Flutter-based Android SDK for Spin Wheel Feature: Detailed Outline

Phase 1: Research and Analyze SDK Requirements

Existing Flutter Spin Wheel Packages Analysis

`flutter_spinning_wheel`

Overview:

The `flutter_spinning_wheel` package provides a customizable widget for creating spinning wheels in Flutter applications. It allows for basic customization of the wheel's appearance and behavior.

Key Features and Customization Options:

- **Image-based Wheel:** The wheel itself is rendered from an image, allowing for custom designs. Users can replace the image with their preference.
- **Dividers:** The number of divisions in the wheel can be specified, assuming all divisions are equal.
- **Dimensions:** `width` and `height` parameters control the size of the wheel container.
- **Initial Spin Angle:** `initialSpinAngle` allows setting an initial rotation for the wheel.
- **Spin Resistance:** `spinResistance` (0.0 to 1.0) influences the speed and deceleration of the wheel.
- **Interaction during Spin:** `canInteractWhileSpinning` (boolean) determines if the user can stop the wheel while it's spinning.
- **Secondary Image:** A `secondaryImage` can be rendered on top of the wheel, unaffected by the animation, with customizable `secondaryImageHeight`,

`secondaryImageWidth`, `secondaryImageTop`, and `secondaryImageLeft` for fine-tuning its position.

- **Callbacks:**
  - `onUpdate(int value)`: Executed when the selected divider changes during the animation.
  - `onEnd(int value)`: Executed when the animation stops.
- **Integration with Scoring (Example):** The example demonstrates a basic scoring system using a `StreamBuilder` and a `RouletteScore` widget, mapping divider values to reward labels (e.g., '1000′,′ 400'). This is a basic example and would need to be expanded for a full SDK.

Limitations/Considerations for SDK Development:

- **Image-dependent Customization:** While flexible, relying solely on images for wheel design might limit dynamic customization of individual segment colors, text, or icons without regenerating the image. A more programmatic approach for segment rendering would offer greater flexibility.
- **Basic Scoring:** The provided example for scoring is very rudimentary. A full SDK would require a more robust and extensible scoring system.
- **No Built-in Leaderboards, Notifications, Analytics:** The package focuses purely on the UI widget and does not include any features related to leaderboards, notifications, or analytics. These would need to be developed as separate components within the SDK.
- **Security and Reliability:** As a UI package, it doesn't address security or reliability concerns for an SDK. These aspects would need to be handled at the SDK level.
- **Documentation:** While the Readme provides basic usage, a comprehensive SDK would require extensive documentation for developers.
- **Dart 3 Incompatible:** The package is 6 years old and marked as Dart 3 incompatible, which is a significant concern for a modern Flutter SDK.

Conclusion:

The `flutter_spinning_wheel` package provides a good starting point for the core spin wheel UI. However, a complete SDK would require significant additional development for advanced customization, scoring, leaderboards, notifications,

analytics, security, reliability, and comprehensive documentation. The age and Dart 3 incompatibility of this package suggest that building a new, modern spin wheel widget from scratch or finding a more actively maintained alternative might be necessary for a robust SDK.

`flutter_fortune_wheel`

Overview:

The `flutter_fortune_wheel` package offers highly customizable fortune wheel widgets for Flutter, supporting mobile, desktop, and web platforms. It provides more advanced customization options compared to `flutter_spinning_wheel`.

Key Features and Customization Options:

- **Programmatic Item Definition:** Instead of relying on a single image, `FortuneItem` objects define individual segments of the wheel. Each `FortuneItem` can have a `child` widget (e.g., `Text`, `Icon`) and a `style` property for fine-grained control over its appearance.
- **Individual Item Styling:** `FortuneItemStyle` allows customization of `color` (fill color), `borderColor`, and `borderWidth` for each segment, enabling dynamic visual changes without image manipulation.
- **Style Strategies:** `StyleStrategy` allows applying common styling logic to all items. `AlternatingStyleStrategy` and `UniformStyleStrategy` are provided, and custom strategies can be implemented.
- **Physics-based Interaction:** The `physics` property, which expects an implementation of `PanPhysics`, controls touch and drag input. `CircularPanPhysics` (for `FortuneWheel`) and `DirectionalPanPhysics.horizontal` (for `FortuneBar`) are available, and custom `PanPhysics` subclasses can be created.
- **`onFling` Callback:** This callback is triggered when a fling gesture is detected, allowing for selection of a new random item.
- **Customizable Indicators:** `FortuneIndicator` allows customization of the position indicators. `TriangleIndicator` and `RectangleIndicator` are provided, and custom indicator widgets can be used.

- **Fortune Bar:** In addition to the circular wheel, a `FortuneBar` widget is provided for scenarios where vertical screen space is limited.
- **Dart 3 Compatible:** This package is actively maintained and compatible with Dart 3.

Strengths for SDK Development:

- **High Customizability:** The programmatic approach to defining and styling wheel segments makes it highly suitable for an SDK that requires extensive customization of colors, text, and icons.
- **Flexible Interaction:** The physics-based interaction and `onFling` callback provide good control over the spinning behavior.
- **Active Development:** Being Dart 3 compatible and actively maintained is a significant advantage for building a modern SDK.
- **Cross-Platform Support:** Works across mobile, desktop, and web, which is beneficial for a versatile SDK.

Limitations/Considerations for SDK Development:

- **No Built-in Scoring, Leaderboards, Notifications, Analytics:** Similar to `flutter_spinning_wheel`, this package focuses on the UI component and does not include features like scoring systems, leaderboards, notifications, or analytics. These would need to be integrated separately.
- **Security and Reliability:** The package itself doesn't inherently address SDK-level security or reliability concerns.
- **Documentation:** While good for a package, an SDK would require more comprehensive documentation, including integration guides, API references, and best practices.

Conclusion:

The `flutter_fortune_wheel` package is a much stronger candidate for the core spin wheel UI component of the SDK due to its high customizability, programmatic approach to segment definition, and active development. It provides a solid foundation upon which to build the required features for the SDK, such as advanced customization, scoring, leaderboards, notifications, analytics, security, and comprehensive documentation.

