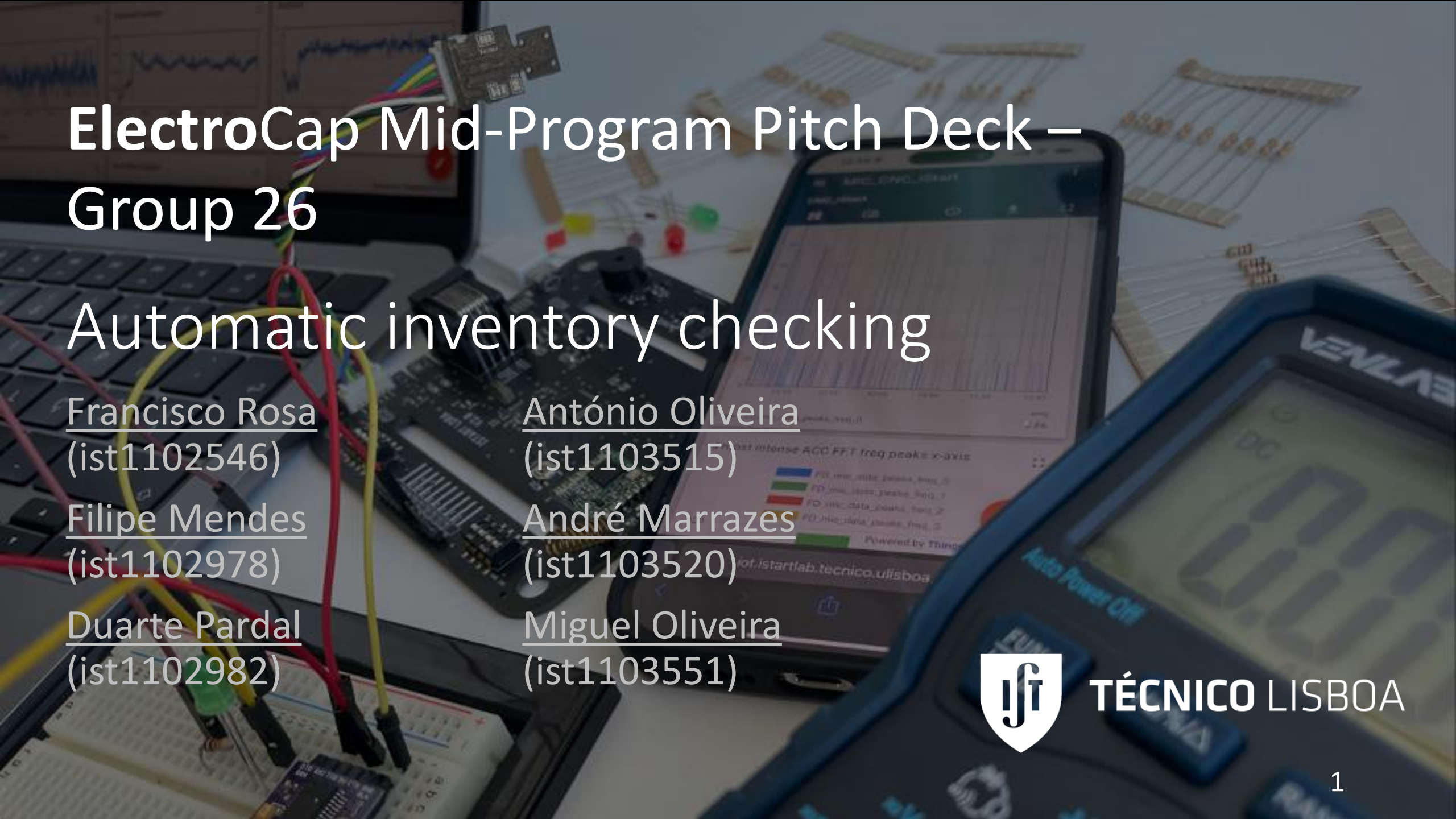


ElectroCap Mid-Program Pitch Deck – Group 26

Automatic inventory checking

Francisco Rosa (ist1102546)

Filipe Mendes (ist1102978)

Duarte Pardal (ist1102982)

António Oliveira (ist1103515)

André Marrazes (ist1103520)

Miguel Oliveira (ist1103551)

TÉCNICO LISBOA

Team

André Marrazes

Filipe Mendes

António Oliveira

Duarte Pardal

Francisco Rosa

Miguel Oliveira

Advisors and Mentors

Scientific Advisor/
Coordinator

Prof. Luís Correia

Co-coordinator

Prof. João Felício

Problem definition

Nowadays, people who use mobile inventories (such as plumbers or electricians) face the problem of equipment loss. Many of these workers carry items on their vans and have little way of knowing if, where and when they get lost. As such, we propose a device to be placed inside these vehicles, which would check whether all predefined objects of interest are present inside the vehicle.

The existing solutions right now are limited not only by their expensive price, but also by the lack of mobility of the system and its difficult use. As a result, the usage of these systems is not common practice with small businesses or individuals.

Solution beneficiaries

Ultimately, this solution can be beneficial to all jobs that require the transportation of equipment between places, like shipping companies or storage facilities. More specifically, we think this well benefit professionals such as: vets, musicians, service installers and maintenance technicians.

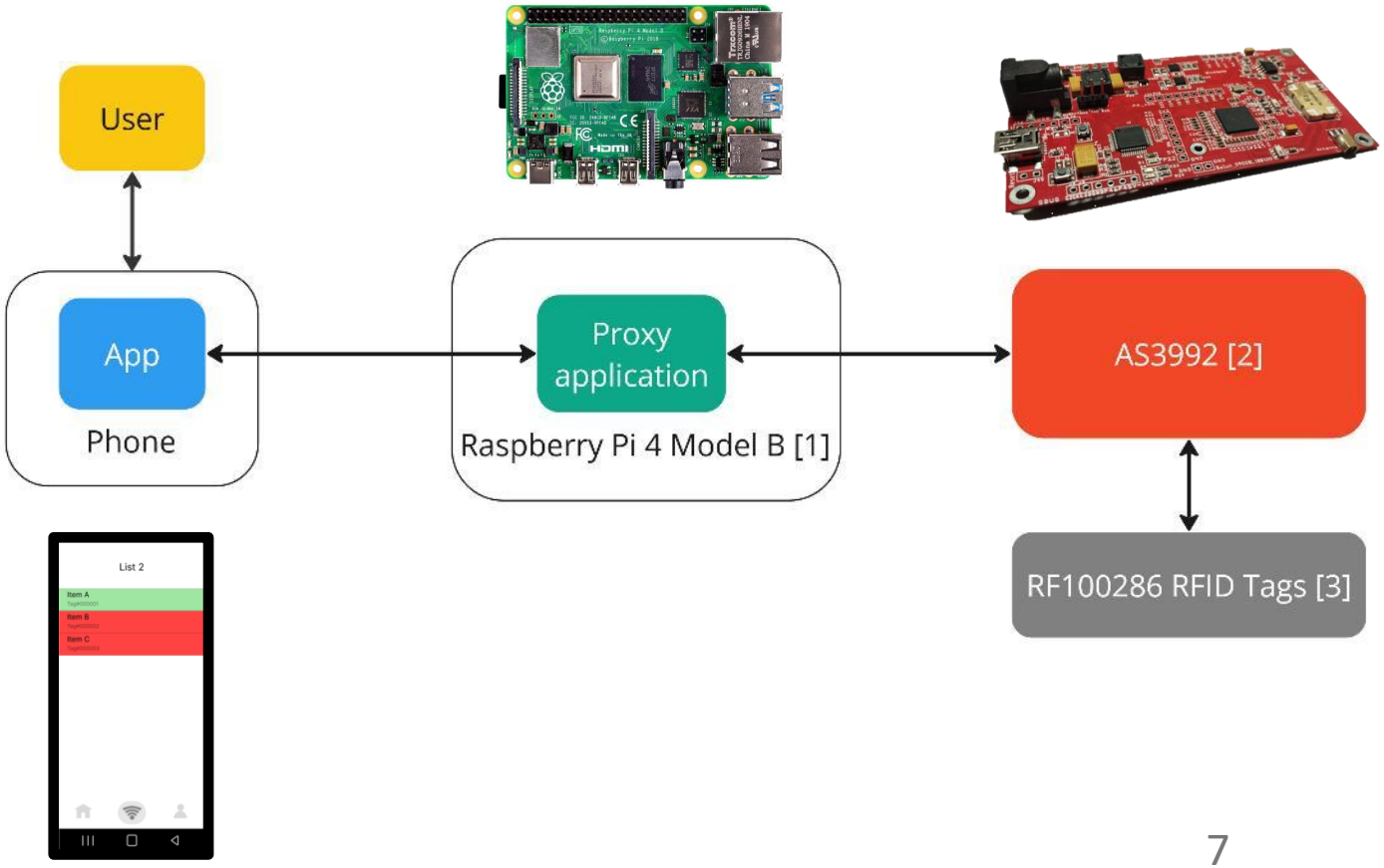
Technological solution (I)

Imagine the following situation:

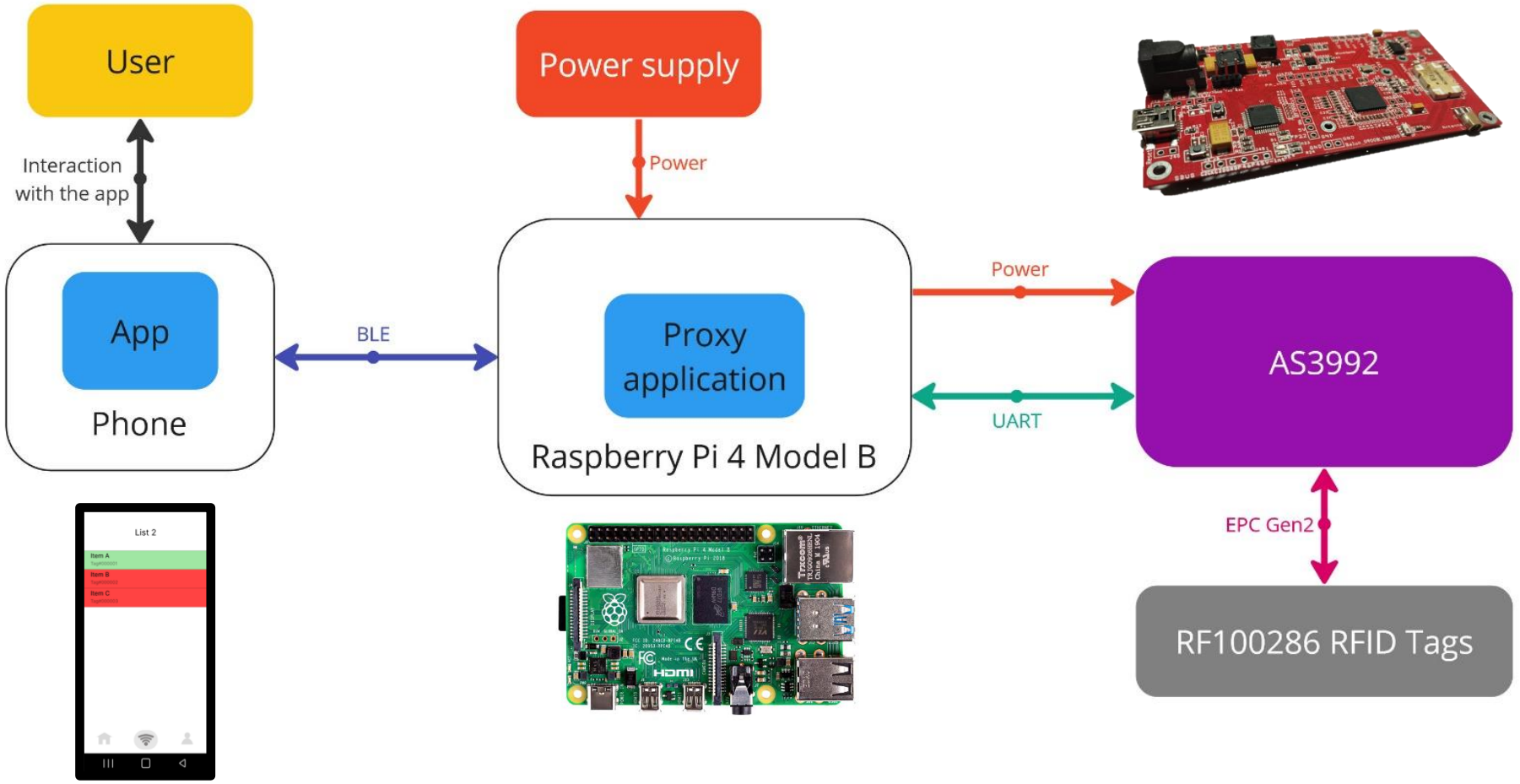
- A plumber carries tools around in a van.
- An RFID tag is placed on each tool.
- A RFID reader installed in the van detects which tools are present/absent.

