Software Requirements Specification

Version 1.1

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Revision History

Version	Date	Explanation
1.0	04.03.2020	Initial use cases are determined. Context diagram is drawn. Project purpose, scope and general information is added.
1.1	13.03.2020	Rest of the document is prepared. Some of use cases are rewritten.

Table 1: Change History

1 Introduction

This document is the Software Specification Requirement (SRS) of a smart store implementation which is Amazon Go, developed by Amazon. Currently, there are 25 Amazon Go stores in the world, and new stores will continue to be opened in the near future. The website for this system and its support systems is https://www.amazon.c
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1.1 Purpose of The System

The purpose of this project is to establish a cashier-less-store concept that allows customers to pick out what they need and simply walk out the door without waiting in lines or check-outs. Thanks to Just Walk Out Shopping which is a concept provided by Amazon Go, employee cost (cashiers and other store staff) and inventory counting / out of stack scanning cost of stores decrease, and people can save their time spending in queues.

1.2 Scope

In the scope of this system, users are able to make their shopping without cash and checkout. To accomplish this, users download the Amazon Go mobile application to their smartphones, register to the system, add their credit cards, and use unique application created QR Code to enter the store. Also, this mobile app has an interface to show the names, amounts, and prices of products in the customers' baskets.

In stores, there are turnstiles that are opened when customers scan their QR codes. During their shopping, cameras and sensors track the customers to identify products in their baskets. When users leave the store, the total amount of payment is withdrawn from the users' registered credit cards automatically.

In this fully automatic system, tracking customers will be done with the help of computer vision, sensor fusion, and various deep learning technologies. In the case of the "Can Not Decide" event (for more explanation refer to Definitions section) which the system cannot define which product is selected, Amazon Go IT staff will intervene and detect the product, these cases will also be recorded.

All of this transaction information of customers, inventory information, items identification lists and "Can Not Decide" events will be recorded in a database service which is called Amazon Relational Database Service. They will be used to improve machine learning, deep learning, and computer vision models.

Amazon Relational Database Service is a service provided by Amazon, and it is used for database requirement and it is out of the scope of this Software Requirement Specification document.

Therefore, the main applications of the system are:

- Mobile Application
- Sensors Management System
- Camera Management System
- Inventory Management System

1.3 System Overview

This section of the document will provide detailed information about the system including all components.

1.3.1 System Perspective

Amazon Go is not a part of a large system. However, it interacts with other services such as Amazon Web Services, Retail Payment System of various banks in order to achieve the cashier-less-store concept. Customers shall download and use the Amazon Go mobile application to enter the store and purchase products.

The interface that customers use during shopping is provided by Amazon Go mobile application. All customers shall download this mobile application to their smartphones in order to do shopping at Amazon Go stores. Also, the system provides different interfaces for store workers, store managers, and IT staff. Besides these interfaces, the general system uses sensors and camera management systems to get data that is used for identifying customers choosing products, inventory management systems to record transactions and system event logs, online retail payment systems of various banks for automatic payment.

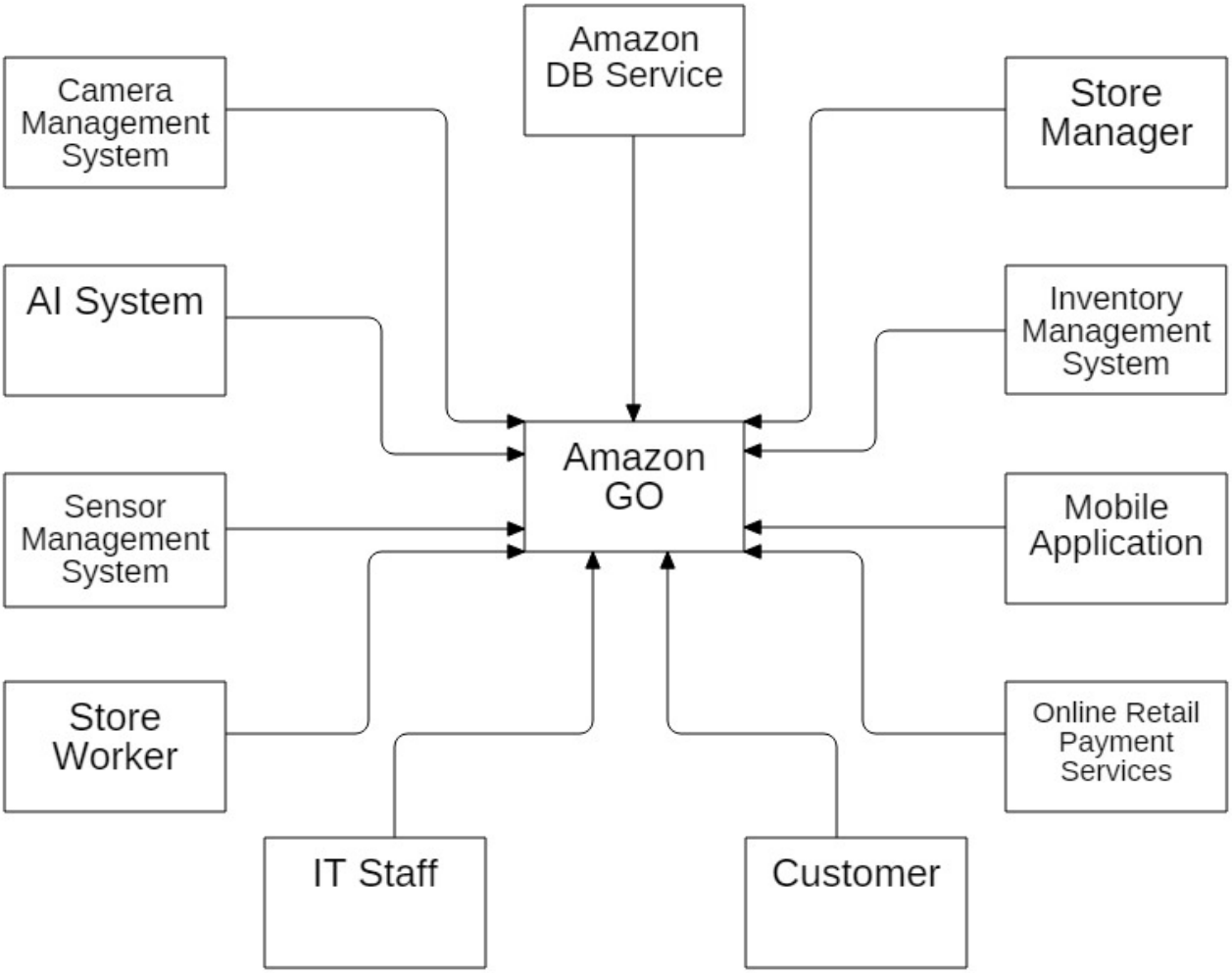


Figure 1: Context Diagram

1.3.1.1 System Interfaces

- **Camera Management System:** In the Amazon GO stores, customer-selected items are identified by the help of sensors and cameras. This camera management system provides control of all cameras in the store, sends pictures and video records to the Amazon Go system. Moreover, this system gives status information about each camera. If there is an error in a camera, this system sends an error message to the main system.

- **Sensor Management System:** Shelf located sensors help to identify customer selected products. Similar to Camera Management System, it also provides control and management functionality of sensors to the main system. Signals of shelf located sensors such as weight sensors and light sensors will be sent through this interface.

- **Inventory Management System:** This system is used for inventory of each store. When a product is sold or refunded, this system updates the amount of this product. Also, there is a quantity limit for each product. If the number of products in the shop is less than its limit, it notifies the system. Moreover, outdated products' information is sent by this system.

- **Online Retail Payment Services:** This service is used for automatic payments. Amazon GO system uses this service to withdraw the total price of products from preregistered credit cards of users.

- **Database Management Interface:** This interface is for management Database Service which is called Amazon Relational Database Service. One of the main system services is Database Management Service because all transactions of customers, system logs, inventories of stores, prices of products, registered credit cards, and system user information are recorded in it. Also, unsuccessful and successful product identification events are recorded in order to improve artificial intelligence models.

- **Mobile Application:** This system is used for delivering end user interfaces, automatic turnstiles, creating QR codes, and customer accounting managements. Although all customer interfaces provided by this mobile application, it is also a system interface for customer market mechanism. In this mechanism, customer-selected products are identified, and they are sent to the mobile application with their amounts and prices to inform customers.

