Software Requirements Specification

for

Smart METU Store

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Contents

Change History

Revision	Date	Author(s)	Description
1.0	03.03.2020	Aktolga I.,Bolat B.	SRS Part I
2.0	07.04.2020	Aktolga I.,Bolat B.	SRS Complete

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Chapter 1

Introduction

1.1 Purpose of the System

In today's digitally connected world, people are not willing to waste their time by waiting in long queues. Scientists and engineers have been seeking alternative ways to reduce these wasted times. One of the daily problems of this kind is shopping store lines. By using advanced perception system that includes sensor fusion, computer vision and deep learning algorithm, Smart METU Store which aims to create a checkout-free shopping system, is introduced as a candidate to solve this problem. The main purpose of the system is to provide "Just Walk Out" technology. In other words, taken and returned items for each customer are tracked in a virtual shopping cart. By doing so, the customer can just walk out whenever he/she is done with shopping. The receipt will be sent on the app and charging will be done via the Smart METU Store account.

1.2 Scope

- The system will have a mobile app for communication with the customer. The customer gets in the store, checks his/her virtual shopping cart, shows accounts those are linked to his/her account via this app.
- The system will have an interface for sensor maintenance system to maintain perception system since perception system depends on sensor fusion. Via the sensor maintenance system, if a non-functional sensor (temperature, camera, etc.) is detected, it will be reported to the related employee.
- The system will communicate with Perception System which will give information on which item is taken or returned and by whom this action is taken. Apart from taken information, System will address action on Management System to keep the virtual shopping cart updated.
- The system will have an interface with Management System which keeps different virtual shopping carts for each customer, actual stock information for items and an interface for the store manager. Via Management System, System can request action for a customer and his/her virtual shopping cart.
- The system will authenticate customers by validating the QR code generated on their mobile phone. Then turnstiles will allow the customer to walk into the store.
- System should track misplaced products on the shelves and warn the employees to avoid confusion.
- The system will interact with Payment System to charge purchases and sends the bill to the customer's mobile phone when the customer leaves the store. Perception System is responsible for detecting leave action.

1.3 System Overview

1.3.1 System Perspective

Smart METU Store works as a system of systems at most cases. Perception System is a significant system that provides main knowledge. Main knowledge includes human tracking, object detection, face recognition and shelf fullness. System uses Management System to maintain the store. Store Manager manages system via Management System. Since the store is a physical environment and there are a few of employee, hardware takes important role. Therefore, System uses Sensor Maintenance System which is a integration of a software that creates report for non-functional sensors and employees to repair them.

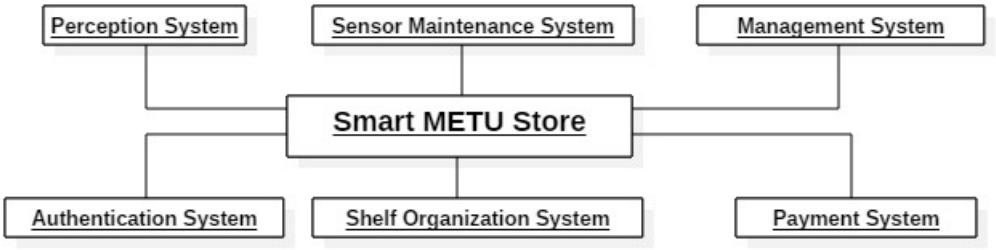

Figure 1.1: Context Diagram

1.3.1.1 System Interface

Perception System Interface: Perception System has a few outputs that are used to decide significant decisions such as who purchased the item and what the item was. These two data are taken via Perception System Interface. Then, Smart METU System transfers appropriate data to the Management System. Furthermore, shelf fullness data is acquired by using these data. On the other hand, there is a bidirectional sensor information traffic. Sensor fusion in Perception System can inform Smart METU Store. The other way includes employee. An employee can send a report about a non-functional sensor to the Smart METU Store. Smart METU Store acknowledges Perception System via interface according to that report so that Perception System doesn't account the data that comes from non-functional sensor.

Sensor Maintenance System Interface: Smart METU Store uses this interface to let appropriate person or system know an issue that arises from a sensor. To clarify, cameras and turnstiles are also regarded as a sensor. When a non-functional sensor is turned functional, Sensor Maintenance System serves that valuable information to the Smart METU Store. With the help of that, Smart METU System recognizes that non-functional sensor was fixed and it also serves that information to the Perception System in order to increase perception ability.

Management System Interface: Management System is responsible for meeting with requests of Store Manager Interface (in Smart METU Store) which are transferred via Management System Interface. However, the most substantial task assigned for it is keeping track of the customer's shopping carts. Smart METU Store sends credential of item and identity of the customer who took that item to the Management System via the interface. Respond of the previous action is also transferred via this interface and used to update shopping cart on the app.

Authentication System Interface: When a customer decides to enter the store, Smart METU Store creates a QR code. Moreover, this QR code is sent to the app and Authentication System. Authentication System Interface is responsible for this data transfer. And, it's response is crucial for Smart METU Store to perceive if a customer allowed to get in or not.

Shelf Organization System Interface: This interface is used to let employees be aware of system re-

quests related to shelves. Smart METU Stores uses the interface to send credentials of shelves, action type (i.e. refill, interchange and relocate) and items' credentials that will be placed on related shelves.

Payment System Interface: Smart METU Store does not store credit card credentials of its customers due to security and legal manners. Therefore, Payment System Interface is essential for Smart METU Store. Smart METU System passes only user credentials and amount of purchase via Payment System Interface. The interface sends confirmation information back to the Smart METU System.

1.3.1.2 User Interface

User interfaces of the Smart METU System will be investigated in 3 part types of users: customer, employee, store manager. Customer will have an interface to easily get information about his/her shopping. On the other hand, the employee and store manager will generally deal with store maintenance through interfaces.

Customer Interface: First, a customer interacts with the Smart METU Store to get a QR code. When a customer is in the store, he/she will use interface to keep track of his/her virtual shopping cart and discounts in the store. At the same time, customer can be in a group that consists of many customers that are linked to a master account. In such a case, the master account has permission to see other's shopping carts.