Technological solution (II)

- The reader (Raspberry Pi [1] & RFID reader module [2]) will look for tags in a range of around 2 meters.
- When the signal broadcast by the reader hits a tag, the tag [3] responds, indicating that the item is present.
- The reader sends the list of detected tags to the app via Bluetooth.
- The list of present/absent items is shown in the app.



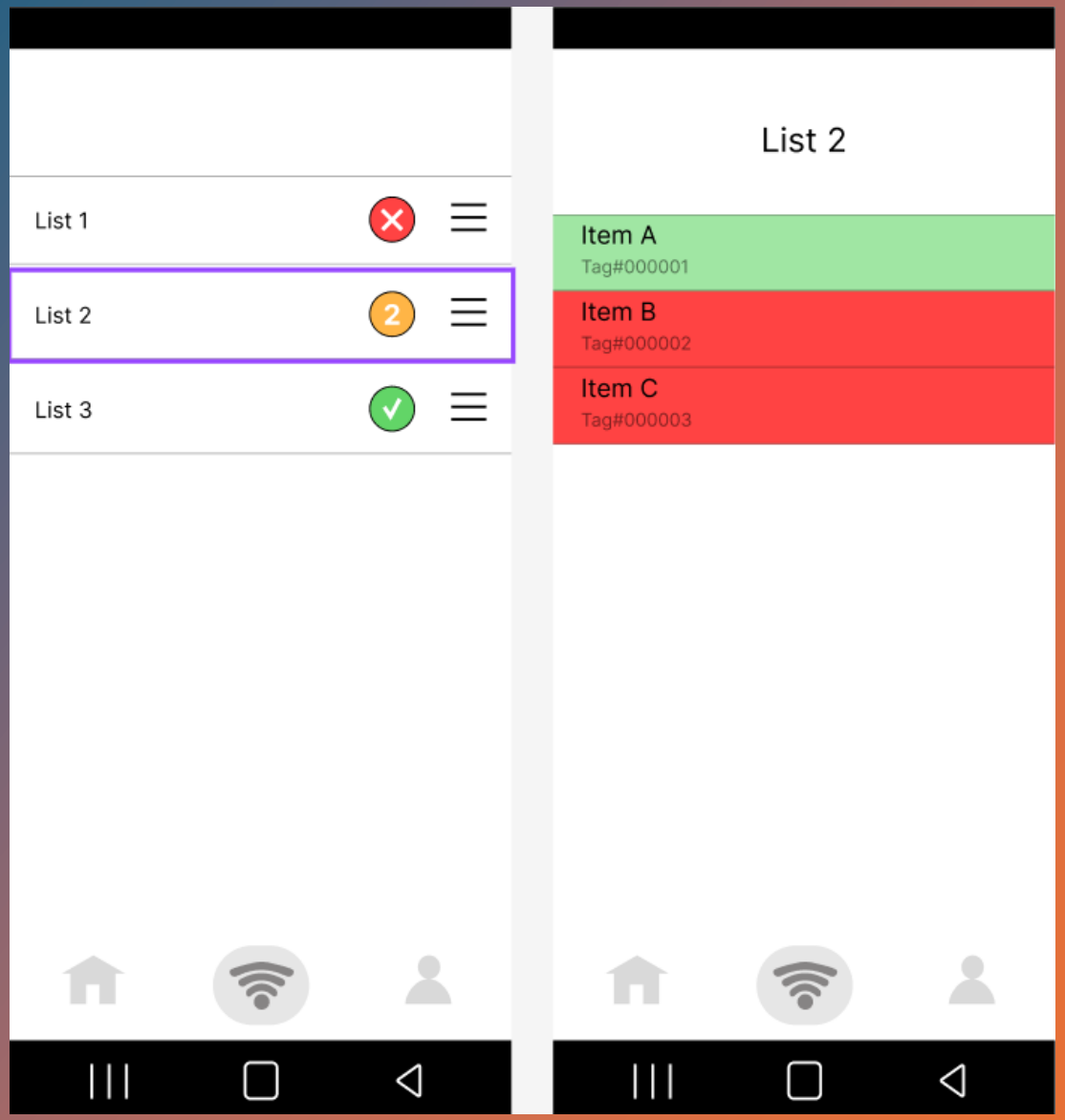
Technological solution (III)



Technological solution (IV)

Material	Quant.	Descrição
AS3992 UHF RFID Reader	1	RFID reader with microprocessor
RF SOLUTIONS ANT-PCB4242-FL	1	Antenna
Avery Dennison RF100286 RFID Tags	10	RFID Tags
Raspberry Pi 4 Model B	1	Microcomputer
Raspberry Pi 4 power supply	1	Power supply for Raspberry Pi
Female-to-female connector	5	Female-to-female connection cables
Barrel connector to male wire connectors	1	Female Barrel Cable – Male Wire Connector (Double)

Details about the list of material can be found here



Technological solution (V)

- The app will receive, via BLE, information about which items are, or not, present within reading range.
- The user can then see for each list which items are present or absent.

Competitors and previous work

Competitors

SmartVan

Sortly

Mobile Inventory Software For HVAC And Plumbing Contractor

Zetes - RFID in Supply Chain

RFID-based Smart Blood Stock System

Previous work

Handheld reader using NFC and BLE (SmartVan) or QR or bar codes (Sortly and Mobile Inventory Software);

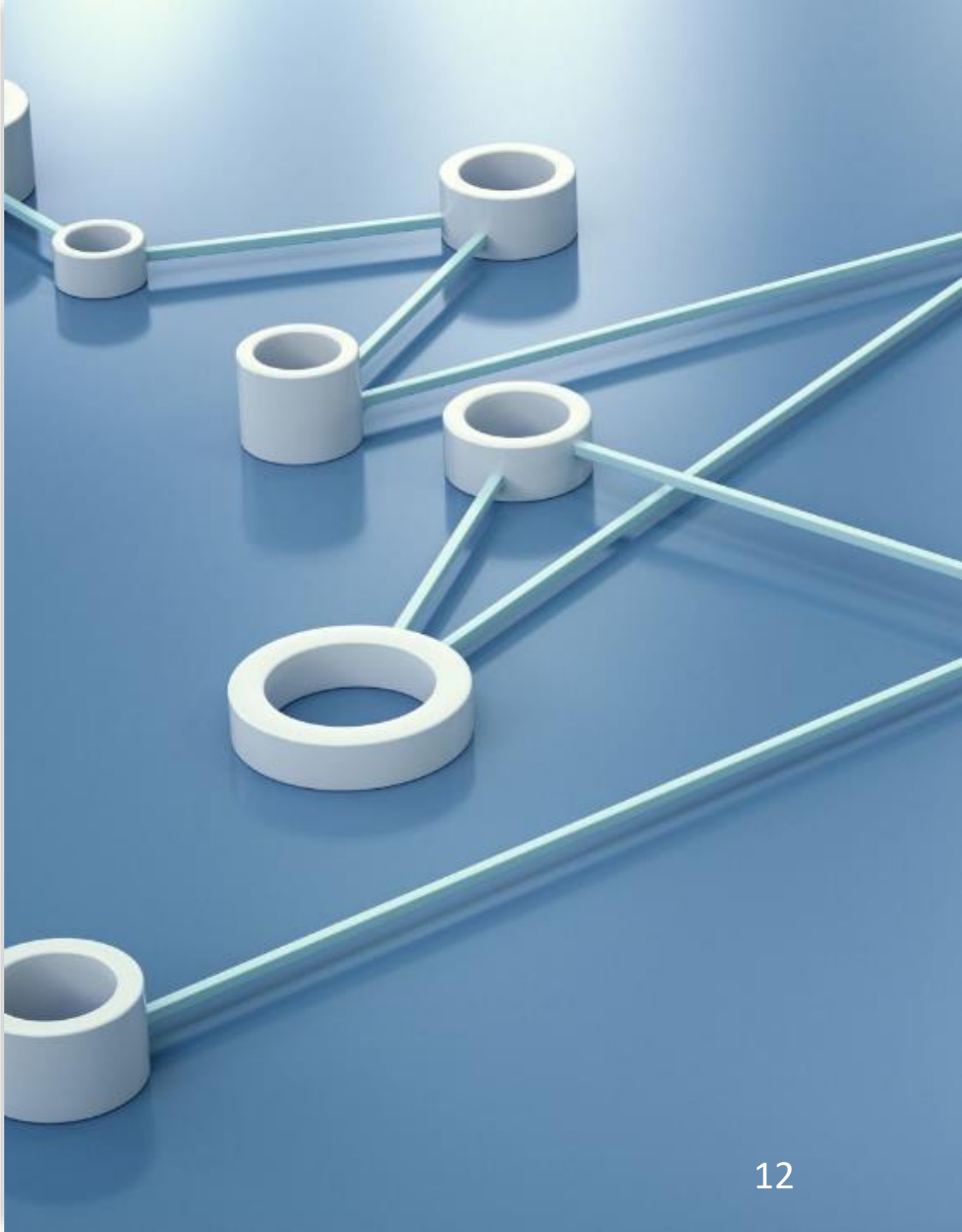
RFID identification using fixed gates or handheld readers (Zetes)

RFID blood bag identification, with Bluetooth communication with an external device

Solution requirements (I)

Our goal is to make a low-cost (no batteries) and practical (no manual checking of each item) solution, by using a single reader placed inside the van and an included app that allows for easy introduction/removal of certain items.

