RM2PT: A Tool for Automatic Generation of Prototypes from Requirements Model

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Motivation

- Requirement errors mostly lead to the failures of software development.
- Customers and end-user are not entirely sure of what is needed before trying out the target software.
- It is very desirable to have a tool to generate prototypes directly from requirements continually and automatically.

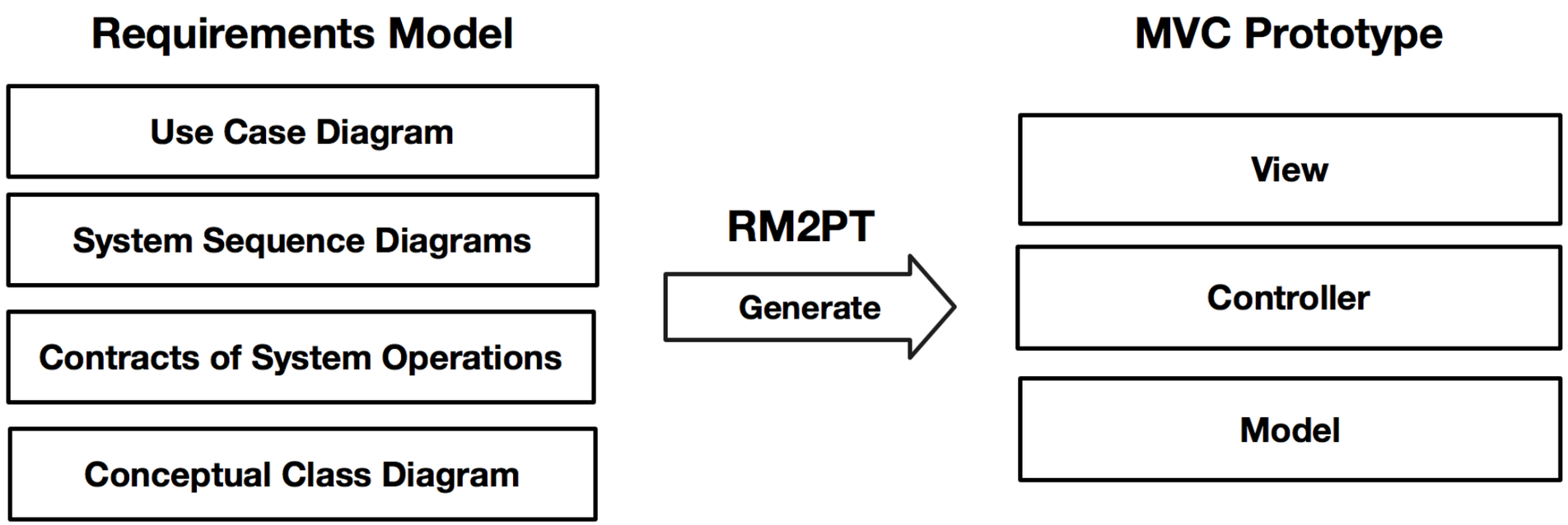
State-of-arts

- Current UML modeling tools can only generate skeleton code, the operations still need to be manually implemented.
- Even if providing a design model to each operation, only less than 48% correct source code can be generated.

RM2PT

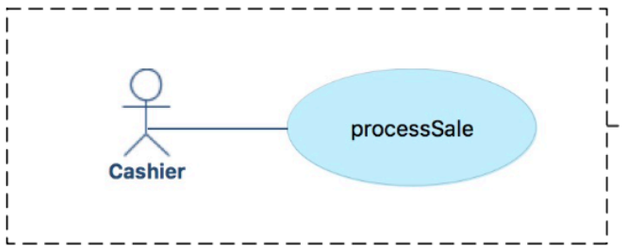
- RM2PT can automatic generate object-oriented prototypes from requirements models.
- The generated prototype can be used for requirements validation and evolution

RM2PT



Available as free software: http://rm2pt.mydreamy.net

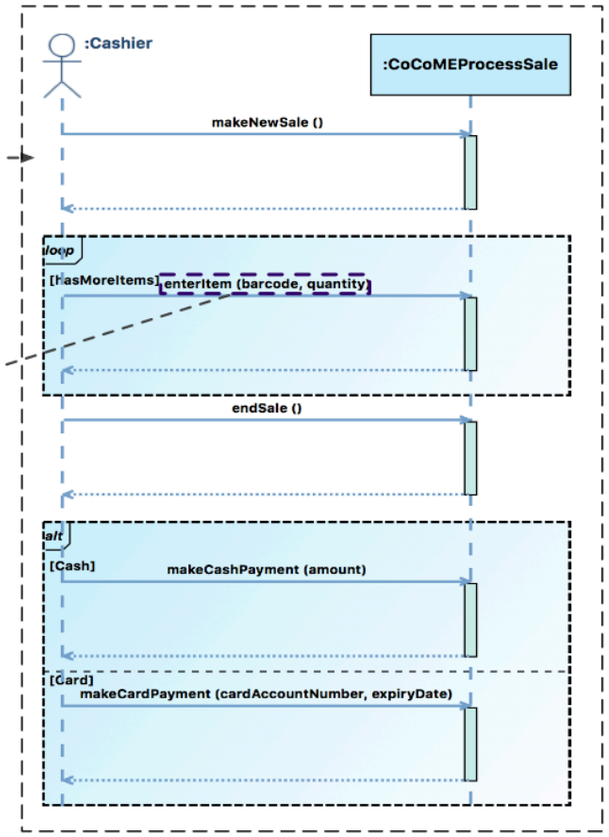
Requirements Model



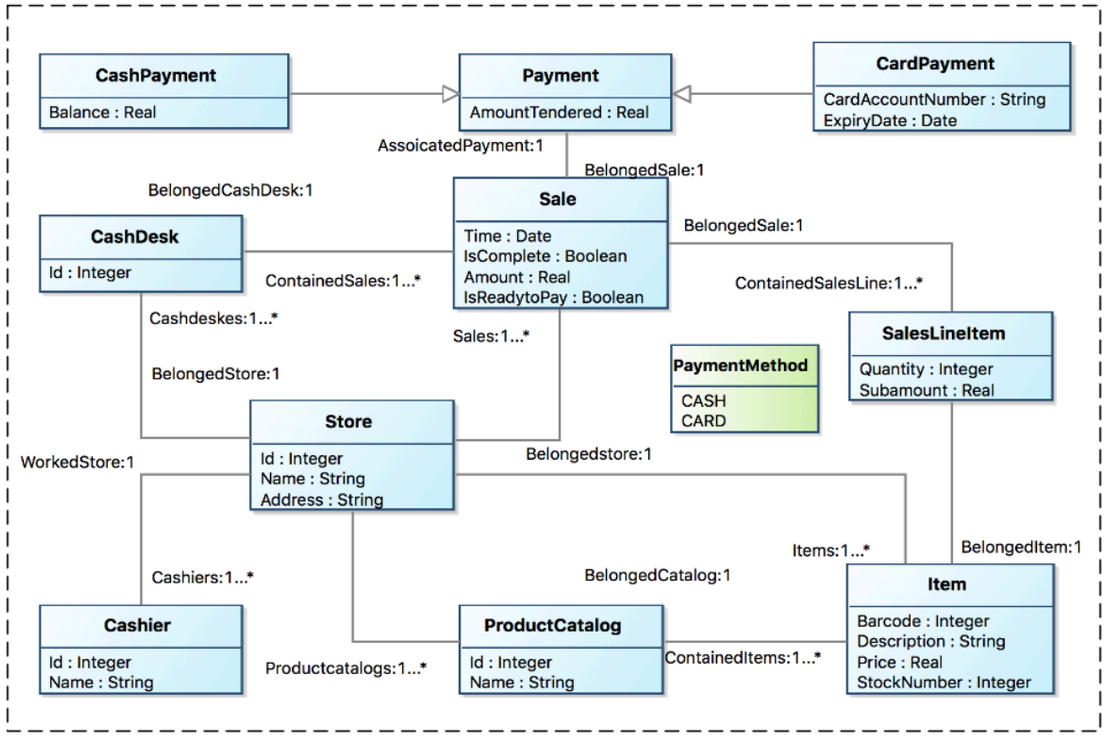
1. Use Case Diagram

```
Contract CoCoMEProcessSale::enterItem(barcode : Integer, quantity : Integer) : Boolean {

    /* Definition: find specific Item instance by barcode */
    definition:
        item:Item = Item.allInstance()->any(i:Item | i.Barcode = barcode)

    /* Precondition: there is a sale underway */
    precondition:
        currentSale.oclIsUndefined() = false and
        currentSale.IsComplete = false

     * A salesLineItem instance sli was created (instance creation).
    postcondition:
        let sli:SalesLineItem in
        sli.oclIsNew() and
        self.currentSaleLine = sli and
        sli.BelongedSale = currentSale and
        currentSale.ContainedSalesLine->includes(sli) and
        sli.Quantity = quantity and
        sli.BelongedItem = item and
        item.StockNumber = item.StockNumber@pre - quantity and
        sli.Subamount = item.Price * quantity and
        SalesLineItem.allInstance()->includes(sli) and
        result = true

}
```

3. Contracts of System Operations



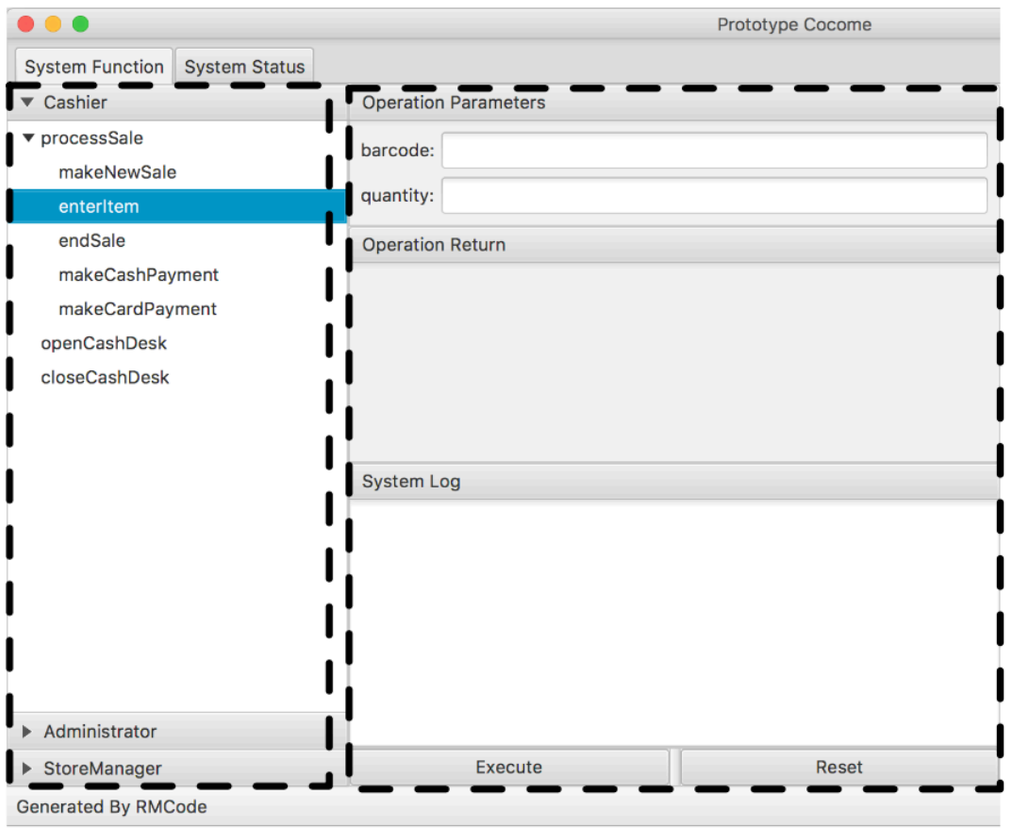
2. System Sequence Diagrams



4. Conceptual Class Diagram

Prototype

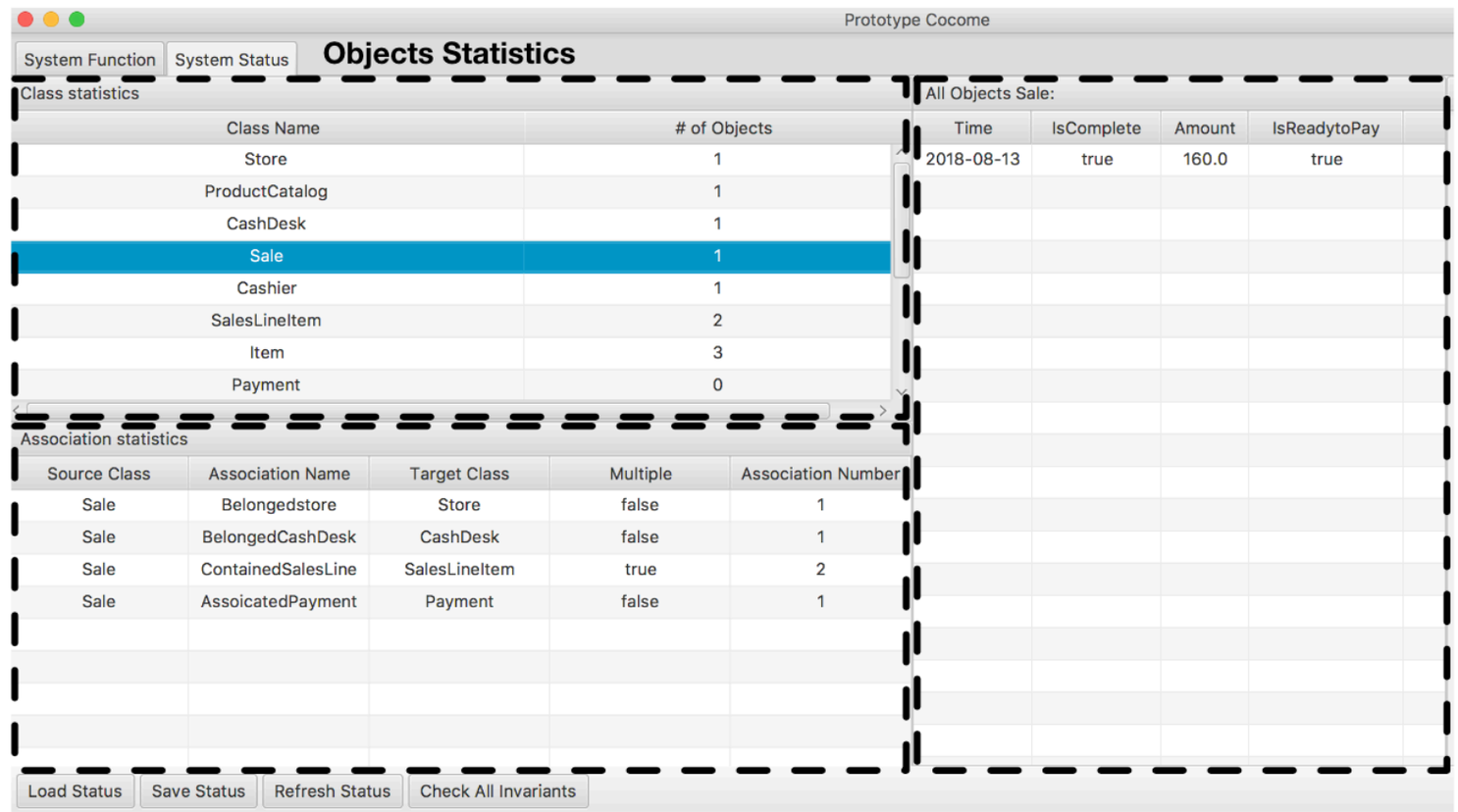
Prototype GUI (Part 1)



System Operation List

Operation Widget

Prototype GUI (Part 2)



The Associations of Objects

The Attributes of Objects

Video Demo

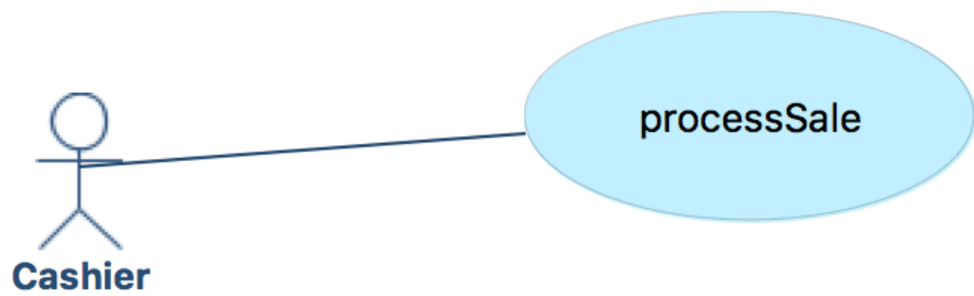
- CoCoME example
  - Requirements Modeling
  - Prototype Generation
  - Requirement Validation

https://youtu.be/rDdpXsjSq8A

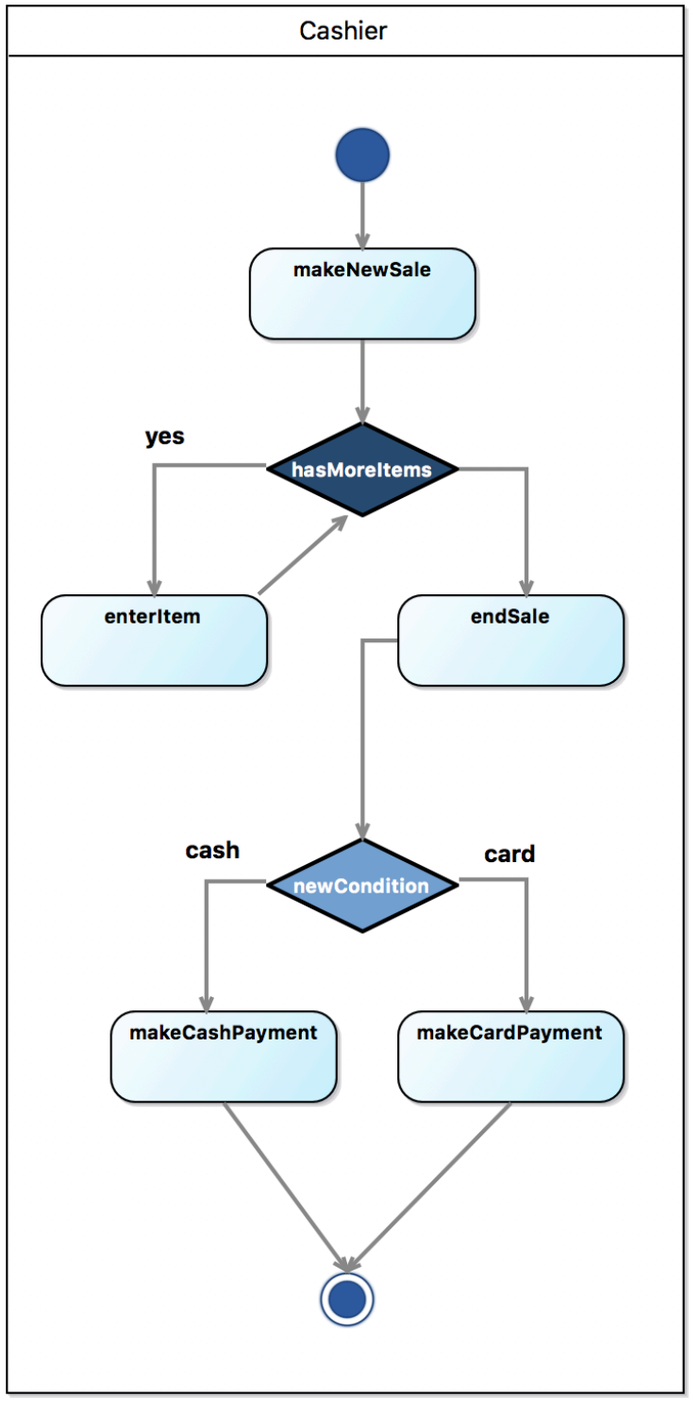
Case Study I

CoCoME (Supermarket System)