Core SDK Requirements

Based on the analysis of existing Flutter spin wheel packages and general mobile SDK best practices, the following core requirements have been identified for the Flutter-based Android SDK:

1. Spin Wheel Feature (Core Functionality)

- **Highly Customizable UI:**
    - **Dynamic Segment Customization:** The SDK must allow for programmatic customization of individual wheel segments, including:
        - **Colors:** Comprehensive control over background, border, and text colors for each segment, allowing for any color combination.
        - **Text:** Support for custom text content within each segment, including font, size, color, and styling.
        - **Icons/Images:** Full flexibility to embed custom icons or images (both local assets and remote URLs) within each segment, with options for sizing and positioning.
    - **Wheel Appearance:** Control over overall wheel properties such as:
        - **Size and Dimensions:** Adjustable width and height.
        - **Border:** Customizable border color and width for the entire wheel.
        - **Background:** Option to set a custom background for the wheel area.
    - **Indicator Customization:** The pointer or indicator that highlights the winning segment should be customizable in terms of its shape, color, size, and position.
    - **Animation Control:** Fine-grained control over spin animation properties, including duration, easing curves, and initial spin angle.
    - **Interaction:** Ability to configure user interaction, such as enabling/disabling manual spinning or flinging.
- **Predefined Themes and Customization Options:**
    - The SDK should offer a set of predefined visual themes to allow for quick integration and consistent branding.

    - A clear and intuitive API for applying these themes and overriding specific customization options should be provided.

- **Reward Mechanism:**
    - A flexible system to define and associate rewards with each wheel segment.
    - Support for various reward types (e.g., points, virtual currency, in-app items, discounts).
    - A callback mechanism to notify the integrating application when a reward is won.

2. Scoring System

- **Flexible Scoring Logic:**
    - The SDK should provide a robust scoring system that can be integrated with the spin wheel outcomes.
    - Ability to define different point values or scoring rules for various rewards or segments.
    - Support for cumulative scoring and session-based scoring.
- **Score Management API:**
    - APIs for adding, deducting, resetting, and retrieving user scores.
    - Secure storage of scores to prevent tampering.
- **Integration with External Systems:** Potential for integration with backend systems for persistent score storage and validation.

3. Leaderboards

- **Leaderboard Management:**
    - APIs for submitting scores to a leaderboard.
    - Retrieval of global and friend-based leaderboards.
    - Support for different leaderboard types (e.g., daily, weekly, all-time).
- **User Ranking:** Display of user's current rank and position relative to others.
- **Pagination and Filtering:** Efficient retrieval of leaderboard data, especially for large datasets.

- **Security:** Measures to prevent fraudulent scores from being submitted to leaderboards.

4. Notifications

- **In-App Notifications:**
    - Ability to trigger customizable in-app notifications based on spin wheel outcomes (e.g.,

'You won!', 'Better luck next time!'). * Customizable notification content, appearance, and sound. * **Push Notifications (Optional but Recommended):** * Integration with push notification services (e.g., Firebase Cloud Messaging) to send notifications to users outside the app (e.g., 'Don't forget to spin the wheel today!'). * Requires clear opt-in/opt-out mechanisms for users.

5. Analytics

- **Event Tracking:**
    - Automatic tracking of key events related to the spin wheel (e.g., wheel spun, reward won, reward redeemed, customization applied, theme changed).
    - Customizable event parameters to capture relevant data (e.g., reward type, spin duration, user ID).
- **User Engagement Metrics:**
    - Collection of data on user engagement with the spin wheel feature (e.g., frequency of spins, average rewards won, time spent).
- **Integration with Analytics Platforms:**
    - Compatibility with popular analytics platforms (e.g., Google Analytics for Firebase, Mixpanel) for data visualization and analysis.
    - APIs for developers to access raw or aggregated analytics data.

6. Security

- **Data Protection:**
    - Secure handling and storage of sensitive user data (e.g., scores, reward information).
    - Encryption of data in transit and at rest where appropriate.

- **Fraud Prevention:**
    - Mechanisms to prevent cheating or manipulation of spin wheel outcomes and scoring.
    - Server-side validation of spin results and reward claims.
- **API Security:**
    - Secure authentication and authorization for any backend API calls (e.g., for leaderboards, persistent scoring).
    - Protection against common vulnerabilities like injection attacks, unauthorized access.
- **Obfuscation and Tamper Detection:**
    - Techniques to make it harder for malicious users to reverse-engineer or tamper with the SDK code.

7. Reliability

- **Stability and Performance:**
    - The SDK must be stable, crash-free, and performant, even under heavy usage.
    - Efficient resource management to minimize impact on the host application.
- **Error Handling and Resilience:**
    - Robust error handling mechanisms to gracefully manage unexpected situations (e.g., network issues, invalid configurations).
    - Offline capabilities or graceful degradation when internet connectivity is unavailable.
- **Backward Compatibility:**
    - Maintain backward compatibility with previous versions to ensure smooth updates for integrating applications.

8. Documentation

- **Comprehensive Developer Documentation:**
    - Clear and concise documentation for integrating and using the SDK.
    - Includes installation guides, API references, code examples, and best practices.

    - Detailed explanations of customization options, scoring logic, and integration points.
- **Getting Started Guides:** Step-by-step tutorials for common use cases.
- **Troubleshooting and FAQs:** Resources to help developers resolve common issues.
- **Version Control and Release Notes:** Clear information on SDK versions, changes, and new features.

9. Platform Compatibility

- **Android Focus:** While Flutter is cross-platform, the primary focus of this SDK is Android, ensuring optimal performance and adherence to Android design guidelines.
- **Flutter Version Compatibility:** Clearly state supported Flutter and Dart SDK versions.

Phase 2: Design SDK Architecture and Technical Specifications

Overall SDK Architecture

The Flutter-based Android SDK for the spin wheel feature will be designed with a modular and extensible architecture to ensure maintainability, scalability, and ease of integration. The SDK will primarily consist of a Flutter module that can be embedded into existing Android applications. This approach leverages Flutter's UI capabilities while allowing seamless integration into native Android environments.

