Report 1:
Smart Parking Garage Management System (SPGMS)

CSCI 441 VC Software Engineering
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Team B

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https://github.com/nbrandenburg/CSCI_441_VC_Team_B

Team Member Contributions Breakdown

NAME	CONTRIBUTION	PERCENTAGE
Nicole Brandenburg, Team Leader	Proposal: - Proposed Solution Report 1, Part 1: - Functional Requirements - Non-Functional Requirements - User Interface Requirements - Glossary of Terms Report 1, Part 2: - Traceability Matrix - Fully-Dressed Descriptions - System Sequence Diagrams - Preliminary Design - User Effort Estimation Report 1, Part 3: - Identifying Subsystems - Architectural Styles - Global Control Flow - Project Size Estimation - References	33.3%
Gene Holt	Proposal: - Problem Diagnosis Report 1, Part 1: - Project Management - Glossary of Terms Report 1, Part 2: - Use Case Diagram - Project Management Update Report 1, Part 3: - Project Management Update - References	33.3%
Oakley Cardwell	Proposal: - Proposal Rough Draft - Plan of Work Report 1, Part 1: - Customer Problem Statement - Decomposition into Sub-Problems - Business Goals - Glossary of Terms Report 1, Part 2: - Stakeholders	33.3%

	- Actors and Goals - Casual Descriptions - Use Case Diagrams - Traceability Matrix - References <u>Report 1, Part 3:</u> - Identifying Subsystems - Connectors and Network Protocols - Hardware Requirements	

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- **Customer Problem Statement**
  - **Problem Statement**

    Many parking garages face challenges such as inefficient space utilization, difficulty in tracking available spots, and lack of real-time data for users. From a user perspective, not finding a spot in a timely manner delays planned activities, increases the chances for the user to park further away from their intended area, and not being able to easily locate their vehicle when they want to leave. If the lot/garage they park at requires payment, the user will need to take time away from their plans to ensure that payment is made when they need to extend their visit or risk being towed.

    The more people searching for a parking space in any given parking lot/garage, the more difficult it is to enter/exit and navigate the parking lot/garage due to congestion. From an owners/operators perspective, if a spot is available and there is no method to advertise it's availability, it can cause potential loss in revenue if no user randomly discovers it's availability. These problems are amplified in densely populated areas where people are randomly searching for parking spaces.

    Our team plans to create a program that introduces interventions such as a user-friendly website for drivers, and predictive analysis data for garage operators. Drivers will be able to check spot availability, reserve spots, and even pay for their parking in advance. Garage operators will have historical statistical data from which to make business decisions regarding pricing and promotions, and to minimize unused space.

  - **Decomposition into Sub-Problems**

    To address the overarching challenges presented in the problem statement, it is essential to break down the proposed solution into specific sub-problems. By doing so, we can ensure that each facet of the problem is addressed comprehensively. Here are the identified sub-problems:

Parking Management

- Spot Addition/Removal: As the physical layout or the usage of the parking garage changes, there should be a mechanism to add or remove parking spots within the system. This ensures that the digital representation of the parking garage is always up-to-date.
- Spot Status Update: The system should be able to update the status of each parking spot in real-time, indicating whether it's occupied or available. This will help in providing accurate information to the users.

Admin Login

- Secure Access: Only authorized personnel should have access to the administrative features of the system. This includes adding/removing spots, viewing analytics, and managing user data.
- Multi-level Access: Different roles (e.g., manager, cashier, security) might require different levels of access. The system should cater to these varying needs.

Analytics

- Parking Trends: The system should be able to analyze and present trends such as peak parking times, average duration of parking, and frequent users.
- Busy Time Analysis: By understanding the busiest times for the garage, operators can make informed decisions about pricing and promotions.
- Space Utilization: Analytics should provide insights into how efficiently the space is being used, highlighting areas that are underutilized.

Payment Gateway

- Flexible Payment Options: Users should be able to pay using various methods, such as credit/debit cards, digital wallets, or even cash (if there's a physical kiosk).
- Payment Extensions: If a user needs to extend their parking time, they should be able to do so easily through the system, without having to physically return to their vehicle.

- Overstay Alerts: Users should be notified if their parking time is about to expire, giving them the option to extend if necessary.

Database Management

- Data Storage: All the data related to parking spots, user reservations, payments, and analytics should be stored securely.
- Data Retrieval: The system should be able to quickly retrieve data when required, ensuring a smooth user experience.
- Backup and Recovery: There should be mechanisms in place to back up the data regularly and recover it in case of any failures.

User Experience

- Spot Reservation: Users should be able to reserve spots in advance, ensuring they have a space when they arrive.
- Vehicle Locator: To address the challenge of users not being able to locate their vehicles, the system could provide a feature that helps users remember where they parked.
- Real-time Updates: The website or application should provide real-time updates on spot availability, ensuring users have the most accurate information.

By addressing each of these sub-problems, the proposed solution will provide a comprehensive answer to the challenges faced by parking garages and their users.

- **Glossary of Terms**

The following glossary provides definitions for key terms and concepts related to the Smart Parking Garage Management System (SPGMS). Understanding these terms will help stakeholders and users better comprehend the functionalities and objectives of the system.

Admin Login: A secure access point in the system where authorized personnel can log in to access administrative features.

Analytics: Data-driven insights and trends derived from the system, helping garage operators make informed business decisions.

Database Management: The system's backend operations that handle the storage, retrieval, backup, and recovery of all data related to the SPGMS.

Digital Transactions: Payments made electronically, either through credit/debit cards, digital wallets, or other online payment methods integrated within the SPGMS.

Driver: A user of the system who is specifically a customer of the garage with a need for a space to park a vehicle for a certain amount of time.

Garage Administrator: A user of the system who is specifically an owner, employee, or person otherwise involved in the operation of the parking garage.

Multi-level Access: A feature in the admin login that provides different levels of system access based on the role of the personnel (e.g., manager, cashier, security).

Overstay Alerts: Notifications sent to users when their parking time is nearing its expiration, giving them an option to extend if necessary.

Parking Management: The process of efficiently managing parking spaces within a garage, including the addition/removal of spots and updating spot statuses in real-time.

Payment Gateway: An integrated system within SPGMS that allows users to make payments for their parking, offering various payment methods.

Real-time Updates: Instantaneous updates provided by the system about spot availability, ensuring users have the most current information.

Space Utilization: The efficiency with which parking spaces in the garage are used, aiming for maximum occupancy.

SPGMS (Smart Parking Garage Management System): A comprehensive software solution designed to address the challenges faced by parking garages and their users, offering features like spot reservation, real-time spot availability, and analytics for garage operators.

Spot Reservation: A feature that allows users to book a parking spot in advance, ensuring its availability upon their arrival.

Systems Administrator: Person responsible for the design and maintenance of the SPGMS.

User Experience: The overall experience and interaction a user has with the SPGMS, encompassing features like spot reservation, vehicle locator, and real-time updates.

Vehicle Locator: A feature within the SPGMS that assists users in remembering and locating where they parked their vehicle within the garage.

