

Software Design Report



E-Charging APP

Group 1

Group Leader: Minzhen Lai

Group Members: Ziheng Huang, Ziyang Lu, Yin Yuan

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1 Introduction

The **E-Charging app** is a smart charging solution designed to address the needs of electric vehicle (EV) owners, providing an efficient way to locate nearby charging stations, monitor charging progress, and manage charging sessions with ease. The primary goal of this app is to enhance the user experience by minimizing the time and effort required to find available charging points. By integrating real-time status updates and convenient features like charging progress tracking, the app aims to provide a seamless and user-friendly experience. It also offers advanced functionalities like reserving a charging station ahead of time, ensuring that users can plan their charging sessions effectively.

The architecture of the application is modular in design, allowing for future extensions and updates. It features advanced features such as an intuitive interface, interactive animation, and real-time charging information, making it an intelligent solution for electric vehicle owners. E-Charging is designed to cater to a wide range of users, including students, commuters and anyone who owns an electric vehicle, offering both practicality and innovation in one package.

2 Requirement Specification

2.1 User Requirements:

2.1.1 Target Audience:

The app is designed for electric vehicle (EV) owners, including but not limited to:

- **Students:** Individuals who may not have access to home charging stations and need a reliable way to charge their EVs while attending classes or on the go.
- **Office Workers:** Commuters who need to find charging stations near their workplace or along their daily route to ensure their vehicles remain charged during the workday.
- **General Commuters:** Any individual who drives an electric vehicle and requires an efficient and convenient solution to find and use charging stations.

The app should be accessible to users of all technological backgrounds, with easy-to-understand navigation and features.

2.1.2 User Account Management:

- **Registration:** Users should be able to register a new account by providing essential details, such as their vehicle registration number

(license plate), a secure password, and an optional email address for notifications and recovery.

- **Password Strength Requirements:** The app should enforce basic security measures like a minimum length for passwords (e.g., at least 6-8 characters), and possibly require a mix of letters, numbers, and symbols.
- **Account Verification:** Users should receive a verification email or SMS message with a one-time code or link to confirm their account registration.
- **Login:** Users should log in using their vehicle registration number and password. To enhance security, the app can offer multi-factor authentication (MFA) for users who want additional protection.
- **Password Reset:** Users should have the ability to reset their password in case they forget it. The reset process will involve answering a security question or verifying their identity through email/SMS.
- **Profile Management:** Users should be able to update their personal information, such as email address, phone number, or password, directly from their account settings.

2.1.3 Location-Based Charging Station Search:

- **Location Detection:** The app should access the user's device location

(via GPS) to provide real-time nearby charging station recommendations.

➤ **Station Filters:** Users should be able to filter available charging stations by various criteria:

◆ **Availability:** Show only stations that are currently available or empty.

◆ **Power Output:** Filter stations based on the charging power (e.g., fast charging vs. regular charging).

◆ **Pricing:** Filter stations based on the price per kilowatt-hour (kWh) to find affordable options. Users can also compare prices at different stations.

➤ **Map Integration:** The app should integrate with a map interface to visually display the location of nearby charging stations. Users should be able to get directions directly from the app to the selected charging station.

2.1.4 Reservation System:

➤ **Booking in Advance:** Users should be able to reserve a charging station before they arrive to ensure availability. They should be able to choose a time slot and select a charging station.

➤ **Reservation Confirmation:** Once a reservation is made, the app

should send a confirmation notification, indicating the station's availability and the time window for usage.

- **Cancellation and Modification:** Users should have the flexibility to cancel or modify their reservation if plans change, provided it is done within a reasonable timeframe (e.g., at least 15 minutes before the scheduled time).
- **Reservation Alerts:** The app should send notifications to users when their reservation time is approaching, when a station becomes available or when the reservation has been canceled due to unforeseen circumstances.

2.1.5 Charging Progress Tracking:

- **Real-Time Updates:** Users should be able to view the real-time progress of their charging session, including:
 - ◆ **Charging Status:** Clear indicators such as "Charging", "Complete", "Paused", or "Error".
 - ◆ **Time Remaining:** An estimated countdown of the remaining time until charging is complete.
 - ◆ **Power Consumption:** The total kWh consumed during the charging session, displayed with an option to see the current consumption rate.

- ◆ **Cost Tracking:** Display the cost of the session based on the price per kWh, with a breakdown of the total cost for users to track their expenses.
- **Progress Indicators:** The app should use visual progress bars or animated elements (e.g., battery icon, loading circle) to represent charging status dynamically.

2.1.6 Charging Session History:

- **Detailed History:** Users should have access to a history of their past charging sessions, with detailed information such as:
 - ◆ **Duration:** Total time spent charging.
 - ◆ **Cost:** The amount spent on each session, based on the power used and the price per kWh.
 - ◆ **Location:** The location or address of the charging station used.
 - ◆ **Charging Power:** The maximum charging rate (e.g., 22 kW or 50 kW).
- **Session Filtering:** Users should be able to filter their history by date range, charging station, or cost for easier analysis and tracking of their usage.

2.1.7 Notifications and Alerts:

- **Session Completion Alerts:** The app should notify users when their charging session is complete, including a reminder of the total cost and time taken.
- **Station Availability Notifications:** If a user is waiting for a charging station to become available, the app should notify them when the station becomes free or when their reserved slot is about to start.
- **Error Alerts:** If an issue arises with the charging station (e.g., "Charging Failed", "Error", "Station Offline"), the app should alert the user and suggest nearby alternatives.
- **Pricing Changes:** The app should notify users if there is a change in the price of charging at a particular station.
- **Customizable Notifications:** Users should be able to adjust their notification preferences, opting to receive push notifications, emails, or SMS alerts for various events, such as session completion, charging progress, and station availability.

2.1.8 Exit and Logout:

- **Secure Logout:** The app should allow users to securely log out of their account at any time, ensuring their session is closed and no sensitive information remains accessible.

- **Session Expiry:** If a user has been inactive for a certain period (e.g., 30 minutes), the app should automatically log them out to ensure security, particularly when accessing sensitive data such as account details and charging history.
- **Logout Notifications:** Users should receive a confirmation prompt when logging out to prevent accidental logouts.
- **Data Security:** All personal data, session information, and payment details should be securely stored and deleted after logout to prevent unauthorized access.

