MOBILE WIRELESS COMMUNICATIONS

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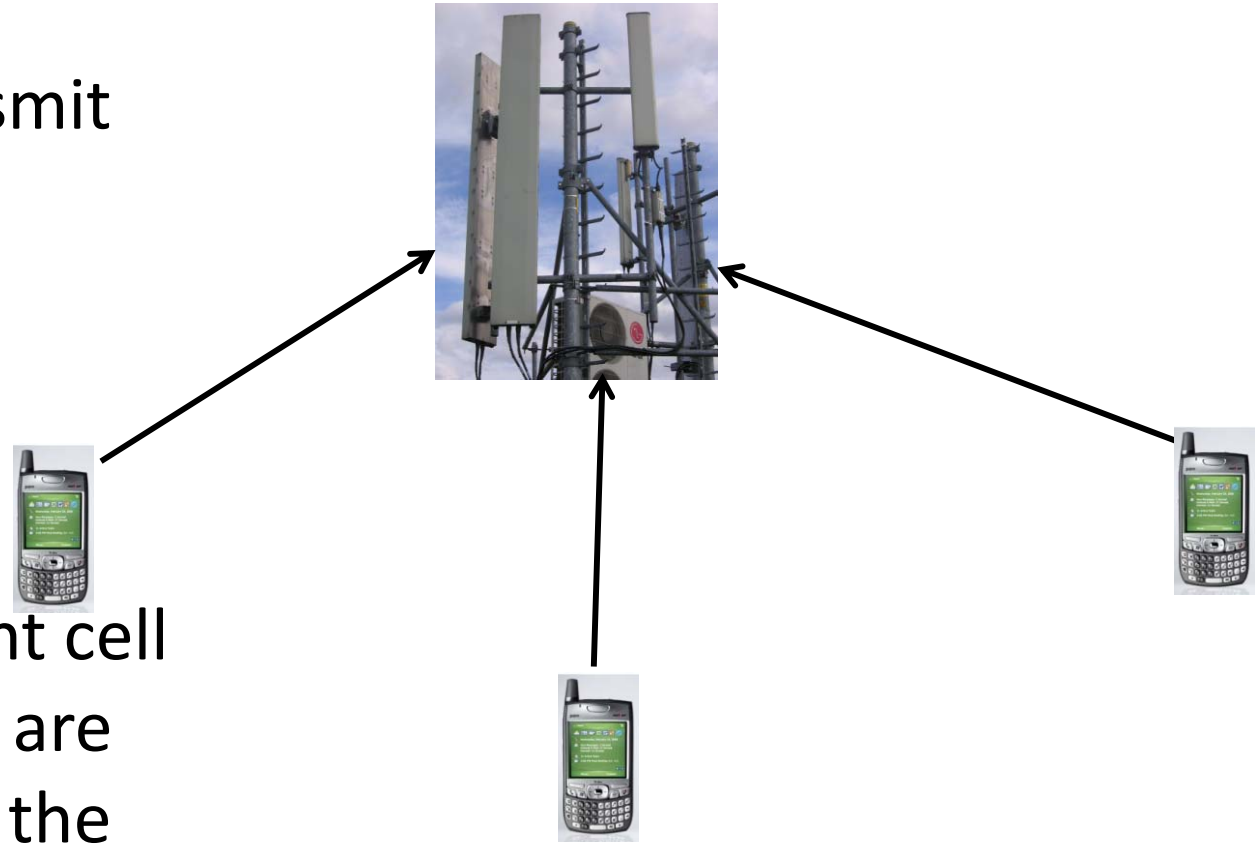
Wireless Communications

- Channel is the air medium.
- Multiple users can simultaneously transmit over the air medium



- For instance, different cell phone users in a cell are trying to transmit to the Base Station.

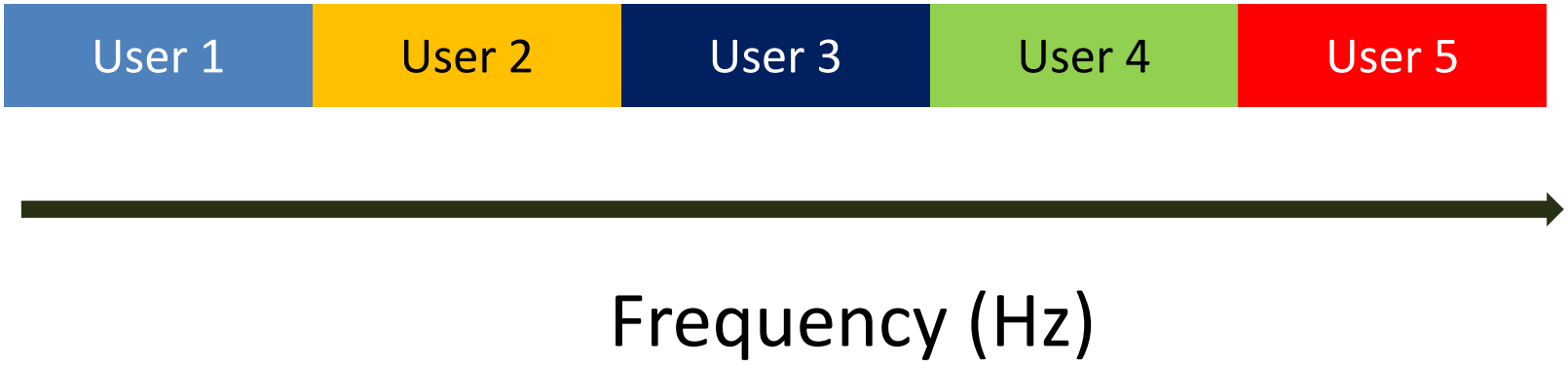
Wireless Communications

How to allocate the medium to a certain user?

