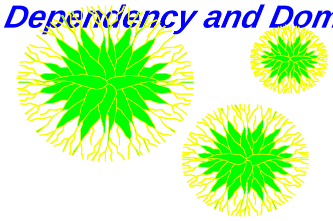
XXIII. Class Design



Class Design

- Within the context of architectural design, class design:
  - ✓ Produces full definitions of classes, associations, algorithms and interfaces of operations;
  - ✓ Adds classes that will be useful during implementation;
  - ✓ Defines object interactions and object lifetimes in terms of interaction and state diagrams;
  - ✓ Optimises data structures and algorithms.

Input/Output for Class Design

- The input is assumed to consist of:
  - ✓ Use cases that describe functional requirements; also sequence, state/activity diagrams that describe the use cases in more detail;
  - ✓ Class diagrams that describe the kinds of things the information system will be managing information about.
- The outputs of class design are:
  - ✓ Class packages which describe the overall software architecture of the new system;
  - ✓ Supporting sequence, state/activity diagrams that give additional details about the design.

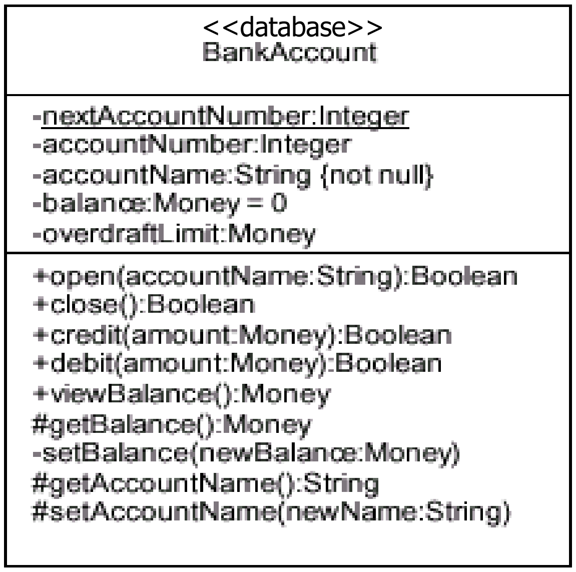
Types of Design Classes

- Most classes defined during requirements analysis represent objects about which information will be stored in the system database.
- Assuming a 4-tier layered architecture, we distinguish four types of classes:
  - ✓ ***Persistent database classes*** (D), correspond to application classes and describe what will be stored persistently in the system database;
  - ✓ ***Entity classes*** (E) represent in-memory, run-time data structures for persistent database classes;
  - ✓ ***Boundary classes*** (B) specify interface functions;
  - ✓ ***Control classes*** (C) specify business logic functions.

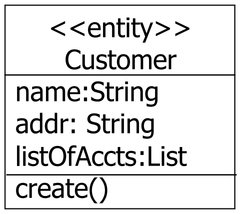
Class Specifications

- Attribute signature
  name: `:´ type-expr `=´ init-value `{property-string}´
- Operation signature
  Operation name: `(´ param-list ´)´ `:´ return-type-expr
- Object Visibility
  - ✓ + Public -- feature directly accessible by any class;
  - ✓ - Private -- feature may only be used by the class that includes it;
  - ✓ # Protected -- feature maybe used by either the class that includes it or by a subclass of that class;

An Example Database Class

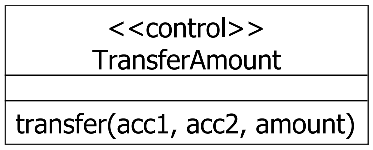

<<database>>
BankAccount
-nextAccountNumber:Integer
-accountNumber:Integer
-accountName:String {not null}
-balance:Money = 0
-overdraftLimit:Money
+open(accountName:String):Boolean
+close():Boolean
+credit(amount:Money):Boolean
+debit(amount:Money):Boolean
+viewBalance():Money
#getBalance():Money
-setBalance(newBalance:Money)
#getAccountName():String
#setAccountName(newName:String)

An Example Entity Class



Notes: *Customer* objects are created by accessing the *CustomerDB* and *BankAccounts* part of the database to build a single *Customer* object which collects all account information about a customer.

