GNG 1503
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SECTION A02 – FA24

DELIVERABLE F: PROTOTYPE I AND CUSTOMER FEEDBACK

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Summary

In the preceding deliverable, Deliverable E, we meticulously crafted the final solution design, drawing upon the comprehensive design drawing, and assembled all the necessary materials for our initial prototype. Now, as we progress to Deliverable F, our focus shifts to the first round of testing and prototyping results. This phase involves a thorough analysis of our systems and soliciting valuable feedback from our selected clients.

Materials Table

Introduction

As upcoming design engineers, it is important that we keep a structured and organized work discipline, following specific and precise steps and instructions, as well as detailed in-sights of what and how the work will be done. As such, following the conceptualization steps of the Design Thinking process, we view it crucial to create a focused prototyping and testing schedule for the next 3 weeks of project work. Throughout this period, the team will be delivering one prototype overview and customer/user feedback report weekly (Deliverables F, G and H). The report will also include information about future work to be done on the prototypes, and improvements made to the design along the way.

In this deliverable, we discuss the client remarks obtained from Client Meet 2, and how they influenced the final design and the work on the first prototype in general, as well as the specifications and analysis making up Prototype I, and how it will be improved upon for Prototype II. We've also included feedback from a selected potential user, regarding interface user-friendliness, usability and efficiency of the scanning system (RFID reader circuit and Bluetooth connectivity), as well as casing size and portability, with handling comfortability.

These elements will help determine the future steps to approach, and the current problems to address.

Detailed Description of Customer Feedback

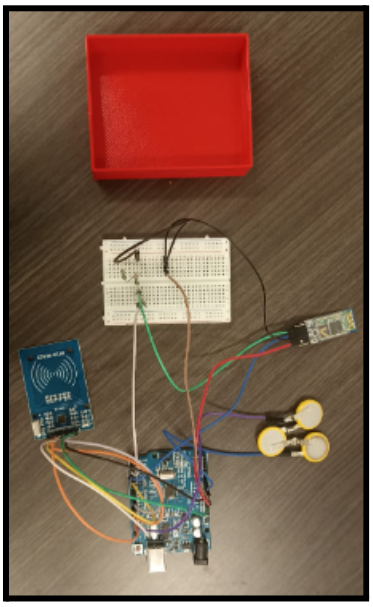
After we presented our final concept to the clients, during the 2nd client meet, they provided us with useful feedback that we took into consideration while making the first prototype. Our initial concept included an expensive long range (2m) RFID reader that would scan the items as soon as they entered the entry door and release the items as soon as they passed the exit door. As it turns out the clients clarified that they were not interested in a long range scanning system, rather, they prefer an RFID reader with a shorter range (5-10 cm) and a more affordable price. This is why we used the (RC 522) RFID reader (5 cm range) connected to an Arduino UNO and an (HC 05) bluetooth module for the first prototype.

Systems Analysis and Considerations for Prototype 1

CALCULATIONS REGARDING USEFUL SPACE IN THE ELECTRONICS COMPARTMENT

In order to guarantee that the electronics compartment will fit all of the crucial electronic elements, we calculated the total usable space in the compartment based on the Onshape measurements for the surface of each face:
Compartment walls: 8 cm * 2.5 cm = 20 cm^2 and 10 cm * 2.5 cm = 25 cm^2
Compartment base: 8 cm * 10 cm = 80 cm^2
Usable volume: 80 cm^2 * 2.5 cm = 200 cm^3
Calculating the total space taken by all electronic components is a difficult task, given that some of them have irregular shapes and geometries. As such, for the sake of simplicity, we suppose that all the electrical components have 2D geometries only, with a presumed thickness of 0 cm. The thickness is neglected due to the fact that all of the elements have a very miniscule thickness (<1 cm), which makes it impossible for them to go past the height of the compartment walls, even when stacked one on top of the other. The calculations give the following:
Surface of the Arduino UNO: 6.86 cm * 5.34 cm = 36.63 cm^2
Surface of the RC522 RFID reader: 6 cm * 4 cm = 24 cm^2
Surface of the HC-05 Bluetooth module: 4 cm * 1.5 cm = 6 cm^2
Surface of 3x CR2032 Lithium coin batteries: π*$(1)^2$ cm *3 = 9.42 cm^2
The sum of all component surfaces gives the following result: 76.05 cm^2
As such, it should be noted that the total surface available on the compartment base (80 cm^2) is sufficient to store all crucial electronic components (The breadboard isn't included

