CRC cards

Design Orientado a Objetos

CRC

- **C**lass-**R**esponsibility-**C**ollaborator cards

Kent Beck, Apple Computer, Inc.

Ward Cunningham, Wyatt Software Services, Inc.

– "A Laboratory For Teaching Object-Oriented Thinking"

- *From the OOPSLA'89 Conference Proceedings October 1-6, 1989, New Orleans, Louisiana And the special issue of SIGPLAN Notices Volume 24, Number 10, October 1989*

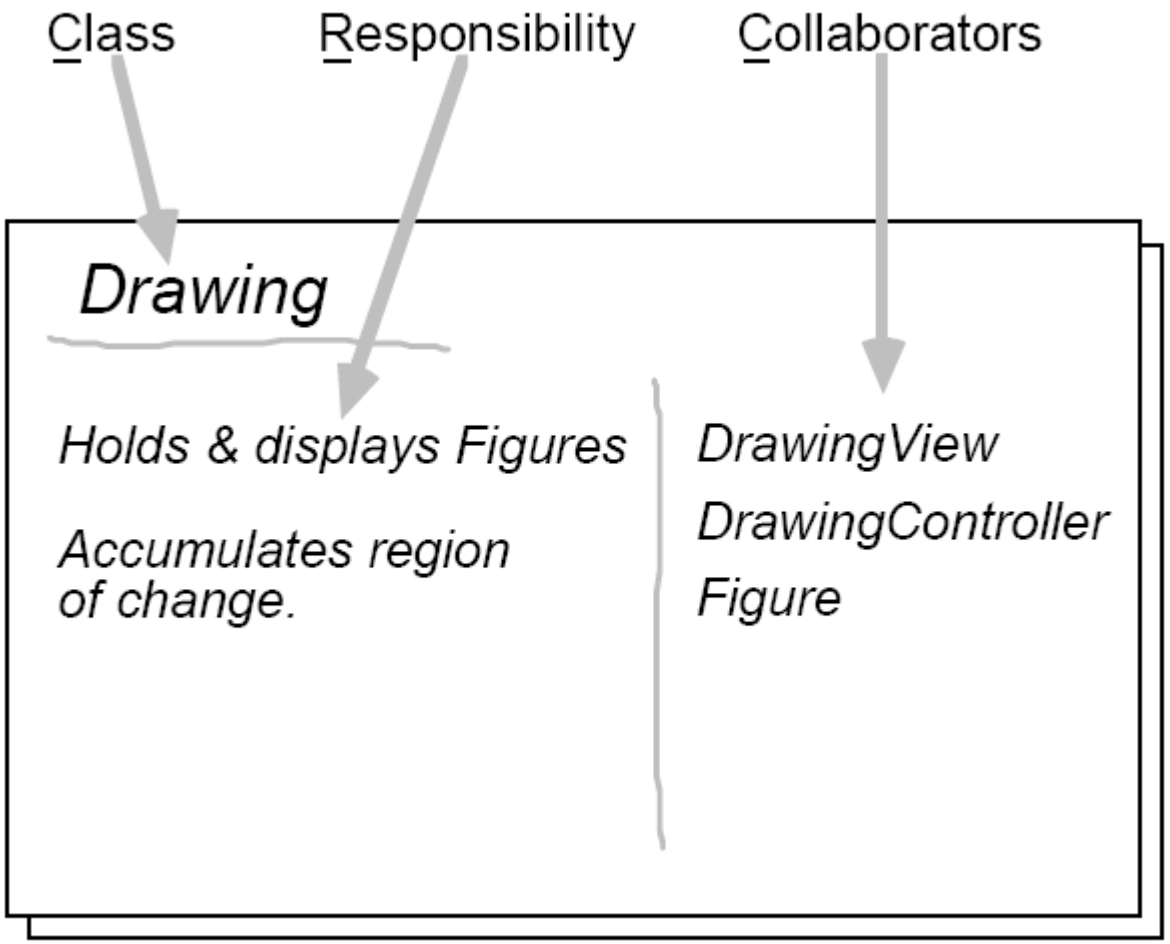
Grade School Example
Object-oriented description

	Responsibility	Collaborators
Teacher	Teaches Lessons Evaluates Students	Secretary Student Principal
Student	Learns Lessons	Teacher Principal
Principal	Administers Funds Diciplines Students Hires Staff	Teacher Secretary Student
Nurse	Gives First Aid Gives Vacinations	Students Teachers
Secretary	Answers Phone Prints Handouts	Teacher Principal
Janitor	Cleans Building Fixes Equipment	Teacher Secretary
Cook	Prepares Meals	Janitor

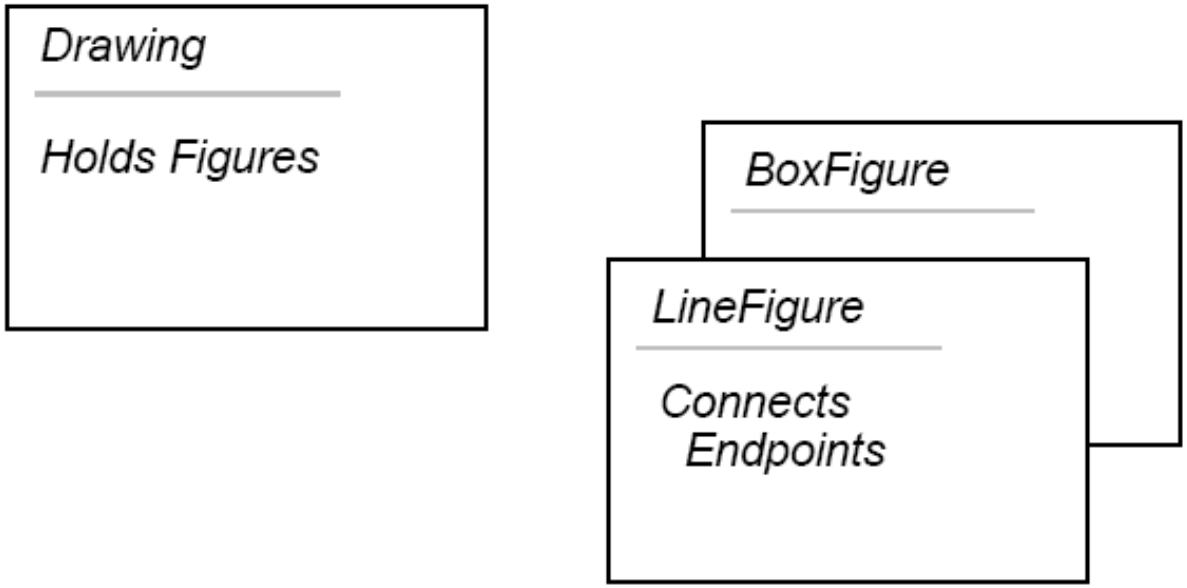
OO Design Representation

- Enumerates all (new) classes.
- Defines responsibilities assumed by members of each class.
- Describes collaborations through which responsibilities are discharged.

