# **Technical Documentation - AI Chatbot Project**

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## **Project Overview**

This project is a full-stack AI-powered chatbot application built with Flask (backend) and Next.js (frontend). The system provides intelligent conversational capabilities with user authentication, product categorization, and search functionality.

### **Key Features**

* AI-powered chatbot conversations
* User authentication and authorization
* Product catalog with search and categorization
* Real-time chat interface
* Email verification system
* Responsive web design

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## **System Architecture**

The application follows a **microservices-inspired architecture** with clear separation between frontend and backend services:

┌─────────────────┐ HTTP/REST API ┌─────────────────┐

│ Frontend │ ◄──────────────────► │ Backend │

│ (Next.js) │ │ (Flask) │

│ │ │ │

│ • Auth Pages │ │ • API Routes │

│ • Dashboard │ │ • AI Services │

│ • Chat UI │ │ • Database │

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│ Database │

│ (SQL) │

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## **Technology Stack**

### **Backend Technologies**

* **Flask**: Python web framework for API development
* **SQLAlchemy**: ORM for database operations
* **SQL Database**: Data persistence layer
* **AI Service Integration**: For chatbot functionality

### **Frontend Technologies**

* **Next.js 14**: React framework with App Router
* **NextAuth.js**: Authentication library
* **TypeScript**: Type-safe JavaScript development
* **Tailwind CSS + shadcn/ui**: UI components and styling
* **Axios**: HTTP client for API communication
* **Zod**: Schema validation
* **Resend**: Email service integration

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### **Development Tools**

* **Environment Variables**: Configuration management
* **Data Seeding**: Mock data generation utilities

## **Backend Architecture**

### **File Structure**

backend/

├── app.py # Main Flask application

├── database.py # Database configuration

├── models.py # SQLAlchemy models

├── sqlfile.sql # Database schema

├── utils/

│ └── data\_seeder.py # Mock data generation

├── services/

│ └── ai\_services.py # AI chatbot logic

└── api/

├── chat.py # Chat endpoints

├── categories.py # Category management

├── products.py # Product endpoints

└── search.py # Search functionality

### **Core Components**

#### **1. Application Entry Point (app.py)**

* Flask application initialization
* Route registration
* Middleware configuration
* CORS setup for frontend communication

#### **2. Database Layer (database.py, models.py)**

* Database connection management
* SQLAlchemy model definitions
* Database session handling

#### **3. API Routes**

* **Chat API**: Handles conversational interactions
* **Products API**: CRUD operations for products
* **Categories API**: Product categorization
* **Search API**: Product and content search

#### **4. AI Services (ai\_services.py)**

* Chatbot response generation
* Natural language processing
* Context management for conversations

## **Frontend Architecture**

### **File Structure**

frontend/

├── app/

│ ├── page.tsx # Home page

│ ├── dashboard/ # Dashboard pages

│ └── (auth)/ # Authentication pages

├── components/ # Reusable UI components

├── api/ # API route handlers

├── lib/ # Utility functions

├── models/ # TypeScript interfaces

├── types/ # Type definitions

└── .env # Environment variables

### **Key Features**

#### **1. Authentication System**

* **NextAuth.js** integration for secure authentication
* Email verification workflow
* Protected routes and middleware
* Session management

#### **2. UI Components**

* **shadcn/ui** component library
* Responsive design patterns
* Reusable component architecture
* TypeScript integration

#### **3. State Management**

* React hooks for local state
* API state synchronization
* Form validation with Zod

## **Database Design**

### **Core Entities**

1. **Users**: User authentication and profile data
2. **Products**: Product catalog information
3. **Categories**: Product categorization system
4. **Chat Sessions**: Conversation history
5. **Messages**: Individual chat messages

### **Schema Design**

-- Example schema structure (from sqlfile.sql)

Users (id, email, password\_hash, created\_at, verified)

Products (id, name, description, category\_id, price, created\_at)

Categories (id, name, description)

ChatSessions (id, user\_id, created\_at)

Messages (id, session\_id, content, is\_user, timestamp)

## **API Documentation**

### **Authentication Endpoints**

* POST /api/auth/signup - User registration
* POST /api/auth/signin - User login
* POST /api/auth/verify - Email verification

### **Chat Endpoints**

* POST /api/chat - Send message to chatbot
* GET /api/chat/history - Retrieve chat history

