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PROGRAM

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1.0 Introduction

Mobile application development is the process of developing mobile software for mobile devices such as personal digital assistants, enterprise digital assistants, or mobile phones. The software applications have been designed to run on mobile devices like tablet computers and smartphones (Wikipedia, 2022).

Advanced mobile application programming is the process employed by Software Engineers through requirements engineering concepts, principles, platforms, and programming languages to design and develop software to run feature phones, smartphones, and digital assistants or tablet computers (Education, 2020).

Examples of tablet computers include (McLellan, 2014):

- Google's Nexus 7
- The Apple iPad Mini
- Samsung's Galaxy Tab 3 7.0

Examples of smartphones include (BY JACOB POUSHTER, 2018):

- iPhone
- Android
- Blackberry
- Windows phone
- Samsung Galaxy

The preinstallation of these applications can be done on these mobile devices during the manufacturing process or delivered as web applications using server-side or client-side processing

like JavaScript to provide an application-like experience within a web browser. Software Engineers must take the following into consideration:

- Hardware specifications
- Software specifications
- Configurations
- Mobile User Interface (UI)

Mobile user interface design is also very crucial during the development of mobile apps with constraints, contexts, screen, input, and mobility as outlines for design. The user is considered central during the development process following the interaction with their device. The interface includes components of both hardware and software.

User input enables the users to manipulate system functionalities while the device's output enables the system to show the effects of the users' manipulations. Mobile user interface design constraints include the following amongst others:

- Screen size of the mobile device relative to the user's hand
- Bottlenecks due to user activities while interacting with the mobile device

The main goal of mobile user interface design is to develop a mobile device that is easily understandable and user-friendly to the users during interactions with these devices. Mobile enterprise application platforms or integrated development environments support the functionalities of these mobile devices.

Mobile User Interfaces(front ends) depend on the mobile back ends to support access to enterprise systems. Mobile-back-ends, support the following functionalities which include system

components such as mobile application server, mobile backend as a service, and service-oriented architectural infrastructure.

- Routing of data
- Authentication
- Security
- Authorization
- Off-line operations
- Service integration

2.0 Advanced Mobile Applications (AMA) and Operating Systems

This is an international developer of games and applications for phones, tablets, interactive televisions, smartwatches, 2-in-1 personal computers, smart speakers, and other connected mobile devices which use the mobile operating system as an operating system (Wikipedia, Wikipedia, 2021). Laptops are typically mobile devices with operating systems meant for desktop computers without specific mobile features. This clear distinction is fading in some newer operating systems that are hybrids made for both purposes.

Mobile operating systems integrate features of a personal computer operating system with other features useful for mobile device use which also include a wireless inbuilt modem and SIM tray for telephony and data connection (Wikipedia, Wikipedia, 2022). Mobile devices having mobile communications capabilities such as smartphones contain two mobile operating systems, and these are:

- Main user-facing software platform

- Low-level proprietary real-time operating system operating the radio and other hardware

Malicious base stations can gain a high level of access and control over mobile devices due to some security vulnerabilities in these low-level systems. Considering a mobile or cell phone as a typical example of a mobile device, a mobile phone is described as a portable telephone which makes and receives calls over a radio frequency link while the user is either static or in motion within a telephone service area.

The mobile phone is connected to the switch rooms of the mobile phone operator through a network of towers which switches have switching capabilities. The radio frequency link establishes a connection between the mobile phone and the switching systems through the transmission infrastructure called the public switched telephone network (PSTN).

Cellular network architecture is used by modern mobile telephone services are referred to as cellular telephones or phones in most parts of the globe. Additionally, digital mobile phones running on 2G,3G,4G, and 5G (G = Generation) upgraded cellular infrastructure support various services such as:

- Text
- Electronic mail
- MMS
- Internet connectivity
- Infrared and Bluetooth (wireless communications in short range)
- Applications of Businesses
- Games of Videos

- Digitalized photography

3.0 Mobile Phone Capabilities and Components

Mobile phones offering basic capabilities are known as feature phones and those with enhanced computing capabilities are called smartphones. The top-rated smartphone and feature phone developers globally include amongst others Samsung, Apple, Huawei, Nokia, Techno, and Alcatel.

