Problem Definition

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A parking lot:

- Accommodate a fixed number of different types of vehicles
- Each of the parking spot is charged by the duration of the vehicle
- Users can pay either credit card or cash when exit the parking lot

What we need to clarify upfront:

Payment flexibility:

- Different exit spots (multiple exits) + different payment methods (credit card or cash or coupon or validation) + different payment receiver (machine vs. human)
- Different payment spots (different floors vs. pay at exits)

Parking spot types: handicapped vs. compact vs. large vs. motorcycle

- How to consider the parking capacity for different vehicles
- What would the program respond when the park lot is full
- How to track of the available spots across different floors

Vehicle types: car vs. truck vs. van vs. motorcycle

- How to allocate the capacity to different vehicle types
- If the parking spot of certain vehicle type is booked, how does the program behave when other vehicles attempt to park at that spot?

Price:

- Flat rate vs. different rate at different time
- Different price for different types of vehicle

Design approach:

- Identify the smallest components in the system such as vehicle, parking spot types, etc.
- Use small components to design bigger components such as the payment system
- Repeat the steps above to get the final parking system design

Requirements

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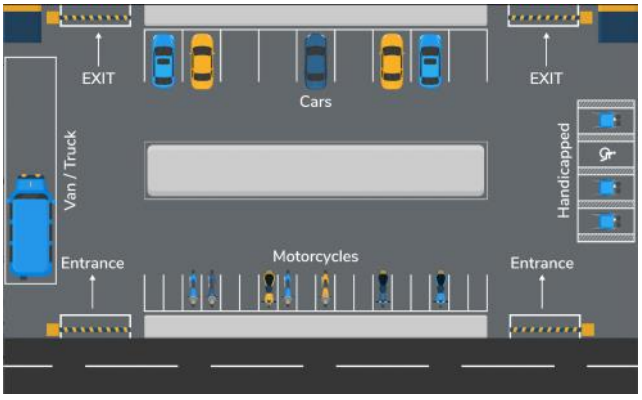
Requirement collections:

- R1: the parking lot should accommodate 40,000 vehicles
- R2: four different types of parking spots are offered: handicapped, compact, large, and motorcycle
- R3: the parking lot has multiple entrances and multiple exits
- R4: four types of vehicles are allowed to park: car, truck, van, motorcycle
- R5: the parking lot has a dashboard to show available spots or the parking is full
- R6: if capacity is reached, no more vehicles can be admitted
- R7: customers can collect parking ticket at the entrance and pay at the exit
- R8: customers can pay either using the automatic payment machine at the exit or human agent at the exit
- R9: the payment is computed using the hourly rate
- R10: payment can be either cash or credit card or debit card



Case Diagram

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System:
- Parking lot

Primary Actors:
- Customer: collect ticket at entrance; park vehicle at the designated space; pay at exit
- Parking agent: collect payment at the exit

Secondary Actors:
- Admin: add, remove, update, change parking spots or entrance/exits
- System: collect available and consumed parking spot information and display

User Activity:
- Admin:
  - add parking spot
  - remove spot
  - Change parking rate
  - Add entrance/exit
  - Remove entrance/exit
  - Add parking agent
  - Remove parking agent
  - View payment information of each vehicle
- Customer:
  - Collect ticket
  - Scan ticket
  - Pay ticket with cash / credit card / debit card
  - Park vehicles
- Parking agent:
  - Take ticket (from the customer)
  - Scan ticket
  - Pay ticket with cash / credit card / debit card
  - Park vehicles (help customers)
  - View parking account (payment information etc)
  - Update parking account
- System:
  - Assign parking spot to certain vehicles
  - Remove parking spots
  - Show available spots / full

Relationships:
- The "parking agent" can do everything that "customer" can do
- "Cash" and "credit card" and "debt card" are equivalent and all of them belong to "pay tickets"

