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Banking and Payment System via Mobile Devices with Biometrics Authentication

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Dedication

- ***To my beloved mother Su’ad***
- ***To my beloved wife Yasmeen***
- ***To my brother Monther***
- ***To my sisters***

Acknowledgements

Praise is to Allah, the Almighty for having guided me at every stage of my life.

This thesis is the result of years of work whereby I have been accompanied and supported by many people. It is wonderful that I now have the opportunity to express my gratitude to all of them.

This work would not have been possible without the constant encouragement and support I received from prof. Hatem hamad, my advisor and mentor. I would like to express my deep and sincere gratitude to him. His understanding and personal guidance have provided a good basis for the present thesis.

I also extend my thanks to prof. Mohammad Mikki and Dr. Aiman Abu Samra the members of the thesis discussion committee.

Also, I would like to take this opportunity to express my profound gratitude to my beloved family – my mother, and my wife- without whom I would ever have been able to achieve so much

Last, but certainly not least, I want to thank my friends and Colleagues, for their moral support during this study.

ABSTRACT

The increase in the number of subscribers companies cellular phones in Palestine, and thus steadily for mobile phones, and those modern ones, opens the way for a required new field of mobile applications, those concerned with trade and business, including banking systems, as well as develop new ways to accomplish the sale and purchase .

Have been better as researchers in the field of computer to be proactive in going into this area, so we in this thesis developed a model for one of these innovative systems, a model be preceded by a study meets the systems mobile phones for payment, and banking services in the world, then get out perception of the entire new system is well suited with the reality of banks in Palestine, and allows the user to buy a commodity or service, or to sell it through his mobile phone at any time, or at any place without any extra cost or pricing.

The model which we have designed is going through stages of the life cycle of one of the latest and the most important methods for object-oriented software engineering, to design concurrent, distributed, and real-time applications with the Unified Modeling Language (UML), a stage of the system requirements specification, and the stage of system analysis, which describes the relations between the objects that reflects the problem domain, and the stage of system design that accurately describe the system structure and structure of active objects and their interrelationships, and this stage focuses on the solution domain.

Protection of digital data is of concern to many people since the occurrence of electronic archiving system, with the occurrence of mobile phone software has become an urgent need to protect and secure the mobile phone itself, or one of its applications from the exploration or the futility of non-authorized use. With the great progress of the capacity, and the capabilities of the mobile phone which has become a small computer, it becomes possible to secure mobile with biometric technologies, as the goal of this thesis is to get out a full system for less cost to the user, we have chosen the voice print as a biometric that you only need a traditional microphone to pick up sound such as that found in all mobile phones.

We have designed and programmed the speaker-verification system, which does not depend on the text, i.e. that the system can verify the speaker regardless of the phrase pronounced. System works entirely on a mobile phone to pick up the sound, and analyze it to extract the characteristics of the vocal tract, then the verification process, which compares the extracted speech's features with the stored vocal model audio of the speaker, which can be modified when necessary.

تلخيص اطروحة الماجستير

الباحث م. كنعان احمد البحيصي

ان ازدياد عدد مشتركي شركات الهواتف الخلوية في فلسطين، وبالتالي انتشار مضطرد لأجهزة الهواتف النقالة، وتلك الحديثة منها، يفتح الطريق امام مجال جديد ومطلوب من تطبيقات الهواتف النقالة، تلك التي تختص بالتجارة والاعمال والتي تشمل الانظمة البنكية، كذلك استحداث طرق جديدة لإنجاز عمليات البيع والشراء.

فكان حري بنا كباحثين في مجال الحاسوب ان نكون سباقين في الخوض في هذا المجال، فقمنا في هذه الاطروحة بوضع أنموذج لإحدى هذه الانظمة المبتكرة، انموذج يكون مسبوقا بدراسة مستوفية لأنظمة الهواتف النقالة للدفع، وخدمات البنوك في العالم، ثم الخروج بتصور كامل لنظام جديد مناسب تماما لواقع البنوك في فلسطين، ويتيح للمستخدم ان يشتري سلعة او خدمة، او ان يبيعها عن طريق هاتفه النقال في أي وقت، او في أي مكان بدون أي تسعيرة او تكلفة اضافية.

الانموذج الذي قمنا بتصميمه يمر بمراحل دورة حياة احدى احدث واهم الطرق لهندسة البرمجيات الشيئية، لتصميم الانظمة المتزامنة والموزعة والآنية مع لغة النمذجة الموحدة، مرحلة توصيف متطلبات النظام، ومرحلة تحليل النظام الذي يصف العلاقات بين الكائنات البرمجية التي تعكس مجال المشكلة نفسها، ومرحلة تصميم النظام التي تصف بدقة بنية وهيكلة الكائنات العاملة وترابطها، وتركز هذه المرحلة على المجال الحل.

حماية البيانات الرقمية امر يشغل بال كثير من الناس منذ ظهور نظام الارشفة الالكترونية، ومع ظهور برامج الهاتف النقال اصبحت الحاجة ملحة لحماية و تامين الهاتف النقال نفسه او احد تطبيقاته من تلصص او عبث الغير مخولين باستخدامه. مع التقدم الكبير لقدرات الهاتف النقال الذي اصبح بمثابة حاسوب صغير متنقل اصبح بالإمكان تأمينه بتقنيات السمات الحيوية، وحيث ان هدف هذه الاطروحة هو الخروج بنظام كامل باقل التكاليف المترتبة على المستخدم، اخترنا بصمة الصوت كسمة حيوية التي تحتاج فقط الى لاقط صوت تقليدي كالذي يوجد في جميع الهواتف النقالة.

قمنا بتصميم وبرمجة نظام التحقق من المتكلم، لا يعتمد على النص، أي ان النظام يمكنه التحقق من المتكلم بغض النظر عن العبارة التي نطقها. النظام يعمل كليا على الهاتف النقال من التقاط الصوت، وتحليله لاستخراج الخصائص المميزة لنبرة الصوت، ثم عملية التحقق وذلك بمقارنة خصائص الصوت المستخرجة مع النموذج الصوتي للمتكلم المخزن والذي يمكن تعديله عند الضرورة.

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Chapter 1

INTRODUCTION

1.1 problem definition

Banks in Palestine are suffering from technical; manage mental, economical and communicational problems. The technical side means lack of services for clients who are interested in remotely querying, these queries may be simple and easy and needn’t many efforts but client must go to bank to get such information and services. Suppose that client is in the middle of any deal and cannot leave customers then must go to the bank to get the needed information (e.g. his account balance and credit transferring), in this case he may lose the deal.

Another client goes to the bank for a one minute procedure, many times in this case he waits in long queue, especially in the salary cashing period here he will spend 2 -4 hours.
Employees (bank customers) may suffer a lot in non-efficient cashing (lack of money) as result of this serious problem they can't buy what the need of different goods so this will effect on the selling-buying movement in the whole area then will cause a country economical parallels.

As a result of these problems the social situation in the country will be badly affected, that is to say because of the delayed salaries people will live in financial distress. This leads to trust issue; clients may stop trusting their banks and their policies because it seems that the bank systems and policies are not made to help and relief customers but they increase their suffering and effect the country economy and industry.
No doubt that this serious social and economic problems cause unemployment and crime in the Palestinian society.

On the other hand many people think that Visa Card may solve most of these problems, even if it can solve some of them but it also brings a lot of more complicated financial problems. It's important to mention that the VC have been spread among a limited category in the Palestinian society, even big merchants don't deal with VC.

No doubt that what we are hearing or watching on T.V about manipulations and tricks including VC and it’s high taxes.

The traditional checks system (paper) is useless and also containing a lot of disadvantages like reversed checks and fake ones or these without balance, absolutely this system is not successful with lost checks or stolen ones because if they are signed directly cashed, also paper checks easy to be damaged.

Personal Identification Number (PIN) code which is a four digits can be forgotten or easily stolen, many customers keep PIN data with its debit card (as written on paper and inserted in the cover of card) , so when this card is stolen or lost the PIN goes with it.

1.2 Mobile Commerce

Mobile Commerce, also known as M-Commerce or mCommerce, is the ability to conduct commerce using a mobile device. such as a mobile phone (cell phone), a PDA, a smartphone, or other emerging mobile equipment such as dashtop mobile devices. Mobile Commerce has been defined as follows: "Mobile Commerce is any transaction, involving the transfer of ownership or rights to use goods and services, which is initiated and/or completed by using mobile access to computer-mediated networks with the help of an electronic device. [1].

Mobile banking (also known as M-Banking, mbanking, SMS Banking etc.) is a term used for performing balance checks, account transactions, payments etc. via a mobile device such as a mobile phone or Personal Digital Assistant (PDA). Mobile banking today (2007) is most often performed via SMS or the Mobile Internet but can also use special programs, called clients, downloaded to the mobile device.

Mobile business is any activity conducted over a wireless telecommunications network or from mobile devices. This includes business to customer (B2C) and business to business (B2B) commercial transactions as well as the transfer of information and services via wireless mobile devices. [2].

1.3 Technologies for Mobile Payments

The mobile technology landscape provides various possibilities for implementing m-payments. Essentially, a GSM mobile phone may send or receive information (mobile data service) through three possible channels – SMS, USSD or WAP/GPRS. The choice of the channel influences the way m-payment schemes are implemented. Secondly, the m-payment client application may reside on the phone or else it may reside in the subscriber identity module (SIM). We briefly describe NFC technology as another possibility.

1.3.1 Short Message Service (SMS)

This is a text message service that enables short messages (140-160 characters) that can be transmitted from a mobile phone. Short messages are stored and forwarded by SMS centers. SMS messages have a channel of access to phone different from the voice channel [6]. SMS can be used to provide information about the status of one's account with the bank (informational) or can be used to transmit payment instructions from the phone (transactional).

1.3.2 Unstructured Supplementary Services Delivery (USSD)

Unstructured Supplementary Service Data (USSD) is a technology unique to GSM. It is a capability built into the GSM standard for support of transmitting information over the signaling channels of the GSM network. USSD provides session-based communication, enabling a variety of applications. USSD is session oriented transaction-oriented technology while SMS is a store-and-forward technology. Turnaround response times for interactive applications are shorter for USSD than SMS [70].

1.3.3 WAP/GPRS

General Packet Radio Service (GPRS) is a mobile data service available to GSM users. GPRS provides packet-switched data for GSM networks. GPRS enables services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access in mobile phones.

1.3.4 Phone-based Application (J2ME/BREW)

The client m-payment application can reside on the mobile phone of the customer. This application can be developed in Java (J2ME) for GSM mobile phones and in Binary Runtime Environment for Wireless (BREW) for CDMA mobile phones. Personalization of the phones can be done over the air (OTA).

1.3.5 SIM-based application

The subscriber identity module (SIM) used in GSM mobile phones is a smart card i.e., it is a small chip with processing power (intelligence) and memory. The information in the SIM can be protected using cryptographic algorithms and keys. This makes SIM applications relatively more secure than client applications that reside on the mobile phone. Also, whenever the customer acquires a new handset only the SIM card needs to be moved [7]. If the application is placed on the phone, a new handset has to be personalized again.

1.3.6 Near Field Communication (NFC)

NFC is the fusion of contactless smartcard (RFID) and a mobile phone. The mobile phone can be used as a contactless card. NFC enabled phones can act as RFID tags or readers. This creates opportunity to make innovative applications especially in ticketing and couponing [8]. The ‘Pay-Buy Mobile’ project launched by the GSM Association (fourteen mobile operators are part of the initiative) targets 900 million mobile users with a common global approach using NFC [9].

1.3.7 Dual Chip

Usually the m-payment application is integrated into the SIM card. Normally, SIM cards are purchased in bulk by telecom companies and then customized for use before sale. If the m-payment application service provider has to write an m-payment application in the SIM card, this has to be done in collaboration with the telecommunications operator (the owner of the SIM). To avoid this, dual chip phones have two slots one for a SIM card (telephony) and another for a payment chip card. Financial institutions prefer this approach as they can exercise full control over the chip and the mobile payment process [10]. But, customers would have to invest in dual chip mobile devices.

1.3.8 Mobile Wallet

A m-payment application software that resides on the mobile phone with details of the customer (and his or her bank account details or credit card information) which allows the customer to make payments using the mobile phone is called as a mobile wallet. Customers can multi-home with several debit or credit payment instruments in a single wallet. Several implementations of wallets that are company-specific are in use globally. See blazewallet.com.

1.4 Biometric authentication

Biometrics is the science and technology of measuring and analyzing human body characteristics such as fingerprints, retina veinal patterns, irises, voice patterns, facial patterns, and hand/finger measurements for authentication or identification purposes. As the "state-of-the-art biometrics excellence roadmap" sidebar indicates, authentication by biometric verification is becoming increasingly common, and biometric technologies are beginning to appear in many facets of everyday life [3].

Voice recognition or speaker recognition is the computing task of validating a user's claimed identity using characteristics extracted from their voices. There are two major applications of speaker recognition technologies and methodologies. If the speaker claims to be of a certain identity and the voice is used to verify this claim, this is called verification or identification.

On the other hand, identification is the task of determining an unknown speaker's identity. In a sense speaker verification is a 1:1 match where one speaker's voice is matched to one template (also called a "voice print" or "voice model") whereas speaker identification is a 1:N match where the voice is compared against N templates.

From a security perspective, identification is different from verification. For example, presenting your passport at border control is a verification process - the agent compares your face to the picture in the document. Conversely, a police officer comparing a sketch of an assailant against a database of previously documented criminals to find the closest match(es) is an identification process.

Speaker verification is usually employed as a "gatekeeper" in order to provide access to a secure system (e.g.: telephone banking). These systems operate with the user's knowledge and typically require their cooperation. Speaker identification systems can also be implemented without the user's knowledge to identify talkers in a discussion, alert automated systems of speaker changes, check if a user is already enrolled in a system, etc.

Speaker recognition systems fall into two categories: text-dependent and text-independent.

If the text must be the same for enrollment and verification this is called text-dependent recognition. In a text-dependent system, prompts can either be common across all speakers (e.g.: a common pass phrase) or unique. In addition, the use of shared-secrets (e.g.: passwords and PINs) or knowledge-based information can be employed in order to create a multi-factor authentication scenario.

Text-independent systems are most often used for speaker identification as they require very little if any cooperation by the speaker. In this case the text during enrollment and test is different. In fact, the enrollment may happen without the user's knowledge, as in the case for many forensic applications. As text-independent technologies do not compare what was said at enrollment and verification, verification applications tend to also employ speech recognition to determine what the user is saying at the point of authentication [4,5].

1.5 COMET

Concurrent [67] or Collaborative [47] Object Modeling and architectural design mEThod COMET is a design method for concurrent, distributed, and real-time system.

The development process for COMET method is an object-oriented software process, which is compatible with the Unified Software Development Process (USDP) [68] and the spiral model [69]. The COMET object-oriented software life cycle model is a highly iterative software development process based around the use case concept. The figure 1.1 shows this lifecycle as a block diagram.

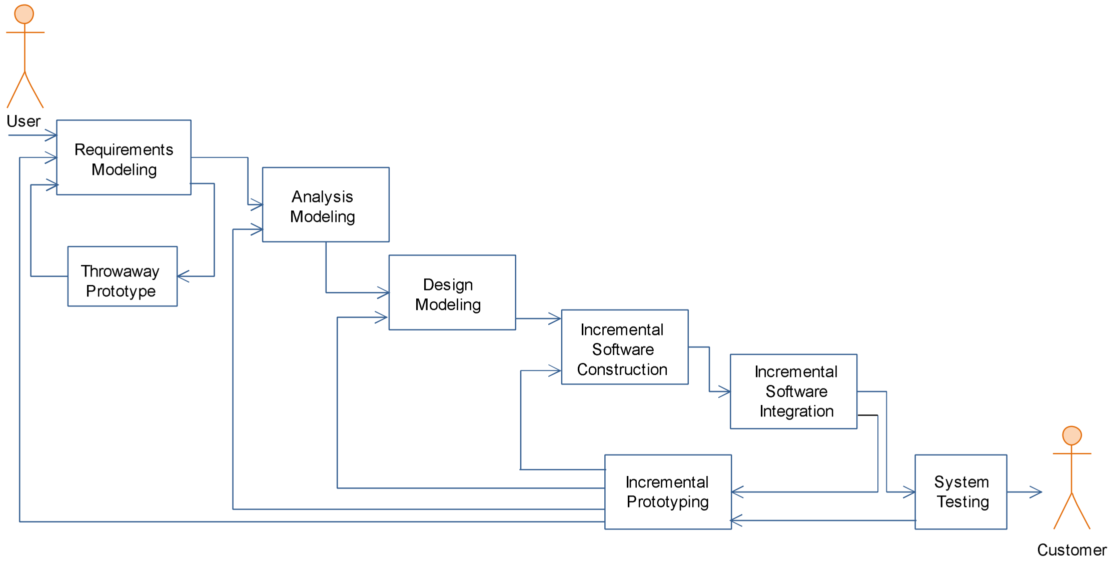


Figure (1.1): COMET object-oriented software life cycle mode

1.6 Motivation

In this thesis, we can conclude our contribution in:

1. We proposed a new approach of mobile commerce, named Debit Mobile.
2. We introduced a new type of electronic Cheque, named soft Cheque.
3. We introduced a new algorithm for soft Cheque offline verification, depending on a new proposed structure of mobile digital certificate.
4. We modeled our banking and payment system using COMET method.
5. We designed, and implemented speaker verification running completely on mobile devices, non-distributed system in J2ME.
6. We implemented three methods of the natural algorithm function in J2ME, all of them are faster than traditional java implementation, and they have high accuracy.

1.7 Thesis outline

The remainder structure of this thesis as follows:

chapter 2 Related literature review: gives an overview of mobile banking, and payment, and explores some biometric authentication technologies for mobile devices.

Chapter 3 Proposed system: Strategies, Algorithms, and Specification: explores and explains in details our proposed system, novel strategies in mobile payment, a new mechanism for speaker verification for mobile devices, existed algorithms for extracting speech features, and finally full specification of our system as system requirements specification (SRS) document in IEEE format [67].

Chapter 4 System analysis model: in this chapter we modeled the complete system, which reflects the problem domain, the system analysis model consists of static and dynamic models, also composite state charts will be developed.

Chapter 5 System design model: the overall system architecture will be investigated, and described briefly, structuring system to subsystem and to concurrent tasks, others system design details will be documented, and all necessary diagrams and descriptions that reflects solution domain.

Chapter 6 Speaker verification system: implementation, and experimental results: for speaker verification subsystem and natural logarithm method in three ways discussion.

Chapter 7 conclusion and future work.

Chapter 2

RELATED LITERATURE REVIEWS

2.1 Overview

M-commerce is a natural extension of E-commerce, the wide ubiquity of mobile devices opens new fields of business, creates new types of services, and attracts new types of customers.

Most mobile financial applications are simply mobile versions of their wireline counterparts, but they have the potential to turn a mobile device into a business tool, replacing bank branches, ATMs, and credit cards by letting a user conduct financial transactions with a mobile device, anytime, anywhere. These services fall into two broad categories: mobile banking and mobile payments.

Mobile phone devices are targets for thefts and lost, when using these devices as business tools, many confidential data is stored on them, many business applications are installed on these mobile phones. It is very dangerous to keep all these data and applications without protection. Studies have shown that even though most of the cell phone users are aware of the PIN security feature more than 50% of them are not using it either because of the lack of confidence in it or because of the inconvenience. A large majority of those users believes that an alternative approach to security would be a good idea [11].

2.2 Mobile banking applications

Throughout Europe, The united states, and Asia, an increasing percentage of banks are offering mobile phones access to financial and account information. These banks enable their customers to use their mobile devices to check balances, monitor transactions, obtain other account information, transfer funds, locate branches or ATMs, and, sometimes, pay bills [12].

The ICICI bank (icicibank.com) offers many mobile banking services, one of these services is iMobile and iMobile mShop applications. iMobile offers a range of services in a simple consolidated menu. Now you can make banking transactions like funds transfer, bill payment, balance enquiry, locate a branch, view your last 5 transactions and much more.

iMobile is a rich client based application that downloads instantly onto your mobile phone and functions similar to any other mobile application menu. With its newer features, smarter interface, quicker navigation and enhanced functionality, iMobile is as simple as ABC....

Now iMobile powered with mShop not only gives you a convenient banking solution, but also gives the facility to purchase and pay for goods or services using mobile phones.

Features of iMobile:

1. **Banking using iMobile**: With its proficient user interface you can now make payments, transfer funds, place request and access banking information with just a single click on your Saving Accounts, Loan Accounts, Demat Accounts and Credit Cards.
2. **It is Safe and Secure**: You will need to enter your unique 4-digit PIN every time you make a payment transaction. This PIN is selected by you at the time of registration.
3. **iMobile mShop:** With the new mobile shop you can now recharge your prepaid mobile number, book movie tickets with Book My Show, book flight tickets with Make My Trip and much more in just few clicks.

   iMobile mShop service is available for customers who activated iMobile after 31st Jan 2010. In case you have activated iMobile before the mentioned date, please upgrade the iMobile application by clicking on the Upgrade option in the Options menu.
4. **Continuous Updates**: Features and services are continuously updated keeping you ahead of the game always.
5. **Higher funds transfer limit**: It allows you to transfer funds to any bank account, pay bills and do prepaid mobile recharge up to a new enhanced limit* of Rs. 50,000/- per day.
6. **Diversity of handsets:** ICICI Bank is the only bank covering more than 650 GSM and CDMA handsets.

2.3 Mobile payment applications

The term mobile payment refers to payment transactions initiated or confirmed using a person’s cell phone or smartphone. These transactions include such things as point-of-sale (POS) purchases, transferring money to a person or business, or purchasing a product or service remotely. Mobile POS payments are also known as proximity or contactless payments. Mobile proximity payments are usually handled using near field communication

(NFC) technology. NFC is wireless technology that enables data exchange between devices that are within a distance of 10 centimeters [13].

In contrast, mobile remote payments are those initiated and settled through a combination of the cellular and associated payment networks. Like mobile banking, these person-to-person, person-to-business, or business-to-business payments typically rely on either SMS text messaging or the web to execute the payment.

2.3.1 Mobile Proximity Payments

Bay Area Rapid Transit (BART) offers a mobile service depending on Translink, allows passengers to pay their fares using their mobile phones.

TransLink, a contactless smart card that contains stored value that can be used for fare payments, had been launched in late 2006 on AC Transit, Dumbarton Express, and Golden Gate Transit lines [14]. It was introduced on BART, SF Muni, and Caltrain in May 2009,[15, 16] and was renamed to Clipper card in 2010. BART had previously promoted the EZ Rider card, a pilot program using similar technology. BART contracted with Cubic Transportation Systems to replace all the faregates with ones that have smart card readers installed[17],the figure 2.1 shows the TransLink system distribution.

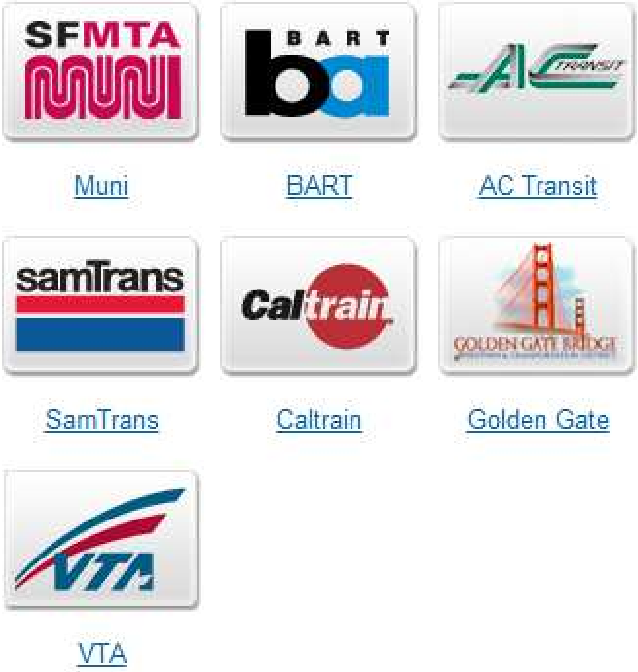


Figure (2.1): Translink system distribution.

Outside the united states, adoption of mobile contactless payments has been a bit broader, especially in japan. NTT DoCoMo offers a number of mobile phones with NFC capabilities. DoCoMo has also reported that there are more than 200,000 NFC card readers in japan (best 2008). To date, approximately 20 million customers use these phones for debit card transaction. In the future they will also use them as credit cards. Interestingly, taxis in japan are also starting to install NFC readers.

2.3.2 Mobile Remote Payments

A number of initiatives have been launched to support mobile remote payments. These initiatives offers services that enable clients and consumers to use their mobile devices to pay their monthly bills, to shop on the internet, to transfer funds to other individual (P2P payments), and to “top off” their prepaid mobile accounts without having to purchase prepaid phone cards.

In the case of mobile bill payments, Internet shopping, P2P payments, and “topping off”, the processes involved in executing a transaction are basically the same:

1. The payer initiating the payment sets up an account with a mobile payment service provider (MPSP).
2. To make a payment, the payer sends a text message or command to the MPSP that includes the dollar amount and the receiver’s mobile phone number.
3. The MPSP receives the information and sends a message back to payer, confirming the transaction and requesting his or her PIN.
4. The payer receives the request on his mobile device and enters the PIN.
5. When the MPSP receives the payer’s PIN, money is transferred to the third party’s account (credit or bank account).
6. After the transaction occurs, the payment information is sent to the payer’s device.

2.4 Mobile Biometric Recognition applications

The Biometric technologies can be classified to physiological and behavioral as shown in figure 2.2.

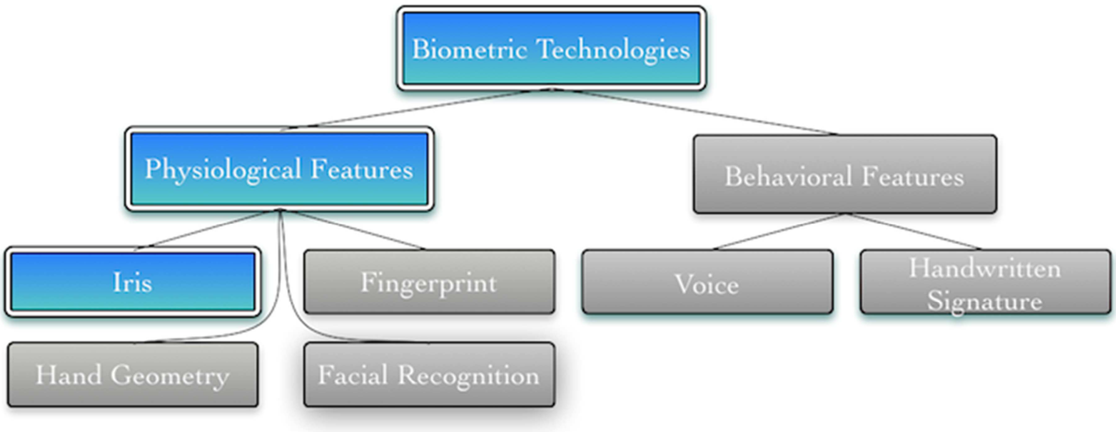


Figure (2.2): Biometric technologies classification.

There are many companies offer applications and technologies for biometric authentication.

2.4.1 Mobbeel (mobbeel.com)

Mobbeel provides biometric security solutions (iris, voice and signature recognition...) for mobile devices. The targeted platforms are Android, iPhone, BlackBerry, Symbian, Maemo, Bada and Windows Phone 7. The company offers two technologies: Iris recognition, and Signature recognition**:**

a) Iris recognition: Mobbeel has concentrated its efforts in the development of this technology, specifically targeting current mobile devices and the wide range of opportunities their features offer. With its technology, iris pattern acquisition does not need a special sensor or infrared light in the mobile device, it simply uses the built-in camera. Most current smart-phones have cameras with enough resolution and sufficient technical specifications to allow for this. The technology has been specially designed to be able to perform the whole recognition process, from the initial capture of the eye, through the acquisition of the biometric iris pattern and final identification of the individual. The technology is capable of processing all the information, taking into account that the samples might be very different. The sophisticated algorithms allow the samples to be taken in a non-controlled environment by the mobile device's built in camera, where the environmental conditions (no special light, different places and distances to the eye, etc) may have had a major impact on the outcome. The technology also works within client/server architecture, where the client (mobile device) is used just as a capture device and the server receives the sample taken by the client, through a secure channel, and performs the recognition process.

b) Signature recognition: Mobbeel has chosen the online recognition model as the fundamental approach in the development of this technology. its implementation of the online model is much more reliable than the offline model, since it is not only based on the final result of the signature but also the behavior patterns of the signature itself (strokes, speed, pressure, time, etc). This significantly raises the level of security and reduces the chances of forgery. It works with the vast majority of touch screens and adapts to individual handset characteristics, being a highly configurable technology. As with iris recognition, the technology works perfectly isolated on a mobile device, performing the capture, processing and identification independently. It is also suited to a client/server architecture where the device just captures the signature and sends it to the server, through a secure channel, for the enrollment or identification process.

Chapter 3

PROPOSED SYSTEM: STRATEGIES, ALGORITHMS, AND SPECIFICATION

3.1 overall description

we assume that there is an organization is responsible of managing banks, deploying a mobile application to customer's mobile, and signing it with its certificate authority server. This organization is connected with Banks's networks with distributed networks, each bank's network contains complete data about its customers to improve performance by locality concept.

The Mobile Banking System has two active actors Seller and buyer, both will be appear as a single actor in use case diagram shown in figure 3.7, buyer sends Soft Cheque from his mobile phone to seller's mobile via Bluetooth link, after that Seller go to bank to cash the Cheque, bank server sends instructions to his mobile and displays them on a instruction screen, bank's customer connect to bank server via a connection link like GPRS, WIFI, WAP and others, can query his account balance and charge his mobile with soft money, Bank server has a Mobile information server to keep necessary data about customer's mobile phones.

In figure 3.1 the overall of the organization's servers, main server, certificate server, D.B server, and mobile information server. Network clouds connect organization system with banks side.

A bank side is shown in figure 3.2 as a M-commerce servers cluster, connection links include WIFI, internet, and Bluetooth connection. In cashing of soft Cheque an instructions screen is needed.

The servers cluster is shown in figure 3.3, Web server to host banking mobile service, and to reply to clients' requests.

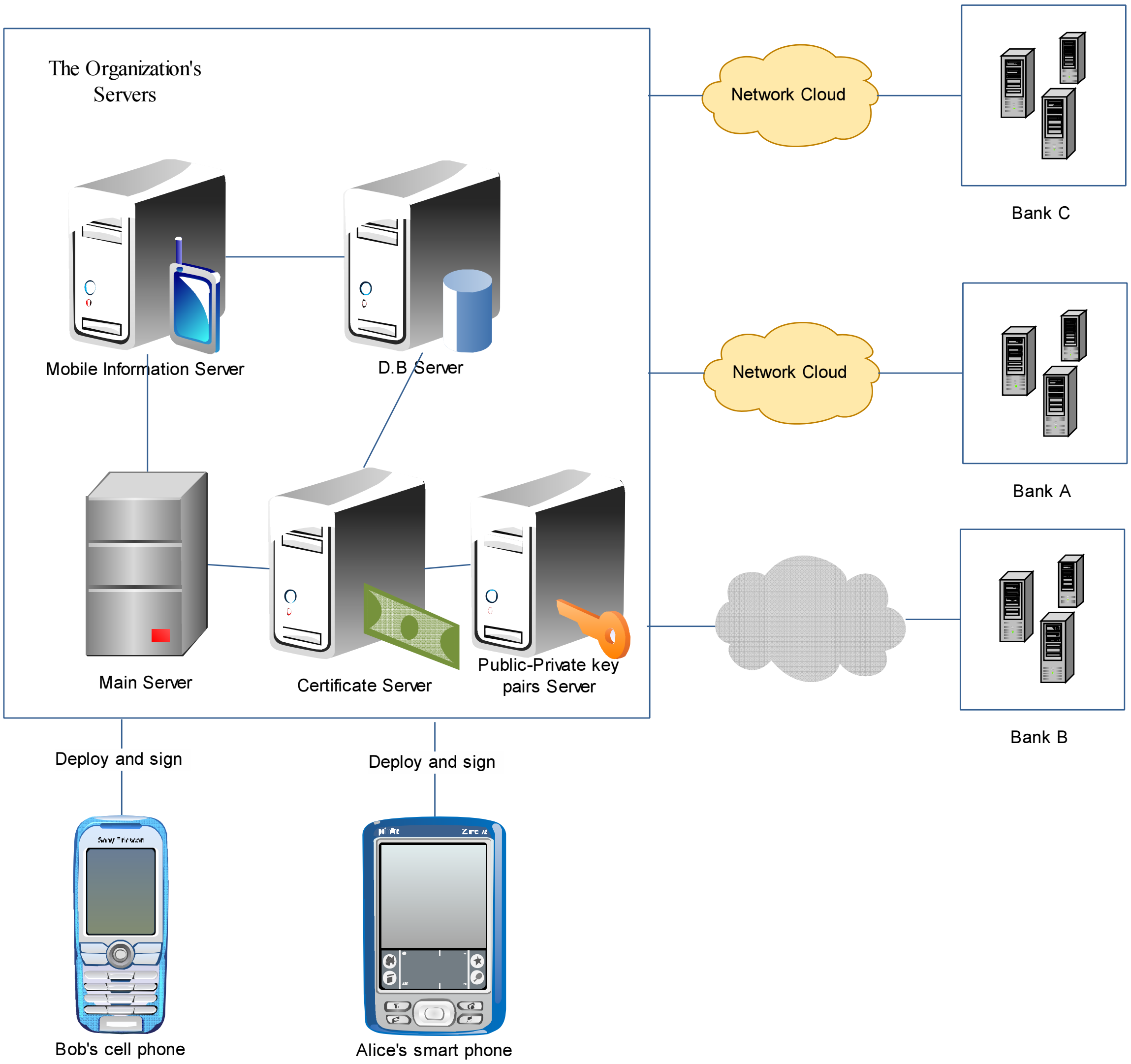


Figure (3.1): Overall Organization's Servers.

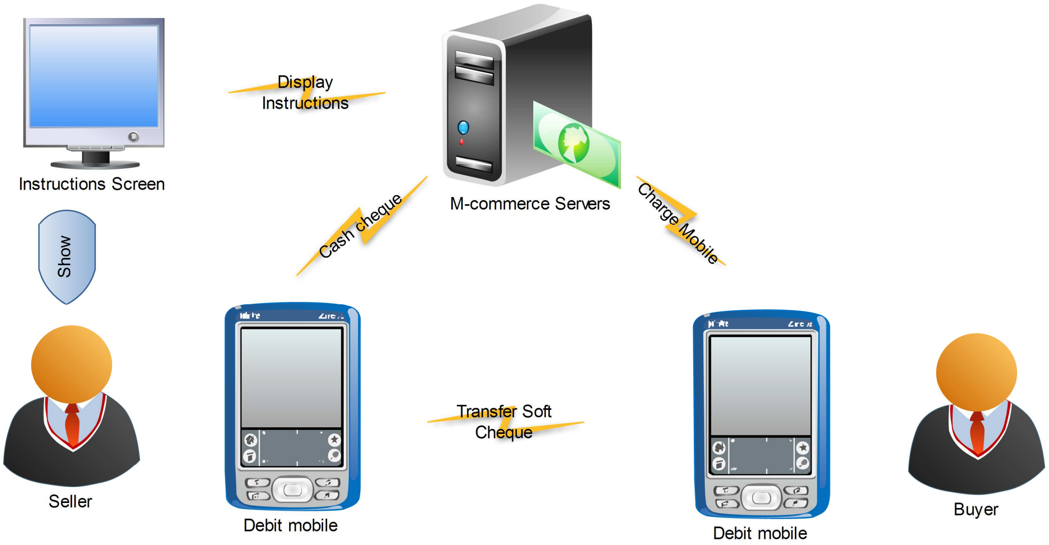


Figure (3.2): A Bank System environment.

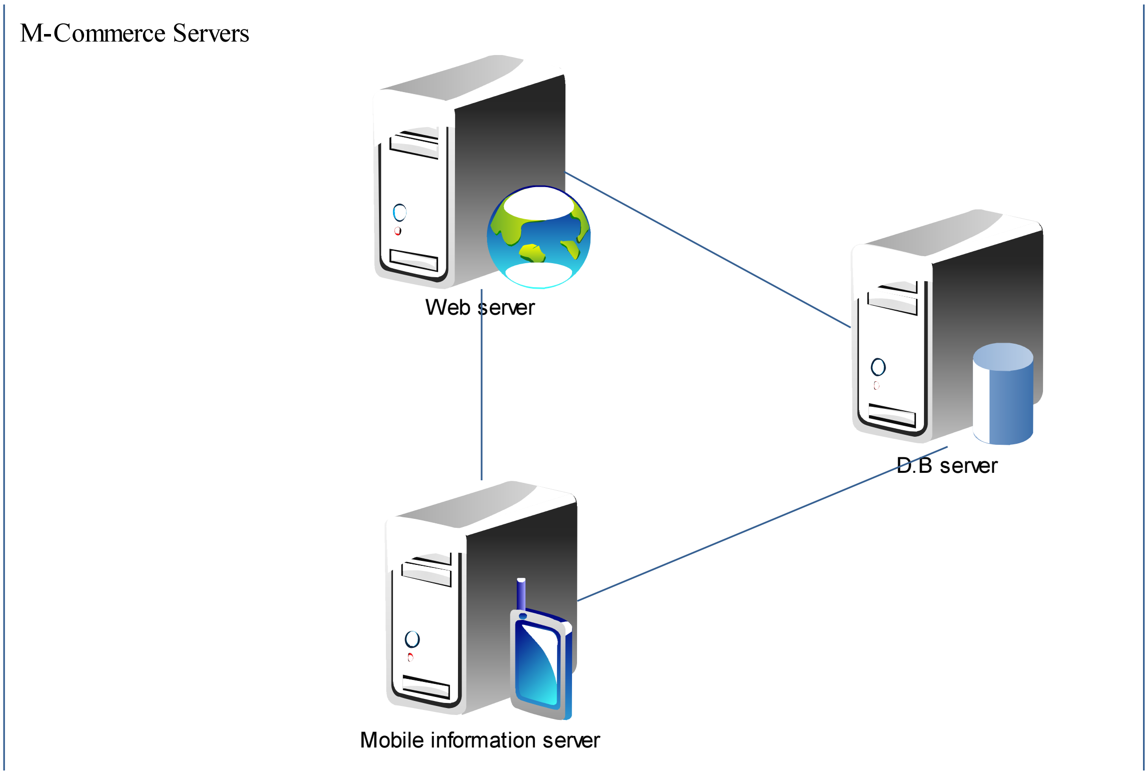


Figure (3.3): A Bank's Servers.

3.2 Debit mobile specification

Debit mobile is a mobile phone device that contains an application or software, this software has a balance, which is charger from customer's bank, which is a member in an organization that deploys and signs the mobile application. This debit mobile can be used as a payment method instead of a cash in purchases.

Debit mobile is protected using a biometric authentication (here voice print), the query, charge mobile and discharge mobile operations or transactions require personal identification number (PIN) and likes automatic teller machine (ATM) this authentication is needed for every transaction. Because to complete previous transactions, there is a connection needed to bank server, the name of this mobile system in performing one of these transactions is online debit system.

In another way these three transactions must include a synchronization operation between the debit mobile balance and that stored on bank's database.

Synchronize transaction : A synchronization between this debit mobile balance and corresponding one in bank server.

Synchronize transaction server process

```
Waiting for a request
Incoming synchronize request
Begin:
    1.  Initialize float db=0.
    2.  Extract request message fields:
    3.  A#= Account number field value;
    4.  db= debit mobile balance field value;
    5.  md= modified date field value;
    6.  mt= modified time field value;
    7.  select account where account number=A#;
    8.  request mobile account branch
    9.  if (md after last modified date or mt after last modified time ) then
            a.  Cheques balance= mobile balance-db;
            b.  mobile balance=db;
            c.  last modified date=this.date;
            d.  last modified time=this.time;
            e.  account balance=account balance-cheques balance
    10. End if
End
```

Query transaction: Mobile requests bank server to get balances that belong to an account associated to this debit mobile .

Query mechanism: After bank server receives a query transaction request, it redirects the request to Query Account Transaction Manager, which extracts account number and requests data from corresponding account with this number. We add to traditional account object a tag called status, if status's value is true then there is a mobile account branch, and bank server replies with two balances: primary and mobile balances, if tag is false then there is no mobile account, and bank server replies with just one balance which is the original account balance.

Query transaction server process

```
Waiting for  a request
Incoming query request
Begin:

        1. Initialize float O=0; M=0; and P=0.
        2. Extract account_number A#
        3. Select account where account_number=A#;
        4. If(status==true) then:
                a. Request mobile account branch
                    i. M= mobile balance;
                b. Request primary account branch
                    i. P=primary balance;
        5. Else then:
                c. O=account balance;
        6. End if
        7. Return O,M, P;

End
```

Charge transaction: Charging debit mobile with a new balance or adding an amount of balance to exist one.

Charge transaction server process

```
Waiting for a request

Incoming charge request

Begin:

        1. Initialize float db=0.
        2. Extract request message fields:
        3. A#= Account number field value;
        4. charge= debit mobile charge field value;
        5. select account where account number=A#;
        6. if (status ==false ) then
              a. Create mobile account branch (balance=0)
```

```
            b. Create primary balance branch (balance=account balance)
        7. End if
        8. request mobile account branch
            a. mobile balance=mobile balance + charge
            b. last modified date=this.date
            c. last modified time=this.time
        9. request primary account branch
            a. primary balance=primary balance-charge

End
```

Discharge transaction: Remove debit mobile balance.

```
discharge transaction server process

Waiting for a request
Incoming discharge request
Begin:

        1. Initialize float discharge=0
        2. Extract request message fields:
        3. A#= Account number field value
        4. discharge= debit mobile discharge field value;
        5. select account where account number=A#;
        6. remove mobile account branch
        7. remove primary account branch
        8. account balance=account balance + discharge
        9. status=false

End
```

3.3 Soft Cheque

We designed a soft Cheque as the way of transfer money between P2P to be compatible with international general format, and be specialized with banking system of Palestine. The soft Cheque has the three parts: Header, Body, and Tail.