The mobile phone is structured into hardware and software relatively like computers. The hardware components common in mobile phones include the following:

- **Central Processing Unit (CPU)** is a microprocessor fabricated on a metal-oxide-semiconductor integrated circuit chip.
- **Battery** powering the functionalities of the phone with Lithium-ion battery for modern cells and Nickel-metal hydride battery powering older cells.
- **Input mechanism** to allow the user to interact with the phone such as the touch screen for smartphones, and keypad for feature phones.
- **Display** to output information and typically it can be a liquid-crystal display (LCD) or Organic light-emitting diode (OLED) display.
- **Speakers** for sounding.
- **Subscriber Identity Module (SIM)** cards and **Removable User Identity Module (R-UIM)** cards
- **Hardware notification LED** on some cell phones.

Software platforms are generally for featured phones having basic capabilities and smartphones with advanced capabilities running operating systems such as Android, iOS, and others. A mobile

app is a computer program designed to run on a mobile device like a smartphone. Software Application is abbreviated as ‘app’.

Basic and common data applications on mobile phones are Short Message Service (SMS) and Multimedia Messaging Service (MMS) typically used in featured phones. Advanced apps commonly used in advanced mobile devices such as smartphones and tablet computers are WhatsApp, Facebook, Twitter, TikTok, and others like video games, music, and business products.

4.0 Application Stores

These are online application distribution stores for software and computer programs that are designed and developed by specific mobile device manufacturers such as:

- Apples App store
- Google Play Store
- BlackBerry App World
- Aptoide (Android-related)
- Opera Mobile Store

Smartphone application distribution depends on third-party sources which offer several platforms like GetJar, Handango, Handmark, and PocketGear. Smartphones and computer tablets are used in the following area amongst others:

- Content distribution and selling of media content such as news, video games, TV content, and Jokes.
- Mobile banking and payment to transfer cash payments from the mobile money systems to banking systems and vice versa. It is also applicable within the same mobile phone operator

or across operators of mobile money systems for example in Uganda we have MTN Mobile Money, Airtel Money, and Remit which is an international mobile app.

- Mobile tracking to collect location data.
- Apps such as Zoom for education and business purposes.

