Parking Lot System

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INFO-C451: System Implementation

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Problem Statement

In urban and high-traffic areas, parking has become a constant challenge for both drivers and parking lot operators. As vehicles increase in number, the demand for organized and efficient parking has grown. Currently, many parking lots rely on manual operations, leading to inefficiencies such as long wait times, difficulty in locating available spots, and challenges in payment processing. Additionally, security concerns and the lack of real-time parking availability contribute to customer dissatisfaction.

Our proposed Parking Lot Management System aims to address these challenges by providing an automated, user-friendly, and efficient solution for managing parking spaces. The system will streamline parking spot allocation, provide real-time availability updates, automate ticketing and payment processing, and ensure secure operations.

Objectives of the System

The primary objective of this system is to enhance parking efficiency, reduce operational costs, and improve customer satisfaction. Specifically, the system will:

- Optimize parking space utilization by dynamically updating availability in real-time.
- Reduce entry and exit congestion through automated ticket issuance and payment processing.
- Enhance security and monitoring by integrating with existing CCTV and security systems.
- Improve customer experience by providing a seamless and automated parking process.
- Support multiple payment methods (cash, credit/debit card, and digital payments).
- Enable parking lot operators to manage operations efficiently with an intuitive dashboard and reporting tools.

System Requirements

The Parking Lot Management System will support the following functionalities:

- Real-time Parking Spot Availability Display
- Automated Entry Ticket Generation
- Payment Processing (Automated and Manual Options)
- Parking Spot Reservation System
- Overcapacity Handling & Notifications
- Security and Integration with CCTV Cameras
- User Role Management (Customers, Operators, Security Personnel, and Administrators)
- Comprehensive Reporting and Analytics for Operators

Typical Customers

The proposed system will cater to different types of users:

Parking Lot Managers: Oversee parking lot operations, monitor availability, and generate revenue reports.

Drivers/Vehicle Owners: Use the system to find parking, pay fees, and exit seamlessly.

Parking Assistants & Security Personnel: Help customers and ensure smooth parking operations.

Business Owners (Malls, Offices, Stadiums, etc.): Use the system to manage parking for their visitors and employees.

Functional Requirements

No.	Priority Weight	Description
REQ-1	High	The system should allow users (parking attendants, and administrators) to securely log in using their credentials (Username, Password, Two-Factor Authentication).
REQ-2	High	Customers should be able to check real-time parking availability through the system before entering the lot.
REQ-3	High	The system should issue a parking ticket automatically upon a vehicle's entry.
REQ-4	High	The system should track and display available parking spots categorized by type (compact, motorcycle, emergency).
REQ-5	High	The system should prevent entry when the parking lot has reached full capacity and display a notification at the entrance.
REQ-6	Medium	Customers should be able to pay for parking via an automated exit panel or through a parking attendant (in the event the system is down).
REQ-7	Medium	The system should allow payments through multiple methods, including credit/debit cards, mobile payments, and cash.
REQ-8	Medium	The system should generate a receipt after payment, either as a printed or digital receipt.
REQ-9	Low	The system should generate and store reports on parking usage, revenue, and occupancy trends for administrators.
REQ-10	High	The system should provide security personnel access to vehicle logs and entry/exit timestamps.

Non-Functional Requirements

No.	Category	Priority Weight	Description
NFR-1	Security	High	The system should provide secure access control with role-based permissions for customers, attendants, and administrators.
NFR-2	Usability	High	The system interface should be user-friendly and intuitive, allowing for seamless navigation.
NFR-3	Usability	Medium	The system should be accessible via mobile devices to allow customers to check parking availability on the go.
NFR-4	Reliability	High	The system should have a high up-time to ensure uninterrupted service.
NFR-5	Reliability	High	Automated backups should be performed daily to prevent data loss.
NFR-6	Performance	High	The system should process ticket issuance, payments, and access control within minimal response time.
NFR-7	Performance	Medium	The system should support concurrent usage of up to 500 users without performance degradation.
NFR-8	Supportability	Medium	The system should provide error logs and diagnostic reports for administrators to troubleshoot issues.
NFR-9	Supportability	Medium	The system should be scalable to accommodate future parking expansions.
NFR-10	Supportability	Low	The system should be compatible with third-party parking management integrations.

