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**COURSE INSTRUCTORS: DR NKEMINI Valery APRIL 2024REPUBLIQUE DU CAMEROUN**

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**CEF440**

**INTERNET PROGRAMMING AND MOBILE PROGRAMMING**

**BY**

**GROUP 25**

**OPERATIONAL RESEARCH**

**LIUNEAR PROGRAMMING PROBLEMS (LPP)**

**BY**

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**Matriculation number: AV19A131**

**SUPERVISOR:**

**ACADEMIC YEAR:**

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**Task 1**

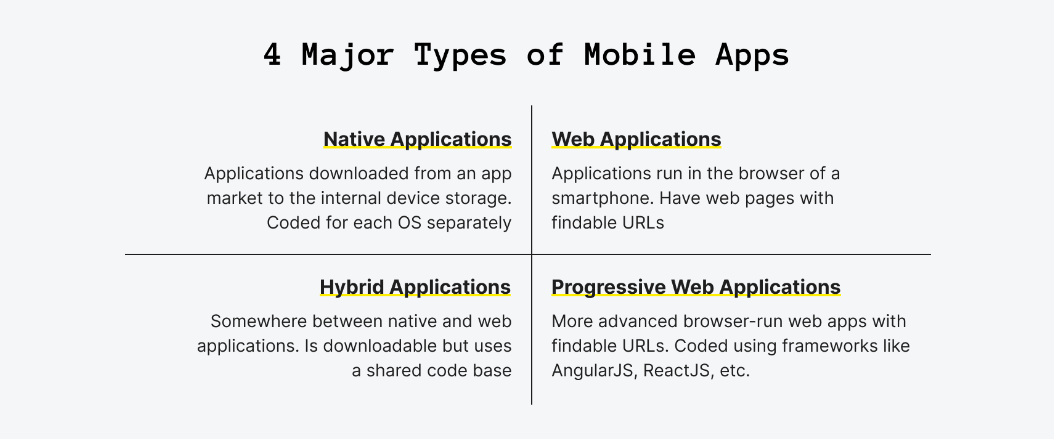
# MAJOR TYPES OF MOBILE APPS AND THEIR DIFFERENCES (NATIVE, PROGRESSIVE WEB APPS, HYBRID APPS)

A mobile application is a kind of software that is created for being run on a mobile device. This includes not only smartphones but also tablets and smartwatches.

There exist various types of mobile applications which differ by purpose and the ways they operate on mobile devices. Shortly mentioning the latter, mobile apps may be coded differently, for instance, depending on the operating systems (OS) of the devices they'll be used on or if they'll be launched in browsers instead of being downloaded to the device's internal storage.

Accordingly, the programming languages and frameworks to create mobile applications vary as well. For instance, Flutter, React Native, and Ionic are considered among the best mobile app development frameworks.

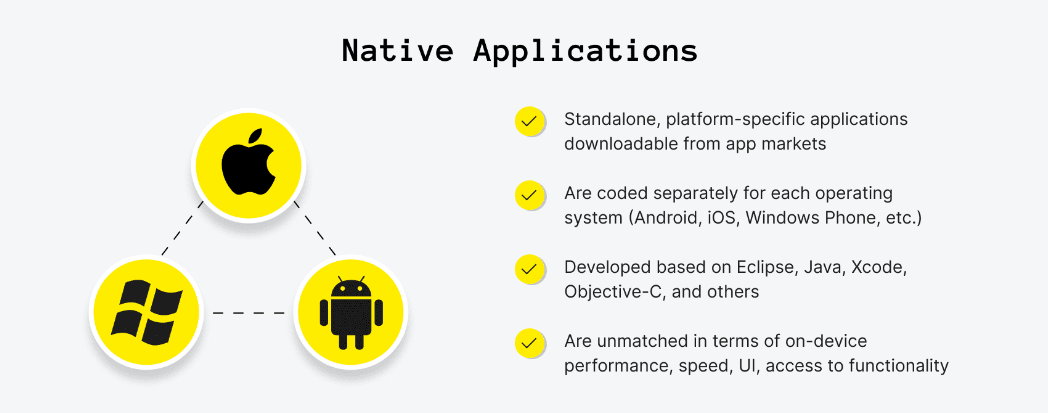
A cross-platform app is an application that works on multiple platforms, such as Android, iOS, or Windows.