The answer is **Multiple Access** (MA) technology!

Multiple Access Technologies

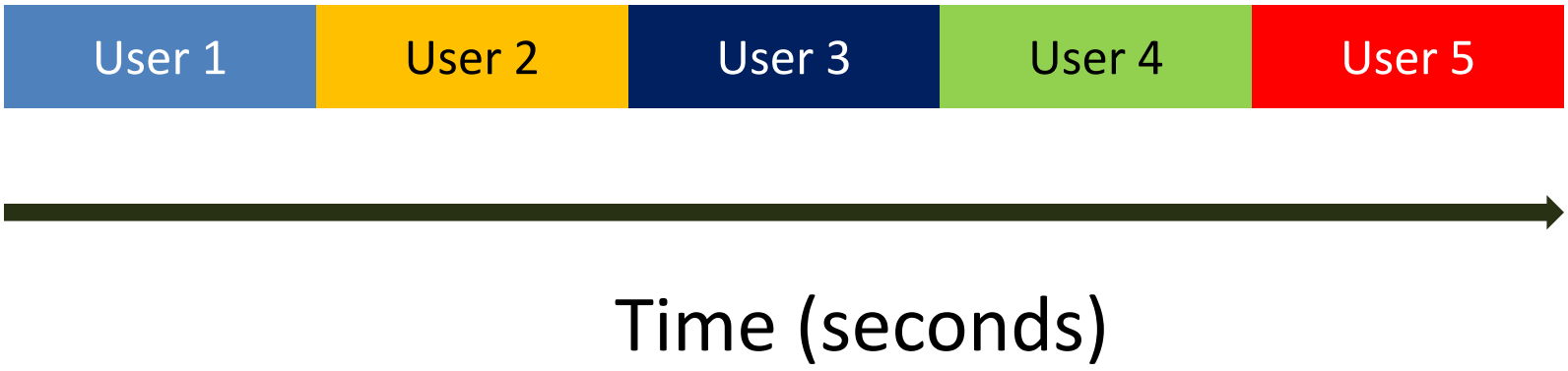
- FDMA – "Frequency Division for Multiple Access"
- Each user is allocated a different frequency band.
  - Forms the 1st Generation or 1G Mobile Technology



An FDMA Phone

Multiple Access Technologies

- TDMA – Time Division for Multiple Access.
- Each user is allocated a certain time “slot” for information transmission.



GSM uses TDMA!

Introduction to GSM

- GSM (*Global System for Mobile Communication*)is an ETSI (European Telecommunication Standards Institute) standard
  - For 2G pan-European digital cellular with international roaming.
- Formed in 1982 by allocating the bands 890-915 MHz and 935-960 MHz for Pan-European PLMN (*Public Land Mobile Network*).

Introduction to GSM

- Main Charter
  - To develop a unified 2G standard to resolve the roaming problem in Europe, with six 1G standards.

Introduction

- GSM went beyond the air-interface and defined a system that complied with ISDN (*Integrated Services Digital Network*) like services.
  - ISDN provides data services over traditional telephone network or PSTN (*Public Switched Telephone Network*)
- Hence, GSM is a robust digital cellular standard.

Timeline – Brief History of GSM

1982	Frequency bands allocated for Pan-European PLMN (*Public Land Mobile Network*).
1986	GSM Task Force formed
1987	Memorandum of understanding signed.
1989	ETSI officially included GSM in its domain. Name of the group was changed to Special Mobile Group (SMG). Hence, the resulting standard was named GSM (***Groupe Spécial Mobile***).
1991	Specification completed.
1992	First deployment
1993	32 Operators in 22 countries.
2001	Deployed in close to 150 countries.