2.2 Functional Requirements:

2.2.1 User Registration and Login:

The app should support simple and secure registration and login processes using vehicle registration numbers and passwords.

Authentication should ensure data security and protect user privacy.

2.2.2 Charging Station Information Display:

The app should provide a real-time display of nearby charging stations, showing details like station status (available, in use, out of order), power rating, and pricing.

Users should be able to click on any charging station for more details, including real-time charging progress, estimated charging time, and remaining power.

2.2.3 Charging Station Reservation:

Users should be able to reserve charging stations in advance, receiving confirmation upon successful reservation.

The reservation system should update in real time, showing whether stations are available or occupied.

2.2.4 Progress and Cost Tracking:

Real-time tracking of the charging session progress, including charging status, estimated time remaining, and the total cost based on power consumption.

The system should automatically update the charging data and present it to the user in an easy-to-read format.

2.2.5 Personalized User Information:

Users should be able to access their profile to view charging history, including details like past charges, costs, and total charging time.

The app should support user-specific statistics and provide insights on usage patterns.

2.2.6 Database Integration:

The app should store user information, charging records, and station data in a local SQLite database, using Room Persistence Library for efficient and stable data management.

The database should be scalable to accommodate future data expansion, such as user behavior data and station analytics.

2.2.7 User Interface:

The app should follow Material Design principles for consistency and responsiveness across devices.

The interface should be intuitive, with clear navigation paths and interactive elements like buttons, sliders, and progress bars for a seamless user experience.

2.2.8 Secure Logout:

The app should provide an easy-to-use logout feature to ensure that users' session data is securely removed from the system, preventing

unauthorized access to their accounts.

By implementing these requirements, E-Charging aims to deliver a robust, intuitive, and secure platform for electric vehicle owners, facilitating a hassle-free charging experience while contributing to the growing trend of smart and sustainable mobility.

3 Overall Design

3.1 Application structure design

This smart charging system APP for new energy vehicles aims to provide users with a convenient and efficient charging service experience. The overall application structure is clear, divided into five core pages, each of which is closely centred on the user's charging needs to ensure that the user can quickly locate the required functions.

3.2 User Interface Design

- **User Login and Registration Page:** As the entrance for users to access the APP, this page provides users with the functions of registering a new account and logging in to an existing account. Users are required to enter necessary information such as user name (licence plate number), password, etc. for authentication to ensure account security.



Pic.1 Login Page



Pic.2 Registration Page

- **Charging Pile Summary Page:** This page summarises all the charging piles, including vacant and occupied piles. Through the intuitive map interface, users can quickly locate the nearby charging piles and view their detailed information, such as location, power, port type, etc., so as to better plan their charging trips.



Pic.3 Charging Pile Summary Page

- **Unoccupied Piles Page:** In order to facilitate users to quickly find available charging piles, this page is dedicated to displaying the information of currently unoccupied charging piles. Users can filter according to the location, power and other conditions of the charging pile, find the most suitable charging pile, and navigate to the destination directly.



Pic.4 Unoccupied Piles Page

- **Occupied Charging Piles Page:** This page shows the information of occupied charging piles, including the expected end time and occupied status of the charging pile. Users can use this page to understand the usage of charging posts and arrange their charging plan to avoid unnecessary waiting.



Pic.5 Occupied Charging Piles Page

- **Personal Trolley Information Page:** This page provides personalised services for users. Users can view their charging records, charging hours, charging costs and other details. At the same time, the page also shows the user's charging statistics, which helps users better understand their charging habits and provides strong support for future travel planning.



Pic.6 Personal Trolley Information Page

3.3 Overview of basic functions

- **User Management:** Provides functions of user registration, login and logout login to ensure the security and privacy protection of user accounts.
- **Charging Pile Information Query:** Through the map interface and detailed information display, users can conveniently query the location, power, interface type and other key information of nearby charging piles.
- **Charging Pile Status Alerts:** Real-time updates on the occupancy status of charging piles, including idle, charging in progress, fault, etc., providing users with smart charging choices.
- **Charging navigation:** Users can navigate directly to the charging station by clicking on the charging station detail page, providing convenient guidance for the charging journey.
- **Personal Charging Information Management:** Users can view their charging records, charging hours, charging costs and other details, and understand their charging habits through the charging statistics function.

3.4 Visual design

The whole APP adopts light green as the theme colour to create a fresh

and comfortable visual atmosphere, which is in line with the environmental protection concept of new energy vehicles. The interface design follows the principles of simplicity, minimalism and clarity, and reduces unnecessary decorative elements to ensure efficient and intuitive information communication. Through reasonable layout and colour matching, it enhances the smoothness and pleasure of user experience.

4 Key Technology

4.1 Build and dependency management

4.1.1 Gradle build System with Kotlin DSL

➤ **Kotlin DSL (build.gradle.kts) :**

- ◆ Writing Gradle build scripts using Kotlin DSL enhances the readability and maintainability of scripts and is especially suitable for Kotlin developers.

➤ **Plugin management:**

- ◆ Use `libs.versions.toml` to centrally manage the versions of plug-ins and libraries, reference plug-ins through alias, reduce version hard coding, improve the consistency and flexibility of dependency management.

```

23 [plugins]
24 androidApplication = { id = "com.android.application", version.ref = "agp" }
25 jetbrainsKotlinAndroid = { id = "org.jetbrains.kotlin.android", version.ref = "kotlin" }
26 androidLibrary = { id = "com.android.library", version.ref = "agp" }
27

```

Pic.7

4.1.2 Version Catalog

➤ Libs.version.toml:

- ◆ Centralized management of all dependent library versions, ensuring consistency and easy maintenance of dependent versions throughout the project.
- ◆ Defining libraries and plugins by alias makes referencing in build.gradle.kts at the module level much simpler.

```

1  [versions]
2  agp = "8.6.0"
3  kotlin = "1.9.0"
4  coreKtx = "1.13.1"
5  junit = "4.13.2"
6  junitVersion = "1.1.5"
7  espressoCore = "3.5.1"
8  appcompat = "1.7.0"
9  material = "1.12.0"
10 activity = "1.8.0"
11 constraintlayout = "2.1.4"
12
13 [libraries]
14 androidx-core-ktx = { group = "androidx.core", name = "core-ktx", version.ref = "coreKtx" }
15 junit = { group = "junit", name = "junit", version.ref = "junit" }
16 androidx-junit = { group = "androidx.test.ext", name = "junit", version.ref = "junitVersion" }
17 androidx-espresso-core = { group = "androidx.test.espresso", name = "espresso-core", version.ref = "espressoCore" }
18 androidx-appcompat = { group = "androidx.appcompat", name = "appcompat", version.ref = "appcompat" }
19 material = { group = "com.google.android.material", name = "material", version.ref = "material" }
20 androidx-activity = { group = "androidx.activity", name = "activity", version.ref = "activity" }
21 androidx-constraintlayout = { group = "androidx.constraintlayout", name = "constraintlayout", version.ref = "constraintlayout" }
22
23 [plugins]
24 androidApplication = { id = "com.android.application", version.ref = "agp" }
25 jetbrainsKotlinAndroid = { id = "org.jetbrains.kotlin.android", version.ref = "kotlin" }
26 androidLibrary = { id = "com.android.library", version.ref = "agp" }
27
28

```

Pic.8

4.2 Project structure

4.2.1 Multi-Module project

➤ **settings.gradle.kts:**

◆ **The project contains:** app and :mylibrary two modules, using modular design.

➤ **Advantages of modularity:**

◆ **Code reuse:** Common functionality is implemented in the mylibrary module and can be used by multiple application modules.

◆ **Build optimization:** Modularity facilitates parallel builds and increases build speed.

◆ **Team collaboration:** Different modules are developed independently by different team members, reducing conflict.

4.3 Permissions and configuration

4.3.1 AndroidManifest.xml

➤ **Permission declaration:**

◆ **INTERNET:** The application needs access to the network for obtaining charging pile data or user authentication.

◆ **READ_MEDIA_IMAGES:** The app needs to read images in the

media, which may be used by users to upload or display pictures of charging stations.

➤ **Component declaration:**

◆ **Activities:**

- ✧ **zzh_MainActivity**: Main interface, not set to start Activity.
- ✧ **LoginActivity**: Login screen, set to launch Activity (with LAUNCHER).
- ✧ **zzh_RegisterActivity**: Registration interface, not exported.

◆ **Provider:**

- ✧ **FileProvider**: Used to securely share in-app files, such as pictures, without directly exposing the file path, in line with Android security best practices.

```
38     <provider
39         android:name="androidx.core.content.FileProvider"
40         android:authorities="com.android.provider.ImageSharing_zzh"
41         android:exported="false"
42         android:grantUriPermissions="true">
43         <meta-data
44             android:name="FILE_PROVIDER_PATHS"
45             android:resource="@xml/paths" />
46     </provider>
```

Pic.9

4.4 User interface and navigation

4.4.1 View Binding and Data Binding

➤ **View Binding:**

◆ In `zzh_MainActivity.kt` and `zzh_RegisterActivity`. Use the View in `kt Binding` (`ActivityMainZzhBinding` and `ActivityRegisterZzhBinding`), Simplify view references and reduce the use of `findViewById`.

➤ **Data Binding:**

◆ Some UI components are bound to the Data model via `DataBinding`, and `DataBindingUtil` is used for layout binding to provide type-safe and concise view references.

```
class zzh_MainActivity : BaseBindingActivity<ActivityMainZzhBinding>() {
    override var layoutRes: Int
        get() = R.layout.activity_main_zzh
        set(value) {}

    override fun onCreate(savedInstanceState: Bundle?) {
        super.onCreate(savedInstanceState)

        binding.apply {
            toolbar.setOnMenuItemClickListener {
                when (it.itemId) {
                    R.id.exit -> {
                        user = null
                        startActivity(Intent(this@zzh_MainActivity, LoginActivity::class.java))
                        finish()
                    }
                    R.id.add -> {
                        zzh_NewFragment().show(supportFragmentManager, "new")
                    }
                }
            }
            true
        }
    }
}
```

Pic.10

4.4.2 Toolbar and Menu items

➤ **Menu click event handling:**

- ◆ Use the toolbar. SetOnMenuItemClickListener processing menu of "off" and "add" operation.

- ✧ **Exit action:** Clear the user information and jump to LoginActivity.

- ✧ **Add action:** Show zzh_NewFragment for adding new charging piles.

4.4.3 ViewPager2 and TabLayout

- **ViewPager2:**

- ◆ Achieve sliding page switching and improve user experience.

- **FragmentManager:**

- ◆ Manage multiple fragments, such as zzh_AllFragment and zzh_PersonalFragment, to switch between different functional modules.

- **TabLayoutMediator:**

- ◆ Combine TabLayout and ViewPager2 to create navigable tabs that allow users to switch between "charging piles", "occupied", "not occupied", and "Personal".

4.5 Database and data management

4.5.1 Room Persistence Library

- **ChargingDatabase:** Inherited from RoomDatabase, defines database

versions and entity tables (charging_data and user_data).

◆ **Database migration:** The current version is 1 with no migration policy defined and applies to the initial version.

◆ **Entity table:**

✧ **charging_data:** Contains charging pile details such as id, isOccupied, location, powerOutput, pricePerKw, progress, chepaihao, image.

✧ **user_data:** Contains user information such as chepaihao, password, isCharging, chargingProgress.

