جامعة اليمامة
Al Yamamah University

AL YAMAMAH UNIVERSITY

College of Engineering and Architecture

Bachelor of Science in Software and Network Engineering

Jadwal: An Intelligent, iOS-based Calendar Manager

Graduation Project

Group Project Submission

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ABSTRACT

With rapid globalization, time management has became a real challenge. This paper introduces Jadwal, which proposes an automatic schedule management system where an individual can integrate multiple calendars and extract the events that have been discussed in informal communication channels, such as Whatsapp.

Key Objectives:

- To develop an intelligent calendar management system that automatically extracts events from the informal communication channels like WhatsApp and adds them to the user's main calendar.
- To create a user friendly interface that allows users to easily add events to the calendar.
- To implement a smart resolution system that notifies users of scheduling conflicts and provides easy options for resolution.
- To integrate all the calendars into Jadwal's single calendar view to make viewing and managing all the events easy.
- To prioritize and automatically schedule daily routines such as prayer time.
- To significantly reduce the time users spend on manual calendar management.

The system will be a mobile application, designed for iOS devices.

ACKNOWLEDGMENT

First and foremost, we would like to thank our Graduation project supervisor Dr. Inayatullah for his invaluable guidance and precious time. His advise was instrumental in shaping our project. He provided support in challenging times. Moreover, he emphasized that all members should be involved in each phase of the project and should gain core knowledge and contribute effectively.

Secondly, we would like to thank all the professors and friends for their insightful recommendations which helped us to enhance our project.

Lastly, we would like to thank our parents for their unwavering support and for preparing us mentally and physically throughout this journey.

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List of Abbreviations and Terminology

APIs	Application programming interface.. xi
APNs	Apple Push Notification service. xi
Baïkal	Baïkal is a lightweight CalDAV+CardDAV server. It offers an extensive web interface with easy management of users, address books and calendars. It is fast and simple to install and only needs a basic php capable server. The data can be stored in a MySQL or a SQLite database. [BaikalServer, 2025]. xi, 27
Bearer Authentication	Bearer authentication (also called token authentication) is an HTTP authentication scheme that involves security tokens called bearer tokens. The name "Bearer authentication" can be understood as "give access to the bearer of this token." The bearer token is a cryptic string, usually generated by the server in response to a login request. The client must send this token in the Authorization header when making requests to protected resources. [BearerAuthentication, 2025]. xi, 24
Bun	Bun is an all-in-one toolkit for JavaScript and TypeScript apps. It ships as a single executable called bun. [Bun, 2025]. xi, 27
CalDAV	Calendaring Extensions to WebDAV. xi
Calendar	A list of events and dates within a year that are important to an organization or to the people involved in a particular activity. [Cambridge, 2024]. xi
Compression	Within Connect RPC, the process of automatically compressing request and response payloads using algorithms like Gzip to reduce network bandwidth. Connect negotiates the use of compression via HTTP headers (e.g., 'Accept-Encoding', 'Content-Encoding').. xi

Connect RPC	A family of libraries for building browser and gRPC-compatible HTTP APIs. Users write a Protocol Buffer schema and implement application logic, and Connect generates code to handle marshaling, routing, compression, and content type negotiation, along with type-safe clients. [ConnectRPC, 2025]. xi, 26, 27
Content Type Negotiation	The mechanism used by Connect RPC to determine the data format (e.g., Protobuf binary, JSON) for API communication based on HTTP headers (‘Content-Type‘, ‘Accept‘). This allows interoperability between different client/server capabilities.. xi
ER diagram	Entity Relationship (ER) Diagram is a type of flowchart that illustrates how entities (people, objects, concepts, or data) relate to each other within a system or database.. xi
Golang	Go is an open source project developed by a team at Google and many contributors from the open source community. [Golang, 2024]. xi
gRPC	A high-performance, open-source universal RPC framework that enables efficient communication between services. [gRPC, 2024]. xi
HTTP/2	The second major version of the HTTP protocol, offering improved performance and features. [HTTP2, 2024]. xi, 27
HTTPS	HyperText Transfer Protocol Secure. xi
iOS	iPhone Operating System. xi
Jadwal	Jadwal is a comprehensive time management tool designed to aggregate and optimize your existing calendars and data sources.. xi
JWT	JSON Web Tokens are an open, industry standard RFC 7519 method for representing claims securely between two parties. [JWT, 2024]. xi
Magic Link	A special type of a Magic Token, that is used for passwordless authentication.. xi
Magic Token	A token to the user to authenticate they own a specific resource, like an email address or temporary access to an endpoint. The user has to send it back to the system to prove they own that resource, since only the owner can receive it.. xi

Marshaling	In the context of Connect RPC, the serialization (encoding) of Protocol Buffer messages into the wire format (like Protobuf binary or JSON) for transmission, and the corresponding deserialization (decoding) upon receipt. Connect performs this automatically based on the negotiated content type.. xi
N/A	Not Applicable. xi
PostgreSQL	A powerful, open-source object-relational database system used for storing application data. [PostgreSQL, 2024]. xi, 27
Protocol Buffers	A language-neutral, platform-neutral extensible mechanism for serializing structured data. [Protobuf, 2024]. xi, 27
RabbitMQ	An open-source message broker that enables asynchronous communication between services. [RabbitMQ, 2024]. xi, 27
Routing	How Connect RPC directs incoming HTTP requests to the appropriate application logic. It maps URL paths derived from the Protocol Buffer service/method definitions (e.g., '/Service/Method') to the corresponding generated handler code, eliminating manual route setup.. xi
Sequence Diagram	An interaction diagram that details how operations are carried out.. xi
SwiftUI	Apple's declarative framework for building user interfaces across all Apple platforms. [SwiftUI, 2024]. xi
UC	Use Case. xi
WebDAV	Web Distributed Authoring and Versioning (WebDAV) consists of a set of methods, headers, and content-types ancillary to HTTP/1.1 for the management of resource properties, creation and management of resource collections, URL namespace manipulation, and resource locking (collision avoidance). [WebDAV, 2007]. xi
WhatsApp	WhatsApp is an alternative to SMS and offers simple, secure, reliable messaging and calling, available on phones all over the world. [WhatsApp, 2024]. xi

WhatsApp Web.js	A WhatsApp client library that enables programmatic interaction with WhatsApp Web. [WhatsAppWebJS, 2024]. xi, 27

1 INTRODUCTION

Time management has become increasingly complex in our interconnected world, where individuals juggle multiple calendars, commitments, and communication channels. This chapter introduces Jadwal, an intelligent iOS-based calendar management system designed to address these modern challenges. We will explore the background, objectives, scope, and significance of this project, highlighting how it aims to revolutionize personal time management through intelligent automation and integration with communication platforms.

1.1 Background of the Project

Calendars have been around a long time now, and they are a handy tool for humans. Both who are busy and who want to plan their days. People throughout history have used paper for calendars, but now with technology, things have changed. Calendars are digital now, and they can even be shared with others!

As the world is becoming one big village with globalization, people tend to squeeze every last minute of their days since competition is higher. Calendars help in that since they allow people to plan their days easily and keep track of when to meet people and do other activities.

People these days use multiple calendars and sometimes forget to insert an event to the correct calendar.

1.2 Problem Statement

Keeping your calendar up to date with event information is challenging, especially with the rise of many informal communication channels like WhatsApp. People nowadays discuss when and where they will meet using those informal communication tools. This leads to calendars being out of sync from real life events you are committed to and might harm relations. The problem lies in the cumbersomeness of adding events to a calendar manually. And when people are busy, they just forget that they didn't add the event to their calendar. Our Jadwal app aims to solve this issue for users in an intelligent way that makes it seamless to manage your time confidently.

1.3 Objectives of the Project

The development of Jadwal is driven by clear, measurable objectives that address the current challenges in calendar management. These objectives focus on creating an intelligent system that seamlessly integrates multiple calendars, automates event extraction, and prioritizes user efficiency while maintaining prayer schedules. Each objective has been carefully defined to ensure the final product delivers meaningful value to users.

The main objectives of Jadwal are:

- To integrate all the calendars into Jadwal's single calendar view to make viewing and managing all the events easy.
- To develop an intelligent calendar management system that automatically extracts events from the informal communication channels like WhatsApp and adds them to the user's main calendar.
- To significantly reduce the time users spend on manual calendar management.
- To create a user friendly interface that allows users to easily add events to the calendar.

- To prioritize and automatically schedule daily routines such as prayer time.
- To implement a smart resolution system that notifies users of scheduling conflicts and provides easy options for resolution.

1.4 Scope of the Project

Jadwal is not just another calendar application; it's a comprehensive time management tool designed to aggregate and optimize your existing calendars and data sources. The scope of the project includes:

- Development of an iOS application as the primary platform.
- Integration with calendars using CalDAV.
- WhatsApp message parsing for event extraction using state-of-the-art LLMs (subject to technical feasibility).
- Target audience: Busy professionals, students, and anyone juggling multiple schedules.
- User testing phase to ensure ease of use and effectiveness. Our testing methods will include:
  - Beta testing with a diverse group of users.
  - Analytics to track user behavior and app performance.

1.5 Significance of the Project

In today's fast-paced environment, effective time management is not just a convenience—it's a necessity. Jadwal addresses critical gaps in existing calendar solutions by introducing innovative features that align with modern users' needs. The project's significance extends beyond simple calendar management, offering transformative benefits for personal productivity, religious observance, and professional organization. By

tackling the challenges of fragmented schedules and missed commitments, Jadwal represents a significant advancement in how people manage their time in the digital age.

Jadwal's significance can be summarized in the following points:

1. **Time is Money**: Since time is the only asset you can't get more of, Jadwal tries to make it less painful and less time consuming to have a good calendar throughout your day by parsing events from your informal communication channels like WhatsApp automatically.
2. **Prayer First Calendar**: Prayer times come first, then your daily scheduled items.
3. **Reduced Human Error**: Automated event extraction and addition to calendars minimize the risk of missing important events or appointments due to manual input errors or forgetfulness.
4. **Conflict Resolution**: The smart resolution system helps users identify and resolve scheduling conflicts efficiently, reducing stress and improving overall time management.
5. **Holistic View of Commitments**: By integrating multiple calendars into a single view, Jadwal provides users with a comprehensive overview of their commitments across various aspects of life, facilitating better decision-making and work-life balance.

1.6 Limitations of the Project

While Jadwal introduces innovative solutions to calendar management, it is essential to acknowledge and understand its current constraints and limitations. These limitations stem from various factors including technological boundaries, privacy concerns, third-party dependencies, and resource constraints. By identifying these limitations early in the development process, we can better manage user expectations and plan future improvements to address these challenges.

Nothing is perfect, and our project is not an outlier. The limitations we have figured out about it are as follows:

- WhatsApp integration allows the app to read the user's messages, so it would be difficult to prove that privacy hasn't been breached.
- WhatsApp integration might not always be there, they are a third-party.
- Learning new technologies for iOS development might require more time than anticipated.
- Accuracy of our algorithms to detect keywords indicating an event agreement has happened, especially for languages other than English.
- Time and manpower constraints may limit the number of features we can implement.
- Dependency on third-party APIs and their limitations.
- We may face a challenges to test the app due to lack of users for testing our app.

1.7 Organization of the Senior Project

To ensure systematic development and timely delivery of Jadwal, we have established a detailed project timeline with clear milestones and deliverables. The Gantt chart, shown in **Figure 1.1**, illustrates our project's phases, tasks, and their respective durations.

1.8 Conclusion

In conclusion, the shift from traditional calendars to digital ones has changed how people organize their schedule. While digital calendars offer easy and conflict free scheduling which makes managing easy. Discussion on informal communication channels like WhatsApp has impacted the planning events and commitments. This impact often leads to missed appointments and scheduling conflicts, especially for someone who is busy.

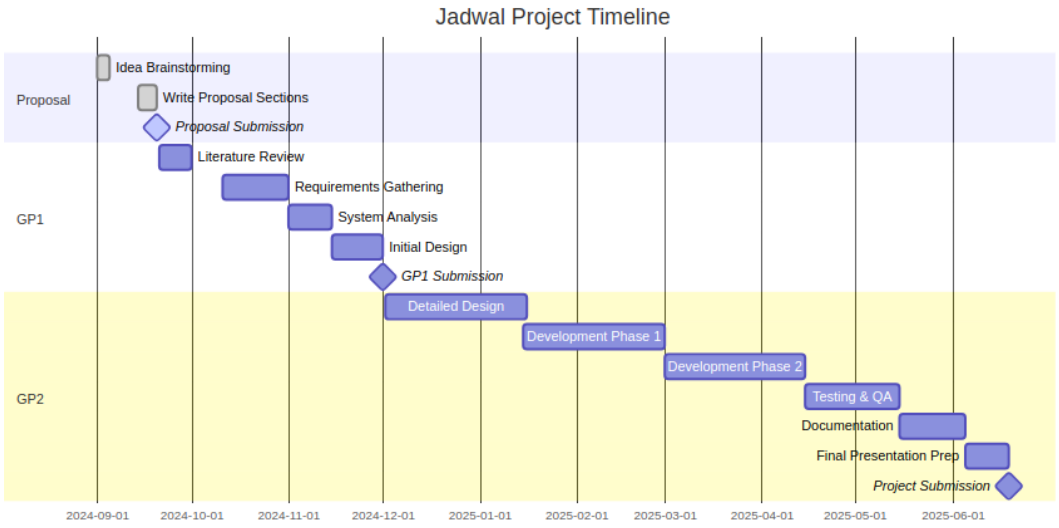

Figure 1.1: Project Gantt Chart

Jadwal aims to solve this issue by providing a seamless and automated solution for integrating informal communication with the application so that no one misses an event or have conflicts.

2 LITERATURE REVIEW

The landscape of calendar management and scheduling applications has evolved significantly with technological advancement and changing user needs. This chapter presents a comprehensive analysis of existing solutions, market research, and technological foundations that inform Jadwal's development. Through examining current tools, academic research, and user behavior patterns, we identify gaps in existing solutions and validate Jadwal's innovative approach to calendar management.

2.1 Introduction

In the modern world, managing time effectively is important for balancing personal and professional responsibilities. The increasing complexity of schedules usually results in missing an important event and overlapping commitments. To solve these challenges, we introduce Jadwal, an innovative iOS-based schedule management application, aims to help individuals and professionals to organize their daily lives.

Jadwal focuses on solving the issue by drawing inspiration from existing solutions like Clockwise, Motion, Reclaim AI, and Calendi, Jadwal stands out by introducing advance features such as conflict resolution, task prioritization, event extraction from informal communicating channels and prioritizing prayer times, which is a unique feature which is not found in any competing applications.

In developing Jadwal, we have drawn inspiration from and built upon existing re-

search and products in the field of intelligent calendar management. Some key references include:

- **Clockwise (https://www.getclockwise.com/):** A smart calendar assistant that optimizes schedules and manages team coordination [Clockwise, 2024]. Clockwise's approach to intelligent time blocking and meeting optimization provides valuable insights for Jadwal's automated scheduling features.
- **Motion (https://www.usemotion.com/):** Motion's Intelligent Calendar takes your meetings, your tasks, your to-do list, your activities, and creates one perfect, optimized schedule to get it all done [Motion, 2024].
- **Reclaim AI (https://reclaim.ai/):** An intelligent time management tool that helps optimize schedules and automate tasks [Reclaim, 2024].
- **Calendi (https://calendi.ai/):** Calendi describes itself as: "Calendi is an AI calendar system. Use it for scheduling tasks, automating meetings, and witness the future of calendar." [Calendi, 2024]
- **An Exploratory Study of Calendar Use:** "Prospective remembering is the use of memory for remembering to do things in the future, as different from retrospective memory functions such as recalling past events." [Tungare et al., 2008]
- **WhatsApp Integration:** Our research indicates that direct WhatsApp integration for event extraction has not been widely implemented in existing calendar applications, making this a unique feature of Jadwal.

Feature	Jadwal	Clockwise	Motion	Reclaim AI	Calendi
Open Source	✅	❌	❌	❌	❌
WhatsApp Integration	✅	❌	❌	❌	❌
CalDAV Support	✅	✅	✅	✅	?
Conflict Resolution	✅	✅	✅	✅	?
Prioritize Prayer Times	✅	❌	❌	❌	❌
iOS Application	✅	✅	✅	✅	?

Figure 2.1: Feature Comparison Table

In Figure 2.1 The table compares *Jadwal*, our project, with four other scheduling applications—Clockwise, Motion, Reclaim AI, and Calendi—based based on several key features:

- **Open Source**: *Jadwal* stands out as the only application that is open-source, allowing users and developers to access, modify, and improve the code. The other applications do not provide this.
- **WhatsApp Integration**: *Jadwal* stands out again as the only application that connects and extract the event discussed over the platform by the user.
- **CalDAV Support**: *Jadwal*, Clockwise, and Reclaim AI offer CalDAV support, which allows users to integrate calendars from different sources, while Motion and Calendi either does not support this.
- **Conflict Resolution**: All listed applications, including *Jadwal*, supports conflict resolution, allowing users to manage overlapping events efficiently.
- **Prioritize Prayer Times**: *Jadwal* is the only one offering this feature where the user be able to have prayer time scheduled
- **iOS Application**: *Jadwal* is available on iOS, along with Clockwise, Reclaim AI, and Motion. The availability of Calendi on iOS is uncertain.

2.2 Comparing Competitors

To thoroughly understand Jadwal's position in the market and its unique value proposition, a detailed analysis of existing calendar management solutions is essential. This section examines four major competitors—Clockwise, Motion, Reclaim AI, and Calendi—evaluating their features, strengths, and limitations to highlight how Jadwal addresses gaps in current offerings.

2.2.1 Clockwise

Clockwise's website tries to touch the user's misery by saying "Your calendar doesn't have to suck" as shown in Figure 2.2.

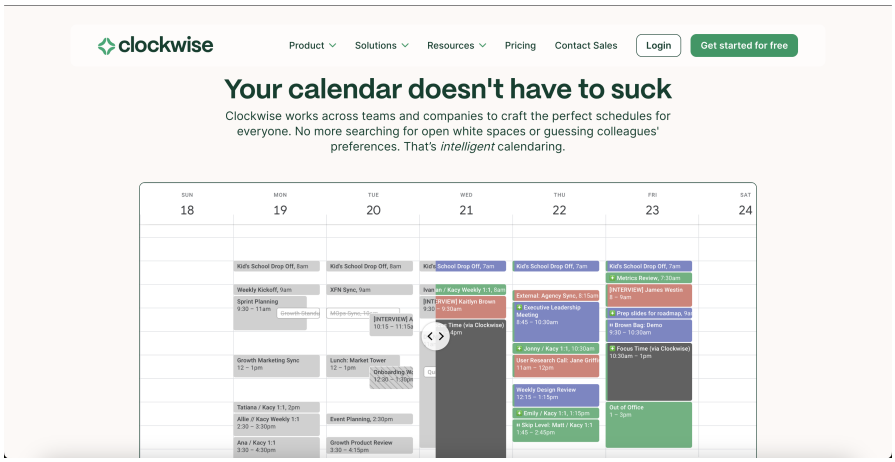

Figure 2.2: Clockwise Landing Page

Based on Figure 2.3, Clockwise has the following features:

- Connect your calendar and set your preferences
- Decide which meetings are flexible
- Let Clockwise optimize your day

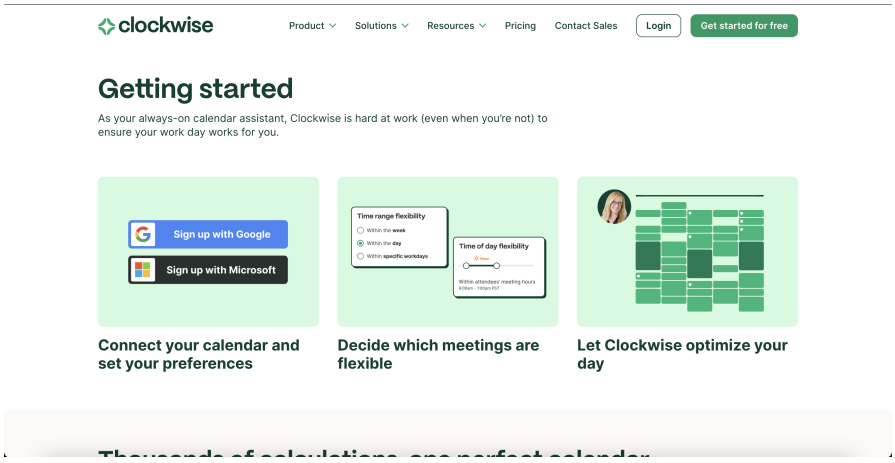

Figure 2.3: Clockwise Features Page

2.2.2 Motion

Motion's website boasts about AI features in their landing page, as shown in Figure 2.4.

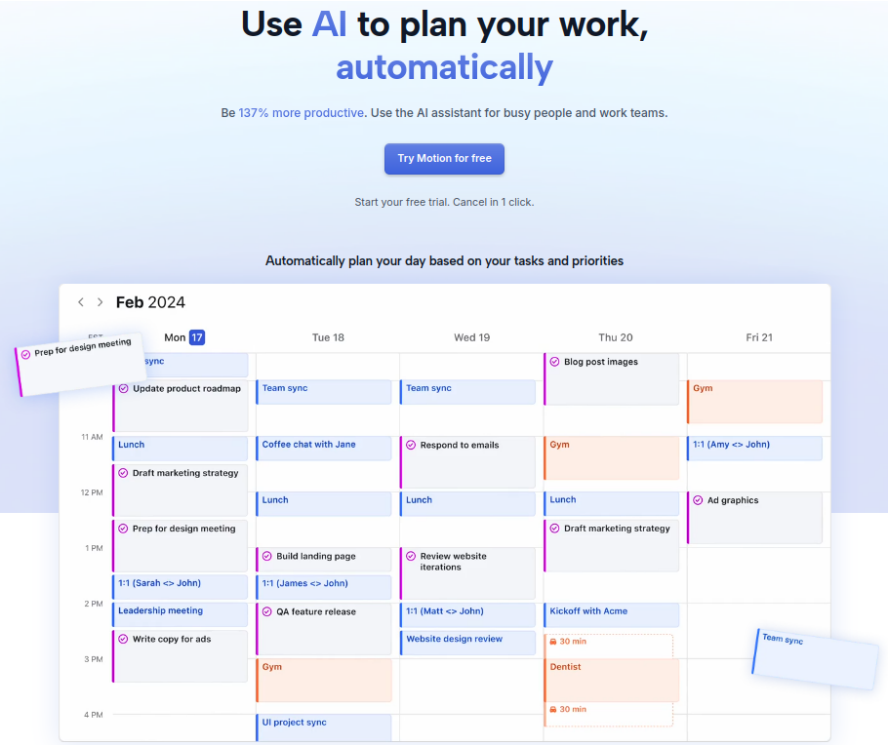

Figure 2.4: Motion's Landing Page

Its features include a dynamic calendar that automatically prioritizes tasks, suggests optimized schedules, and helps users adapt to changes seamlessly.

The tool also provides team collaboration features, allowing shared schedules and streamlined task management to enhance team productivity. These features ensure that users can achieve maximum efficiency with minimal effort.

Motion allows you to combine your calendars in one view also, shown in Figure 2.5.

Motion also has a time blocking feature which they boast about in the website. It is shown in Figure 2.6.

Jadwal platform, such as linking the calendar to WhatsApp for automatic event addition and integrating prayer times, which adds a unique level of customization and day organization.

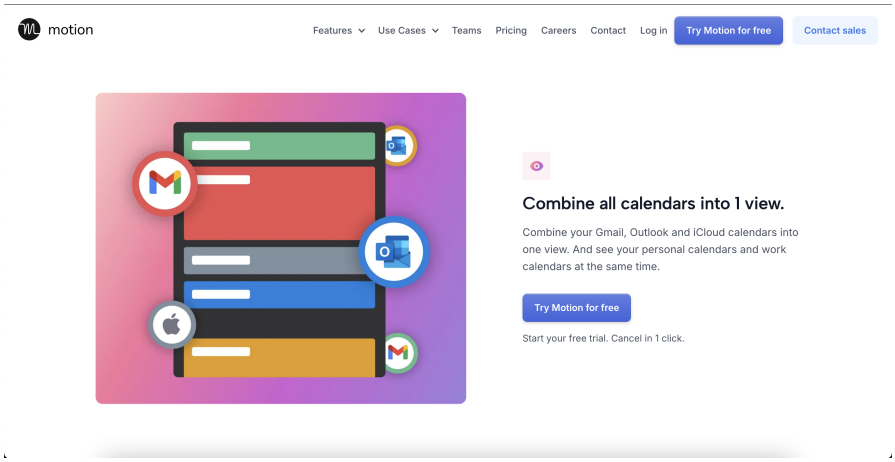

Figure 2.5: Motion's Combined Calendar Feature

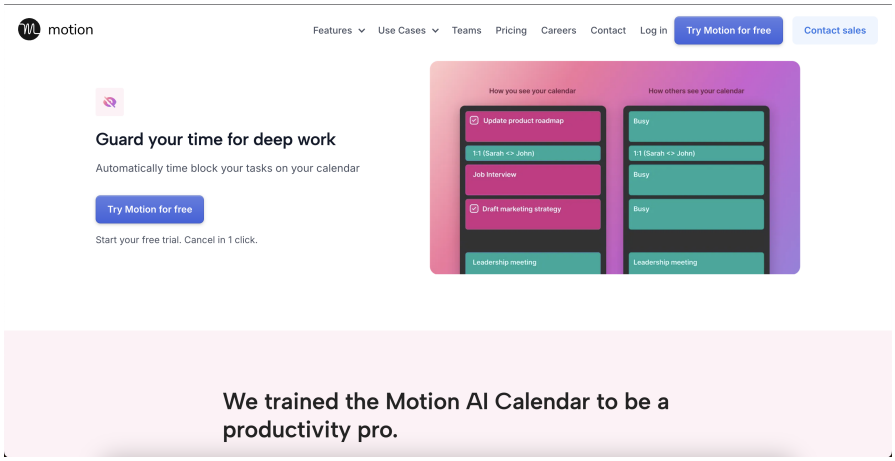

Figure 2.6: Motion's Time Blocking Feature

2.2.3 Reclaim AI

Reclaim.ai offers the following features: It is an AI-powered platform designed to manage tasks, habits, meetings, and personal events seamlessly. Figure 2.7 shows the the landing page of Reclaim and their focus on AI as you can see.

