Environment-Driven Music Recommendation Application High-Level Design

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Purpose

This document outlines the general use-cases, scope, and design for a music recommendation application that takes into account a user's general environment, physiological factors, and personal preferences. In turn, it lays a set of guidelines to craft low-level designs to describe interactions with external APIs and data flows in more depth.

Overview

Music recommendation applications, models, plugins, curated lists, and general word-of-mouth all generally disclude a critical piece of user data: the environment of the user. Not only is every user's preference in music style unique, but additionally their receptivity to genres, artists, tempos, and even volumes changes when their surroundings change.

For example, this can include physiological data such as heart rate variability (HRV), heart rate, blood sugar levels, breathing rate, and exercise data. By accentuating these data points with the user's surroundings such as ambient sound and light, time of day, geolocation, and baseline personal preferences, it becomes apparent how vast the body of data to train ML models and neural networks can grow.

Providing environment-based music recommendations can improve daily life challenges such as cognition, stress management, sleep patterns, and job or school performance. Additionally, it allows the user to fully disengage from the responsibility of picking a well-suited playlist to listen to based on the situation. For many, this offload of responsibility is the only solution to having to manage a burdensome background task that inhibits sustained focus patterns.

As for companies that own rights and licenses to stream songs, this application provides a layer of detail and user compatibility that is incredibly difficult to generalize and predict at a large scale. With properly-tuned integration points, platforms that support this application will benefit from customer engagement, satisfaction, and retention.

Functional Requirements

Users of this application can expect the following user patterns and milestones below.

#	Functional Requirement Description (User POV)	Effort	Priority
1	I should be able to play back a previous playlist up to 30 days later. In other words, I should have access to a catalog of music I've listened to	Low	P0
2	I should expect my music recommendations and generated catalogs/playlists remain private to me	Low	P0
3	I should be able to create, update, and delete a user preference profile of my current favorite artists, genres, and playlists	Med	P0
4	I should expect to receive new song recommendations with each refresh of the application.	High	P0
5	I should expect that new song recommendations have a TTL in which they should not come up again until 30 days later	Low	P1
6	I should expect a customizable amount of music that I am familiar with to come up in my recommendations, in that I have added it to a playlist within my account.	Low	P1
7	I should expect the ordering of the songs to be relevant, but have the ability to shuffle the playlist	Med	P1
8	I should be able to change the genre of the music with a single button	Low	P1
9	I should be able to speed up or slow down the intensity of the songs chosen with a single button	Med	P1
10	I should be able to control the playback mechanism of my underlying music platform (Spotify, Apple Music, etc)	High	P1
11	I should have ambient sound volume affect the recommendations of songs that are given to me	High	P1
12	The application should store any Personal Health Data in compliance with HIPAA	Med	P2
13	I should have HRV data from my smart devices (Apple Watch, Fitbit, Garmin, Oura ring, etc) sync to this application in near-real-time when the measurements are taken.	High	P2
14	The application should improve its personal customizations over time as it learns from my data	High	P2

