Requirements Analysis

Overview

- What is **requirement**?
- Classification of requirements
- Iterative and evolutionary requirements analysis
- Use Cases
- Domain models

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Requirements

- Definition [LAR]
  - Capabilities and conditions to which the system—and more broadly, the project—must conform
- Focusing on the **WHAT** not the **HOW**

Requirements Analysis Is Hard

- Major causes of project failures
  - Incomplete requirements
  - Changing requirements
  - Poor user input
- Essential solutions
  - Classification of requirements
  - Iterative and evolutionary requirements analysis
  - Use Cases

Classification of Requirements

- Functional: features, capabilities, security
  - "The system reads employee records and prints paychecks"
  - All other reqs are non-functional
- Usability: human factors, help documentation
  - "Text on the display must be visible from 1 meter."

Classification of Requirements

- Reliability: frequency of failure, recoverability, predictability
  - "When doing search, the radar should have 28 hours MTBF(mean time between failures)"
- Performance: response times, throughput, accuracy, availability, resource usage
  - "The server response time is <1 sec for 90% of the accesses"

Classification of Requirements

- Supportability: adaptability, maintainability, internationalization, configurability
  - "The system should allow frequent and easy changes in the network configuration"
- Implementation: resource limitations, languages, tools, hardware
  - "Must use Linux and Java"

Iterative and Evolutionary Requirements Analysis

- Motivation
  - 20-50% of the original reqs change because of miscommunication or changing business needs
- Strategies
  - 10-20% of the most architecturally significant, risky, and high-business-value requirements are specified before the initial implementation
  - The short duration of iterations allows quick adaptation and increments of reqs.

Requirements Elicitation

- Brainstorming
  - Gather stakeholders, collect ideas and prune
- Interviewing
  - Formal or informal interviews with stakeholders
- Ethnography
  - A social scientist observes and analyzes how people actually work
- Strawman/Prototype
  - GUI, flow charts of UIs

Requirements Analysis in the UP

- Major artifacts: Use Cases and Supplementary Specification
  - Use Cases: functional requirements
  - Supplementary specification: non-functional requirements

How to do iterative requirement analysis?

- Inception, 2 days
  - Identify names of use cases and features, and key non-functional requirements
  - 10% are analyzed in detail due to high-risk, high-business-value, and architecture significance
- Iteration planning meeting
  - Choose a subset of the 10% for implementation, break them down to detailed iteration tasks

Possible Timeline

- Elaboration, iteration #1, 4 weeks
  - Design, implement, and test selected features
  - Demo it to collect feedback
  - Pick another 15-20% to analyze in detail (2 days)
- Iteration planning meeting
- Elaboration, iteration #2, 4 weeks
  - Repeat iteration #1

… …

- Elaboration, iteration #4, 4 weeks

At the end of Elaboration, ...

- 80-90% use cases are analyzed and written in detail
- 10% implementation done
- Other phases do very little work on use cases

Definitions—Stakeholders

- People who support, benefit from, or are affected by a software project
  - Managers
  - Communicators
  - Software engineers
  - Maintainers
  - System administrators
  - Users
  - Customers

Definitions

- Use case is a story of using the system to fulfill stakeholder goals
  - It is a **text document**, not a diagram
  - Its name usually contains a verb
- Use-Case Model: the set of all written use cases
- Use-Case Modeling: primarily an act of **writing text**, not drawing diagrams

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Use Cases

The Role of Use Cases

- The most widely used approach for capturing requirements
- Input to many subsequent activities and artifacts

Running example: point-of-sale (POS) system [LAR]

- **Process Sale** use case

  A customer arrives at a checkout with items to purchase. The cashier uses the POS system to record each purchased item. The system presents a running total and line-item details. The customer enters payment information, which the system validates and records. The system updates inventory. The customer receives a receipt from the system.

Q1: Who Are the Stakeholders?