- **AI System:** This system interface is the core of the Amazon GO system. It is the main part of identifying customer selected products. It uses different machine learning, data fusion, computer vision algorithms. This system follows the customer from the moment he or she enters the store, monitors the interaction with the products and decides whether he or she has bought the product. Also, this system trains itself with new cases.

- **CND Events Management Interface:** This system is used for the management of CND events (refer to the Definitions section). When a CND event occurs, this system sends all information coming from sensors and cameras to the IT staff interface.

- **Google Maps API:** This system is used for showing the all Amazon GO stores in the world. Thanks to Google Maps API, users can see their locations, and other Amazon GO stores near them in the user interface (check 1.3.1.2 for details).

1.3.1.2 User Interfaces

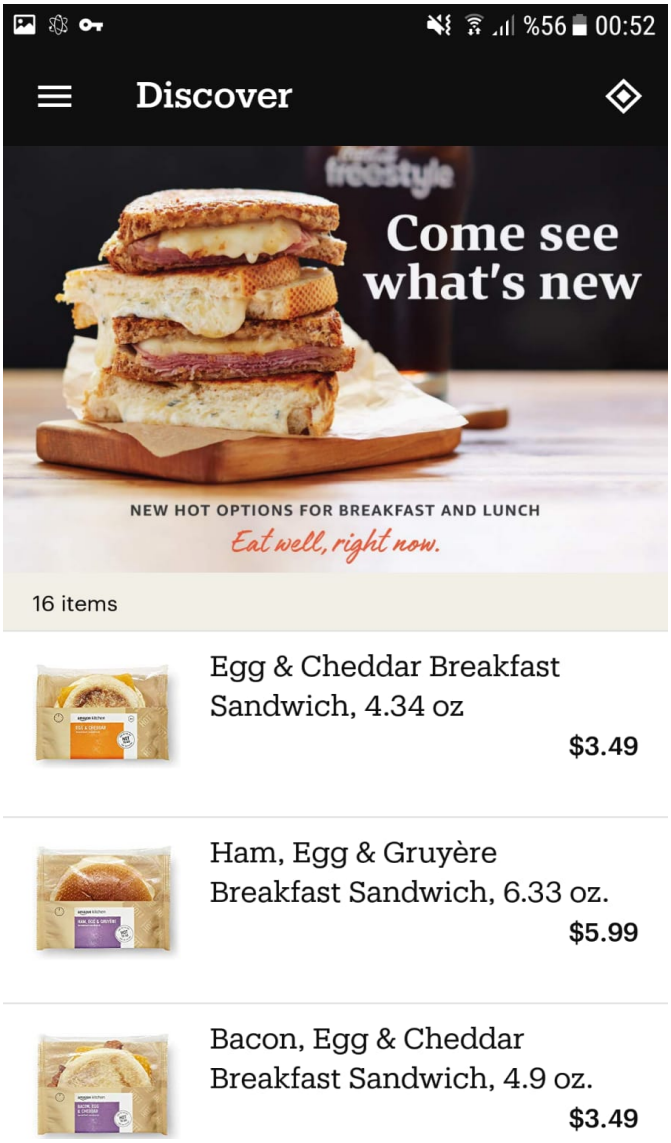
Customers who want to use Amazon GO stores shall download and install Amazon GO mobile application to their smartphones. Moreover, they should add their credit cards to the system. The reason for this is that the system uses this application in entering, product identification, and payment process automatically. Turnstiles in the entrance of store scan customers' QR codes which is created in the mobile application for each user. After entering the store, users can put their smartphones into their pockets or bags because all identification and payment processes don't need the mobile application. However, the customer basket is shown and updated in the mobile application screen anyway. Lastly, users are shown the quick introduction of the system when they login to the system for the first time. In addition to the mobile application, there are separate interfaces for IT staff, store managers, and store workers.

- **Registration Interface:** The system doesn't have any specific registration interface for end users. Simply, it uses the general Amazon accounting system. This means that any user has already registered in the any Amazon services can use this account to sign in the system. Unregistered users should use the Amazon registration page. Therefore, if an unregistered user

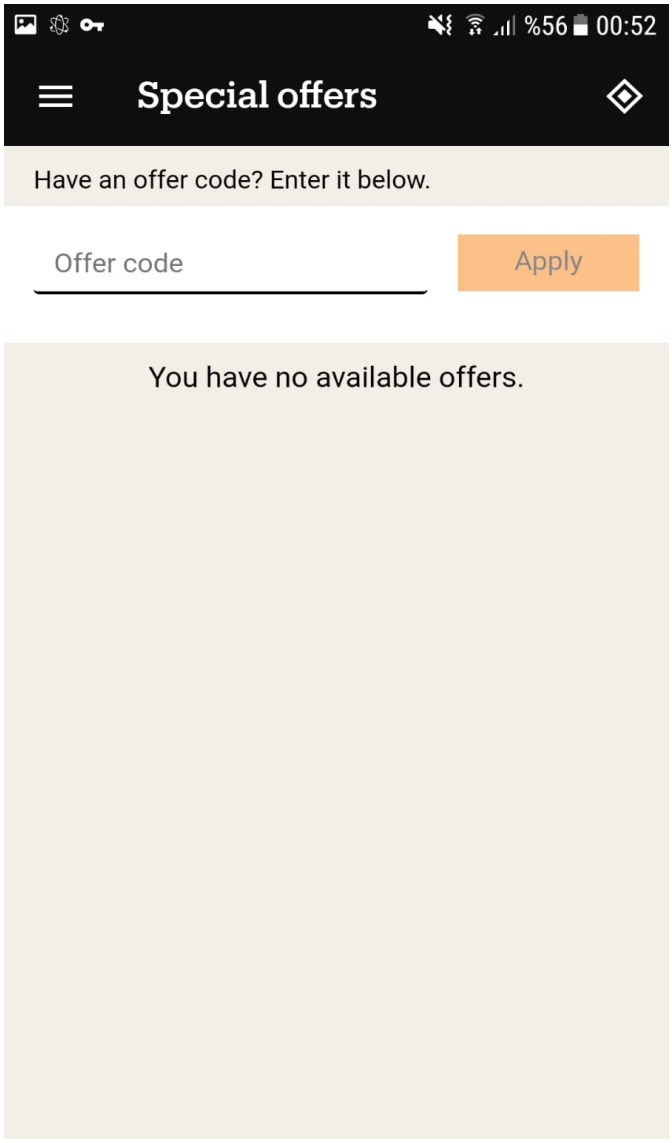
Figure 2: Quick Introduction to System

touches the **Create your Amazon Account**, the interface redirects the user directly to the Amazon registration page. In order to complete the registration step, users shall add a credit card to their accounts.

- **User Interface:** Customers use the interface in order to enter the store. After signing in the system, a personal QR code is shown. After a while, this QR code is refreshed for security reasons. Users can see the locations of stores in the Google Map. Moreover, the system shows the selling products and their prices for a selected store. There are also interface sections for all past receipts, discount code, application settings, replay for a quick introduction, help, and contact. While doing shopping, users also see their baskets through this interface.