An Example Control Class



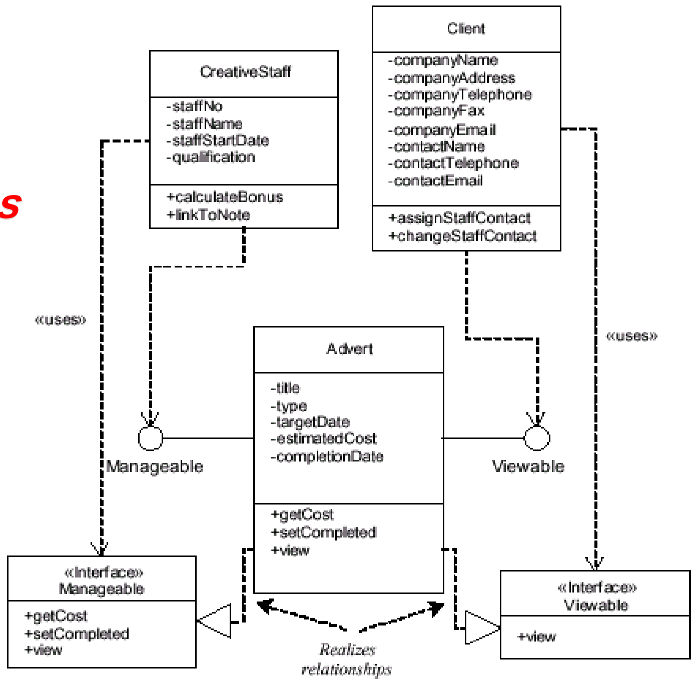
An Example Boundary Class

Look at examples of view and control classes from the previous section.

Class Interfaces

- An ***interface*** is a group of externally visible (public) operations.
- An interface is like a class, but contains no internal structure, has no attributes, no associations and no implementation of its operations.
- The ***realizes*** relationship indicates that the target class supports at least the operations listed in the interface

Class Interfaces



Class Design

- So, a class design consists of a set of packages which contain classes and other packages, and which represent components or sub-systems.
- The grouping of classes into packages may be done from several different points of view:
  - ✓ By architectural tier -- Boundary, Control, Entity, Database;
  - ✓ By functional relationship -- MVC;
  - ✓ By authorship -- who designed what;
  - ✓ …

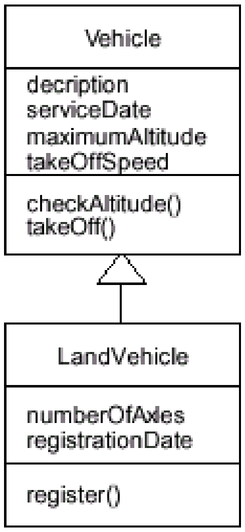
Cohesion and Coupling

Criteria for good sub-system/package design:

- **Coupling** measures the degree of interconnectedness between design classes/components/sub-systems/packages.
- The degree of coupling is reflected by the number of links a class has, and by the degree of interaction the class has with other classes.
- Low coupling is preferrable in a design for many good reasons, e.g., easier to understand and modify the design.
- **Cohesion**, on the other hand, measures the degree to which an element (class/component/sub-system/package) contributes to a single purpose.
- Of course, we want a highly cohesive design.

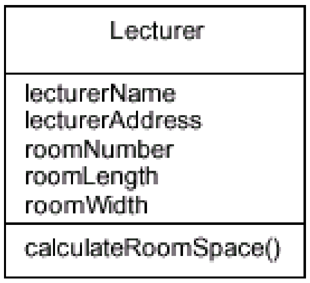
Minimizing Coupling

- Interaction coupling
  - ✓ Measures number of message types and the number of parameters passed with these message types;
  - ✓ Should be kept to a minimum in order to reduce the possibility of changes rippling through interfaces;
- Inheritance coupling
  - ✓ Degree to which a subclass actually needs the features it inherits;
  - ✓ A subclass with unnecessary attributes or operations is more complex than it needs to be.



Maximizing Cohesion

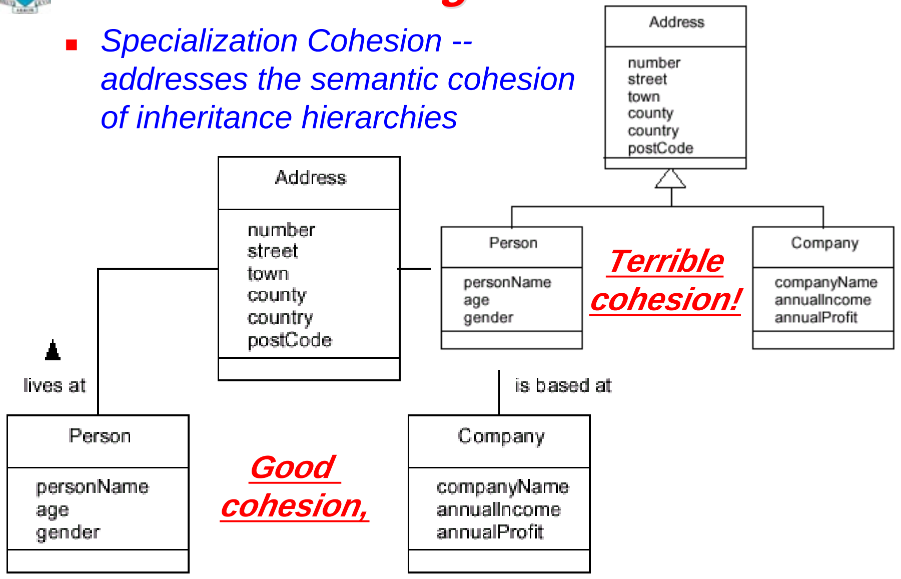
- Operation cohesion
  - ✓ Measures degree to which an operation focuses on a single functional requirement.
  - ✓ Good design produces highly cohesive operations, each of which deals with a single functional requirement.
- Class cohesion
  - ✓ Degree to which a class is focused on a single requirement.



Good operation cohesion,
...but lousy class cohesion

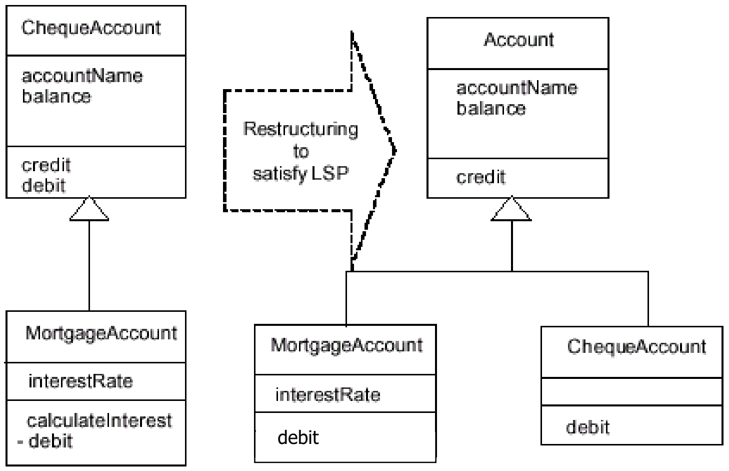
Maximizing Cohesion

- Specialization Cohesion -- addresses the semantic cohesion of inheritance hierarchies



Liskov Substitution Principle

- In class hierarchies, it should be possible to treat a specialized object as if it were a base object.



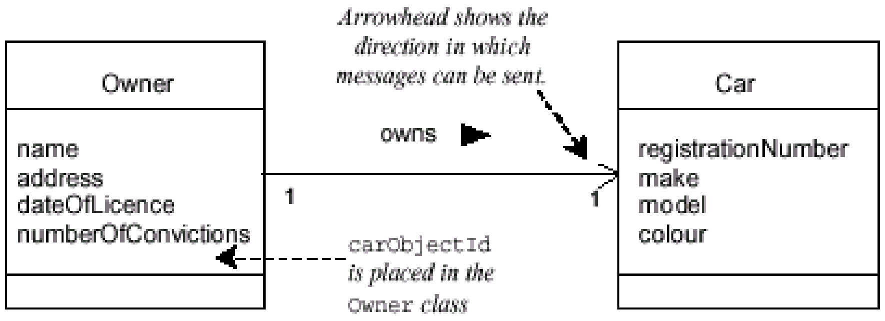
More Design Principles

- ***Clarity*** -- *A design should be easy to understand.*
- ***Do not over-design*** -- *Developers are tempted to produce designs that may not only satisfy current requirements but may also be capable of supporting a wide range of future requirements.*
- ***Inheritance hierarchies*** -- *Not too deep nor too shallow!*
- ***Keep messages and operations simple****: Limit number of parameters; specify operations in one page.*
- ***Design volatility*** -- *A good design should be stable in response to change in requirements; enforcing encapsulation is a key factor in producing stable systems.*
- ***Design by delegation****: A complex object should be decomposed into component objects forming a composition or aggregation*

Designing Associations

- *Each association needs to be analysed to determine whether it should be a* ***one-way*** *or a* ***two-way*** *association.*
- *Depending on multiplicities, we may use collection classes (e.g., lists).*
- *Need to ask questions about object visibility:*
  - ✓ *does object A need to know object B's object-id?*
  - ✓ *does it need to communicate to third-party objects the object-id?*

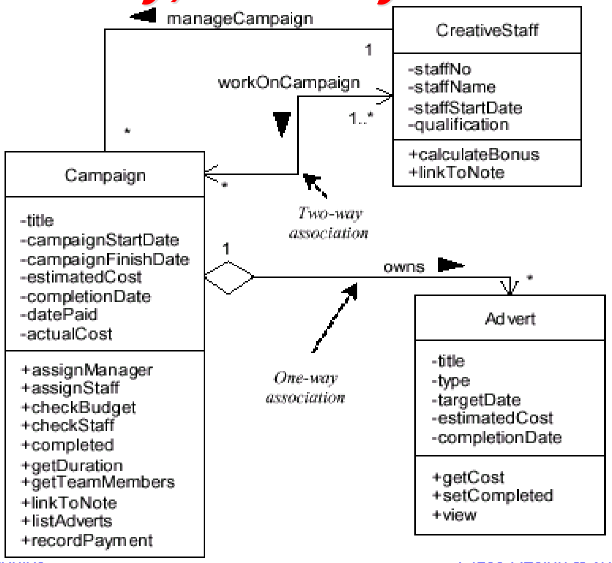
Designing Associations One-to-One, One Way


Arrowhead shows the direction in which messages can be sent.
Owner
name
address
dateOfLicence
numberOfConvictions
owns
1
1
Car
registrationNumber
make
model
colour
carObjectId is placed in the Owner class

- *Owner* needs to send messages to *Car*, not vice versa.
- Association may be implemented by placing an attribute to hold the identifier for the *Car* class in *Owner* objects.

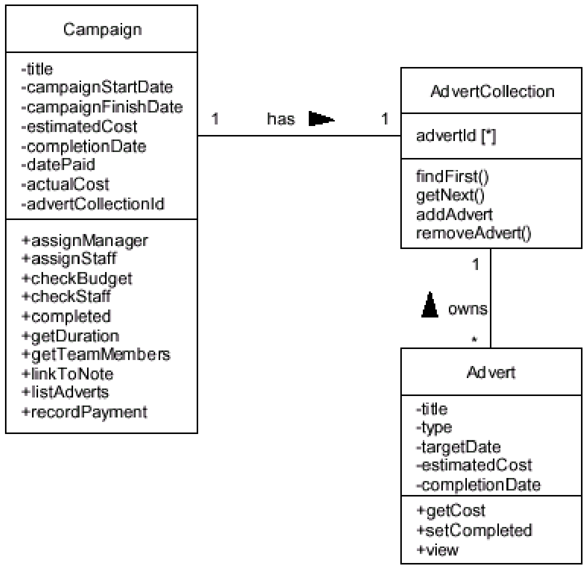
Designing Associations: One-to-Many, One-Way

