The ATM case study

in AsmetaL

ATM (Cash machine) (Egon Boerger and Robert Staerk. Abstract State Machines: A Method for High-Level System Design and Analysis. Springer, March 11, 2003) : The Problem

Design the control for an ATM, where via a GUI the customer can perform the following operations:

- Op1. Enter the ID (the PIN number). Only one attempt is allowed per session; upon failure the card is withdrawn.
- Op2. Ask for the balance of the account. This operation is allowed only once and only before attempting to withdraw money.
- Op3. Withdraw money from the account. Only one attempt is allowed per session. A warning is issued if the amount required exceeds the balance of the account.

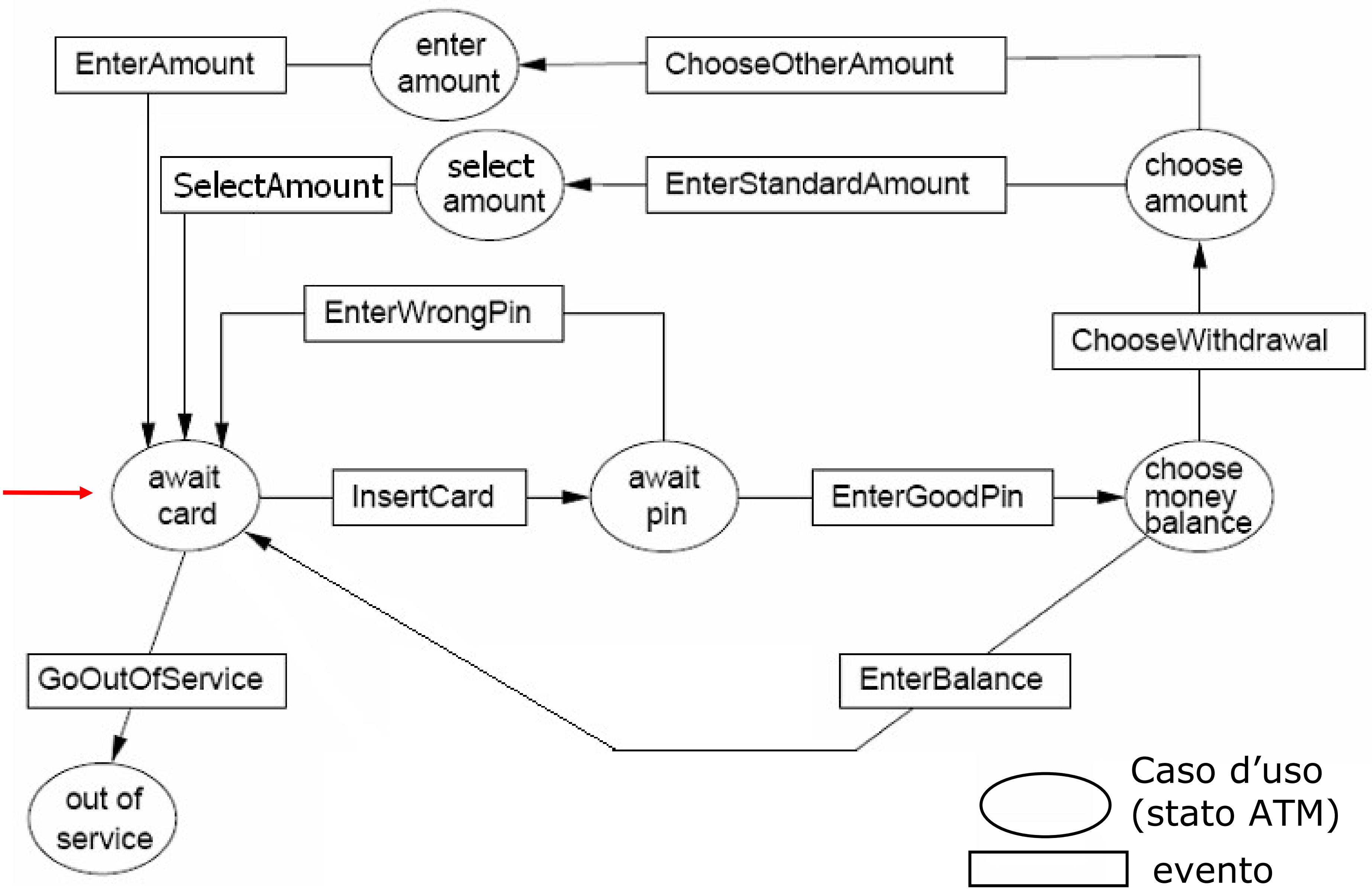
ATM – other requirements

Acc. The central system is supposed to be designed separately.

