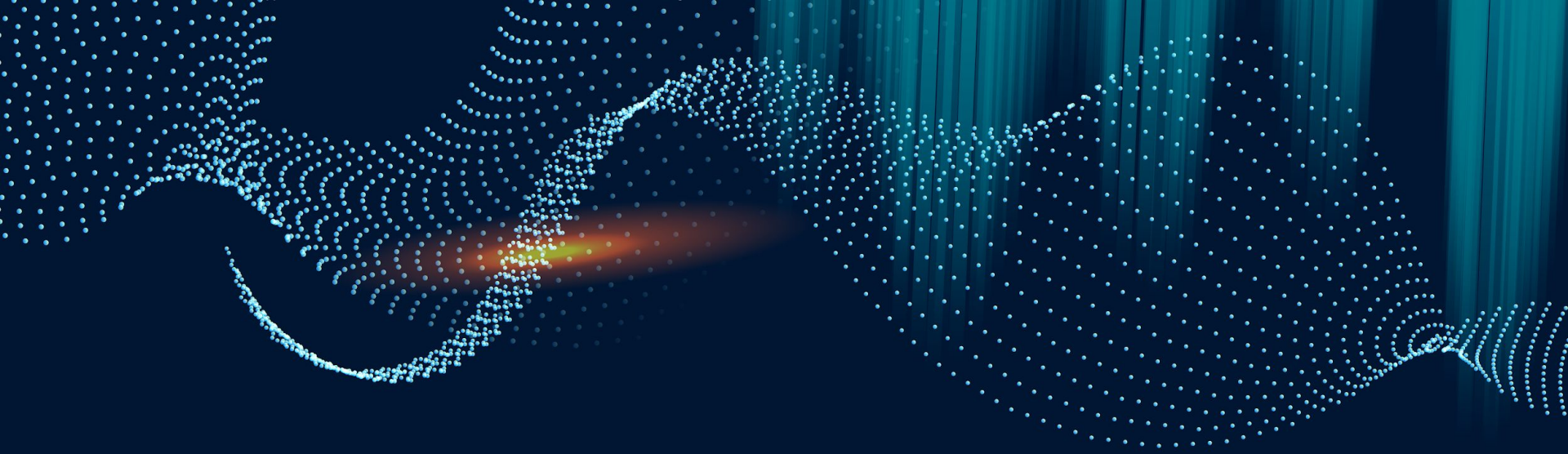


Package Bot

Blank

Requirements Engineering



01 | **Problem Statement**

Problem Statement:

- The problem at hand is the lack of a convenient way to send and receive packages across the increasingly large campus.
- This package can come in any form, such as: assignments, books, food, electronics etc. It is quite troublesome to manually deliver these packages on foot and can be a waste of time.





02

**As Is - To Be
Model**

As-Is -- To-Be Model:

- The problem is currently defined As an inconvenience of sending / receiving packages across the GIU campus.
- It is desired that we solve this issue by utilizing a delivery robot that roams the campus and sends / receives packages on behalf of the Giuans



As-Is -- To-Be Model:

- Core problem is user should be able to send requests to other users which means we needed sign up / login functionality
- Was resolved by adding a sign up requirement using university ID, email and password



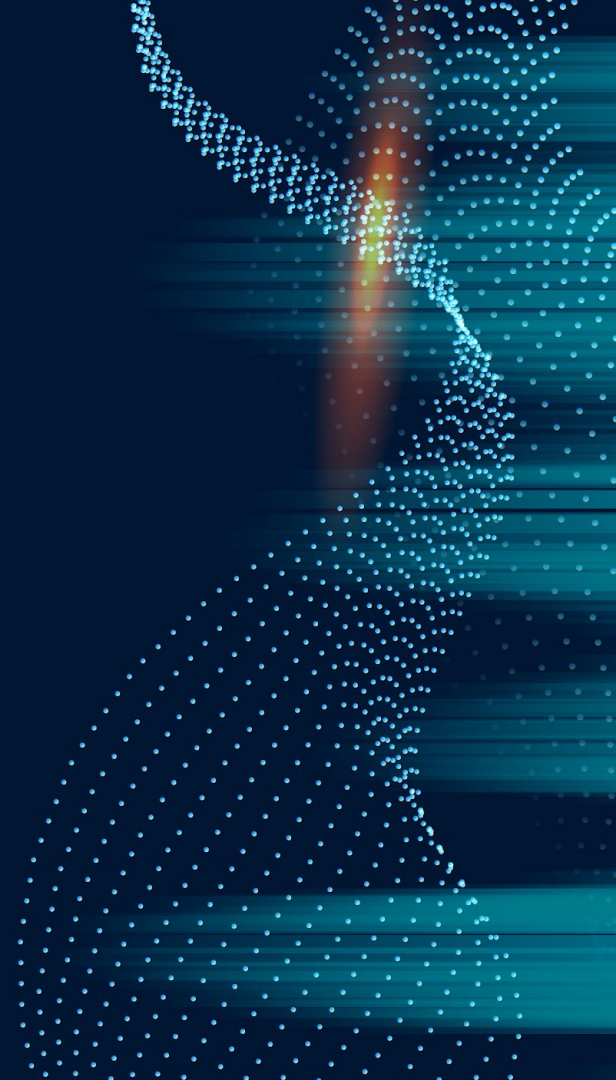
As-Is -- To-Be Model:

- Core problem was User was supposed to provide pick up location but this location can be in an obstructed area leading the robot functionality to halt.
- Was resolved by adding many predefined locations that the user can choose from on a map representation.



As-Is -- To-Be Model:

- Core problem was when signing up users, we needed to verify that they're a valid GIU entity which means we needed access to the university's user database.
- Was resolved by adding a world assumption that our backend can communicate with the university database through an API.





03

Issues with Preliminary Definition

Description:

- Preliminary definition had issues with both domain and requirements
- Issues with domain: too narrow, only specified the outdoor areas.
- Issues with requirements:
 - Too vague and ambiguous
 - Very similar requirements



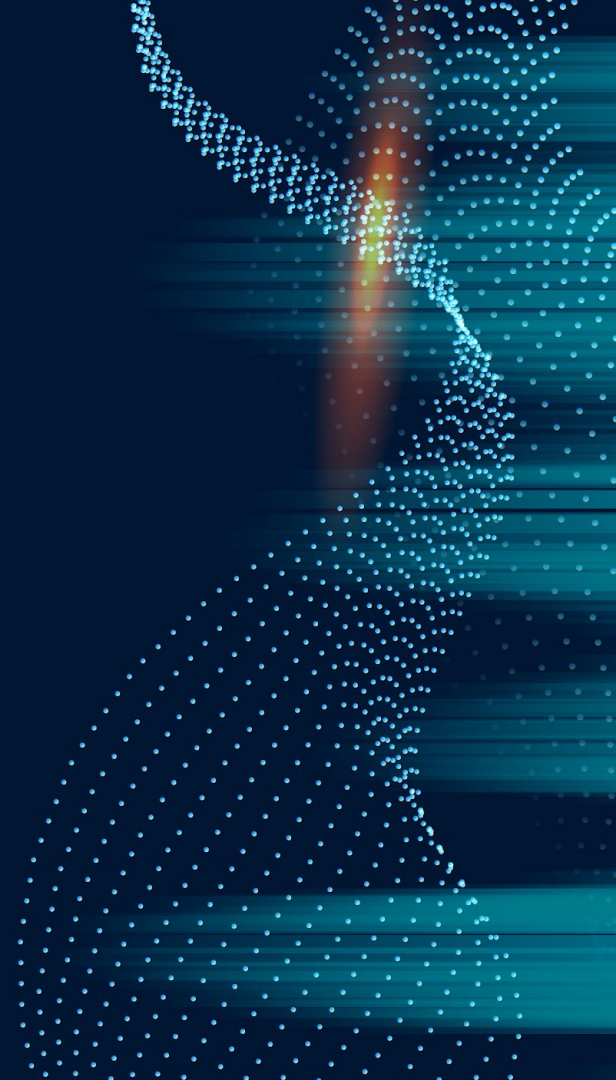
Resolution Options

- Domain:
 - Expand domain to include buildings as well as outdoor areas.
 - Expand domain to only include ground floor of buildings as well as outdoor areas.
- Requirements:
 - Rewrite vague requirements to have a clear definition
 - Combine similar requirements to fewer requirements