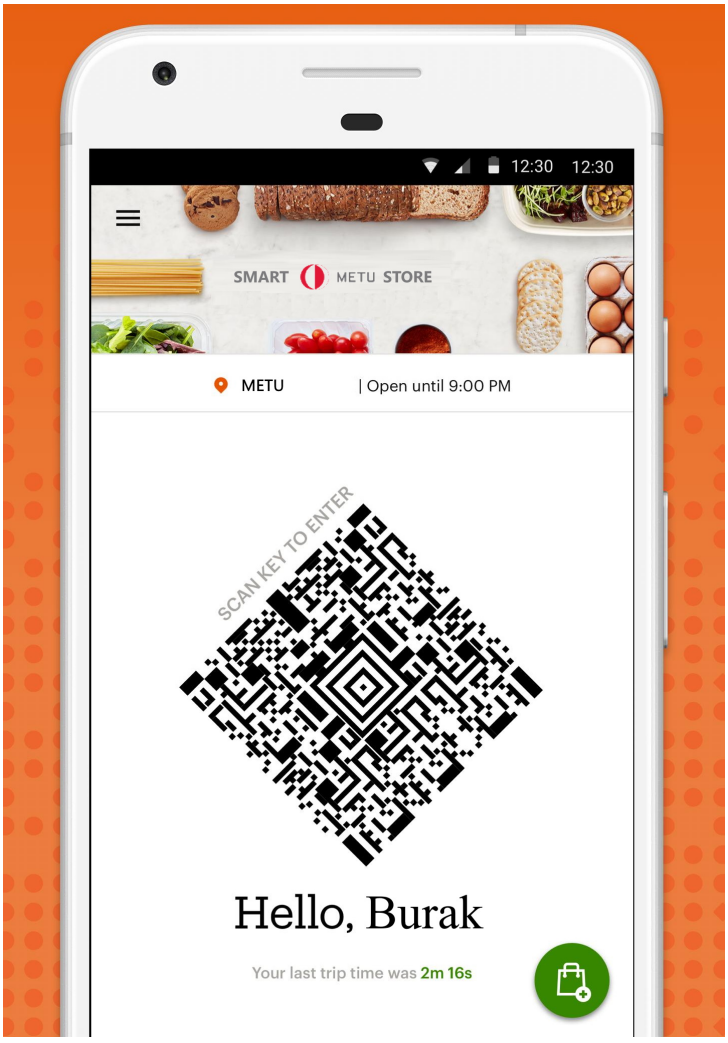

Figure 1.2: Smart METU Store Mobile App

Employee Interface: Employees can see attended shifts to themselves via Employee Interface. Also, an

employee sees shelf fullness information to carry out proactive refill action. Employee Interface provides reports belongs to non-functional sensors, wrongly placed items and refill requests.

Store Manager Interface: Store Manager uses this interface to manage the store. The manager can order new items, set a new price for an item, make a discount on an item and notify customers in the store, buy a sensor to replace it with the non-functional sensor, add a new shelf and set a new design for the store.

1.3.1.3 Software Interface

Database : Smart METU Store uses a database to store stock of products, prices of products. It also stores customer shopping carts, employee information and transactions.

Human pose estimation package : To help the classification of actions that customers make during shopping, a human pose estimation module is required. A pre-trained neural network model on basic actions like "taking an item" and "leaving an item" is sufficient.

Object detection package : Detecting objects is the core part of the project and the perception system. There should be dataset contains images of products are on sale. A neural network would be trained on this dataset. Also, the dataset may be updated occasionally.

Operating system: The operating system would be server distributions of Linux and/or Windows.

1.3.1.4 Hardware Interface

Smart METU Store needs numerous cameras and sensors as a part of its perception system.

Cameras are used to track customers and products which they take or leave. **Sensors** will be placed for shelves to decide user actions. Besides, at the entrance end exit of the store, **turnstiles** are needed. The working mechanism of these two types of turnstiles is different. Turnstiles at the entrance scan QR code then opens. However, turnstiles at the exit allow a customer to leave without asking QR code.

1.3.1.5 Memory Constraints

Memory is an important constraint for this project. Multiple cameras are used for tracking and detecting multiple customers and their actions. Moreover, cameras are not the only member of the Perception System, there are many other sensors. Handling sensor fusion also needs fast primary storage. In order to achieve such hard tasks at real-time, primary storage is crucial for the system. On the other side, In the database of Smart METU Store, we store face images for customers in order to track them in the store. Also, item meshes are stored to increase the performance of item detection. Therefore, secondary storage requires a higher storage capacity than an average system. Besides, the speed of secondary storage is substantial to have a qualified service. For instance, at the exit of a customer, the system recognizes the face of the customer and opens turnstiles. Decreasing time between taking face image from Perception System and from Management System increases the performance of the whole system on the customer side.

1.3.1.6 Operations

The operations that take place in Smart METU Store can be listed as the following:
Customer Operations:

- Enter
- Link Acount

- Leave
- Pick Item
- Place Back Item

Store Manager Operations:

- Enter
- Set Price
- Order

Perception System Operations:

- Relocate Request
- Refill Shelf Request
- Send Sensor Errors

Employee Operations:

- Enter
- Send Sensor Errors

1.3.2 System Functions

Functions	Summary
Enter	Responsible for verifying person and sending QR code to let him/her in.
Link Account	Enables many account purchase simultaneously and pay through one master account.
Leave	Awakes Payment System to handle payment actions.
Pick Item	Adds a correct item to the correct customer's shopping cart.
Place Back Item	Removes a correct item from the correct customer's shopping cart.
Relocate Request	Sends a request to the Shelf Organization System when a wrongly placed item detected.
Send Sensor Errors	Creates a report related to non-functional error and sends it to the Sensor Maintenance System.
Refill Shelf Request	Awakes Employee via Employee Interface by sending a refill request.
Set Price	Changes price of the selected item and inform customers who are currently in the shop.
Order	Order items with a given amount.

Table 1.1: System Functions

1.3.3 User Characteristics

The target users of the Smart METU Store can be divided into 3 types as customers, store manager and employees.

Customers will need to have a smartphone that supports Smart METU Store's mobile application. People who want shopping are expected to know how to use this application. Therefore there will be an introduction part that contains a tutorial will be shown when they have launched the application for the first time. Besides, since the customers shouldn't deal with the technical side, the mobile interface will be simple to use. Later on, the customer is free to buy anything he/she wants. When the shopping is finished, they are free to go by walking out.

