GoClub

Architecture of a Location-Aware Social Platform

CS3305-2025-Team-8 - University College Cork

February 2026

Abstract

This report documents the architecture of GoClub, a location-aware social platform built as part of CS3305 Team Software Project at University College Cork. It is written in the style of *The Architecture of Open Source Applications* (AOSA) — a format that asks not what a system does, but why it was built the way it was. That distinction is the lens through which every section of this report should be read.

Full service descriptions, API references, data models, and endpoint documentation are maintained as a living artefact at the project documentation site: theparliment.github.io/cs3305_2026_team_8. Readers seeking the internals of any individual service should go there. This report does not reproduce that material. It explains the thinking behind the architecture that documentation describes.

Three decisions shaped this project more than any others. First, how a team of four coordinated parallel development across five services without integration becoming a bottleneck — the answer involves Agile process, Git discipline, and documentation used as a development contract rather than a retrospective deliverable. Second, how a seven-container system was made to run identically on every developer's machine and demo reliably under pressure — the answer is Docker Compose, but the interesting part is the discipline behind it. Third, what happened when the team discovered that GPS coordinate data is fundamentally incompatible with a relational database under real-time load — the answer is Valkey, an in-memory geospatial store arrived at through deliberate research and tool selection rather than custom implementation. These three decisions are where the depth of this report lies. Everything else is supporting context.

Contents

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1 Introduction

Most student software projects, at their core, end up being a single service sitting on top of a database. GoClub is not that.

It is a location-aware social platform that depends on real-time data from active users, an event system with flexible visibility controls, a friend-circle model built around invitation state, and a wider community layer for broader group membership. All of these pieces need to work together, built by a team of four students under academic time pressure, across development environments that ranged from one laptop to another.

At the centre of the application is the idea of the **inner circle**: a small group of close contacts who share live location, making it possible to answer a simple spontaneous question

— who is nearby right now, and do they want to meet? Layered on top of this are Groups (communities based on shared interests) and Events (structured gatherings with RSVP and configurable visibility, similar in concept to Eventbrite but aimed at a university setting).

However, the most interesting part of this project is not the feature set. It is the engineering decisions the team was pushed into making by three problems that turned out to be far more difficult than expected:

- coordinating parallel development across multiple services
- achieving reproducible environments and deployments
- handling high-frequency, real-time GPS data that did not fit the assumptions of a traditional relational database

This report tells the story of those three problems, and how the architecture evolved in response to them.

2 Requirements and Constraints

2.1 Functional Requirements

Five core capabilities drove how the system was split into services.

Users need to be able to register, authenticate, and manage their profiles. They need to form inner circles — small, invitation-only groups of close contacts. They also need to join and create broader Groups based on shared interests, and create, discover, and RSVP to Events with flexible visibility (public, private, circle-only, or group-only).

On top of this, the platform supports real-time location sharing within a user's circle, allowing them to see who is physically nearby within a configurable distance.

The proximity feature introduces a constraint that none of the other features share: it requires continuous, high-frequency updates from active users. This has significant architectural implications and is explored in more detail in Section XXXX.

2.2 Non-Functional Constraints

Team size was the most consequential constraint. Four developers, each responsible for one or more services, with a fixed academic deadline juggling other course work. This created an immediate tension: microservices architecture enables parallel development, but it also introduces integration complexity and coordination overhead that a monolith avoids. The team had to earn the benefits of microservices by investing in the process and tooling that make parallel development safe.

Deployment environment was the second major constraint. The system needed to run identically on every team member's machine and produce a reliable demo. "It works on my machine" is not a viable outcome for a graded project. This constraint drove the containerisation decisions described in Section XXX.

Privacy was a real constraint, not an afterthought. Sharing real-time GPS coordinates with other users is sensitive. The architecture had to support granular controls: a user shares location with their circle but not with broader Groups or the public. This shaped both the data model and the JWT claims structure.

Scope was explicitly bounded. This is an academic project, not a production system. Certain production concerns — horizontal scaling aka Kubernetes, JWT refresh and revocation, message queues for asynchronous events — were out of scope. Acknowledging this is not an apology; it is honest engineering. The decisions made are appropriate for the constraints that existed.

3 System Overview

GoClub is composed of five backend microservices, an API gateway, a shared common library, a Valkey in-memory cache, and a Jinja-templated frontend. All components are orchestrated by Docker Compose into a single deployable stack. The service decomposition maps directly to the six functional domains: Frontend, Auth, Circles, Groups, Events and Proximity.

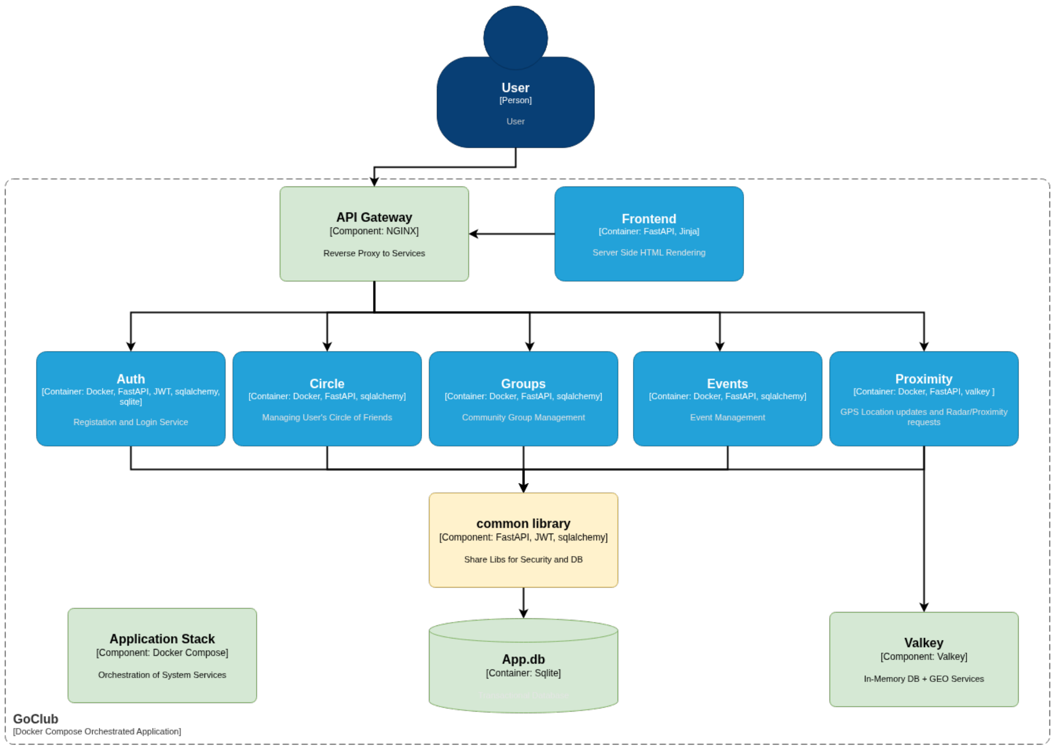

User
[Person]
User
API Gateway
[Component: NGINX]
Reverse Proxy to Services
Frontend
[Container: FastAPI, Jinja]
Server Side HTML Rendering
Auth
[Container: Docker, FastAPI, JWT, sqlalchemy, sqlite]
Registation and Login Service
Circle
[Container: Docker, FastAPI, sqlalchemy]
Managing User's Circle of Friends
Groups
[Container: Docker, FastAPI, sqlalchemy]
Community Group Management
Events
[Container: Docker, FastAPI, sqlalchemy]
Event Management
Proximity
[Container: Docker, FastAPI, valkey]
GPS Location updates and Radar/Proximity requests
common library
[Component: FastAPI, JWT, sqlalchemy]
Share Libs for Security and DB
Application Stack
[Component: Docker Compose]
Orchestration of System Services
App.db
[Container: Sqlite]
Valkey
[Component: Valkey]
In-Memory DB + GEO Services
GoClub
[Docker Compose Orchestrated Application]

Figure 1: GoClub Archiecture

Each service is a self-contained Python FastAPI application packaged as a Docker container, communicating with the outside world exclusively through the NGINX gateway. The common library is not a service; it is a shared Python package mounted into each service container at runtime, providing database session management, SQLAlchemy base models, and JWT processing utilities.

The gateway routes requests by URL path prefix: any request to `/auth/*` is forwarded to the Auth service, `/circles/*` to the Circles service, and so on. This design means adding a new service requires one additional to the NGINX configuration block.

Valkey sits alongside the relational database as a second data tier, serving exclusively the Proximity service. Its role and the reasoning behind its selection are the subject of Section XXX.

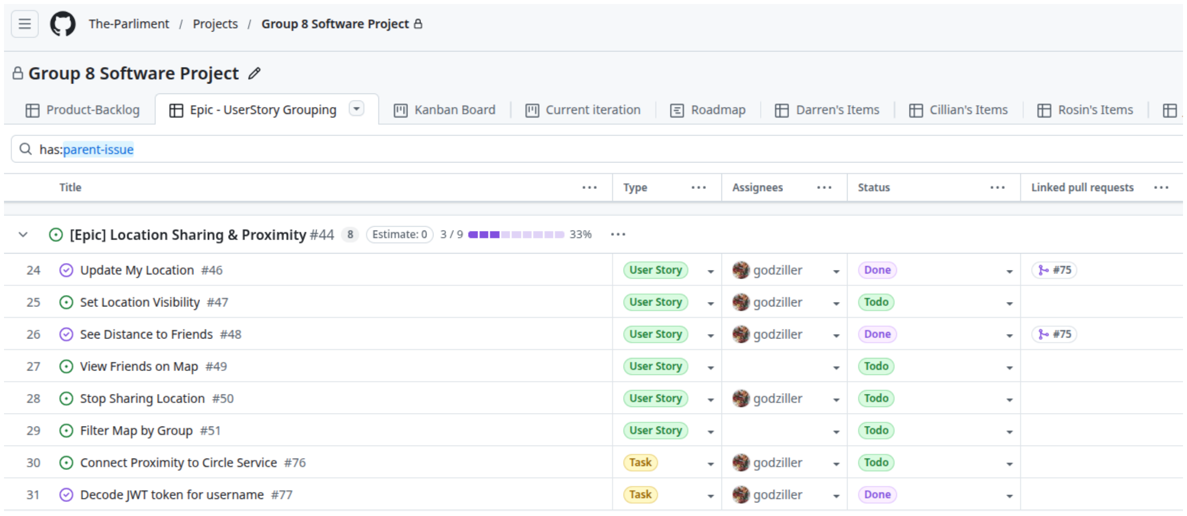
4 Challenge One — Coordinating Parallel Development

The microservices decomposition was not chosen because it is architecturally fashionable. It was chosen because the team needed to build six microservices simultaneously without each developer's work becoming a bottleneck for everyone else. That goal is only achievable if the coordination problem is solved. A microservices architecture with poor coordination is worse than a monolith: all the integration headache, none of the parallel development.

The team's response was three-layered: Agile process to align work to service boundaries, Git discipline to protect integration points, and documentation as a contract that enabled work to proceed before all services existed.

4.1 Agile Process and the Mapping of Stories to Services

The team used Google Projects to track work using epics and user stories. The team tried to make sure story boundaries matched service boundaries. An epic for "Proximity Feature" decomposed into stories that could each be owned by a single developer: the Valkey integration, the location update endpoint, the nearby-users query, and the frontend map component. These stories could be worked on in parallel because their integration points were agreed upfront as API contracts, not figured out the hard way when everything tried to merge at once.



The-Parliment / Projects / Group 8 Software Project

Group 8 Software Project

Product-Backlog | Epic - UserStory Grouping | Kanban Board | Current iteration | Roadmap | Darren's Items | Cillian's Items | Rosin's Items

has:parent-issue

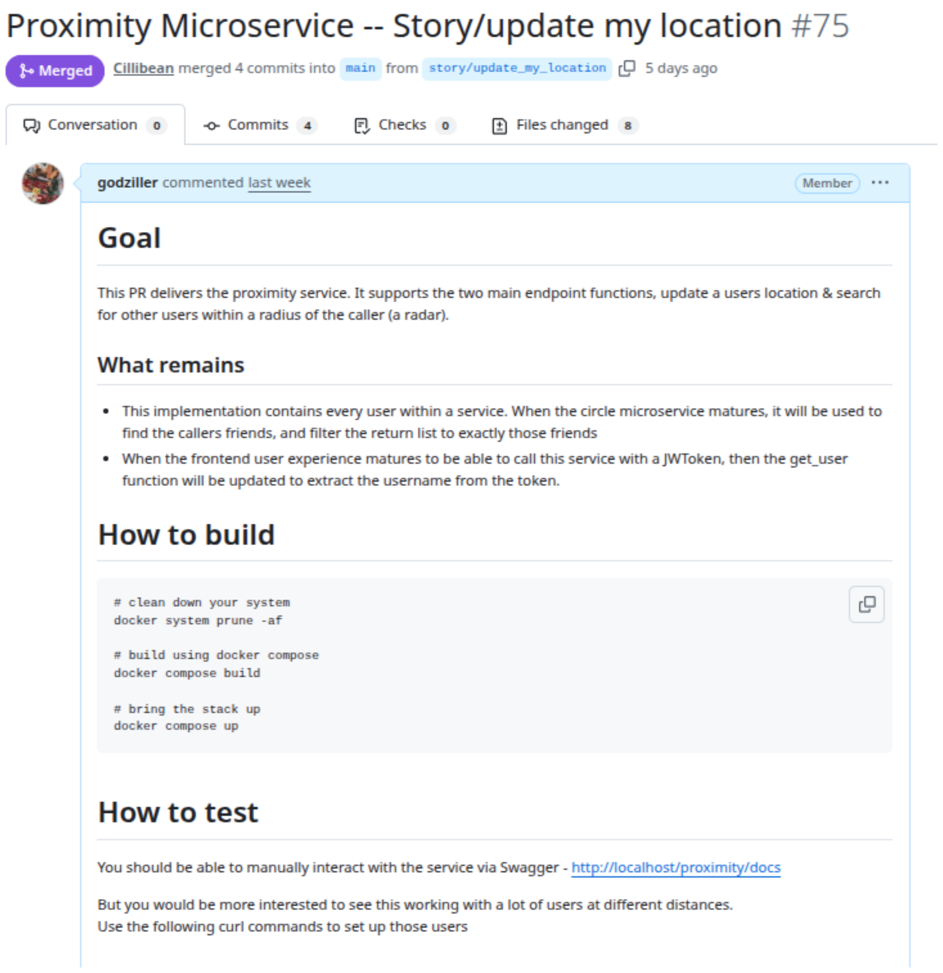
[Epic] Location Sharing & Proximity #44 8 Estimate: 0 3 / 9 33%

	Title	Type	Assignees	Status	Linked pull requests
24	Update My Location #46	User Story	godziller	Done	#75
25	Set Location Visibility #47	User Story	godziller	Todo	
26	See Distance to Friends #48	User Story	godziller	Done	#75
27	View Friends on Map #49	User Story		Todo	
28	Stop Sharing Location #50	User Story	godziller	Todo	
29	Filter Map by Group #51	User Story		Todo	
30	Connect Proximity to Circle Service #76	Task	godziller	Todo	
31	Decode JWT token for username #77	Task	godziller	Done	

Figure 2: Agile Epics and Stories

4.2 Git Discipline and the Pull Request as Integration Gate

Each story lived on its own feature branch. Code only reached main through a pull request, which acted as the team's integration gate — the point where a change went from "works on my machine" to "works in the system." With 50+ tracked issues across the project, this wasn't optional. Branch names followed the story structure, so there was always a clear line from a tracked issue to the code that closed it. Keeping this up consistently across four people over 8 weeks, especially under deadline pressure, was harder than it sounds.


Proximity Microservice -- Story/update my location #75
Merged
Cillibean merged 4 commits into main from story/update_my_location
5 days ago
Conversation 0
Commits 4
Checks 0
Files changed 8
godziller commented last week
Member

Goal

This PR delivers the proximity service. It supports the two main endpoint functions, update a users location & search for other users within a radius of the caller (a radar).

What remains

- This implementation contains every user within a service. When the circle microservice matures, it will be used to find the callers friends, and filter the return list to exactly those friends
- When the frontend user experience matures to be able to call this service with a JWToken, then the get_user function will be updated to extract the username from the token.

How to build

```
# clean down your system
docker system prune -af

# build using docker compose
docker compose build

# bring the stack up
docker compose up
```

How to test

You should be able to manually interact with the service via Swagger - http://localhost/proximity/docs

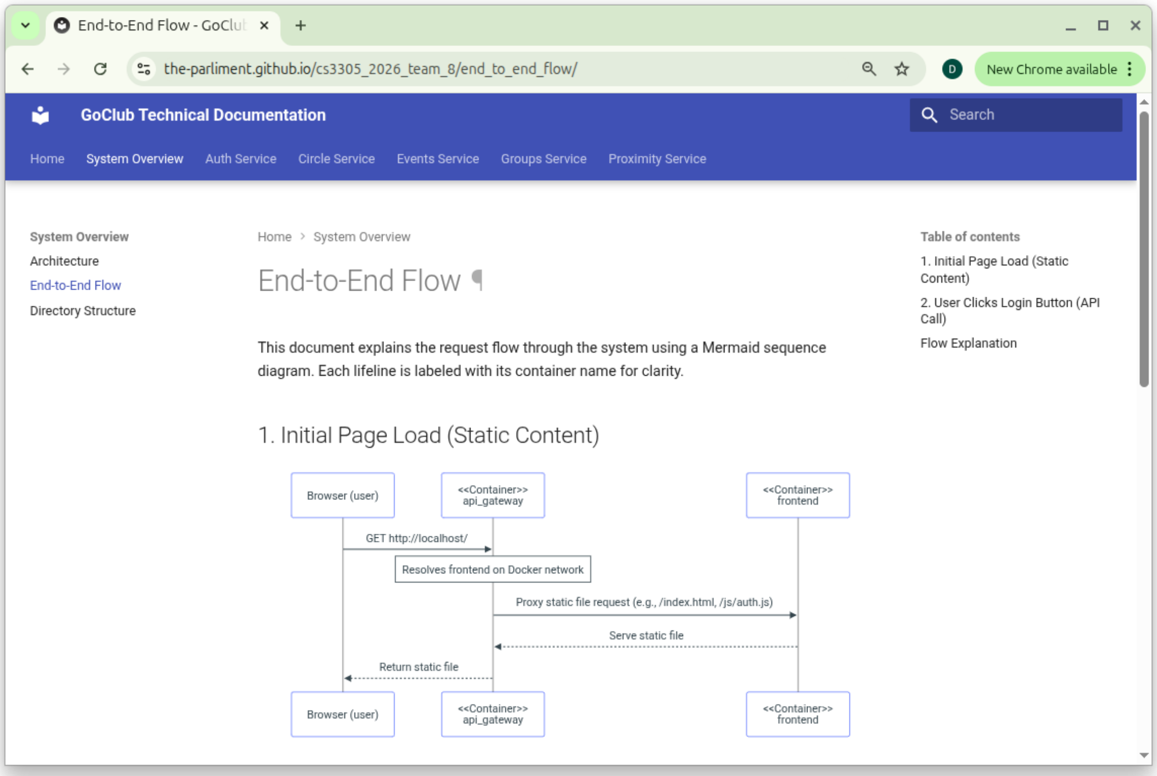
But you would be more interested to see this working with a lot of users at different distances.
Use the following curl commands to set up those users

Figure 3: Example PR

4.3 MkDocs as a Development Contract

This is the most underappreciated decision in the project's process story. The team adopted MkDocs not as a documentation deliverable to be produced at the end, but as a coordination tool used during development. Each service owner documented their API design — endpoints, request schemas, response structures — before or alongside implementation.

As the team had already been documenting APIs and designs in a docs/ folder, adding a mkdocs.yaml took minutes — but the benefits far outweighed the effort.


End-to-End Flow - GoClub

the-parliment.github.io/cs3305_2026_team_8/end_to_end_flow/

New Chrome available

GoClub Technical Documentation

Search

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System Overview
Architecture
End-to-End Flow
Directory Structure

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End-to-End Flow ¶

This document explains the request flow through the system using a Mermaid sequence diagram. Each lifeline is labeled with its container name for clarity.

1. Initial Page Load (Static Content)

Table of contents
1. Initial Page Load (Static Content)
2. User Clicks Login Button (API Call)
Flow Explanation

Browser (user)
<<Container>> api_gateway
<<Container>> frontend
GET http://localhost/
Resolves frontend on Docker network
Proxy static file request (e.g., /index.html, /js/auth.js)
Serve static file
Return static file
Browser (user)
<<Container>> api_gateway
<<Container>> frontend

Figure 4: GoClub Website

The real power of MkDocs here was that it packaged everyone's APIs and designs into a single searchable site — one place to check rather than hunting through files or waiting on a teammate to reply. The consequence was significant: a developer building the Events service could code against the Circles API without the Circles service being complete, because the contract was written down and easily searchable. The documentation site became a substitute for a developer being physically available to answer questions. In a team working across different schedules and locations, this is not a minor convenience — it is the difference between parallel work and sequential work.

> **Key insight:** Documentation written *during* development is a design tool. Documentation written *after* development is a historical record. Only the former enables parallel work.

5 Challenge Two — Reproducible Deployment of a Multi-Service Stack

> **Intent:** Explain the deployment problem and the discipline behind the Docker Compose solution — not what Docker is, but why it mattered here.

5.1 Container-Per-Service and the Isolation Benefit

Intent: Explain what containerisation bought the team in terms of consistency, isolation, and conflict-free collaboration.

5.2 NGINX as the Unifying Gateway

Intent: Explain why a single gateway — single origin, extensible by addition — was the right choice.

```
server {
    listen 80;
    server_name _;

    # Auth service: /auth/* -> auth container, strip /auth prefix
    location /auth/ {
        rewrite ^/auth/(.*)$ /$1 break;
        proxy_pass http://auth:8000/;
        proxy_set_header Host $host;
        proxy_set_header X-Real-IP $remote_addr;
        proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
        proxy_set_header X-Forwarded-Proto $scheme;
    }
```

5.3 The Two-Phase Development Loop

Intent: Describe the local-dev/full-stack-dev split(aka uvicorn vs docker) and why keeping both modes viable avoided slow feedback loops.

5.4 The Nuclear Option

Intent: Frame the full state-reset command as a first-class operational tool, not an admission of failure.

```
docker compose down --volumes --remove-orphans
docker system prune -af
sudo rm common/app.db
```

6 The Core Services

Four of the five services — Auth, Circles, Groups, and Events — share a common character: they manage entities that change infrequently, have clear relational structure, and benefit from transactional consistency. This section describes each concisely, focusing on boundary decisions and architecturally notable design choices. Full API references and data model details are available at the MkDocs documentation site.

6.1 Auth Service

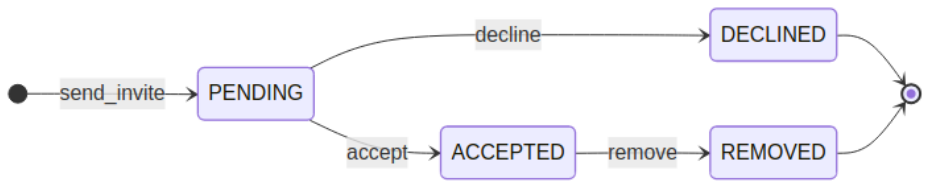
The Auth service owns user identity: registration, login, and profile management. Its core architectural responsibility is JWT issuance. Token verification is local — each service validates the JWT signature using the shared secret from the common library, without a network call back to Auth on every request. This removes both a single point of failure and a latency cost that would otherwise appear on every authenticated API call across the system.

The scope boundary is deliberate: Auth answers "who are you?" It does not answer "what are you allowed to do here?" Keeping authorisation logic in the relevant domain service means Auth stays small and focused, and avoids becoming a bottleneck as the system grows.

6.2 Circles Service

Circles are the social core of the application: small, invitation-based groups representing close friendships. The defining data model decision is the invitation state machine. A circle membership passes through explicit states — invited, accepted, declined, removed — and the service enforces valid transitions. This prevents a user from appearing in circle queries before their invitation is accepted.

The circle boundary is also the privacy boundary for location sharing. Onlyaccepted circle members can see each other's positions in the Proximity service. The Circles service is the authority on membership; the Proximity service delegates that question rather than reimplementing it.



6.3 Groups Service

Groups serve a different social function from Circles. Where a Circle is intimate and invitation-only, a Group is a community of shared interest that can be public or private. The distinction is set by the creator at the time of group creation.

A public group is discoverable by any user via `/list` and open to join without any approval — any authenticated user can add themselves.

A private group is invisible to non-members entirely; it does not appear in discovery at all. Rather than a request-and-approve flow, membership in a private group is entirely owner-controlled: only the creator can add users via `/join` on their behalf. This keeps the permission model simple — there is no pending state, no invite negotiation, the owner either adds someone or they are not in the group.

The same owner authority extends to removal. The `/removemember` endpoint is restricted to the group owner — members cannot remove each other, only the creator can manage the roster. This binary owner/member model is intentionally lightweight for the scope of the project; a production system might introduce moderator roles, but for GoClub the distinction was sufficient.

The public/private flag also propagates into the Events service: an event scoped to a group is only visible to its members, so the Events service must resolve group membership at query time. The Groups service remains the single source of truth for membership, and the Events service defers to it rather than duplicating that logic.

6.4 Events Service

Roisin to add…….

6.5 Frontend Service

Cillian to add - benefit of server side html rendering with jinja

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7 Challenge Three — When the Database Is the Wrong Tool

Every service in Section XXX fits comfortably into the same data model: SQLAlchemy-managed tables in SQLite, accessed through the common library. Users, circles, groups, events, memberships — these change infrequently, have stable relational structure, and benefit from ACID guarantees.

GPS coordinates do not fit this model. Understanding why, and finding a better tool for the problem, is what this section covers.

7.1 The Problem with GPS Location in a Relational Database

Every active user sends a position update at high frequency — potentially every few seconds. In a realistic scenario with twenty concurrent active users, that is twenty writes per second. SQLite uses file-level locking — only one write at a time. With twenty users pinging updates every few seconds, they'd be queuing behind each other, and that latency would be immediately visible.

The read side is equally problematic. A proximity query — "which of my circle members are within 500 metres?" — requires computing the spherical distance between the querying user's coordinates and every other active user's coordinates. This involves expensive mathematical operations across every row in the active-user set. Without a spatial index this becomes a full-table scan on every proximity request.

A further mismatch: location data has no meaningful durability requirement. If the application restarts, users send a fresh position within seconds of reconnecting. Forcing volatile state into durable storage solves a problem that does not need to be solved.

7.2 The Research Process and the Discovery of Valkey

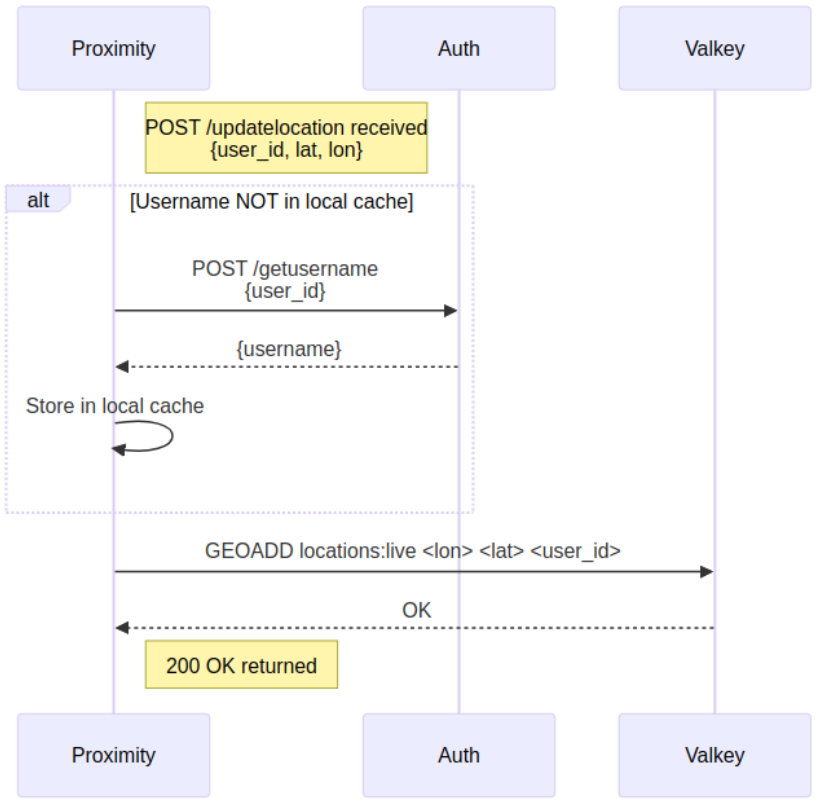
Rather than building a custom solution, the team stepped back and asked what the data actually needed — then searched for tools built for exactly that.

The tool needed to do four things: keep data in memory for speed, handle geospatial queries natively, expire stale positions automatically, and handle high write volume without locking.