Part.1 The Header which stores the digital certificate of mobile that edited the Cheque (buyer), the size of digital certificate is about 1 KB.

Part.2 The Body, which stores the actual Cheque information and tags and consists of:

- **Bank ID:** which consists of 5 decimal digits, 2 for bank number, and 3 for branch number.

- **Account number:** which consists of 11 decimal digits, 7 for account identification its self in this bank and 4 for account type identification.

- **Cheque number:** which consists of 8 decimal digits.

- **Cash date:** which storing the cash date which is the time stamp of transferring this soft Cheque, using ISO 8601 of year 2004 [18], we choose Calendar date with YYYY-MM-DD format Example: 2003-04-01 represents the first day of April in 2003.

- **Amount:** is used to store the amount of this Cheque**,** because this value can be real number with fraction, a double format will be use. The representation of the specified floating-point value according to the IEEE 754 floating-point [19].

Part.3 The Tail which is used for storing the digest of the Body content for security issues.

3.4 Security

Our proposed debit mobile system is a form of two types of debit system: online debit system for banking service part, and offline debit system for payment part.

Offline debit system

In many payment situations no connection to bank server or to trusted third party is available to approve the soft Cheque. So offline debit system is used, we choose the digital certificate as an offline debit system technology.

A certificate is a piece of information that proves the identity of a public-key's owner. Like a passport, a certificate provides recognized proof of a person's (or entity) identity. Certificates are signed and delivered securely by a trusted third party entity called a Certificate Authority (CA) [21, 22, 23].

Our CA is the organization itself, each mobile application is distributed by the organization must be signed. Mobile debit which installed on a customer's mobile phone is a J2ME MIDlet. A MIDlet is an application that uses the Mobile Information Device Profile (MIDP) of the Connected Limited Device Configuration (CLDC) for the Java ME environment [20].

To sign a MIDlet, we must have sun java 2 SDK or JRE, and sun wireless tool kit (WKT), the sign scenario is a three necessary steps:

1. Generate public/private key pairs
2. Generate Certificate Signing Request (CSR) and submit it to CA
3. Sign the MIDLet with the certificate

Now the debit mobile contains a certificate that signed from CA organization 's server, this certificate will be included in each soft Cheque that is generated from a debit mobile. This certificate which signed from our organization contains many fields like:

1. Mobile IEMI.

2. Mobile public key.
3. The certificate start date.
4. The certificate expire date.
5. The organization CA’s signature of this certificate (the organization encrypts the customer’s certificate digest with its primary key).

To be sure, the certificate of a debit mobile is not altered, it is digested using a hash algorithm [24, 25, 26, 27, 28, 29], and this digest is encrypted with an organization’s private key, which corresponding public key is available to all debit mobile, by an authorization security mode on Bluetooth device, a device can request remote mobile’s IEMI .

The certificate validation process contains:

1. Validity period of the certificate.
2. The certificate ownership using IEMI match.
3. The certificate has been signed with CA organization’s server.
4. The certificate has not been altered using digest technique.

So consider a scenario where a buyer wants transfer a soft Cheque to s seller’s debit mobile, to secure transfer the two debit mobiles must use link level enforced security mode. Buyer asks to get seller’s certificate CerS, after receiving it, he requests the seller’s IEMI (S_IEMI) and processes previous four steps of verification process, after validation is completed successfully, he creates the Body of soft Cheque data (see section 3.2) then the buyer digests the soft Cheque to create SCDigest=$[\text{soft Cheque}]_{hash}$ and signs it with his private key prkB and inserts encrypted digest $[\text{SCDigest}]_{prkB}$ at the Tail of soft Cheque , after that he appends his certificate CerB at the Header of soft Cheque, buyer’s debit mobile sends soft Cheque to seller’s debit mobile.

Seller receives the soft Cheque, after that he extracts the buyer’s certificate and the original soft Cheque digest SDigest and compare it with the digest of received soft Cheque to ensure that the soft Cheque was not altered. The CerB is verified too with validation process, the next sequence diagram (figure 3.4) shows briefly this scenario.

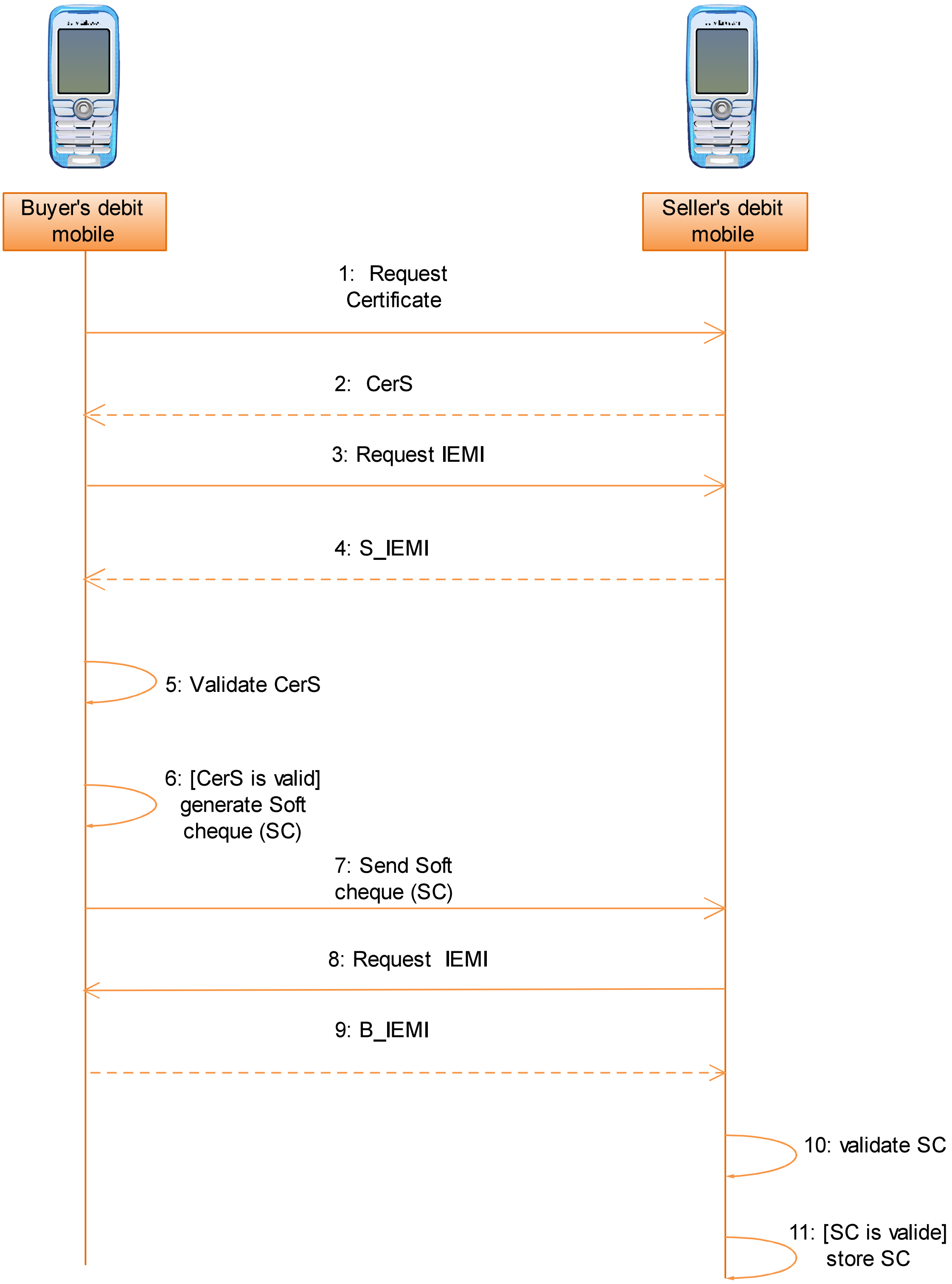


Figure (3.4): Transfer soft Cheque scenario.

In the same way the certifications is validate between customer's debit mobile and bank server in cash Cheque transaction, when hand checking is completed, the soft Cheque SC is accepted and received on bank server side, because the soft Cheque editor (Buyer's debit mobile) is a member of bank's customers, the bank server extracts IEMI code and account number from received soft Cheque certificate, compare them with data stored in its mobile information database.

3.5 Speaker verification system

A speaker recognition/verification process consists two main steps: features extraction, and features matching.

Feature extraction: is a special form of dimensionality reduction, in other words convert the speech waveform to some type of parametric representation [30].

To select the proper one algorithm for feature extraction, we search about a one that can be implemented effectively to work on a mobile device. The mobile phone is a personal device, so we need to develop a speaker verification rather than a speaker identification, because the last one needs more computation and size to store all data speakers[30], note that we will develop a system for speaker verification works completely on mobile device.

In another hand we choose our system to be text-independent rather than text-dependent, which gives more flexibility and user is not forced to remember a phrase[31]. Any speaker verification system is a closed-set since all speakers are known.

In digital processing of speech signals there are many algorithms developed for feature extraction purpose like: Linear Prediction Coding (LPC) [32], Mel frequency Cepstral Coefficients (MFCCs) [33], Perceptual Linear Prediction (PLP) [34].

There are attributes must be in the extracted features to be considered desirable for speaker recognition automatic system [35] as:

- Occur naturally and frequently in speech
- Easily measurable
- Not change over time or be affected by speaker's health
- Not be affected by reasonable background noise nor depend on specific transmission characteristics
- Not be subject to mimicry

For more than three decades the MFCC algorithm is the popular one for extract speaker features[36][37][38] and became a standard algorithm for this purpose especially for mobile devices as The European Telecommunications Standards Institute (ETSI). All of these reasons motive us to choose MFCCs algorithm for extracting speech signal features. MFCCs as the most spectrum techniques is the most effective in automatic speaker recognition system.

MFCC algorithm has a processor which is shown in following block diagram (figure 3.5), which consists of following steps:

- Frame blocking
- Windowing using hamming window
- Discrete Fourier transform using Radix-4 Fast Fourier transform (FFT)
- Mel-frequency wrapping by Mel frequency spaced filter banks
- Cepstral Coefficients

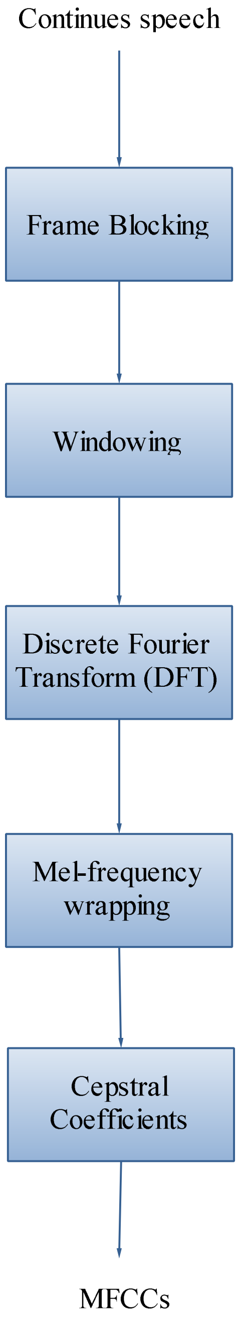


Figure (3.5): MFCC processor block diagram.

Features clustering: we successfully extracted 18 MFCC features, which means hundreds of records with 18 attributes, this stills a lot of data, but by adding additional block in speaker verification system we can reduce the amount of data by clustering it, this means increasing in insert voice print process time (training) that happens once when deploying and installing the application on mobile device versus decreasing in login process time (testing) that happens each time a user start the application.

To clustering MFCCs features we compress them by Vector Quantization VQ technique which is effective and shown high performance in speaker recognition field [39]. To implement the VQ technique we are using Linde, Y., Buzo A., Gray, R. M (LBG) algorithm [40], which is shown in figure 3.6.

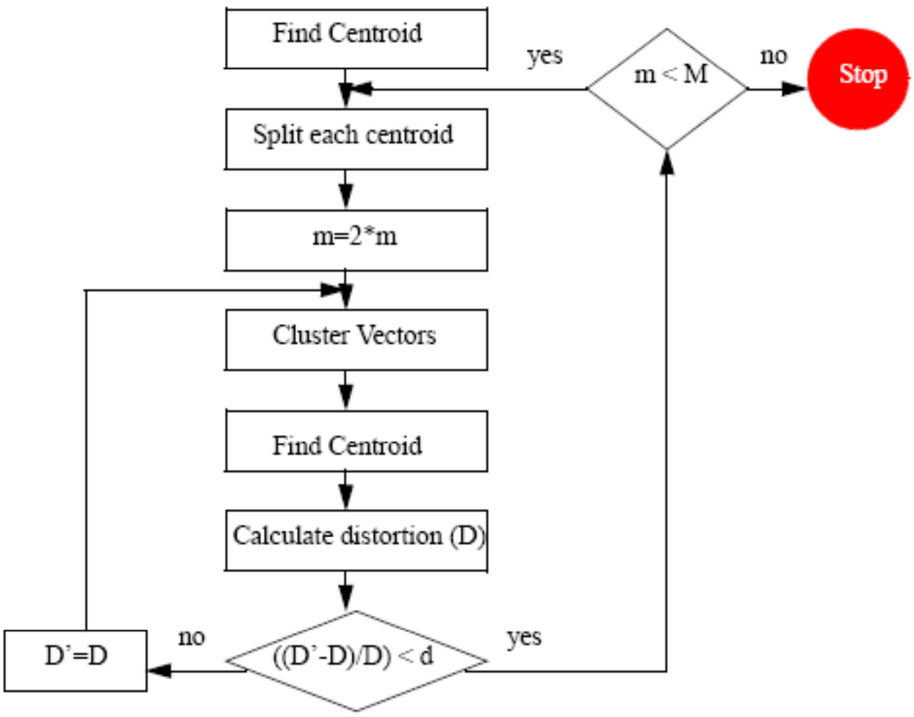


Figure (3.6): LBG algorithm flow chart diagram.

Features matching: when a user login to the application his speech's features compared with stored features that clustered using LBG algorithm, in fact the features matching is the verification part, where MFCCs of claimant speaker compared with clustering vectors that forms the only model stored on mobile phone.

The verification task is a statistical hypothesis testing [41] problem that can be formulated as follows. Suppose that the unknown speaker produced an utterance **X** and claims to be a person **S**. The two opposite hypotheses are:

$$\begin{cases} H_0 : & X \text{ was produced by } S \\ H_1 : & X \text{ was not produced by } S, \end{cases} \qquad \textbf{((3.1))}$$

and the verification engine must choose one of them to be true.

Suppose for a given moment of the time that the likelihoods of both hypotheses are known. In this case, the likelihood ratio [42] gives the optimal decision in Bayes sense (minimum risk classification) [42, 43]. The decision rule is then

$$\text{Decide } \begin{cases} H_0\,,\ if\ LR_{H_0\,,H_1}\ >\ \Theta_S \\ H_1\,,\ \ if\ LR_{H_0\,,H_1}\ \leq\ \Theta_S \end{cases} \qquad \textbf{((3.2))}$$

where $LR_{H_0\,,H_1}$ is the ratio of the likelihoods of the two hypotheses, and Θ_S is a decision threshold for speaker *S*. The thresholds Θ_i are determined from the training data so that a desired balance between false acceptances (FA) and false rejections (FR) is obtained. The threshold can be global for all speakers, or it can be speaker-depended [44].

The data for speaker verification is obtained in the form of *acoustic feature vectors {**xi**}* extracted from real speech utterances.

In the enrollment phase, a speaker model is trained from the training vectors. In the verification phase, the input utterance is first converted into feature vectors, which are then used for estimating the likelihoods of the two hypotheses H_0 and H_1.

The likelihood of the *null hypothesis* H_0 is estimated by matching the vectors *X* = *{**xi**}* against the claimed speaker's model *S*, which is intuitively reasonable. Suppose that the probability density of the claimant's feature vectors $p(\mathbf{x}|S)$ is known; in this case, the matching is carried out by computing the likelihood $p(X|S)$ under some simplifying assumptions (independence of the test vectors). In reality, due to finite amount of training data, the densities are only estimates of the true underlying distributions.

The estimation of the likelihood of the *alternative hypothesis* H_1 is considerably much harder. Estimating this is equivalent to solving what is the likelihood that *anyone else in the world* (except *S*) produced *X*. In speaker recognition community, there have emerged two main approaches for modeling the alternative hypothesis [45], so-called *world model* and *cohort model* approaches.

The world model *W* (*background model*, *universal background model*, *global speaker model*) is a large model that aims characterizing all possible speakers and speaking contexts of the "world". It is trained from a large amount (several hours) of speech data from a variety of speakers. Estimating the likelihood of H_1 then translates simply to computing the likelihood $p(X|W)$ similarly as with the client model.

The second approach for estimating the likelihood of H_1 uses the concept of *cohort models* [46]. Rather than modeling the whole world, cohort approach uses a small representative set of models, called *cohort set*. Individual cohort models' scores are obtained and combined e.g. by averaging.

We use in our verification system a threshold distance, that if feature vectors (user model) are close enough to that features belong to claimed speaker, close less than a given threshold then claimed speaker is accepted else is rejected.

We use Euclidean distance as a distance measurement, and averaging cohort set concept, we have the following equation, where n the size of cohort set, Eucdistance$_{\text{claimant}}$ is the distance between speaker model and that extracted from claimant, and EucDistance$_{\text{cohort(i)}}$ is the distance between speaker model and i$^{\text{th}}$ cohort speaker model.

$$Ratio = \left[\frac{EucDistance^2_{claimant}}{\frac{1}{n}\sum_{i=1}^{n} EucDistance_{cohort(i)}}\right]^4 \qquad ((3.3))$$

So if this ratio is less than a given threshold, then claimant speaker is accepted, else he is rejected.

3.6 System requirements specification (SRS)

The use case of our system as shown in figure 3.7, one actor named mobile user, any use case needs a bank connection includes validate PIN, and Synchronize balance.

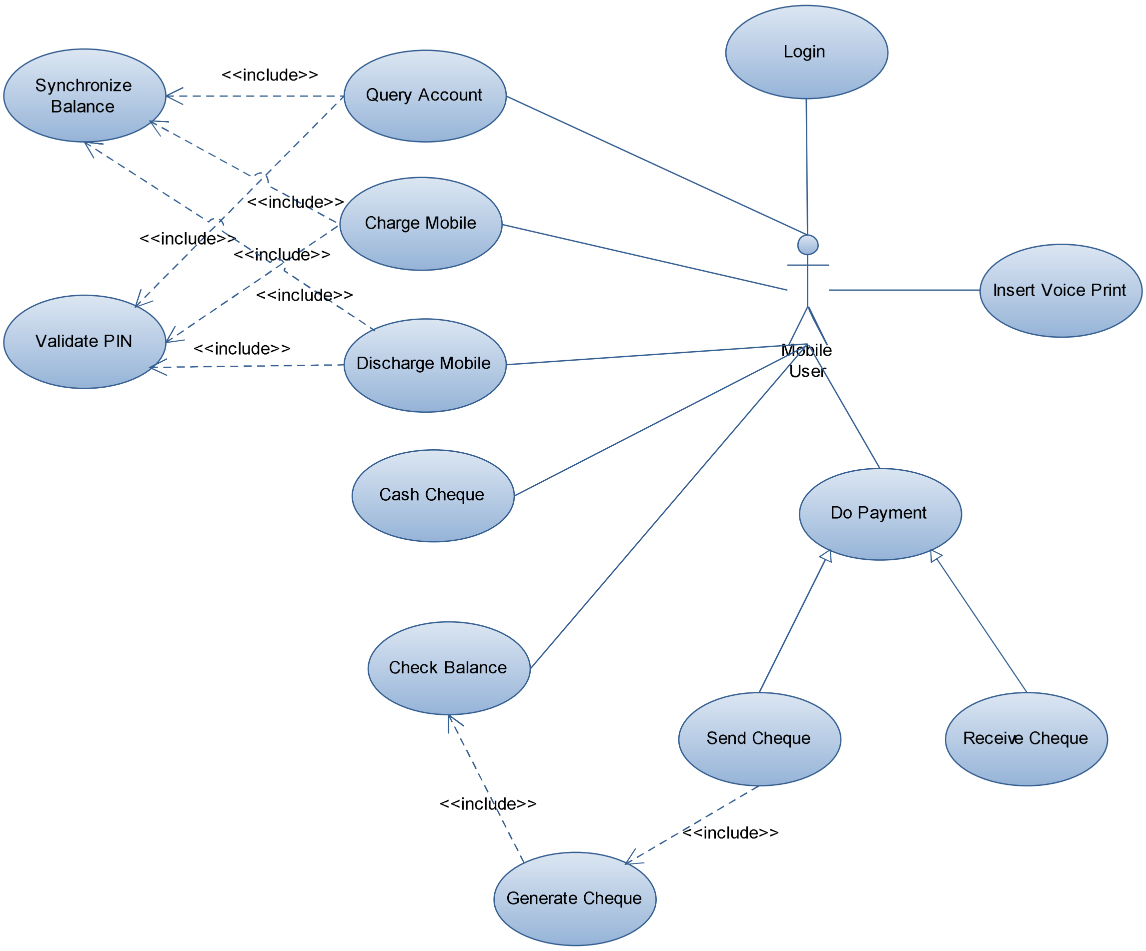


Figure (3.7): Banking and payment application use case diagram.

Table (3.1): Insert voice print use case description.

USE CASE #	A.1	
USE CASE Name	Insert Voice Print	
ACTOR	Mobile User	
Purpose	Inserting a voice print of mobile user as speaker model	
Overview and scope	When the Organization installs the system into a customer’s mobile phone, and user begins using it the system requires inserting a voice print.	
Level	Primary	
Preconditions		
Postconditions	After speaker model is stored then system restarts .	
Trigger	User start mobile banking and payment application for first time	
Included Use Cases	Non	
Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User run the application.	
		2. System records the background noise for 2 seconds and the power of this data is calculated. After that system prompts user to speak.
	3. User speaks with high voice.	
		4. After about 8 seconds, system calculates the power of real speaker data, if this power is greater than the noise power, the system extracts speech’s features and clustering them as code book.
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	The speech power is low	Prompt user to speak with higher voice
Frequency	One time when deploying the application	

Table (3.2): Login use case description.

USE CASE #	A.2	
USE CASE Name	Login	
ACTOR	Mobile User	
Purpose	Authenticate to mobile banking and payment system	
Overview and scope	Mobile user using his voice as biometric authentication, using speaker verification techniques.	
Level	Primary	
Preconditions	User voice print must be stored in mobile application	
Postconditions	After user was verified, system loads main menu	
Trigger	User start mobile banking and payment application	
Included Use Cases	non	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User run the application.	
		2. System records the background noise for 2 seconds and the power of this data is calculated. After that system prompts user to speak.
	3. User speaks with high voice.	
		4. After about 6 seconds, system calculates the power of real speaker data, if this power is greater than the noise power, the system compares the characteristics of speaker data with recorded voice print if close to it, speaker verified and main menu is loaded.
UNSUCCESSFUL	**Conditions**	**Actions**

SCENARIOS	The speech power is low	Prompt user to speak with higher voice
	The speaker is not verified(less than 4 times)	Prompt user to try again
	The speaker is not verified for 4 times	The application is blocked
Frequency	Each time the application is started	

Remainders use cases descriptions are in Appendix A : System requirement Specification

Chapter 4

SYSTEM ANALYSIS MODEL

4.1 Static model

In software engineering static model describes the static structural of system, that reflects the problem domain [47]. In static model we use class diagram concept [48] to define class's attributes and relations between them later in section 5.4 Class design we will define the operations for each class, class diagram build on UML is a powerful tool for detailed description [49, 50].

4.1.1 static modeling of the problem domain

In real world there is an organization responsible of manage all banks and distribute this modeled system, each bank has a group of mobile accounts, each mobile owns by one customer, which has an account in the corresponding bank, and one customer can has more than one a mobile device, the physical mobile phone is a composition of a lot devices like: Screen, keypad, Mobile User GUI, Bluetooth adapter, WIFI adapter and Microphone. (See figure 4.1)

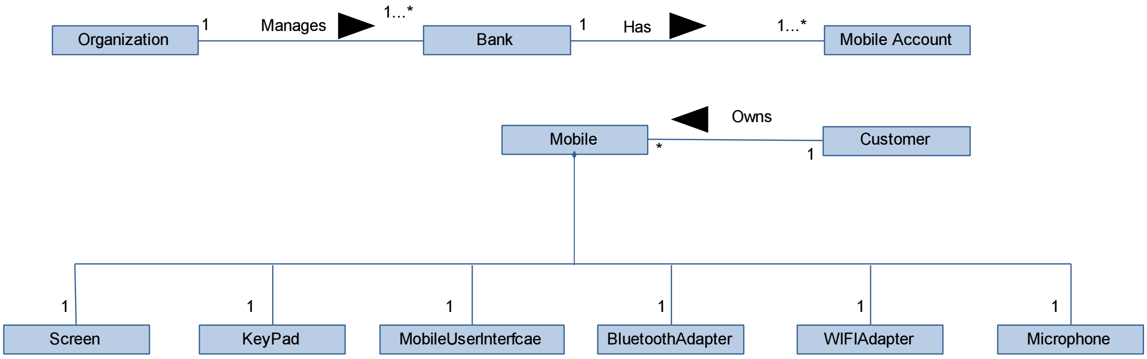
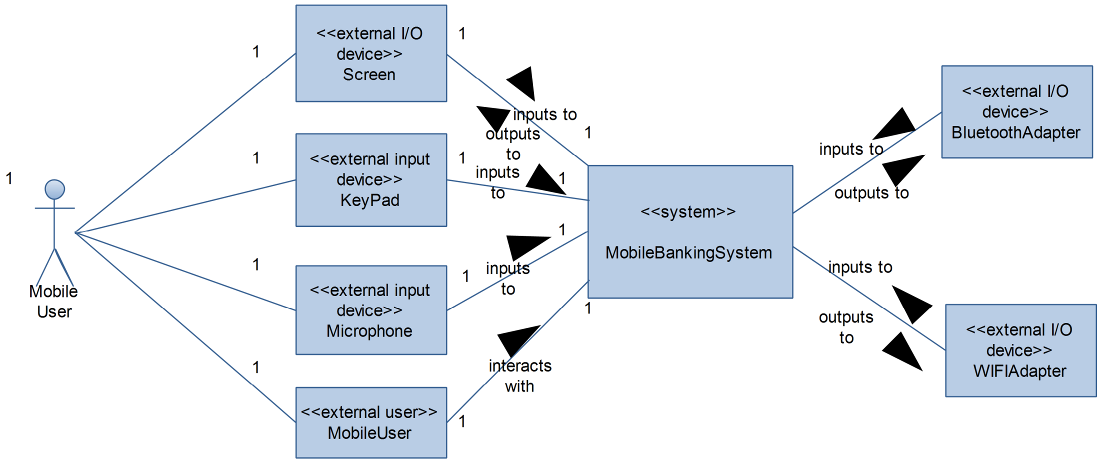


Figure (4.1): Conceptual static model for the problem domain: physical classes

4.1.2 Static modeling of the system context

Problem Context Diagram is a diagram that structures the world into the system domain, and the problem domain (which includes problem sub domains), and shows how they are connected. It is not limited to the parts of the world that are directly connected to the system. A problem context diagram shows what the real world will be when the system is running [51, 52, 53].

In figure 4.2 a mobile user interacts with Mobile Banking system via: a touchscreen as input / output device which a new and a popular technology in mobile industry, keypad, microphone and mobile user GUI. The system communicate with others systems via Bluetooth and WIFI channels.



<<external I/O device>> Screen
<<external input device>> KeyPad
<<external input device>> Microphone
<<external user>> MobileUser
<<system>> MobileBankingSystem
<<external I/O device>> BluetoothAdapter
<<external I/O device>> WIFIAdapter
Mobile User
1
inputs to
outputs to
inputs to
inputs to
interacts with
inputs to
outputs to
inputs to
outputs to

Figure (4.2): Mobile Banking System context class diagram

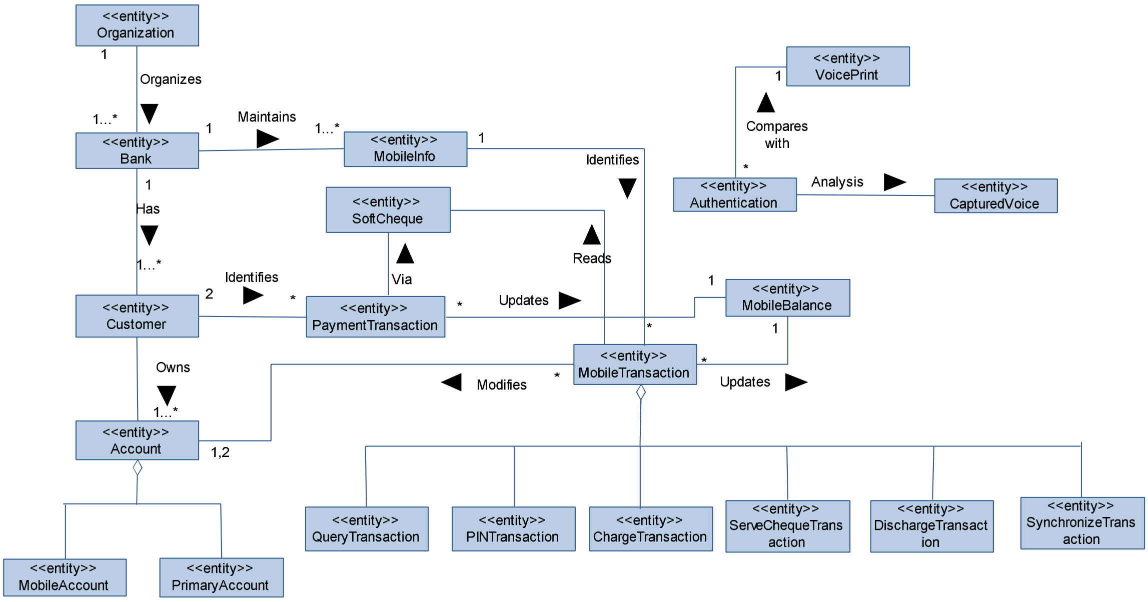


Figure (4.3): Conceptual static model for the problem domain: entity classes

4.1.3 Static modeling of the entity classes

In figure 4.3 the Organization organizes many banks, each bank maintains information about many mobiles, also each bank has many customers, for each one there is an account which is an aggregation from primary account and mobile account, mobile info is an entity identifies all mobile transaction which a collective aggregation from many transactions as shown in figure 4.3, customer identifies payment transaction which has soft Cheque entity as backbone, to complete payment process mobile phone holds mobile balance as soft credit using in generating soft Cheque.

Voice print is stored at system installation and deployment on user's mobile phone, after that it is using in login process by authentication, authentication analysis captured voice to extract human speech features and then compared them with stored voice print.

The figure 4.4 contains entity classes with attributes, for example organization has: organization name as string attribute, organization address and organization ID.

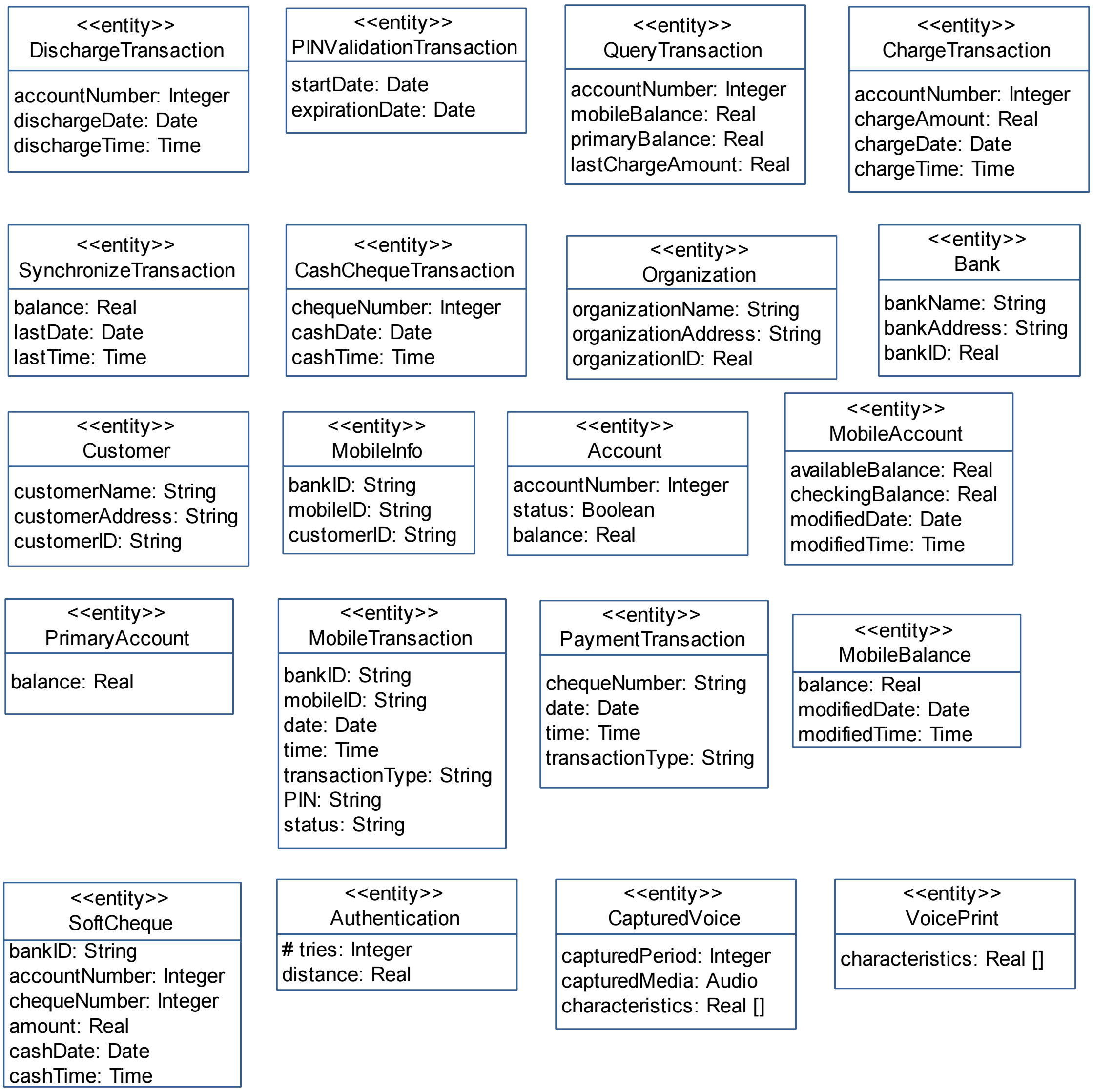


Figure (4.4): Conceptual static model for the Mobile Banking system: class attributes

4.2 Object structuring

4.2.1 Major subsystem

In system requirement specification we defined a lot of use cases, part of them needs user to enter PIN code, and needs a connection to bank server , we can group these use cases in a subsystem called mobile client subsystem with client stereotype, second part needs another identical peer to transfer data and complete payment process, so these use cases can be grouped in second subsystem called payment subsystem with peer stereotype, third part stands alone, and these use cases needs no more its self-machine to complete its scenario these are: insert voice print and login use cases, which we grouped them in third software subsystem called authentication with shortly DSP stereotype. The last subsystem is a service subsystem called mobile banking service subsystem which is necessary to complete mobile transactions and cash Cheque transaction, the structure of these subsystems is shown in figure 4.5 .

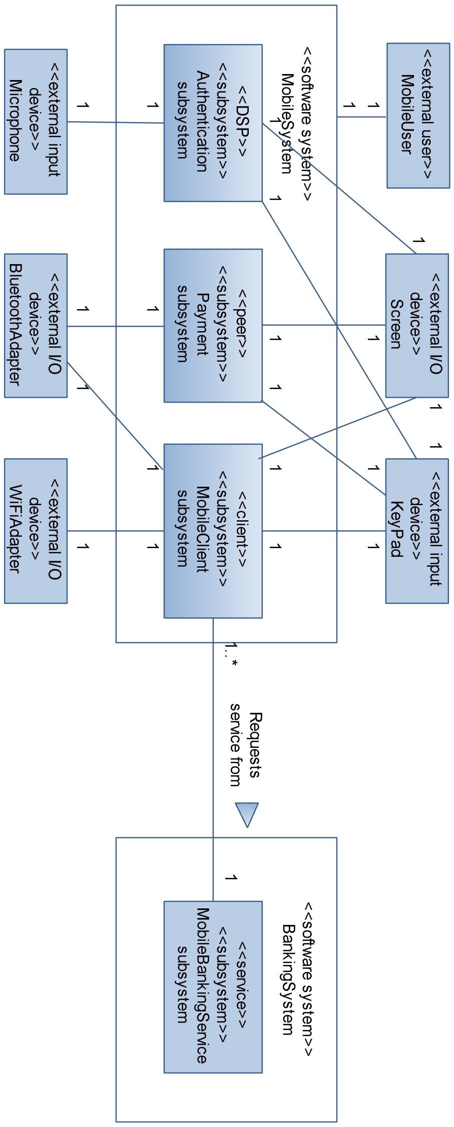


Figure (4.5): Mobile Banking system: major subsystem

It is good to packaging use cases according the functionality of each subsystem, figure 4.6 shows a subsystem for example authentication includes insert voice print, and login use cases, and the figure also shows the relations between use cases in deferent subsystem.

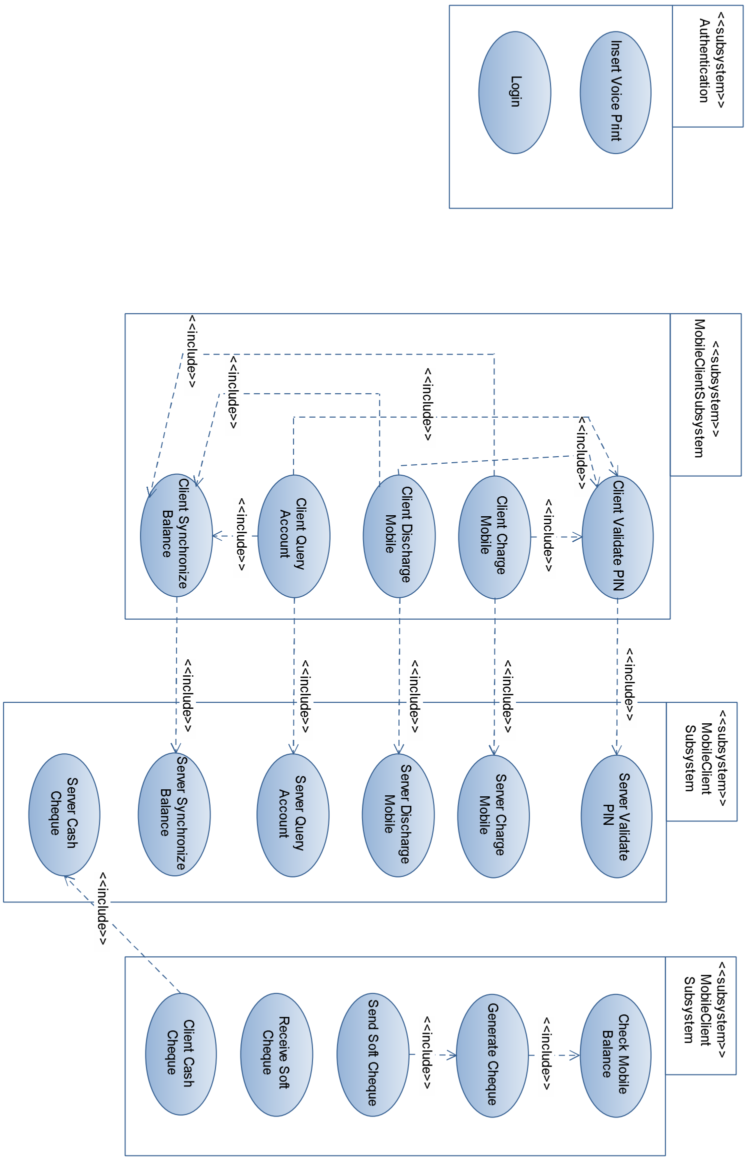


Figure (4.6): subsystem packaging of use cases

4.2.2 Mobile subsystems object structuring: interface objects

The figure 4.7 briefly describes Mobile System external and boundary classes, our mobile system interacts with the world with input/output devices like: keypad, screen and others, and communicates with user via Mobile User Interaction object

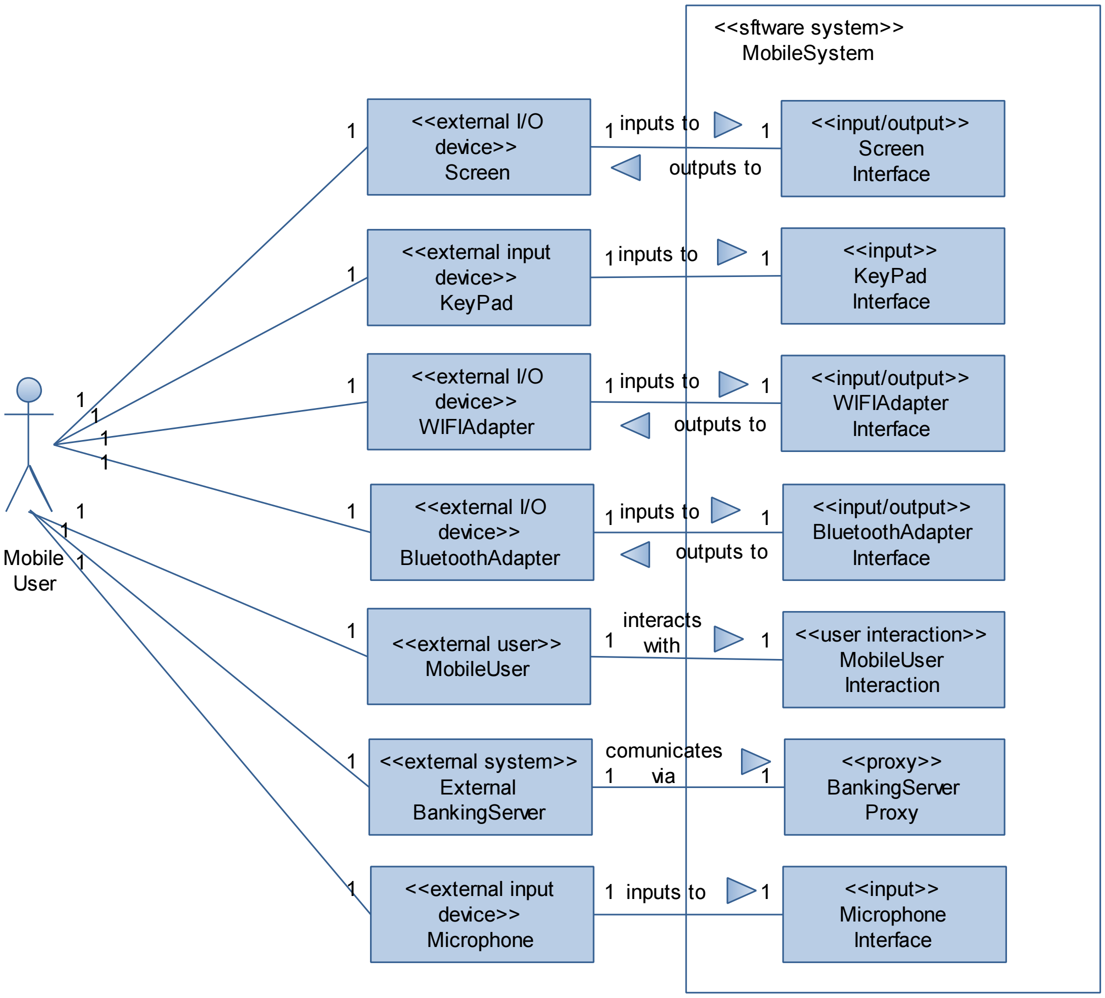

<<sftware system>>
MobileSystem
Mobile User
<<external I/O device>> Screen
inputs to
outputs to
<<input/output>> Screen Interface
<<external input device>> KeyPad
inputs to
<<input>> KeyPad Interface
<<external I/O device>> WIFIAdapter
inputs to
outputs to
<<input/output>> WIFIAdapter Interface
<<external I/O device>> BluetoothAdapter
inputs to
outputs to
<<input/output>> BluetoothAdapter Interface
<<external user>> MobileUser
interacts with
<<user interaction>> MobileUser Interaction
<<external system>> External BankingServer
comunicates via
<<proxy>> BankingServer Proxy
<<external input device>> Microphone
inputs to
<<input>> Microphone Interface
1

Figure (4.7): Mobile subsystems external classes and interface classes

4.2.3 Mobile Client subsystem object structuring: objects in use cases

Given the preceding analysis, figure 4.8 shows the classes in Mobile Client subsystem which are necessary for use cases accomplish. Mobile Client control object is a state dependent control, which controls the execution of all business logics in use cases.

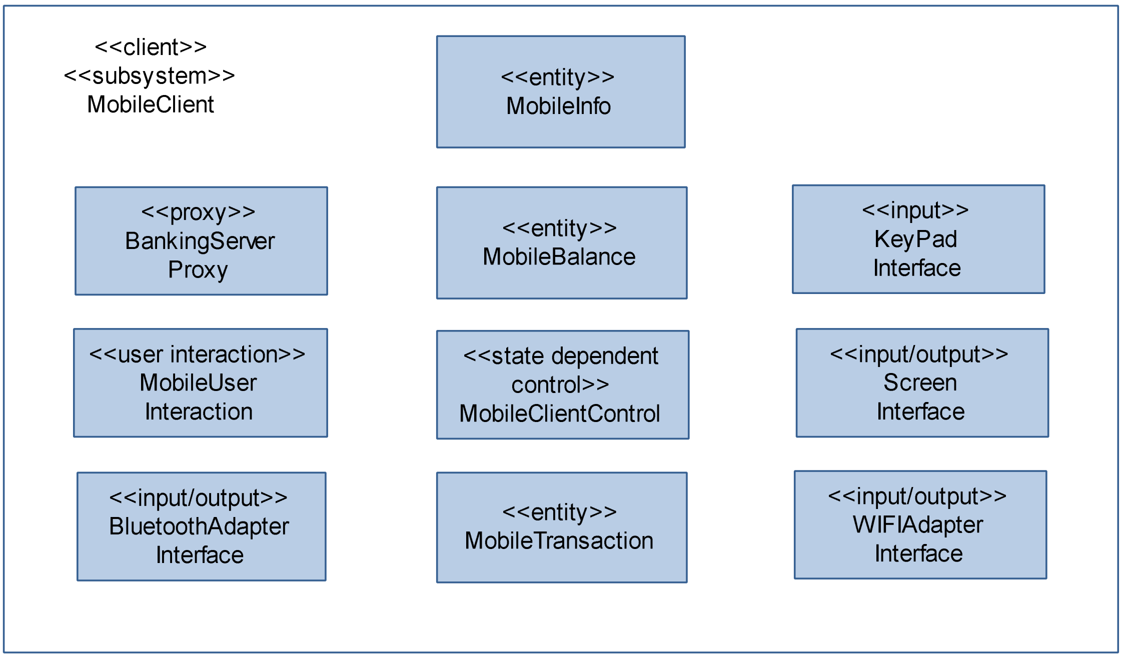


Figure (4.8): Mobile client subsystem classes

4.2.4 payment subsystem object structuring: objects in use cases

Given the preceding analysis, figure 4.9 shows the classes in Payment subsystem which are necessary for use cases accomplish.

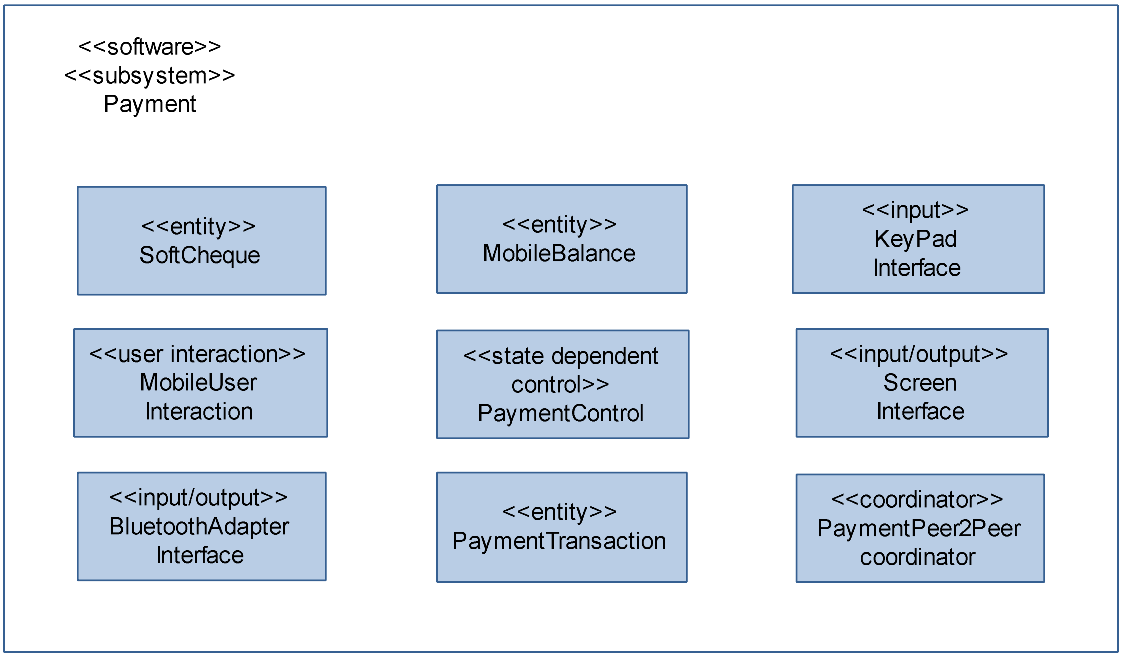
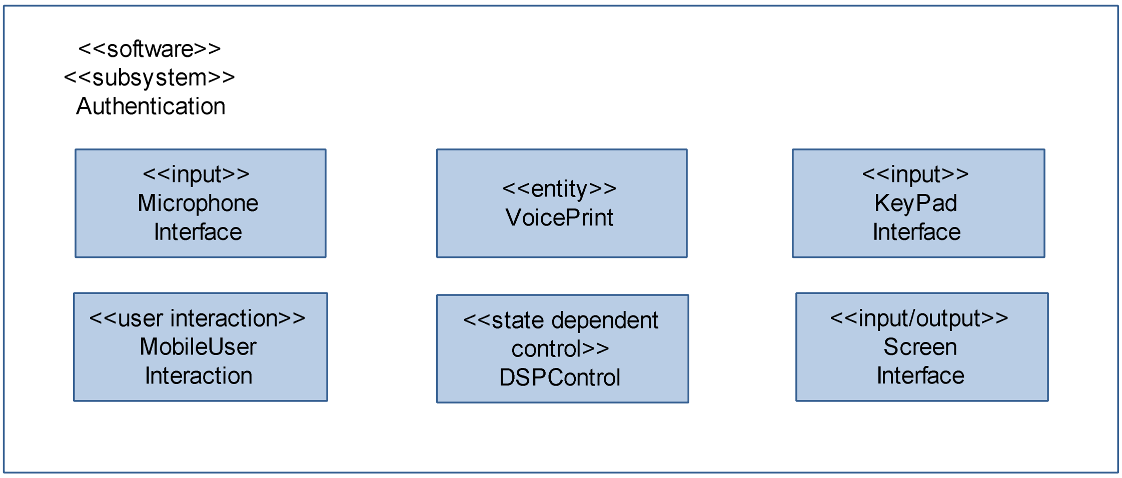


Figure (4.9): Payment subsystem classes

4.2.5 Authentication subsystem object structuring: objects in use cases

Given the preceding analysis, figure 4.10 shows the classes in Authentication subsystem which are necessary for use cases accomplish.



<<software>>
<<subsystem>>
Authentication
<<input>> Microphone Interface
<<entity>> VoicePrint
<<input>> KeyPad Interface
<<user interaction>> MobileUser Interaction
<<state dependent control>> DSPControl
<<input/output>> Screen Interface

Figure (4.10): Authentication subsystem classes

4.2.6 Banking server subsystem object structuring

Several entity objects are in bank server subsystem, and need to be accessible from any mobile which its info resides in mobile information server, but the most entities like: Customer, Account, Mobile Account and others stored in M-Commerce server.

Business logic objects at the server are needed to define the business specific application logic for processing client requests like Mobile Transactions objects.

4.3 Dynamic Modeling

4.3.1 Message sequence description for create voice print use case

The create voice print use case happens at first time when application just has been deployed, first DSP control object received a request that start test environment, then DSP control notifies microphone interface to capture noise, then microphone interface prompts microphone to start record about 2 seconds, input interface for microphone device keeps recorded stream on entity Captured Voice.

DSP Control object requests Power Estimation algorithm object which is responsible of estimating the signal’s power, after Power estimation returned power value to DSP control object DSP update threshold Power value to 1.5 times the noise power value, and the last object sends talk message to user interaction object Mobile User Interaction that prompts user to press start talk button and immediately begin speak, microphone start again recording and after 8 seconds stop.

As previous DSP control redirect recorded stream that was stored on Captured voice entity object to Power Estimation algorithm object, after calculating power DSP checks if human speech signal has enough power higher than threshold Power value, if no DSP object sends talk again with higher voice to Mobile User Interaction object which prompts user to speak again with higher voice, and again microphone records the speech and the signal's power is calculated.

when the power is enough, DSP object redirects spectrum signal to MFCC Processor algorithm object, MFCC Processor object extracts MFCC features of signal and returns them to DSP control object, now is the turn of VQ algorithm object to cluster MFCC data to reduce its size, after successfully generating code book DSP object stores the code book as Voice Print entity. (See figure 4.11).

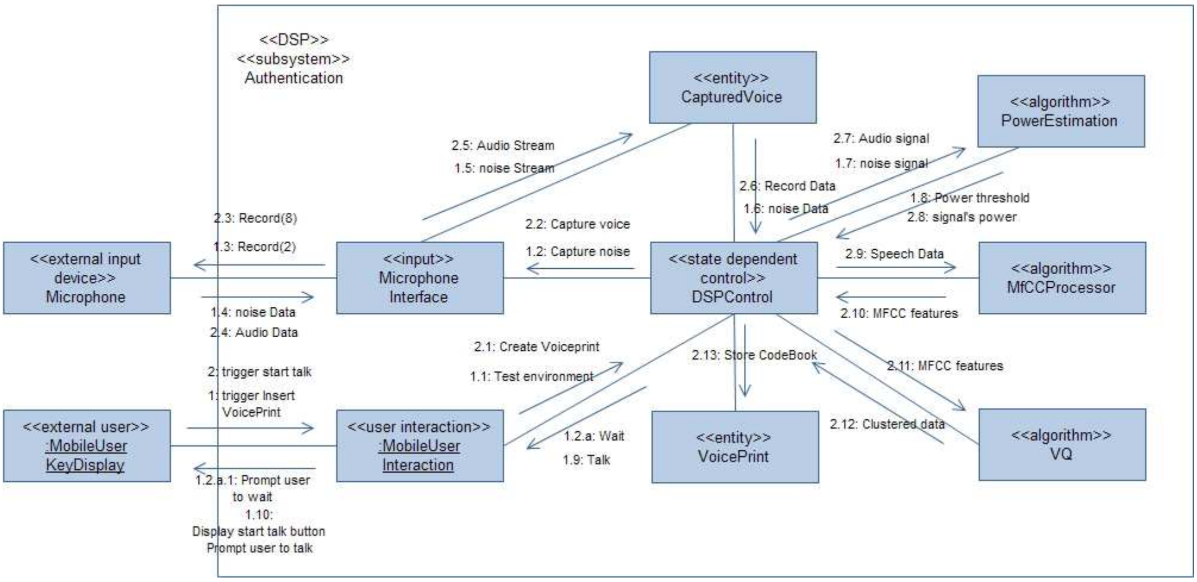


Figure (4.11): collaboration diagram: Create voice print use case

4.3.2 Message sequence description for Login use case

The Login use case happens each time application is launched, first DSP control object received a request that start test environment, then DSP control notifies microphone interface to capture noise, then microphone interface prompts microphone to start record about 2 seconds, input interface for microphone device keeps recorded stream on entity Captured Voice.

DSP Control object requests Power Estimation algorithm object which is responsible of manipulate signal to spectrum one and estimate power of it, after Power estimation returned power value to DSP control object DSP update threshold Power value to 1.5 times the noise power value, and the last object sends talk message to user interaction object Mobile User Interaction that prompts user to press start talk button and immediately begin speak, microphone start again recording and after 6 seconds stop, as previous DSP control redirect recorded stream that was stored on Captured voice entity object to Power Estimation algorithm object.

After calculating power DSP checks if human speech signal has enough power higher than threshold Power value, if no DSP object sends talk again with higher voice message to Mobile User Interaction object which prompts user to speak again with higher voice, and again microphone records the speech and the signal's power is calculated.

when the power is enough, DSP object redirects spectrum signal to MFCC Processor algorithm object, MFCC Processor object extracts MFCC features of signal and returns them to DSP control object, DSP Control object requests EU Distance algorithm object to calculate the ratio, EU Distance algorithm object receives MFCC features from DSP object and using data stored in entity objects Voice Print and Cohort Speaker to complete calculating ratio process.

when EU distance object finished returns the ratio value to DSP Control object, DSP object check if the received ratio less than the threshold Distance if no notifies speaker that his voice has been not recognized and prompts user to speak again after three unsuccessfully login the application is blocked, if the calculated ratio is less than threshold Distance value the user successfully login and the main menu will be appeared. (See figure 4.12).

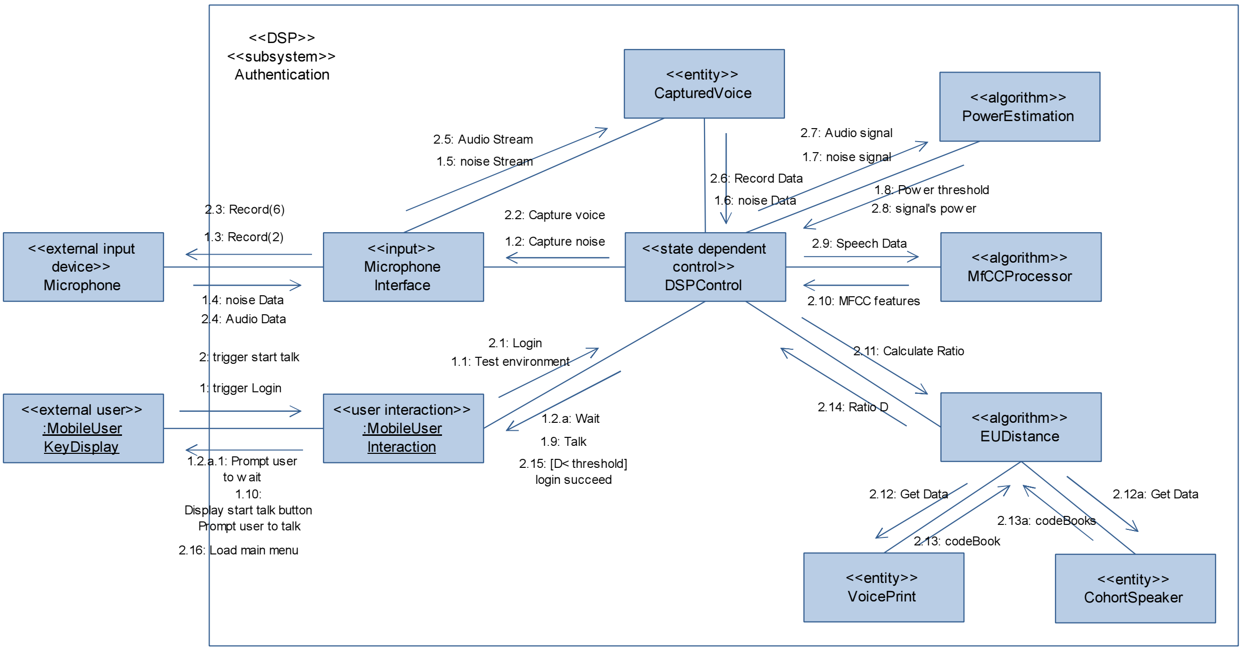


Figure (4.12): Collaboration diagram: Login use case

4.3.3 Message sequence description for Mobile client: Validate PIN use case

The client validate PIN use case starts when mobile user chooses bank option from main menu, first the Mobile Client Control object sends Get PIN message to Mobile User Interaction (message 1.1) which prompts user to insert PIN (message 1.2).

Mobile User Interaction receives PIN(message 2) and redirects it to Control object (message 2.1) which requests Mobile Info entity object (message 2.2) and gets Mobile ID (message 2.3), then the Control object sends PIN and Mobile ID data to Mobile Transaction entity object (message 2.4), then the last entity creates PIN validation transaction and sends it to Mobile Client Control object (message 2.5), then the Control requests Banking Server Proxy object which is a Software object that interfaces to and communicates with an external system or subsystem, and hides the details of "how" to communicate with the external system (message 2.6), communicates with external subsystem Mobile Banking Service and gets result which contains validity tag if PIN is correct or not, if correct Mobile Banking Service reply with Account number, then the proxy reply to Mobile control with result (message 2.7) as shown in figure 4.13.

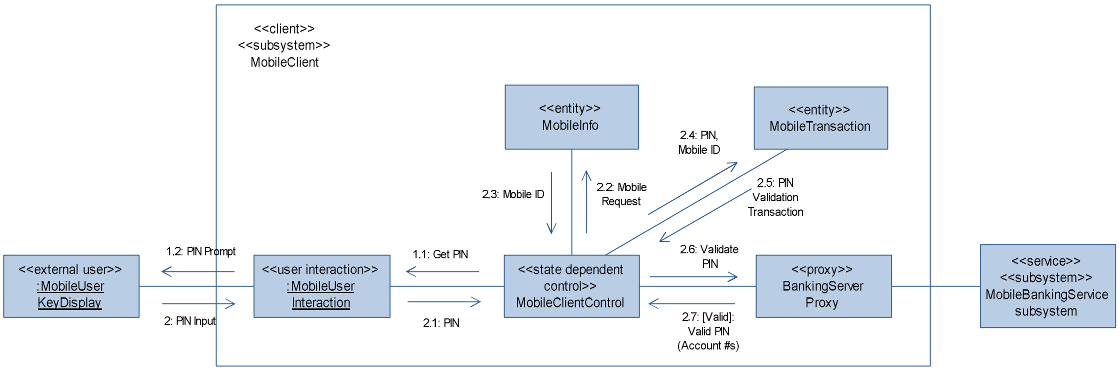


Figure (4.13): Collaboration diagram: Mobile client Validate PIN use case

4.3.4 Message sequence description for Server side: Validate PIN use case

As in ATM system, there is a Debit entity called Debit Mobile entity object that after V1 message which contains Pin validation transaction, the business logic object PIN Validation Transaction Manager extracts fields Mobile Id and PIN and asks Debit Mobile object to Validate this PIN for a corresponding Mobile ID (message V2), if valid PIN Validation Transaction Manager reads Account number from Account entity for a given Mobile ID (messages V4 and V5), in message V6 PIN Validation Transaction Manager records the transaction on Transaction Log entity and reply to Mobile Client (message V7). The figure 4.14 shows the message sequence.

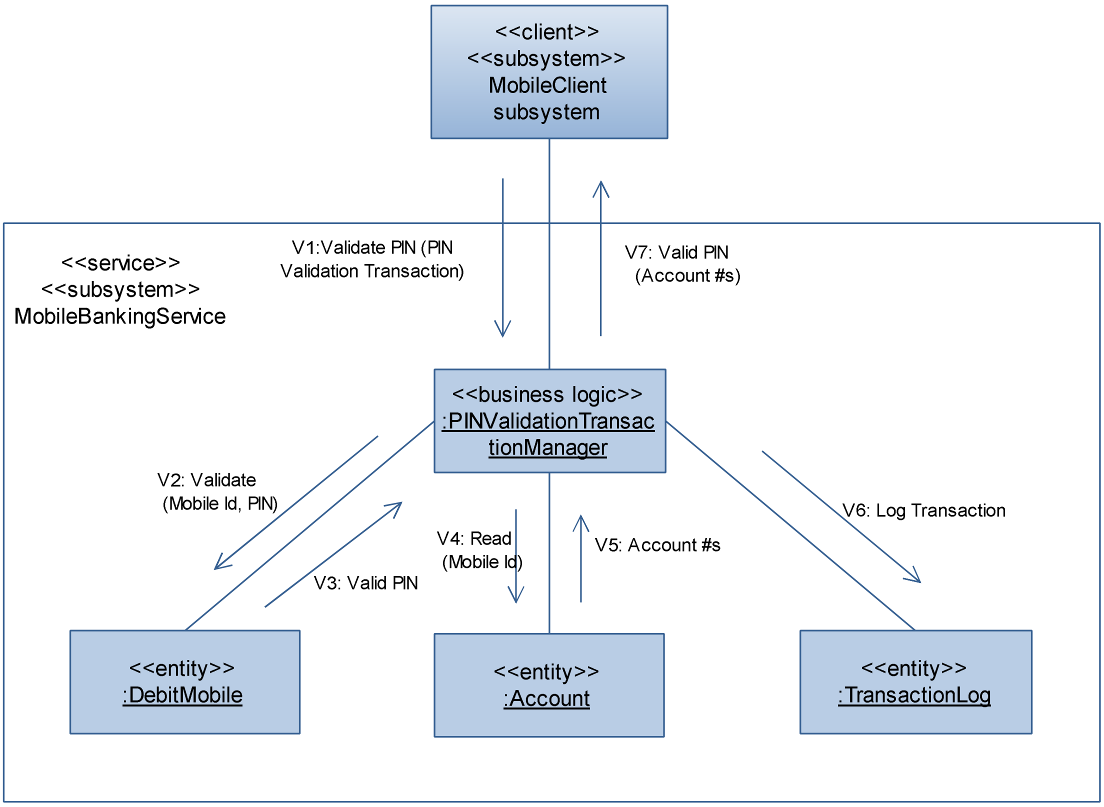


Figure (4.14): Collaboration diagram: Server Side Validate PIN use case

4.3.5 Message sequence description for mobile client: Charge mobile use case

After loading bank menu customer presses charge mobile (message 1), Mobile User Interaction object sends charge option to Mobile Client Control Object (message 1.1) then the control object which Validated PIN previously and get Account Number, this use case includes Synchronize and Query account use cases, so Control Object after Query account to determine if this mobile is already charged if yes the Control object includes synchronize use case, in messages 1.2 and 1.3 Mobile Client Control makes a Query transaction then requests Banking Server Proxy (message 1.4), there are two reply alternative messages (message 1.5 and 1.5A), the tag status is true if and only if a mobile account exists, the tag status is an attribute of Account class on bank server side as mentioned on later subsection.

In the case of status is true then Mobile Client control will extract the primary and mobile balances from reply data and sends them to Mobile User Interaction (message 1.6A), if status is false account balance will be extracted and send to Mobile User

Interaction (message 1.6), and the corresponding data for each case will be appeared on mobile screen and system prompt mobile user to enter the amount of balance to be added or charged (messages 1.7A and 1.7).

In message 2 user enters the amount of balance, then Mobile User Interaction receives it and directs it to Mobile Client Control which requests Mobile transaction entity object to create charge transaction (messages 2.2 and 2.3), concurrently the control object requests Banking Server Proxy and adds amount balance to mobile balance which resides on Mobile Balance entity object (messages 2.4 and 2.4a). As shown in figure 4.15.

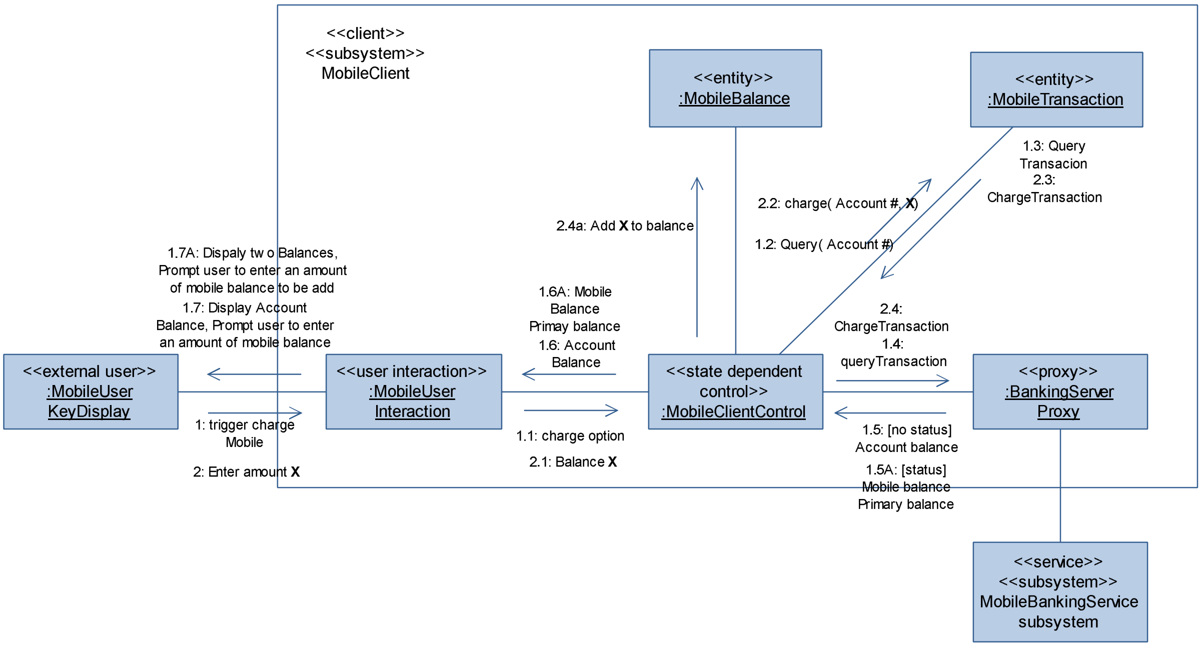


Figure (4.15): Collaboration diagram: Mobile client Charge mobile use case

4.3.6 Message sequence description for Server side: Charge mobile use case

After receiving a Charge Transaction request from a mobile client (message C1), Charge Mobile Transaction Manager object extracts Account number and amount of balance X to be added and invokes charge method of Account entity object, a status Boolean attribute in Account object determines if mobile account exists (true value) using concurrent messages C3A and C3aA or not (false value) using C3 and C3a concurrently, after that Charge Mobile Transaction Manager records the activity on Transaction Log entity object (message C4). After that a C5 confirmation message to mobile client. As shown in figure 4.16.

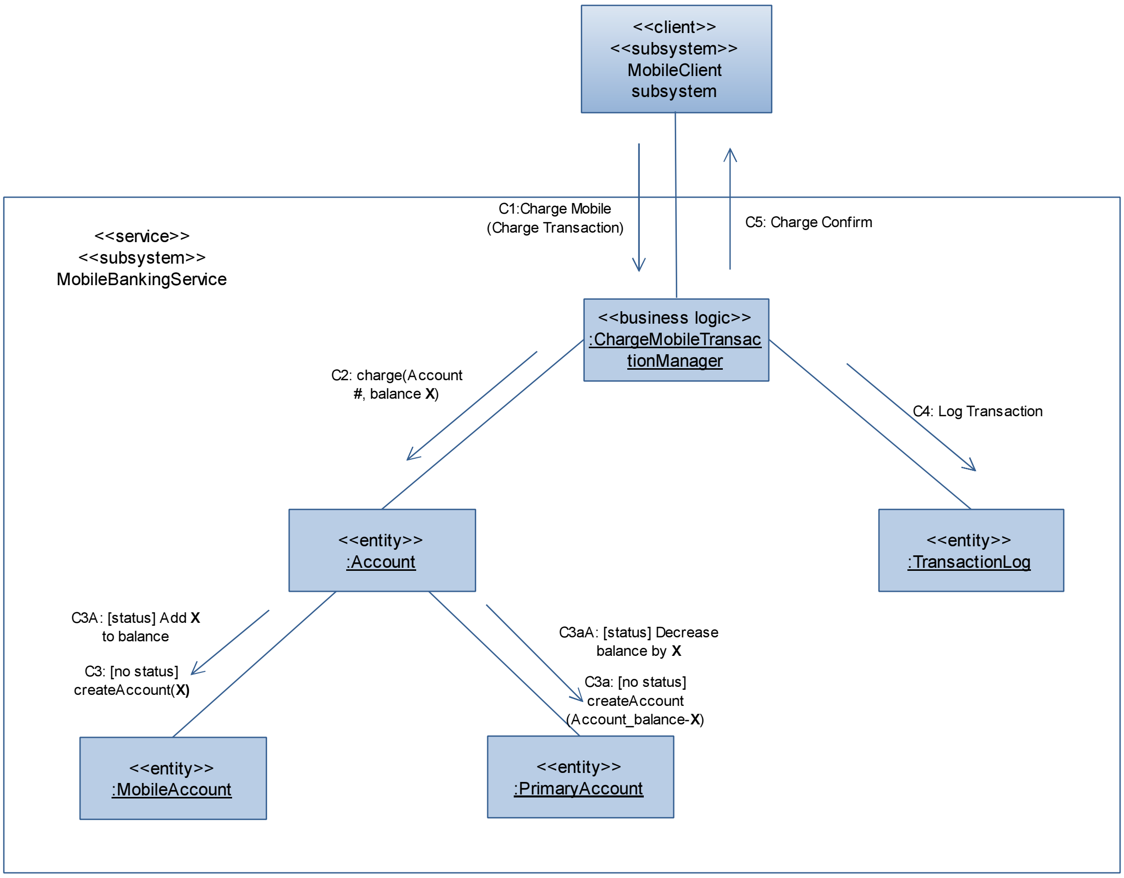


Figure (4.16): Collaboration diagram: Server Side Charge mobile use case

4.3.7 Message sequence description for mobile client: Discharge mobile use case

The abstract use case is shown in figure 4.17, that means the included use cases is not presented here, after mobile user choose discharge mobile option (message 1), Mobile User Interaction sends discharge option to Mobile client control object (message 1.1), then the control object asks an entity object Mobile Transaction to create Discharge Transaction details and receives it (message 1.3), then concurrently the control object sends a discharge transaction request to Banking Server Proxy object (message 1.4) and resets the mobile balance (message 1.4a). as shown in figure 4.17.

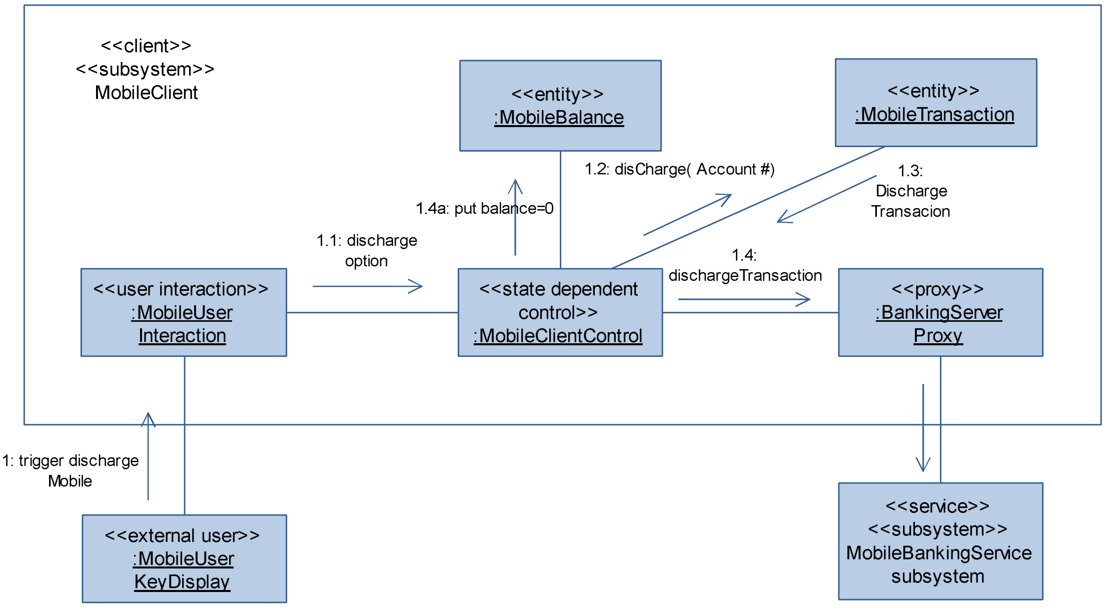


Figure (4.17): Collaboration diagram: Mobile client Discharge mobile use case

4.3.8 Message sequence description for server side: Discharge mobile use case

A Discharge mobile transaction request comes and received by a business logic object Discharge Mobile Transaction Manager (message D1), then the manager invokes discharge method of Account object (message D2), concurrently Account objects reads mobile balance and primary balance (messages D3 and D3a), and receives the two values: X and Y (messages D4 and D4a), the original balance will be stored on Account entity object with value equals to X+Y, and the status Boolean attributes put as false. Later the Database daemon will eliminate corresponding Mobile and Primary Accounts, Discharge Mobile Transaction Manager records the process on Log Transaction (message D6). As shown in figure 4.18.

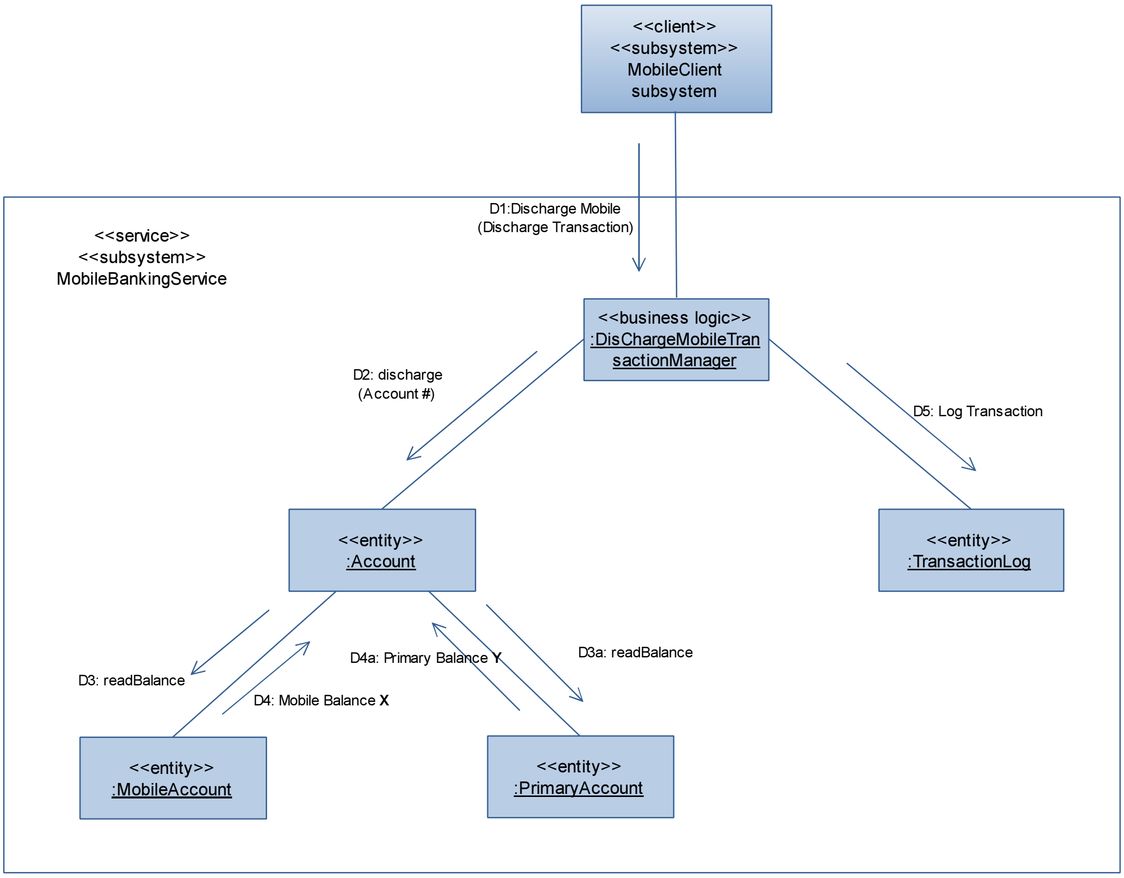


Figure (4.18): Collaboration diagram: Server side Discharge mobile use case

4.3.9 Message sequence description for mobile client: Query account use case

A Query account command comes from client side (message 1.1), the Mobile User Interaction object requests Mobile Client Control object to query the account (message 1.2), the control object asks Mobile Transaction entity object to create Query Account Transaction corresponding to this Account number (messages 1.3 and 1.4), then the control requests the corresponding Banking Server Proxy with Query Account Transaction (message 1.5) and waits reply after receiving reply which contains primary and mobile balances (message 1.8), the control object redirects result to Mobile User Interaction object (message 1.7) and displays it to mobile screen (message 1.8). As shown in figure 4.19.

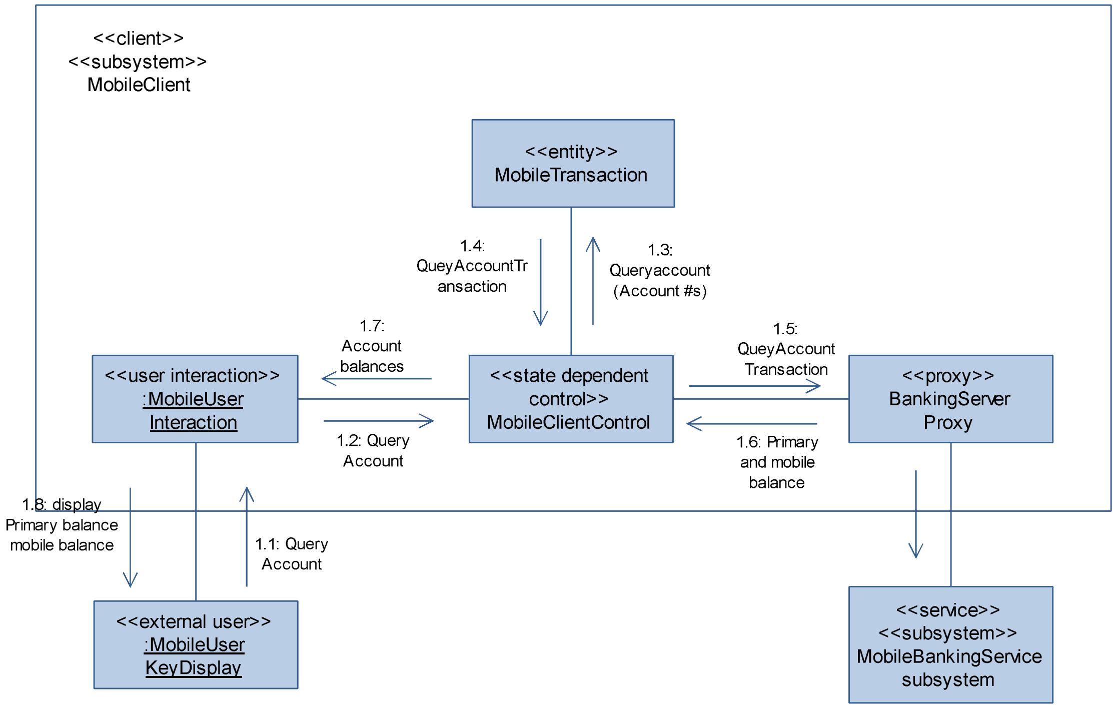


Figure (4.19): Collaboration diagram: Mobile client Query account use case

4.3.10 Message sequence description for Server side: Query account use case

A Query Account Transaction requests received by Query Account Transaction Manager object (message Q1) which extracts Account number field and queries corresponding Account (message Q2), if status is true the condition messages Q3 and Q3a will be sent to get the mobile and primary balances (messages Q4 and Q4a), also Account object replies with Q5 message to Query Account Transaction Manager object which records the operation on Transaction Log (message Q6) and replys client with two balances (message Q7), if status is false the Account directly replies with original balance (message Q3A) and the sequence becomes Q4A and Q5A. As shown in figure 4.20.

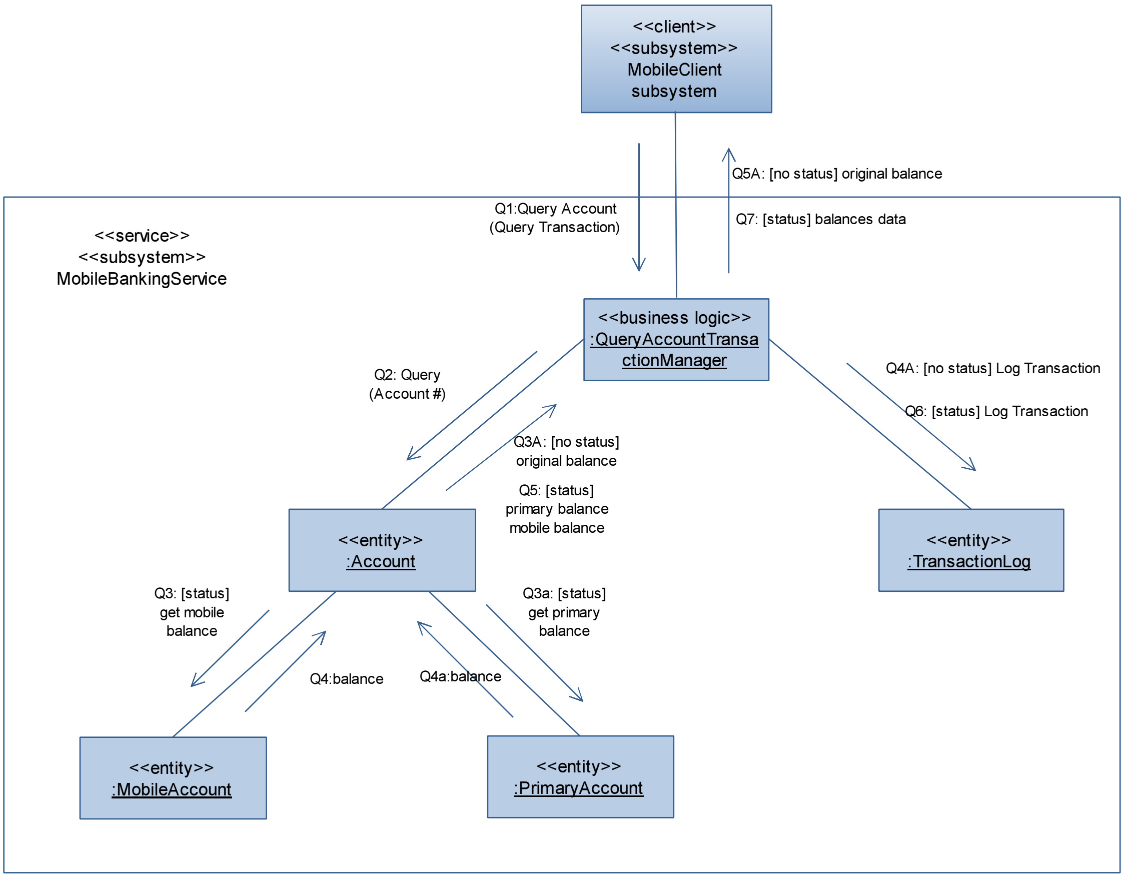


Figure (4.20): Collaboration diagram: Server side Query account use case

4.3.11 Message sequence description for Mobile client: Synchronize balance use case

Mobile Client Control object requests the mobile balance Data which contains: Amount, modified Date and modified Time (message 1.1) and receives it (message 1.2), the control object asks Mobile Transaction object to create Synchronize Transaction with given balance Data (message 1.3) the Mobile Transaction object creates the transaction and sends it to state dependent control object (message 1.4), the control object requests the bank server to synchronize balances via its Banking Server Proxy object (message 1.5). As shown in figure 4.21.

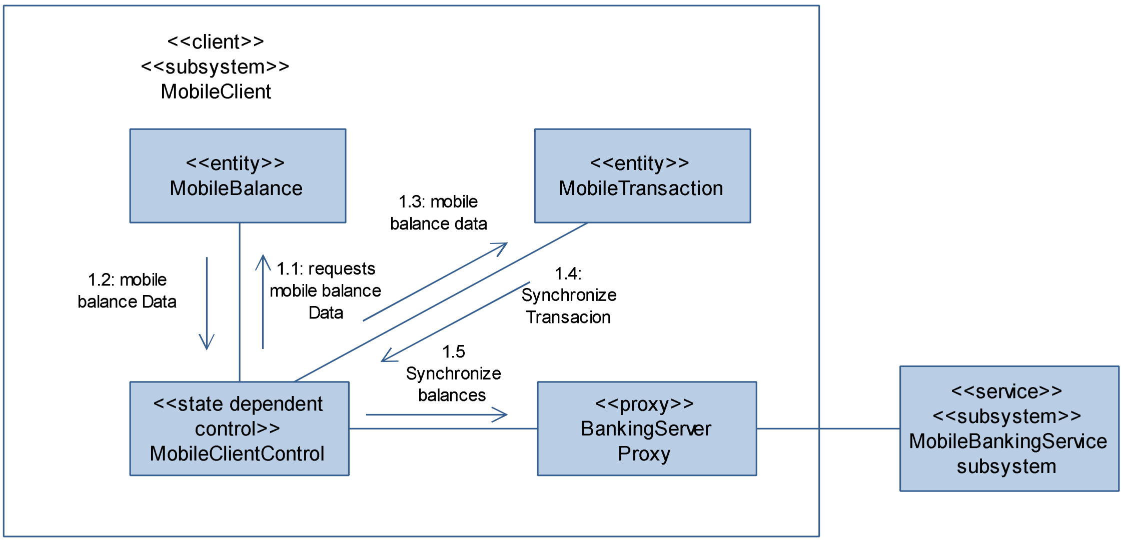


Figure (4.21): Collaboration diagram: Mobile client Synchronize balance use case

4.3.12 Message sequence description for Server side: Synchronize balance use case

When a Synchronize Transaction received on server side it redirected to Synchronize Transaction Manager object (message S1), the business logic object extracts the field Account number to request proper one, the request from Synchronize Transaction Manager is a question if Account's Data is dirty (not up to date) or not, so the Account object extracts Mobile Date and Time (message S2) to answers manger's question if yes it is dirty (message S3) then the Manager object commands Account object to modify its Data (message S4) after that Account object confirms Synchronize Transaction Manager about completion the process (message S5) then Manager object creates recording message and sends it to Transaction Log Object (message S6), and a confirmation message is backed to client if necessary (message S7). As shown in figure 4.22.

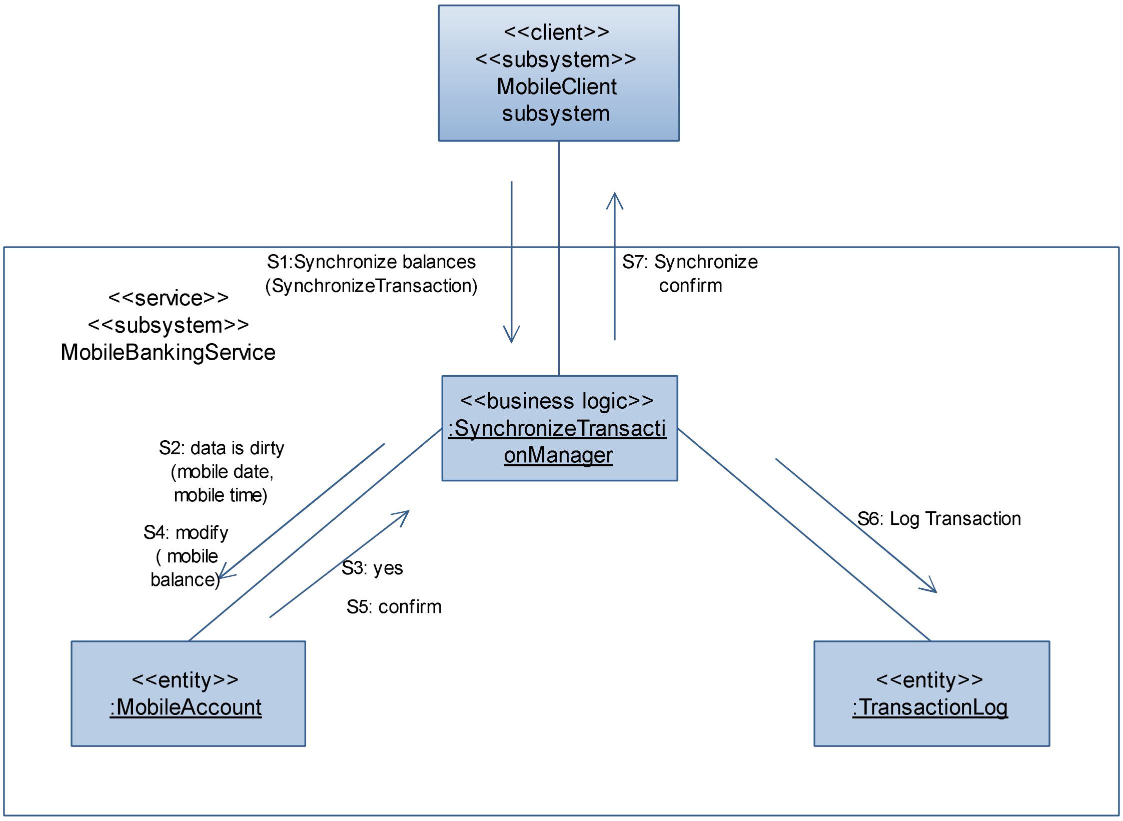


Figure (4.22): Collaboration diagram: Server side Synchronize balance use case

4.3.13 Message sequence description for Payment: Send Cheque use case

This use case is a special one of general Do Payment use case, when user trigger buy option (message 1), Mobile User Interaction sends buy message to state dependent control object Payment Control (message 1.1), then Payment Control asks Bluetooth Adapter Interface to turn on Bluetooth device (message 1.2), after Bluetooth is on (message 1.3), Payment Control object sends search devices (message 1.4) to Bluetooth Adapter Interface object which do scan operation on Bluetooth Adapter (message 1.5), Bluetooth Adapter completes search and creates devices List and returns it to Bluetooth Adapter Interface (message 1.6), the devices list takes a path until reaches mobile display screen (messages 1.7, 1.8 and 1.9), in message 1.9 a prompt to user to select a device to be connect with it.

After user chooses a device (message 2), the device name reaches Payment Control object through Mobile User Interaction (message 2.1), the Control object invokes connect operation of Bluetooth Adapter Interface (message 2.2) which is responsible of commanding physical device (message 2.3), after a connection is accomplished physical device confirms that (message 2.4), Payment Control sends get price to Bluetooth Adapter Interface (message 2.5), the Interface object commands the corresponding Bluetooth adapter device to request Price service that hosting in another peer (Payment subsystem on seller’s mobile phone) via message 2.6 and replys with message 2.7 which contains the price that reaches to Payment Control (message 2.8), Payment Control checks and gets mobile balance (messages 2.9 and 2.10), if balance is enough then redirects the price to Mobile User Interaction (message 2.11) the last object prompts user to accept the price through displaying the prompt on mobile screen (message 2.12).

When user accepts the price (message 3), Mobile User interaction receives the acceptance and sends message 3.1 to Payment Control that prompts it to create a soft Cheque, the Payment Control object requests Mobile info entity object for necessary information needed to complete creation of the soft Cheque (messages 3.2 and 3.2), the creation of the soft Cheque by a request from Payment Control to soft Cheque entity object, this request contains needed tags (message 3.3), after creation of soft Cheque and reply it to Payment Control object (message 3.5), the control object prompts Bluetooth Adapter Interface to begin transfer the soft Cheque (message 3.6) via Bluetooth adapter device (message 3.7). As shown in figure 4.23.

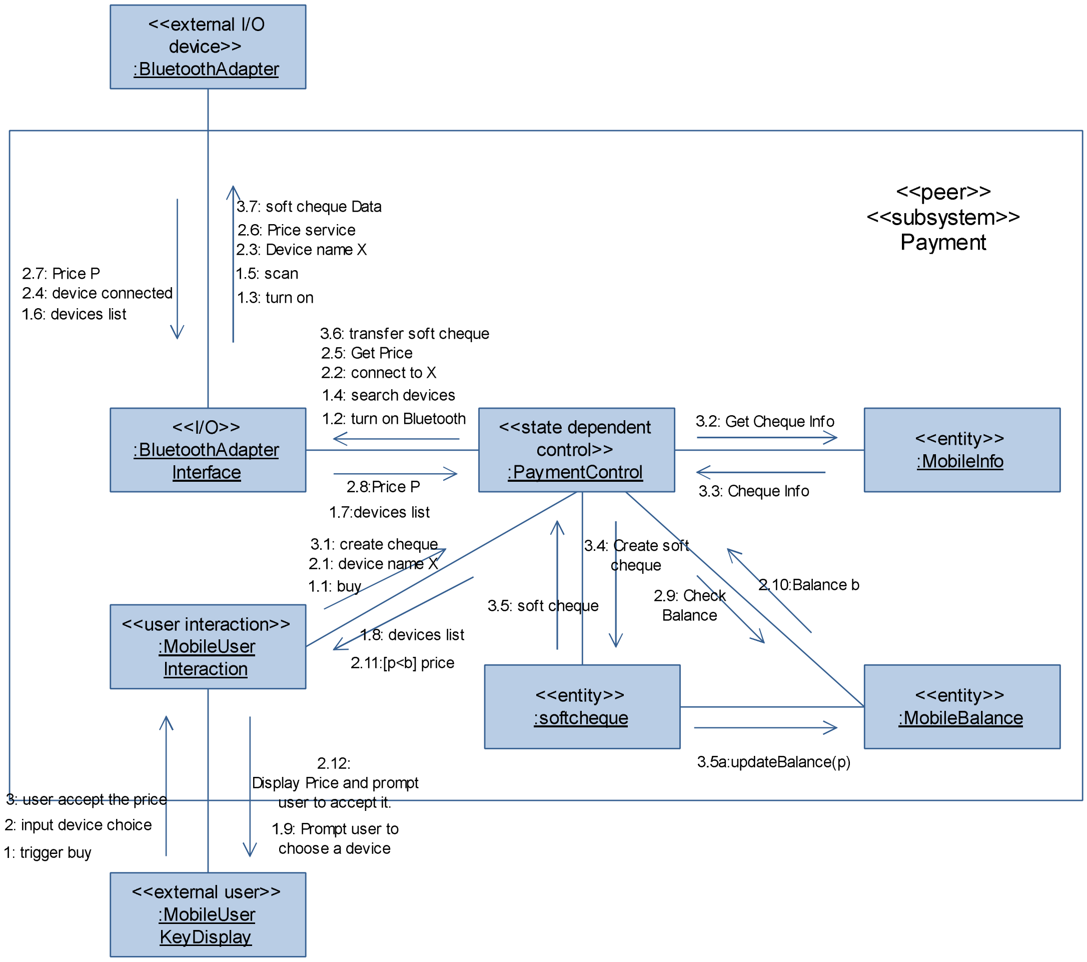


Figure (4.23): Collaboration diagram: Payment Send Cheque use case

4.3.14 Message sequence description for Payment: Receive Cheque use case

When a seller which is a person who provides service or pays product trigger sell option, the Mobile User Interaction object receives this request (message 1) and redirects it as a message 1.1 to Payment Control object which directly commands Bluetooth Adapter Interface to turn on Bluetooth Adapter device (messages 1.2 and 1.3), Payment Control sends get price to Mobile User Interaction object (message 1.4) to prompt user to enter the price of product (message 1.5) and waits user enters the price.

User enters the price and the Mobile User Interaction which captures it via message 2, when Payment Control object receives price amount (message 2.1) creates an instance of Pay Service with given price (message 2.2), then the Pay Service registers itself on Bluetooth device through Bluetooth Adapter Interface object (message 2.3) and waits for a request from client (here is buyer mobile phone), when a request comes at Bluetooth adapter device (message 2.4) the request goes to Bluetooth Adapter Interface object which in turns requests Pay Service and gets the price (messages 2.5 and 2.6) and replys it to client through Bluetooth adapter device (message 2.7).

When a client accepts the price and generates and sends a soft Cheque which is received on Bluetooth device (message 2.8), Bluetooth Adapter Interface object redirects soft Cheque data to Payment Control (message 2.9) the control object stores it in Cheque Container entity object (message 2.10). As shown in figure 4.24.

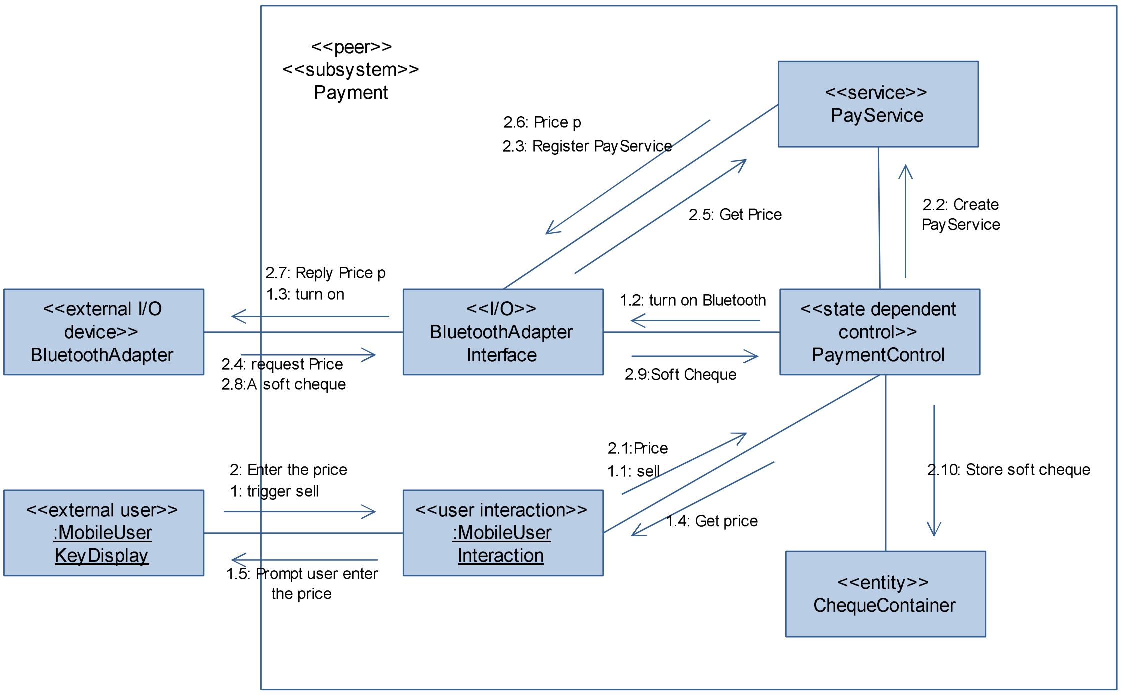


Figure (4.24): Collaboration diagram: Payment Receive Cheque use case

4.3.15 Message sequence description for Payment: Check balance use case

A check balance is an additional service provided in payment subsystem, when a mobile user triggers check balance option the command goes to Mobile User Interaction (message 1), the last object requests the balance directly without needed a Payment Control object, Mobile Balance reply a balance as message 1.2 then Mobile User Interaction displays the balance on screen (message 1.3). As shown in figure 4.25.

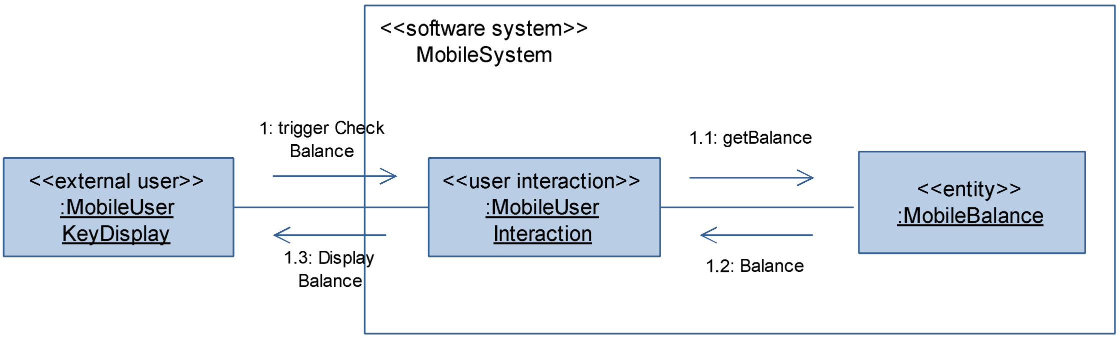


Figure (4.25): Collaboration diagram: Payment check balance use case

4.3.16 Message sequence description for Payment customer: Cash Cheque use case

The soft Cheque is the result of Payment process, to cash it mobile user triggers cash Cheque and Mobile User Interaction object receives the command (message 1), and directs it as message 1.1 to Payment Control object then Control object asks Bluetooth Adapter Interface to search available devices (message 1.2), after searching is completed and a devices list is returned (messages 1.4 and 1.5), Payment Control object represents banks names and sends them to Mobile User Interaction (message 1.6) which prompts user to choose a bank (message 1.7).

Mobile user chooses a bank and Mobile User Interaction object redirects the choice to Payment Control object (message 2.1), the control object brings corresponding Cheques to this bank from Cheque Container (messages 2.2 and 2.3) concurrently with bringing a Cheques list Payment Control object sends an order to Bluetooth Adapter Interface to discover and connect with cash service hosting on given bank (messages 2.2a and 2.3a) and when Payment Control sends Cheques list to Mobile User Interaction (message 2.4), the Bluetooth Adapter Interface object sends connected message 2.4a to Payment Control object that the connection with bank server is accomplished, Mobile User Interaction sends a prompt to user to choose a Cheque from the list to be cashed (message 2.5).

Mobile user enters his choice as message 3, mobile user Interaction redirects this message to Payment control (message 3.1), the control object sends an order to Bluetooth Adapter Interface to request cash service (message 3.2), in order Bluetooth Adapter Interface object commands the Bluetooth device to request the service and gets the information.

When a reply is coming from the service to Bluetooth adapter (message 3.4) which contains an information about completing cashing of a Cheque, the corresponding interface sends the information to Payment control (message 3.5), the state dependent control Payment Control object represents this information as service info and sends it to Mobile User Interaction object (message 3.6) and concurrently marks the cashed Cheque in Cheque Container entity object as cashed and adds cash Date and Time (message 3.6a), the Mobile User Interaction object sends the service info in addition to remainder Cheques list (message 3.7), the mobile device shows data and Mobile User Interaction object waits user to press finish or choosing another Cheque to cash it. As shown in figure 4.26.

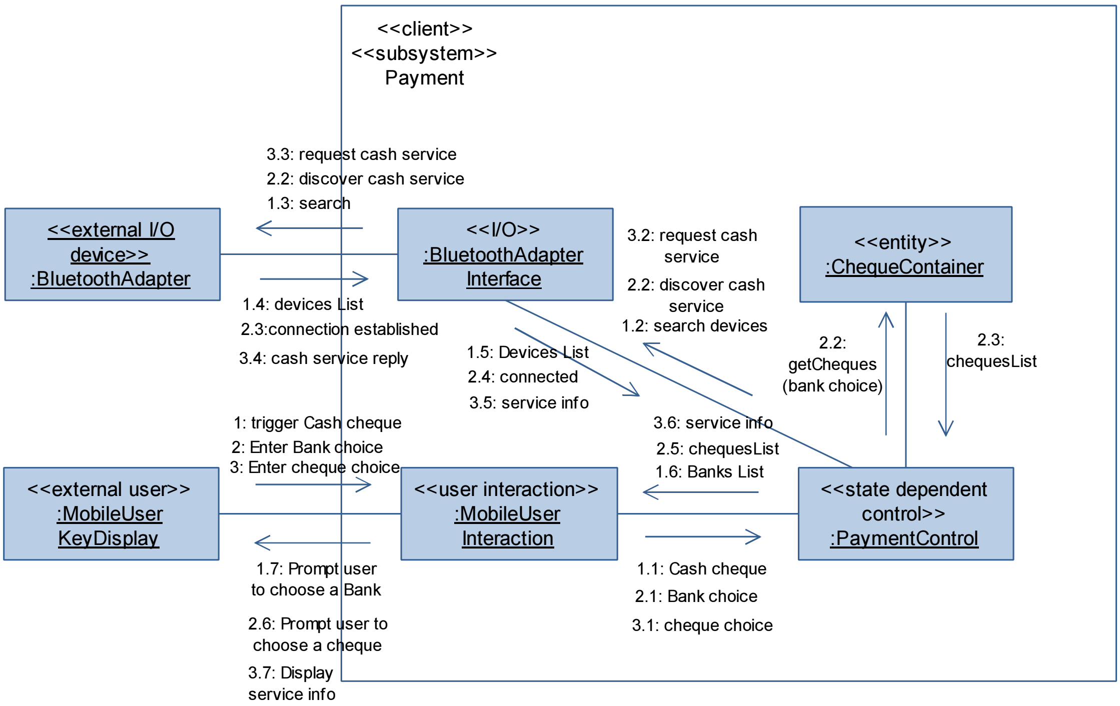


Figure (4.26): Collaboration diagram: Payment customer Cash Cheque use case

4.3.17 Message sequence description for Payment server side: Cash Cheque use case

When a request comes to cash service, the corresponding service object sends Serve Cheque message with Cheque transaction details parameter (message SC1) to Cash Cheque Transaction Manager business logic object, the last object invokes cash operation of corresponding Account object (message SC2), the Account entity object sends a conditional order (status flag is true) to mobile account to remove given value of Cheque from mobile balance (message SC3), after that Cash Cheque Transaction Manager object records the last transaction on Transaction Log entity (message SC4). As shown in figure 4.27.

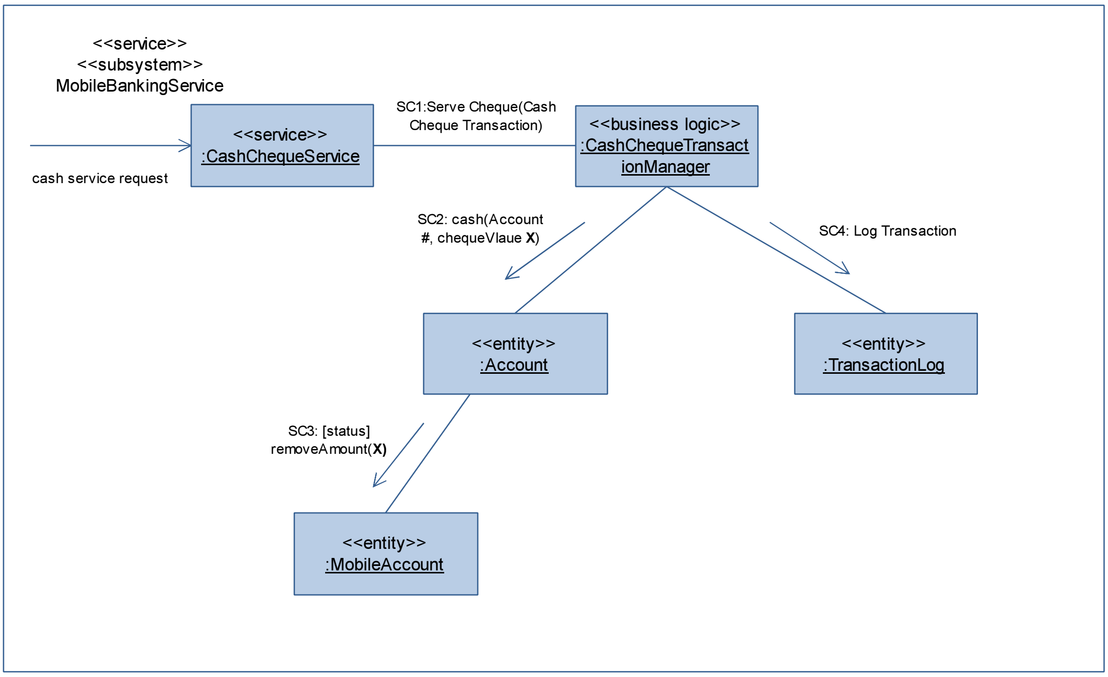


Figure (4.27): Collaboration diagram: Payment server side Cash Cheque use case

4.4 Mobile Banking and paymnet System Statechart

4.4.1 Authentication Statechart

There is one control object in Authentication subsystem called DSP Control so it is necessary to develop a hierarchical DSP Control Statechart that it can be presented in stages.

Top-level Statechart for DSP Control is presented in figure 4.28, after starting the mobile application the DSP Control takes the control of it, displaying a message to user that is :"please wait until recording noise", then DSP control's state transients to a superstate state Test Environment, the test is finished Environment tested even occurs and select option action displays, and the state again transients now to Extract Features composite state, after finishing recording and analyzing human speech an event Features Extracted occurs, according to condition of what user select in the beginning of Extract Features composite state, the DSP control state transients to Verify Speaker composite if the choice was login or to Create Voice Print composite state if the choice was insert voice print.

in the first case login choice, if user was successfully verified then verified event occurs and main menu is displayed and the DSP Control goes to END state, if the speaker failed to login for three times then Third Imposter event occurs and blocking the application action is taken and DSP Control dies.

But if the choice was insert voice print and speech features were clustered with enough non dead centroids then VP stored event occurs and its state transients to END state, and update status action is executed. If there are not enough good centroids then much dead centroids event occurs, and the state transients to Extract Features composite state again.

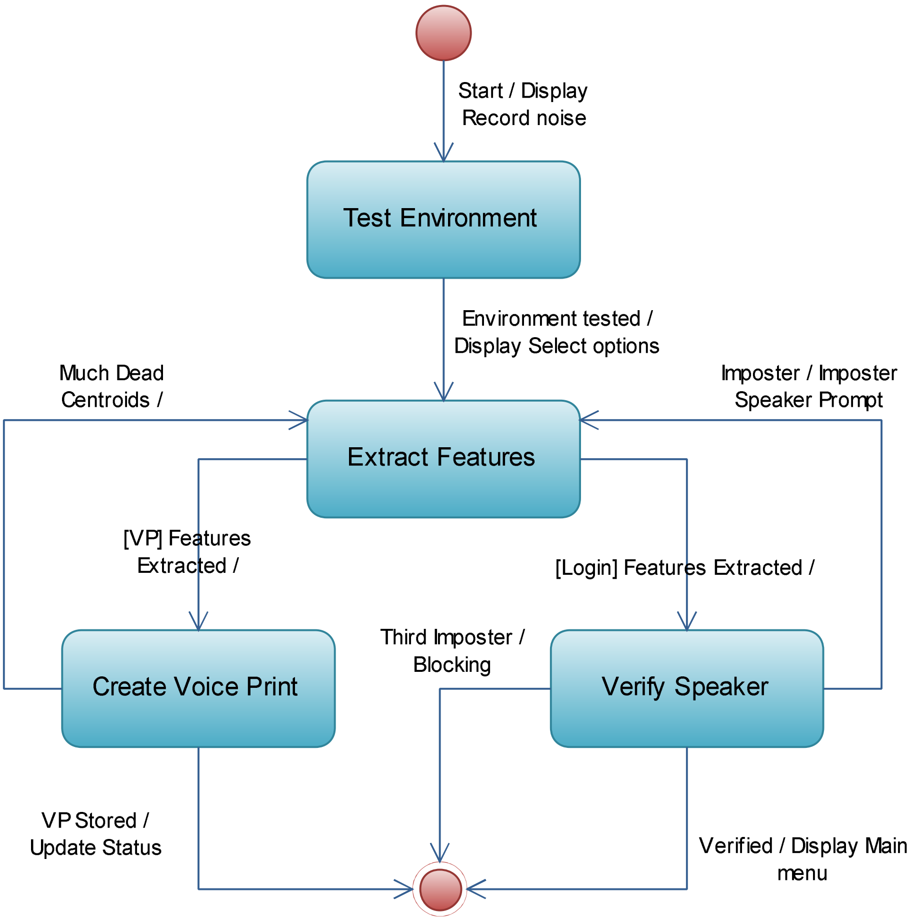


Figure (4.28): Top-level statechart for DSP Control

Consider the Test Environment superstate, is decomposed into two substates. Recording Noise, and Calculating Power Threshold as shown in figure 4.29.

1. Recording Noise. This substate is entered from Idle state when customer opens the application. In this substate the microphone of mobiles captures surrounding noise, after 2 seconds of recording an After 2seconds event occurs.
2. Calculating Power Threshold. This substate is entered as result of an After 2 seconds event when the DSP in previous state. In this substate, the authentication subsystem calculates the power of noise signal and puts the power threshold equals to 1.5 times the noise’s power.

Also consider the Extract Features superstate, is decomposed into two substates. Waiting For Customer Selection, Recording Speech, Estimating Speech Power, and MFCC Processing as shown in figure 4.29.

1. Waiting For Customer Selection. This substate is entered from Calculating Power Threshold substate in Test Environment superstate as result of an Environment tested event (see figure 4.29). in this state, the mobile user enters a selection: insert voice print or login.
2. Recording Speech. This substate is entered from Waiting for customer selection previous substate in the same Extract Features superstate as result of Login event or Insert VP event, in Login case put elapsed time equals to 6 seconds action is executed, else put elapsed time equals to 8 seconds action is executed. It is entered also from Decision making substate of Verify Speaker superstate as result of Imposter event and note that the Imposter Speaker Prompt action is executed in transients between two states. Another way to enters to Recording Speech substate is from VQ Clustering substate of Create Voice Print superstate as result of Much dead centroids. Last it can be entered from Estimating Speech Power substate in the same superstate as result of Low power event. In this state a “ please speak with high voice” message displays on mobile screen and the microphone starts captures the speech.
3. Estimating Speech Power. This substate is entered from Recording Speech previous substate as result of after elapsed time event. In this state, the signal speech power is calculated.
4. MFCC Processing. This substate is entered from Estimation speech power previous substate as result of enough power event. In this state the MFCC features of speech is extracted.

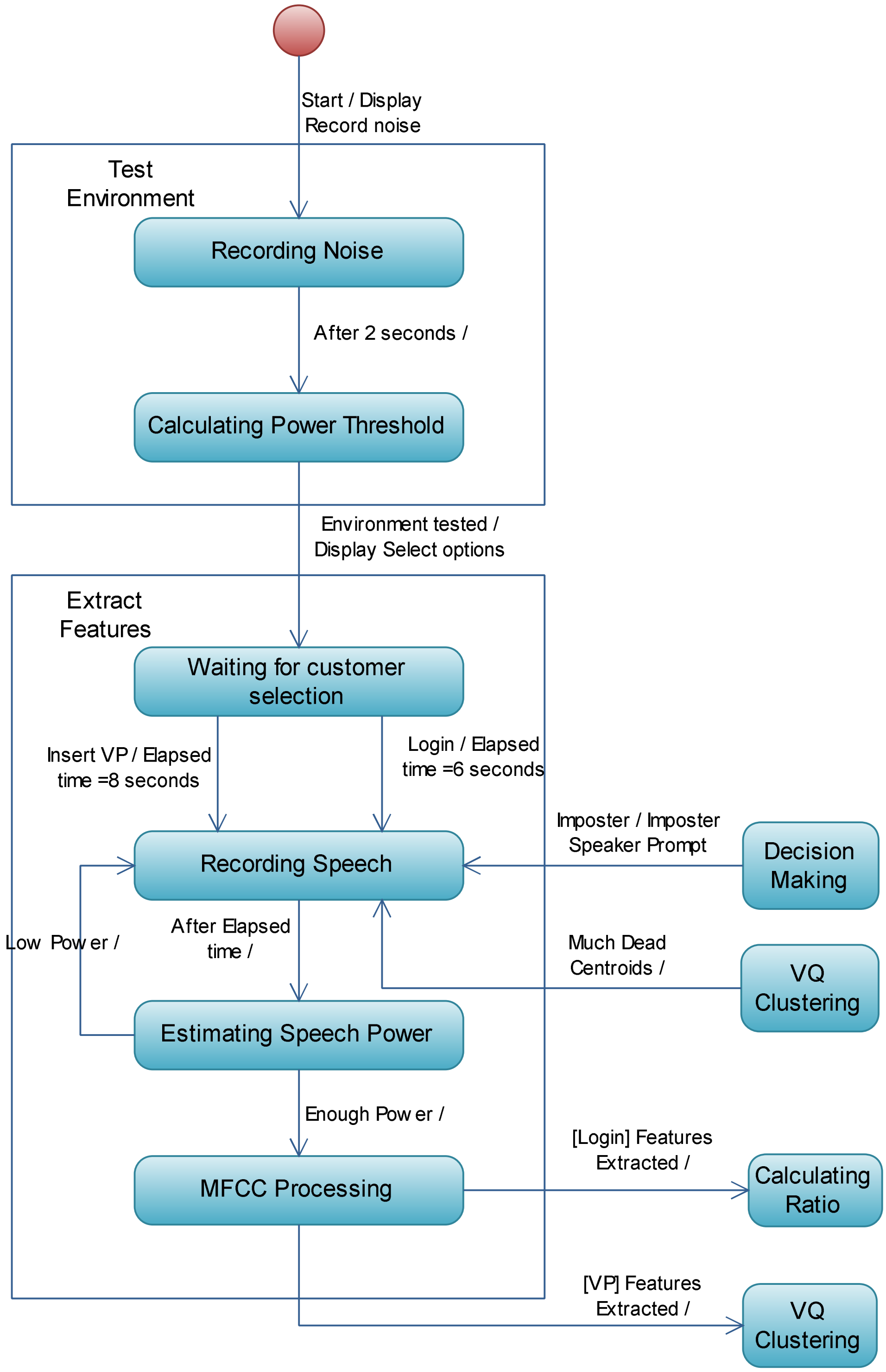


Figure (4.29): Statechart for DSP control: Test environment & Extract features composite states

In another way Verify Speaker composite state consists of two substate, Calculating Ratio, and Decision Making. See figure 4.30.

1. Calculating Ratio. This substate is entered from MFCC Processing substate of superstate Extract Features as result of Features extracted event with login choice condition . In this substate, a ratio in formula 3.3 is calculated.
2. Decision Making. This substate is entered from previous substate as result of Ratio calculated event. In this substate, if ratio that was calculated in previous substate is less than a threshold, then the claimant is true and Verified event occurs, which transients the state of DSP control to END state, and during the transients display main menu action is executed. If the ratio is more than the threshold then Imposter event occurs that transients this state to Recording Speech substate in Extract Features composite state, and Imposter speaker prompt action is executed, but if this is a third imposter which means failing three times for login, then Third imposter event occurs and the state transients to END state, and application blocking action is executed.

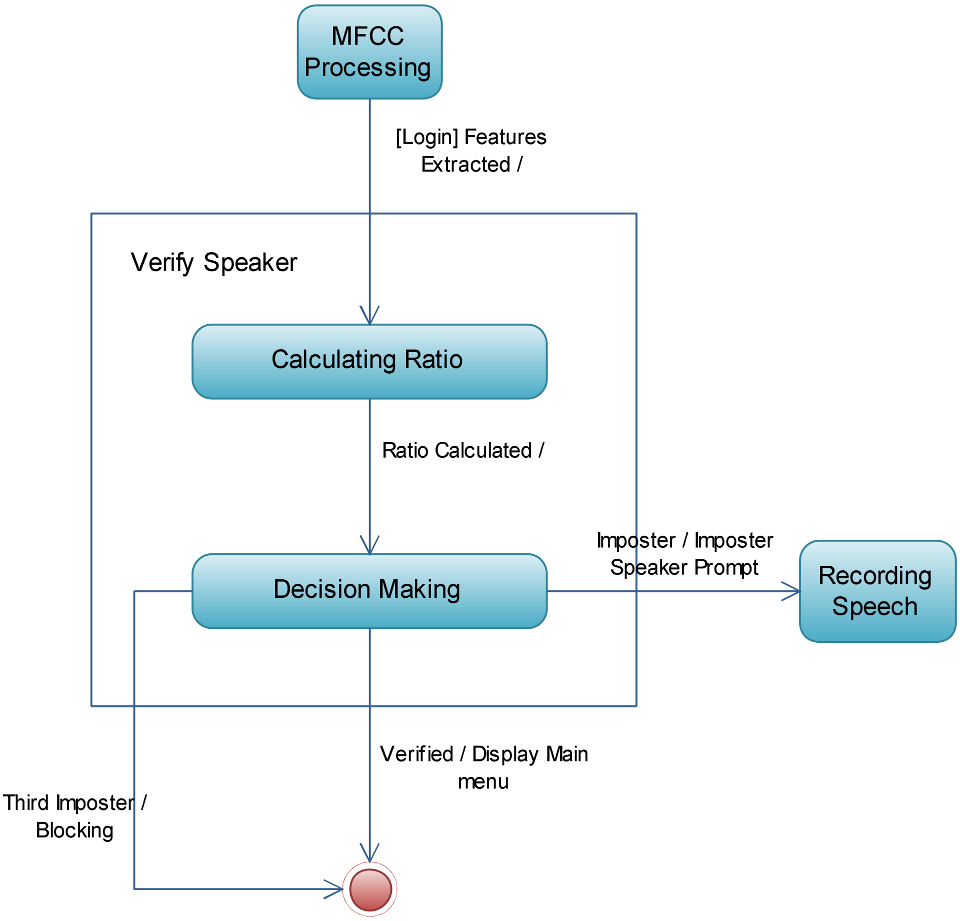

MFCC Processing
[Login] Features Extracted /
Verify Speaker
Calculating Ratio
Ratio Calculated /
Imposter / Imposter Speaker Prompt
Decision Making
Recording Speech
Verified / Display Main menu
Third Imposter / Blocking

Figure (4.30): Statechart for DSP control: verify speaker composite state

The last composite state in DSP Control top-level statechart is Create Voice Print, which consists of VQ clustering substate, and Storing Voice Print substate. See figure 4.31

1. Create Voice Print. This substate is entered from MFCC Processing substate of Extract features superstate as result of Features extracted event with insert voice print choice condition. In this substate the extracted features are clustered using VQ and LBG.
2. Storing Voice Print. This substate is entered from previous VQ Clustering substate as result of Enough good centroids event. In this substate the voice print is stored on a file. Storing voice print substate transients to END state as result of VP stored event and update status action is executed.

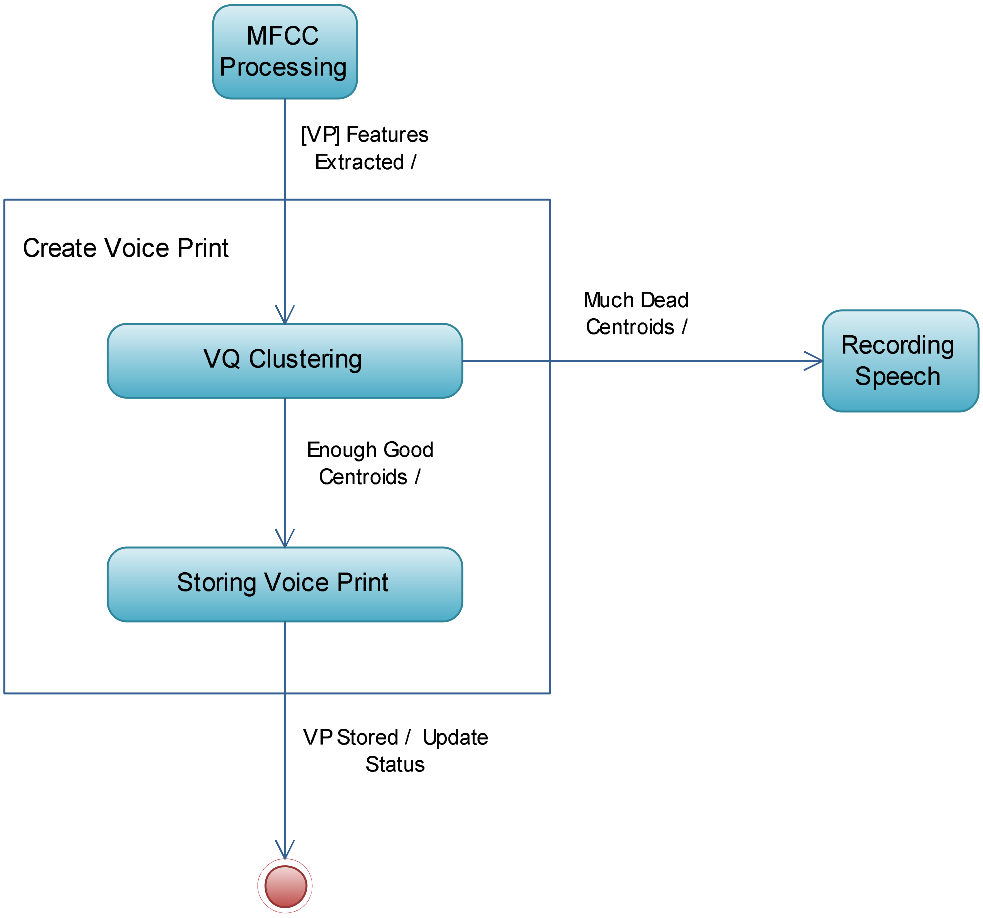


Figure (4.31): Statechart for DSP control: create voice print composite state

4.4.2 Mobile client statechart

There is one control object in Mobile Client subsystem called Mobile Client Control so it is necessary to develop a hierarchical Mobile Client Control Statechart that it can be presented in stages.

Five states are shown on the top-level statechart in figure 4.32: initial state , END, and three composite states, Processing Customer Input, Processing Transaction, and Terminating Transaction. Each composite state is decomposed into its own statechart, as shown on Figures 4.33, 4.34, and 4.35, respectively.

When the Banking menu is chosen, then start event occurs and Mobile Client control transitions from initial state to Processing Customer Input composite state.

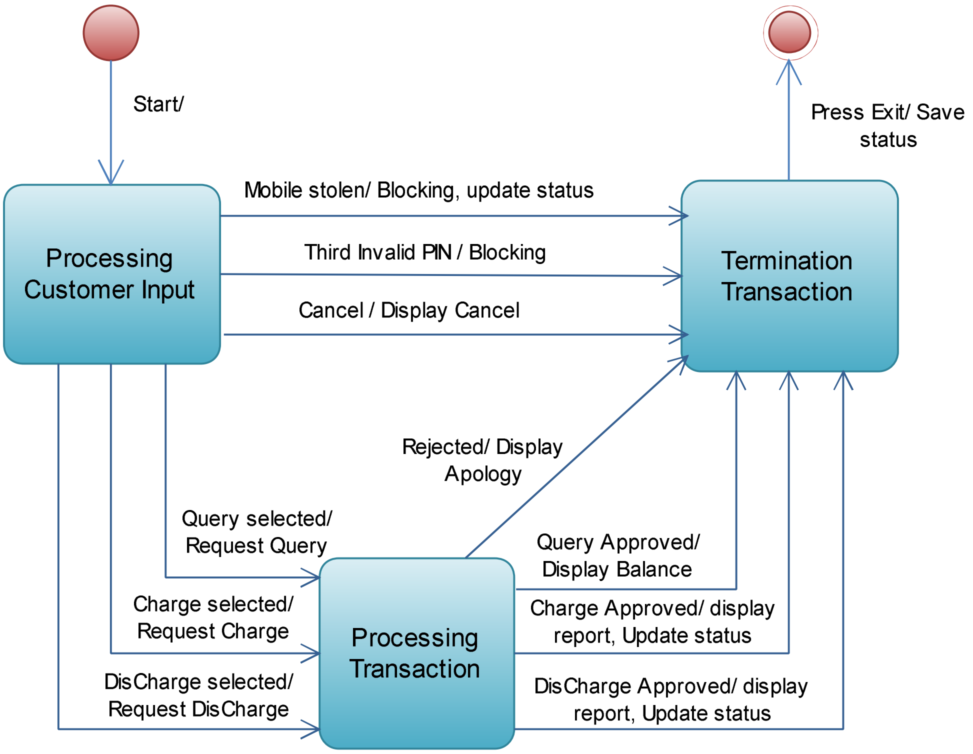

Start/
Press Exit/ Save status
Mobile stolen/ Blocking, update status
Processing Customer Input
Third Invalid PIN / Blocking
Termination Transaction
Cancel / Display Cancel
Rejected/ Display Apology
Query selected/ Request Query
Query Approved/ Display Balance
Charge selected/ Request Charge
Processing Transaction
Charge Approved/ display report, Update status
DisCharge selected/ Request DisCharge
DisCharge Approved/ display report, Update status

Figure (4.32): Top level statechart for mobile client control

Consider Processing Customer Input composite state, it is decomposed to five substate: Waiting for PIN, Validating PIN, Synchronizing, and Waiting for customer selection.

1. Waiting for PIN. This substate is entered from initial state as result of start event. Also it can entered from Validating PIN substate as result of Invalid PIN

event, and Invalid PIN prompt action is executed In this state, the Mobile client control waits for the customer to enter the PIN.

2. Validating PIN. This substate is entered from previous substate when user enters the PIN. In this substate, the Banking Service validates the PIN.
3. Synchronizing. This substate is entered from previous substate as result of a Valid PIN event. In this substate bank server synchronizes its mobile account balance with this mobile balance.
4. Waiting For Customer Selection. This substate is entered from previous substate as result of a Synchronize complete event, and display bank menu action is executed. In this state, the customer enters the selection: Query Account, Charge or Discharge mobile.

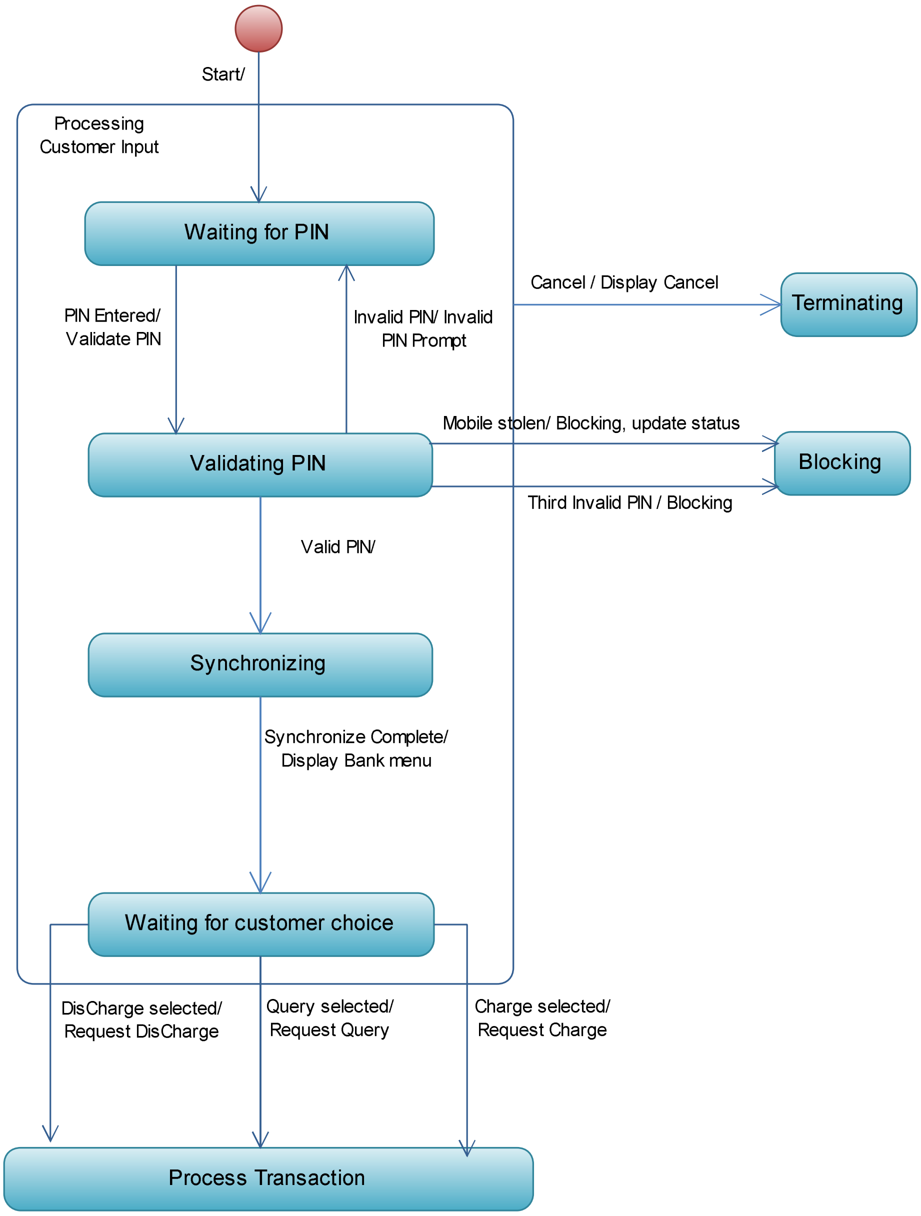

Start/
Processing Customer Input
Waiting for PIN
PIN Entered/ Validate PIN
Invalid PIN/ Invalid PIN Prompt
Cancel / Display Cancel
Terminating
Mobile stolen/ Blocking, update status
Validating PIN
Blocking
Third Invalid PIN / Blocking
Valid PIN/
Synchronizing
Synchronize Complete/ Display Bank menu
Waiting for customer choice
DisCharge selected/ Request DisCharge
Query selected/ Request Query
Charge selected/ Request Charge
Process Transaction

Figure (4.33): Statechart for mobile client control: Processing Customer Input composite state

Consider Processing Transaction composite state, it is decomposed to three substate, one for each transaction: Processing Query, Processing Charge and Processing discharge.

1. Processing Query. This substate is entered from Waiting for customer selection substate of Processing Customer Input superstate, as result of Query selected event, and Request query action is executed. The mobile Client control requests bank service to get Account balances: mobile and primary balance.

2. Processing Charge. This substate is entered from Waiting for customer selection substate of Processing Customer Input superstate, as result of Charge selected event, and Request charge action is executed. The mobile Client control requests bank service to charge the mobile with credit.
3. Processing Discharge. This substate is entered from Waiting for customer selection substate of Processing Customer Input superstate, as result of Discharge selected event, and Request discharge action is executed. The mobile Client control requests bank service to returns credit on this mobile to original account.

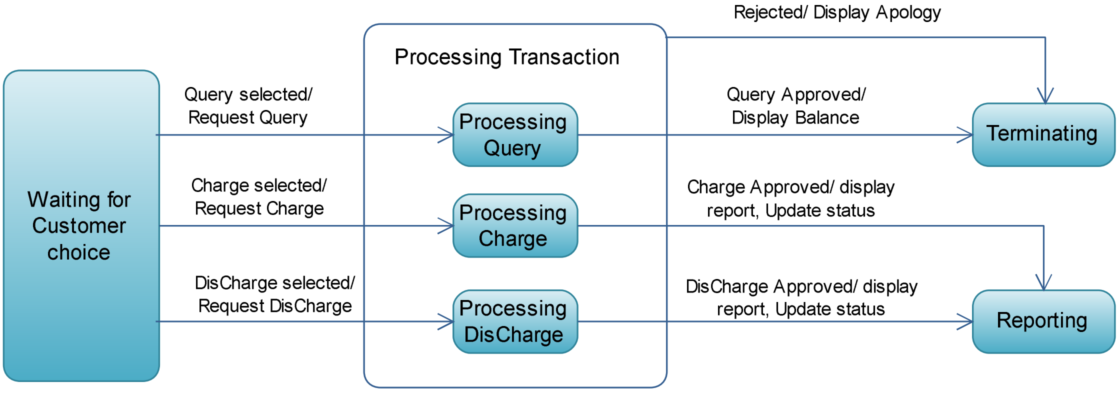

Rejected/ Display Apology
Processing Transaction
Query selected/ Request Query
Waiting for Customer choice
Processing Query
Query Approved/ Display Balance
Terminating
Charge selected/ Request Charge
Processing Charge
Charge Approved/ display report, Update status
DisCharge selected/ Request DisCharge
Processing DisCharge
DisCharge Approved/ display report, Update status
Reporting

Figure (4.34): Statechart for mobile client control: Processing Transaction composite state

Consider Termination Transaction composite state, it is decomposed to three substate: Blocking, Reporting, and Terminating.

1. Blocking. This substate is entered from Processing Customer Input superstate, as result of mobile stolen event, and blocking and update status actions are executed. Another event causes a transition from Processing Customer Input composite state is third invalid PIN, and blocking action is executed. In this substate the mobile application is blocked and permitted for launch again.
2. Reporting. This substate is entered from Processing Transaction composite state, as result of two events: Charge approved event, and display report and update status actions are executed, Discharge approved event, and display report and update status actions are executed. In this substate a report about last transaction is created and can be stored send to Bluetooth printer for example.
3. Terminating. This substate is entered from Processing Customer Input superstate, as result of cancel event, and display cancel action is executed. It is entered from Processing Transaction composite state, as result of Rejected event, and display apology action is executed, and another event is Query approved, and display balance action is executed. Also it can be entered from two substates: blocking and reporting from same Termination Transaction

composite state, when user press finish. In this substate Mobile Client subsystem finishes update its status and waits user to press exit to enters END state and save status action is executed.

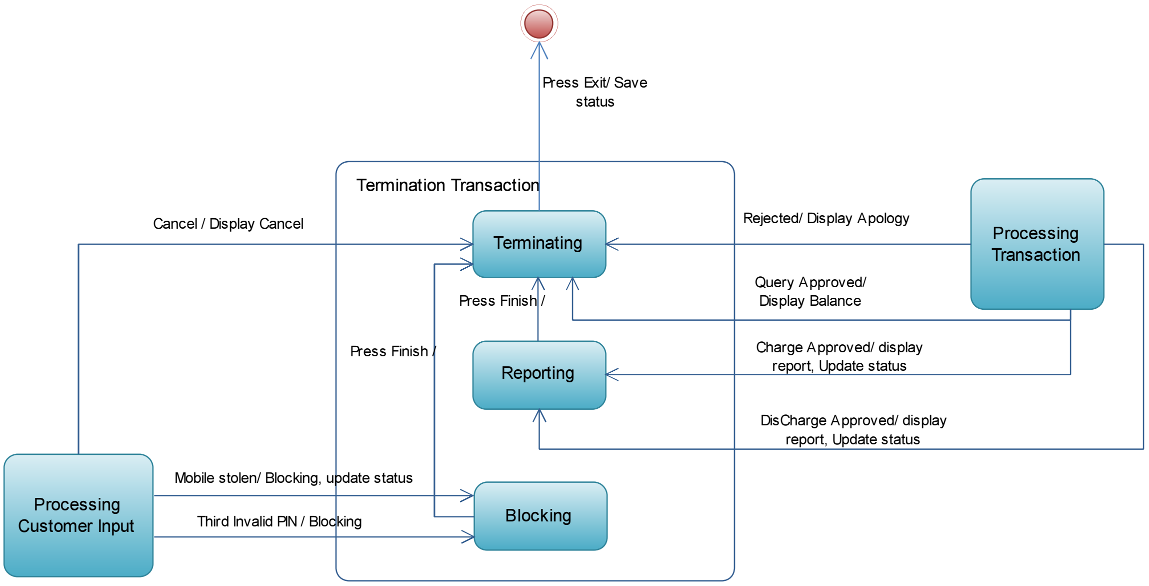

Press Exit/ Save status
Termination Transaction
Cancel / Display Cancel
Terminating
Rejected/ Display Apology
Processing Transaction
Query Approved/ Display Balance
Press Finish /
Press Finish /
Reporting
Charge Approved/ display report, Update status
DisCharge Approved/ display report, Update status
Processing Customer Input
Mobile stolen/ Blocking, update status
Third Invalid PIN / Blocking
Blocking

Figure (4.35): Statechart for mobile client control: Terminating Transaction composite state

4.4.3 Payment statechart

There is one control object in Paymnet subsystem called Payment Control so it is necessary to develop a hierarchical Payment Control Statechart that it can be presented in stages.

Six states are shown on the top-level statechart in figure 4.36: initial state , END, and four composite states, Sending Soft Cheque, Receiving Soft Cheque, Cash soft Cheque, and Terminating Transaction. Each composite state is decomposed into its own statechart, as shown on Figures 4.37, 4.38, 4.39, and 4.40, respectively.

When Payment menu is chosen, the Payment control object is created and resides in initial state and Payment menu is displayed that contains three options: Sell, Buy, and Cash, and events: send, receive, and cash are occur respectively. So the Payment control transitions to corresponding composite state as shown in figure 4.36.

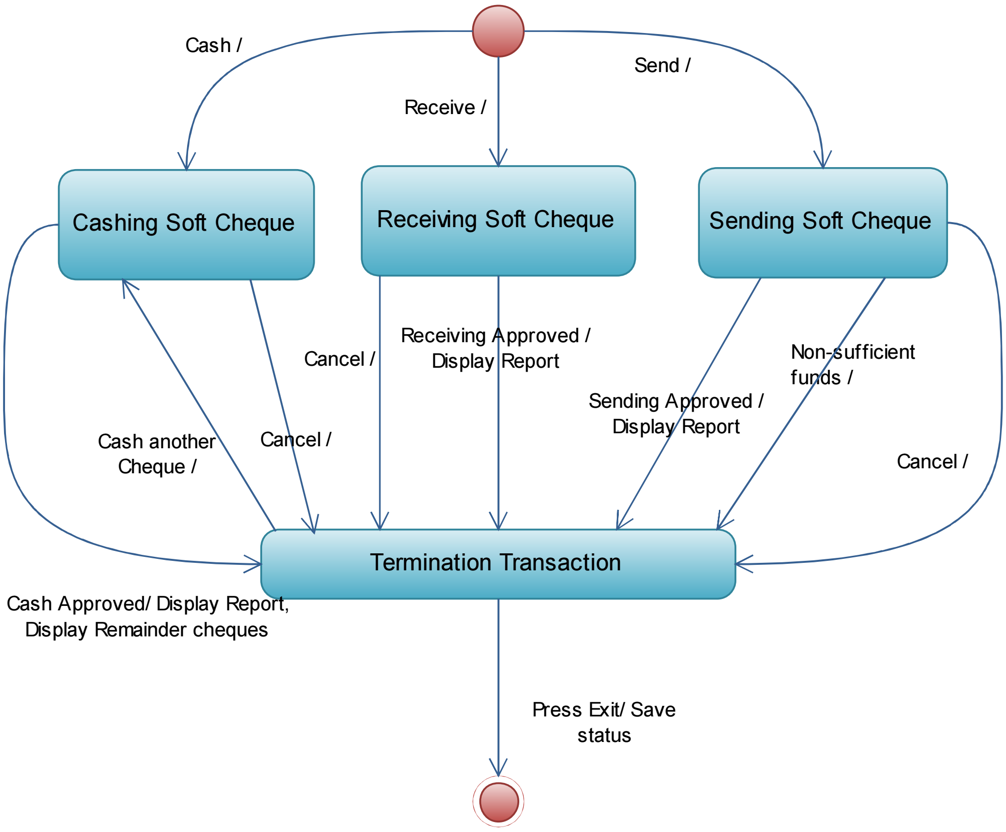


Figure (4.36) Top level statechart for Payment control

Consider Sending Soft Cheque composite state, it is decomposed to seven substate: Turning ON Bluetooth, Searching devices, Waiting for customer selection, Requesting price, Checking balance, Creating soft Cheque, and Transferring soft Cheque .

1. Turning ON Bluetooth. This substate is entered from initial state, as result of send event. In this substate the Bluetooth Adapter is turned ON.
2. Searching devices. This substate is entered from previous substate, as result of adapter is ON event. In this substate a Bluetooth scan neighborhood mobile devices Bluetooth adapter.
3. Waiting for customer selection. This substate is entered from Previous substate, as result of scan complete event, and display devices action is executed. In this substate, Mobile user selects one of scanned devices to connect with it.
4. Requesting price. This substate is entered from previous substate, as result of a device is chosen event, and connect to mobile device action is executed. In this substate buyer's mobile requests a price from seller's mobile.
5. Checking balance. This substate is entered from previous substate, as result of a price is get event. In this substate buyer's mobile balance is checked.

6. Creating soft Cheque. This substate is entered from previous substate, as result of a sufficient funds event, and get Cheque data action is executed. In this substate, a soft Cheque is created.
7. Transferring soft Cheque. This substate is entered from previous substate, as result of a Cheque created event. In this substate, the buyer's mobile sends a soft Cheque to seller's mobile.

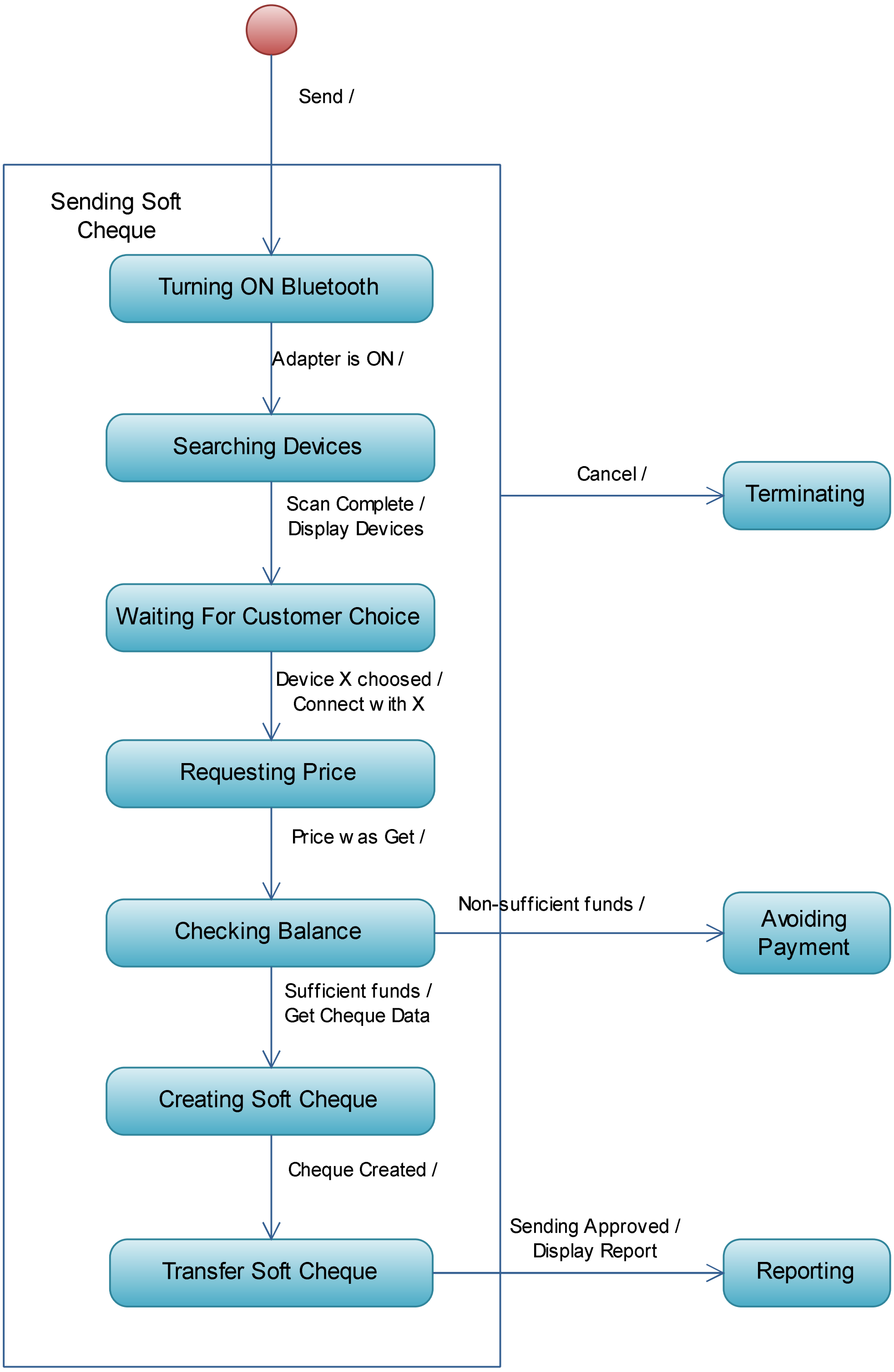


Figure (4.37): Statechart for Payment control: Sending Soft Cheque composite state

Consider Receiving Soft Cheque composite state, it is decomposed to four substate: Turning ON Bluetooth, Waiting for price, Waiting for request, and Waiting for soft Cheque.

1. Turning ON Bluetooth. This substate is entered from initial state, as result of send event. In this substate the Bluetooth Adapter is turned ON.
2. Waiting for price. This substate is entered from previous substate, as result of adapter is ON event. In this substate a seller enters the price of product.
3. Waiting for request. This substate is entered from Previous substate, as result of price entered event, and start price service action is executed. In this substate, mobile waits for incoming request.
4. Waiting for soft Cheque. This substate is entered from previous substate, as result of a device is requested event, and reply with price action is executed. In this substate, seller's mobile waits a soft Cheque data from buyer's mobile.

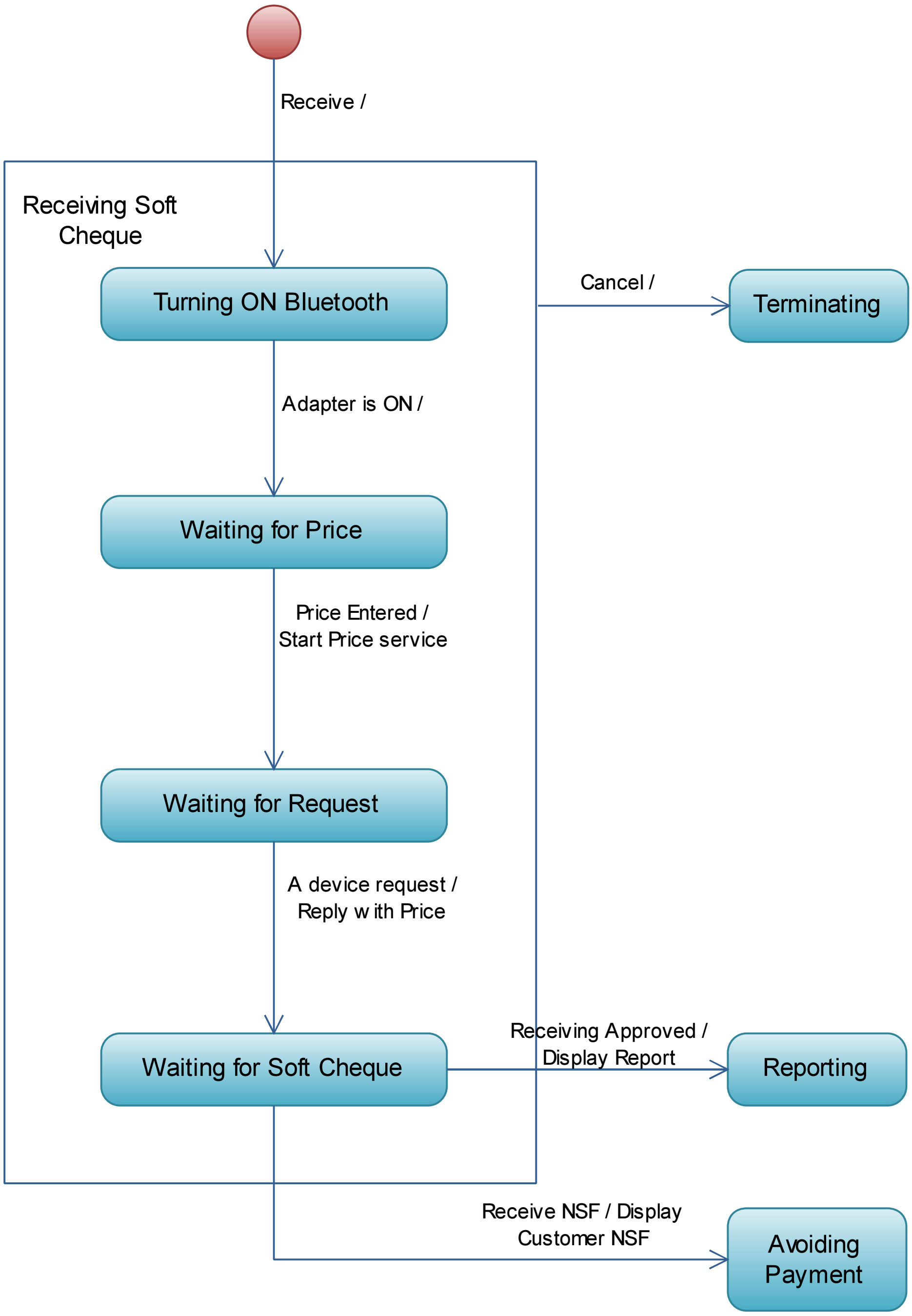


Figure (4.38): Statechart for Payment control: Receiving Soft Cheque composite state

Consider Receiving Soft Cheque composite state, it is decomposed to six substate: Turning ON Bluetooth, Scanning banks , Waiting for a bank selection, creating soft Cheques list, waiting for a Cheque selection, and process cash transaction.

1. Turning ON Bluetooth. This substate is entered from initial state, as result of cash event. In this substate the Bluetooth Adapter is turned ON.
2. Scanning banks. This substate is entered from previous substate, as result of adapter is ON event. In this substate a Bluetooth device scans other available devices.
3. Waiting for a bank selection. This substate is entered from previous substate, as result of scan complete event, and display list action is executed. It is also entered from creating soft Cheques list substate in the same superstate as result of no bank’s Cheque found, and remove bank from list action is executed. In this substate, mobile user selects one bank from the list to cash a Cheque.
4. Creating soft Cheques list. This substate is entered from previous substate, as result of a bank entered event. In this substate, a list of soft Cheques is created that belong to selected bank.
5. Waiting for a Cheque selection. This substate is entered from previous substate, as result of a list created event, and display list action is executed. In this substate, mobile user selects one Cheque from the list.
6. Process cash transaction. This substate is entered from previous substate, as result of Cheque entered event. It is also entered from Reporting substate of Termination Transaction composite state, as result of cash another Cheque event. In this substate, mobile sends soft Cheque to bank server to cash it.

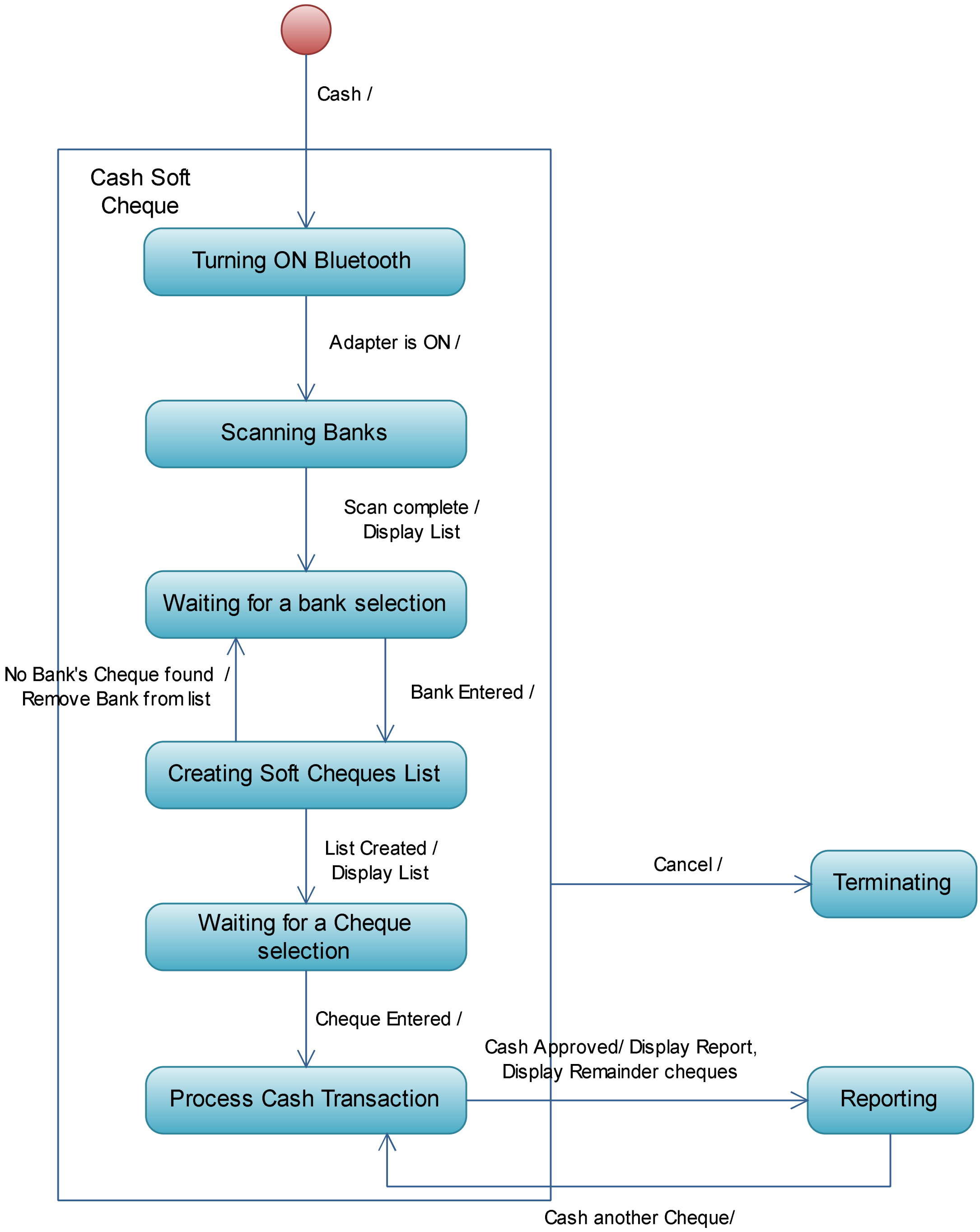

Cash /
Cash Soft Cheque
Turning ON Bluetooth
Adapter is ON /
Scanning Banks
Scan complete / Display List
Waiting for a bank selection
No Bank's Cheque found / Remove Bank from list
Bank Entered /
Creating Soft Cheques List
List Created / Display List
Cancel /
Terminating
Waiting for a Cheque selection
Cheque Entered /
Cash Approved/ Display Report, Display Remainder cheques
Process Cash Transaction
Reporting
Cash another Cheque/

Figure (4.39): Statechart for Payment control: Cash soft Cheque composite state

Consider Termination Transaction composite state, it is decomposed to three substate: Avoiding Payment, Reporting , and Terminating.

1. Avoiding Payment. This substate is entered from Sending Soft Cheque composite state, as result of Non-sufficient funds event, and display NSF action is executed. It is also entered from Receiving Soft Cheque, as result of receiving NSF event, and display customer NSF action is executed. In this substate, the payment control reset status of mobile before payment process.
2. Reporting. This substate is entered from Sending Soft Cheque composite state, as result of Sending approved event, and display report action is executed. Also it is entered from Receiving Soft Cheque composite state, as result of Receiving approved event, and display report action is executed. It is entered also from Cashing Soft Cheque composite state, as result of cashing approved event, and display report, display remainder Cheques actions are executed. In this substate a report about last operation that can be printed or sended.
3. Termination. This substate is entered from Sending Soft Cheque, Receiving Soft Cheque, and Cashing Soft Cheque composite states, when a mobile user cancel the operation. It is also entered from Reporting, and Avoiding Payment substates in the same superstate, when a mobile user press finish. In this substate Payment subsystem finishes update its status and waits user to press exit to enters END state and save status action is executed.

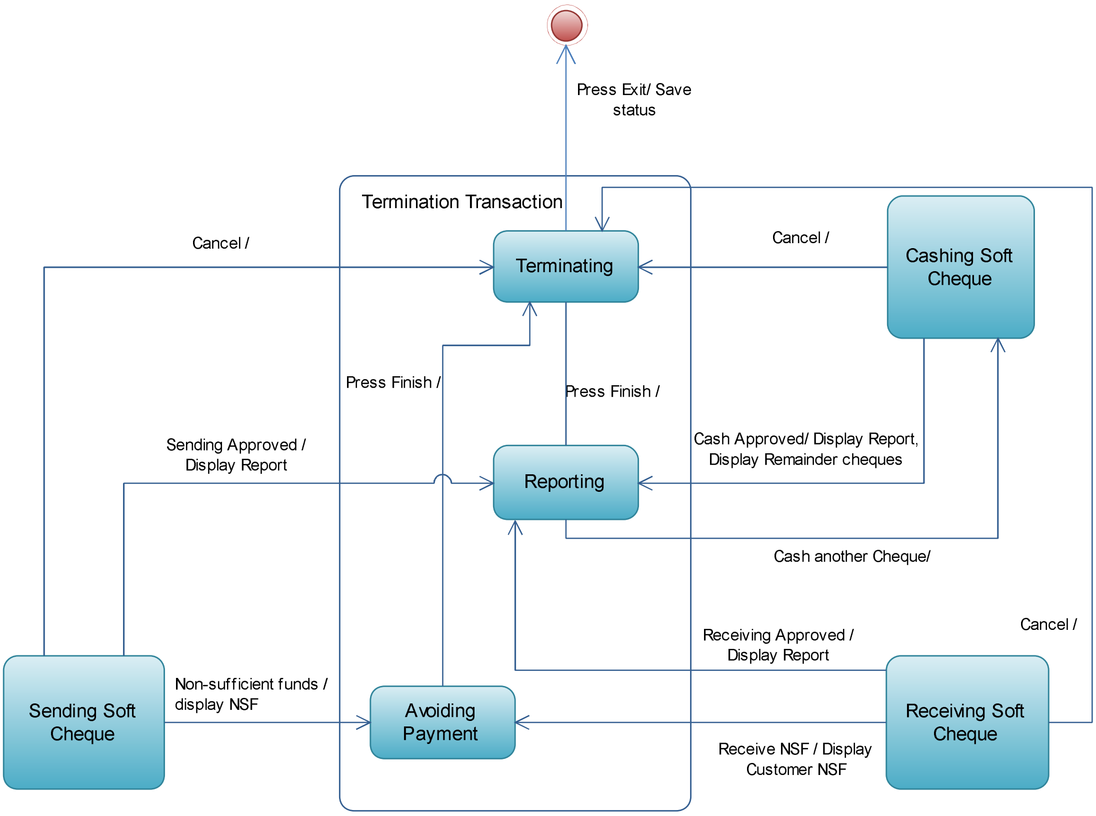


Figure (4.40): Statechart for Payment control: Termination Transaction composite state.

Chapter 5

SYSTEM DESIGN MODEL

5.1 System consolidating collaboration model

5.1.1 Authentication subsystem consolidating collaboration model

The figure 5.1 is the result of consolidating the collaboration diagrams of use cases: Insert voice print, and Login, without messages numbers.

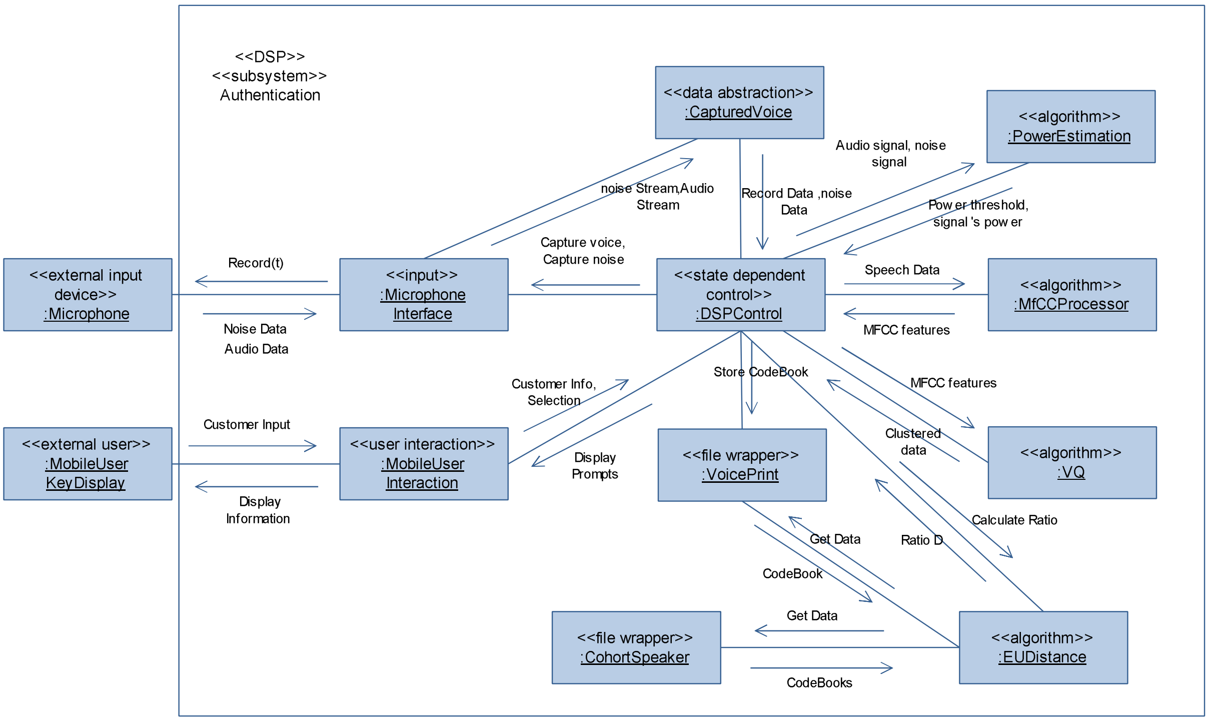


Figure (5.1): Consolidated collaboration diagram for Authentication subsystem

Table (5.1): Message Dictionary for consolidated Authentication Subsystem

Message Dictionary for consolidated diagram of Authentication Subsystem	
Customer Inputs	a) Trigger Insert Voice Print
	b) Trigger Start Talk
	c) Trigger Login
Display Information	a) Prompt user to wait
	b) Display start talk button and Prompt user to talk
	c) Load main menu
Customer Info, Selection	a) Test environment
	b) Create Voiceprint
	c) Login
Display Prompts	a) Wait
	b) Talk
	c) login succeed
Variable t on Record(t)	a) t =2 seconds for recording noise.
	b) t =8 seconds for insert voiceprint.
	c) t =6 seconds for login.

5.1.2 Mobile Client subsystem consolidating collaboration model

The figure 5.2 is the result of consolidating the collaboration diagrams of use cases in Mobile Client Subsystem package, without messages numbers.

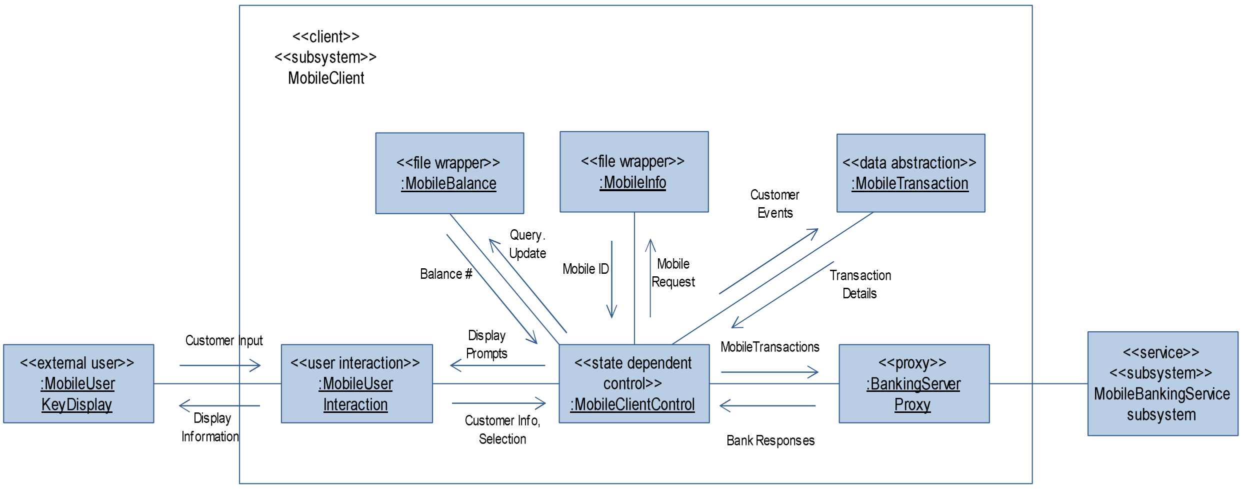


Figure (5.2): Consolidated collaboration diagram for Mobile Client subsystem

Table (5.2): Message Dictionary for consolidated Mobile Client Subsystem

Message Dictionary for consolidated diagram of Mobile Client Subsystem	
Customer Inputs	a) PIN Input
	b) trigger charge Mobile
	c) Enter Charge Amount
	d) trigger discharge Mobile
Display Information	a) PIN Prompt
	b) Display Account Balance, Prompt user to enter an amount of mobile balance
	c) Display two Balances, Prompt user to enter an amount of mobile balance to be add
Customer Info, Selection	a) PIN
	b) charge option
	c) Balance Amount
	d) discharge option
Customer Events	a) PIN, Mobile ID
	b) Query(Account #)
	c) charge(Account #, **X**)
	d) disCharge(Account #)
Transaction Details	a) PIN Validation Transaction
	b) Query Transaction
	c) Charge Transaction
	d) DisCharge Transaction

5.1.3 Payment subsystem consolidating collaboration model

The figure 5.3 is the result of consolidating the collaboration diagrams of use cases in Payment Subsystem package, without messages numbers.

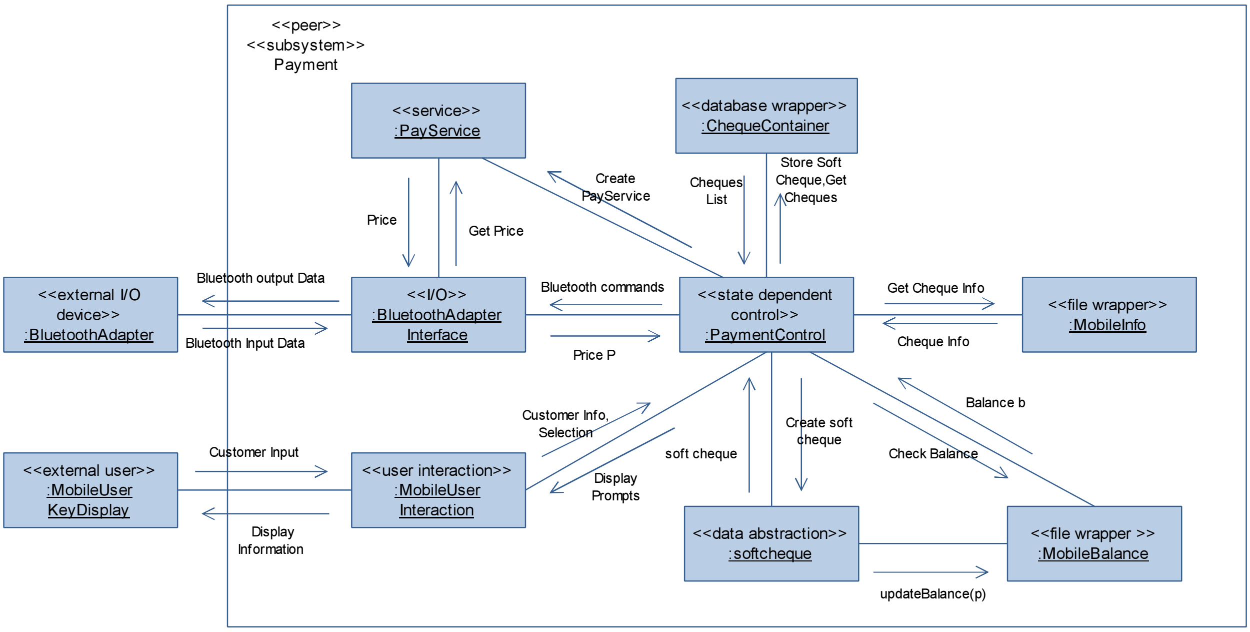


Figure (5.3): Consolidated collaboration diagram for Payment subsystem.

Table (5.3): Message Dictionary for consolidated Payment Subsystem

Message Dictionary for consolidated diagram of Payment Subsystem	
Customer Inputs	a) Trigger Buy
	b) Input device choice
	c) Accept the Price
	d) Trigger Sell
	e) Enter the Price
	f) Trigger Cash Cheque
	g) Enter bank choice
	h) Enter Cheque choice
Display Information	a) Prompt user to choose a device
	b) Display the Price and Prompt user to accept it
	c) Prompt user to Enter the Price
	d) Prompt user to choose a Bank
	e) Prompt user to choose a Cheque
Customer Info, Selection	a) Buy
	b) Device Name
	c) Create Cheque
	d) Sell
	e) Price
	f) Cash Cheque
	g) Bank Choice
	h) Cheque Choice
Display Prompts	a) Devices List
	b) Price
	c) Get Price
	d) Banks List
	e) Cheques List
Bluetooth Commands	a) Turn On Bluetooth Adapter
	b) Transfer soft Cheque
	c) Get Price
	d) Connect to device
	e) Search devices
Bluetooth output Data	a) Turn ON
	b) Soft Cheque Data
	c) Price service Request
	d) Device Name
	e) Scan
	f) Price Service Reply
Bluetooth Input Data	a) Devices list
	b) Connection with device is Established
	c) Price
	d) Request Price Service
	e) A soft Cheque

5.1.4 Mobile Banking Service consolidating collaboration model

The figure 5.4 is the result of consolidating the collaboration diagrams of Mobile Banking Service, without messages numbers.

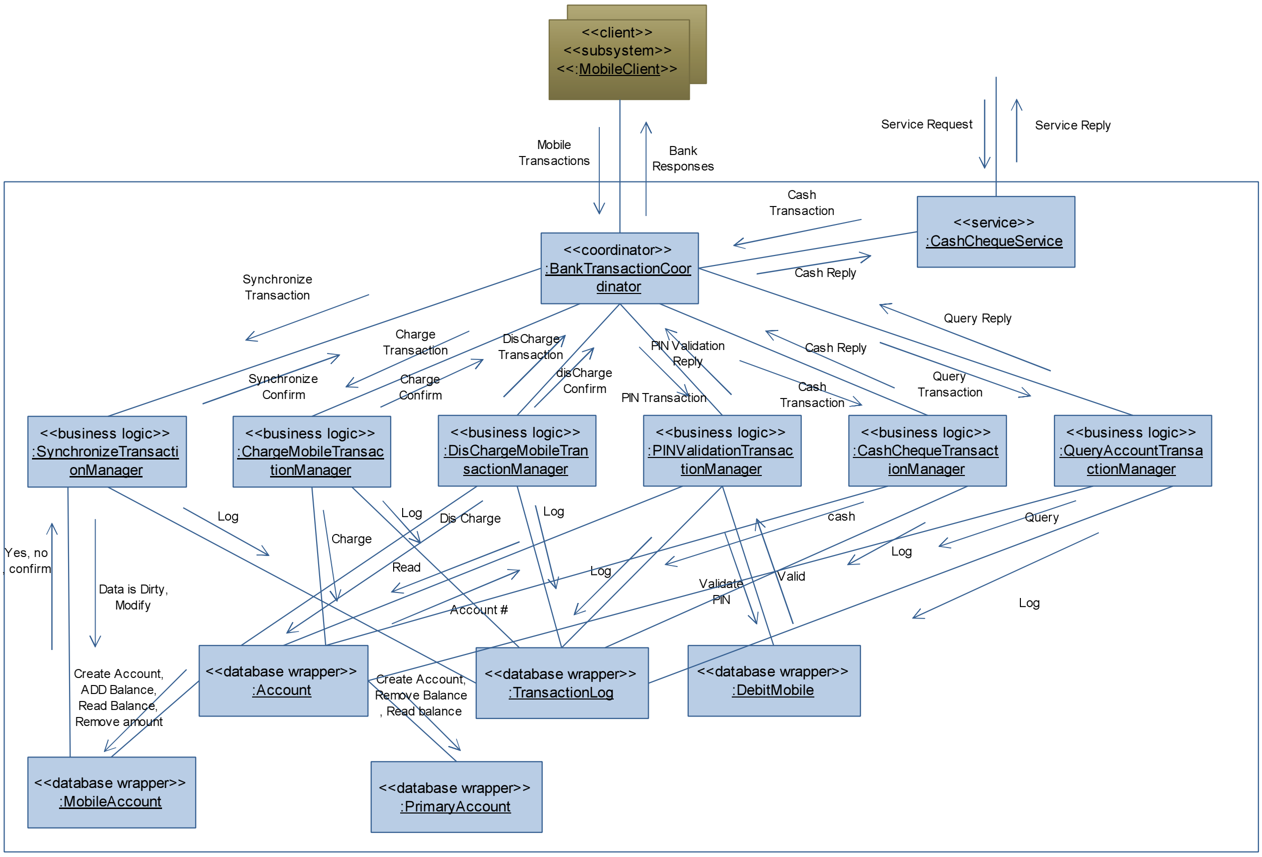


Figure (5.4): Consolidated collaboration diagram for Mobile Banking Service subsystem

5.2 Task structuring

5.2.1 Authentication subsystem task structuring architecture

1. Event Driven I/O Tasks
   - << event driven>> <<input>> :MicrophoneController Task
2. Control Clustering tasks
   - <<demand>> <<state dependent control>> :DSPControl Task
3. User Interaction tasks
   - <<event driven>> <<user interaction>> :MobileUserInteraction Task
4. Demand Driven Tasks

- <<demand>> <<algorithm>> :PowerEstimation Task
- <<demand>> <<algorithm>> :MFCCProcessor Task
- <<demand>> <<algorithm>> :VQ Task
- <<demand>> <<algorithm>> :EUDistance Task. As shown in figure 5.5.

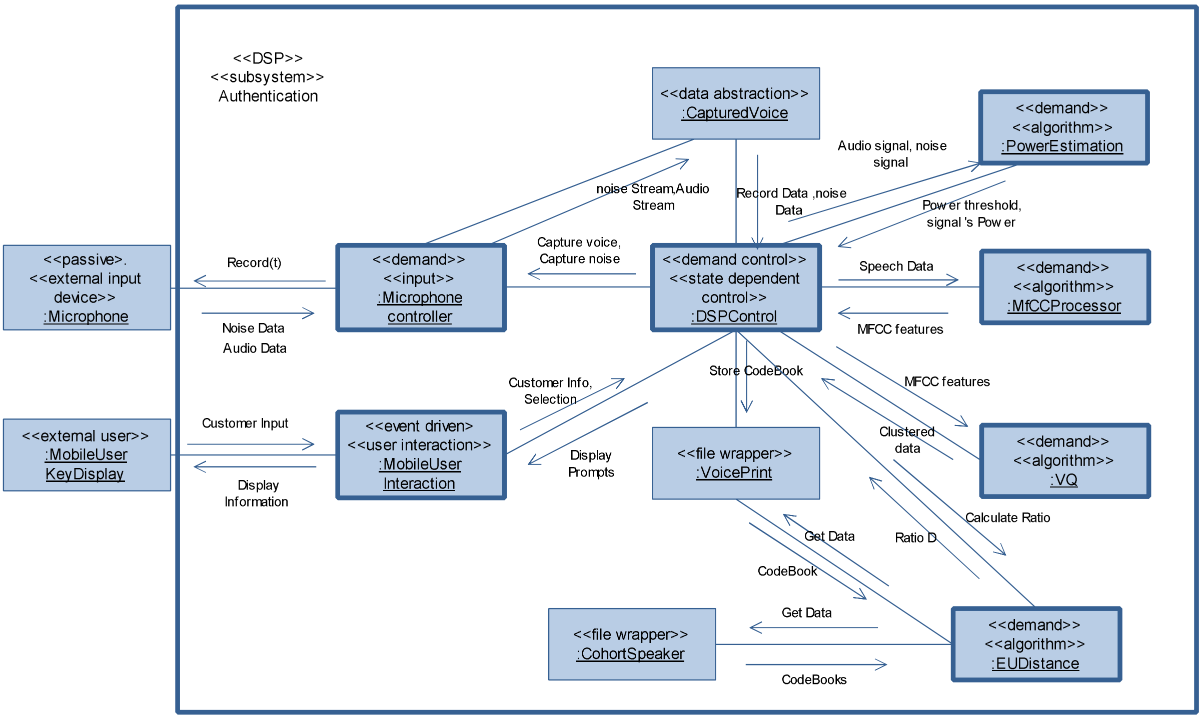


Figure (5.5): Task architecture: initial concurrent collaboration diagram for Authentication subsystem

Task clustering criteria

Microphone Controller task is responsible of recording voice or noise, after any recording operation there is corresponding Power estimation job performed by Power Estimation task so by sequential clustering criteria we can merge Microphone Controller Task with Power Estimation Task to be <<demand>> <<sequential clustering>> :Record&PowerEstimation Task, after this merge, the data abstraction Captured Voice object is accessed only by Microphone Controller Task and Power Estimation Task which was merged we by the definition of hidden information object, the passive object Captured Voice hidden in :Record&PowerEstimation Task.

Because mobile user can insert a voice print or verified by his voice at certain time, we can merge VQ Task with EUDistance by Mutually Exclusive Clustering Criteria to be:

<<demand algorithm>> <<mutually exclusive clustering>> :VQ&EUDistance Task, and the file wrapper objects Cohort Speaker and Voice Print are accessed only by VQ and EUDistance objects so the previous passive objects will be hidden in :VQ&EUDistance Task.

In another hand MFCCProcessor is a state-dependent action that is triggered by the control object because of a state transaction. So simply DSP Control task and MFCCProcessor may be grouped into a control clustering task called the DSP Controlling as following synthase:

<<demand control>> <<control clustering>> :DSPController,

So the overall remaining concurrent tasks running on Authentication subsystem as shown in figure 5.6

Define the Authentication subsystem Task Interfaces

Speaker verification process is explain briefly in section 3.5, it contains many sequential stages, each stage uses data or result estimated on previous one, so we will use tightly coupled message communication with reply interface between all tasks and data abstraction as shown in figure 5.6.

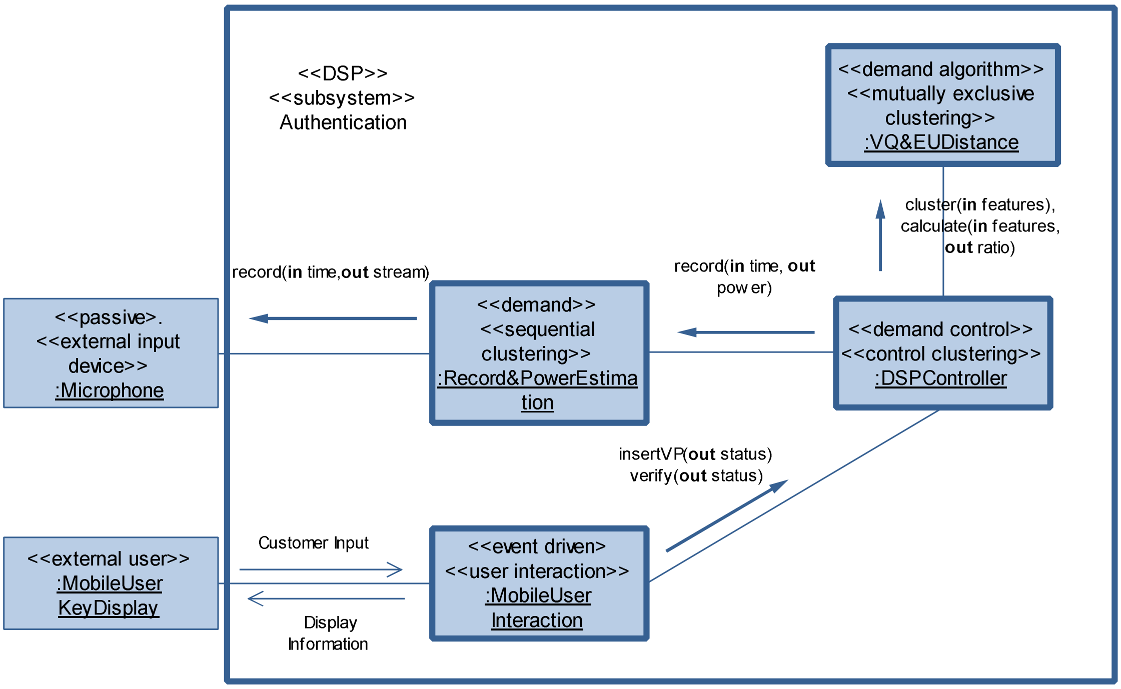


Figure (5.6): Task architecture diagram for Authentication subsystem: task interface.

5.2.2 Mobile Client subsystem task structuring architecture

1. Event Driven I/O Tasks
   - << event driven>> <<proxy>> :BankingServerProxy Task
2. Control Clustering tasks
   - <<demand>> <<state dependent control>> :MobileClientControl Task
3. User Interaction tasks
   - <<event driven>> <<user interaction>> :MobileUserInteraction Task. As shown in figure 5.7.

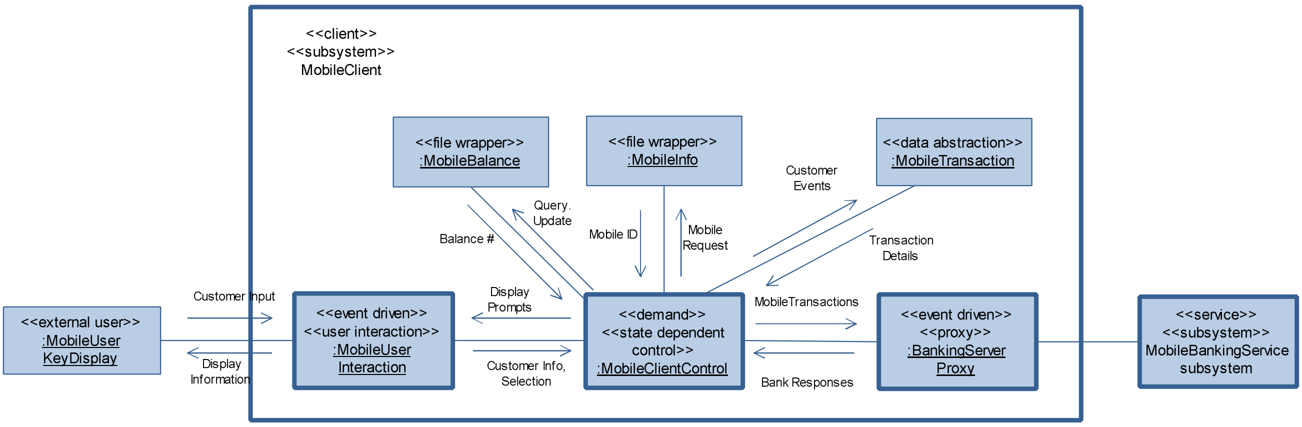


Figure (5.7): Task architecture: initial concurrent collaboration diagram for Mobile Client subsystem.

Define the Mobile Client subsystem Task Interfaces

Because user can press Cancel at any moment, it is desirable the interface between Mobile Client control task and Mobile User Interaction to be loosely coupled so the user interaction is not suspended to wait results.

All data abstractions: Mobile Transaction, mobile Info, and Mobile Balance are passive objects so any interface between any of them and Mobile Client Control is tightly coupled with synchronous call scenario.

Any proxy object Banking Server proxy hides the details of “how” to communicate with the external subsystem Mobile Banking Server. A Proxy object is event driven task so the interface between it and the control object is loosely coupled with asynchronous messages. As shown in figure 5.8.

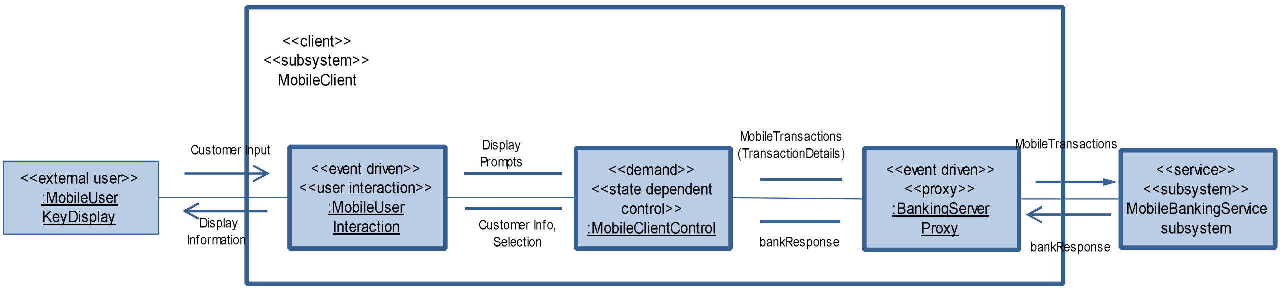


Figure (5.8): Task architecture diagram for Mobile Client subsystem: task interface.

5.2.3 Payment subsystem task structuring architecture

1. Event Driven I/O Tasks
   - <<event driven>> <<I/O>> :BluetoothAdapterInterface Task
2. Control Clustering tasks
   - <<demand>> <<state dependent control>> :PaymentControl Task
3. User Interaction tasks
   - <<event driven>> <<user interaction>> :MobileUserInteraction Task
4. Demand driven tasks
   - <<demand>> <<service>> :PayService Task. As shown in figure in 5.9.

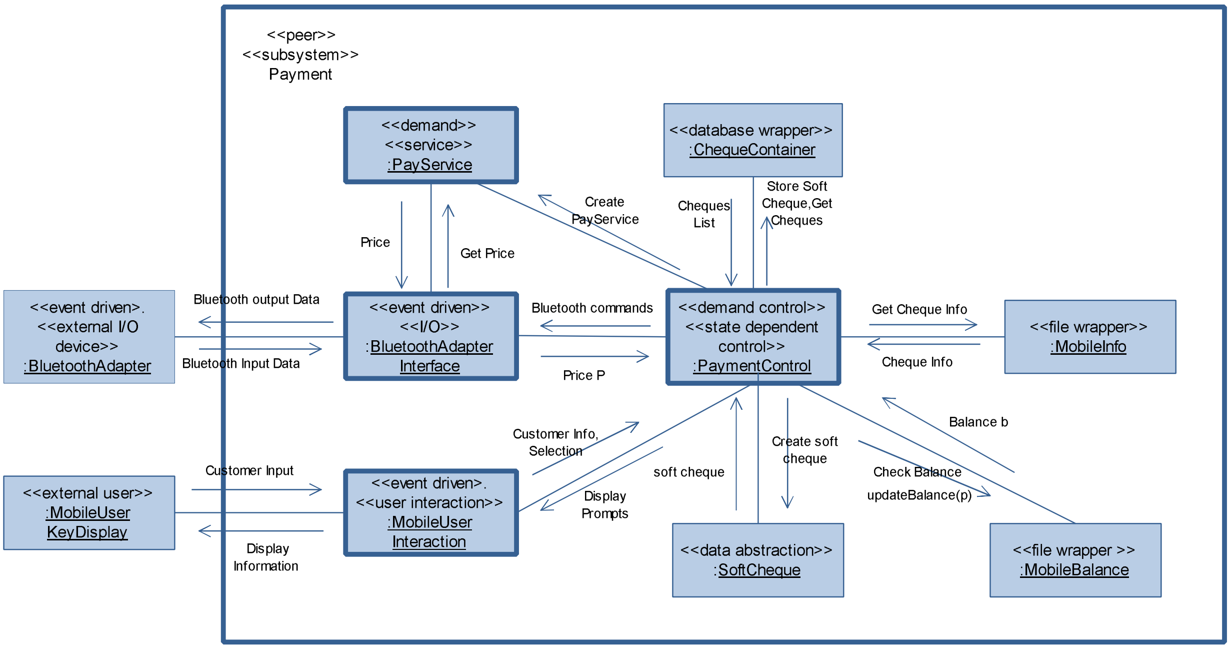


Figure (5.9): Task architecture: initial concurrent collaboration diagram for Payment subsystem.

Define the Payment subsystem Task Interfaces

Consider the interface between Payment Control Task and Bluetooth Adapter Interface task. It is desirable for this to be loosely coupled because Bluetooth device is asynchronous, so an asynchronous message interface is used.

Because user can press Cancel at any moment, it is desirable the interface between Payment control task and Mobile User Interaction to be loosely coupled so the user interaction is not suspended to wait results.

All data abstractions: Cheque container, Payment Transaction, mobile Info, Pay service, Mobile Balance and Soft Cheque are passive objects so any interface between any of them and a task like Payment Control and Bluetooth Adapter Interface is tightly coupled with synchronous call scenario.

Any proxy object acts as server behavior with request-reply behavior, so the interface between Banking Server Proxy Task and Payment Control task is tightly coupled.

Also consider the interface between Payment control and Connection Manager, it is desirable for this to be tightly coupled with synchronous messages. As shown in figure 5.10.

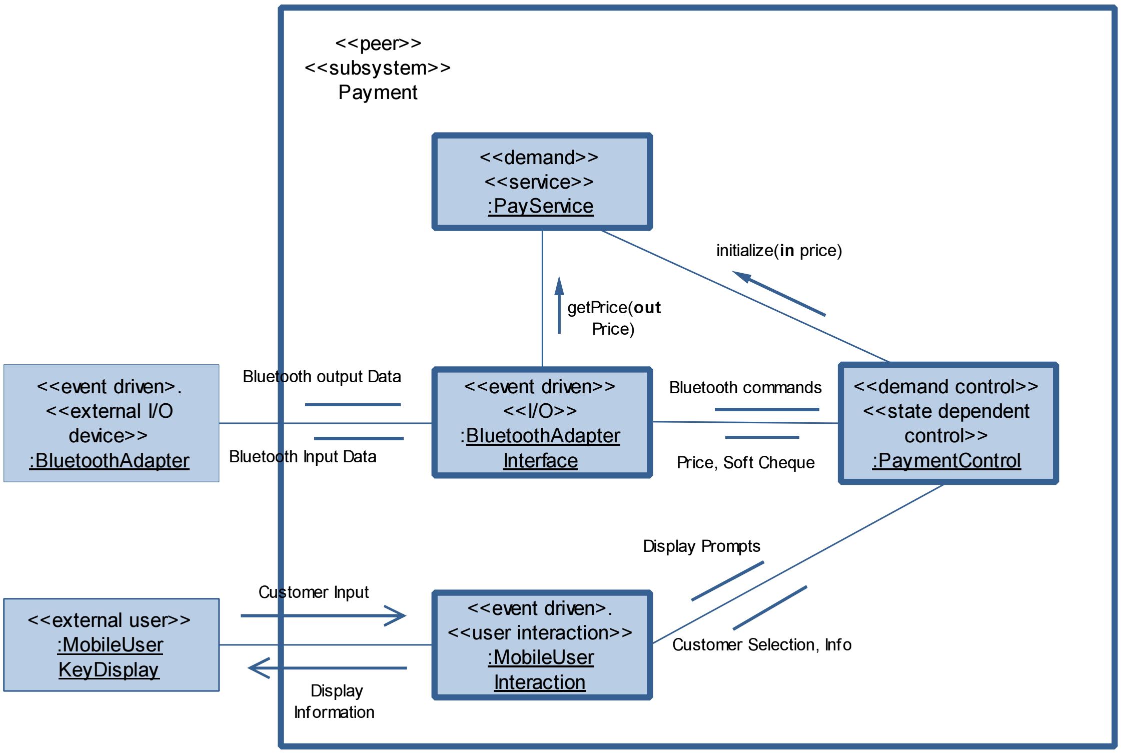


Figure (5.10): Task architecture diagram for Payment subsystem: task interface

5.2.4 Mobile Banking Service subsystem task structuring architecture

We assume that the bank server is a sequential machine, this means no concurrency between objects, simply Mobile Banking Service subsystem is a one task as shown in figure 5.11.

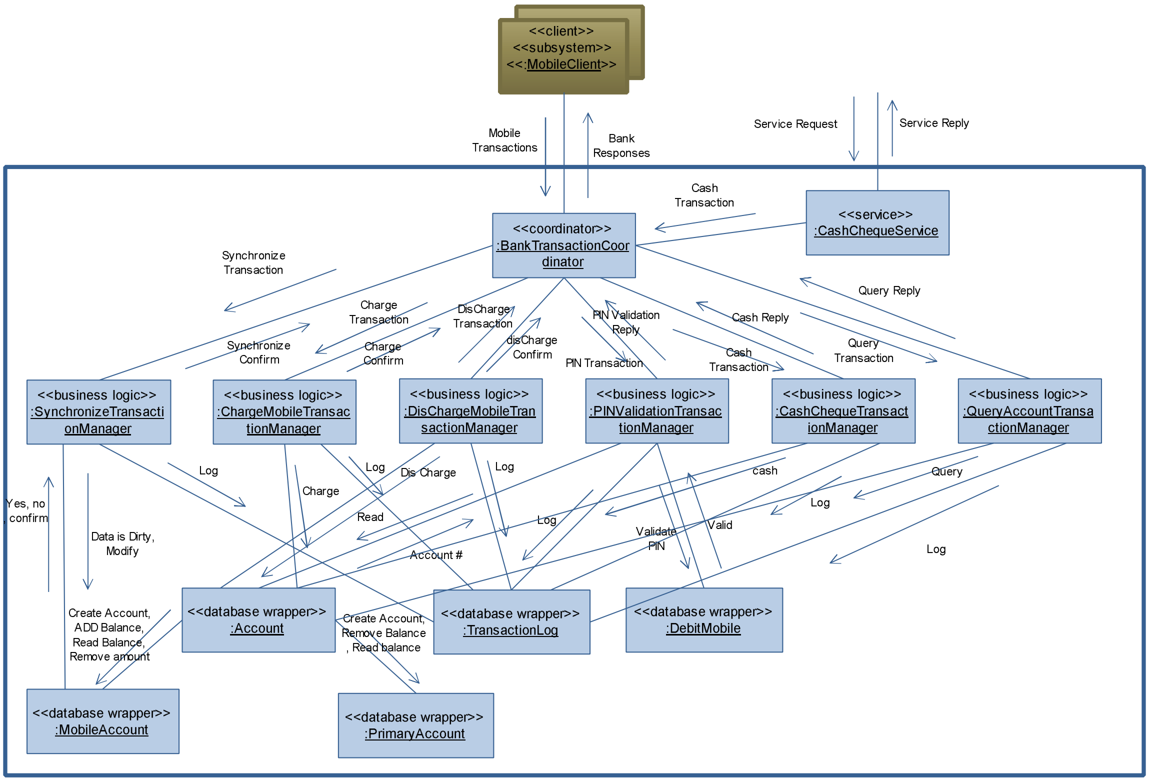


Figure (5.11): Task architecture: initial concurrent collaboration diagram for Mobile Banking Service subsystem.

Mobile Bank Service subsystem execute transactions, which needs tightly coupled message with reply interfaces as shown in figure 5.12.

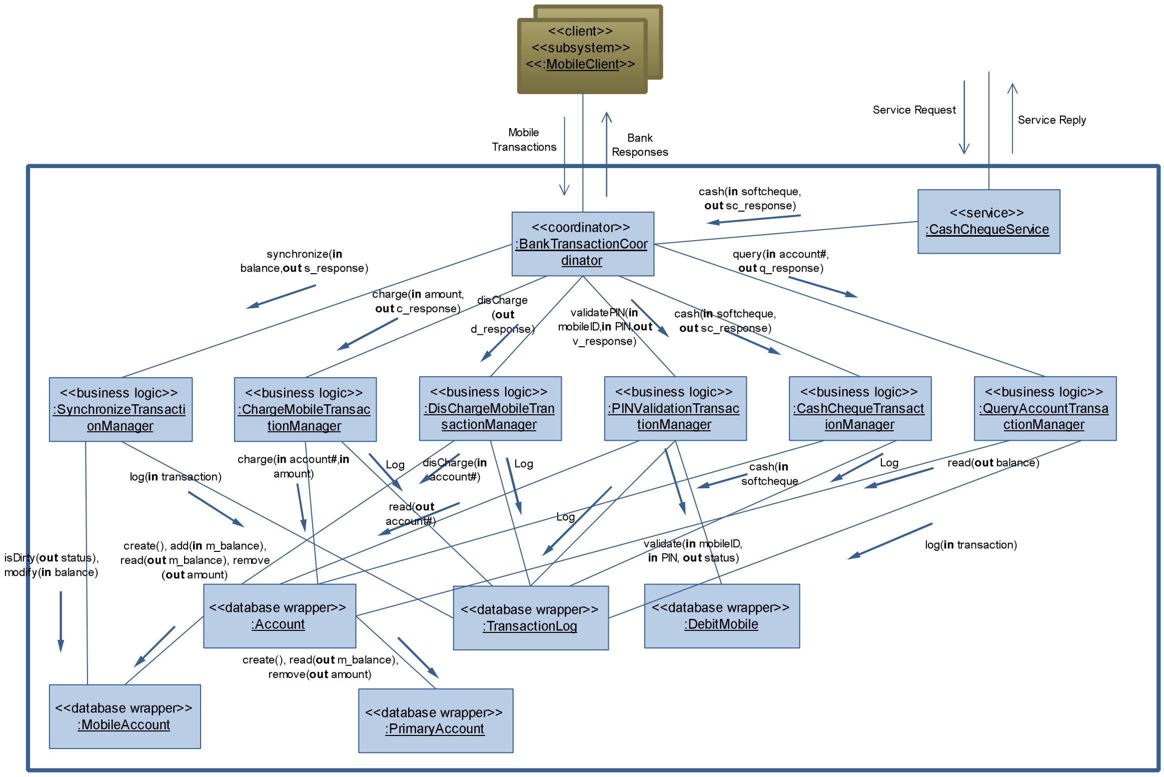

<<client>>
<<subsystem>>
<<:MobileClient>>
Mobile Transactions
Bank Responses
Service Request
Service Reply
<<coordinator>>
:BankTransactionCoordinator
<<service>>
:CashChequeService
cash(in softcheque, out sc_response)
query(in account#, out q_response)
synchronize(in balance,out s_response)
charge(in amount, out c_response)
disCharge (out d_response)
validatePIN(in mobileID,in PIN,out v_response)
cash(in softcheque, out sc_response)
<<business logic>>
:SynchronizeTransactionManager
<<business logic>>
:ChargeMobileTransactionManager
<<business logic>>
:DisChargeMobileTransactionManager
<<business logic>>
:PINValidationTransactionManager
<<business logic>>
:CashChequeTransactionManager
<<business logic>>
:QueryAccountTransactionManager
log(in transaction)
charge(in account#,in amount)
Log
disCharge(in account#)
Log
read(out account#)
Log
cash(in softcheque
Log
read(out balance)
validate(in mobileID, in PIN, out status)
log(in transaction)
isDirty(out status), modify(in balance)
create(), add(in m_balance), read(out m_balance), remove (out amount)
<<database wrapper>>
:Account
<<database wrapper>>
:TransactionLog
<<database wrapper>>
:DebitMobile
create(), read(out m_balance), remove(out amount)
<<database wrapper>>
:MobileAccount
<<database wrapper>>
:PrimaryAccount

Figure (5.12): Task architecture diagram for Mobile Banking Service subsystem: task interface

5.3 Class design

5.3.1 Authentication subsystem classes design

In authentication subsystem many classes for implementing speaker verification, and accomplish use case: Insert voice print, and Login. Data abstraction Captured Voice needs set and get methods, the functions signature of all classes are shown in figure 5.13.

