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END OF STUDY THESIS

Option: **Information Systems Engineering**

THEME:

Use of proximity sensors to facilitate the
epidemiological investigation of covid-19

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Thanks

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I do not forget my brothers and sisters and all my family and friends because they made everything available to me the means at their disposal.

Dedicate

I dedicate this work to My dear parents, my brothers and sisters and all my family, Dear friends, and all who love them.

Résumé

Alors que les technologies continuent d'évoluer et de devenir plus intelligentes, nous avons dû trouver un moyen de les interconnecter. C'est pourquoi les réseaux personnels ont vu le jour.

Ce mini-projet fournira un bref aperçu des réseaux personnels et de leurs différentes implémentations dans le monde réel, enfin, l'utilisation des balises de proximité pour contribuer à empêcher la propagation de la crise réelle (Covid-19).

Mots-clés:

Bluetooth Low Energy (BLE), application mobile, Covid-19

Abstract

As technologies continue to evolve and get smarter, we had to find a way to interconnect them. Therefore, the Personal Area Networks has emerged.

This mini-project will provide a brief overview of personal area networks and their different implementations in real-world, finally, the use of proximity Beacons to contribute to preventing the spreading of the actual crisis (Covid-19).

Keywords:

Bluetooth Low Energy (BLE), mobile application, Covid-19

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Abbreviations List

Abbreviation	Full Expression	Page
PAN	Personal Area Networks	03
WPAN	Wireless Personal Area Networks	03
IEEE	Institute of Electrical and Electronics Engineers	03
LAN	Local Area Network	04
PDA	Personal Digital Assistant	04
MIT	Massachusetts Institute of Technology	05
IBM	International Business Machine	05
BWT	Bluetooth Wireless Technology	06
SIG	Special Interest Group	07

BLE	Bluetooth Low Energy	08
SOC	System On Chip	08
ATT	Attribute Protocol	08
GATT	Generic Attribute Protocol	08
SMP	Security Manager Protocol	08
GAP	Generic Access Profile	08
HCI	Host Controller Interface	08
RFID	Radio Frequency Identification	09
AIDC	Automatic Identification and Data Capture	09
NFC	Near Field Communication	10
NXP	Next Experience (formerly Philips Semiconductors)	10
TBTT	Target Beacon Transmission Time	13
SSID	Service Set Identifier	14
SDK	Software Development kit	15
ATCRBS	Air Traffic Control Radar Beacon System	21
WHO	World Health Organization	

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General Introduction

As technology continue to evolve, new devices keep storming in our lives. Nowadays, most of these devices are smart and interconnected using different types of connections, some of which are wired and some are wireless and these are called Wireless Personal Area Networks.

These networks are mostly used in IoT to connect smart devices such as laptops, cellular phones, personal digital assistants (PDAs), pocket video games, and pagers. Moreover, these networks have different forms and use different technologies as an implementation like Bluetooth Wireless Technology, Bluetooth Low Energy, Near Field Communication, Radio Frequency Identification, Zigbee and Beacons. The advantages of these technologies are numerous, which covers a broad range of applications that demand low power consumption and low complexity scenarios encountered in home and work automations, medical supervision, sensor networks, logistics, and other similar applications.

As of our time, personal area networks can be used to contribute in solving the universal crisis (COVID-19), Beacons can help in tracking and monitor the spread of the virus around the globe, and with a good implementation, it would be even able to help prevent its spreading and block its way.

This thesis is composed of two chapters, in the 1st Chapter we will learn about the Personal Area Networks and its different implementations and technologies, in the 2nd chapter we will see the different domains where beacons are implemented their impact on the world-wide technologies, and how would it help to end this actual world crisis (COVID19).

Chapter One

Personal Area Networks

1.1 Introduction

As electronic devices become smaller, low power, and cheaper, we have begun to adorn our bodies with wearable computer devices such as cellphones, personal digital assistants (PDAs), Palmtops, Pocket video games, smart Wristwatches, pagers, digital cameras, and GPS receivers. As our homes continue to contain an increasing number of them, there is a growing demand for networking them together in a manageable way. The concept of Personal Area Networks has arisen as means of enabling these devices to interconnect and share data [1].

A PAN may be either wired or wireless. It is wired when it is carried over wired computer buses such as USB and FireWire. Wireless PAN or WPAN is based on the standard IEEE 802.15 and employs wireless technologies such as infrared, ZigBee, Bluetooth, and ultrawideband. WPAN allows devices such as keyboards, audio headsets, and printers to connect to personal digital assistants, cell phones, or computers wirelessly. It allows connection to the Internet [2].

In this chapter, we will define what are PANs and their most common implementations such as Bluetooth, BLE, RFID, NFC, ZigBee, and beacon.

1.2 Personal Area Networks (PAN)

A personal area network (PAN) is the interconnection of information technology devices within the range of an individual person, typically within a range of 10 meters. For example, a person traveling with a laptop, a personal digital assistant (PDA), and a portable printer could interconnect them without having to plug anything in, using some form of wireless technology. Typically, this kind of personal area network could also be interconnected without wires to the Internet or other networks.

Also see wireless personal area network (WPAN) which is virtually a synonym since almost any personal area network would need to function wirelessly. Conceptually, the difference between a PAN and a wireless LAN is that the former tends to be centered around one person while the latter is a local area network (LAN) that is connected without wires and serving multiple users.

PANs are used to convey information over short distances among a private, intimate group of participant devices. Unlike a WLAN, a connection made through a WPAN involves little or no infrastructure or direct connectivity to the world outside the link, this allows small, power-efficient, inexpensive solutions to be implemented for a wide range of devices

The figure below shows the different domains and usages for personal area networks technologies in daily life [3].

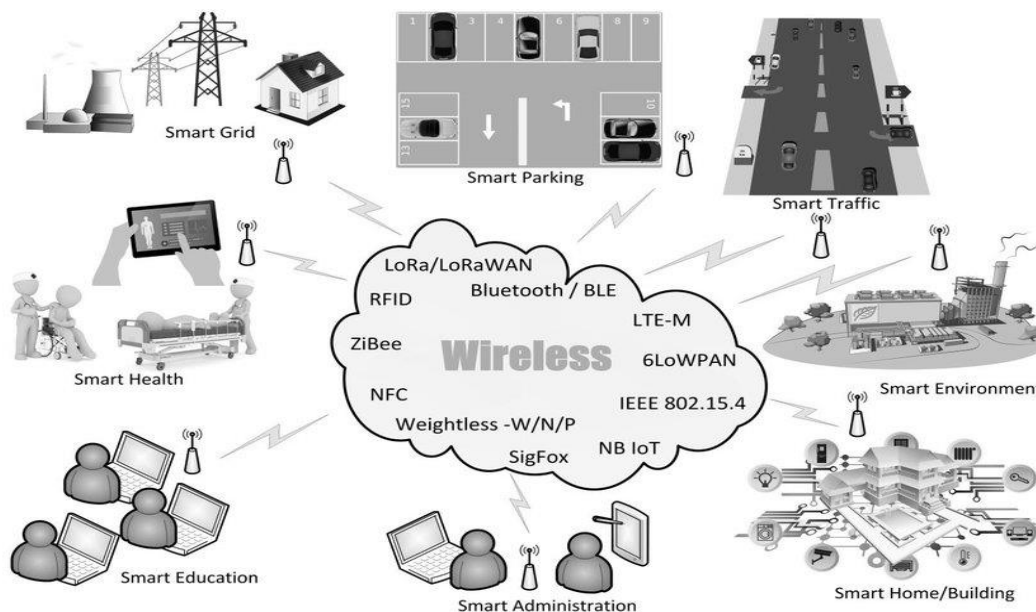


Figure 1- Different implementations for PANs [4]

In another usage, a personal area network (PAN) is a technology that could enable wearable computer devices to communicate with other nearby computers and exchange digital information using the electrical conductivity of the human body as a data network. For example, two people each wearing business card-size transmitters and receivers conceivably could exchange information by shaking hands. The transference of data through intra-body contact, such as handshakes, is known as linkup. The human body's natural salinity makes it a good conductor of electricity. An electric field passes tiny currents, known as Pico amps, through the body when the two people shake hands. The handshake completes an electric circuit and each person's data, such as e-mail addresses and phone numbers, are transferred to the other person's laptop computer or a similar device. A person's clothing also could act as a mechanism for transferring this data.

The concept of a PAN first was developed by Thomas Zimmerman and other researchers at M.I.T.'s Media Lab and later supported by IBM's Almaden research lab.

1.2.1 Bluetooth Wireless Technology (BWT)

Ericsson in Sweden created the first version of Bluetooth wireless technology (BWT) in 1994. The aim of BWT was to remove the need for proprietary cable connections between devices like computers and televisions. PDAs and notebook PCs are examples of such devices. Infrared communication was available at the time, but it involved line-of-sight communication. As a result, Ericsson chose to include a low-cost, low-power radio in each device, allowing devices to communicate wirelessly through walls and other nonmetallic materials. After Ericsson started working on BWT, it evolved into a radio technology that can connect several devices in a wireless personal area network at the same time (WPAN). Because of the unlimited potential of BWT. Because of the unlimited potential of BWT, the Bluetooth Special Interest Group (SIG) was formed in 1998 to develop the Bluetooth Specification IEEE 802.15 [5].

The following figure explains the innovation of Bluetooth Wireless Technology and its different usage in daily basic life.

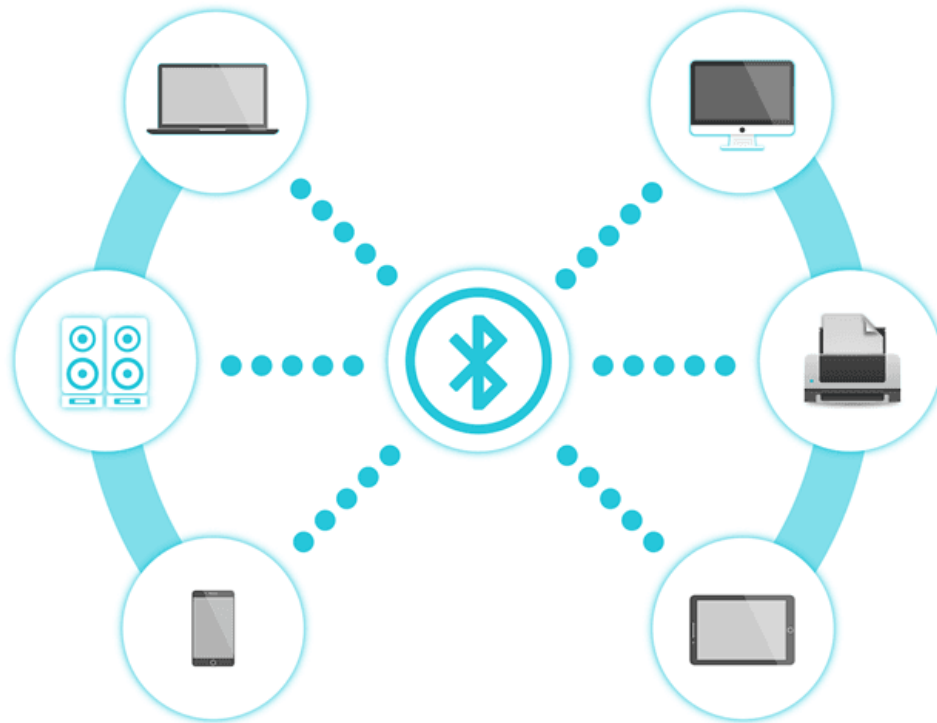


Figure 2-Bluetooth Wireless Technology Innovation [6]

The specification standardized the production of BWT-enabled devices, allowing devices from various manufacturers to communicate with one another. What does this imply for you personally? You can use BWT to run your presentation on a client's BWT-enabled projector without using a cable. Don't worry if you accidentally leave a file on your office's desktop PC. Use your BWT enabled PDA or laptop to connect to your office LAN via your BWT-enabled mobile phone without taking the phone out of your briefcase. Exchange electronic business cards with everyone in the room, regardless of where they are sitting, with a few taps on your PDA. Then, the PDA saves you time by automatically synchronizing their contact information with the email application on your laptop. These BWT-enabled products are the ones we use in today's world.

1.2.2 Bluetooth Low Energy (BLE)

Bluetooth Low Energy (BLE) is an emerging wireless technology developed by the Bluetooth Special Interest Group (SIG) for short-range communication. In contrast with previous Bluetooth flavors, BLE has been designed as a low-power solution for control and monitoring applications. BLE is the distinctive feature of the Bluetooth 4.0 specification. The advent of BLE

has occurred while other low-power wireless solutions, such as ZigBee, 6LoWPAN or Z-Wave, have been steadily gaining momentum in application domains that require multi hop networking.

However, BLE constitutes a single-hop solution applicable to a different space of use cases in areas such as healthcare, consumer electronics, smart energy and security. The widespread use of Bluetooth technology (e.g., in mobile phones, laptops, automobiles, etc.) may fuel adoption of BLE, since implementation of the latter can leverage similarities with classic Bluetooth. According to published forecasts, BLE is expected to be used in billions of devices in the near future. In fact, the IETF 6LoWPAN Working Group (WG) has already recognized the importance of BLE for the Internet of Things [7].

Like in classic Bluetooth, the BLE protocol stack is composed of two main parts: The Controller and the Host. The Controller comprises the Physical Layer and the Link Layer, and is typically implemented as a small System-on-Chip (SOC) with an integrated radio. The Host runs on an application processor and includes upper layer functionality, i.e., the Logical Link Control and Adaptation Protocol (L2CAP), the Attribute Protocol (ATT), the Generic Attribute Profile (GATT), the Security Manager Protocol (SMP) and the Generic Access Profile (GAP). Communication between the Host and the Controller is standardized as the Host Controller Interface (HCI). Finally, non-core profiles (i.e., application layer functionality not defined by the Bluetooth specification) can be used on top of the Host [8].

The figure below shows the differences between the classic Bluetooth Wireless Technology (BWT) and the Smart Bluetooth (BLE).

