Technical University of Denmark

02293 System Integration

Toll System

Group number: 3

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Contents

1 Introduction (s144449)

The modelling of the toll system for this project was done with an agile approach where we chose to design and realize the most important use cases first to ensure that there are working functionalities. We also abstracted away from the presentation layer and focused on a domain-driven design so any implementation language would be possible to use or any type of interface. For an object-oriented design, we used CRC cards to determine which required objects there are and which relationships they should have so the chosen use cases can be implemented.

2 Requirements

2.1 Glossary (s172016 + s144449)

Antenna	A device used at express lanes to receive RFID signals from toll tags during check-ins and check-outs
Barrier	A barrier used at the entrances and exits of toll lanes. It is controlled by a toll lane computer.
Cashier	A staff member who works with the sales of single tickets at a toll lane and deals with possible problems happening at check-outs
Customer	A person with a vehicle who uses the toll system
Cash register	A device used by a cashier to handle cash payment. It is connected to a toll lane computer.
Credit card reader	A credit card reader placed at normal check-in lanes. It is used for credit card payment of single tickets and requires a pin during payment.
Enterprise	A toll enterprise consisting of an enterprise server, an enterprise client and a set of toll stations
Enterprise client	A client that the enterprise manager can use to access the enterprise server
Enterprise manager	A person who manages the enterprise
Enterprise server	A server, which is connected to all toll stations and the internet. It is used to manage toll rates and users.
Express lane	A toll lane that can be used by toll tag users for easier check-ins and check-outs.
Normal lane	[Cash lane]: A toll lane entering a motorway (check-in lane) where cash payment is accepted. [Credit card only lane]: A toll lane entering a motorway (check-in lane) where only credit card payment is accepted. [Check-out lane]: A toll lane exiting a motorway with a single ticket

Single ticket (ticket)	A ticket used to enter and exit a motorway. The ticket is valid for one trip within a limited time (max. 24 h). It has a fixed price and is purchased at normal check-in lanes.
Single ticket reader	A ticket reader used at normal check-out lanes to check whether a single ticket is valid or not.
Station client	A client that a station manager can use to access the station server
Station manager	A person who manages a toll station
Station server	A server that is connected to all toll lanes. It is used to keep records of check-ins and check-outs.
Toll lane	A lane with which one can enter (check-in) a motorway or exit (check-out) a motorway. Every toll lane has a toll lane computer and a barrier.
Toll lane computer (toll lane pc)	A computer that connects the different hardware components at each toll lane. It also communicates with the bank.
Toll station	A station placed at an entrance or exit to a motorway. Each station has a station client, a station manager, a station server and a set of toll lanes.
Toll tag	An RFID transponder used to wirelessly identify the vehicle to which it belongs via an antenna at an express lane. A toll tag can be purchased online or at a toll station, which must therefore be done before use.
Touchscreen	A touchscreen used by cashiers to operate toll lane computers.
User	A person with a vehicle who is registered in the toll system. He has a name and an address and may have an e-mail address.
Vehicle	Vehicle identified by a vehicle identification number (VIN). It can be of type car, truck or motor bike
Web Server	Server used to connect the enterprise server to the Internet

