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Bachelor's Thesis

SMART FITTING ROOM: APLLYING IOT IN RETAIL ENVIRONMENTS

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A memorable 4-year journey full of joy, laugh, countless hours of studying and stress, finally comes to an end. I wish to express my sincere appreciation to my supervisor Dr. Lambros Lambrinos, for his patience and unstoppable guidance throughout my dissertation. Without his tireless assistance and cooperation, I wouldn't have managed to carry out my research to this extent. Closing this note, I wish to express my deepest gratitude to my boyfriend and friends for encouraging me throughout the entire procedure. Thank you very much, I am grateful.

ABSTRACT

Considering the needs and demands of contemporary society, this study follows a technological approach. The use of technology and precisely the Internet of Things (IoT), flourishes among miscellaneous sectors due to the innumerable benefits that it grants. It plays a fundamental role in creating more efficient operations, as well as reshaping and facilitating people's everyday lives.

The current thesis focuses on the implementation of IoT technology in retail stores. It pursues an experimental methodological strategy which involves qualitative data. Specifically, through the literature review and interviews which were materialized, the tracking process and facilitation of garments within retail environments, were proven to have been significantly lacking. These processes noticeably influence customers' service, as well as their experience and satisfaction. Hence, the development of a smart fitting room aims to enhance these segments and boost the store's functional operation. Briefly, a smart fitting room is the evolution of the stores' traditional changing room. The basic cabin is transformed to an enhanced consumer service environment, through the networked software and devices provided by the IoT ecosystem.

Keywords: Internet of Things, IoT, smart fitting room, retail, RFID, human presence sensor

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

IoT:	Internet of Things
RFID:	Radio Frequency Identification
GUI:	Graphical User Interface
EPC:	Electronic Product Code
RGB LED:	Red Green Blue Light-Emitting Diode
API:	Application Programming Interface

1 Introduction

In a world where device automation is rapidly expanding the boundaries and opportunities of every societal facet, it is observed that the link between virtual and physical worlds in retail environments is blurred (Piotrowicz & Cuthbertson, 2014). According to Ives, Palese and Rodriguez (2016), "business organizations are again challenged to understand how to evolve their value propositions to remain attractive to their customers as rapid technological evolution raises customers' expectations". It is a matter of fact that to meet their expectations, the company needs to think innovatively and perform its entrepreneurial activities efficiently (Caro & Sadr, 2019). For such achievements, Internet of Things (IoT) technology lends a hand, which according to Hassija et al., it "is the next era of communication" (2019). It is a global system of devices that interact with each other via the Internet (Mukhopadhyay & Suryadevara, 2014). A large percentage of retail companies are adopting the IoT technologies, in order to encourage customer satisfaction and retain their business (Thomas, 2019).

The retail industry faces significant challenges. One of these issues include the necessity for shops to provide a variety of products in the correct quantities based on customer consumption. It is often observed that this tsunami of merchandise leads to inventory inaccuracy issues (Caro & Sadr, 2019). It is a matter of fact that out-of-stock products are a major concern, due to the staff's lack of awareness concerning their shop's supply quantities at any given moment (Wu et al. 2009, as cited in Nayak, Singh, Padhye, & Wang, 2015). In addition, the inability of utilizing product tracking also results in an increased number of larcenies, due to the weakness and incapability of salespeople to diagnose a theft attempt punctually (IoT@Intel, 2019).

It is worth noting that, consumers are becoming more and more demanding and the expectations of their overall experience are getting higher. Therefore, stores need to be consumer-centric and perform efficiently in their interactions with clients, to fully satisfy them. Also, the application of RFID technology could contribute to labor minimization, since shopkeepers will be more aware of product quantities (Wu et. al., 2009, as cited in Nayak et al., 2015).

The challenges mentioned above, helped facilitate the aims intended to be presented in this experimental research. The goal of the study is to identify technologies from the

IoT domain, which could be integrated in novel solution that improve the shops' merchandise management. Simultaneously, it aims to reduce asset losses and pave the way for a successful customers service and enhance the consumer's experience. The terms "inventory management", "customer service" and "consumer's experience" are the research's key-concepts which are thereafter explained and analyzed within the "Theoretical Background" chapter. For the reasons discussed above, the existing research focuses on the development of a smart fitting room, using a combination of hardware and software tools. It requires "smart" devices and sensors, such as Radio Frequency Identification (RFID), human presence sensors, XBees, RGB LEDs and tablets, as well as the Android Studio software, for the creation of the required applications.

In conclusion, this special issue possesses a mixed method approach, with a combination of experimental and qualitative data gathering. Significantly, it focuses on strong theoretical and practical aspects of IoT potentials in retail. Additionally, the "Literature Review" section, includes state-of-the-art retail environment research based on the IoT concept. Further, the theories and key-concepts on which the stated research is relied on, are defined in the "Theoretical Background" chapter. Thereinafter, the methodology represents the overall research procedure, while describing the required tools and sample. The system's requirements are demonstrated within the "Requirement Analysis" chapter, while the overall system is analyzed in the "System Design". An in-depth commentary of the technologies used to carry this development out is addressed in the "Implementation" part. Finally, the "Conclusions" chapter underlines suggestions for future amelioration and reveals the difficulties that were found and confronted throughout this research project.

2 Problem Description – Study Necessity

We live in a world where technology and more specifically IoT, plays an increasingly vital role in our daily activities. The ecosystem of IoT is recognized as a key component in device management and monitoring transformation (Elnashar, 2019). The Gartner Research Company estimated that by 2020, there will be around 25 billion smart devices, which will improve the quality of our life (Johnson & Burkett, 2015). However, four years later another research predicts that by 2022, this number will be doubled (Elnashar, 2019). Hence, practitioners and academics are truly interested in studying and exploiting IoT technology (Xia, Yang, Wang, & Vinel, 2012). Nonetheless, few studies have focused on the implementation of IoT in retail environments. Therefore, many problems and challenges are awaiting to be addressed in this sector (Gong, 2016; Nguyen & Simkin, 2017).

Consumers' expectations of their shopping experience in retail shops, keep rising rapidly. It was shown that simple omissions often have significant negative implications. Alluding to these shortages, salespeople need to remember a shopper's face, the garments he/she selected and the number of the dressing room he/she has been assigned to, in order to make recommendations on alternative or additional items one might like. If staff members cannot rely on their memory to recall this information, they would have to write it down, which is an extra burden for them. Besides that, it is a well-known fact that the inadequate number of staff members, doesn't allow the efficient service of many shoppers. Hence, there are consumers who often leave the store with minimal, or even no assistance at all, which is in essence a negative shopping experience (Patent No. US6313745B1, 2001). To that extent, the consumer's experience is minimized when he/she thinks that the store's services didn't reach his/her expectations (Te-Lu & Lien, 2014).

Moving to the technological part, another drawback which is observed, is the fact that the exploitation of RFID technology for garment tracking is error-prone, due to the massive variety and number of moving products within the store. To be more precise, the application of RFID can recognize the shop's garments and their location, but not the ones inside the fitting rooms. Such information could be vital for shop clerks, since they can recommend other products based on what clients are interested in (Hauser, Griebel, Hanke, & Thiesse, 2017) and ultimately create potentials for further purchases.

According to a blog at Intel’s website (2019), numerous shortages are observed related to the garments of the store. Examples of these deficiencies are out-of-stock or overstocked products, as well as their misplacement in the store by consumers. After all, it is common for customers to leave clothes having previously tried on, in a random place within the store. This action makes it difficult for salespeople and other consumers to detect their whereabouts. Unfortunately, these errors can negatively affect behaviors and their overall shopping experience. Particularly, customers could conclude their loyalties with the brand therefore, leading to the company’s loss of large amount of income (IoT@Intel, 2019).

Despite this, a worrying reality is the large number of thefts which are accomplished within the retail context. It is almost impossible for retailers to instantly notice that a product among hundreds is missing from the store (IoT@Intel, 2019). As studied, shoplifting usually happens inside the fitting rooms, where consumers can easily conceal the items they are not willing to purchase. When the dressing room staff is called to undertake another duty, changing rooms are even more vulnerable to theft (Patent No. US 7,123,146 B1, 2006). Consequently, this causes billions of dollars in losses annually to retail industries. The most common security measures currently taken, are staffing a couple of salespeople or guards at the stores’ exits, or using video surveillance systems to follow up any suspicious actions. However, these practices are not cost effective or truly efficient concerning the detection of illegal acts (Patent No. US 7,920,063 B2, 2011).

According to Roberti (2016, as cited in Caro & Sadr, 2019), retail industries can leverage the vast majority of IoT potentials and perform more efficiently. It is possible to provide information about the merchandise to the consumer, as well as afford personalized suggestions, based on the shopper’s consumption habits. These techniques are undoubtedly granted by smart devices and can lead to in-store sales increment, while improving the customer's shopping experience (Roberti, 2016, as cited in Caro & Sadr, 2019). Moreover, by integrating interconnected smart devices and especially the RFID technology, it is possible to locate each product and its moving direction (Patent No. US

7,920,063 B2, 2011). Through this security method, supply control is achieved and concurrently, theft attempts can be recognized and prevented.

Taking everything into account, retail industries appear in some cases, to provide inadequate customer service and insufficient inventory handling for the enhancement of the customer's experience. These elements are important for this research, since its main objective is to develop a smart dressing room that fulfills the aforementioned criteria. As said earlier, there are limited studies related to the exploitation of IoT in retail industries. For that reason, there is a need to bridge the observed gap, by utilizing the latest and most innovative solutions and technologies of IoT. This special study comprises a state-of-the-art analysis of the implementation of IoT in retail context, and by doing so, intends to encapsulate the existing literature within a theoretical and practical spectrum.

Consequently, the following research question was put forth: "How can a Smart Fitting Room improve inventory tracking and customer's service and enhance their in-store experience?". Therefore, the main objective of this paper is to promote the development of a system – namely a smart fitting room, that could alleviate the impact of the already cited issues, by delivering better customer's experience and enhancing asset control at the store.

3 Literature Review

The current chapter begins with presenting generic applications of IoT and gradually reaches a more specific dimension; a state-of-the-art analysis which outlines previous applications related to smart fitting rooms. Through the study of previous research, the issues existing in retail areas are identified. It is worth noting that the association between previous works and the current research, is the deployment of a smart dressing room, which would minimize significant in-store issues as much as possible and simultaneously enhance consumer's experience, and the store's inventory operation.

To begin with, IoT technologies are applicable in numerous sectors. Sensor-based applications were initially deployed to serve the aerospace manufacture and factories' automation (Caro & Sadr, 2019). Nowadays, IoT spans in multiple domains which consist of cities and transportation, logistics, homes, hospitals and healthcare, agriculture and farming, supply chain operation and many more (Tyo, 2006, as cited in Caro & Sadr, 2019; Porkodi & Bhuvaneswari, 2014). The immense number of smart devices and sensors used in these fields, provide services which collect and manage data, and help accomplish human's objectives (Porkodi & Bhuvaneswari, 2014).

Concerning the retail business environment, it is generally agreed today that the deployment of IoT connected devices brings to light new innovative opportunities, which could be incredibly beneficial for both the company and the consumer (Miller, 2015). To be more precise, IoT contributes to creating new operations for the retail company and improving its existing ones, as well as ameliorates the way it serves customers to a large extent. These actions subsequently improve customer service and enhance in-store experiences (Gregory, 2015).

Various companies succeeded in enhancing consumer behavior or/and increasing their sales by exploiting IoT. One example is "Dohle", a German grocery store that deployed smart shopping carts at its stores, which provide details about available products. In addition, they can collect and store information, and answer any questions that shoppers may have. Apart from these, the evolved shopping carts allow consumers to automatically check out their groceries, without needing to wait in line (Balaji & Roy, 2016). Even though the tools that were used for this development are not referenced anywhere in the research, it couldn't be omitted that its operations could be truly efficient. Precisely, they allow a bidirectional interaction between shoppers and technology, which leads to the enhancement of customer service and consumer's experience.

Another example is a jewelry store named "BaubleBar". Inside this store, interactive screens, sensors, and recognition technologies were established, in order to create a unique and memorable experience to visitors. These elements provide additional information for each product in the form of animations. To be more definite, the system recognizes a product as soon as it gets picked up by a client and the interactive screen starts displaying animations and giving extra details about that particular product (Balaji & Roy, 2016).

Moreover, the ulterior aim the famous designer "Hugo Boss" managed to accomplish by using smart devices, was to increase its in-store sales. In order to accomplish its goal, infrared sensors were placed in several spots of its store in London, which recognized the shoppers' movements by tracking their body heat. Given the above, the exact areas which have the highest traffic were recognized. Shopkeepers had placed quality and perhaps profitable products in these aisles, and achieved higher sales (Dlamini & Johnston, 2016).

A truly useful application of RFID technology was accomplished by the manufacturer "American Apparel", at eight of its stores. It should be noted that such a technology benefited the company by improving the management of the shop's inventory and by extension conserved 60 – 80 hours of labour. In the meantime, RFID utilization contributed to minimizing of out-of-stock goods, which were due to store managers' unawareness regarding the quantities of products. Likewise, a Japanese clothing company called "Sankei", applied this technology with the aim of tracking garments whilst manufacturing operations took place. Therefore, this company managed to speed up its processes and was more aware of its product quantity (Wu et. al., 2009, as cited in Nayak et al., 2015).

Various fitting room applications were proposed and/or deployed, in an attempt to deal with the problems identified within the retail sector. One example, is a system developed by Suzuki (Patent No. US6313745B1, 2001), which recognizes the merchandise brought into a dressing room. In order to achieve that, the following tools were required: wireless tags, antenna/receiver, a server and store clerks' and customers'

ID cards. In more detail, each store's item had an embedded wireless tag with a product identifier; that made it recognizable by the antenna placed in the interior of the fitting room. As soon as the customer makes his/her way into the fitting room with the garments, the store's server collects the product's information through the identifier and transmits it via an in-store terminal to the salesperson. Apart from these, the server also examines the characteristics of the product, such as its style, color and brand and suggests to the customer other items, based on the features of the ones that he/she took in the dressing room. If the shopper presents his/her customer ID card, then the recommended items also depend on the customer's profile and purchase history (Patent No. US6313745B1, 2001).

