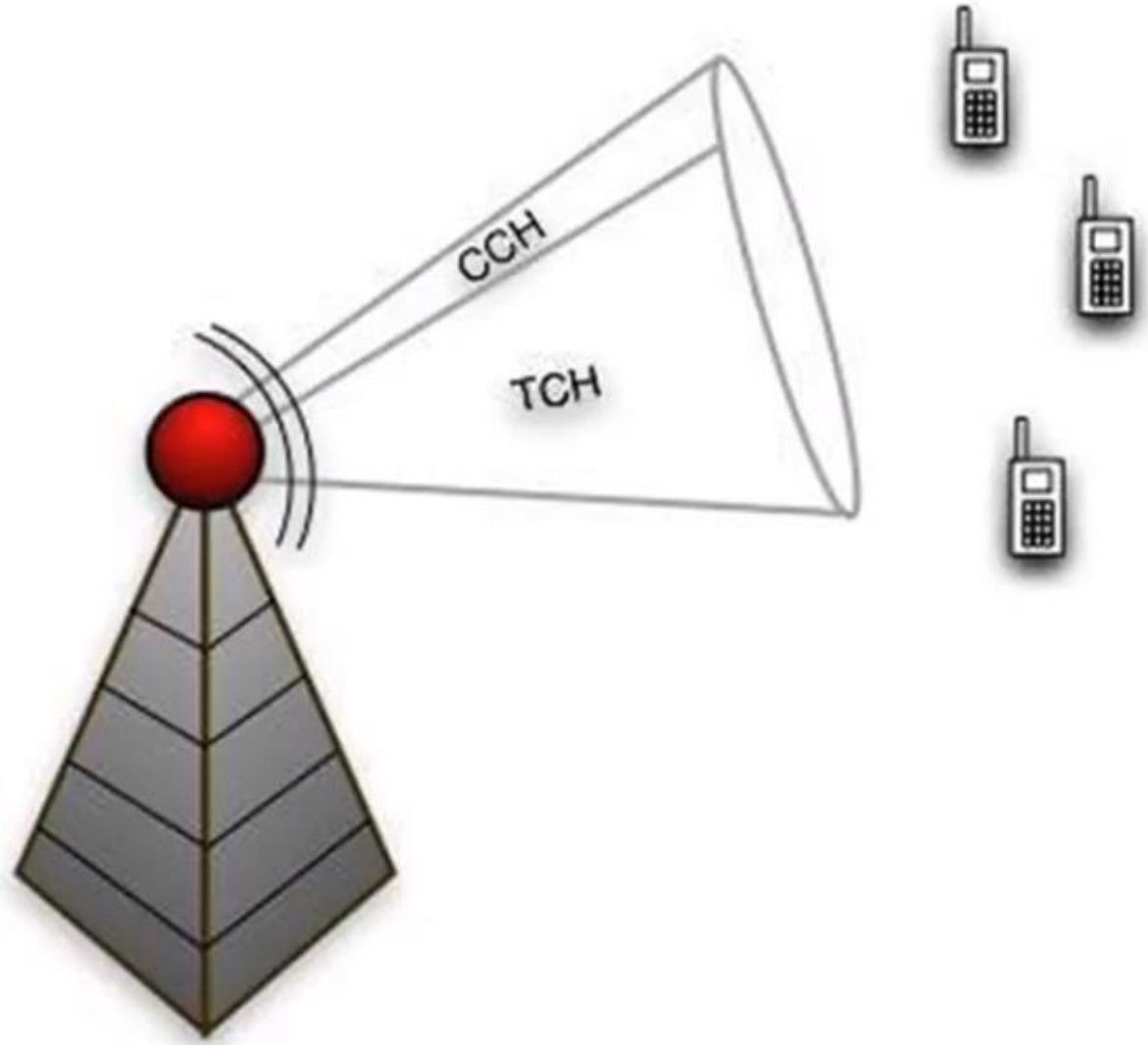


AIR INTERFACE

Dedicated Control Channels (DCCHs)

- Carry messages between MS and network.
- SDCCH is used for call setup, update, authentication

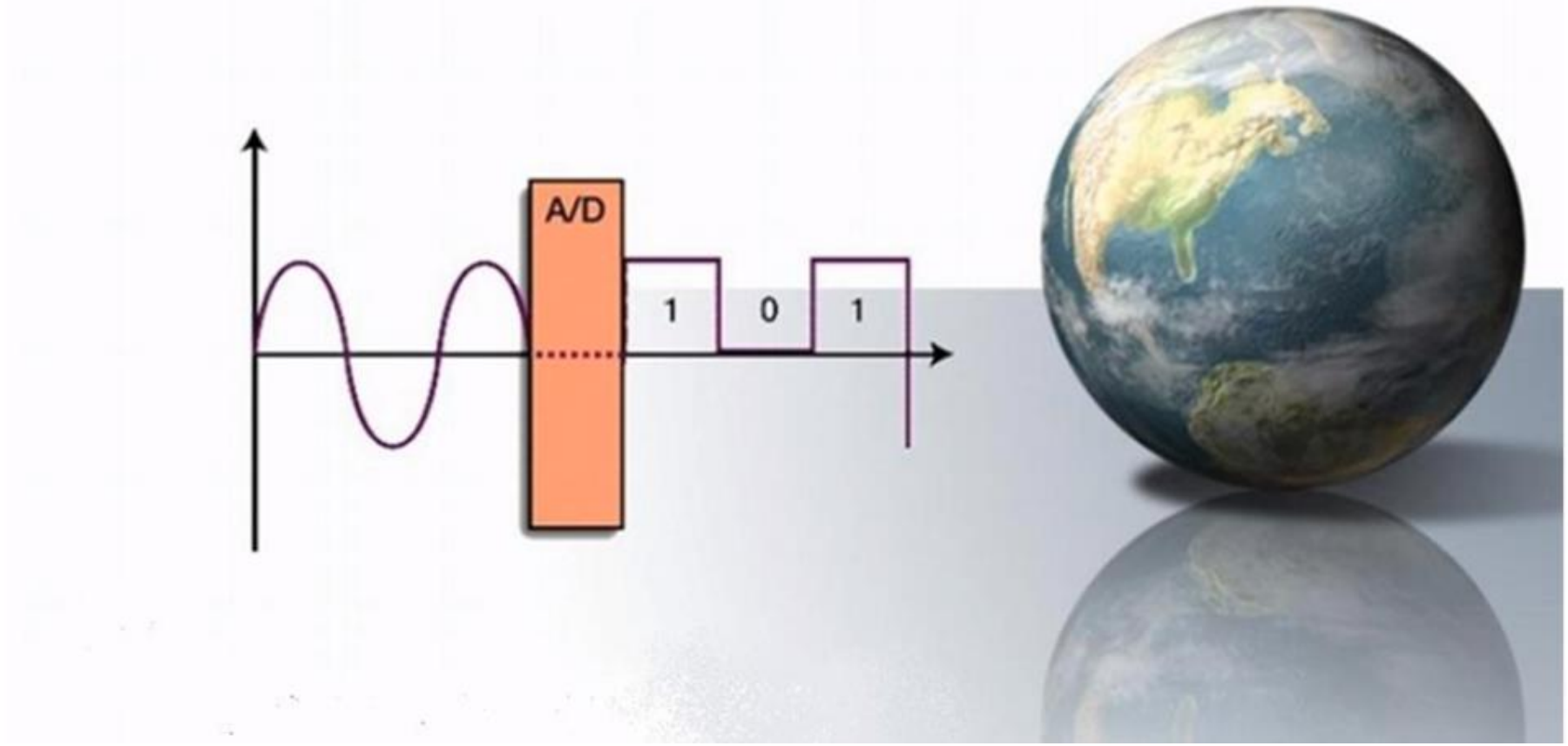
Logical ch.	Function	BTS	MS
Stand-alone Dedicated Control Channel (SDCCH) UL+DL	·Exchange signaling information in uplink and downlink.	•Switches to SDCCH. •Call set-up is performed in idle mode. •BSC assigns a TCH.	•Switches to SDCCH. •Call set up is performed. •MS receives TCH assignment [carrier + time slot]
Slow Associated Control Channel (SACCH) UL+DL	·Conveys power control and timing information in downlink. ·Conveys link quality reports in uplink.	•Instructs MS about: ≺Transmit power ≺Time advance.	•Sends measurements of its BTS and neighboring BTSs during a call.
Fast Associated Control Channel (FACCH) UL+DL	·Steals TCH to carry handover and channel reassignment.	•Transmits handover information.	•Transmits handover request..


CCH
TCH


GSM Course
CH4

CH 4

ELEMENTS OF DIGITAL MOBILE

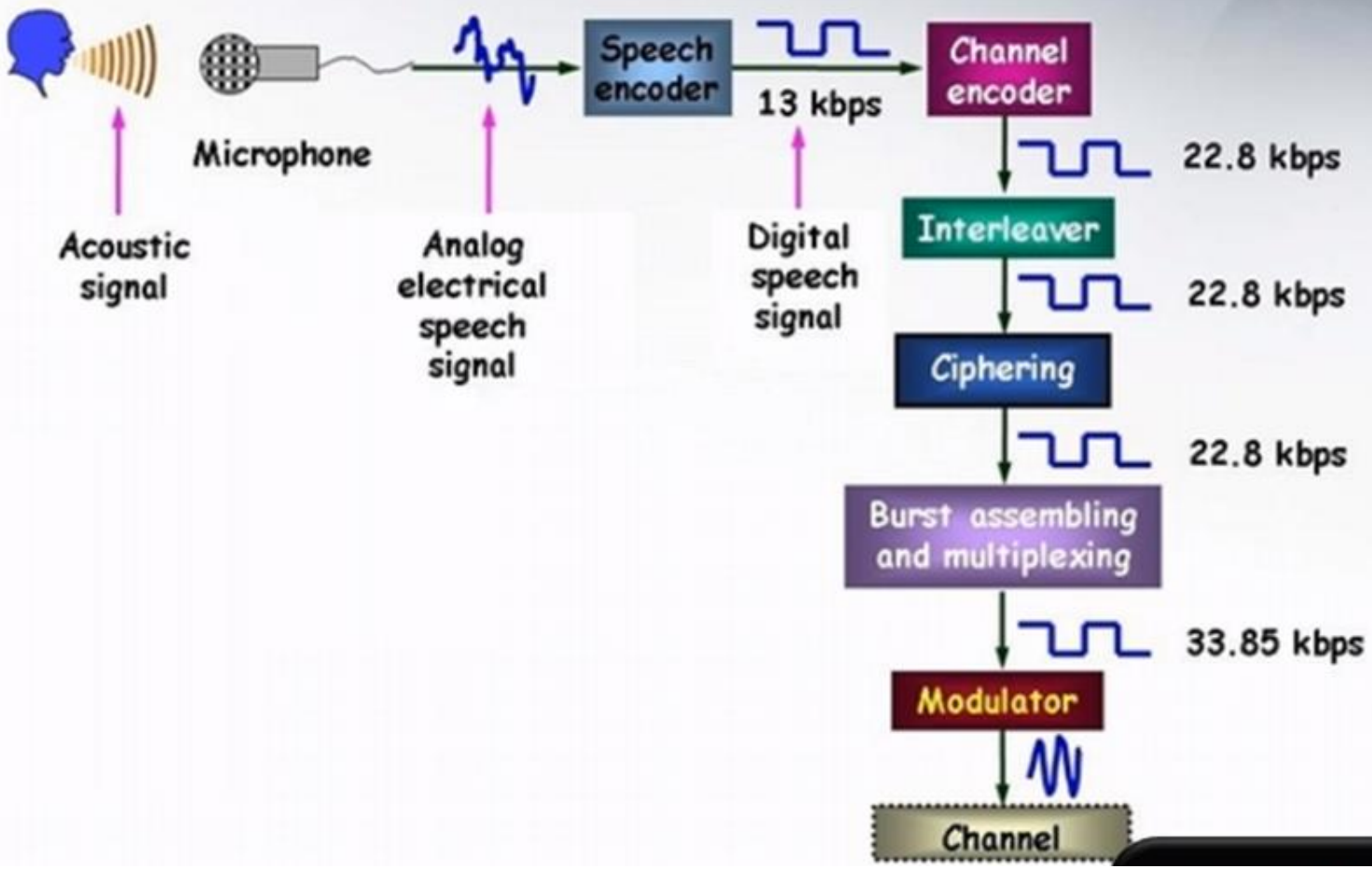


ELEMENTS OF DIGITAL MOBILE

- In this chapter we will see :
  1. Elements of digital mobile
  2. speech coding
  3. Channel coding
  4. Interleaving
  5. Security in GSM
  6. Modulation in GSM

