06-18191 Software Engineering Part II

Group: Smooth Operators

Smart Bank ATM

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Introduction

The Smart Bank ATM (Automated Teller Machine) is an advanced ATM system developed for Smart Bank that provides services for both customers of Smart Bank and for customers of other banks. The Smart Bank ATM enables users to perform a number of standard transactions such as: withdraw cash, deposit cash or a cheque, view the balance of their account, print an account statement, top-up their mobile phone account and pay a bill.

The ATM automatically connects to either Smart Bank's online banking system or the Card Consortium's system to both authenticate a user and to authorise transactions requested by the customer. A further security feature of the ATM is the provision of a fingerprint scanner, and the customer is required to present his or her fingerprint as part of the customer authentication process at the beginning of each new user session.

A unique feature is the voice recognition and synthesis module, which is automatically selected when a user enters his or her bank card. If the user enters the PIN number by tapping on the keypad then the ATM switches to normal non-voice mode. If the user speaks the PIN number (one digit at a time) then the ATM automatically switches to voice mode and uses voice recognition and voice synthesis to communicate with the customer for the remainder of the session. The voice recognition module automatically recognises the language of the speaker, and switches to one of the supported languages which are English, French, Spanish, Portuguese, German, Italian and Chinese.

To comply with the banks' own auditing practices and the Financial Services Authority (FSA) regulations, the ATM incorporates a logging device that records the details of every transaction placed through the ATM and can provide an audit trail when requested by a bank teller operative. The audit trail is held in persistent memory and is available even if the ATM has been powered off.

In order to pay a bill or top-up a mobile phone account, the customer must have previously set up these services on his or her account before using the ATM system. Services already set up can be selected by the customer as part of the appropriate transactions. The customer also has the option of requesting a receipt for any of the ATM transactions.

The system design for the Smart Bank ATM is presented in UML (Unified Modelling Language) with explanations of the diagrams and analyses.

Scope

The scope of the design is limited to the design of the Smart Bank ATM machine only. In this report, the use case diagram presented shows the actors of 'technician' and 'bank teller' and these have been included for completeness but the subsequently documented use cases and scenarios don't involve these actors. The use case diagram shows the bounds of the system.

In the design of this system, it is assumed that the Smart Bank online system authenticates users and authorises transactions for Smart Bank customers only, and that the Card Consortium performs these tasks for customers of other banks. It is also assumed that the ATM can detect from the card whether the user is a customer of Smart Bank or not and route the messages to the appropriate online system. The mobile network in this design is assumed to be the network that the user has previously set up on his account for the purposes of topping-up, and that the ATM can contact the mobile network's online system directly.

In this report the word 'transaction' means all the operations that the user can perform on the Smart Bank ATM and so this includes 'print statement', not just financial transactions involving the movement of funds.

Some further assumptions are:

- Cash and cheque deposits are handled by the system in the same way
- Cheques are cleared instantly by the system
- The ATM only dispenses cash in the local currency
- Account balance information represents the amount of cash available for withdrawal
- Bill providers have accounts with SmartBank into which bill payments can be made
- A bank account is associated with one customer only and one bank card only (no joint accounts, powers of attorney etc.)

Requirements

The requirements for the ATM system are split into two sections: functional and non-functional. The non-functional requirements are grouped by Sommerville's (Sommerville, 2000) non-functional requirements classification. Each group of requirements is identified by a major number, for example, REQ1. Each individual requirement within a group is given a major and minor number, for example REQ1.1.

Functional

REQ1 User authentication
REQ1.1 For authentication purposes, the system shall require the user to insert his bank card.
REQ1.2 For authentication purposes, the system shall require the user to specify the correct PIN.
REQ1.3 For authentication purposes, the system shall require the user to pass the fingerprint check.
REQ1.4 The system shall retain the customer's card should the authentication procedure fail three times in succession.
REQ1.5 The system shall enable the user to select a different PIN.
REQ1.6 The system shall accept cards from customers of SmartBank
REQ1.7 The system shall accept cards from customers of other banks in the card consortium

REQ2 Withdrawals and deposits
REQ2.1 The system shall enable the user to withdraw cash (notes) from their bank account.
REQ2.2 The system shall enable the user to deposit cash (notes) into their bank account.
REQ2.3 The system shall enable the user to deposit cheques into their bank account.

REQ3 Account information
REQ3.1 The system shall enable the user to view their account balance.
REQ3.2 The system shall enable the user to print a mini-statement, comprising the last 10 transactions.
REQ3.3 The system shall enable the user to print a statement, comprising the transactions within the last month.

REQ4 Paying bills and mobile phone top-ups
REQ4.1 The system shall enable the user to top up a prepay mobile phone, by providing a code.
REQ4.2 The system shall enable the user to pay a bill where the provider has been previously set up on the account.

REQ5 Miscellaneous
REQ5.1 The system shall enable the user optionally print a receipt for any transaction.
REQ5.2 The system shall terminate a user session in the event that no user input has been received after 30 seconds.

Non-functional

Classified by Sommerville's (Sommerville, 2000) non-functional requirements.

REQ6 Product requirements
REQ6.1 (Usability) the system shall enable the user to select the language.
REQ6.2 (Usability) the system shall optionally allow the user to interact with the ATM using voice.
REQ6.3 (Usability) the system shall be designed to enable a bank teller to replenish the ATM (including the retrieval of cash and cheque deposits) within 10 minutes.
REQ6.4 (Efficiency -> Performance) the system shall provide a response to user input within 10 seconds.
REQ6.5 (Efficiency -> Space) the system shall fit within the physical boundaries occupied by the existing terminals.
REQ6.6 (Reliability) the system shall be available for 99.9% of operating time.
REQ6.7 (Reliability) the system shall be designed to have a servicing interval of at least 12 months.
REQ6.8 (Portability) the terminal application software shall operate within the 60GB hard disk and 1GB memory space provided by the hardware.

REQ7 Organisational requirements
REQ7.1 (Implementation) the system shall be designed using the Unified Modelling Language.
REQ7.2 (Standards) the system shall comply with Smart Bank's ISO 9001 accredited quality processes.

REQ8 External requirements
REQ8.1 (Interoperability) the system shall operate with the existing database.
REQ8.2 (Interoperability) the system shall accept cards issued by other financial institutions.
REQ8.3 (Interoperability) the system shall communicate transaction information to other banks.
REQ8.4 (Legislative -> Privacy) the system shall minimise the risk of accidental disclosure of private information to third parties.
REQ8.5 (Legislative -> Safety) the system shall comply with current health and safety regulations.
REQ8.6 (Legislative) the system shall locally log every transaction.

Use Case Diagram

This is the Use Case Diagram for the Smart Bank ATM. The actors that have been identified are shown outside of the system boundary, which is denoted by the large rectangle (solid black line). The main use cases are shown with their relationships to the main actors and each other.

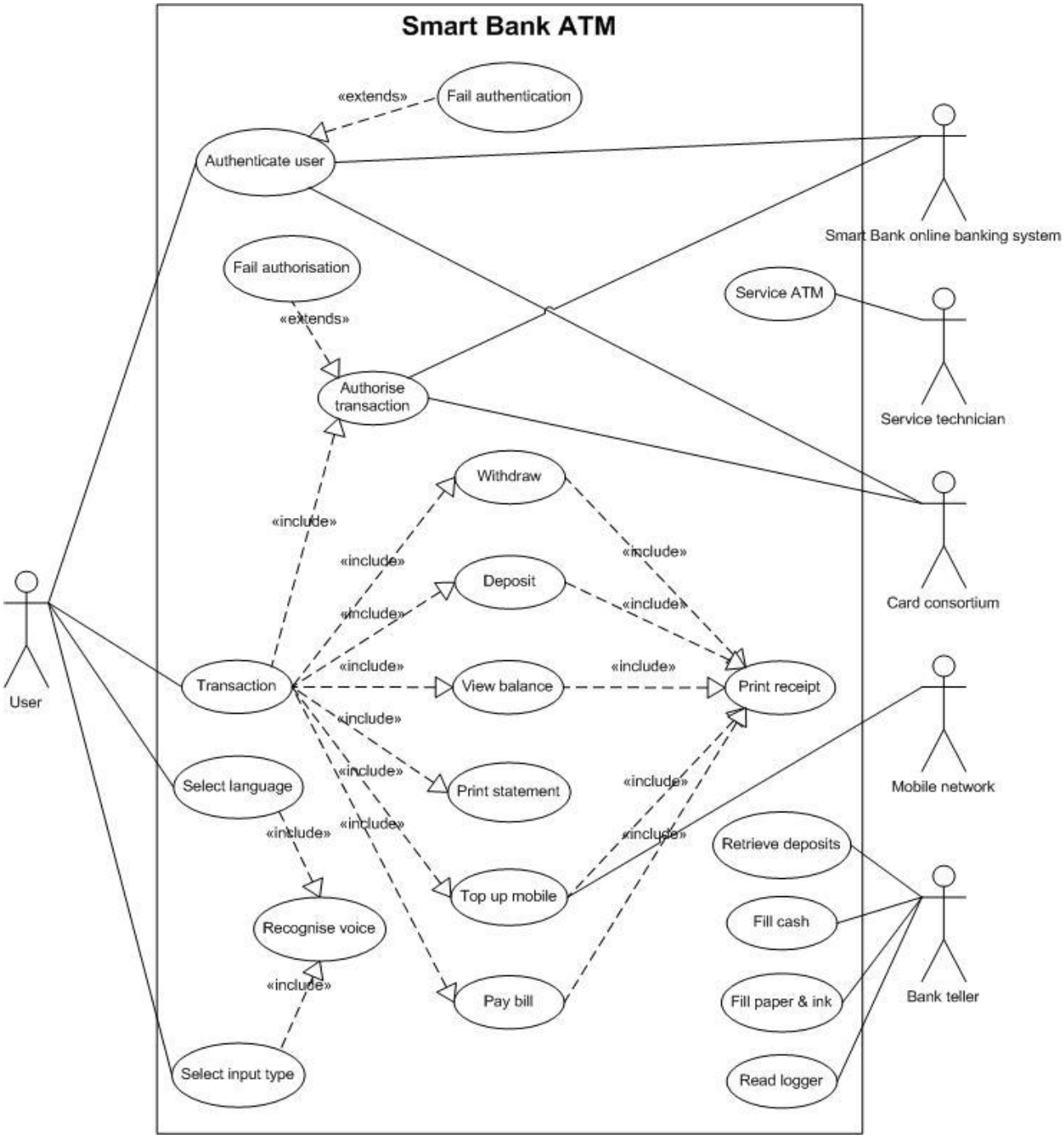

Figure 1 - Use-Case Diagram

Documented use cases

Two use cases have been selected for further documenting. These are the 'print statement' and 'top up mobile' use cases. These are detailed below, showing the relevant actors, preconditions, event flow and post-conditions.

Use case: Print statement	
Actors	User, Smart Bank online banking system, card consortium
Preconditions	1. ATM is powered up and connected to the network 2. ATM has passed its Built-In Self Test (BIST) diagnostics 3. There is no bank card currently in the ATM 4. There is a supply of paper in the ATM 5. There has not been two unsuccessful user authentication attempts
Flow of events	1. ATM operation begins in the idle state 2. User inserts his bank card 3. If the bank card originates from a foreign country then the ATM requests the user (on screen, in multiple languages) to select a language: a. User selects a language by pressing a key: ATM now uses keyboard and screen as input/output b. User selects a language by speaking the name of the language: ATM detects the language and uses voice recognition and synthesis as input/output 4. ATM requests user to place his index finger on the fingerprint reader and scans the fingerprint 5. ATM requests user to specify the PIN 6. If card is from Smart Bank then ATM contacts Smart Bank with the encrypted authentication data, else ATM contacts the Card Consortium 7. If ATM receives a 'failed authentication' response then ATM: a. Alerts the user b. Ejects the card c. Goes to the idle state 8. ATM requests user to make a selection from a choice of operations 9. If user selects operation by pressing a key then keyboard and screen are used, else if user speaks the operation then voice is used 10. User specifies the 'print statement' operation 11. If user is a customer of Smart Bank then the ATM sends a request to Smart Bank to retrieve the most recent transactions from the user's account, else the ATM sends a request to the Card Consortium 12. The ATM receives the response and prints the statement 13. ATM goes back to the main menu 14. User specifies no other transactions 15. ATM ejects the user's card and goes to the idle state
Post-conditions	1. The card has been successfully ejected from the card slot 2. Smart Bank and/or the Card Consortium have updated their records as a result of the transaction 3. The pre-selected mobile network has updated its records as a result of the transaction

Use case: Top up mobile	
Actors	User, Smart Bank online banking system, card consortium, mobile network
Preconditions	1. ATM is powered up and connected to the network 2. ATM has passed its Built-In Self Test (BIST) diagnostics 3. There is no bank card currently in the ATM 4. There is a supply of paper in the ATM 5. There has not been two unsuccessful user authentication attempts 6. The user's preferred mobile network and account number has been previously set up on the account
Flow of events	1. ATM operation begins in the idle state 2. User inserts his bank card 3. If the bank card originates from a foreign country then the ATM requests the user (on screen, in multiple languages) to select a language: a. User selects a language by pressing a key: ATM now uses keyboard and screen as input/output b. User selects a language by speaking the name of the language: ATM detects the language and uses voice recognition and synthesis as input/output 4. ATM requests user to place his index finger on the fingerprint reader and scans the fingerprint 5. ATM requests user to specify the PIN 6. If card is from Smart Bank then ATM contacts Smart Bank with the encrypted authentication data, else ATM contacts the Card Consortium 7. If ATM receives a 'failed authentication' response then ATM: a. Alerts the user b. Ejects the card c. Goes to the idle state 8. ATM requests user to make a selection from a choice of operations 9. If user selects operation by pressing a key then keyboard and screen are used, else if user speaks the operation then voice is used 10. User specifies the 'top up mobile' operation and amount 11. If user is a customer of Smart Bank then the ATM sends a request to Smart Bank to authorise the transaction, else the ATM sends a request to the Card Consortium 12. If the response is 'failed authorisation' then the ATM: a. Alerts the user b. Ejects the card c. Goes to the idle state 13. ATM contacts the pre-selected mobile network with the top-up details 14. ATM prints a receipt with details of the transaction 15. ATM goes back to the main menu 16. User specifies no other transactions 17. ATM ejects the user's card and goes to the idle state
Post-conditions	1. The card has been successfully ejected from the card slot 2. Smart Bank and/or the Card Consortium have updated their records as a result of the transaction 3. The pre-selected mobile network has updated its records as a result of the transaction

Activity Diagram

The ‘top up mobile’ use case was selected for further analysis using an activity diagram. The activity diagram is shown below.

The user inserts his card and the ATM decides whether it is a card from a foreign country or the home country. If the card is a foreign card then the user must specify the chosen language either by means of the keypad or spoken voice. The ATM stores the user’s choice and the user then submits his fingerprint by placing his finger on the fingerprint scanner. The ATM reads and stores the fingerprint data. The user enters his PIN number either by keypad or voice.

Once the basic authentication data has been obtained, the ATM sends the data to either the Smart Bank online system or the Card Consortium for authentication of the user and the result is sent back to the ATM. If the authentication has failed then the user reads and/or hears the failure message and specifies no further transactions. The ATM ejects the user’s card and the user removes his card from the card slot.

If the authentication succeeds then the user selects the ‘top-up mobile’ option and amount for the transaction and the ATM contacts either the Smart Bank online system or the Card Consortium to authorise the transaction. If the authorisation fails then the user hears the failure message and the activities proceed as if the user authentication failed as above. If the authorisation passes, then the ATM contacts the mobile network with a message to top-up the mobile account.

To complete the transaction, the ATM prints a receipt, the user removes this from the printer slot, the user specifies no other transactions, the ATM ejects the user’s card and the user removes his card from the card slot.

Assumptions:

- The ‘mobile network’ represents the mobile network that the user has previously set up on his account.
- It is the ATM that contacts the mobile network and not the Smart Bank online system or the Card Consortium.
- The ‘select top-up mobile’ activity also includes the user specifying the amount of value to add to his mobile account.

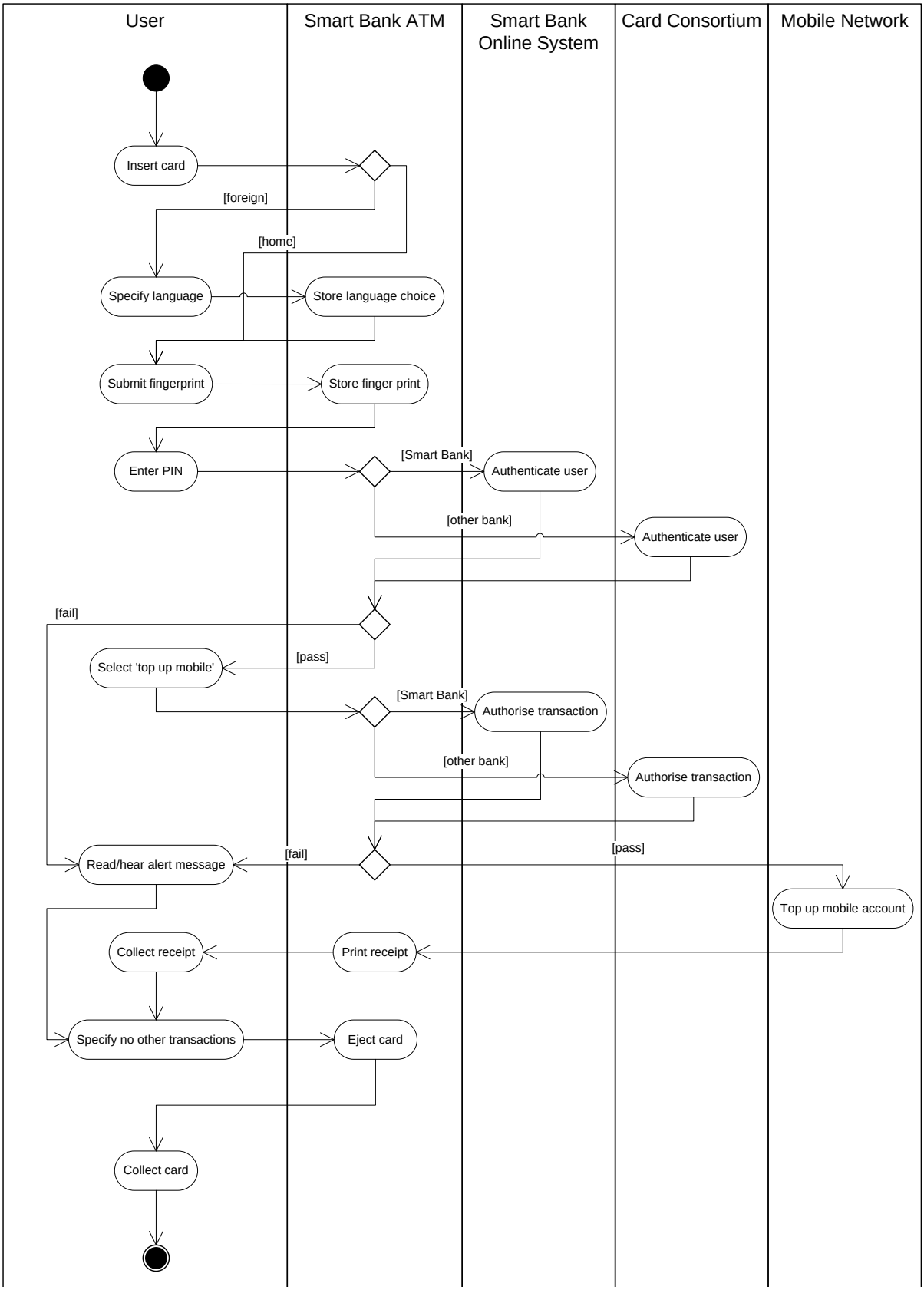

Figure 2 - Activity Diagram

Noun/Verb Analysis

In order to identify our candidate classes we performed a noun/verb analysis, using the specification outlined by our use-cases and requirements. The following table of nouns were identified as potential classes, and the following table of verbs were suggested as potential operations.

Candidate Classes (Nouns)

ATM	Transaction	VoiceOutput
Balance	Keypad	ServiceTechnician
BankAccount	VoiceInput	Printer
BankCard	UserSession	CardConsortium
Cash	LanguageSelection	BankTeller
Cheque	Receipt	MobileNetwork
FingerPrint	Screen	DepositReceiver
MiniStatement	MobilePhone	Logger
OtherBankCustomer	BillProvider	
PIN	Bill	
SmartBankCustomer	CardReader	
Statement	CashDispenser	

Candidate Operations (Verbs)

insertCard()	topupPhone()	
authenticate()	payBill()	
enterPIN()	setupBill()	
checkFingerPrint()	terminateSession()	
passAuthentication()	selectLanguage()	
failAuthentication()	selectVoiceActivation()	
withdraw()	startSession()	
depositCash()	serviceATM()	
depositCheques()	retrieveDeposits()	
viewBalance()	fillCash()	
printMiniStatement()	fillInk()	
printStatement()	fillPaper()	

Responsibility-Driven Analysis

To supplement the noun/verb analysis, we also performed a responsibility-driven analysis to generate CRC (Class, Responsibilities and Collaborations) cards for each candidate class. Responsibilities briefly outline what each candidate class might do, and the collaborators are the classes it will need to interact with in some way.

ATM	
Responsibilities	**Collaborators**
Maintain overall control of ATM functionality, including operation of all I/O devices and UserSession. Coordinates ATM availability for servicing and replenishment.	BankTeller CashDispenser DepositReceiver Keypad Loudspeaker Microphone Printer Screen ServiceTechnician UserSession

BankAccount	
Responsibilities	**Collaborators**
Maintain data concerning details for a specific bank account, including security information and transaction records. In addition to any bill providers set-up on an account.	Customer BankCard Balance Statement MiniStatement BillProvider

BankCard	
Responsibilities	**Collaborators**
Maintain data relating to a specific bank card, which belongs to only one customer and one account. Must provide means for card authorisation.	Customer BankAccount PIN

PIN	
Responsibilities	**Collaborators**
Maintain data relating to a PIN entry for a specific transaction relating to a specific card	BankCard

Customer	
Responsibilities	**Collaborators**
Maintain data for a given customer during the authentication process. Must provide a means to identify a specific customer.	FingerPrint

Statement	
Responsibilities	**Collaborators**
Maintain data concerning transactions performed on a specific bank account for a given month	BankAccount

MiniStatement	
Responsibilities	**Collaborators**
Maintain data concerning the 10 most recent transactions performed on a specific bank account	BankAccount

BillProvider	
Responsibilities	**Collaborators**
Maintain data relating to a specific bill provider. Must provide a means to set-up the new provider and to execute payment of a bill.	BillPayment

Transaction	
Responsibilities	**Collaborators**
Maintain data relating to the amount, time and date of a specific transaction. Allows the user to perform a transaction.	BillPayment Deposit MobileTopUp UserSession Withdrawal

Balance	
Responsibilities	**Collaborators**
Maintain data relating to the amount, time and date of a specific transaction.	BankAccount

FingerPrint	
Responsibilities	**Collaborators**
Maintain data relating to the finger print record of a given customer. Must provide means of authenticating finger print against records.	Customer

FingerPrintScanner	
Responsibilities	**Collaborators**
Coordinates the functionality of the finger print scanner device on the front of the ATM.	ATM

BillPayment	
Responsibilities	**Collaborators**
Maintain data relating to a single bill payment for a BillProvider which has been set-up on a customer's bank account.	Transaction BillProvider

Receipt	
Responsibilities	**Collaborators**
Maintain data for a receipt, relating to a single ATM session. Should provide means to print receipt.	UserSession Transaction

Printer	
Responsibilities	**Collaborators**
Maintain data relating to the print functionality of the ATM. Should enable printing of a receipt, statement or mini-statement.	Receipt Statement MiniStatement

Customer	
Responsibilities	**Collaborators**
Maintain data relating to the time, date and transactions performed by a customer on the ATM. Should enable transactions to be performed for the customer's bank account. Coordinates retrieval of BankAccount via ATM for a given BankCard and PIN.	Transaction ATM BankCard BankAccount

CashDispenser	
Responsibilities	**Collaborators**
Maintain data and control the functionality of the cash dispenser device on the ATM.	ATM

DepositReceiver	
Responsibilities	**Collaborators**
Maintain data relating to a given quantity of cash to be withdrawn or deposited from the ATM.	ATM

Screen	
Responsibilities	**Collaborators**
Maintain data relating to information which is to be displayed to the user	ATM

Keypad	
Responsibilities	**Collaborators**
Maintain data relating to user input via keypad on front of ATM.	ATM

VoiceInput	
Responsibilities	**Collaborators**
Maintain data relating to user input via voice commands from the microphone.	Microphone

Microphone	
Responsibilities	**Collaborators**
Coordinate functionality of microphone device on front of ATM	ATM VoiceInput

VoiceOutput	
Responsibilities	**Collaborators**
Enable ATM output via voice over *SmartBank Phased-Array Loudspeaker*™ technology	ATM Loudspeaker

Loudspeaker	
Responsibilities	**Collaborators**
Coordinate functionality of *SmartBank Phased-Array Loudspeaker*™ on front of ATM.	VoiceOutput

BankTeller	
Responsibilities	**Collaborators**
Provides data and functionality requied by bank tellers. Must allow bank teller to remove ATM from service, replenish supplies of paper, cash and ink.	ATM

ServiceTechnician	
Responsibilities	**Collaborators**
Provides data and functionality requied by service technicians. Must allow technician to remove ATM from service for repairs and maintenance, including disconnection from the networks before power-down.	ATM

MobileNetwork	
Responsibilities	**Collaborators**
Coordinates connectivity with mobile telecommunications network in order to credit customer mobile accounts.	ATM

PhoneTopUp	
Responsibilities	**Collaborators**
Maintains data relating to a single mobile phone top-up transaction. Allows the user to pay for mobile phone credit directly from the funds in their bank account.	Transaction

CardConsortium	
Responsibilities	**Collaborators**
Coordinates connectivity with the card consortium network. Provides services for authorisation of card transactiosn.	ATM

SmartBankSystem	
Responsibilities	**Collaborators**
Coordinates connectivity with the main SmartBank network, for access to bank account records and security details held in the databases.	ATM

Deposit	
Responsibilities	**Collaborators**
Maintain data relating to a single deposit transaction.	Transaction

Withdrawal	
Responsibilities	**Collaborators**
Maintain data relating to a single withdrawal transaction.	Transaction

LanguageSelection	
Responsibilities	**Collaborators**
Maintain data relating to the language selected by the user. Should translate output and input to correct language.	VoiceInput VoiceOutput

First-Cut Class Diagram

Following the CRC and Noun/Verb Analysis we outlined the classes for the Smart Bank ATM using a First-Cut Class Diagram. This diagram shows only the names of potential classes and the relationships between them. Multiplicity and directionality of relationships have been omitted at this stage. Some candidate classes have been condensed into single classes (such as I/O) to avoid over-complicating the system. The transaction details are passed from the Transaction class back to the ATM class for communication with the external databases.