It is an efficient system that can recognize the garments taken into the fitting room and provide recommendations to the shopper on other garments he/she might be interested in. Thus, such a system can contribute to providing better customer service, enhancing product control, and giving the consumer a unique experience. Even though Suzuki's work (Patent No. US6313745B1, 2001) explains the system comprehensively, there is no report of the exact tools (e.g. the kind of wireless tags) that were used for the development of his operation.

By the same token, Hauser et al. (2017) deployed a system that could recognize the products brought in a changing room, aiming to provide additional services to potential customers. Hardware sensors were used to collect data, which is then handled by a software-based unit. This unit is responsible for determining the exact position of garments by comparing their real-time measurements with their marks at several spots. The hardware tools that were used, consist of a ceiling-attached low-frequency RFID reader and an antenna array with 52 wide-range antenna beams. The software components include machine learning and probabilistic models, which are in charge of identifying products inside the cabin. The experiment was applied in three fitting rooms (Hauser et al., 2017). This approach was described in detail and it listed the hardware and software-based technologies which were leveraged.

Furthermore, a different experiment pursued in a store but hasn't been adopted permanently by it, contributes to the garment-tracking process, by providing an interactive dressing room experience to the shopper. Specifically, when somebody enters the changing room, he/she is recognized through a facial recognition, biometric information or password. The garments taken inside, are identified via their RFID tag and displayed on the interactive mirror which is placed there. This mirror shows further details concerning the product and suggests extra garments or accessories. Besides that, the touch-surfaced mirror, has a Graphical User Interface (GUI) capability, which allows the consumer to interact with it, by requesting another item that is displayed, or even conform the fitting room environment. To be more particular, the user can adjust the lighting, customize the background of his/her reflection, and draw anything he/she likes on the surface. Besides these services, the changing room delivers the possibility to the consumer to complete a purchase just by interacting with the mirror (Patent No. US 10,366,174 B2, 2019).

By evaluating the system, it is concluded that the user's experience might not be enhanced after all, since it may lead to extending a client's time spent in the dressing room. Even though a satisfying experience will be provided to the person having used it, this will no doubt cause dissatisfaction among customers awaiting to be assigned a dressing room. On that account, a suitable and efficient fitting room should offer services that could improve the customer service, but it is crucial not to make the consumer overstay their welcome longer than necessary. As a consequence, changing rooms demand the creation of a remarkable consumption experience to every individual, whether he/she is inside the room, or waiting in line.

Summarizing through the study of prior literature, it is evident that a gap does exist within the retail environment. In addition, the attempted solutions suggested by previous practitioners helped form the purpose of this research. Particularly, the aim of this work is to apply IoT technology in retail industries, in order to differentiate and improve the way consumers experience shopping. Furthermore, this study addresses the goal of enhancing business' inventory administration, regarding garment tracking and shoplifting minimization.

To meet the objectives, the present work focuses on the design and implementation of a smart changing room, by which, consumers can experience a unique digital interaction with the store. As soon as the person enters the cabin, the garments that he/she took are recognized via RFID technology and are displayed on the tablet. The screen informs the user about alternative sizes and colors of these products and allows him/her to request one from the salespeople, without exiting the changing room. The store clerks can easily and quickly identify the location of the product through RFID technology and offer it to the consumer. Summarizing, embracing IoT in retail stores has foreseen a modification in the way consumers experience shopping, and thereby gives a long-term visualization for its exploitation in that sector (Balaji & Roy, 2016).

4 Theoretical Background

The key-concept on which the current research is based on, is IoT. This evolving technology can be ingrained in solution implementations that could significantly boost the industry’s inventory handling, and subsequently minimize shoplifting. Besides that, IoT can enrich customer service, which in turn has the potential to enhance the consumer's experience. The terms “consumer experience”, “customer service” and “inventory management” have been extracted from previous research and are explained and analyzed thereafter.

4.1 Internet of Things (IoT)

“A revolution is happening via the Internet of Things (IoT) – one that will have tremendous impact on the world as we know it”, according to Nguyen and Simkin (2017). Particularly, the IoT era refers to a global system of networked computers, sensors and devices, which communicate with each other under a common infrastructure (Constantinides, 2016, as cited in Gong, 2016). Under this “umbrella”, intelligent devices keep human beings informed about the condition of things and provide them the capability to control situations around them (Madakam, Ramaswamy, & Tripathi, 2015). In other words, ubiquitous internet allows everyday objects to acquire another dimension, through interconnectivity and “smart” advancements (Hoffman & Novak, 2015, as cited in Nguyen & Simkin, 2017). The concept of IoT will revolutionize the concept of things which exist in the real world, into “smart” - digital ones (Madakam et al., 2015), and to that extent provide many opportunities that fulfill human needs and improve their quality of life (Xia et al., 2012). The IoT can be exploited in and benefit a long list of domains, such as in cities, homes, the environment, retail industries and many more (Elnashar, 2019).

4.2 Inventory Management

IoT can play a fundamental role in retail environments, in terms of enabling and enhancing capabilities. In particular, its adoption can benefit both the company and the consumer, especially when it comes to supply handling (Caro & Sadr, 2019). Inventory management, according to previous studies, is the controllability and tracking processes of a business’ assets, where each object passes through a counting cycle (Ramakrishnan, Gaur, & Singh, 2016). Assets are extremely important for an enterprise, whether they are high or low value, and for this reason they need to be securely managed (Wang, Tan, & Li, 2015). An efficient supply operation can be accomplished through the advent of IoT, since such a technology allows recognition of every single object of the store, whilst offering the potential to further benefit the company in terms of theft detection and prevention (Ramakrishnan et al., 2016).

4.3 Customer Service – Consumer’s Behavior

Ramakrishnan et al. (2016) stated that inventory management is key in customer service. It is expressed that customer service is a “persuasive, boundary-spanning activity that takes place from within and beyond the firm” and is a major component to be considered, when a retail company is evaluated (Innis & La Londe, 1994). In light of this view, an efficient asset management system can give insights to the store clerks about the availability and the exact location of each product. Hence, they are capable of providing qualitative assistance to the customer by delivering him/her the desired item it faster.

Another point to take into consideration is a retail company’s customer service, having a major impact on the consumer’s behavior. The theory of consumer’s behavior, claims to be the study of procedures, where people or groups of people choose, purchase, use or reject products, services, ideas, or experiences, in order to fulfill their needs or desires (Solomon, 2018). To put it more simply, the theory is based on the question “why people buy?”, which studies and analyses consumer’s consumption: the reasons behind individuals purchasing specific products or services (Blackwell, Miniard, & Engel, 2006). The consumer’s behavior is greatly affected by the environment in which he/she is in (Kotler, 1973). Therefore businesses need to understand their consumers’ behavior, in order to develop strategies that can influence them efficiently (Blackwell et al., 2006).

4.4 Consumer’s Experience

The behavior of the consumer plays an important role in shaping his/her final experience. As stated by Janiszewski (2009, as cited in Schmitt, 2010) “benefits are not in the products. Benefits are in the consumer experience". The meaning that derives from this standpoint, is that consumers' interests don't only depend on the product itself, its quality and the benefits they can receive from it (core product), but on the experience that it provides (augmented product) (Kotler, 1973). Consequently, retailers need to re-evaluate their store's environment and services, in order to generate a remarkable and unforgettable experience for the consumer.

4.5 Human Presence Sensor

In order to transform the basic fitting room and provide a unique shopping experience to consumers, as well as an efficient garment management by the staff, a list of hardware is required, which is a crucial part of IoT. Beginning with the human presence sensor, according to the manufacturer Seeed (n.d.), it can be used to detect humans or any other infrared objects that are within the sensor's three meter range – the maximum distance from which it can read information (Nikitin & Rao, 2006). It consists of four IR sensors and an integrated circuit for characteristic compensation, which contribute to detecting motion, as well as the direction toward which the person moves (Seeed, n.d.).

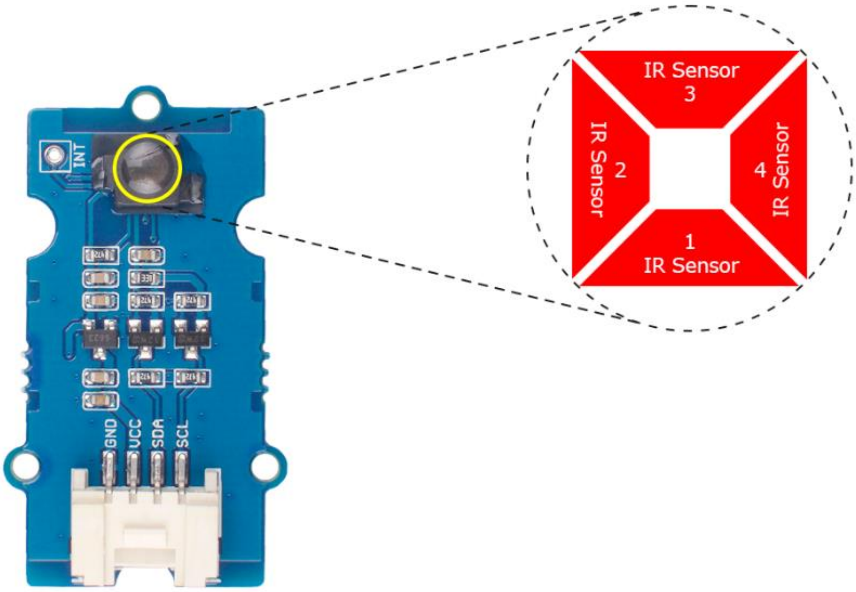

Figure 1: Human Presence Sensor (retrieved from Seeed's website)

4.6 Radio Frequency Identification (RFID)

Moving forward, another key component of the smart fitting room implementation is Radio Frequency Identification (RFID). RFID is one of the most promising technological innovations (Dutta et al. 2007; Whitaker et al. 2007; Bottani et al. 2009, as cited in Nayak et al., 2015) and it refers to the transmission of data using radio frequency waves. It can read and collect data from tags or smart labels from a distance and without a line of sight. It is similar to barcodes, where a device collects data from a tag or label, however its advanced system also communicates without any human intervention. Also, RFID allows two-way communication and can store up to 1000 data bytes (Nayak et al., 2015).

Each RFID system consists of at least two segments: the RFID reader (or transceiver) and the RFID tag (or transponder), but other components such as antennas, middleware, edge servers and application software can also be used (Nayak et al. 2007; Rao et al. 2005; Chao et al. 2007, as cited in Nayak et al., 2015). The reader is responsible for communicating with a tag, so it is continuously sending out radio waves (Want, 2006). The RFID tag is a small label, which can be built into an item, a person, or an animal. It includes a very small chip that stores the Electronic Product Code (EPC), which is a unique identifier of the item and stores information about the product (e.g. the name of the company, price, etc.). It also contains an antenna which is in charge of responding to and receiving radio frequency queries from an RFID reader or antenna (Sarma et al. 2001; Myny et al. 2010, as cited in Nayak et al., 2015). When an object that has an embedded RFID tag is in the range of the reader, its tag transmits the data of the EPC to the reader. Hence, the RFID reader can identify or track more than one object, as long as it is in the distance that it can reach (Want, 2006).

In line with prior research, there are three types of RFID tags: passive, semi-passive and active tags. Passive RFID tags do not have a built-in unit for power provision, e.g. a battery, and for this reason, they are tiny and cheaper in comparison to semi-passive and active tags. Passive tags are comprised of an antenna which is powered via the electricity produced by the reader’s radio frequency waves. Given this, the tag has enough power which allows it to be activated and to respond back to the transceiver (Bouet & Dos Santos, 2008, as cited in Nayak et al., 2015). Its range spans from around

2mm up to some meters, depending on the RFID reader's characteristics (Nayak et al., 2015; Nikitin & Rao, 2006).

Moving on to semi-passive tags, are these have an onboard battery (Zhang & Amin, 2006, as cited in Nayak et al., 2015), which allows the tag to be supplied with power continuously (Li et al., 2009, as cited in Nayak et al., 2015). However, in order to transmit its data to the reader, it relies on the signal coming from the reader. By virtue of their battery, semi-passive tags have a greater read performance (Che et al., 2010) and respond faster than passive tags (Nayak et al., 2015). Another advantage of this kind of tag, is its hardware platform, which allows various sensors' operations (Che et al., 2010).

Lastly, active RFID tags have their own power source (Ni et al., 2004; Jin & Lu, 2006, as cited in Nayak et al., 2015), which lasts for up to ten years (Nayak et al., 2015). It allows them to send a stronger signal and hence can be accessed from a greater distance by the reader and transfer to it their data (Weinstein, 2005). Apart from their bigger operating range, they also have larger memory compared to passive tags. According to Nayak et al., active tags are about the size of a coin (2015) and they are mostly used in bigger-sized items that need to be tracked from far away (Weinstein, 2005).

Figure 2: RFID tag (retrieved from Nayak et al., 2015)

Nowadays, RFID technology is highly utilized in the apparel sector, due to its positive impact in warehousing, manufacturing, logistics, distribution, asset detection, as well as supply chain operations (Nayak et al., 2015). Some manufacturers that have already applied this technology are Tesco, Walmart, Procter & Gamble, Prada and CVS. Its tracking capability also contributes to other areas such as healthcare, agriculture operations, environmental monitoring, transportation, animal tracking, security and theft prevention, tracking library books and military (Jia, Feng, Fan, & Lei, 2012; Nayak et al., 2015).

