

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**

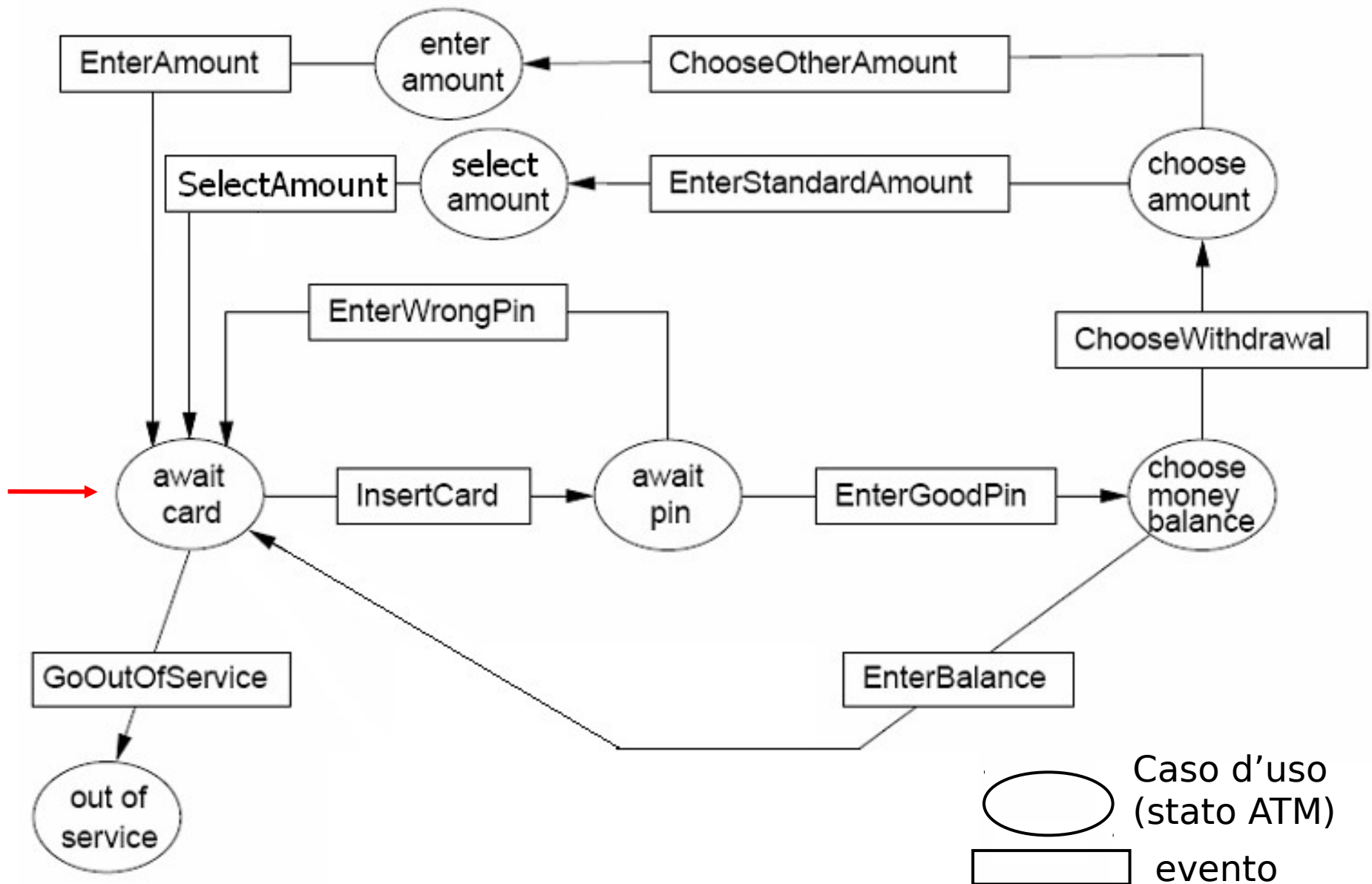
Design the control for an ATM, where via a GUI the customer can perform the following operations:

- 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 Only one attempt is allowed per session; upon failure the card is withdrawn.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



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}

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.

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 \geq to the requested money

function allowed($\$c$ in NumCard, $\$m$ in Integer) =
balance($\$c$) \geq $\$m$

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 inaccessible: 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

Main rule:

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