Introduction to UML (Part 1)

Contents

The Analysis Phase (Steps done early in the elaboration process)

1. **Understanding the Requirements – Defining Use Cases**
2. **The Conceptual Model**
3. **System Sequence Diagrams**
4. **UML Contracts**

Requirements Analysis

Use Cases – A narrative describing the sequence of events of an actor (external agent) using a system to complete a process.

Example – Making a Withdrawal from an ATM Machine

Use case:	**Withdrawal**
Actors:	Customer
Type:	primary* ← **defined on next slide**
Description:	A customer *arrives* at an ATM machine, *inserts* her Debit Card into the machine, *enters* her passcode when prompted to do so, *selects* the Withdrawal option from the menu of choices *presented*, *enters* the amount in increments of the appropriate denominations, and if the amount specified is less than or equal to the limit allowed and less than her current balance, bills *are dispensed*, the amount *deducted from* her account, and her Card *returned*.

Requirements Analysis

In the use case example on the previous page, noun phrases have been underlined, and verb phrases, written in italics. Use cases are vehicles for identifying the **concepts** in the problem domain and the **associations** between these concepts.

The Type field in the previous example may be either:

- **primary** – use case represents major or common process.
- **secondary** – use case represents a minor or rare process.
- **optional** – use case represents a "frill" that may not be implemented

Requirements Analysis

Use cases and Functional Requirements

- **End users have *goals* that they want the system to help meet**
- **Use cases capture these goals and describe the *functional requirements* of the system needed to meet these goals**
- **A scenario is a specific sequence of actions and interactions between actors and the system being modeled**
- **A use case is a collection of related success and failure *scenarios* that describe the actions of the system to support a goal.**

Requirements Analysis

"Fully Dressed" Use Case template

Use Case name (and number)

Primary Actor

Stakeholders and Interests

Preconditions

Post-conditions

Main Success Scenario

Extensions or Alternate Flows

The goal being described

Parentheses here are used to denote optional

Captures behaviors related to each stakeholder's interests

Statements that must be true before and after the successful completion of the goal

Records all interactions between actors, and validations of actions and changes of state by the system

Additional references to constructing use cases

Requirements Analysis

Main Success Scenario

Actor Action	System Responsibility
1. User card verified (see Access System)	
2. User selects withdrawal option	
	3. System presents Withdrawal Menu
4. User selects “from Checking”	
	5. System requests enter amount
6. User keys in amount	
	7. System debits amount from user account
	8. System dispenses the correct cash
	9. System asks if user wants other transact.
10. User says No	
	11. System prints and dispenses receipt
	12. System records transaction at home bank and in consortium computer
	13. System disconnects from user’s bank
	14. System displays Welcome Screen

Requirements Analysis

Extensions or Alternate Flows (partial listing)

Actor Action	System Response
System failure can occur at any time during the transaction →	*a Connection to member bank is lost State information must be maintained in ATM 1. Consortium computer reconnects 2. System reconstructs prior state 2a. System unable to reconnect or recover 1. System alerts user of failure 2. System displays Welcome Screen
	7a. Amount is greater than account balance 1. System voids transaction 2. System notifies user that the request cannot be processed 3. System displays transaction screen
There can be more than one alternate path at a numbered flow →	7b. Amount is not multiple of base denomination 1. System prompts user to re-enter

Requirements Analysis

A Use Case is a kind of thing or object. Much of the language of the object-oriented paradigm can be applied to the writing of use cases.

A Use Case may be modularized by identifying abstract or subfunction use cases, and it may be extended when there is need to add conditional steps to a base case that has already been established as being stable.

These are two examples of refinements to Use Cases that may be made during later iterations of the Unified Process.

Requirements Analysis

Consider two Use Case Descriptions for a Library Management System.

Check-out Books

2. Patron hands card to librarian
3. Librarian swipes card
4. System verifies Patron's ID
5. System retrieves Patron's account

Check-in Books

2. Patron hands card to Librarian
3. Librarian swipes card
4. System verifies Patron's ID
5. System retrieves Patron's account

"Factor out" the sequence of actions common to more than one use case and create a new Use Case – Verify Patron

2. Process Patron's Card: Verify Patron ← "Include" notation shortens the Use Case notation and modularizes the description.

The new Use Case is an "Abstract Use Case" -- It is never instantiated by itself, but is a subfunction Use Case.