5 Research Methodology

The current work follows a certain methodology in order to achieve its goal. Specifically, its approach is mainly based on an experiment, whose implementation also requires qualitative data. The experiment is developed to minimize the aforesaid issues as much as possible.

5.1 Research Tools

Before the actual smart fitting room implementation, semi-structured interviews with open-ended questions were conducted. The questions focus on inadequacies noticed within the retail sector, as well as on the personal views of the interviewees, related to the implementation of such technology. Through these interviews, it was also possible to further grasp these problems to a greater extent and confirm or contradict the ones that have been distinguished and encountered in prior literature. From a technological perspective, the required hardware tools include an RFID reader, antennas, and passive tags, in order to achieve garment tracking. Also, a human presence sensor is needed to descry the consumer when entering the dressing room, as well as XBee modules, Arduino boards, base shields, XBee shields, leds, and tablets. This hardware is provided by the Department of Communication and Internet Studies at the Cyprus University of Technology. Along with the hardware, tools for software development (Android studio, XCTU, database) will be utilized, in order to develop the necessary software components (applications, database etc.).

5.2 Sample

The sample of this work consists of consumers within retail stores, regardless of gender and age. The current study will follow a convenience sampling method for the collection of qualitative data. Initially a decision was made to conduct interviews with consumers, as well as shopkeepers of retail stores located in Larnaca and Nicosia. These areas were chosen on account of being easily accessed by the researcher. It is worth noting that, the number of interviews was not decided in advance, since they will be conducted until they reach information saturation. Unfortunately, due to the global coronavirus pandemic, interviews with shopkeepers were unattainable. It is expected that in the future, the experimental system will be deployed within a retail store in Larnaca, so to observe the changes that its implementation could have in the whole operation of the business, as well as in consumers' behavior.

5.3 Experimental Procedure

For the execution and development of a smart fitting room, a strategic procedure is required. The appropriate approach considered within the current research is the waterfall model, which according to Bassil (2012), is a sequential process of software development. Its evolution can be associated with a waterfall, since it follows a downwards increasing flow of phases, which are essential for the execution of a system. This model comprises of five stages and the moving procedure from one phase to the next, occurs only after the preceding one is checklisted and completed (Bassil, 2012).

The first phase is called "requirement analysis" and it includes an in-depth description of the possible criteria and requirements of a "smart" dressing room, as well as any limitations and difficulties may occur. The second phase is that of the "design", where the system's architecture is defined and its overall structure formed, including the necessary hardware and software elements. The "implementation" stage includes the system's code development and hardware integration. Following this, the smart fitting room system enters the "testing" phase, to ensure that it meets all requirements and any software errors are rectified. Finally, post system installation is manifested within the "maintenance" process, in which the smart changing room's system gets modified. This is done in order to enhance its operational efficiency and solve any problems detected, as well as implement new user requirements (Bassil, 2012).

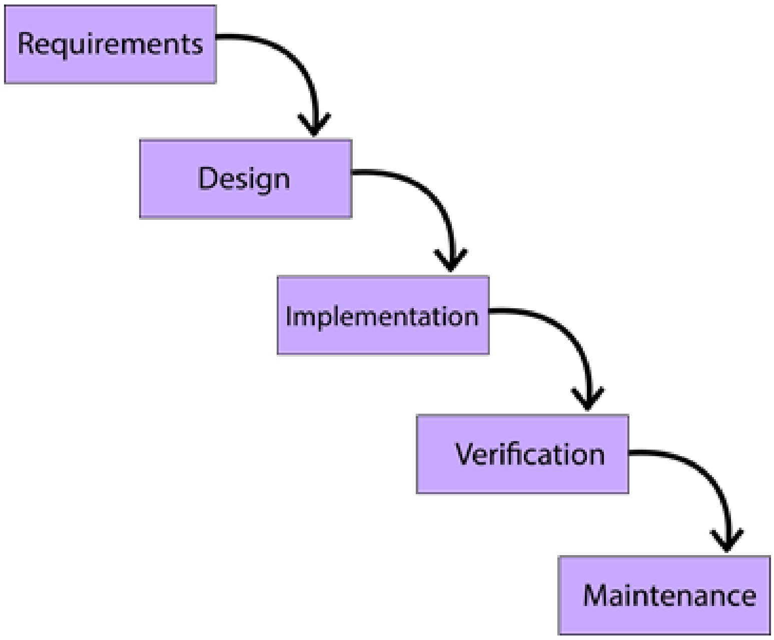

Figure 3: The Waterfall Model (data was taken from Bassil's article "A Simulation Model for the Waterfall Software Development Life Cycle")

6 Requirement Analysis

As explained, this stage describes the requirements of the system, as well as any difficulties that might appear. Since the deficiencies and issues of stores are recognized, the current system needs to be effective enough to cover them. In detail, the fitting room should be able to assist consumers and accord them a unique shopping experience. In order to succeed in this, the smart changing room will inform them about size availability and color variation of each product. Aside from that, customers will be able to request for different size or color of a product, without leaving the cabin. These opportunities will be offered to the consumers through an application that will be installed on a tablet inside each fitting room.

Another objective of the stated research is to track every item and in effect, help store managers and employees control supplies. By knowing where every product of the store is, they can provide it faster to the client. Also, they will be aware of the quantities of products and obviate out-of-stock items. A staff application is suitable for these requirements, which would display the location of a requested product (e.g. shelf 2) by just pressing a button. Beyond this, it should inform them about the state of each fitting room (occupied/empty), how many and which items are in each one – if there are any - and whether a customer needs assistance.

Additionally, each segment appends information to a database, which is then extracted and combined to draw conclusions and proceed to pertinent actions. For this reason, the communication between the system's elements is of paramount importance. Without correct communication, the data will not be credible and thus, the proposed system cannot achieve its goals.

Another issue that might occur is the fact that people are not keen to try out such technologies in retail stores. Hence, it is possible that shopkeepers will have a negative outlook on the implementation of such technologies within their stores. Equally important is the potential lack of consumers' knowledge regarding the use of tablets. If they are not technologically literate, they will not use these technologies during their shopping. Therefore, it was essential to learn about people's opinions regarding the use of technology in retail environments before its actual implementation.

Due to the corona virus restrictions, even though store clerks' interview questions were prepared in advance (see Appendix I), they could not be carried out. The aim of these interviews was to further investigate the discomforts and shortages within retail shops and how they affect the store's operations, consumers' behaviors, and experiences. Moreover, the intent of the interview was to target shopkeepers interested in the utilization and application of such technologies within their stores.

Fortunately, consumers' interviews still went ahead and were accomplished through internet communication platforms. Precisely, they were in the form of a questionnaire with open ended questions (see Appendix II). The questionnaire's content included more general questions at the beginning and gradually moving on to more specific ones. Initially, the questions were about the interviewee's familiarity with technology, then about any discomforts she/he may confront within stores and fitting rooms. The final questions encouraged people to express their opinion concerning the exploitation of technology in the stores and whether they would make use of it. The questionnaire was published on social media and 60 participants took part, of whom 33 were women and 27 men, aged 18-60. Before sharing the questionnaire, a pilot study was conducted, which consisted of 8 participants. This procedure was followed to help diagnose any mistakes and make sure that the questions were completely understandable by the interviewees.

The answers gathered from the interviews have shown that half of the participants are currently using technologies whilst shopping. Moreover, one of the problems consumers have identified, is spending too much time searching for specific items when they are sold out. Further, they noted that crowded fitting rooms and long queues at the cash register, are also prominent issues, usually due to bad customer service care. Others have reported that cluttered stock also leads to having a negative impression on the store. These issues were also identified through research in academic literature. However, some people mentioned further issues encountered: the absent prices on garments, thus compelling them to seek a staff member's assistance, as well as the small number of store assistants leading to unsatisfactory service.

The majority of consumers have rated the received customer service as average. When in need of a specific item or a different size/color of a product, 78% of the interviewed participants said to have asked for staff assistance, since they don't want to waste their time searching for it. A percentage of 96.7%, stated to have used the dressing rooms whilst shopping, mostly for 10-15 minutes. Moving forward, 70% of interviewees would be interested in using new technologies in a store, if available.

When the consumers were asked about any advanced services they would like to use in the fitting room, many of them reported that a button or something similar to call the clerks would be helpful, as well as an indication of which cabins are available to be used. Furthermore, some people expressed that it would be interesting if changing rooms included an interactive screen that would allow them to ask for help, e.g. to receive a different size/colour, or view other available clothing. Last but not least, 50 participants commented that the ability to request a product without leaving the dressing room, would be truly beneficial, since it would save them effort and time. Out of these 50 participants, 30 were women, mostly between the age of 20-25 and 20 were men aged 21-36.

7 System Design

As previously indicated, the stated research focuses on the deployment of a system – namely a smart fitting room, that would benefit the environment of retail shopping. The current chapter demonstrates the overall system architecture and its functionality. Furthermore, the system's operations address the needs it is called to cover, which were recognized in previous chapters.

7.1 Structure

The system consists of several sensor devices, boards, and applications, which all together form a completed development. It is divided in two generic units: the fitting rooms and the rest of the store's floor. The fitting room section contains an application, an RFID system and IoT controller and sensors. Similarly, the shop floor includes RFID technology, an application and IoT controller and sensors. Although these two parts correspond to diverse operations of the system, the produced data of one affects the actions of the other. The diagram below illustrates the two units of the system.

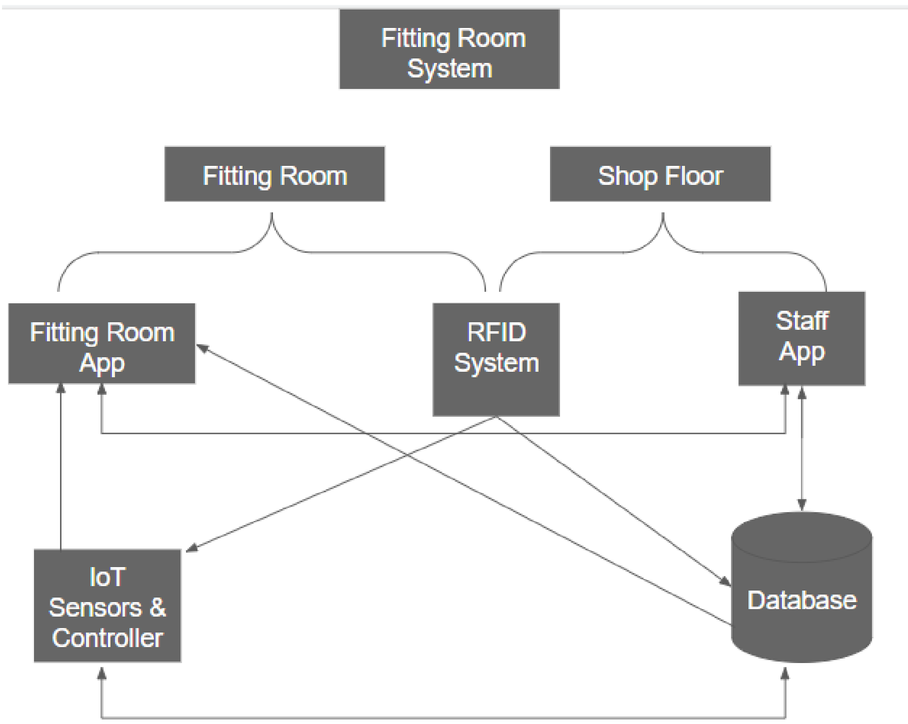

Figure 4: Abstract of the fitting room system

As articulated above, the data produced in the fitting room section is important to and affects the data of the shop floor and vice versa. To be more specific, as soon as a consumer takes a product to a dressing room, the RFID system "informs" the database about the alteration of the item's location and therewithal the IoT controller fetches that data and informs the staff's application that the specific changing room is occupied. Likewise, assistants' application updates whenever a changing room is empty, or when someone has forsaken an item inside.

Another case in which the two activities exchange data, is when a person requests a product from the fitting room's application. The dressing room number in which the consumer made his/her request and the desired item, are pieces of information transferred from the changing room application to that held by the staff. As soon as an assistant accepts the request and delivers the product to the consumer, the petition is deducted from the staff's application. Under those circumstances the alteration of an event can affect other elements of the system.

7.2 Detailed Description

The proposed system calls to maximize supply operations of retail industries and provide a more efficient customer service. Both functions can have a positive impact on consumers' satisfaction and their shopping experience. For these reasons, an effective system is necessary. Particularly, the stated development allows shop employees to be aware of the whole supply, the quantity of each product, the available colors and sizes, as well as the exact location of each garment.

Among new technologies, RFID is of interest as it has the capability of providing significant assistance for the fulfillment of these functions. Particularly, it can identify the location of each product and transmit this data to the database, where all the information is stored. Since the database organizes all this information, store clerks can not only be aware of garments' whereabouts but can also be more conscious of the quantities of their supplies and replenish them when required.

After a close comparison of the three tag types, a decision was made to utilize the "passive" ones, by virtue of their lower cost. They will be entrenched into each product's label and as noted in the "Theoretical Background" chapter, they do not contain batteries. Thus, the tags will be supplied with power when they are within the range of an RFID antenna or reader, by the electric current produced by the transceiver's radio waves. The generated electricity is received by the tag's embedded antenna (Bouet & Dos Santos, 2008, as cited in Nayak et al., 2015). This power supply allows the tag to be constantly activated and broadcast its response – the information consisted in its tiny chip. This will then feed-back to the antennas which will be installed in multiple spots of the store: inside the fitting rooms, on the shelves, in the storage room.

Apart from the garment tracking ability, store employees will be apprised of the dressing rooms' state, that is if they are occupied or empty. In order to distinguish whether there is a consumer inside a fitting room, a human presence sensor is required, which is placed on a controller board. As pointed out earlier, it will detect people that are within the sensor's three-meter range. It will be established on the ceiling above the changing room, so that it can detect the person inside of it.

