SoundLink - Enhancing Community Through Location-Based Music Engagement

BENCE SZABO*, Aalborg University in Copenhagen, Denmark
LOUISE FOLDØY STEFFENS*, Aalborg University in Copenhagen, Denmark
SARA SELMAN*, Aalborg University in Copenhagen, Denmark
SOFIA GRAN*, Aalborg University in Copenhagen, Denmark

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Abstract

This paper presents SoundLink, a mobile application developed to investigate how location-based music sharing may support community engagement in digital environments. SoundLink enables users to create and explore location-linked music "hotspots" through Spotify integration, facilitating anonymous, short-term interactions based on shared listening experiences and comment threads.

Developed with a community-first design philosophy, the app discourages persistent profiles and algorithmic visibility in favour of spontaneous, location-driven participation. We detail the system's architecture, design iterations informed by focus group feedback, and the results of an in-lab user study (n=9). Findings show that participants engaged with hotspots as social touchpoints, appreciated anonymity, and often shifted from passive observation to active contribution when seeking musical validation. Performance testing confirmed the system's scalability under concurrent usage. This study contributes to ongoing discussions in HCI on digital community-building, demonstrating how spatially grounded, music-centred interactions can cultivate a sense of belonging and shared culture without relying on personal branding or social graphs.

1 Introduction and motivation

Humans are often described as "social animals", given that social bonds have helped ensure survival for thousands of years. Socialising is instinctive - it is proven to be a basic human need and plays a crucial role in maintaining personal mental health [Michalski et al. 2020].

The emergence of the World Wide Web also opened new doors for connecting with new people, fostering communities, facilitating discussions, and keeping in contact with one's network in a way previously unseen. Social media sites have promoted themselves for over a decade with slogans such as *"Facebook helps you connect and share with the people in your life"* [Facebook 2009].

On the other hand, with time, social media has gone through a fundamental shift towards individualism - very well represented by Twitter's transition to X, changing their slogan from *"Let's Talk / It's what's happening"* to *"Blaze your glory"* [Frenkel and Hirsch 2023]. Mayer et al.'s findings also indicate that online interactions have become more influencer-centred, with just 10% of users being responsible for 80% of all tweets created by American users, and the average American Twitter user only tweeting twice a month [Mayer et al. 2020]. At the same time, a global loneliness "epidemic" has been observed and studied [Demarinis 2020].

"Studies have reported how the digital age promotes new forms of individualism with self-tracking technologies and self-presentation in social networks", [Michalski et al. 2020].

While this individualistic focus is prominent, it coexists with an ever-persisting interest in how digital platforms can also foster collective experiences and social belonging. This duality motivates us to examine how digital tools might not only serve personal identity formation but also contribute to communal ties. When talking about how apps can "enhance a sense of community", we must first understand what the word "community" can cover and what it means to become a member. First, it is crucial to make a distinction of whether the community in question is purpose-driven or relational.

Purpose-driven communities are generally characterised by following a clear mission statement (what you do), vision (where you are going), and values (how you interact). People become members of such communities primarily to contribute to a perceived greater good rather than fostering personal relationships. One such community can be a volunteer organisation like the Red Cross or a research group such as CERN's Large Hadron Collider team [Carreno 2024], [CERN 2017], [Danish Red Cross 2025].

On the other hand, people join relational communities with the primary goal of establishing and nurturing personal relationships. These communities are highly interaction-focused and personal, for example, a local book club where members can bond and exchange their personal insights. Members of relational communities share a deep sense of community, which does not depend on their whereabouts, i.e. fans of a sports team or enthusiasts in online book discussion groups [Chih et al. 2017].

*All authors contributed equally to this research.

Authors' Contact Information: Bence Szabo, bszabo21@student.aau.dk, Aalborg University in Copenhagen, Copenhagen, Denmark; Louise Foldøy Steffens, Aalborg University in Copenhagen, Copenhagen, Denmark, lfst21@student.aau.dk; Sara Selman, Aalborg University in Copenhagen, Copenhagen, Denmark, sselma24@student.aau.dk; Sofia Gran, Aalborg University in Copenhagen, Copenhagen, Denmark, sgran21@student.aau.dk.

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Depending on the degree of openness/closedness, communities can also support either hierarchical or decentralised governance and control structures and different degrees of focus on inclusivity, membership exclusivity, and diversity. Communities do not tend to be completely open nor completely closed, so it is useful to understand the degree of openness and how these characteristics affect their inner workings, e.g. internal information sharing [Moore 2021].

Most communities are not purely relational or purpose-driven, but determining where they are placed between the two extremes can aid a lot in determining an appropriate approach to designing an optimal solution or product. Another important takeaway is that a community does not necessarily consist of people who know each other beforehand, but can also be those with shared interests and/or goals on two opposite sides of the globe. Given that a main focus of this project is enhancing communities, understanding the nature of the community in question and its needs is a fundamental step in designing an appropriate solution.

2 Related work

Enhancing community feeling through digital interactions. The first app that likely comes to mind when thinking of geo-location-driven social platforms is Pokémon GO, which still maintains a large, active community of players who connect augmented reality gameplay with real-world social interactions. Vella et al.'s paper, *A Sense of Belonging: Pokémon GO and Social Connectedness* [Vella et al. 2019], researches and discusses whether Pokémon GO motivates social connectedness through play in the real world, and how transforming public places into significant play areas can encourage engagement.

The key takeaways are that an app can be a good icebreaker for initiating interactions with strangers, and applications enabling the discovery of common interests can enhance the user's sense of belonging. Furthermore, seeing others' engagement can give the feeling of increased social cohesion to some players.

This paper argues that, despite the general shift in focus towards individualism and the generally influencer-dominated activity displayed on social media, digital tools still play an important role in fostering and enhancing communities.

The concept of community-building through digital interactions has been explored across other research, e.g. *Using a Mobile Application to Encourage Community Interactions at a Local Event* [Hanna et al. 2015], and implemented in existing products in various domains. For instance, in Last.fm there are features such as *neighbours* and music taste *compatibility* [Last.fm 2025], and Snapchat's *Snap Map* displays global stories in the form of a heat map [Snap Inc. 2017].

One key tendency amongst current implementations is that community building is a secondary focus, almost an afterthought compared to their primary, hedonistic goals - maintaining a personal image and brand.

An alternative approach could emphasise community over individual presence, focusing on meaningful participatory interaction in a collective space rather than self-promotion.

Community feeling and social interactions in the context of modern music listening are also explored in Kirk et al.'s paper through their own location-based mobile music-sharing application, Pocketsong. The paper argues that *"networked devices now offer rich opportunities not just for personal music consumption but also for personally broadcasting music and for sharing digital meta-data concerning tastes, preferences and general listening habits."* [Kirk et al. 2016].

The main findings of the paper emphasise the focus on self-expression and broadcasting one's listening practices. However, not all users choose to be genuine about sharing what they are listening to at all times - rather, carefully selecting songs and playlists that they find best to fit their personal image/branding. Some users even reported that their listening habits changed *"not just through desiring to present a certain image of themselves, but also by anxieties of feeling overlooked by others"*, [Kirk et al. 2016].

Despite these issues, numerous users reported excitement to learn about people with similar listening habits in their area, giving them validation in their cultural values and further motivation to engage with the community, [Kirk et al. 2016].

One aspect specific to PocketSong is "sharing tracks", which is a very personal action where users *drop* a song directly to another person. This has been observed to result in numerous users being discouraged from sharing music in fear of *"being uncool"* or *"lacking sufficient musical knowledge"*. Furthermore, a need for immediacy was also discovered amongst users, with real-time or recent data proving to be more interesting and valuable for fostering a social experience, [Kirk et al. 2016].

Overall, Pocketsong is highly relevant to our project, offering valuable insights through both its successes and shortcomings that can inform the development of our product. The study also highlights the relevance of using geolocation as a tool to enhance communities. Geolocation enables real-time, location-based music interactions that foster spontaneous community engagement beyond personal branding. Furthermore, the study is an outstanding example of how users appreciate discovering others with similar music tastes nearby, validating their cultural identity and encouraging participation. Unlike traditional platforms that prioritise individual self-expression, a geolocation-based approach can create shared musical experiences in collective spaces.

Narrowing down the topic to music-driven communities. Approaching this problem in the context of music makes sense because music is not geographically bound to a location like sports, and it has a very diverse crowd and an endless number of subcultures. The paper *"User Perspectives on critical factors for collaborative playlists"* demonstrates that shared music activities can enhance social bonding, [Park and Kaneshiro 2022].

Existing social music platforms often focus on individual curation and self-expression (Last.fm [Last.fm 2025], RateYourMusic [Rate Your Music 2025], Airbuds [Airbuds 2025]), catering primarily to a hedonistic model where users seek validation and, at best, achieve passive discovery through personal profiles. Furthermore, these platforms focus on tracking individual listening habits and fostering friend-based interactions at best. However, these apps do not fully utilise location-based social interactions to enhance community engagement. Comparisons for a more location-driven app can be drawn with Strava, a physical exercise tracking app which

encourages activity-based social connections without necessarily prioritising individual profiles; however, there is no contribution to any common hub, but only sharing individual achievements to potentially motivate other runners, hikers or bikers.

Observing the aforementioned products, we learned that in the digital world, there are many features designed to enhance communities. However, nearly all of the platforms implementing said features exhibit three dominant trends:

Personal Brand Building (Individual-Centric Design): Users are encouraged to develop and maintain personal profiles, where self-expression often becomes the primary motivation.

Friend-Only Connections (Closed Universe): Interactions are largely limited to pre-existing social circles, reinforcing existing networks rather than fostering broader community engagement.

Algorithmic Constraints & Misuse of Real-Time Following: Users can only expand their reach or visibility by conforming to complex, opaque algorithms, and there is a significant risk of features being used for stalking or intrusive surveillance rather than genuine social interaction.

In essence, music-driven communities offer an opportunity for geographically unbound social engagement, fostering diverse subcultures. Although existing social music platforms do attempt to enhance communities, they have been observed to have taken a highly individualistic approach in their fundamental design, characterised by personal branding, closed universes and algorithmic constraints, limiting broader community interactions.

3 Project Goals and Research Question

In this project, we want to find out whether the three aforementioned hedonistic features - *personal brand building*, *friend-only connections*, and *algorithmic constraints* - are necessary for enhancing community feeling in open relation/interaction-driven music communities. The nature of such communities gives a lot of freedom for approaching the problem, considering the completely decentralised and ungoverned content creation and information sharing in the diverse landscape of music subcultures.

This project aims to deviate from a hedonistic direction by taking a community-driven approach, emphasising an active participation-based direction, taking the focus off of the passive user as an individual unless they make active contributions.

It is important to highlight that individualistic actions do not necessarily take away from community building - in many cases, they can support it. Prosocial action is often motivated by personal interest and incentives - five of the six psychological functions attributed to American voluntarism were found to advance individuals' self-interest in some way [Kemmelmeier and Hartje 2007]. A driving force behind prosocial action is often broadcasting one's pride in personal ethics, values and culture to their surroundings, [Kemmelmeier and Hartje 2007]. It is therefore not the goal to completely exclude any individualistic features from a potential solution, but to approach the development of a platform where individualistic psychological functions actively contribute to enhancing the community.

An application, inspired by "Peer-to-peer community on social media", could adopt a community-first approach where user identity exists only within active engagement, promoting collective musical engagement rather than personal branding. Even the existence of a "user" itself can also be put up for debate, [Voramontri and Klieb 2022].

The challenge is to design a platform that prioritises communal interaction while avoiding the pitfalls of individual self-promotion, exclusivity, and intrusive tracking. A few alternative design principles could be explored:

- **Anonymised or Semi-Anonymised Participation:** Instead of focusing on personal profiles, engagement could be tied to shared spaces, events, or collective contributions.
- **Open and Dynamic Social Structures:** Instead of reinforcing friend-based connections, interactions could be driven by shared musical tastes, real-world locations, or community-driven discussions.
- **Opt-In Location-Based Participation:** Rather than enabling continuous public tracking (e.g. Snapchat), users could engage in time-bound, consent-based participation in specific community events or spaces. User information can be aggregated to areas to mitigate privacy and stalking-related dangers.

3.1 Research Question

In the digital world, there are many apps for contributing to communities, but the vast majority have three pre-eminent trends; *personal brand building* (individual user-centric), *friend-only connections* (closed-universe) where you can only get out of the universe by complying with complex underlying algorithms, and a *danger of misuse of semi real-time information* (stalking).