Decision

- Domain:
 - Expand domain to also include ground floor of buildings.
- Requirements:
 - Rewrote several requirements with additional details.
 - Combined many requirements to fewer requirements





04 | **Functional Requirements**

Functional Requirements

- User should be able to sign up to with university ID, email and password
- User should be able to login to app or to logout
- User should be able to select a pickup / drop off location from the provided predefined locations
- User shall specify type of package being sent from a pre specified list of items
- User shall set a pin at sign up that will be used for unlocking robot's compartment for sending / receiving packages



Functional Requirements

- User shall be able to change forgotten password or private pin code
- User shall have a contact list of sending / receiving users
- User shall be able to search for users by name or university ID and add / remove them to / from their contact list
- User shall be able to choose a user to send / receive a package from their contact list
- System shall (RE)calculate the ETA using parameters sent by the robot



Functional Requirements

- User shall be able to accept / reject incoming / outgoing delivery requests
- User can order food from pre-defined restaurants in the contact list
- User shall be able to type a message when specifying a delivery
- User should be able to track robots current location on the app
- User should be able to submit a complaint to the apps help center in case of unsuccessful deliveries



Functional Requirements

- Robot shall be able to move to only the ground floor of university buildings & outdoor areas of the university campus.
- Robot shall stop at the user specified pick up / drop off or predefined location
- Robot shall notify the sender and receiver when the destination is reached
- Robot shall emit it's live location to the user
- Robot should be able to detect obstacles at a close enough distance and go around it (turn) in order to avoid collision



Functional Requirements

- Robot shall notify Users about pick up / drop off general arrival time, 2 min to arrival time & package waiting time in delivery queue
- Robot should have different compartments with different doors for simultaneous deliveries
- Robot shall notify sender & receiver in case of delays or failure to deliver scenarios
- Robot shall emit a notification when it is busy on delivery and unable to receive packages
- Robot shall unlock storage bin when correct user pin is provided



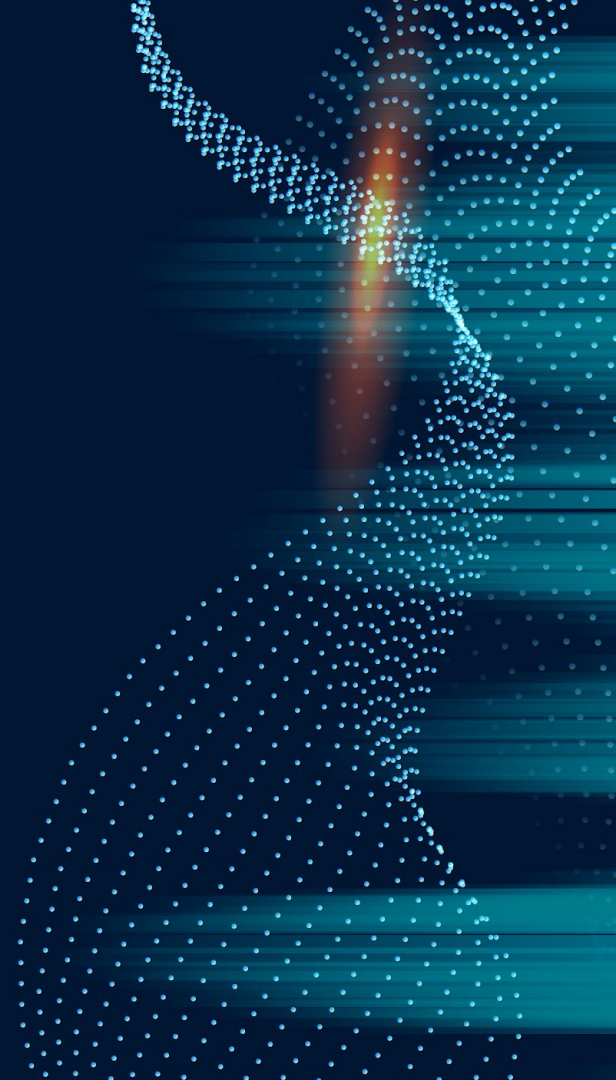
Functional Requirements

- Robot should be able to tell which compartment is associated with which sending / receiving user when pin is entered
- Robot should be able to tell if an item is taken out of a compartment by an unauthorized user and notify admin with user details
- Robot shall tell sending / receiving user to enter pin to insert / receive package
- Robot shall calculate shortest path between pickup point and drop off point & recalculate after obstacle resolution



Functional Requirements

- Robot shall wait for 5 minutes at drop off location for receiving user to take his package
- Robot shall confirm user when package is received successfully in case of sending user is different from receiving user
- Robot shall emit a notification to the users if it is unable to complete a delivery, and take the package to the lost and found storage.
- Robot shall send required data for calculating ETA
- Robot shall send a notification about it's remaining battery life



Functional Requirements

- Robot shall automatically charge in the charging dock when experiencing a low battery and notify users of time till completion.
- Robot shall have a physical key slot for opening the compartments in case of a bug occurring or for maintenance
- Admins should be able to temporarily shut down the system for maintenance
- Admins should be able to temporarily shut down the system for maintenance and notify users beforehand.





05 | **Non-functional Requirements**

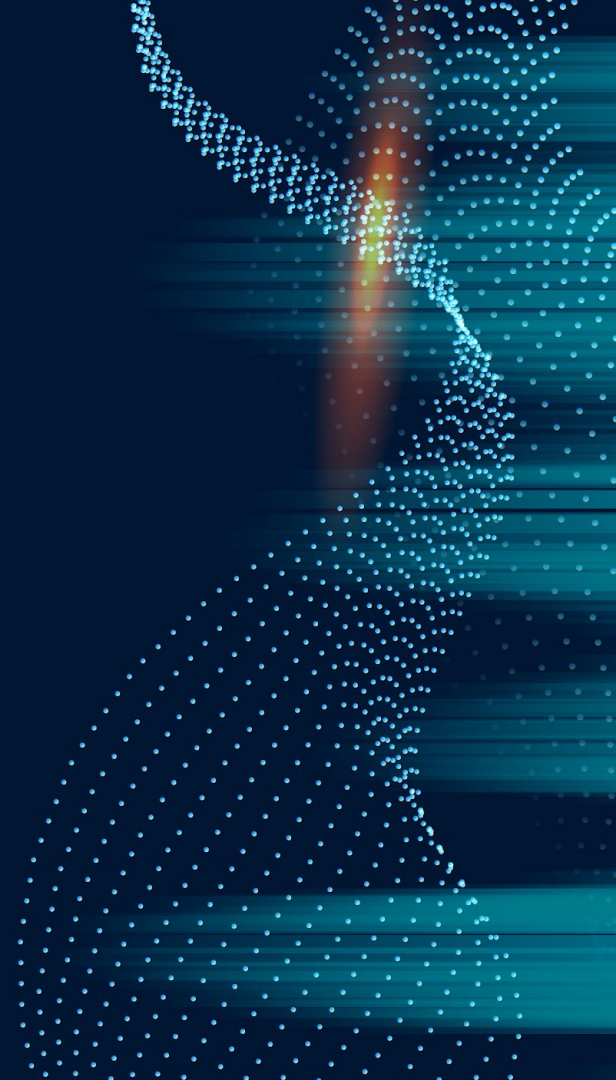
Non Functional Requirements

- System shall assist robot to navigate safely by providing routes suitable for robot
- System should be able to convert route to a series of instruction that robot can follow
- System should have app level & physical level security measures to prevent unintended parties from receiving the package
- Robot should move at high speeds in order to make deliveries quickly