because it will be ditched in future prototypes, where welding will be used for cable management and connections, which takes virtually no additional space). The additional space that comes with the 2.5 cm compartment depth, will be used to house all the cables and wiring.
Finally, it is deduced that this space is optimal for both containing all of the elements necessary, and providing space efficiency and economy.



CONSIDERATIONS FOR THE ELECTRONIC SETUP AND LAYOUT

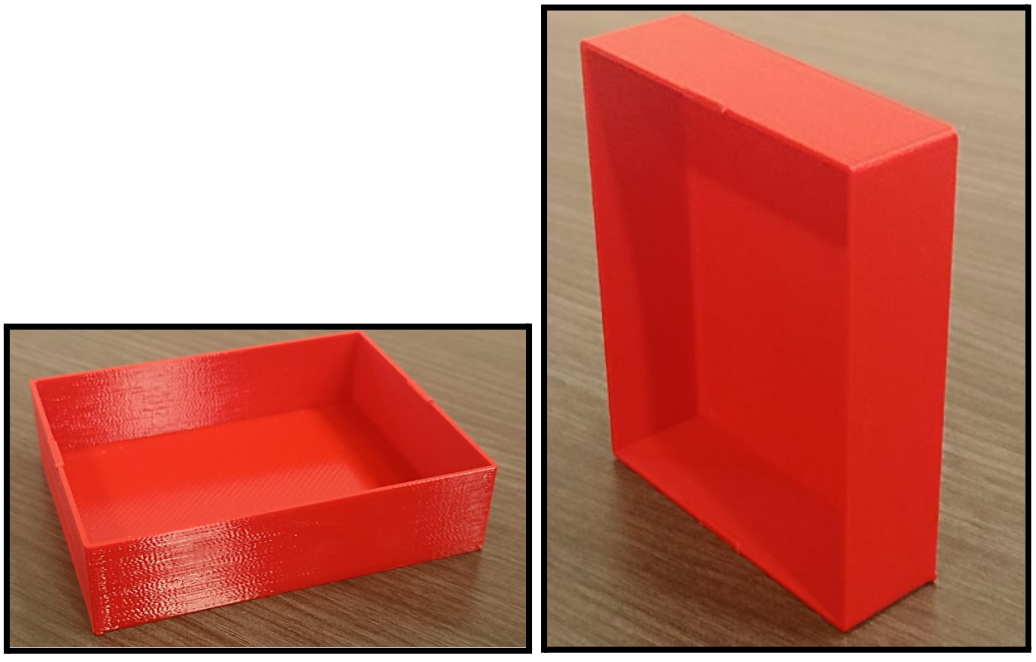
The overall circuit is supplied by a 9V power supply, originating from the 3x CR2032 Lithium coin batteries. However, it should be noted that the main electronic components (RC522 RFID reader and HC-05 Bluetooth module) have different voltages for nominal operation. We decided to rely on the integrated Arduino UNO voltage regulator, in order to split the circuit into a 3.3V flow (for the RC522 RFID reader) and a 5V flow (for the HC-05 Bluetooth module). This way, we can save on the materials required for building a regulating circuit (using resistors). However, this is not an option for the HC-05 Bluetooth module RXD pin, which has a level of 3.3V, unlike the rest of the pins which operate on a 5V voltage. In order to avoid frying the Bluetooth module, we were forced to implement a "level-shifter" circuit between the RXD pin on the Bluetooth module, and the GND and Digital(2) pins on the Arduino UNO.
We also calculated the longevity of the electrical circuit by determining the life span of 3x CR2032 Lithium coin batteries in a series composition:

Assuming the HC-05 module and the RC522 reader are always at 100% peak consumption (30 mA and 20mA respectively), and the Arduino UNO is at its nominal consumption too (50 mA), we can add up the consumptions to find:
Total consumption in the circuit = 30 mA + 20 mA + 50mA = 100mA
And with every battery having an average capacity, presumed to be at 225 mAh, then we can calculate the total capacity to be at:
1/Total capacity = 3*1/225 mAh = 1/75 mAh ===> Total capacity = 75 mAh
Using a standard battery life calculator, conveniently available openly on the Internet [3], we can find the battery life to be at: 36 minutes.
It is worth noting that this value is expected to be tremendously superior to what was estimated, due to the fact that the circuit is not functioning at 100% operability all the time, which means that the battery life can even be extended to a year, in optimal conditions.

Prototyping Test Results (Prototype 1 components)

ELECTRICAL COMPARTMENT

For the first prototype, we've decided to work on 3D printing the first electrical compartment to store the final electrical components and organize their layout.
The first prototype features the casing uniquely, without the cover (the locking mechanism for the cover will be developed with the second prototype). The purpose of this prototype is to test the permeability of the 3D printing materials (PLA) for the radio waves coming from the RFID reader and tags, as well as their structural integrity and strength.



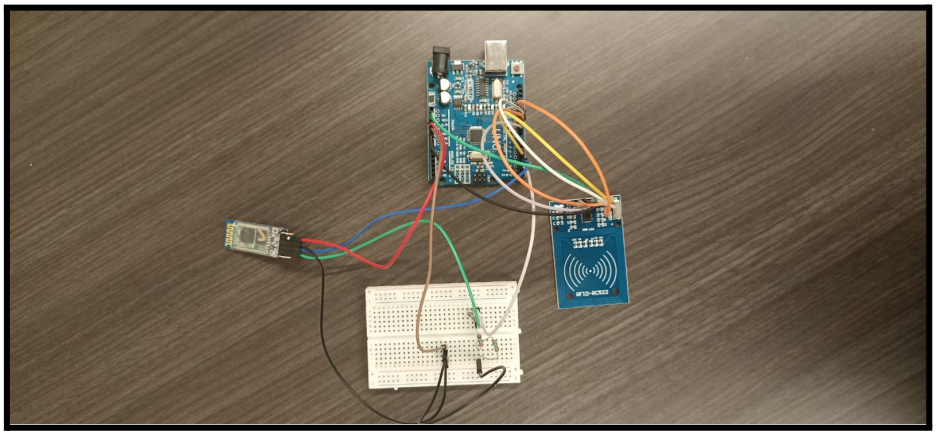
Test number	Methodology/Procedure	Results
4	The RFID reader was placed within the container, and the tag was introduced on the other side of the container wall.	Successful detection of the RFID tag at an acceptable distance (~5 cm maximum), as evidenced by the display of the contents of the RFID tag in the serial monitor of the Arduino IDE upon conducting the test. This result was expected, as it is known through research and experimentation that high frequency radio waves can penetrate plastics, including 3D printing PLA.

NOTE: Test number 3 was abandoned due to the inability to prepare a proper compartment cover for this prototype specifically, as such, that test was delayed to the second prototyping phase.

ELECTRICAL LAYOUT

The electrical layout used for testing the functionality of the electrical elements is very similar to the final targeted concept, with a key difference being:

- The presence of a breadboard: The final concept will feature the usage of welding for complex connections, rendering the breadboard useless. This is beneficial in the fact that it saves space and money by eliminating one of the most voluminous and expensive parts of the project.



As shown in the image, the prototype contained the following components:

- Top-middle: Breadboard.
- Middle-left: RC522 RFID reader.
- Middle-right: HC-05 Bluetooth module.
- Bottom-right: 3x Lithium coin batteries.
- Bottom-middle: Arduino UNO microcontroller.

