

Parking Garage System Design

Course title: Software Engineering

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Contribution Breakdown

The workload was distributed equally to each team member.

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Customer Statement of Requirements

Finding a place to park has been an inevitable struggle since the creation and prominence of the modern car. Today, the parking industry generates over \$100 billion worldwide and that number is expected to only increase. Parking garages provide space efficiency in space-limited areas like cities. However, these garages still rely on outdated, simple ticketing systems. As technology continues to increase, a fully automated parking garage will become standard in the near future. Such a system will maximize space conservation and profits at the same time, and assure customer satisfaction. This will be achieved by encouraging customers to reserve parking spaces beforehand with a simple online registration or contract, but will cater to walk-in customers as well.

This automated system will be designed for a specific garage with unique pieces of hardware for each parking spot, and an elevator car lift. Hardware will include two license plate readers, one at the gate and another in the elevator, a sensor at each parking spot to detect whether a car is parked there, occupancy lights which show the occupancy state at each spot, and cameras for security. For the system to work flawlessly, the equipment will have to work with maximum accuracy; namely the license plate detector, car sensors, and the communication between these devices and the user interface. Otherwise the system accounts for many other errors made by customers or other, which must be taken into account in any real life situation.

A system can never fully account for the irregular nature of humans, like if a customer leaves immediately after entering. However, this system must do its best to maximize customer satisfaction and should account for that option, and many other common occurrences, on the interface. On the first screen the customer should be able to press "cancel" to leave. Another option to take into consideration would be when a customer does not go to their assigned parking spot. For a walk-in, this won't matter since they will be allowed to park anywhere, but if a car parks in a contracted or reserved customer's spot, the system will be notified by the car sensors and will then notify the garage keeper to resolve the situation. If the spot the customer takes does not interfere with another reservation, the system will take note of which spots are occupied by the sensors and will update accordingly. Customers can also be expected to take different cars to park in the same spot or share their parking spot with other people. In such cases when the license plate reader doesn't recognize the vehicle at the gate, customers will be prompted to register as a walk-in, or asked for the confirmation number they received at the time of registration. This system assumes most customers will be regular users, and so it prioritizes these customers, but will also cater to "walk-ins".

To register as a walk in, a customer will have to give their name and number and their profile will be automatically created. The license plate detector will record the license plate number and enter it into the user's profile. These users can choose how to pay when they are exiting the garage, whereas registered customers must pay in advance

online. The system will also be able to record statistics about the garage by recording how many customers come into the garage each day.

The online registration system has two operation modes: administration mode and user mode. The administration mode allows managers check current status of the parking lot through hourly statistical analysis graph or current map-view of the garage of which data is collected through sensors installed on each parking spot. The manager can also check the reservation status for up to one month in advance. This data is recorded in the reservation database. Payment management is also available on administration mode. A manager can check current charging rate for any parking spot and make changes. On the other end, user mode will allow users to log in for reservation, and let the user make reservation for up to one month. That means, for each parking spot on the map, the system shall hold up to one month reservation information. When first time users sign up, they need to provide relevant information such as name, home address, credit card number and plate number. The system categorizes users as either contracted users or registered users. A contracted user (usually daily comers) will be assigned a permanent spot by the system and get charged monthly at a fixed rate. These spots are reserved by the system and are not available for other customers. The registered users, who may not come as frequently, can log in on the website or phone application and choose a specific date and time they want to park. After that, the users will see the map view of the garage at the specified time they chose. The system allows them to select from available spots as those spots are marked green. Upon completion, the chosen spot will turn red on the map view. If the driver arrives and the reserved spot is still occupied, the system will assign another spot to the user immediately upon request via website or phone application.

Sensor accuracy is another problem the system shall resolve. New technology can already make sensors detect cars and ignore other objects. Installing a sensor on each spot may be costly and inefficient. The system shall resolve such problems by using case analysis and algorithm. When sensors on some spot detect objects, the system shall be able to recognize if it is a car or some other objects by analyzing reservation database and data collecting from plate readers at the entry/exit. (e.g. boxes unintentionally covering the sensor, or someone standing in front a vacant spot will be ignored by the reservation system) If the system finds something suspicious and cannot tell if it is a car or not, administrator will receive an announcement and shall check such cases.

To attract more users, our system also includes commercial functions which will offer users places of interests around the garage. When the user chooses to see “places of interest”, the system will provide options such as restaurants, gas stations, entertainment places and shopping centers. Users can click on and check information about those places such as address, phone number, descriptions and photos. If they are interested in any place nearby, the system will provide navigation service to these places via google map. This service should generate more business opportunities for the garage owner as they will be able to cooperate with other companies around them

and make profits.

Customers are given confirmation numbers to type in the keyboard on the gate to enter in case failing recognizing by our system, also customers' names are required to input. The confirmation number is given when the online reservation is finished. Customers are able to extend their current occupancy as long as it does not interfere with other reservations. The customers who overstay will be charged a fee to maintain the system policy. In the event a reserved spot is occupied by another customer mistakenly, the system will report to the garage service desk. Then the customer will be assigned to an empty spot.

Payment will be available through online payment methods. The system supports all popular payment system including all kinds of credit card, UnionPay, PayPal, Google Checkout, and Amazon Payment. Registered customers may maintain various payment methods on the system, however, they will select one method to complete the payment on the transaction page. The system will send request to process the payment once the reservation is confirmed but not charged till the customer left the garage. The reservation fee and violation fee will be charged through the payment system. Registered customers will be able to edit their payment methods and view their past transactions on the system webpage. System managers will be able to view but edit registered customers' profiles and payment methods. System managers may be assigned accessibility for refunding reservation fees and choose return methods.

To maximize security, there must be a system that can ensure that the customer receives his or her car back in the same condition. Not only will the system keep track of the customer's car's condition, it will also ensure that the manager will not be held liable for possible damages not incurred within the garage. To accomplish this, the cameras will take pictures of the car from all angles before it enters the garage and right as it's about to leave. With the recorded images stored in the database, the manager has a way of making sure the car that enters the garage is the same as when the car leaves the garage. He/she will be able to dispute or verify any claims from a customer who believes that their car was damaged within the parking garage. All data will be backed up daily and encrypted using disk encryption for security purpose. Only garage managers will have access to the database.

Regarding the garage owner as the client of this software, the system is designed to be compatible for different garage architectures and charging policies. Besides normal parking spots, the system reserves the garage keeper the option to have special spots for charging electric cars. For example, by the trend of environmental protection, some garage may have "eco-spot" that provides charging service for electric cars, and the system allows these spots to be priced differently from normal parking spots. For the purpose of reducing congestion and maximizing profit, the system allows the garage keeper to categorize coming customers into different roles with corresponding privilege and pricing policies. In order to encourage users to register in the system, only spots on the first floor are open for non-registered, or "walk-in" customers. Registration service is

provided online for registered users, allowing customer to pick a spot in a specific time period. The garage keeper can set a different charging rate for reservations of different time periods in order to encourage long-term, or contracted, parking which improves the average occupancy rate of the garage. Contracted service is provided for drivers who live or work nearby and require a stable parking place. By making a monthly contract, the customer will have a guaranteed parking spot at a discounted rate.

The new electric car is becoming a trend of the future. The plug-in electric vehicle industry will increase exponentially in the next few years, and New Jersey-Long Island is one of the most promising areas. However, there still exists some hindrances preventing the wide use of EV. For example, charging stations are few and far between, and sometimes the drivers even have to wait in line to charge their vehicles. To meet these potential customers' needs, there will be ten eco-charging spots on the second and the floors above. Each spot will be equipped with a supercharging system. Electrical car owners will have the incentive to pay more in order to have access to these spots. Some of them may live in an apartment and it is difficult to charge the cars at home, or some of them may live in a suburban area and drive to the city to work. They can leave their vehicle in the garage and be sure their car is charged by the time they leave work.

Furthermore, the eco-charge spots can be used as a substitute to normal spots in the case of overbooking. The walk-in customers will be given the choice whether to pay more money to park at the eco-charge spots when the first floor is full. The same goes for customers who want make a reservation when there are no normal spots. This strategy can earn more profits by attracting the EV owners and maximize the occupancy rates.

Chart 1.1 Annual Light Duty PEV Sales, Top Five MSAs, United States: 2012-2020



When it comes to a large garage, time efficiency maximization should include a type of “navigation system” specific to the garage. It will be used when customers are entering the parking lot. Along with the map view of the current floor where they are at, customers will get the suggested route to their spot from the mobile application. There will be little red flags set up at cross roads corners to mark the turn of the route and act

as small stop signs. It is truly customer's choice whether to follow the suggested route or not, but the system will get the statistical information from the daily traffic and make changes on the suggested route to make it more efficient.

There are three main goals that need to be accomplished for this project. The first is that a website should be created that can interact with the database and be accessed by both the customers and the garage keeper. The second is that there needs to be a mobile application which has two versions for customers and garage keepers respectively. The last but not least is that an algorithm has to be devised to maximize space within the parking garage through changing fees, suggested routes and the assignment of parking lots.

Glossary

Registered customer - a customer who made a reservation online, and can arrive at the garage and be recognized and allowed entry by the license plate reader. They pay when they leave - or they pay online

Contracted customer - a customer who parks in the same spot every day and pay by monthly bill. Their spots are guaranteed

Walk-in customer - A customer who just walked in and provided their customer information and park on first floor

Customer information - name, phone number, credit card information if applicable, (walk-ins can pay in cash)

Garage keeper - The manager or employee of the garage who will oversee certain duties which require human intervention

Occupancy state - There are two occupancy states; occupied meaning the sensor detects a car, and vacant, meaning the sensor does not occupy a car. These are denoted by the occupancy light.

