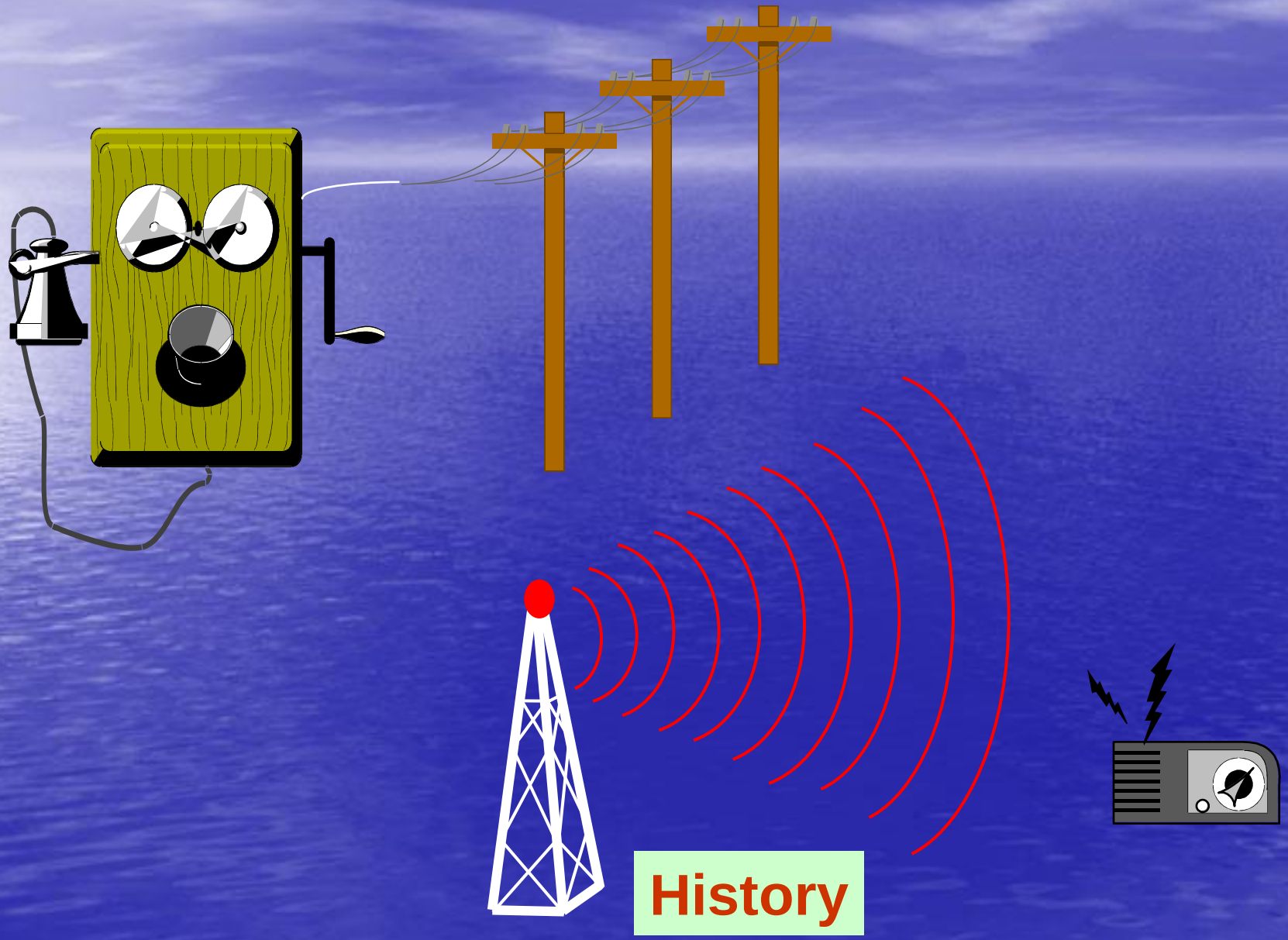
GSM

- Topics Covered
  - History and Principal of Cellular Communication
  - GSM Features
  - GSM Network Components
  - GSM Terrestrial Interfaces
  - Logical and Physical Channels
  - GSM Air Interface
  - Radio Interface Optimization, Supplementary services

History and Principles of Cellular Communication

Introduction

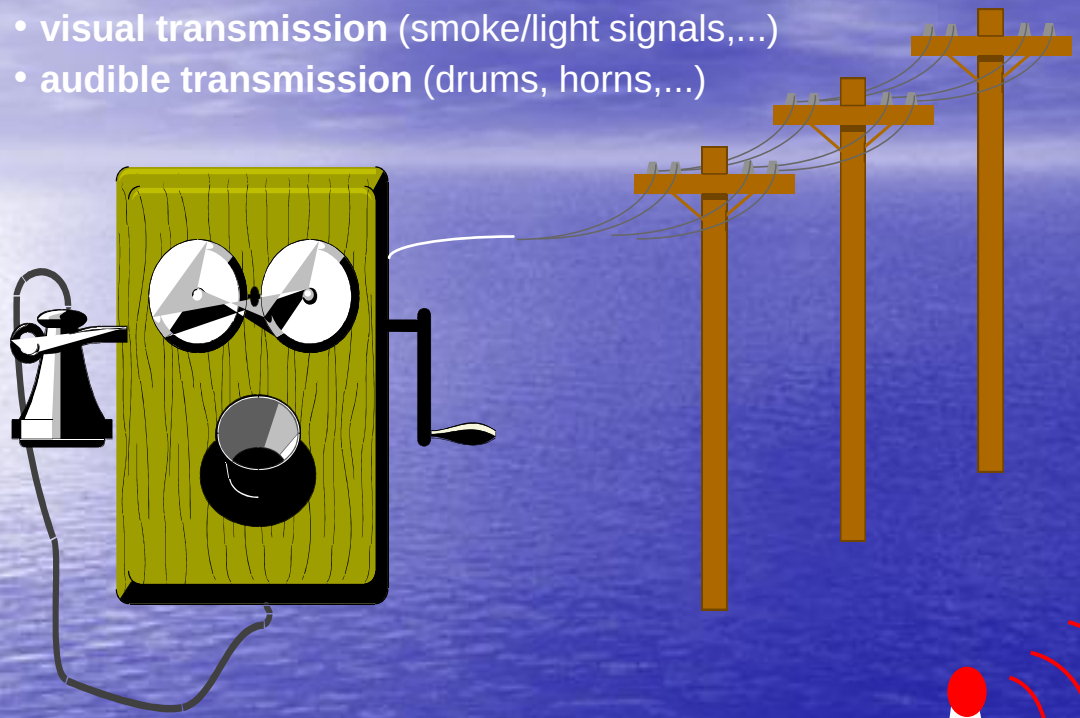


History

History of Mobile Communications

The beginnings: "archaic mobile communication"

- **visual transmission** (smoke/light signals,...)
- **audible transmission** (drums, horns,...)

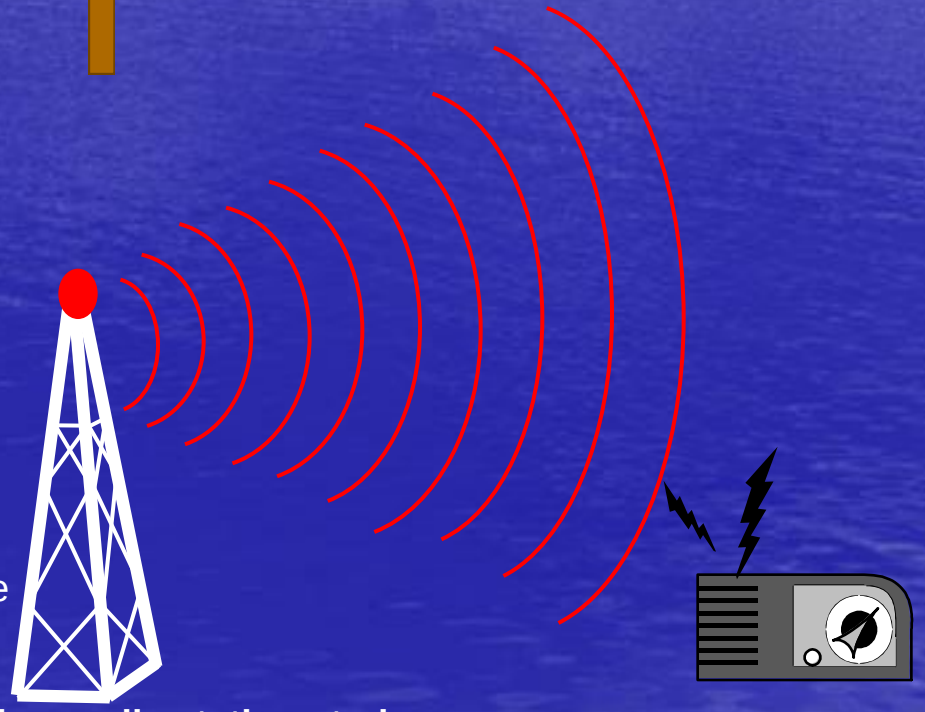


Electronic communication: "terrestrial network"

- **Telegraph**
  1st telegraph line 1843
  Washington - Baltimore
- **Telephone**
  P. Reis 1861
  A.G. Bell 1876
  World Exhibition Philadelphia

Radio transmission:

1873 Maxwell‘s theory of electromagn. waves
1887 H. Hertz: experimental proof
1895 Marconi: **1st wireless transmission**
1901 1st transatlantic transmission
1903 Dt. Telefunken GmbH: AEG, Siemens& Halske
1906 **1st speech and sound transmission**
1909 **1st radio broadcast**



1917 1st mobile transmission: radio station - train

Simplex Connection:

transmit **or** receive

Duplex Connection:

simultaneous
transmission **and** reception

Wireless Telephony

Cellular Communication

- A cellular system link

  Mobile subscribers to Public Telephone System or to another Mobile subscribers.

- removes fixed wiring used in a traditional telephone installation.

- Mobile subscriber is able to move around

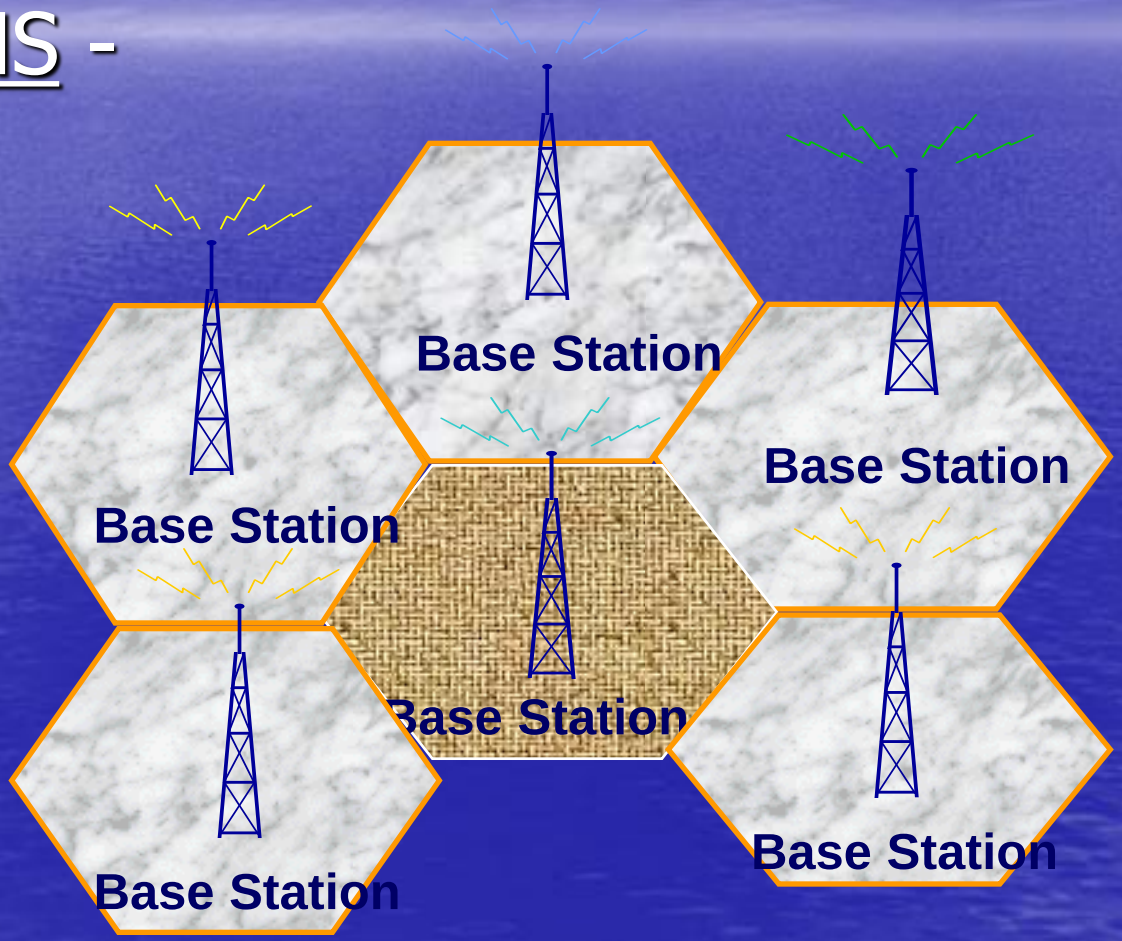
WHAT IS CELLULAR TELEPHONY ?

CONSIDERATIONS -

*FREQUENCY

*SUBSCRIBER DENSITY

*COVERAGE



The Cell

- Cellular Radio involves dividing a large service area into regions called “cells.”
- Each cell has the equipment to switch, transmit and receive calls.
- Cells - Reduce the need of High powered transmission
- Cells - Conventionally regarded as being hexagonal, but in reality they are irregularly shaped.
- Cell shape is determined by the nature of the surrounding area e.g. Hills , tall building etc.

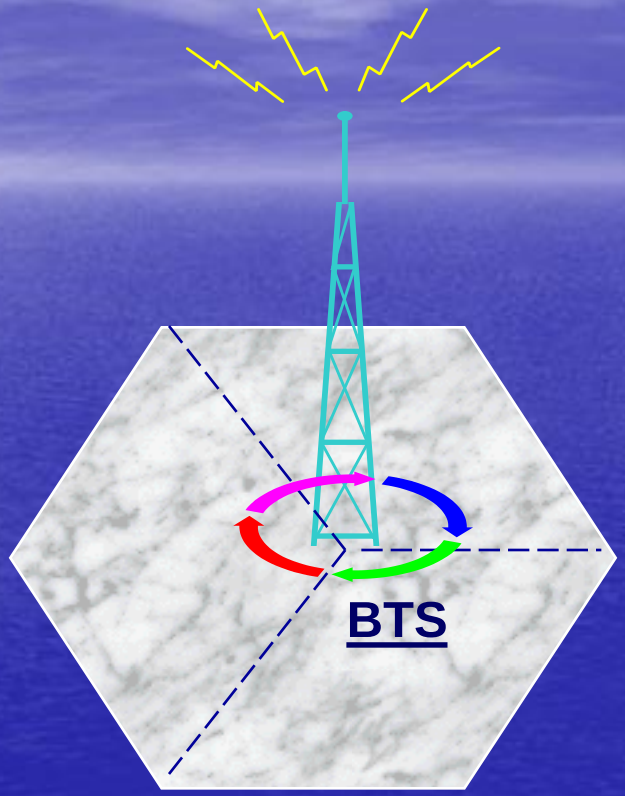
The CELL

- What is a cell ?

  - A cell is a certain area that can be reached with one transceiver

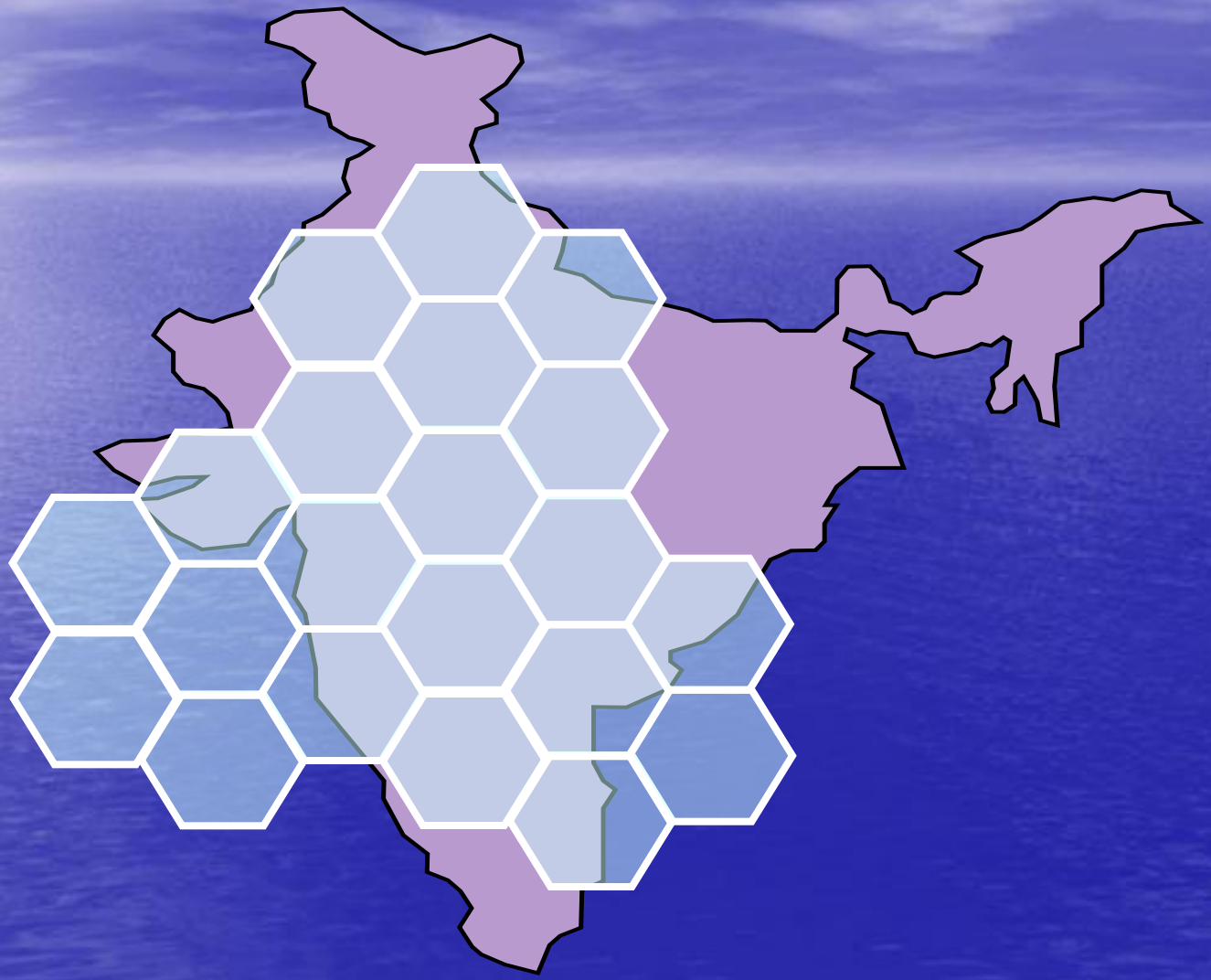
  or

  - A small collection of transceivers on different channels at a single base site.



The hexagonal-shaped communication cells are artificial & are generated to simplify the planning & design of a cellular network.

Cells



Cell Size

- Large Cells
- 35 Km
- Remote Areas
- High Transmission Power
- Few subscribers

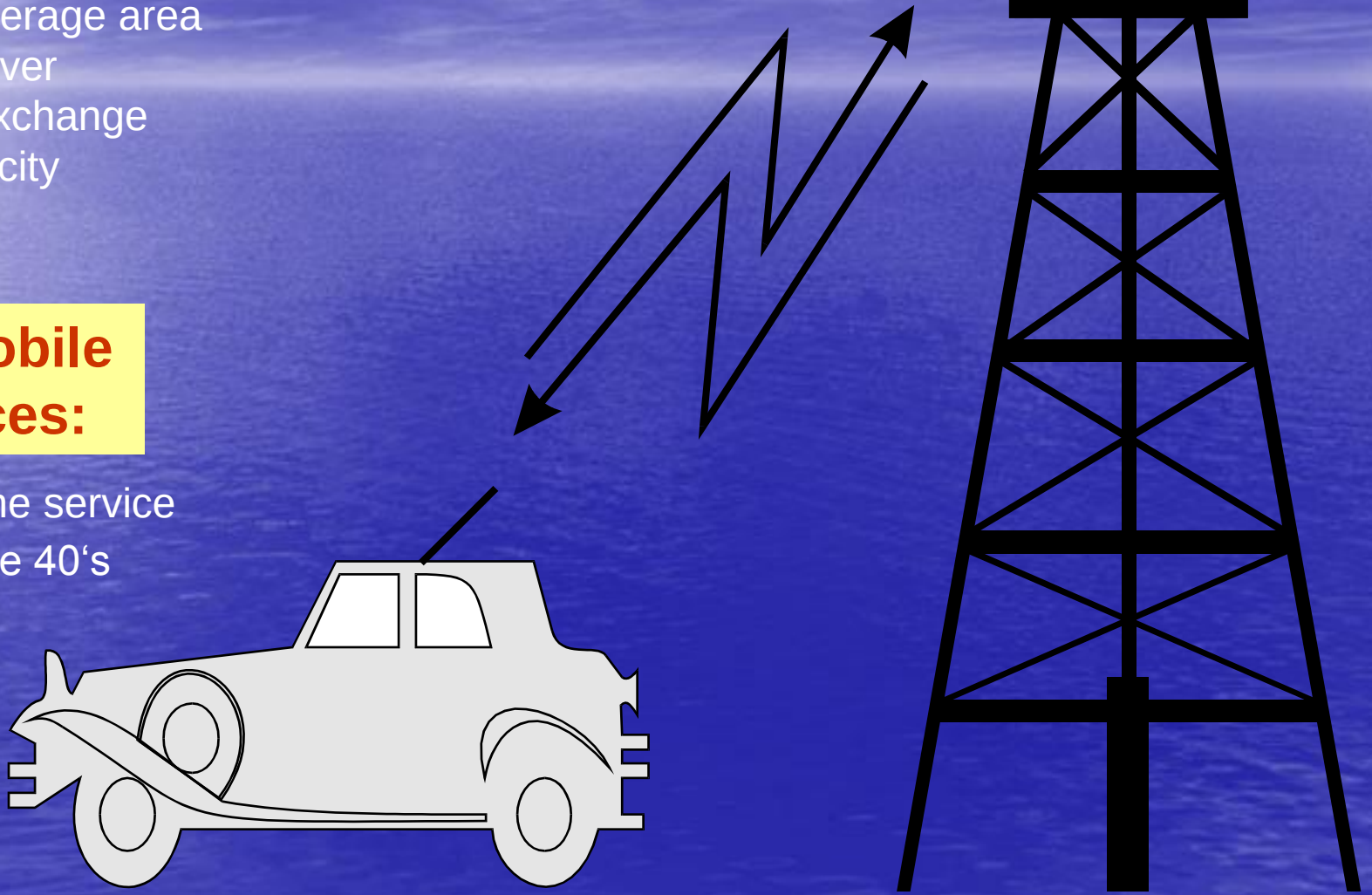
- Small Cells
- Near about 1 KM
- Urban Areas
- Low Transmission Power
- Many Subscribers

OLD CONCEPT: Single Cell Systems:

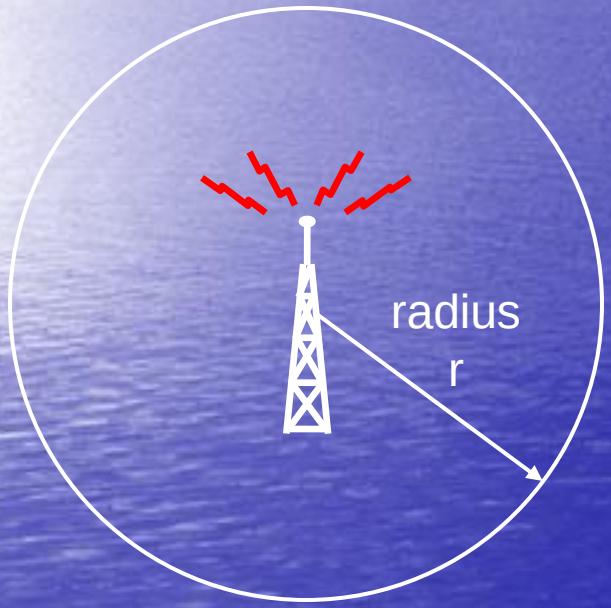
- Low service and speech quality
- Heavy, bulky and expensive equipment
- Small coverage area
- No handover
- Manual exchange
- Low capacity

First Mobile Services:

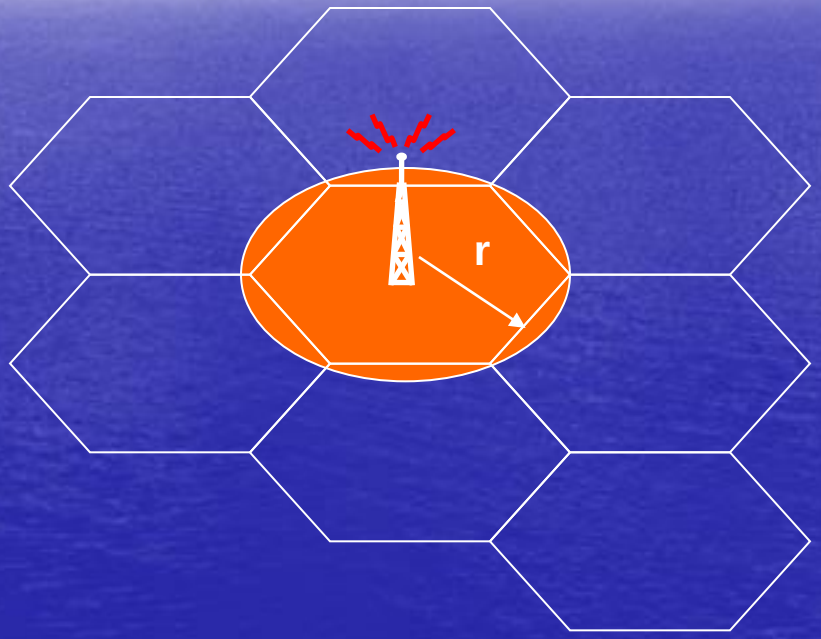
- Car telephone service
- Since the late 40‘s



