GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS (GSM)

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AP/CSE

Introduction

- The primary goal of GSM is to provide a mobile phone system that allows users to roam throughout the environment and provides voice services.
- GSM → 2G system.
- GSM operates in 900 MHz or in 1800 MHz.
- Some countries (USA and Canada)operates in 850 MHz and 1900 MHz.
- Rarely used frequency bands 400MHz and 450 MHz (Scandinavia)
- 900MHz → Uplink(890-915MHz), Downlink(935-960MHz)

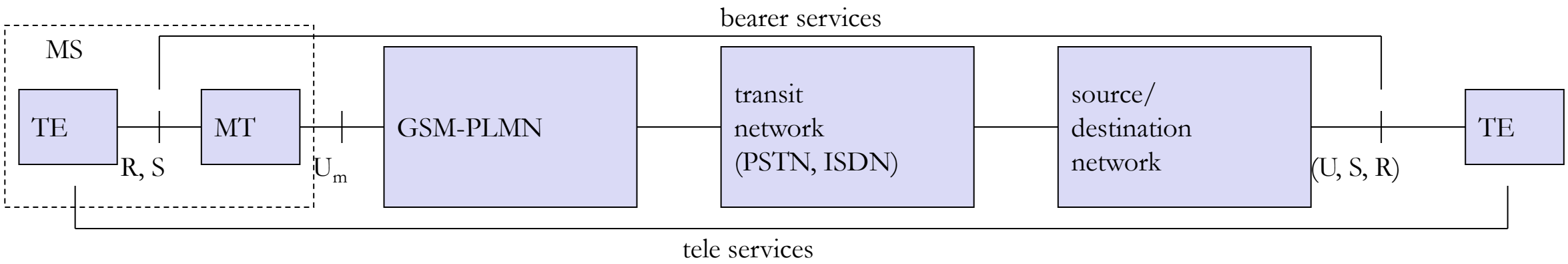
GSM Frequency Bands

Type	Channels	Uplink [MHz]	Downlink [MHz]
GSM 850	128-251	824-849	869-894
GSM 900 classical extended	0-124, 955-1023 124 channels +49 channels	876-915 890-915 880-915	921-960 935-960 925-960
GSM 1800	512-885	1710-1785	1805-1880
GSM 1900	512-810	1850-1910	1930-1990
GSM-R exclusive	955-1024, 0-124 69 channels	876-915 876-880	921-960 921-925

GSM SERVICES

GSM Services

- Three service domains
  - Bearer Services
  - Teleservices
  - Supplementary Services



Bearer Services

- Send/Receive data to/from remote phones/ computers
- Therefore it is known as Data services
- Provides transparent transmission between GSM and other Networks like PSTN, ISDN etc
- PSTN (public switched telephone network)
- ISDN(Integrated Services Digital Network)
- Bearer services are implemented on lower 3 layers of OSI/ISO
- Data rate 9.6 kbps

Bearer Services

- Synchronous and asynchronous modes of transmission
- Transparent Bearer Service
  - Use the functions of Physical Layer to transmit data.
  - Forward Error Correction (FEC) is used to increase transmission quality.
  - FEC → Codes redundancy into the data stream and helps to reconstruct the original data in case of transmission errors
  - Data Rates → 2.4, 4.8 or 9.6 kbps
- Non-Transparent Bearer Service
  - Use protocols of layers 2 and 3 to implement error correction and Flow control
  - Use the transparent bearer services, in addition to Radio Link Protocol (RLP).
  - This comprises mechanism of HDLC
  - Data Rates → 1.2, 2.4, 4.8 or 9.6 kbps

Teleservices

- GSM mainly focuses on voice oriented Tele services through mobile phones.
- All these basic services have to obey cellular functions, security measurements etc.
- Offered services
  - Mobile Telephony
    Primary goal of GSM was to enable mobile telephony offering the traditional bandwidth of 3.1 kHz
  - Emergency number
    Common number throughout Europe (112); mandatory for all service providers; free of charge; connection with the highest priority (preemption of other connections possible)
    Well known emergency number in the world today alongside **911** and **999**
    India police**100 , Medical 102**,**1298**,**108**,**112** Fire**101** Emergency management 2611

Teleservices

- Additional services
  - Non-Voice-Teleservices
    - Voice mailbox (implemented in the fixed network supporting the mobile terminals)
    - Short Message Service (SMS)
      Alphanumeric data transmission to/from the mobile terminal (160 characters) using the signaling channel, thus allowing simultaneous use of basic services and SMS
    - Enhanced Message Service (EMS)
      Offers a larger text message (760 characters)
    - Multimedia Message Service (MMS)
      Transmission of large pictures, short video clips etc.

