BAYONET DEVICES PROJECT TBH

ENG 4000 – Capstone 2020: Gate 2 Preliminary Design Gate Review

Bayonet Devices

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ABSTRACT

RE: NSPA Supply Opportunity No. 20LDS067
Tactical Handheld Multi-Modal Biometric Data Capture, Storage and Matching Device

Project TBH by Bayonet Devices aims to be the most secure and feature rich multimodal biometric data capture handheld device on the market along with a streamlined user experience and a ruggedized and durable exterior. The purpose of this device is to serve our clients on-demand biometric profiling needs while being secure during the whole process of capturing and matching biometric profiles of persons of interest. TSA agents are the target audience for this project. To maintain the integrity of such a government organization that serves the interest of national security, the technology used must be reliable, secure, easy to maintain, and cost effective.

Keeping these parameters in mind as well a full list of well-defined requirements, a series of system level and subsystem level trade studies for both hardware and software, were conducted in order to provide the best possible combination of hardware and software integration, to achieve the desired level of security and user experience. This led to the development of preliminary designs on a system level, detailed hardware, and software architectures. Complete with a full set of software designs for all aspects including, backend services, database, and app functionality. In this Preliminary Design Review Documentation, are schematic diagrams for all hardware components, as well as various software, use case diagrams and UML Classifications. Furthermore, preliminary engineering budgets for mass and power were also provided along with a full list of components and a supervisor approved budget for the various components that will be used. Below you will also find work packages as well work distributions charts and diagrams outline how each of the team members contribute to the development process as well the management and precise documentation of every aspect considered during research and development. Potential risk has also been identified on a hardware, software, and a system level along with mitigation approaches. Changes to any requirements are noted and should be cross checked with the original Requirements Review Gate Documentation. The purpose of this is to be fully transparent with TSA as our client during the development process. This provides the opportunity for feedback should the client choose to provide any. The team has also provided some of their personal reflections on the peer feedback reviews as well as a statement on conflict management.

Contents

1 Preliminary Design

The preliminary design outlines the link between the conceptual design that was outlined in the previous Gate 1 document and the current, more detailed, and rigid design that is going to be implemented. The schematics shown below are the ideation of a high-level overall hardware and software design for the Tactical Handheld Biometric Device.

1.1 Hardware Design

On the hardware side, the biometric device will include a capacitive fingerprint sensor and a serial camera, both of which will communicate to the Android device via an IOIO board. A battery will power a step-up converter for the IOIO board and the serial camera. External IR LEDs will be connected to the IOIO board for the serial camera. The overall hardware architecture design is outlined below.

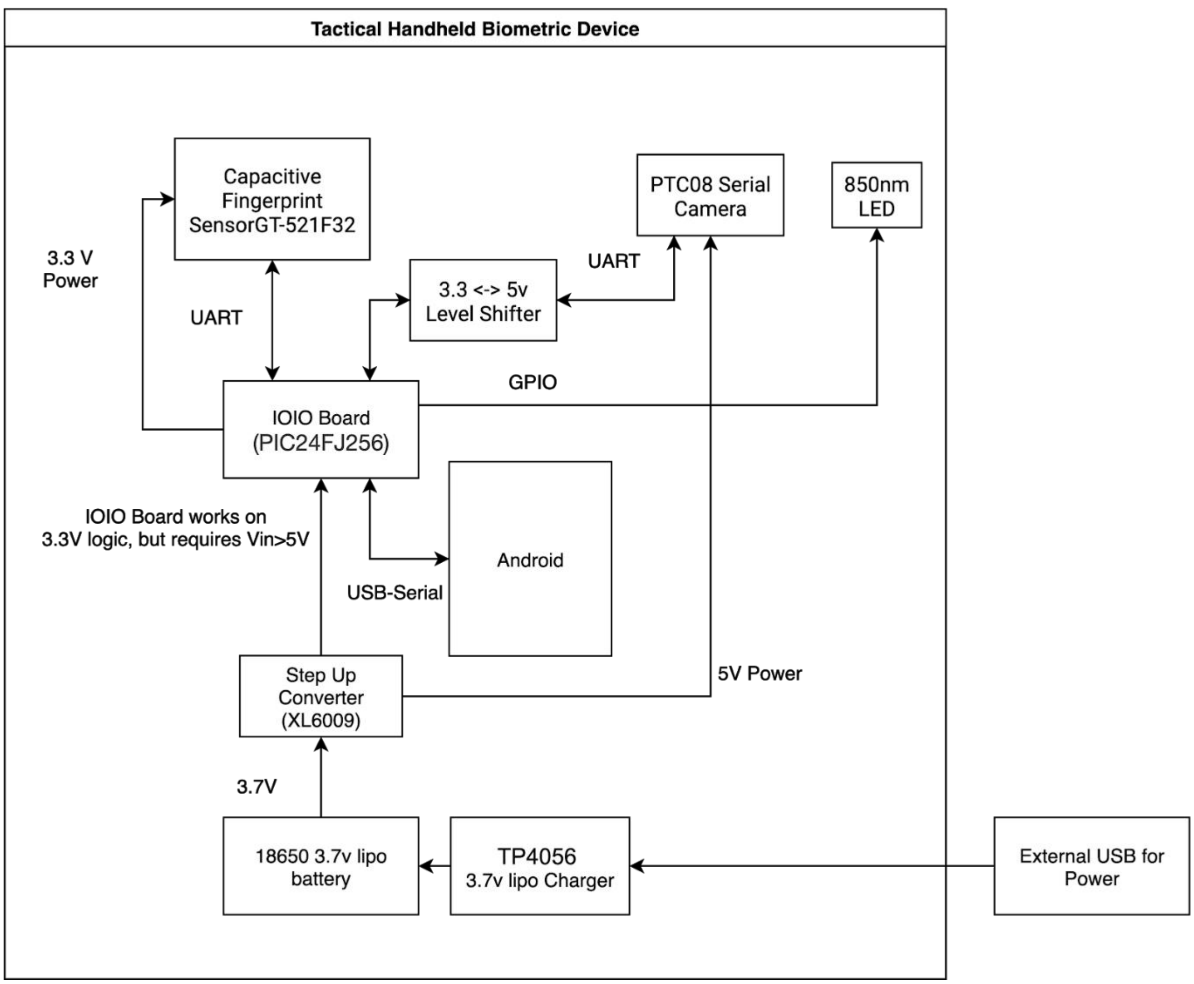


Figure 1.1.1: Hardware Architecture Diagram

1.2 Software Design

On the software side, the app for the biometric device will be running on an Android device where the front-end will be programmed in React-Native. This front end will send data to an API gateway that will make REST calls to the cloud service endpoints that direct to either classification models for the biometric information or a NoSQL database housing all the profile information. The overall software architecture design is outlined below.

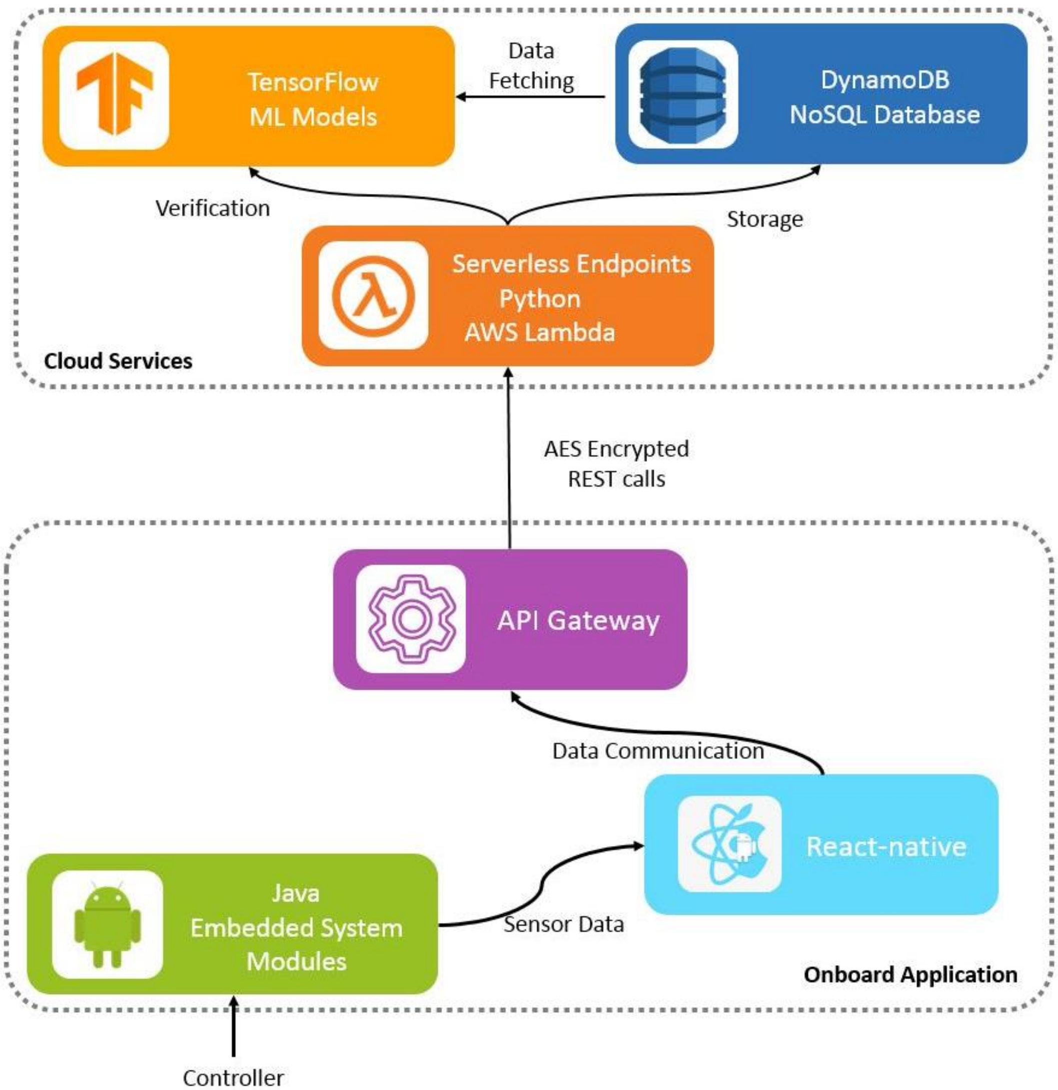


Figure 1.2.1: Software Architecture Diagram

2 Engineering Trade Studies

2.1 Trade Study 1: Hardware Architecture

Biometric sensors must be interfaced with the android phone to allow multimodal biometric collection. The integrated phone camera will be used for facial and body feature recognition. A handheld, multimodal, biometric, android device will have multiple hardware components for sensing and communication, as well as for charging and power delivery. Three possible designs were constructed to achieve the requirements of the system. All three designs have a removable 18650 lithium polymer battery, as well as the charging circuitry (TP4056). To step up and regulate the voltage from the battery, an XL6009 boost converter is used in all three cases.

Design A: Fingerprint Sensor Only

This design is the simplest of the three, as it only has one external sensor connected to the Android phone. This sensor is a TTL-Serial (UART) device and will only require a USB to serial converter chip for communication as opposed to a whole controller. Without additional sensors and a controller to power, this device is expected to have the best battery life of the three. The obvious disadvantage is that there is only one additional biometric sensor, whereas designs B and C both have two additional biometric sensors.

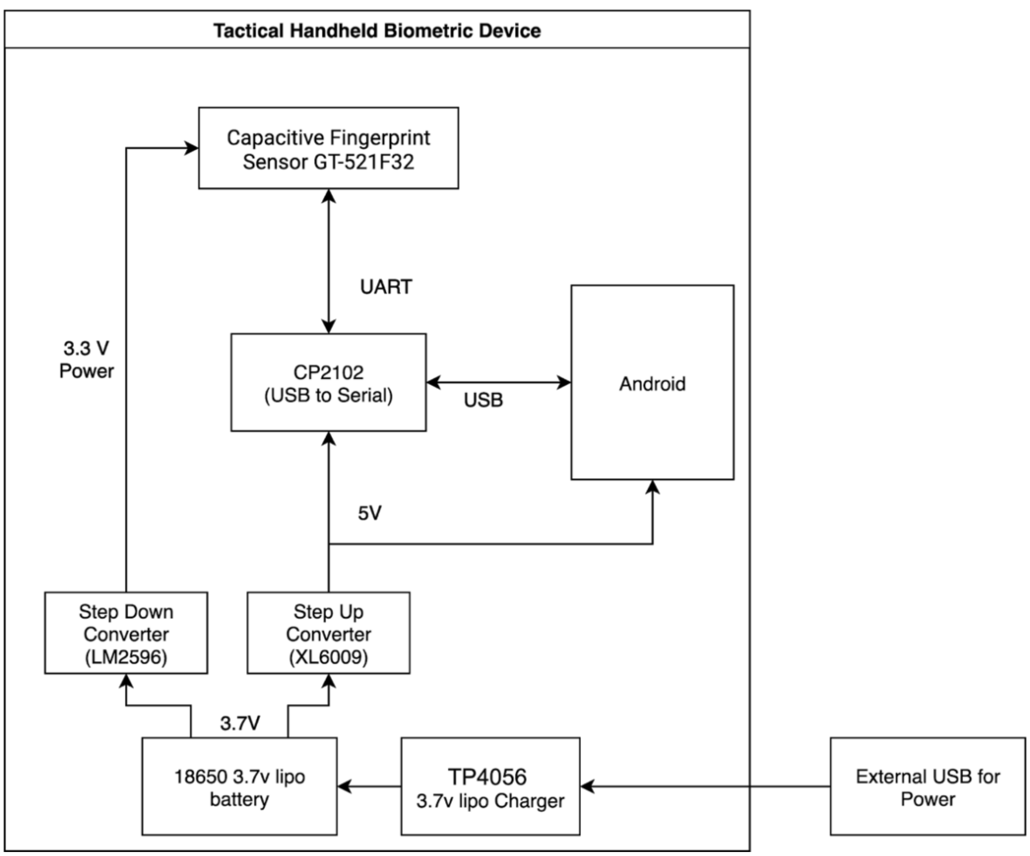


Figure 2.1.1: Design A

Design B: Fingerprint Sensor and Iris Camera (Raspberry Pi)

This design allows for a large amount of flexibility and has a wide range of documentation available making it easier to use. It allows for two biometric sensors with the option to expand further.

The disadvantages of this design are mainly due to the battery consumption of the Raspberry Pi microcontroller, as well as its larger physical footprint. This design is expected to be the least efficient one in terms of battery life. This option falls short on power delivery to the external sensors since it does not have the capability to power external devices without the need for more step-up converter modules. Two XL6009 boost converters are required as the android and raspberry pi together will exhaust its capacity. Boost converter modules with larger power capacity are available, however they exceed the power capacity that is required for our use case.

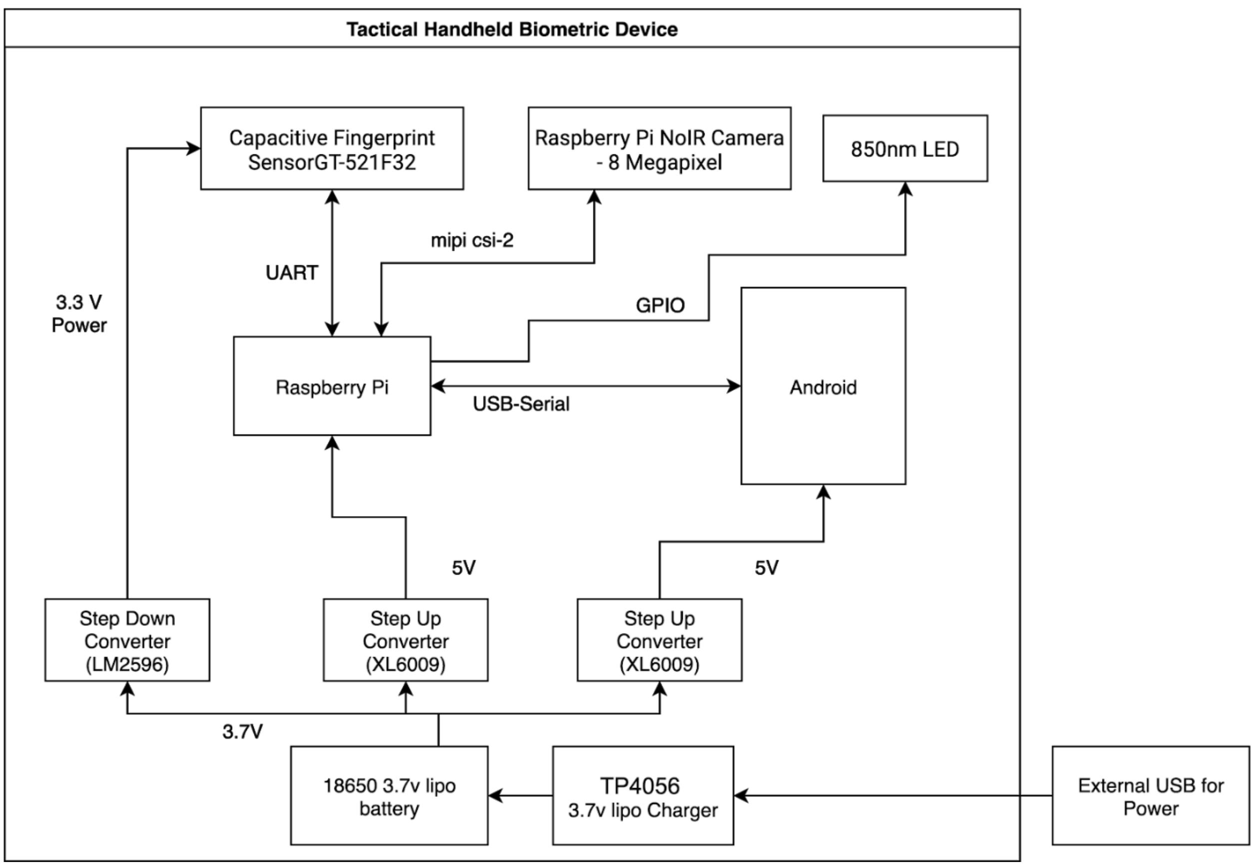


Figure 2.1.2: Design B

Design C: Fingerprint Sensor and Iris Camera (IOIO board)

This design uses a microcontroller called the IOIO board based on a 16bit PIC system on a chip. This board includes power electronics for charging powering large peripherals, in fact it is designed specifically for charging an android phone. It also has sufficient current available on the 3.3-volt line, eliminating the need for an additional step-down converter.