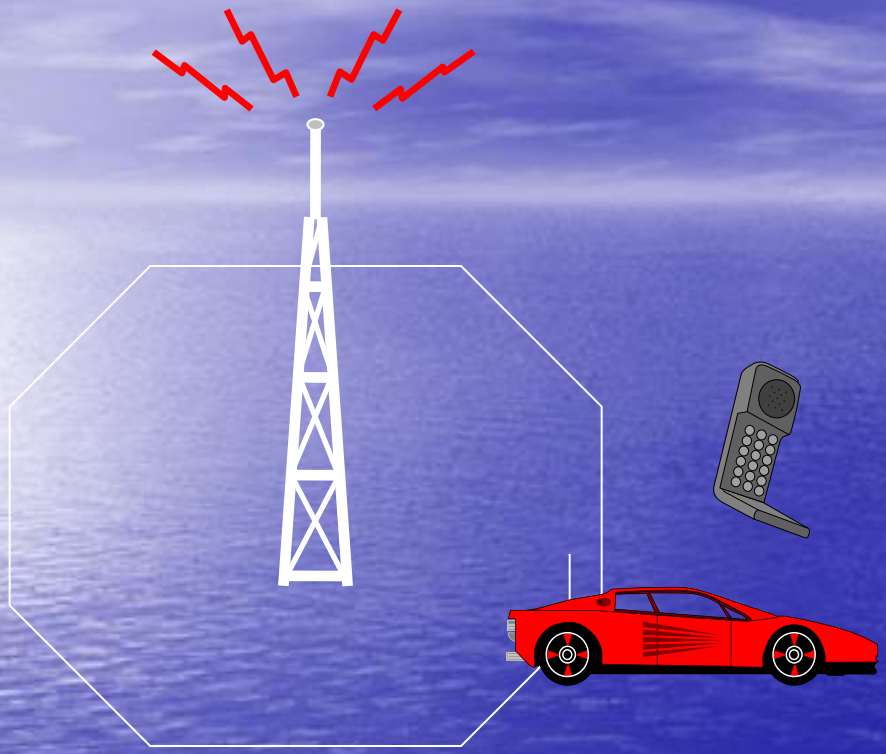
Quantum Leap in Mobile Communications: Single Cell Systems → Cellular Systems

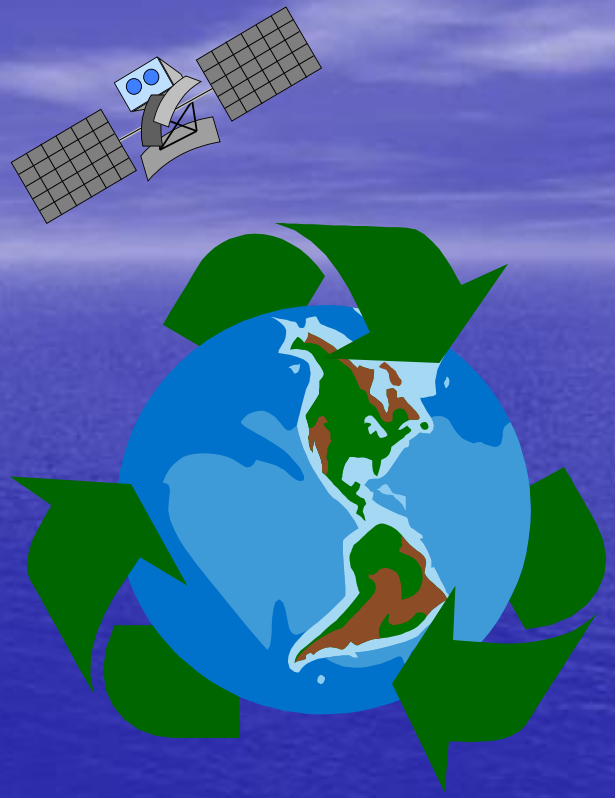


Single Cell System



Cellular System





Single cell systems

Cellular mobile communication systems

	1st generation	2nd generation GSM (Ph1/2)	incl. satellite roaming (GSM Ph2+)
Limits:	cell	national	GSM service area	unlimited

GSM Air Interface

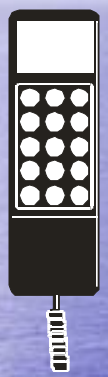
Fig. 15 (TM2100EU03TM_0001 Transmission Principles, 31)

First Generation Cellular Mobile Radio Systems

Country	System	Frequency range [MHz]	Introduced in year
USA	AMPS	800	1979
Japan	NTT-MTS	800	1979
Sweden, Norway, Finland, Denmark	NMT	450, 900	1981 - 86
Great Britain	TACS	900	1985
Germany	C450	450	1985
France	Radiocom2000	450	1985
	NMT	900	1989
Italy	RTMS	450	1985
	TACS	900	1990

2nd Quantum Leap:
Analog (1st Generation) → Digital (2nd Generation)

Different Generations of Mobile Stations



First generation mobile telephones for fixed vehicle installation and analog mobile telephones

Analog technology. Terminal devices were bulky and heavy.

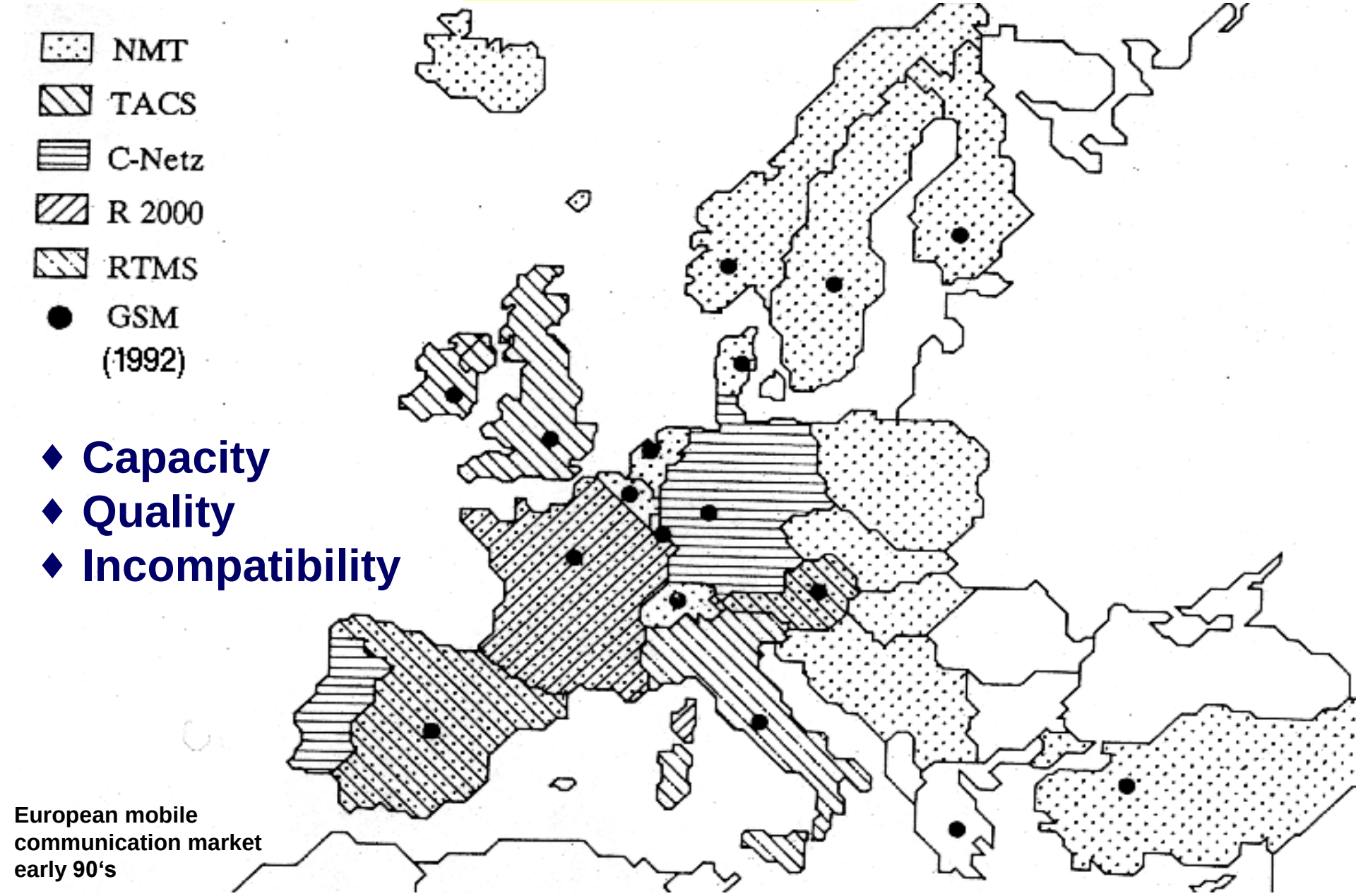
Second generation GSM mobile telephones

Digital GSM technology. Terminal devices were less bulky, but still too heavy (battery capacity problems).

Second generation GSM mobile telephones

Digital GSM technology. Terminal devices are handier and have greater battery capacity.

1G Limitations

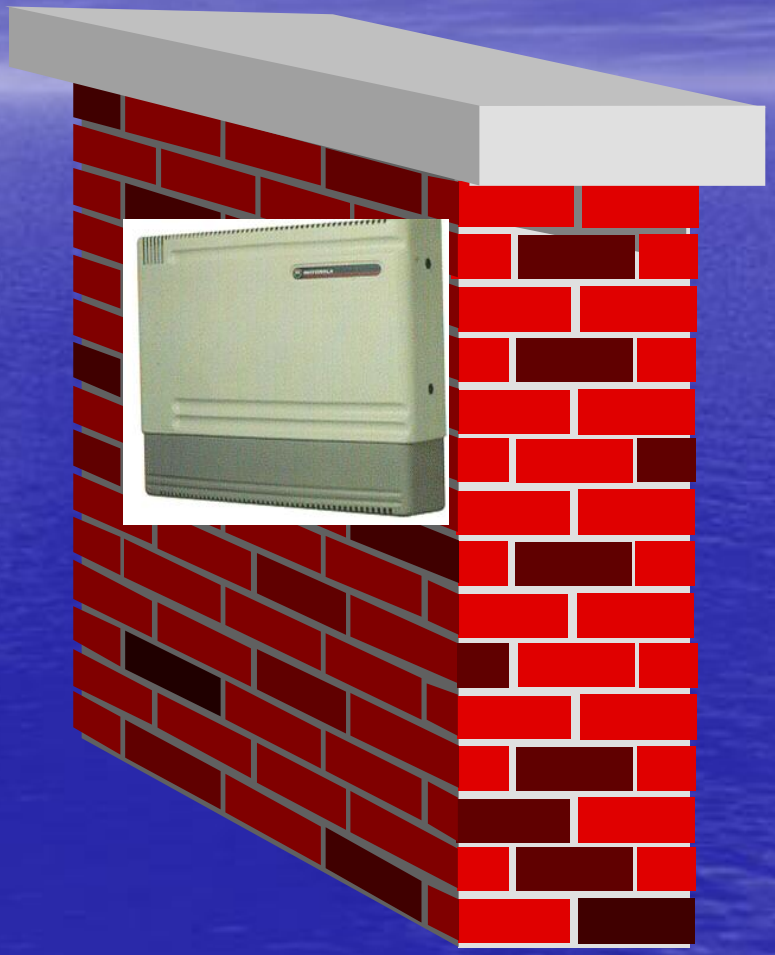


- Capacity
- Quality
- Incompatibility

European mobile communication market early 90‘s

MICRO CELL

- Below Rooftop
  - ~ Railway Platforms, Airports,
  - ~ Busy Shopping Bazaar etc.
- Low Tx Power
  - ~ 1 Watt max.
- Limited Coverage
  - ~ 200m - 500m
- Hotspot Solution
- Special Algorithms for HO



PICO CELLS

- Inside offices, Buildings
- Very Low Tx Power
  ~ Less than 1 Watt
- Limited Coverage
  ~ 50 -100m
- Capacity Solution
- Special Algorithms for HO

Analog Mobile Telephony

- End of 1980's Analog Systems unable to meet continuing demands
  - Severely confined spectrum allocations
  - Interference in multipath fading environment
  - Incompatibility among various analog systems
  - Inability to substantially reduce the cost of mobile terminals and infrastructure required

Digital Mobile Telephony

- Spectrum space - most limited and precious resource
- Solution - further multiplex traffic (time domain)
- Can be realized with Digital Techniques only

Advantages of Digital Information Transmission

- **Network capacity** → speech compression
- **Service offer** → signaling
- **Cost aspect** → manufacture, operation, maintenance
- **Miniaturization** → microelectronics
- **Security aspect** → easily coded
- **Transmission quality** → regenerability

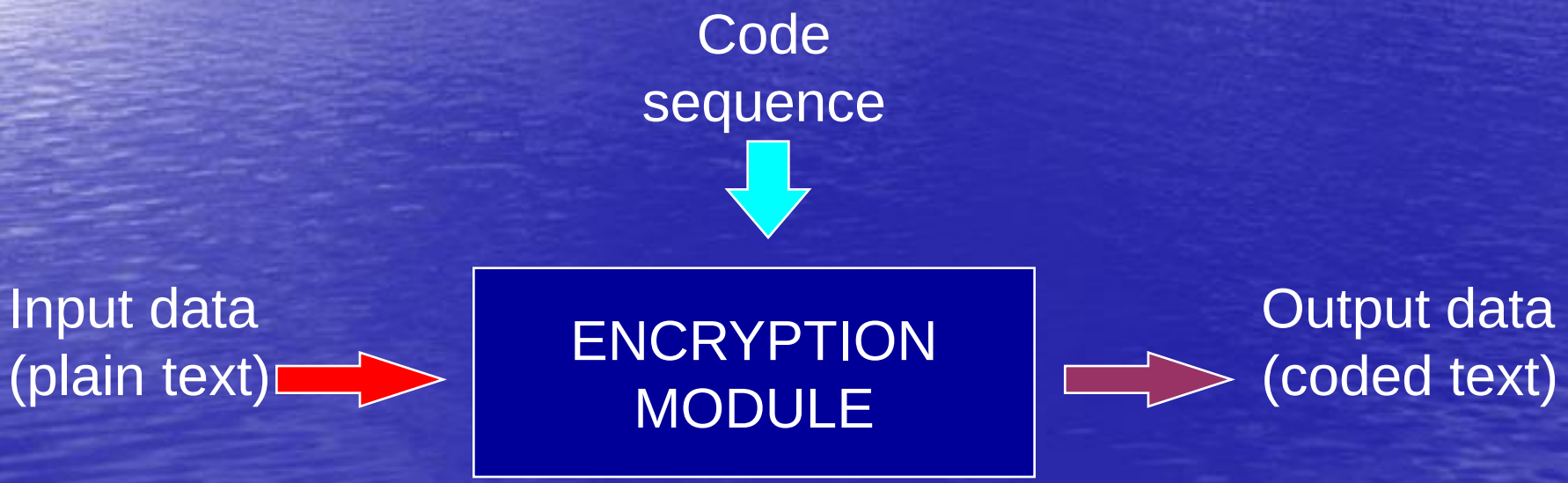
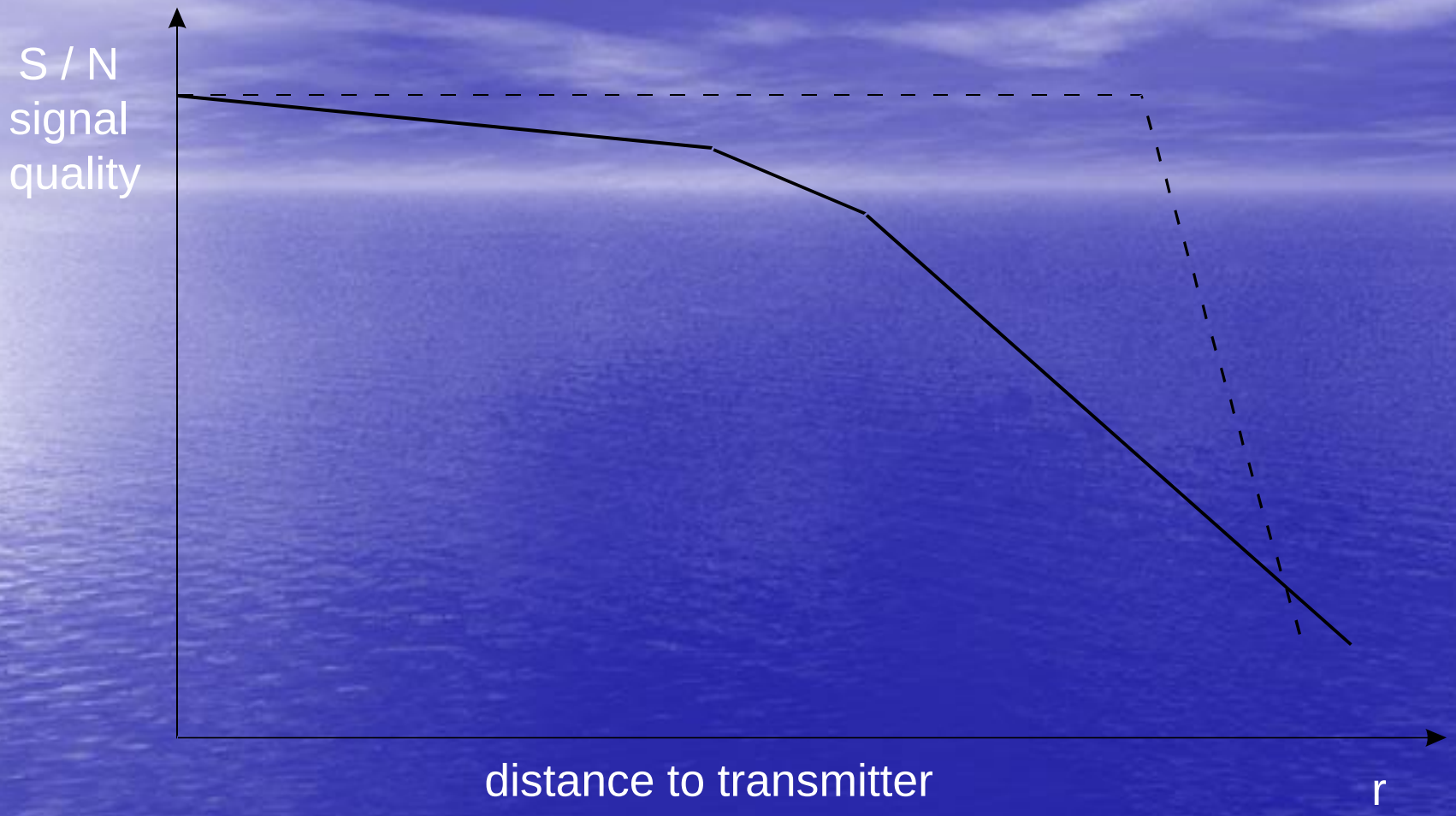


Fig. 19 (TM2100EU03TM_0001 Transmission Principles, 39)

Quality of Digital & Analog Signal Transmission



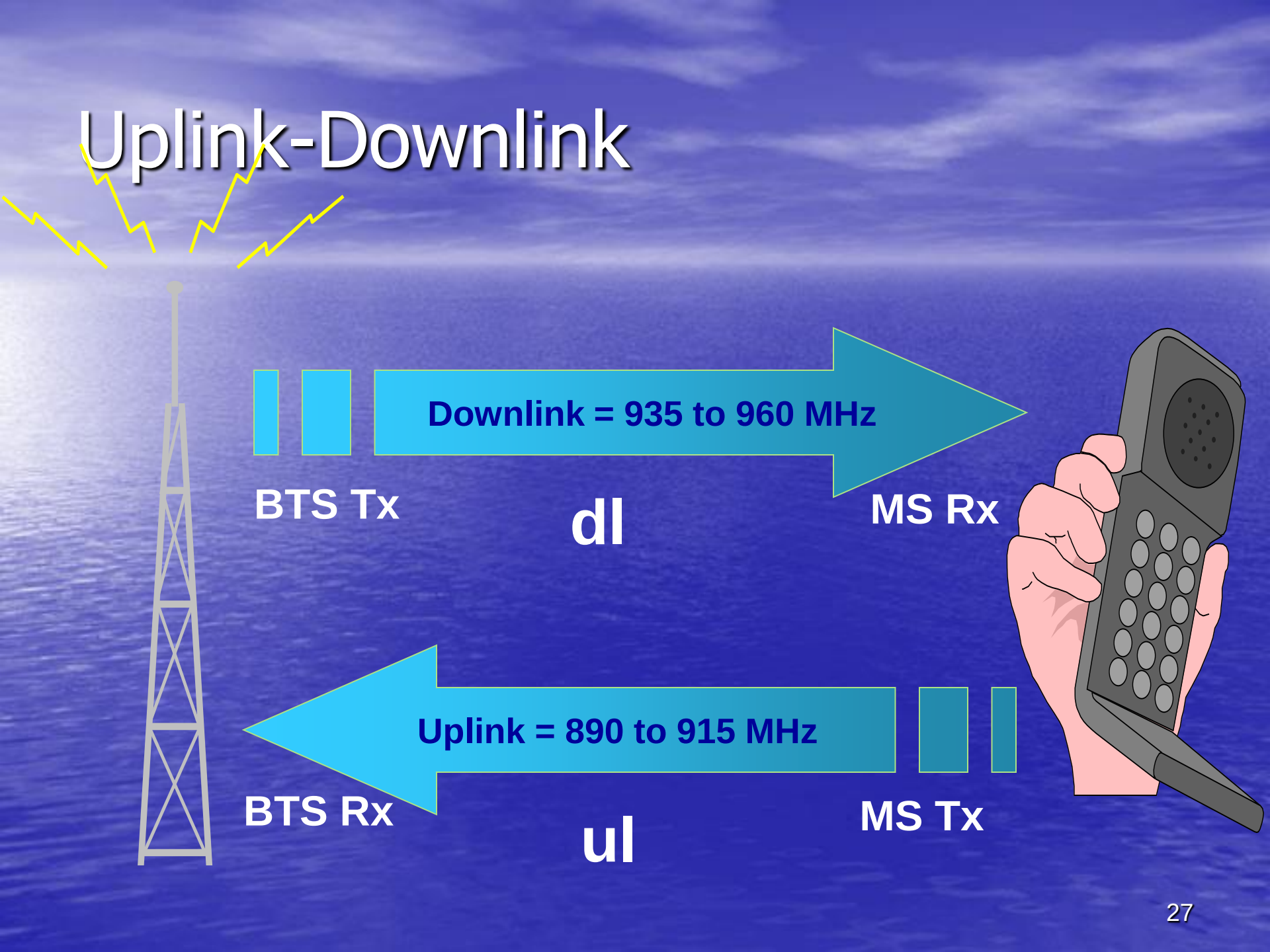
GSM History and Organization

- **1979** **Europe wide frequency band reserved for Cellular**
- **1982** **"Groupe Speciale Mobile" created within CEPT**
- **1986** **GSM had full time in Paris**
- **1988** **ETSI takes over GSM Committee**
- **1990** **The phase 1 GSM Recommendations frozen**
- **1991** **GSM Committee renamed "Special Mobile Group" and GSM renamed as "** Global System for Mobile Communication"
- **1992** **GSM is launched for commercial operations**

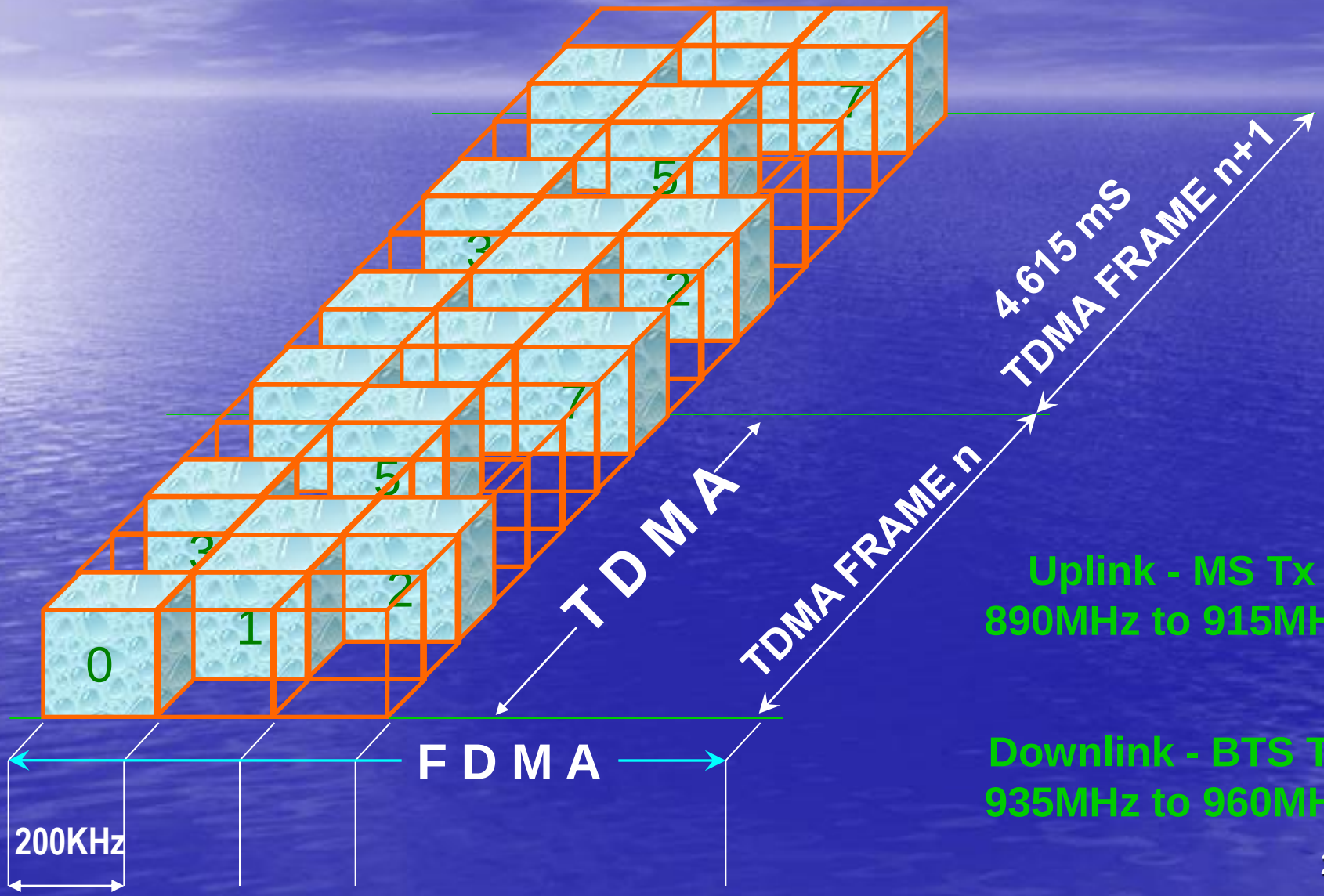
GSM - IN CELLULAR TELEPHONY

- Each Cell in the Cellular Network consists of one or more RF carriers.
- An RF carrier is a pair of radio frequencies
  - One used in upward direction by MS - Uplink
  - Other used in downward direction by BTS - Downlink
  - The transmit and receive frequencies are separated by a gap of 45 MHz in GSM of 75 MHz in DCS.
- There are 124 carries in GSM Band. With each carrier carrying 7 timeslots, only 124 x 7 = 868 calls can be made!
- Frequency Reuse is the solution

Uplink-Downlink



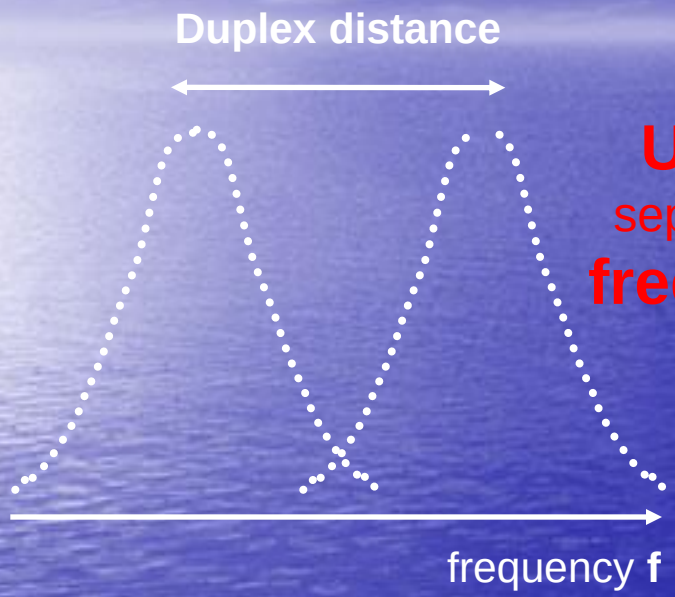
TDMA & FDMA



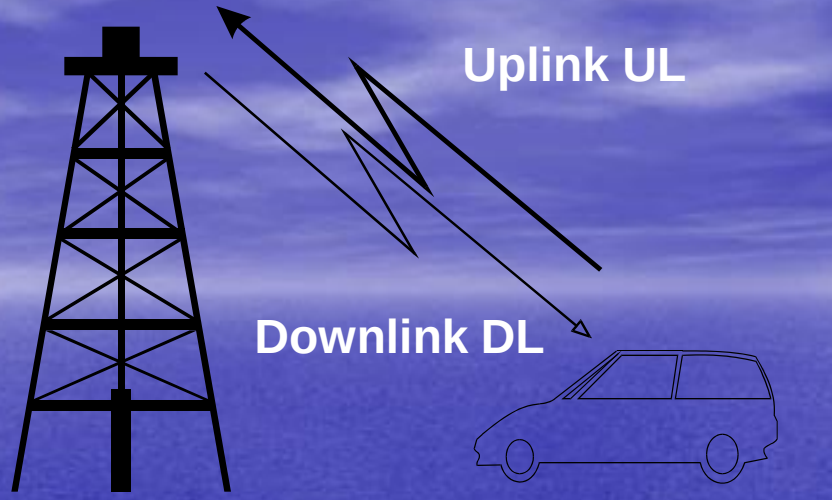
Uplink - MS Tx
890MHz to 915MHz

Downlink - BTS Tx
935MHz to 960MHz

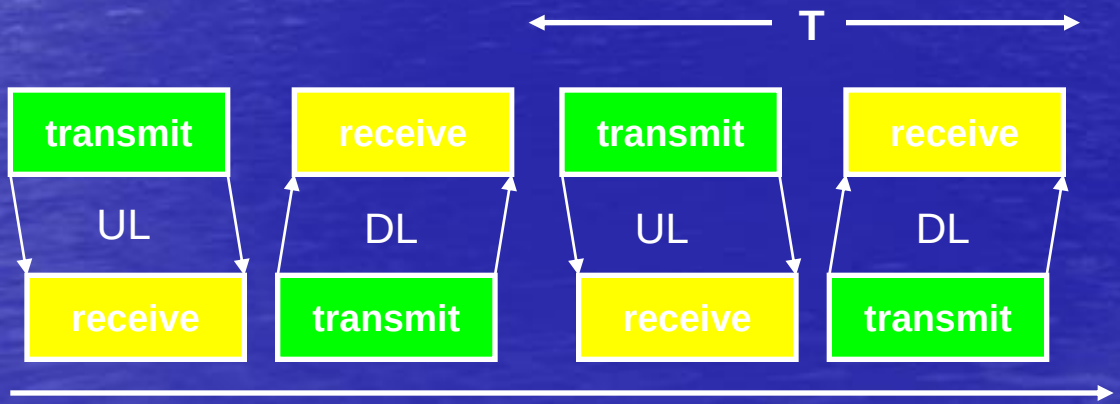
FDD
Frequency Division Duplex



UL / DL
separated by
frequency !