Reclaim.ai provides features such as smart time blocking, which automatically schedules tasks based on their priority and deadlines, integrates with tools like Google Calendar, Slack, and project management platforms (e.g., Asana, Jira, and Todoist), and supports habit tracking with auto-rescheduling to adapt to life changes. Figure 2.8 shows the integrations that this platform supports.

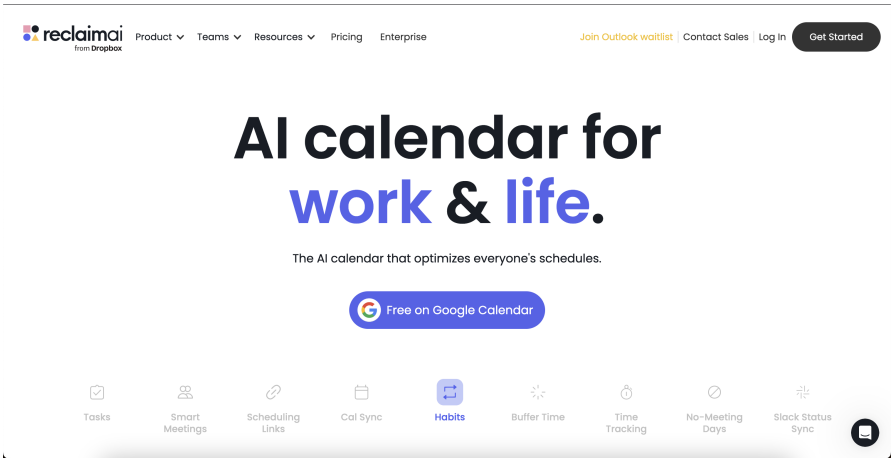

Figure 2.7: Reclaim Landing

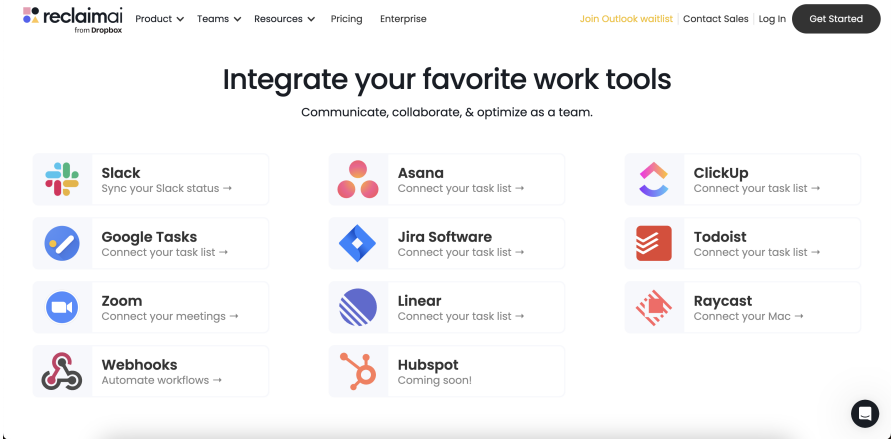

Figure 2.8: Reclaim Integrations

While these features enhance productivity and optimize time management, Reclaim.ai does not include features like WhatsApp integration for automatically adding events or prayer time scheduling, both of which are unique to the Jadwal platform. These features provide users with cultural and practical benefits that further enhance their daily organization.

2.2.4 Calendi

Calendi.ai claims to offer features focused on speeding up scheduling with AI-powered assistance.

It claims to allow users to add tasks via text or voice input and automates meetings

scheduling, including sending links and calendar invites. Those claims are shown in Figure 2.9.

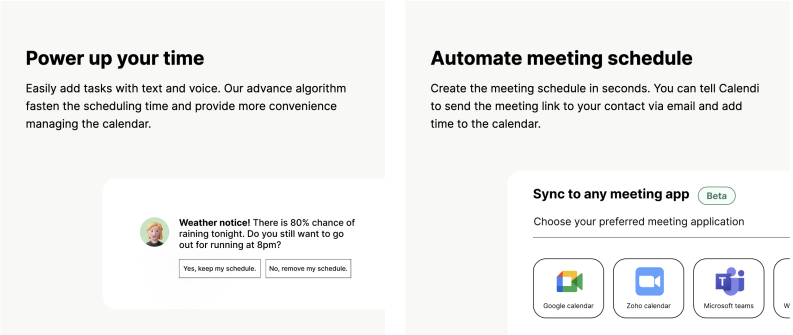

Figure 2.9: Calendi Features of Voice Input and Automatic Meeting

Calendi claims to integrate with platforms like Google Calendar, Apple Calendar, and Outlook, making it compatible across multiple systems. This is shown in Figure 2.10, as they say "We replace them all, help you save 'clock emoji' 'money emoji' and schedule better."

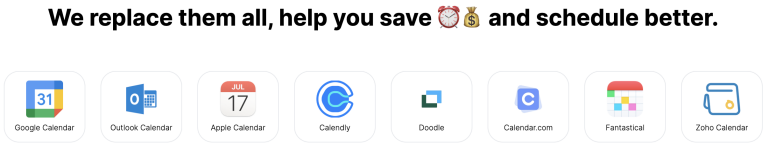

Figure 2.10: Calendi Claims to Replace Them All

It claims to provide intelligent assistance by analyzing habits and tasks, suggesting improvements, and incorporating external factors like weather or transit schedules. Those are shown in Figure 2.11.

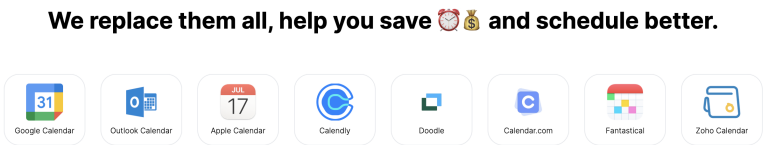

Figure 2.11: Calendi Claims to Replace Them All

However, it does not offer unique features like WhatsApp integration or prayer time

scheduling, which are distinct to Jadwal.

Also the website as of writing this part, on 26 Nov 2024, is broken and not working. This can be illustrated via the broken timer shown in Figure 2.12 and many other things that are broken.

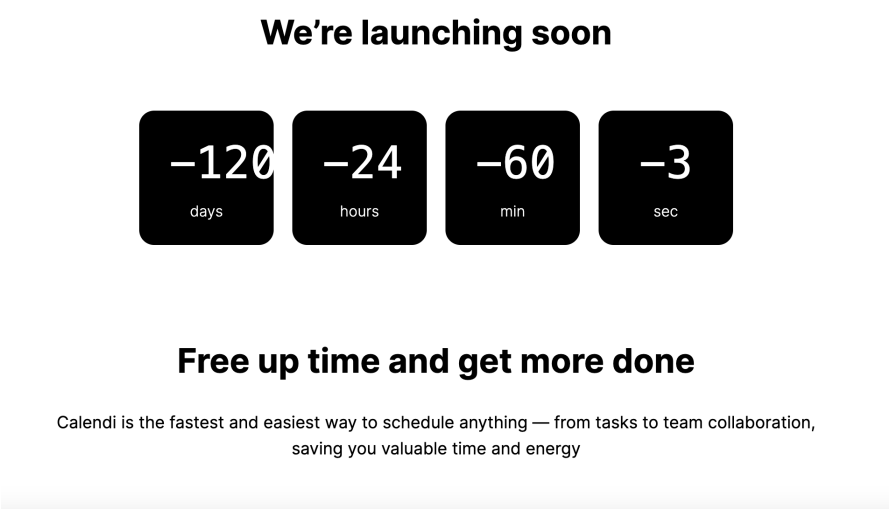

Figure 2.12: Calendi Broken Timer

2.3 Survey Results

We have conducted a survey using Google Forms, and have sent it out to our peers in the university, and also shared it on our social media, especially LinkedIn, to get more diverse responses. That is since our main audiences are students, employees, and who do both at the same time. The results were fascinating. Especially since 75 responses were recorded with their email to authenticate the responses.

As shown in Figure 2.13, the results showed that 8% only were both employed and students, while 53% were students only and 39% were employed only. We believe this is a good mix between the two audience we are aiming to get responses from.

Based on Figure 2.14, it is important to note that 72% of our respondents were of the age range 20-30 years.

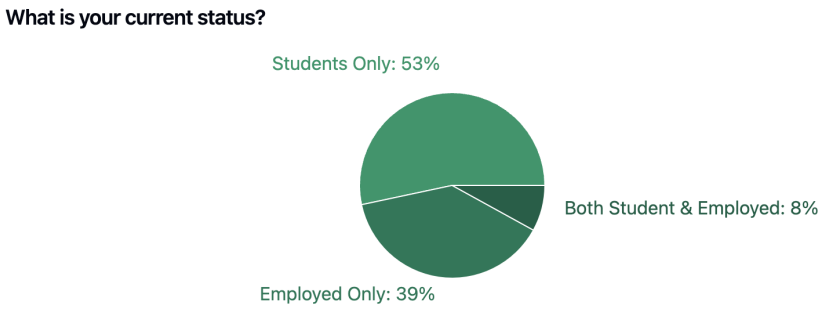

Figure 2.13: Survey Respondents Status

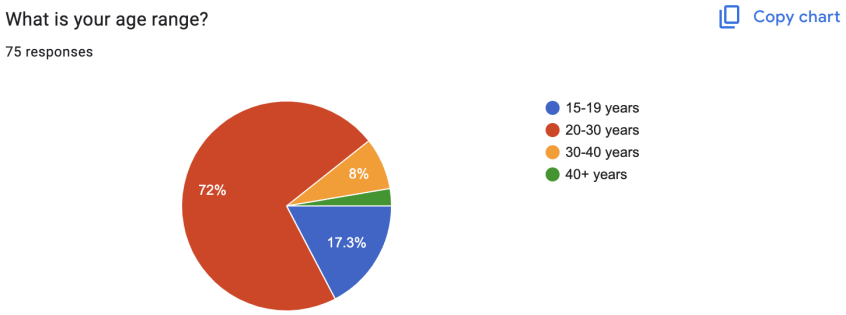

Figure 2.14: Age Range

As shown in Figure 2.15, 66.7% of people reported that they a calendar application to manage their daily schedule. This shows that people might be interested in a better way of managing their schedules that could elevate their time management skills.

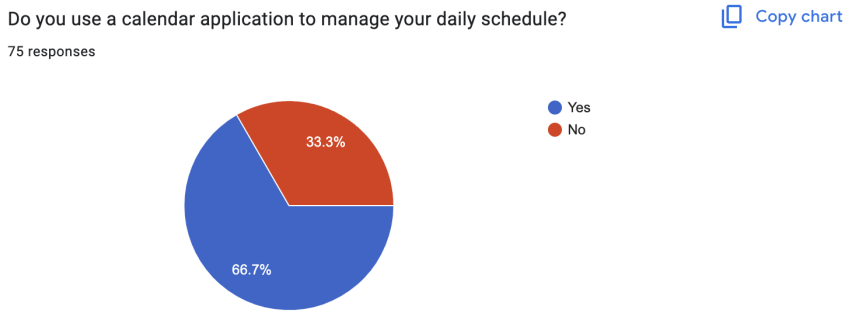

Figure 2.15: Percentage of People Who Use Calendars to Ones Who Don't

In Figure 2.16, the results showed us the need for our app to exist, since 70.7% of the population use WhatsApp to discuss upcoming events! Another big percentage, 53.3% used Email also. Our app won't be focusing on this, nevertheless, this is also an opportunity in the future to help those people who use Emails and might not find the

flow easy to schedule the events in the calendar.

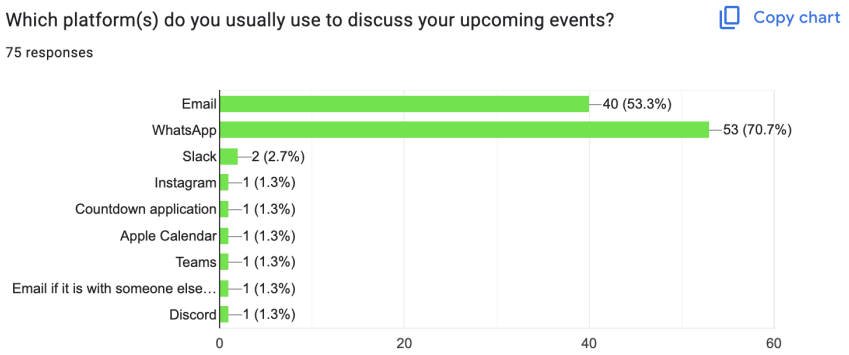

Figure 2.16: Platform Used to Discuss

Although 21.3% might not seem like a lot, but as shown in Figure 2.17, 58.7% of the population reported they would find it extremely useful to have a WhatsApp integration that automatically adds events from your conversations to the calendar?

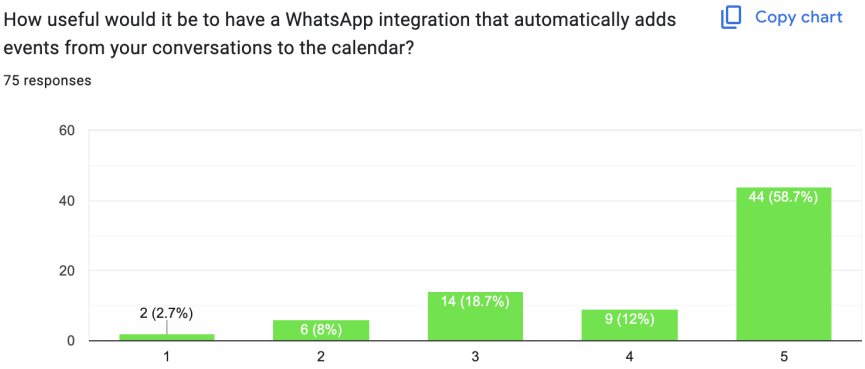

Figure 2.17: Usefulness of Having a WhatsApp Integration

As shown in Figure 2.18, on average, 21.3% forget to add events to their calendar. That is great news, since our differentiating factor is the direct WhatsApp integration that should be able to solve this.

As shown in Figure 2.19, 41.3% use 2 calendars, that shows the need for a integrated view of calendars.

As shown in Figure 2.20, 53.3% of people have 1-3 calendar events per week. That might seem a little, but 33.3% have 4-6 calendar events per week.

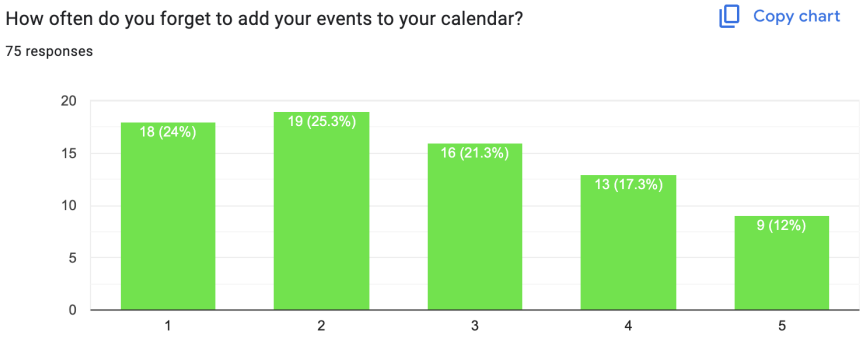

Figure 2.18: Chart of Forgetting to Add Likeliness

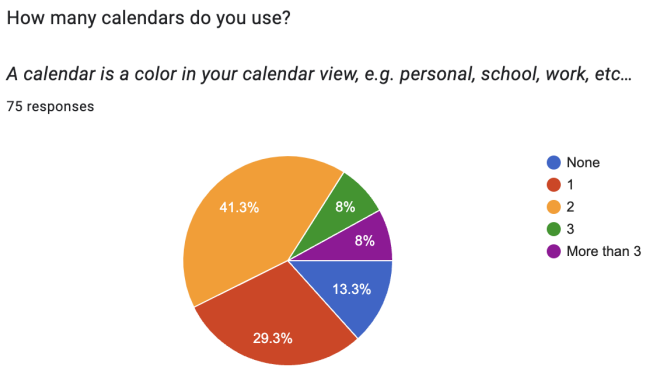

Figure 2.19: Number of Calendars

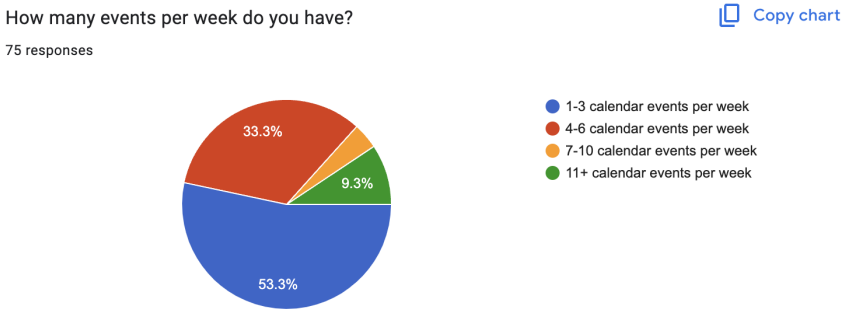

Figure 2.20: Events per Week

2.4 Conclusion

Through this literature review, we have identified several key gaps in existing calendar management solutions. While platforms like Clockwise, Motion, Reclaim AI, and Calendi have made significant strides in intelligent scheduling and calendar integration, none provide a comprehensive solution that addresses the full spectrum of modern

scheduling challenges. The review reveals three primary opportunities for innovation:

First, while existing solutions focus on traditional calendar management, there remains an untapped potential in integrating informal communication channels. Jadwal's WhatsApp integration addresses this gap, offering automated event extraction from everyday conversations—a feature notably absent in current market offerings.

Second, our analysis shows that while many applications offer conflict resolution features, none combine this with prayer time prioritization, creating a unique opportunity to serve users who prioritize religious obligations alongside professional commitments.

Finally, the review demonstrates that current solutions often operate in isolation, whereas Jadwal's approach of unifying multiple calendars while maintaining intelligent event extraction and conflict resolution presents a more holistic solution to modern scheduling challenges.

These findings validate Jadwal's approach and highlight its potential to address significant unmet needs in the calendar management space, particularly in combining automation, religious considerations, and comprehensive calendar integration.

3 SYSTEM ANALYSIS AND DESIGN

The development of a complex calendar management system like Jadwal requires careful analysis of requirements and thoughtful system design to ensure robust functionality and seamless user experience. This chapter presents a detailed examination of Jadwal's architecture, from its core requirements to the intricate relationships between system components. Through use case diagrams, activity diagrams, class diagrams, and database design (both ER and Relational), we provide a comprehensive blueprint of how Jadwal transforms its innovative concepts into a practical, functioning system.

3.1 Introduction

A well-designed system requires a good understanding of both functional and non-functional requirements to meet user expectations and deliver a seamless experience.

This section shows the functional and non-functional requirements which is the backbone of Jadwal's development. The functional requirements focus on core features, such as user authentication, calendar integration and event management. Ensuring the users can effectively manage their schedules. The non-functional requirements focuses on performance, security, compatibility, and user experience, ensuring the application stands well with the industry standards by providing efficient interface.

Combining all these requirements helps in the design and implementation of Jadwal which will lead to a better application solving real issues and meeting the needs of the

user.

3.2 Functional Requirements

The following requirements outline the core features and capabilities that Jadwal must provide to fulfill its purpose as an intelligent calendar management system:

- The user shall be able to access their account using either Google OAuth or magic link via Email. For new users, a new account is created, and for existing users, they are given access to their account directly.
- The system shall send a welcome email to new users.
- The user should be able to create a calendar.
- The user should be able to connect a calendar using CalDAV.
- The user should be able to connect their WhatsApp account.
- The user should be able to add events manually.
- The user should be able to view integrated calendar.
- The user should be able to schedule prayer times.
- The system shall send event notifications to the user.
- The system shall add the WhatsApp extracted events to the calendar. If a conflict occurs, the user shall get a notification to resolve the conflict with suggestions.
- The user should be able to manage scheduling conflicts.

Each functional requirement listed above will be explained in details through a use case description in the coming sections.

3.3 Non-Functional Requirements

While functional requirements define what the system does, non-functional requirements specify how the system performs its functions. These requirements focus on the quality attributes, performance standards, and technical constraints that ensure Jadwal delivers a reliable, secure, and user-friendly experience.

- **Platform Compatibility:** The app shall be compatible with iOS devices running iOS 16.0 or later.
- **Performance:** The app shall load the main calendar view within 3 seconds on 5G with speeds above 200mpbs.
- **User Experience:** The user interface shall follow iOS Human Interface Guidelines for consistency and ease of use.
- **Security:** All data transmissions between the app and servers shall be encrypted using HTTPS.

3.4 Security Architecture

In today's digital world, security is a key concern for any application that handles user data. Jadwal places a strong emphasis on ensuring the security and trustworthiness of the platform for its users, implementing multiple layers of security measures to protect user data.

3.4.1 Authentication: Magic Token and JWT Tokens

To provide secure authentication, Jadwal implements Magic Token authentication. Instead of relying on traditional username and password combinations, which is vulnerable to various attacks, such as credentials leakage through database dumps. To mitigate

this, Jadwal sends the users trying to authenticate a secure magic link to their verified email address. A magic link is a special URL that contains a secure token, the magic token. For example:

```
https://jadwal.app/magic-link?token=some-uuid
```

In this URL, `some-uuid` is the secure token, which we call magic token, and the complete URL is what we call the magic link. When sent to the user's email, clicking this link proves they have access to the email account they're trying to use.

When a user logs in using the magic link sent to their email, Jadwal secures the user's account by verifying the magic token provided. This ensures that the account can only be accessed by the legitimate user who has access to the registered email account. To enhance security, the magic token has a limited lifetime of 15 minutes, significantly reducing the window of opportunity for potential attacks.

Upon successful magic token verification, Jadwal issues two JWTs (JSON Web Token) signed with the platform's private key. This digital signature serves as a cryptographic guarantee of the token's authenticity, allowing the system to verify that tokens haven't been tampered with and were legitimately issued by Jadwal's own system.

The first JWT is called the *access token*, and it is a short-lived token that expires after 5 minutes. This token is back by the client in the *Authorization* HTTP header as a *Bearer Authentication* token, also known as *token authentication*, to authenticate themselves when calling protected resources.

The second JWT is called the *refresh token*, and it is transmitted securely encrpyted in-transit to the device. This is a long-lived token that allows the user to ask for a new token every time the access token expires.

3.4.2 Magic Token Storage and Security

To ensure the security of magic tokens, Jadwal implements secure storage practices for storing the magic token in the database. Magic tokens are never stored in their original form; instead, they are protected using the SHA-256 hashing algorithm before being saved in the database. When verifying magic tokens, the system hashes the user-provided magic token and compares it with the stored hash, ensuring that even in the unlikely event of a database breach, the original magic tokens remain secure.

3.4.3 Secure Logout Implementation

Jadwal implements a secure logout mechanism by removing the refresh token from the user's device upon logout. This practice ensures that once a user logs out, their refresh token cannot be reused for unauthorized access, maintaining the integrity of user sessions.

3.4.4 Transparency Through Open Source

As part of our commitment to security and privacy, Jadwal will be released as open-source software. This transparency allows security experts and users to verify our security implementations and privacy practices. Users can inspect exactly how their data is handled and verify that our privacy commitments are upheld through code review.

3.5 System Architecture

Jadwal's system architecture separates functionality into multiple modular services. These include the backend API server, the WhatsApp integration service, a calendar synchronization server, and a centralized relational database. Communication between

the iOS frontend and the backend API is handled using ConnectRPC over HTTP/2, ensuring efficient, structured data exchange.

The system design emphasizes modularity, scalability, and maintainability, with clear separation of concerns across components. While initial deployment targets a single environment, the system is designed to allow future horizontal scaling across multiple instances.

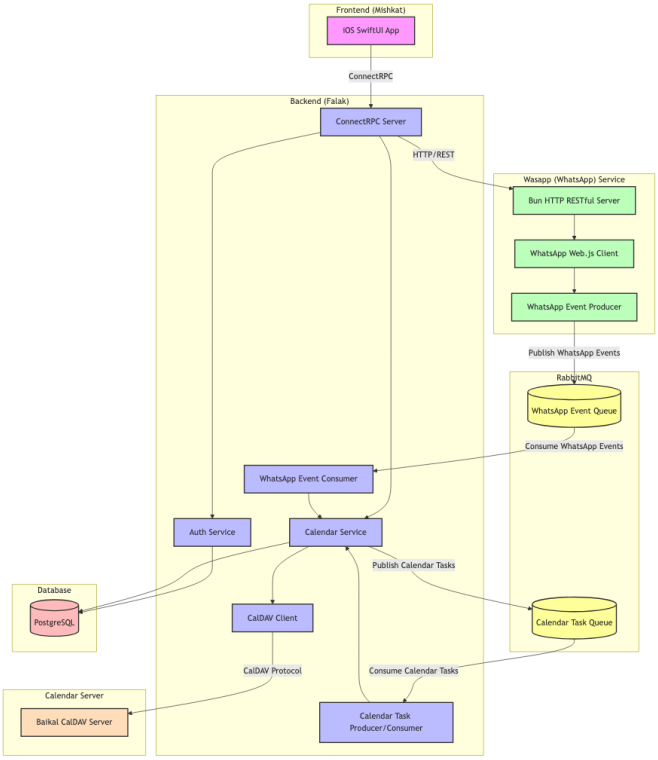

Figure 3.1: Jadwal System Architecture

The architecture, shown in **Figure 3.1**, consists of the following main components:

1. **Frontend (Mishkat)**
    - iOS SwiftUI application implementing the client-side Connect RPC communication
    - Handles user interface and local state management
2. **Backend (Falak)**
    - Connect RPC server implementing the primary business logic
    - Auth service managing user authentication

- Calendar service making use of a CalDAV client enabling connection to our Baïkal server to add events to the WhatsApp calendar
- Event consumer processing WhatsApp events from the messages queue
- Event producer and consumer for extracted calendar events to process

3. **Wasapp (WhatsApp) Service**
    - Bun HTTP RESTful API that allows *falak* to communicate with this
    - WhatsApp Web.js client for message receiving
    - Event producer publishing detected events to the message queue
4. **RabbitMQ Queue**
    - RabbitMQ handling asynchronous event processing
    - Ensures reliable delivery of WhatsApp events to the backend
    - Ensures reliable handling of adding calendar events and sending user notifications
5. **Database**
    - PostgreSQL storing customer data, calendar credentials, device IDs, magic tokens, Wasapp chats, and Wasapp messages
    - Maintains data consistency across all services

This architecture enables several key benefits:

- **Performance**: Connect RPC's use of Protocol Buffers and HTTP/2 ensures efficient communication between services
- **Scalability**: Separate services can be scaled independently based on load
- **Reliability**: Message queue ensures no events are lost during processing
- **Maintainability**: Clear separation of concerns makes the system easier to maintain and update

3.6 System Use Cases

The functionality of Jadwal can be best understood through its various use cases, which demonstrate how users interact with the system. Each use case details specific interactions and flows that make up the core functionality of Jadwal. The diagram in Figure 3.2 provides an overview of all use cases and their relationships.

