Part I: Description of Overall Test Plan

Our approach to testing the Smart Parking System is multi-phased. Initially, individual system components, such as the IoT sensors, server communication, and mobile application, will undergo isolated testing with simulated data under normal, abnormal, and boundary conditions. This phase will ensure that each component functions as intended.

Following component-level testing, we will conduct integration tests to verify seamless communication between the sensors, server, and mobile app. A production-like environment will be used to evaluate real-time data processing and communication efficiency, enabling us to identify and address potential bottlenecks or integration issues.

Finally, a comprehensive system-level test will simulate real-world scenarios by deploying the system in an urban parking lot. This phase will evaluate the system's reliability, accuracy, and performance under varying levels of demand, ensuring its readiness for real-world application.

Part II: Test Case Descriptions

1. **Test Case ID**: SPS1.1
   Purpose: Validate sensor data transmission.
   Description: Verify that IoT sensors correctly detect parking spot availability and transmit the data to the server.
   Inputs: Simulated sensor inputs (e.g., car detection, no detection).
   Expected Outputs: Server receives accurate data about parking spot occupancy.
   Case Type: Normal
   Test Type: Blackbox
   Test Category: Functional
   Test Level: Unit

2. **Test Case ID**: SPS1.2
   Purpose: Test real-time data synchronization.
   Description: Ensure that the server updates the app with real-time parking availability.
   Inputs: Live data stream from sensors.
   Expected Outputs: Updated parking spot status displayed on the app within 2 seconds.
   Case Type: Normal
   Test Type: Blackbox
   Test Category: Performance
   Test Level: Integration

3. **Test Case ID**: SPS1.3
   Purpose: Validate user authentication.
   Description: Check the functionality of the login system using valid and invalid credentials.
   Inputs: Valid credentials (email/password), invalid credentials (incorrect email/password).
   Expected Outputs: Successful login for valid inputs; error message for invalid inputs.
   Case Type: Normal/Abnormal
   Test Type: Blackbox
   Test Category: Functional
   Test Level: Unit

4. **Test Case ID**: SPS1.4
   Purpose: Test boundary conditions for parking space detection.
   Description: Verify sensor accuracy under extreme conditions (e.g., partial vehicle detection).
   Inputs: Partial obstruction over the sensor.
   Expected Outputs: Accurate detection or a flagged error.
   Case Type: Boundary
   Test Type: Blackbox
   Test Category: Functional
   Test Level: Unit

5. **Test Case ID**: SPS1.5
   Purpose: Assess server scalability.
   Description: Test the server's ability to handle multiple simultaneous connections.
   Inputs: Simulated 10,000 concurrent user requests.
   Expected Outputs: Server processes all requests without crashing.
   Case Type: Normal
   Test Type: Whitebox
   Test Category: Performance
   Test Level: Integration

6. **Test Case ID**: SPS1.6
   Purpose: Evaluate GPS integration accuracy.
   Description: Confirm that the app provides correct parking lot locations.
   Inputs: GPS coordinates for various parking lots.
   Expected Outputs: Correct locations displayed on the app.
   Case Type: Normal
   Test Type: Blackbox

Test Category: Functional
Test Level: Integration

7. **Test Case ID**: SPS1.7
   Purpose: Validate app UI responsiveness.
   Description: Ensure that the app remains responsive during heavy user interactions.
   Inputs: Multiple UI interactions (e.g., zooming, panning, and selecting parking spots).
   Expected Outputs: App remains responsive with no delays.
   Case Type: Normal
   Test Type: Blackbox
   Test Category: Performance
   Test Level: Unit

8. **Test Case ID**: SPS1.8
   Purpose: Test the accuracy of parking history logs.
   Description: Verify that users can view their parking session history accurately.
   Inputs: A series of parking start and end times.
   Expected Outputs: Accurate log of parking sessions displayed.
   Case Type: Normal
   Test Type: Blackbox
   Test Category: Functional
   Test Level: Unit

9. **Test Case ID**: SPS1.9
   Purpose: Test abnormal server responses.
   Description: Simulate server downtime and verify app handling.
   Inputs: Server unresponsive or slow response times.
   Expected Outputs: App displays appropriate error messages or retries.
   Case Type: Abnormal
   Test Type: Blackbox
   Test Category: Functional
   Test Level: Integration

10. **Test Case ID**: SPS1.10
    Purpose: Assess real-time analytics accuracy.
    Description: Confirm that analytics provide accurate insights into parking trends.
    Inputs: Simulated parking data over 24 hours.
    Expected Outputs: Accurate reports on parking usage trends.
    Case Type: Normal
    Test Type: Whitebox
    Test Category: Functional
    Test Level: System

11. **Test Case ID**: SPS1.11
    Purpose: Validate app notifications for parking availability.
    Description: Ensure that users receive push notifications when parking becomes available in their selected areas.
    Inputs: User selects a parking area; a parking spot becomes available.
    Expected Outputs: User receives a push notification within 5 seconds of availability.
    Case Type: Normal
    Test Type: Blackbox
    Test Category: Functional
    Test Level: Unit

