Regulation and Policy in the Telecommunications Industry TM 612-WS

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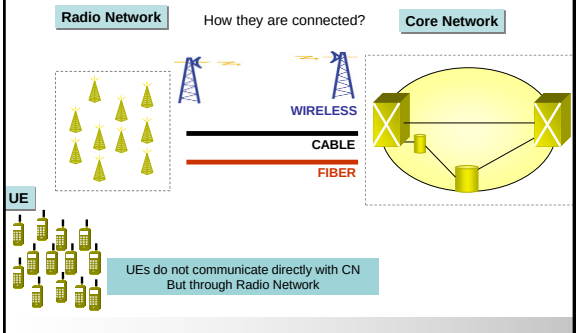
Lecture—06
Wireless Technologies

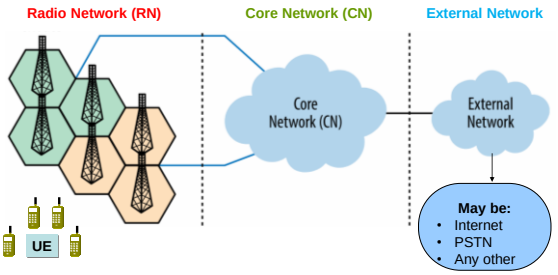
Contents

Bigger Picture

Bigger Picture



Bigger Picture



Walk Through 1G Architecture

1G Network Architecture

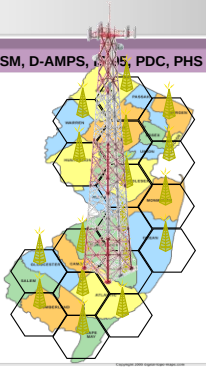
- **Based on Radio Transmission Principle**
- **Narrow band (CS 8Kb/s)**
  - Mainly for Voice
- **Analog systems**
  - FDMA
- **Security/Privacy**
  - No Security/Privacy (Listened by third party)
- **Examples**
  - AMPS= Advanced Mobile Phone System
  - TACS= Total Access Communication System
  - ETACS = Extended total Access Communication System

Walk Through 2G Architecture

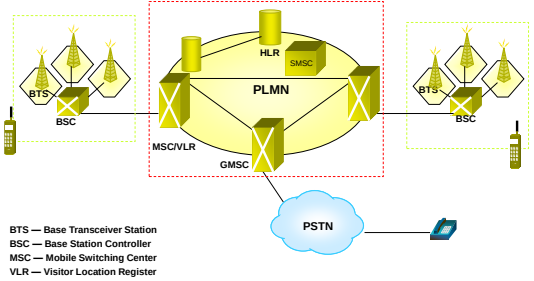
2G Network Architecture

- **It is Cellular**
- **Hand off capability**
- **Digital**
  - TDMA
  - CS 8Kb/s Voice plus some data
- **User Privacy**
- **Narrow Band**
  - Mainly Voice, but superior voice quality
  - Very Limited Text Service (very less data)
    - Control channel is used for SMS

E.g. GSM, D-AMPS, [illegible]5, PDC, PHS

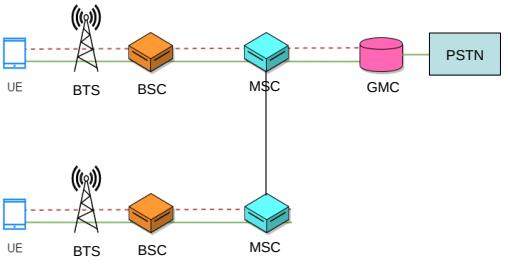


2G Network Architecture (Contd.)

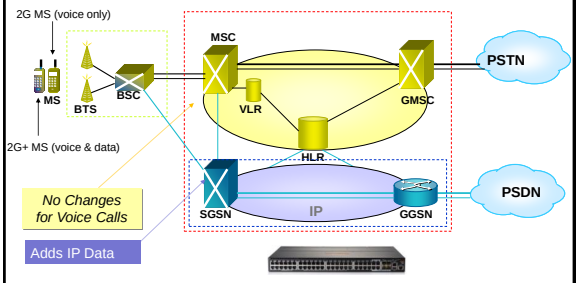


BTS — Base Transceiver Station
BSC — Base Station Controller
MSC — Mobile Switching Center
VLR — Visitor Location Register
HLR — Home Location Register

2G Network Architecture (Simplified one line block diagram)



