

Software Design Description

Amazon Go

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Change History

Version	Date
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1 Introduction

1.1 Purpose of the System

The purpose of this system, namely 'Amazon Go', is to enable customers to shop without making them wait in line with a few requirements only, which are a smart phone and an Amazon account with a registered credit card. To achieve this purpose, Amazon has opened lots of stores, which are highly equipped with cutting edge sensors and cameras. These cameras and sensors track the customer and products, and after the customer is done with shopping, she/he just walks out of store. The amount of his/her shopping will be automatically deduced from his/her specified payment method.

1.2 Scope

- System will have a mobile application, which will enable users (i.e, store customers) to interact with the system. Customers will log in to store by using the QR code provided to them by their mobile application. Mobile application is also the place where customers sign up to the system, see their current cart status, and past shoppings.
- System will use remote servers to keep data of the customers, such as current shopping session, payment information, etc. Remote server will also communicate with the mobile application to enable a customer to see his/her current shopping session, past shoppings, etc.
- System will have physical stores, which are equipped with very sensitive sensors and cameras. Using Artificial Intelligence and Computer Vision algorithms, these cameras and sensors will gather information from the store and communicate with the remote server.
- System will use several APIs to communicate with the specified payment method of the customers, such as bank accounts. By doing so, system will be able to withdraw money from the customer's account when she/he is done with shopping.
- System will use a database to store customer related information (such as user ID), temporary customer shopping cart, store workers' information, products' information and a database table for the system admins. Those mentioned tables such as customer related information actually consist of multiple tables. Only the system admins are able to make changes and read the database.
- System will keep log of all the shoppings of the users on the remote server for legal purposes. Only system admins can see these logs.
- System will also have a store worker interface to enable the store worker to troubleshoot in case something goes wrong in the store, such as sensor malfunctioning, incorrect amount of money withdrawn from the customer, wrong product was added to a customer's cart, etc.

1.3 Stakeholders and their concerns

- **Amazon:** Being the owner of the whole system and the store, Amazon's main concern is reliability of the system so that Amazon will not lose money due to sensor failures or due to customers tricking the sensors and being charged less than they are supposed to be charged. Privacy of the customers is also important as this may have legal consequences.
- **Users:** Users are actually the customers that visit Amazon GO stores. They have four main concerns, which are, firstly, not waiting in line to pay for what they had bought; secondly, precision of the sensors so that they do not pay extra money due to sensors' fault; thirdly, security of their personal information such as their credit card information, place of residence etc., which are stored in the Amazon servers; and lastly, having a mobile application which is easy to use.
- **System Developers:** Developers are very critical for this system, because it completely relies on the software. Their main concern is maintainability, due to complexity of the system. For this purpose, the documentation and the system itself should be organized very well. Also, the system must be set up in a way that if one component fails, restoration of this component and integration of the new component, which replaces the faulty one, with the system must be easy.
- **IT Staff:** IT Staff are basically the system administrators, who are responsible to maintain databases and communicate with the store workers when needed. They are essential in the continuity of the system. Their major concern is that sustainability of the database, which is created by the system developers when the system is being developed.
- **Store Workers:** Store workers are the people that are responsible for the product placement and shelf maintenance. They are mostly concerned about the illegal actions. Therefore, they should be trained to what to do for the most of the possible scenarios. Their main concerns are being able to easily reach a system admin in case of a failure, and being able to contact with the security in case of an illegal action by the customers.

2 References

This document is written with respect to the specifications of the document below:

1016-2009 - IEEE Standard for Information Technology–Systems Design–Software Design Descriptions

Other sources:

- Cheng, A. (2019, January 13). Why Amazon Go May Soon Change The Way We Shop. Retrieved from <https://www.forbes.com/sites/andriacheng/2019/01/13/why-amazon-go-may-soon-change-the-way-we-want-to-shop>
- Wingfield, N. (2018, January 21). Inside Amazon Go, a Store of the Future. Retrieved from <https://www.nytimes.com/2018/01/21/technology/inside-amazon-go-a-store-of-the-future.html>

3 Glossary

Term	Definition
User	A customer that is signed up to Amazon Go application and has a unique user ID.
Database	A MySQL database.
User ID	A unique number which can be used to identify a user.
Store Worker	A real person working in an Amazon Go store.
API	Application Programming Interface
Mobile Application	An application that must be installed to an Android or iOS device in order to access Amazon GO features.
QR Code	An image which contains information about the user. It is generated by the mobile application.
System admins	The people who are responsible for the maintenance and the order of the Amazon GO system.
Remote server	A real physical computer away from the stores, at the Amazon HQ, which can be accessed via SSH by system admins.
SSH	Secure Shell
Sensor	A physical electronic device that collects information about the environment it is currently in.
Product	The goods that are sold at the Amazon GO stores.

