Cultour—an AI-powered smart tourism application

Group 5: deptrAI

December 16, 2025

Abstract

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2 Idea

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3 System Overview

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4 Sequence Diagram

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5 Class Diagram

5.1 Granular Search Service

The search pipeline is built upon a hybrid architecture that combines semantic search and lexical search techniques to optimize both relevance and precision in results. The key components of this pipeline are as follows:

1. **Data Embedding and Indexing:** The system utilizes **ChromaDB** as a vector database. To enhance retrieval accuracy, raw data from architecture and restaurant CSVs is pre-processed into descriptively refined documents before being embedded. We utilize the state-of-the-art `BAAI/bge-m3` sentence transformer model to generate these vector embeddings.

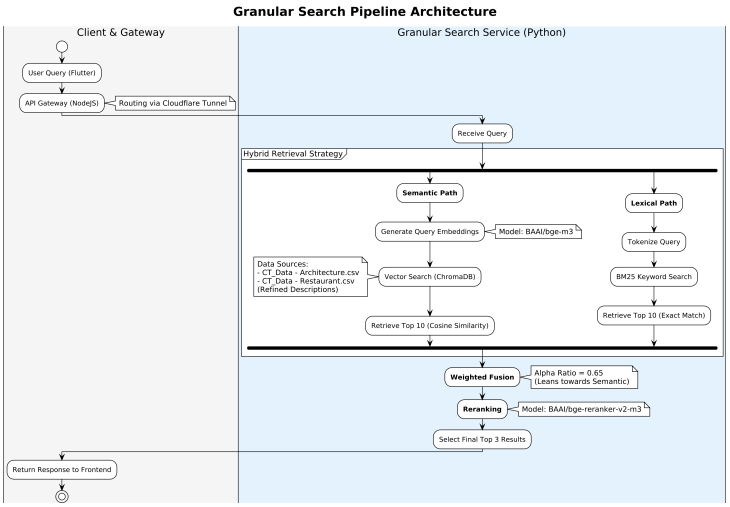
2. **Hybrid Retrieval:** The retrieval phase fuses two distinct methodologies.

   - *Semantic Search:* Calculates **cosine similarity** between the user's query vector and stored document vectors to find the top 10 conceptually relevant results.
   - *Lexical Search:* Utilizes the **BM25** algorithm to identify the top 10 results based on exact keyword matching.

   These results are combined using a weighted fusion mechanism with an alpha ratio (α) of 0.65. This weighting prioritizes semantic search (under-

standing user intent) while retaining the precision of keyword matching for specific entity names.

3. **Reranking:** The combined pool of candidates undergoes a final filtering stage using the `BAAI/bge-reranker-v2-m3` model. This cross-encoder assesses the relevance of each candidate pair deeply, adding precision and selecting the final top 3 results to be returned to the client.



6 Test Cases and Scenarios

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7 Completed Feature

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8 Planning

8.1 Phase 1: Minimum Viable Product (MVP)

The initial phase focuses on establishing the foundational features that differentiate Cultour from conventional travel applications, emphasizing intelligent search capabilities and community-driven event discovery.

8.1.1 Granular Search System

- **Multi-modal Search Implementation**: Deploy advanced search functionality supporting text queries, category-based filters, and image-based location recognition.
- **Technical Implementation**: Integration of fuzzy search algorithms and semantic search powered by Python backend services (`/search` and `/search-by-image` endpoints).

- **AI-Powered Query Processing**: Leverage natural language processing to interpret user intent and return contextually relevant results.
- **Filter Architecture**: Implement comprehensive filtering system including tags, location proximity, operating hours, and venue age/historical significance.

8.1.2 Intelligent Recommendation System

- **Personalization Engine**: Develop machine learning models to analyze user preferences, search history, and interaction patterns.
- **Collaborative Filtering**: Implement algorithms to suggest locations and events based on behavior of similar user profiles.
- **Preference Management**: Create user preference storage and updating mechanisms integrated with user session management.
- **Dynamic Suggestions**: Real-time recommendation updates based on user location, time of day, and seasonal factors.

8.1.3 Event Services Platform

- **Event Discovery**: Comprehensive event browsing interface with categorization and filtering capabilities.
- **Event Creation**: Full-featured event creation workflow allowing users to establish public or private events with detailed metadata (name, location, description, start/end times, participant limits).
- **Event Participation**: User subscription system enabling participants to join/leave events with real-time participant tracking.
- **Event Management**: CRUD operations for event lifecycle management through `EventService` API.

8.2 Phase 2: Scaling & Community Development

This phase transitions Cultour from a functional application to a comprehensive travel community platform capable of handling significant user traffic and fostering user-generated content.

8.2.1 Social Hub Development

- **User Review System**: Implement five-star rating system with text reviews, photo attachments, and review verification mechanisms.
- **User-Generated Itineraries**: Enable users to create, share, and publish custom travel itineraries with day-by-day breakdowns and location recommendations.

- **Travel Journals**: Develop journaling functionality allowing users to document trips with multimedia content, timestamps, and geolocation data.