- The *Advert* object identifiers could be held in a simple one-dimensional array in the *Campaign* object, but program code would have to be written to manipulate the array.



Collection Classes

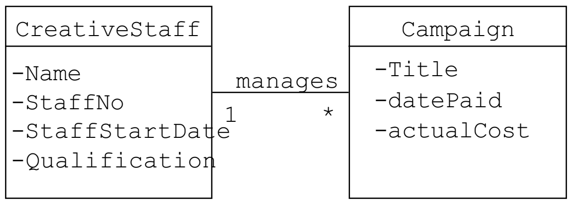
These are classes whose instances are lists, bags, or sets. Collection classes are useful for one-to-many associations



Integrity Constraints

- We'll discuss three types of integrity constraints (...there are many others,….)
- ***Referential Integrity*** ensures that an object identifier mentioned in one object actually refers to an object that exists.
- ***Dependency Integrity*** ensures that attribute dependencies are maintained, where one attribute may be calculated from other attributes.
- ***Domain Integrity*** ensures that attributes only hold permissible values.

Referential Integrity

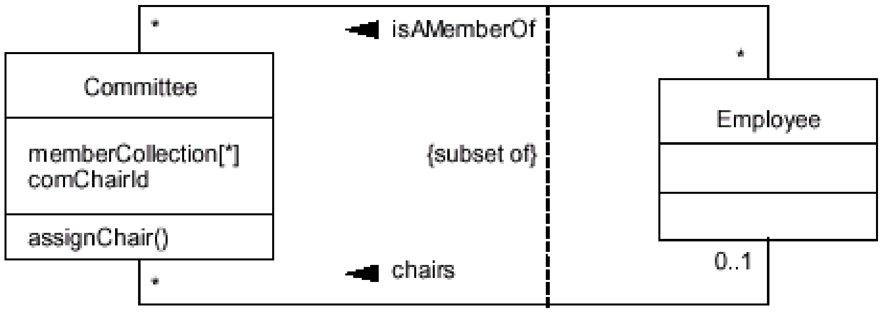


- *A* `Campaign` *must have a* `CreativeStaff` *instance as its manager.*
- *What happens if the manager is deleted?*
- *Referential integrity is maintained by ensuring that the deletion of a* `CreativeStaff` *object that is a campaign manager* ***always*** *involves allocating a new campaign manager.*

Dependency Constraints: Derived Attibutes

- *The value of a derived attribute may be calculated from other attributes.*
- *For example, total advertising cost can be calculated by summing individual advert costs and storing value in the attribute totalAdvertCost in the Campaign class or by re-calculating every time it is required.*
- *However, whenever the cost of an advert changes, or an advert is added to/removed from a campaign the totalAdvertCost attribute has to be adjusted.*
- *This can be done by sending message adjustCost() to the Campaign object.*

Constraints Between Associations



- *Enforced by placing a check in assignChair() to confirm that the Employee object identifier passed as a parameter is already in the collection class of committee members.*

Designing Operations

- *Determine the best algorithm for the required function.*
- *Factors constraining algorithm design:*
  - ✓ *The cost of implementation;*
  - ✓ *Performance constraints;*
  - ✓ *Requirements for accuracy;*
  - ✓ *The capabilities of the chosen platform.*
- *Factors to be considered when choosing among alternative algorithm designs*
  - ✓ *The computational complexity of candidates;*
  - ✓ *Ease of implementation and understandability;*
  - ✓ *Flexibility;*
  - ✓ *Fine-tuning the object model.*