Table 1- Differences between BLE and BWT

Specifications	BWT	BLE
Range	100m	Greater than 100 m
Data Rate	1Mbps	1-3Mbps
Application Throughput	0.7-2.1 Mbps	0.27 Mbps
Frequency	2.4GHz	2.4GHz
Security	56/128-bit	128-bit AES/CBC-MAC
Robustness	Adaptive fast frequency	24-bit CRC ,32-bit MIC
Latency	100 ms	6 ms
Time lag	100 ms	3 ms

Voice Capable	Yes	No
Network Topology	Star	Star
Power Consumption	1 W	0.01 to 0.5 W
Peek Current consumption	Less than 30 mA	Less than 15 mA

1.2.3 Radio Frequency Identification (RFID)

RFID is one of the most exciting and rapidly rising innovations for increasing efficiencies and profits today. RFID is a technology that enables almost any entity to "self-identify" by combining a computer chip with a tiny radio antenna. The British used it to identify their planes when it was produced for use in World War II.

The modern Radio Frequency Identification (RFID) technology first emerged in the early 1980s, and it was used for applications such as object monitoring and access control. These wireless automatic identification data capture systems allow non-contact data reading and writing, making them ideal for use in manufacturing and other harsh environments where barcode labels would fail [9]. RFID has been used in a variety of markets since the 1980s, including livestock, retail sales, wireless purchases, courier and logistics, printing, automated vehicle recognition systems, and so on. RFID is defined by (Chachra, 2003) as:

«Radio Frequency Identification (RFID) is the technology that is slated to replace barcodes in library applications. It is a form of identification that is contact-less and does not require line of sight. The technology, though new to libraries, has been in use in other sectors for more than 20 years. The RFID tags are placed in books and generally covered with a property sticker. Antennas of different sizes, based on application, are used to read the tags and manage the various library functions. The RFID Solution is a revolutionary application of automatic identification and data capture (AIDC) technology. In a library environment, RFID technology resembles a traditional barcode system in that it provides a means of assigning an ID to an item and reading that ID to perform circulation transactions or to take inventory. » [10].

1.2.4 Near Field Communication (NFC)

System that originated from a combination of existing contactless identification and interconnection technologies. Sony and NXP Semiconductors (formerly Philips) collaborated on it. NFC is a technology that provides data sharing such as phone numbers, photos, MP3 files, and digital authorizations between two NFC-enabled devices, such as cell phones, or between an NFC-enabled mobile phone and a compatible RFID chip card or reader that are kept close together. NFC is designed to be used as a key to access content as well as for services like cashless payment, ticketing, and access control.

NFC transmits data at a rate of up to 424 Kbit/s over a distance of around 10 centimeters and operates in a frequency range based on 13.56 MHz in contrast to traditional contactless technology in this frequency range (which only allows for active-passive communications), communications between NFC-capable devices can be both active-active (peer-to-peer) and active-passive, making NFC a connection to the RFID world. NFC is backwards compatible with the commonly used ISO/IEC 14443 A (e.g., NXP's MIFARE technology) and ISO/IEC 14443 B Smart Card infrastructure, as well as the Sony Felica card (JIS X 6319-4) [11].

The following figure shows some of the wild usage of the Near field Communication technology.

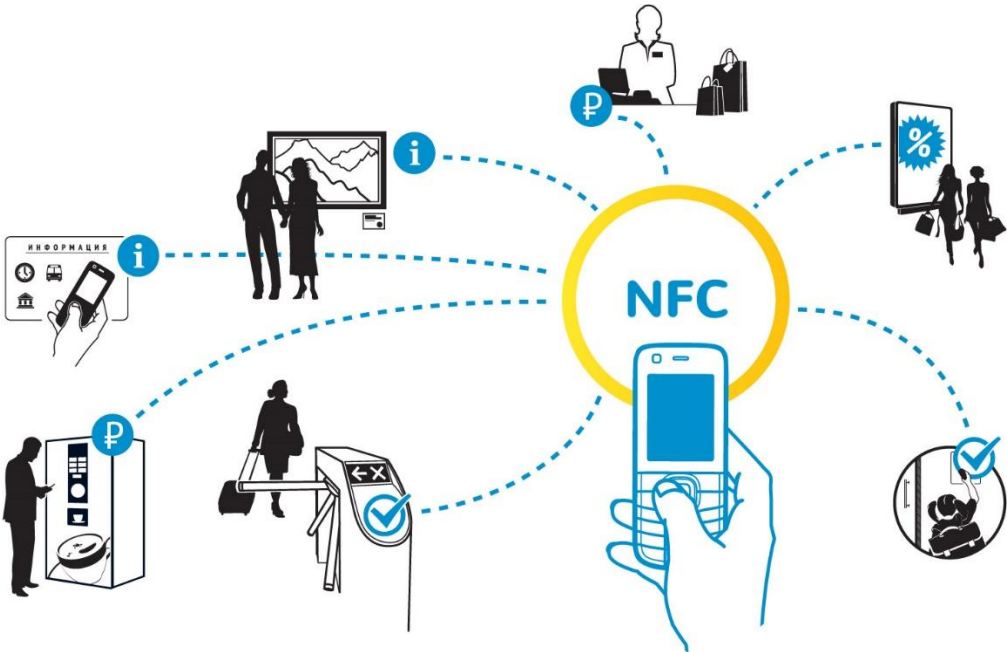


Figure 3-NFC Technology Processing [12]

A new protocol was established for the exchange of information between two NFC devices, which is specified in the standards ECMA-340 and ISO/IEC 18092. NXP, Sony, and Nokia created the NFC Forum in 2004 to harmonize the NFC technology and encourage its adoption. The NFC Forum creates standards to ensure that NFC devices and services work together. Any of the above-mentioned specifications are included (ISO/IEC 14443 A, B, ISO/IEC 18092, and JIS X 6319-4/Felica). Since December 2010, the NFC Forum has been certifying NFC units that meet its requirements. Digital protocol tests and RF measurements on NFC devices are needed to ensure interoperability between cell phones and RFID chip cards from various manufacturers. Timing measurements, signal intensity measurements in polling mode, carrier frequency measurements, reception sensitivity measurements in polling mode, and load modulation measurements are all part of the RF measurements (signal strength of the listener signal) [11].

1.2.5 ZigBee

The ZigBee wireless mesh networking protocol is the most widely used industry standard for connecting sensors, instrumentation, and control systems. The "Internet of things" has been dubbed ZigBee, a specification for networking in a wireless personal area network (WPAN). Your ZigBee-enabled coffee maker should theoretically be able to connect with your ZigBee-enabled toaster. ZigBee is an open, global, packet-based protocol that provides a simple architecture for stable, reliable, low-power wireless networks. ZigBee and IEEE 802.15.4 are low-data-rate wireless networking protocols that can be used in industrial control applications to replace expensive and damage-prone wiring [13].

The advantages of this technology are numerous; for instance, ZigBee applications include:

- Automation in the home and at work
- Automation in the workplace
- Medical supervision is required.
- Sensors with low power consumption
- Thermostat regulation

In addition, there are several other control and monitoring applications.

The following figure identifies a portion of different domains where ZigBee technology is implemented.



Figure 4-ZigBee's different usages [14]

1.2.6 Beacon

When it comes to technology, most people are unaware of its true effect on their lives. Many devices we communicate with on a daily basis without giving them much thought: lightbulbs that turn on instantly after we flip a switch, cars that turn on in a fraction of a second, wireless internet router signals that allow instant connections, and so on. Many of these things are being coupled with other technology via Bluetooth Beacons as the world becomes more linked.

Beacon technology has become ingrained in many business sectors, especially retail and marketing. Before becoming an Apple trademark technology, beacons had gone through a long development process. Many issues associated with mobile visibility and user interface were solved after Apple iBeacon was launched in 2013. The demand for beacon technology is expected to reach \$25 billion by 2024, according to Global Market Insights. As can be seen, technology has a bright future ahead of it and can be combined with excellent mobile apps to boost proximity marketing and more.

Beacons are low-cost wireless transmitters that transmit proximity-based signals to other nearby devices using Bluetooth Low Energy technology. Since less energy is used, the battery life is doubled, allowing Beacons to be used for longer periods of time. Beacons are typically made up of three parts: batteries, a central processing unit (CPU), and a radio, each Beacon system has a Unique ID (Universally Unique Identifier) that is transmitted through Bluetooth to a receiver (such

as a phone), and an application on that receiver provides information about the broadcaster's proximity.

Beacons are used in a variety of settings, including grocery stores, restaurants, hotels, airports, and even sports stadiums, to provide more precise position within a limited range than GPS. Beacon technology is commonly used in restaurants to deliver marketing messages, while it is also used in hotels to open doors and speed up the check-in process [15].

1.2.6.1 Beacon's Frame Format

The access points (and stations in an IBSS) use beacon frames to convey the characteristics of the link provided to cell members in the serviced region. Clients attempting to link to the network, as well as clients already associated with the BSS, use this information.

Beacons are sent periodically at a time called Target Beacon Transmission Time (TBTT), Beacon interval = 100 TU (100x 1024 microseconds or 102.4 milliseconds). The figure below shows the format of a Beacon Frame [16].

The figure below shows a beacon format .

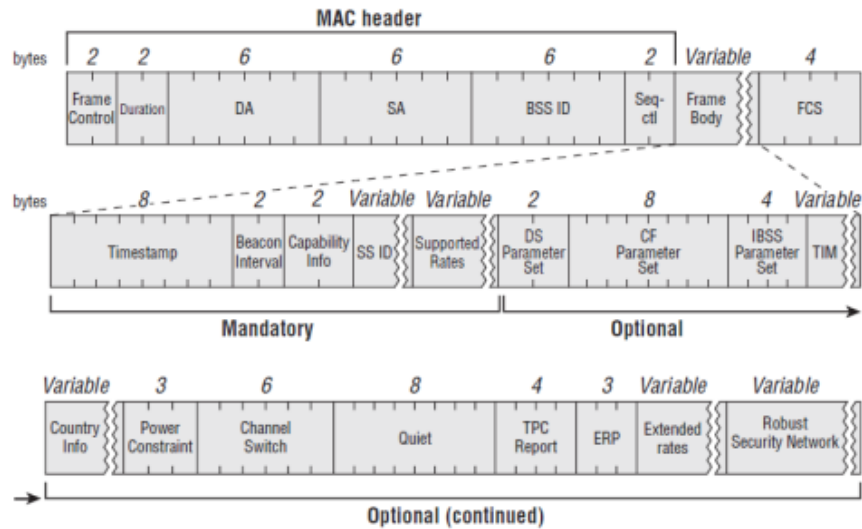


Figure 5-Beacon Frame Structure [17]

There are a few mandatory and optional fields in the frame body area. The mandatory fields in a Beacon frame are listed below.

Timestamp

A value representing the time on the access point, which is the number of microseconds the Access Point has been active. When timestamp reach its max (2^{64} microsecond or ~580,000 years) it will reset to 0. This field contain in Beacon Frame & Probe Response frame.

Beacon Interval

Beacon Interval field represent the number of time units (TU) between target beacon transmission times (TBTT). Default value is 100TU (102.4 milliseconds)

Capability information

This area comprises a variety of subfields that are used to denote optional capabilities that have been requested or advertised.

Service Set Identifier (SSID)

All beacons, probe requests, probe responses, association requests, and re-association requests contain this information. For the SSID IE, the Element ID is 0. The maximum length of an SSID is 32 characters.

Supported Rates

Beacons, Probe Request, Probe Response, Association Request, Association Response, Re-association Request, and Re-association Response all have this. It's an 8-octet area in which each octet represents a single supported rate. Each octet's last bit (7th) specifies whether the data rate is “basic rate or mandatory” or “supported rate”. A basic rate is indicated by a 7th bit value of 1, while an assisted rate is indicated by a value of 0. The next seven bits (0-6) define the data rate in 500kbps units.

1.2.6.2 Beacon Functioning

When a user walks past an area with a positioning system or an IoT network with beacons, the closest beacon sends a code to their mobile device with a message. The message is then shown as a notification on the user's mobile device via a third-party or branded app.

To make a beacon-based system work, three things should be available:

- There should be at least one more beacon kit.
- API for mobile devices

- Permission granted by the use

A software development kit (SDK), back-end management tools, and beacon devices are usually included in beacon technology offerings. As a result, software engineers will be required to set up your positioning system, particularly if beacons are part of a larger IoT network with other devices.

1.2.6.3 Types of Beacons

For any form and scale of positioning system, there is a large variety of beacons available. They vary in terms of size, battery life, use cases, and exogenous factor resistance. The following are the most popular forms of beacons [18]:

Standard Beacon

For proximity solutions and indoor monitoring, use devices the size of a Wi-Fi router or smaller.

Portable / Small Beacon

Asset monitoring and proximity solutions (the size of a credit card or a large sticker).

USB Beacon

Asset tracking and proximity solutions using beacons the size of a flash drive. (small, compact, and easy to deploy). Video beacons are devices that are plugged into the back of a screen that are used to provide contextual visual information (for example, when a user enters a display in a restaurant, the display displays customized deals based on the user's use of the beacon-enabling app) as well as digital signage.

AI Beacon

A device that uses machine learning to detect various motions and gestures.

Sticker Beacon

The smallest of beacons, used to track assets.

Parent Beacon

(About the size of a large Wi-Fi router) is used to monitor other beacons, collect data, and store it in the cloud, among other things.

Dedicated Beacon

Indoor monitoring and proximity solutions in harsh environments include devices that are immune to exogenous factors (dust, water, shattering, antistatic, and Ultraviolet radiation).

1.2.6.4 Estimote Beacon

Estimote Proximity Beacon is a Bluetooth Low Energy (BLE) beacon that can detect and respond to the presence of a smartphone within a certain range. Compatible with Eddystone and iBeacon. It has Bluetooth 5.0 built-in radios and a 3-year battery life by default. It is compatible with a variety of programming languages, including Objective-C, Swift, Java, and Kotlin. iBeacon, Eddystone-URL/UID, and other BLE packages [19].

1.2.6.5 iBeacon

iBeacon is an Apple technology standard that allows Mobile Apps (running on both iOS and Android devices) to listen for and respond to signals from beacons in the real world. In essence, iBeacon technology enables Mobile Apps to recognize their location on a micro-local scale and deliver hyper-contextual content to users based on their location. Bluetooth Low Energy is the underlying communication technology [20].

1.3 Conclusion

In this chapter we learned that Personal Area networks are used in the daily basic life covering our bodies our personal devices making our life easier and maybe even safer, we covered different types of the most know Personal Area Network implementations such as Bluetooth Wireless Technology, Bluetooth Low Energy, Radio Frequency Identification, Near Field Communications, Zigbee, and we focused precisely on Beacon which is the most advanced technology from all of the above, we learned about Beacon's frames format and it's functionalities Finally, we had a brief information about different types of beacons that are most common and used more often.