Table 1: Glossary

4 Architectural Views

4.1 Context View

In this viewpoint, the systems that Amazon GO interacts with are shown on the Context Diagram below. The following Use Case Diagram shows the actors and their possible interactions with different scenarios. The detailed information about these use case functions can be found on the tables after the Use Case Diagram. These tables give detailed information for each use case function including alternative scenarios. During the implementation, these tables shall be considered and implementation must follow the mentioned scenarios.

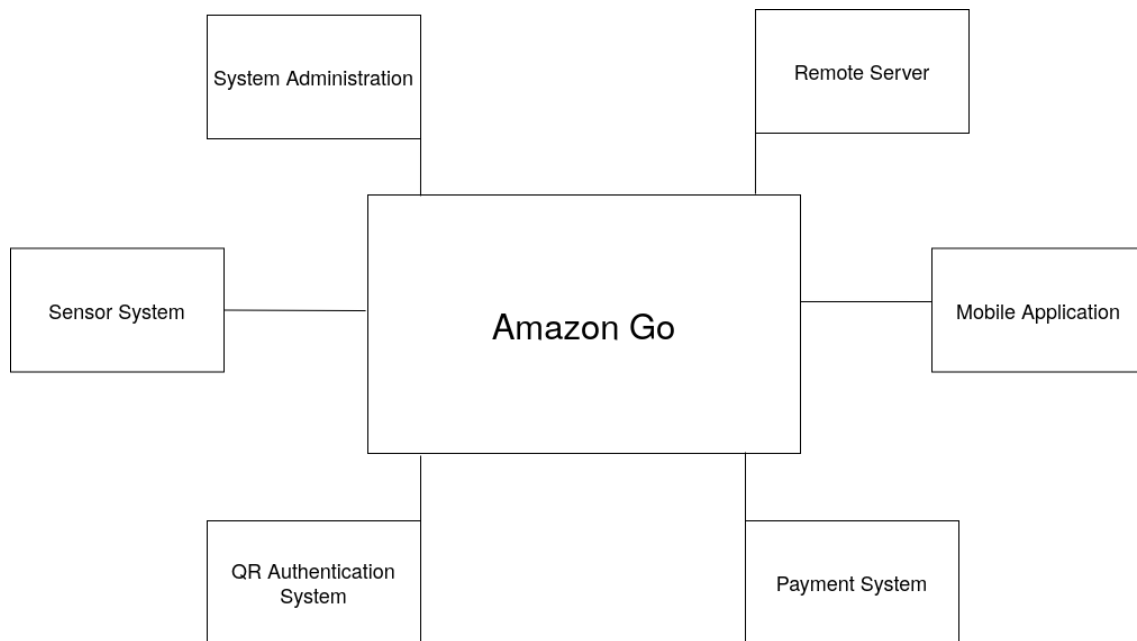


Figure 1: Context Diagram

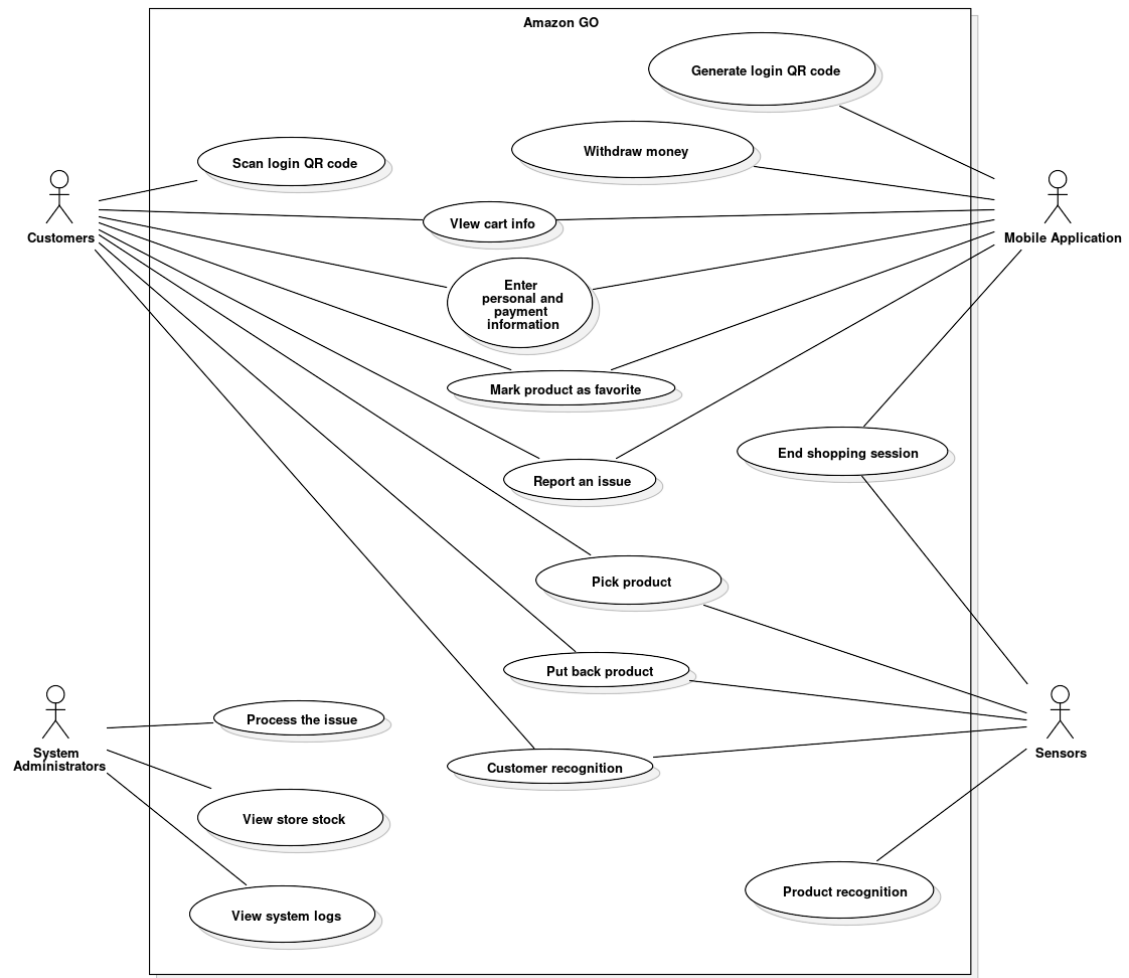


Figure 2: Use Case Diagram

Use case name	Customer recognition
Actors	Customers, Sensors
Description	Immediately after the customer gets his/her QR code scanned, environmental cameras must track his/her movements and positions continuously. Cameras must regularly recognize the customers with their face, clothes etc. and must communicate with the remote server until the customer leaves the store. In order to not to lose visual contact with the customer, every angle in the store must be watched by the cameras and the sensors.
Data	Customers' physical details such as clothes, face, and body movements.
Stimulus	The customer getting his/her QR code scanned.
Response	Match the user ID with the acquired visual data of the customer.
Basic Flow	1- Upon QR scanning, visual sensors receive a user ID and identify the unknown customer with the ID. 2- Visual sensors track customer's movements and position continuously. 3- Customer picks up a product. 4- Customer information is sent to the server. 5- Flow goes back to step 2.
Alternative Flow #1	3- Customer puts a product back to a shelf. 4- Customer information is sent to the server. 5- Flow goes back to step 2.
Alternative Flow #2	3- Customer leaves the store. 4- Customer information is sent to the server. 5- System stops tracking the customer.
Comments	Immediately after a customer logs in to store, sensors must assign a unique customer ID to that user.