Supplementary services

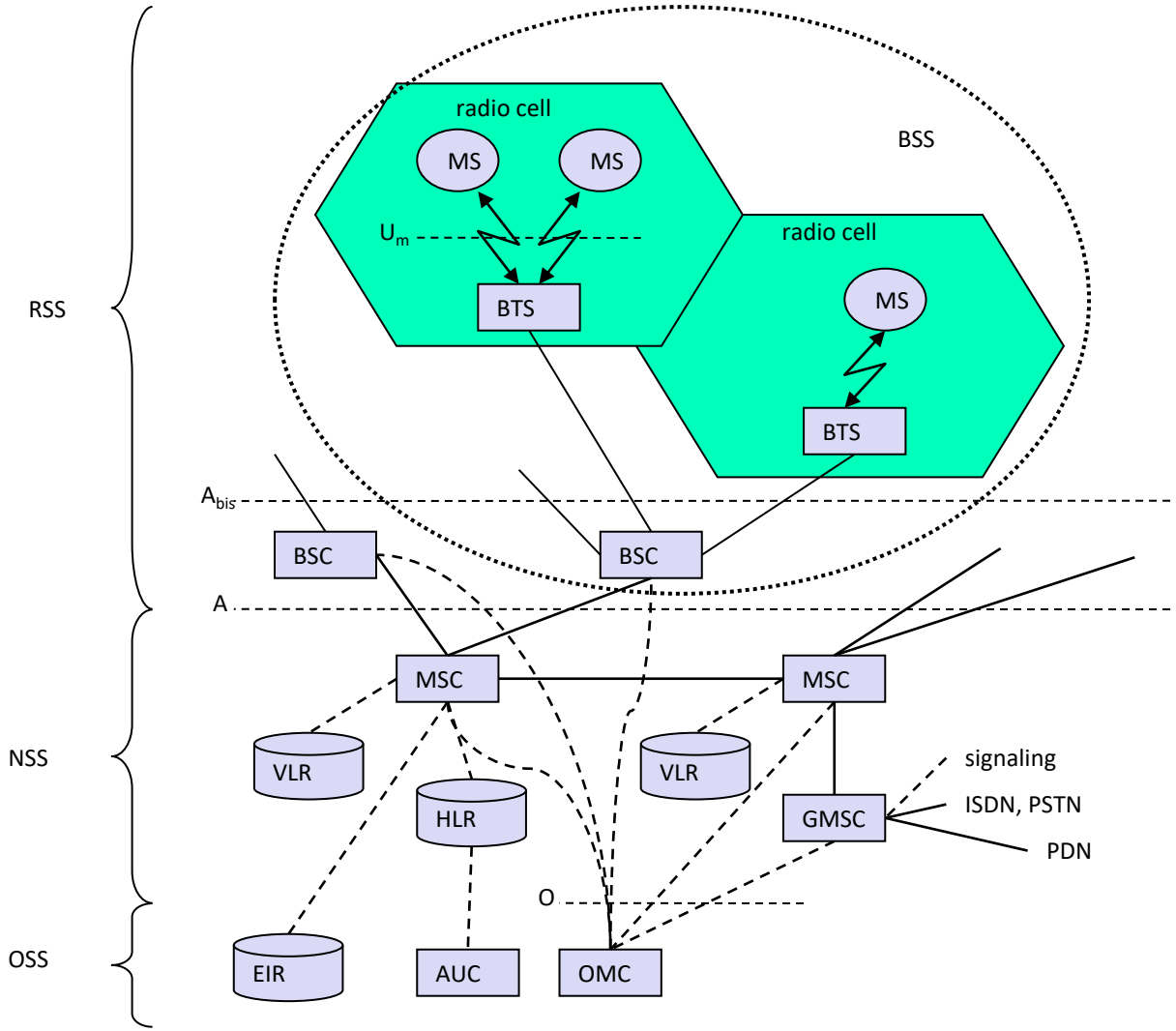
- GSM offers Supplementary services
- May differ between different service providers, countries and protocol versions
- Important services
  - User Identification
  - Call redirection
  - Forwarding of ongoing calls
  - Closed user group
  - Multiparty communication(Conferencing with up to 7 participants)