➤ **DAO interface:** ChargingDao: Defines CRUD operations, using Kotlin Coroutines and Flow for asynchronous data manipulation and data flow processing.

```
@Dao
interface ChargingDao {
    @androidx.room.Insert
    fun insert(zhuang: Plie)

    @androidx.room.Query("SELECT * FROM charging_data")
    fun getAllPilesAsFlow(): kotlinx.coroutines.flow.Flow<List<Plie>>

    @Query("SELECT * FROM charging_data")
    fun getAllPlies(): List<Plie>

    @androidx.room.Query("SELECT * FROM charging_data WHERE id = :id")
    fun getPlie(id: String): Plie

    @androidx.room.Update
    fun updatePlie(zhuang: Plie)

    @androidx.room.Delete
    fun deletePlie(zhuang: Plie)

    @androidx.room.Insert
    fun insertUser(user: User)

    @androidx.room.Query("SELECT * FROM user_data WHERE chepaihao = :id LIMIT 1")
    fun getUserByChepaiHao(id: String): User?

    @Update
    fun updateUser(user: User)
```

Pic.11

4.5.2 Entity Class

- **Plie and User:** Define the database table structure with Room annotations (`@Entity`, `@PrimaryKey`). Contains the necessary fields and default values for easy data manipulation and presentation.

```
@Entity(tableName = "charging_data")
data class Plie(
    @PrimaryKey
    var id: String,
    var isOccupied: Boolean,
    var location: String,
    var powerOutput: String,
    var pricePerKw: Double,
    var progress: Int = 0,
    var chepaihao: String = "",
    var image: String = "data:image/jpeg;base64,/9j/4AAQSkZJRgABAQAAQABAAQ/2wCEAAkGBxAPDw0NDxAQDw0PDw8NDw8PDw8NDw8NFRUWFhURFRUYH
)

@Entity(tableName = "user_data")
data class User(
    @PrimaryKey
    var chepaihao: String,
    val password: String,
    var isCharging: Boolean = false,
    var chargingProgress: Int = 0,
)
```

Pic.12

4.6 Asynchronous programming

4.6.1 Kotlin Coroutines and Flow

- **Kotlin Coroutines:** Start coroutines using `lifecycleScope.launch` in `zzh_RegisterActivity.kt` and Fragments to handle asynchronous database operations.


- ◆ Thread switching:

- ✧ Use Dispatchers. Default for background database operations to avoid blocking the main thread.

- ✧ Use Dispatchers. Main to update the UI, such as displaying Toast messages.

➤ Flow:

- ◆ Use Flow in ChargingDao for responsive data flow, updating UI components in real time.



```
lifecycle.coroutineScope.launch {
    getDao().getUserAsFlow().collect() {
        it.first { it.chepaihao == user!!.chepaihao }?.let {
            username.text = "车牌号: ${it.chepaihao}"
            password.text = "密码: ${it.password}"

            chepaohao.text = it.chepaihao
            progress.setProgress(it.chargingProgress, true)
        }
    }
}
```

Pic.13

4.7 User interaction and event handling

4.7.1 Event listeners

➤ **Button click Events:**

- ◆ Use `setOnClickListener` to handle button click events such as register button, stop charging button.

➤ **Custom keyboard bindings:**

- ◆ Bind a custom keyboard via `uid.bindVehicleKeyboard()` to improve user input experience and reduce misoperation.

```

31 fun EditText.bindVehicleKeyboard() {
32     VehicleKeyboardHelper.bind(this)
33 }
34

```

Pic.13

4.8 Dependency Injection and modularity

4.8.1 Obtaining DAO Instances

➤ Singleton pattern:

- ◆ The database is instantiated through the Singleton pattern to ensure global uniqueness.

```

abstract class ChargingDatabase : androidx.room.RoomDatabase() {
    abstract fun chargingDao(): ChargingDao

    companion object {
        private var instance: ChargingDatabase? = null

        fun getInstance(context: Context): ChargingDatabase {
            if (instance == null) {
                instance = androidx.room.Room.databaseBuilder(
                    context.applicationContext,
                    ChargingDatabase::class.java,
                    "charging_database"
                ).build()
            }
            return instance!!
        }
    }
}

```

Pic.14

```

209 fun Context.getDao() = ChargingDatabase.getInstance(this).chargingDao()
210
211 fun Fragment.getDao() = ChargingDatabase.getInstance(requireContext()).chargingDao()
212

```

Pic.15

4.9 UI Design

4.9.1 Material Design components

➤ **Components to use:**

◆ **oToolbar:** Used to apply the top navigation bar and integrate menu items.

◆ **oViewPager2 and TabLayout:** Implement sliding TAB pages to improve user experience.

◆ **oMaterialButton:** A modern and consistent button style that enhances UI visuals.

◆ **oGlide:** Used to efficiently load and cache images, improve image display performance and user experience.

➤ **Themes and styles:**

◆ **Apply custom themes via android:** `theme="@style/AppTheme"` to ensure consistency and visual beauty of UI components.

4.10 Custom controls and utility classes

4.10.1 Customize the keyboard

➤ **VehicleKeyboardHelper:**

◆ Located in the mylibrary module, it is responsible for customizing

the binding and interaction logic of the keyboard to improve the user input experience.

4.10.2 Tools

➤ Common tool functions:

◆ toast function:

- ✧ Simplify the display of Toast messages.

```
229 fun Context.toast(s: String) {  
230     Toast.makeText(this, s, Toast.LENGTH_SHORT).show()  
231 }  
232  
233 fun Fragment.toast(s: String) {  
234     requireContext().toast(s)  
235 }  
236
```

Pic.16

◆ Thread management functions:

- ✧ **runOnWorkThread** and **runOnUiThread**: Simplify the execution of background tasks and mainline tasks.

```
213 fun AppCompatActivity.runOnWorkThread(block: () -> Unit) {  
214     lifecycleScope.launch(Dispatchers.IO) {  
215         block()  
216     }  
217 }  
218  
219 fun Fragment.runOnWorkThread(block: () -> Unit) {  
220     lifecycleScope.launch(Dispatchers.IO) {  
221         block()  
222     }  
223 }  
224  
225 fun Fragment.runOnUiThread(block: () -> Unit) {  
226     requireActivity().runOnUiThread(block)  
227 }  
228
```

Pic.17

4.11 Image loading

4.11.1 Glide

➤ **Use Case:**

- ◆ Use Glide to load charging pile pictures in `zzh_allfragmenti.kt`, support error placeholder map and picture cache.



```
66 Glide.with(requireContext()).load(plie.image).error(resources.getDrawable(R.drawable.logo)).into(iv)
68
```