Similar to customers, employees should be familiar with the mobile application. They will use the same app to get into the store. Besides, different groups of employees have different responsibilities. Some of the employees will be working for shelf design. When the signal comes from the perception system, they will act to either fill the shelves or relocate the misplaced items. For this type of employees, only basic computer knowledge is enough. Another group of the employee will be responsible for tracking the sensor status and handling the problems by repairing or replacing hardware. In this group, employees should be an expert in the technical field. While shopping, some products require human assistance, like cutting meat or preparing some of the foods. For this kind of tasks, a human employee should wait ready to perform orders. Employees that react with customers should be polite and helpful.

Manager of the store should have the basic computer knowledge to monitor stocks of products by viewing shelf info from the interface and should order when needed. Also, he/she set new prices for items (e.g give a discount)

1.3.4 Limitations

- **Regulatory limitations:** Although not keeping customers' payment credentials slows down the System, by-laws it is forbidden and safer. Secondly, the credentials of customers and employees should not be published.
- **Hardware limitations:** Since the whole system relies on Perception System and Perception System has complex structure behind it, perceiving is slower than real-time systems. Sensor fusion requires a few time to process signals that come from many sensors. Human Pose Estimation and Object Detection are relatively slower than sensor fusion since they process signals coming from cameras, afterwards estimation and detection use models that have many layers in it which makes computation slower.
- **Interfaces to other applications:** Smart METU Store must be compatible with Payment Systems from different banks. Since it will decide action by using perception data, it should be compatible with estimation and detection models.
- **Parallel operation:** Parallel operation is highly important. Perception takes a long time as mentioned above. Without parallel processing, it is nearly impossible to track every user and his/her shopping cart along with maintaining the store.
- **Audit functions:** Smart METU Store just follows accounts when a customer is in the store. After leaving the store, financial operations are done between banks and customer.
- **Control Functions:** Stock and shelf are controlled only by the store manager. On the customer side, the customer doesn't have permission to send a sensor error. Sending error belongs to Perception System and employee.
- **Higher-order language requirements:** The system must be written in various languages since sensor fusion and detection algorithms are written in different languages. Detection algorithms generally run on Python interpreter, so Smart METU Store will communicate through Python interpreter. To merge sensor fusion, estimation and detection data, a compiled language such as C/C++ should be used. Using

C/C++ will speed up the system so that it would be work in closer to the real-time. The App will be written in Kotlin for Android and Swift for Apple

- **Quality requirements:** Maintenance of items is crucial and the supply chain is slow. Therefore, Smart METU Store informs the store manager about the stock when a day end. Again at the end of a day, Smart METU Store checks connections of sensors whether there is a weak or noisy connection.
- **Criticality of the application:** The most critic part is the shopping cart and sensor maintenance. Other errors can be tolerated.
- **Safety and security considerations:** Security of payments totally belongs to banks and financial intermediary. Also, if a sensor has leakage of electricity, it should be reported as non-functional. Nevertheless, fixing the sensor is up to the employee.
- **Physical/mental considerations:** Any customer who is shorter than a threshold can not use the store since detection system fails to track such customers.

1.4 Definitions

Term	**Definition**
METU	Middle East Technical University
App	Application
OS	Operating System
QR	Quick Response

Table 1.2: Definitions

Chapter 2

References

This document is written with respect to IEEE 29148-2011 standard:

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Chapter 3

Specific Requirements

3.1 External Interfaces

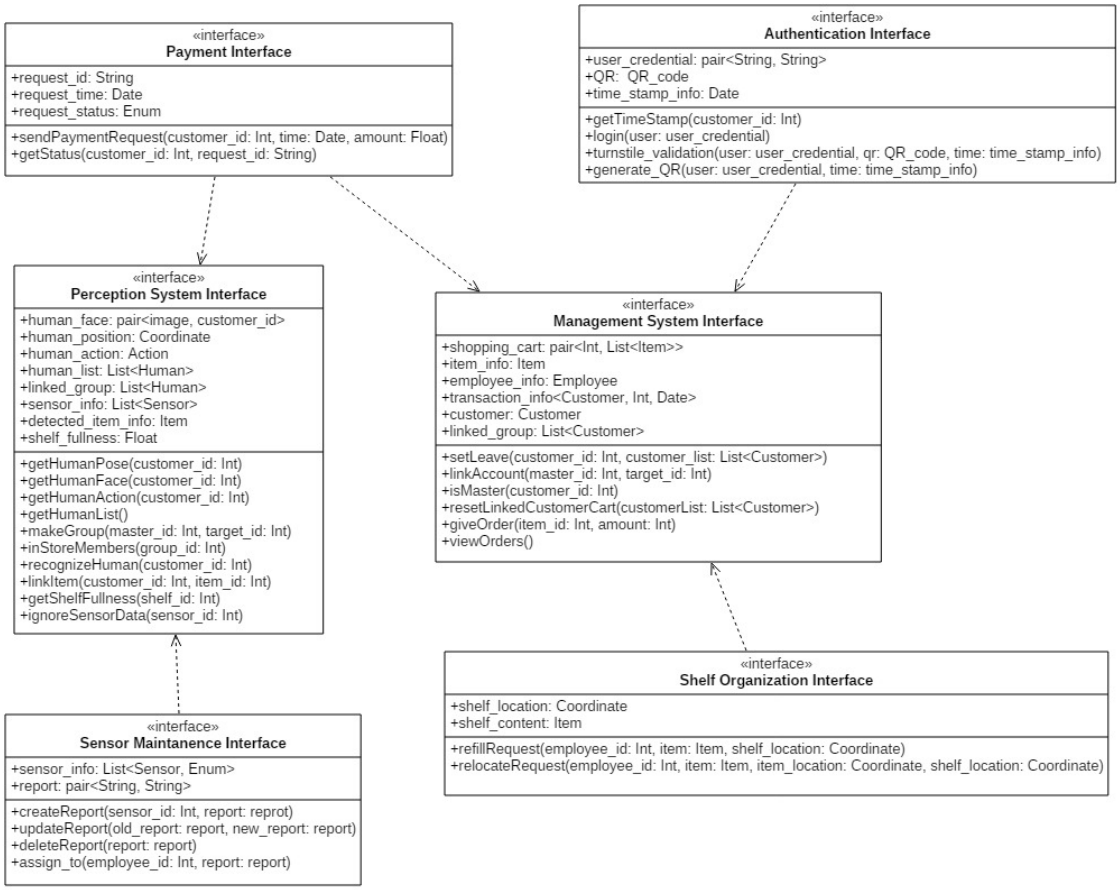

Figure 3.1: External Interfaces Class Diagram

3.2 Functions

Figure 3.2: Use Case Diagram

Use Case Name	Link Account
Actors	Customer, Management System
Description	There may be multiple users who want to pay through one account. In that case, a user can link her/his account with other users.
Data	The user account of a master user, the User account that desired to be linked with
Preconditions	User has logged in the app.
Stimulus	Linking Request by clicking create link button
Basic Flow	Step 1: App asks for login again to satisfy security requirements. Step 2: The system waits for the target customer id from the customer. The target customer id is accepted via the app. Step 3: Linking request is passed to Management System with master and target customer ids. Step 4: Validation check for target customer is made. Step 5: An acceptance message is sent to the target customer. Step 6: The shopping cart of target customer attached to the master's cart.
Alternative Flow	Step 5: If a validation check for target customer fails, the error message is shown via app to the customer. Step 6: The system turns back to Step 2 in Basic Flow.
Exception Flow #1	If a user can not log in again as stated in the first step, it is written to the Log File. Login trial number is increased by one. In case this number exceeds the predetermined number, the customer is logged out from the App.
Exception Flow #2	If the target customer denies linking request, the whole process is cancelled. Master customer is informed about the rejection of his/her request.
Post conditions	Group list with all linked users is shown to master customer via the app.

Table 3.1: Link Account

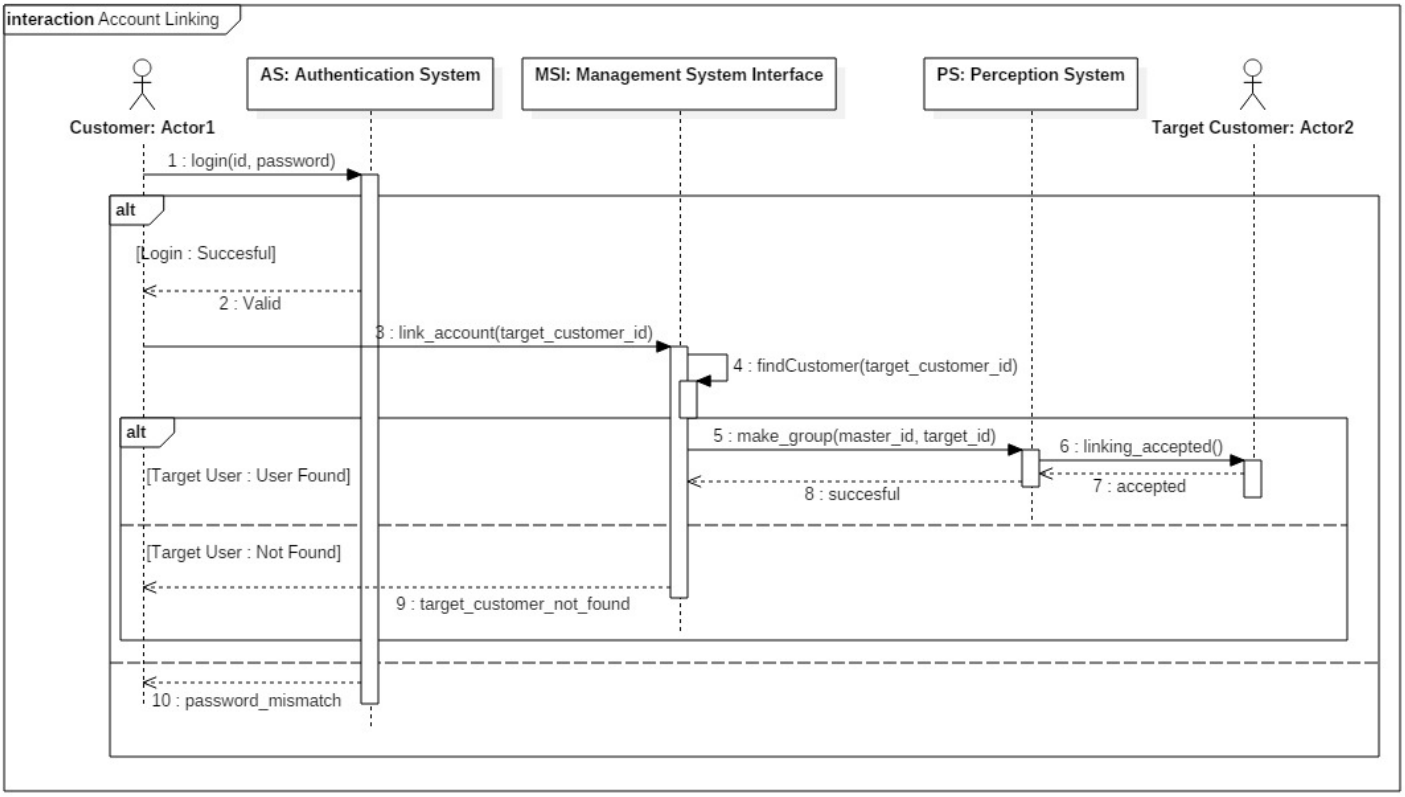

Figure 3.3: Sequence Diagram of Link Account

Use Case Name	Enter
Actors	Customer, Authentication System, Employee, Store Manager
Description	When a person decides to enter the Store, Smart METU Store sends a QR code to the app on the person's phone.
Data	Login time and date, User credentials
Precondition	Customer must be a verified customer.
Stimulus	Logging in the app
Basic Flow	Step 1: App sends an entrance request Step 2: Virtual shopping cart is created on Management System Step 3: The authentication system is awakened with customer id and date of entrance. Then, it creates a QR code with a timestamp. Step 4: Created QR code is sent to the customer via app and turnstiles with a timestamp. Step 5: Turnstile matches QR code which is on the screen of customer's mobile device with its QR database. If they match, it checks whether QR code is out of date by using a timestamp.
Alternative Flow	Step 3: If a customer is in a group and not the master of the group, the master is asked for his/her acceptance for merged payment. Step 4: Customer is notified with the response of the previous step. Afterwards, execution continues from Step 3 of Basic Flow.
Exception Flow	If the timestamp of QR code is out of date, the system asks for sending a new QR code to customer via the app.
Post conditions	When the entrance is successfully done, the app switches the shopping cart view.