GSM ARCHITECTURE

System Architecture of GSM

- GSM consists of 3 Subsystems
  - RSS (Radio SubSystem):
    - Covers all radio aspects
  - NSS (Network and Switching Subsystem):
    - Call forwarding, handover, switching
  - OSS (Operation SubSystem):
    - Management of the network

GSM: Elements and Interfaces



- *BSS* (Base Station Subsystem)
- *BTS* (Base Transceiver Station): sender and receiver
- *BSC* (Base Station Controller): controlling several transceivers
- MSC (Mobile Station Controller)
- HLR (Home Location Register)
- VLR (Visitor Location Register)
- GMSC (Gateway Mobile Station Controller)
- EIR (Equipment Identity Register)
- AuC (Authentication Centre)
- OMC (Operation and Maintenance Centre)
- Interfaces
  - Um : radio interface
  - Abis : standardized, open interface with 16 kbps user channels
  - A: standardized, open interface with 64 kbps user channels

Radio SubSystem

- Components
  - MS (Mobile Station)
  - BSS (Base Station Subsystem):
  - BTS (Base Transceiver Station)
  - BSC (Base Station Controller)

Mobile Station

- A mobile station (MS) has different types of interfaces
  - Display, loudspeaker, microphone and programmable soft keys
  - Connection with computer modems(USB), Bluetooth.
- Many vendor specific functions and components such as cameras, fingerprint sensors, calendars, address books, games, and Internet browsers.

Mobile Station

- SIM (Subscriber Identity Module):
  - Personalization of the mobile terminal, stores user parameters
  - Stores all user specific data that is relevant to GSM(protected memory, flash memory)
  - Without a SIM only emergency calls are possible.
  - Contains
    - PIN (Personal Identity Number)
      - To unlock MS. Using wrong PIN 3 times will lock the SIM.
    - PUK (PIN unblocking key)
    - Authentication key Ki
    - International Mobile Subscriber Identity (IMSI)

Mobile Station

- International Mobile Equipment Identity (IMEI)
  - Device specific mechanisms Ex. For Theft protection use the device specific IMEI
  - It is usually found printed inside the battery compartment of the phone.
  - It can also be displayed on the screen of the phone by entering *#06# into the keypad on most phones.
- International Mobile Subscriber Identity (IMSI)
  - is a unique identification associated with all GSM network mobile phone users. It is stored as a 64 bit field in the SIM inside the phone and is sent by the phone to the network
  - An IMSI is usually presented as a 15 digit long number, but can be shorter .

Base Station Subsystem (BSS)

- Each BSS is controlled by a BSC (Base Station Controller)
- Functions of BSS
  - Maintaining Radio connection to MS
  - Coding/ Decoding of voice
  - Rate adaptation from /to the wireless network part

Base Transceiver Station

- Comprises of
  - Radio components including sender, receiver, antenna
- BTS connected to MS via U_m interface
- BTS connected to BSC via A_{bis}
- U_m interface Contains all the mechanisms necessary for wireless transmission (TDMA, FDMA)
- A GSM cell can measure between 100m to 35km depending on the environment (buildings, open source, mountains etc)

Base Station Controller

- Manages several BTSs.
- Handles
  - Switching between BTSs
  - Controlling BTSs
  - Managing of network resources
  - Multiplexes the radio signals and transmit to MSC

Network and Switching Subsystem

- NSS is the main component of the public mobile network GSM
  - switching, mobility management, interconnection to other networks, system control
- Components
  - MSC (Mobile Station Controller)
  - HLR (Home Location Register)
  - VLR (Visitor Location Register)
  - GMSC (Gateway Mobile Station Controller)