Chapter Two

Beacon Technology

2.1 Introduction

Beacons are a small device that broadcast a low-energy Bluetooth (BLE) signal nearby. You can use this signal strength to tell the approximate distance between the beacon and another Bluetooth enabled device. This enables the ability to trigger actions based on proximity to that device. This could be sending an alert or performing an action once the app detects the beacon is a certain distance away, or it could be used as a method to track locations of people or products in an indoor environment. Due to satellite location systems being unable to work indoors, beacons are fast emerging as one of the primary indoor location technologies.

When a beacon is transmitting its signal, it will take something else to absorb and utilize the signal in some manner, usually with a smartphone and corresponding app. With the most current research in 2018 suggesting that 40 to 50 per cent of consumers leave Bluetooth turned on making their devices easily receptive to beacon messages, there's a real opportunity to reach users through this channel.

In this chapter we will talk about the various domain beacon is used in and focus at the end at the COVID-19 tracking app using beacon technology its advantages and disadvantages and how beacon is deployed in this domain.

2.2 Area of Use

According to a research published by [Global Market Insights](#) in February 2018 business owner in all fields are beginning to adopt leveraging modern technologies to offer a personalized, digital and rich content-driven shopping experience to the customers at their stores [33]. And in this chapter, we will take a closer look at beacon use in 7 of the most important domains.

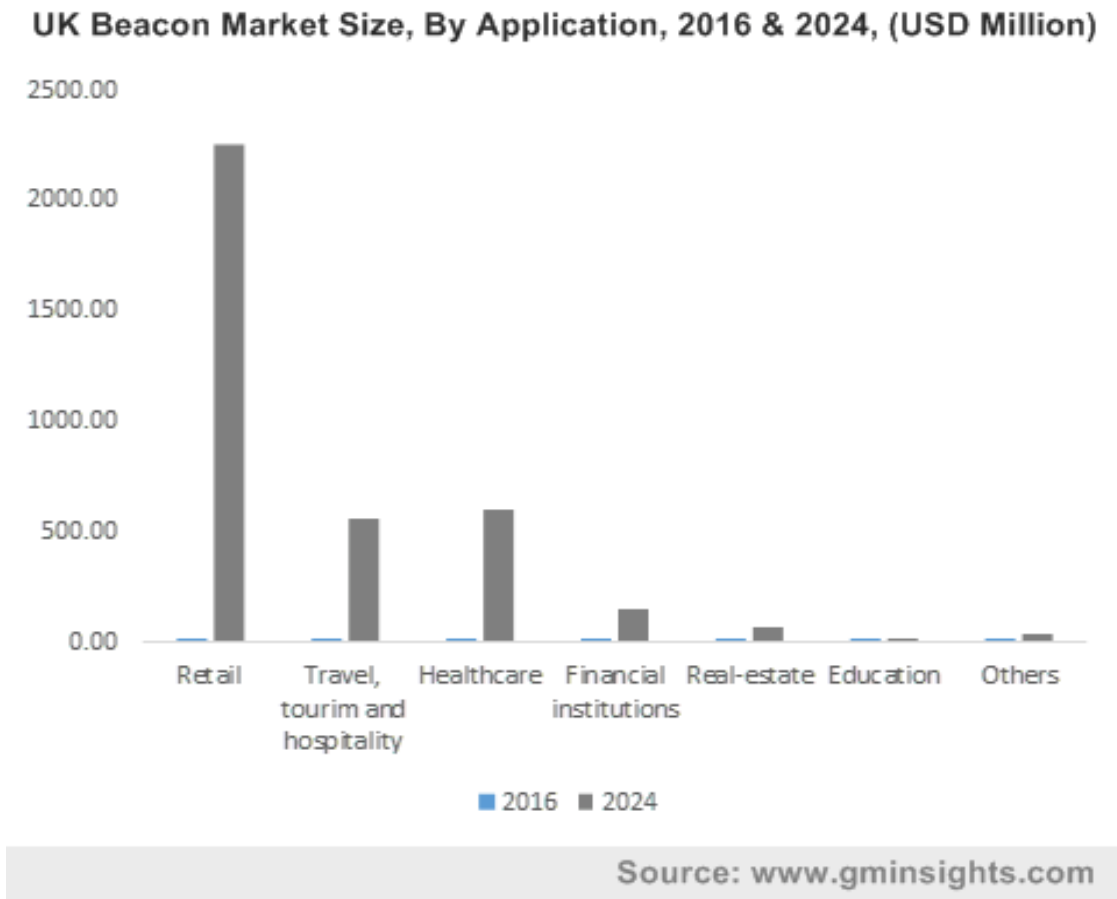


Figure 6- UK beacon Market Size [28]

2.2.1 Location Based Technology

While mobile technology has allowed us to break down geography and stay connected from anywhere, location is proving to be more important than ever. For many categories of mobile apps, personalization, context, and location are the trifecta of exceptional user experience.

A personalized and contextually relevant experience is more compelling to users, and increasingly, location is a factor that enhances personalization and makes the user experience more relevant ». As the Internet of Things (IoT) gains traction, location is becoming even more important. According to TechTarget: “Location is a vital dimension of the IoT concept that encompasses the ability of ‘things’ to sense and communicate their geographic position. In this context, location acts as an organizing principle for anything connected to the Internet.” And especially location-based technologies in indoor environments, using beacon is much more efficient than GPS and this table can provide us with a comparison:

Table 2- Comparison between GPS and beacon [21]

Comparison between GPS and Beacon	GPS	Beacon
Standard protocol and ability to work across platforms and devices	X	✓
Well documented and standardized app development architecture	X	✓
Very low power usage to preserve device battery life	X	✓
High accuracy via proximity detection (message triggering based on user’s location in relation to a beacon)	X	✓
Best option for context-aware messaging	X	✓
Widely accessible technology	X	✓
Opt-in (requires user consent)	X	✓

Interaction between devices and things is a fundamental necessity for IoT. This is why every sophisticated segmentation and hyper-local, context-aware technologies are essential. The device needs to know precisely what it's dealing with, meaning there needs to be a way to distinguish between objects inside the network.

Beacons are by far the most brilliant way to do this in comparison to WIFI or GPS. Beacons are also the best available technology to facilitate indoor location positioning on a more granular scale; provide hyper-relevant, personalized messaging to users; and gather more detailed user intelligence [21].

2.2.2 Air Traffic

In airports location is very important whether for passengers inside or for airplanes. ATCRBS, the Air Traffic Control Radar Beacon System, is a secondary surveillance radar system developed for use within the air traffic control system for more precise position reporting of planes. It is used in conjunction with the primary radar ATCRBS Developed in 1956, which is used to determine the presence of planes in the airspace. ATCRBS supplements this positional information with positive identification and altitude information, allowing controllers to track each plane more precisely and efficiently. The figure bellow explain how beacon works in the new ATCRBS radar system. [23]

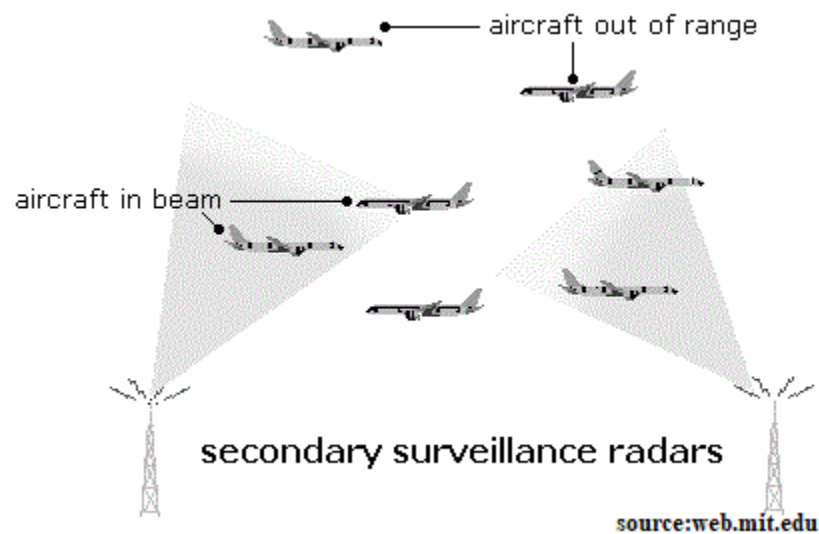


Figure 7 the new ATCRBS radar system [23]

Moreover, beacon technology proved to be one of the best indoor navigation technologies. Upon arrival at the airport, the beacon navigation map of the airport provides directions from the parking area to the terminal, safety check in and round-trip navigation to the gates, aid desks, restaurants, ATMs, exit routes and other facilities.

For example, if a passenger arrives two hours before his connecting flight departs, through an airport indoor navigation app, you can immediately send information on where he is, where he needs to go for his next flight, and the best way to get to that place, where the facilities are, etc.

2.2.3 Retail Business

Right before the 2014 holiday season, Macy's (Macy's is one the largest department store chain in the world founded in 1858) rolled out retail's largest beacon installation at the time. After some successful testing at their New York City and San Francisco flagships, the department store chain decided to implement the use of beacon technology in all of its stores nationwide. Macy's worked with shopkick to install 4,000 shop Beacons, and as shoppers entered Macy's, they were reminded to open their Macy's apps in order to receive notifications, promotions, deals, and discounts. And after the success of this experiment many retail companies around the world followed their experience and deployed even more beacon devices in their stores.

Through using beacon technologies, retailers can better fulfill consumer requirements and create online-to-in-store seamless experience.

2.2.3.1 Benefits of Beacon Technology for Retailers

There are numerous benefits to adopting beacon technology. Ultimately, it enables retailers to create more tailored experiences for customers, thereby deepening their relationships. In this section, we'll break down a few more benefits to using beacons in retail.

- ✓ **Advertising Tool:** Gone are the days when retailers could only rely on print, TV, and radio advertisements to drive customers into their stores. Now, shoppers expect more tailored messaging, with personalization that makes sense. Not only can beacon technology provide that, it can trigger the ad based on a customer's proximity to the store. This helps troubleshoot some of the physical limitations of brick-and-mortar stores. Now, shoppers can be marketed to at the right time and in the right place. [35]
- ✓ **The Power of Personalization:** Just as ecommerce businesses like Amazon offer customers personal shopping recommendations based on previous purchases, beacon technology can do this in the context of brick-and-mortar stores. Everything from coupons, deals, and product recommendations can be tailored to individual customer preferences and shopping habits. This not only helps develop long-term customer loyalty, but a more engaging shopping experience as well. While you employ sales associates, they can't always be available to help every customer. Personalized shopping through beacon technology helps bridge that gap. [35]

- ✓ **Accessing Data:** Tracking shopping habits and preferences allows retailers to access insightful consumer data. For example, retailers can analyze what day of the week and time of day shoppers are more likely to download and use certain coupons. From there, they can take a look at demographics, and other connecting points, such as what other items are purchased on the same shopping trip. [35]
- ✓ **Affordability:** Compared to some other tech hardware and software, beacon technology is affordable to adopt. According to [Product Mavens](#), a set of three or four iBeacon transmitters linked to an app and content management system costs around \$100. The tech is also relatively easy to set up, install, and start using, making it a low-risk and worthwhile product to try out. [35]
- ✓ **Increase in Mobile App Use:** Shoppers often download apps to their smartphones and forget they exist. Beacon-triggered notifications not only act as a reminder, but increase interest in using the app. According to [Product Mavens](#), French retailer Carrefour saw a 400% increase in mobile application engagement following the implementation of beacons. By leveraging beacon technology, apps can become even more useful and engaging tools for shoppers [35].

2.2.4 Beacon Technology in Marketing



Figure 8-Beacon transformation in-store experience

The proximity data received from beacon technology may provide brick-and-mortar retailers and other organizations with some of the same physical personalization and targeting advantages experienced by online retailers.

For instance, beacons can help marketers gain detailed customer insights, such as how long customers spend on average in a store, as well as which product sections are being visited. This data can provide the information marketers need to enact more precise customer advertising through a mobile app. [25]

Beacon marketing can give a business the attention it wants for their marketing messages. The geo-targeted messages beacons transmit can significantly increase the open rate of mobile marketing offers. Research shows that people open standard push notifications about 14% of the time, but they [open messages transmitted by a beacon more than 50% of the time](#) because those messages appear more relevant. [34]

Not forgetting how affordable advertising with beacon devices is for companies, a set of 3–4 iBeacon transmitters linked to a mobile app and content management system costs around \$100.

Finally, beacon marketing can increase interest in using a business' mobile app. Consumers often download apps and forget they exist, but beacon-triggered notifications can act as a reminder. [25] Some retailers have seen as much as a [400% increase in mobile application engagement](#) following the implementation of beacons. By leveraging beacon technology, apps can become even more useful and engaging tools for shoppers [35].

2.2.5 Beacon and Tourism

In view of the hyper-local and contextual capabilities of beacons, they are of immense value to both travelers and players in the tourism industry, in the smart phones era more than 70% of the world's population uses mobile phones, and these gadgets can prove to be very smart while traveling. with mobile phones proliferating, wearables and the power of beacons, travelers can now discover a host of experiences while they travel – from easier airport navigation to discovering a new city through access to rich digital content on their mobile phones to personalized hotel experiences. Beacons are also of great value to players in the tourism and hospitality industry; beacons with their ability to source customer data around physical locations, activities, time and personal interests, provide a huge window of opportunity to target customers with personalized

and contextual experiences in order to ensure business success. For example, given the data collected, restaurants and hotels can use beacons to regain any lost revenue by filling unbooked appointments simply by alerting nearby travelers of deals and offers. [27]

How beacons enhance experiences at:

- ✓ **Airports:** by providing a precise direction to gateway to ensure a smooth transition for air travelers, and providing important information about the structure of the air port for example the tourist do not need to ask for direction to store, restaurant, bathrooms, items prices, inside the airport everything is provided automatically directly to his phone. [27]
- ✓ **Hotels:** by helping provide highly personalized and intelligent services to customers, without adding to the cost of hiring and training new staff. [27]
- ✓ **travel discovery:** tourists can be alerted about information on the history of the place, transportation schedules, weather updates and public services in multiple languages, and at relevant times during the day. [27]



Figure 9 beacon device providing real time information to visitors [36]

2.2.6 Mobile Payment

Mobile Payments refers to any payment made via a mobile device in place of using cash or a credit card to process a transaction.