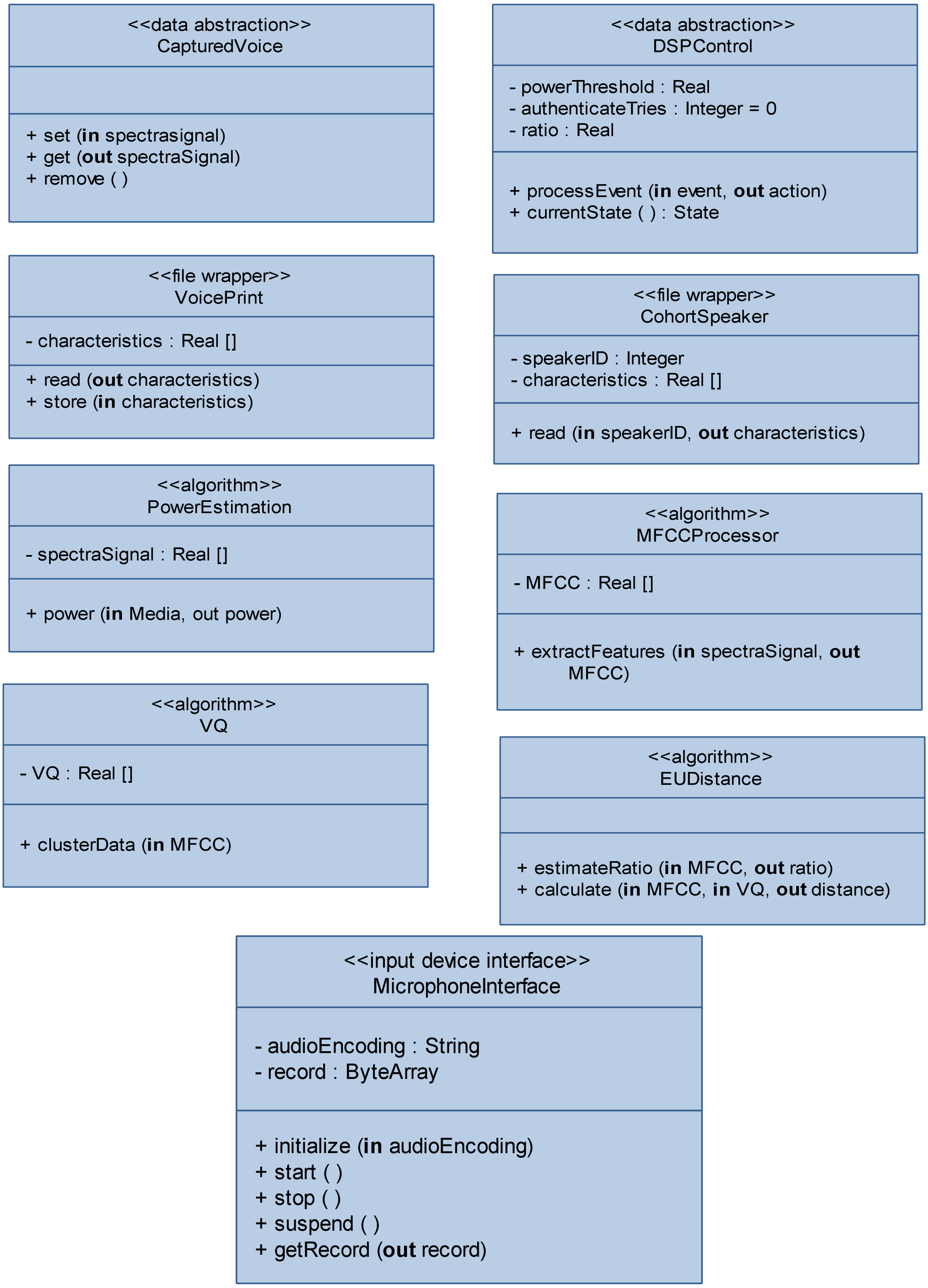

<<data abstraction>>
CapturedVoice
+ set (in spectrasignal)
+ get (out spectraSignal)
+ remove ( )
<<data abstraction>>
DSPControl
- powerThreshold : Real
- authenticateTries : Integer = 0
- ratio : Real
+ processEvent (in event, out action)
+ currentState ( ) : State
<<file wrapper>>
VoicePrint
- characteristics : Real []
+ read (out characteristics)
+ store (in characteristics)
<<file wrapper>>
CohortSpeaker
- speakerID : Integer
- characteristics : Real []
+ read (in speakerID, out characteristics)
<<algorithm>>
PowerEstimation
- spectraSignal : Real []
+ power (in Media, out power)
<<algorithm>>
MFCCProcessor
- MFCC : Real []
+ extractFeatures (in spectraSignal, out MFCC)
<<algorithm>>
VQ
- VQ : Real []
+ clusterData (in MFCC)
<<algorithm>>
EUDistance
+ estimateRatio (in MFCC, out ratio)
+ calculate (in MFCC, in VQ, out distance)
<<input device interface>>
MicrophoneInterface
- audioEncoding : String
- record : ByteArray
+ initialize (in audioEncoding)
+ start ( )
+ stop ( )
+ suspend ( )
+ getRecord (out record)

Figure (5.13): Authentication subsystem information hiding classes

5.3.2 Mobile Client subsystem classes design

The consolidated collaboration diagram of mobile client subsystem shows different objects interact with together to accomplish a given use case scenario these objects are Mobile Client Control, Banking Server Proxy, Mobile Transaction, Mobile Info, Mobile Balance and Mobile User Interaction, the use cases description are in Appendix A , Mobile User Interaction object is a composite graphical user interaction object composed of several simpler interaction objects as shown in figure 5.14.

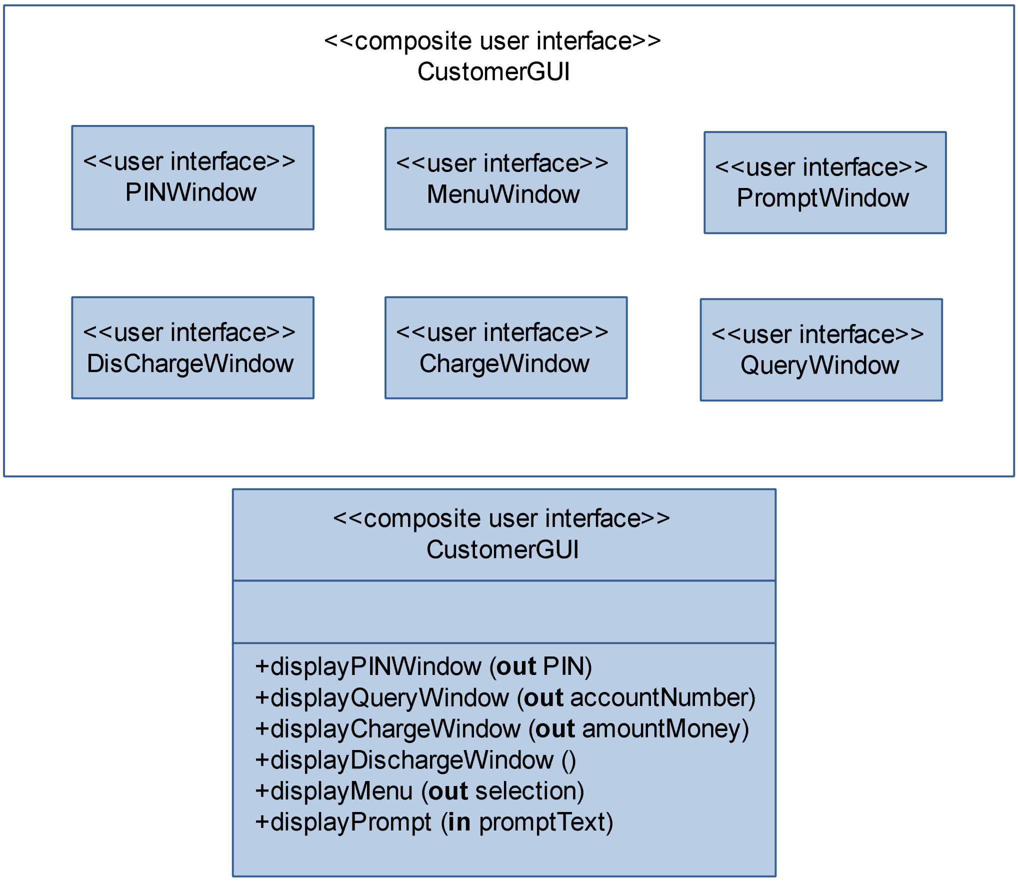

<<composite user interface>>
CustomerGUI
<<user interface>>
PINWindow
<<user interface>>
MenuWindow
<<user interface>>
PromptWindow
<<user interface>>
DisChargeWindow
<<user interface>>
ChargeWindow
<<user interface>>
QueryWindow
<<composite user interface>>
CustomerGUI
+displayPINWindow (**out** PIN)
+displayQueryWindow (**out** accountNumber)
+displayChargeWindow (**out** amountMoney)
+displayDischargeWindow ()
+displayMenu (**out** selection)
+displayPrompt (**in** promptText)

Figure (5.14): Mobile Client GUI classes

Mobile Transaction object is used to keep data for a long time without store it on disk or on database so the desirable choice is a data abstraction class, which keeps any modifications to customer selection and information, the mobile info stored on disk and serialize to Mobile Info class, also the balance stored on disk and serialize to Mobile Balance class, we use Proxy Pattern so we need a proxy class Banking Server Proxy. An instance of Mobile Client Control state dependent control class executes Mobile Client finite state chart in figures 4.32, 4.33, 4.34, and 4.35. more information about Mobile Client subsystem classes in figure 5.15.

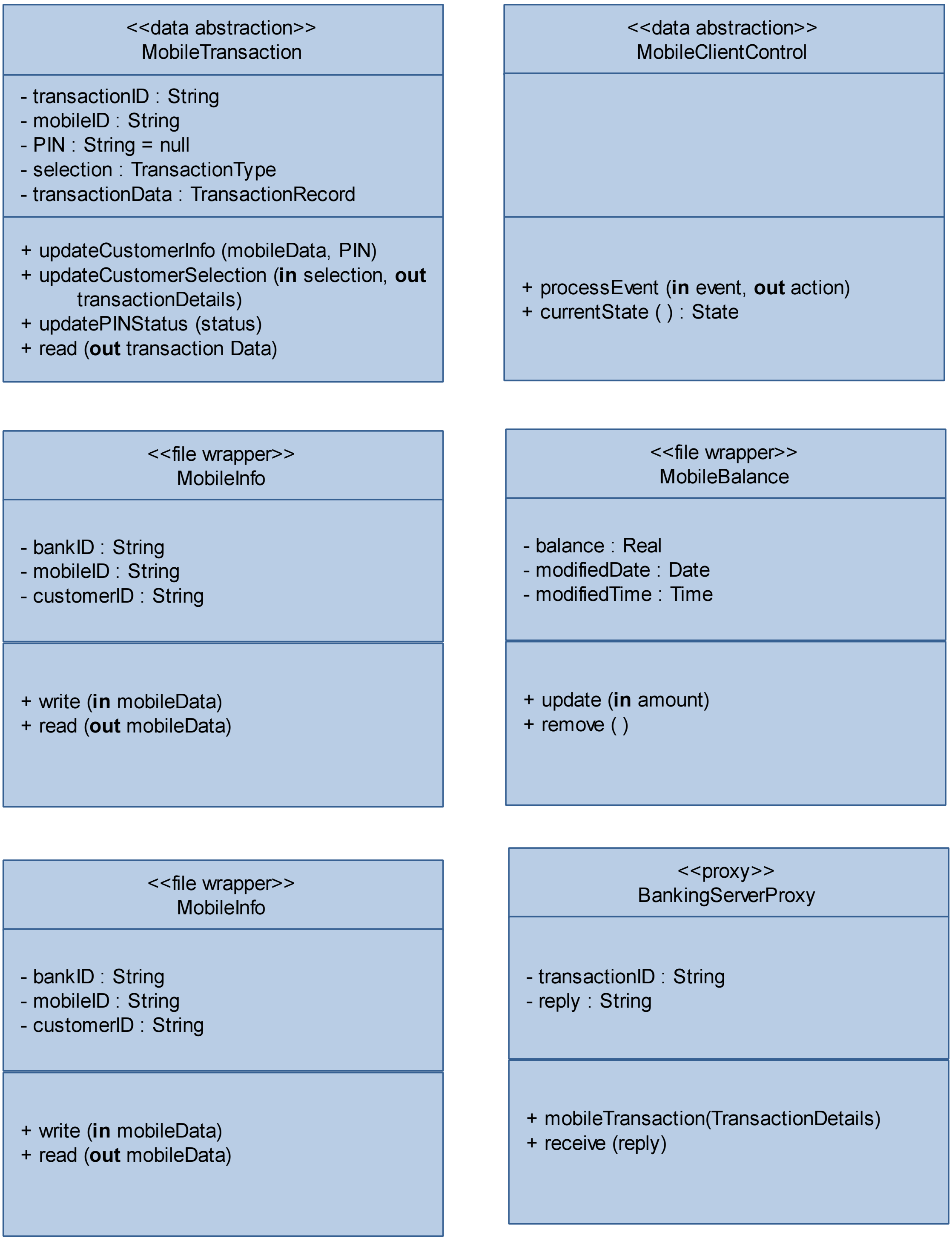


Figure 5.15 Mobile Client subsystem information hiding classes

5.3.3 Payment subsystem classes design

First we determine and briefly design classes details about GUI of Payment subsystem as a composite user interface. Figure 5.16 shows this classes and its methods.

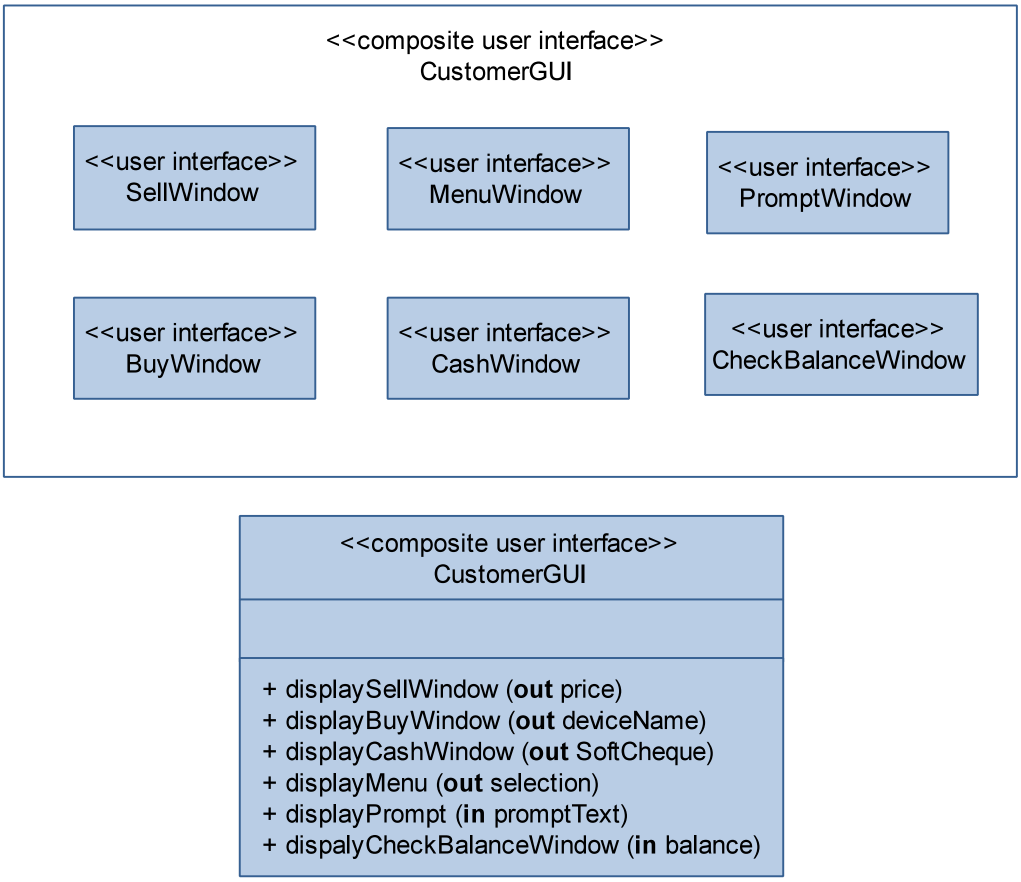

<<composite user interface>>
CustomerGUI
<<user interface>>
SellWindow
<<user interface>>
MenuWindow
<<user interface>>
PromptWindow
<<user interface>>
BuyWindow
<<user interface>>
CashWindow
<<user interface>>
CheckBalanceWindow
<<composite user interface>>
CustomerGUI
+ displaySellWindow (out price)
+ displayBuyWindow (out deviceName)
+ displayCashWindow (out SoftCheque)
+ displayMenu (out selection)
+ displayPrompt (in promptText)
+ dispalyCheckBalanceWindow (in balance)

Figure (5.16): Payment customer GUI classes

In another hand figure 5.17 shows remainders classes in Payment subsystem including for example state dependent control Payment Control object, which usually has processEvent function to execute the statechart in chapter 4, and currentState function which returns the current state of this control.

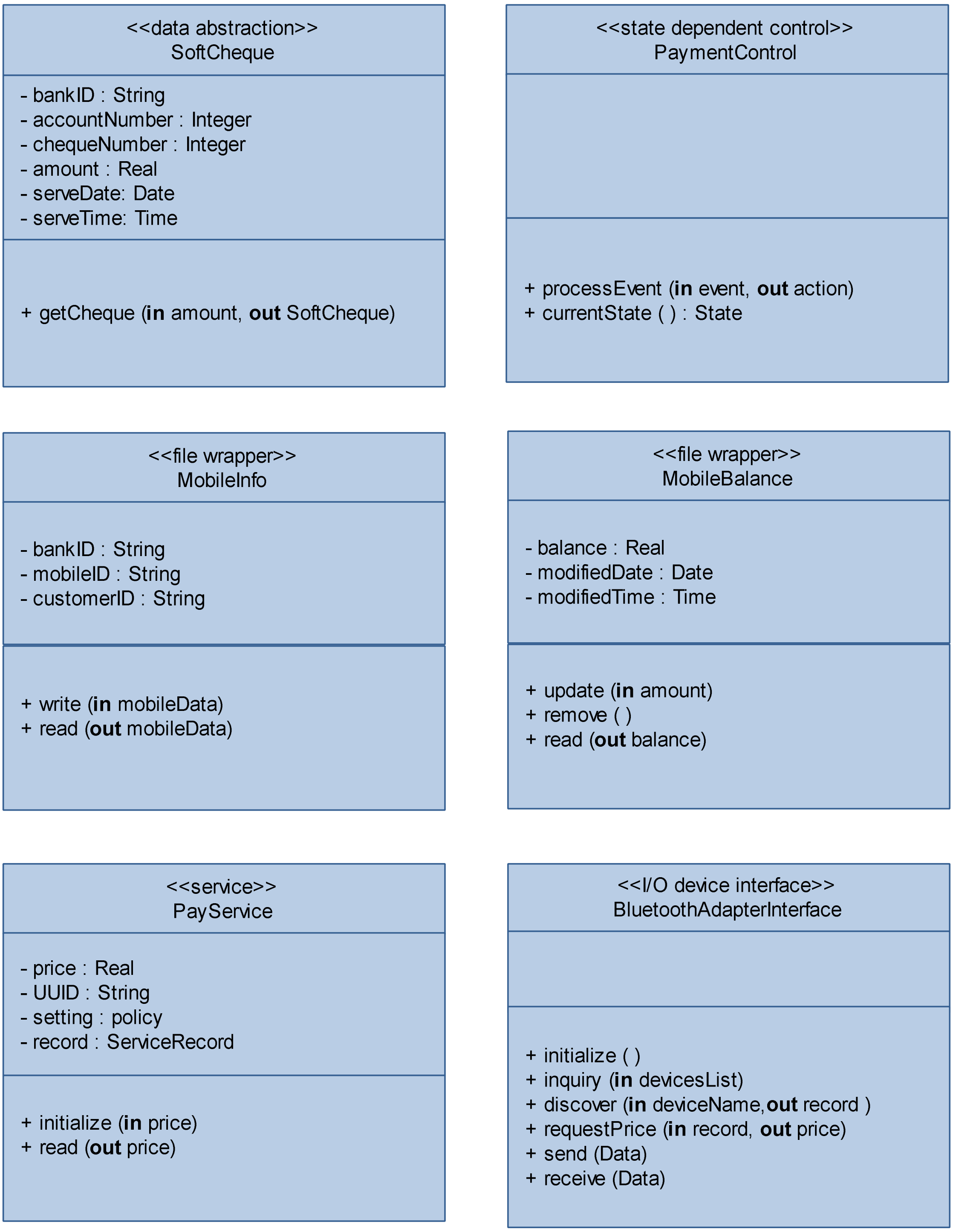
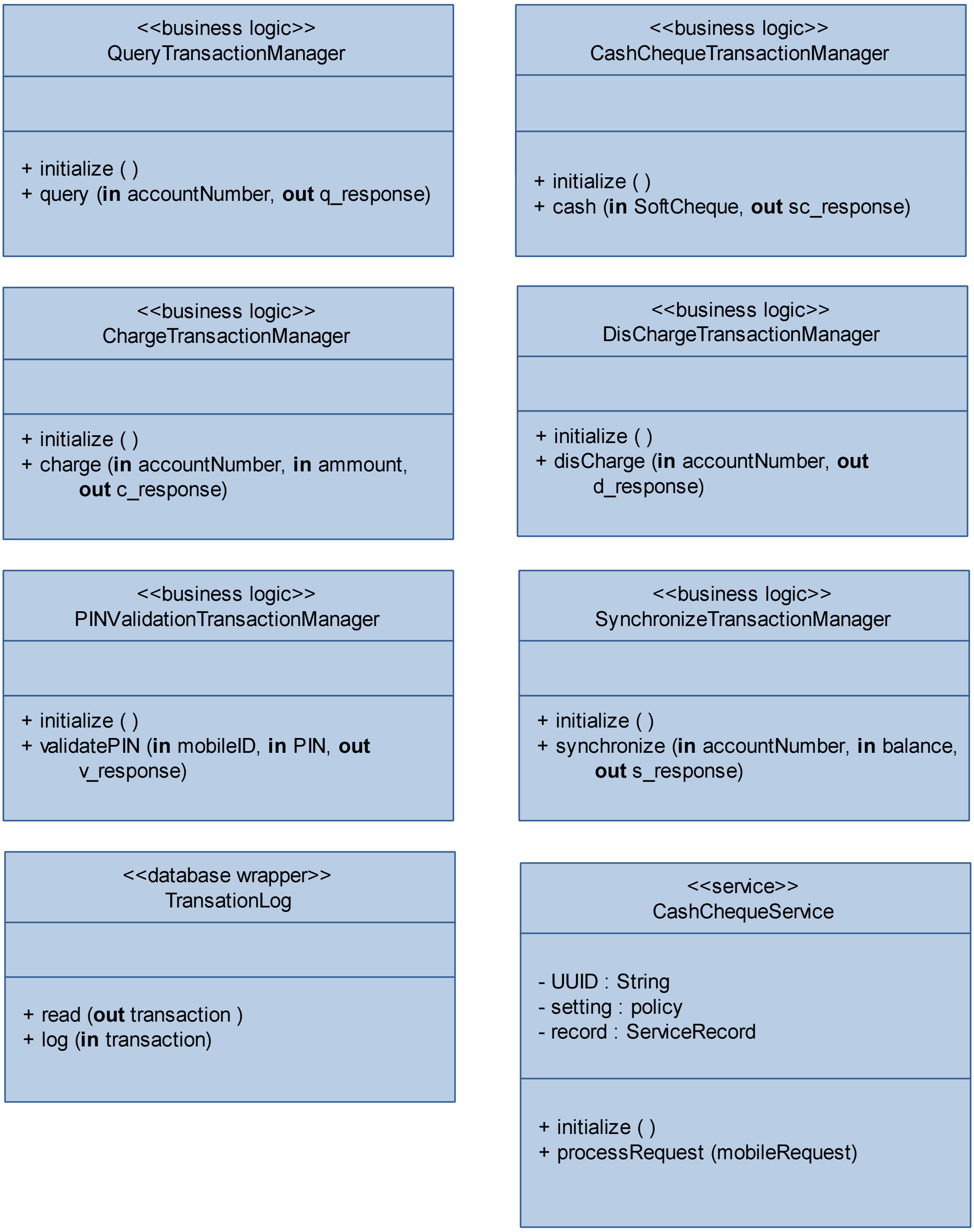


Figure (5.17): Payment subsystem information hiding classes

5.3.4 Mobile Banking Service subsystem classes design

Mobile Banking contains many business logic object to complete all client transactions, more details about classes and its functions in figure 5.18.


<<business logic>>
QueryTransactionManager
+ initialize ( )
+ query (**in** accountNumber, **out** q_response)
<<business logic>>
CashChequeTransactionManager
+ initialize ( )
+ cash (**in** SoftCheque, **out** sc_response)
<<business logic>>
ChargeTransactionManager
+ initialize ( )
+ charge (**in** accountNumber, **in** ammount, **out** c_response)
<<business logic>>
DisChargeTransactionManager
+ initialize ( )
+ disCharge (**in** accountNumber, **out** d_response)
<<business logic>>
PINValidationTransactionManager
+ initialize ( )
+ validatePIN (**in** mobileID, **in** PIN, **out** v_response)
<<business logic>>
SynchronizeTransactionManager
+ initialize ( )
+ synchronize (**in** accountNumber, **in** balance, **out** s_response)
<<database wrapper>>
TransationLog
+ read (**out** transaction)
+ log (**in** transaction)
<<service>>
CashChequeService
- UUID : String
- setting : policy
- record : ServiceRecord
+ initialize ( )
+ processRequest (mobileRequest)

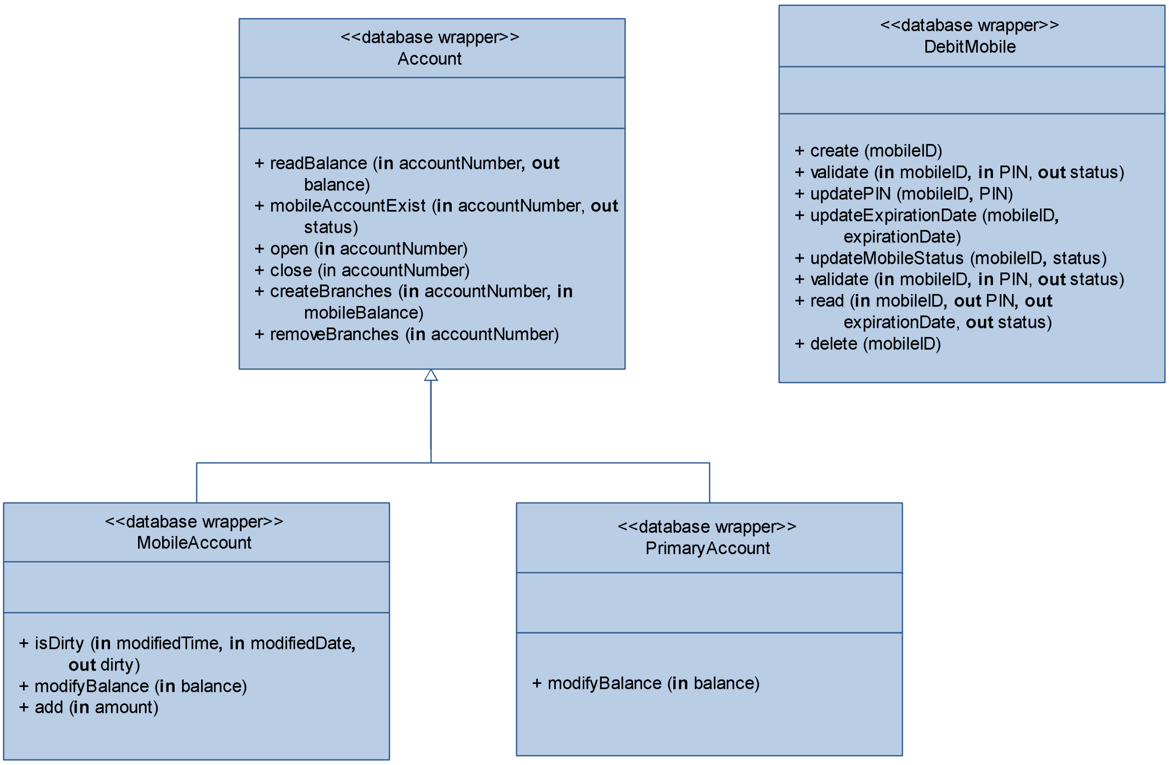

<<database wrapper>>
Account
+ readBalance (in accountNumber, out balance)
+ mobileAccountExist (in accountNumber, out status)
+ open (in accountNumber)
+ close (in accountNumber)
+ createBranches (in accountNumber, in mobileBalance)
+ removeBranches (in accountNumber)
<<database wrapper>>
DebitMobile
+ create (mobileID)
+ validate (in mobileID, in PIN, out status)
+ updatePIN (mobileID, PIN)
+ updateExpirationDate (mobileID, expirationDate)
+ updateMobileStatus (mobileID, status)
+ validate (in mobileID, in PIN, out status)
+ read (in mobileID, out PIN, out expirationDate, out status)
+ delete (mobileID)
<<database wrapper>>
MobileAccount
+ isDirty (in modifiedTime, in modifiedDate, out dirty)
+ modifyBalance (in balance)
+ add (in amount)
<<database wrapper>>
PrimaryAccount
+ modifyBalance (in balance)

Figure (5.18): Mobile Banking Service subsystem information hiding classes.

5.4 Detailed design

5.4.1 DSPController composite task

This composite task hides a DSP Control state dependent control object, and MFCC Processor algorithm object. The figure 5.19 shows the detailed software design of the DSP Controller task.

There is a coordinator called DSP Coordinator, it is responsible of receiving request from other tasks and replying to them. Also it translates these requests to methods syntax and invokes two main methods: extractFeatures in MFCC Processing object, this method has spectra signal as parameter and returns MFCC data, and processEvent method in DSP Control object, which has event as parameter, and generates actions as result of execution DSP Control statechart.

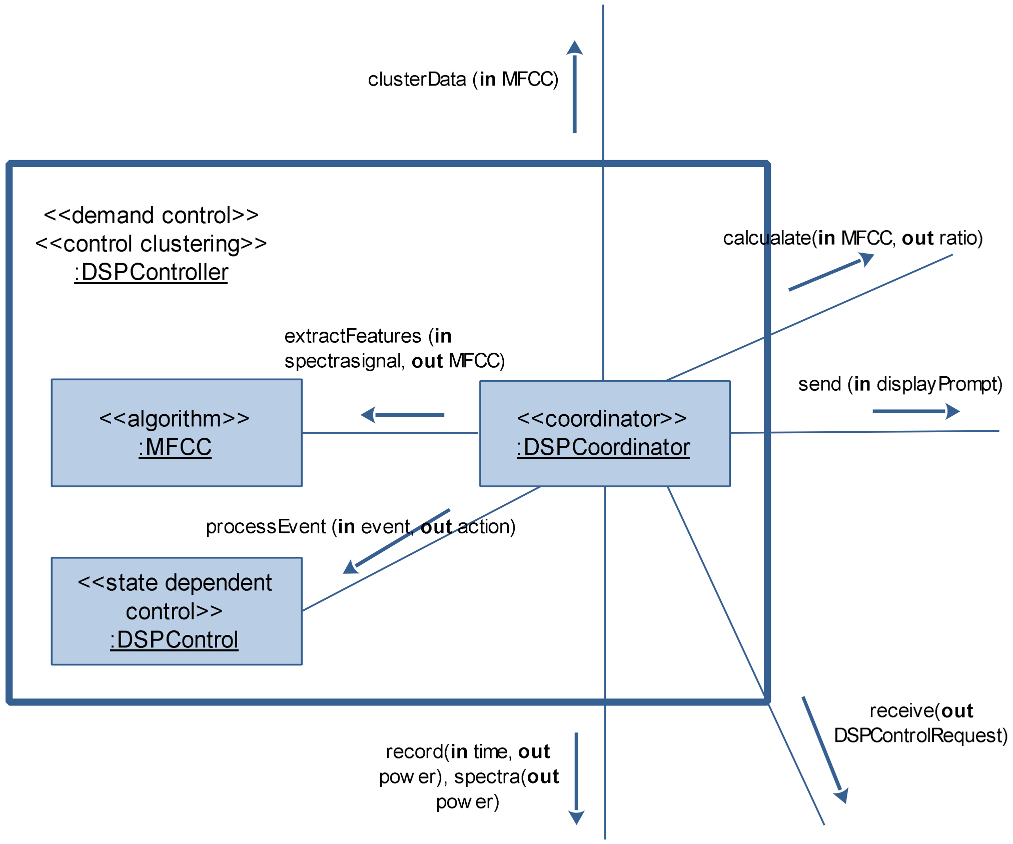

clusterData (**in** MFCC)
<<demand control>>
<<control clustering>>
:DSPController
calcualate(**in** MFCC, **out** ratio)
extractFeatures (**in** spectrasignal, **out** MFCC)
send (**in** displayPrompt)
<<algorithm>>
:MFCC
<<coordinator>>
:DSPCoordinator
processEvent (**in** event, **out** action)
<<state dependent control>>
:DSPControl
receive(**out** DSPControlRequest)
record(**in** time, **out** pow er), spectra(**out** pow er)

Figure (5.19): DSPController task

5.4.2 VQ&EUDistance composite task

This composite task contains information hiding objects: VQ algorithm object, Voice Print file wrapper object, Cohort Speaker file wrapper object, and EUDistance algorithm object. The figure 5.20 shows the detailed software design of the VQ&EUDistance task.

There is a coordinator called the VQ&EUDistance monitor, it monitors incoming messages and forward each message to corresponding algorithm by invoking its methods. This task communicates only with DSP Controller task.

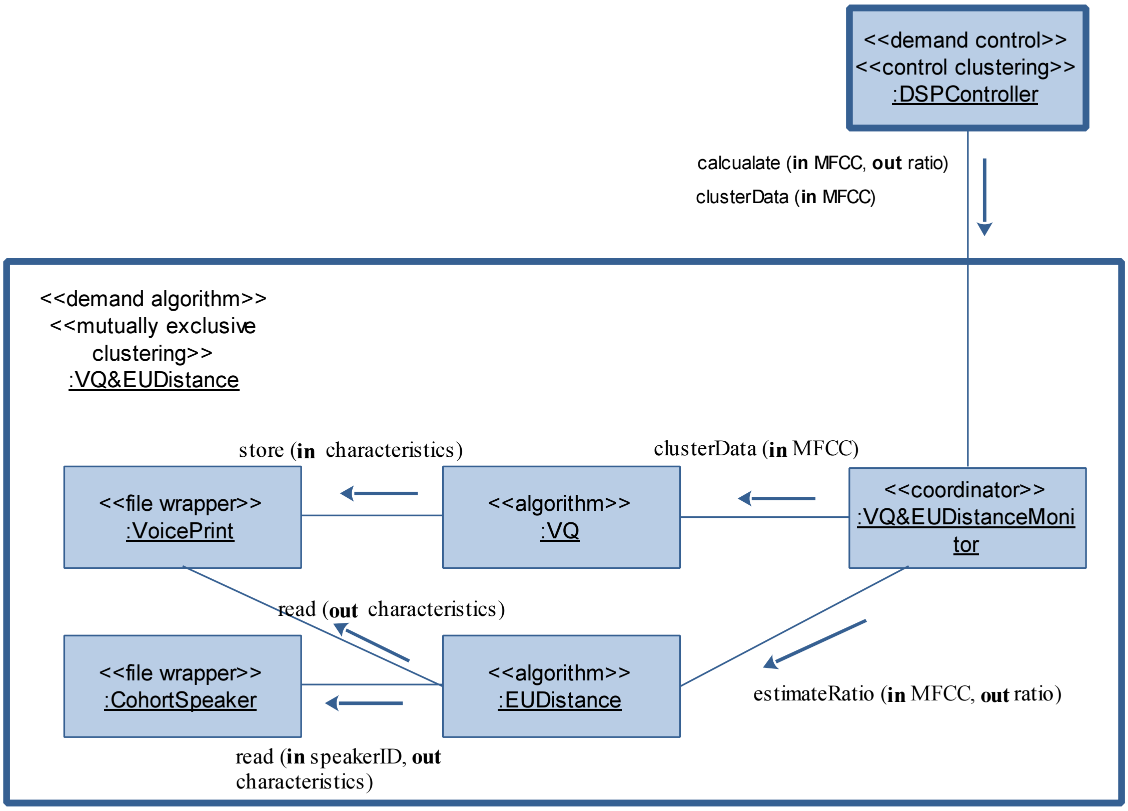


Figure (5.20): VQ&EUDistance task

5.4.3 Mobile Control composite task

This composite task contains information hiding objects: Mobile Client Control state dependent control object, Mobile Info file wrapper object, Mobile Balance file wrapper object, and Mobile Transaction data abstraction object. The figure 5.21 shows the detailed software design of the Mobile Control task.

We called this task a Mobile Client Control not Controller, because there is no more than one task which is Mobile Client Control itself, other objects are entity objects according to information hiding concept. There is a coordinator called the Mobile Client Coordinator, it is responsible of translating received messages to events, which causes Mobile Client Control statechart transitions from state to another.

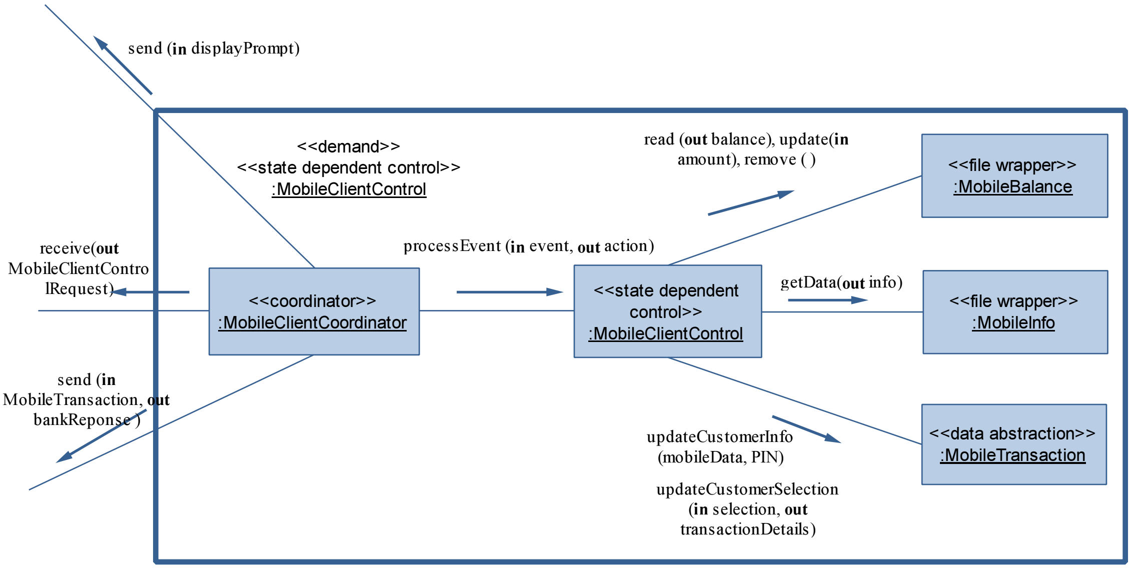
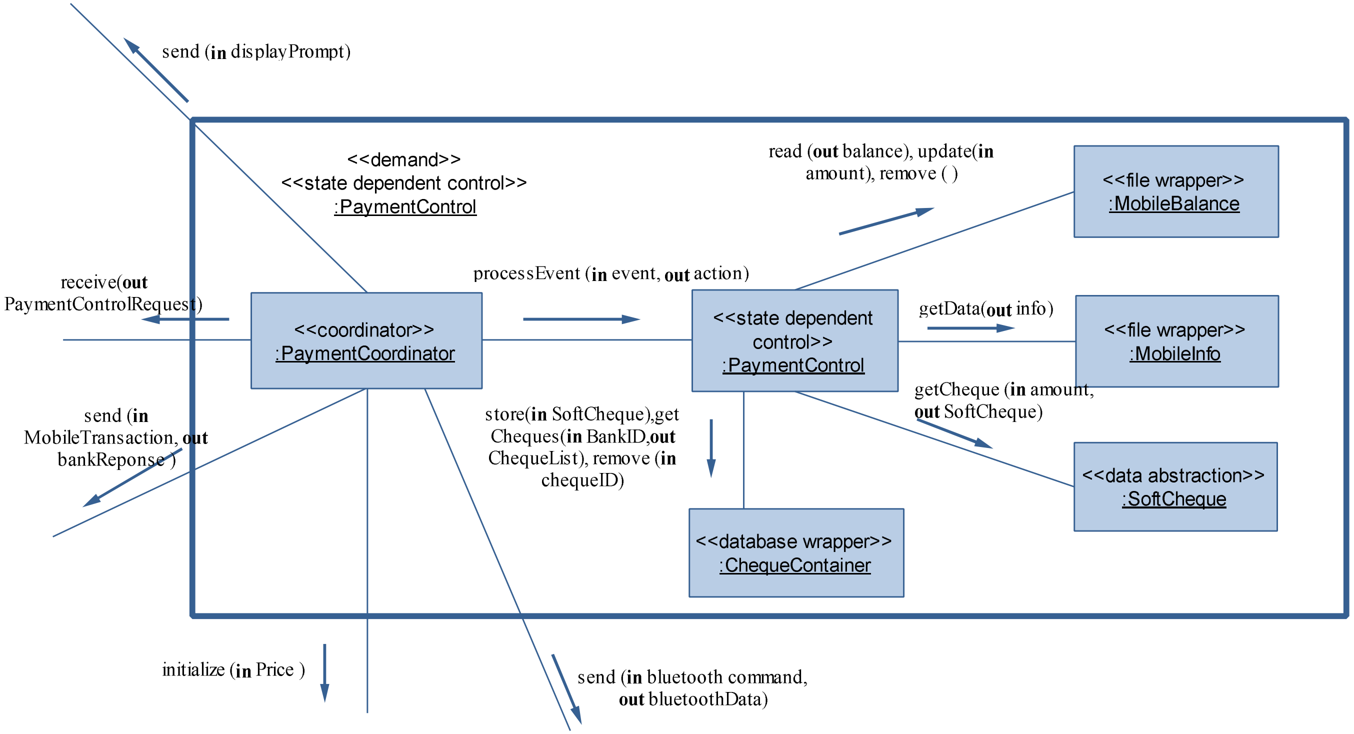

send (in displayPrompt)
<<demand>>
<<state dependent control>>
:MobileClientControl
read (out balance), update(in amount), remove ( )
<<file wrapper>>
:MobileBalance
receive(out MobileClientControlRequest)
processEvent (in event, out action)
<<coordinator>>
:MobileClientCoordinator
<<state dependent control>>
:MobileClientControl
getData(out info)
<<file wrapper>>
:MobileInfo
send (in MobileTransaction, out bankReponse)
updateCustomerInfo (mobileData, PIN)
<<data abstraction>>
:MobileTransaction
updateCustomerSelection (in selection, out transactionDetails)

Figure (5.21): Mobile Control task

5.4.4 Payment Control composite task

This composite task contains information hiding objects: Payment Control state dependent control object, Cheque Container database wrapper object, Soft Cheque data abstraction object, Mobile Info file wrapper object, and Mobile Balance file wrapper object. The figure 5.22 shows the detailed software design of the Payment Control task.

We called this task a Payment Control not Controller, because there is no more than one task which is Payment Control itself, other objects are entity objects according to information hiding concept. There is a coordinator called the Payment Coordinator, it is responsible of translating received messages to events, which causes Payment Control statechart transitions from state to another.



send (in displayPrompt)
<<demand>>
<<state dependent control>>
:PaymentControl
read (out balance), update(in amount), remove ( )
<<file wrapper>>
:MobileBalance
receive(out PaymentControlRequest)
<<coordinator>>
:PaymentCoordinator
processEvent (in event, out action)
<<state dependent control>>
:PaymentControl
getData(out info)
<<file wrapper>>
:MobileInfo
send (in MobileTransaction, out bankReponse)
store(in SoftCheque),get Cheques(in BankID,out ChequeList), remove (in chequeID)
getCheque (in amount, out SoftCheque)
<<data abstraction>>
:SoftCheque
<<database wrapper>>
:ChequeContainer
initialize (in Price)
send (in bluetooth command, out bluetoothData)

Figure (5.22): Payment Control task

Chapter 6

SPEAKER VERIFICATION SYSTEM: IMPLEMENTATION, AND EXPERIMENTAL RESULTS

6.1 Recording speech

To capture a voice from the microphone we use the statement:

```
Player p1 =
Manager.createPlayer("capture://audio?encoding=pcm&rate=8000&bits=16&channels=
1&endian=big&signed=signed");
```

This statement contains many parameters that can be specialized for digital signaling:

- **Encoding format:** we use Pulse Code Modulation [54], encodes an audio waveform in the time domain as a series of amplitudes.