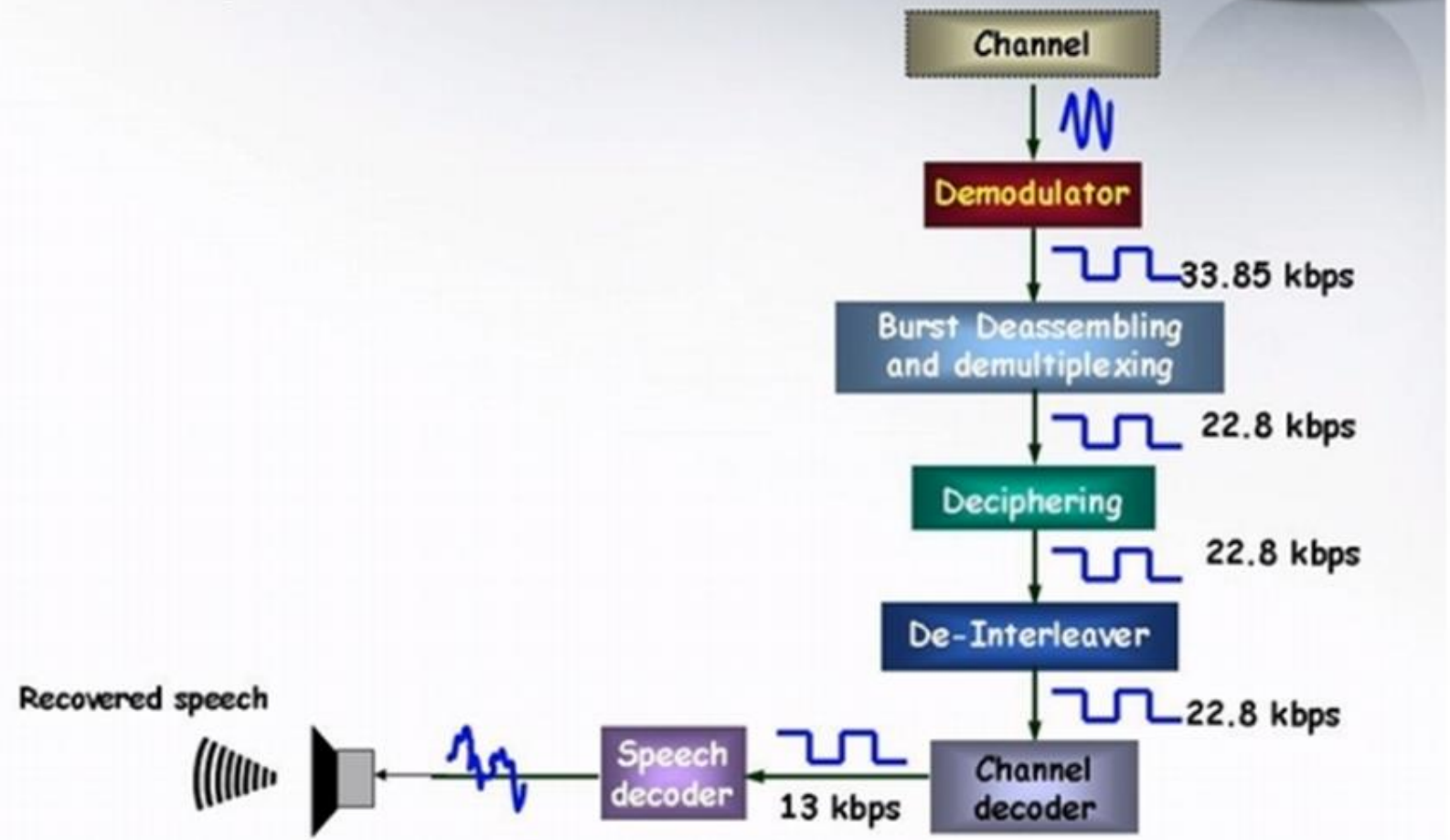
ELEMENTS OF DIGITAL MOBILE

GSM Transmission Chain



ELEMENTS OF DIGITAL MOBILE

GSM Reception Chain




Speech Encoder
الخصائص
Low Bit Rate
Good Quality Signal
Low Cost
الوظائف
Analog to Digital Conv.
Segmentation
Predictive Coding

ELEMENTS OF DIGITAL MOBILE

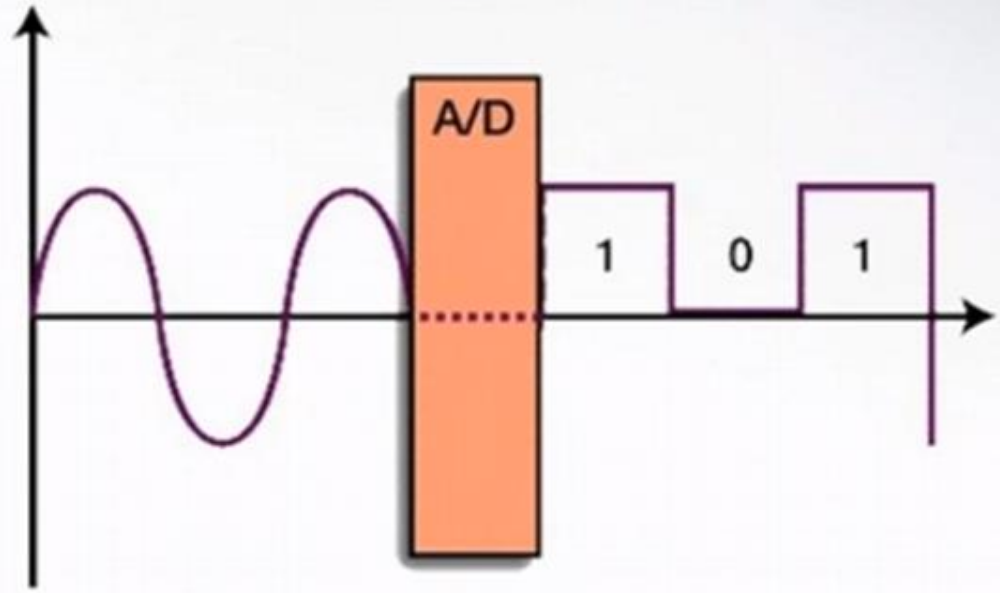
- speech coding must give :

1. Low bit rate
2. Preserving the essential elements of speech quality
3. An acceptable cost of the equipment

- GSM sends information about speech not the speech itself

ELEMENTS OF DIGITAL MOBILE

- First step A/D converter



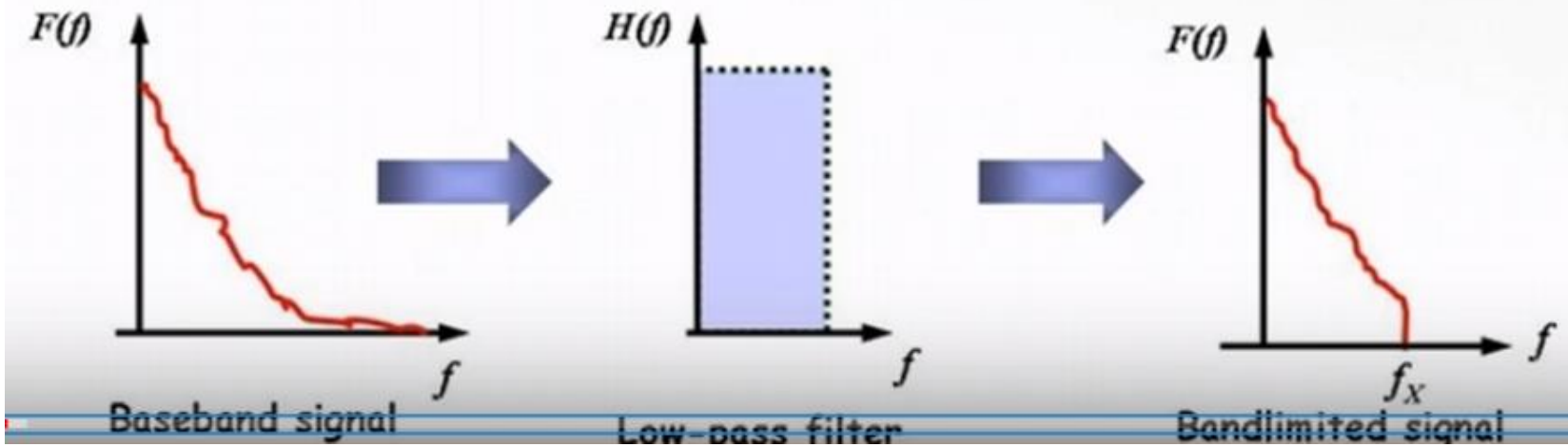
ELEMENTS OF DIGITAL MOBILE

Pulse Code Modulation

- A/D is performed by PCM.
- **PCM involves 4 steps:**
  - 1- Bandlimiting (FILTERING)
  - 2- Sampling
  - 3- Quantizing
  - 4- Encoding

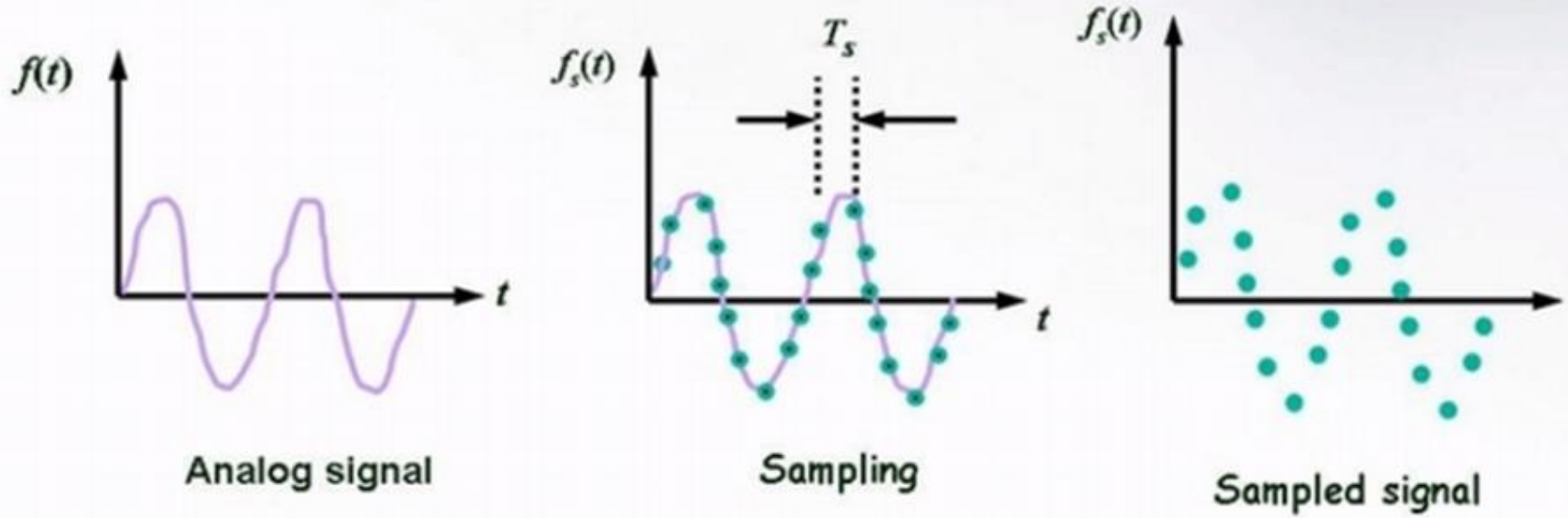
-Bandlimiting

ENG_TRCT



ELEMENTS OF DIGITAL MOBILE

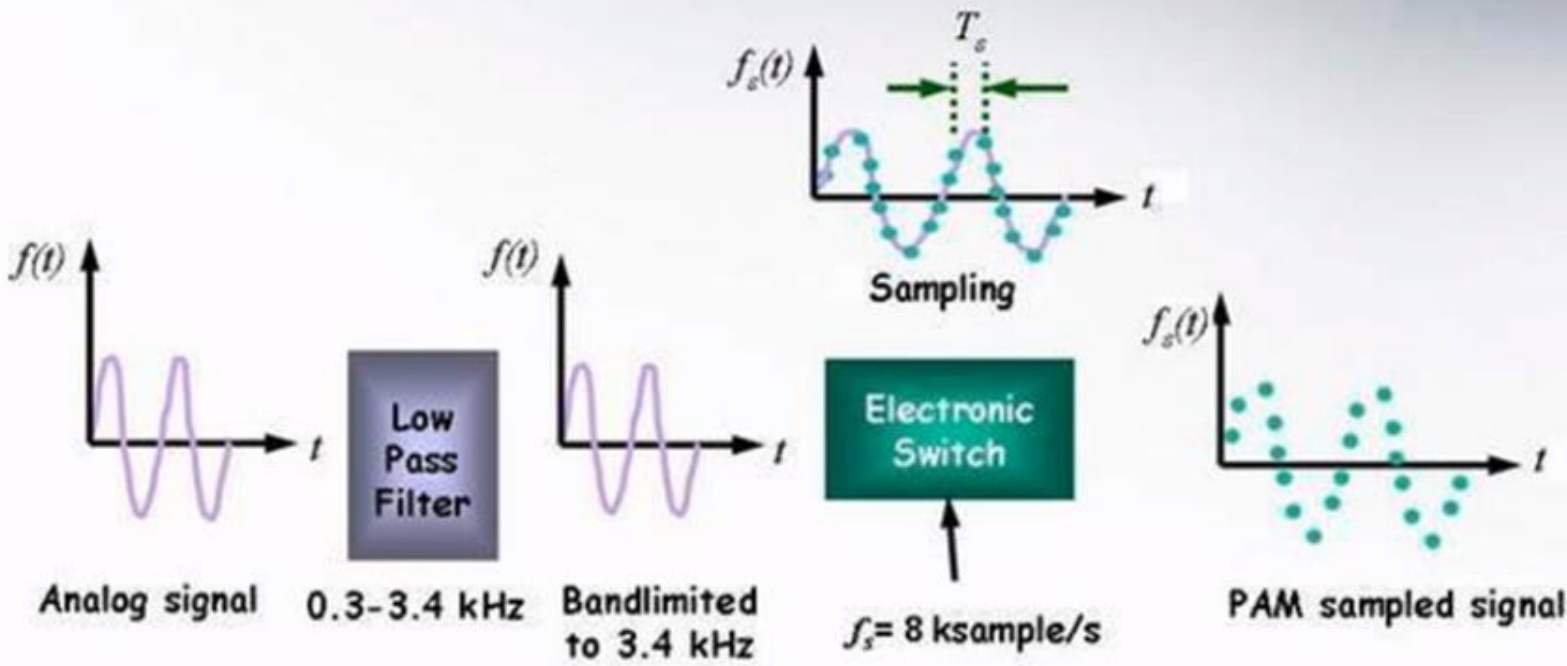
-Sampling



$$f_s = 2 f_x \text{ sample/sec}$$

ELEMENTS OF DIGITAL MOBILE

Bandlimiting + Sampling

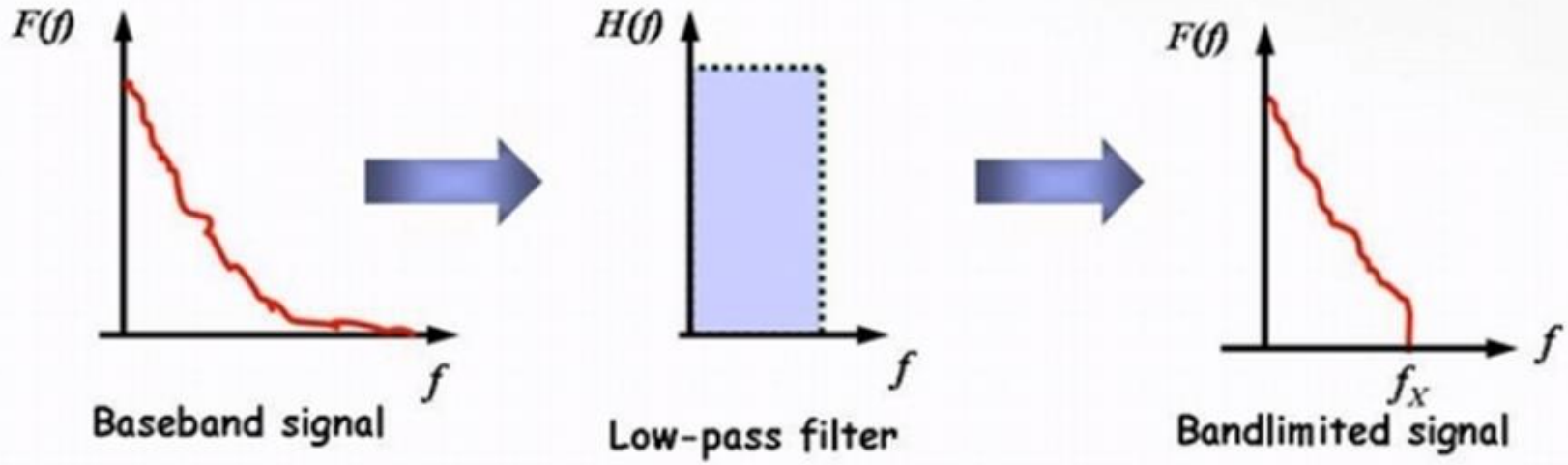


ELEMENTS OF DIGITAL MOBILE

- A/D is performed by PCM.
- **PCM involves 4 steps:**
  - 1- Bandlimiting
  - 2- Sampling
  - 3- Quantizing
  - 4- Encoding