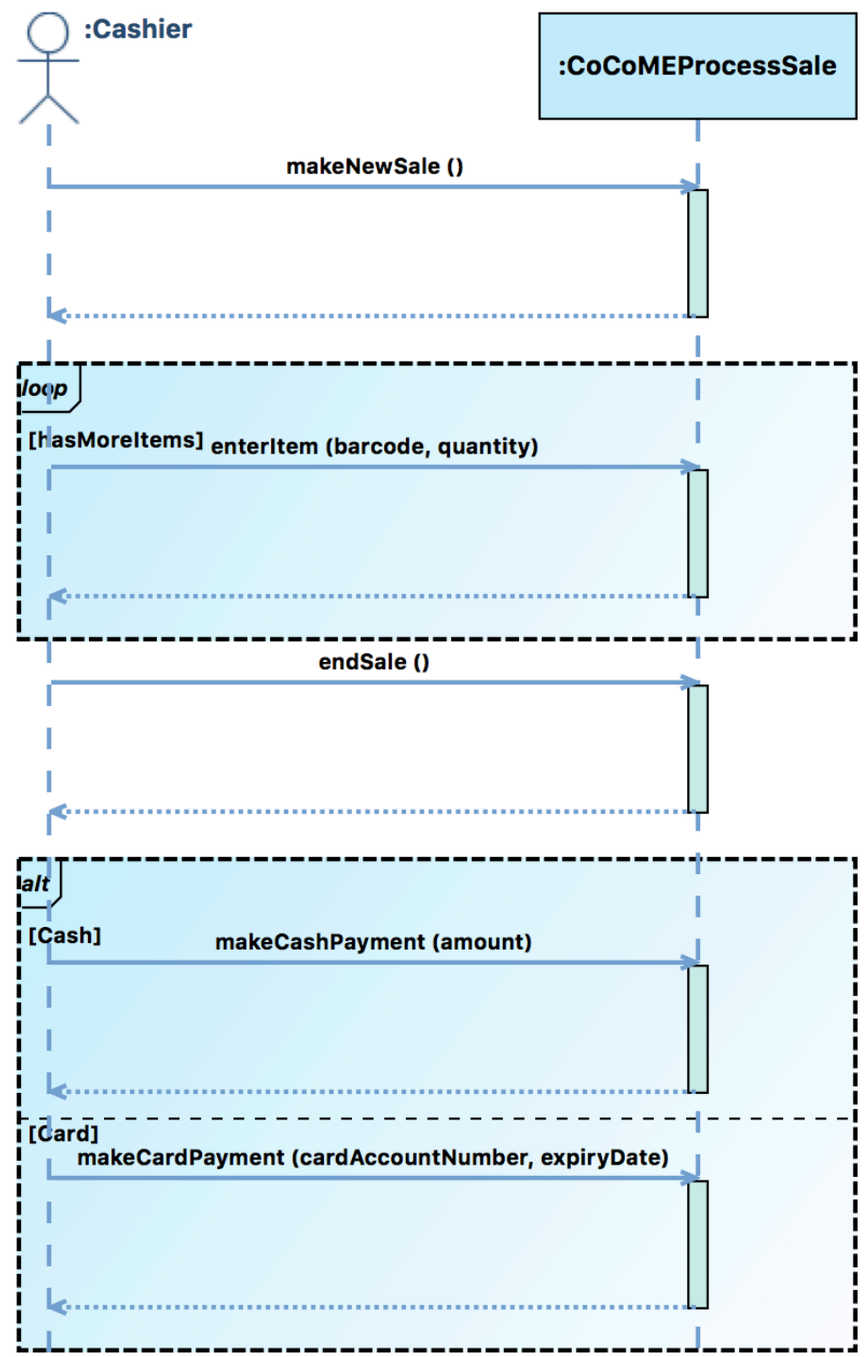
Use Case Diagram



System Interactions

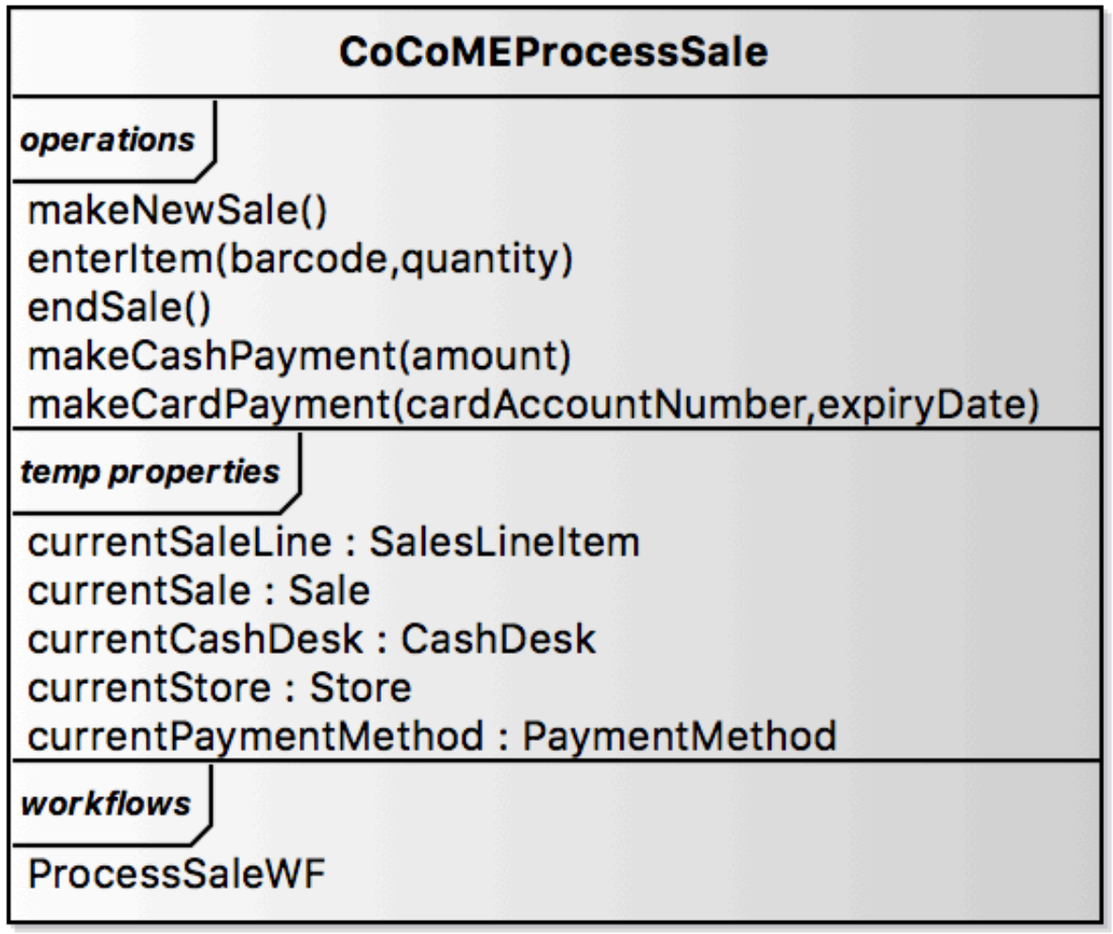


Activity Diagram

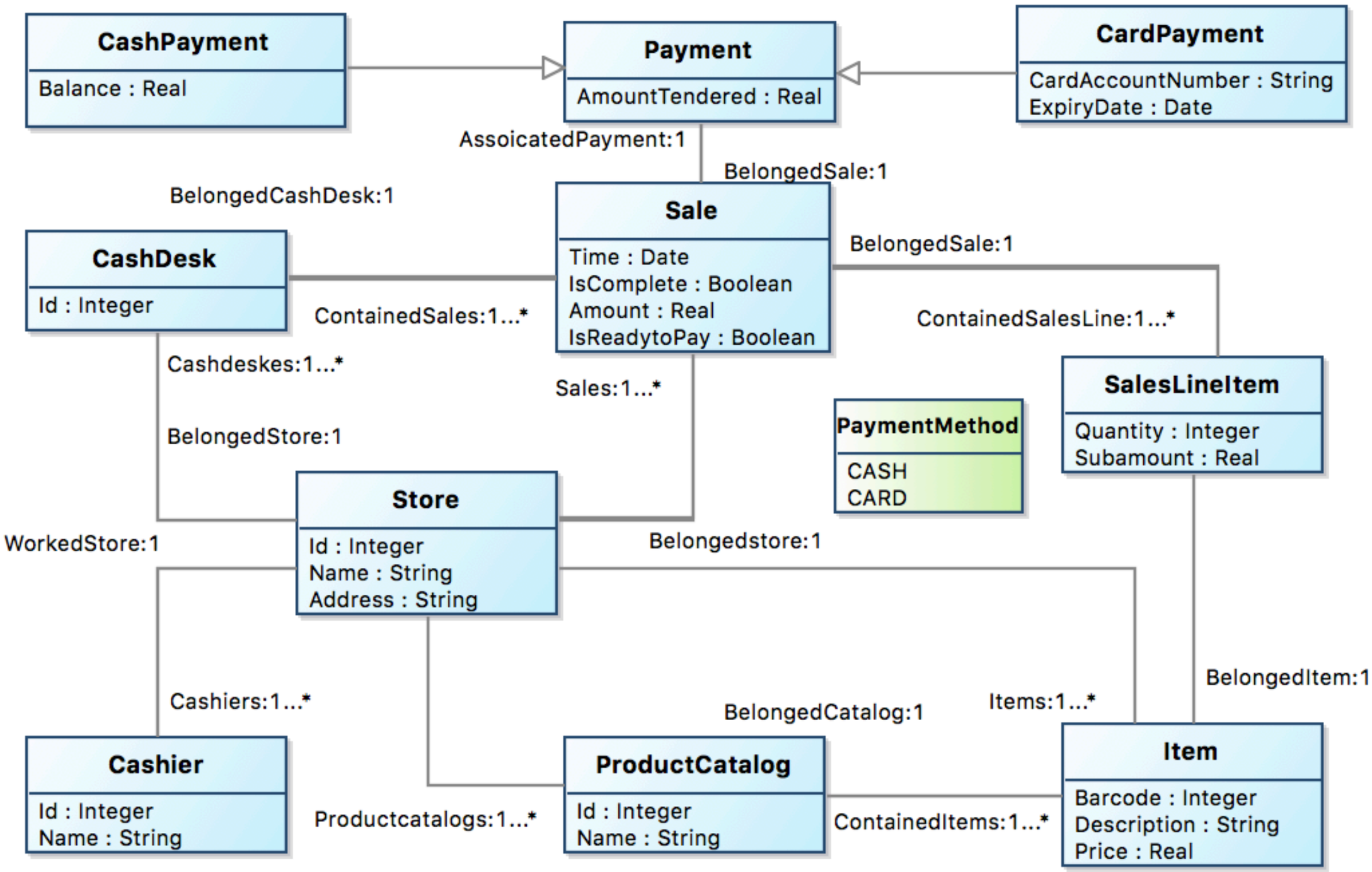


System Sequence Diagram

Interface of Process Sale



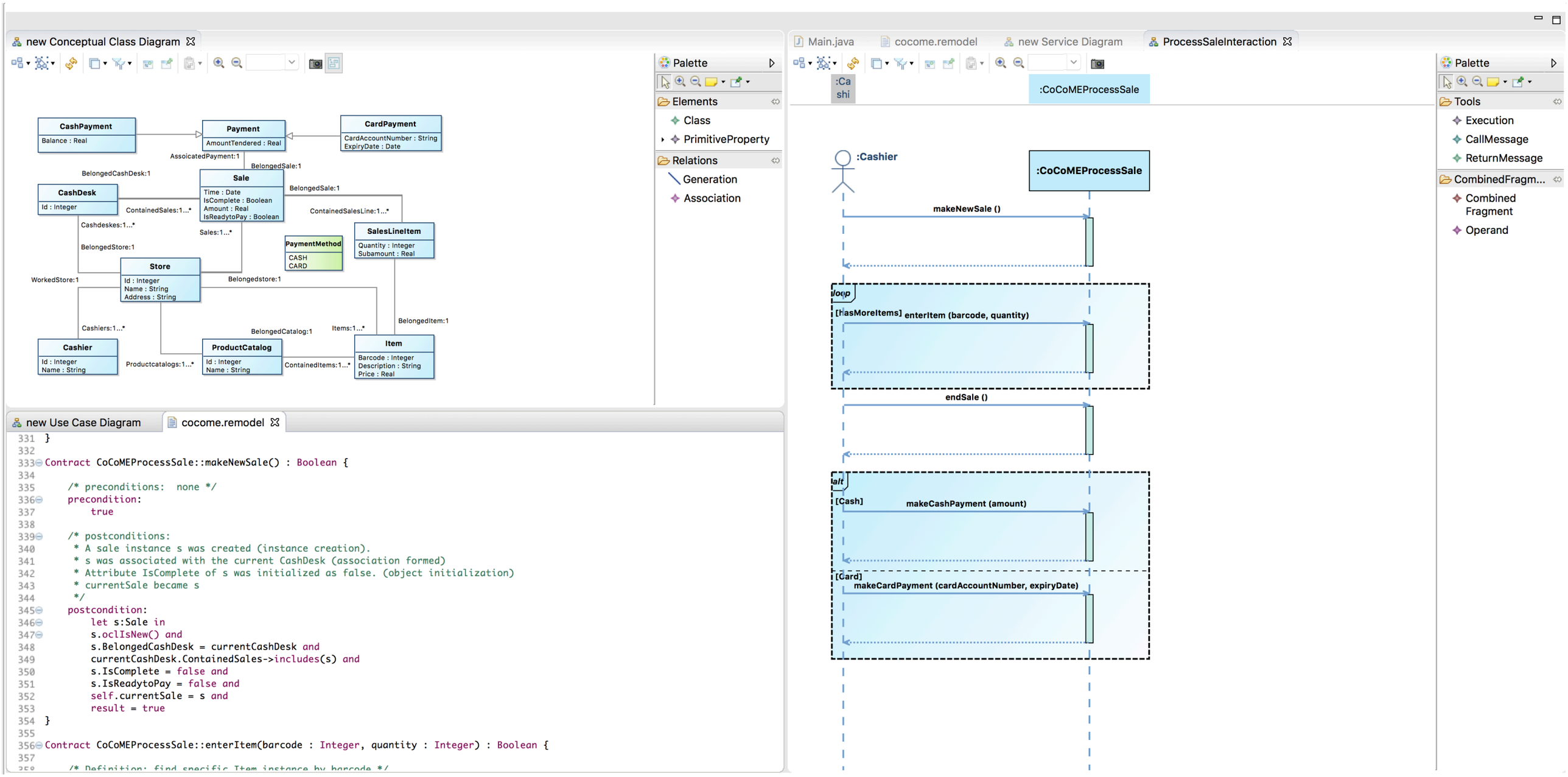
Conceptual Class Diagram



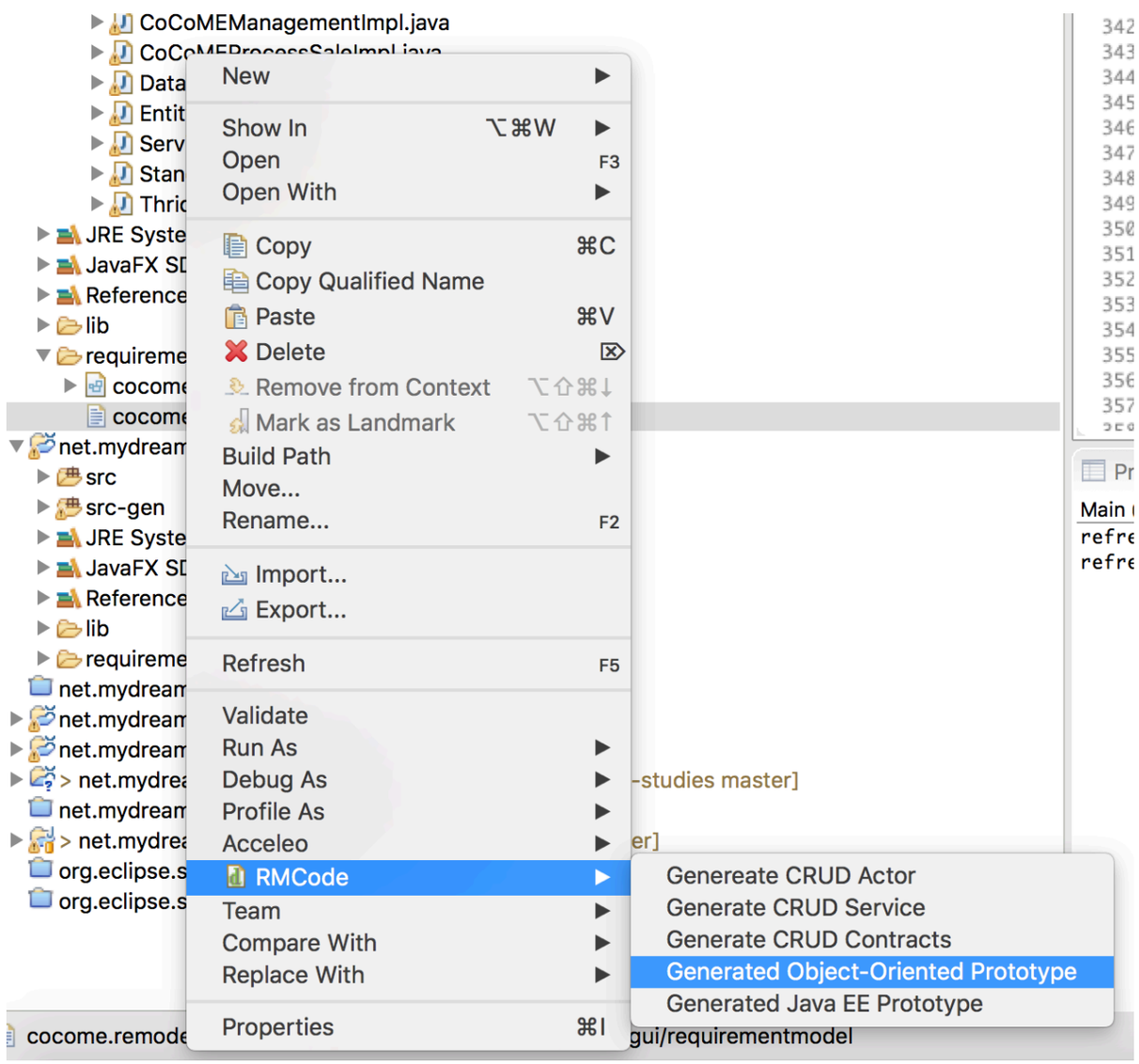
Operation Contract

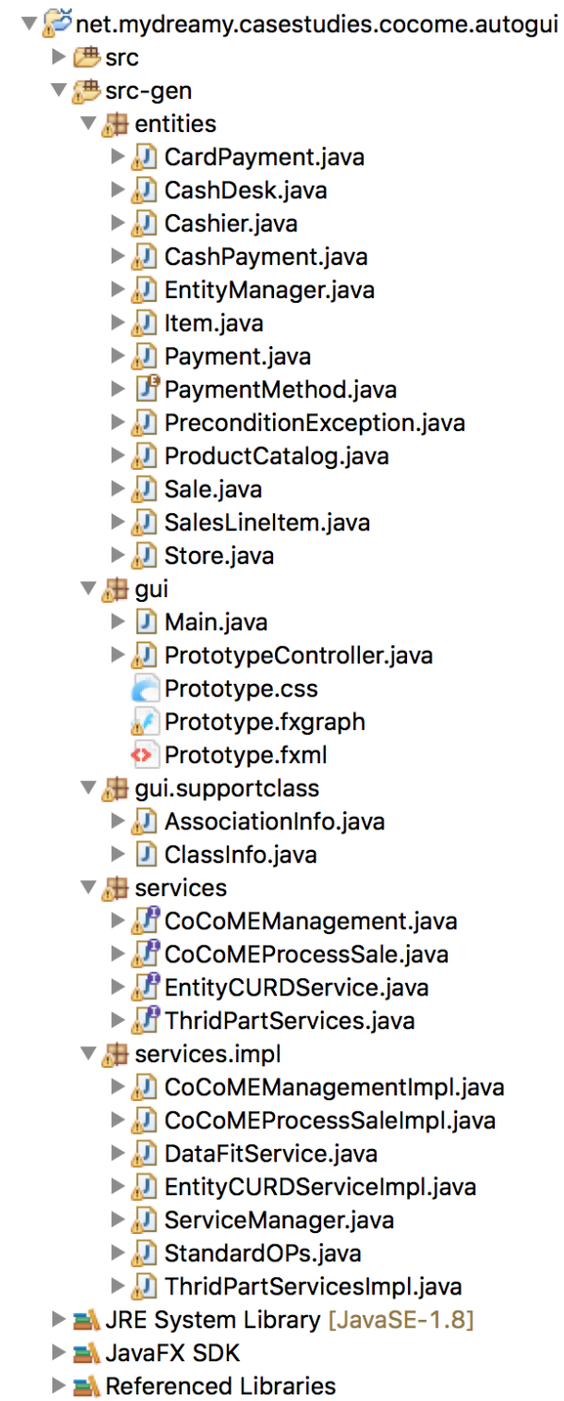
```
Contract CoCoMEProcessSale::makeNewSale() : Boolean {

    /* preconditions:  none */
    precondition:
        true

    /* postconditions: ..
    postcondition:
        let s:Sale in
        s.oclIsNew() and
        s.BelongedCashDesk = currentCashDesk and
        currentCashDesk.ContainedSales->includes(s) and
        s.IsComplete = false and
        s.IsReadytoPay = false and
        self.currentSale = s and
        result = true
}
```

Requirement Model in RM2PT



Generate Prototype





Prototype: System Operations

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
- Administrator

Operation Parameters

barcode:

quantity:

Operation Return

System Log

Execute | Reset

Definition

```
item:Item = Item.allInstance()->any(i:Item | i.Barcode = barcode)
```

Precondition

```
currentSale.IsComplete = false
```

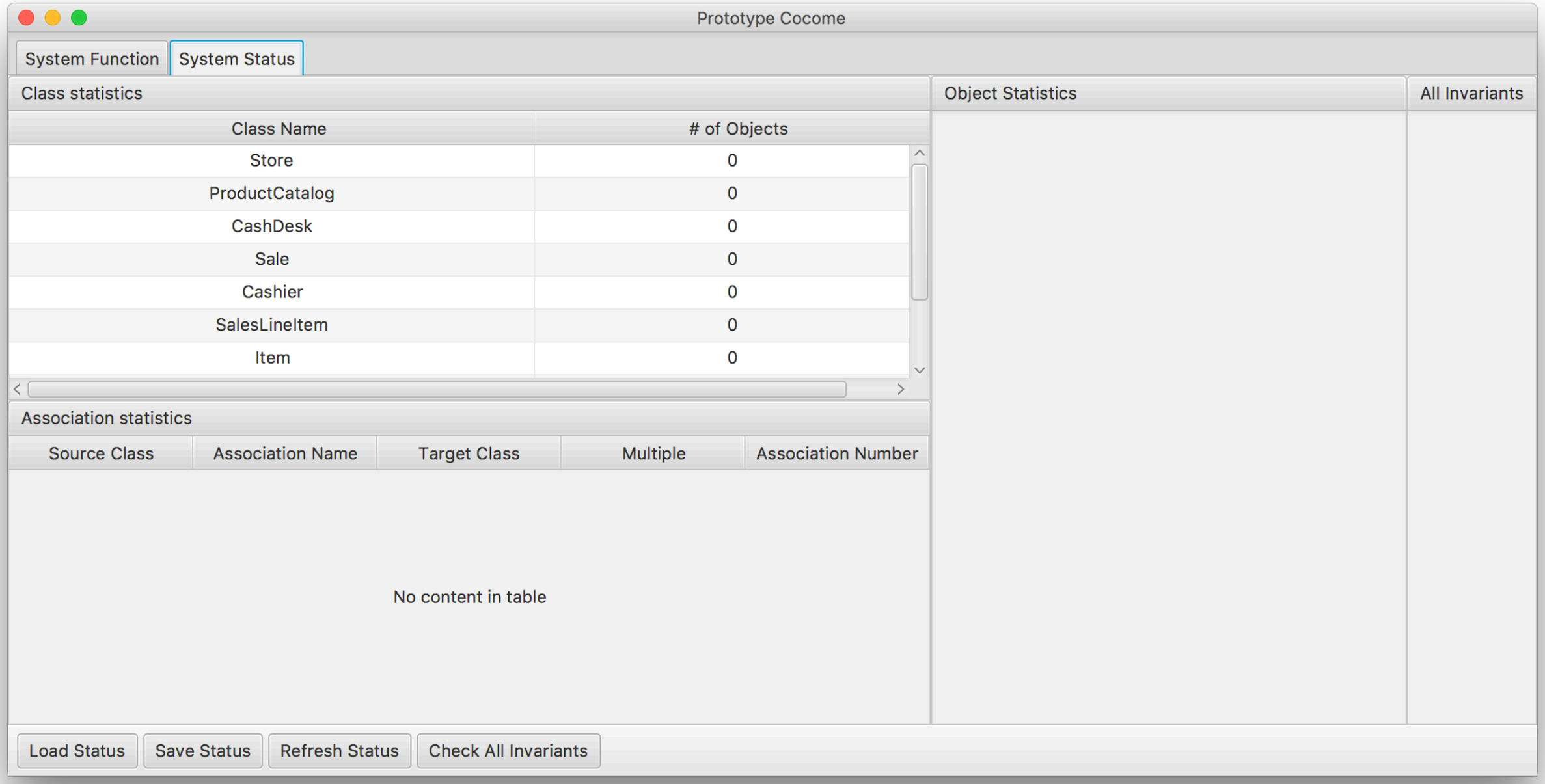
Postcondition

```
let sli:SalesLineItem in
sli.oclIsNew() and
self.currentSaleLine = sli and
sli.BelongedSale = currentSale and
currentSale.ContainedSalesLine->includes(sli) and
sli.Quantity = quantity and
sli.BelongedItem = item and
```

Invariants

Generated By RMCode

Prototype: System State