User Interface Requirements

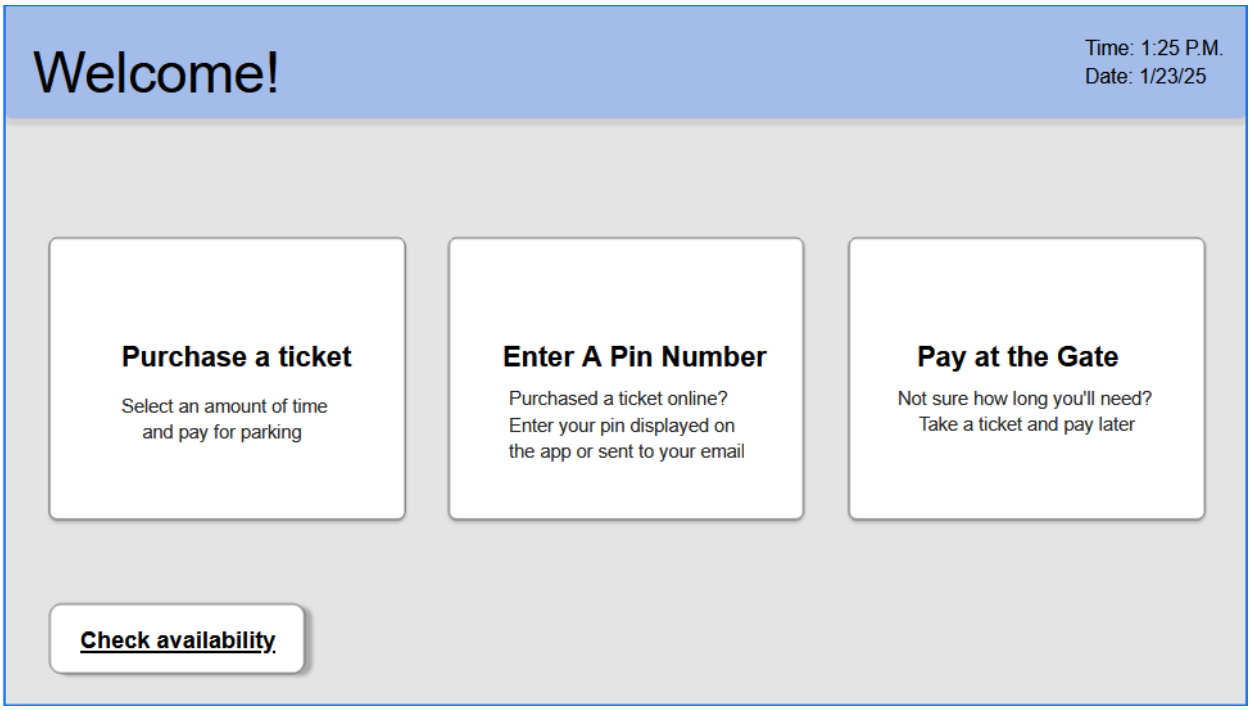
No.	Priority Weight	Description
UI-1	High	The system should have a clear and intuitive dashboard displaying available parking spaces, ticket status, and payment options.
UI-2	High	The login page should be simple with clear instructions for account recovery, login, and authentication.
UI-3	High	The system should have a responsive design that works across different screen sizes, including desktops, tablets, and mobile devices.
UI-4	High	Navigation menus should be clear and consistent across all pages, allowing users to easily access ticket status, payment options, and parking history.
UI-5	Medium	The real-time parking availability page should display a map for customers to see their parking spot.
UI-6	Medium	Notifications and alerts should inform users about the available parking spots, payment reminders, and entry/exit logs.
UI-7	Medium	The system should display parking time and charges in a clear and readable format for customers.
UI-8	Low	The color scheme and typography should be accessible, especially for visually impaired users.
UI-9	Low	The system should allow users to customize notification preferences (email, SMS, app alerts).
UI-10	Low	A help button should be implemented to allow users the option to speak with a parking assistant to aid with customer inquiries.