Another subject that should be discussed is powering the sensor, since it doesn't have an integrated battery and without electricity supply it cannot operate. Hence, a power bank or an external battery are required for a wireless power provision. Also, through short range wireless communication, it is possible to achieve data transmission from the controller board to the IoT controller – the component that is responsible for informing the database that a person has entered the fitting room.

The association of the two aforementioned sensors data, grants different and momentous information to staff members. To be more precise, if the human presence sensor does not detect a person inside a dressing room, while the RFID system tracks products within it, then these two simultaneous events imply that some garments have been left in the cabin. However, the correlation of these two events could also signify that a consumer tried an item on and exited the cabin (e.g. to ask for their companion's opinion). For both cases, store assistants need to check the fitting room and empty it once it is no longer in use. If the human presence sensor identifies a person, while the RFID antenna tracks garments, then the fitting room is occupied. When both sensors do not identify a person and an item in the fitting room, then the cabin is empty.

Another service that the proposed system provides, is informing the consumer about other available colors and sizes of the garments he/she brought into the dressing room. The customer can browse through the available range of colors and sizes available, and if desired, ask the staff for another item, by pushing a button. This is attainable through an application on a tablet located inside the cabin.

The store assistants are informed right away through the staff's application. This notifies them about the number of fitting rooms from which the request was received, as well as which product is needed and where it can be found in the store. Thus, they can easily catch sight of it and deliver it to the consumer.

Apart from the application, it is also possible for staff members to be aware of customer requests and the fitting room's current state, through a different IoT component; the Red Green Blue Light-Emitting Diodes (RGB LEDs). These LEDs will be installed right outside each dressing room, using different colours to represents different events. More specifically, when the fitting room is occupied, the LED turns red and when it is not, it turns green. Moreover, when there isn't a person in the changing room, but products are located, the LED turns blue. In the case that a customer requests another item, the LED red light starts blinking and only stops once the item has been given to the customer.

It is of paramount importance to note that the fitting room and store managers' applications need to be user-friendly. In order to achieve that, the needs and desires of users must be distinguished, to pay attention to the sustainability of the application's design. According to Norman's suggestions (1988, as cited in Abras, Maloney-Krichmar, & Preece, 2004) regarding the design of a task, it is essential to clearly display what actions are available at a specific point in time, as well as the resulting effects. In addition, a user should be able to interpret the system's present state without any confusion. Last but not least, a system designer needs to follow natural mappings between intentions and actions, the actions and their outcomes, as well as the visible information and the evaluation of the system's current state (Norman, 1988, as cited in Abras et al., 2004).

Given the above, before the actual development of applications, their screens were designed using a user experience design tool, in order to produce the desired appearance of a user–friendly program. The creation of the applications' prototypes contributed to spotting deficiencies and ambiguities that could confuse users instead of serving their purpose of easier facilitation. The cabin application is comprised of four screens. As soon as the consumer enters the dressing room with his/her garments, the application is activated, and the first screen is displayed (see Figure 5). It is worth noting that the application will only start to function as soon as these two events occur (there is a person and an item in the cabin). The illustrated "cart"-named interface demonstrates the products that are in that fitting room, as well as the total price.

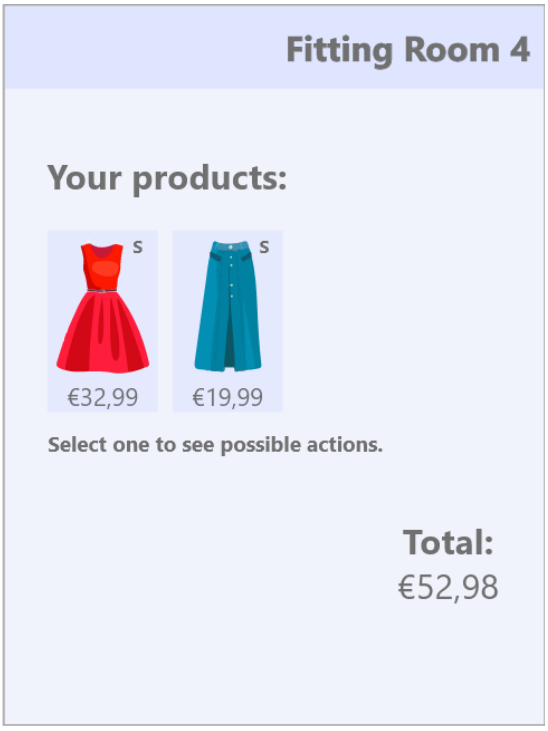

Figure 5: Fitting Room Application Prototype – The "cart" screen

The garments displayed above are in the form of clickable items. When the consumer clicks one of them, it leads him/her to screen number two (see Figure 6). The second interface demonstrates all the colors that the product comes in and all six sizes, while determining the characteristics (size, color) of the product that it is in the changing room. It is equally indispensable to point out that the consumer can select a different color or size, provided that it is available in the store. Hence, when he/she selects a different size or color, the availability of colors and sizes may vary. Sold out colors and sizes cannot be selected. Also, the application's interfaces are connected with one another, since the user can return to the "cart" screen by pressing the "Back to cart" button.

Figure 6: Fitting Room Application Prototype – Screen 2

In case a consumer is not satisfied with the product he/she tried on, it is possible to select a different size or color and request it from the staff. The "Request" button appears only when one chooses a different product (see Figure 7). As soon as he/she proceeds to this action, he/she is informed with a relevant message (see Figure 8). At this point, the staff is notified through their application that a consumer in the changing room requested a certain item. Other notification options, as indicated earlier, are the RGB LEDs, which allow store employees to be aware if somebody requires assistance. Further, once a staff member accepts the request, a relevant notification appears on the consumer's application (see Figure 9).

Figure 7: Fitting Room Application Prototype - Selection of a different size

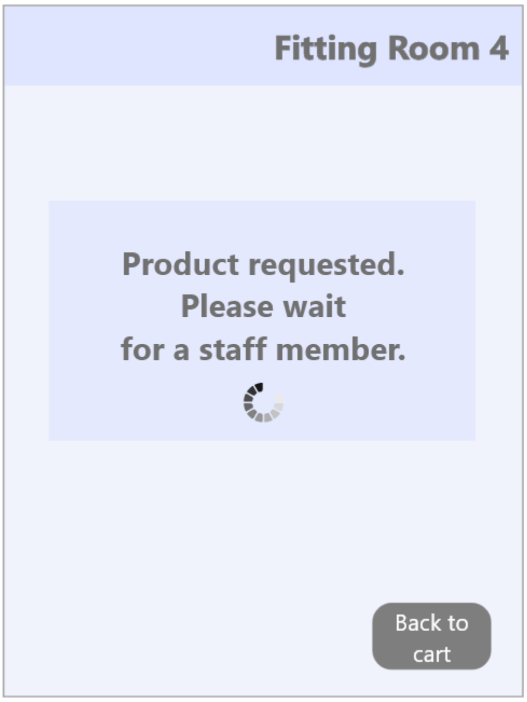

Figure 8: Fitting Room Application Prototype – Product requested

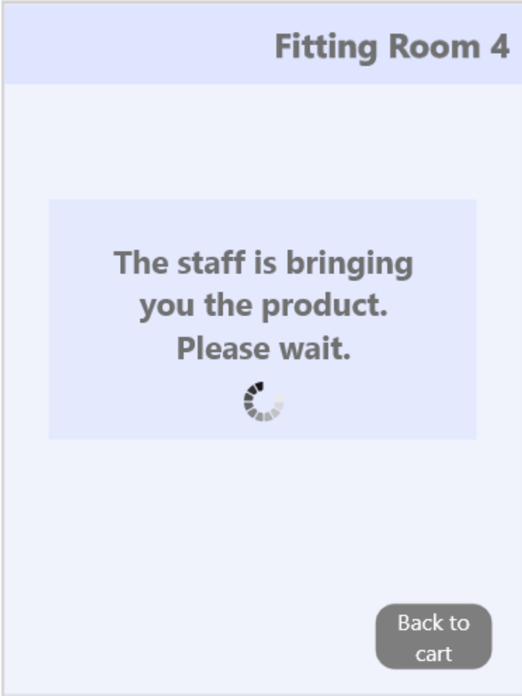

Figure 9: Fitting Room Application Prototype – Request Accepted

Regarding the store clerk's application, three prototypes of three interfaces were created before reaching the final result. The first prototype (see Figure 10) was rejected, since it contained unnecessary text and the colors covered a small surface of the application which did not attract the staff's eye. On the second attempt, these issues were acknowledged and obliterated (see Figure 11). However, it was regarded important to separate the main screen into two rows and increase the number of dressing rooms, which led to the design of the third prototype.

The main screen (see Figure 12) is divided in ten rectangles and each one symbolizes a fitting room cabin. The numbers at the top of each rectangle, stand for the number of the fitting room. They are button-handled and when pushed, store clerks can take a look at the items located in each one – if there are any (see Figure 13). The colors red, green, and blue portend the three states of a changing room. The yellow "Request" button illustrates instances in which staff members are called on duty. Particularly, when a consumer asks for a product, then this button starts flashing and when pressed, presents details concerning the desired product (see Figure 14). As soon as a staff member accepts the request, a relevant notification appears on the consumer's application, as previously indicated (see Figure 9).

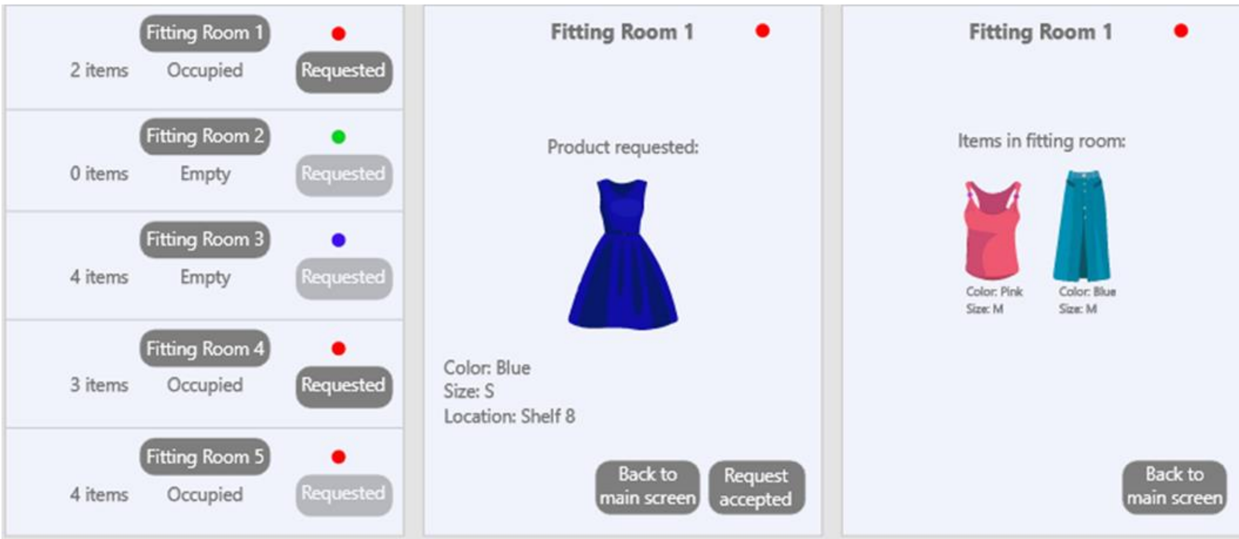

Figure 11: Staff's Application Prototype 1

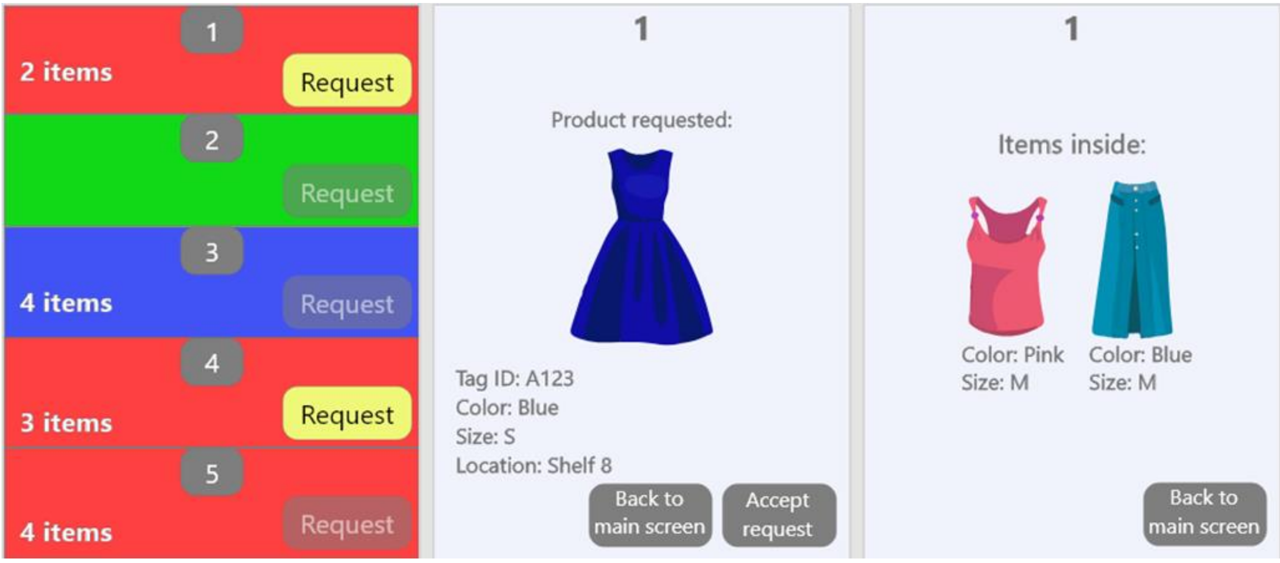

Figure 10: Staff's Application Prototype 2

Figure 12: Staff's Application Prototype 3 – Main screen

Figure 13: Staff's Application Prototype 3 – Items in a Fitting Room

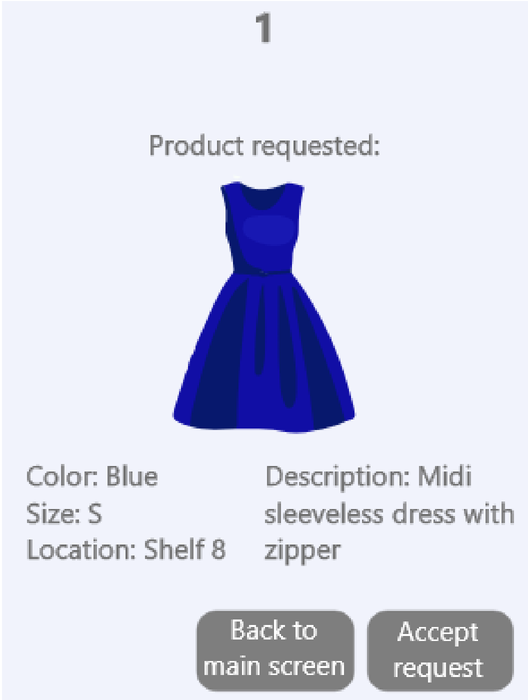

Figure 14: Staff's Application Prototype 3 – Requested item

8 Implementation

This chapter describes the steps undertaken for the implementation of the overall system analyzed in the previous chapter. Due to time constraints this development was not completed entirely and therefore could not proceed to the verification phase. Even though it wasn't feasible to verify the system in a physical environment (fitting room), each accomplished component was tested to ensure that it met all requirements necessary for its future implementation. The elements which were integrated are the database, the human presence sensor and the wireless communication through the XBee modules. Moreover, the fitting room application has been developed to a large extent, but it is not completed yet. The diagram below represents all the components required for the creation of an integrated system.