Occupancy light - these are the lights on the floor of a parking spot. They show red for occupied and green for vacant

Car sensor – a piece of hardware at each parking spot in the garage capable of detecting, with sufficient accuracy, whether a car is parked in the spot or not and communicating this information to the rest of the system

License plate reader – a piece of hardware capable of reading a license plate and communicating the information seen to the rest of the system

Priority ratings (5,4,3,2,1) –

- 5: This is crucial for the system to work
- 4: This is important for the system to work best
- 3: This is important to maximize profit, customer service, or efficiency of the system
- 2: This is optional, but may provide some sort of benefit to the customer or the company
- 1: This is could be removed from the system with no considerable repercussions]

Eco-Charging spot – a place where a customer can park and also charge their electric car for a higher fee which covers the cost of energy used and allows for profit

Normal spot – a place with all the normal hardware mentioned above except an electric car charge

System Requirements

| Identity | Priority | Non-Functional Requirements |
|----------|----------|---|
| REQ-1 | 3 | The first page of the website of the system will ask a user to either log in or sign up, or cancel (Guan) |
| REQ-2 | 5 | To sign up a user must provide their name, phone number, license plate, and credit card information (Guan) |
| REQ-3 | 3 | Once the user has signed up or logged in, they will be able to enter a date and time to reserve a spot(Guan) |
| REQ-4 | 5 | The user will be able to reserve a spot once they see that it is available and will receive a confirmation number(Guan)(Zhiheng) |
| REQ-5 | 2 | The customer will be able to modify their existing reservations up until the starting time of their reservation as long as it does not interfere with another reservation (Zhiheng) |
| REQ-6 | 5 | When a walk in customer approaches the garage they will be asked for their name and phone number (nettie) |
| REQ-7 | 4 | A user can choose to be a contracted customer or reserve a spot one time(Guan)(Shen) |
| REQ-8 | 3 | A walk in will park on the first floor (Shen) |
| REQ-9 | 2 | A user will be able to choose a vacant spot from the map (Guan) |
| REQ-10 | 3 | A person who is contracted or has reserved a spot will be allowed to use another car in their spot or allow another person to park in their spot via confirmation number (nettie) |
| REQ-11 | 5 | A customer who overstays their reservation by more than a half hour will be billed for extra time at a higher rate (Shen) |
| REQ-12 | 5 | A customer who has reserved a spot but there is another car in their spot will be given another vacant spot(Guan)(Zhiheng) |
| REQ-13 | 4 | If there are no vacant spots a person will be allowed to park in the eco-charging spot for regular fee (Shen)(Yunhao) |
| REQ-14 | 5 | there will be 10 eco-charging spots available for an extra fee for electric car owners, or in the case of overbooking (Shen)(Yunhao) |
| REQ-15 | 2 | A contracted customers spot will never be used by anyone else. Their spot's detection light will always show red to prevent people parking there(Guan) |
| REQ-16 | 3 | Customers will be able to view their past transactions (Zhiheng) |
| REQ-17 | 1 | The garage keeper will be able to view but not edit the profiles of registered customers (Guan) |

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| REQ-18 | 1 | A walk in will be registered after their first visit and will be able to be recognized by the license plate detector the next time they come in (nettie) |
| REQ-19 | 4 | If the first floor is full, a walk-in will be offered to park in an eco-charging spot with a higher rate (Shen)(Yunhao) |

| Identity | Priority | Functional Requirements |
|----------|----------|--|
| REQ-20 | 5 | The system will maintain a database of customers information, the occupational state of each parking lot, current reservations, and various statistics about the garage usage(Guan) |
| REQ-21 | 1 | The system shall record the traffic of cars coming in hourly (nettie) |
| REQ-22 | 4 | The system will allow users to choose a vacant spot from a map that represents spaces on the garage's floor(Guan) |
| REQ-23 | 3 | The system will detect which spot is occupied by the sensors and will update the occupancy state based on this information(Guan) (nettie) |
| REQ-24 | 5 | The system will be able to read and recognize license plates with the license plate detectors (nettie) |
| REQ-25 | 5 | If the license plate detectors do not recognize the plate number, the customer will be asked to choose between registering as a walk-in or to give a confirmation number (nettie) |
| REQ-26 | 3 | If a registered customer parks in a contracted customers spot, the garage keeper will be notified immediately and will be able to make the customer move their car before they leave. (nettie) |
| REQ-27 | 2 | If a registered customer parks in a different spot than they registered for, the system will update which spots are taken by the sensors (nettie) |
| REQ-28 | 1 | The system will allow the garage keeper to set different prices for different services (Shen) |
| REQ-29 | 4 | The system will consist of a customer interface and garage keeper interface(Guan) |
| REQ-30 | 3 | The website will have a map view of garage and display the occupancy state of each spot(Guan) |
| REQ-31 | 2 | The sensors will be able to differentiate something standing in the way of a parking spot and a real car(Guan) |
| REQ-32 | 5 | The system will maintain payments made by a customer (nettie) |
| REQ-33 | 3 | The system will keep track of transaction history for a customer and link this with the customer's profile. (Zhiheng) |
| REQ-34 | 2 | The system will provide nearby places of interest near the garage to attract more users(Guan) |

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| REQ-35 | 3 | All information gathered by the system will be backed up daily and encrypted using disk encryption (Zhiheng) |
| REQ-36 | 1 | The system will be incorporated for one parking garage, but can be altered for use at different parking garages with different architecture (Shen) |
| REQ-37 | 3 | If a customer's reserving spot is occupying by another car, the system allows customer to report the car(Shen) |
| REQ-38 | 3 | The system is able to calculate to get the best route of customer's choice to get to their assigned spot when they travel from entrance to the spot and from spot to exit.(luke) |
| REQ-39 | 5 | A hosting machine with a console interface is presented in front of the garage entrance to allow system interacting with customer (Shen) |

| <u>Identity</u> | <u>Priority</u> | <u>On-Screen Appearance Requirements</u> |
|-----------------|-----------------|---|
| REQ-40 | 4 | In order to make an account online, the user needs to have a device that has internet access to use the site or app. When making the account, the user must be able to input registration information, such as last name, first name, date of birth, phone number, etc. (Guan) |
| REQ-41 | 4 | To log into an account, the user must be able to provide his or her account ID and password (Guan) |
| REQ-42 | 4 | To edit or delete an account, the user must be able to log into his or her account. There the user will be given the option to delete or edit the account. If the user selects to delete the account, a message will appear asking if they are sure about deleting it with "yes" and "no" buttons. If the user select "yes", the message will disappear and he or she will be directed back to the home page.If the user selects "no", the message will disappear and he or she will remain in the account page. If the user selects to edit the account, the text will turn into fields that will allow them to edit any of their information. (Zhiheng) |
| REQ-43 | 3 | If the user wishes to make a reservation online, he or she will be asked how long he or she wishes to reserve for. If the user does not have an account, then he or she will be required to input information, such as last name, first name, date of birth, phone number etc. If the user does have an account, then the personal information fields on the reservation page will be auto-filled. When reservation is completed, the user will be asked for credit/debit card information to pay for the |

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| | | reservation.After the transaction has completed, the user will be given a confirmation number. (Guan) |
| REQ-44 | 5 | To cancel or modify a reservation, the user will be asked for his or her confirmation number. The user will then be given the option to cancel their reservation or to modify any information on his or her reservation page. If the user selects to cancel the reservation, a message will appear asking if the user is sure about cancelling it with “yes” or “no” buttons.If the user chooses “yes” the message will disappear and he or she will be directed back to the home page.If the user chooses “no”, the message will disappear and he or she will remain on the reservation page. If the user selects to modify the reservation, the text on the page will turn into fields that will allow them to modify any of the information. (Guan) |
| REQ-45 | 5 | If the customer wishes to access the valet account, he or she must be able to provide the account ID and password.On the account page, the first thing the customer will see is the map of the garage . On the map the customer will be able to highlight the spots and times that are occupied or vacant.(Guan) |
| REQ-46 | 5 | If the customer wishes to see the customer account/reservation information, he or she will have to select that button or link on the home page. After selecting it, he or she will be directed to another page that will ask for the customer’s reservation confirmation number. If the customer does not have the confirmation number, then the customer will have the option to input the customer’s personal information, such as his or her name, date of birth, etc. (Zhiheng) |
| REQ-47 | 5 | When the customer log in the mobile application after reservation, they will see a road map with the suggested route mark on it. (luke) |
| REQ-48 | 5 | The login page will present the user with login icons representing services they can use to login such as Google+, Facebook, and so on. (Zhiheng) |
| REQ-49 | 3 | Login page has a option of creating account for the people who use the system first time. Another page will come up to ask users input identification information including: customer’s name, license plate, vehicle’s color, make, and model.(Zhiheng) |
| REQ-50 | 3 | After selecting parking spot, a confirmation message appears for completing reservation, or turn to another page if the user has not finish payment method to ask user have a valid |

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| | | payment method.(Zhiheng) |
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Functional Requirements Specification

Stakeholders:

- Parking Garage owners – the primary stakeholders of this system as it will be used to maximize occupancy and profits for the owners
- Parking Enterprises – with the projected success of this project, other companies in the industry will be interested in the system as well
- Customers – this system aims to maximize not only profits, but consistency and customer satisfaction
- Database managers – the database of this system will need to be continually maintained and so will require a database manager who will need to rely on the performance of the system

Actors and Goals:

| <u>Actor</u> | <u>Goal</u> |
|----------------------|---|
| Garage Keeper | The employee of the garage who makes business decisions from statistical data like pricing, checks current and future status of each parking spot, and intervenes with customers in specific use cases when human interaction is necessary. |
| Manager Interface | Display the real-time information and future reservations of the garage. It also allows manager to view customer personal information, statistical data of the garage, and change price rate. |
| User Interface | Display the real-time information and future reservations of the garage. It also allows users register at the first time, make/change reservations, view their past transactions, and update/input their information. |
| Console Interface | Provides interactions between incoming users and the system, allows system to request confirmation number and display parking spot information as well as user entering confirmation number |
| Customer | The person who uses the user interface with the intent of parking and gives their information and payments while doing so |
| License-Plate Reader | Read plate information for each incoming vehicle and send the information to the system, if unrecognizable, send error or empty information. |
| Cameras | Take pictures of car to mark the enter/exit conditions of the car. |