Figure 3.2 shows the complete use case diagram for Jadwal's system, illustrating the relationships between these fourteen distinct use cases and their actors.

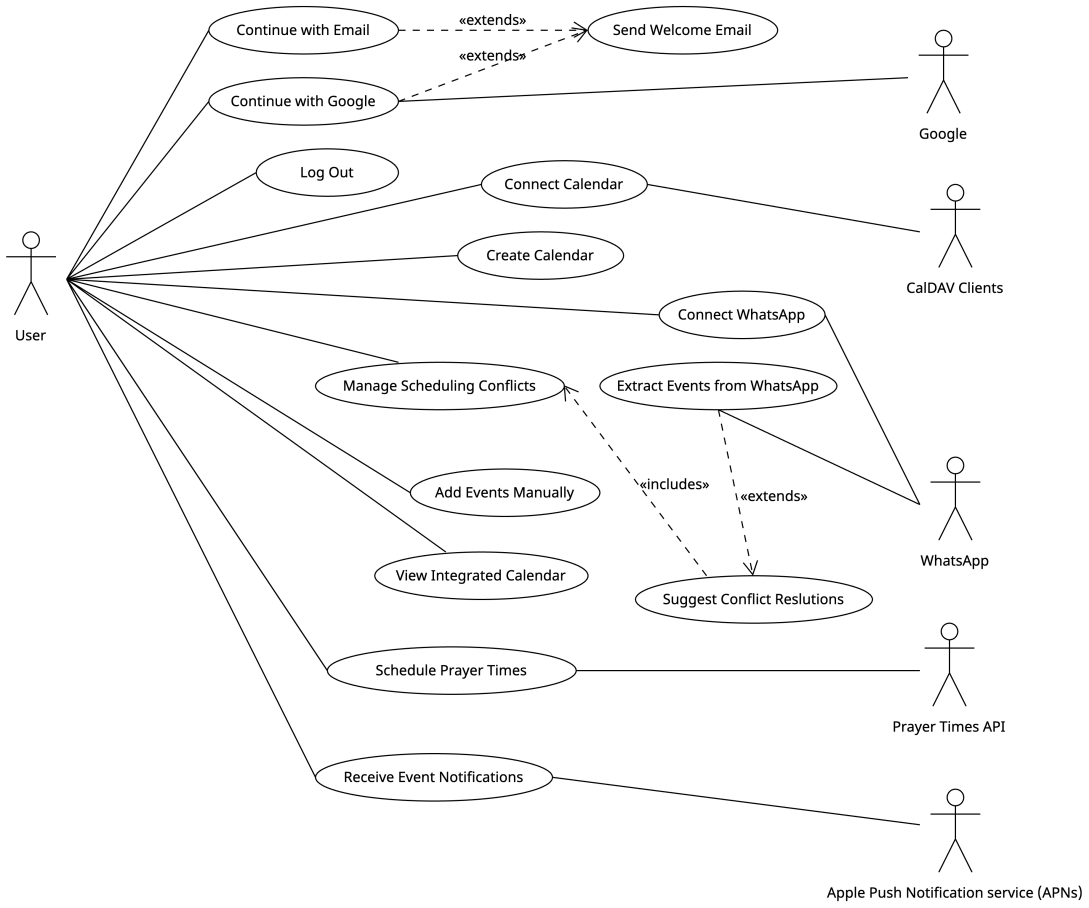

Figure 3.2: Use Case Diagram of Jadwal

3.6.1 Authentication and User Management

User authentication is the first interaction point with Jadwal. We support both email-based authentication through magic links and Google OAuth to provide secure and convenient access options. The following use cases detail the login flows and account management features.

Use Case 1: Continue with Email

Basic Information

ID Number: 1 **Priority:** High **Type:** Regular

Short Description

This UC allows users to login or create an account using their email.

Trigger

This UC starts when the user enters their email to the system.

Actors

Primary: User **Secondary:** None

Preconditions

User must have an email

Relationships

Extends: Send Welcome Email **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Email** (Source: User)
- **Magic link (from email)** (Source: User)

Major Outputs

- **Magic link email** (Destination: User)
- **Confirmation messages** (Destination: User Interface)
- **JWTs** (Destination: App)

Main Flow

1. The user enters their email.

   Information: System displays an email input field.

2. System creates an account if the user has no account, and then generates and sends the magic link.

   Information: App displays “Check your email” message.

3. The user clicks the magic link in the email.

   Information: The app is opened on the device of the user.

4. The app sends the token to the system to log the user in.

   Information: System verifies token and logs user in.

Alternate Flows

- The user cancels the authentication request.

Exceptions

- Invalid email format.
- Magic link token expired or invalid.
- **Request sending failure**: If sending the request fails due to network issues, the system prompts the user to try again.

Conclusion

This UC ends when the user is logged in.

Post-conditions

The system generates two JWTs.

Special Requirements

An email server must be present to send magic link email.

Table 3.1: Continue with Email

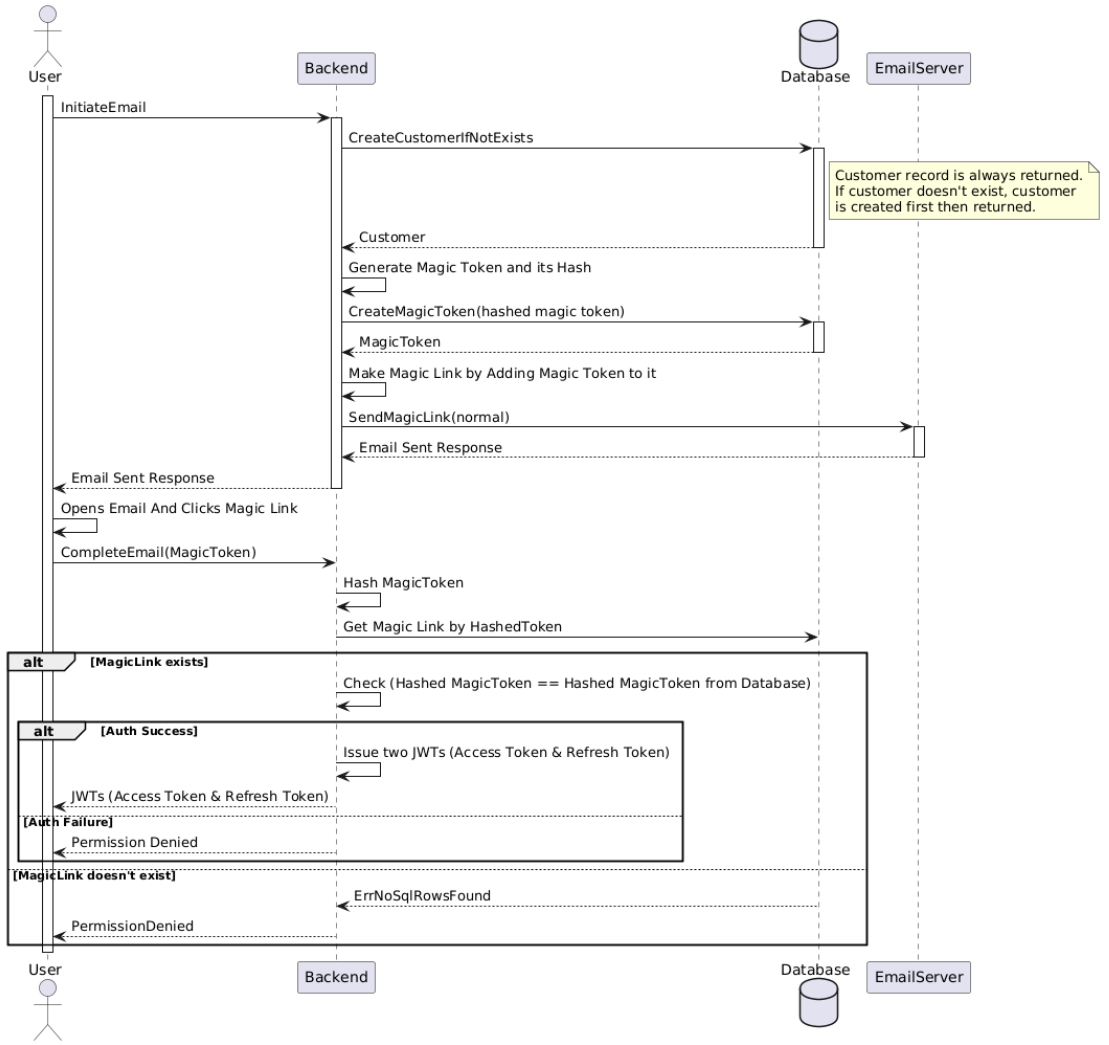

Figure 3.3: Continue with Email Sequence Diagram

The “Continue with Email Sequence Diagram”, shown in **Figure 3.3**, illustrates the process of email-based magic link authentication, involving interactions between the User, Backend, Database, and EmailServer. The process begins when the user initiates email authentication process. The backend executes the CreateCustomerIfNotExists function to retrieve an existing customer record or create a new one if none exists. Once the customer is identified, the backend generates a magic token and its hashed version using the GenerateMagicToken function. The hashed token is stored in the database, and a magic link containing the token is created. The backend then sends the magic link to the user’s email using the SendEmail function via the email server. The user clicks the magic link, triggering the CompleteFlow(MagicToken) request to the backend, where the provided token is validated against the stored hashed token in the database. If the

tokens match, authentication succeeds, and the backend issues two JSON Web Tokens (JWTs) to the user for future access. In cases where the token is invalid, expired, or the customer record is missing, the system responds with appropriate errors, such as PermissionDenied or EntryNotFound. This diagram demonstrates a secure flow for handling authentication via email magic links.

Use Case 2: Continue with Google

Basic Information

ID Number: 2 **Priority:** High **Type:** Regular

Short Description

This UC allows users to login or sign up with their Google account.

Trigger

This UC starts when the user clicks “Continue with Google” button in the app.

Actors

Primary: User **Secondary:** Google

Preconditions

The user must have an active Google account.

Relationships

Extends: Send Welcome Email **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Google access token** (Source: User)

Major Outputs

- **Authentication response** (Destination: User)
- **JWT** (Destination: App)

Main Flow

1. The user click continue with Google.

   Information: App uses OAuth to authenticate with Google

2. App sends Google access token to the system.

   Information: System verifies the token is issued for us and then issues JWT for usage within the app.

Alternate Flows

- The user cancels the authentication request.

Exceptions

- Google access token invalid or expired.
- **Request sending failure**: If sending the request fails due to network issues, the system prompts the user to try again.

Conclusion

This UC ends when the user is logged in.

Post-conditions

The system generates a JWT.

Special Requirements

A google client must be present for the validation of the access token to be possible.

Table 3.2: Continue with Google

The "Continue with Google Sequence Diagram", shown in **Figure 3.4**, illustrates how users can authenticate with Jadwal using their Google account. The user first obtains an access token from GoogleAuth through our application and shares it with the backend. The backend validates the token and retrieves user details through GoogleAuth. If the token is valid, the backend ensures the user exists in the database, creating a record

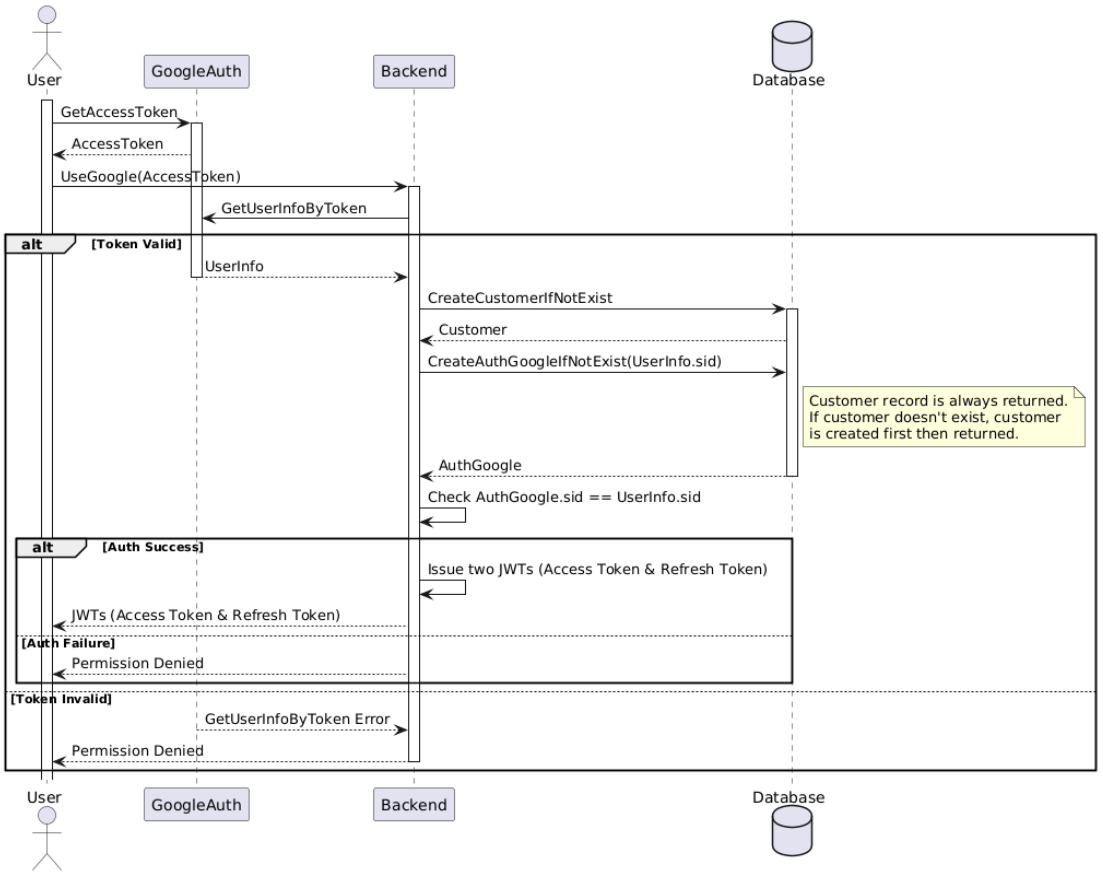

Figure 3.4: Continue with Google Sequence Diagram

if necessary, and associates the user's Google account with it. It then verifies the "sid", issuing a JSON Web Token (JWT) for successful authentication or returning an error, such as Permission Denied, for invalid credentials. This process ensures secure and efficient authentication.

Use Case 3: Send Welcome Email

Basic Information

ID Number: 3 **Priority:** Low **Type:** Regular

Short Description

This UC welcomes the user to the platform.

Trigger

This UC starts when the user account is created.

Actors

Primary: User **Secondary:** None

Preconditions

User account must be created in the system.

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **User name** (Source: System)
- **Welcome email template** (Source: System)

Major Outputs

- **Welcome email** (Destination: User)

Main Flow

1. The system fetches the user information.

   Information: The database is used.

2. The system fetches the send welcome email template.

   Information: The template is filled with the user name.

3. The system sends the email with the template.

   Information: The email is received by the user welcoming them.

Exceptions

- Email server is down.

Conclusion
This UC ends when the user receives an email from us welcoming them.

Special Requirements
An email server must be present to send welcome email.

Table 3.3: Send Welcome Email

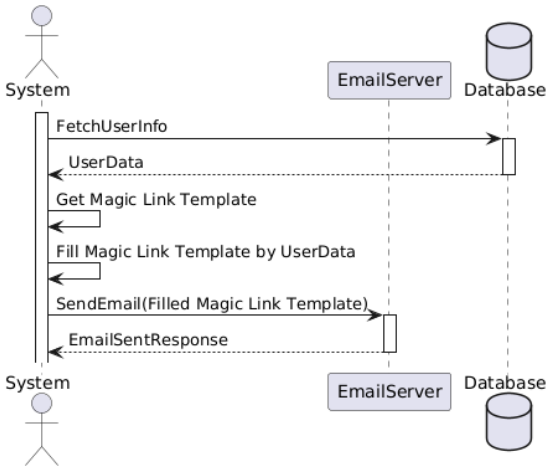

Figure 3.5: Send Welcome Email Sequence Diagram

The “Send a Welcome Email Sequence Diagram”, shown in **Figure 3.5**, shows the process of sending a welcome email to new customers. It begins with the system retrieving user data from the database using the FetchUserInfo function. Once the user data is fetched, the system requests a magic link email template via Get Magic Link Template. The template is then customized with the retrieved user data using Fill Magic Link Template by UserData. The system sends the filled email template to the email server via SendEmail, which delivers the email. Finally, the email server responds with EmailSentResponse, confirming the email’s successful dispatch. This sequence ensures personalized and reliable email delivery.

Use Case 4: Logout

Basic Information

ID Number: 4 **Priority:** High **Type:** Regular

Short Description

This UC allows the user to logout from the app.

Trigger

This UC is triggered when logout button in the settings page is clicked.

Actors

Primary: User **Secondary:** None

Preconditions

The user must be logged in.

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Main Flow

1. The user click the logout button

   Information: The app deletes the JWT and moves the user to the onboarding screen.

Conclusion

The user is logged out.

Post-conditions

The user will be logged out from the system

Table 3.4: Logout

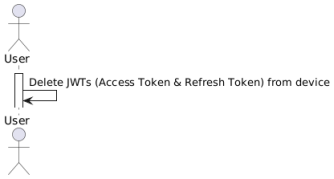

Figure 3.6: Logout Sequence Diagram

The "Logout Sequence Diagram", shown in **Figure 3.6**, demonstrates the secure logout process in Jadwal. Unlike other operations that require server interaction, the logout process is handled entirely on the client side for efficiency and immediate security effect. When the user initiates logout, the application immediately removes the JWT (JSON Web Token) from the device's secure storage.

This local-only operation ensures immediate session termination, as any subsequent requests would fail without the authentication token. This approach provides several benefits:

- Instant logout response, regardless of network conditions
- Guaranteed security even if network connectivity is lost
- Clean session termination without server-side state management

After token removal, the user is automatically redirected to the onboarding screen, effectively preventing any further access to authenticated features until a new login is performed.

3.6.2 Calendar Management

At its core, Jadwal helps users manage their calendars effectively. These use cases show how users can create new calendars, connect existing ones through CalDAV, and view all their calendars in one integrated interface.

Use Case 5: Connect Calendar

Basic Information

ID Number: 5 **Priority:** Medium **Type:** Regular

Short Description

This UC allows the user to add Jadwal's Baikal calendar credentials using a .mobileconfig profile to their iOS device calendar accounts.

Trigger

This UC is triggered when the user wants clicks "Easy Setup" in the mobile app.

Actors

Primary: User **Secondary:** iOS Settings

Preconditions

User must be logged in

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Magic Token with type CalDav** (Source: System)
- **.mobileconfig profile** (Source: System)

Major Outputs

- **Calendar configuration status** (Destination: iOS Settings)

Main Flow

1. The user taps ”Easy Setup” in the app.

   Information: The app calls the backend to get a Magic Token of type CalDAV.

2. The app prompts the user to download the file from the backend endpoint.

   Information: The Magic Token is used to authenticate the user and get his credentials and give him his unique file to download.

3. The user approves the profile installation.

   Information: iOS configures the CalDAV account with our Baikal server automatically.

4. The app shows the user a success page when he goes back to it.

   Information: Success is shown only after confirming the calendar configuration is complete.

Alternate Flows

1. If the user denies profile installation:
   - The app shows an error page with ”Setup cancelled - Try again later”
   - The user can retry the setup process later
2. If the calendar configuration fails:
   - The app shows an error page with ”Calendar setup failed”
   - The user may need to contact support or retry the process

Conclusion

The UC ends when either the calendar is successfully configured or an error page is shown to the user.

Post-conditions

Either the user’s iOS device is configured to sync with our Baikal calendar server, or the user is informed of the failure with appropriate guidance.

Special Requirements
The system must generate secure, user-specific .mobileconfig profiles.

Table 3.5: Connect Calendar

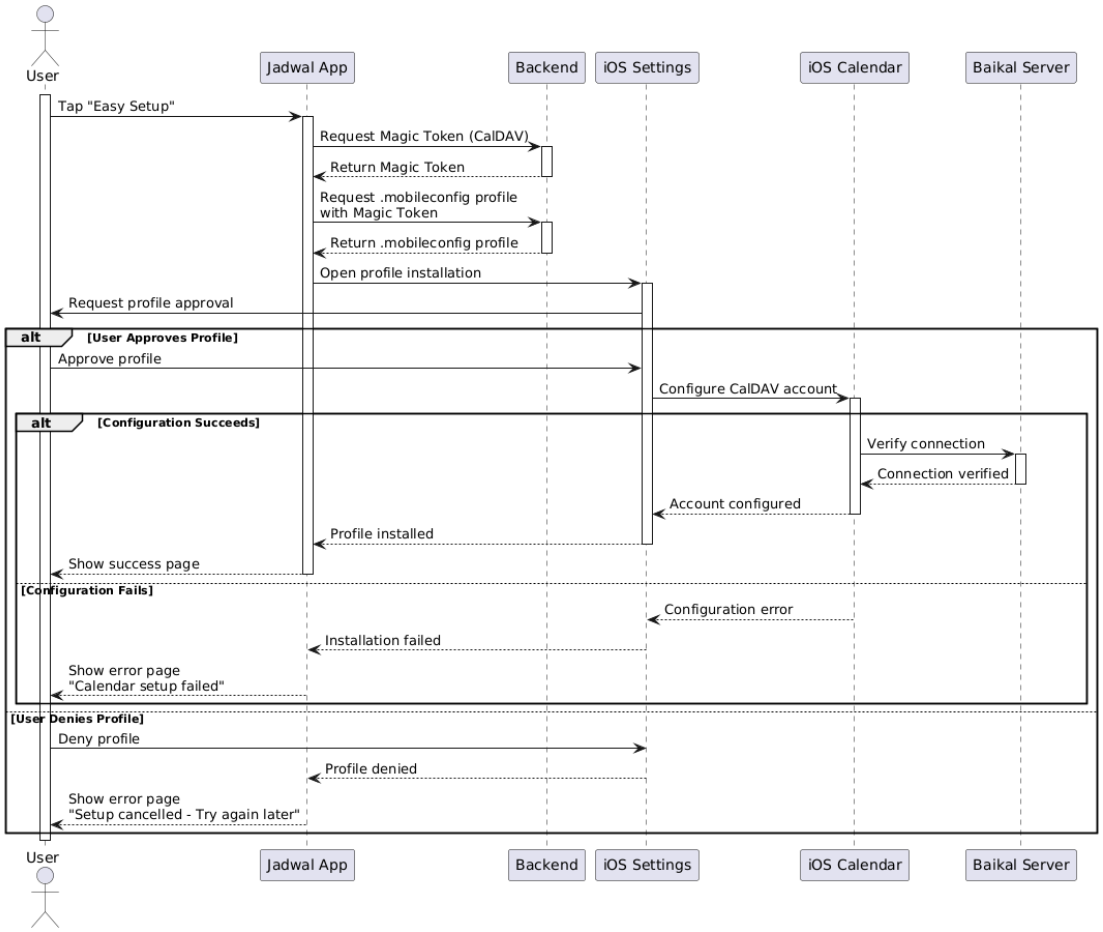

Figure 3.7: Connect Calendar Sequence Diagram

The "Connect Calendar Sequence Diagram", shown in **Figure 3.7**, illustrates the streamlined process of connecting an iOS device to Jadwal's Baikal calendar server. The sequence begins when the user taps "Easy Setup" in the app.

The process follows a secure flow where the app first requests a Magic Token of type CalDAV from the backend. Using this token, the app then requests a user-specific *.mobileconfig* profile that contains the pre-configured CalDAV credentials. When the user downloads this profile, iOS Settings takes over to handle the secure installation process.

The diagram illustrates the following possible paths:

1. **Success Path:** The user approves the profile installation in iOS Settings, which then automatically configures the CalDAV account. Upon returning to the app, the user is shown a success page after the system confirms the calendar configuration is complete.
2. **User Denial Path:** If the user denies the profile installation, they return to the app which displays ”Setup cancelled - Try again later”, allowing them to retry the process at their convenience.
3. **Configuration Failure Path:** If the profile installation is approved but the calendar configuration fails, the app shows a ”Calendar setup failed” message, prompting the user to either contact support or retry the process.

This implementation leverages iOS's native configuration profile system to ensure a secure and user-friendly setup process. The use of Magic Tokens and encrypted *.mobileconfig* profiles during transit guarantees that calendar credentials are transmitted and stored securely on the user's device. The clear error handling paths ensure users receive appropriate guidance when issues occur during any stage of the setup process.

Use Case 6: Create Calendar

Basic Information

ID Number: 6 **Priority:** High **Type:** Regular

Short Description

This UC allows the user to create a new calendar using iOS EventKit.

Trigger

This UC is triggered when the user clicks “Create Calendar” in the app.