12. **Test Case ID**: SPS1.12
    Purpose: Test the accuracy of parking duration timers.
    Description: Ensure the system tracks parking durations accurately from arrival to departure.
    Inputs: Parking start and stop triggers from sensors.
    Expected Outputs: Correct duration recorded and displayed to the user.
    Case Type: Normal
    Test Type: Blackbox
    Test Category: Functional
    Test Level: Unit

13. **Test Case ID**: SPS1.13
    Purpose: Test security of user data during login.
    Description: Validate that user credentials are securely transmitted and stored.
    Inputs: User credentials (username and password).
    Expected Outputs: Encrypted transmission of data; no sensitive information in plain text.
    Case Type: Normal
    Test Type: Whitebox
    Test Category: Functional
    Test Level: Unit

14. **Test Case ID**: SPS1.14
    Purpose: Assess system performance during peak traffic hours.
    Description: Simulate high usage during peak hours and test system response.
    Inputs: 50,000 concurrent app users.
    Expected Outputs: No server crashes; response times under 2 seconds.
    Case Type: Normal
    Test Type: Blackbox
    Test Category: Performance
    Test Level: System

15. **Test Case ID**: SPS1.15
    Purpose: Test app compatibility with different devices.
    Description: Verify that the app performs consistently across various devices and screen sizes.
    Inputs: iOS and Android devices of varying screen sizes and resolutions.
    Expected Outputs: Proper UI scaling and functionality across devices.
    Case Type: Boundary
    Test Type: Blackbox
    Test Category: Functional
    Test Level: Unit

16. **Test Case ID**: SPS1.16
    Purpose: Validate database integrity after multiple transactions.
    Description: Ensure the database maintains accuracy after adding, updating, and deleting parking records.
    Inputs: Simulated parking data updates and deletions.
    Expected Outputs: Consistent database state after all operations.
    Case Type: Normal
    Test Type: Whitebox
    Test Category: Functional
    Test Level: Integration

17. **Test Case ID**: SPS1.17
    Purpose: Test failover mechanism for server outages.
    Description: Simulate server failure and test system recovery.
    Inputs: Server shutdown during active usage.
    Expected Outputs: System switches to backup server with minimal downtime.
    Case Type: Abnormal
    Test Type: Whitebox
    Test Category: Functional
    Test Level: System

18. **Test Case ID**: SPS1.18
    Purpose: Validate parking spot reservation feature.
    Description: Test the ability of users to reserve parking spots in advance.
    Inputs: User selects a parking spot and reservation time.
    Expected Outputs: Reservation confirmation; spot marked as reserved.
    Case Type: Normal
    Test Type: Blackbox
    Test Category: Functional
    Test Level: Unit

19. **Test Case ID**: SPS1.19
    Purpose: Evaluate data visualization features.
    Description: Test the analytics dashboard for displaying parking trends and usage statistics.
    Inputs: Historical parking data.
    Expected Outputs: Accurate and visually appealing charts and graphs.
    Case Type: Normal
    Test Type: Whitebox
    Test Category: Functional
    Test Level: Unit

20. **Test Case ID**: SPS1.20
    Purpose: Assess user feedback integration.
    Description: Ensure the system records and processes user feedback effectively.
    Inputs: Feedback submitted through the app.
    Expected Outputs: Feedback stored in the database; confirmation to the user.

Case Type: Normal
Test Type: Blackbox
Test Category: Functional
Test Level: Unit

Part III: Test Case Matrix

Test Case ID	Normal/Abnormal/Boundary	Blackbox/Whitebox	Functional/Performance	Unit/Integration/System
SPS1.1	Normal	Blackbox	Functional	Unit
SPS1.2	Normal	Blackbox	Performance	Integration
SPS1.3	Normal/Abnormal	Blackbox	Functional	Unit
SPS1.4	Boundary	Blackbox	Functional	Unit
SPS1.5	Normal	Whitebox	Performance	Integration
SPS1.6	Normal	Blackbox	Functional	Integration
SPS1.7	Normal	Blackbox	Performance	Unit
SPS1.8	Normal	Blackbox	Functional	Unit
SPS1.9	Abnormal	Blackbox	Functional	Integration
SPS1.10	Normal	Whitebox	Functional	System
SPS1.11	Normal	Blackbox	Functional	Unit
SPS1.12	Normal	Blackbox	Functional	Unit
SPS1.13	Normal	Whitebox	Functional	Unit
SPS1.14	Normal	Blackbox	Performance	System
SPS1.15	Boundary	Blackbox	Functional	Unit
SPS1.16	Normal	Whitebox	Functional	Integration
SPS1.17	Abnormal	Whitebox	Functional	System
SPS1.18	Normal	Blackbox	Functional	Unit

SPS1.19	Normal	Whitebox	Functional	Unit
SPS1.20	Normal	Blackbox	Functional	Unit