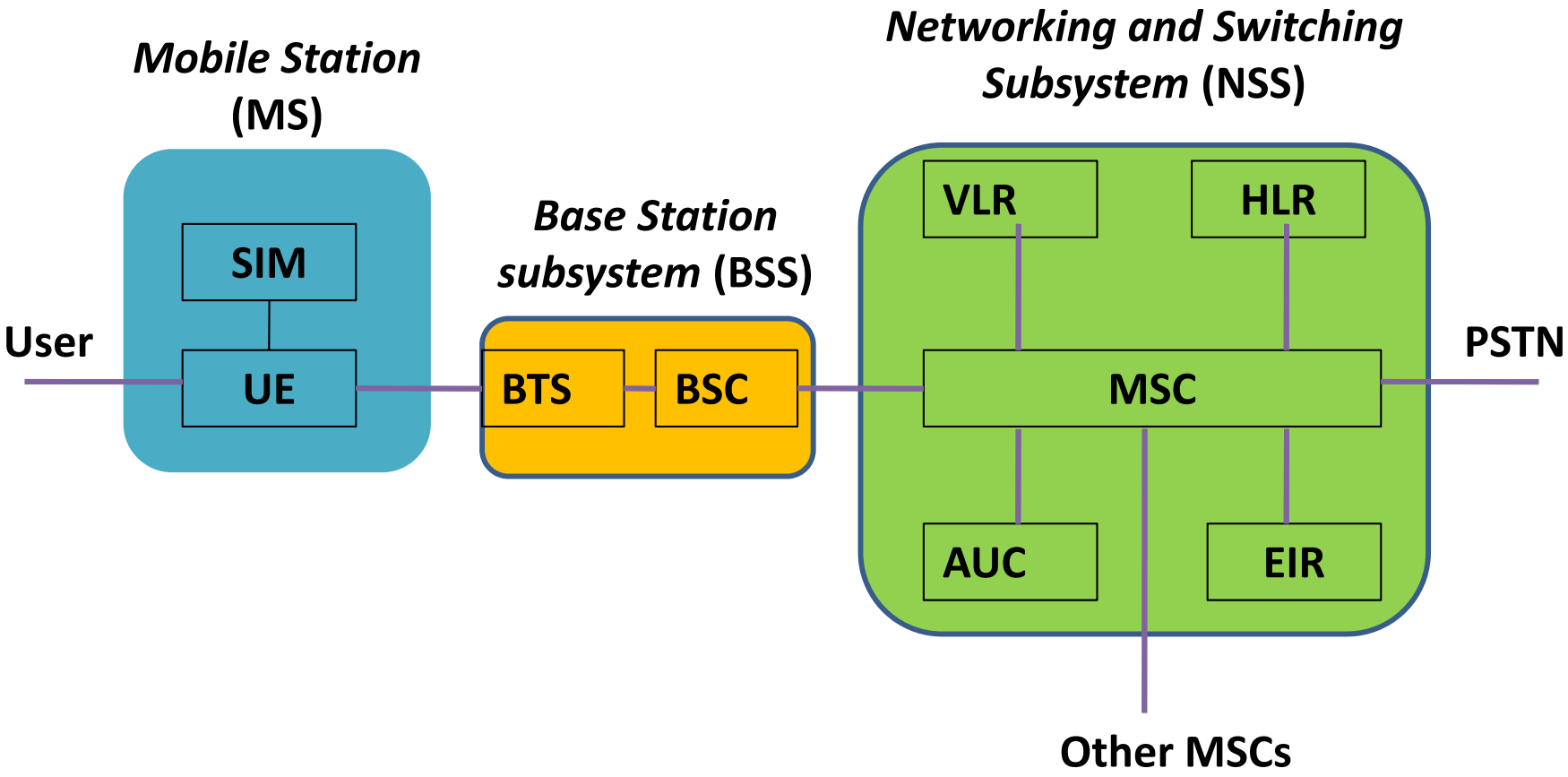
GSM Services

- Analog cellular systems were designed for the sole purpose of voice traffic similar to PSTN.
- GSM is an integrated voice-data service that provides a number of services beyond voice.

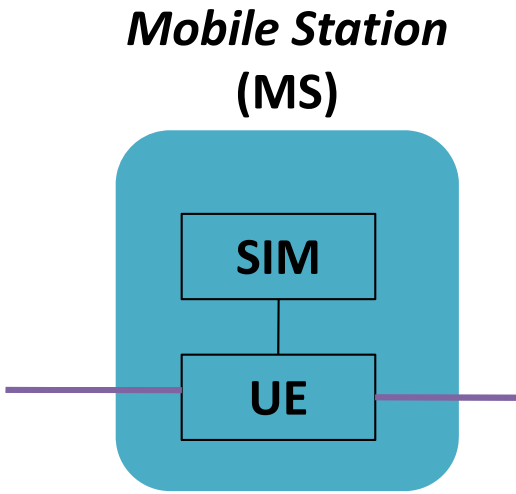
GSM Reference Architecture

- Wireless standard description involves
  - Detailed terminal specs.
  - Fixed hardware (H/W) backbone.
  - Software (S/W) databases for operational support.
- GSM is organized into three major segments.
  - Mobile station (MS).
  - Base station subsystem (BSS).
  - Network and switching subsystem (NSS).

GSM Reference Architecture

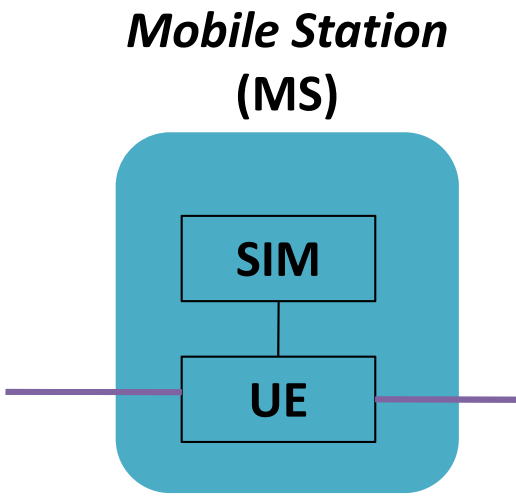


Mobile Station (MS)