Avoiding these three common pitfalls, how can we develop a location-service-focused mobile application that contributes to an increased feeling of community and active participation amongst users by having a community-first approach where users' identity exists only within active hotspots, promoting collective musical engagement rather than personal branding?

The sentiment of this problem statement largely aligns with research on social identity and digital spaces, as seen in *"Enhancing Community Awareness of and Participation in Local Heritage with a Mobile Application"*, [Han et al. 2014]. By turning music into a communal rather than an individualistic experience, the application should aim to transform public spaces into socially meaningful cultural hubs where users engage with shared content rather than exclusively broadcasting their own.

As demonstrated in *"Exploring Local Music's Place in Global Streaming"* [Way et al. 2024], local engagement is crucial for cultural sustainability. This project envisions an interactive music landscape where users contribute to a shared cultural experience, transforming public spaces into dynamic, socially interpreted musical environments.

As further research suggests [Han et al. 2014], *transforming a traditional notion of public space into a socially interpreted space* can lead to stronger community ties and a greater sense of belonging, ultimately redefining the way we experience music in shared spaces.

For the user study, we will try to get an answer to these research questions to provide an answer for our overarching problem statement

- **Community Enhancement**: How do music-centred interactions facilitated by community-focused features, such as location-based hotspots, comments, and localised statistics, contribute to users' sense of community within the application?
- **Personal Expression**: How does the app support users in expressing personal identity and values through music sharing and commentary?
- **Spatial Interaction**: What value do users find in exploring location-based music hotspots? How does this compare to location-less music-listening experiences?

4 System requirements

To ensure the system addressed both user needs and theoretical concerns raised in section 3, we derived a set of functional requirements grounded in the literature on social connectedness and digital individualism, (see section 2). Based on these insights, we used the MoSCoW prioritisation method to distinguish core functionality from supplementary features. The complete specification, including *Must have*, *Should have*, *Could have* and *Won't have* requirements, with justifications of all requirements, is provided in Appendix A.

R1: Real-time Spotify playback

This feature delivers live, expressive cues for community interaction, addressing both RQ1 and RQ2. Users must be able to authenticate via Spotify and allow access to their current playback data. This enables real-time musical presence, where users become visible through their current listening, allowing others to discover shared interests. These live listening cues become natural icebreakers by providing immediate musical context, much like Pokémon GO's accidental meetups [Vella et al. 2019]. The UI implementation is shown in Figure 15 (login and playback fetch).

R2: Hotspot creation with temporary identity and location anchoring

This requirement supports short-term, location-specific contributions instead of persistent profiles, aligning with RQ1 and RQ3. To turn that passive discovery into active participation, users can create 24-hour, location-based hotspots tagged with their current track. Inspired by Pokemon GO's social hubs, these short-term markers spark real-world music conversations in place. Locking hotspots to a fixed 24-hour schedule aligns with our goal of encouraging fresh, spontaneous interactions [Vella et al. 2019]. Each hotspot includes a lightweight comment thread, encouraging micro-interactions and local dialogue without requiring user follow lists or profiles. The 24-hour expiry encourages fresh contributions while preserving user agency. Drawing inspiration from *Using a Mobile Application to Encourage Community Interactions at a Local Event* [Hanna et al. 2015], the platform will encourage users to share and interact with music in public spaces without the necessity of maintaining a persistent profile. See Figure 4 for hotspot display and Figure 9 for hotspot creation.

R3: Anonymous alias system

This feature discourages personal branding while maintaining conversation continuity, in support of RQ2. To lower the barrier to genuine interaction and avoid the self-branding pitfalls of full profiles, we assign each comment or hotspot a randomised adjective–animal alias gathered from the user. This approach gives users a consistent handle for short conversations while preventing lasting personas. We considered full anonymity (no handle at all), which hampers conversational continuity, and persistent pseudonyms, which can reintroduce identity competition. The adjective–animal aliases strike the right balance: unique within the active user pool, memorable enough for dialogue and respecting user privacy, yet lightweight enough to discourage any long-term personal branding and identity farming. These aliases appear in the comment threads under each hotspot, shown in Figure 10.

R4: Passive exploration via aggregated listening data

This enables community discovery without relying on intrusive connection models or opaque algorithms, addressing RQ1 and RQ3. The system surfaces "most played songs and artists" for the current map view, allowing users to browse anonymously and notice patterns in shared taste. This promotes a shared sense of place and culture through passive exploration, offering cultural validation and prompting contribution from under-represented users. The UI representation of this feature is seen in Figure 1.

R5: Privacy and location aggregation controls

This requirement leverages location for community discovery while preventing stalking or surveillance-like behaviours. Location is aggregated to avoid precise tracking. Hotspots are shown with limited granularity (capped zoom level), and popular content is only shown when a minimum activity threshold is met. Users can delete their data and account at any time, complying with ethical and regulatory standards. The capped zoom level in map interactions, and the hotspot deletion flow is detailed in Appendix H.

Together, our core requirements turn solo listening into shared, place-based interactions: real-time Spotify data and adaptive polling spark icebreakers; a top 10 list of local songs and artists highlights community trends; 24-hour hotspots fuel spontaneous conversations; and randomised aliases protect privacy without stifling dialogue. These elements together are the building blocks for genuine music-driven community bonding.

5 Design process

We designed the Minimal Viable Product (MVP) using a iterative design process, where we developed the first iteration of the high-fidelity prototype and got it evaluated by a focus group. The feedback from the focus group was then incorporated in the second iteration of the high-fidelity prototype, which we used as the baseline design for the MVP.

5.1 First iteration prototype

The first iteration of the high-fidelity prototype was developed using Canva. We used the requirement specifications described in section 4, to identify all flows that needed to be included in the prototype. Based on the requirements, we identified four 'Must have' flows and three 'Nice to have' flows.

When we created the prototype, we wanted to ensure that the design was intuitive to the user, therefore, we focused on using familiar UI elements from Spotify, Google Maps and Snapchat (Snap Map). We primarily focused on recreating the Spotify UI elements, including colour-pallets, buttons layout and overall pop-up UI, to ensure that it felt like a extension to Spotify, rather than a completely new app. For Google maps, we used their API for the map layout and recreated their icon for 'go to my location' button. For the hotspots, we based it off the Snapchats 'Snap Map' heat map feature, which many users are familiar with.

A short description of each flow can be read below.

'Must Have' flows:

Flow 1. Log-in: The log-in flow was designed to provide an easy login experience in mind, where the user is only required to grant access to playback status. See figure 6, in Appendix G.1 for the design.

Flow 2. Browse most listened to: Showing 'Most listened to songs/artists in the region' is one of the key functionalities in the app. The pop-up was designed as a draggable bottom-sheet, where default shows three songs. There was a design alternative, to make it possible to expand (scroll-up) and see ten songs at most, or shrink (scroll-down) and see none. There were also a design alternative, so that the most listened to showed both artists and songs. See figure 7 and 8, in Appendix G.1 for the design.

Flow 3. Display hotspot and comments: Another key functionality of the app is displaying hotspots. The prototypes showed how the display hotspot pop-up could look in different scenarios - single hotspot no comments, single hotspots many comments, multiple hotspots without comments, multiple hotspots with comments. The pop-up was designed as a traditional modal dialogue pop-up, that can be closed using the 'x' symbol. However, there were multiple alternatives to if the pop-up should be on the centre of the screen, or at the bottom, and how many default comments should be shown, how to expand the comments section. See figure 10, and figure 11, in Appendix G.1 for the design.

Flow 4: Create hotspot: The last 'Must have' flow is 'Create hotspot'. The pop-up was designed as a traditional modal dialogue pop-up, centralised on the screen. The system fetches the current playback track from Spotify, and displays it to the user. See figure 9, in Appendix G.1 for the design.

'Nice to have' flows:

Flow 5. Like on comments: The design for like on comments was a heart (as we know from from Instagram and TikTok), with a number behind to indicate the number of likes. Instead of having a red heart when you liked, the heart goes from dark grey, to light grey. This is implemented to ensure that unified colour scheme. See figure 12, in Appendix G.1 for the design.

Flow 6. Search bar: The search bar was designed as a possibility to search for songs/artists and see either hotspots with those songs/artists or where they are most played. See figure 12, in Appendix G.1 for the design.

Flow 7. Display upcoming events: The display upcoming events at venues was designed as a pop-up, similar to the one for displaying and creating hotspots, where a lists of upcoming event would be shown when the user clicked on a song venue on the map. See figure 12, in Appendix G.1 for the design.

5.2 Focus Group Set-up

We used focus groups in our study to gather in-depth feedback on our prototype. The focus group consisted of six participants, one female and five males, aged 19-25. A focus group is defined as "*a group of people who have been brought together to discuss a particular subject in order to solve a problem or suggest ideas*" (Cambridge Dictionary [Dictionary 2024]).

For the focus group, we provided participants with high-fidelity prototypes to interact with and critique. This format fostered an open dialogue in which users could freely share their impressions and suggestions. Acting as both moderators and observers, we guided the session by presenting the prototype, posing targeted questions about key functionalities, and recording all feedback, ideas, and usability concerns raised during the discussion.

Following the focus group sessions, we conducted a thematic analysis to categorise the discussion topics. We refined our notes and grouped feedback by feature area. This approach clarified participant consensus on design alternatives and helped us prioritise features effectively.

5.3 Focus Group Evaluation

Below is the feedback from the focus group summed up based on flows.

'Must Have' flows:

Flow 1. Log-in: The login flow received positive feedback for its clean and easy design. However, participants added that it would make sense to have the log-in screens in dark mode, since the rest of the app was in dark mode as well.

Flow 2. Browse most listened to: The participants was a huge fan of having the 'most listened to' as a draggable bottom-sheet with possibility to drag-up and see ten songs, or drag-down and see none. They emphasised that it should be both for songs and artists. They pointed out that there should be clearer distinction between whether you choose to see songs or artists, and suggested to have something that mimic a switch button.

Flow 3. Display hotspot and comments: When it came to the display hotspot pop-up, the focus group discussed a lot regarding the design, but in the end agreed that the app would benefit from a more uniform design, where hotspots were also a draggable bottom-sheet. However, it should be clear when a user is browsing 'most listened to' and when they are on a hotspot. Therefore, some techniques to distinct them should be implemented, such as the background should be blurred and the screen should centralised around the hotspot you clicked on.

Flow 4: Create hotspot: Regarding the 'Create hotspot' pop-up, the participants had no comments, they agreed that in this case, it made sense to have a traditional pop-up, rather than a draggable bottom-sheet.

'Nice to have' flows:

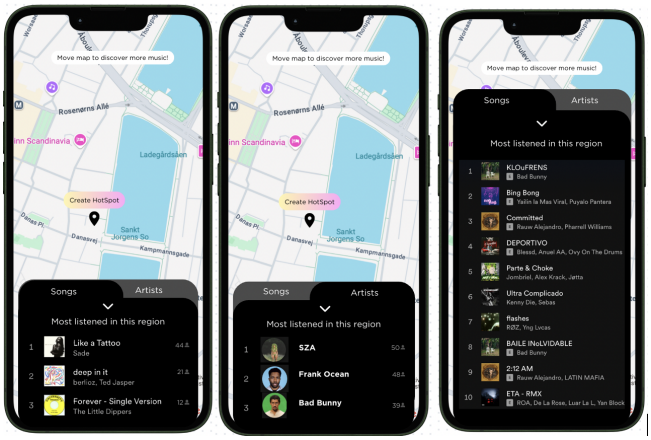

Fig. 1. Flow 2. Browse most listened to. Design from second iteration

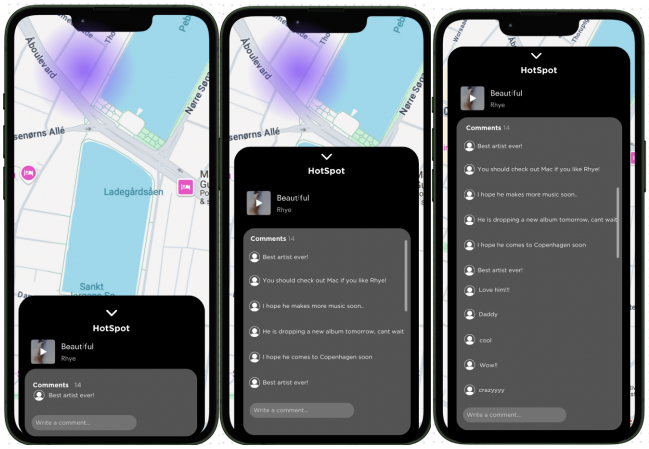

Fig. 2. Flow 3. Display hotspot and comments. Design from second iteration

Flow 5. Like on comments: The focus group loved the design for comments, and all agreed that having likes on comments would be a great feature encouraging connections and community building.