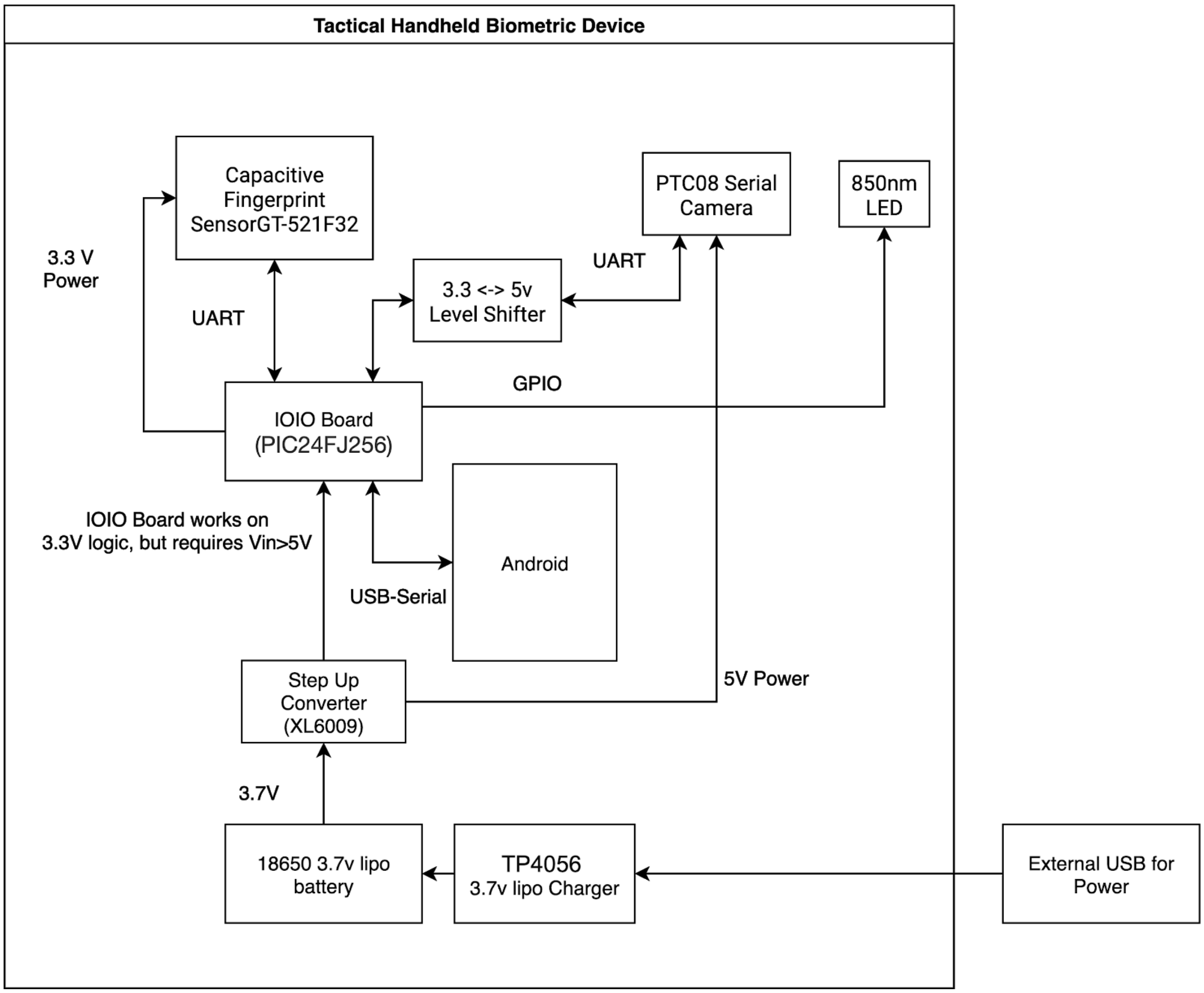


Figure 2.1.3: Design C

Decision

To gain an understanding of which of the designs were most suitable for our application, a decision matrix was created, as shown below.

Criteria	Weight	Design A	Design B	Design C
Power Consumption	4	5	1	4
Biometric Variety	5	1	5	5
Software App Complexity	1	5	4	4
Power Delivery Complexity	3	3	2	5
Software Integration (Data Acquisition) Complexity	4	5	3	4
Hardware Integration Complexity	2	5	3	2
	Total	**69**	**57**	**80**

Table 2.1.1: Decision Matrix

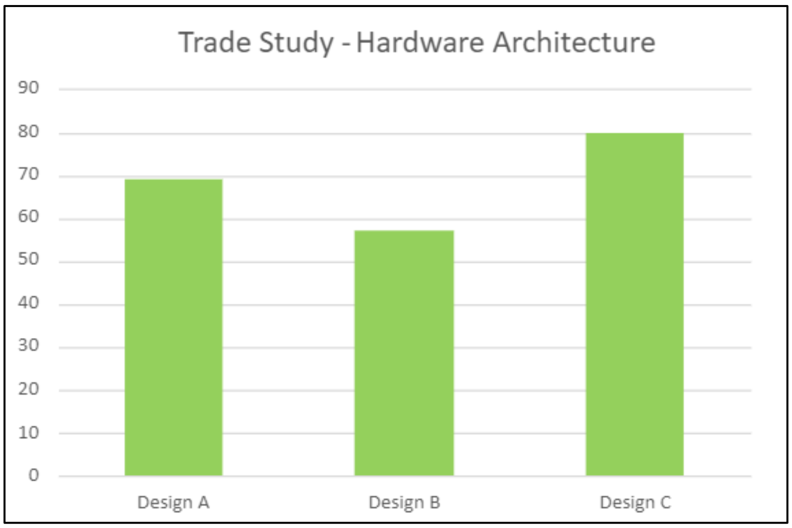


Figure 2.1.4: Hardware Architecture Graph

Power consumption is an important decision criterion, as the device is intended to be used on battery. Design A has the least amount of hardware components, which results in the lowest power consumption. Design B uses a Raspberry Pi 3, which uses a relatively large amount of power. Design C consists of a low power controller, however due to the additional sensor, does not perform to the same efficiency as Design A.

The device is intended to be a multi-modal biometric device, meaning that it is intended to collect different forms of biometric data from an individual. For all 3 designs, the android camera is intended to be used for facial and body feature recognition. Design A only has a fingerprint sensor, whereas design B and C include an infrared camera (and LED) for iris images.

The application on the android will have to communicate with the external sensors. Design A only requires the application to read a UART stream from the android COM port. The android things library supports CP210X USB to TTL chips. Design B will require the android to communicate with the raspberry pi. The raspberry pi is popular among hobbyists, and the process of interfacing an android with a pi is well documented. The firmware of the IOIO board allows a developer to communicate with the pic controller through a java application. The android app will use the IOIO board library to configure the controller to read the UART streams.

Some of the modules in the device require 5v, and some require 3.3v. The LiPo battery supplies an unregulated 3.7V output. Buck and boost converters are used to step and regulate the battery voltage. The IOIO board has buck and boost converters mounted on its PCB and has sufficient power available for all the other devices.

Design A only has one sensor and no controller. The android things library has drivers to communicate with the CP2102 chip. Design B requires an android app, but it also requires the raspberry pi to read the sensors, and then communicate with the android application, adding a layer of software complexity. The IOIO board comes with firmware that achieves a purpose similar to the raspberry pi.

Designs B and C are undoubtedly more complex than design A, as they have multiple sensors as well as the LED. The PTC08 camera works on a 5V logic level, but the IOIO board uses a 3.3V level for its UART communication. This requires design C to have a shifter to convert the 3.3V to 5V TTL and vice versa.

2.2 Trade Study 2: Fingerprint Sensor

The sensors that were deemed sufficient for this project consisted of three main options, being the GT521F32, the SEN0348, and the R305. According to the provided requirements for this project the device should abide by EBTS standards for biometric data collection. Based on this criterion and other limiting factors such as the desired dimensions of the final product, the sensors that are available with either capacitive or optical technologies or the possible implications due to fragile parts within each design are factors that were considered for our decision. Baud Rate, Resolutions, various performance metrics, and cost were all considered while conducting our research. Table 3 represents our findings and the decision matrix below outlines our decision-making process for selecting this component.

The R305 Sensor seemed to have all the features we needed except for its large size due to the type of technology it uses which makes it more susceptible to damage and would not be suitable for a handheld device. This sensor would have to protrude too far out of the device wherever it is placed to accommodate its dimensions. This would also mean it will increase the surface area of the device and therefore potential damage especially to the fingerprint sensor. To find a sensor with less fragile parts for durability and robustness to withstand a mobile environment, a different technology should be used. A sensor with a flat design to fit flush against the device would be more ideal, capacitive fingerprint sensors, offer just that, accurate scanning, sleek design, and overall comparable performance to its optical counter parts. Capacitive sensors are generally harder to spoof or trick, therefore from a security standpoint, the stronger technology is capacitive. On the other hand. the SEN0348 sensor had a very small scan area which was even more limiting for rolled fingerprints while the GT-521F32 had a larger scan area which is closer to the EBTS standard for scan area.

Another important factor was how much documentation and support are available for each of these sensors. This is particularly important, due to the team's lack of experience with this level of development; it is likely that development will slow down when the team eventually runs into a technical problem. Hence, having the resources to debug, be readily available and with extensive developer communities, that will allow for faster problem solving and therefore will prevent progress from being hindered. Our top 3 choices for sensors all had good documentation and support forums.

The main deciding factor was the best combination of functionality, support available, and availability of the device in our region as well as its cost. As shown in the decision matrix provided, the R305 sensor got the highest score, however it is an optical sensor and physically much larger in size than its capacitive alternative. Therefore, we opted to go with the **GT-521F32** sensor, since it is the best option for this stage of the project.

Model	Type	Baud Rate	Resolution	Matching Modes (1:1, 1:N)	Storage Capacity	Price	Can we get an image?	Documentation
FPC1020A	Capacitive	9600-115200	500 DPI	1:1, 1:N	N/A	17.13	N/A	Bad
GT-521F32	Capacitive	9600-115200	450dpi	1:1, 1:N	200	47.06	Yes	Good, Image, PDF
ad751	Optical	9600-57600	N/A	1:1, 1:N	162	65.38	Probably	Bad
R503	Capacitive	9600-115200	508	1:1, 1:N	200	52.29	N/A	Satisfactory
SEN0348	Capacitive	9600-115200	508	1:1 (300-400ms)	80	21.60	N/A	Satisfactory
Parallax 29126	Optical	9600-57600	N/A	1:1, 1:N	1000	75.38	Yes	Good
AD-013	Capacitive	57600	508	1:1, 1:N	40	31.99	No	Excellent
R305	Optical	9600-57600	508	1:1, 1:N	200	26.73	Yes	Excellent
R301T	Capacitive	9600-115200	508	1:1, 1:N	1700	32.77	Probably	Bad

Table 1.2.1: Fingerprint Sensor Option

Criteria	Weight	FPC1020A	GT-521F32	ad751	R503	SEN0348	Parallax 29126	AD-013	R305	R301T
Documentation	4	1	5	1	3	3	4	5	5	1
Functionality	2	4	4	3	5	5	3	3	5	5
Cost	3	1	2	2	2	5	1	2	3	2
	Total	**15**	**34**	**16**	**28**	**37**	**25**	**32**	**39**	**20**

Table 2.2.2: Fingerprint Sensor Decision Matrix

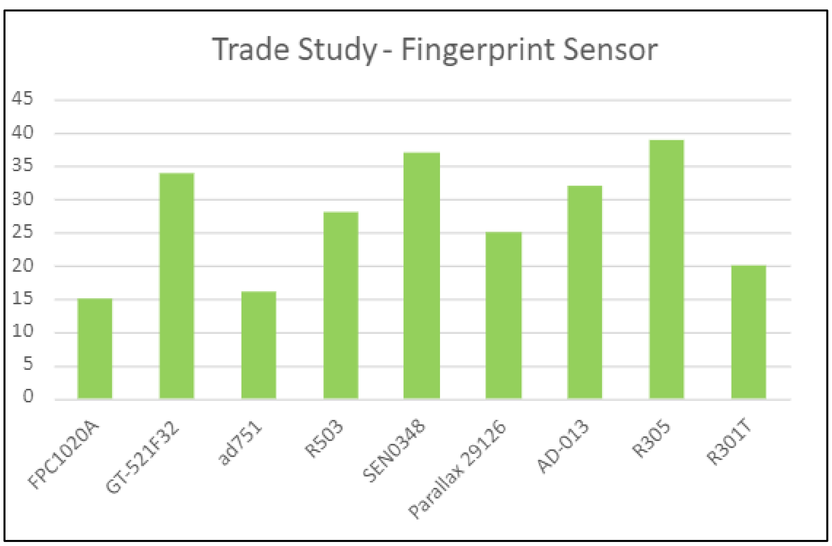


Figure 2.2.1: Fingerprint Sensor Graph

2.3 Trade Study 3: Iris Sensor Trade Study

The main iris sensor choices that were deemed suitable for our use case consisted of the Pi NoIR, the PTC08, the SC03MPC, and the See3CAM_CU55M.

To capture a high-resolution image of the iris, it is vital that the camera utilized for this purpose is sensitive to Near Infrared (NIR) light. NIR-sensitive cameras are optimized in performance in the NIR range which helps to pick up unique textures and features of the iris that would not normally be captured, particularly in dark coloured eyes. To capture the iris image, two NIR LEDs will be used to illuminate the eye and the NIR-sensitive camera will be used to capture an image. Thus, in this trade study, only NIR-sensitive cameras were considered.

Additionally, a key driving factor in the selection of the iris sensor was its communication protocol. The iris sensor shall have the capability to communicate over UART. This is required for the sensor to be compatible with the IOIO board. Other criteria considered in this trade study are resolution, cost, and availability.

As evident in Table 5 although the Pi NoIR camera has the highest resolution, cost and availability scores, it does not have a serial interface. Thus, scoring the least on the compatibility criterion. It is important to note, for this reason, this option does suit this project and should be omitted regardless of its score. The PTC08 camera scores very well on all criteria. Its resolution is in line with the ISO/IEC 19794-6 recommendations for the iris image properties, which is 630 x 480 pixels. Additionally, it is compatible with the IOIO board and available from reliable sources. The SC03MPC camera appeared to be an excellent option due to the fact that it includes built-in LED for infrared (IR) illumination. However, it has a resolution that is below the ISO/IEC 19794-6 recommendations and also is not available to purchase from reliable sources. Lastly, the See3CAM_CU55M camera scores well for the resolution however, it is very costly and presents complex issues with compatibility to the IOIO board.
As summarized in the tables below, the PTC08 camera concludes to be best suited iris sensor for this project.

Model	Resolution	Price	Communication Protocol
Pi NoIR	3280 x 2464	39.16	MIPI CSI
PTC08	640 x 480	56.06	UART
SC03MPC	640 x 480	quote pending	UART
See3CAM_CU55M	2592 x 1944	182.96	USB

Table 2.3.1: Iris Sensor Comparison

Criteria	Weight	Pi NoIR	PTC08	SC03MPC	See3CAM_CU55M
Resolution	4	5	4	4	5
Compatibility	5	1	5	5	1
Cost	3	5	4	2	1
Availability	5	5	5	1	2
	Total	**65**	**78**	**48**	**34**

Table 2.3.2: Iris Sensor Decision Matrix

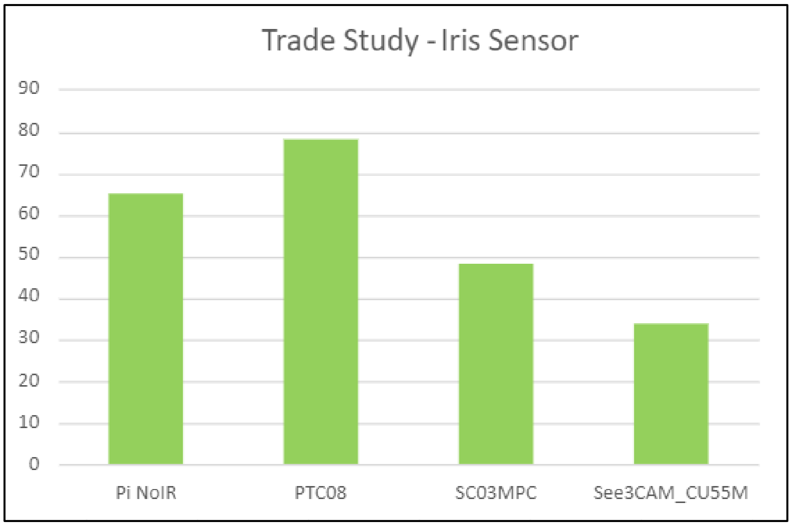


Figure 2.3.1: Iris Sensor Graph

2.4 Trade Study 4: Onboard Device Framework

For this trade study, the team analyzed three possible options for the programming frameworks that could be used to develop the Android based application. For this, three heavily used Android development frameworks: Java, React-Native, and Ionic were compared.

Criteria	Weight	Java	React-native	Ionic
Performance	3	5	4	3
Cost	5	5	5	5
Compatibility	3	5	4	4
Security	5	5	4	4
Ease of Implementation	4	3	5	3
Application Size	1	3	4	5
User Experience	5	4	5	5
	Total	**115**	**118**	**108**

Table 2.4.1: Onboard Device Framework Decision Matrix

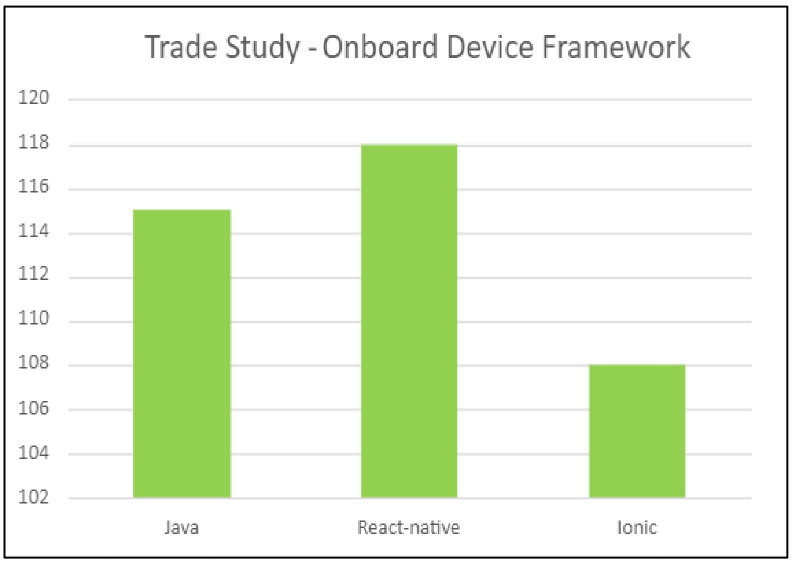


Table 2.4.1: Onboard Device Framework Graph

The three major parts of this trade study were cost, security, and user experience. Cost is a critical aspect of this product due to a limited budget. However, when comparing the device framework, options A, B, and C were all available as open source development platforms and were therefore equivalently weighted.

Since this system handles highly sensitive data and is being used by the TSA the need for stringent security is essential. From the onboard framework perspective, using a framework that is heavily secured, has many security compliance libraries, and has an active security community to resolve unknown threats. From the perspective of security, option A was the winner in this case due to the native framework that matches the OS of Android. This means that there is no additional communication layer between the OS and the onboard application.

After analyzing our trade study, we decided to use React-Native as our Android framework. The speed of development was a critical motivator for us considering the short timeline that this product needs to be made in. Additionally, when we did our competitor analysis, the user experience of competitors was heavily critiqued, and React-Native is heavily user-centric. Overall, React-Native is the overall best choice for this project based on the trade analysis.

2.5 Trade Study 5: Backend Development Language

The premise of this trade study is to compare the various backend languages that can be used for development on the platform as a service used within the project. Three common languages were compared based on a variety of factors that are integral to the success of this project. The three languages compared were: Python, Java, and Node.js (JavaScript).

Criteria	Weight	Python	Java	Node.js
Performance	5	4	5	5
Low Overhead	3	5	3	3
Security	5	5	3	4
Ease of Implementation	4	5	4	3
Learning Curve	4	4	5	3
Connectivity	5	5	3	5
	Total	**121**	**100**	**103**

Table 2.5.2: Backend Development Language Decision Matrix

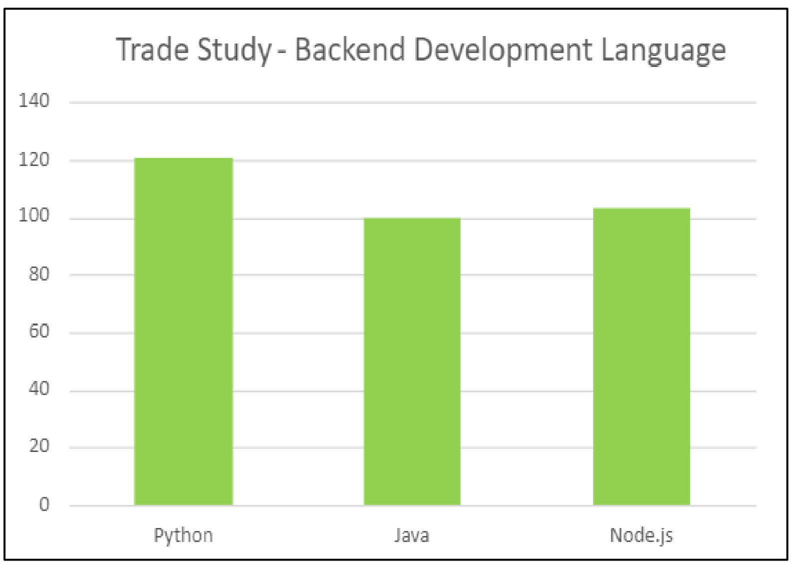


Figure 2.5.1: Backend Development Language Decision Matrix Graph

For this trade study, majority of the criteria analyzed had a significant impact on the choice of language. The three most critical aspects were performance, security, and connectivity. However, ease of implementation for the developers and the learning curve within development were also major deciding factors.