## 1.1 Native Applications

Native mobile apps are applications downloaded from an app market to the internal device storage. They are usually coded for each device separately.

When building native apps developers have to code the app at least twice for Android and iOS so that the audience would have the chance to get it. Twice because the two most popular mobile OS are based on different programming languages, so the code is not reusable.



The best-fit software programming languages for native application development fully depend on the operating systems and their mobile application requirements. For instance, Android applications are usually developed based on Eclipse and Java while iOS apps use Xcode and Objective-C. But then again there are specially designed SDKs (software development kits) and frameworks that can help speed things up.

### 1.1.1 Native Application Advantages

- On the bright side, because native applications are standalone and platform-specific, they are practically unrivaled in terms of usability and compatibility.

- They can boast unmatched on-device performance, advanced security, the capability of working offline, tend to have fewer bugs, and are tailored to make the most of each device's native UI.

- Plus, they have no roadblocks to accessing the smartphone's hardware and features like the microphone, GPS, or camera.

- Since the application may be up on app markets, this could mean additional discoverability.

- It is possible to charge users for downloading the app, providing a monetization path.

### 1.1.2 Native Application Disadvantages

- These types of mobile applications are quite costly to develop. Launching a native app requires additional investment and possibly time. And their maintenance won't come easy nor cheap either.

- After being coded for separate OSs, these apps have to go through the process of approval to become available on the app markets. This may also be time-consuming and can possibly delay your mobile app launch on the market.

-The step that follows launch on the app markets may be even harder as you'd need to make your users manually install the app on their devices to use it.

- There’s no guarantee that users won't delete the app after installing if it isn't used regularly. This is a common scenario since native applications are usually weighty, and not everyone likes their smartphone's internal memory to be clogged with applications they might not use often.

- Native applications require users to make updates. Whenever the application gets a new version rolled out even with minor changes, the users must make corresponding updates on their mobile devices. At times, they'll lose access to the app completely until the update is made.

Hence, opting for classic native application creation might not be the right path for all businesses or ideas.

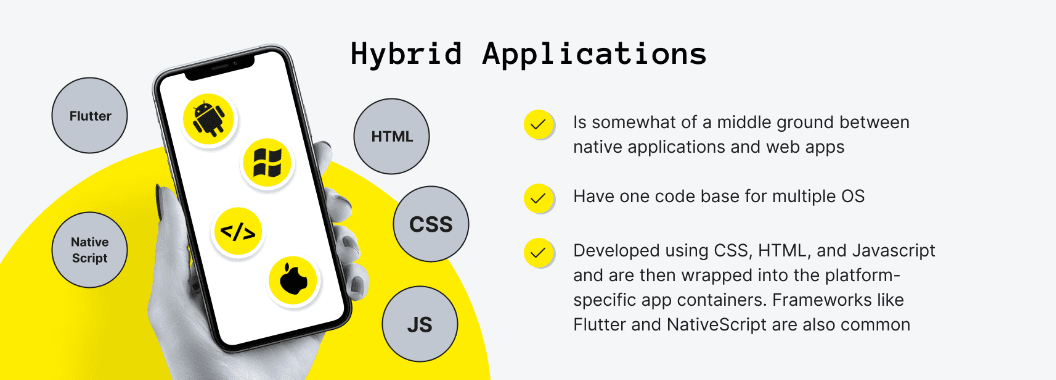
### 1.1.3 Examples of Native Application

Google Play or AppStore, comprises of dozens of mobile apps categories to choose from. Among them, there are plenty of native applications available for download. WhatsApp Messenger is a native app example.

## 1.2 Hybrid Applications

Hybrid mobile apps are applications that combine web apps with the native capabilities of a platform. They are developed in one go for all platforms, which means less time and money spent on cross-platform development. This brings us to one more mobile application type.

Hybrid mobile apps are similar to the cross-platform mobile app development concept, hybrid application development values the reusability of code and accessibility on numerous devices. This solution is somewhat of a middle ground between native applications and web apps.



They are developed using web technologies like CSS, HTML, and Javascript and are then wrapped into the platform-specific app containers (meaning that they integrate well both with iOS and Android). Hybrid applications are also commonly developed using specially designed mobile application development frameworks like Flutter or React Native.