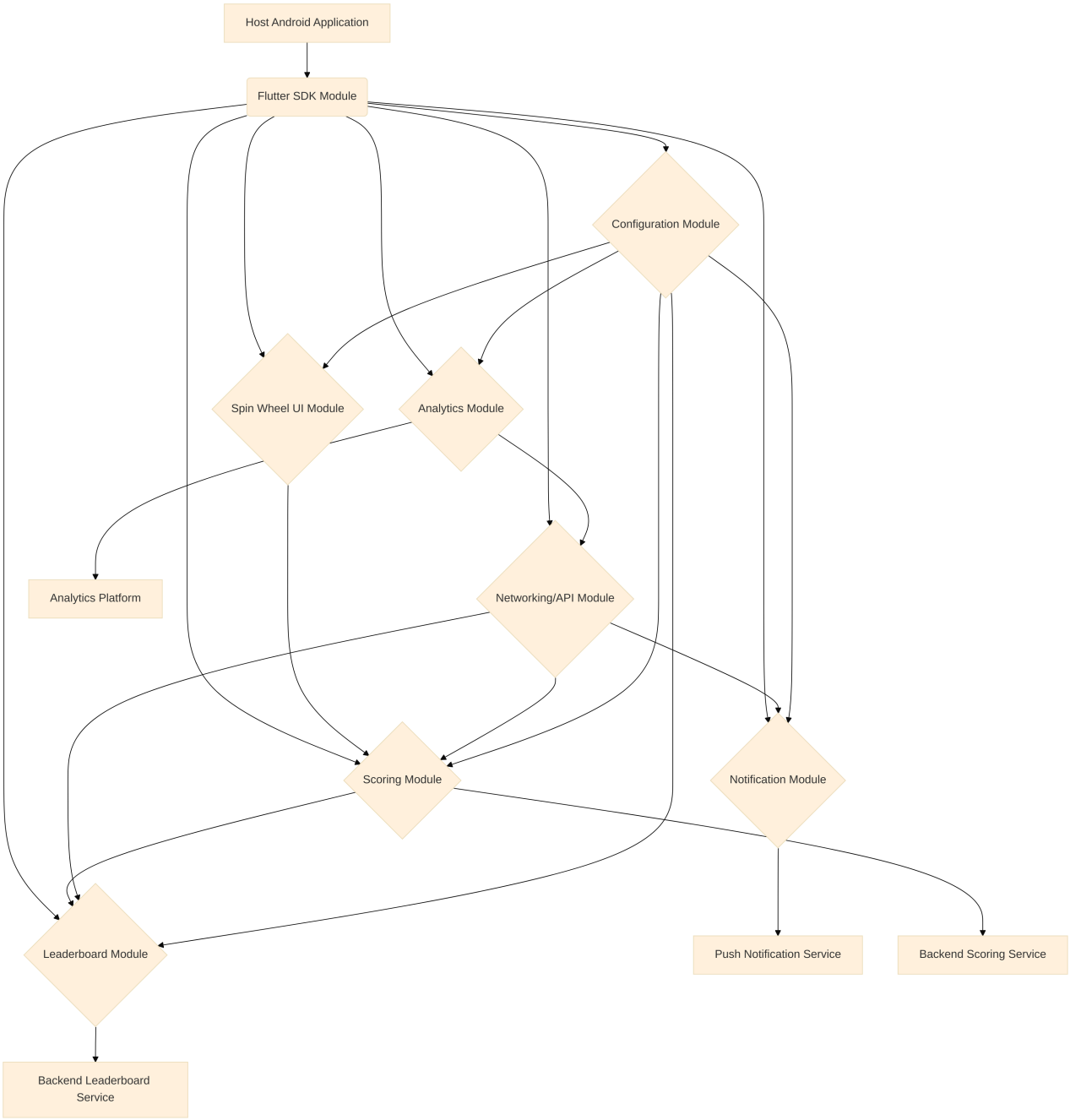
Key Architectural Principles:

- **Modularity:** The SDK will be broken down into distinct, self-contained modules, each responsible for a specific set of functionalities (e.g., UI, scoring, analytics, networking). This promotes separation of concerns and simplifies development and testing.
- **Extensibility:** The architecture will be designed to allow for easy addition of new features or customization options without requiring significant changes to

existing code. This will be achieved through well-defined interfaces, abstract classes, and dependency injection.

- **Configurability:** The SDK will provide a clear and centralized mechanism for configuration, allowing developers to easily enable/disable features, set customization parameters, and integrate with their backend systems.
- **Performance:** Emphasis will be placed on optimizing the SDK's performance to ensure smooth animations, responsive UI, and minimal impact on the host application's resources.
- **Security:** Security considerations will be integrated throughout the design process, including secure data handling, API communication, and protection against tampering.
- **Testability:** The modular design and clear interfaces will facilitate comprehensive unit, integration, and UI testing.

High-Level Component Diagram:



Explanation of High-Level Components:

- **Host Android Application:** The native Android application that integrates the Flutter SDK module.
- **Flutter SDK Module:** The core Flutter module containing all the SDK functionalities. This module will be exposed as a library that Android developers can easily add to their projects.
- **Spin Wheel UI Module:** Responsible for rendering the spin wheel, handling animations, and managing user interactions. This module will leverage the

`flutter_fortune_wheel` package as a foundation, with significant enhancements for advanced customization.

- **Scoring Module:** Manages the scoring logic, including point calculation, score storage, and retrieval. It will interact with the Networking/API Module for persistent storage and validation.
- **Leaderboard Module:** Handles the submission and retrieval of scores to and from leaderboards. It will communicate with a backend leaderboard service via the Networking/API Module.
- **Notification Module:** Manages in-app notifications and integrates with push notification services to deliver timely alerts and reminders to users.
- **Analytics Module:** Tracks user interactions and events within the spin wheel feature, sending data to configured analytics platforms.
- **Networking/API Module:** Provides a secure and standardized way for other modules to communicate with backend services for scoring, leaderboards, and other data-driven functionalities.
- **Configuration Module:** Centralizes all SDK configuration parameters, including API keys, theme settings, and feature toggles.

Module Breakdown and Technical Specifications

2.1 Spin Wheel UI Module

Purpose: To provide a highly customizable and interactive spin wheel widget.

Key Classes/Components:

- `SpinWheelWidget` : The main Flutter widget for the spin wheel. It will encapsulate the `FortuneWheel` from `flutter_fortune_wheel` and extend its capabilities.
- `SpinWheelController` : A controller class to programmatically control the spin wheel (e.g., start spin, stop spin, set outcome).
- `SpinWheelTheme` : A class defining the visual properties of the spin wheel, including colors, fonts, and icon styles. This will support predefined themes and custom overrides.
- `SpinWheelSegment` : A data model representing a single segment of the spin wheel, including its value, reward, and visual properties.

- `Reward`: A data model representing the reward associated with a spin wheel segment.

Customization Technical Details:

- **Segment Customization:** Each `SpinWheelSegment` will expose properties for `backgroundColor`, `borderColor`, `borderWidth`, `textColor`, `textFont`, `textSize`, `iconPath` (for local assets), `iconUrl` (for remote assets), and `backgroundImagePath` or `backgroundImageUrl` for segment-specific background images.
- **Theme System:** The `SpinWheelTheme` will utilize Flutter's `ThemeData` and `InheritedWidget` concepts to allow for easy application of themes and overriding individual properties. Predefined themes will be provided as static instances of `SpinWheelTheme`.
- **Animation:** Leverage Flutter's animation framework (`AnimationController`, `Tween`, `CurvedAnimation`) for smooth and customizable spin animations. The `spinResistance` and `initialSpinAngle` from `flutter_fortune_wheel` will be exposed and enhanced.
- **Interaction:** The `canInteractWhileSpinning` property will be exposed. Additionally, methods will be provided to enable/disable touch interaction with the wheel.
- **Event Callbacks:** `onSpinStart`, `onSpinEnd(SpinWheelSegment result)`, `onRewardWon(Reward reward)` callbacks will be provided to allow the integrating application to react to spin events and reward outcomes.