Table 1: Glossary

2.2 Domain Model

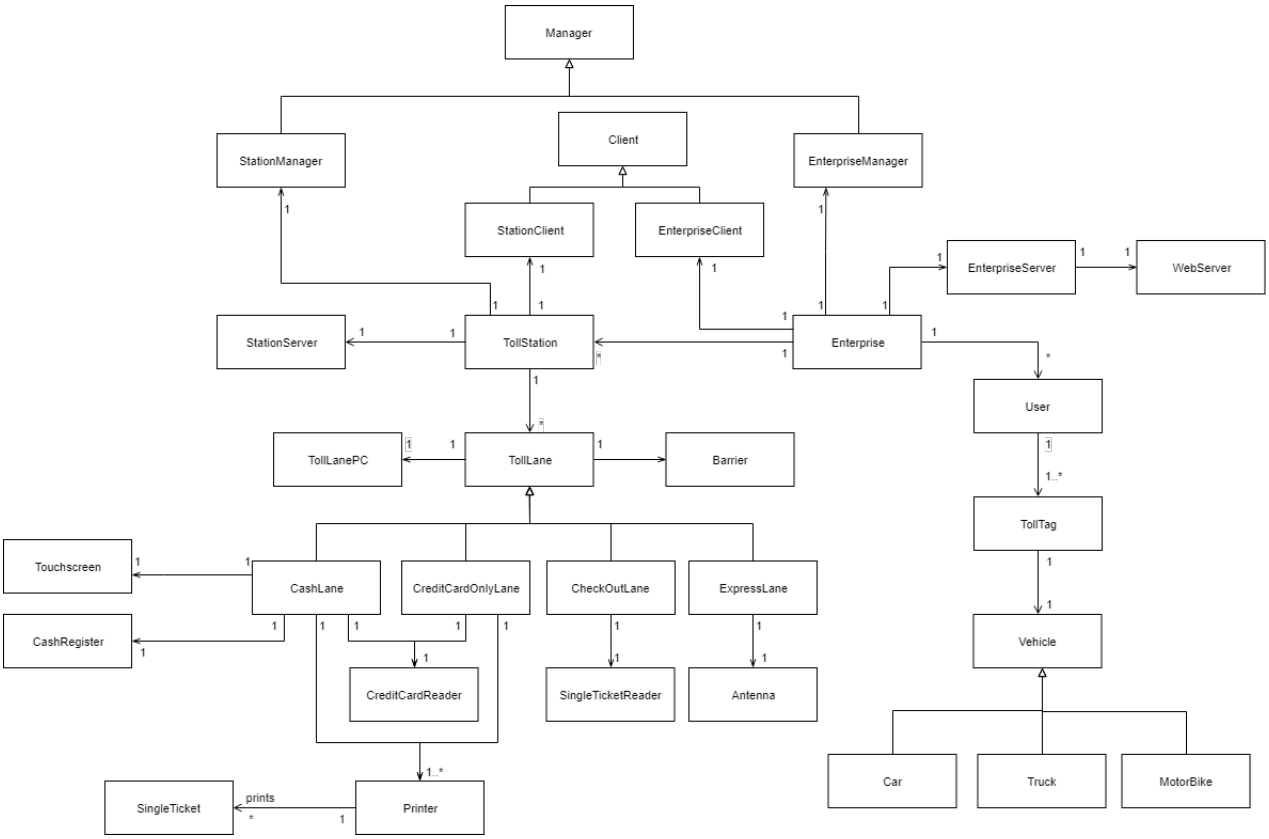

Figure 1: Class diagram of toll system domain

2.3 Activity Diagrams

2.3.1 Check In with Ticket

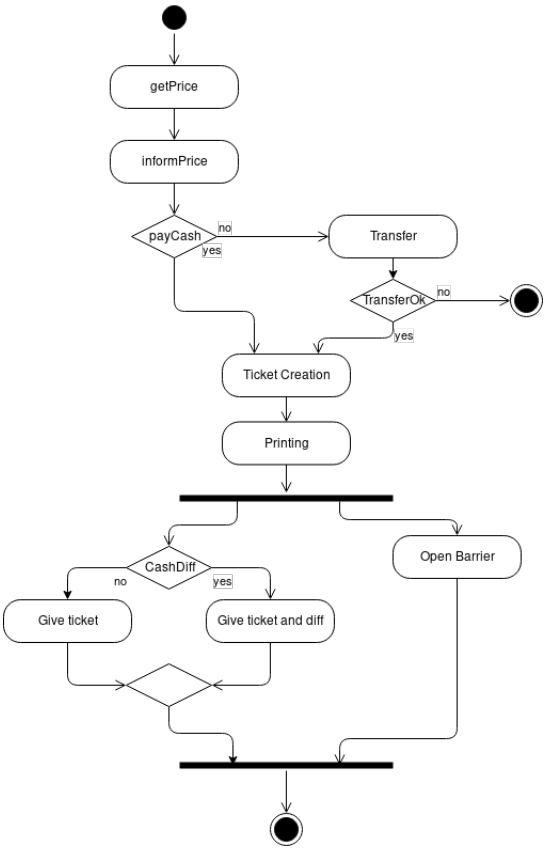

Figure 2: Activity diagram for *Check In with Ticket*

2.3.2 Check Out with Ticket

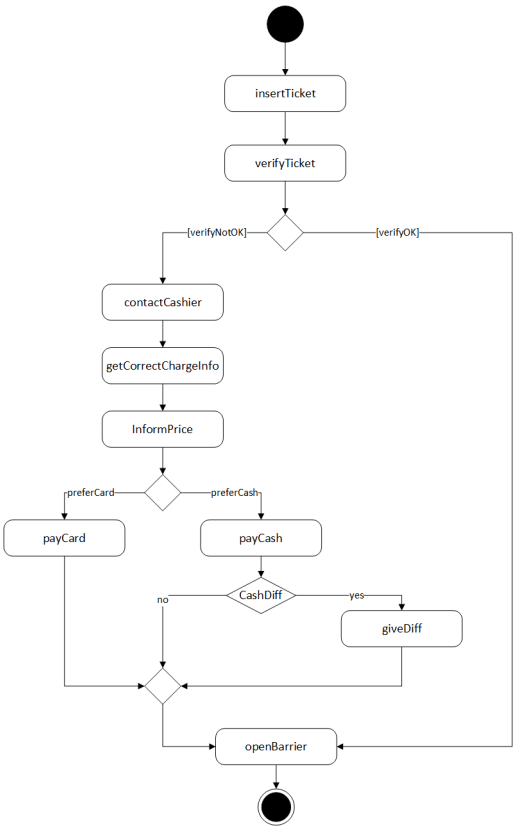

Figure 3: Activity diagram for *Check Out with Ticket*

2.3.3 Buy Tag

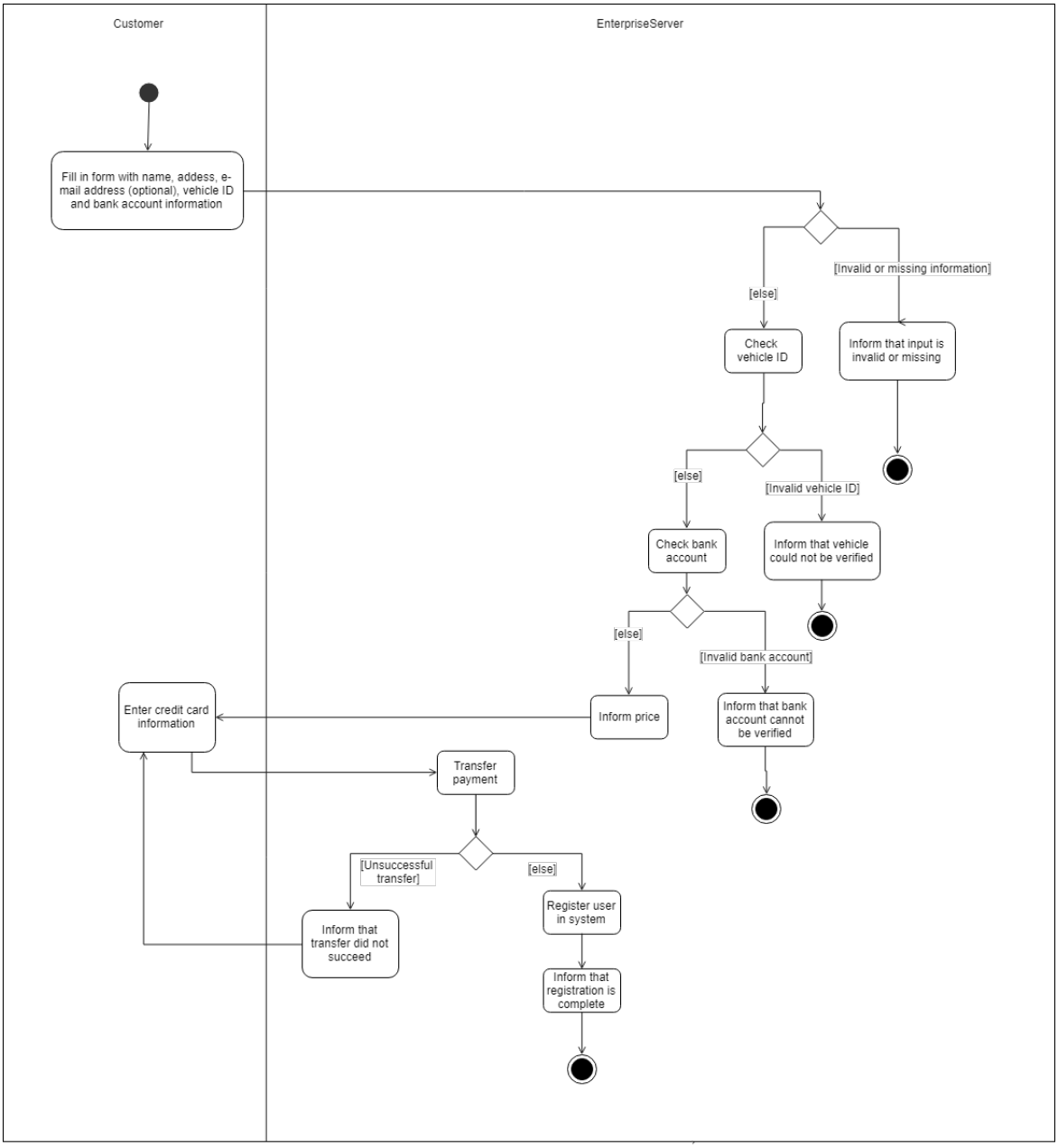

Figure 4: Activity diagram for *Buy Tag*

2.3.4 Change Rate

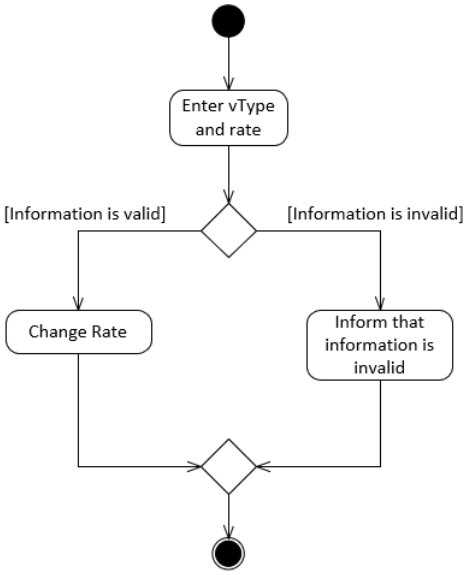

Figure 5: Activity diagram for *Change Rate*

2.3.5 Notify Users

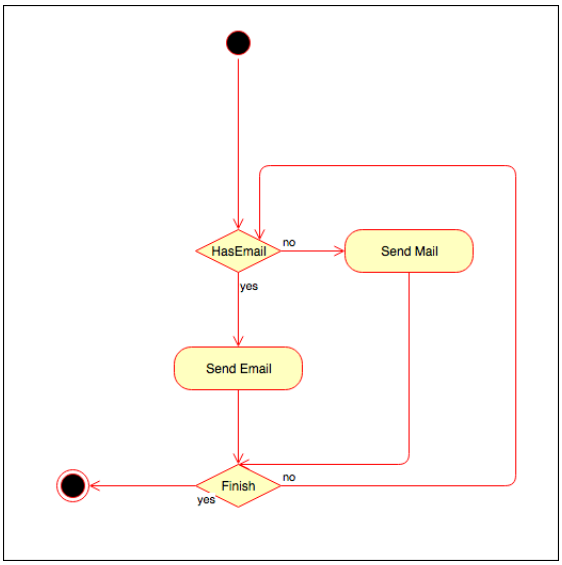

Figure 6: Activity diagram for *Notify Users*

2.3.6 Get Report (as Enterprise Manager)

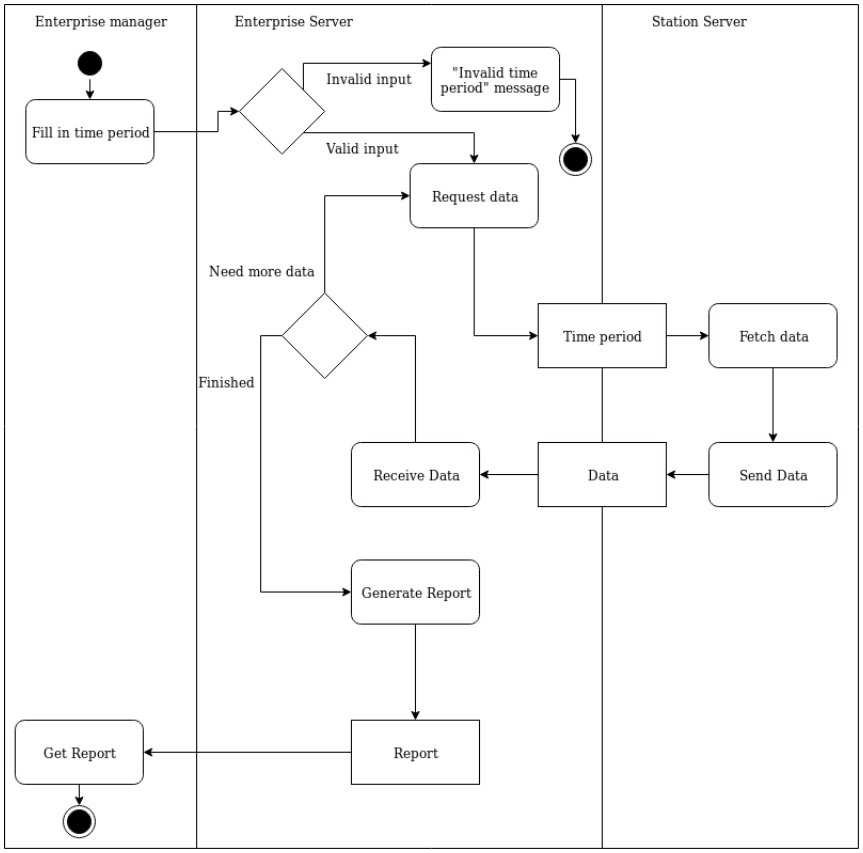

Figure 7: Activity diagram for *Get Report (as Enterprise Manager)*

2.4 Functional Requirements

2.4.1 Use Case Diagram

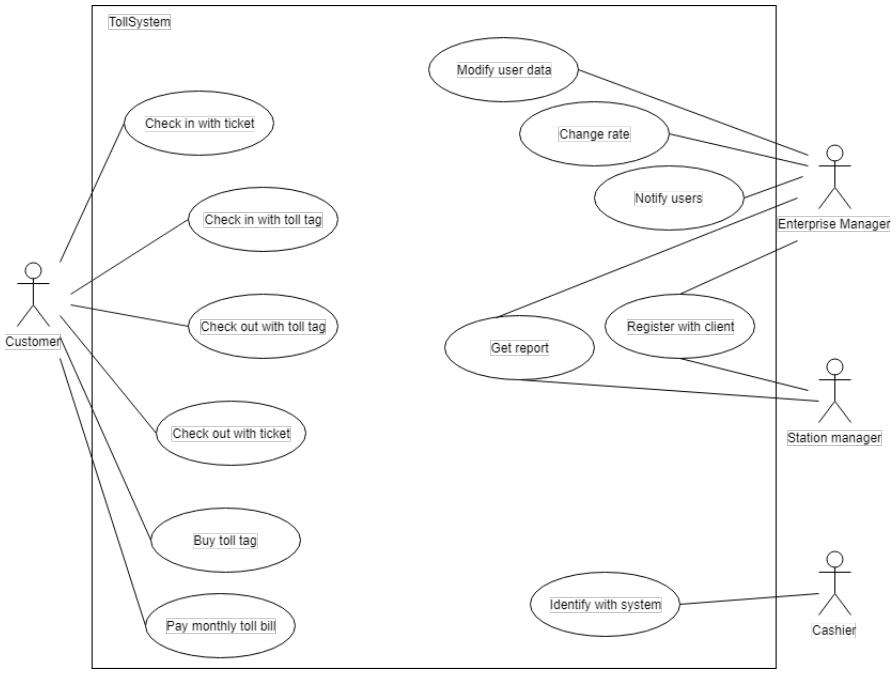

Figure 8: Use case diagram