Mobile Services Switching Center

- High performance digital ISDN switches
- Setup connections to other MSCs and to the BSCs via the A interface.
- Forms the backbone of the GSM network.
  - Switching functions
  - Connection Setup
  - Connection Release
  - Call Handoff
  - C all forwarding
  - Conference calls
- GMSC → Gateway MSC

Home Location Register

- Central master database
- Comprise static information such as MSISDN and IMSI
- MSISDN
  - Mobile subscriber ISDN number(Phone number)
  - Services → Call forwarding, Roaming, GPRS etc.
  - The MSISDN together with IMSI are two important numbers used for identifying a mobile subscriber.
  - The latter identifies the SIM, i.e. the card inserted in to the mobile phone, while the former is used for routing calls to the subscriber.
- Contains Dynamic information such as LA ie current Location area and MSRN (Mobile subscriber Roaming Number)
- When MS leaves current LA, the information in the HLR is updated.
- HLRs can manage data for several million customers.

Visitor Location Register

- Dynamic database which stores information needed for the MS in the current LA. Such as IMSI, MSISDN, HLR address.
- When a new MS comes into an LA the VLR is responsible for copying all information for this user form HLR.
- This hierarchy avoids frequent HLR updates.

Operation SubSystem

- The OSS (Operation Subsystem) enables centralized operation, management, and maintenance of all GSM subsystems
- Authentication Center (AUC)
  - Protects intruders targeting the air interface.
  - AUC stores information concerned with security features such as user authentication and encryption.
- Equipment Identity Register (EIR)
  - Registers GSM mobile stations and user rights
  - Stolen or malfunctioning mobile stations can be locked and sometimes even localized
- Operation and Maintenance Center (OMC)
  - Different control capabilities for the radio subsystem and the network subsystem
  - Traffic monitoring, status reports of network entities,, subscriber management, security management, accounting, billing

GSM SECURITY

Security

- GSM offers security services with the help of Confidential information stored in
  - The AuC
  - The individual SIM
- AuC contains
  - The algorithms for authentication and generates the values needed for user authentication
  - The keys for encryption
- SIM stores
  - Personal data
  - Secret data.
  - These are protected with the help of PIN

Security Services

- Access control and Authentication
  - Authentication of a valid user for the SIM.
  - The user needs a secret PIN to access the SIM
  - Subscriber Authentication has to be done.
- Confidentiality
  - User data is encrypted
  - After authentication, BTS and MS apply encryption to voice, data, and Signal.
  - Confidentiality exists only between MS and BTS.
- Anonymity
  - User identifiers are not used over the air.
  - TMSI (newly assigned by the VLR) is transmitted after each location update
  - VLR can change the TMSI at any time.