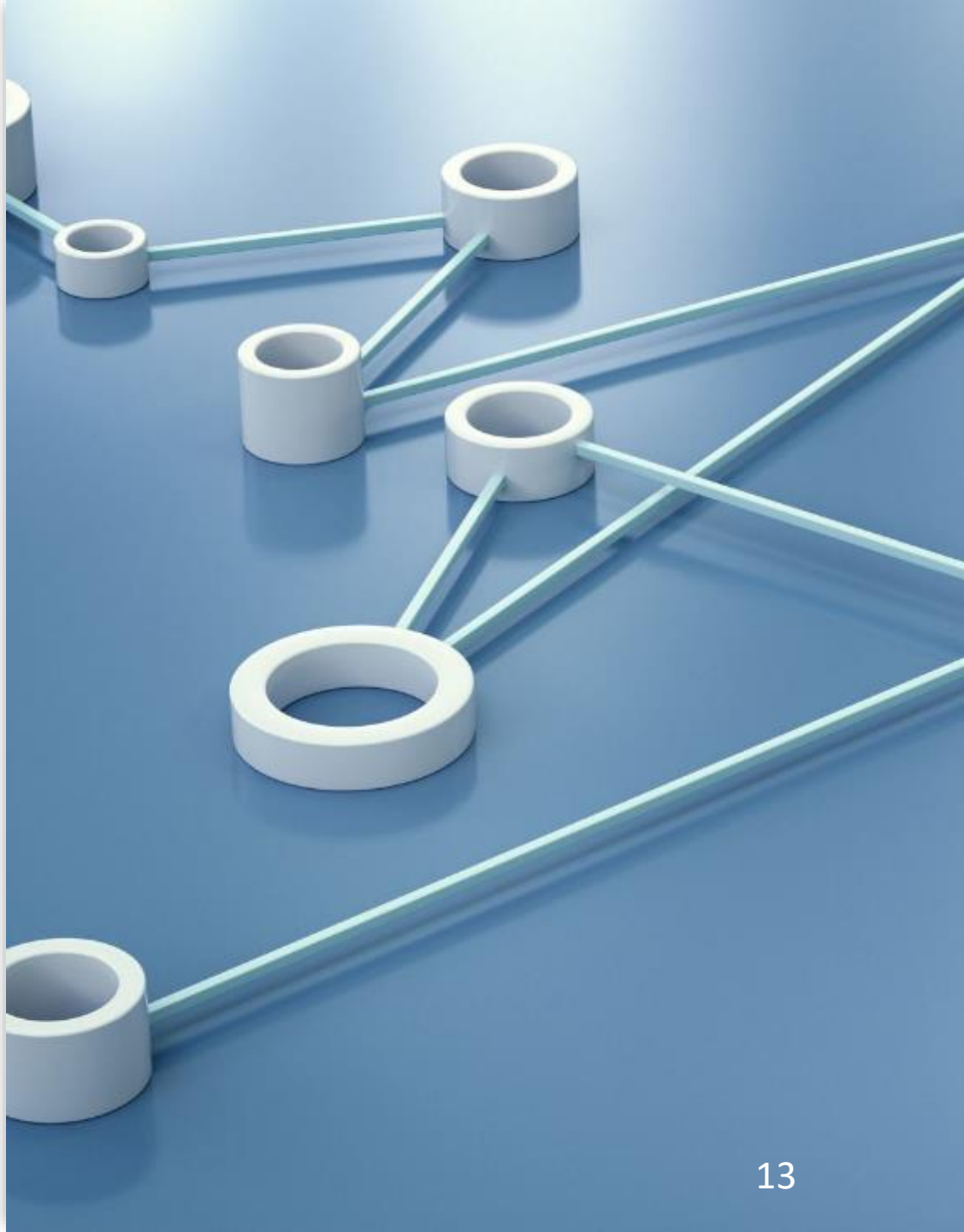
These are our main objectives in building this product, thus the usage of passive tags and wireless technologies at a distance.



Solution requirements (II)

We impose ourselves the following requirements for this project:

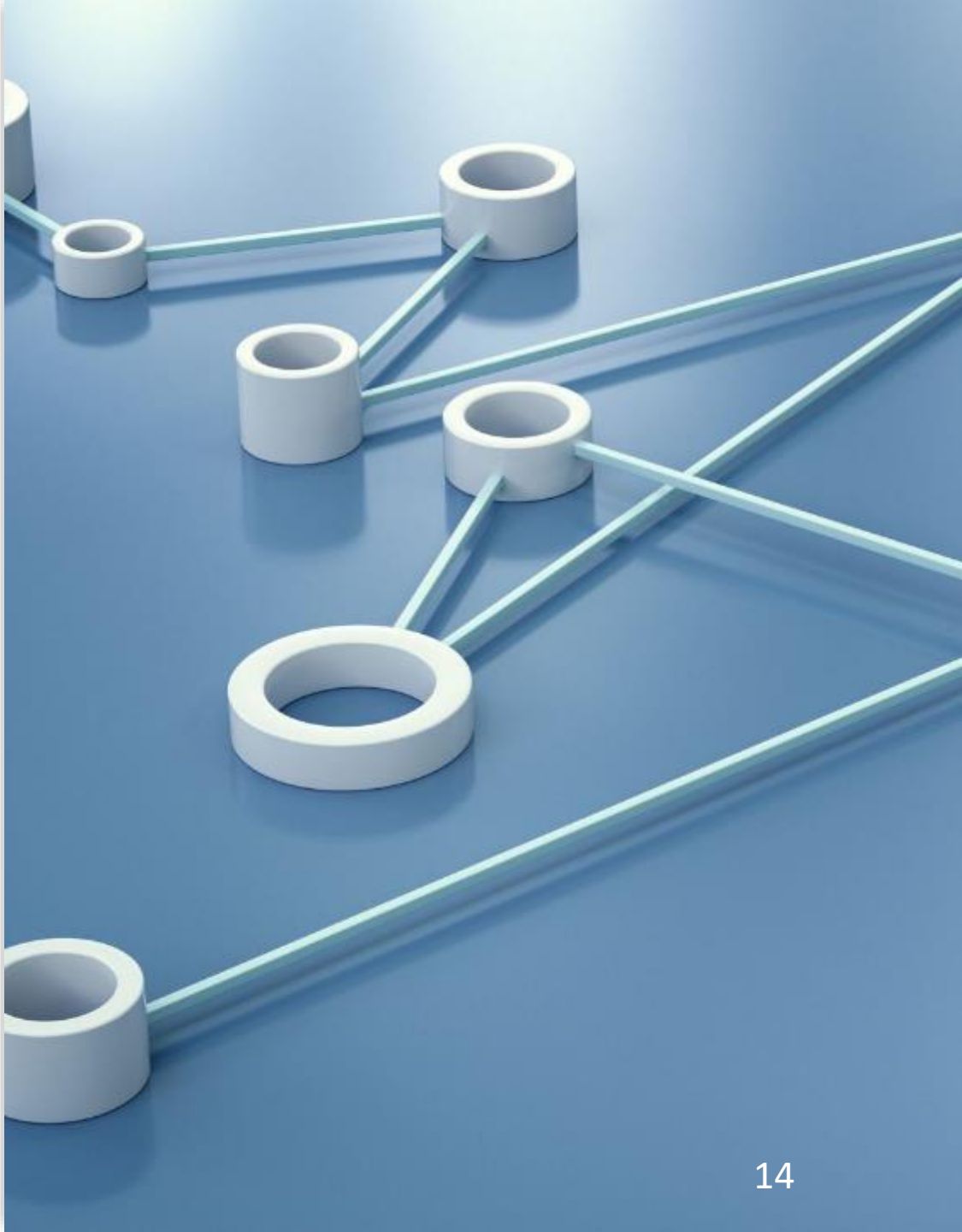
- Reliable reading of tags in a 2-meter radius of the reader;
- Reliable reading of at least 100 tags concurrently;
- Reliable reading of tags placed upon different materials.

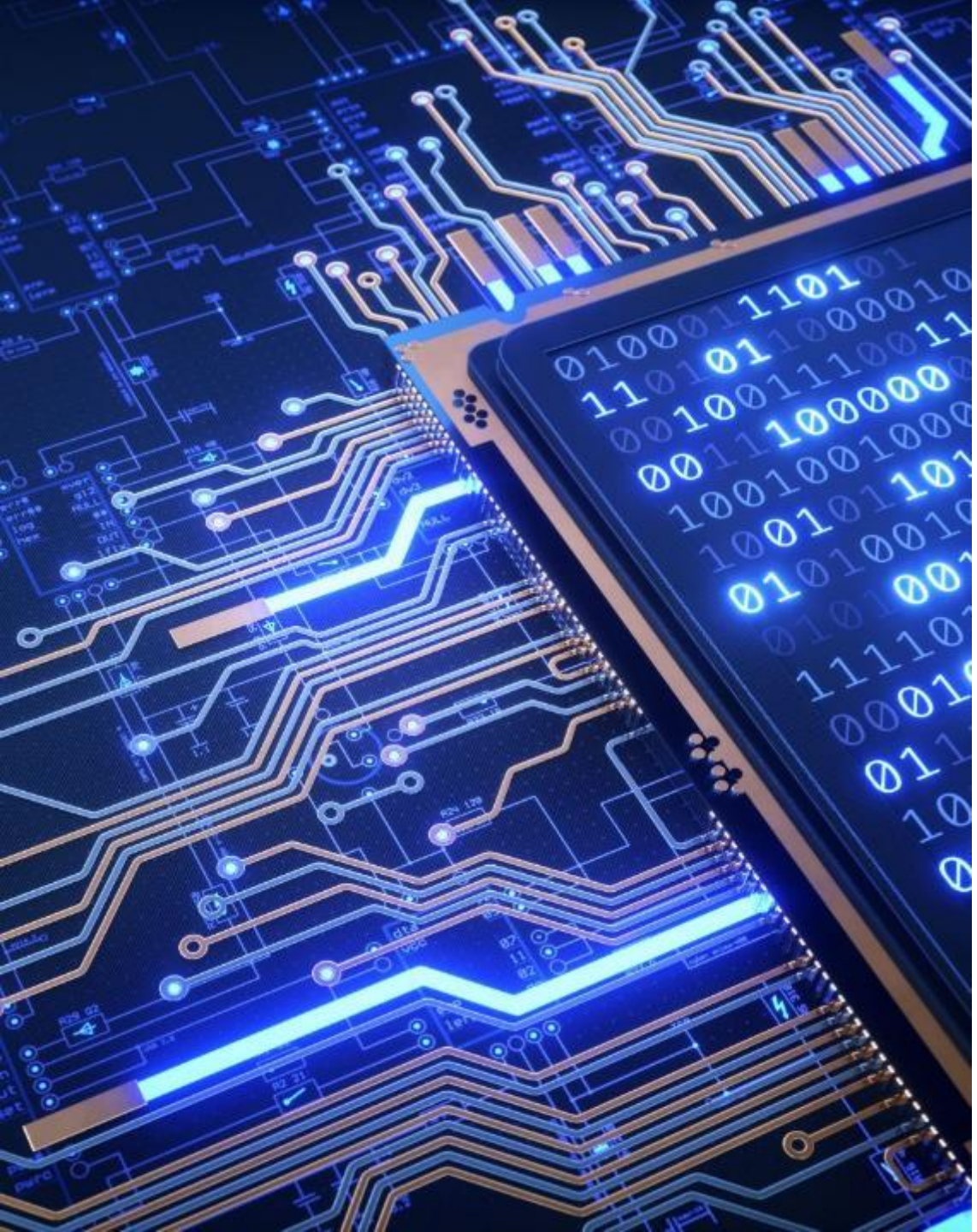


Solution requirements (III)

As for the proof of concept to be presented, we expect to be able to meet the following:

- Reliable reading of tags in a 2-meter radius of the reader;
- Reliable reading of at least 10 tags concurrently;
- Reliable reading of tags placed upon different materials, although problems are expected when working around metallic objects.





Technical challenges

The main hurdle in our planning is how to integrate RFID technology. To allow for a large range of detection (i.e., larger than 1 meter) of tags placed in the objects, Ultra High Frequency RFID is needed, which requires more power, an increased risk of interference with our types of radio communications, a higher cost and a higher overall complexity.

Along with this, working with BLE technology has proven to be a challenge for the development of the app-microcomputer communication.

We predict that getting tags to work properly when placed on or near metallic objects will be also a great issue to overcome.

Partners

Currently we have established a partnership with the artistic space *Lisboa Incomum*, where we are going to conduct our later tests using a medium sized van. Due to the variety of equipment used (from electronic equipments, to cables, to metal tools, etc…), we find this to be an optimal place for testing. We are also going to use this opportunity to ask for different kinds of input and suggestions to improve the product, not just from this institution but also from other possible users.

Testing and validation metrics

Our first step will be to test the rate of successful tag detections, the reader's detection speed, the real usage range (between the reader and the tags), if tags placed on all kinds of items (metallic, wood, etc...) work, the reader’s optimum placement and direction inside the van, and if there is any kind of interference while using the items.

In addition, we will ensure that our app is easy to use and that the reader and tags are well integrated.

As a final test, we are going to try and test our prototype inside a real van, with tags in different items.

