# A framework of biometric recognition and personalized mobile application to establish a dynamic connection with the ATM to enable secure transaction.

By

Syeda Prima Tasnim 16366008

A thesis project submitted to the Department of Computer Science & Engineering in partial fulfillment of the requirements for the degree of M.Engg in Computer Science & Engineering

> Department of Computer Science & Engineering Brac University August, 2019

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# Declaration

It is hereby declared that

1. The thesis project submitted is my/our own original work while completing degree at Brac

University.

2. The thesis project does not contain material previously published or written by a third party, except

where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or

diploma at a university or other institution.

- 4. I/We have acknowledged all main sources of help.
- 5. I would like to request the embargo of my thesis for 24M from the submission date due to

conference/journal publication process and procedures

#### Student's Full Name & Signature:

Syeda Prima Tasnim 16366008

# Approval

The project titled "A framework of biometric recognition and personalized mobile application to establish a dynamic connection with the ATM to enable secure transaction." submitted by

• Syeda Prima Tasnim: 16366008

of Summer,2019 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of M.Engg in Computer Science & Engineering on 28 August, 2019.

#### **Examining Committee:**

Supervisor:

Md. Khalilur Rahman, Ph.D. Associate Professor, Department of Computer Science & Engineering, BRAC University, Dhaka Bangladesh.

Departmental Head: (Chair)

Chairperson, Department of Computer Science & Engineering, BRAC University, Dhaka Bangladesh

### Abstract

Secure transaction of money is the prime concern of banking industries for establishing a strong banking network worldwide. By the vast uses of Automated Teller Machine (ATM) in this industry transaction of money has become easier for the customers. But the system needs more secure transaction method for avoiding unwanted incidents. Smart and secure transaction through ATM is the thing people want now a days. For making the transaction through ATM more reliable as well as smart a biometric based system along with an android application has been approached in this research paper. The system consists of a fingerprint-based device which is connected with the ATM software and a personalized mobile application for user. Using the application customer can make a 1:1 connection with the ATM software. For transaction customer can control the account using the mobile application and make transaction command which is also connected with the central server. At the very last stage customer needs to give finger print on the designated device for verifying the account holder's presence during the transaction. In this way the less safe ATM card system can be replaced with a smart and secure system. Testing of the system using a custom-made ATM software along with fingerprint sensor justify the authenticity as well as efficiency of the system.

Keywords—fingerprint sensor, ATM banking, mobile application

# Acknowledgement

I would like to thank the almighty for giving me the opportunity and ability to achieve a valuable amount of knowledge in this lifetime and with his blessings, I shall continue to pursue all the good things in my life ahead.

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# **Chapter 1**

# Introduction

#### **1.1 Introduction**

Services related to banking is used by most of the people worldwide. With the help of emerging technologies people can now enjoy the banking facilities for twenty-four hours a day. Services like online banking, Automated Teller Machine (ATM) etc. helps the customer to use transaction services without thinking about the banking hours. For cash transaction ATM is the vastly used system in the whole world. Using a designated ATM card people can easily withdraw cash money from wherever they want. With this very much useful service there are also chance of facing unwanted incidents like hacking passwords of ATM cards and many more. For avoiding these types of incidents more secure and smart transaction system needs to developed.

In the current ATM system using a card anyone can withdraw cash from someone's account if he has the ATM card pin. As password-based system can be hacked so people can face unwanted problems if they lost their ATM card or their ATM card pin. For securing ATM based transaction system there needs to introduce more authentic and complex verification system for avoiding undesired loose. With a vast scope of research and development the topic has been selected for this research paper.

Biometric based authentication is getting popular day by day. As this type of system verify the biological data which is unique for every person so it can secure any system rather than any password-based technique. With the thought of implementing this biometric based authentication system for securing ATM based transaction a fingerprint recognition-based system has been approached in this research paper. In the proposed system a custom-made finger print device has been connected with the ATM. Using a custom designed personalized mobile application people can easily establish a 1:1 connection with the ATM machine via Bluetooth communication facilities into the fingerprint device. The mobile application is also connected with the central server. So, using the mobile application people can easily make command of transaction but before the final confirmation they need to give the fingerprint in the designated device so that the system can make a credible authentication of the account owner. This type of systems can replace the pin-based ATM card system to secure the banking transactions.

#### **1.2 Literature Review**

Investigating related works which has been done previously enrich our knowledge about the topic and give us the scope of research and updates on the designated topic. For this research a couple of related works has been explored. In the research paper [1] an Aadhaar card number based biometric log in system has been described for internet banking in India. Aadhaar card is basically a national Identity card and every citizen has a unique ID number which carries biometric information about the card holder. In the next research paper [2] a face scanning ATM system has been approached where the system only allows the transaction when it can scan the customers face. In the research work [3] a fingerprint based biometric authentication system has been proposed for managing multiple bank accounts for a single person. In this system client can access multiple bank accounts through their unique fingerprint. In the next research work [4] a biometric based secure approach has been proposed with SMS services which uses J2EE technology. After analyzing all these related research works it can be said that there are different approaches taken by many researchers for introducing biometric based authentication system for banking industry. In this research a biometric fingerprint-based system is also proposed with a custom designed personalized

mobile application which can control the command instead of ATM cards and this differentiate the research from other research works.

#### 1.3 Reasons for problem selection

The banking security systems we have right now, do they all provide the security to its maximum capacity? Are we still not facing a lot of problems in terms of keeping our banking secure and easy? In my perspective currently, the banking system is at risk. We use ATM cards, which is not fully safe. People suffer remembering their pin numbers. Sometime the users have to try several times. At the same time, now we are living in an age, where almost a lot of things are in biometric, the unique identity of any human being. In the very near future, our passwords/pin will be replaced by fingerprints. Using fingerprints recognition instead of pin/password is the next generation security level, but this still didn't get much attention in our country. Hence, I have selected this problem as my topic.

#### **1.4 Research Review**

The HSBC Mobile Banking, manages your money on the move and around the clock with this secure Personal Banking app from HSBC. This is an application for mobile banking.

Tap 'n Pay, three layers of security via NFC Card, PIN Number, OTP (One Time Password). The customers go to the nearest agent and pay via NFC card, PIN number and OTP security. Tap 'n Pay is a unique product of Mobility iTap Pay (Bangladesh) Limited. It refers to the 4th generation technology of Mobile Financial Service (MFS) through use of terminal and a near field communication (NFC) based card or any other object integrated with NFC Tag.

I have found a research on the existing global banks which are using biometric in their operations [11]. The list of 121 global banks is given below;

