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**Design and Implementation of Mobile
Applications - Polaris project VINCENZO
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1 Introduction

1.1 Purpose

This document provides a detailed description, mainly of the architecture and the UI, of the 'Polaris' mobile application.

'Polaris' application is a system used to enhance travelling experience through idea sharing among people, exploration of other users' travels, documentation and easy manipulation of trip destinations and ideas. The system itself is made so the user has every single information regarding his travel in one place, without having to remember or worry about any details.

'Polaris' is mainly an Android mobile application, with a possibility of being also expanded as a web application and/or iOS application in the future.

1.2 Scope

'Polaris' is an application that helps all travellers around the world to easily and efficiently manage their travels and thus enhance their travelling experience. The target audience for this application is everyone who uses a smartphone and has at least some experience in using mobile applications, as some of the patterns and application usages might not be intended for the novices in the field. Thus the target audience ranges from 15 to 50 years old, although there are no strict boundaries.

The application is mainly intended to be used when a user is planning and making their own trip and has a liberty to organize their free time and places to visit.

Another important usage of the application is sharing trip ideas with friends and other users around the world. Planning trips by itself is a daunting and time consuming task, and with the lack of adequate applications on the market, we wanted to create something that is going to allow users to easily share and modify their previous trips and therefore improve the overall travelling experience for others. The most important functions of the application are arranging a trip, finding points of interest in the area, organizing visits to those points, exploring accommodation and restaurants in the area, and crafting your own views of the travel by providing additional comments on the whole experience.

1.3 Definitions, Acronyms, Abbreviations

1.3.1 Definitions

- **Application:** a computer (mobile) program that is designed for a particular purpose.
- **Smartphone:** a mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, internet access, and an operating system capable of running downloaded apps.
- **Google Maps:** a web mapping service developed by Google, used both as a standalone app and as an integrated mapping solution in most of the apps.
- **iOS:** operating system developed by Apple, used by their portable devices like iPads and iPhones.
- **Android:** most popular operating system for smartphones and tablets, developed by Google and partners.
- **Backend:** the part of a computer system or application that is not directly accessed by the user, typically responsible for storing and manipulating data.

1.3.2 Acronyms

- **API:** Application programming interface, computing interface which defines interactions between multiple software intermediaries
- **UI:** User interface
- **GUI:** Graphical user interface
- **DB:** Database
- **REST:** Representational state transfer - software architectural style used in web services

1.3.3 Abbreviations

- **App:** Application.

2 Overall Description

2.1 Product perspective

2.1.1 Technologies overview

- Android Studio Development Kit
 - Kotlin
 - Android Compose
- Data management
 - Google Firestore
 - Google Firebase
 - Database
 - Room
 - Shared preferences
- Authentication
 - Google Authentication
 - Facebook Authentication
 - Email Authentication
- External APIs
 - Google Maps
 - Google Translate
 - Google Cloud Messaging
 - Google Places
 - OpenWeatherMap
 - GPT 3 - OpenAI

2.1.2 Internal structure

The proposed system uses an application on the server side that is connected with the APIs to the Android on the phone.

The Way of communication between the parts of the system and logic behind the system is presented in the following figure:

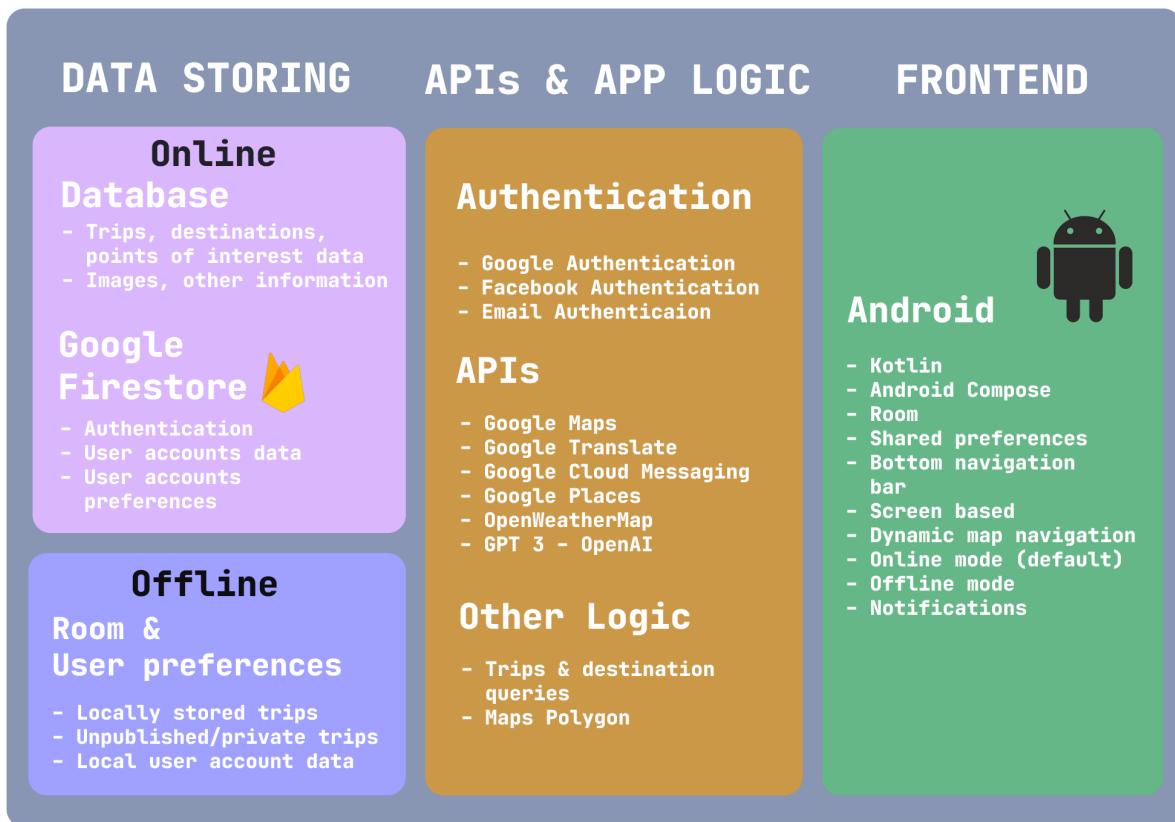


Figure 1: Internal structure of the system

Data storing

The database part is divided into two separate entities. Most of the authentication part is done directly through Google Firebase and Firestore frameworks, which offer great support for Google and Facebook accounts login integration, as well as native support for email based accounts. Controlling authentication via Google services is fast, easy, and seamless, so we have decided to keep most of our logic, as well as account data, stored here.

User account details, such as username, ID, and user preferences, are stored in the Google Firestore database, and are fetched after every login, so that the local user account data is consistent with the one on the servers.

Images that are used for trips and destinations are also stored in the Google Firestore database.

The other part of the database, which stores the data about the destinations, trips, points of interests, and other features related directly to the workflow of the app, are stored in another, separate database. This decision was due to the fact that Google Firestore is a NoSQL database, so putting relational data there would make it inefficient and slow compared to the traditional SQL database.

This is what made us decide to transfer this data to completely other place and use a different technology than with the accounts. Account data storing and fetching works exceptionally well and fast with Google services, so we had no real reason to move it from there, especially since that data is more sensitive and Google services provide high level of protection.

Android framework also supports numerous features for working locally. We have used these features to have an additional "offline" mode of our application, which allows full functionalities despite the user not having internet connection. We use Android Room to store all the desired trips downloaded and edited by the user, as well as the ones that the user has created locally and decided not to publish yet. "Offline" mode is then synced as soon as the user gets Internet connection, if any additional changes have been made to the local or public trips.

