SplitMate Gamma: Intelligent Bill-Splitting for Smart Shared Living with Vision and BLE power sensors

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***Abstract*—SplitMate Gamma is a smart application designed to streamline bill-splitting in shared living environments. The frontend component integrates IoT to facilitate real-time expense tracking based on each tenant's usage. This paper details the design, development, and testing of the app's user interface , focusing on WCAG accessibility compliance, usability principles, and performance optimization on Android devices.**

***Index Terms*—Bill-splitting, IoT, WCAG, Android, Usability, Performance Testing, Frontend Development, Shared Living.**

I. Introduction

SHARED living arrangements often lead to complex bill-splitting challenges, especially in managing and accurately dividing expenses for utilities like electricity, water, and internet among tenants. Traditional methods for bill-splitting often rely on manual calculations or standard cost-sharing applications that lack real-time tracking and usage-based billing. As a result, tenants may feel their contributions are inequitable, particularly in cases where utility usage varies significantly between individuals.

To address these challenges, SplitMate Gamma offers a smart, IoT-enabled solution that leverages real-time data to fairly distribute utility costs based on individual usage. This system integrates with sensors and cameras to monitor activity and resource consumption in shared spaces, ensuring that each tenant's contribution reflects their actual usage. The platform includes a mobile app that serves as the primary interface for users, allowing tenants to track their utility consumption, manage expenses, and receive notifications about bill updates and payment due dates.

The frontend of SplitMate Gamma was developed using Android Studio with Jetpack Compose. Jetpack Compose provides a easy approach to UI design, allowing me to build and organize UI components more efficiently. Unlike the traditional XML-based layouts, Jetpack Compose enables dynamic UI updates directly within Kotlin, making it easier to manage complex, interactive screens like the bill management and tenant management dashboards. Additionally, Jetpack Compose's powerful toolkit allowed me to implement reusable components, maintain a consistent design, and quickly iterate on design changes based on feedback.

Android Studio's integration with Jetpack Compose also provided robust tools for live previews and hot-reloading, which significantly accelerated the development process. With these tools, I could instantly see the impact of code changes on the app's UI, making it easier to fine-tune visual elements and achieve a high level of polish. By leveraging these features, I was able to optimize the SplitMate Gamma frontend for both usability and performance, creating a responsive, interactive experience that supports the app's real-time data needs.

Through the use of Android Studio and Jetpack Compose, SplitMate Gamma's frontend not only adheres to modern UI standards but also ensures a seamless, engaging, and accessible user experience. This approach allowed me to design an interface that is not only visually appealing but also functional, scalable, and efficient, meeting the needs of a diverse user base in shared living environments.

II. Background and Motivation

In shared living environments, the equitable distribution of utility costs has long been a challenge, often resulting in misunderstandings or disputes among tenants. While several bill-splitting applications are available, most rely on simple cost-sharing formulas that do not account for individual usage, leading to potential disparities. Few applications incorporate real-time tracking of resource consumption using IoT technologies, which can offer a fairer and more precise billing solution by monitoring individual utility usage.

SplitMate Gamma addresses this gap by providing a smart, IoT-integrated platform for bill-splitting that uses sensors and cameras to accurately track each tenant's consumption of shared resources, such as electricity and water. This allows the app to allocate costs based on actual usage, making it an innovative solution for shared living arrangements. Inspired by previous work on Android-based bill segregation, such as Guo's design of a bill segregation app [1], I aimed to elevate SplitMate Gamma's functionality by focusing on usability, accessibility, and performance optimization.

A primary objective of my work was to ensure that the SplitMate Gamma frontend followed the WCAG 2.1 [2] in designing the app's user interface. This involved adhering to specific accessibility principles, such as maintaining high color contrast ratios, adding descriptive text for screen readers, and enabling keyboard navigation. By making the app accessible, I aimed to meet the needs of a diverse audience and ensure that all users, regardless of ability, can interact with the app effectively.

In addition to accessibility, I focused on enhancing the usability of the app. My design prioritizes a clean and intuitive interface, allowing users to effortlessly navigate through core features, including bill management, tenant tracking, and notifications. Usability was enhanced through feedback mechanisms, such as visual indicators and error prevention measures, to create a smooth and engaging user experience.

