Chapter 4: General Radio Packet System (GPRS)

- **GPRS Architecture**

  Following is the GPRS Architecture diagram:

  ![GPRS Architecture Diagram]

  - GPRS architecture works on the same procedure like GSM network, but, has additional entities that allow packet data transmission.
  - This data network overlaps a second generation GSM network providing packet data transport at the rates from 9.6 to 171 kbps.
  - Along with the packet data transport the GSM network accommodates multiple users to share the same air interface resources concurrently.
  - GPRS is usually attempts to reuse the existing GSM network elements as much as possible.
  - There are new entities called GPRS that supports nodes (GSN) which are responsible for delivery and routing of data packets between mobile stations and external packets networks. There are two types of GSNs,
    - Serving GPRS Support Node (SGNS)
    - Gateway GPRS Support Node (GGNS)
  - There is also a new database called GPRS register which is located with HLR. It stores routing information's and maps the IMSI to a PDN (Packet Data Network) address.
- **GPRS Mobile Stations**
  - New Mobile Stations (MS) are required to use GPRS services because existing GSM phones do not handle the enhanced air interface or packet data.
  - A high-speed version of current phones are used to support high-speed data access, a new PDA device with an embedded GSM phone, and PC cards for laptop computers.
  - These mobile stations are backward compatible for making voice calls using GSM.

- **GPRS Base Station Subsystem**
  - Each BSC requires the installation of one or more Packet Control Units (PCUs) and a software upgrade.
  - The PCU provides a physical and logical data interface to the Base Station Subsystem (BSS) for packet data traffic.
  - The BTS can also require a software upgrade but typically does not require hardware enhancements.
  - When either voice or data traffic is originated at the subscriber mobile, it is transported over the air interface to the BTS, and from the BTS to the BSC in the same way as a standard GSM call.
  - However, at the output of the BSC, the traffic is separated; voice is sent to the Mobile Switching Center (MSC) per standard GSM, and data is sent to a new device called the SGSN via the PCU over a Frame Relay interface.

- **GPRS Support Nodes (GSN)**
  - A GSN is a network node which supports the use of GPRS in the GSM core network.
  - All GSNs should have a $G_N$ interface and support the GPRS tunnelling protocol.
  - There are two key variants of the GSN, namely Gateway and Serving GPRS support node.
  - There are two new components, called Gateway GPRS Support Nodes (GGSNs) and Serving GPRS Support Node (SGSN) are added.

- **Gateway GPRS Support Node (GGSN)**
  - The Gateway GPRS Support Node acts as an interface and a router to external networks.
  - It contains routing information for GPRS mobiles, which is used to tunnel packets through the IP based internal backbone to the correct Serving GPRS Support Node.
  - The GGSN also collects charging information connected to the use of the external data networks and can act as a packet filter for incoming traffic.

- **Serving GPRS Support Node (SGSN)**
  - The Serving GPRS Support Node is responsible for
    a. Authentication of GPRS mobiles,
    b. Registration of mobiles in the network,
    c. Mobility management, and
    d. Collecting information on charging for the use of the air interface.
- At higher speeds GPRS is designed to provide packet-data services at higher speeds than those available with standard GSM circuit switched data services.
- In theory GPRS could provide speeds of up to 171 kbps over the air interface, although such speeds are never achieved in practical network. In fact, the practical maximum speed is a little over 100 kbps.

**GPRS Data Services**
- GPRS speeds are far greater than the 9.6 kbps maximum provided by standard GSM.
- The greater speeds provided by GPRS are achieved over the same basic air interface (i.e., the same 200 kHz channel, divided into eight time slots).
- With GPRS, the mobile station (MS) can have access to more than one time slot.
- In fact, GPRS defines a number of different channel coding schemes, the most commonly used coding scheme for packet-data transfer is **Coding Scheme 2 (CS-2)**, which enables a given time slot to carry data at a rate of 13.4 kbps.
- If a single user has access to multiple time slots, then speeds such as 40.2 or 53.6 kbps become available to that user.
  - The following lists the various coding schemes available and the associated data rates for single time slot.