Finally, shared preferences are used to store the user's local information such as username, theme preferences, display name, and other features that help user while navigating the app. These are updated with the data located in the Google Firestore framework.

APIs & App Logic

Authentication used for the application is done directly through Google Firebase. Account creation can be done directly through email, after which it has to be confirmed via confirmation email. The other way of creating account is logging in with either Facebook or Google account. This way account gets automatically created, or joined if it has already been previously created with the same email. This allows users to not have to worry with which account they have logged in before, as it is all connected to the same email. Users would have to be logged in to either their Google or Facebook account before using those methods to log in to the app.

Google and Facebook "button" directly communicate with their respective APIs and only after the conversation has successfully ended do communicate with Google Firebase servers.

Another thing that is used from Google framework is the Google Maps API. From that API, several different features are used, such as Maps presentation, location searching, cities searching, distance calculation, and others. Google Maps are dynamically presented in the app and allow users to search through them either by text or by touch.

Another important thing is a small PHP script that is running on the server. It serves as a backend of the app, handling query fetching, control, and execution, as well as handling and displaying data that is coming and going through Google Maps API.

This PHP script is returning all the necessary data in the form of JSON files, which are then handled by the app accordingly and to its needs.

Frontend

On the frontend side, we have decided to use all of the latest technologies recommended by Google for Android app development.

Kotlin is used as the programming language, which allows better data and variable control in Android environment than the previous official language Java.

From the pure design perspective, Android Compose is used instead of the previous template/xml based design. Compose allows for creation of certain elements, as well as their dynamic modelling, which allows for reusability and code cleanliness. Compose allows for elements to be dynamically inserted into specific places, as well as to be dynamically changed, hidden, or manipulated in a much faster and easier fashion. It also allows for faster development since the previews of those compose components can be rendered much faster.

As the base of the system, bottom bar with different pages has been used. More on that part is explained in latter chapters of this document.

The app supports both online and offline mode, with shared preferences used for storing local display preferences of the app.

2.1.3 Scenarios

Scenario 1

Marco wants to go to a trip to France. His friend, Federico, already went on a trip in a similar area and visited points of interest that Marco likes. Marco asked Federico to tell him all of the places he visited, how did he travel, and the order in which he visited these places. Federico made some notes for Marco, but it still left Marco with the problem of having everything in his phone organized and in one place. That's when Marco found out about the app and asked Federico to put everything he remembers from the trip here. That way Marco had all of the locations in the correct order, as well as comments about certain places and other detailed information all in one place, which allowed him to easier follow the trip during his time in France.

Scenario 2

Rebecca, the friend of Marco and Federico, heard about their trip to France and decided to go there as well. However, she is not as interested into visiting so many French castles like Marco and Federico, and wants to add some other destinations to her trip. However she still wants to keep the first half of the trip, where guys visited the southern part of France. She also uses the app and copies the trip, after which she edits it and replaces castle destinations with beaches on the northern part of the country. She renames the trip and publishes it with a different name. This way Rebecca saved some time and effort on planning the entire first half of the trip, whilst being able to modify the experience in the latter half.

Scenario 3

Giovanna wants to on a trip but she already visited France. She needs some new ideas. By using the "explore" function in the app she finds some of the top rated trips around Europe - her favourite of those is a trip to Iceland. Giovanna follows all of the guidelines in the trip and has an amazing time.

2.2 Product functions

Functions of the system provide easy and intuitive ways to use the app. They are somewhat connected and have overlapping features. Nevertheless, the users may use only certain parts of the system and still get the full functionality they need from the app. These functions are mentioned in several places in the document, but their most thorough explanation can be found here.

2.2.1 Adding a trip

Adding a trip is the most essential part of the system. The function features several parameters and allows for high level of customizability in order to create a fully unique travel experience. Each point of interest is featured as a specific "destination", although even places that are not regarded as specific destinations can be inserted into a trip. Destination fetching is done through the Google Maps API, with the users also having the ability to add and edit their own destinations. The function features the following:

- Selecting a starting point, that is then connected to the nearest city on the map
- Adding other destinations to the trip
- Writing a trip description
- Adding preferred way of travel between destinations

- Identifying trip price level
- Adding comments to trip destinations
-

2.2.2 Editing a trip

Editing a trip can be done on two different types of trips - public or private. If the trip is public, either published by the user editing it or someone else, by starting to editing an exact copy of that trip is created, which can then be published again under different name and different trip ID.

If the trip is private and has not yet been published, then a new trip is not created, but rather the trip ID stays the same. If the trip is then published and edited again, the new edited version of the trip has a new trip ID and is a whole new entity.

Editing a trip features all of the same functions that adding a trip does, which means that everything from a small comment to the whole trip can be changed.

2.2.3 Finding a trip

Finding a trip can be done in several different ways. The first way features a search bar which then searches a trip by the starting point name or by the city which is the closest to that destination. The second way is a search by the trip ID or a hyperlink, which can be directly received from other users. The third way is by accessing a specific user's account page and scrolling through their published trips. Finally, trips can also be found by looking at the interactive map, selecting the area of the desired starting point of the trip, and finding the trip through the distinct trip name and photo.

2.2.4 Following a trip

This function mainly uses a specific trip and sets it as an active trip of the user. This makes it easily accessible by the user at all times by using the bottom navigation bar, and allows him to follow certain steps of the trip without losing progress. This function also allows the user to change the current active trip and still keep the progress of an old trip, so that the progress can be easily restored when that trip is again set as an active trip.

2.2.5 Updating account settings

Only a few settings can be changed in the user account. List is the following:

- Changing a username
- Changing a profile picture
- Switching between dark and light colour scheme
- Setting preferred price level
- Switching between offline mode and online mode

2.2.6 Offline function

The system allows the users to be disconnected from the Internet and still use the app fully. Individual trips can be downloaded and store in the phone internal storage, and then accessed at any time. If any changes are made to the trip during the offline time, a new iteration of the trip gets created and published as soon as the connection is restored and the user has come back to the online mode. Multiple trips can be downloaded and kept in the storage of the phone at all times.

3 Architectural Design

3.1 Overview

Architectural design of the application is based on the three-layer model used in most applications. The three layers are the presentation layer, or frontend, the application layer, or middleware, and the data layer, or backend. Each of those layers does its own part of the job and communicates with other layers in order to present the correct information to the user.

The architecture is also a typical client-server implementation where server holds the data and the client is accessing it through requests (besides the offline mode where the user stored some of the data from the server locally and is accessing it without using online requests).

3.2 Backend architecture

3.2.1 User database

As previously mentioned, user database is located in the Google Firestore service. This service uses real-time NoSQL database. This database is organized in collection->document system. Everything starts with one collection, which can hold as many documents (entities) as possible. Each document can have an unlimited number of attribute fields, which can be with a specified type or without one, and at most one collection. Then the cycle repeats again.

Working with NoSQL has its advantages when it doesn't have a lot of relational and connected data. We can extract only the small amount of data we want, it is very fast, and also very efficient. Since accounts are not connected in any way, using NoSQL database seemed like a viable choice since it saves our users time and data.

The architecture of this database is the following: the first collection contains all the users as their unique IDs, where they are represented by a document. The first level of the document holds only the info of the display name and the ID. The second collection is made for storing user preferences, and every user has their own. In that collection there is a document that holds all of the parameters needed for the user's usage of the app, such as colour mode, economy level, thumbnail URL; and two optional ones, real name and real surname

The following figure represents the structure of the explained database.

