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Utilize Quick Response Code Technology as Secure and Productive Payment Method

Bachelor's Paper in Information Technology

Academic Advisor —
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Anotācija

Darba autor: Dilan Indika Senavirathna
Darba temats: Ātrās reaģēšanas koda tehnoloģiju izmantošana kā drošs un produktīvs maksājuma veids
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Atslēgas vārdi: QR kods, bankas lietojumprogramma, e-kvītis, drošs un produktīvs maksājums
Pētījuma mērķis: Izstrādāt maksājuma programmu ar drošākām funkcijām un veidot E-kvītis, izmantojot QR koda skeneri. Tā samazinot laiku tirdzniecības vietā un vienlaikus samazinot tirgotāju darba izmaksas ar inovatīvu sistēmu.
Darba saturs: Šis darbs satur aptauju un tās analīzi attiecībā uz respondenta maksājuma vēlmēm, literatūras apskatu par QR koda tehnoloģijām un tās lietojumiem, tehniskie pētījumi un risinājumi maksājuma lietojumprogrammas izstrādei, izmantojot QR koda tehnoloģiju.
Pētījuma metodes: Kvantitatīvās pētījumu metodes - anketas un aptaujas; Teorētiskais pētījums - dokumentācijas izpēte.
Darba rezultāti: No aptaujas rezultātiem ir iegūti secinājumi par to, kā respondenti izmanto dažādas norēķinu metodes, kā arī viņu zināšanu trūkumu un QR maksājuma izmantošanu. Analizējot rezultātus, autore spēja parādīt iespēju uzlabot QR koda apmaksas metodes sabiedrībā. Turklāt tehniskās analīzes parāda, kā drošāk un produktīvāk attīstīt QR koda tehnoloģiju. Ir izstrādāts uzlabots aplikācijas prototips.
Darba izmantojamība: Šis darbs parāda, ka QR kodu var izmantot kā maksājuma veidu salīdzinājumā ar tradicionālajām maksāšanas metodēm, to var izmantot jaunu tehnoloģiju un pieeju izstrādei, izmantojot QR kodus.

Summary

Author of the Paper: Dilan Indika Senavirathna

The theme of the Paper: Utilize Quick Response code technology as a secure and productive payment method

Type of the Paper: Bachelor thesis

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Academic Advisor: Kristine Mackare, MSc. Opto., lecturer

Volume: 54 pages

Keywords: QR Code, Banking Application, E-Receipts, Secure and productive payment

Aim of the Research: To develop a payment application with more secure functionalities and produce e-receipts using QR code scanner. To reduce time at the sales point while reducing the cost of operation of the merchants with an innovative system

Contents: This paper content of the survey and its analysis regarding respondent's payment desires, literature review on QR code technology and its uses, technical research and solutions for developing a payment application using QR code technology.

Methods of the Research: Quantitative research methodologies as Questionnaires and Survey; Theoretical research - documentation research

Results of the Research: The author has found the respondents' usage of different payment methods and their lack of knowledge and usage of QR payment from the survey results. Through the analysing of the results, the author was able to show the possibility of improving QR code payment methods in the public. Moreover, technical analyses demonstrate how to develop QR code technology more securely and productively. An improved application prototype has been developed.

Applicability of the Paper: This paper shows that QR code can be used as a payment method over the traditional payment methods, which can be used to develop new technologies and approaches using QR codes.

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Introduction

Daily payments are essential expenses every person must expose. Buying a cup of coffee, taking transport to a certain location, entering a museum or theatre, and paying for airline tickets online or online shopping are done by the transaction of a particular financial value. Customers and vendors may transfer some financial value in different ways, such as basic cash payments, debit cards or credit cards, cheques and internet or mobile transfers by banking application or other payments application.

With the rapid development of the technology, the Quick Response code was designed in 1994 by the Japanese automotive industry. QR code often contains data for a locator and tracker to a website or application which are using numeric, alphanumeric, byte/binary, and kanji for efficient data storing by standardising encoding modes. Currently, over a hundred million people around the world are using QR code for different purposes for instance of encrypted data storing and sharing [3].

Quick Response payment methods is a contactless payment method where a transaction is done by scanning a QR code from a mobile device and a mobile application [26]. Somehow QR code payments methods are not quite popular in Europe and some other countries in the world, even though the methods are dominating in China and India as a primary way to pay daily expenses.

Therefore, throughout this research, the author willing to demonstrate that usage of QR payment methods with additional functionally might improve customers experience of effective and secure way to make their daily payments. By developing a prototype of an application that can be used to pay daily expenses and receive electronics receipts which can be saved into local storage inside the application instead of printed receipts which generally could be disposed within few minutes.

The aim of the research is the promoting QR payment method as alternative daily secure and effective payment option and electronic receipts to reduce the waste of printed receipts while reducing the cost of functional materials of the vendors.

Main objectives of the research are to provide better customer experience by using new technology and as a merchant to adopt new technologies to keep up with changing world by using cost-effective and environment-friendly business strategy.

The author’s main goal is to demonstrate that Quick Response codes can be used to deliver secure and productive payment methods than cash and bank cards. QR code encryption is used to store information that cannot be read by humans or a device without specific software functionality. That can be used to make sure the security of the QR code, while the authors proposed to develop an application that uses QR code for transferring banking details, receiving and creating the electronic receipts for the users instead of printed hardcopy receipts at the sales points. The main tasks to reach by the author can be listed:

1. Conduct literature research on topics related to QR code technology and payment methods
2. User and potential user research by survey
3. Research on the existing applications and solutions
4. Data analysis
5. Research on software libraries and development of new QR code payment application
6. Creation of application prototype
7. Evaluation of the prototype

The hypothesis of the author are, usage of Quick Response code technology as an alternative payment method would provide a more secure and productive payment option for customers and merchants. As an additional outcome of the proposed technology, the electronic receipts procedure would be helpful for sustainable development.

A survey has been used and sent out to collect data from the potential users of the proposed application. A wide range of published papers related to QR code technology and consumers behaviour on daily payment and its cost of operations have been studied in this paper. Summarised and logical explanations of the related literature have been done in this paper to demonstrate that the author's suggestions are effective. On the other hand, a comparison of the latest software packages for QR code technology has been made to develop the application in its highest usability and efficiency.

At the time of this research, the world has been going through a problematic historic period due to Covid – 19 outbreak which was caused by an unassailable virus, its spreading has been proved by a human to human or by the objects contaminated to the virus by a human who is positive with the virus. The contagious objects also could be banknotes and coins, bank cards and the printed receipts at the sales point which are mostly exchanging objects by a human to human. The author’s research is based on reducing the usage of methods as mentioned above of payment and receiving E-receipts. When considering practicality and worthiness of this system,

rapid usage of, and availability of this technology could have been supportive of falling Covid-19 outbreak.

This Bachelor thesis is written in English on 54 pages. It contains 30 figures, 04 tables, 25 references and 06 appendixes.

Literature review

1.1 QR code

In 1994 Quick Response codes were created by a Toyota auxiliary called Denso Wave to help in assembling procedure, the auxiliary maintained in following cars and its parts. The intention was to develop QR code is considering speeding up decrypting various data, so it was called the Quick Response code. The foundation of the QR code is barcodes; the success of barcodes and its uses opened up the existence of QR codes. The most significant advantage of QR code is its high storage capacity compared to barcodes, while both types of codes have slightly similar in speed[3].

QR codes have made considerable progress since their creation, today they have various purposes, including transport tagging, amusement, business following, and item naming/showcasing, just to give some examples. QR codes being utilized to send crowds to a site for perusing, to bookmark a site page, to start calls, send short messages, send messages, produce connects to web URL's, start talks with blackberry clients, associate with WI-FI systems, get to data, get coupons, see recordings, buy things, process orders, publiced items, and recently as digital payment option[4].

QR codes are better for getting to information nonetheless there are dangers with the way it uses. They include possibly connecting to a risky website page that employs or includes malware or harmful content, though that it is possible to access personal and sensitive data such as passwords, contacts and stored files on personal device. To avoid this kind of frauds, QR code users must make sure to scan the QR codes that are generated by a trusted party [28].

What would be the future of the QR code technology, which can be answered by the development of new technology. Since its birth, it has been shown to grow in popularity and usage, it might continue its popularity for more year, somehow new technologies like NFC has challenged the popularity of the QR code recently. Compared to other similar technologies, QR codes are widely available for the public with mobile devices. However, the popularity and usage of the QR codes would depend on innovations based on QR codes technology and by decreasing its weakness [27].

1.2 Users acceptance of the proposed system

Consumers acceptance of new technology and methods is more important for introducing a new way or concept to replace an existing situation and situations. Several theoretical models of psychology and sociology have been implemented to understand user's behaviour of accepting and usage of new technology. The Unified Theory of Acceptance and Use of Technology (UTAUT)[1] has filtered analytical elements and eventualities regarding possible usage behaviour of technology essentially in the organisational level where UTAUT described percentage of the variance in behavioural intention to use a technology and technology use as follows 70 per cent and 50 per cent in from employees. UTAUT has served as a baseline model and has been applied to the study of a variety of technologies in both organisational and non-organizational settings [1]. UTAUA consists of 3 types of combinations which are new technologies, expanding existing technology and derive possible technologies.

According to UTAUA, the proposed system (QR payment) is expanding of existing technology. The success of the proposed system relies on by fulfilling few integrations of UTAUA, such as Hedonic Motivation which is defined as user-friendliness of a technology, Price Value which is defined as cost-effectiveness of technology and Experience and Habit which can be described as user's post-training when technology was established, examples usage of social media[1].

The proposed system would accomplish UTAUA integrations by user-friendly interfaces for Hedonic Motivation, saving the cost of printed receipts and the payment option as an extended version of a banking application for price value and giving a new experience of daily payments for experience and habit.

1.3 Time efficiency and cost of operations

At the sales points in retail stores such as supermarkets, restaurants, and entertainment avenues the consumers can make the payments with coins and banknotes, bank cards such as debit cards, credit cards and prepaid cards, and even through smartphone devices. Daily payments at the sales points create a huge influence on the whole economy while moving currency between different entities through exchanging goods and services. Even though consumers were provided with a wide range of availability of goods and services, payment methods are quite limited [6].

With these limited payment methods, consumers would choose the way of payments methods linked to their personal preference or only available option at the situation, for instance,

paying by cash or bank cards at the supermarket cashier and paying by only cash at an open market where digital payment methods are not mostly available[6].

In another scenario where multiple payment methods are at hand, consumers would choose the payment methods for their satisfaction, such as which way of payment methods is faster and efficient for them as an example, instead of exchanging currency between the cashier and themselves consumers would prefer to use digital payment methods at the sales points. Giving a banknote to a cashier and taking back changes with a printed receipt would take consume some time at the queues, so consumers would prefer to spend less time at the sales point [6].

There are links between consumers satisfaction of a retailer and the retailers' profitability. Long queues at the cashier and waiting for an unsuccess full payment to be done are not consumers preference. On the other hand, long queues and spending more operational time of a casher or an employee per customer are not healthful for retailers' profitability and competitiveness on the market.

Remodelling consumers movement to the sales point and increasing employees' efficiency while declining time to a successful payment may result of reducing long queues at the sale points and enlarging consumers' satisfaction which might affect the outcome of both retailers and consumers benefits on the market.

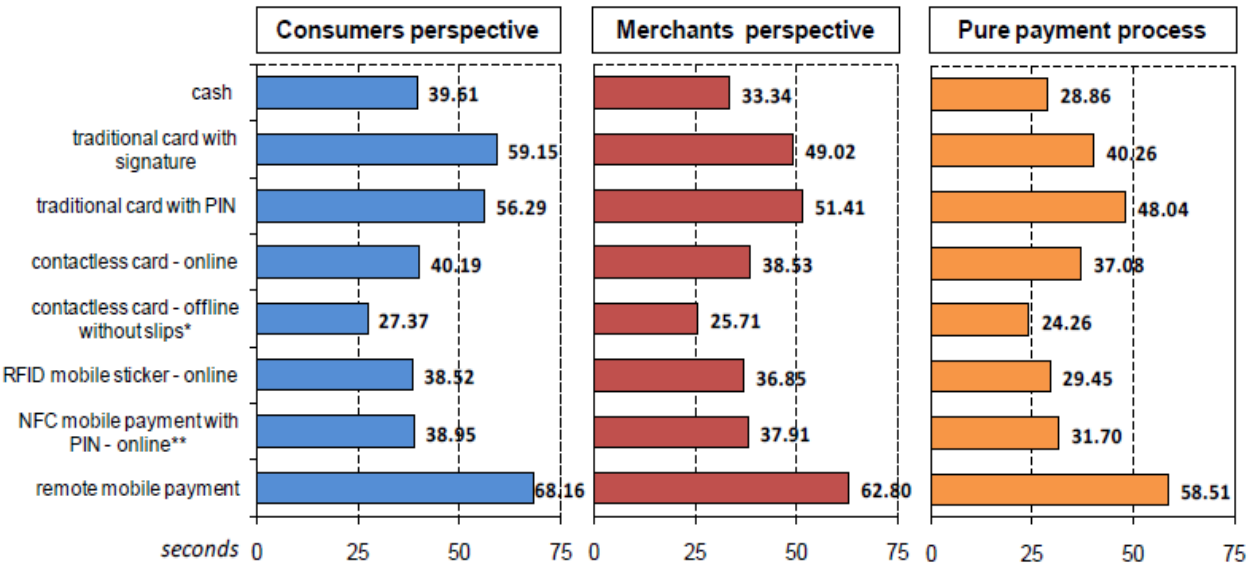

Figure. 01: Average time in seconds of the successful payment by payment methods(13-p) [6]

*Due to the lack of a sufficient number of observation for a contactless card in an office mode without printing paper slips, the time for this payment method was estimated analyses thw simulation procedure

**By analogy to a contactless card, the NFC mobile payment with PIN in offline mode and without slips printed would be shorter by about 13 seconds (13-p) [6].