Mobile proximity payments can be processed by leveraging a host of technologies and platforms today. Digital wallets like, Apple Pay, Samsung Pay and iBeacon technology among others are some of the popular technologies that are leveraged by businesses and brands today to deliver mobile proximity payments. However, digital wallets like Apple Pay and Samsung Pay face certain barriers to adoption since they are phone specific, and do not allow businesses to make customizations. A good way to overcome this problem is to leverage iBeacon technology, that not only allows for customization, but also gathers valuable customer insights. Beacon-based payment apps are also phone agnostic, thus making it practically accessible to any smartphone user.

Here are some of the Key features of Beacon Mobile Payment:

- **Contactless payment:** Ibeacon enabled Payment Wallet works similar to a QR code-based payment system but have an advantage of getting invoice & payment request on the mobile from quite a reasonable distance.
- **Highly secure:** Highly Secure All operations will be done on the server; no data communicate in beacon signals. beacons have no facility to store any data in itself.
- **Value addition:** Present unique value addition to your customers & ease their shopping experience.
- **Reward system:** Your customer earns reward points on each transaction done through payment wallet.

When talking about mobile payment the first method that crosses our mind is NFC because it is older a widely used among people beacon is not that common. The difference between the two approaches is that whereas with Beacon it is the consumer's location that facilitates the engagement, with NFC it is the consumer's response to a call-to-action that does it. Neither technique is superior, they proceed, as both have their respective merits in specific circumstances [30].

This figure is an example how a beacon payment app works:

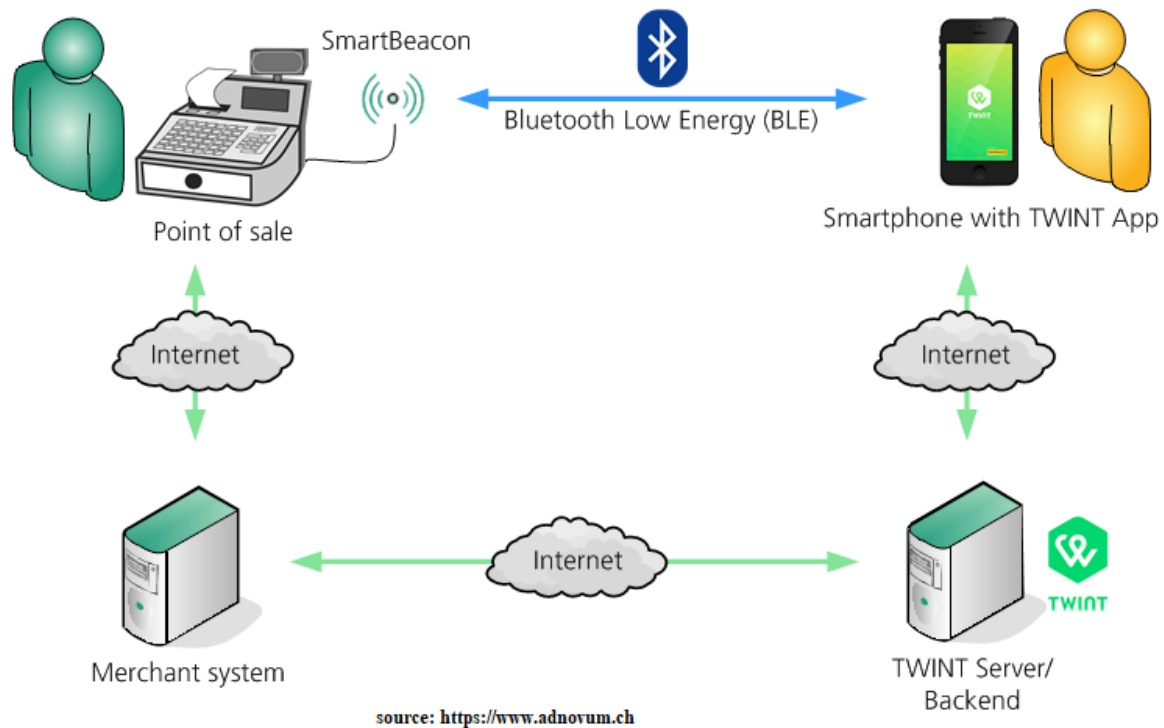


Figure 10 Beacon payment system [37]

2.2.7 Smart House

Imagine that! You return home after a long day and are greeted with a cup of freshly brewed coffee. Your house is aware of your presence. As soon as you walk in, it switches on the lights and plays your favorite songs. This is not some kind of science fiction with the deployment of beacon devices this is possible.

Beacons make it possible for homeowners to build smart living spaces by using a smart mechanism that controls their entertainment units, security systems, home appliances, thermostats, fixtures, ceiling fans, surveillance cameras, and more, through their smartphones [28].

They are truly a brilliant demonstration of how IoT is fast empowering the integration of digital and physical worlds, with beacons devices all set up and ready to use, your physical environment is made digitally rich as your home detects your presence through home automation applications and behaves according to your will, besides providing you with vital controls [28]. According to ABI Research, BLE Beacon shipments are forecasted to exceed 400 million units in the next five years. And this fast-growing use of beacon-based devices in homes did not come from

nothing, it's the result of the huge beacon benefits, this are some of the most important advantages beacon technology can offer for us:

- **Convenience:** Beacons turn off/on based on your micro-location, work as occupancy sensors, whenever the homeowners leave for their office it automatically switches off the lights without any manual interference.
- **Conservation of energy:** Beacons are lightweight BLE transmitters that convert a simple home to a smart one at an affordable price. Also, most of the tasks including switching on/off lights are automated which results in low energy consumption.
- **Security:** Beacons can control locks at home to prevent theft. When homeowners forget to lock their homes, beacons will automatically lock their homes. They also alert users when there is a fire or smoke.
- **Personalize your Home:** with beacon devices you can customize your house as you wish and make your home unique on its functionalities even compared to other houses with same technology and provide you a comfortable living experience by examining your behavioral patterns.
- **Easy installation:** Setting up beacons devices does not require any technical or developing knowledge for installation. Anyone can easily deploy it to their home without the help of a developer [28].

2.3 Existing Covid-19 Tracking Applications

Since the beginning of the COVID-19 pandemic, A plethora of mobile data collection applications have been developed to help users report their symptoms and track the disease in countries like South Korea these 'apps' even provide health authorities the ability to alert users when they've been in direct contact with a confirmed positive case [31-38].

In order to slow down the spread of this deadly disease the WHO insist that beside finding, testing, isolating, and treating every positive case of COVID-19 it's important to trace all the contacts of individual positives with other people in order to curtail virus spread rates the best way to do so is by using a devices with internet access carried by people every time everywhere and the best device with this proprieties is smart phones a devices that is widely used among all king of people, smart phone phones. Smart phones provide a valuable tool to make this job easier by using an application that collect user data. Going back to the example of South Korea this kind of

applications proved to be one of the key factors of how they controlled this outbreak in just 20 days despite having a direct contact with the country of origin of COVID-19 China [38].

According to a [study published in Science magazine](#) in late March, the use of a contact tracing app that builds a memory of proximity contacts of positive cases “*can achieve epidemic control if used by enough people.*” [35].

How do these applications really work? are they breaching users’ privacy in any way? and how effective are they really to control the coronavirus pandemic? [38]

2.3.1 How do these Applications Work?

To understand how these applications work, the first thing that should be kept in mind is that not all of them work in the same way. In general, the ‘apps’ rolled out to date in Spain and in other western countries focus on self-diagnosing the disease, symptom monitoring and notifying cases to health authorities. For example, [AsistenciaCovid19](#), which launched first as a pilot in the Community of Madrid and has now been rolled out by [other autonomous communities](#) in Spain, features a questionnaire based on which users can check whether the symptoms they may be experiencing are compatible with typical COVID-19 symptoms. Based on this information, the ‘app’ provides recommendations regarding the need to isolate or contact health services. It also allows users to track how their symptoms evolve.

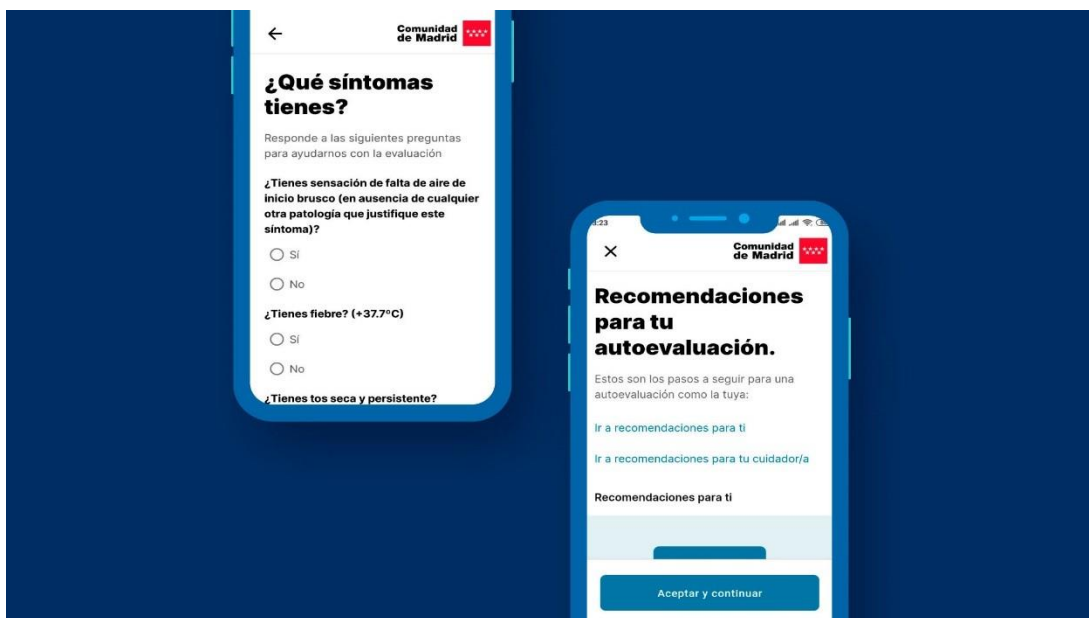


Figure 11 Spanish covid19 tracking application [40]

Optionally, users can also accept to share their device's location data with the app, "with the purpose of guaranteeing the quality of the data and its epidemiological analysis," as they explain [on the app's website](#). What the app does require users to do is to fill out a form with personal info, including a contact address where health authorities can reach the person if necessary. This 'app' has some similarities with [Stop Covid19 Cat](#), offered in Catalonia. However, the latter requires users to consent to share their geolocation data, which allows authorities to gather information on how the pandemic is spreading throughout the region.

"These applications are chiefly intended to help prevent COVID support hotlines from collapsing and collecting certain socio-demographic data, such as user gender and age. And, while at it, they can also gather geolocation data from users' devices, although, in principle, all this data is anonymized and aggregated," says Murillo, a member of the Data Strategy team at BBVA and an expert in the use of 'big data' for the greater good. And having this kind of applications is optional in most of countries [38].

2.3.2 Users Privacy

And this brings us to the most debated problem. In the country of origin for this health outbreak China, having this application is mandatory this law caused a debate on the limits of user privacy. This application is collecting a very important data on individual it can collect even data about people, places a person contacted with every single day, activities done by each individual. And this very valuable information can be used in every way possible by companies, governments or whoever poses this information [32].

"Solutions differ from country to country and depend a lot on their level of democratization and individual rights protection. In Europe, where data protection is a fundamental right, measures tend to be much more scrupulous when it comes to privacy, and always seek voluntary consent when dealing with potentially intrusive situations," [recently said Ana Segovia](#), from the BBVA Digital Regulation team [38].

2.3.3 Some mobile contact tracing apps in the European Union

This are some examples of COVID tracking applications from the European union:

Table 3- tacking apps in European union [38]

Countries	App	Interoperable - is this app potentially interoperable?	Interoperable - can this app already talk to another app ?
Austria	Stopp Corona App	Yes	Yes
Belgium	Coronalert	Yes	Yes
Croatia	Stop COVID-19	Yes	Yes
Cyprus	CovTracer	Yes	No
Czechia	eRouška	Yes	No
Danmark	Smittestop	Yes	Yes
Denmark	Smittestop	Yes	Yes
France	TousAntiCovid	No	No
Germany	Corona-Warn-App	Yes	Yes
Italy	Immuni	Yes	Yes
Spain	Radar Covid	Yes	Yes

2.4 Advantages and Disadvantages

2.4.1 Advantages

The fundamental technologies behind the application in itself are advantages. Here's a description for the main technologies used in this kind of apps:

- ❖ **Location:** Some apps identify a person's contacts by tracking the phone's movements (for instance, using GPS or triangulation from nearby cell towers) and looking for other phones that have spent time in the same location.

- ❖ **BLE/Beacon:** Some systems use “proximity tracking,” in which phones swap encrypted tokens with any other nearby phones over Bluetooth. It is easier to anonymize and generally considered better for privacy than location tracking.
- ❖ **Google/Apple:** In the United states Google and Apple are collaborating to build a joint API. It lets iOS and Android phones connect with each other through BLE, making it easier developers to create a single app that works with both of them. Later, the two firms are planning to integrate this option directly into their operating systems.
- ❖ **DP-3T:** This stands for decentralized privacy-preserving proximity tracing. It’s an open-source protocol for Bluetooth-based tracking in which an individual phone’s contact logs are only stored locally, so no central authority can know who has been exposed.

So basically, this is a big advantage for this application the cross-platform compatibility with all kind of devices and easy development with a little bit of money and time spent to develop the application, another advantage is that this application offers us a pinpoint accuracy of individual behaviors and activities during him/her time before having obvious symptoms so the health authorities can contact every person with direct contact with the positive person.

Not forgetting that the application can provide us with the general development of COVID-19 case in specified areas.