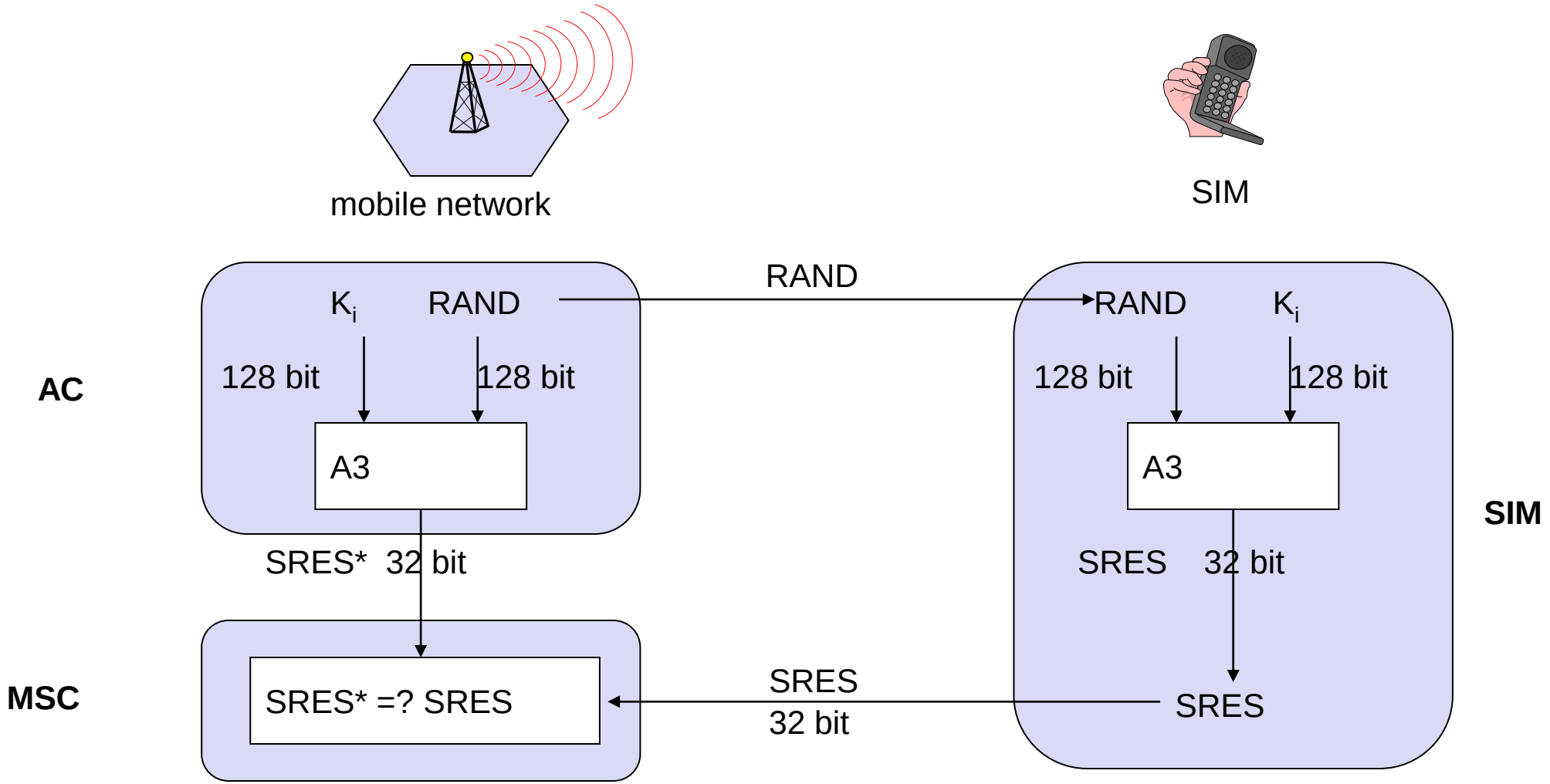
Security Services

- 3 Algorithms
- Algorithm A3 is used for authentication
- Algorithm A5 for Encryption
- Algorithm A8 for the generation of a Cipher Key.

Authentication

- The user should be authenticated, before using any service from the network.
- Authentication is based on SIM
- SIM contains
  - Authentication key K_i
  - User Identification IMSI
  - Algorithm A3 → algorithm used for authentication.
- Authentication uses a challenge-response method.

