Object Oriented Analysis and Design

(OOA/D)

COMP3607
Object Oriented Programming II

Week 1

Outline

- Object-Oriented Analysis
  - Use Case
  - Conceptual Model
  - Collaboration Diagram
  - Class Diagram
- Conceptual Modelling
  - Building a conceptual model
  - Adding associations
  - Adding attributes

Critical Skill

Desert Island Skill in object oriented analysis and design:

To skilfully assign responsibilities to software objects.

- must be performed either while drawing UML diagrams or programming

- strongly influences the robustness, maintainability and reusability of software components

Object Oriented Analysis and Design

Critical questions to ask when designing a system:

- How should responsibilities be allocated to classes of objects?
- How should objects interact?
- What classes should do what?

Analysis vs Design

Analysis emphasizes an investigation of the problem and *requirements* rather than a solution. e.g. Finding and describing the objects or concepts in a problem domain.

Design emphasizes a conceptual solution (in software and hardware) that *fulfils* the requirements, rather than its implementation. e.g. Defining classes, interfaces relevant for the scope of the solution.

Analysis and Design Phases

Define Essential Use Cases

Define Conceptual Model

Define Collaboration Diagrams

Define Class Diagrams

Representing the Domain

Identifying a **rich set of objects** or **concepts** is at the heart of OOA. This leads to an understanding of the meaningful concepts in a problem domain

Use Case

A **use case** describes processes in a domain in narrative format.

Defining use cases is a preliminary step in describing the requirements of a system.

Use cases are an important requirements analysis artifact, but they are not really object-oriented. They emphasise a **process view** of the domain.

Example: Use Case

Simple example: Dice Game

A player rolls 2 die. If the total on the dice equals to 7, the player wins otherwise the player loses.

Goal

Use Case: Play a game

Actor(s): Player

Description: Use case begins when the player picks up the dice and rolls them. If the total on the dice equals to 7, then the player wins otherwise the player loses.

Success and failure scenarios for the goal

Conceptual Model

A **conceptual model** represents real-world things, not software components.

It is represented in UML notation as a static structure diagram and may show:

- Concepts
- Associations between concepts
- Attributes of concepts

Conceptual models illustrates the different categories of things in the domain and it may clarify the roles of people involved in processes.