<table>
<thead>
<tr>
<th>Coding Scheme</th>
<th>Air-interface Data Rate (kbps)</th>
<th>Usable Data Rate (kbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS-1</td>
<td>9.05</td>
<td>6.8</td>
</tr>
<tr>
<td>CS-2</td>
<td>13.4</td>
<td>10.4</td>
</tr>
<tr>
<td>CS-3</td>
<td>15.6</td>
<td>11.7</td>
</tr>
<tr>
<td>CS-4</td>
<td>21.4</td>
<td>16.0</td>
</tr>
</tbody>
</table>

- The air-interface rates are given in Table.
- The transmission of data in GPRS involves a number of layers above the air interface, with each layer adding certain amount of overhead.
- The amount of overhead generated by each layer depends on a number of factors, such as the size of the application packed to be transmitted for a given amount of data to be transmitted.
- Smaller application packet sizes cause a greater net overhead than larger packet sizes. The result is that the rate for usable data is approximately 20 to 30 percent less than the air-interface rate.
- The most commonly used coding scheme for user data is CS-2. This scheme provides error correction over the air interface.
- Although CS-3 and CS-4 provide higher throughput, they are more susceptible to errors on the air interface. In fact, CS-4 provides no error correction at all on the air interface.
The biggest advantage of GPRS is not simply the fact that it allows higher speeds. Perhaps the greatest advantage of GPRS is the fact that it is a packet switching technology.

This means that a user consumes RF resources only when sending or receiving data. If a user is not sending data at a given instant, then the time slots on the air interface can be used by another user for example a user that is browsing the Web.

Data is transferred only when a new page is being requested or sent, Nothing is being transferred while the subscriber just reading the contents of a page.

During this time, same other user can access in the air-interface resources with no effect on Web-browsing friend. Clearly this is a very efficient use of scarce RF resources.

The advantages of GPRS are that multiple users can share air-interface resources.

The functionality of GPRS is such that this request-allocation procedure is well hidden from the user; and the service appears to be “always on”.

**GPRS Bearer Services:**

GPRS is a wireless extension of data networks. It can access to data networks, such as IP-based networks (public internet, private intranet, and IPv4 and IPv6 protocols) and X.25 based networks.

GPRS upgrades GSM data services and provides the following services

1. **Point-to-point (PTP) service:** internetworking with the Internet (IP protocols) and X.25 networks.
2. **Point-to-multipoint (PTM) service:** point-to-multipoint multicast and point-to-multipoint group calls.
3. **SMS service:** Bearer for SMS
4. **Anonymous service:** Anonymous access to predefined services
5. **Future Enhancements:** Flexible to add new functions, such as more capacity, more users, new accesses, new protocols, new radio networks.

**GPRS Applications, Limitations**

**Applications:**
- Mobility - The ability to maintain constant voice and data communications while on the move.
- Immediacy - Allows subscribers to obtain connectivity when needed, regardless of location and without a lengthy login session.
- Localization - Allows subscribers to obtain information relevant to their current location.

**Limitations:**
- **Limited Cell Capacity for All Users**
- GPRS does impact a network’s existing cell capacity. There are only limited radio resources that can be deployed for different uses
- **Speeds Much Lower in Reality**
- Achieving the theoretical maximum GPRS data transmission speed of 172.2
kbps would require a single user taking over all eight timeslots without any error protection.

- **Transit Delays** GPRS packets are sent in all different directions to reach the same destination. This opens up the potential for one or some of those packets to be lost or corrupted during the data transmission over the radio link.