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| Vacancy Display | Displays to customers if there are vacant spots within the garage. |
| Database | Stores data such as customer information, transaction history, and statistics such as number of cars entering and exiting the garage. Should also store the parking schedule of each parking spot for up to one month. |
| Sensor | Sense cars on the spot. send signal to system when state changes. |

Use Cases:

Casual Descriptions

UC1: Registration- The first time a customer enters the garage or opens the website or mobile app, they will be required to create an account for making a reservation online. The customer can create an account through user interface (website or mobile application) by giving certain information required in this process. (Yunhao)

UC2: Reservation: allows a driver to select a spot for a given period of time if there is a vacancy. System also allows users to cancel reservation before time or extend reservation if applied. (Guan)

UC3-Penalty: System can detect and cancel reservations or charge fines to late arrivers/no-show customers. (Guan)

UC4: Entering- when a car comes to the garage, the system identifies the role of coming user and provides entrance correspondingly (Shen)

UC5: Park - when a driver's car is already inside the garage and is directed to their spot (Luke)

UC6: Reporting - when a customer's reserving spot is occupied or unable to be parked due to another user, the customer is allowed to report another user to the system (Shen)

UC7: Reassigning: when a car arrives and his reserved spot is still occupied, system will assign a spot to the driver immediately. (Guan)

UC8: Overstay - implements the policies on drivers who have reserved and overstayed. (Zhiheng)

UC9: Exit - to retrieve the car and leave the garage (Luke)

UC10: Payment management - allows customers to make payments through multiple methods. (Zhiheng)

UC11: Check statistics - Allowing the garage keeper to obtain statistics of the number of people parked in a day, the amount of time they stayed, and relevant data. (Yunhao)

UC12: Sensor accuracy - Sensors must be able to recognize cars from other objects. (Guan)

Full-Dressed Descriptions

| | |
|--|------------------|
| Use Case UC-1: | Register(Yunhao) |
| <p>Related Requirements: REQ-1, REQ-2, REQ-3, REQ-19, REQ-21, REQ-36, REQ-38, REQ-47</p> <p>Initiating Actor: Customer Actor's Goal: To create an account that will be stored in the database allowing for reservation for the parking lot.</p> <p>Participating Actors: User Interface, Database</p> <p>Preconditions: The system will request all the required information needed from the custome.</p> <p>Postconditions: The customer's account will be stored in the database and backed up once a day.</p> <p>Flow of events for Main Success Scenario: →1. Customer accesses the user interface and choose the "Register" option ←2. The system returns the display that states the required information. →3. The customer fills out the required data fields. ←4. The system takes the information to verify it. If not valid, move back to 3 If valid,continue ←5. Information is stored into the database.</p> | |

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| Use Case UC-2: | Online Reservation(Guan) |
| <p>Related Requirements: REQ-4,REQ-8,REQ-10, REQ-21, REQ-23, REQ-31</p> <p>Initiating Actor: Registered Customer Actor's Goal: To select and reserve a spot in the parking garage</p> <p>Participating Actors: User interface, Database</p> | |

Preconditions: The user should be logged into his account. The system will prompt a map of the garage and let the user select available spot.

Post-conditions: The system will put requested parking time into database and send confirmation message to the user.

Flow of events for Main Success Scenario:

- >1. User enters time that he wants to reserve.
- <-2. System gets availability of each spots of such time, if no such spot available , move to 4
- <-3. System forms and displays map view of the garage of such time. Move to 5
- <-4 System display spots that mostly fulfills user's need
- >5. User chooses available spot(shown as green) from the map
- <- 6. System store information to database and send confirmation to user
- >7. User request for reservation extension
- 8 <- System check availability of the spot. If it satisfy user's need, move to 6.If not, move to 4.
- 9-> user ask for cancellation
- 10<- System check request time,if it is more than 20 minutes before scheduled time,move to 6
- If not, System send reject message to User.

Use Case UC-4: Enter Garage(Shen)

Related Requirements: REQ-7 REQ-8 REQ-9 REQ-25 REQ-26

Initiating Actor: Customer

Actor's Goal: to initialize the parking process of the system and get access to the garage

Participating Actors: License-Plate Reader, Camera, Database, Console interface

Preconditions: The garage is not fully occupied

Post-conditions: The entrance for customer is provided, and navigation will be provided to registered user

Flow of events for Main Success Scenario:

- >1.a driver coming to the garage and initiates the system
- if Plate reader successfully read the license, go to 2
- if Plate reader cannot read the license, go to 4
- >2.Plate Reader successfully read the license information and send to system
- <-3.system compare the license with database,system identify the role of user
- if plate information is not found, go to 4
- if plate information is found, go to 7
- >4.system request user for confirmation number

if user provides confirmation number, go to 5
 if user does not provide confirmation number, go to 6
 ->5.system validate the confirmation number by searching database
 if confirmation number validated, go to 8
 if confirmation number not validated, go (back) to 4
 *if the user inputs an invalid confirmation number for too many times(e.g. 3 times), system stop requesting conf.# and directly treat user as walk-in customer.
 ->6.system provides entrance to the first floor
 go to 11
 ->7.system search for reserve/contract information from database
 if reserve/contract information found go to 8
 if reserve/contract information not found go to 9
 ->8. system check the availability for reserved parking spot
 if available, go to 10
 if not available, go to 9
 ->9. system generates parking spot for user
 if user had a reservation, the parking period equals time of reservation
 if user had no reservation, the parking period is set by default (e.g.3 hours)
 <-10. system provide entrance to corresponding floor
 ->11. Process terminated

Use Case UC-5:

Park(luke)

Related Requirements: REQ-21 REQ-23 REQ-27 REQ-30 REQ-38 REQ-46

Initiating Actor: Customer

Actor's Goal: To park the customer's car in the garage

Participating Actors: Database, user interface, sensor

Preconditions: The user has a reservation created and the assigned spot is available.

Post-conditions: The car will be parked in the garage.

Flow of events for Main Success Scenario:

->1. The Customer drives to the floor of the assigned spot using an elevator.
 ->2. The Customer requesting the suggested route to get to the spot by touching the corresponding button on the user interface
 <-3. System provides the suggested route(map view through mobile device) for the user to get to the spot

- >6. User follows the route and park the car.
- >7. User confirms that the car is parked at the right spot by stroking the corresponding button of the user interface.
- >8. System request the current status of the spot from the sensor
- <-9. Sensor detects the occupancy of the spot and feedback to the system
- <-10. System gives user feedback of the spot confirmation
- >10. System asks the database for updating
- <-11. Database confirms update

Use Case UC-8:

Overstay(Zhiheng)

Related Requirements: REQ-5, REQ-12, REQ-13, REQ-14, REQ-15, REQ-24

Initiating Actor: System

Actor's Goal: To follow the policies on overstays

Participating Actors: System, manager, database

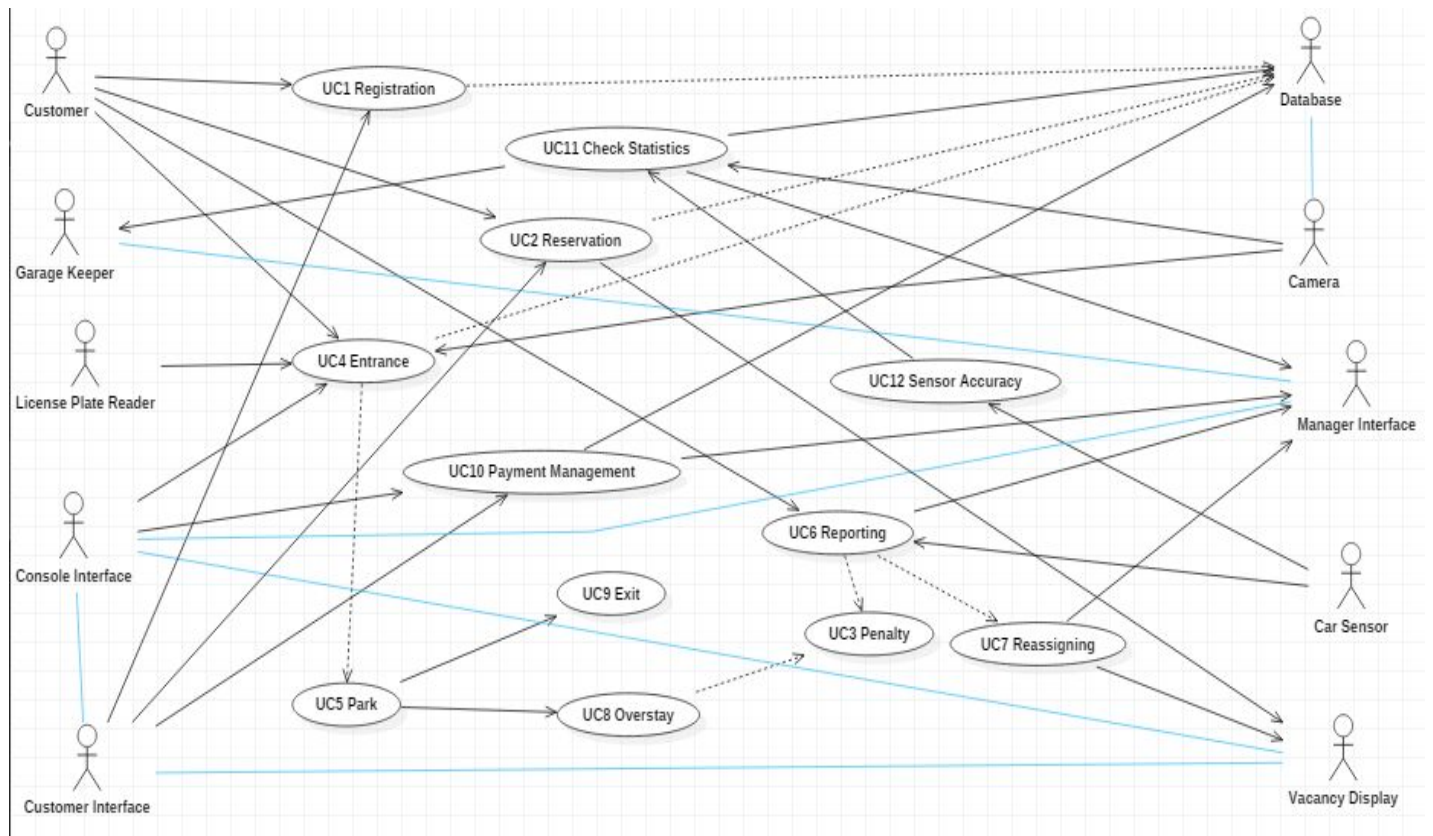
Preconditions: The customer has not left after time is over.