The test done using the circuit was follows:

Test number	Methodology/Procedure	Results
2	The Bluetooth circuit was initiated through Arduino code. We use a Serial Bluetooth Terminal app on our mobile phone in order to communicate with the Bluetooth module and verify connectivity. We increase distance until we lose connection.	The maximum distance was determined to be around ~30 meters, which is more than sufficient considering a small to medium depot/warehouse to be the target clientele.

Note: Test number 1 regarding the battery longevity was abandoned, due to the fact that a more convenient and precise solution was found (analytically calculated).

Potential User Feedback

By discussing our options and strategies with previous students and friends who may have an interest in the subject of this project, we managed to obtain the following feedback:
Mohammed Boustta: “3D printing the electronics compartment might seem like a good idea, however, I don’t see it as time-efficient, strong, and convenient as laser-cutting a wooden box with simple joints as attachment points between the faces of the box. This will render it easily openable and secure at the same time, it will also save the trouble of failed 3D printing attempts that waste precious hours at a time.”
Mostafa Boulayad: “While using a publicly available app development service may seem convenient and quicker, you would miss out on the opportunity to develop your app development skills, which may come in handy in future projects. I suggest manually

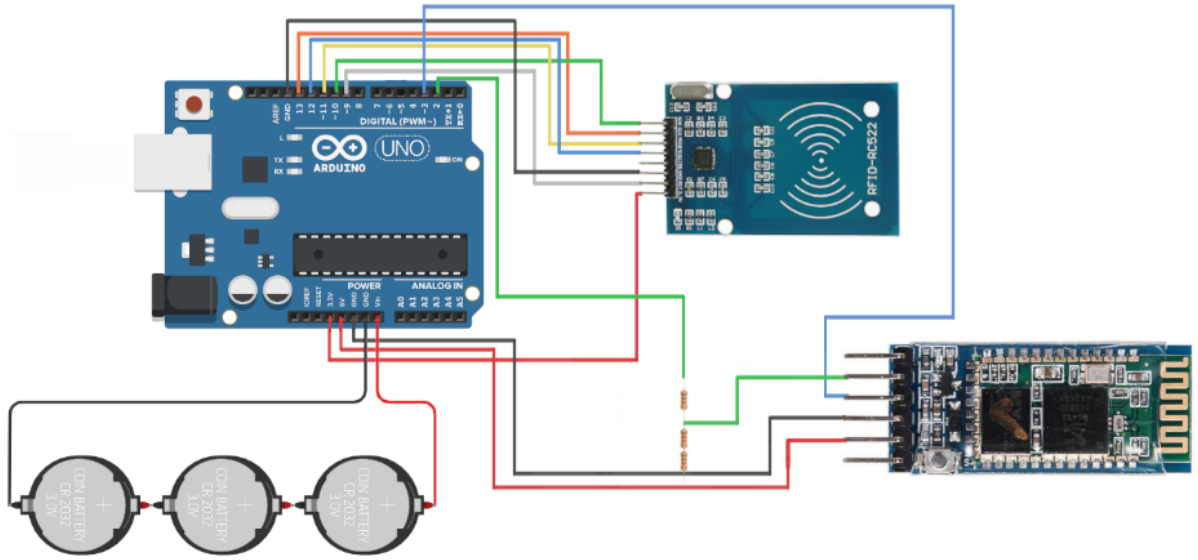
composing your app using Microsoft Visual Studio Express as a starting point, while referring to Youtube tutorials and guides, as well as already available code, in order to learn and advance when it comes to coding. This will also make your app completely customisable, and you could make it however you wish then."

Updated concept based on prototype testing results

ELECTRONICS CASING

No changes.

ELECTRICAL LAYOUT



- Removal of the breadboard.
- Adoption of welding as the principle way of building complex connections (level-shifters for the HC-05 Bluetooth module)

WIREFRAME

Here is the wireframe for the application. This one is medium fidelity, compared to the low fidelity, this one has 4 new pages.

The old pages

The interface: It's the main menu. From there, you have access to every option that the app provides .