Table 3.2: Enter

Use Case Name	Leave
Actors	Customer, Perception System, Management System, Payment System
Description	When a customer decides to leave the Store, Payment System is triggered to invoice.
Precondition	-
Data	Shopping Cart of the customer, User card info
Stimulus	Leave info from the Perception System
Basic Flow	Step 1: Perception System informs the Smart METU System about leave action of the customer. Step 2: Smart Metu System request invoice from Management System. Step 3: The amount taken from the invoice is passed to Payment System. Step 4: Payment System asks for payment type which can be cash or online via the app.
Alternative Flow #1	Step 5: Authentication System creates a QR code for cash payment. Created QR code is sent to the customer via the app and cash payment kiosk Step 6: Same as entrance, the customer has his/her QR code scanned to the kiosk. Step 7: Shopping cart is shown on the screen of the kiosk to the customer and waits for verification from the customer. Step 8: After the customer verified his/her shopping cart, kiosk waits for payment.
Alternative Flow #2	Step 5: Payment System directs payment request to the intermediary payment system which will handle payment request and bank interaction. Payment System can not handle this action without intermediary system since it is prohibited legally. Step 6: Stocks are decreased according to purchased items. Furthermore, the endorsement of the store is updated.
Exception Flow	Customer may not have enough money in his/her bank account or enough cash with him/her. Another case is that customer can select cash payment and just walk through. These cases are called no payment case. In no payment case, the customer is informed via the app and sent a message. Also, the Store Manager is informed with customer credentials and his/her invoice.
Post conditions	A copy of an invoice is sent to the customer via the app. In the case at least one of the purchased item has low stock, The Store Manager is notified with the item and its remaining amount.

Table 3.3: Leave

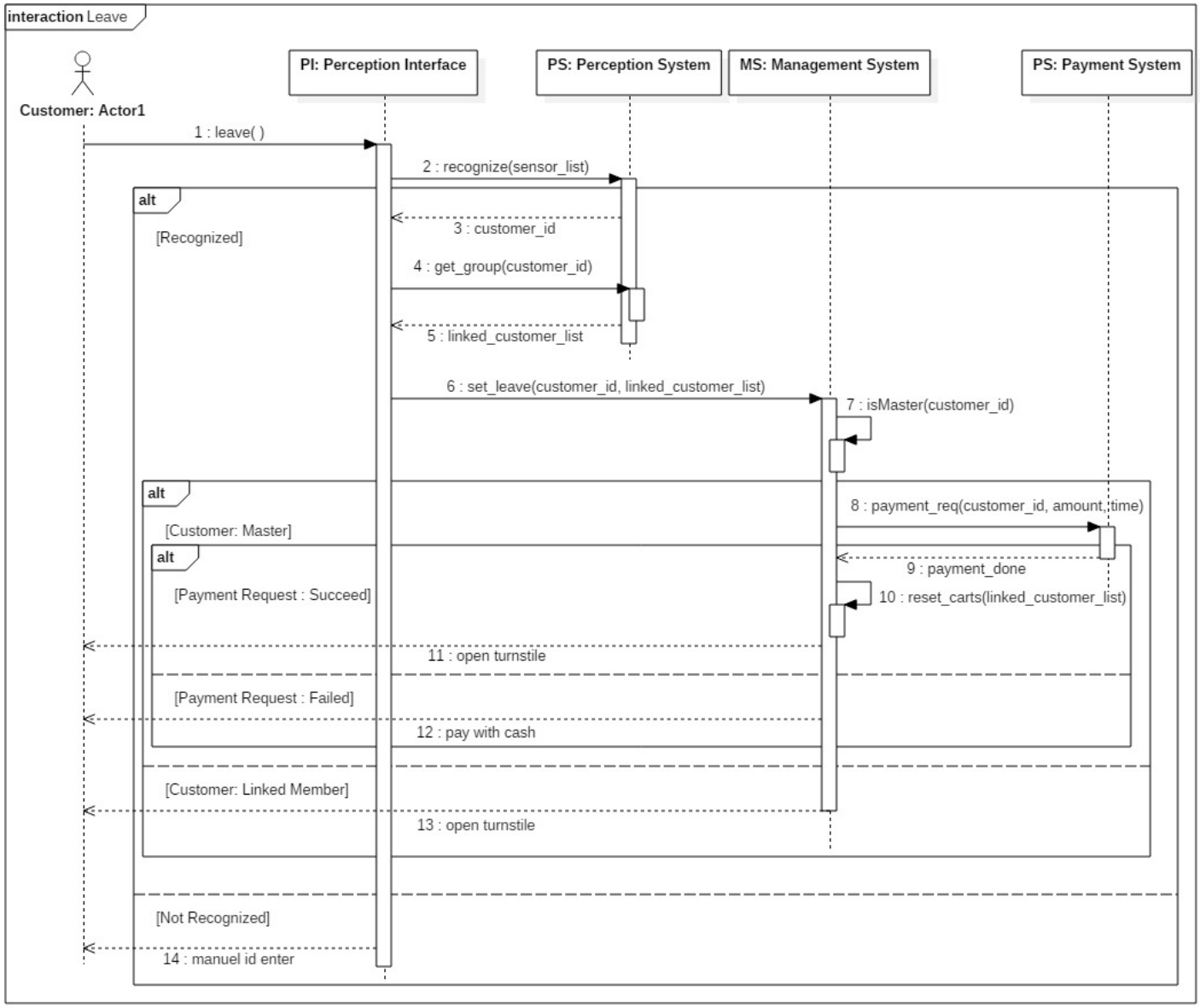

Figure 3.4: Sequence Diagram of Leave

Use Case Name	Pick Item
Actors	Customer, Perception System, Management System
Description	Customer picks an item from any shelf that he/she wants. Perception System perceives taken item. Then, it sends item info to the Management System. Finally, the Management System adds the item to the customer's shopping cart.
Precondition	-
Data	Item info, Customer info
Stimulus	Picking action detected by sensors while taking an item from a shelf
Basic Flow	Step 1: Perception system awakes the Smart METU Store with the information of customer and item that has been picked. Step 2: Smart METU Store passes that data to the Management System. Step 3: Management System adds item given by Smart METU Store to the related customer. Moreover, it returns whether the action is successful to the Smart METU Store and other additional information.
Alternative Flow #1	Step 4: If the return value of the Management System indicates that the given item is not found, Smart METU Store sends a notification to the customer via the app. After notification being shown, the app asks for manual adding for the undetected item.
Alternative Flow #2	Step 4: The app is updated with a shopping cart and the total amount.
Exception Flow	The picked item shouldn't be given to another customer. In that case, the picked item remains in the shopping cart of the first customer who has picked the item.
Post Condition	If any low amount of information is taken from the Management System, Store Manager is informed.