Post-conditions: The car will be charged fee.

Flow of events for Main Success Scenario:

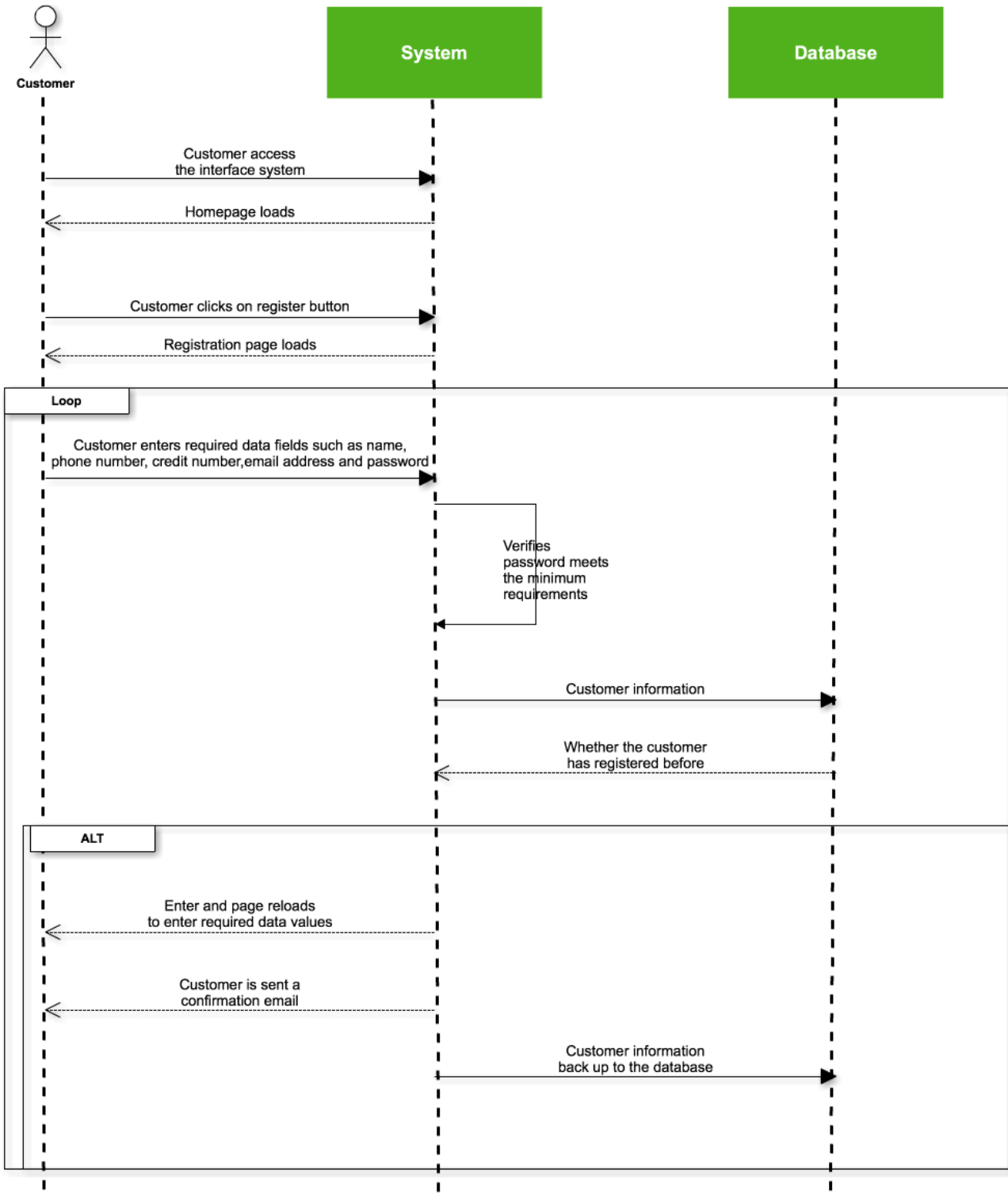
- > 1. System sends notify to customers before time's up through text
- <- 2. System updates database immediately
- > 3. System blocks the spot for reservation
- <- 4. System notifies the customer about overstay and charging started
- > 5. Charging fee is processed through the payment method the customer made for the reservation
- <- 6. Coming customers report the occupy of the spot
- > 7. A confirmation number and spot number is given to the coming customers who have reservations on schedule
- <- 8. System updates database with new customer's confirmation number and spot number
- > 9. Overstaying customer leaves the spot, then spot detector notifies the system
- <- 10. System updates and reopen the spot reservation once the customer left
- > 11. Final charging fee request is sent to the system

Use Case Diagram (Nettie):

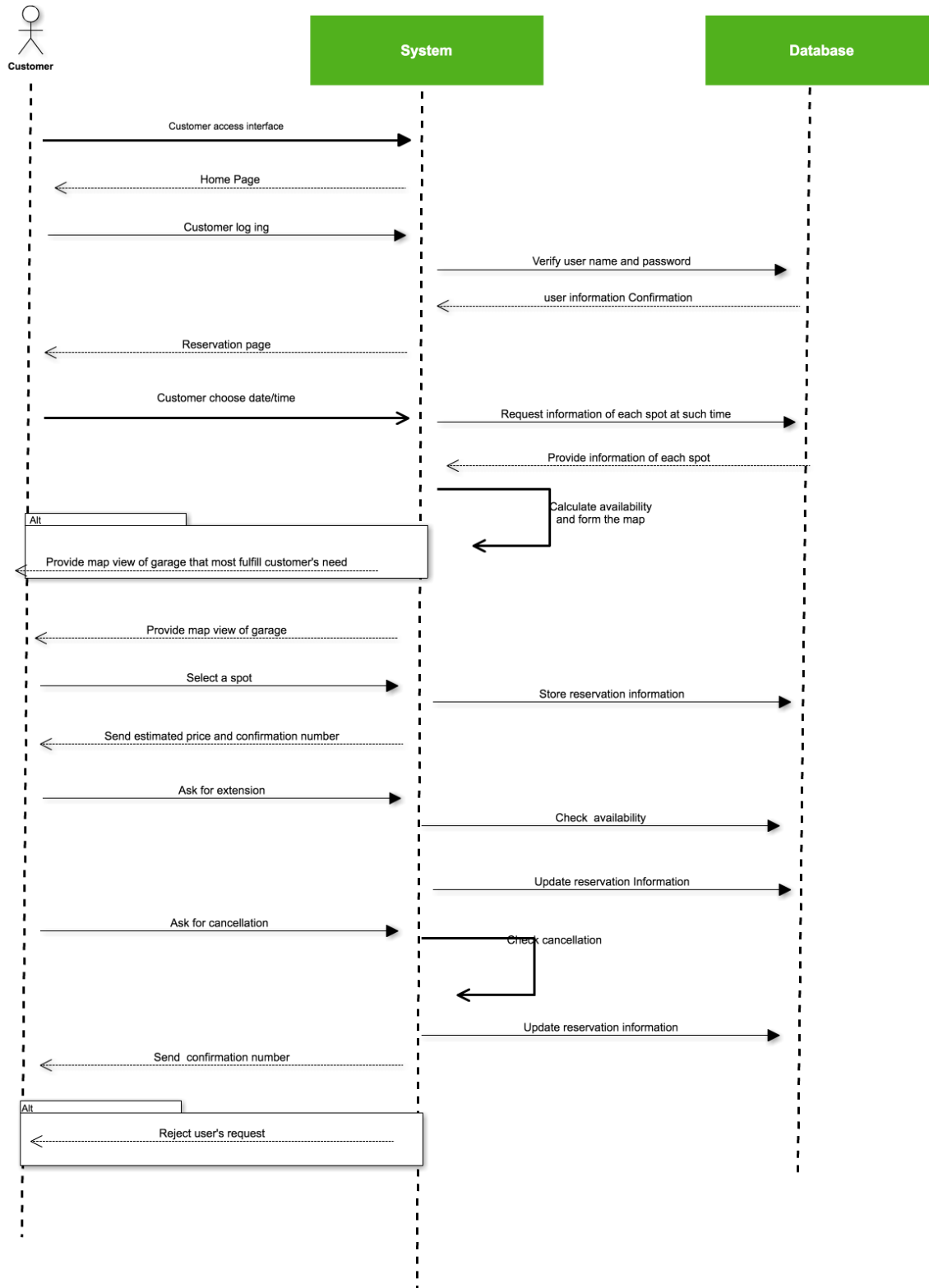


System Sequence Diagram:

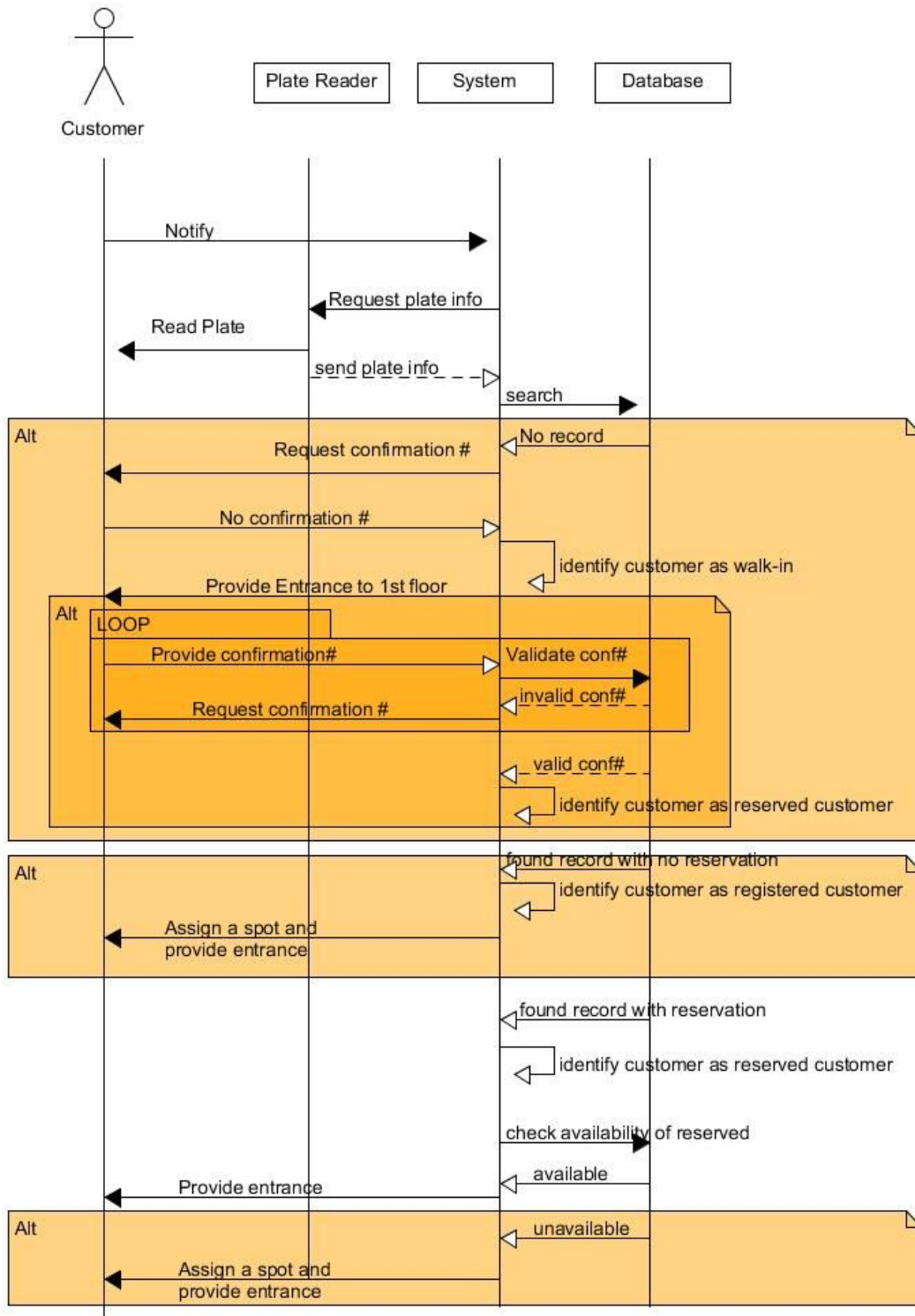
Use Case UC-1: Register(Yunhao)



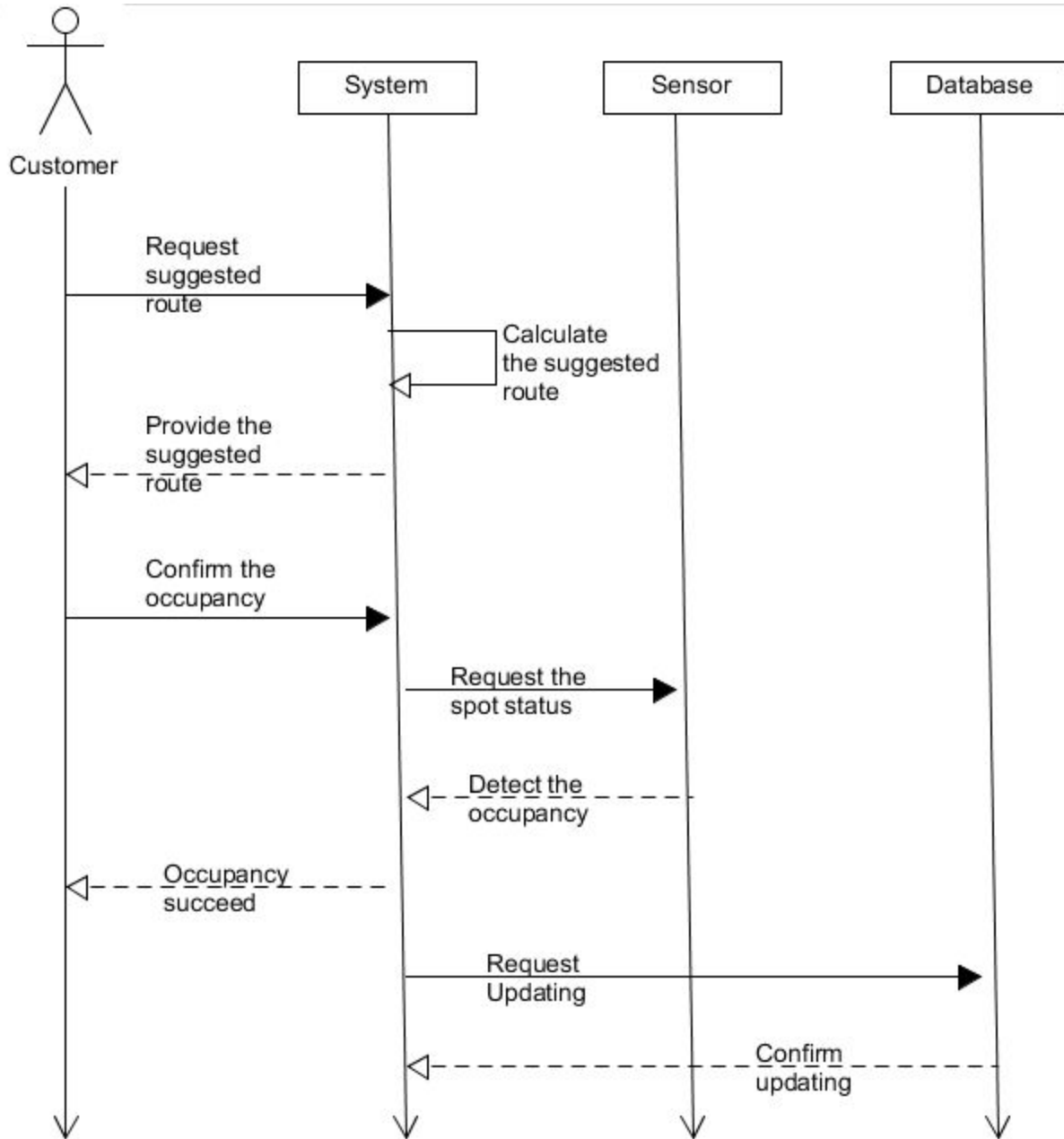
Use Case UC-2: Online Reservation(Guan)



Use Case UC-3: Enter Garage (Shen)



Use Case UC-4: Park(Luke)



User Interface Specification:

(Screen 1-Yunhao) This is the first screen that the customer will see. It will display “Welcome” and prompt for email and password. If the user doesn’t have an account yet, it will take them to screen 2. If the user successfully logs in, it will proceed to screen 3.

The screenshot shows a login interface titled "WELCOME". Below the title, it says "LOG IN!". There are two input fields: "Email:" and "Password:". To the right of the "Password:" field is a link "Forget Password?". Below the "Password:" field is a "Login" button. At the bottom right, it says "New Customer? [Register Here](#)".

(Screen 2-Yunhao) This is the registration screen which asks for basic information including name, Email, setting password, phone number and credit card number. If a user clicks the button register, the information will be stored in database and it will bring the user back to screen 1. If the user clicks the button cancel, the information is void and it will bring the user

The screenshot shows a registration interface titled "Registration". It contains several input fields: "First Name:", "Last Name:", "Email:", "Password:", "Re-Enter Password:", and "Phone number:". Below these fields is a section titled "Credit or Debit Cards" with a sub-header "Add a card". This section includes labels "Name on card", "Card Number", and "Expiration date", each followed by an input field. At the bottom right, there are two buttons: "Register" and "Cancel".

back to screen 1, too.

(Screen 3 Guan) This is the screen displayed after logging in or signing up, it will display “please enter arrival time” and “ please enter leave time”. After the confirmation of this time selection, it will proceed to screen 4.

Please enter arrive time : day hour: minute

:

Please enter leave time : day hour :minute

:

(Screen 4 Guan) This is the screen for choosing the spot at the given period of time and it will display map-view of the garage and let user choose from available spots. After choosing the spot and confirming, it will go to screen 5. If no spot is available at this period, screen will proceed to 6

Please choose a spot from green ones:

Grid of spots (blue and red squares):

| | | | |
|--------------------------|--------------------------|-------------------------------------|-------------------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |

(Screen 5 Guan) This screen will display “you have reserved a spot”, give the confirmation number and estimated cost. When the user gets to the entrance of the garage, they can request suggested route and this page will proceed to screen 11. If the user wants to cancel the reservation, he can click “cancellation” and the screen proceeds to 6. If the user want to extend his reservation, screen page proceeds to 9

Your confirmation number is:
Your parking spot number is:
Your estimated cost is:

Suggested Route

Log out

Cancellation

Extension

Report Overstay

(Screen 6 Guan)

If user chooses “display the next available period”, screen will get available spots and proceed to 6; If user chooses “Enter another time” screen will proceed to 3.