Table 2: Customer Recognition

Use case name	Product recognition
Actors	Sensors
Description	Right after a product is placed to a shelf by the store staff and the product is marked as 'exist' on the store database, the corresponding ID which belongs to the same product set must be assigned to the product. After that point, until someone buys the product and leaves the store, product must be tracked by using its weight information, visual information, and shelf location. A customer is allowed to take a product, put it into his/her bag, and put the product back to any shelf. In that case, for some time, the visual contact with the product would be lost, but after the product is put back to the shelf, system must recover and continue tracking this product. A customer can put a product back to a different shelf, in that case, the product must be recognized by its visual data and weight again.
Data	Weight, physical characteristics, and the location of products.
Stimulus	A product is placed to a shelf by the store worker and marked as exist in the store.
Response	Match the product with the products in the database.
Basic Flow	1- A product is placed to a shelf by the staff. 2- Query the database with the shelf location, visual data and weight. 3- Assign the received product ID to corresponding product set. 4- Sensors work continuously to detect product movements. 5- A product is taken from a shelf. 6- Product information is sent to the server. 7- Flow goes back to step 4.
Alternative Flow	5- A product is placed to a shelf by a customer. 6- Product information is sent to the server. 7- Flow goes back to step 4.
Comments	Initially, products must be registered to the database and must be assigned to a shelf.

Table 3: Product Recognition

Use case name	Scan login QR code
Actors	Customers
Description	A procedure to log users in to store by scanning their QR code via turnstiles. Turnstiles must allow access after a successful scan. Turnstiles must not allow the customers to enter the store if the scan fails and must display the reason. For security reasons, if the same QR is scanned while there is a shopping session with that QR code, login must not be allowed and QR code must be disabled for security purposes. Additionally, customer must be informed about every login with an SMS.
Data	User information.
Stimulus	Users showing their QR code to turnstiles.
Response	Validation or invalidation of the QR code.
Basic Flow	1- Customer shows the QR code to turnstile QR scanner. 2- Turnstile scans the QR and sends the data to the server. 3- Server processes the store information and the customer information. 4- Server responds with success. 5- Turnstile gives access to the customer. 6- Server sends SMS notification to the customer.
Alternative Flow	4- Server responses with failure. 5- Failure reason is displayed. 6- Server sends SMS notification to the customer.
Comments	Customer must be a registered member. GPS can be used to improve the security.

Table 4: Scan Login QR Code

Use case name	Pick Product
Actors	Customers, Sensors
Description	A procedure to detect customers when they pick up a product from the shelves. When a customer picks a product, weight sensors must detect the change and must send the related data, also visual sensors must recognize the customer who picks up the product and provide additional data about the product. If the customer picks up multiple products at the same time, sensors must be precise enough to handle the situation.
Data	Customer information, product's price and other information related to that product.
Stimulus	Customers picking products.
Response	Add the picked product to customer's cart, update the cart information.
Basic Flow	1- Customer picks a product up from a shelf. 2- Weight sensors detect the change. 3- Visual sensors detect the customer action and assists product recognition. 4- Sensors send data to server. 5- Server processes data, adds the related product to customer's cart.
Alternative Flow	-
Comments	Customers must get their QR code scanned successfully before shopping.

Table 5: Pick Product

Use case name	Put back product
Actors	Customers, Sensors
Description	A procedure to detect customers when they put a product back to shelves. When a customer puts a product back to a shelf, weight sensors must detect the change and must send shelf information, weight information and other related data, also visual sensors must recognize the customer who puts the product back and must provide additional data about the product. System must analyze the cart to be precise about the product. If the customer puts back multiple products at the same time, sensors must be precise enough to handle the situation.
Data	Customer information, product's price and other information.
Stimulus	Customers putting a product back to shelf.
Response	Delete the related product from the customer's cart.
Basic Flow	1- Customer puts a product back to a shelf. 2- Weight sensors detect the change. 3- Visual sensors detect the customer action and assists product recognition. 4- Sensors send data to server. 5- Server processes data, removes the related product from customer's cart.
Alternative Flow	-
Comments	The product must have been picked up beforehand and this must be in the same session.

Table 6: Put Back Product

Use case name	View cart info
Actors	Customers, Mobile Application
Description	A customer must be able to see it's current cart status by using the mobile app. Customer shall see the products she/he picked up, with their quantity and price. Total price must be also displayed.
Data	The customer's cart status.
Stimulus	The customer pressing the 'My Cart' button on the app.
Response	Show the customer's current cart status.
Basic Flow	1- Customer opens the app. 2- Customer logs in if not signed in already. 3- Application opens the cart screen automatically. 4- Application sends view cart request to the server. 5- Server responds with the related data. 6- Application shows the cart status.
Alternative Flow	-
Comments	Data must be fetched from the remote server in case of an attempt to cheat. User must be shopping to be able to see the cart screen.