Performance is defined as the critical speed of doing computations; specifically, this was narrowed to consider data references, and mutations to object structures. This was defined as the most critical aspect performance because of the EBTS reformatting required and the speed at which matching can be done. Latencies in storage time or model training time were less significant because the system user would be unaware of these bottlenecks. As a result, Java and Node.js were the fastest options, due to Java's rigid design and Node.js consistent usage of JSON objects to store data. Common benchmarking tests were compared against all three choices to verify this.

Security was also a notable criterion that was evaluated, similarly to the on-board application because this system is being used to handle sensitive personal data, where any data breach could be a significant risk to the safety and security of many individuals. Security was looked at from the perspective of available encryption libraries, as well as active communities developing tools and software patches to fix new threats. From this view, Python was by far the most secure option with a large security development community, and many internal systems in place to resolve security issues.

Finally, connectivity of this system to the other elements within the project was defined as a critical motivator for selection. Since this system involves many complex independent subsystems, reducing the complexity of cross-system communication is essential for a design that will be able to be made within the short timeframe. With this in mind Python and Node.js were the two standout options. Due to their flexible variable structuring and intrinsic REST communication capabilities, these two options will be quintessential in creating a simple, but flexible system in a short duration.

Overall, this trade study has led the development team in deciding that the backend will be written in Python, which satisfies most of the critical requirements while not neglecting the other aspects of this trade study.

2.6 Trade Study 6: Cloud Database Services

For this trade study, the development team analyzed four options for the cloud services that could be used to host the collected data. The four options listed are key market leaders within this segment, which are also commonly used for government storage systems, and other systems with stringent security requirements. NoSQL and SQL databases were also compared, to ensure that the trade study encompassed all possible programming paradigms.

Criteria	Weight	AWS DynamoDB	Google Cloud FireStore	Azure Databricks	IBM DB2 Lite
Performance	4	5	4	5	5
Cost	5	4	5	5	4
Security	5	5	4	4	5
Scalability	3	5	4	5	4
Connectivity to HART	5	5	4	3	3
Ease of Setup	4	4	5	4	4
Ease of Maintenance	5	5	5	5	5
	Total	**146**	**138**	**136**	**133**

Table 2.6.1: Cloud Database Services Decision Matrix

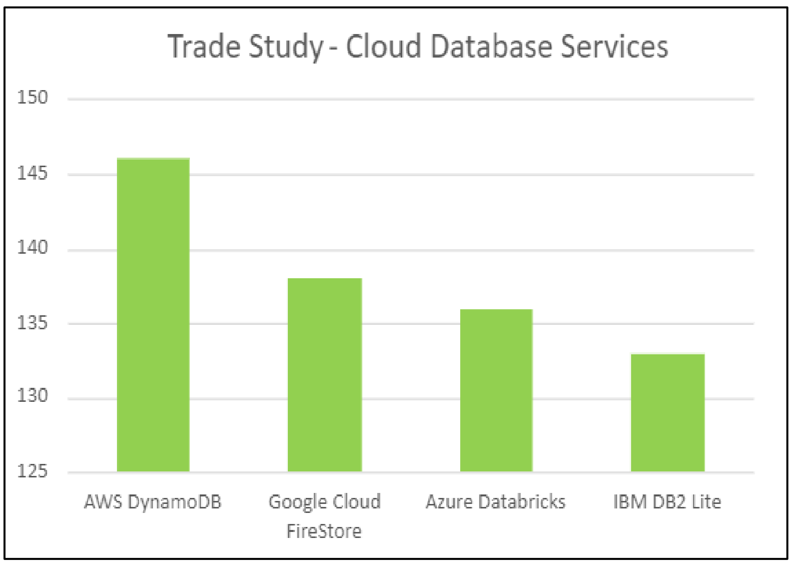


Figure 2.6.1: Cloud Database Services Graph

There were many factors that were analyzed across the four options. One of these was cost, due to a limited budget and many physical components required for this project, the need for cheap software was essential to ensure the project was within budget. In this case, Firestore and Databricks were the cheapest options for a project of this size. However, it should be noted that this analysis was done from the perspective of the project's use and not a fully implemented system used by TSA, where budgets would be much higher.

As with all other trade studies conducted, the need for a secure system was paramount. From the security perspective two systems were determined to have the highest security features and reliability, which were DynamoDB and DB2 Lite. This is because both these systems have government packages explicitly built for safely storing critical data and both systems are currently in heavy use within many government systems.

The HART system is the current development project being undertaken by Northrop Grumman on behalf of the Department of Homeland Security. This project is intended to create a new cloud storage system for sensitive data from American citizens, including biometric data. TSA's system will eventually be connected to the HART storage system, so it was logical to develop a system that would be highly compatible and portable. The HART system is using AWS GovCloud to store their data, which includes DynamoDB, making it the obvious best choice. Google Firestore was also ranked highly because of the similar data structuring to DynamoDB; since it also follows a NoSQL schema.

The final aspect of the system that was considered was ease of maintenance. From this perspective all four options offered many tools to maintain and update data in a simple to use fashion and so they were all equivalently graded. However, overall DynamoDB offered the most flexibility while still being a highly secure database system and so was the best choice for use.

2.7 Trade Study 7: Platform as a Service

For this trade study, four services were analyzed. The need of this service is to host the product code on a private server rather than locally. This approach is a more realistic system that would be commonly employed in a real product. Additionally, since the Android device has difficult power requirements, offloading computationally expensive procedures onto a cloud system will be a large benefit towards meeting the power requirements. By using a non-local server, the system will also be able to leverage faster CPUs and dedicated GPUs to complete the matching computations much faster than on device, which will also improve the user experience.

Criteria	Weight	Azure Functions	Google App Engine	AWS Lambda	Salesforce Heroku
App Deployment	4	3	4	3	5
Low Cost	5	4	4	5	2
Security	5	4	4	4	5
Scalability	4	4	2	5	3
Development Tools	3	5	3	3	4
Ease of Use	5	5	3	4	5
Testing Capabilities	4	4	2	4	5
	Total	**124**	**96**	**122**	**124**

Table 2.7.1: Platform as a Service Decision Matrix

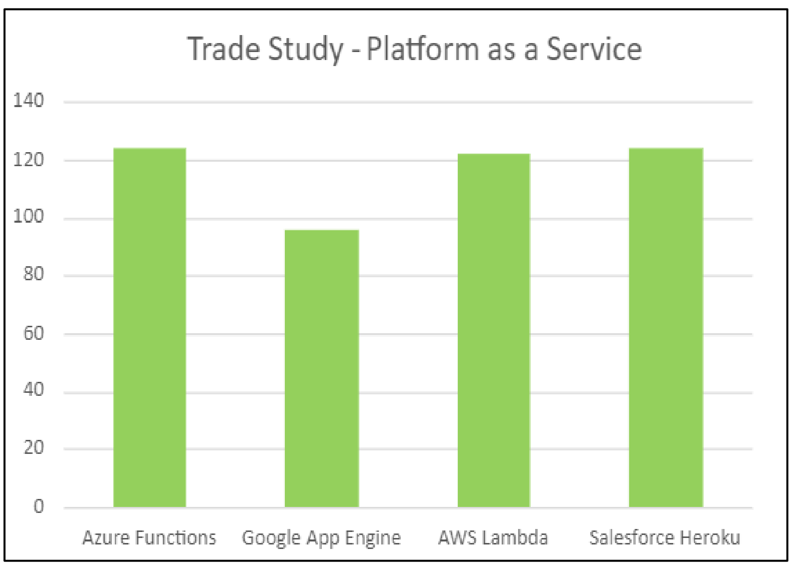


Figure 2.7.1: Platform as a Service Graph

As with all the trade studies done from the software perspective there were three main motivating factors that outweighed other requirements, which were: cost, security, and ease of use.

From the cost perspective, AWS Lambda was the best choice for a system of this size. The service providers offer 1 million transactions to Lambda endpoints every month without cost. Most of the other systems either offered a free one-use credit across all their services, or a scaling system that increased with use.

From the security perspective, the competitors were analyzed based on their security offerings and threat detection benchmarks. From this perspective, Salesforce Heroku seemed to be the strongest competitor, which is logical considering the higher pricing model that the system follows. Finally, ease of use was also analyzed in terms of setup complexity, as well as server maintenance throughout deployment. Azure's Functions and Salesforce's Heroku were the best options and offered the most services at the pricing tier that was being considered. The other two providers had equivalent services and maintenance; however, these were only available at higher pricing tiers.

From this trade study, either Functions or Heroku would be the best choices for development, with AWS Lambda trailing just slightly behind. However, after careful consideration, the development team has decided to deviate away from the trade study and use AWS Lambda, the 2nd best option. There were many motivators for this that could not be explicitly covered within the trade study. Since the clear database winner was AWS DynamoDB, there were additional benefits to using a full system that was developed by one company. Using a hybrid model of Azure and AWs, or Heroku and AWS would add a lot of unnecessary overhead, as well as fewer tools for diagnostics across multiple products. The ease of implementation from the perspective of using one service provider encourages the choice of AWS Lambda.

3 Updates to Requirements

Edit Type	Reason	Req. ID	Description	Source	Justification	Subsystem	Validation timing	Validation Approach
Updated	Phone purchased has only 16gb (Old value: 32 GB) of internal memory but has extendable storage.	**HW-FUNC-09**	The device shall have a minimum of 16GB of onboard storage shall have expandable storage via micro SD card reader with support up to 128GB of expandability.	NSPA Supply Opportunity No. 20LDS067 Document	To allow the devices well as store a minimum of 100 unique profiles locally as well hold all necessary software packages.	Storage	Preliminary Design Phase	Check android device storage capacity and size of all software package file sizes.
Removed	Design has been updated and no longer requires a multiplexor to connect to the sensors. Instead, the sensors are now connected to IOIO board.	**HW-IF-02**	The sensors shall be connected to the phone via a multiplexer that will determine which sensor shall communicate with the Android app.	Hardware Team	Required for information to not collide and allow for data traffic to operate using a bus topology	Hardware Interfacing	Preliminary Design Phase	Software selectors shall be implemented to allow for data communication through the multiplexer.
Removed	Design has been updated and no longer requires a multiplexor to connect to the sensors. Instead, the sensors are now connected to IOIO board	**HW-IF-03**	The multiplexer shall have a minimum of 4 channels to allow 4:1 operation.	Hardware Team	Required for communication purposes between the sensors and the android device	Hardware Interfacing	Preliminary Design Phase	Select a device that meets the specification.

Removed	IOIO board communicates with Android device via USB	**HW-IF-04**	The circuit shall communicate to the phone via the TX and RX pins of the phone.	Hardware Team	Required for communication purposes	Hardware Interfacing	Preliminary Design Phase	The TX and RX pins of the Android device will be accessed for data transmission and data receiving.
Added	The iris sensor needs to be compatible with the IOIO board	**HW-IF-07**	The iris sensor shall be able to communicate over UART.	Hardware Team	Required for communication purposes	Hardware Interfacing	Preliminary Design Phase	Select a device that meets the specification.
Added	IOIO board has been introduced into design so that android app can communicate with the sensors	**HW-IF-08**	An IOIO board shall be connected to an Android device via USB connection.	Hardware Team	The IOIO board will be responsible for the communication between the android phone and sensors. The android phone can communicate with this board, by telling it which sensor it wants to read. The IOIO board then communicates with the sensor and gives this information to the android application.	Hardware Interfacing	Preliminary Design Phase	The android application can select which sensor it wants to read. The IOIO board then reads sensor information and provides it to the application. The application can then validate if the biometric information is correct.
Added	IOIO board will be connected to 2 sensors which are the iris module and fingerprint sensor.	**HW-IF-09**	The IOIO board shall be connect to at least 2 different sensor modules	Hardware Team	The IOIO board will connected to sensors. It will provide sensor data from the sensor module to the android application	Hardware Interfacing	Preliminary Design Review	2 or more sensors are connected to the IOIO board and can send information to the board

Removed	Sensor obtained has 450 dpi specification	**HW-PERF-REG-02**	The fingerprint sensor shall have a resolution greater than 500 DPI.	NGI-DOC-01862-1.1 (EBTS Standards Documentation)	Sensors with resolution around this value are readily available and fall within our budget. This resolution is sufficient to capture the details of a fingerprint such that they can be matched.	Fingerprint Sensor	Preliminary Design Phase	Check the data sheet of the sensor.
Removed	Iris Sensor obtained will only capture one eye at a time	**SW-FUNC-30**	The device shall be able to conduct iris scan of both eyes simultaneously.	NSPA Supply Opportunity No. 20LDS067 Document	As per request.	Iris Scanner Module	Preliminary Design Phase	Can capture readings from both eyes at the same time
Added	Iris Sensor obtained will only capture one eye at a time.	**SW-FUNC-35**	The device shall conduct a iris scan one at a time	NSPA Supply Opportunity No. 20LDS067 Document	Need a multimodal biometric device. An iris scan is another biometric reading that can be tracked	Iris Scanner Module`	Preliminary Design Review	Can capture iris reading and send to IOIO board.
Updated	Will be implementing DynamoDB instead based on design choice.	**SW-FUNC-03**	The database shall be implemented using a cloud database (DynamoDB)	Software Team	Will help with data organization and clarity in development	Backend Software	Preliminary Design Phase	Profiles are stored in DynamoDB database

Updated	A design change was made to use the IOIO board to communicate with Android Phone. This board uses a USB connection for communication.	**SW-FUNC-15**	The application shall have access to the data coming in from IOIO board via the USB	Software Team	Required to have communication between the Sensors and Application	Application Software	Critical Design Review	A wired connection will be setup to the device, and the application will access the GPIO pin data responsible for transmission.
Updated	The EBTS file formatting will be done in the backend instead of the application. It is harder to create and send files in the application, so the design choice was to do this in the cloud instead.	**SW-FUNC-17**	The backend service used to store profile information shall convert user information into EBTS file standards	Software Team	Required for any government level biometric storage.	Backend Software	Critical Design Review	The generated format will match the specification documentation for EBTS

Table 3.1: Updated Requirements

4 Use Cases & Performance Parameters

For this biometric device, there are three primary actors defined. An actor is any person or entity that can use the biometric device. Any action that an actor can perform is a use case. The diagrams outlined in *Section 4.4 Use Case Diagrams for Actors*, show the primary actors on the left side of the system. On the right side of the diagram are secondary actors such as other services and databases. These actors also communicate with the system so that the action done by the primary actor is successful. Additionally, two types of relationships can exist in between actions in these diagrams. These types are the extend and include relationships.

Extend: Is a feature that is an extension of another use case. This use case does not rely on the use case it extended from but instead, is an optional thing that can be use by the primary actor.

Include: Is a use case/action that must be done by the user or subsystem to perform the use case.

4.1 Actors

4.1.1 TSA Agent – Actor

A TSA agent is the first primary actor defined. There are main actions that a TSA agent can perform which are onboarding of biometric profiles and identification of people. Additionally, other actions they can do is login and get training from the device. A detailed set of actions a TSA agent can perform are Figure 4.2.1.

Onboarding

Onboarding is process in which a persons biometric and personal information are gathered by the device and are sent and stored in the cloud database backend. When onboarding someone, the TSA agent will have to perform a few actions which include, scanning a person's fingerprint, iris and face and getting their personal information. Once they do this, the onboarding use case is complete.

Matching

Matching is a process that involves identifying a person with a match or no match response from the device after scanning some bio readings and entering some personal information into the device. The TSA agent must perform the above two actions for the overall system to give a classification.

Login

The TSA agent would additionally need to login into the device. They will do this by entering their username and password on the device. To do anything on the device the TSA agent must login.

Help

The TSA agent also needs to be trained to use the device. On the device, the TSA agent can access manuals and training modules which they can see anytime after they login.

4.1.2 TSA Manager – Actor

A TSA manager is the secondary primary actor defined. A manager is an extension of an agent which means that all actions that an TSA agent can perform, can also be done by a manager. The unique actions that a manager can do are edit agent employees and enable and disable device features for agents on biometric devices. A detailed set of actions and relationships are outlined in Figure 4.2.2

Edit Employees

Editing employees involves two different actions which are adding employees to the system and removing employees from the system. When a TSA agent employee is created and added to the system, they can then login into the biometric device and perform actions like onboarding and matching. Likewise, when removing an employee from the system, the removed employee can no longer login to the biometric device.

Enable and Disable Features for Agents

When a TSA manager enables and disables a feature on the biometric device, the TSA agent they were changing permissions for can no longer access that specific feature.

4.1.3 - System Administrator – Actor

A system administrator is responsible for managing managers, agents, and permissions. Like the manager they remove, add employees, and manage their permissions. The main difference is that they can also manage TSA managers. A detailed list of actions and relationships can be viewed in Figure 4.2.3.