5.0 Health Effects of Using Mobile Devices

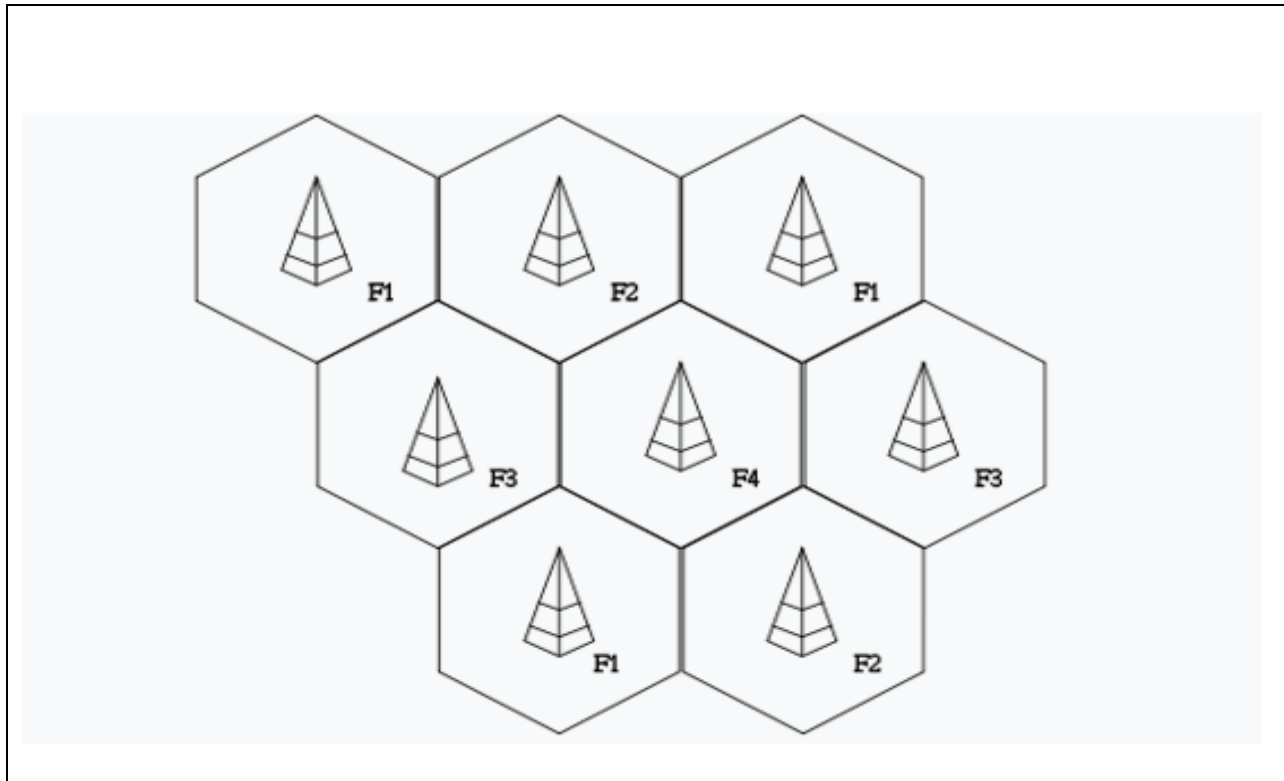
Mobile phones use electromagnetic radiation in the microwave range (invisible range). Epidemiological and experimental research in humans and non-human animals show that there is no definite causative relationship between exposure to mobile devices (cell phones) and harmful biological effects in humans.

On the contrary, World Health Organization (WHO) on 31st/May/2011, stated that the usage of mobile phones could pose a long-term health risk classifying mobile phone radiation as possibly carcinogenic to humans after reviewing studies on mobile phones safety by a team of scientists. The mobile phone is categorized as Category 2B ranking it alongside coffee and other possibly carcinogenic substances (Wikipedia, Wikipedia, 2022).

6.0 Infrastructure

Cellular networks function by only reutilizing radio frequencies in non-adjacent cells to avoid interference. The example below displays frequencies (f1-f4). Cell towers are planted to provide coverage across a telephone service area of which both featured and smart mobile phones use these towers to communicate. A telephone service area is divided up into units called cells.

Each cell uses a different set of frequencies from the nearby surrounding cells and typically is covered by three towers planted at different locations usually interconnected to each other and connected to the Internet and the phone network by optical fibers, cables, or wireless connections.



Bandwidth limitations cause each cell to have a maximum number of cell phones it can handle at a go and in this case, cells are sized depending on the usage density expectations, and in the cities, the sizing could be reduced for lower transmitter powers are used to deter broadcasting beyond the cell.

Several towers are installed in the same area with different frequencies to handle high traffic transmissions. This installation can be done either permanently or temporarily when traffic is always expected to be high such as big events in the cities. Here a telecommunications company

will always bring a mobile tower (portable cell) installed on a truck to host the abnormally high traffic.

Cellular technology enhances the capacity of concurrent wireless phone calls. A telecommunications company can be licensed to the tune of 1,000 frequencies and each cell must use unique frequencies when each call utilizes one of them during communications.

The same frequency range can be reused (Jayagopal Kannan, 2015), because cells slightly overlap.