Actors

Primary: User **Secondary:** EventKit

Preconditions

- User must be logged in
- Calendar access must be authorized in iOS Settings
- Baikal CalDAV account must be configured

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Calendar name** (Source: User)
- **Calendar account to add calendar under** (Source: User)
- **Calendar color** (Source: User)

Major Outputs

- **New calendar** (Destination: EventKit)
- **Creation status** (Destination: App)

Main Flow

1. The user taps the “Calendar” icon button in the app toolbar in the “Calendar” screen.

   Information: The app presents a “Calendars” sheet.

2. The user clicks the “plus” icon button in the toolbar of the “Calendars” sheet.

   Information: The app presents a form for calendar name, selector to choose account to add calendar under, and calendar color.

3. The user enters calendar name, selects a color, and selector to choose account to add calender under.

   Information: The app uses EventKit to create a new calendar.

4. EventKit creates the calendar and handles synchronization.

   Information: The calendar appears in the user’s calendar list.

Alternate Flows

- If calendar creation fails, the app shows an error and allows retry.

Exceptions

- **EventKit access denied:** The app prompts to enable calendar access in Settings.
- **Network issues:** EventKit handles synchronization internally.

Conclusion

The UC ends when EventKit confirms the calendar creation.

Post-conditions

A new calendar is created through EventKit.

Special Requirements

The system must use EventKit for all calendar operations.

Table 3.6: Create Calendar

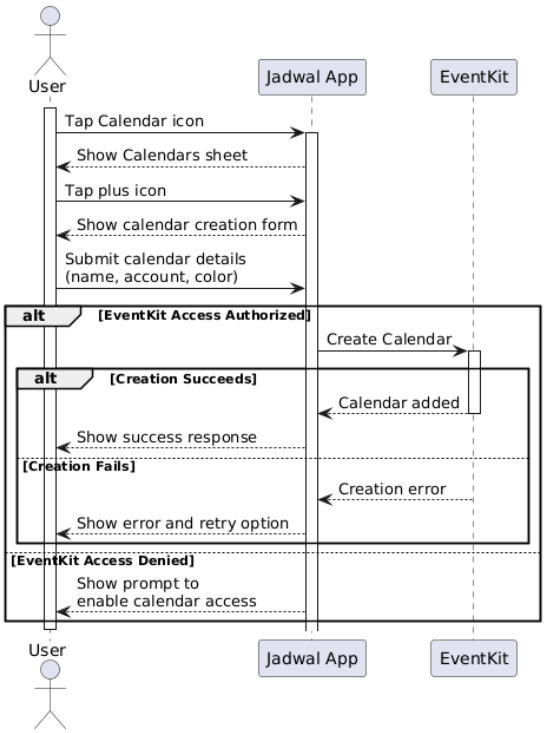

Figure 3.8: Create Calendar Sequence Diagram

The "Create Calendar Sequence Diagram", shown in **Figure 3.8**, illustrates the process of creating a new calendar in the Jadwal app. The sequence begins when the user accesses the calendar creation interface through the "Calendars" sheet, accessed via the calendar icon in the toolbar.

The flow involves several key steps:

1. The user provides essential calendar details through a form interface:
    - Calendar name
    - Account selection (where to add the calendar)
    - Calendar color
2. The app communicates with EventKit to create the new calendar
3. EventKit handles the calendar creation and all necessary synchronization

The process is designed to be robust and user-friendly:

- If EventKit access is denied, the app guides users to enable calendar access in iOS Settings

- If creation fails, the app shows an error and allows retry
- EventKit handles all synchronization internally

This implementation leverages iOS's native EventKit framework, which manages all calendar operations and synchronization internally. This provides a reliable and native iOS experience while ensuring proper calendar management.

Use Case 7: View Integrated Calendar

Basic Information

ID Number: 7 **Priority:** High **Type:** Regular

Short Description

Allows users to view their calendar events using iOS EventKit integration

Trigger

User opens the calendar view in the app.

Actors

Primary: User **Secondary:** EventKit

Preconditions

- User must be logged in
- Calendar access must be authorized in iOS Settings

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Calendar data** (Source: EventKit)
- **View preferences** (Source: User settings)

Major Outputs

- **Integrated calendar view** (Destination: App UI)

Main Flow

1. The user opens the calendar view.

   Information: The app queries EventKit for calendars and events.

2. EventKit provides calendar and event data.

   Information: The app processes and displays events.

3. The app updates in real-time as EventKit receives changes.

   Information: Changes from the Baikal server or other sources are reflected immediately when EventKit notifies us.

Conclusion

User views their calendar events in a unified interface powered by EventKit.

Post-conditions

Calendar events are displayed and stay in sync with iOS Calendar.

Special Requirements

- The app must observe EventKit changes for real-time updates.
- The app must handle calendar access permissions gracefully.

Business Rules

- **Events must be displayed according to user preferences.**
- **All calendar sources must be treated equally in the integrated view.**

Table 3.7: View Integrated Calendar

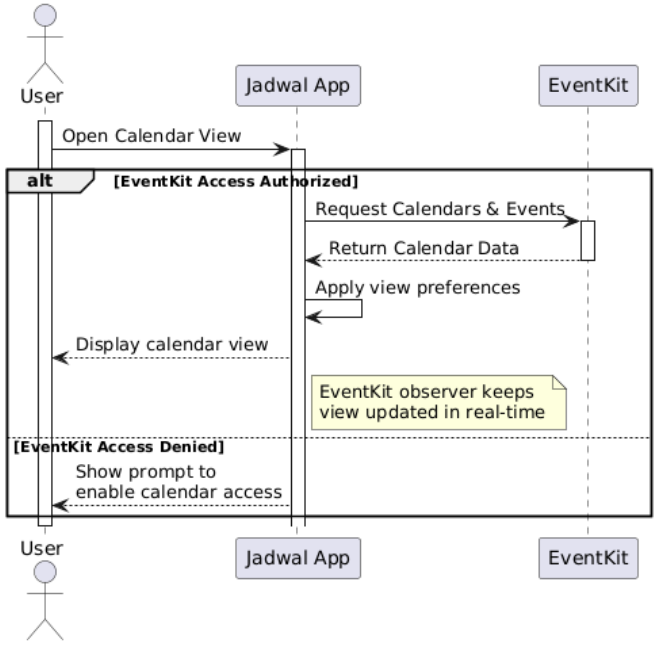

Figure 3.9: View Integrated Calendar Sequence Diagram

The "View Integrated Calendar Sequence Diagram", shown in **Figure 3.9**, demonstrates how the app leverages iOS EventKit to provide a unified calendar view. The sequence begins when the user opens the calendar view in the app.

The app uses EventKit to access calendar and event data directly from iOS's calendar database. This includes events from our Baikal server (synced via CalDAV) and any other calendars the user has configured. EventKit provides real-time updates through its observer system, ensuring the app's display stays synchronized with the system calendar.

This client-side approach eliminates the need for separate backend queries, as EventKit efficiently manages data access and synchronization. The app focuses on presenting the data in a user-friendly way, applying custom styling and organization while maintaining consistency with the iOS Calendar app.

3.6.3 WhatsApp Integration and Event Extraction

One of Jadwal's key features is its ability to automatically extract events from WhatsApp conversations. These use cases explain how users connect their WhatsApp account and how the system processes messages to identify and add events to their calendar.

Use Case 8: Connect WhatsApp

Basic Information

ID Number: 8 **Priority:** Medium **Type:** Regular

Short Description

This UC allows the user to connect their WhatsApp account to the system.

Trigger

This UC is triggered when the user clicks on "Connect WhatsApp" button in the app.

Actors

Primary: User **Secondary:** WhatsApp

Preconditions

User must be logged in

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **WhatsApp phone number** (Source: User)

Major Outputs

- **WhatsApp linking code** Destination: System
- **WhatsApp auth credentials** (Destination: System)

Main Flow

1. The user clicks “Connect WhatsApp” button.

   Information: The system asks for the user’s WhatsApp phone number.

2. The user enters their WhatsApp phone number.

   Information: Our app shows the WhatsApp linking code.

3. The user enters the linking code in WhatsApp.

   Information: The app shows a success screen if connection was sucessful.

Alternate Flows

- If the WhatsApp connection fails, the user must redo the steps and try again.
- If the user enters a wrong linking code, the connection of the WhatsApp account will fail unless they enter the correct code.

Exceptions

- **Wrong linking code:** If the user enters a wrong linking code too many times, the connection of the WhatsApp account will fail.
- **Network issue:** A network issue interrupting the communication between the app, the server, and WhatsApp.

Conclusion

The UC ends when the user has a connected WhatsApp account in the system.

Post-conditions
The system has access to the user's WhatsApp account.

Table 3.8: Connect WhatsApp

The "Connect WhatsApp Sequence Diagram", shown in **Figure 3.10**, illustrates the process of connecting a WhatsApp account to Jadwal. The sequence begins when the user clicks the "Connect WhatsApp" button in the app, which prompts them to enter their WhatsApp phone number.

After the user provides their phone number, the Jadwal App sends an InitiateWhatsApp request to the Backend, which then communicates with the Wasapp service (built on whatsapp-web.js) to request a linking code. The process can follow several paths:

1. **Successful Path:**
   (a) The Wasapp service successfully generates and returns the linking code
   (b) The code is displayed to the user through the Jadwal App
   (c) The user enters this code in their WhatsApp application
   (d) WhatsApp validates the code and, if valid:
      - Shows a success message to the user
      - Sends authentication credentials to the Wasapp service
      - The Wasapp service stores these credentials
      - The Backend is notified of successful authentication
      - The Jadwal App shows a success screen to the user
2. **Invalid Code Path:**
   - If the user enters an invalid code, WhatsApp shows an error
   - The auth failure is propagated through the system
   - The Jadwal App shows an "Invalid code" error to the user
3. **User Cancellation Path:**
   - The user can choose to cancel the connection process
   - The Jadwal App notifies the Backend to cancel the setup

- The Backend tells the Wasapp service to cancel the linking code
- The user is shown a ”Setup cancelled” message

4. **Request Failure Path:**
    - If the initial linking code request fails
    - The failure is propagated back through the system
    - The user is shown an error message with a retry option

This implementation ensures a secure and user-friendly WhatsApp integration process by utilizing a secure verification approach: the user's phone number and a WhatsApp-generated linking code. The system provides clear feedback at each step and handles various failure scenarios gracefully, ensuring users always know the status of their connection attempt.

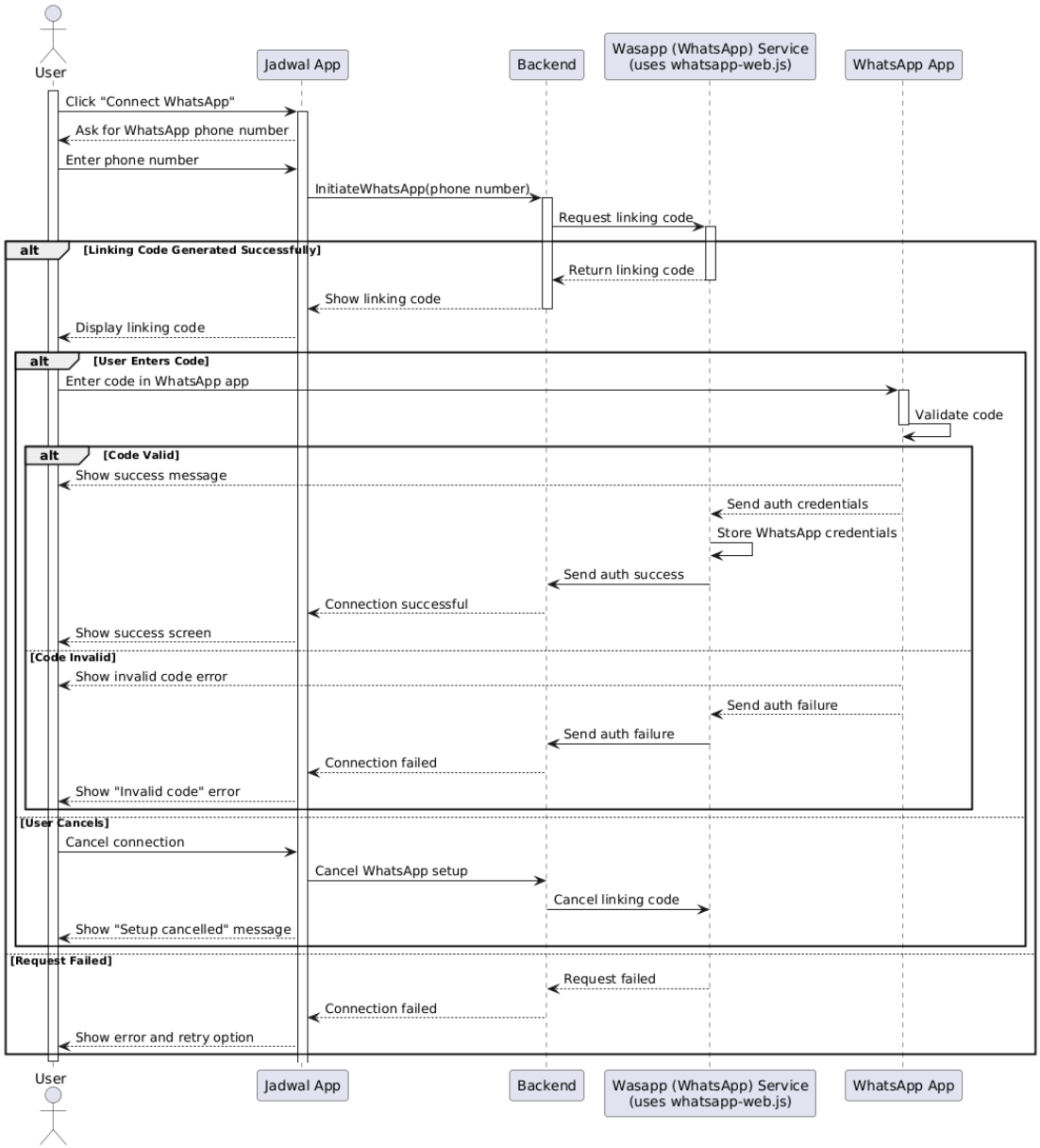

Figure 3.10: Connect WhatsApp Sequence Diagram

Use Case 9: Extract Events from WhatsApp

Basic Information

ID Number: 9 **Priority:** High **Type:** Regular

Short Description

System monitors WhatsApp messages through whatsapp-web.js, analyzes conversations using OpenAI API compatible LLMs to detect events, and adds confirmed events to a dedicated WhatsApp calendar via CalDAV.

Trigger

A non-group message is sent to or from the connected WhatsApp account.

Actors

Primary: WhatsApp, LLM Service, CalDAV Server **Secondary:**

Preconditions

- WhatsApp account must be connected via whatsapp-web.js
- RabbitMQ message queues must be operational
- OpenAI API compatible LLM must be configured
- CalDAV server must be accessible

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **WhatsApp message details** (Source: whatsapp-web.js)
- **Message history from database** (Source: System Database)

Major Outputs

- **Event analysis result** (JSON with status and details)
- **Calendar event** (Added to CalDAV server)
- **Push notification** (To user's devices)

Main Flow

1. System receives a non-group message via whatsapp-web.js client

   Information: Message details including sender, body, timestamp are captured

2. Message is published to RabbitMQ queue for processing

   Information: Message consumer retrieves message context from database

3. LLM analyzes message context with specialized prompt

   Information: Analysis determines if message contains event and its status (*NO_EVENT*, *HAS_EVENT_BUT_NOT_CONFIRMED*, *HAS_EVENT_AGREED*, *HAS_EVENT_DENIED*)

4. If event is detected and agreed upon:
   - Event is published to calendar queue
   - CalDAV credentials are retrieved
   - Event is added to WhatsApp Events calendar on CalDAV server
   - Push notification is sent to user's devices

Alternate Flows

- If event is detected but not confirmed, system continues monitoring chat
- If event is denied, chat history is cleared

Exceptions

- LLM analysis errors are logged for debugging
- Message processing failures trigger message requeuing
- WhatsApp client disconnections trigger automatic cleanup
- CalDAV server connection failures are handled gracefully

Conclusion

Event is successfully extracted, added to CalDAV calendar, and user is notified

Post-conditions

- Event is added to WhatsApp Events calendar on CalDAV server
- User receives push notification
- Chat history is cleared after successful processing

Business Rules

- Group messages are ignored
- Events require explicit agreement to be added
- WhatsApp Events calendar has a dedicated format
- Push notifications include event details for user verification

Special Requirements

- whatsapp-web.js client for WhatsApp integration
- RabbitMQ for message queuing
- OpenAI API compatible LLM service
- CalDAV server (Baikal) for calendar storage
- Push notification service configuration
- Encryption keys for securing sensitive data at rest:
  - WhatsApp messages encryption key
  - CalDAV credentials encryption key

Table 3.9: Extract Events from WhatsApp

The "Extract Events from WhatsApp Sequence Diagram", shown in **Figure 3.11**, illustrates the event extraction workflow through a message queue architecture. The system consists of several components working together, with a focus on security through encryption at rest:

- The WhatsApp Service (using whatsapp-web.js) monitors non-group messages
- RabbitMQ message queues handle asynchronous processing:
  - Message Queue for WhatsApp messages
  - Calendar Queue for confirmed events
- Message Consumer processes messages and coordinates with the LLM
- Calendar Consumer handles CalDAV integration
- Push notification service for user updates
- Database stores sensitive data encrypted at rest:
  - WhatsApp messages are encrypted with a dedicated key
  - CalDAV credentials are encrypted with a separate key

The workflow operates as follows:

1. The WhatsApp Service filters out group messages and publishes individual messages to a RabbitMQ queue
2. The Message Consumer:
   - Retrieves the message context from the database
   - Sends the context to the LLM Service for analysis
   - Handles different event statuses returned by the LLM:
     - *NO_EVENT*: No action needed
     - *HAS_EVENT_BUT_NOT_CONFIRMED*: Continues monitoring
     - *HAS_EVENT_DENIED*: Clears chat history
     - *HAS_EVENT_AGREED*: Publishes to calendar queue
3. When an event is agreed upon, the Calendar Consumer:
   - Retrieves encrypted CalDAV credentials from database
   - Initializes the WhatsApp Events calendar on CalDAV server if needed

- Adds the event directly to the calendar via CalDAV
- Sends a push notification to user's devices
- Clears the chat history from database

This queue-based architecture ensures reliable message processing and proper separation of concerns between message analysis and calendar integration. The system's ability to handle different event statuses allows for natural conversation flow while maintaining accurate event tracking. All sensitive data, including WhatsApp messages and CalDAV credentials, are encrypted at rest in the database, while the actual calendar events are stored securely on the CalDAV server.

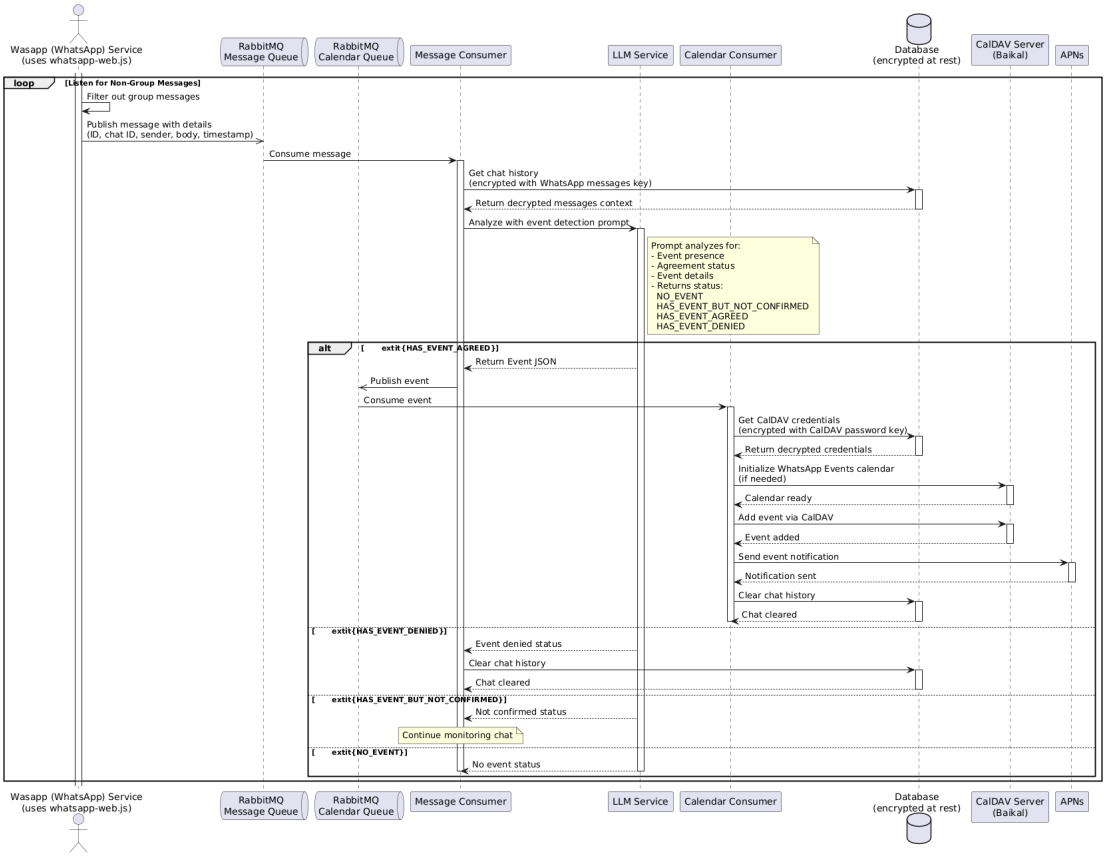

Figure 3.11: Extract Events from WhatsApp Sequence Diagram

3.6.4 Event Management and Conflict Resolution

Managing events and resolving scheduling conflicts are daily challenges for users. These use cases demonstrate how Jadwal handles event creation, conflict detection,

and provides smart resolution options.

Use Case 10: Suggest Conflict Resolutions

Basic Information

ID Number: 10 **Priority:** High **Type:** Regular

Short Description

This UC provides users with conflict detection and resolution options for calendar events.

Trigger

The UC is triggered when a new event is added that overlaps with existing events

Actors

Primary: User **Secondary:** iOS App

Backend Service

Preconditions

- The user has calendar access authorized
- The user has notifications enabled
- The calendar contains at least one event

Relationships

Extends: N/A **Includes:** Manage Scheduling Conflicts

Generalization/Specialization: N/A

Major Inputs

- **Event details** (Source: Calendar)
- **User resolution choice** (Source: User Interface)

Major Outputs

- **Updated calendar events** (Destination: Calendar)
- **Conflict notifications** (Destination: User Device)

Main Flow

1. The backend service sends event details to the iOS app via push notification

   Information: When a new event is added, the backend sends both a visible notification and background event data.

2. The iOS app checks for conflicts

   Information: The app processes the event data in the background to detect overlaps with existing events.

3. The iOS app notifies the user about conflicts

   Information: If conflicts are found, a notification is shown to the user.

4. The app presents resolution options

   Information: When the user opens the conflict notification, they are presented with three options:

   - Keep all events (with conflict warning)
   - Reschedule the new event to a different time
   - Cancel the new event

5. The user selects a resolution option

   Information: The system provides a visual timeline to help users understand the conflict and make an informed decision.

6. The system applies the chosen resolution

   Information: The calendar is updated according to the user's choice:

   - If keeping both, events are marked as conflicting
   - If rescheduling, the event is moved to the new time
   - If canceling, the new event is removed

Alternate Flows

1. No conflicts detected

   Information: If no overlapping events are found, the event is added normally without user intervention.

2. User ignores conflict notification

   Information: Conflicts remain in the app's conflict manager and can be resolved later from the conflicts view.

Exceptions

- If calendar access is not authorized, conflict detection cannot proceed
- If notifications are disabled, the user won't be notified of conflicts immediately
- If event modification fails, the system retains the conflict state for later resolution

Conclusion

The UC ends when either the conflict is resolved according to user choice, or the conflict is retained for later resolution.

Post-conditions

- The calendar reflects the user's chosen resolution
- The conflict is marked as resolved in the conflict manager if user acted on it
- The conflicts view is updated accordingly

Special Requirements

- The system must provide real-time visual feedback of conflicts using the timeline view
- The conflict resolution interface must be intuitive and user-friendly
- The system must handle background event processing with best

Table 3.10: Suggest Conflict Resolutions

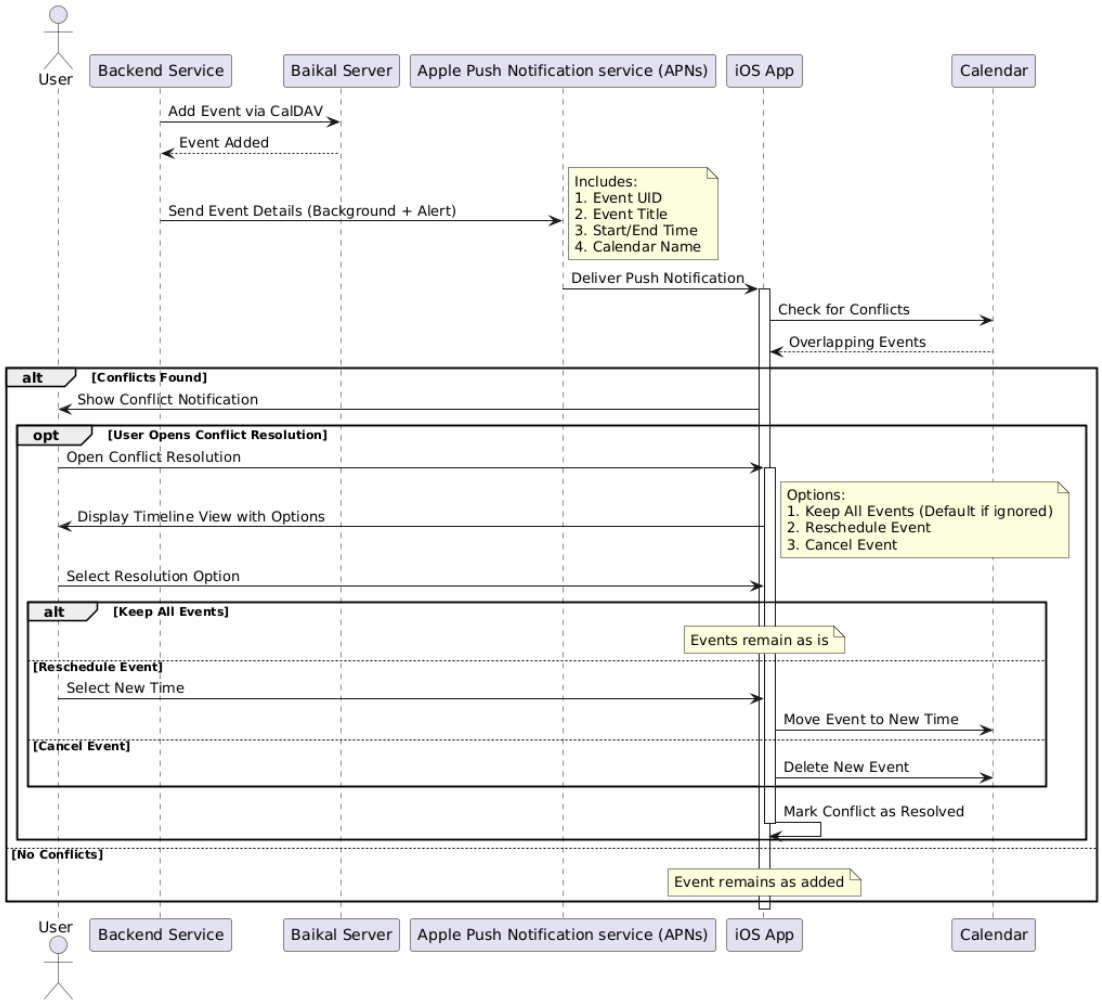

Figure 3.12: Suggest Conflict Resolutions Sequence Diagram

The sequence diagram in Figure 3.12 illustrates the conflict detection and resolution workflow in Jadwal. The process begins when a new event is added to the calendar, particularly through WhatsApp extraction. The backend service sends both a visible notification and background event data through Apple Push Notification service (APNs).