Table 7: View Cart Info.

Use case name	Enter personal and payment information
Actors	Customers, Mobile Application
Description	When a customer signs up, s/he must provide personal information and payment method. If the payment method is invalid, application must request a valid method and must not allow another action to be taken by the customer until a valid payment method is provided.
Data	Personal data and payment data.
Stimulus	When a customer signs up or updates his/her information.
Response	Validation or invalidation of the payment method. If validated, sign up or update the user.
Basic Flow	1- Application shows a personal information form or a payment form. 2- User enters information. 3- Application checks the validity of the information at the same time. 4- If everything is valid, a button is enabled to finish the process. 5- User presses the button. 6- Server inserts the related information to the database.
Alternative Flow	-
Comments	If the customer is a member, then instead of signing him/her up, update the information.

Table 8: Enter Personal and Payment Information

Use case name	End shopping session
Actors	Mobile Application, Sensors
Description	Visual sensors must detect when the customer leaves the store and report to remote server. Details about the shopping session must be visible from the application after session ends.
Data	Customer ID, store information.
Stimulus	Customer leaving the store.
Response	Session information.
Basic Flow	1- Customer walks out from the store. 2- Visual sensors detects the action. 3- End shopping session request is sent to servers with the customer ID. 4- Server processes the request and saves the sessions information to the database. 5- Visual sensors stop tracking that customer.
Alternative Flow	-
Comments	Log the current session to database for possible further use.

Table 9: End Shopping Session

Use case name	Generate login QR code
Actors	Mobile Application
Description	Application must generate a unique QR code to enable customers log in. A generated QR code can be used multiple times until it is disabled due to security or user prompt. QR codes must be user specific.
Data	Customer information.
Stimulus	User pressing the 'QR Code' button on the mobile app.
Response	Produce and show the QR code
Basic Flow	1- A customer signs up. 2- Application requests a QR code for the customer. 3- Server generates a QR code that is unique to the customer.
Alternative Flow	1- Customer presses the Refresh QR button. 2- Application requests a QR code for the customer. 3- Server generates a QR code that is unique to the customer.
Comments	QR code must be generated and sent by the remote server in case of a cheating attempt.

Table 10: Generate Login QR Code

Use case name	Withdraw money
Actors	Mobile Application
Description	When user leaves the store, withdraw money from his/her registered payment method. System must use the payment method provided by the customer. If the payment attempt fails due to lack of money or other reasons, notifications must be sent regularly until customer pays. Customer must not be allowed to shop until she/he pays.
Data	User ID.
Stimulus	Upon the 'End shopping session' procedure.
Response	Confirmation that payment is successful.
Basic Flow	1- System is informed by the End Shopping Session function. 2- System requests a payment from the user's payment method via the Payment API. 3- Payment is successful. 4- Receipt is created.
Alternative Flow	3- Payment is failed. 4- An SMS notification is sent to the customer. 5- The customer is blacklisted until the she/he pays.
Comments	Further actions can be taken by the authorities if a payment is not received for a long time.

Table 11: Withdraw Money

Use case name	View store stock
Actors	System Administrator
Description	System admins must be able to see current stock status of each store and main warehouse. User must be warned about low stocks.
Data	Store ID, admin ID.
Stimulus	User pressing the 'View Stock' button on the mobile app.
Response	Stock information .
Basic Flow	1- System admin opens the administration page. 2- User presses the stock status tab. 3- Overall stock status of each store is listed to the user. Stocks are colored according to the amount. 4- User selects a store. 5- Detailed stock status of the selected store is shown to the user.
Alternative Flow	-
Comments	User must be authorized to view stock information.

Table 12: View Store Stock

Use case name	View system logs
Actors	System Administrators
Description	Administrators must be able to see previous shopping session details of customers. Any inconsistency in sessions must be reported.
Data	Time and date, Store ID, Customer ID
Stimulus	Administrators reaching the log files.
Response	Previous cart information, payment method
Basic Flow	1- System admin opens the administration page. 2- User presses the view logs tab. 3- Several filter options are shown to the user. 4- User fills some of the filtering fields. 5- User presses the search button. 6- Results are listed.
Alternative Flow	-
Comments	Only administrators can see the log files.