### 1.2.1 Hybrid Applications Advantages

- Cost-effectiveness and an accelerated time to market are the major benefits of this mobile app type compared to native applications.

- You don't have to work on separate mobile apps in terms of iOS and Android code. Hybrid apps have one code base for multiple OS, so maintenance is simple. This partially explains why hybrid applications are currently gaining popularity and why they've become one of the mobile application trends.

- Hybrid apps exist in the form of downloadable applications from app markets, so technically they're sort of like native apps.

- They can be accessed offline or with a bad internet connection (but only to a limited extent).

- They're capable of supporting the built-in smartphone hardware and features (just like native applications do but aren't compatible with all the functionality).

### 1.2.2 Hybrid Applications Disadvantages

- Their speed may be dependent on the browser (so, regular native apps usually operate faster).

- They aren't as interactive and quick as native applications.

- Hybrid applications might not perform flawlessly if the application is too complex since this requires more power and speed.

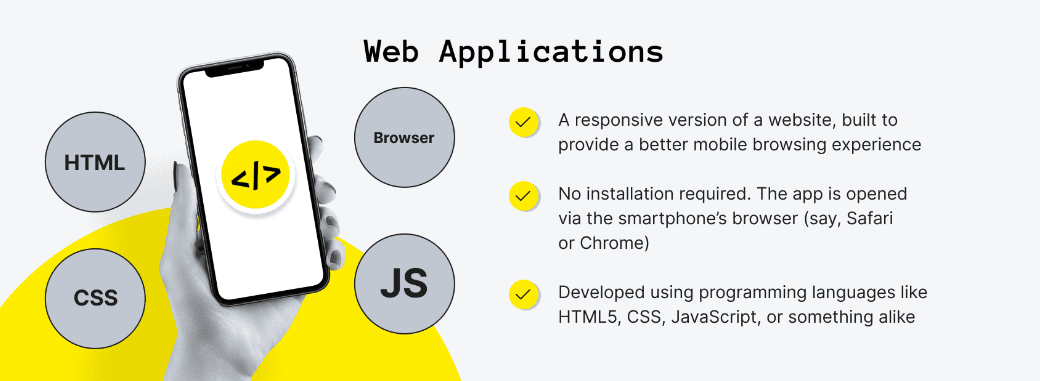
### 1.2.1 Hybrid Applications Examples

There are tons of hybrid applications today, including Instagram, Gmail, Facebook, and many others.

## 1.3 Web Applications

Web apps are a responsive version of a website, built to provide a better mobile browsing experience when compared to using the website's regular mobile version.

A web app makes a website responsive, it is launched via the browser (so you don't have to force users to install the app to the device to use it like in the case with native apps). Mobile websites are the version of a website that people see when opening a site from a mobile browser, but they are commonly unoptimized, not user-friendly, slow, and look like the shrunk desktop website version.



Once again, web applications are basically websites that are designed to be responsive and work well on a mobile device. Hence, they are developed using programming languages like HTML5, CSS, JavaScript, or something similar.

### 1.3.1 Web Applications advantages

- Cross-platform and cross-device accessibility using a smartphone browser without installation.

- Increased user satisfaction with their mobile experience (if compared to opening a static website version that's poorly optimized for mobile).

- No internal device storage nor updates are required on the user's end.

- Not missing out on SEO (because web applications have URLs like any website, search bots see the pages separately and people can find them via a fast Google search or direct URL address input).

- They are cheaper to develop than native mobile applications.

### 1.3.2 Web Applications Disadvantages

- If the users fail to have decent access to the internet, they won't have the chance to enjoy the web app to the fullest until the connection is back.

- When a user closes the web page, they'll have to find a way to reopen it in the browser and return to the website again (to compare, native applications are downloaded to the device and are accessible in one tap).

- There may also be additional restrictions with such types of apps due to limited hardware accessibility (such as with sending push notifications).

- Web applications might be far from perfect in terms of UX, security, and speed.