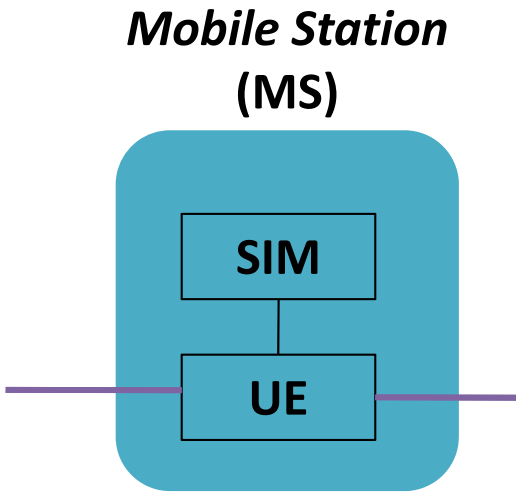
- Functionality
  - Communicates information with user.
  - Demodulates radio signals, extracts digital voice
  - Modifies user info for transmission over the air-interface to communicate with the BS.
- MS has two elements
  - Mobile Equipment (ME)
    - Purchased from equipment vendor.
    - Components include speaker/microphone and the *radio modem* (modulation-demodulation).

Mobile Station (MS)



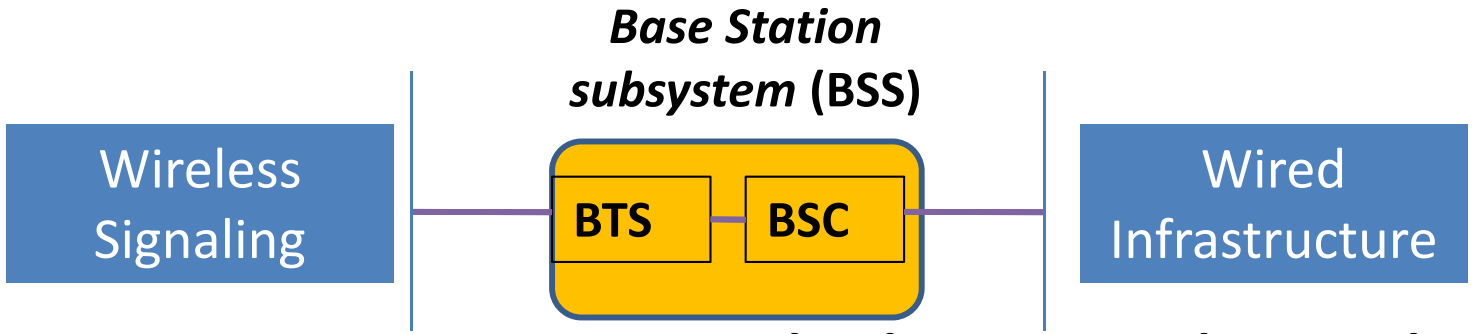
- Subscriber Identity Module (SIM)
  - Smart card issued at the subscription time identifying the user specs such as operator, service type.
    - Identity of user in the mobile network
  - Calls in GSM are directed to the SIM rather than the terminal
  - SMS (Short Message Service) messages are also stored in the SIM.

Mobile Station (MS)



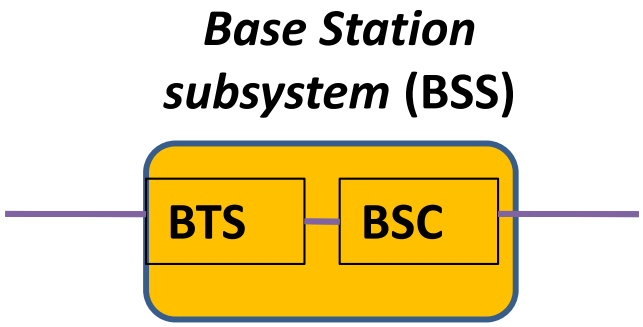
- SIM has a significant impact on the way that a user transacts with the service provider.
  - For instance, determines charging, roaming etc.
- SIM carries the user personal information, which enables a number of useful applications.
- SIM is identified with an IMSI (*International Mobile Subscriber Identity*) for the internal network.

Base Station Subsystem (BSS)



- BSS communicates with the user through the wireless air-interface (through ME).
- Communicates with the wired infrastructure through a different set of wired protocols.
- BSS provides for the translation from air-interface protocols to the wired medium protocols.
- Separates packet data from PSTN traffic.
  - To implement packet data services such as GPRS.