Case Diagram

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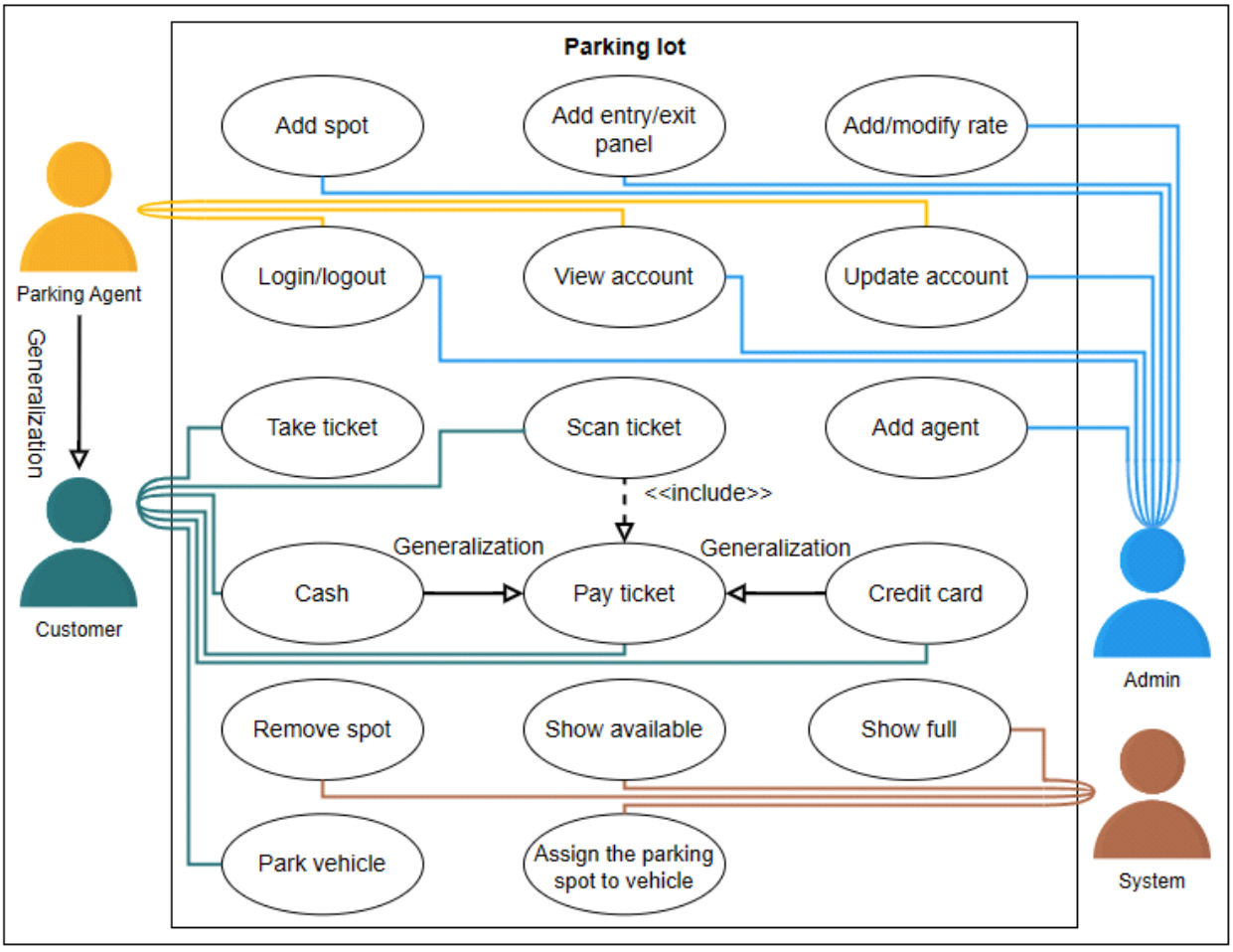
Admin	Customer	Parking Agent	System
Add spot	Take ticket	Update account	Assigning parking spots to vehicles
Add agent	Scan ticket	Login/Logout	Remove spot
Add/modify rate	Pay ticket	View account	Show full
Add entry/exit panel	Cash	Take ticket	Show available
Update account	Credit card	Scan ticket	
Login/Logout	Park vehicle	Pay ticket	
View account		Cash	
		Credit card	
		Park vehicle	