Non Functional Requirements

- System shall determine the fastest route
- Robot should be able to handle packages up to 10kg
- Robot should be able to survive severe weather conditions
- System shall be easily accessible to all members of the university
- System should have over 90% successful deliveries



Non Functional Requirements

- System should be able to handle several simultaneous deliveries
- System will only be accessible to users currently on campus





06

**Backward/
Forward
Traceability**

Prelim Reqs	Backwards / issues	Improved Reqs	Forward / effect
FR#1 User shall provide pickup location	FR is too vague and ambiguous. Needed additional details to solidify its definition.	IFR#1 User should be able to select a pickup location from the provided predefined locations	We can clearly define the pick up points that need to be placed on the map for the robot to navigate too
FR#2 User shall provide drop off location	FR is too vague and ambiguous. Needed additional details to solidify its definition.	IFR#2 User should be able to select a drop off location from the provided predefined locations.	We can clearly define the drop off points that need to be placed on the map for the robot to navigate too
FR#3 User shall see robot location	FR is too vague and ambiguous. Needed additional details to solidify its definition.	IFR#3 User should be able to track robots current location on the app	User can see current location on the map and ETA can be calculated based on current location

FR#4 Robot shall emit location	Needed more clarification on when / how often location will be emitted	IFR#4 Robot shall emit it's live location to the user	ETA and GPS location can be continuously updated in the app and not periodically giving better tracking details to the user.
FR#5 Robot shall move a certain distance	FR is too vague and ambiguous. Needed additional details to solidify its definition.	IFR#5 Robot shall be able to move to only the ground floor of university buildings & outdoor areas of the university campus.	Can define the perimeter of movement for the robot and better calculate obstacle free paths (due to the limited area and thus limited number of possible safe routes)
FR#6 Robot shall stop at the appropriate location	FR is too vague and ambiguous. Needed additional details to solidify its definition.	IFR#6 Robot shall stop at the user specified pick up / drop off predefined location	User tracking for receiving the his/her package will be more accurate
FR#7 Robot shall turn when necessary	Too similar and could be combined into fewer and clearer requirements	IFR#7 Robot should be able to detect obstacles at a close enough distance and go around it (turn) in order to avoid collision	No change to functionality but combined in order to decrease requirement redundancy

FR#8 Robot shall detect obstacles	Too similar and could be combined into fewer and clearer requirements	IFR#7 Robot should be able to detect obstacles at a close enough distance and go around it (turn) in order to avoid collision	No change to functionality but combined in order to decrease requirement redundancy
FR#9 Robot shall avoid obstacles	Too similar and could be combined into fewer and clearer requirements	IFR#7 Robot should be able to detect obstacles at a close enough distance and go around it (turn) in order to avoid collision	No change to functionality but combined in order to decrease requirement redundancy
FR#10 Robot shall send notification when destination is reached	Doesn't specify who the notification will be sent to	IFR#8 Robot shall notify the sender and receiver when the destination is reached	We will now be sure that the notification is going to be receiving by both sender and receiver so they can receive their deliveries
FR#11 Robot shall unlock storage bin when correct user pin is provided	Same requirement no changes	IFR#11 Robot shall unlock storage bin when correct user pin is provided	Same requirement no changes

FR#12 Robot shall send notification when something is wrong	too vague and ambiguous. Needed additional details to solidify its definition.	IFR#12 Robot shall notify sender & receiver in case of delays or failure to deliver scenarios	Reduces scope of possible error messages for easier debugging on the app maintainers side
FR#13 User shall sign up on app with university email, ID, and password	Same requirement no changes	IFR#12 User shall sign up on app with university email, ID, and password	Same requirement no changes
FR#14 User shall be able to login to app	Same requirement no changes	IFR#38 User shall be able to login to the app or to logout	Same requirement no changes
FR#15 User shall specify type of package being sent from a pre specified list of items	Same requirement no changes	IFR#13 User shall specify type of package being sent from a pre specified list of items	Same requirement no changes

FR#16 User shall set a pin at sign up that will be used for unlocking robot's compartment for sending / receiving packages	Same requirement no changes	IFR#14 User shall set a pin at sign up that will be used for unlocking robot's compartment for sending / receiving packages	Same requirement no changes
FR#17 User shall be notified of waiting time till robot's arrival at pick up / drop off point	Too similar and could be combined into fewer and clearer requirements	IFR#10 Robot shall notify Users about pick up / drop off general arrival time, 2 min to arrival time & package waiting time in delivery queue	Combining requirements has lead to reduced redundancy and thus savings in costs for the company and better functionality for the user.
FR#18 Robot shall emit a notification when it is busy on delivery and unable to receive packages	Same requirement no changes	IFR#15 Robot shall emit a notification when it is busy on delivery and unable to receive packages	Same requirement no changes
FR#19 User should be able to submit a complaint to the apps help center in case of unsuccessful deliveries	Same requirement no changes	IFR#16 User should be able to submit a complaint to the apps help center in case of unsuccessful deliveries	Same requirement no changes

FR#20 Robot should have different compartments with different doors for simultaneous deliveries	Same requirement no changes	FR#17 Robot should have different compartments with different doors for simultaneous deliveries	Same requirement no changes
FR#21 User shall have a contact list of sending / receiving users	Same requirement no changes	IFR#18 User shall have a contact list of sending / receiving users	Same requirement no changes
FR#22 System shall (RE)calculate the ETA using parameters sent by the robot	Same requirement no changes	IFR#19 System shall (RE)calculate the ETA using parameters sent by the robot	Same requirement no changes
FR#23 User shall be able to search for users by name or university ID and add / remove them to / from their contact list	Same requirement no changes	IFR#20 User shall be able to search for users by name or university ID and add / remove them to / from their contact list	Same requirement no changes

FR#24 User shall be able to choose a user to send / receive a package from their contact list	Same requirement no changes	IFR#21 User shall be able to choose a user to send / receive a package from their contact list	Same requirement no changes
FR#25 User shall be able to accept / reject incoming / outgoing delivery requests	Same requirement no changes	IFR#22 User shall be able to accept / reject incoming / outgoing delivery requests	Same requirement no changes
FR#26 User can order food from pre-defined restaurants in the contact list	Same requirement no changes	IFR#23 User can order food from pre-defined restaurants in the contact list	Same requirement no changes
FR#27 User shall be able to type a message when specifying a delivery	Same requirement no changes	IFR#24 User shall be able to type a message when specifying a delivery	Same requirement no changes