Table 3.4: Pick Item

Use Case Name	Place Back Item
Actors	Customer, Perception System, Management System
Description	A customer left free to put an item back where he/she wishes for.
Precondition	-
Data	Item info, Place back location
Stimulus	Human action estimator output, Sensor info that gives an item put into the shelf
Basic Flow	Step 1: Perception System awakes Smart METU Store with the information of customer and item that being placed back by the customer. Step 2: Smart METU Store informs Management System. Step 3: Management System removes the item from related customer's shopping cart and returns whether the action is successful. Step 4: Smart METU Store updates shopping cart on the app. Step 5: The Management System is updated with an increment of item.
Post Condition	In case the customer leaves item to the wrong place, Perception System takes place and makes "relocate request" which is another use case.

Table 3.5: Place Back Item

Use Case Name	Relocate Request
Actors	Perception System, Shelf Organization System
Description	It is possible to have such a situation that a customer places back an item to an undesired position in the store. Perception System detects these items. Furthermore, it sends a warning to the Shelf Organization System which will handle the Relocating Operation.
Precondition	Beforehand, Place Back Item function is called. Afterwards, Perception System checks for the item's current place, and, if it is placed wrong place, this function is called.
Data	Current location of wrong placed item, the correct shelf of the wrong placed item
Stimulus	The estimation that reveals an item is in the wrong position
Basic Flow	Step 1: Perception System notifies Smart METU Store with credentials of the item, current location of the item and correct location of the item. Step 2: Smart METU Store searches in available employees for the title "stand organizer". Step 3: List of stand organizer list is sorted by the workload of employees in increasing order. The workload for an employee is the sum of estimated times of his/her tasks. Step 4: Relocate Request is assigned to first three (or determined another number) employee from the list. Assigned three employee is notified with request. Step 5: First Employee who accepted task is assigned to the task. Assignment is recorded with its starting time, due time, description and credentials of assigned employee. Also, task list of the employee is updated with relocate task. Step 6: Remaining two employees are notified with that the task is taken.
Alternative Flow	Step 5: In case, a predetermined time for accepting task is passed and any of the picked three (or determined another number) employee has not accepted the task, the System picks the following three (or determined another number) of employees from the list. This step reoccurs until an employee accepts the task. Step 6: All employees that are asked for accepting the task and not accepted it is notified with that the task is no longer available.
Exception Flow	If the available list of stand organizer is ended and there is no employee assigned for the task, the Store Manager is warned with that situation.
Post Condition	Employees interface is updated with his/her task, remaining time of tasks and priority of tasks.

Table 3.6: Relocate Request

Use Case Name	Send Sensor Error
Actors	Perception System, Sensor Maintenance System, Employee
Description	In case, a sensor becomes non-operational, Perception System informs Smart METU Store. Then, Smart METU Store creates a report for the Sensor Maintenance System which will fix the error. Although Perception System catches errors well enough, sending error messages by employees is allowed because there are still some errors. For instance, the temperature of a refrigerator sends incorrect values to the Perception System. One way to catch that is by observing the melting. This is an insuperable problem for the Perception System. At that point, catching the error is the responsibility of the employee.
Precondition	The sensor is not reported as non-functional. If so, this request is not created.
Data	Non-operational sensor identity, Error description
Stimulus	Connection loss or data loss that belongs to a sensor, "Create Sensor Error Report" button in the employee app
Basic Flow	Step 1: Perception System directs sensor id, sensor location and sensor type of the non-functional sensor to the Smart METU Store. Step 2: Smart METU Store decides the priority of error by using the predetermined impact of the sensor in perception, a number of items that are non-functional in near area and type of error. Step 3: Smart METU Store sends a report to Sensor Maintenance System with sensor credentials, error time, error type, error time and priority of sensor. Step 4: The error instance is kept in the system until it is fixed and whenever the due date is close it notifies Sensor Maintenance System and Store Manager.
Alternative Flow	Step 1: An employee sends sensor error report via the employee interface. The report contains sensor id, sensor location and sensor type of the non-functional sensor. Execution continues from Basic Flow Step #2

Table 3.7: Send Sensor Error

Use Case Name	Refill Shelf Request
Actors	Perception System, Shelf Organization System
Description	To maintain service at the store, shelves must be refilled when they are empty or not far away from being empty. Sensor data taken from shelves are used to sense this case. As a result, the Perception System sends “Refill Request” to the Management System.
Precondition	Sensor group that is creating this request must be functional. In other words, if a few sensors in the group is reported to Sensor Maintenance System and Smart METU Store still has an open issue for these sensors, the request is not processed.
Data	Shelf identity, Fulfillment of the shelf
Stimulus	Low item signal comes from a shelf
Response	Report of request that contains which item will be refilled with the amount of it and shelf identity, Validity of the request
Basic Flow	Step 1: Perception System sends Refill Request with the information that consists of shelf location and type, item credentials and amount of item. Step 2: METU Store checks the item whether it is in the stock via Management System. This is called the validity of the request. If so, the METU Store notifies Shelf Organization System to refill. Step 3: Smart METU Store searches in available employees for the title "stand organizer". Step 4: List of stand organizer list is sorted by the workload of employees in increasing order. The workload for an employee is the sum of estimated times of his/her tasks. Step 5: Relocate Request is assigned to first three (or determined another number) employee from the list. Assigned three employees is notified with a request. Step 6: First Employee who accepted task is assigned to the task. An assignment is recorded with its starting time, due time, description and credentials of the assigned employee. Also, the task list of the employee is updated with relocate task. Step 7: Remaining two employees are notified with that the task is taken.
Alternative Flow	Step 6: In case, a predetermined time for accepting task is passed and any of the picked three (or determined another number) employee has not accepted the task, the System picks the following three (or determined another number) of employees from the list. This step reoccurs until an employee accepts the task. Step 7: All employees that are asked for accepting the task and not accepted it is notified with that the task is no longer available.
Exception Flow #1	If the available list of stand organizer is ended and there is no employee assigned for the task, the Store Manager is warned with that situation.
Exception Flow #2	If the validity of the request returns false, i.e. item is out of stock, Management System is responsible for ordering the item. Smart METU Store notifies Store Manager to take action.
Post Condition	After refill request is done, the employee states that. The amount of the item in the shelf is updated.