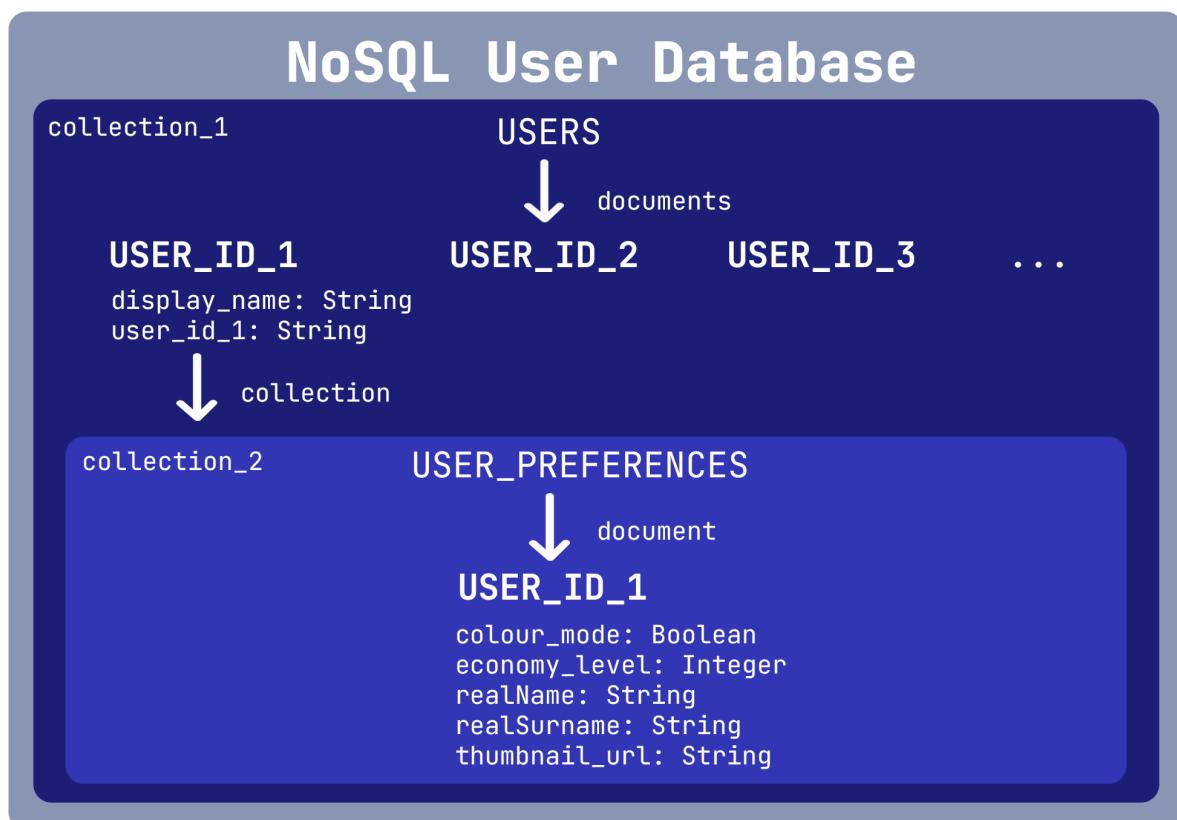


Figure 2: **Structure of the NoSQL user database**

3.2.2 Trips database

Database regarding trips has several different parts that make the whole system work. The most integral part of every trip are destinations. There are two types of destinations in the database - destinations retrieved from Google Places API and user created destinations.

When adding a destination to the trip, users can either find a destination using Google Places API, or if they are not satisfied with the search, they can create their own destination, with a unique name and a location on the map. This destination can then be provided with a specific name, GPS coordinates, rating, and an thumbnail image. Newly added destinations receive an ID generated by the backend, while Google Places destinations have their own unique ID, which has a different form and shape. Users are always going to be urged to use already existent destinations, so unless there is not a really specific location in question, they would have no need to create their own, especially since the Google database is quite large.

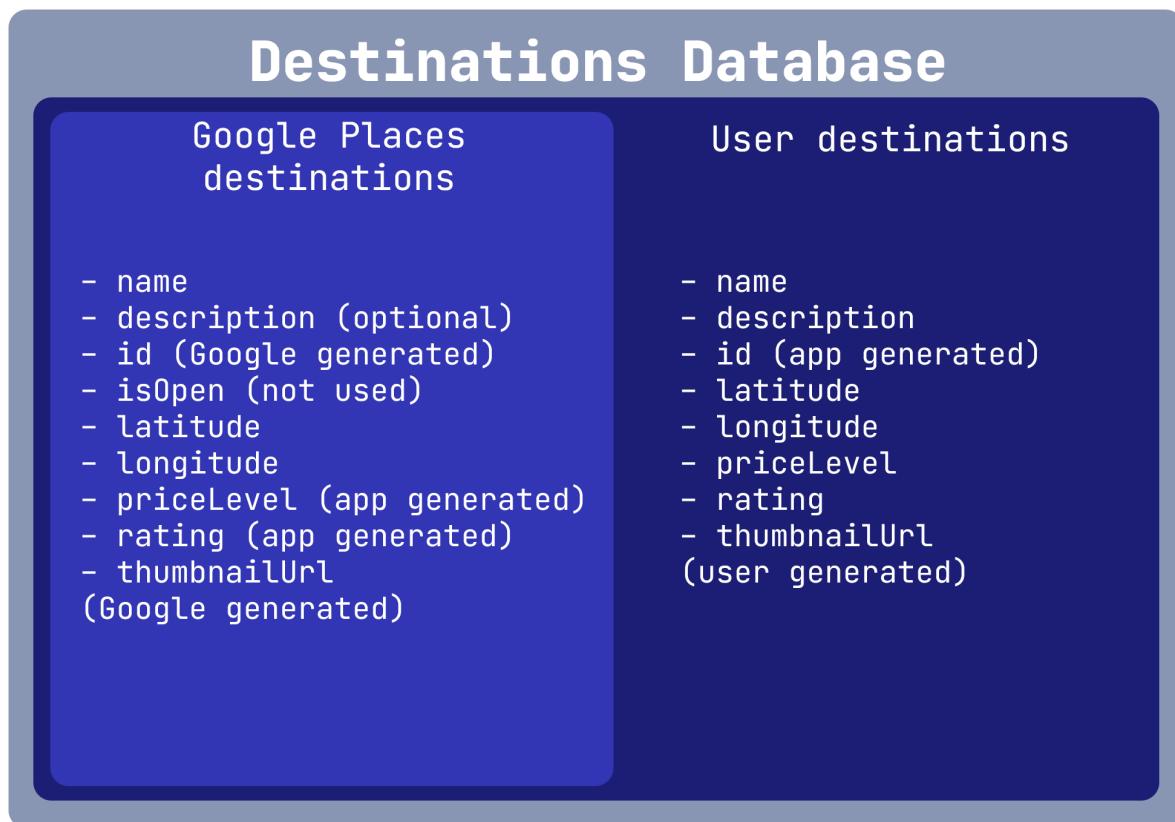


Figure 3: Structure of the "Destination" entities

Trips structure are much more complex and detailed. Every trip is defined by several important attributes. Besides the basic information like name, id, description, and thumbnail URL, trips are mainly defined by destinations. Central point destination is the most important point of the trip, which necessarily doesn't have to be a beginning or an ending destination. Then for every single day of the trip there could be one or more destinations defined. Along with the regular destination attributes, those destinations feature the distance to the next destination (both in minutes and kilometers) taken with the recommended mean of transport, which is calculated through Google Maps and Places APIs. Those destinations also feature approximate hours of arrival and a recommended time to be spent there so that a plan could be fully followed. Every destination can also feature notes which could give users additional information about it or just provide some tips on what to do and what to see. A list of image URLs can also be added for every specific destination in the list.

Besides all of the destinations and the basic info, trip entity also features creator of the trip, creation date, recommended season of travel, rating, and public boolean, which defines whether the trip is private (and therefore hidden from other users) or public (and can be seen by everyone).