User Interface Specifications

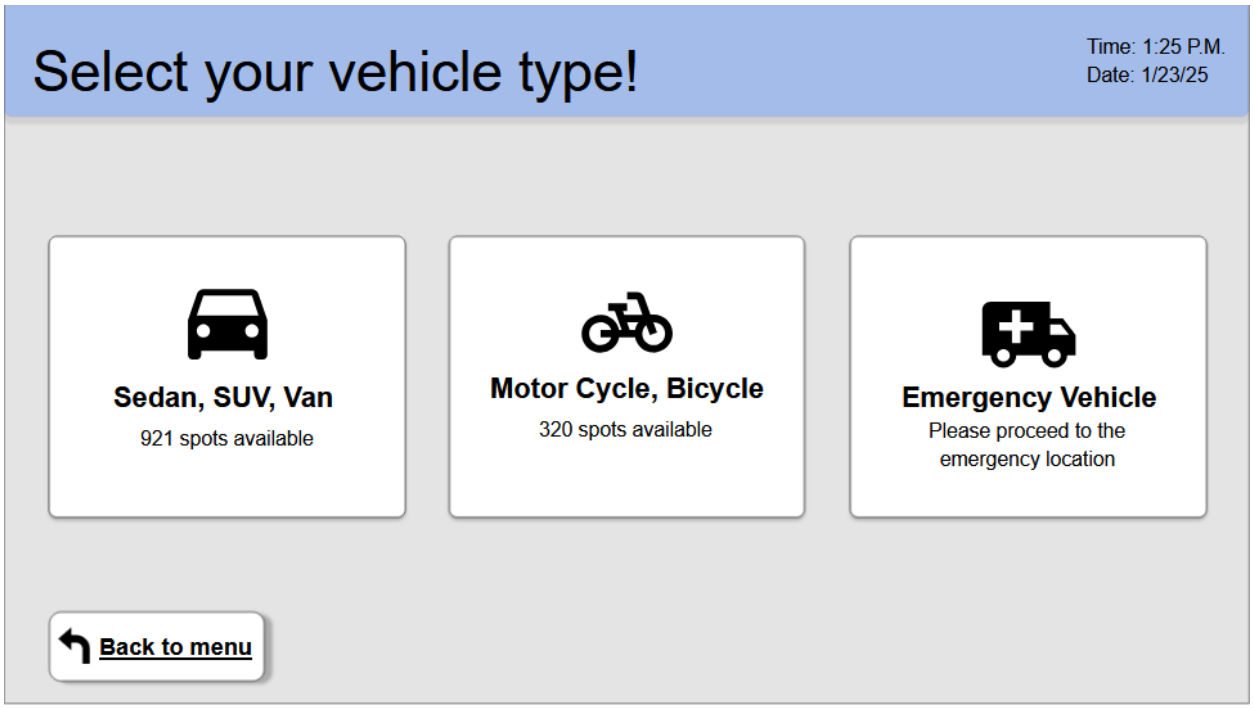
Preliminary Design

1.) Ticket Issuance

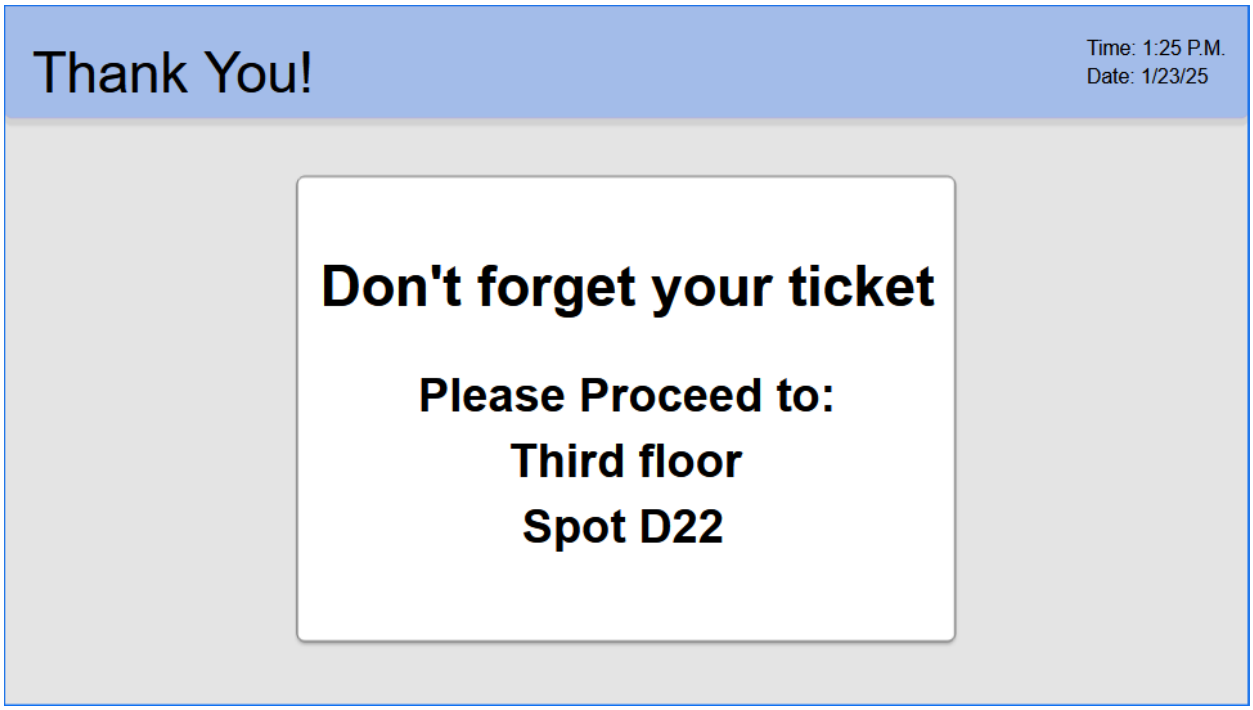
As the customer pulls into the parking lot, they will arrive near the terminal in which they will interact with the system to receive their parking ticket. There they can choose to take a ticket and be billed after exiting or to enter a pin if a ticket was purchased online or via app.



From here, the customer will select their vehicle type and the availability of parking spaces.

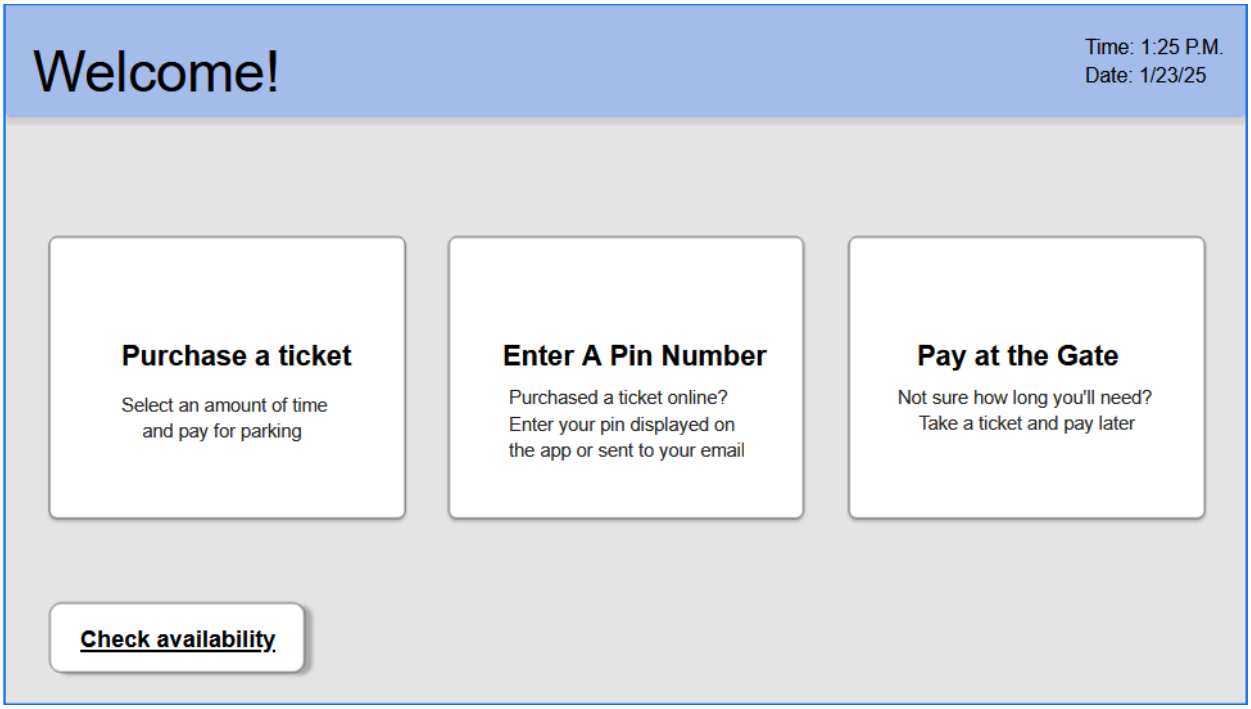


After selecting, the terminal will dispense a ticket with the designated parking space for the user and display the location on screen before returning to the main menu.



