System Architecture and Data Flow

High-Level Architecture

The following diagram illustrates the overall system architecture, showing how different components interact:

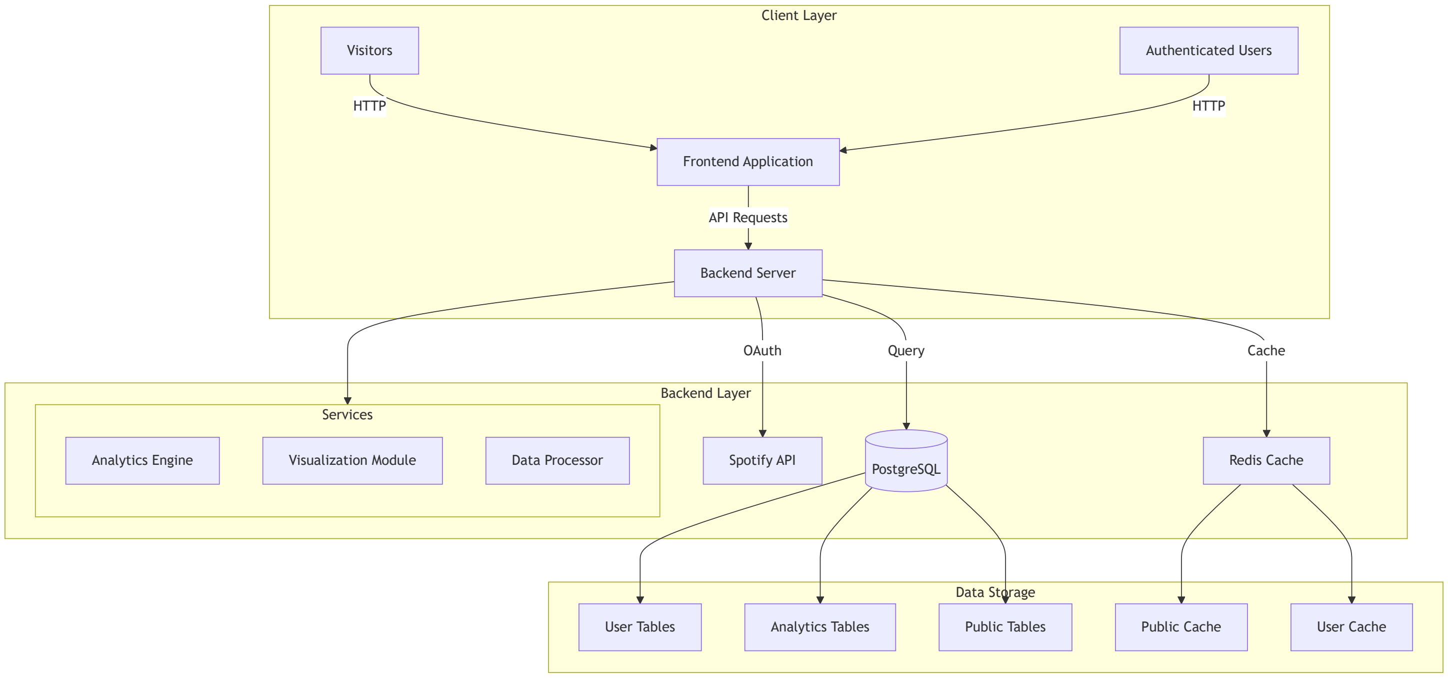


Diagram Explanation:

- **Client Layer**: Represents how both visitors and authenticated users access our application through the frontend interface
- **Backend Layer**: Shows the core server components and their connections to external services
- **Data Storage**: Illustrates our data persistence strategy using both PostgreSQL and Redis
- **Services**: Displays the main processing modules that handle different aspects of data analysis

Data Flow for Visitors

This diagram shows how visitors interact with our system and how we handle public data requests:

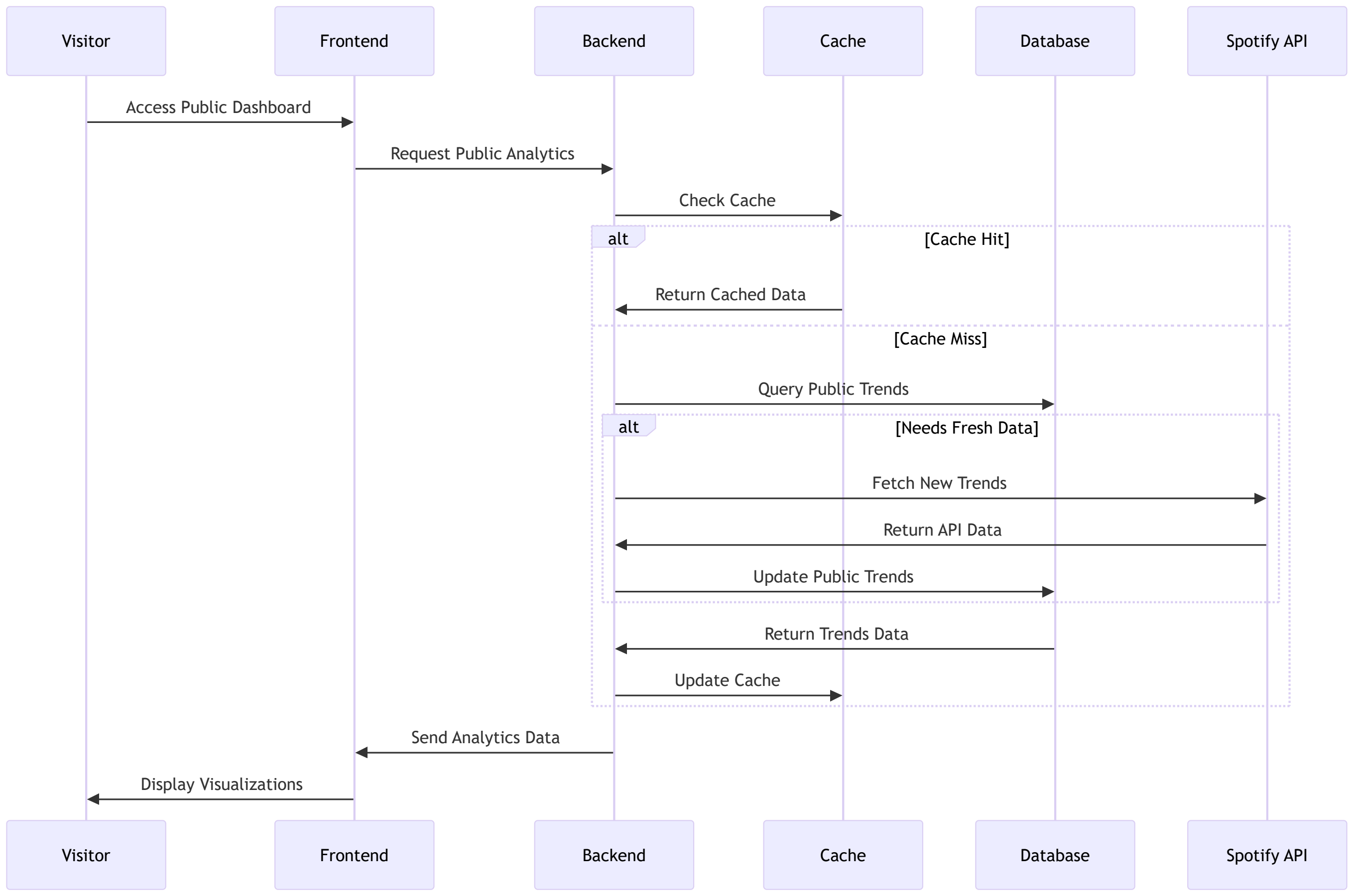


Diagram Explanation:

- **Initial Request**: Visitor accesses the public dashboard
- **Cache Check**: System first checks if requested data is in cache
- **Data Retrieval**: If cache misses, system fetches from database or Spotify API
- **Data Flow**: Shows how data moves from source to visitor's screen
- **Optimization**: Demonstrates caching strategy for better performance

Data Flow for Authenticated Users

This diagram illustrates the authentication process and data access for registered users:

