Class Diagrams

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Class Diagrams

- support **architectural design**
  - Provide a structural view of systems
- Represent the basics of **Object-Oriented systems**
  - identify what **classes** there are, how they **interrelate** and how they **interact**
  - Capture the **static** structure of Object-Oriented systems - how systems are structured rather than how they behave
- Constrain interactions and collaborations that support functional requirements
  - **Link to Requirements**

Class Diagram Rationale

- Desirable to build systems **quickly** and **cheaply** (and to meet requirements)
  - All required behaviour can be realized simply from objects in the classes of the system
  - The system consists of a collection of objects in the implemented classes (e.g., there may be a GUI coordinate human interaction with the other parts of the system)
- Desirable to make the system easy to **maintain** and **modify**
  - The classes should be derived from the (user) domain – avoid abstract object
  - Classes provide limited support to capture system behaviour - avoid to capture non-functional requirements of the system as classes

Class Diagrams in the Life Cycle

- They can be used throughout the development life cycle
- Class diagrams carry different information depending on the phase of the development process and the level of detail being considered
    - The contents of a class diagram will reflect this change in emphasis during the development process
    - Initially, class diagrams reflect the **problem domain**, which is familiar to end-users
    - As development progresses, class diagrams move towards the **implementation domain**, which is familiar to software engineers

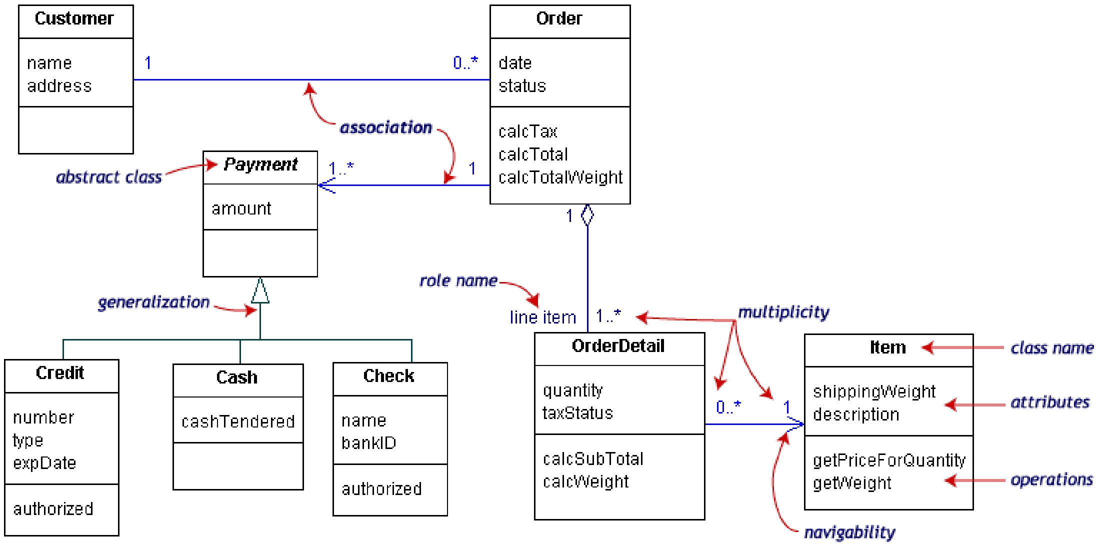
Class Diagrams at a Glance

Class Diagram Basics

- Classes
  - Basic Class Components
  - Attributes and Operations
- Class Relationships
  - Associations
  - Generalizations
  - Aggregations and Compositions

Construction involves

1. Modeling classes
2. Modeling relationships between classes and
3. Refining and elaborate as necessary



Classes and Objects

- Classes represent groups of objects all with similar roles in the system
  - Structural features define what objects of the class know
  - Behavioral features define what objects of the class can do
- Classes may
  - inherit attributes and services from other classes
  - be used to create objects

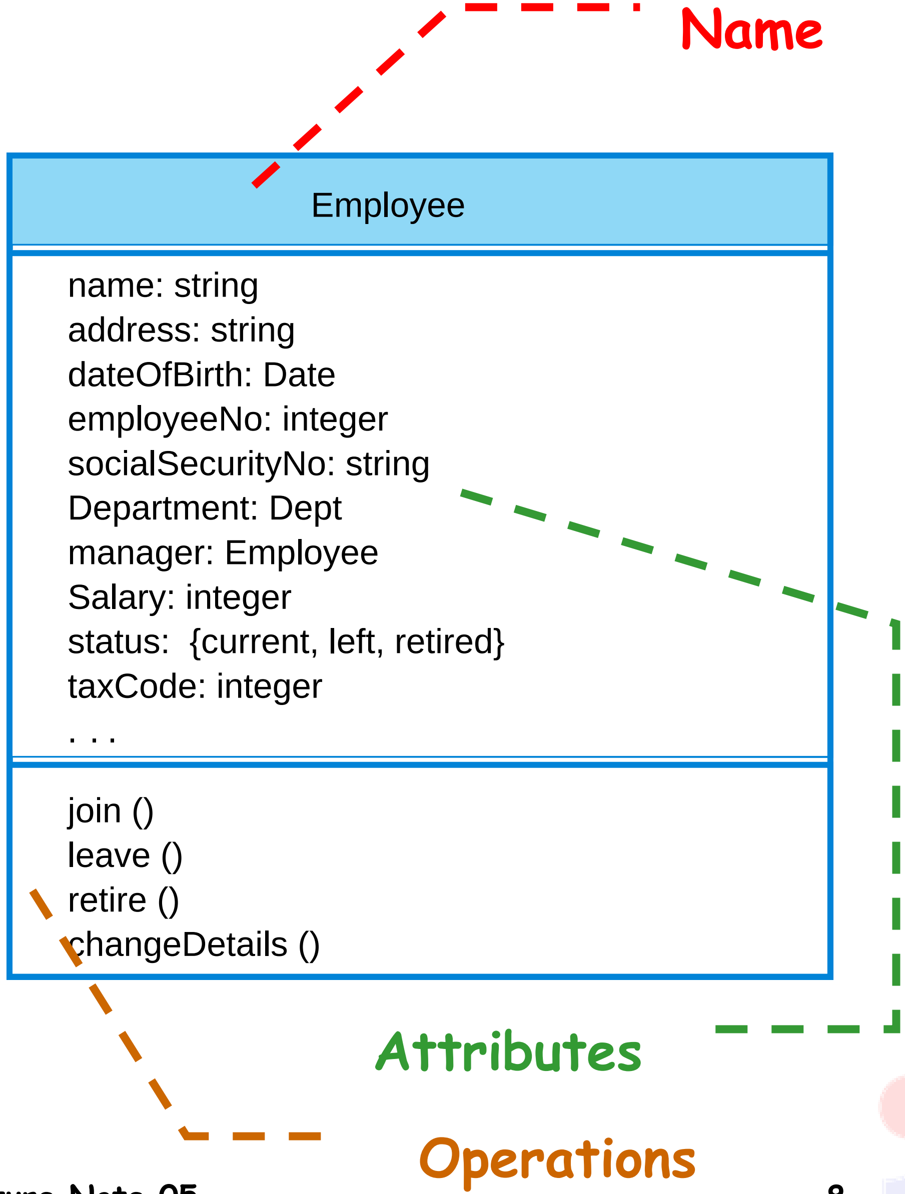
- Objects are
  - entities in a software system which represent instances of real-world and system entities
  - instances of classes
- Objects derive from:
  - **Things**: tangible, real-world objects, etc.
  - **Roles**: classes of actors in systems, e.g., students, managers, nurses, etc.
  - **Events**: admission, registration, matriculation, etc.
  - **Interactions**: meetings, tutorials, etc.

Classes and Objects

- An **object** is an entity that has a state and a defined set of operations which operate on that state
- The state is represented as a set of object attributes
- The operations associated with the object provide services to other objects, which request these services when some functionality is required
- Objects are created according to some **class** definition
- A class definition
  - serves as a template for objects
  - includes declarations of all the attributes and operations which should be associated with an object of that class
- Note that the level of detail known or displayed for attributes and operations depends on the phase of the development process

Basic Class Compartments

- Name
- Attributes
  - represent the state of an object of the class
  - are descriptions of the structural or **static** features of a class
- Operations
  - define the way in which objects may interact
  - are descriptions of behavioral or **dynamic** features of a class



Name

Employee

name: string
address: string
dateOfBirth: Date
employeeNo: integer
socialSecurityNo: string
Department: Dept
manager: Employee
Salary: integer
status: {current, left, retired}
taxCode: integer
. . .

join ()
leave ()
retire ()
changeDetails ()

Attributes

Operations

Attributes

Visibility / name : type multiplicity = default {property strings and constraints}

- **Visibility**
  - public (+), protected (#), package(~), private (-)
- / derived attribute
- **Name**
- **Type** is the data type of the attribute or the data returned by the operation
- **Multiplicity** specifies how many instances of the attribute's type are referenced by this attribute
  - **[n..m]** - **n** to **m** instances; **0..1** - zero or one instance; **0..*** or ***** - no limit on the number of instances (including none). **1** - exactly one instance; **1..*** at least one instance
- **Property strings**
  - readOnly, union, subset <attribute-name>, redefines <attribute-name> composite
- **Constraints**

Attributes

- **Attributes by relationship** allow the definition of complex attributes
- Visibility
  - public (+), protected (#), package (~), private (-)
  - From **More accessible** to **Less Accessible**
  - Java allows access to protected parts of a class to any class in the same package

Operations

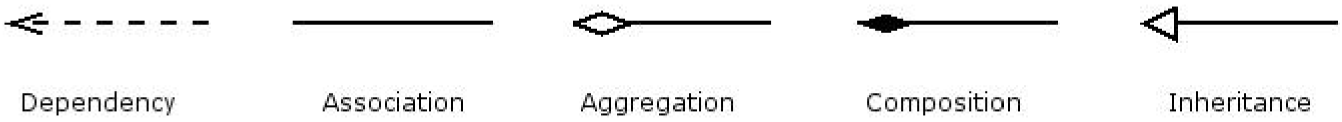
visibility name (parameters) : return-type {properties}

- **(Parameters)**

  direction parameter_name : type [multiplicity] = default_value {properties}

- **direction**
  - in, inout, out or return
- **Operation constraints**
  - preconditions, postconditions, body conditions, query operations, exceptions
- **Static operations**
  - Specify behaviour for the class itself
  - Invoked directly on the class
- **Methods** are implementations of an operations
  - Abstract classes provide operation signatures, but no implementations

Class Relationships

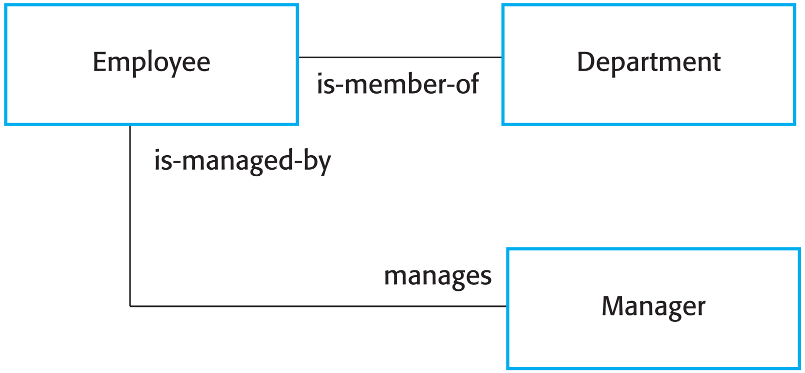


- **Dependency**: objects of one class work briefly with objects of another class
- **Association**: objects of one class work with objects of another class for some prolonged amount of time
- **Aggregation**: one class owns but share a reference to objects of other class
- **Composition**: one class contains objects of another class
- **Inheritance (Generalization)**: one class is a type of another class

Dependency and Association

- Dependency between two classes means that one class uses, or has knowledge of, another class
  - a transient relationship

- Associations
  - an attribute of an **object** is an associated **object**
  - a method relies on an associated object
  - an instance of one class must know about the other in order to perform its work
  - Passing messages and receiving responses



- Associations may be annotated with information
  - Name, Multiplicity, Role Name, Ends, Navigation

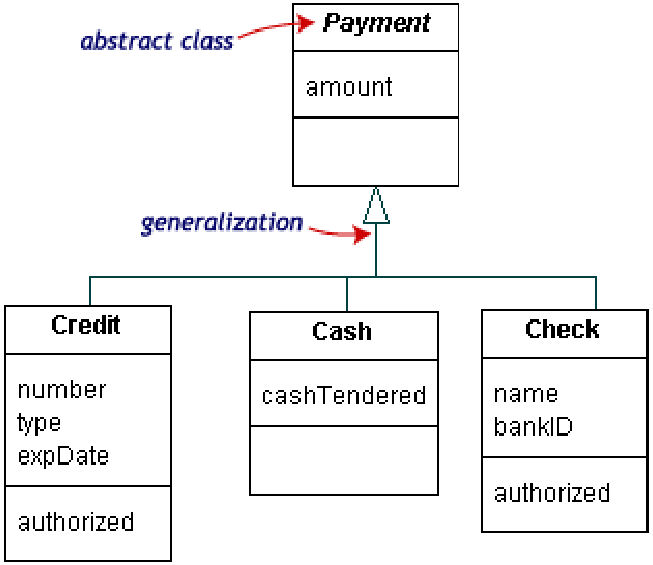
Aggregation and Composition

- Aggregation
  - Is a stronger version of association
  - is used to indicate that, as well as having attributes of its own, an instance of one class may consist of, or include, instances of another class
  - are associations in which one class belongs to a collection
- The java code implementation for an aggregation (composition) relationship is exactly the same as the implementation for an association relationship; it results in the introduction of an attribute.

- Compositions
  - imply coincident lifetime. A coincident lifetime means that when the whole end of the association is created (deleted), the part components are created (deleted).

Generalization (Inheritance)

- an inheritance link indicating one class is a superclass of the other, the subclass
  - An object of a subclass to be used as a member of the superclass
  - The behavior of the two specific classes on receiving the same message should be similar



- **Checking Generalizations**
  - If class A is a generalization of a class B, then "Every B is an A"
- **Design by Contract**
  - A **subclass** must keep to the contract of the **superclass** by: ensuring operations observe the pre and post conditions on the methods and that the class invariant is maintained
- **Implementing Generalizations**
  - Java: creating the subclass by extending the super class
  - Inheritance increases system coupling
  - Modifying the superclass methods may require changes in many subclasses
  - Restrict inheritance to conceptual modeling
  - Avoid using inheritance when some other association is more appropriate

More on Classes

- **Abstract Classes** provide the definition, but not the implementation
- **Interfaces** are collections of operations that have no corresponding method implementations
  - Safer than Abstract classes – avoid many problems associated with multiple inheritance
  - Java allows a class to implement any number of interface, but a class inherit from only one regular or abstract class
- **Templates** – or parameterized classes – allow us to postpone the decision as to which classes a class will work with

Modeling by Class Diagrams

- Class Diagrams (models)
  - from a **conceptual viewpoint**, reflect the requirements of a problem domain
  - From a **specification (or implementation) viewpoint**, reflect the intended design or implementation, respectively, of a software system
- Producing class diagrams involve the following iterative activities:
  - Find **classes** and **associations** (directly from the **use cases**)
  - Identify **attributes** and **operations** and allocate to classes
  - Identify **generalization** structures

How to build a class diagram

- Design is driven by criterion of completeness either of data or responsibility
  - Data Driven Design identifies all the data and see it is covered by some collection of objects of the classes of the system
  - Responsibility Driven Design identifies all the responsibilities of the system and see they are covered by a collection of objects of the classes of the system
- Noun identification
  - Identify noun phrases: look at the use cases and identify a noun phrase. Do this systematically and do not eliminate possibilities
  - Eliminate inappropriate candidates: those which are redundant, vague, outside system scope, an attribute of the system, etc.
- Validate the model…

Common Domain Modeling Mistakes

- Overly specific **noun-phrase analysis**
- Counter-intuitive or incomprehensible **class** and **association names**
- Assigning **multiplicities** to associations too soon
- Addressing **implementation issues** too early:
  - Presuming a specific implementation strategy
  - Committing to implementation constructs
  - Tackling implementation issues
- Optimizing for **reuse** before checking use cases achieved

Class and Object Pitfalls

- Confusing basic **class relationships** (i.e., is-a, has-a, is-implemented-using)
- Poor use of **inheritance**
  - Violating encapsulation and/or increasing coupling
  - Base classes do too much or too little
  - Not preserving base class invariants
  - Confusing interface inheritance with implementation inheritance
  - Using multiple inheritance to invert is-a

Summary

- Class Diagrams in the life cycle
- Class Diagram Rationale
- Classes
  - Basic Class Components
  - Attributes and Operations
- Class Relationships
  - Dependency, Association, Aggregation, Composition and Generalization (Inheritance)
- Modeling by Class Diagrams
  - How to build a class diagram
  - Common domain modeling mistakes
  - Class and Object Pitfalls

Reading/Activity

- Please review the use of ArgoUML in the generation of UML diagrams
  - http://argouml.tigris.org/tours