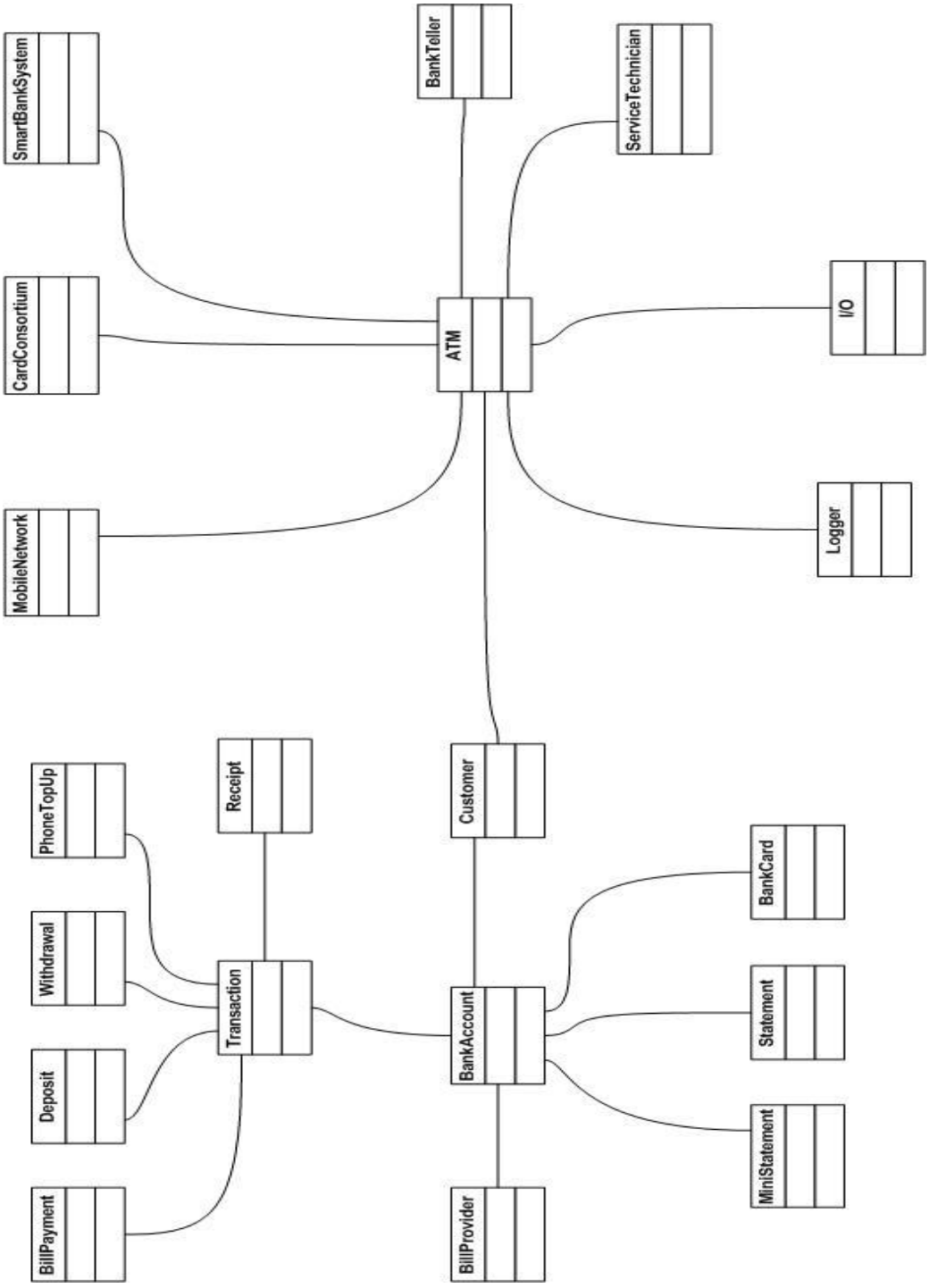

Figure 3 - First-Cut Class Diagram

Class Diagram

The following is the final class diagram, which details all main classes, relationships, attributed and operations.

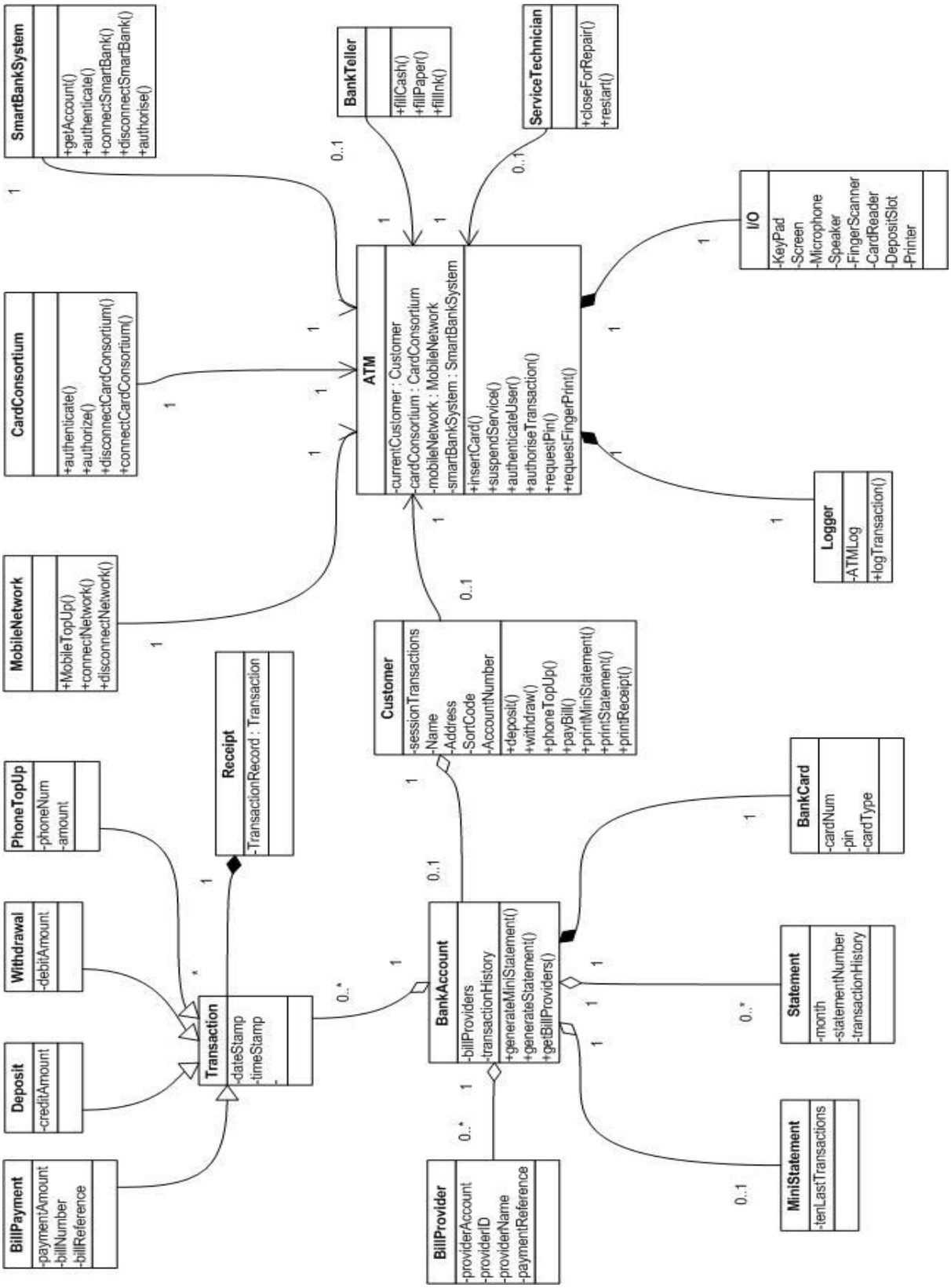

Figure 4 - Class Diagram

Object Diagram

The following is an object diagram for the system, outlining the main objects used in the selected scenario of a mobile phone top-up transaction.