Reglages (Settings) : From there, we can change the language, the display, the notification you receive and the sound.

Aide (Help) this page gives you access to the FAQ (for more general questions about how the application works) and to a phone number and an Email to contact when you have a more specific problem.

ITEM: This page shows the information about the item that you are searching for : the serial number, the location, the date of entry(=When did the item enter the inventory), the history of this item(= every move in the inventory). With the option « partager »(share) you can share the information you found with other members of your team.

Historique (History): shows the user every item that they searched previously .

Enterprise: From there, the user can chat with all their colleagues who use the application.

Scan: from there, the owner of the app can use their phone as a scanner for the item.

Informations : this page shows the information about the person that logs in; their name, their email, their phone number and the name of their company. They can edit the information whenever they want.

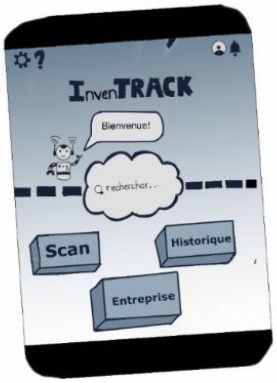
Notifications : From there, we can see the moves of every item register in the inventory.

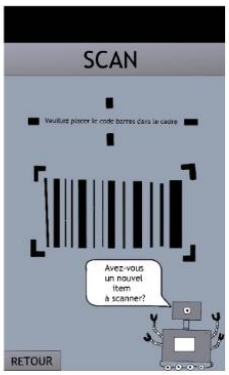
The new pages

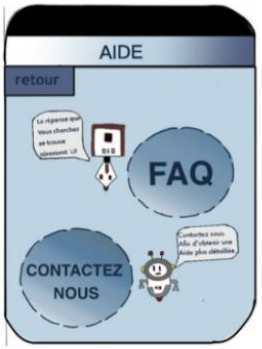
Login page: From here the user can log in to their account using either their email address or their phone number and entering their password.

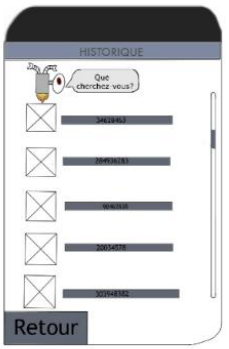
The FAQ page: From here the user has access to several questions through which the answer to his problem can be found.

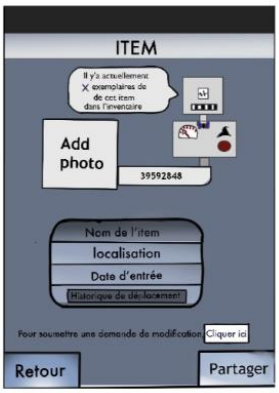
The two discussion pages: From the first one, the user has access to all their conversations with their co-workers and on the second one, the user can chat with one specific co-worker.