Consider the cell number and frequency range table relative to the geographic area below:

Frequency Re-Use and Cell Structure		
Cell Number	Geographic Separation	Frequency Range
Cell One	Door One (Geographic Separation-One)	1-500
Cell Two	Door Two (Geographic Separation-Two)	501-1000
Cell Three	Door Three (Geographic Separation-Three)	1-500

Cells one and three are not interfering (touching) because the same frequency range is in two different geographically separated areas and hence the same frequency range can be reused as depicted in the table above. Cell structures employed for telephone networks are assumed hexagonal such that no spaces between the base stations are left without coverage.

6.1 Platform

Many components and tools allow a Software Engineer (Developer) to write, test and deploy mobile applications. This includes front-end and back-end development tools. The front-end development tools are focused on the user interface and user experience. The environment and the programming languages are tabulated below.

Environment	Programming Language
Accelerator	C#, HTML5
Mobile Together	XPath/XQuery, Action Trees visual programming language
Android	Java but some of the codes can be written in C, C++, Kotlin
App Inventor for Android	A visual blocks-oriented programming language with an interface designer
Appcelerator	JavaScript
Basic4android	Visual-Basic like syntax
BlackBerry	Java
Codename One	Java
Corona SDK	Lua
DragonRAD	Visual Drag and Drop tiles
GeneXus for Mobile and Smart Devices	Knowledge representation and Declarative program-modeling for easy development, with code autogenerated for each platform

IBM MobileFirst Studio	JavaScript, CSS3, HTML and native SDK languages
iOS SDK	Swift, Objective C
iOS SDK	Object Pascal
Java ME	Java
Lazarus	Object Pascal
LambdaNative	Schema
LiveCode	LiveCode
Macromedia Flash Lite	ActionScript
Marmalade	C++, C
Meme IDE	MemeScript
Monaca	CSS, JavaScript, HTML5
Mono for Android	C#
MonoTouch	C#
MoSync	HTML5, Lua, C++C, CSS, JavaScript
NetBeans	Java, C++
OpenPlug	XML, ActionScript
OutSystems	CSS, JavaScript, OutSystems
PhoneGap and Apache Cordova	CSS, JavaScript, HTML
Qt SDK	QML, C++

Rhomobile	Ruby with HTML interface features which are compiled through an interpreter into native applications
RubyMotion	Ruby
Sencha Touch	HTML, JavaScript, CSS
Smartface	WYSIWYG design editor with JavaScript coded editor
Stencyl	Drag and Drop editor based on scratch objective C
Telerik Platform and AppBuilder	JavaScript, HTML5, CSS
Unity	JavaScript, Boo, C#, and other NET-Based languages
Verivo AppStudio	WYSIWYG graphical drag and drop, JavaScript, Appery.io
V-Play Engine	JavaScript, QML, Java, Objective C, C++
Wakanda	HTML5, JavaScript
Xamarin	C#
Xojo	Xojo with similarity to VB

6.2 Back-end Servers

Back-end tools provide a set of reusable services which are controlled and managed centrally with the following capabilities:

- Integrated with back-end systems
- User authorization
- User authentication
- Services of data
- Reusable business logic

Available tools in terms of platforms and programming languages are registered below:

Environment	Programming Languages
WebORB Integration Server	C#, VB.NET, Java, PHP, ActionScript, JavaScript, Objective C, XML
Wakanda	JavaScript
Verivo Akula	Java
Metismo	Java
IBM MobileFirst Server	HTML5, CSS3, JavaScript and native SDK languages
Globo plc GO! AppZone	JavaScript, Custom integrated connectors/server-side logic#, VB.NET
Altova Mobile Together Server	Browser-Based interface

6.3 Security Add-on Layers

Bring your own device (BYOD) is becoming the norm within many enterprises. Information Technology departments always need a stopgap, calculated solution which is a layer on top of the existing apps, phones, and platform components. These features include the following:

- Security Application wrapping
- Encryption of data
- Reporting and statistics
- Client Interactions

6.4 System Software

Several system levels of components are required to have a functioning environment for developing mobile device applications. The environment and the programming languages include the following as tabulated below:

Environment	Programming Languages
Windows Phone	C#, Visual Basic, C, C++
Windows Mobile	C, C++
Ubuntu Touch	HTML5, CSS, JavaScript, QML, C, C++
WebOS	JavaScript, CSS, HTML, C and C++ through the PDK
Tizen	HTML5, CSS, JavaScript, C++, C
Symbian	C++
Python	Python

Palm OS	C, C++, Pascal
OpenFL	Haxe with similarity to ActionScript and Java
.NET Compact Framework	C#, Basic4ppc, VB.NET
Firefox OS	HTML5, JavaScript, CSS
BREW	C where the APIs are provided in C with a C++ interface
Adobe AIR	HTML, CSS, JavaScript, ActionScript

The basis for selecting a development environment usually contains the target mobile platforms, existing infrastructure, and development skills. The effect of the applied tool on the user experience should be taken into consideration when targeting cross-platform development. Performance is yet another important basis for selecting an environment for development because mobile app research shows that there is a strong correlation between the performance of the application and the satisfaction of the user.

Additionally, the availability of technology and the project's requirements may possibly drive the development between native and cross-platform environments following published guidelines and benchmarks. Cross-platform environments are reusable across many platforms, strengthening a native container while utilizing HTML, CSS, and JavaScript for the user interface.

In disparity, native environments are targeted at one platform for each of those environments. For example, the development of Android occurs in the covering of IDE using Android Developer Tools (ADT) plugins. Apple iOS development occurs using XCode IDE with objective C and /or Swift, Windows, and BlackBerry with their own development environments.

7.0 Testing of Mobile Applications

Using emulators, mobile applications are initially tested within the development environment and later subjected to practical or field testing. Emulators bring down the cost of testing to test applications on mobile devices such as phones and computer tablets that are not in most cases physically accessible by Testers.

Across the most popular mobile operating systems, some of the tools below are used for testing applications.

Google Android Emulator was patched to run on a windows environment as a standalone app, without completely downloading and installing the complex Android SDK. Following installation, Android compatible apps can be tested on it.

The Official Android SDK Emulator imitates all the hardware and software features of a typical mobile device.

TestiPhone is a web browser-based simulator used to test iPhone web applications. It works well with Firefox 2, Safari 3, and I.E 7.

Iphoney Powered by Safari, gives it a pixel-accurate web browsing environment used while developing websites for the iPhone. It is designed for web developers who want to create 320 by 480 or vice versa to be used in iPhones and it only runs on OS X 10.4.7 or later.

BlackBerry Simulator exists in a variety to emulate the functionality of actual BlackBerry products and test how the device software, screen, keyboard, and trackwheel work with the application.

Windows UI Automation is used to test applications that use the Microsoft user interface automation technology and requires Windows Automation API 3.0 preinstalled on Windows 7, Windows Server 2008 R2, and later versions of windows.

The tools include the following:

- EggPlant which is a graphical user interface-based automated test tool for the mobile app across all operating systems and devices.
- Ranorex are automated test tools for mobile, web, and desktop applications.
- Testdroid are automated test tools for mobile and web applications.

8.0 Conclusion

Advanced mobile application programming or development is employing advanced techniques of mobile application design and development to write software that runs mobile devices such as smartphones and digital assistants (tablet computers). These mobile devices require an infrastructure to network their functionalities, and this is provided mostly by telecommunications companies and Internet Service Providers.

The mobile devices function by running mobile operating systems and the most common ones are iOS and Android in addition to third-party software that can be downloaded and installed by the user from the mobile device manufacturer's online application store such as Google Play Store and Apple App Store. These mobile devices and their operation infrastructure have undergone evolution and can execute simple to advanced functionalities to suit the user's needs.

Software Engineers and developers can work together using several available platforms and programming languages to design and develop the software that runs these mobile devices by employing requirements engineering concepts and principles. Both smartphones designed and developed with advanced capabilities and feature phones with basic capabilities have changed the way the globe works in terms of the following:

- Content distribution
- Mobile banking and financing
- Mobile Tracking
- Health and Education
- Security and mineral conflicts

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