2.2 Scoring Module

Purpose: To manage user scores and integrate with backend scoring services.

Key Classes/Components:

- `ScoreManager`: A singleton class responsible for managing user scores. It will handle score updates, retrieval, and persistence.
- `ScoreEvent`: A data model representing a scoring event (e.g., points awarded, points deducted).
- `ScoreRepository`: An abstract class defining the interface for score persistence (e.g., local storage, remote server).

- `LocalScoreRepository`: An implementation of `ScoreRepository` for local score storage (e.g., using `shared_preferences` or `sqflite`).
- `RemoteScoreRepository`: An implementation of `ScoreRepository` for interacting with a backend scoring service via the Networking/API Module.

Technical Details:

- **Score Data Model:** Scores will be associated with a `userId` and `scoreValue`. Additional metadata like `timestamp` and `source` (e.g., 'spin_wheel_win') can be included.
- **Score Persistence:** The `ScoreManager` will use a `ScoreRepository` to abstract the underlying storage mechanism. This allows for easy switching between local and remote storage, or even supporting both simultaneously.
- **Score Validation:** For remote scoring, server-side validation will be crucial to prevent cheating. The SDK will provide mechanisms to send necessary data for validation to the backend.
- **Offline Support:** Scores can be temporarily stored locally and synchronized with the backend when connectivity is restored.

2.3 Leaderboard Module

Purpose: To display user rankings and facilitate competition.

Key Classes/Components:

- `LeaderboardManager`: A singleton class for managing leaderboard interactions.
- `LeaderboardEntry`: A data model representing a single entry in the leaderboard (e.g., `userId`, `username`, `score`, `rank`).
- `LeaderboardRepository`: An abstract class defining the interface for fetching and submitting leaderboard data.
- `RemoteLeaderboardRepository`: An implementation of `LeaderboardRepository` for interacting with a backend leaderboard service via the Networking/API Module.

Technical Details:

- **Leaderboard Types:** Support for different leaderboard scopes (e.g., global, friends, daily, weekly). The `LeaderboardManager` will expose methods to query these different types.
- **Data Fetching:** Leaderboard data will be fetched from the backend using the Networking/API Module. Pagination will be implemented for efficient retrieval of large leaderboards.
- **Real-time Updates (Optional):** Consider implementing real-time updates for leaderboards using WebSockets or similar technologies if the backend supports it.
- **Security:** All leaderboard submissions will be validated on the server-side to prevent fraudulent entries.

2.4 Notification Module

Purpose: To deliver timely and relevant notifications to users.

Key Classes/Components:

- `NotificationManager`: A singleton class for handling in-app and push notifications.
- `InAppNotification`: A data model for in-app notifications, including `title`, `message`, `type` (e.g., success, warning), and `duration`.
- `PushNotificationService`: An interface for integrating with external push notification providers (e.g., Firebase Cloud Messaging).

Technical Details:

- **In-App Notifications:** The `NotificationManager` will provide methods to display customizable in-app notifications (e.g., using Flutter's `SnackBar` or custom overlay widgets).
- **Push Notifications:** The SDK will provide an abstraction layer for push notifications. Developers can configure their preferred push notification service. The SDK will handle the registration of devices and the parsing of incoming notification payloads related to the spin wheel feature.
- **Customization:** Notification content, appearance, and trigger conditions will be configurable.

2.5 Analytics Module

Purpose: To track user behavior and collect data for insights.

Key Classes/Components:

- `AnalyticsManager`: A singleton class for tracking events and user properties.
- `AnalyticsEvent`: A data model for analytics events, including `eventName` and `properties` (key-value pairs).
- `AnalyticsProvider`: An abstract class defining the interface for integrating with different analytics platforms.
- `FirebaseAnalyticsProvider`: An implementation of `AnalyticsProvider` for Google Analytics for Firebase.
- `CustomAnalyticsProvider`: A generic implementation allowing developers to integrate their own analytics solutions.

Technical Details:

- **Event Tracking:** The `AnalyticsManager` will provide a simple API to log events (e.g., `logEvent('spin_wheel_spun', {'reward_type': 'points', 'value': 100})`).
- **User Properties:** Ability to set user properties (e.g., `setUserId`, `setUserProperty('has_spun_wheel', true)`).
- **Provider-based Integration:** The `AnalyticsManager` will use an `AnalyticsProvider` to send data to the configured analytics platform. This allows for easy switching or integration with multiple platforms.
- **Data Privacy:** Ensure compliance with data privacy regulations (e.g., GDPR, CCPA) by providing options for user consent and data anonymization.

2.6 Networking/API Module

Purpose: To handle secure communication with backend services.

Key Classes/Components:

- `ApiClient`: A class responsible for making HTTP requests to backend endpoints.

- `AuthInterceptor`: An interceptor for adding authentication tokens to API requests.
- `ErrorInterceptor`: An interceptor for handling API errors and network issues.
- `ApiConfig`: A class for configuring API endpoints and authentication details.

Technical Details:

- **HTTP Client:** Use a robust HTTP client library (e.g., `dio` or `http` package) for making network requests.
- **Authentication:** Support for various authentication mechanisms (e.g., API keys, OAuth tokens). The `AuthInterceptor` will ensure that all authenticated requests include the necessary credentials.
- **Error Handling:** Centralized error handling for network requests, including retries, timeouts, and clear error messages.
- **Data Serialization/Deserialization:** Use `json_serializable` or similar packages for efficient and type-safe handling of JSON data.
- **Security:** Implement HTTPS for all API communication. Validate SSL certificates. Avoid storing sensitive information directly in the SDK. Consider token refresh mechanisms.

2.7 Configuration Module

Purpose: To provide a centralized and easy-to-use configuration interface for the SDK.

Key Classes/Components:

- `SpinWheelSdkConfig`: A class containing all configurable parameters for the SDK.
- `SpinWheelSdkInitializer`: A utility class for initializing the SDK with the provided configuration.

Technical Details:

- **Initialization:** The SDK will be initialized via a single `SpinWheelSdkInitializer.initialize(SpinWheelSdkConfig config)` method.
- **Configuration Parameters:** The `SpinWheelSdkConfig` will include parameters such as:

    - `apiKey`: For authenticating with backend services.
    - `baseUrl`: Base URL for API endpoints.
    - `defaultTheme`: The default theme to apply to the spin wheel.
    - `enableAnalytics`: Boolean to enable/disable analytics tracking.
    - `enableLeaderboards`: Boolean to enable/disable leaderboard features.
    - `debugMode`: Boolean to enable/disable debug logging.
- **Validation:** Input validation for configuration parameters to ensure correct usage.