Authentication

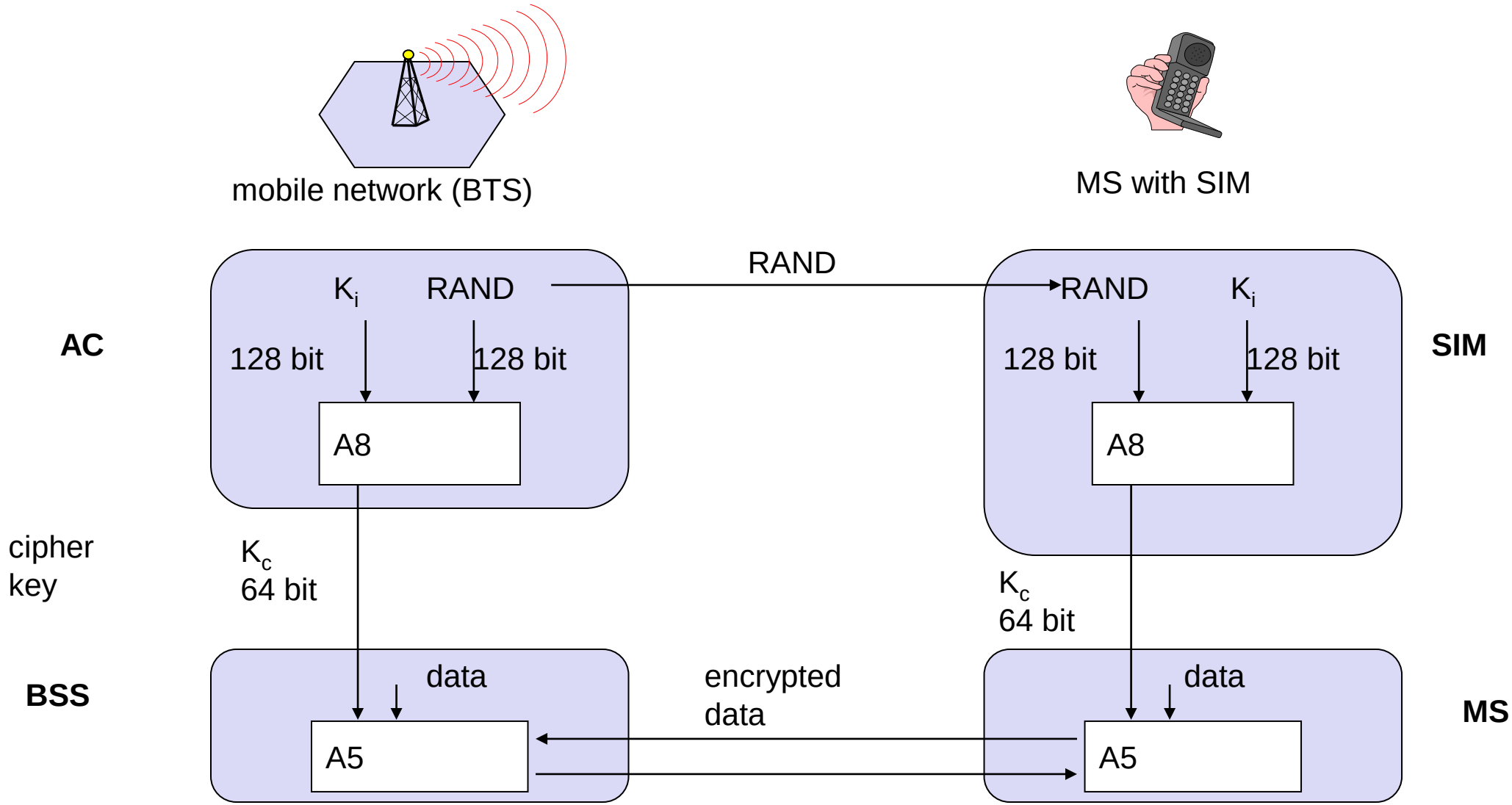


K_i: individual subscriber authentication key SRES: signed response

Encryption

- User data are encrypted
- MS and BTS uses k_c (cipher key) for encryption
- K_c is generated using the authentication key k_i and a random value by applying the algorithm A8

Encryption


mobile network (BTS)
MS with SIM
AC
SIM
RAND
K_i
RAND
RAND
K_i
128 bit
128 bit
128 bit
128 bit
A8
A8
cipher key
K_c
64 bit
K_c
64 bit
BSS
MS
data
data
encrypted data
A5
A5

Summary

- GSM Services
  - Bearer service
  - Teleservice
  - Supplementary service
- GSM Architecture
  - RSS
  - NSS
  - OSS
- GSM Security

Test your understanding

- Identify the main reason as to why a mobile handset is compact and lightweight and yet provides a large number of features such as roaming, camera, audio and video play, record internet etc., while traditional landline phone handsets are bulky and provide only limited features.

References

Jochen H. Schller, “Mobile Communications”, Second Edition, Pearson Education, New Delhi, 2007.

Prasant Kumar Pattnaik, Rajib Mall, “Fundamentals of Mobile Computing”, PHI Learning Pvt. Ltd, New Delhi – 2012.