2.4.2 Disadvantages

This application has 5 main problems:

- ❖ **Privacy and Trust:** in Contact Tracing Apps is the biggest disadvantage for this application, using an approach that focused on proximity not location and keeping in mind that patient and public health authority confidentiality is key.
- ❖ **Design Flexibility:** Contact tracing apps need the same system to be able to be implemented by different mobile providers. Also, the design must be culturally appropriate and fit local public health goals.
- ❖ **Rapid Notification and Integration:** To maximize benefits for public health officials, the app needs to provide rapid notifications and integrate with the manual contact tracing process.
- ❖ **false negatives:** these apps will fail to flag individuals as potentially at risk even when they’ve encountered someone with the virus. Smartphone penetration in the United States

remains at about 81 percent—meaning that even if we had 100 percent installation of these apps (which is extremely unlikely without mandatory policies in place), we would still only see a fraction of the total exposure events (65 percent according to Metcalf’s Law). Furthermore, people don’t always have their phones on them. Imagine the delivery person who leaves her phone in the car. Or consider that the coronavirus can be transmitted via the surfaces on which it lingers long after a person and their phone has left the area. The people in the highest risk groups—the aging or under-resourced—are perhaps least likely to download the app while needing safety most. Others may download the app but fail to report a positive status—out of fear, because they are never.

- ❖ **The Apple-Google proposal:** this proposal is both an advantage and disadvantage because of the security of private data stored especially by these 2 Mega corporations for example, their application stores the information about what “contacts” the device has made on each users’ device, rather than reporting that information to a central server as is the case with some of the other approaches. This “decentralized” architecture isn’t completely free of privacy and security concerns, however, and actually opens apps based on these APIs to new and different classes of privacy and security vulnerabilities. For example, because these contact-tracing systems reveal health status in connection with a unique (if rotating) identifier, it is possible to correlate infected people with their pictures using a stationary camera connected to a Bluetooth device in a public place.

Though technologists at Apple, Google, and a number of academic institutions have given some thought in their planning documents to the possibility that their tools could be exploited and abused, they need to be much more candid about the limitations of the technology—including the fact that these approaches should never be used in isolation, if they are used at all. Like thermometers, tires, and many other products that operate safely only within a specific range, these apps should come with a warning about their many points of failure [32].

2.5 Conclusion

Beacon Technology offered us at this age a huge benefit that will help us improve our daily routines and interfered in every aspect of our life it became a necessity, every object in our lives is smart and can be customized to our need who knows what 20 years from now can offer us, especially with our current situation we need any mean to at least reduce the damage caused by the virus and beacon offer us a good opportunity despite some few issues especially regarding privacy concerns.

Chapter Three

Concept and Modeling

3.1 Introduction

The use of modeling is an essential practice for development software. Its role is to identify the problems: identify them, find their solutions, schematize these, then finally prepare the ground for action.

A model is, in fact, an abstract representation of a system in order to facilitate its study and documentation. It is a major communication tool between different stakeholders within a project. In addition, as systems become more and more complex, their understanding and their overall mastery is beyond the capabilities of a single individual. Building an abstract pattern helps remedy this.

This chapter will be devoted to the design of our application. First, we will introduce the UML language and its different diagrams. Then we will present the actual modeling of our project using three types of diagrams.

3.2 Concept

The concept of our final project is to create a mobile App that tracks the spreading of the actual virus Covid-19 via Bluetooth technology and minimize the risk by storing all interactions between two devices that takes more than two minutes withing a specified range, in a server and provide the authorities with the data whenever necessary.

The administrator uses the website to navigate through the data and manage them and do what is necessary to prevent the spreading.



Figure 6- Bluetooth Technology

3.3 modelling

The development of any information system requires a very important process in the life cycle of software, and modelling in practice is important in software developments, in our project we choose the UML modelling language which we will expose right below.

3.3.1 UML definition

UML, or Unified Modelling Language, is a standard modelling language consisting of an integrated set of diagrams that's been developed to facilitate in the specification, visualization, construction, and documentation of software system artifacts, as well as business modelling and other non-software systems.

The UML is a list of best engineering practices for modelling large and complex systems that have been shown to work. The UML is an important factor of object-oriented software development and the software development process. To express the design of software projects,

the UML primarily utilizes graphical notations. The UML allows project teams to collaborate and discuss new design options.

There are two main types of diagrams in UML. Behavioral, such as Use-case, Activity, and Sequence diagram, and structural such as Class, Component, and Object diagram, in this project we are using Use-case and sequence diagrams as behavioral and class diagram as structural [41].

3.3.2 Use-Case diagram

In terms of use cases, a use-case model defines a system's functional specifications. It's a representation of the system's intended functionality (use cases) as well as its surroundings (actors). You can use use-cases to connect what you need from a system to how it serves those needs. Use-case diagrams are used in UML to model a system's behavior and to capture the system's specifications.

Use-case describe a system's high-level functions and scope. The relations between the system and its actors are also represented in these diagrams. In use-case diagrams, the use cases and actors explain what the system does and how the actors interact with it, but not how the system works internally.

Use-case diagrams depict and describe the meaning and specifications of an entire system or specific system components. A single use-case diagram can be used to model a complex system, or multiple use-case diagrams can be used to model the system's components [42].

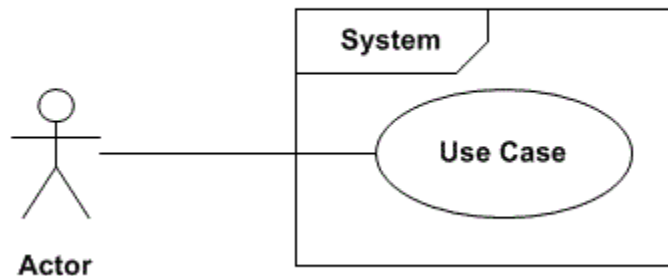


Figure 7 Simple Use-Case diagram example

3.3.3 Sequence Diagram

The sequence diagram, also known as an event diagram, represents the flow of messages through the system. It helps in the visualization of a variety of complex scenarios. It describes interaction between any two lifelines as a time-ordered series of events, as if these lifelines were present at the same time.

Sequence diagrams are a popular dynamic modelling solution in UML because they specifically focus on lifelines, or the processes and objects that live simultaneously, and the messages exchanged between them to perform a function before the lifeline ends [43].

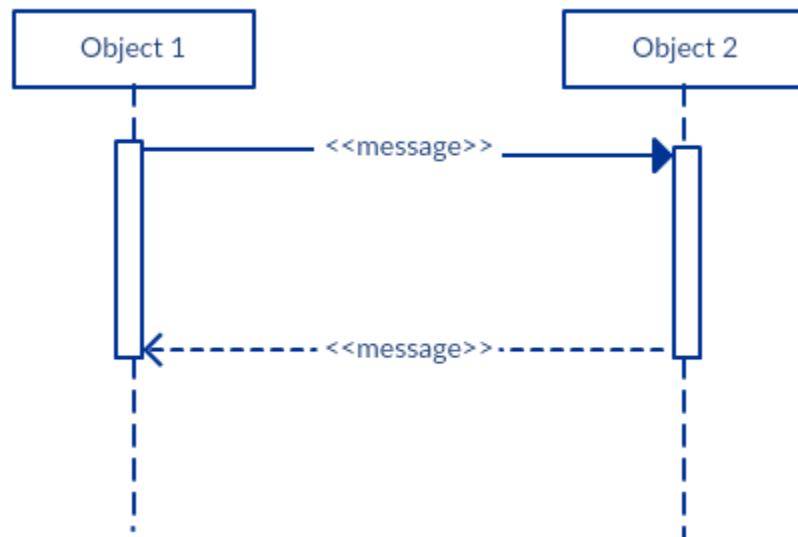


Figure 8-Simple Sequence diagram example

Sequence diagrams can be useful references for businesses and other organizations. Try drawing a sequence diagram to:

- Represent the details of a UML use case.
- Model the logic of a sophisticated procedure, function, or operation.
- See how objects and components interact with each other to complete a process.
- Plan and understand the detailed functionality of an existing or future scenario.

3.3.4 Class Diagram

The UML Class diagram is a graphical notation for creating and visualizing object-oriented structures. In the Unified modelling Language (UML), a class diagram is a type of static structure diagram that portrays a system's structure by displaying the system's:

- Classes.
- Their attributes.
- Operations (or methods).
- Relationships among objects.

Class diagrams are one of the most useful types of diagrams in UML as they clearly map out the structure of a particular system by modelling its classes, attributes, operations, and relationships between objects [44].

Class diagrams offer a number of benefits for any organization. Use UML class diagrams to:

- Illustrate data models for information systems, no matter how simple or complex.
- Better understand the general overview of the schematics of an application.
- Visually express any specific needs of a system and disseminate that information throughout the business.
- Create detailed charts that highlight any specific code needed to be programmed and implemented to the described structure.
- Provide an implementation-independent description of types used in a system that are later passed between its components

The figure below shows a simple example of a UML Class Diagram.

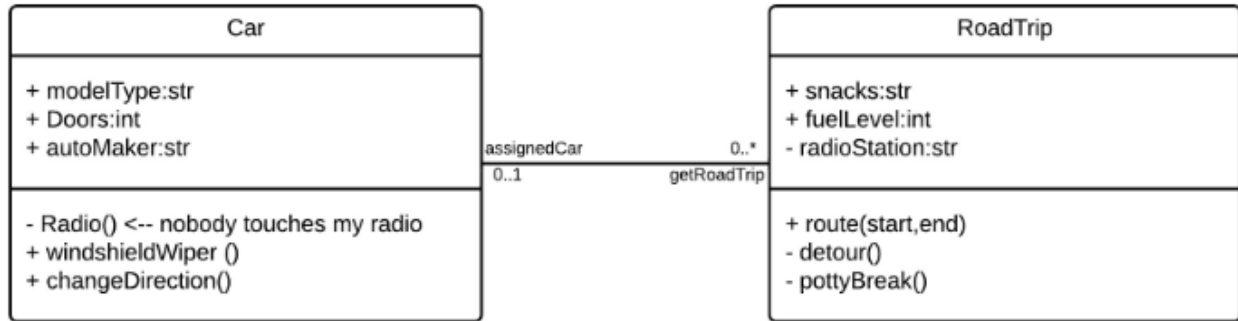


Figure 9- Simple Class diagram example

3.4 modelling the Mobile App

The use of the standard UML modelling language which makes it possible to manage complexity and make communication between stakeholders in the project.

He recommends the use of visual modelling tools that allow:

- Model the architecture and its components using diagrams.
- Facilitate the management of OR models and contribute to the maintenance of the consistency between the different phases of the process: from the expression of needs to the implementation;

3.4.1 Use-Cases

A user opens CovidOut app and tries to authenticate, if the user is already registered, he can log in simply by typing the email address and the password he created when he registered first time. However, if a user is not already registered, he must register to use continue using the app, and for that the user is required to enter the full name, date of birth and the physical as well as the email address specify the gender and finally create a password.

When a user finally enters the required data, he submits and will be redirected to the home page.

The figure below explains what is declared above in graphical form using UML Use-Case diagram.

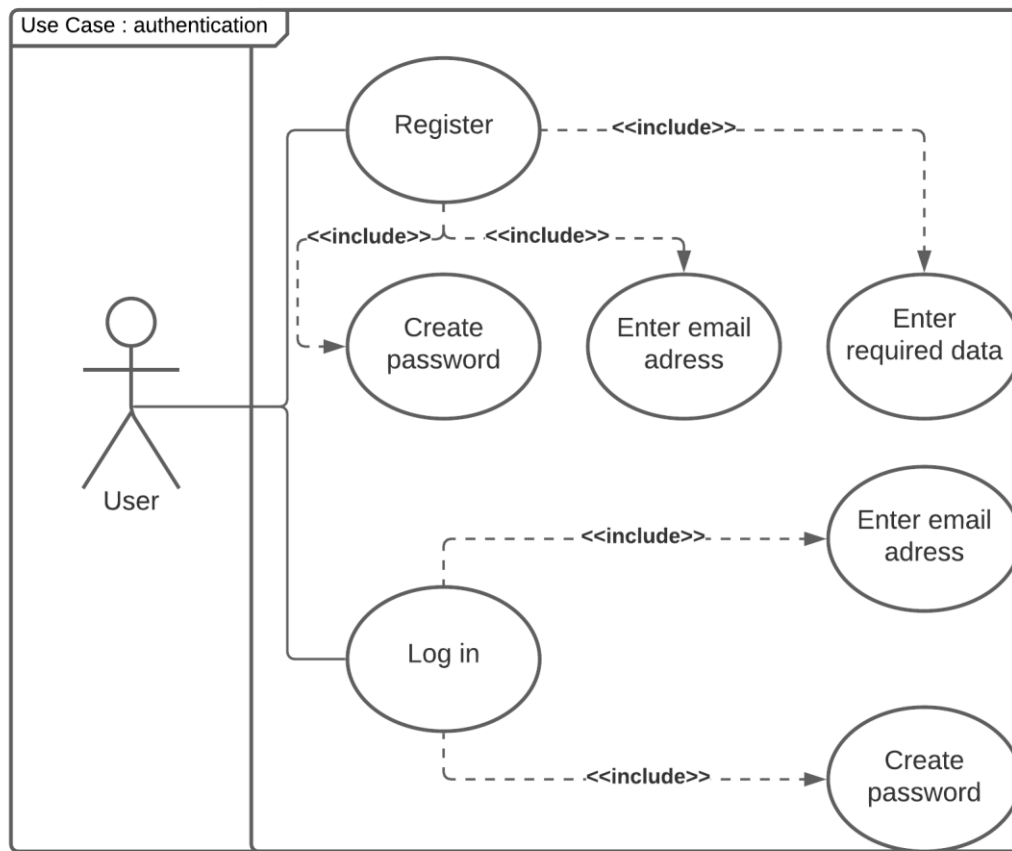


Figure 10-Use-Case diagram for authentication

After a user is successfully authenticated either by registering if he was new to the app or by logging in if he was already registered, the user is redirected to the home page which contains a map (The map Of Algeria) which shows in general the contaminated areas, Moreover , the user is able to navigate through different pages such as the profile page which shows modifiable data of the user as well as an auto generated unmodifiable ID which will be used later by the administrator to declare weather a specific user is healthy or not. The stat page, and this page gives some details about interactions the user made with other devices through a specific amount of time (day, week, month).