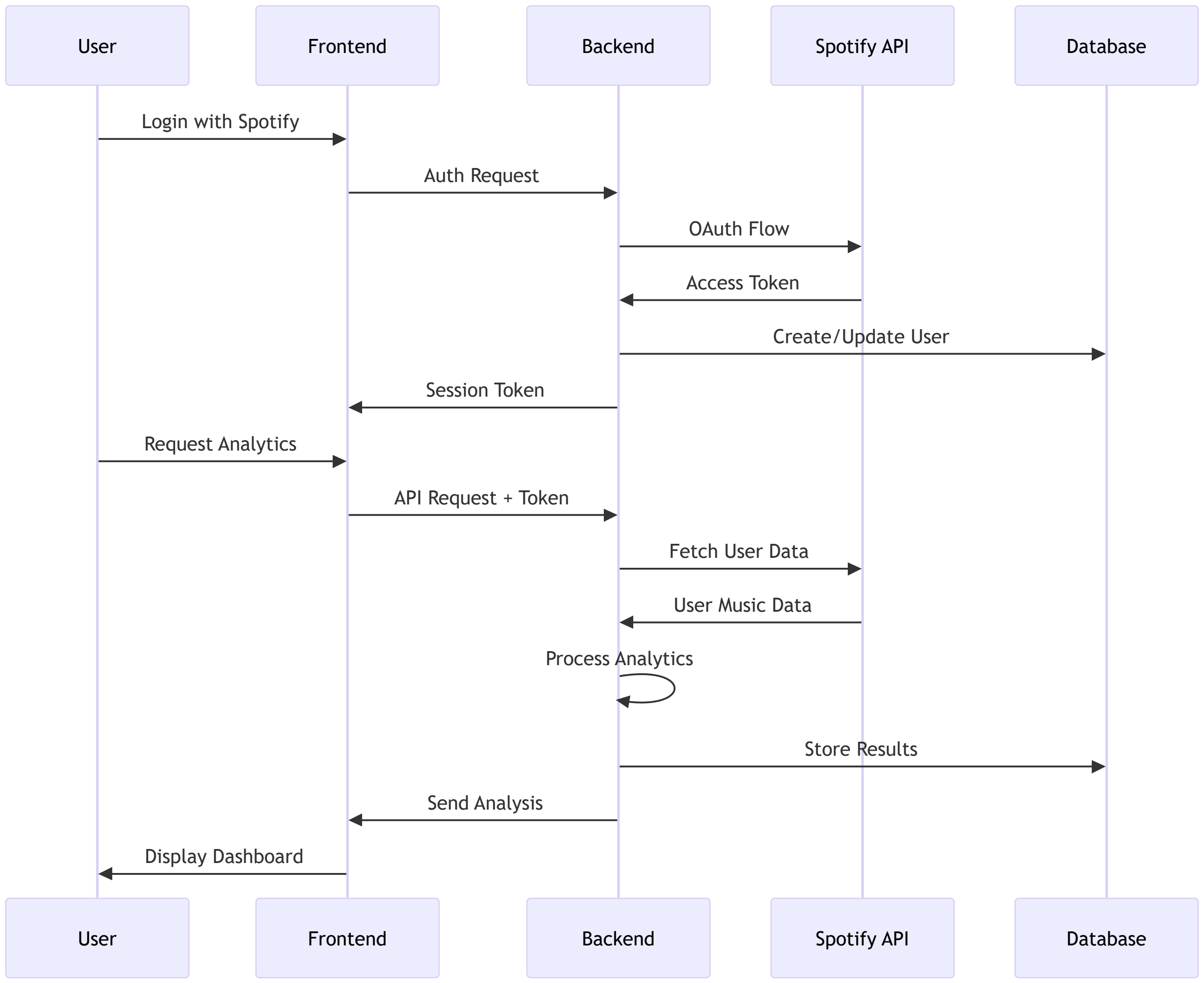
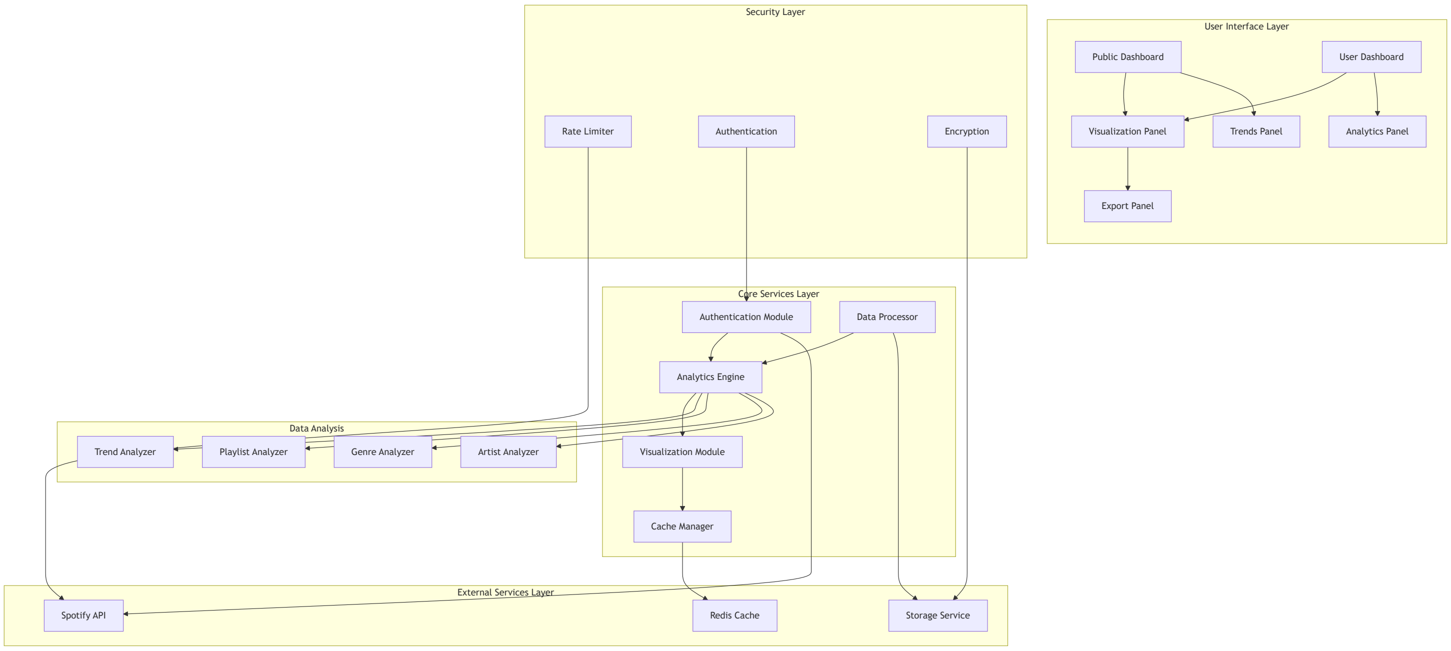