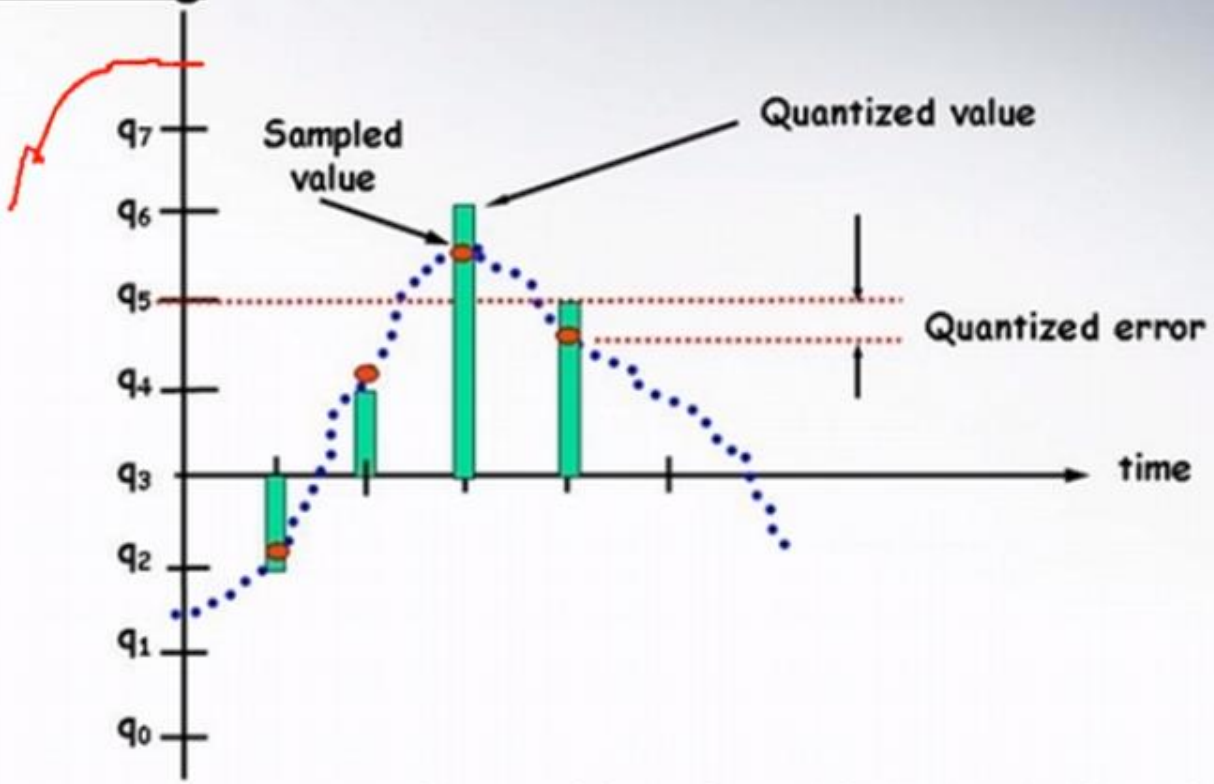
-Bandlimiting

ENG_TRCT



ELEMENTS OF DIGITAL MOBILE

Quantizing



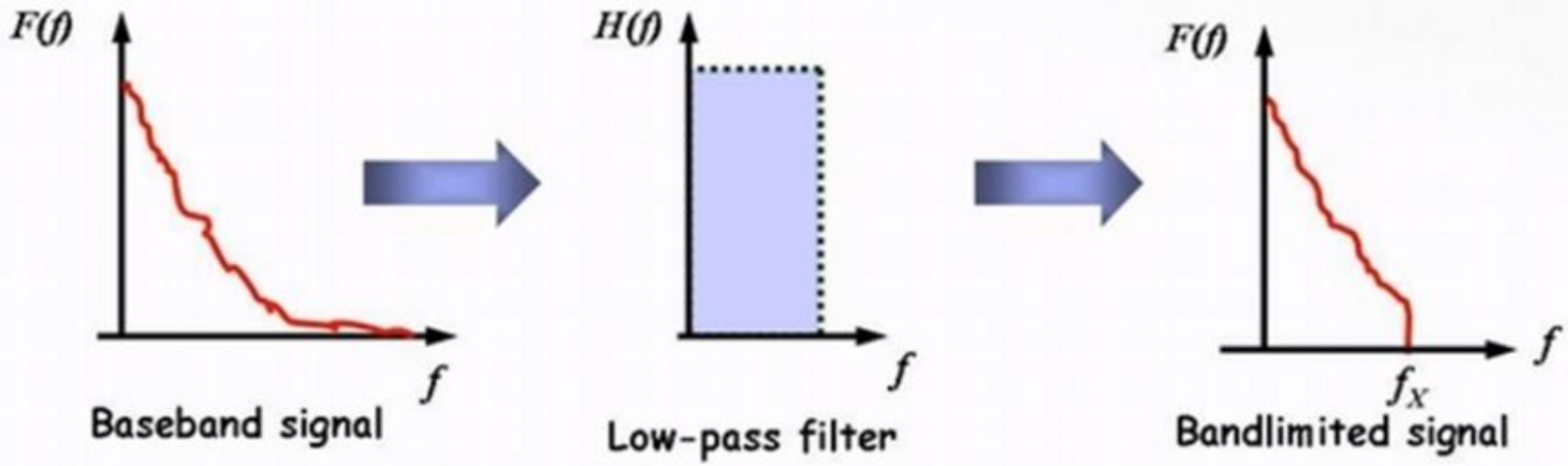
- Number of levels = 2^13=8192 levels.
- This gives 13 bit/sample.

ELEMENTS OF DIGITAL MOBILE

- A/D is performed by PCM.
- **PCM involves 4 steps:**
  - 1- Bandlimiting
  - 2- Sampling
  - 3- Quantizing
  - 4- Encoding

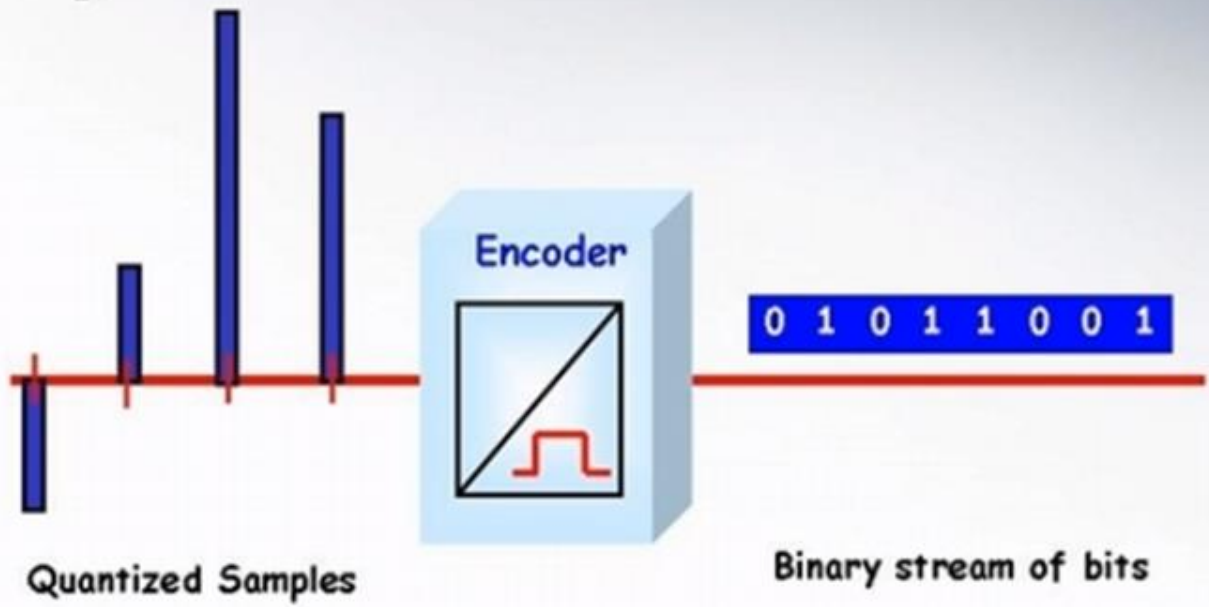
-Bandlimiting

ENG_TRCT



ELEMENTS OF DIGITAL MOBILE

Encoding

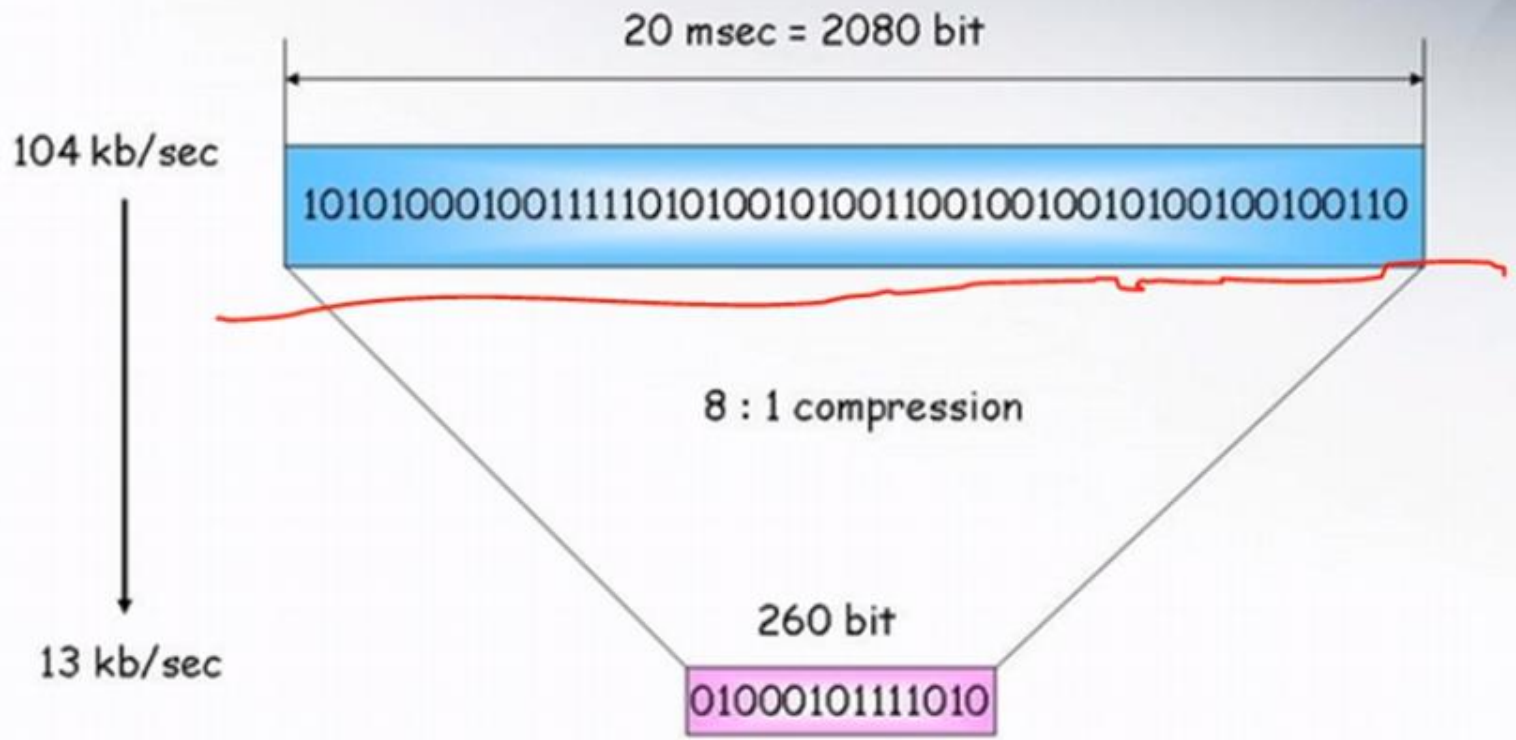


- Encoding rate = 8000 x 13 = 104 kb/sec.