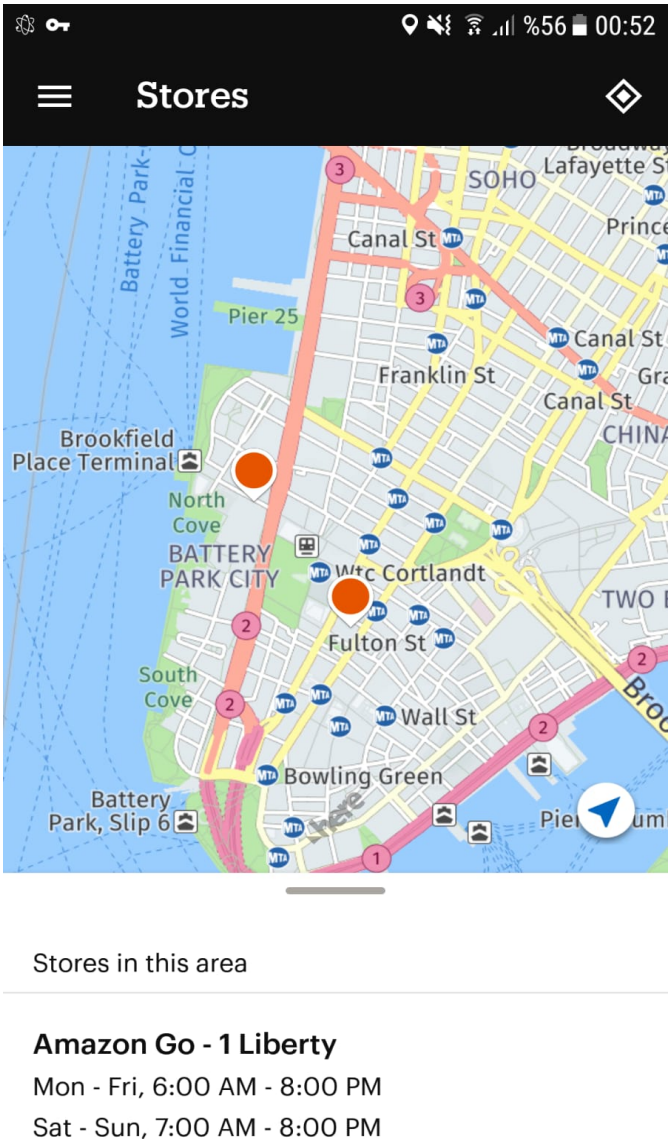


(a) Product Lists

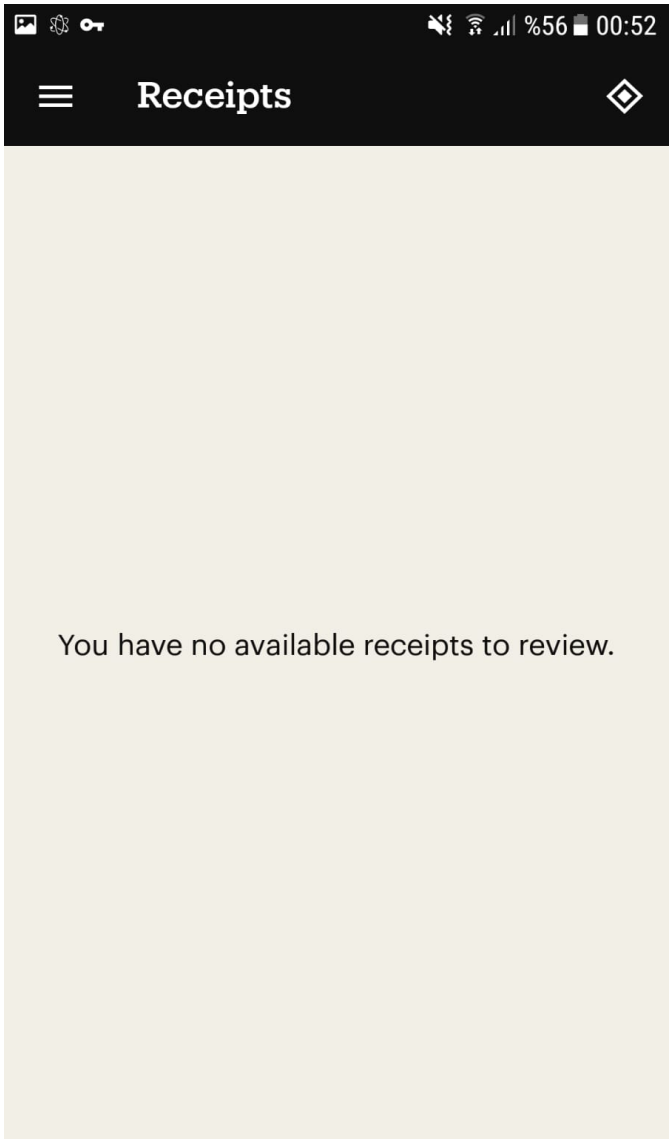


(b) Discount Code Submit Section

Figure 3: Discount Code and Product Lists Section



(a) Store Locations



(b) Past Receipts

Figure 4: Store Locations and Receipts Section

- **Store Worker Interface:** System provides an interface for store workers. In the store, one of these workers' responsibility is arranging the shelves. Therefore, the store locations of products left in the wrong places by customers are marked in the store map, and this information is provided to store workers. After rearranging these products, they can approve items locations through this interface. Also, they can open a temporary customer account, and see outdated products and products that are not on the shelves using the interface.

- **Store Manager Interface:** Store manager interface has similar capabilities like store worker interface but has more additional features. Managers can apply discounts on some products in the store, submit new products to stocks, see daily sales of the store and see the damaged or broken sensors and cameras in the interface.

- **IT Staff Interface:** IT Staff interface is used for checking logs and errors. When a CND event occurs, IT Staff is informed from warning tabs. Then, he or she identifies a CND, solves the issue, and adds this event's details to the database, and AI models to train the system more accurately. They can also reach the database, and Amazon GO stores' systems through this interface.

1.3.1.3 Hardware Interfaces

The system requires a smartphone from their users because provided services are supported by only smartphones. Moreover, Amazon Go stores have several sensors and cameras in their stores. These sensors include light sensors, weight sensors, color sensors, movement sensors, etc. Cameras that are used in stores support computer vision technologies. Also, turnstiles that open after validating customers and payments are mechanic components of the system. In order to communicate with the main system and getting instructions, all of these devices are connected to the Internet. To achieve this connection, sensors, turnstiles, and cameras are parts of WSN. Therefore, the wireless module devices are required. ZigBee wireless transmission modules are used for this purpose.

1.3.1.4 Software Interfaces

- **Database:** Logs, CND events, transactions, any events that help to train models, products and their properties are held in Amazon provided database.

Figure 5: Cameras and Sensors

- **Payment Services:** Payment services contracted with banks are used for automatic payment. The linkage between this service and the main system handles the payment of customers.
- **Operating Systems:** Different operating systems are supported. For Amazon GO mobile application, there are different distributions for Android, iOS, and Windows Phones. Also for sensors and cameras, applicable embedded device operating systems are used.
- **Google Maps:** It is used for displaying users' and stores' locations in a world map.

1.3.1.5 Communications Interfaces

The mobile application uses the HTTPS protocol for communication with the backend system. HTTPS protocol encrypts the internet packets to avoid the MITM attacks. With the help of HTTPS, users' credentials, shopping information, and credit cards information cannot be seen by network packet analyzers. Also, some ZigBee protocols are used to decrease power consumption and increase efficiency for WSN.

1.3.1.6 Memory Constraints

Memory constraints are not a big deal for the Amazon GO system. For users, small storage in their mobile phones is required for the size of the mobile application. Sensors in the stores have enough capabilities to store sensor data until the data is acknowledged by the main system.

1.3.1.7 Operations

The operations of Amazon GO system can be partitioned into:

Customer Operations:

- Entering store
- Pick a product
- Release a product

- Show Past Receipts
- Use promotion code
- Exiting store
- Registering a credit card

Mobile Application Operation:

- Qr code timeout
- Get location information

IT Staff Operation:

- Show CND events
- Solve CND events

Store Manager Operation:

- Apply discount to product
- Show hardware status of store
- Submit new products
- Show daily sales

Store Worker Operation:

- Show disorganized products
- Open temporary accounts
- Show outdated products
- Receive notification of empty shelves

Camera Management System and Sensor Management System:

- Control the hardware of devices
- Sending sensor data

Amazon DB Service:

- Recording events
- Recording product attributes

All details of these operations are in the 3.2 Functions section.

1.3.2 System Functions

Function	Summary
Entering store	Every store has turnstiles in their entrance and customers can enter the store by scanning their unique QR codes received from their mobile applications. After scanning, if the system identifies QR code, turnstiles are opened.
Exiting store	Customers can exit stores when turnstiles in the exit of stores are opened. When exiting is happened, the AI system determines the customer who has left in order to complete shopping by withdrawing the total price from the customer's credit card registered in the system.
Release a product	If a customer releases a product, the AI system determines which customer releases which product in order to delete it from the customer's basket.
Pick a product	To add a product to a customer's basket, the AI system in stores must determine which product picked by which customer.
Show past receipts	Users can see their previous shopping in detail in their mobile applications.
Registering a credit card	Users can add credit card information to their accounts.
Receive notification of empty shelves	If a shelf becomes empty, the AI system detects this situation and informs store workers to put new products to empty shelves.
Show disorganized products	When a product is put on a wrong shelf, the AI system detects this situation and informs store workers to put the product into its shelf.
Open temporary accounts	Store workers create temporary accounts for customers who are not registered in the system to do shopping.