Pic.18

4.12 Event handling and user interaction

4.12.1 Confirm Charging dialog box

➤ **Logical flow:**

- ◆ When the user clicks on the free charging pile, an AlertDialog is displayed asking if it is confirmed to charge.
- ◆ If the charging post is already occupied, it says "cannot be used while charging".
- ◆ If the user is already charging, the message "Please stop charging first" is displayed.
- ◆ Once confirmed, update the status of the user and the charging

pile, use `runOnWorkThread` for database updates, `runOnUiThread` to update the UI and display the Toast message.

```

88         root.setOnClickListener {
89             if (plie.isOccupied) {
90                 toast("正在充电不能使用")
91             } else {
92
93                 if (user!!.isCharging) {
94                     toast("请先停止充电")
95                     return@setOnClickListener
96                 }
97
98                 AlertDialog.Builder(requireContext()).apply {
99                     setTitle("确认充电")
100                     setMessage("是否对车牌为[${user!!.chepaihao}]的新能源车进行充电?")
101                     setPositiveButton("确认") { dialog, which ->
102                         runOnWorkThread {
103                             user?.let {
104                                 // 双更新
105                                 it.isCharging = true
106                                 val progress = Random.nextInt(100)
107                                 it.chargingProgress = progress
108
109                                 plie.isOccupied = true
110                                 plie.progress = progress
111
112                                 getDao().updatePlie(plie)
113                                 getDao().updateUser(user!!)

```

Pic.19

```

114
115         runOnUiThread {
116             toast("${user!!.chepaihao} 开始充电")
117             dialog.dismiss()
118         }
119     }
120 }
121 }
122 setNegativeButton("取消") { dialog, which ->
123     dialog.dismiss()
124 }
125 }.show()
126 }
127 }
128 }
129 }
130 }
131 }

```

Pic.20

4.13 Asynchronous task and thread management

4.13.1 Thread management functions

➤ **Background Tasks:**

- ◆ Use `runOnWorkThread` to perform database operations, making sure not to block the main thread.

➤ **Main Thread tasks:**

- ◆ Update the UI with `runOnUiThread`, such as displaying Toast messages.

```
219 fun Fragment.runOnWorkThread(block: () -> Unit) {  
220     lifecycleScope.launch(Dispatchers.IO) {  
221         block()  
222     }  
223 }  
224  
225 fun Fragment.runOnUiThread(block: () -> Unit) {  
226     requireActivity().runOnUiThread(block)  
227 }  
228  
229 fun Context.toast(s: String) {  
230     Toast.makeText(this, s, Toast.LENGTH_SHORT).show()  
231 }  
232  
233 fun Fragment.toast(s: String) {  
234     requireContext().toast(s)  
235 }
```

Pic.21

5 Technology Challenge

- **Initial configuration and dependency management:** In the early stages of a project, Gradle configuration and dependency management face version compatibility issues. Dependency conflicts between different libraries lead to build failures and take a lot of time to troubleshoot and adjust. Through the introduction of the Version Catalog and unified management of dependent versions, these issues are gradually resolved to ensure a stable build of the project.
- **Asynchronous programming complexity:** Thread safety and data consistency must be ensured when using Kotlin Coroutines and Flow for asynchronous operations. In a multi-coroutine environment, managing state changes and avoiding race conditions becomes a challenge. Through reasonable coroutine structure design and using the cold Flow characteristic of flow, the asynchronous task is managed effectively, and the responsiveness and stability of the application are improved.
- **Custom control integration:** When implementing controls such as custom keyboard and progress bar, it is necessary to take into account functionality and user experience to ensure seamless integration with existing UI components. The implementation of custom keyboard VehicleKeyboardHelper involves complex input logic and interface

interaction. After many iterations and tests, the VehicleKeyboardHelper finally achieves the expected result.

- **Login verification vulnerability:** In the user login and registration functions, it is found that occasionally there is a problem that an unregistered account and password can be successfully logged in. This problem mainly stems from the imperfect user authentication logic, which causes the login operation to not be properly blocked when the user does not exist. By modifying the query logic of the DAO interface, the user is confirmed before password authentication, which enhances the security of the application.
- **The logic of new charging piles is unreasonable:** in the initial design, users can build new charging piles at will, which lacks necessary permission control and data verification, resulting in the authenticity of charging pile information being affected. In some cases, users cannot correctly add charging pile information, which affects the operating experience.

6 APP Testing Analysis

(Detail testing report of our app could be viewed from <https://www.testin.cn/s/7fe95ca6>)

6.1 Testing Overview

The testing phase was carried out on five Android devices spanning various brands, operating systems, and hardware configurations. The goal was to validate the app's functionality, performance, and robustness under both standard and stress conditions.

➤ **Tested Devices:**

- ◆ Redmi K40 (Android 13)
- ◆ iQOO Neo5 (Android 13)
- ◆ Black Shark 4 (Android 12)
- ◆ Honor 50 Pro (Android 12)
- ◆ Realme Q3 Pro (Android 11)

➤ **Test Scenarios:**

- ◆ Installation testing
- ◆ Startup testing
- ◆ Functional stability testing
- ◆ Stress testing (Monkey testing)

➤ **Key Achievements:**

- ◆ **Pass Rate:** 100% for all tested devices.
- ◆ **Failure Rate:** 0% (including installation, startup, and runtime).

◆ **Device Coverage:** Compatibility verified across multiple OS versions and hardware specifications.

名称	系统	型号	版本	分辨率	IMEI
Redmi K40	android	M2012K11AC	13	1080 x 2400	863074053631967
iQOO Neo5	android	V2055A	13	1080 x 2400	862257058714711
黑鲨 游戏手机4	android	KSR-A0	12	1080 x 2400	869901051570074
荣耀 50 Pro	android	RNA-AN00	12	1236 x 2676	861400055812101
Realme Q3 Pro	android	RMX2205	11	1080 x 2400	macd097fed8557b

Pic.22

6.2 Detailed Testing Results and Analysis

6.2.1 Installation and Startup Performance

➤ **Installation Time:**

The app exhibited an average installation time of 5.16 seconds, outperforming the industry standard of 7-10 seconds.

◆ **Fastest Device:** Black Shark 4 (3.32 seconds), indicating optimal APK size and file unpacking processes.

◆ **Slowest Device:** iQOO Neo5 (9.91 seconds), likely due to temporary storage conditions.

➤ **Startup Time:**

The app demonstrated an impressive average startup time of 0.46 seconds, highlighting its lightweight initialization processes.