Loading or adding start-up data

Prototype Cocome

System Function | System Status

- Cashier
- Administrator
  - createStore
  - queryStore
  - modifyStore
  - deleteStore
  - createProductCatalog
  - queryProductCatalog
  - modifyProductCatalog
  - deleteProductCatalog
  - createCashDesk
  - queryCashDesk
  - modifyCashDesk
  - deleteCashDesk
  - createCashier
  - queryCashier
  - modifyCashier
  - deleteCashier
  - createItem
  - queryItem
  - modifyItem
  - deleteItem

Operation Parameters

id: 1

name: UMStore

address: Taipa

Operation Return

true

System Log

18:03:18 -- execute operation: createStore in service: EntityCURDService -- success!

Execute | Reset

Definition

store:Store = Store.allInstance()->a

Precondition

store.oclIsUndefined() = true

Postcondition

let sto:Store in
sto.oclIsNew() and
sto.Id = id and
sto.Name = name and
sto.Address = address and
Store.allInstance()->includes(sto) a
result = true

Invariants

Generated By RMCode

Start-up Data: UM Store

Prototype Cocome

System Function | System Status

Class statistics

Class Name	# of Objects
Store	1
ProductCatalog	0
CashDesk	0
Sale	0
Cashier	0
SalesLineItem	0
Item	0
Payment	0

All Objects Store:

Id	Name	Address
1	UMStore	Taipa

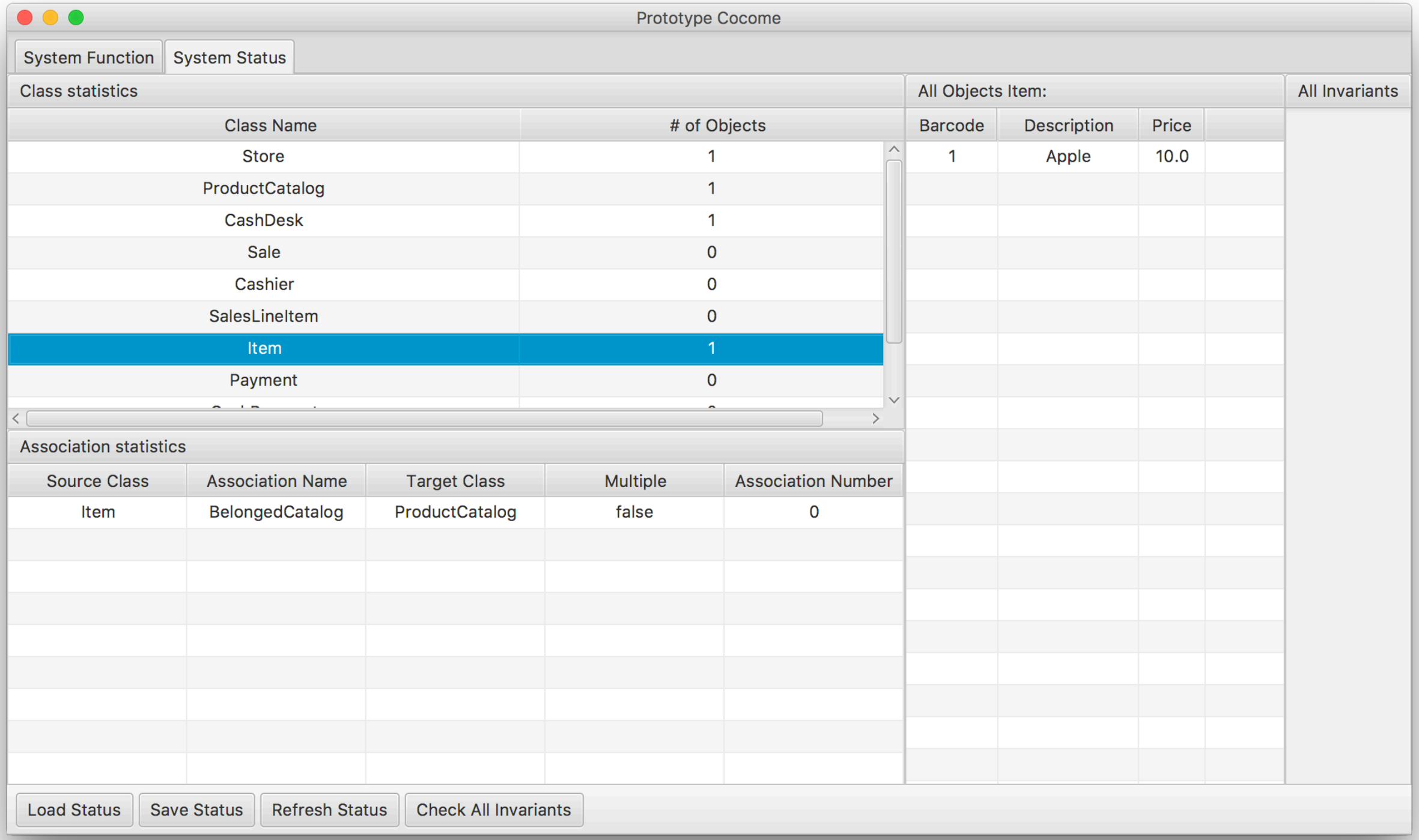
All Invariants

Association statistics

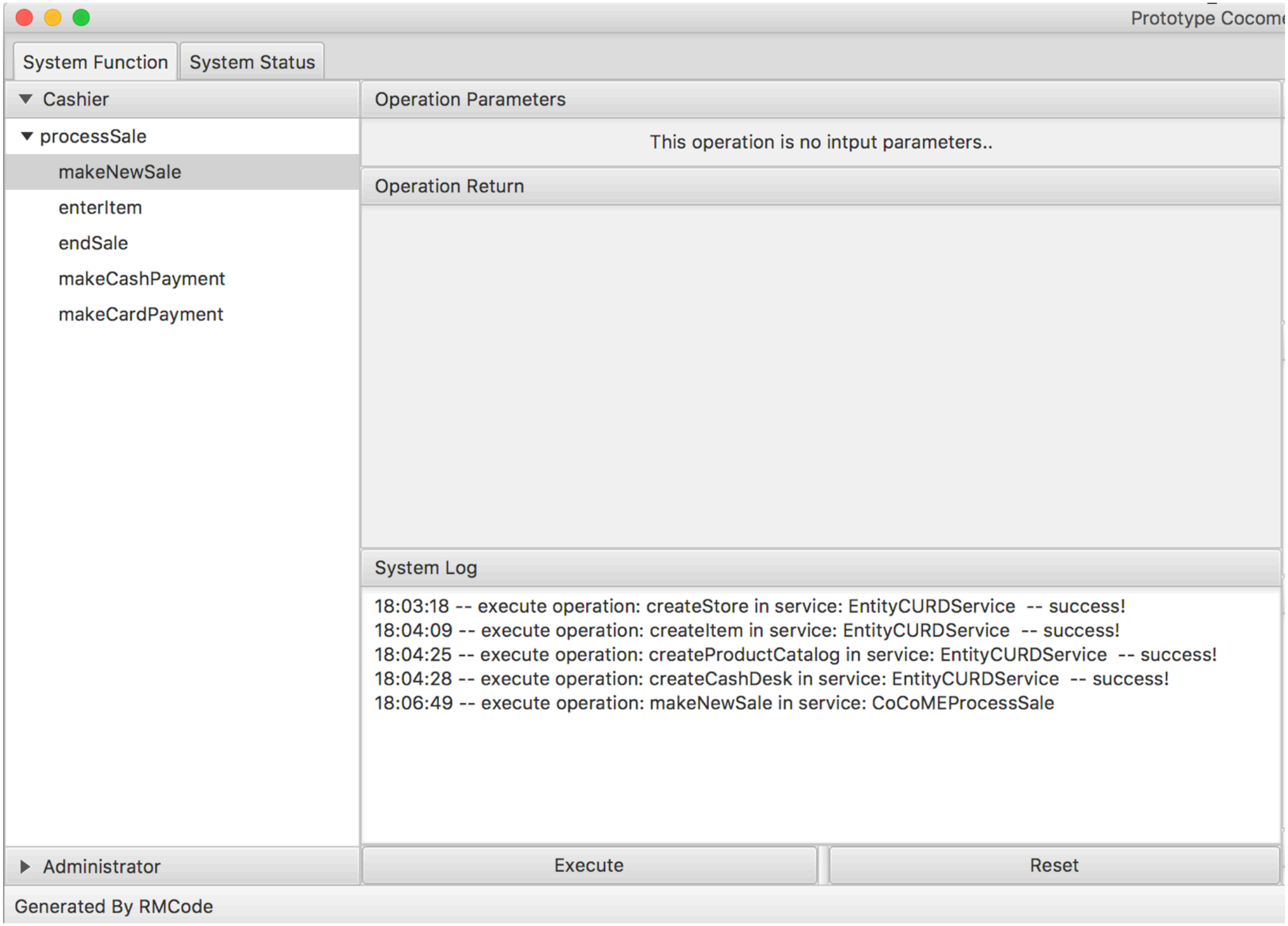
Source Class	Association Name	Target Class	Multiple	Association Number
Store	Cashdeskes	CashDesk	true	0
Store	Productcatalogs	ProductCatalog	true	0
Store	Items	Item	true	0
Store	Cashiers	Cashier	true	0
Store	Sales	Sale	true	0

Load Status | Save Status | Refresh Status | Check All Invariants

Start-up data: Item Apple



Validate ProcessSale



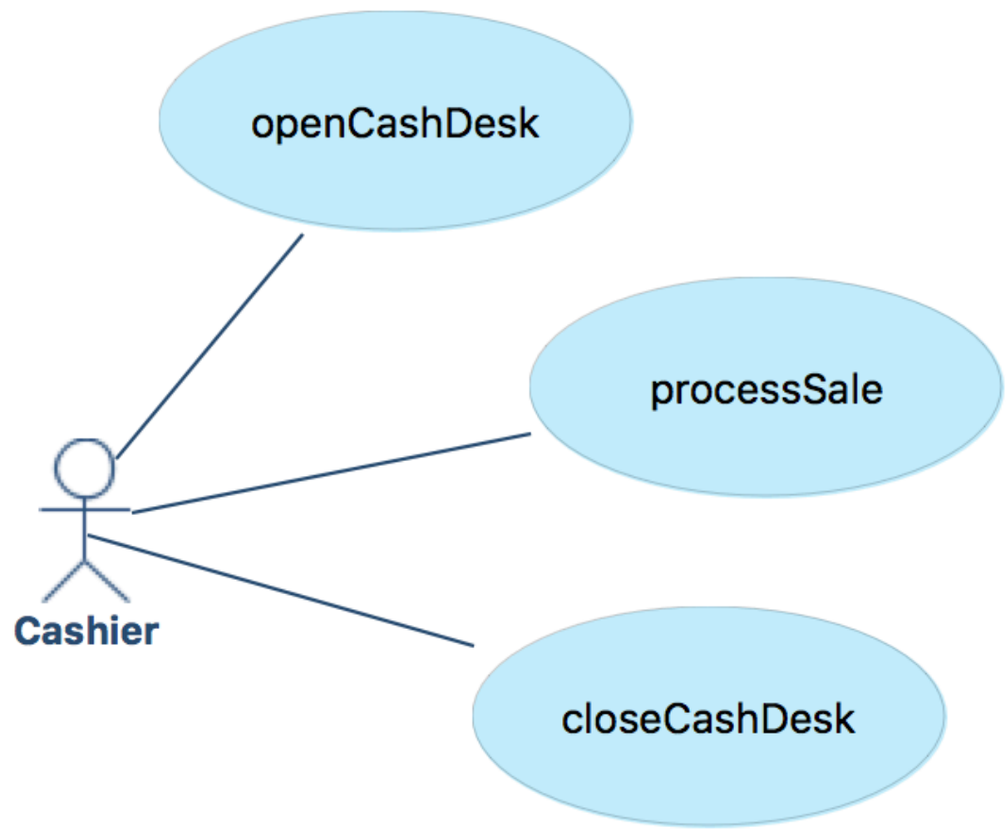
Validate ProcessSale

```
Exception in thread "JavaFX Application Thread" java.lang.RuntimeException: java.lang.reflect.InvocationTargetException
        at javafx.fxml.FXMLLoader$MethodHandler.invoke(FXMLLoader.java:1770)
        at javafx.fxml.FXMLLoader$ControllerMethodEventHandler.handle(FXMLLoader.java:1653)
        at com.sun.javafx.event.CompositeEventHandler.dispatchBubblingEvent(CompositeEventHandler.java:86)
        at com.sun.javafx.event.EventHandlerManager.dispatchBubblingEvent(EventHandlerManager.java:238)
        at com.sun.javafx.event.EventHandlerManager.dispatchBubblingEvent(EventHandlerManager.java:191)
        at com.sun.javafx.event.CompositeEventDispatcher.dispatchBubblingEvent(CompositeEventDispatcher.java:59)
        at com.sun.javafx.event.BasicEventDispatcher.dispatchEvent(BasicEventDispatcher.java:58)
        at com.sun.javafx.event.EventDispatchChainImpl.dispatchEvent(EventDispatchChainImpl.java:114)
        at com.sun.javafx.event.BasicEventDispatcher.dispatchEvent(BasicEventDispatcher.java:56)
        at com.sun.javafx.event.EventDispatchChainImpl.dispatchEvent(EventDispatchChainImpl.java:114)
        at com.sun.javafx.event.BasicEventDispatcher.dispatchEvent(BasicEventDispatcher.java:56)
```

Postcondition

```
let s:Sale in
s.oclIsNew() and
s.BelongedCashDesk = currentCashDesk and
currentCashDesk.ContainedSales->includes(s) and
s.IsComplete = false and
s.IsReadytoPay = false and
self.currentSale = s and
result = true
```

Requirement Model (v2)



OpenCashDesk()

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
  - openCashDesk
  - closeCashDesk
- Administrator
- StoreManager

Operation Parameters

cashDeskID: 1

Operation Return

true

System Log

```
18:15:41 -- execute operation: createStore in service: EntityCURDService  -- su
18:15:51 -- execute operation: createProductCatalog in service: EntityCURDSer
18:16:25 -- execute operation: createCashDesk in service: EntityCURDService
18:17:31 -- execute operation: openStore in service: CoCoMEProcessSale  -- su
18:17:37 -- execute operation: openCashDesk in service: CoCoMEProcessSale
```

Execute | Reset

Definition

cd:CashDesk = CashDesk.allInstance()->any(s:CashDesk | s.Id = cashDeskID)

Precondition

cd.oclIsUndefined() = false and
cd.IsOpened = false and
currentStore.oclIsUndefined() = false and
currentStore.IsOpened = true

Postcondition

self.currentCashDesk = cd and
cd.IsOpened = true and
result = true

Invariants

CashDesk_UniqueCashDeskId

Generated By RMCode

CashDesk1 Status:

All Objects CashDesk:

Id	Name	IsOpened
1	CashDesk1	true

ProcessSale - makeNewSale

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
  - openCashDesk
  - closeCashDesk
- Administrator
- StoreManager

Operation Parameters

This operation is no intput parameters..

Operation Return

true

System Log

```
18:15:41 -- execute operation: createStore in service: EntityCURDService  -- success!
18:15:51 -- execute operation: createProductCatalog in service: EntityCURDService  -- success!
18:16:25 -- execute operation: createCashDesk in service: EntityCURDService  -- success!
18:17:31 -- execute operation: openStore in service: CoCoMEProcessSale  -- success!
18:17:37 -- execute operation: openCashDesk in service: CoCoMEProcessSale  -- success!
18:18:28 -- execute operation: makeNewSale in service: CoCoMEProcessSale  -- success!
```

Execute | Reset

Definition

Precondition

```
currentCashDesk.oclIsUndefined() =
currentCashDesk.IsOpened = true an
(currentSale.oclIsUndefined() = true
    (currentSale.oclIsUndefined() =
        currentSale.IsComplete = tr
```

Postcondition

```
let s:Sale in
s.oclIsNew() and
s.BelongedCashDesk = currentCashD
currentCashDesk.ContainedSales->i
s.IsComplete = false and
```

Invariants

Sale_AmountGreatAndEqualZero

Generated By RMCode

Class statistics

Class Name	# of Objects
Store	1
ProductCatalog	1
CashDesk	1
Sale	1

ProcessSale - enterItem

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
  - openCashDesk
  - closeCashDesk
- Administrator
- StoreManager

Operation Parameters

barcode: 1

quantity: 2

Operation Return

true

System Log

```
18:15:41 -- execute operation: createStore in service: EntityCURDService  -- success!
18:15:51 -- execute operation: createProductCatalog in service: EntityCURDService  -- success!
18:16:25 -- execute operation: createCashDesk in service: EntityCURDService  -- success!
18:17:31 -- execute operation: openStore in service: CoCoMEProcessSale  -- success!
18:17:37 -- execute operation: openCashDesk in service: CoCoMEProcessSale  -- success!
18:18:28 -- execute operation: makeNewSale in service: CoCoMEProcessSale  -- success!
18:18:59 -- execute operation: createItem in service: EntityCURDService  -- success!
18:19:16 -- execute operation: enterItem in service: CoCoMEProcessSale  -- success!
```

Execute | Reset

Definition

```
item:Item = Item.allInstance()->any(i:Item | i.Barcode
```

Precondition

```
currentSale.oclIsUndefined() = false and
currentSale.IsComplete = false
```

Postcondition

```
let sli:SalesLineItem in
sli.oclIsNew() and
self.currentSaleLine = sli and
sli.BelongedSale = currentSale and
currentSale.ContainedSalesLine->includes(sli) and
```

Invariants

- Item_UniqueBarcode
- Item_PriceGreatThanEqualZero
- Item_StockNumberGreatThanEqualZero

Generated By RMCode

Input Variables:

Operation Parameters

barcode: 1

quantity: 2

ProcessSale - enterItem()

System Function | System Status

Class statistics

Class Name	# of Objects
Store	1
ProductCatalog	1
CashDesk	1
Sale	1
Cashier	0
SalesLineItem	1
Item	1

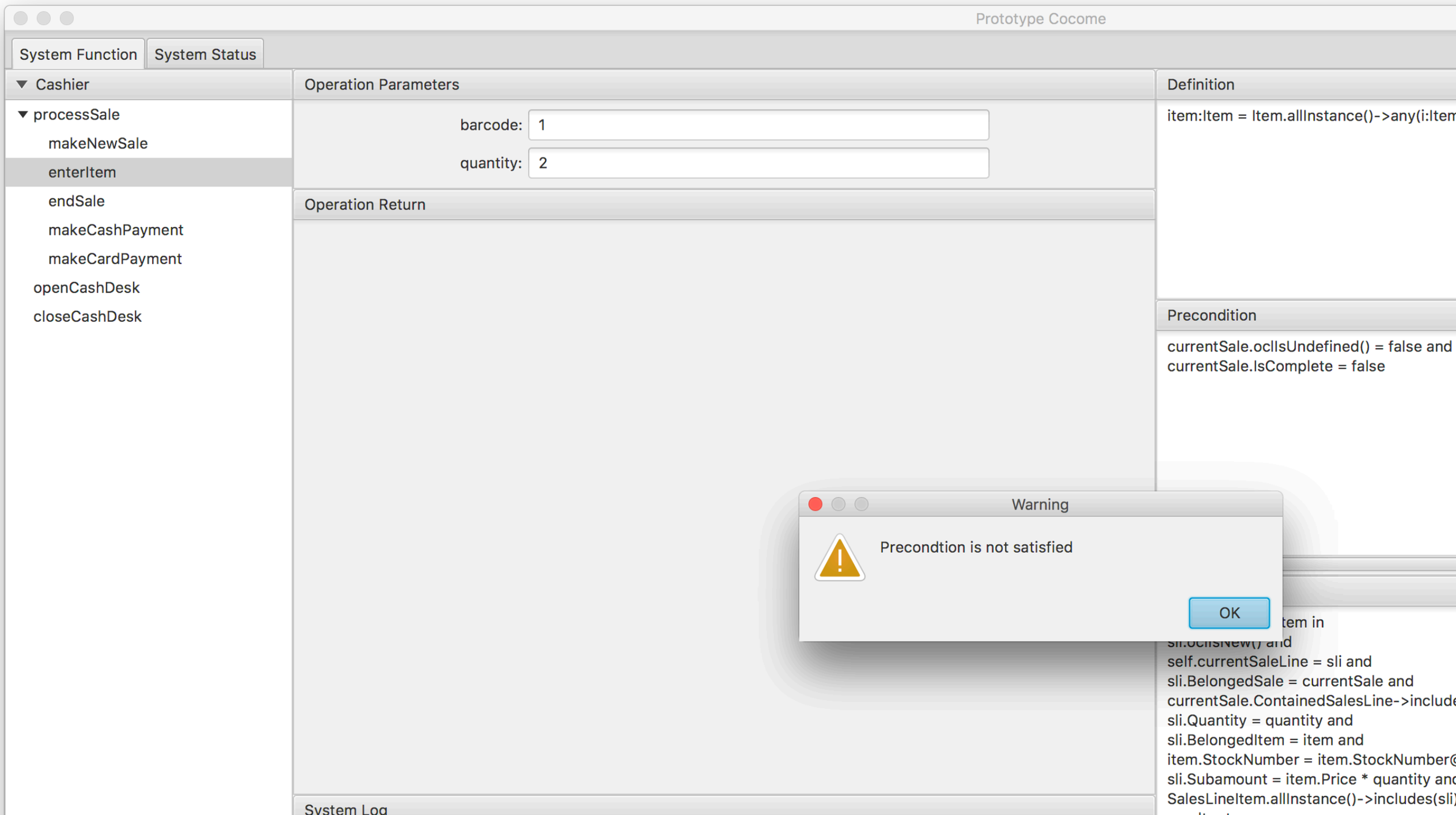
All Objects SalesLineItem:

Quantity	Subamount
2	20.0

Association statistics

Source Class	Association Name	Target Class	Multiple	Association Number
SalesLineItem	BelongedSale	Sale	false	1
SalesLineItem	BelongedItem	Item	false	1

Execute enterItem() before makeNewSale()



ProcessSale - endSale()

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
  - openCashDesk
  - closeCashDesk
- Administrator
- StoreManager

Operation Parameters

This operation is no intput parameters..

Operation Return

20.0

System Log

```
18:15:41 -- execute operation: createStore in service: EntityCURDService  -- success!
18:15:51 -- execute operation: createProductCatalog in service: EntityCURDService  -- success!
18:16:25 -- execute operation: createCashDesk in service: EntityCURDService  -- success!
18:17:31 -- execute operation: openStore in service: CoCoMEProcessSale  -- success!
18:17:37 -- execute operation: openCashDesk in service: CoCoMEProcessSale  -- success!
18:18:28 -- execute operation: makeNewSale in service: CoCoMEProcessSale  -- success!
18:18:59 -- execute operation: createItem in service: EntityCURDService  -- success!
18:19:16 -- execute operation: enterItem in service: CoCoMEProcessSale  -- success!
18:22:39 -- execute operation: endSale in service: CoCoMEProcessSale  -- success!
```

Execute | Reset

Definition

Precondition

currentSale.oclIsU
currentSale.IsCon
currentSale.IsRea

Postcondition

currentS
currentSale.A
and
currentSale.IsRea
result = currentSa

Invariants

Generated By RMCode

ProcessSale - endSale()

Class statistics

Class Name	# of Objects
Store	1
ProductCatalog	1
CashDesk	1
Sale	1
Cashier	0
SalesLineItem	1
Item	1

All Objects Sale:

Time	IsComplete	Amount	IsReadytoPay
	false	20.0	true

ProcessSale - makeCashPayment()

Prototype Cocome

System Function | System Status

- Cashier
  - processSale
    - makeNewSale
    - enterItem
    - endSale
    - makeCashPayment
    - makeCardPayment
  - openCashDesk
  - closeCashDesk
- Administrator
- StoreManager

Operation Parameters

amount: 20

Operation Return

true

System Log

```
18:16:25 -- execute operation: createCashDesk in service: EntityCURDService  -- success!
18:17:31 -- execute operation: openStore in service: CoCoMEProcessSale  -- success!
18:17:37 -- execute operation: openCashDesk in service: CoCoMEProcessSale  -- success!
18:18:28 -- execute operation: makeNewSale in service: CoCoMEProcessSale  -- success!
18:18:59 -- execute operation: createItem in service: EntityCURDService  -- success!
18:19:16 -- execute operation: enterItem in service: CoCoMEProcessSale  -- success!
18:22:39 -- execute operation: endSale in service: CoCoMEProcessSale  -- success!
18:25:03 -- execute operation: makeCashPayment in service: CoCoMEProcessSale  -- success!
```

Execute | Reset

Definition

Precondition

```
currentSale.oclIsU
currentSale.IsCom
currentSale.IsReac
amount >= curren
```

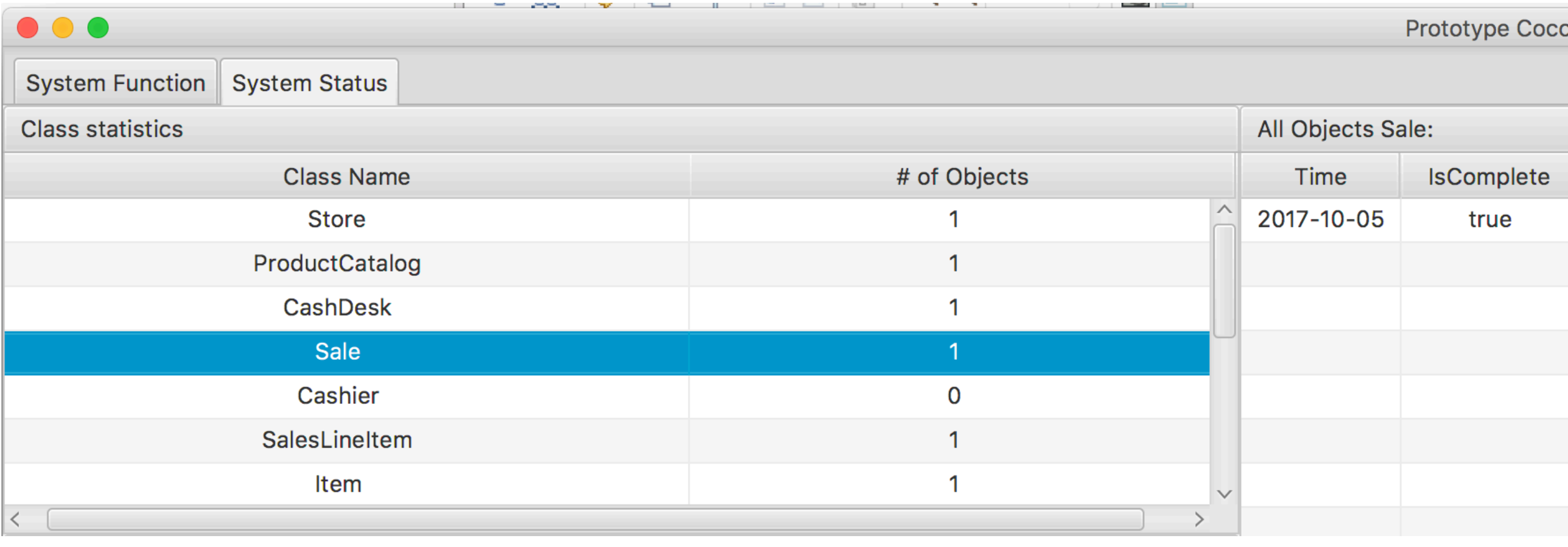
Postcondition

```
let cp:CashPayme
cp.oclIsNew() and
cp.AmountTender
cp.BelongedSale =
currentSale.Assoic
currentSale.Belong
currentStore.Sales
```

