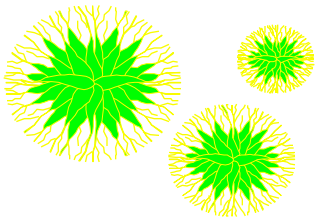
XX. Object Design

What is Object Design?
Class Specifications and Interfaces
Cohesion and Coupling
Designing Associations
Integrity Constraints
Referential, Dependency and Domain Integrity



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Object Design

- Within the architectural decisions of systems design, object design
  - ✓ Produces full definitions of classes, associations, algorithms & 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.

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Class Specifications

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

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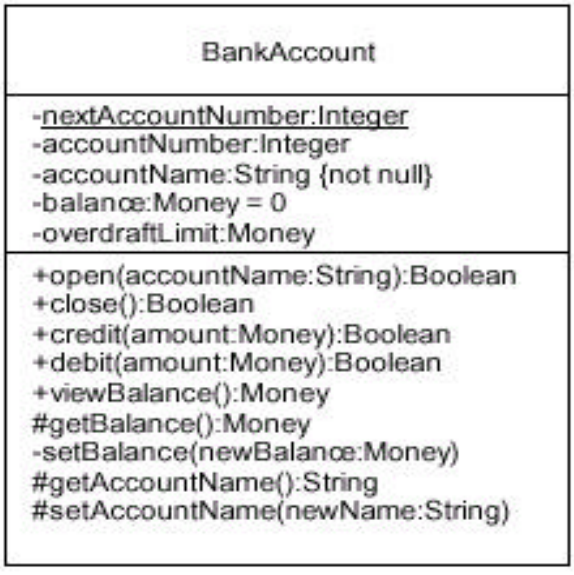
An Example



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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

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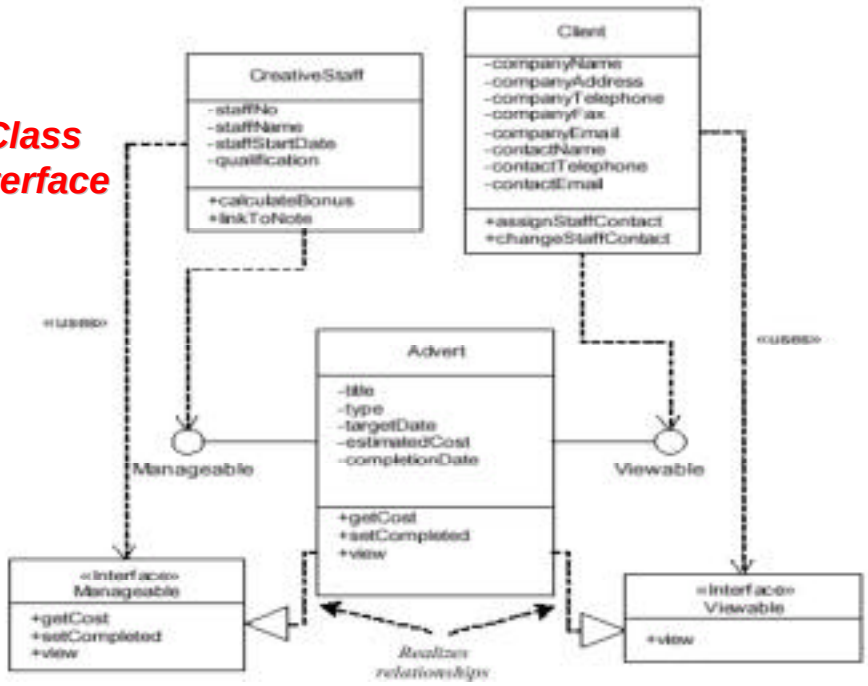
Class Interface



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Criteria for Good Design: Cohesion and Coupling

- ***Coupling*** measures the degree of interconnectedness between design components.
- The degree of coupling is reflected by the number of links an object has, and by the degree of interaction the object has with other objects.
- 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 (subsystem, module, or class) contributes to a single purpose.
- Of course, we want a highly cohesive design.

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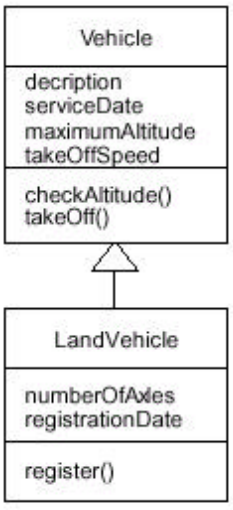
Minimizing Coupling

- Interaction coupling
  - ✓ Measures the number of message types an object sends to other objects 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 object interfaces;
- Inheritance coupling
  - ✓ Degree to which a subclass actually needs the features (attributes or operations) it inherits;
  - ✓ A subclass with unnecessary attributes or operations is more complex than it needs to be and instances of the subclass unnecessarily use up more memory.



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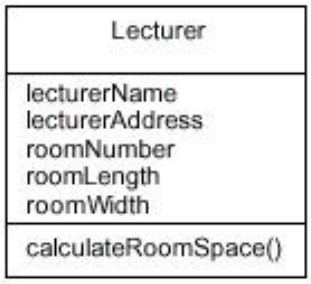
Maximizing Cohesion

- Operation cohesion
  - ✓ Measure the 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

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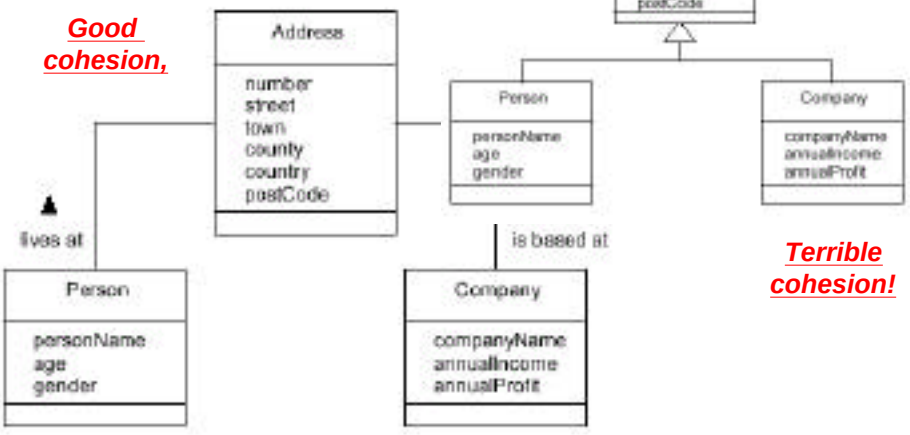
Maximizing Cohesion

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

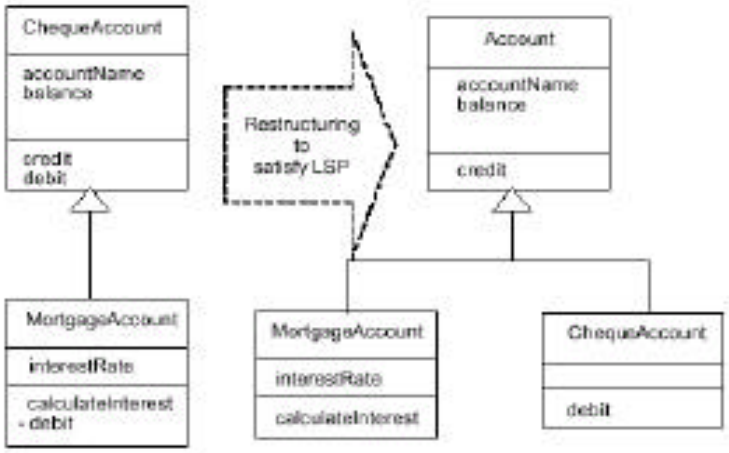
Good cohesion,



Terrible cohesion!

Liskov Substitution Principle

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



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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*** -- Neither too deep nor too shallow!
- ***Keep messages and operations simple***: Limit the numbers of parameters passed in a message; specify operations in no more than 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.
- ***Evaluation by scenario*** -- Can be done with a role play based on use cases, using CRC cards.
- ***Design by delegation***: A complex object should be decomposed into component objects forming a composition or aggregation

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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?

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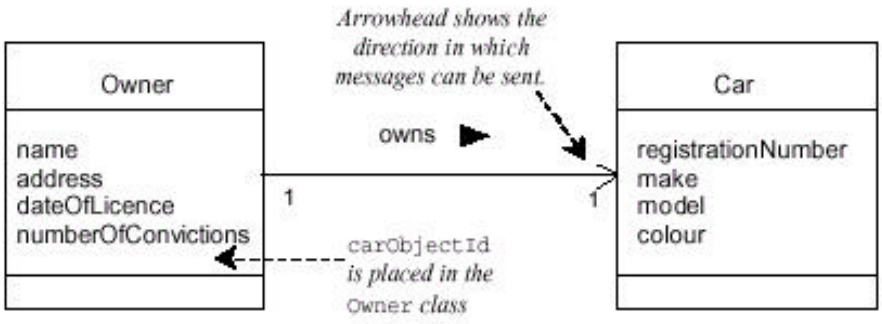
Designing Associations One-to-One, One Way