Flow 6. Search bar: The search bar was also a functionality the focus group was a huge fan of, and they also wanted to make it possible to search for specific locations as well.

Flow 7. Display upcoming events: Lastly, the participants was very excited about the ability to click on song venues and see upcoming events, and thought it would bring a lot of value and encourage physical meet-ups on concerts with people you connect with based on shared musical interests. They noted that, as with the display hotspot pop-up, this should be a draggable bottom-sheet to ensure unified user experience.

5.4 Second iteration prototype

The feedback from the focus group was incorporated in a second iteration of the prototypes developed. The second iteration of the prototype is described below.

'Must Have' flows:

Flow 1. Log-in: Based on the feedback from the focus group, we redesigned the log-in screen to have a dark theme, which matched the rest of the app. See figure 13, in Appendix G.2 for the design.

Flow 2. Browse most listened to:

The focus group reacted positively to having both artists and songs, and we revised the design, such that there were a clearer division between when artists and songs are played. This is implemented by the look of overlapping cards. This is shown in figure 1.

Flow 3. Display hotspot and comments: Since the focus group argued that the app would benefit from a more unified design and suggested it to look like the 'most played' pop-up. Therefore, we revised the designed to also use a draggable bottom sheet, but where the background changes so it darkens and focus on the hotspot that is clicked on. This is shown in figure 2. The design for multiple hotspots, can be seen in figure 14, in Appendix G.2.

Flow 4: Create hotspot: No revised design.

'Nice to have' flows:

Flow 5. Like on comments: No revised design.

Flow 6. Search bar: No revised design.

Flow 7. Display upcoming events: No revised design.

5.5 Summary

Having an iterated design process, where a focus group was able to discuss and evaluate the design, provided valuable feedback and contributed to decide on the final design. As the product developed in this paper, is only a Minimal Viable Product, only the 'Must Have' flows (1.-4.) where implemented, however, the prototype for the other three 'Nice to have' flows, can be used as inspiration for future work.

6 System Architecture

6.1 Overview

The system follows a client-server architecture, composed of a Flutter-based mobile frontend, a Fastify backend API, and a Supabase database for persistent storage. Additionally, the application integrates with the Spotify Web API to access real-time playback metadata. The architecture is designed to support dynamic location-based content generation, anonymous social interaction, and scalable aggregation of music data in public spaces.

The backend is organised as a microservice architecture, where each core responsibility, such as authentication, hotspot management, geolocation handling, and comment processing, is implemented as an independent service. These microservices are developed and deployed separately on individual Ubuntu servers, allowing for modular scalability and isolated failure handling. Each service is stateless and exposes a well-defined RESTful API, facilitating horisontal scaling and independent development cycles. Constructing the backend with a microservice architecture in mind is a very efficient way to prevent one high-payload service, for example login

and token exchange, bottleneck the rest of the system or other services that other users interact regularly with, for instance updating playback status.

To simplify client-side integration and improve security, the system uses a central API Gateway based on NGINX. The gateway acts as the single entry point for the mobile frontend, routing incoming requests to the appropriate backend service. All backend servers are firewalled to only accept incoming traffic from the gateway's IP address, effectively blocking direct access from external sources. This design enhances security, supports centralised logging and rate limiting, and decouples client-side logic from the internal structure of backend services.

The application enables two primary interaction modes: *passive discovery* and *active contribution*. For discovery, users view an aggregated list of the most played songs and artists in their current map view. For contribution, users can create 24-hour time-limited "hotspots" displayed as heat map markers, that reflect their currently playing song and invite social interaction through a lightweight comment system. This approach encourages spontaneous community participation without requiring persistent profiles.

6.2 Component Diagram

The component diagram of the system shows the interactions between the client, API gateway, and the individual backend microservices. The Flutter mobile client communicates exclusively with the API Gateway, which routes requests to six independently deployed Fastify microservices: spotify-service, comment-service, hotspot-service, user-service, song-service, and geolocation-service. These services each handle CRUD operations related to their domain and communicate with a shared Supabase database for persistent storage. The spotify-service additionally integrates with the external Spotify Web API to fetch playback data. This modular design enables independent development, deployment, and scaling of each service without impacting the others, thereby supporting maintainability and high availability under varying load conditions. See Figure 5 in Appendix F.

6.3 Component Responsibilities

Flutter App: The mobile frontend is responsible for rendering the UI, capturing user location, and managing playback permissions through Spotify authentication. It facilitates the creation of hotspots, displays the top songs/artists in the visible map area, and handles all anonymous interaction via comments and aliases.

Fastify API: The backend exposes RESTful endpoints to the mobile client for operations such as hotspot creation, top-song aggregation, and comment management. It also handles Spotify OAuth token exchange, ensures proper validation of incoming requests, and enforces privacy rules (e.g., not returning data unless listener thresholds are met).

Supabase Database: Supabase stores structured data on users, hotspots, songs, and comments. It also provides JSON Web Tokens (JWT) based authentication used by the mobile client and backend services. The database schema supports efficient geospatial queries to dynamically aggregate music listening data based on map view boundaries.

Spotify Integration: The application relies on Spotify's Web API to retrieve metadata for the currently playing track. This metadata is used to populate hotspots and identify aggregated content without storing any playback history or user identity data.

7 Implementation

Based on the functional requirements from section 4, we implemented the minimal viable product explained further in this section.

7.1 Frontend (Flutter)

The mobile application was implemented using Flutter and designed for IOS devices. The app uses the 'location' package to obtain the user's GPS position, which is updated whenever the user pans or zooms the map.

Spotify authentication is handled through a browser-based OAuth 2.0 flow, after which an authorisation code is returned to the app and exchanged for tokens via a backend endpoint. The Spotify playback API is used to fetch the user's currently playing track when creating a hotspot.

The UI is centred around a dynamic Google Map overlay widget. Upon launch, the map centres on the user's current location, and top songs/artists within the visible viewport are fetched through API calls.

Anonymous interactions are implemented using a random name generator that assigns users adjective–animal aliases (e.g., "Pretentious Panda"). The 'provider' package manages authentication state and shared user/session data across views. See figure 15, in Appendix H, for the full login flow.

Comments below each hotspot are fetched through periodic polling every 30 seconds. Hotspots themselves are synchronised in real time using WebSockets: initial data is loaded via a REST API, and any subsequent inserts or deletions are pushed to the client live, ensuring the map reflects updates without requiring a manual refresh. Figure 3, shows how hotspots and most played are displayed on the map, and figure 4, shows how hotspots and comments are displayed when they are clicked on. To see the other flow, such as creating hotspots, expanded view of most listened to, delete hotspots. multiple comments, delete account and write comment view, see Appendix H.

To protect user privacy and reduce the risk of stalking, two key security measures are implemented: (1) the map imposes a maximum zoom level to obscure the exact location of each hotspot, and (2) most played content is only displayed if a minimum activity threshold is met, preventing the exposure of music activity from individual users.

7.2 Backend (Fastify)

The backend is implemented using Node.js and the Fastify framework, structured modularly with route-specific handlers for users, hotspots, songs, and comments.

Spotify OAuth token exchange and refresh flows are implemented on the backend to reduce exposure of client secrets. Access tokens have hard-limited to a lifetime of an hours defined by Spotify's API. To ensure seamless access token regeneration, when a playback request is sent with an invalid token, the user's refresh token is

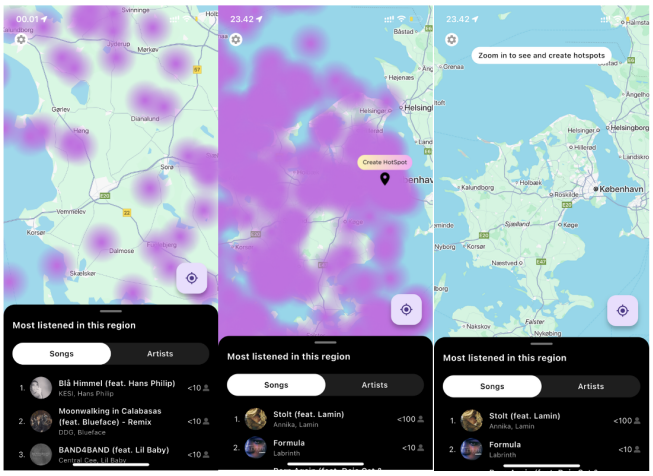

Fig. 3. Most listened to map

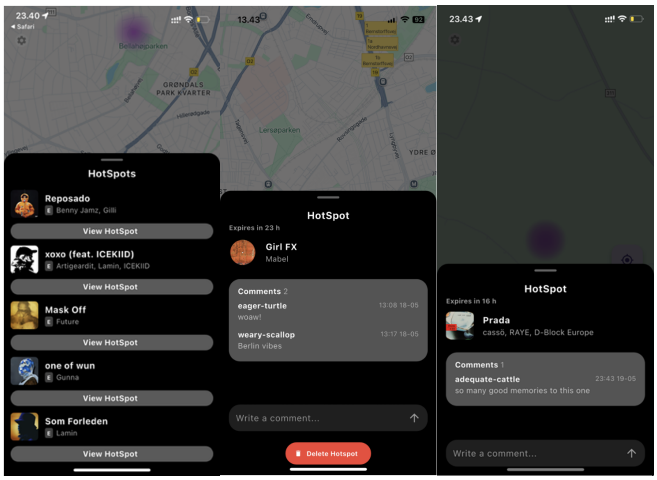

Fig. 4. Hotspots

immediately used to get a new access token and return it with playback status and update it in local memory.

Hotspot creation includes payload validation, token verification, and insertion into the database with a server-side timestamp. A scheduled clean-up process periodically removes expired hotspots (those older than 24 hours). The backend uses bounding box queries for determining top songs and artists within the user's current map view.

To preserve privacy, aggregation endpoints only return data when a minimum threshold of distinct listeners exists in the viewport. No raw user IDs, exact locations, or playback timestamps are returned to clients outside of the hotspot context.

7.3 Database (Supabase)

Supabase hosts the PostgreSQL database.

The database includes the following key tables:

- `users` — stores user IDs, assigned anonymous aliases and foreign key references to the song they are currently playing and the song used in their active hotspot.
- `songs` — stores Spotify track metadata.
- `hotspots` — contains GPS coordinates, creation timestamp.
- `comments` — contains text entries linked to specific hotspots and ordered by timestamp.
- `geolocation` — contains geolocation data for the specific user.

8 Methodology

In this section, we will describe the methodology used for the user study, detailing the research design, data collection and data analysis methods used to answer the research question presented.

8.1 Study type

Originally, the study type was designed as a week-long remote deployment. The study has been adapted into a lab-based technology probe due to distribution limitations on Apple's TestFlight platform. The app will now be tested in a semi-controlled, in-person setting, where participants engage with the app under observation. This setup allows us to gather insights into interaction patterns, user motivations, and perceptions of community and identity in a shorter, structured time frame.

To preserve validity after shifting our plan, we implemented parallel testing enabling participants to interact in real time, and a two-round structure, where users return for a follow-up once the novelty has worn off. This ensures multi-user dynamics are captured and mitigates first-use bias.

Gathered from the bullet list in the appendix E of trade-offs, we found that while a remote study would have yielded richer usage logs, natural mobility insights, and minimised facilitator effects, it sacrifices the nuanced behavioural observations possible in a lab. The lab setting allows us to spot subtle interactions and guarantee simultaneous, in-person user engagement. Our hybrid approach balances real-world realism, solid data collection, and direct observation.

8.2 Practical Information

The study consists of in-person lab sessions conducted at AAU with each participant spending approximately 35–50 minutes in two parts. The study is run with several participants in parallel. A total of eight participants are recruited, aged 20–60, drawn from AAU students, friends and family. To qualify, participants must regularly use Spotify as a primary music service, be comfortable with iPhone-based apps, and have basic mobile navigation skills.