Show outdated products	Inventory management system has information about products' expiration date and if a product becomes outdated, store workers are notified.
Show daily sales	Store manager can see daily sales of the store from Amazon DB service.
Apply discount to product	Store manager can apply a discount to products in the store and he/she saves it in Amazon DB service.
Submit new products	Store managers submit new products' information into the inventory management system.
Show hardware status of store	Store manager can see the status of sensors, cameras that compose the hardware of the store.
Solve CND Events	IT staff solves CND events when he/she is notified and sends the situation to the AI system.
Show CND Events	IT staff is notified when a CND event happens.
QR code timeout	QR code is refreshed in the mobile application when determining time is up.
Location Information	Locations of customers and Amazon GO stores' can be seen in the mobile application.
Sending sensor data	In order to track customers, sensor data is sent periodically.

Table 2: System Functions

1.3.3 User Characteristics

There are four main users of the Amazon GO system which are customers, store workers, store managers, and IT staff.

Customers are the people who want to do shopping in Amazon GO stores. They are required to be registered in the system before shopping in order to be identified by the system in stores. They have accounts in the mobile application of Amazon GO. Therefore, they will need to have basic smartphone skills.

Store workers are responsible for helping customers and organizing shelves. They need to have good communication skills, know the system in detail and be able to use the mobile application, their interface, and the computer.

Store managers are authorized people for their stores. They should have good management skills such as having economic knowledge, calculating incomes and

outgoings to increase revenues and manage their stores properly. Moreover, like store workers, they should know how to use the mobile application, their interface, and computers.

IT staff are in charge of solving technical issues. Therefore, having high computer skills, knowing the system well and producing appropriate solutions to improve the system are essential for them.

Finally, English knowledge is required for all users, because Amazon GO mobile application is in English and all stores are located in the USA.

1.3.4 Limitations

- **Regulatory Policies:** The system holds critical personal data of customers such as credit card information, email addresses, shopping habits. Therefore, the system shall not leak this data and shall store this data as encrypted.
- **Hardware Limitations:** Amazon GO stores detect user-selected products with processing sensor and camera data. Therefore, these hardware devices shall send data to the system without any delay. For customers, internet connected smartphone which Amazon GO app is installed in is enough.
- **Interfaces to other applications:** Amazon GO system shall be compatible with database web service, hardware management system, and smartphone operating systems for each customer.
- **Parallel Operation:** Parallelization is the most vital part of the system because all customers in the stores shall be tracked. Therefore, the AI system functions run concurrently for each customer.
- **Audit Functions:** Payment operations will be done via Online Retail Payment Services.
- **Control Functions:** All control functions are reachable for only IT staff, and it requires necessary privileges.
- **Higher-order Language Requirements:** For mobile application interface, React Native programming language is chosen because of its cross-platform support. The main system is written in Java, and sensor components are written in microprocessor specific assembly.

- **Signal Handshake Protocols:** Mobile application uses HTTPS protocol for sending and receiving information from the webserver. Also, WSN uses ZigBee communication protocols.
- **Quality Requirements:** IT Staff update and take backups of the system regularly. Network and application penetration tests are performed by both Amazon and third-party information security consulting firms.
- **Criticality of the application:** Failures cause financial loss. Therefore, any system failure shall be solved rapidly.
- **Safety and security considerations:** Account and credit card information are protected by Amazon IT Staff. The whole system is regularly tested against attack vectors.
- **Physical/Mental considerations:** Physically/Mentally disabled people can use Amazon GO stores with the help of store workers.

1.4 Definitions

Term	Definition
AI System	Artificial Intelligence System. It includes computer vision algorithms, machine learning algorithms and many more. It is responsible for detecting customer movements in the GO Stores.
CND Event	Means Can Not Decide Event. AI system is not able to detect some situations. In this case, these events are called CND events and they are sent to IT Staff.
DB Service	Means Database service. It is provided by Amazon Relational Database Service.
API	Application Programming Interface
WSN	Wireless Sensor Network. It provides communication to sensor devices.
IT Staff	Information Technology Staff

Table 3: Definitions

2 References

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

29148-2011 - ISO/IEC/IEEE International Standard - Systems and software engineering – Life cycle processes –Requirements engineering.

Other sources:

Amazon Go Editorial Staff (2017). *Amazon Go*. URL: https://www.amazon.com/b?node=16008589011.

Focal Systems (2019). *Analysis of the Amazon Go Platform and Its Implications on Large Format Grocery Stores*. URL: https://medium.com/focal-systems/analysis-of-the-amazon-go-platform-and-its-implications-on-large-format-grocery-stores-727d9b25f04a.

3 Specific Requirements

3.1 External Interfaces

Following class diagram represents the relationship between interfaces and their functionalities. For explanation of interfaces, please refer to section **1.3.1.2**.