According to the research of *Time Efficiency of Point-of-Sale Payment Methods: The Empirical Results for Cash, Cards and Mobile Payments [6] by researchers of Nicolaus Copernicus University and Warsaw University*, traditional payment methods such as a traditional card with signature, a traditional card with PIN and remote mobile payment methods are consuming more average time up to 68 seconds at the sales points while cash, contactless card, RFID mobile sticker and NFC mobile payment with PIN methods are consuming mild average time around 39 seconds in consumer prospective and around 36 seconds in merchants perspective. According to the published data, it demonstrates contactless card without slips is consuming far less average time to complete a successful payment by both consumer prospective and merchant perspective, where it revels even in same technology without printing slips could save time to complete a successful payment. The proposed system mainly focused on digital slips through QR code reading instated of printed slips which could lead to time efficiency of both consumers and saving operational cost by increasing employees working capacity.

1.4 Security analysis of Quick Response code

With the rapid increase in technology, the security of the technology is a more important part, while using the up-to-date innovation of technology. Especially when an innovation work

with personal data management such as banking systems, health care databases, personal registration systems and social media. There are many methods of security and authentication systems are implemented in such systems to protect personal details and assets from illegal misusing.

User authentication plays a significant role in distributed computer systems to verify each legal users' access to the system and protect the system from unauthorised uses. Username and password-based authentication, biometric authentication, Two-Factor verifications and OTP (one-time passwords) are the most common authentication methods used at present. According to *the Analysis of Secure Authentication System Using QR Code.* Preetham C, Gowtham M, Aditya D N (2018), another verification framework is utilising QR codes (Quick reaction code) and OTP. In the first-place clients make a novel id then the server produces a QR code, this confined unapproved client gets to the framework and takes out the shortcoming of secret key verification. This Authentication framework stores item data over a system(11-p) [7].

Advantages and Disadvantages of QR codes . *(Preetham C, Gowtham M, Aditya D N-03p) [7]*

1. Advantages of QR code
    a. QR code is two dimensional and comprehensible at any heading.
    b. Capacity limit of QR code is up to 4,296 alphabetic-muneric characters.
    c. It is lucid on the off chance that they are somewhat harm.
    d. It is anything but difficult to check with a camera-based gadget.
    e. QR code are decipherable by an individual.
    f. QR code can stores information which is put away in one-dimensional scanner tag in one-tenth space.
    g. It can deal with any sorts of information like numeric, alphabetic.
2. Disadvantages of QR code
    a. It is only readable by machines

Author's proposed system mainly focused on using Quick Response code in existing banking applications and payment applications for payment verification. Therefore, as existing banking applications and payment applications are well equipped with security methods, the proposed system may focus on the efficiency of data transfer each system, such as vendors API and consumers smart device.

It is using the advantages mentioned above of the QR code. The proposed system may store 4296 alphabetic characters and share the saved characters to the user's device in seconds. In this case, there is no third party would involve completing successful payment and successful data transfer between two systems. Moreover, it is expressed clearly that its negative effects are somewhat unlikely to find. Even though Quick Response codes can deal with different types of information such as numeric and alphabetic, it is highly unlikely to read the stored data without a camera-based device with QR code reading function.

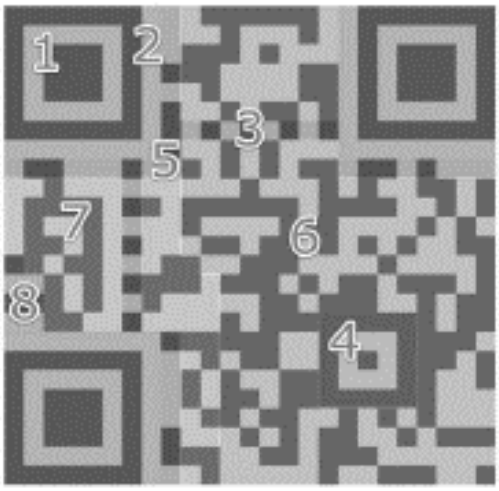

Figure 2 - Example QR code version [8].

There are 40 versions of QR codes data capacities. Version 1 consists of 21 X 21 modules from which 133 can be used for storing the encoded data. Version 40, which produces the largest QR code, has 23,648, hence 4296 alphanumeric characters can be encoded. Figure 2 shows an example of a version 2 QR code, which is the most commonly used one [8].

Version type 2 QR code is mainly popular in access control in social media, in the advertising field to store URLs, contact information and location of a company by encoding into QR code and in the mobile payment field to redirect the user to an instant payment page.

In reality, QR codes are safely available for sharing data between two devices; it is only readable by a device with QR reading software. Compared to bank cards which have written details of the card and customer details with signature most of the time which can be readable and comprehensible by humans. Even though the QR code is an entirely safe practice for sharing data, some reported vulnerabilities can be found.

Figure 3 - the modification attack, as proposed by Kieseberg et al. [8][9].

A. The process of replacing the entire QR code is done to misplace whole stored information.
B. Modification of part of the QR code as shown in Figure: 3 to use original content to attract the user to redirect it to a false website for payments(example http://gbay.com instead of http://ebay.com).

Furthermore, Seeburger et al. [10] and Vidas et al. [11] advocate, showing a QR code is not a perfect approach because to decode and see the stored information of a QR code before the user decides whether the information is correct or incorrect [8]. This argument is due to the unreadability of QR code by users themselves. When considering about above vulnerabilities, the proposed system would be able to eliminate those vulnerabilities (A, B) by considering work as a QR reader and the argument of Seeburger and Vidas can disregard by trusted QR screener where QR generator will be the legitimate worker of a vendor at the sales point or verified print of the QR code from a legitimate service provider at the service place or verified website of the vendor.

1.5 Comparing traditional payment methods to the proposed system

A) The most known method of payment at the sales points or the markets is banknotes and coins which have been using from hundreds of years ago and which is still being a better and easy way to transfer financial values between two entities. The popularity of using cash is coming from the wide availability of it and knowledge about using the cash.

With the development of the world and its financial situation, using cash is the better and easy way has been questioned by its users while comparing the presently available way of payments [15]. By merchant's view, using cash is better for their liquidity, it is coming with additional costs and treats such as the risk of theft, robbery, and counterfeiting, as well as the risk of human error during the exchange. Security measures (e.g., surveillance cameras and

security guards), secure storage (vaults and cash registers), and investment in counterfeit-detection training are necessary fixed costs associated with cash [14].

Cash is being the most labor-intensive way of payment because of handling cash, needs time to make the cash registers, balance the amount of the daily payment and deposits the cash into banks. According to the merchant's scope, their employees or armoured transportation services would transfer the cash to the financial institutes which comes with extra costs.

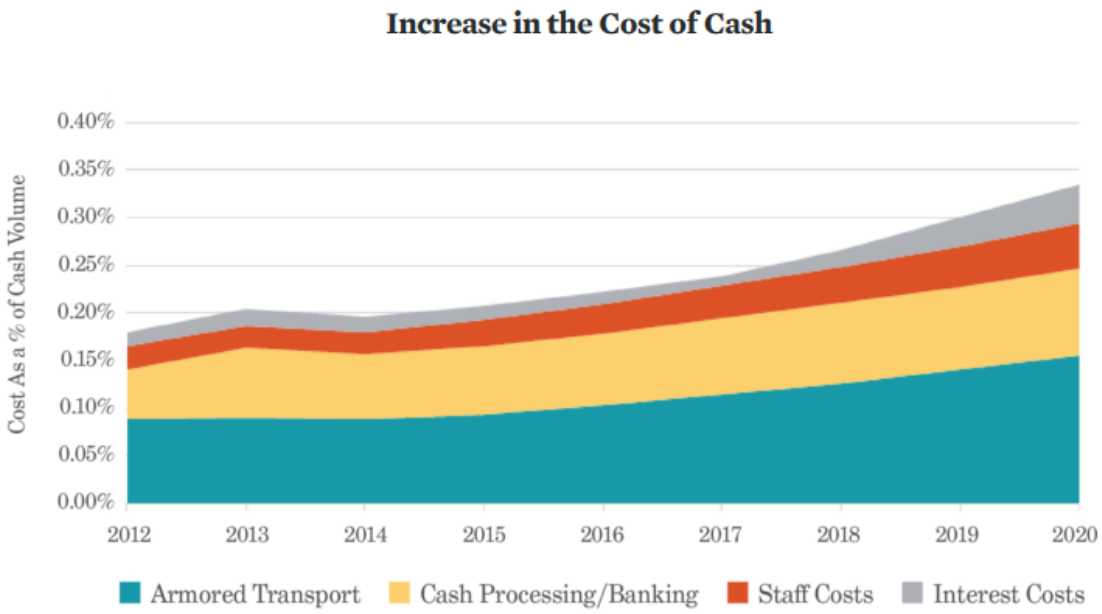

Figure 4 – Increase in the cost of cash [16]

Figure 4 shows the projected cost of using money, a percentage of cash volume. The cost of using armoured transport, cash processing/banking, staff costs and interest costs are gradually increasing year by year from 2012 to 2020. Figure 4 demonstrate that using money is getting more cost-inefficient by the merchant's view, which recommends better to have another way of payment method for the cost efficiency of the business.

B) Presently, bank card payment is considered as another popular and one of the most available way of daily payment. To accept bank cards through a sales point vendor must have payment processing system from a bank. Usually, vendors lease a point of sales (POS) system from the service providing companies or large merchants have their own POS system and terminals. Cost of bank card operations varies on the service provider and amount of transaction by bank cards. Even though merchants have to pay the various fees for using POS terminals, merchants could advantage from POS systems by reducing the cost of operation such as labour costs, cash holding costs and banking costs for cash withdrawal. On the other hand, using POS

systems, merchants attempt to keep up with new changes which lead to the satisfaction of the consumer by providing different methods of payment [14].

C) Another type of payment method can be described as cheques and vouchers, which still uses rarely for daily payments. With the development of technology, these type of payment methods is slowly disappearing out. Especially with the development of digital payment methods usage of cheques and gift vouchers can be presented as an online application or through a QR code or Barcode.

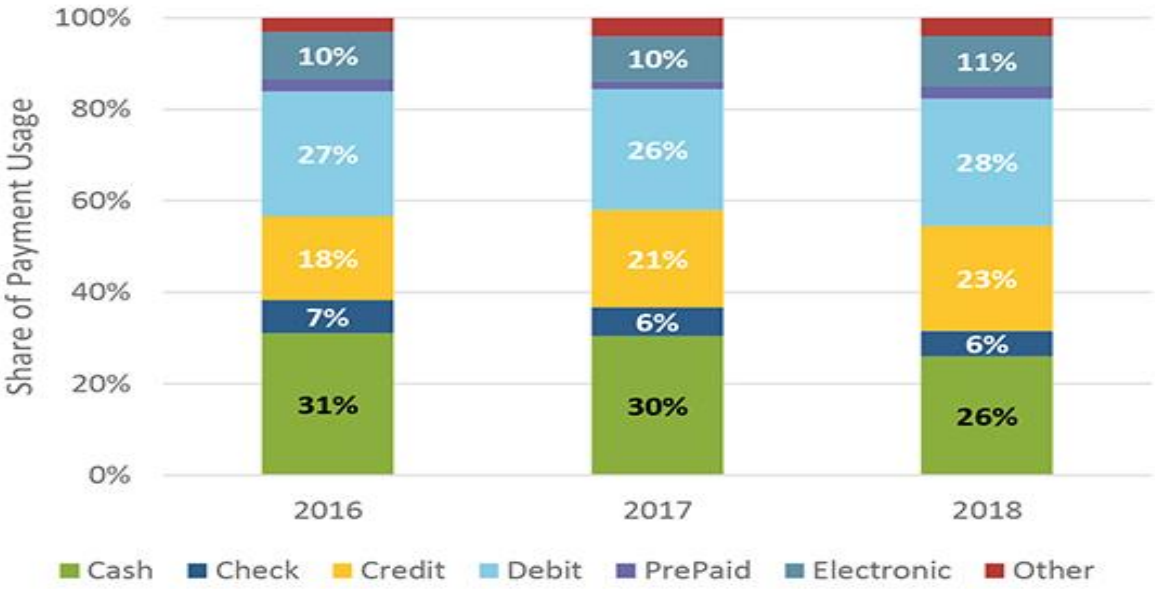

Figure 05 - Share of Payment Instrument Usage by Year [17]

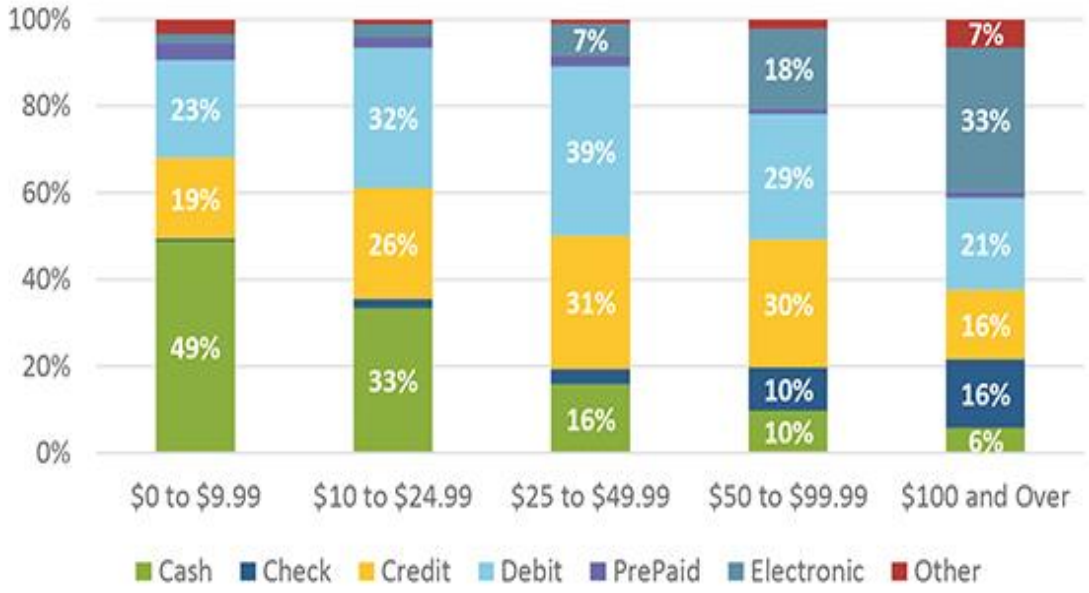

Figure 06- Payment Instrument Usage by Purchase Amount - 2018 [17]

In figures 05 and 06 show consumers choice of payment methods and its change according to the amount of purchase. Year by year bank cards and electronics payment methods usage has been increased while the usage of cash is slightly decreasing. The customers used to pay electronically mostly when the purchase amount is high and paying by cash is more popular with small purchase amounts. It might be cases by payment commission fees regulated by payment companies such as PayPal. If there was a payment option to pay directly through your bank account no matter what the payment amount is, more consumers should have shifted to it.