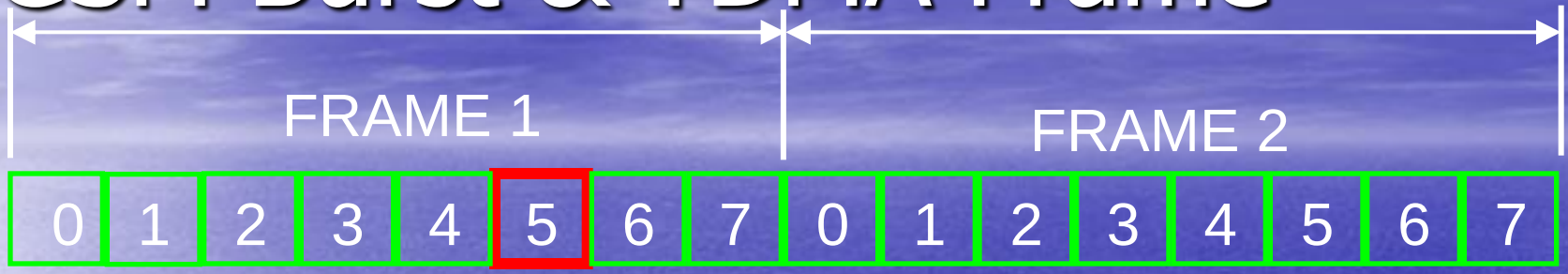


TDD
Time Division Duplex

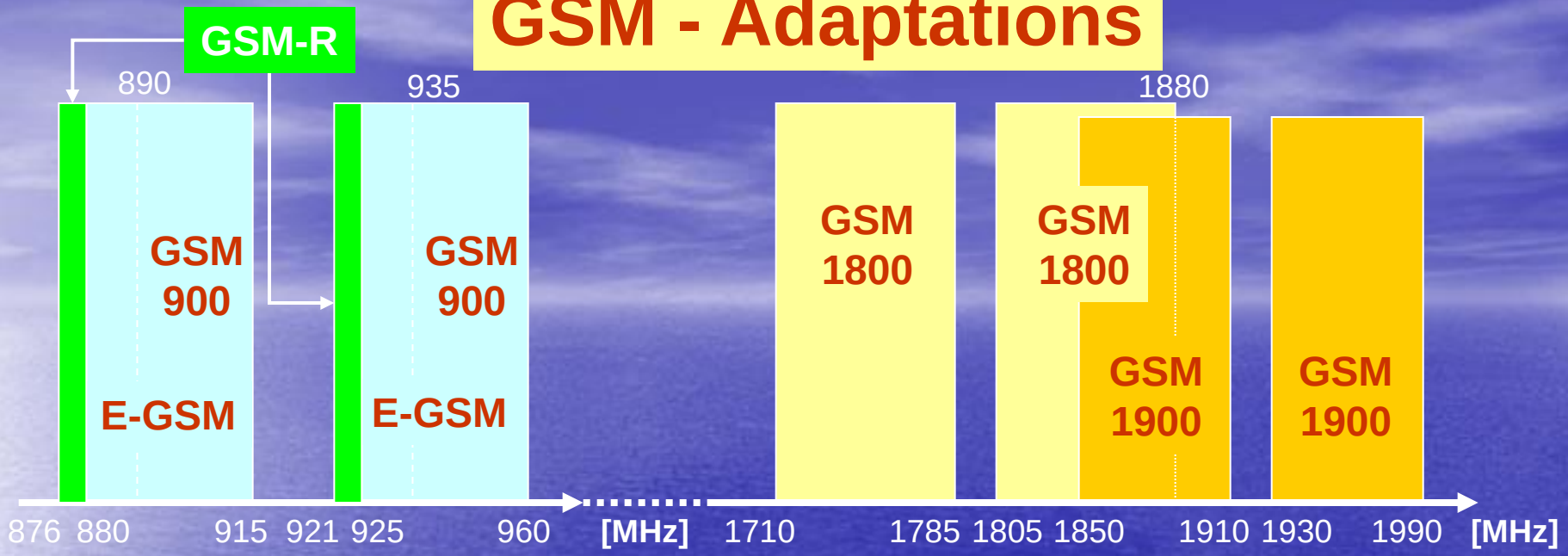


Same frequency
UL / DL
separated by
time!

GSM Burst & TDMA Frame



GSM - Adaptations



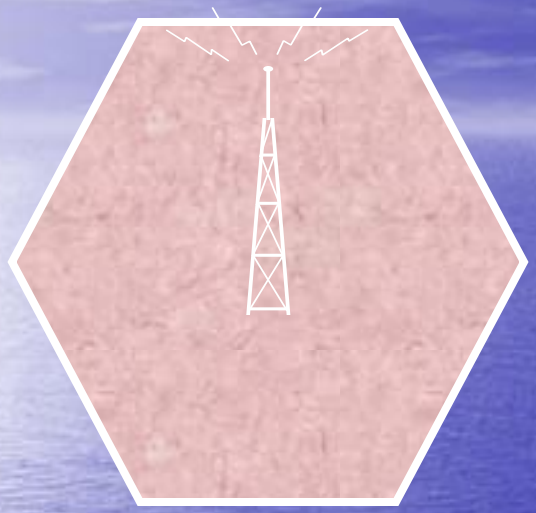
	Frequency Range [MHZ]	Useable HF channels	Application Area
GSM400	450.4 – 457.6 / 460.4 – 467.6 478.8 – 486 / 488.8 - 496	35	rural environment
GSM900 **E-GSM**	890 - 915 / 935 - 960 880 - 915 / 925 - 960	124 174	Worldwide except America
GSM1800	1710 - 1785 / 1805 - 1880	374	Worldwide except America
GSM1900	1850 - 1910 /1930 - 1990	299	America
GSM-R	876 - 880 / 921 - 925	19	Railway systems

Fig. 15 (TM2100EU03TM_0001 Introduction, 31)

Principal Of Sectorization

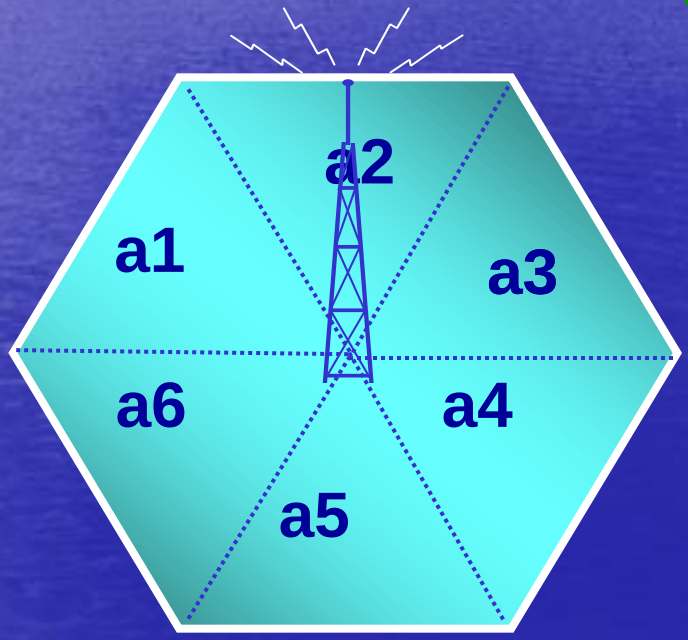
- Omni Directional Cells
- 120 degree Sectors
- 60 Degree sectors
  - Each Sector in a Site has its own allocation of Radio Carriers.

Cell Sectorisation



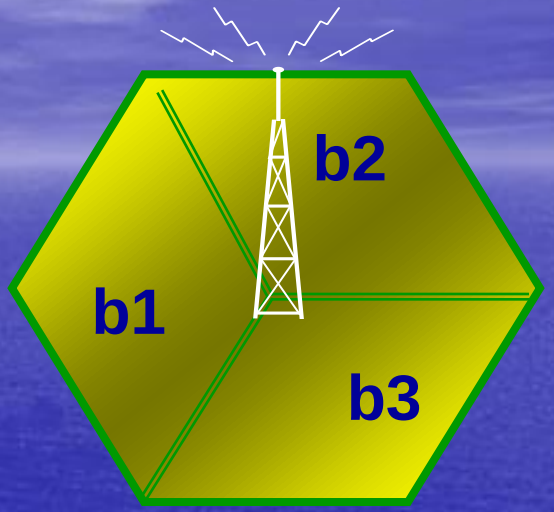
OMNI CELL

1 ANTENNA



60^{O} CELLS

6 ANTENNAS

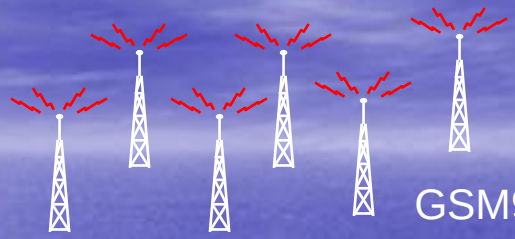


120^{O} CELLS

3 ANTENNAS

The Air Interface Um:
Problems of radio transmission and possible solutions

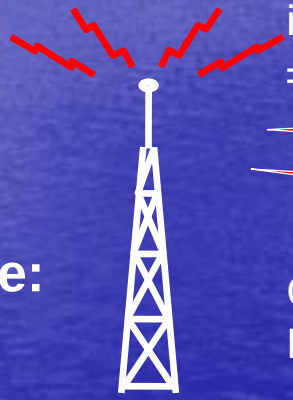
Cost Aspect:

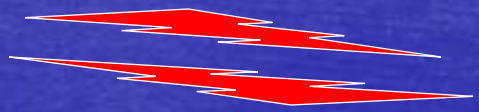


Construction of mobile communication network cheaper than terrestrial network

Capacity:

GSM900 / E-GSM: 124 / 174 frequency bands
GSM1800: 374 frequency bands
increasing subscriber numbers, data transmission
⇒ **Resource optimization / protection !!!**



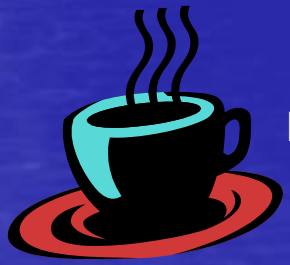


Data Transmission Rate:

GSM Ph1/2: ≤ 9.6 kbit/s
Ph2+: HSCSD, GPRS, EDGE > 100 kbit/s

Security Aspect:

Eavesdropping easy!
GSM offers **encryption**



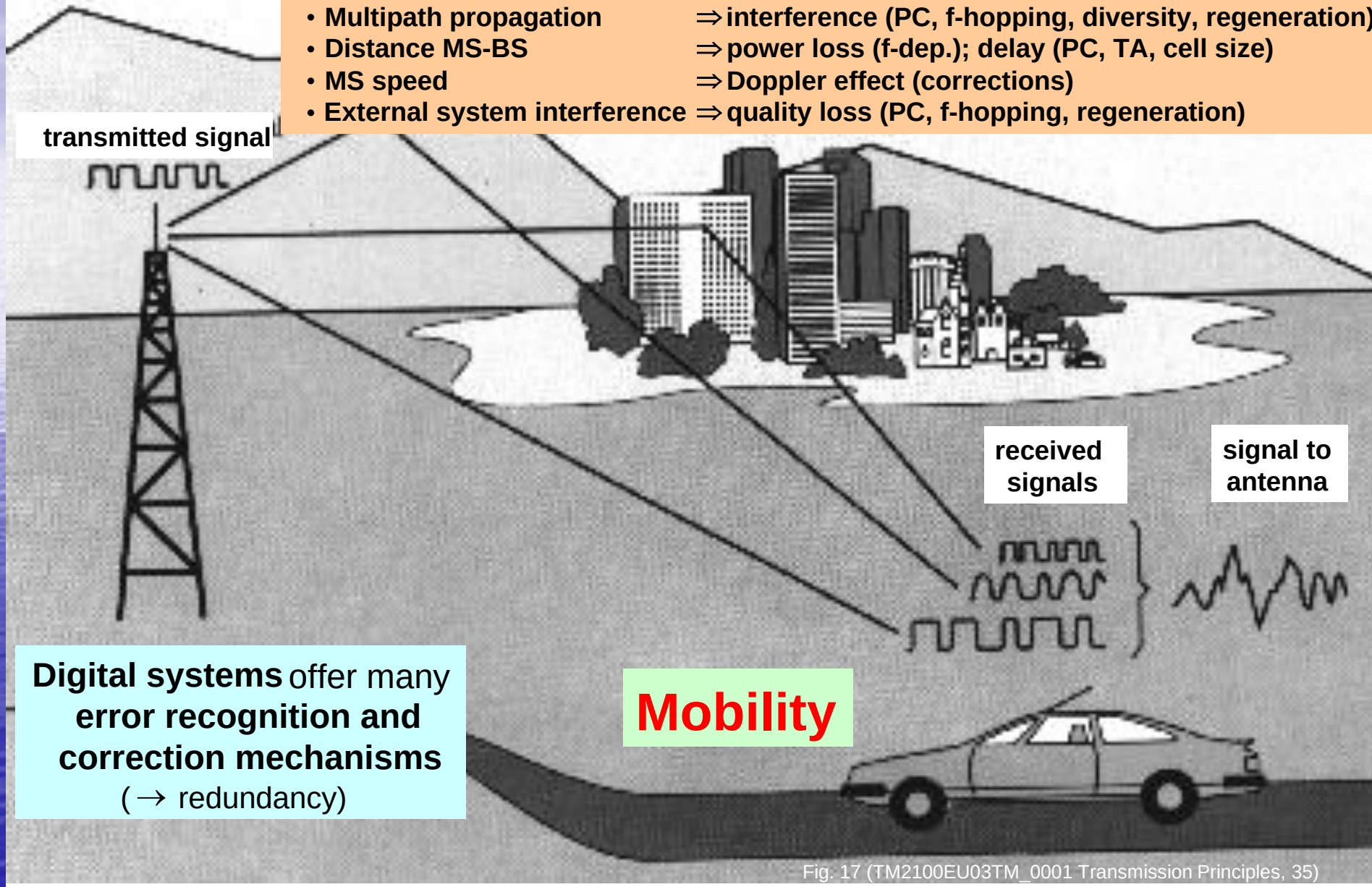
Health Aspect:

H_2O resonance frequency (2.45 GHz)
Thermal load
⇒ $\mathbf{P_{max}}$ **= 2 / 1 W** (GSM900/1800)

Fig. 16 (TM2100EU03TM_0001 Transmission Principles, 33)

Radio Transmission: Physical Disturbances

- Screening ⇒ signal attenuation (Power Control PC)
- Multipath propagation ⇒ interference (PC, f-hopping, diversity, regeneration)
- Distance MS-BS ⇒ power loss (f-dep.); delay (PC, TA, cell size)
- MS speed ⇒ Doppler effect (corrections)
- External system interference ⇒ quality loss (PC, f-hopping, regeneration)



Digital systems offer many **error recognition and correction mechanisms** (→ redundancy)

Fig. 17 (TM2100EU03TM_0001 Transmission Principles, 35)

FEATURES OF GSM

Features of GSM

- Compatibility
- Noise Robust
- Increased Capacity & Flexibility
- Use of Standard Open Interfaces
- Improved Security & Confidentiality
- Cleaner Handovers
- Subscriber Identification
- ISDN Compatibility
- Enhanced Range of Services

Compatibility

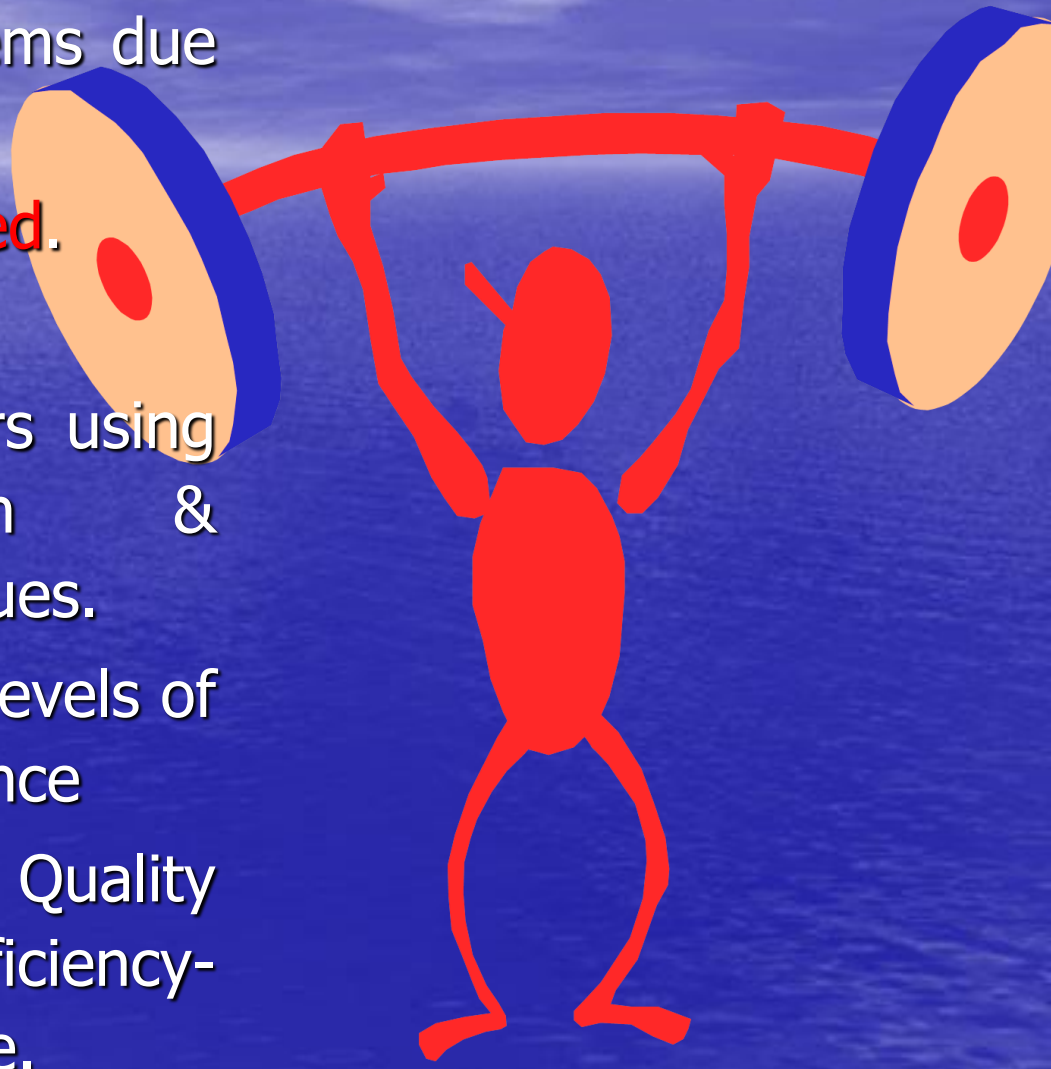
- With rapid Developments there was a need for a common Standard for Mobile Communication.
- With GSM, one could drive from Germany to Spain without a Call Drop.

Noise Robust

- To combat the problems due to Noise-

  Digital Interface is used.

- Digital Interface
  - Protect these errors using Error Detection & Correction Techniques.
  - Immune to higher levels of noise and interference
  - Improvements in Quality as well as Efficiency- Robust Air Interface.



Increased Capacity and Flexibility

- *Analogue Air Interface*
  - Every connection requires a separate RF carrier and thus RF hardware.
  - System Expansion
    - Time Consuming
    - Costly & Labor Intensive.
    - Intricate RF Planning.
- *Digital Interface*
  - 8 simultaneous conversations on one RF carrier.

Standardized Open Interfaces

- Low Price
  - Uses standard interfaces like C7, X.25 etc. Versatility to choose equipment from different manufacturer thereby reducing the pricing monopoly.
- Flexibility
  - Great flexibility in situating Network components because of Standard Interfaces.
  - Efficient use of terrestrial links.

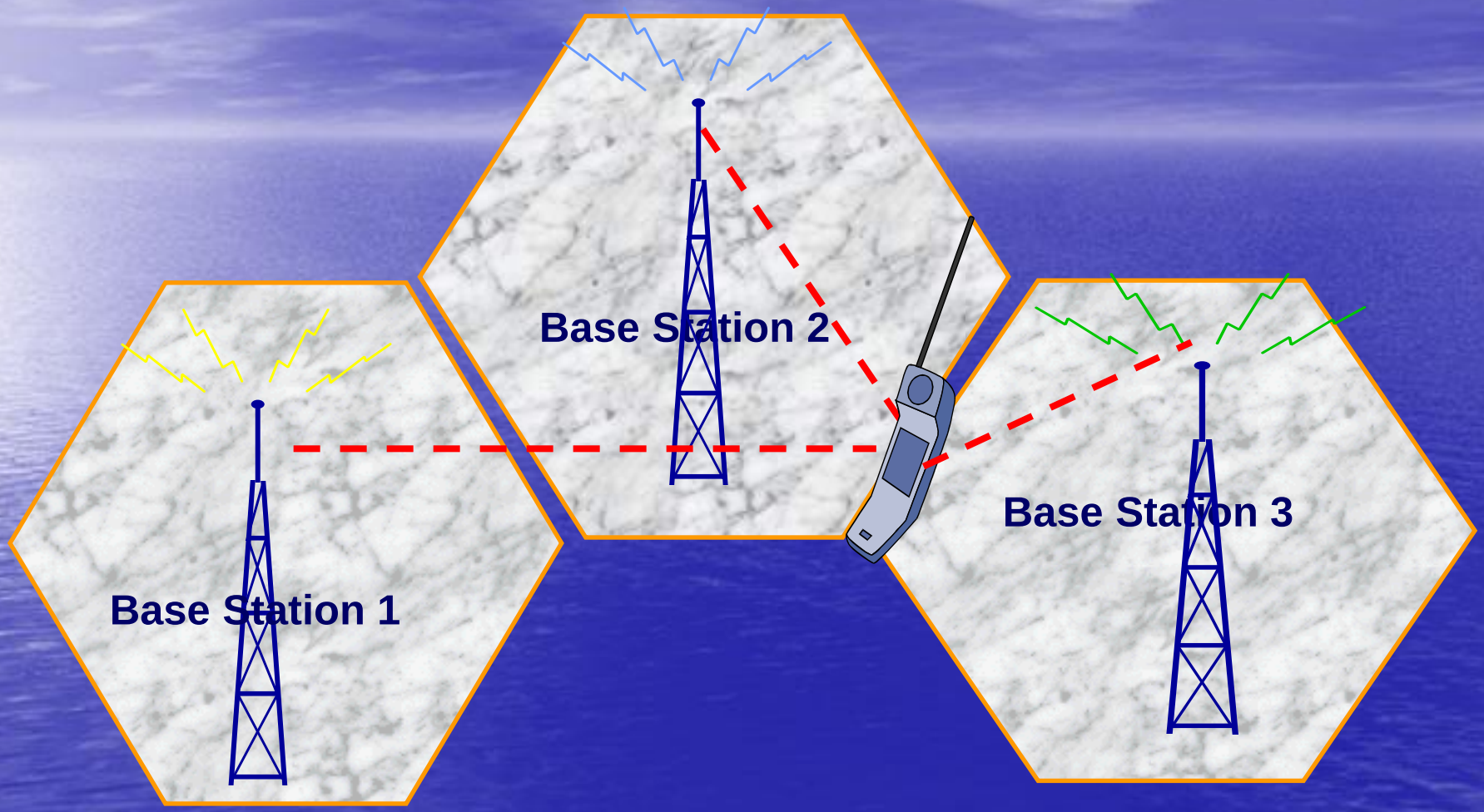
Better Security & Confidentiality

- High Security risk for Analogue System operators.
- GSM
  - High speech and data confidentiality.
  - Digitized, Encoded and Encrypted (A8 algorithm)
  - Subscriber Authentication (A3 algorithm)

Cleaner Handovers

- The mobile measures up to 32 adjacent cells for
  - Signal Strength (RxLevel)
  - Signal Quality (RxQual)
  - updated every 480 mS and sends to BTS
- Sophisticated Handover based on
  - RxLevel
  - Interference
  - RxQual
  - Timing Advance
  - Power Budget

Handovers



ISDN Compatibility

- ISDN (Integrated Services Digital Network)
  - Advanced Telecom Network designed to carry voice and user data over the standard telephones lines.
- 2B+D Signalling and information on ISDN line.
- The GSM Network is designed to operate within the ISDN System.
- GSM provides features compatible with ISDN.