- ## Goals, Requirements, and Analysis
  - ### Business Goals

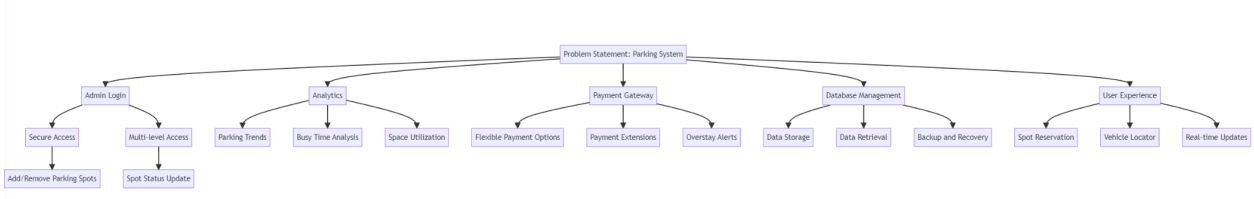

Figure 1: Diagram HQ

The Smart Parking Garage Management System (SPGMS) aims to revolutionize the way parking garages operate and how users interact with them. The primary business goals (Figure 1) for implementing the SPGMS are:

1. Optimize Space Utilization: Ensure that every available parking spot is utilized to its maximum potential, thereby increasing the revenue for garage operators.

2. Enhance User Experience: Provide a seamless and hassle-free parking experience for users by offering features like spot reservation, real-time spot availability updates, and vehicle locator.

3. Increase Revenue Streams: By offering advanced features such as spot reservation and predictive analysis for pricing, the system aims to create new revenue streams for garage operators.

4. Reduce Operational Costs: With real-time data and analytics, garage operators can make informed decisions that can lead to reduced operational costs. For instance, understanding peak times can help in efficient staffing.

5. Promote Digital Transactions: By integrating a payment gateway, the system encourages users to make digital payments, reducing the need for physical cash handling and the associated risks.

6. Enhance Security: With features like admin login and multi-level access, the system ensures that only authorized personnel can access critical functionalities, thereby maintaining the integrity of the system.

7. Data-Driven Decision Making: The analytics provided by the system will empower garage operators to make decisions based on data, such as adjusting pricing during peak times or offering promotions during off-peak hours.

8. Environmental Impact: By reducing the time users spend searching for parking spots, the system indirectly contributes to a reduction in vehicle emissions, promoting a greener environment.

9. Expand Market Reach: With a user-friendly interface and advanced features, the system aims to attract more users, expanding the market reach for garage operators.

10. Future Scalability: The system is designed keeping future growth in mind. As the needs of the garage operators evolve, the system can be scaled up or modified to accommodate new features or expanded operations.

By achieving these business goals, the SPGMS will not only address the current challenges faced by parking garages and their users but also ensure sustainable growth and profitability for garage operators in the future.

- **Functional, Non-Functional, and User Interface Requirements**

  Requirements are broken down by sub-problem, as described in Section 1 of this report. For each sub-problem, the functional, non-functional, and user interface requirements are provided.

  The functional requirements of our system were designed to address the problems faced by our target customers: garage administrators and their customer base of drivers. They are our team's goals for our system presented as concrete, testable statements.

  Non-functional requirements were designed using the FURPS structure as described by Marsic (75). FURPS accounts for system properties relating to additional functionality (such as security), usability, reliability, performance, and supportability.

The user interface requirements describe what the website will present on the screen for users to navigate and access the features of the system. Preliminary graphics are provided to demonstrate the proposed layout of the user interface.

Priority weights were calculated on a scale of 1 to 3, with 1 representing requirements of the highest priority. Priority 1 requirements are critical for the system's core functionality and provide significant business value. Priority 2 requirements are important to enhance user experience or system efficiency, but not critical. Priority 3 requirements are of a lower priority and can be implemented in later phases.

Parking Management

Functional Requirements		
REQ	**Priority**	**Description**
REQ-01	3	The system shall allow administrators to add and remove parking spaces if the physical layout of the garage changes.
Non-Functional Requirements		
REQ-02	1	The system shall update the availability status of each parking spot in real-time.

Admin Login

Functional Requirements		
REQ	**Priority**	**Description**
REQ-03	1	The system shall allow the creation of a variety of administrator accounts, e.g. manager, cashier, security.
Non-Functional Requirements		
REQ	**Priority**	**Description**

REQ-04	1	The system shall provide secure access for parking garage administrator accounts for viewing analytics.
REQ-05	1	The system shall provide secure access for parking garage administrator accounts for managing user data.

User Interface Requirements		
Number	**Priority**	**Description**
REQ-06	1	The system shall allow for multiple levels of administration accounts. (Figure 2)

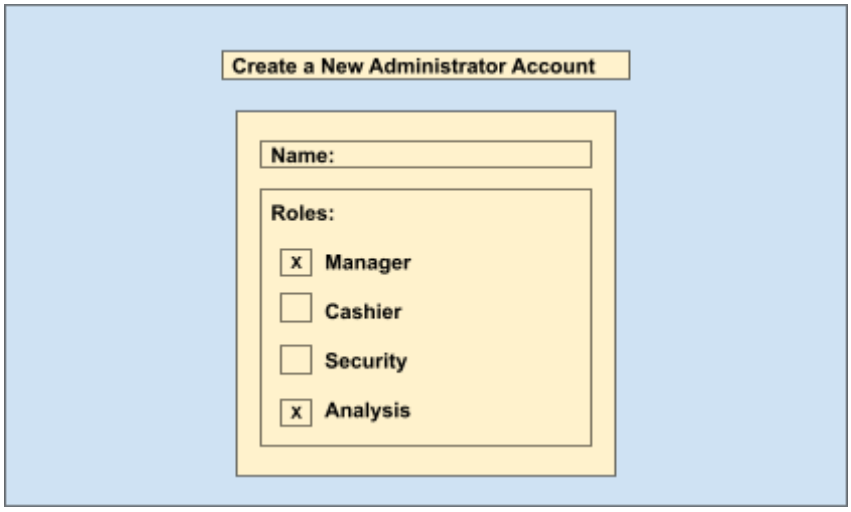

Figure 2

Analytics

Functional Requirements		
REQ	**Priority**	**Description**
REQ-07	2	The system shall display peak parking times to administrators.
REQ-08	2	The system shall display average duration of parking to administrators.

REQ-09	3	The system shall display frequent drivers to administrators. Frequent drivers will be considered drivers who utilize the garage at least once per week for at least a month.
REQ-10	3	The system shall highlight parking areas that are underutilized to administrators. Parking areas shall be considered underutilized if they are empty more than 30% of the peak time frame.
Non-Functional Requirements		
REQ	**Priority**	**Description**
REQ-11	2	The system shall analyze peak parking times.
REQ-12	2	The system shall analyze average duration of parking.
REQ-13	3	The system shall analyze frequency of use by each driver.
REQ-14	3	The system shall analyze frequency of use of each parking space.

User Interface Requirements		
Number	**Priority**	**Description**
REQ-15	2	The system shall display analytical data for administrators. Figure (3)

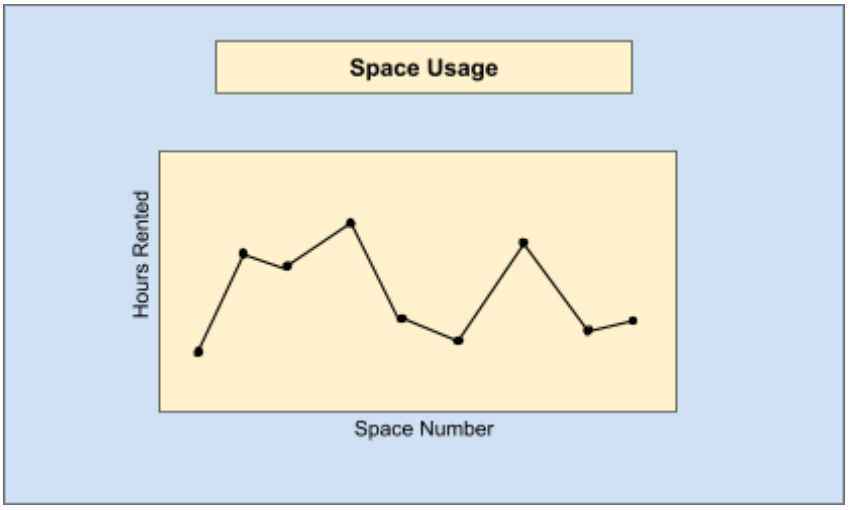

Figure 3

Payment Gateway

Functional Requirements		
REQ	**Priority**	**Description**
REQ-16	1	The system shall allow for payment using various methods, such as credit/debit cards, digital wallets, and cash.
REQ-17	2	The system shall allow for extension of parking time and payment.
REQ-18	2	The system shall send alerts when parking time is close to expiration.