Speech Encoder
الخصائص
Low Bit Rate
Good Quality Signal
Low Cost
الوظائف
Analog to Digital Conv.
Segmentation
Predictive Coding

ELEMENTS OF DIGITAL MOBILE

Segmentation

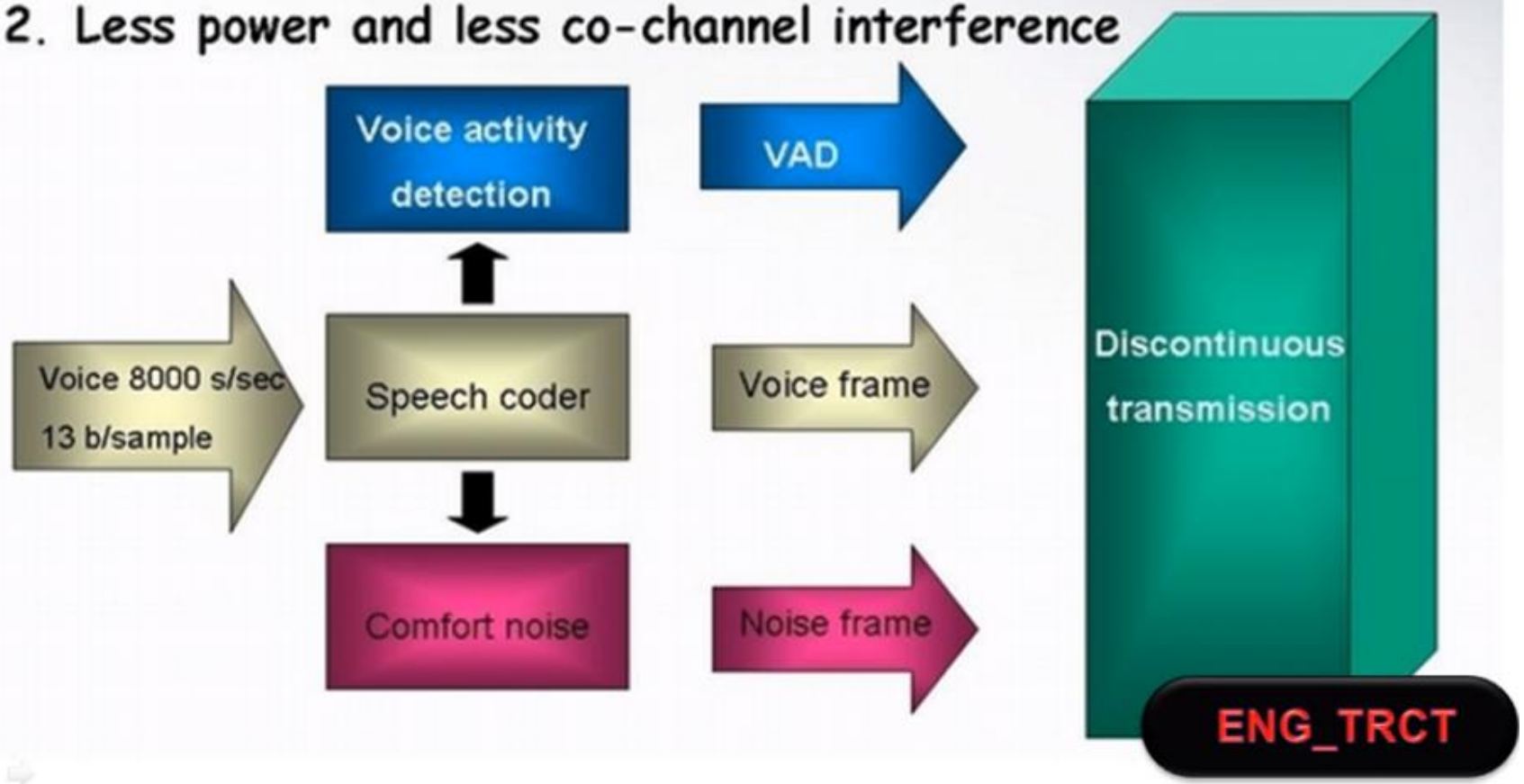



Speech Encoder
الخصائص
Low Bit Rate
Good Quality Signal
Low Cost
الوظائف
Analog to Digital Conv.
Segmentation
Predictive Coding

ELEMENTS OF DIGITAL MOBILE

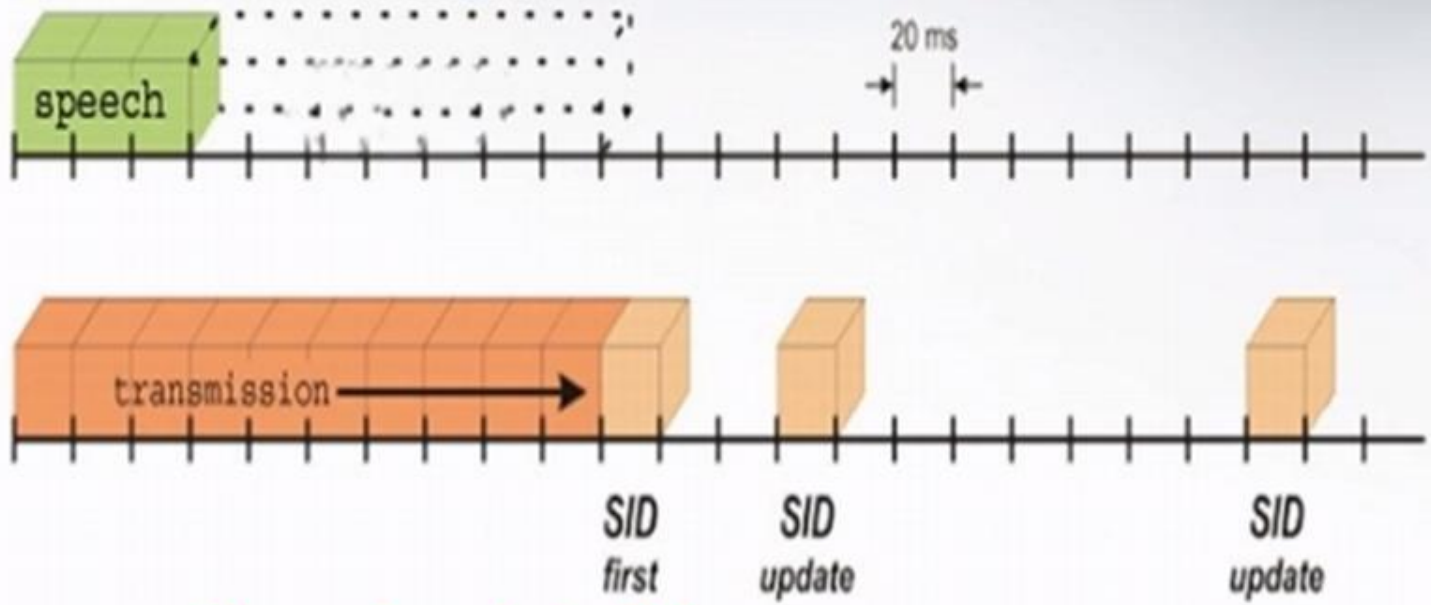
- Predictive coding

1. We send information about noise not the voice itself (pitch, tone,….etc)
2. Less power and less co-channel interference



