CS5373-Fall2022-Software Modeling and Design

Term Project: Highway Toll System

Your group has been assigned to a project to design a client/server system for a Highway Toll System. The system is developed in two phases as follows:

Term Project: Phase I

For Phase 1 of the project, you are required to develop an analysis model of the system. In particular:

a) Develop a software system context class model depicted on a class diagram showing how the system interfaces to the external environment. (3 pts)

b) Develop a static model showing the entity classes in the system, the attributes of the classes, and the relationships between them. (3 pts)

c) Develop interaction diagrams (one for each use case) using sequence or communication diagrams, depicting the sequence of interactions among the objects participating in each use case. Identify the object structuring criteria for the objects participating in each interaction diagram. (6 pts)

d) For use cases involving entering and leaving the highway, show the statechart. Make sure that each statechart is consistent with the appropriate interaction diagram. (5 pts)

Term Project: Phase II

For Phase II of the project, you are required to develop a Design Model for the Highway Toll System. In particular:

a) Develop an integrated communication diagram(s) showing all the objects and message interfaces in the system. (3 pts)

b) Define the software architecture (depicted on a concurrent communication diagram) that shows the clients and server of the system. Define the message communication interfaces between the clients and server. (5 pts)

c) Define the task architecture (depicted on concurrent communication diagrams) showing the concurrent tasks in each subsystem and the interfaces between the tasks. Describe the criteria used for task structuring. Define the message communication interfaces. (5 pts)

d) Develop a task interface specification for each concurrent task in the system. (2 pts)

State any assumptions you make.

HIGHWAY TOLL SYSTEM: PROBLEM DESCRIPTION

Drivers who use the toll road may pay the tolls by using a transponder placed in their vehicle or by paying with cash or with credit cards at selected tollbooths.

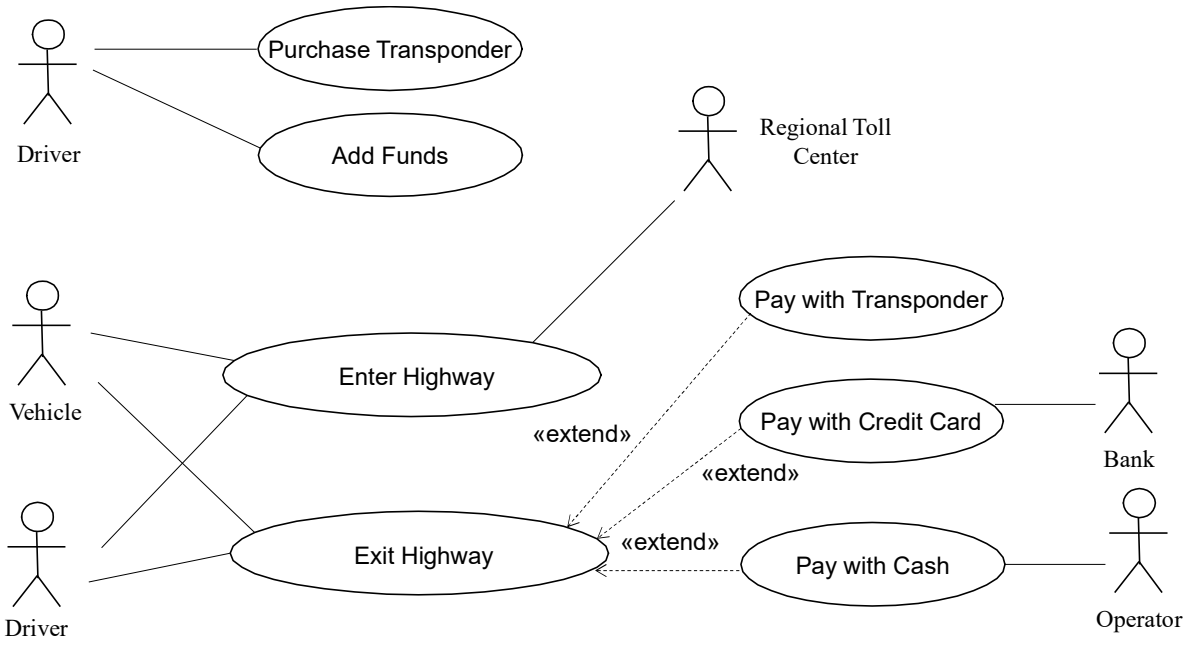
Drivers wishing to use transponders purchase the transponders through the regional toll center. This regional toll center maintains driver accounts in a database including the owner, vehicle information, account balance, and toll use history. Drivers purchasing a transponder must pay ahead for toll fees by credit card. Accounts are reduced by the toll amount incurred at the end of each trip. The toll amount to be paid depends on the length of the trip.

For access to the toll highway, there is a ticket issuing booth with a barrier. The driver presses a button to receive the ticket. The driver with a transponder does not need to receive the ticket. To leave the toll highway, there is a human-operated booth with a barrier.

All tollbooths consist of an operational light to indicate whether the tollbooth is available for use; a vehicle-approaching sensor (placed 50 feet in front of the tollbooth); a vehicle-passed sensor; a traffic light to indicate whether the vehicle has been authorized to pass through the tollbooth; a transponder sensor. Additionally, all tollbooths contain a vehicle barrier that is raised and lowered to enforce payment. Exit tollbooths have a display to indicate the required toll amount. Exit tollbooths have a card reader device, which can read both tollbooth-issued tickets and credit cards, and an operator who collects the appropriate toll and authorizes a car to pass. After the driver inserts the ticket into the card reader or the system detects a transponder on a vehicle, the entry point and toll amount (which are read off the ticket) will be displayed on the operator's and driver's displays.