After considering the theoretical part of the research, a clear view was given about QR Code and its benefits, security, how QR code can be used for information sharing, how traditional payment methods cost for the people and consumers behaviour on new technology and its adaption. In the practical part, the author's effect on finding a solution has been revealed by the possibility of developing a new payment method from existing technology. When introducing new payment methods, the author has described that the mobile application can be developed with additional innovations and functionality to improve its usability and applicability for possible consumers.

2. Practical part

2.1 Methodology

2.1.1 Survey

An online survey has been used to collect data from the potential group of users from especially Latvia, Sri Lanka, some European countries and other countries around the world. The survey purpose was to acquire a clear image about the user's present behaviour of smart payment methods. First three questions of the survey were acquired basic information about the users such as age, gender and country of residence. Fourth and fifth questions of the survey acquired respondent's manner of using payment methods and type of mobile device currently respondents are owning. Respondents usage of alternative payment methods besides cash and bank cards, usage of banking applications, ways of banking applications are used for daily expenses and respondent's usage and knowledge about Quick Response code payment methods are acquired by sixth to ninth questions of the survey. The last question of the survey reserved to obtain respondents usage of present alternative smart payment options and type of smart payment applications are used (Appendix- Research questionnaires).

2.1.2 Respondents

The survey acquired sixty responses from different ages and different countries by sending out an online Google form. Respondents' age was eighteen to fifty plus category. Among total responses, thirty-two of them were male while the rest of twenty-eight were female. Most of the responses came from European countries as 45 while second-most of the responses were from Sri Lanka as nine, and the rest of them were from other countries as six respondents around the world.

2.1.3 Analysis

Quantitative research methodologies as questionnaires and survey have been used to collect data for the analysing, the data have been summarised, visualised, described as mean, median and percentage of total data for each question. Grading methods and functionality research have been done for similar applications, and the proposed application development methods.

2.2 Survey results

In this section, the author describes the finding by analysing the online survey data and possible outcomes for the proposed system. Average, mean, median and percentage of the data for each question have been shown while describing conceivable reasons for the results.

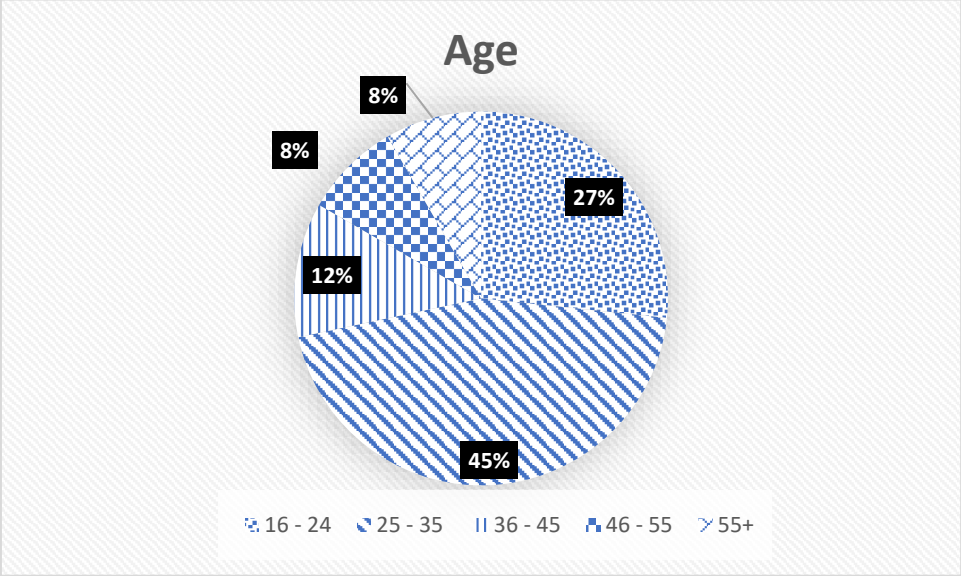

Figure 07 – Age category of the respondents as percentage.

The 1st question of the survey was designed to collect the age of the respondents. Age groups were presented for respondents and be able to select. According to the received data from the survey, age groups and its percentage from total respondents are as followed: 16 responses in 16-24 age group as 26.7% of total responses, 27 responses in 25-35 age group as 45%, seven responses in 36-45 age group as 11.7%, five responses in 46-55 age group as 8.3%, and five responses were reported in 55+ category as 8.3% of total responses.

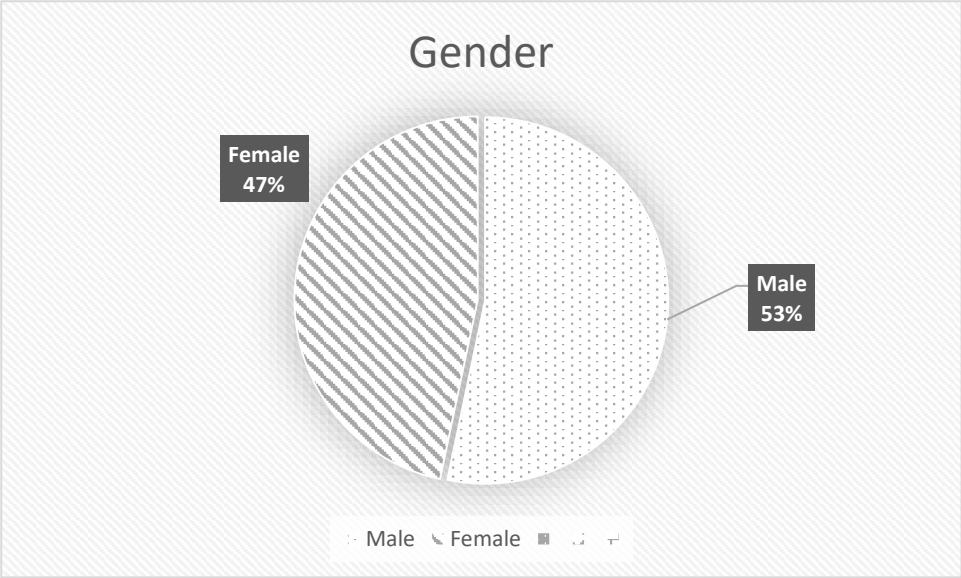

Figure 8 – Gender percentage of the respondents.

Figure. 8 shows question No 2, the gender of the respondents. That was category type question: male, female and other. There were 32 male respondents and 28 female respondents. There were not any respondents in another category. Respectively, the percentage is being 53.3% of male and 46.7% of female from total respondents.

Analysis of Figure 7 and Figure 8;

Table 01(Number of respondents and their gender by each age category).

Age Category	**16-24**	**25-35**	**36-45**	**46-55**	**55+**	Total
Male	07	17	03	02	03	**32**
Female	09	10	04	03	02	**28**
Total	**16**	**27**	**07**	**05**	**05**	**60**

Comparing age category frequency of the respondents and age category frequency of each gender, mean and median of the respondents' age are follows, mean age of the total respondents = 32.98, while the median is being 30.20, female respondents' mean and median age are 32.80 and 30. Male respondents' mean and median age are 30.32 and 33.13. In conclusion, as the majority of the respondents are in work-active age and they are the main money spenders and more likely to use a new application when it is introduced.

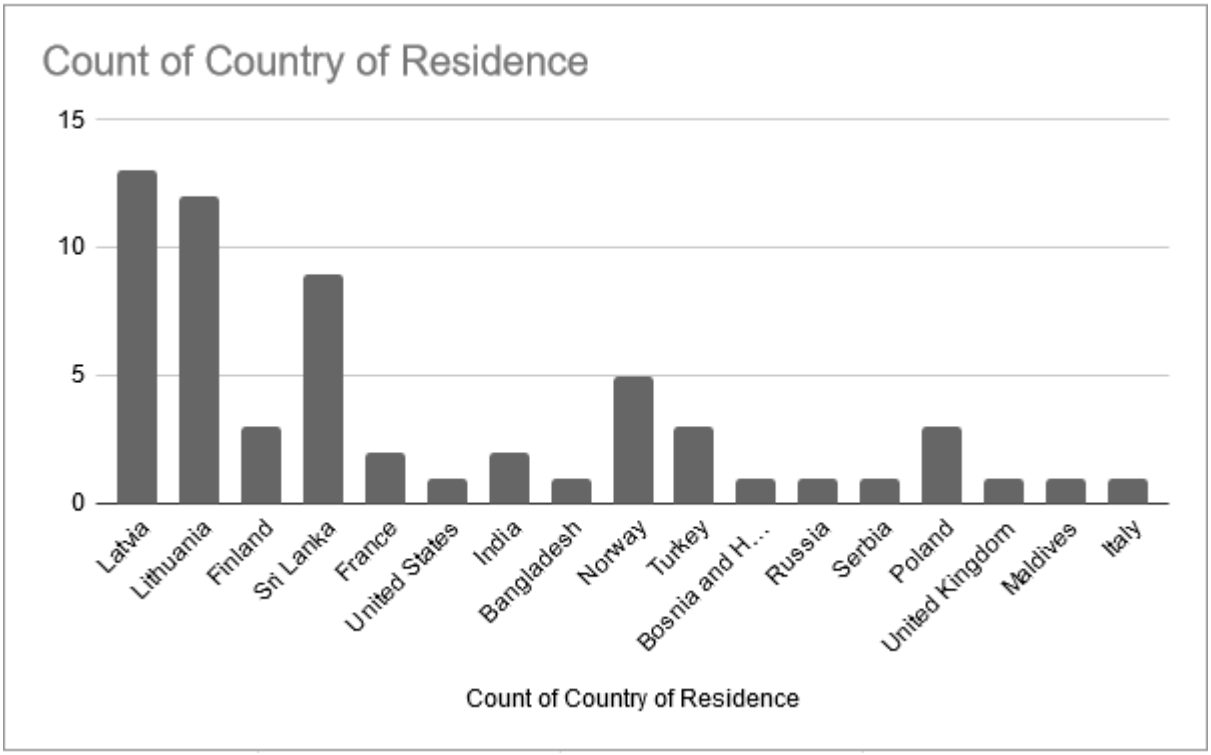

Figure 9 - Number of Respondents by their country.

According to the survey results, most respondents were from Latvia, Lithuania and Sri Lanka, its percentages are 22%, 20.3% and 15.3% from the total respondents. Forty-five respondents from Europe as percentage 75% and the other 15 of them were from other countries such as Sri Lanka and India. Respondents' geographical distribution is related to the author's University localisation and social contacts.

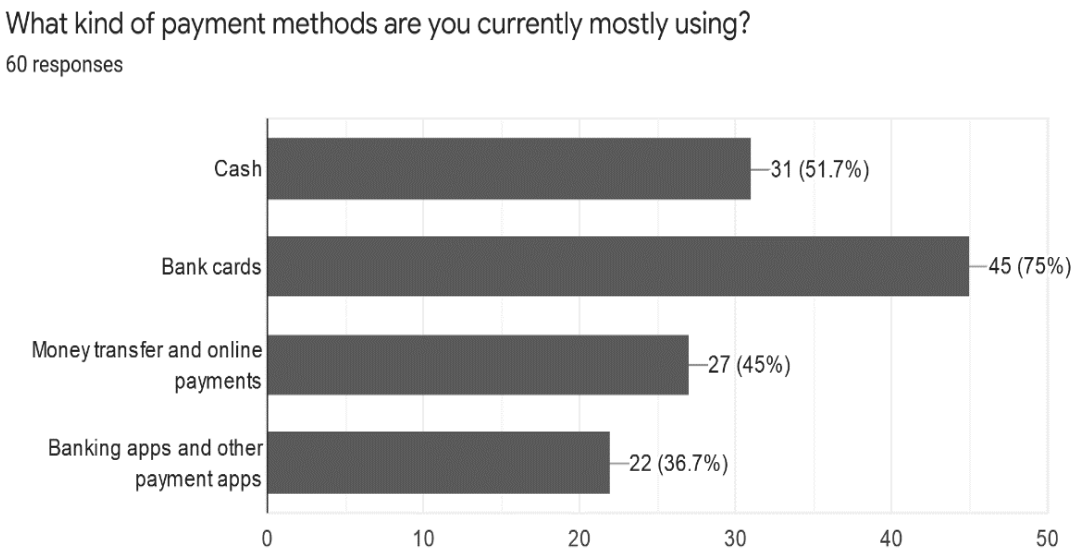

Figure 10 - Most used payment methods by the respondents.

Figure 10 displays respondents desire to use different types of payment methods for their daily needs. It was a multiple-choice question to get an idea about the most used way of payments. Cash and Bank cards are being the most used category as amount 31 and 45, of 60 responses. Mobile transfer/online payments and Banking applications/other payment applications are being used only by less than 50% of people. By analysing the data, it demonstrates that cash and bank cards are still the most used methods, its percentages being 51.7% and 75%.

Moreover, 12 respondents prefer only cash, and their average age is 45 years, while 14 of them use only bank cards, and their average age is 35 years. Average age below 30 years old, 11 respondents, use all four methods of payment for their needs. Twenty-six respondents do not favour using cash as daily payment. Their average age is 32 years and 97% of them own a smartphone. 75% in total 45 respondents use at least bank cards as a payment method and 99% of them are holders of a smartphone.

In the conclusion of figure 10, most of younger respondents are prefer bank cards and other electronic payment methods instead of cash, even though older respondents prefer cash payment, some of them are already using electronic payment methods. Younger people are more likely to adopt new technology while older people seem to prefer to use traditional methods due to the complexity of digital payment methods. New proposed application would suggest more user-friendly and more adoptable technology for everyone no matter how old they are.

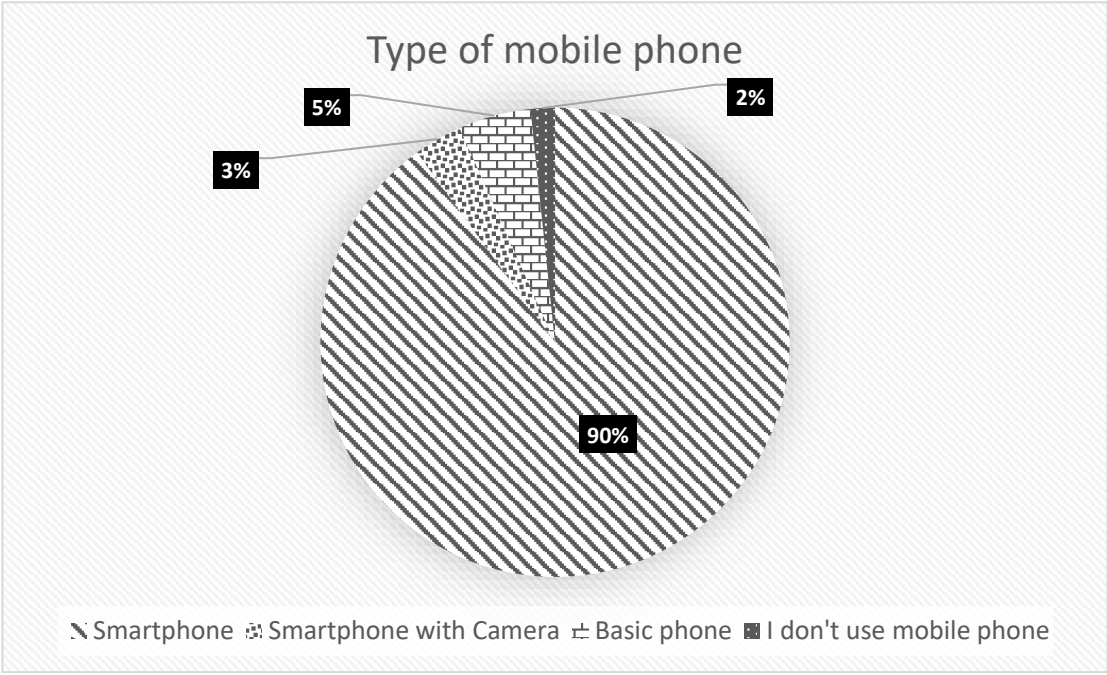

Figure 11 - Respondents' mobile ownership and type of mobile device.

When considering respondents' usage of a mobile phone and type of the device, figure 11 illustrates 90%, 54 of them own a smartphone, 3 of them are using basic phones, and 2 of them are using smartphones with a camera and only one respondent does not own any device of this kind. As considered, 94% of respondents who are below 40 years old have a smartphone. However, only 70% of respondents are using a smartphone and 30% of them do not own a smartphone in the above 40 years age category. The data shows that most of the respondents are using a smartphone even in the older age group; more people are owning and using a smartphone. The high percentage of ownership of a smartphone by respondents would fulfil the main basic technical requirement of the proposed application, which makes the proposed application more accessible for potential users.

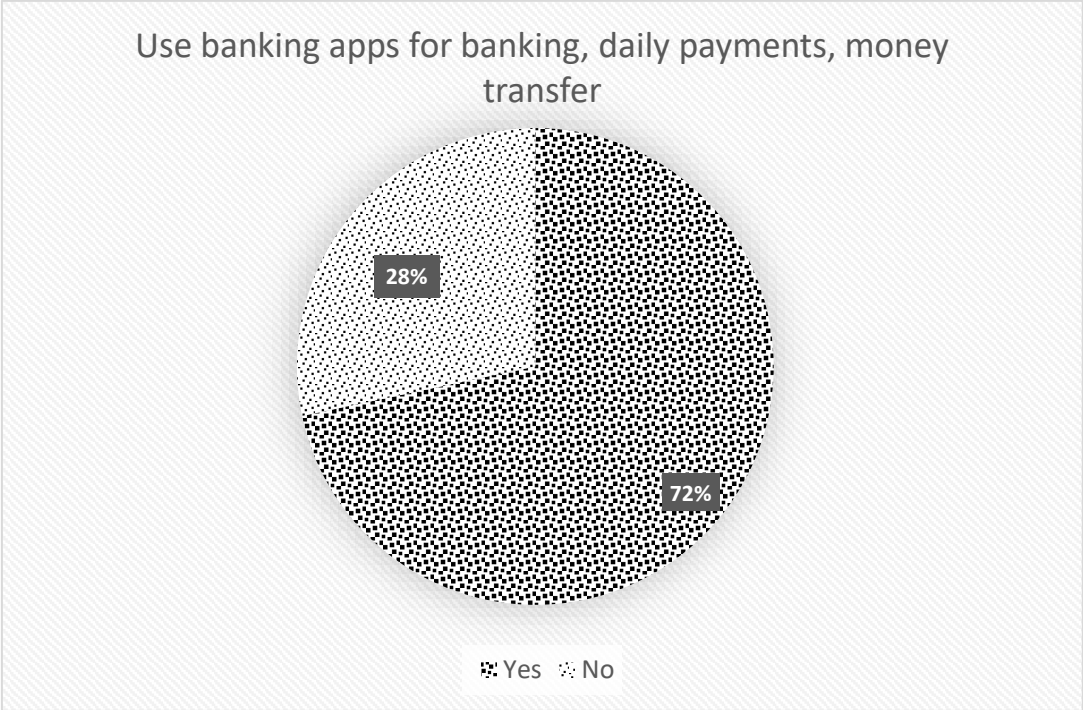

Figure 12 - Respondents' usage of banking apps for daily needs.

Figure 12 demonstrates 43 respondents who are 71.7% of the total, are currently using banking applications for banking and daily payments. In the average age below 40 categories, the usage rate is going up to 79% from the total, however in the average age in the above 40 categories, and the usage rate is only 46%. While 55+ age class, there are no banking app users even though some of them own a smartphone. The possible users of the application are in the age group that already are using a banking application; therefore, the group is also the target group for the proposed application. To attract more elderly users, authors suggest more user-friendly and easy steps to complete a successful payment via the proposed application at the sales points.

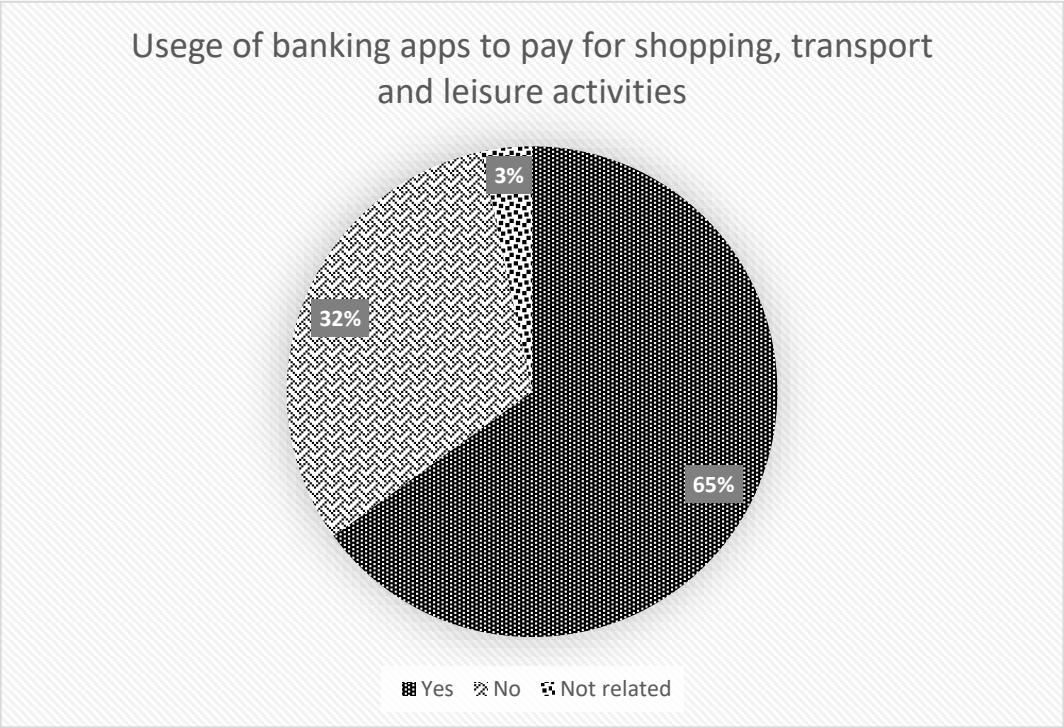

Figure 13 - Respondents' usage of banking apps for shopping, transport and leisure activities.

By question number 07, expected to get an idea about the way of using banking apps from the group who are using banking apps. Figure 13 illustrates despite figure 12 data which shows 43 respondents and 71.7% of the total are using banking application, the usage of a banking application for shopping, transport and leisure activities are slightly going down as 39 respondents and 65% of the total, which means around 7% of banking application users are not using the banking applications for triggers as mentioned earlier. 19 respondents are not using banking applications for the above activities, even though 26% of them are using banking applications for figure 12 activities.

The average age 35 of the respondents who are not using banking applications for figure 13 triggers, while 15 of 19 respondents are owning a smartphone. Therefore, the data shows more potential users of the newly proposed application because one of the main basic requirements has been satisfied by the average age above 35-year-old group.

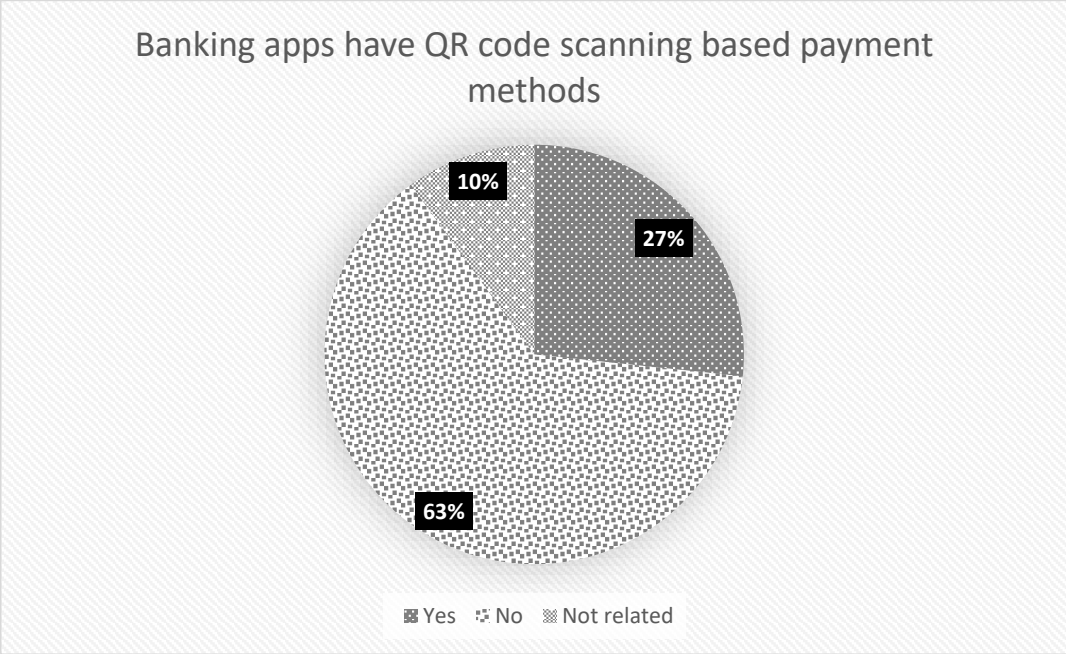

Figure 14 - QR code payment availability on banking apps.

Graph illustration of figure 14 shows the availability of Quick Response code in the banking application of the users. Thirty-eight respondents from the total said there is no such technology available while 16 of them are aware of the QR code technology as a payment method. A most interesting scenario is, the above 22 of 38 respondents are using banking applications for figure 13 triggers. It shows that QR code payment availability has been limited among the active users of banking applications. Furthermore, the above 19 of 22 group people are recorded from Europe while only 3 of them are from other countries. In the case of development of QR code payment methods, the group of 22 would be able to use the QR code payment methods and increase the total 'Yes' users as figure 14 up to 65%. Around 93% of respondents who already have the QR payment method are currently using banking applications for both figure 12 and 13 triggers. It demonstrates the availability of the QR code method is cultivating usage of banking applications for different purposes.

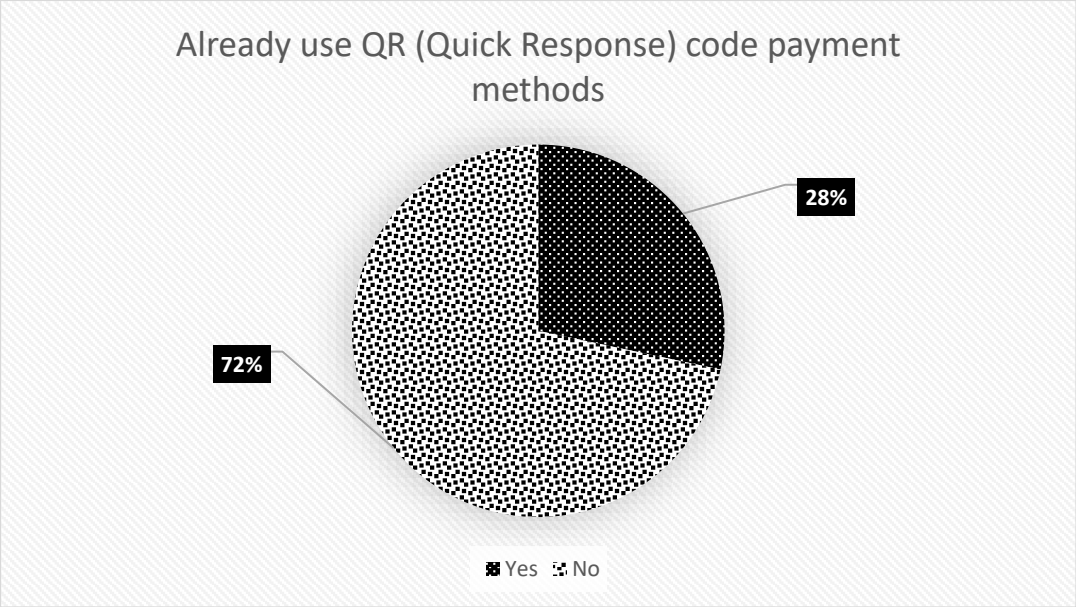

Figure 15 - Current usage of the QR code payment methods.

Seventeen respondents of out 60, it is equivalent to 28.4% of the total group, are already using QR code payment methods for their daily needs, most of them are from Finland, Norway and Poland, while none of recorded from Latvia. That assumes, lack of availability of the QR technology has made unreachable for Latvians who are being major portion of this survey. 43 of 60 respondents are not available or using the QR payment method even though most of them are owning a smartphone and using banking applications for daily payments. On the other hand, most respondents are from Sri Lanka, Latvia and Lithuania. Which evidence, the unavailability of technology might have limited respondents' usage of QR payment methods.

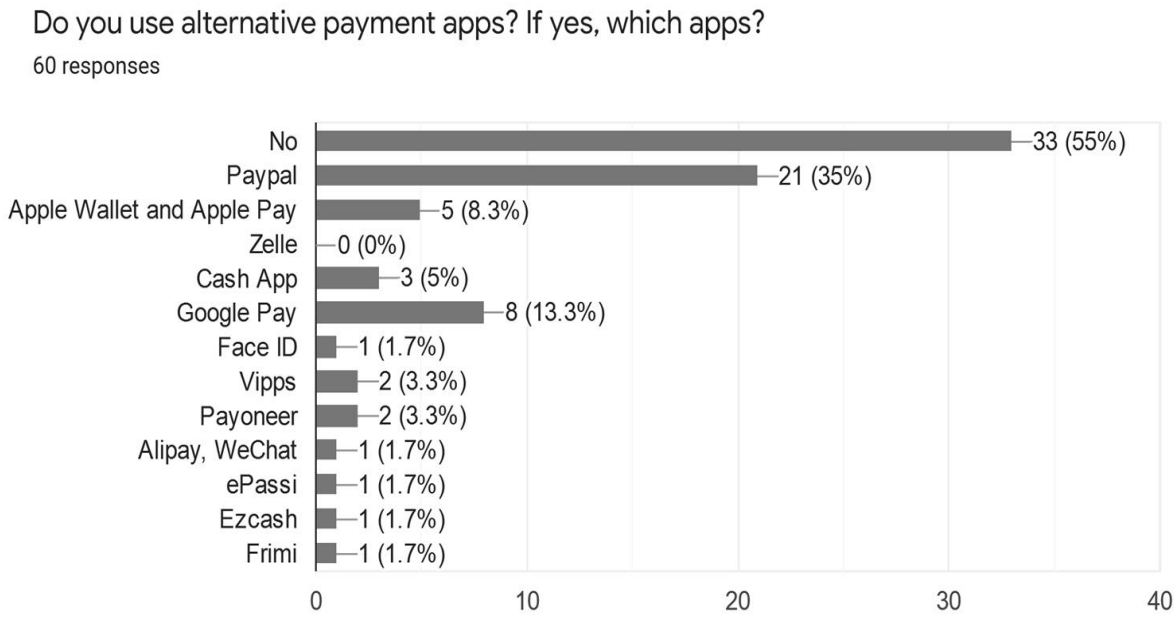

Figure 16 - Current usage of different type of payment applications.

Figure 16 illustrates respondents' usage of alternative payment applications, 33 of 60 respondents are not using any alternative payment applications, even though 85% of them own a smartphone and around 40% of them are using banking applications. From the group who uses alternative payment applications, 78% of them at least use PayPal as a payment application. Other most-used applications are Google Pay and Apple Wallet/Apple Pay which are coming as default payment options for Android and IOS operating systems. After examining respondents' behaviour of using and selecting an alternative payment application, that shows more Latvian respondents are not using an alternative payment application meanwhile respondents from other European countries are using their own countries payment application. That shows limitations of the choice of applications could have bordered some respondents. They might have chosen what they have given from the limitation.

2.3 The proposed QR system

2.3.1 Existing related products

This section would state manual comparison of similar payment applications with the proposed system. Which gives a clear view of the uniqueness of the application to one another. The author has chosen different parameters to evaluate available functionality and options, by 0 to 4 assessing scores as a way of existence of each parameter.

Existing Tools – Parameters

Evaluating Score Description Between 0 to 4.

0 – There are no such options in the tool to evaluate from the parameter.

1 – There are low possibilities to use/poor quality in the tool to evaluate from the parameter.

2 – The options are limited availability**.**

3 – The options are available in the tool Different way.

4 – The options are fully available in the tool as expected by the parameter like High Quality, User friendly and Quick reaction time.

Table. 2 - Evaluation of Existing Similar Applications

Parameters	ePassi Finland	Bluecode Austria	Momo Pocket Spain	Vipps Norway	Ali Pay China	The prediction for the proposed Application
1. QR code Reading	0	0	0	4	4	4
2. QR code Generating	0	0	0	1	4	1
3. Mobile OS/ Android Availability	4	4	4	4	4	4
4. Mobile OS/ iOS Availability	4	4	4	4	4	4
5.Pre-Paid Payment App/Negative Parameter	0	0	0	0	2	4
6.Banking App Extension or Not	0	0	0	0	0	4
7.Use of alternative security methods	2	1	1	2	2	4
8. Number of available Languages	3	3	2	2	2	3
9. Duration for successful payment	2	4	2	4	4	4
10. QR Payment amount flexibility	0	0	0	2	2	4
11. Ability to pay through bank account	0	0	3	4	0	4
12. Creating E-receipt and/or Tickets	0	0	0	4	0	4
13. Minimum Required Memory	3	3	3	3	3	3
14. Reaction Time to success payment	3	4	3	4	3	4
15. User friendliness	3	4	4	4	3	4
Total Score	24	27	26	42	37	55

In table 2 lists all parameters chosen by the author and its given scores to each similar payment application and the proposed application according to their functionality and usability. There are 15 parameters used to evaluate each application. Parameters were created based on the proposed system functionality and the general requirement of a payment application such as

security requirements and user-friendliness. In this evaluation, the proposed application has gained more scores with its proposed functionalities and options, which makes the application more possible to accomplish its objectives. By adapting and comparing existing technologies in similar payment applications, and reducing existing applications' vulnerabilities, the proposed application has proven to be unique among other similar applications with its exclusive development.

2.3.2 The development of QR system

Quick response code (QR code) has been used for many technical innovations such as security, device verification, marketing, data storing and payment verification. Extensive data storing ability and easy accessibility of the stored data through a smart device have made QR codes more secure on data sharing methods and user-friendly on usability. Author's proposed system suggests usage of QR code for payment verification by using its advantages.

2.3.2.1 Usability of the system

A. **Built-in QR code reader – user mobile application**

   The option of reading a QR code in payment applications such as a banking application and retrieving the data from a QR code. The QR reader transfers data to application functions.

B. **Data Organizer – user mobile application**

   This functionality is used to collect data from the QR code and organise the received data to send to a banking server/payment processor.

C. **E-receipt creator – user mobile application**

   The functionality would create a digital receipt which includes the human-readable data set upon confirmation of successful payment from a banking server/payment processor.

D. **Built-in Storage – user mobile application**

   The digital receipt created by E-receipt creator functionality will be saved here by date of payment. It comes with a user's accessible to saved receipts. The user would be able to open the saved receipts, delete and upload into a cloud.

E. **QR code generator – merchant application**

   This option is used to create a QR code which mainly contains merchant's banking details such as unique id of a system operator, the total amount of the purchase and as well as details of the list of items.

F. Payment confirmation – merchant application

A notification that would display on merchant's screen once payment has been successfully received to the merchants' account from current user/customer under a specific receipt number

G. Banking Server/Payment processor

This would be the back end of the system, which takes the received banking details of a user and a merchant, verifies them and transfers the total purchase value between two bank accounts while sending notifications to both user mobile application and merchants' application.

2.3.2.2 User case

Figure 17 shows the use case diagram of the proposed system with its system, actors and functionalities. The system is the proposed software, actors can be defined as a person, organization or an external system which is connected to the proposed software, and functionalities are listed the actions would be able to be completed by the actors or else would be completed by the system. On users end, below steps can be described.

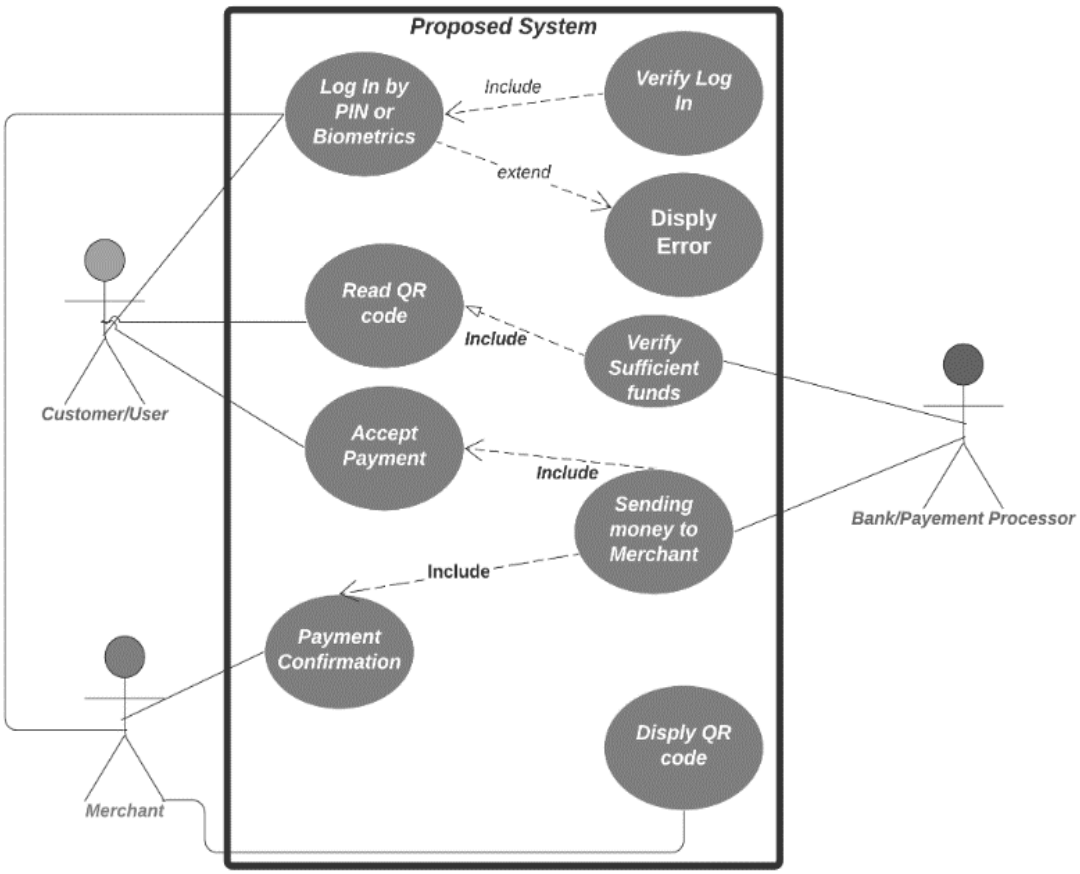

Figure. 17- User case diagram.

Step 01- Customer/User Login (Actor): Login with username and password or biometrics if it is available on a user's smart device.

Step 02- Verify Log in (Functionality): Check the validity of entered username and password or biometrics. This is an included functionality which means this functionality works itself with login (step 01 completed)

Step 03- Display error (Functionality): This is an extended functionality. It works only if step 02 functionality is failed.

Step 04- Read QR code (Actor): An action should be complete by a user, using a built-in QR reader (Usability A).

Step 05- Verify sufficient (Functionality): An included functionality to check the available funds of the user's account on the banking server/payment processor.

Step 06- Accept Payment (Functionality): Once step 05 is satisfied, the accept payment option would show up to the user to execute.

Step 07- Sending money to merchant account (Functionality): Upon acceptance of step 06, banking server /payment processor (Actor) would transfer the funds to merchants account details while the user's account would deduct the amount.

Step 08- Payment confirmation (Functionality): This is an included functionality, once the banking server/payment processor has executed 07, Payment received message would display on merchant's view.

Step 09- Display QR code (Functionality): The functionality would generate a QR code and display on the screen. To complete this step, a merchant must complete step 01.

2.3.3 Proposed system architecture

Authors' one of the main objectives of the proposed system is a more efficient and secure payment option for users by developing a QR code mobile payment method. When it is considered, the solution would be to understand standing methods of mobile payment methods and create new possible methods to outcome the existing methods. Usage of new techniques and technologies have been the answer to innovations or new methods.

2.3.3.1 Proposed server design

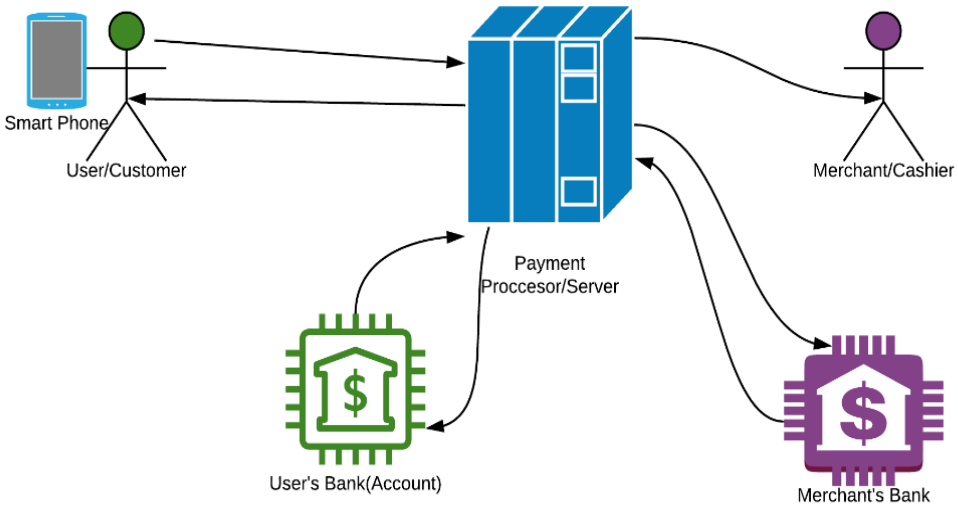

Figure 18 - Proposed server design.

When considering digital banking payments, fundamentally, the banking payment processor/server is coming into mind. Payment processor/server is the main component of a banking system, which is processing requests between parties. With figure 18, the author suggests one main payment processor/server handle all requests from users, the proposed system mainly considers an actor interaction to perform a payment request by scanning a provided QR

code which contains banking details of the fund receiver. The payment processor is responsible for verifying sending persons banking details such as an available amount of funds and comparing it with the requested amount by the QR code creator(merchant), while transferring the fund between users and merchants. By connecting both the user's bank and the merchant's bank, the system would allocate the funds. On the other hand, the system would transfer funds between two in the bank accounts in the same bank; for example, both user and merchant have their bank account in a specific bank.

2.3.3.2 Connectivity of the proposed system

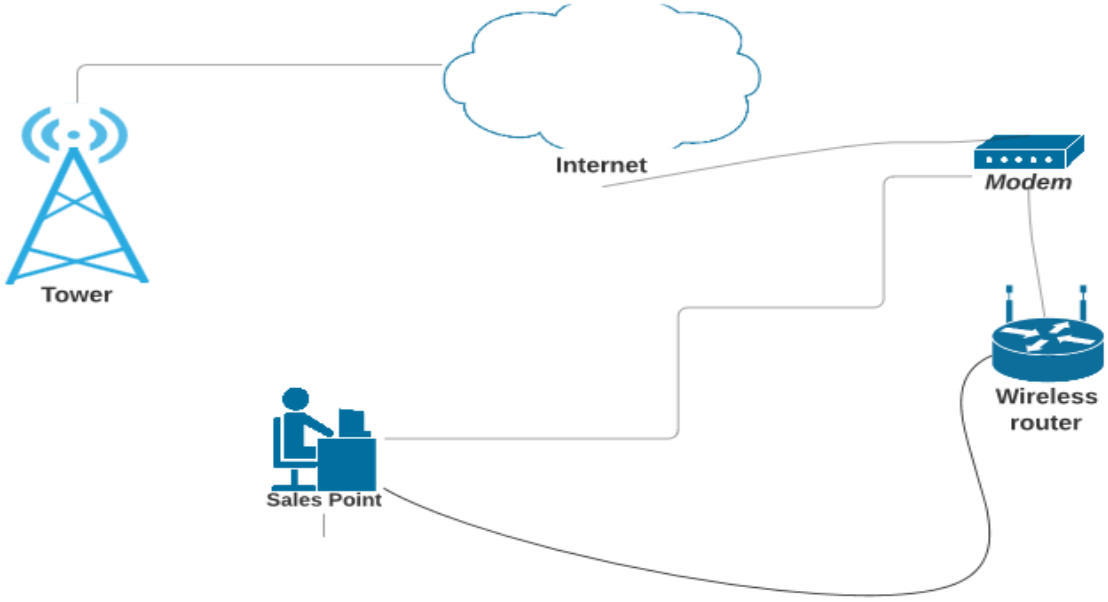

Figure. 19 - Merchant's view

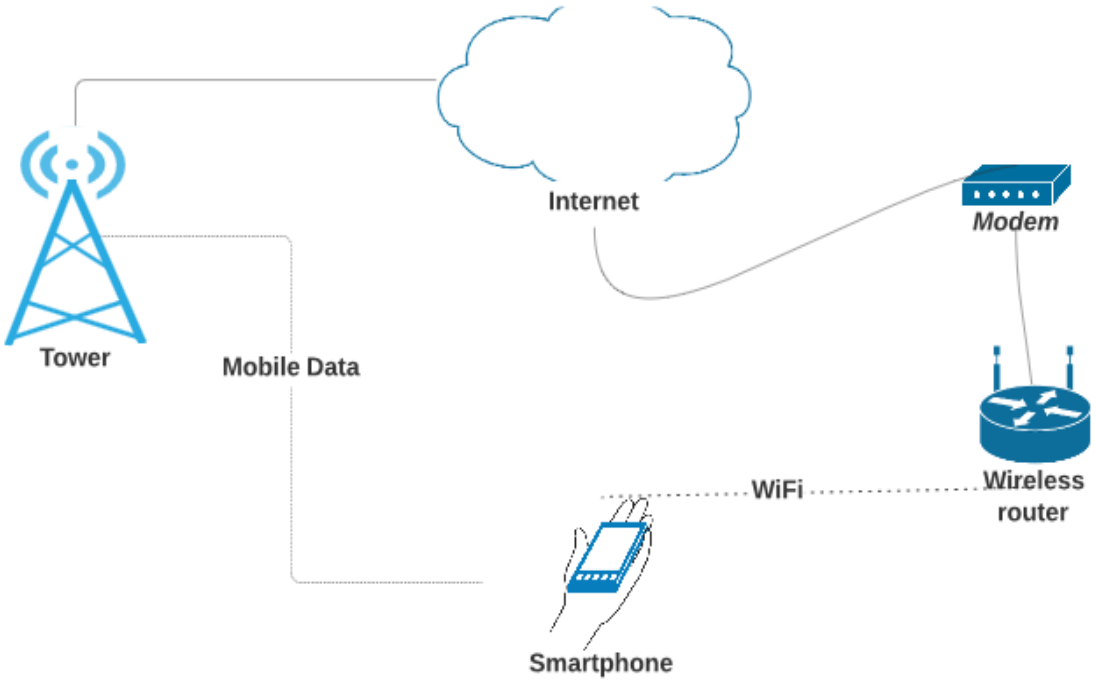

Figure 20 - Customer's view

Figure 19 and figure 20 demonstrate the technique of connectivity of the system in its actors' view. Figure 19 shows how the merchant can keep connectivity to the banking server through the internet. Sales points would connect via a modem or wireless router with the wired cable to retain the connectivity to the banking server (via the internet). In the customer's view, figure 20, a smartphone would be able to connect the banking server over the mobile application when it is connected to the internet via a WIFI connection or mobile data. Actors' connectivity is more important in the proposed system for executing a successful transaction between the parties while ensuring the security of the banking server by verifying users' access. In case of a failure on the connectivity of one actor, a successful payment process will be interrupted by the system and its security methods.

2.3.3.3 Database design

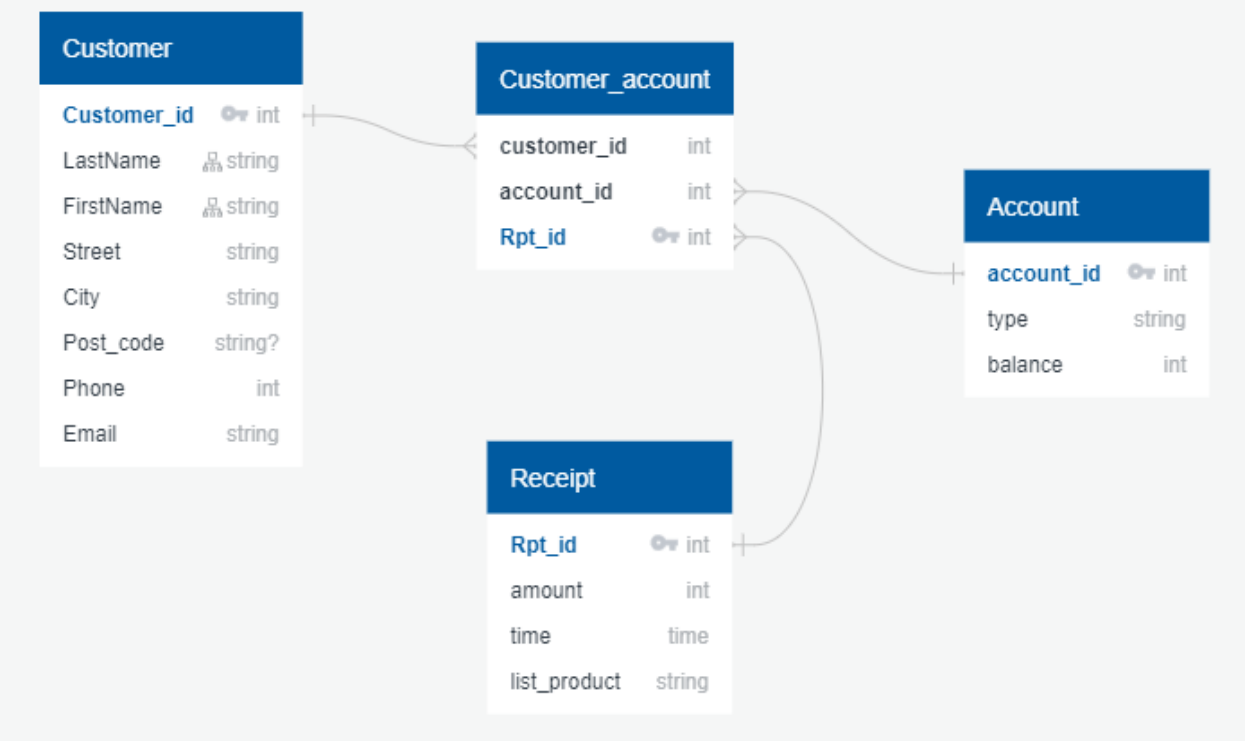

Figure. 21 - Database tables and their connections

Figure 21 displays a conceivable database structure of the proposed system; it is included in 4 tables which are Customer, Customer_account, Account and Receipt. Customer table stores each users' details such as name, address, contact details and unique Customer_id, the ID would be used to recognise each user individually. Account table contains 3 attributes which are account_id, type and balance of the account, account_id is a primary key and used to recognise each account individually. Customer_account table would react as a summarised details table and which would save Customer_id, account_id and Rpt_id, all attributes are foreign keys from other tables. This table would mainly store details of successful payment transactions, and it can be used to calculate total payment details and the amount. Receipt table contains Rpt_id, amount, time and list_product; it is the time attribute would record when the QR code generated and the payment has received to the merchant at the sales point, the amount would save the total sum of each customer according to each the Rpt_id, of which will be automatically created by a system function.

2.3.3.4 Using technology and methods of the proposed system

I. JSON (JavaScript Object Notation)

As a lightweight data format, JSON is to be the best option for the proposed system compared to similar data formats. Comparison of JSON, XML (Extensible Markup Language) and other data formats, JSON appears to provide the right data format for data storing in the QR codes. XML is mostly used on the internet to improve simplicity, generality, and usability of the data formats and its use in worldwide web consortiums (W3C). BSON (Binary JSON) is another type of similar data format, which is an extension of JSON and introduced to mainly work with MongoDB databases.

i. Comparison of JSON and XML data formats [18,19].