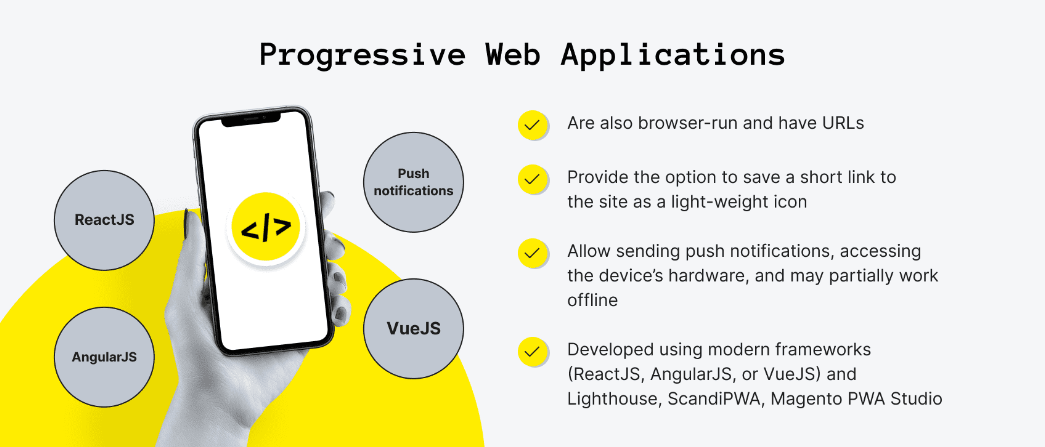
1.3.3 Progressive Web Applications examples

Numerous websites have chosen custom web application development and made web apps to improve the mobile experience of their users, including Trello.

## 1.4 Progressive Web Applications

Progressive Web Apps (PWA) are web apps that simulate the behavior of native mobile apps (they can send notifications, use the camera, ask for location, etc.) They are typically accessed via a web browser of your choice but can be installed and accessed on a device. PWAs are radically accessible, making them a great choice for dynamic eCommerce solutions.

Web application development is constantly moving forward, and the progressive web application (PWA) solution emerged not too long ago. This web-based technology overcomes many of the previously existing web app issues (including the ability to be used offline or send push notifications).



Progressive web apps are built using modern frameworks like React.js, Angular.js, or Vue.js. Lighthouse, ScandiPWA, and Magento PWA Studio are also commonly used for their development.

### 1.4.1 Progressive Web Applications advantages

- PWAs are also browser-run and have URLs (so the pages can be promoted in terms of SEO and found via the web search).

- They put page loading speed in the spotlight (while native apps still perform faster, PWAs use optimized rendering to accelerate the page loading times).

- Progressive web apps are immersive and may resemble the look of native applications.

- They also provide the option to save a short "Add to Home Screen" link to the site (and this link will look like any other app icon on the smartphone's screen). Importantly, these bookmarks are low-weight.

- These types of mobile applications allow sending push notifications, accessing the device's camera and other functionality, and may partially work offline.

- Notably, when rebuilding a website into a PWA, the desktop version of the website can get optimized as well.

- Progressive web apps cost less to develop when compared to native applications.

### 1.4.2 Progressive Web Applications Disadvantages

- These apps aren't available in app stores and can be saved to the home screen only after the website was accessed via a browser.

- PWA technologies are advancing, yet there is still room for improvement, including offline use and device functionality access limitations on iOS.

But the main question is can a PWA be considered a mobile app substitute? Perhaps, not. They target different audience groups and have different aims.

### 1.4.3 Progressive Web Applications examples

The implementation of progressive web apps has been especially seen in the e-commerce sector recently. Many renowned companies including Starbucks have converted their websites into PWAs.

# MOBILE PROGRAMMING LANGUAGES

Businesses of all types are increasingly turning to Indian firms that specialize in mobile app development to find qualified personnel to design and build their mobile applications. With so many programming languages out there, it’s important to pick the one that works best for creating apps.

Choosing the proper programming language is crucial when creating apps. It determines how easy it will be to create and manage your application as well as its effectiveness, scalability, and performance. Due to the advent of new languages and the development of existing ones, it can be challenging to navigate through the multitude of alternatives available.

Selecting the proper programming language is crucial when creating apps for a variety of reasons. Your app’s functionality, performance, scalability, maintainability, and developer productivity will all be significantly impacted by the programming language you choose.