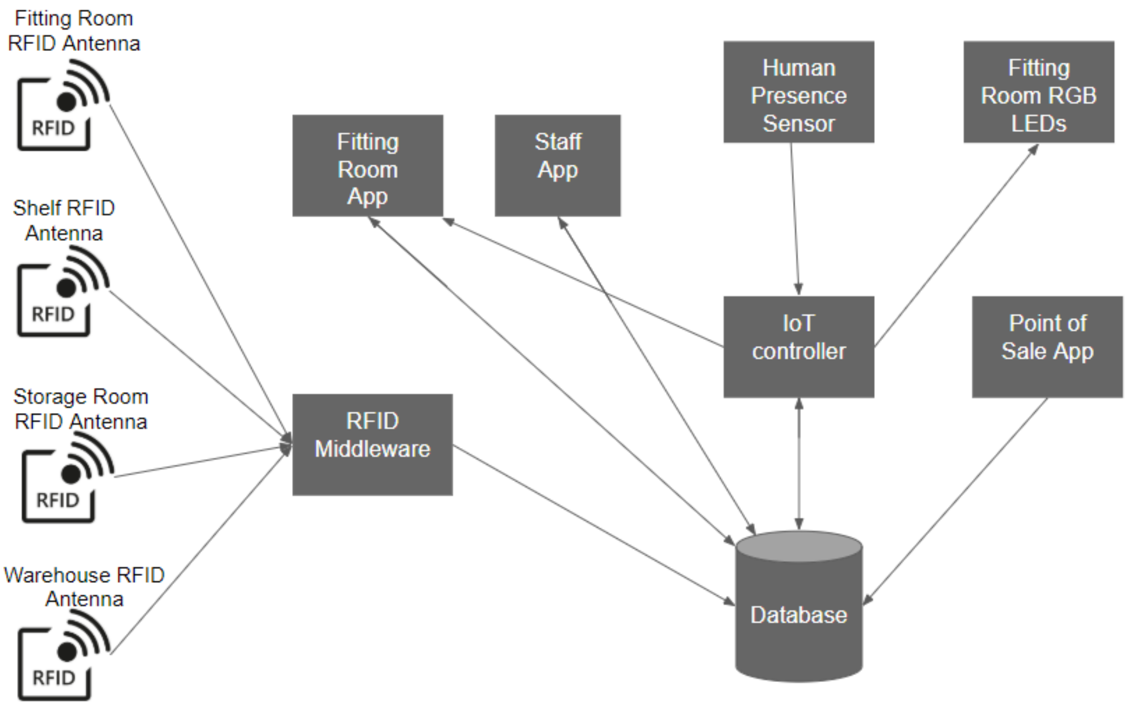

Figure 15: System Architecture

8.1 RFID System

Beginning with the RFID system, such a technology allows store managers to control the inventory and minimize thefts, while consumers can acquire an improved customer service experience. Regarding the implementation of the system, an antenna will be placed inside each changing room, on the shelves, in the storage room, as well as in the warehouse. The antennas will have a specific distance with one another, so that each one's tracking range won't overlap the range of the other. Therefore, a product can be tracked by only one antenna at a specific time, but it can be identified right after by another one. Such actions denote that the product is moving. When an antenna tracks a product within its radio waves, it reads its built-in tag, which includes a unique EPC code. The code reflects what kind of garment it is, its brand name and price. All this information along with the location, is transmitted to the developed database, through a middleman: the RFID middleware. The middleware reaches the database only when a product is moved in order to update its location. The RFID system has not yet been tested, but its capabilities were studied and understood.

8.2 Database

The database records all the information related to the products, as well as the data produced by the IoT sensors. This design was created in such a way as to organize this data and allow it to be retrieved by other components of the system (the IoT controller and applications) in order to perform the appropriate actions. For the purposes of this research, a database with fictitious data was established.

As depicted below, the data is organized in a relational database, i.e. tables related to one another. The most generalized table is "clothes_categories", from which other tables inherit information. The most specific and truly important one is the "stock" table, which records all necessary data of a certain product: its unique tag ID, its size, color, price, which kind of product it is (e.g. workout top), its location and the date it arrived at the store. As soon as an item is sold, it is moved from the "stock" to the "sold" table. The data of the "stock" table is fetched from the more general tables which contribute to the system's operations. A deeper explanation of the tables' relations is provided in Appendix III: Tables of Database.

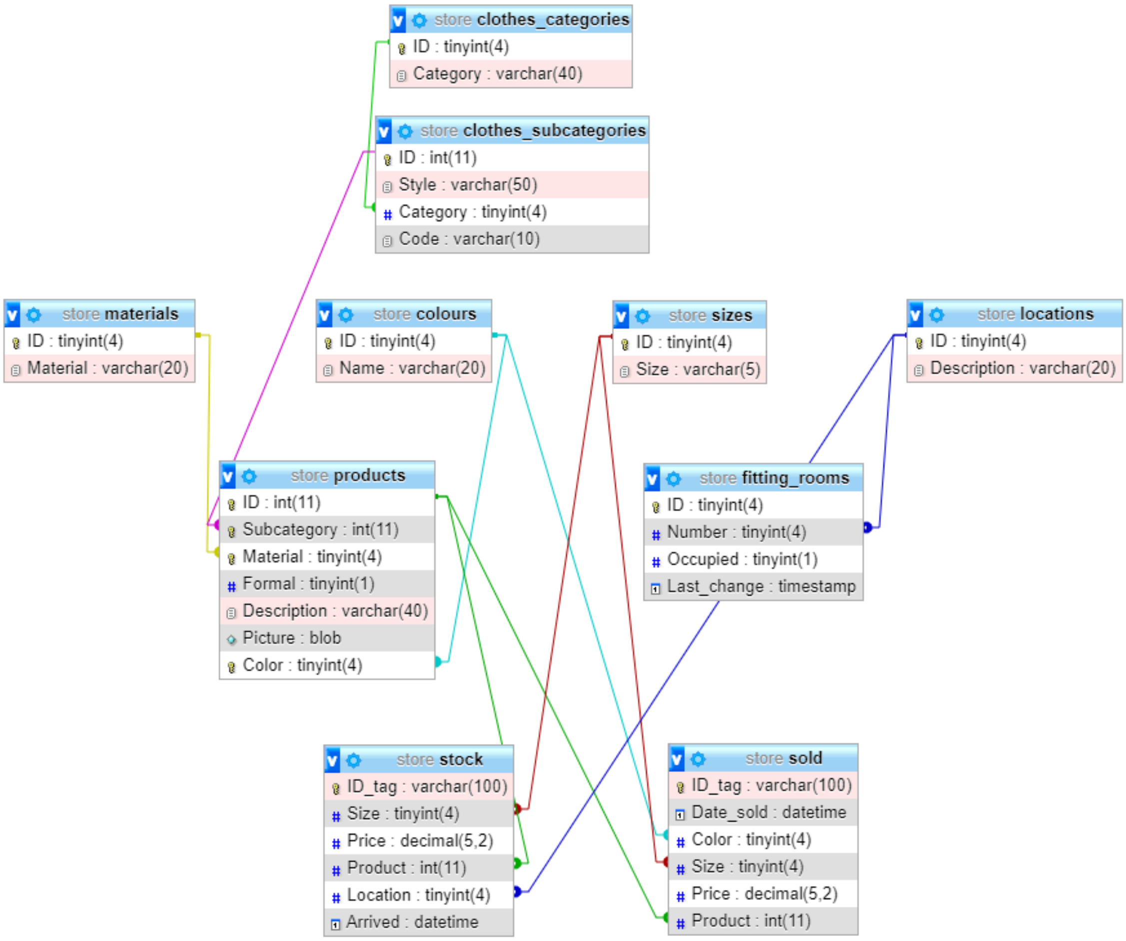

Figure 16: Developed Database

8.3 Human Presence Sensor

Another essential component of the system is the human presence sensor. It was connected to an Arduino board using a base shield. Then, the code was typed in processing language and uploaded to the board (see Appendix IV). The output of the code presented the measurement data of the four IR sensors, which ranges from -32767 to 32767, as well as the room temperature. The values of the four IR sensors reflect the intensity of the detected infrared light. The stronger the infrared intensity, the higher the IR value.

It is highly important to specify that the frequency which the sensor searches for a human body and captures data, in our case this was set to two seconds. This time interval is suitable for such an implementation, since it is important to apprehend all human entries and exits in the fitting room. The increasement of the capturing frequency would influence the generated data and lead to incorrect outcomes and actions.

The sensor was tested twice to inspect its fulfilment of the requirements of an actual dressing room. Particularly, it was examined in two different-sized rooms, in order to observe the effect of the room size in the parameter values. During the experiment, the researcher entered the room and behaved as a consumer in a fitting room would have. Before entering the room and after exiting it, the time was written down, to compare the output values of the occupied room, with the ones of the empty.

The first experiment lasted around 2.4hours and took place in a room with the following dimensions (length, width, height): 2m x 1m x 2m. During this experiment, the researcher entered the room 15 times and remained in it around one minute each time. The diagram below illustrates the produced values.

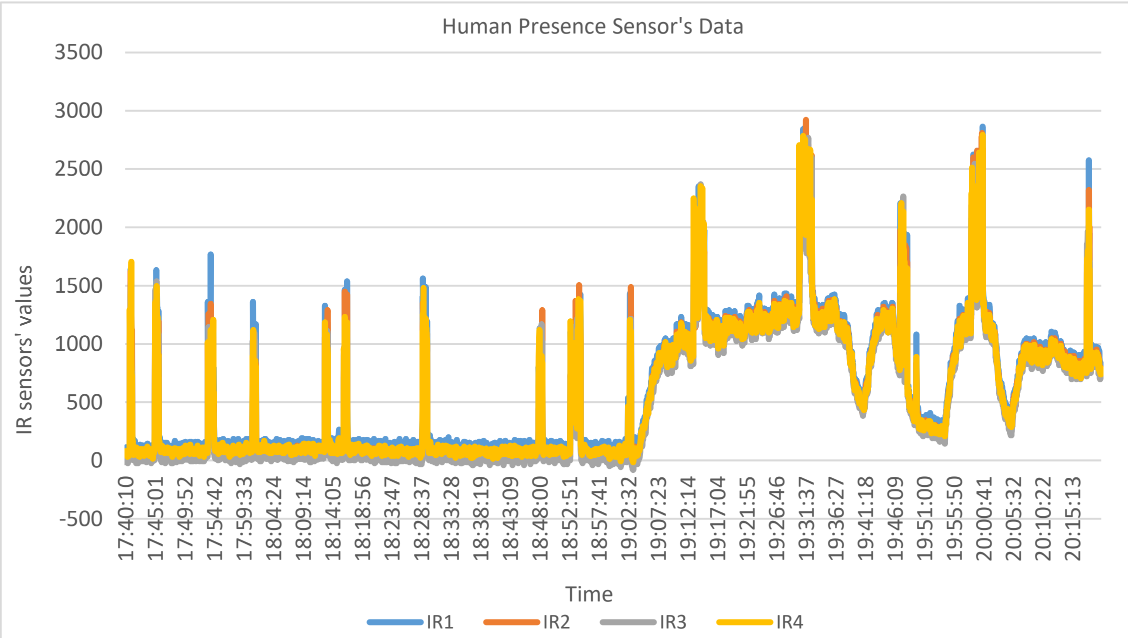

Figure 17: Human Presence Sensor's Data – Experiment 1

As seen above, the 15 times during which the researcher entered the room are visible through the abrupt increase of IR sensor values. However, around 19:05 even though the researcher kept entering the room as she did before, a high and unpredictable value increase was observed, which should not have been the result. The high values at the beginning, which imply with a human presence, are then (from 19:05 and after) the low values, that correspond to an empty fitting room. The peaks can be clearly identified, but such a value raise could lead to wrong and unreliable actions. For instance, if the values are higher than 1000, then the IoT controller will ask the RGB LED to light a red color, so that people will know that the fitting room is occupied. However, as shown at the figure above, around 19:07, the IR values surpassed that number, but the room was empty.