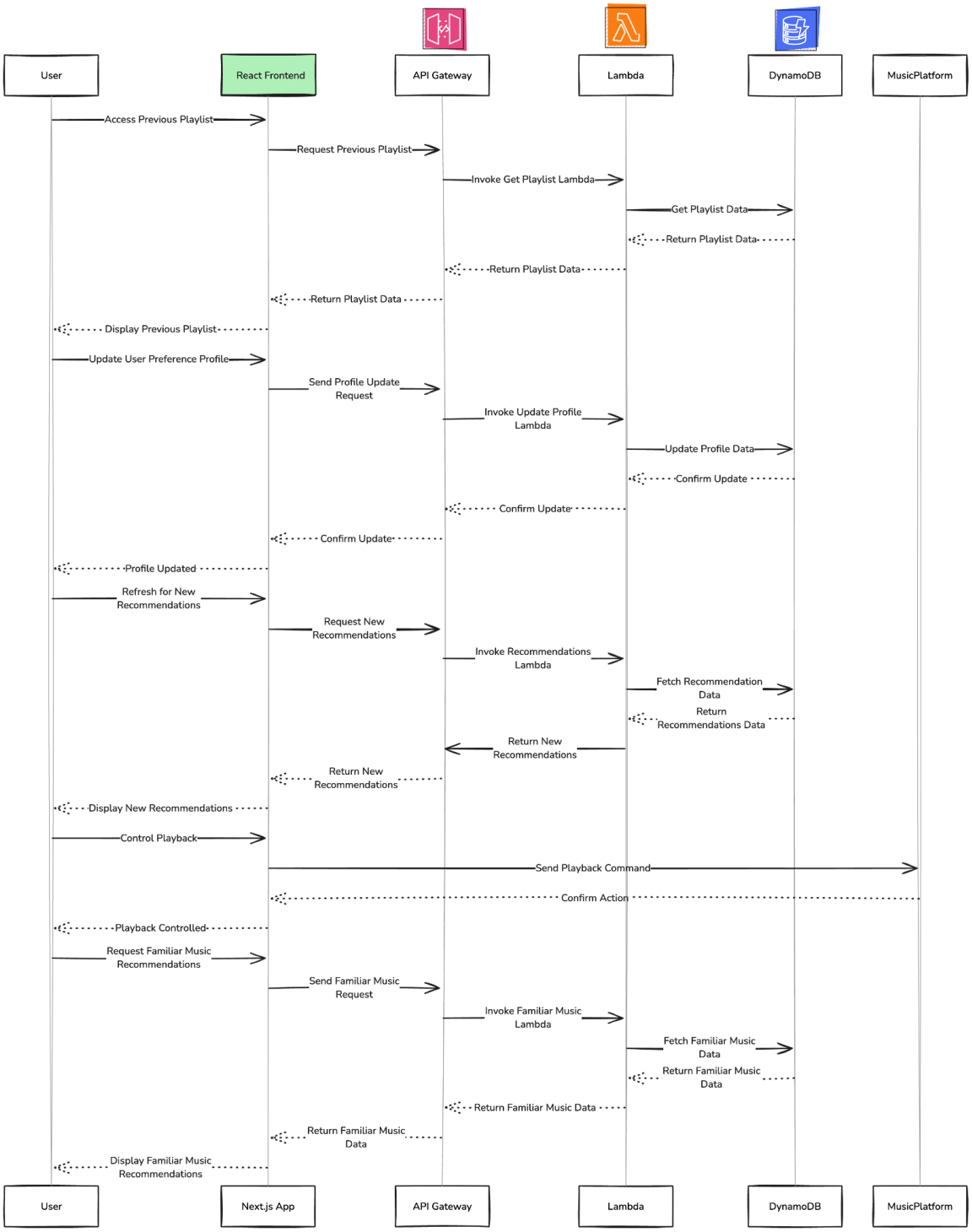
Non-functional Requirements

In order to deliver quickly, the technical requirements were split accordingly.

#	Non-Functional Requirement Description	Effort	Priority
Performance			
1	The system should process and display song recommendations within 300 milliseconds of a request.	Low	P0
2	HRV data from connected devices should sync and process updates in near-real-time, within 2 seconds of data arrival.	High	P2
3	Ambient sound analysis should update recommendations in under 1 second after changes in sound volume.	Med	P1
Scalability			
4	The system should support up to 10,000 concurrent users with no performance degradation.	Med	P0
5	The system should scale to handle a 50% increase in data ingestion during peak usage periods (e.g., syncing multiple devices).	Med	P0
Security			
6	User preferences and playlist data should remain private and be encrypted at rest and in transit (AES-256 and TLS 1.2+).	Low	P0
7	Personal Health Data (PHI) must comply with HIPAA regulations, including encryption and access auditing.	Med	P2
8	All user authentication should include multi-factor authentication (MFA).	Low	P1
Availability			
9	The system should achieve 99.9% uptime, ensuring that playlist playback and catalog access are reliable.	Med	P0
10	Playback control for Spotify/Apple Music should function with no more than 1 second of delay.	Low	P1
Usability			
11	The user interface should allow single-button actions for genre switching, intensity adjustment, and shuffle functionality.	Low	P1
12	The interface should provide clear feedback for actions like playlist creation or song skipping within 200 milliseconds.	Low	P1
Maintainability			
13	The system should include at least 90% automated test coverage for all critical components	High	P0
14	New deployments should occur without downtime using rolling updates.	Low	P0
Privacy			

15	The application should anonymize all user data stored for analytics or model training.	Low	P0
16	The application should allow users to export or delete their personal data in compliance with GDPR.	Med	P1
Personalization			
17	Recommendations should incorporate user preferences (favorite artists, genres) and learn dynamically from recent actions.	High	P0
18	Playlist updates should reflect changes in user preferences within 24 hours.	Low	P0
Cost Optimization			
19	The infrastructure cost of delivering recommendations and storing user data must not exceed $20/month per user base of 10,000.	Med	P0
20	The system should scale down resources automatically during periods of low activity.	Med	P0
Disaster Recovery			
21	User data and playlists must be backed up daily, with recovery achievable within 1 hour of a failure.	Low	P0

High-Level Architecture Diagram



[Diagram created by Excalidraw]

Components

1. React Frontend Application
    a. This framework excels at maintaining reusable components that can enable complex user interfaces
    b. The app will be built in `react-native-web` to enable extensibility in the case that this app should be pivoted to focus on mobile development
2. AWS API Gateway (APIGW)
    a. This service is a fully-managed API integration that allows seamless proxies to AWS Lambda
    b. API GW comes with default features within security, caching, custom domain names, monitoring/analytics, and fits the cost structure that is necessary in early releases of this product
3. AWS Lambda Backend
    a. The Lambda backend serves as a low-cost platform for hosting the backend service.This layer enables both synchronous and asynchronous workflows to run in response.
    b. Lambda can be optimized by enabling the function code with snapstart, and transitioning to the autoscaling provisioned concurrency feature if user adoption grows to support lower latencies
4. AWS DynamoDB (DDB)
    a. In the early stages of development of this app, the best way to scale fast, efficient retrieval will be by fetching in a non-relational DB.
    b. DDB also has convenient integrations for caching including DAX.
5. AWS SageMaker
    a. The AWS-internal platform for ML and AI model training enables easy integration when training datasets based on user preferences.
6. Music Platform
    a. The end goal is to integrate this with popular music streaming services such as Spotify, Amazon Music, and Apple Music

Appendix

1. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2019.01199/full