User Interface Requirements		
Number	**Priority**	**Description**
REQ-19	2	The system shall alert the driver when their parking time is within 15 minutes of expiration and offer the option to extend their time. (Figure 4)

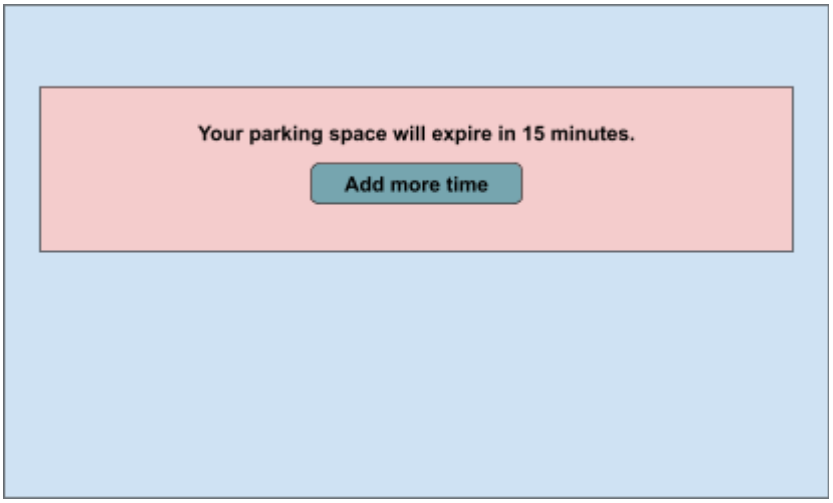

Figure 4

Database Management

Non-Functional Requirements		
REQ	**Priority**	**Description**
REQ-20	1	The system shall store all data relating to parking spots, user data, payments, and analytics to be stored securely.
REQ-21	1	The system shall retrieve data quickly.
REQ-22	1	The system shall backup data daily.
REQ-23	1	The system shall provide recovery of data from backups in case of failures.

User Experience

Functional Requirements		
REQ	**Priority**	**Description**
REQ-24	3	The system shall provide vehicle location assistance for users returning to their vehicles.
REQ-25	1	The system shall allow for recurring reservations for drivers needing a regular parking space.
REQ-26	1	The system shall display nearby attractions to interested drivers.

User Interface Requirements		
Number	**Priority**	**Description**
REQ-27	1	The system shall allow drivers to create personal accounts. (Figure 5)

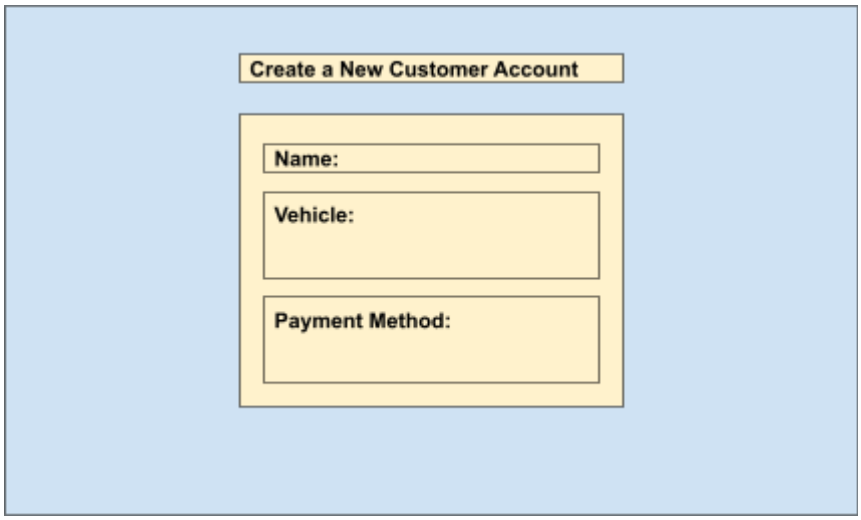

Figure 5

User Interface Requirements		
Number	**Priority**	**Description**
REQ-28	1	The system shall allow the driver to reserve a parking space in advance. (Figure 6)

Figure 6

User Interface Requirements		
Number	**Priority**	**Description**
REQ-29	3	The system shall provide vehicle location assistance for drivers returning to their vehicles. (Figure 7)

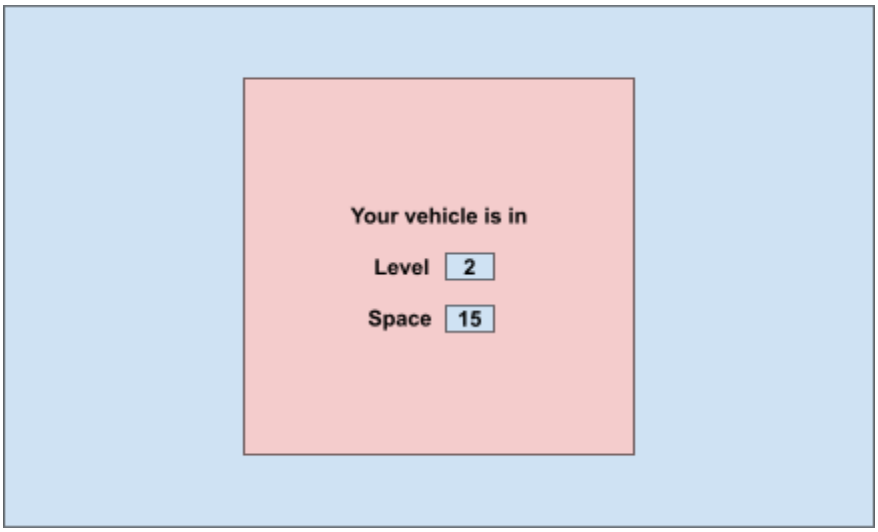

Figure 7

- **Use Cases**
  - **Stakeholders**

End Users (Drivers)

- Description: Individuals who will use the Smart Parking Garage Management System to find and reserve parking spaces.
- Needs & Interests:
  - Easy-to-use interface.
  - Real-time availability of parking spaces.
  - Secure payment methods.
  - Quick reservation process.

Parking Garage Owners/Operators

- Description: Entities or individuals who own or operate the parking garages integrated with SPGMS.
- Needs & Interests:
  - Efficient space management.
  - Accurate reporting and analytics.
  - Increase in revenue due to optimized space utilization.
  - Seamless integration with existing infrastructure.

System Administrators

- Description: Individuals responsible for the maintenance, updates, and overall health of the SPGMS.
- Needs & Interests:
    - Robust and secure system architecture.
    - Easy troubleshooting and diagnostic tools.
    - Regular updates and patches.

Local Authorities/City Planners

- Description: Government entities or organizations responsible for urban planning and transportation.
- Needs & Interests:
    - Reduction in traffic congestion due to efficient parking management.
    - Data sharing for urban planning and development.
    - Compliance with local regulations and standards.