Requirements Analysis

An example of extending a Use Case Description

UC1: Process Sale (the base case)

…..

Extension Points: VIP Customer, step 1. Payment, step 7.

Main Success Scenario:

1. Customer arrives at POS checkout with goods to purchase.

…….

7. Customer pays and System handles payment

…….

UC 15: Handle Gift Certificate Payment (the extending use case)

……

Trigger: Customer wants to pay with gift certificate.

Extension Points: Payment in Process Sale.

Level: Subfunction

Main Success Scenario:

1. Customer gives gift certificate to Cashier.
2. Cashier enters gift certificate ID.

……..

Requirements Analysis

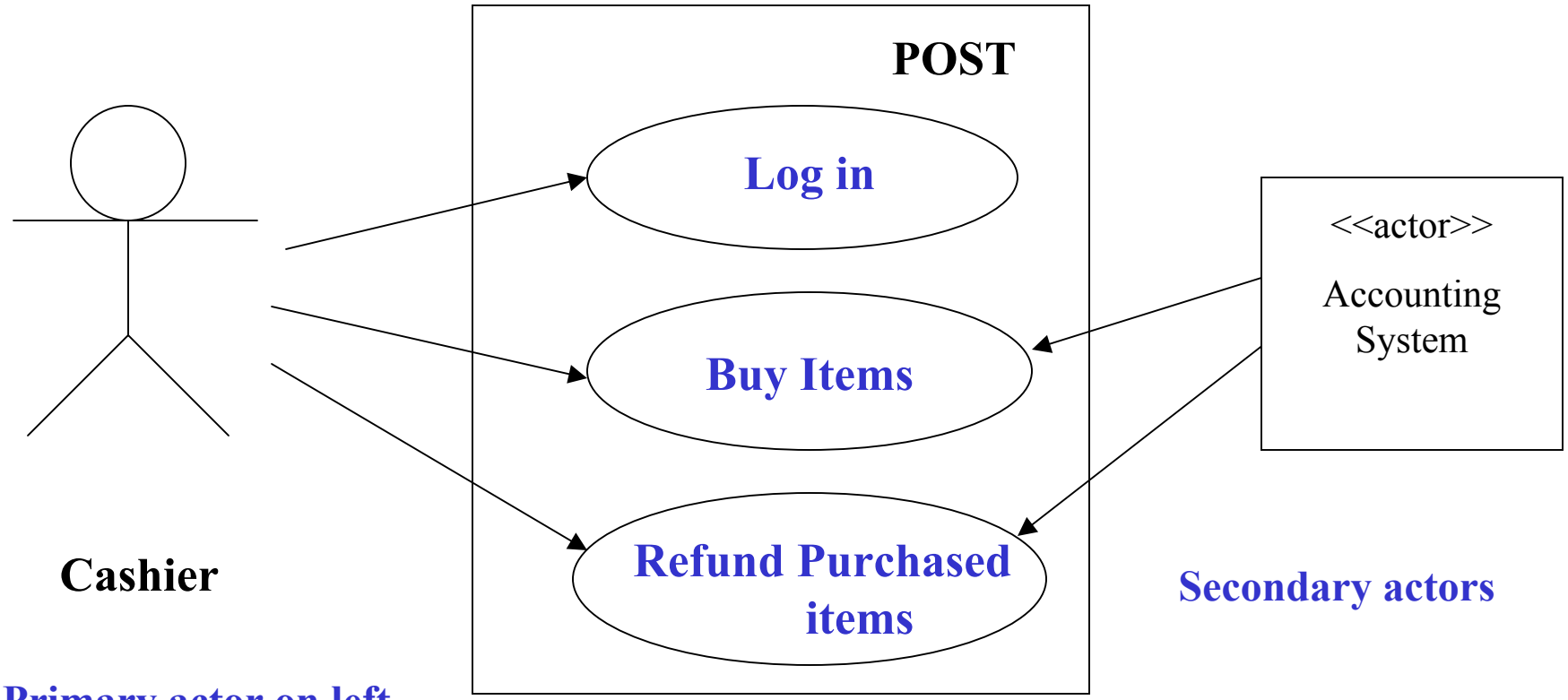
In specifying the requirements for the system to be built, the analyst must identify the boundaries of the system, the Actors (or outside agents) that will interact with the system, and the high level use cases that outline the processes that the system will be called upon to perform.