2.5G Network Architecture

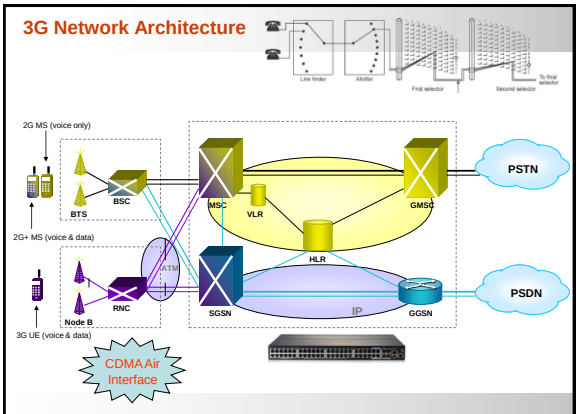


SGSN — Serving GPRS Support Node

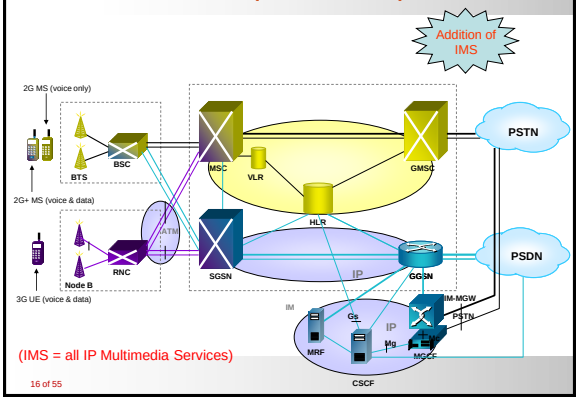
GGSN — Gateway GPRS Support Node

Walk Through 3G Architecture

3G Network Architecture



3G Network Architecture (Addition of IMS)



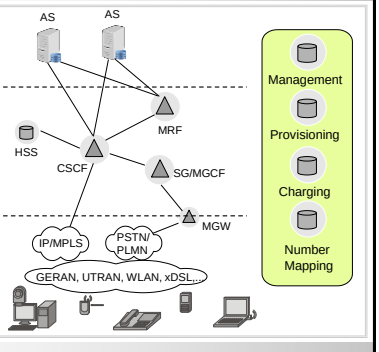
(IMS = all IP Multimedia Services)

IMS

- **What is IMS**
  - IMS is an open-systems architecture defined by 3GPP
  - It supports IP-based services e.g., IP based voice/text/media
- **Key Building Blocks of IMS**
  - All-IP Core Network (CN)
  - All-IP Radio Access Network (RAN)
  - Session Initiation Protocol (SIP) for multimedia call control
  - Quality of Service (QoS) support for IP traffic

Simplified Architecture of IMS

- **Architecture**



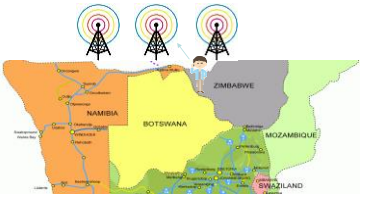
Abbreviations

- **HSS: Home Subscriber Server**
- **CSCF: Call Session Control Function:**
  - S-CSCF: Serving CSCF
  - I-CSCF: Interrogating CSCF
  - P-CSCF: Proxy CSCF
- **GCF: Gateway Control Function**
  - BGCF: Breakout Gateway Control Function
  - MGCF: Media Gateway Control Function
- **AS: Application Server**
- **MGW: Media Gateway**
- **MRFC: Multimedia Resource Function Controller**
- **MRFP: Multimedia Resource Function Processor**
- **CAMEL: Customized Applications for Mobile network Enhanced Logic**
- **OSA: Open Systems Adapter**

Need for Two Security

- **Provides Network Security**

TWO WAY Security Used in LTE



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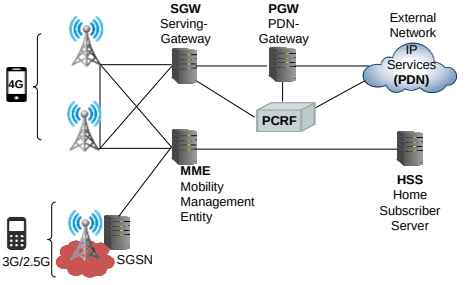
4G Architecture

21 of

4G/SAE Architecture (Non Roaming Scenario)



Source 3GPP

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High Level Requirements

4G

- **Spectrum flexibility**
  - 4G can operate in any, small or broadband
  - 1.25 MHz
  - 2.5 MHz
  - 5 MHz,
  - 10 MHz
  - 15 MHz
  - 20 MHz

Small Shop

Big Shop

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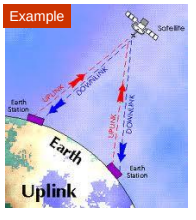
High Level Requirements (Contd.)

4G

- **Peak data Rate in 20 MHz Ch**
  - DL: 100 Mbps
  - UL: 50 Mbps

Example



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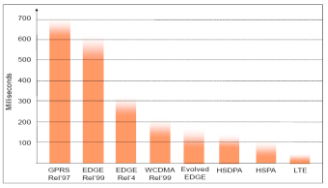
High Level Requirements (Contd.)