Introducing CRC Cards

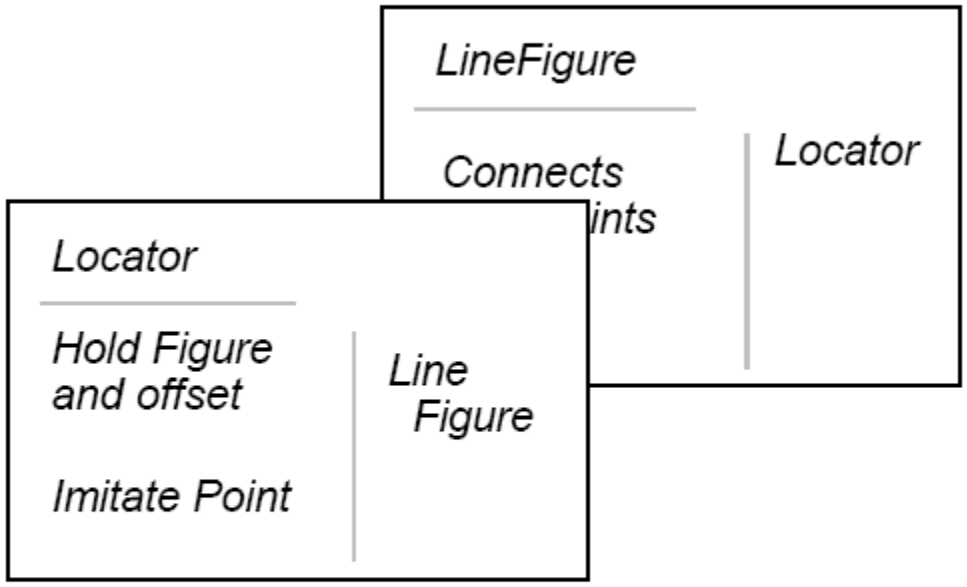


Step 1: Start With Knowns



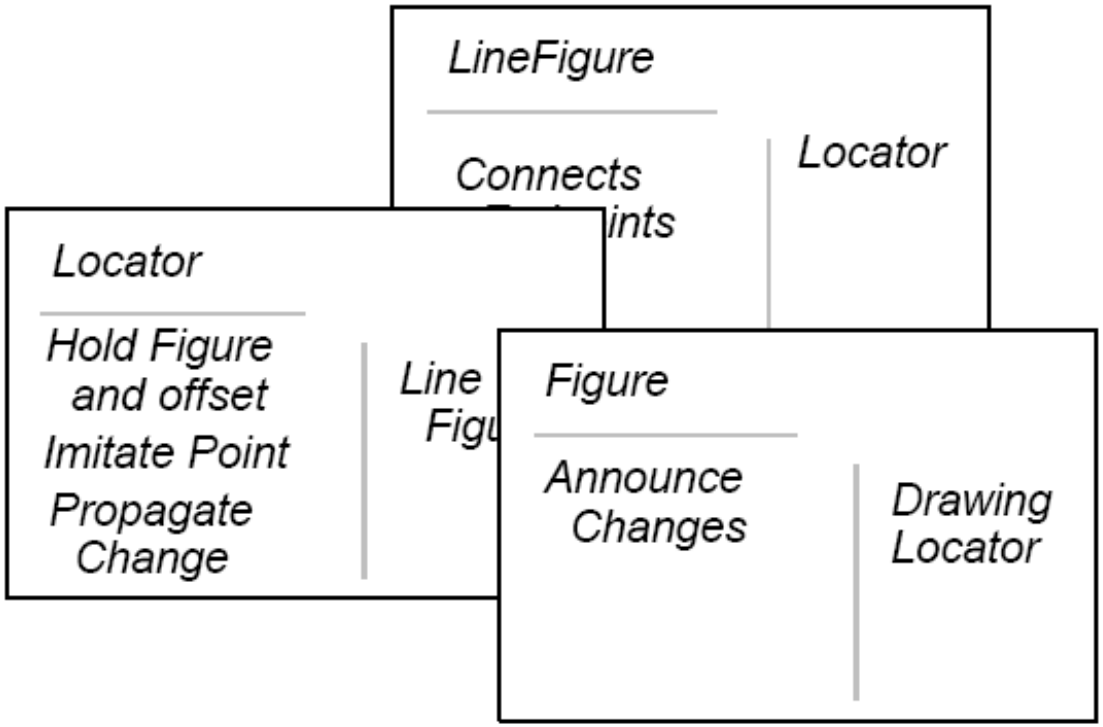
- A Drawing is composed of Figures
- Figures come in several kinds

Step 2: Hypothesize Support



- A line may connect to other figures
- A "smart" point does the work

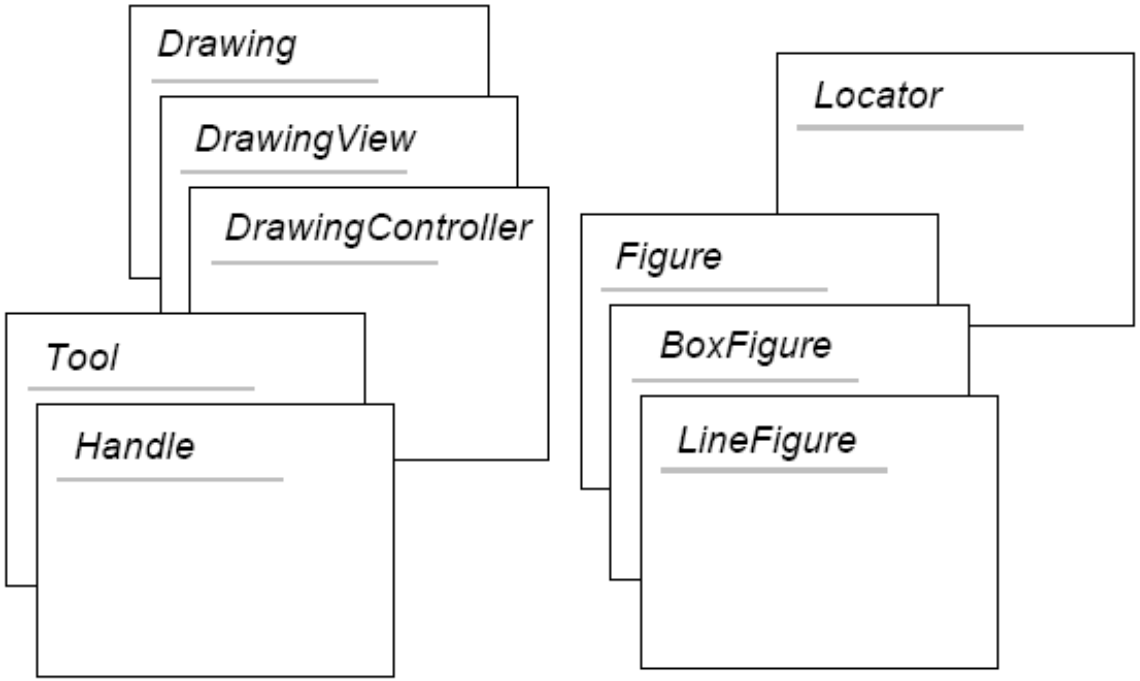
Step 3: Test with Scenarios



- Figures notify the Drawing and dependent Locators when moved.