ELEMENTS OF DIGITAL MOBILE

- DTX

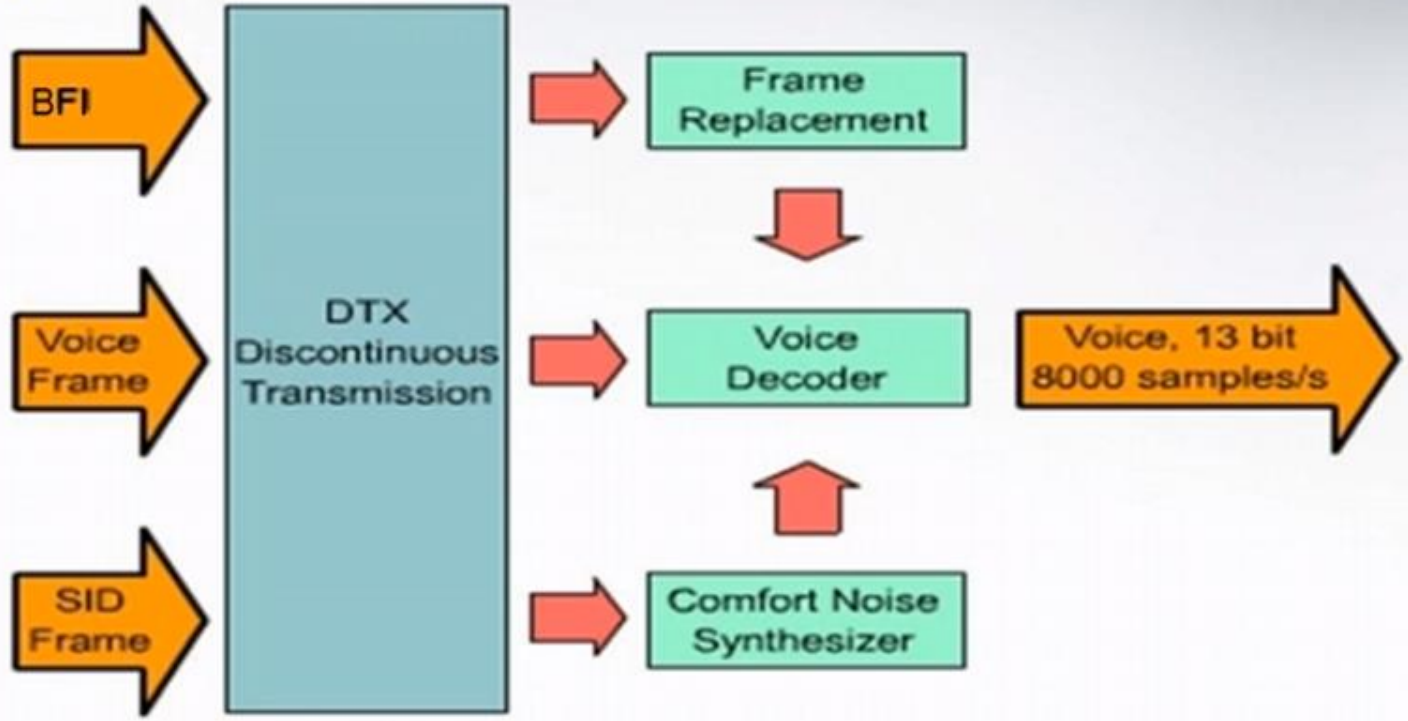


Silence Descriptor SID

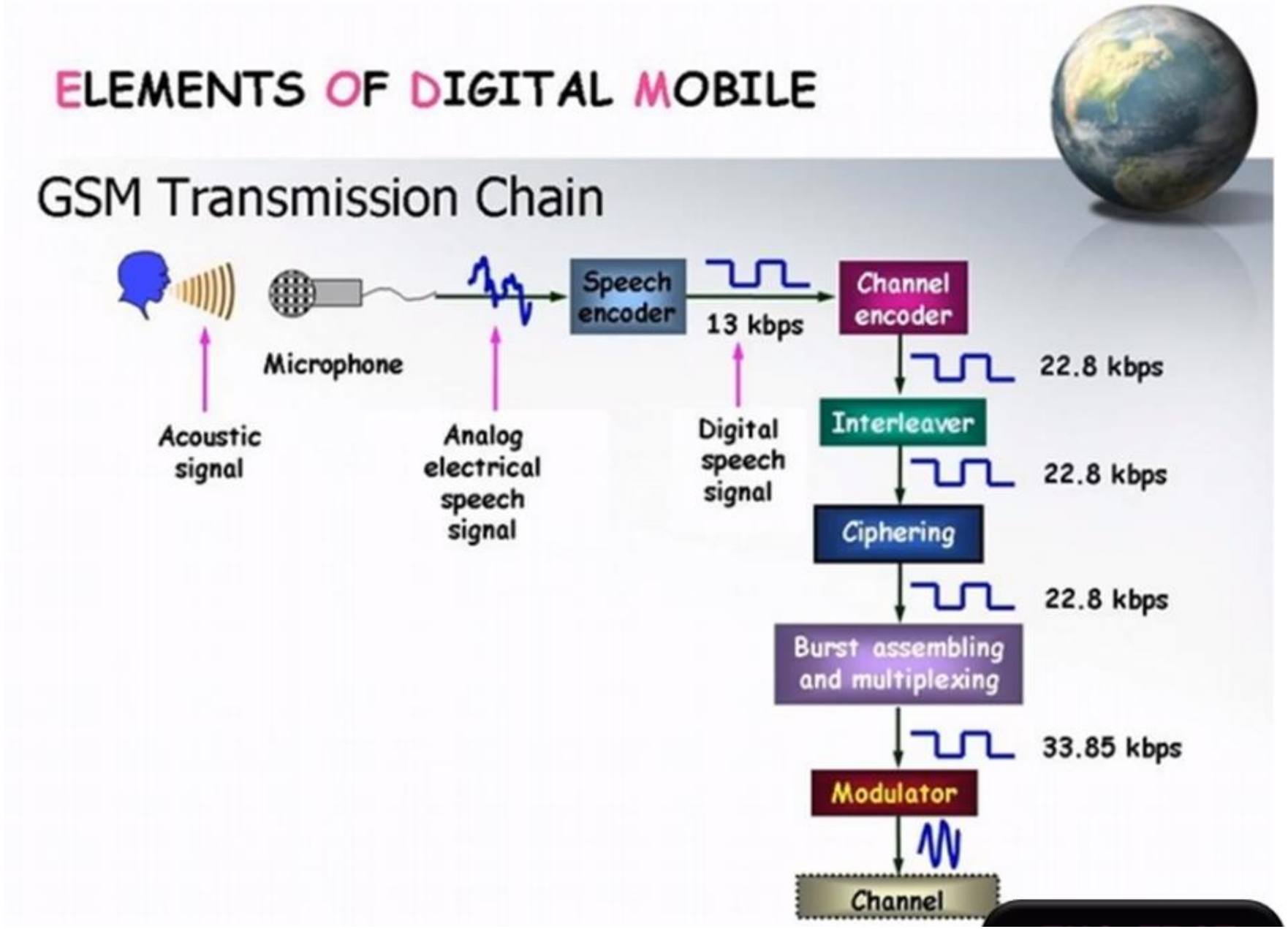
ELEMENTS OF DIGITAL MOBILE

- Predictive decoding

Bad Frame Replacement

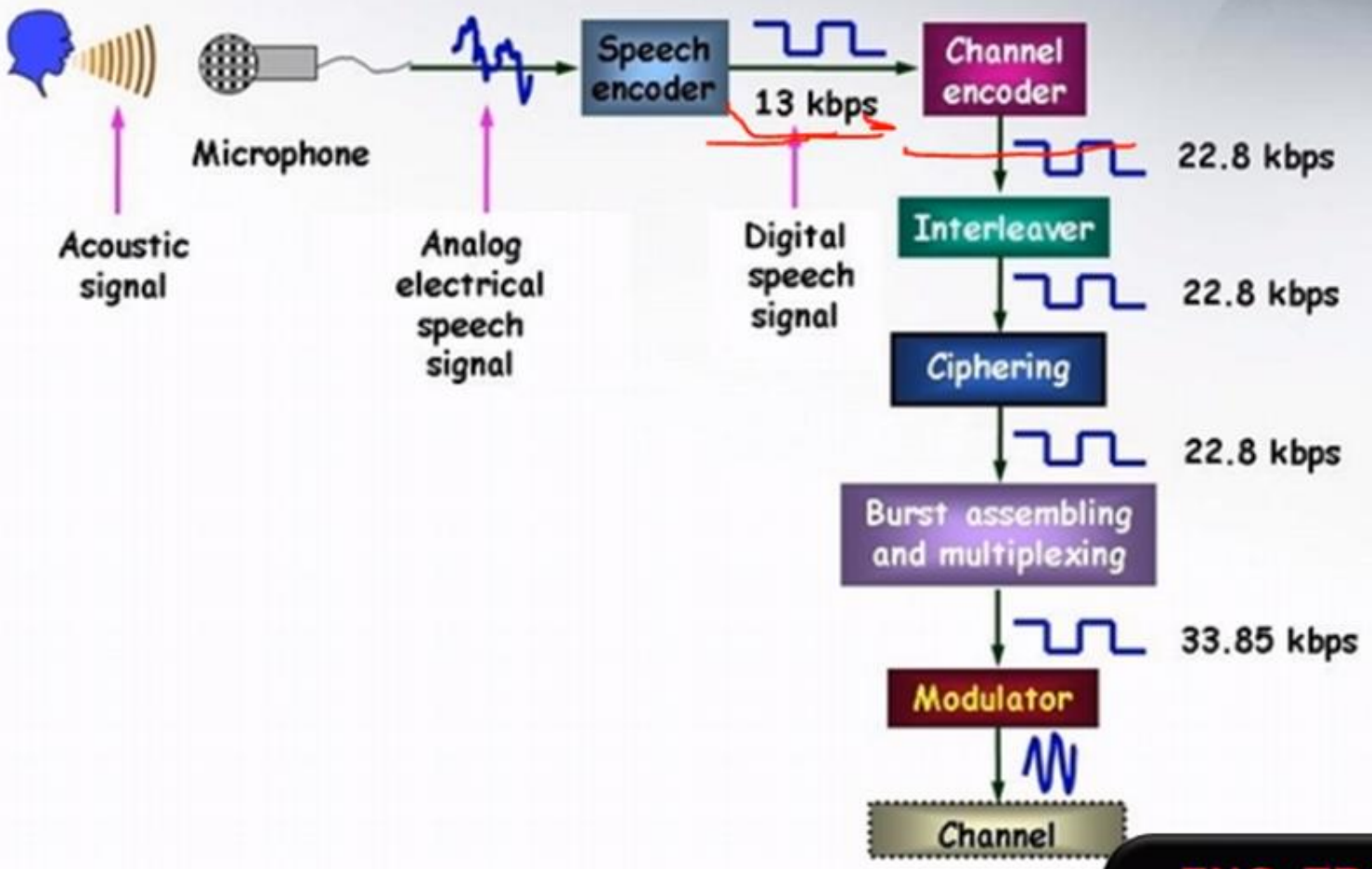


ELEMENTS OF DIGITAL MOBILE



ELEMENTS OF DIGITAL MOBILE

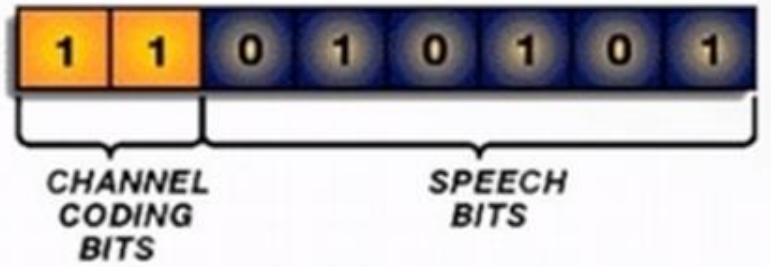
GSM Transmission Chain



ENG_TRCT

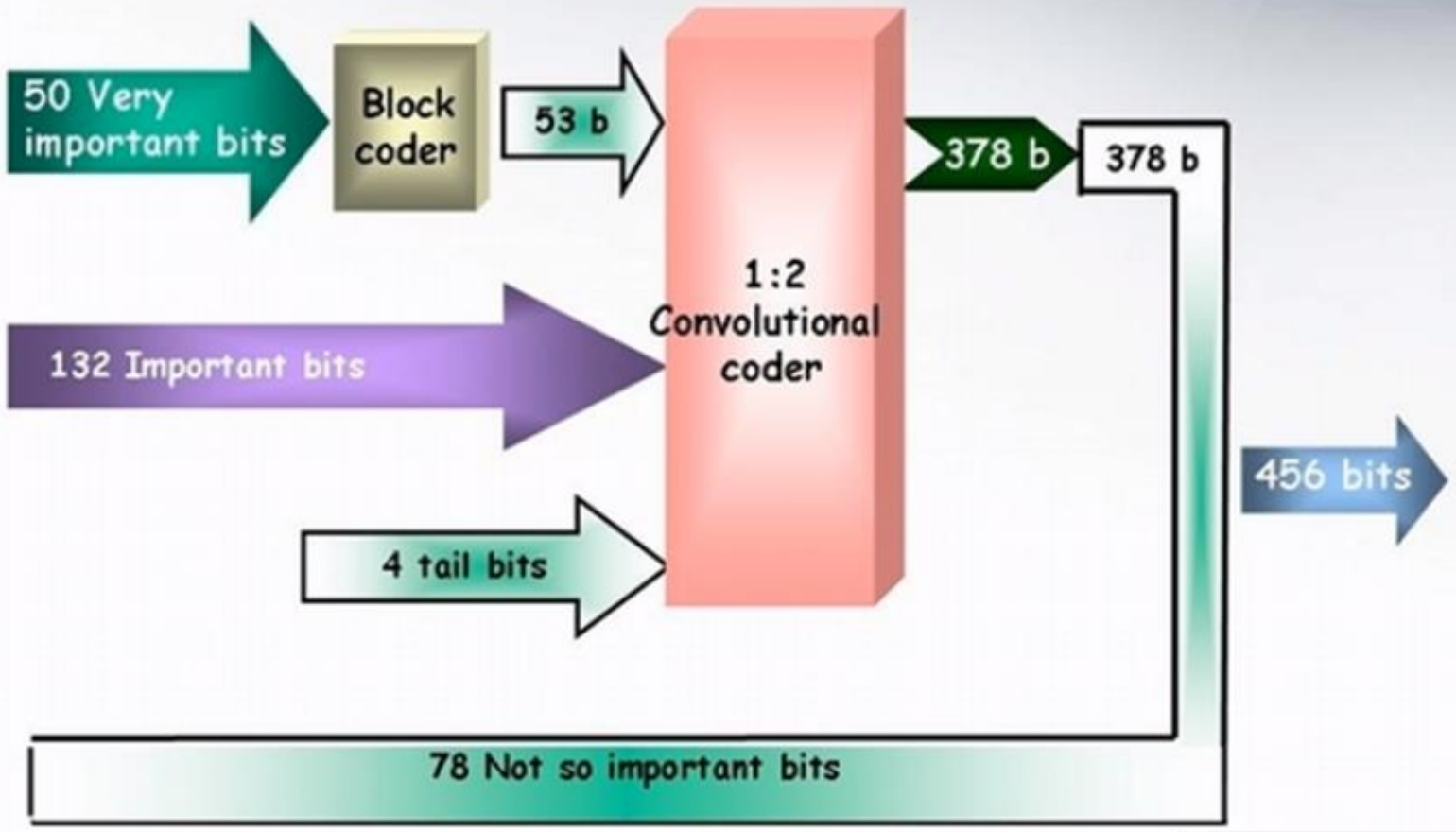
ELEMENTS OF DIGITAL MOBILE

- **Channel coding**
  - Mobile channel is error-prone.
  - Compressed speech is sensitive to errors.
  - Error correction is necessary.
  - Channel coding adds extra bits to help in error correction.
  - <u>GSM uses:</u>
    1. Block code
    2. Convolutional code