- Customer
- Cashier
- Store
- Government tax agencies
- Credit card company

Terms Relevant to Use Cases

- Actor: Something with behavior
  - Person, computer system, organization
- Scenario (use case instance)
  - a specific sequence of actions and interactions between actors and the system
- Use case: a collection of related success and failure scenarios that describe an actor using the system to support a goal

Three Kinds of Actors

- Primary actor: uses the system to fulfill goals
  - E.g., cashier
  - Why? To find user goals and drive use cases
- Supporting actor: provides a service to the system
  - E.g., Payment authorization service
  - Why? To clarify external interfaces and protocols
- Offstage actor: has an interest in the behavior
  - E.g., Tax agencies
  - Why? To ensure that all necessary interests are identified and satisfied

Handle Returns use case

- Main Success Scenario: A customer arrives with items to return. The cashier uses the system to record each returned item …
- Alternative Scenarios:
  - If they paid by credit, and the reimbursement transaction to their credit account is rejected, pay by cash
  - If the system detects failure to communicate with the external accounting system, …
  - (Any other alternatives?)

Black-Box Use Cases

- Do NOT describe the internal workings of the system
  - Only system responsibilities
  - Focus on "what" the system should do
  - Good: "The system records the sale"
  - Bad:
    - "The system writes the sale to a database"
    - "The system generates SQL INSERT statement for the sale"

Levels of Formality

- Brief: one-paragraph, for the main success scenario
  - Process Sale example is brief
- Casual: multiple paragraphs that cover several scenarios
  - Handle Return example is casual
- Fully dressed: all steps and variations
  - Developed iteratively during elaboration; the product of requirement analysis

Fully Dressed Use Case - Outline

Use Case UC1: Process Sale

Primary Actor: Cashier
Stakeholders and interests:
E.g., Cashier: want accurate and fast payment
Preconditions
Success guarantee
Main success scenario
Extensions
Special requirements
Technology and data variation List
Frequency of Occurrence

Preconditions

- States what **must always** be true before a scenario is begun in the use case
  - Often the postconditions of another use case
  - Don't bother with it unless you are stating something noteworthy
    - "The system has power" –not interesting

Preconditions: Cashier is identified and authenticated

Success Guarantees (Postconditions)

- State what **must** be true on successful completion of the use case—either the success scenario or alternative ones

Success guarantee: Sale is saved. Tax is correctly calculated. Accounting and Inventory are updated. Commissions are recorded. Receipt is generated.

Main success scenario (Basic Flow)

- Defer all conditional and branching statements to the Extension section
- Records three kinds of steps:
  - An interaction between actors
  - A validation (usually by the system)
  - A state change by the system

Main Success Scenario:
1. Customer arrives at a POS checkout with items to purchase
2. Cashier starts a new sale
3. Cashier enters item identifier
4. System records the item, presents description and price. Price and total are calculated based on a set of rules.

Main Success Scenario: (cont'd)

Repeat 3-4 until cashier indicates done.

5. System presents total with tax calculated by an external Tax Calculator system.
6. Cashier asks Customer for payment.
7. Cashier enters cash amount tendered, System handles payment.
8. System logs completed sale and sends sale and payment information to the external Accounting system and external Inventory system.
9. System presents receipt.

Q2: What are the actors?

Primary: cashier

Supporting: Tax Calculator, Accounting, Inventory

Customer could be considered as an actor, but has no direct interaction with the system

Extensions (or Alternative Flows)

- Often comprise the majority of text
- Indicate all the other scenarios or branches, both success and failure
- Notated with respect to its corresponding steps 1..N in the main success scenario.

Main Success Scenario:
… …
3. Cashier enters item identifier
… …

Extensions:
3a. Invalid identifier
    1. System signals errors and rejects entry.
    2. Cashier responds to the error:
        2a. There is a human-readable item ID(e.g., a numeric UPC)
            1. Cashier manually enters the item ID.
            2. System displays description and price.
                2a. Invalid item ID: System signals error. Cashier tries alternative method.
        2b. There is no item ID, but there is a price on the tag:
            1. Cashier asks Manager to perform an override operation.
            2. Manager performs override.
            3. Cashier manually enters the price

Special Requirements

- If a non-functional requirement relates specially to a user case, record it with the use case

Special Requirements:
- Touch screen UI on a large flat panel monitor. Text much be visible from 1 meter.
- Credit authorization response within 30 seconds 90% of the time.
- Robust recovery when access to remote Inventory service fails
- Language internationalization on the text

Technology and Data Variations List

- Technical variations in "how" something must be done
  - Early design decisions or constraints
    - Technical constraint imposed by stakeholders about input/output technologies.
  - Try to avoid premature design decisions unless they are obvious or unavoidable
- Data scheme variations necessary to understand

Technology and Data Variations List:

3a. Item identifier entered by laser scanner or keyboard.