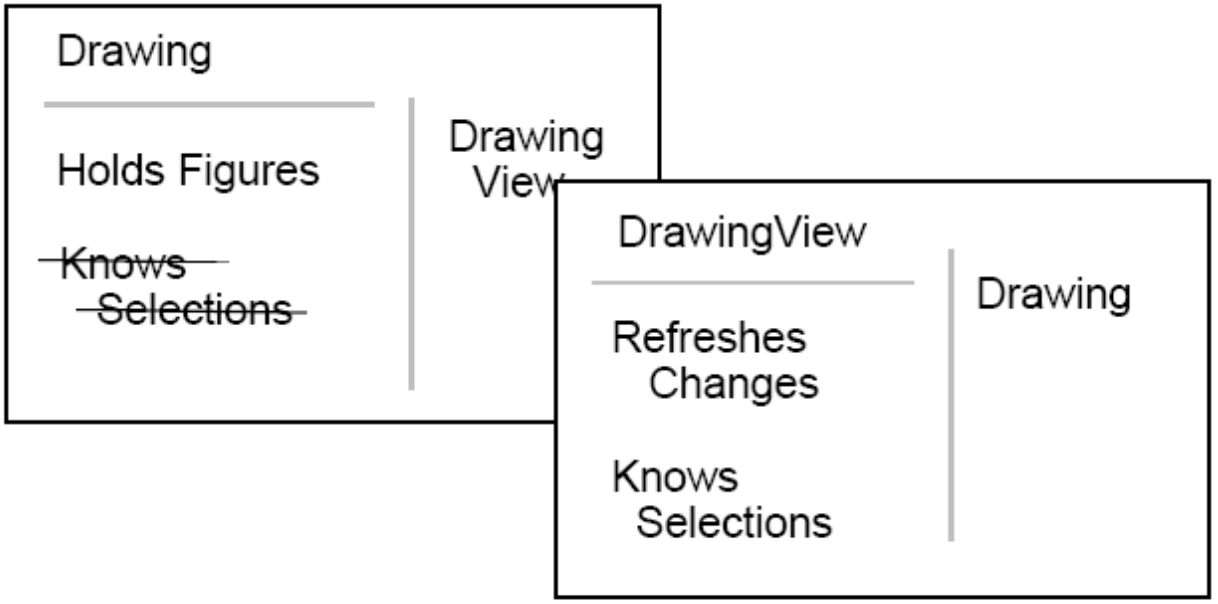
- Change propagates through Locators

Step 4: Try Various Groupings



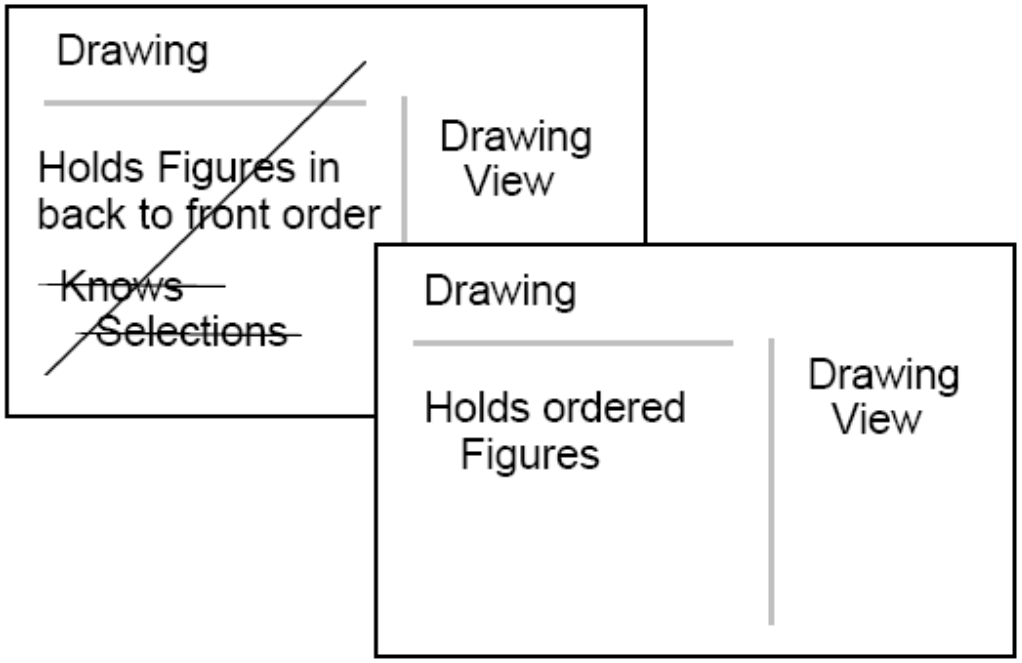
- A Handle is like a Tool ...
- Locators are quite unique ...

Step 5: Redistribute Responsibilities



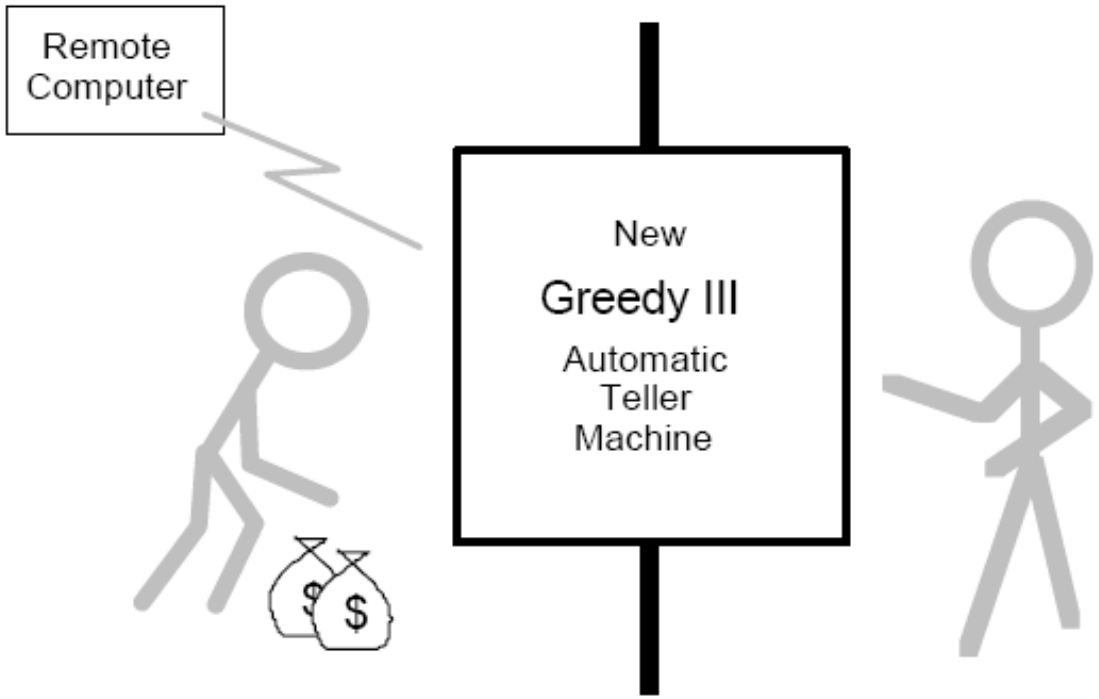
- Selections are kept in the View
- Selections won't be saved with a Drawin

Step 6: Rewrite for Clarity



- It is important that Figures are ordered

- Design Exercise (Requirements)



Requirements Statement for Example ATM System

The software to be designed will control a simulated automated teller machine (ATM) having a magnetic stripe reader for reading an ATM card, a customer console (keyboard and display) for interaction with the customer, a slot for depositing envelopes, a dispenser for cash (in multiples of $20), a printer for printing customer receipts, and a key-operated switch to allow an operator to start or stop the machine. The ATM will communicate with the bank's computer over an appropriate communication link. (The software on the latter is not part of the requirements for this problem.)

The ATM will service one customer at a time. A customer will be required to insert an ATM card and enter a personal identification number (PIN) - both of which will be sent to the bank for validation as part of each transaction. The customer will then be able to perform one or more transactions. The card will be retained in the machine until the customer indicates that he/she desires no further transactions, at which point it will be returned - except as noted below.

The ATM must be able to provide the following services :

A customer must be able to make a **cash withdrawal** from any suitable account linked to the card, in multiples of $20.00. Approval must be obtained from the bank before cash is dispensed.

A customer must be able to make a **deposit** to any account linked to the card, consisting of cash and/or checks in an envelope. The customer will enter the amount of the deposit into the ATM, subject to manual verification when the envelope is removed from the machine by an operator. Approval must be obtained from the bank before physically accepting the envelope.

A customer must be able to make a **transfer of money** between any two accounts linked to the card.

A customer must be able to make a **balance inquiry** of any account linked to the card.

A customer must be able to **abort a transaction** in progress by pressing the Cancel key instead of responding to a request from the machine.

The ATM will **communicate each transaction to the bank** and obtain verification that it was allowed by the bank. Ordinarily, a transaction will be considered complete by the bank once it has been approved. In the case of a deposit, a second message will be sent to the bank indicating that the customer has deposited the envelope. (If the customer fails to deposit the envelope within the timeout period, or presses cancel instead, no second message will be sent to the bank and the deposit will not be credited to the customer.)

If the bank determines that the customer's **PIN is invalid**, the customer will be required to re-enter the PIN before a transaction can proceed. If the customer is unable to successfully enter the PIN after three tries, the card will be permanently retained by the machine, and the customer will have to contact the bank to get it back.