4G

- **Latency**
  - User Plane: Less than 5 milli-sec
  - Control Plane: Less than 100 milli-sec.



High Level Requirements (Contd.)

4G

- **Mobility**
  - 120 km/h
  - 500 km/h (with slightly degraded performance)

High Level Requirements (Contd.)

4G

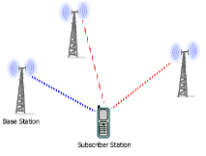
- **Coverage**
  - 5 km/cell
  - 30 km/cell (with slightly degraded performance)

High Level Requirements (Contd.)

4G

- **Handover**
  - Homogeneous
    - Intra-Technology
  - Heterogeneous
    - Inter-Technology

Handover or hand off is a process in which Communication Session is transferred from one base station to another

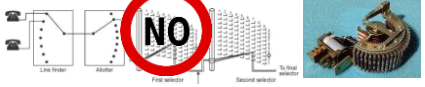


High Level Requirements (Contd.)

4G

- **IP**

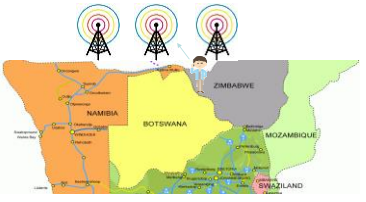
No CS Based



Fully PS Based

TWO WAY Security is Also in LTE

- **Provides Network Security**



5G Architecture

5G Requirements

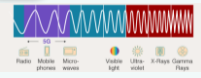
Requirements for 5G?

1. Data Rates
1-10Gbps
10 billion bits/sec
(download a 4K movie in 30 seconds

2. Capacity
36TB/month/user
18,000 hours worth of movie

Ultra-dense networks

3. Spectrum
Higher frequencies
Spectrum flexibility



4. Energy
~10% of today's consumption
Battery life~10 years

Requirements for 5G?

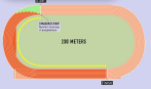
5. Latency Reduction
~ 1ms

6. M2M Comm
ITS, V2V, communication

7. Security and Reliability
99.999% within time budget

Ultra Reliable System

8. Coverage
>200 meters



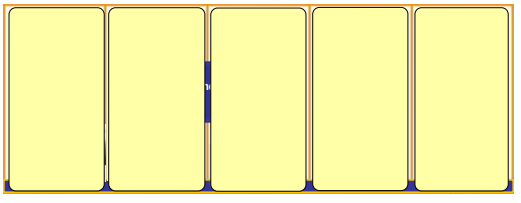
Requirements for 5G?

10. Devices per area
300 per access node

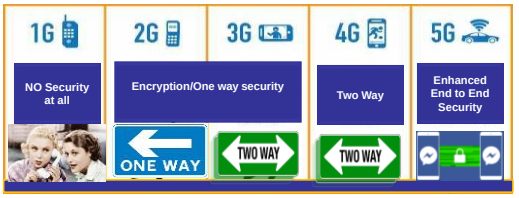
Massive Machines

11. Hand-off
Homogeneous/
Heterogeneous

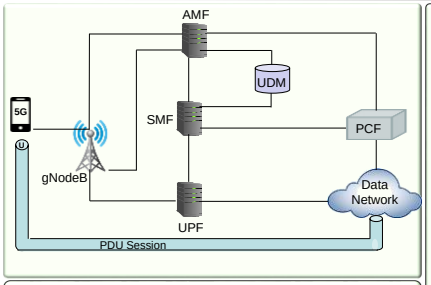
Security



Security



5G Core Network Architecture



PDU: Protocol Data Unit

gNodeB: Next Generation Node B

AMF: Access and Mobility Management Function

SMF: Session Management Function

UPF: User Plane Function

UDM: Unified Data Management

PCF: Policy Control Function

All these components or functional entities are designed to:
- Keep the PDE session active for a user, and
- All the PDU session follows him as he moves around the network

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Network Slicing

- **Network Slicing (NS)**
  - Important technology in 5G
  - Operator can create multiple networks on the same physical network infrastructure
    - Each network slice is:
      - Unique, logical, virtualized, and isolated end-to-end network
      - Tailored to fulfil the requirements of a particular application, i.e. (connectivity, speed, and capacity, suitable for that application)
    - Each network slice:
      - Supports innovative services with vastly different requirements, e.g.
        - » Connected vehicles (Require different throughput, latency, and reliability)
        - » Voice calls (Require different throughput, latency, and reliability)
        - » M2M Sessions ((Require different throughput, latency, and reliability)