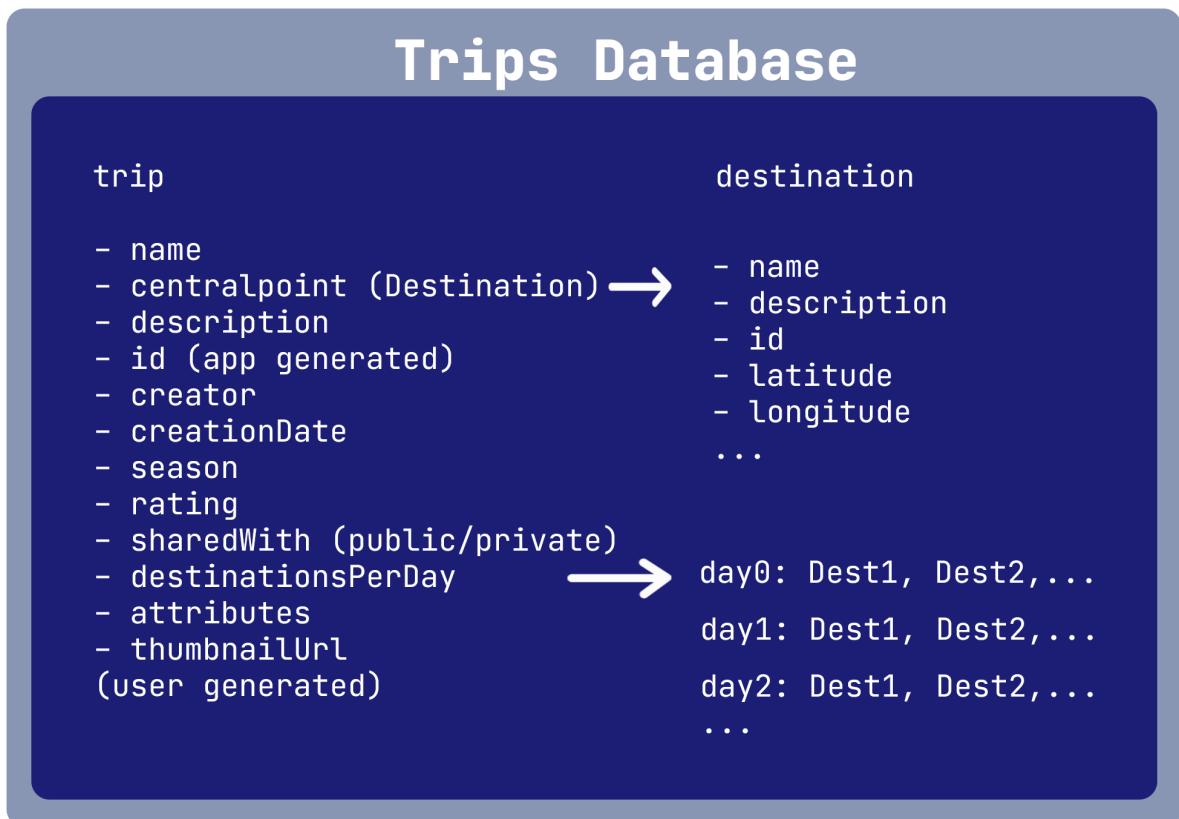


Figure 4: Structure of the "Trip" entities

3.3 Middleware architecture

In order to connect the data on the server to the screen of the phone and to allow the user to properly see the data, we have implemented a complicated layer of functions and classes in order to create easy-to-use and esthetically pleasing experience for the user.

3.4 Runtime view

In the following section, sequence diagrams that represent the most important use cases are shown and explained in detail. We have focused only on the most commonly used use cases in the app, as well as their crucial parts. We do not go into too much detail when it comes to specific parts of interaction between the layers, but rather want to present the vague idea and how it all works.

3.4.1 Create a trip

Create a trip use case starts with opening the app and pressing on the "Create a trip" button. A new screen opens up which allows us to change certain attributes about the trip and add different destinations. Every trip needs to have a name, which doesn't have to be unique, since there is an ID that is automatically allocated to the every trip. Every trip needs to have at least two destinations. We can search through destinations via the search bar or by using the interactive map and selecting a destination from the map. After selecting a destination, we add it to the trip. Destinations can be reordered and removed from the trip at any time, which is not shown in the diagram due to simplicity and concision. The price level of the trip should also be defined before saving the trip. Trip can also be discarded. In the end, if the user is satisfied with its trip, they can publish it in which case it will be stored directly in the database. Local database is not used for storing unpublished trips, since this would mean that by losing local data, all of the unpublished trips would be lost. All of the trips are stored in the online database and are can be found by other users only if published.