2.) Real-Time spot availability display

To check availability, the customer will tap the button on the main menu “Check availability” which is displayed on the lower left corner of the screen. This will redirect to the real-time availability screen.



Tapping on the vehicle will then display the purchase screen, locking in their vehicle selection for a seamless checkout.

Select your vehicle type!

Time: 1:25 P.M.
Date: 1/23/25

Sedan, SUV, Van

921 spots available

Motor Cycle, Bicycle

320 spots available

Emergency Vehicle

Please proceed to the emergency location

Back to menu

Select your Payment Option!

Time: 1:25 P.M.
Date: 1/23/25

Purchase a ticket

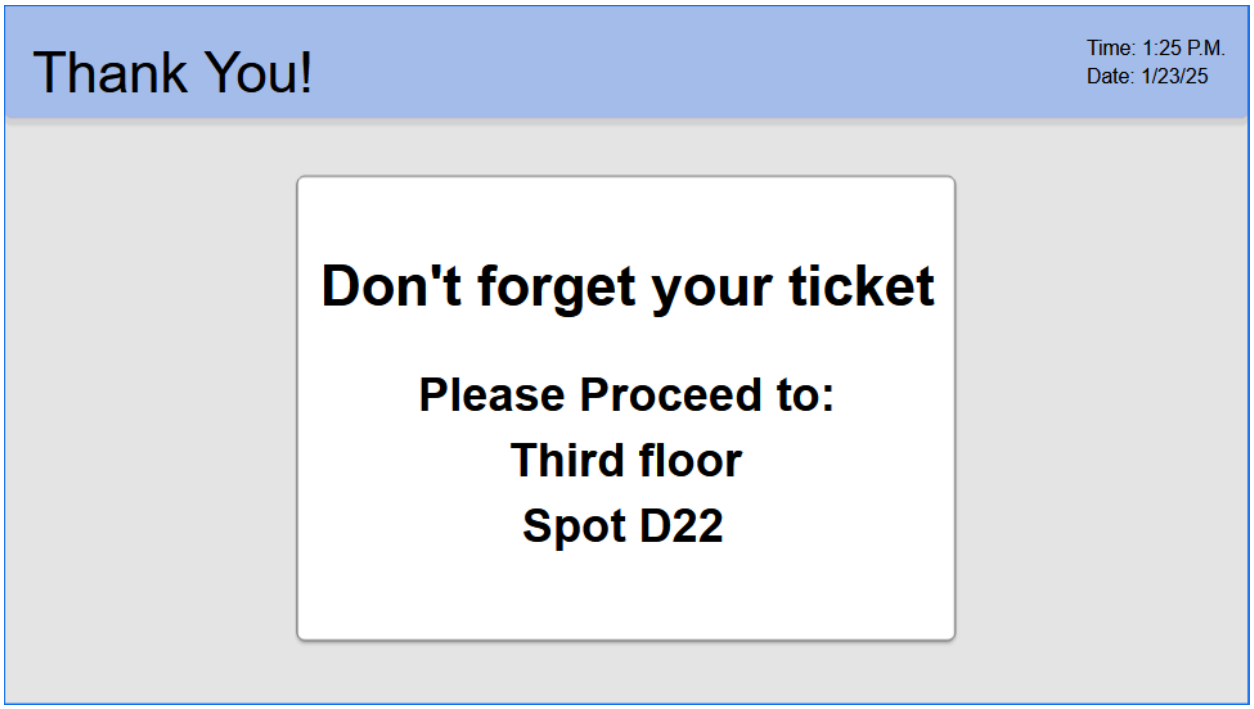
Select an amount of time and pay for parking

Enter A Pin Number

Purchased a ticket online? Enter your pin displayed on the app or sent to your email

Pay at the Gate

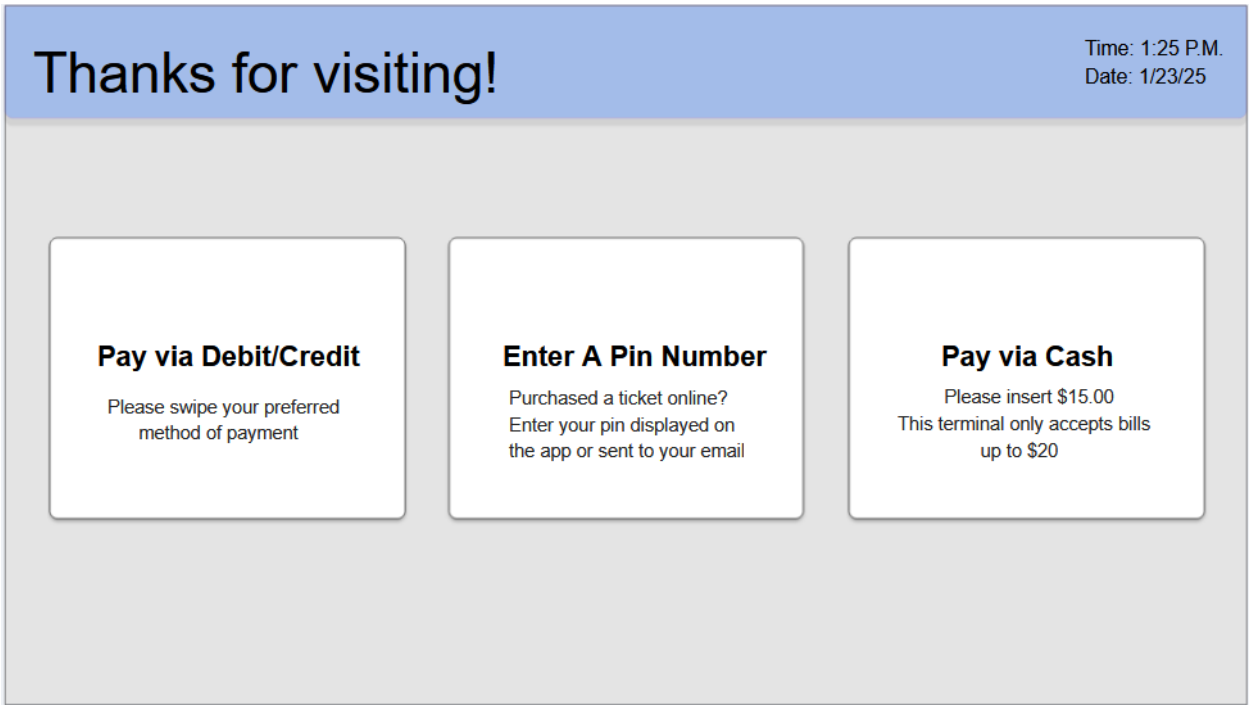
Not sure how long you'll need? Take a ticket and pay later