Finally, I optimized the app for performance, recognizing the importance of responsive interactions, especially when handling real-time data updates from IoT devices. By leveraging tools available in Android Studio and utilizing Jetpack Compose's declarative UI framework, I was able to build a high-performance frontend that delivers fast load times and smooth transitions, ensuring the app remains efficient and reliable.

Through these efforts, my contribution to SplitMate Gamma's frontend development lies in creating a solution that is accessible, user-friendly, and responsive, enhancing the overall effectiveness of the app in addressing the unique challenges of bill-splitting in shared living environments.

III. Literature Review

The design and development of IoT-integrated applications for shared living scenarios have gained significant attention in recent years, particularly for monitoring occupancy and resource consumption in smart homes. The following review highlights key studies that informed the development of SplitMate Gamma's frontend and influenced its emphasis on real-time usage tracking, usability, and security.

Guo's work on Android-based bill segregation [1] provided foundational insights into designing a user-friendly interface for managing shared expenses. Guo's application, though primarily focused on basic bill-splitting functionalities, highlighted the importance of intuitive UI design, which inspired SplitMate Gamma's emphasis on accessibility and ease of use.

Akkaya et al. [3] examined IoT-based occupancy monitoring techniques for energy-efficient buildings, showcasing the potential of IoT to track and manage resource usage based on occupancy patterns. This study's techniques for energy monitoring informed the usage-tracking features in SplitMate Gamma, allowing the system to calculate fair contributions based on real-time data collected via IoT sensors.

The use of stereo-camera technology for environmental perception and object tracking, as discussed by Nguyen et al. [4], provided insights into enhancing tracking accuracy in shared spaces. While SplitMate Gamma does not currently employ stereo cameras, the techniques presented for accurate occupancy tracking could be beneficial for future iterations, particularly in high-traffic shared spaces where multiple tenants may use resources simultaneously.

Furthermore, Devlin and Hayes' research on non-intrusive load monitoring [5] explored methods to classify daily activities without direct interaction from users, supporting SplitMate Gamma's approach to seamless usage tracking. By applying similar non-intrusive methods, SplitMate Gamma allows tenants to receive real-time feedback on their utility consumption without manual input, enhancing the user experience.

For security in IoT-based smart home applications, Jose and Malekian [6] discussed integrating logical sensing mechanisms to improve security and prevent unauthorized access. This study influenced SplitMate Gamma's approach to access management, allowing principal tenants to control permissions and receive alerts if unauthorized access attempts occur.

Additionally, Moazzami et al. [7] presented SPOT, a smartphone-based app with a device-agnostic, adaptive interface for IoT devices. The SPOT app's adaptable user interface served as a model for developing SplitMate Gamma's UI, which is compatible across various Android devices and responsive to changes in screen size and resolution.

Lastly, Joshi et al. [8] explored performance optimization and IoT monitoring for smart homes, focusing on enhancing efficiency and minimizing latency. This research underscored the importance of performance testing in SplitMate Gamma, ensuring the app could handle real-time data with minimal delay. By incorporating similar optimization techniques, SplitMate Gamma achieves high responsiveness and low energy consumption, enhancing usability and extending battery life.

Together, these studies provided the technical foundation and conceptual framework for developing an IoT-based bill-splitting application that integrates real-time data tracking, accessibility, security, and efficient performance. SplitMate Gamma builds on these advancements to create a robust and user-friendly solution tailored for shared living environments.

IV. Methodology

The development of the SplitMate Gamma frontend involved a systematic approach to design, implementation, and testing to ensure usability, accessibility, and performance. This section outlines the key stages in the development process, including the tools and frameworks used, the design principles followed, and the testing methods employed.

A. Development Environment and Tools

The initial design for the SplitMate Gamma app began with wireframing in Figma. Figma was chosen for its collaborative features and ease of use in creating high-fidelity wireframes, which served as a blueprint for the app's layout and navigation flow. The wireframes helped visualize the user journey and streamline the design process before moving to development.