The use cases with highest priority are check-ins and check-outs since these are the core operations in the system. For this we decided to model *"Buy toll tag"*, *"Check in with ticket"* and *"Check out with ticket"* in order to have a wide variety in use cases. Since "Buy toll tag" is done at a station or through the internet, it is also interesting to see how payment and communication work at the toll lane - hence the choice of check-in and check-out with tickets and not toll tags. Another use case of high priority is *"Change rate"* since it is very valuable for a business to be able to change prices. Along with this, we also chose *"Notify users"* to show how users of the system are stored and also because it is important that customers are notified if prices change since users might be paying their monthly toll tag bill automatically. Finally, *"Get report"* is modelled because it can be used for analysis of the system and thereby help to improve the system - this is mostly useful when done for all stations, so the use case is modelled as getting a report as the enterprise manager. (It is assumed that only the enterprise manager can modify user data since users are not associated with specific toll stations and hence not saved locally at each station)

2.4.2 Detailed Use Case Descriptions

Name	Check In with Ticket
Summary	Customer checks in at a normal check-in lane and enters the motorway
Actor	Customer
Preconditions	The customer is at a normal check-in lane
Main scenario	
1	The customer requests a single ticket
2	The customer is shown the price for a single ticket
3	The customer pays for the single ticket with his/her credit card
4	The customer receives the single ticket and the barrier opens
Alternative scenarios	
3a	The customer pays for the single ticket with cash
4	The customer receives the single ticket and the difference between the received amount and the actual price and the barrier opens
4b	The credit card information is invalid
5	The customer is told that the payment could not be processed

Name	Check Out with Ticket
Summary	Customer checks out at a normal check-out lane and exits the motorway
Actor	Customer
Preconditions	The customer is at a normal check-out lane
Main scenario	