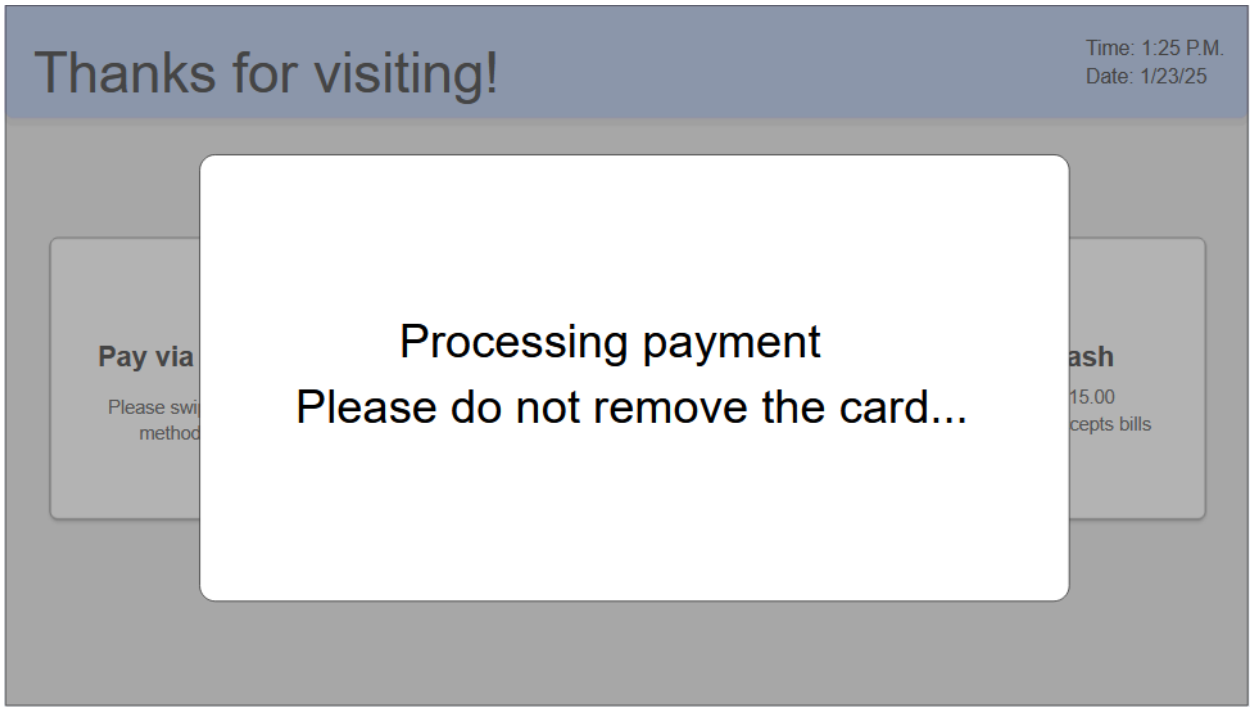
Note: The operation is relatively the same but allows the customer a chance to see any slots available in a different order. In this specific case, the customer chose the following path: Check availability, Sedan, Pay at the gate.