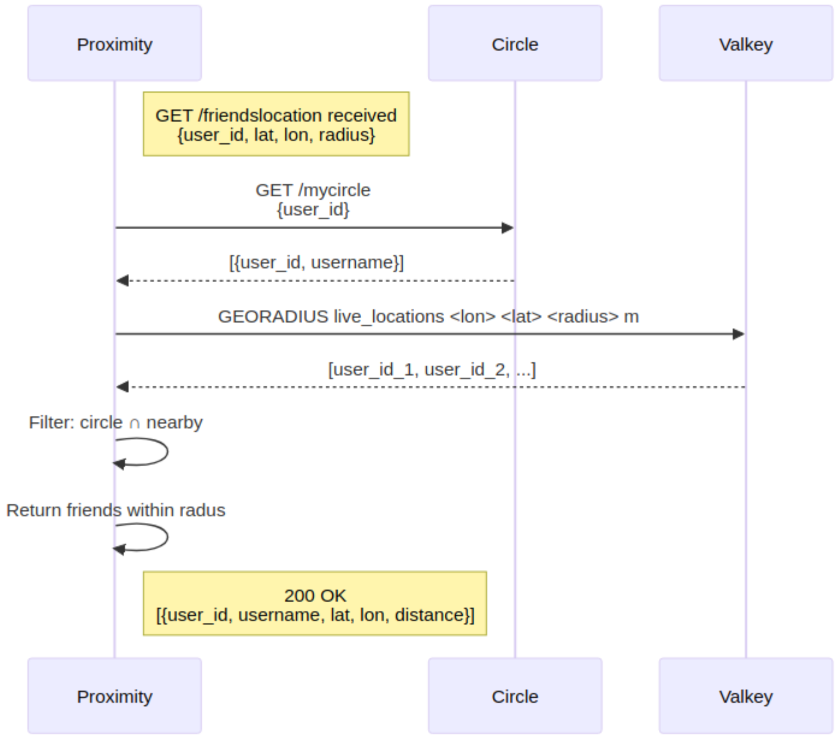
Redis already had all of this built in through its geospatial command set. `GEOADD` stores a coordinate under a named key. `GEODIST` computes distance between two stored points, applying complex math formula internally. `GEOSEARCH` returns all stored points within a given radius. The spherical geometry that would have required significant custom implementation is a single command.

We chose Valkey over Redis because it felt more in line with the spirit of the project. When Redis changed their license in 2024, the community forked it into Valkey to keep it truly open. Honestly, we picked it because it sounded cooler—a bit more anarchist, backed by the Linux Foundation, and a direct 'thumbing of the nose' at the rug-pull. Technically, it was a perfect drop-in; we got the native GEOADD and GEORADIUS commands we needed for high-frequency GPS data without changing a single line of the Redis Python client.

7.2.1 Update Location


Proximity
Auth
Valkey
POST /updatelocation received {user_id, lat, lon}
alt
[Username NOT in local cache]
POST /getusername {user_id}
{username}
Store in local cache
GEOADD locations:live <lon> <lat> <user_id>
OK
200 OK returned
Proximity
Auth
Valkey

7.2.2 Get Friends Inside Radius


Proximity
Circle
Valkey
GET /friendslocation received {user_id, lat, lon, radius}
GET /mycircle {user_id}
[{user_id, username}]
GEORADIUS live_locations <lon> <lat> <radius> m
[user_id_1, user_id_2, ...]
Filter: circle ∩ nearby
Return friends within radus
200 OK [{user_id, username, lat, lon, distance}]
Proximity
Circle
Valkey

7.3 The Resulting Two-Tier Data Architecture

The Valkey integration pushed the project toward two separate data tiers.

SQLite with SQLAlchemy, managed through the common library, serves all durable, relational, slowly-changing data: user accounts, circle memberships, group memberships, events, RSVPs. This is the system of record.

Valkey serves short-lived, high-frequency, spatially-indexed data: the current position of active users. Data carries a TTL and expires automatically when a user goes offline. No explicit delete logic is required.

This is a multi-database architecture — different storage engines for data with genuinely different needs.

> **The transferable lesson:** Valuable engineering move in this project was the decision not to write code. Knowing that a problem is already solved — and finding the tool that solves it — is a more valuable skill than building something from scratch.

8 Cross-Cutting Concerns

> **Intent:** Cover the two elements that span all services and explain the trade-offs of each choice. Perhaps we present the schema?

8.1 The Common Library

Intent: Justify centralised shared code as the right coupling decision at this scale, while honestly acknowledging the trade-off.

8.2 JWT and Distributed Authentication

Intent: Explain local token verification and the benefits as a shared library - aka the verify & decode commonality.

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9 Future Improvements

Intent: Record chapter per future work — not as apologies.

9.1 User Lifecycle Event Bus and DB per service

Intent: Identify the user-deletion cleanup problem and describe an event bus as the correct solution using existing infrastructure.

9.2 Priority Two API Completion

Intent: Note that descoped work is documented and intentional, not a gap.

10 Lessons Learned

10.1 On Deployment: Make the Environment a First-Class Artefact

Intent: Argue that containerising early and treating docker-compose.yml as canonical saved the team from an entire class of failures.

11 Conclusion

Intent: Close by arguing that the problems encountered — and the thinking required — are the same ones that appear at any scale.

- **GitHub:** https://github.com/The-Parliment/cs3305_2026_team_8
- **Documentation:** https://the-parliment.github.io/cs3305_2026_team_8/