◆ **Fastest Device:** Redmi K40 (0.09 seconds), showcasing excellent synergy with high-end hardware.

◆ **Slowest Device:** Honor 50 Pro (0.81 seconds), still well within acceptable thresholds.

Fast installation and startup times reflect meticulous optimization during development. These results ensure users can quickly access the app with minimal waiting time, contributing to a positive user experience.

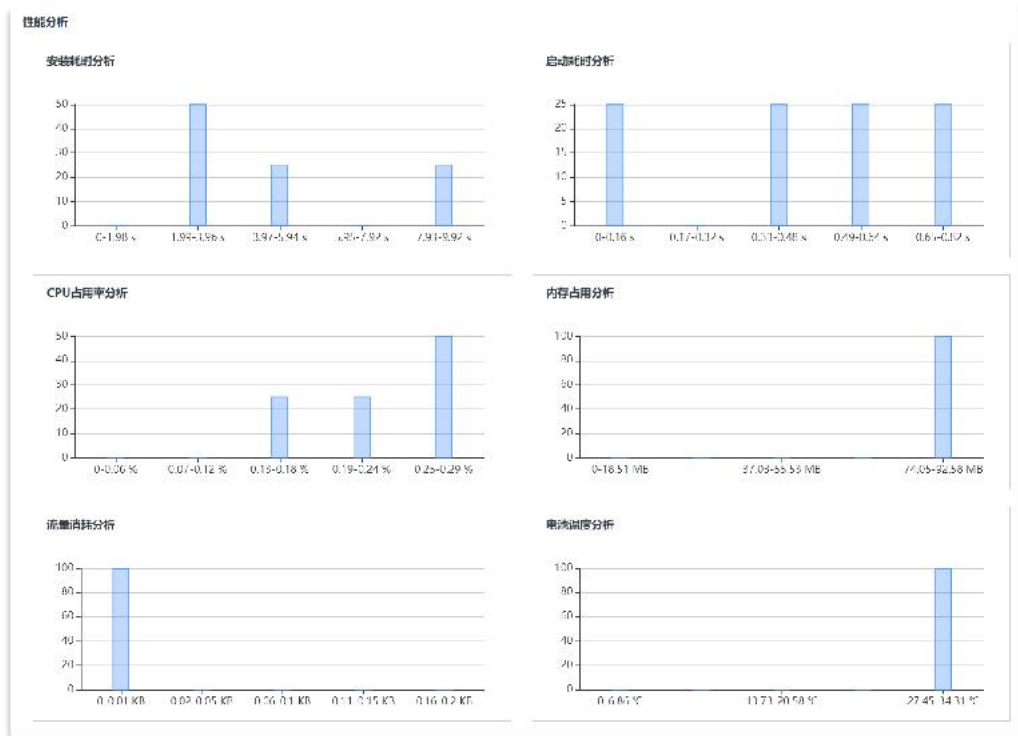
6.2.2 Resource Utilization

- **CPU Usage:** The app maintained an average CPU utilization of 0.24%, with a peak of 0.28% on Redmi K40 during high-intensity operations. This efficiency minimizes impact on device performance and ensures smooth multitasking.
- **Memory Usage:** Average memory consumption was 86.24 MB, significantly below the recommended 100 MB threshold, enabling seamless operation even on mid-range devices.
- **Battery Temperature:** The app sustained an average temperature of 31.98°C, reflecting efficient power usage and thermal management.

◆ **Cooltest Device:** Redmi K40 (29.5°C).

◆ **Warmest Device:** Black Shark 4 (34.3°C), attributed to its gaming hardware under stress testing.

The app's low resource consumption underscores its efficient architecture and careful management of system resources. These results validate the app's suitability for prolonged usage without noticeable impact on device performance or battery health.



Pic.23



Pic.24

终端数据						
设备名称	安装耗时(s)	启动耗时(s)	平均CPU(%)	平均内存(MB)	流量消耗(MB)	平均电池温度(°C)
Redmi K40	5.16	0.09	0.28	81.35	0.00	29.5
iQOO Neo5	9.91	0.49	0.28	56.72	0.00	32.5
Realme Q3 Pro	--	--	--	--	--	--
荣耀 游戏手机4	5.37	0.45	0.23	83.72	0.00	34.3
荣耀 50 Pro	4.09	0.81	0.17	92.57	0.00	31.6

Pic.25

6.2.3 Stability Testing

The stability testing comprehensively evaluated the core functionalities and extreme usage scenarios of the app, and the results demonstrate exceptional stability under all conditions.

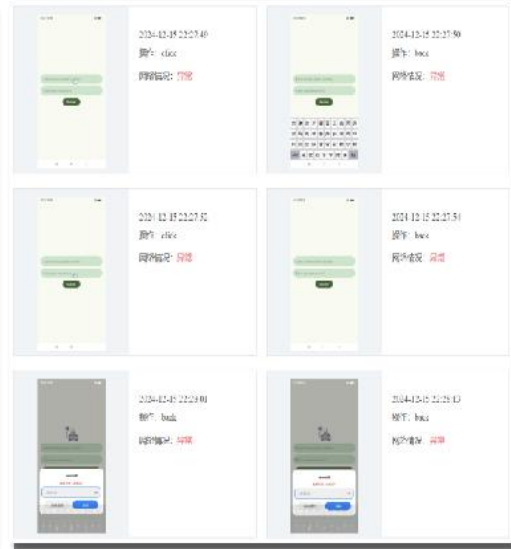
➤ Functional Stability Testing

The app underwent functional tests, including navigation, data input, and API calls, without any crashes, ANR (Application Not Responding), or exceptions.

The chart below records the detailed process of user actions (clicks, back navigation), showing that every interaction was successfully executed without errors or interruptions. This highlights the app's responsive and stable user interaction design.