The figure below explains what is stated above in a graphical form using UML Use-Case diagram

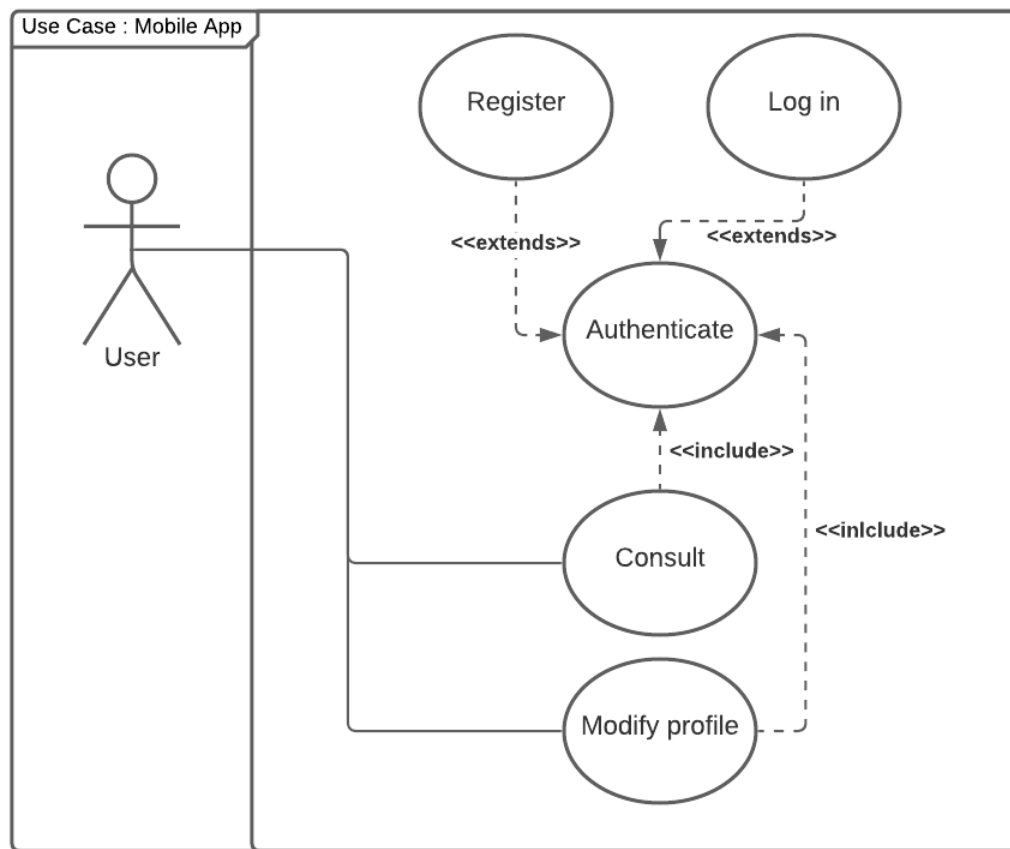


Figure 11-Use-Case diagram for CovidTrack Mobile app

3.4.2 Sequence Diagram

A user opens the app, he is required to authenticate either by logging in if he is already registered or by registering, the user is required to choose one of the ways to authenticate.

- **Logging in:** A user then is required to enter the email address and the password he created during the process of registering. The user must leave no empty fields, if a user does leave one of all of the fields empty, he cannot continue to the home page. However, if none of the fields is empty the data entered by the user must pass through the controller and will be checked if it matches the data in the data base which are basically provided during the process of registering. If the data are a match, then the user will be redirect to the home page and he can proceed to use the app properly, otherwise if the data are not a match the

user will be notified through an error message that the mail address or the password is incorrect and will be asked to try again.

- **Registering:** A user in then new to the app, to continue to the homepage the user must register and provide the app by the data required. In order to register, the user must fill out all fields of information (full name, date of birth, gender, physical address, and email address). If any of the fields is left empty, the user cannot validate the data and continue to the homepage. However, if none of the fields is empty the data entered by the user will be collected and stored in the data base, and then the user is redirected to the homepage.

The figure below shows a sequence diagram of the authentication process described above.

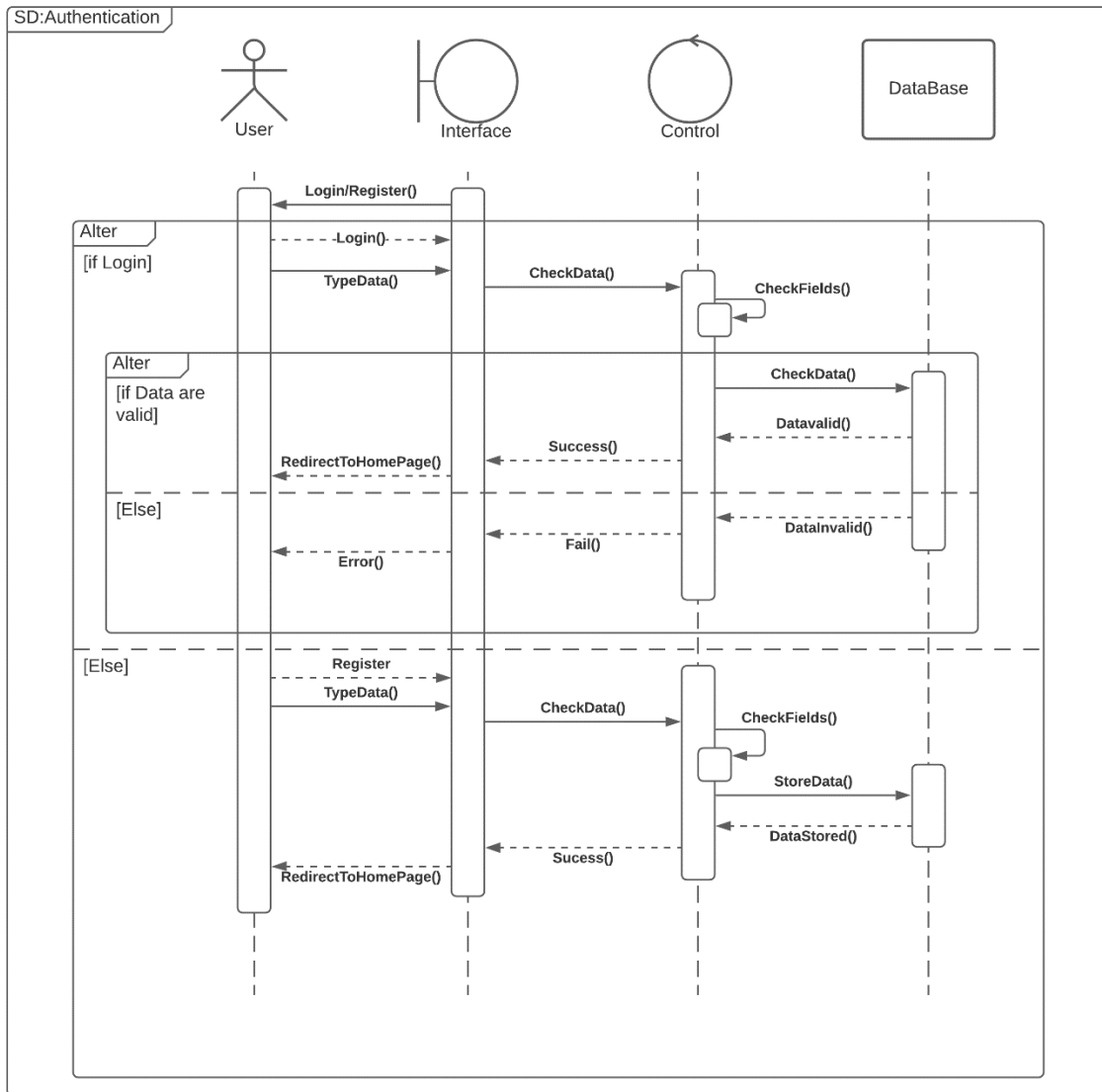


Figure 12-Sequence diagram of the authentication process

3.4.3 Class Diagram

The stored data of the application will be as following:

- A user is represented by an auto-generated id, full name, phone number, physical address, email address and a password, these data will be provided by the user during the registering process.
- An administrator is represented by an auto-generated id, a username, an email address, and a password.

- Every user is considered either healthy or not healthy (exposed), we call that a status, each status is represented by an autogenerated id and a value that implements the health status of the user (healthy/not healthy)
- If two devices containing the app make an interaction that takes more than two minutes, that interaction is taking by consideration and will be stored in the data base. An interaction is represented by a date of interaction and duration.

The figure below explains the information sited above as graphical form using UML Class diagram.

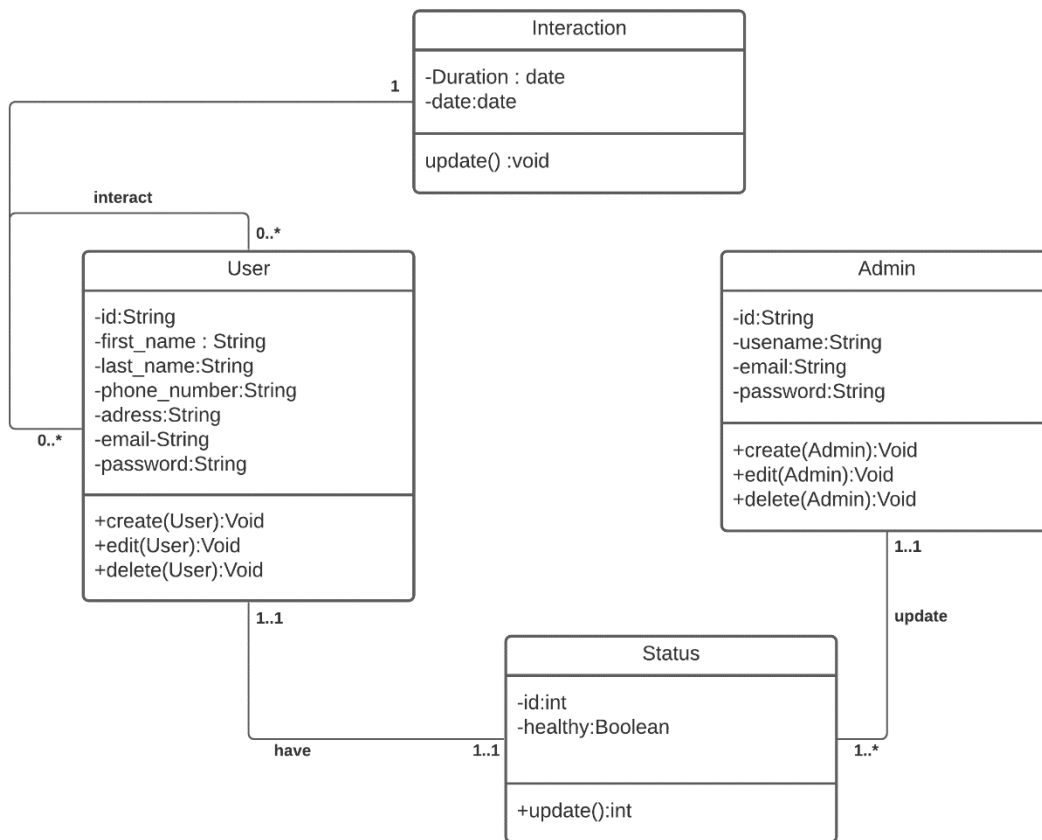


Figure 13-Class diagram, CovidTrack mobile app

3.5 Conclusion

Throughout this chapter, we have detailed the design of the system to be carried out using an object-oriented approach, in order to guarantee the reliability and efficiency of the construction phase. We have, therefore, presented the different UML diagrams used, namely: the class diagram, the use case diagram and the sequence diagrams represented with the visual paradigm.

The following chapter will be devoted to the actual realization of the application; where we will present the development, tools used and some interfaces of the App and Website as well as an explanation of how the application works.

Chapter Four

Implementation

4.1 Introduction

The development of a software product is a vast operation that can take a lot of time. It is therefore useful to divide the work into several parts which are so many mini-projects.

This phase corresponds to the production of a first usable version of the product. It is therefore strongly focused on design, implementation and testing activities. Indeed, components and functionalities not implemented in the previous phase will be here.

During this phase, the management and control of resources as well as cost optimization are the essential activities to achieve the product.

4.2 Problematic

This work focuses particularly on tracking the virus Covid-19 through the proximity sensors, to track sick users and control the spread of the disease and advise and inform the users with the right steps to do to prevent the spreading and stay healthy.

4.3 Proposition

using a mobile application as publicly used, and a website privately used by an administration, the app consists of getting the location of the users privately and keep track of users' interaction and store the interaction along with interacted users Id in the database for the later use

If any user of the application is declared as unhealthy or sick with Corona virus, the users that made an interaction with the sick user get notified that they have been flagged as suspicious and will be advised to visit the hospital for a test.

4.4 Solution

In order to realize this proposition and resolve the problematic described above, we created a mobile application for public users using Flutter in the frontend and Django Framework in the Backend. A website for private use and administrative works using Bootstrap 4 Framework for the frontend and Django framework for the backend.

The database of the app and the website is one multiplatform database.

4.5 Software and Tools

4.5.1 Visual Studio Code (VS Code)

Visual Studio Code is a lightweight yet capable source code editor for Windows, macOS, and Linux that runs on your desktop. It contains built-in support for JavaScript, TypeScript, and Node.js, as well as a large ecosystem of extensions for additional languages and runtimes (such as C++, C#, Java, Python, PHP, Dart, and Go) (such as .NET and Unity).

Visual Studio Code combines the simplicity of a source code editor with powerful developer tooling, like IntelliSense code completion and debugging [45].

First and foremost, it is an editor that gets out of your way. The delightfully frictionless edit-build-debug cycle means less time fiddling with your environment, and more time executing on your ideas.

4.5.2 Flutter

Google's Flutter is an open-source user interface software development kit. It is used to create cross-platform applications from a single codebase for Android, iOS, Linux, Mac, Windows, Google Fuchsia, and the web.

Flutter was first released under the codename "Sky" and ran on the Android operating system. It was announced during the 2015 Dart developer summit with the stated goal of rendering at 120 frames per second on a regular basis. Google released Flutter Update Preview 2, the final major release before Flutter 1.0, at the keynote at Google Developer Days in Shanghai. At the Flutter Live event on December 4, 2018, Flutter 1.0 was released [46].

4.5.3 Dart

Dart is a client-oriented programming language that can be used to create quick apps on any platform. Its purpose is to provide the most productive programming language for cross-platform development, as well as a flexible runtime platform for app frameworks.

Dart is also the backbone of Flutter. Dart not only powers Flutter apps with its language and runtimes, but it also helps developers with formatting, analyzing, and testing code [47].

