Mobile Computing: An Introduction

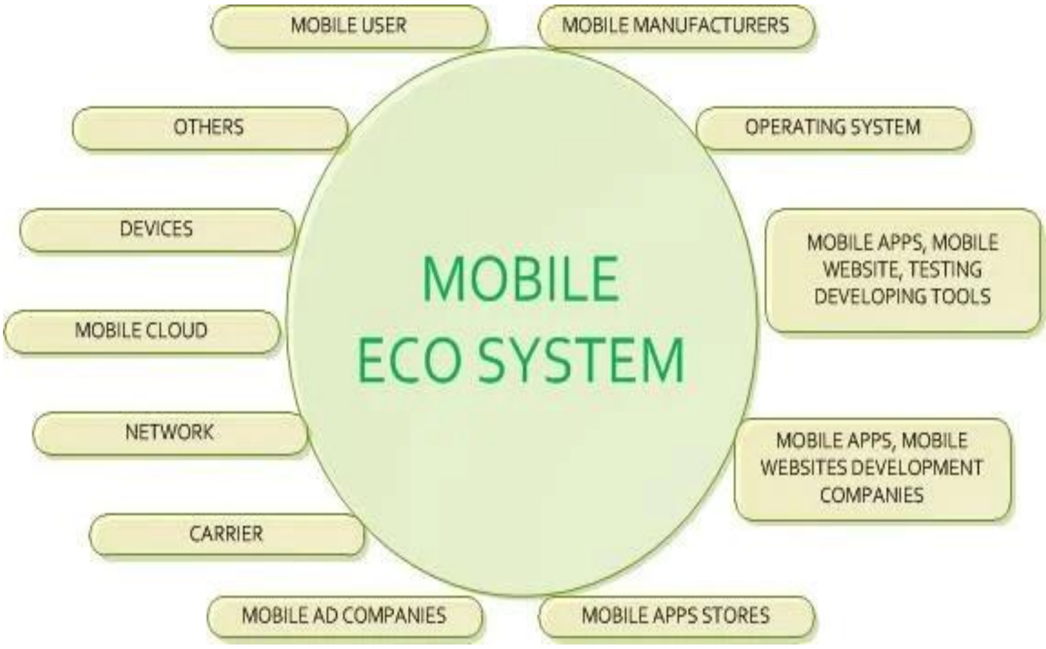
Mobile computing allows us to access information and utilize computing power through portable devices like smartphones, laptops, and tablets. It frees us from the constraints of wires and cables, enabling connectivity and interaction anytime, anywhere.

Key Components :

Mobile computing involves a complex interplay between various elements:

1. **Mobile Devices:** These are the user interfaces, such as smartphones, tablets, and laptops, equipped with wireless communication capabilities.
2. **Wireless Networks:** These networks provide the infrastructure for data transmission, using technologies like cellular networks, Wi-Fi, and Bluetooth.
3. **Mobile Operating Systems:** These operating systems are designed to run on mobile devices, providing a platform for applications and managing resources.
4. **Applications:** Mobile applications (apps) are software programs specifically designed for use on mobile devices, offering a wide range of functionalities.

Figure 1: Mobile Computing Ecosystem



Characteristics of Mobile Computing

Mobile computing environments have distinct characteristics that differentiate them from traditional desktop computing:

- **Limited Processing Power:** Mobile devices generally have less processing power compared to desktops.
- **Limited Storage Capacity:** Storage space on mobile devices is typically constrained.
- **Battery Dependence:** Mobile devices rely on batteries for operation, necessitating power management strategies.
- **Limited Display Size:** Screens on mobile devices are smaller than traditional monitors.
- **Wireless Connectivity:** Mobile communication relies on wireless networks for data transmission.
- **Context-Awareness:** Mobile devices can potentially leverage sensors and location data to adapt to user context.

First Generation (1G):

First generation mobile networks were reliant upon analog radio systems which meant that users could only make phone calls, they couldn’t send or receive text messages. The 1G network was first introduced in Japan in 1979 before it was rolled out in other countries such as the USA in 1980. In order to make it work, cell towers were built around the country which meant that signal coverage could be obtained from greater distances. However, the network was unreliable and had some security issues.

Second Generation (2G)

The 1G network was not perfect, but it remained until remained until 1991 when it was replaced with 2G. This new mobile network ran on digital signal, not analog, which vastly improved its security but also its capacity. On 2G, users could send SMS and MMS messages (although slowly and often without success) and when GPRS was introduced in 1997, users could receive and send emails on the move.