Phase 3: Detailed Implementation Outline

This section provides a detailed implementation outline for each module of the Flutter-based Android SDK. It covers the specific steps, technologies, and considerations for developing each component, building upon the architectural design established in Phase 2.

3.1 Spin Wheel UI Module Implementation

Objective: To develop a highly customizable and interactive spin wheel widget using Flutter.

Implementation Steps:

1. **Project Setup:**
    - Create a new Flutter module project (`flutter create --template=module spin_wheel_sdk`).
    - Add `flutter_fortune_wheel` as a dependency in `pubspec.yaml`.
    - Set up asset folders for default images/icons.
2. **Core `SpinWheelWidget` Development:**
    - Create the `SpinWheelWidget` class, extending `StatelessWidget` or `StatefulWidget` as needed for internal state management.

- Integrate `flutter_fortune_wheel.FortuneWheel` as the underlying UI component.
- Expose key properties from `FortuneWheel` (e.g., `selected`, `items`, `physics`, `indicators`) through the `SpinWheelWidget` constructor.
- Implement `onSpinStart` and `onSpinEnd` callbacks to notify the integrating application.

3. **`SpinWheelController` Implementation:**
   - Create a `SpinWheelController` class using `StreamController` to manage the `selected` stream for `FortuneWheel`.
   - Provide methods like `spin(int selectedIndex)` to programmatically trigger a spin to a specific segment.
   - Add methods to control animation properties (e.g., `setDuration`, `setCurve`).

4. **`SpinWheelSegment` and `Reward` Data Models:**
   - Define `SpinWheelSegment` with properties for `value`, `reward`, `backgroundColor`, `borderColor`, `borderWidth`, `textColor`, `textFont`, `textSize`, `iconPath`, and `iconUrl`.
   - Define `Reward` with properties like `id`, `type`, `value`, and `description`.
   - Implement `fromJson` and `toJson` methods for serialization/deserialization if segments need to be loaded from configuration or remote sources.

5. **Customization and Theming (`SpinWheelTheme`):**
   - Create `SpinWheelTheme` class with properties for global wheel styling (e.g., default segment colors, text styles, indicator styles).
   - Implement a mechanism (e.g., `ThemeData` and `Theme.of(context)`) to allow the `SpinWheelWidget` to inherit theme properties.
   - Provide static factory methods for predefined themes (e.g., `SpinWheelTheme.light`, `SpinWheelTheme.dark`, `SpinWheelTheme.carnival`).
   - Ensure that individual `SpinWheelSegment` properties can override theme properties for fine-grained control.

6. **Indicator Customization:**
    - Expose properties in `SpinWheelWidget` to allow customization of the `FortuneIndicator`.
    - Provide default `TriangleIndicator` and `RectangleIndicator` with customizable colors, sizes, and elevations.
    - Allow developers to pass their own custom `Widget` for the indicator.
7. **Asset Management:**
    - Provide clear guidelines for including custom images/icons in the host application's assets.
    - Implement logic to load assets from both local paths and remote URLs.
8. **Example Usage and Demo Application:**
    - Develop a comprehensive example application within the SDK project to demonstrate all customization options and features.
    - Include various scenarios, such as different themes, custom segments, and interaction types.

3.2 Scoring Module Implementation

Objective: To implement a flexible and secure scoring system.

Implementation Steps:

1. **`ScoreManager` Development:**
    - Create `ScoreManager` as a singleton class to ensure a single instance manages scores.
    - Implement methods for `addScore(int value)`, `deductScore(int value)`, `getScore()`, `resetScore()`, and `setUserId(String userId)`.
    - Use `StreamController` or `ValueNotifier` to broadcast score changes to listeners.
2. **`ScoreRepository` Abstraction:**

- Define `abstract class ScoreRepository` with methods like `saveScore(String userId, int score)`, `getScore(String userId)`, and `clearScore(String userId)`.

3. **`LocalScoreRepository` Implementation:**
    - Implement `LocalScoreRepository` using `shared_preferences` for simple key-value storage of scores.
    - Consider `sqflite` for more complex local data storage if needed for historical scores or detailed transaction logs.
4. **`RemoteScoreRepository` Implementation:**
    - Implement `RemoteScoreRepository` to interact with the backend scoring service via the `Networking/API Module`.
    - Define API endpoints for `POST /scores` (to submit scores) and `GET /scores/{userId}` (to retrieve scores).
    - Implement request and response models for score data.
    - Crucially, implement server-side validation logic to prevent score manipulation. The SDK will send relevant data (e.g., `rewardId`, `spinTimestamp`, `clientHash`) to the backend for verification.
5. **Score Synchronization and Offline Support:**
    - Implement logic in `ScoreManager` to synchronize local scores with the remote server when connectivity is available.
    - Queue score updates when offline and send them in batches once online.

3.3 Leaderboard Module Implementation

Objective: To enable display and submission of scores to leaderboards.

Implementation Steps:

1. **`LeaderboardManager` Development:**
    - Create `LeaderboardManager` as a singleton.

- Implement methods like `submitScore(String userId, int score, String leaderboardType)` and `getLeaderboard(String leaderboardType, {int limit, int offset})`.
- Provide methods to get a user's rank (`getUserRank(String userId, String leaderboardType)`).

2. **`LeaderboardRepository` Abstraction:**
   - Define `abstract class LeaderboardRepository` with methods for `fetchLeaderboard` and `postScore`.
3. **`RemoteLeaderboardRepository` Implementation:**
   - Implement `RemoteLeaderboardRepository` to communicate with the backend leaderboard service via the `Networking/API Module`.
   - Define API endpoints for `GET /leaderboards/{type}` and `POST /leaderboards`.
   - Implement pagination for fetching large leaderboards.
4. **Leaderboard UI Components (Optional, but recommended for SDK):**
   - Provide pre-built Flutter widgets for displaying leaderboards (e.g., `LeaderboardListWidget`, `UserRankWidget`).
   - These widgets should be customizable to match the host application's UI.
5. **Security Considerations:**
   - Emphasize that all score submissions to the leaderboard *must* be validated on the backend to prevent cheating. The SDK will facilitate sending necessary data for this validation.

3.4 Notification Module Implementation

Objective: To provide flexible in-app and push notification capabilities.

Implementation Steps:

1. **`NotificationManager` Development:**
   - Create `NotificationManager` as a singleton.

- Implement `showInAppNotification(InAppNotification notification)` method.
- Implement `schedulePushNotification(PushNotification notification)` and `cancelPushNotification(String notificationId)`.