JSON=>

```
{
"firstName": "Jonathan",
"lastName": "Freeman",
"loginCount": 4,
"isWriter": true,
"worksWith": ["Spantree Technology Group", "InfoWorld"],
"pets": [
{
"name": "Lilly",
"type": "Raccoon"
}
]
}
```

XML=>

```
<person>
  <first_name>Jonathan</first_name>
  <last_name>Freeman</last_name>
  <login_count>4</login_count>
  <is_writer>true</is_writer>
  <works_with_entities>
    <works_with>Spantree Technology Group</works_with>
    <works_with>InfoWorld</works_with>
  </works_with_entities>
  <pets>
    <pet>
      <name>Lilly</name>
      <type>Raccoon</type>
    </pet>
  </pets>
</person>
```

Comparison of JSON and XML shows using the data as a collective array make the data more readable and organise, and less memory consumed which makes JSON data format is more easily transferable. Those are the main valuable abilities in JSON for the proposed system.

II. MYSQL database technology

MYSQL is one of the main relational database management systems, and its most of services are free and open source. Without hesitation, the system would use MYSQL database service because of its functionality and accessibility

III. React-Native development

React-Native is one of most leading mobile development frameworks, which is an open-source deployment and use of development IOS, Android Applications and UWPs (Universal Windows Platform). React-Native would be the best development framework for the proposed system, since its cross-platform development capability. Potential customers are using different kinds of mobile operating systems with its devices; therefore, to gain more popularity of the proposed system, the availability of the application must be improved to everyone. Currently, many mobile development tools are available such as Ionic, Xamarin and PhoneGap for developing mobile applications, even though there were many possible options to choose, React-Native is coming with its advantages with usability and popularity, table 1 shows React-Native would be the best option for developing the proposed system.

Table. 1 – Parameterized comparison of possible tools [18].

Parameters	React-Native	Ionic	Xamarin	PhoneGap
Purpose	Learn one, Write anywhere	Write once, Run anywhere	Write one, Run anywhere	Write one, Run anywhere
Owner	Facebook	Drifty	Microsoft	Adobe Systems
Language Stack	React.js & JavaScript	HTML, CSS, JavaScript, Angular Js, TypeScript	C#	HTML, CSS, JavaScript
Performance	Native Experience	Slow in comparison to React Native	Performance is Stable	Slower in comparison to others.
GitHub Stars	75K	37K	3K	4K
Testing	Real mobile devices or Emulator required	By using any browser, the user can test the code	Testing can be done using mobile apps	Testing can be done using browsers, mobile devices or emulators

Hardware Compatibility	React Native itself is capable	Apache Cordova is used	SDK kit is required	It doesn't offer much control over hardware; therefore, apps might become slower with frequent render updates
Reusability	The platform-specific code needs to be changed	Optimum reusability of code	It allows you to reuse 95% of the code	You can reuse existing native libraries

Table 1. comparison of the existing tools reveal React-Native is far ahead from many parameters such as Language stack, Performance, GitHub starts, Testing and Hardware compatibility. On the other hand, the cost of development can be minimized by cross-platform development. The proposed system would require developing in different platforms for enhancing the usability of potential customers by refining availability for all users and their mobile devices. Instead of deploying a multi dev team, which is not cost-effective, by using React-Native, one dev team would be able to fulfil availability requirements by cross-platform development.

2.3.4 The proposed system requirements

I. User/Customer – mobile application

User/Customer is one of the main parts of the proposed system, the people, who pay their daily expenses through the mobile application. To acquire a successful payment User/Customer must accomplish a list of requirements;

i. Smart mobile device with working front-camera and Android or IOS operating system.
ii. Internet connection, Wi-Fi or Mobile data, as figure 20.
iii. Has installed the mobile/banking application.
iv. Valid bank account which is connected to the mobile/banking application.

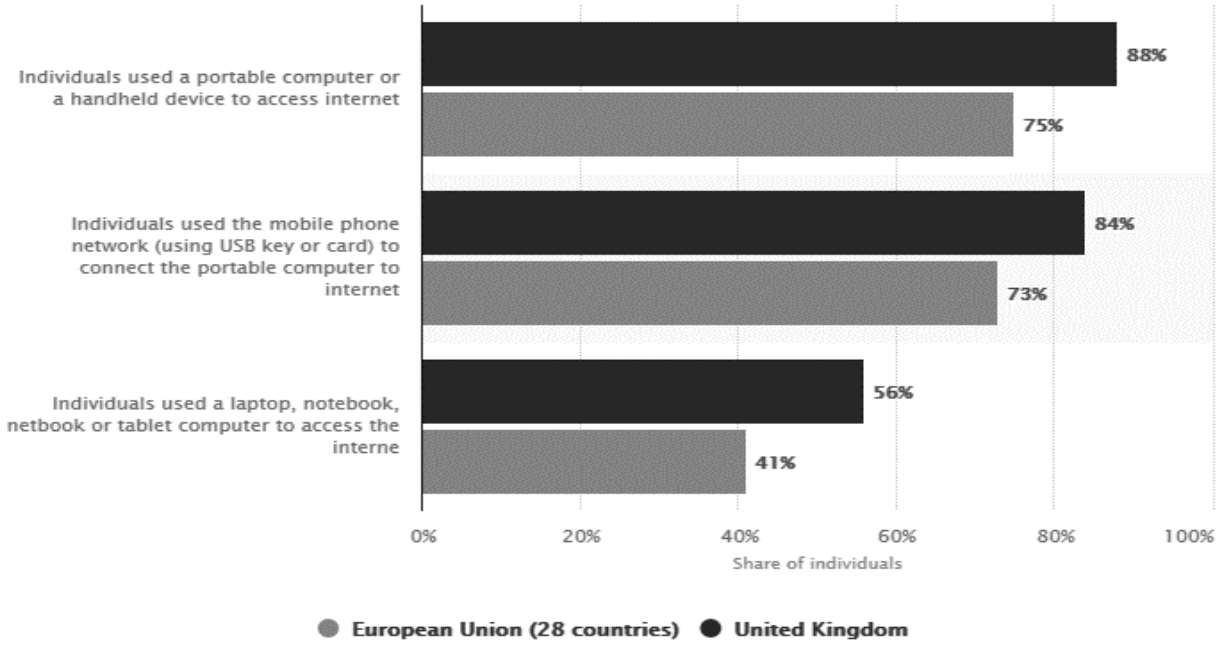

Figure 22– Mobile data usage of the European Union [5].

When considering the user side requirement – ii as the figure. 20, there is an argument of the internet connectivity of customers, without connectivity between the servers and the application customers would not be able to execute a payment. Figure 22 displays the data published by Dennis Schmid, Jan 23, 2020; it shows 75% of individuals have their own mobile data connection in the European Union. Author's suggestions are, as the figure, 22 higher percentage of mobile data usage would outcome the argument of the internet connectivity of the customers at the sales point, and wide availability of public Wi-Fi connections at the shopping centres would provide essential connectivity for the customers who accomplish other requirements of the proposed system.

II. Vendor/Merchant – billing system

The vendor/merchant is another main human interaction of the system to deliver a successful payment. Vendor/merchant would be needed to accomplish list to requirements to execute a payment process;

i. Computerised devices for billing facilities such as barcode reader, screen etc. and has installed the system
ii. A valid bank account that is connected with the system/banking payment processor
iii. Portable display for screening generated QR code
iv. Internet connection, as the figure. 19

III. Banking payment processor – processing server

This is the server part of the proposed system, which works with a list of functionalities that are facilitated into the system. The server works itself without human interaction on a request of payment by the system actors.

i. Data processing hardware devices handle multiple requests at the same time
ii. Databases to store the data
iii. Facilitated system software
iv. The internet connectivity
v. have implemented the data encryption and security methods
vi. Unique domains to communicate with the actors

2.3.5 Functionality and Development of the Proposed System

Software functionality and suitable libraries for the proposed system would be explained in this section.

1. React-Native Biometrics

This React-native package is used to connect with iOS and Android key store management without additional functionality by allowing users to create their biometrics and store them in native key stores and use them lately, which makes easier to use stored security keys for the proposed application.

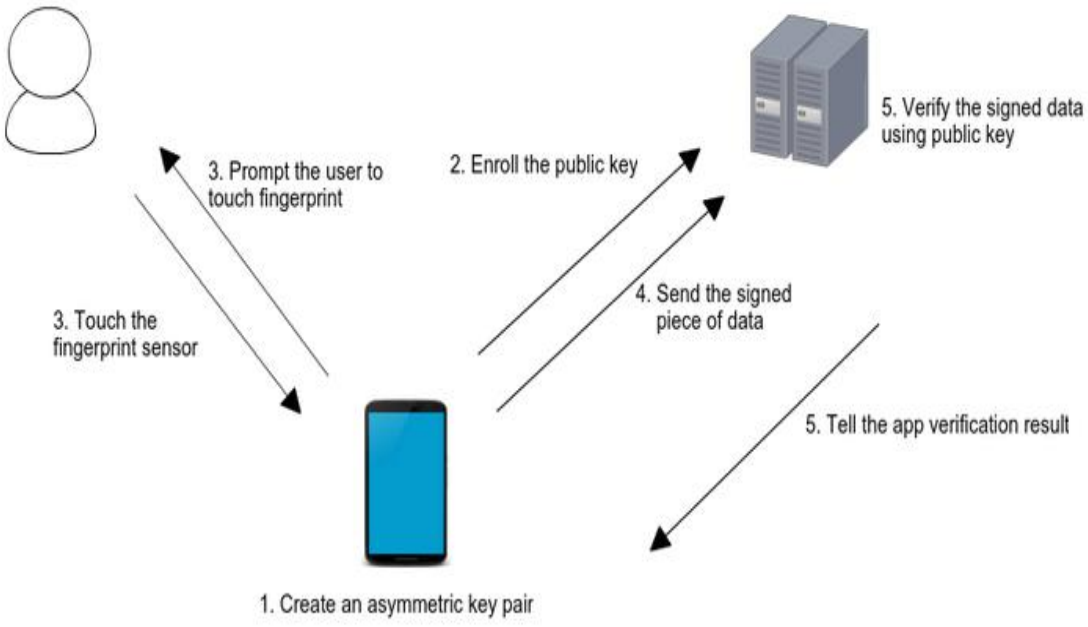

Figure 23 - User case of the React-Native Biometrics Package [21].

Figure 23 shows how the react-native package is executing users' biometrics verification requests on mobile devices. Users will create the biometrics keys on their devices and the devices store them, upon a verification request, the devices verify and send the result of a signed piece of data by the application.

```
import ReactNativeBiometrics from 'react-native-biometrics'

ReactNativeBiometrics.isSensorAvailable()
  .then((resultObject) => {
    const { available, biometryType } = resultObject

    if (available && biometryType === ReactNativeBiometrics.TouchID)
{
      console.log('TouchID is supported')
    } else if (available && biometryType === ReactNativeBiometrics.Fa
ceID) {
      console.log('FaceID is supported')
    } else if (available && biometryType === ReactNativeBiometrics.Bi
ometrics) {
      console.log('Biometrics is supported')
    } else {
      console.log('Biometrics not supported')
    }
  })
```

Figure. 24 – Sample code of the package [21].

The package can be used to verify stored biometrics of the device such as FaceID and TouchID, if the functionalities are available in the devices. The proposed system will use TouchID; also, FaceID is possible to integrate as an upgrade of the application.

2. React-Native Pin Code

React native pin code is an NPM JavaScript package which is used to store and verify security PINs locally on the application. This package would be used to authenticate a payment request and/or the application login process in the devices which are not equipped or not executable with biometrics authentications such as mobile devices below Android version 10 and iOS version 10.

```
<CodePin
  number={4}
  checkPinCode={(code, callback) => callback(code === '1234')}
  success={() => console.log('hurray!')}
  text="A simple Pin code component"
  error="You fail" // If user fail (fill '2017' for instance)
  autoFocusFirst={false} // disabling auto-focus
/>
```

Figure. 25 Sample code of React-native Pin Code [22]

checkPinCode is the function which checks ***code*** (the pin number entered by users) with the stored pin number by the users. ***Code*** must be called true or false by the ***callback*** function, if the call is true, the entered pin is correct while the false call for incorrect entered pin numbers.

3. React-Native camera

The proposed application will get access to mobile device cameras by React-native camera packages. Generally, the 3rd party mobile applications on Android and iOS devices must have permission to use its device components such as cameras, microphone, speaker and GPS (global positioning system). This package gives access to mobile phone camera for the proposed application, which will use the front camera for scanning QR codes;

```
import { RNCamera } from 'react-native-camera';
class TakePicture extends Component {
  takePicture = async () => {
    try {
      const data = await this.camera.takePictureAsync();
      console.log('Path to image: ' + data.uri);
    } catch (err) {
      // console.log('err: ', err);
    }
  };
  render() {
    return (
      <View style={styles.container}>
        <RNCamera
          ref={cam => {
            this.camera = cam;
          }}
          style={styles.preview}
        >
          <View style={styles.captureContainer}>
            <TouchableOpacity style={styles.capture}
onPress={this.takePicture}>
              <Icon style={styles.iconCamera}>camera</Icon>
              <Text>Take Photo</Text>
            </TouchableOpacity>
          </View>
        </RNCamera>
        <View style={styles.space} />
      </View>
    );
  }
}
```

Figure. 26- Sample code of react-native camera [23].

Figure 26 shows RNCamera library from react-native-camera package request and enable the permission of using a mobile camera by the application.