Table 13: View System Logs

Use case name	Mark Product as Favorite
Actors	Customers, Mobile Application
Description	Customers should be able to add a product that they buy frequently or a product that they wish to buy to their favorite products list.
Data	Product ID, Customer ID
Stimulus	A user pressing the 'Star' on the page of the product using the mobile application.
Response	A message indicating whether the operation was successful or not.
Basic Flow	1- Customer logs in to the mobile application. 2- User navigates to the product's page on the mobile application via the search button or via the categories. 3- System loads the product page. 4- User presses the dimmed 'Star' icon on the loaded page. 5- 'Star' icon is lighted up and the product is added to the user's favorites.
Alternative Flow	4- User presses the already lighted up 'Star' icon 5- 'Star' icon is dimmed and the product is removed from the user's favorites.
Comments	On each press to 'Star' icon, the icon is basically toggled.

Table 14: Mark Product as Favorite

Use case name	Report an Issue
Actors	Customers, Mobile Application
Description	A user should be able to communicate with the system admins in case of any problems or questions.
Data	User ID, User Message
Stimulus	User presses the 'Report an Issue' button at the main page of the mobile application.
Response	Validation that issue is reported or not.
Basic Flow	1- Customer logs in to the mobile application. 2- User navigates to the issue reporting page by pressing the 'Report an Issue' button. 3- A textbox appears on the screen which waits for user to enter his message. 4- User enters his/her message and presses the send button. 5- A notification appears if the message is transmitted successfully or not.
Alternative Flow	-
Comments	If a user sends two seperate messages consecutively, these messages shall be merged to avoid spam. Also a user should be able to send only one message in ten minutes.

Table 15: Report an Issue

Use case name	Process the Issue
Actors	System Administrators
Description	System admins inspect the issue provided by the user and take action accordingly.
Data	Response Message, User ID
Stimulus	An admin pressing the 'Inspect Issues' button on the admin page and selecting an issue.
Response	The status of the selected issue is updated (such as ongoing, solved etc.)
Basic Flow	1- An admin logs into the admin page using his Admin ID and password. 2- The admin presses the 'Inspect Issues' button on the admin page. 3- A list of unsolved issues are shown to the admin. 4- The admin selects an issue by the date (early messages first). 5- The admin takes action (such as inspecting the logs) and sends a reply to the issuer.
Alternative Flow	6- The admin marks the issue as solved.
Comments	

Table 16: Process the Issue

4.2 Composition View

In this viewpoint, the components of the system are shown from a top-level point of view. Also, the design rationale for each decision is provided right after the Component Diagram.