3b. Item identifier may be any UPC, EAN, JAN, or SKU coding scheme.

7a. Credit account information entered by card reader or keyboard.

7b. Credit payment signature captured on paper receipt. But within two years, we predict many customers will want digital signature capture.

Unified Modeling Language (UML)

- Definition
  - A visual language for specifying, constructing, and documenting the artifacts of systems
  - Standard diagramming notation for drawing pictures related to software
  - Includes 13 types of diagrams

Two Categories of UML Diagrams

- Structural UML diagrams
  - Class diagram
  - Object diagram

  … …
- Dynamic UML diagrams
  - Use case diagram
  - Sequence diagram

  … …

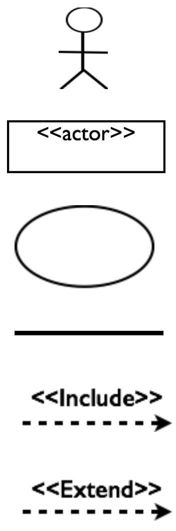
We will discuss

- Use case diagram (Requirement)
- Class diagram (Requirement & Design)
- Sequence diagram (Design)
- Communication diagram (Design)

Use case diagram

- Definition
  - A representation of interactions between actors and the system
- It shows relationship between actors, use cases, and the system
  - the scope of the system
  - the external actors
  - how actors use the system
- It is secondary to text documentation

Legends



Actor: an entity that interacts with the system.

Actor: a computer system that interacts with the system under discussion

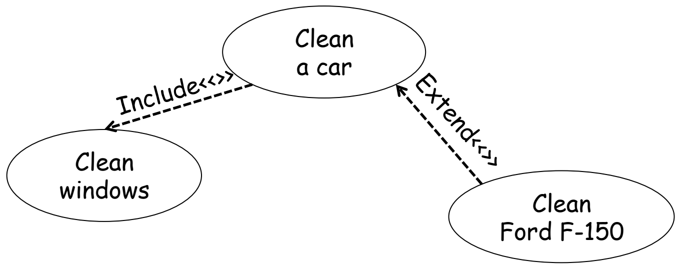
Use case: usage of a system

Association: relation between an actor and a use case

Includes dependency: a base use case includes a sub use case as component

Extends dependency: a use case extends the behavior of a base use case.

What are the relations?



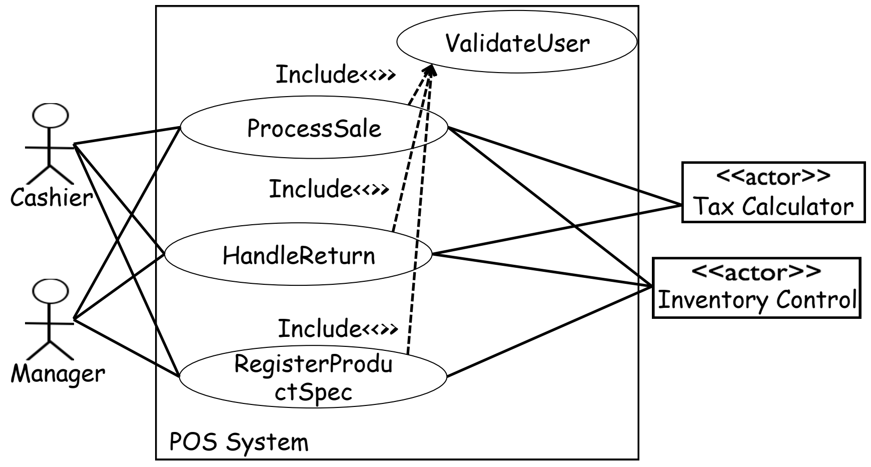
Case study: POS system

- With a POS system,
  - a cashier can perform the following tasks (with help of the manager if necessary):
    - Process sale
    - Handle return
    - Register product specification
  - For each activity, the system may first authenticate the cashier or manager
- The POS system interfaces to third-party tax calculator and inventory control

Use Case Diagram

- What are the actors?
- What is included in the system?
- What are the use cases?
- What is the relationship between use cases?