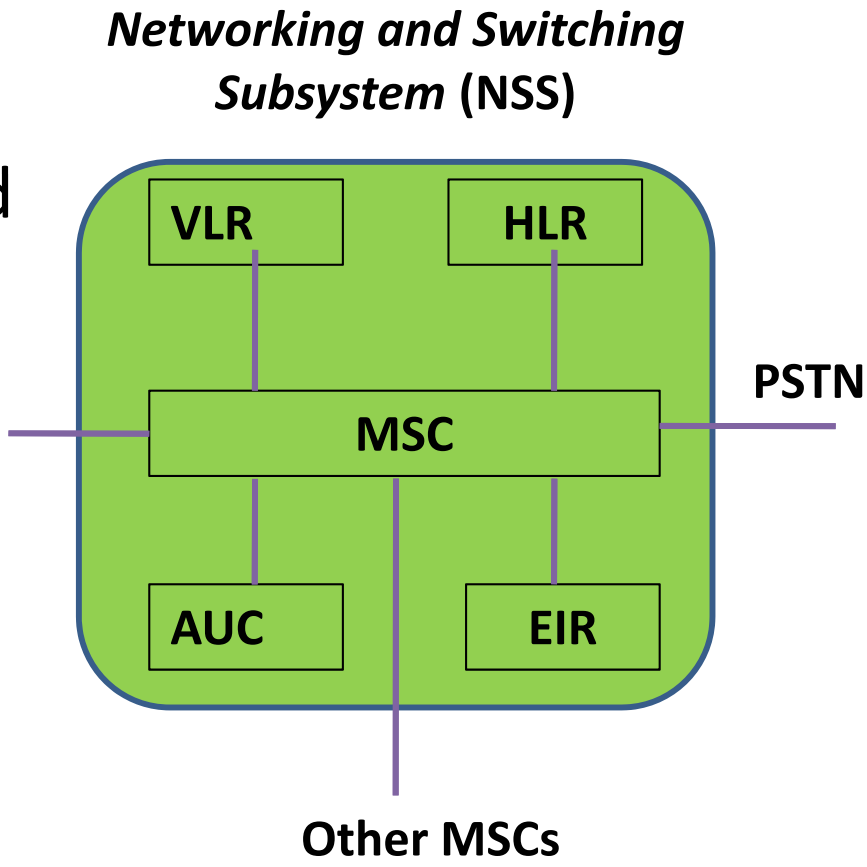
Base Station Subsystem (BSS)



- BSS has two architectural elements
  - Base Transceiver Station (BTS)
    - Counterpart of MS for physical communication.
    - Includes Tx, Rx and signaling equipment for Demod
    - One BSS may have several BTSs in its domain.
  - Base Station Controller (BSC)
    - Small switch inside the BSS that is in charge of frequency administration.
    - Also in charge of handover among the BTSs inside a BSS.

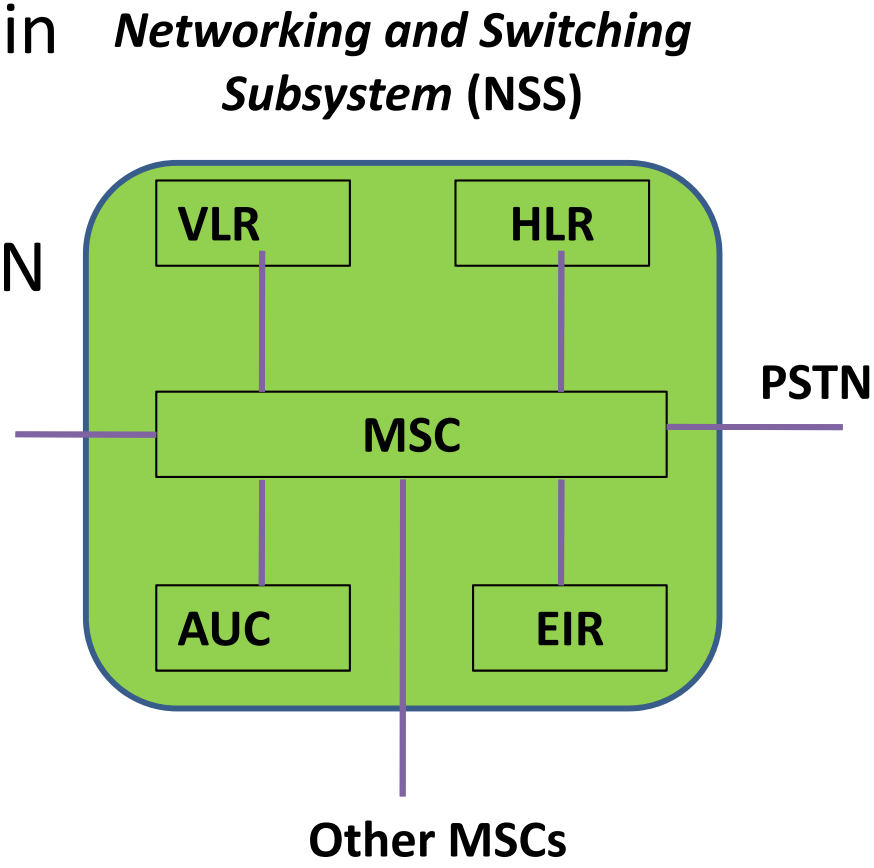
Network and Switching Subsystem

- NSS is master system responsible for network operation.
- It is responsible for
  - Communication with other wired and wireless networks.
  - Also support for registration and maintenance of the connection with the MSs.
- Connects to the PSTN (Public Switched Telephone Network) through ISDN protocols.
- It has one H/W element i.e. MSC and four S/W elements – VLR, HLR, EIR and AUC.