4.2 Use Case Diagrams for Actors

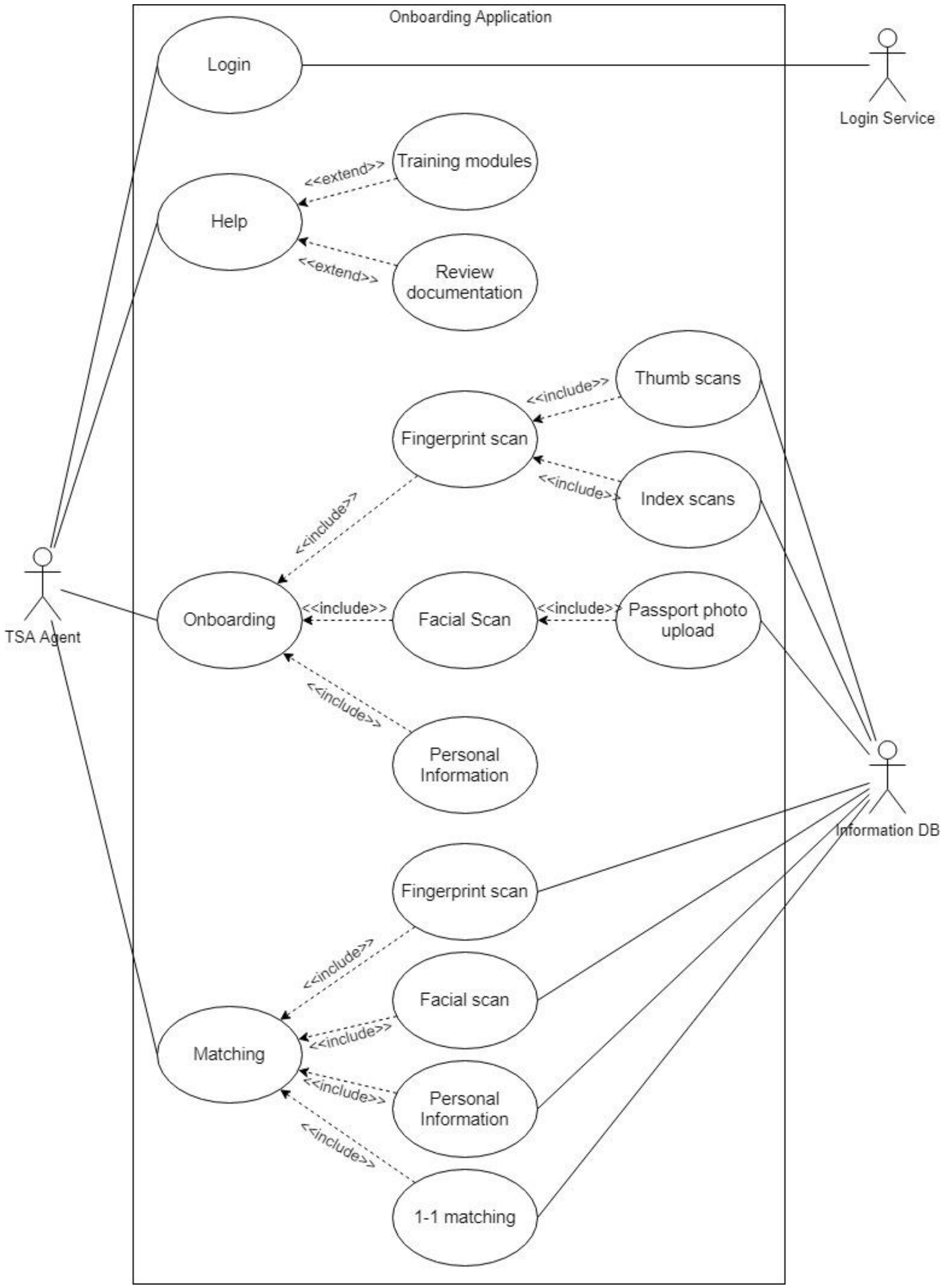


Figure 0.2.1: Use Case diagram for TSA Agent

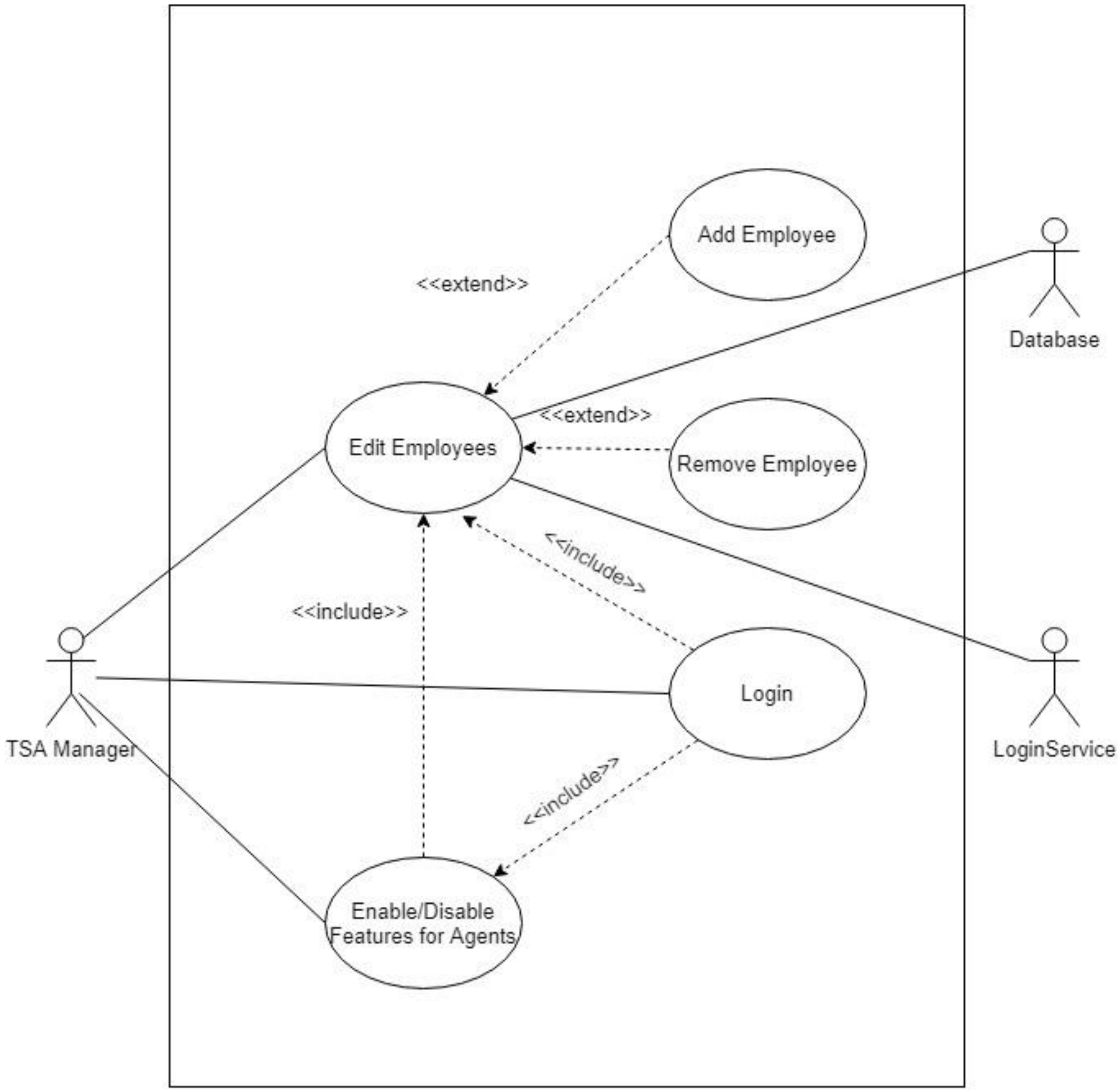


Figure 0.1.2: Use Case Diagram for TSA Manager

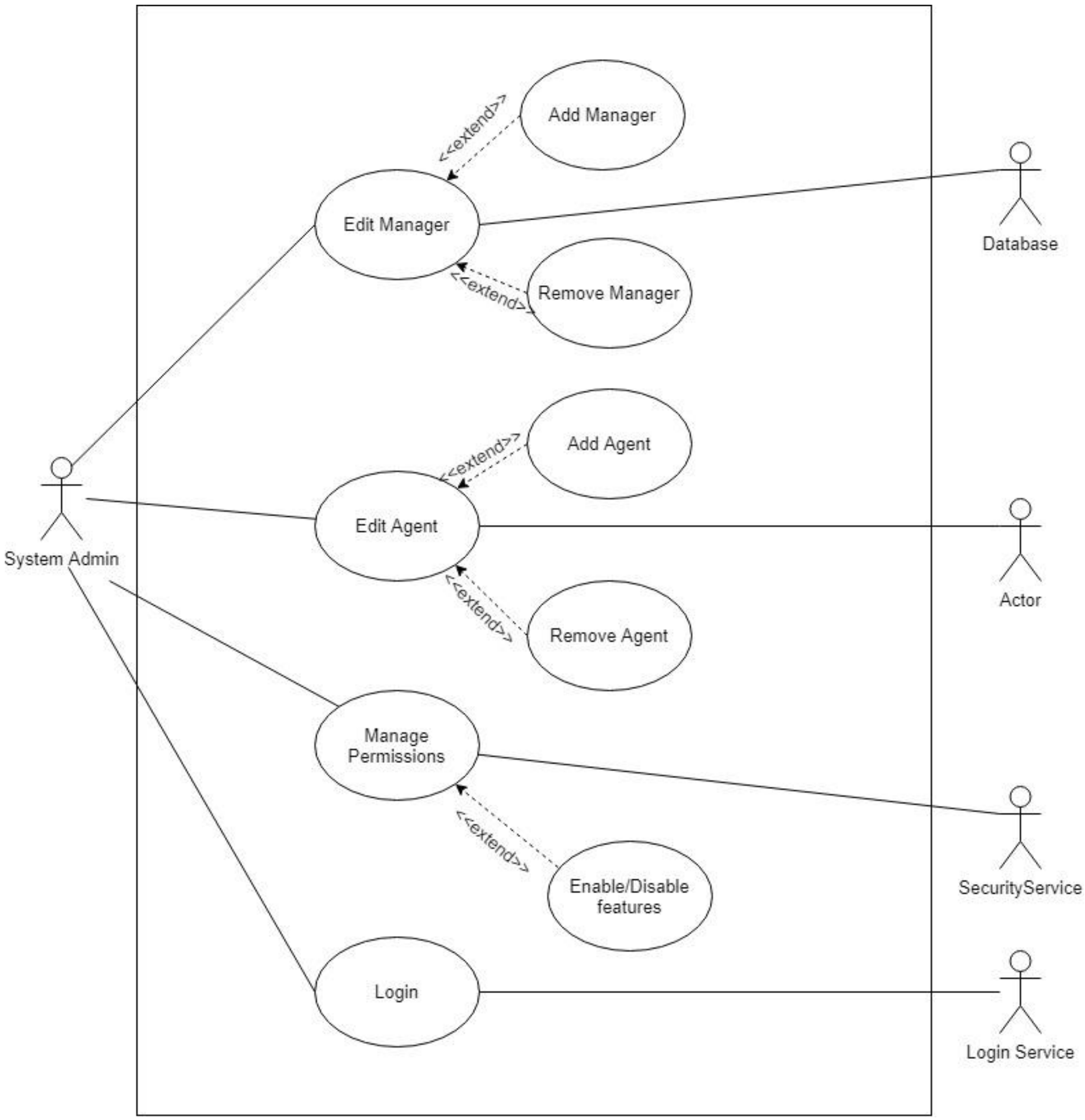


Figure 0.2.3 Use Case Diagram for System Administrator

4.3 System Performance Parameters

Performance metrics are divided into two main sections which are the hardware related parameters and software related parameters to the device.

4.3.1 Hardware Performance Parameters

Table 4.3.1 shows performance parameters related to the fingerprint sensor, iris scanner, camera of device and specifications of the selected android device.

Component	Parameter
Fingerprint Sensor Resolution	450 dpi
Iris Scanner Resolution	640 x 480 pixels
Device Camera	13 MP w/ autofocus
Power Output Voltage	5V
Communication Voltage	3.3V
Battery Capacity	3000mAH (Device), 3000mAh (Hot Swappable Battery)
Device to Sensor Max Link Speed	480 MB/s (USB 2.0 5GB/s)
Device Processor	Qualcomm Snapdragon MSM 8917 1.4 GHz Quad-Core
Device on-board memory	2 GB
Device Storage Capacity	16 GB ROM
Device Storage Expandable Upto	128 GB (Micro SD)
Device Screen Size	5.45” (Diagonal)
Device Connectivity	2G GSM 850/900/1800/1900 MHz, 3G UMTS/HSPA+ Bands: B2/B4/B5, 4G LTE Bands: B2/B4/B5/B12/B14
Device Security	Rear Fingerprint sensor

Table 4.3.1: Hardware related performance specifications for sensors and Android device.

4.3.2 Software Performance Parameters

Lambda Service

Lambda is an Amazon Web Service that will be utilized to implement the backend services. It is a serverless service where code can be uploaded and launched in the cloud. The device can then call this code in the cloud via API endpoints. The code called will then be executed in the cloud by the lambda service.

Resource	Quota
Function and layer storage	Terabytes (default 75GB)
Timeout	15 minutes
Availability	99.95% Constant Uptime in a month (less than 0.336 hours downtime a month)
Concurrent Executions	Hundreds of thousands (default 1000)
Function Layers	5 layers
Invocation payload	6 MB (synchronous) 256 KB (asynchronous)

Table 2.3.2.1: Lambda Service Performance Parameters

DynamoDB Storage Database

DynamoDB is a cloud database service offered by Amazon Web Services. It is a non relational database, and its main job is to store profile information, and biometric data.

Resource	Quota
Availability	99.999% Constant Uptime in a month (less than 0.00672 hours downtime a month)
Request Throughput	40,000 read/write request units
Table Size	Unlimited

Table 4.3.2.2: DynamoDB Storage Performance Parameters

5 Engineering Design Budgets

The engineering budgets are a clear representation of the design of the system. The following engineering budgets are constructed to reach their respective requirements outlined in the Gate 1 document.

5.1 Power Budget

To determine and design the power system, an accurate list of how much power each module will consume must be created. In the table below, the specifications for power drawn by each module is determined so the overall system will not be overwhelmed.

Component	Idle Power Draw [W]	Max Expected Power Draw [W]	Margin [%]	Max Possible Power Draw [W]
IOIO Board	0.00264	0.5	10	0.55
Iris Camera Sensor	0	0.375	5	0.39375
Fingerprint Sensor	0	0.5	5	0.525
850nm LED	0	0.064	10	0.0704
Android Phone	0	5	10	5.5
Total Power Required	0.00264	6.439		7.03915
Total Power Available	10	10		10

Table 5.1.1: Power Budget

5.2 Mass Budget

Each component's mass contribution to the overall system is listed in the table below.

Components	Mass [Grams]	Max Expected Mass [g]	Margin [%]	Max Possible Mass [g]
IOIO Board	125	150	15	172.5
Iris Camera Sensor	35	45	10	49.5
Fingerprint Sensor	25	45	10	49.5
850nm LED	1	3	5	3.15
18650 Battery Charger	2	4	10	4.4
18650 Battery Holder	1	2	10	2.2
18650 Battery	44	46	10	50.6
Step-up Boost converter	3	5	5	5.25
Level Shifter	3	5	5	5.25

Wires & Solders	5	7	10	7.7
Mounting Hardware	25	35	25	43.75
Device Enclosure	115	150	30	195
Android Device	180	205	15	235.75
Total	**564**	**702**		**824.55**

Table 5.2.1: Mass Budget

5.3 Cost Budget

The cost budget outlines every single part to the overall project. This includes components that group members already own that will be used in the project. The "Contingency" column is meant for if products are defective or will need to be re-bought for any reason. The subtotal of all the components, the components plus the contingency, and components, the contingency, and the margin (if the prices change by some amount) are listed below.

Component	Quantity	Cost (Including Tax and Shipping) [CAD]	Contingency [CAD]	Margin [%]	Max Spending
IOIO Board	1	$54.48	$108.96	5	$114.41
Iris Camera Sensor	1	$52.26	$104.52	5	$109.75
Fingerprint Sensor	1	$51.44	$102.88	5	$108.02
850nm LED	2	$2.85	$5.70	5	$5.99
18650 Battery Charger	1	$0.50	$1.00	5	$1.05
18650 Battery Holder	2	$0.63	$1.26	5	$1.32
18650 battery	2	$31.61	$63.22	5	$66.38
Step-up Boost Converter	1	$3.17	$6.33	5	$6.65
Level Shifter	1	$0.25	$0.50	5	$0.53
Wires & Solders	TBD	$1.00	$2.00	10	$2.20
Mounting Hardware	TBD	$1.25	$2.50	10	$2.75
Device Enclosure	1	$10.00	$20.00	15	$23.00
Android Device	1	$157.07	$314.14	10	$345.55
Total		**$366.51**	**$733.01**		**$787.60**

Table 5.3.1: Cost Budget

6 Simulation / Prototyping

Many simulations and prototypes have been developed to ensure that the project is both logical and feasible. From the hardware portion of the project a schematic was built to show the sensor interfacing and power system design. For software, there were three types of prototype schematics made, the first was a UML class diagram which defines the low-level specification of how the software will be developed and the classes, interfaces and functions required. Additionally, a user-interface specification was prototyped to show the user centric flow. This diagram is a significant aspect of the project since a main differentiating factor for this system against competing product BioSled, is a better user experience. Finally, activity diagrams were designed to prototype data transfer within the system, which is a critical aspect to be prototyped because there are many subsystems that need to communicate seamlessly.

6.1 Hardware Schematics

Three schematics were created for the hardware of this system, including the microcontroller unit schematic, the power system which supplies power for all the sensors, and extended battery life for the Android device, and the pinout specification.