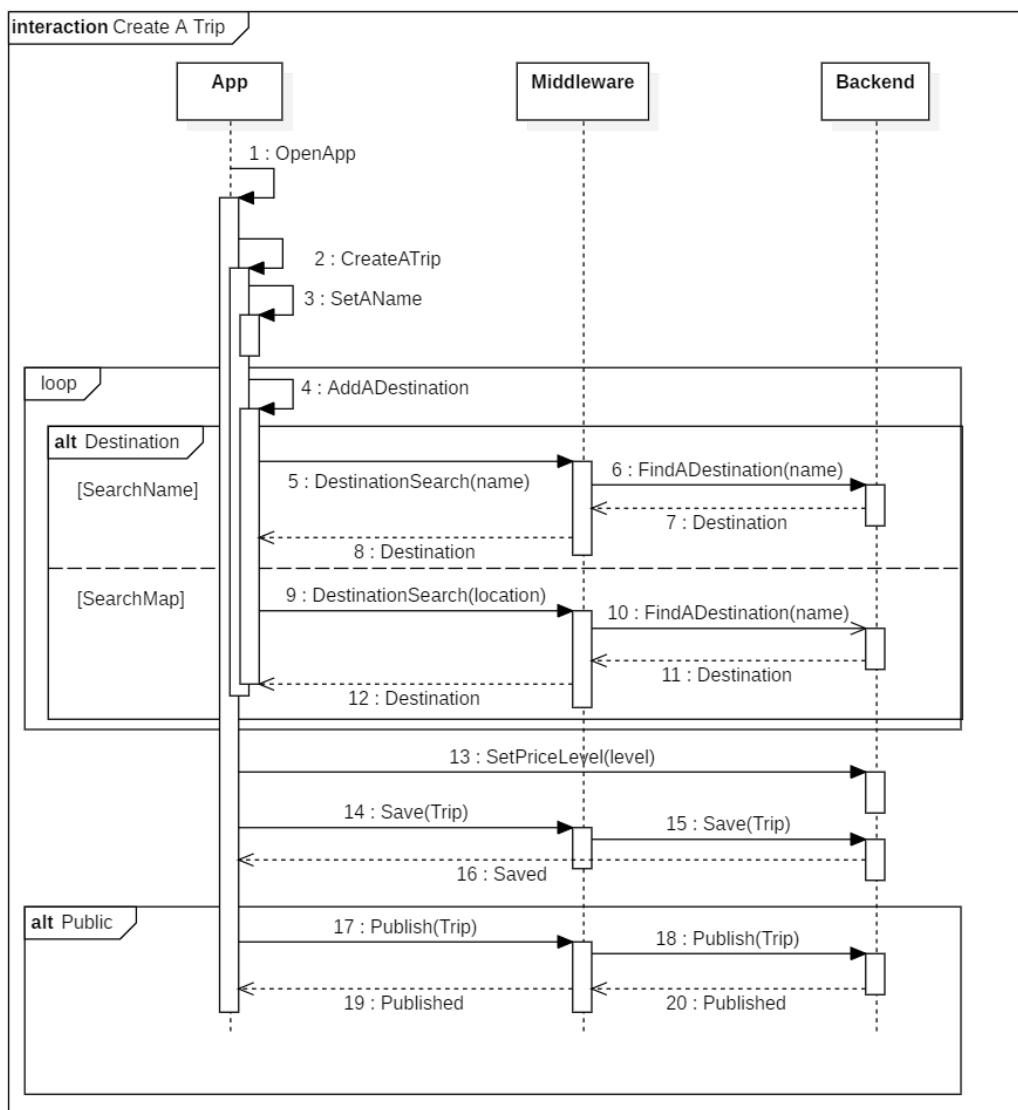


Figure 5: Sequence diagram 1 - Create a Trip

3.4.2 Edit a trip

Edit a trip use case starts with opening the app and choosing one of two ways of searching for a trip. One way is searching for a trip name/ID directly through the search bar, and another is by searching for a trip on the interactive map. After the trip is found, it is somewhat "copied" to the instance of the user. User can then edit every single bit of the trip - change the name, change the price level, and add/remove destinations (again, destination removal is not shown in the graph due to simplicity). Finally the user can choose to save the trip without publishing it, or publish it so that everyone else is able to find it. Either way, the trip gets a brand new ID only if it has been changed in any way (changing only the trip name and/or price level is not regarded as a change). Again, due to data safety, in either case it is stored online.

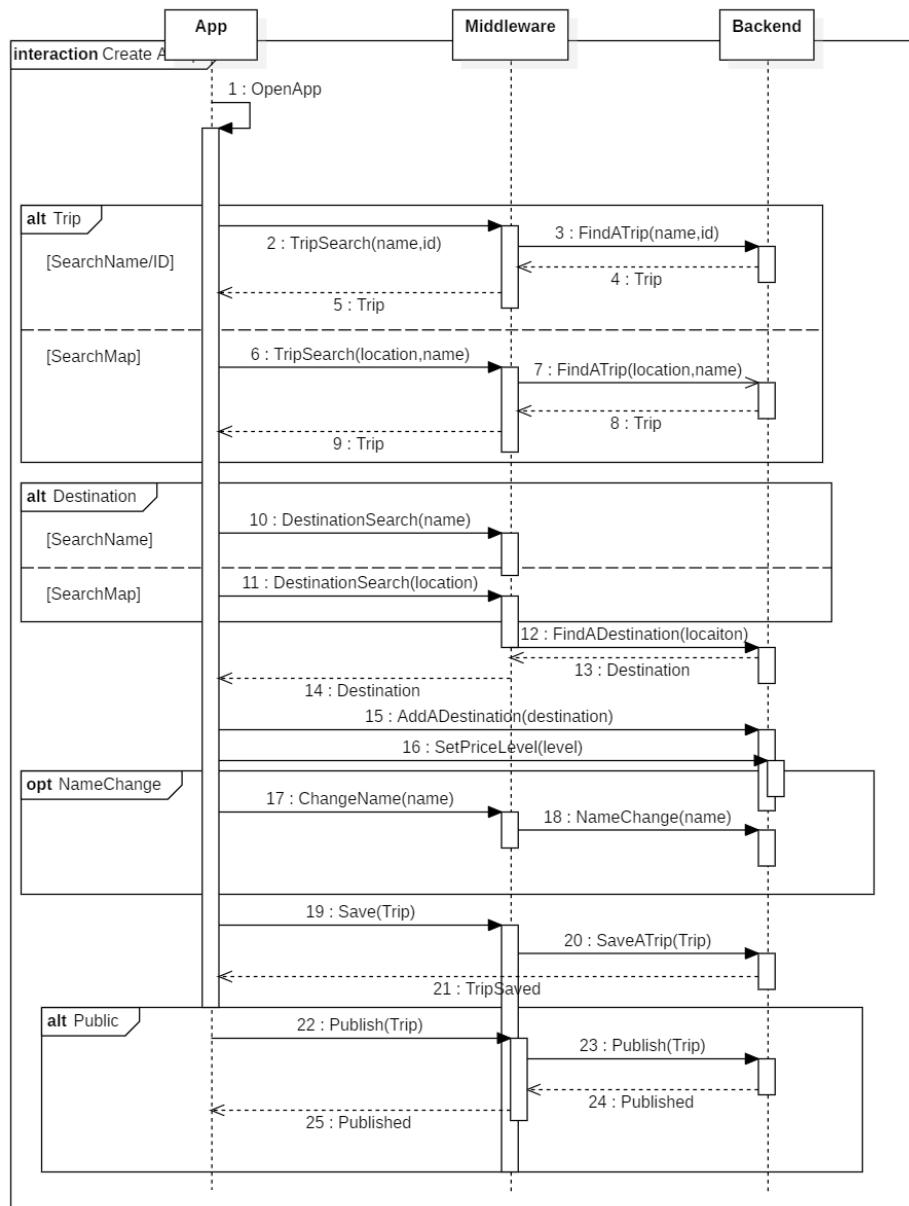


Figure 6: Sequence diagram 2 - Edit a Trip

3.4.3 Add a destination

Add a destination use case starts with opening the app and choosing one of two ways of adding destination - either by using the dynamic Google Maps API, or by using a search function which searches for specific places and locations in the Google database. By using a Google Maps way, the user can specify the exact location, while by using the search way, the user can pick of the previous existing locations in the database. After picking a location, the user can change a name and/or add an specific image of this location. This way the user is allowed to personalize locations for their trip needs. After saving all of the data in the form of a destination, the new destination is published and can be found by other users and added to their trips. There are no local and unpublished destinations.