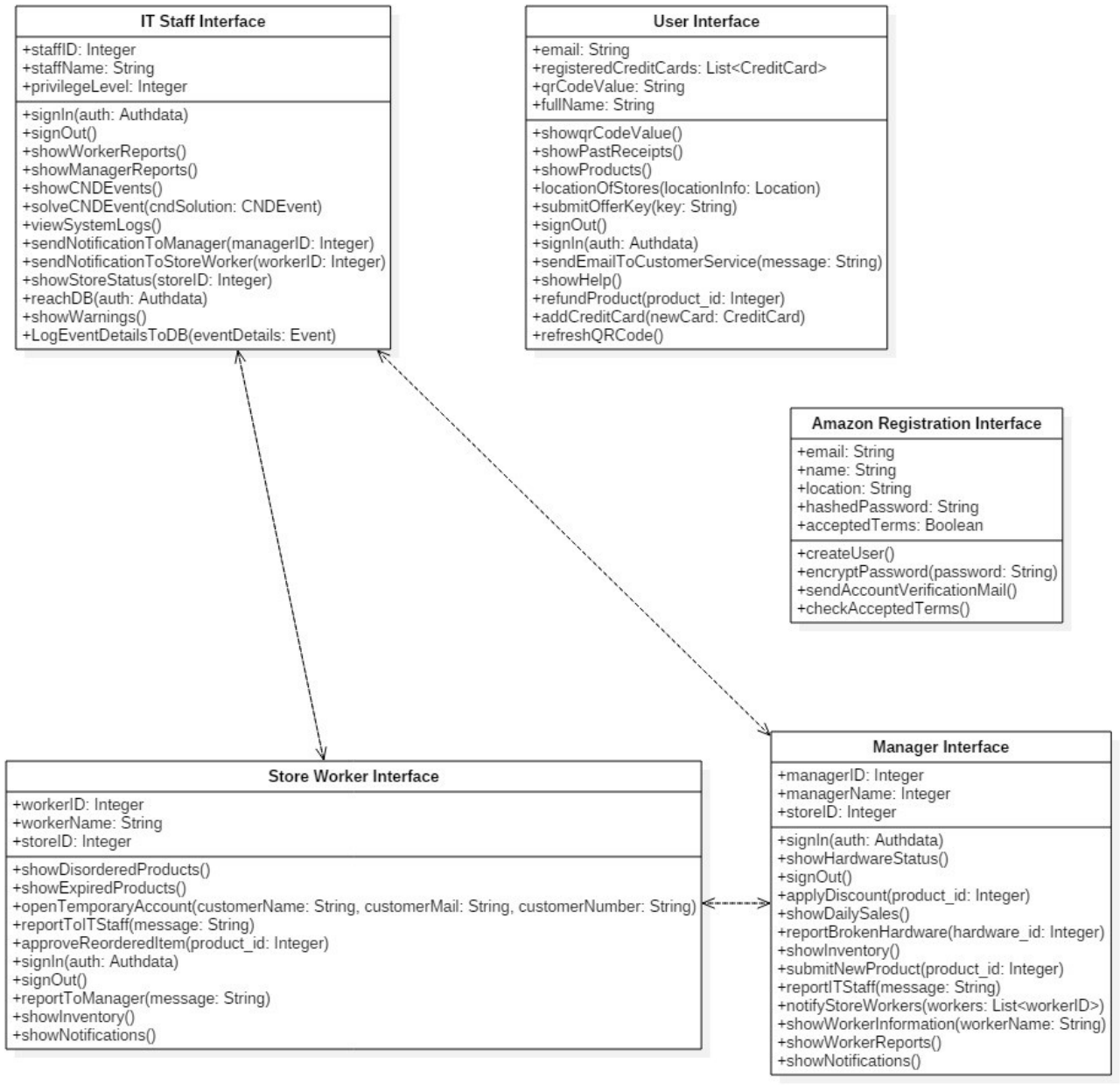


Figure 6: External Interfaces Class Diagram

3.2 Functions

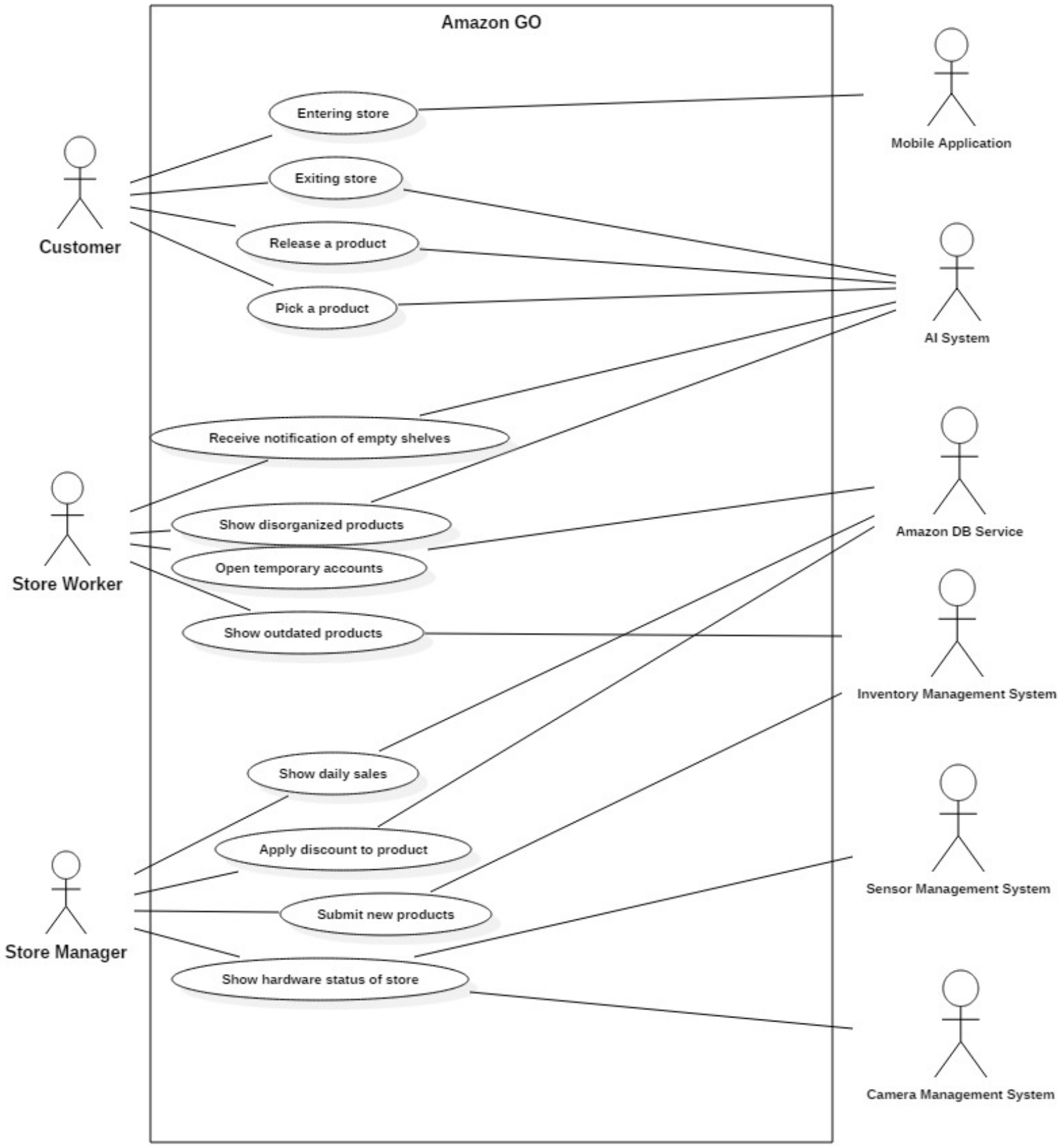


Figure 7: Use Case Diagram

Use case name	Entering store
Actors	Customer, Mobile application
Description	When a customer enters the store he/she scans his/her unique QR code received from the mobile application. System identifies the QR code and opens the turnstiles.
Data	User's QR code
Preconditions	User shall be registered to the system, user shall register at least one credit card and receive a QR code
Stimulus	QR reader on turnstiles reads the QR code of user.
Basic Flow	Step 1: Customer opens the mobile application Step 2: User signs in his/her account Step 3: Unique QR code is shown in the interface Step 4: Customer scans the QR code into the tourniquets placed in entrance of the store Step 5: System identifies the QR code and the user. Step 6: The tourniquet opens, and the customer can get in the store. System tracks the user
Alternative Flow #1	Step 2: If the customer has not signed the system yet sign in interface is shown. If the user opened the application for the first time, a quick introduction is also shown
Alternative Flow #2	Step 3: If the user hasn't registered any credit card information, or chosen any main payment method, payment method selection is shown
Exception Flow	Step 6: If an error occurs in turnstiles, store workers are notified.
Postconditions	The system opens the turnstiles, starts tracking the user, closes them after passing the turnstiles.