1	The customer inserts his ticket into the single ticket reader
2	The barrier opens and the customer leaves
Alternative scenarios	
2a	The customer is told that the ticket could not be read and that he must wait for a cashier
3	The customer is charged correctly at the toll station
4	The barrier opens and the customer leaves
Postconditions	The customer is not on the motorway

Name	Buy Toll Tag
Summary	Customer buys a toll tag for a vehicle
Actor	Customer
Main scenario	
1	The customer fills in a form with his name, address, e-mail address (optional), vehicle ID and his bank account information through the toll system's website (also accessible from a toll station)
2	The customer fills in his credit card information and purchases the toll tag
3	A toll tag is mailed to the customer
Alternative scenarios	
2a	There is missing or wrongly formatted information*
3	A message stating that there is invalid or missing information is displayed
2b	The vehicle ID is not legit
3	A message stating that the vehicle cannot be verified is displayed
2c	The bank account information is not valid
3	A message stating that the bank account cannot be verified is displayed
3a	The credit card information is not valid
4	A message stating that the credit card information cannot be verified is displayed
3b	Payment did not succeed**
4	A message stating that the payment failed is displayed
Notes	
*****	Information here includes name, address and e-mail address. E-mail address can be omitted, but must be in the correct format if included.
******	The reason could be insufficient account balance on an account type that cannot go negative or a technical error

Name	Change Rate
Summary	The enterprise manager changes the toll rate
Actor	Enterprise manager
Preconditions	The enterprise manager has registered with the enterprise client
Main scenario	
1	The enterprise manager enters a vehicle type and new toll rate for single tickets or toll tags
2	The changes are saved
Alternative scenarios	
2a	There is invalid information*
3	A message stating that there is invalid information is displayed
Notes	
*****	The entered toll rate is not a number or the number is too big or too small.