1     Jordan Commercial Bank     Jordan     Iris     Branch banking, ATM, Internet banking       2     Cairo Amman Bank     Jordan     Iris     Branch banking, ATM, Internet banking       3     National Bank of Australia     Jordan     Iris     Branch banking, ATM, Internet banking       3     National Bank of Australia     Australia     Voice     Telephone banking       4     Tallinn Business Bank (TBB)     Estonia     Dynamic Signature     Internet banking       5     Bank Hapoalim     Israel     Dynamic Signature     Branch banking, Password/PIN reset		Bank's name	Country	Biometric	Application
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29     Dammon Bank     Indexes in Voice     Password/PN Isort       21     Bonkry Water Bank     USA     Fingerprint     Access control (Comparer system)       23     Bronkry Water Bank     USA     Fingerprint     Access control (Comparer system)       23     Bronkry Water Bank     USA     Fingerprint     Access control (Comparer system)       24     Barther Bank     USA     Fingerprint     Access control (Network)       25     California Conserve Bank     USA     Fingerprint     Access control (Network)       26     Mellon Bank     USA     Fingerprint     Access control (Network)       27     California Conserve Bank     USA     Fingerprint     Rest Nataling       28     Bank of America     USA     Fingerprint     Rest Nataling       29     Bank of America     USA     Fingerprint     Rest Nataling       20     Fort American Bank     USA     Fingerprint     Rest Nataling       21     Western Bank     USA     Fingerprint     Access control (Network)       23     Fort American Bank     USA     Fingerprint     Access control (Network)       24     Stacteon Hamil     USA     Fingerprint     Access control (Network)       25     Fort American Math     USA     Fingerprint     A					
11     Bark Negra Indonsia (IN)     Indonesia     Voice     Pinacyoff Neet       21     Bouk Nyater, Bark     USA     Fingerprint     Access control Compare system       23     Kroger Bark     USA     Fingerprint     Access control Compare system       24     InTrus Bark     USA     Fingerprint     Access control       25     Ear Trade     USA     Fingerprint     Access control       26     Melion Bark     USA     Fingerprint     Access control       27     Bark of Amorica     USA     Fingerprint     Access control       28     Melion Bark     USA     Fingerprint     Access control       29     Bark of Amorica     USA     Fingerprint     Heren Abarking       21     Workern Bark     USA     Fingerprint     Access control (Physical)       21     Workern Bark     USA     Fingerprint     Access control (Physical)       23     Saccon Hamil Incontrol     USA     Fingerprint     Access control       24     Saccontrol     USA     Fingerprint     Access control       25     Carly Charle Bark     USA     Fingerprint     Access control       26     Find Accontrol     USA     Fingerprint     Access control       27     Carly Schould Bark (Congo					
21     Boundry Water Bink     USA     Fingerprint     Access control (Compater system)       23     Koger Bink     USA     Fingerprint     PCSA       24     Infrue Bink     USA     Fingerprint     Access control (Physica)       25     ETrade     USA     Fingerprint     Access control (Physica)       26     Annerican Expert Bink     USA     Fingerprint     Access control (Physica)       27     Bank of America     USA     Fingerprint     Access control (Physica)       28     Bank of America     USA     Fingerprint     Access control (Physica)       29     Bank of America     USA     Fingerprint     Access control (Physica)       20     United Banker's Bank     USA     Fingerprint     Access control       21     Wester Bank     USA     Opamic Signature     Bank Banking       23     Find American Bank     USA     Fingerprint     Access control       24     Skarowshamil Investment Bank     USA     Fingerprint     Access control       25     Find American Bank     USA     Fingerprint     Access control       26     Find Terrestow Bank     USA     Fingerprint     Access control       27     Concresce Bank     USA     Fingerprint     Access control					
21     Kroger Bark     USA     Fragerprint     POS       25     ETrade     USA     Noice     Brack hasing       25     ETrade     USA     Friggrprint     Access control       26     American Express     USA     Friggrprint     Access control       27     Calciantic Control Chernols     USA     Friggrprint     Access control       28     Back of America     USA     Friggrprint     Access control       29     Back of America     USA     Friggrprint     Access control       20     United Backar's Back     USA     Dynamic Signature     Brack hashing       21     First American Itali     USA     Dynamic Signature     December					
24     Infrask Bank     USA     Yose     Branch hanking       25     E'Toake     USA     Fingerprint     Access control       26     American Express     USA     Fingerprint     Access control (Network)       28     Melion Bank     USA     Fingerprint     Access control (Network)       29     Bok O America     USA     Fingerprint     Access control (Network)       20     United Banker     USA     Fingerprint     Decursent processing       30     Chack Mushtata Bank     USA     Optime: Signature     Decursent processing       31     Chack Mushtata Bank     USA     Pringerprint     Access control (Network)       32     Scoraron-Hanif Brownment Bank     USA     Fingerprint     Access control (Network)       33     Chack Mushtata Bank     USA     Fingerprint     Access control (Network)       34     Finst Scional Bank Group     USA     Fingerprint     Access control (Network)       35     Finst Scional Bank Group     USA     Fingerprint     Access control (Network)       36     Finst Terma sce Bank     USA     Fingerprint     Access control (Network)       37     Controls Schan Bank     USA     Fingerprint     Access control (Network)       36     Finst Terma sce Bank     USA					
25     E-Tadać     USA     Figuprint     Access control (Physical)       27     California Commerce Bark     USA     Figuprint     Access control (Physical)       28     Mellon Bark     USA     Figuprint     Access control (Physical)       29     Bark of America     USA     Figuprint     Access control (Physical)       20     Bark of America     USA     Figuprint     Access control (Physical)       21     Bark America Bark     USA     Figuprint     Access control (Physical)       23     First America Bark     USA     Dynamic Signature     Documer processing       24     Shearoon-Hamil Investment Bark     USA     Hand geometry     Access control (Physical)       25     Char Ochean     USA     Figuprint     Access control (Physical)       26     First National Bark Group     USA     Figuprint     Access control (Physical)       27     Charles Schwab Bark     USA     Figuprint     Access control (Sa Control (Physical)       27     Charles Schwab Bark     USA     Figuprint     Access control (Sa Control (Physical)       28     First Terme see Bark     USA     Figuprint     Access control (Sa Control (Physical)       29     Charles Schwab Bark     USA     Figuprint     Access control (Sa Control (Sa Control (Sa Control (Sa C					
26     Antericer Express     USA     Fingerprint     Access control (Network)       28     Melion Econnece Plank     USA     Fingerprint     Clecking the history of individuals       28     Bark of America     USA     Fingerprint     Ence the backing       30     United Enaker's Bank     USA     Fingerprint     Ence the backing       31     Wistern Bank     USA     Dynamic Signature     Branch backing       32     First American Bank     USA     Dynamic Signature     Document processing       33     Merican Bank     USA     Fingerprint     Access control (Pres and anterdambace)       34     Steacon-Hamil Increational     USA     Fingerprint     Access control (Pres and anterdambace)       35     Charty Chace bank     USA     Fingerprint     Access control (Pres and anterdambace)       36     First National Bank Georg     USA     Fingerprint     Access control (Pres and anterdambace)       37     Connecre bank of International     USA     Fingerprint     Access control (Pres anterdambace)       37     Connecre bank of International     USA     Fingerprint     Access control (Pres anterdambace)       38     Finderprint     Access control (Pres anterdambace)     Finderprint     Access control (Pres anterdambace)       39     Charle Shawab Bank					~
21     California Commerce Bank     USA     Fingerprint     Access control (Arbon Access)       23     Bank of America     USA     Fingerprint     Decking the binary of individuals       23     United Banker's Bank     USA     Fingerprint     Bernet banking       24     United Banker's Bank     USA     Fingerprint     Bernet banking       25     First American Bank     USA     Dyname: Signature     Document processing       26     Park American Bank     USA     Dispersion     Document processing       27     Stearono Hamil Brocetment Bank     USA     Fingerprint     Access control (Parkont)       26     Chev Chese bank     USA     Fingerprint     Access control (Stearon)       27     Connece bank of International     USA     Fingerprint     Access control (Stearon)       27     Connece bank of International     USA     Fingerprint     Access control (Stearon)       28     Finit Terna see Bank     USA     Fingerprint     Access control (Stearon)       27     Connece bank of International     USA     Fingerprint     Access control (Stearon)       29     Checke Schem Bank     USA     Fingerprint     Access control (Stearon)       20     Checke Schem Bank     USA     Fingerprint     Access control (Stearon)    <					
28         Melion Bank         USA         Fingerprint Face         Clocking the history of individuals           29         Bark of America         USA         Fingerprint Face         Branch banking           30         Uristed Bankar's Bank         USA         Fingerprint Face         Branch banking           31         Find American Bank         USA         Dynamic Signature Bank banking         Branch banking           33         Chack Manktan bank         USA         Dynamic Signature Bank banking         Branch banking           34         Shearos Hamil Bowetmert Bank         USA         Fingerprint Access control (Thera and tencharcher)           35         Carly Chace bank         USA         Fingerprint Access control (Dera and tencharcher)           36         Finst National Bank Group         USA         Fingerprint Access control (Dera ond)           36         Finst Schaw Bank         USA         Fingerprint Access control (Dera ond)           37         Connerce bank of International (US)         USA         Fingerprint Access control (Dera ond)           38         Finst of Thank         USA         Fingerprint Access control (Dera ond)           41         Pode State Bank         USA         Fingerprint Access control (Dera ond)           42         Station Bank         USA					
29         Bask of America         Usia         Fingerprint         Internet banking           30         United Baske's bank         USA         Finequerprint         Internet banking           31         Western Bank         USA         Dynamic Signature         Banch banking           31         Charek Mankina Bank         USA         Dynamic Signature         Docement processing           32         Charek Mankina Bank         USA         Noise         Branch banking           33         Charek Mankina Bank         USA         Finequerprint         Access control/Time and attendance/           34         Stearcen Jennill Investment Bank         USA         Finequerprint         Access control/Time and attendance/           36         Firits Toinna Bank         USA         Finequerprint         Access control/Internet banking           37         Connerse bank of the transional (USA genometry access control/Internet banking)         Access control/Internet banking           38         Firits Tennexee Bank         USA         Fingerprint         Access control/Internet banking           39         Charles Schwab Bank         USA         Fingerprint         Access control/Internet banking           41         Bank of Conrink         USA         Fingerprint         Access control/Internet banking					
See         Brack basing           30         United Baske's Data         USA         First perior basing           31         First American Bank         USA         Dynamic Signature         Branch basing           33         Cheve Munitara Bask         USA         Dynamic Signature         Document processing           34         Stearcon-Hamill Investmert Bank         USA         Hind geometry         Access control (Physical)           34         Stearcon-Hamill Investmert Bank         USA         Fingerprint         Access control (Physical)           36         Chev/ Chee kank         USA         Fingerprint         Access control (Physical)           36         First Tennessee Bank         USA         Fingerprint         Access control           37         Chefes Sdraw Bank         USA         Fingerprint         Access control         Checking transaction biolisty           38         First Tennessee Bank         USA         Fingerprint         Access control         Checking transaction biolisty           39         Charles Sdraw Bank         USA         Fingerprint         Access control         Checking transaction biolisty           30         Bank of Hawaii         USA         Fingerprint         Access control         Checking transaction bisty					· ·
90     United Back* Isoak     USA     Pingerprint     Iseres banking       91     Wester Bank     USA     Dynamic Signature     Document processing       93     Chesk Muhatan Bank     USA     Voice     Banch banking       94     Shearon-Hamill Investment Bank     USA     Voice     Banch banking       95     Chery Ches bank     USA     Hind genery     Access control/Time and attenduce:       96     First National Bank     USA     Firgerprint     Access control (Sectores)       97     Connerce bank of International     USA     Firgerprint     Access control (Sectore)       98     Chery Ches bank     USA     Firgerprint     Access control (Sectore)       90     Cherk Schwab Bank     USA     Firgerprint     Access control (Sectore)       90     Bank of Currinock     USA     Firgerprint     Access control (Sectore)       91     Parke Schwab Bank     USA     Firgerprint     Access control (Sectore)       92     Cherk Schwab Bank     USA     Firgerprint     Access control (Sectore)       93     Cherk Schwab Bank     USA     Firgerprint     Access control (Sectore)       94     Bank of Charina     USA     Firgerprint     Access control (Sectore)       94     Sardi'rin Bank     USA		arment of a solid form	001		· · · · · · · · · · · · · · · · · · ·