Division of labor (I)

Duarte	Francisco	Miguel
App + Electronics	**Electronics + Coordination**	**Electronics**
BLE Interface (app-wise)	Project specifications and documentation	Bluetooth Protocol Integration
Tag-Item Association in App	Task Management	Device-to-Phone Connection
App Performance Optimization	Electronics assembling and research	Schematics and Prototype Design
	Communication protocol between the RFID reader and the microcomputer	Final Prototype Design

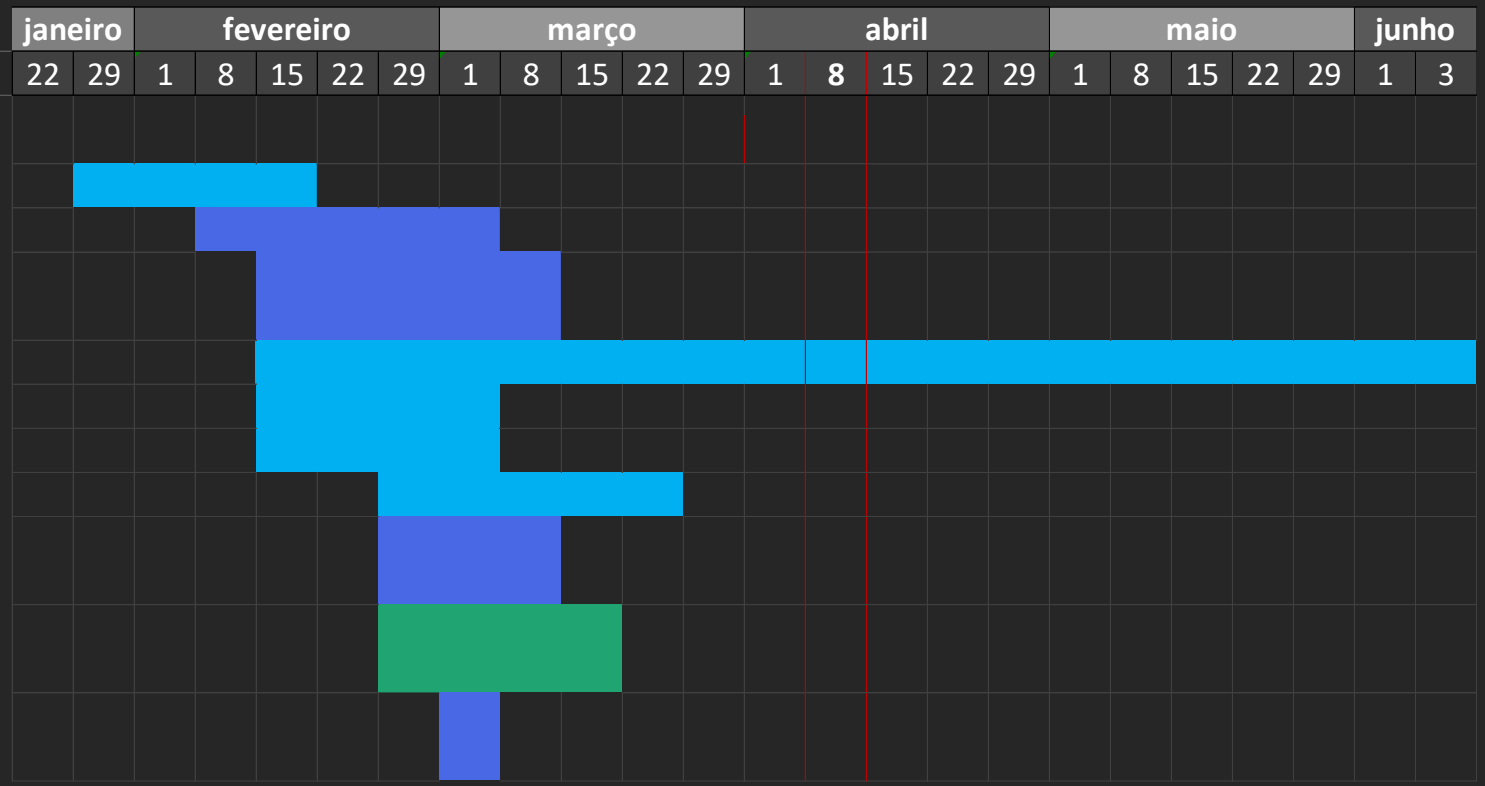
Division of labor (II)

André	António	Filipe
Website	**App**	**Website**
Project Presentation Page	Item List Verification	Project Presentation Page
Blog	App Navigation	Blog
Project Poster	App Performance Optimization	Project Poster
Demo Video	App UI Implementation and Design	Demo Video
App UI Implementation		App UI Implementation

Original Schedule (I)

Legenda: App + Website | Electronics | Everyone

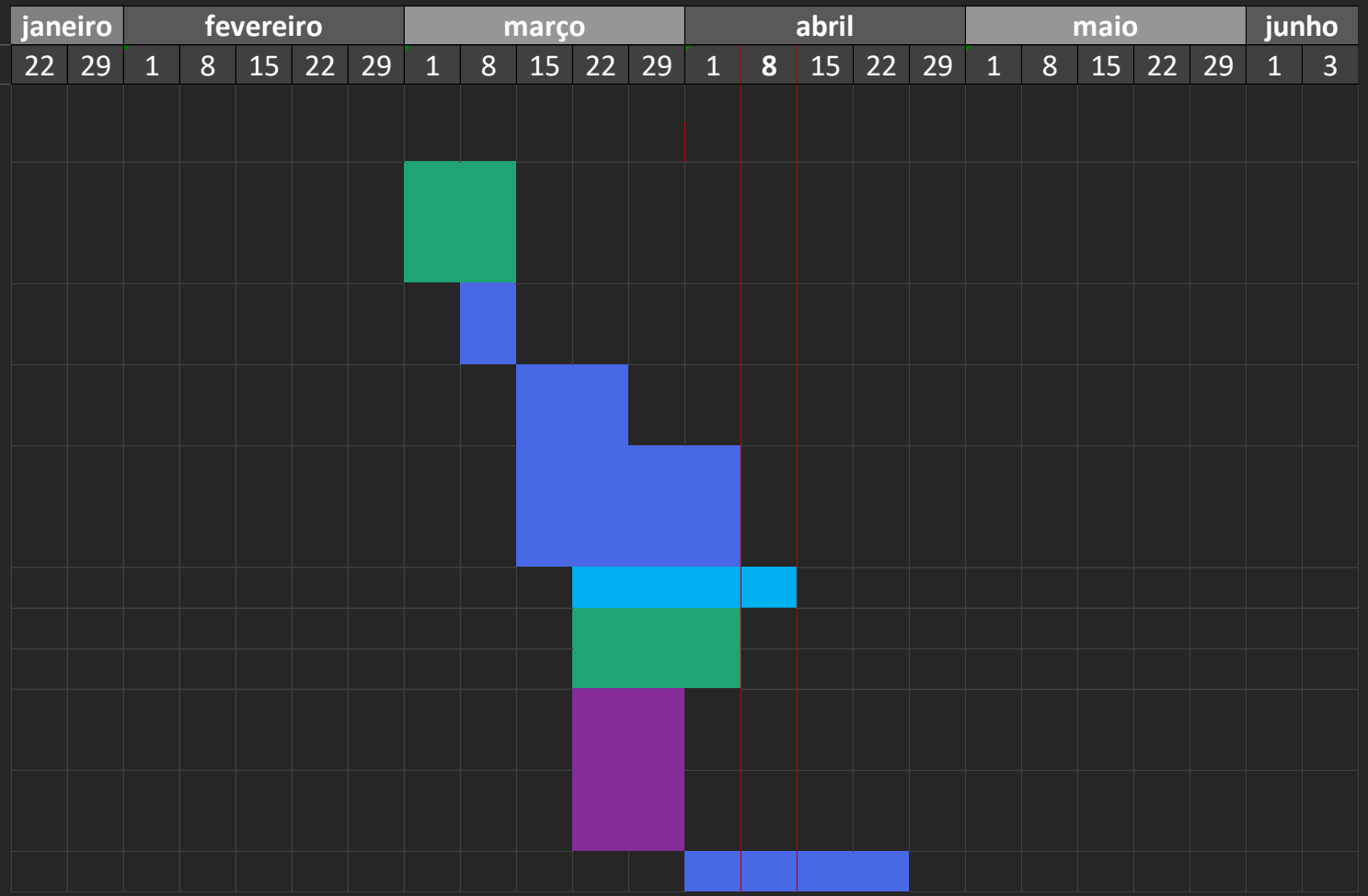
Descrição do marco	Progresso	Início	Dias
Project Presentation Page	0%	29/01/2024	21
Tag Recognition	0%	08/02/2024	28
Bluetooth Protocol Integration in Raspberry	0%	15/02/2024	28
Blog and Weekly Report	0%	15/02/2024	117
Website	0%	09/02/2024	28
App Design Concept	0%	12/02/2024	23
App UI	0%	25/02/2024	29
Device-to-Phone Connection (hardware side)	0%	23/02/2024	21
Device-to-Phone Connection (software side)	0%	23/02/2024	22
Electronics Assembly (USB build and connection to Raspberry Pi)	0%	01/03/2024	7



Original Schedule (II)

Legenda: App + Website | Electronics | Everyone

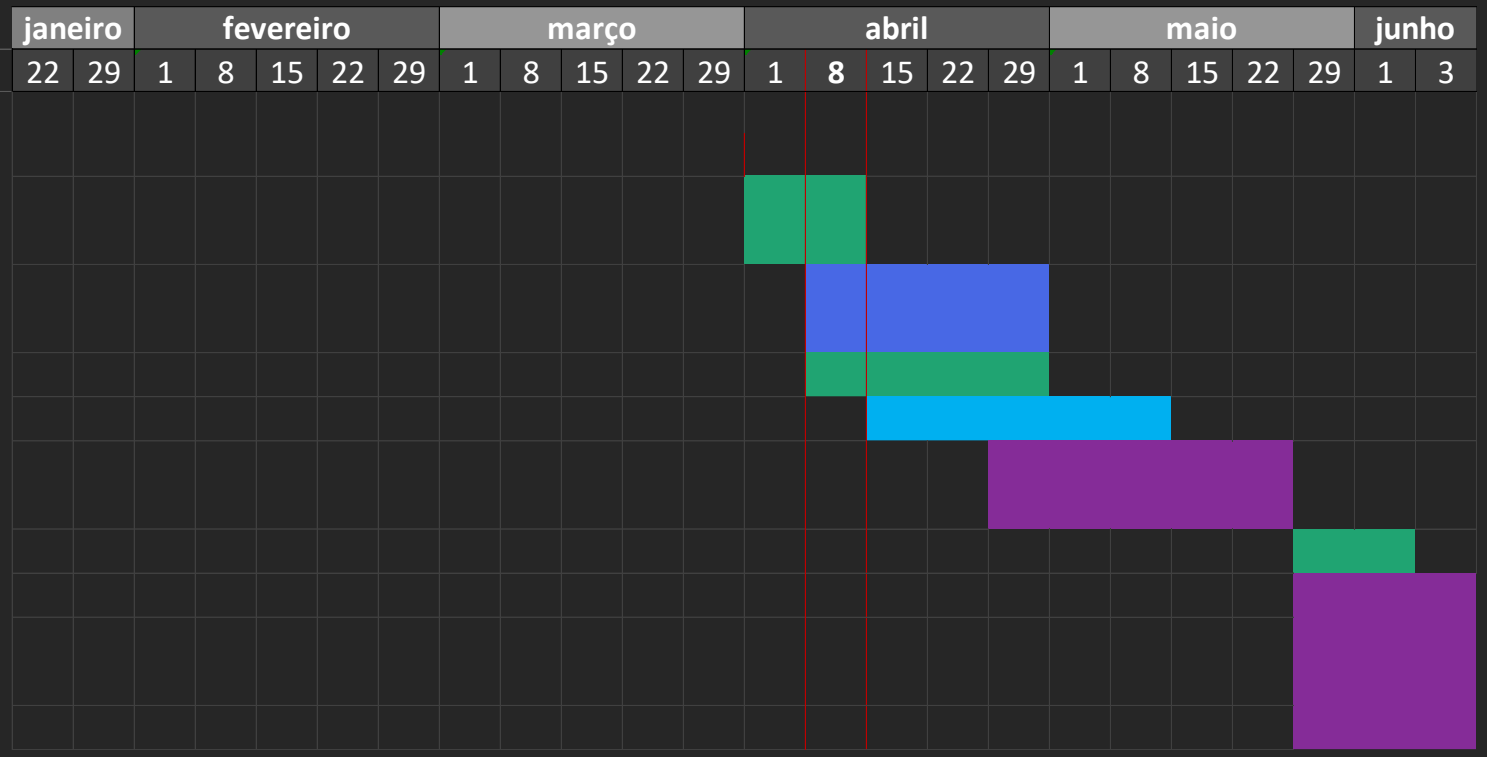
Descrição do marco	Progresso	Início	Dias
Development of protocol for communication from phone to reader	0%	01/03/2024	14
Testing the RFID communication in Windows	0%	08/03/2024	7
Schematics and Prototype Design	0%	15/03/2024	14
Change of protocol from Windows to Raspeberry Pi (via commands Json)	0%	15/03/2024	22
Project Poster	0%	22/03/2024	22
Scanning Functionality	0%	22/03/2024	14
Real-time Inventory Display	0%	22/03/2024	14
Preparation of intermediate delivery	0%	20/03/2024	11
Preparation of intermediate presentation	0%	20/03/2024	11
Final Prototype Design	0%	01/04/2024	28