Example: Conceptual Model

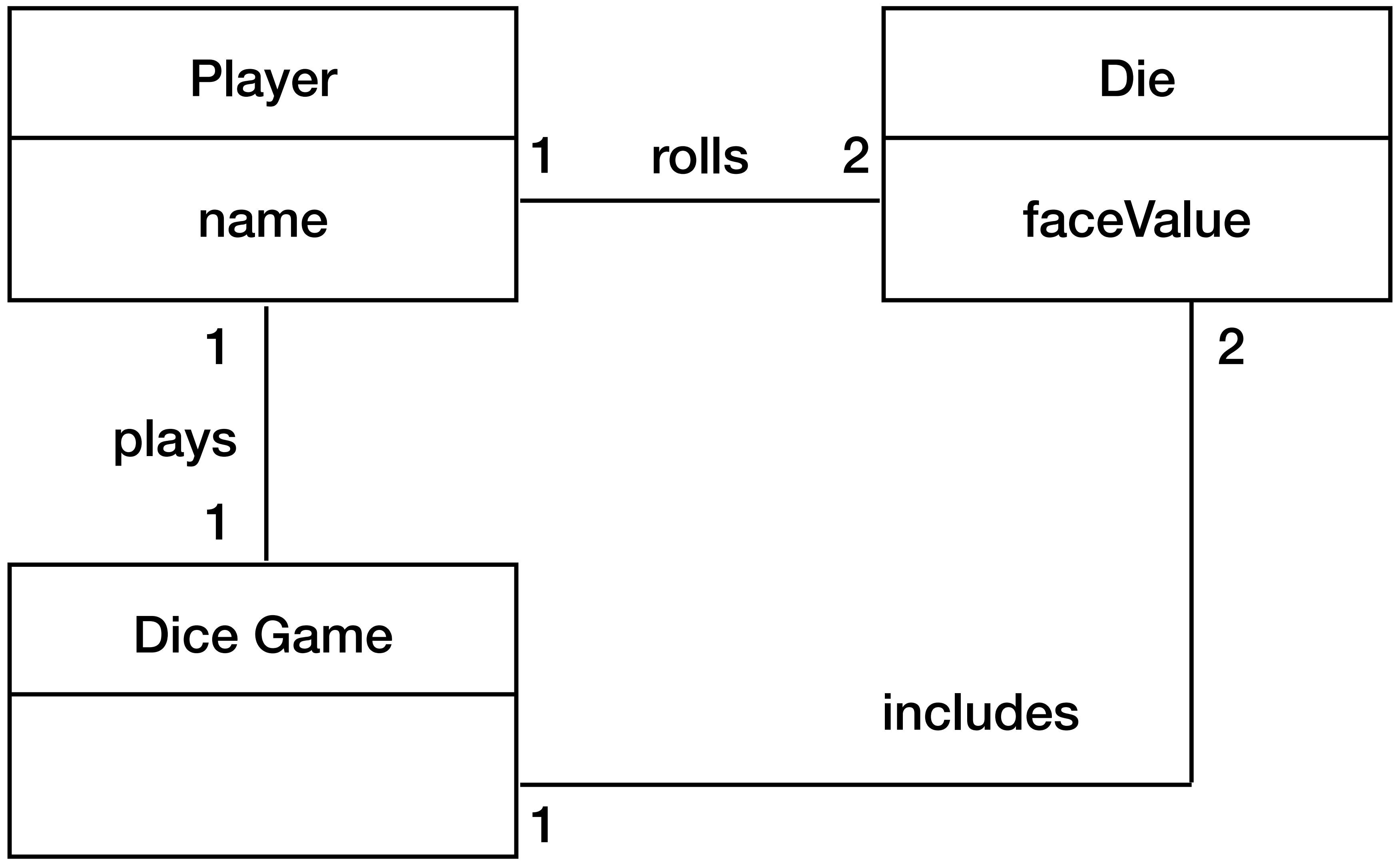


Figure 1: Conceptual Model of the Dice Game

Collaboration Diagram

A **collaboration diagram** illustrates how objects interact via messages. It shows the **flow** of **messages** and the invocation of **methods**.

Sequence diagrams are a type of collaboration diagram.