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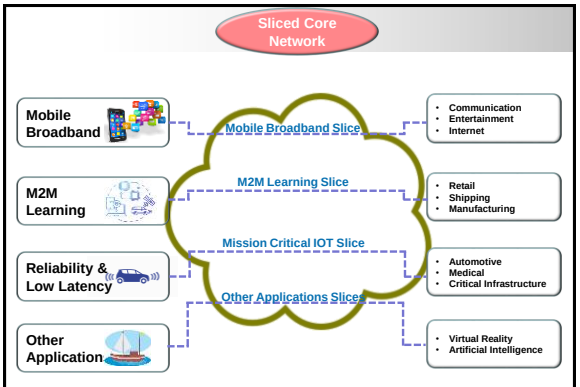
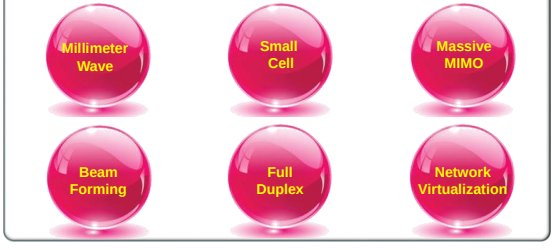


5G Enabling Technologies

5G Enabling Technologies



5G

- **Watch the video at the following link**

https://www.youtube.com/watch?v=GEx_d0SjvS0

Enabling Technologies

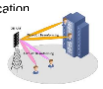
- **Millimeter Wave**
  - Use 30 to 300 gigahertz frequencies (10 to 100 times higher than 4G & WiFi networks)
  - Initial 5G systems will use frequencies from 30 to 39 GHz

- **Small Cell**
  - Millimeter waves cannot travel longer distances, 5G will use small range BSs/Cells
  - Handle fewer simultaneous sessions of voice/data/internet browsing

- **Massive MIMO**
  - Increased number of transmitting antennas at a base station
  - Each antenna will use Beamforming, and will work like line of sight communication

Enabling Technologies

- **Beam Forming**
  - Allows antenna to transmit radio signal in the direction where the mobile device is
  - Thus creates a stronger, faster and more reliable wireless communication



- **Full Duplex**
  - Enables system to simultaneously transmit and receive over the same frequency band
  - Thus it doubles the system capacity

- **Network Virtualization**
  - Replacing hardware-based network functions with software-based ones
  - Optimizes the network, increases efficiency, flexibility, and capacity

There is one bonus question

Chapter Review Questions (CRQ)

Chapter-06

Q1

- **Multiple Access Technology used in 4G Wireless network is:**

A. High Speed Packet Data Access (HSPDA)

B. Orthogonal Frequency Division Multiple Access (OFDMA)

C. Wavelength Division Multiple Access WDMA)

D. Code and Time Division Multiple Access (CDMA)

Q2

- **One of the features of the 4G Mobile Communication is:**

A. It is only for a high quality voice communication

B. It provides two way security

C. It uses Frequency Division Multiple Access

D. It uses Mobile Switching Centers (MSCs) for routing the calls.

Q3

- **The main feature(s) of 3G (CDMA) Networks are:**
  - A. 3G Systems are partly Packet Switched (PS) and partly Circuit Switched (CS)
  - B. 3G Systems use Orthogonal Frequency Division Multiple Access technology
  - C. 3G systems use Analog Communication techniques for IMS
  - D. Both B and C are correct

Q4

- **In mobile communication networks, Handover is a process in which:**
  - A. New mobile phones can be received by handing in the used ones
  - B. Packets are handed over from one router to an other in a core network
  - C. Home Location Register (HLR) hands over the data to the Visiting Location Register (VLR)
  - D. Communication Session is transferred from one base station to another

Q5

- **A method that delivers the data in the form of packets over a shared network is called:**
  - A. PS (Packet Switching)
  - B. Shared Packets Delivery (SPD)
  - C. Data Shared Network (DSN)
  - D. Transmission Control Packets (TCP)

Bonus

- **In LTE (Long Term Evolution) terminology, EPS (Evolved Packet System) has three major parts. These are:**
  - A. LTE, EPC (Evolved Packet Core), and UE (User Equipment)
  - B. Core Network, Radio Network and EUTRAN (Evolved UTRAN)
  - C. Backhaul, Last Mile, and Middle Mile
  - D. None of above

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Answers to CRQ (Chapter Review Questions)

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B. Orthogonal Frequency Division Multiple Access (OFDMA)

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A. PS (Packet Switching)

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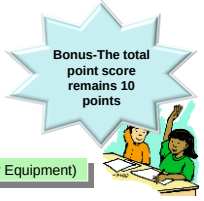

A: LTE, EPC (Evolved Packet Core), and UE (User Equipment)

HAQ#1

HW 06

- **Q1.**
  - Draw and label the network architecture for 4G and 5G systems
  - What is Homogeneous and Heterogeneous Handover
- **Q2.**
  - What are the Service Requirements of 5G?
- **Q3**
  - What are 6 brand new technologies emerging as the foundation of 5G?


Thank
You!