Original Schedule (III)

Legenda: App + Website | Electronics | Everyone

Descrição do marco	Progresso	Início	Dias
Tag <-> Item Association Functionality	0%	30/03/2024	14
Testing and Performance Evaluation	0%	08/04/2024	22
App Navigation	0%	08/04/2024	22
Demo Video	0%	15/04/2024	30
Testing and Improve Functionalities	0%	23/04/2024	31
App Performance Optimization	0%	23/05/2024	10
Evaluation material preparation	0%	23/05/2024	12
Preparation of final presentation	0%	23/05/2024	12
Preparation of final delivery	0%	23/05/2024	12



Mid-program status

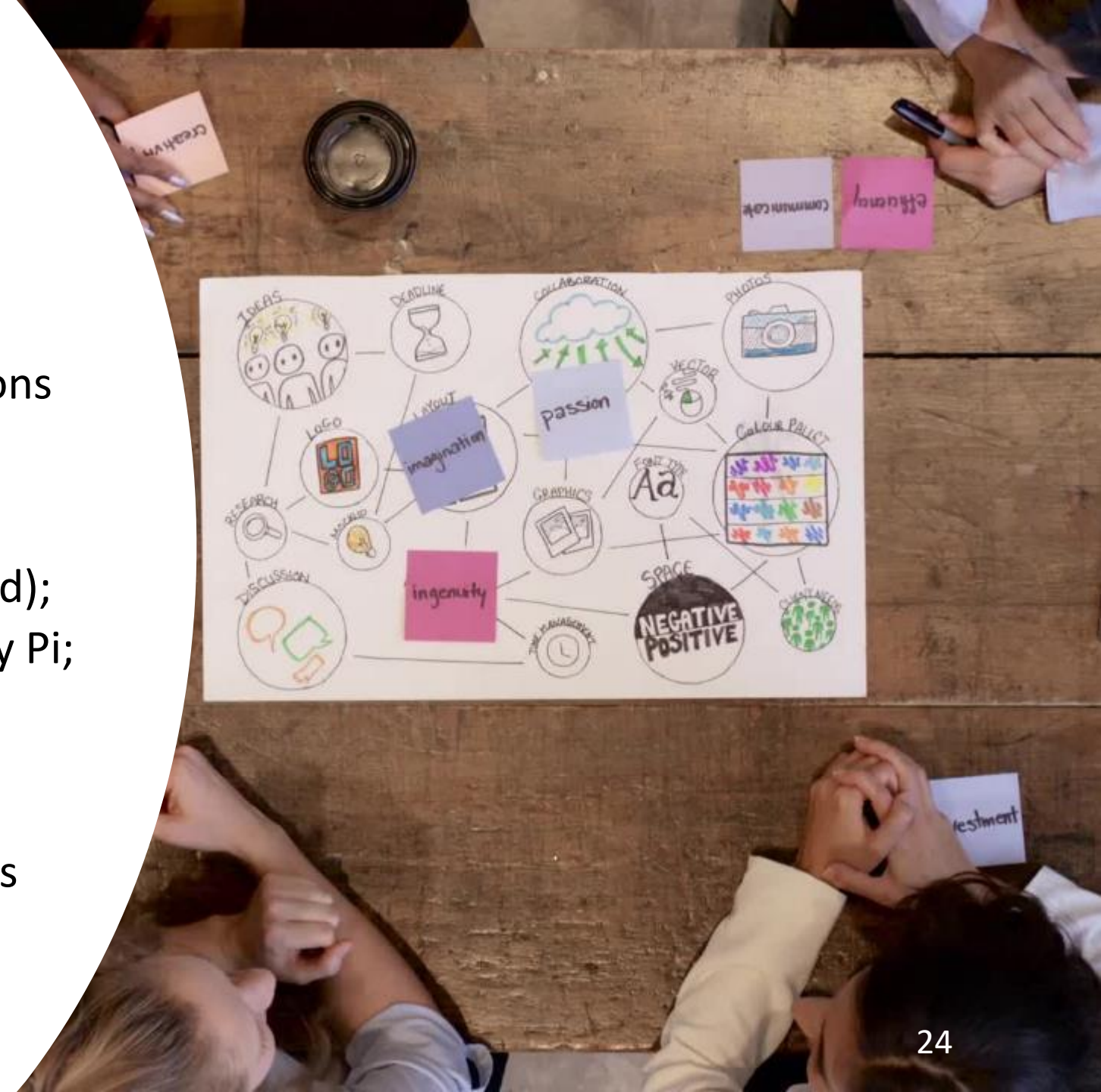
As of today, the following steps of the project are concluded:

- Changed the list of material (selecting the AS3992 reader) and the programming reader language from C to JavaScript;
- Changed from real-time reading to user-prompted reading;
- Established all communication protocols;
- Established the final system's architecture;
- Defined our final team's structure and tasks;
- Website online and almost completed;
- App design completed and implementation midway;
- Raspberry Pi ↔ App communication achieved (via BLE).

Achieved results

As of today, the following steps of the project are concluded:

- Final project definition completed;
- Full electrical and system specifications and requirements;
- App Design;
- Website Design and Implementation (Project Presentation Page completed);
- BLE Protocol Integration in Raspberry Pi;
- Device-to-Phone Connection (both sides);
- RFID communication protocol;
- Documentation of the technical steps (using flowcharts, Notion pages, and block diagrams);



Challenges faced by the team (I)

Identify the main challenges that the team faced in the first part of the project, for example:

- Difficulties in understanding and implementing app-board communication mechanisms (D-Bus, *bluez*), leading to the change from C to JavaScript;
- Problems with the need to code in previously unknown programming languages (JavaScript, CSS, HTML);

Challenges faced by the team (II)

- Getting the website to be responsive, and working in various platforms;
- Difficulty in defining with precision the scope of the project;
- Finding an accessible RFID reader that is also compatible with our requirements, and with available documentation online;
- Balancing coursework with other commitments;

Deviations from original schedule

Deviations from the original schedule were caused by, for example:

- Unclear project scope and objectives;
- Underestimation of task complexity (regarding the RFID and BLE communication);
- Unforeseen difficulty in finding a suitable RFID reader;
- Limited access to equipment;
- Inefficient communication and task division;
- Inefficient time management;

Contribution of each team member (I)

Francisco	Filipe	Duarte
Coordination and Electronics	**Website**	**App & Microcomputer Programming**
System and electrical requirements	Project Presentation Page	BLE & Microcomputer research
Project Specifications	Blog	App BLE communication code
Electronics and material research	Website Design and Implementation	Microcomputer BLE communication code
Task management		General programming assistance

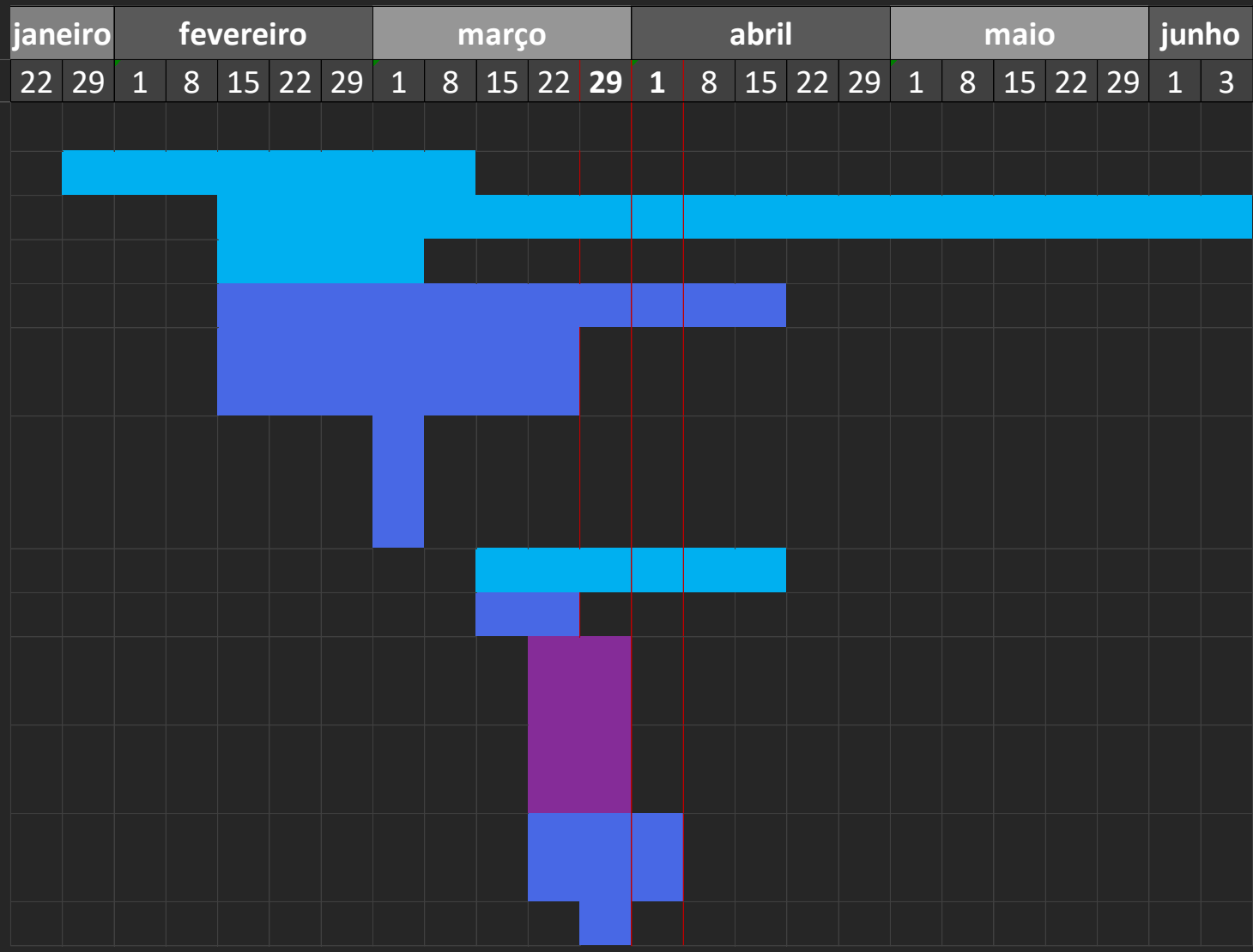
Contribution of each team member (II)

António	André	Miguel
App	**Website**	**App-Board Communication**
App Concept and Design	Project Presentation Page	Development of the messaging protocol
App UI development	Blog	Raspberry Pi Setup
App Navigation	Website Design and Implementation	BLE Connection Research and App-Board communication