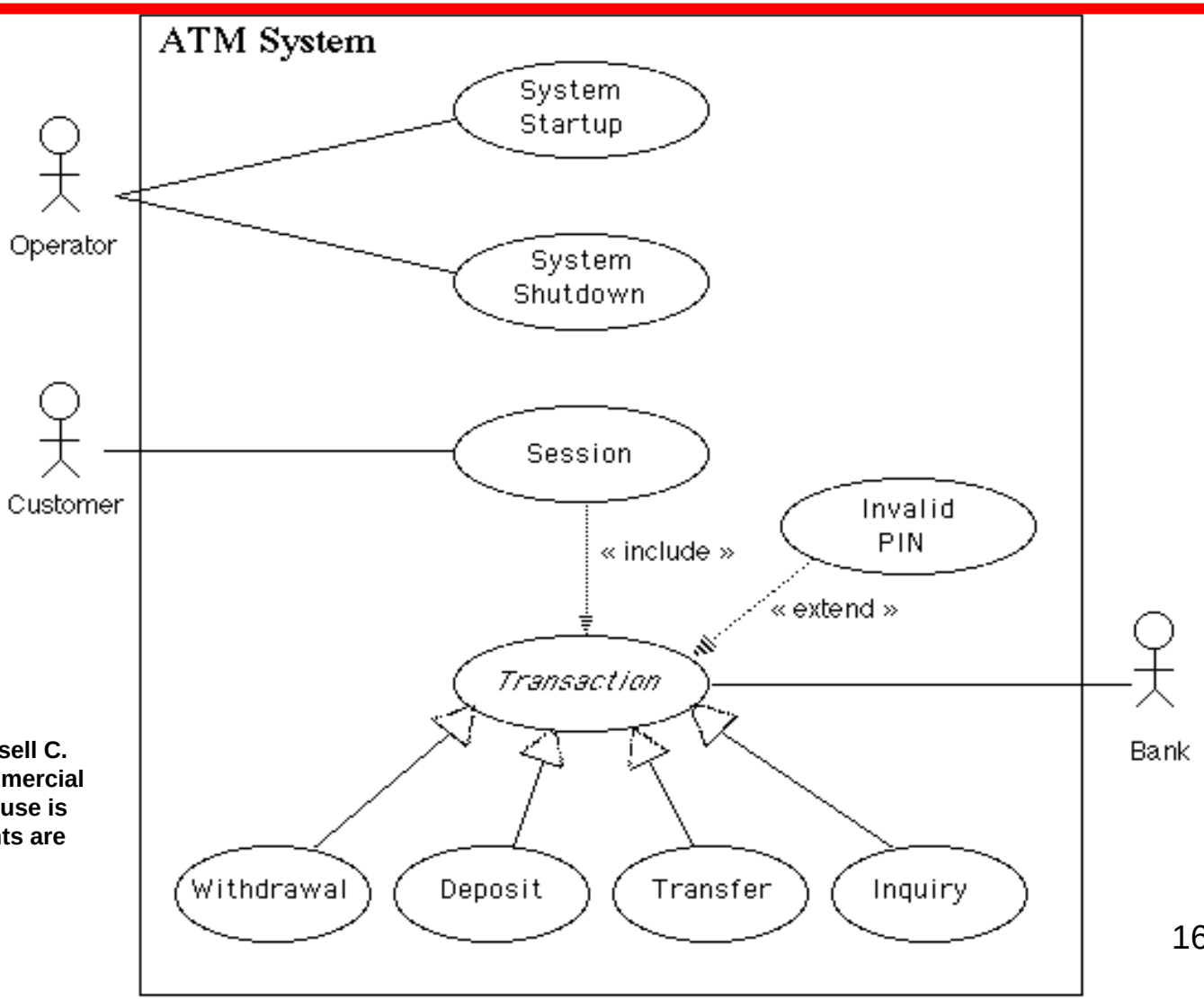
If a **transaction fails** for any reason other than an invalid PIN, the ATM will display an explanation of the problem, and will then ask the customer whether he/she wants to do another transaction.

The ATM will provide the customer with a **printed receipt** for each successful transaction, showing the date, time, machine location, type of transaction, account(s), amount, and ending and available balance(s) of the affected account ("to" account for transfers).

The ATM will have a **key-operated switch** that will allow an operator to start and stop the servicing of customers. After turning the switch to the "on" position, the operator will be required to verify and enter the total cash on hand. The machine can only be turned off when it is not servicing a customer. When the switch is moved to the "off" position, the machine will shut down, so that the operator may remove deposit envelopes and reload the machine with cash, blank receipts, etc.

The ATM will also maintain an **internal log of transactions** to facilitate resolving ambiguities arising from a hardware failure in the middle of a transaction. Entries will be made in the log when the ATM is started up and shut down, for each message sent to the Bank (along with the response back, if one is expected), for the dispensing of cash, and for the receiving of an envelope. Log entries may contain card numbers and dollar amounts, but for security will *never* contain a PIN.

DCU



Classes

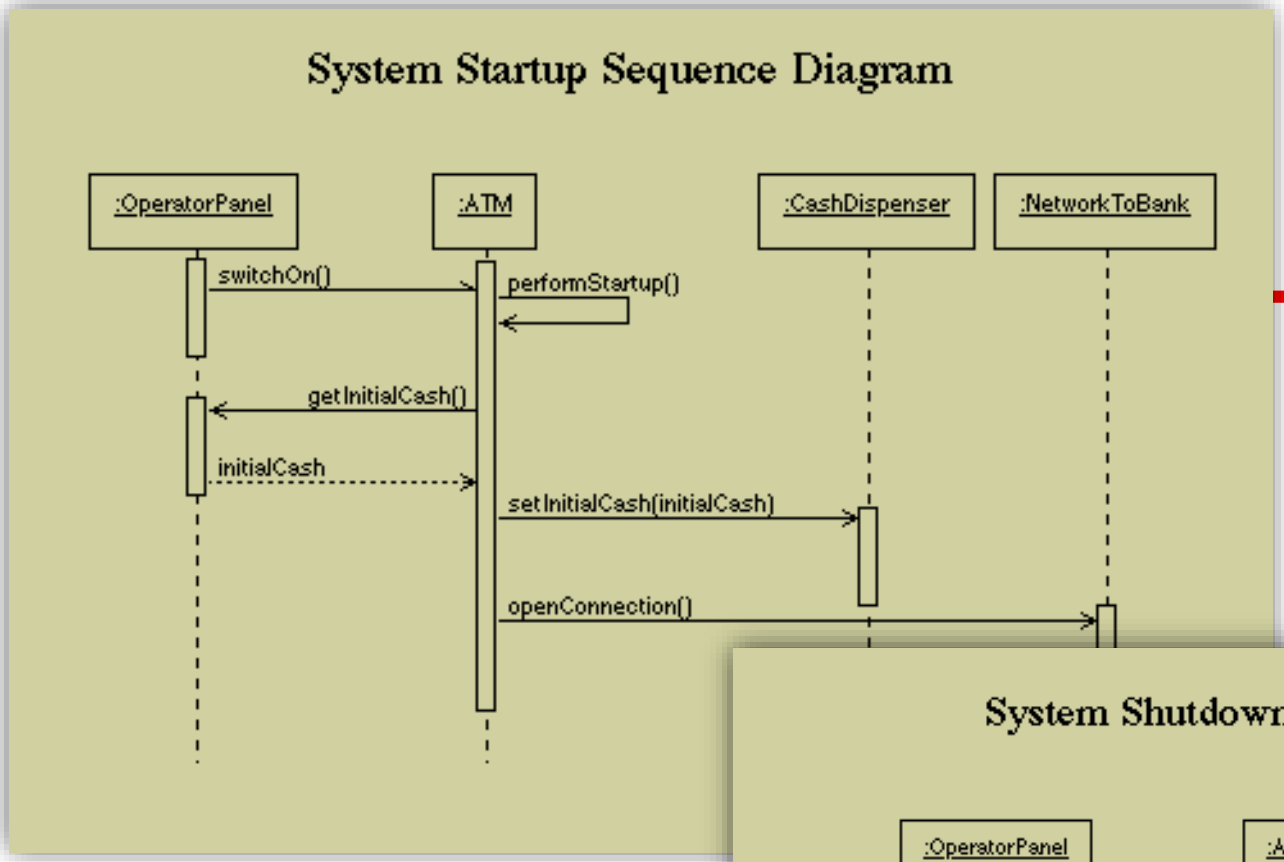
- Class ATM
- Boundary/entity objects - component parts of the ATM:
  - Class CardReader; Class CashDispenser; Class CustomerConsole; Class EnvelopeAcceptor ; Class Log ; Class NetworkToBank ; Class OperatorPanel; Class ReceiptPrinter