Invariants

Generated By RMCode

ProcessSale - makeCashPayment()



Errors in Pre-condition

Precondition

```
currentSale.oclIsUndefined() = false and
currentSale.IsComplete = false and
currentSale.IsReadytoPay = true and
amount >= currentSale.Amount
```

If we miss this condition

Postcondition

```
let cp:CashPayment in
cp.oclIsNew() and
cp.AmountTendered = amount and
cp.BelongedSale = currentSale and
currentSale.AssoicatedPayment = cp and
currentSale.Belongedstore = currentStore and
currentStore.Sales->includes(currentSale) and
currentSale.IsComplete = true and
currentSale.Time = Now and
cp.Balance = amount - currentSale.Amount and
CashPayment.allInstance()->includes(cp) and
result = true
```

Invariants

CashPayment_BalanceGreatAndEqualZero

Balance >= 0

Errors in Pre-condition

System Function | System Status

Class statistics

Class Name	# of Objects
Store	1
ProductCatalog	1
CashDesk	1
Sale	1

All Objects Sale:

Time	IsComplete	Amount	IsReadytoPay
2017-10-06	true	100.0	true

We need to pay 100 MOP, but we pay 80 MOP

Invariant violation

Class statistics		All Objects CashPayment:	
Class Name	# of Objects	AmountTendered	Balance
Store	1	80.0	-20.0
ProductCatalog	1		
CashDesk	1		
Sale	1		
Cashier	0		
SalesLineItem	1		
Item	1		
Payment	0		
CashPayment	1		

System Status After executing of CashPayment with only 80 payment

Invariants

CashPayment_BalanceGreatAndEqualZero

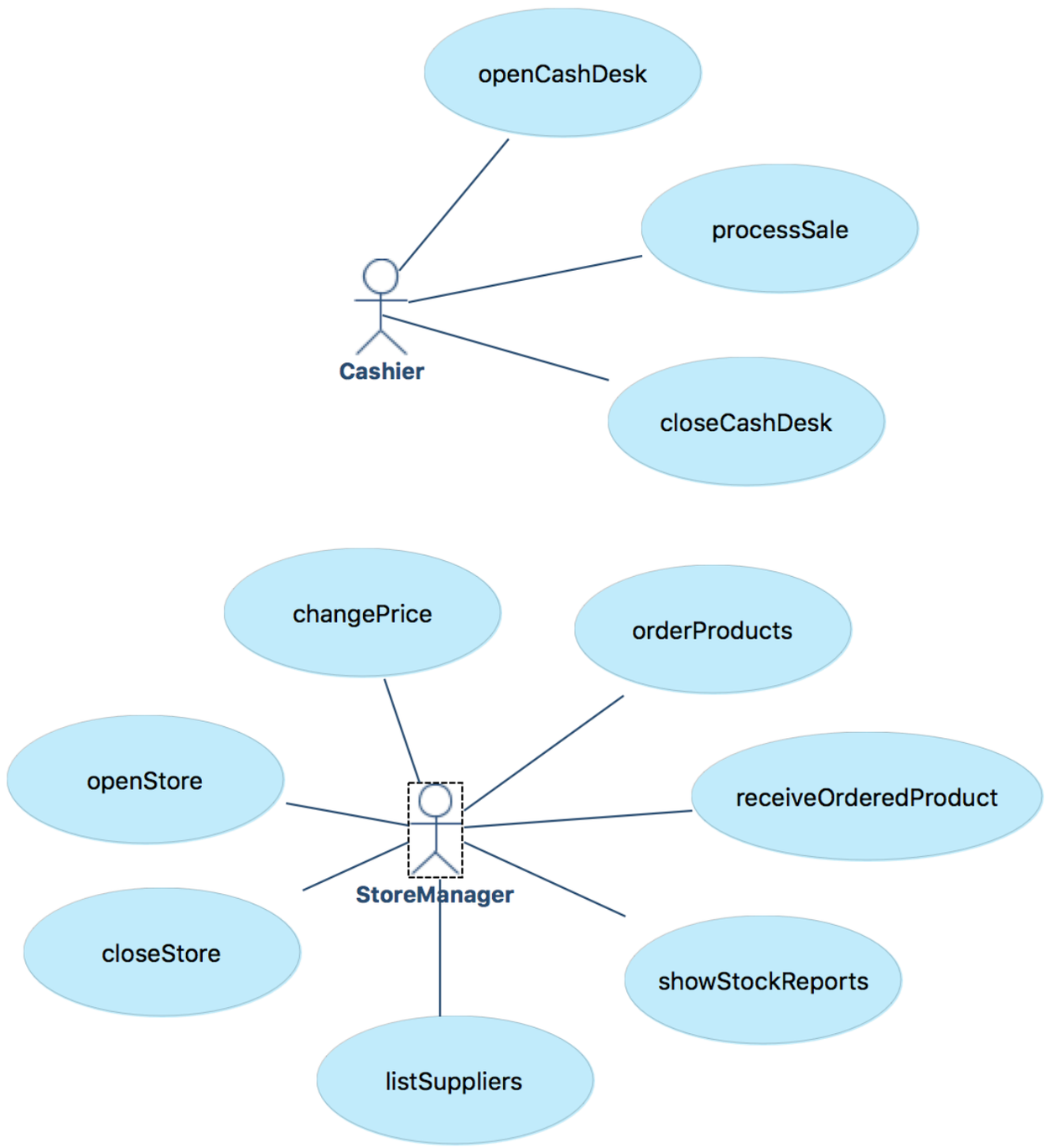
CashPayment Invariant is not holding at this moment

Next Step

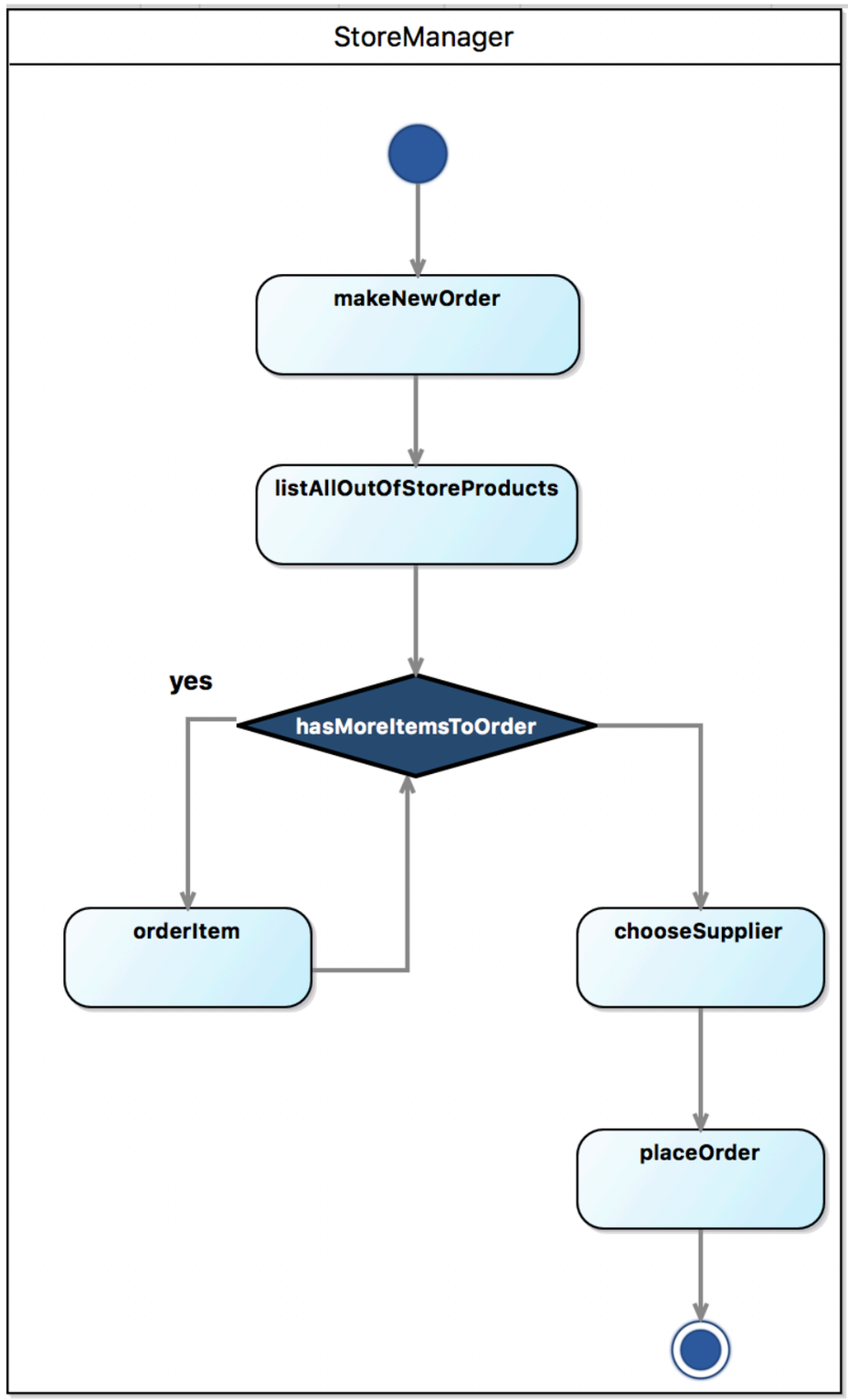
- We specified main functionality about Cashier about checking out.

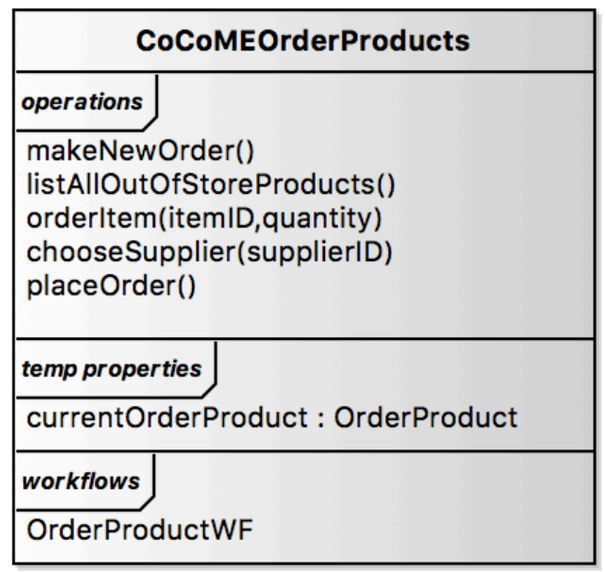
- We did not touch storage management yet….

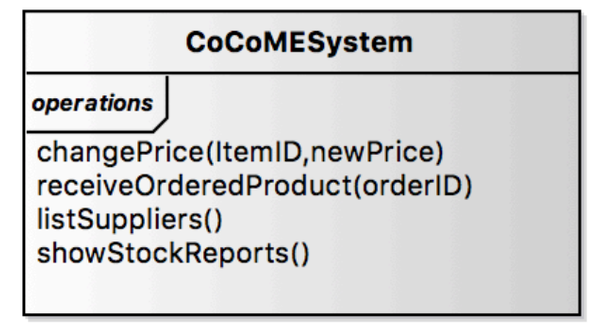
Requirements Model (v3)