GSM NETWORK ELEMENTS

GSM Network Structure: Concept

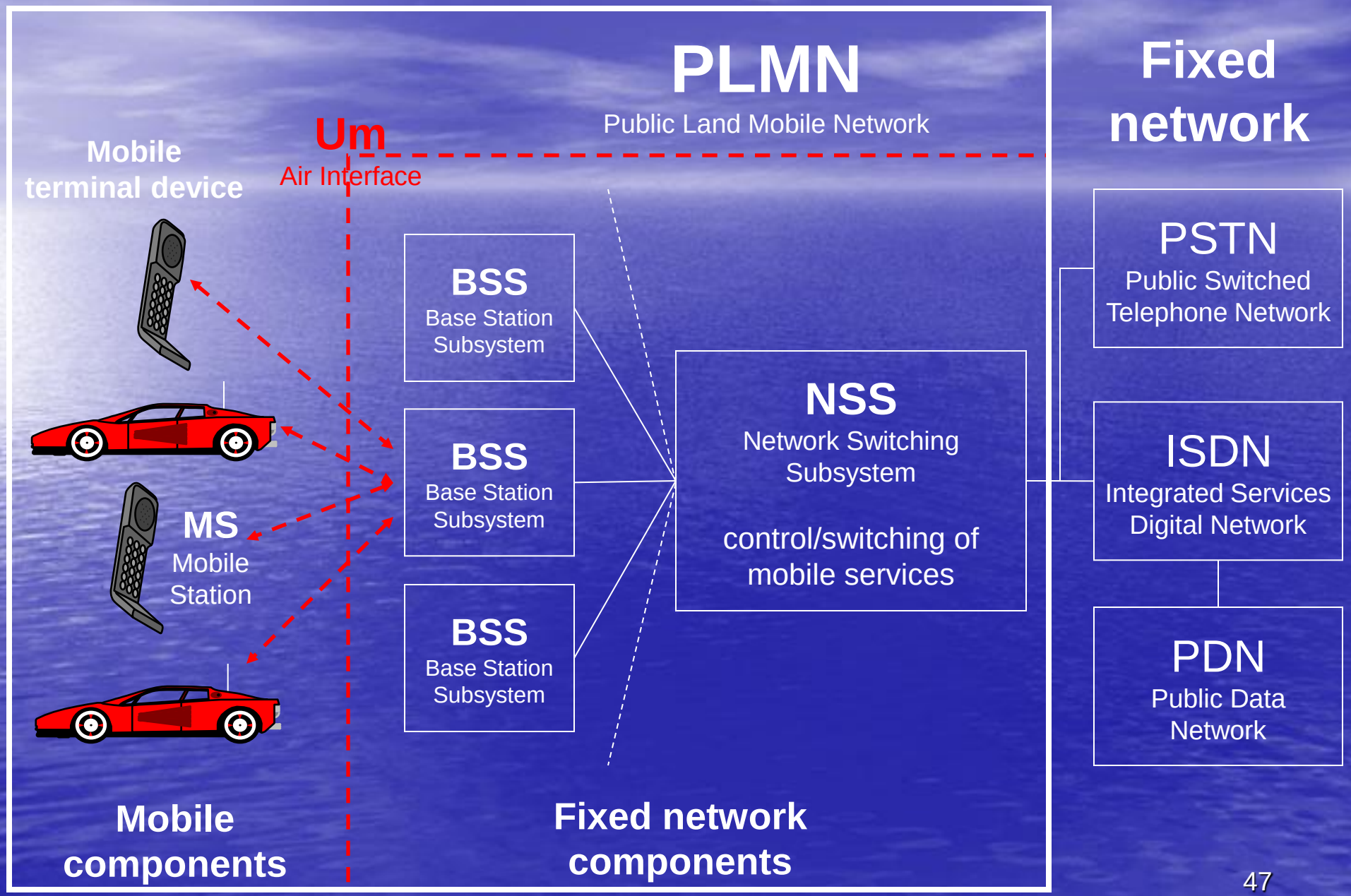
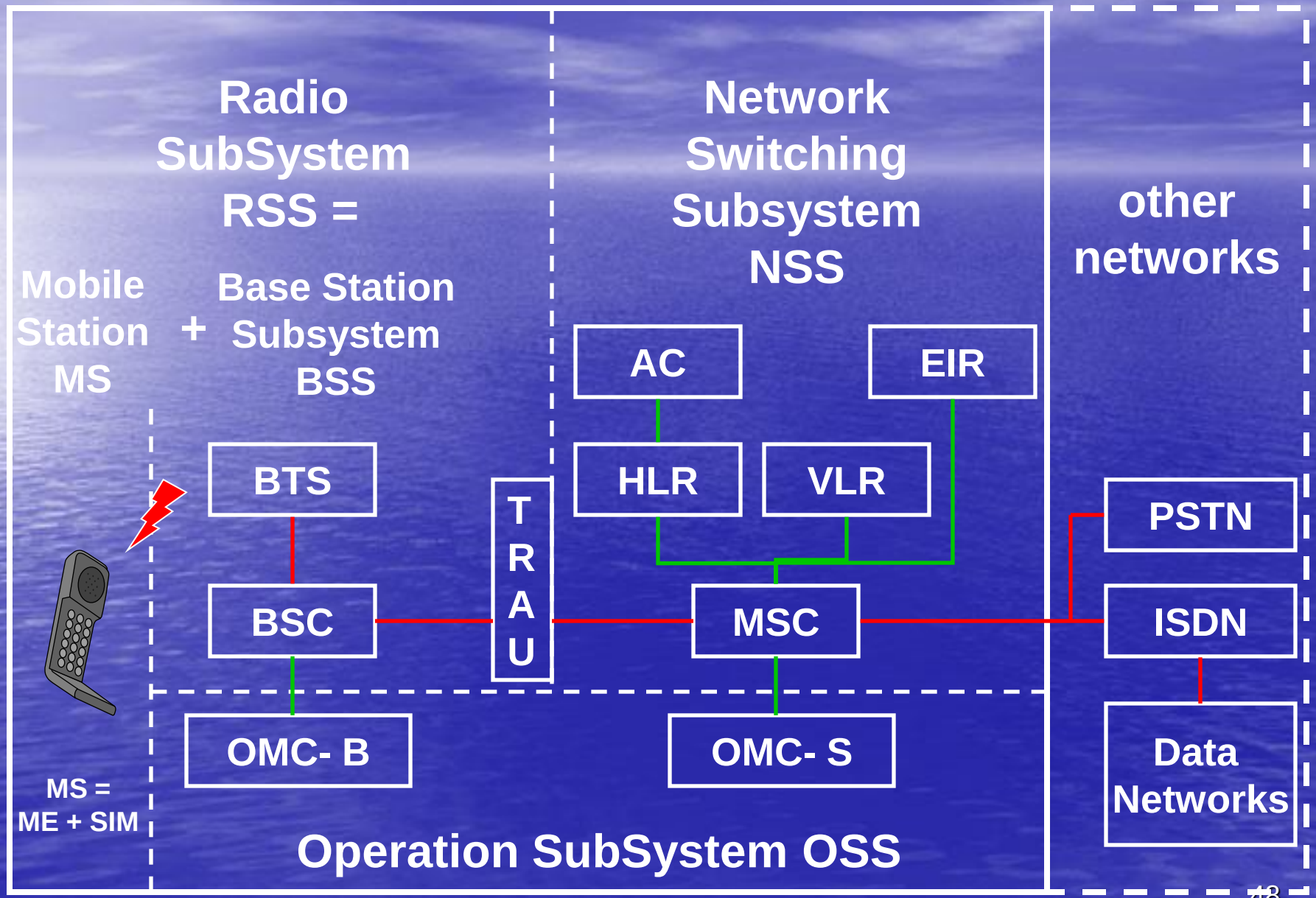


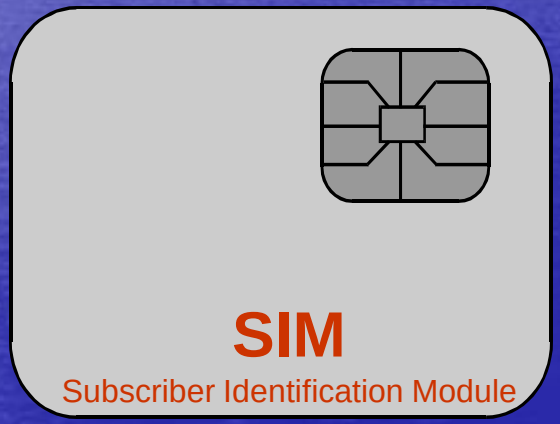
Fig. 2 (TM2100EU03TM_0001 Transmission Principles, 5)

GSM-PLMN


Radio
SubSystem
RSS =
Mobile
Station
MS
+
Base Station
Subsystem
BSS
Network
Switching
Subsystem
NSS
other
networks
AC
EIR
HLR
VLR
BTS
BSC
TRAU
MSC
PSTN
ISDN
Data
Networks
OMC- B
OMC- S
MS =
ME + SIM
Operation SubSystem OSS

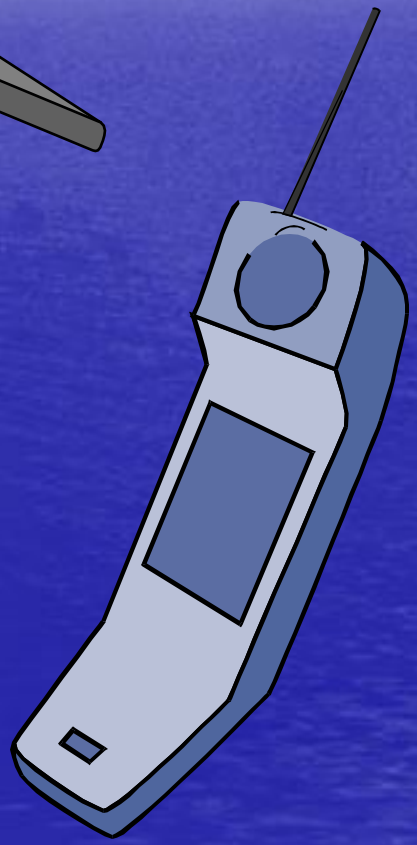
Mobile Components

MS = ME + SIM



SIM

Subscriber Identification Module

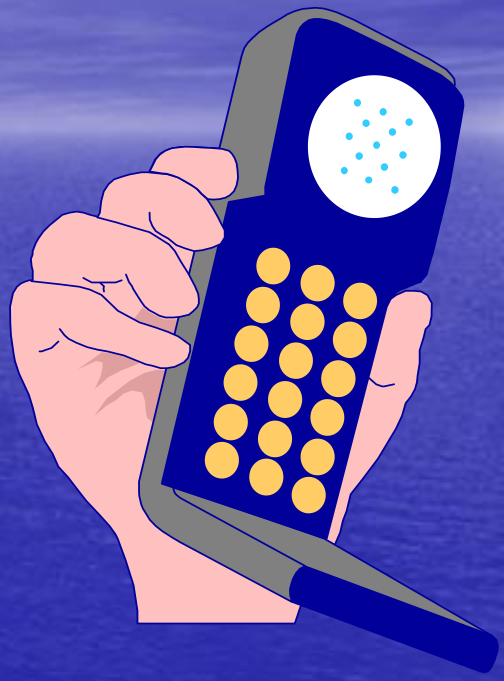


GSM Network Components

- Mobile Station consists of two parts-
  - Mobile Equipment (ME)
  - Subscriber Identity Module (SIM)
- ME
  - Hardware e.g. Telephone, Fax Machine, Computer.
- SIM
  - Smart Card which plugs into the ME.

Mobile Equipment (ME)

- ME are of three types-
  - Vehicle Mounted
  - Portable Mobile Unit
  - Handportable Unit



- ME's have distinct features-Classmarks sent in initial message to Network.

ME (Classmark Information)

- Revision Level
  - Phase of the GSM specs ME comply with.
- RF Power Capability
  - Max power ME is able to Transmit.
- Ciphering Algorithm Used
  - Presently A5
  - Phase 2 specifies Algorithms A5/0 to A5/7.
- Frequency Capability

Mobile Equipment

Class	Power O/p
1	20 W
2	8 W
3	5 W
4	2 W
5	0.8 W

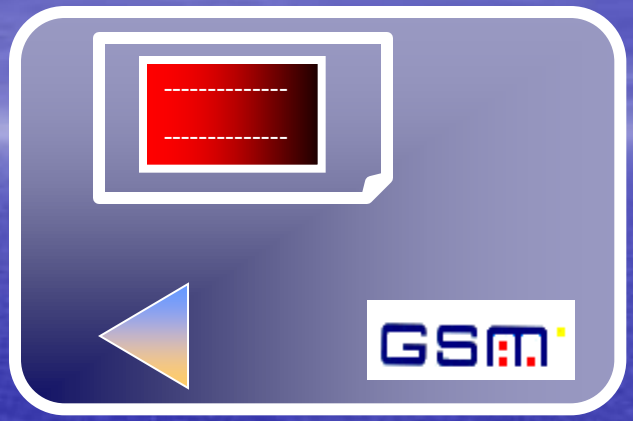
NETCOMP

SIM

- Subscriber Interface Identity Module

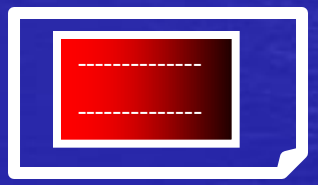
The SIM stores

- Subscriber Parameters
- Personal Data for identifying Subscriber to the Network.
- IMSI,, MSISDN, PIN, PUK, Ki, A3, A8 (for Kc generation)
- Space reserved for TMSI & LAI



Full Size SIM Card

Small SIM



SIM(IMSI)

- IMSI(International Mobile Subscriber Identity)
  - Transmitted over Air Interface on initialization
  - Permanently stored on SIM card
  - 15 digit Decimal

SIM (LAI)

- LAI (Location Area Identity)

  - MCC 3 digit number (BCD), two Octets (A & B)
  - MNC 2 digit number (BCD), one Octet
  - LAC 3 digit number (Binary) , two Octets
    0-65535
  - CI 5 digit number (Binary) , two Octets
    0-65535

SIM

- MSISDN
  - 10 digit number to which a subscriber is being called.
- PIN (Personal Identification Number)
  - Four digit PIN
  - An internal security to Protect the SIM from illegal use.
  - Card blocks itself after three wrong entries
- PUK (Personal Unblocking Key)
  - 8 digit code to unblock the SIM Card
- Ki (Authentication Key), A3 & A8 Algorithms

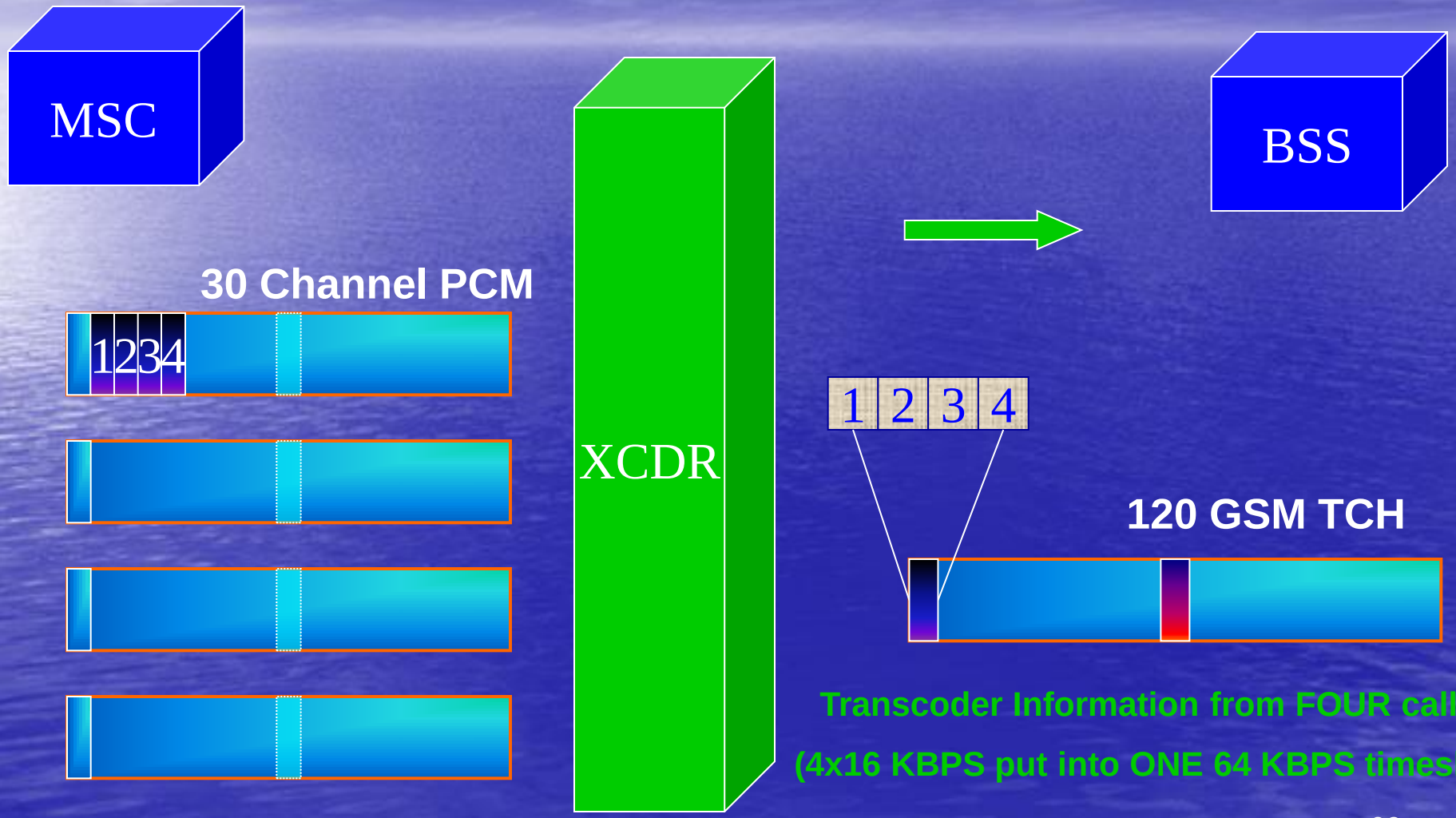
SIM (TMSI)

- Temporary Mobile Subscriber Identity
  - Periodically changed by the System Management on instances like location update etc.
- Reason for use of TMSI
  - To prevent a possible intruder from identifying GSM users, TMSI is used
- Management
  - Assignment, Administration & Updating is performed by VLR.

Transcoder

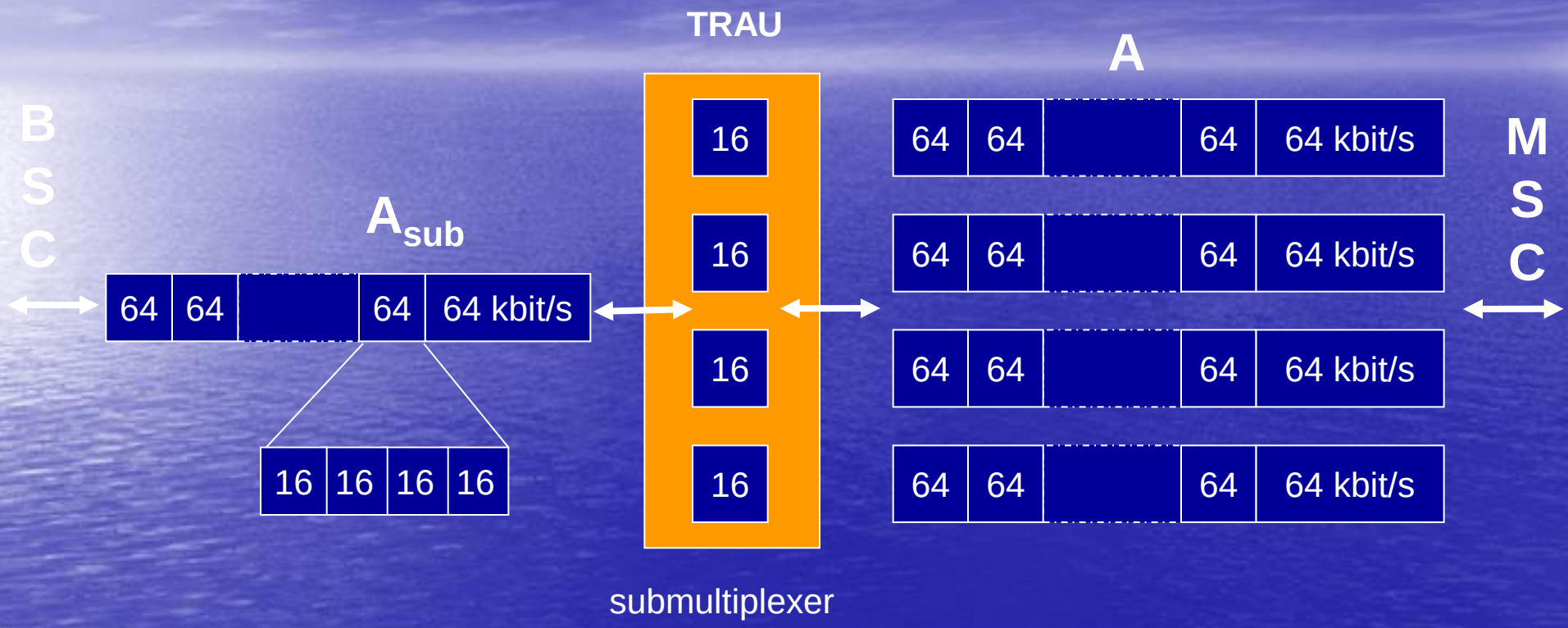
- Converts 64 Kbps PCM circuits from MSC to 16 Kbps BSS circuits.
- Each 30 channel 2 Mbps PCM link can carry 120 GSM - specified voice channels.

Transcoder


NETCOMP
MSC
BSS
30 Channel PCM
1234
XCDR
1 2 3 4
120 GSM TCH
Transcoder Information from FOUR calls
(4x16 KBPS put into ONE 64 KBPS timeslot

TRAU

Transcoding & Rate Adaptation Unit

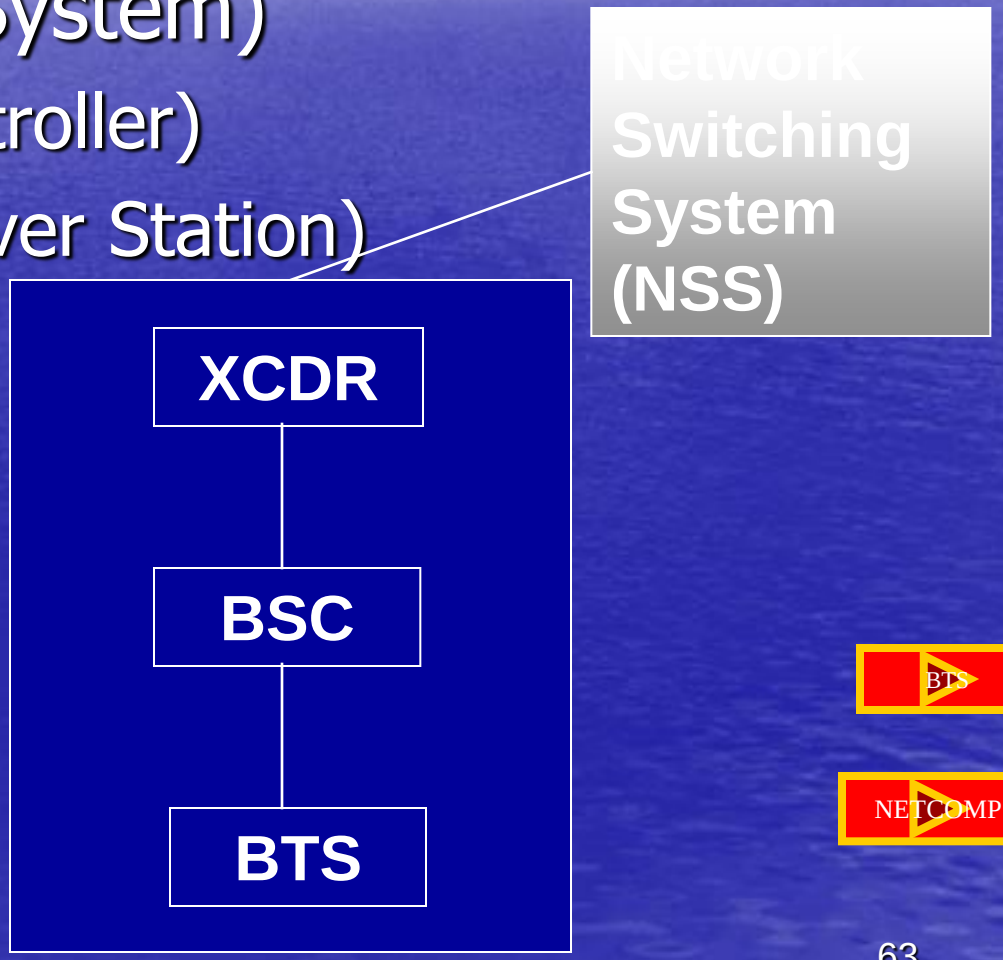


- speech compression: 64kbit/s ↔ 13 or 5.6 kbit/s + inband signaling
- data transmission: "64 kbit/s" ↔ 0.3 - 9.6 kbit/s + inband signaling
- signaling: transparent

Generally,
Transcoder is collocated with MSC
so as to reduce the number of
2 Mbps A-links
to efficiently use the BW.