MCU Schematic

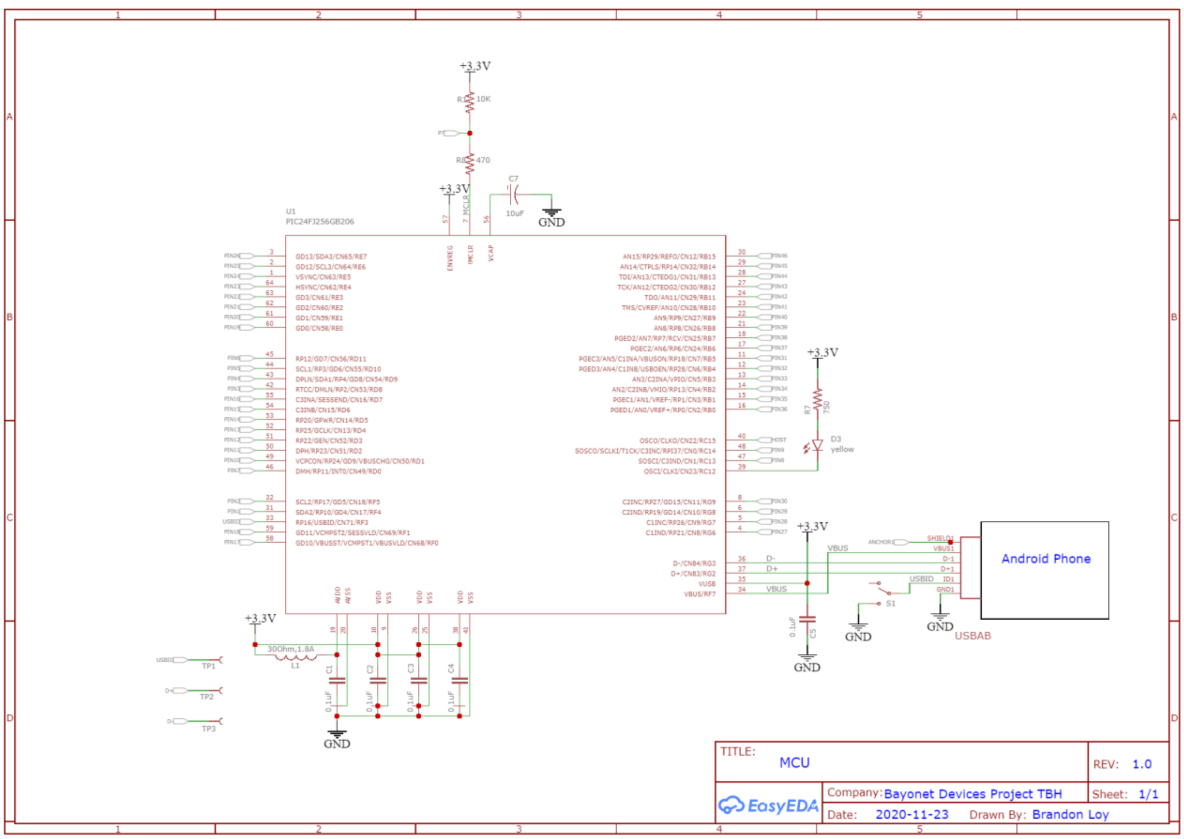


Figure 6.1.1: Microcontroller Unit Schematic

Power System Schematic

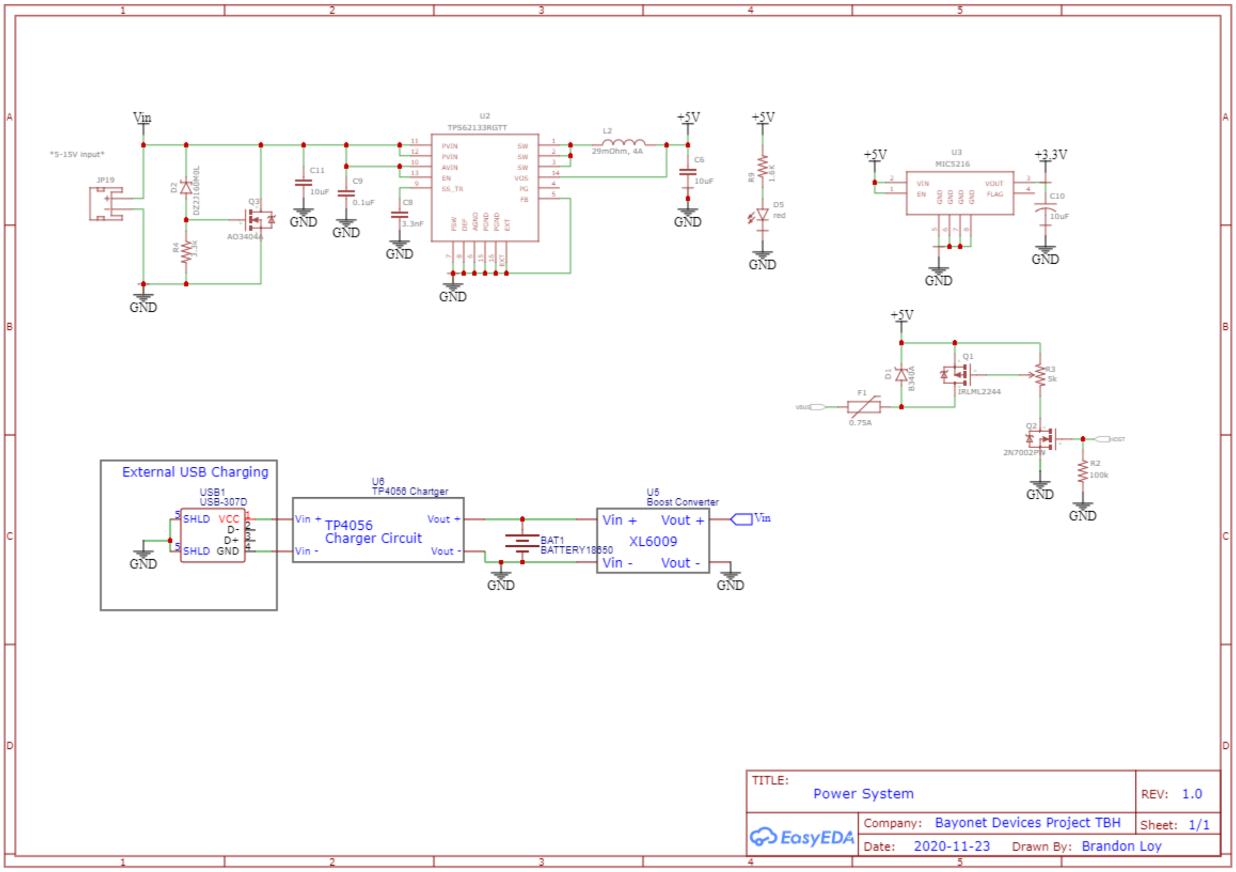


Figure 6.1.2: Prototype of power system for sensors and Android device

Footprint Pinout

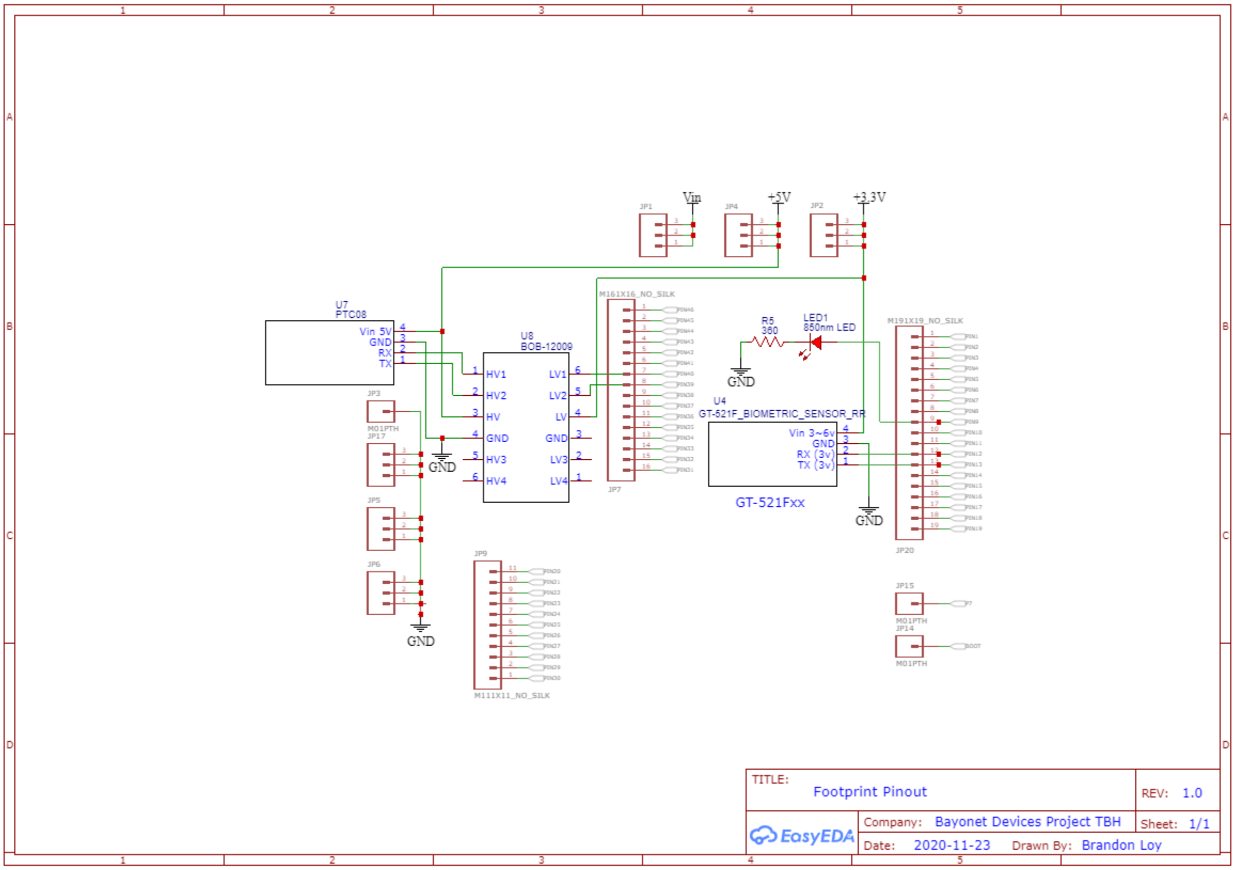


Figure 6.1.3: Footprint Schematic depicting the pin assignments

6.2 UML Class Diagrams

The two class diagrams shown, depict the detailed functional aspect of the software system. The first diagram is for the onboard Android application, which will be created in React-Native based off the trade-study conducted. This diagram shows the various functions, objects, data types, and class structuring. A similar software prototype is also defined for the backend software that will be hosted on AWS Lambda as per the trade studies.

Android System Class Diagram

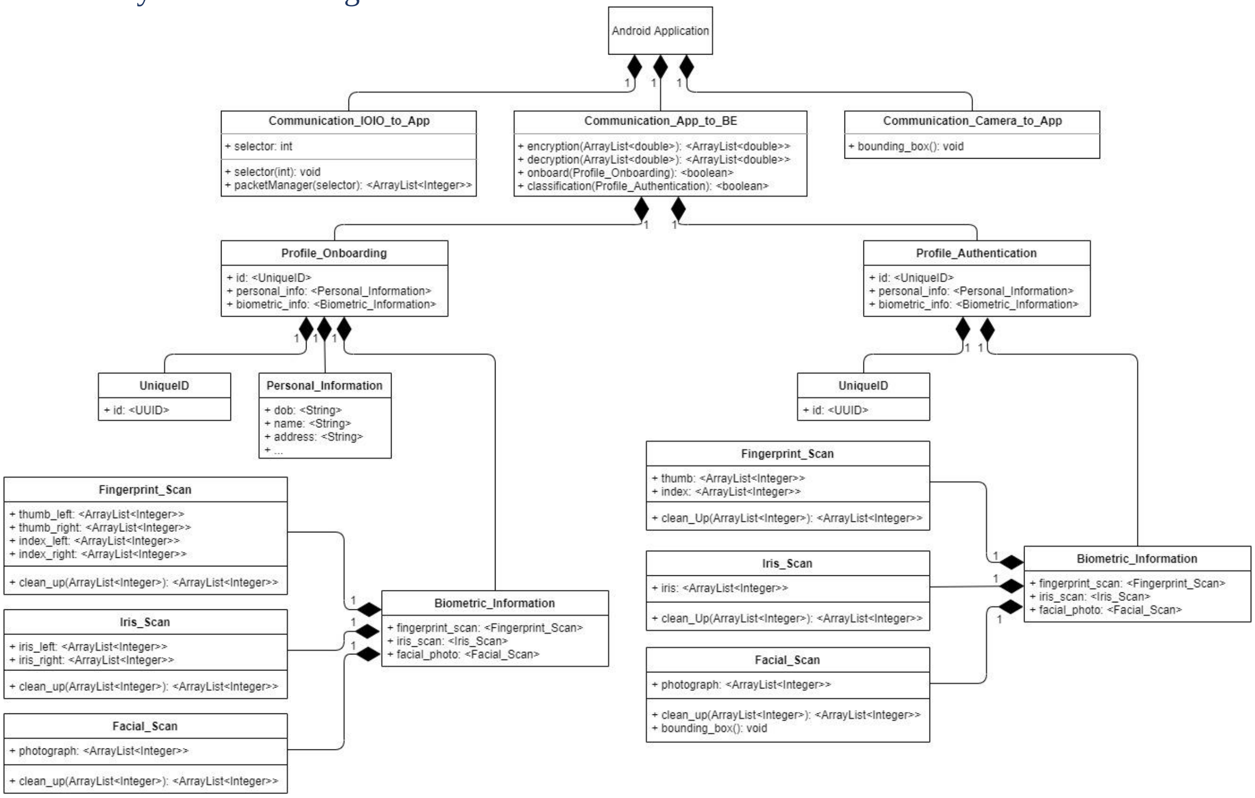


Figure 6.2.1: Class Diagram for the Android device

Backend System Class Diagram

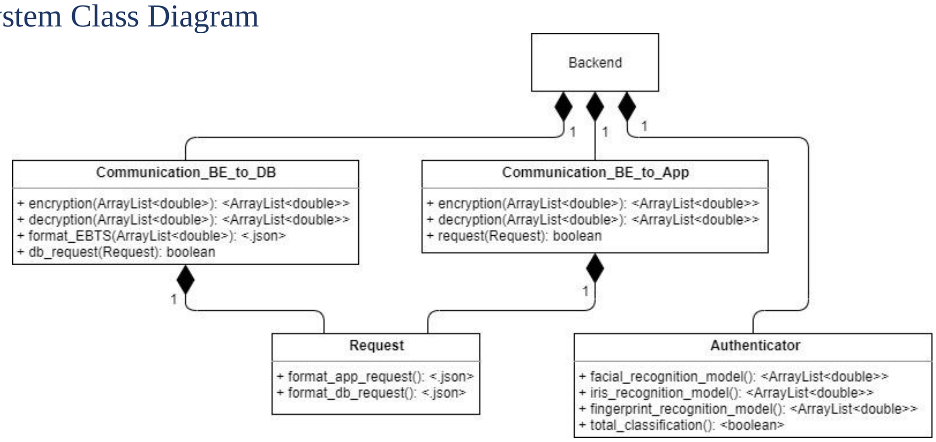


Figure 6.2.2: Class Diagram for the backend software

6.3 User-Interface Specifications

Along with the more technical prototypes provided, the need for design documentation is also a critical aspect of this project that must be accounted for. As a result, the team developed a design specification to ensure that user-experience is always at the forefront of development.

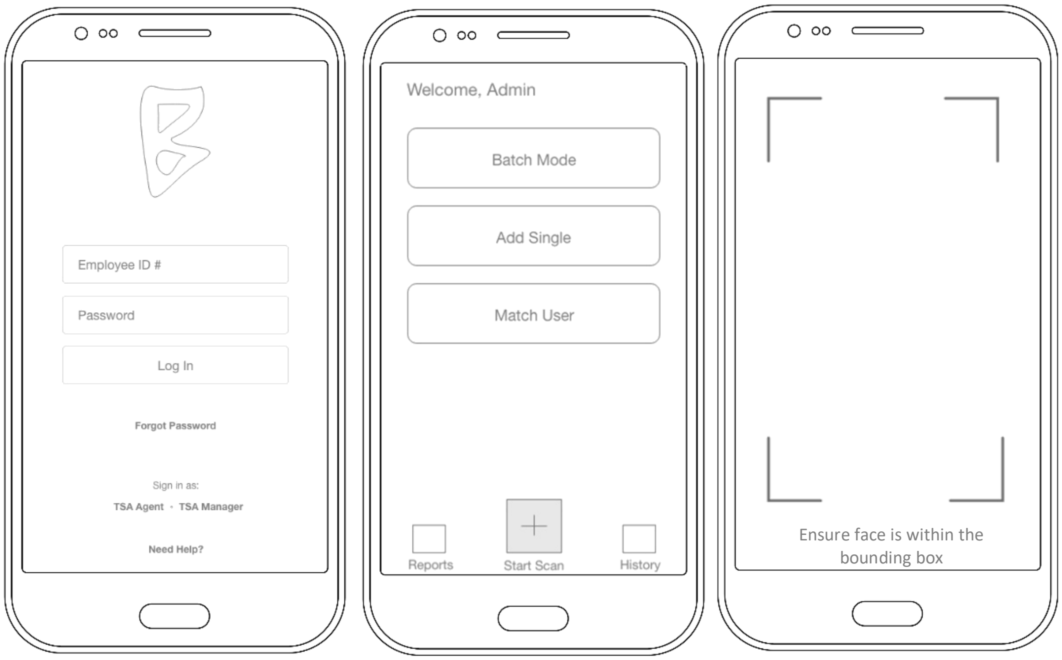


Figure 4.3.1: Data capture sequence UI/UX

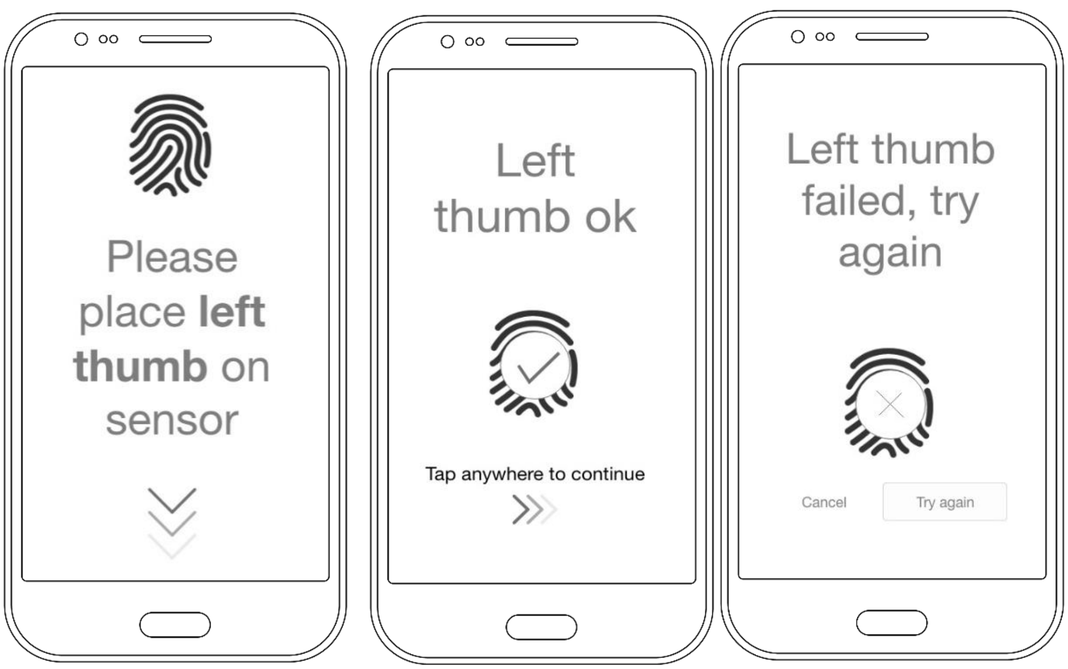


Figure 6.3.2: Thumb data capture sequence

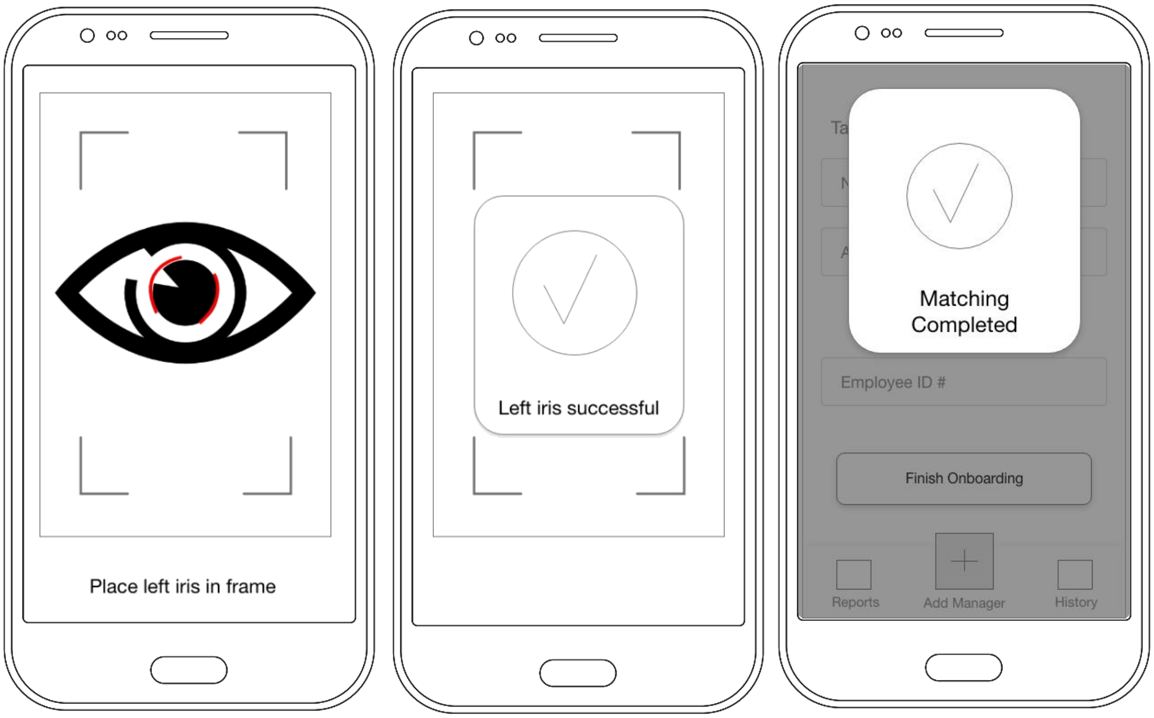


Figure 6.3.3: Final matching sequence

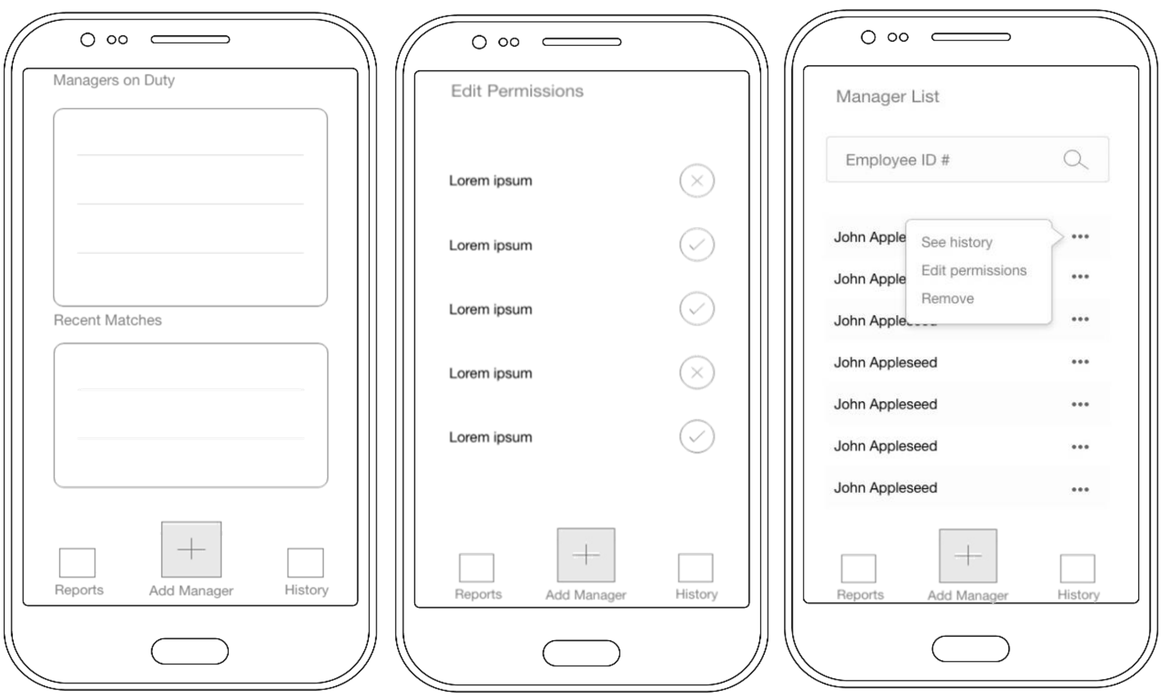


Figure 6.3.4: System Administrator views

6.4 Activity Diagrams

Activity diagrams are essential in depicting data flow across various uses cases and the potential branching and merging of data flow options. Four activity diagrams were included to depict the following use cases: System Administrator usage, TSA Manager usage, TSA Agent onboarding, and TSA Agent matching.