Table 4: Entering store

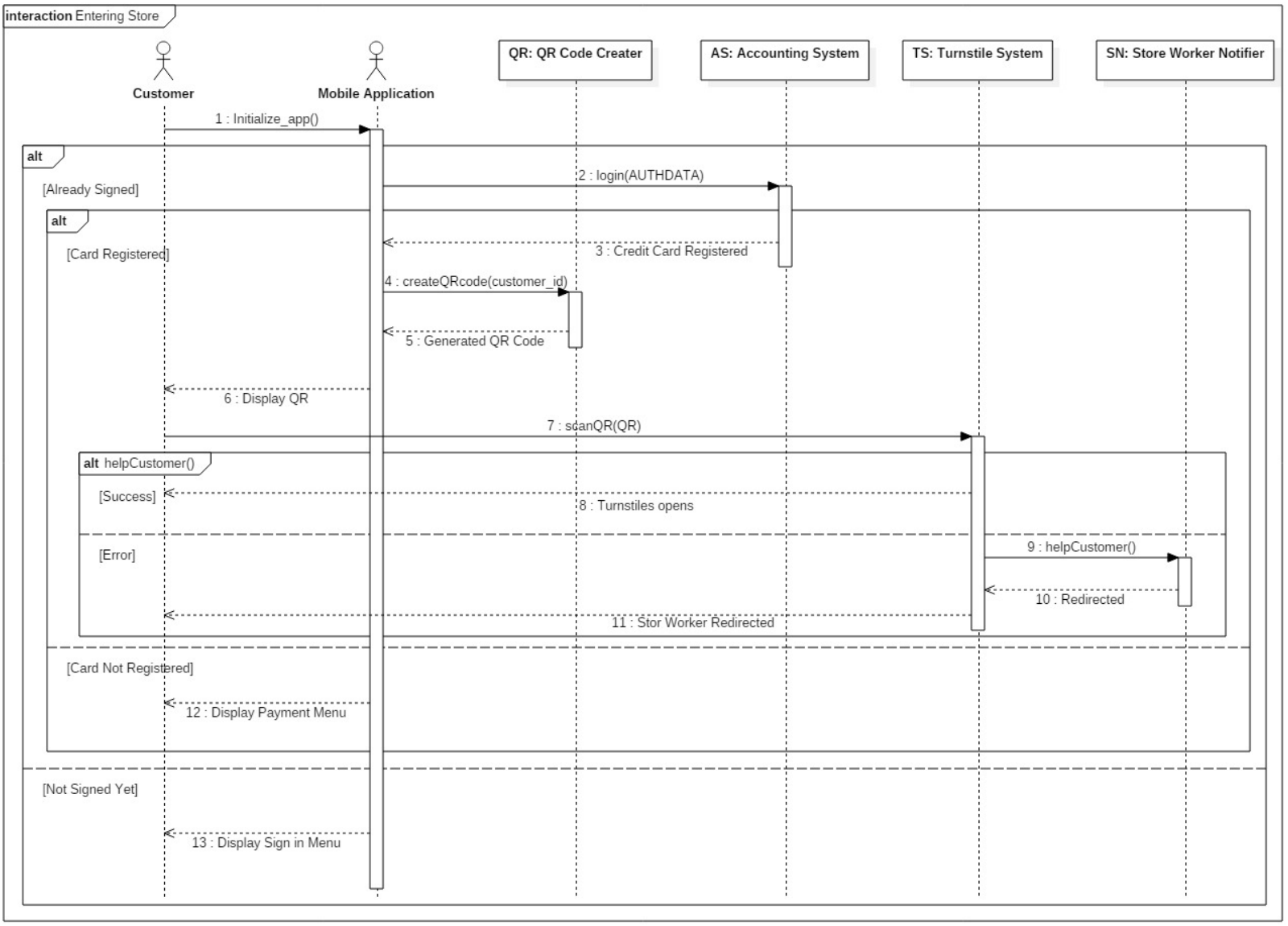


Figure 8: Sequence diagram of "Entering Store"

Use case name	Exiting store
Actors	Customer, AI System
Description	Tourniquets which allow one-way pass is opened automatically when a customer wants to leave the store. Therefore, AI system must determine which customer goes out of the store and total price of his/her shopping is withdrawn.
Data	Information of customer exiting from the store
Preconditions	User shall be registered to the system, enter the store.
Stimulus	Customer passes through the tourniquet and goes outside of the store.
Basic Flow	Step 1: Customer comes to the tourniquets. Step 2: The tourniquet opens for the customer to go outside. Step 3: The tourniquet closes to disallow the entrance through it. Step 4: Total price of products bought by the customer is withdrawn from the credit card of the customer saved in the system before.
Alternative Flow	-
Exception Flow	Step 4: If any error occurs, the event is logged with customer and products information
Postconditions	After the customer exits from the store, the tourniquet closes, the customer is charged with the products bought and the total price is withdrawn from the credit card of the customer saved in the system before. Also, receipt of the customer is recorded in the system.

Table 5: Exiting store

Use case name	Release a product
Actors	Customer, AI System
Description	AI system in Amazon GO stores recognizes when a customer releases a product after he/she picks it. This system identifies which product is released and which customer does it by using various machine learning techniques. After the identification, the product left to the shelves is deleted from the user's basket in the mobile application.

Data	Information of customer who releases the product, Product released by the customer
Preconditions	User has entered the store, identified by the system, and picked a product
Stimulus	User releases the product which he or she has selected
Basic Flow	Step 1: Customer enters the store. Step 2: The AI system starts to watch the customer. Step 3: The customer walks around the store. Step 4: The customer chooses a product and picks it up. Step 5: The AI system identifies the product. Step 6: The AI system provides the product to be added to the customer's basket. Step 7: The customer changes the decision and releases the product. Step 8: The AI system identifies which product is released. Step 9: The AI system provides the product to be deleted from the customer's basket.
Alternative Flow	Step 9: After deleting it from the basket, if the customer doesn't release the product into its previous location its location is sent to the store worker as disorganized product
Exception Flow	Step 8: If the product released is not recognized by the AI system, it is identified as a CND event, and is reported to IT Staff immediately.
Postconditions	The customer's basket is updated.

Table 6: Release a product

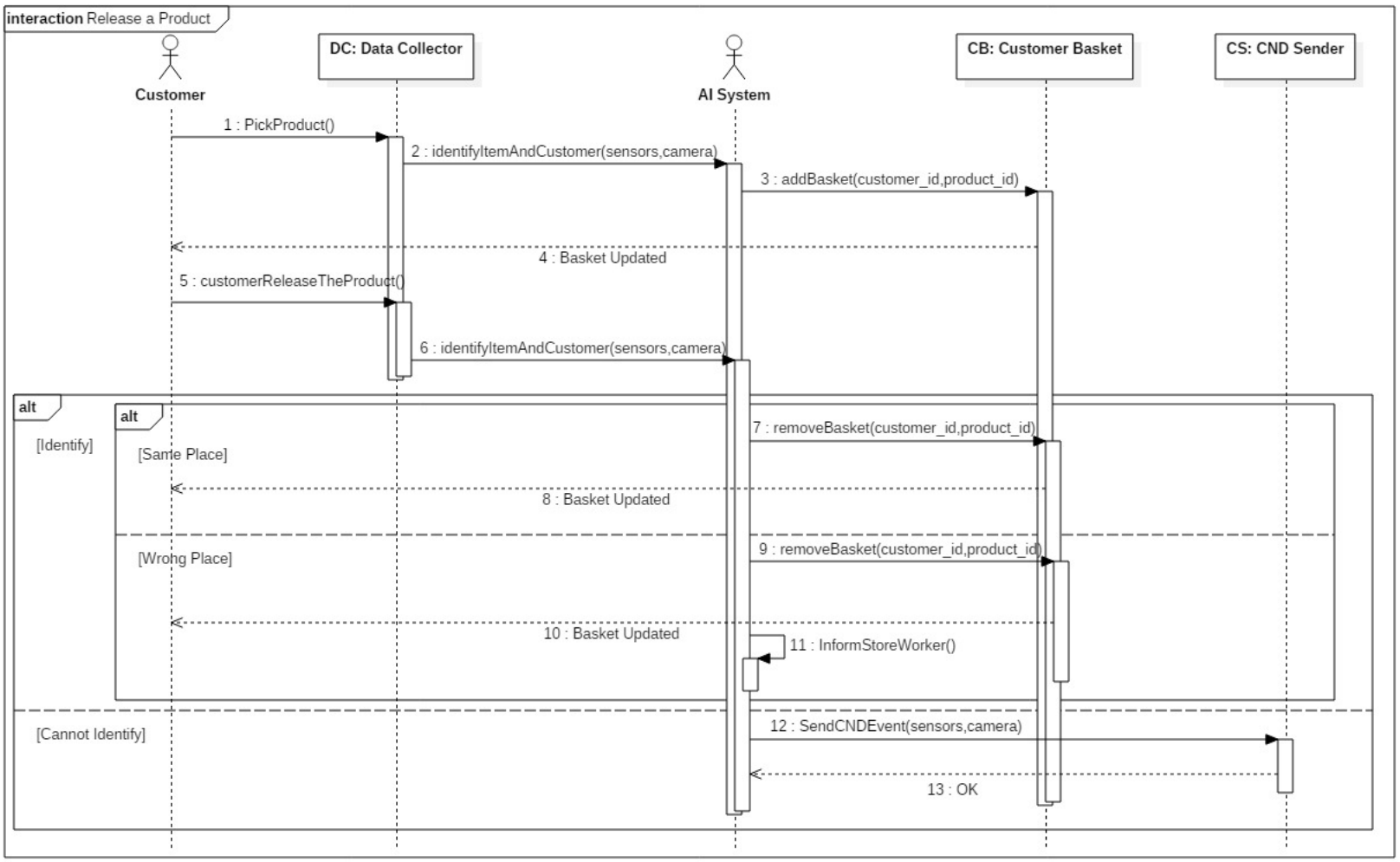


Figure 9: Sequence diagram of "Release a Product"

Use case name	Pick a product
Actors	Customer, AI System
Description	AI system in Amazon GO stores recognizes when a customer picks a product. This system identifies which product is selected and which customer picks it by using various machine learning techniques. After the identification, the product wanted to be bought is added into the user's basket in the mobile application.
Data	Information of customer who picks the product, Product selected by the customer
Preconditions	User has entered the store, and he/she is identified by system
Stimulus	User selects a product from shelves and lifts it
Basic Flow	Step 1: Customer enters the store. Step 2: The AI system starts to watch the customer. Step 3: The customer walks around the store. Step 4: The customer chooses a product and picks up it. Step 5: The AI system identifies the product. Step 6: The AI system provides the product to be added to the customer's basket.
Alternative Flow	-
Exception Flow	Step 5: If the product is not recognized by the AI system, it is identified as CND event, and is reported to IT Staff immediately
Postconditions	The customer's basket is updated.