## 2.1 Importance of Choosing the Right Programming Language for App Development

Choosing the right programming language for your app is like picking the right tool for the job. It impacts everything from how your app works to how smoothly it runs and its success. Here is why selecting the perfect language is crucial:

1. Fitting In: Platform Acceptance

Just like you wouldn’t use a hammer on a screw, some languages are best suited for specific platforms. For iOS apps, Swift or Objective-C are the go-to choices, while Ruby, JavaScript, or even web development languages might be better for multi-platform apps.

2. Building Blocks: Libraries and Frameworks

Think of libraries and frameworks as pre-built toolkits. They save you time and effort by providing ready-made solutions for common tasks like database interaction or user interface creation. Choose a language with robust libraries and frameworks that match your app’s needs.

3. Playing with Others: Third-Party Integrations

Your app might need to connect with external services, APIs, or other platforms. Make sure the language you choose plays well with others. Check for available APIs, SDKs (software development kits), and a supportive community to help with integrations.

4. Speed Demons vs. Efficiency Champs: Performance and Efficiency

Some languages are known for their speed and control, like C and C++, making them ideal for resource-intensive tasks. But don’t forget about development efficiency. Languages like Python or JavaScript might be faster to develop with but may have some performance trade-offs. Find the right balance for your app’s needs.

5. Specialized Tools: Domain-Specific Capabilities

Not all languages are created equal. Some excel in specific areas like data analysis (R and MATLAB) or blockchain development (Solidity). If your app deals with a particular domain, consider languages with specialized features and tooling to streamline development.

6. Growing Your App: Extensibility and Customization

As your app evolves, you should add new features or functionalities. Choose a language that provides flexibility and customization options. C++ or Java offer features like inheritance and custom annotations, allowing you to create reusable components and even extend the language itself.

## 2.2 Best Programming Languages for Mobile App Development

### 1. Swift

Developed by Apple, Swift is the go-to language for iOS app development. Its clean syntax and powerful features make it easy to write and maintain code.

Swift offers safety features like optional and automatic memory management, reducing the chances of runtime errors. Popular apps like Airbnb and LinkedIn use Swift for their iOS versions due to its performance and reliability.

### 2. Kotlin

Kotlin has gained popularity for Android app development due to its interoperability with Java and concise syntax. It offers features like null safety and extension functions, enhancing productivity and code safety. Apps like Pinterest and Trello have embraced Kotlin for its modern language features and seamless integration with existing Java codebases.

### 3. Java

As a long-standing player in the mobile app development scene, Java remains a robust choice for Android app development. Its platform independence, strong community support, and extensive libraries make it a versatile language. Apps like WhatsApp and Instagram rely on Java for their Android versions due to its stability and scalability.

### 4. Dart (used with Flutter)

Dart, paired with Google’s Flutter framework, enables cross-platform app development with native-like performance. Its Just-in-Time compilation allows for fast development cycles, while Ahead-of-Time compilation ensures efficient production builds. Flutter powers apps like Alibaba and Google Ads due to its fast development pace and expressive UI capabilities.

### 5. JavaScript (used with React Native)

React Native leverages JavaScript to build cross-platform mobile apps with a single codebase. Its component-based architecture and hot reloading feature accelerate development. Popular apps like Facebook and Instagram use React Native for their ability to deliver native-like performance and seamless user experiences a cross platforms.

### 6. C# (used with Xamarin)

Xamarin, powered by C#, allows developers to build native Android, iOS, and Windows apps with a shared codebase. Its strong integration with Visual Studio and access to native APIs ensure high performance and platform-specific functionalities. Apps like UPS and Alaska Airlines rely on Xamarin for its code-sharing capabilities and native user experiences.

### 7. Objective-C

While Swift has largely replaced Objective-C for iOS development, it remains relevant for maintaining legacy codebases. Objective-C offers dynamic messaging and runtime reflection, allowing for flexible app development. Apps like Airbnb and Uber initially relied on Objective-C before transitioning to Swift.

### 8. Python

Python’s simplicity and versatility extend to mobile app development, particularly with frameworks like Kivy and BeeWare. Its readable syntax and extensive libraries facilitate rapid prototyping and development. Apps like Instagram and Dropbox use Python for backend services and automation tasks, showcasing its flexibility beyond mobile development.