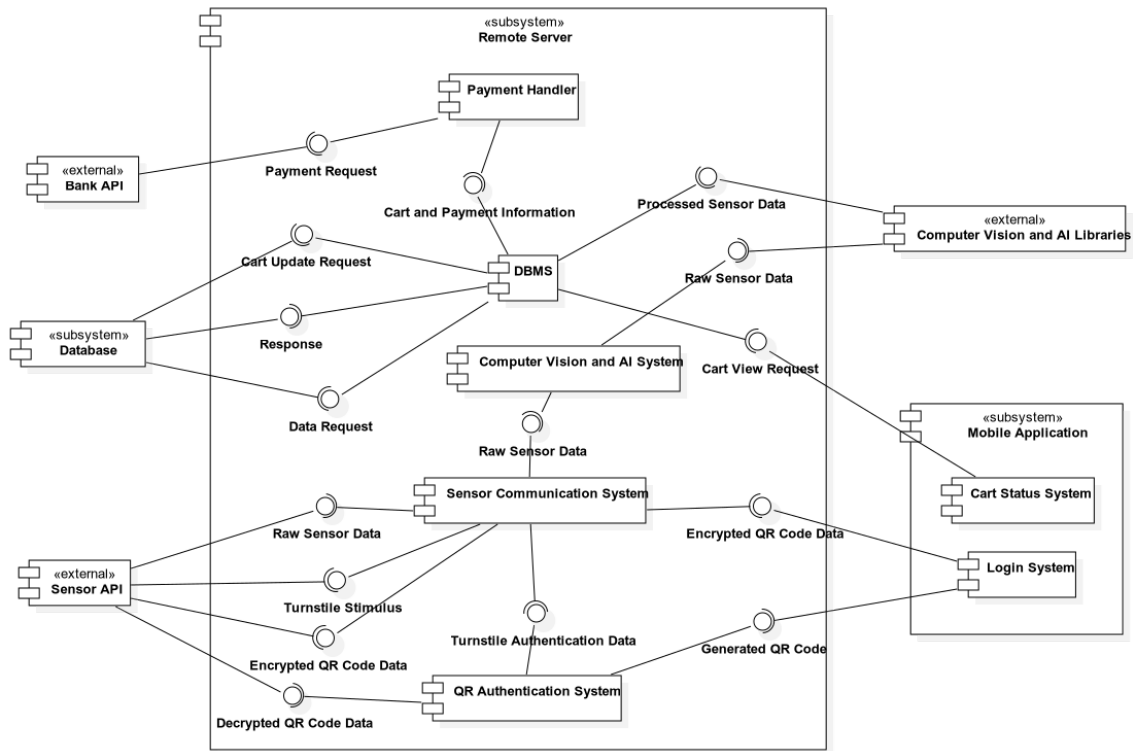


Figure 3: Component Diagram

Design Rationale:

- AmazonGo is a system that needs to handle several different tasks at the same time. Some of these tasks follow similar routines, therefore we used some generic components and interfaces like Sensor Communication system. Which allow to keep the diagram simple and more understandable.
- Remote Server subsystem is the system tha

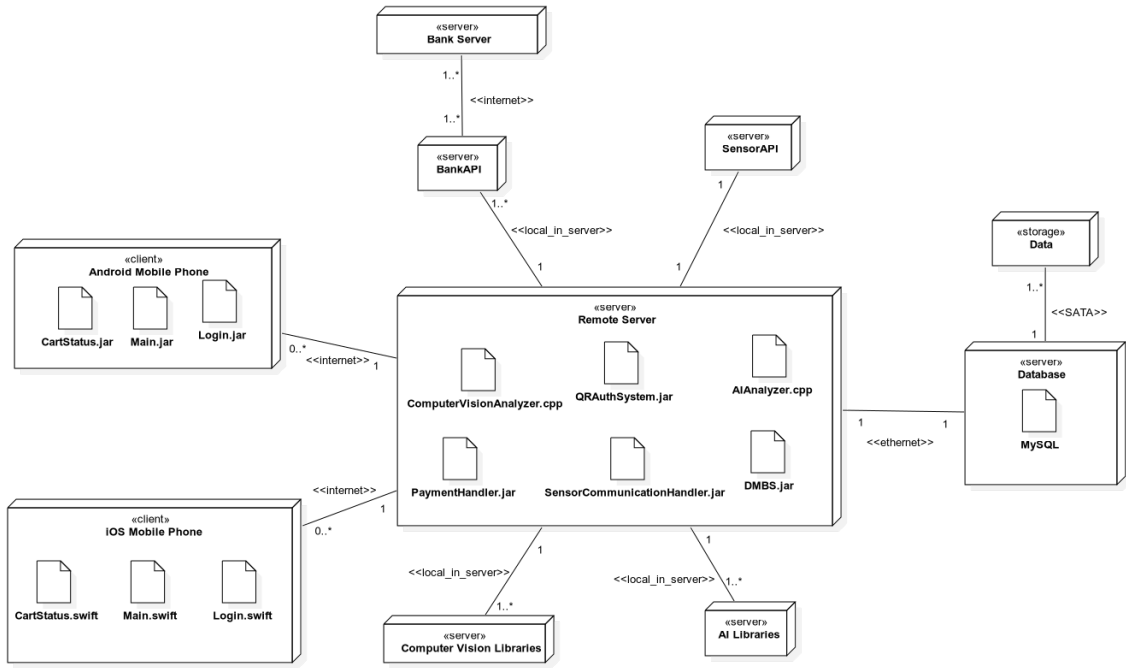


Figure 4: Deployment Diagram

4.3 Information View

4.4 Interface View