Components of Parking Lot

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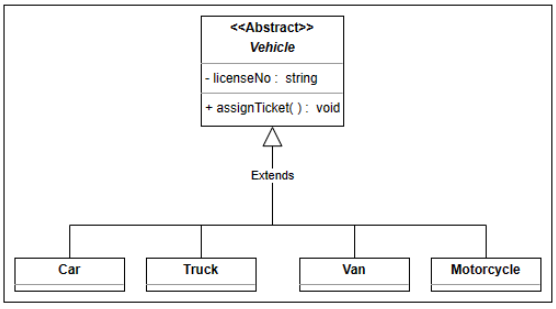
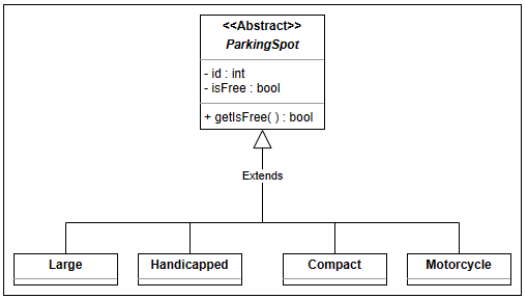
Vehicle:

- Enumeration class: create user-specified four types of vehicles. Not recommended because it is not future proof when we want to add more vehicle types
- Abstraction class: create a base class as vehicle and create four vehicle classes
- Class data: license plate number
- Class method: receive a ticket with time stamp



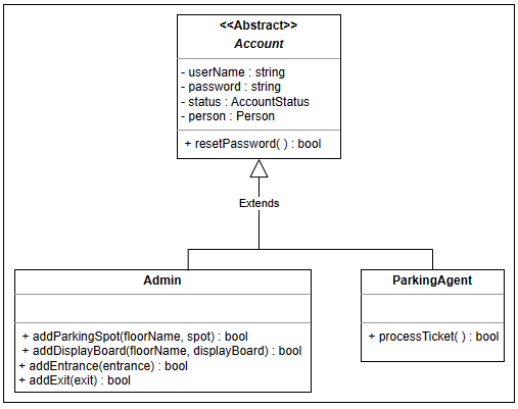
Parking spot:

- The parking lot should be an abstract class and then four different types of classes should be derived
- Class data: ID (denoting the spot number), is free (denoting whether the spot is available)



Account:

- It should be an abstract class: the parking agent and admin shall be inherited from this base class.
- Class data: user name, password, status, person
- Class method: reset password;



Components of Parking Lot

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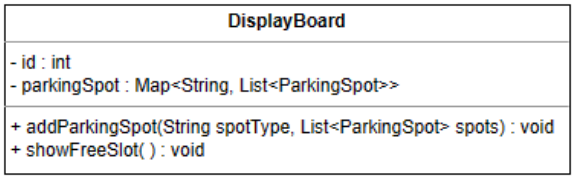
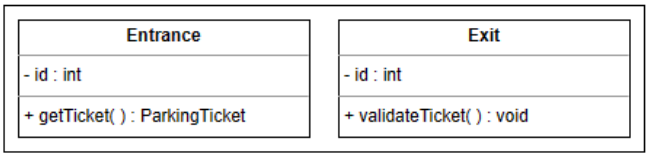
Dashboard:

- A class visualize available parking spots for different types of vehicles
- Class data: ID (multiple dashboard at multiple entrance), parking spots availability



Entrance and Exit:

- Entrance: delivers parking ticket when vehicle is coming.
  - Class data: ID (multiple entrances)
  - Class method: get the parking ticket
- Exit: collects parking ticket when vehicle is exiting
  - Class data: ID (multiple exits)
  - Class method: validate the parking ticket (make sure it is paid)

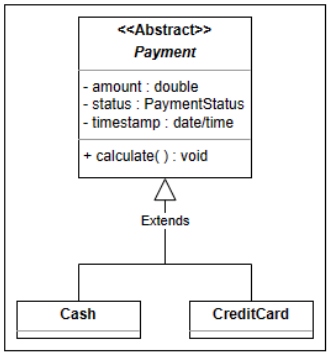


Parking ticket:

- Class data: ticket ID, entering and exiting time stamps, payment amount, payment status

Payment:

- Abstract class to derive two sub-classes: cash and card payment
- Class data: payment amount, payment status, timestamp
- Class method: calculate the parking fee



Components of Parking Lot

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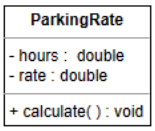
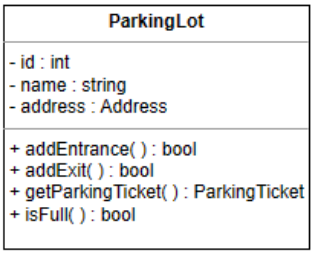
Parking Rate:

- Class method: calculate the final payment amount based on rate and time duration



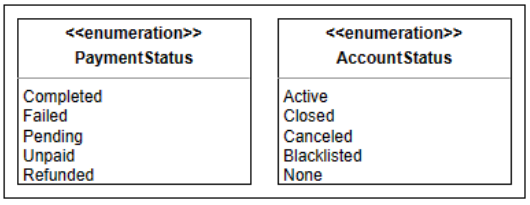
Parking Lot:

- Include all smaller components covered above.



Enumerated Class:

- Payment status: paid, refund, etc
- Account status: activate, revoked, etc



Address:

- The address of the parking lot: zip code, address, city, state, country

Person:

- The class stores person related information, such as name, address, contact, etc.

Class Relationship

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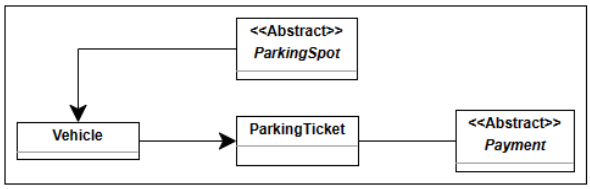
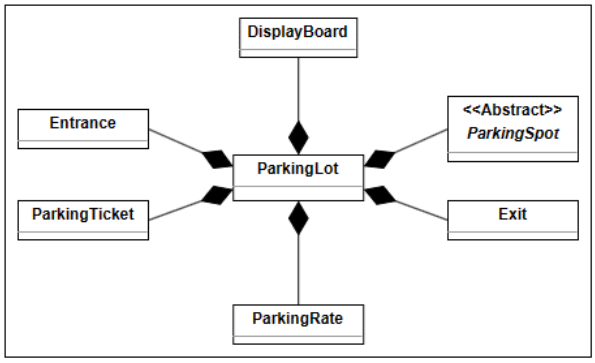
Association:

- Parking lot is one-way associated with Vehicle
- Vehicle is one-way associated with Parking Ticket
- Payment is two-way associated with Parking Ticket



Composition:

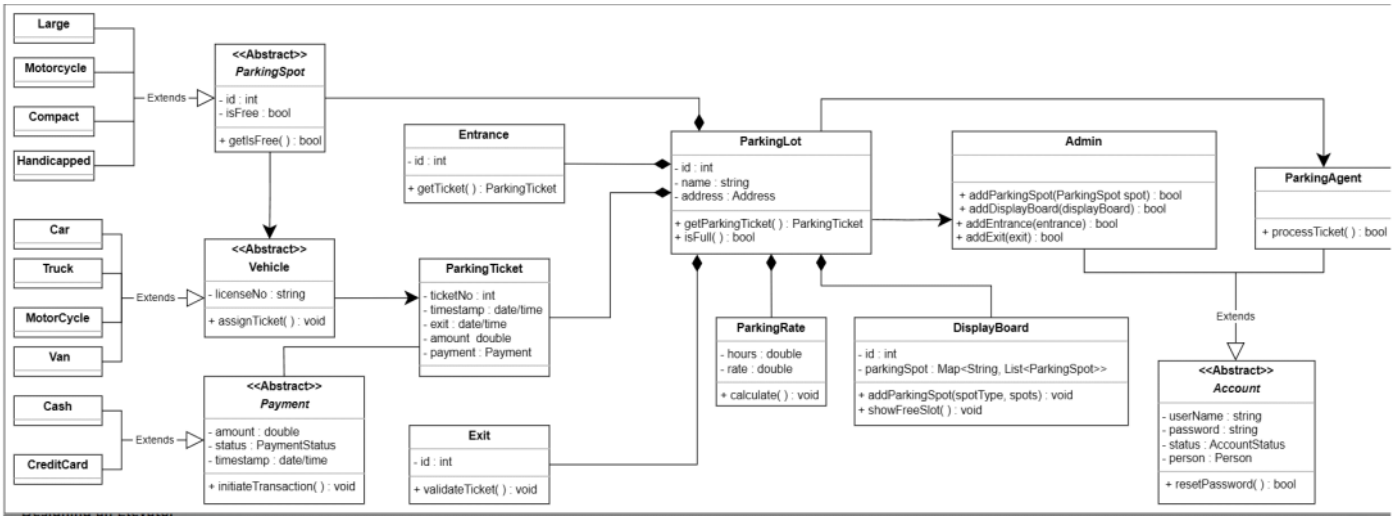
- The parking lot includes Entrance, Exit, Parking Rate, Display Dashboard, Parking Ticket, Parking Spot.



Inheritance:

- Vehicle can derive multiple types of vehicles: Car, Motorcycle, Truck, Van
- Parking Spot can derive multiple types of spots: handicapped, large, compact, motorcycle
- Payment derive cash and card payment subclasses

Entire Design:



Additional Design Info

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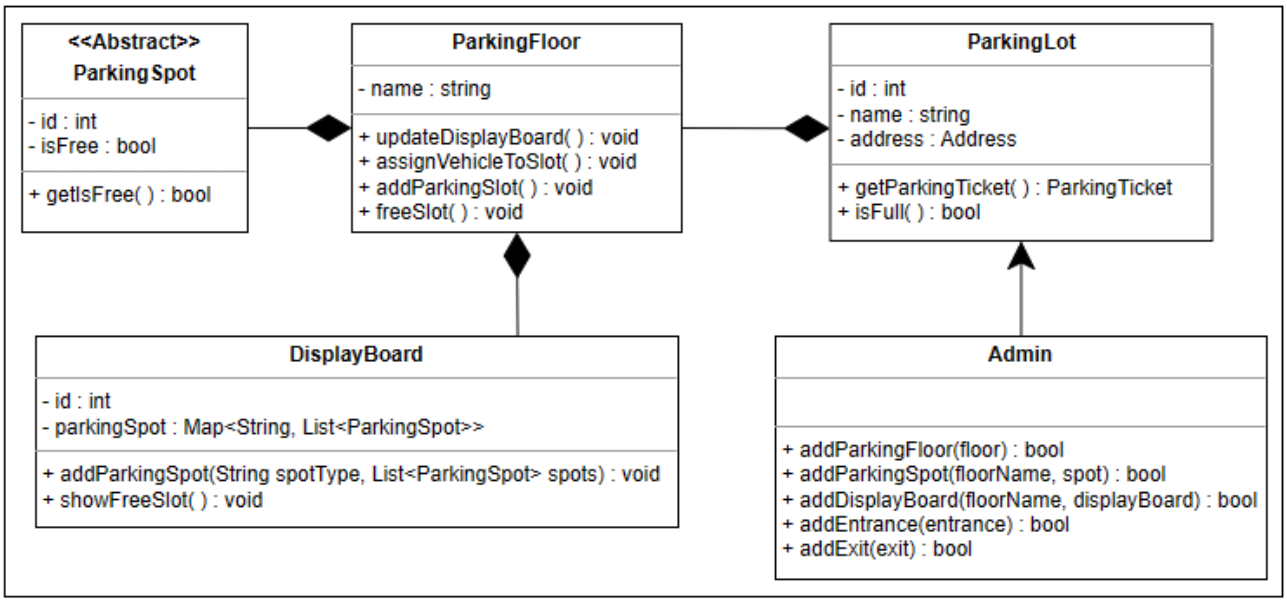
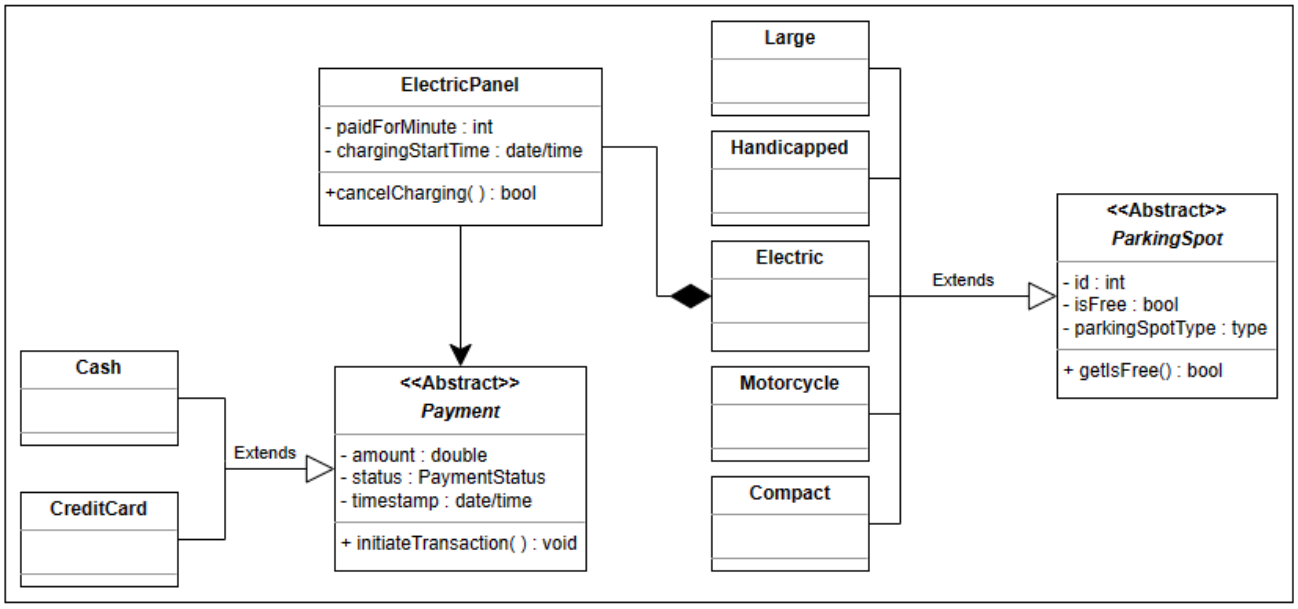
If we need to include parking floor:



If we need to reserve parking spots for electric cars:



Sequence Diagram

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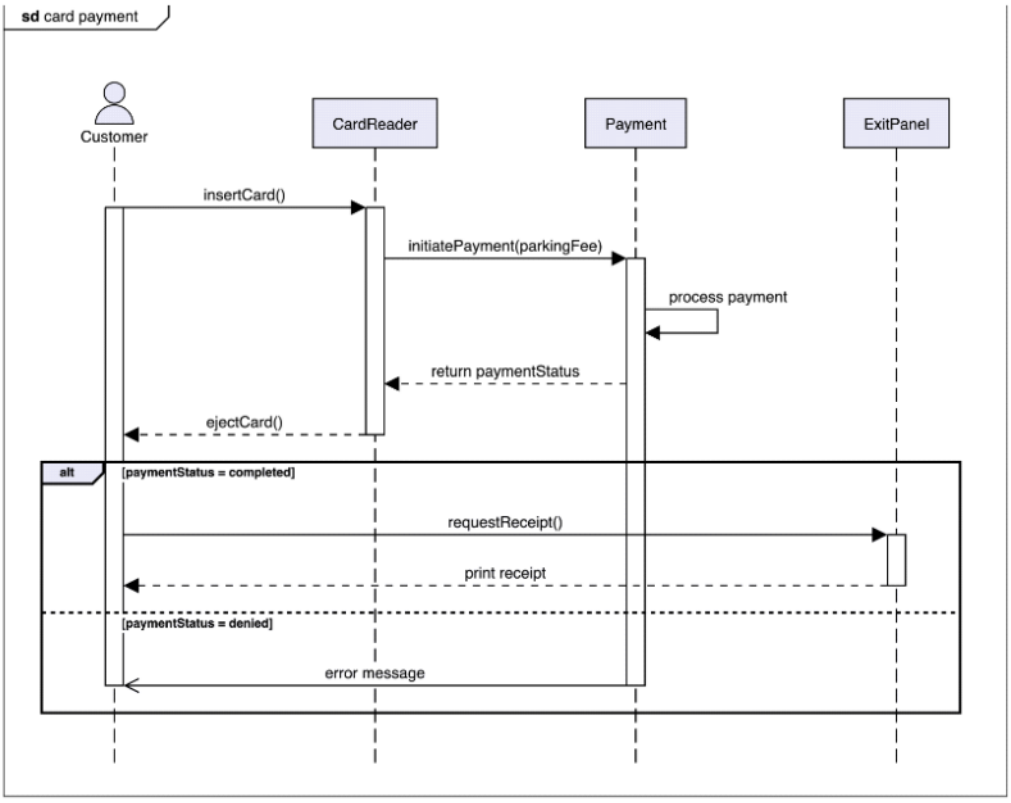
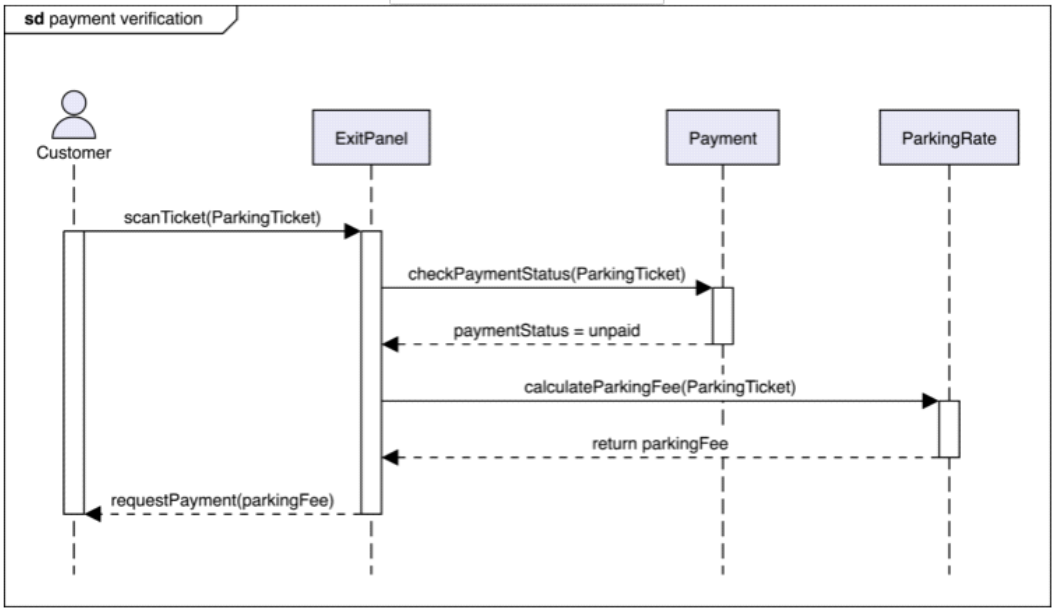
Paying parking fee:



Payment verification:



Activity Diagram

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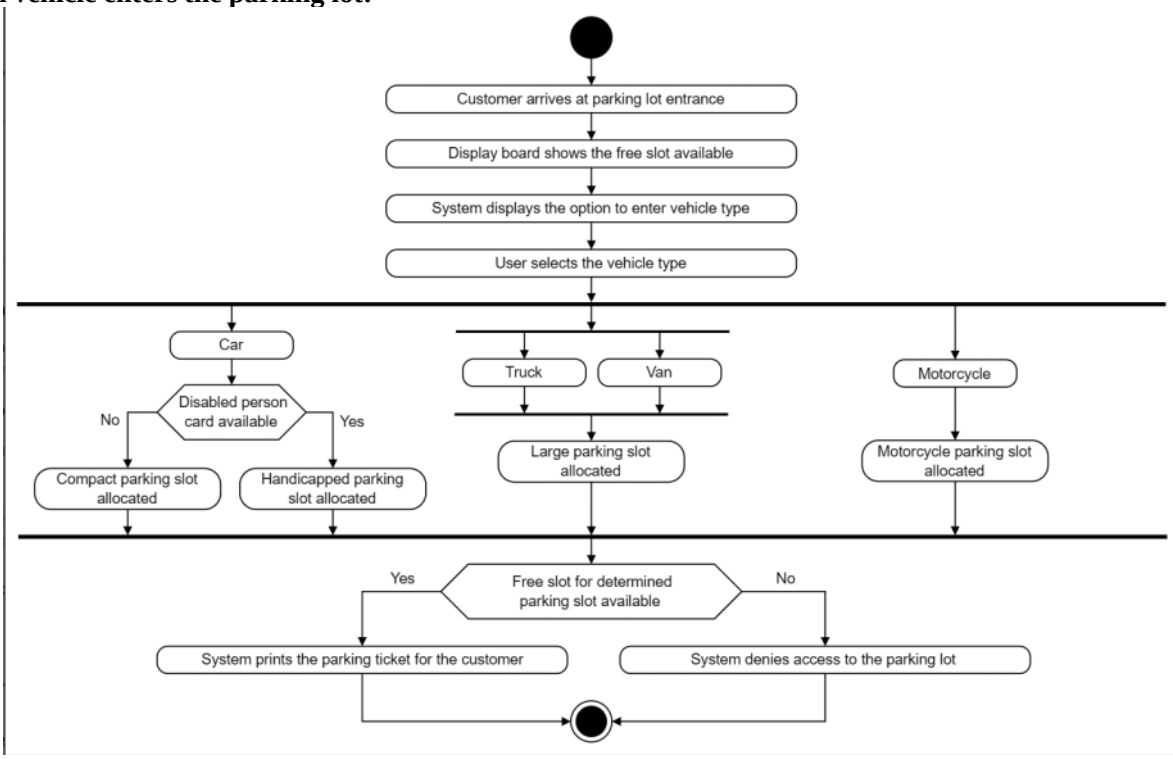
When vehicle enters the parking lot:



The customer pays the parking ticket: