NFC-ENABLED SMARTPHONE APPLICATION FOR THEME PARK SAFETY AND CONTROL

by

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ABSTRACT

The U.S. Consumer Product Safety Commission has stated that the number of children who experience accidents and injuries inside theme parks increases yearly. Adults also face difficulties inside theme parks and suffer from ride-related injuries. In order to avoid such problems, theme park visitors should be aware of the importance of reading the warnings and instructions and ensure that the ride regulations are met. However, these instructions are largely ignored. This thesis presents a novel theme park mobile application that aims to decrease theme park accidents and increase safety by ensuring that theme park visitors meet the requirements of the chosen ride. The NFC-based smartphone approach ticket system aims to minimize the waiting time for purchasing tickets, reduce the time spent waiting for ticket collecting, and provide a more secure electronic ticketing system by using the advantages of NFC technology. Moreover, the smartphone application provides theme park statistics for theme park management teams, and immediate updates for the number of theme park visitors inside a theme park. The system features enhance the entire theme park experience for visitors while ensuring that they have a safe experience. The application has been implemented on an Android platform and tested for different use cases, reliability, and performance.

LIST OF ABBREVIATIONS USED

ADT Android Development Tools

DDMS Dalvik Debug Monitor Server

NFC Near Field Communication

RFID Radio Frequency Identification

SDK Software development kit

CPSC U.S. Consumer Product Safety Commission

CARES Council for Amusement and Recreational Equipment Safety

TSSA Technical Standards and Safety Authority

ADIPS Amusement Device Inspection Procedures Scheme

Symbols

FR Functional Requirement

NFR Non-Functional Requirement

CHAPTER 1: INTRODUCTION

Amusement parks are meant to be places to entertain visitors of different ages. Over the years, the parks have become an essential tourism attraction for people looking for a family-friendly vacation that emphasizes fun for all ages. Theme parks are important and complex forms of entertainment, with a broad user-base and a substantial economic impact [1]. Thus, all efforts taken to enhance and facilitate services inside theme parks are valuable and important.

Despite their ongoing success, theme parks can still be improved. Technology has proven its effectiveness in improving our lives, and it can also be utilized in the theme park industry as well. For instance, technology can be applied to provide solutions for issues such as enhancing safety, reducing wait-times in lines, managing crowd numbers inside the park, and so on. Technology is already being used inside theme parks for 'fun' purposes such as computer games or for financial solutions such as booking rides or hotels. However, it has not been used as frequently for safety issues.

Nowadays, mobile media is an integrated part of our everyday life, as it has become a general habit never to leave home without our smartphone. We constantly carry these devices in our pockets, hands, or bags and use them in a variety of different contexts [2]. Moreover, there has been an increasing interest in designing location-aware mobile content for theme parks, as this type of content has become a golden opportunity to communicate with guests of the theme parks prior to, during, and after their visit [2]. The aim in so doing is to enrich and enhance the visiting experience.

All of these aspects combined allow for theme parks to be an interesting area for mobile

user experience research. Lately, technologies such as Near Field Communication (NFC), Global Positioning System (GPS), Wi-Fi, and Bluetooth have become standard in many mobile devices. Location-aware mobile content has emerged as a widely popular field that can be very useful in designing smartphone applications using these technologies. The research goal is to solve some of the most important issues around theme parks, namely safety, waiting times for ticket collecting or waiting for rides, and crowd control. Additionally, this research aims to contribute to theme park improvements and development facilitation through providing instant statistics about the current status in a park.

The NFC-based theme park mobile application can meet the required goals through providing services for three types of audience: theme park ride operators, theme park visitors, and theme park administrators. Firstly, services that are designed to improve safety inside theme parks and fall under theme park ride operator services are: information comparison, which ensures that theme park riders' general and health information meets the attraction's minimum required instruction. As well, the warning emails service enables ride operators to send warning emails should a visitor become lost or trapped in an attraction. In such a case, the ride operator can send an automatic email through the smartphone application to the visitor's family as an alert.

Moreover, a service provided for theme park visitors under the category of raising safety services is visitor ride reports, which allows a visitor to inquire about the current location of another visitor by entering his or her ID in the smartphone application. A detailed report by date and time shows the list of all the rides that a certain visitor took and which ride they are currently on. In addition, the registration services that is provided by theme

park administrator in the field of increasing safety which allows administrators to fill out a short electronic form that will be used to ensure that theme park visitors take rides that are suitable for their condition and thus help prevent risks. The term ‘administrator’ we use in the thesis refers to registration office employees.

Service that are designed in the application to meet the goal of reducing waiting time comes under services provided for theme park ride operators, which is the NFC-ticket system, that will be discussed in detail in the following sections and chapters.

Finally, there are services provided for controlling, managing, or improving the theme park in total, such as crowd-checking services, which is an attempt to control crowds. Crowd management is important for solving crowd problems that could occur in many public places, such as airports, bus or train stations, as well as amusement parks [3]. The crowd check service allows visitors to know the current number of visitors inside the theme park to help him or her decide whether or not to go (if they want to avoid crowds).

Additionally, the statistics service provides different types of instant statistics regarding preferred rides, ages groups of theme park visitors, and preferred days for visiting theme parks such as some holidays and vacations. The motivations behind this NFC-enabled smartphone application for theme park application are as follows: to help increase safety inside theme parks, as safety is a top priority in the theme park ride industry. It is very important for amusement parks to provide safe rides and activities for visitors of all different ages. We designed this application because we believe in the importance for all theme park operators, managers, and visitors to work together in order to deliver a safe theme park visit.

Generally, theme parks are considered to be one of the safest public activities, and we aim to support theme parks safety procedures with technology solutions that provide many advantages such as saving time. According to the International Association of Amusement Parks and Attractions (IAAPA) [4], the 2013 Fixed-Site Amusement Ride Injury Surveys stated that in 2013, there were about 315 million theme park visitors who visited around 400 American theme parks. The statistics also indicated that the visitors took in about 1.4 billion theme park attractions safely. Moreover, the statistics showed some common sports activities and the number of related injuries. In fact, the estimated number of related injuries for roller skating (according to the National Sporting Goods Association) was 912 in about one million days, 799 at the same period of time for basketball, and 704 in football [4]. Starting in 2001, the IAAPA carried out an annual survey that aims to collect and analyze data regarding theme park attractions, attendance, and activities-related injuries [4]. The survey provided by IAAPA focuses on theme park-related injuries in the United States. Table 1 below shows the estimated number of injuries for both attendance-related injuries and ridership-related ones in the period of time from 2003 to 2013 [4]. Usually, the term “theme parks” is used for theme parks that include rides and attractions such as Disney land, and Six Flags; nevertheless, the definition of theme parks can also include other places such as zoos, social activities centers, and annual festivals [8]

Table 1: Attendance-Related Injuries and Ridership-Related Injuries

Year	Attendance-Based		Ridership-Based		Difference between attendance-based and ridership-based injury count
	Estimated Annual Number of Ride-Related Injuries	Injuries per Million Attendance	Estimated Annual Number of Ride-Related Injuries	Injuries per Million Patron-Rides	
2003	2,044	7.0	1,954	1.0	+90
2004	1,637	5.2	1,648	0.9	-11
2005	1,783	5.2	1,713	0.9	+70
2006	1,797	6.6	1,546	0.9	+251
2007	1,664	4.6	1,309	0.7	+355
2008	1,523	4.7	1,343	0.8	+180
2009	1,181	4.4	1,086	0.6	+95
2010	1,299	4.4	1,207	0.7	+92
2011	1,204	4.3	1,415	0.8	-211
2012	1,424	4.6	1,347	0.9	+77
2013	1,356	4.7	1,221	0.9	+135

Source: International Association of Amusement Parks and Attractions (IAAPA)

Moreover, the application is designed to provide a practical solution for the problem of waiting in long lines. A very important issue inside theme parks for both theme park visitors and theme park employees is tickets. It can take a long time to wait in lines to purchase tickets, especially on holidays and during high season. These are inconveniences for both visitors and employees. The same inconveniences can occur when ride operators collect tickets from riders. Riders may have to wait a long time until a ride operator finishes collecting tickets from all riders, especially when there are many riders on a particular ride.

According to Lith in his paper "Queue Management," many studies have been performed to determine the reasons for declining attendance in many theme parks. Although conclusive evidence has not been found, some surveys have revealed that a very high visitor dissatisfaction rate was due to the long wait times. Accordingly, many theme

parks require solutions for this issue [5]. Some theme parks have attempted to reduce waiting times by dividing the queue into smaller queues; others have tried to make the queue itself an attraction or activity. Attempts are still ongoing to eliminate the most boring waiting time inside a theme park, which is the ride queues, according to many visitors' opinions [5]. Some theme parks have attempted to develop a ticket system that can help to reduce such problems, but usually these ticket systems require credit card information, which is not a choice for people that do not have a credit card or for those who view them as a security threat for their bank accounts.

Our designed ticket system uses NFC technology to provide instant virtual tickets that allow users to avoid long line-ups. The virtual tickets are registered directly in the theme park's user database and connected through NFC technology to the user's bracelet. Moreover, the ticket system is highly secure, as it does not require any banking or credit card information. The NFC-ticket system is useful, practical, and simple. It increases value and the quality of theme parks, and solves one of the largest dissatisfactions for theme park visitors, which is long waiting lines. Additionally, this developed theme park smartphone application system allows people to know in advance the crowd rate inside theme parks by providing immediate updates of the number of people inside a particular theme park. People can check the crowd status through our smartphone application.

Finally, the application provides significant statistics regarding popular rides, most preferable rides for a certain age group, and most preferable days for people to visit the theme parks. These statistics are very important for theme park management teams in order to develop the theme park and recognize what improvements are required. The smartphone application system uses NFC technology, an Android operating system,

Eclipse, visual studio, and SQL databases.

The main objective of this thesis is to outline the value, development, and use of a smartphone application system that use NFC-enabled devices under a Wi-Fi coverage area to minimize accidents in theme parks due to the misusage of rides. Likewise, the application also helps theme park managers develop and improve the theme park facilities. Just as importantly, the application is environmentally-friendly because there is no need for paper tickets. This process is completed entirely in a simple user interface. The following properties should be included in the smartphone application system:

* Providing theme park statistics for theme park management teams.

* Reducing the time spent waiting for ticket purchasing.

* Reducing the time spent waiting for ticket collecting.

* Increasing safety procedures inside theme parks.

* Providing immediate updates for the number of theme park visitors inside a theme park.

The theme park NFC-based smartphone application system has been implemented using Google Nexus 7 tablet with an Android 4.4.4 platform, NTAG203 tags, visual studio, SQL databases containing information of theme park employees (administrators and ride operators), theme park visitors, and rides requirements. The remaining chapters for this thesis are organized as follows. Chapter 2 discusses the current situation of theme parks and their existing safety procedures, and also provides an historical overview of theme parks and the main improvement stages that they have experienced over decades of

existence. As well, the chapter provides a short introduction to NFC technology and other similar technologies, discusses the current technology systems in theme parks, and shows important features that are provided by our theme park NFC-based mobile application that are not found in other theme parks' existing systems. Chapter 3 discusses the proposed framework of the NFC-based smartphone application for theme park visitors' safety and theme park control. Chapter 4 presents system scenarios and use cases that lead to system requirements. Chapter 5 discusses the system's implementation, and Chapter 6 provides information on testing of the system, including network tracking, CPU load, and memory usage. Finally, Chapter 7 discusses the system's limitations and future work.

Chapter 2: Background and Literature review

2.1 Historical Overview of Theme Parks

Many historians claim that the first amusement park was founded in medieval Europe. In fact, Bakken, which is the world's oldest theme park, is still in operation. It was opened in Denmark in 1583 [6]. Since the world's first amusement park was created, theme parks have been attracting people of all generations, offering perpetually new and exciting ways of entertainment that keep people returning [6].

In the beginning, amusement parks were more like gardens, but starting in the early 1900s, amusement parks gradually began taking the form and concept of today's parks [6]. Many large landscapes transformed into sets of attractions and exciting rides in order to please people that were looking to experience new thrills and adventures.

Since the early 1900s, amusement park visitors have experienced different games and attractions that have sometimes required special body movements and positions [6]. The ability of an individual to perform these body movements and positions depends on his or her ability to control a certain ride as well as his or her physical condition. One of the largest and most attractive amusement parks is Disneyland, which was founded in 1955 [6]. People still travel from all over the world to live the magical experience inside this storied theme park. Disneyland was the beginning of a different era in the world of amusement parks by moving from old-fashioned, traditional, and simple amusement parks to the amusement parks that we know today which have lots of rides and thrills [6]. Moreover, the amusements parks went through several improvement steps in 1971 when Walt Disney World was founded and created a new and enhanced shape for amusement

parks [6]. However, the amusement park industry must take safety very seriously as many rides and attractions execute high speeds and turns. Safety is especially important in rides where there is interaction with other close riders, which could lead to collisions and varying degrees of risks [7].

2.2 Current State of Amusement Parks

Currently, there are many smartphone applications that are designed for different purposes and services related to theme parks. Many of these smartphone applications are supported with technologies such as wireless connection (e.g., RFID, NFC, and Bluetooth), Short Messaging Service (SMS), or Multimedia Messaging Service (MMS). Some of the applications can be used outside theme parks, such as the ones that are specialized for providing information regarding theme park special events or offers, ticket purchasing before the visit, or attraction reservations. Others are designed to be used inside theme parks, such as smartphone applications for navigation inside the parks [9].

Claus highlighted two theme park smartphone applications that use technologies such as SMS, MMS or GPS. The first theme park application that he mentioned is using SMS for sending visitors notification alerts or messages [9]. Visitors have to register first for the SMS notification service when they enter the theme park, then they will be able to receive three types of SMS notification messages during their stay in the theme park: SMS messaging for providing visitors information as a customer service, SMS messages that contain quizzes which visitors can solve while waiting in lines (as a way to pass the time), and SMS messages of theme park special offers.

The second application mentioned by the author is a smartphone theme park system that

uses NFC technology and GPS. The system is designed for a zoo and provides visitors with information about many zoo animals. Visitors can choose a special animal through the device touch screen and receive information about it. The smartphone system includes information about all zoo animals and is supported with images, audios, or videos that are displayed on a website. Zoo visitors can borrow the device from the park [9].

2.2.1 Overview of some parks' safety policies

Theme parks usually set a number of instructions, rules, and regulations that visitors should respect and follow in order to have a safe theme park visit. Many organizations were founded mainly for raising safety inside theme parks and ensuring safe visits for park guests. In the following section, several organizations from different countries (United States, Canada and the United Kingdom) are presented and described.

* The U.S. Consumer Product Safety Commission (CPSC):

In the United State, theme park attractions and rides are regulated through federal and state laws as well as other standards [10]. One of the organizations in the U.S. that takes care of safety regulations inside theme parks is the U.S. Consumer Product Safety Commission (CPSC) [10], which is permitted to inspect and analyze theme park accidents. Additionally, CPSC works with other theme parks industries to set up suitable theme park rules and regulations [10].

* Council for Amusement and Recreational Equipment Safety (CARES)

CARES is a union of agencies from the U. S., Canada, and other countries. They aim to

share experiences and find best practices between organizations that can raise safety awareness in theme parks. According to the organization's official site, CARES defines themselves as an "organization of government officials responsible for enforcement of amusement ride and recreational equipment regulations. CARES maintains information pertaining to the safety of amusement rides as a public service for use by regulatory officials, industry, and consumers" [11].

* Technical Standards and Safety Authority (TSSA)

The Technical Standards and Safety Authority (TSSA) provides theme park visitors with a number of useful information related to public safety [12]. Many conducted studies and reports are included in the TSSA website. In addition, the website contains valuable technical information regarding safety inside theme parks. TSSA is supported by the government of Ontario, Canada [12].

* The Amusement Device Inspection Procedures Scheme (ADIPS)

The Amusement Device Inspection Procedures Scheme (ADIPS) performs inspections on theme park attractions and rides to ensure that they are in good working order and safe condition [13]. The inspections are done on theme park rides before being operated and also under service. ADIPS checked the rides regularly to ensure their safety [13].

2.2.2 Overview of theme park mobile-based systems

Our NFC-based smartphone application is highly unique. Through a literature review of a number of NFC- and RFID-based systems used for different purposes at theme parks, we noticed the uniqueness of our NFC-based application in terms of its services and features

that it uses and combines.

2.2.2.1 Using RFID or NFC in theme parks for reducing waiting times

Currently, a very significant issue for many amusement park companies is increasing visitors' satisfaction. Long waiting times for attractions has been known as a reason for a decrease in theme park visitors' satisfaction [14]. Therefore, theme parks have recently produced several RFID- and NFC-based systems to overcome this problem.

2.2.2.1.1 Disney experience

One of the most well known experiences using RFID technology in the entertainment industry is Disney. Disney is a leading company in the entertainment industry, and therefore their experiences are important. Steve Brown, the operating officer at the British company Lo-Q stated: “When Disney makes a move, it moves the culture” [15]. Disney presented an RFID wristband and card that facilitated a number of tasks which make amusement park visits more enjoyable, easy, and fun for visitors. The RFID-based wristband (called MagicBands) and cards allow visitors to do a variety of actions such as unlock the doors of their reserved hotel rooms or check in at Disney fast pass entrances, where visitors use their wristbands or cards to enter their favorite attractions that they previously reserved. As a result, visitors can enjoy their favorite attractions without long waiting times. Moreover, visitors can charge food to their reserved hotel rooms using their wristbands or their cards.

However, there are some concerns regarding privacy when using Disney's RFID system. Disney tracks their clients' behavior through the RFID system such as their preferred purchases, kinds of attractions they enjoy, and the Disney character they are most

interested in meeting. The visitor information is stored in special databases. These actions raise arguments around privacy concerns, as some people do not like the idea of tracking this information and consider it a privacy violation [15].