Third-party Developers/Integrators

- Description: Developers or companies that might want to integrate their solutions or apps with SPGMS.
- Needs & Interests:
    - Open APIs and documentation.
    - Support and community forums.
    - Compatibility with various platforms and technologies.

○ Actors and Goals

Actor: Daily Commuter

- Primary Goals:
    - Find a parking space near their workplace.
    - Set up recurring reservations for convenience.
    - Receive daily updates or reminders about their reservation.

- Secondary Goals:
    - Opt for discounted monthly or weekly parking rates.
    - Report issues like blocked parking spaces or malfunctioning equipment.

Actor: Occasional Visitor (e.g., Tourist, Shopper)

- Primary Goals:
    - Locate a parking garage near their destination.
    - Understand the pricing and maximum parking duration.
    - Get directions to the parking garage.
- Secondary Goals:
    - Find out about nearby attractions or businesses.
    - Get recommendations for parking based on their planned activities.

Actor: Parking Garage Security Personnel (Garage Administrator)

- Primary Goals:
    - Monitor the security cameras and systems of the parking garage.
    - Handle any security-related incidents or emergencies.
    - Ensure the safety of vehicles and visitors.
- Secondary Goals:
    - Assist visitors with directions or issues.
    - Report maintenance needs or hazards.

Actor: Parking Garage Maintenance Staff (Garage Administrator)

- Primary Goals:
    - Ensure all equipment (like ticket machines, barriers, lights) is functional.
    - Address any reported maintenance issues promptly.
    - Keep the parking area clean and free from obstructions.
- Secondary Goals:
    - Schedule regular maintenance checks.
    - Recommend upgrades or replacements for outdated equipment.

Actor: Payment Processing System

- Primary Goals:
    - Process payments securely and promptly.
    - Handle refunds or disputes.
    - Generate payment receipts and transaction records.
- Secondary Goals:
    - Offer multiple payment options (credit card, mobile payment, etc.).
    - Ensure compliance with financial regulations and standards.

Actor: Local Business Owner (e.g., Restaurant, Shop)

- Primary Goals:
    - Collaborate with SPGMS for promotional offers (e.g., validated parking).
    - Attract more customers by ensuring convenient parking options.
- Secondary Goals:
    - Advertise their business on the SPGMS platform.
    - Get insights on parking usage to predict customer footfall.

○ Use Cases

■ Casual Description

UC-1: User registers online.

- Actor: Driver (Daily Commuter or Occasional Visitor) or Garage Administrator
- Description: The user creates a secure account on the system website.

UC-2: User logs in online.

- Actor: Driver (Daily Commuter or Occasional Visitor) or Garage Administrator
- Description: The user accesses their secure account on the system website.

UC-3: Driver makes a reservation online.

- Actor: Driver (Daily Commuter or Occasional Visitor) or Garage Administrator
- Description: The Driver makes a reservation from their account on the system website.

UC-4: Driver arrives without a reservation (walk-in customer).

- Actor: Driver (Daily Commuter or Occasional Visitor) or Garage Administrator
- Description: A walk-in customer arrives at the garage to park their vehicle without a reservation.

UC-5: Vehicle parks in a space.

- Actor: Driver (Daily Commuter or Occasional Visitor)
- Description: A Driver checks into the garage and parks in a space.

UC-6: Vehicle exits the garage.

- Actor: Driver (Daily Commuter or Occasional Visitor)
- Description: A Driver exits the garage.

UC-7: Daily Commuter Reserves a Recurring Spot

- Actor: Daily Commuter
- Description: The commuter uses the system to reserve a parking spot near their workplace on a recurring basis, ensuring they have a spot every workday.
- Steps:
    - Commuter logs into the SPGMS.
    - Searches for a parking garage near their workplace.
    - Selects a recurring reservation option.
    - Sets the frequency (e.g., every weekday).
    - Makes a payment or links to a payment method.
    - Receives a confirmation of the recurring reservation.

UC-8: Occasional Visitor Finds Nearby Attractions

- Actor: Occasional Visitor
- Description: After parking, the visitor uses the system to find nearby attractions or businesses.
- Steps:
    - Visitors access the SPGMS after parking.
    - Selects the option to view nearby attractions.
    - Browse through a list of recommended places.
    - Chooses a place and gets directions or details.

UC-9: Security Personnel Monitors Garage Activity

- Actor: Parking Garage Security Personnel
- Description: The security personnel use the system's integrated cameras and sensors to monitor activity and ensure safety.
- Steps:
    - Security logs into the security module of SPGMS.
    - Views live feeds from various cameras.
    - Receives alerts for any suspicious activity.
    - Takes necessary action based on alerts.

UC-10: Maintenance Staff Schedules Equipment Check

- Actor: Parking Garage Maintenance Staff
- Description: The maintenance staff schedules regular checks for equipment like ticket machines and barriers.
- Steps:
    - Maintenance staff accesses the maintenance module of SPGMS.
    - Schedules a check for specific equipment.
    - Receives reminders as the scheduled date approaches.
    - Logs any issues found and actions taken.

UC-11: Payment Processing for Parking Fees

- Actor: Payment Processing System
- Description: The system processes payments made by users for parking reservations.
- Steps:
    - User selects a parking spot and duration.
    - User chooses a payment method.
    - Payment system processes the payment securely.
    - User receives a payment confirmation and receipt.

UC-12: Local Business Offers Parking Discounts

- Actor: Local Business Owner
- Description: A local restaurant owner collaborates with SPGMS to offer parking discounts to their customers.
- Steps:
  - Business owner logs into the SPGMS business portal.
  - Sets up a promotional offer (e.g., 1-hour free parking with a meal purchase).
  - Provides validation codes or methods to customers.
  - Tracks the usage and success of the promotion.