8.3 Procedure

Participants begin with a five-minute briefing, during which we explain the study's purpose, obtain consent for data collection, and encourage them to treat the app as if they'd just downloaded it from the App Store. In the first exploration phase (10–15 minutes), they freely navigate the app's features in a simulated environment while researchers unobtrusively observe and log both qualitative notes and background system metrics. In the second phase (another 10–15

minutes on a different day), participants continue open-ended use, but we subtly prompt them to engage with any core features they may have missed, such as creating or interacting with hotspots, so we can assess both first-time discovery and more experienced interactions. Finally, a 10–15 minute semi-structured interview followed by a written survey gathers participants' subjective impressions of usability, community dynamics, and self-expression. We wrap up with a brief debriefing that reveals the use of mock users in the study and answers any remaining questions.

8.4 Data collection methods

We will gather two types of data. Telemetry will record session length, counts of key interactions (such as hotspot creations, comments, and map pans/zooms), engagement with the Top-10 lists, navigation patterns (camera movements), and any errors or crashes. In parallel, semi-structured interviews will probe participants' sense of social connection and community, their feelings of self-expression, overall enjoyment and motivation, and specific usability feedback.

8.5 Variables

In our study, we vary two independent factors: whether participants believe they are interacting alongside real parallel testers or mock users, and whether the environment includes pre-populated hotspots complete with comments and playback history. Beyond injecting these elements, we make no further manipulations which is allowing us to observe genuine user responses.

We then track several dependent outcomes. Quantitatively, we measure how often and richly users interact, the volume and variety of content they generate (hotspots and comments), and patterns in navigation. Qualitatively, we analyse interview responses for community feeling, self-expression, and engagement, as well as participants' ratings of ease of use and feeling connected.

8.6 Study Contexts

We ran the study in a dedicated lab space to keep conditions consistent and avoid distractions. Each participant returned for two back-to-back sessions to reduce first-use novelty, though this design does not capture longer-term habits. Whenever possible, we scheduled sessions so multiple people used the app at the same time, encouraging real interactions; if that wasn't feasible, participants worked alone. During each session, they listened to Spotify and used our app simultaneously, mimicking a typical user experience.

9 Results

This section presents the findings from our in-person user study ($n = 9$), structured around our three research questions: community enhancement, personal expression, and spatial interaction, in addition to some questions related to their general experience and usability reflections. The results include observations of participants while conducting the study, and combine qualitative feedback from the follow-up survey (see Appendix for full list of appendix questions B) with light quantitative aggregation of user responses.

9.1 Observations

Across both test sessions, participants demonstrated exploratory behaviour, curiosity-driven interaction, and occasional confusion related to the app's functionality and purpose. A common initial action was scrolling through the map to view "most played" songs, with nearly all participants attempting to click on top songs or hotspots expecting playback functionality. Several users interpreted the interface cues as suggesting that songs could be played directly, leading to confusion when this was not supported. Some users also believed the purpose of hotspots were to "listen together" and therefore, were confused to why they could not pay the song directly in the app. An observable difference between the two sessions were that users were more interested in the most listened to artists/songs in their region the second time around, spending more time discovering local taste before accessing hotspots.

Also, when creating a hotspot and the message "no song currently playing" was shown, many participants did not understand, or found it burdensome, that they had to close the app and open Spotify to play a song, and pointed out that this should be better integrated in the app.

In addition, when the message "You already have an active hotspot song" was shown, most users did not understand, or found it burdensome, to go back to their active hotspot and delete it, and explained that it would be natural to be able to replace the hotspot directly from the pop-up.

Hotspots prompted engagement, with all users leaving comments and responding to others. Users enjoyed the anonymity and the randomised usernames, describing the interaction as fun and low-pressure. Some users would have appreciated a "like" to show appreciation without words. However, some participants expressed difficulty locating their own hotspot after creation (since the display hotspot pop-up is not automatically opened after creation). A observation present across some users was a flow of validation seeking (looking for a hotspot of someone with similar music taste), followed by the lack of validation, prompting users to broadcast their taste and actively participate, by choosing instead to create their own hotspot.

Map-based behaviours varied. While some users explored different cities and zoomed out to compare musical tastes across regions, others remained local in focus. In the second round of testing, participants paid more attention to the "most listened to" list and spent time interpreting its contents.

Some usability issues were observed. One participant experienced persistent problems with dragging the pop-up down (as it has to be dragged down with a drag movement and not a swipe), and others expressed a desire to play or preview music directly within the app. Some participants wished to create multiple hotspots and to better distinguish between new and older hotspots such as through colour-coded hotspots or visible lifespan indicators.

Overall, participants grasped the core interaction model and found it enjoyable to explore music geographically and interact with others. However, expectations regarding playback, clearer feedback flows, and improved navigation were consistent themes that emerged across sessions.

9.2 Research question 1: Community Enhancement

"How do music-centred interactions facilitated by community-focused features, such as location-based hotspots, comments, and localised statistics, contribute to users' sense of community within the application?"

Presence of Others and Social Awareness. Six participants answered that they felt that that there were other people active on the app, one stating that *"Yes, the hotspots on the map and being able to interact with users (e.g. through comments) made the app feel like it had a community"*. The other three participants mentioned that it did not feel like real-time data and one wrote that it seemed like bots.

When asked about activity from other users all nine participants answered that they came across activity from other users, and emphasised that it *"(...) gave a sense of community and made me want to interact with them"* and that *"It was nice seeing some comments, made it seems real. I also got a comment, really nice (:" "I came across a bit of everything, and it was a nice touch to see other people's comments and choice of music."*, *"Yes. I liked looking at hotspots from the different parts of the city/country, cool to see if music taste is location based. Made the experience fun."*.

Sense of Belonging or Participation. Five participants said they felt the urge to seek out other users with similar music taste to themselves, while one said maybe, and the other three said no. However, when asked if they felt an urge to move on the map and seek out top songs and hotspots in other places than their own location, all nine participants answered positively. Some participants focused on what was nearby *"Yes, it's nice to see what music is trending around me"* and **"I would have liked to explore different countries, but I were mostly interested in what people nearby were listening to"**, while other preferred to go more broad *"Yes! I even tried outside of Denmark, which will likely be a cool implementation in the future"* and **"Yes, I wanted to see what people listened to in different cities"**.

Not all users felt equally drawn into participation. Six participants reported feeling inclined to actively respond or contribute by commenting or creating hotspots, but three out of the six that answered yes, emphasised that they would only interact if it was a song that they found interesting and/or niche. Out of the three people that answered no, their reasoning was based on personal preferences, such as being an observer or not wanting to share location/music data.

9.3 Research question 2: Personal Expression

"How does the app support users in expressing personal identity and values through music sharing and commentary?"

Expressing Self Through Actions. All nine participants reported that they found ways to express their musical identity through the app. The ability to create hotspots, leave comments, and share songs anonymously was frequently mentioned as a key expressive outlet: *"(...) you were able to express your taste through your hotspot and your identity through the comments"*, however, one added that *"I mean, you can share a hotspot with your music. I suppose that is taste and identity, but I did not feel I could express myself"*.

The participants mentioned that they could express their taste in music and show appreciation/excitement about songs. One mentioned that they left 'rude' comments on songs they do not like, and another mentioned that they defend artists/songs when people leave rude messages, while another one said they used the opportunity to express memes and humorous messages.

Alignment with Personal Use. When asked if they though the app could reflect something about who you are or how you see yourself musically or socially, five answered yes, two were unsure and two said no. Some of the comments were *"I guess. I feel kinda distanced from the app as the activity is anonymous. Also when all the activity is temporary it will only reflect a momentary version of me"* and *"I see potential for people that want to share and engage with people in this way, but I am not one of these people"*.

Only four participants would like to show others what kind of music they are into, where some stated that *"Yes I would, I already share a lot of songs with friends so having a medium for it is nice"* and *"(...) It would be cool if each user could save a history of their hotspots... Then you could get flashbacks like Snapchat does, i.e.: you listened to this, at this location, some years ago on this date...."*. On the other hand, some participants pointed out that *"(...) it's a cool way to discover new music, but I mostly like to exchange music with people I care about. Like I know the person and that is why I value their opinion on music"* and *"I just want to listen to the songs myself, don't care about others"*.

9.4 Research question 3: Spatial Interaction

"What value do users find in exploring location-based music hotspots? How does this compare to location-less music-listening experiences?"

Spatial Engagement and Movement. When asked *"How would you compare the differences in your experience between using Spotify and using Spotify alongside the application's location-related features (hotspots, local statistics)"*, the participants emphasised how *"It's really cool that it's real time and you get even more specified local data than just the Spotify playlists (e.g. Hot Hits Denmark)"*, *"I think the application alongside Spotify allows you to see what people are listening to (outside of your friends), which brings an entirely new experience. I suppose if I wanted to discover some new music, this would be an interesting way to do so"* and that *"much more fun to get music recommendations in the area you are in at any time :) vacation"*. However, one participant pointed out that *"It is not integrated into Spotify, you have to open the other app, and you will have to switch between the 2 apps if you want to switch songs and so on. This makes it feel tedious"*.

Six participants said they felt the location-based features like the map or hotspots made them feel a sense of closeness to other users, while one participant answered *"I guess"* and two said *"Not really"*. Some of participants that answered yes, explained it by saying that *"(...) it was interesting to see where they actually are, which sort of ties the users to an actual person a bit more rather than some arbitrary user who could be anywhere"* and *"I feel more like I am a part of something"*.

All nine participants reported that they felt motivated to explore other areas of the map or visit specific hotspots. Some comments were *"Yes, I was interested to see what people are listening to on the other side of the country for example. I think I would be particularly interested to see what people are listening to in other countries as well though"*, *"Yes. I wanted to know what kind of music I need to listen to, to fit in with the cool Nørrebro people"* and *"Yes, curious what was being listened to"*.

Interpretation of Hotspot Content. When asked if the presence of hotspots encourage them to create one themselves, seven of the participants answered positively, some explaining that *"(...) creating a hotspot with a bunch of others is more comfortable than for example being to the only person that is sharing music with others"* and *"(...) When I can see that others are sharing their music, it is definitely easier to do it yourself. I think I'm often just a passive user, I mostly like to look at what others are doing"*.

Six participants responded affirmatively when they were asked whether combining music and location felt meaningful to them in any way. Some noted that the geographical layer added cultural or emotional significance: *"It makes sense, especially since music might change based on countries and regions (...)"* and *"I think so, not necessarily in location of a single country (...), but I think it would be interesting to see what people listen to in other countries. I do however think I would be interested in seeing what people listen to during the evening"*.

9.5 General Experience and Usability Reflection

The participants expressed particular enjoyment with expressing their music taste through hotspots, connect with others through comments and browsing the discover what other listens to. Some also added that the app was easy to use and worked seamless when creating and commenting on hotspots.

When asked about frustrations or confusions, three users pointed out that they would like to be able to play songs directly in the app, one wanted to post more than one hotspot, one pointed out that deleting a hotspot did not feel intuitive and one did not feel that most listen to panel was responsive.

Three participants reported that they would use the app daily, three reported that they may use the app, but not daily (maybe when they want to explore new music, when they are at festivals or if they were particularly interested at some specific time or in a region), and three reported that they would not use the app, where one pointed out that *"(...) I do not like sharing location and information about myself"*.

When asked "Would it add to your enjoyment of the app if you had a way to have an easy way to see your friends' activity (e.g. directly see what they are listening to or have their hotspots highlighted)?" Six participants answered yes, while some pointed out that *"(...) Would be creepy if I could see my friends location and song choices all the time"* and another that *"Not necessarily, I would be more interested in what people are aren't my friends are listening to"*.

Lastly, the participants were asked what would make them more likely to use the app regularly. Two people mentioned friends/followers, two mentioned better Spotify integration, where one wanted the app to be fully integrated in Spotify, and one wanted to be able to use the app without sharing their own location.

9.6 Summary of Findings

The user study revealed strong engagement with the app's location-based features, moderate levels of active participation, and broad recognition of expressive potential through anonymous music sharing. Six out of nine participants felt a sense of presence from others, citing hotspots and comments as cues of community activity. All participants came across user-generated content, and six felt inclined to contribute themselves, particularly when the song or context was personally relevant.

In terms of identity, All nine participants used hotspots and comments to convey their musical taste or personality, but only five felt these features meaningfully represented their identity.

Exploration was a particularly strong theme: all participants navigated beyond their immediate area, and seven reported that the presence of hotspots encouraged them to create their own. Six found the combination of music and location meaningful, often linking it to regional diversity or real-time cultural context. However, a few users questioned the utility of location-awareness in daily music listening, especially due to the lack of full Spotify integration. A common complaint was the lack of controlling the playback status directly from the app.