Example: Sequence Diagram

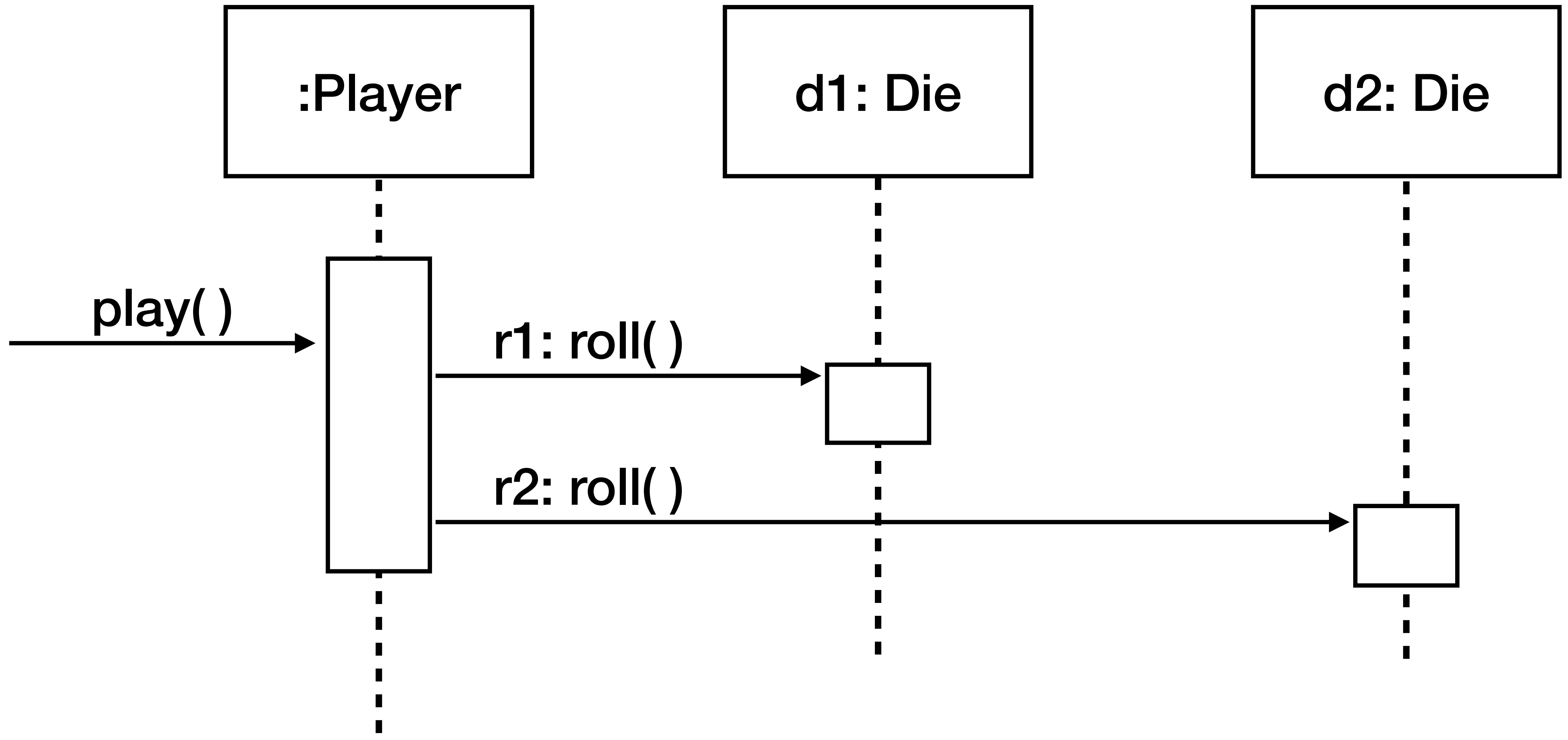


Figure 2: Sequence Diagram of the Dice Game Illustrating Message Flow and Method Invocation

Class Diagram

A **Class diagram** shows the structure of a designed system. It shows the

- level of classes and interfaces
- salient features and state for classes/objects
- constraints and relationships
  - associations
  - generalizations
  - dependencies

Class Diagram

A class diagram specifies how objects connect to other objects and what are the operations of the objects.

Class diagrams describe actual software components rather than real-world entities (as in the conceptual model).

Types of Class Diagrams

Some common types of class diagrams are:

- domain model diagram
- diagram of implementation classes.