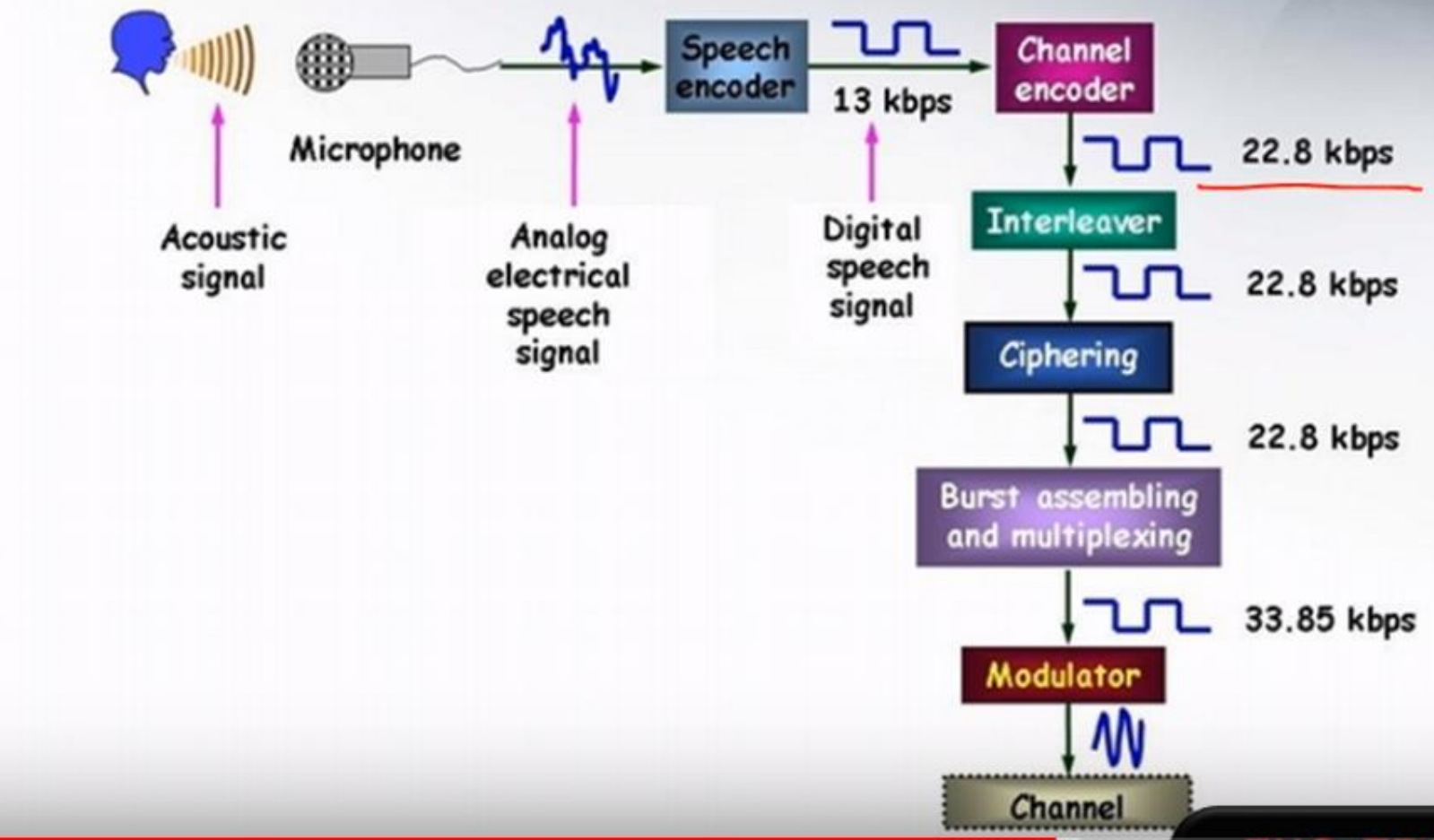
ELEMENTS OF DIGITAL MOBILE

- Convolutional code



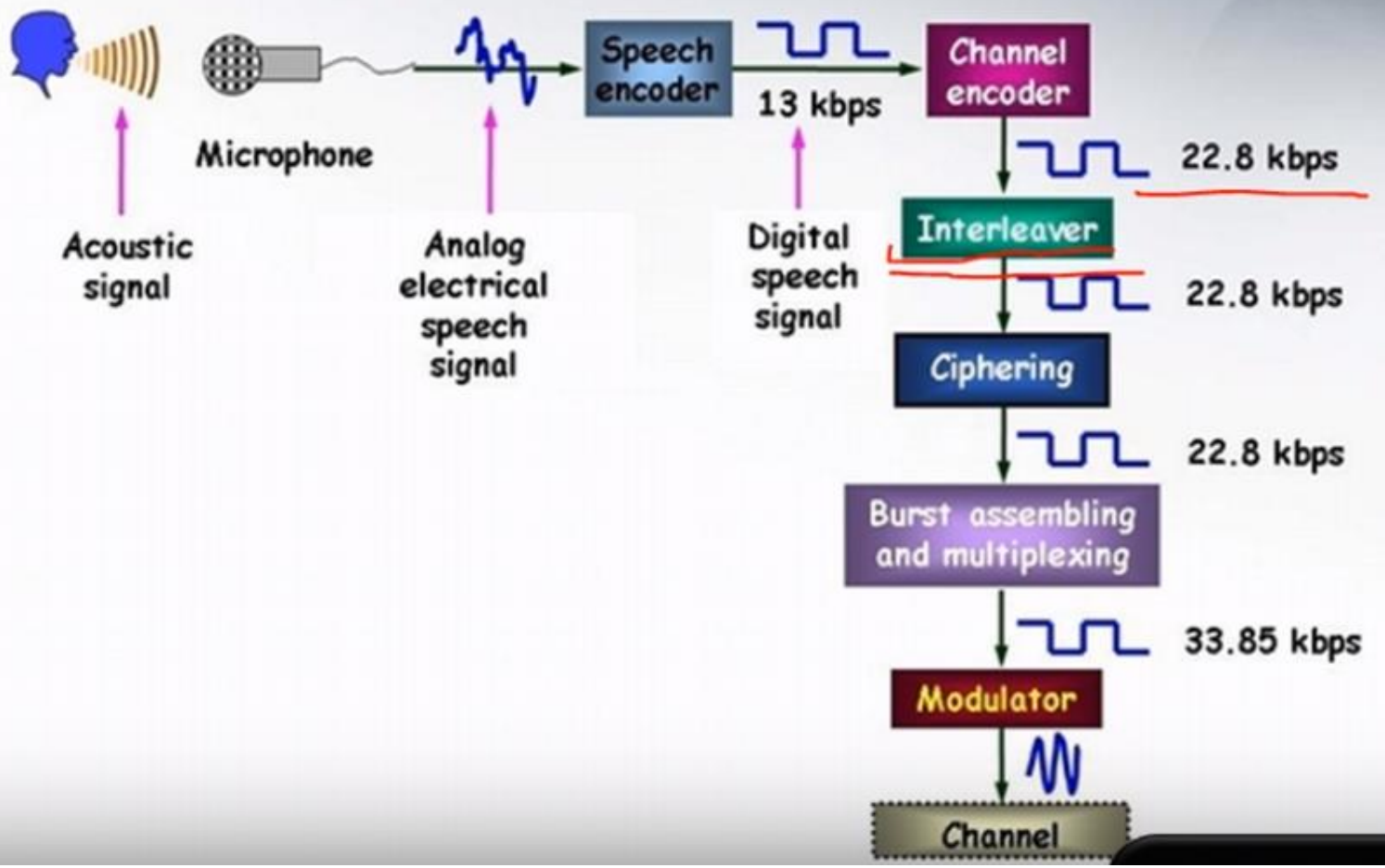
ENG_TRCT

ELEMENTS OF DIGITAL MOBILE



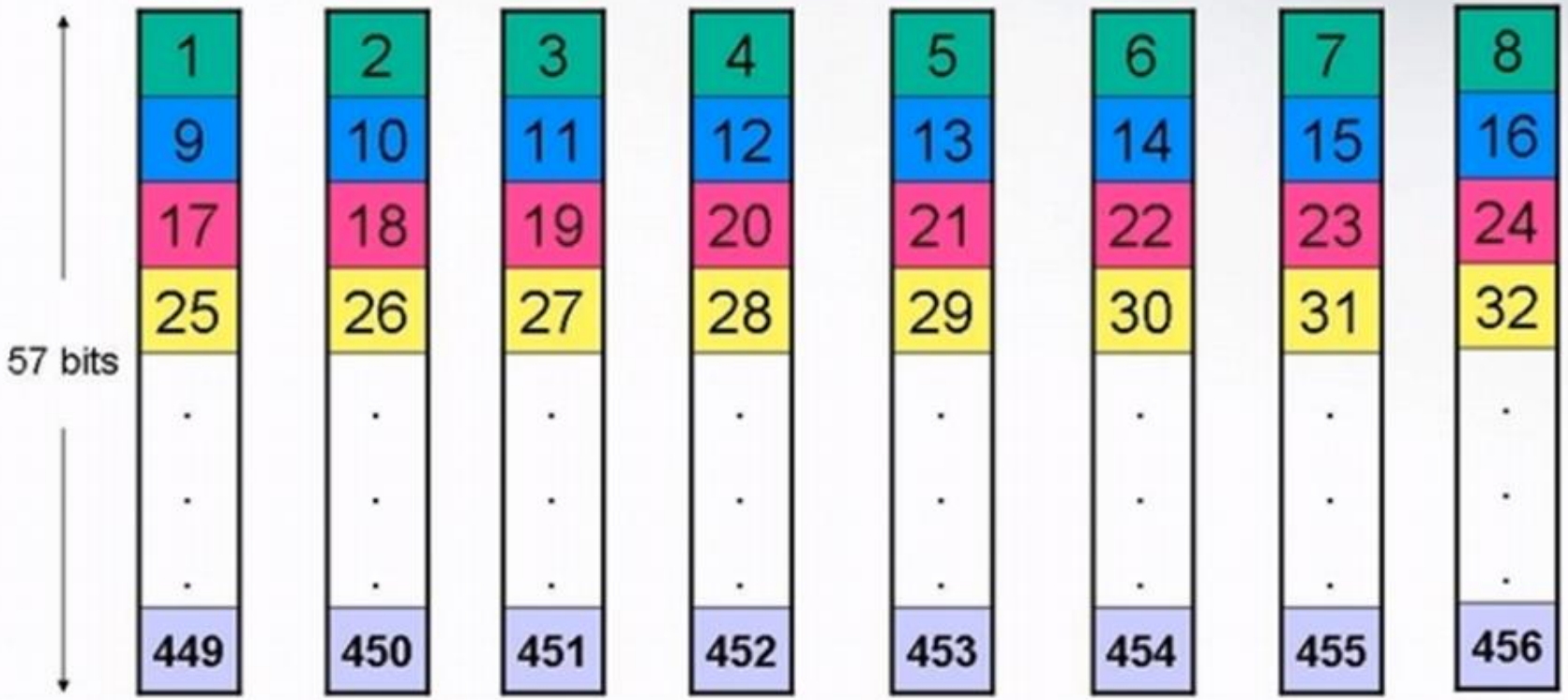
ELEMENTS OF DIGITAL MOBILE

GSM Transmission Chain



ELEMENTS OF DIGITAL MOBILE

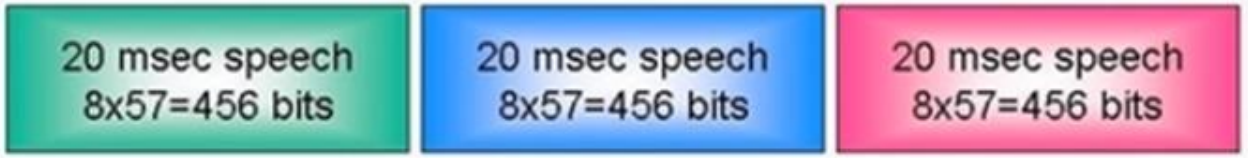
- Interleaving
  - First level :Block interleaving

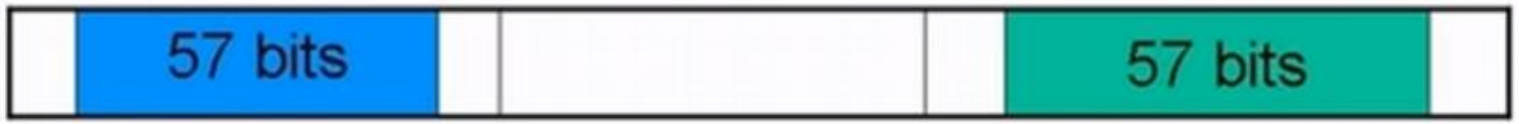


ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

- second level :Burst interleaving
  - -Normal Burst has 2 of 57b blocks
  - -If Burst is lost BER=25%
  - -To reduce it to 12.5% we put 2 blocks of two 20 msec



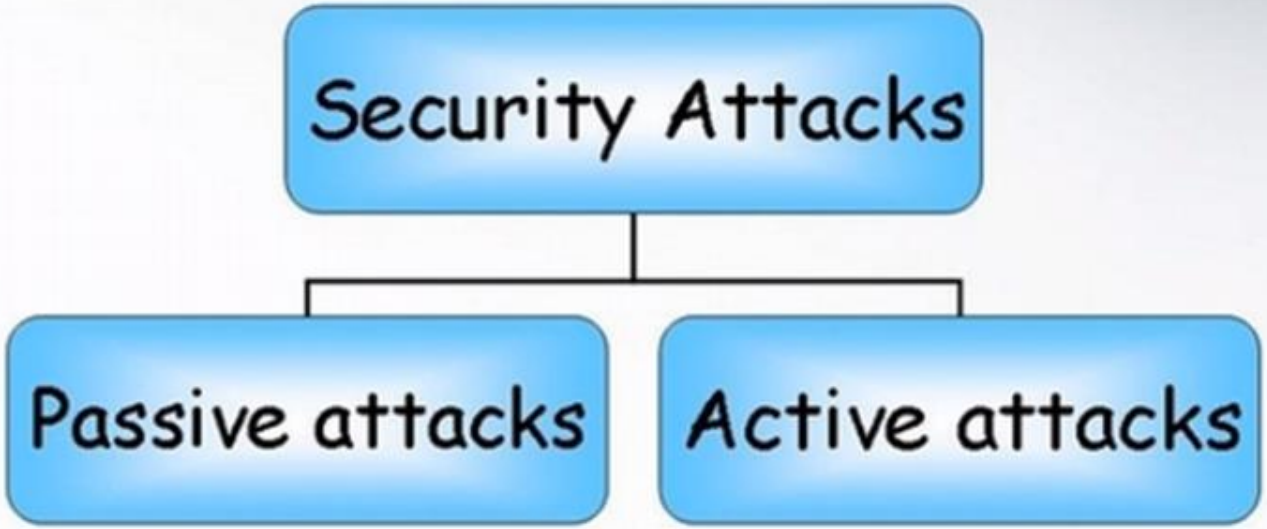


Normal Burst

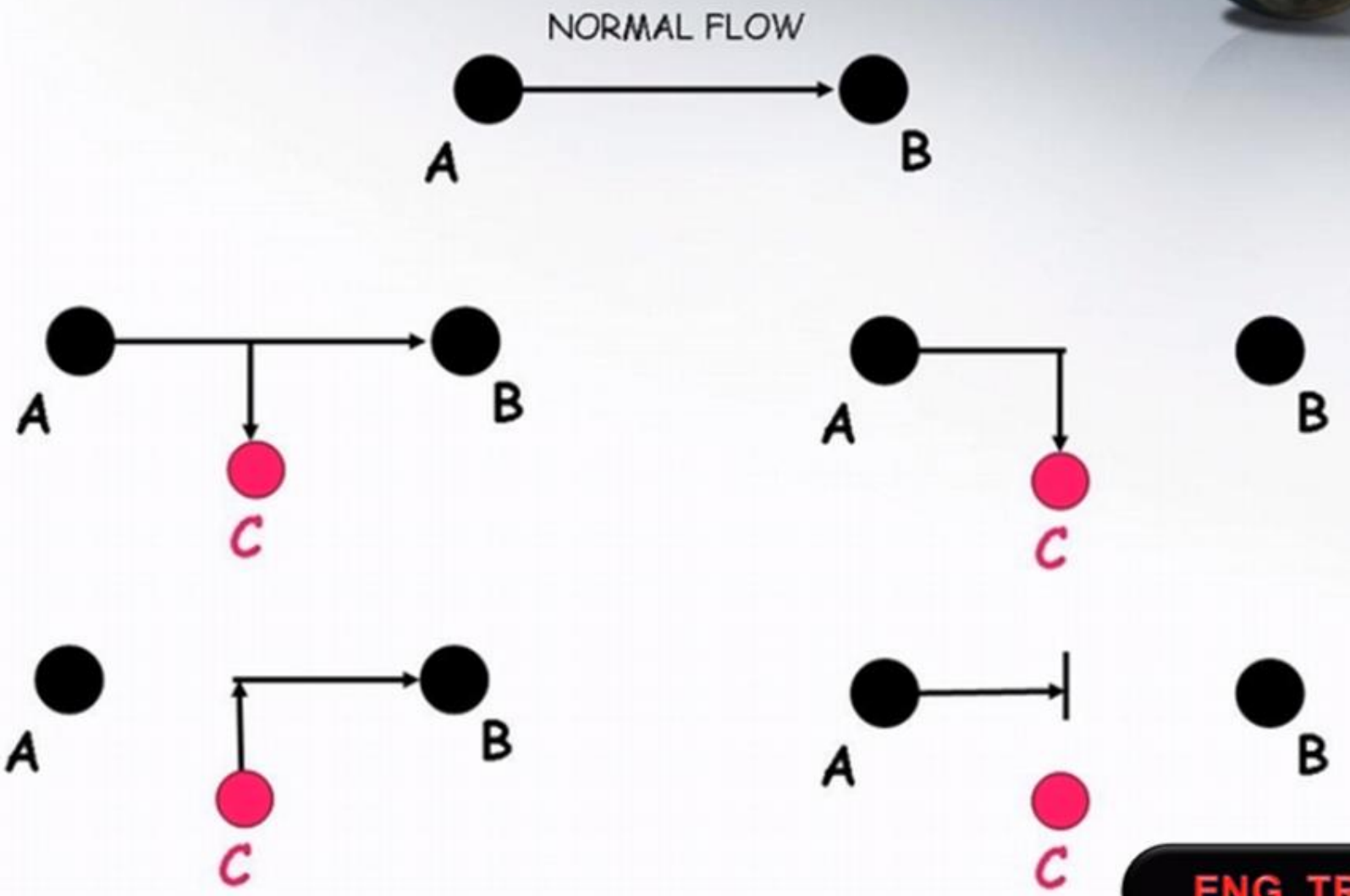
ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

security



ELEMENTS OF DIGITAL MOBILE



ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

GSM security

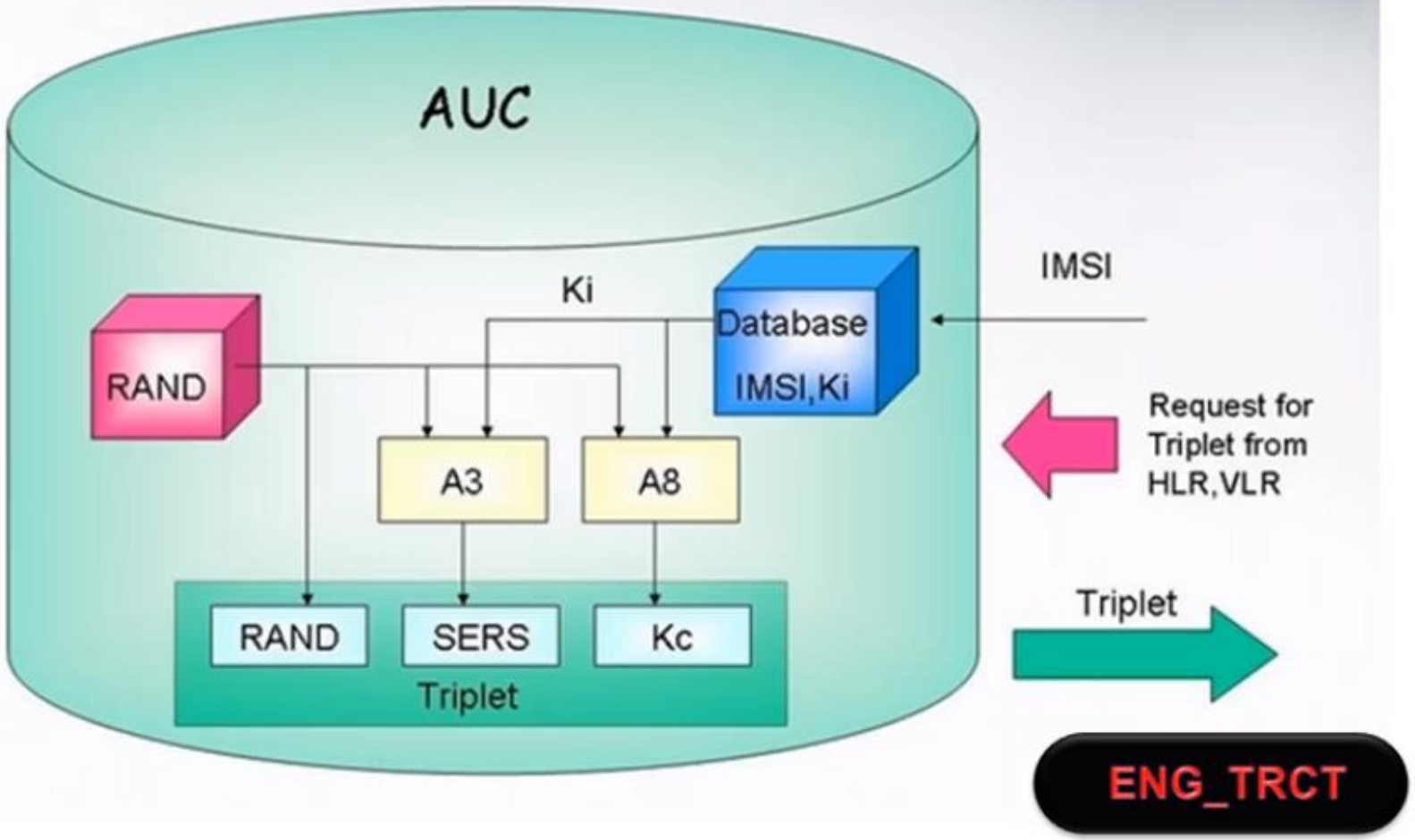
- TMSI
- Authentication
- IMEI check
- ciphering

ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

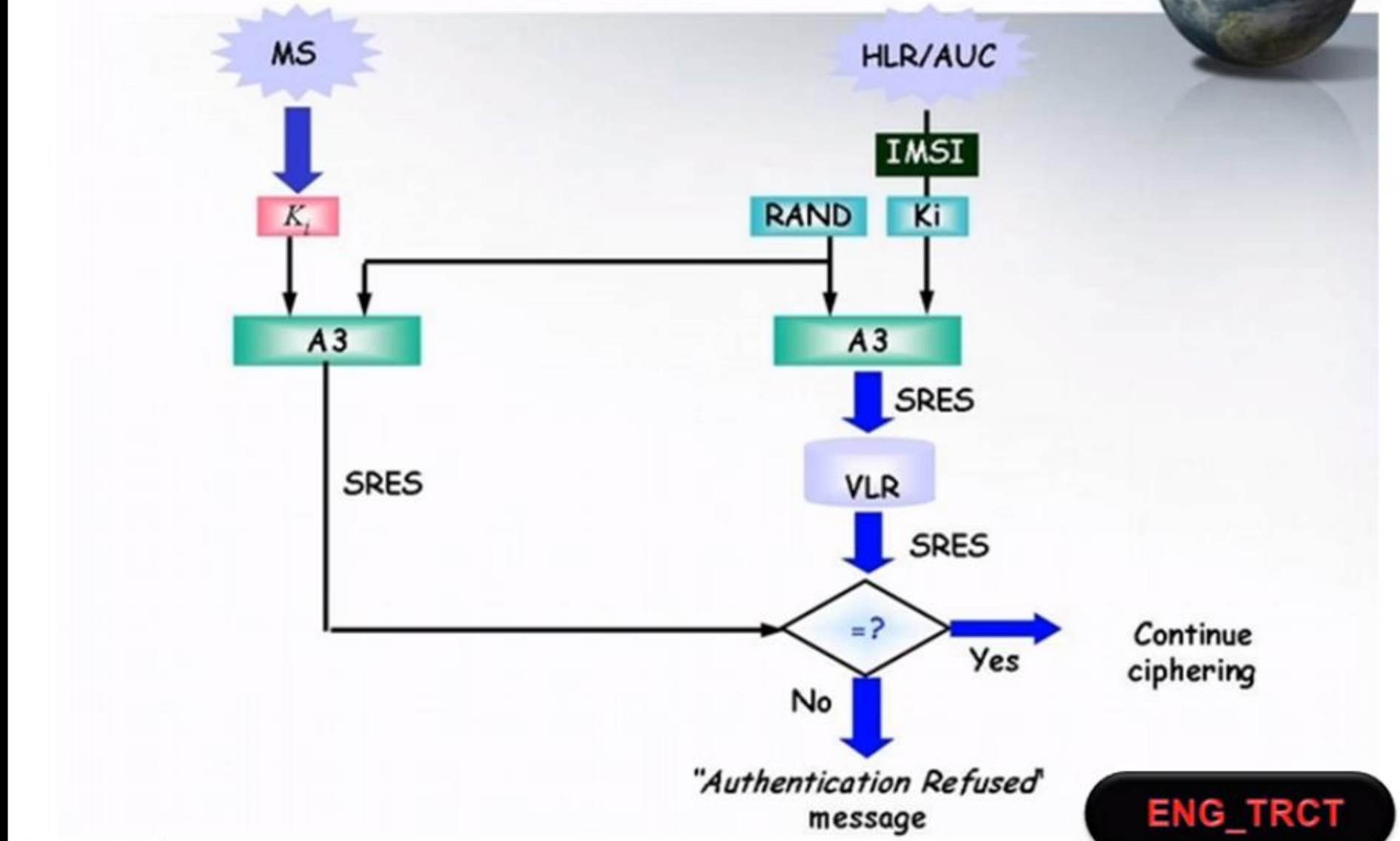
Authentication

- It is a processor system that performs the authentication function



ENG_TRCT

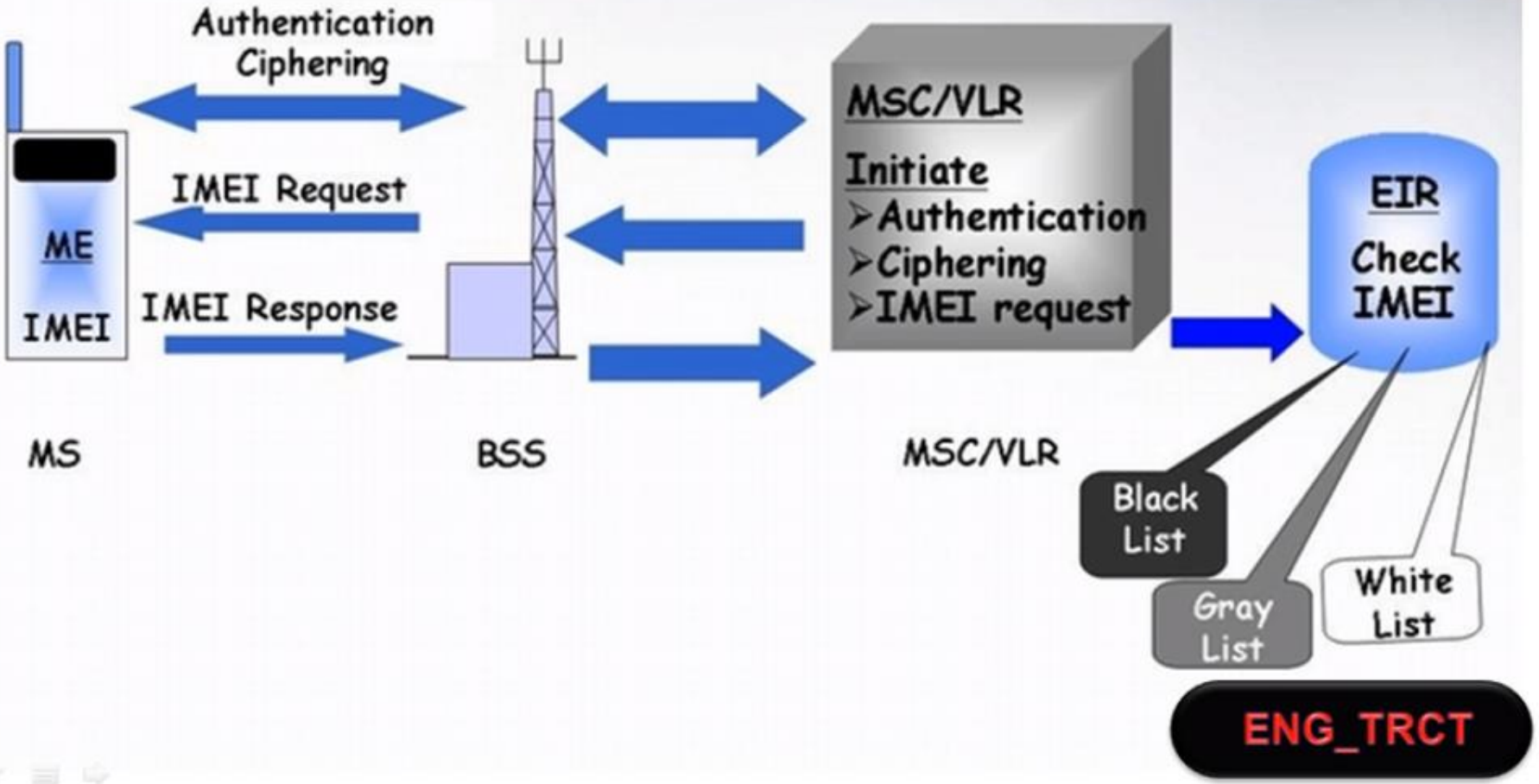
ELEMENTS OF DIGITAL MOBILE



ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

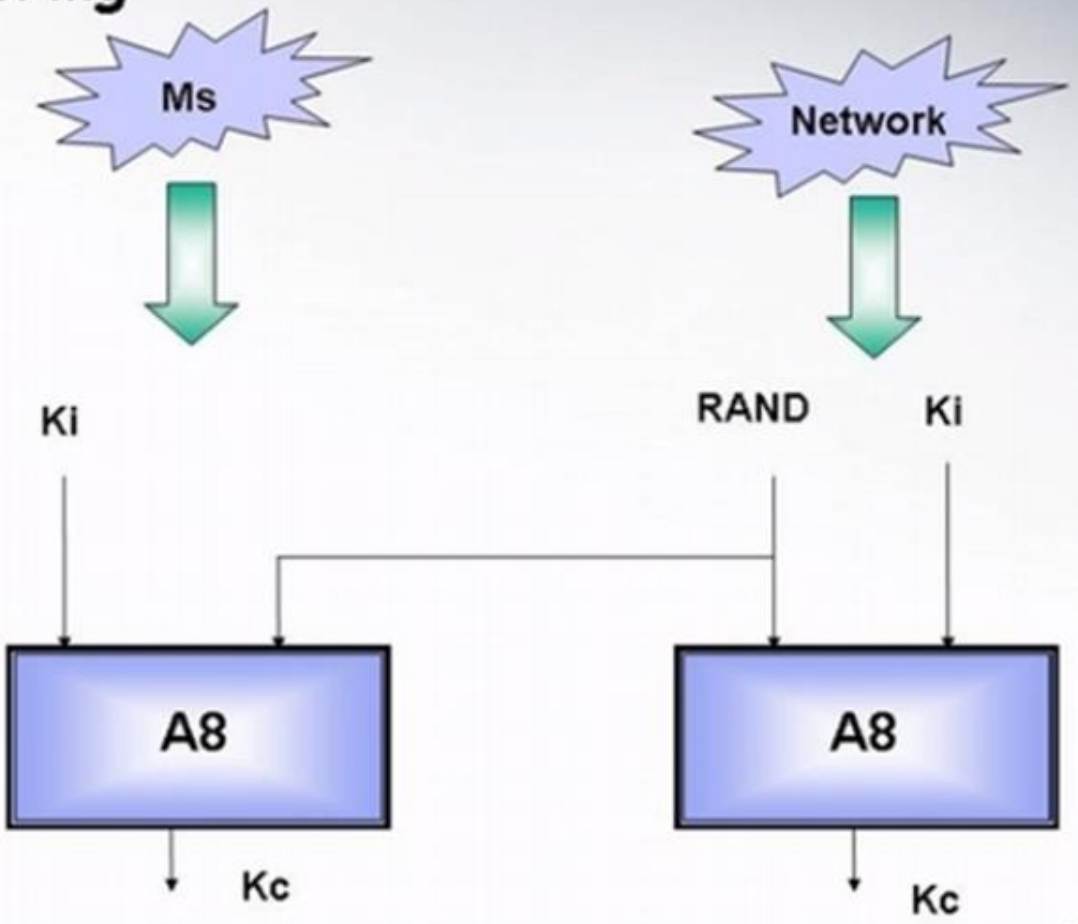
IMEI check



ENG_TRCT

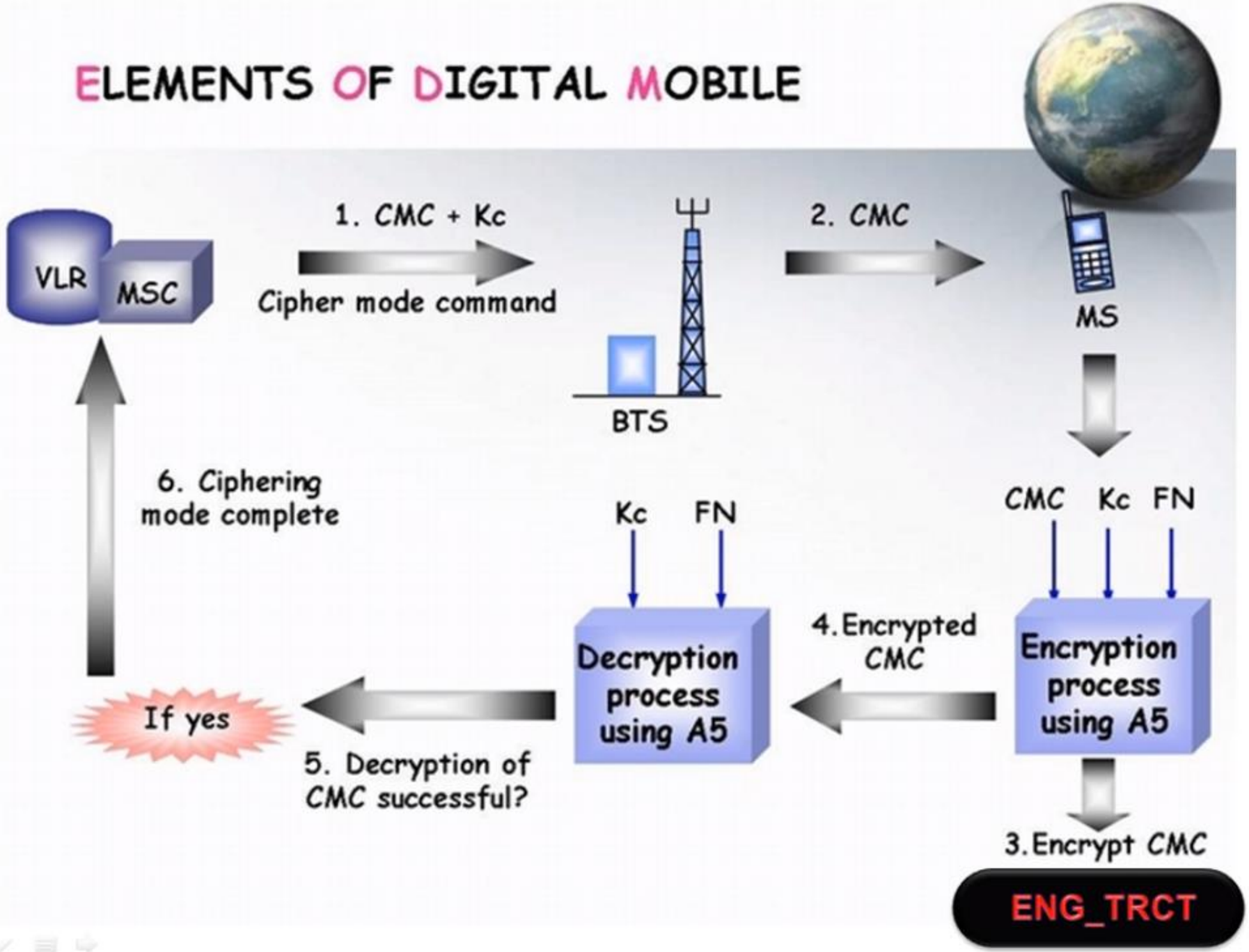
ELEMENTS OF DIGITAL MOBILE

- ciphering



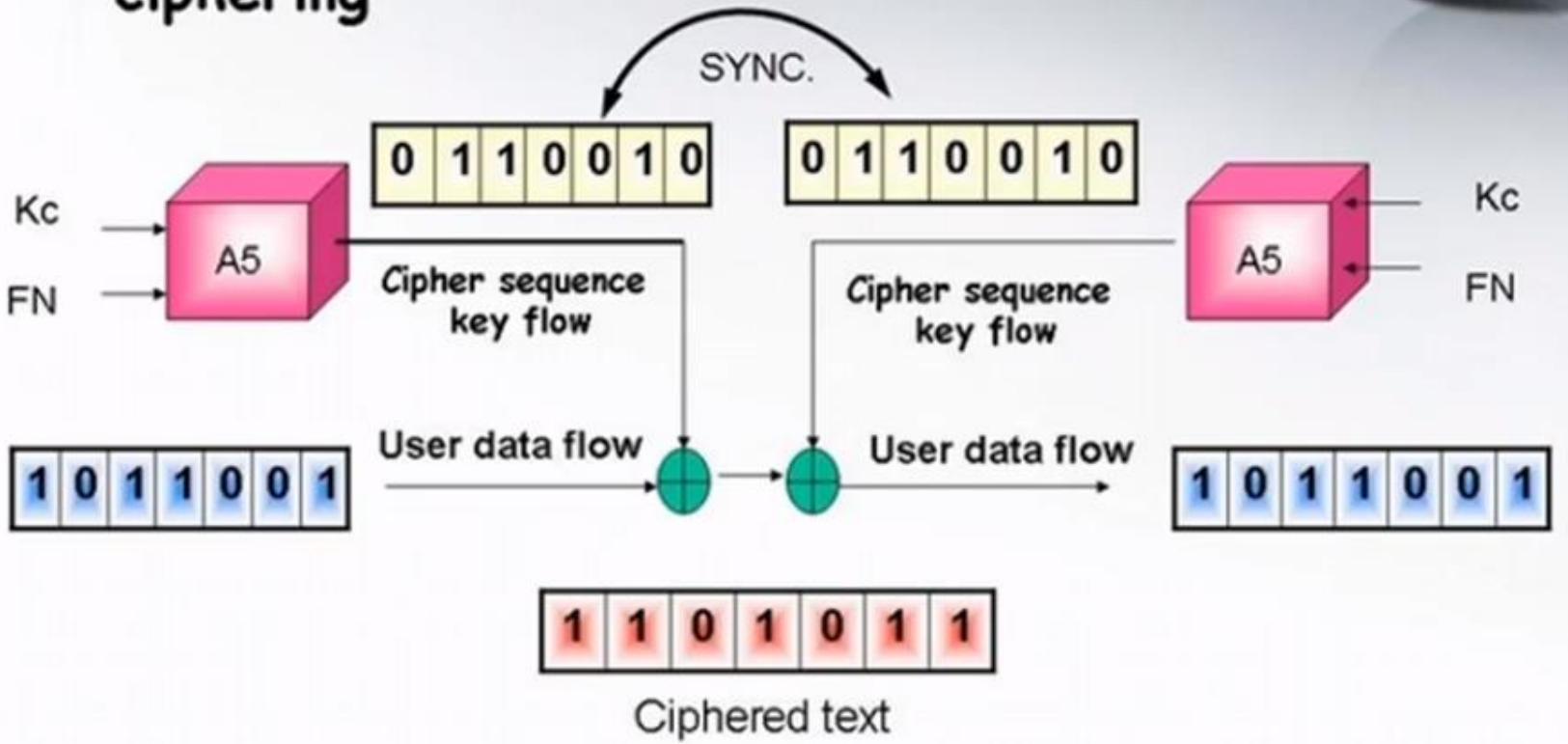
ENG_TRCT

ELEMENTS OF DIGITAL MOBILE



ELEMENTS OF DIGITAL MOBILE