- It receives the information about every withdrawal and updates the account balance correspondingly.
- The ATM becomes inaccessible for the customer for any other transaction until this update has become effective.

Ref. Extend the ATM to go out-of-service when not enough money is left.

ATM use case description



EnterAmount

enter amount

ChooseOtherAmount

SelectAmount

select amount

EnterStandardAmount

choose amount

EnterWrongPin

ChooseWithdrawal

await card

InsertCard

await pin

EnterGoodPin

choose money balance

GoOutOfService

EnterBalance

out of service

Caso d'uso (stato ATM)

evento

ASM signature

Domains:

- **abstract domain** NumCard
- **enum domain** State = { AWAITCARD | AWAITPIN | CHOOSE | OUTOFSERVICE | CHOOSEAMOUNT | STANDARDAMOUNTSELECTION | OTHERAMOUNTSELECTION}
  States of the ATM
- **enum domain** Service = {BALANCE | WITHDRAWAL | EXIT}
  The customer can: ask for the balance or withdraw money or exit
- **domain** MoneySize **subsetof** Integer
  e.g. = {10, 20, 40, 50, 100, 150, 200}
- **enum domain** MoneySizeSelection = {STANDARD | OTHER}

ASM signature

Functions

- **dynamic controlled** currCard: NumCard
the currently inserted card
- **dynamic controlled** atmState: State
records the state of the ATM
- **dynamic controlled** outMess: Any
an output function whose values abstractly represent the messages to be displayed on the screen
- **static** pin: NumCard -> Integer the PIN of a card
- **dynamic controlled** balance: NumCard -> Integer
the account’s balance
- **dynamic controlled** accessible: NumCard -> Boolean
indicates whether or not a previous customer ATM operation is still pending in the central system. By setting accessible(CurrCard) to false (see the rule guards for entering a pin number) prevent further transactions until the central system changes the accessibility back to true.

ASM signature

Other functions

- **dynamic monitored** insertedCard: NumCard

inserted card

- **dynamic monitored** insertedPin: Integer

inserted PIN

- **dynamic monitored** selectedService: Service

selected service

- **dynamic monitored** standardOrOther: MoneySizeSelection

selected money size: STANDARD or OTHER

- **dynamic monitored** insertMoneySize: Integer

selected money size (in case of OTHER)

- **dynamic controlled** moneyLeft: Integer

ATM cash

- **derived** allowed: Prod(NumCard, Integer) -> Boolean

withdrawal iff the balance is >= to the requested money

```
function allowed($c in NumCard, $m in Integer) =
                  balance($c) >= $m
```

ASM transition rules

Insert a card:

By requirement Op1, the insertion of a card (preceding entering an ID) can be formalized as follows

```
rule r_insertcard =
   if (atmState=AWAITCARD) then
                                   par
                                          currCard := insertedCard
                                          atmState := AWAITPIN
                                          outMess := "Enter pin"
                                   endpar
                            endif
```

ASM transition rules

Enter the PIN: By Op1 the inserted PIN must be correct and by the requirement Acc, access should be granted only if the account of the current card is *accessible*

```
rule r_enterPin =
if (atmState=AWAITPIN) then
  if (insertedPin=pin(currCard) and accessible(currCard))
    then par
              outMess := "Choose service"
              atmState := CHOOSE
           endpar
    else  //wrong PIN or account inaccesible: the card is returned
           //by setting atmState := AWAITCARD
           par
              atmState := AWAITCARD
              if (insertedPin!=pin(currCard))
              then outMess := "Wrong pin” endif
              if (not(accessible(currCard)) and insertedPin=pin(currCard))
              then outMess := "Account non accessible‟ endif
           endpar
  endif
endif
```