The iOS app implements a sophisticated conflict resolution system that:

1. Processes background notifications to detect conflicts
2. Maintains a conflict manager to track and handle conflicts
3. Provides a visual timeline interface for understanding conflicts
4. Offers three resolution options:
    - Keep all events with an explicit conflict warning
    - Reschedule the new event to a different time

- Cancel the new event

The implementation focuses on user experience by:

- Providing immediate notification of conflicts
- Offering a visual timeline to understand event overlaps
- Allowing flexible resolution timing (immediate or later)
- Maintaining a dedicated conflicts view for managing all unresolved conflicts

This approach ensures users have complete control over their calendar while being promptly informed of scheduling conflicts. The system maintains conflicts until explicitly resolved, allowing users to make decisions at their convenience while ensuring no scheduling issues go unnoticed.

Use Case 11: Manage Scheduling Conflicts

Basic Information

ID Number: 11 **Priority:** Medium **Type:** Regular

Short Description

This UC allows users to view and manage all unresolved scheduling conflicts in their calendar through a dedicated interface.

Trigger

This UC is triggered when the user opens the Conflicts view in the iOS app.

Actors

Primary: User **Secondary:** iOS App

Preconditions

- The iOS app is installed and running
- Calendar access is authorized
- There are unresolved conflicts in the ConflictManager

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Unresolved conflicts** (Source: ConflictManager)
- **User resolution choices** (Source: User Interface)

Major Outputs

- **Updated calendar events** (Destination: iOS Calendar)
- **Updated conflict status** (Destination: ConflictManager)

Main Flow

1. The user opens the Conflicts view in the app

   Information: The app displays a list of all unresolved conflicts using ConflictRowView for each conflict.

2. For each conflict, the user can:

   Information:

   - View the conflicting events in a timeline visualization
   - See the event titles, times, and number of conflicts
   - Select a conflict to resolve

3. When selecting a conflict, the user is presented with resolution options

   Information: The ConflictResolutionView presents three options:

   - Keep All Events - Leave events as is with known conflict
   - Reschedule Event - Move the new event to a different time
   - Cancel Event - Remove the new event from the calendar

4. The user can visualize the impact of their choice

   Information: The ConflictTimelineView provides a visual representation of:

   - Current event positions
   - Proposed new time (when rescheduling)
   - Conflict resolution preview

Alternate Flows

1. If no unresolved conflicts exist:

   Information: The app displays a ”No Scheduling Conflicts” message with a checkmark.

2. If the user dismisses without resolving:

   Information: The conflict remains in the unresolved state and can be addressed later.

Exceptions

- If calendar access is revoked, the app prompts for re-authorization
- If event modification fails, the conflict remains unresolved and can be retried

Conclusion

The UC ends when the user has reviewed and optionally resolved their calendar conflicts.

Post-conditions

- Resolved conflicts are marked as such in the ConflictManager
- Calendar events reflect any changes made through conflict resolution
- Remaining unresolved conflicts are preserved for later

Special Requirements

- The interface must provide clear visual feedback through the timeline view
- Resolution options must be easily accessible and understandable
- The system must maintain conflict state across app sessions

Table 3.11: Manage Scheduling Conflicts

The sequence diagram in Figure 3.13 illustrates how users can manage their calendar conflicts through the iOS app's dedicated Conflicts view. This interface serves as a central hub for reviewing and resolving all scheduling conflicts.

The process leverages several key components:

- **ConflictManager**: Maintains the state of all conflicts and their resolution status
- **ConflictsView**: Provides the main interface listing all unresolved conflicts
- **ConflictResolutionView**: Offers the resolution interface with timeline visualization
- **ConflictTimelineView**: Delivers an interactive visual representation of conflicts

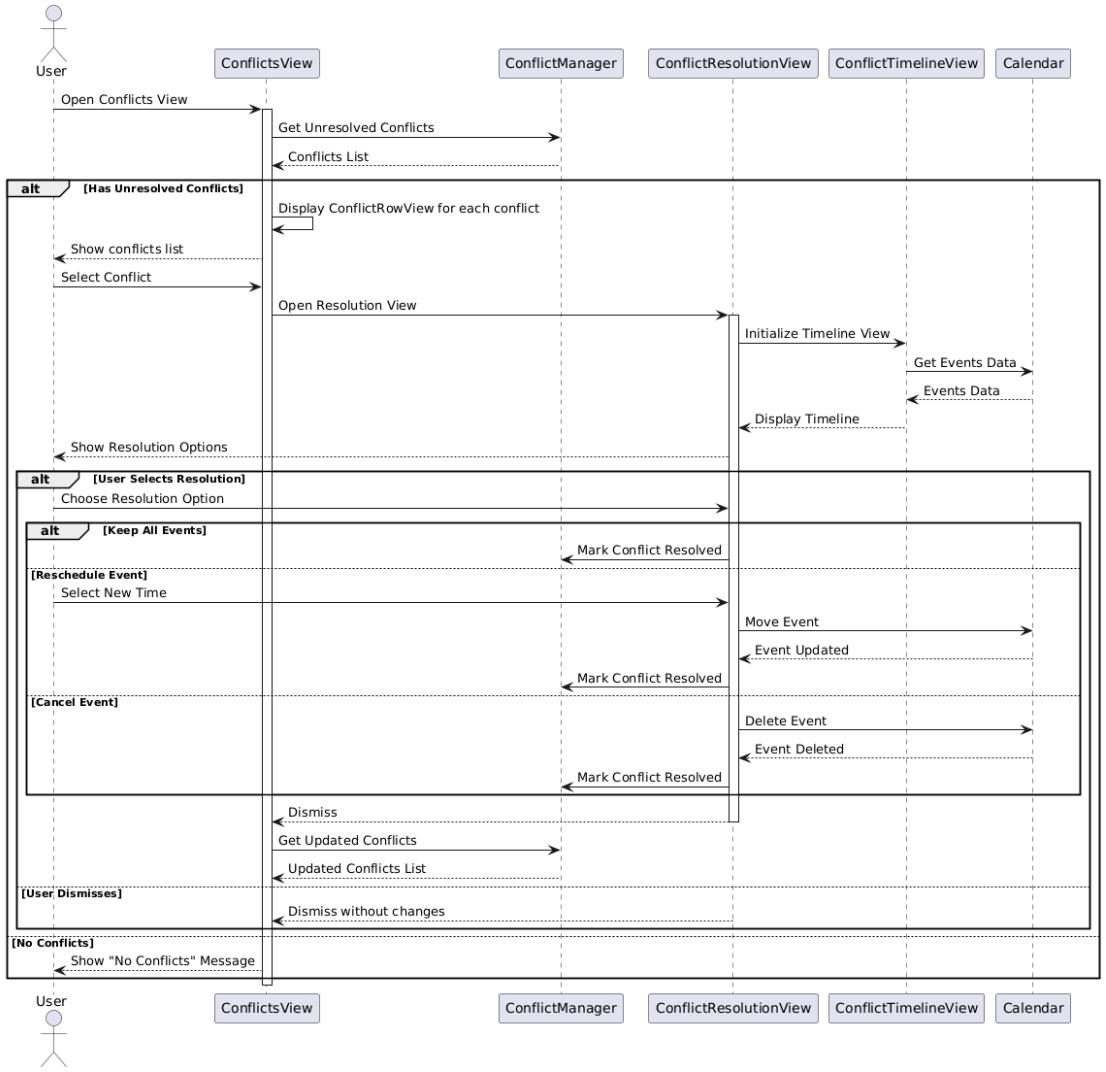

Figure 3.13: Manage Scheduling Conflicts Sequence Diagram

This implementation ensures that users can:

- View all their conflicts in one place
- Understand conflicts through visual timeline representation
- Make informed decisions about resolution
- Address conflicts at their convenience

The system maintains conflicts until they are explicitly resolved, allowing users to manage their schedule conflicts efficiently while ensuring no scheduling issues go unnoticed.

Use Case 12: Add Event Manually

Basic Information

ID Number: 12 **Priority:** High **Type:** Regular

Short Description

This UC allows users to add events manually.

Trigger

The user clicks add event manually icon or a date on the calendar and adds the events.

Actors

Primary: User **Secondary:** None

Preconditions

The user is logged into the application.

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **Event Name** (Source: User)
- **Event Location** (Source: User)
- **Is all day?** (Source: User)
- **Event Date (Start and End)** (Source: User)
- **Event Time (Start and End)** (Source: User)
- **Note** (Source: User)
- **Notifications/Reminders** (Source: User)

Major Outputs

- **New Calendar event** (Destination: Calendar)

Main Flow

1. The user clicks the add event manually icon in the top corner '+'.

   Information: The add event manually form is displayed.

2. The user sets the details of the event in the respective fields and saves the event.

   Information: The event is displayed on the calendar with its details.

Alternate Flows

1. If the validation fails the user can try again after fixing the issues.

Exceptions

- The end time is before the start time.
- The user attempts to save the event without filling in mandatory fields.

Conclusion

The UC ends when the event has been successfully added to the calendar, and displayed.

Post-conditions
The event is successfully added to the calendar and displayed in the correct time slot.

Special Requirements
The interface must be simple and allowing users to input events with less efforts.

Table 3.12: Add Event Manually

The "Add Event Manually Sequence Diagram" illustrates a simple flow of creating a calendar event. The sequence starts with the user filling in event details. The system then performs validation by EventKit:

1. If validation succeeds:
    - The Add button becomes enabled
    - User can proceed to create the event
    - EventKit processes the creation request
    - Event creation confirmation is returned
2. If validation fails:
    - The Add button remains disabled
    - User must correct the input before proceeding

This straightforward workflow ensures data validation before any attempt to create an event, preventing invalid entries from being submitted to the calendar system.

3.6.5 Prayer Time and Notification Management

Prayer time scheduling is a unique feature of Jadwal, and timely notifications ensure users never miss important events. These use cases detail how prayer times are scheduled and how the notification system keeps users informed.

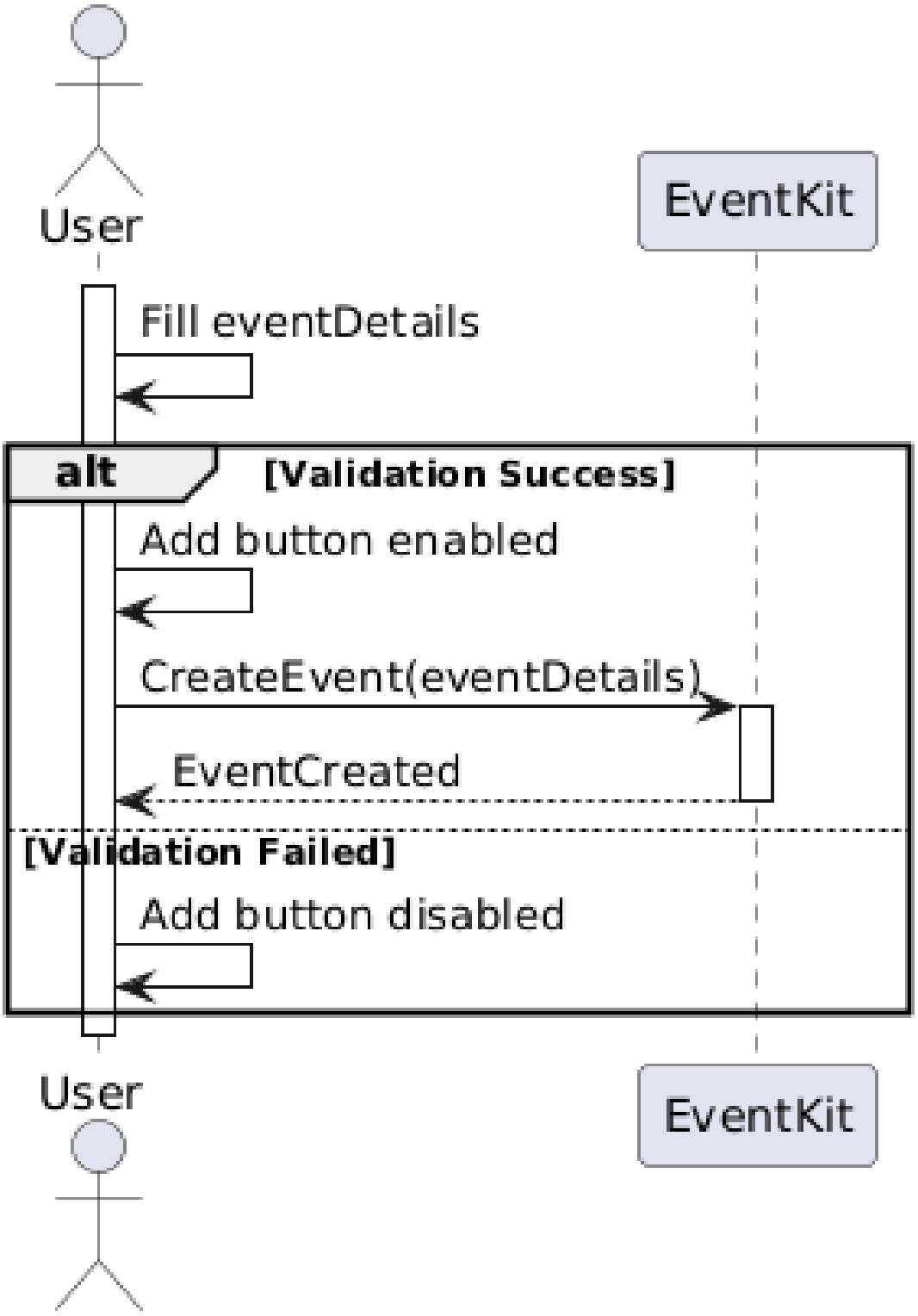

Figure 3.14: Add Event Manually Sequence Diagram

Use Case 13: Schedule Prayer Times

Basic Information

ID Number: 13 **Priority:** High **Type:** Regular

Short Description

The calendar is blocked and updated automatically according to the person's time zone prayer time.

Trigger

This usecase is triggered when the user clicks the prayer time feature button in the settings page in the app.

Actors

Primary: User **Secondary:** None

Preconditions

User must be logged into the system.

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs

- **User's IP Address** (Source: User)
- **User's City** (Source: System)

Major Outputs

- **.mobileconfig file for subscription calendar** (Source: System)
- **Prayer Time Calendar** (Source: System)

Main Flow

1. User clicks the option to schedule prayer times.

   Information: The system sends a request to start the process of adding schedule prayer times to the backend, sends the IP Address.

2. A sheet is shown to the user to download the '.mobileconfig' file

   Information: The user clicks the 'Begin Download' button to start it in a Safari WebView, with instructions on what to continue.

3. The user continues in the settings, opened automatically, to finish setting up the provisiong profile.

   Information: The provisioning profile adds a subscription calendar forr the prayer times of the user's city to their calendat account.

Alternate Flows

- The user doesn't enable the scheduling prayer time.

Exceptions

- If there's a system error, display a relevant error message.

Post-conditions

The system generates calendar with prayer time

Special Requirements

The system must show the calendar according to their city

Conclusion

User's prayer times are successfully scheduled.

Table 3.13: Schedule Prayer Times

The "Schedule Prayer Times Sequence Diagram", shown in **Figure 3.15**, illustrates Jadwal's unique feature of automatically integrating prayer times into the user's device

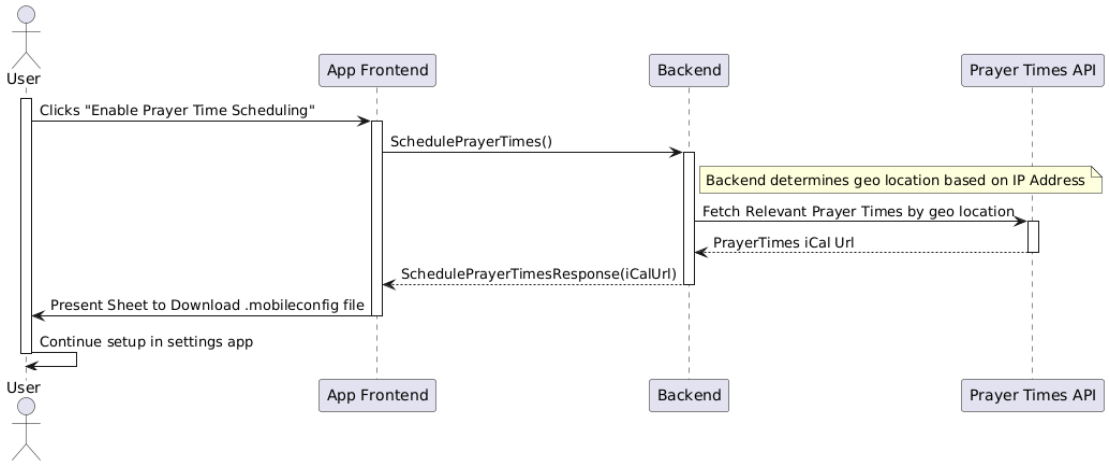

Figure 3.15: Schedule Prayer Times Sequence Diagram

calendar via a subscription, based on their location. The process begins when the user clicks the option to add prayer times to the calendar within the app's settings.

Upon activation, the sequence follows these steps:

1. The **User** taps the "Add Prayer Time Scheduling" option in the **App Frontend**.
2. The **App Frontend** initiates the `SchedulePrayerTimes()` gRPC call to the **Backend**.
3. The **Backend** determines the user's geographical location (e.g., using the IP address provided or other user information).
4. The **Backend** queries the **Prayer Times API** using the determined location to fetch the relevant prayer times, receiving back a specific **iCal URL** that provides these times in a standard calendar format.
5. The **Backend** returns the `iCalUrl` to the **App Frontend** in the `SchedulePrayerTimesRes`
6. The **App Frontend** presents a sheet or prompt to the **User**, guiding them to download a `.mobileconfig` file. This configuration file is pre-filled with the received `iCalUrl`, setting up a calendar subscription.
7. The **User** proceeds with the download and follows the device prompts (often involving the Settings app) to install the configuration profile, thereby subscribing their device's calendar to the provided iCal URL.

This subscription-based process ensures that:

- Prayer times are accurately sourced based on geographical location via the iCal feed.
- The user's device calendar automatically fetches and displays the prayer times, updating them as needed according to the subscription.
- Users can easily view their prayer schedule alongside other commitments within their standard calendar application.

The system's ability to facilitate this calendar subscription demonstrates Jadwal's commitment to supporting users' religious obligations seamlessly within their existing digital tools.

Use Case 14: Receive Event Notifications

Basic Information

ID Number: 14 **Priority:** High **Type:** Regular

Short Description

Users receive notifications about upcoming events.

Trigger

The UC is triggered when the chosen time of an event's reminder has arrived.

Actors

Primary: User **Secondary:** None

Preconditions

User must be logged into the system and have set a reminder for a specific event.

Relationships

Extends: N/A **Includes:** N/A

Generalization/Specialization: N/A

Major Inputs	Major Outputs
• **Event reminders/alerts** (Source: User)	• **Local notifications displayed to the user.** (Destination: System)

Main Flow
1. The system iterates over all events with reminders set.
2. For each event, a local notification is scheduled to remind the user.

Alternate Flows
• **If the user denies notification permissions, notifications cannot be sent.**

Exceptions
• **System error or failure to schedule notifications.**

Conclusion
The system schedules local notifications for all events with reminders.

Post-conditions
Notifications are displayed to the user at the appropriate time.

Special Requirements
Notification permissions must be granted by the user.

Business Rules
The system must ensure notifications are scheduled accurately and on time.

Table 3.14: Receive Event Notifications

The "Receive Event Notifications Sequence Diagram", shown in **Figure 3.16**, depicts the flow of how local event reminders are scheduled and delivered to the user. When the user sets a reminder for a calendar event, it is saved using EventKit. The application

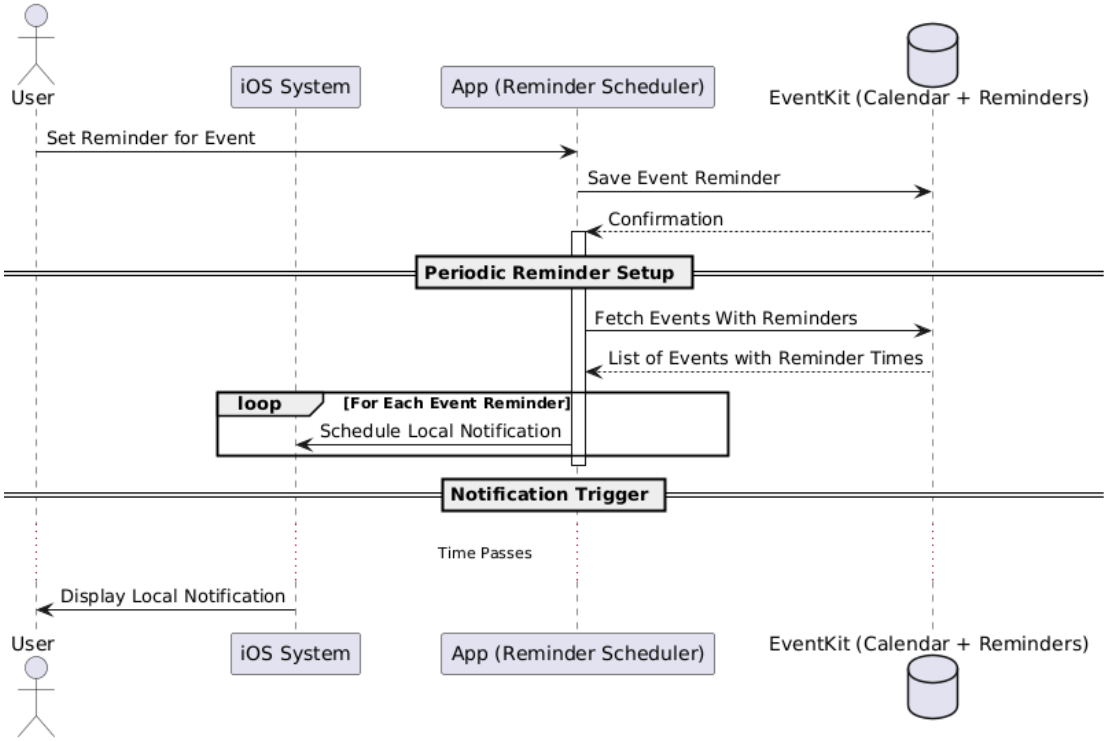

Figure 3.16: Receive Event Notifications Sequence Diagram

periodically retrieves all upcoming events with reminders from EventKit and schedules local notifications for each of them via the iOS notification system. At the scheduled time, iOS automatically triggers the corresponding local notification, ensuring the user is reminded promptly. This flow assumes the user has granted the necessary notification permissions and is logged into the application.

3.7 Activity Diagram

Activity diagrams provide a visual representation of the workflow and business processes within a system. For Jadwal, the activity diagram maps out the user's journey through the application, from authentication to daily interactions, illustrating the various paths and decision points users encounter. This diagram is particularly important as it demonstrates how different features of Jadwal—such as calendar management, WhatsApp integration, and conflict resolution—interconnect in actual usage.

An activity diagram is shown in Figure 3.17 above, and it illustrates the flows the user of the app can take. It starts with the authentication which supports both Google and Email. We call it authentication because we don't let the user think whether he has an account or not, we just ask them for the email, or Google account, and the rest is handled by the system. This makes the experience easy for the user, and especially with the user of Magic Links and OAuth, users don't need to memorize passwords to access Jadwal. Even though this method is easier for the user than other methods, it doesn't offer lower security. In fact, it is even more secure than other methods since the challenge allows the user to prove they own an account without needing to provide a password they make.

Then after the token is verified, a check is done to see if the user has a calendar or not. If the user has a calendar, we just move on, but if they don't have one, we create one and then move on. Here the user is inside the app and has two options, he can either view the calendar or open the settings page. When he views the calendar, he can view an event, or add one.

After any of the previous two steps, the user can go back to view calendar or open settings page. If the choose to open settings page, they have three actions available. They can add their Jadwal calendar account to iOS calendar accounts on their device, connect WhatsApp, schedule prayer times, or logout.

Starting with adding adding the Jadwal calendar account, the user can initiate the process by clicking on a button. Then the device installs a '.mobileconfig' file that sets the credentials on the user's device with their permission. This '.mobileconfig' is what we call a provisining profile, and it allows you to change phone settings with good user experience, since asking users to enter three pieces of information and navigating alot of pages just to add a calendar account will result in them hating the app.