■ **Use Case Diagram**

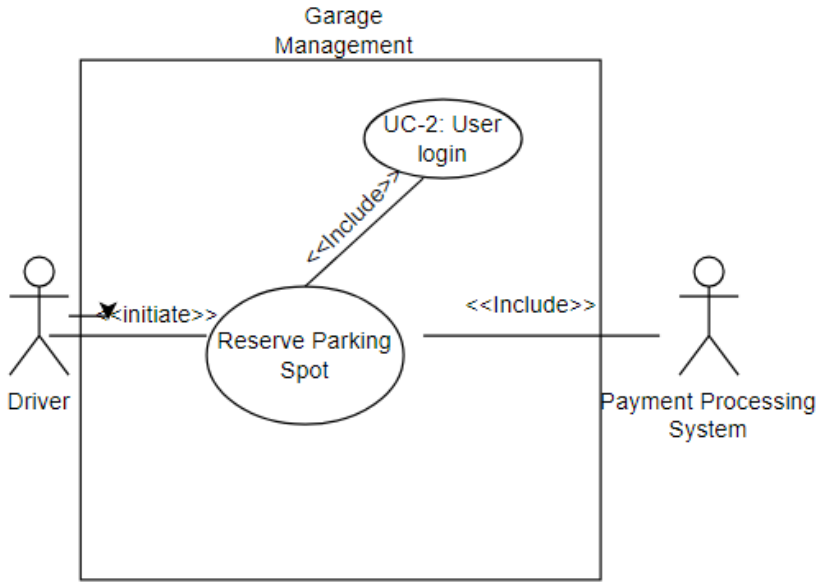

Figure 8

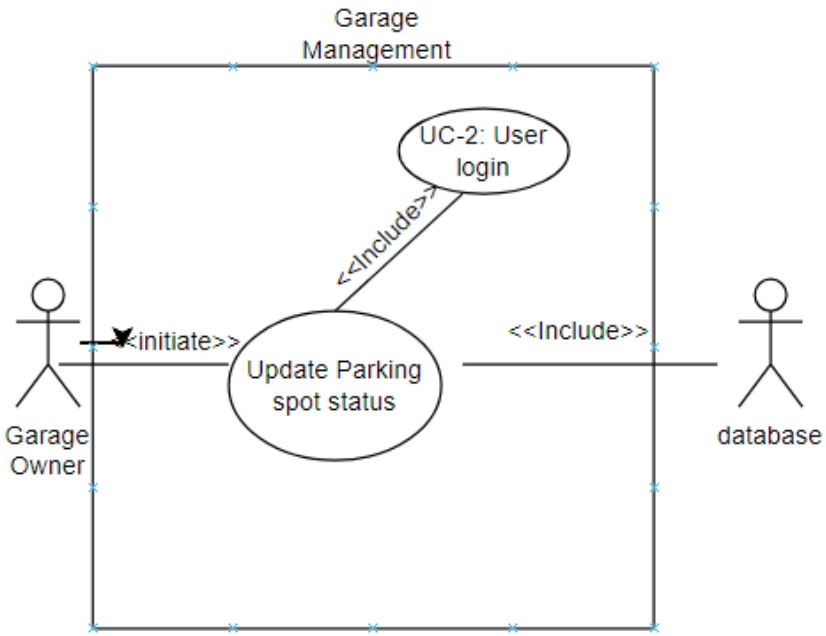

Figure 9

- **Traceability Matrix**

  The Traceability Matrix will map the system requirements outlined in the Functional, Non-Functional, and User Interface Requirements section of this report to the use cases. The format of the Traceability Matrix was influenced by Full Report 1 of the Blockchain and Docker Assisted Secure Automated Parking Garage System (24).

REQ	Priority Weight (PW)	USE CASE					
		User Registers	User Logs In	Reservation is Made	Vehicle Parks	Vehicle Exits	Analytics Viewed
01	3		X				
02	1			X	X	X	
03	1	X					
04	1		X				
05	1		X				
06	1	X	X				
07	2		X				X
08	2		X				X
09	3		X				X
10	3		X				X
11	2		X				X
12	2		X				X
13	3		X				X
14	3		X				X
15	2		X				X
16	1		X	X	X		
17	2		X	X	X		
18	2			X	X		
19	2		X	X	X		
20	1	X					
21	1	X					X
22	1	X					X
23	1	X					X

REQ	Priority Weight (PW)	USE CASE					
		User Registers	User Logs In	Reservation is Made	Vehicle Parks	Vehicle Exits	Analytics Viewed
01	3		X				
02	1			X	X	X	
03	1	X					
04	1		X				
05	1		X				
06	1	X	X				
24	3		X		X	X	
25	1	X	X	X			
26	1	X	X		X		
27	1	X					
28	1		X	X			
29	3		X				

- **Fully-Dressed Descriptions and System Sequence Diagrams**

Use Case: Daily Commuter Reserves a Recurring Spot (Figure 10)
Related Requirements: REQ-02, REQ-09, REQ-13, REQ-16, REQ-18, REQ-19, REQ-20, REQ-25, REQ-26
Initiating Actor: Driver
Actor's Goal: Reserve a parking space on a recurring basis
Participating Actors: Driver, Website, Database, Payment Processing System
Preconditions: The Driver has a user account in the SPGMS System.

Postconditions: There is a space automatically allocated to the Driver on a recurring basis.	
Flow of Events for Main Success Scenario:	
→	1. Driver submits a request for a recurring parking space for a specified time frame.
→	2. Website searches Database for spaces available for the requested time frame.
←	3. Website displays available spaces to Driver.
→	4. Driver selects a space to reserve.
→	5. Website opens Payment Processing System.
←	6. Payment Processing System requests payment from Driver.
→	7. Driver provides payment information securely on the Payment Processing System.
←	8. Space is reserved in the Database on a recurring basis.
←	9. Website displays reservation to Driver.

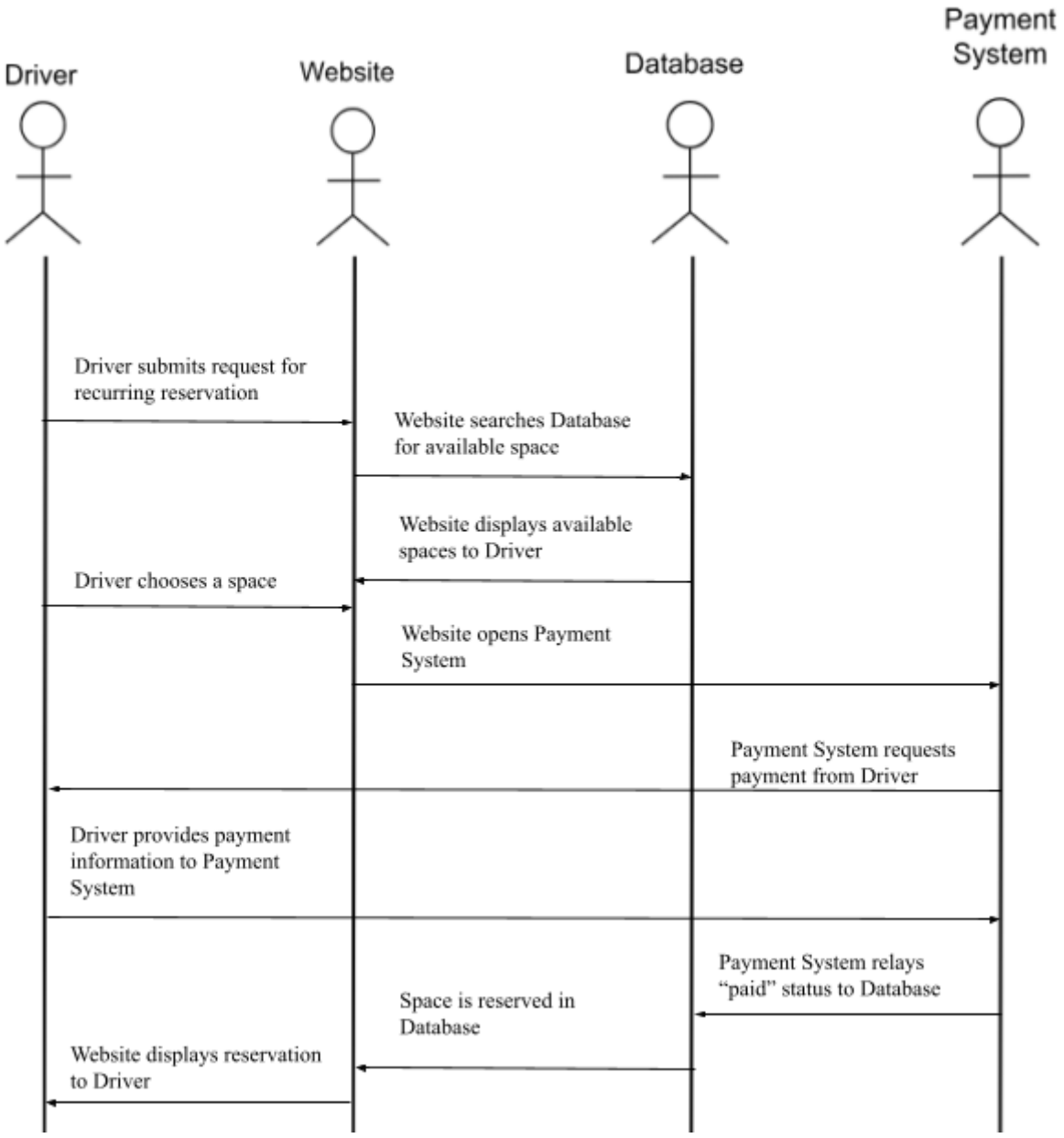

Figure 10. System Sequence Diagram for Use Case: Daily Commuter Reserves a Recurring Spot