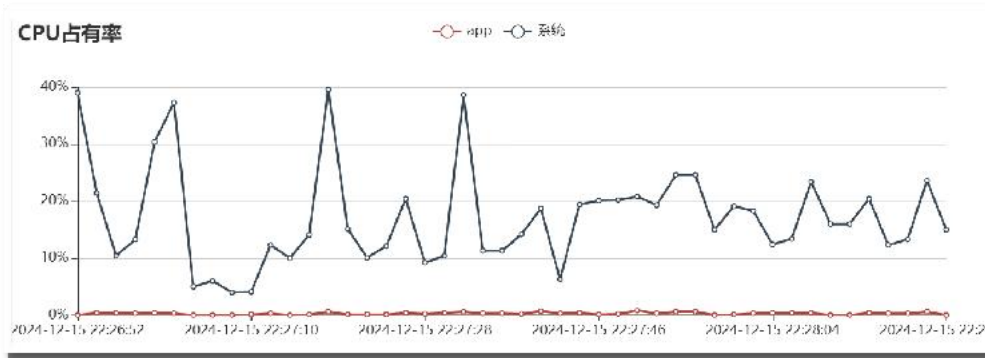
Pic.26



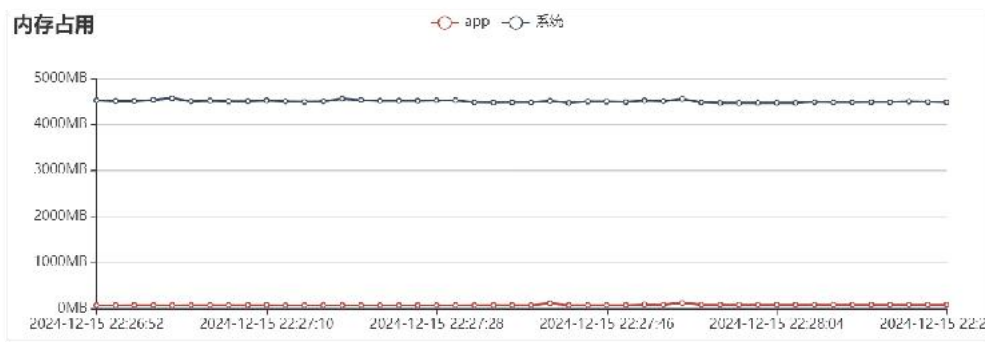
Pic.27

➤ Performance Trend Analysis

The chart below illustrates CPU usage and memory consumption trends during testing, with stable curves and no abnormal fluctuations, indicating smooth operation under high loads. The stable resource consumption reflects the app's optimized resource allocation, delivering a seamless user experience.



Pic.28



Pic.29

➤ Performance Insights

As shown in the table, the app consistently outperformed benchmarks in installation, startup, and resource utilization. All tested devices successfully completed the evaluation, with a 100% pass rate, validating the app's stability and compatibility.

◆ Efficient Installation and Startup

The results demonstrate that the app installed and started without any failures across all devices, showcasing exceptional

operational efficiency and adaptability to various hardware configurations.

◆ **Stability Verification**

No installation failures, startup failures, or runtime failures were recorded during the tests, confirming the app's robust stability under both standard and complex scenarios. Additionally, the app encountered no issues during Monkey testing or runtime operations, highlighting its fault-tolerant and reliable design.

◆ **Thermal Management**

The app exhibited excellent thermal efficiency during testing, with battery temperatures remaining within a reasonable range. This ensures a comfortable user experience even during prolonged usage, without overheating or performance degradation.

The data and detailed table above clearly illustrate that the app has achieved its design goals in terms of compatibility, stability, and resource efficiency, making it suitable for a wide range of devices and scenarios.

测试基本信息					
	测试应用	ECharging	测试通过率	100.0%	
	系统平台	Android			
	机型数	5			
	未执行机型数	1			
	测试结果	测试终端数		测试结果百分比	
	安装失败	0		0.0%	
	启动失败	0		0.0%	
	monkey失败	0		0.0%	
	卸载失败	0		0.0%	
	运行失败	0		0.0%	
通过	4		100.0%		
测试机型列表					
未执行 (1) 款					
Realme Q3 Pro					
通过 (4) 款					
Redmi K40		iQOO Neo5	黑鲨 游戏手机4		
荣耀 50 Pro					

Pic.30

6.3 Summary of Testing Insights

The testing results highlight the app's exceptional design, showcasing high efficiency, unparalleled stability, and remarkable energy optimization. The app demonstrated fast installation and startup times, allowing users to access its features quickly and seamlessly. Additionally, its low CPU and memory usage reflects a highly optimized performance, ensuring smooth operation even on mid-range devices.

The app's stability was also proven through comprehensive functional and stress testing, with zero failures recorded. This robust and fault-tolerant design guarantees reliable performance across a wide range of devices, emphasizing its broad compatibility and the engineering

team's excellence in development.

Moreover, the app exhibited outstanding energy efficiency, maintaining minimal battery temperature rise during extended usage. This result demonstrates effective power optimization, ensuring user comfort and device longevity even in high-demand scenarios. Overall, the testing results affirm the app's superior design, achieving a balance of performance, stability, and resource efficiency, making it highly suitable for diverse user needs.

7 User Feedback Analysis

7.1 Positive Feedback

To better understand how the app meets user needs and identify areas for further improvement, we collected feedback from 10 students across different colleges and academic years after they downloaded and used the app. This diverse user group provided valuable insights into the app's real-world performance and specific user expectations.

The feedback highlighted several strengths of the app. Users consistently praised the clear and modern interface design, which made navigation intuitive and seamless. The personal account management features and detailed charging station information was also well-received, significantly enhancing the overall user experience. For instance, one user remarked, "If every charging station could be reviewed, it would show that the platform truly values user input." This feedback reflects not only satisfaction with the app's current features but also the expectation for continued improvements.

By analyzing this feedback, we were able to validate the app's core functionalities and identify the features that had the greatest impact on user satisfaction. These positive remarks underscore the importance of engaging with users regularly to refine and further develop the app.

7.2 Suggestions and Hypothetical Feedback

In addition to positive feedback, users offered valuable suggestions and raised thoughtful questions about potential improvements. These ideas highlight areas where the app could be further optimized:

➤ **Interface Customization:**

"Could there be an option to adjust font sizes and button layouts?"

Users believe that adding customization options could enhance accessibility, particularly for older users or those with specific needs.

➤ **Enhanced Navigation Features:**

"What if there were options like 'fastest route' or 'most economical route'?"

Providing flexible navigation settings could better accommodate diverse user preferences.