In the example illustrated on the next slide, this process of identifying the system boundary along with the actors that interact with the system, and the complete set of high level use cases for this system, is depicted diagrammatically for a Point of Sales Terminal (POST) System.

Requirements Analysis

System Boundaries

Indicate Actors for each use case



System Analysis – Building the Conceptual Model

Terminology

- **Concept –** Idea, thing, or object in the the problem domain
- **Class –** Realization of a concept in the design and implementation of the system.
- **Attribute –** Descriptive characteristic of a concept
- **Association –** An ongoing relationship between concepts.

System Analysis – Building the Conceptual Model

In constructing an object-based system, one must begin by:

1. **Identifying the objects (classes) that collaborate to produce the required functionality of the system.**

   Start by identifying the Concepts in the problem domain

2. **Identifying the long-term associations between classes of objects that have to be "remembered";**

   To what kind of objects do members of each class send messages?

3. **Identifying the data that each object must hold;**

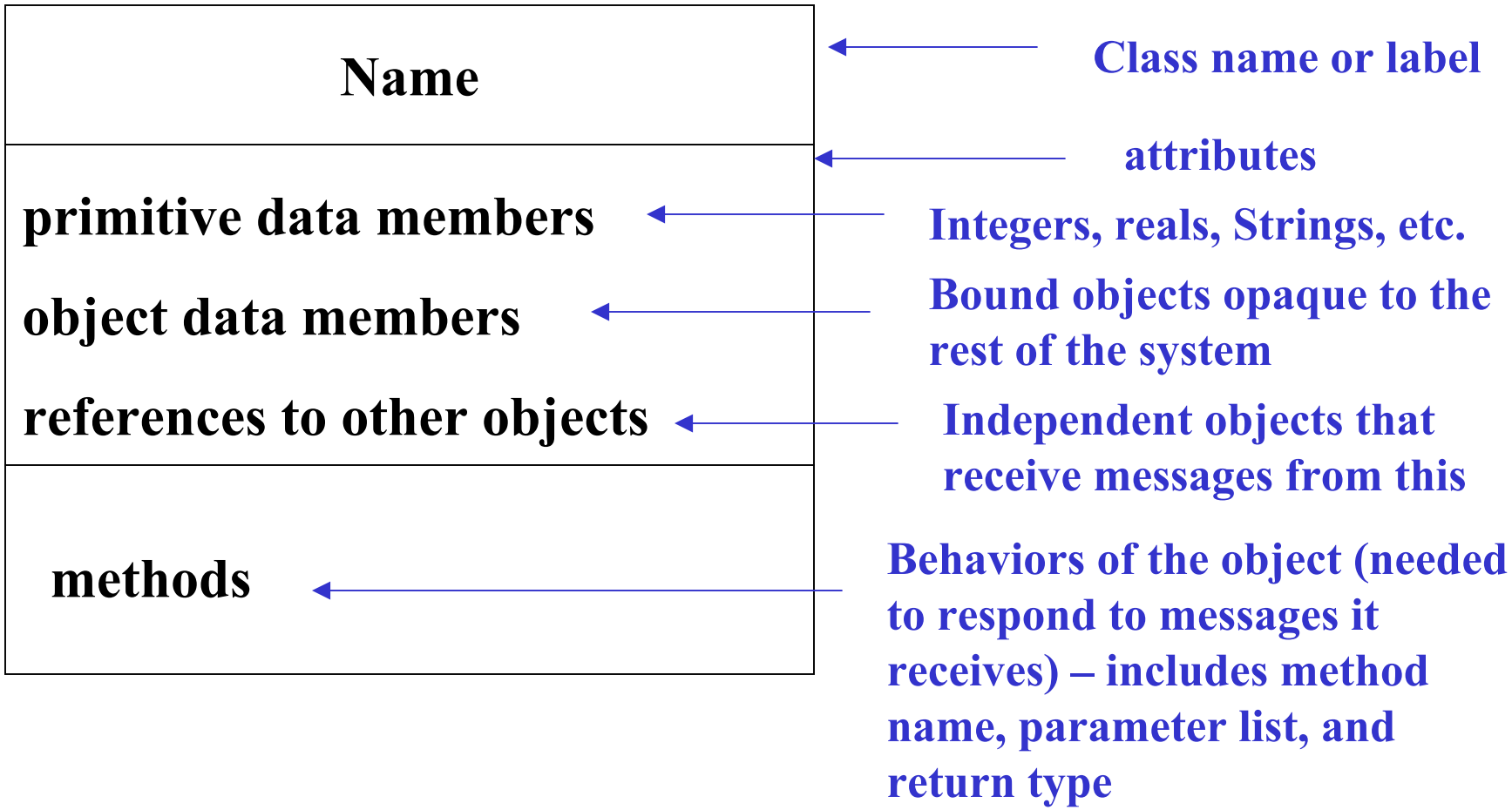
   These are the attributes of each Concept in the problem domain