11         Western Bank         USA         Dynamic Signature         Branch banking           23         First American Bank         USA         Voice         Branch banking           33         Chese Munham Bank         USA         Voice         Branch banking           34         Skerson-Hamill Investmert Bank         USA         Hand gometry         Access control (Physical)           36         Chery Chase bank         USA         Fingerprint         Access control (Physical)           36         First Vices bank         USA         Fingerprint         Access control (Skr deposit)           37         Contrace Sade Bank         USA         Fingerprint         Access control (Skr deposit)           38         First Terms see Bank         USA         Fingerprint         Access control           31         Bank of Hawaii         USA         Fingerprint         Access control           34         Bank of Hawaii         USA         Fingerprint         Access control (Skr deposit)           35         Saterion Bank         USA         Fingerprint         Access control (Skr deposit)           36         Saterion Bank         USA         Fingerprint         Access control (Skr deposit)           37         West Finst Bank         USA	30	United Banker's Bank	USA		
21     First American Bank     USA     Dynamic Signature     Document processing       33     Chee Manhatan Bank     USA     Voice Branch banking       44     Shearon-Hamili Investment Bank     USA     Hand genery     Access control (Time and attendance)       54     Shearon-Hamili Investment Bank     USA     Fingerprint     Access control (Workal)       55     Chery Chee bank     USA     Fingerprint     Access control (Metwork)       611     (HC)     International     USA     Fingerprint     Access control (Metwork)       70     Commerce bank     USA     Fingerprint     Access control (Metwork)       711     Portel Schwab Rank     USA     Fingerprint     Access control (Metwork)       712     Shakin Bank     USA     Fingerprint     Access control (Metwork)       714     Bank of Currinuck     USA     Fingerprint     Access control (Schedponit)       714     Bank of Hawaii     USA     Fingerprint     Access control (Schedponit)       714     Bank of Hawaii     USA     Fingerprint     Access control (Schedponit)       714     Bank of Hawaii     USA     Fingerprint     Access control (Schedponit)       715     Bank of Hawaii     USA     Fingerprint     Access control (Schedponit)       716 <t< th=""><th></th><th></th><th></th><th></th><th></th></t<>					
33         Check Mathum Bank         USA         Voice         Branch having           54         Shearon Hamill Invisioned Bank         USA         Hand geometry         Access control (Time and attendance)           54         Chevy Chase bank         USA         Fingerprint         Access control (Time and attendance)           56         First National Bank Group         USA         Fingerprint         Access control (Safe deposit)           57         Connerse bank of International         USA         Fingerprint         Access control (Safe deposit)           58         First Termessee Bank         USA         Dometry         Branch banking. Document processing           59         Charles Schward         USA         Fingerprint         Access control (Safe deposit)           59         Charles Schward         USA         Fingerprint         Access control (Safe deposit)           50         Bank of Chah         USA         Fingerprint         Access control (Safe deposit)           50         Bank of Uah         USA         Hand vein         Access control (Safe deposit)           51         Bank of Uah         USA         Hand vein         Access control (Safe deposit)           52         Confers Schward         Hernet banking.         Access control (Safe deposit)				,	
Dynamic Spatner         Documents           44         Sterow Hamil Investment Bank         USA         Had georetry         Access control (Thread attendance)           55         Chevy Chase bank         USA         Fingerprint         Access control (Revol.)           56         Finst National Bank Group         USA         Fingerprint         Access control (Network)           57         Commerce bank of International         USA         Fingerprint         Access control (See deposit)           58         First Temessee Bank         USA         Dynamic Signature         Brack banking, Document processing           59         Charles Schwab Bank         USA         Fingerprint         Access control (See deposit)           50         Charles Schwab Bank         USA         Fingerprint         Access control (See deposit)           51         Back of Lanania         USA         Fingerprint & Access control (See deposit)           52         Sachin Bank         USA         Fingerprint & Access control (See deposit)           53         Bank of Hanania         USA         Fingerprint & Access control (See deposit)           54         Sachirin Bank         USA         Fingerprint & Access control (See deposit)           55         Mark of Hanania         USA         Fingerprint & Access contro					
34     Shearon Hamil Invisioner Bank     USA     Hand geometry     Access control (Time and attendance)       35     Chery Chase hank     USA     Fingerprint     Access control (Mework)       36     First National Bank Group     USA     Fingerprint     Access control (Safe deposit)       37     Connerse bank of International     USA     Fingerprint     Merret banking. Access control (Mework)       37     Charles Schwah Bank     USA     Fingerprint     Merret banking. Access control       38     First Temessee Bank     USA     Engerprint     Access control     Merret banking. Access control       39     Ontries Schwah Bank     USA     Fingerprint     Access control     Merret banking.       30     Bank of Uah     USA     Fingerprint     Access control (Safe deposit)       31     Bank of Uah     USA     Hand wint     Access control (Safe deposit)       34     Bank of Uah     USA     Hand wint     Access control (Safe deposit)       35     Markin Elas     USA     Hind wint     Access control (Safe deposit)       36     Safe first Bank     USA     Hind wint     Access control (Safe deposit)       37     Vost Texas National Bank     USA     Fingerprint     Check Cashing       38     Texas Sank Unried     USA     Fin					
35     Chevy Chase bank     USA     Fingerprint     Access control (Phycical)       36     Finst Kaincal Bank Group     USA     Fingerprint     Access control (Network)       37     Commerce bank of International     USA     Fingerprint     Interest banking, Access control (Network)       38     First Temessee Bank     USA     Dingerprint     Access control (Safe deposit)       39     Charles Schwab Bank     USA     Dingerprint     Access control (Safe deposit)       30     Charles Schwab Bank     USA     Fingerprint     Access control (Safe deposit)       31     Shafan Bank     USA     Fingerprint     Access control (Safe deposit)       41     People Sate Bank     USA     Fingerprint     Checking Instascion history       43     Bank of Hawail     USA     Fingerprint     Access control (Safe deposit)       44     Bank of Hawail     USA     Fingerprint     Access control (Safe deposit)       45     Sandrint Bank     USA     Fingerprint     Access control (Safe deposit)       46     Sandrint Bank     USA     Fingerprint     Check Cashing       47     West Texas National Bank     USA     Fingerprint     Check Cashing       48     Texas Bank Unicat     USA     Fingerprint     Access control (Data center)	34	Shearson-Hamill Investment Bank	USA		
56     First National Bank Group     USA     Fingerprint     Access control (Network) (IBC)       37     Connerce bank of International (IBC)     USA     Fingerprint & Hand     Access control (Sefe deposit)       38     First Tennessee Bank     USA     Dynamic Signature     Branch banking, Document processing       40     Bank of Currituck     USA     Fingerprint     Access control (Sefe deposit)       41     Popel State Bank     USA     Fingerprint     Access control (Sefe deposit)       42     Shnkin Bank     USA     Fingerprint     Access control (Sefe deposit)       43     Bank of Tanait     USA     Fingerprint     Access control (Sefe deposit)       44     Bank of Utah     USA     Fingerprint     Access control (Sefe deposit)       45     Sandirist Bank     USA     Fingerprint     Access control (Sefe deposit)       46     Sandirist Bank     USA     Fingerprint     Check Cashing       47     Meta Crass Bank Zonos First National     USA     Fingerprint     Check Cashing       48     Sandirist Bank     USA     Fingerprint     Check Cashing       49     Bank of Utah     USA     Fingerprint     Check Cashing       40     Departint     Fingerprint     Check Cashing       50     Bank Indiansco	35		USA		
(IBC)         Charles         USA         Fingerprint & Hand geometry         Access control (Safe deposit) geometry           30         Charles         Schwab Bank         USA         Dynamic Signature         Branch banking. Document processing           40         Bank of Currinok.         USA         Fingerprint         Access control (Safe deposit)           41         People State Bank         USA         Fingerprint         Access control (Safe deposit)           42         Shninin Bank         USA         Fingerprint act Mand         Access control (Safe deposit)           43         Bank of Tumin         USA         Fingerprint act Mand         Access control (Safe deposit)           44         Bank of Tumin         USA         Fingerprint act Mand         Access control (Safe deposit)           45         Stanfirst Bank         USA         Fingerprint act Mand         Access control (Safe deposit)           46         Bank         USA         Fingerprint act Mand         Access control (Safe deposit)           47         West Texas National Bank         USA         Fingerprint act Mand         Access control (Safe deposit)           48         Texas Bank Uitato         USA         Fingerprint act Mand         Access control (Safe deposit)           49         Sonene Trust Bank         <	36	First National Bank Group	USA	Fingerprint	Access control
38     First Tenes see Bank     USA     Fingerprint & Hand gometry     Access control (Safe deposit) gometry       39     Charles Schwab Bank     USA     Dynamic Signature     Branch banking, Document processing       41     People State Bank     USA     Fingerprint     Access control (Safe deposit)       41     People State Bank     USA     Fingerprint     Access control (Safe deposit)       43     Bank of Hawaii     USA     Fingerprint     Access control (Safe deposit)       44     Bank of Unah     USA     Keystroke     Internet banking       45     Safirist Bank     USA     Hand vein     Access control (Safe deposit)       46     Bank of Clains     USA     Fingerprint     Check Cashing       47     West Texas National Bank     USA     Inis     ATM       48     Texas Bank United     USA     Inis     ATM       49     Some Trust Bank     USA     Voice     Telephone banking       50     Banco Anthrosiano Veneto     Bank     Isa     ATM       51     Banco Bradesco     Brazi     Voice     Telephone banking       52     Bank Islam Brunei Darussalam     Brunei     Fingerprint     Access control (Data center)       53     HSBC Bank     UK     Voice     Telephone bankin	37	Commerce bank of International	USA	Fingerprint	Internet banking, Access control (Network)
geometry           99         Charles Schwab Bank         USA         Proprinto Signature         Branch banking. Document processing           10         Bank of Carrituck         USA         Fingerprint         Access control           11         People State Bank         USA         Fingerprint         Checking transaction history           12         Shinkin Bank         USA         Fingerprint R         Access control (Server room)           13         Bank of Hawaii         USA         Fingerprint R         Access control (Safe deposi)           14         Bank of Uah         USA         Hand vein         Access control (Safe deposi)           15         StanFirst Bank         USA         Fingerprint R         Access control (Oat center)           16         Bank         USA         Fingerprint R         Access control (Cast deposi)           16         Bank         USA         Fingerprint R         Access control (Cast deposi)           17         West Texas National Bank         USA         Fingerprint R         Access control (Cast deposi)           16         Bank blam Brunci Darusalam         Brunci         Fingerprint A         ATM           15         Banck blam Brunci Darusalam         Brunci         Fingerprint A         AtM		(IBC)			
99     Charles Schwab Bank     USA     Dynamic Signature     Brace banking, Document processing       410     Back of Curritude     USA     Fingerprint     Access control       411     People State Bank     USA     Fingerprint     Access control (Sarver room)       43     Bank of Hawaii     USA     Fingerprint     Access control (Sarver room)       44     Bank of Uah     USA     Keyrotxe     Recess control (Sarver room)       45     Suffrist Bank     USA     Keyrotxe     Recess control (Data center)       46     Zone Bank (Zione Finst National     USA     Fingerprint     Access control (Safver foor)       47     West Torax National Bank     USA     Fingerprint     Check Cashing       48     Texas Bank United     USA     Fingerprint     Check Cashing       49     Somer Trunt Bank     USA     Voice     Telephone banking       50     Banco Androsiano Veneto     Raly     Inis     ATM       51     Banco Indesco     Baral     Voice     Telephone banking       52     Bank Islam Burnei Darussalam     Branci     Fingerprint     ATM       51     HSBC Bank     UK     Face     Access control (Data center)       52     Bank Islam Burnei Darussalam     Fingerprint     ATM	38	First Tennessee Bank	USA		Access control (Safe deposit)
40     Bask of Curritude     USA     Fingerprint     Access control       41     People State Bank     USA     Fingerprint     Checking transaction history       42     Shinkin Bask     USA     Fingerprint     Access control (Safe deposit)       43     Bank of Hawaii     USA     Fingerprint     Access control (Safe deposit)       44     Bank of Utah     USA     Fingerprint     Access control (Safe deposit)       45     SunFirst Bank     USA     Hand vein     Access control (Safe deposit)       46     Bank (Zions First National     USA     Fingerprint & Hand     Access control (Safe deposit)       47     West Texas National Bank     USA     Fingerprint     Check Cashing       48     Texas Bank United     USA     Iris     ATM       49     Somer Trust Bank     USA     Voice     Telephone banking       50     Banco Anthrosiano Veneto     Italy     Iris     ATM       51     Banco Bradesco     Brazil     Voice     Telephone banking. Password/PIN reset       52     Bank Islam Brunei Darussalam     Brunei     Fingerprint     ATM       53     HSBC Bank     UK     Voice     Telephone banking.       54     Liopkin TSB     UK     Voice     Telephone banking.    <					
41       People State Bank       USA       Fingerprint       Checking transactional history         43       Bank of Hawaii       USA       Fingerprint & Hand       Access control (Stare troom)         44       Bank of Hawaii       USA       Fingerprint & Hand       Access control (Stare troom)         45       Suffict Bank       USA       Keystroke       Internet banking         46       Suffict Bank (Zions First National Bank       USA       Hand vein       Access control (Stare deposit)         47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Fingerprint       Check Cashing         49       Somer Titust Bank       USA       Fingerprint       Check Cashing         50       Bacco Androsiano Veneto       Italy       Itis       ATM         51       Banco Stardesco       Brazil       Voice       Telephone banking       Fingerprint         51       Banco Stardesco       Brazil       Voice       Telephone banking       Fingerprint         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ACcess control (Data center)         51       HSIC Bank       UK       Face       Access control (Data center					
12       Shakki Bank       USA       Fingerprint R Hand       Access control (Sterver noom)         43       Bank of Utah       USA       Fingerprint R Hand       Access control (Sterver noom)         44       Bank of Utah       USA       Hermer banking         45       Sturfiers Bank       USA       Hand vein       Access control (Sterver noom)         46       Sturfiers Bank       USA       Hand vein       Access control (Sterver noom)         47       West Texas National Bank       USA       Hingerprint       Check Cashing         7       West Texas National Bank       USA       If ingerprint       Check Cashing         48       Texas Bank United       USA       If is       ATM         49       Somer Trust Banc       USA       Visit       TATM         50       Banco Androxiano Vento       It ally       It is       ATM         51       Banco Bradesco       Brazial       Voice       Telephone banking. Password/PIN reset         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       Atcess control (Data center)         53       HSBC Bank       UK       Voice       Telephone banking.         54       Lloyds TS       UK       Voice       Branch b					
43       Bark of Hawaii       USA       Fingerprint & Hand geometry       Access control (Safe deposit)         44       Bark of Ulah       USA       Keystroke       Interart banking         45       Surfirst Bark       USA       Hand vein       Access control (Safe deposit)         46       Surfirst Bark       USA       Fingerprint       Access control (Safe deposit)         47       West Texas National Bank       USA       Fingerprint       Check Cashing         47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       It is       ATM         49       Somer Trast Bark       USA       Voice       Telephone banking       Banco Banco Somor Trast Bark       UK       Noice       Telephone banking       Paster         51       Barco Anbrosian Overtoo       Brazit       Voice       Telephone banking       Paster         52       Bank Islam Brone Dravisalam       Brone       Fingerprint       Access control (Data center)         54       Lloyds TB       UK       Face       Access control (Data center)         54       Layds       Branch       Dutce       Telephone banking         55       United Bank Limited (ULB)					
44       Bank of Unh       USA       Keystroke       Inernet banking         45       Sturfirst Bank       USA       Hand vein       Access control (Data center)         46       Zions Bank (Zions First National       USA       Fingerprint       Access control (Safe deposit)         47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Fingerprint       Check Cashing         50       Banco Anthrosiano Veneto       Italy       Itis       ATM         50       Banco Anthrosiano Veneto       Italy       Itis       ATM         51       Banco Anthrosiano Veneto       Italy       Itis       ATM         52       Bank Islum Brunei Darussalam       Brunei       Fingerprint       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Lloyds TB       UK       Voice       Telephone banking         55       United Bank Limited (ULB)       Pakistam       Voice       Telephone banking         56       Credicorp Bank       Puerto Rico       Fingerprint       Accesso					
44     Bank of Uah     USA     Keystroke     Internet banking       45     SumFirst Bank     USA     Hand vein     Access control (Safe deposit)       46     Bank)     Fingerprint & Hand     Access control (Safe deposit)       47     West Texas National Bank     USA     Fingerprint     Check Cashing       48     Texas Bank United     USA     Hits     ATM       49     Somer Trust Bank     USA     Hits     ATM       49     Somer Trust Bank     USA     Hits     ATM       50     Banco Ambrosiano Veneto     Haly     Hits     ATM       51     Banco Ambrosiano Veneto     Haly     Kits     ATM       51     Banco Ambrosiano Veneto     Haly     Kits     ATM       51     Banco Ambrosiano Veneto     Haly     Kits     ATM       51     Banco Standscoo     Brazil     Voice     Telephone banking.       53     HSBC Bank     UK     Face     Access control (Data center)       54     Loyds TSB     UK     Voice     Telephone banking.       55     United Bank Limited (ULB)     Pakistan     Voice     Brach banking.       56     Credicorp Bank     Puerto Rico     Hand geometry     Access control (Tims & Attendance)	45	Bank of Hawaii	USA		Access control (sale deposit)
45     SunFirst Bank     USA     Hand vein     Access control (Data center)       Zions Bank (Zions First National Bank)     USA     Fingerprint & Hand geometry     Access control (Safe deposit)       47     West Texas National Bank     USA     Fingerprint     Check Cashing       48     Texas Bank United     USA     Fingerprint     Check Cashing       48     Texas Bank United     USA     Fingerprint     Check Cashing       49     Somer Trust Bank     USA     Voice     Telephone banking       50     Banco Androsiano Veneto     Italy     Iris     ATM       51     Banco Androsiano Veneto     Italy     Iris     ATM       52     Bank Isam Brunei Darussalam     Brunei     Fingerprint     ATM       53     HSBC Bank     UK     Face     Access control (Data center)       54     Lloyds TSB     UK     Voice     Breachen banking       55     United Bank Limited (ULB)     Pakistan     Voice     Brachen banking       57     Western Bank     Puero Rico     Fingerprint     Access control (Offysical, staf deposit box), Branch banking       57     Western Bank     Turkey     Finger vein     ATM       61     IsBan     Turkey     Finger vein     ATM       62 <t< th=""><th>44</th><td>Bank of Utah</td><td>USA</td><td></td><td>Internet banking</td></t<>	44	Bank of Utah	USA		Internet banking
Zions Bank (Zions First National Bank)       USA       Fingerprint gengerprint       Access control (Safe deposit)         46       Texas National Bank       USA       Fingerprint       Check Cashing         47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Iris       ATM         49       Some Trust Bank       USA       Voice       Telephone banking         50       Banco Anbroison Vencto       Italy       Iris       ATM         51       Banco Bradesco       Brazil       Voice       Telephone banking. Password/PIN reset         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ATM         53       HSBC Bank       UK       Voice       Telephone banking         54       Lloyds TSB       UK       Voice       Branch banking         55       United Bank Limited (ULB)       Pakistan       Voice       Branch banking         56       Credicorp Bank       Puerto Rico       Fingerprint       Branch banking, ATM. Internet banking         58       FirstBank Puerto Rico       Puerto Rico       Hand geometry       Access control (Physical, safe deposit box), Branch banking         50       Vakithan					
Image: Antional Bank       Image: Check Cashing         47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Iris       ATM         49       Somer Trust Bank       USA       Voice       Telephone banking         50       Banco Androsiano Veneto       Italy       Iris       ATM         51       Banco Bradscoo       Brazil       Voice       Telephone banking, Password/PIN reset         52       Bank Islam Brunei Darussalam       Bruzei       Fingerprint       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Loyds TSB       UK       Voice       Telephone banking         55       United Bank Limited (ULB)       Pakstan       Voice       Telephone banking         56       United Bank Limited (ULB)       Panama       Fingerprint       Access control (Data center)         56       United Bank       Turkey       Fingerprint       Access control (Data center)         57       Western Bank       Puerto Rico       Hand goometry       Access control (Data center)         57       Western Bank       Puerto Rico       Hang doremetry       Access control (Dina cent		Zions Bank (Zions First National	USA	Fingerprint & Hand	Access control (Safe deposit)
47       West Texas National Bank       USA       Fingerprint       Check Cashing         48       Texas Bank United       USA       Iris       ATM         49       Somer Trust Bank       USA       Voice       Telephone banking         50       Banco Androsiano Veneto       Italy       Iris       ATM         51       Banco Bracksco       Brazil       Voice       Telephone banking, Pasword/PIN reset         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Lloyds TSB       UK       Voice       Telephone banking         55       United Bank Limited (ULB)       Pakistan       Voice       Branch banking         56       Credicorp Bank       Patero Rico       Fingerprint       Access control (Physical, std deposit box), Branch banking         57       Western Bank       Puerto Rico       Hand geometry       Access control (Time& Attendance)         58       FirstBank Puerto Rico       Patero Rico       Hand geometry       Access control (Time& Attendance)         59       Vakithank       Turkey       Finger vein       ATM         61       IsBank	46	Bank)		geometry	
48       Texas Bank United       USA       Fris       ATM         49       Somer Trust Bank       USA       Voice       Telephone banking         50       Banco Ambrosino Vencto       Italy       Iris       ATM         51       Banco Ambrosino Vencto       Italy       Iris       ATM         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ATM         (BIBD)       .       .       .       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Lloyds TSB       UK       Voice       Branch banking         56       Credicorp Bank       Panama       Fingerprint       Access control (Data center)         54       Lloyds TSB       UK       Voice       Branch banking. ATM, Internet banking         56       Credicorp Bank       Puerto Rico       Fingerprint       Branch banking. ATM, Internet banking         57       Western Bank       Puerto Rico       Fingerprint       Branch banking. ATM, Internet banking         58       FirstBank Puerto Rico       Puerto Rico       Hirad geometruk       ATM         61       IsBank       Turkey       Fingerprint       ATM				Fingerprint	Check Cashing
9         Somer Trust Bank         USA         Voice         Telephone banking           50         Banco Anbrosiano Veneto         Italy         Iris         ATM           51         Banco Bracksco         Brazil         Voice         Telephone banking, Password/PIN reset           52         Bank Islam Brunei Darussalam         Brunei         Fingerprint         ATM           53         HSBC Bank         UK         Face         Access control (Data center)           54         Lloyds TSB         UK         Voice         Telephone banking           55         United Bank Limited (ULB)         Pakistan         Voice         Branch banking           56         Credicory Bank         Panama         Fingerprint         Branch banking, ATM, Internet banking           58         FirstBank Puerto Rico         Panama         Finger vein         ATM           59         Vakitbank         Turkey         Finger vein         ATM           60         Akbank         Turkey         Finger vein         ATM           61         IsBank         Republic of         Finger print         Access control (Bank building)           64         Industrial &Commercial Bank         China         Dyaamic Signature         Workflow automation </th <th>47</th> <td>West Texas National Bank</td> <td>USA</td> <td>Fingerprint</td> <td>Check Cashing</td>	47	West Texas National Bank	USA	Fingerprint	Check Cashing
50       Banco Ambrosiano Veneto       kaly       Iris       ATM         51       Banco Bradesco       Brazil       Voice       Telephone banking, Password/PIN reset         52       Bank Islam Brunei Darussalam (BIBD)       Brunei       Fingerprint       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Lloyds TSB       UK       Voice       Telephone banking         55       United Bank Limited (ULB)       Pakistan       Voice       Branch banking         56       Credicorp Bank       Panama       Fingerprint       Access control (Physical, safe deposit box), Branch banking         57       Western Bank       Puerto Rico       Fingerprint       Access control (Time & Attendance)         58       FirstBank Puerto Rico       Puerto Rico       Hand geometry       Access control (Time & Attendance)         59       Vakifbank       Turkey       Finger vein       ATM         61       IsBank       Turkey       Finger vein       ATM         61       IsBank       Turkey       Finger vein       ATM         64       Industrial & Commercial Bank       China       Dynamic Signature       Workflow automation         65       China Merchant Ba	48	Texas Bank United	USA	Iris	ATM
S1       Banco Bradesco       Brazil       Voice       Telephone banking, Password/PIN reset         52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ATM         53       HSBC Bank       UK       Face       Access control (Data center)         54       Lloyds TSB       UK       Voice       Branch banking         55       United Bank Limited (ULB)       Pakistan       Voice       Branch banking         56       Credicorp Bank       Panama       Fingerprint       Access control (Physical, safe deposit box), Branch banking         57       Western Bank       Puerto Rico       Hang gometry       Access control (Time& Attendance)         58       FirstBank Puerto Rico       Puerto Rico       Hang gometry       Access control (Time& Attendance)         59       Vakifbank       Turkey       Finger vein       ATM         61       IsBank       Turkey       Finger vein       ATM         62       Ziraut Bank       Turkey       Hand vein       ATM         63       Mauritius Commercial Bank       China       Dynamic Signature       Workflow automation         64       Industrial&Commercial Bank       China       Fingerprint       Access control (Physical, Tresury)         67 <th>49</th> <td>Somer Trust Bank</td> <td>USA</td> <td>Voice</td> <td>Telephone banking</td>	49	Somer Trust Bank	USA	Voice	Telephone banking
52       Bank Islam Brunei Darussalam       Brunei       Fingerprint       ATM         (BIBD)       (BIBD)       Face       Access control (Data center)         53       HSBC Bank       UK       Voice       Telephone banking         54       Lloyds TSB       UK       Voice       Branch banking         55       United Bank Limited (ULB)       Pakistan       Voice       Branch banking         56       Credicorp Bank       Pamana       Fingerprint       Access control (Physical, safe deposit box), Branch banking         57       Western Bank       Puerto Rico       Fingerprint       Branch banking, ATM, Internet banking         58       FirstBank Puerto Rico       Puerto Rico       Hand geometry       Access control (Physical, safe deposit box), Branch banking, ATM         59       Vakitbank       Turkey       Finger vein       ATM         60       Akbank       Turkey       Finger vein       ATM         61       IsBank       Turkey       Hand yeoin       ATM         62       Zirnat Bank       Republic of       Fingerprint       Access control (Bank building)         63       Mauritius Commercial Bank       China       Dynamic Signature       Workflow automation         64       Industrial & Co		Banco Ambrosiano Veneto			
(BIBD)     Gradient of the service of th				Voice	Telephone banking, Password/PIN reset
53HSBC BankUKFaceAccess control (Data center)54Lloyds TSBUKVoiceTelephone banking55United Bank Limited (ULB)PakistanVoiceBranch banking56Credicorp BankPanamaFingerprintAccess control (Physical, safe deposit box), Branch banking57Western BankPuerto RicoFingerprintBranch banking, ATM, Internet banking58FirstBank Puerto RicoPuerto RicoHand geometryAccess control (Time& Attendance)59VakitbankTurkeyIrisATM61IsBankTurkeyIrisATM62Zirnat BankTurkeyHingerveinATM63Mauritius Commercial BankRepublic of MauritiusFingerprintAccess control (Bank building)64Industrial&Commercial BankChinaDynamic SignatureWorkflow automation65China Merchant Bank (CMB)ChinaVoiceTelephone banking66People's Bank of ChinaChinaFingerprintAccess control (Physical, Treasury)67Bank of ChinaJapanHand veinATM, Branch banking70Customers Japan Post BankJapanHand veinATM71Mizub BankJapanFinger veinATM72Bank of KyotoJapanFinger veinATM73Suminoto MitsuiJapanFinger veinATM74Resona BankJapanFinger veinATM75Joyo Bank <t< th=""><th>52</th><td></td><td>Brunei</td><td>Fingerprint</td><td>ATM</td></t<>	52		Brunei	Fingerprint	ATM
54Lloyds TSBUKVoiceTelephone banking55United Bank Limited (ULB)PakistanVoiceBranch banking56Credicorp BankPanamaFingerprintAccess control (Physical, safe deposit box), Branch banking57Western BankPuerto RicoHand geometryAccess control (Thiski, ATM, Internet banking58FirstBank Neurol RicoPuerto RicoHand geometryAccess control (Time&Attendance)59VakifbankTurkeyFinger veinATM60AkbankTurkeyFinger veinATM61IsBankTurkeyFinger veinATM63Mauritius Commercial BankTurkeyHand veinATM64Industrial&Commercial BankChinaDynamic SignatureWorkflow automation65China Merchant Bank (CMB)ChinaFingerprintAccess control (Physical, Treasury)66People's Bank of ChinaChinaFingerprintAccess control (Physical, Treasury)67Bank of ChinaJapanHind veinATM70Customers Japan Post BankJapanFinger veinATM71Mizubo BankJapanFinger veinATM73Suminoto MitsuiJapanFinger veinATM74Resona BankJapanFinger veinATM75Joyo BankJapanFinger veinATM76Juroku BankJapanFinger veinATM77Bank of FukuoaJapanFinger vein <th>50</th> <td></td> <td>112</td> <td></td> <td>Assess sector (D)</td>	50		112		Assess sector (D)
55     United Bank Limited (ULB)     Pakistan     Voice     Branch banking       56     Credicorp Bank     Panama     Fingerprint     Access control (Physical, safe deposit box), Branch banking       57     Western Bank     Puerto Rico     Fingerprint     Branch banking, ATM, Internet banking       58     FirstBank Puerto Rico     Puerto Rico     Hand geometry     Access control (Time& Attendance)       59     Vakitbank     Turkey     Finger vein     ATM       60     Akbank     Turkey     His     ATM       61     IsBank     Turkey     His     ATM       62     Ziraat Bank     Turkey     Hand vein     ATM       63     Mauritius Commercial Bank     Republic of Mauritius     Fingerprint     Access control (Bank building)       64     Industrial&Commercial Bank     China     Dynamic Signature     Workflow automation       65     China Merchant Bank (CMB)     China     Fingerprint     Access control (Physical, Treasury)       66     People's Bank of China     China     Fingerprint     Access control (Physical, Treasury)       67     Bank of China     China     Finger vein     ATM, Branch banking       68     Nanto Bank     Japan     Hand vein     ATM, Branch banking       70     Customers Japan					
56Credicorp BankPanamaFingerprint BankingAccess control (Physical, safe deposit box), Branch banking57Western BankPuerto RicoFingerprintBranch banking, ATM, Internet banking58FirstBank Puerto RicoPuerto RicoHand geometryAccess control (Tim&& Attendance)59VakifbankTurkeyFinger veinATM60AkbankTurkeyFinger veinATM61IsBankTurkeyFinger veinATM62Ziraat BankTurkeyHand veinATM63Mauritius Commercial BankChinaDynanic SignatureWorkflow automation64Industrial&Commercial BankChinaDynanic SignatureWorkflow automation65China Merchant Bank (CMB)ChinaFingerprintAccess control (Physical, Treasury)66People's Bank of ChinaChinaFingerprintAccess control (Physical, Treasury)67Bank of ChinaChinaFingerprintAccess control (Physical, Time&Attendance)68Nanto BankJapanHand veinATM70Customers Japan Post BankJapanFinger veinATM71Mizuho BankJapanFinger veinATM72Bank of KyotoJapanFinger veinATM73Sumimoto MitsuiJapanFinger veinATM74Resona BankJapanFinger veinATM75Joyo BankJapanFinger veinATM76Juroka Bank<					
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62       Ziraat Bank       Turkey       Hand vein       ATM         63       Mauritius Commercial Bank       Republic of Mauritius       Fingerprint       Access control (Bank building)         64       Industrial&Commercial Bank       China       Dynamic Signature       Workflow automation         65       China Merchant Bank (CMB)       China       Voice       Telephone banking         66       People's Bank of China       China       Face       Access control (Physical, Treasury)         67       Bank of China       China       Fingerprint       Access control (Physical, Time&Attendance)         68       Nanto Bank       Japan       Hand vein       ATM, Branch banking         69       Hiroshima Bank       Japan       Hand vein       ATM         70       Customers Japan Post Bank       Japan       Finger vein       ATM         71       Mizubo Bank       Japan       Finger vein       ATM         72       Bank of Kyoto       Japan       Finger vein       ATM         73       Suminoto Mitsui       Japan       Finger vein       ATM         74       Resona Bank       Japan       Finger vein       ATM         75       Joyo Bank       Japan       Finger vein					
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Mauritius         64       Industrial&Commercial Bank       China       Dynamic Signature       Workflow automation         65       China Merchant Bank (CMB)       China       Voice       Telephone banking         66       People's Bank of China       China       Face       Access control (Physical, Treasury)         67       Bank of China       China       Fingerprint       Access control (Physical, Treasury)         68       Nanto Bank       Japan       Hand vein       ATM, Branch banking         69       Hiroshima Bank       Japan       Hand vein       ATM, Branch banking         70       Customers Japan Post Bank       Japan       Finger vein       ATM         71       Mizubo Bank       Japan       Finger vein       ATM         72       Bank of Kyoto       Japan       Finger vein       ATM         73       Sumimoto Mitsui       Japan       Finger vein       ATM         74       Resona Bank       Japan       Finger vein       ATM         75       Joyo Bank       Japan       Finger vein       ATM         76       Juroku Bank       Japan       Finger vein       ATM         76       Juroku Bank       Japan       Finger vein </th <th>63</th> <th>Mauritius Commercial Bank</th> <th></th> <th>Fingerprint</th> <th>Access control (Bank building)</th>	63	Mauritius Commercial Bank		Fingerprint	Access control (Bank building)
65China Merchant Bank (CMB)ChinaVoiceTelephone banking66People's Bank of ChinaChinaFaceAccess control (Physical, Treasury)67Bank of ChinaChinaFingerprintAccess control (Physical, Time&Attendance)68Nanto BankJapanHand veinATM, Branch banking69Hiroshima BankJapanHand veinATM, Branch banking70Customers Japan Post BankJapanFinger veinATM71Mizubo BankJapanFinger veinATM72Bank of KyotoJapanFinger veinATM73Suminoto MitsuiJapanFinger veinATM74Resona BankJapanFinger veinATM75Joyo BankJapanFinger veinATM76Juroku BankJapanFinger veinATM77Bank of FukuoaJapanFinger veinATM78CITI BankJapanFinger veinATM			Mauritius		
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73     Sumimoto Mitsui     Japan     Finger vein     ATM       74     Resona Bank     Japan     Finger vein     ATM       75     Joyo Bank     Japan     Finger vein     ATM       76     Juroku Bank     Japan     Finger vein     ATM       77     Bank of Fukuoa     Japan     Finger vein     ATM       78     CITI Bank     Japan     Finger vein     ATM					
74     Resona Bank     Japan     Finger vein     ATM       75     Joyo Bank     Japan     Finger vein     ATM       76     Juroku Bank     Japan     Finger vein     ATM       77     Bank of Fukuoa     Japan     Finger vein     ATM       78     CITI Bank     Japan     Finger vein     ATM					
75     Joyo Bank     Japan     Finger vein     ATM       76     Juroku Bank     Japan     Finger vein     ATM       77     Bank of Fukuoa     Japan     Finger vein     ATM       78     CITI Bank     Japan     Finger vein     ATM					
76     Juroku Bank     Japan     Finger vein     ATM       77     Bank of Fukuoa     Japan     Finger vein     ATM       78     CITI Bank     Japan     Finger vein     ATM					
77         Bank of Fukuoa         Japan         Finger vein         ATM           78         CITI Bank         Japan         Finger vein         ATM					
78 CITI Bank Japan Finger vein ATM					
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81	Suruga Bank Japan	Hand vein ATM.	Branch banking
82	Shinkin Bank Japan	Hand vein ATM	
83	Ogaki Kvoritsu Bank Japan	Hand vein ATM	
84	Ikeda Bank Japan	Hand vein ATM	, Branch banking
85	Norinchukin Bank Japan	Hand vein ATM	
86	Senshu Bank Japan	Hand vein ATM	
87	Citi Bank Singapore Fingerprint ATM		
88	Pictet&Cie Swiss Face Access control (Building, Time&attendance)		
89	Banco Falabella Chile Fingerprint ATM, Branch banking		
90	Al Rajhi Bank Saudi Arabia Hand geometry ATM		
91	Bank of CostaRica Costa Rica Fingerprint Access control		
92	Woori Bank South Korea Fingerprint Internet banking		
93	BanCafe Col ombia Fingerprint ATM		
94	Foreign Trade Bank (FTB) Cambodia Fingerprint ATM		
95	BankMed-Lebanon Lebanon Iris Branchbanking		
96	Podkar <b>Padkn®</b> ank Spoldzielczy (PBS)	Finger vein ATM	
97	Bank Polsk iej Spoldzielczy (BPS) Poland	Finger vein	ATM, Branch banking
98	Reserve Bank Malaysia Fingerprint Biometric card, Online purchase		
99	Bank of Cairo Egypt Fingerprint Branch banking		
100	Misr Bank Eg ypt Iris Branchbanking		
101	Group Financiero Banorte Mexico	Fingerprint ATM	
102	Banco Azteca Mexico Fingerprint Branch banking		
103	Den Norske Bank No rway	Iris	ATM
104	First Bank Nigeria Fingerprint ATM		
105	Royal Microfinance Bank Nigeria	Fingerprint	POS
106	ABN AMRO Netherland Voice Telephone banking		
107	Union Bank of India India Fingerprint ATM		
108	ICICI Bank India Fingerprint Access control (Network, Treasury)		
109	Indian Bank India Fingerprint ATM		
110	Canara Bank India Fingerprint ATM		
111	Oriental Bank of Commerce India Fingerprint ATM		
112	State Bank of India (SBI) India Fingerprint Access control		
113	Central Bank of India India Fingerprint ATM		
114	Reserve Bank of India India Fingerprint ATM		
115	Punjab National Bank India Fingerprint ATM		
116	Dena Bank India Fingerprint ATM		
117	Andhra Bank India Fingerprint ATM		
118	Syndicate Bank India Fingerprint ATM		
119	HDFC India Fingerprint ATM		
120	Catholic Syrian Bank India Fingerprint ATM		
121	Cooper <b>Mirne®nAlpiicuBuzadiChedik</b> ing, Internet banking, Acœss control(Time Bank		and attendance)

Table 1: The list of 121 banks using biometric in the world

If we do the mathematics, among the 121 banks around the world, 52% of the banks in Asia uses biometric technology and the second continent is the America with 32%, 9% in Europe, 6% in Africa and 1% in Australia [11]. Shown in fig. 1.

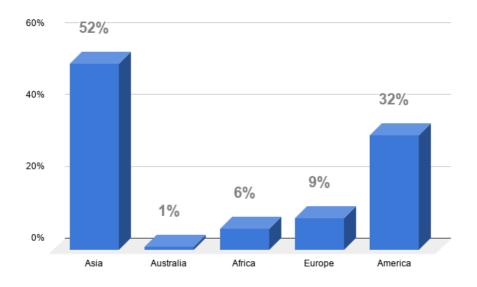
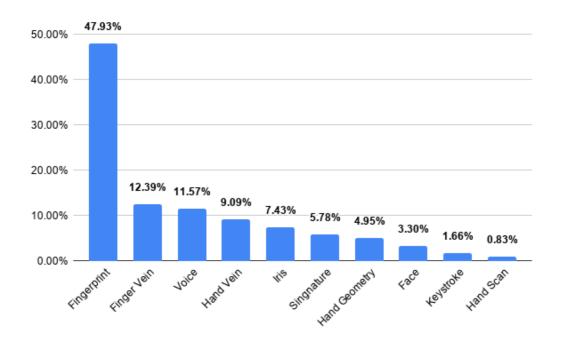


Figure 1: Percentage of Banks using Biometric in the world

Surprisingly, the most used biometric technique which are being used in the world's banks is fingerprint. Approximately 48% of the banks use fingerprint in their different operations. The finger vein pattern and the voice biometric is the next biometric technologies that is being used mostly by the banks with about 12%. Other biometric technologies with less than 10% are respectively: hand vein, iris, signature, hand geometry, face, keystroke and hand scan. [11]



#### Figure 2: Percentage of biometric techniques being used

#### **Comparison between the fingerprint scanners:**

There are three types of scanner: Optical, Capacitive and Ultrasonic scanner.

In old times the Optical and capacitive fingerprint technology creates a 2D scan of the fingerprint. Where the Optical fingerprint is the oldest & uses LED light to capture the image of finger ridges and valleys. While the Capacitive scanner uses electrical signals for the mapping of the fingerprint. And the Ultrasonic uses a very high-frequency ultrasonic sound to creates a detailed 3D model of the scanned fingerprint.

Optical Scanner: As the Optical or capacitive fingerprint technology use light or electronic pulses to create a 2D blueprint of your finger. It is easy to fool an Optical fingerprint sensor by a high-resolution photo or a fake scan of a fingertip. It is also slow as compared to others, there is also a visibility issue for sensors which can result in lower recognition rates in strong sunlight. In term of speed, the optical fingerprint sensor is slowest among others. The Optical finger sensor uses arrays of LEDs as a flash to light up the picture. It captures the picture of fingerprint like a photograph and uses algorithms to detect unique patterns on the surface, such as ridges, marks and analyze the lightest & darkest areas of the image. Nowadays, the Optical fingerprint is also used as In-display fingerprint sensors, in many mobiles like oneplus 6t, vivo,Nokia.

Capacitive Scanner: The Capacitive fingerprint scanner works better than that of optical, it is faster & It is not easy to fool the scanner, as it uses an electric pulse. The Capacitive fingerprint scanner is a bit faster than Ultrasonic fingerprint sensor. The Ultrasonic fingerprint sensor has about 250-millisecond latency for unlocking. The capacitive scanner uses capacitors, which can store electrical charge, also it uses many tiny capacitor circuits to collect data about a fingerprint. On placing a finger on the screen,

the charge in the capacitor will change slightly, while an air gap will leave the charge at the capacitor relatively unchanged. An op-amp integrator circuit is used to track these changes, which is then recorded by an analog-to-digital converter.

Ultrasonic fingerprint sensor: It is best among all, in term of accuracy. It has an error rate of 1%, and can operate through thin materials, such as plastic, glass, or aluminum. It scans through up to 800 µm of glass and up to 650 µm of aluminum and works through dirt, grime, water or even oil. since sound waves can travel through them all. The Ultrasonic hardware consists of a transmitter and a receiver. An ultrasonic pulse placed over the scanner, transmits against the finger, the pulse bounced back to the sensor. Depending upon the ridges & pores, it creates a detailed 3D reproduction of the scanned fingerprint.

Therefore, from the above comparison, we can see that either the capacitive scanner or the ultrasonic scanner can be a good fit for this automation software. Capacitive scanner is accurate, safe and it is good in terms of speed. So, we have chosen capacitive scanner for this research topic.

#### 1.5 Challenges to overcome

In order to develop the entire system, there are many challenges since the entire system has automated machine to machine socket communication and detection. After that verification and finalization. The major challenge will be;

• Detecting real human being: Capacitive scanners is the solution. The system consists of capacitive scanner which ensures the detection of real human being. A capacitive scanner has a capacitor to store little electrical charge in it, which is more difficult to fool. Also, a fake plastic finger will not contain electrical charge in it, as a result the scanner will detect a fake finger.

- Detecting the real time access: The capacitive scanner and a very secure software to detect real time access. The ATM will detect the mobile application once the user establishes a connection. There will be session timeout process which will disable the establishment after a certain time. The user will put his finger on the capacitive scanner, which measures the fingerprint electrically. Instead of creating a traditional image of a fingerprint, capacitive fingerprint scanners use arrays tiny capacitor circuits to collect data about a fingerprint. As capacitors can store electrical charge, connecting them up to conductive plates on the surface of the scanner allows them to be used to track the details of a fingerprint. The charge stored in the capacitor will be changed slightly when a finger's ridge is placed over the conductive plates, while an air gap will leave the charge at the capacitor relatively unchanged. An op-amp integrator circuit is used to track these changes, which can then be recorded by an analogue-to-digital converter. This process will ensure the real time user, because the air gap is not possible with a real time user.
- Machine to machine communication establishment: Automatic socket programming which ensure the detection of the machines (mobile phones) near to the machine (ATM) and collect data from the server about the user who requests access. The socket programming ensures the communication and data transferring between the machines. The machine (ATM) will collect data from the cloud using the existing secure channel and store data itself. the desktop software will be developed in the development process which is an automated fingerprint identification system. In order to transfer data between the machines, it uses restful API within the software. SQLite database, stores the data within the android application, which makes the process easier for the user and also it makes the interface user-friendly

Implementation of fingerprint banking security system faces multiple challenges. Detecting real human being, real time and machine to machine connection are the three major challenge. In terms of solving them, I've come up with concepts and procedures.

Capacitive fingerprint scanners are the popular type which is mostly used in smartphones. The work principle is that if the distance is short enough, it's possible to transfer electricity from a capacitor and the skin. It has capacitor within itself. At the scale of such capacitors, fingerprint ridges are like hills and valleys. Ridges will seem closer to the capacitor, and more electricity will flow away. If you have an array or a grid of capacitors (the more, the higher the resolution), they can act like pixels with varying gray-level intensity (higher electricity flow, darker pixel), thus forming a 2D fingerprint image. It's complex, very robust and only works with skin.

One can't fool it with a piece of paper, and if you try to make a mold of a real fingerprint, you need to find a material that has the same conductivity as skin. Not impossible, but inconvenient enough to weed out most perps.

The downside of capacitive fingerprint readers is that they can't work if the finger isn't clean, or has water/sweat on it because that changes the conductivity upon which the system is built. Also, they don't work behind metal. That's why there's always a visible fingerprint reader.

In order to detect real time human being, capacitive fingerprint scanner is the best concept to use. This scanner works with capacitor which passes electricity. The main advantage of a capacitive scanner is that it requires a real fingerprint-type shape, rather than the pattern of light and dark that makes up the visual impression of a fingerprint. This makes the system harder to trick. Additionally, since they use a semiconductor chip rather than a CCD unit, capacitive scanners tend to be more compact that optical devices

10

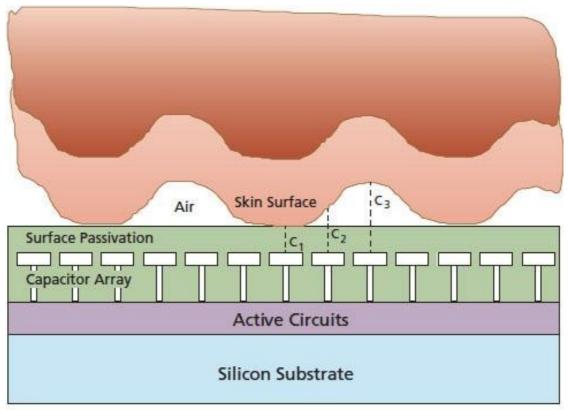


Figure 3: Capacitive Scanner diagram

# 1.6 Biometric & Banking, why it's difficult?

• Easily hackable/Easy to find - A fingerprint is easy to find. You can get the

fingerprints of any specific person from his house/office/car/papers.

• Big repercussions - By any chance if the fingerprint is stolen, then it will be hard to

replace and regenerate a new fingerprint, but in text-based password it is easy to

regenerate a new password at any time.

• Lack of revocability - Cannot be replaced easily like password, once a fingerprint is

associated with a user, it will be a complex process to change it later

• Biometrics aren't for everyone - not for everyone, disable person might not be able to

use it, without internet cannot use it, without smartphones cannot use it

The advantages of biometric technology are given below;

12

- **1.7 Proposed solution to the problems** 
  - Fingerprints are easy to get, but my proposed system is very complex and uses very secure software, as a result it will not be possible to get access to the account even if

- else. You do not have to remember and write down the fingerprints like password/PIN.
- and computer networks etc. 10. With biometrics technology, fingerprints won't be lost and can't be attained by someone
- transaction identification. 9. It can be used to access to ATMs, cellular phones, smart cards, desktop PCs, workstations,

accessing accounts, it turns out to be the best and most suitable solution for secure mobile

- identification and prison security. 8. Biometric technology can meet the increased requirement for accurate verification when
- reproduced for security and accuracy 7. It can be effectively used in forensics. This technology can be utilized for criminal
- resulting in accurate verification. 6. Biometric technology can be used in a lot of industries, means the same concept can be

training, is inexpensive and accesses distinctive recognition features of individuals

less in danger to damage and sudden changes. 5. It is less time consuming, dependable, user friendly, hard to falsify, requires negligible

biometric verification such as fingerprints, iris/retina, voice, pulse, DNA, vein, etc. are

- superior level of security 4. It is hard to be damaged or changed. The behavioral and physical elements used for
- accurate technique of authenticating end users. 3. Biometric characteristics cannot be recreated or stolen, biometric systems present a

individual identification accuracy is why a lot of companies use biometrics for their security purposes. Biometrics relies on the use unique physical traits rendering a very

1. Biometric technology is very useful for ID verification 2. Accuracy is one of the main advantages associated with biometric technology. The high you know the fingerprints. My system will detect plastic or any other no-realistic

- finger very easily, it will detect if the finger is not real time also.
- The reason behind introducing fingerprint banking system is to ensure that the user have uniform identity, which will never be repeated. This system can perform more secure than the existing system where people use passwords to get access to their account.
- Again, the secure software will ensue that you do not have to change it frequently. This biometric system is the ultimate secure channel and ensures secure money transfer in a very short time.

Therefore, this automation includes capacitive fingerprint scanner which will detect a real time fingerprint image. The 1:1 connection between your mobile phone and the ATM will ensure secure connection and identify the user even before the user puts the fingerprint. The mobile application will be real time synced with the server, which ensures the security of the user profile and the account.

# **Chapter 2**

# System Analysis and Research Methodology

## 2.1 System Analysis & Design

Analyzing biological data for authentication is safe and credible option than any passwordbased authentication system. With the motive of developing a biometric smart authentication system for banking industry a fingerprint based complex authentication system has been proposed in this research.

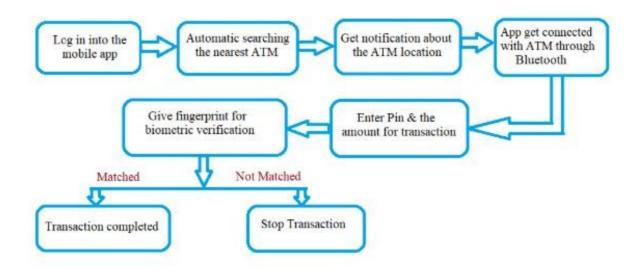


Figure 4.1. Complete System Block Diagram

The flow diagram of the prototype [figure 4 .1] is given above. There are six steps to complete the entire process and successfully exchange money between the account holder and the bank account. This is the most challenging part in my thesis. The six steps are described below;

1. Establish 1:1 connection with the ATM, send account\_id to the ATM and receive atm\_id

from the ATM

- 2. Input account\_id from the user through the UI of the mobile application
- 3. The ATM establishes connection with the server and use the secure channel to identify the

user and collect data from the server

4. Take input of fingerprint from the user using the capacitive scanner through the ATM

machine

- 5. Compare the two-fingerprint received from the central server and the ATM scanner input
- 6. If matches, send acknowledgement to the server with data and enable access (atm\_id and

device\_id,acount\_id)

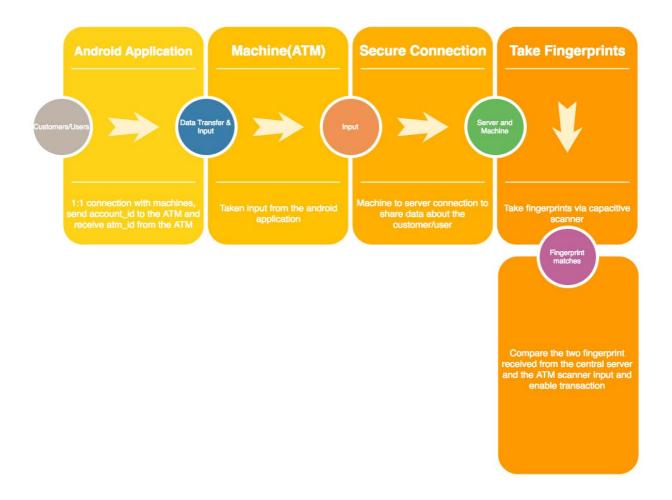


Figure 4.2. Information flow Diagram

As discussed above 1:1 connection with the ATM will be done in a secure channel. After the connection is established, it will share its id from the database and sync with the user.

Once a user comes within a network of an ATM machine, it will auto establish the connection. Every customer/user will have an android application installed in their phone, on the other hand every ATM machine will have desktop software installed in their CPU. This two software will exchange ids within themselves through API. The first connection will be established at that moment. The ATM machine will detect the customer/user's unique id, if that matches with its central server then the first 1:1 connection will be established. In the second step, the customer/user will input account\_id in the given mobile application through its user interface. The ATM then will establish a connection with the server and use the secure

channel to identify the user and collect data from the server regarding that user. In the third step, the customer/user will insert fingerprints into the machine. The ATM machine will have capacitive scanner integrated in it.

Capacitive fingerprint scanners generate an image of the ridges and valleys that make up a fingerprint. But instead of sensing the print using light, the capacitors use electrical current.

In the capacitive fingerprint scanner, the sensor is made up of one or more semiconductor chips containing an array of tiny cells. Each cell includes two conductor plates, covered with an insulating layer. The cells are tiny -- smaller than the width of one ridge on a finger. The functions of capacitive scanner is discussed more in this paper section 1.4

The ATM receives the fingerprint from the customer/user via capacitive scanner, as it has already stored the customer/user's data earlier from second step, now it matches two of the fingerprints, the one which it has received from the capacitive scanner and the second is from the customer's profile via secure channel from data server. All of the connection will happen within a secure channel of APIs.

Finally, if the fingerprint matches, the ATM will give access of the account to the customer/user and will let the customer/user make transactions. The mobile device will connect with the nearest free channel.

There are several challenges to face to secure the channel. This system will choose one existing secure channel, which is being used for the ATM machine, but it will enable the new era of banking security system by enabling easy and reliable banking. Biometric banking security system is not new, but secure fingerprint recognition for banking is a unique concept. I have introduced two layers of security; in first step the 1:1 connection between the android mobile app and the ATM machine and in second step the connection happens between the android mobile application and the data server via ATM machine.

#### 2.2 Methodology

Collecting biometric data from the customer and sending those data to the central server is an important task for this system. For ensuring a structured process of biometric data collection a custom designed software has been developed named the ATM admin software using C# programming language. In the software customer can submit bank account number, pin number and the fingerprint. After collecting the data from the customer, the software automatically generated a folder in the central server and save those data. By using this software authority can input data regarding the existing ATM booths. ATM booth's GPS location, address and

FP ATM ADMIN		×
FP ATM	Dashboard	
Dashboard NEW CUSTOMER Customer	NEW ATM ATM Location ATM Address ATM Status	INSERT

Figure 5.1 Customer Data collection

FP ATM ADMIN		
<b>FP ATM</b>	New Customer	
Dashboard	Name	
NEW CUSTOMER	Pin	
Customer	Balance Acc Number	
	Finger ID	
Enroll Mode	INSERT	

Figure 5.2 Data regarding ATM

status can be added into the central server as input through this software [9].