**UMTS Universal Mobile Telecommunications System (UMTS)**

- UMTS is an upgrade from GSM via GPRS or EDGE
- The standardization work for UMTS is carried out by Third Generation Partnership Project (3GPP)
- Data rates of UMTS are:
  a. 144 kbps for rural
  b. 384 kbps for urban outdoor
  c. 2048 kbps for indoor and low range outdoor

**UMTS Frequency Spectrum**

- UMTS Band
  a. 1900-2025 MHz and 2110-2200 MHz for 3G transmission
  b. In the US, 1710–1755 MHz and 2110–2155 MHz will be used instead, as the 1900 MHz band was already used.
- UMTS (Universal Mobile Telecommunications Service) is a third-generation (3G) broadband, packet-based transmission of text, digitized voice, video, and multimedia at data rates upto 2 megabits per second (Mbps).
- Universal Mobile Telecommunications System (UMTS) is a air interface standard and has evolved since late 1996 under the European Telecommunications Standards Institute (ETSI).
- European carriers, manufacturers, and government regulators collectively developed the early versions of UMTS as a competitive open air-interface standard for 3G wireless telecommunications.
- **UMTS offers a consistent set of services to mobile computer and phone users, which is not depend on the location.**
- UMTS is based on the Global System for Mobile (GSM) communication standard.
- Once UMTS is available, computer and phone users can be continuously connected to the Internet wherever they travel, will have the same set of capabilities.
- Users will get access to internet via combination of terrestrial wireless and satellite transmissions.
- Earlier cellular telephone systems were using circuit-switched connection, where the connections were always dependent on circuit availability.
- A packet-switched connection uses the Internet Protocol (IP), meaning that a virtual connection is always available.
- The 3G W-CDMA air interface standard had been designed for “always-on” packet based wireless service, so that computers, entertainment devices, and communication device all share the same wireless network and be connected to...
the Internet, anytime, anywhere.

- W-CDMA is used to transfer packet up to 2.048 Mbps per user (if the user is stationary), thereby allowing high quality data, multimedia, streaming audio, streaming video and broadcast-type services to consumers.
- Future versions of W-CDMA will support stationary user data rates in excess of 8 Mbps.
- W-CDMA designers contemplate that broadcasting, mobile commerce (mcommerce), games, interactive video, and virtual private networking will be possible throughout the world, all from a small portable wireless device.
- UMTS also makes it possible to provide new services like alternative billing methods or calling plans. For instance, users can choose to pay-per-bit, pay-per-session, flat rate, or asymmetric bandwidth options.
- The higher bandwidth of UMTS also enables other new services like video conferencing.
- UMTS may allow the Virtual Home Environment (VHE) to fully develop, where a roaming user can have the same services to either at home, in the office or in the field through a combination of transparent terrestrial and satellite connections.

**4G (LTE stands for Long Term Evolution)**

- Next Generation Mobile broadband technology
- LTE, an abbreviation for Long-Term Evolution, commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminal
- Promises data transfer rates of 100 Mbps while moving and 1 Gbps while stationary.
- Based on UMTS 3G technology
- Optimized for All-IP traffic
- It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements.
- The standard is developed by the 3GPP (3rd Generation Partnership Project).
- LTE is the natural upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks.
- The different LTE frequencies and bands used in different countries will mean that only multi-band phones will be able to use LTE in all countries where it is supported.
Advantages of LTE

- High network throughput
- Low latency
- Plug & Play architecture
- Low Operating Costs
- All–IP network
- Simplified upgrade path from 3G networks

- Faster data downloads/uploads
- Improved response for applications
- Improved end-user experience

### 3G vs. 4G
- Less Complexity, Faster Transmission
- Unlike the 3G networks which are a combination of circuit switched and packet switched networks, 4G will be based on packet switching only. This will allow low-latency data transmission.

### 4G Possibilities
- **Enhanced Mobile Gaming**
- **Virtual Presence** Use hologram-generating virtual reality programs that provide an artificial presence just about anywhere. For example, decide if you want to personally respond when someone rings your front door while you are away from home.
- **Broadband Access in Remote Locations**
  4G networks will provide a wireless alternative for broadband access to residential and business customers. In addition, 4G will provide the first opportunity for broadband access in remote locations without an infrastructure to support cable or DSL access.