Sorry, no spot is available at the time period you choose.

Display the next available period

Enter another time

Log out

(Screen 7 Guan)

If the user cancel the reservation ahead of time, he will see the following the screen. If not, screen proceeds to 8

You have successfully cancelled your reservation.
Your confirmation number is:

Log out

Screen 8 Guan

Sorry, you cannot cancel your reservation at this time.

Log out

Screen 10 Guan The user can type in the amount of time he wants to extend

Enter the amount of time you want to extend:_____

Your confirmation number is:

Your parking spot number is:

Your estimated cost is:

Suggested Route

Extension

Log out

Report Overstay

Screen 10 Guan If such extension is allowed, the screen shows as below

You have successfully extend your reservation

Your confirmation number is:

Your parking spot number is:

Your estimated cost is:

Suggested Route

Cancellation

Log out

Report Overstay

Screen 11 Guan If such extension is not allowed, he will see the following screen.

Sorry, such extension is not allowed because other customer has booked the spot.

Your confirmation number is:
Your parking spot number is:
Your estimated cost is:

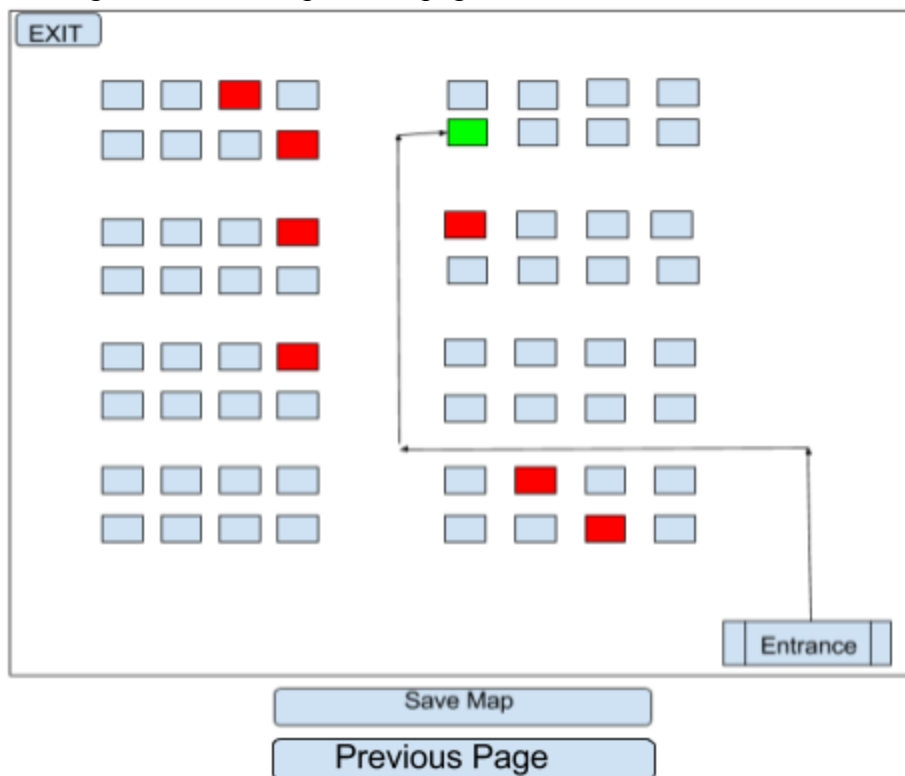
Suggested Route

Log out

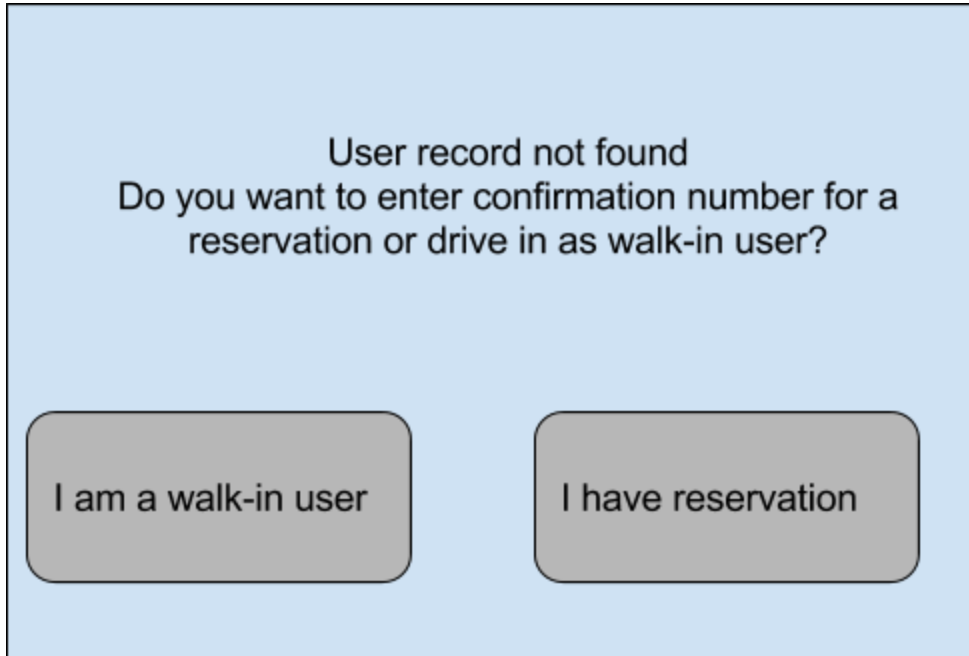
Cancellation

Report Overstay

(Screen 12- Luke) This is the screen for suggested route that user can request. User can download the image beforehand. And user can go back to the confirmation page(screen 5) by clicking on the button “previous page”



(Console interface-Shen-screen 1)The console interface is presented in the host machine in front of the garage entrance for incoming customers' interaction with the controller entering_unrecognized_plate/walk-in, and if the user choose reservation button, it will go to page 2:



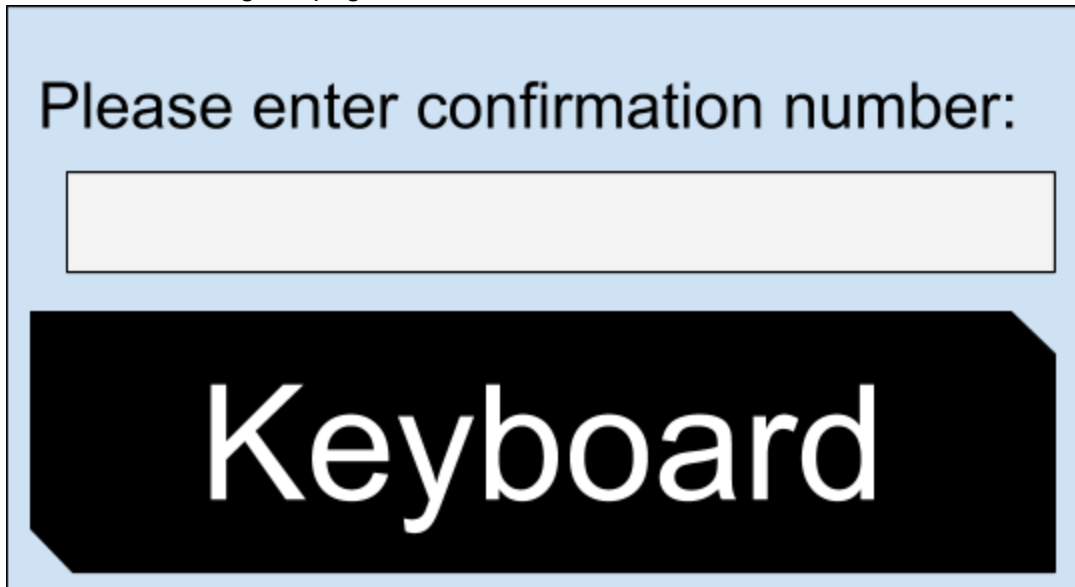
User record not found
Do you want to enter confirmation number for a reservation or drive in as walk-in user?

I am a walk-in user

I have reservation

This screen has a light blue background. It contains a title 'User record not found' and a question 'Do you want to enter confirmation number for a reservation or drive in as walk-in user?'. Below the question are two grey buttons with rounded corners. The left button is labeled 'I am a walk-in user' and the right button is labeled 'I have reservation'.

(page 2)entering_input_conf#, if the confirmation number input is invalid, it will go to page 3;otherwise, it will go to page 5:



Please enter confirmation number:

Keyboard

This screen has a light blue background. It contains the text 'Please enter confirmation number:' followed by a white rectangular input field. Below the input field is a large black rectangle with the word 'Keyboard' written in white.

(page 3)entering_conf##_invalid:

A screenshot of a user interface with a light blue background. At the top, the text "Sorry, the number is invalid" is displayed in red. Below it, a question is asked in black text: "Do you want to enter confirmation number for a reservation or drive in as walk-in user?". At the bottom, there are two grey buttons with rounded corners. The left button contains the text "I am a walk-in user" and the right button contains the text "I have reservation".

Sorry, the number is invalid

Do you want to enter confirmation number for a reservation or drive in as walk-in user?

I am a walk-in user

I have reservation

(page 5)entering_registered_non_reserve, if the spot is being occupied, it will go to page 6:

A screenshot of a user interface with a light blue background. It displays the text "Your parking spot number is" followed by "#2341" in a large, bold font. Below this, it says "Please use the elevate to arrive the 2nd floor".

Your parking spot number is

#2341

Please use the elevate to arrive the 2nd floor

(page 6)entering_registered_reserve_unavailable(reassign):

Sorry, your reserved parking spot
is currently unavailable.