Base Station System (BSS)

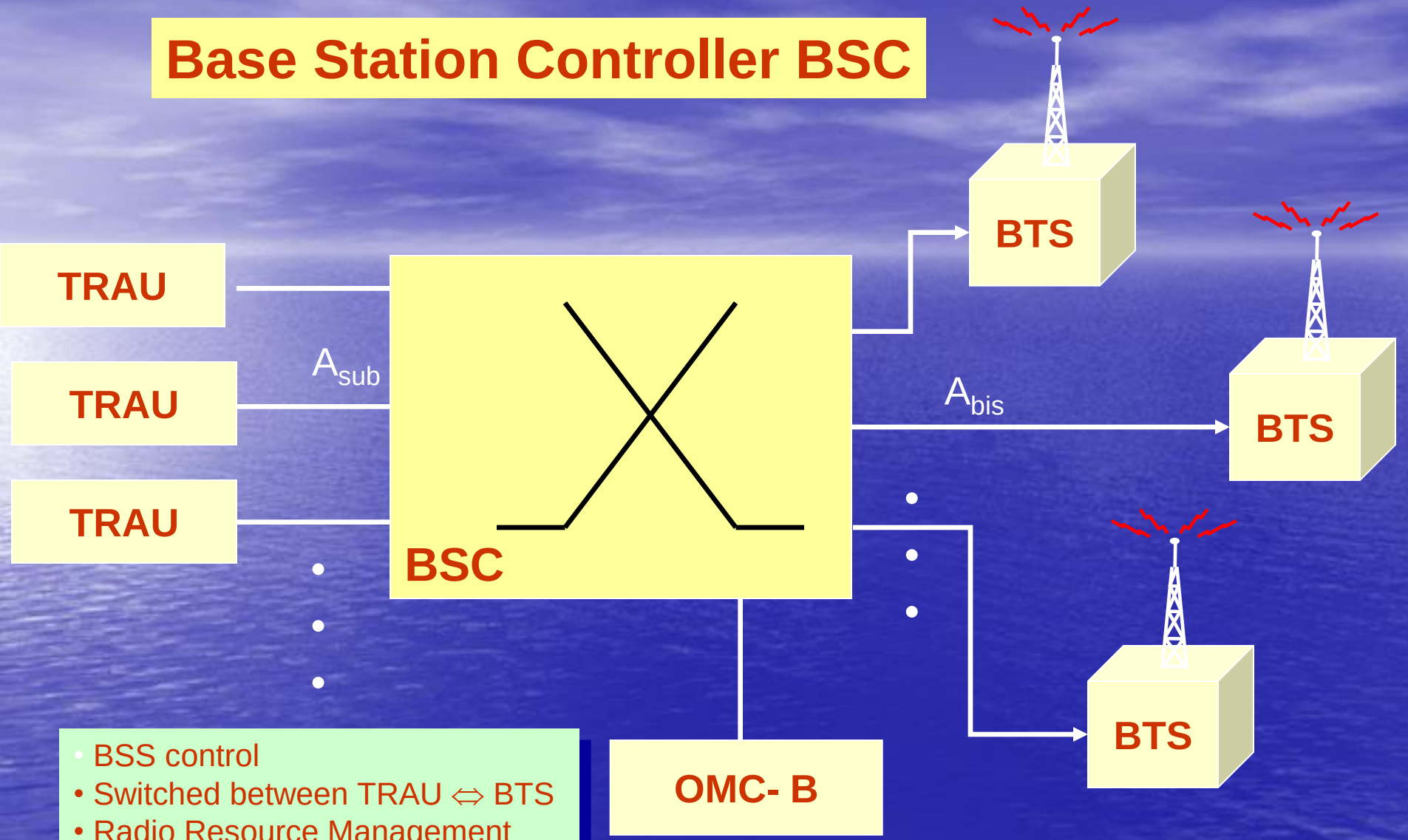
- BSS (Base Station System)
  - BSC (Base Site Controller)
  - BTS (Base Transceiver Station)
  - XCDR (Transcoder)



Base Station System (BSS)

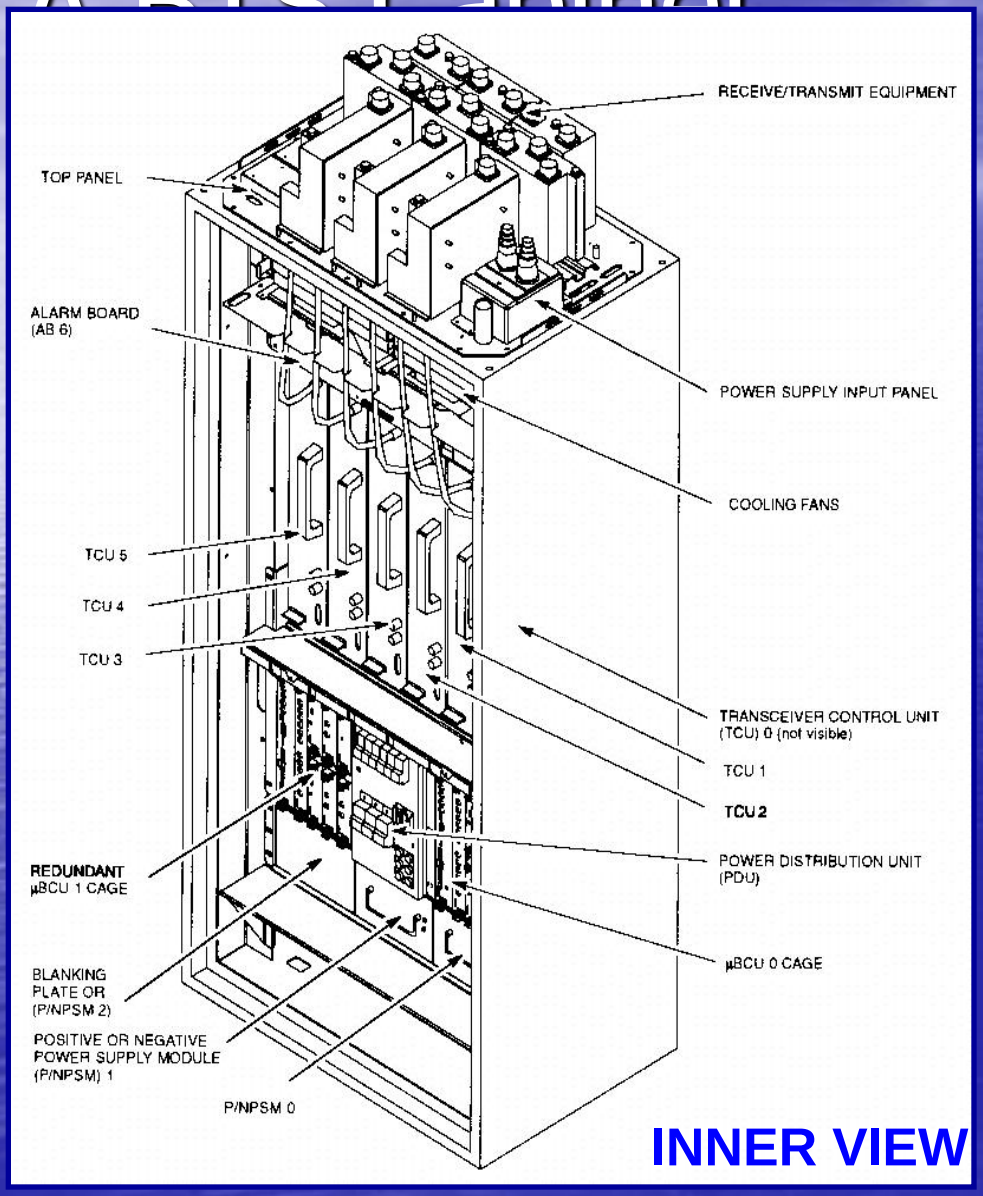
- BSC
  - Controls upto 40 BTS
  - Conveys information to/from BTS
  - Connects terrestrial circuits & Air Interface Channels
  - Controls handovers between BTSs under itself
- BTS
  - Contains RF Hardware
  - Limited control functionality
  - 1 - 6 carriers in a BTS Cabinet
  - 7 - 48 simultaneous calls per BTS

Base Station Controller BSC



- BSS control
- Switched between TRAU ⇔ BTS
- Radio Resource Management
- Collecting error messages in BSS
- Contact to OMC-B
- Database storage, SW of BSS

A BTS Cabinet



INNER VIEW

OUTER VIEW

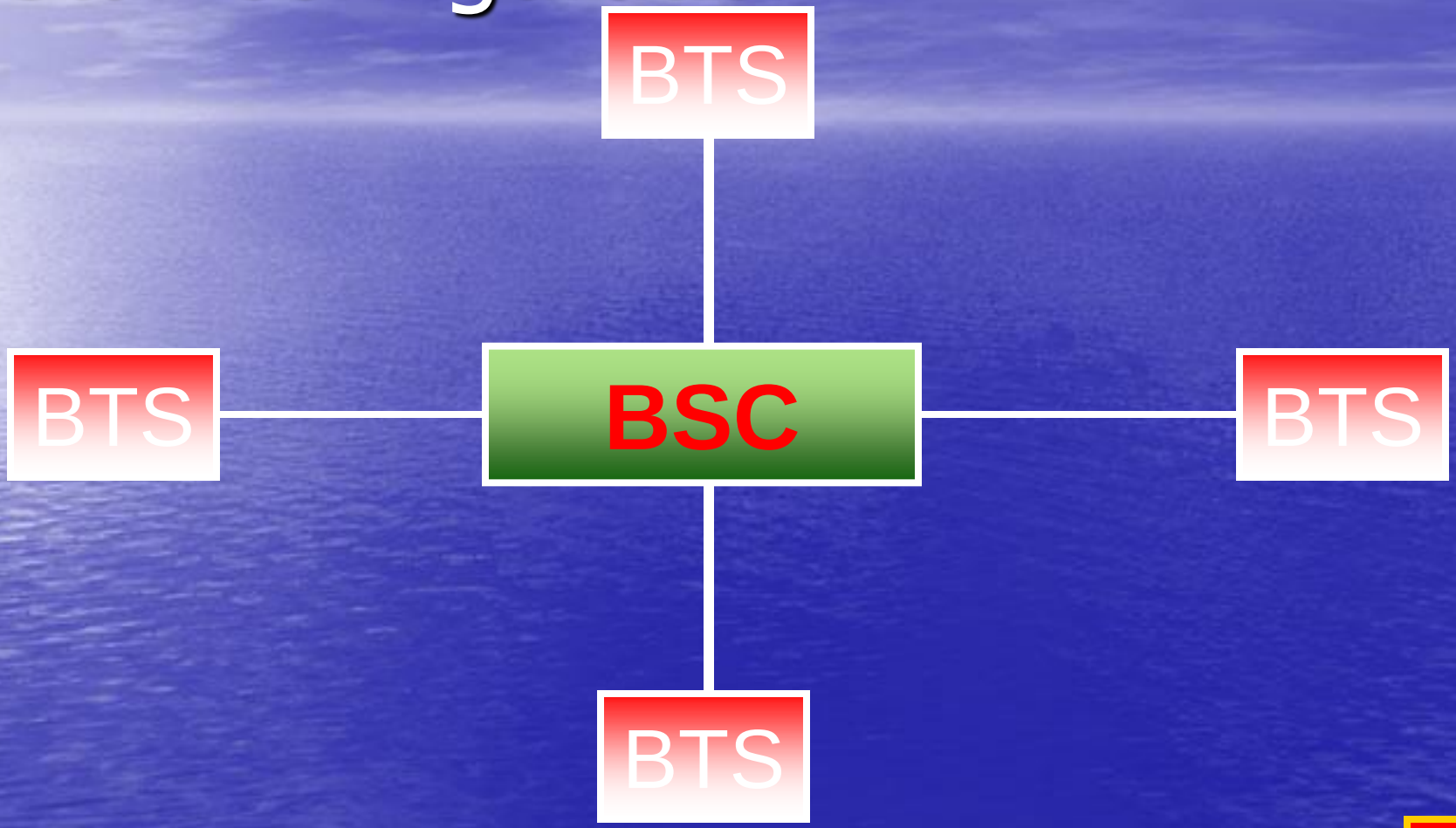
NETCOMP

BSS Configuration

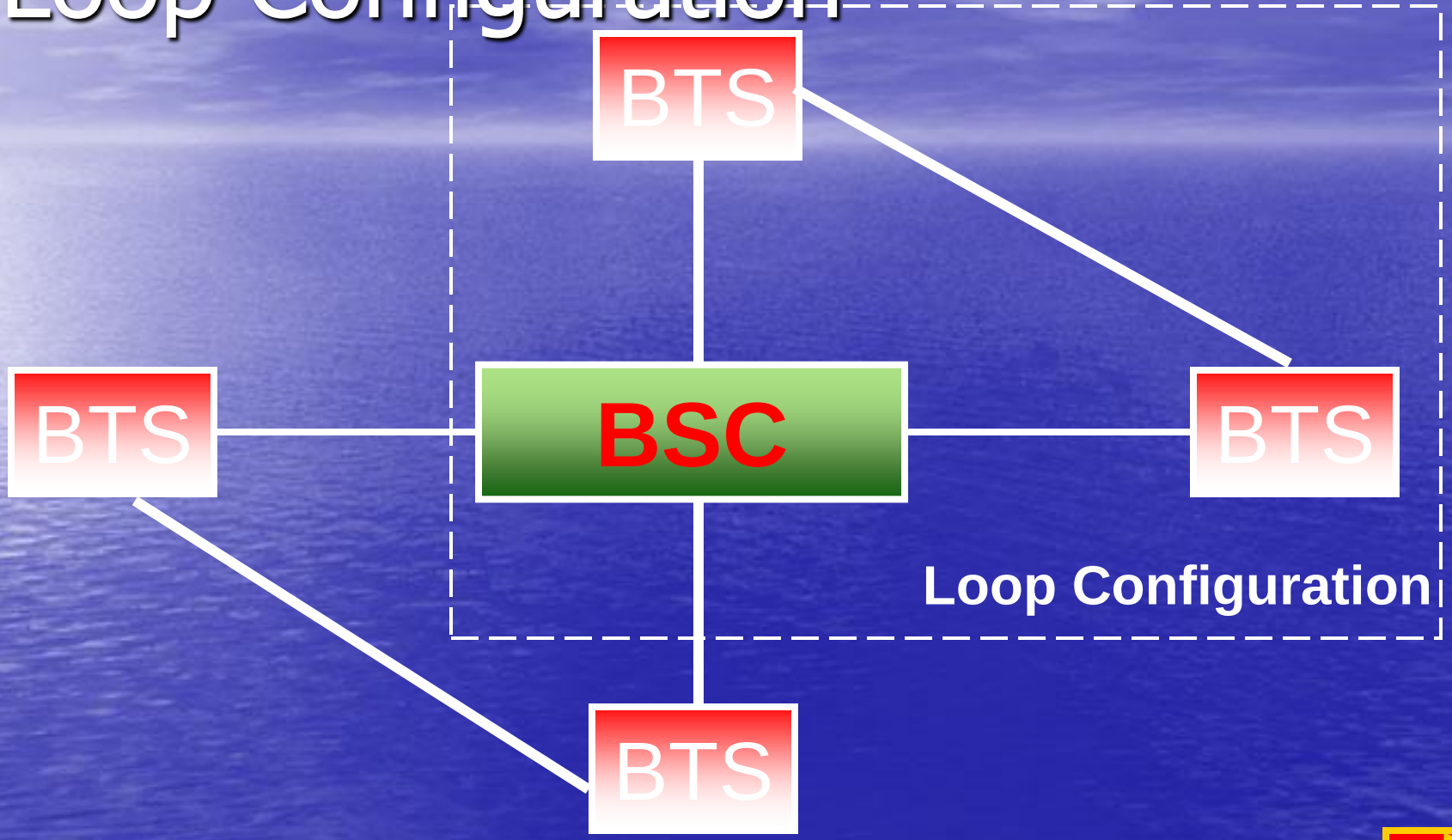
- Collocated BTS
- Remote BTS
- Daisy Chain BTS
- Star Configuration
- Loop Configuration

Daisy Chain Configuration

Star Configuration



Loop Configuration

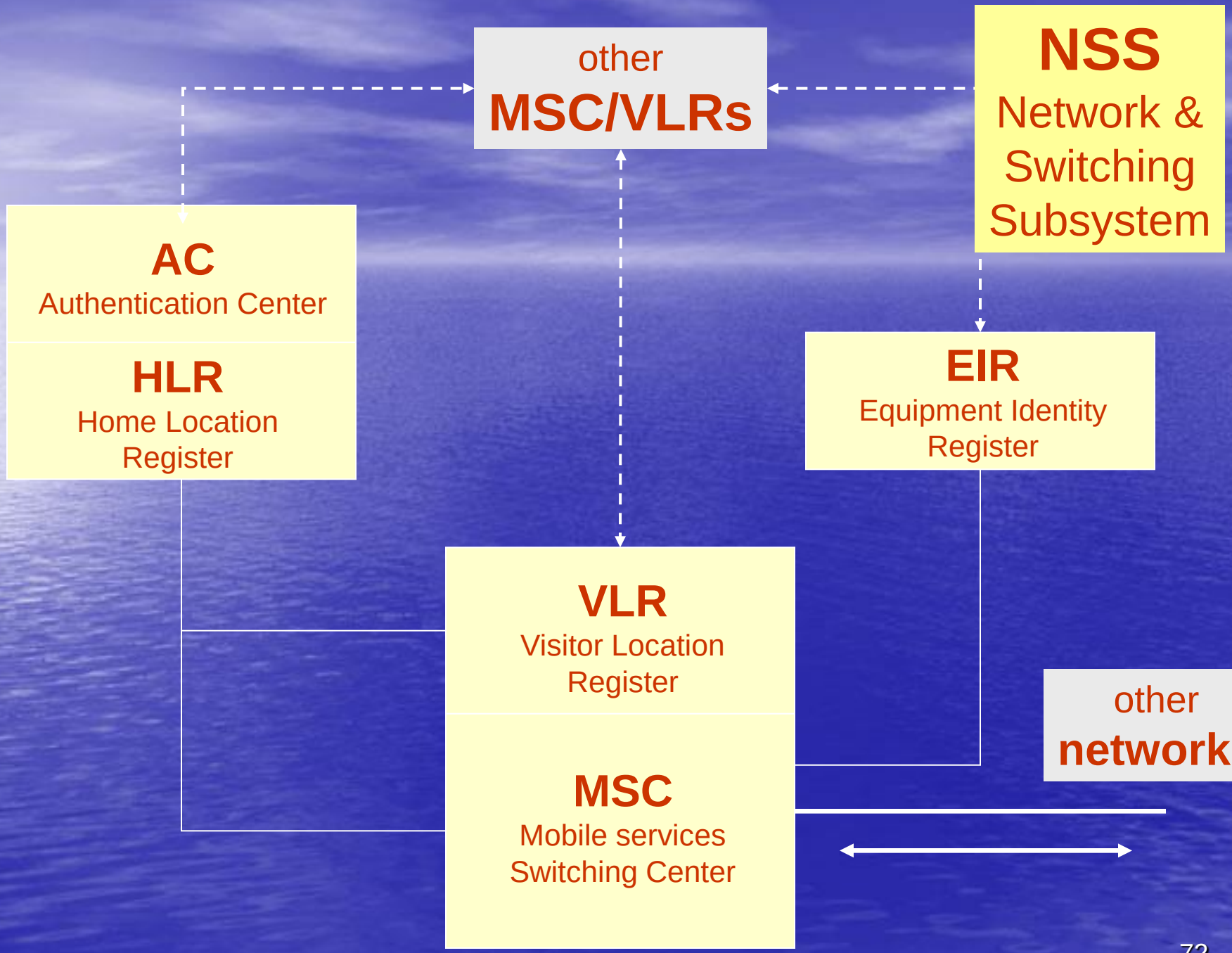


Network Switching System(NSS)

- NSS (Network Switching System)
  - MSC (Mobile Switching Centre)
  - HLR (Home Location Register)
  - VLR (Visitor Location Register)
  - EIR (Equipment Identity Register)
  - AUC (Authentication Centre)
  - IWF (Interworking Function)

MSC

NETCOMP


other
MSC/VLRs
NSS
Network &
Switching
Subsystem
AC
Authentication Center
HLR
Home Location
Register
EIR
Equipment Identity
Register
VLR
Visitor Location
Register
MSC
Mobile services
Switching Center
other
networks

MOBILE SWITCHING CENTRE

NETCOMP

GSM Network Component

- MSC
  - Call Switching
  - Operation & Management Support
  - Internetwork Interworking
  - Collects call billing data

- Gateway MSC
  - MSC which provides interface between PSTN & BSS's in the GSM Network.

- NSS “heart & center”
- Serves several BSS (BSC)
- Set-up & switching of user traffic & signaling
- Always associated with VLR
- Association with HLR/AC and EIR possible
- Gateway MSC: Gateway to external networks
- Visited MSC: MSC serving certain MS

call processing functions
(similar to fixed network exchange)

mobile communication - specific functions

call processing functions
(similar to fixed network exchange)

- Set-up of signaling / user connections
- Signaling evaluation
  → destination determination
- Connection path selection
- Processing of abnormal signaling information
- Supplementary Service support
- Call monitoring
- Traffic monitoring & measurement
- Overload protection
- Billing
- Priority control (e.g. emergency call)
- Support of O&M functions

mobile specific functions

- Signaling with BSC, MS & NSS databases
- Processing of mobile-specific services
- Mobility Management,
  e.g. Paging, Inter-MSC Handover, Location Update,...
- Overload handling, e.g. OACSU
- Interworking Function for data services
- Mobile specific announcements

Fig. 13 (TM2100EU03TM_0001 GSM PLMN, 27)

Home Location Register (HLR)

- Reference database for the Subscriber profiles-
  - Subscriber ID (IMSI & MSISDN)
  - Current VLR Address
  - Supplementary Services subscribed
  - Supplementary Service Information
  - Subscriber Status (Registered/deregistered)
  - Authentication Key and AUC functionality
  - TMSI
  - MSRN

Visitor Location Register (VLR)

- Temporary Data, which exists as long as the subscriber is active in a particular Coverage area.
- Contains the following-
  - Mobile Status (Busy/ Free/ No Answer/etc.)
  - Location Area Identity (LAI)
  - TMSI
  - MSRN (Mobile Station Roaming Number)

Equipment Identity Register (EIR)

- Contains Database for validating IMEI
  - White List (valid ME)
  - Black List (Stolen ME)
  - Grey List (Faulty ME)

Inter Working Function

- Provides function to enable the GSM System to interface with Public/Private Data Networks.

- The basic feature of the IWF are
  - Rate Conversion
  - Protocol adaptation
- IWF incorporates Modem Bank.

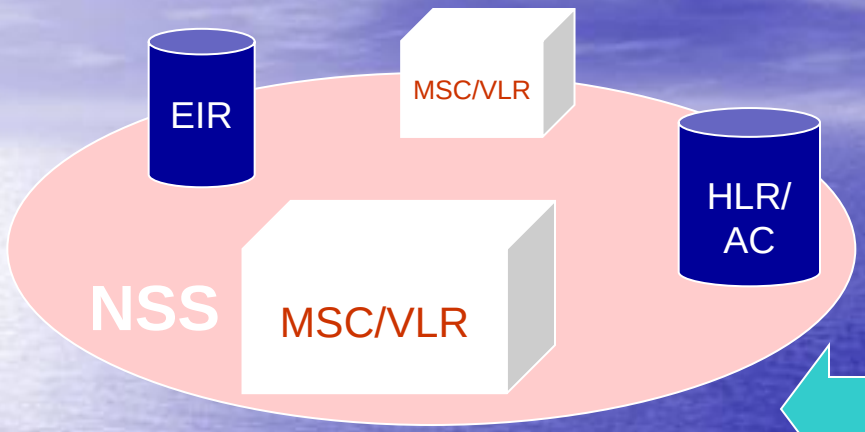
e.g. GSM DTE PSTN DTE

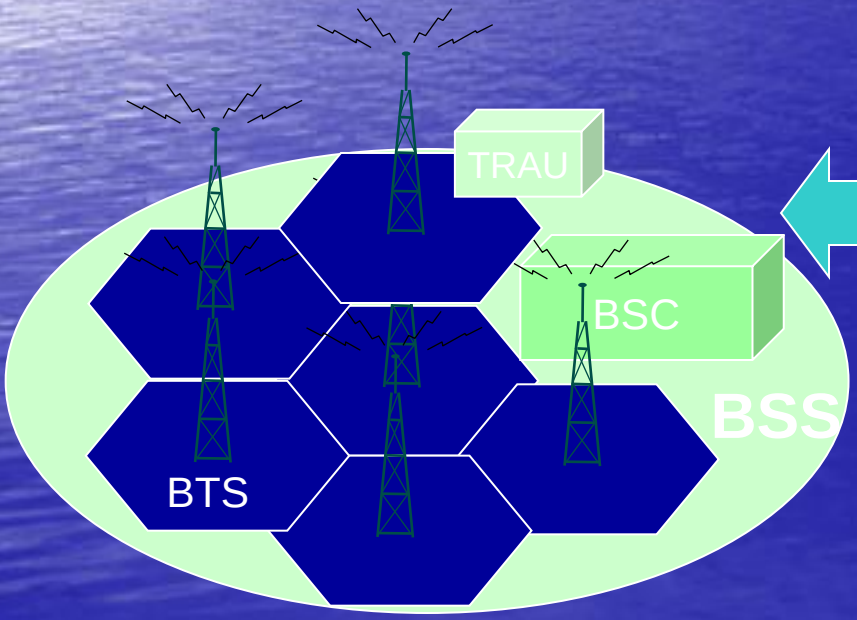
IWF ⟷ Analogue Modem

Echo Canceller

- Echo is apparent only in Mobile - Land conversation & is generated at the 2 wire to 4 wire interface.
- To avoid it, Echo Canceller (EC) is used.
  - Echo is irritating to MS Subscriber
  - Total Round Trip delay of 180 ms in the GSM system
  - EC is placed on the PSTN side of the Switch
  - Cancellation up to 68 ms with EC

OSS
Operation SubSystem





OMC

Operation & Maintenance Center

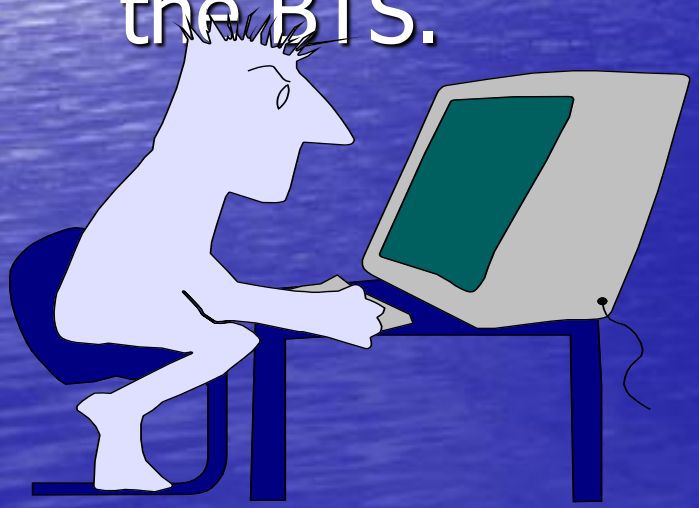
- Subscriber and equipment data management
  e.g. clearing services, bills
- Network operation, configuration & management
- Collecting network load information & compiling statistics
- Error detection & correction
- Security management
- Performance control

Operation & Maintenance Centre

- Event & Alarm Management
- Fault Management
- Performance Management
- Configuration Management
- Security Management

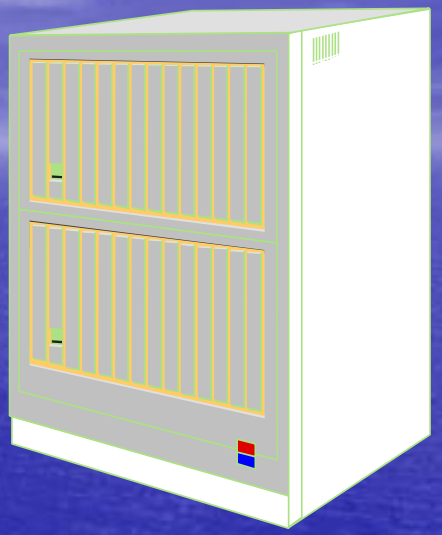
Operation & Maintenance Centre

- The OMC has access to the (G)MSC, BSC.
- Handles error messages being reported from the Network
- Controls the traffic load of the BSC, and the BTS.