2. **In-App Notification UI:**
   - Develop a custom Flutter overlay widget or utilize existing Flutter components (e.g., `SnackBar`, `showDialog`) for displaying in-app notifications.
   - Ensure notifications are customizable (text, color, icon, duration).
3. **Push Notification Integration:**
   - **Android Setup:** Provide clear instructions for setting up Firebase Cloud Messaging (FCM) in the host Android application.
   - **SDK-side FCM Handling:** The SDK will include logic to:
     - Initialize FCM and obtain the device token.
     - Register the device token with the backend (if required for targeted notifications).
     - Handle incoming FCM messages related to the spin wheel feature (e.g., parsing data payloads, triggering local notifications).
   - **Abstraction:** Use an `abstract class PushNotificationService` to allow for other push notification providers if needed in the future.

3.5 Analytics Module Implementation

Objective: To track user interactions and events for data-driven insights.

Implementation Steps:

1. **`AnalyticsManager` Development:**
   - Create `AnalyticsManager` as a singleton.
   - Implement `logEvent(String eventName, Map<String, dynamic> properties)` method.

- Implement `setUserId(String userId)` and `setUserProperty(String key, dynamic value)`.

2. **`AnalyticsProvider` Abstraction:**
   - Define `abstract class AnalyticsProvider` with methods like `logEvent`, `setUserId`, `setUserProperty`.
3. **`FirebaseAnalyticsProvider` Implementation:**
   - Implement `FirebaseAnalyticsProvider` using the `firebase_analytics` Flutter package.
   - Map SDK events and properties to Firebase Analytics events and user properties.
4. **`CustomAnalyticsProvider` Implementation:**
   - Provide a generic `CustomAnalyticsProvider` that allows developers to inject their own analytics logging function.
   - This enables integration with any analytics platform not directly supported by the SDK.
5. **Event Definitions:**
   - Define a clear set of standard events to be tracked (e.g., `spin_wheel_spun`, `reward_won`, `theme_changed`, `leaderboard_viewed`).
   - Specify recommended properties for each event.
6. **Data Privacy:**
   - Include mechanisms for developers to enable/disable analytics tracking based on user consent (e.g., GDPR compliance).
   - Provide options for anonymizing data where necessary.

3.6 Networking/API Module Implementation

Objective: To provide secure and reliable communication with backend services.

Implementation Steps:

1. **HTTP Client Setup:**
    - Use the `dio` package for robust HTTP client capabilities (interceptors, retries, error handling).
    - Configure `Dio` instance with `baseUrl`, `connectTimeout`, `receiveTimeout`.
2. **`ApiClient` Development:**
    - Create `ApiClient` class with methods for `get`, `post`, `put`, `delete` requests.
    - Handle common HTTP status codes and throw custom exceptions for API errors.
3. **Interceptors:**
    - **`AuthInterceptor`:** Intercept requests to add authentication headers (e.g., `Bearer Token`). The token will be provided during SDK initialization or fetched from a secure storage.
    - **`ErrorInterceptor`:** Intercept responses to handle API errors, network issues, and refresh expired tokens.
    - **`LoggingInterceptor`:** (For debug builds) Log request and response details for debugging purposes.
4. **Data Serialization/Deserialization:**
    - Use `json_serializable` and `build_runner` for automatic code generation of `fromJson` and `toJson` methods for all data models (e.g., `SpinWheelSegment`, `Reward`, `LeaderboardEntry`).
5. **Security Best Practices:**
    - **HTTPS Enforcement:** Ensure all API calls use HTTPS.
    - **Certificate Pinning (Advanced):** Consider implementing certificate pinning for enhanced security against Man-in-the-Middle attacks, especially for highly sensitive data.
    - **Token Management:** Securely store and refresh authentication tokens (e.g., using Flutter Secure Storage for Android).

- **Input Validation:** Validate all data sent to and received from the API.

3.7 Configuration Module Implementation

Objective: To provide a centralized and easy-to-use configuration interface.

Implementation Steps:

1. **`SpinWheelSdkConfig` Definition:**
    - Define `SpinWheelSdkConfig` class with all configurable parameters (e.g., `apiKey`, `baseUrl`, `defaultTheme`, `enableAnalytics`, `enableLeaderboards`, `debugMode`).
    - Use `final` fields and a constructor for immutability.
2. **`SpinWheelSdkInitializer` Development:**
    - Create `SpinWheelSdkInitializer` with a static `initialize(SpinWheelSdkConfig config)` method.
    - This method will:
        - Validate the provided configuration.
        - Initialize all SDK modules (e.g., `ScoreManager`, `LeaderboardManager`, `AnalyticsManager`) with the appropriate configurations.
        - Set up the `ApiClient` with the `baseUrl` and `apiKey`.
        - Perform any necessary platform-specific initialization (e.g., FCM setup).
3. **Configuration Validation:**
    - Implement robust validation logic within `initialize` to ensure all required parameters are provided and are in a valid format.
    - Throw descriptive exceptions for invalid configurations.

3.8 Android Native Integration Layer

Objective: To ensure seamless integration of the Flutter module into native Android applications.

Implementation Steps:

1. **Flutter Module as a Library:**
    - Configure the Flutter module to be built as an Android Archive (AAR) file.
    - Provide instructions on how to include the AAR in an Android project's `build.gradle`.
2. **Platform Channels (if necessary):**
    - If there are specific Android-only functionalities that cannot be achieved directly in Flutter (e.g., very deep system integrations, specific hardware access), use Flutter Platform Channels.
    - Define method channels to communicate between Flutter and native Android code.
    - Implement the native Android side of the platform channels (Kotlin/Java).
3. **Android Manifest Configuration:**
    - Provide clear instructions for necessary Android Manifest permissions (e.g., `INTERNET`, `ACCESS_NETWORK_STATE`, `RECEIVE_BOOT_COMPLETED` for notifications).
    - Guide developers on adding necessary FCM services or other Android components.
4. **Resource Management:**
    - Ensure that Flutter assets and resources are correctly bundled and accessible within the Android application.

Phase 4: Develop Security and Analytics Framework

This phase focuses on outlining the robust security measures and comprehensive analytics framework essential for a reliable and insightful SDK. These aspects are critical for protecting user data, preventing abuse, and providing valuable insights into SDK usage and user engagement.

4.1 Security Framework

Objective: To ensure the SDK is secure, protects user data, and prevents fraudulent activities.

Key Security Principles:

- **Defense in Depth:** Employ multiple layers of security controls to protect against various threats.
- **Least Privilege:** Ensure the SDK and its components operate with the minimum necessary permissions.
- **Secure by Design:** Integrate security considerations from the initial design phase, rather than as an afterthought.
- **Transparency:** Clearly communicate data collection and usage practices to developers and end-users.