Use Case: Occasional Visitor Finds Nearby Attractions (Figure 11)	
Related Requirements: REQ-26	
Initiating Actor: Driver	
Actor's Goal: After parking in the garage, use the system to find nearby attractions or businesses.	
Participating Actors: Driver, Website	
Preconditions: The Driver has parked in a smart parking garage space and needs directions to a nearby attraction or business.	
Postconditions: The System directs the Driver to a desired destination.	
Flow of Events for Main Success Scenario:	
→	1. Driver accesses the SPGMS Website.
→	2. Driver selects the option to view nearby attractions.
←	3. Website displays a list of recommended places.
→	4. Driver chooses a destination.
←	5. Website provides details and directions to the selected destination.

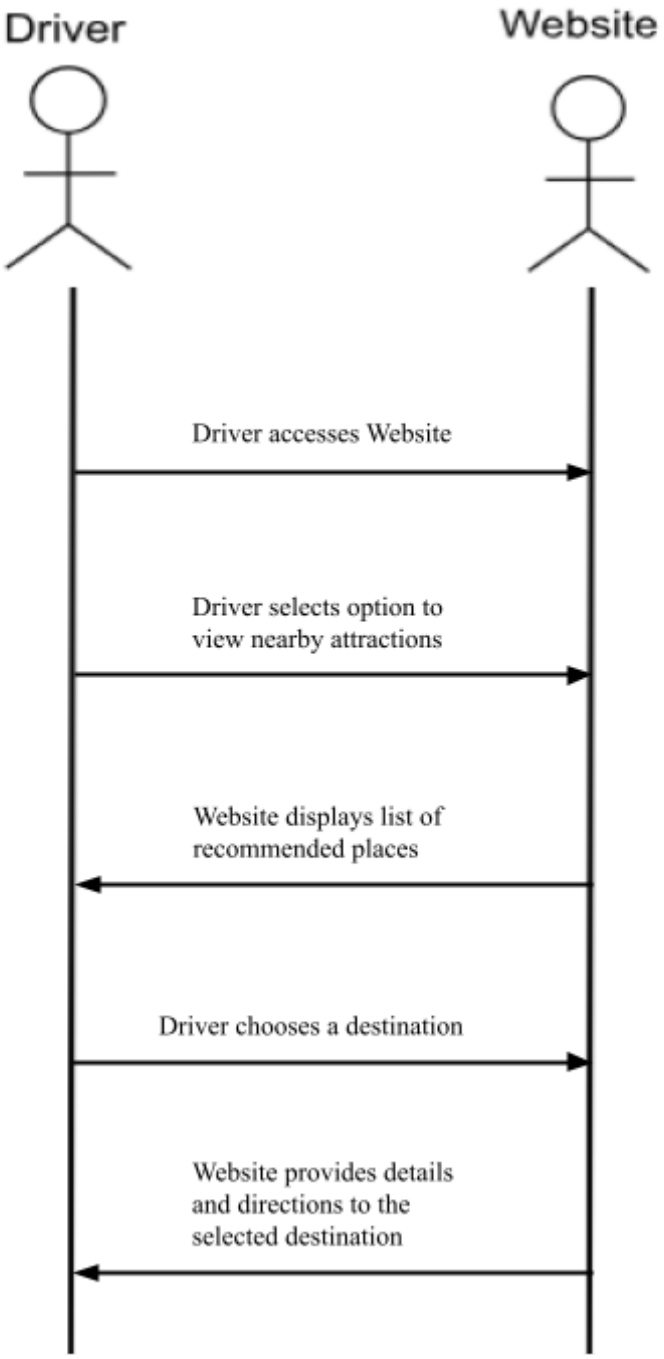

Figure 11: Use Case: Occasional Visitor Finds Nearby Attraction

Use Case: Security Personnel Monitors Garage Activity (Figure 12)	
Related Requirements: REQ-02, REQ-03, REQ-06	
Initiating Actor: Parking Garage Security Personnel	
Actor's Goal: Identify and respond to any security issues within the parking garage from a single station/location.	
Participating Actors: Parking Garage Security Personnel, System, Cameras	
Preconditions: Security Personnel is on staff in a parking garage equipped with security cameras. The Security Personnel has access to a SPGMS account with security level permissions.	
Postconditions: Security issues within the parking garage are identified by appropriate personnel.	
Flow of Events for Main Success Scenario:	
→	1. Security Personnel accesses an administrator account with security level permissions.
→	2. The security account accesses video feed from cameras throughout the parking garage.
←	3. The system displays the video feed to authorized security personnel.

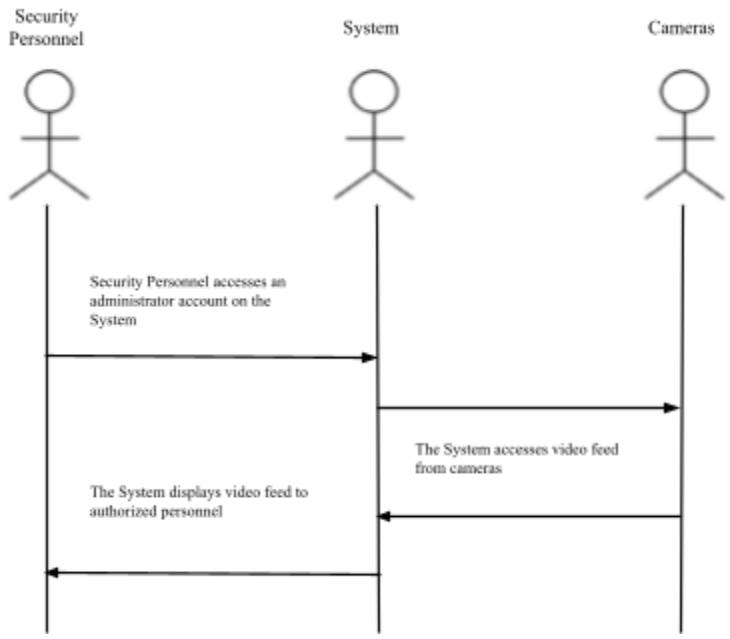

Figure 12: Use Case: Security Personnel Monitors Garage Activity

- **User Interface Specification**
  - **Preliminary Design**

    The preliminary design for the screen that will be displayed to the driver to schedule a recurring reservation for a parking space is shown in Figure 13.

    The driver will select the days of the week that they wish to reserve a space. Then, they will type in the arrival and departure time for each day. They will enter the dates they would like to begin and end the schedule.

    The display of the parking spaces will change color to reflect the availability of each space according to the dates and times entered by the driver. The driver may click on the buttons for additional levels to view more spaces. Once the driver has decided on an available space, they may select the space. When all of the date and time information has been entered and a space has been selected, the driver will click on the “proceed to payment” button to move to the next screen.