FR#28 Robot should be able to tell which compartment is associated with which sending / receiving user when pin is entered	Same requirement no changes	IFR#25 Robot should be able to tell which compartment is associated with which sending / receiving user when pin is entered	Same requirement no changes
FR#29 Robot should be able to tell if an item is taken out of a compartment by an unauthorized user and notify admin with user details	Same requirement no changes	IFR#26 Robot should be able to tell if an item is taken out of a compartment by an unauthorized user and notify admin with user details	Same requirement no changes
FR#30 Robot shall tell sending / receiving user to enter pin to insert / receive package	Same requirement no changes	IFR#27 Robot shall tell sending / receiving user to enter pin to insert / receive package	Same requirement no changes
FR#31 Robot shall calculate shortest path between pickup point and drop off point & recalculate after obstacle resolution	Same requirement no changes	IFR#28 Robot shall calculate shortest path between pickup point and drop off point & recalculate after obstacle resolution	Same requirement no changes

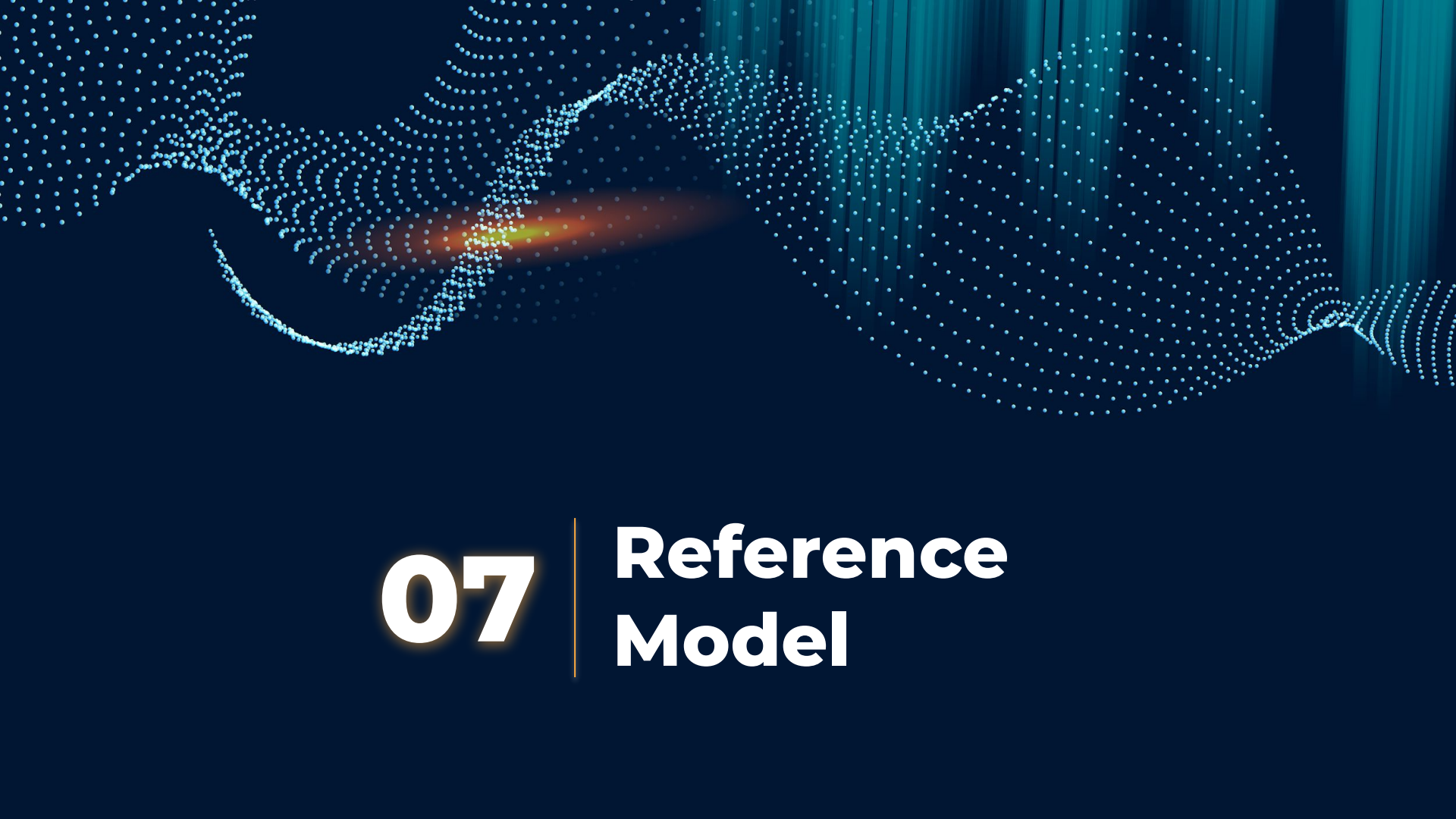
FR#32 Robot shall wait for 5 minutes at drop off location for receiving user to take his package	Same requirement no changes	IFR#29 Robot shall wait for 5 minutes at drop off location for receiving user to take his package	Same requirement no changes
FR#33 Robot shall confirm user when package is received successfully in case of sending user is different from receiving user	Same requirement no changes	IFR#30 Robot shall confirm user when package is received successfully in case of sending user is different from receiving user	Same requirement no changes
FR#34 Robot shall emit a notification to the users if it is unable to complete a delivery, and take the package to the lost and found storage.	Same requirement no changes	IFR#31 Robot shall emit a notification to the users if it is unable to complete a delivery, and take the package to the lost and found storage.	Same requirement no changes
FR#35 Robot shall send required data for calculating ETA	Same requirement no changes	FR#32 Robot shall send required data for calculating ETA	Same requirement no changes

FR#36 Admins should be able to temporarily shut down the system for maintenance and notify users beforehand.	Same requirement no changes	IFR#29 Admins should be able to temporarily shut down the system for maintenance and notify users beforehand.	Same requirement no changes
FR#37 * Robot shall send a notification about the current package in the waiting queue	Too similar and could be combined into fewer and clearer requirements	IFR#10 Robot shall notify Users about pick up / drop off general arrival time, 2 min to arrival time & package waiting time in delivery queue	Combined to reduce redundancy which leads to lower costs for company and better experience for the user
FR#38 Robot shall send a notification about it's remaining battery life	Same requirement no changes	IFR#34 Robot shall send a notification about it's remaining battery life	Same requirement no changes
FR#39 Robot shall automatically charge in the charging dock when experiencing a low battery and notify users of time till completion.	Same requirement no changes	IFR#35 Robot shall automatically charge in the charging dock when experiencing a low battery and notify users of time till completion.	Same requirement no changes

FR#40 Robot shall have a physical key slot for opening the compartments in case of a bug occurring or for maintenance	Same requirement no changes	IFR#36 Robot shall have a physical key slot for opening the compartments in case of a bug occurring or for maintenance	Same requirement no changes
NFR#1 System shall assist robot to safely navigate on campus	Needed more clarification	INFR#1 System shall assist robot to navigate safely by providing routes suitable for robot	Same functionality no changes just more clarification. Test cases will be changed to only include routes for robot instead of general navigation tests
NFR#2 System shall determine the fastest route	Same requirement no changes	INFR#5 System shall determine the fastest route	Same requirement no changes
NFR#3 System shall navigate robot through selected route	Needed more clarification	INFR#2 System should be able to convert route to a series of instruction that robot can follow	Better clarifies for developer what he needs to do but same general functionality

NFR#4 Robot should be able to handle packages up to 10kg	Same requirement no changes	INFR#6 Robot should be able to handle packages up to 10kg	Same requirement no changes
NFR#5 Robot should be able to survive severe weather conditions	Same requirement no changes	INFR#7 Robot should be able to survive severe weather conditions	Same requirement no changes
NFR#6 System should have security measures to prevent unintended parties from receiving the package	Needed more clarification	INFR#3 System should have app level & physical level security measures to prevent unintended parties from receiving the package	Requirement is less vague and system will be more robust due to multiple layers of security (physical and app level wise).
NFR#7 Robot should make deliveries quickly	Needed more clarification	INFR#4 Robot should move at high speeds in order to make deliveries quickly	Robot might need better alerting systems for passing people to warn them of it incoming towards them. More battery consumption due to higher speeds to battery needs to be upgraded. Route recalculation in case of obstacles needs to happen at a fraction of a second to make use of the high speeds of the robot.