Then with the connecting a WhatsApp account feature. After a successful connection of the user's WhatsApp account, the system will start to extract events from the user's WhatsApp account automatically. If any conflicts arise after adding an event to the calendar, the system suggests a conflict resolution, and the user can take action by managing the scheduling conflict. But if no conflicts arise, the system just continues normally.

The flows above allows the user to continue using the app and doing other things with their account but the last action will block you from doing this. The logout action terminates the session and the user is logged out of the app. This is an end state, and you need to start again from the start to be able to use the app again.

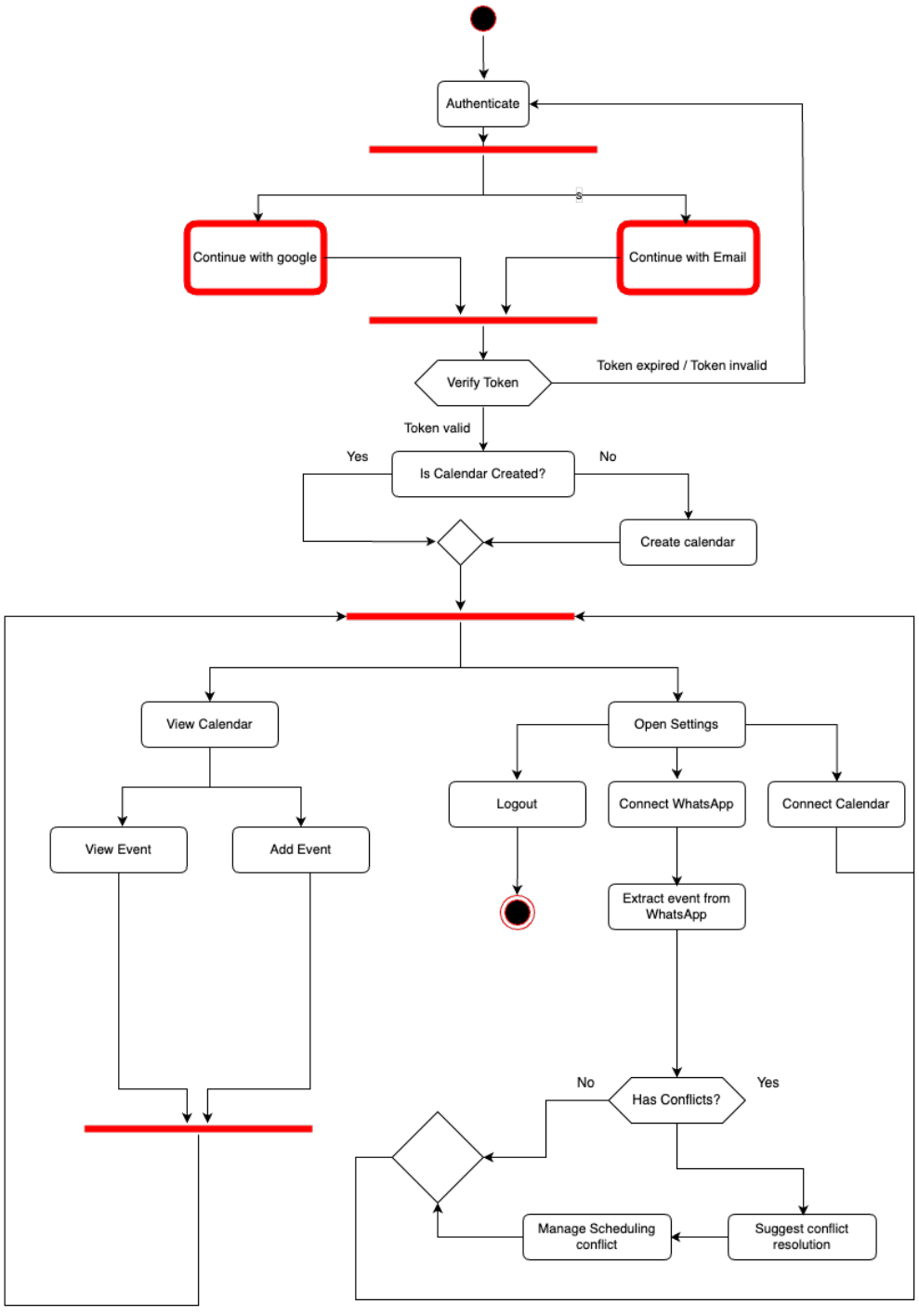

Figure 3.17: Activity Diagram of Jadwal

3.8 Class Diagram

The figures below show the main classes Jadwal's system includes. The figures give an overview of interfaces in the system to help in understanding the different parts of the system. Since Golang will be used for the backend mainly, the diagrams below are more suited for it.

Of course that doesn't mean they can't be used for implementing in other languages, but the way it was written took into consideration the language features. Golang is neither fully object oriented neither fully functional. It has `interface` and `struct`, and has implicit implementation. Implicit implementation means as long as a struct has the methods that an interface expects, that struct implemented the interface. Below is a key for the class diagrams coming below:

- S - `struct` (Go struct type)
- T - `type` (Go type definition)
- C - `class` (Go interface implementations)
- I - `interface` (Go interface definition)

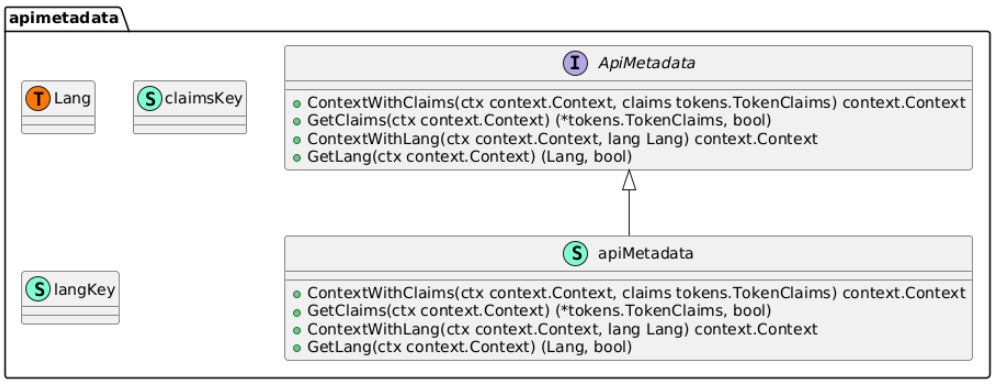

Figure 3.18: Api Metadata Class Diagram

In Figure 3.18, the diagram shows the Api Metadata interface and its implementation along with important fields. It basically extracts data from the headers and includes it in the context of the requests. It helps you put stuff into the context and extract it from them. Context in Golang allows you to attach stuff to it, but it is not type safe, so

we are making a wrapper to make it safe. Below we are adding wrappers for `Claims` and `Lang`. `Claims` are extracted from the JWT (JSON Web Token). `Lang` is self-explanatory.

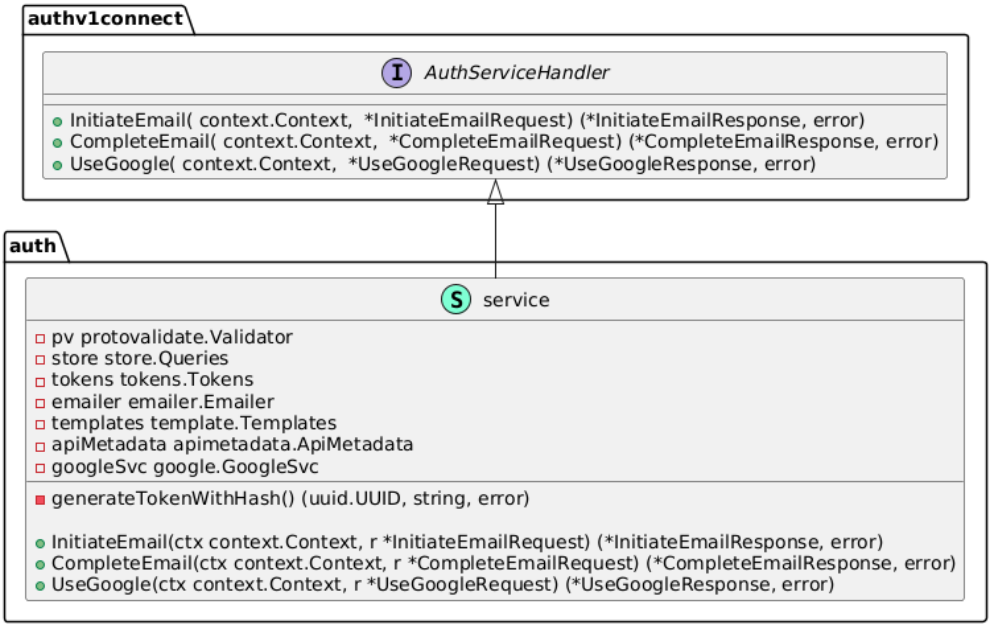

Figure 3.19: Auth Class Diagram

In Figure 3.19, the diagram shows the Auth API interface with its dependencies. It also shows the `authv1connect` which is the generated code for the API. This includes the flow for using email to authenticate and using Google.

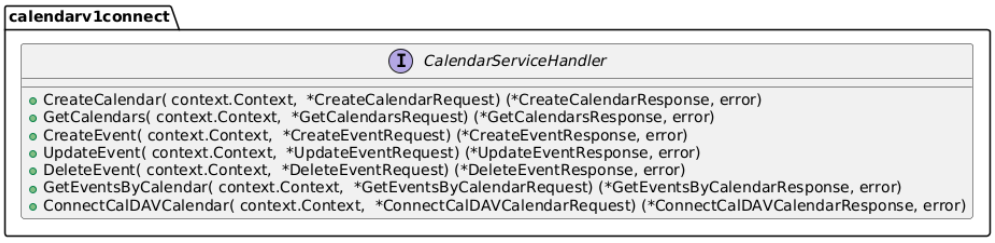

Figure 3.20: Calendar V1 Class Diagram

In Figure 3.20, the diagram shows the api layer service calendar. It allows Jadwal's clients to manage their calendar data easily. It shows the interfaces and the implementation structs with their fields and methods.

In Figure 3.21, the Google client, and its methods. It allows Jadawl to verify with Google that tokens its gets are good, and it also allows Jadwal system to get the user

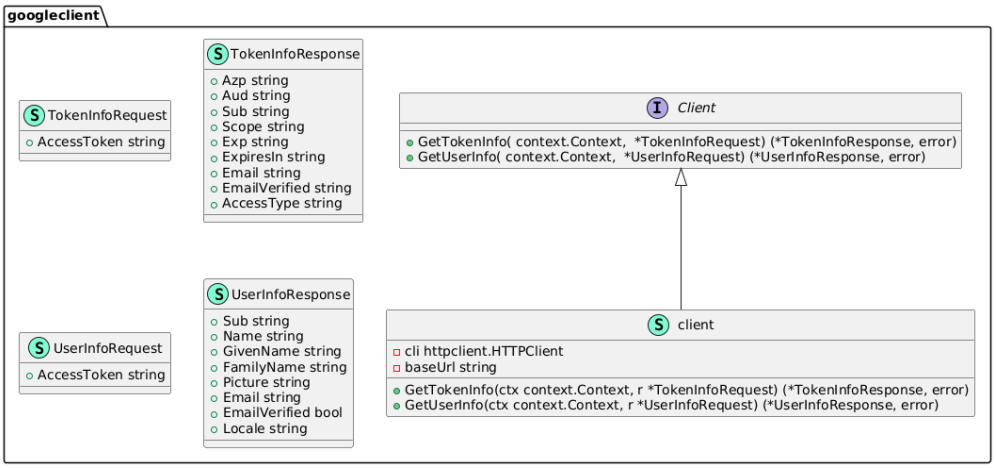

Figure 3.21: Google Client Class Diagram

info the system was granted access for.

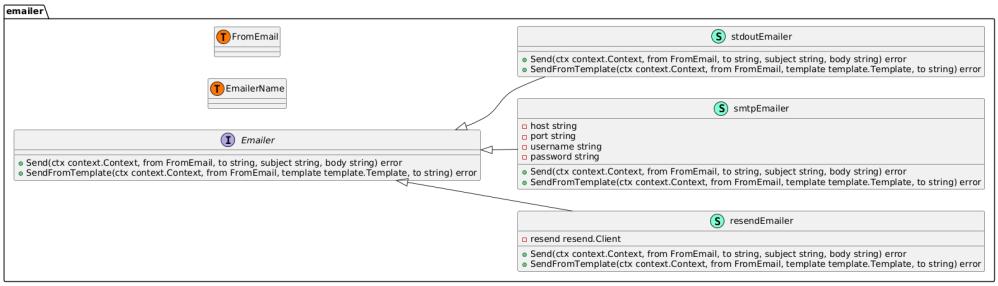

Figure 3.22: Emailer Class Diagram

In Figure 3.22, the diagram shows the `emailer` interface with its three implementations. This allows for using the textttstdoutEmailer when testing locally, and using either of the `resendEmailer` or `smtpEmailer` in production to send real emails.

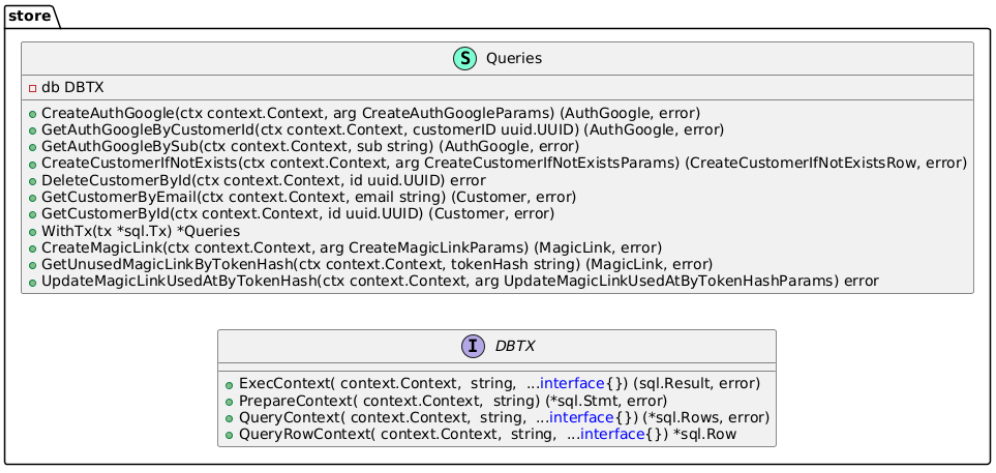

Figure 3.23: Store Class Diagram

In Figure 3.23, the diagram shows the store, or in other words the database. The

store holds all the methods needed to query the database for information it holds. More methods can be added as needed, but those are the core methods.

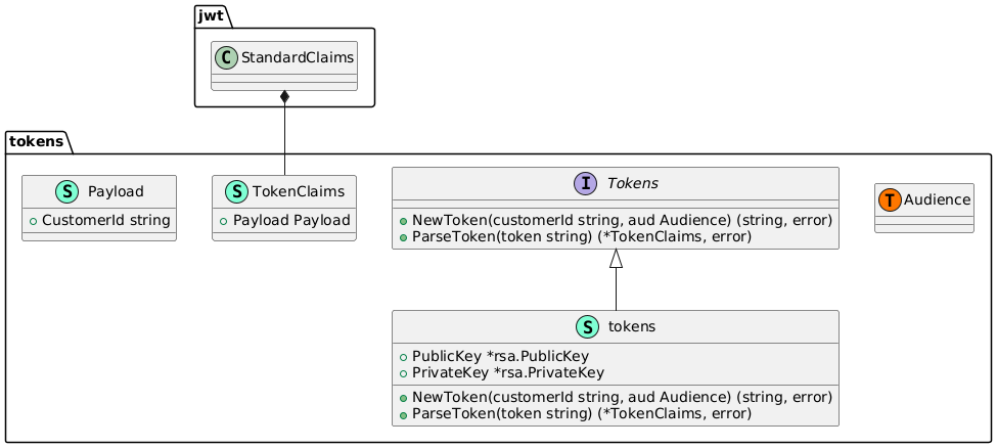

Figure 3.24: Tokens Class Diagram

In Figure 3.24, the diagram shows the tokens service implementation along with its interface. The diagram also illustartes the needed `struct` representation for any data passed to and from the service.

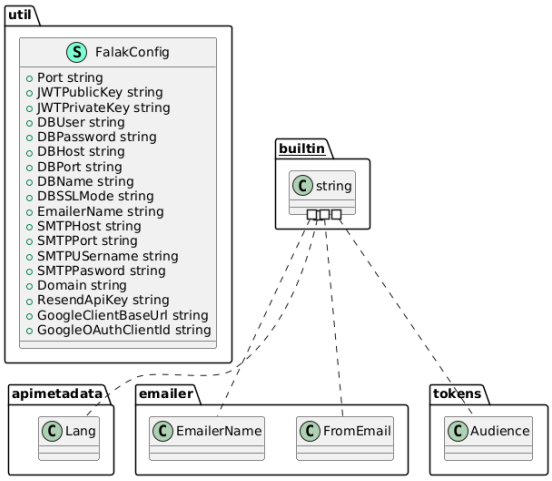

Figure 3.25: Util Class Diagram

In Figure 3.25, the diagram shows config needed to support both production and development without committing secrets to the codebase. Falak in this context is the codename for the backend. The config here is represented as a `struct` since it is hold data and doesn't need implementations.

3.9 Database Design

The foundation of Jadwal's robust functionality lies in its carefully structured relational database architecture. This section presents both the Entity-Relationship model and Relational Schema that support the application's core features, from user authentication to calendar integration and event management. The database design ensures efficient data organization while maintaining the flexibility needed for future scalability.

3.9.1 Entity-Relationship Model

The Entity-Relationship model, illustrated in **Figure 3.26**, depicts the conceptual structure of Jadwal's database system. This model follows standard ER notation and demonstrates the relationships between the system's primary entities.

Core Entities and Relationships

1. **User Management**
    - `customer`: Central entity with attributes `id` (UUID), `name`, and `email`
    - `auth_google`: Represents Google OAuth authentication
    - `magic_link`: Manages email-based authentication tokens
2. **Calendar Organization**
    - `calendar_accounts`: Links customers to calendar providers
    - `vcalendar`: Represents individual calendars with metadata
    - One-to-many relationship from accounts to calendars
3. **Event Management**
    - `vevent`: Core event entity with timing and details
    - `vevent_exception`: Handles recurring event modifications
    - `valarm`: Manages event notifications

Key Relationships

- Customer ”has” authentication methods (one-to-many)
- Customer ”owns” calendar accounts (one-to-many)
- Calendar accounts ”contain” calendars (one-to-many)
- Calendars ”schedule” events (one-to-many)
- Events ”have” exceptions and alarms (one-to-many)

3.9.2 Relational Database Schema

The relational database schema, shown in **Figure 3.27**, provides the detailed logical structure of the database implementation. This representation demonstrates the actual table structures, attributes, and relationships as implemented in the database system.

Table Structures

1. **Authentication Tables**
   - `customer` (id, name, email, created_at, updated_at)
   - `auth_google` (id, customer_id, sub, created_at, updated_at)
   - `magic_link` (id, customer_id, token_hash, expires_at, used_at, created_at, updated_at)
2. **Calendar Tables**
   - `calendar_accounts` (id, customer_id, provider, created_at, updated_at)
   - `vcalendar` (uid, account_id, prodid, version, display_name, description, color, timezone, created_at, updated_at)
3. **Event Tables**
   - `vevent` (uid, calendar_uid, dtstamp, dtstart, dtend, duration, summary, location, status, classification, transp, rrule, rdate, exdate, sequence, created_at, updated_at)

- `vevent_exception` (id, event_uid, recurrence_id, summary, description, location, dtstart, dtend, status, created_at, updated_at)
- `valarm` (id, event_uid, action, trigger, description, summary, duration, repeat, attendees, created_at, updated_at)

Implementation Details

- **Primary Keys**: Underlined attributes represent primary keys
- **Foreign Keys**: Attributes ending in "_id" or "_uid" represent foreign key relationships
- **Audit Fields**: All tables include created_at and updated_at timestamps
- **Data Types**:
  - UUID for unique identifiers
  - VARCHAR for variable-length strings
  - TIMESTAMPTZ for timezone-aware timestamps
  - JSONB for complex data structures (rdate, exdate, attendees)

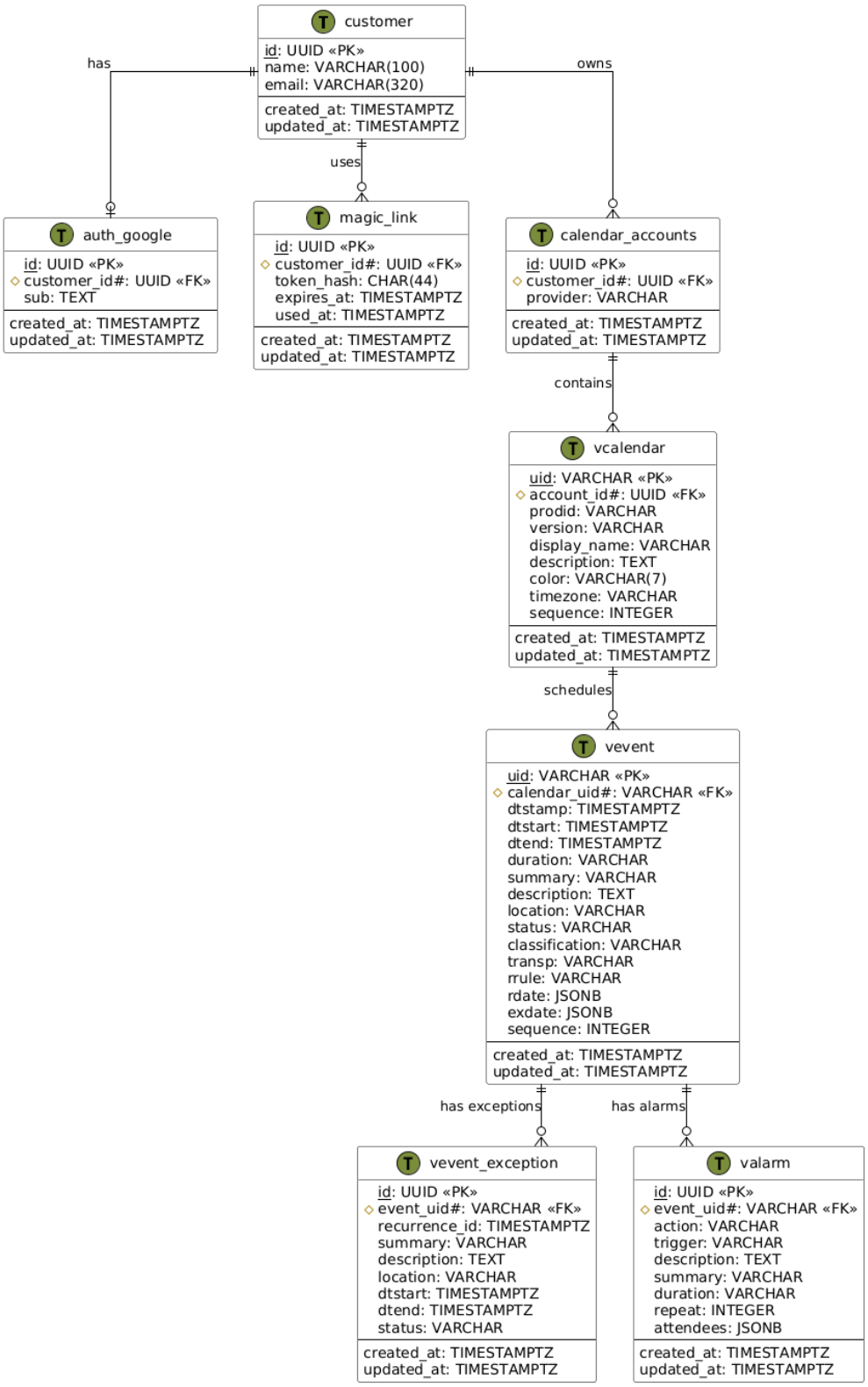

Figure 3.26: Entity-Relationship Diagram

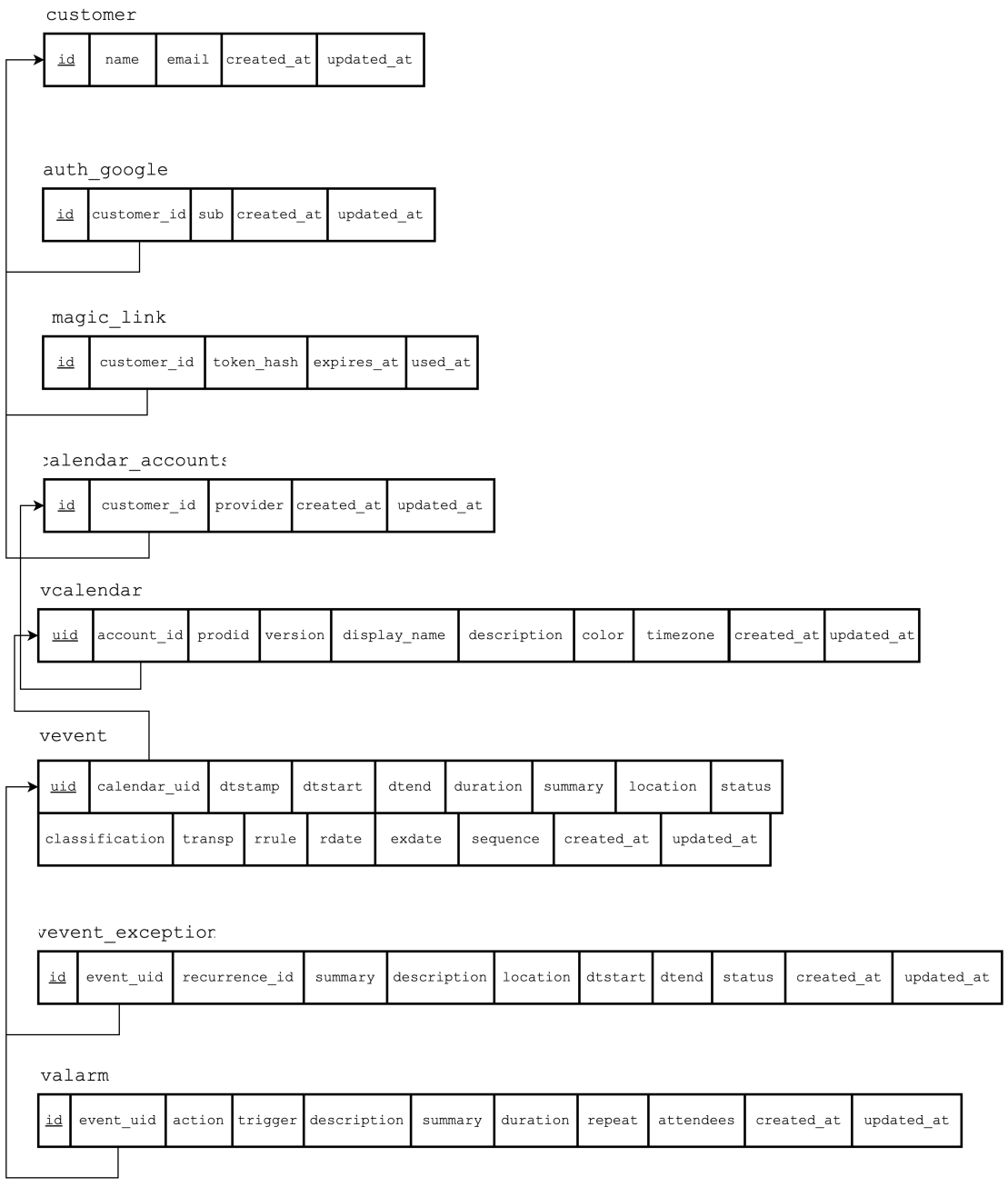

Figure 3.27: Relational Schema

3.10 User Interface Prototype

The user interface design of Jadwal plays a crucial role in delivering an intuitive and efficient calendar management experience. This section presents a comprehensive walkthrough of the application's key screens, from initial user onboarding to daily calendar interactions. The prototype demonstrates how Jadwal's core features—including authentication, calendar viewing, event management, and settings configuration—are implemented in a user-friendly manner that adheres to iOS design principles. Each screen has been carefully designed to balance functionality with simplicity, ensuring users can easily navigate and utilize all of Jadwal's features.

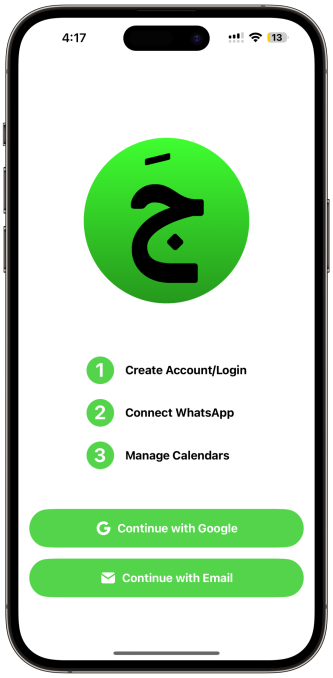

Figure 3.28: UI Screen 1: Onboarding View

In Figure 3.28, the screen shows the user the steps he needs to take in the future so he knows what he is going to do. It also has two way of authenticating, Google and Email (Magic Link).

In Figure 3.29, the screen is showing the continue with email screen which allows a user to enter their email, click ”Continue”, and receive an email if all is good.

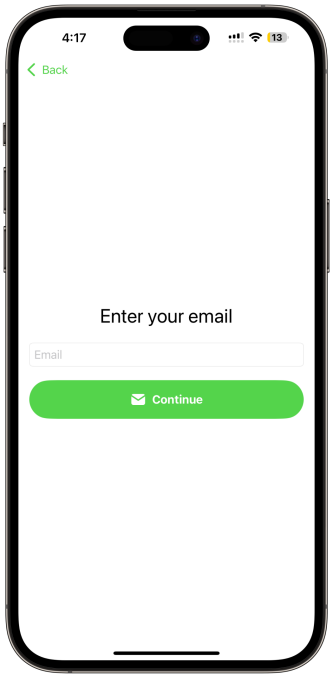

Figure 3.29: UI Screen 2: Continue with Email View

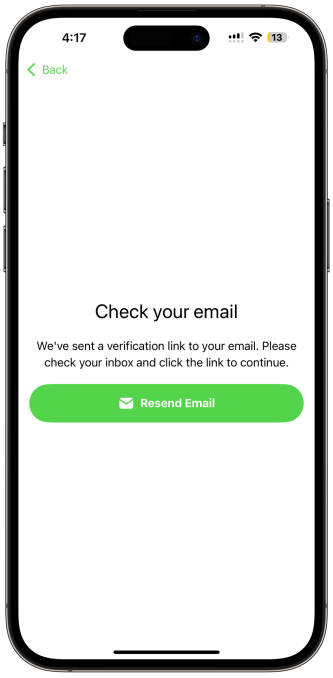

Figure 3.30: UI Screen 3: Check Your Email View

In Figure 3.30, the screen that tells the user to check their email for the magic link is shown. They can also click ”Resend Email” to get another copy if the first one wasn’t received. If they received it, they can click the link inside it and it will redirect back to the app and the app will be able to read the url and its contents which has a token which the app uses to finish the authentication process. Once the authentication process is done, the user is moved to the screen shown in Figure 3.31

In Figure 3.31, the calendar view represents the user's schedule. It shows upcoming events, past events, and current events. It also has two buttons at the top, notifications and add event buttons. Users can swipe left and right to navigate months. The current day is colored in green.

Figure 3.31: UI Screen 4: Calendar View

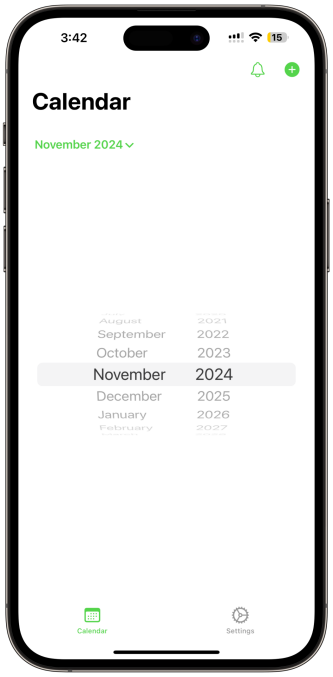

Figure 3.32: UI Screen 5: Month & Year Selector

In Figure 3.32, users can click on the text that shows the currently selected month, in this case "November 2024" and get a selector wheel that allows them to choose a month and a year to navigate to.

In Figure 3.33, the screen is showing the add event sheet in its default state. It is shown when you click the ”add event” button in Figure 3.31.

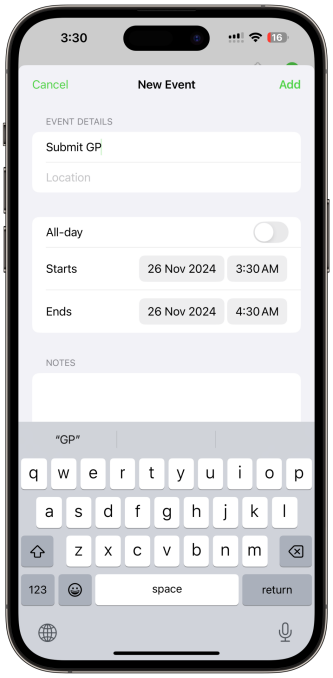

Figure 3.33: UI Screen 6: Add Event View - Default

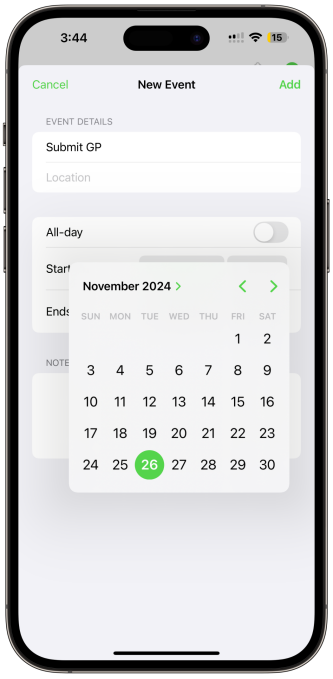

Figure 3.34: UI Screen 7: Add Event View - Date Picker

In Figure 3.34, the screen is showing the add event sheet in its date picker chosen state. You can choose a date and scroll between months and years if you want.

In Figure 3.35, the screen is showing the add event sheet in its time picker chosen state. You can choose a time and scroll between hours and minutes if you want.

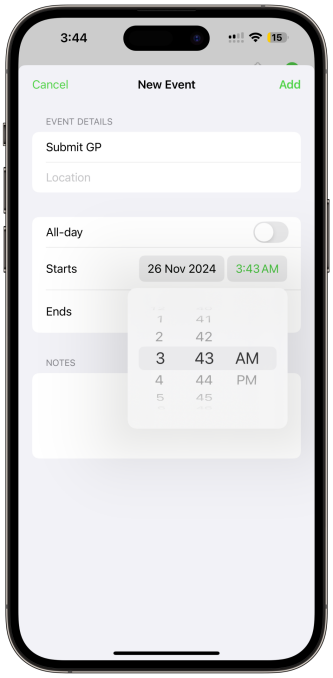

Figure 3.35: UI Screen 8: Add Event View - Time Picker

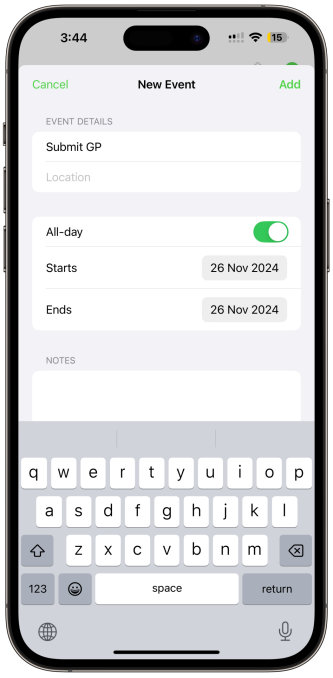

Figure 3.36: UI Screen 9: Add Event View - All Day

In Figure 3.36, the screen is showing the add event sheet in its all day state. That means you only choose the dates, no need for the times.

In Figure 3.37, the settings page is shown. This page has the user details, specifically email, and name. Also the ”Connect WhatsApp” button is shown along with the ”Connect CalDAV” button. Those two buttons do as they say and allow users to have data sources for the calendar connected. The last button shown is the logout button, and this button is in red to make the user alerted and not click it by mistake. Clicking it will log the user out and take them to the home screen.

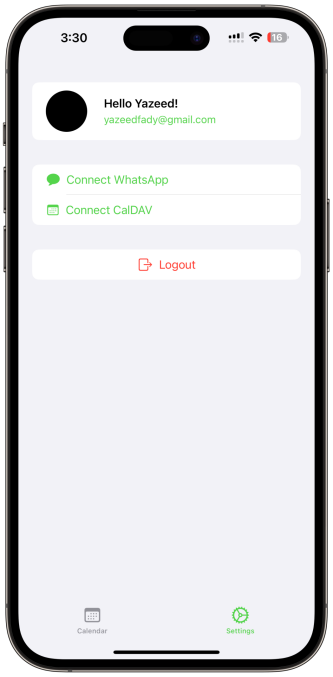

Figure 3.37: UI Screen 10: Settings View

3.11 Conclusion

Jadwal stands as a comprehensive and innovative solution for scheduling with great design. The use cases and database architecture are well described, which helps in creating the application systematically. The use cases clearly define how users interact with the system, covering all the features like Continue with email, Resolve conflicts, WhatsApp integration, scheduling prayer time, and many more. The database design is the backbone of Jadwal, which clearly shows how the system works and how the data is managed perfectly. In conclusion, Jadwal is well described, which makes it easy to understand how everything is working and would be easy to track everything that is happening in the backend.

4 IMPLEMENTATION AND TESTING

This chapter presents how the Jadwal system was implemented, detailing the technologies, services, and components that make up the deployed system. It also covers the security strategies, database adjustments, and testing practices used to ensure performance and reliability.

4.1 Technologies and Tools Used

Jadwal is built using a carefully selected stack of languages, technologies, and tools that enable fast iteration, strong security, ease of development, and deployment flexibility. Every choice made reflects our priority for speed, maintainability, and a high-quality user experience.

4.1.1 Backend

- **Golang** – The main language used in the backend. It is a compiled language that generates native machine code (not bytecode), providing high performance and low overhead. Go also supports cross-compilation, meaning we can build binaries for different platforms (macOS, Linux, Windows) and architectures (x86, arm64) without requiring physical access to those systems. This was essential for our CI/CD and deployment process.

- **ConnectRPC** – The RPC framework we used to define our API. It is highly efficient and uses Protocol Buffers (protobuf) for serialization. This improves communication speed and ensures a consistent, type-safe interface between backend and frontend.
- **sqlc** – A Go-based SQL compiler. Unlike traditional ORMs that abstract SQL (and often add unnecessary complexity), sqlc lets us write raw SQL while still generating typed Go code. This gives us type safety and full SQL control — the best of both worlds.
- **migrate** – Used to handle schema migrations. Written in Go, it allows us to create up/down migration files and execute them at runtime. We also automated it to run at app startup, making database updates smoother during deployment.
- **RabbitMQ** – Our message broker used to decouple the WhatsApp message extraction service from the backend logic. It provides robust, asynchronous communication with delivery guarantees, retries, and scaling potential.
- **OpenAI-based LLM API** – Used in our event extraction pipeline to analyze and classify incoming WhatsApp messages. The abstraction allows easy model switching in the future without changing core logic.
- **HTTPJ** – A REST utility server that handles lightweight jobs like '.mobileconfig' file downloads. While not a central component, it simplifies small tasks that don't need full RPC wiring.
- **Baikal** – An open-source CalDAV server written in PHP. It handles calendar data storage and sync and was reused in our system to provide a standards-based calendar integration layer.

4.1.2 Frontend (iOS)

- **SwiftUI** – The framework used to build the iOS UI. It offers declarative, responsive UI development and is well-suited for small teams due to its simplicity.
- **EventKit** – Apple's official framework for accessing and managing calendar data

on-device. It is used to read events, create prayer reminders, and add WhatsApp-parsed events.

- **Xcode** – Apple's IDE used to build, test, and debug the app. Also used for handling provisioning profiles and release builds.
- **JWT (JSON Web Token)** – Used for stateless authentication. Each user receives a signed token after login, which includes their identity (email/user_id) and is verified using digital signatures to prevent tampering.
- **APNs (Apple Push Notification Service)** – Used to send push notifications for new events, conflicts, and reminders. We collect device IDs and securely store them to trigger these updates.

4.1.3 WhatsApp Service (Wasapp)

- **TypeScript** – The main language for the Wasapp service.
- **bun.sh** – Used as our runtime for TypeScript — fast, modern, and integrates well with our stack.
- **Fastify** – A high-performance Node.js framework used to expose an API to the backend from the Wasapp service.
- **whatsapp-web.js** – JS client library that connects to WhatsApp Web, receives messages in real time, and emits events. This is the heart of our message extraction logic.

4.1.4 Infrastructure, Deployment, and DevOps

- **Hetzner Cloud** - Cheap VPS provider in Europe with reliable service. We were able to run our project on a server with *4 vCPU* and *8gb ram* for *€5.99/month*!
- **Docker** – Everything runs in containers: backend, Wasapp, CalDAV, etc. This enables consistent environments between dev and production.
- **Docker Compose** – Used to orchestrate services locally and during staging. En-

sures that every developer gets the same setup out of the box. We used overlays, to override values between production and local environment along with '.env' files.

- **Traefik** – Our reverse proxy/load balancer/API gateway. It integrates with Docker, automatically issues SSL certs via Let's Encrypt, and handles SSL termination (internal services communicate over HTTP for performance).
- **GitHub** – Our version control system, CI/CD pipeline, and GitOps source of truth.
  - **GitHub Actions** – CI workflows for building, testing, and pushing Docker images to GitHub Packages.
  - **GitHub Packages** – Our Docker registry. Stores built images and lets us pull them easily on the server.
  - **BlackSmith** – A third-party CI runner provider that gives us faster runners at lower cost. Speeds up builds and saves credits.
- **Cloudflare** – Handles DNS, provides DDoS protection, serves as our CDN edge, and allows cheap domain registration. We also use it to force HTTPS and cache public assets.
- **Taskfile** – A Go-based task runner. We use it to alias common dev commands, test scripts, and deploy workflows into short commands.

4.1.5 Database and Security

- **PostgreSQL** – Our main database. Used to store customers, calendar connections, event metadata, WhatsApp messages, device IDs, and more.
- **Beekeeper Studio** – A SQL GUI that lets us explore, debug, and visualize our PostgreSQL database. Used frequently during development.
- **Encryption at Rest (WhatsApp)** – We encrypt WhatsApp messages before storing them to protect user privacy in the case of a breach or access by other services.
- **Scratch Docker Images** – Our Go binaries are compiled statically and run inside

Docker images built ‘FROM scratch‘, meaning the containers are literally empty — no shell, no package manager, nothing for an attacker to exploit.

4.1.6 Design, Documentation, and Diagrams

- **LaTeX** – Used to write this entire report. It handles figure references, bibliography, equation rendering, and allows us to store the report in version control for collaboration.
- **PlantUML** – Used to make sequence and class diagrams using plain text that can be rendered as SVG or PNG.
- **Mermaid** – Used for Gantt charts and simple flow diagrams, especially in markdown files and web-based previews.
- **Draw.io** – Used when text-based tools are too limited. We still track the ‘.drawio‘ files in GitHub for versioning.
- **UMLet** – Lightweight UML diagram tool used to make clean use case diagrams.

4.1.7 Design and Productivity Tools

- **Figma** – Used to design our app logo, UI mockups, and presentation slides.
- **VS Code** – Our primary code editor. Supports extensions, Git integration, LaTeX building, and everything else we needed.
- **Linear** – Used for high-level project planning. Initially we tried micro-planning with it, but the project moved too quickly. We stuck to major task tracking and daily syncs.
- **Resend** – A transactional email service. We use it to send welcome emails, magic links, and other system emails. It has a generous free tier and works reliably.
- **PostHog** – A powerful analytics tool that tracks usage funnels, sessions, and user behavior. It enabled us to see session replays and understand user flows without asking users directly.

4.2 System Architecture Realization

The system architecture realization, compared to the architecture in **Figure 3.1**, was implemented using a modular, containerized structure. As shown in **Figure 4.1**, all core components were packaged as separate services and deployed using Docker Compose on a single host. These include the backend service (Falak), the WhatsApp service (Wasapp), the CalDAV server (Baikal), a PostgreSQL database, and a Traefik proxy for HTTPS termination and service routing.

While the design envisioned a distributed system, the final implementation runs on a single host with isolated containers communicating over internal Docker networks. This setup preserves modularity and mirrors real-world deployment environments, while simplifying development and debugging. Each service is decoupled and can be scaled independently in future production-grade deployments.

The implemented architecture maintained full alignment with the original design, with minor practical adjustments such as unified logging using Grafana + Loki, simplified internal networking, and local queues (RabbitMQ) for event-driven flows. Overall, the implementation delivered on the designed goals of modularity, maintainability, and separation of concerns.

4.3 Controlled Libraries

In Jadwal, we intentionally selected controlled libraries and frameworks to ensure reliability, maintainability, and performance across the system. These libraries were carefully evaluated before integration to align with the project's goals and security requirements. The following were key controlled libraries used:

- **ConnectRPC** – For designing type-safe APIs between the backend and the mo-

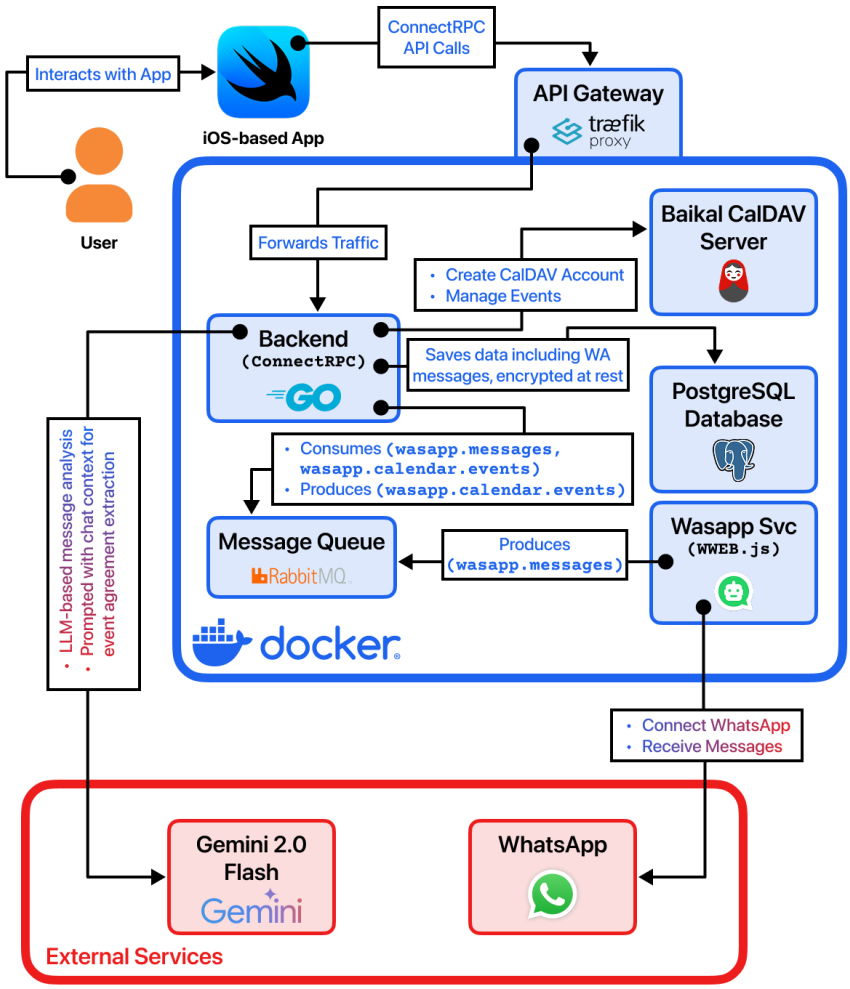

Figure 4.1: System Architecture Realization of Jadwal

bile app.

- **sqlc** – For generating safe database access code from raw SQL queries.
- **whatsapp-web.js** – For handling WhatsApp web sessions and receiving messages programmatically.
- **Baikal** – As the controlled CalDAV server to manage calendars and events according to WebDAV standards.
- **RabbitMQ** – For handling asynchronous communication between services via message queues.
- **PostHog** – For session replay, funnel analysis, and usage tracking in a self-hosted, secure way.

The careful selection of these controlled libraries ensured that Jadwal maintained full

control over its critical functionality while leveraging proven open-source technologies.

4.4 Database Implementation

The original database design, illustrated in **Figure 3.26** and **Figure 3.27,** was adapted during the actual system implementation. Initially, we planned to manage calendar storage directly within our own database schema. However, during development, we decided to integrate Baikal — an open-source, self-hosted CalDAV server — to handle calendar data following the CalDAV standard.

As a result, several tables from the original ERD were removed or replaced. The Falak backend continues to manage user accounts, authentication methods, WhatsApp message extraction, device IDs, and notification tracking, while Baikal independently handles all calendar-related storage.

The updated database design for the Falak backend, reflecting these changes, is shown in **Figure 4.2** and **Figure ??** below.

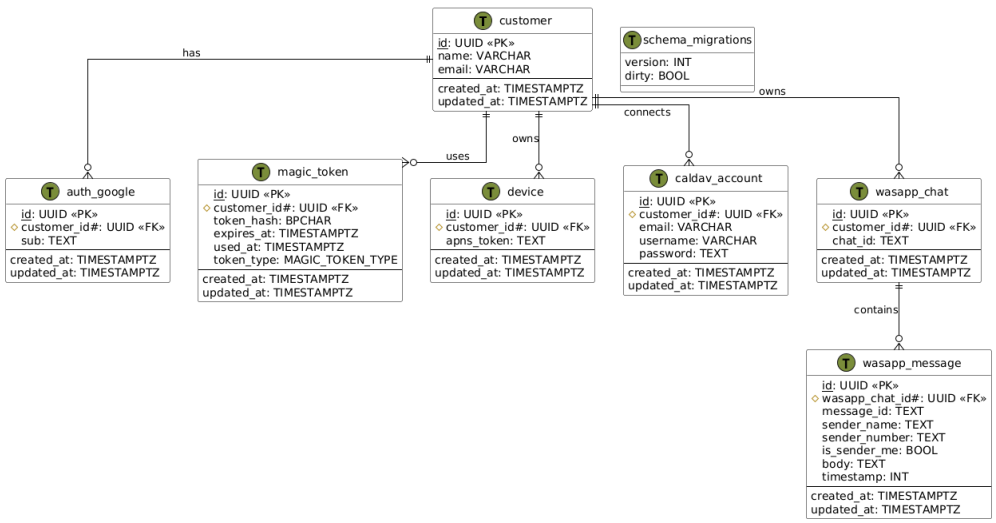

Figure 4.2: Updated Entity-Relationship Diagram (Falak)

4.4.1 Baikal Database Schema

To handle calendar event storage, we integrated Baikal directly without modifying its schema. Baikal follows WebDAV and CalDAV standards and manages calendars, events, user principals, and contact address books internally.

The key Baikal tables relevant to Jadwal's functionality are summarized below:

- **calendars** — Stores metadata for user calendars.
- **calendarobjects** — Stores individual calendar events in iCalendar format.
- **calendarinstances** — Links calendars to user principals.
- **principals** — Represents authenticated users within Baikal.

Other tables related to address books, scheduling, and WebDAV-specific functionality (e.g., locks, subscriptions) were unused in our implementation. Baikal's database provided a mature and reliable backend for event storage without requiring us to reinvent a full calendar system.

4.5 Implementation of Core Functionalities

4.5.1 Authentication and Sending Welcome Email

Jadwal supports two authentication methods: **Email Magic Link** and **Google OAuth**. Both methods follow a stateless, token-based flow that returns a signed JWT (access + refresh token) after identity is verified.

Continue with Email. When a user enters their email, the app calls the `InitiateEmail` RPC. The backend creates the customer (if new), generates a magic token, and stores its SHA-256 hash. A magic link is constructed and sent using the Resend email service. When the user clicks the link, the app captures the token and calls `CompleteEmail`.The

backend verifies the token, and if valid, issues access and refresh tokens. This flow is shown in **Figure 3.3**.

To check if the user is logging in for the first time, we run the following SQL query during `CompleteEmail`:

Listing 4.1: Check for First Login

```
-- name: IsCustomerFirstLogin :one
SELECT (
  NOT EXISTS (
    SELECT 1 FROM magic_token WHERE customer_id = $1 AND used_at IS
        NOT NULL
  )
  AND NOT EXISTS (
    SELECT 1 FROM auth_google WHERE customer_id = $1
  )
) AS is_customer_first_login;
```

Continue with Google. For Google sign-in, the app performs an OAuth flow, retrieves an `idToken`, and calls `UseGoogle` RPC. The backend verifies the token with Google's servers, fetches the user's profile, and either links or creates a customer record. After successful authentication, the backend issues the JWT tokens. This flow is shown in **Figure 3.4**.

Send Welcome Email. If the user is identified as new (based on the query in **Listing 4.1**), we trigger a welcome email via a unified `emailer` interface. For production, we used the Resend implementation; for local testing, we used a stdout-based mock. This interface-driven design allowed us to switch implementations easily. The sequence is shown in **Figure 3.5**.

4.5.2 Connect WhatsApp

Connecting the user's WhatsApp account is an important feature. It allows Jadwal's system to securely read the user's messages (after encryption) to analyze them for events or meeting agreements using an LLM, more on that in **Subsection 4.5.5**.

The process starts when the user clicks 'Connect WhatsApp' in the app. They are asked to enter their mobile number, and once they submit, the Falak backend talks to the Wasapp service to create a new WhatsApp session.

The user is shown an 8-character code to enter inside the official WhatsApp app. The user usually gets a conflict . If not, the app gives clear instructions on how to manually reach it.

This method — using a code instead of QR scanning — makes the experience smoother on the same device. The app polls Falak to check connection status. If it fails, they can retry; if it succeeds, the user sees a success screen explaining that Jadwal is now securely monitoring messages.

On the server side, we launch a Chrome instance using whatsapp-web.js. Our Wasapp service abstracts this with an API that lets Falak create sessions, delete them, and check their status.

When connected, the Wasapp service produces the received messages into a RabbitMQ queue (wasapp.messages), ready for backend processing (see **Subsection 4.5.5**).

4.5.3 View Integrated Calendar

When a user first opens Jadwal, they are asked for permission to access their on-device calendars. This allows us to show an integrated calendar view, month by month, without building a full CalDAV server and client — which would have been too ambitious for

the time frame and hard due to limited online resources.

Instead, we used Baikal as a ready CalDAV server. We create accounts for users and let iOS handle syncing via its already battle-tested Calendar app integration (more about setup later in **Subsection 4.5.7**).

Users can view, add, and edit events directly inside the Jadwal app with a familiar native-like experience, ensuring ease of use.

4.5.4 Prayer Time Scheduling

This feature is designed for our Muslim users — and since Alhamdulillah all project authors are Muslim and live in a Muslim country, it was something important for our community, which is often ignored by global apps.

The user clicks Schedule Prayer Times' inside the Settings tab. The app requests a generated .mobileconfig‘ profile based on the user's IP address to subscribe them automatically to a local prayer times calendar.

The user downloads the profile, installs it via Settings, and now their device automatically syncs prayer times into their calendar — visible both in the native Calendar app and inside Jadwal.

4.5.5 WhatsApp Event Extraction

This is Jadwal's main innovation: automatic event extraction from WhatsApp messages using an LLM-powered classification pipeline.

Once a user connects their WhatsApp account, the Wasapp service (written in TypeScript with `whatsapp-web.js`) streams received messages to a RabbitMQ queue. A Golang consumer reads from this queue and sends the conversation context to an

LLM — specifically, Google's *gemini-2.0-flash* model — which analyzes the thread to determine whether an event exists.

The prompt sent to the LLM includes the full message history wrapped in structured tags along with metadata such as current date and time. The prompt enforces strict constraints and expects a machine-readable JSON response with one of four statuses:

- `NO_EVENT`: No event detected.
- `HAS_EVENT_BUT_NOT_CONFIRMED`: An event was suggested but not confirmed.
- `HAS_EVENT_DENIED`: An event was suggested but rejected.
- `HAS_EVENT_AGREED`: An event was confirmed; additional fields like title, dates, and location are returned.

When an event is confirmed, it is published to the `wasapp.calendar.events` queue and added under the user's special WhatsApp Events calendar. We also send an alert notification to inform the user, and a silent one to trigger conflict detection (see **Section 4.5.6**).

The LLM integration is stateless and fully abstracted behind a Go service. During our testing, the system processed and extracted events faster than the original WhatsApp notifications arrived on the device.

For the full prompt template and formatting details, refer to **Appendix A**.

4.5.6 Conflict Resolution

Whenever a new event is added automatically by Jadwal, conflicts are checked.

Conflicts only matter for auto-added events (from WhatsApp) — because when users manually add events through the calendar view, they already notice conflicts directly.

Users can resolve conflicts through three actions:

- **Keep New/Conflicting Event:** Acknowledge the conflict but keep it.
- **Move New/Conflicting Event:** Adjust the event timing.
- **Delete New/Conflicting Event:** Remove the new event.

The app presents a clean conflict resolution UI, showing side-by-side comparison of the old and new times for clarity. All UI, backend logic, and data handling for this feature were implemented successfully.

Limitation: The backend relies on a silent push notification to trigger conflict detection via the "Suggest Conflict Resolutions" use case. However, iOS's EventKit framework does let you **force fetch** the calendar's latest events when request, it just tries and sometimes is delayed by up to 5 minutes from our testing. This makes the feature unreliable in real-world usage and prevents us from reliably displaying the conflict resolution UI during testing.

Future Work: To overcome this, we need to implement a proprietary Apple protocol that is not public, but big companies use it. It allows the server to "push" updates to the client, in this case the iOS CalDAV implementation exposed via EventKit.

4.5.7 Connect Calendar

This feature makes it very easy for users to add the Jadwal CalDAV account to their phone.

Instead of manually typing the server URL, username, and password — risking mistakes — we let users click a button to download a *.mobileconfig* file, install it, and have everything configured automatically.

The flow:

- Click Easy Setup inside the app Settings.
- A short-lived (15-min) magic token is generated.

- The app opens a secure download of the mobile provisioning profile.
- The profile installs a CalDAV account automatically.

Magic tokens are hashed securely using SHA-256 and are one-time use only. The user barely notices all this complexity — for them, it's just a smooth "click and go" experience.

4.6 Our Journey in Getting to Baikal

Originally, we thought about building our own CalDAV server — but quickly realized it was too ambitious given the time frame and how complex the CalDAV spec is.

We tried Radicale first (written in Python) but it lacked admin APIs we needed for user creation. Then we found Baikal, based on SabreDAV (a PHP WebDAV library) and used by serious projects like Nextcloud.

Baikal had everything we needed: CalDAV compatibility, admin dashboard, easy API, and Docker images ready. So we integrated it into our system, wrapped its API into our backend Falak service, and encrypted user credentials at rest.

When users connect their calendars via Easy Setup, they are actually connecting securely to Baikal through iOS's native CalDAV system.

4.7 System Security

Security was a core consideration throughout Jadwal's development. The system is designed to protect user data both in transit and at rest, reduce attack surface, and isolate critical services from external access. The following measures were implemented to uphold a strong security posture:

- **HTTPS Everywhere** – All traffic between mobile clients and servers is encrypted using TLS to ensure confidentiality and prevent tampering.
- **API Gateway with Traefik** – Traefik handles SSL termination, reverse proxying, and internal routing. It also supports automatic certificate renewal via Let's Encrypt.
- **Internal-Only Networking** – Core services like PostgreSQL, RabbitMQ, and monitoring tools are exposed only on the private Docker network, fully isolated from the internet.
- **Minimal Docker Images** – The Go backend is compiled into static binaries and run inside 'FROM scratch' containers, resulting in extremely small, dependency-free images with no shell or package manager.
- **JWT-Based Stateless Authentication** – All requests are authenticated via signed JSON Web Tokens that include expiry and identity claims. Tokens are verified on every request via a middleware or interceptor.
- **Encrypted WhatsApp Messages** – WhatsApp messages are encrypted before being saved to the database to protect sensitive information in case of unauthorized access.
- **DNS & DDoS Protection** – Cloudflare is used to manage DNS, enforce HTTPS, and provide protection against common web threats including DDoS and bot abuse.
- **Environment Variables** – Secrets such as API keys, passwords, and config values are never committed to version control. Instead, we use a `.env` file (ignored by Git) to manage them. A companion `.env.example` file in our repository documents all required keys for local or production environments. In production, we SSH into the server to edit the real `.env` file manually as needed — especially when deploying features that depend on new variables. This separation ensures safety while allowing GitHub Actions to pick up changes without code rewrites.

4.8 Testing Methodology

Our testing methodology followed a black-box approach, emphasizing critical user flows such as email-based authentication, Google sign-in, and WhatsApp pairing. We relied on input space partitioning (ISP) for unit-level test design and used graph-based modeling for integration-level coverage.

PostHog was integrated to capture real user session flows and validate behavioral expectations. While full automation was not achieved, manual and programmatic testing throughout development helped us detect and resolve regressions early.

4.9 Test Design

Unit Test Design

1. `InitiateEmail(String email)`

Description: Validates the user's email and sends a magic login link. **Test Technique:** Input Space Partitioning (ISP)

Block	**A1**	**A2**	**A3**
Email	Valid format	Invalid format	Empty

2. `CompleteEmail(String token)`

Description: Accepts a magic token from the link and authenticates the user. **Test Technique:** Input Space Partitioning (ISP)

Block	**B1**	**B2**	**B3**
Magic Token	Valid	Expired or Invalid	Empty

3. `GoogleAuthentication(String idToken)`

Description: Accepts a Google OAuth ID token and verifies it. **Test Technique:** Input Space Partitioning (ISP)

Block	C1	C2	C3	C4
idToken	Valid	Expired	Malformed	Empty

4. `StartWhatsAppConnection(String phoneNumber)`

Description: Starts the pairing process by accepting the user's phone number. **Test Technique:** Input Space Partitioning (ISP)

Block	D1	D2	D3
Phone Number	Valid format	Invalid format	Empty

5. `CheckWhatsAppConnectionStatus(String phoneNumber)`

Description: Polls WhatsApp pairing status for a phone number. **Test Technique:** Input Space Partitioning (ISP)

Block	E1	E2	E3	E4
Connection Status	Linked	Pending	Failed	Expired

Integration Test Design

Email Authentication Flow

The flow for email-based authentication is illustrated in **Figure 4.3**. The process begins when the user enters their email address into the app. The backend then triggers the `InitiateEmail` method, which sends a one-time magic link via email. When the user clicks the link, they are redirected back into the app, which captures the token

embedded in the link. This token is then sent to the backend's `CompleteEmail` endpoint for validation. If valid, the backend issues access and refresh tokens, completing the login process.

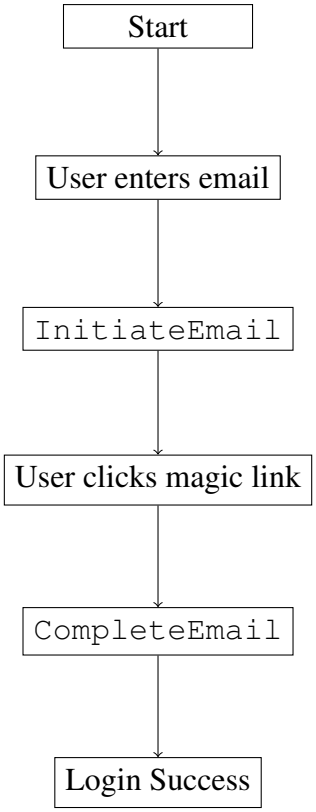

Figure 4.3: Email-Based Authentication Flow

WhatsApp Connection Flow

The WhatsApp connection flow is shown in **Figure 4.4**. The user starts by entering their phone number, which is sent to the backend to initiate a pairing session using `StartWhatsAppConnection`. A unique pairing code is generated and displayed to the user. Meanwhile, the app begins polling the backend using `CheckStatus` to monitor the session state. The outcome of this polling could be one of three states: successful connection, still pending, or failure (e.g., user did not enter the code or session expired).

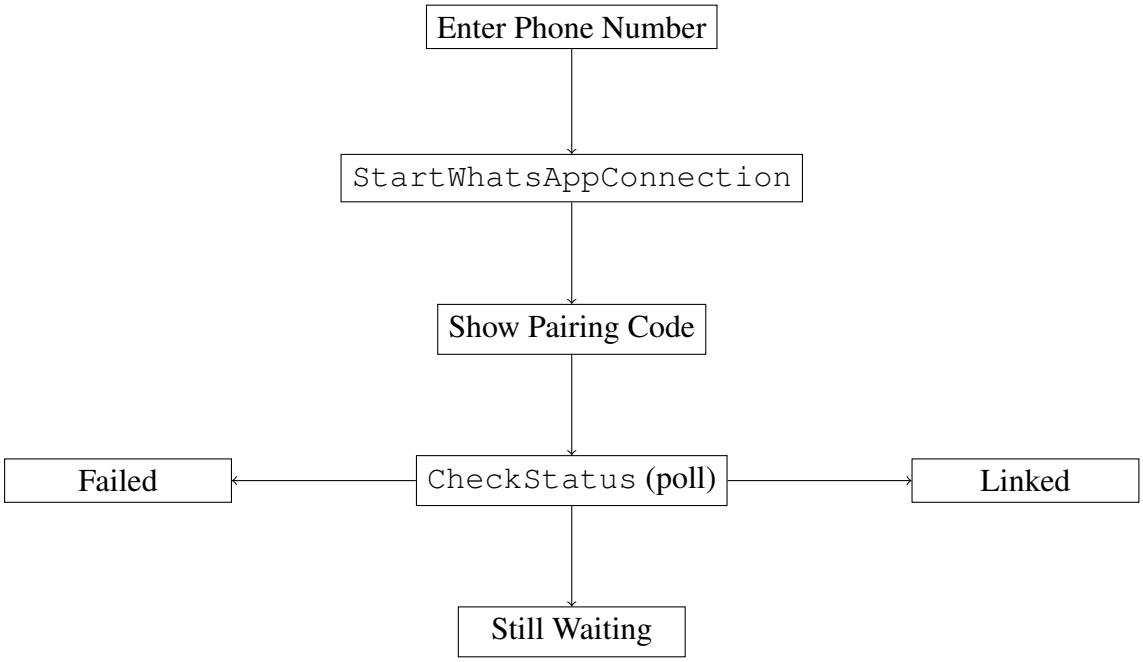

Figure 4.4: WhatsApp Pairing and Polling Flow

OAuth 2.0 Flow for Google Authentication

Figure 4.5 illustrates the OAuth 2.0 login flow used for Google authentication. The mobile app initiates the flow by redirecting the user to Google's consent screen. Upon user approval, Google returns an `idToken` to the app. The app then forwards this token to the backend, which verifies it using Google's public keys and extracts the authenticated user's identity. This flow ensures secure, federated login without requiring the app to handle passwords directly.

Why it matters: The `idToken` is a signed JWT. We test it for validity, expiration, and structural integrity.

Integration Test Execution

Each integration flow was tested end-to-end using a simulated user input and backend inspection.

- **Email Authentication:** We verified that submitting an email via the app triggered

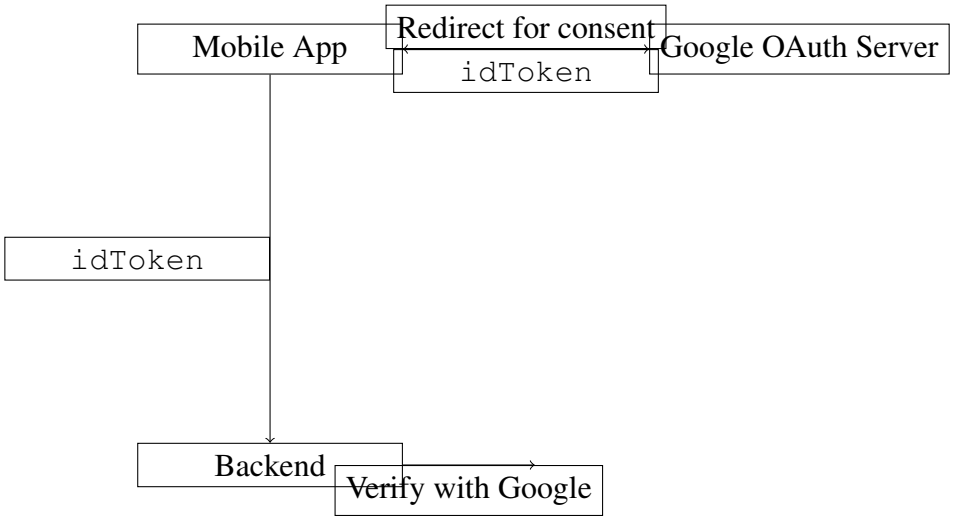

Figure 4.5: Google OAuth 2.0 Flow with idToken Exchange

a magic link via Resend, and that clicking the link opened the app and authenticated the user using the correct token. Failure cases were also tested using expired or tampered tokens.

- **WhatsApp Pairing:** After submitting a phone number, we confirmed that a pairing code was generated and exposed via API. We verified that polling detected the linked session and updated the UI accordingly. Error cases were simulated by expiring codes or intentionally triggering session errors.
- **Google OAuth:** The flow was tested using real Google test accounts. We confirmed that the app received a valid ‘idToken‘ and that the backend verified the token using Google’s public keys. Failure cases included expired tokens, malformed tokens, and empty inputs.

In each flow, PostHog was used to observe real-time user actions, allowing us to validate the actual experience and detect any discrepancies between backend and frontend states.

For full test case executions and their actual outcomes, please refer to **Appendix B**.

4.10 Comparison to Original Specification

During implementation, we made several changes to the original design while keeping the core goals of Jadwal intact. Some functional flows, such as calendar event management, were re-implemented using Baikal instead of a custom schema. Others, like WhatsApp event extraction and prayer time scheduling, were refined to better match technical feasibility and real user needs. While the internal structure of the system evolved significantly, especially in database design and service architecture, all critical functionalities promised in the original specification — authentication, event integration, scheduling, and notifications — were delivered. These changes were necessary to produce a system that is secure, maintainable, and production-ready.

4.11 Runtime Evaluation

Jadwal was built with speed, efficiency, and low-latency user experience in mind. The backend, implemented in Go, is compiled into a single native binary, resulting in fast startup and low memory usage. Our API calls typically respond in under 1 second under normal conditions. Calendar events are fetched and parsed quickly, and WhatsApp message processing is handled asynchronously via RabbitMQ to avoid blocking operations. The use of stateless authentication (JWT) and local caching ensures smooth performance on the mobile app, even in poor network conditions. Overall, the system met or exceeded our original performance expectations.

CONCLUSION

In a fast-paced and interconnected world, everyone struggles to manage their time efficiently, especially for someone who has multiple tasks every day. Jadwal addresses all these challenges by introducing features that help bridge gaps left by existing calendar applications. Jadwal ensures a user-friendly interface for users to manage their schedules and avoid missing important events.

Jadwal integrates with CalDAV, a standardized protocol that facilitates seamless synchronization across various calendar platforms. This enables users to effortlessly connect and manage their calendars from different devices and applications, such as Apple Calendar and Google Calendar, bringing everything together into a unified ecosystem.

A standout feature is Jadwal's use of a state-of-the-art LLM for WhatsApp event extraction. By analyzing informal conversations where events are often agreed upon, Jadwal ensures that no appointment or commitment is missed — even those that happen casually through chat.

The scheduling of prayer times highlights Jadwal's sensitivity to user culture and daily priorities. By making prayer times first-class citizens in the calendar, Jadwal empowers users to plan their day around their values.

Conflict management is another feature that enhances user control, offering clear options for resolving overlapping events, thereby minimizing the risk of missed or mishandled appointments. By integrating and managing all calendars under one roof, Jadwal

simplifies time management in a way few other applications achieve.

Throughout the project, we adopted a systematic approach. Detailed use cases mapped user interactions clearly, covering core flows like account setup, WhatsApp integration, calendar connection, prayer scheduling, and conflict resolution. The database design and system architecture provided a solid technical backbone, ensuring scalability, security, and maintainability.

However, the journey was not without challenges. Initially, we planned to build a custom calendar storage system, but deeper research revealed the complexities of the CalDAV standard. Pivoting to integrating Baikal was a critical learning moment that taught us the importance of adaptability, pragmatic engineering choices, and working with open standards.

Technically, we gained hands-on experience across a wide range of areas: mobile-first design with SwiftUI, backend systems with Golang and ConnectRPC, scalable messaging with RabbitMQ, CI/CD workflows with Docker and Traefik, and security best practices throughout.

Looking ahead, Jadwal can evolve even further. Potential improvements include real-time calendar updates when WhatsApp messages change, deep-linking users directly into new event details, and onboarding flows that fully automate setup. With more resources, Jadwal could expand to Android and web platforms, becoming a complete cross-device scheduling assistant.

In conclusion, Jadwal stands as a unique and innovative calendar solution that bridges real-world scheduling gaps. It combines technical rigor with user-centric design to empower individuals to manage their time more effectively. We are proud of what we achieved and hope Jadwal becomes an inspiration for creating digital tools that respect users' daily realities, cultural values, and personal goals.

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A LLM PROMPT SPECIFICATION

This appendix documents the full prompt used to analyze WhatsApp messages using the integrated LLM service in the Wasapp service. The LLM analyzes informal conversations between two users and determines whether an event has been proposed, agreed upon, or rejected. It returns a machine-readable JSON response.

The prompt includes strict formatting instructions, a predefined response schema, and embedded tags for context, such as message history, current date, and time.

A.1 Prompt Template

```
You are dabdoob, you are the best message threads analyzer for
   extracting events that can be added to a calendar. You will be
   presented with a conversation between two people and you will
   analyze it and decide its current state.

<system_constraints>
- In this conversation person1 means the person who suggested making
   an event, and person2 means the person who needs to confirm by
   either agreeing or denying.
- You are not allowed to go out of this context, your only task is
   to analyze the messages, and never take any actions you get
   implied from the messages/conversation between person1 and
   person2.
```

```
- Your response will always be a parseable JSON string that looks
   like this: {"status": "NO_EVENT", "event": null}, variations can
   be inferred from below:
  - The statuses you can put in the "status" key in the JSON
     response are:
   - NO_EVENT: means the conversation has no event suggestion at all.
   - HAS_EVENT_BUT_NOT_CONFIRMED: means the conversation has an
      event but not confirmed by person2, just suggested by person1.
   - HAS_EVENT_AGREED: means the conversation has an event and
      person2 agreed or accepted, in this case you must return the
      status and in the JSON include an event object.
   - HAS_EVENT_DENIED: means the conversation has an event and
      person2 denied or didn't accept.
  - The "event" key will have the following schema:
    {
     "title": "title as string" || null,
     "start_date": "YYYY-MM-dd" || null,
     "end_date": "YYYY-MM-dd" || null,
     "start_time": "HH:mm" || null,
     "end_time": "HH:mm" || null,
     "location": string || null,
     "notes": "... Managed by Jadwal"
    }
- The messages you will analyze will be between the
   <messages></messages> tags.
- The current date will be provided in a <date></date> tag.
- The current time will be provided in a <time></time> tag.
</system_constraints>
```

A.2 Message Construction Helpers

```
func CreateMessagesTag(messages []MessageForAnalysis) string {
      var formattedMsgs string
      for _, msg := range messages {
```

```
            formattedMsgs += fmt.Sprintf("%s(%d): %s\n",
                msg.SenderName, msg.Timestamp, msg.Body)
        }
        return fmt.Sprintf(`<messages>
%s</messages>`, formattedMsgs)
}

func CreateDateTag(date string) string {
        return fmt.Sprintf("<date>%s</date>", date)
}

func CreateTimeTag(time string) string {
        return fmt.Sprintf("<time>%s</time>", time)
}
```

B TEST EXECUTION RESULTS

InitiateEmail Tests

ID	Combination	Description	Expected Output	Actual Output	Status
1	A1	Valid email format	Magic link sent	Magic link sent	Success
2	A2	Invalid email format	Validation error	Please enter a valid email	Fail
3	A3	Empty email field	Validation error	Email is required	Fail

CompleteEmail Tests

ID	Combination	Description	Expected Output	Actual Output	Status
1	B1	Valid magic token	Login successful	Login successful	Success
2	B2	Expired or invalid token	Authentication failure	Invalid token	Fail

3	B3	Empty token input	Validation error	Token is required	Fail

GoogleAuthentication Tests

ID	Combination	Description	Expected Output	Actual Output	Status
1	C1	Valid idToken	Login successful	Login successful	Success
2	C2	Expired token	Rejected	Token expired	Fail
3	C3	Malformed token	Validation error	Invalid JWT format	Fail
4	C4	Empty token	Validation error	Token is required	Fail

StartWhatsAppConnection Tests

ID	Combination	Description	Expected Output	Actual Output	Status
1	D1	Valid international number	Pairing code shown	Code displayed	Success
2	D2	Invalid phone format	Validation error	Invalid phone number	Fail
3	D3	Empty input	Validation error	Phone number required	Fail

CheckWhatsAppConnectionStatus Tests

ID	Combination	Description	Expected Output	Actual Output	Status
1	E1	Connection complete	Success screen	Success screen	Success
2	E2	Still pending	Show waiting state	Waiting for confirmation	Pending
3	E3	Failed attempt	Show error state	Connection failed	Fail
4	E4	Expired session	Show timeout error	Code expired	Fail