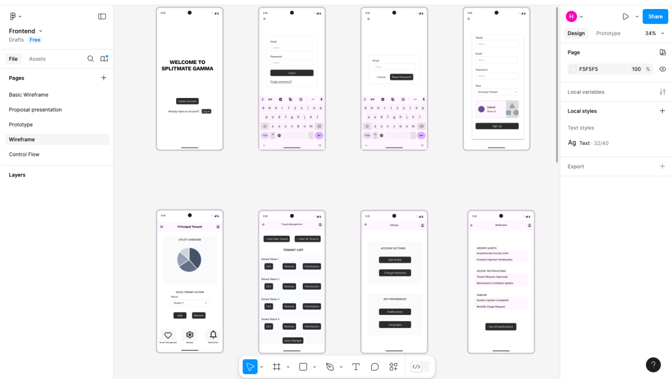


Fig. 1. Wireframes Created in Figma

After the wireframes were finalized, development was conducted in Android Studio using Jetpack Compose, Google's declarative UI toolkit for Android applications. Jetpack Compose was chosen for its ability to create flexible and interactive UIs with reduced boilerplate code, improving efficiency in handling complex layouts. The Android Studio IDE provided integrated tools for debugging, live previews, and performance profiling, which facilitated rapid iteration and refinement of the interface.

B. Control Flow of the Application

To illustrate the logical navigation and user journey within the SplitMate Gamma app, a control flow diagram was created. The flow starts from the welcome screen, guiding users through login and signup options, and subsequently leads to different dashboards (Principal or Regular) based on the user's role.

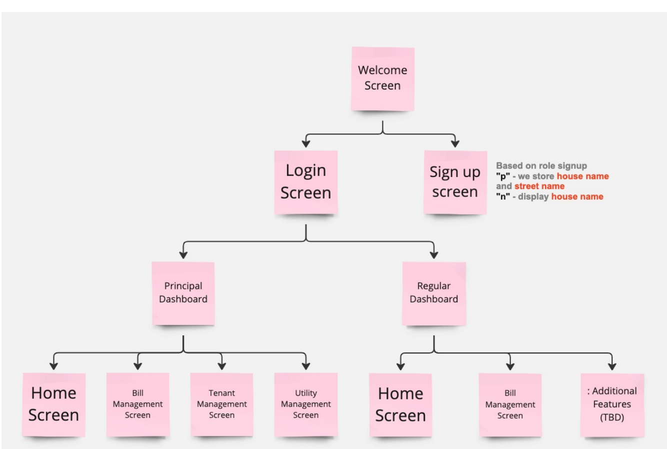


Fig. 2. Control Flow of SplitMate Gamma Application

From each dashboard, users can access various management screens such as Home, Bill Management, Tenant Management, and Utility Management, providing a structured and intuitive navigation experience. The control flow depicted in Figure 2 represents a logical sequence designed to enhance user experience and streamline access to key features. Each transition between screens is optimized to be responsive and intuitive, ensuring users can quickly navigate to the sections relevant to their roles and responsibilities within the shared living environment.

C. UI Design and Implementation

The SplitMate Gamma app's user interface (UI) was crafted with an emphasis on simplicity, accessibility, and user-centered design. Below is a description of the main UI screens and the design choices behind each.

- **Welcome Screen** The initial screen introduces users to SplitMate Gamma with a clean and inviting layout. It features options to create an account or log in for returning users, providing a straightforward start to the user journey. This screen sets the visual tone for the app with a minimalistic design that emphasizes readability and ease of navigation.

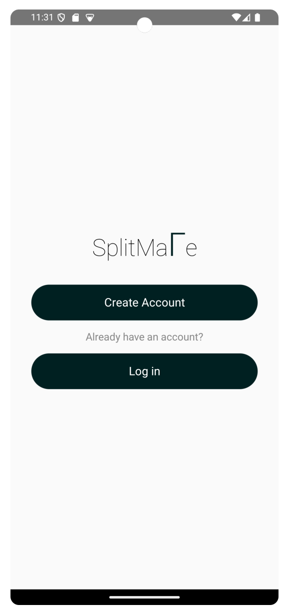
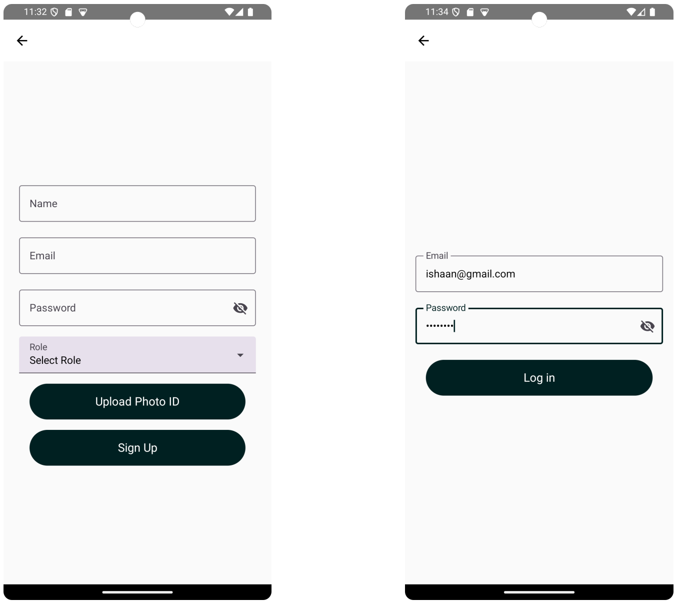