2.2.2.1.2 Six Flags experience

In order to use technology to reduce waiting times in theme parks, Six Flags presented an RFID-embedded wristband called FLASH PASS. Visitors wear this special band to ride their favorite attractions without having to wait a long time in lines. The attraction is reserved in advance, and when a visitor's turn is approaching, he or she receives alerts. The visitor can then ride the attraction immediately with no waiting time [16].

2.2.2.2 RFID in theme parks for child safety purposes

2.2.2.2.1 Legoland experience

Legoland's RFID-based system has been a leader in terms of using RFID tags and a smartphone-based system for child safety purposes. It presents a child-tracking RFID and WiFi-based system. In this case, parents lose some of their privacy rights for the sake of having more peace of mind regarding their children’s safety. The Danish theme park allows parents or caregivers to tag their kids, and then they can easily track their children’s locations through a wireless network. Legoland has presented this system specifically for the lost-child problem. The child-tracking system depends on radio frequency identification (RFID) combined with a wireless network. Adult visitors who accompany children in the theme park and have a smartphone with text-messaging can then obtain special wristbands for their children. They will then be able to track their children up to about five feet of their parents' location in case the children and parents become separated. The system allows parents to obtain an RFID-embedded bracelet for

their kids. If the children become separated from their parents inside the park, the parents can receive quick alerts, which are text messages received on their smartphones that inform them about the location of their lost children.

Moreover, in case a child leaves the amusement park, a message will be sent to all security guards who are at the amusement park gates. Messages are also sent to parents' phones, so they can take the necessary actions for finding their child [17].

2.3 Overview of Near Field Communication Technology Concept

NFC stands for Near Field Communication, which is a relatively new wireless technology that was initially developed by Sony and Philips [18]. This technology enables mobile devices to communicate with other objects or mobile devices in a short range distance. In order to generate communication between two devices, one can make these devices touch together physically or put them close at a short distance [18]. Communication can be with passive objects or actively with mobile devices that contain NFC readers. In the case of passive communication, one device initiates the communication through the 13.56 MHz field, while both devices generate the power in active mode. This form of communication allows for the transfer of data in a way that helps users obtain services more flexibly and accomplish tasks in easier, faster, and more secure ways [21] [18].

NFC implementation is becoming more widely used, and its applications are growing every day. The result has been increased popularity for this new technology [22]. For example, NFC has been involved in many significant implementations in mobile

payments, flight reservations, access control, product advertisements, indoor navigation, as well as other implementations and uses in areas such as health care and education.

2.3.1 NFC types of operating modes

NFC devices allow for communication and the transfer of data through supporting three types of operation: reader/writer mode, peer-to-peer mode, and card emulation mode [19].

1- Reader/writer mode: In reader/writer mode, one NFC device can read data from one NFC tag at a time. The NFC device in this mode can also write data on the detected NFC tag. Reader/writer mode allows date to be transferred from or to an NFC tag by an NFC device. Two modes are defined in this type: reader mode and writer mode. Advertisement posters that use NFC tags are an example of reader/writer mode. When a person passes or taps the NFC tag with his or her NFC-enabled smartphone, he or she can read more information about the advertisement or open a related link [19].

2- Peer-to-peer mode: In peer-to-peer mode, two mobile devices can communicate with each other in order to share information or data, such as personal contact information. However, the number of applications that have been developed with the use of peer-to-peer operating mode is fewer than the other two operating modes. Peer-to-peer operating mode is commonly used in device pairing, file sharing, and networking [19].

3- Card emulation mode: In card emulation mode, an NFC-enabled phone can be used as a contactless smart card. Widely known examples of contactless smart cards are credit cards, identity cards, and debit cards. In card emulation mode, a user does not need to

carry his or her contactless smart card with him or her at all times. Card emulation mode gains its importance from its integration with very important applications such as payment applications, ticketing applications, and access control applications [19].

2.3.2 NFC applications and uses

Recently, NFC technology has been widely used in a large number of applications, which shows people's preferences and acceptance of this relatively new technology. In fact, experts expect a new generation of brilliant applications that use NFC in the near future. Opportunities for smartphone application developers to invent several useful applications have increased due to the availability of NFC in mobile devices [20]. For instance, NFC technology has been widely used in payment applications, as it shows a high level of security. For example, in Japan and Hong Kong, the use of credit cards through NFC technology has been in existence for a long time, as has using NFC technology in public transportation cards, grocery stores, and advertisement posters [20]. Moreover, some posters and magazine pages use NFC by attaching NFC tags that contain data such as coupons, schedules, and product information [20].

2.3.3 NFC security aspects

There are some issues regarding security in wireless connection in general, such as man-in-the-middle (MITM) problem and user privacy concerns [23]. These issues are of particular concern in RFID technology. In NFC technology, however, these problems are less complicated and easier to solve due to the short communication distance in data transferring. Unlike other wireless technologies such as some RFID systems or Bluetooth technology, it is very difficult in NFC to set up attacks or data sniffing in real

life MITM. However, there are three main types of attacks that can occur:

Eavesdropping. Eavesdropping or communication sniffing is one of the most common attacks on wireless technologies. Attackers are able to listen to data being transferred through Wi-Fi technologies by using special tools. Fortunately, eavesdropping is hard to be implemented in NFC due to the close distance required for data transferring. This is a major concern in other communication technologies that offer data transferring in a wider wireless rang. Listening to transferred data through a passive mode is more difficult than in an active one [23].

Data Modification. Data modification refers to any modification of data that is done by an attacker that produces wrong messages. The attackers in this operation have to work on RF signals to be able to change the data. The success of data modification attacks depends on how strong the amplitude modulation is [24].

Man-in-the-middle. In a man-in-the-middle attack, the attacker sits between two people who are communicating wirelessly. The attacker receives the information from the sender, and sends information in another communication between him to the receiver. [23]. To ensure that neither communicators discover the attack, he captures the information from the sender and prevents it from reaching the receiver by sending another one [23]. However, NFC can detect if the sent information does not match the original information. Moreover, the short distance required for information transferring in NFC makes it difficult for MITM attacks to occur [23].

2.3.3.1 Our NFC-enabled application and privacy protection

It is important to note that, in our application, we do not focus on gathering detailed information, as we wish to protect the visitors' privacy. Instead, we ask that only very short answers be given, and we state that lengthy health and disease details are not required. Furthermore, the application relies on the ID, not names, and the first name only is given. Moreover, data saved in the theme park database can only be revealed to theme park administrators.

2.4 Overview of Radio Frequency Identification Concept

Radio Frequency Identification (RFID) is a technology that depends on radio frequency waves to perform different tasks such as identifying or tracking objects [25]. RFID systems basically transfer data using RFID tags and a reader [25]. NFC inherits some characteristics of RFID and can even be defined as an extension of RFID technology [26] [27]. However, NFC is a more secure way of transferring data [28].

2.4.1 RFID system components

There are two basic types of elements that together make up the RFID system: hardware-type elements and software-type elements. More precisely, the process of receiving data and identifying it is executed through the hardware element, while the software element processes the received data [25].

2.4.1.1 Hardware components

RFID hardware components include: the RFID tag, which holds the data; the reader, which reads or writes the data from or to a certain RFID tag; and the antenna, which is essential for transferring data between a reader and an RFID tag [25].

2.4.1.2 Software components

The software components in RFID systems differ based on the purpose of the system. RFID software components can generally be categorized into three parts: system software, RFID middleware, and host application. The system software is the required software for allowing communication between a reader and an RFID tag [25]. The RFID middleware facilitates communications between the readers and RFID tags with the host application. The host application is the software element that receives data by the reader from an RFID tag [25].

2.5 Summary

In this chapter, NFC technology concepts, implementation and security aspects were discussed. An historical background of theme park development was also summarized and an overview of the current state of theme parks was presented. Finally, a number of current theme park systems were presented and explained.

CHAPTER 3: PROBLEM STATEMENT AND PROPOSED FRAMEWORK

This chapter highlights the problem statement of the thesis. The chapter also presents the initial proposed framework of the application to obtain the required results.

3.1 Problem Statement

Theme parks are meant to be places where families can enjoy each other's company and play safely. Entertainment plays an important role in a child's healthy growth and development, and it also helps to empower the relationships of families and bind them together. As stated on a report from the official journal of the American Academy of Pediatrics, playing is important to children and their families because it supports the children's physical and social development as well as their emotional and cognitive improvement [29]. Moreover, play helps parents and children spend quality time together [29]. Therefore, every effort taken to improve and support children and their families' special play places is important, and as theme parks are usually the top preferences for play, taking care of such parks is a very significant job.

Unfortunately, many accidents and injuries occur in theme parks, and as indicated in earlier chapters of this thesis, investigations show that one of the main reasons for such accidents is ignoring instructions, requirements, and warnings associated with theme park rides. Therefore, this thesis presents a novel NFC -based theme park application that is designed to protect children and their families from theme park accidents. It provides

services that are designed to enhance the families' overall visits to theme parks in order to derive the maximum possible benefits for children and families.

3.2 Proposed Framework

This section presents the proposed framework for the NFC-based smartphone application for theme park safety and control. The proposed smartphone application is intended to provide services for theme park visitors, ride operators, and theme park administrators, with the ultimate goal of helping develop and improve theme parks. The main interface of the application gives a choice to enter as an employee or as a theme park visitor. Additionally, there are two other services in the main interface: providing the current number of theme park visitors, and presenting statistics regarding preferred rides, preferred days for visiting theme parks, and more.

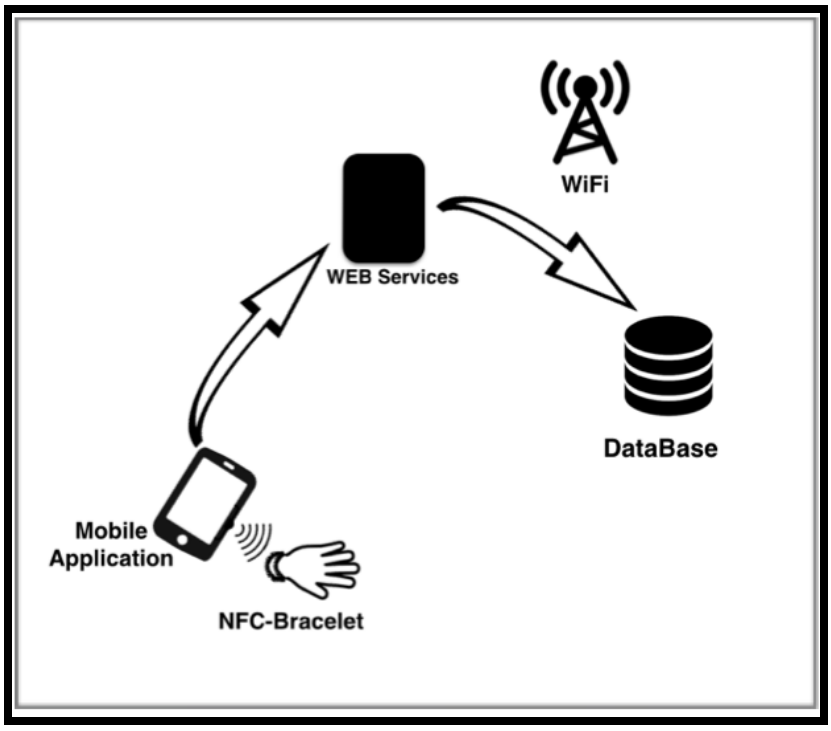

Figure 1. The proposed framework system of the NFC-based application.

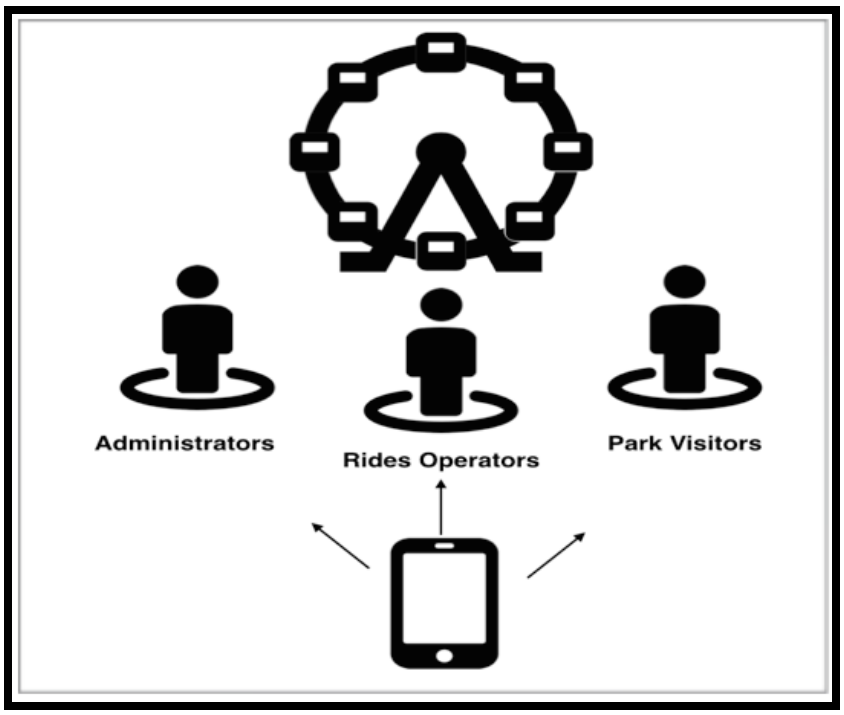

Figure 2. Target audience of the NFC-based application.

3.2.1 Accessing the application as an employee

3.2.1.1 Theme park administrators

Theme park employees can be classified into two categories: theme park administrators and theme park ride operators. The interface of the proposed application when entering as an administrator (registration employee) shows three buttons: adding new visitor, NFC-tickets, and main gate checking.

Adding new visitors. One of the three tasks that the administrator can perform through the application is adding and registering a theme park visitor. The visitors will be asked to provide information regarding their general and health status to ensure that they access only the rides that are suitable to their conditions. In this way, accidents caused by ignored ride instructions will be avoided. When a visitor's registration form is completed, an automatically generated ID will be produced by the NFC-application, and the

administrator writes it in the visitor's NFC-bracelet.

NFC-Tickets. In this theme park application, a new technique of paying for tickets is provided. NFC tickets are designed to offer valuable advantages, such as:

* No long lines for having to buy tickets (reduced delays)

* Saves time

* Does not require any credit cards or banking information (more secure). In each ride, the ride operator with his or her NFC mobile application scans the visitor's NFC wristband for taking a ride ticket, and the ticket is discounted from the visitor's account.

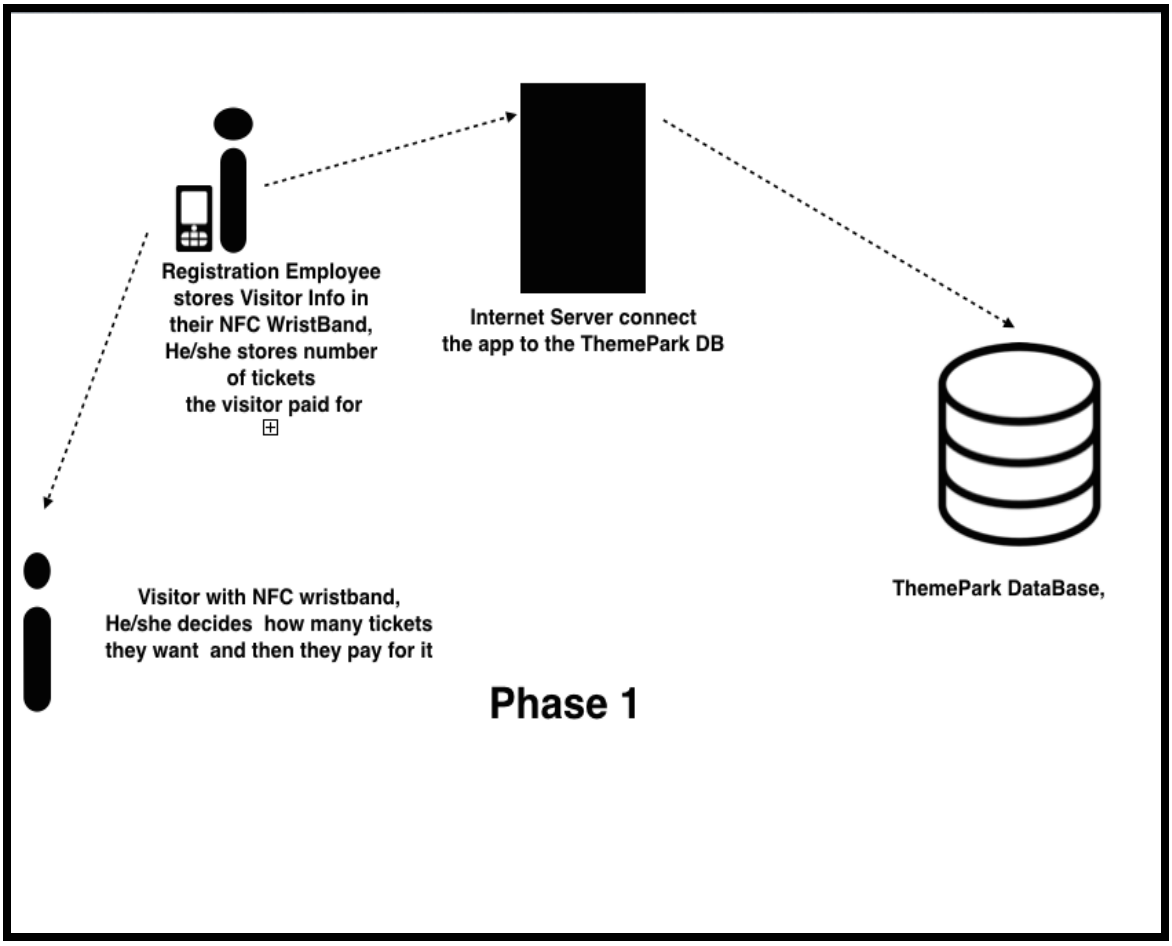

Figure 3. NFC-ticket system workflow.

As shown in Figure 3, when the administrator completes the visitor's quick electronic form in the registration phase, they register how many tickets the visitor wants, and the visitor pays the amount directly to the administrator. The visitor's account is charged with the purchased tickets immediately, and his or her NFC wristband will be linked with the charged tickets. Whenever a park visitor chooses a certain ride, the operator scans his or her wristband with the NFC mobile application to count one ticket that will directly be discounted from his or her total number of tickets. Through the web service, the number of tickets for the park visitor will be updated.

Main gate checking. The third service provided by the proposed theme park application is crowd checking, which shows the number of current visitors at the theme park. People can check the number of visitors at the theme park from home before leaving for the park. This feature allows people to decide whether or not to come, depending on how crowded the park already is. The application includes a main gate check in/out button. Visitors who enter the theme park are checked in, and the ones who go outside are checked out by scanning their NFC wristband with the administrator's NFC application mobile device. The number is directly counted, updated and saved by the application, and through the web server, people can check the application from anywhere to know the actual number of people inside the theme park. In so doing, they can avoid crowds, if they desire.

There is, however, a difference between the main gate check-in and rides check-in. As Figure 4 shows, the main gate check-in service is designed to provide information about the number of checked-in visitors. On the other hand, the rides check-in service is

designed to collect the NFC-tickets , as well as to perform informational comparisons of the visitors and rides in order to ensure that the ride is safe for the visitor.

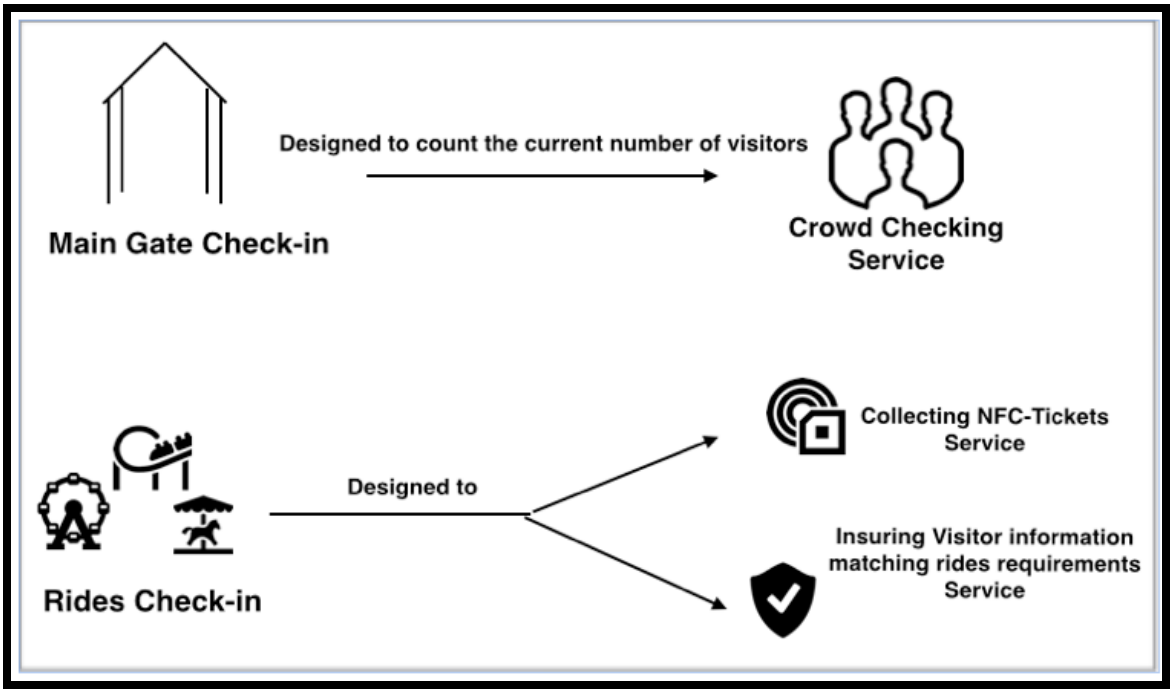

Figure 4. The difference between main gate check-in and rides check-in.

3.2.1.2 Theme park ride operators

3.2.1.2.1 Visitor information and ride instruction comparison

This mobile application aims to ensure the safety of theme park visitors and control playing inside the theme park by comparing the general information of users (e.g., height and date of birth) as well as health information. Health information includes only answers to the following question: Is the theme park visitor pregnant or suffering from any asthma, heart disease, or back pain? The information is then used to ensure that the chosen ride is safe for the theme park visitor and is not a risk to him or her. Detailed information about the visitors' health will not be maintained, and the information will serve as a check point only. For example, if a visitor suffers from heart disease, he or she will not be required to give any more details about the specifics of the disease. As shown

in Figures 5 and 6, the ride operator then passes his or her mobile device that contains the theme park's application over the visitor's NFC wristband to check if the chosen ride is suitable for the visitor.

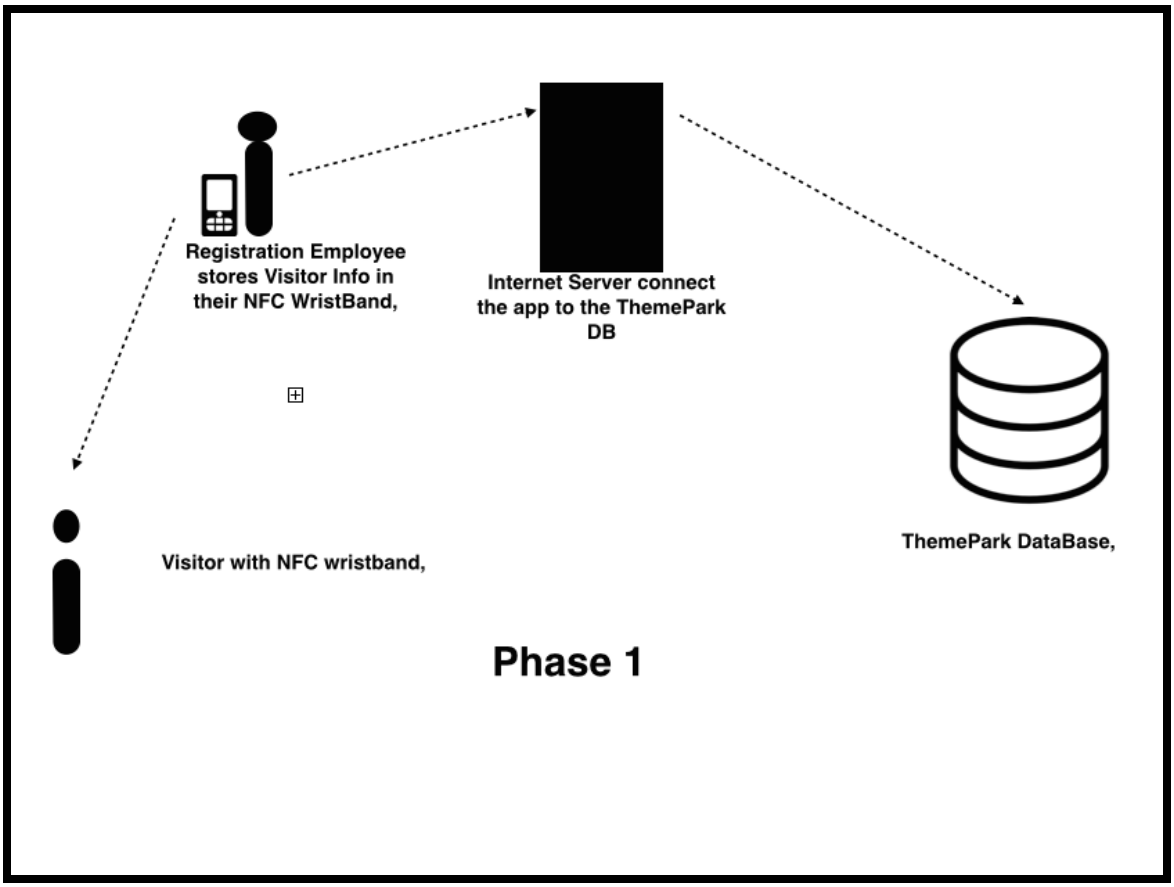

Figure 5. Workflow of the ride operator task: phase 1.

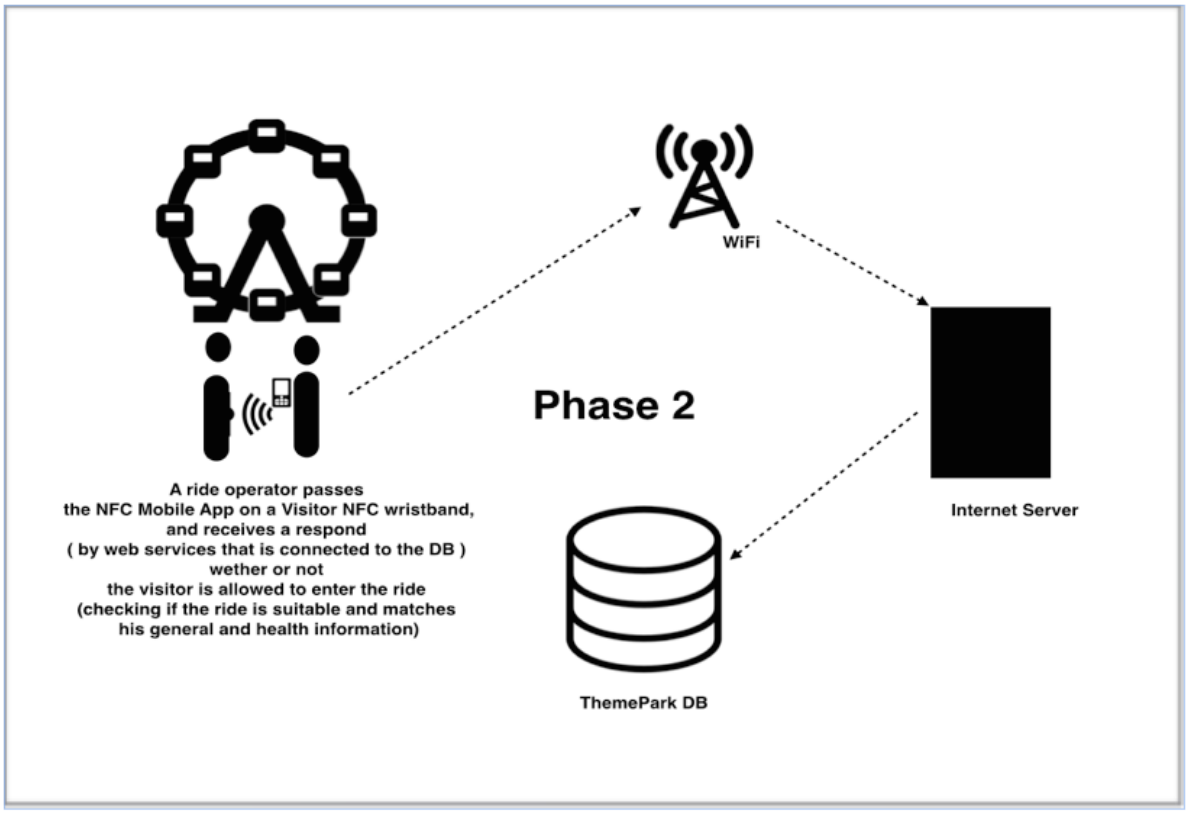

Figure 6. Workflow of the ride operator task: phase 2.

3.2.1.2.2 Warning email service

In this service, a warning email is sent to the visitor's family by the ride operator if the visitor does not check out of the ride that they checked in, to give their family an alert, as the visitor could be lost or trapped in the ride. In this service, a connection is made by a web service through a wireless connection to retrieve the previously stored email from the database.

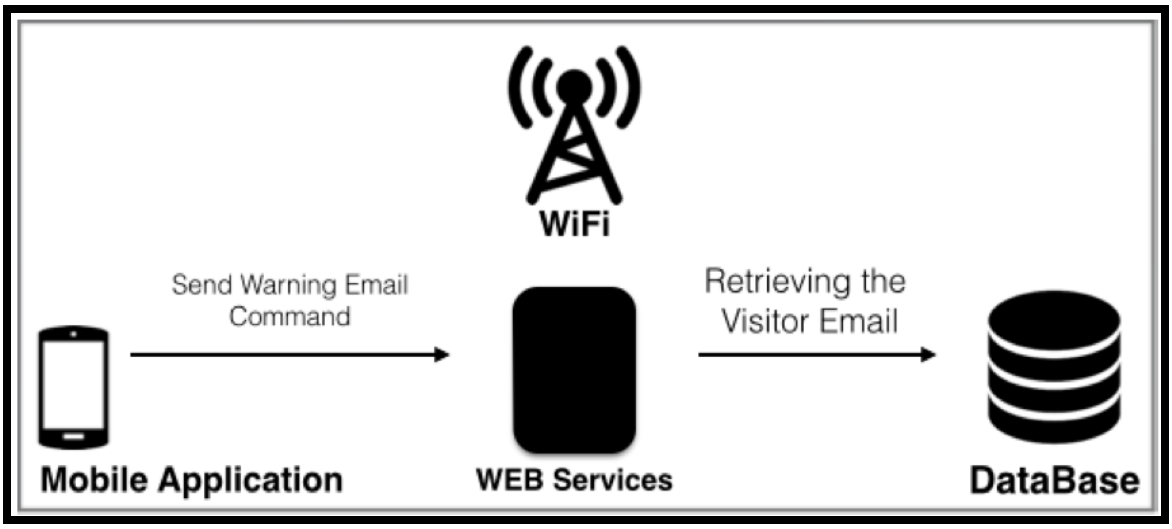

Figure 7. Warning email service.

3.2.1.3 Statistics service

As mentioned earlier, the theme park NFC-based smartphone application is designed to provide services for theme park visitors, operators, and management teams. A service that is provided for management is theme park statistics that can be used by the theme park management team for park improvements and development purposes. Specifically, the application shows immediate statistics regarding preferred rides in general as well as preferred days to visit the theme park, and the preferred rides by each age group: kids, teens, and adults.

3.3 Summary

This chapter presented the proposed framework for the NFC-based smartphone application for theme park safety and control, discussed the applications different features and services, and provided an insight into the tasks and functions introduced by the application.

CHAPTER 4: SYSTEM SCENARIOS AND USE CASES

A number of use cases and scenarios are introduced in this section to help better understand the preferred behavior of the smartphone application system. Thus, this section will help in defining the requirements and system limitations.

4.1 Scenarios

A scenario is defined as a description of a system from a user point of view. It is a useful method for explaining a certain system and also helps provide a better understanding of the suitable behaviour and necessary functionality an application system should have. The scenarios presented in this section describe how a park visitor, a park administrator, and a ride operator would use the developed mobile application for different purposes. The scenarios will help in defining the domain of the problem, the requirements, and the limitation of the application [30].

4.1.1 Scenarios of park visitors

*** Adam is a construction worker who works really hard all year round. He usually takes an extra part-time job in the summertime, but this year he decided not to do that. Instead, he wants to take a vacation and take his three daughters to visit the amusement park. He prefers to avoid crowds, as a less-crowded venue helps him take better care of his three kids, especially that Adam's wife could not get a break, so Adam will be responsible for taking care of the girls at the park himself, he decides to check the park's mobile application to see the current number of visitors. This helps him choose a suitable time for them (i.e., when it is not very crowded in the park).*

*** Mary has a daughter named Madeline who is 13. Madeline is a very active girl and*

loves exploring. She is a member of a sports club. Her favourite sport is running. She won many prizes in several sports competitions. Mary decided to take her daughter to the amusement park as a gift for her daughter's performance in the last running competition.

Inside the park, Mary decides to read a book and have a cup of tea in the Cafe area while Madeline is enjoying the rides. However, Mary wants to check how her daughter is doing from time to time. She wrote her daughter's ID on piece of paper, in case she forgets it. Mary opens the mobile application and enters the ID of her daughter. The report shows her what rides her daughter took, as well as the date and time of checking in and out. Additionally, the report shows her what ride her daughter is currently on. Mary read the report and returned to reading her book with peace of mind about her daughter.

4.1.2 Scenarios of park administrators

*** Mark is an employee at the amusement park. He works in the park's registration office. He likes his job because he is a fast typist and is very good at working with smartphone applications. A new visitor to the park is coming to the registration office, Mark wants to register him, so he opens the amusement park smartphone application to fill a new visitor electronic form. Mark asks the visitor some quick information regarding height, age group, phone number, and email address. He also fills out a brief check list regarding the visitor's health condition which indicates whether or not the visitor suffers from asthma, heart disease, or back pain. Finally, Mark saves the electronic record, which will be stored in the amusement park database.*

*** Sara is a university student who is pursuing her Master of Computer Science degree.*

She heard about the amusement park NFC-ticket system and wanted to try it. In the registration office after opening a visitor account with the employee Mark, Sara asks for NFC-tickets. She pays for five tickets, and then Mark opens the mobile application and charges Sara's account with the cost of five tickets. The amusement park registration office employee gives Sara an NFC-bracelet that contains her ID and is linked to all her information, including the stored tickets.

4.1.3 Scenarios of ride operators

***Suzan suffers from back pain. She regularly visits a clinic for physiotherapy that makes her feels better and keeps her healthy. She feels so good that she decides to take a break and visit her local amusement park. Inside the amusement park, and after she gets registered at the registration office, she goes towards the Twisted Train ride. She lines up, and then when her turn comes, the Twisted Train ride operator scans her NFC-bracelet with the amusement park smartphone application. He gets a response message on the application indicating that the ride is not suitable for Suzan's back condition. So she cannot check in to the ride, and instead has to look for another ride that is more suitable for her health condition.*

*** Sami is an average teen. Like most teens, he loves sports and amusement parks. One day, his family decides to visit the amusement park. Sami is very excited. Inside the theme park, and after the family gets registered at the registration office, everyone heads for their favourite ride. Sami loves cars and races, so he goes towards the fast cars ride. After lining up there, and when his turn is approaching, the ride operator scans Sami's NFC-bracelet. The scan shows that Sami is not suffering from any issues that could*

prevent him from taking a certain ride, so Sami can check in. Then, directly by scanning Sami's NFC-bracelet, the ticket was discounted from Sami's NFC-ticket account.

4.2 Use Case

Developers are concerned about issues related to the quality of the developed application and systems. In fact, the release of a new application or system help developers to know more about customers experiences with any low quality standards, such as poorly designed interfaces or difficulty understanding how the system works. Thus, developers need to avoid misunderstandings around their system requirements. One way to do this is to get sufficient information about the proposed system [31].

Today, one of the best practices provided to developers to help them avoid problems regarding poor system requirement definitions is "use cases". A use case is a "description of a set of sequences of actions, including variants, that a system performs that yield an observable result of value to an actor" [31]. Use cases help developers understand the system from a user's point of view. Moreover, use cases help developers validate and verify their system architecture during the implementation process [31]. Below are use cases of our application:

1.A: Use case " Checking crowd " details and conditions:

Actor: The visitor.

Goal: The visitor gets the number of the current park visitors.

Precondition: The visitor must be connected to Wi-Fi.

Post-condition: The system displays the number of current park visitors

1.B: Event flow of the use case “Check Crowd”

Normal Course:

1. The system displays options for the user.

2. The user hits the ‘Check Crowd’ button.

3. The system contacts the web service.

4. The system sends the web service a request for the information to the database.

5. The system queries the database used for retrieving the number of current visitors.

6. The system responds by displaying the number of current visitors.

Alternative course:

4. The web service does not respond (the system cannot contact it).

4.1 The system displays an error message.

4.2 The user will be directed automatically to go back to the ‘options’.

4.3 Repeat step 3.

2.A: Use case “Checking User Records” details and conditions:

Actor: The visitor.

Goal: The visitor gets a detailed report (through the entered ID check in/out) about what rides another visitor has gone on and where he or she currently is.

Precondition: The visitor must enter the ID of the other visitor to get his or her location.

Post-condition: The system displays a report about the visitors with the entered

IDs.

2.B Event flow of the use case "Check User Records"

Normal Course

1. The system displays options for the user.
2. The user selects the option of displaying another user's report.
3. The system prompts the user for the visitor ID.
4. The user enters the user ID of the visitor whose record he or she wants to check.
5. The system validates that the user ID.
6. The system contacts the web service.
7. The system sends the web service a request for the information to the database.
8. The system queries the database using the entered visitor ID.
9. The system displays the required visitor record.

Alternative Courses

5. The entered visitor ID is not valid.

5.1 The system displays an error message.

5.2 The system returns back to step 3.

6. The system is not able to contact the web service.

6.1 The system displays an error message.

6.2 The user is automatically directed back to step 1.

3.A Use case “Register Park Visitor” details and conditions

Actor: The administrator.

Goal: To register the park visitor’s information and store it in the theme park database.

Precondition: The administrator must get the information from the park visitor.

Post-condition: The system stores the park visitor’s information in the specified database.

3.B Event Flow of the use case “Register Park Visitor”

NORMAL COURSE:

1. The system displays options for the user.
2. The user selects the option to enter as an employee.
3. The system prompts the user for the user ID and password.
4. The user (the registration employee) enters his or her ID and password.
5. The system displays options for administration tasks.
6. The user chooses the ‘Add new visitor’ option.
7. The system displays the visitor information form.
8. The user fills out the information of the visitor and stores it.
9. The system generates an ID for the visitor.
10. The user scans the visitor’s NFC-bracelet with the application.
11. The system stores the ID on the visitor’s bracelet.

ALTERNATIVE COURSE:

5. The system validates that the entered user ID or password is not valid.

5.a The system displays an error message.

5.b The system returns to step 3.

4.A Use case "Register NFC-tickets" details and conditions

Actor: The administrator.

Goal: To assign a number of the desired tickets to the visitor's account.

Precondition: The visitor makes the payment for the required number of tickets.

Post-condition: The system stores the desired number of NFC-tickets in the visitor's account.

4.B Event Flow of the use case "Register NFC-tickets"

NORMAL COURSE:

1. The system displays options for the user

2. The user selects the option to enter as an employee

3. The system prompts the user for the user ID and password.

4. The user (the registration employee) enters his or her ID and password.

5. The system displays options for administration tasks.

6. The user chooses the 'NFC-ticket' option.

7. The system displays a form requiring the ID of the visitor and the number of desired tickets.

8. The user enters the visitor ID and number of purchased tickets.

9. The system stores the information in the theme park Database.

10. The user scans the visitor's bracelet with the application.

11. The system stores the ID on the visitor's bracelet.

ALTERNATIVE COURSE:

5. The system validates that the entered user ID or password is not valid.

5.a The system displays an error message.

5.b The system returns to step 3.

9. The system responds that the entered visitor ID is not valid.

9.a The system displays an error message.

9.b The system returns to step 7.

5.A Use case "Check in/out visitors" details and conditions

Actor: The administrator

Goal: To calculate number of current people

Precondition: The administrator must pass his or her mobile phone contained the application over visitors' NFC bracelet.

Post-condition: The number of check in/out visitors is stored in the system.

5.B Event flow of the use case "Check in/out visitors"

NORMAL COURSE:

1. The system displays options for the user.
2. The user selects the option to enter as an employee.
3. The system prompts the user for the user ID and password.
4. The user (the registration employee) enters his or her ID and password.
5. The system displays options for administration tasks.
6. The user chooses 'Main Gate Checking' option.
7. The system displays two choices: check in and check out.

8. The user chooses the required option and passes the application over the visitor bracelet.

9. The system stores the visitor ID as a check in or check out, based on the chosen option.

ALTERNATIVE COURSE:

5. The system validates that the entered user ID or password is not valid.

5.a The system displays an error message.

5.b The system returns to step 3.

8. The user chooses the wrong option.

8.a The user goes back to the main interface.

8.b The user repeats the steps from step 6.

6.A use case "Check visitor's information and ride requirements" details and conditions.

Actor: The ride operator.

Goal: To check whether or not the chosen ride is safe for the visitor.

Precondition: The ride operator must pass his or her mobile phone containing the application over the visitor's NFC bracelet.

Post-condition: The ride operator gets a response whether or not the rider can check in to the chosen ride.

6.B Event flow of the use case "Check visitor's information and ride requirements"

NORMAL COURSE:

1. The system displays options for the user.

2. The user selects the option to enter as an employee.

3. The system prompts the ride operator for the user ID and password.

4. The user (the ride operator) enters his or her ID and password.

5. The system displays the ride that the ride operator is responsible for.

6. The ride operator passes the application over the visitor's bracelet.

7. The system displays a message whether or not the rider can check into the ride.

ALTERNATIVE COURSE:

4. The ride operator enters a wrong ID or password.

4.a The system displays an error message.

4.b The system repeats step 3.

7.A Use case "Collect NFC-tickets" details and conditions

Actor: The ride operator.

Goal: To collect NFC-tickets from riders.

Precondition: The ride operator must pass his or her mobile phone containing the application over the visitor's NFC bracelet.

Post-condition: The required NFC-tickets get discounted from the rider's account.

7.B Event flow of the use case "Collect NFC-tickets"

NORMAL COURSE:

1. The system displays options for the user.

2. The user selects the option to enter as an employee.

3. The system prompts the ride operator for the user ID and password.

4. The user (the ride operator) enters his or her ID and password.

5. The system displays the ride that the ride operator is responsible for.

6. The user passes the application over the visitor's bracelet.

7. The system discounts the required NFC-tickets from the rider's account.

ALTERNATIVE COURSE:

7. The system does not discount the required tickets because the number of NFC-tickets in the rider's account is not enough for the chosen ride.

7.a The system displays a message indicating that there are not enough tickets in the user's account.

7. b The visitor will not be able to ride, and the ride operator moves to another rider.

8.A Use case "Send alerts" details and conditions

Actor: The ride operator.

Goal: To send email alerts to a visitor's companion when the visitor does not check out of a certain ride.

Precondition: The ride operator must check the check-out lists on the application to find out who did not check out when the ride was done.

Post-condition: A list appears with the riders' IDs of all those who did not check out.

8.B Event flow of the use case "Send alerts"

NORMAL COURSE

1. The user hits the 'check in' button.

2. The system displays a list of riders' IDs who are still on the ride and did not check out.

3. The user hits the 'send email' button.

4. The system sends email alerts to the visitors' families.

ALTERNATIVE COURSE

2. The system does not display any ID of riders who are still on ride (all riders are checked out).

2.a The system automatically directs the user to the ride operator task options.

All use cases listed above presented important goals required to be met during the application implementation stages. We derived several important tasks that must be done. First, users must be able to obtain the actual number of theme park visitors. This supports managing and controlling crowds inside the theme park, which is one of the main goals of this application. This was successfully accomplished in the application implementation phase.

Next, the goal derived from the second use case was to obtain a detailed report of which rides the visitor has checked in or out with the entered ID. This goal is accomplished in the application and works simply by inputting a visitor's ID and then getting a report about another visitor.

Regarding registering the park visitor's information and storing it in the theme park database, this is an essential goal, as most of the services require that this step (i.e., the registration step) be done first. Furthermore, in the NFC-ticket system, the desired number of desired tickets is first assigned to the visitor's account by the registration office, and then collected by the ride operators by passing their mobile application over the visitor's NFC-bracelet. These two tasks are derived from the use cases mentioned earlier. The application successfully allows sending notification emails to a visitor's family about a visitor's delay in checking out of a certain ride. Finally, the application calculates the number of current visitors and also provides a comparison of a user's

general health information with the chosen ride requirements.

4.3 Application System Functional and Non-Functional Requirements

As presented in the earlier analysis, system scenarios along with use cases form the desired system behavior, based on a user's point of view. In this section, we define both functional and non-functional NFC-based application system requirements.

4.3.1 Functional and non-functional requirement definitions

4.3.1.1 Functional requirements

Functional requirements are mainly planned to define the expected achievement of the system [30]. From a system engineering perspective, functional requirements are the software functions, such as system processes, services, and components. These requirements have different specifications, but they all share a common point, which is defining the 'desired' behaviour of the system [32]. Scenarios and use cases are utilized to generate these functional requirements. Clearly defined scenarios and well-designed uses cases help to derive proper functional requirements. Table 2 below shows the functional requirements of our mobile application based on the earlier defined system scenarios and use cases.

Table 2. Functional Requirements of the Proposed Application System

Requirement ID	Requirement Name	Requirement Description
FR-1	NFC availability	User's smart phone must support NFC technology
FR-2	Email support	User's smart phone should allow receiving electronic mails
FR-3	Visitors	Users should be able to view their generated ID, number of current park visitors, and visitors' reports.
FR-4	Registration employees	Registration employees must be able to log in to their account and perform their tasks.
FR-5	Ride operators	Ride operators must be able to log in to their accounts and perform their tasks.

4.3.1.2 Non-functional requirements

Non-functional requirements are planned to define system properties that have effects on the system quality in general [30]. However, they usually highlight the user's desired system properties. Therefore, they are very significant kinds of requirements [30]. Moreover, from a system engineering perspective, non-functional requirements are more about the system's operations than the system's functions [32]. Table 3 shows the application system's non-functional requirements.

Table 3. Non-Functional Requirements of Proposed Application System

Requirement ID	Requirement Name	Requirement Description
NFR-1	Data confidentially	The system should restrict access to users information stored in the database to authorized users only.
NFR-2	User-friendly interfaces	The graphical user interface (GUI) should be clear.
NFR-3	Performance	The system must be able to retrieve the required information from the remote databases and apply the required processes on it in a reasonable time.

When discussing meeting NFC-Smartphone application requirements, we start with the importance of the availability of NFC in users' smartphones in order to get all the services and advantages of the application, as well as the importance of supporting email service in the smartphone to be able to receive the electronic mails. Visitors need to view their ID to be able to retrieve visitors' reports, which is easily can be done through passing the application over the NFC-bracelets. Moreover, the application allows the registration employees as well as the ride operators to accomplish their task by using their account through entering their user names and passwords. Below are some details regarding data confidentially, user-friendly interface, and performance.

Data confidentially. The system must restrict access to users' information stored in the database to authorized users only. All information gathered from theme park visitors, including general and health information, should be protected from access by

unauthorized users. Although, as Martin stated, the main challenge in database privacy is protecting data saved in a database [33], database privacy issues can best be resolved by using solutions designed mainly for database security. Database privacy and security depend on several factors, of which confidentiality is one of the most important [33]. However, in our NFC-enabled theme park smartphone application, there are several means to supporting data confidently. All information is restricted and cannot be accessed without special user names and passwords, which are given to authorized users only. Moreover, information gathered is as brief as possible to achieve the application's main goals. So, for example, for health information (e.g., heart diseases), the question was only about whether or not the user is suffering from a disease, but no disease history, details or specifications are required.

User-friendly interface. First, it is important to note that the word 'friendly' can be misleading [34]. Generally, what users want from computer systems is for them to meet their needs and solve their problems in a simple and efficient way [34]. There are no precise user-friendly measurement specifications, since user-friendliness depends on several factors, such as users skill level [34]. However, there are still some basic rules that can be applied to evaluate the level of user-friendliness of a certain application.

First and foremost, well-organized action sequences and clear outputs are essential [34]. Successful action sequences are critical, and this includes large series of linked actions in a certain application, regardless of whether these actions are applied via a number of screens or through several verbal prompts [34]. Moreover, the logical and well-organized sequences of actions should make sense to the users of the system, and the sequences should be simple and uncomplicated [34]. In our NFC-enabled smartphone application

for theme parks, we kept in mind the importance of the logical sequence of actions, such as applying the authentication steps for system users to determine, first, who is using the system (e.g., park administrators, ride operators, or park visitors), and next, suitable tasks for each category, depending on the user.

Additionally, messages printed out for users should be clear and unambiguous, with as few abbreviations as possible and no spelling or grammar mistakes. Users generally ignore long instructions and do not like to be directed to another source [34]. In our NFC-theme park smartphone application, we tried to meet these criteria by providing users with short and simple messages and avoiding directing them to other links or sources.

Performance. The system must be able to retrieve the required information from the remote databases and apply the required processes on it in a reasonable time. This is especially important in the case of our NFC-enabled theme park application, because it is designed to be used in a public place and by many users at the same time. The goal here is to avoid unwanted delays. We attempted to achieve an acceptable level of time required to finish specific tasks using the theme park application, and avoided designing unrequired services or long detailed processes that could cause some delays.

4.4 Summary

A detailed analysis for the proposed application system was presented in this chapter. We defined the scenarios and use cases, and listed a number of them that are related to the proposed system. Moreover, we developed lists of functional and non-functional system requirements. Those requirements were derived from the application system's previously defined scenarios and use cases.

CHAPTER 5: IMPLEMENTATION

This chapter presents the proof of concept for the proposed application. The application was implemented in the Computer Science Lab at Dalhousie University, Canada, and was also tested there. In this chapter, we discuss the three main points about the implementation of our application: namely, the experimental tools we used, the experimental services, and the experimental model of our proposed application.

5.1 Experimental tools

This section briefly introduces the experimental tools we used. The following sections explain in detail how the tools were used.

5.1.1 NFC tags

The type of NFC tag used in the proposed mobile application is NTAG203. The required distance between the NFC tag and the NFC-enabled smartphone or tablet to communicate is four centimeters or less.

5.1.2 NFC-enabled tablet

The tablet used in this application is Google Nexus 7, and we installed the application on an Android 4.4.4 platform. We installed and tested the developed NFC-based application in this tablet.

5.1.3 ADT (Android Development Tools)

ADT is defined as a plugin for Eclipse, which offers a set of combined tools with the Eclipse IDE. It gives the developer an access to several valuable and useful features, which is required in developing Android applications [35].

5.1.4 Eclipse

One useful plugin for the Eclipse IDE, provided by Android, called ADT, which stands for Android Development Tools. This plugin helps develop android applications in a productive and practical environment. Eclipse can be defined as a platform which is designed to build useful application developing tools. It contains unique features, and it is one of the most popular tools for Java-based application development [36].

5.1.5 Microsoft SQL server

The Microsoft SQL server is one of the best known database systems today. It is a database management system that can be used for different analysis and building projects purposes [37]. We built all the databases for our application using the Microsoft SQL server.

5.1.6 Microsoft Visual Studio

Visual Studio, by Microsoft, offers a development environment that a developer needs for different purposes. It is an integrated development environment (IDE) that provides platforms for building several kinds of applications such as web applications and mobile applications as well as web services. It supports building applications in different programming languages such as C++, C#, VB, and Javascript [38]. We used it in our application to build the web services that connect between the databases and the android application.

5.2 Experimental Services

This section will explain the experimental services required by our NFC-enabled application, and provide a brief overview of each.

5.2.1 Email service

Our application requires an email service in order to send warning emails to visitors' families in case they check in in a certain ride and do not appear as checked out. We use the Google mail (Gmail) email service.

5.2.2 Wireless connection

The availability of wireless connection is essential in our application for its proper work. The wireless service that we used in our application was Dal-WPA 2, in order to connect the android application that installed in the mobile phone with the several databases through the web services.

5.3 Experimental Model

This section explains the implementation of the NFC-based mobile application for theme park safety and control. We describe the various services and features that are provided by our NFC-based application, starting with the services of the theme park employees, administrators and ride operators. These features contain visitor registration services, a comparison of visitor condition and ride instructions, and email service and visitor report inquiries. Moreover, we explain theme park statistics for preferred rides, days, and age group. Finally, we discuss the crowd-checking service that enables people to check the number of current visitors inside the theme park to help them decide either to come early or to avoid the most crowded days.

5.3.1 The application interface

As Figure 8 shows, the main application interface includes four buttons. The first button is for employees, as mentioned in previous chapters. There are two types of employees: theme park administrators and ride operators.

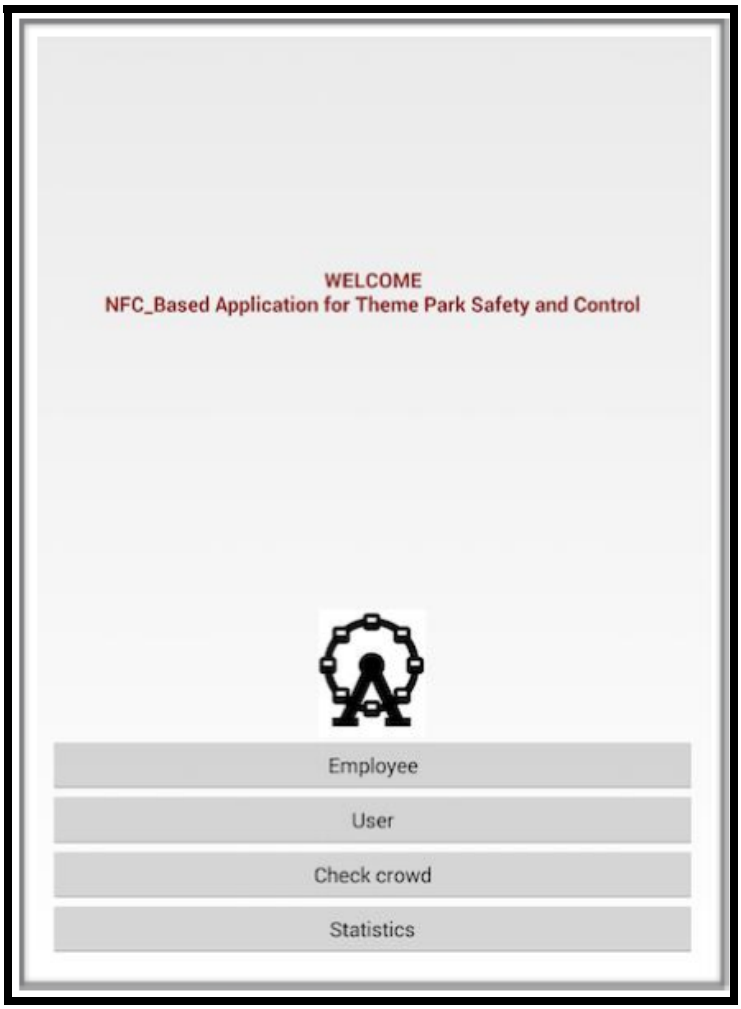

Figure 8. Application interface.

Each employee enters an employee user name and password to access his or her account. There is a visitor button in the application interface for connecting the visitor with the reports services, and the crowd checking button for displaying the current number of theme park visitors. There is also a statistics inquiry button, which provides statistical

information.

5.3.2 Employee services types

In this section, we discuss the various services provided by the application for both administrators and rides operators.

5.3.2.1 Administrators

5.3.2.1.1 Visitors' information

In order to obtain the desired advantages and safety procedures, visitors have to provide their information to the registration employees (administrators). The administrator will store the information through the android application to the visitors' database that was implemented using SQL server, together with the rides' information database and the employees' database. These databases will be accessible through web services that were implemented using the visual studio development tool. The web services work as a connector between the android application and the databases, and perform various operations on the databases.

Figure 9 shows a visitor information form and an example of filled form. The visitor information includes both general information (name, height, and age group) and health information that indicates whether or not the user suffers from any of back pain, asthma, or heart diseases. The user age group, as shown in Figure 9, is defined by choosing one group out f many (adult, teen, school age, and preschool). A list of age groups is shown, and the suitable is chosen from this list. Figure 9 shows an example of a visitor named Ashley who belongs to the 'adult' age group.

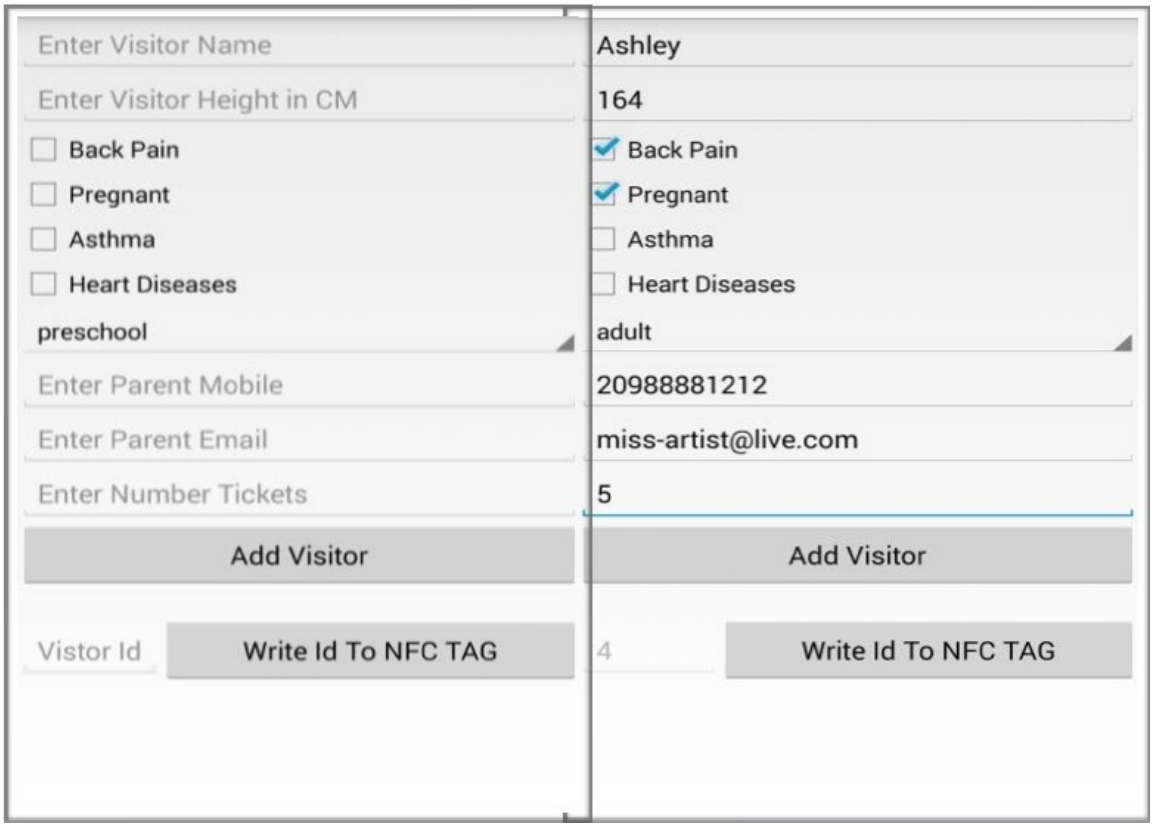

Figure 9. Theme park visitor's information form.

After filling in the requested information and pressing the 'Add Visitor' button, the visitor ID automatically appears. The employee then passes the application over the visitor's NFC bracelet and hits 'Write ID to NFC tag' to store the visitor's ID on their NFC bracelet. This ID is important, as it links to the visitor's information stored on the visitors' database.

Both general and health-related information about theme park visitors is stored in the theme park database as well as the other databases that contain theme park employee information and theme park rides' instructions and requirements. Each theme park visitor is assigned a unique ID. Along with his or her other information, the ID is the key that links the visitor with all the theme park services, such as comparing his or her information with the chosen theme park ride or requesting a certain visitor's record.

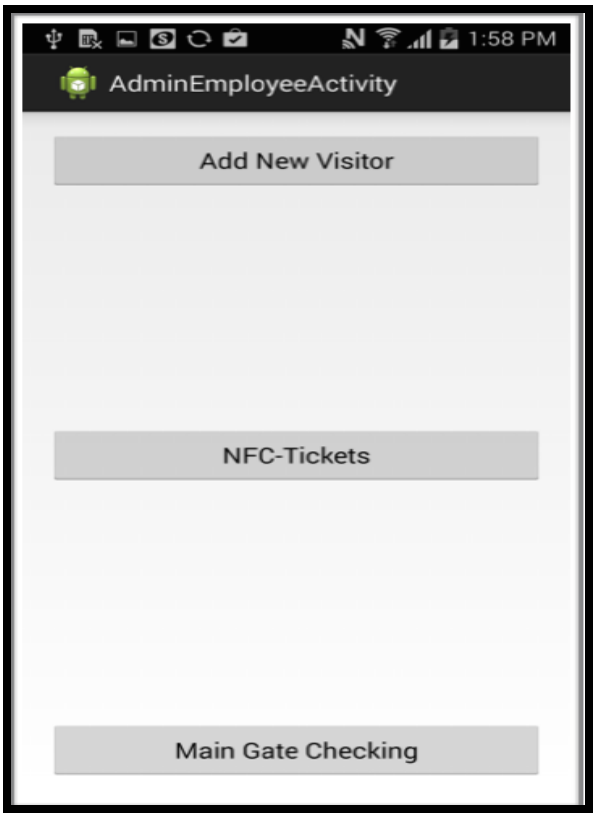

Figure 10. Administrator's activities.

5.3.2.1.2 Visitors' main gate checking

Administrators can check in visitors through the theme park' main gate by their mobiles only. Employees pass their mobile devices (open to the android application) over each visitor's bracelet and hit the 'Check in' button. This service is important, as it will be used in different purposes, such as counting the number of current visitors. So, when people hit the 'Check crowd' button in the main android application interface, they will find out the number of park visitors. Furthermore, this information will help in providing statistics for theme park management for development and improvement purposes.

5.3.2.1.3 NFC-ticket registration and update

As mentioned in Chapter 3, the administrator registers the visitor's information in the

quick electronic form in the visitors' information registration phase. At the same time, the administrator registers the number of tickets the visitor is purchasing. The visitor then gets the desired number of tickets stored in his or her account, and their NFC-bracelet will be connected (through their account) with their tickets. So, when a park visitor wants to ride a specific ride, the ride operator simply scans his or her bracelet with the NFC mobile application to directly discount one ticket from his or her total number of tickets. Through the web service, the visitor's number of tickets will be updated.

Figure 11. NFC-ticket update example.

5.3.2.2. Ride operators

5.3.2.2.1 Comparison of visitors' information and ride requirements

In ensure a safe visit to the theme park, one of the most important safety procedures

provided by this application is making sure that each visitor only accesses rides that are suitable for him or her. This can be done through comparing the visitor's registration information, stored in the visitor's database, with the ride restrictions stored in the ride information database. A connection between the visitor information and ride instruction is done through the web service. In other words, each ride operator is responsible for a certain ride and has a restricted access to this ride by entering his or her employee user name and password, Figure 12 shows an example of employees gaining access to the rides they are responsible for.

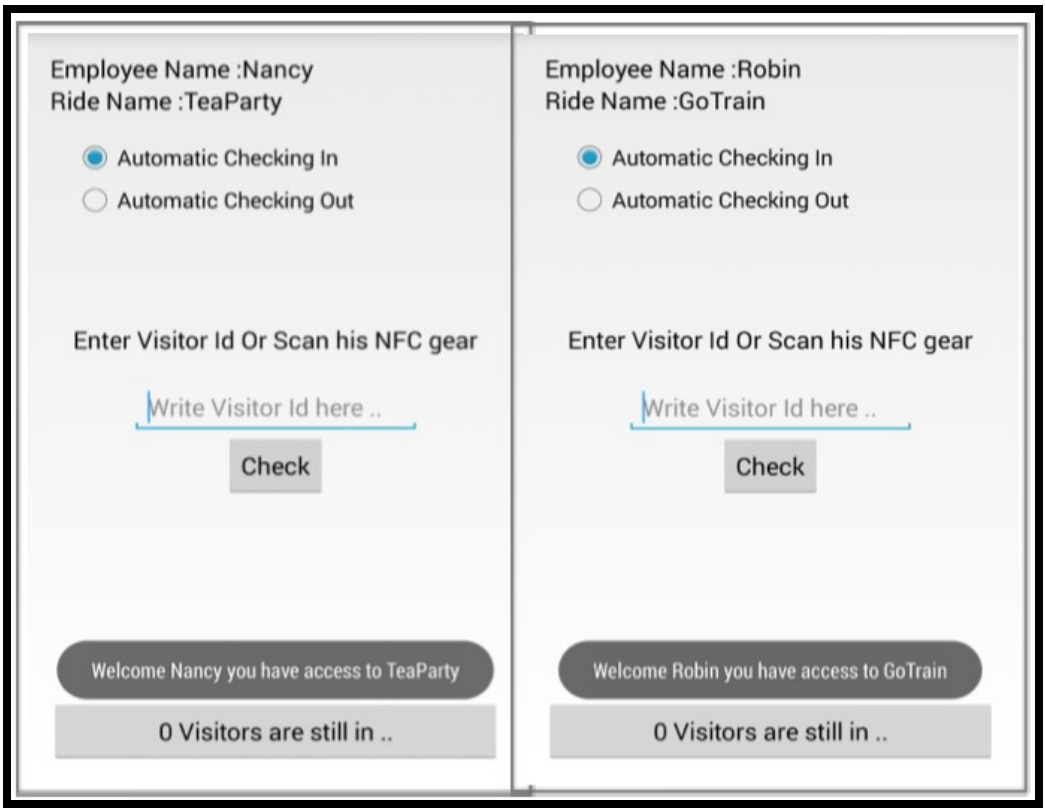

Figure 12. Examples of two ride operators accessing their rides.

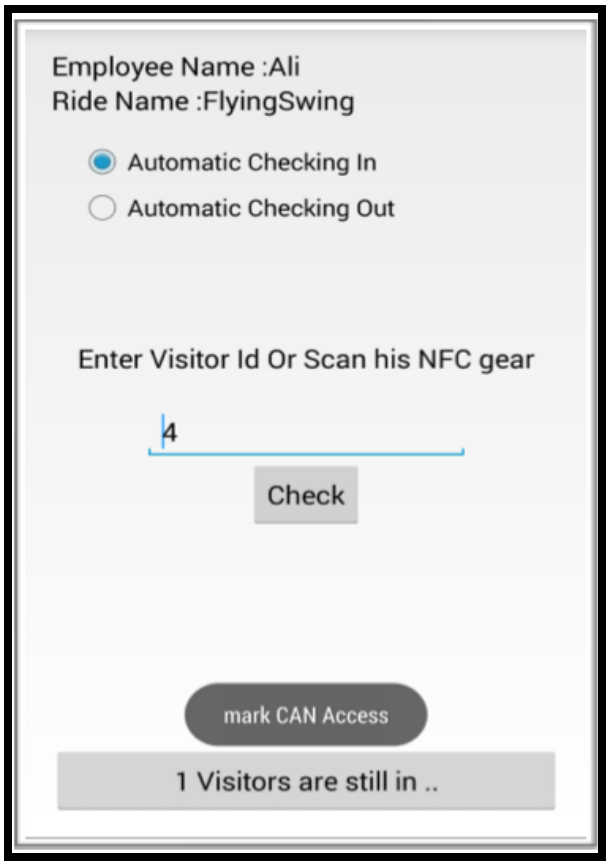

Figure 13. Example of a visitor who was allowed to access a ride.

When a visitor wants to ride a certain ride, the ride operator scans the visitor's NFC bracelet that contains his or her ID, and then through the web service, the android app get access to the visitor's information and compares it with the chosen ride instruction. A message is then displayed, indicating whether or not the visitor can access the ride (Figure 13).

5.3.2.2.2 Warning emails

Safety procedures are the main purpose of our application. Should a visitor not check out from a ride after it is finishes, the ride operator sends a warning email to the visitor's family. The visitor's family or parents' email is already registered in the visitor's database and will be retrieved by the web services. Figure 14 shows an example of two

riders still on the ride; the ride operator can hit the button “Send Email to Parents” to send an email right away.

Figure 14. Sending warning emails.

5.3.3. Visitor services

The proposed android application allows for the checking of visitors’ locations. Simply by entering a visitor’s ID, visitors can get a report with dates and times showing what rides the other visitor has gone to and what ride he or she is currently on. This is another safety procedure. To explain this more, suppose a mother and daughter came to the theme park, and the daughter went to play while the mother is in the coffee area. The mother can use the application to track the location of her daughter by entering her daughter’s ID in the specific location in the application. Then she will get a report showing her what

rides her daughter has gone to and what ride she is currently on. This service gives parents peace of mind about their children's safety while in the park. Figure 15 shows an example of a visitor's report.

Figure 15. Example of a visitor location finder.

5.3.3. Statistics services

The application uses information that is collected when registering visitors. The information is stored and sorted in the appropriate database (visitors' database, employees' database, and rides' database) and retrieved when required by the android application through the web service. The statistics service helps the theme park management team know more about visitor preferences, such as which rides are the most

popular and which days are preferred days for families to visit the park (Figure 17).

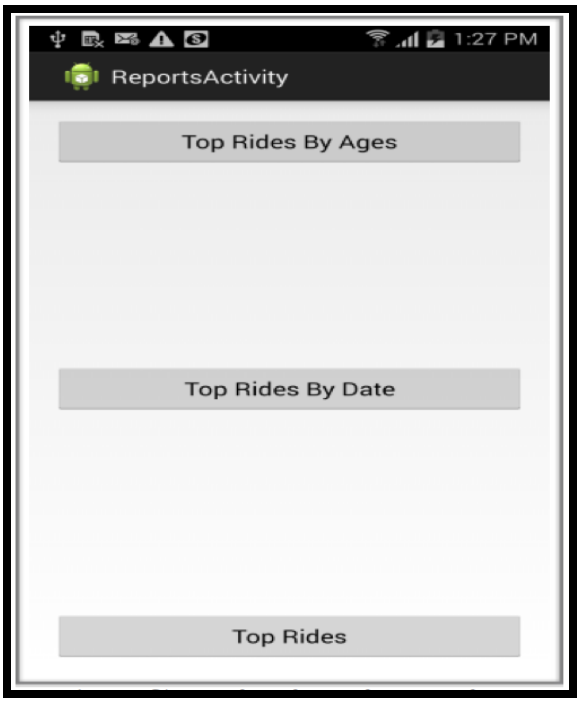

Figure 16. Statistics inquiry reports.

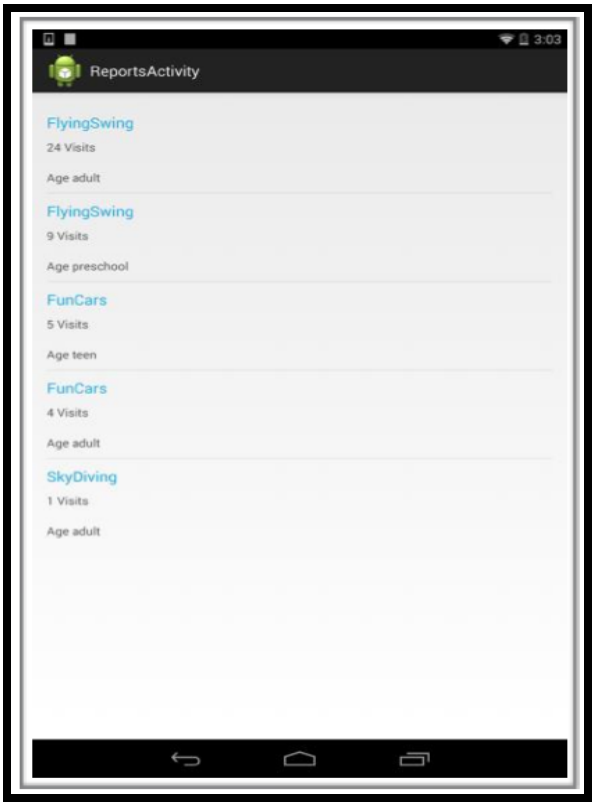

Figure 17. Statistics inquiry example.

There are some steps that would increase security in terms of protecting visitors' IDs and prevent them from being used by other people. One step would be attaching a visitor photo to the same NFC bracelet. This is not implemented in our NFC-enabled theme park application yet, but it would be a good solution that can be implemented in a live system, especially for big theme parks. Theme park sizes vary (generally between small, medium, and large) and so system features would change to fit a particular theme park's size as well as other factors such as theme park popularity and location. However, in our NFC-theme park application, it is important to increase the number of registration employees in case it would be used in a large theme park, to avoid crowds in the registration office and to let visitors register and enter the theme park as quickly as possible.

5.4 Summary

In this chapter, we discussed the implementation of our android application. Furthermore, we explained in greater detail how each type of service works, starting from the employee services, which is classified into two main categories: theme park administrators and ride operators. Services include registering visitors and comparing their information with the chosen ride instruction. We also discussed the visitor report information, warning emails services, and the statistics service.

CHAPTER 6: TESTING

We perform a number of tests in this chapter using the tool Dalvik Debug Monitor Server (DDMS). We test the network accessing behavior, as it is very important for the application to have proper accessing of a network. The application depends on network requests. The test includes examining the packets and bytes being transferred and received, and the time it takes to perform each operation.

6.1 DDMS

Android presents the Dalvik Debug Monitor Server (DDMS) as a tool for android application debugging and testing purposes [39]. In fact, DDMS provides numerous valuable application testing services and allows the developer to take screen captures of the devices while performing the tests [39] [40].

6.2 Network Tracking

6.2.1 Why network testing

Our android application requires Wi-Fi availability to work, since most of the application functions requires the use of web services to access the database that contains the relevant information about theme park visitors, employees, attractions, and rides. Therefore, network tests are very important. Fast network access has a positive impact on the overall quality of the application function performance. Moreover, knowing when a certain application uses network resources helps when trying to minimize network requests by an application towards better battery efficiency. Because our android application depends on

network access, and due to the importance of testing and tracking the network requests on it, we evaluate network requests in our application as well as the packets and bytes being transmitted and received, and the speed of those operations.

6.2.2 DDMS and network tracking

The DDMS contains tools that allow the android application developer to track when the application requests network. By using DDMS, developers can find out when the process of data transfer is being performed by a certain android application [39]. Through this tool, developers can clearly monitor when and how a certain android application is transferring data [41].

6.2.3 Network tracking for the developed application

We chose four main services offered in our developed application to track network requests. These services have an important impact on the entire application, as they are basic services in the application. The network tests are: network tracking of the visitors' registration process; visitors' main gate check-in; comparison of visitor information and ride requirements; and statistics inquiry. Additionally, we performed these four tests at three different times to monitor network requests and speed, in order to obtain more detailed results.

6.2.3.1 Network tracking for the process of visitor registration

Because visitor registration is usually the first process that requests network access, we chose it first when performing the test. Figure 18 shows the network tracking for this

process and the time taken to perform it, and Table 4 lists the transferred and received bytes and packets. As seen from the above-mentioned figure and table, the process did not require a long time, and the number of transferred and received bytes and packets was small.

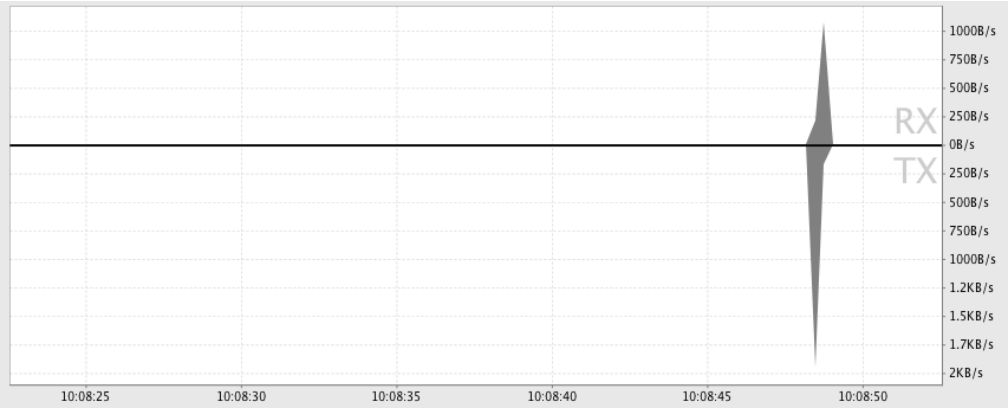

Figure 18. First track of network request for the process of visitor registration.

Table 4. Bytes and Packets Sent and Received During the Process of Visitor Registration

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
371	2	620	4

6.2.3.2 Network tracking for visitors' main gate check-in

A primary consideration in designing the gate check-in process is that it be fast. In a typical scenario, many visitors want to check in more or less at the same time and none of them want to wait in a line-up. Therefore, decreasing waiting time is an important client satisfaction factor, as mentioned in earlier chapters of this thesis. Figure 19 shows the short duration of transferring and receiving data, and Table 5 lists the number of transferred and received bytes.

Figure 19. First tracking test of network requests for the process of main gate check-in.

Table 5. Bytes and Packets Transferred and Received During the Process of Main Gate Check-in

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
953	4	878	8

6.2.3.3 Network tracking for comparison of visitor information and chosen ride requirements

One of the core services provided by our android application is the process and results of the visitor information and ride requirements comparison. The application requests network resources to allow web services to contact both databases of the park attractions and visitor information to give a response to the ride operator.

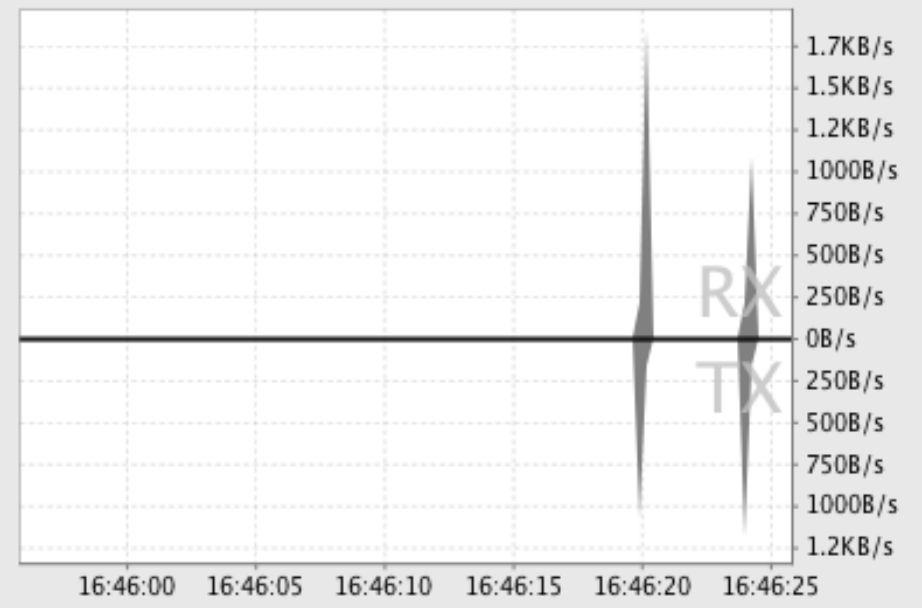

Figure 20. First tracking test of network requests for the process of comparing information and results.

Table 6. Bytes and Packets Sent and Received During the Process of Comparing Information and Results

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
3811	18	3294	37

6.2.3.4 Network tracking for statistics inquiry

The statistics inquiry service includes three types of statistics: preferred rides, crowded days, and age groups of park visitors. Each inquiry requires contacting the database to retrieve results every time an inquiry request is sent. These services provide instant updated results.

Figure 21. First tracking test of network requests for the process of statistics inquiry.

Table 7. Bytes and Packets Sent and Received During the Process of Statistics Inquiry

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
3347	10	1990	24

In each tracking test, we listed in the tables the number of transferred packets and bytes and the number of received packets and bytes for each process. As can be seen, the numbers show that the packets and bytes were sent in a short time. Figure 22 illustrates the time taken (in seconds) during each process in the first tracking test of our application.

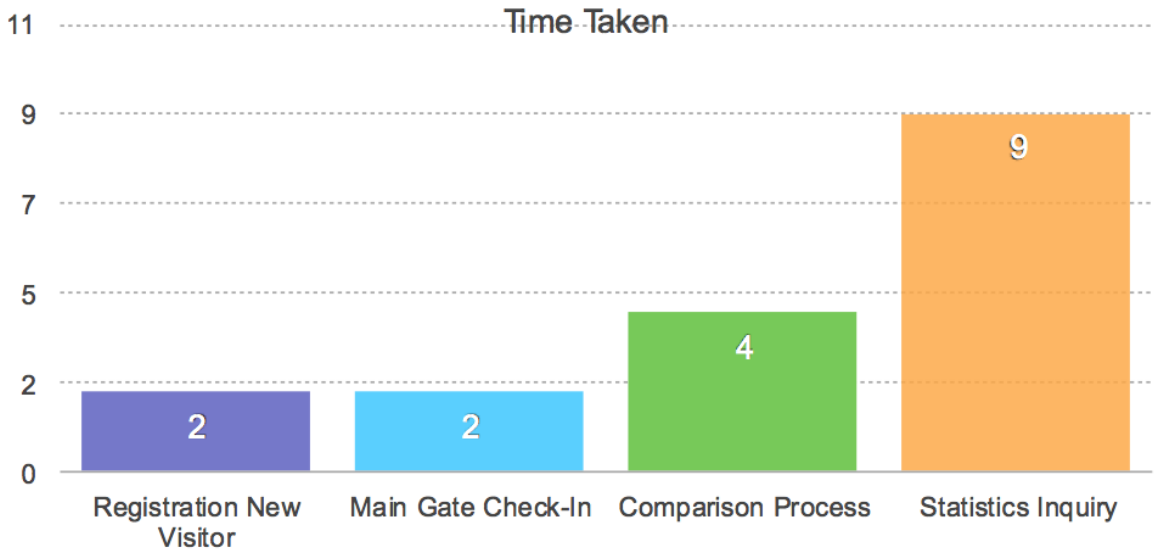

Figure 22. Time taken during each process in the first network tracking test.

First round of network testing. As Figure 23 shows, the process of statistics inquiry took the longest (9 seconds), while the process of information comparison of the visitor information and the chosen ride instruction took 4 seconds, and both the new visitor registration and main gate check-in processes took only 2 seconds.

6.2.4 Second network tracking test for the developed application

6.2.4.1 Adding new visitor process

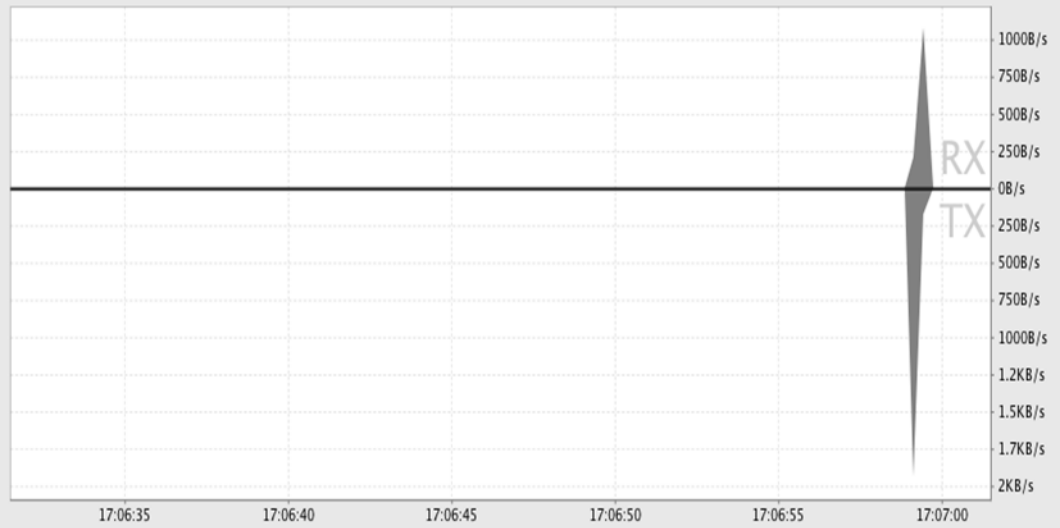

Figure 23. Second test of network tracking of new visitor registration.

Table 8. Bytes and Packets Sent and Received in New Visitor Registration Process

Rx Bytes	Rx Packets	Tx Bytes	Tx packets
371	2	699	5

In reviewing the data, we can see that the values of the received and transferred data are similar between the first and second tracks of the service when adding new visitors. However, the transferred data in the second test takes somewhat longer than in the first test. This is because some visitors have more information than others, such as having more than one health issue.

6.2.4.2 Main gate check-in

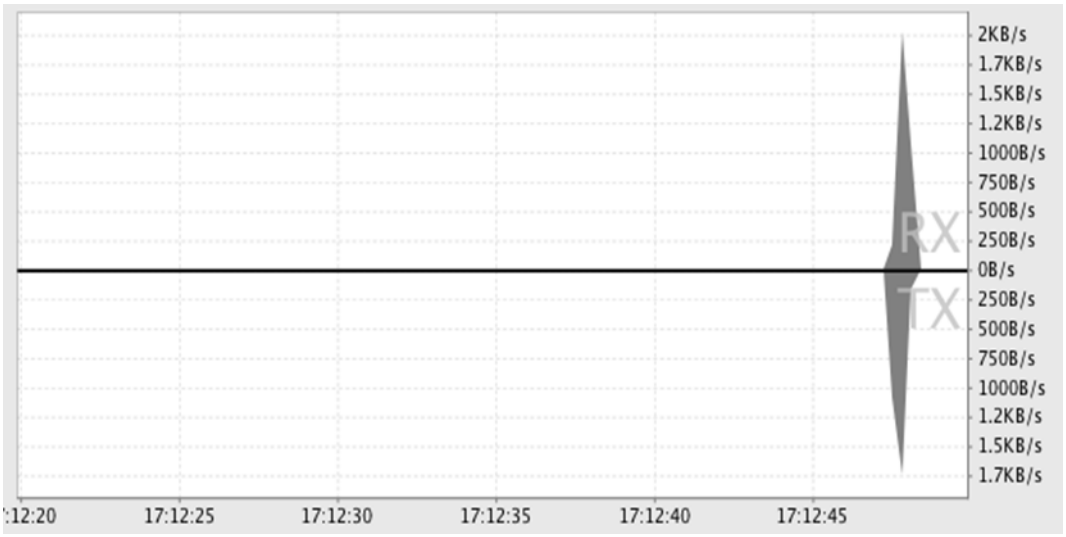

Figure 24. Second test of network tracking of main gate check-in.

Table 9. Bytes and Packets Transferred and Received During Second Test of Network Tracking of Main Gate Check-in

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
1802	8	1303	13

The main gate check-in process second tracking test shows that the total packets sent is 13 and received is 8, and the total number of the sent bytes is 1,303 and received is 1,802. The time taken for sending and receiving all these data is two seconds.