Example: Class Diagram

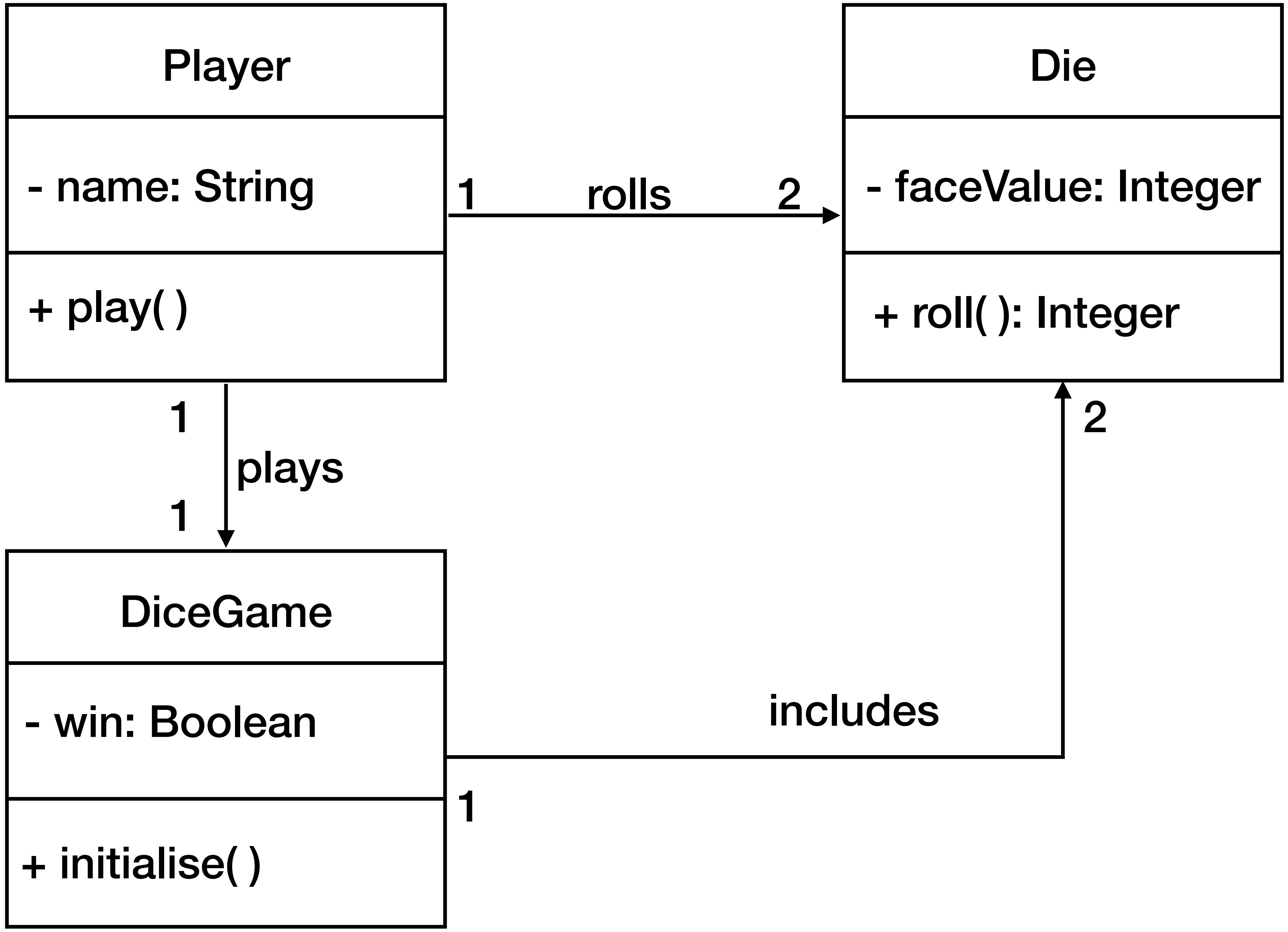


Figure 3: Class Diagram of the Dice Game

Use Cases

A use case is a narrative document that describes the sequence of events of an actor (an external agent) using a system to complete a process.

They are stories or cases of using a system that illustrate the requirements of the system.

Example: High Level Use Case

The following example describes the process of buying things at a store when a point-of-sale terminal is used.

Use Case: **Buy Items**

Actors: Customer, Cashier

Type: primary

Description: A Customer arrives at a checkout with items to purchase. The Cashier records the purchase items and collects payment. On completion, the Customer leaves with the items.

Expanded Use Cases

An expanded use case shows more detail than a high level one; they are useful for gaining a deeper understanding of the processes and requirements.

These are done often in conversation style between the actors and the system.

Expanded Use Cases -Format-

Use case: Name of use case

Actors: List of actors (external agents) indicating who initiates the use case

Purpose: Intention of the use case

Overview: Repetition of the high-level use case, or some similar summary.

Type: 1. Primary, secondary or optional

2. Essential or real

Cross References: Related use cases and system functions

Typical Course of Events

Example: Expanded Use Case

Expanded use case for the Buy Items that has been simplified to handle cash payments only and ignore inventory management (for simplicity).

Use Case: **Buy Items with Cash**

Actors: Customer (initiator), Cashier

Purpose: Capture a sale and its cash payment

Type: primary and essential

Overview: A Customer arrives at a checkout with items to purchase. The Cashier records the purchase items and collects a cash payment. On completion, the Customer leaves with the items.

Example: Expanded Use Case

Typical Course of Events

Actor Action	System Response
1. This use case begins when a Customer arrives at a POS checkout with items to purchase	
2. The cashier records the identifier from each item. If there is more than one of the same item, the Cashier can enter the quantity as well.	3. Determines the item price and adds the item information to the running sales transaction. The description and price of the current item are presented
4. On completion of item entry, the Cashier indicates to the POS that the item entry is complete	5. Calculates and presents the sale total

Alternative Courses

- Line 2: Invalid identifier entered. Indicate error

Example: Expanded Use Case

Actor Action	System Response
6. The Cashier tells the Customer the total	
7. The Customer gives cash payment - the cash tendered- possibly greater than the sale total	
8. The Cashier records the cash received amount	9. Shows the balance due back to the Customer Generates a receipt.
10. The Cashier deposits the cash received and extracts the balance owing. The Cashier gives the balance owing and the printed receipt to the Customer	11. Logs the completed sale.
12. The Customer leaves with the items purchased	

Alternative Courses

- Line 7: Customer didn't have enough cash. Cancel sales transaction

Actors

An actor is an entity external to the system who in some way participates in the story of the use case.

An actor typically stimulates the system with input events or receives something from it.

Actors are represented by the role they play in the use case, e.g. Customer, Cashier.

Kinds of actors:

- roles that people play
- computer systems
- electrical or mechanical devices

Identifying Use Cases

- One method used to identify use cases is actor-based:
  - Identify the actors related to the system or organisation
  - For each actor, identify the processes they initiate or participate in.
- A second method to identify use cases is event-based:
  - Identify the external events that a system must respond to
  - Relate the events to actors and use cases

Systems and Boundaries

Typical system boundaries:

- hardware/software boundary of a device or computer system
- department of an organisation
- entire organisation

Defining system boundary is important in order to identify what is internal vs external.

Primary, Secondary and Optional Use Cases

Primary use cases: represent major common processes e.g. Buy Items

Secondary use cases: represent minor or rare processes such as Request for Stocking New Product

Optional use cases: represent processes that may not be tackled

Essential Use Cases

Essential use cases are :

- expanded use cases that are expressed in ideal form
- relatively free of technology and implementation details
- high-level use cases (brevity, abstraction)

Real Use Cases

Real use cases concretely describe the process in terms of :

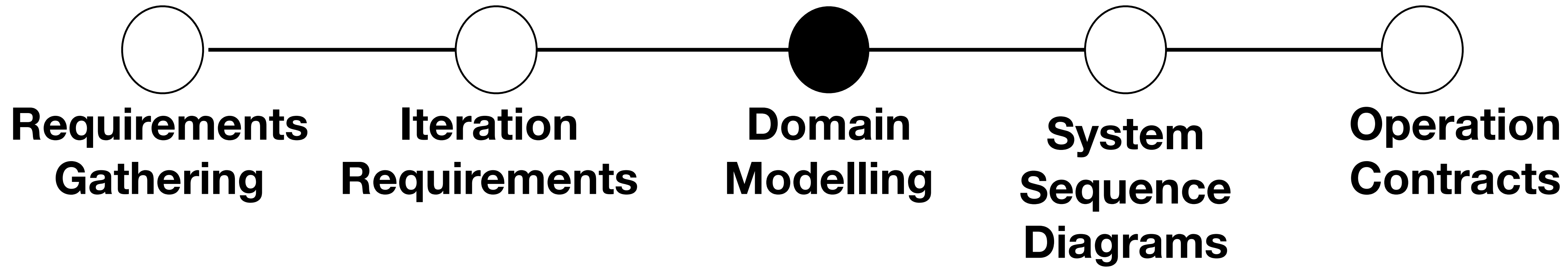
- its real current design
- specific input and output technologies

These are design artefacts.

Domain Modelling

A domain model is not a description of software objects; it is a visualisation of the concepts or mental models of a real-world domain.

- It is also called a conceptual model



Conceptual Modelling

Creating a conceptual model aids in clarifying the terminology or vocabulary of a domain.

It can be viewed as a model that communicates what the important terms are, and how they are related.

Conceptual models describe things in the real world, not software design. The following elements are therefore not suitable for a conceptual model:

- No software artefacts (database, windows)
- No responsibilities or methods

Example

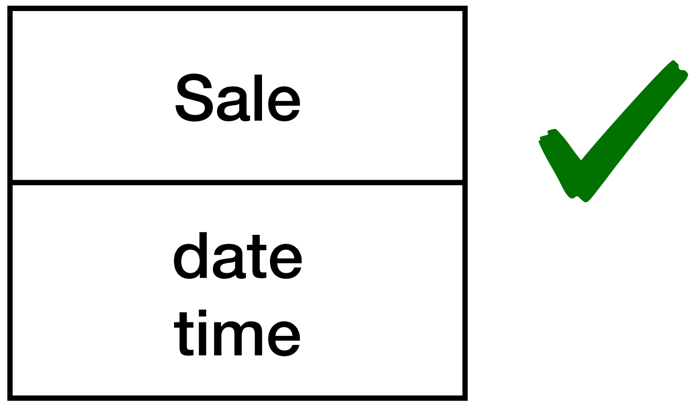
Consider the domain of a retail store where a point-of-sale system is used to record the sales made and handle payments.

The concepts of payments and sales are significant in this problem domain.