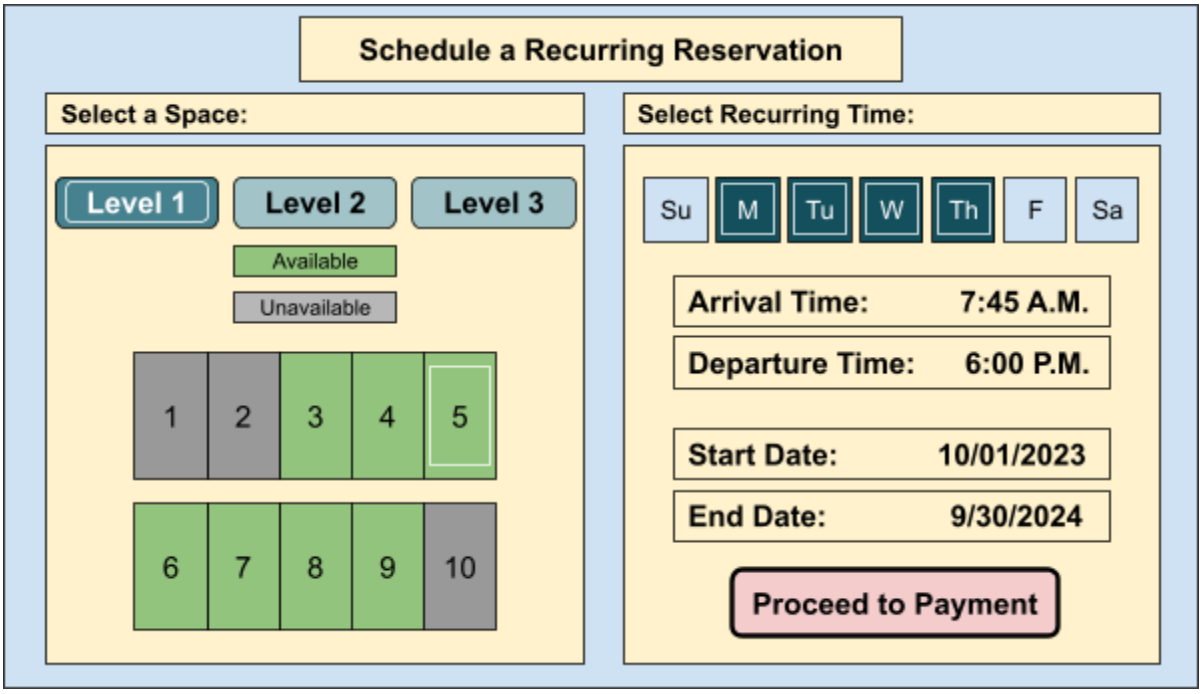

Figure 13: Use Case: Daily Commuter Reserves a Recurring Spot

- **User Effort Estimation**

  For Use Case: Daily Commuter Reserves a Recurring Spot, the user will begin by clicking a button to schedule a recurring reservation on their personal SPGMS dashboard. Counting this button as the first click, this use case should require between 8 and 14 clicks, depending on how many days of the week the user selects, and how many levels of the garage they view. Keystrokes for this use case will be limited to typing the times and dates, and then entering their payment information on the following screen. These totals assume that the user already had an existing SPGMS account.

- **System Architecture**
  - **Identifying Subsystems**

    The SPGMS subsystems are outlined in the package diagram in Figure 14.

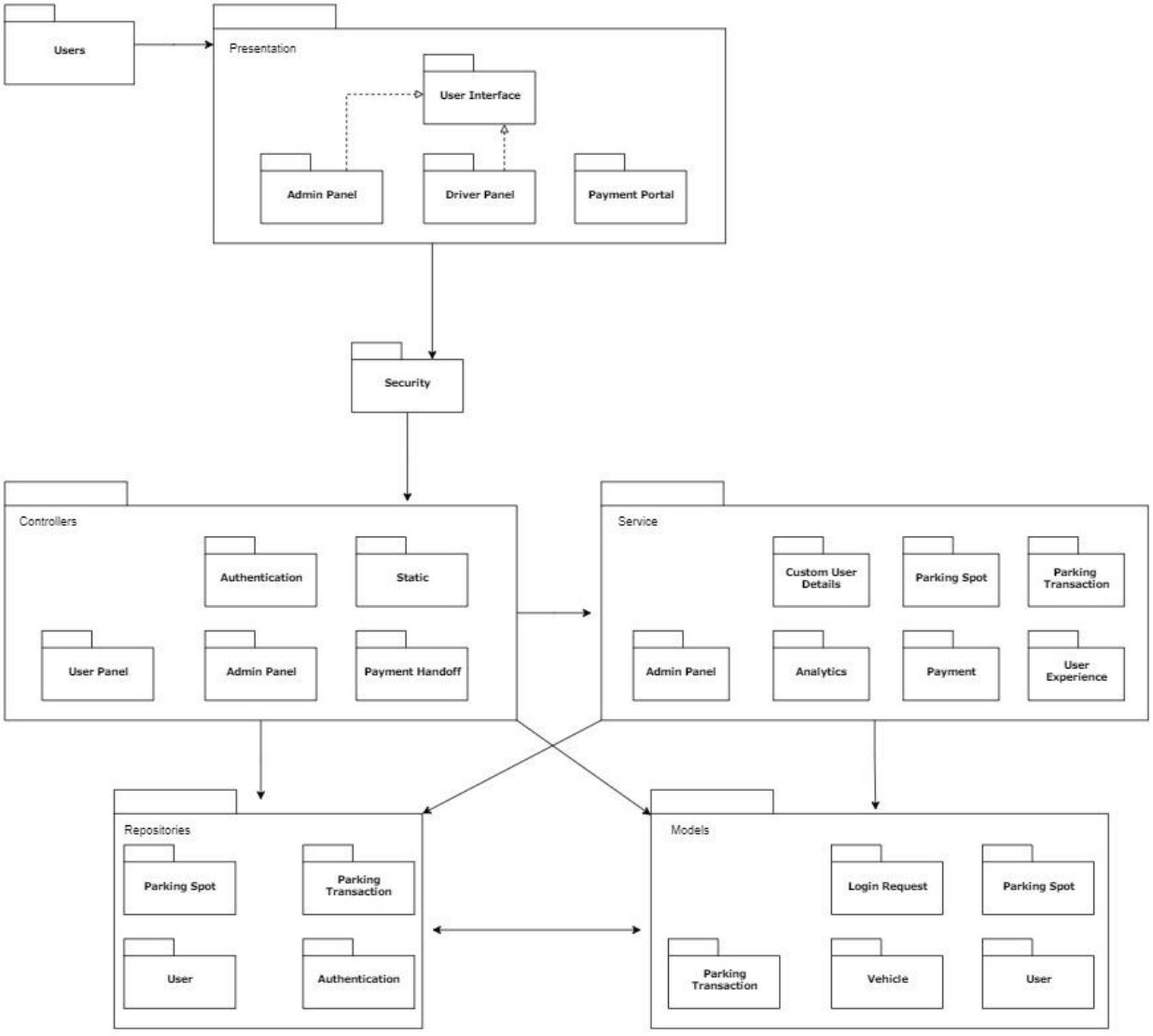

Figure 14: SPGMS Package Diagram

  - **Architectural Style**

    The system architecture has a layered style, as described by Sharma, Kumar and Agarwal (2015). The layered style features three basic layers: presentation, business, and infrastructure. The SPGMS presentation layer contains the user interface, which includes the user panels (driver and administrator), the payment portal, and the security packages.

The business layer consists of the controllers and service packages. The infrastructure layer contains the repositories.

The system also contains elements of client-server architecture, which is used by many applications that access data via the internet (Sharma, Kumar and Agarwal 2015). The website (client) will request information from the server database and return it to the user as needed.