Name	Notify Users
Summary	The enterprise manager sends notifications about changed toll rates
Actor	Enterprise manager
Preconditions	The enterprise manager has registered with the enterprise client
Main scenario	
1	The enterprise manager accesses the information about toll rates
2	The enterprise manager notifies users
3	E-mail notifications are sent to users with e-mail addresses and physical notification mails are printed for users without e-mail addresses
Postconditions	Customers are informed about rate changes

Name	Get Report (as Enterprise Manager)
Summary	The enterprise manager request a report from the enterprise server
Actor	Enterprise manager
Preconditions	The enterprise manager has registered with the enterprise client
Main scenario	
1	The enterprise manager chooses a time period
2	The enterprise manager requests a report from the enterprise server with the chosen time period
3	The enterprise server returns a report containing information for the given time period
Alternative scenarios	
1a	The enterprise manager chooses an invalid time period*
2	A message stating that the time period is invalid is displayed
Notes	
*****	An invalid time period can be triggered by a wrong input format or dates entered in the wrong sequence

2.5 Non-functional requirements

- The system should be a high throughput of vehicles at the toll lane
- The enterprise manager should be able to get reports within 5 ms
- The graphical user interface at the toll lane should be user-friendly

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3 Acceptance Tests

3.1 Check In with Ticket

Main scenario

ActionFixture		
check	Price	50
enter	Credit card	0000-0000-0000-0000
enter	Pin code	1234
press	OK	
check	Error message	none

Table 2: Pay with credit card

RowFixture: Single ticket	
Time	20-04-18 14:27

Table 3: Single ticket

Alternative scenario 3a

ActionFixture		
check	Price	50
enter	Cash	100
check	Error message	none

Table 4: Pay with cash

RowFixture: Single ticket and change	
Time	20-04-18 14:27
Change	50

Table 5: Single ticket and change

Alternative scenario 4b

ActionFixture		
check	Price	50
enter	Credit card	0000-0000-0000-0000
enter	Pin code	1235
press	OK	
check	Error message	”Payment could not be processed”

Table 6: Pay with credit card

RowFixture: Single ticket	

Table 7: Returned single ticket

3.2 Check Out with Ticket

Main scenario

check	Message	”Please insert your ticket”
enter	Ticket	ticket
check	Message	”Ticket accepted”
check	Barrier opens	true

Table 8: Check out

Alternative scenario 4b

ActionFixture		
check	Message	”Please insert your ticket”
enter	Ticket	ticket
check	Error message	”Ticket invalid”
check	Correct Payment Fee	50
enter	Cash	100
check	Barrier opens	true

Table 9: Check out invalid ticket

RowFixture: Change	
Change	50

Table 10: Correct payment change

3.3 Buy Toll Tag

Main scenario

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r@gmail.com*
enter	Vehicle ID	3YTLO52GBFD986483
enter	Bank account	31270035491745
press	Proceed	
enter	Card number	5019-3145-8910-0475
enter	CVV	444
enter	Expiry	01/20
press	Purchase	
check	Message	”Registration complete”

Table 11: Purchase

RowFixture: Toll tag	
Name	Tom Riddle
Vehicle ID	3YTLO52GBFD986483

Table 12: Created toll tag

Alternative scenario 2a

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r*
enter	Vehicle ID	3YTLO52GBFD986483
enter	Bank account	31270035491745
press	Proceed	
check	Error message	”Information is invalid or missing”

Table 13: Purchase

RowFixture: Toll tag	

Table 14: Created toll tag

Alternative Scenario 2b

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r@gmail.com*
enter	Vehicle ID	3YTLO52GBFD98648
enter	Bank account	31270035491745
press	Proceed	
check	Error message	”Vehicle could not be verified”