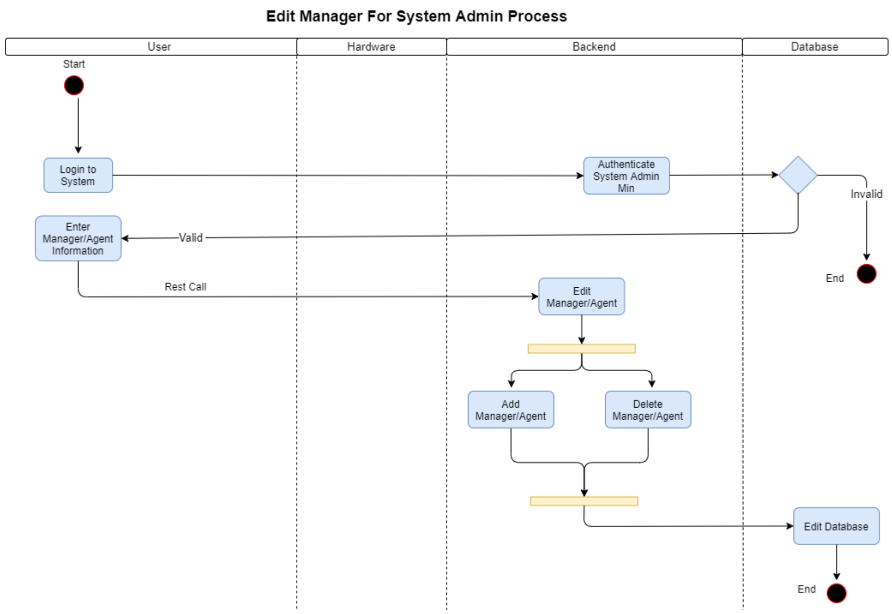


Figure 6.4.1: System Administrator

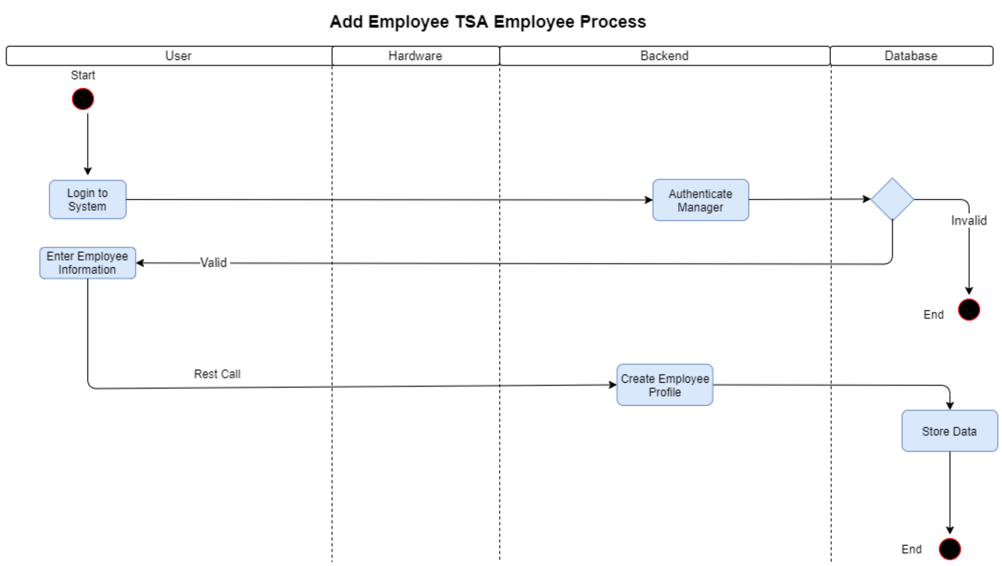


Figure 6.4.2: TSA Manager - Add Employee

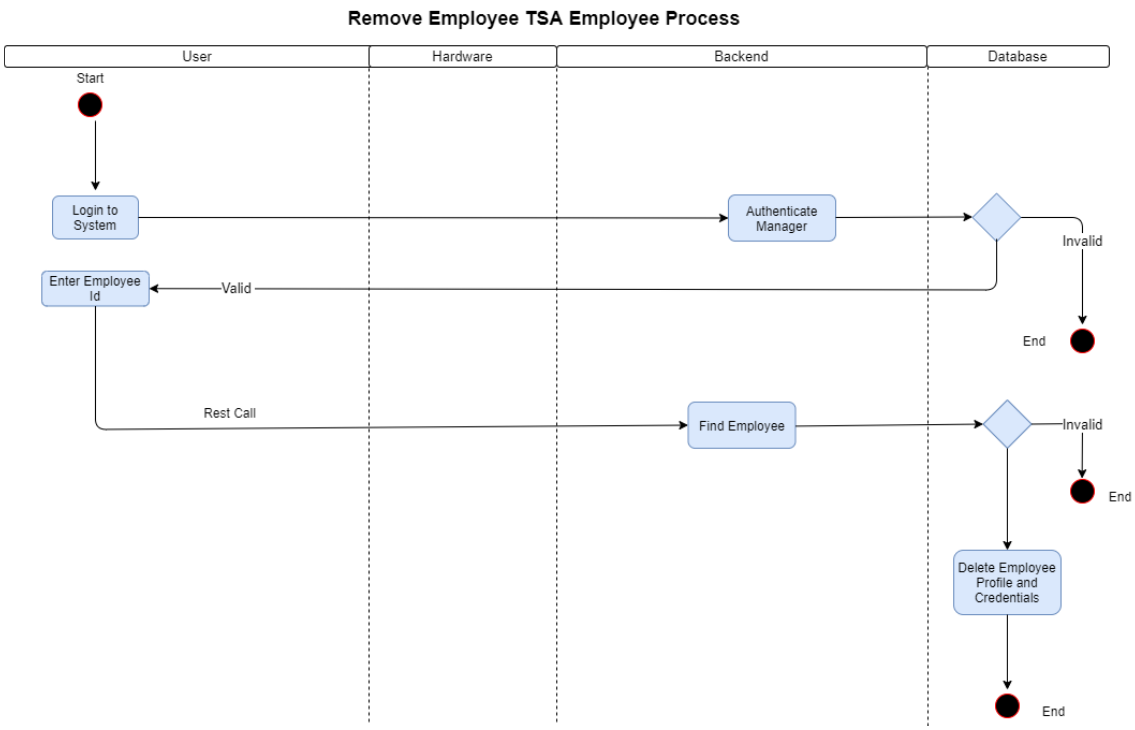


Figure 6.4.3: TSA Manager - Remove Employee

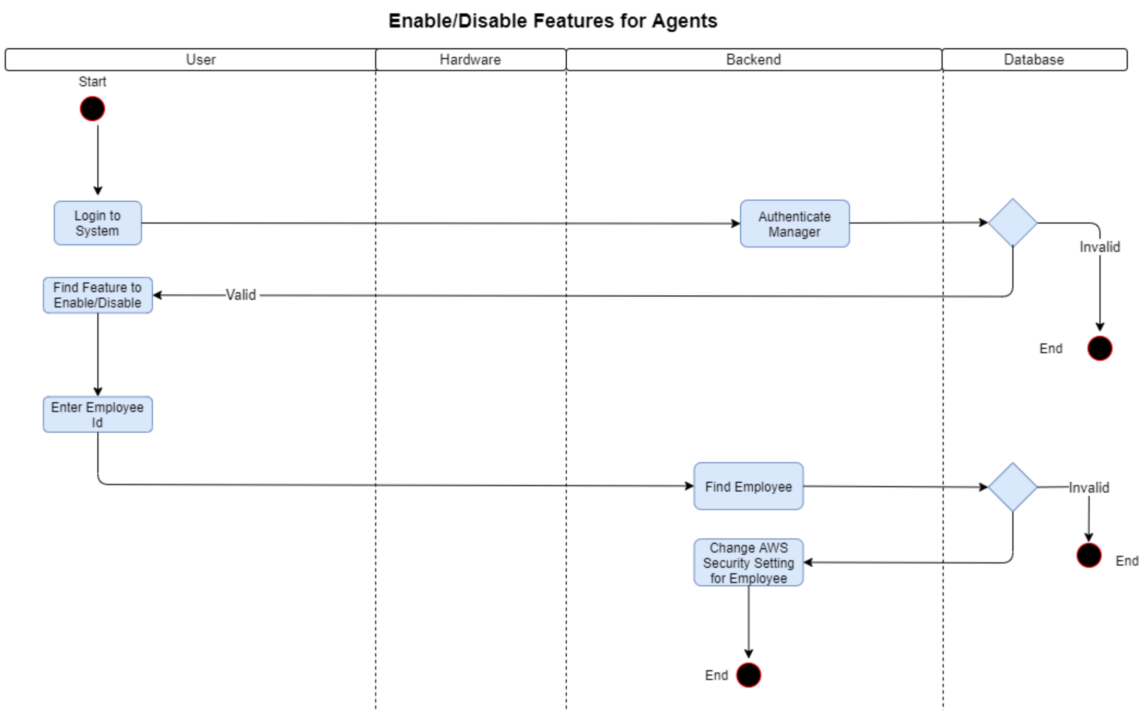


Figure 6.4.4: TSA Manager - Disable/Enable TSA Agent Features

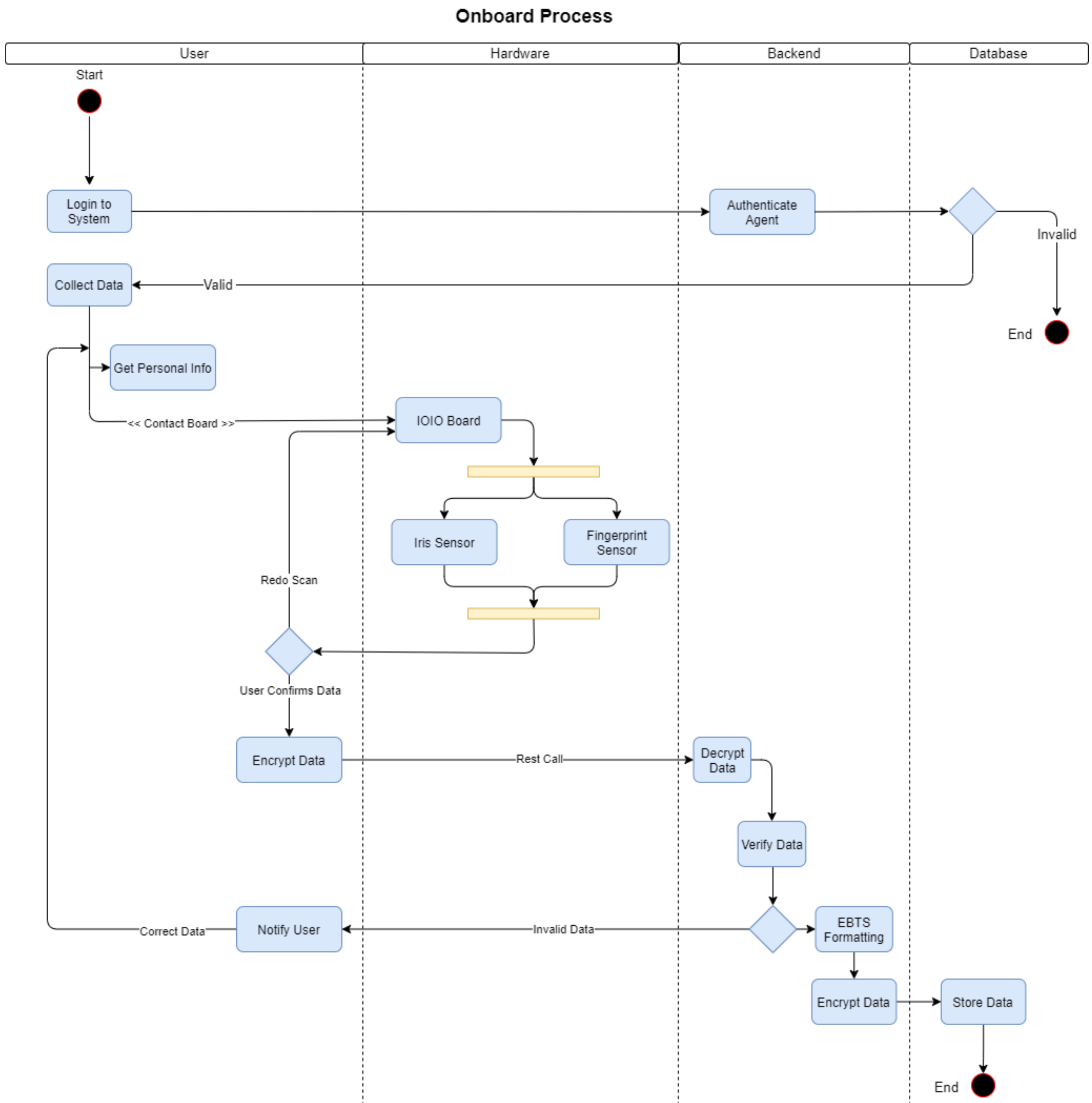


Figure 6.4.5: TSA Agent - Onboarding Process

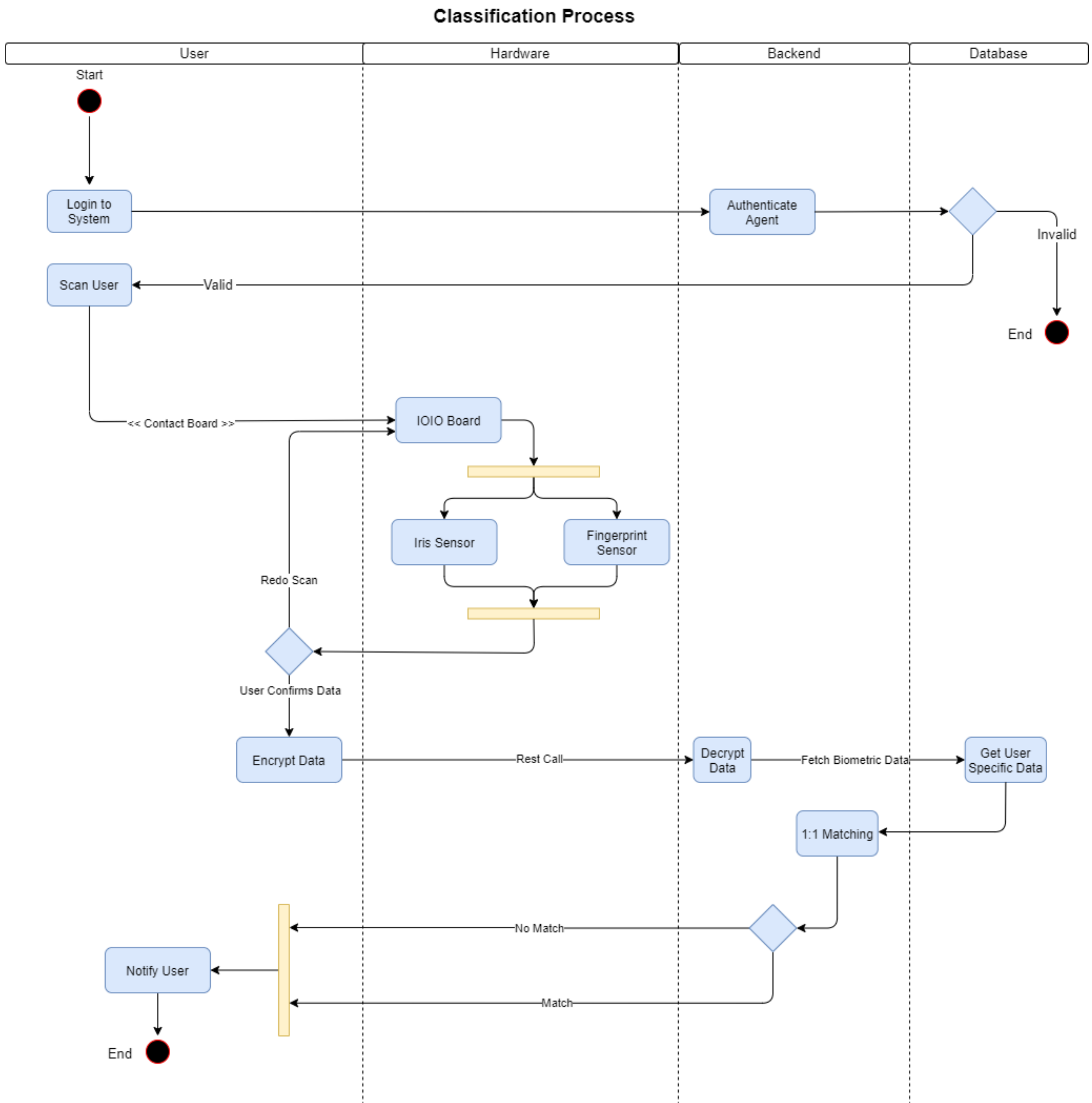


Figure 6.4.6: TSA Agent - Classification Process

7 Universal Design Principles

Principle 1: Equitable Use

The device is designed to be charged by a standard USB connector which is the same in all countries. In contrast if it were an AC input, the line frequency would be dependent on what region of the world you live in. Furthermore, the application is designed to be user friendly and simple to use. The requirements specified the application to be in the English language, however it can be translated to others if necessary.

Principle 2: Flexibility in Use

Multimodal biometric collection was the intended purpose of the device, however there is nothing stopping the user from using only one biometric as opposed to all. Furthermore, the User can decide to use a subset of the biometrics. The device is intended to have long operating time in the field. This device can be recharged directly from the USB port, or the removable lithium ion battery can be replaced with a fully charged one.

Principle 3: Simple and Intuitive Use

The application is designed to walk the user through the process. Written instructions as well as graphics will assist the user in biometric collection.

Principle 4: Perceptible Information

The device is intended to be used in the field. In real operating conditions it may be difficult for a user to hear information from the device. Visual indicators and cues will be the primary mode of communicating with the user. For users that would also like audio, most smartphones natively support reading aloud.

Principle 5: Tolerance for Error

Hardware modules will be encapsulated in a chassis along with the android phone, restricting access from the user. Components for reverse voltage protection will be installed at the battery connections. All other user induced modes of failure will be prevented through software.

Principle 6: Low Physical Effort

Device operation is performed through the application interface, which requires minimal physical effort. The battery cover will be easily removeable without the use of tools.

Principle 7: Size and Space for Approach and Use

The device will be portable, and therefore must be light. Since it is a handheld device, the chassis must be ergonomic for hands of different sizes.

8 Sustainable Development Goals

Good Health and Well-Being

One potential future stakeholder of this device could be the medical industry. A positive consequence of this device in this area could be the identification of patients in emergency rooms or in situations like car accidents. For example, a nurse or first responder can use this device on someone if that person does not have any identification on them. If the person is in the system, they can then see their medical history and view information like allergies to drugs and treat appropriately. This would be very effective is developing countries as ids may not exist.

Industry, Innovation, and Infrastructure

This device can be used in industry to provide a cheap way to increase security measures in developing countries. For example, a power plant will need to have a security system and identification system. Using this device, companies can then focus their resources and money on improving other aspect of their infrastructure.