Corrected Schedule (I)

Legenda: App + Website | Electronics | Everyone

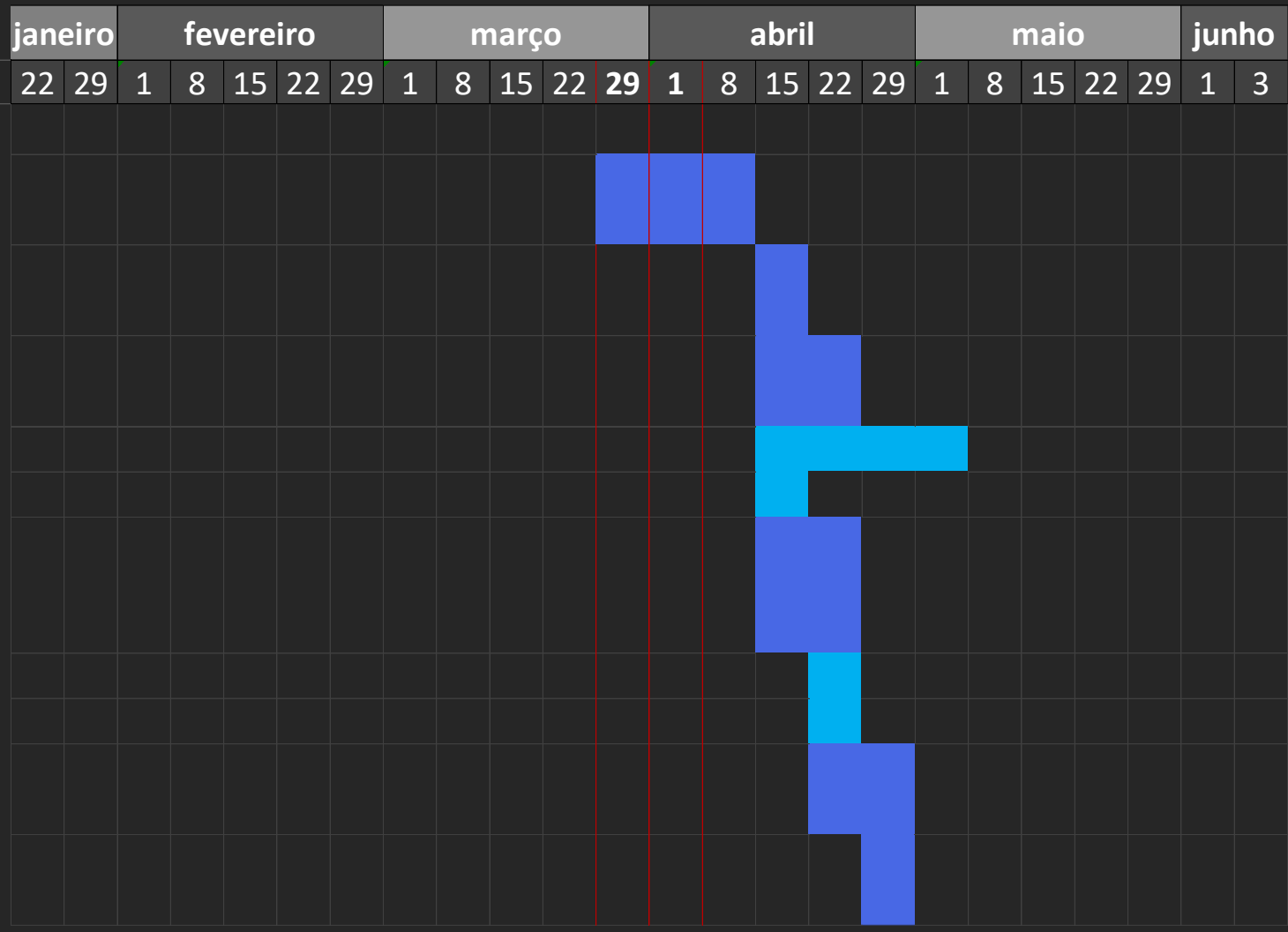
Descrição do marco	Progresso	Início	Dias
Project Presentation Page	80%	29/01/2024	45
Blog	50%	15/02/2024	117
App Design Concept	100%	12/02/2024	23
BLE App-Board Communication	50%	15/02/2024	63
Bluetooth Protocol Integration in Raspberry	100%	15/02/2024	42
Electronics Assembly (USB build and connection to Raspberry Pi)	75%	01/03/2024	7
App UI	40%	10/03/2024	40
System Design	100%	15/03/2024	14
Preparation of intermediate delivery	100%	20/03/2024	11
Preparation of intermediate presentation	100%	20/03/2024	11
System Specifications and Requirements	100%	22/03/2024	14
Basic BLE communication	100%	23/03/2024	7



Corrected Schedule (II)

Legenda: App + Website | Electronics | Everyone

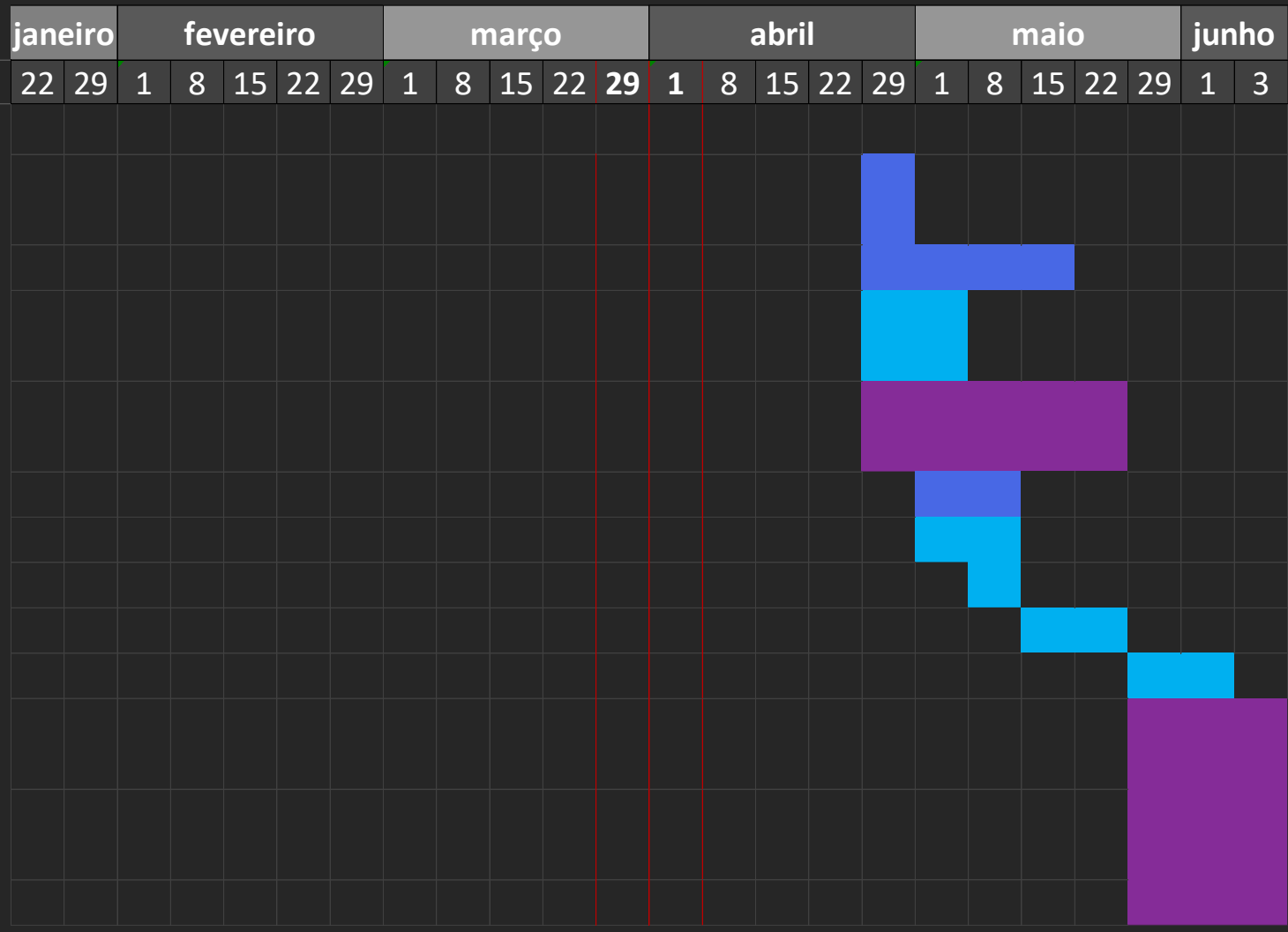
Descrição do marco	Progresso	Início	Dias
Reader communication protocol implementation	30%	24/03/2024	21
Establishment of BLE messaging protocol	10%	15/04/2024	7
Implementation of the BLE messaging protocol	10%	15/04/2024	14
App Navigation	50%	15/04/2024	22
Website Animation	0%	11/04/2024	10
Integration of board communication and app communication	0%	14/04/2024	14
Poster Concept	0%	21/04/2024	6
Demo Video Concept	0%	21/04/2024	8
Testing and Performance Evaluation	0%	21/04/2024	10
Reader communication protocol establishment	0%	23/04/2024	7



Corrected Schedule (III)

Legenda: App + Website | Electronics | Everyone

Descrição do marco	Progresso	Início	Dias
AS3992 + RFID protocol implementation	0%	23/04/2024	7
Final Prototype Design	0%	29/04/2024	21
Collection of Information for the Poster	0%	27/04/2024	8
Testing and Improve Functionalities	0%	23/04/2024	31
Scanning Functionality	0%	01/05/2024	14
Demo Video Recording	0%	01/05/2024	9
Poster Design	0%	04/05/2024	8
Demo Video Editing	0%	10/05/2024	14
App Performance Optimization	0%	23/05/2024	10
Evaluation material preparation	0%	23/05/2024	12
Preparation of final presentation	0%	23/05/2024	12
Preparation of final delivery	0%	23/05/2024	12