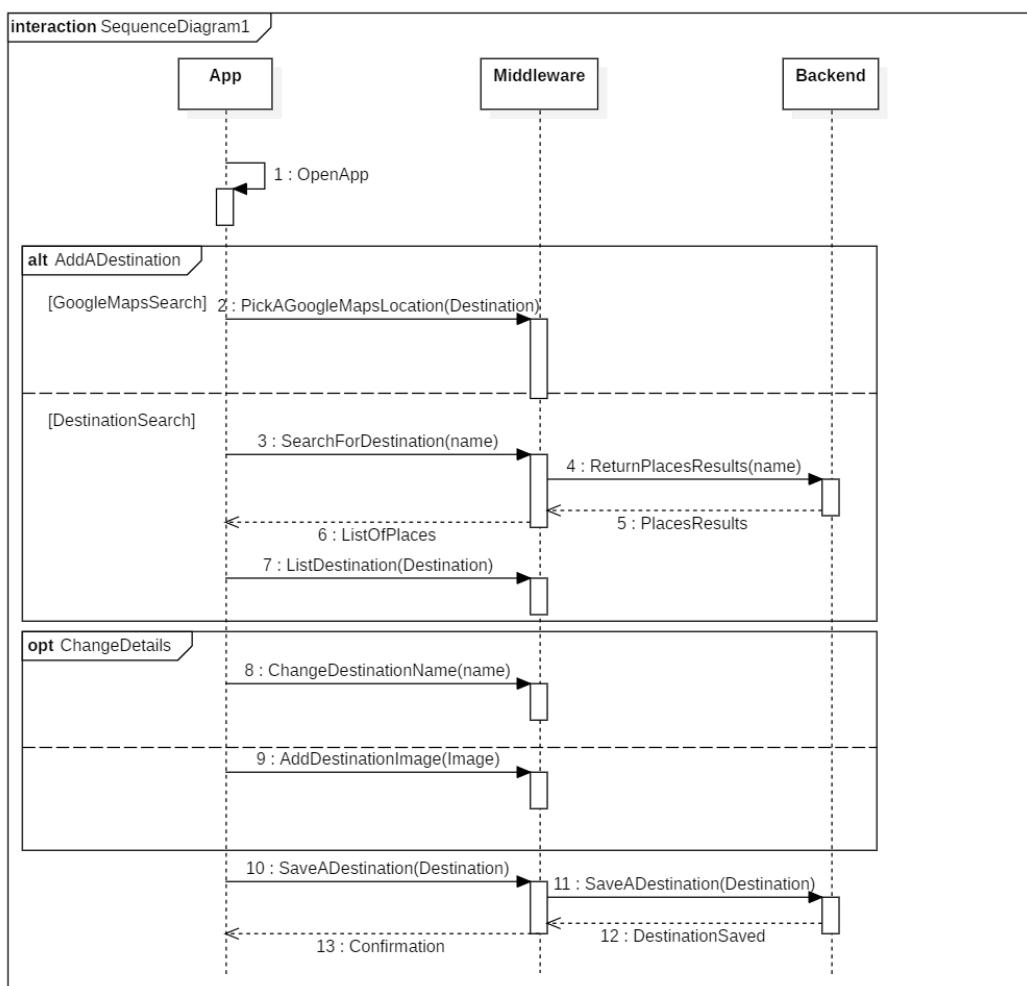


Figure 7: Sequence diagram 3 - Add a destination

3.4.4 Search for a trip/explore

3.5 Design constraints

3.5.1 Hardware limitations

As previously mentioned, the application is currently only made for Android OS, using native Android development. iOS devices, as well as Windows Mobile OS devices, and Web/Desktop version of the software is currently not available.

The application will only work on Android devices that support Android 7.0(Nougat) which is Android API 24 or above, due to security reasons, and due to specific software features that are not available in the previous versions of this software. As this version is over six years old, and vast majority (over 90%) of Android users are currently running this or higher version, we estimated this to be a viable choice for the lowest supported version. As of right now, the latest version of the Android OS is 12 or API level 31, which is also the target build for the app.

Device use is required to have access to the Internet for the initial(and any subsequent) login, and for the initial data fetching. The Internet connection is not required when using the application in offline mode, after the desired trips have been downloaded and locally stored. In case of using the application without Internet connection, the full features of the app may not be available to the user.

3.5.2 Privacy limitations

The user is not required to insert any personal information in the app, besides their email or social media account which is necessary for login. This email will not be visible to the other users. The user may provide his real name and surname, which would make them easier to find by other users, although the primary identification will still be in the form of username, which is initially set by the user. User may also provide an image that will be used for the thumbnail of their account, which is also optional. User's comments on trips will be seen by everyone if the trip has been made public. If the user wants to keep the comments to themselves, it is possible to leave the trip unpublished.

4 User Interface Design

4.1 Identity and colours

The official name of the app is 'Polaris'. The app identity is an astronaut, with the idea of a user acting as an astronaut, which has an overview of the planet Earth and can just pick a place and travel wherever. This feature is also presented in one of the screens in the app, as user searches for already existing trips by searching the globe.

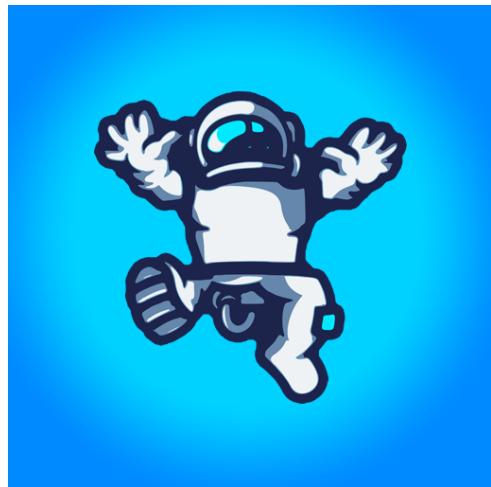


Figure 8: **'Polaris'** icon featuring an astronaut on a blue background

The main colours used for the app are two slightly different blues. Primary blue has the RBG value of #0083FF while secondary blue has the RBG value of #0460D9. They are used interchangeably throughout the app.

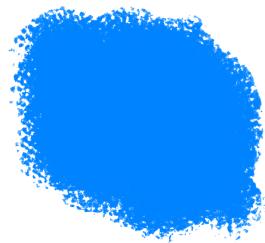


Figure 9: Primary color #0083FF

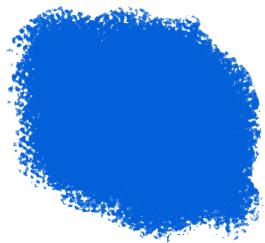


Figure 10: Secondary color #0460D9

As app features both light and dark mode, there are also colour palettes used for those instances. The same primary and secondary colours are used for accents, but for backgrounds and texts, the colours presented in the following two figures are used.



Figure 11: **Background colours for light theme**



Figure 12: **Background colours for dark theme**

4.2 User interface design

This section features the main design choices of the entire UI of the app, which includes navigation bars, menus, buttons, and other choices. It will not go into too much detail about every component, as all of the screens will be shown with a short comment about it.

The main part of the app is divided into four major components, with additional screens available for

other functionalities, such as adding and editing destinations and trips. At the bottom of the app there is a navigation bar that leads the user to all of the main screens. Additionally, users can navigate to the settings/account screen either by pressing the 'Polaris' icon in the upper right corner of the screen, or by pressing the last icon in the bottom navigation bar. Right above the navigation bar, a search bar is located which allows the users to search for their previously saved trips.

As previously mentioned, the app features both light and dark themes. The following figures present the same screens for both of the themes.