Suppose the date and time of each sale is recorded.

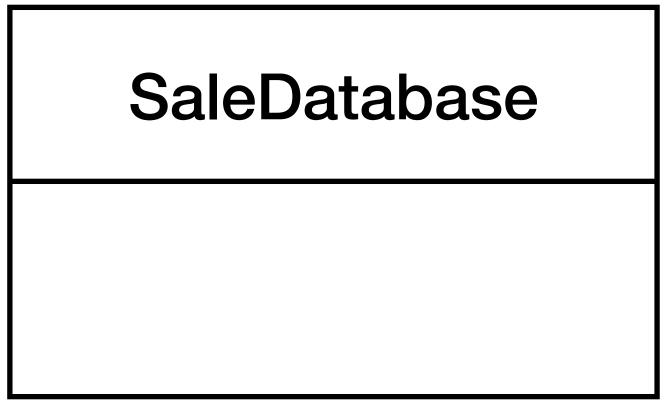
Example

Real world concept

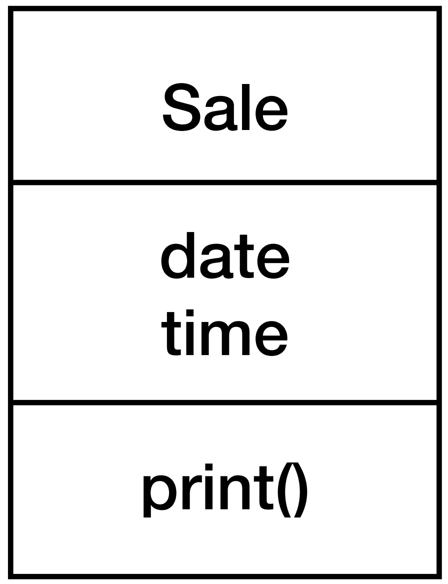


Software Artifact; Not part of a conceptual model

Avoid



Avoid



Software Class; Not part of a conceptual model

Concepts

A **concept** is an idea, thing or object. It may be formally considered in terms of its symbol, intension and extension.

- **Symbol**: words or images representing a concept
- **Intension**: the definition of a concept
- **Extension**: the set of examples to which the concept applies.

Example

Purchase transaction event:

This may be named by the symbol *Sale*.

The intension of a *Sale* may state that it represents the event of a purchase transaction, and has a date and time.

The extension of a *Sale* is all of the examples of sales, i.e., the set of all sales.

Strategies to Identify Concepts

The conceptual model identifies the different concepts in a problem domain.

A useful guideline in identifying concepts is to overspecify with lots of fine-grained concepts rather than to underspecify it.

Strategies to Identify Concepts

- **Concept category list:** physical or tangible objects, places, transactions, roles of people, containers of other things, events, organisations, processes, rules, policies, catalogues, records, services, mechanical/computer systems (external.

  Make a list of candidate concepts that are worth considering.

Strategies to Identify Concepts

- **Noun phrase identification**: identify nouns and noun phrases in the textual description of a problem domain and consider whether they should be candidate concepts or attributes.

  Expanded use cases are a good description to draw from for this analysis. This works well with the concept category list from the previous slide.

Concepts vs Attributes

A rule of thumb: If we do not think of some concept X as a number or text in the real world, X is probably a concept not an attribute.

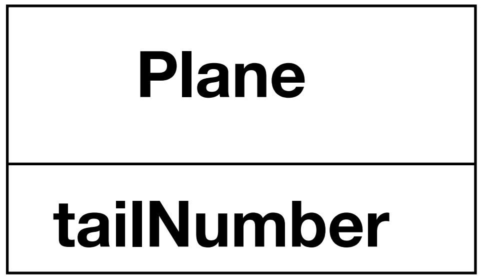
Eg. Domain of airline reservations

Should destination be an attribute of *Flight*, or a separate concept, *Airport*?

In the real world, a destination airport is not considered a number or text; it is a massive thing that occupies space. There *Airport* should be a concept.