### 9. HTML/CSS

Web technologies like HTML and CSS, combined with frameworks like Cordova and PhoneGap, enable the building of hybrid mobile apps. Their familiarity and ease of use make them accessible to web developers. Apps like Untappd and Untitled Goose Game employ HTML/CSS for their cross-platform compatibility and rapid development cycles.

### 10. Rust

Rust’s focus on safety and performance makes it a compelling choice for mobile app development, especially for resource-intensive applications. Its ownership model and zero-cost abstractions ensure memory safety and prevent data races. While less widely adopted in the mobile space, Rust is gaining traction for apps like Firefox Focus due to its security and efficiency benefits.

### 11. Ruby

Although primarily associated with web development, Ruby can be used for mobile app development with frameworks like RubyMotion. Its elegant syntax and developer-friendly features promote rapid development. Apps like Basecamp and Couchsurfing have utilized Ruby for its productivity gains and expressive codebase.

### 12. Prolog

Prolog’s declarative programming paradigm makes it suitable for certain types of mobile applications, particularly those involving rule-based logic or expert systems.

Its built-in pattern matching and backtracking capabilities simplify complex problem-solving tasks. While not commonly used for mobile development, Prolog finds applications in niche domains like educational apps and decision support systems.

### 13. LISP

Lisp’s flexibility and metaprogramming capabilities make it a niche choice for mobile app development, particularly in AI and game development. It’s homoiconicity and macro system enable powerful abstractions and domain-specific languages.

Apps like Autodesk SketchBook and WolframAlpha demonstrate Lisp’s potential for innovative and specialized applications.

### 14. Malboge

Malboge, known for its esoteric nature and challenging programming style, is not a practical choice for mainstream mobile app development. Its intentionally obscure syntax and unconventional execution model make it unsuitable for real-world projects.

While it may serve as a curiosity or educational tool, Malboge lacks the practicality and support required for mobile app development.

### 15. Go

Go’s simplicity, concurrency support, and fast compilation times make it an appealing option for mobile app development, particularly for backend services and command-line tools. Its built-in garbage collection and static linking simplify deployment and maintenance.

While not as prevalent as other languages in the mobile space, Go is gaining traction for apps like Docker and Kubernetes due to its performance and scalability benefits.

When considering the top programming languages for app development in 2024, it is essential to prioritize versatility, platform compatibility, performance, and security. Python stands out for its adaptability, while JavaScript excels in creating both websites and mobile apps.

Swift remains the go-to choice for iOS app development, while Java remains strong for cross-platform and corporate applications. Rust emerges as a formidable option for its combination of performance and security, while Kotlin gains ground for Android app development over Java.

# MOBILE DEVELOPMENT FRAMEWORKS

# MOBILE APPLICATION ARCHITECTURES AND DESIGN PATTERNS

# USER REQUIREMENTS FOR A MOBILE APPLICATION

Mobile app requirements document the business logic, technical specifications, and development guidelines for mobile app developers to design the application of your business dreams.

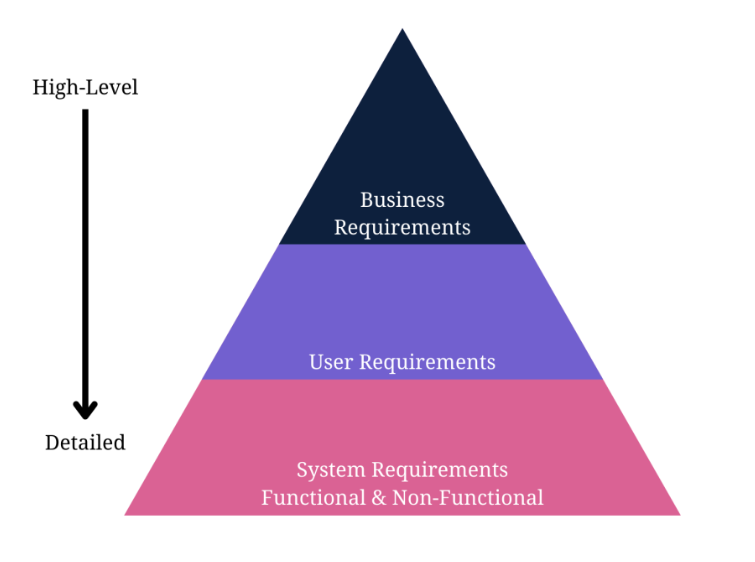
It includes the key app’s features, app user personas, and business goals to ensure that multiple team members are on the same page before the software development process commences.