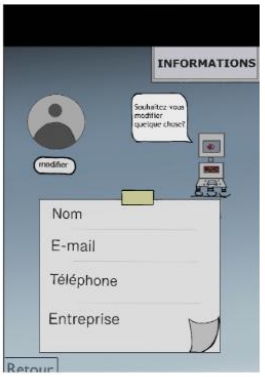


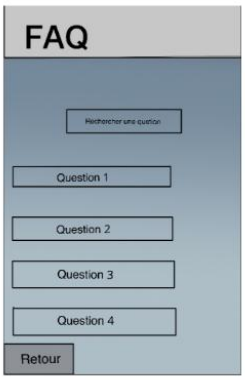


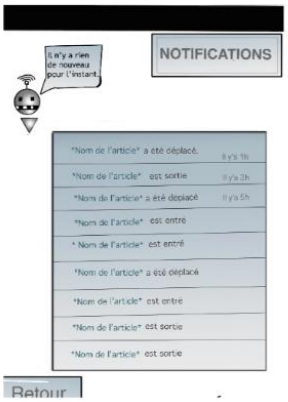












Wireframe pages

MATERIAL NAMING

	Item Name	Description	Unit of measurement	Quantity	Unitary Cost	Expected cost	Link
1	RFID reader (RC 522)	Scanner + tag	Unit	1	5$	5$	https://www.amazon.ca/CANADUINO-RFID-Starter-13-56MHz-Keyfob/dp/B07B2CV31T/ref=sr_1_2?crid=YZTDLLULKJU5&keywords=RFID+reader+Arduino+UNO&qid=1698606710&sprefix=rfid+reader+arduino+uno%2Caps%2C89&sr=8-2
2	Arduino Uno	Arduino UNO microcontroller (processing unit)	Unit	1	17$	17$	https://makerstore.ca/shop/ols/products/arduino-uno-r3/v/A001-WTH-USB
3	Bluetooth module (HC 05)	Bluetooth transceiver replacing the serial cable	Unit	1	9$	9$	https://makerstore.ca/shop/ols/products/hc-05-wireless-bluetooth-module-with-at-button
4	Jumper cables	1x 10-pack Male-to-Male (20 cm) 2x 10-pack	Unit	3	1$	3$	https://makerstore.ca/shop/ols/products/jumper-cables-

		Male-to-Female (20 cm)					per-10/v/JMP-CBL-20C-ML
5	Battery	CR 2032 - 3V	Unit	3	1$	3$	https://makerstore.ca/shop/ols/products/cr2032-lithium-coin-cell-battery/v/ELC003-CR2
6	Resistance	-1KΩ	Unit	3	1$	3$	N/A
7	Data base	SQlite	N/A	N/A	0$	0$	https://flutterflow.io/
8	RFID case	A plastic case that contains the Arduino, the RFID and the batteries (3D-printed)	Unit	1	0$	0$	https://cad.onshape.com/documents/8f4b0cc50aac21c20323d64b/w/f1718eea2c8e68708ef56824/e/fe41029a669a977626162548?renderMode=0&uiState=653ea72120e66a34a1bbd021
9	Code librairies	-MFRC522 -Software Serial	Unit	2	0$	0$	https://github.com/miguelbalboa/rfid
	Total without Tax or delivery fee					≃44$	N/A

	Total with tax and delivery	≃49.59$+0$	N/A

[2]

Prototyping Test Plan (Prototype 2)

N° of the test	Objective of the test	Description of the prototype used and test methodology/procedure.	Description for results to gather and how they will be used	Estimated duration and time of beginning of the test
1	Verify app interface user-friendliness	Analytical and partially comprehensive, we will allow a test-user (a friend, or random person) to use the app for a few minutes and discover its features (Simulating an early-access phase of the app)	User feedback and suggestions. These suggestions will be taken into account during the development of the third prototype, where we will consider the test-user's rating for each functionality and its usability. Any functions with a notably low rating will be reworked and improved upon.	30 minutes, 18th of November, 2023
2	Verify integrity and functionality for the cover locking	Physical and partially comprehensive, we will attempt to close the cover and attach it to the compartment	Observe whether the cover falls off easily, or whether it's too hard to re-open. Redesign	10 minutes, 18th of November, 2023

	mechanism	firmly, we will check its integrity by repeatedly shaking the casing while upside-down.	of the locking mechanism in either cases.	

[3]

Conclusion

Following both user and customer feedback, we were able to appropriately adapt our first prototype and test its components (electricals and compartment). However, it appears that there is much more work to be done in order to perfect them and optimize them, as this will guarantee keeping up to the standards and the competition. As such, we look forward to applying these newly-acquired acknowledgements in order to improve upon our existing prototype and making our second prototype, which should include 3D printing the cover for the compartment, welding the level-shifter circuit in order to abandon the breadboard, and starting off the app development process with the user interface and basic information display tasks and features. We also look forward to the feedback and recommendations that will arise from this prototype.

References

[1] https://www.omnicalculator.com/other/battery-life

[2] Développement professionnel/Gestion de projet/Guide d'achat — Wiki CGEC

[3] https://uottawa.brightspace.com/d2l/le/content/382673/viewContent/5596392/View