- **Connectors and Network Protocols**

  The Smart Parking Garage Management System (SPGMS) is designed with a focus on secure, efficient, and reliable communication between its various components. Here's an overview of the connectors and network protocols employed:

  Spring Boot Server on EC2:

  - Connector: Embedded Tomcat server, which comes by default with Spring Boot, will be used as the servlet container to deploy the application.
  - Protocol: HTTPS (HTTP over TLS/SSL) will be employed to ensure secure communication between the client and the server.
  - Port: Production will use port 8443.

  Communication between EC2 and RDS:

  - Connector: JDBC (Java Database Connectivity) will be used to connect the Spring Boot application with the RDS databases.
  - Protocol: Secure Socket Layer (SSL) encryption will be enabled for connections between the EC2 instance and RDS to ensure the confidentiality and integrity of data during transmission.
  - Port: The default port for MySQL is 3306.

By employing these connectors and protocols, SPGMS ensures a robust and secure communication framework, facilitating efficient data exchange and real-time updates where necessary.

- **Global Control Flow**

  The SPGMS will operate in real-time. The status of the parking spaces (available or occupied) will have to be accurate in real-time in order for reservations to be made remotely and for costs to be calculated accurately. Business analysis functions will be available for Garage Administrators based on blocks of time of various lengths, such as hourly, daily, monthly, and yearly.

  The Driver functions of the system will be procedure-driven. The reservation and payment steps for the Driver will always happen in the same order. However, the analysis functions available to the Garage Administrator will be accessible in any order, and will therefore be more event-driven. For example, a Garage Administrator will be able to view the annual data for the garage without first viewing the hourly, daily, and monthly data if desired.

- **Hardware Requirements**

  The Smart Parking Garage Management System (SPGMS) will be hosted on Amazon Web Services (AWS), leveraging its robust and scalable infrastructure. Below are the AWS resources and potential hardware components that will be utilized:

  - Amazon EC2 (Elastic Compute Cloud): This service will provide the resizable compute capacity required to run the SPGMS application. EC2 instances will be configured to ensure optimal performance, security, and scalability.

  - Amazon S3 (Simple Storage Service): S3 will be used for storing and retrieving any data, assets, or backups related to SPGMS. It offers high durability and availability, ensuring that our data remains safe and accessible.

  - Amazon RDS (Relational Database Service): RDS will host the relational databases for SPGMS. It will be set up to ensure data integrity, security, and high availability. Regular backups and maintenance tasks will be scheduled to keep the database in optimal condition.

- Amazon Route 53: This will be the DNS web service used to route end users to the SPGMS application. It will ensure that the domain name of SPGMS resolves quickly and reliably to the application.

- Amazon SES (Simple Email Service): SES will handle all email communications for SPGMS, ensuring that notifications, alerts, and other communications are delivered promptly and securely to the intended recipients.

- Amazon ELB (Elastic Load Balancing): To distribute incoming application traffic across multiple EC2 instances, ensuring fault tolerance and high availability.

- Amazon CloudFront: A content delivery network (CDN) service that will help deliver content to users with low latency and high transfer speeds.

Physical Hardware Components:

- Cameras: For surveillance and license plate recognition, aiding in the automation of entry and exit points.
- Gate Control Hardware: Automated gates or barriers that can be controlled by the system to manage vehicle entry and exit.
- Payment Kiosks: Physical machines where users can make payments for parking if not done through the application.
- Display Boards: To show real-time parking availability, directions, and other relevant information to users.

By leveraging these AWS resources and hardware components, SPGMS aims to provide a seamless and efficient experience for its users, ensuring high availability, security, and scalability.

- **Project Size Estimation**

UC Number	Use Case Description	Estimated Size
UC-1	User Registers Online	1
UC-2	User Logs In Online	1
UC-3	Driver Makes a Reservation	3
UC-4	Driver Arrives Without a Reservation	2

UC-5	Vehicle Parks in a Space	1
UC-6	Vehicle Exits Garage	1
UC-7	Daily Commuter Reserves a Parking Spot	5
UC-8	Occasional Visitor Finds Nearby Attractions	5
UC-9	Security Personnel Monitors Garage Activity	6
UC-10	Maintenance Staff Schedules Equipment Check	4
UC-11	Payment Processing for Parking Fees	3
UC-12	Local Business Offers Parking Discounts	4

- **Plan of Work / Project Management**

Our team plan of work is outlined in the Gantt chart in Figure 15. The periods in the chart represent weeks in the Fall 2023 semester. The chart will be updated accordingly as the project progresses.

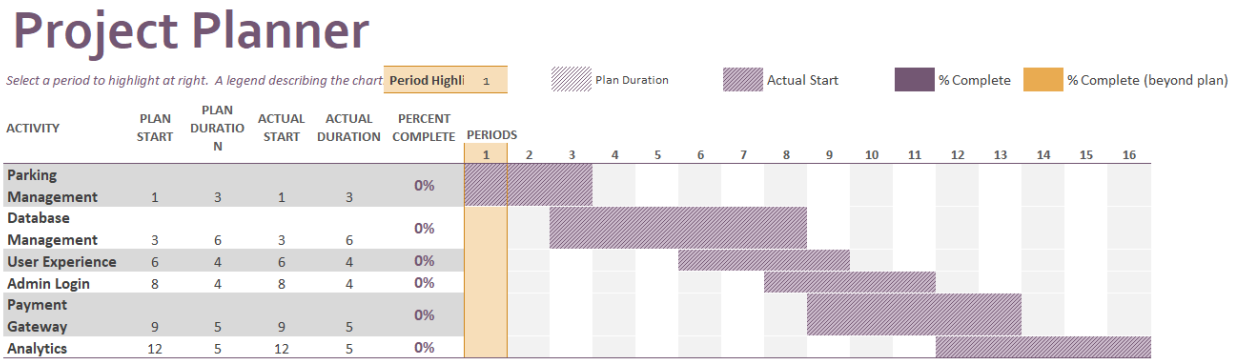

Figure 15: Gantt Chart

The team meets weekly to discuss the project and plan the next steps. Our plan for the coding phase is for Oakley Cardwell to design and code the back-end aspects of the project. Gene Holt and Nicole Brandenburg will focus on the design and implementation of the front-end aspects.

- **References**

  - Marsic, I. (2012). *Software Engineering* [online]. New Brunswick: Rutgers University. Available from: https://www.ece.rutgers.edu/~marsic/books/SE/book-SE_marsic.pdf [accessed 28 Aug 2023].
  - Sharma, A., Kumar, M., Agarwal, S. (2015). 'A Complete Survey on Software Architectural Styles and Patterns', *Procedia Computer Science*, vol. 70, pp. 16-28 [online]. Available from: https://www.sciencedirect.com/science/article/pii/S187705091503183X [Accessed 24 Sep 2023].
  - Tran, L., Nguyen K., Choudhury S., Ngo T., Nguyen, D., Xiao, Z., Patel, N. (2019). *Blockchain and Docker Assisted Secure Automated Parking Garage System* [online]. Available from: https://www.ece.rutgers.edu/~marsic/books/SE/projects/ParkingLot/ [Accessed 8 Sep 2023].

- **Modifications and Improvements**

  Per the instructor's review of Parts 1 and 2 of this report, modifications to the Use Case diagram and Traceability Matrix were made prior to the submission of the Full Report 1.

  The Use Case Diagram was broken into two separate diagrams, each with a single boundary line.

  The Traceability Matrix was re-formatted to display use cases, requirements, and priority weights in a single, tabular format.