The second experiment lasted around two hours and it took place in a different room with the following dimensions: 3m x 1.10m x 2.70m. The sensor was installed on the ceiling, around 50cm away from the door. Each time (7 in total) the researcher entered the room, she made sure to occupy only 1 meter in length of the space, just like a consumer would in an actual fitting room with dimensions of 1m x 1m. As through the interview process, it was made evident that participants use the fitting room for 10-15 minutes, it was considered important to test the sensor's output based on human presence for that amount of time. This is illustrated in the chart below.

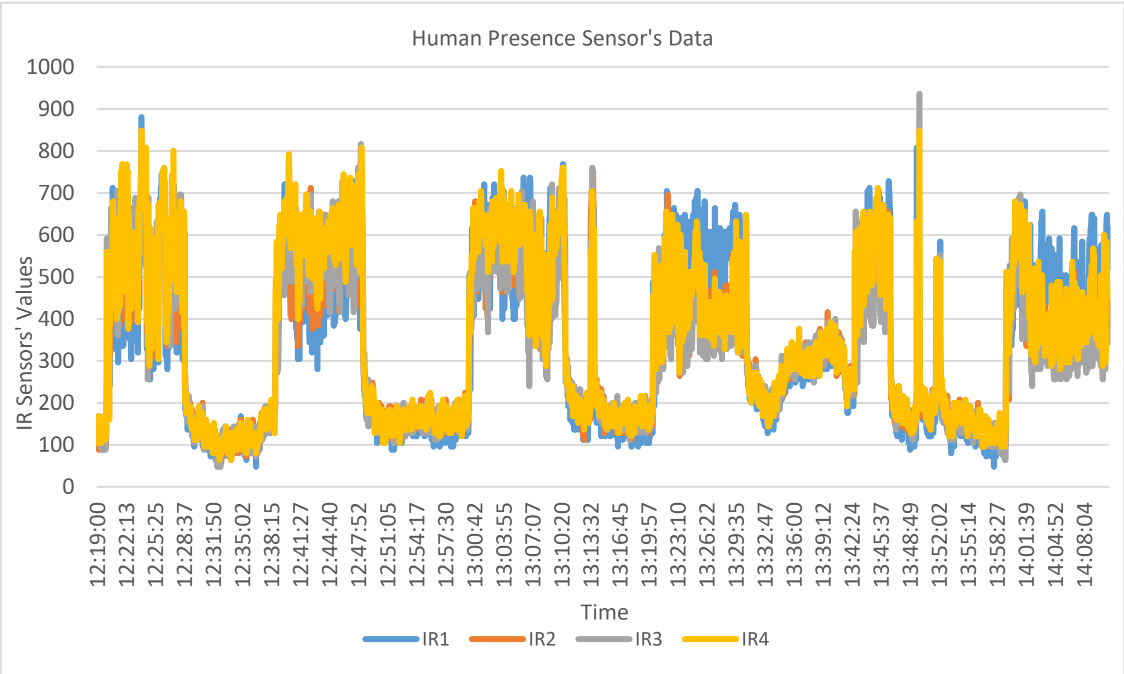

Figure 18: Human Presence Sensor's Data – Experiment 2

Figure 19: Human Presence Installation Test

Given the above, the values have a more stable fluctuation in comparison to the first experiment. Each time the sensor detected a person, the parameter values were about 333 higher than when the room was empty. On the first experiment, the ceiling was just 25cm above the researcher’s head and on the second, 1m away. The infrared intensity was stronger the first time and therefore the values of the four quantum-type sensors where larger. The analysis of the two experiments concluded that the distance between the sensor and the human plays a vital role; the sensor can produce reliable values if the ceiling is around 1m away from the person.

8.4 IoT Controller

The values of the sensor are transmitted to the IoT controller, which recognizes if the fitting room is occupied. The IoT controller, which stands for the intermediary of the human presence sensor and the RGB LEDs, reaches the database and transmits information that is only displayed when an event needs updating. Furthermore, the controller retrieves information from the database about items inside the cabins, which is added by the RFID antennas. Depending on the changing room’s status, the controller asks the LED to project the appropriate color.

8.5 XBee Modules – Wireless Communication

It is worth mentioning that, XBee modules will be attached to the board along with the human presence sensors. Through this exploitation, a wireless communication between the sensor and the IoT controller is achieved. The modules have been configured in Application Programming Interface (API) mode, which allows bidirectional communication within multiple XBee nodes (Digi, 2019).

8.6 Applications

The fitting room application is activated when the human presence sensor identifies a person and the RFID antenna tracks at least one product in the cabin. As soon as these events appear, the IoT controller notifies the application to switch on. The application is connected to the database from which it retrieves data by executing appropriate queries. Initially, the consumer is asked to enter the fitting room number, as well as the limit of the items one can take in the fitting room (see Figure 20). The user can only proceed to the second screen, as soon as both fields are filled out. This screen was developed, so that the application can be established in numerous fitting rooms, as well as in various stores that have different limits concerning the maximum products a consumer can take into the changing room.

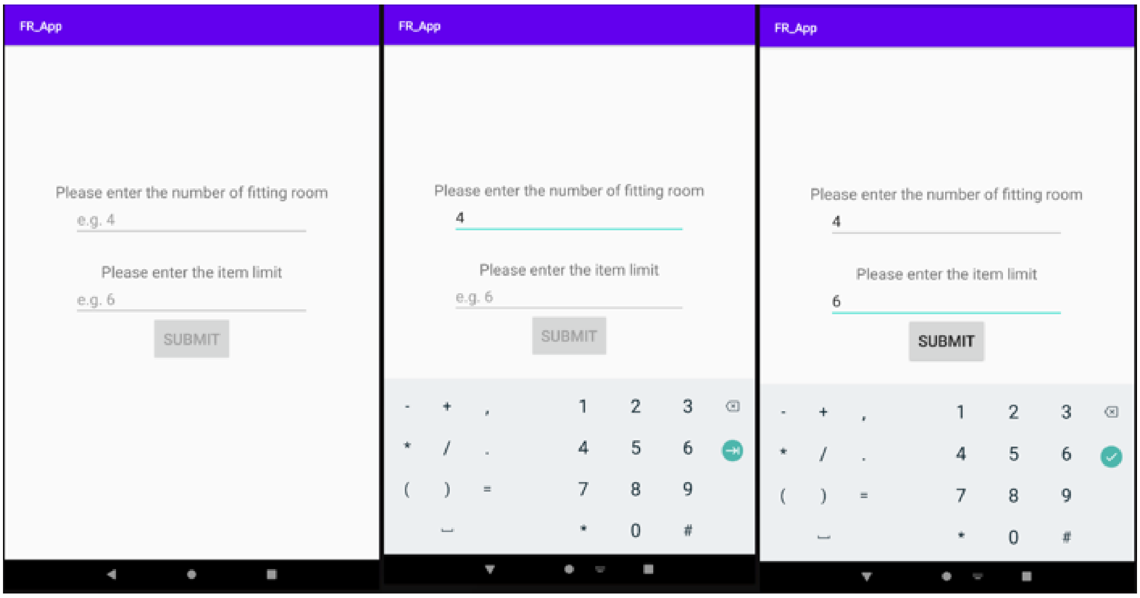

Figure 20: Fitting Room Application - Screen 1

The second screen displays the fitting room number, which is provided by the user. It also “asks” the database which items are in the dressing room, in order to display them (see Figure 21). When a consumer selects the product from the cart screen, he/she proceeds to the third activity (see Figure 22). The three activities are connected and pass information with one another. The size and the color buttons of the item are highlighted at the third activity, and the unavailable sizes and colors cannot be selected by the user. When he/she orders an item from the application, the request is transmitted though the IoT controller to the staff’s application. As soon as the RFID antenna locates the desired product at the fitting room, the request button at the staff’s application and the LED outside the cabin stop blinking.

The third activity of the changing room’s application is not completed yet (the colors are not added). Furthermore, the staff’s application has not entered the implementation phase, but it will, in the near future.

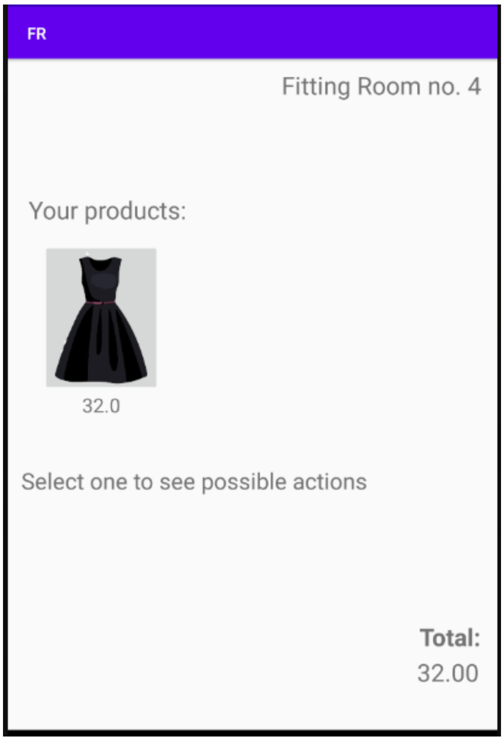

Figure 21: Fitting Room Application - Screen 2

Figure 22: Fitting Room Application - Screen 3

9 Conclusions

In conclusion, the research question previously put forth, was covered in the "Requirement Analysis", "System Design" and "Implementation" chapters. Through the review of previous literature, as well as interviews that were conducted, it was possible to identify the main problems faced by both staff and consumers within clothing stores. The data collected, helped design the overall system in hope of diminishing the indicated problems.

During the implementation of the proposed research, new ideas were developed as well as several restrictions. The primary idea was to develop a fitting room system, that would allow the consumer to request a different size or color of the product he/she tried on and view other items that the system suggests. A decision was made to limit the recommendations to five, so that the consumer doesn't spend too much time in the cabin scrolling through endless options of garments provided by the application. Due to its complexity, the idea of recommending products was later rejected. From then onwards, another idea was brought to the foreground of providing details concerning the fitting room's state to store assistants and consumers through the exploitation of RGB LEDs.

9.1 Limitations

One of the issues that came about was the inability to perform the constructed interviews to the shopkeepers, due to the restrictive measures of covid-19. Thus, shopkeepers' opinions and feedback on the use of advance technology in retail stores are unknown.

Furthermore, due to time constraints, not every system's component was finished and tested. As a result, it wasn't possible to test the efficiency of the overall system, yet it was possible to check the reliability of individual components. Although the system was not completed fully, it reached a satisfactory stage and could be revisited and entirely accomplished in the future.

9.2 Improvements

Several suggestions could improve the functionality of this system. Particularly, during the interviews a few consumers reported that it would be considerably awkward for them to ask for a product and wait for a staff member to deliver it to them. Another participant mentioned that this would not be ethical, as it would violate the consumer's personal space. Therefore, an appropriate solution would be for the assistant to deliver the product to the customer without having any physical contact with him/her.

Another point of reference addressed throughout this study has to do with supply control. To be precise, it would be more effective if the application notified store clerks whenever a product is running out. This action would provide better assistance in controlling quantities of products and would help make staff members more aware of stock which needs replenishing.

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11 APPENDICES

11.1 Appendix I

Shopkeepers’ Interview Questions

1. What difficulties / challenges does the store staff face concerning…

    a. the customer service (e.g. small number of staff - a lot of consumers)?

    b. supply management (e.g. incorrect placement of products by consumers)?

2. Has anyone ever stolen something from your store?

    a. If so, when did you realize it?

3. When a customer is looking for a specific product, how does the staff locate it to help them?

    a. Do you easily locate products?

4. Do you offer any advanced services in your store (e.g. the consumer can ask the staff for help by pressing a button, scan the products with his mobile phone, etc.)?

    a. Would you be interested in adding more advanced services to your store (e.g. tablets, sensors to easily locate products)?

5. Do you have any restrictions on the number of clothes a consumer is allowed to take in the rehearsal room?

    a. Why;

6. How often is there a queue at the fitting rooms?

    a. What days does this usually happen?

7. What do you think is a smart fitting room?

    a. What features / services would you like it to provide to you and the customer?

8. Suppose we can create a smart test drive through which consumers could ask for another product from you. How do you like such an implementation?

9. Do you think consumers would easily get acquainted with a smart fitting room with new technologies?

a. Why?

10. How do you like the design of these two applications? What remarks do you have to make? (Show them the prototypes of the two applications)

11.2 Appendix II

Consumers' Interview Questions

1. Can you describe your familiarity with technology? What new technologies do you use in your daily life (e.g. smartphones)? Why;

2. Do you use any technology when you go clothes shopping? If so, how do you use it and how does it serve you in your shopping? If not, why?

3. What problems / difficulties do you face in clothing stores when you go shopping?

4. How do you evaluate customer service (the service you receive) in the clothing stores of Cyprus?

	1	2	3	4	5	
very bad	○	○	○	○	○	very good

5. Why?

6. When you are looking for a specific product in a clothing store, how easily do you find it?

	1	2	3	4	5	
very difficult	○	○	○	○	○	very easily

7. Why?

8. Do you usually ask for the opinion / help of the staff? If so, in which cases do you request it?

9. Do you use the fitting room?

Yes

No

10. If so, how much time do you spend in it?

11. If you chose yes to question 9: Is there anything that bothers you when using the fitting room? If so, what and why?

12. If in question 9 you chose yes: When you want to try another garment or size / color that you are not holding while you are in the fitting room, do you usually go to pick it up yourself, or someone else brings it to you (e.g. you ask the staff, or a friend)?

13. If you are used to pick it up yourself: Do you leave your things in the fittings room and come back, or go out and wait again in line to enter?

I leave my things in the fitting room and return

I go out and wait my turn again to enter

14. If a clothing store provided new technologies to service you better (e.g. an interactive display), would you use them? Or do you prefer the traditional way: go-try on-buy?