Diagram Explanation:

- **Authentication**: Shows the OAuth flow with Spotify
- **Session Management**: Illustrates how user sessions are handled
- **Data Access**: Demonstrates the process of fetching and analyzing user data
- **Security**: Highlights token-based authentication and secure data flow
- **Analytics Process**: Shows how user data is processed and stored

Component Interaction

Detailed breakdown of how different system components work together:



Component Details:

1. **User Interface Layer**
   - **Public Dashboard**: Entry point for visitors, showing general trends and public analytics
   - **User Dashboard**: Personalized interface for authenticated users
   - **Visualization Panel**: Renders charts, graphs, and interactive visualizations
   - **Export Panel**: Handles data export and sharing functionality
   - **Analytics Panel**: Shows detailed music analysis
   - **Trends Panel**: Displays current music trends and patterns
2. **Core Services Layer**
   - **Analytics Engine**: Core processing unit for music data analysis
   - **Visualization Module**: Transforms data into visual representations
   - **Cache Manager**: Handles data caching for improved performance
   - **Authentication Module**: Manages user authentication and sessions
   - **Data Processor**: Processes raw data from various sources
3. **Data Analysis Components**
   - **Trend Analyzer**: Processes and identifies music trends
   - **Playlist Analyzer**: Analyzes playlist composition and patterns
   - **Genre Analyzer**: Processes genre-related data and statistics
   - **Artist Analyzer**: Analyzes artist popularity and metrics
4. **External Services Layer**
   - **Spotify API**: External music data source
   - **Storage Service**: Handles persistent data storage
   - **Redis Cache**: In-memory data caching
5. **Security Layer**

    - **Rate Limiter**: Controls API request frequency
    - **Authentication**: Handles user authentication
    - **Encryption**: Manages data encryption/decryption

Inter-Component Communication:

- UI components communicate with core services through RESTful APIs
- Core services interact with external services using appropriate protocols
- Data flows through the security layer for all external communications
- Cache manager optimizes data access across all components
- Analytics engine coordinates with all analysis components for comprehensive insights

This architecture ensures:

- Scalability through modular design
- Security through layered approach
- Performance through effective caching
- Reliability through service isolation
- Maintainability through clear separation of concerns