From a usability perspective, participants found the app intuitive and enjoyable, particularly for browsing and lightweight interactions. While three participants expressed interest in using the app regularly, three were ambivalent, and three said they would not use it, primarily due to privacy concerns or lack of personal relevance.

10 Scalability and Quality of Service

This section evaluates the system's ability to handle increasing user activity (scalability) and its performance consistency under load (quality of service). We aimed to assess whether SoundLink could maintain responsive interactions (e.g., hotspot creation, song loading) when subjected to concurrent usage and repeated backend requests.

10.1 Scalability of System Architecture and Components

The system architecture of SoundLink is explicitly designed to support modular, scalable growth in both functionality and user base. Each core service runs as a stateless Fastify microservice on a dedicated Ubuntu server. These services handle authentication, hotspot management, geolocation, and comment processing, and all communication is routed through a central NGINX-based API gateway. This separation of concerns ensures that high-load features (e.g., Spotify authentication or comment submission) do not degrade the performance of unrelated services, such as geospatial data aggregation.

The backend infrastructure is dockerised, enabling independent horisontal scaling of individual components. In practice, multiple containers of each microservice can be automatically deployed in response to increased demand, while standby containers can be reserved for fault tolerance. The statelessness of the services and

their RESTful interfaces further support scalability through service replication and load balancing.

The Supabase PostgreSQL database supports efficient spatial queries via PostGIS extensions. This enables fast, region-based aggregation of music data even as the dataset and user base grow. To improve performance under load, an `earth_point` column was added to the `Hotspot` and `GeoLocation` table, precomputing geospatial coordinates for efficient radius filtering via GiST indexing.

Third-party services used in SoundLink, such as the Spotify API and Supabase, are scalable cloud-based platforms and are not expected to pose bottlenecks in a public rollout.

10.2 Experimental Setup

To simulate realistic user behaviour and system load, we conducted backend load testing using the k6 framework. Virtual users performed read and write operations to core endpoints such as `/hotspots`, `/comments`, `/songs/top-songs`, and `/songs/top-artists`. Three test scenarios were executed: a progressive load test (up to 300 VUs), a write-intensive stress test (800 VUs), and a long-running soak test (300 VUs for 8 minutes).

10.3 Metrics Observed

The following metrics were collected during the tests:

- **Latency:** Time between user action and backend response.
- **Throughput:** Number of successful requests per second.
- **Error Rate:** Proportion of failed requests.
- **Frame Time:** Average time to render a frame on the mobile app UI.

10.4 Performance Results

To evaluate responsiveness and system stability, we conducted the aforementioned load scenarios under increasing concurrency and sustained activity. The system handled all tests with high throughput and minimal errors.

Backend response times: In the load test, the system handled 5,716 requests with zero failures and an average response time of 1.52 s (p95 = 5.97 s). This represents a substantial improvement from the pre-optimisation state, where average response times exceeded 4 s and p95 latencies reached over 16 s. The improvement was primarily due to the introduction of a spatial index (`earth_point`) on the `Hotspot` and `Geolocation` table, allowing PostgreSQL to resolve proximity queries efficiently without recomputing distances at runtime.

Hotspot creation latency: In the stress test, 6,266 `POST /hotspots` operations were completed with a mean latency of just 83 ms (p95 = 153 ms) and a 0.87% error rate. This demonstrates that the write path remains highly performant even under abrupt spikes in load.

Soak test stability: During the 8-minute soak test, the system processed 37,867 requests with an average latency of 1.86 s (p95 = 6.81 s) and only 3 errors (0.008%). This indicates that the system can sustain prolonged usage while maintaining stable performance and availability.

See the detailed results in table 2 in Appendix I.

While the overall results are positive, some latency spikes remain for, particularly in endpoints involving wide-radius aggregation queries. Further optimisations such as query caching, materialised views, or result throttling may be required to fully meet interactive latency expectations under public-scale usage.

10.5 Summary

In summary, the SoundLink system demonstrates strong scalability and quality of service under realistic usage conditions. Performance improvements introduced through geospatial indexing and optimised query handling enabled the backend to respond reliably under both burst and sustained user activity. While occasional latency spikes persist in complex aggregation queries, the system's modular architecture and index-backed spatial queries provide a solid foundation for future scalability.

11 Discussion

This section reflects on the key findings from the user study and relates them to the design objectives of SoundLink. We interpret user behaviours, engagement patterns, and feedback in relation to our research questions, while also discussing limitations of the study and proposing directions for future work.

11.1 Discussion of Findings

A key benefit of conducting a lab-based user study on a Minimum Viable Product (MVP) version of SoundLink was that it helped surface unmet user expectations. We observed that users naturally attempted to engage with static UI elements (e.g., trying to play songs or tap on user aliases), offering valuable insight into which features felt "missing" despite not being implemented. The inability to preview songs, see user profiles, or navigate directly to one's own hotspot became design signals for future iterations. In the originally planned remote study, attempts to access non-existing features would not have received any logging with the current logging setup, for example tapping on static UI elements.

Beyond usability, the user study offered valuable insight into community engagement and spatial interaction patterns. Hotspots and the "most played" panels successfully acted as focal points for social awareness and lightweight passive participation. Most users actively engaged in browsing, commenting, or posting, and several felt a sense of real presence, even in a simulated context. This validates the community-first design goal: that location-based aggregation, even when anonymous, can prompt social curiosity and participatory behaviours without relying on direct identity or persistent profiles.

The emphasis on anonymity was generally appreciated and enabled users to express themselves without the fear of judgement. Interestingly, some users reported feeling more inclined to participate because of this anonymity, while others craved more expressive tools such as like buttons. This reflects a broader duality in digital community design: fostering low-barrier entry through anonymity while simultaneously supporting deeper identity expression.

All participants explored beyond their immediate area, and many were drawn to patterns and regional diversity in musical tastes. This validates the assumption that spatial context can add a meaningful cultural and exploratory dimension to music discovery. Nevertheless, the lack of real-time Spotify integration and seamless transitions

between apps caused friction. Some users noted that switching apps to trigger playback was disruptive, pointing to the need for deeper Spotify integration.

Another noteworthy finding was the emergent pattern of self-validation and cultural signalling. Users looked for music that matched their taste, and when it was not found, they often responded by contributing their own hotspots, resulting in transforming from passive browsers into actively participating. This behaviour demonstrates the project's success in enabling participation without relying on personal profiles, algorithmic push, engagement farming, or follower systems. Instead, cultural contribution itself became a motivating factor.

11.2 Limitations

Participants' awareness of being observed and the use of simulated "bot" users may alter behaviour, affecting internal validity. The study's short, lab-based sessions with only nine participants limit external validity, making it hard to generalise findings to broader populations or long-term use. Controlled conditions, time constraints, and artificial social interactions further reduce ecological validity by failing to capture the spontaneity and evolving behaviours of real-world app use.

The design and implementation of mock users introduced several limitations that affected the validity of the user study. A key challenge was making the bots appear realistic and diverse. Given that participants were aware of the university project context, the presented number of users did not feel realistic. Additionally, fake comments were drawn from a generic pool of sentences, and most songs associated with hotspots were sourced from Spotify's Top 50, which limited the potential for surprising or novel interactions. An improved approach could be to use the team members' personal playlists to assign more distinctive personalities to each bot. Moreover, generating contextually relevant comments based on song metadata—such as genre, mood, or artist—could have made interactions feel more believable. Overall, the requirements for the bots could have been more thoroughly defined, considering not just functional completeness but also their contribution to a richer and more meaningful user experience.

Another notable limitation of our user study lies in the use of open-ended questions where a structured response format would have been more appropriate. In particular, we asked participants to freely describe their level of agreement rather than employing a 5-point Likert scale [McLeod 2019]. While open-ended responses can yield rich qualitative insights, they make it difficult to quantify overall sentiment or to identify clear trends across the entire participant group.

11.3 Future work

Tackling the TestFlight-related issues by conducting the originally planned week-long remote deployment study could provide valuable insights for answering the proposed research questions. During remote deployment, even more meaningful usage patterns and tendencies in the logs would emerge compared to the lab study. In future work, prioritising bots with richer personality and behavioural diversity would be essential for improving ecological validity.

If there was enough time, conducting this study with different versions of the application could also give interesting findings. For instance, A-B tests could be conducted with/without direct user tracking instead of aggregated data, experimenting locking the map to current user location to "force" users to be mobile, and enabling direct messages or even group conversations.

Focusing on the product itself, several of the should/could have features whose relevance was confirmed by the user study should be implemented for improved UX and potentially increased engagement retention and active participation rates. These are features such as likes, distinct hotspots, and controlling Spotify playback through SoundLink mentioned in section 9.

Based on the user study, enhanced Spotify integration should also be a main focus area for future work, as it was observed to be a recurring point of friction - especially the lack of seamless playback control within the app. Other avenues, such as in-app playback, playlist management, or synchronised listening, could improve usability and support richer interaction modes. Achieving this may require transitioning to a Spotify Premium-only model or exploring collaborative playback APIs.

Although music is the primary focus of SoundLink, future work could extend to other media types (e.g. podcasts, cultural events, or live streams) or to broader use cases, such as heritage engagement or local activism. Exploring these applications could further test the generalisability of the community-first interaction model.

11.4 Broader implications for social media design

Beyond SoundLink, our findings offer generalisable lessons for the design of social media platforms that aim to promote community belonging over personal branding, encourage passive-to-active participation, and responsibly leverage location-based data.

First, anonymity combined with contextual relevance, namely location and musical culture, can lower participation barriers while fostering authentic expression. This suggests that platforms seeking to cultivate community without fostering competitive self-presentation (e.g. influencer culture) should explore identity-minimised modes of interaction, while still enabling users to contribute meaningfully.

Second, location-based aggregation can prompt social curiosity and local engagement without requiring persistent identity or real-time location tracking. SoundLink's design avoided stalking risks by aggregating user content anonymously and spatially, which offers a promising pattern for future apps: use spatial metaphors for discovery without individual traceability. Designers should consider aggregated proximity-based content rather than pinpointed user locations to strike this balance.

Third, we observed that cultural contribution itself was a motivator for users, especially when their tastes were under-represented. This finding may inform other platforms aiming to reduce reliance on algorithms or social capital systems. Instead of pushing content through engagement farming, platforms could invite participation by showing under-represented or diverse perspectives and providing space for organic contribution.

Lastly, we learned that even minimal social cues (e.g. hotspots, top charts) can foster a sense of shared experience. This suggests that heavy social features (friends lists, comment wars, follower

counts) may not be necessary for community engagement. Instead, platforms might consider incorporating simple signals of collective activity, such as the use of aliases, to encourage belonging while avoiding social comparison.

In summary, our study highlights the potential of SoundLink to support location-based, anonymous music sharing as a form of lightweight community interaction. While several limitations were identified, the findings offer valuable design insights and point toward promising directions for future development and research.

12 Conclusion

SoundLink set out to explore how music can foster community in digital spaces by moving away from individual-centric paradigms toward anonymous, location-based engagement. The system's core concept—allowing users to contribute and discover music tied to physical locations—proved both technically feasible and socially engaging in a controlled lab setting. Participants responded positively to the sense of presence, the opportunity for self-expression, and the exploratory nature of the interface. On the other hand, the project also revealed some limitations, both conceptual and technical, that must be addressed before the platform can deliver on its full potential.

The study also revealed several areas for improvement, both conceptually and technically. On the technical side, the microservice-based architecture and spatial indexing enabled reliable performance under simulated load, though real-world deployment conditions remain untested.

Conceptually, SoundLink challenged dominant trends in social media by resisting persistent profiles and algorithmic curation. This design lowered participation barriers and encouraged open contribution.

Moreover, the study's methodological constraints, including short-term lab-based testing with mock users, limit the generalisability of its findings. Participants often recognised the simulated nature of the environment, and the cultural texture of the experience (e.g. song diversity, comment realism) suffered as a result. A remote test deployment would offer a more realistic evaluation of how the system performs in organic, socially embedded contexts.