Table 3.8: Refill Shelf Request

Use Case Name	Set Price
Actors	Store Manager, Management System
Description	Store manager set new prices for items whenever he/she wants.
Precondition	Store Manager is logged in the Management System.
Data	Item description, New price
Stimulus	Selecting a new price in the management application
Basic Flow	Step 1: Store Manager asks Smart METU Store to set the price of an item. He/she selects an item from a list or gives item id. Step 2: Smart METU Store calculates the percentage of the change in the price. Step 3: If change is small in the percentage, Smart METU Store sends a request to the Management System. Step 4: After Management System is updated, Smart METU Store asks Management System for customers who are currently in the store and has already picked that item. Also, Smart METU Store request shopping cart update for the customers in the response. Step 5: Smart METU Store updates shopping carts on the app of customer who is in the return of Step #4.
Alternative Flow	Step 3: If change is big in the percentage, Smart METU Store needs to log in again by the Store Manager. Step 4: If the action is discount execution follows Basic Flow Step #4. Otherwise, if the action is marking up the price, the customers in the return of Basic Flow Step #4 purchase that item with the price when they have picked the item. Furthermore, the old price is in use until the end of this Alternative Flow. Step 5: An employee is notified to change the price tag on the shelf, which has high priority.
Exception Flow	If the Store Manager logged in and tries to make a big change in price and then fails to log in again, the Store Manager has 2 more chances. Setting price is banned for a while in case of no remaining trial.
Post Condition	If there is a discount, a message that informs customer in the store is sent.

Table 3.9: Set Price

Use Case Name	Order
Actors	Store Manager, Management System
Description	Store Manager orders items.
Precondition	The Store Manager is logged in the Smart METU Store
Data	Item description, Order amount
Stimulus	Clicking the "Order" button in the management application
Basic Flow	Step 1: Store Manager selects an item to order and decides the amount of it. Step 2: Order request passed to Management System and is checked if the item exists. After the item is found, the amount is also checked. The amount is limited by predetermined capacity. For instance, the Store Manager can not order more than warehouse capacity. Step 3: Management System returns that it is ready for order. Step 4: Smart METU Store asks for Store Manager to log in again to meet with security requirements. Step 5: Smart METU Store confirms the order and sends confirmation info to Management System. Step 6: Management System handles the order and returns a copy of the invoice to Smart METU Store. Step 7: Store Manager is notified that order is done.
Alternative Flow	Step 3: If the item is not found or amount is higher than the threshold, Smart METU Store warns the Store Manager. Execution restarts with selecting the item to order and amount.
Exception Flow	If security requirement does not meet, System locks ordering for a while and asks for restarting password.
Post Condition	Warehouse employees are notified with the order so that design warehouse appropriately.

Table 3.10: Order

3.3 Usability Requirements

1. Smart METU store mobile app shall be only usable to member customers by logging into the system with their credentials.
2. Customer shall be able to view own account information through the app.
3. Customer shall be able to change payment credentials in the app which will ask current password to verify before the change.
4. Mobile app should support both Turkish and English.
5. Up-to-date item information with the item search field should be provided to customers in the mobile app.
6. When in the background, the mobile app should send push notifications to the phone's notification panel.
7. While the QR code is shown on the phone, screenshot option should be disabled.
8. Customer should be able to export bill as pdf or jpeg.

9. Employees should be able to view shifts assigned them and other information in chronological order by default which can be changed to "sort by importance" and requires dynamic page in the interface that updates automatically.
10. Store manager should be able to use sliders in the interface to set new prices or order amounts, tick boxes to order multiple items and big buttons to submit and save their request.

3.4 Performance Requirements

1. Smart METU Store system shall be able to host more than 30.000 users at the same time.
2. Smart METU Store mobile app should response to touchscreen inputs in 500ms.
3. Information about purchase should be sent to the mobile app in 20 minutes after the customer leaves the store.
4. In case of electricity cut-off, emergency power unit shall start within 2000 ms.
5. System backend shall have at least 3 Gbps bandwidth with upload/download speed higher than 1 Gbps.
6. Face detection should be work real-time without more than 1-2 second delay.
7. Mobile app should receive a response no more than 5 seconds after the request has been sent.