### **Product Endpoints**

* GET /api/products - List all products
* GET /api/products/:id - Get product details
* POST /api/products - Create new product

### **Search & Categories**

* GET /api/search?q=query - Search products
* GET /api/categories - List categories

## **Authentication & Authorization**

### **NextAuth.js Configuration**

* **Providers**: Email/password authentication
* **Sessions**: JWT-based session management
* **Callbacks**: Custom authentication logic
* **Middleware**: Route protection

### **Security Features**

* Password hashing and salting
* Email verification workflow
* CSRF protection
* Secure session handling

## **Data Flow**

### **User Authentication Flow**

1. User submits registration form
2. Frontend validates input with Zod
3. API creates user account
4. Email verification sent via Resend
5. User verifies email and gains access

### **Chat Interaction Flow**

1. User sends message through chat interface
2. Frontend sends request to Flask API
3. AI service processes message
4. Response generated and stored
5. Real-time update in chat UI

## **Mock Data Creation**

### **Data Seeding Strategy (utils/data\_seeder.py)**

The data seeding system creates realistic test data for development and testing:

#### **Product Data Generation**

* **Categories**: Electronics, Clothing, Books, Home & Garden
* **Products**: Generated with realistic names, descriptions, and prices
* **Relationships**: Proper category associations

#### **User Data**

* Test user accounts with verified status
* Sample chat histories
* Varied user interaction patterns

#### **Implementation Approach**

# Example seeding structure

def seed\_categories():

# Create product categories

def seed\_products():

# Generate products for each category

def seed\_users():

# Create test user accounts

def seed\_chat\_data():

# Generate sample conversations

### **Benefits of Mock Data**

* **Development**: Enables frontend development without production data
* **Testing**: Provides consistent test scenarios
* **Demonstration**: Showcases full application functionality
* **Performance Testing**: Allows load testing with substantial datasets

## **Challenges & Solutions**

### **Challenge 1: Cross-Origin Resource Sharing (CORS)**

**Problem**: Frontend and backend running on different ports caused CORS issues.

**Solution**:

* Configured Flask-CORS with specific origins
* Set proper headers for preflight requests
* Implemented credential sharing for authenticated requests

### **Challenge 2: Authentication State Management**

**Problem**: Synchronizing authentication state between NextAuth and Flask backend.

**Solution**:

* Implemented JWT token passing
* Created custom NextAuth callbacks
* Added middleware for route protection

### **Challenge 3: Real-time Chat Experience**

**Problem**: Creating responsive chat interface with proper message handling.

**Solution**:

* Implemented optimistic UI updates
* Added loading states and error handling
* Used React hooks for state management

### **Challenge 4: Database Relationship Management**

**Problem**: Complex relationships between users, products, and chat data.

**Solution**:

* Designed normalized database schema
* Used SQLAlchemy relationships
* Implemented proper foreign key constraints

### **Challenge 5: AI Service Integration**

**Problem**: Managing AI service responses and context.

**Solution**:

* Created abstraction layer in ai\_services.py
* Implemented conversation context management
* Added error handling for service failures

### **Challenge 6: Type Safety Across Stack**

**Problem**: Ensuring type consistency between frontend and backend.

**Solution**:

* Defined TypeScript interfaces
* Used Zod for runtime validation
* Created shared type definitions

## **Future Enhancements**

### **Short-term Improvements**

1. **WebSocket Integration**: Real-time messaging
2. **File Upload**: Image and document sharing in chat
3. **Advanced Search**: Elasticsearch integration
4. **Caching**: Redis for improved performance

### **Long-term Features**

1. **Multi-language Support**: Internationalization
2. **Mobile App**: React Native companion
3. **Analytics Dashboard**: User behavior insights
4. **AI Model Training**: Custom model fine-tuning

### **Scalability Considerations**

1. **Microservices**: Service decomposition
2. **Load Balancing**: Horizontal scaling
3. **Database Optimization**: Query optimization and indexing
4. **CDN Integration**: Static asset delivery

## **Conclusion**

This AI chatbot project demonstrates a modern full-stack architecture with clear separation of concerns, robust authentication, and scalable design patterns. The combination of Flask's simplicity with Next.js's powerful features creates a maintainable and extensible application foundation.

The documented challenges and solutions provide valuable insights for similar projects, while the mock data strategy ensures consistent development and testing environments.