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

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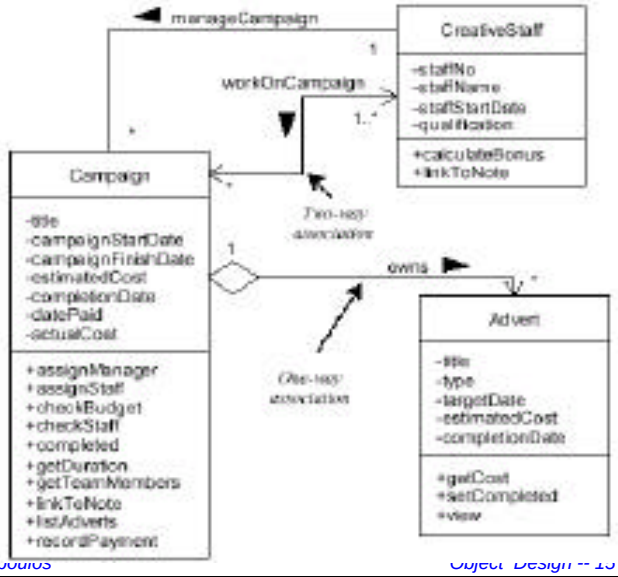
Designing Associations
One-to-Many, One-Way Associations

- The 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.



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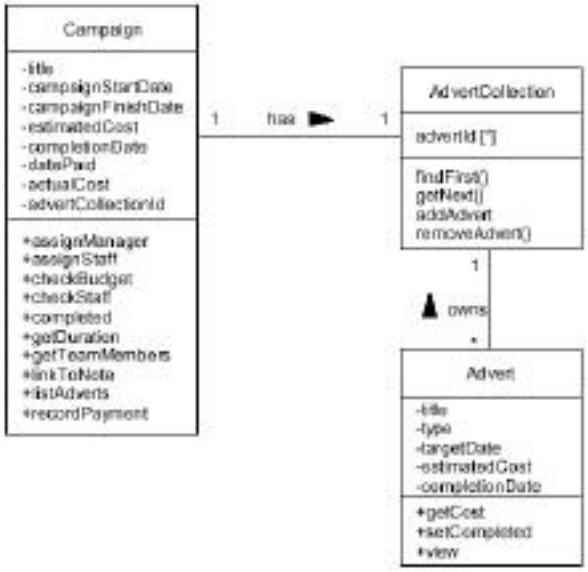
Collection Classes

Collection classes are useful for one-to-many associations



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Integrity Constraints

- We'll discuss three types of integrity constraints (...there are many others….)
- ***Referential Integrity*** ensures that an object identifier in an 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

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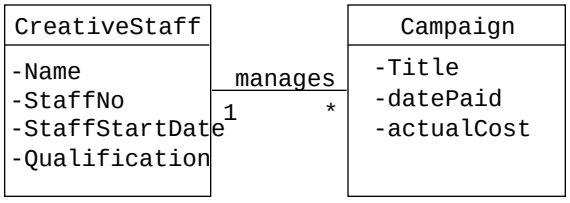
Referential Integrity



- 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.

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Dependency Constraints: Derived Attibutes

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

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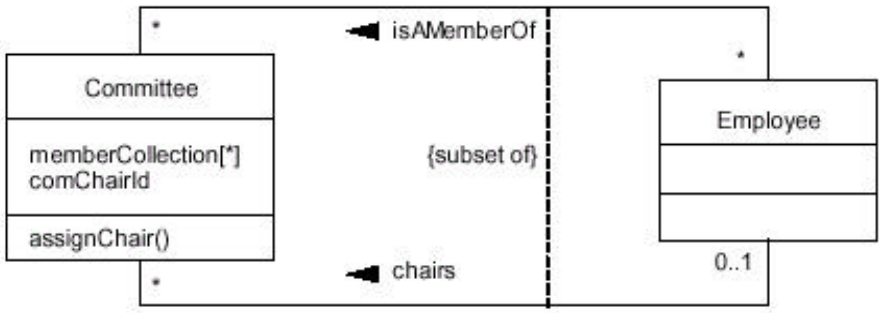
Constraints Between Associations



- 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.

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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 candidate algorithms;
  - Ease of implementation and understandability;
  - Flexibility;
  - Fine-tuning the object model.

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