4.2.1 Main screen

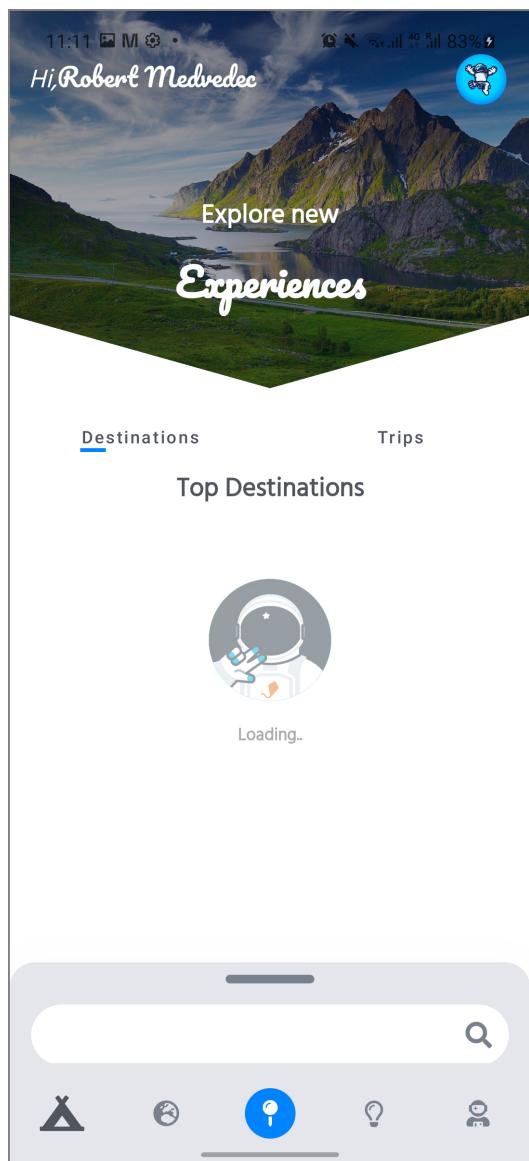


Figure 13: Main screen in light style

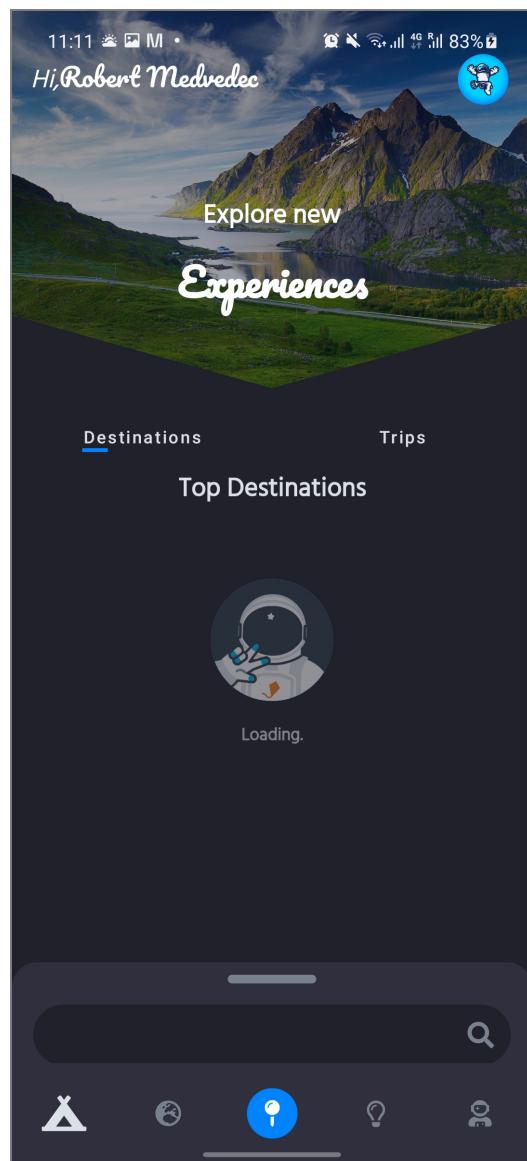


Figure 14: Main screen in dark style

Main screen provides user with the information about the existing destinations and trips. It offers the user a fast way to access some of the information about the locations that they might find useful to build on or to explore.

4.2.2 Map screen



Figure 15: Map screen in light style



Figure 16: Map screen in dark style

Map screen allows users to interactively go through the desired locations on the map and find small icons that represent trips in that area. Map takes into account the boundaries that are shown on the screen and actively adjusts the search parameters, fetching from the database only the trips that are in the current area. Map helps users explore certain areas when they are not sure which specific destination to center their trip around.

4.3 Saved trips screen

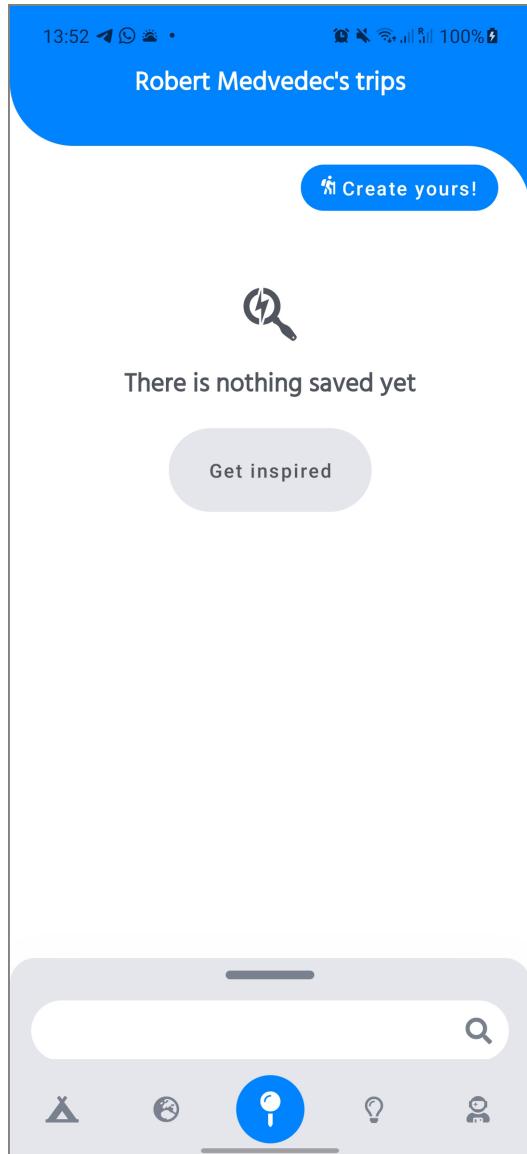


Figure 17: Saved trips screen in light style

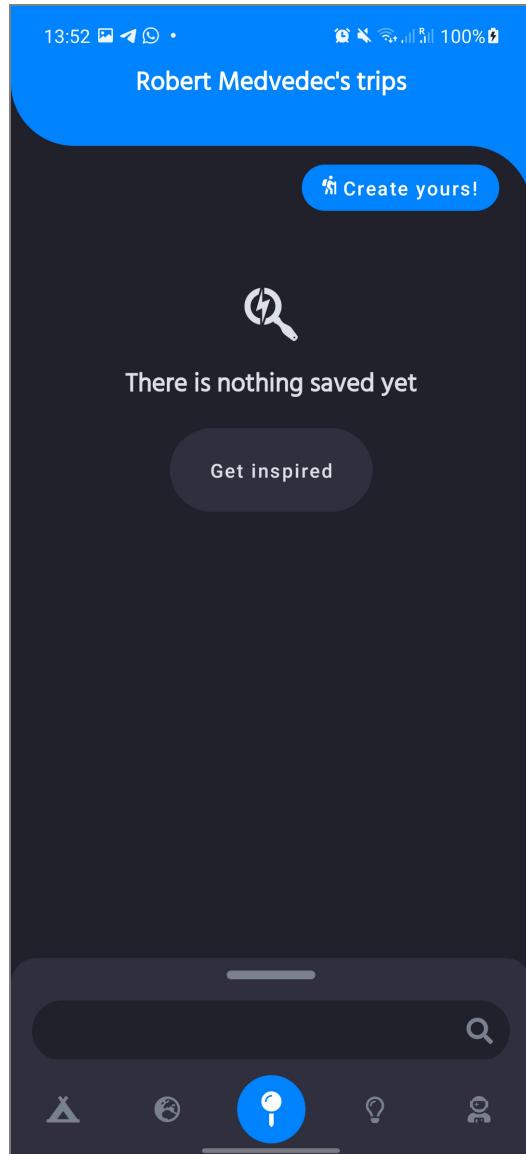


Figure 18: Saved trips screen in dark style

Saved trips screen holds the information of all of the trips the user has created or saved. It is also a quick way of finding older trips that users found interesting and allows them to organize their travels in an easy and effective way.