In summary, SoundLink presents a proof of concept that challenges the individualistic defaults of modern music platforms. Our findings suggest that the system effectively supported exploratory social engagement (RQ1), lightweight musical self-expression (RQ2), and place-based cultural participation (RQ3), although within the constraints of a lab environment. The core interaction model is promising, but its success depends on further development, real-world testing, and a more nuanced understanding of the balance between anonymity, identity, and community. In the future, SoundLink could act as a tool for music discovery and a potential platform for cultural interpretation of public space. This opens up broader questions about how digital tools might redefine public culture and shared experience in the era of algorithmically curated media. This work contributes to ongoing HCI discourse on how anonymity, location-awareness, and ambient interaction can support community practices in digital public spaces.

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A MoSCoW Prioritization

Table 1. MoSCoW Prioritization (spanning pages with X-columns)

Priority	Feature	Description	Reasoning
Must have	Pop-up for permission to track location	A pop-up for the user to agree with before being able to use the app, since we track the location of the user	It is the GDPR rules to inform the user and have consent before gathering sensitive information
	Spotify integration	Users must be able to log in using Spotify (authorization to be able to get playback metadata). Integrate tokens as well	We need metadata access
	Track currently playing song	The app must track what song by which artist a user is currently playing when the app is open and display it to the user.	We need real-time data and to show system status
	Delete user	Enable the user to delete their user	It is GDPR to allow users to control their data by having the option to delete their data
	Top songs in area	Users must be able to see the most popular songs in an area and the number of people listening to that song (either the most recent song or currently listening)	Providing an aggregate of top songs/artists is part of the MVP and a must-have for the passive (yet non-individualistic) discovery aspect of community building
	Top artists in area	Users must be able to see the most popular artists in an area and the number of people listening to that artist (either the most recent artist or currently listening)	Providing an aggregate of top songs/artists is part of the MVP and a must-have for the passive (yet non-individualistic) discovery aspect of community building. Also, popular artists releasing albums should not necessarily bloat the list
	Dynamic data aggregation on map area	The map area displayed on the screen decides the most listened-to song/artist (more zoomed-out map = more data points taken into aggregate)	Lets users explore other areas than their own and can scale in how much data is aggregated
	Hotspots	Users must be able to create a hotspot, featuring the song they were currently playing when creating the hotspot. A hotspot lives for 24 hours	This is a way the user can actively contribute to the community and spark discussions
	Comments	Users must be able to comment on hotspots	There needs to be a way to engage with other users in a social space
	Random usernames	Users must be assigned a randomly generated anonymous alias when created (for example, a random adjective and random animal)	Some identification is necessary for global channels below hotspots

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Priority	Feature	Description	Reasoning
	Spotify-inspired UI elements	UI elements to match or resemble Spotify's current design	Recognize rather than recall
Should have	Concert hotspots	Concert hotspots at venues where events are shown sorted by date	Promoting physical meetups and connecting to fuel the community
	Limit map zoom-in	The map has limited zoom-in	No songs would be displayed if the user was overly zoomed in
	Make hotspots disappear when too zoomed-out	Hotspots disappear when the user zooms too far out	It would be difficult to get hotspots to scale well, and the whole map would be one big hotspot (draw inspiration from the snap map)
	Only display songs on the top songs list with over x listeners	The most popular songs in an area should only be displayed if the number of users in that area exceeds a limit (ex. 50)	Privacy and security - we do not want stalking
	Limit active hotspots	There should be a limit of active hotspots per user (ex. 1)	We want to avoid spam
	Report users	Users should be able to report other users for inappropriate behaviour	Safety and compliance with EU social media regulations
	Likes	Users should be able to like hotspots and comments	Gathered from the lab study
	Distinct hotspots	Users should be able to tell the difference from their own hotspots and other users hotspots	Gathered from the lab study
	Playback through SoundLink	Users should be able to play songs from spotify directly from SoundLink	Gathered from the lab study
Could have	No close hotspots with the same song	Users are not allowed to make a hotspot in the same area as another hotspot with the same song	Redundant, rather connect the users to one place
	Bundle hotspots in busy areas	Areas with more than one user hotspot display a list of hotspots which are individually shown when clicking on them	Reduce clutter on the screen, more minimalistic - usability
	Colored hotspot bundles	Bundled hotspot color changes based on the number of hotspots coupled together	Usability
	Likes for hotspots	Users could like each other's hotspots	Incentive for active participation and a new form of low-effort interaction
	Likes for comments under hotspots	Users could like each other's comments	Incentive for active participation and a new form of low-effort interaction

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Priority	Feature	Description	Reasoning
	Artist hotspots	A hotspot nearly identical to user hotspots but marked with a badge or something to show its author's authenticity	Connecting artists with their audience, creating the ultimate hub for discussion for fans of an artist
	Location search	Search for a location on the map and navigate to it	Quicker than manual navigation
	Song search	Search for songs and find the nearest hotspot based on the query and navigate to it	Users may not find a community in their area
	Artist search	Search for artists and find the nearest hotspot based on the query and navigate to it	Users may not find a community in their area
	Prioritise popular artists at concert hotspots	At concert hotspots, the currently top listened-to artists in the area have priority in the list if they have a concert booked	We want to display relevant information to the local community
Won't have	Compatibility with more streaming services	Users could log in using other music platforms like Apple Music or Soundcloud	Not everyone uses Spotify - inclusivity. Unfortunately, each streaming platform has its own API, so a new service would need to be created for each
	Get concert data from Ticketmaster	Concert and artist hotspots could have links and/or fetch info from Ticketmaster	Facilitate users' planning and booking of tickets to concerts more easily
	Personal profiles	The app will not contain more profile information about its users, other than their aliases and what music they listen to (or, for example, maybe their Instagram handle)	We want to minimise individualistic goals and focus on community building

B questions for follow-up interview

B.1 Research Question 1: Community Enhancement

"How do music-centered interactions facilitated by community-focused features—such as location-based hotspots, comments, and localized statistics—contribute to users' sense of community within the application?"

1. Presence of Others and Social Awareness
   - Q1.1: While using the app, did you feel like there were other people around or active in the app? What made you feel that way?
   - Q1.2: Did you come across any hotspots, comments or other activity from other users? If so, how did that affect your experience?
2. Sense of Belonging or Participation
   - Q1.3: Did you or would you have the urge to seek out other users with similar music taste to you? If you did, would you interact with them in any way?
   - Q1.4: Did you feel an urge to move on the map and seek out top songs and hotspots in other places than your own location?
   - Q1.5: Did you feel inclined to respond to others or participate in ongoing activity (like commenting or creating a hotspot)? Why or why not?

B.2 Research Question 2: Personal Expression

How does the app support users in expressing personal identity and values through music sharing and commentary?

3. Expressing Self Through Actions
   - Q2.1: Did you feel you had ways to express your taste or identity in the app? How?
   - Q2.2: If you created a hotspot or left a comment, what did you want to express or share with others?
4. Alignment with Personal Use
   - Q2.3: Do you think this app could reflect something about who you are or how you see yourself musically or socially?
   - Q2.4: Would you use this app as a way to show others what kind of music you're into? Why or why not?

B.3 Research Question 3: Spatial Interaction

"What value do users find in exploring location-based music hotspots? How does this compare to location-less music-listening experiences?" 5. Spatial Engagement and Movement

   - Q3.1: How would you compare the differences in your experience between using Spotify and using Spotify alongside the application's location-related features (hotspots, local statistics)?
   - Q3.2: Did the location-based features like the map or hotspots make you feel a sense of closeness to other users?
   - Q3.3: Did you feel motivated to explore other areas of the map or visit specific hotspots? Why?

6. Interpretation of Hotspot Content
   - Q3.4: Were there any hotspots that stood out to you? What caught your attention?
   - Q3.5: Did the presence of hotspots encourage you to create one yourself?
   - Q3.6: Did the combination of music and location feel meaningful to you in any way?

B.4 General Experience and Usability Reflection

7. Overall Impressions
   - Q4.1: What did you enjoy most about using the app?
   - Q4.2: Was there anything that confused you or felt frustrating?
8. Motivation to Return
   - Q4.3: Can you imagine yourself using this app in your daily life? When or where?
   - Q4.4: Would it add to your enjoyment of the app if you had a way to have an easy way to see your friends' activity (e.g. directly see what they are listening to or have their hotspots highlighted)?
   - Q4.5: What would make you more likely to use this app regularly?

C Remote User Study Protocol

C.1 Study type

Technology Probe / Deployment Study:
This study aims to understand how users interact with our music-centred social app in real-world contexts over a one-week period. The app is deployed as a technology probe to explore emergent behaviours, motivations, and perceptions of community and identity.

C.2 Product Context

Participants will use a Minimum Viable Product (MVP) version of the app. It is designed to explore core interaction patterns and social dynamics, not to deliver a finalised user experience. While technical bugs may occur, all known blocking issues will be fixed prior to the study. The MVP includes Spotify integration (users' playback data is fetched from the Spotify account), location tracking with free navigation, hotspot creation, comments under hotspots, and display and real-time update of top artists and songs in the users' area.

C.3 Practical Information

- Format: Remote experiment conducted over 1 week on iPhones using Testflight.
- Participants: 5-10 individuals between ages 20-30 (some friends, some AAU students).
  Inclusion criteria: Participants must have an iPhone with Spotify installed and iCloud and Spotify accounts (both free and Premium are okay).
- Data collection methods:
  Quantitative: In-app telemetry (usage frequency, time, location, interactions, etc.).
  Qualitative: Semi-structured interviews conducted after the usage period to capture subjective experiences and behavioural insights.

C.4 Mock users

- Pre-programmed mock users are included to simulate a populated environment and increase ecological validity.
- Bots will appear near human users, and will have pre-programmed interaction patterns and active listening data.

C.5 Guidelines

- Participants are encouraged to explore the app organically throughout their day with no fixed usage schedule.
- Users are to figure out themselves how, why, and what they use the app for - they are granted complete freedom.
- Users are made aware of others on the app (without knowing which are bots) to foster a sense of live community.
- To ensure that no technical issues or blocker issues are present, users are welcome to reach out to the team during the research period.

C.6 Collected data (logs)

- Number of app sessions (app opens).
- Duration of sessions (From app open to background state / close).
- Geolocation of session initiation (Save location on app opens).
- Number of hotspots created and visited, and deleted.
- Number of comments made.
- Distance from previously visited location - mobility patterns (Save when the camera is moved and stopped).
- Log when swiping on top 10 list / taps.
- Any errors.

C.7 Variables

Independent variables:

- Presence of other users (real vs mock, although not disclosed).
- Prefabricated hotspots and listening data visible to the human users.
- This study does not manipulate independent variables directly other than bots. Instead, we observe naturally occurring variations in use.

Dependent variables:

- Frequency of app engagement (usage events per day).
- Number of user-generated interactions (hotspots, comments).
- Qualitative themes related to perceived community feeling, self-expression, and user motivation.
- Reported enjoyment and perceived social connection.

C.8 Study contexts

- Physical context: Conducting a continuous study where users integrate the app into their everyday activities means that the physical context is highly dynamic and depends on the users' preferences. Data gathered during the study should reflect the physical circumstances the app would be used upon an official release.
- Temporal context: The team assumes relatively low usage durations spread out through the day. Although users are asked to use the app, the times and duration are not specified. Data gathered during the study should reflect when and for how long the app would be used upon an official release.
- Social context: If multiple participants are familiar with each other beforehand they can be expected to experiment with the app in a social setting, since it is a community enhancing tool. Hopefully we will see interactions between users previously unfamiliar with each other too. Data gathered during the study should reflect social interactions between users.
- Task-related / Technical context: The app should be used while listening to music, which means that it should be a foreground application while Spotify is a background application.

C.9 Limitations

Internal validity

- Limitations to the trustworthiness of the results respect to the study's research goals/questions.
- The presence of mock users may influence behavior in unpredictable ways (e.g., users reacting to bots differently than real users).
- Self-selection bias: Participants are likely to be tech-savvy and interested in music, which may skew results.
- Lack of control over external distractions or parallel smartphone activity during app use.

External validity

- Limitations to the generalizability of the results to other contexts (populations, tasks, devices, cultures, etc.).
- Small and demographically homogeneous participant pool (mostly university students aged 20–30) limits generalizability to broader populations.
- Results may not transfer directly to Android platforms or non-academic settings
- Cultural context of primarily Danish university students may not reflect global music sharing or community interaction norms.

Ecological validity

- Limitations to the generalizability of the results to real-life contexts.
- While the field setting adds realism, participants are still aware they are part of a study, which may influence behaviour (Hawthorne effect).
- The presence of mock users and an unfinished MVP could lead to atypical interaction patterns not representative of real-world use.
- Short duration (1 week) may be insufficient to capture long-term engagement patterns or deeper community bonds.