NFR#8 System shall be easily accessible to all members of the university	Same requirement no changes	INFR#8 System shall be easily accessible to all members of the university	Same requirement no changes
NFR#9 System should have over 90% successful deliveries	Same requirement no changes	INFR#9 System should have over 90% successful deliveries	Same requirement no changes
NFR#10 System should be able to handle several simultaneous deliveries	Same requirement no changes	INFR#10 System should be able to handle several simultaneous deliveries	Same requirement no changes
NFR#11 System will only be accessible to users currently on campus	Same requirement no changes	INFR#11 System will only be accessible to users currently on campus	Same requirement no changes



07 | **Reference Model**

W1: There is a dedicated entrance for the delivery robot in each of the buildings (M, S) so that the robot can make deliveries on the ground floor.

R1: Robot shall send notification when destination is reached

S1: There will be a notification system that will notify each of the sender or the receiver when the robot reaches its specific destination, the robot will send a request to the server then the server will notify the user..

M - robot processor and user's device

P - Program

Eh: Robot and the users

Ev: The destination

Sv: Information sent in the notification

Sh: How the server will notify the user

W2: Campus is well suited for robot to navigate with no unavoidable obstacles in the possible routes.

R2: Robot shall detect obstacles

S2: Robots will be using high quality cameras and high quality sensors, so they will be able to detect any obstacles they will face in the route and they must find solutions from the many solutions they are programmed to overcome. For example, like turning around this obstacle or finding another easy clear way to go through it.

M - Cameras and sensors

P - Program

Eh: Robot
Ev: Obstacles
Sv: How the system will react when facing obstacles
Sh: How the system will recognize the obstacles

W3: When the delivery robot is about to run out of battery life, it automatically goes to recharge at the nearest charging dock.

R3: Robot shall automatically charge in the charging dock when experiencing a low battery and notify users of time till completion.

S3: Robots will automatically charge themselves when they experience a low battery state and will notify all the users about that including the completion time for fully recharging, if there are some requests it will be delayed or canceled.

M - Battery stations and charging slots in the robots.

P - Program

Eh: Robot
Ev: The charging station
Sv: Low battery affects robots' progress
Sh: How system tells when experience low battery

W4: We will assume that the shortest delivery path is also the fastest one.

R4: Robot shall calculate shortest path between pickup point and drop off point & recalculate after obstacle resolution

S4: Robot will be able to calculate the shortest path between pickup point and drop off point using the Dijkstra algorithm for finding the shortest path nodes which are the pick up and drop off points and the robot will be able to recalculate after any obstacle resolution.

M - Robot processor.

P - Program

Eh: Robot

Ev: The path

Sv: the distance of the path

Sh: The algorithm used for calculation

W5: There will be a "lost and found" room present in the campus with one security guard present at all times to drop off failed to receive deliveries.

R5: Robot shall emit a notification to the users if it is unable to complete a delivery, and take the package to the lost and found storage.

S5: Robot will notify the user if the delivery can not be completed for any reason and the package will be taken to the lost and found storage and will also notify in which section in the storage so the user can go and get it.

M - Robot processor and user's device.

P - Program

Eh: Robot

Ev: The location of the lost and found

Sv: The undelivered package

Sh: Sending the notification through the server

W6: The delivery robot as well as users are both always connected to high speed WIFI through routers that are evenly distributed across the GIU campus.

R6: Robot shall unlock storage bin when correct user pin is provided

S6: The robot will unlock its storage bin when the user puts his or her own pin correctly by typing the pin on a keypad constructed on the robot's body, the robot will check the database after receiving the pin. If that pin is correct it will respond to the user by unlocking the bin. If it is not correct it will tell the user to re-enter the pin and this is of course for security and privacy. Each pin is saved with each account that has been made for this service so the pin code is like the id the robot can check to ensure it belongs to the user.

M - Routers and robot processor

P - Program

Eh: Robot and the users

Ev: Pin code

Sv: Buttons

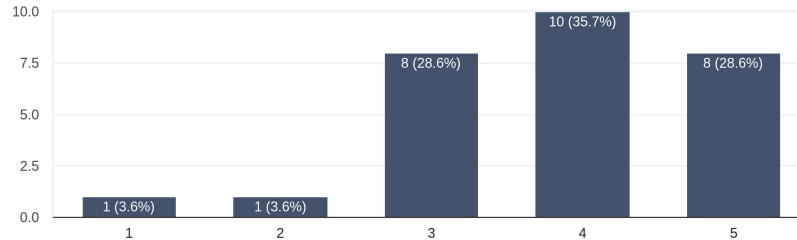
Sh: How the system checks if it's the correct pin or not



08 | **Questionnaire**

On a scale of 1 to 5, How receptive are you of the idea of a campus delivery bot ?

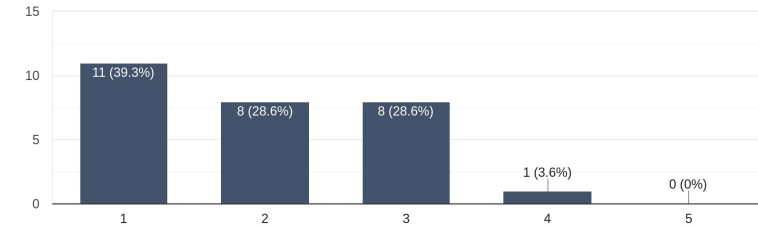
28 responses



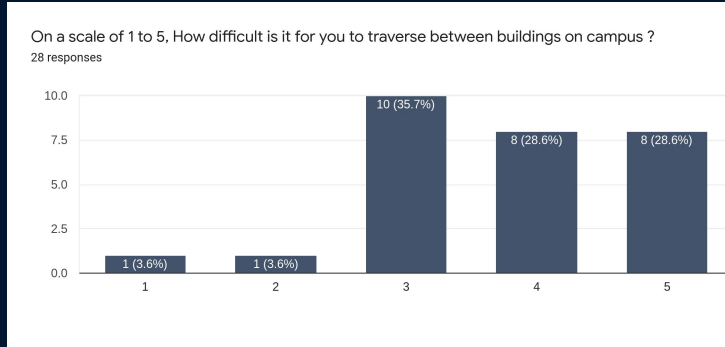
- We initially wanted to know how well the idea would be received
- Clearly people think it's a good idea

On a scale of 1 to 5, Do you believe that the time in between classes is enough for you to buy food ?