Use Case Diagram



Domain Models

- A domain model is a visual representation of conceptual classes or real-situation objects showing:
  - Domain objects or conceptual classes
  - Relationship between conceptual classes
  - Attributes of conceptual classes
- Illustrated with a set of UML Class diagrams

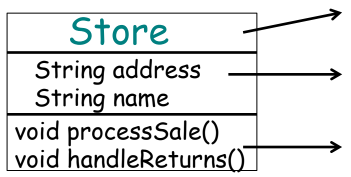
Roles of a Domain Model

- Built upon use cases
- Basis for design and implementation
- The most important and classic model in OO analysis

UML Class Diagram

- Definition
  - A visual representation of main objects and their relations for a system
- Elements
  - Classes containing: Attributes, Operations
  - Various relationship: Association, Aggregation, Composition, Generalization

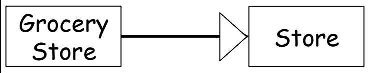
Legends



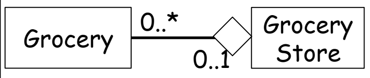
Class name: abstract concepts

Attributes: properties relevant to the problem

Operation (Method signatures): behaviors of the class

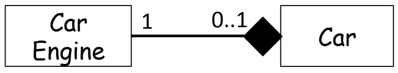


Generalization: "is-a" relationship. A sub-class inherits all attributes and operations of its super class

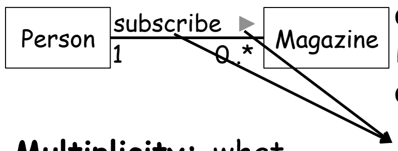


Aggregation: "has-a" relationship. The container and elements can exist independently from each other

Legends



Composition: stronger "has-a" relationship. If the container is destroyed, the elements it contains are usually destroyed as well.



Association: can generally represent any relationship other than "is-a". Both **Aggregation** and **Composition** are variants of **Association**.

Multiplicity: what number of instances can be associated?

Name and Direction Arrow: to enhance understanding of the relationship

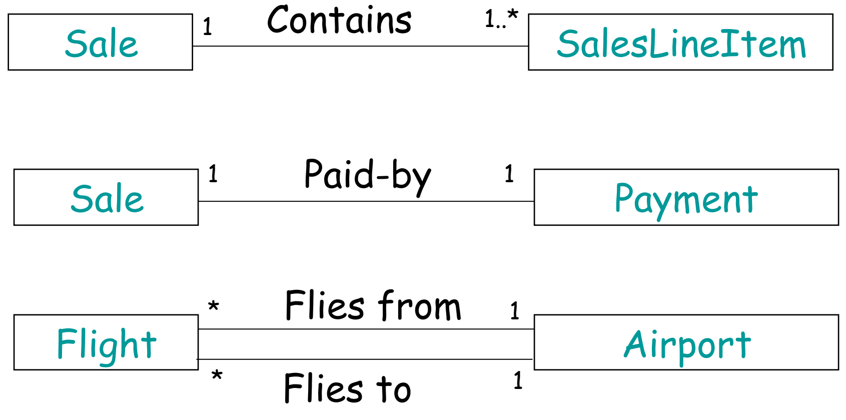
Multiplicity

- Range: x..y
- Common notation for ranges
  - x..x -> x
  - x..infinity -> x..*
  - 0..infinity -> *
- Combination of ranges
  - x..y, z..w
  - e.g. “2,4” -> number of doors in a car
- Most common multiplicities: *, 1..*, 0..1, 1

Association Examples

- SalesLineItem-Sale
  - A sale contains lines of sale items
- Payment-Sale
  - A payment is always related to a sale
- Flight-Airport
  - A flight flies from an airport and to another airport