Responsible Consumption and Production

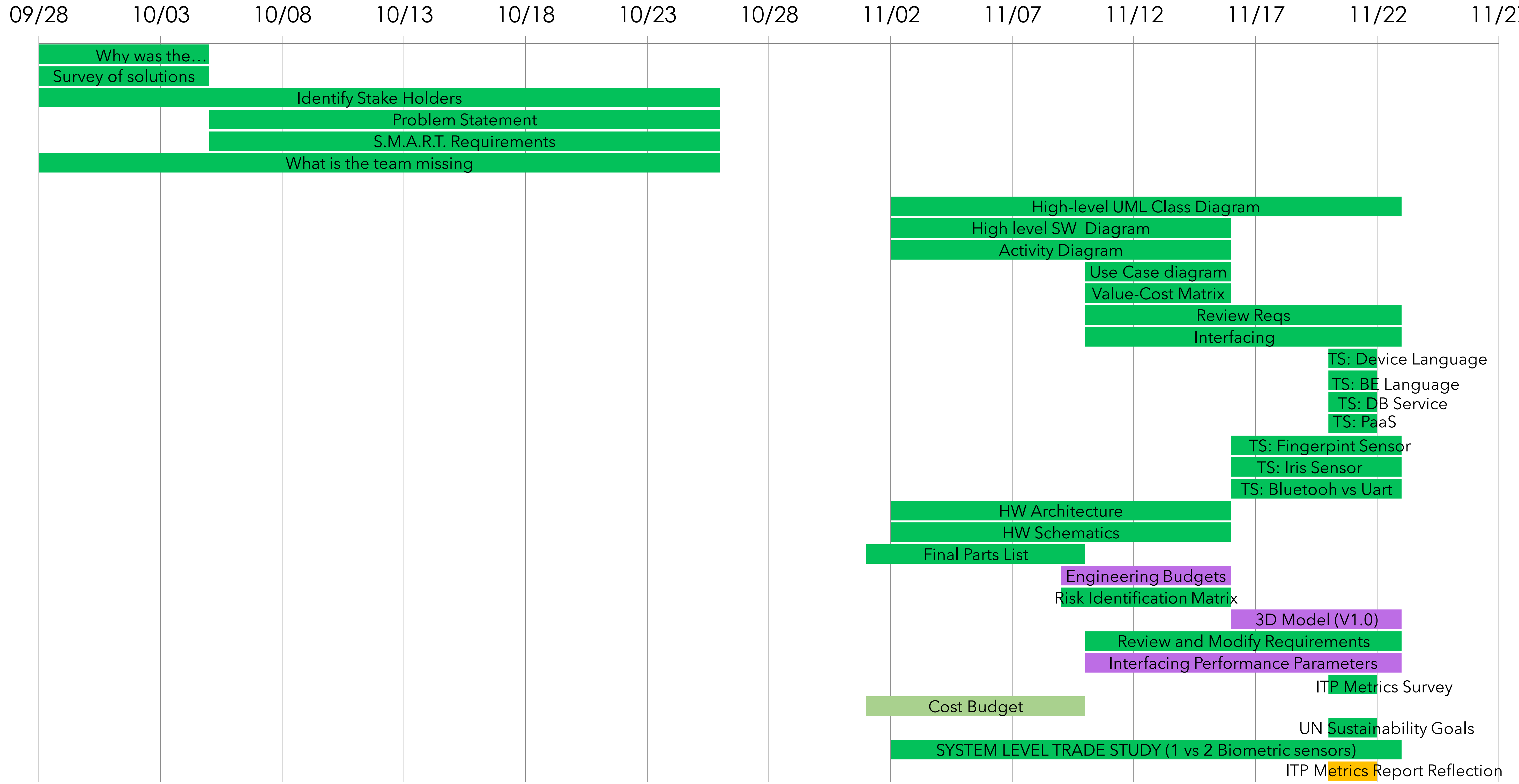
This device positively impacts this sustainable development goal. The biometric device is created from repurposing an Android device for biometric data recordings. In the future, the device can be made from old Android phones so that they can be repurposed and not thrown away. However, the sensors used by the device are another source of electronic waste after it breaks or is thrown away.

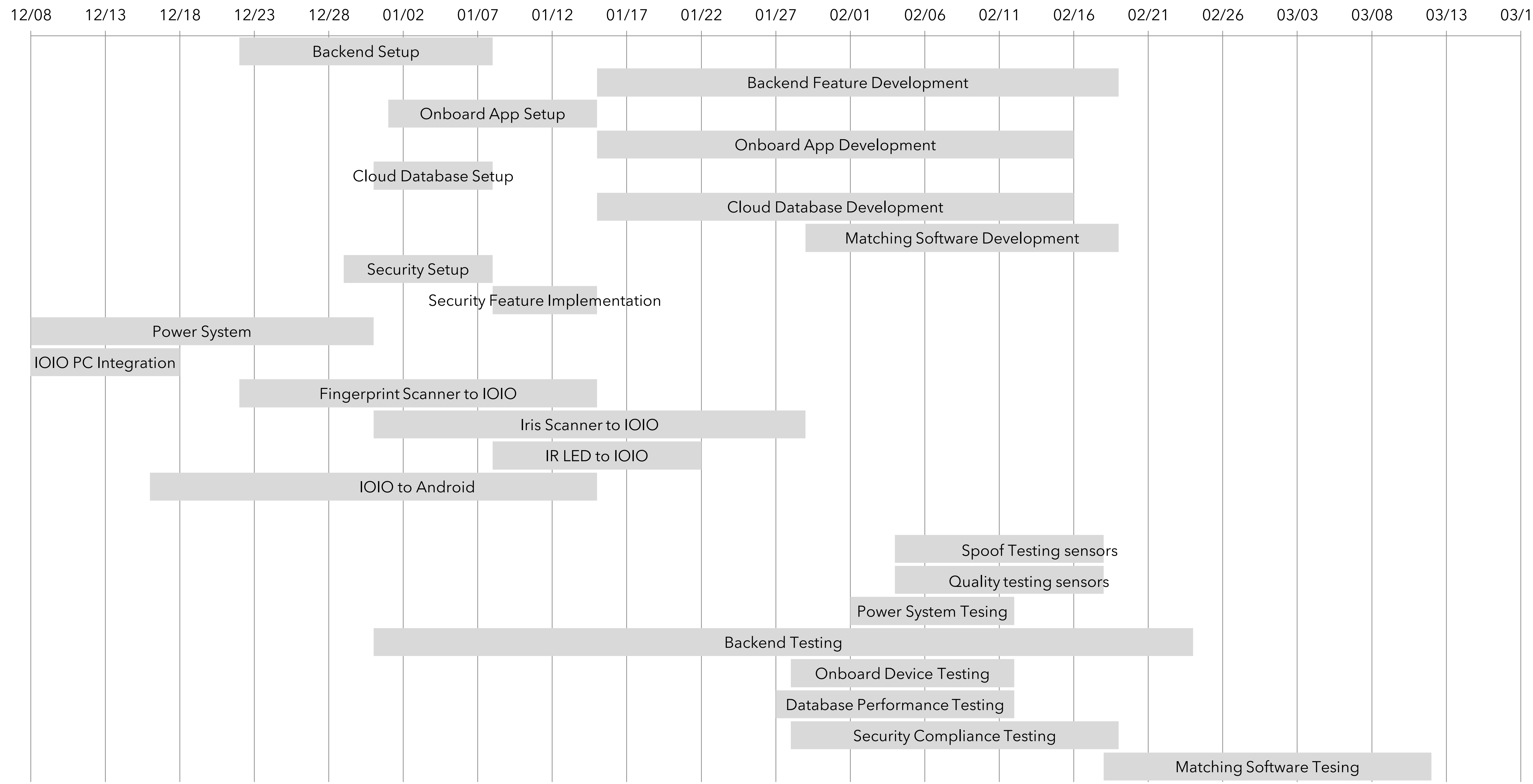
Peace, Justice and Strong Institutions

This device can help contribute to many different parts of this goal. Target 16.1 requires reducing violence and related death rates worldwide. The original stakeholder and project creator of this device was NATO as they required a biometric recording device that can be used on the battlefield and in stealth missions. NATO soldiers can use this as a tool to help identify targets in remote areas. Target 16.2 states it wants to end child trafficking. This device can be used as a tool by investigators to see if the child under investigation has been kidnapped in the past. Target 16.9 is to provide legal identity for all. This device can be easily used by governments to register citizens in their country. For example, India launched a biometric identification system called AADHAAR which is used by banks to identify citizens. This type of system would be very beneficial in developing countries where paper trails for people's identity is hard to find. Section 16a wants to prevent violence and combat terrorism. Our device is currently attended for TSA. TSA will most likely use this to determine persons of interest and see if an individual is on a no-fly list.

9 Work Breakdown Structure

9.1 Gantt Charts

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02/26
03/03
03/08
03/13
03/18
Backend Setup
Backend Feature Development
Onboard App Setup
Onboard App Development
Cloud Database Setup
Cloud Database Development
Matching Software Development
Security Setup
Security Feature Implementation
Power System
IOIO PC Integration
Fingerprint Scanner to IOIO
Iris Scanner to IOIO
IR LED to IOIO
IOIO to Android
Spoof Testing sensors
Quality testing sensors
Power System Tesing
Backend Testing
Onboard Device Testing
Database Performance Testing
Security Compliance Testing
Matching Software Tesing

9.2 Work Breakdown Packages

9.2.1 Past Work Packages - SW

<table>
<tr><th>WP ID: PDR-SW-01</th><th>WP Name: Diagrams</th></tr>
<tr><td>Expected effort in hours: 9h</td><td>WP Manager: Josh – 3h
Support:
• Sam – 3h
• Dennis – 3h</td></tr>
<tr><td>Expected start date: Mid-October</td><td>Expected end date: Early November</td></tr>
<tr><td colspan="2">Inputs needed:
• Knowledge taken from EECS 4312: Software Engineering Requirements</td></tr>
<tr><td colspan="2">Tasks to be performed:
• Create activity diagrams
• Create use case diagrams
• Create UML class diagrams
• Create architecture diagrams</td></tr>
<tr><td colspan="2">Outputs generated:
• Completed software diagrams for preliminary design</td></tr>
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<table>
<tr><th>WP ID: Trade Study - PDR-SW-01</th><th>WP Name: Onboard Device Framework</th></tr>
<tr><td>Expected effort in hours: 2h</td><td>WP Manager: Josh – 2h</td></tr>
<tr><td>Expected start date: Mid-October</td><td>Expected end date: Early November</td></tr>
<tr><td colspan="2">Inputs needed:
• Java framework documentation
• React-Native framework documentation
• Ionic framework documentation</td></tr>
<tr><td colspan="2">Tasks to be performed:
• Analyze possible options for the programming framework to develop Android-based applications
• Create a decision matrix to decide which trade study best suits the project</td></tr>
<tr><td colspan="2">Outputs generated:
• Decide which framework to utilize that best fits the use case</td></tr>
</table>

<table>
<tr><th>WP ID: Trade Study - PDR-SW-02</th><th>WP Name: Backend Development Language</th></tr>
<tr><td>Expected effort in hours: 2h</td><td>WP Manager: Josh – 2h</td></tr>
<tr><td>Expected start date: Mid-October</td><td>Expected end date: Early November</td></tr>
<tr><td colspan="2">Inputs needed:
• Java documentation
• Python documentation
• Node.js documentation</td></tr>
<tr><td colspan="2">Tasks to be performed:</td></tr>
</table>

• Compare backend development languages that are suitable for the project • Create a decision matrix to determine the optimal development language
Outputs generated: • Determine a suitable development language

WP ID: Trade Study - PDR-SW-03	**WP Name: Cloud Database Service**
Expected effort in hours: 2h	**WP Manager:** Josh – 2h
Expected start date: Mid-October	**Expected end date:** Early November
Inputs needed: • AWS documentation • Google Cloud documentation • Azure documentation • IBM DB2 documentation	
Tasks to be performed: • Determine the type of databases that would be available to us to host captured data onto • Determine which of the selected databases are used for government related systems to ensure compatibility • Create a decision matrix to decide which of the options is best for our requirements	
Outputs generated: • Decide which cloud database service best suits our needs and offers compatibility with existing services	

WP ID: Trade Study - PDR-SW-04	**WP Name: Platform as a Service**
Expected effort in hours: 2h	**WP Manager:** Josh – 2h
Expected start date: Mid-October	**Expected end date:** Early November
Inputs needed: • AWS Lambda research documents • Google App Engine research documents • Azure Functions research documents • Salesforce Heroku research documents	
Tasks to be performed: • Research which platforms are suitable for the project • Determine which platform to host backend code onto, that ensures reliability, speed, and security • Create a decision matrix to determine which option is best	
Outputs generated: • Decide upon the platform which fits the requirements of the project and offers the most benefits	

WP ID: PDR-SW-02	**WP Name: UI/UX Specifications**
Expected effort in hours: 6h	**WP Manager:** Daniel – 6h
Expected start date: Mid-October	**Expected end date:** Early November

<table>
<tr><td>Inputs needed:
• Activity diagrams
• Use case diagrams</td></tr>
<tr><td>Tasks to be performed:
• Provide wireframe for all screens of the app, for each use case</td></tr>
<tr><td>Outputs generated:
• Compiled a list of all completed software diagrams for preliminary design</td></tr>
</table>

9.2.2 Future Work Packages - SW

<table>
<tr><th>WP ID: SW-01</th><th>WP Name: Backend Setup</th></tr>
<tr><td>Expected effort in hours: 5h</td><td>WP Manager: Sam – 5h</td></tr>
<tr><td>Expected start date: Late December</td><td>Expected end date: Early January</td></tr>
<tr><td colspan="2">Inputs needed: (all documents, materials, etc. required to perform the WP)
• UML class diagrams</td></tr>
<tr><td colspan="2">Tasks to be performed:
• Setup AWS account
• Create dummy functions
• Testing to see if the backend is set up properly</td></tr>
<tr><td colspan="2">Outputs generated: (all systems/subsystems/documents or other outputs from this WP)
• A working backend system</td></tr>
</table>

<table>
<tr><th>WP ID: SW-02</th><th>WP Name: Backend Feature Development</th></tr>
<tr><td>Expected effort in hours: 50h</td><td>WP Manager: Sam – 20h
Support:
• Dennis – 20h
• Josh – 10h</td></tr>
<tr><td>Expected start date: Mid-January</td><td>Expected end date: Mid-February</td></tr>
<tr><td colspan="2">Inputs needed:
• UML class diagrams
• Use case diagrams
• Activity diagrams
• Architecture diagram</td></tr>
<tr><td colspan="2">Tasks to be performed:
• Add Python classes/methods to accurately implement the diagrams
• Set up communication between backend and database
• Set up communication between backend and app</td></tr>
<tr><td colspan="2">Outputs generated:
• Functional methods that operate on data in the way that the developers expect</td></tr>
</table>

<table>
<tr><th>WP ID: SW-03</th><th>WP Name: Backend Testing</th></tr>
<tr><td>Expected effort in hours: 20h</td><td>WP Manager: Dennis – 7.5h
Support:
• Sam – 7.5h</td></tr>
</table>

	• Josh – 5h
Expected start date: Late December	**Expected end date:** Mid-February
Inputs needed: • Python testing framework • Backend feature development	
Tasks to be performed: • Add Python test classes/test methods to determine correct functionality • Adding test methods in line with backend feature development so that functionality can be tested during development	
Outputs generated: • All test cases are in a "Pass" state, determining correct functionality of backend feature development	

WP ID: SW-04	**WP Name: Onboard App Setup**
Expected effort in hours: 12h	**WP Manager:** Josh – 8h **Support:** • Dennis – 4h
Expected start date: Early January	**Expected end date:** Early January
Inputs needed: • Android Studio environment	
Tasks to be performed: • Create basic onboard device file structure • Emulate content on Android Studio	
Outputs generated: • A basic Android application	

WP ID: SW-05	**WP Name: Onboard App Development**
Expected effort in hours: 80h	**WP Manager:** Josh – 30h **Support:** • Daniel – 25h • Dennis – 12.5h • Sam – 12.5h
Expected start date: Mid-January	**Expected end date:** Mid-February
Inputs needed: • UI/UX design document • UML class diagram • Use case diagrams • Activity diagrams	
Tasks to be performed: • Develop login page • Develop manager view • Develop system administrator view • Develop TSA agent view • Develop sensor data fetching system	

• Develop endpoints for Lambda connection • Store data on the phone
Outputs generated: • An onboard application capable of fetching sensor data and communicating with the cloud service provider

WP ID: SW-06	**WP Name: Onboard App Testing**
Expected effort in hours: 20h	**WP Manager:** Daniel – 15h **Support:** • Dalan – 5h
Expected start date: Late-February	**Expected end date:** Early-March
Inputs needed: • Jest testing framework • Onboard application development	
Tasks to be performed: • Functionality testing for onboard communication • Design verification of UI/UX • Confirm device storage capabilities	
Outputs generated: • An application that meets the designated onboard software requirements	

WP ID: SW-07	**WP Name: Cloud Database Setup**
Expected effort in hours: 12h	**WP Manager:** Sam – 8h **Support:** • Dennis – 4h
Expected start date: Early January	**Expected end date:** Early January
Inputs needed: • Database schema • AWS DynamoDB account	
Tasks to be performed: • Create the needed layouts for the various data tables • Create data links to the Lambda services	
Outputs generated: • A database capable of holding all required data formats specified by the schemas created	

WP ID: SW-08	**WP Name: Cloud Database Development**
Expected effort in hours: 16h	**WP Manager:** Sam – 8h **Support:** • Dennis – 4h • Josh – 4h
Expected start date: Mid-January	**Expected end date:** Late January
Inputs needed: • Database schema	

<table>
<tr><td>

- Cloud database setup
- AWS DynamoDB account

</td></tr>
<tr><td>

Tasks to be performed:

- Create the needed queries for the database
- Create equivalent links from the database to Lambda

</td></tr>
<tr><td>

Outputs generated:

- A subsystem capable of communicating data to and from the cloud database storage

</td></tr>
</table>

<table>
<tr><th>WP ID: SW-09</th><th>WP Name: Cloud Database Testing</th></tr>
<tr><td>Expected effort in hours: 9h</td><td>

WP Manager: Dennis – 5h
Support:

- Sam – 2h
- Josh – 2h

</td></tr>
<tr><td>Expected start date: Late January</td><td>Expected end date: Early February</td></tr>
<tr><td colspan="2">

Inputs needed:

- Database testing framework
- Cloud database setup
- AWS DynamoDB account

</td></tr>
<tr><td colspan="2">

Tasks to be performed:

- Test all query commands
- Ensure data is stored in the proper EBTS specification
- Ensure the system meets speed and performance requirements

</td></tr>
<tr><td colspan="2">

Outputs generated:

- A complete database that meets all system requirements

</td></tr>
</table>

<table>
<tr><th>WP ID: SW-10</th><th>WP Name: Matching Software Development</th></tr>
<tr><td>Expected effort in hours: 30h</td><td>

WP Manager: Brandon – 12h
Support:

- Sam – 6h
- Josh – 6h
- Dennis – 6h

</td></tr>
<tr><td>Expected start date: Late January</td><td>Expected end date: Mid-February</td></tr>
<tr><td colspan="2">

Inputs needed:

- Scanned data
- Cloud database setup
- Lambda setup
- AWS DynamoDB account
- Sufficient data to do training

</td></tr>
<tr><td colspan="2">

Tasks to be performed:

- Import prebuilt models
- Create any models that do not exist
- Train models for iris, facial and fingerprint

</td></tr>
<tr><td colspan="2">Outputs generated:</td></tr>
</table>

• A fully built classification model capable of doing 1:1 matching

WP ID: SW-11	**WP Name: Matching Software Testing**
Expected effort in hours: 10h	**WP Manager:** Brandon – 5h **Support:** • Sam – 2.5h • Daniel – 2.5h
Expected start date: Late February	**Expected end date:** Early March
Inputs needed: • Scanned data • Cloud database setup • Lambda setup • AWS DynamoDB account • Sufficient data to do training • Trained iris, facial, and fingerprint models	
Tasks to be performed: • Test quality of models on a variety of quality of data	
Outputs generated: • A fully built classification model capable of doing 1:1 matching for a variety of data	

WP ID: SW-12	**WP Name: Security Setup**
Expected effort in hours: 5h	**WP Manager:** Dennis – 5h
Expected start date: Early January	**Expected end date:** Mid-January
Inputs needed: • AWS database • EBTS format documentation	
Tasks to be performed: • Download correct standard encryption/decryption Python libraries • Create schema for database implementation	
Outputs generated: • A framework set up for encryption/decryption • A database schema	

WP ID: SW-13	**WP Name: Security Feature Implementation**
Expected effort in hours: 10h	**WP Manager:** Dennis – 5h **Support:** • Sam – 5h
Expected start date: Mid-January	**Expected end date:** Early February
Inputs needed: • AWS database • EBTS format documentation • Encryption/decryption Python libraries • Architecture diagram	

Tasks to be performed: • Create Python methods to encrypt/decrypt incoming/outgoing biometric information • Create Python methods to properly follow EBTS protocol • Create Python methods to properly access AWS database using its schema
Outputs generated: • An encryption for outgoing information into the AWS database and to the app • A decryption for incoming information from AWS database and from the app

WP ID: SW-14	WP Name: Security Testing
Expected effort in hours: 9h	**WP Manager:** Dennis – 3h **Support:** • Sam – 3h • Josh – 3h
Expected start date: Mid-January	**Expected end date:** Early February
Inputs needed: • AWS database • Security feature implementation	
Tasks to be performed: • Add Python test classes/test methods to determine correct functionality • Adding test methods in line with security feature development so that functionality can be tested during development	
Outputs generated: • All test cases are in a "Pass" state, determining correct functionality of security feature development	

9.2.3 Past Work Packages – HW

WP ID: PDR-HW-01	WP Name: Fingerprint Sensor TS1
Expected effort in hours: 10h	**WP Manager:** Brandon – 4h **Support:** • Hossam – 2h • Dalan – 2h • Zeenia - 2h
Expected start date: Mid-September	**Expected end date:** Mid-October
Inputs needed: • Datasheets for various fingerprint sensors	
Tasks to be performed: • Gather information on various fingerprint sensors including operating current, resolution, baud rate, and speed • Compile a list of potential fingerprint sensors that meet requirements • Formulate a decision matrix to determine which option is best to use	
Outputs generated: • Selecting the appropriate fingerprint sensor that meets requirements	

WP ID: PDR-HW-02	WP Name: Iris Scanner Selection

Expected effort in hours: 16h	**WP Manager:** Zeenia – 10h **Support:** • Daniel – 3h • Brandon – 3h
Expected start date: Mid-September	**Expected end date:** Early November
Inputs needed: • Datasheets for various Iris Scanners	
Tasks to be performed: • Gather information on various scanners that are IR sensitive, and can communicate via UART • Compile a list of potential iris scanners that meet requirements • Formulate a decision matrix to determine which option is best to use	
Outputs generated: • Selecting the appropriate iris scanner that meets requirements	

WP ID: PDR-HW-03	**WP Name: Communication**
Expected effort in hours: 15h	**WP Manager:** Brandon – 10h **Support:** • Zeenia – 5h
Expected start date: Mid-October	**Expected end date:** Early November
Inputs needed: • Research on UART communication • Research on USB communication	
Tasks to be performed: • Research possible methods of establishing communication between the sensors and the android device • Create a hardware architecture diagram for various designs based on the research conducted • Tabulate advantages and disadvantages of each design to decide which to use	
Outputs generated: • Communication Interface	

WP ID: PDR-HW-04	**WP Name: System Level Trade Study**
Expected effort in hours: 15h	**WP Manager:** Brandon – 8h **Support:** • Hossam – 4h • Zeenia – 3h
Expected start date: Mid-October	**Expected end date:** Early November
Inputs needed: • Requirements • Architecture Diagrams	
Tasks to be performed: • Define parameters to score system performance • Compare the overall score of the multiple designs • Choose the best design	
Outputs generated:	

• HW Architecture • HW Engineering Budgets: Cost, Mass. & Power

WP ID: PDR-HW-05	WP Name: Schematic
Expected effort in hours: 4h	**WP Manager:** Dalan – 3h **Support:** • Brandon – 1h
Expected start date: Mid-October	**Expected end date:** Early November
Inputs needed: • Hardware Architecture Diagram	
Tasks to be performed: • Import/Create all modules and components • Wire together components according to architecture diagram	
Outputs generated: • System Electrical Schematic Diagram	

9.2.4 Future Work Packages – Hardware

WP ID: HW-01	WP Name: Power System
Expected effort in hours: 16h	**WP Manager:** Brandon – 7h **Support:** • Dalan – 5h • Daniel – 3h • Hossam – 2h
Expected start date: Early December	**Expected end date:** Late-December
Inputs needed: • TP4056 Charger Module • 18650 Battery • 18650 Battery Holder • XL6009 Step up Converter	
Tasks to be performed: • Solder all connections • Confirm that the TP4056 Charges the battery from USB power • Configure Boost Converter to output 5V DC	
Outputs generated: • Replaceable, large capacity battery	

WP ID: HW-02	WP Name: IOIO PC Integration
Expected effort in hours: 10h	**WP Manager:** Brandon – 6h **Support:** • Dalan – 2h • Zeenia – 2h
Expected start date: Late November	**Expected end date:** Early December
Inputs needed:	

• IOIO Board • IOIO Documentation (Datasheets & Github) • USB cable • Windows 10 PC
Tasks to be performed: • Establish connection with USB to Windows PC • Test basic functionality (handshaking, GPIO) with IOIO bridge on PC with Java App • Test UART Communication
Outputs generated: • Communication between IOIO and PC for debugging and testing.

WP ID: HW-03	**WP Name: Fingerprint Scanner to IOIO**
Expected effort in hours: 15h	**WP Manager:** Brandon – 5h **Support:** • Daniel – 5h • Hossam – 5h
Expected start date: Late December	**Expected end date:** Early January
Inputs needed: • GT-521F32 Fingerprint sensor • GT-521F32 Fingerprint sensor Datasheet • IOIO Board • IOIO Board Datasheet	
Tasks to be performed: • Connect the sensor to GPIO pins 12 and 13 of the IOIO board for UART communication. • Connect 3.3V power and ground wires to enable sensor functionality • Establish firmware on the IOIO board for receiving transmitted data. • Test ability to receive fingerprint images to android emulator on PC using IOIO bridge	
Outputs generated: • Communication between fingerprint sensor and IOIO board	

WP ID: HW-04	**WP Name: Iris Scanner to IOIO**
Expected effort in hours: 15h	**WP Manager:** Zeenia – 7h **Support:** • Hossam – 5h • Brandon – 3h
Expected start date: Late December	**Expected end date:** Late-January
Inputs needed: • Level Shifter (BOB 12009) • PTC08 Serial IR Camera • IOIO Board	
Tasks to be performed: • Connect Tx and RX of Camera to level shifter • Connect TX and Rx of shifter to IOIO UART channel	

• Connect Power to modules • Test ability to receive images to android emulator on PC using IOIO bridge
Outputs generated: • Communication between IR camera and IOIO board

WP ID: HW-05	**WP Name: IR LED to IOIO**
Expected effort in hours: 5h	**WP Manager:** Dalan – 5h
Expected start date: Early January	**Expected end date:** Late January
Inputs needed: • IR LED • 360 Ohm Resistor	
Tasks to be performed: • Connect LED and resistor with correct polarity to the correct GPIO pin • Use Java or Android to toggle GPIO high and low	
Outputs generated: • IR Illumination	

WP ID: HW-06	**WP Name: IOIO to Android**
Expected effort in hours: 35h	**WP Manager:** Dalan – 15h **Support:** • Hossam – 10h • Brandon – 5h • Josh – 5h
Expected start date: Late December	**Expected end date:** Mid-January
Inputs needed: • Android development environment • IOIO Board • IOIO Documentation (Datasheets & Github) • USB cable	
Tasks to be performed: • Establish connection with Android Debug Bridge (ADB) or OpenAccessory • Test basic functionality (handshaking, GPIO) with IOIO bridge on Android Device • Test UART Communication	
Outputs generated: • Communication between IOIO and Android Phone	

9.2.5 Future Work Packages – Documentation

WP ID: DOC-01	**WP Name: Requirements Review Gate**
Expected effort in hours: 32h	**WP Manager:** Josh– 4h **Support:** • Sam – 4h • Dennis– 4h

	• Hossam-4h • Zeenia – 4h • Brandon – 4h • Dalan – 4h • Daniel - 4h
Expected start date: Mid-October	**Expected end date: Late October (Oct 30th)**
Inputs needed: • Project Definition • Understanding of problems to be solved • Knowing the stakeholders • NATO project definition doc: NSPA Supply Opportunity No. 20LDS067 Document	
Tasks to be performed: • Identify requirements that can't be met and are out of scope • Understand the source of each requirement • Identify key requirements that will drive the design of the project • Identify requirements that are out of compliance • Identify validation approaches for the requirements created and gathered	
Outputs generated: • Requirements Review Gate Document	

WP ID: DOC-02	**WP Name: Preliminary Design Gate Review**
Expected effort in hours: 32h	**WP Manager:** Daniel– 4h **Support:** • Sam – 4h • Dennis– 4h • Hossam-4h • Zeenia – 4h • Brandon – 4h • Dalan – 4h • Josh – 4h
Expected start date: Mid November	**Expected end date: Late November (Nov 27th)**
Inputs needed: • Previous Requirements Review Gate Document • Discussions of designs for both hardware and software components of device • Sustainable development goals document	
Tasks to be performed: • Identify requirements that have been updated/removed/added • Create Work breakdown structures • Create budget • Analysis of project with sustainable development goals • Engineering design budgets broken down by top level constraints • Technical systems trade studies	

<table>
<tr><td>Outputs generated:
Approved budget by supervisor
Simulations or early prototyping
Preliminary Design Gate Review document</td></tr>
</table>

<table>
<tr><th>WP ID: DOC-03</th><th>WP Name: Critical Design Gate Review</th></tr>
<tr><td>Expected effort in hours: 32h</td><td>WP Manager: Hossam– 4h
Support:
Sam – 4h
Dennis– 4h
Josh - 4h
Zeenia – 4h
Brandon – 4h
Dalan – 4h
Daniel – 4h</td></tr>
<tr><td>Expected start date: Mid November</td><td>Expected end date: Early December (Dec 4th)</td></tr>
<tr><td colspan="2">Inputs needed:
Previous Critical Review Gate Document
Updates on any new designs</td></tr>
<tr><td colspan="2">Tasks to be performed:
Executive Summary
Requirements Review
Baseline Design
Baseline design compliance analysis
Trade study identification
Sustainability and unintended consequence analysis
Work package descriptions
Resource allocation matrix
Project schedule
Project procurement/equipment/travel list
Risk Register
Team member statements
Individual ITP metrics review statements
Team ITP metrics review statements</td></tr>
<tr><td colspan="2">Outputs generated:
A final breakdown budgets
A list of software, tools and equipment required/procured
Critical design Gate Review Document</td></tr>
</table>

<table>
<tr><th>WP ID: DOC-04</th><th>WP Name: Test Readiness Review Gate</th></tr>
<tr><td>Expected effort in hours: 32h</td><td>WP Manager: Josh– 4h
Support:
Sam – 4h
Dennis– 4h</td></tr>
</table>

	• Hossam-4h • Zeenia – 4h • Brandon – 4h • Dalan – 4h
Expected start date: Mid-February	**Expected end date: Early March (March 5th)**
Inputs needed: • Protypes of assembled device	
Tasks to be performed: • Identify paths for completion of device • Identify things that are still missing in device • Identify what aspects of the device needs to be tested and if it will address meeting requirements • Identify procedures to test the device • Identify how failed tests will be handled • Reflection on ITP metric reports	
Outputs generated: • Test Readiness Gate Review document	

WP ID: DOC-05	**WP Name: Test Readiness Review Gate**
Expected effort in hours: 32h	**WP Manager:** Josh– 4h **Support:** • Sam – 4h • Dennis– 4h • Hossam-4h • Zeenia – 4h • Brandon – 4h • Dalan – 4h
Expected start date: Mid-March	**Expected end date: Early April (Apr 2nd)**
Inputs needed: • Results obtained from testing • Prototype of android biometric device	
Tasks to be performed: • Tests are reviewed and are checked to see if requirements were met • Identify deviations from original plan • Understood and explain deviations • Identify failures • Identify fixes to failures • Track system configuration through the development cycle • Identify unresolved issues • The status of verification for requirements are tracked	
Outputs generated: • Test Gate Review document	

WP ID: DOC-06	WP Name: Final Project Deliverable
Expected effort in hours: 32h	**WP Manager:** Josh– 4h **Support:** • Sam – 4h • Dennis– 4h • Hossam-4h • Zeenia – 4h • Brandon – 4h • Dalan – 4h
Expected start date: Late March	**Expected end date: Early April (Apr 9th)**
Inputs needed: • Final version of Android biometric device	
Tasks to be performed: • Executive summary • Requirements review • As-built design • As-built design compliance analysis • As-built work breakdown structure • As-built work package descriptions • As-built resource allocation matrix • As-built project schedule • As-built project procurement/equipment/travel list • Preliminary business case • Deviations from plan • Failure report • Lessons learned	
Outputs generated: • Final Project Deliverable document	

9.3 Risk Register

Risk ID	Risk Description	Impact Description	Impact Level	Prob. Level	Priority Level	Mitigation Notes
RSKHW-01	Delivery delays due to covid-19	Slows down the hardware development process	4	3	12	Order in advance, as soon as budget is approved.
RSKHW-02	Hardware quality defects / part failure	Will require new parts, impacting the hardware development schedule	5	2	10	Order extra parts if budget allows.
RSKHW-03	Hardware Performance shortfall	Will have an impact on the overall integrity of our final product, possibly	4	2	8	Identified alternative parts and verify attainability.

		resulting in not meeting the stakeholder's expectations and requirements.				
RSKSW-01	Software Performance shortfall	Will have an impact on the overall integrity of our final product, possibly resulting in not meeting the stakeholder's expectations and requirements.	4	2	8	Initial testing to identify performance points of failure (performance not meeting requirements) and using alternative software development resources outlined in PDR software trade studies.
RSKVF-01	Lack of data for testing scenarios	Unable to evaluate the performance of the product thoroughly	3	5	15	Extend optional participation to household residents to expand test pool as much as possible during pandemic lockdown. (Worst Case Scenario: Current). Ideally participation would be optional for all faculty and peers to maximize our sample size (Best Case: Future)
RSKVF-02	Lack of stakeholder/user involvement and feedback	Inability to confirm whether the product meets all expectations and requirements of the customer	3	5	15	Industry professionals and peer feedback is an effective way of receiving constructive criticism

10 Budget

The budget below indicates the price (in CAD) that each module will cost. The rightmost price includes shipping and tax to get the most accurate representation of the price that is spent on the construction of this project. For development, due to the construction of the project done in different households due to COVID-19, three sensors each will be purchased for development to be done in parallel.

Component	Quantity	Price per Unit (CAD) (includes shipping)	Overall Price of Units (CAD) (shipping and tax included)
Fingerprint Scanner TTL (GT-521F32)	3	$51.44	$174.38
IOIO-OTG - v2.2	3	$54.48	$181.30
XL6009 Boost Converter	2	$3.17	$7.15
TP4056 Charger Circuit for 18650 Battery	2	$1.95	$4.41
18650 Battery	2	$13.99	$31.62
LG Prime 2	1	$139.00	$157.07
Iris Sensor - TTL Serial Camera (1528-1401-ND)	3	$52.26	$177.16
850 nm IR LED	5	$1.24	$7.01
TOTAL AMOUNT			$740.10

Table 10.1: Budget

11 ITP Reflection

Team Feedback - Hossam

For anyone to grow, they must recognize their shortcomings and realize an appropriate solution. So, carefully considering my team's feedback is an essential part of understanding how to effectively communicate with my team members. It comes as no surprise and I welcome this honest criticism. I value my team and their hard work, and I can recognize that my team values me just the same.

Every member deserves an equal chance of contributing during our meetings. The general voice I heard is unfortunately, “MINE”, specifically, using it too often. This is a personal flaw of mine that I try to avoid exaggerating in both my personal and professional life. The most obvious solution is to simply allow all members the chance to voice their opinions

Lastly, I want to address the fact that I sometimes get distracted from the topic at hand. This is factual, I do that sometimes not intentionally and not to take away from the importance of said topic. Often when I find myself swamped with tasks to complete; my brain will scatter thoughts for unrelated topics at random. The result is usually me jumping from topic to topic once I remember specific items that need to be discussed. I recognize that timing is part of this problem. Personally, I found that a solution that worked consistently is writing everything down so I can get it out of my head and instead into an explicitly written list of sorts. This helps me organize my thoughts and time when I should be discussing each, as opposed to a more sporadic manner.

Communication is key and so is timing, in any project, and this is no different. My goal is to allow my team members more chances to share their ideas, instead of limiting whoever is listening to just my perspective as well preparing for meetings with specific and well-defined discussion points instead of attempting to remember everything on the spot. This will give the team more time to work on actual development; not to mention the breathing room to explore new, viable, and perhaps inspired ideas.

Team Feedback – Brandon

Based on the ITP metrics report, it appears that my team is satisfied with my performance. I am glad to see that my efforts are paying off. It was brought to my attention that I can sometimes fuel off topic discussions. This is something that I will work to improve on.

Team Feedback – Joshua

Overall, the feedback that I have received has been extremely positive, and overall, the teamwork from my perspective has been very good. Since I didn’t have any negative feedback, to me implies that I am doing a good job, and my hard work is being well appreciated. I will continue to work diligently, to ensure the teams success. I think our biggest challenge is learning to work as a team. This seems to be more of a team size issue because it is very hard to communicate solely virtually as a team of 8, plus pivot designs quickly as a team. I think that is our biggest area of weakness as a team, which will be difficult as time constraints become more prevalent.

Team Feedback – Dennis

Based on the ITP metric reports given by my team members, they are satisfied with my inputs and the discussions I fuel during our meetings. A lot of my feedback is to help drive the meeting back to the original topic at hand when the group gets off topic. I will aim to keep discussion flowing in productive fashion as our meetings continue.

Team Feedback – Dalan

Based on what I've gathered from the ITP metrics reports, it seems that overall the group is satisfied with my performance when it comes to tasks that I'm designated to do, with the main critique being to voice my opinion more during our team meetings. While I am content with my performance for designated tasks, I also realize that I should become more assertive and undertake more than my assigned tasks when needed. I sometimes deem my input on certain topics as unnecessary, however I will try to state them anyways, if only to provide input that may not have been accounted for previously. Lastly, I've noticed that during longer meetings, the group as a whole tends to get sidetracked, to combat this, I will try to push the group focus towards the path that we intended in order to get our work completed more efficiently.

Team Feedback – Daniel

It is a lot easier to be introspective when using hindsight. That being said, it is even easier when you receive feedback from your peers, as oftentimes they do not share your biases, and can provide a fresh new perspective on your behaviour; rewarding what is good and acknowledging what could be improved. I value this feedback greatly, especially because it is founded in mutual respect for one another. I can trust wholeheartedly that the feedback I receive is made with honest intentions and is rooted in a desire to succeed together. That is a large reason why I chose this group.

As much as different perspectives and opinions of your behaviour are important, under most circumstances, one should not be surprised with the feedback they receive. Such is the case with myself, I understand where my team is coming from when they say that I can improve upon deadlines. They are right, it is something that is not new to me. It has recently been something I have had to deal with on a day to day basis for the past year due to my work situation as well as school. It is very easy to make a sweeping statement and cover it up by saying I am really busy, which in almost every case is factual, however, all of my partners being engineers as well have the same excuses as me so it is important to understand when I'm being reasonable and when I am not. It is a weekly challenge that sometimes I manage with grace, but other times, barely make it out the other end. When I say it is something that I am not surprised to hear, that does not mean it is a burden to hear it. I welcome it. I'm always trying to improve myself, and I'm hoping to use this opportunity to come out of this with a larger sense of accountability. Every

Upon inspection of my conflict resolution report, it seems pretty accurate, I find that I try my best to keep everyone level-headed, and make sure everyone is heard and respected. It is different sometimes when it is with close friends, people who I've gotten to know over the years, and for the first time I get to experience each other's personalities and behaviours firsthand. The size of the group has led to a difference of opinion at times, and as project manager it is important to have that under control. But at the same time those conversations do need to happen, so the best course of action has been to approach the problem as pragmatically as possible, with everyone's best interest in mind, which is what I have tried to do, and it has been successful from my perspective, so that is what I will continue to do.

Team Feedback – Sam

Within the gate 1 peer review, my peers gave me higher ratings than the ratings I gave myself for all sections in the quick summary chart. This probably shows that I might be lacking confidence within my own abilities as all my teammates gave me a high rating. I did receive one comment which stated a concern for how I like to shoot for the stars and do not consider if an idea is feasible within the 8 months. I will consider this for the future gates. After completing gate 2 conflict management, I agree with its results. I received a 0 for avoiding which is accurate because I hate trying to run away from a problem. My mindset is that if I have a problem, I will do everything I can to solve it. For the peer feedback, my group members mentioned that I have good problem-solving skills and can come up with solutions quickly. I did not know if my group members appreciated my ideas but from their feedback, I am glad they like them.

Team Feedback - Zeenia

My team members have pointed out that I am more on the quiet side when it comes to communicating during meetings. This does not surprise me as I understand I am usually reserved and perhaps lack confidence in my opinions as I do not have much of a background in the topic of our project. After the first peer evaluation, I decided to work on this and look for opportunities to provide valuable input to our discussions. Additionally, I am starting to feel much more comfortable with my group and sharing my thoughts on the matter of discussion as I understand that my group values my viewpoint. I will continue to try to improve on this point.

Team Feedback (All members)

Poor communication in a team will always be the first limiting factor. This is how bad projects are made when there is no cohesion between the individuals. Even if the team communicates constantly, they must do it effectively. This means everyone is on the same page and heading towards the exact same end goal. I have experienced this downfall previously in other teams, it makes for a poorly put together final product, whatever that may be. On the bright side, my team consists of highly capable and competent engineers that require very little management if at all. Everyone in a team needs to be committed at 110%, day in and day out, to achieve the best possible outcome within our limitations. This can only be achieved if everyone gets their opportunity to contribute to the progress of this project.