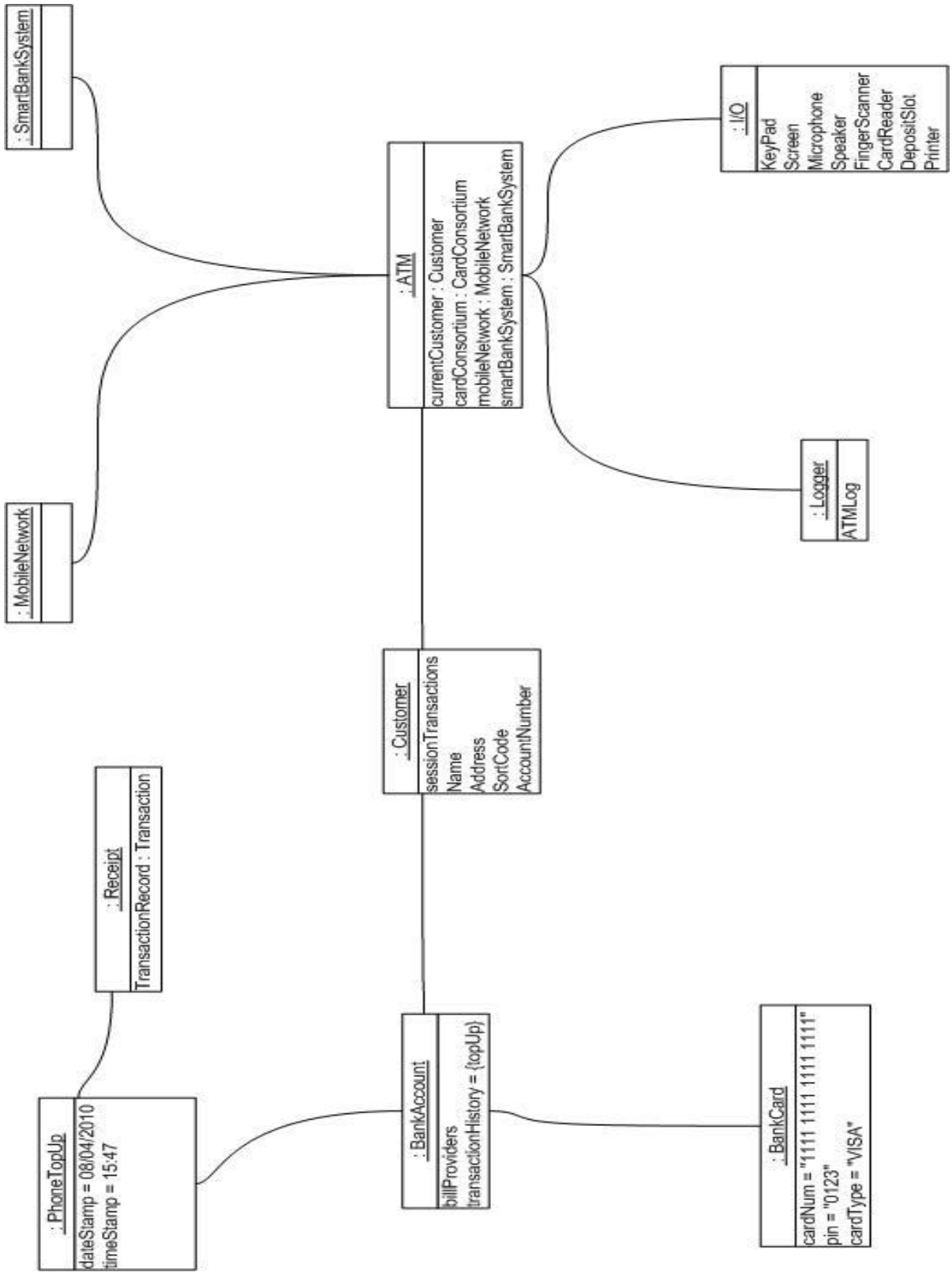

Figure 5 - Object Diagram for Phone Top-Up Scenario

Sequence Diagram

This is a sequence diagram for a scenario for topping up a mobile phone. The interaction start when the user enters their bankcard and is prompted by the machine to enter pin and the ATM prompts the user to enter the fingerprints. The ATM machine then contacts the SmartbankSystem for authentication and authorisation. The ATM then contact the mobile Network for top-Up and a receipt is printed.

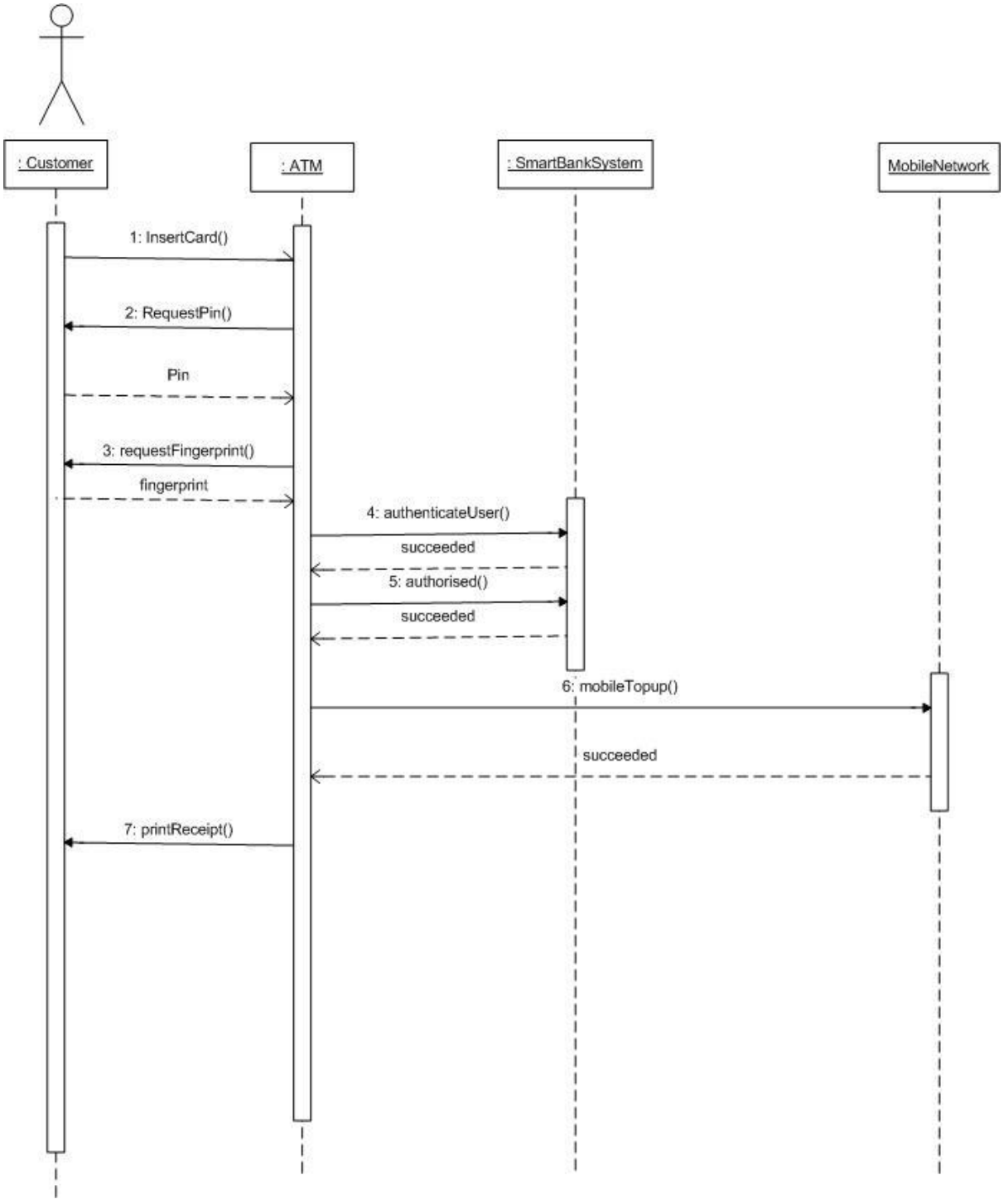

Figure 6 - Sequency Diagram for Phone Top-Up Scenario

Collaboration Diagram

This is the collaboration diagram which shows how the objects interact with each other.

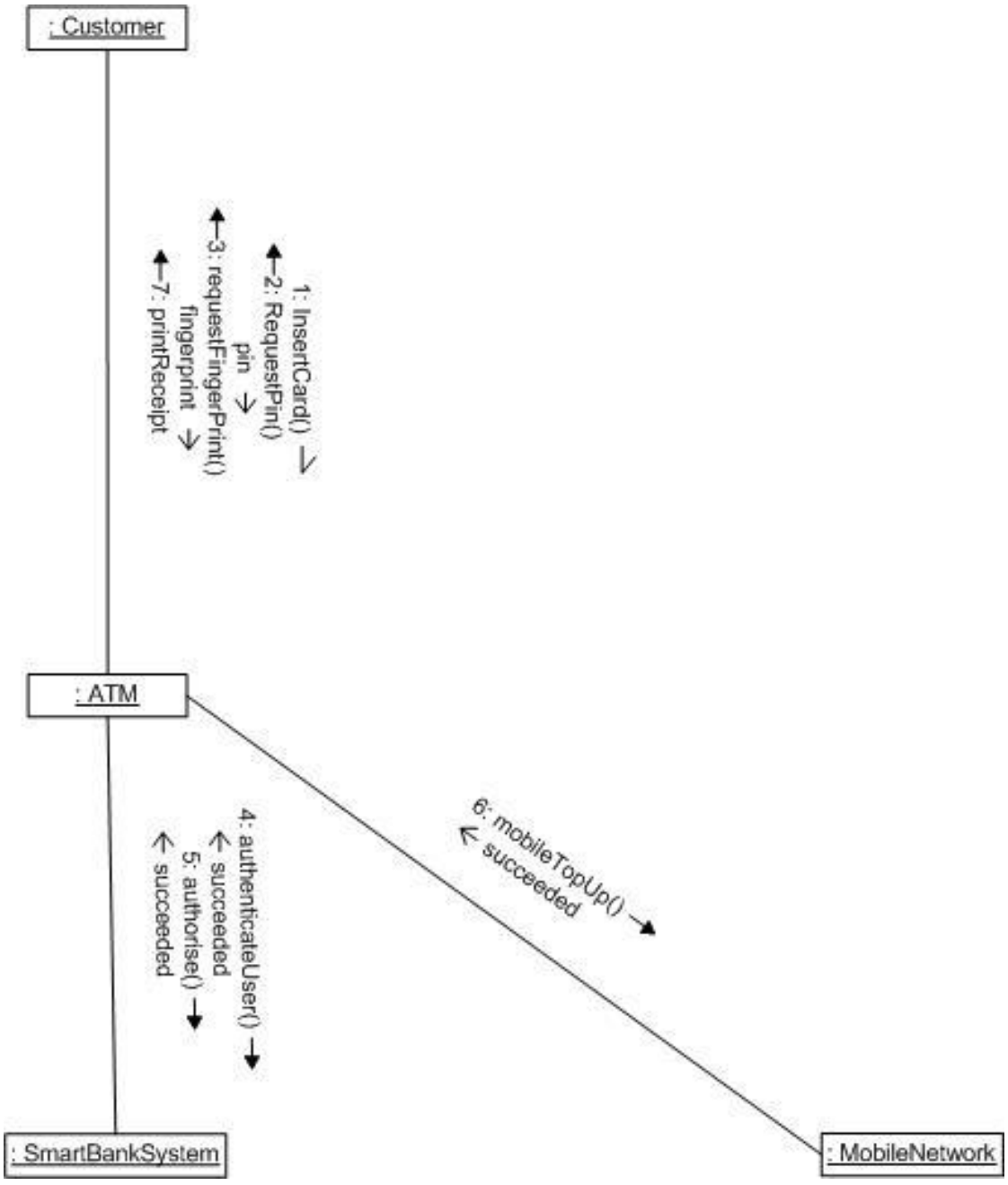

Figure 7 - Sequence Diagram for Phone Top-Up Scenario

Component Diagram

This diagram shows the key components and interfaces between modules in the ATM system.

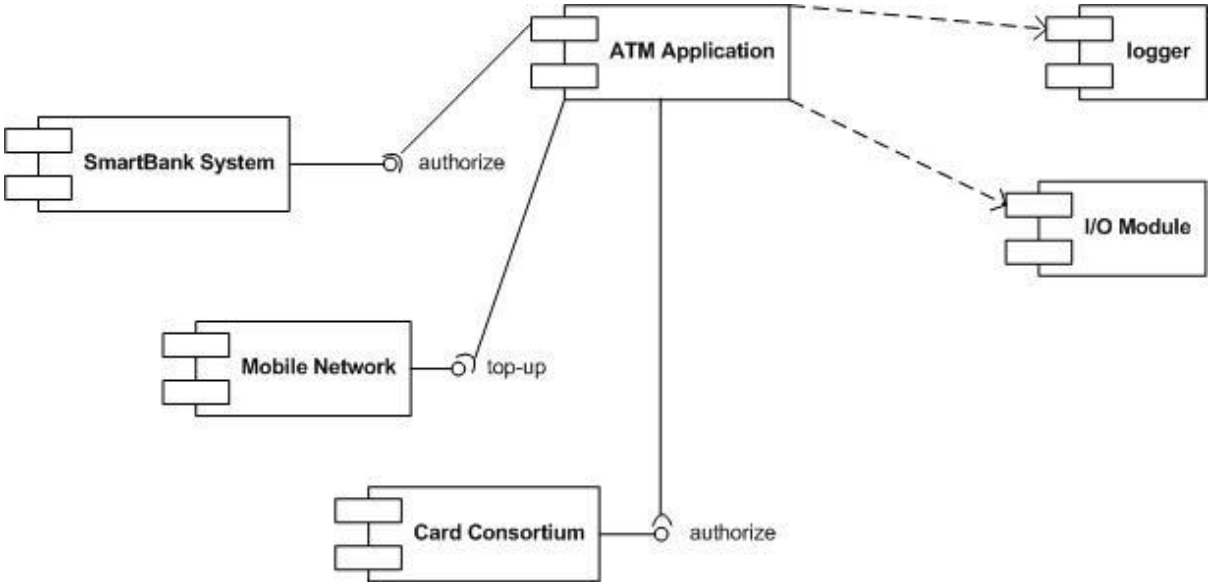

Figure 8 - Component Diagram for SmartBank System

Deployment Diagram

The deployment diagram shows the mapping of the software components of the system onto the ATM platform. The external databases which interact with the ATM system are mapped to hardware outside the scope of the system.