➤ **Review Sorting and Filtering:**

"Would it be possible to filter reviews by 'most helpful' or 'latest'?"

This feature could improve user efficiency in locating relevant feedback and making informed decisions.

➤ **Detailed Charging Station Information:**

"Could the app display real-time availability and charging speeds for stations?"

Users expressed a strong interest in more detailed station data to optimize

their charging schedules.

➤ **Offline Functionality:**

"Could offline navigation support be added for areas with poor connectivity?"

This feature could be especially useful for users traveling in remote or rural areas.

7.3 Developer Responses

The development team carefully reviewed the user suggestions and provided the following responses to address their expectations:

- The suggestion to add font size and button layout adjustments is under evaluation, with plans to introduce these features in future updates.
- Enhancements to navigation algorithms are being prioritized, with additional route options expected in upcoming releases.
- The proposal for review sorting and filtering has been acknowledged, and the team is assessing implementation feasibility.
- Real-time charging station information is already part of the development roadmap, with plans to integrate it into future versions.
- Offline navigation functionality is being assessed for technical feasibility, ensuring stability before potential deployment.

名字	张*	简*	刘**	张**	廖**
学院	入院	国商	入院	阿伯丁	阿伯丁
评价	要是能写评论就好了	个人账户界面可以变得更全面，比如增加一些增值服务	定位功能挺准确的，地图加载也很快，体验感很不错	可以删除一些让不必要的界面，操作更加直观	希望有导航筛选功能
改进意见	建议增加评论筛选功能，比如查看“最新”或“最有帮助”的评论	增值服务可以增加使用指南或教程，让用户更清楚如何使用这些功能	建议支持离线地图功能，这样在信号不好的地方也能使用导航	可以在首页增加一个快速导航栏	希望能提供更多路线选择，比如“最快路线”或“最省钱路线”
开发者分析	好的，我们会增加这部分功能的	好的，后续我们会继续制作的，谢谢你的反馈	你没更新版本	我们后续会改进的！谢谢你的提议	可以通过算法优化来实现，提升导航系统的灵活性

Pic.31

名字	万**	韦**	陈**	陈**	王**
学院	阿伯丁	阿伯丁	入院	国商	阿伯丁
评价	充电桩的详情界面非常详细，可以看到充电桩数量、费用和实时状态	希望可以看到其他用户对充电桩的评价和评分	可以新上线一些增值服务，比如会员折扣和预约功能	APP界面风格更加现代化了，颜色搭配舒适，界面布局也很清晰	要是每个充电桩都能进行评价，就说明平台真的在听取用户意见，期待未来更多优化功能
改进意见	能否增加充电桩拥挤程度的实时显示，避免到达后充电桩全部占用？	评分可以增加维度，比如充电速度和服务态度	建议在个人账户显示增值服务的使用记录和节省的费用	部分字体和按钮较小，尤其是老人使用时不太方便，可以增加字体放大功能	建议开发者定期总结用户反馈，推出改进报告
开发者分析	好的，这个提议非常实用，已经将这个功能提上日程了	增加充电速度是我们没想到的，谢谢你的提议	okok，后续调整	收到，因为开发者都是年轻人，所以忘记了老年人的需求，会改进的	是的，我们确实有在认真听取用户意见，已经在做用户反馈了

Pic.32

7.4 Summary

The feedback gathered from users has provided invaluable insights into both the strengths of our app and the areas where it can be further refined. Users expressed satisfaction with the app's clean interface, smooth navigation, and newly added features, such as detailed charging station information and improved account management. These positive remarks

affirm the thoughtful design and functionality of our app, demonstrating that it meets many of the core needs of its target audience.

However, users also raised thoughtful questions and suggestions, which highlight opportunities for growth. Requests for interface customization, enhanced navigation flexibility, real-time charging station updates, and offline functionality reflect the evolving expectations of our user base. These suggestions align with our vision for creating a comprehensive and user-centric app.

We recognize that a single semester of development is insufficient to implement all the features our users desire. Nevertheless, we view this feedback as a roadmap for future work. This project has laid a strong foundation, and we are optimistic about the potential to build upon it in the future. As students, we hope to continue improving this app, leveraging the insights gained during this semester to create a product that fully meets user expectations.

With the lessons learned and the feedback received, we are committed to exploring further opportunities to refine and expand the app. Although this semester marks the conclusion of the initial phase, it is only the beginning of what could become a deeper, more impactful project.

8 Conclusion

In the process of project development, we have made remarkable achievements. The application features are comprehensive, covering the addition and search of charging piles, user registration and login, and real-time update of charging status. Using Room persistence library combined with Kotlin Coroutines and Flow, it realizes efficient local data storage and asynchronous data operation, ensuring data consistency and high performance of applications. Multi-modular architecture and centralized dependency management improve code reusability and maintainability, facilitating subsequent extension and team collaboration. The application of Material Design components and Glide library makes the interface simple and beautiful, smooth operation, and improves the user's visual and operational experience.

The development process also encountered some challenges. At the beginning, there were compatibility problems in Gradle configuration and dependency management, which led to frequent errors during project construction and spent a lot of time checking and adjusting. The logical design of the new charging pile is not reasonable enough, and users can build new charging piles at will, which affects the authenticity. And in the login registration, sometimes there will be an unregistered account password can also log in, that is, the user does not exist can directly skip

the verification, resulting in any password can pass.

The next step we plan to take is that, applications could introduce dependency injection frameworks, such as Dagger-Hilt or Koin, to optimize dependency management and improve modularity and testability of code. During login, the user authentication logic first checks whether the user exists through the `getUserByChepaiHao` method of `ChargingDao`. Only when the user exists, the password is verified. If the user does not exist, it should prompt "Account is not registered" or similar message, and prevent login; Redesign the creation process of charging piles, simplify the operation steps, ensure that users can smoothly add charging pile information, and improve the user experience; Add more unit tests and UI tests to ensure the functional correctness of each module and component, improve application stability and user experience. ; Introduce more practical functions, such as map navigation of charging piles, appointment charging and payment system integration, to further enhance the practicality and competitiveness of the application; At the same time, optimize the database management, plan the version migration strategy, ensure the stability and consistency of data during the version update process, and improve the efficiency of data access.