Third Generation (3G)

Third generation mobile networks are still in use today, but normally when the superior 4G signal fails. 3G revolutionized mobile connectivity and the capabilities of cell-phones. In comparison to 2G, 3G was much faster and could transmit greater amounts of data. Users could video call, share files, surf the internet, watch TV online and play online games on their mobiles for the first time. Under 3G, cell-phones where no longer just about calling and texting, they were the hub of social connectivity.

Fourth Generation (4G)

The introduction of 4G went one step further than the revolutionary 3G. It's five times faster than the 3G network – and can in theory provide speeds of up to 100Mbps. All mobile models released from 2013 onwards should support this network, which can offer connectivity for tablets and laptops as well as smartphones. Under 4G, users can experience better latency (less buffering), higher voice quality, easy access to instant messaging services and social media, quality streaming and make faster downloads.

Fifth Generation (5G)

The 5G network is yet to be released but is widely anticipated by the mobileindustry. Many experts claim that the network will change not just how we use ourmobiles, but how we connect our devices to the internet. The improved speed andcapacity of the network will signal new IoT trends, such as connected cars, smartcities and IoT in the home and office.

Application of Mobile Computing :

Mobile computing has revolutionized various aspects of our lives with a vast array of applications:

- **Communication:** Enables voice calls, video conferencing, instant messaging, and social media interaction.
- **Information Access:** Provides access to news, weather, email, and web browsing anytime, anywhere.

- **Entertainment:** Offers mobile games, music and video streaming, and e-books.
- **Productivity:** Facilitates mobile office applications, remote work collaboration, and document management.
- **Navigation:** Provides GPS-based navigation services and location-based information.
- **E-commerce:** Enables online shopping, mobile banking, and financial transactions.
- **Mobile Learning:** Offers access to educational resources, online courses, and educational apps.
- **Healthcare:** Supports remote patient monitoring, telehealth consultations, and health information management.

Mobile computing continues to evolve, shaping how we interact with information, access services, and conduct our daily lives. As technology advances, we can expect even more innovative applications and a future where mobility forms the core of our computing experience.

Mobile Development Frameworks: Architectural Approaches

Mobile application development involves various architectural approaches that define how components interact and data flows within the application. Here's an overview of some common architectures used in mobile development.

1. Client – Server Architecture

In client server computing, the client requests a resource and the server provides that resource. A server may serve multiple clients at the same time while a client is in contact with only one server. Both the client and server usually communicate via a computer network but sometimes they may reside in same system.

Concept:

C/S architecture separates the application into two main parts:

- **Client:** The mobile device running the user interface and handling user interactions.

- **Server:** A remote server that manages the application logic, data storage, and business processes.

```
 +----------+        +-----------------+
 |  Client  |        |     Server      |
 +----------+        +-----------------+
     |             |
     |  Requests   | (Data & Processing)
     |             |
     V             V
+---------+      +---------+      +---------+
|  Data   |----> | Logic   |----> |  Data   |
+---------+      +---------+      +---------+
```

Advantages of Client Server Computing

The different advantages of client server computing are −

- All the required data is concentrated in a single place i.e. the server. So it is easy to protect the data and provide authorization and authentication.
- The server need not be located physically close to the clients. Yet the data can be accessed efficiently.
- It is easy to replace, upgrade or relocate the nodes in the client server model because all the nodes are independent and request data only from the server.
- All the nodes i.e clients and server may not be building on similar platfor**ms** yet they can easily facilitate the transfer of data.

Disadvantages of Client Server Computing

The different disadvantages of client server computing are −

- If all the clients simultaneously request data from the server, it may get overloaded. This may lead to congestion in the network.
- If the server fails for any reason, then none of the requests of the clients can be fulfilled. This leads of failure of the client server network.
- The cost of setting and maintaining a client server model are quite high.

Applications:

- Simple mobile apps with limited data processing needs.
- Suitable for situations where internet connectivity is reliable.

2. N – Tier Architecture

N-tier architecture is also called **multi-tier architecture** because the software is engineered to have the processing, data management, and presentation functions physically and logically separated. That means that these different functions are hosted on several machines or clusters, ensuring that services are provided without resources being shared and, as such, these services are delivered at top capacity. The "N" in the name n-tier architecture refers to any number from 1.