4. React-Native QR Code Scanner

This module acts as a QR code scanner as well as a Barcode scanner even though it was developed mainly for QR code scanning. The module is coming with a simplified setup requirement, and that can be plugged into a project simply. Compatible software development kits(SDK) would be Android 7 or higher and iOS 10 or higher version devices, fortified with this module.

```
import QRCodeScanner from 'react-native-qrcode-scanner';
import { RNCamera } from 'react-native-camera';

class ScanScreen extends Component {
  onSuccess = e => {
    Linking.openURL(e.data).catch(err =>
      console.error('An error occured', err)
    );
  };
  render() {
    return (
      <QRCodeScanner
        onRead={this.onSuccess}
        flashMode={RNCamera.Constants.FlashMode.torch}
        topContent={
          <Text style={styles.centerText}>
            Go to{' '}
            <Text
style={styles.textBold}>wikipedia.org/wiki/QR_code</Text> on
            your computer and scan the QR code.
          </Text>
        }
        bottomContent={
          <TouchableOpacity style={styles.buttonTouchable}>
            <Text style={styles.buttonText}>OK. Got it!</Text>
          </TouchableOpacity>
        }
      />
    );
  }
}
```

Figure 27 – Sample code of react-native QR scanner module [24].

QRCodeScanner package from 'react-native-qrcode-scanner' included all necessary functionality to build up the QR scanner and connect the mobile camera with the QR scanner. Above mention module 3, RNCamera executes its functionality to open the device camera while ScanScreen reads a QR code and revives its data.

5. React Native Firebase

Firebase certification APIs (application programming interface) from React-Native components allow submitting users' credentials to register and log into the application.

- mkdir database – Which makes Local Directory to access by the APIs
- touch database/firebase.js –create JavaScript file to save credentials

```
import * as firebase from 'firebase';

const firebaseConfig = {
    apiKey: "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx",
    authDomain: "reactnativefirebase-00000.firebaseapp.com",
    databaseURL: "https://reactnativefirebase-00000.firebaseio.com",
    projectId: "reactnativefirebase-00000",
    storageBucket: "reactnativefirebase-00000.appspot.com",
    messagingSenderId: "000000000000000",
    appId: "1:000000000000000:web:000000000000000"
};

firebase.initializeApp(firebaseConfig);

export default firebase;
```

Figure 28 – Sample code of Firebase authentication services APIs [25].

This configuration will allow the application to access the Firebase authentication from its APIs.

2.4 Evaluation of The Proposed System

This section would describe the author's proposed system overall evaluation to use in practice. Evaluation of the survey of users' behaviour on daily payment, similar systems are currently in use, and the technical analysis of the application in some parameters would be shown and discussed to archive the authors' objectives of this thesis by testing and analysing the prototype of the system and its performance.

2.4.1 Evaluation of the survey

Comparison of key figures of the survey for the accomplishment of the proposed system can be estimated and evaluated. The collected data can prove the application to get into more users without any additional effort. Figure 29 and 30 demonstrate the survey data and its benefits to archive the authors' objectives.

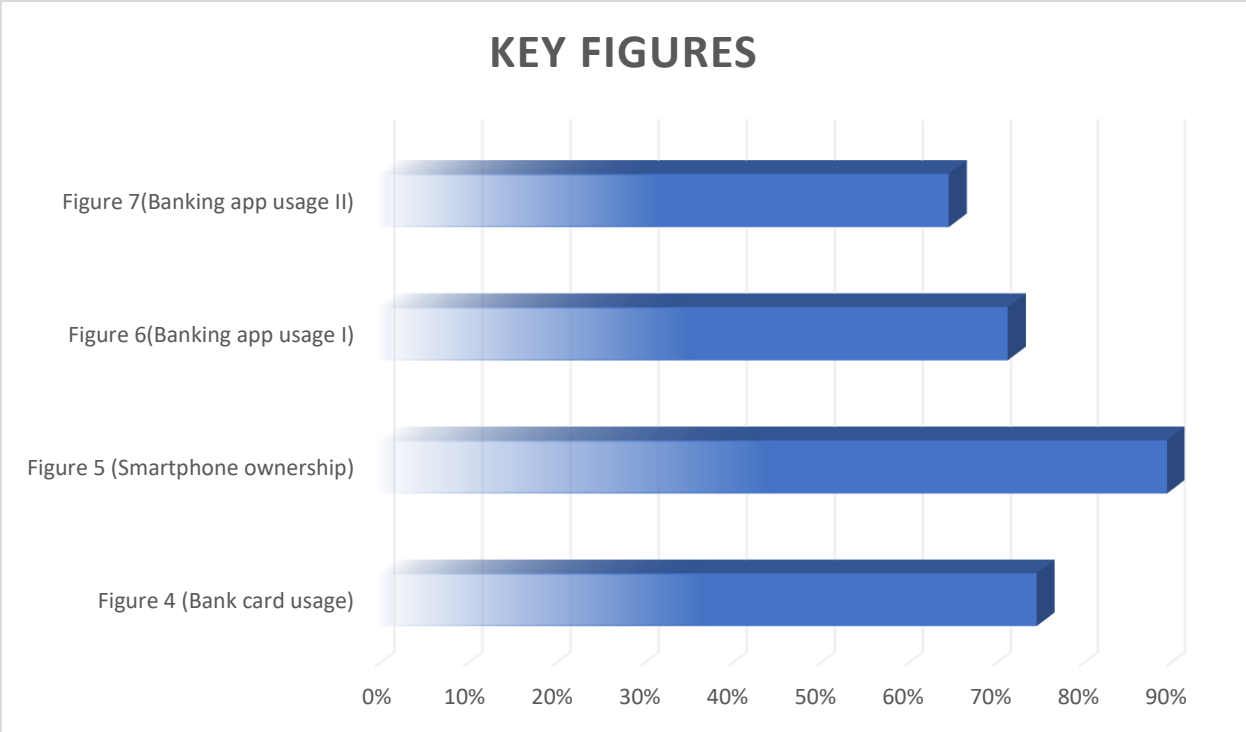

Figure. 29 – Key figures comparison of the survey data.

Figure 10, 11, 12 and 13 can be categorised as main key factors for an introduction of alternative payment methods by mobile devices. The higher percentage of bank cards usage among the respondents is intended to replace the application via its security and functionality for both consumers and merchants. 90% of smartphone use can be evaluated as high accessibility to use the application. Figure 12 and 13 show the way of using banking applications by the respondents currently, which displays an average of 75% of the respondents use a banking application for any kind of daily payments. Meanwhile, the proposed application suggests many payment methods through its functionality such as payment at the salespoint, purchasing a bus ticket and a theatre or movie ticket, are proving the usability of the application among its possible users.

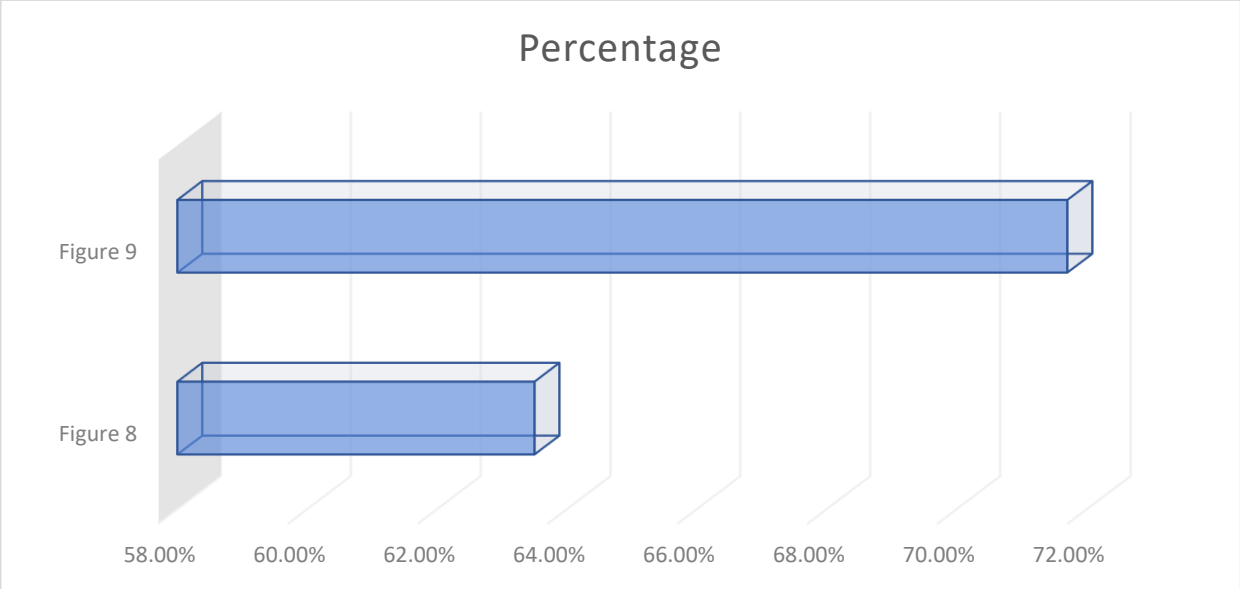

Figure. 30 - Availability of the QR code technology on mobile devices.

When considering the QR code availability, figure 14 and 15 data shows, a greater number of the respondents are not accessible or known to such a technology usage as a payment method. Availability of new technology and methods may encourage possible users to adapt to the proposed system. Improvement of the availability of QR code payment methods would be helpful to measure the customers' willingness to use such methods than unavailability.

2.4.2 Evaluation of the application features and functionality

The proposed application features and functionality have been evaluated in this section. Estimated evaluation of working features and functionality and its further development summarised.

Table. 3 – Additional Security features availability by mobile device version

N/A – Not applicable, x – Applicable

Features	Android 10 or Higher	iOS 10 higher	Android below 10 version	iOS 10 below
Fingerprints	**x**	**x**	**N/A**	**N/A**
Face Recognition	**x**	**x**	**N/A**	**N/A**
4 PIN	**x**	**x**	**x**	**x**

Additional security options would be provided by the application for its users as their preference such as Fingerprints, Face recognition and 4 PIN. The security options have been implemented by using latest programming packages as, for example, React-Native Biometrics and Pin Code, which provide easy access of mobile devices features to the application, as well

as the used packages are cross-platform, which means the application functionalities are executable in both Android and iOS mobile devices. The 4 PIN authentication method is accessible to users who own a mobile device with any Android and iOS version. If the users' mobile devices are not facilitated with Fingerprints and/or Face recognition functions, users can select a 4-PIN option for their application security purposes. For the mobile devices, those are equipped with fingerprint scanning pads and face recognition options and Android 10 or higher, or iOS 10 higher version is capable of using Fingerprint and Face Recognition security methods. Even though some mobile devices are met the minimum operating system requirements, those devices are not capable of using some security methods due to hardware unavailability. Also damaged hardware is not able to use software functionality due to its faulty communication between the device and the application. As well as the application must improve its cording functionality to the devices which are equipped with necessary hardware, nevertheless, those have a lower version of mobile operating systems.

2.4.3 Evaluation of newly developed application

The evaluation of the proposed application can be described in different criteria such as performance, regular functionality, innovative options, security and user-friendliness. Performance and regular functionality for a payment application have been implemented by used latest technology as mentioned in 2.3.5, using React-Native the application is accomplished with its performance and functionalities such as access of mobile camera, QR code and reading functionality within 1000 milliseconds.

As innovative options, receiving Creating E-receipt and/or Tickets and save into the application can be defined which have gain more scores to the proposed application on similar application evaluation (2.3.1). As security options, application login and payment confirmation by PIN or biometrics have been successfully implemented and tested (see, Appendix, testing documentation) as well as the proposed application has been built as part of a banking application which makes the application unique and possibility to upgrade the QR code payment technology into existing banking applications.

When developing the proposed application user-friendliness has been applied by creating brighter interfaces, fewer steps to complete a successful payment and availability to upgrade in different languages in future desires(see, Appendix, user documentation). These methods and functionality have been made the application fulfilled with the author's goal to develop a secure and productive payment method by using the QR code.

Conclusion

In conclusion, the author can reveal from the survey results analysis; the public has not given various options when it has come to the availability of digital payment methods such as Quick Response payments, even though the majority of the population is equipped with essential appliances. The choice of payment has been limited by the unavailability of a variety of digital payment methods. Somehow the author has found that the public is willing to adopt new technology that could lead to its success. Moreover, the finding shows that the cost of using traditional payment methods is going up year by year and the cost has to be subsidised by the public.

QR code payment method has been using in many counties in different ways, the author's payment application evaluation demonstrates most of the payment applications are not facilitated with QR code technology; while few of chosen payment applications are quite compatible with the author's proposed application. Somehow the proposed application has proven to be unique and innovative with its used technology and methods to deliver a successful payment.

By using technical and programming languages analysis, the author was able to discover a better way to deliver QR code payment technology to the public more securely and productively by a different approach. Developing a mobile payment application using QR code with extra security functionalities such as biometrics and PIN codes, pay bills and receiving the E-receipts at the same time through a reading QR code have been established that the proposed application has evidenced the author's hypothesis are happened to be true. More secure methods guarantee a secure payment transaction, while E-receipt would save time at the sale point and operational costs of merchants which could lead to improve the productivity of the business.

From this research, the author was able to achieve its research goals while considering about future possibility to research on developing payment processing system using QR code technology which would be able to reduce transaction fees for the merchants by global payment processors such as Master and Visa. The possible research would be based on making daily payments the proposed system, while having its payment processors to handle transactions in the same server, it is similar to sending money between two bank accounts in same the bank without any fee.

List of Abbreviation

QR	**Quick Response**
PIN	**Personal Identification Number**
DB	**Data Base**
iOS	**An operating system used for mobile devices manufactured by Apple Inc.**
APIs	**Application Programming Interface**
SDK	**software Development Kit**
WIFI	**Wireless Fidelity**
POS	**Point of Sales,**
URL	**Uniform Resource Locator**
RFID	**Radio-frequency identification**
NFC	**Near-field communication**
UTAUA	**The Unified Theory of Acceptance and Use of Technology**

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Appendix

Research questionnaires

User Documentation

Software Requirement Specification

Software Design Description

Software Test Reports

Evaluation Form

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