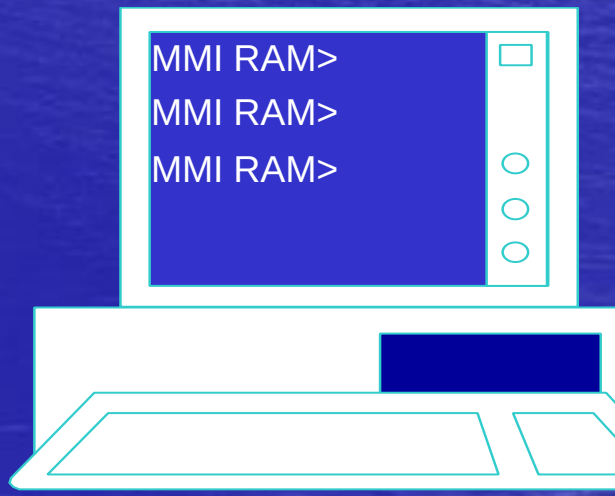


NETWORK MANAGEMENT CENTRE

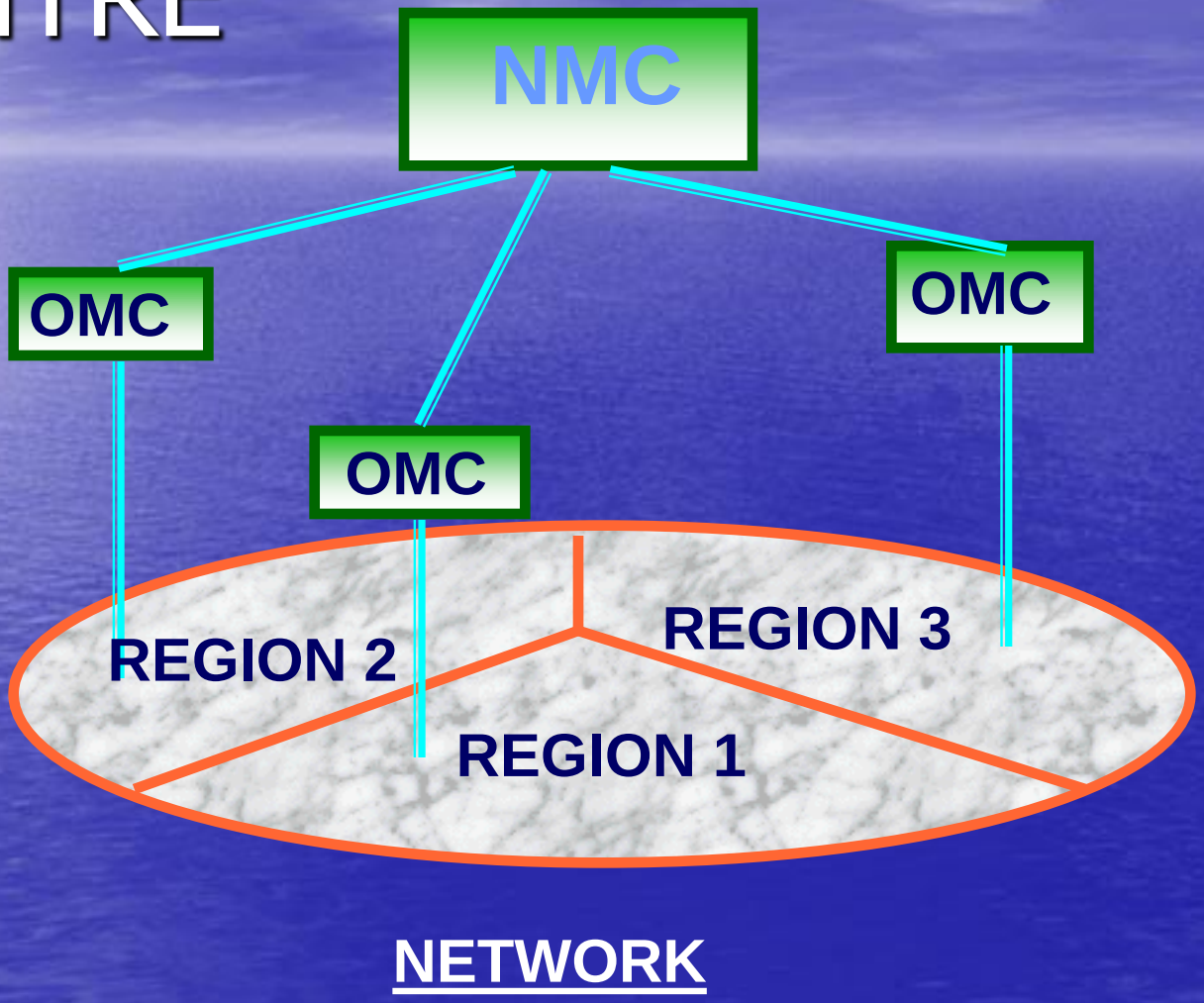
- NETWORK MANAGEMENT CENTRE (NMC)
  - Offers Hierarchical Regionalised Network Management of a complete GSM system.



- Functionality of the NMC
  - Monitors Nodes on the Network
  - Monitors Network Element Statistics
  - Monitors OMC regions & provides information to OMC staff
  - Enables Long Term Planning for entire Network



NETWORK MANAGEMENT CENTRE



GSM Terrestrial Interfaces

Broadly classified into two types of interfaces-

- Standard Interfaces
  - 2 Mbps Trunks (E1)
  - Signalling System No. 7 SS7 (CCS7)
  - X.25 (Packet Switched Mode)
- GSM Interfaces

GSM Interfaces

- Um MS - BTS
- Abis BTS - BSC
- A BSC - MSC
- B MSC - VLR
- C MSC - HLR
- D VLR - HLR
- E MSC - MSC
- F MSC - EIR
- G VLR - VLR
- H HLR - AUC

LOGICAL CHANNELS
PHYSICAL CHANNELS

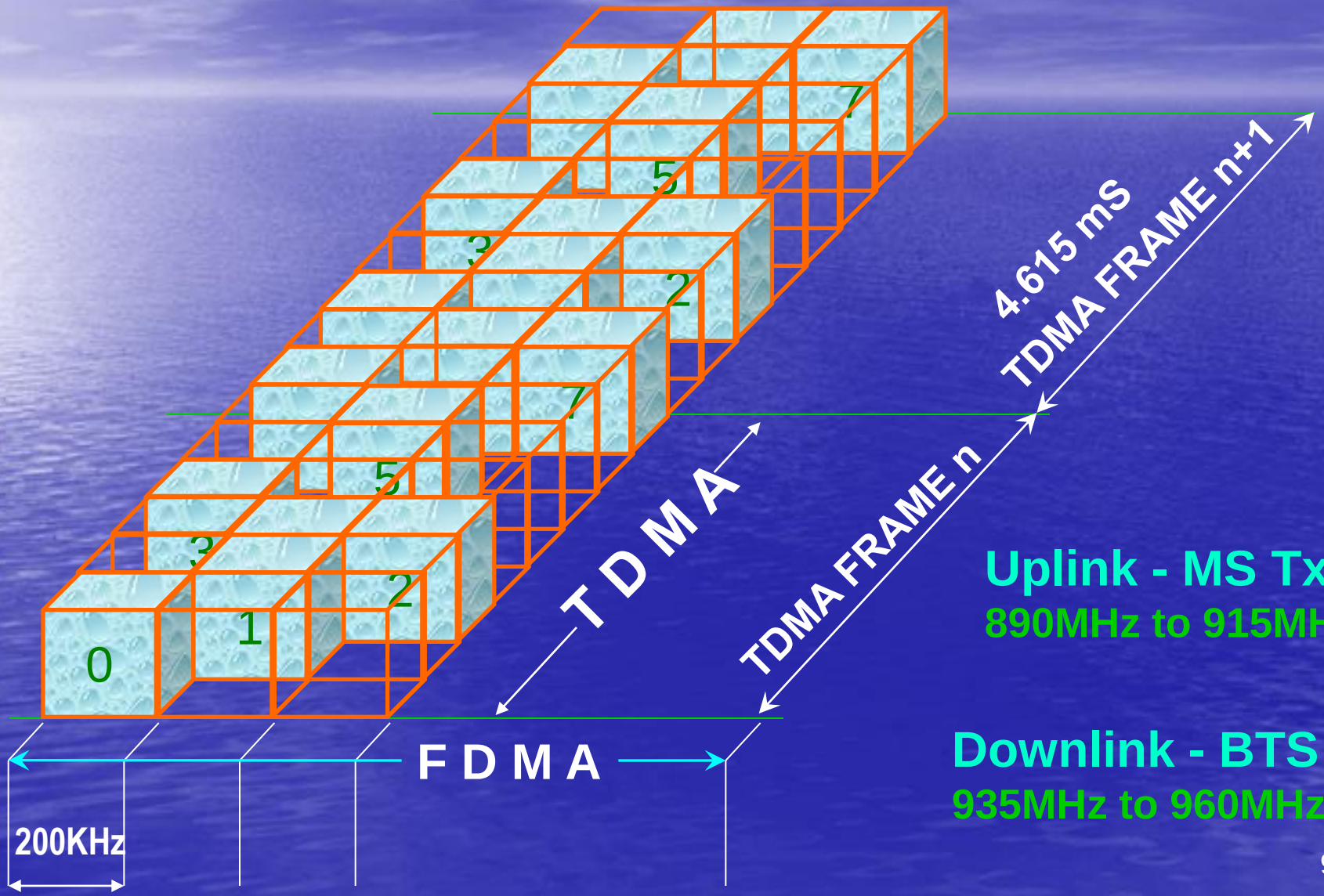
Channels On Air Interface

- Physical Channel
- Logical Channel

- Physical Channel
  - Physical channel is the medium over which the information is carried.

- Logical Channel
  - Logical channels consists of the information carried over the Physical Channel.

TDMA & FDMA



Uplink - MS Tx
890MHz to 915MHz

Downlink - BTS Tx
935MHz to 960MHz

BURST

- Time is divided into discrete periods called "Timeslots"
- The Time Slots are arranged in a sequence , conventionally numbered 0 to 7.
- Each repetition of this sequence is called a TDMA Frame.
- The information content carried in one time slot is called a "burst".

BURST

- Information
  - Main Area where the Speech, Data or Control info is held
- Guard Period
  - To enable the burst to hit the time slot (0.031ms)
- Stealing Flags
  - 2 bits are set when TCH is to stolen by a FACCH
- Training Sequence
  - For estimation of transfer characteristics of physical media
- Tail Bits
  - Used to indicate beginning and end of the burst.

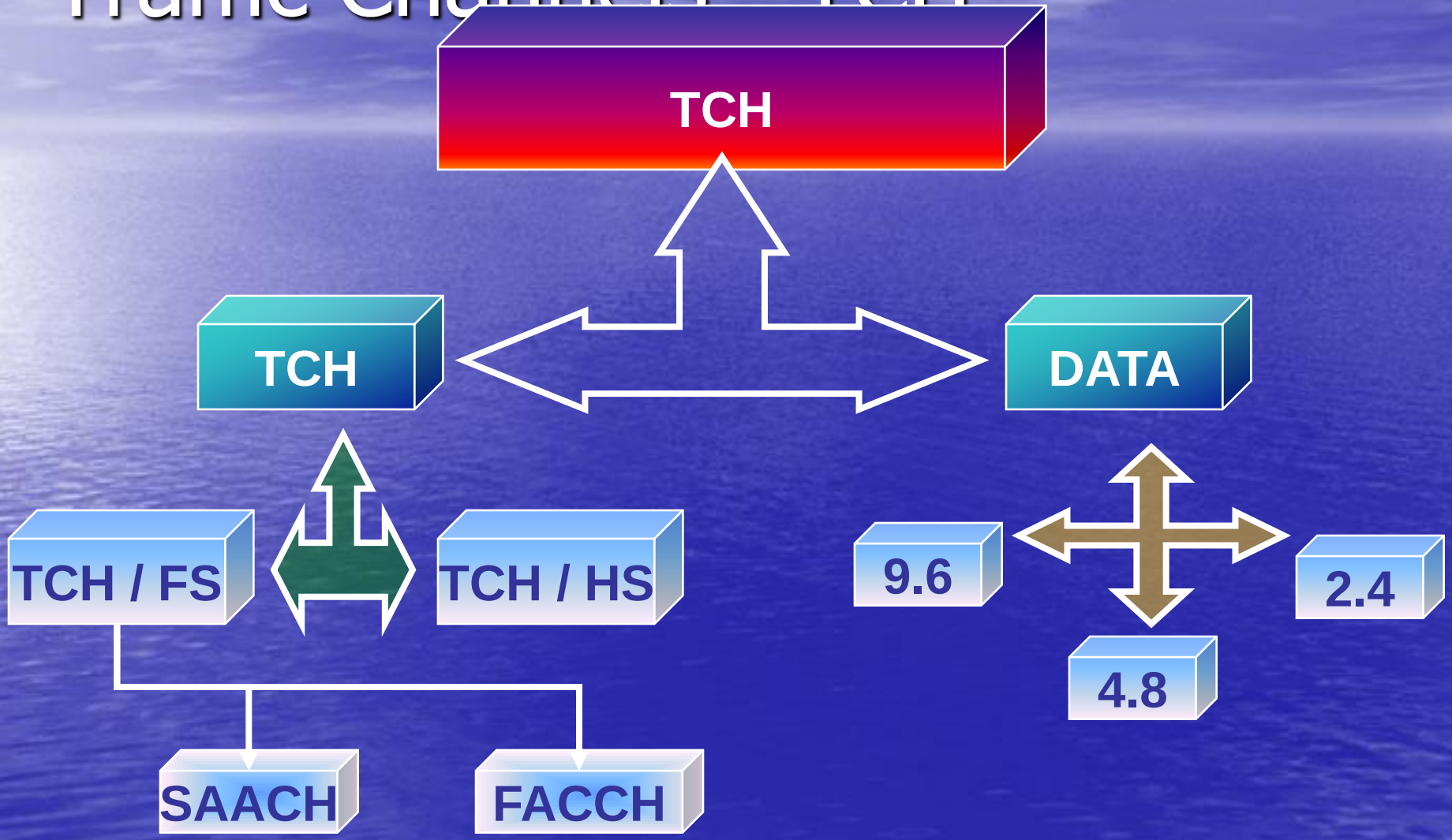
Five Types of Burst

- Normal Burst
  Traffic & Control Channels — Bi-directional
- Frequency Correction Burst
  FCCH — Downlink
- Synchronization Burst
  SCH — Downlink
- Dummy Burst
  BCCH Carrier — Downlink
- Access Burst
  RACH — Uplink

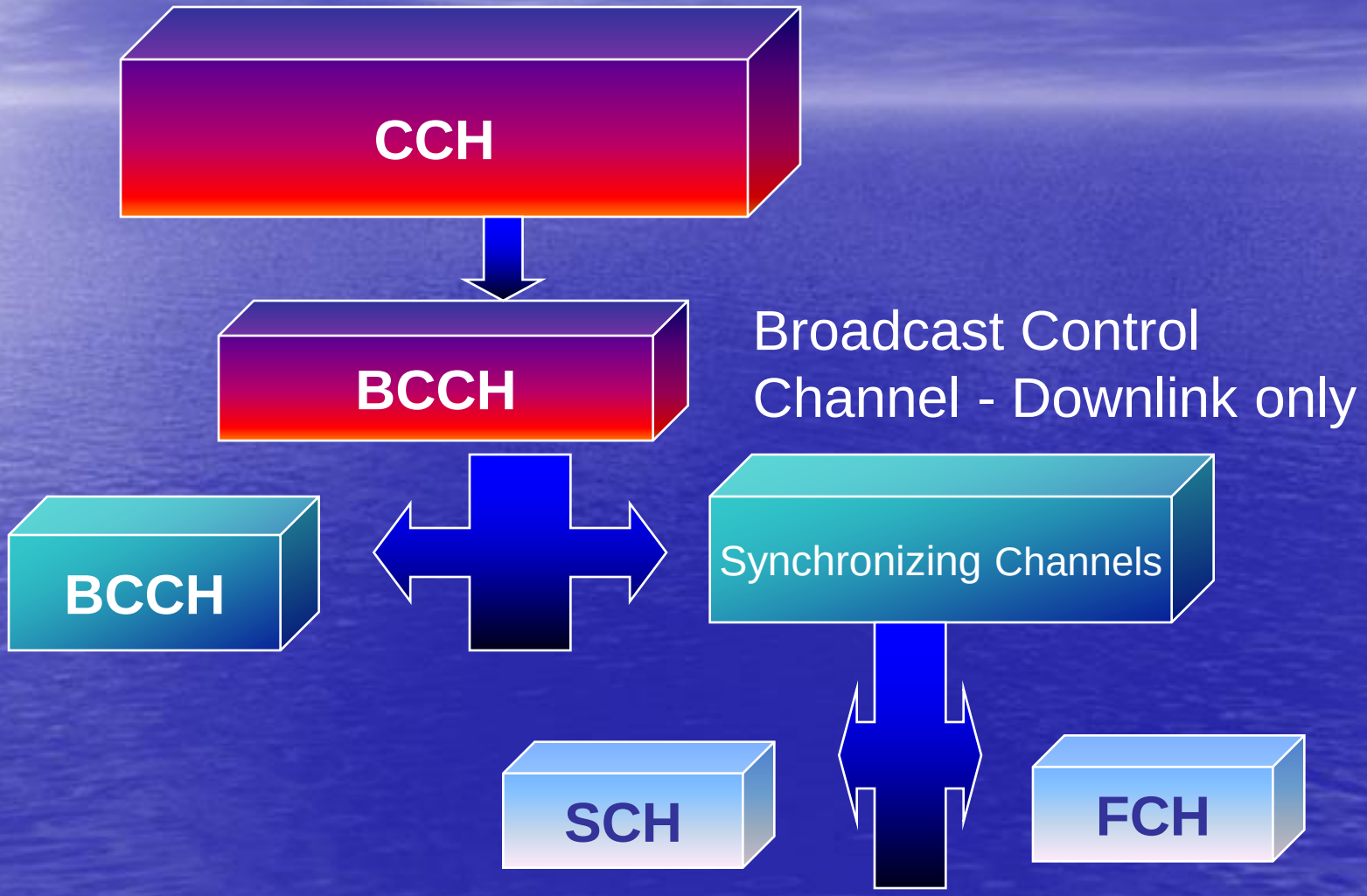
GSM Logical Channels

- TCH
  - SACCH
  - FACCH
- Control Channels
  - BCCH
  - CCCH
  - ACCH
  - DCCH

Traffic Channels - TCH



BCCH Channel



Channels On Air Interface

- BCCH
  - Transmitted at all times & conveys information about Cell Timing and Configuration
    - BCCH, FCCH, SCH
- CCCH
  - Used by BSS & MS when trying to initiate a connection over the air
    - RACH, PCH, AGCH, CBCH

Channels On Air Interface

- DCCH
  - Used to convey signaling information during call setup
    - SDCCH
- ACCH
  - Used to transmit signaling information when a call is in progress
    - FACCH & SACCH

Channels On Air Interface

- ACCH
  - SAACH
    - Conveys Power Control & Timing Information in the downlink direction.
    - RSSI and Quality reports in the uplink direction.
  - FACCH
    - To carry out user authentication and handovers. It steals the TCH burst and inserts its own information.

Channels On Air Interface

- Acronyms
  - BCCH Broadcast Control Channel
  - CCCH Common Control Channel
  - DCCH Dedicated Control Channel
  - ACCH Associated Control Channel
  - SDCCH Standalone Dedicated Control Channel
  - RACH Random Access Channel
  - PCH Paging Channel
  - AGCH Access Grant Channel

Channels On Air Interface

- BCCH
  - Location Area Identity
  - List of neighbouring cells, to be monitored
  - List of frequencies used in the cell
  - Cell Identity
  - Power Control Indicator
  - DTX permitted
  - Access Control (e.g emergency calls, call barring)

Channels On Air Interface

  - Always transmitted at constant power at all times
  - Dummy burst are sent to ensure continuity when no traffic information is sent.
- FCCH
  - Mobile corrects the frequency of its internal time base by reading this logical channel.
  - Easily detected by the mobile.
  - After FCCH, mobile is able to detect SCH which contains timing information.

Channels On Air Interface

- SCH
  - Carries the information for mobile to synchronize to the TDMA frame structure & know the timing of the individual timeslots.
  - Frame Number & BSIC (Base Station Identity Code)
- CCCH
  - RACH
    - Transmitted by the Mobile when it wishes to gain access to the system

Channels On Air Interface

- PCH
  - Transmitted by the BTS when it wishes to contact a specific mobile.
- AGCH
  - Transmitted by the BTS to assign dedicated resources to an MS such as SDCCH
- CBCH
  - To transmit messages to all mobiles within a cell. CBCH will steal some time of an SDCCH to do this.

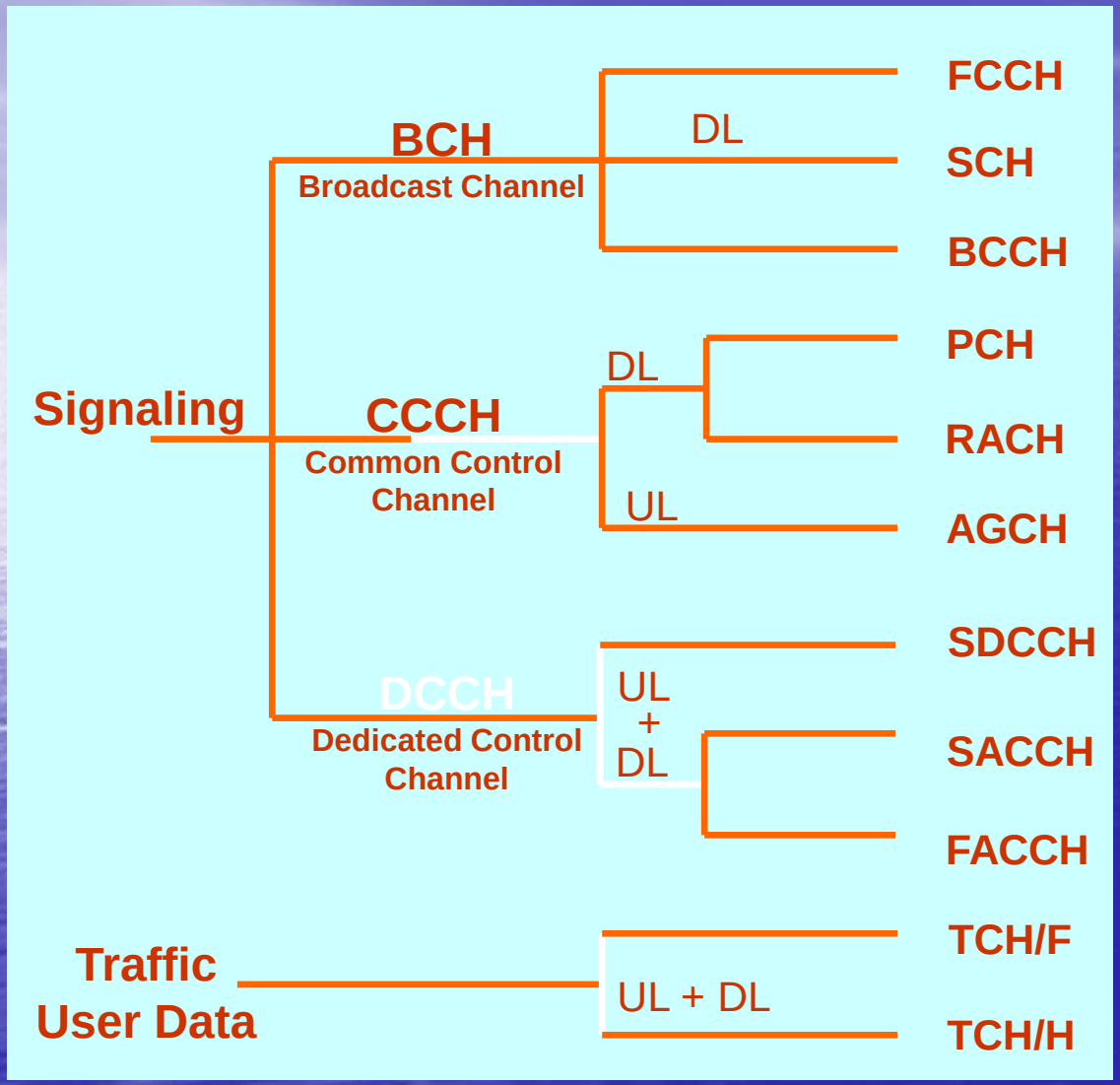
Channel Coding

- Error Protection And Detection
  - To protect the logical channel from transmission errors by the radio path, different coding schemes are used.
- Coding & Interleaving Schemes dependent upon logical channel to be encoded.

- 3 Coding Protection schemes
  - Speech Channel Encoding
  - Control Channel Encoding
  - Data Channel Encoding

Call Sequence

Logical channels



Frequency synchronization

Time synchronization + BSIC, TDMA-No.

CGI, FR/EFR/HR, VAD/DTX, HSCSD, frequency hopping, channel combinations

Paging / Searching (MTC)

Request for signaling channel

Allocation of signaling channel

Signaling MS ↔ BTSE for e.g. Call Setup (Authentication, Cipher start, IMEI check, Setup info,..) LUP, SMS,...

Measurement Report, TA, PC, cell parameters,...