3.5 Logical Database Requirements

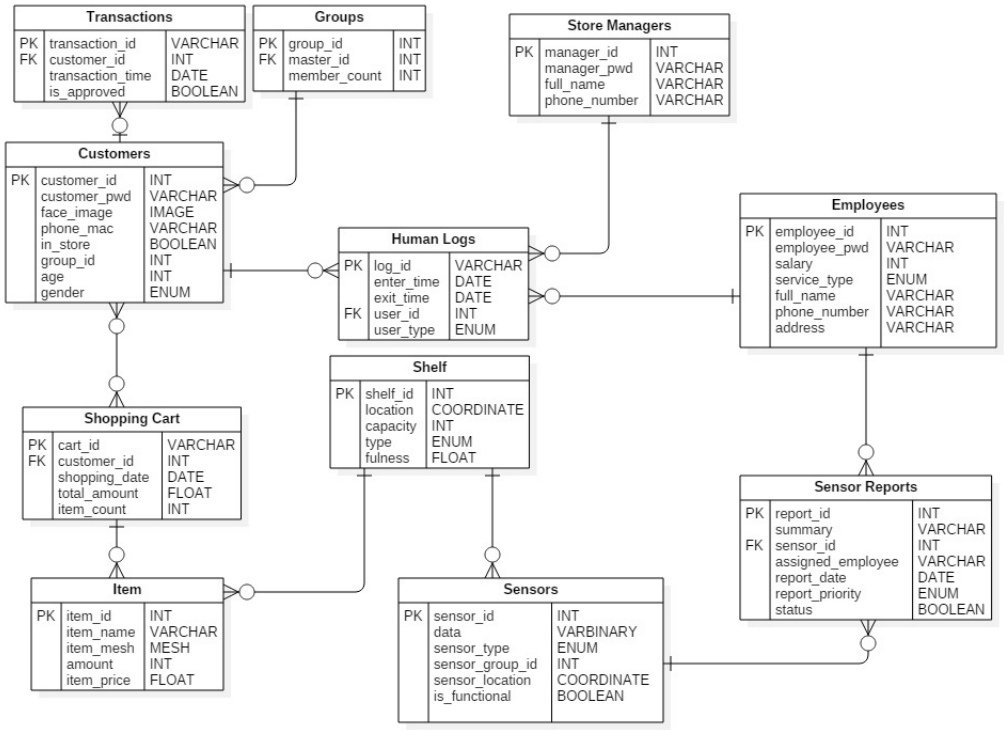

Figure 3.5: Logical Database Diagram

1. Each entrance and exit of a human should be kept in Human Logs class with a specific log_id.
2. Customers who are not in a group shall have -1 as group_id.
3. Shelves should have location as COORDINATE type and each COORDINATE in the store for shelves are unique. There can be a shelf above another shelf, that located using same x and y coordinates. Therefore, COORDINATE should have additional axis "z" which defines volume to occupy a space in COORDINATE type and avoids overlapping shelf problem.
4. To meet with security requirements, customer_pwd, i.e. the password of a customer, should be kept encrypted.
5. Shopping Cart for a customer may have many item instances and the count for that item should be kept in Shopping Cart table as item_count.
6. A customer should have a unique Shopping Cart instance for each entrance to the Smart METU Store.
7. A Shopping Cart can include items for more than one customers. Therefore, a few customers may be related to only one Shopping Cart that is common for all group members. Nevertheless, each member of a group still has a unique Shopping Cart.
8. Smart METU Store may have more than one Store Manager and their credentials should be in Store Managers table.
9. Only Store Manager/Managers should be allowed to view and search in Employees table by using their interface. Additionally, only Store Manager should be able to add new employees to the Employee table and set their salary.
10. Store Manager shall manipulate the Item table in case of adding an item into the store or removing an item from the store. Moreover, he/she should be able to change the price of an item.
11. Sensor Reports table shall be edited by Employees and Perception System.
12. Sensor reports should be ordered by their *report_priority*.
13. Each sensor shall have a unique *sensor_id* to identify.
14. Store Manager should edit Sensors table and Shelf table to add a new sensor to a shelf. In another case, the Store Manager shall add a new shelf with its sensors and items on it.
15. Customer_id and time of each transaction shall be stored and operation status should be approved which should also be saved as boolean.
16. Database backup shall be done 2 times a day.
17. Only the customer with master_id can add or remove members to the group by using the mobile app.
18. At the end of each week, reports with finished status shall be removed.
19. Sensor data shall be kept as VARBINARY since INT or LONG types are short data types to keep data from sensors. VARBINARY provides to store sensor data as a sequence of binary characters. Since we use different kinds of sensors, data can be divided into different classes when VARBINARY is used.
20. For each item, item mesh shall be stored. This will be used for the 3D segmentation and object detection.
21. An entry to the Customers table shall be added when a customer creates Smart METU account and the validation for the account is approved. Moreover, if the customer deletes his/her account, the table should remove that customer.
22. Groups table must have "on delete cascade" policy since whenever the master is removed from Customer table group becomes invalid.
23. An entry of Transactions table shall be stored for 2 years after the entry is created.

24. An entry of Human Logs shall be stored for 2 years after the entry is created since Transactions and Human Logs are highly related in terms of legality and preservation of rights.
25. Because of the fact that each employee may have different responsibilities such as IT, shelf_refilling, employee table should keep service_type of each employee as ENUM to indicate divisions.

3.6 Design Constraints

1. All the shopping sessions shall be stored for legal purposes at least for 2 years.
2. For face detection, customer face photos shall be saved to train object recognition model. Customer shall be notified regarding the issues and be informed that his/her photos are stored for technical and legal reasons.
3. The system shall follow all the regulations that are forced by the law.
4. Credit card credentials shouldn't be saved directly on the METU Store system.
5. All customer information shall be kept private and cannot be subject to any trade.

3.7 Software System Attributes

- **Reliability**
  - Shopping logs should be backed up to keep safe every day at 02.00 am.
  - Comprehensive testing shall be done before the releasing of the system. Result of the testing error shouldn't exceed 0.002.
  - Employees responsible for sensor maintenance shall review and handle errors hourly to ensure reliability.
- **Availability**
  - System shall be available to users as long as they have the app and are connected to the Internet.
  - Preferred downtime for maintenance shouldn't exceed 1 hour.
  - Minor failures such as failed shelf sensor shouldn't affect main operations such as perception, payment etc.
  - If the system is restarted, it should become available after 5 minutes.
- **Privacy & Security**
  - Databases that are used in the Management System shall be durable to any database injection attacks.
  - All the customer, employee and store manager information shall be private.
  - As a precaution, by using checksum calculations, Smart METU Store system checks the integrity of transmitted messages which are hashed, and suspicious actions shall be reported immediately.
  - Connections between external and internal systems shall be in secured channels.
  - Customers shall agree on the End User Agreement to take precautions for user-related issues. By agreeing that, the customer will be responsible for his/her activities.
  - Password variables in the database shall be encrypted.
- **Maintainability**
  - Detailed documentation of the Smart METU System shall be done within the frame of international standards to reduce the adaption period for new employees.

  - Documentation should be clear and understandable when referenced by employees to provide fast recovery for problems.
  - System shall use modular design to increase maintainability.

- **Portability**
  - Smart METU Store mobile app shall be available for different mobile phones. (i.e. not hardware dependent)
  - Smart METU Store mobile app shall be available for different operating systems. (e.g. Android, ios and other mobile OS's)
  - Libraries that are available for more than one programming language shall be preferred during the implementation of Smart METU Store System.

3.8 Supporting Information

Smart METU Store is a partially-automated system, with customers being able to purchase products without using a cashier or checkout station. It is a visionary project that uses state-of-art perception technology which consists of computer vision, sensor fusion and deep learning. This technology can detect when products are taken or returned to the shelves and keeps track of them in your virtual cart. As a promising feature when compared to normal stores, after a customer leaves the Smart METU Store with his/her goods, Smart METU account is charged and the receipt is sent. All in all, it provides a unique experience to the customers and accelerates the METU's campus life transition to automated systems that will save more time.