Table 7: Pick a product

Use case name	Receive notification of empty shelves
Actors	Store worker, AI system
Description	When a shelf becomes empty after customers' shopping, the AI system can detect it and informs the store workers so that new products are placed on the shelf. After the store worker places the products on the shelf, the AI system can again detect it and products on the shelf are approved by the store worker.

Data	Location of the empty shelf on the store and which product belongs to that shelf
Preconditions	-
Stimulus	The shelf becomes empty
Basic Flow	Step 1 – Customers buy products on a shelf. Step 2 – The shelf becomes empty. Step 3 – The AI system detects the empty shelf. Step 4 – The notification containing the information about which shelf is empty and which products will be placed on that shelf is given to store workers.
Alternative Flow	-
Exception Flow	Step 4: Any error in the system will be recorded. The sensor and camera data is also added to this log file.
Postconditions	Notification is sent to store worker, he/she puts the products to the shelves and approved by both system and store worker

Table 8: Receive notification of empty shelves

Use case name	Show disorganized products
Actors	Store worker, AI system
Description	If a customer puts a product on a shelf that does not belong to it, the AI system detects it and warns store workers with a notification to fix it.
Data	The name and location of product which is on the wrong shelf
Preconditions	A product is put in the wrong place by a customer.
Stimulus	AI system scans the store and detects a product in wrong place
Basic Flow	Step 1 – A customer picks up a product. Step 2 – The customer does not put the product on its' previous shelf. Step 3 – The AI system detects the situation. Step 4 – The notification containing the information about which product is put on the wrong shelf and where is this shelf on the store is given to store workers.
Alternative Flow	-

Exception Flow	Step 3: If the product is not recognized by AI system, it is identified as CND event, and is reported to IT Staff immediately
Postconditions	Item status is updated, and system send a notification to store worker

Table 9: Show disorganized products

Use case name	Open temporary accounts
Actors	Store worker, Amazon DB service
Description	In order to enter the store and do shopping, customers shall be registered in the system. However, for a customer who has not an Amazon account and wants to do shopping in Amazon GO stores, a new, temporary account is opened by the store worker.
Data	Information of customer
Preconditions	A customer who will be registered has not had an account before.
Stimulus	Store worker clicks **Open temporary account** button
Basic Flow	Step 1 – A customer comes to the store. Step 2 – He/she asks for help from a store worker to get in the store. Step 3 – The store worker opens a temporary account for the customer. Step 4 – The store worker fills out the information of the customer. Step 5 - System tracks the user with this information and relates the picked product to this account
Alternative Flow	-
Exception Flow	Any error in the system will be recorded in error logs.
Postconditions	The customer enters the store with the temporary account and the account is deleted automatically after he/she leaves the store.

Table 10: Open temporary accounts

Use case name	Show outdated products
Actors	Store worker, Inventory management system
Description	Products are saved in inventory management system with their expiration date. If a product becomes outdated, it is notified by the inventory management system to store workers.
Data	Name and place of the outdated product on the store
Preconditions	Outdated product is on the store
Stimulus	The expiration date of a product passes.
Basic Flow	Step 1: A product becomes expired. Step 2: Inventory management system sends a notification to store workers. Step 3: Store workers see which product is outdated and where it is on the store.
Alternative Flow	-
Exception Flow	If the product is shown as outdated, but it has been already sold, the store worker reports the IT Staff
Postconditions	The store worker receives the notification of outdated products from the shelves and their locations

Table 11: Show outdated products

Use case name	Show daily sales
Actors	Store manager, Amazon DB service
Description	Daily sales of stores are saved in Amazon DB service and can be seen by the store's manager to follow incomes and outgoings of the store.
Data	Daily information of products sold with names and amounts, and total price earned in that day.
Preconditions	Store manager shall sign in his/her account
Stimulus	Store manager clicks the **Show Daily Sales** button.

Basic Flow	Step 1: Store manager sign in his/her account Step 2: He/She clicks the Show Daily Sales button Step 3: Database service queries and sends the information about all sales. Step 4: All information of sales is appeared in store manager interface.
Alternative Flow	-
Exception Flow	Any error in the flow is recorded in system error logs.
Postconditions	Daily sales of stores and related information is appeared in store manager interface.

Table 12: Show daily sales

Use case name	Apply discount to product
Actors	Store manager, Amazon DB service
Description	It is the duty of the store manager to increase the sales in a store. Therefore, the store manager can apply discount to products in his/her store and he/she saves it to Amazon DB service.
Data	Product code, and new price of product
Preconditions	Store manager shall sign in his/her account
Stimulus	Store manager clicks the **Apply Discount** button.
Basic Flow	Step 1: Store manager sign in his/her account Step 2: He/She clicks the Discount section in his/her interface Step 3: He/She writes product code and new price, then clicks the Apply button Step 4: New price is set, and DB is updated according to new price.
Alternative Flow	-
Exception Flow	If any error occurs, its details are recorded in system error logs
Postconditions	The new price is updated in DB, and store manager can see the old and new price of product in his/her interface.

Table 13: Apply discount to product

Use case name	Submit new products
Actors	Store manager, Inventory management system
Description	When new products come to the store, store manager shall submit the information of products such as Expiration date, stock etc. into inventory management system.
Data	Amounts, prices and names of the products that come to the store.
Preconditions	Store manager shall sign in his/her account
Stimulus	Store manager clicks the Submit New Products to Inventory button.
Basic Flow	Step 1: New products arrives in the store. Step 2: Store manager sign in his/her account Step 3: He/She clicks the Submit New Products to Inventory button, and a product identification form appears Step 4: After filling the form, store manager clicks the submit button Step 5: Inventory Management System updates stock information of store by using form information.
Alternative Flow	-
Exception Flow	If an error occurs, it is written to error logs.
Postconditions	Inventory management system updates the stock information of store.

Table 14: Submit new products

Use case name	Show hardware status of store
Actors	Store manager, Sensor management system, Camera management system
Description	Hardware of a store consists of sensors and cameras connected with their management systems and the store manager can see the status of them such as erroneous components, battery powers etc. .
Data	Status information of components, and location information of them
Preconditions	Store manager shall sign in his/her account
Stimulus	Store manager clicks the Show Status of Store button.

Basic Flow	Step 1: Store Manager sign in his/her account Step 2: After login process, he/she clicks the Show Status of Store button. Step 3: The statuses of cameras and sensors, and locations of them are appeared in the interface
Alternative Flow	-
Exception Flow	Step 3: Store manager shall inform required people regarding an error if there is any.
Postconditions	Hardware status of the store is appeared in Store Manager Interface.

Table 15: Show hardware status of store

3.3 Usability Requirements

- Users shall be able to do shopping without internet connection in their smartphones after successfully entering the store.
- Registered users shall be able to use the GO store in 4 seconds after opening the application
- Whenever a user wants to search a product in the catalog provided by the mobile application, he/she shall be able to find it at most 5 steps.
- Customers that come to store with their families may do shopping with using only one account.
- All system users, except IT staff, shall be able to use the system efficiently with basic computer or smartphone knowledge after seeing the quick introduction information.
- A CND event shall be solvable by IT Staff in 20 seconds using cameras' information and sensors' information.
- Training a store worker to use the application shall not be longer than 2 hours.

3.4 Performance Requirements

- The Amazon GO system shall be able to track 50 customers simultaneously.
- After customers pick a product, their baskets shall be updated in 5 seconds.
- After customers release a product, their baskets shall be updated in 5 seconds.
- After a customer exits the store, payment of the total amount of his/her purchase must be withdrawn from the registered credit card within 10 seconds.
- Users shall be redirected to a required page such as sign in form, add payment method form in 3 seconds after the opening mobile application.
- Message retrieval latency of both cameras and sensor components shall not exceed 400 milliseconds.
- Database response latency time for any related operations shall not exceed 4 seconds.