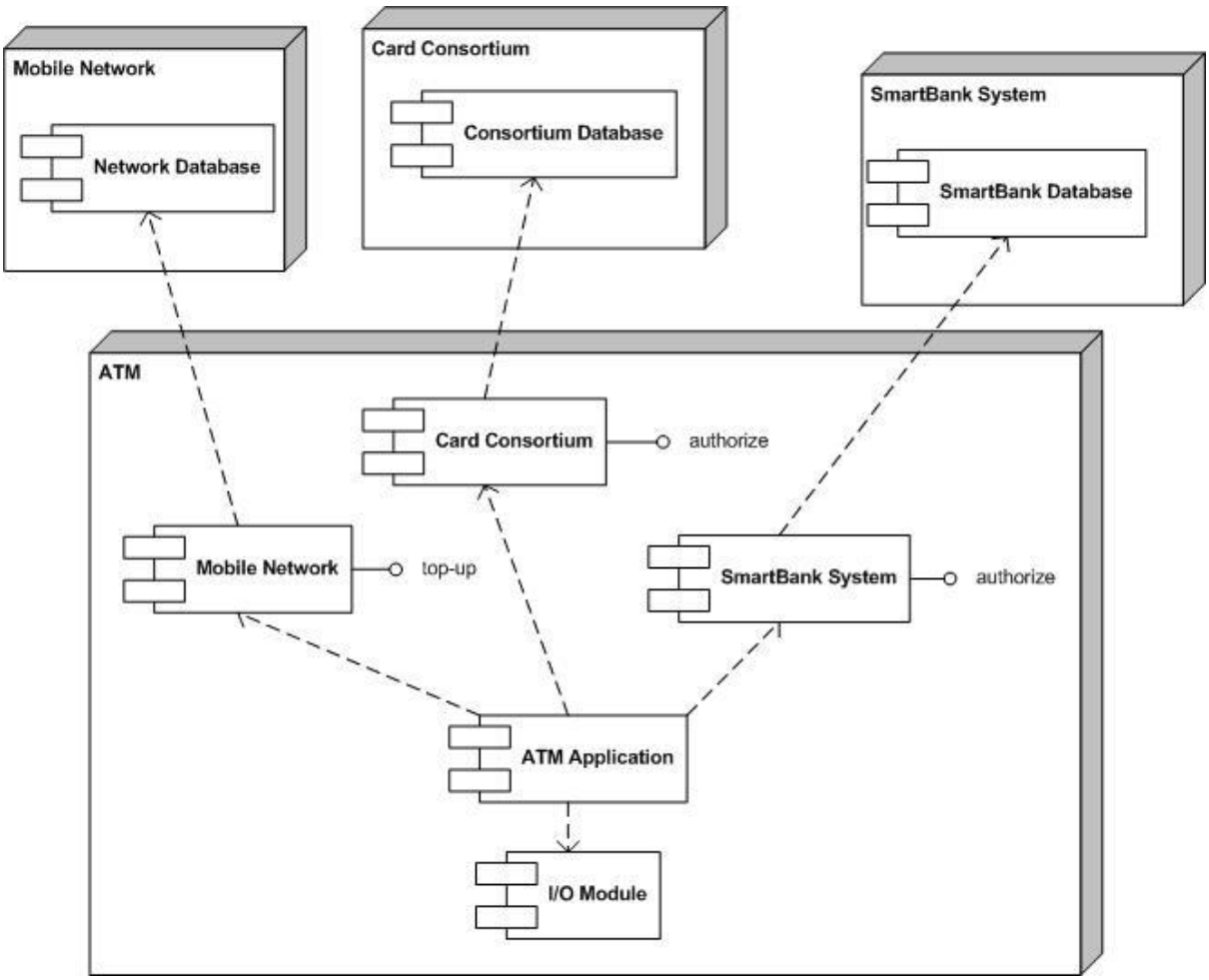

Figure 9 - Deployment Diagram for SmartBank System

Statechart Diagram

The statechart diagram shows the best-case scenario for the ‘top-up mobile’ use case. It corresponds to the activity diagram presented earlier in the report.

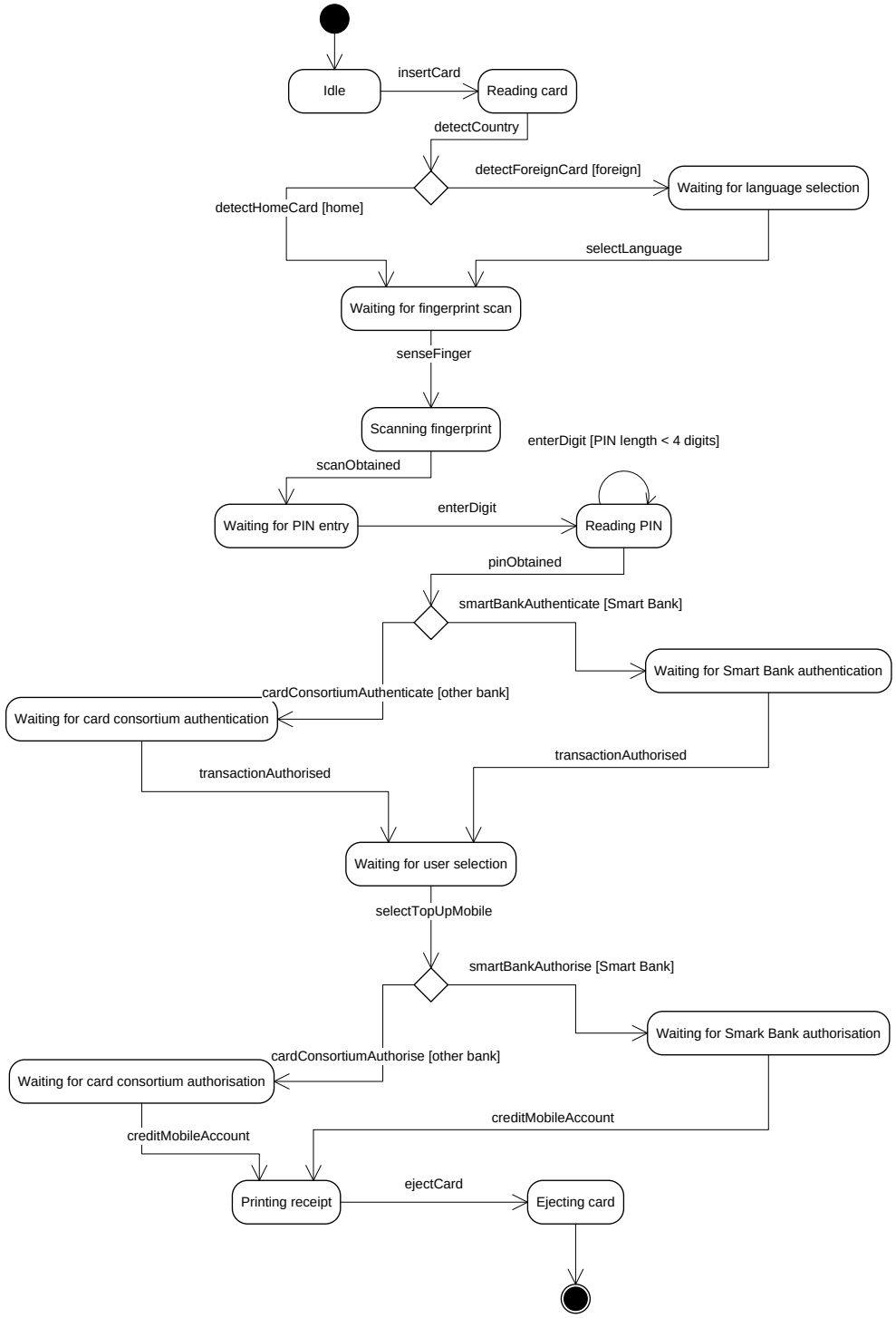

Figure 10 - Statechart Diagram for Phone Top-Up Scenario

Summary

The Smart Bank ATM system detailed here provides functionality which allows customers to withdraw funds from and deposit funds into their bank accounts. The system provides additional features which allow customers to top-up their mobile phone account and pay pre-existing bill payments.

Users can access their balance details and print statements of their account history. The key scenario chosen to illustrate the functionality of the system in this report is the mobile phone top-up transaction. The system also makes full use of Smart Bank finger print recognition security and voice recognition.

References

General references consulted during this project:

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Bahsoon, R (2010) *Software Engineering Part II Lecture Notes*, University of Birmingham