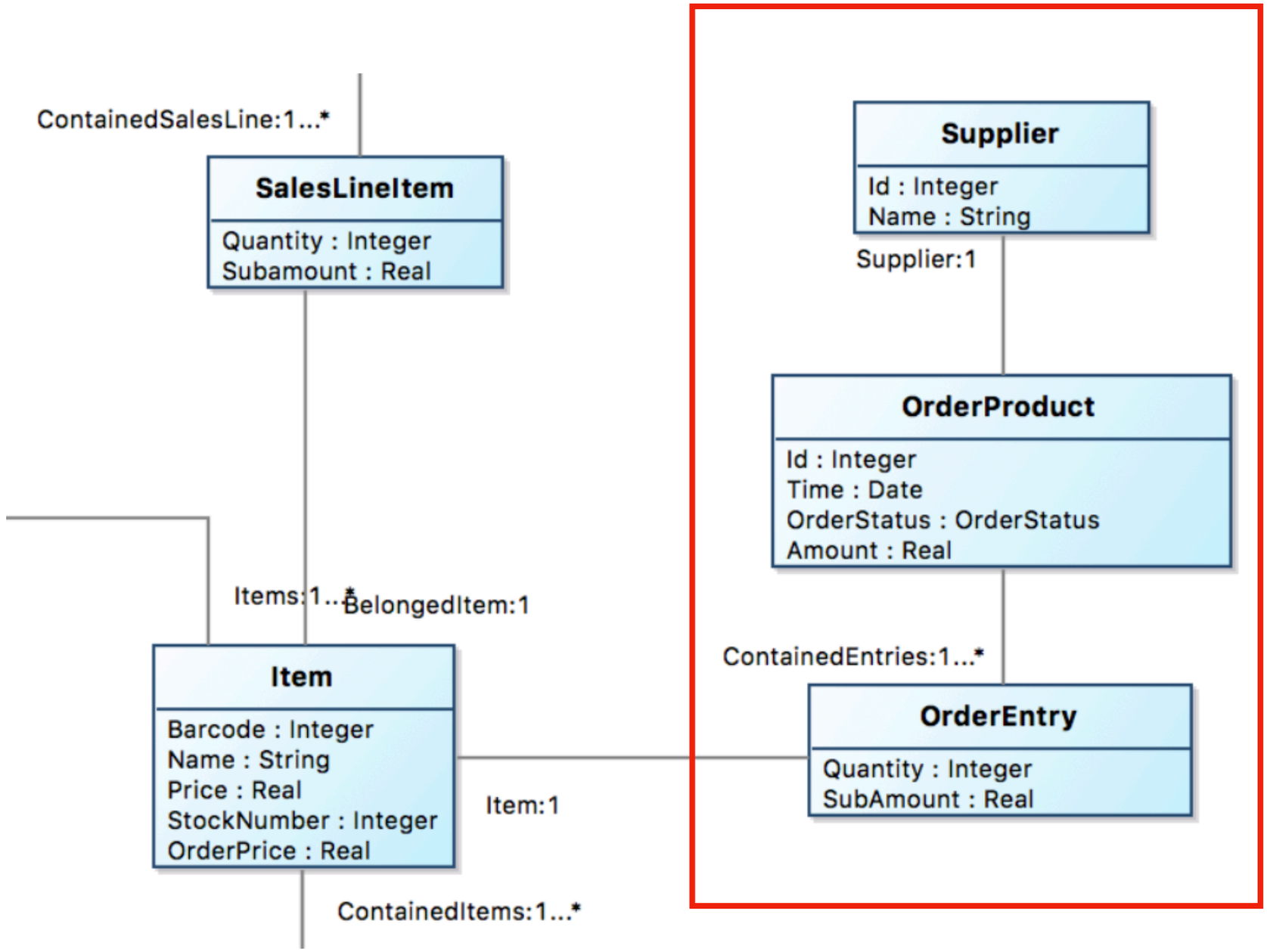
UseCase: OrderProducts



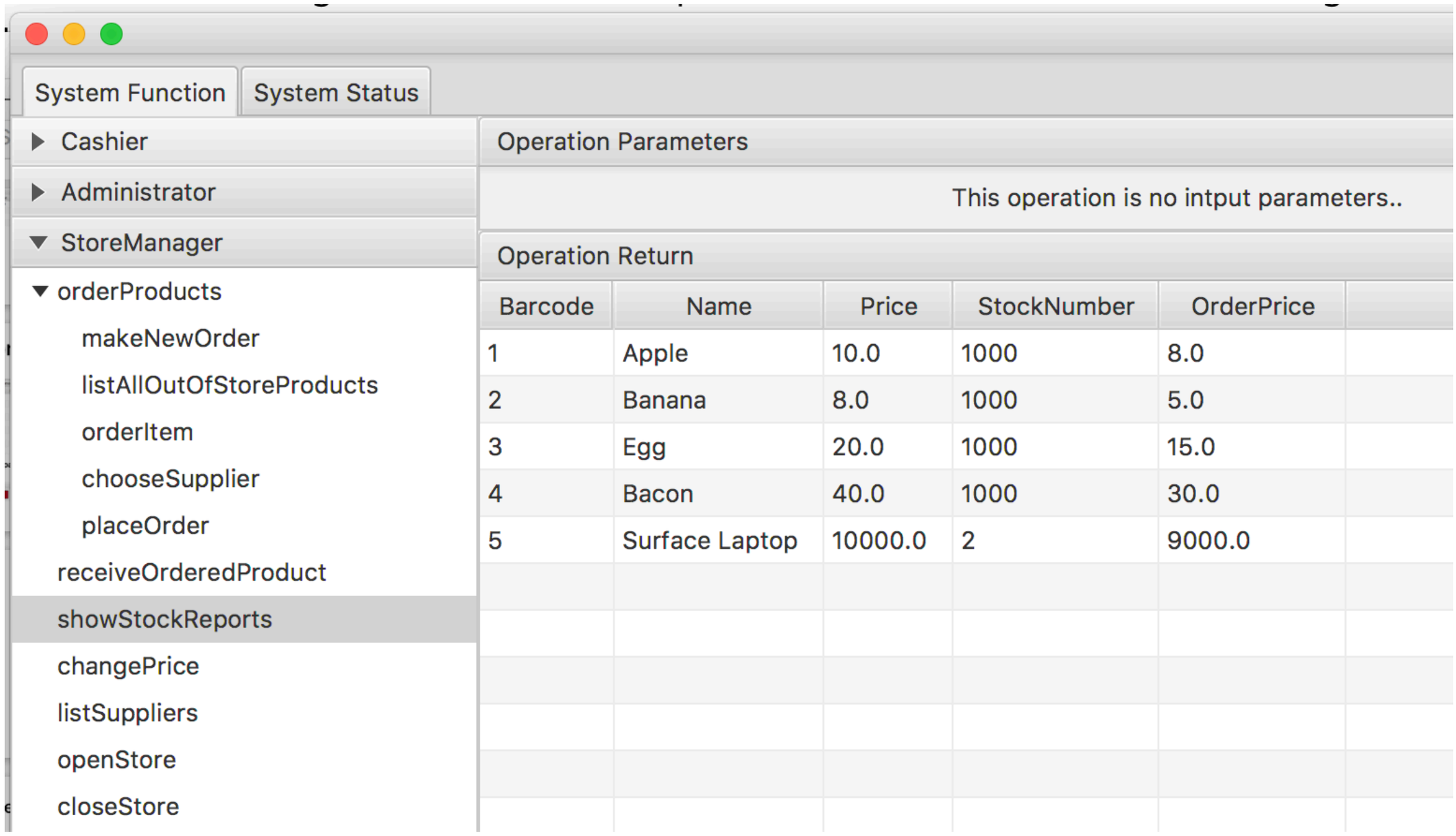




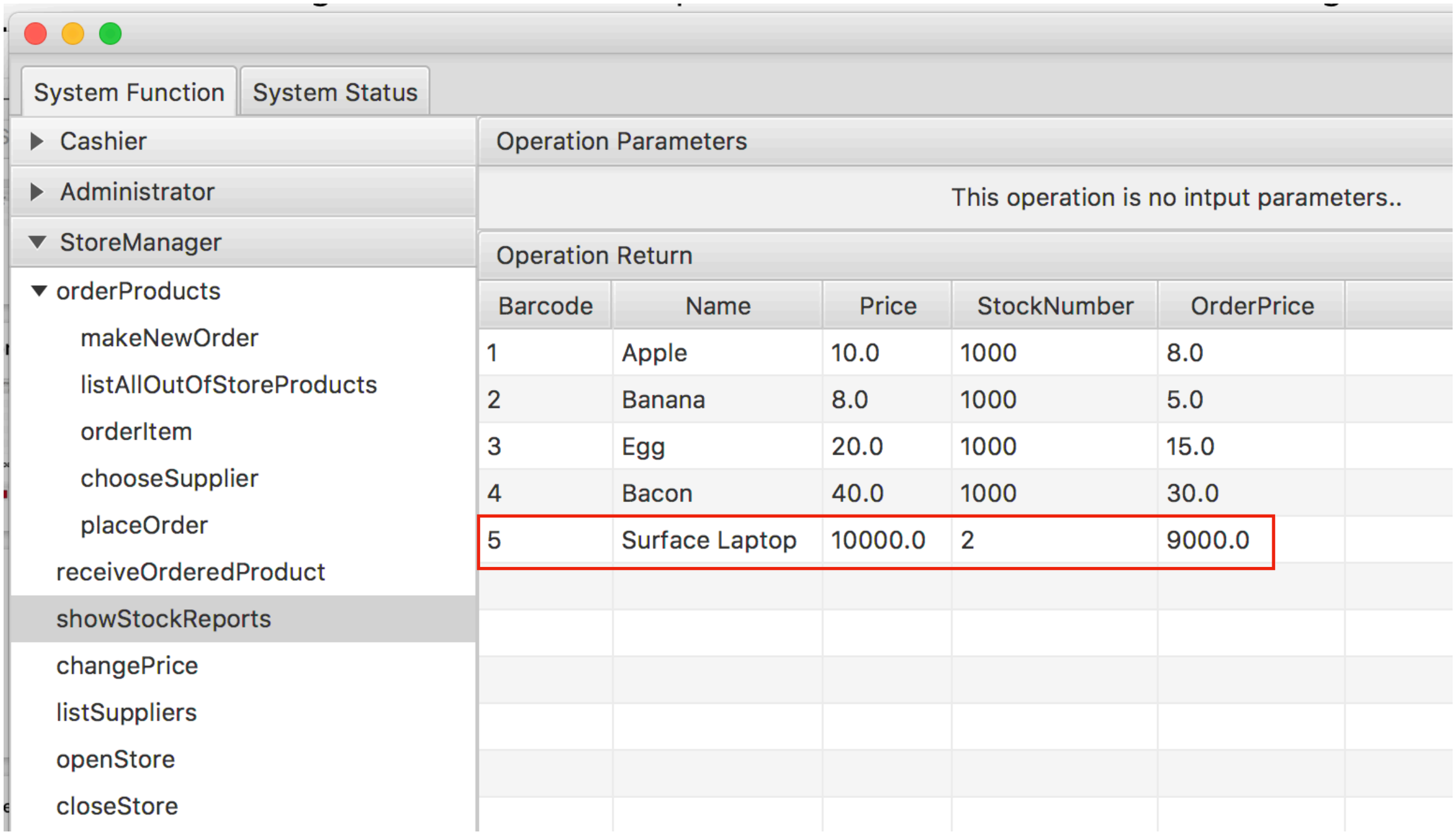
Refining Conceptual Class Diagram



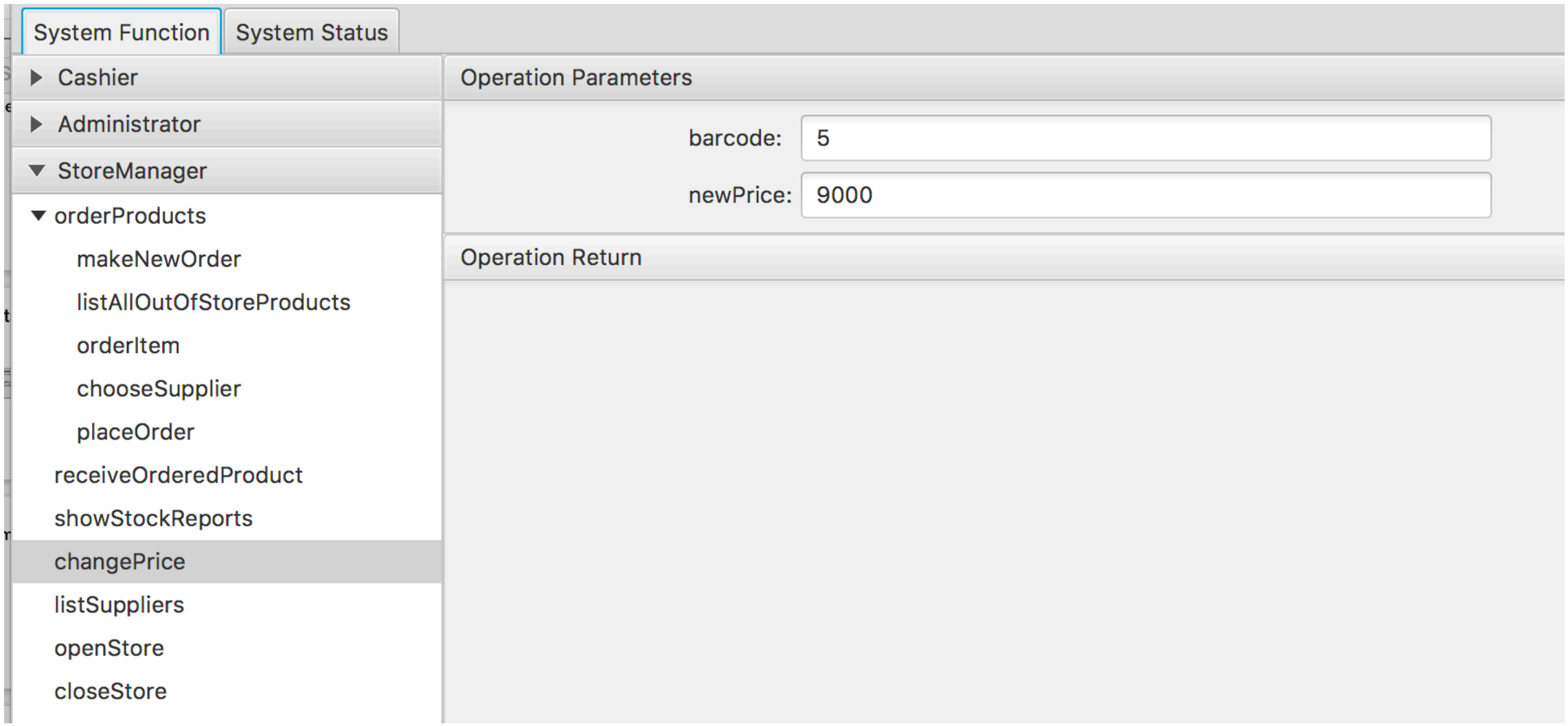
showStockReports



showStockReports



changePrice



changePrice

All Objects Item:

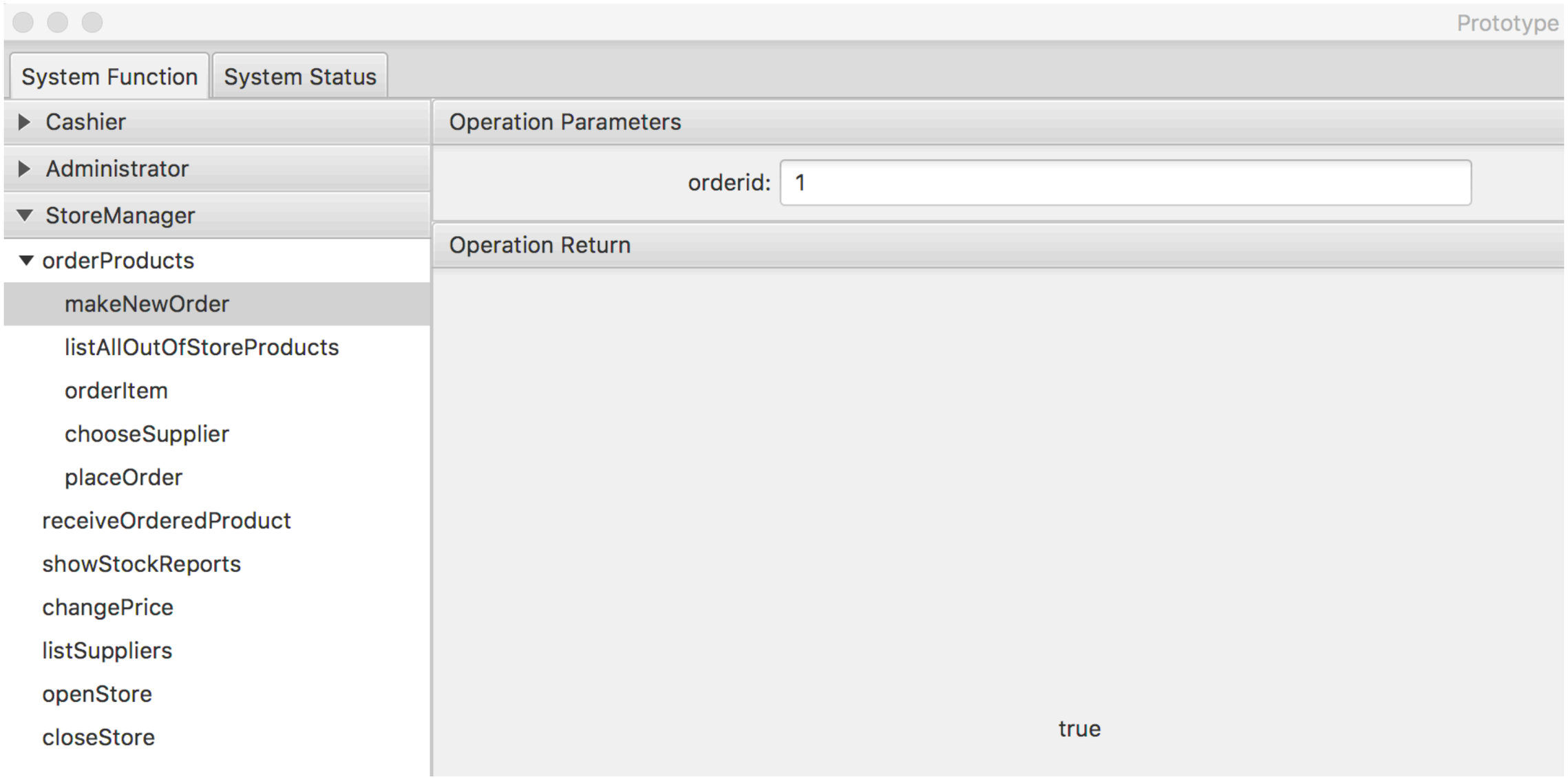
Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	2	9000.0

After checking out this two surface laptop

All Objects Item:

Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	0	9000.0

makeNewOrder



Listing out of stock products

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports
  - changePrice
  - listSuppliers
  - openStore
  - closeStore

Operation Parameters

This operation is no intput parameters..

Operation Return

Barcode	Name	Price	StockNumber	OrderPrice

No content in table

Bug? Let`s check post-condition

Postcondition

```
result = Item.allInstance()->select(item:Item | item.Price = 0)
```

Should be item.StockNumber = 0

Fixing error requirement, re-generation, and running prototype

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports
  - changePrice
  - listSuppliers
  - openStore
  - closeStore

Operation Parameters

This operation is no intput parameters..

Operation Return

Barcode	Name	Price	StockNumber	OrderPrice

No content in table

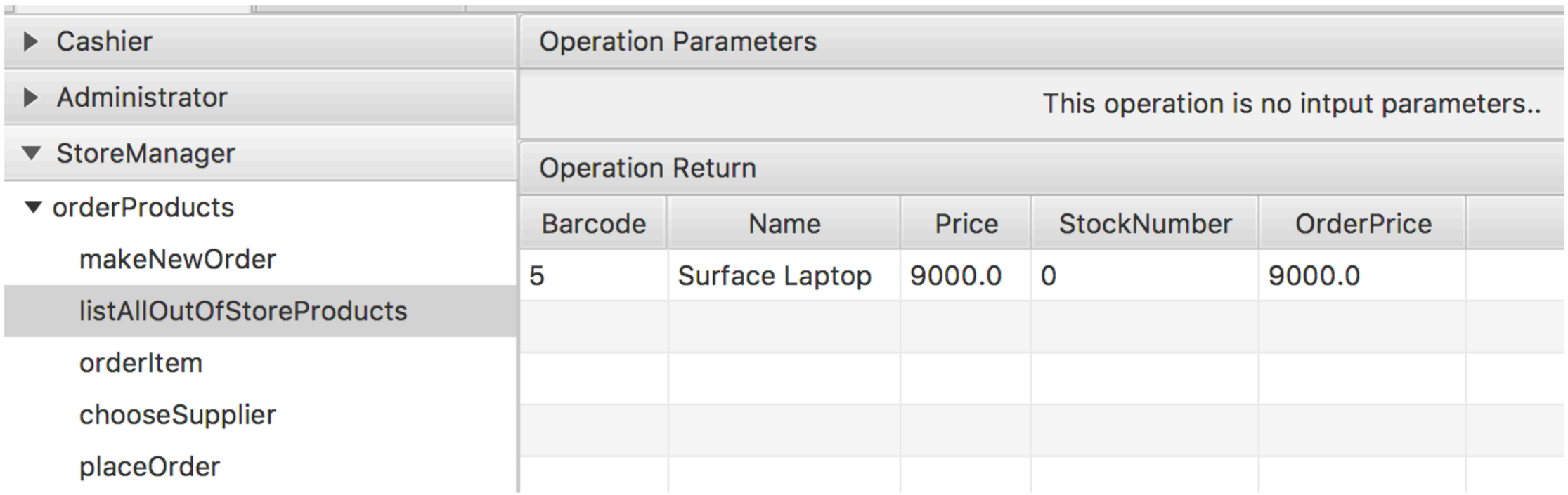
Bug? Let`s check post-condition

Postcondition

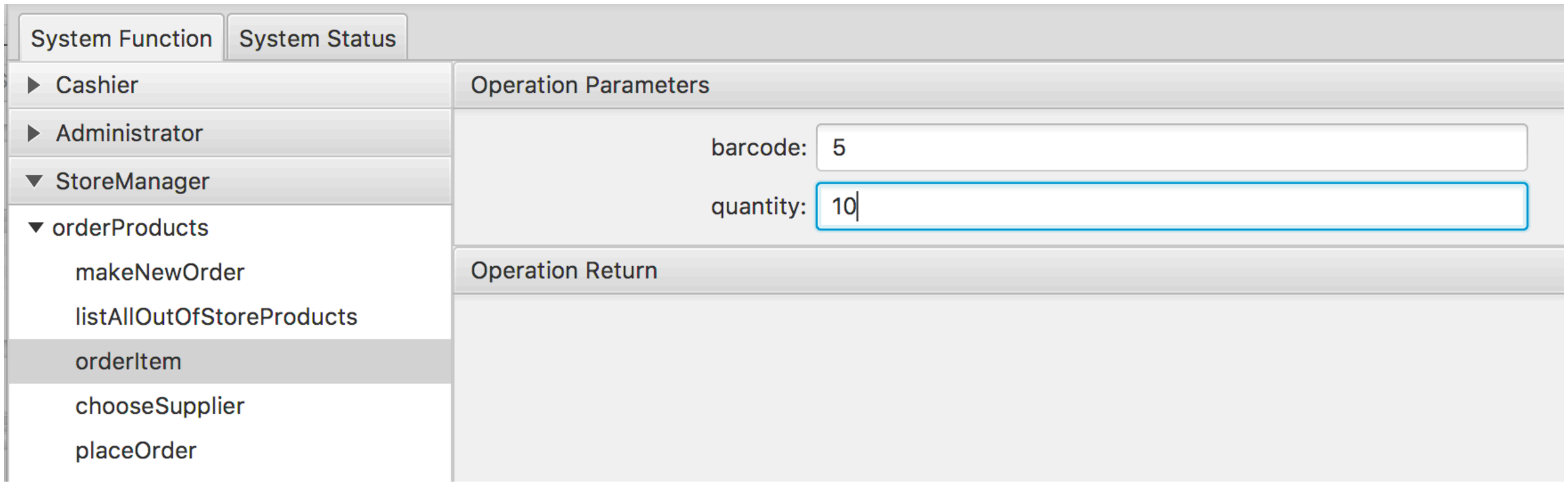
result = Item.allInstance()->select(item:Item | item.Price = 0)