I would use them

I wouldn't use them, I prefer the traditional way

15. Why?

16. What services would you like a fitting room to provide to satisfy you better?

17. Let's say there was a fitting room that would somehow suggest other products based on what you tried. Would you like it?

Yes

No

18. Why?

19. If you had the opportunity to ask someone to bring you specific clothes in the fitting room without you having to get out of it, how would you feel? Why;

20. Gender:

Male

Female

21. Age:

11.3 Appendix III

Tables of the Database

clothes_categories

Columns:

- **ID**: Primary key – unique number of each product category, auto-increment, type tinyint(4)
- **Category**: clothes categories, type varchar(40)

clothes_subcategories

Columns:

- **ID**: primary key – unique number of each clothes subcategory, auto-increment, type int(11)
- **Style**: style of the clothes subcategory (e.g. loose, tight, etc), type varchar(50)
- **Category**: clothes category – it is inherited from the "clothes_categories" table from the "ID" column, type tinyint(4)
- **Code**: the codes of the clothes subcategory, e.g. A123, type varchar(10)

colours

Columns:

- **ID**: primary key – unique number of each item's color, auto-increment, type tinyint(4)
- **Name**: name of the colors, type varchar(20)

sizes

Columns:

• **ID**: primary key – unique number of each item's size, auto-increment, type tinyint(4)

• **Size**: sizes of the garments, type varchar(5)

fitting_rooms

Columns:

• **ID**: primary key – unique number of each fitting room, auto-increment, type tinyint(4)

• **Number**: the number of fitting room, type tinyint(4), it is inherited from the "locations" table from the "ID" column

• **Occupied**: the state of the fitting room (occupied or empty), type tinyint(1) 0 = empty, 1 = occupied

• **Last_change**: last time that the state of the fitting room has changed, type timestamp, default current_timestamp(), on update current_timestamp()

locations

Columns:

• **ID**: primary key – unique number of each location, auto-increment, type tinyint(4)

• **Description**: description of the location (e.g. fitting room 1, shelf 1, etc), type varchar(20)

materials

Columns:

• **ID**: primary key – unique number of each material, auto-increment, type tinyint(4)

- **Materials**: materials of the garments, type varchar(20)

products

Columns:

- **ID**: primary key – unique number of groups of products, auto-increment, type int(11)
- **Subcategory**: subcategory of the group of products, type int(11), it is inherited from the “clothes_subcategories” table from the “ID” column
- **Material**: material of the products, type tinyint(4), it is inherited from the “mterials” table from the “ID” column
- **Formal**: it the products are formal or not, tinyint(1), 0 = unformal, 1 = formal
- **Description**: description of the products (e.g. red dress with zipper), type varchar(40)
- **Picture**: picture of the product, type blob
- **Color**: color of the product, type tinyint(4), it is inherited from the “colours” table from the “ID” column

stock

Columns:

- **ID_tag**: the unique id of each item, which is written in its RFID tag, primary key, type varchar(100)
- **Size**: the size of the item, tinyint(4), it is inherited from the “sizes” table, from the “ID” column
- **Price**: price of the product, type decimal(5,2)
- Product: the kind of product that the item is, int(11), it is inherited from the “products” table, from the “ID” column
- **Location**: location of the item, tinyint(4), it is inherited from the “locations” table, from the “ID” column

- **Arrived**: the date that the item has arrived at the store, type datetime

sold

Columns:

- **ID_tag**: the unique id of each sold item, which is written in its RFID tag, primary key, type varchar(100)
- **Date_sold**: the date when the product is sold, type datetime
- **Color**: color of the sold item, type tinyint(4), it is inherited from the “colours” table, from the “ID” column
- **Size**: the size of the sold item, type tinyint(4), it is inherited from the “sizes” table, from the “ID” column
- **Price**: the price of the sold item, type decimal(5,2)
- **Product**: the kind of product that the sold item is, type int(11), it is inherited from the “products” table, from the “ID” column

11.4 Appendix IV

Code for the human presence sensor

```
#include <Wire.h>

#include "Grove_Human_Presence_Sensor.h"

AK9753 movementSensor;

int ir1, ir2, ir3, ir4;

float temp;

void setup(){

	Serial.begin(9600);

	Serial.println("Grove - Human Presence Sensor example");

	Wire.begin();

	pinMode(LED_BUILTIN, OUTPUT);
```

```
	if (movementSensor.initialize() == false){
		Serial.println("Device not found. Check wiring.");
		while (1);
	}
}
void loop(){
	if (movementSensor.dataReady()){
		ir1 = movementSensor.getRawIR1();
		ir2 = movementSensor.getRawIR2();
		ir3 = movementSensor.getRawIR3();
		ir4 = movementSensor.getRawIR4();
		temp = movementSensor.getTMP();
		movementSensor.startNextSample();
		Serial.print("");
		Serial.print(ir1);
		Serial.print(", ");
		Serial.print(ir2);
		Serial.print(", ");
		Serial.print(ir3);
		Serial.print(", ");
		Serial.print(ir4);
		Serial.print(", ");
		Serial.print(temp);
		Serial.print(", ");
		Serial.print(millis());
		Serial.println();
```

```
        }
        delay(2000);
}
```

11.5 Appendix V

<u>Queries for identifying the items in the fitting room</u>

The fictitious data below was inserted in the database for the purposes of the research.

"products" table

ID	Subcategory	Material	Formal	Description	Picture	Color
1	2	2	1	Long dress with zipper	[BLOB - 21.8 KiB]	1
2	1	1	0	Workout tank top.	[BLOB - 11.0 KiB]	2
3	2	2	1	Long dress with zipper	*NULL*	2
4	2	2	1	Long dress with zipper	*NULL*	3
7	2	3	1	Jacket with pockets and zipper	*NULL*	3
8	2	3	1	Jacket with pockets and zipper	*NULL*	4
9	1	6	0	Bootcut high-waisted jeans	*NULL*	2
10	2	2	0	Sweatpants with waistband tie	*NULL*	9
15	1	6	0	Bootcut high-waisted jeans	*NULL*	3
16	2	2	0	Sweatpants with waistband tie	*NULL*	5
17	1	1	0	Workout tank top.	*NULL*	3

"stock" table

ID_Tag	Size	Price	Product	Location	Arrived
A1232	2	20.00	2	1	2020-04-09 15:52:37
A1233	2	20.00	2	1	2020-04-08 10:52:37
A345	3	24.99	1	7	2020-04-09 15:52:37
A346	4	24.99	1	7	2020-04-09 15:52:37
A756	3	24.99	1	2	2020-04-09 15:52:37
A757	3	24.99	1	2	2020-04-09 15:52:37
A767	2	24.99	1	2	2020-04-09 15:52:37
A768	5	24.99	1	2	2020-04-09 15:52:37
B123	1	20.00	2	5	2020-04-12 18:09:37
B124	3	20.00	2	5	2020-04-12 18:09:37
B322	6	34.00	4	2	2020-04-12 13:19:56
B323	2	34.00	4	2	2020-04-12 13:19:56
B324	3	34.00	4	2	2020-04-12 13:19:56
B325	3	34.00	4	2	2020-04-12 13:19:56

B326	4	34.00	4	2	2020-04-12 13:19:56
B545	1	28.99	9	3	2020-03-31 12:38:49
B546	3	28.99	9	3	2020-03-31 12:38:49
B723	1	20.00	2	3	2020-04-01 23:34:40
M123	2	32.99	1	4	2020-04-12 13:19:56

String query1 = “SELECT * FROM stock WHERE Location = ” + fr_num; //Asking the database to give me the details of the product(s) that are in the location added by the user.

String query2 = “SELECT * FROM products WHERE ID = ” + product_ID; //Got the ID from the previous query. Getting more details about the product – what color it is

String query3 = “SELECT Color FROM products WHERE Subcategory = ” + subcategory;

query3 += “ AND Material = ” + material;

query3 += “ AND Description = ” + description; //Learning the other colors that the product is available

String query4 = "SELECT Size, Product, Location, Picture, Color, Description";

query4 += " FROM products p";

query4 += " LEFT JOIN stock s";

query4 += " ON p.ID = s.Product";

query4 += " WHERE Subcategory = " + subcategory;

query4 += “ AND Material = 2 AND Description = " + description;

query4 += " GROUP BY Color"; //Gives all the possible colours of a products, regardless which are in stock

String query5 = “SELECT Size, Product, Location, Picture, Color, Description”;

query5 += “ FROM products p RIGHT JOIN stock s ON p.ID = s.Product”;

query5 += “ WHERE Subcategory = ” + subcategory;

query5 += “ AND Material = ” + material;

query5 += “ AND Description = ” + description; //Gives all the sizes of a product that are in stock

String query6 = “SELECT Size, Product, Location, Picture, Color, Description”;

query6 += “ FROM products p”;

query6 += “ LEFT JOIN stock s”;

query6 += “ ON p.ID = s.Product”;

query6 += “ WHERE Subcategory = ” + subcategory;

query6 += “ AND Material = ” + material;

query6 += “ AND Description = ” + description;

query6 += “ AND Color = ” + color; //This query executes when a user selects a color

String query7 = “SELECT Size, Product, Location, Picture, Color, Description”;

query7 += “ FROM products p”;

query7 += “ LEFT JOIN stock s”;

query7 += “ ON p.ID = s.Product”;

query7 += “ WHERE Subcategory = ” + subcategory;

query7 += “ AND Material = ” + material;

query7 += “ AND Description = ” + description;

query7 += “ AND Size = ” + size; //This query executes when a user selects a size

11.6 Appendix VI

Fitting Room Application – MainActivity

```
package com.example.fr;

import androidx.appcompat.app.AppCompatActivity;

import android.content.Intent;
import android.os.Bundle;
import android.text.Editable;
import android.text.TextWatcher;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;

public class MainActivity extends AppCompatActivity {
    EditText fr_input, items_input; //user's inputs
    Button submit;
    public static final String EXTRA_NUMBER1 =
"com.example.fr_app.EXTRA_NUMBER1";
    public static final String EXTRA_NUMBER2 =
"com.example.fr_app.EXTRA_NUMBER2";

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);

        fr_input = (EditText) findViewById(R.id.fr_input);
        fr_input.addTextChangedListener(inputTextWatcher); //to make the
submit button unabled when the fr_input is not added

        items_input = (EditText) findViewById(R.id.items_input);
        items_input.addTextChangedListener(inputTextWatcher); //to make the
submit button unabled when the items_input is not added
```

```
        submit = (Button) findViewById(R.id.submit);
        submit.setOnClickListener(new View.OnClickListener() {
            @Override
            public void onClick(View v) {
                openCart();
            }
        });
    }

    private TextWatcher inputTextWatcher = new TextWatcher() {
        @Override
        public void beforeTextChanged(CharSequence s, int start, int count,
int after) {

        }

        @Override
        public void onTextChanged(CharSequence s, int start, int before, int
count) {
            String input1 = fr_input.getText().toString().trim(); //trim
means that the input doesn't accept empty spaces
            String input2 = items_input.getText().toString().trim();

            submit.setEnabled(!input1.isEmpty() && !input2.isEmpty());
        }

        @Override
        public void afterTextChanged(Editable s) {

        }
    };

    public void openCart() {
        int fr_num = Integer.parseInt(fr_input.getText().toString());
        int items_num = Integer.parseInt(items_input.getText().toString());

        Intent intent = new Intent(MainActivity.this, Cart.class);
        intent.putExtra(EXTRA_NUMBER1, fr_num);
```

```
        intent.putExtra(EXTRA_NUMBER2, items_num);
        startActivity(intent);
    }
}
```

11.7 Appendix VII

Fitting Room Application – Cart Activity

```
package com.example.fr;

import androidx.appcompat.app.AppCompatActivity;

import android.content.Intent;
import android.graphics.Bitmap;
import android.graphics.BitmapFactory;

import android.os.AsyncTask;
import android.os.Bundle;
import android.view.View;
import android.widget.ImageButton;
import android.widget.TextView;
import android.widget.Toast;

import java.io.InputStream;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.ResultSetMetaData;
import java.sql.Statement;
import java.text.DecimalFormat;

public class Cart extends AppCompatActivity {

    //Declaring my variables
    private static final String url = "jdbc:mysql://192.168.10.8:3306/store";
//192.168.10.8 is my laptop's IP Address and 3306 is default port number to
connect on MySQL
    private static final String user = "marina";
    private static final String pass = "marina";

    TextView fr_number, item_price, total_price, total;
    ImageButton item_image;
    double price = 0.0;
    String ID_tag, product_ID;
    int fr_num, max_items; //int to get the intents


    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_cart);

        fr_number = (TextView) findViewById(R.id.fr_number);
```

```
        //Receiving the values sent by the MainActivity (at the openCart() 
method)
        Intent intent = getIntent();
        fr_num = intent.getIntExtra(MainActivity.EXTRA_NUMBER1, 0);
        fr_number.setText("Fitting Room no. " + fr_num);
        max_items = intent.getIntExtra(MainActivity.EXTRA_NUMBER2, 0);

        item_price = (TextView) findViewById(R.id.item_price);

        total_price = (TextView) findViewById(R.id.total_price);

        total = (TextView) findViewById(R.id.total);

        item_image = (ImageButton) findViewById(R.id.item_image);
        item_image.setOnClickListener(new View.OnClickListener() {
            @Override
            public void onClick(View v) {
                openItem();
            }
        });

        // TODO Auto-generated method stub
        ConnectMySql connectMySql = new ConnectMySql();
        connectMySql.execute("");
    }

    private class ConnectMySql extends AsyncTask<String, Void, String> {
        String res = "";

        @Override
        protected void onPreExecute() {
            super.onPreExecute();
            Toast.makeText(Cart.this, "Please wait...", Toast.LENGTH_SHORT)
                    .show();
        }

        @Override
        protected String doInBackground(String... params) {
            try {
                Class.forName("com.mysql.jdbc.Driver");
                Connection con = DriverManager.getConnection(url, user, 
pass);

                String result = "Database Connection Successful\n";

                Statement st = con.createStatement();
                ResultSet rs = st.executeQuery("select * from stock where 
location = " + String.valueOf(fr_num));
                ResultSetMetaData rsmd = rs.getMetaData();

                product_ID = rs.getString(4);

                String query = "select * from products where ID = " + 
product_ID;
                st = con.createStatement();
                ResultSet rs2 = st.executeQuery(query);
                rs.next();
                rs2.next();
```

```java
                InputStream binaryStream = rs2.getBinaryStream(6);
                price = rs.getDouble(3);
                ID_tag = rs.getString(1);

                show_item(binaryStream, price);

                calculate_total(price);

                while (rs.next()) {

                }
                res = result;
            } catch (Exception e) {
                e.printStackTrace();
                res = e.toString();
            }
            return res;
        }

        @Override
        protected void onPostExecute(String result) {
            //total_price.setText(result);
        }
    }

    public void show_item(final InputStream str, final double price) {
        runOnUiThread(new Runnable() {
            @Override
            public void run() {
                Bitmap bitmap = BitmapFactory.decodeStream(str
                item_image.setImageBitmap(bitmap);

                String timi = "" + price;
                item_price.setText(timi);
            }
        });
    }

    public void calculate_total (final Double price) {
        runOnUiThread(new Runnable() {
            @Override
            public void run() {
                DecimalFormat df = new DecimalFormat("####0.00");
                total_price.setText(df.format(price));
            }
        });
    }

    public void openItem() {
        Intent intent1 = new Intent(getBaseContext(), Item.class);
        intent1.putExtra("ID_tag", ID_tag);
        startActivity(intent1);
    }
}
```