4. **Identifying the messages to which an object must be able to respond, who they are sent by, and what behaviors an object is required to exhibit.**

   Adding behaviors (and the algorithms for implementing them) is a major focus of the design process

Systems Analysis – Building the Conceptual Model

Structure of a Class (The progressive refinement of a Concept)



System Analysis – Building the Conceptual Model

Step 1 – Identify concepts from the use cases

If it exists in the problem domain and is not a number or text, it's a concept.

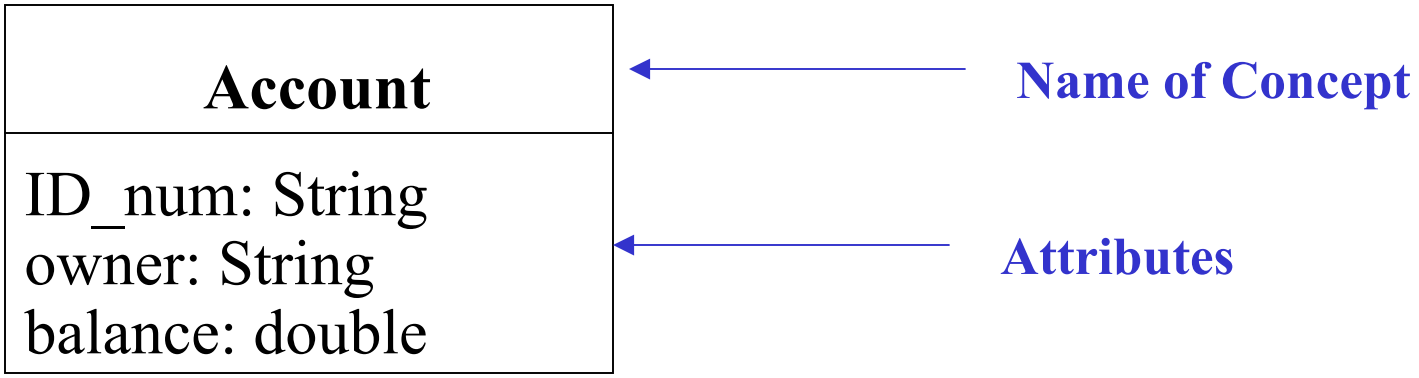
Example – Consider the *Withdrawal* use case previously shown

Candidates

Noun phrase	Decision
Customer	Concept (Actor)
ATM Machine	Concept
Debit Card	Concept
passcode	Concept
Menu of options	Concept
Withdrawl option	Concept
Amount	Attribute (of Transaction)
Increments ….	Constraint
Limit allowed	Concept
Account	Concept
Current Balance	Attribute of Account
Bill (Currency denomination)	Concept

System Analysis – Building the Conceptual Model

Step 2 – For each concept identified, draw a rectangular box

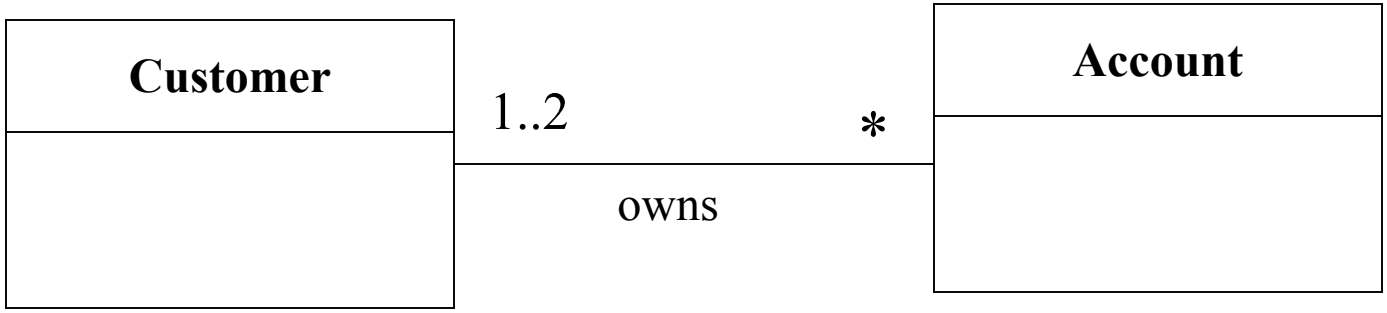


In the first Conceptual Model it is not necessary (nor necessarily desirable) that all of the attributes and their types be listed. You should limit yourself to just those attributes appearing in the use cases, and you should not list the types. (It is an implementation detail left for the Class Model Diagram.)