Your parking spot number is
#3421

Please use the elevator to arrive the 3rd floor

Manager Interface Specification (Zhiheng):

Managing Garage Open Time

Start Date:

End Date:

Start Time:

End Time:

Or select

☐ Every day

Or select

☐ 24 hours

Spots Managing

Green is open

Red is closed

| | |
|---|--|
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">1</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">10</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">2</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">11</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">3</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">12</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">4</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">13</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">5</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">14</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">6</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">15</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">7</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">16</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">8</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">17</div> |
| <div style="width: 20px; height: 15px; background-color: green; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">9</div> | <div style="width: 20px; height: 15px; background-color: red; border: 1px solid black; display: flex; align-items: center; justify-content: center; margin: 2px;">18</div> |

Figure 1.1 and 1.2 shows first two pages after manager logged in. Manager sets the garage available time and spots by clicking on the spaces.

Figure 1.3 shows a form when the manager is logged in. The form is utilized to enter data which

the manager has recorded to improve profits.

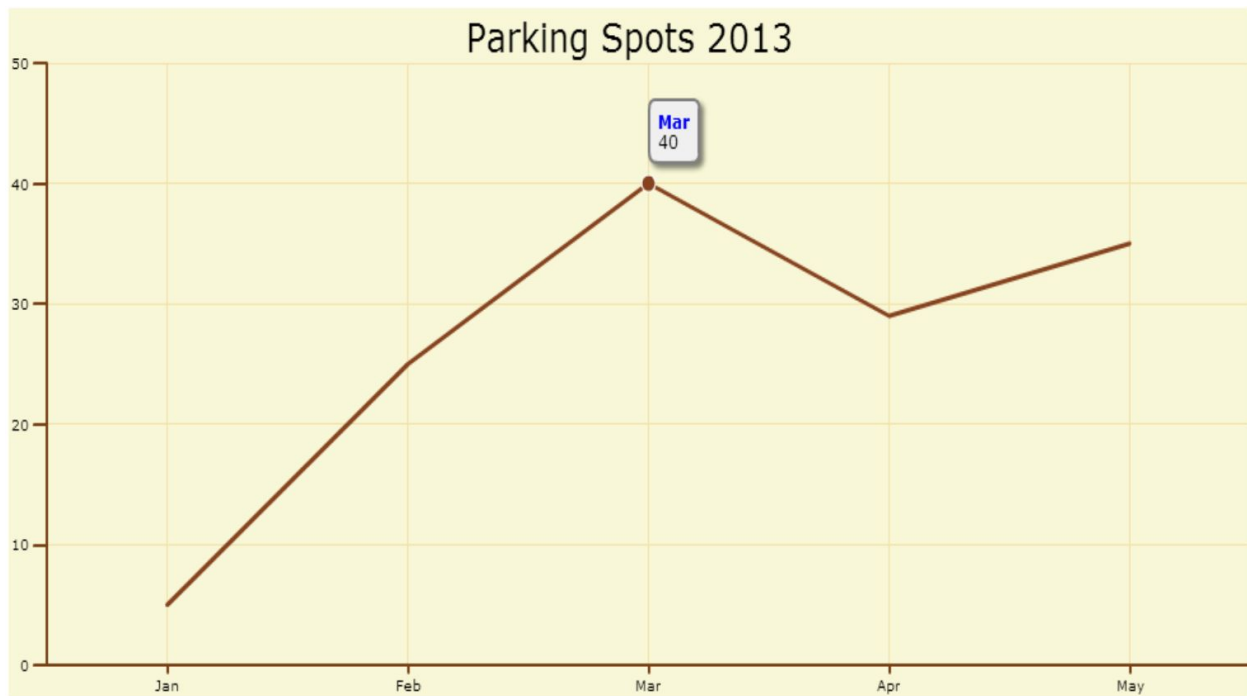


Figure 1.3 shows a graph which the manager may utilize to increase profits at the parking garage.

Traceability Matrix (Nettie):

[illegible]

Effort Estimation for Use Case Points

Login on the website needs an average of 15-20 keystrokes for email; an average 8 keystrokes for password; and if the user does not have an account at the time and is creating one, an additional click for them to get to the registration page.

Registering an account on the website keeps the amount of clicking to a minimum. It's an average of 15-20 keyboard strokes for the first and last name; about 16 for creating a password and confirming it, 10 strokes for the phone number; average of 15-20 strokes for email address; 16-20 strokes for the credit card number, 4-5 strokes for the expiration date, 4 for the security code; and one click to confirm.

Once the person is logged in they will have to enter the time they wish to reserve a spot for and this will take about one click, 9 strokes to enter the date, and another 12-16 strokes to enter the times. The person will then see a map display at the times entered, and will have to click a vacant spot, click through different floors of the garage, and then click confirm.

The manager can access the database to find out logistics and trends with minimum amount of strokes by first clicking once to select the administrator option; then an average of 10-30 keystrokes depending on the login information; 1 click to select data type, then depending on what the manager selects, the amount of strokes differ as follows:

- Manage Prices (1 click to select either “Adjust/ Hour rates”, “Adjust Possible Deals”, or 1-2 clicks to select other options; 4-8 strokes to enter/adjust prices.) and 1 click to confirm
- Manage Employee Information (1 click to select type of Employee; 1 click to select the Employee, 1 click to select “Employee Data” or “Manage Pay”. If Employee Data, 1 or 2 clicks to browse data. If Manage Pay, 5-6 strokes to enter pay amount and 1 click to confirm.)
- Check Statistics (1 click to choose what type of trends to observe; 1-2 clicks to analyze the statistics in the database; 1 stroke to exit the option)
- After the manager is complete with their action, it takes 1 stroke to log out.

Key-Stroke Level Model*

The following was calculated using the following values:

| | | |
|-----------|------|-----|
| Keystroke | 0.28 | sec |
| Button | 0.1 | sec |
| Point | .8 | sec |
| Home | 0.4 | sec |
| Mental | 1.2 | sec |

| Identity | Screen | KLM code | Total Time |
|----------|-----------------------------------|---|------------|
| K1 | Home Page | p kkkkkkkkkkkkkkk k kkkkkkkk p b | 8.70s |
| K2 | Register Page | p kkkkkkkkkkkkkkk k m kkkkkkkk k kkkkkkkk k kkkkkkkkkk k kkkkkkkkkkkkkkkkk k kkkkkkkkkkkkkkkk k kkk k kk k kkkk p b | 28.66s |
| K3 | Date/Time | m p kkkkkkkkk kkkkkkkkkkkkkkkkk p b | 10.46s |
| K4 | Map Page | m b b m b b b | 2.90s |
| K5 | Welcome Screen | M b | 1.90s |
| K6 | Confirmation Number Screen | mm kkkkkkkk | 4.64s |
| K7 | Walk-in Registration Screen | mm b p kkkkkkkkk kkkkkkkk kkkkkkkk p b | 11.76s |

Technical Complexity

| Factor | Description | Weight (W) | Rated Value (RV) | Calculate d impact (=W *RV) |
|--------|---------------------|---------------|------------------------|-----------------------------------|
| T1 | Distributed System | 2.0 | 5 | 10 |
| T2 | Response Time | 2.0 | 3 | 6 |
| T3 | End User Efficiency | 1.0 | 4 | 4 |
| T4 | Internal Processing | 2.0 | 3 | 6 |
| T5 | Reusable Code | 0.5 | 2 | 1 |
| T6 | Ease of Use | 1.0 | 4 | 4 |
| T7 | Easy to update | 0.5 | 2 | 1 |
| T8 | Database Security | 2.0 | 5 | 10 |
| T9 | Concurrent Use | 2.0 | 5 | 10 |

$$TF = 52, TCF = .6 + TF/100 = 1.12$$

UUCW (Unadjusted Use Case Weight)

| Use Case | Description | Category | Weight |
|--------------------------|--|----------|--------|
| Register (UC-1) | Average User Interface. 5 steps for main success scenario. 2 participating actors (System, Database) | Average | 10 |
| Online Reservation(UC-2) | Complex User Interface. 10 steps for main success scenario. 2 participating actors (System, Database) | Complex | 15 |
| Enter Garage(UC-3) | Complex. 8 steps for main success scenarios 4 participating actors | Complex | 15 |
| Park(UC-4) | Simple. 11 steps for main success scenario. 3 participating actors. (Database, user interface, sensor) | Average | 10 |
| Overstay(UC-5) | Average. 11 steps for main success scenario 3 participating actors (System, manager, database) | Average | 10 |
| Exit (UC-6) | Average 4 steps for main success scenario | | |
| Reassign(UC-7) | Average 4 steps for main success scenario 3 participating actors. (System, sensor, database) | Average | 10 |
| Reporting (UC-8) | Average 4 steps for main success scenario 3 participating actors. (System, sensor, database) | Average | 10 |
| Penalty (UC-9) | Average 5 steps for main success scenario | Average | 10 |

| | | | |
|--|---|--|--|
| | 3 participating actors. (System, sensor, database) | | |
|--|---|--|--|

Unadjusted Actor Weight

| Actor Classification | Type of Actor | Weight |
|----------------------|----------------------|--------|
| Complex | Garage Keeper | 3 |
| Complex | Manager Interface | 3 |
| Complex | User Interface | 3 |
| Complex | Customer | 3 |
| Average | Console Interface | 2 |
| Simple | Cameras | 1 |
| Average | Vacancy Display | 2 |
| Simple | License Plate Reader | 1 |
| Average | Database | 2 |
| Simple | Sensor | 1 |

$$UAW = 4*3 + 3*2 + 3*1 = 21$$

Environmental Factors

| Factor | Description | Weight |
|--------|-------------------------------------|--------|
| E1 | Familiarity with project model used | 3 |
| E2 | Application Experience | 1 |
| E3 | Object Oriented Experience | 4 |
| E4 | Lead analyst capability | 3 |
| E5 | Motivation | 5 |
| E6 | Stability of Requirements | 5 |

| | | |
|----|--------------------------------|---|
| E7 | Part Time Staff | 0 |
| E8 | Difficult Programming Language | 1 |

$$ECF = 1.4 - 0.3 * TW = -5.2$$

Domain Analysis

Domain model:

Concept Definitions (D-doing K-knowing N-neither):

| Responsibility Description | Type | Concept Name |
|--|------|----------------------|
| To extract plate's number & send to the controller | K | License Plate Reader |
| To prompt and receive confirmation number | D | Console Interface |
| To obtain information from user and make/extend/cancel reservation for user | D | User Interface |
| To verify the new customer information and update it to database | D | Controller |
| To reassign a spot for user | D | Controller |
| To validate user confirmation number | D | Controller |
| To record and display statistics of the number of people parked in a day, the amount of time they stayed, and relevant data. | D | Manager Interface |
| To allow changes in price rate of each parking lot | D | Manager Interface |
| To store and send information to controller/user interface/manager interface/console interface | D | Database |

| | | |
|---|---|--------|
| To detect cars on the spot | K | Sensor |
| To accept payment request and process money transaction | K | Bank |

Association Definitions:

| Concept Pair | Association Definition | Association Name |
|--|---|---|
| Controller $\leftarrow \rightarrow$ Database (Shen) | controller retract reservation information with from database by providing confirmation number, if no reservation information is found, then the confirmation number is invalid | getReservation(conf#) |
| Controller $\leftarrow \rightarrow$ Database (Shen) | controller search customer information from database in order to identify the role of coming user | getUserInfo(plate#) |
| Controller $\leftarrow \rightarrow$ Console Interface (Shen) | controller request confirmation number | requestConf() sendConf() |
| User Interface $\leftarrow \rightarrow$ Controller (Guan) | User interface ask permission from controller to request availability of each spot controller from database and store updated reservation information to database | requestAccessstoData() |
| User Interface $\leftarrow \rightarrow$ Database (Guan) | User Interface sends and receives reservation information from/ to database | requestSpotInfo() sendSpotInfo() requestCustomerInfo() sendCustomerInfo() display() |
| Controller $\leftarrow \rightarrow$ Manager | request and set each spot's | setSysDate() |

| | | |
|---|--|--|
| Interface (Zhiheng) | information by day/week/month, receive statistic data sheet. | setSysTime() openSpots() closeSpots() getStatistic() display() |
| Controller \longleftrightarrow Database (Zhiheng) | Timing and charging overstay Record open time period and available spots | overstay() systemStart() |
| Controller \longleftrightarrow User Interface (Zhiheng) | User interface requests a overstay event and controller gives a new spot number. | requestOverstay() verify() newSpot() timeExpire() spotBlock() |
| Controller \longleftrightarrow Bank (Zhiheng) | Request payment process | requestPayment() paymentDone() |
| Controller $\leftarrow \rightarrow$ User Interface (Yunhao) | User interface transfer the date fields collected from the customer and system check the information whether meet the requirement.After registration succeed, send verify email. | setPersonalinfo() addPayment() checkPassword() sendVerifyemail() |
| Controller $\leftarrow \rightarrow$ Database (Yunhao) | Controller sends customer information to database to verify whether the customer has registered, if not, update the new customer account. | checkCustomerInfo() checkEamiladdress() updateCustomerInfo() |
| Cameras \longleftrightarrow controller (nettie) | Captures images of cars entering the garage and begins entrance use case | InitiateEntering() |
| user interface \leftrightarrow controller (Luke) | system provide calculated route based on the database analysis. | requestRoute() |
| controller \leftrightarrow database(Luke) | system ask for the current traffic from the database to | requestTraffic() |

| | | |
|---|---|----------------------|
| | analyze. | |
| user interface<--> controller (Luke) | customer confirm the parking is done successfully. | confirmOccupancy() |
| controller<-->sensor (Luke) | system check ask sensor to check whether the given spot is occupied | checkSpot() |
| Controller<-->Database (Luke) | system update customer info on the database | updateCustomerInfo() |

Attribute Definitions:

| Concept | Attributes | Attribute Definition |
|-----------------------------|----------------------|---|
| Console Interface(Shen) | confirmationNumber | stores the user's input confirmation number |
| | reserveSpot | stores the user's reservation spot number which is retracted from database |
| | assignedSpot | stores the user's spot number which is calculated by the system |
| | reservePeriod | stores the user's reservation parking spot which is retracted from database |
| User Interface (Zhiheng) | requestOverstay | Sending a request to check if the customer overstays. |
| | verify | Return the status of the customer. |
| | newSpot | Processing a new spot to the customer. |
| Manager Interface (Zhiheng) | StatusofParkingspots | Set of all the parking spots status in the garage. |
| | OperatingTime | Time of the garage running. |
| | getCustomerInfo | list the profile of the |

| | | |
|--|-------------|--------------------------------|
| | | customer. |
| | setReserve | Reserve a spot for a customer. |
| | managePrice | Manager edit prices |

| Concept(Guan) | Attributes | Attribute Description |
|---------------|-------------------|---|
| Database | ParkingSpots | Record each spots current availability and future schedules. |
| | UserInfo | Record User's information and associate such information with spots each reservation is made and cars' plate numbers. |
| UserInterface | UserLogin | Request for username and password |
| | CreateReservation | Create reservation for user |
| | MapDisplay | Display a map for user and let user choose a parking spot |
| | ExtendReservation | Allow user to extend his reservation is the spot is available at the request time period. |
| | cancelReservation | Allow user to cancel a reservation ahead of time. |
| | reporting | Allow user to report in case he arrives at his reserved spot but some other car occupied that spot. |
| | reassigning | Reassign a spot for the user |

| | | |
|----------------------------|---|--|
| | | |
| User Interface (Yunhao) | userRegistration collect Information | Allow user to create new account Collect the user information including name, phone number, credit number, email address and password Driver License number and License Plate number |
| Controller (Yunhao) | verifyPassword checkEmail checkInformation sendEmail | Check whether the password has meet the requirement Check whether the email address has been used Check whether the user has already registered before Send an email to verifying |
| Database | UpdateNewcustomer | Update the new customer information |

System Operation Contract(Responsibility Description):

| | |
|------------------|--|
| Operation (Shen) | Identify user |
| Preconditions | the customer's plate information is received from plate reader |
| Postconditions | customer is identified(customer.role) as "walk-in", "non-reserve customer", "reserve customer" |

| | |
|------------------|---|
| Operation (Shen) | Assign Spot |
| Preconditions | <p>.The user does not have a reservation (reservation == null)</p> <p>OR</p> <p>The user's reservation spot is currently unavailable (reservation.spot.spotState == occupied)</p> <p>.The garage currently has at least one free spot</p> |
| Postconditions | .assigned spot is linked with customer information in database |

| | |
|---------------------|--|
| Operation (Zhiheng) | Overstay |
| Precondition | <ul style="list-style-type: none"> · The user overstays after reservation ended · The user receives reminder before reservation ended. · The user receives notification of charging overstay. · System has updated database on overstay. |
| Postcondition | <ul style="list-style-type: none"> · Spot on reservation map is blocked for reserve and the customer has been overcharged. · The spot on reservation map is reopened once the customer left. |

| | |
|---------------------|--|
| Operation (Zhiheng) | Manage Price |
| Preconditions | <ul style="list-style-type: none"> · Login to manager interface |

| | |
|----------------|--|
| | <ul style="list-style-type: none"> · Manager selected open date and time · Manager selected open spots · Manager updated price charge |
| Postconditions | <ul style="list-style-type: none"> · Prices for parking spots have been changed |

| | |
|-----------------|---|
| operation(Guan) | Online Reservation |
| Preconditions | <ul style="list-style-type: none"> . The user should be logged into his account . If user's request time is not available, he can choose another time or let the system find the next available period. |
| Postcondition | The reservation will be completed and added to database. |

| | |
|-----------------|---|
| operation(Guan) | Cancellation |
| Preconditions | <ul style="list-style-type: none"> . The user should be logged into his account . The user must start this action by 30 minutes before reservation starting time. |
| Postcondition | The reservation will be cancelled and updated to database. |

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|-----------------|--|
| operation(Guan) | Extension |
| Preconditions | <ul style="list-style-type: none"> . The user should be logged into his account . The user's request extended time should have no conflicts with the next customer who reserves the same spot. |
| Postcondition | The reservation will be extended and added to database. |

| | |
|-----------------|---------|
| operation(Guan) | penalty |
|-----------------|---------|

| | |
|---------------|--|
| Preconditions | <p>. The user is more than twenty minutes late.</p> <p>. If the user is late he can choose to pay some fee to keep his reservation</p> |
| Postcondition | The reservation will be cancelled and user will be charged for the whole reservation time. |

| | |
|-------------------|---|
| operation(Yunhao) | Registration |
| Preconditions | <ul style="list-style-type: none"> • The customer does not have an account • The email address has not been registered • Password is $x > 8$ • Name, phone number, Driver License number, License Plate number, email address, credit card number, password will be collected |
| Postcondition | <ul style="list-style-type: none"> • Account is successfully created and stored into database |

Mathematical Model:

Simulation of arrival and departure:

This project will use a poisson process to simulate the arrival and departure of random customers, setting the time t as unit interval, the possibility that one customer arrive will be

$P(n) = -\lambda * t * e^{(-\lambda * t)}$, in which λ represents the average arrival rate.

For each arrive customer, its information is randomly assigned after being created. Since the system mainly focuses on services provided to registered customers, created customer should have a large chance to be registered customer, for example, 80% of created customers are directly assigned the information currently stored in the database.

Project Management

1. First period working target: we will Study more on how to design an algorithm which maximizes the opportunity of parking and also shows the guide from the entrance to the target parking location. In the meanwhile, study more on the Mobile application, and research on the database we have to build.
2. Second period working target: Implement the algorithm and the mobile application. In the meanwhile, Study more on how to develop the website for registration and the reservation.
3. Third period working target: Implement the website ideas and made the first demo and get feedback.

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