Example: Plane

1. Domain concept



2. Visualisation of concept

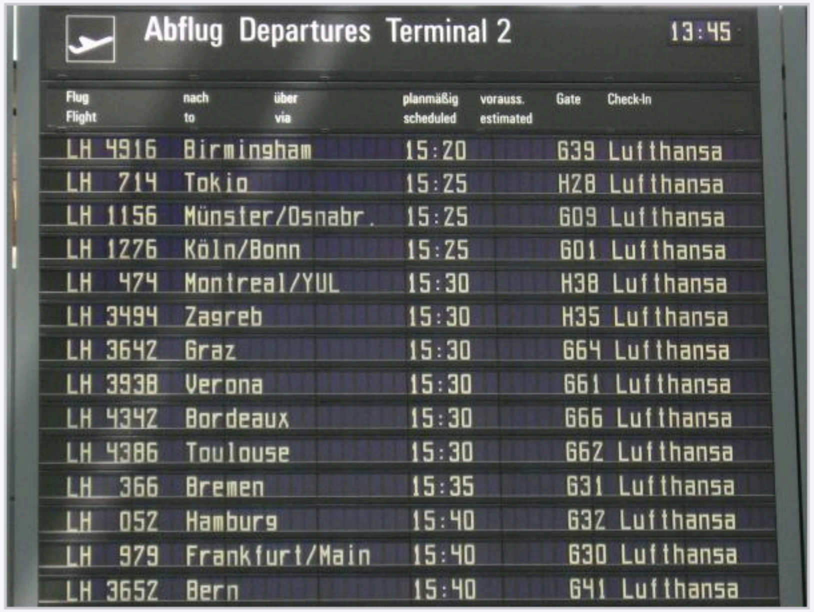
```
public class Plane{
private String
tailNumber;


public List
getFlightHistory(){…}
}
```

3. Representation in OO programming language

Exercise

Identify the concepts in a Flight Information System

A **flight information display system** (**FIDS**) is a computer system used in airports to display flight information to passengers, in which a computer system controls mechanical or electronic display boards or TV screens in order to display arrivals and departures flight information in real-time. The displays are located inside or around an airport terminal. A virtual version of a FIDS can also be found on most airport websites and teletext systems. In large airports, there are different sets of FIDS for each terminal or even each major airline. FIDS are used to inform passengers of boarding gates, departure/arrival times, destinations, notifications of flight delays/flight cancellations, and partner airlines, et al.



Flug Flight	nach to	über via	planmäßig scheduled	vorauss. estimated	Gate	Check-In
LH 4916	Birmingham		15:20		G39	Lufthansa
LH 714	Tokio		15:25		H28	Lufthansa
LH 1156	Münster/Osnabr.		15:25		G09	Lufthansa
LH 1276	Köln/Bonn		15:25		G01	Lufthansa
LH 474	Montreal/YUL		15:30		H38	Lufthansa
LH 3494	Zagreb		15:30		H35	Lufthansa
LH 3642	Graz		15:30		G64	Lufthansa
LH 3938	Verona		15:30		G61	Lufthansa
LH 4342	Bordeaux		15:30		G66	Lufthansa
LH 4386	Toulouse		15:30		G62	Lufthansa
LH 366	Bremen		15:35		G31	Lufthansa
LH 052	Hamburg		15:40		G32	Lufthansa
LH 979	Frankfurt/Main		15:40		G30	Lufthansa
LH 3652	Bern		15:40		G41	Lufthansa

Flight information display LCD board at Munich International Airport

(Sourced from Wikipedia)

Domain Model vs Use Case

A **domain model** is the most important (and classic) model in OO analysis.

A domain model illustrates noteworthy concepts in a domain.

Use cases are an important requirements analysis artefact but they are not object-oriented. They emphasise an activity view

UML stands for **Unified Modelling Language**. It is a language for specifying, visualising and constructing the artefacts of software systems.

Reading Resource: www.uml.org

UNIFIED MODELING LANGUAGE™ UML®

WHAT CAN YOU MODEL WITH UML?

UML 2.0 defines thirteen types of diagrams, divided into three categories: Six diagram types represent static application structure; three represent general types of behavior; and four represent different aspects of interactions:

- **Structure Diagrams** include the Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram.
- **Behavior Diagrams** include the Use Case Diagram (used by some methodologies during requirements gathering); Activity Diagram, and State Machine Diagram.
- **Interaction Diagrams,** all derived from the more general Behavior Diagram, include the Sequence Diagram, Communication Diagram, Timing Diagram, and Interaction Overview Diagram.

Reading Resource: http://uml.org/what-is-uml.htm

References

- C. Larman. Applying UML and Patterns
  - Part III: Domain Models