Object-oriented Design

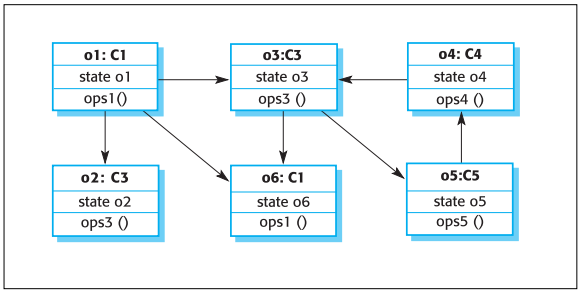
Object-oriented development

- Object-oriented analysis, design and programming are related but distinct.
- OOA is concerned with developing an object model of the application domain.
- OOD is concerned with developing an object-oriented system model to implement requirements.
- OOP is concerned with realising an OOD using an OO programming language such as Java or C++.

Characteristics of OOD

- Objects are abstractions of real-world or system entities and manage themselves.
- Objects are independent and encapsulate state and representation information.
- System functionality is expressed in terms of object services.
- Shared data areas are eliminated. Objects communicate by message passing.
- Objects may be distributed and may execute sequentially or in parallel.

Interacting objects



Advantages of OOD

- Easier maintenance. Objects may be understood as stand-alone entities.
- Objects are potentially reusable components.
- For some systems, there may be an obvious mapping from real world entities to system objects.

Objects and object classes

- Objects are entities in a software system which represent instances of real-world and system entities.
- Object classes are templates for objects. They may be used to create objects.
- Object classes may inherit attributes and services from other object classes.

Objects and object classes

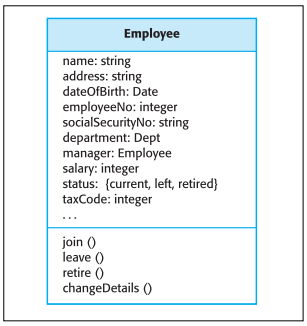
*An **object** is an entity that has a state and a defined set of operations which operate on that state. The state is represented as a set of object attributes. The operations associated with the object provide services to other objects (clients) which request these services when some computation is required.*

*Objects are created according to some **object class** definition. An object class definition serves as a template for objects. It includes declarations of all the attributes and services which should be associated with an object of that class.*

The Unified Modeling Language

- Several different notations for describing object-oriented designs were proposed in the 1980s and 1990s.
- The Unified Modeling Language is an integration of these notations.
- It describes notations for a number of different models that may be produced during OO analysis and design.
- It is now a *de facto* standard for OO modelling.

Employee object class (UML)



Object communication

- Conceptually, objects communicate by message passing.
- Messages
  - The name of the service requested by the calling object;
  - Copies of the information required to execute the service and the name of a holder for the result of the service.
- In practice, messages are often implemented by procedure calls
  - Name = procedure name;
  - Information = parameter list.

Message examples

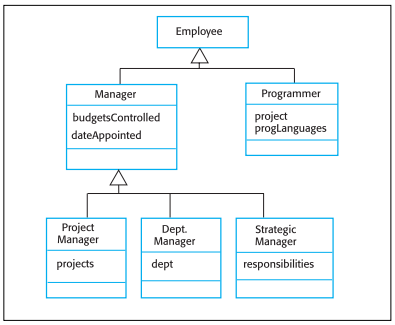
```
// Call a method associated with a buffer
// object that returns the next value
// in the buffer
        v = circularBuffer.Get () ;

// Call the method associated with a
// thermostat object that sets the
// temperature to be maintained
        thermostat.setTemp (20) ;
```


Generalisation and inheritance

- Objects are members of classes that define attribute types and operations.
- Classes may be arranged in a class hierarchy where one class (a super-class) is a generalisation of one or more other classes (sub-classes).
- A sub-class inherits the attributes and operations from its super class and may add new methods or attributes of its own.
- Generalisation in the UML is implemented as inheritance in OO programming languages.

A generalisation hierarchy



Advantages of inheritance

- It is an abstraction mechanism which may be used to classify entities.
- It is a reuse mechanism at both the design and the programming level.
- The inheritance graph is a source of organisational knowledge about domains and systems.

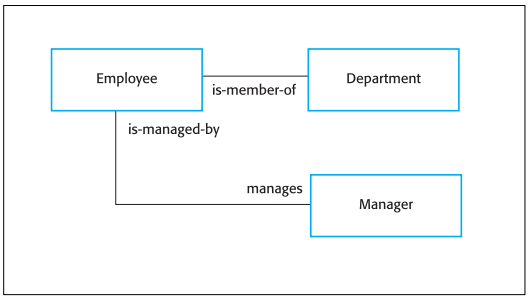
Problems with inheritance

- Object classes are not self-contained. they cannot be understood without reference to their super-classes.
- Designers have a tendency to reuse the inheritance graph created during analysis. Can lead to significant inefficiency.
- The inheritance graphs of analysis, design and implementation have different functions and should be separately maintained.

UML associations

- Objects and object classes participate in relationships with other objects and object classes.
- In the UML, a generalised relationship is indicated by an association.
- Associations may be annotated with information that describes the association.
- Associations are general but may indicate that an attribute of an object is an associated object or that a method relies on an associated object.

An association model



Concurrent objects

- The nature of objects as self-contained entities make them suitable for concurrent implementation.
- The message-passing model of object communication can be implemented directly if objects are running on separate processors in a distributed system.

Servers and active objects

- Servers.
  - The object is implemented as a parallel process (server) with entry points corresponding to object operations. If no calls are made to it, the object suspends itself and waits for further requests for service.
- Active objects
  - Objects are implemented as parallel processes and the internal object state may be changed by the object itself and not simply by external calls.

Active transponder object

- Active objects may have their attributes modified by operations but may also update them autonomously using internal operations.
- A Transponder object broadcasts an aircraft's position. The position may be updated using a satellite positioning system. The object periodically update the position by triangulation from satellites.

An active transponder object

```
class Transponder extends Thread {

        Position currentPosition ;
        Coords c1, c2 ;
        Satellite sat1, sat2 ;
        Navigator theNavigator ;

        public Position givePosition ()
        {
                return currentPosition ;
        }

        public void run ()
        {
                while (true)
                {
                        c1 = sat1.position () ;
                        c2 = sat2.position () ;
                        currentPosition = theNavigator.compute (c1, c2) ;
                }

        }

} //Transponder
```


Java threads

- Threads in Java are a simple construct for implementing concurrent objects.
- Threads must include a method called run() and this is started up by the Java run-time system.
- Active objects typically include an infinite loop so that they are always carrying out the computation.