Signaling instead of TCH (e.g. for HOV, IMSI Detach, Call Release)

User data Full Rate

User data Half Rate

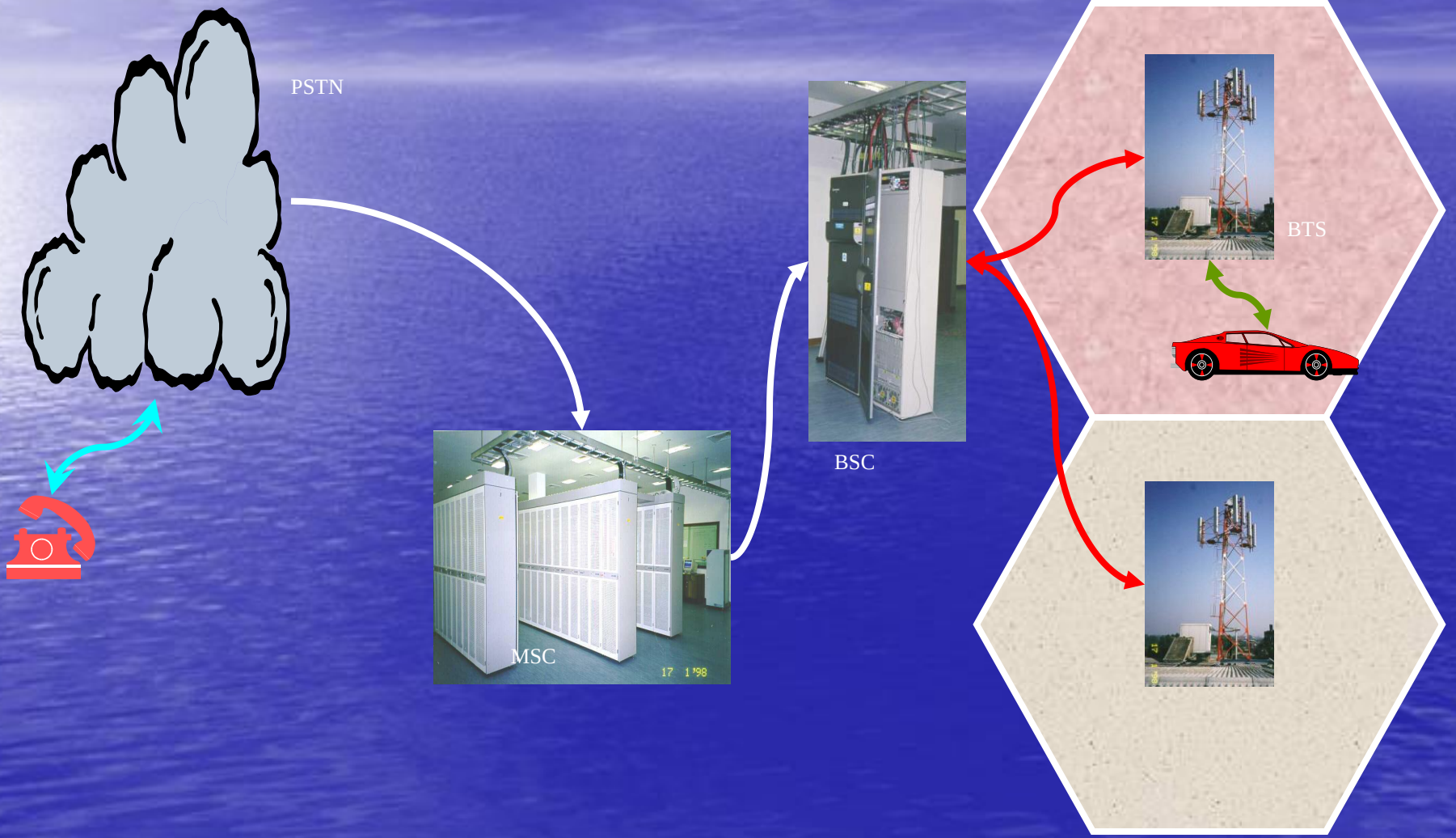
BCCH: Broadcast Control Channel
FCCH: Frequency Correction Channel
SCH: Synchronisation Channel
PCH: Paging Channel

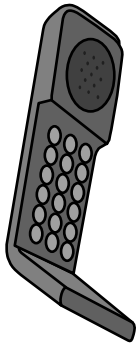
AGCH: Access Grant Channel
RACH: Random Access Channel
SDCCH: Stand-alone Dedicated Control Channel

SACCH: Slow Associated Control Channel
FACCH: Fast Associated Control Channel
TCH: Traffic Channel

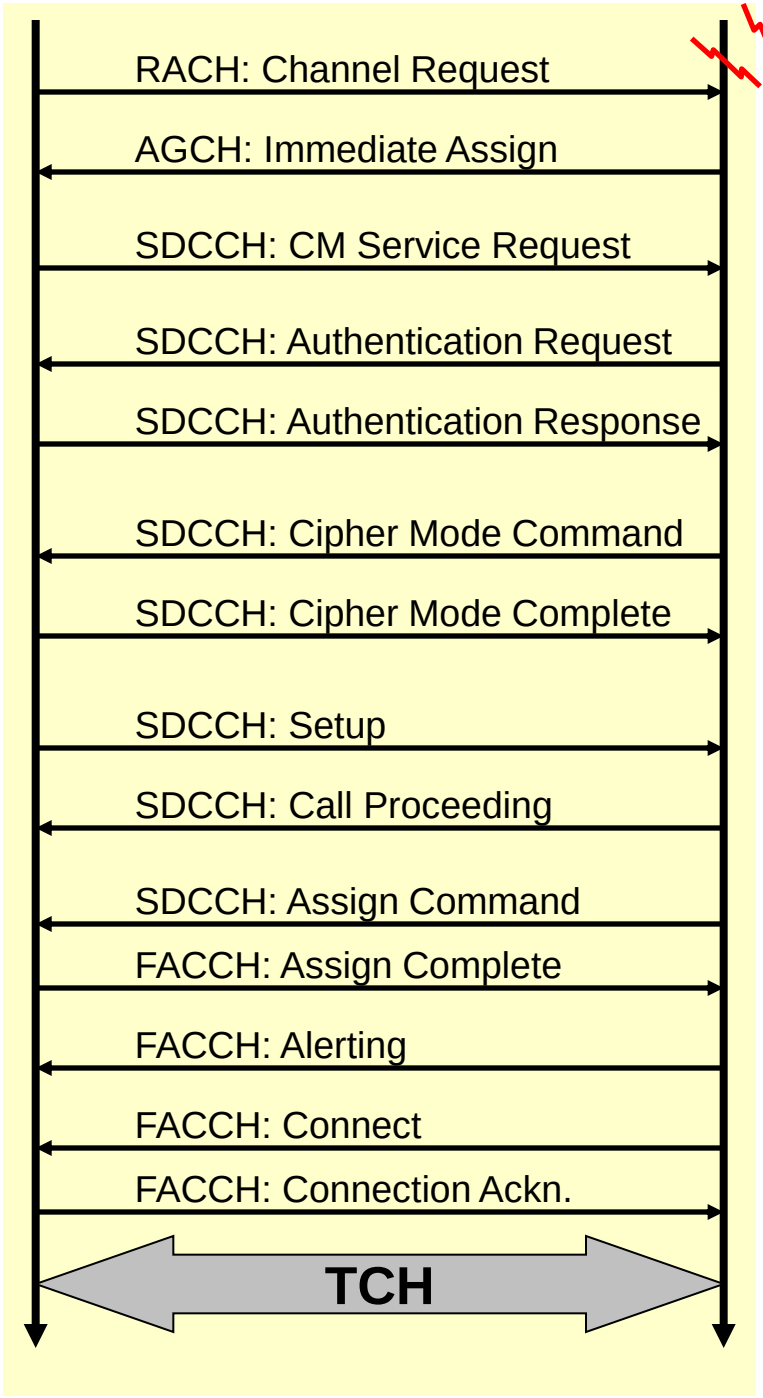
Fig. 11 (TM2100EU03TM_0001 Radio Interface, 23)

MOBILE TO LAND





MOC
Mobile Originating Call



MS requests for signaling channel

Signaling channel allocation [SDCCH x, TA]

Request MOC (SMS, Emergency Call,..) [TMSI/IMSI]

Request Authentication [RAND]

Authentication Response [SRES]

Start Ciphering [A5-X]

Acknowledgement; 1st ciphered message

Setup Message [Called No.]

Requested Service possible
(after subscriber profile check in VLR)

TCH-Allocation [frequency, TS]

Acknowledgement on TCH resource

“Ringing at B-Subscriber”,
start ringing signal in MS

“B-Subscriber accept call”

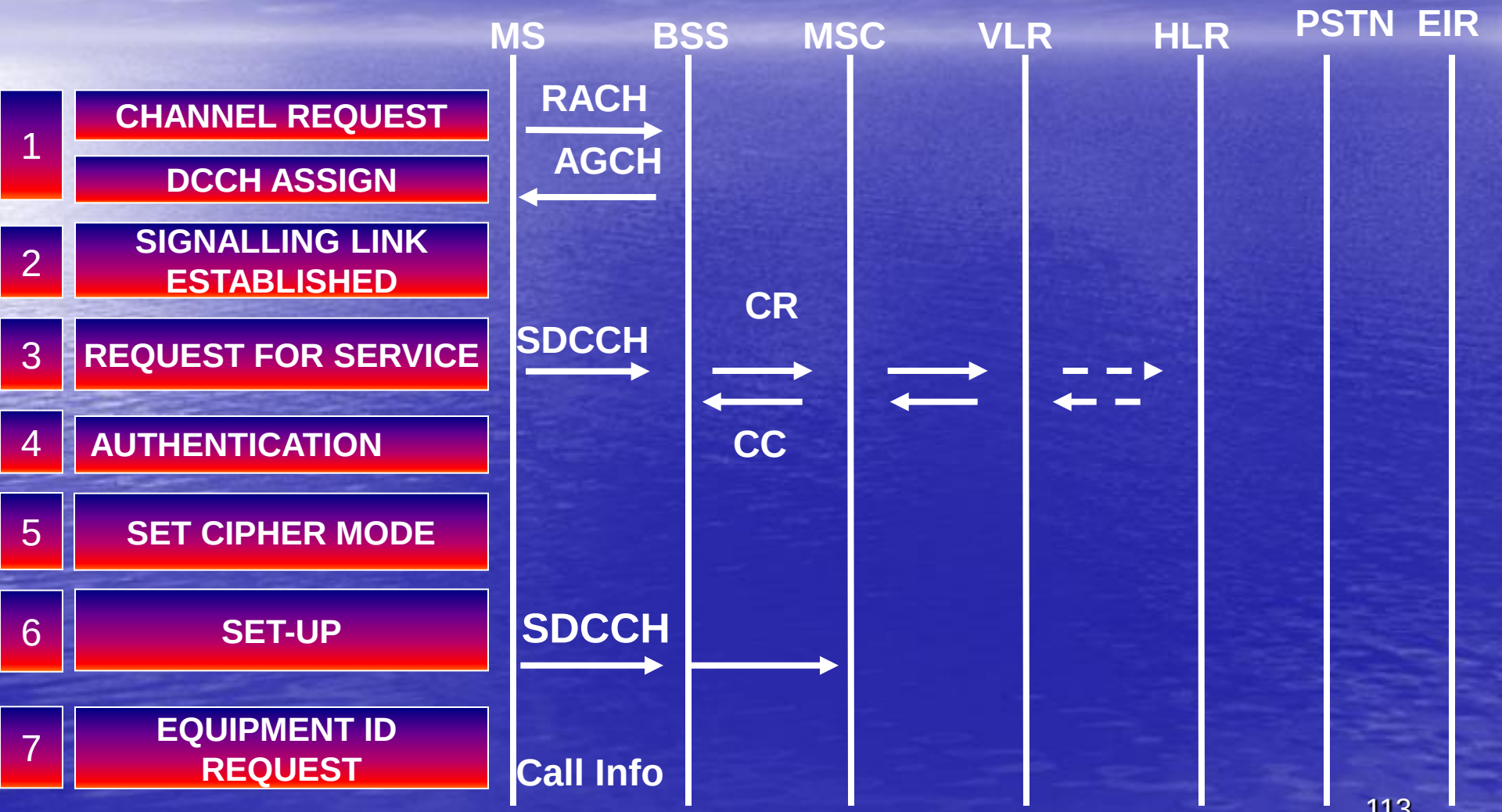
Acknowledgement
Start of user data transmission & charging

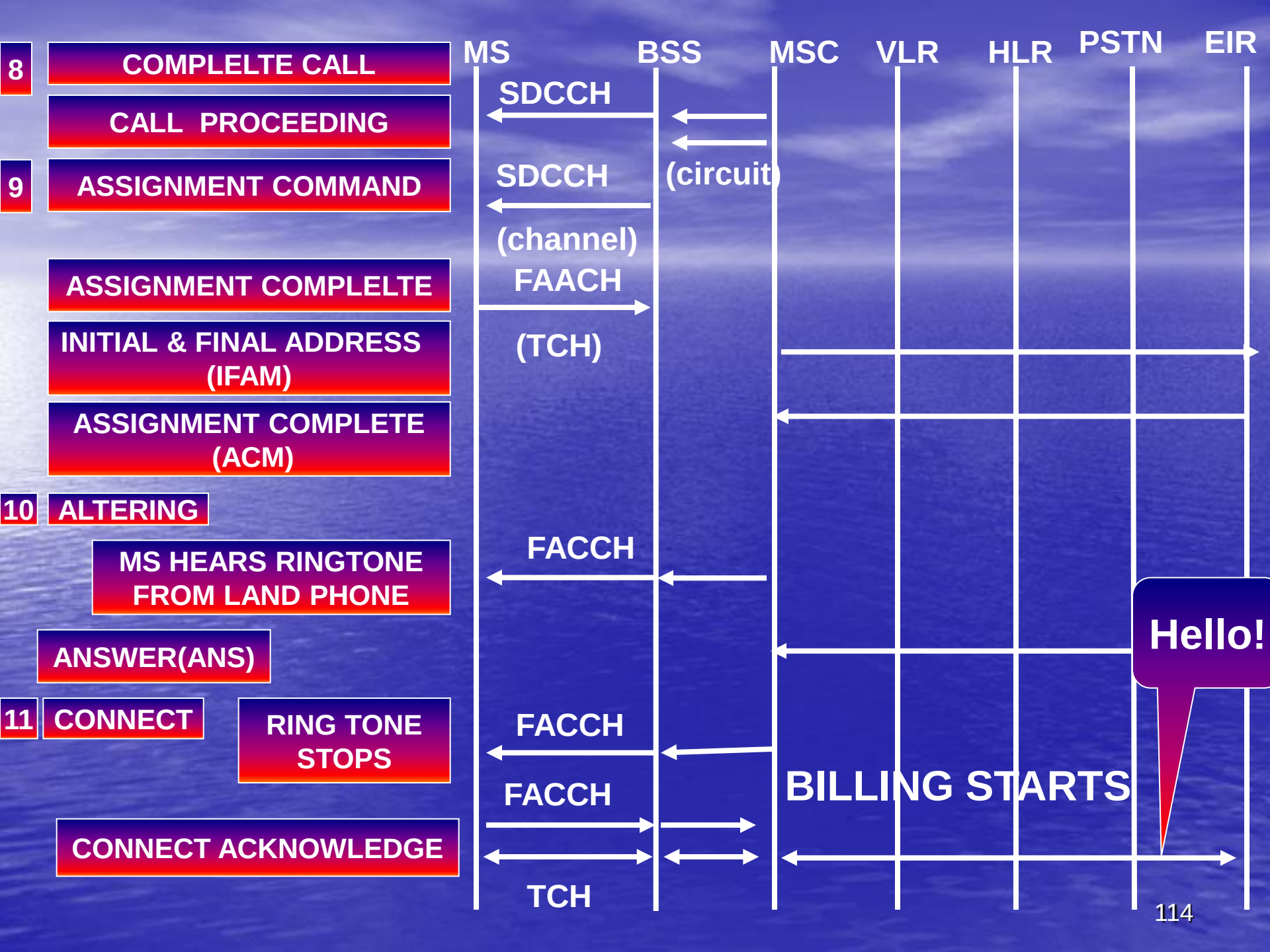
Fig. 17 (TM2100EU03TM_0001 Radio Interface, 35)

Call Scenarios

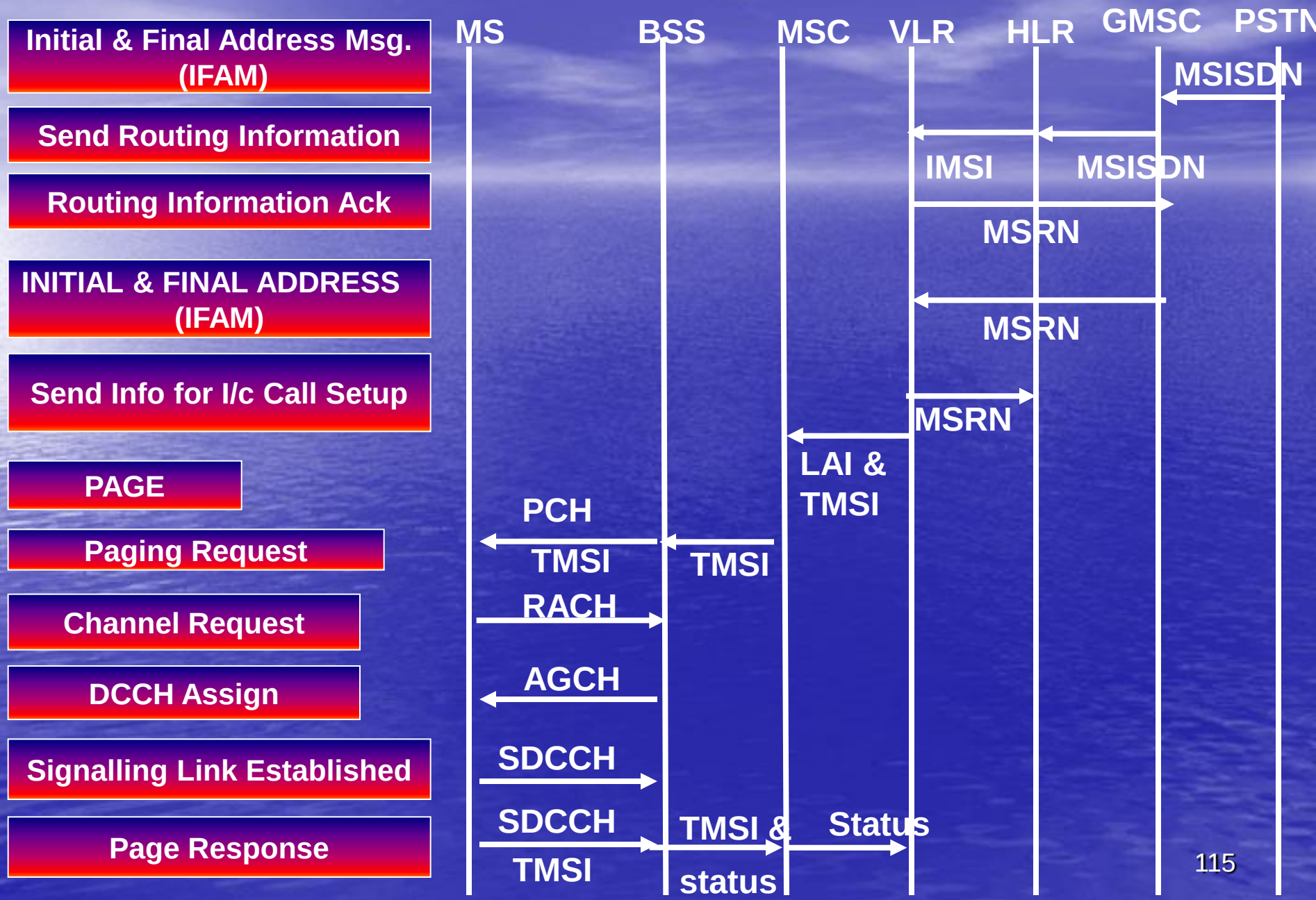
- Mobile to Mobile
  - Intra-city
  - Inter-city
- Mobile to Land
  - Intra-city
  - Inter-city
- Land to Mobile
  - Intra-city
  - Inter-city

Mobile To Land Sequence

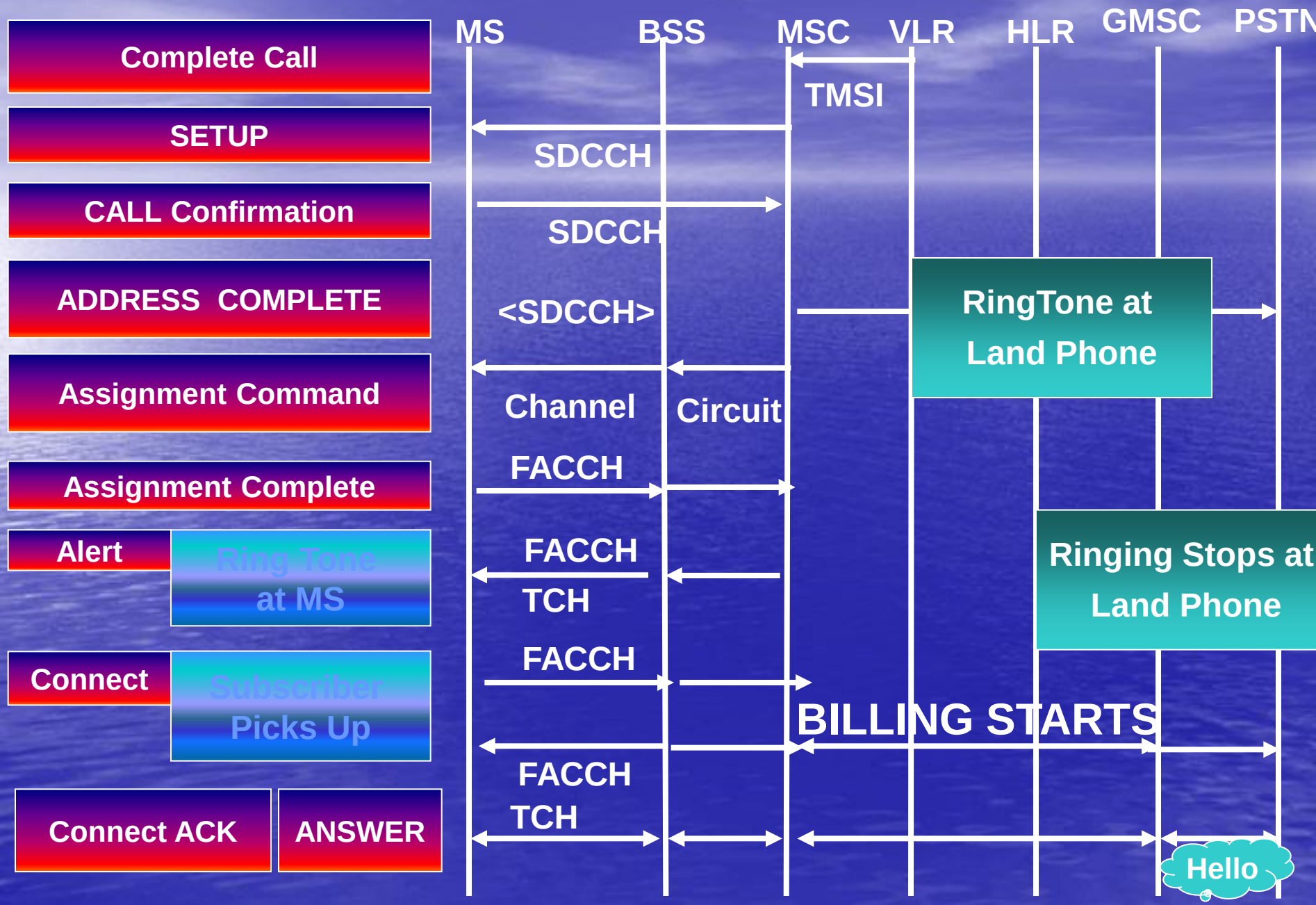



8
COMPLELTE CALL
CALL PROCEEDING
9
ASSIGNMENT COMMAND
ASSIGNMENT COMPLELTE
INITIAL & FINAL ADDRESS (IFAM)
ASSIGNMENT COMPLETE (ACM)
10
ALTERING
MS HEARS RINGTONE FROM LAND PHONE
ANSWER(ANS)
11
CONNECT
RING TONE STOPS
CONNECT ACKNOWLEDGE
MS
BSS
MSC
VLR
HLR
PSTN
EIR
SDCCH
(circuit)
SDCCH
(channel)
FAACH
(TCH)
FACCH
FACCH
FACCH
TCH
BILLING STARTS
Hello!