Implementation Details:

1. **Data Protection and Privacy:**
    - **Data Minimization:** Collect only the data absolutely necessary for the SDK's functionality.
    - **Encryption:**
        - **Data in Transit:** All communication between the SDK and backend services (e.g., for scoring, leaderboards, analytics) MUST use HTTPS/TLS to encrypt data in transit. This prevents eavesdropping and Man-in-the-Middle (MITM) attacks.
        - **Data at Rest:** Sensitive data stored locally on the device (e.g., cached scores, user preferences) should be encrypted using platform-specific secure storage mechanisms (e.g., Android Keystore for encryption keys, Flutter Secure Storage for encrypted preferences).
    - **GDPR/CCPA Compliance:** Provide clear mechanisms for developers to obtain user consent for data collection and processing, especially for analytics and personalized notifications. Implement features for data deletion and access requests if applicable.
2. **Fraud Prevention and Anti-Tampering:**

- **Server-Side Validation:** This is the most critical component of fraud prevention. All sensitive operations, especially score submissions and reward claims, MUST be validated on a trusted backend server. The SDK will send sufficient context (e.g., `spinId`, `selectedSegmentIndex`, `timestamp`, `clientHash`) to the server for verification. The server should independently determine the spin outcome and reward based on its own logic and data.
- **Obfuscation and Minification:** Apply code obfuscation and minification techniques to the Flutter module and any native Android code. This makes reverse engineering more difficult, deterring casual attackers.
- **Root/Jailbreak Detection (Optional but Recommended):** Implement checks to detect if the device is rooted or jailbroken. While not foolproof, this can provide an additional layer of defense and allow the SDK to adjust its behavior (e.g., disable certain features or log warnings) on compromised devices.
- **Signature Verification:** Verify the integrity of the SDK's own code and assets at runtime to detect any unauthorized modifications.
- **Rate Limiting:** Implement rate limiting on API calls from the SDK to prevent abuse and denial-of-service attacks against backend services.

3. **API Security:**

    - **Authentication and Authorization:**
        - Use secure authentication mechanisms (e.g., API keys, OAuth 2.0 tokens) for all backend API calls. API keys should be securely stored and rotated regularly.
        - Implement proper authorization checks on the backend to ensure the SDK only performs actions it is permitted to do.
    - **Input Validation:** Strictly validate all input received from the SDK on the backend to prevent injection attacks (e.g., SQL injection, XSS).
    - **Secure Token Management:** If using tokens (e.g., JWTs), ensure they are short-lived, refreshed securely, and stored in secure locations (e.g., `FlutterSecureStorage` on the client, HTTP-only cookies or secure server-side storage on the backend).
    - **API Key Protection:** Provide clear guidance to developers on how to securely store API keys (e.g., using environment variables, Gradle secrets, or

a secure backend service) and prevent them from being hardcoded or exposed in public repositories.

4. **Error Handling and Logging:**
    - Implement secure logging practices. Avoid logging sensitive user data or API keys. Use appropriate log levels.
    - Ensure error messages do not expose sensitive internal information or stack traces to the end-user or to publicly accessible logs.

4.2 Analytics Framework

Objective: To provide comprehensive event tracking and user insights without compromising privacy.

Key Analytics Principles:

- **Actionable Insights:** Focus on collecting data that can drive improvements in user engagement, feature adoption, and monetization.
- **Privacy by Design:** Integrate privacy considerations into the analytics framework from the outset.
- **Flexibility:** Allow developers to choose their preferred analytics platform and customize event tracking.

Implementation Details:

1. **Event Taxonomy and Standardization:**
    - Define a clear and consistent event taxonomy for all tracked events. This ensures data consistency and ease of analysis.
    - **Core Events:**
        - `spin_wheel_initialized`: When the spin wheel widget is first displayed.
        - `spin_started`: When a user initiates a spin.
        - `spin_completed`: When the spin animation finishes.
        - `reward_won`: When a user wins a reward.

        - `reward_redeemed`: When a won reward is successfully redeemed (requires integration with host app's reward system).
        - `customization_applied`: When a user applies a custom theme or changes wheel appearance.
        - `leaderboard_viewed`: When a user views a leaderboard.
        - `score_submitted`: When a score is submitted to the backend.
    - **Event Properties:** For each event, define relevant properties to capture context. For example, `reward_won` might include `reward_type`, `reward_value`, `segment_index`, `spin_duration`.

2. **Analytics Provider Integration:**
    - The `AnalyticsManager` will act as an abstraction layer, allowing developers to plug in different analytics providers.
    - **`FirebaseAnalyticsProvider`:** Provide a robust implementation for Google Analytics for Firebase, which is a common choice for mobile apps. This will involve mapping SDK events to Firebase events and user properties.
    - **`CustomAnalyticsProvider`:** Offer a generic provider interface where developers can supply a callback function to receive all SDK events. This allows integration with any custom or third-party analytics system (e.g., Mixpanel, Amplitude, custom backend logging).

3. **User Identification:**
    - The SDK will allow developers to set a `userId` (e.g., their internal user ID) to enable cross-device tracking and personalized analytics.
    - If no `userId` is provided, the SDK should use an anonymous device ID for tracking.

4. **Data Collection and Transmission:**
    - Events will be collected locally and then batched and sent to the configured analytics provider to minimize network overhead and battery consumption.
    - Implement retry mechanisms for failed transmissions.
    - Allow for offline event queuing, where events are stored locally and sent once connectivity is restored.

5. **Debugging and Testing Analytics:**
    - Provide a `debugMode` flag in the SDK configuration that enables verbose logging of analytics events to the console. This helps developers verify that events are being tracked correctly.
    - Offer tools or instructions for using analytics platform debug views (e.g., Firebase DebugView) to see events in real-time.
6. **Performance Considerations:**
    - Ensure analytics tracking does not introduce significant performance overhead or block the UI thread.
    - Use asynchronous operations for data transmission.

Phase 5: Design Documentation and Testing Strategy

This phase outlines the comprehensive documentation and rigorous testing strategies crucial for the SDK's usability, reliability, and adoption. Well-structured documentation empowers developers to integrate the SDK efficiently, while a robust testing strategy ensures its stability and performance across various Android environments.

5.1 Documentation Strategy

Objective: To provide clear, comprehensive, and accessible documentation that enables developers to easily integrate, customize, and troubleshoot the SDK.

Key Documentation Principles:

- **Developer-Centric:** Focus on the needs of the integrating developer, providing practical guidance and actionable examples.
- **Accuracy and Completeness:** Ensure all information is correct, up-to-date, and covers all aspects of the SDK.
- **Clarity and Conciseness:** Use plain language, avoid jargon where possible, and present information efficiently.
- **Accessibility:** Organize content logically with clear headings, tables, and code blocks for easy readability.

- **Version Control:** Maintain documentation alongside the SDK code, with clear versioning and release notes.