3.) Payment Processing

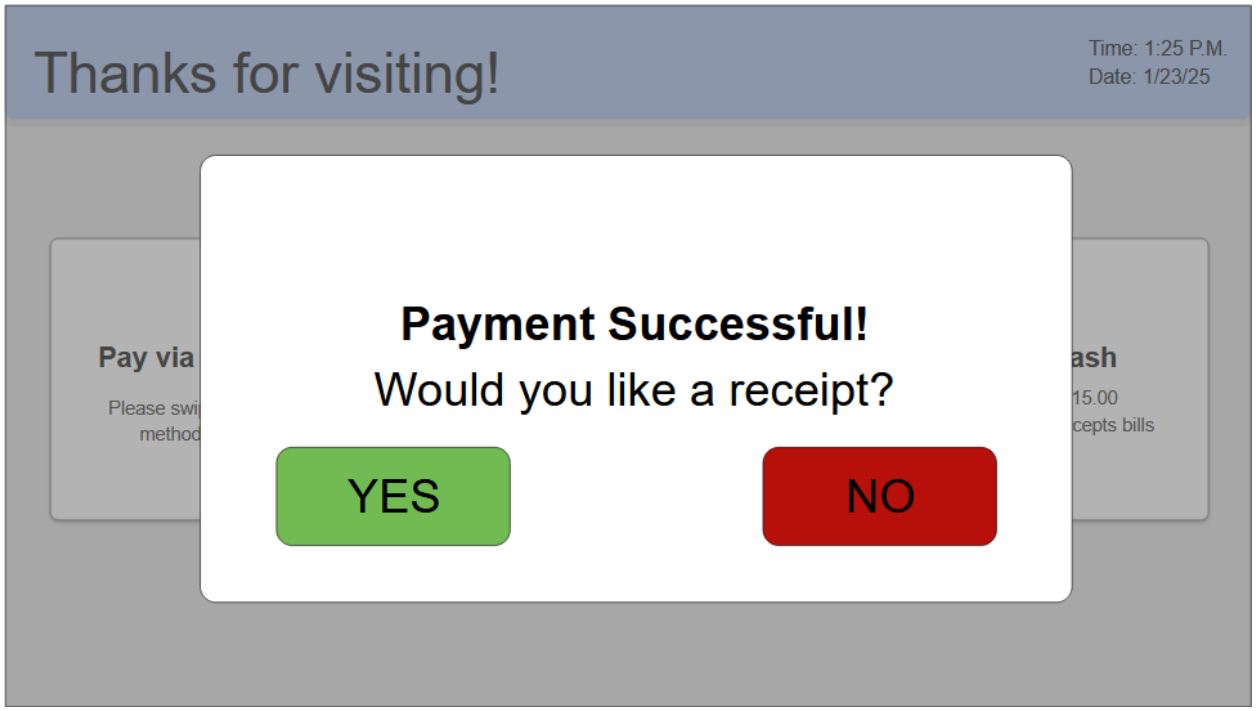
Using the “Pay at the gate option”, the customer will be prompted to insert cash or swipe a credit/debit card. If a customer purchased their ticket and paid previously but extended their time, the system will charge an additional fee based on 15-minute increments for the additional time used.



In this example, the debit card was used to pay for the ticket.



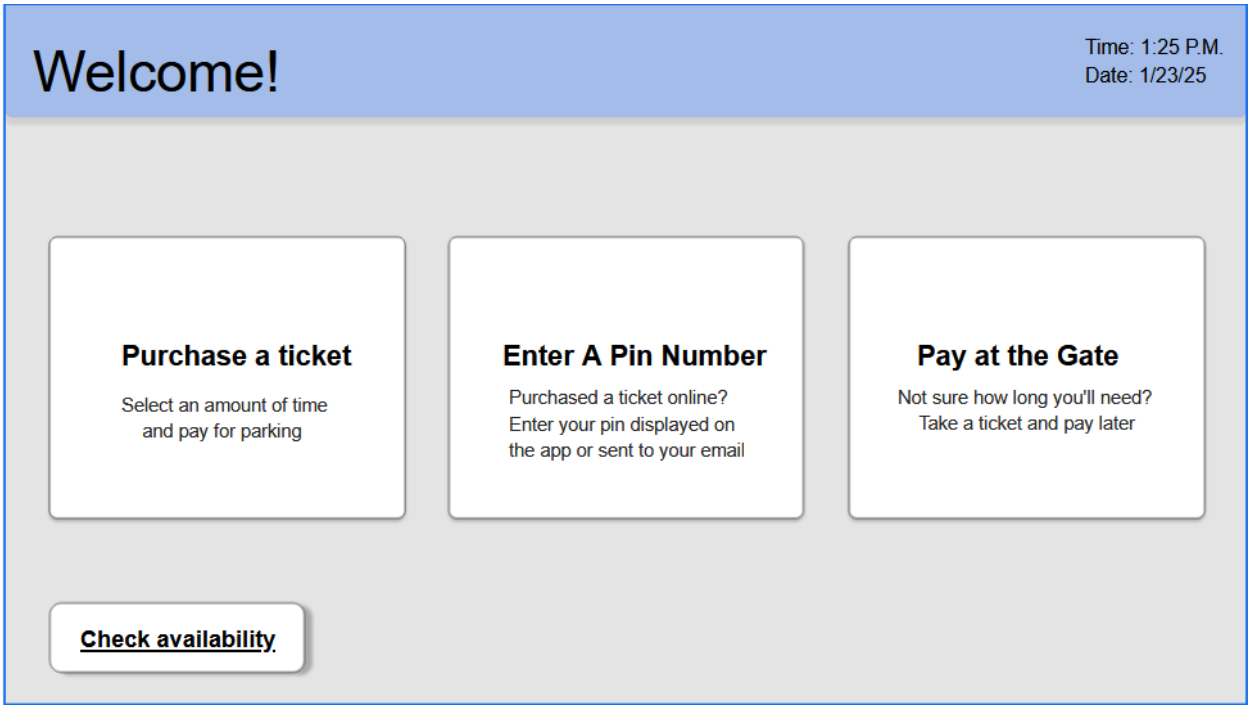
After the payment is processed, the system will notify the customer that the payment was successful and give the option to receive a receipt.