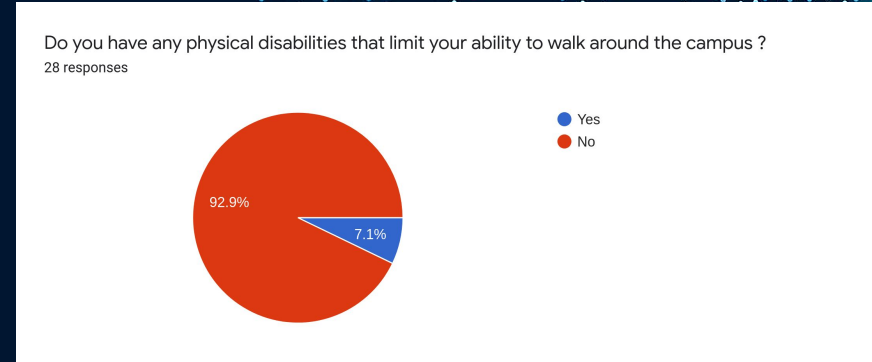
28 responses



- We were trying to confirm that there is actually a problem that needed a solution.
- This proved that there is



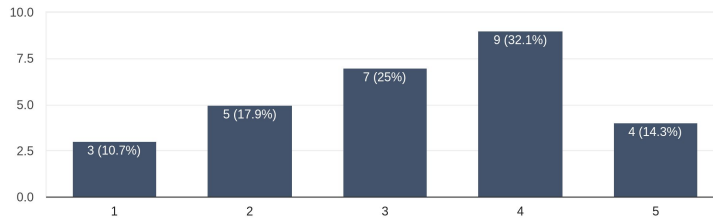
- This confirms that everybody finds it difficult to traverse on campus.
- Further proves that there is a problem.



- Shows that for some, a delivery robot is a necessity not just a convenience.

On a scale of 1 to 5, Would you mind waiting a little longer to receive your food but have it delivered to your current location ?

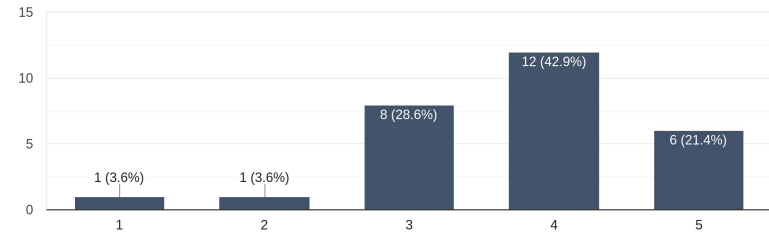
28 responses



- Purpose was to find if people were willing to be a bit delayed for the sake of convenience.
- Mixed results

On a scale of 1 to 5, How likely are you to trust a robot with making deliveries for you ?

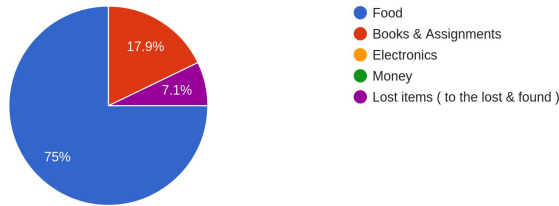
28 responses



- Wanted to find out if people would be hesitant to trust an automated delivery.
- Most were not

If you had a campus delivery bot, what type of items would you send?

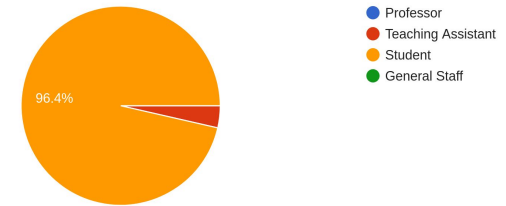
28 responses



- This question was meant to give an idea of what items would be sent the most, to design robot accordingly.

What is your role in the GIU ?

28 responses



- Questionnaire was limited, as most participants were students.

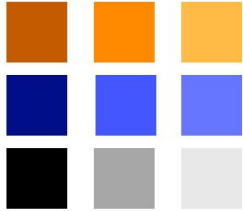


09 | **Mockup Designs**

Onboarding and Auth

Package Bot

Color Palette



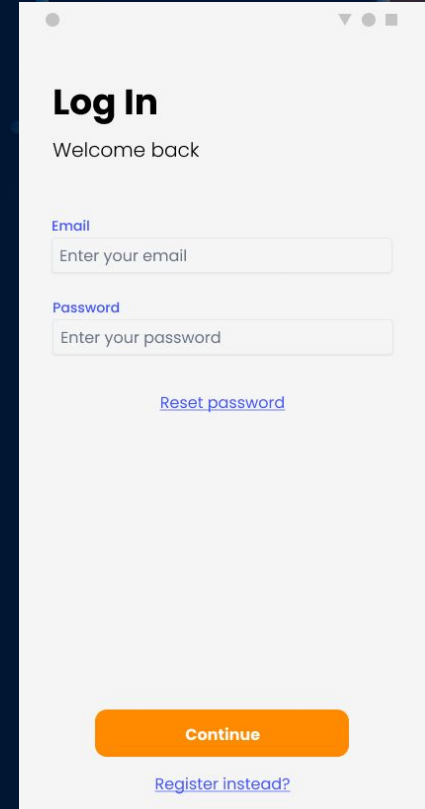
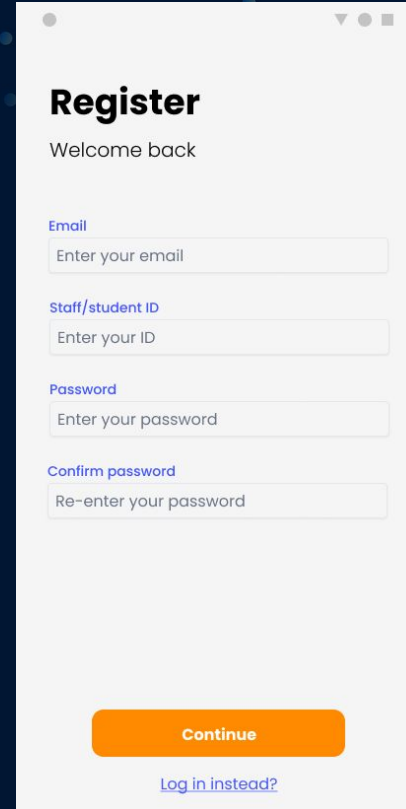
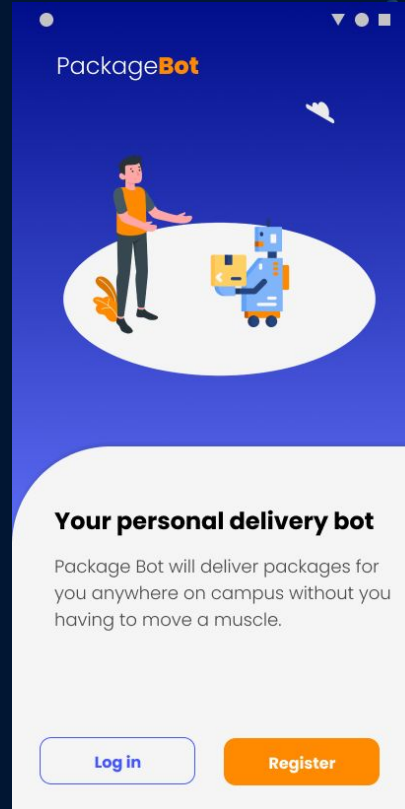
Font (Poppins)