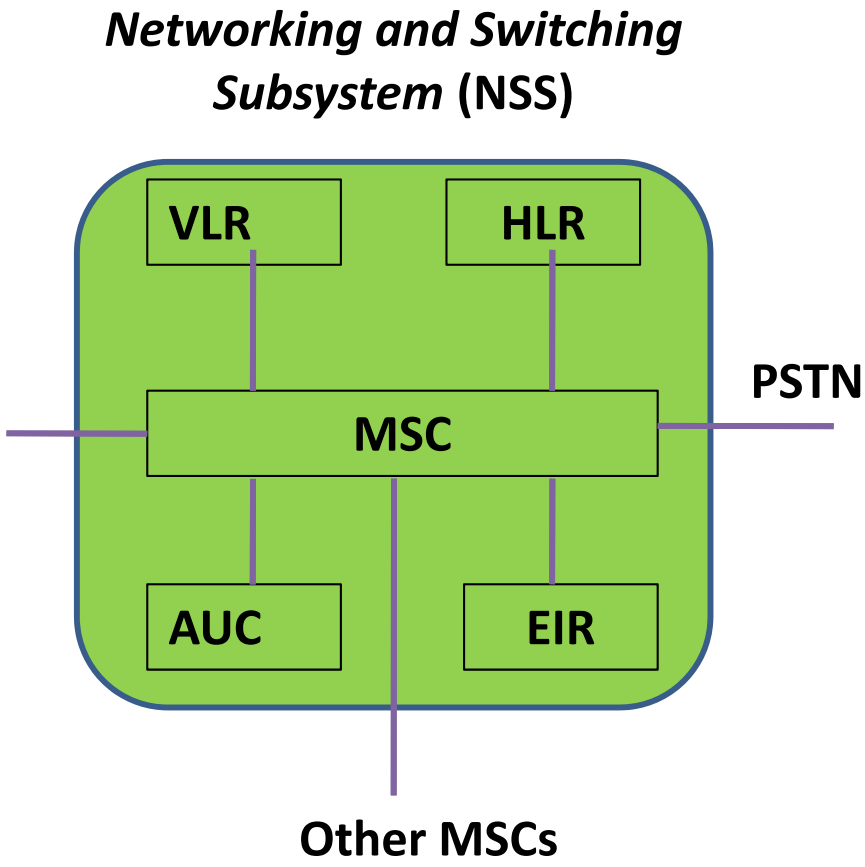
NSS Architectural Elements

- Mobile Station Controller (MSC)
  - The H/W part of the NSS.
  - Communicates with other MSCs in the coverage area of the service provider.
  - Also communicates with the PSTN switches.
    - This is the Gateway MSC (GMSC)
- Home Location Register (HLR)
  - Database S/W that handles management of the mobile subscriber account.
  - Stores the subscriber's address, service type, current location, forwarding address etc.



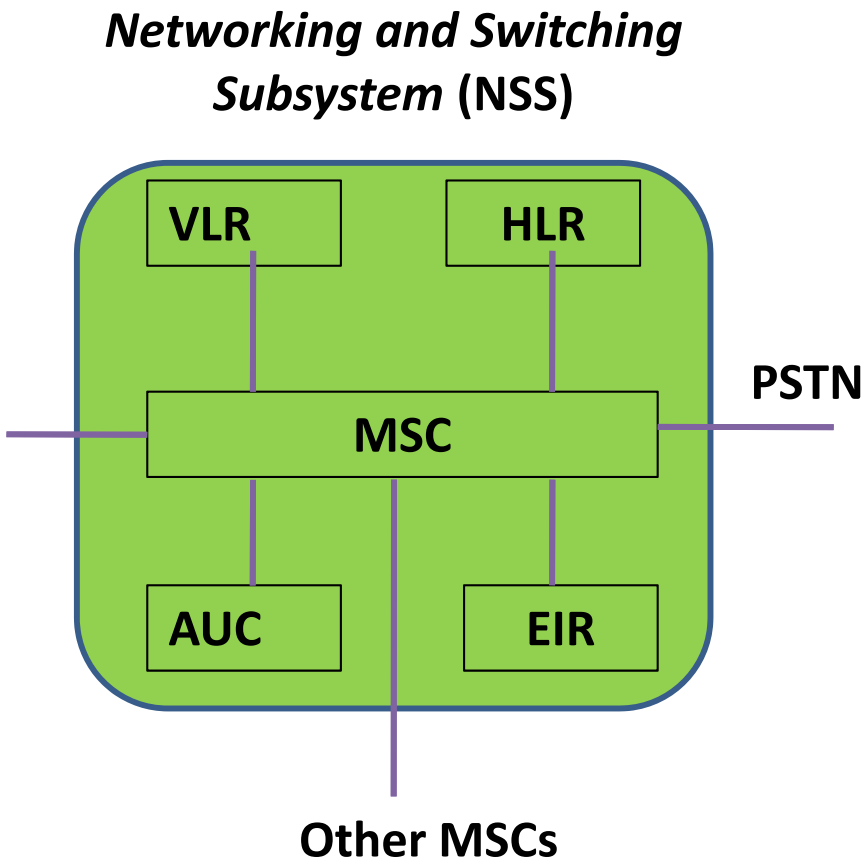
NSS Architectural Elements

- Visitor Location Register (VLR)
  - Temporary database S/W in *Visiting Cell*, similar to the HLR.
  - Identifies the subscribers *visiting* inside the coverage area of the MSC.
  - Thus, calls from Home MSC can be forwarded to visiting MSC.