4.5.4 LucidChart

Lucidchart is an intelligent diagramming tool that helps teams simplify complexity, align their insights, and design the future more quickly. Everyone can work visually and interact in real time while creating flowcharts, mock-ups, UML diagrams, and more with this straightforward, cloud-based solution.

Lucidchart is a collaborative web-based diagramming and flowchart program developed by Lucid Software. It's developed using web standards like HTML5 and JavaScript, so it'll work on any device with a browser. It's capable of producing flowcharts, iPhone app mock-ups, mind maps, organizational charts, website wireframes, UML diagrams, network diagrams, and a variety of other diagram types [48].

4.5.5 Django framework

Django is a free, full-stack, open-source website framework made with Python that promotes speedy development as well as clean, pragmatic design.

It was created by experienced developers to take care of most of the complexity of Web development, allowing you to focus on building your app instead of reinventing the wheel [49]

It is both free and open source and we can mention some of his main advantages:

- **Ridiculously fast:** Django was created to make it as easy and fast as possible for developers to get from concept to completion.
- **Reassuringly:** Django prioritizes security and help developers in avoiding numerous typical security blunders.
- **Extremely scalable:** Django's ability to expand swiftly and flexibly is used by some of the Web's busiest sites (NASA, Instagram, Dropbox, Spotify...)

4.5.6 Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built-in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed.

Often, programmers fall in love with Python because of the increased productivity it provides. Since there is no compilation step, the edit-test-debug cycle is incredibly fast. Debugging Python programs is easy: a bug or bad input will never cause a segmentation fault. Instead, when the interpreter discovers an error, it raises an exception. When the program doesn't catch the exception, the interpreter prints a stack trace. A source level debugger allows inspection of local and global variables, evaluation of arbitrary expressions, setting breakpoints, stepping through the code a line at a time, and so on. The debugger is written in Python itself, testifying to Python's introspective power. On the other hand, often the quickest way to debug a program is to add a few print

statements to the source: the fast edit-test-debug cycle makes this simple approach very effective [50].

4.5.7 Bootstrap 4

Bootstrap is a well-known and widely used CSS framework. It was created in 2010 by Twitter. This framework uses a 12-column grid layout, with four different sorts of displays depending on the width of the user's screen. We can customize the site's look based on the information provided by visitors. Bootstrap provides components that are attractive and simple to use since the release of version 3. The elements adjust to the screen's width by sliding one underneath the other when the width shrinks [51].

As previously stated, the adaption is also accomplished by a distinct presentation on the screen. Its Queries media, which are pre-programmed, have become vital for cell phones. The bootstrap site offers many examples of directly usable templates. Bootstrap is associated with the Less preprocessor, a language that offers many features, such as using variables and including portions of code. In terms of CSS frameworks [52][53], Bootstrap is a safe pick providing the following features:

- a) A responsive grid, CSS styles for all standard HTML elements (form, button, text, image).
- b) JS components such as dynamic drop-down lists, interactive navigation or carousel.
- c) a font that is actually a set of icons. The advantage is that the icons are not images but fonts, they are vectorized and therefore always sharp on all types of devices.

4.6 Implementation of Mobile App

4.6.1 Graphical charter

4.6.1.1 Logo

The figure below shows the logo used as an app icon launcher for the CovidOut app.



Figure 20 CovidOut Logo

4.6.1.2 Colors

Alongside with the black and white colors we used blue as primary color and other colors as secondary.

The figure below shows the colors used in the mobile app.



Figure 21- Colors used in the App

4.6.2 Authentication

If the user is new to the app, he has to register to continue using the app, the register process is relatively short, the user is required to only provide his email and a new password to continue.

If the user is already registered, they will have to log in using the email and password they previously provided in the register process.

The figure below shows the login/register interfaces

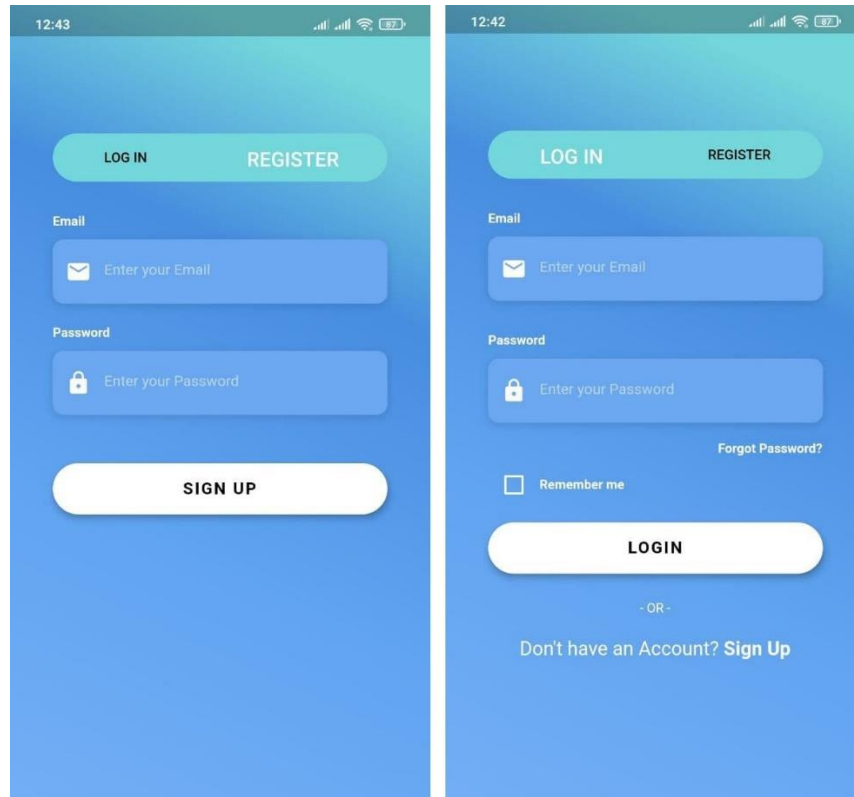


Figure 22- Authentication Interfaces

4.6.3 Statistic View

After the user authenticates, they will be redirected to the statistic page as the first view, this view consists of getting Algerian Covid-19 Updates from the internet and visualize it to the user as stats.

Moreover, the page contains some SVG pictures used to advise and remind the user with right preventions to stay healthy.

The figure below shows the Statistic Page of CovidOut App.

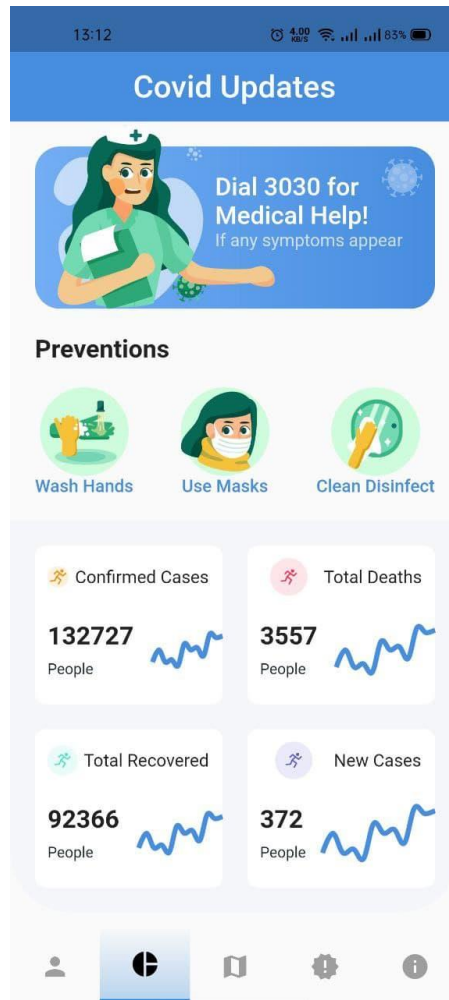


Figure 23- Statistic View of CovidOut App

4.6.4 Nearby Hospitals and Vaccination Centers View

The user can then navigate through the different views of the app using the bottom navigation bar. Among these pages, the Nearby Hospitals and Vaccination Centers page, this page will load a map with the hospitals and vaccination centers close to you pinned in the map after allowing the app to use the Location feature of the device to access your location and pin it on the map.

The user can use direction by clicking on the direction icon which will redirect them to Google Map app and shows the direction and calculate the distance and travelling time

The figure below shows the Nearby Hospitals and Vaccination Centers View.

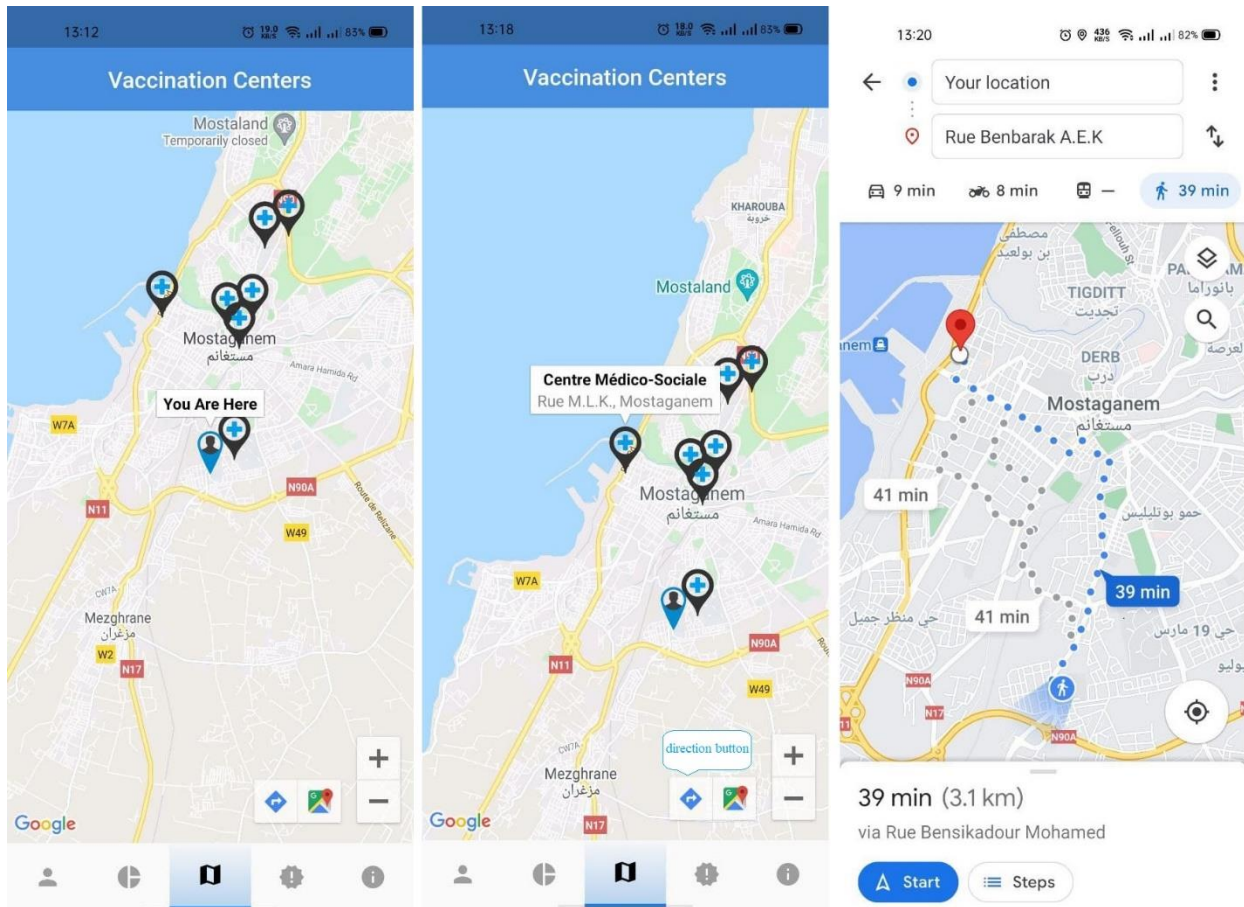


Figure 24-Nearby Hospitals and Vaccination Centers View

4.6.5 Newsfeed View

This view consists of displaying the news about Covid-19 in Algeria from the World Health Organization (WHO).

The figure below shows the WHO Algerian News updates



Figure 25- WHO Algerian News

4.6.6 Info View

This view is placed to advise the user about the symptoms of Covid-19 and the right preventions to keep away the disease

The figure below shows the Info view.

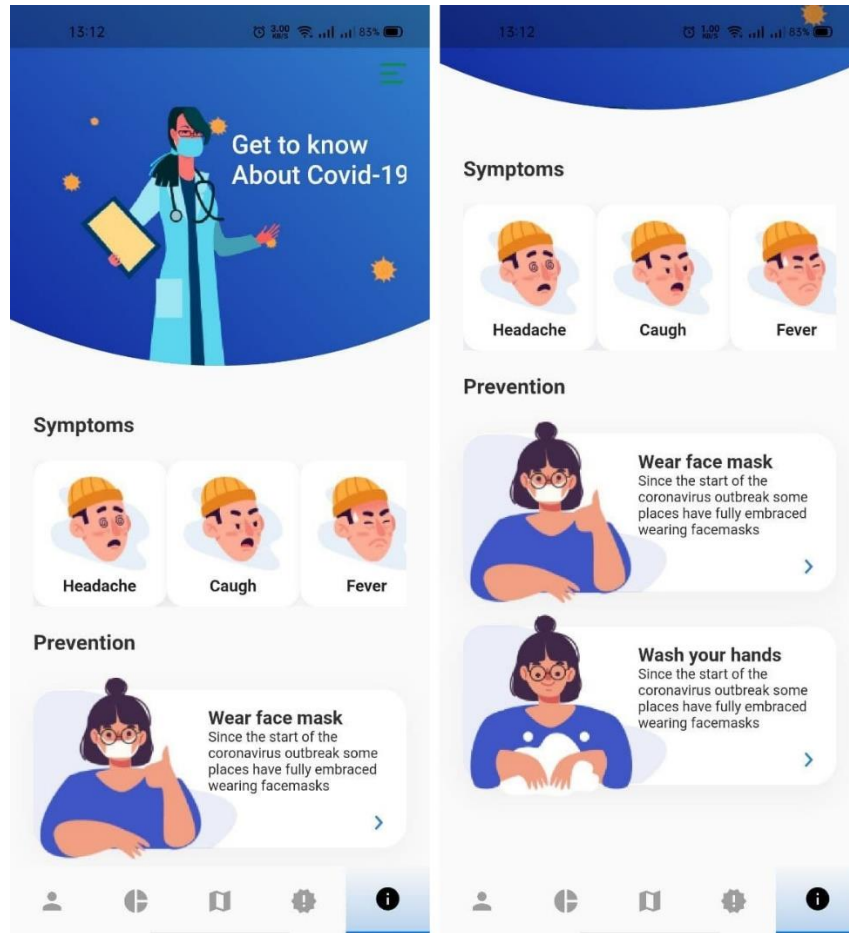


Figure 26-Info View of CovidOut App

4.6.7 Profile View

This Page will provide the user information including his name and ID and the email.