Bold

Medium

Regular

Light



Pin setting

Set a pin

This pin will be used to verify you
upon receiving and sending
packages



1	2	3
4	5	6
7	8	9
	0	

Continue

Set a pin

This pin will be used to verify you
upon receiving and sending
packages



1	2	3
4	5	6
7	8	9
	0	

Continue

Confirm pin



1	2	3
4	5	6
7	8	9
	0	

Done

Bot status

Package Bot Status

Requests

Philip Coulson

Wants you to recieve a pacakge

Jemma Simmons

Wants you to send a package

In progress

Incoming

Niles Caulder

ETA 7:24

Outgoing

Leopold Fitz

ETA 1:48

Waiting

Leopold Fitz

Leaving in 1:20

+ New delivery

Deliveries

Contacts

Settings

Package Bot Status

Capacity

Battery

Ongoing deliveries 4

Available for deliveries

Requests

Philip Coulson

Wants you to recieve a pacakge

Jemma Simmons

Wants you to send a package

In progress

Incoming

Niles Caulder

ETA 7:24

Outgoing

Leopold Fitz

ETA 1:48

+ New delivery

Deliveries

Contacts

Settings

Package Bot Status

Battery

Charging - 1 hour until active

Requests

Philip Coulson

Wants you to recieve a pacakge

Jemma Simmons

Wants you to send a package

In progress

Incoming

Niles Caulder

ETA 7:24

Outgoing

Leopold Fitz

ETA 1:48

+ New delivery

Deliveries

Contacts

Settings

Package Bot Status

Full capacity - try again later

Requests

Philip Coulson

Wants you to recieve a pacakge

Jemma Simmons

Wants you to send a package

In progress

Incoming

Niles Caulder

ETA 7:24

Outgoing

Leopold Fitz

ETA 1:48

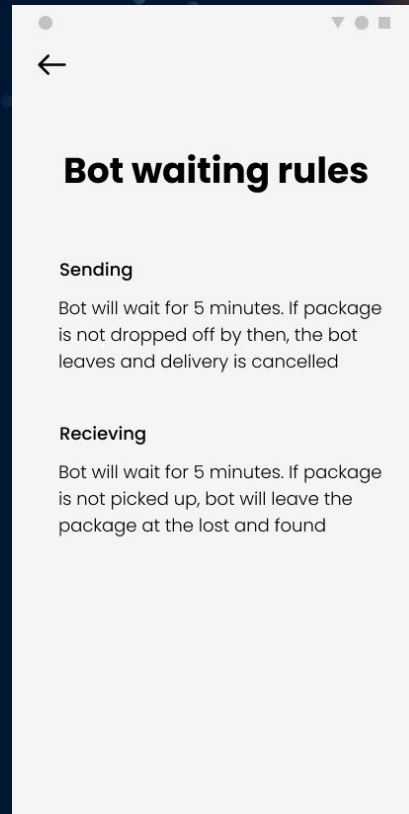
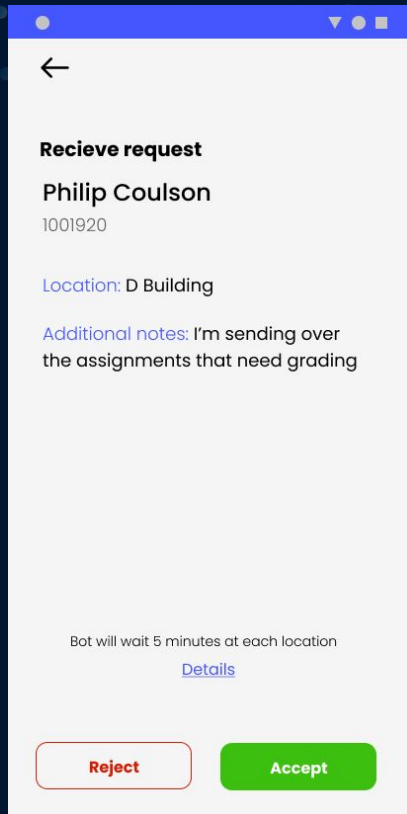
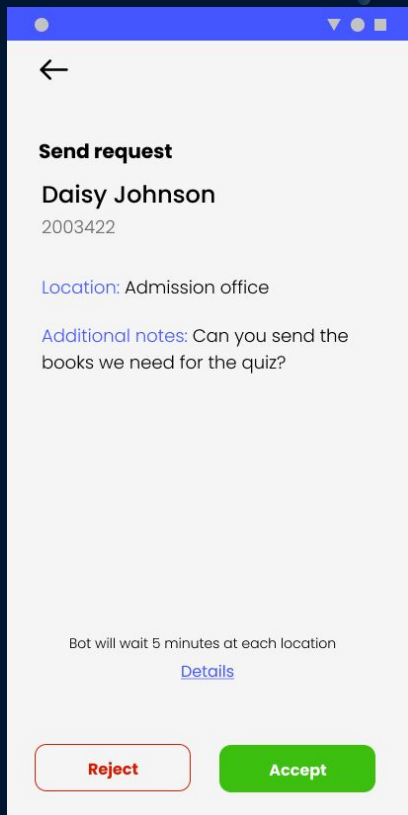
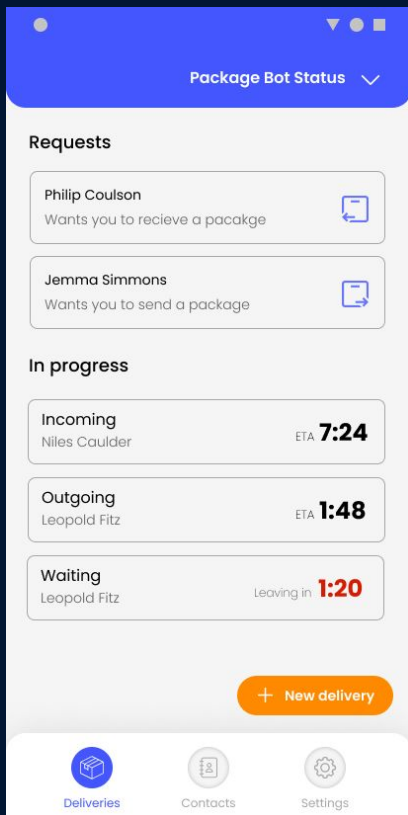
+ New delivery