Demo day presentation plan

We plan to …

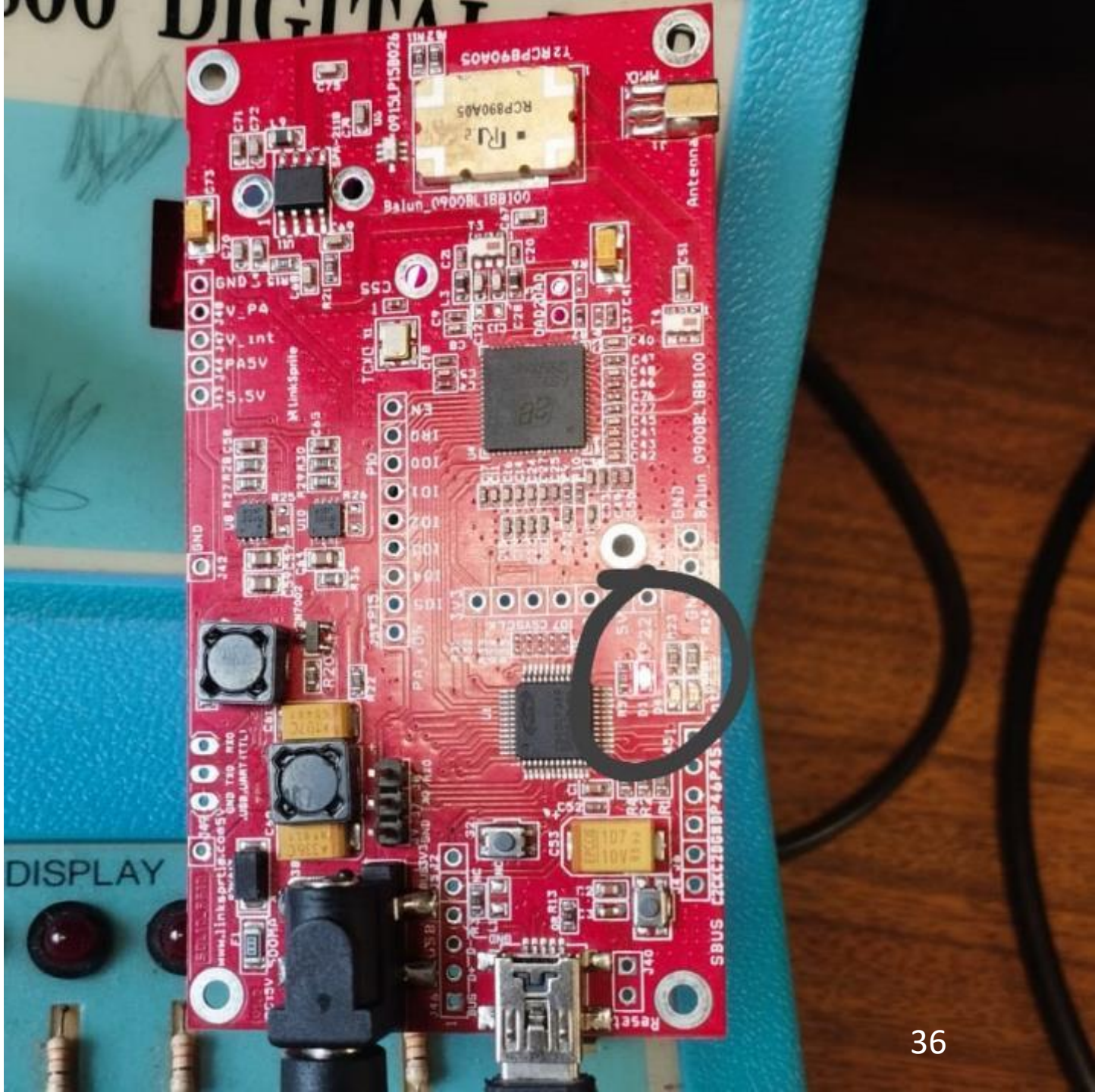
- Place tags in objects near the reader, show how one can register them in the inventory of the app, and that as we place them away from the reader the app reports them as missing;
- Place those objects out of reading range and show the status change in the app;

End of presentation

Further information

List of material and system documentation

- Together with the final definition on the list of material, we wrote some documentation about the material.
- Besides the list, we also drafted a document with the project specs, requirements and dimensioning.
- Details about the list of material can be found here, and the project specifications can be found in our website.



40	Tamanho da mensagem
FE	Modo *hop* OFF (seria FC se fosse ON)
FF	Terminador

Comandos relevantes (*transponder oriented*)

- Estes comandos forçam o microcontrolador do leitor AS3992 a comunicar com as tags, exigindo que a alimentação da antena esteja ligada (comando OUT_ANTENNA_POWER), e que haja tags na vizinhança (*byte* 0 ≠ 0xFF → ver Mensagens de erro)
- Existem vários comandos para realizar a leitura, mas os sugeridos aqui possuem mais documentação e são mais adequados
- Para o projeto em questão, não é necessário escrever ou ler conteúdo das tags, pelo que também não encontram aqui esses comandos

OUT_INVENTORY_RSSI (0x43)/IN_INVENTORY_RSSI(0x44)

- A leitura é efetuada apenas quando o *host* indica que esta se realize, com a flag 0x01 (iniciar inventário). Depois, a resposta inclui o número de tags que foi lida (juntamente com o ID da primeira tag a ser lida), indicando também ao *host* o número de vezes que a função necessita de ser chamada com a flag 0x02 (informação da próxima tag).
- Estrutura:
  - OUT_INVENTORY_RSSI (0x43)

Byte 0/ID	Byte 1	Byte 2
0x43	Frame Length	Start inventory / Next tag information

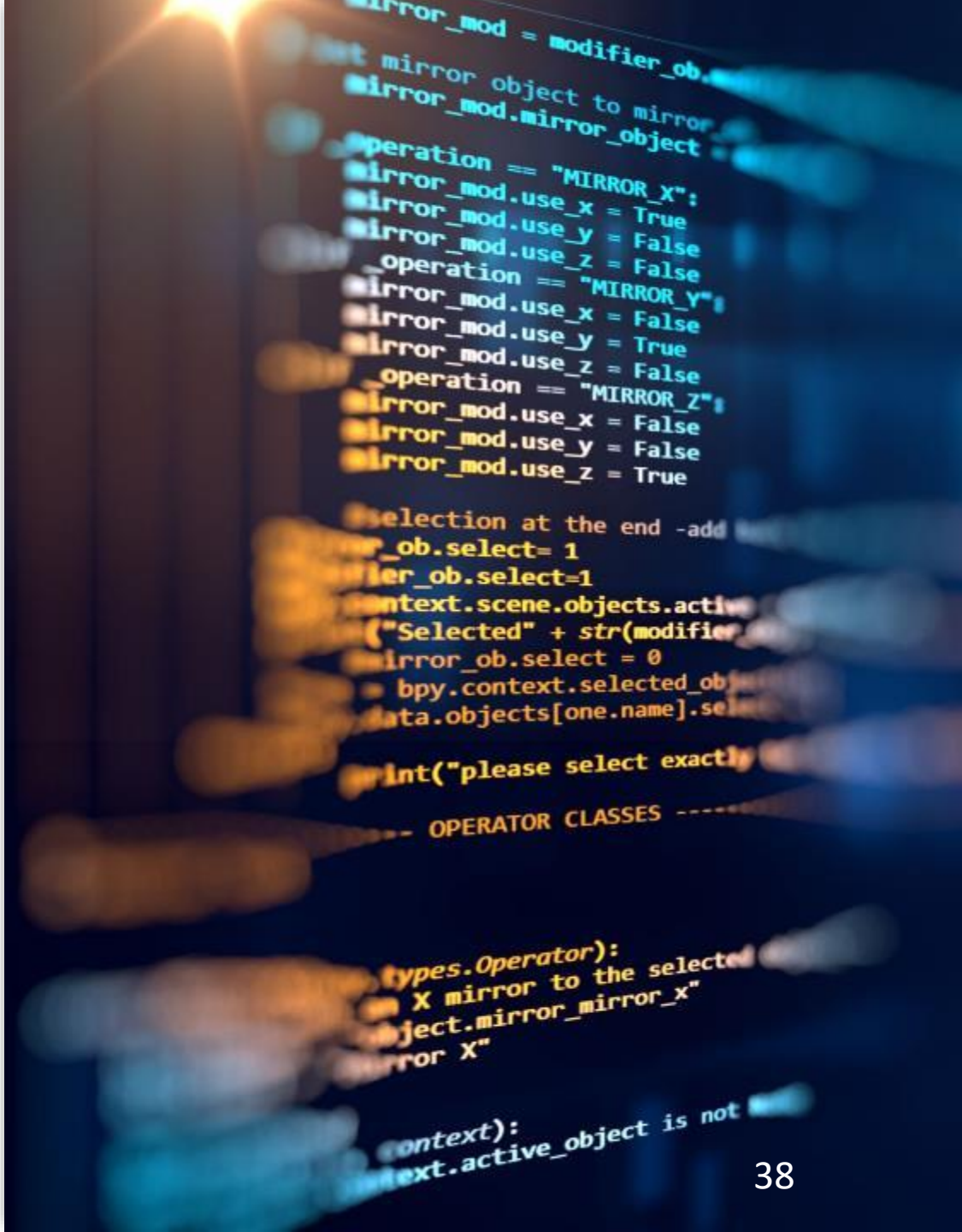
    - O *byte* 2 pode ser 0x01 para "Start inventory" (para começar a leitura), ou 0x02 para obter a informação acerca da próxima tag

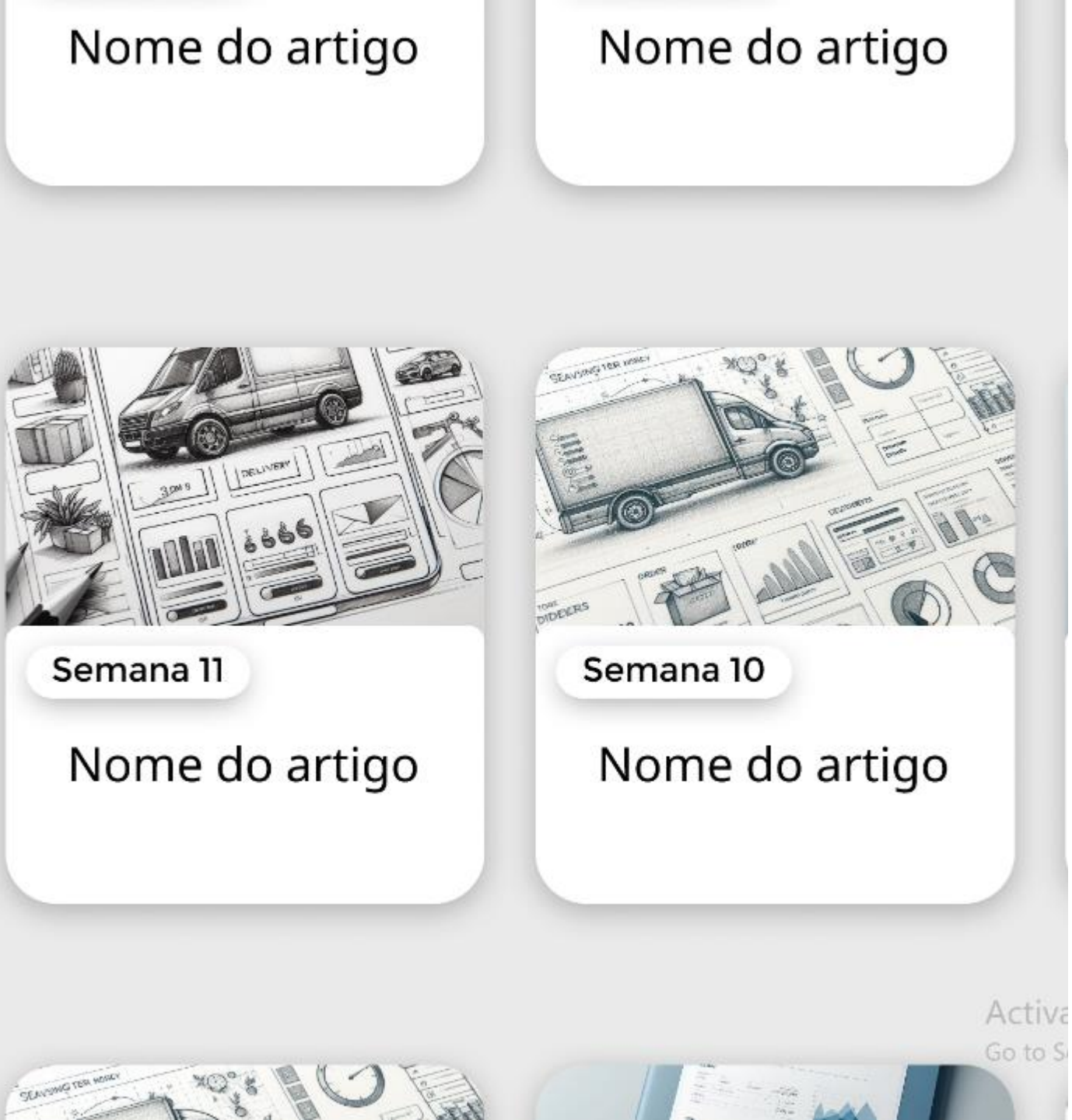
RFID protocol documentation

- After defining the final list of material, the protocol of communication between the host (Raspberry Pi [1]) and the RFID reader was designed, based on the datasheets available and the pre-programming of the AS3992 RFID reader [2].
- Details about the protocol can be found here.