Mobile apps have different requirement types to collect, including:

Business requirements are high-level requirements that ensure the app will align with business objectives, and the project’s scope, and identify the key stakeholders.

User requirements are valuable insights into what your target audience needs and wants, how you can solve their problems, and what the audience experiences from your prototyping app.

Product or system requirements are non-functional requirements and functional requirements that include technical requirements and technical specifications for the engineering team.



* A functional specification document will outline the product’s features and how users interact with the app.
* On the other hand, non-functional requirements include the technical specification for the app’s quality attributes.
* For example, a functional requirement refers to the sign-up button users click on before using your services.
* However, non-functional requirements refer to how fast the system responds to the user clicking on that button and how the system protects their data while clicking the button.

The following steps to gather requirements for a mobile application to ensure you meet the business requirements and key features necessary to develop a profitable product.

## Step 1: Define Your App Idea and Purpose

Mobile development requirements-gathering starts with a business idea. The first information you need is the idea or purpose of the mobile app.

What purpose will it serve? Does it offer a solution to a potential problem?

You need to identify a problem the app will solve to recognise the idea or purpose behind it.

Requirements gathering and management for mobile apps require some effort with massive results.

## Step 2: Gather and Align the App and Business Objectives or Goals

An app idea is fruitless without understanding business needs, business goals, and business rules.

This step encourages you to gather business requirements to understand how the enterprise aligns with the idea from the first step.

Gathering business requirements to document involves these steps:

* Identify the stakeholders for the right mobile application software development based on the business idea.
* Define clear and concise business goals and objectives to understand the project’s scope.
* Elicit stakeholder requirements and user requirements with elicitation techniques.
* Document the requirements in a business requirements document.
* Validate your requirements with stakeholders for a further transparent and opportunistic process.

## Step 3: Run a Market Analysis and Competitor Analysis

Conduct a market or competitor analysis to truly understand the user’s perspective and design the appropriate user personas.

It also helps your team gather more user requirements for the development company.

The following steps explain the process of gathering user and competitor requirements:

* Identify the direct, indirect, secondary, and substitute competitors for the mobile app. Remember to recognise any businesses offering similar mobile app services or products and those offering different products in a broader niche umbrella.
* Gather competitor information, including products, descriptions, pricing structures, geographic reach, engaging promotions, target market positioning, business reputation, user profiles, and key partnerships to understand what your product needs to compete against.
* Use a SWOT analysis to determine your competitor’s strengths, weaknesses, opportunities, and threats. You could learn from another app’s mistakes to improve your requirements and identify possibly unique features other apps don’t provide.

## Step 4: Determine Scenarios and a User Persona

The next major step in mobile app requirements-gathering is to design user personas and scenarios to guide the requirements.

A user persona fictionalises the target users for the mobile app.

It should describe the ideal person who uses the app, with some flexible aspects for alternate users.

The ultimate user person could include the following details about target users:

* Age (also, typical generational qualities)
* Behavioural considerations
* Gender (including non-binary if relevant to the product)
* Geographic location
* Goal or problem the app addresses or solves
* Goal quotes or principles
* Goal-related frustrations
* Motivation to use the app
* Range of hobbies and daily activities
* Typical occupation range
* How would you transform user personas into scenarios?

Create a persona scenario or storyboard by focusing on the goals, how their typical behaviours affect them, and how the persona’s background motivates them to respond differently.

Write the scenario as a short paragraph for starters, as you’ll design user stories later. Meanwhile, identifying stakeholders for requirements gathering means creating personas.

## Step 5: Gather and Prioritise Functional and Non-Functional Requirements

Your user and business requirements are shaped through the initial steps of app requirements gathering.

You still need to document them, but you’ll do that soon enough.

Meanwhile, start prioritising the functional and non-functional requirements for the technical details, which also design use cases.

Functional and non-functional requirements differ.