ASM transition rules

Choose service:

By Op2 and Op3: ask for balance, or for money, or exit

```
rule r_chooseService =
 if (atmState=CHOOSE)
 then  par
         if (selectedService=BALANCE) //display the balance
         then outMess := balance(currCard) endif
         if (selectedService=WITHDRAWAL)
         then  par
                 atmState := CHOOSEAMOUNT // standard or other
                 outMess := "Choose Standard or Other"
                endpar endif
         if (selectedService=EXIT)
         then par
                atmState := AWAITCARD // choice: EXIT
                outMess := "Goodbye"
              endpar endif
       endpar
 endif
```

ASM transition rules

Choose amount: By Op3

```
rule r_chooseAmount =
  if (atmState=CHOOSEAMOUNT) then
        par
         if (standardOrOther=STANDARD) then
            par
             atmState := STANDARDAMOUNTSELECTION
             outMess := "Select a money size"
            endpar
         endif
         if (standardOrOther=OTHER) then
            par
               atmState := OTHERAMOUNTSELECTION
               outMess := "Enter money size"
            endpar
         endif
        endpar
   endif
```

ASM transition rules

Withdraw money: By Op3

```
rule r_withdraw =
  par
   if (atmState=STANDARDAMOUNTSELECTION)
   then if (exist $m in MoneySize with $m=insertMoneySize)
           then if (insertMoneySize<=moneyLeft)
                   then r_processMoneyRequest [insertMoneySize]
                   else outMess := “No enough cash in the ATM"
                  endif
           endif
   endif
   if (atmState=OTHERAMOUNTSELECTION)
     then if (mod(insertMoneySize, 10)=0)
              then if (insertMoneySize<=moneyLeft)
                       then r_processMoneyRequest [insertMoneySize]
                       else outMess := " No enough cash in the ATM "
                       endif
             else  outMess := “Money size not available"
             endif
     endif
  endpar
```

ASM transition rules

Process money request: By Op3

```
rule r_processMoneyRequest ($m in Integer) =
    if (allowed(currCard, $m))
    then  r_grantMoney[$m]
    else outMess := "Not enough money in your account"
    endif
```

ASM transition rules

Grant money: By Op3

```
rule r_grantMoney($m in Integer) =
par
    r_subtractFrom[currCard, $m] //update the account balance
    moneyLeft := moneyLeft - insertMoneySize //ATM cash decreases
    seq
      accessible(currCard) := false //set the account inaccessible
      accessible(currCard) := true //Another agent should unblock
                                  //the account!   Così inutile
    endseq
    atmState := AWAITCARD //the card is returned to the customer
    outMess := "Goodbye"
endpar
```

```
  rule r_subtractFrom ($c in NumCard, $m in Integer) =
                 balance($c) := balance($c) - $m
```

ASM transition rules

Go out of service: By ref.

```
macro rule r_goOutOfService =
        if (moneyLeft < minMoney) then
            par
                atmState := OUTOFSERVICE
                outMess := "Out of Service"
            endpar
        endif
```

where (a new function is added to the signature):

static minMoney: Integer

Minimum amount of money to permit the ATM to work

ASM transition rules

Go out of service: By ref.

```
macro rule r_goOutOfService =
        if (moneyLeft < minMoney) then
            par
                atmState := OUTOFSERVICE
                outMess := "Out of Service"
            endpar
        endif
```

where:

static minMoney: Integer
Minimum amount of money to permit the ATM to work

static maxPrelievo: Integer
Maximum amount of money one can withdraw

ASM transition rules

Main rule:

```
main rule r_Main =
                seq
                        r_goOutOfService[]
                        par
                                r_insertcard[]
                                r_enterPin[]
                                r_chooseService[]
                                r_chooseAmount[]
                                r_prelievo[]
                        endpar
                endseq
```