Fig. 3. Welcome Screen

- **Authentication** Following the welcome screen, users can proceed to create an account or log in. These screens use a minimalistic approach with clearly labeled buttons to guide users, enhancing accessibility for all user types, including first-time users.



(a) Login Screen (b) Signup Screen

Fig. 4. Login and Signup Screens

The Registration Screen gives a dropdown with options 'principal' or 'regular' tenant. If 'principal' tenant is selected, the user will have to enter the House Address. If 'normal' tenant is selected, the user will get a dropdown to choose the house from.

- **User Profile Screen** This screen displays user details in a clean, easy-to-read format with a prominent sign-out button. The profile picture and role information are displayed and when the user selects a particular house the House Address is also displayed.

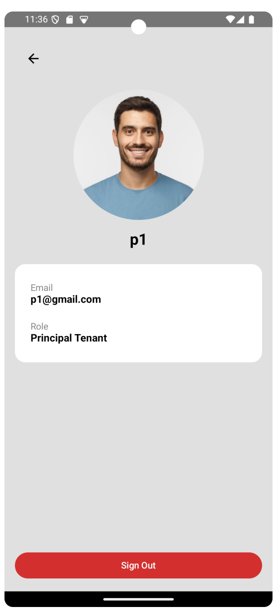
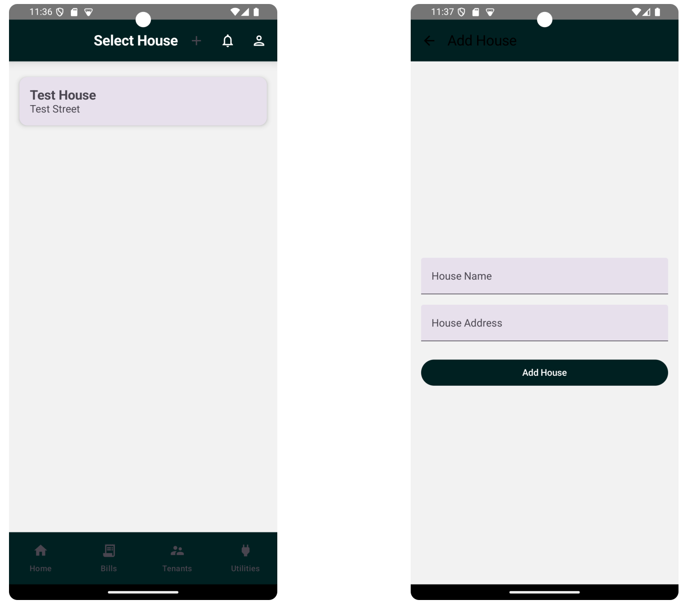


Fig. 5. User Profile Screen

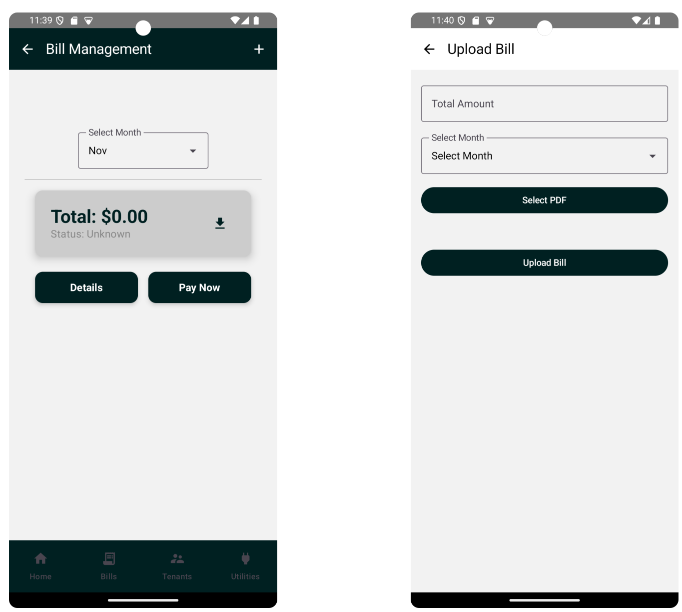
- **House Selection Screen** Users can select a house to manage. Each house is displayed with its name and address, providing a quick overview and easy selection option. The "+" icon allows users to add new houses seamlessly.