Documentation Components:

1. **Getting Started Guide:**
    - **Introduction:** Brief overview of the SDK's purpose and key features.
    - **Prerequisites:** List of required software (Flutter SDK, Android Studio, etc.) and minimum versions.
    - **Installation:** Step-by-step instructions for adding the Flutter SDK module to an existing Android project (e.g., adding to `pubspec.yaml`, configuring `build.gradle` for AAR import).
    - **Initialization:** Clear instructions and code examples for initializing the SDK with `SpinWheelSdkInitializer` and `SpinWheelSdkConfig`.
    - **Basic Usage:** A simple, runnable code example demonstrating how to display a basic spin wheel and handle a spin outcome.
2. **API Reference (DartDoc):**
    - Automatically generated documentation from the SDK's source code using DartDoc.
    - Detailed descriptions of all public classes, methods, properties, and enums.
    - Includes parameter descriptions, return values, and potential exceptions.
    - Examples for each major API call.
3. **Customization Guide:**
    - **Theming:** Explain how to use predefined themes and how to create custom themes using `SpinWheelTheme`.
    - **Segment Customization:** Detailed guide on customizing individual `SpinWheelSegment` properties (colors, text, icons/images).
    - **Indicator Customization:** Instructions for changing the spin wheel indicator's appearance.
    - **Animation Control:** How to adjust spin duration, curves, and other animation properties.

- **Event Handling:** Comprehensive explanation of all available callbacks (`onSpinStart`, `onSpinEnd`, `onRewardWon`) and how to implement them.

4. **Feature-Specific Guides:**

   - **Scoring System Integration:** How to use `ScoreManager` to update and retrieve scores, and integrate with backend scoring services.
   - **Leaderboard Integration:** Guide on submitting scores to leaderboards and displaying leaderboard data using provided UI components or custom implementations.
   - **Notification Usage:** How to trigger in-app notifications and integrate with push notification services (FCM setup, handling payloads).
   - **Analytics Integration:** Instructions for configuring analytics providers and understanding the tracked events and properties.

5. **Advanced Topics:**

   - **Security Best Practices:** Recommendations for securing the host application when integrating the SDK (e.g., protecting API keys, server-side validation).
   - **Offline Support:** How the SDK handles offline scenarios for scoring and analytics.
   - **Performance Optimization:** Tips for ensuring optimal performance when using the SDK.
   - **Platform Channels (if applicable):** Detailed explanation and examples for any platform-specific integrations.

6. **Troubleshooting and FAQs:**

   - Common issues and their solutions.
   - Debugging tips for SDK integration and behavior.
   - Frequently asked questions.

7. **Release Notes and Versioning:**

   - A clear changelog for each SDK version, detailing new features, bug fixes, and breaking changes.
   - Semantic versioning (e.g., MAJOR.MINOR.PATCH) will be followed.

Documentation Tools:

- **Markdown:** For writing all conceptual and guide documentation.
- **DartDoc:** For generating API reference documentation directly from source code comments.
- **Static Site Generator (e.g., Jekyll, MkDocs):** To compile Markdown and DartDoc into a browsable, searchable documentation website.

5.2 Testing Strategy

Objective: To ensure the SDK is reliable, performant, secure, and compatible across a range of Android devices and Flutter versions.

Key Testing Principles:

- **Automated Testing:** Prioritize automated tests (unit, widget, integration) to ensure rapid feedback and prevent regressions.
- **Comprehensive Coverage:** Aim for high test coverage across all modules and functionalities.
- **Real-World Scenarios:** Test the SDK in scenarios that mimic real-world usage patterns and edge cases.
- **Performance Testing:** Measure and optimize the SDK's performance to ensure it doesn't negatively impact the host application.
- **Security Testing:** Actively test for vulnerabilities and potential exploits.

Testing Levels and Methodologies:

1. **Unit Tests:**
    - **Scope:** Individual functions, methods, and classes within each module (e.g., `ScoreManager` methods, `SpinWheelController` logic, data model serialization).
    - **Framework:** Flutter's built-in `test` package.
    - **Methodology:** Write isolated tests for each unit, mocking dependencies as needed.
2. **Widget Tests:**

- **Scope:** UI components of the `SpinWheelWidget` and any provided leaderboard/notification widgets.
- **Framework:** Flutter's `flutter_test` package.
- **Methodology:** Test widget rendering, state changes, user interactions (taps, gestures), and animations. Verify that customization options are applied correctly.

3. **Integration Tests:**

- **Scope:** Interactions between different modules within the SDK (e.g., `SpinWheelWidget` interacting with `ScoreManager`, `AnalyticsManager` sending events to a provider).
- **Framework:** Flutter's `integration_test` package.
- **Methodology:** Simulate end-to-end user flows within the SDK. Test network calls, data persistence, and cross-module communication.

4. **Android Platform-Specific Tests:**

- **Scope:** The Android native integration layer, platform channels, and Android Manifest configurations.
- **Framework:** Android JUnit, Espresso (for native UI interactions if any).
- **Methodology:** Verify that the Flutter module is correctly embedded, platform channels function as expected, and necessary Android permissions are handled.

5. **Performance Testing:**

- **Metrics:** Frame rate (FPS), CPU usage, memory consumption, battery usage, app size.
- **Tools:** Flutter DevTools, Android Studio Profiler.
- **Methodology:** Run the SDK on various Android devices (emulators and physical devices) and measure performance under different loads (e.g., rapid spins, multiple concurrent features). Identify and address performance bottlenecks.

6. **Security Testing:**

- **Vulnerability Scanning:** Use automated tools to scan for common vulnerabilities in the SDK's codebase.
- **Penetration Testing:** Conduct manual penetration tests to identify potential exploits (e.g., data tampering, unauthorized access to backend APIs).
- **Fuzz Testing:** Provide malformed inputs to the SDK to test its robustness and error handling.
- **Static Application Security Testing (SAST):** Analyze source code for security flaws.
- **Dynamic Application Security Testing (DAST):** Test the running application for vulnerabilities.

7. **Compatibility Testing:**

   - **Android Versions:** Test the SDK on a range of Android OS versions (e.g., API 21+).
   - **Device Fragmentation:** Test on various device manufacturers, screen sizes, and resolutions.
   - **Flutter Versions:** Ensure compatibility with a defined range of Flutter SDK versions.

8. **Manual Testing and User Acceptance Testing (UAT):**

   - **Scope:** Overall user experience, visual correctness, and adherence to requirements.
   - **Methodology:** Integrate the SDK into a sample host application and perform manual tests. Engage potential users or internal teams for UAT to gather feedback on usability and functionality.

9. **Continuous Integration/Continuous Deployment (CI/CD):**

   - Integrate all automated tests into a CI/CD pipeline (e.g., GitHub Actions, GitLab CI, Jenkins).
   - Automatically run tests on every code commit to catch regressions early.
   - Automate the build and release process for new SDK versions.