System Analysis – Building the Conceptual Model

Step 3 – Adding associations

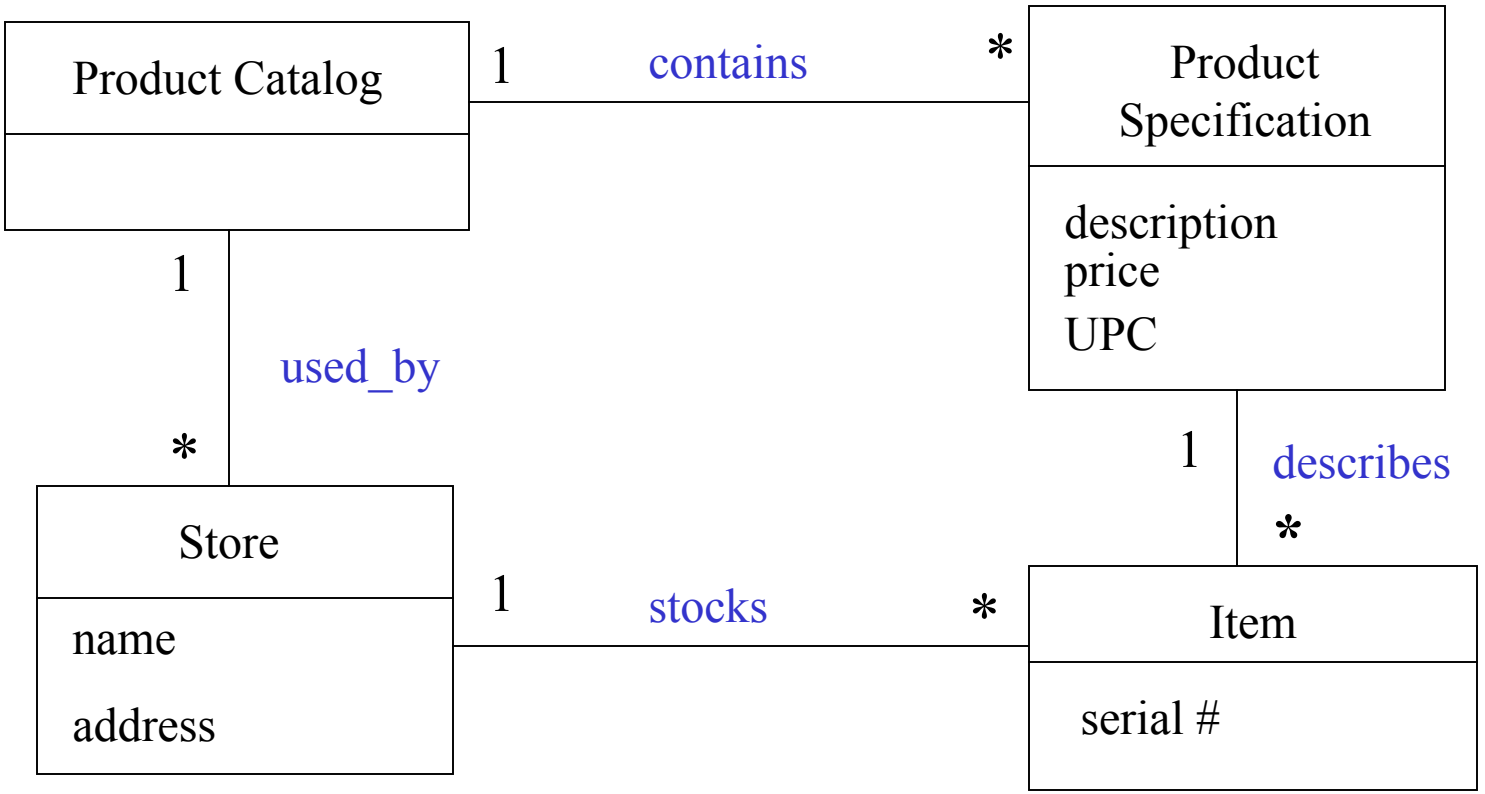
Associations can be discovered from the verb phrases in the use cases.