Domain Models



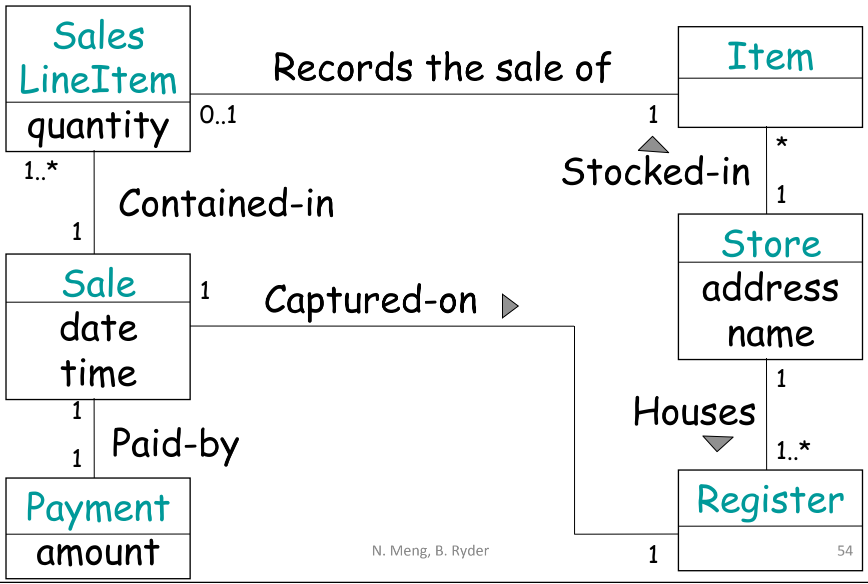
Key Points about UML Class Diagram

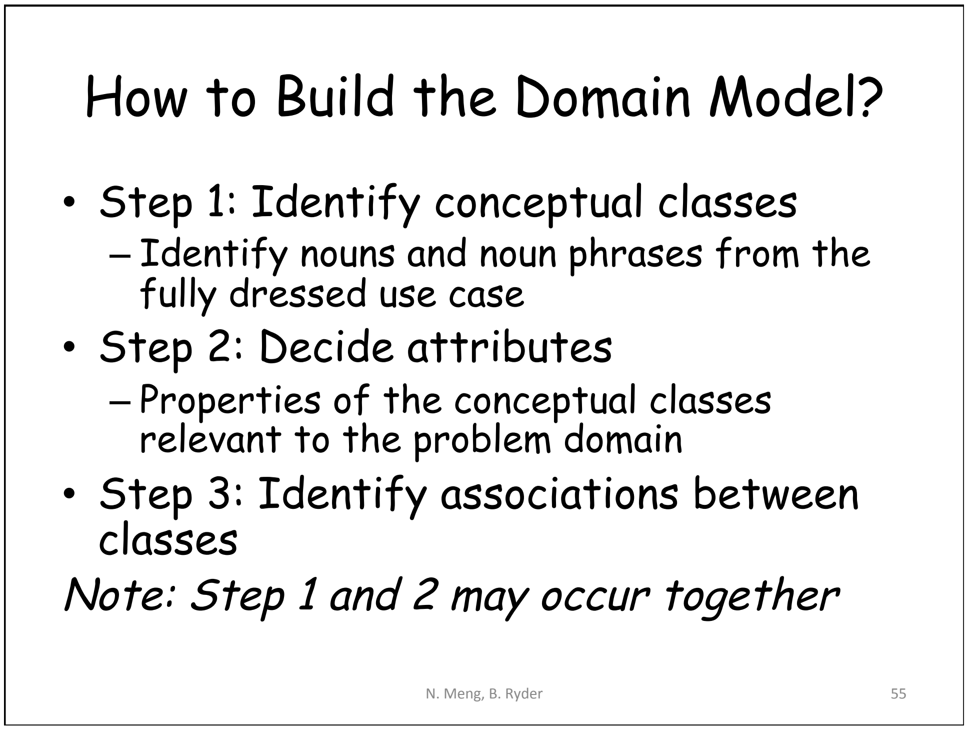
- UML is just notation
- UML class diagram means different things in different contexts
  - Conceptual perspective: description of the domain model
  - Specification perspective: description of software abstractions or components
  - Implementation perspective: description of Java classes

Domain model

- A small set of UML class diagram elements
  - Classes
    - Attributes
    - Operations
  - Relationship
    - Generalization
    - Aggregation
    - Composition
    - Association
  - Multiplicity of relationship

A Conceptual Class Diagram





How to Build the Domain Model?

- Step 1: Identify conceptual classes
  - Identify nouns and noun phrases from the fully dressed use case
- Step 2: Decide attributes
  - Properties of the conceptual classes relevant to the problem domain
- Step 3: Identify associations between classes

Note: Step 1 and 2 may occur together

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