- **Rate:** or frequency This parameter measures how many samples/channel are played each second. Frequency is measured in samples/second (Hz).

- **Resolution/Sample Size:** This parameter specifies the amount of data used to represent each discrete amplitude sample. The most common values are 8 bits (1 byte), which gives a range of 256 amplitude steps, or 16 bits (2 bytes), which gives a range of 65536 amplitude steps.

- **Channels And Interleaving:** If the PCM type is monaural, each sample will belong to that one channel. If there is more than one channel, the channels will almost always be interleaved: Left sample, right sample, left, right, etc., in the case of stereo interleaved data.

- **Byte Order:** or computer system “Endianness”, When more than one byte is used to represent a PCM sample, the byte order (big endian vs. little endian) must be known. In our statement we have two PCM bytes byte0, and byte1, it is presented in big endian as: byte1byte0 rather than byte0byte1 for small endian system.
  ARMv6 and above introduces several architectural extensions to support mixed-endian access in hardware. A PSR Endian control flag, the E bit, which dictates the byte order used for the entire load and store [64].

- **Sign:** It is not enough to know that a PCM sample is, for example, 8 bits wide. Whether the sample is signed or unsigned is needed to understand the range. If the sample is unsigned, the sample range is 0..255 with a center point of 128. If the sample is signed, the sample range is -128..127 with a center point of 0. If a PCM type is signed, the sign encoding is almost always 2's complement. In very rare cases, signed PCM audio is represented as a series of sign/magnitude coded numbers.

6.2 ARM VFP architecture

ARM-11 processor has a vector floating point (VFP), The Vector Floating-Point (VFP) architecture is a coprocessor extension to the ARM® architecture. It provides single-precision and double-precision floating-point arithmetic, as defined by ANSI/IEEE standards.

A complete implementation of the VFP architecture must include a software component, known as *support code*. The support code provides the features of the IEEE 754[19] compliance that are not supplied by the hardware [64].

Double-precision format: A double-precision value consists of two 32-bit words, with the following formats:

1. Most significant word:

31	30 20	19 0
S	Exponent	Fraction [51:32]

2. Least significant word:

31 0
Fraction [31:0]

The S is sign flag, when the number is negative S=1, else S=0. The exponent is called biased exponent all double precision numbers use a bias of 3FFH. The fraction from bit0 to bit51 is called significand or mantissa.

When held in memory, the two words must appear consecutively and must both be word-aligned. The order of the two words depends on the endianness of the memory system:

- In a little-endian memory system, the least significant word appears at the lower memory address and the most significant word at the higher memory address.

- In a big-endian memory system, the most significant word appears at the lower memory address and the least significant word at the lower memory address.

A VFP implementation must use the same endianness as the ARM® implementation it is attached to. If the ARM implementation has configurable endianness, double-precision values must not be loaded or stored before the ARM processor endianness has been set to match that of the memory system.

Converting decimal to floating-point form is a simple task that is accomplished through the following steps[55]:

1. Convert the decimal number into binary.
2. Normalize the binary number.
3. Calculate the biased exponent.
4. Store the number in floating-point format.

The four steps are illustrated for the decimal number 100.25, the decimal number is converted to a double-precision format (64-bit) floating-point number.

Table (6.1): Converting 100.25 decimal to floating-point form

Step	**Result**
1	100.25= 11100100.01
2	1100100.01=1.10010001× 2^6
3	110+01111111111=10000000101

4	Sign = 0
	Exponent = 10000000101
	Significand = 1001000100000000000000000000000000000000000000000000

Converting (C039200000000000H) floating-point form to a double-precision decimal number is a simple task that is accomplished through the following steps [55]:

1. Separate the sign bit, biased exponent, and significand.
2. Convert the biased exponent into a true exponent by subtracting the bias.

3. Write the number as a normalized binary number.
4. Convert it to a denormalized binary number.
5. Convert the denormalized binary number to equivalent decimal.

Table (6.2): Converting a floating-point from to equivalent decimal number.

Step	Result

1	Sign = 1
	Exponent = 10000000011
	Significand = 1001001000000000000000000000000000000000000000000000

2	10000000011 – 01111111111 = 100
3	1.1001001×2^4
4	11001.001
5	- 25.125

6.3 Natural logarithm

J2ME is a micro edition of java language, it not contains many mathematic functions, it leaves the implementation of these functions to developers, developers write own function by the optimum way that trading between performance, usage memory and disk size, and accuracy.

One of the most popular mathematic formulas is the natural logarithm, J2ME doesn't offer the logarithms' implementation, the natural logarithm is used frequently in speech features extraction especially for MFCCs features. In this thesis we present two versions of method implementation of the natural logarithm.

ICSILog approach [71] introduced C-method for implementing natural logarithm for single precision numbers, this approach depends on look-up table that resides on cash memory. In mobile phones, the cash is very expensive and relatively is small, also C language is not platform independent like java technology. Single precision 32 bits is not enough for representing numbers and has less accuracy.

Method 1:

Suppose that we need to find a natural logarithm for the real number **X,** in previous section we briefly explained the floating-point double precision form. The number **X** can be rewritten as :

X= significand × 2^{exponent} , where the signficand is a normalize number between 1 and 2.
$\ln(X) = \ln[\text{significand} \times 2^{\text{exponent}}] = \ln(\text{significand}) + \text{exponent} \times \ln(2)$.
ln (2) is a constant and equals to 0.693147180559945309417232121458l8.
The remainder right term is ln (significand) can be solved by the Taylor series [56], in more specific the Mercator series or Newton–Mercator [57] series is the Taylor series for the natural logarithm:

$$\ln(1+X) = \sum_{n=1}^{\alpha} \frac{(-1)^{n+1}}{n} X^n, \quad |X| < 1$$
$$= X - \frac{X^2}{2} + \frac{X^3}{3} - \frac{X^4}{4} + \cdots \qquad \textbf{((6.1))}$$

We have implemented the natural logarithm depends on Mercator series in the following J2ME code:

```
    public static double mercatorLog(double x) {
            long l = Double.doubleToLongBits(x);
            long exp = ((0x7ff0000000000000L & l) >> 52) - 1023;
            double man = (0x000fffffffffffffL & l) / (double)0x10000000000000L +
            1.0;
            double lnm = 0;
            double a = (man - 1);
            for( int n = 1; n < 7; n ++) {
                if (n%2!=0)
                     lnm += pow(a, n) / n;
               else
                     lnm -=pow(a,n)/n;
                                 }
    return lnm + exp * 0.6931471805599453094172321214581 8;
}
```

For more accuracy, increase the range of "for loop" . And we need to implement the power method too, because is not defined in J2ME:

```
public static  double pow(double base, int exp){

    if(exp == 0) return 1;

    double res = base;

    for(;exp > 1; --exp)

            res *= base;

    return res;

}
```

Method 2

Because the significand is in normalized form: 1.XXX, so it can be written as : 1+X where X is between 0 and 1, so there is another more efficient series based on the Area Hyperbolic Tangent function [58] can be applied for natural logarithm estimation:

$$\ln(X) = 2 \times artTanh\,\frac{X-1}{X+1}\ ,\ 0 < X < 1 \qquad \mathbf{((6.2))}$$

Where,

$$artTanh\ Z = Z + \frac{Z^3}{3} + \frac{Z^5}{5} + \frac{Z^7}{7} + \cdots$$

$$= \sum_{n=0}^{\infty} \frac{Z^{2n+1}}{(2n+1)}, \quad |Z| < 1 \qquad \mathbf{((6.3))}$$

We have implemented the natural logarithm depends on Area hyperbolic tangent function in the following J2ME code:

```
public static double hyperbolicLog(double x) {
        long l = Double.doubleToLongBits(x);
        long exp = ((0x7ff0000000000000L & l) >> 52) - 1023;
        double man = (0x000fffffffffffffL & l) / (double)0x10000000000000L +
                1.0;
        double lnm = 0.0;
        double a = (man - 1) / (man + 1);
        for( int n = 1; n < 7; n += 2) {
                lnm += pow(a, n) / n;
        }

        return 2 * lnm + exp * 0.6931471805599453094172321214581 8;

}
```

And again we use the implementation of pow formula as in method 1. Method 2 is more accuracy than method 1, but it slower as will be discussed in the results.

Method 3

We implemented a more practical, and very fast natural logarithm method, but of course it is little less accurate than previous methods. The right term in the summation ln(X) = ln (significand) + exponent × ln (2), the term: ln (significand) is between ln (1), and ln(2) or between 0, and 0.6931471805599453094172321214581 8.

In large numbers, the very small right term can be neglected respect to very large left term, the term: exponent × ln (2), and we can write a fast method in J2ME without pow method need.

```
        public static double mlog(double x){
                long l = Double.doubleToLongBits(x);
                long exp = ((0x7ff0000000000000L & l) >> 52) - 1023;
                return exp * 0.6931471805599453094172321214581 8;

}
```

6.4 Data privacy

We need to store very sensitive data in mobile storage media like:

1. Mobile info which contains many critical fields like: Mobile ID.
2. Mobile balance which contains: mobile balance, modified date, and modified time.
3. Voice print codebook.

The Java Community Process$_{sm}$ (JCP^{SM}) (see jcp.org) is the mechanism for developing standard technical specifications for Java technology. Anyone can register for the site and participate in reviewing and providing feedback for the Java Specification Requests (JSRs), and anyone can sign up to become a JCP Member and then participate on the Expert Group of a JSR or even submit their own JSR Proposals.

The File Connection Optional Package (FCOP) is one of two optional packages defined by JSR 75 through the Java Community Process. The other, the PIM Optional Package. We use the first package, and to import only needed packages your code must include:

```
import javax.microedition.io.Connector;
import javax.microedition.io.file.FileConnection;
```

JSR 75 provides a mechanism to store data in private folder, and keep this data away from accessing or modifying by another MIDlet. This mechanism is called Private work directory of MIDlet suite by using the string argument “fileconn.dir.private”, suppose we want store a data in a private folder as mobileinfo.txt we do that by the following J2ME code to create the file, and open it for reading, and writing :

```
import javax.microedition.io.Connector;
import javax.microedition.io.file.FileConnection;


  String galleryPath = System.getProperty("fileconn.dir.private");
  String path = galleryPath + "mobileinfo.txt";
  try {
```

```
 FileConnectio fconn =
   (FileConnection)Connector.open(path,Connector.READ_WRITE);

 if (!fconn.exists())
       fconn.create();
else{
      fconn.delete();
      fconn.create();
    }
```

By this mechanism we protect the application files from manipulate, stolen and remove, the mobile user itself cannot change the mobile balance or ID.

6.5 Natural logarithm methods experiments and results

We tested the three methods for calculating natural logarithm at two ranges of numbers, the first rang is a set of numbers between 10, and 350 as a double values, the range 2 is a set of numbers between 5000, and 10000000 double values. By choosing one rang for small numbers, and another for large numbers we cover many application fields and algorithms [72, 73].

Because most of processors today (Intel, AMD, ARM,…) use the IEEE 754 standard, we can test our methods in personal computer, by this way we can take the java log as reference in measurement as ICSILog approache used C-log in standard Math.h C library. So we simulate our methods on laptop Dell Inspiron 1545, with Intel Core™ 2 Duo 2.00 GHz for each one, the operating system was Microsoft windows 7 Ultimate service pack 1.

We measured the accuracy of the three methods, and by taking the java log as a reference, we assumed that the java log is 100% accurate. Also we compared between the three methods on execution time, we reflected the execution time with the speedup of java log too.

In range 1 The average error rate of method1 and method2 is very small, it is near the zero, but the method3 has a big average error rate, the rate 7.8% effects the results when the numbers are small and does bad performance (figure 6.1).

Also in range 1 method 1 fasters than the java method with 6.5 times, while method2 only with 1.4 times, as an expected, method3 is a faster one, with 10.5 times faster than the java method.

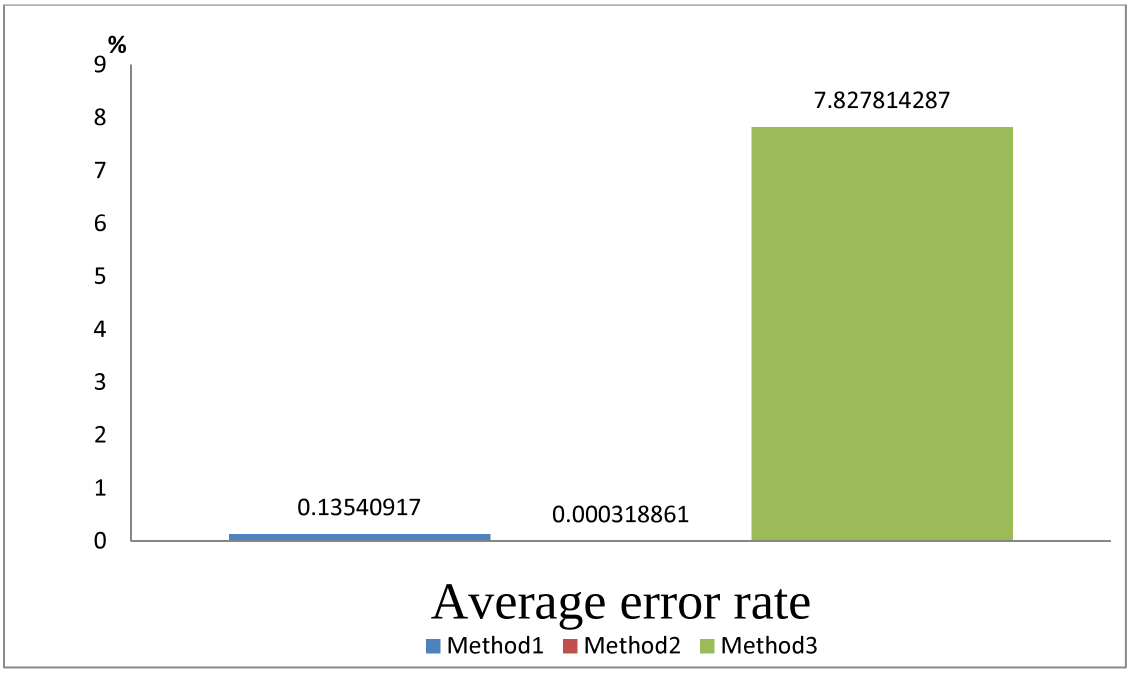


Figure (6.1): Average error rate in small numbers (range 1).

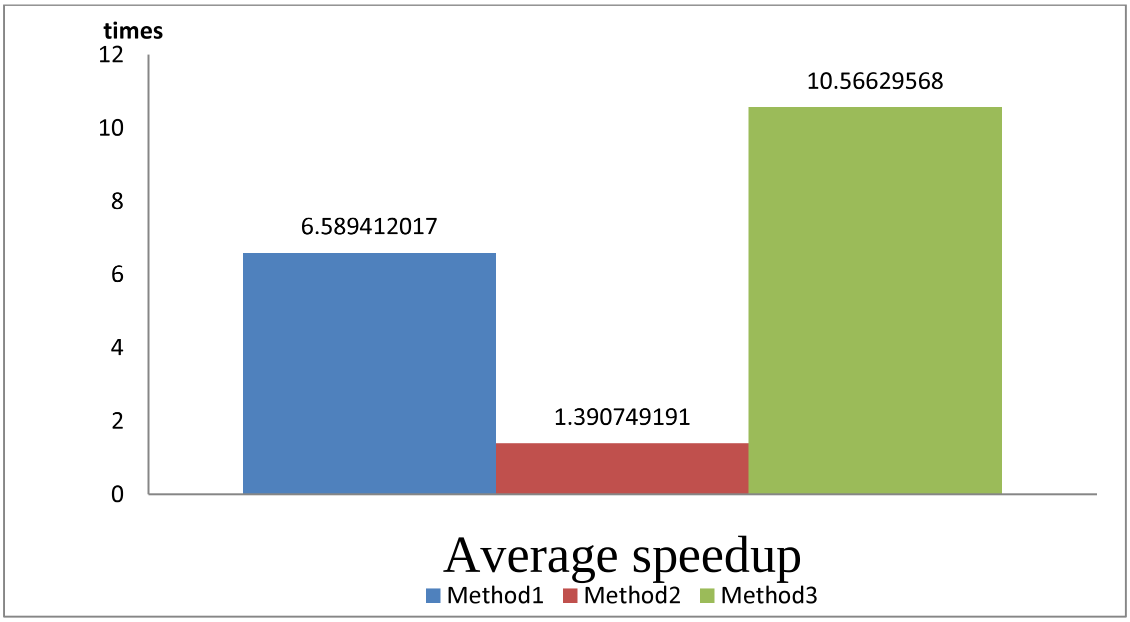


Figure (6.2): Average speed up for small numbers (range 1).

In range 2 the average error rate of both method1, and method2 stills very small and can be considered zero with respect to corresponding large number. The average error rate of method3 in this range is about 3 which is less than that in range 1.

Method1 is faster 6 times than java method, method2 about 1.4 times faster, and method3 stills the fastest with 9 times over java method.

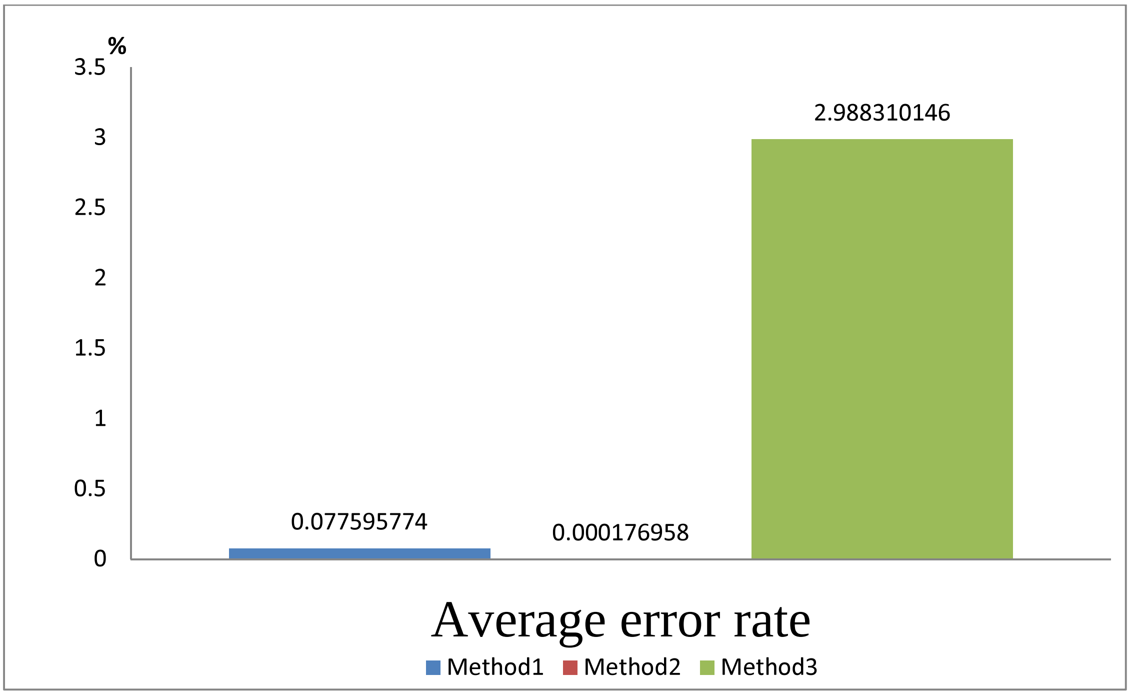


Figure (6.3): Average error rate for large numbers (range 2).

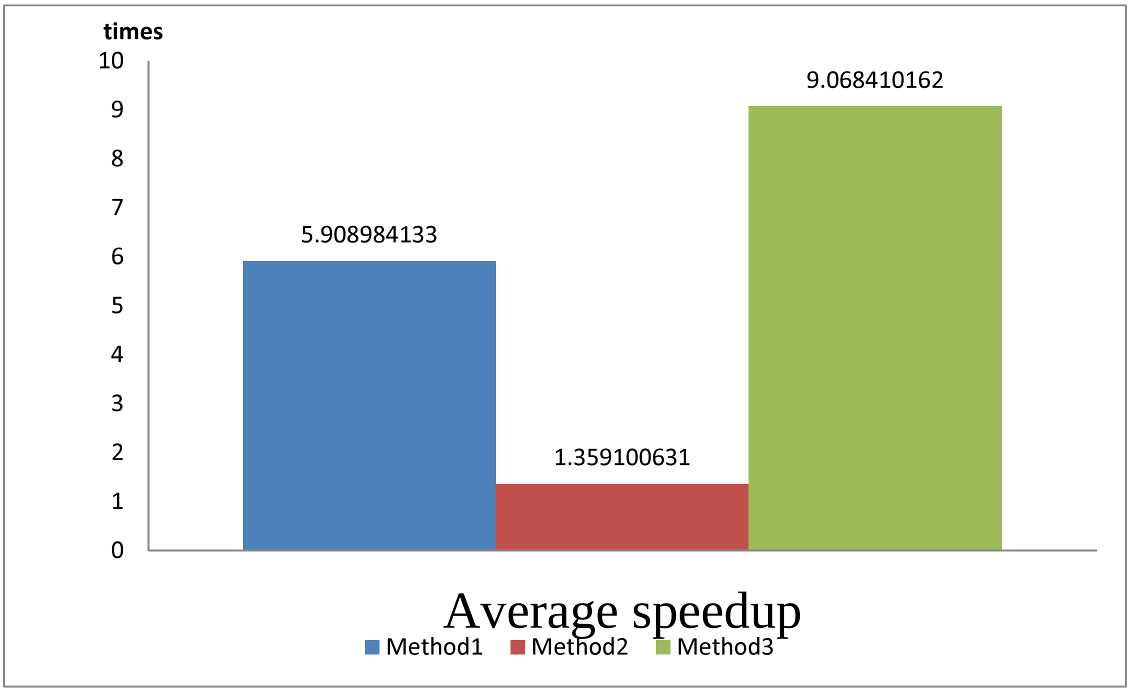


Figure (6.4): Average speed up for large numbers (range 2).

MFCC attributes has large value, which obtained by taking natural logarithm of very large numbers, method 3 is a proper one for calculating the natural logarithm.

Others speech features extraction algorithms like: Gaussian Mixture Models combined with Hidden Markov Models they use log-likelihood function, method 2 is the best in this algorithm especially when the parameters are normalized because it is the most accurate.

6.6 Calculating the threshold

In section 3.4 we give an abstract derived of the Ratio formula, and we mentioned if this ratio is less than a given threshold then the speaker is accepted else he is rejected. Calculating this threshold is a hard and very long time, and needs digital signal laboratory, and in the first place, a speech database must be existed.

To overcome these obstacles we depended on previous work for implementing a speaker verification system in Java [59], in this thesis the authors used a database called NTIMIT8 which is a part of NTIMIT [60]. According to the fact of J2ME is a special edition of traditional Java, all java algorithms experiments and results can be applied for J2ME. Of course after taking into our consideration the differences between the equipment, since the Java works and runs on computers, J2ME for embedded systems.

The NTIMIT (Network TIMIT) database was collected by transmitting the Texas Instruments Massachusetts Institute of Technology (TIMIT) [61] database over the telephone network. More over the NTIMIT database include a carefully selected diversity of speech dialects and extensive breadth and depth of phonetic coverage.

TIMIT, NTIMIT, and others speech databases are available at The Linguistic Data Consortium [8] at university of Pennsylvania.

Previous work on speaker verification in java, they selected 100 persons from NTIMIT8, were used randomly selected from 3 different areas. The selection of female and male utterances is 50% - 50%. [59].

The performance of a speaker verification system [62] is measured in terms of false acceptance rate (FA%) and false rejection rate (FR%):

$$F_A = \left(\frac{I_A}{I_T}\right) \times 100 \qquad \textbf{((6.4))}$$

$$F_R = \left(\frac{C_R}{C_T}\right) \times 100 \qquad \textbf{((6.5))}$$

Where I_A is the number of imposter classified as true speakers, I_T is the total number of speakers, C_R is the number of true speakers classified as imposters, C_T is the total number of speakers. To calculate the total error of a verification system, T_E, the false acceptance rate is added to the false rejection rate giving:

$$T_E = F_A + F_R \qquad ((6.6))$$

The following picture (figure 6.5) shows the ratio calculations of the Java system.

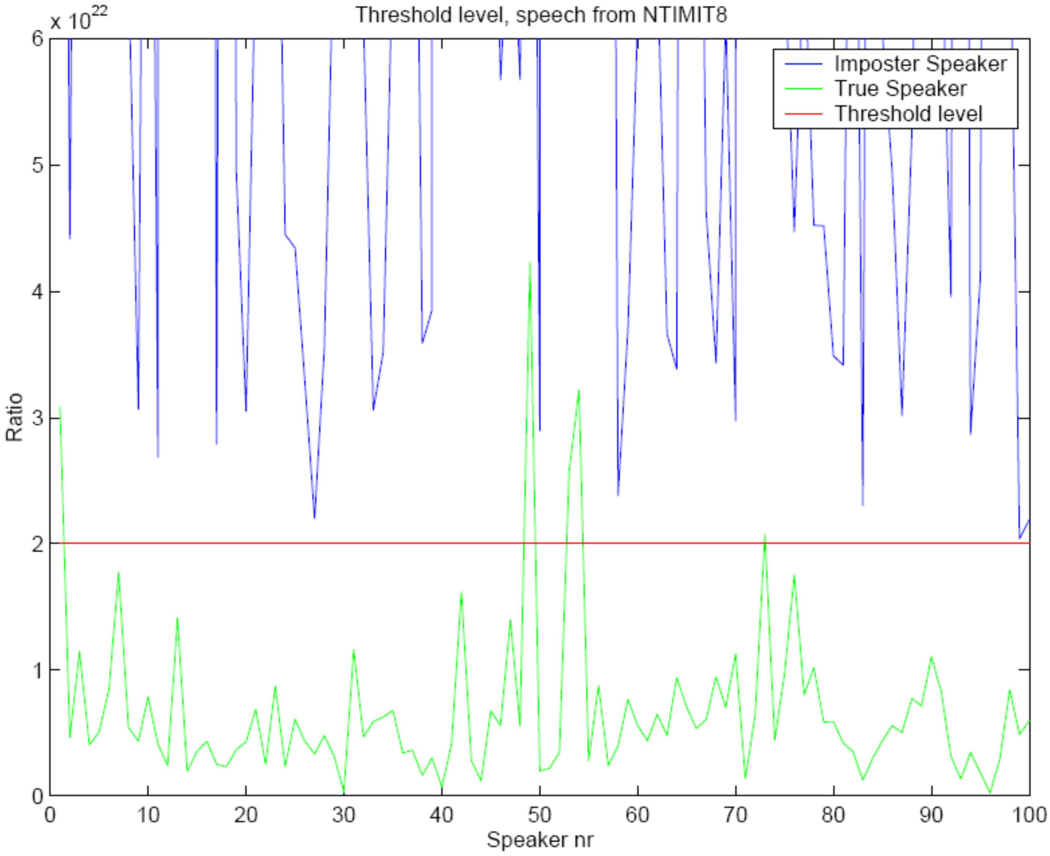


Figure (6.5): Threshold and error rate plot from NTIMIT8 [59]

The figure shows on four percent total error, zero percent false acceptance and four percent false rejection. The number of entries in the codebook, and under what conditions the speech was recorded has a great part in the total error result. The table below shows an approximation of the error rate when using different number of entries in the codebook [63].

Table (6.3): Speaker verification accuracy depending on Codebook Entries

Number of code entries	Speaker verification accuracy (%)
32	96.0
64	97.7
128	97.9
256	98.1
512	98.2

Chapter 7

CONCLUSION AND FUTURE WORK

7.1 Conclusion

In this thesis, we have proposed a new approach for M-Commerce named Debit Mobile, that is a phone-based J2ME application payment technology, and enables a bank's customer to query his account balance, charge his mobile, and discharge his mobile. A mobile customer who owns debit mobile can easily pay for services or products, via transferring a novel proposed Cheque, called a soft Cheque.

We introduce a new mechanism for query account, and put pseudo codes for query, charge mobile, discharge mobile, and synchronize balances operations. Also we structured a new digital certificate format suited with mobile phones.

We have introduces a new scenario of transferring, and cash the soft Cheque, with no third party, or a connection to the bank server for verifying it in payment case. This scenario depends on proposed digital certificate.

We modeled our system with COMET method, our model contains analysis model which consists of static and dynamic modeling, subsystem structuring, object structuring, and control objects composite statecharts. And also contains design model which consists of consolidated collaboration modeling, system architectural design, concurrent task structuring with clustering criteria, and detailed design.

Also we have developed a software component for voice authentication depends on speaker verification algorithms, we have chosen algorithms, and modified them to be able to work on mobile phones equipment.

We suggested an exist way to calculate the ratio for speaker-verification java systems, and experimental results show that is no fear of false acceptance and also false rejection can be decreased with increasing of codebook size.

In speaker verification implementation we implemented natural logarithm with three methods, we compared between them by taking java log as reference, our methods are very fast and suitable with mobile devices.

7.2 Future work

We plan to propose the Debit Mobile system as a new Bluetooth profile to be included in the new versions of Bluetooth, and introduce it to Bluetooth Special Interest Group (SIG) (Bluetooth.org). By this way many applications can be developed for Bluetooth marketing and payment applications such as NFC applications.

DSP is a hot computer engineer field, many complex algorithms can be implemented as a cheap hardware chips. For example FFT radix-4 is an important and complex algorithm for time domain to frequency domain signal transformation, it is implemented as a special form of butterfly called dragonfly [65], also many modern industries for implementing FFT are available (e.g. xilinx.com).

Although our beloved Palestine has small area, there are many dialects of Arabic, and so there is a real need for a database of speech contains all of these accents, in fact, there are a few Arabian countries has its database of speech e.g. Saudi Arabia [66].

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Appendix A

SYSTEM REQUIREMENT SPECIFICATION

Table (A.1): Check balance use case description.

USE CASE #	A.3	
USE CASE Name	Check balance	
ACTOR	Mobile user	
Purpose	A query about the internal balance	
Overview and scope	The mobile contains balance which gives ability to customer to get services with price below this balance without need to cash money.	
Level	Primary and included	
Preconditions	The mobile was charged	
Postconditions	The amount of balance is displayed on mobile screen	
Trigger	Client click check balance in his mobile	
Included Use Cases	non	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. Client login locally in his mobile and choose check balance	

		2. System shows the internal balance
Frequency	Frequently used	

Table (A.2): Validate PIN use case description.

USE CASE #	B.1	
USE CASE Name	Validate PIN	
ACTOR	Mobile user	
Purpose	System validates customer PIN	
Overview and scope	For each transaction needs access to bank server Database, system prompts user to inter the PIN code for more security.	
Level	included	
Preconditions	There is a connection between the mobile and the bank server.	
Postconditions	The mobile and user authorized to complete the transaction .	
Trigger	There are many transactions use case B.2, B.3,B4 and B5 needs authorization before they completed, so all these use cases trigger this use case.	
Included Use Cases	non	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. Mobile user choose one of bank transaction.	
		2. To complete the transaction, System prompts customer for PIN
	3. Customer enters PIN.	

		4. System checks whether the mobile has been reported as lost or stolen. If card is valid, system then checks whether the user-entered PIN matches the mobile PIN maintained by the system.
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	If the system determines that the mobile has been reported lost or Stolen.	The system blocks the application.
	If the customer-entered PIN does not match the PIN number for this mobile.	The system re-prompts for the PIN.
	If the customer enters the incorrect PIN three times.	The system blocks the application.

Table (A.3): Query account use case description.

USE CASE #	B.2
USE CASE Name	Query account
ACTOR	Mobile user
Purpose	Customer receives the balance of this bank account.
Overview and scope	This an traditional Query asks about the related account with this mobile, if mobile was charged before, the system will retains two balances one for primary and second for branch account which we called mobile account.
Level	Primary
Preconditions	There is a connection between the mobile and the bank server.
Postconditions	Customer account has been queried.
Trigger	After loading banking menu, user trigger Query Account button .
Included Use Cases	B.1, B.6

Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. 2. Customer selects Query Account option.	
		2. System Includes Validate PIN use case B.1.
		3. System includes B.6 use case.
		4. System reads account balance(primary and mobile if exist), and shows it to mobile screen .

Table (A.4): Cash Cheque use case description.

USE CASE #	B.3	
USE CASE Name	Cash Cheque.	
ACTOR	Mobile user	
Purpose	Customer asks a bank to get cash money by cashing a soft Cheque.	
Overview and scope	To serve Cheque we need a system that can read and recognition it, as traditional Cheque reader which reads a magnetic pink to recognition Cheque, our system will replace the old system with electronic one that reads soft Cheque from mobile customer.	
Level	Primary	
Preconditions	There is a connection between the mobile and the bank server.	
Postconditions	Customer gets cash money.	
Trigger	After loading banking menu, user trigger Cash Cheque button .	
Included Use Cases	non	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User trigger Serve Cheque button .	

		2. System shows a list contains Cheques(not served) with this bank as a source.
	3. User selects one or more Cheque from the list.	
		4.System push selected Cheque(s) to bank server.
		5. Bank System receives the Cheque validates it, extracts the amount of money, update its Database which includes discount the amount of Cheque from source mobile account balance and notifies customer to go to specific teller to get his money.
		6. Mobile system removes the served Cheque(s) from its Database or marked it as a served
frequently	Frequently used	

Table (A.5): Charge Mobile use case description.

USE CASE #	B.4	
USE CASE Name	Charge Mobile	
ACTOR	Mobile user	
Purpose	Transfer balance to mobile as a soft money.	
Overview and scope	In our system as ATM one, an Account has two types which we called primary and mobile account, if customer wants to charge his mobile with credit(soft money), Bank server creates two branch accounts that form the original one, the mobile branch account has balance equals to the choice of customer below the main balance, and primary account balance now equals to :total balance – mobile balance .	
Level	Primary	
Preconditions	There is a connection between the mobile and the bank server.There is enough balance which greater than the balance we want to charge mobile with it .	
Postconditions	The mobile has been charged with a soft money as a balance.	
Trigger	After loading banking menu, user trigger Charge Mobile button .	
Included Use Cases	B.1, B.6	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User triggers charge mobile button.	
		2. System Includes Validate PIN use case B.1.
		3. System checks if the mobile is not already charged, if not queries Balance from Bank server and shows on screen the balance and prompts user to inters amount of mobile balance

	4. User enters the amount of mobile balance X.	
		5. System checks the mobile balance to ensure that is below the main balance of account, and send it to bank server to complete transaction.
		6. Bank server creates two branches primary and mobile account, put mobile balance as user input X, and primary balance equals to total balance- mobile balance.
		7. Mobile system put its internal balance equals to "X".
OTHER SUCCESSFUL SCENARIOS	**Step**	**Branching action**
	3.a 4.a 5.a 6.a 7.a	If was charged system includes B.6, returns primary and mobile balance…… User enters the amount of mobile balance to be add X. That is below the primary balance…. Bank server withdraws the amount X from primary account to deposit into mobile account. Mobile system put its internal balance equals to" old balance + X"
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	If the system determines that the mobile has been reported lost or Stolen.	The system blocks the application.
	If the customer-entered PIN does not match the PIN number for this mobile.	The system re-prompts for the PIN.

	If the customer enters the incorrect PIN three times.	The system blocks the application.
	The mobile balance input is more than the account balance.	The system notifies user to input amount below the account balance.

Table (A.6): Discharge mobile use case description.

USE CASE #	B.5	
USE CASE Name	Discharge mobile	
ACTOR	Mobile user	
Purpose	Empty mobile from credit “soft money” .	
Overview and scope	The payment system allows transferring money as credit soft check from buyer mobile phone to seller mobile phone.	
Level	Primary	
Preconditions	There is a connection between the mobile and the bank server. The mobile was charged before.	
Postconditions	The mobile has been discharged from the soft money. The primary and mobile accounts have been merged to one original main account.	
Trigger	After loading banking menu, user trigger Discharge Mobile button .	
Included Use Cases	B.1, B.6	
Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User triggers discharge mobile button.	
		2. System Includes Validate PIN use case.
		3. System includes B.6 use case.

		4.Bank server merge primary and mobile accounts to one original account with balance equals to primary balance + mobile balance
		5. Mobile system puts its balance equals to zero .
Frequently	Medium used	

Table (A.7): Synchronize Balance use case description.

USE CASE #	B.6
USE CASE Name	Synchronize Balance
ACTOR	Mobile user
Purpose	Synchronize local balance with mobile account balance
Overview and scope	User can perform payment operations offline without need exist of third party or connection to bank server, which means local balance modifies without effects on original mobile account, so we need this use case to synchronize two balances .
Level	Included
Preconditions	There is a connection between the mobile and the bank server.
Postconditions	Two balances have been Synchronized
Trigger	B.2, B.4 and B.5
Included Use Cases	Non
Extended Use Cases	Non
MAIN SUCCESSFUL SCENARIO	**Systems Actions**
	1. After connection between this mobile and a bank server is established, mobile system checks if the target bank server contains the account corresponding to this mobile if yes proceeds to next step.
	1. Mobile System sends local balance to bank server.

	2. Bank Server reads the new value **Y,** if the mobile balance value **X** in the bank server equals to **Y** do nothing, else put checking_balance= **X-Y.** and available_balance= **Y.**	
UNSUCCESSFUL SCENARIOS	**Condition**	**Action**
	1.a If no	System terminates the transaction
Frequently	frequently used	

Table (A.8): Do payment use case description.

USE CASE #	C.1	
USE CASE Name	Do payment	
ACTOR	Mobile user	
Purpose	Transfer soft Cheque from customer mobile to service provider mobile .	
Overview and scope	The soft Cheque is the backbone of our payment subsystem, in this use case two actors communicate to perform a payment scenario.	
Level	Primary	
Preconditions	There is a Bluetooth connection between two mobiles. There is enough fund to complete the payment.	
Postconditions	Service provider mobile has been get a soft Cheque. Mobile customer balance has been decreased by the value of payment price.	
Trigger	After loading main menu, user trigger Payment button .	
Included Use Cases	non	
Extended Use Cases	non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. Mobile user triggers Payment button and then selects his option .	

		2. Mobile system receives user choice, if the choice is buy the use case go to special use case C.1.a .
	3. Mobile user asks seller to choose sell option	
		4. the another mobile system now go to special case C.1.b
Frequently	Frequently used	

Table (A.9): Send Cheque use case description.

USE CASE #	C.1.a	
USE CASE Name	Send Cheque	
ACTOR	Mobile user	
Purpose	Send a soft Cheque to another mobile .	
Overview and scope	This is a special use case of general use case Do Payment, the person he want get services or products from another part execute this use case.	
Level	Primary	
Preconditions	There is enough balance to complete the payment process.	
Postconditions	A soft Cheque has been sent.	
Trigger	After loading payment menu, user trigger Buy button .	
Included Use Cases	C.1.aa Generate Cheque use case.	
Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User triggers Buy button.	
		2. System turns on Bluetooth device and discovers others mobiles.

	3. User asks another part (seller) about its mobile name.	4. In the same time the system displays on the screen the discovered devices.
	5. User choose the appropriate mobile	
		6. After successful connection(اقتران .) system notifies user and displays request Price button.
	7.User triggers Request Price button.	
		8. System sends Get Price request to target mobile.
		9. System receives the price amount and displays it on the screen with OK or Cancel options.
	10. User triggers OK button	
		11. System includes Generate Cheque use case C.1.aa.
		12. System sends the generated soft Cheque to target mobile and notifies user about the complete of transaction.
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	10.a User triggers Cancel button.	The system terminates the transaction.
	11.an unsuccessful included use case .	The system notifies user about lack of money and terminates the transaction .

Table (A.10): Generate Cheque use case description.

USE CASE #	C.1.aa	
USE CASE Name	Generate Cheque	
ACTOR	Mobile user	
Purpose	Create a soft Cheque	
Overview and scope	Soft Cheque as traditional one contains necessary information to be able to served later like bank id and Account number.	
Level	Included	
Preconditions	There is enough mobile balance	
Postconditions	A soft Cheque has been created.	
Trigger	After loading payment menu, user trigger sell button .	
Included Use Cases	Check balance use case	
Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**System Actions** 1. Payment control includes this use case. 2. System receives the amount of price. 3. System checks mobile balance (check balance use case). 4.System insures the balance is enough 5. System creates a Cheque format contains bank ID, Account number, Cheque number, amount of currency and date of issue. 6.System returns the created soft Cheque	
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	4.a The balance is not enough .	The system notifies user the balance is not enough and terminates the transaction.

Table (A.11): Receive Cheque use case description.

USE CASE #	C.1.b	
USE CASE Name	Receive Cheque	
ACTOR	Mobile user	
Purpose	receive a soft Cheque from another mobile .	
Overview and scope	This is a special use case of general use case Do Payment, the person he want provide services or products to another part execute this use case.	
Level	Primary	
Preconditions	non	
Postconditions	A soft Cheque has been received.	
Trigger	After loading payment menu, user trigger sell button .	
Included Use Cases	Non	
Extended Use Cases	Non	
MAIN SUCCESSFUL SCENARIO	**Actor Action**	**System Action**
	1. User triggers sell button.	
		2. System turns on Bluetooth device and prompts user to input the price.
	3. User inputs the price and press OK button.	
		4. System starts the Bluetooth pay service and waits for request.
	5.User notifies another person about the mobile name .	
		6. System receives request and prompts user to accept it.
	7. User triggers Accept button	

		8. System sends the reply which contains the amount of price.
		9. System receives the soft Cheque and notifies user about the complete of transaction.
UNSUCCESSFUL SCENARIOS	**Conditions**	**Actions**
	7.a User triggers Reject button.	The system terminates the transaction.