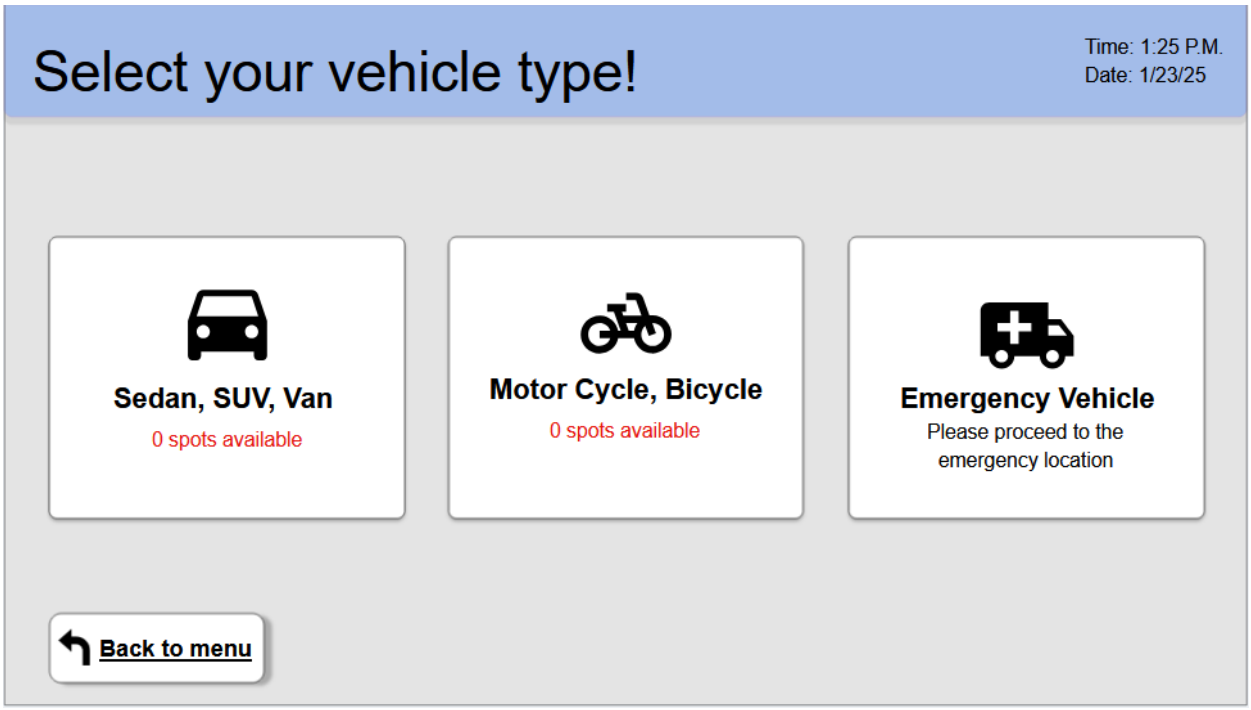


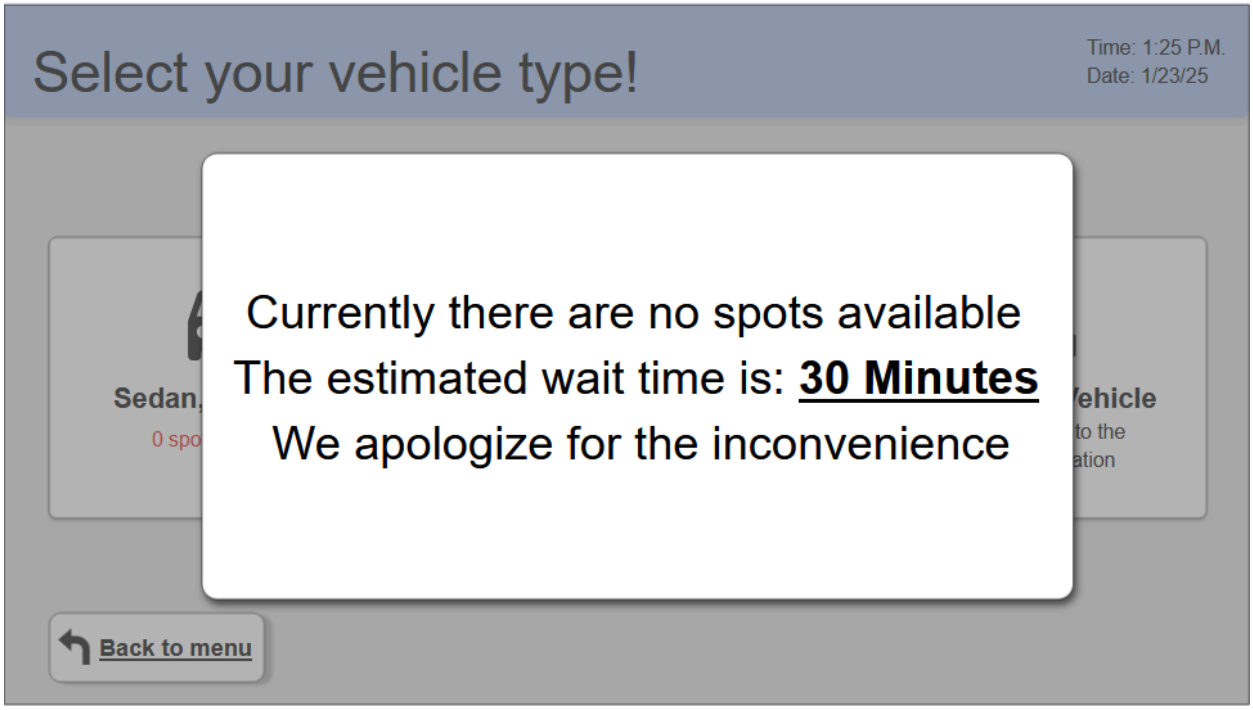
Tapping yes will dispense a receipt with the total amount, rate for time, date, time, and payment method used before returning to the main menu. Selecting no will simply return to the main menu.

4.) System Overcapacity display

While checking availability and selecting a vehicle option that does not have any spots available, the system will output an overcapacity message with an estimated time until a new spot is available.