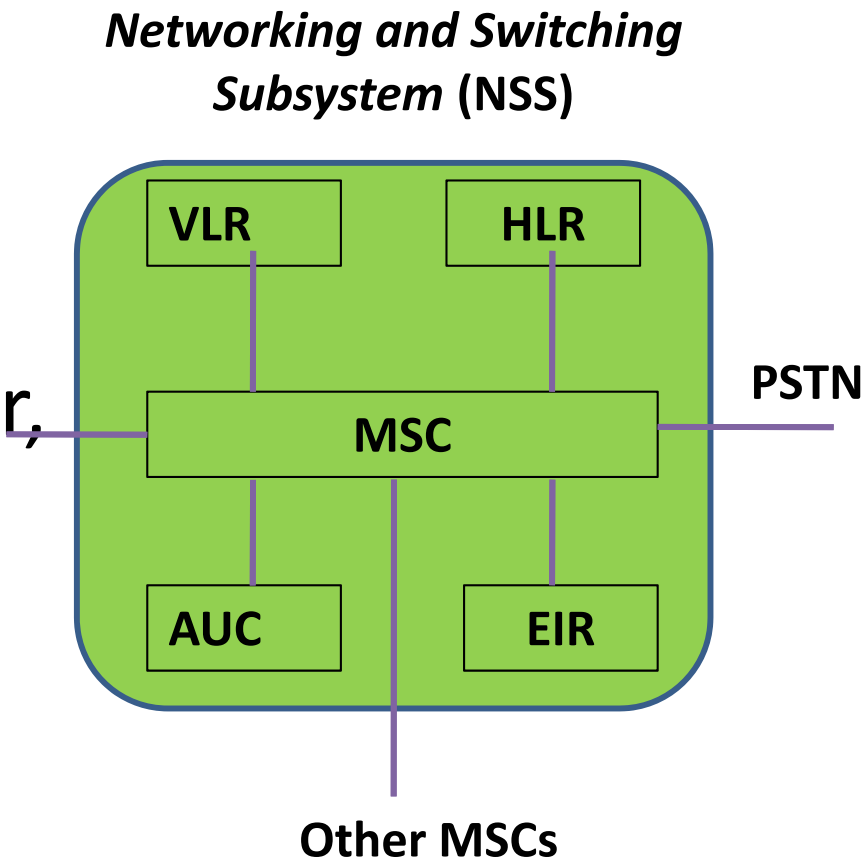
NSS Architectural Elements

- Authentication Center (AUC)
  - Holds different algorithms that are used for authentication and encryption of subscribers.
  - Different SIM cards have different algorithms and the AUC collects all of these algorithms.



NSS Architectural Elements

- Equipment Identification Register (EIR)
- Keeps the IMEI (International Mobile Equipment Identity) that reveals the manufacturer, country of production, terminal type.
  - Used to report stolen phones and to check if the phone is operating according to the service type.



GSM Basic Operation

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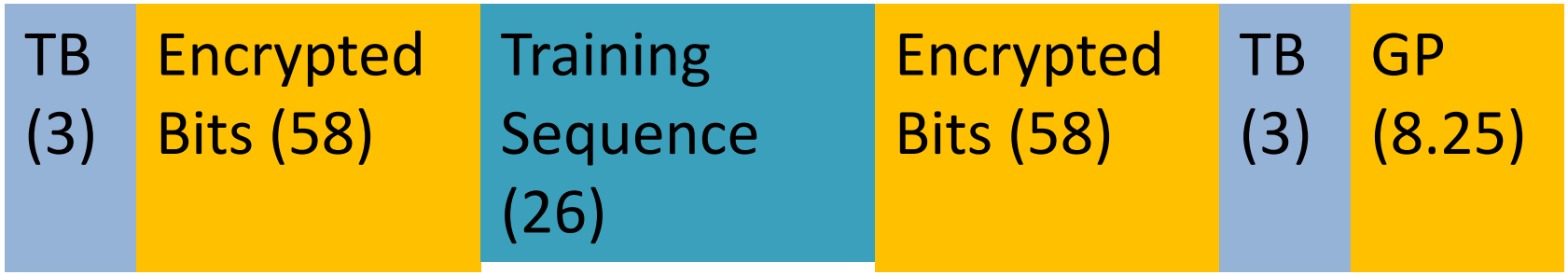
What happens in a GSM phone?

- GSM (Global System for Mobile) uses TDMA, ie Time Division for Multiple Access technology.
- Each user is allocated a time “slot” on a frame of data bits.
- The raw data rate of GSM is 270 Kbps.
- Each user transmits for 577 micro seconds
  - This corresponds roughly to 156 bits of information.
- 8 users use the same frequency band
  - Which implies that a frame size is 8 x 577 micro - secs or 4.615 ms.