6.2.4.3 Network tracking test for comparison of visitor information and chosen ride requirements process

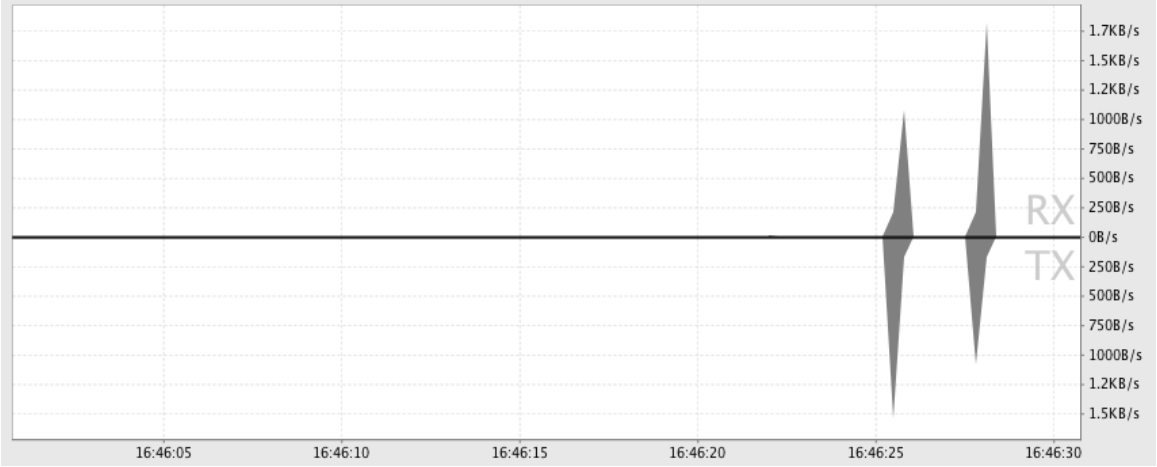

Figure 25. Second test of network tracking of comparison information.

Table 10. Bytes and Packets Transferred and Received in Second Test of Network Tracking of Comparison Process

Rx Bytes	Rx Packets	Tx Bytes	Tx Packets
2086	8	1744	20

Figure 26 and Table 27 sum up the results of the second test of network tracking of the comparison information process for theme park visitors and ride requirements. We can see that the time taken for sending and receiving data during this process is 3 seconds. The received bytes are 2,086 and received packets are 8, while the sent bytes are 1,744 and sent packets are 20.

6.2.4.4 Second test of network tracking of statistics inquiry

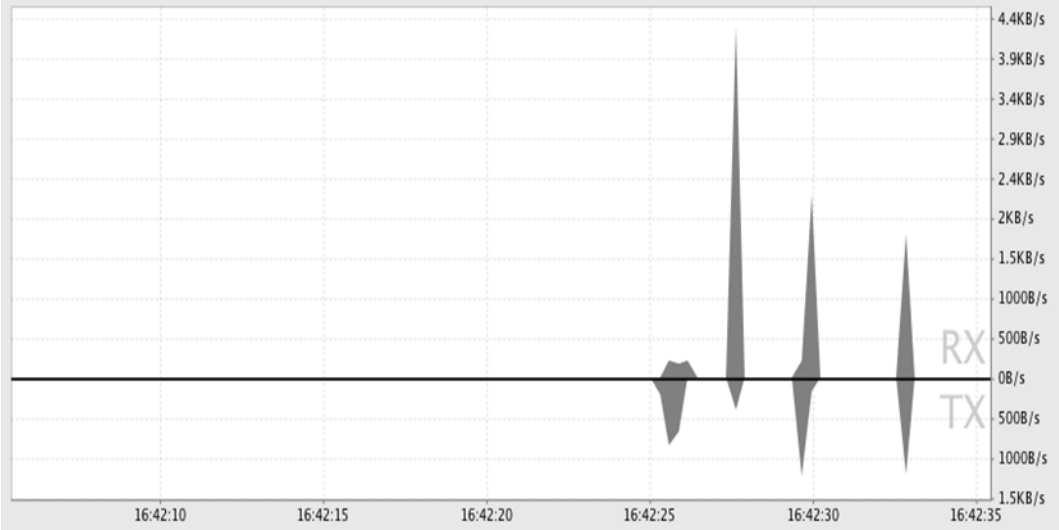

Figure 26. Second test of network tracking of statistics inquiry process.

Table 11. Bytes and Packets Transferred and Received During the Second Test of Network Tracking of Statistics Inquiry Process

Rx	Rx	Tx	Tx
3922	13	2242	26

According to the results of this test and of all previous ones, a similarity emerges among the results. Specifically, they all show the short time taken to transfer and receive data in each process. In this test, the number of received bytes is 3,922 and packets is 13, while the number of transferred bytes is 2,242 and packets is 26.

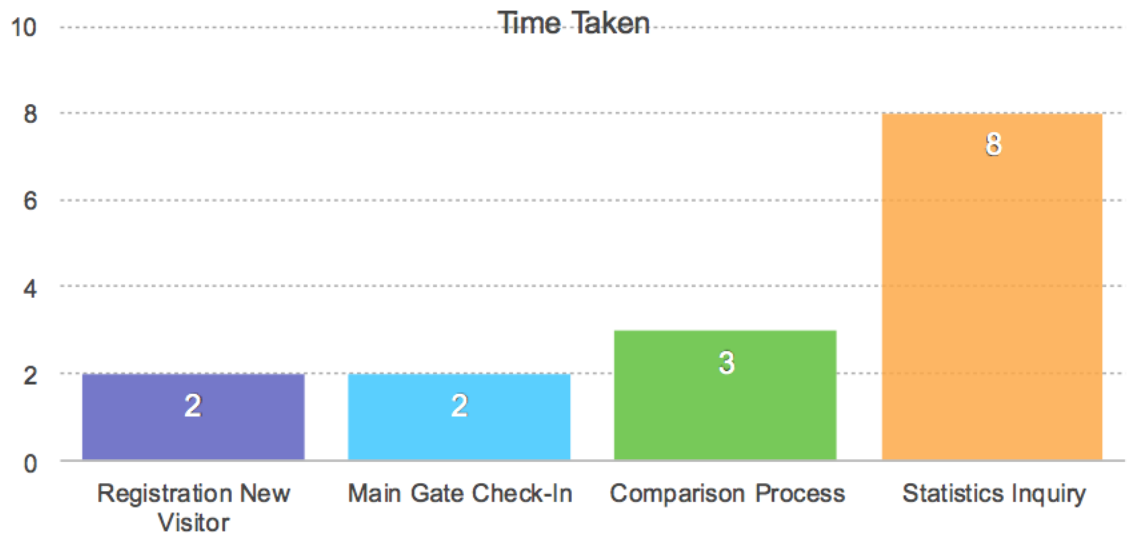

Figure 27. Time taken during all processes in the second network tracking test.

Second round of network testing. In analyzing of the second round of network results, we record (as Figure 27 shows) the time taken (in seconds) to send and receive data in all four processes during the second network request tracking tests. The four processes are: a new visitor registration, main gate check-in, comparison of information on visitors and rides, and statistics inquiry.

6.2.5 Third network request tracking test for the application

6.2.5.1 Network tracking for the visitor registration process

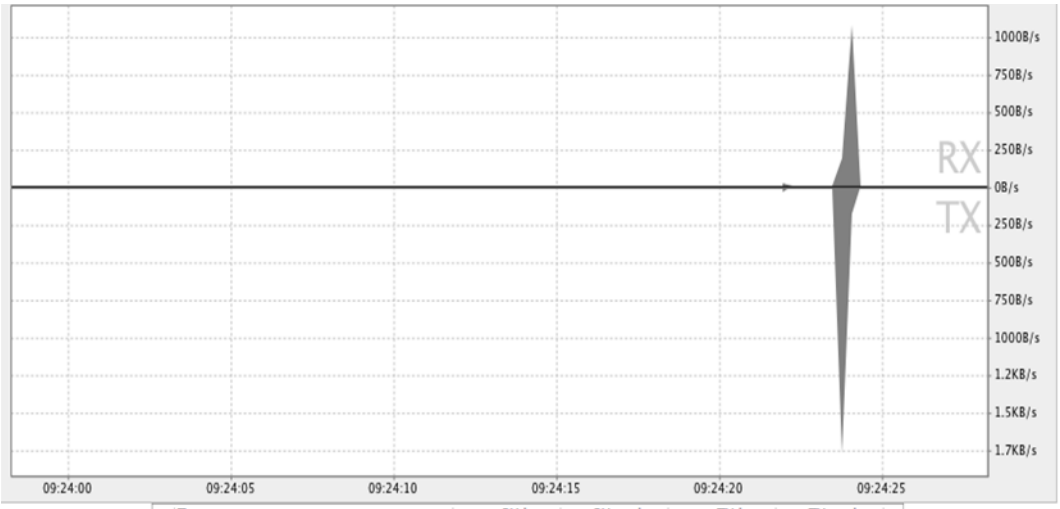

Figure 28. Third test of network tracking of new visitor registration.

Table 12. Bytes and Packets Sent and Received During New Visitor Registration Process

RX bytes	RX packets	TX bytes	TX packets
742	4	1,276	9

As Figure 28 and Table 12 illustrate, the time taken during the process of registering a new visitor was about 2 seconds. The number of received bytes is 742, the number of received packets is 4, while the number of transferred bytes is 1,276 and the number of transferred packets is 9.

6.2.5.2 Main gate check-in network request tracking test process

Figure 29. Network request tracking test during main gate check-in process.

Table 13. Transferred and Received Data of Main Gate Check-In Process

RX bytes	RX packets	TX bytes	TX packets
1,603	8	942	9

The tracking test of the network request for the main gate check-in process in this third round shows that the received bytes numbered 1,603 and the packets numbered 8; it also showed that there were 942 transferred bytes and 9 packets. The time required to send and receive all data during this process was 3 seconds.

6.2.5.3 Comparison of visitor information and chosen ride requirements

Figure 30.Third tracking test of network request of comparison processes.

Table 14. Transferred and Received Data of Comparison Process in the Third Test

RX bytes	RX packets	TX bytes	TX packets
2,872	10	2,517	27

As seen in Table 14, the network request tracking test in its third round for the process of visitor information comparison with the chosen ride requirements shows that the total time taken for sending and receiving data is two seconds, and the total number of received bytes during this process is 2,872. Furthermore, the total number of received packets is 10, the number of transferred bytes is 2,517, and the number of transferred packets is 27.

6.2.5.4 Network tracking for statistics inquiry

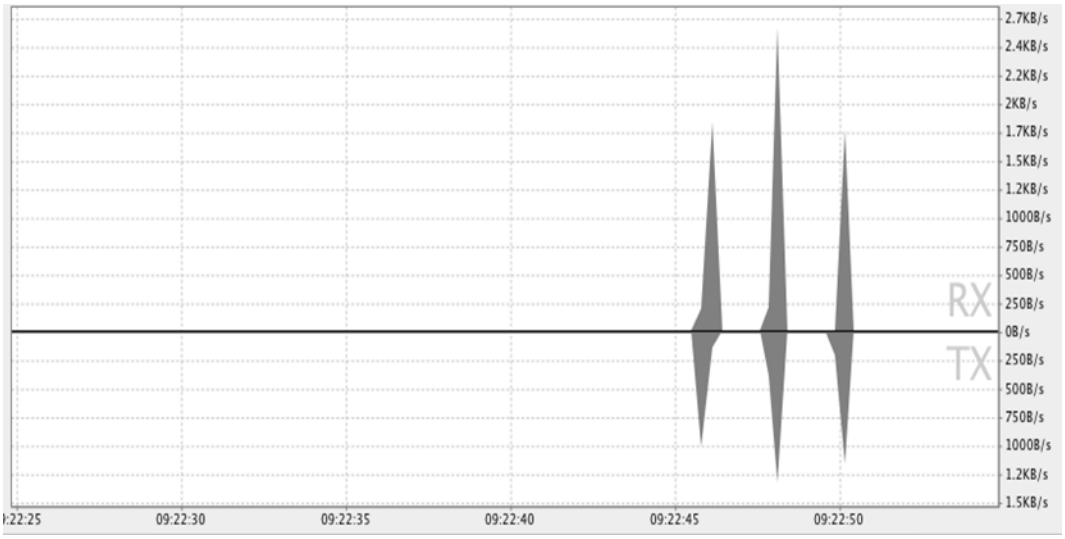

Figure 31. Third tracking test for statistics inquiry process.

Table 15. Transferred and Received Bytes of Statistics Inquiry Process in the Third Test

RX bytes	RX packets	TX bytes	TX packets
1,975	6	1,223	15

Figure 31 and Table 15 show the results of the third test of the network tracking of statistics inquiry process. As we can see, there are 1,975 received bytes and 6 received packets, and 1,223 sent bytes and 15 sent packets. The time required to send and receive these data during this process was five seconds.

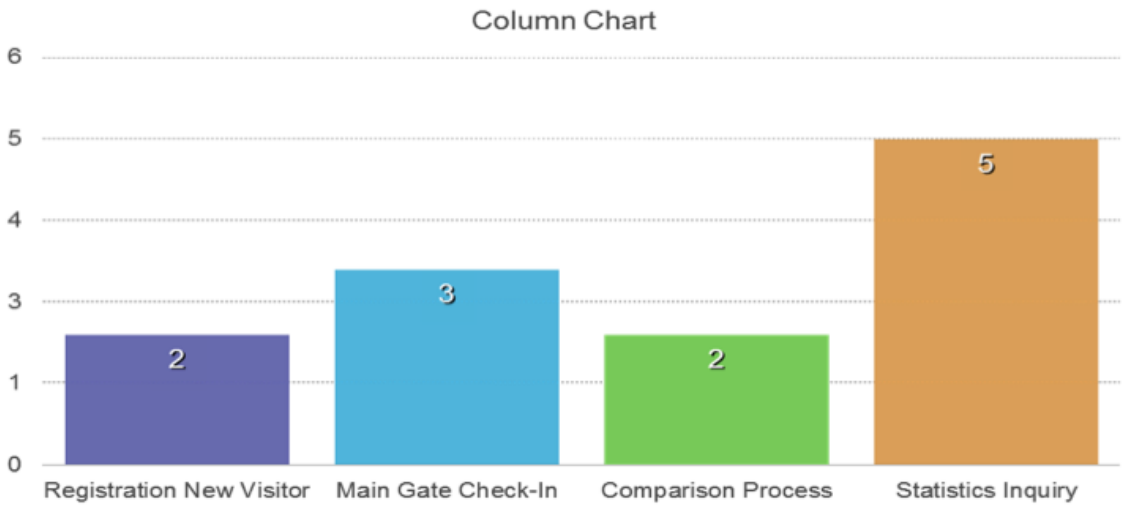

Figure 32. Time taken during all processes in the third network tracking test.

Third round of network testing. The process of statistics inquiry took the longest (five seconds), while the process of information comparison of the visitor information and the chosen ride instruction took two seconds, the visitor registration process took three seconds, and the main gate check-in process took two seconds (Figure 32).

6.3 Test results discussion

Clearly, and as noticed in all previous tests, the time taken to transfer and receive data was short, and the number of sent and received bytes and packets was relatively small. Figure 33 shows a comparison of the percentages of the averages of the time required for each process in all of the tests. In monitoring the number of data being received and transferred for each process during each connection, we noticed that only a short time is

required for each process. Moreover, as Figure 33 shows, the average time taken for the complete sending and receiving of data during the new visitor registration process is 14%, for the main gate check-in is 16%, and for the process of information comparison is 20%. We noticed, however, that the process of statistics inquiry takes the longest of the four services (50%) because of the amount of information being transferred. This process itself includes three processes, all of which are types of statistics inquiries. Still, the average time taken is reasonable (7 seconds). Table 16 lists a summary of all results of the network requests tracking tests.

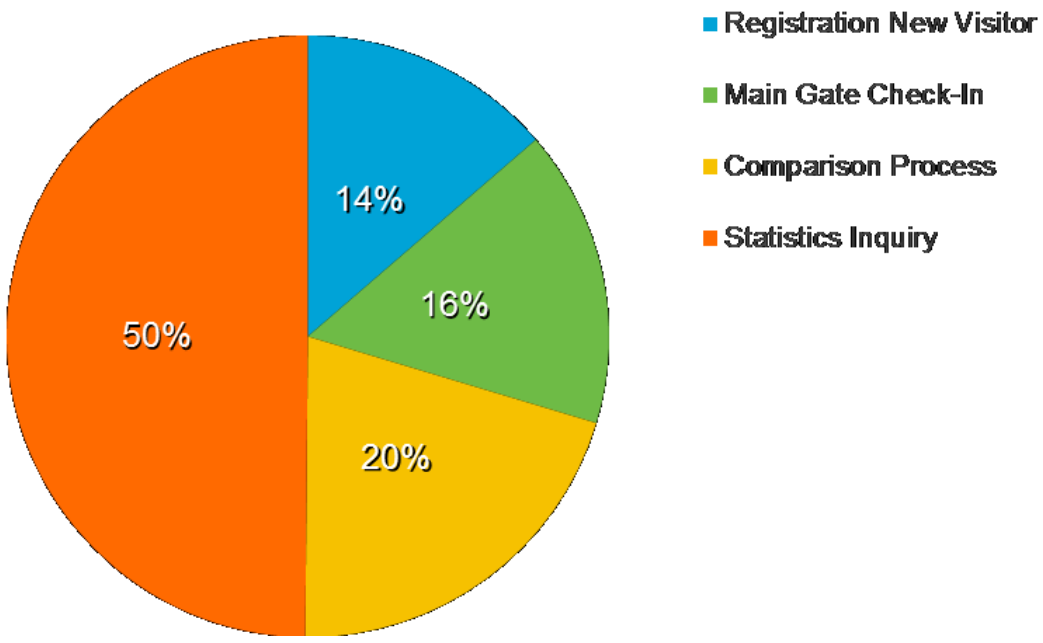

Figure 33. Percentage of the average time taken for each process in all tests.

As mentioned earlier, attaching a visitor photo to the same visitor's NFC bracelet would protect visitors' IDs from being used by other people and ensure that each visitor uses only his or her own NFC-bracelet. However, this is not implemented in our NFC-enabled

theme park application yet, but it would be a good solution that can be implemented in further stages. Moreover, system services and features would change to fit a specific theme park's location, popularity or size. Small sizes parks are not like big ones. However, in our NFC-theme park application, we strongly recommend to increase the number of registration employees in case it would be used in a large theme park, this is to avoid crowds in the registration office and to let visitors register without any delays.