Concept:

N-Tier architecture extends the C/S model by dividing the server-side functionality into multiple tiers:

- **Presentation Tier:** Handles user interface logic and interacts with the user.
- **Business Logic Tier:** Implements the core business rules and processes application logic.
- **Data Access Tier:** Manages data access and communication with the database.
-
  - **Figure 3: N-Tier Architecture**
  - +----------+ +-----------------+ +---------+
  - | Client | | Presentation Tier| | Business |
  - +----------+ +-----------------+ + Logic +
  - | | | +---------+
  - | Requests | (User Interface) | |
  - | | | V
  - V V +---------+
  - +---------+ +---------+ +---------+ | Database|
  - | Data | ----> | Logic | ----> | Data | ----> +---------+
  - +---------+ +---------+ +---------+

Applications:

- More complex mobile apps requiring robust data processing and scalability.
- Provides better separation of concerns and easier maintenance.

Limitations:

- Increased development complexity compared to C/S architecture.
- Requires managing multiple tiers and potential network overhead.

Advantages:

- Scalable – Scale separate tiers without touching other tiers
- Individual management – Prevents cascade effects; isolates maintenance
- Flexible – Expands in any way according to requirements
- Secure – Each tier can be secured separately and in different ways

3. N-Tier Architecture with WWW : (Web development usage)

- A front-end web server serving static content, and potentially some cached dynamic content. In web-based application, front end is the content rendered by the browser. The content may be static or generated dynamically.
- A middle dynamic content processing and generation level application server (e.g., Symfony, Spring, ASP.NET, Django, Rails, Node.js).
- A back-end database or data store, comprising both data sets and the database management system software that manages and provides access to the data.

  Example: MakeMyTrip.com, Amazon.com

Concept:

This approach combines N-Tier architecture with web technologies like HTTP and HTML. The presentation tier leverages web technologies to deliver content to mobile devices through a web browser.

Applications:

- Mobile apps that require access to web content and services.
- Enables development of web-based mobile applications (WBAs) accessible through a browser.

Limitations:

- May not offer the same level of performance as native apps.

- Relies on a web browser for functionality, which can be limited.

4. **Peer – to – Peer Architecture**

A peer-to-peer (P2P) architecture consists of a decentralized network of peers - nodes that are both clients and servers. P2P networks distribute the workload between peers, and all peers contribute and consume resources within the network without the need for a centralized server. However, not all peers are necessarily equal. Super peers may have more resources and can contribute more than they consume. Edge peers do not contribute any resources, they only consume from the network.

Figure 4: Peer-to-Peer Architecture

```
+----------+        +----------+
| Device 1 |        | Device 2 |
+----------+        +----------+
     |              |
     |   Data   <---> |   Data   |
     |              |
```

Applications:

- Mobile apps for file sharing, multiplayer games, or collaborative tasks without a central server.

Limitations:

- Complex to manage device discovery and security.
- Scalability can be an issue with a large number of devices.

uses of P2P architecture:

- File Sharing
- Instant Messaging
- Voice Communication
- Collaboration
- High Performance Computing

5. **Mobile Agent Architecture**

The architecture gives the structure of the system which consists of some components, their individual functionalities and their interrelationship with each other. The basic architecture of the mobile agent can be thought of as a client sends out an agent who travels the network visiting servers in order to perform some required action.

Concept:

This architecture utilizes software agents that can migrate between mobile devices and servers autonomously. Agents can carry out tasks on remote devices and report back, enabling distributed processing.

The architecture consists of:

A. Agent Manager:

Agent manager has few responsibilities as it: Sends agents to and receives agents from remote hosts. It also prepares agents for transport by serializing the agent. Reconstructs received agents and creates the agents execution context.

B. Security Manager:

Responsibilities of security manager are: Authenticates agents before allowing execution. It is automatically invoked when the agents tries to use any system resource or tries for any unauthorized activity. It protects the host and agent from unauthorized access.

C. Language Manager:

The language manager is used for the efficient transfer of data and provides the developer with the tools to efficiently implements the system. Most current agent systems are implemented on top of the Java Virtual Machine (JVM), which provides object serialization and basic mechanism to implement weak mobility.

Applications:

- Mobile applications requiring offline functionality with data synchronization later.
- Scenarios where network connectivity is intermittent or unreliable.

Limitations:

- Complex development and security considerations for mobile agents.
- Requires infrastructure to support agent migration and communication.

Choosing the right mobile development framework architecture depends on the specific needs of your application. Consider factors like complexity, performance requirements, scalability, and offline functionality when making your decision.

Topic: 1.3 Wireless Transmission Terminologies:

1. Signal: An electrical impulse or radio wave transmitted or received.

A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another.

It is the key component behind virtually all:

- Communication
- Computing
- Networking
- Electronic devices

A signal can be either analog or digital.

1. Signals:

- In wireless transmission, information is carried by electrical signals that are converted into radio waves using a process called modulation (explained later).
- These radio waves travel through the air and carry the encoded information.