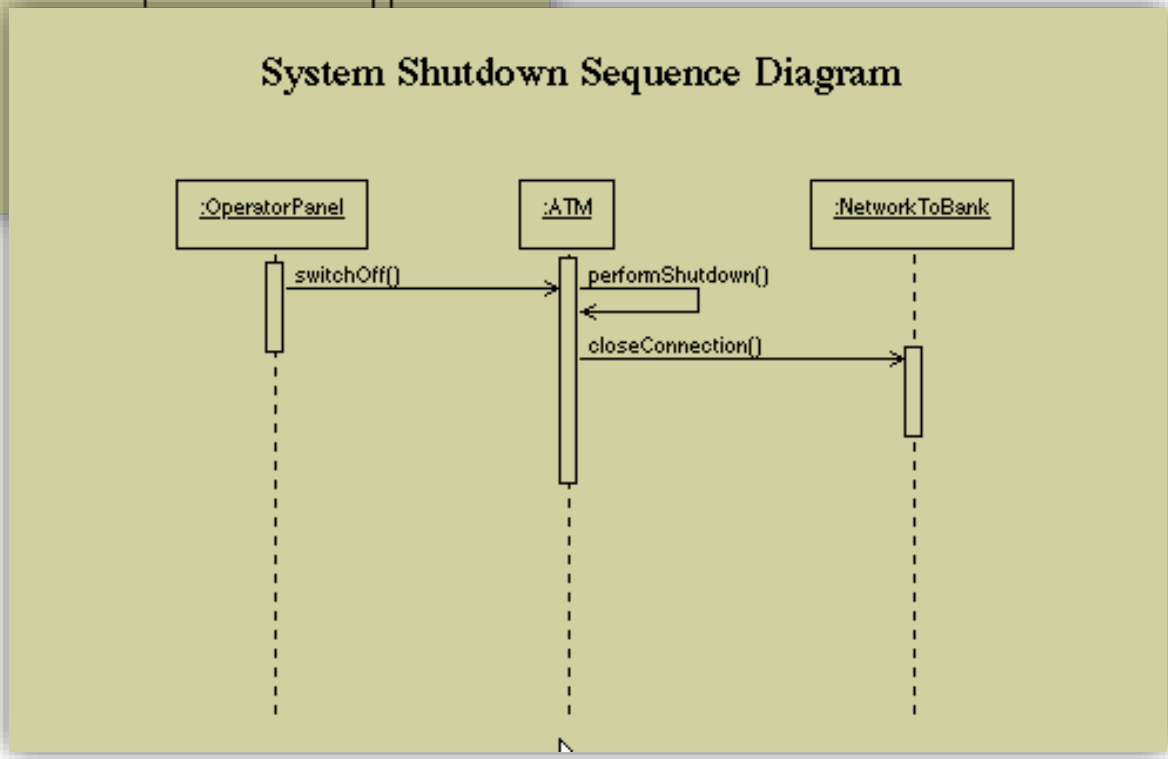
- Controller objects corresponding to the various use cases:
  - Class Session
  - Class Transaction
  - Class Withdrawal
  - Class Deposit
  - Class Transfer
  - Class Inquiry

- Entity objects found necessary when assigning responsibilities to other objects:
  - Class Balances; Class Card; Class Message; Class Receipt; Class Status

Classe ATM

Responsibilities	**Collaborators**
Start up when switch is turned on	OperatorPanel CashDispenser NetworkToBank
Shut down when switch is turned off	NetworkToBank
Start a new session when card is inserted by customer	CustomerConsole Session
Provide access to component parts for sessions and transactions	


System Startup Sequence Diagram
:OperatorPanel
:ATM
:CashDispenser
:NetworkToBank
switchOn()
performStartup()
getInitialCash()
initialCash
setInitialCash(initialCash)
openConnection()


System Shutdown Sequence Diagram
:OperatorPanel
:ATM
:NetworkToBank
switchOff()
performShutdown()
closeConnection()

Classe CardReader

Responsibilities	**Collaborators**
Tell ATM when card is inserted	ATM
Read information from card	Card
Eject card	
Retain card	

Classe CashDispenser

Responsibilities	**Collaborators**
Keep track of cash on hand, starting with initial amount	
Report whether enough cash is available	
Dispense cash	Log

Classe CustomerConsole

Responsibilities

Display a message

Display a prompt, accept a PIN from keyboard

Display a prompt and menu, accept a choice from keyboard

Display a prompt, accept a dollar amount from keyboard

Respond to cancel key being pressed by customer

Collaborators

Classe EnvelopeAcceptor

Responsibilities	Collaborators
Accept envelope from customer; report if timed out or cancelled	Log

Classe Log

Responsibilities	**Collaborators**
Log messages sent to bank	
Log responses from bank	
Log dispensing of cash	
Log receiving an envelope	

Classe NetworkToBank

Responsibilities	**Collaborators**
Initiate connection to bank at startup	
Send message to bank and wait for response	Message Log Balances Status
Terminate connection to bank at shutdown	

Classe OperatorPanel

Responsibilities	Collaborators
Inform ATM of changes to state of switch	ATM
Allow operator to specify amount of initial cash	

Classe ReceiptPrinter

Responsibilities	**Collaborators**
Print receipt	Receipt

Class Session

Responsibilities

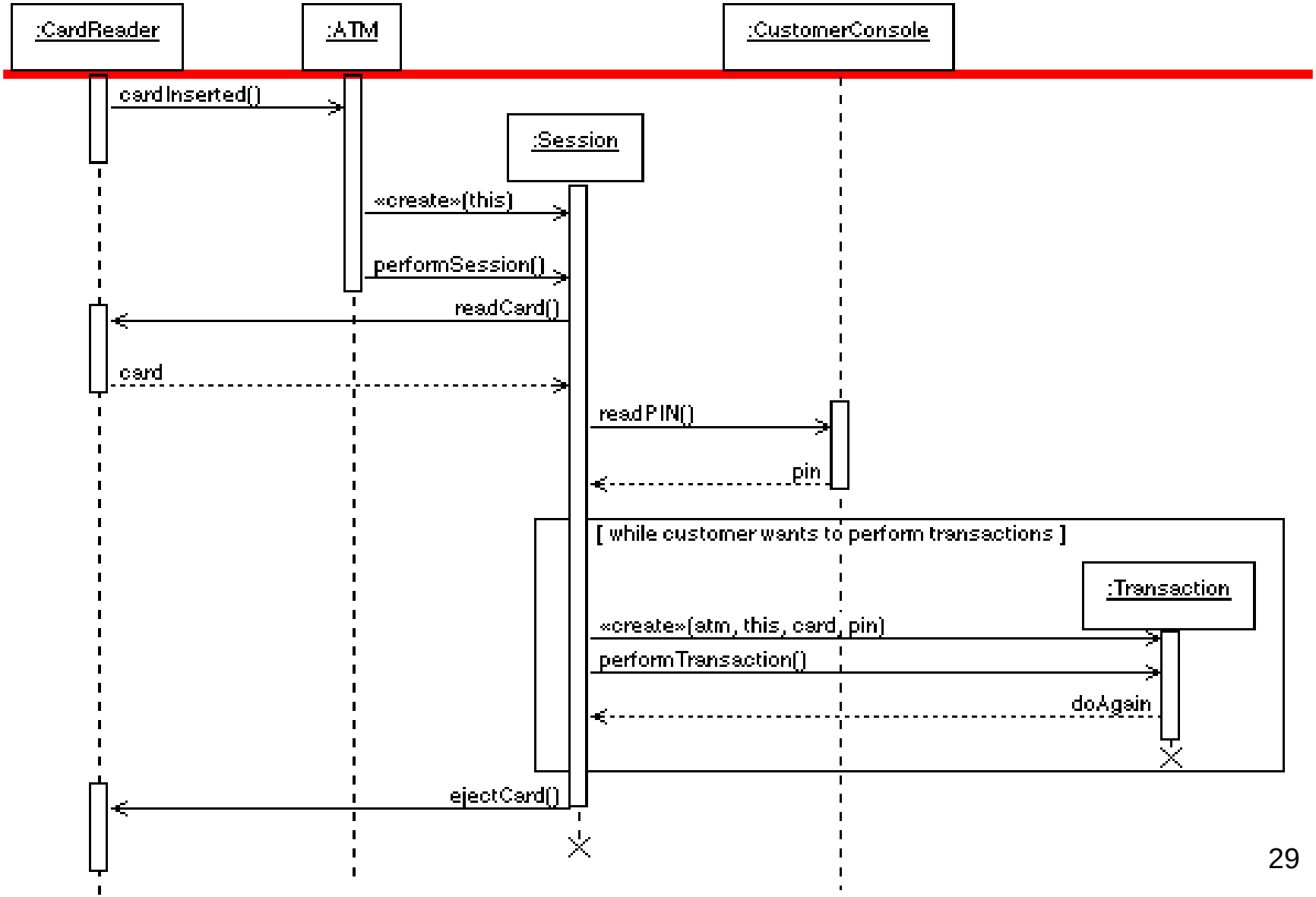
Perform session use case

Update PIN value if customer has to re-enter it

Collaborators

ATM
CardReader
Card
CustomerConsole
Transaction

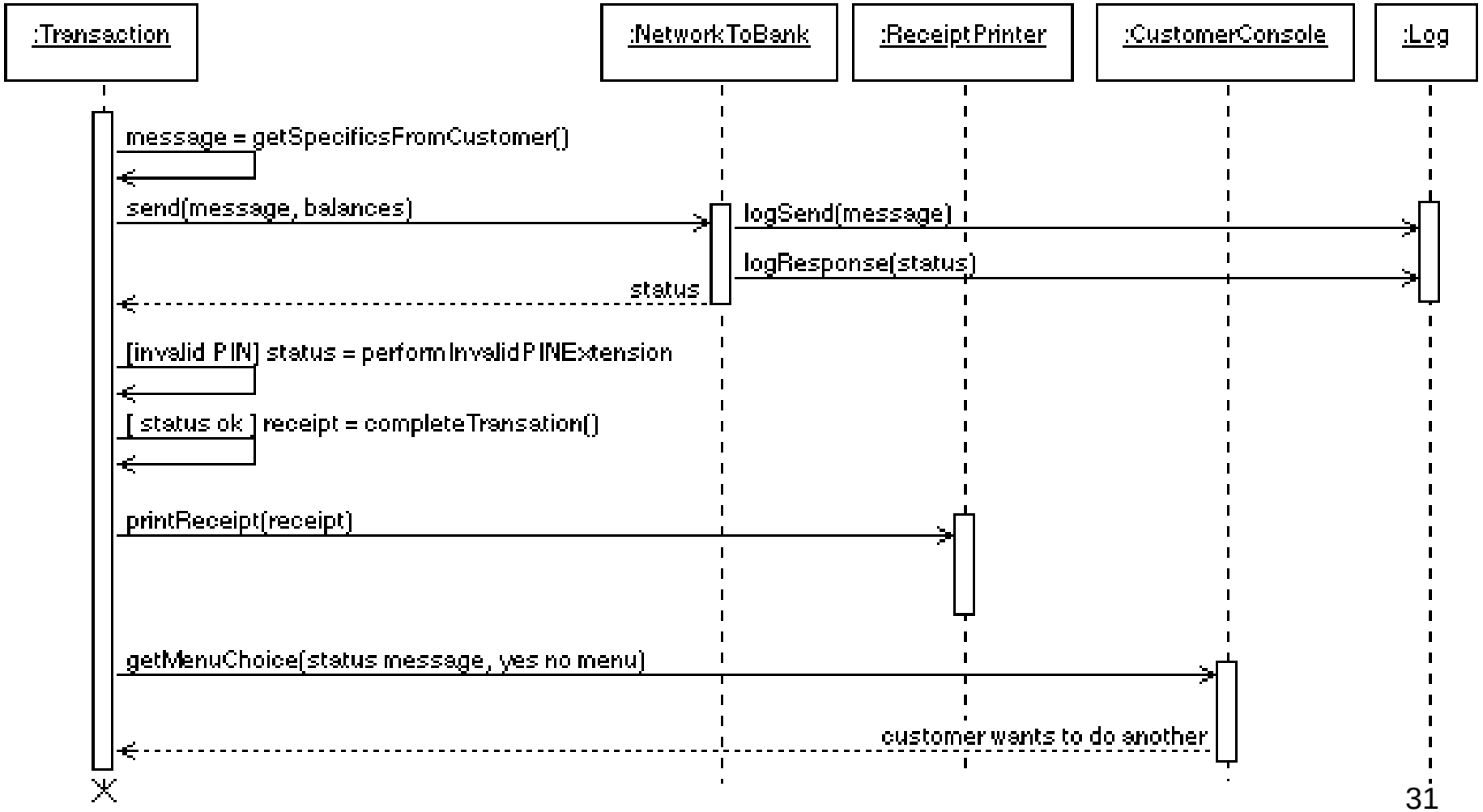
Session Sequence Diagram



Classe Transaction

Responsibilities	Collaborators
Allow customer to choose a type of transaction	ATM CustomerConsole Withdrawal Deposit Transfer Inquiry
Perform Transaction Use Case	ATM CustomerConsole Withdrawal Deposit Transfer Inquiry Message NetworkToBank Receipt ReceiptPrinter
Perform invalid PIN extension	CustomerConsole Session CardReader