An Account may have a multiplicity of 1 or 2 (joint) owners

System Analysis – Building the Conceptual Model

Distinguish between the physical object and the specification of that object when: deleting the physical object leads to loss of information that needs to be maintained



System Analysis – Building the Conceptual Model

During a later elaboration, we will convert the conceptual model into the Class Diagram (also called the Object Model Diagram). At that time we will not only add classes from the solution domain (the domain of the software implementation), but we will also add additional refinements to the description of the associations

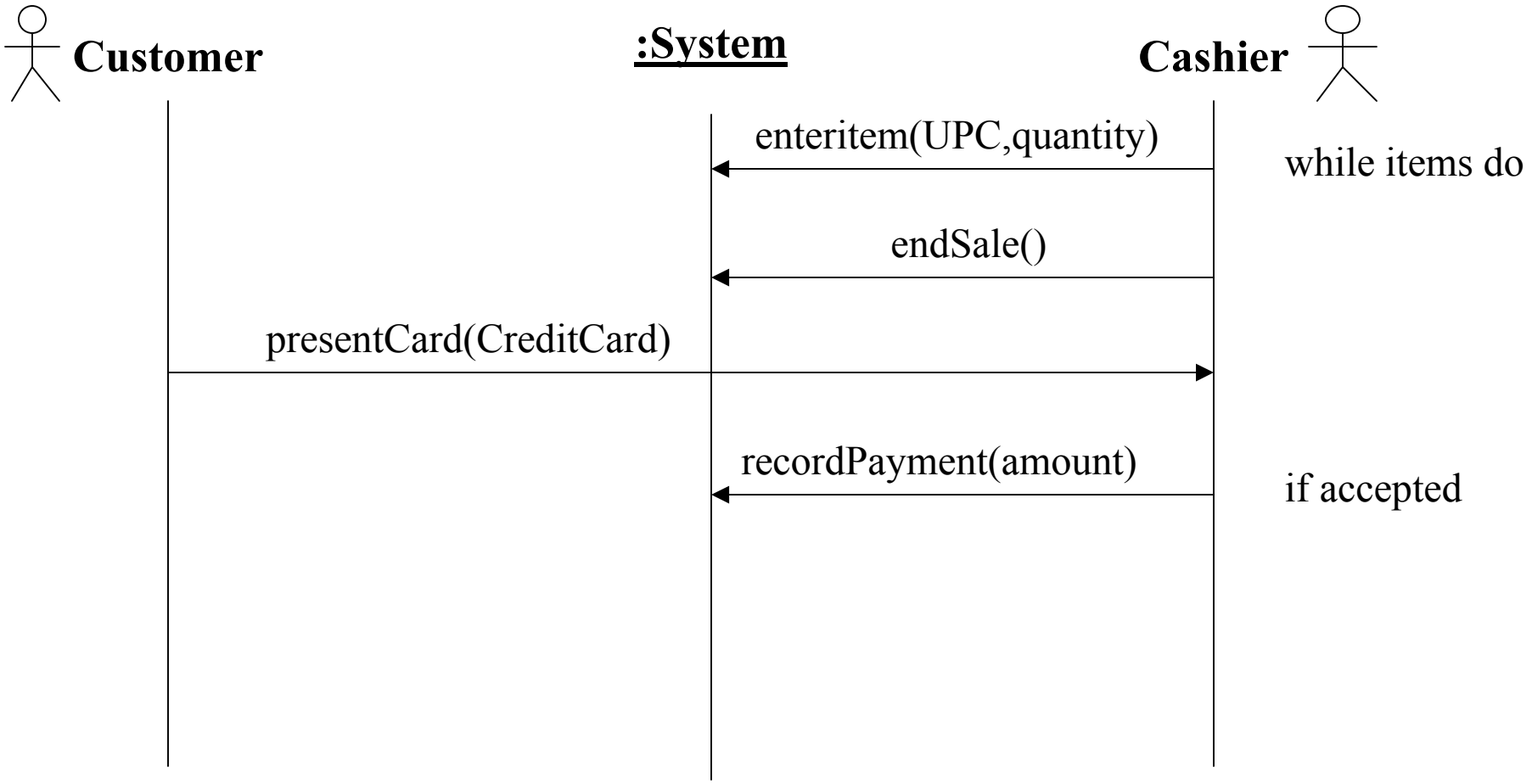
System Analysis – Use Case Model

Use case model diagrams illustrate the operations that Actors request of a system (system Operations) and the external events (if any) that the system produces as a result of each operation.