The traffic light at each tollbooth is initially red, and the barrier is lowered. When a vehicle approaches the tollbooth, the vehicle sensor detects the vehicle's presence. Drivers not possessing a transponder or having insufficient funds on their transponder must use pay with cash or with credit cards. In each of these cases, the toll is calculated based on entry and exit times, and entry and exit locations. The driver can pay by credit card or pay an operator who manually collects the required toll and authorizes the vehicle to pass. If a toll payment is successful, the light will be turned green, and the barrier will be raised. The traffic light is switched to red, and the barrier is lowered after the car passes.

Use Case Diagram for Highway Toll System



Use case descriptions

Use Case Name: Purchase Transponder
Actor: Driver
Summary: The driver applies for a new transponder account online.
Precondition: None
Description:

1. Driver accesses the transponder account registration website and selects "Create a new account."
2. System requests driver's information.
3. Driver enters name, login id, password, email, address, phone number, driver's license number, and vehicle license plate, then submits information.
4. System creates a new driver's account and registers the driver.
5. System displays the account information (account id, driver name) to the driver.

Alternatives:

- **Missing information:** If the driver omits required information, such as name, the system displays an error message and requests missing information.

Postcondition: A transponder account has been created for the driver.

Use Case Name: Add funds
Actor: Driver
Summary: Driver adds funds to transponder account.
Precondition: Driver account exists.
Description:

1. Driver accesses transponder account registration website and selects "Add funds to the account."
2. System prompts driver for login id and password.
3. Driver enters login id and password.
4. System requests the amount of funds to add, in multiples of $10.00.
5. Driver enters amount.
6. System requests billing information.
7. Driver enters billing information, such as credit card number and expiration date.
8. Driver submits amount and billing information.
9. System displays receipt.

Alternatives:

- **Invalid login id or password:** If the login id or password is invalid, the system displays an error message and prompts for login id and password.
- **Invalid Credit card:** If the credit card is invalid, the system displays an error message and requests updated billing information.

Postcondition: Funds have been added to the transponder account.

Use Case Name: Enter Highway
Actor: Driver
Summary: The vehicle enters the highway through a tollbooth with a barrier, and a ticket is issued to the driver with the time and day of entry and location.
Precondition: Tollbooth is open, the traffic light at the tollbooth is red, and the barrier is down.
Description:

1. Vehicle approaches tollbooth with a barrier.
2. System detects vehicle's presence.
3. Driver presses a button to receive a ticket.
4. System prints out a ticket with the time and day of entry and location.
5. System raises the barrier and switches the traffic light to green.
6. Vehicle leaves the tollbooth.
7. System detects that the vehicle has departed, lowers the barrier, and switches the traffic light to red.

Alternatives:

- Step 3: If the machine is low on tickets, an alert is sent to the regional toll center.
- Step 3: If the system detects a valid transponder in the approaching vehicle, it records the time of entry, day, location, and transponder id. Go to step 5.

Postcondition: A ticket has been issued to the driver.

Use Case Name: Exit Highway
Actor: Driver
Summary: The vehicle exits the highway through a tollbooth with a barrier.
Precondition: Tollbooth is open, and the traffic light at the tollbooth is red.
Description:

1. Vehicle approaches tollbooth.
2. System detects vehicle's presence.
3. Driver enters ticket into ticket reader.
4. System calculates charges based on entry and exit times, and entry and exit locations.

5. System displays charges and prompts for the type of payment (cash, credit card, or transponder account).
6. <payment>
7. System raises the barrier and switches the traffic light green.
8. Vehicle passes through the tollbooth.
9. System detects that the vehicle has departed, lowers the barrier, and switches the traffic light to red

Alternatives:

- Step 3: If the system detects a valid transponder in the approaching vehicle, it records the time of exit, day, location, and transponder id. Go to step 4.

Postcondition: The driver has paid the toll, and the vehicle has passed through the toll booth.

Use Case Name: Pay with credit card
Actor: Driver, Bank
Dependency: Extends Exit Highway use case
Summary: The driver pays toll charges with a credit card.
Precondition: Charges are calculated and displayed for the approaching vehicle.
Description:

1. Driver selects "Pay with credit card."
2. Driver scans a credit card.
3. System requests authorization for charges on the credit card.
4. Bank authorizes the credit card payment.
5. System prints a credit card receipt.

Alternatives:

- Step 3: If charges are not authorized on the credit card, the system prompts for another form of payment.

Postcondition: The credit card has been charged with the toll amount.

Use Case Name: Pay with transponder account
Actor: Driver
Dependency: Extends Exit Highway use case
Summary: The driver pays toll charges with a transponder account.
Precondition: Charges are calculated and displayed for the approaching vehicle.
Description:

1. Driver selects "Pay with transponder account."
2. System detects a valid transponder on the vehicle.
3. System deducts the toll amount from the driver's account and prints a receipt.

Alternatives:

- **No transponder / Invalid transponder:** If there is no transponder on the vehicle or the transponder is invalid, the system prompts for another form of payment.
- **Insufficient funds:** If the system determines that there are insufficient funds in the account, ~~additional charges are billed to the driver's account~~ the system displays the due amount.

Postcondition: The transponder account has been charged with the toll amount.

Use Case Name: Pay with cash
Actors: Driver, Operator
Dependency: Extends Exit Highway use case
Summary: The driver gives cash to an operator to pay for the toll charges.
Precondition: Charges are calculated and displayed for the approaching vehicle.
Description:

1. Driver selects "Pay with cash."
2. Driver gives cash to the operator.
3. Operator gives the driver change, if necessary, and issues a receipt to the driver.
4. Operator commands the system to raise the barrier.

Alternatives:

- Step 2: If the driver does not have enough money, the operator bills the driver using the information on the driver's license. (Operator records the license number offline.)

Postcondition: The driver has paid the toll charges and has been issued a receipt.