In this page the user can edit his profile by clicking on the edit field and access the info view by clicking on prevention tips field, moreover, the user can log out from the app and they will be redirected to the log in page

The figure below shows a profile example of CovidOut App.

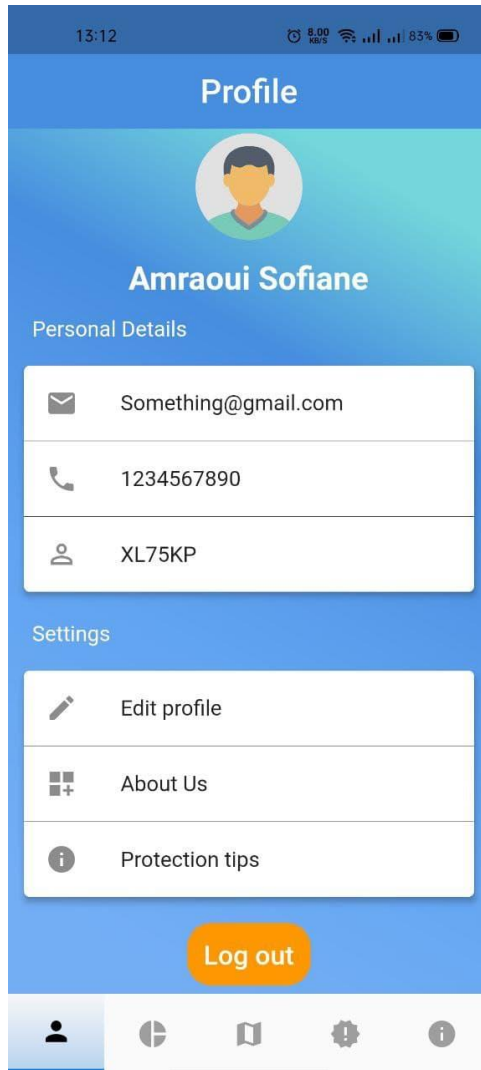


Figure 27-Profile example of CovidOut App

4.7 Implementation of the website

4.7.1 Graphical charter

4.7.1.1 Colors

Alongside with the black and white, the figure below shows the colors used in the mobile app.

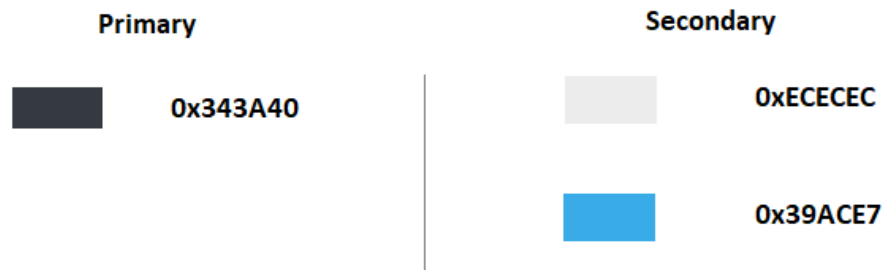


Figure 28- Color used on the website

4.7.2 Login

A simple user or visitor of this web site can only review the home page (statistic page), the other pages are reachable only with a login (email and password) created with the website developers for the authorities to make all the available functionalities. The figure below shows the login interface.

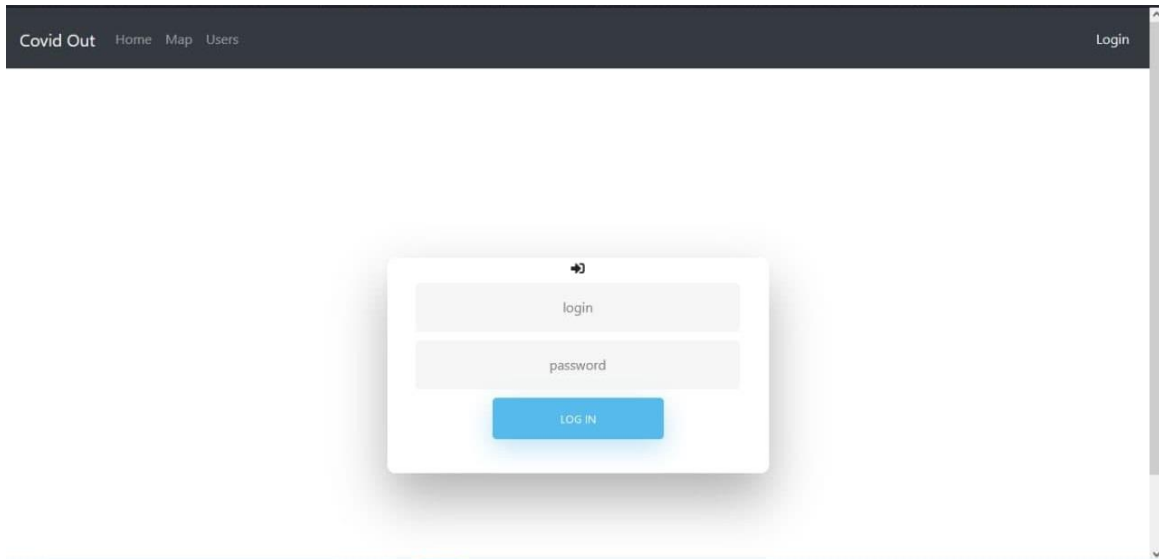


Figure 29- Login page

4.7.3 Home page View

The home page is reachable by any visitor and it represent the official COVID-19 numbers in Algeria provided by the Algerian health ministry and WHO implemented in our website with 2 APIs and we can see on that web page:

- The total number of cases since the beginning of outbreak in Algeria.
- Total number of people recovered from COVID-19.
- Total deaths.
- New daily recovered updated automatically each day.
- Today's COVID-19 cases.
- Clinically ill patients.
- Today's casualties from COVID-19

And some more statistics. The figure below shows the home page interface.

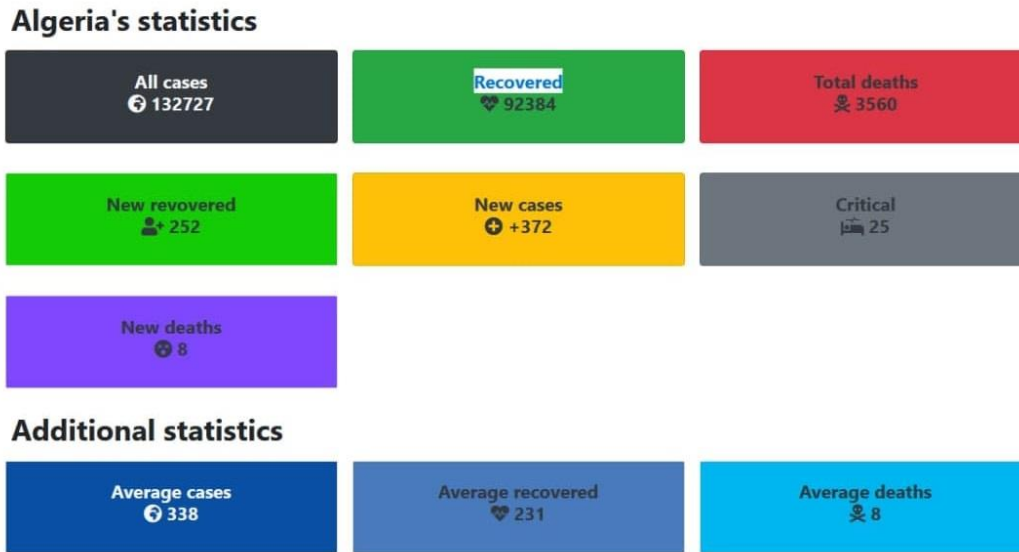


Figure 30- Home page interface

4.7.4 Map View

This interface represents a generated map using python folium library with our mobile application users placed on a map shown as markers with each marker with its description the figure below represents the map webpage.

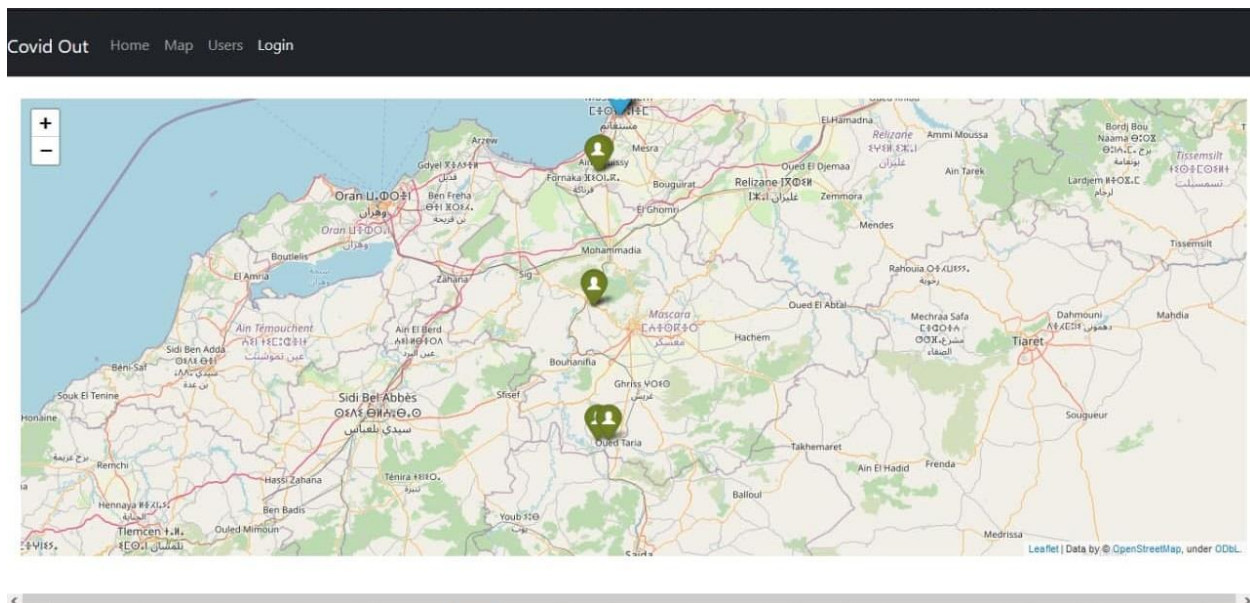
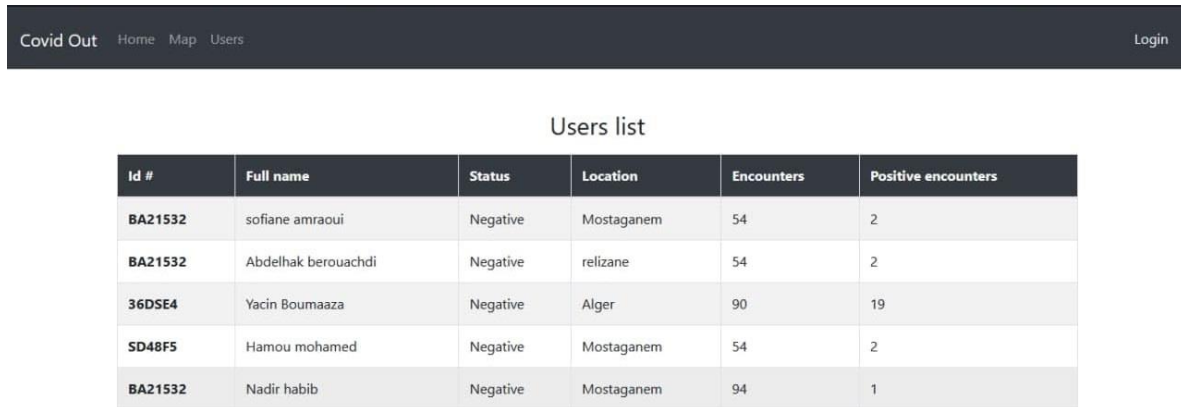


Figure 31- Map webpage

4.7.5 Users list View

This webpage shows all of our web page users with all of the necessary information of each mobile app users so the website admin can examine of user individually and this view is available only for the website admin, the figure bellow represents the users list.



Id #	Full name	Status	Location	Encounters	Positive encounters
BA21532	sofiame amraoui	Negative	Mostaganem	54	2
BA21532	Abdelhak berouachdi	Negative	relizane	54	2
36DSE4	Yacin Boumaaza	Negative	Alger	90	19
SD48F5	Hamou mohamed	Negative	Mostaganem	54	2
BA21532	Nadir habib	Negative	Mostaganem	94	1

Figure 32- Users' list interface

4.8 Conclusion

The implementation phase is the most important step in the lifecycle of an application. We tried in this chapter to explain our realization of the application on both mobile and web application according to our understanding. The results we have been able to have are the visualization of the changes in the descriptions of the covid tracking services.

General Conclusion

As electronic devices become low power and affordable, it is common for homes to contain an increasing number of them. These digital devices are connected by personal area networks. PAN is a wired or wireless communication network that allows digital devices on and near the human body to exchange information through nearfield electrostatic coupling. Although PAN is expedient and handy, it has its own inherent limitations. PAN is an emerging technology for future short range indoor and outdoor multimedia and data centric applications.

A comprehensive study of the architecture and protocols of Wireless Personal Area Networks (WPANs) has been conducted in this thesis. The objectives of introducing these new communication paradigms have been given first along with a brief definition of each technology.

The proposed network architecture for low rate and high rate WPANs and the differences among these network topologies have been described. Also, the proposed utilization of the Beacon technology in different domains. The flexibility, low-cost and low power consumption characteristics of the Beacon Technology make it the ideal choice to create an application that will help monitor and track the spreading of the actual crisis (COVID-19).

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