Table 15: Purchase

RowFixture: Toll tag	

Table 16: Created toll tag

Alternative Scenario 2c

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r@gmail.com*
enter	Vehicle ID	3YTLO52GBFD986483
enter	Bank account	3125
press	Proceed	
check	Error message	”Bank account could not be verified”

Table 17: Purchase

RowFixture: Toll tag	

Table 18: Created toll tag

Alternative Scenario 3a

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r@gmail.com*
enter	Vehicle ID	3YTLO52GBFD986483
enter	Bank account	31270035491745
press	Proceed	
enter	Card number	5019-3145-8910-0475
enter	CVV	444
enter	Expiry	01/18
press	Purchase	
check	Error message	”Credit card could not be verified”

Table 19: Purchase

RowFixture: Toll tag	

Table 20: Created toll tag

Alternative Scenario 3b

ActionFixture		
enter	Name	Tom Riddle
enter	Address	Kollegiebakken 15A
enter	E-mail address	*tom_r@gmail.com*
enter	Vehicle ID	3YTLO52GBFD986483
enter	Bank account	31270035491745
press	Proceed	
enter	Card number	5019-3145-8910-0475
enter	CVV	443
enter	Expiry	01/20
press	Purchase	
check	Error message	”Payment failed”

Table 21: Purchase

RowFixture: Toll tag	

Table 22: Created toll tag

3.4 Change Rate

Main scenario

RowFixture: Toll rate	
1.Single tickets price for Truck	55
2.Toll tags price for Truck	1.6
3.Single tickets price for Car	50
4.Toll tags price for Car	1.2
5.Single tickets price for Motorbike	40
6.Toll tags price for Motorbike	1.0

Table 23: Toll rates before change

ActionFixture		
enter	Type	4
enter	Rate	1.5
press	Change	
check	Error message	none

Table 24: Change toll rate

RowFixture: Toll rate	
1.Single tickets price for Truck	55
2.Toll tags price for Truck	1.6
3.Single tickets price for Car	50
4.Toll tags price for Car	1.5
5.Single tickets price for Motorbike	40
6.Toll tags price for Motorbike	1.0

Table 25: Changed toll tag rate for car

Scenario 1a

RowFixture: Toll rate	
1.Single tickets price for Truck	55
2.Toll tags price for Truck	1.6
3.Single tickets price for Car	50
4.Toll tags price for Car	1.2
5.Single tickets price for Motorbike	40
6.Toll tags price for Motorbike	1.0

Table 26: Toll rates before change

ActionFixture		
enter	Type	4
enter	Rate	a
press	Change	
check	error message	”Information is invalid”

Table 27: Change toll rate

RowFixture: Toll rate	
1.Single tickets price for Truck	55
2.Toll tags price for Truck	1.6
3.Single tickets price for Car	50
4.Toll tags price for Car	1.2
5.Single tickets price for Motorbike	40
6.Toll tags price for Motorbike	1.0

Table 28: Toll rate is unchanged

3.5 Notify Users

Main scenario

ActionFixture		
press	Notify	
check	Error message	none

Table 29: Notify users

RowFixture:	Sent e-mails	Sent mails
Receiver(s)	{peter@gmail.com,...}	{Kollegiebakken 15A,...}
Subject	Changed toll rate	Changed toll rate
Content	Dear customer, The toll rate...	Dear customer, The toll rate...

Table 30: Sent notifications

3.6 Get Report (as Enterprise Manager)

Main scenario

ActionFixture		
enter	Start date	20/1/2018
enter	End date	22/1/2018
press	Request report	
check	Error message	none

Table 31: Get report (as Enterprise Manager)

RowFixture: Generated report	
Start date:	20/1/2018
End date:	22/1/2018
Check-in:	100
Check-out:	95
Tickets:	60
Toll tags:	70

Table 32: Generated report

Alternative Scenario

ActionFixture		
enter	Start date	twenty/one/two thousand and eighteen
enter	End date	22/1/2018
press	Request report	
check	error messages	“Wrong date format”

Table 33: Get report (as Enterprise Manager)

RowFixture: Generated report	

Table 34: Generated report