Table 16. Average Time Taken in Each Process

PROCESS	AVERAGE OF TIME TAKEN	PERCENTAGE
Registration New Visitor	2	14
Main Gate Check-In	2	16
Comparison Process	3	20
Statistics Inquiry	7	50

Table 17. Summary of All Test Results

Process	Bytes Sent	Bytes Riceved	Packets sent	Packets Received	Time Taken (Seconds)	Tracking Test Round
registration new visitor	620	371	4	2	2	First Tracking Test (1)
main gate check-in	878	953	8	4	2	
comparison process	3294	3811	37	18	4	
Statistics Inquiry	1990	3347	24	10	9	
registration new visitor	699	371	5	2	2	Second Tracking Test (2)
main gate check-in	1303	1802	13	8	2	
comparison process	1744	2086	20	8	3	
Statistics Inquiry	2242	3922	26	13	8	
registration new visitor	1276	742	9	4	2	Third Tracking Test (3)
main gate check-in	942	1603	9	8	3	
comparison process	2517	2872	27	10	2	
Statistics Inquiry	1223	1975	15	6	5	

6.4 CPU Monitor and DiskUsage Monitoring Applications

6.4.1 CPU Monitor

CPU monitor is a useful application. It provides rich information about systems,

including memory usage and CPU utilization. It is utilized, in addition to the DDMS, to give us a more detailed analytical data about our android application.

Figure 34. CPU Monitor application logo.

6.4.2 DiskUsage:

DiskUsage is a monitoring application which is specialized for monitoring memory usage. DiskUsage provides a set of information regarding system and application memory consumption. We use it in testing our application in terms of memory consumption.

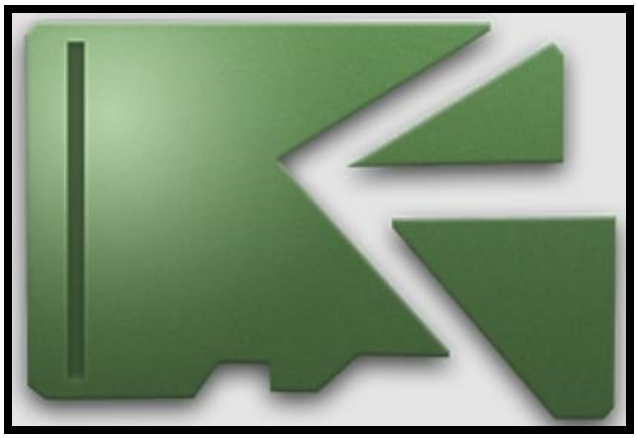

Figure 35. DiskUsage application logo.

6.4.3 System Information: CPU load and memory usage

DDMS includes tools that provide useful information about CPU load and memory usage of android devices. It is important to monitor memory usage and CPU consumption. Figure 36 is a screenshot taken by the DDMS tool and it shows the CPU load. Clearly, the CPU load is not high. Figure 37 shows the memory usage of the android device, Figure 38 shows the size of our android application, which is named (DHC), and Figure 39 shows the CPU consumption of the android application. As can be seen from the figures, the android application does not cause high CPU load and does not consume a large amount of memory.

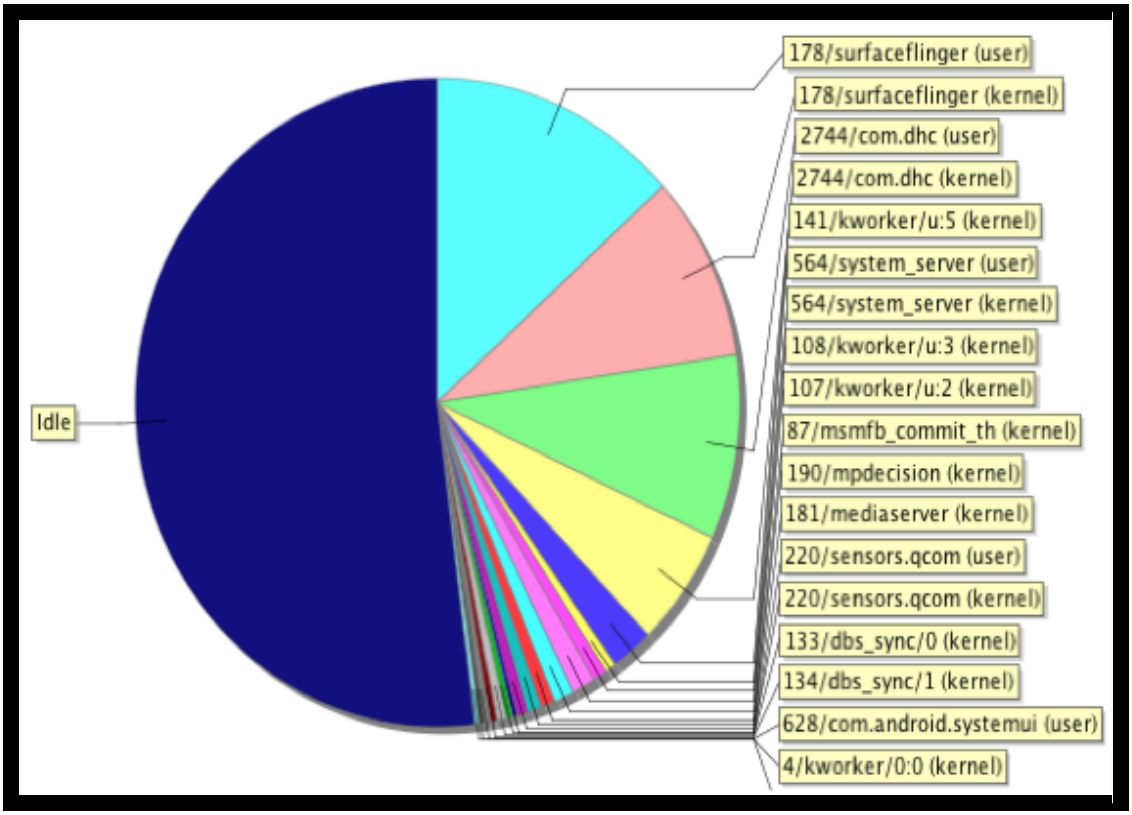

Figure 36. DDMS screenshot of CPU load.

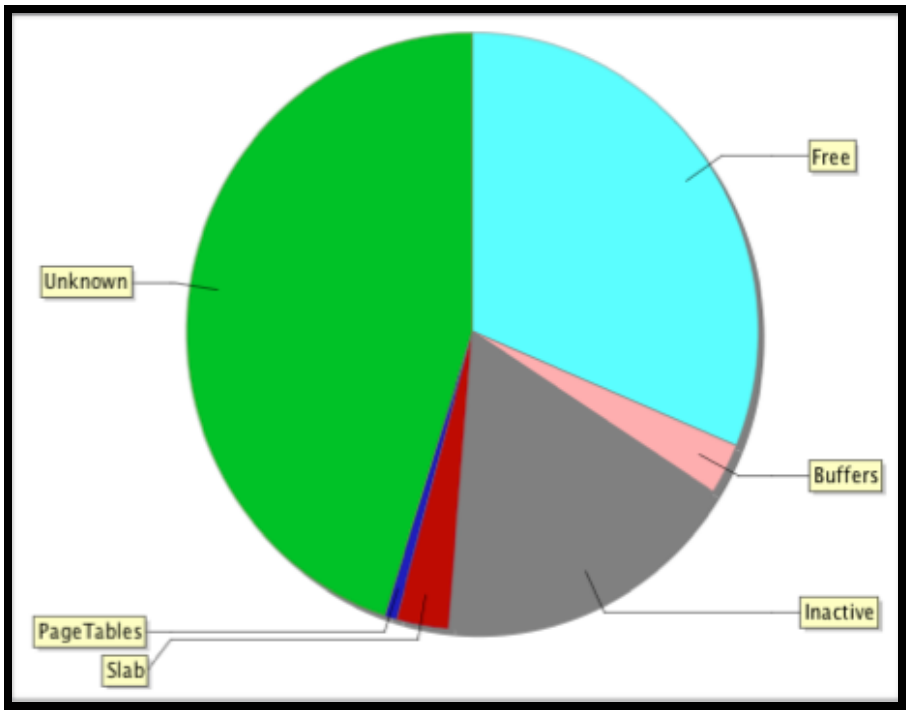

Figure 37. DDMS snapshot of memory usage.

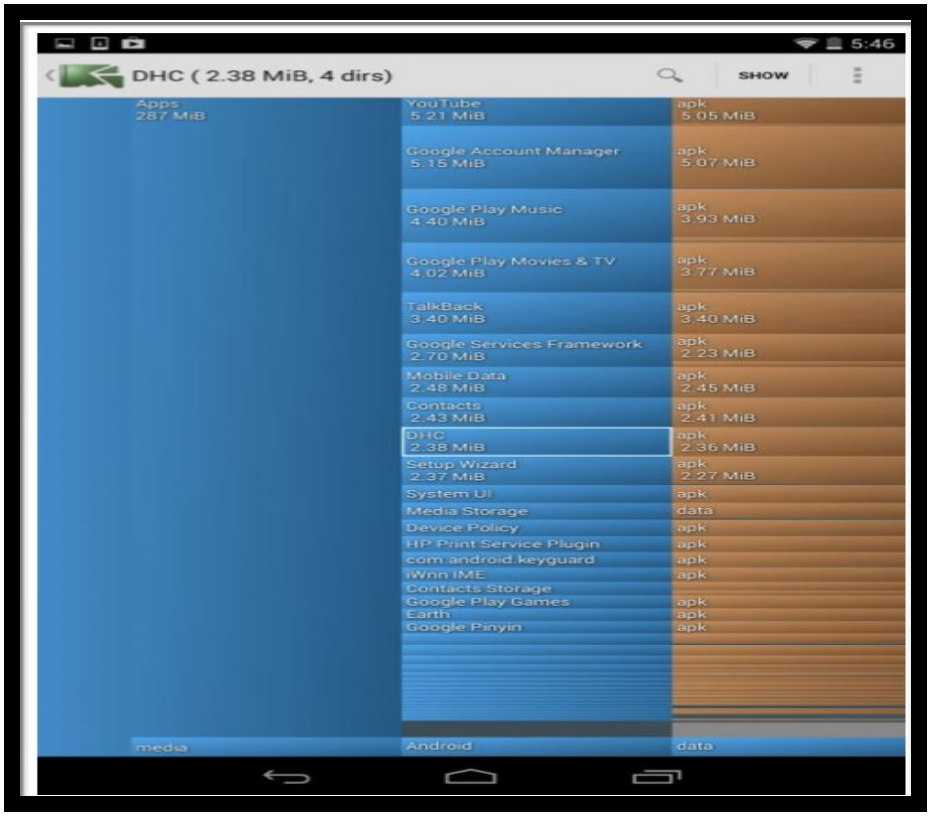

Figure 38. DiskUsage information about the system and android application (DHC) memory.

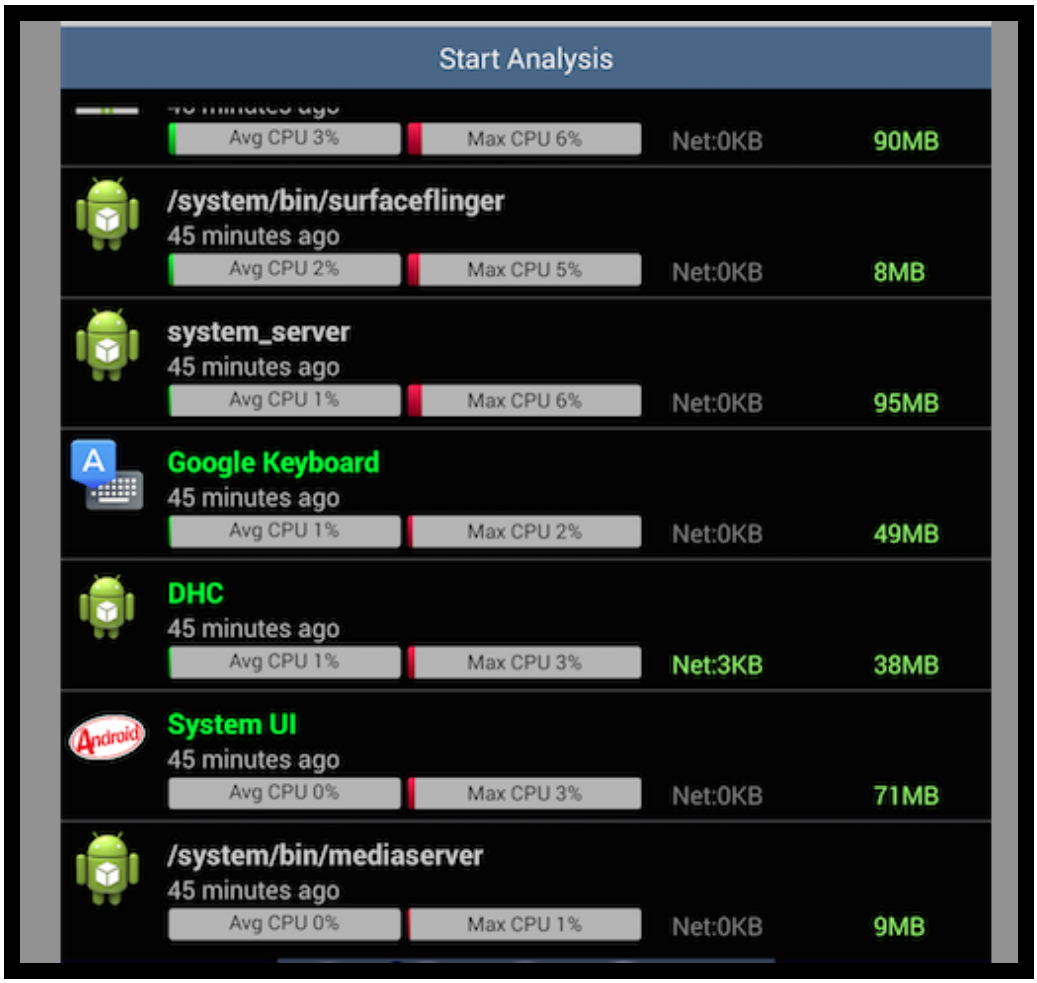

Figure 39. CPU consumption of the Android application (DHC).

As Figure 39 illustrates, our android application (DHC) does not cause high CPU usage. Information about our application CPU consumption, which is provided by the monitoring application “DiskUsage”, indicates that our android application CPU usage average is 1%.

6.5 Summary

In this chapter, we presented the testing tools used, which is the Dalvik debug monitor server. We performed network requests tracking tests for four different services of the application, namely visitor registration, main gate check-in, visitor information and ride

requirements comparisons, and statistics inquiry. The results showed the number of transferred and received packets as well as the number of transferred and received bytes in each period of time. In general, the results showed that only a short time was required for each data transfer process. Moreover, we performed additional memory usage and CPU load tests for our android applications using the monitoring applications DiskUsage and CPU monitor.

Chapter 7: Conclusion and Future Work

Our NFC-enabled smartphone application for theme park application aims to support safety inside theme parks, as it is very important for theme parks to provide safe rides for visitors of all different ages. Furthermore, the application is designed to provide a useful solution for the problem of waiting in long lines. In fact, visitors may have to wait a long time to purchase tickets. Also, riders may need to wait a long time until a ride operator finishes collecting tickets from all riders.

However, our designed ticket system provides instant virtual tickets that help users to avoid long line-ups. The virtual tickets are registered directly in the theme park's user database and connected through NFC technology to the user's NFC bracelet. We provided a novel solution for theme park safety and control purposes.

Our NFC-based mobile application provides a range of services that were designed to enhance the overall visitor experience at theme parks. In fact, the NFC-based theme park mobile application can meet the required goals by providing services for park ride operators, theme park visitors, and theme park administrators.

Initially, services that are designed to support safety inside theme parks and used by theme parks' ride operators are: information comparison, which compares theme park riders' general and health information with the chosen attraction's requirements. Additionally, the emails service that enables ride operators to send warnings should a visitor become lost or trapped in an attraction. In such a case, the ride operator can send an automatic email through the NFC application to the rider's family as an alert. Furthermore, a service designed for theme park visitors under the category of supporting

safety services is the visitor report inquiry. Through this service, a visitor can inquire about the current location of another one by entering his or her ID in the NFC-application. Then, a detailed report by date and time shows the list of all the rides that a certain visitor took and which ride they are currently on.

Moreover, the registration services that is provided by theme park registration office employees in the field of raising safety which allows employees to fill out a brief electronic form that will be used to ensure that theme park visitors take rides that are suitable for their condition which helps to prevent accidents.

Next, Service that are designed in the application to meet the goal of reducing waiting time comes under services provided for theme park ride operators, which is the NFC-tickets that allow visitors to purchase electronic tickets without waiting a long time in line-ups. Finally, the NFC application includes services designed for managing and controlling the theme park, such as crowd-checking services, which is an attempt to control crowds. Crowd management is important for solving crowd problems that could occur in many public places, Through crowd checks service provided by our application, visitors can check the current number of visitors inside the theme park before their visit. Also, the statistics service provides different types of instant statistics about preferred rides, preferred days for visiting theme parks, and ages groups of theme park visitors, which help park management teams in developing the theme park and recognize what improvements are needed.

The theme park NFC-based smartphone application system was implemented using Google Nexus 7 tablet with an Android 4.4.4 platform, NTAG203 tags, visual studio,

SQL databases containing information of theme park employees, theme park visitors, and rides requirements.

There is, however, room for improving and enhancing an application. The proposed android application can be made even more useful by providing a map for the theme park to locate the different ride positions in order to avoid confusion or wasting time looking for ride locations. The android application can also be improved by adding special features such as suggesting suitable rides for visitors in advance through offering a list of available rides that includes information such as user height restrictions and ride costs.

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