11.8 Appendix VIII

Fitting Room Application – Item Activity

```
package com.example.fr;

import androidx.appcompat.app.AppCompatActivity;

import android.annotation.SuppressLint;
import android.content.Intent;
import android.graphics.Bitmap;
import android.graphics.BitmapFactory;
import android.graphics.Color;
import android.graphics.drawable.BitmapDrawable;
import android.graphics.drawable.Drawable;
import android.os.AsyncTask;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import android.widget.ImageView;
import android.widget.TextView;
import android.widget.Toast;

import java.io.InputStream;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.ResultSetMetaData;
import java.sql.Statement;
import java.util.ArrayList;

public class Item extends AppCompatActivity implements View.OnClickListener {

    //Declaring my variables
    private static final String url = "jdbc:mysql://192.168.10.8:3306/store";
//192.168.10.8 is my laptop's IP Address and 3306 is default port number to
connect on MySQL
    private static final String user = "marina";
    private static final String pass = "marina";
```

```java
    Button back_to_cart, xs, s, m, l, xl, xxl, BLACK, BLUE, CYAN, DKGRAY,
GRAY, GREEN, LTGRAY, MAGENTA, RED, TRANSPARENT, WHITE, YELLOW;
    TextView size_value, color_value, item_price;
    ImageView item_image;
    String item_tag;
    int item_size, item_color;

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_item);

        item_image = (ImageView) findViewById(R.id.item_image);

        item_price = (TextView) findViewById(R.id.item_price);

        size_value = (TextView) findViewById(R.id.size_value);

        color_value = (TextView) findViewById(R.id.color_value);

        back_to_cart = (Button) findViewById(R.id.back_to_cart);
        back_to_cart.setOnClickListener(new View.OnClickListener() {
            @Override
            public void onClick(View v) {
                openMainActivity();
            }
        });

        xs = (Button) findViewById(R.id. xs);
        xs.setOnClickListener(this);
        xs.setOnClickListener(new View.OnClickListener() {
            @SuppressLint("SetTextI18n")
            @Override
            public void onClick(View v) {
                TextView tv = (TextView)findViewById(R.id.size_value);
                tv.setText("XS");

                xs.setBackgroundColor(Color.DKGRAY);
```

```java
        xs.setTextColor(Color.WHITE);

        s.setBackgroundResource(android.R.drawable.btn_default);
        s.setTextColor(Color.BLACK);

        m.setBackgroundResource(android.R.drawable.btn_default);
        m.setTextColor(Color.BLACK);

        l.setBackgroundResource(android.R.drawable.btn_default);
        l.setTextColor(Color.BLACK);

        xl.setBackgroundResource(android.R.drawable.btn_default);
        xl.setTextColor(Color.BLACK);

        xxl.setBackgroundResource(android.R.drawable.btn_default);
        xxl.setTextColor(Color.BLACK);
    }
});

s = (Button) findViewById(R.id. s);
s.setOnClickListener(this);
s.setOnClickListener(new View.OnClickListener() {
    @SuppressLint("SetTextI18n")
    @Override
    public void onClick(View v) {
        TextView tv = (TextView)findViewById(R.id.size_value);
        tv.setText("S");

        s.setBackgroundColor(Color.DKGRAY);
        s.setTextColor(Color.WHITE);

        xs.setBackgroundResource(android.R.drawable.btn_default);
        xs.setTextColor(Color.BLACK);

        m.setBackgroundResource(android.R.drawable.btn_default);
        m.setTextColor(Color.BLACK);

        l.setBackgroundResource(android.R.drawable.btn_default);
        l.setTextColor(Color.BLACK);
```

```
        xl.setBackgroundResource(android.R.drawable.btn_default);
        xl.setTextColor(Color.BLACK);

        xxl.setBackgroundResource(android.R.drawable.btn_default);
        xxl.setTextColor(Color.BLACK);
    }
});

m = (Button) findViewById(R.id. m);
m.setOnClickListener(new View.OnClickListener() {
    @SuppressLint("SetTextI18n")
    @Override
    public void onClick(View v) {
        TextView tv = (TextView)findViewById(R.id.size_value);
        tv.setText("M");

        m.setBackgroundColor(Color.DKGRAY);
        m.setTextColor(Color.WHITE);

        xs.setBackgroundResource(android.R.drawable.btn_default);
        xs.setTextColor(Color.BLACK);

        s.setBackgroundResource(android.R.drawable.btn_default);
        s.setTextColor(Color.BLACK);

        l.setBackgroundResource(android.R.drawable.btn_default);
        l.setTextColor(Color.BLACK);

        xl.setBackgroundResource(android.R.drawable.btn_default);
        xl.setTextColor(Color.BLACK);

        xxl.setBackgroundResource(android.R.drawable.btn_default);
        xxl.setTextColor(Color.BLACK);
    }
});

l = (Button) findViewById(R.id. l);
l.setOnClickListener(new View.OnClickListener() {
```

```
        @SuppressLint("SetTextI18n")
        @Override
        public void onClick(View v) {
            TextView tv = (TextView)findViewById(R.id.size_value);
            tv.setText("L");

            l.setBackgroundColor(Color.DKGRAY);
            l.setTextColor(Color.WHITE);

            xs.setBackgroundResource(android.R.drawable.btn_default);
            xs.setTextColor(Color.BLACK);

            s.setBackgroundResource(android.R.drawable.btn_default);
            s.setTextColor(Color.BLACK);

            m.setBackgroundResource(android.R.drawable.btn_default);
            m.setTextColor(Color.BLACK);

            xl.setBackgroundResource(android.R.drawable.btn_default);
            xl.setTextColor(Color.BLACK);

            xxl.setBackgroundResource(android.R.drawable.btn_default);
            xxl.setTextColor(Color.BLACK);
        }
    });

    xl = (Button) findViewById(R.id. xl);
    xl.setOnClickListener(new View.OnClickListener() {
        @SuppressLint("SetTextI18n")
        @Override
        public void onClick(View v) {
            TextView tv = (TextView)findViewById(R.id.size_value);
            tv.setText("XL");

            xl.setBackgroundColor(Color.DKGRAY);
            xl.setTextColor(Color.WHITE);

            xs.setBackgroundResource(android.R.drawable.btn_default);
            xs.setTextColor(Color.BLACK);
```

```java
            s.setBackgroundResource(android.R.drawable.btn_default);
            s.setTextColor(Color.BLACK);

            m.setBackgroundResource(android.R.drawable.btn_default);
            m.setTextColor(Color.BLACK);

            l.setBackgroundResource(android.R.drawable.btn_default);
            l.setTextColor(Color.BLACK);

            xxl.setBackgroundResource(android.R.drawable.btn_default);
            xxl.setTextColor(Color.BLACK);
        }
    });

    xxl = (Button) findViewById(R.id. xxl);
    xxl.setOnClickListener(new View.OnClickListener() {
        @SuppressLint("SetTextI18n")
        @Override
        public void onClick(View v) {
            TextView tv = (TextView)findViewById(R.id.size_value);
            tv.setText("XXL");

            xxl.setBackgroundColor(Color.DKGRAY);
            xxl.setTextColor(Color.WHITE);

            xs.setBackgroundResource(android.R.drawable.btn_default);
            xs.setTextColor(Color.BLACK);

            s.setBackgroundResource(android.R.drawable.btn_default);
            s.setTextColor(Color.BLACK);

            m.setBackgroundResource(android.R.drawable.btn_default);
            m.setTextColor(Color.BLACK);

            l.setBackgroundResource(android.R.drawable.btn_default);
            l.setTextColor(Color.BLACK);

            xl.setBackgroundResource(android.R.drawable.btn_default);
```

```
                xl.setTextColor(Color.BLACK);
            }
        });

        // TODO Auto-generated method stub
        Item.ConnectMySql connectMySql = new Item.ConnectMySql();
        connectMySql.execute("");

        //Receiving the value sent by the Cart Activity (at the openItem()
method)
        String savedExtra = getIntent().getStringExtra("ID_tag");
        item_tag = savedExtra;
    }

    //implement the onClick method
    @Override
    public void onClick(View v) {
        // Perform action on click
        if (v.getId() == R.id.size_value) {
            display_size(item_size);
        }
    }

    private class ConnectMySql extends AsyncTask<String, Void, String> {
        String res = "";

        @Override
        protected void onPreExecute() {
            super.onPreExecute();
            Toast.makeText(Item.this, "Please wait...", Toast.LENGTH_SHORT)
                    .show();
        }


        @Override
        protected String doInBackground(String... params) {
            try {
                Class.forName("com.mysql.jdbc.Driver");
                Connection con = DriverManager.getConnection(url, user,
```

```
pass);

                String result = "Database Connection Successful\n";

                //Query1: Find which products are in the FR
                Statement st = con.createStatement();
                ResultSet rs = st.executeQuery("select * from stock where
location = 4");
                ResultSetMetaData rsmd = rs.getMetaData();


                //Query2: Using the ID from Query1, asking for further info
about the kind of the product. I get its photo and color.
                String query = "select * from products where ID = 1";
                st = con.createStatement();
                ResultSet rs2 = st.executeQuery(query);
                rs.next();
                rs2.next();

                InputStream binaryStream = rs2.getBinaryStream(6);
                String price = rs.getString(3).toString();
                show_image(binaryStream, price);

                item_size = rs.getInt(2);
                display_size(item_size);

                item_color = rs2.getInt(7);
                display_color(item_color);

                while (rs.next()) {

                }
                res = result;
            } catch (Exception e) {
                e.printStackTrace();
                res = e.toString();
            }
            return res;
        }
```

```java
    @Override
    protected void onPostExecute(String price) {
        //item_price.setText(price);
    }
}

public void show_image(final InputStream str, final String price) {
    runOnUiThread(new Runnable() {
        @Override
        public void run() {
            Bitmap bitmap = BitmapFactory.decodeStream(str);
            item_image.setImageBitmap(bitmap);
            String timi = "" + price;
            item_price.setText(timi);
        }
    });
}

public void display_size(int item_size){
    if (item_size == 1) {
        xs.setBackgroundColor(Color.DKGRAY);
        xs.setTextColor(Color.WHITE);
        size_value.setText("XS");
    }
    else if (item_size == 2) {
        s.setBackgroundColor(Color.DKGRAY);
        s.setTextColor(Color.WHITE);
        size_value.setText("S");
    }
    else if (item_size == 3) {
        m.setBackgroundColor(Color.DKGRAY);
        m.setTextColor(Color.WHITE);
        size_value.setText("M");
    }
    else if (item_size == 4) {
        l.setBackgroundColor(Color.DKGRAY);
        l.setTextColor(Color.WHITE);
        size_value.setText("L");
```

```java
        }
        else if (item_size == 5) {
            xl.setBackgroundColor(Color.DKGRAY);
            xl.setTextColor(Color.WHITE);
            size_value.setText("XL");

        }
        else if (item_size == 6) {
            xxl.setBackgroundColor(Color.DKGRAY);
            xxl.setTextColor(Color.WHITE);
            size_value.setText("XXL");
        }
    }

    //Method to get all the colours (available and not) that a product comes.
    public void get_colors(ArrayList existing_colors) {
        if (existing_colors.contains(1)) {
            BLACK.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(2)) {
            BLUE.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(3)) {
            CYAN.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(4)) {
            DKGRAY.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(5)) {
            GRAY.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(6)) {
            GREEN.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(7)) {
            LTGRAY.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(8)) {
            MAGENTA.setVisibility(View.VISIBLE);
```

```
        }
        else if(existing_colors.contains(9)) {
            RED.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(10)) {
            TRANSPARENT.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(11)) {
            WHITE.setVisibility(View.VISIBLE);
        }
        else if(existing_colors.contains(12)) {
            YELLOW.setVisibility(View.VISIBLE);
        }
    }

    public void display_color(int item_color) { //This method will display
the color selected by the user. It is unfinished
        if (item_color == 1) {
            color_value.setText("Black");

        }
    }

    public void openMainActivity() {
        Intent intent = new Intent();
        setResult(RESULT_OK, intent);
        finish();
    }
}
```