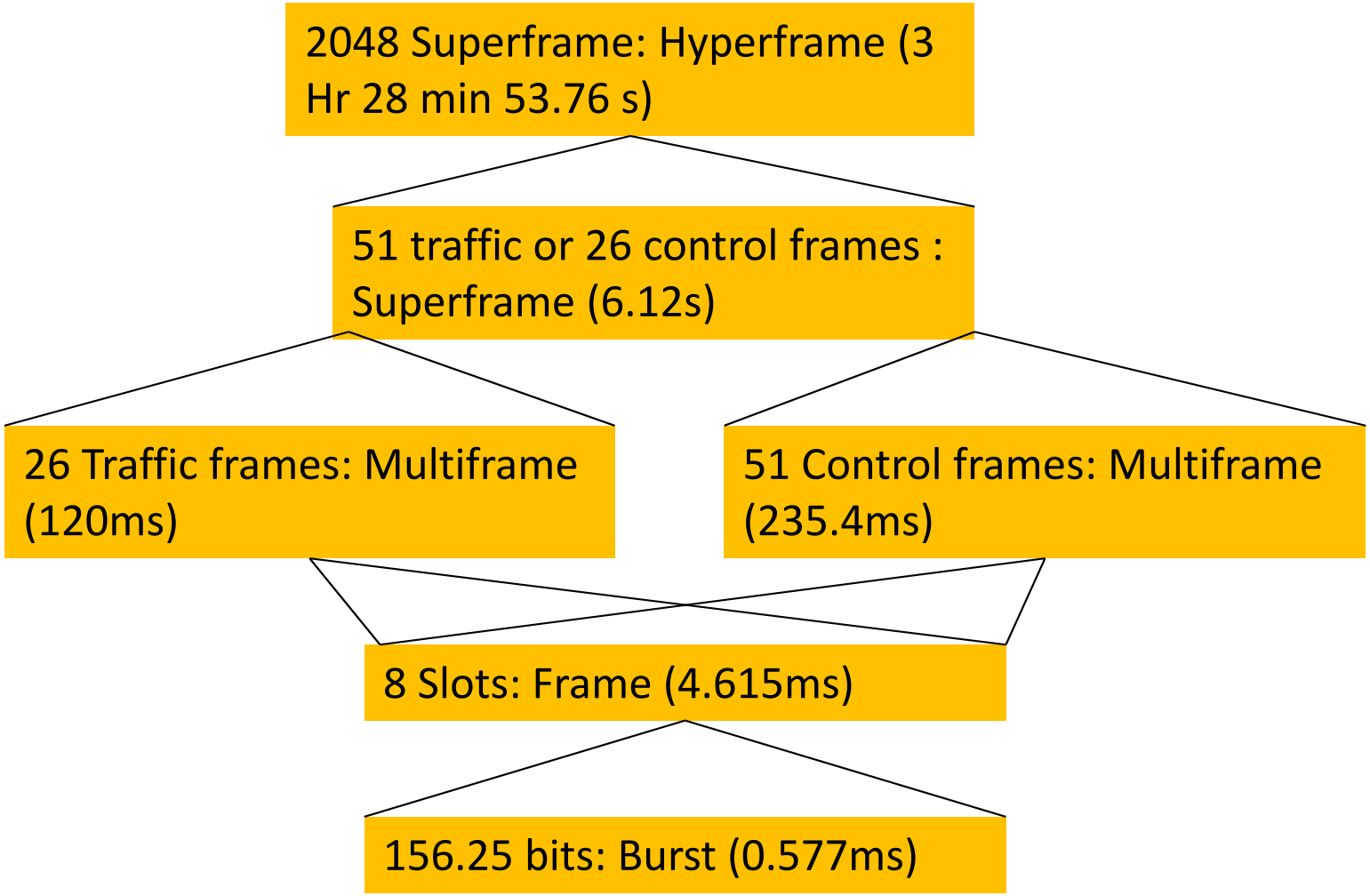
What happens in a GSM phone?

- Each segment of user data of 156 bits is known as a “Burst”.
- Each user burst has the following structure.



- The “Bursts” of 8 users together form a frame.
- These frames are hierarchically organized in a frame structure.

GSM Frame Hierarchy



Handoff (Handover) in GSM

- Transfer from one BTS/BSS to another
- Two types of handover
  - Internal
    - Between two BTSs of the same BSS.
  - External
    - Between two BSSs controlled by same MSC.
- Sometimes between BSSs controlled by different MSC, where old MSC handles call management.

Handoff (Handover) in GSM

- Handover is initiated for different reasons.
  - Most common is signal strength deterioration.
  - Traffic balancing, to ease traffic congestion by moving calls to a lightly loaded cell.

Handover Procedure in GSM

- Outline of the Handover procedure
  - BTS provides the MS with a list of available channels in the neighboring cells via BCCH (Broadcast Channel).
  - MS monitors the RSS (Received Signal Strength) from the BCCHs of the neighboring cells and reports values to BSC.
  - This is termed as *mobile-assisted* handover.

Handover Procedure in GSM

- BTS also monitors RSS from the MS to make a handover decision.
  - BSC negotiates a new channel with the new BSS and indicates to the MS.
  - Upon completion, MS indicate this with a handoff complete message to the BSC.