- ciphering



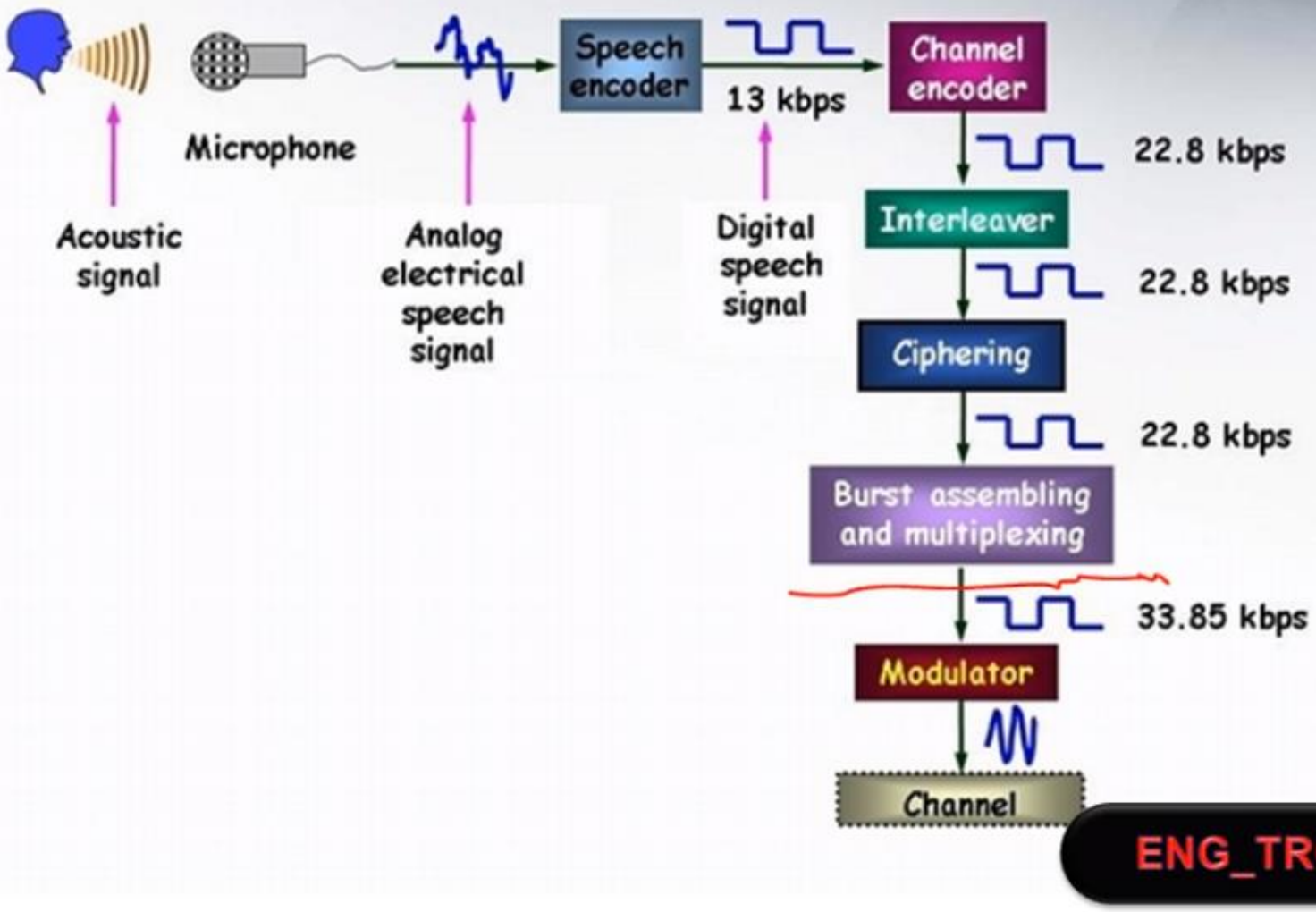
Ciphering Process

Deciphering Process

ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

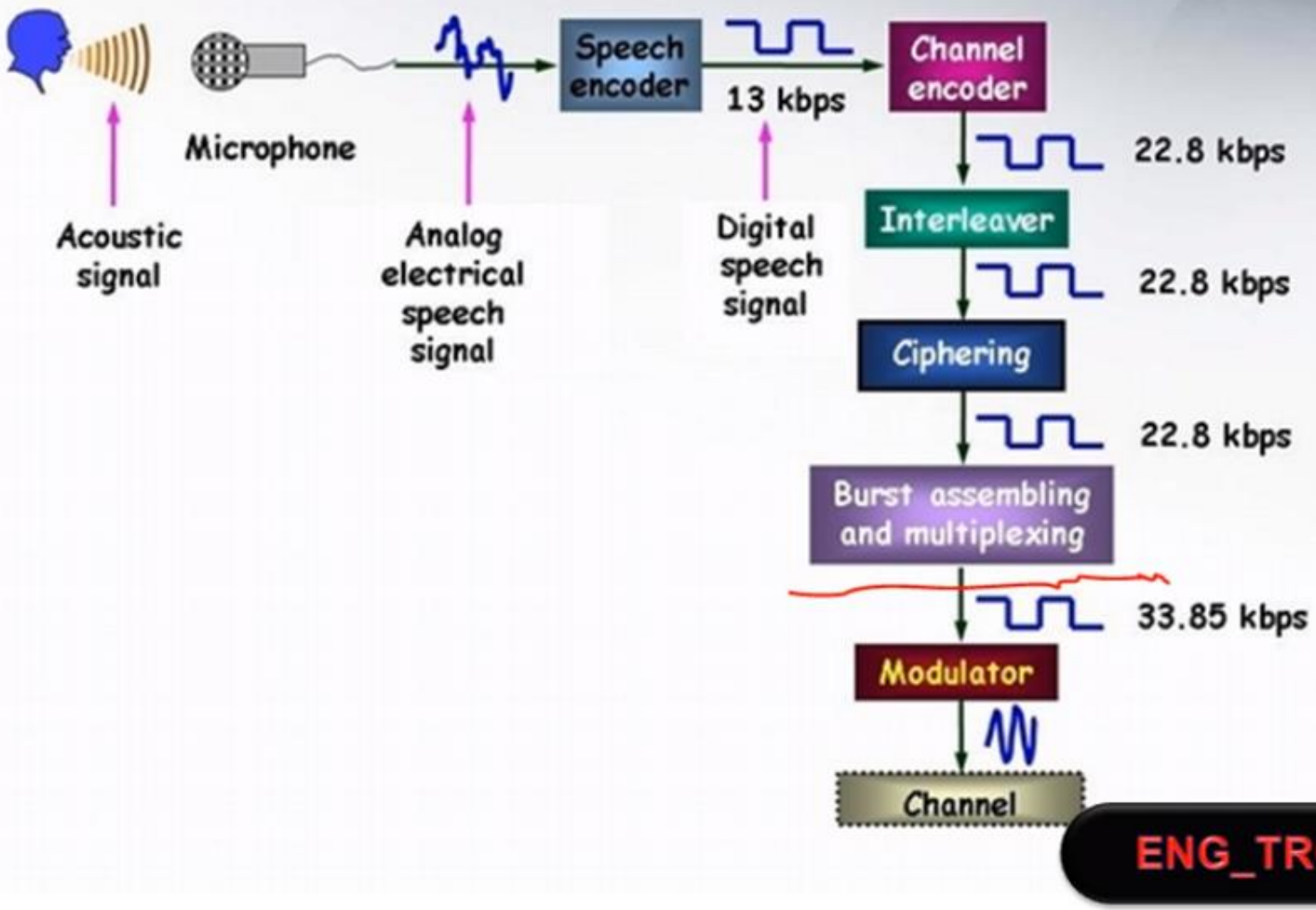
GSM Transmission Chain



ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

GSM Transmission Chain



ENG_TRCT

ELEMENTS OF DIGITAL MOBILE

- **Modulation** — Gaussion Minimum Shift Keying

1. High bandwidth efficiency i.e. high bit rate per Hz
2. Low power drain
3. Good BER performance
4. Low implementation cost

- GMSK is the modulation scheme of the GSM system

Thanks