First, determine which functional app requirements the project needs.

Here are some examples of functional mobile requirements:

* A complete description of a feature the app offers or software interfaces.
* How the app allows users to sign up, verify accounts, or subscribe to a newsletter.
* Buttons and dashboards users interact with to complete a specified task.
* External and internal interfaces users interact with on the app.
* The necessary administrative functions for different user classes.
* Transaction adjustment, correction, and cancellation functions.
* Secondly, determine the non-functional requirements necessary to run your app.

Here are some examples of non-functional requirements in mobile development:

* How fast the app responds to user input.
* How the app protects user and business data.
* Whether the app can work on multiple platforms.
* How much data does the app store and is it scalable?
* How reliable and maintainable the app remains.
* Does the app comply with local laws and regulations?

Next, you’ll prioritise the non-functional requirements (NFRs) and functional requirements for an app.

Priorities determine the tech stack and importance of each function.

The technique requires you to put every technical requirement into one of four categories:

* Must Have – The highest-level requirements are critical to the requirements document to ensure the project’s success.
* Should Have – The second highest-level specifications are necessary for the project but won’t delay the progress of development or success.
* Could Have – The medium-level specifications could enhance user experience but aren’t dealbreakers if you don’t develop them right away.
* Won’t Have – The low-level requirements aren’t important to stakeholders at the time of requirements documentation and won’t affect the development process.

Include requirements for user experience (UX) and user interface (UI) with your functional and non-functional requirements.

## Step 6: Design Use Cases and User Stories

A mobile system requirements document won’t be complete unless you add use cases and stories.

Design them before documenting the specifications for the development company or team.

Use stories and cases to add visual representation to your documents for mobile app development documentation.

## Step 7: Write an App Requirements Document

* Formulate the App’s Idea Statement

Every app requirements document should include an idea statement that lets every stakeholder and software developer understand the document before diving into the details.

Start your app requirements document with a simple single-sentence statement that aligns with the app’s idea.

* Document All Relevant App Details

A detailed description of development plans in the requirements document is instrumental to completing the documentation.

A successful mobile app requirements document includes more than the details of an application and its functions for the development team.

* Descriptions to Include in a Mobile Requirements Document

A mobile application requirements document should include a detailed description of functional and technical requirements and the app’s functionality to properly capture and represent the project’s scope.

* Prepare a Navigation Sequence

The development team requires a simple navigation sequence they can follow during software development.

The mobile app requirements document outlines the sequence in which the software development process flows.

* Add Requirements Formats for Visuals

Add your user stories from a user’s perspective and the use case overviews you designed to the app requirements document to help stakeholders and the development team understand every aspect of the app requirements document.

* Add Cost Optimisation Details

The development team, stakeholders, and the client will appreciate a cost-benefit analysis to ensure cost optimisation throughout the software development process.

Business analysts also insist on adding a cost-benefit analysis to an app requirements document to meet the business needs and have a greater chance of success against competing apps.

* Add Communication Protocols

Ensure another key element is in your document before delivering the mobile app requirements document to a project manager, stakeholder, developer, or operating environment.

## Step 8: Deploy Prototyping and Wireframing

Prototyping and wireframing let you design the user flow of user interfaces and basic app functions.

It also lets you test and validate layouts and transitions between app pages.

Here are the steps to wireframe your requirements for an app, which you will then validate in the next step:

* Map the target user flow.
* Sketch the flow’s core part.
* Set a mobile wireframe.
* Determine the layout with boxes.
* Use design patterns.
* Add intended copy.
* Connect the app’s pages to design a flow.
* Design a prototype.
* Release the initial design to gather feedback.

## Step 9: Validate the App Requirements

Validation is a quality control process you use before launching the final product based on your requirements.

The prototype app collects feedback from stakeholders, and you can invite stakeholders to verify that the app meets the documented requirements. Use the feedback for the final step.

The benefits of collaborative requirements gathering share insights about feedback and collaboration.

## Step 10: Apply Agile Methodology

Agile methodology in requirements-gathering means you’ll always adapt the requirements document as per the feedback from stakeholders, testing, and initial product releases.

Agile methodology focuses on user experience and constant testing and validation to further improve your application.

# MOBILE APP DEVLOPMENT COST