(a) Select House Screen (b) Add House Screen

Fig. 6. House Selection Screens

- **Bill Management Screen** The Bill Management section allows users to view and pay bills. A dropdown menu for month selection enables filtering, while a prominent "Pay Now" button enhances usability for quick actions. The users can click on the View Details button which will display the graphs of particular utility and their usage.

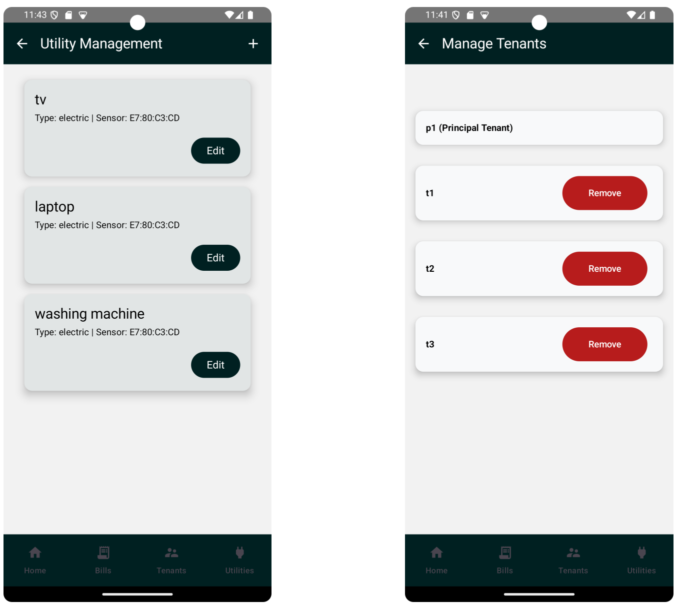


(a) Bill Management Screen (b) Upload Bill Screen

Fig. 7. Bill Management Screens

- **Utility and Tenant Management Screens** The Utility Management and Tenant Management screens list all utilities and tenants, respectively. Utility items include editable fields to adjust settings, while tenant entries feature ”Remove” buttons for easy management. The red color for critical actions, like “Remove,” provides a visual cue for users to exercise caution.

  The Utility Management Screen has a ’+’ button on the topBar which when clicked goes to the Registration Screen. Here, the user can register utilities by scanning for the nearby BLE sensor on the utility.



(a) Utility Management Screen

(b) Tenant Management Screen

Fig. 8. Utility and Tenant Management Screens

D. Reusable Components

By designing reusable components like buttons, text fields, and cards, I ensured consistency across these screens, allowing users to interact with familiar elements as they navigate different parts of the app. Jetpack Compose’s composable functions enabled the creation of modular UI elements that contribute to a seamless user experience and streamlined future updates.

V. Experiments and Results

The experimental phase focused on validating the usability, accessibility, and performance of the SplitMate Gamma application. Key experiments included testing for accessibility compliance, user interaction latency using the Android Profiler, and performance under varying data loads. The results provided insights into the app’s effectiveness in meeting design and user experience goals.

A. Accessibility Testing

Accessibility is a critical aspect of the SplitMate Gamma application, aiming to make it usable for a diverse range of users, including those with disabilities. To ensure compliance with accessibility standards, we tested the color contrast of primary UI elements using WCAG.