3.5 Logical Database Requirements

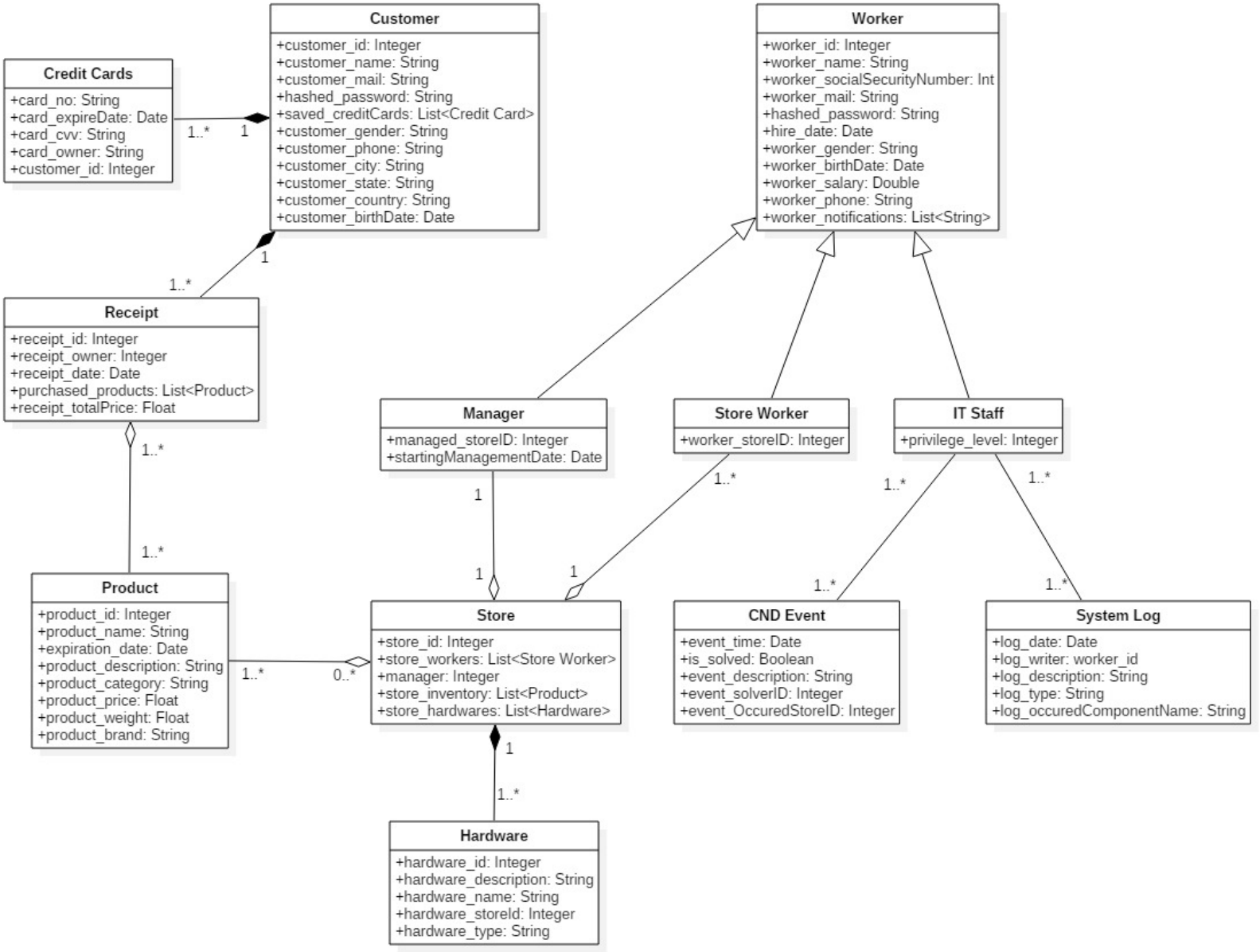


Figure 10: Logical Database Requirements Class Diagram

- When a user registers in the system a customer entry shall be created and each user gets a unique customer id.
- Customer may change his/her information, except for customer id.
- IT staff may access the Customer table, except for the password information, but this access shall be read-only.
- An e-mail cannot be used by more than one customer.
- When a customer saves a new credit card, a new credit card entry is created, and it is added to the saved credit card list of the customer.
- If there is no user, the credit card table cannot exist, therefore Credit Cards table is a weak entity.
- Credit Cards table shall be in many to one relationship with Customers table because each customer can save many credit cards to the system, but these credit cards shall belong to only that customer. Also, each customer shall have at least one credit card.
- Credit card information, excluding customer id, can be changed by only its owner.
- All columns in the credit card relation shall not be NULL.
- Worker id is received by the system and it is unique.
- Worker table, excluding the password information, shall be accessed by IT staff, store manager and the worker himself.
- Workers cannot change their worker ids, social security numbers, hire dates and salaries. They are changed only by privileged IT staff.
- Workers are store managers, store workers, and IT staff. Therefore, Worker class is a generalization for Manager, Store Worker, and IT Staff.
- Manager id is received by the system, it is unique and changed by only IT staff.

- Each store has only one manager, and each manager can be a manager of only one store, therefore the Store table and Manager table are in one to one relationships.
- A store worker can work on only one store, and each store may have many store workers, therefore Store table and Store Worker table are in many to one relationship.
- CND Event table records CND Events occurred in the system. Many IT staff may see many CND events, therefore CND Event table and IT Staff table are in many to many relationships.
- Many IT staff may see many System Logs; therefore, System Log table and IT Staff table are in many to many relationships. Also, the System Log table is only accessed by IT Staff.
- Hardware table keeps a record of hardware components of a store. There may be much hardware in a store, but each hardware status belongs to only one store; therefore, Hardware table and Store table are in many to one relationship. Also, without stores, there would be no hardware. Therefore, it is a weak entity.
- There are many products in stores, but a product may not exist in any store.
- Receipt table and product table are in many to many relationships, because many products may belong to many receipts.
- When a customer has done shopping, products bought are saved in the purchased products list in Receipt table.
- Product entries shall be added to the store inventory list in the Store table when a new product comes to the store, and it shall be deleted when a product is sold automatically.
- A receipt table is created when a user exists. Therefore, the Receipt table is a weak entity.
- Receipt table shall be in many to one relationship with the Customer table because a customer has many receipts, but these receipts belong to only that customer.

3.6 Design Constraints

System concerns to protect all private information of users such as their identity information, password, last receipts and credit card information saved in the system. These cannot be accessed by anyone else from the user.

All information belongs to customers are encrypted in DB, and during communication, all information shall not be transmitted in plain text.

These requirements under the Fair and Accurate Credit Transactions Act of 2003 law.

3.7 Software System Attributes

a) Reliability

- Failure time of system's hardware components shall be less than 20 minutes in a month.
- Data loss in compressed sensors' and cameras' data shall be less than 0.01.
- In case of a sensor node shutdown, other sensor nodes shall continue their operations as if there are no missing nodes in the network in 30 seconds.

b) Availability:

- In case of a system restart, the whole system shall be available in less than 5 minutes.
- If the mobile application requires to be updated, it is allowed for users to use the application without updating for 30 days.
- The system backup shall be done at a time when all the shops are closed, and its duration shall not exceed 15 minutes.

c) Security:

- All sensor and camera data shall be transmitted as encrypted.

- All stored data related to the customer shall be in hashed form. Broken hashing algorithms shall not be used. Moreover, the salting technique shall be used before hashing.
- The system components shall be tested regularly to avoid zero-day attacks.
- Whenever a new functionality is added, application logic tests shall be performed to avoid broken access controls and insecure direct object reference vulnerabilities.

d) Maintainability:

- Integration of new sensors or cameras shall not cause to an error.
- Documentation of system shall be updated regularly and shall help to use of system.

e) Portability:

- Mobile application shall be runnable on different mobile operating systems such as Android, Windows Phone, iOS.
- Programming language which is chosen for the development of the main system shall not be OS dependable.
- Libraries which are used in the main system shall be applicable for different programming languages.

3.8 Supporting Information

Although Amazon GO system is a cashierless system, there is at least one cashier in stores to obey different states' laws.

4 Verification

5 Appendices

5.1 Assumptions and Dependencies

5.2 Acronyms and Abbreviations