D Get Started - Message for remote testers

Super cool user study guide for participants

Tusind tak for at deltage i vores brugerundersøgelse!!!:)
I dette dokument kan du læse om de vigtigste informationer.

Før du kommer i gang

(1) Det er super vigtigt at **du har en iPhone og bruger Spotify som din primære musikstreaming tjeneste**. Hvis du ikke opfylder disse krav, så kan du desværre ikke deltage i undersøgelsen. Hvis du gør, er det fantastisk.
(2) **Før du kan komme i gang, skal du sende din email tilknyttet til din Spotify konto og App Store til os**. Dette skal gøres fordi vi skal give dig adgang manuelt på Spotifys developer platform og Testflight. No funny business.
Hvordan finder jeg min email på Spotify? Open Spotify → tap på dit profilbillede (øverst til venstre) → settings → du kan se email her
Hvordan finder jeg min email på Apple Store? Open Settings (på iPhone) → Tap på dit profilbillede / navn, det burde stå øverst i settings → du kan se email her
(3) **Det er vigtigt at du giver samtykke til at vi må automatisk indsamle relevant data mens du bruger app'en**. Dataen indsamles **anonymt og bliver slettet** når vi har afsluttet det nuværende semester. Se mere om data nedenunder.

Skriv til os hvis der er noget der driller eller hvis du er i tvivl om noget. <3

Kom i gang:

(1) **Download App Store Connect fra App Store.** Log in with your Apple ID - you should see the app available for download.
(2) Når du åbner app'en for første gang, vil du blive mødt med en Spotify login popup. Du skal acceptere dette for at kunne bruge app'en. Du kan altid fjerne adgang igen fra dine kontoindstillinger inde på Spotifys egen hjemmeside.
(3) Go wild!

Igen, skriv til os hvis der er noget der driller eller hvis du er i tvivl om noget. <3

Det er helt op til dig hvordan du bruger Soundlink. Det eneste vi gerne vil bede dig om er at huske at åbne app'en 1-2 gange om dagen og gøre det du har lyst til og udforske mulighederne.

Du er selvfølgelig mere end velkommen til at stille os spørgsmål ift. features, komme med feedback eller rapportere fejl mens brugerundersøgelsen er i gang <3

Data info Dataen indsamles anonymt og bliver slettet når vi har afsluttet det nuværende semester. Når du downloader app'en giver du samtykke til at vi må logge de følgende:

- Number of app sessions (App opens).
- Duration of sessions (From app open to background state / close).
- Geolocation of session initiation (Save location on app opens).
- Number of hotspots created and visited, and deleted.
- Number of comments made.
- Distance from previously visited location - mobility patterns Save when the camera is moved and stopped.
- Log when swiping on top 10 list / taps.
- Any errors.

Vi bruger dine data til at drage konklusioner mht. produktet, og det er kun gruppemedlemmerne der har adgang til det. No funny business.

Hvis du har spørgsmål er du velkommen til at kontakte os <3

E Study type tradeoffs

Measures taken to maintain validity despite the change of plans:

- Parallel testing: To account for the importance of multiple users connecting on the platform, tests are designed to be conducted in parallel, meaning that users will be able to interact with each other in real time.
- 2-round structure: To reduce the novelty effect and common exploratory-focus of first time app use, participants are invited to a follow-up test where they can further interact with the application they are now familiar with.

Trade-offs between the originally planned remote study and lab study:

- Remote study would have provided more meaningful quantitative data (logs) and more representative patterns could have been identified because of the time spent with the application.
- Remote study would have given more ecological validity to the study's conclusions because of the natural physical setting.
- Remote study would have provided a better opportunity to compare metrics to self-reported statements.
- Remote study would have provided meaningful information about the mobility aspect of the product (e.g. would users use the app at home or on the bus?)
- Remote study would allow the users to gradually familiarise themselves with the app's functionalities over time and find its purpose for them.
- Participants would not be affected by the presence of test facilitators in a remote study (Hawthorne effect). Although logging is disclosed to them, participants would still experience it to some extent.
- User behaviour can be observed firsthand during a lab study, opening up for noticing subtleties that might have gone unnoticed during a remote study.
- Parallel testing in the lab setting ensures that human users are nearby at the same time and human-to-human interaction can occur.

F System component diagram

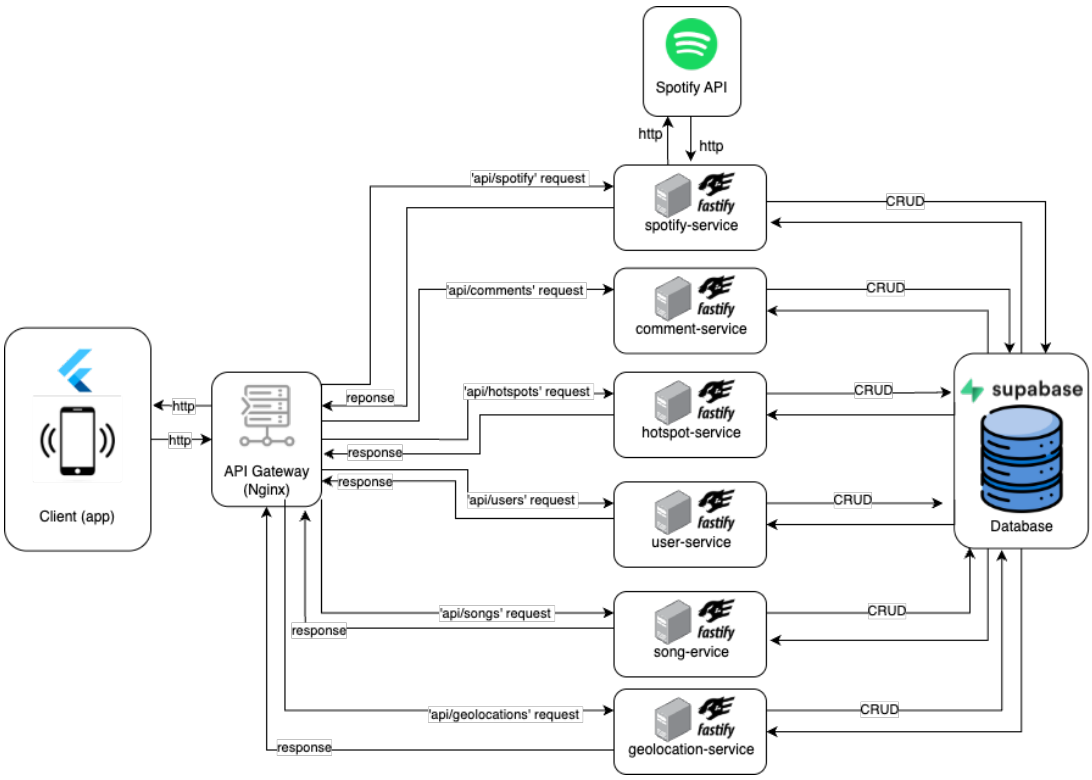

Fig. 5. System component diagram showing interactions between the frontend, API Gateway, and individual microservices.