App-Raspberry Pi Communication (via BLE)

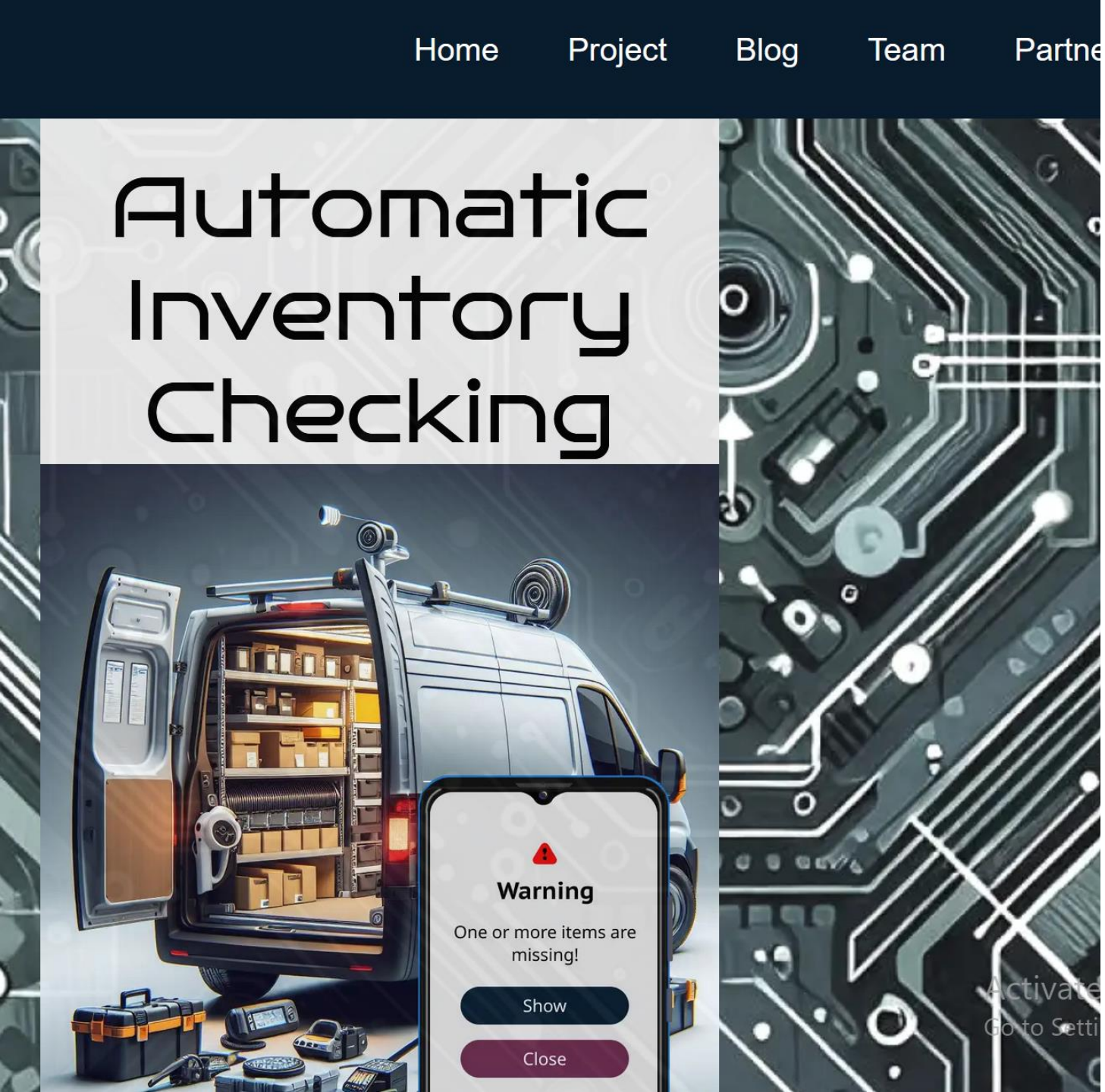
- As mentioned above, we were able to achieve basic communication between the Raspberry Pi [1] and the app, using BLE, creating reading and writing abstractions in both devices;
- A demonstration can be seen in related blog post in the site.





Website design

- To create our website, we spent some time researching about website design, until we had enough knowledge do develop our own;
- The result of this research can be seen here, with the sketch of the website design;

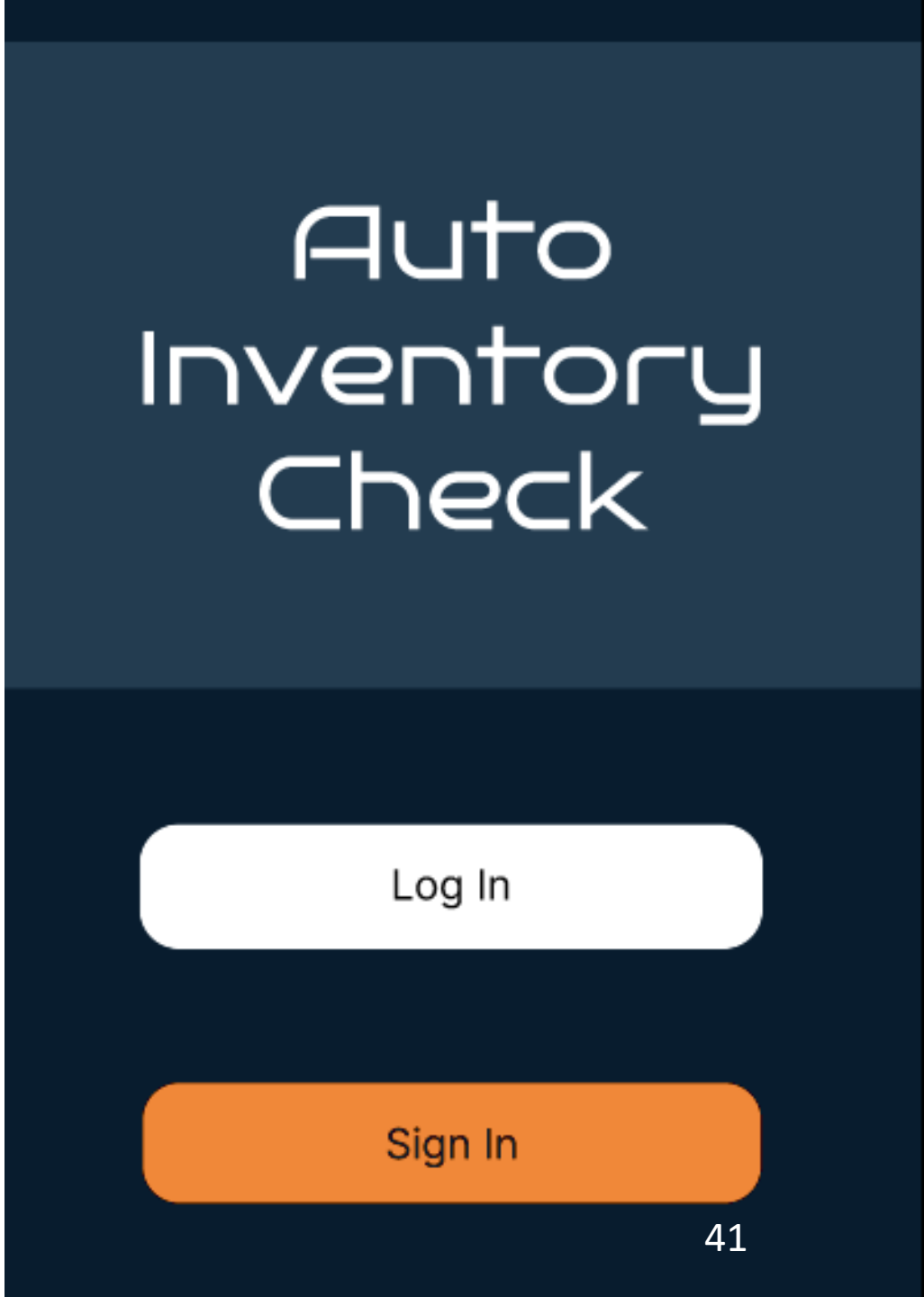


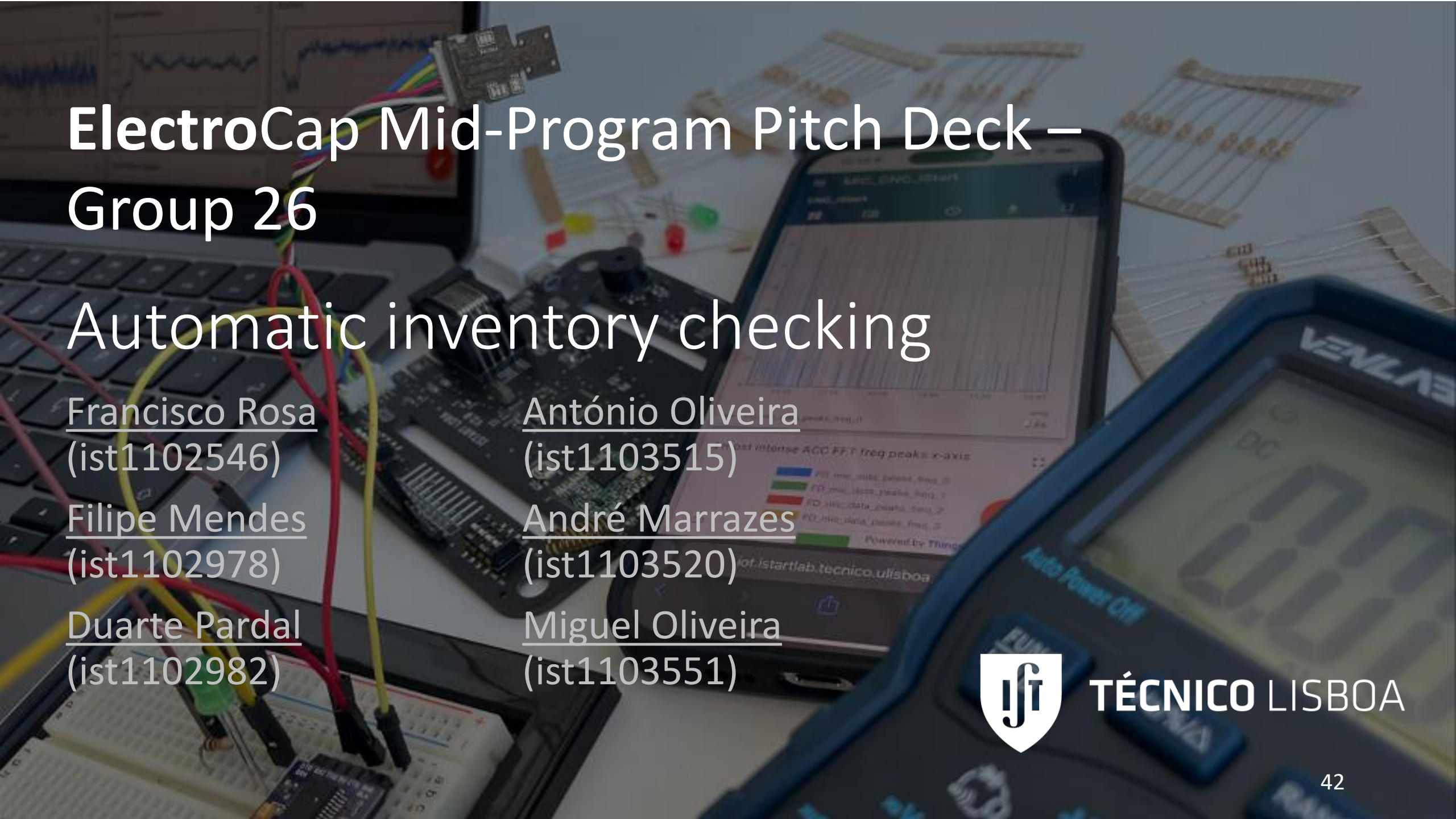
Website implementation

- As the work progressed, many pages were altered, and many details were added to the design of the website, based on suggestions given by the professors.
- The website (as it is now) can be consulted here.

App design

- The same process applied to the website was applied to the app, creating a sketch of the design that is being created.
- This sketch can be seen in this link.





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