8.2.2 Infrastructure Scaling

- **Load Balancer Implementation**: Deploy horizontal scaling architecture using containerized services (Docker infrastructure already established in codebase).
- **Database Optimization**: Implement database sharding, indexing strategies, and caching layers to manage high-volume queries.
- **CDN Integration**: Utilize Content Delivery Networks for image and static asset distribution to reduce latency.
- **API Gateway**: Establish API gateway with rate limiting, request routing, and microservices orchestration.

8.2.3 Geographic Expansion

- **Regional Data Collection**: Systematic gathering of location data from underrepresented regions throughout Vietnam.
- **Data Source Integration**: Partnership with local tourism boards, cultural organizations, and government databases.
- **Crowdsourced Data**: Enable verified users to contribute location information, photos, and metadata with quality control processes.
- **Multi-language Support**: Implement internationalization for Vietnamese, English, and additional languages.

8.3 Phase 3: Monetization Strategy

Upon establishing a stable user base and comprehensive content library, Phase 3 introduces revenue generation mechanisms while preserving platform accessibility.

8.3.1 Premium Event Listings

- **Organizational Accounts**: Create business-tier accounts for tourism organizations, hotels, and event companies.
- **Featured Event Placement**: Offer prominent positioning in search results and recommendation feeds for a service fee.
- **Analytics Dashboard**: Provide event organizers with participant demographics, engagement metrics, and conversion analytics.
- **Tiered Pricing Model**: Implement flexible pricing based on event visibility duration, geographic reach, and promotional features.

8.3.2 Affiliate Marketing Integration

- **Partnership Establishment**: Develop affiliate relationships with major booking platforms (Agoda, Klook, Booking.com).
- **Deep Linking Implementation**: Seamless integration enabling users to book accommodations and activities directly through Cultour.

8.4 Partner Verification & Quality Assurance

To maintain platform credibility and ensure user safety, a comprehensive partner verification system will be implemented.

8.4.1 Verification Process Architecture

- Multi-Tier Verification System.

8.4.2 Verification Requirements

- Documentation Standards.
- Review Process.

8.4.3 Badge & Trust System

- Verification Badges.
- Graduated Privileges.
- Ongoing Monitoring.

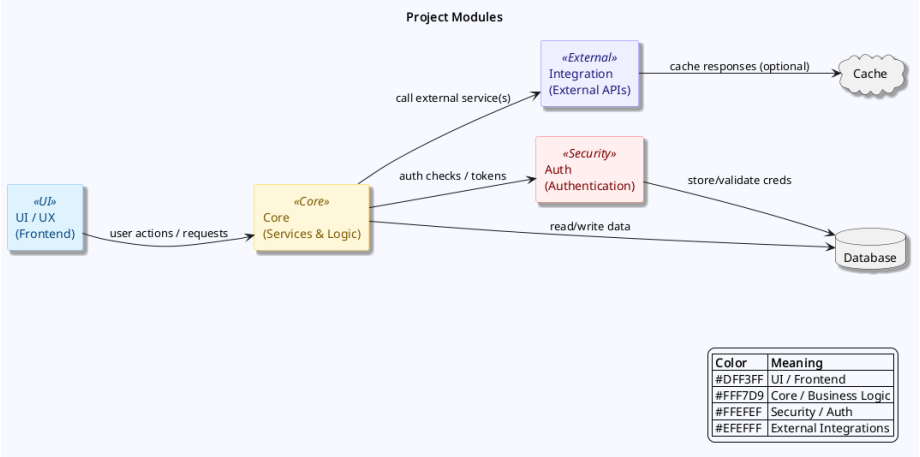
9 Technical Solution and Architecture

The project, in its core, is a Flutter mobile application that utilizes a NodeJS backend with assistance from Python backend servers that form into a single clean API that the frontend can use. The project's overall architecture can be split into three main architecture styles: the system-level architecture, the client architecture and the backend architecture.

System level architecture. The interaction between the frontend and the backend is a classic three-tier client-server architecture. More specifically, the Flutter client, which we call the *presentation*, utilizes the Node and Python API (the *application*). The backend then utilizes the database and external services to parse upstream data and pass it to the downstream clients. This is the simplest architecture for an MVP achievable within a reasonable time frame.

Client architecture. The frontend is primarily developed vertically via a feature-first architecture. The codebase can be grouped by separate features (including but not limited to login, map screen, trips, saved place, location searching), each has its own logic and UI implementation. We choose this architecture because it is a simple and intuitive architecture primarily derived from the user flow. This ensures ease of development and understanding from the team.

Backend architecture. The backend is a NodeJS express app comprising of multiple endpoints grouped into categories callable from the frontend via dio. In its core, it is an MVC architecture. An endpoint is structured by the core logic's within its service function, express handling and parameters fetching within its controller functions, and routing via an express's Router object. Middlewares for authorization and checking are also included, allowing decoupling and reducing code duplication. Other minor backend servers are also made for training AIs and AI-based searching, and the main backend calls these servers via Cloudflare tunnels. This allows for separation of duties and dependency decoupling.



10 Conclusion and Future Development