2. Frequency and Bandwidth :

The frequency of a signal defines the total number of complete cycles of a waveform that are existing per sec. The frequency of a signal is specified as cycles/second.

Bandwidth is the range of frequency of signal while transmission. Bandwidth shows capacity of data flow.

3) An antenna

An Antenna is a device to transmit and/or receive electromagnetic waves. Electromagnetic waves are often referred to as radio waves.

4) Signal propagation

Signal Propagation is the behavior of radio waves as they travel, or are propagated, from one point to another, or into various parts of the atmosphere as a form of electromagnetic radiation. (Hindi – Prasaar, Gujarati – Prachaar)

5) Multiplexing :

In telecommunications and computer networks, multiplexing (sometimes called muxing) is a method by which multiple analog or digital signals are combined into one signal over a shared medium. The aim is to share a scarce resource.

Multiplexing (or muxing) is a way of sending multiple signals or streams of information over a communications link at the same time in the form of a single, complex signal

The multiplexed signal is transmitted over a communication channel such as a cable. The multiplexing divides the capacity of the communication channel into several logical channels, one for each message signal or data stream to be transferred. A reverse process, known as demultiplexing, extracts the original channels on the receiver end.

6) Modulation :

In electronics and telecommunications, modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted

A modulator is a device that performs modulation.

In telecommunication and radio communication, spread-spectrum techniques are methods by which a signal (e.g., an electrical or electromagnetic signal) generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.

7) A Cellular Network :

Mobile Network is a communication network where the last link is wireless. The network is distributed over land areas called "cells", each served by at least one fixed-location transceiver, (Transmitter + Receiver) which is known as Base Station. These base stations provide the cell with the network coverage which can be used for transmission of voice, data, and other types of content. A cell typically uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed service quality within each cell

Wireless Transmission Terminologies

Wireless transmission refers to the transfer of information through electromagnetic waves without the use of physical cables. Here's a breakdown of key terms:

1. Signals:

- In wireless transmission, information is carried by electrical signals that are converted into radio waves using a process called modulation (explained later).
- These radio waves travel through the air and carry the encoded information.

2. Frequency and Bandwidth:

- **Frequency:** Measured in Hertz (Hz), it represents the number of cycles a wave completes per second. Higher frequencies correspond to shorter wavelengths. (**Figure 1**)
- **Bandwidth:** Measured in Hertz (Hz) or bits per second (bps), it represents the range of frequencies used to transmit a signal. A wider bandwidth allows for faster data transmission.

Figure 1: Frequency and Wavelength Relationship

High Frequency (Short Wavelength)

Low Frequency (Long Wavelength)

3. Antennas:

- Antennas are devices that convert electrical signals into radio waves for transmission and vice versa for reception.
- Different antenna types have varying properties like directionality, gain (signal strength), and operating frequency.

4. Signal Propagation:

- It refers to how radio waves travel through the air. Factors like frequency, environment (obstacles, weather), and distance can affect signal propagation.
- Common propagation modes include:
  - **Line-of-Sight (LOS):** Direct path between transmitter and receiver for strongest signal.
  - **Ground Wave:** Follows the curvature of the earth, useful for lower frequencies.
  - **Skywave:** Reflected by the ionosphere, enabling long-distance communication but can be unreliable.

5. Multiplexing:

- This technique allows for transmitting multiple signals on the same carrier frequency to improve efficiency.
- Common multiplexing techniques include:
  - **Frequency Division Multiplexing (FDM):** Divides the available bandwidth into sub-channels for different signals.
  - **Time Division Multiplexing (TDM):** Assigns different time slots on the same frequency for each signal.

6. Modulation:

- Modulation is the process of encoding information onto a carrier wave by varying its characteristics like amplitude, frequency, or phase.
- Common modulation techniques include:
  - **Amplitude Modulation (AM):** Varies the amplitude of the carrier wave based on the information signal.

  - **Frequency Modulation (FM):** Varies the frequency of the carrier wave based on the information signal.
  - **Phase Modulation (PM):** Varies the phase of the carrier wave based on the information signal.

7. Spread Spectrum:

- A modulation technique where the information signal is spread over a wider bandwidth than the original signal.
- This makes it more resistant to interference and improves security.
- Applications include Wi-Fi and Bluetooth.

8. Cellular System:

- A cellular system divides a geographical area into smaller coverage areas called cells.
- Each cell has a base station that communicates with mobile devices within its range.
- Handoffs occur when a mobile device moves from one cell to another, ensuring seamless connectivity.

By understanding these terminologies, you can gain a deeper understanding of how wireless communication works and the technologies that enable it.