When any customer logs in into the mobile app then it can automatically start searching for the nearest ATM booth. In this process Haversine formula[10] has been applied for calculating the shortest path. For navigation this formula works as a vital equation [06] and works with maximum accuracy [05]. Conventionally Haversine formula has been used for calculating the distance between two coordinates on a sphere. From [07] [08] the conventional equation of the popular Haversine formula is

Haversine ( $\theta$ ) =  $[\sin] \wedge 2 \quad \theta/2 \dots (1)$ 

Using this the distance between two coordinates for radius r can be calculated through

d=2r  $[sin] \land (-1) \lor ([sin] \land 2 ((\alpha_2 - \alpha_1)/2) + cos (\alpha_1) cos (\alpha_2) [sin] \land 2 ((\beta_2 - \beta_1)/2))$ .....(2)

Here r is the radius of the earth and  $\alpha$ ,  $\beta$  are the latitude and longitude respectively. Based on the two equation a location-based recommendation algorithm has been developed [5]. In this algorithm input will be the customer's location (latitude and longitude) and couple of ATM booth locations which can be acquired from the central server. Then an array has been initialized for storing the interspace values between customer and the ATM booth. For example, If the system takes 3 ATM booth location a1, a2, a3 and a single customer location C then it will calculate the interspace for customer location vs each ATM booth location separately using Haversine formula and store the final value in the array I. Then the system will place all the resultant values in ascending order. After that a map will be generated with all the A locations and the nearest ATM booth location will turn Green as per customers closeness.

Algorithm: Location Based Recommendation Algorithm

#### Input:

Customer's location (latitude and longitude) C ( $\alpha_1$ ,  $\beta_1$ )

Multiple ATM Booths location (latitude and longitude): A = [a1 ( $\alpha_2$ ,  $\beta_2$ ), a2 [ ( $\alpha$ ] \_3,  $\beta_3$ ), a3 [ ( $\alpha$ ] \_4,  $\beta_4$ )]

#### **Output:**

Values of interspaces between customer and all the ATM booths location categorized in ascending order according to customers adjacent.

Steps:

Initializing: Array I

For every a in A,

- Calculate the interspace between C and a using Haversine formula.
- Store the interspace values in I

Categorized the array I in ascending order

Generate a map including all the A locations and separate the nearest location based on closeness of C locations.

# **Chapter 3**

# **System Implementation**

The total system has been divided into three primary subsystems. The subsystems are as follows- Fingerprint Device, Mobile Application, ATM Software.

## **3.1 Fingerprint Device**

The Designing a fingerprint device for collecting biometric data from the client is the first step of this research. As the device needs to be fit for the present ATMs that's why a design has been chosen with omnipresent configuration so that it can configure itself with the existing machines. The device consists of three major components which are an optical fingerprint sensor, microcontroller board Arduino Uno with microchip ATmega328P and a Bluetooth module. The total device needs to be compact so that it can be easily placed on the ATM. Every module has been chosen under the consideration of building a robust device. The developed device shown in Fig. 5 is connected with a central server through the ATM software.

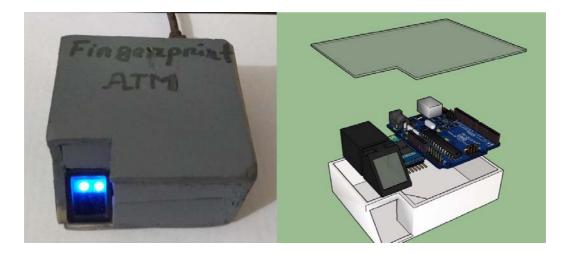


Figure 6. Original Device and 3D CAD Model

# **3.2 Mobile Application**

The second step of this research is to develop a custom designed mobile application for the customers. As android operating system is more popular and user friendly that's why android studio has been used for designing this mobile application. User needs to log in into the application using a user ID and a password.

This mobile app can automatically search the nearest ATM booth and get connected with an ATM when the phone maintains a specific distance using the Bluetooth option of the phone. Through internet the application is get connected with a central server management. A user-friendly graphical user interface has been created for the customers shown in Fig. 6.

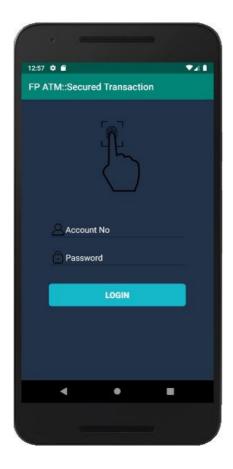


Figure 7. Graphical User Interface of mobile application

#### 3.3 ATM Software

The developed fingerprint device needs to get connected with an ATM for processing any transaction. In this case for test purpose a desktop software has been developed which can behave like a real-life ATM shown in Fig. 7. For developing this software C# programming language has been used. The graphical user interface has been developed in a way that user can get real life experience of using a real ATM. This software is also connected with the central server. From fast cash option to balance inquiry option even fund transfer option has been included into the desktop software. User can easily control the movement of this desktop software using the personalized mobile application.

Each element of this total system is dependent on one another. For completing one single transaction each part of this system needs to work properly. If one single section of the

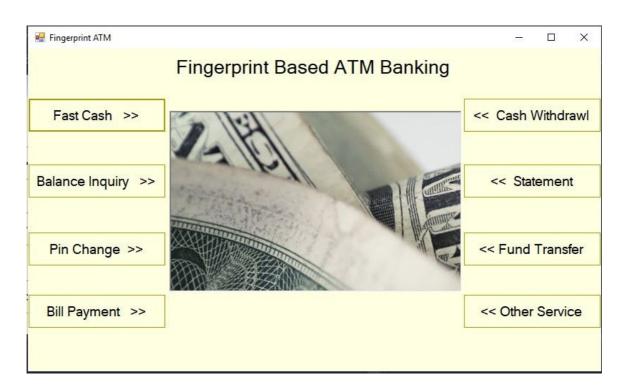


Figure 8. Graphical User Interface of desktop ATM software

system is missing then the transaction process will not work. Using this type of complex verification proper authentication can be ensured.

# **Chapter 4**

## **Experimental Analysis**

Testing the developed system in real life is the way to justify the accuracy and reliability. In this case there are two types of experiment have been conducted for verifying the system. First

one is the testing of search algorithm, where finding the nearest ATM booth in the customized mobile application using Haversine formula-based algorithm has been tested. Three different ATM booth coordinates and a user coordinate from the place Mohakhali, Dhaka -1212, Bangladesh has been used as input in the algorithm. When the user turns on the mobile application then it automatically searches the nearby ATM booth. The application suggests the nearest ATM booth using the algorithm values by turning the atm location identifier into green. In this process the algorithm successfully detected all the three ATM booths and suggested the nearest ATM booth to the user show in Fig. 9.1 and 9.2.

Secondly, with real ATM there are a lot of sophisticated and confidential data connected to the system, that's why bank authorities did not give the permission to test the developed device with a real ATM. As there are restrictions about this issue so the device had been tested using the custom designed ATM software in a local machine. The ATM software works as a real-life ATM which will respond to the commands through showing some specified notes on the monitor. So, the fingerprint device has been connected with the ATM software via a desktop computer. The ATM software has been named ATM machine and the location of the ATM has been selected as Mohakhali, Dhaka-1212, Bangladesh. When the user turns on the mobile application then it automatically gets connected with the ATM software using Bluetooth shown in fig 10. After placing the pin and the amount when the user gave the fingerprint on the designated device which is connected with the ATM software then a note "Transaction Completed" has been shown in the ATM software graphical user interface in Fig. 11. In this way the developed fingerprint device and the ATM software has been tested successfully.

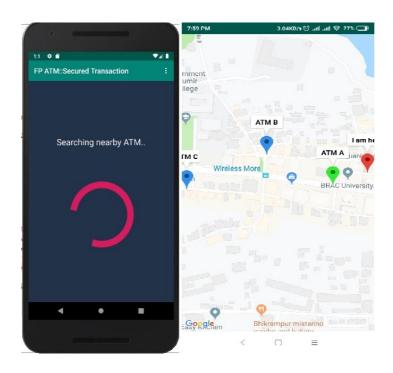


Figure 9.1 Automatically searching nearby ATM. 9.2 Generated Map using the location-based algorithm

· ·
1:28 Ф 🖬 🔍 🖬
FP ATM::Secured Transaction
Connected to ATM Machine 98:D3:31:F5:93:4A Mohakhali, Dhaka
<ul> <li>Pin</li> <li>S Amount</li> </ul>
SUBMIT
< • •

Figure 10. Building connection with the ATM software through mobile application

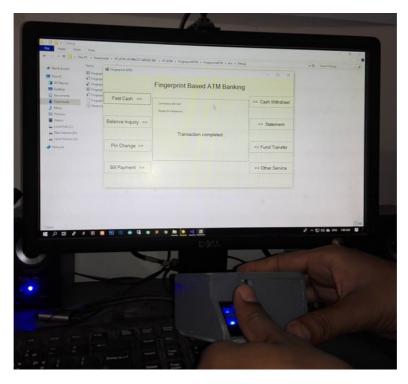


Figure 11. Successful completion of transaction

Table 2. Experin	ment Result
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Experiments			
	1. Search Algorithm Test		
Search between ATM	Detection of ATM booth	Detection of nearest ATM	
booth locations	locations in map	booth location in map	
3	3	1	
2. Transaction Test in ATM Software			
Mobile application	Applying pin, amount & finger   Transaction Status		
connection with	print as input		
Fingerprint Device			
Successfully	Successfully Received by the	Transaction Completed	
Established	Device & the ATM Software	Successfully	

# **Chapter 5**

#### Conclusion

#### 5.1 Concluding the research

Utilization of biometric based authentication systems in the banking sector is getting more popular. For this type of system clients can enjoy secure transaction than past times. In this research a total banking authentication system has been introduced and developed. Fingerprint based biometric data collection device makes the system smooth. The locationbased algorithm ensures successful tracking of nearest ATM booths for user. Different custom designed software makes the data collection and testing process easier. In the near future the system can be modified for fulfilling all the requirements so that it can be tested with real ATM. Collection of data can be increased for covering a large area and a large number of customers. If all the modification can be done then this type of system can protect us from unwanted situation during transaction and people can enjoy carefree banking services.

#### 5.2 Future Work

In this research I have found a lot of scope of improvements in the automation software in order to make the software more effective. So, in the future I will implement artificial intelligence for searching the nearest ATM in the shortest time possible. I intent to work towards minimizing the total transaction time for a user in the ATM. I can optimize the time by implementing AI for shortest path available. At first, I will take all of the ATM in Dhaka City as a knowledge base and implement the AI to find the nearest ATM in the shortest possible time, eventually the entire country and the world.

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