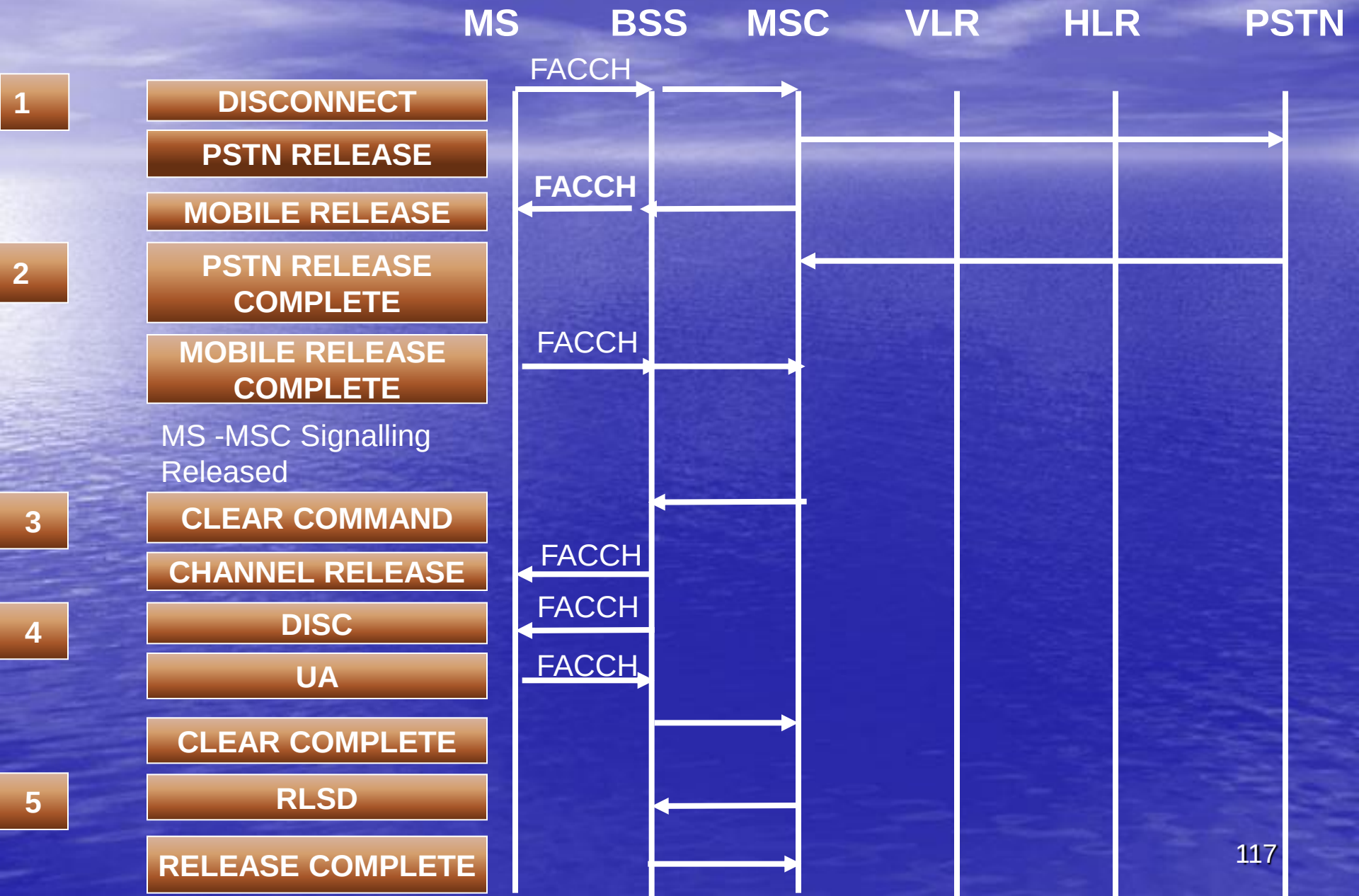
Land to Mobile Sequence



Land to Mobile Sequence

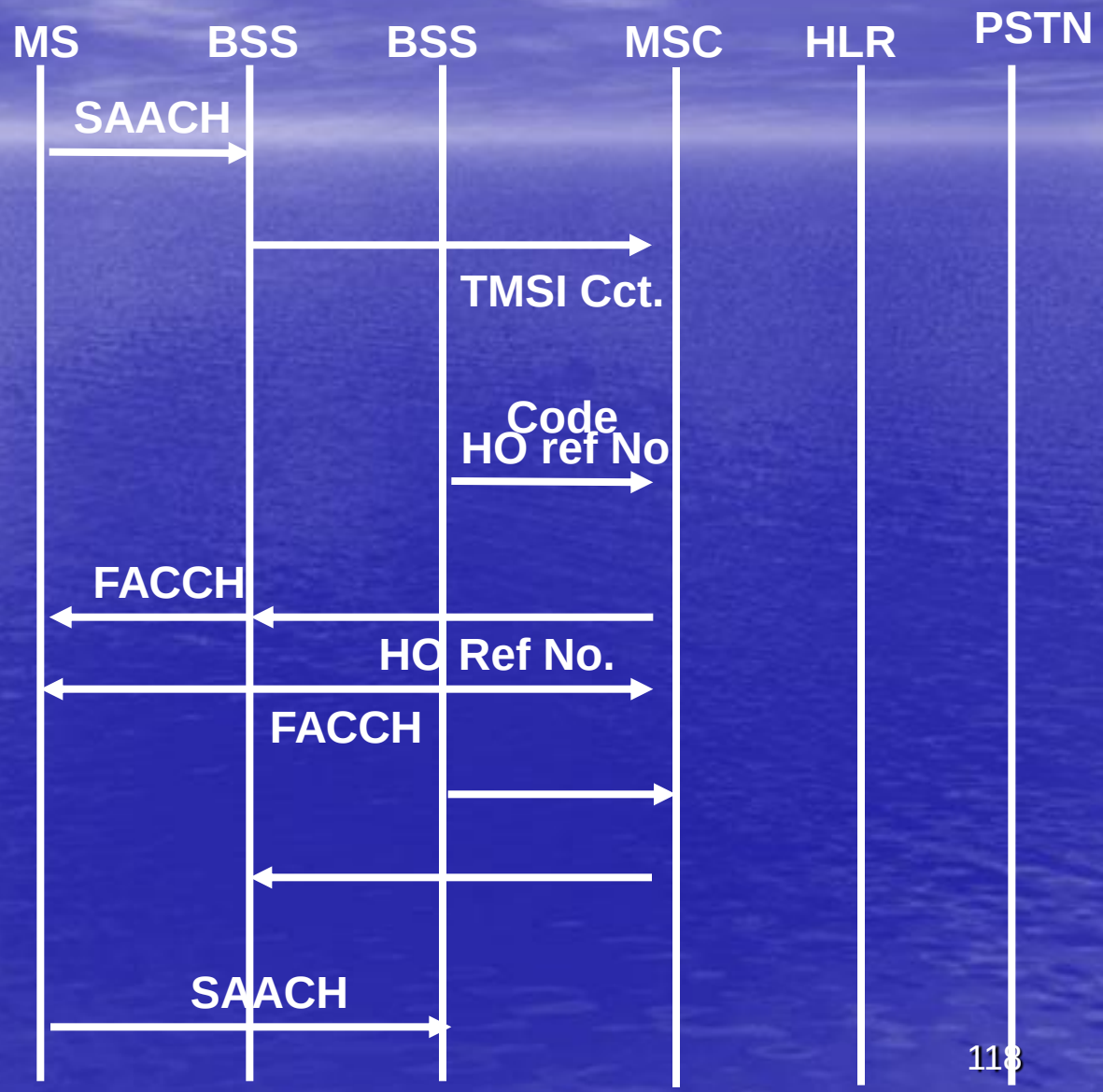


Mobile Initiated Call Clearing



Inter-BSS Handover Sequence

1	Periodic Measurement Reports
2	Handover Required
3	Handover Request
4	Handover Req Ack
5	Handover Command
6	Information Interchange
7	Handover Complete
8	Clear Command
9	Periodic Measurements Reports



RADIO OPTIMISATION

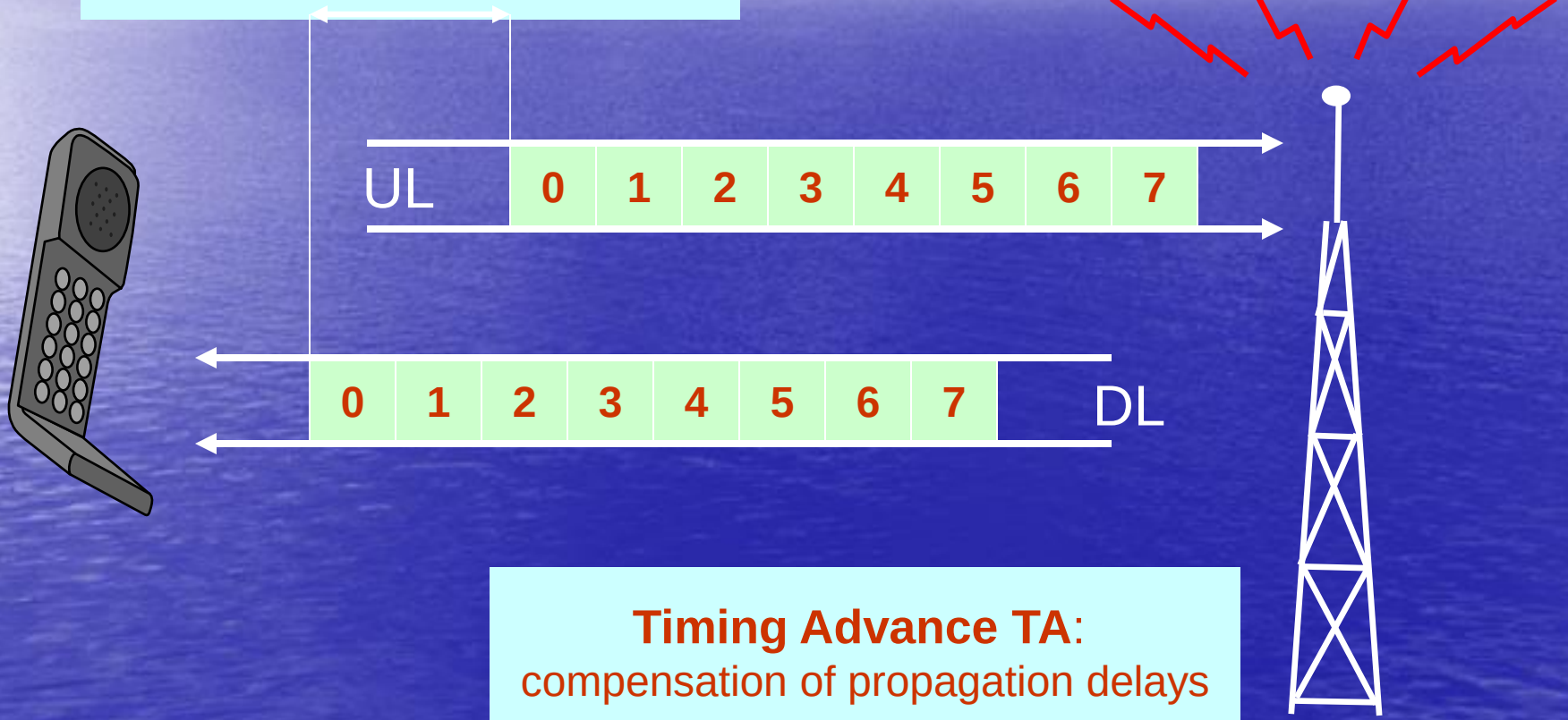
Radio Interface Optimization

- Transmission Timing
- Power Control
- VAD and DTX
- Multipath Fading
- Equalization
- Diversity
- Frequency Hopping

Adaptive frame alignment / Timing Advance TA

Adaptive frame alignment:
preventing simultaneous transmission / receiving

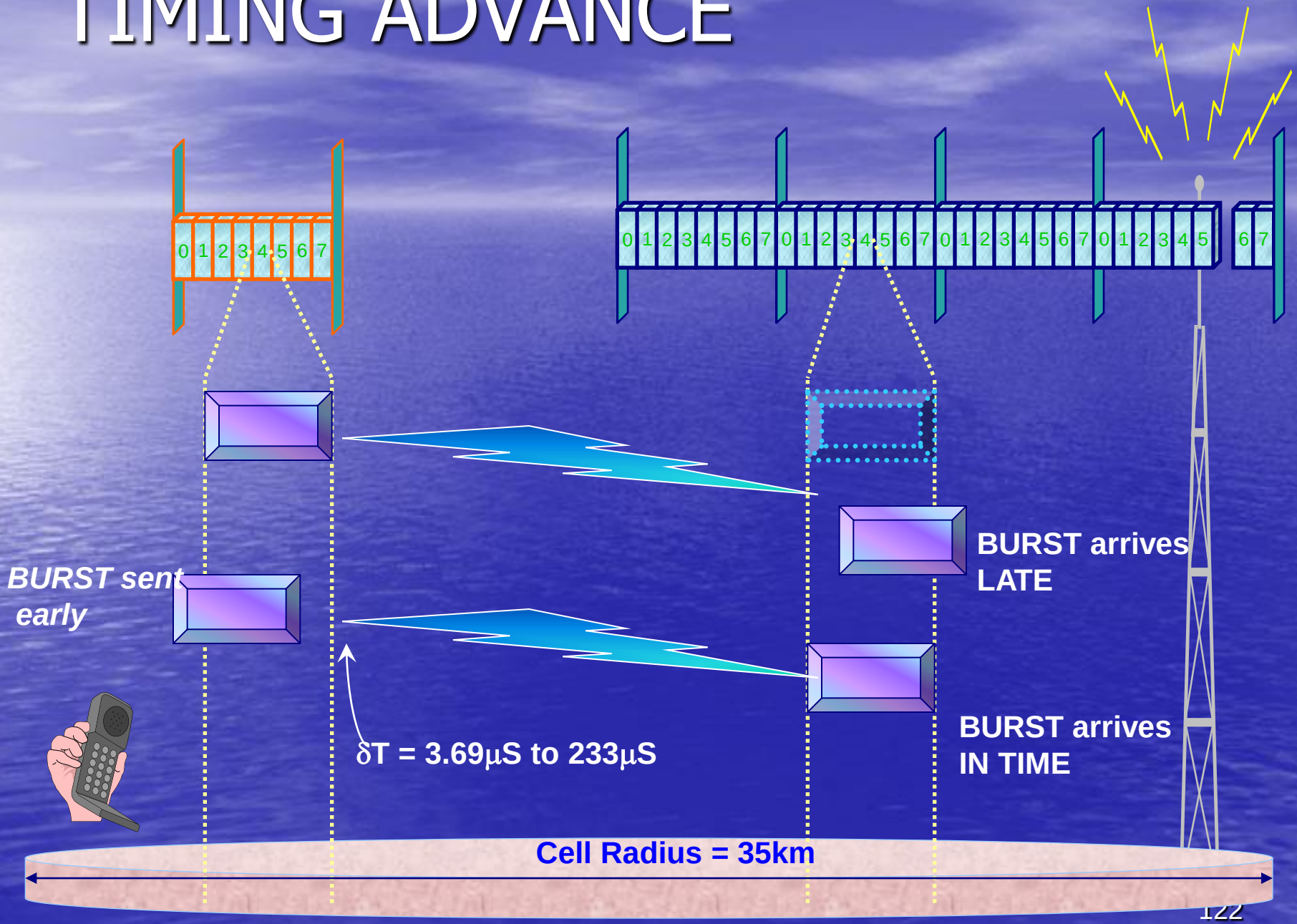
UL/DL shifted by 3 TS



Timing Advance TA:
compensation of propagation delays

BTS commands MS to transmit earlier:
2 x propagation time MS - BTS

TIMING ADVANCE



Power Control

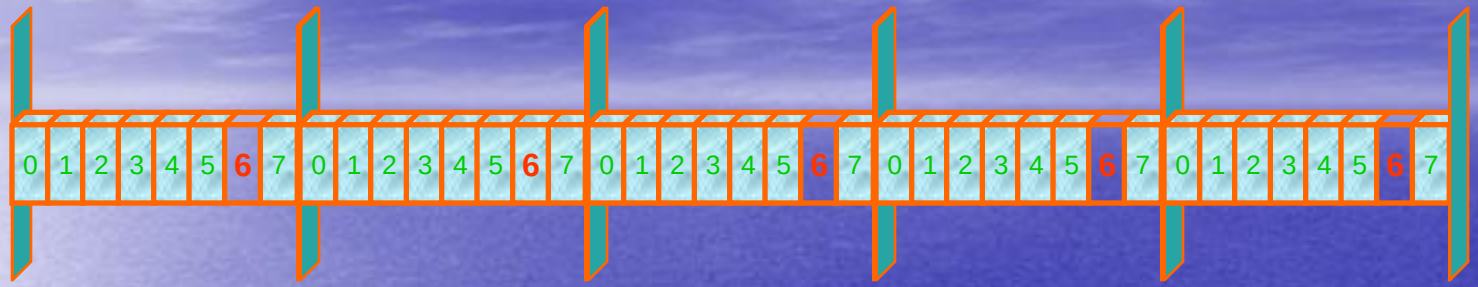
- In steps of 2dB
- Enhances Battery Life
- Reduces Interference

13 dBm (min)

33 dBm (max)

Cell Radius = 35km

Dis-Continuos Transmission



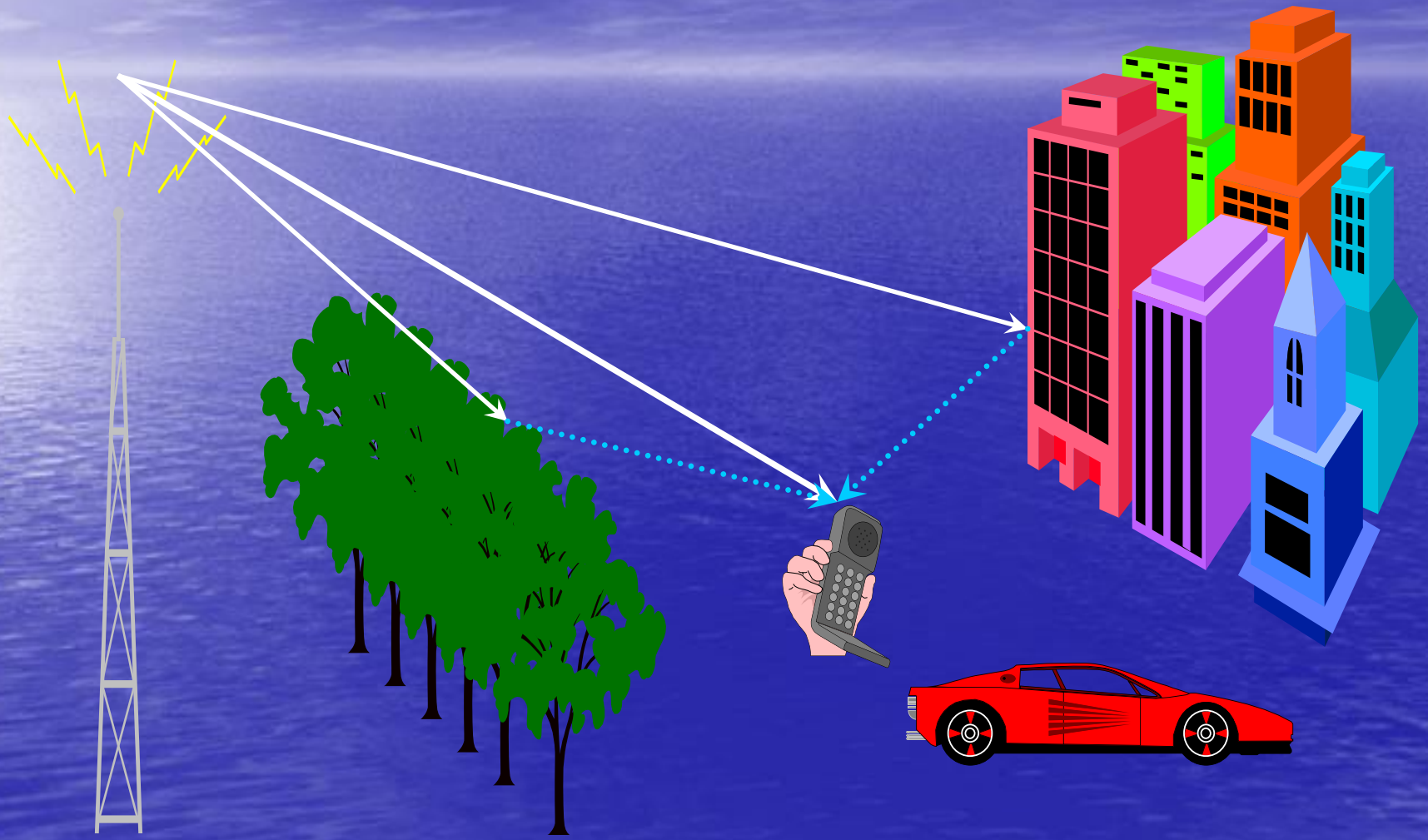
VAD - Voice Activity Detection

- **MS identifies presence/ absence of speech**
- **Generates Comfort noise**

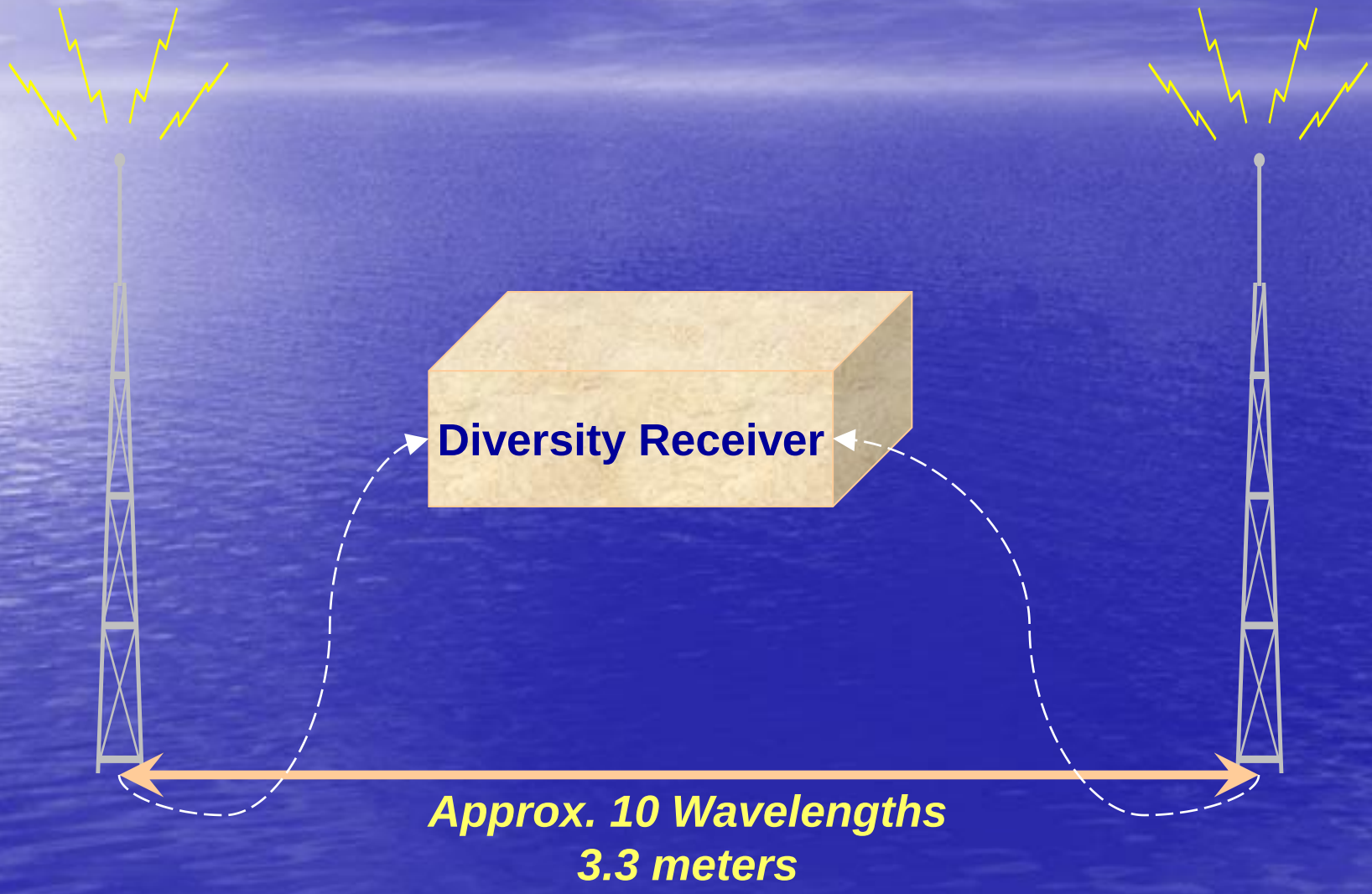
DTX - Dis-Continuous Transmission

- **MS does not TX during silence period**

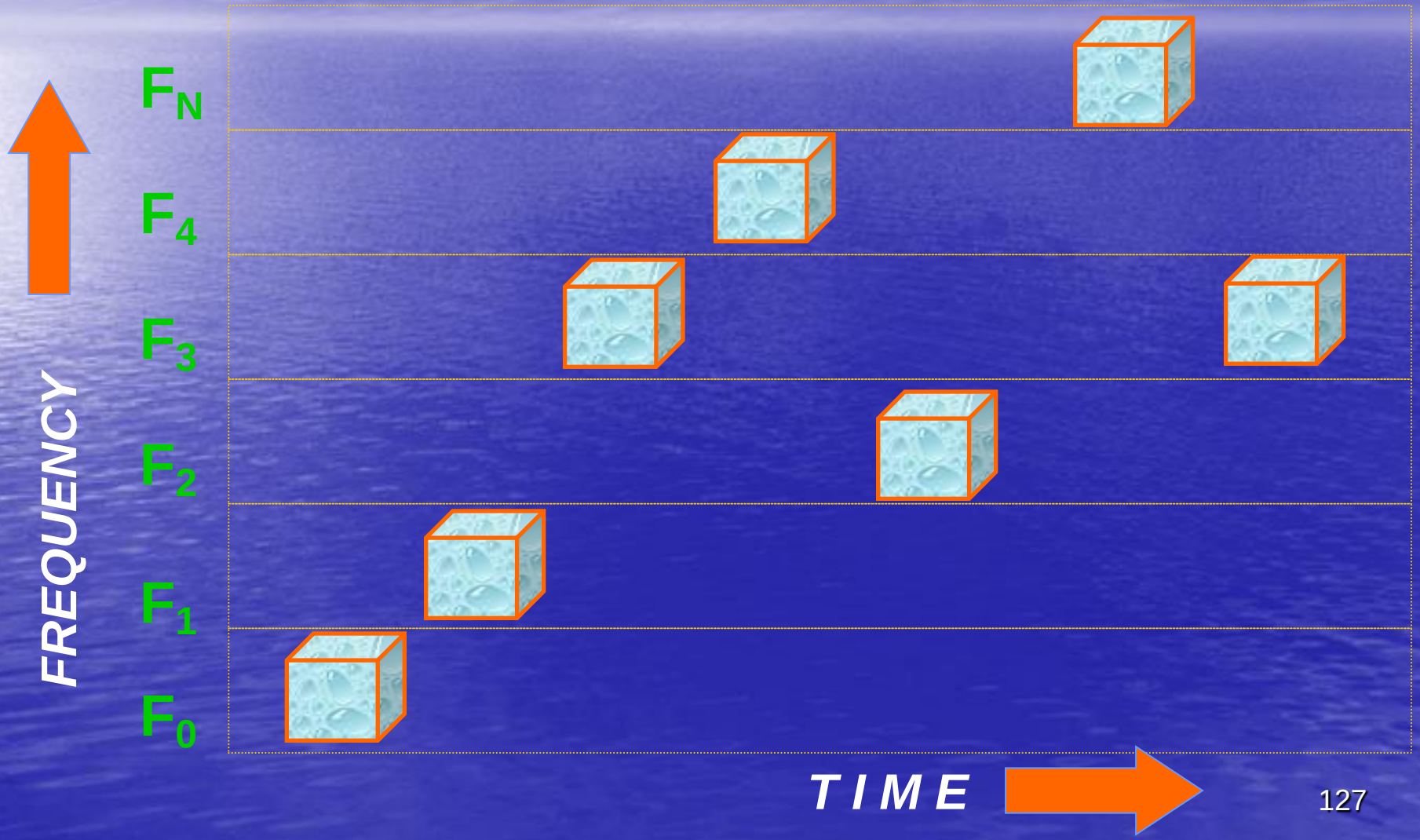
MULTI-PATH PROPAGATION



DIVERSITY



FREQUENCY HOPPING



GSM FEATURES

Speech Services

- Telephony (13 kbps full rate)
- Emergency Call (with/without SIM card in the Mobile Station)
- Short Message Services (SMS)
- Point to Point (128 Byte Max.)
- Cell Broadcast(75 bytes Max.)
- Dual Personal and Business Numbers.
  - Allows calls to be made and billed, either to business or personal numbers.

Data Services (Bearer Services)

- Data rates supported as of today are
  - 2.4 Kbps
  - 4.8 Kbps
  - 9.6 Kbps

Supplementary Service - Call Waiting

Supplementary Services - Call Hold

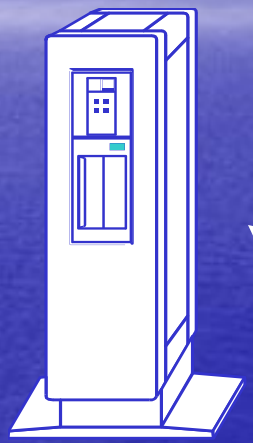
1. Call in Progress

2. Put on Hold

3. Calls another Mobile

Supplementary Services - Call Forwarding

Voice Mail System



Divert if

- All Calls
- Busy
- Not Reachable
- No Answer

Incoming Call

Supplementary Services

- Calling Line Identification
  - Present
  - Absent
- Connect Line Identification
  - Present
  - Absent
- Closed User Group - CUG
  - Only incoming
  - Only outgoing
- Operator Controlled Barring


THANK YOU