Computer systems do not initiate events – they can only respond to requests or stimuli from agents outside the system boundary. Each system operation will initiate changes in the state of the system that may be accompanied by an output (external event).

It is the job of the analyst to establish the pattern of collaboration between the objects in the system needed to perform each system operation.

System Analysis – System Sequence Diagrams



Example taken from the use case Buy Items

System Analysis – Sequence Diagrams

To construct a system sequence diagram for a typical sequence of events for a use case:

1. **Draw a vertical line representing the system as a black box. (We are only concerned with the "stimuli" and response of the system – not its internal details.) Time increases in the direction of the line from top to bottom.**
2. **Draw a line for each Actor identified in the use case.**
3. **Identify the System Operations that each Actor generates, and indicate them as directed horizontal line segments arranged in sequence on the diagram.**
4. **Indicate with textual notes those operations that occur conditionally or repeatedly.**

System Analysis -- Contracts

For each System Operation a Contract will indicate

- **Name:** Name of the system Operation
- **Description:** Brief narrative
- **Collaborating Objects (Classes)**
  - **Creates:** Classes of objects created
  - **Changes:** Classes of objects whose state is changed
  - **Reads:** Classes of objects read, not altered
- **Output:** Value or object returned
- **Preconditions:** States that will not raise an exception
- **Exception:** Action taken if preconditions not met\
- **Post-conditions:** State of system after completion

System Analysis -- Contracts

To make a Contract (Schema) for each use case:

1. **Identify system operations from the sequence diagrams**
2. **For each system operation, construct a contract**
3. **Start by writing the Description, informally describing the purpose of the operation (in terms of the concepts previously defined)**
4. **List the preconditions that must be true for this operation to be successfully completed**
5. **Describe the post-conditions, listing objects created or dissolved, attributes modified, associations formed or broken**
6. **From the description and the post-conditions, determine which (classes of) objects are created, changed, or read during the implementation of the operation.**

System Analysis -- Contracts

Example: **Consider a system operation in the ATM example –**

processWithdrawl(amount: double)

Description: If the amount indicated is less than the balance in the customer's account, is less than or equal to the transaction limit, and is divisible by the minimum denomination, then a transaction occurs in which the customer's account balance is reduced by the amount of the transaction, the transaction is recorded by the bank, and the customer is issued money and a receipt.

System Analysis -- Contracts

Precondition: The amount of the transaction is less than the customer's account balance, AND the amount is less than or equal to the transaction limit, AND the amount is divisible by the minimum denomination

Exception: The failed transaction is recorded by the bank and no money is dispersed to the customer. The transaction is dissolved and a new menu is presented.

System Analysis -- Contracts

Post-conditions:

Transaction is completed

Account.balance changed

Transaction.data added to *BankRecord*

StartMenu is displayed

Account association is discontinued

State transition

Attribute Modification

Association formed or broken

Instances of creation/deletion of objects

System Analysis -- Contracts

Changes:	Account.balance
	Transaction.data
	BankRecord
	Menu
Reads:	Account.balance
	Transaction_limit
	Min_denomination
Creates/Dissolves:	Transaction
Output:	Bills – to Customer

Analysis Phase

This concludes the formal analysis stage. As you proceed with the design in later elaborations, concepts will become more clearly delineated, omissions will be recognized, and you will undoubtedly return and refine your analysis models. Realize that the whole purpose of this exercise is to improve your design and facilitate the implementation and maintenance of your system. The analysis and design is not an end in itself, but a precursor to the construction of a robust and useful system. Building a significant software system with inadequate analysis and design is analogous to constructing a major building without appropriate blueprints and architectural models. Every step in the analysis and design should ultimately translate to the implementation details, or else it is an inherently useless exercise.

Postscript

I met a traveller from an antique land
Who said: Two vast and trunkless legs of stone
Stand in the desert … Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them, and the heart that fed:
And on the pedestal these words appear:
'My name is Ozymandias, king of kings:
Look on my works, ye mighty and despair!'
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away.

Percy Bysshe Shelly 1818