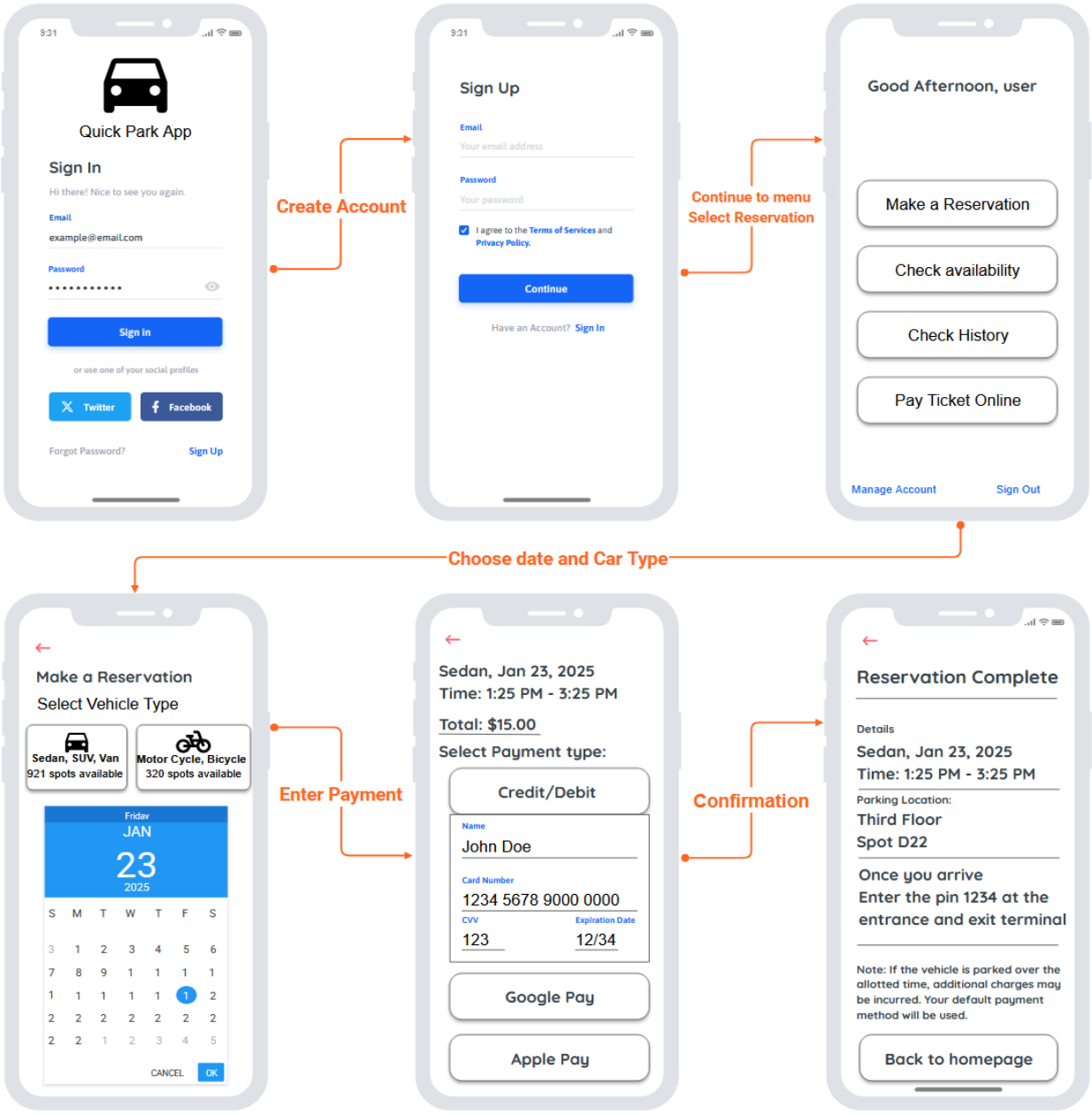





Select your vehicle type!
Time: 1:25 P.M.
Date: 1/23/25
Currently there are no spots available
The estimated wait time is: 30 Minutes
We apologize for the inconvenience
Back to menu

5.) Parking Spot Reservation (Mobile App)

Downloading the Quick Parking App, A user can sign up and make a reservation online to expedite the process. After signing in/creating an account, the user will be prompted with options. The one for this example will be to make a reservation. After selecting their vehicle type and date, it will display the spots available before proceeding to the payments screen. After validation and processing payment, it will display a success screen with the reservation details, parking spot location, directions, pin number to enter the lot, and a notte that informs users that charges can be incurred if the vehicle stays over the paid time limit.



User Effort Estimation:

Usage Scenario	Navigation	Clicks	Keystrokes
Ticket Issuance	Select Payment, Select Vehicle, Accept ticket, park at assigned location.	2	0
Real-time Spot Availability Display	Select Availability, Select vehicle	1	0
Payment Processing	Drive to exit terminal, Select payment option (Swipe card), take receipt	2	0
System Overcapacity Handling	Select availability, Select Vehicle type, display message	1	0
Create Online Reservation	Download the app, create an account, Select “make a reservation”, choose vehicle type and date, enter payment details, receive confirmation.	11	>100

Project Plan

Development Approach

Software & Technologies

- Front-end: React.js (for a user-friendly web interface)
- Back-end: Node.js with Express.js (for handling API requests and business logic)
- Database: MySQL (for efficient data management and transaction processing)
- Security Integration: CCTV API for real-time monitoring and security alerts
- Payment Processing: Stripe API and PayPal API for digital transactions
- Cloud Hosting: AWS or Firebase for scalability and high availability

Hardware & Network Requirements

- Servers: Cloud-based or on-premises servers to store data and run applications.
- Parking Sensors & Display Boards: IoT-enabled sensors to detect parking availability.
- Automated Entry/Exit Gates: Integrated with the system to validate tickets and control access.
- Network Connectivity: Stable internet/Wi-Fi for real-time updates and cloud synchronization.

Future Development

I intend to implement a few systems to allow employees (parking attendants and administrators) to log into the system, in addition to allowing security to access logs of vehicle history both in and out of the parking lot to document which vehicles were parked within the lot.