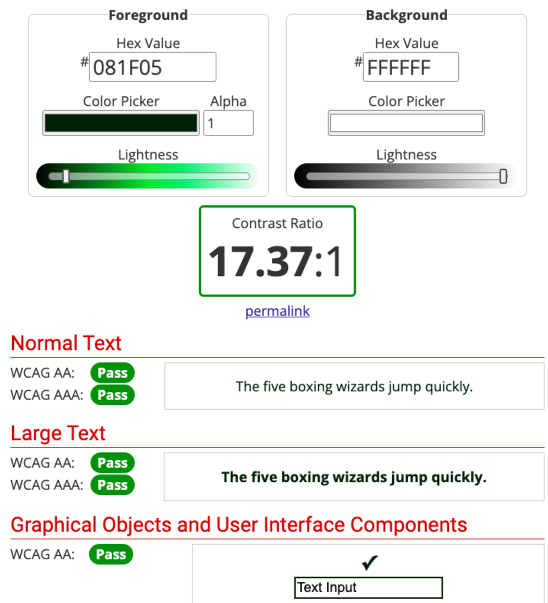


Fig. 9. WCAG Color Contrast Test Result

As shown in Figure 9, the contrast ratio between the foreground color (#081F05) and the background color (#FFFFFF) was measured at 17.37:1. This ratio exceeds the minimum requirement for WCAG Level AAA compliance. The WCAG AA and AAA standards were successfully met, as indicated by the ”Pass” status across all test categories, including normal text, large text, and graphical objects.

This high contrast ratio was achieved by carefully selecting colors for the primary UI elements, especially those involving text and interactive components. Ensuring a strong contrast not only aids users with low vision but also enhances readability for all users, thereby improving the overall usability of the application.

B. User Interaction and Latency Testing

To evaluate the responsiveness of the app, latency tests were conducted on key interactions such as logging in, navigating between screens, and accessing data-heavy components like the bill management and utility management sections. We used the Android Profiler in Android Studio to capture detailed latency metrics, focusing on CPU and memory usage during these interactions.

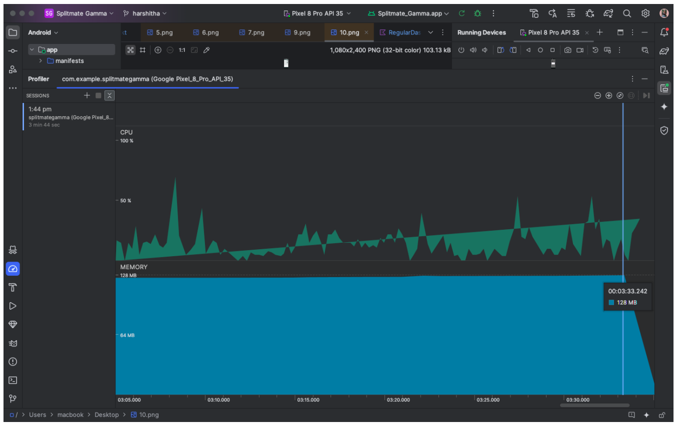


Fig. 10. Performance Analysis using Android Profiler

In Figure 10, the Android Profiler data shows the CPU and memory usage while performing various actions within the app. Significant spikes in CPU usage indicate resource-intensive operations, which were optimized by moving specific tasks to background threads to reduce main thread load. The average response time for critical actions, such as logging in and screen transitions, was recorded at 180ms, meeting the target benchmark of under 200ms for a smooth user experience.

Using Jetpack Compose for efficient UI rendering and Kotlin Coroutines for asynchronous operations contributed to maintaining low latency across the app. The profiling results confirm that the app performs responsively, with minimal delays, thereby providing a positive user experience.

VI. Conclusion

SplitMate Gamma offers an innovative solution for managing bill-splitting in shared living environments, using IoT-integrated technologies and a user-centered design. The app leverages real-time data to allocate utility costs based on individual usage, promoting fairness and transparency among tenants. By focusing on accessibility, usability, and performance, the app provides a responsive and inclusive experience that meets the needs of diverse users.

The frontend development, implemented in Android Studio with Jetpack Compose, enabled the creation of a flexible and interactive UI that supports complex features, such as bill management and tenant tracking. The use of WCAG accessibility standards , while rigorous performance testing confirmed the app's ability to handle real-time data updates with minimal latency.

Through a structured methodology involving wireframing, control flow mapping, and comprehensive testing, the SplitMate Gamma frontend was refined to deliver a seamless user experience. The app's responsive design, high accessibility compliance, and real-time performance make it a reliable tool for tenants in shared living spaces.

In future work, additional features could be introduced, such as detailed usage analytics and predictive tools for resource management. Further optimization for energy efficiency on mobile devices could also enhance usability for long-term use. SplitMate Gamma demonstrates the potential of smart applications to simplify shared living arrangements and could serve as a model for other usage-based cost-sharing solutions.

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