Should be item.StockNumber = 0

Fixing error requirement, re-generation, and running prototype



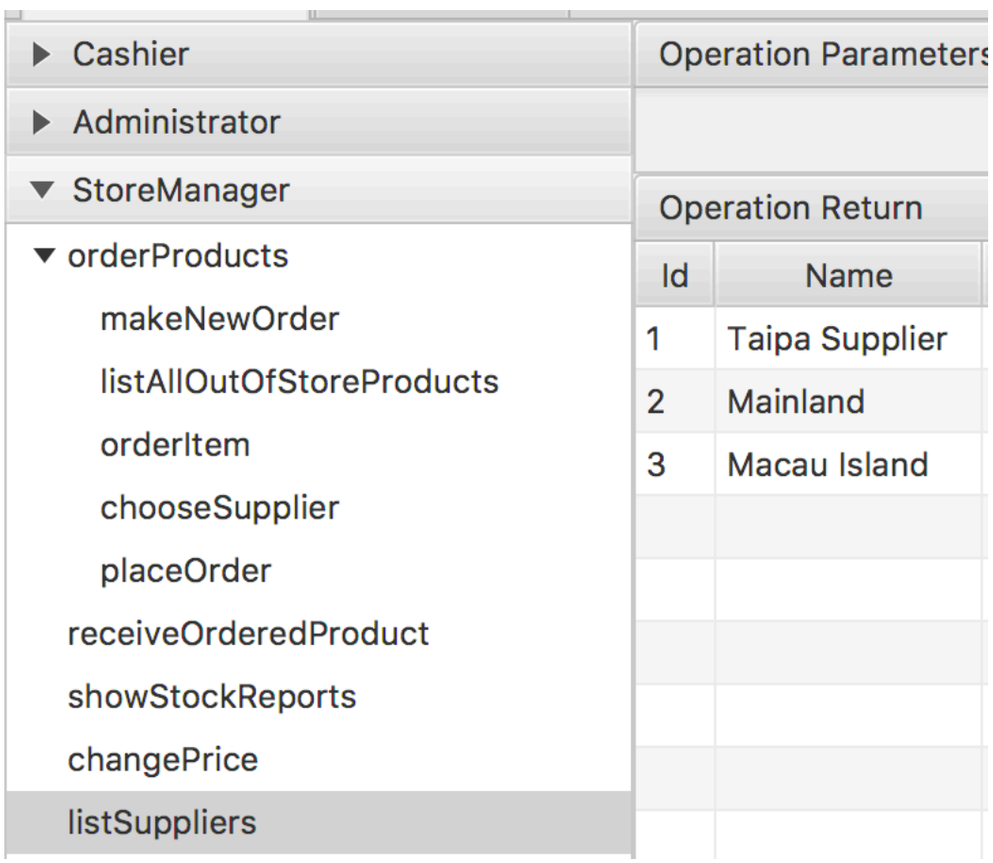
Executing orderItem

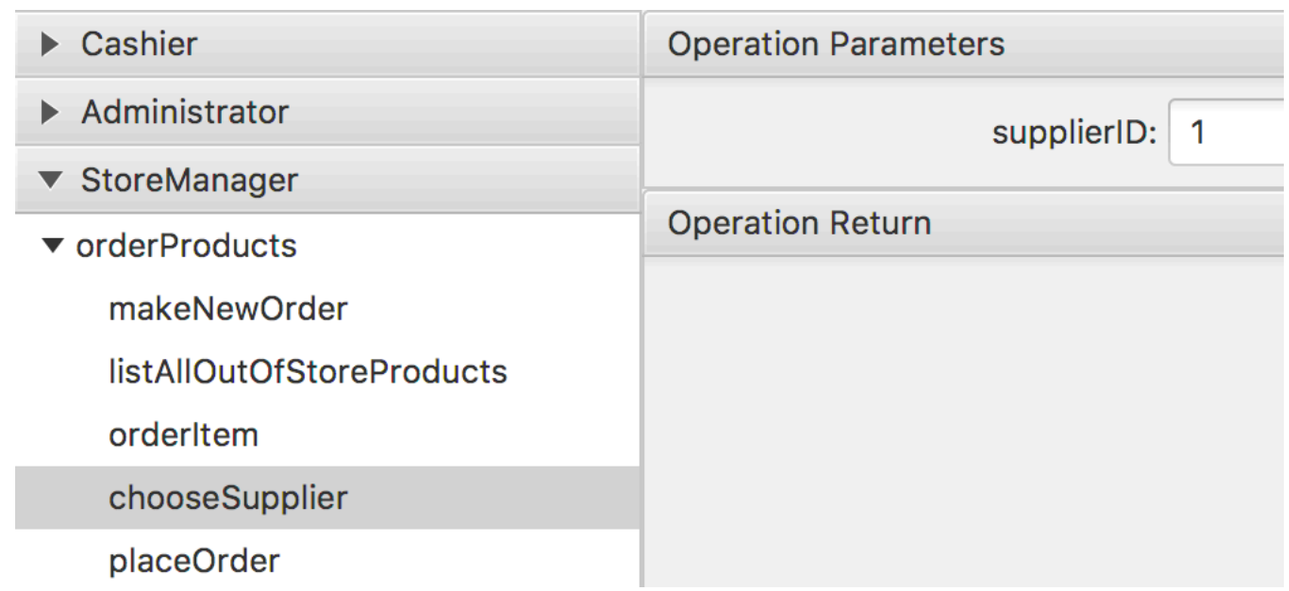


All Objects Item:

Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	0	9000.0

List suppliers and choose one





Place Order

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports
  - changePrice
  - listSuppliers
  - openStore
  - closeStore

Operation Parameters

This operation is no intput parameters..

Operation Return

true

All Objects Item:

Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	0	9000.0

Place Order

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports
  - changePrice
  - listSuppliers
  - openStore
  - closeStore

Operation Parameters

This operation is no intput parameters..

Operation Return

true

All Objects Item:

Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	0	9000.0

All Objects OrderProduct:

Id	Time	OrderStatus	Amount
3	2017-10-25	REQUESTED	90000.0

Receive Ordered Products

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports
  - changePrice
  - listSuppliers
  - openStore
  - closeStore

Operation Parameters

orderID: 3

Operation Return

- Cashier
- Administrator
- StoreManager
  - orderProducts
    - makeNewOrder
    - listAllOutOfStoreProducts
    - orderItem
    - chooseSupplier
    - placeOrder
  - receiveOrderedProduct
  - showStockReports

Operation Parameters

This operation is no intput parameters.

Operation Return

Barcode	Name	Price	StockNumber	OrderPrice
1	Apple	10.0	1000	8.0
2	Banana	8.0	1000	5.0
3	Egg	20.0	1000	15.0
4	Bacon	40.0	1000	30.0
5	Surface Laptop	9000.0	10	9000.0

Case Study II

UM Library Management System

Use Case Diagram

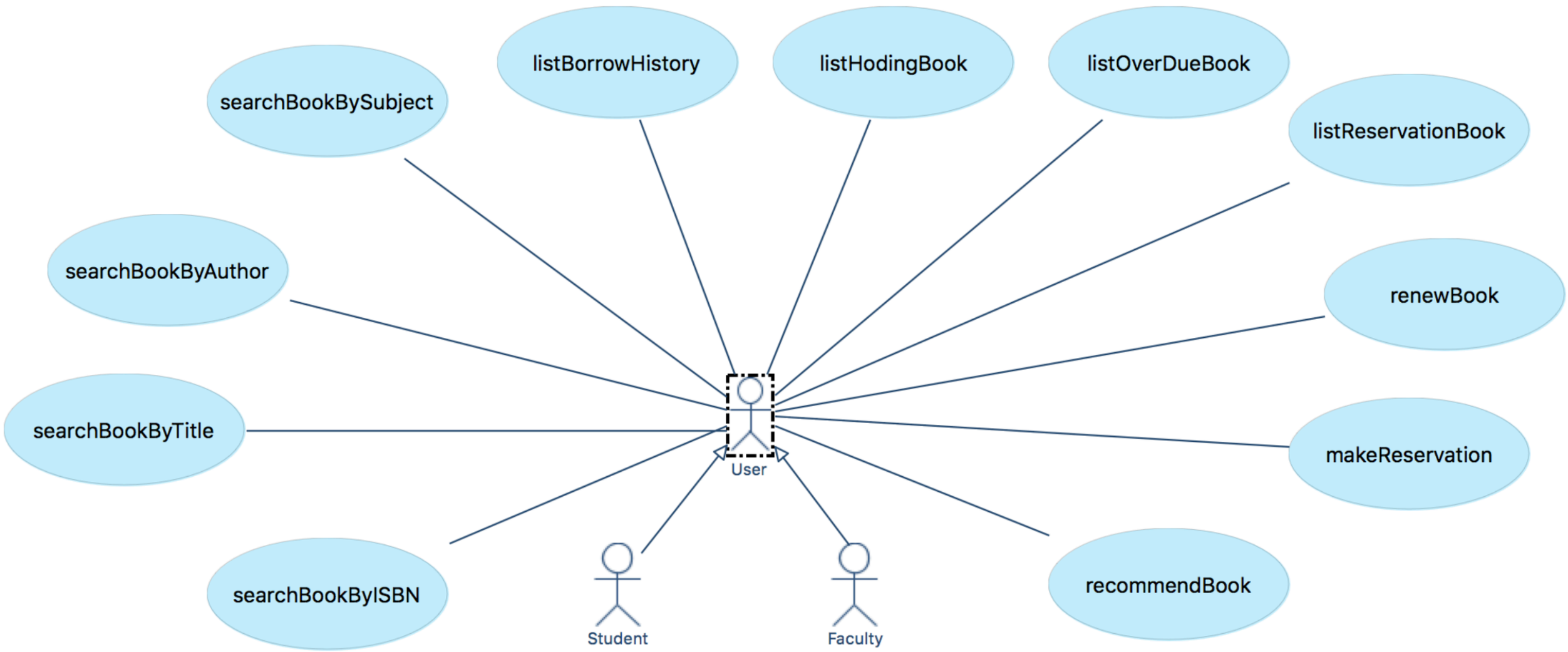


Figure 2. Use Cases of Actor Librarian

Use Case Diagram

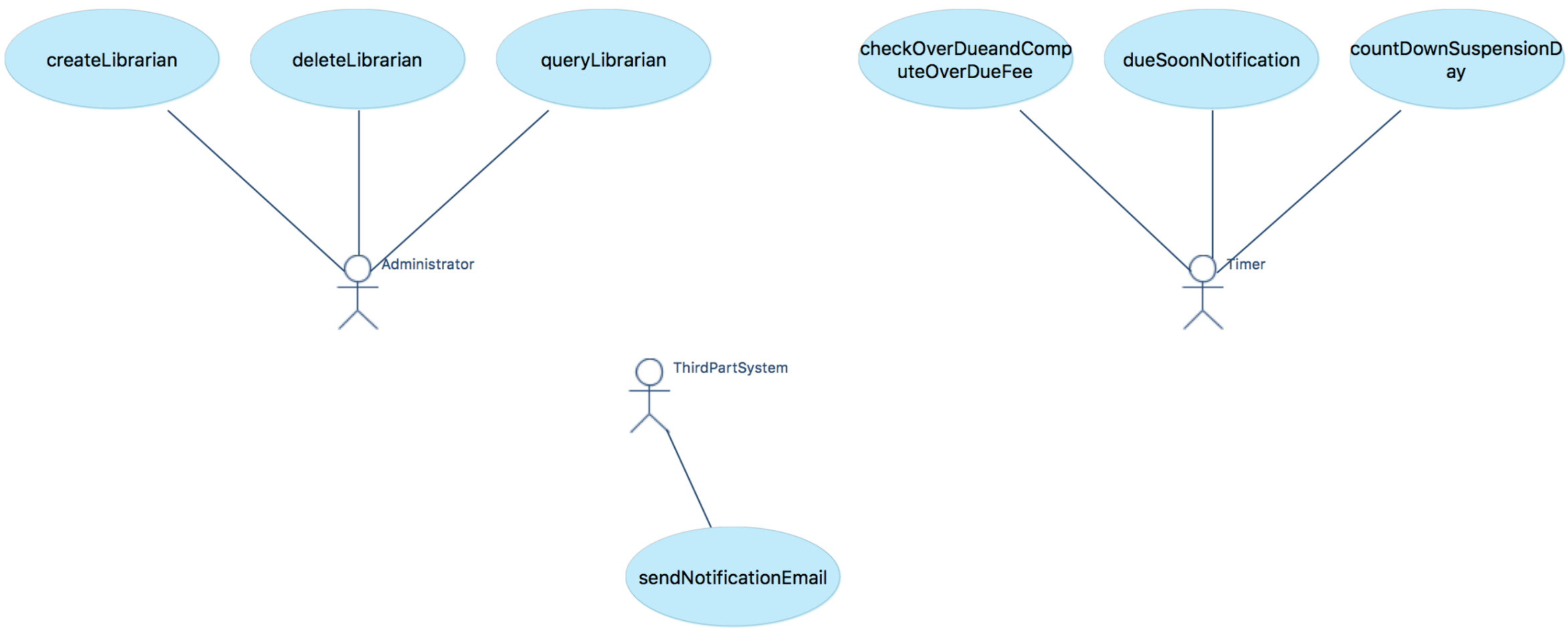
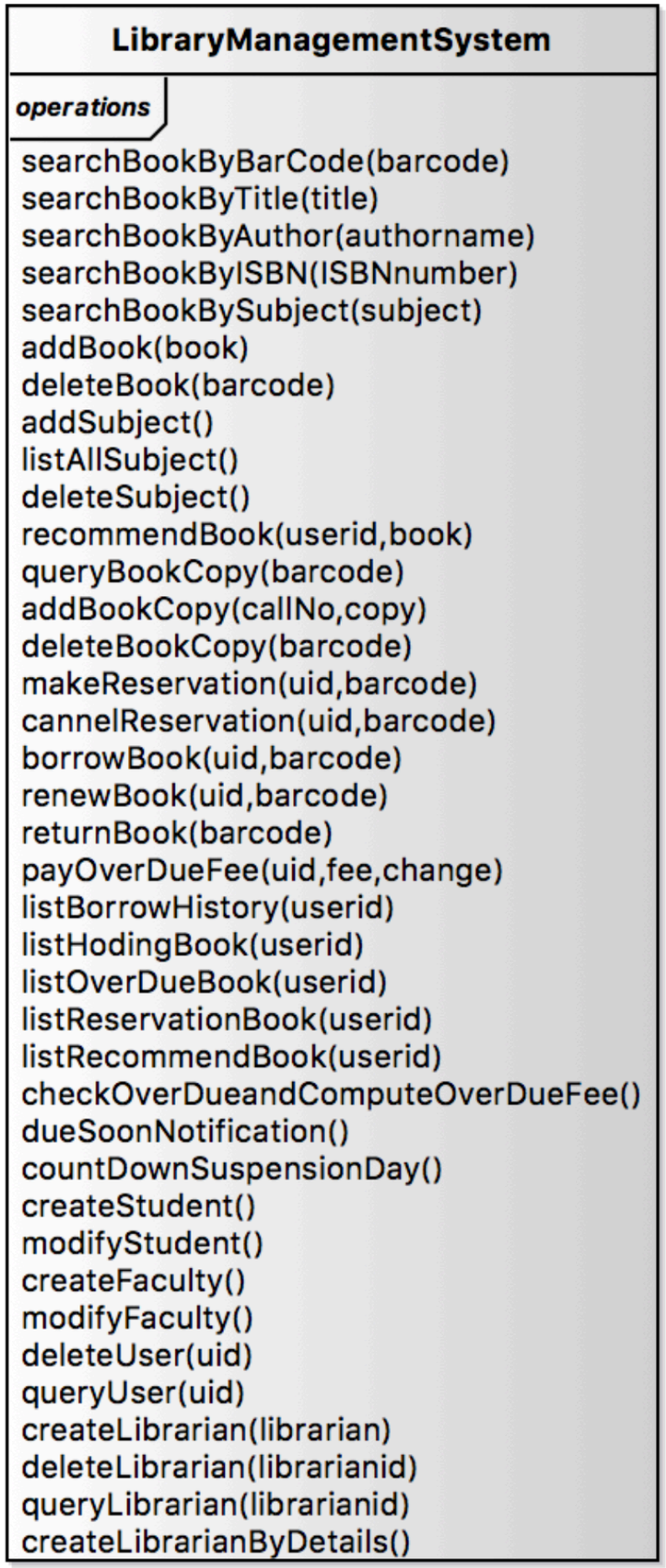
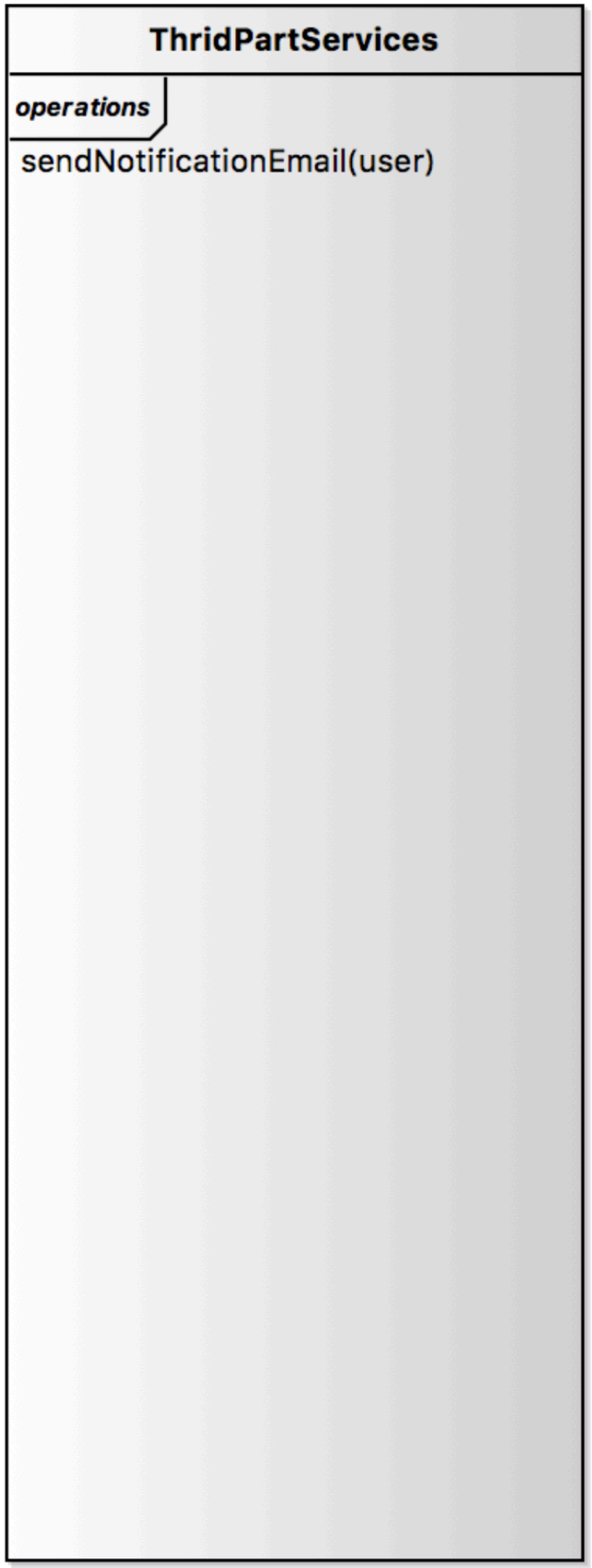
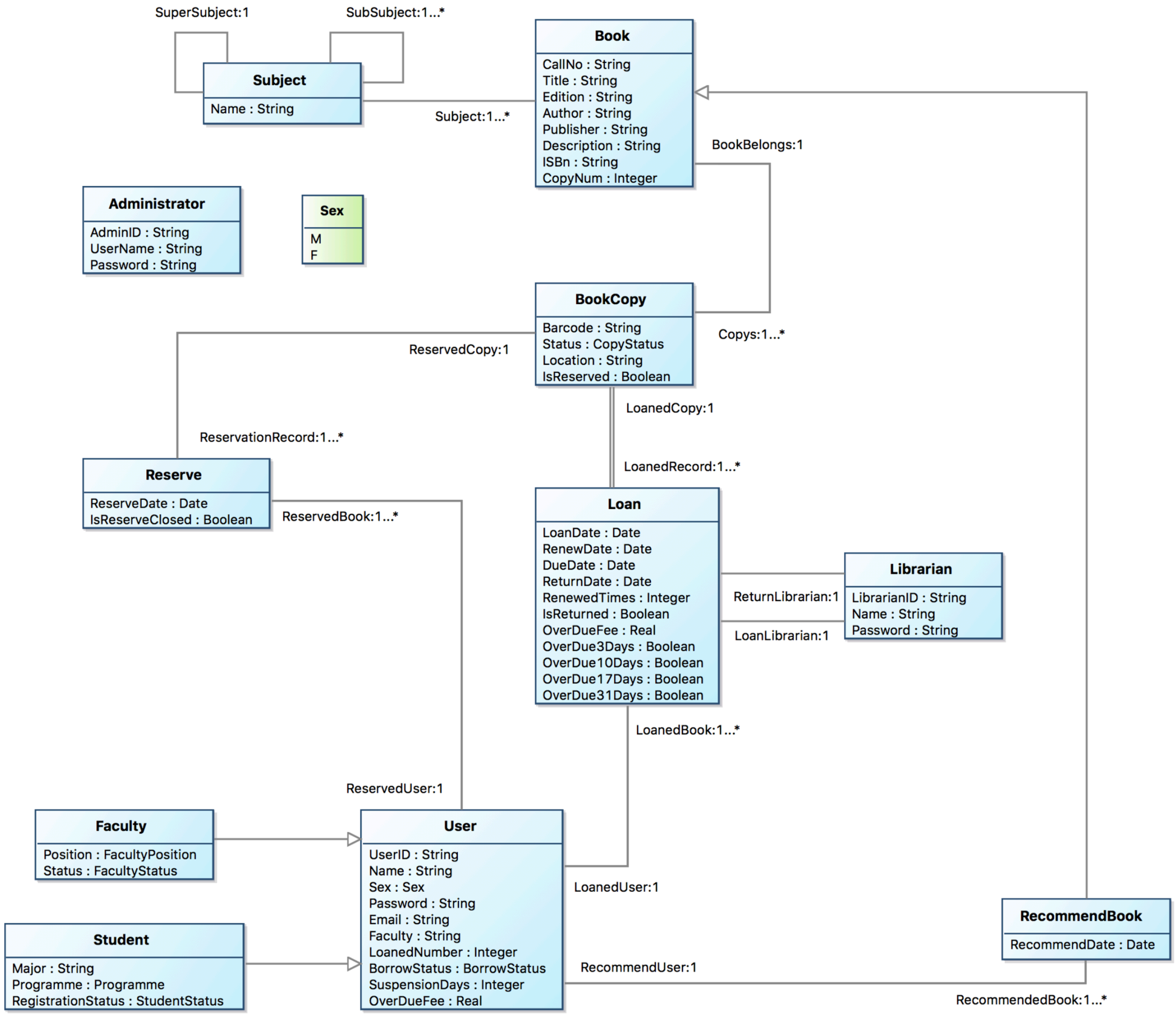