4.3.1 Explore screen

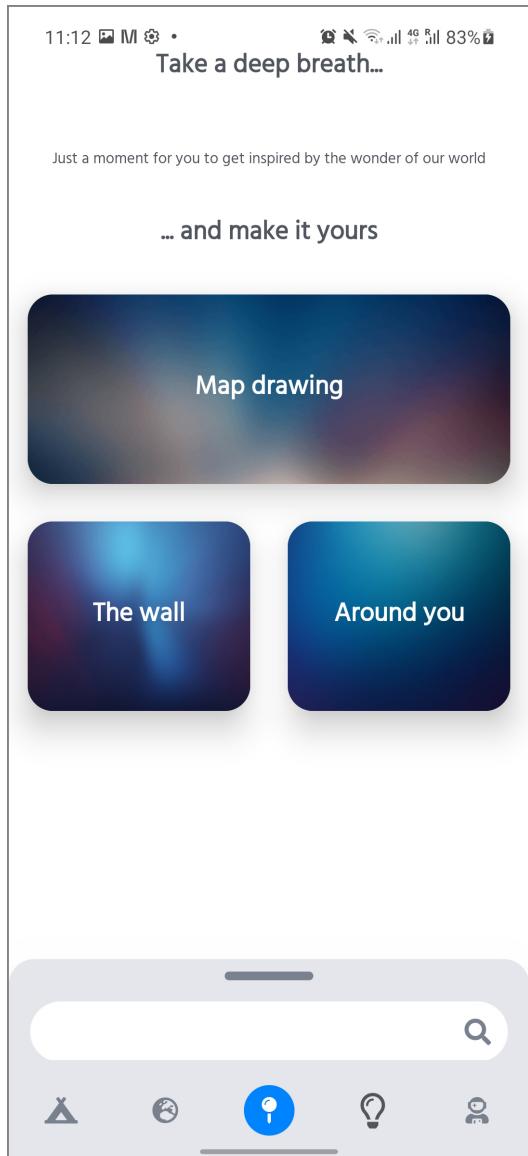


Figure 19: **Explore screen in light style**

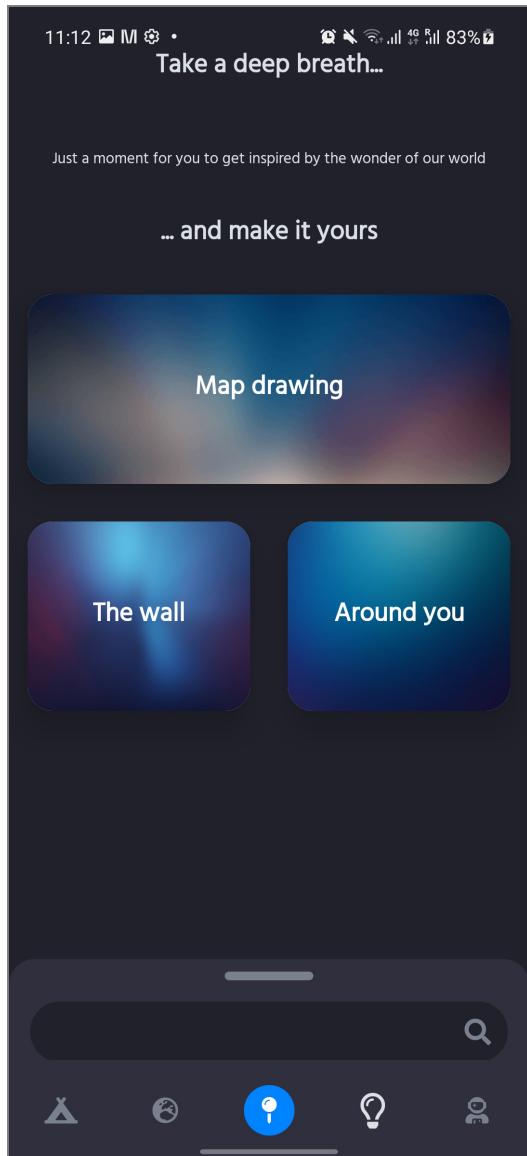


Figure 20: **Explore screen in dark style**

Explore screen allows users to search for their future trips in multiple ways. The first way is by searching on the map, and by clicking the 'Map drawing' button, the app takes the user to the previously explained screen.

The next option, 'The wall', - DOESN'T DO ANYTHING NOW.

Finally, 'Around you' button asks the user for location permission, and if granted, searches for interesting destinations and trips in the user's vicinity.

4.3.2 Settings screen

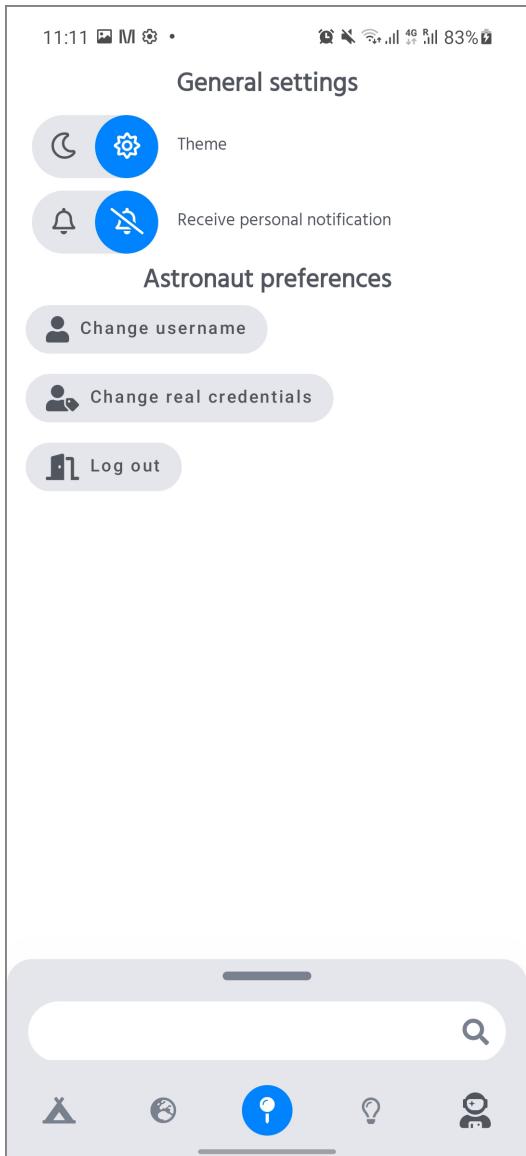


Figure 21: **Settings screen in light style**

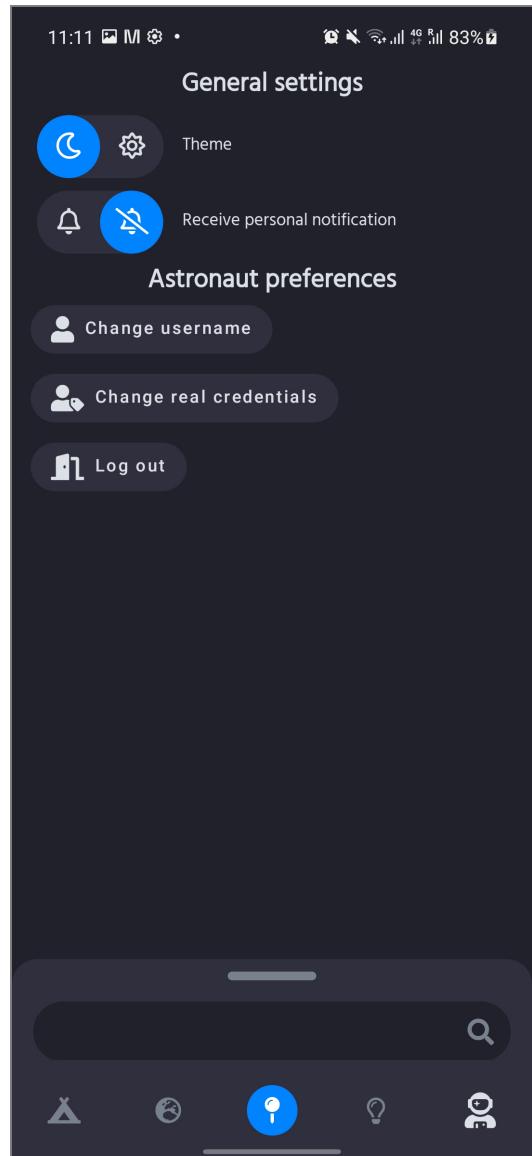


Figure 22: **Settings screen in dark style**

Settings screen allows users to change between dark and light theme, to turn the notifications on or off, and to change user preferences such as username and real credentials, which are optional. It also features an option to log out, if user ever wishes to change their account.

5 Testing

UI