### Considerations in the Evolution to 4G:
- The deployment of LTE is another step in the evolution of mobile broadband networks.
- While the deployment of 4G radio access networks receives considerable attention, the multimedia core network has emerged as a critical element in the delivery of next generation mobile broadband services.
- Communication services provider migration strategies in the evolution to 4G can be classified into three main categories:
  - Data-only services on 4G
  - Data-only services on 4G with 2G/3G voice
  - Voice and data services on 4G
To mitigate the risks of their 4G deployments, communication services providers may incorporate one or more of these strategies at different times. Therefore, the three migration strategies are not diametric to one another, but rather build upon their predecessor.

**Evolution considerations for an integrated approach include:**

- Does your existing 3G network support a software upgrade to 4G functions?
- Have you analyzed the optimization you can achieve by integrating functions when migrating from 3G to 4G and growing 4G networks?
- Does the platform chosen for 3G scale to support the capacity required for 4G?
- Another potential near-term deployment model is a complete EPC (Evolved Packet Core) overlay with separate functional elements handling LTE connections. This approach may mitigate some risk and allow slow migration to EPC.

**Considerations for these deployments include:**

- How will handover support be provided between 2G/3G and 4G?
- Will end customers be happy if their common applications - FTP, email, HTTP, and YouTube - do not have seamless service mobility?
- Are the existing platforms ready for the performance challenges of separate elements?

**Multimedia Services**

One of the biggest disruptions in the mobile industry is the movement to an open, IP-based architecture designed to deliver converged voice, data, and multimedia services. The emerging mobile packet technologies, High Speed Packet Access (HSPA) and LTE, provide an all-IP infrastructure from the mobile device, whether it is a handset, smartphone, data card, or other emerging intelligent device. With all-IP networks, the door is open to providing the traditional circuit-based services, including voice and video over the packet infrastructure.

<table>
<thead>
<tr>
<th>Advantages of 4G:</th>
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<tbody>
<tr>
<td>Quickly download files over a wireless network</td>
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<tr>
<td>Extremely high voice quality</td>
</tr>
<tr>
<td>Easily access Internet, IM, Social Networks, streaming media, video calling, etc.</td>
</tr>
<tr>
<td>Higher bandwidth</td>
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<tr>
<td>WiMAX, LTE, and HSPA+ are all versions of 4G, WiMAX is used by Sprint, LTE is used by Verizon and AT&amp;T, HSPA+ is used by AT&amp;T and TMobile</td>
</tr>
<tr>
<td>4G is 10 times faster than 3G</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Disadvantages of 4G:</th>
</tr>
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<tbody>
<tr>
<td>New frequencies means new components in cell towers.</td>
</tr>
<tr>
<td>Higher data prices for consumers</td>
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</table>
Consumer is forced to buy a new device to support the 4G

- It is impossible to make your current equipment compatible with the 4G network
- 4G is only currently available in certain cities.

**WiMAX [World Interoperability for Microwave Access]**

- There are two main applications of WiMAX:
  - **Fixed WiMAX** (IEEE 802.16-2004) - Fixed WiMAX applications are point-to-multipoint enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL for homes and businesses.
  - **Mobile WiMAX** (IEEE 802.16e-2005) - Mobile WiMAX offers the full mobility of cellular networks at true broadband speeds.
- WiMAX uses *private, licensed spectrum* and provides Wi-Fi-like service with guaranteed performance to larger public areas, similar in coverage to cellular networks today.
- Wi-Fi uses *shared spectrum* and operates at short distances, making it ideal for low-cost, private networks (where usage of the network is constrained to an office building or campus) or free public systems (where service guarantees are not required).

**Questions**

1. Describe data services used in GPRS. (4M S-15)
2. Explain UMTS in detail. (4M S-15)
3. Give application and limitation of GPRS. (4M S-15)
4. Explain GPRS architecture in detail with neat sketch. (8M S-15)
5. Describe data services used in GPRS. (4M S-15)
6. State the two features and two Limitations of 4G Wireless Technology.
7. State four features of UMTS.
8. With the neat diagram give step by step procedure to describe DES.