G Prototypes

G.1 First iteration

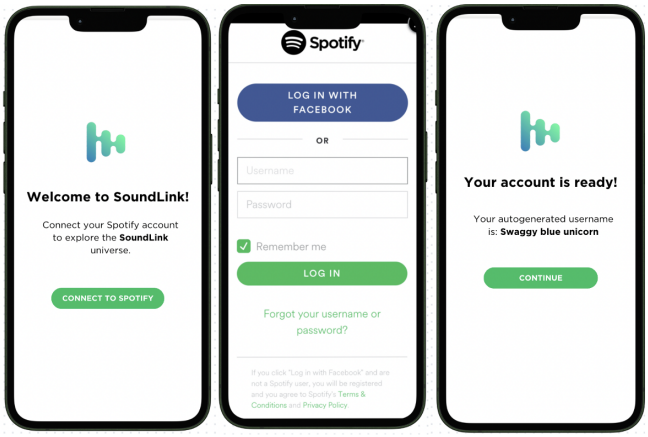

Fig. 6. Login

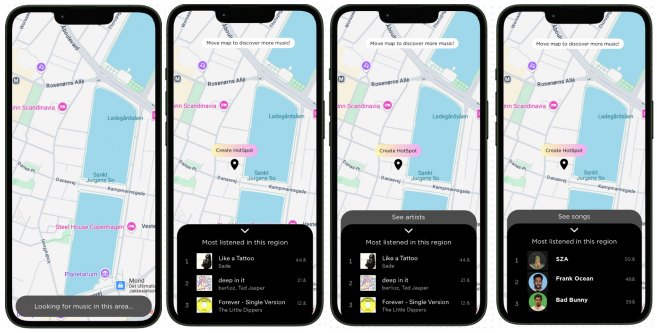

Fig. 7. Most listened to

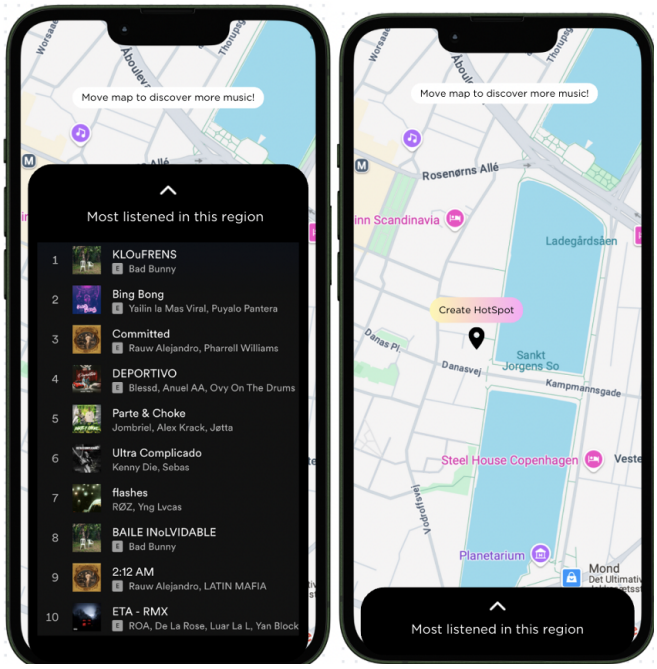

Fig. 8. Most listened to expanded

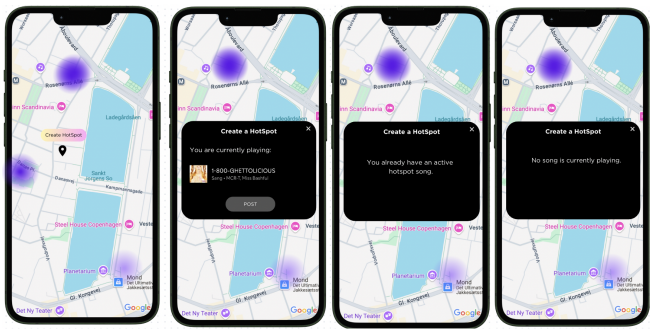

Fig. 9. Create hotspot

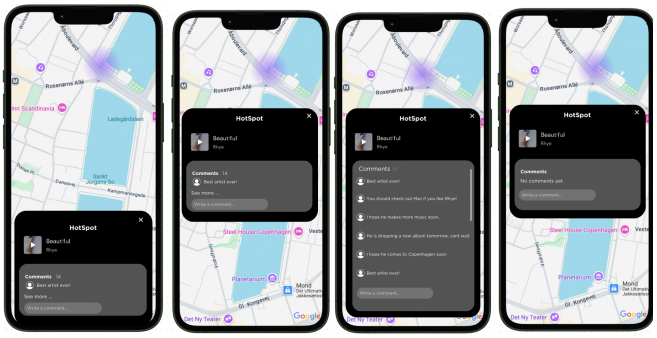

Fig. 10. Display hotspot

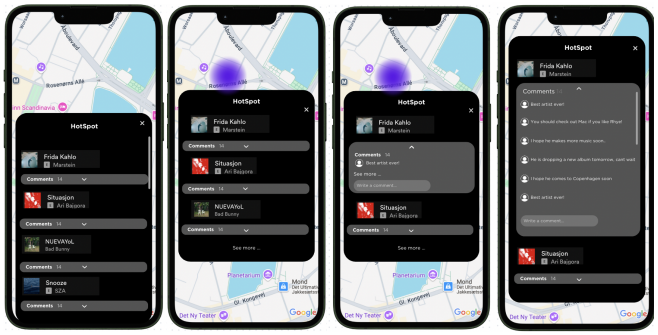

Fig. 11. Display multiple hotspots

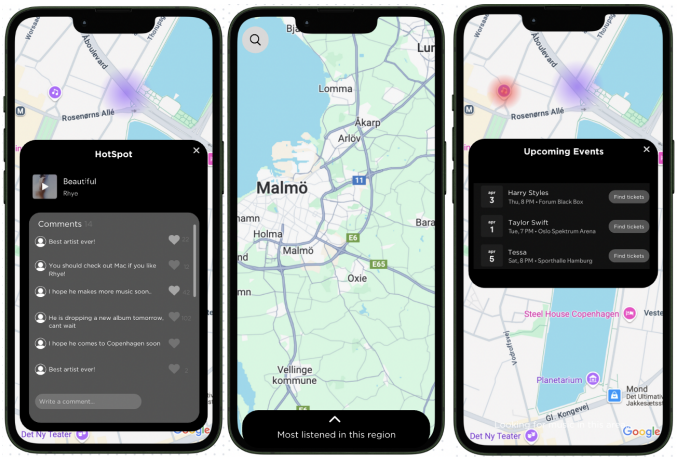

Fig. 12. other

G.2 Second iteration

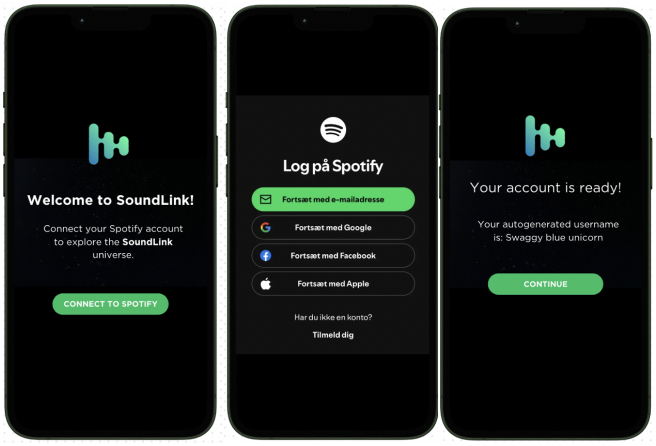

Fig. 13. Login

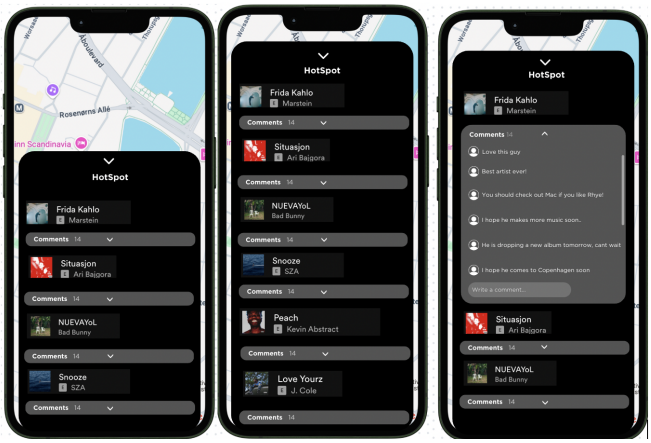

Fig. 14. Display multiple hotspots

H MVP

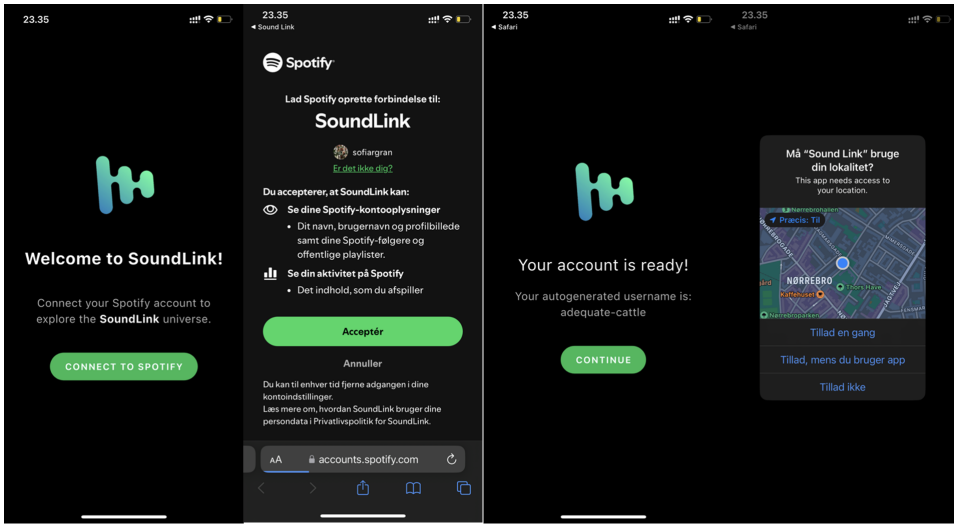

Fig. 15. Login

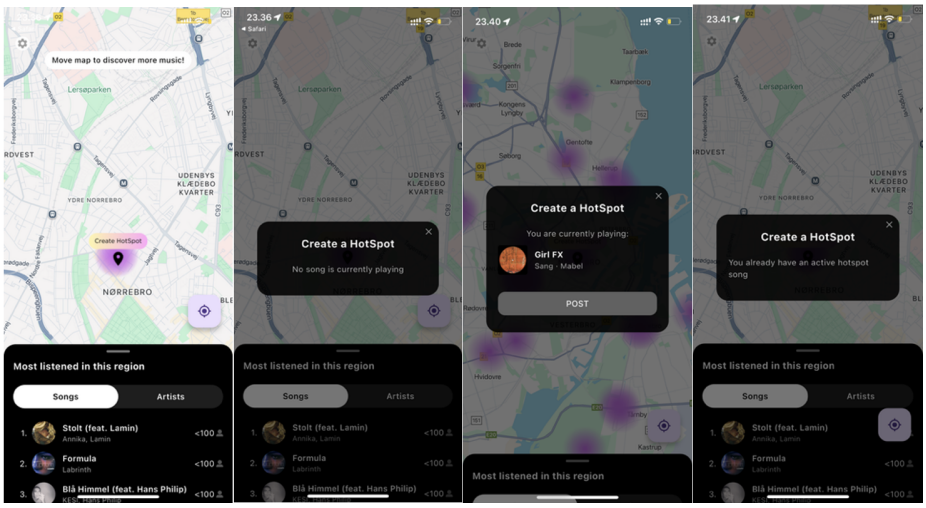

Fig. 16. Create hotspot

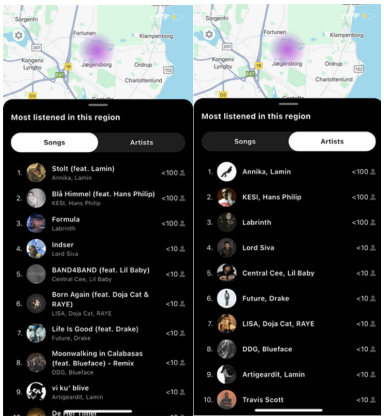

Fig. 17. Most listened to map - expanded

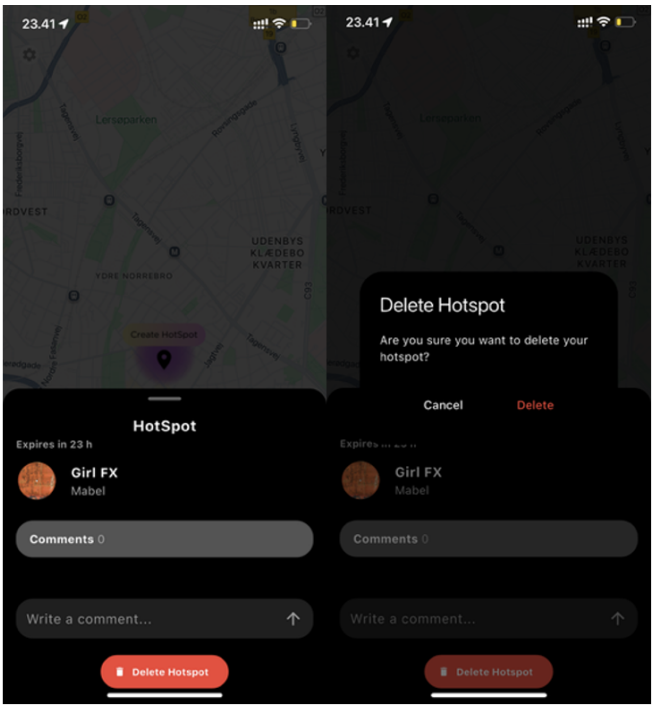

Fig. 18. Delete hotspot

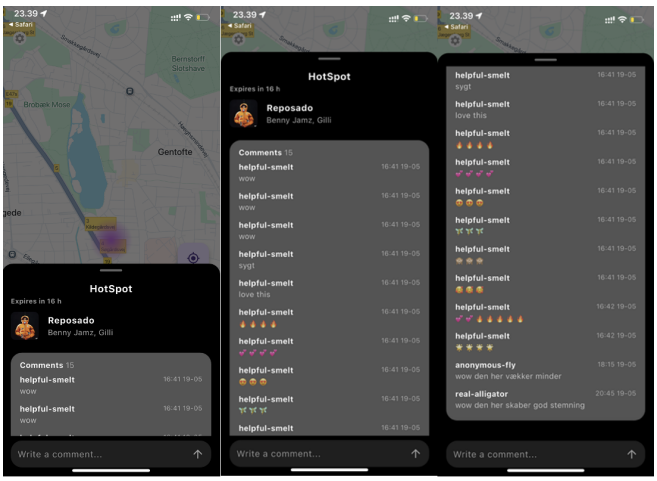

Fig. 19. Multiple comments on hotspot

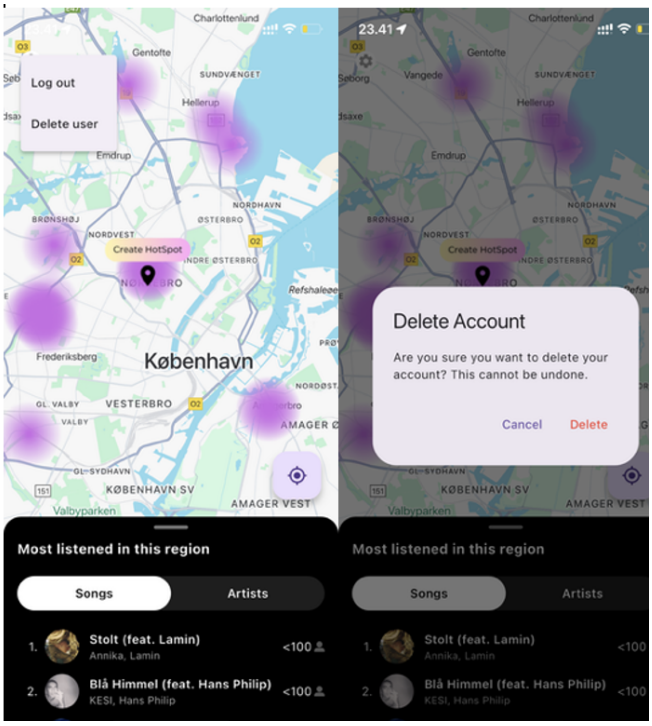

Fig. 20. Delete account

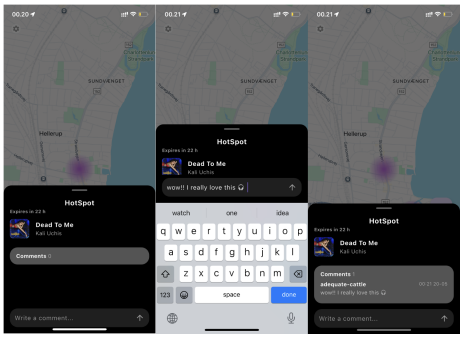

Fig. 21. Write comments on hotspot

I Metrics

Table 2. Backend performance across test scenarios

Test Type	Requests	Avg. Latency	P95 Latency	Max Latency	Error Rate
Load Test (300 VUs)	5,716	1.52 s	5.97 s	21.23 s	0.00%
Stress Test (800 VUs)	6,266	83 ms	153 ms	354 ms	0.87%
Soak Test (300 VUs, 8m)	37,867	1.86 s	6.81 s	59.91 s	0.008%