Figure 3. Use Cases of Actor Timer, Administrator, and ThridPartSystem


LibraryManagementSystem
operations
searchBookByBarCode(barcode)
searchBookByTitle(title)
searchBookByAuthor(authorname)
searchBookByISBN(ISBNnumber)
searchBookBySubject(subject)
addBook(book)
deleteBook(barcode)
addSubject()
listAllSubject()
deleteSubject()
recommendBook(userid,book)
queryBookCopy(barcode)
addBookCopy(callNo,copy)
deleteBookCopy(barcode)
makeReservation(uid,barcode)
cannelReservation(uid,barcode)
borrowBook(uid,barcode)
renewBook(uid,barcode)
returnBook(barcode)
payOverDueFee(uid,fee,change)
listBorrowHistory(userid)
listHodingBook(userid)
listOverDueBook(userid)
listReservationBook(userid)
listRecommendBook(userid)
checkOverDueandComputeOverDueFee()
dueSoonNotification()
countDownSuspensionDay()
createStudent()
modifyStudent()
createFaculty()
modifyFaculty()
deleteUser(uid)
queryUser(uid)
createLibrarian(librarian)
deleteLibrarian(librarianid)
queryLibrarian(librarianid)
createLibrarianByDetails()


ThridPartServices
operations
sendNotificationEmail(user)


SuperSubject:1
SubSubject:1...*
Subject
Name : String
Subject:1...*
Book
CallNo : String
Title : String
Edition : String
Author : String
Publisher : String
Description : String
ISBn : String
CopyNum : Integer
BookBelongs:1
Administrator
AdminID : String
UserName : String
Password : String
Sex
M
F
BookCopy
Barcode : String
Status : CopyStatus
Location : String
IsReserved : Boolean
Copys:1...*
ReservedCopy:1
LoanedCopy:1
ReservationRecord:1...*
LoanedRecord:1...*
Reserve
ReserveDate : Date
IsReserveClosed : Boolean
ReservedBook:1...*
Loan
LoanDate : Date
RenewDate : Date
DueDate : Date
ReturnDate : Date
RenewedTimes : Integer
IsReturned : Boolean
OverDueFee : Real
OverDue3Days : Boolean
OverDue10Days : Boolean
OverDue17Days : Boolean
OverDue31Days : Boolean
Librarian
LibrarianID : String
Name : String
Password : String
ReturnLibrarian:1
LoanLibrarian:1
LoanedBook:1...*
ReservedUser:1
Faculty
Position : FacultyPosition
Status : FacultyStatus
User
UserID : String
Name : String
Sex : Sex
Password : String
Email : String
Faculty : String
LoanedNumber : Integer
BorrowStatus : BorrowStatus
SuspensionDays : Integer
OverDueFee : Real
LoanedUser:1
RecommendBook
RecommendDate : Date
Student
Major : String
Programme : Programme
RegistrationStatus : StudentStatus
RecommendUser:1
RecommendedBook:1...*

The contract of *borrowBook*

```
Contract LibraryManagementSystem::borrowBook(uid:String, barcode:String) : Boolean {

    definition:
        user:User = User.allInstance()->any(u:User | u.UserID = uid),
        stu:Student = Student.allInstance()->any(s:Student | s.UserID = uid),
        fac:Faculty = Faculty.allInstance()->any(f:Faculty | f.UserID = uid),
        copy:BookCopy = BookCopy.allInstance()->any(bc:BookCopy | bc.Barcode = barcode),
        res:Reserve = Reserve.allInstance()->any(r:Reserve | r.ReservedCopy = copy and r.ReservedUser = user and r.IsReserveClosed = false)
```

```
precondition:
    user.oclIsUndefined() = false and
    copy.oclIsUndefined() = false and
    user.BorrowStatus = BorrowStatus::NORMAL and
    user.SuspensionDays = 0 and
    if
        user.oclIsTypeOf(Student)
    then
        if
            stu.Programme = Programme::BACHELOR
        then
            stu.LoanedNumber < 20
        else
            if
                stu.Programme = Programme::MASTER
            then
                stu.LoanedNumber < 40
            else
                stu.LoanedNumber < 60
            endif
        endif
    else
        fac.LoanedNumber < 60
    endif and
    (copy.Status = CopyStatus::AVAILABLE or
        (copy.Status = CopyStatus::ONHOLDSHELF and
            copy.IsReserved = true and
            res.oclIsUndefined() = false and
            res.IsReserveClosed = false
        )
    )
```

```
postcondition:
    let loan:Loan in
    loan.oclIsNew() and
    loan.LoanedUser = user and
    loan.LoanedCopy = copy and
    loan.IsReturned = false and
    loan.LoanDate = Today and
    user.LoanedNumber = user.LoanedNumber@pre + 1 and
    user.LoanedBook->includes(loan) and
    copy.LoanedRecord->includes(loan) and
    if
        user.oclIsTypeOf(Student)
    then
        loan.DueDate = Today.After(30)
    else
        loan.DueDate = Today.After(60)
    endif and
    if
        copy.Status@pre = CopyStatus::ONHOLDSHELF
    then
        copy.IsReserved = false and
        res.IsReserveClosed = true
    endif and
    copy.Status = CopyStatus::LOANED and
    loan.OverDue3Days = false and
    loan.OverDue10Days = false and
    loan.OverDue17Days = false and
    loan.OverDue31Days = false and
    Loan.allInstance()->includes(loan) and
    result = true
```

The contract of *renewBook*

```
Contract LibraryManagementSystem::renewBook(uid:String, barcode:String) : Boolean {

    definition:
        user:User = User.allInstance()->any(u:User | u.UserID = uid),
        stu:Student = Student.allInstance()->any(s:Student | s.UserID = uid),
        fac:Faculty = Faculty.allInstance()->any(f:Faculty | f.UserID = uid),
        copy:BookCopy = BookCopy.allInstance()->any(bc:BookCopy | bc.Barcode = barcode and bc.Status = CopyStatus::LOANED),
        loan:Loan = Loan.allInstance()->any(l:Loan | l.LoanedUser = user and l.LoanedCopy = copy)
```

The contract of *renewBook*

```
precondition:
    user.BorrowStatus = BorrowStatus::NORMAL and
    user.oclIsUndefined() = false and
    copy.oclIsUndefined() = false and
    loan.oclIsUndefined() = false and
    copy.IsReserved = false and
    loan.DueDate.isAfter(Today) and
    if
        user.oclIsTypeOf(Student)
    then
        loan.RenewedTimes < 3
    else
        loan.RenewedTimes < 6
    endif and
    loan.OverDueFee = 0
```

The contract of *renewBook*

```
postcondition:
    loan.RenewedTimes = loan.RenewedTimes@pre + 1 and
    loan.RenewDate = Today and
    if
        user.oclIsTypeOf(Student)
    then
        if
            stu.Programme = Programme::BACHELOR
        then
            loan.DueDate = loan.DueDate@pre.After(20)
        else
            if
                stu.Programme = Programme::MASTER
            then
                loan.DueDate = loan.DueDate@pre.After(40)
            else
                loan.DueDate = loan.DueDate@pre.After(60)
            endif
        endif
    else
        loan.DueDate = loan.DueDate@pre.After(60)
    endif and
    result = true
```

The contract of *returnBook*

```
Contract LibraryManagementSystem::returnBook(barcode:String) : Boolean {

    definition:
        copy:BookCopy = BookCopy.allInstance()->any(bc:BookCopy | bc.Barcode = barcode and bc.Status = CopyStatus::LOANED),
        loan:Loan = Loan.allInstance()->any(l:Loan | l.LoanedCopy = copy and l.IsReturned = false),
        loans:Set(Loan) = Loan.allInstance()->select(l:Loan | l.LoanedUser = loan.LoanedUser and l.IsReturned = false and l.DueDate.isAfter(Today)),
        res:Reserve = copy.ReservationRecord->any(r:Reserve | r.ReservedCopy = copy)
```

The contract of *returnBook*

```
precondition:
    copy.oclIsUndefined() = false and
    loan.oclIsUndefined() = false

postcondition:
    loan.LoanedUser.LoanedNumber = loan.LoanedUser.LoanedNumber@pre - 1 and
    loan.IsReturned = true and
    loan.ReturnDate = Today and
    if
        copy.IsReserved = true
    then
        copy.Status = CopyStatus::ONHOLDSHELF and
        sendNotificationEmail(res.ReservedUser.Email)
    else
        copy.Status = CopyStatus::AVAILABLE
    endif and
    result = true
```

The contract of *dueSoonNotification*

```
Contract LibraryManagementSystem::dueSoonNotification()  {

    precondition:
        true

    postcondition:
        let users:Set(User) = User.allInstance()->select(user:User | user.LoanedBook->exists(loan:Loan |
            loan.IsReturned = false and Today.After(3).isAfter(loan.DueDate)
        )) in
        users->forAll(u:User |
            sendNotificationEmail(u.Email))
}
```

The contract of *makeReservation*

```
Contract LibraryManagementSystem::makeReservation(uid:String, barcode:String) : Boolean {

    definition:
        user:User = User.allInstance()->any(u:User | u.UserID = uid),
        copy:BookCopy = BookCopy.allInstance()->any(bc:BookCopy | bc.Barcode = barcode)


    precondition:
        user.oclIsUndefined() = false and
        copy.oclIsUndefined() = false and
        copy.Status = CopyStatus::LOANED and
        copy.IsReserved = false
```

The contract of *makeReservation*

```
postcondition:
    let res:Reserve in
    res.oclIsNew() and
    copy.IsReserved = true and
    res.IsReserveClosed = false and
    res.ReserveDate = Today and
    res.ReservedUser = user and
    res.ReservedCopy = copy and
    user.ReservedBook->includes(res) and
    copy.ReservationRecord->includes(res) and
    Reserve.allInstance()->includes(res) and
    result = true
```

Prototype Functionality

Prototype Library

System Function | System Status

- User
- Student
- Faculty
- Librarian
  - searchBookByTitle
  - searchBookByAuthor
  - searchBookBylSBN
  - searchBookBySubject
  - searchBookByBarCode
  - payOverDueFee
  - borrowBook
  - renewBook
  - returnBook
  - listRecommendBook
  - addBook
  - modifyBook
  - deleteBook
  - addSubject
  - listAllSubject
  - deleteSubject
  - createStudent
  - modifyStudent
  - createFaculty
  - modifyFaculty
  - deleteUser
  - queryUser
- Administrator
- Timer
- ThirdPartySystem

Operation Parameters

uid:

barcode:

Operation Return

System Log

Execute | Reset

Definition

```
user:User = User.allInstance()->any(u:User | u.UserID = uid)
stu:Student = Student.allInstance()->any(s:Student | s.UserID = uid)
fac:Faculty = Faculty.allInstance()->any(f:Faculty | f.UserID = uid)
copy:BookCopy = BookCopy.allInstance()->any(bc:BookCopy | bc.Barcode = barcode)
res:Reserve = Reserve.allInstance()->any(r:Reserve | r.ReservedCopy = copy and r.ReservedUser = user and r.IsReserveClose
```

Precondition

```
user.oclIsUndefined() = false and
copy.oclIsUndefined() = false and
user.BorrowStatus = BorrowStatus::NORMAL and
user.SuspensionDays = 0 and
if
    user.oclIsTypeOf(Student)
then
    if
```

Postcondition

```
let loan:Loan in
loan.oclIsNew() and
loan.LoanedUser = user and
loan.LoanedCopy = copy and
loan.IsReturned = false and
loan.LoanDate = Today and
user.LoanedNumber = user.LoanedNumber@pre + 1 and
user.LoanedBook->includes(loan) and
```

Invariants

- Loan_OverDueFeeGreatThanEqualZero
- Loan_RenewedTimesLessThanEqualSix
- Loan_LoanOverDueFeeGreatThanEqualZero
- Loan_RenewDataAfterLoanDate
- Loan_DueDateAfterLoanDate
- Loan_ReturnDateAfterORSameLoanDate
- Loan_DueDateAfterORSameRenewDate
- Loan_ReturnDateSameORAfterRenewDate
- BookCopy_BarCodeUnique
- User_UniqueUserID
- User_OverDueFeeGreatThanEqualZero
- User_LoanedNumberGreatThanEqualZero
- User_SuspensionDaysGreatThanEqualZero

Generated By RMCode

Prototype Status

Prototype Library

System Function | System Status

Class statistics

Class Name	# of Objects
User	0
Student	0
Faculty	0
Book	0
Subject	0
BookCopy	0
Loan	0
Reserve	0
RecommendBook	0
Administrator	0
Librarian	0

Association statistics

Source Class	Association Name	Target Class	Multiple	Association Number

No content in table

Object Statistics

All Invariants

- User_UniqueUserID
- User_OverDueFeeGreatThanEqualZero
- User_LoanedNumberGreatThanEqualZero
- User_SuspensionDaysGreatThanEqualZero
- Student_StudentLoanLessThanEqualTwelve
- Student_StudentLoanedBookAssociationInvariants
- Faculty_FacultyLoanLessthanEqualTwentyFour
- Faculty_FacultyLoanedBookAssociationInvariants
- Book_BookCallNoUnique
- Book_BookISBNUnique
- Book_BookCopyNumGreatThanEqualZero
- BookCopy_BarCodeUnique
- Loan_OverDueFeeGreatThanEqualZero
- Loan_RenewedTimesLessThanEqualSix
- Loan_LoanOverDueFeeGreatThanEqualZero
- Loan_RenewDataAfterLoanDate
- Loan_DueDateAfterLoanDate
- Loan_ReturnDateAfterORSameLoanDate
- Loan_DueDateAfterORSameRenewDate
- Loan_ReturnDateSameORAfterRenewDate
- RecommendBook_BookCallNoUnique
- RecommendBook_BookISBNUnique
- RecommendBook_BookCopyNumGreatThanEqualZero
- Administrator_AdministratorIDUnique
- Librarian_LibrarianIDUnique

Load Status | Save Status | Refresh Status | Check All Invariants