Transaction Sequence Diagram



Classe Withdrawal

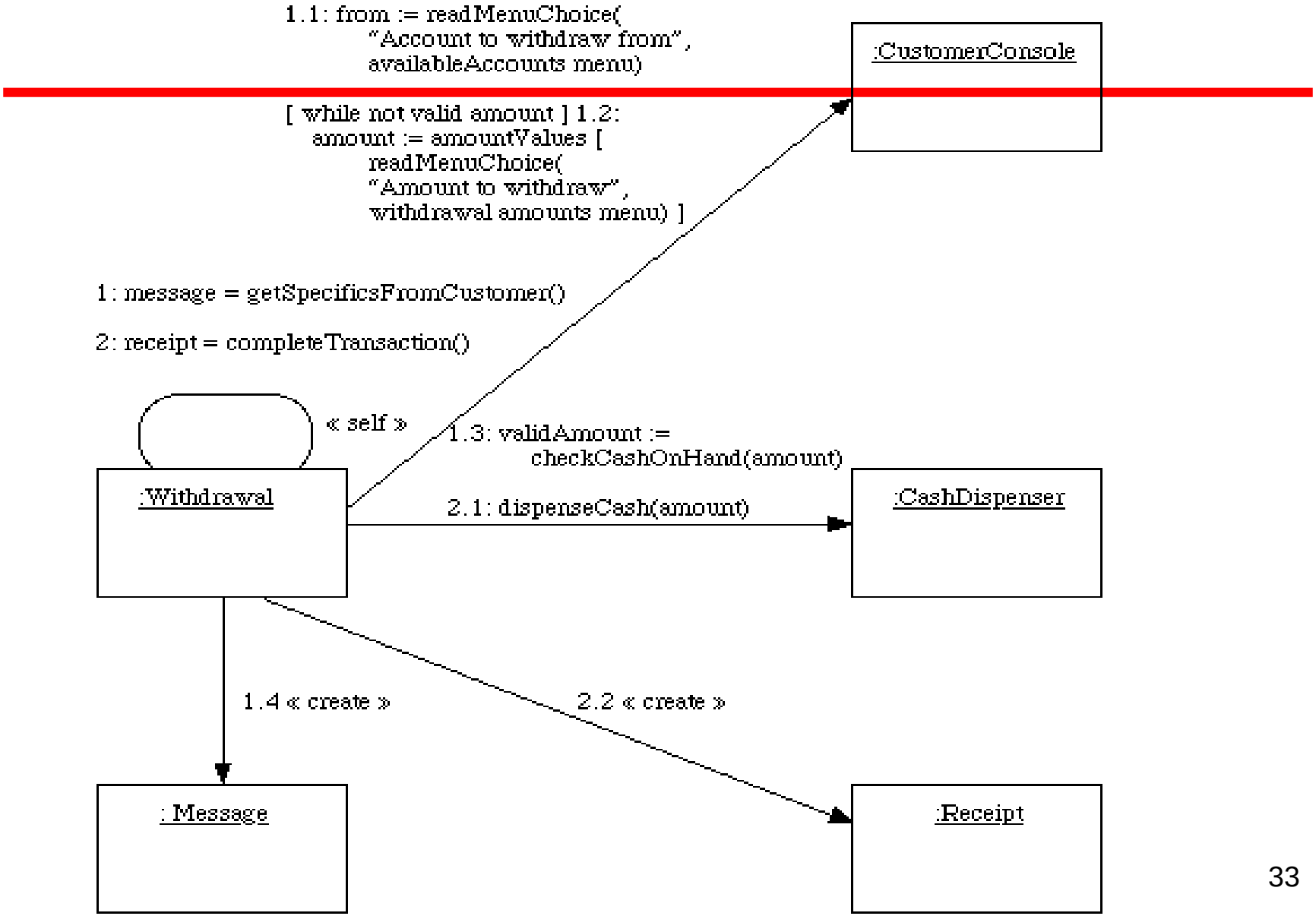
Responsibilities

Perform operations peculiar to withdrawal transaction use case

Collaborators

CustomerConsole
CashDispenser
Message
Receipt

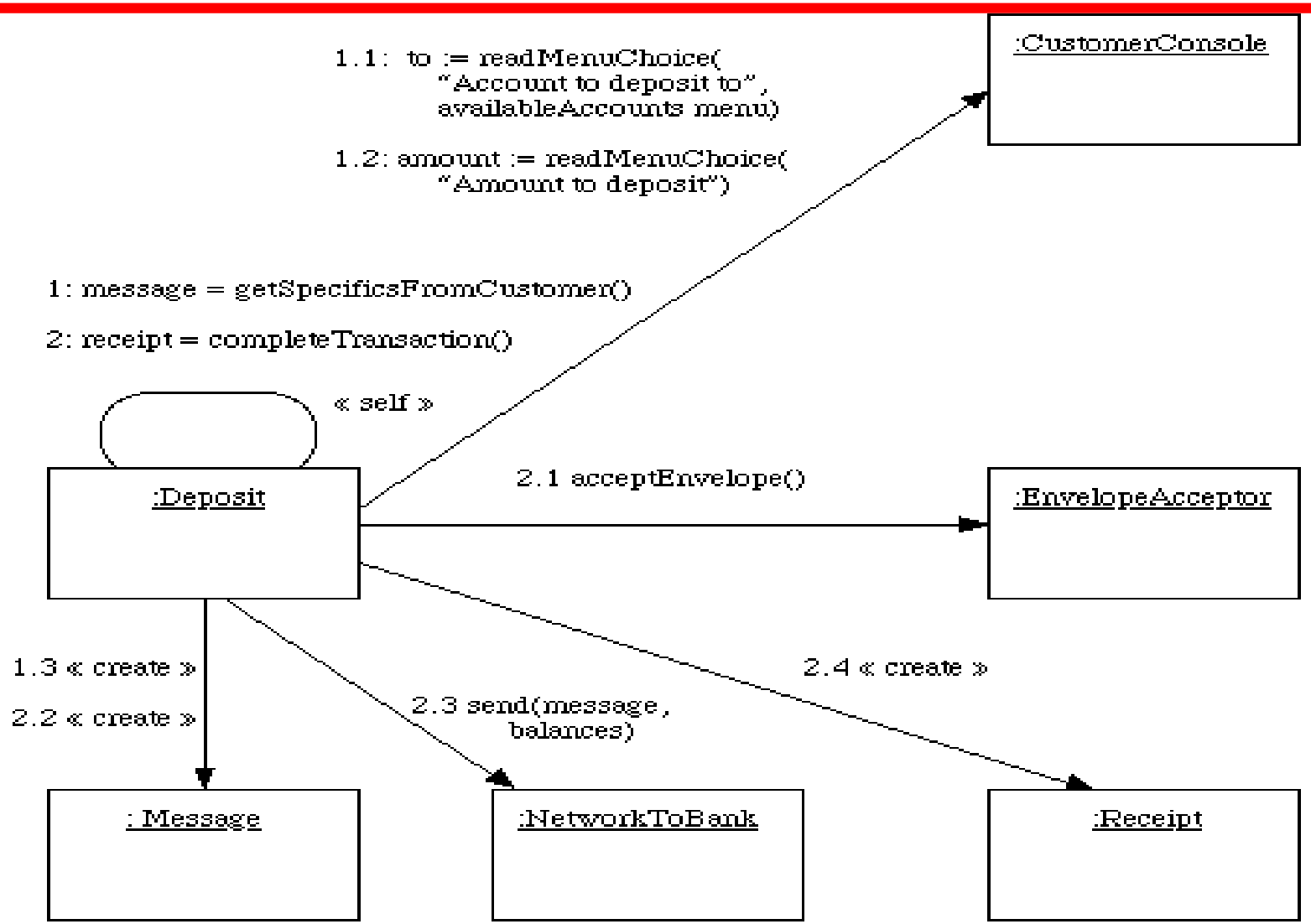
Withdrawal Transaction Collaboration



Classe Deposit

Responsibilities	**Collaborators**
Perform operations peculiar to deposit transaction use case	CustomerConsole Message EnvelopeAcceptor Receipt

Deposit Transaction Collaboration



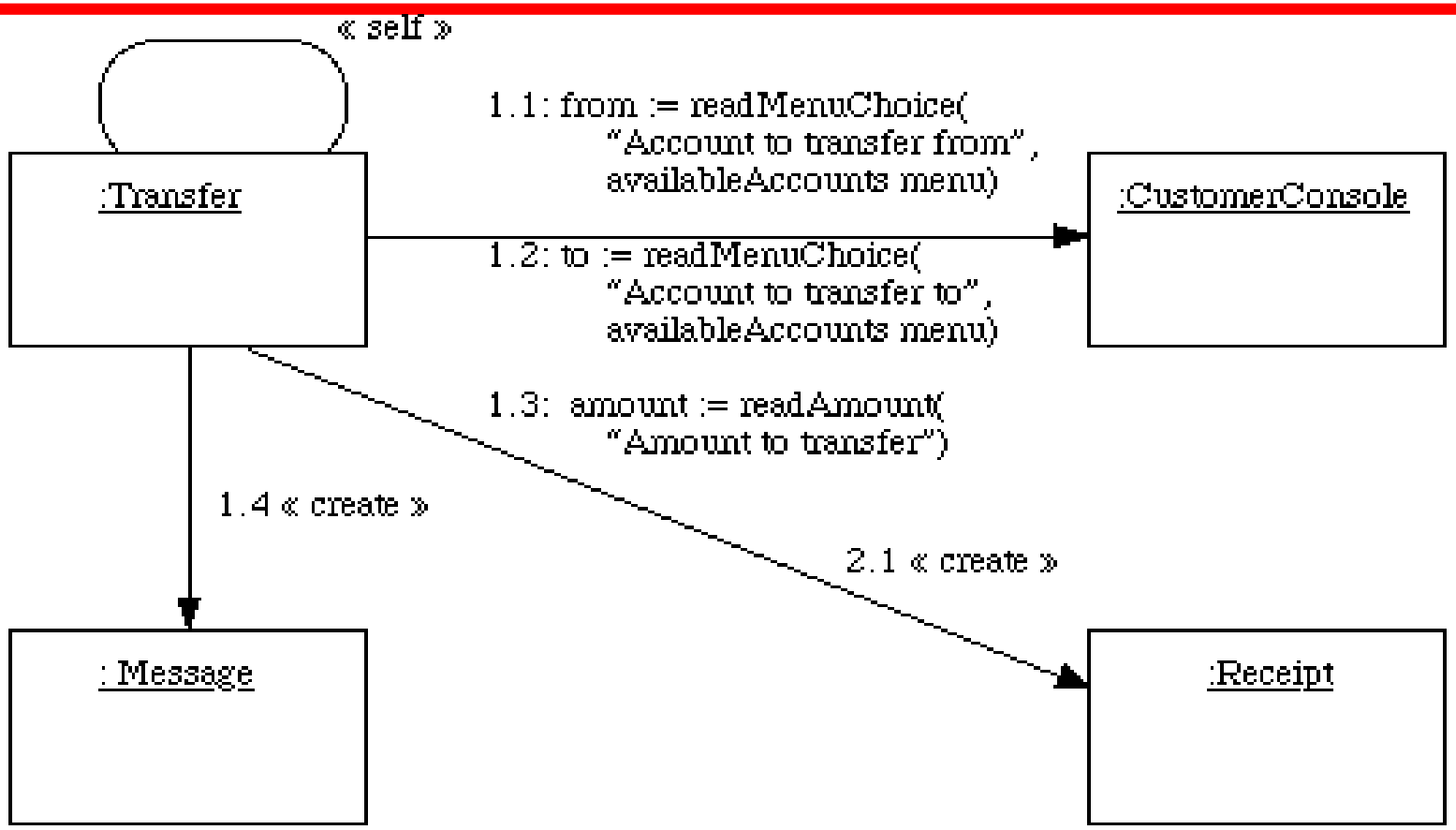
Classe Transfer

Responsibilities	**Collaborators**
Perform operations peculiar to transfer transaction use case	CustomerConsole Message Receipt

Transfer Transaction Collaboration

1: message = getSpecificsFromCustomer()

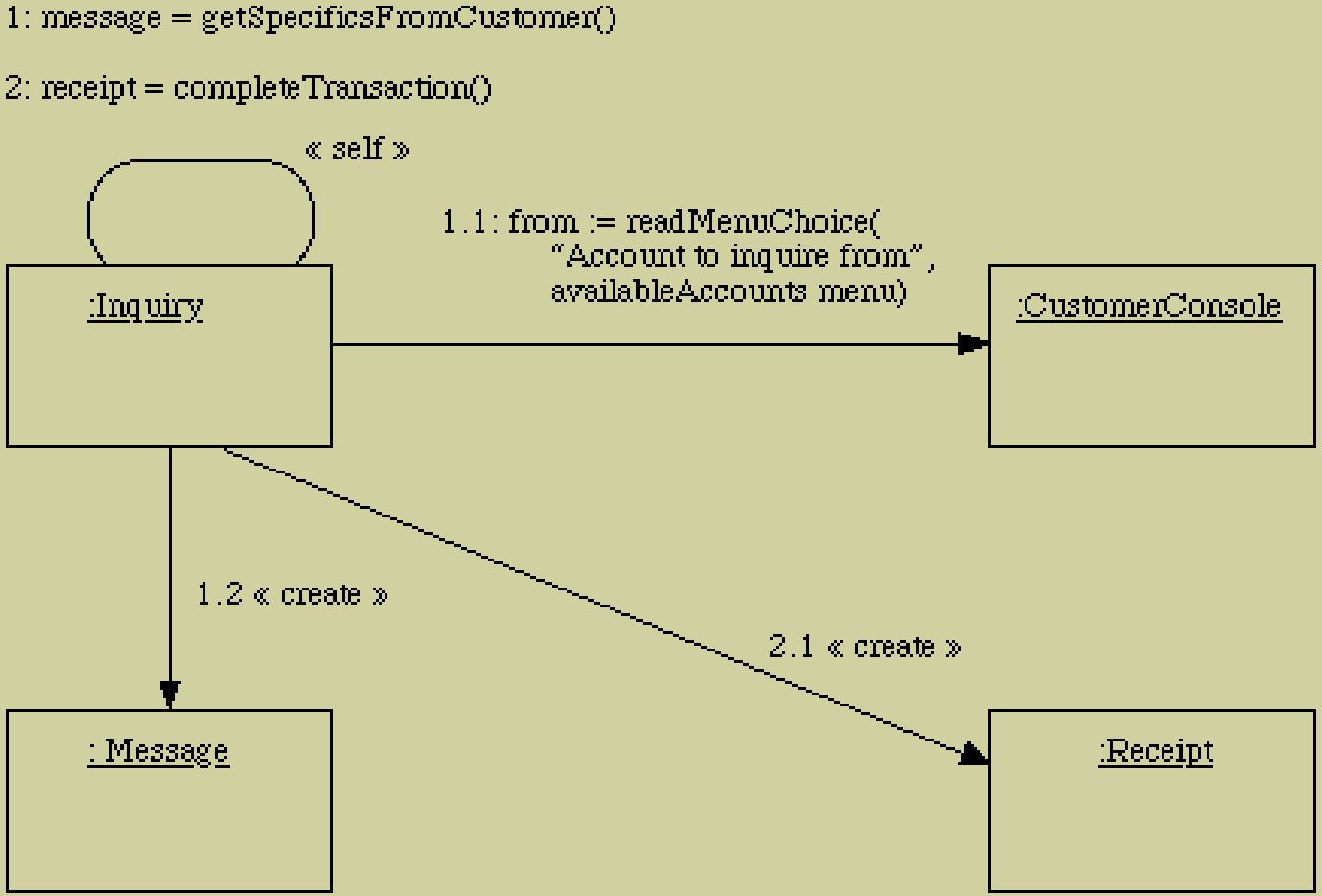
2: receipt = completeTransaction()



Classe Inquiry

Responsibilities	**Collaborators**
Perform operations peculiar to inquiry transaction use case	CustomerConsole Message Receipt

Inquiry Transaction Collaboration



Classe Balances

Responsibilities

Represent account balance information returned by bank

Collaborators

Classe Card

Responsibilities

Represent information encoded on customer's ATM card

Collaborators

Classe Message

Responsibilities

Represent information to be sent over network to bank

Collaborators

Classe Receipt

Responsibilities

Represent information to be printed on a receipt

Collaborators

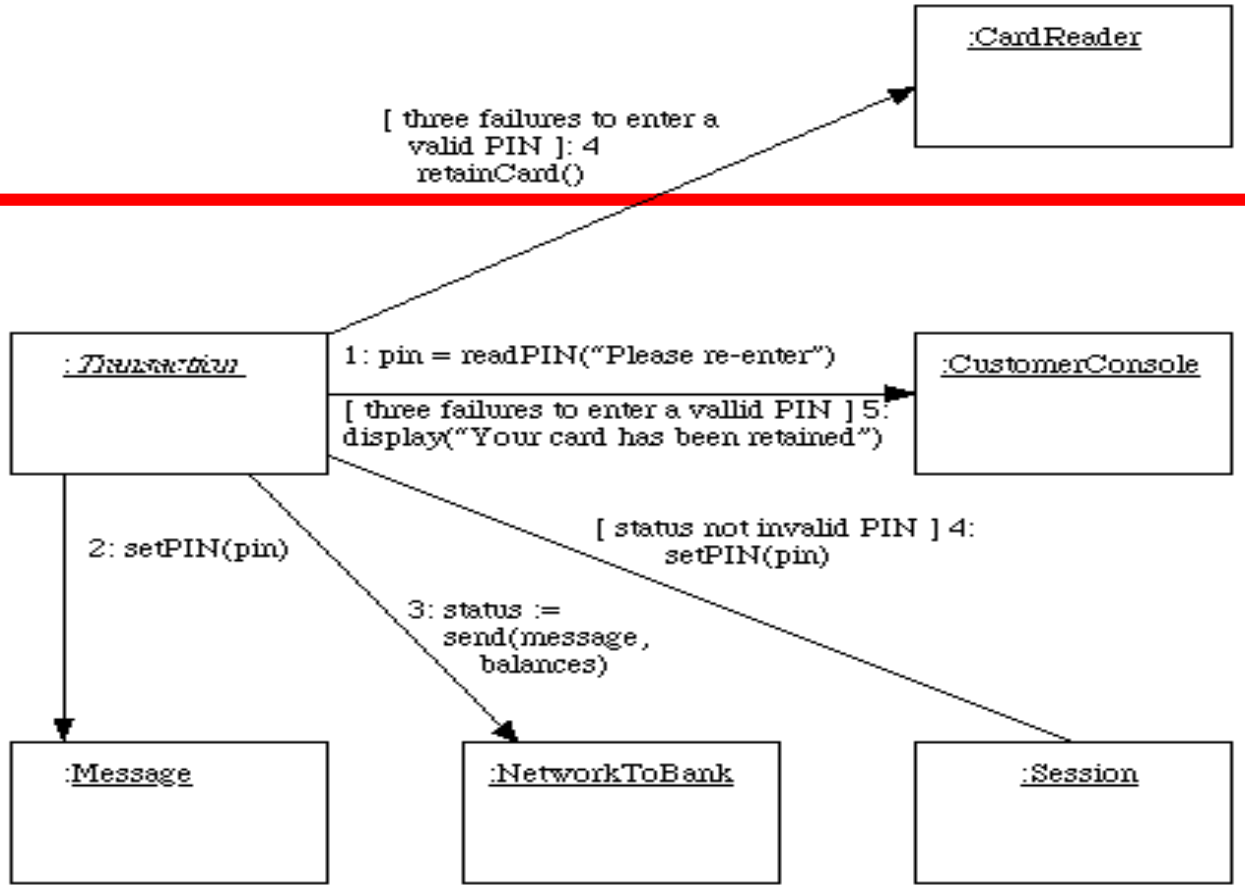
Classe Status

Responsibilities

Represent transaction status information returned by bank

Collaborators

Invalid PIN Extension Collaboration



As soon as the customer enters a valid PIN (send() returns a status other than incorrect PIN, the extension is terminated. If the customer re-enters invalid PINs three times, the ATM card is retained and the extension (and session of which it is a part) is aborted. If the user presses Cancel, this extension is aborted immediately, and the transaction that initiated is aborted immediately as well.