Deliveries

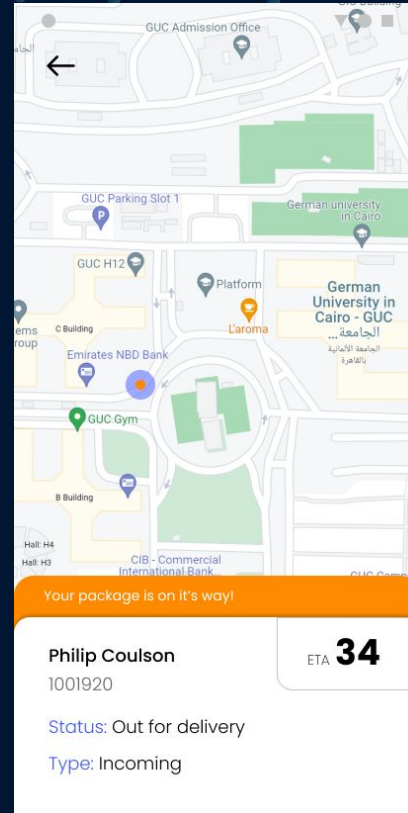
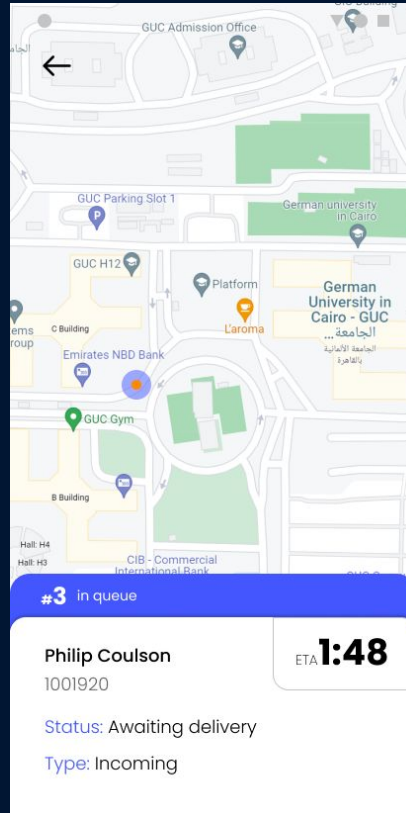
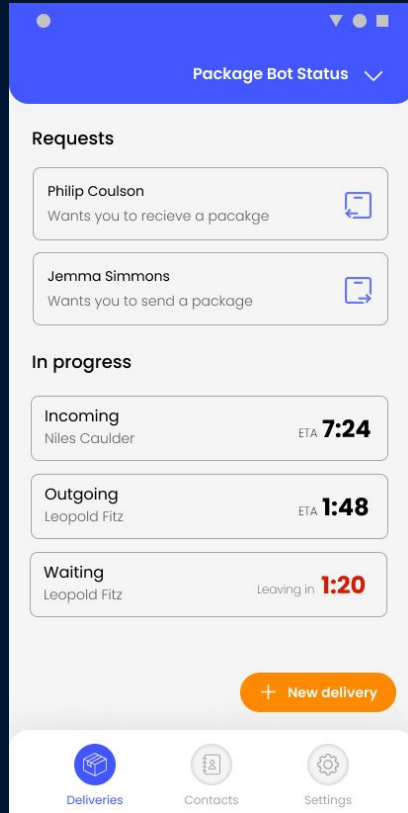
Contacts

Settings

Delivery Requests

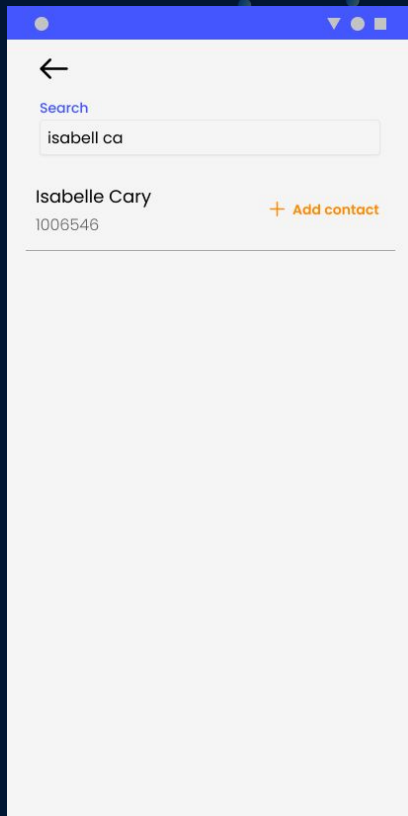
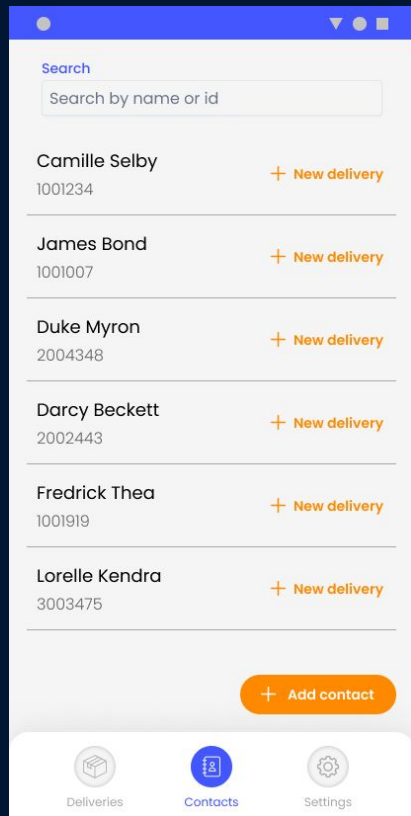


In progress deliveries



GUC map used for convenience

Contacts



New Delivery

← New delivery

Sender:

Receiver:

Pickup location:

Dropoff location:

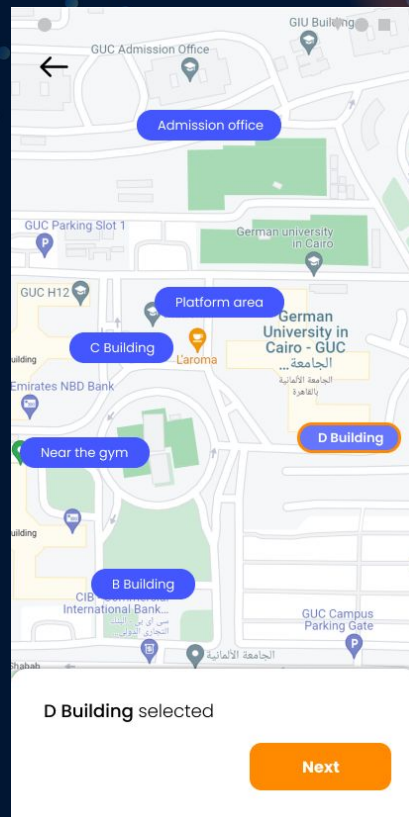
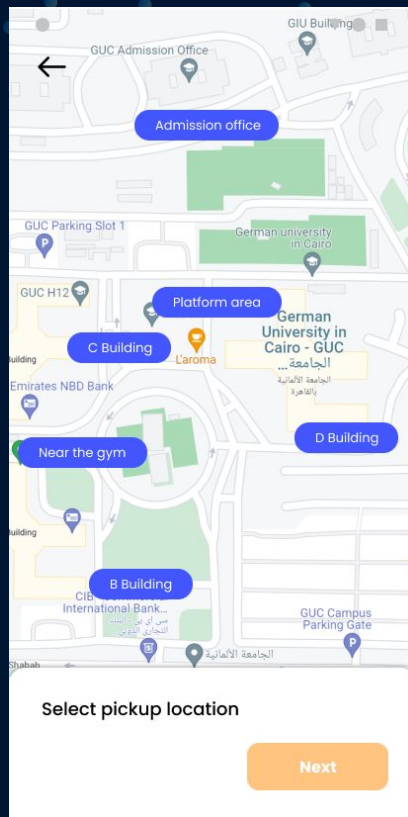
Additional notes:

←

Search

Isabelle Cary

1006546



New Delivery (Cont)

▼ ● ■

←

New delivery

Sender:

Me

Reciever:

Camille Selby

Pickup location:

D Building

Dropoff location:

Admission office

Additional notes:

I'm sending over the assignments that need grading

Send request

▼ ● ■

Request sent!

Delivery request has been sent, you will be notified when the recipient accepts or rejects your request

Bot will wait 5 minutes at each location

[Details](#)

Done

Settings

