Design Patterns

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CSC 331-631
Fall, 2013

Reusable Object-Oriented Design is Hard

From Design Patterns, Gamma et. al, 1995

Design challenges

- Finding objects, defining classes, interfaces, inheritance hierarchies, key associations, etc.
- Design should be specific to the problem but general enough to address future needs
- Design should be reusable and flexible

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Expert designers

- Know not to solve every problem from first principles
- Reuse previous successful solutions
- Evidence: recurring patterns of classes and communicating objects

Patterns

- **Design pattern**: a record of design experience

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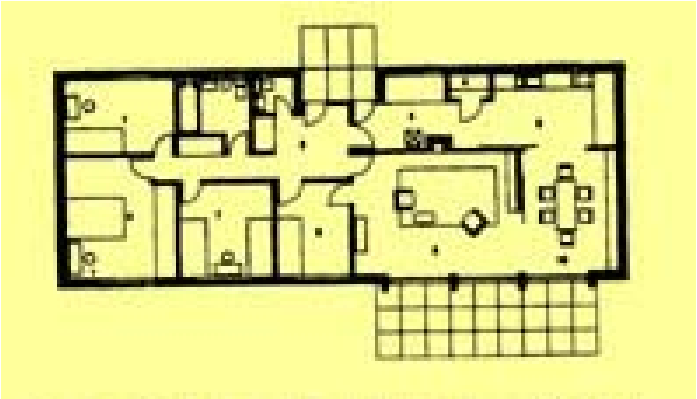
He was talking about buildings and cities not software!



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4. Can also help with documentation and maintenance of existing systems

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4. **Consequences**: Results and trade-offs of applying the pattern. Help provide a voice to important design decisions

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Gamma et. al Catalog of Design Patterns

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- Iterator: Prove a way to access the elements of an aggreate object sequentially without exposing its underlying representation

How Design Patterns Solve Design Problems

Finding appropriate objects

- Many conflicting factors to consider when decomposing a system into objects: encapsulation, granularity, dependency, etc.
- **How to decompose the system?**
  - Associate nouns with clases and verbs with methods
  - Look for and model collaborations and responsibilities
  - Model the real world directly
- The key is to find abstractions that make the design flexible
- Design patterns help identify less-obvious abstractions.

How Design Patterns Solve Design Problems

Determining object granularity

- How large should objects be in size and number? Objects can represent entire applications or represent individual hardware
- How to decide what should be an object?

- **Facade** describes how to represent complete subsystems as objects
- **Flyweight** describes how to support huge numbers of objects at the finest granularities
- Others describe ways to decompose an object into smaller objects

How Design Patterns Solve Design Problems

Specifying object interfaces

- Interfaces are fundamental in OO
  Objects are known only through their interfaces, their implementations are hidden
- Design patterns help identify what elements or data to include or not include in the interface
- Suppose you must be able to restore an object's data to a previous state
- **Memento** suggests defining two interfaces: 1) a restricted client interface to hold and copy *mementos*, and 2) a privileged interface for the original object to store and retrieve states
- **Decorator** and **Proxy** allow specific relationships between interfaces, requiring similar interfaces or placing constraints on the interfaces of some classes

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  Derive from an **abstract class**, so that **all** subclass instances can respond to requests in the interface
  - Allows manipulation of objects based solely on their interface
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  - Allows manipulation of objects based solely on their interface
  - Clients don't need to worry about the *class* of the object they use
  - Clients don't need to worry about the specific implementations
- Key benefit: greatly reduced implementation dependencies

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Object composition, an alternative to class inheritance

New functionality obtained by assembling objects of simpler functionality, by objects acquiring references to other objects

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  Advantages
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  Disadvantages

  - Can't change implementation of inherited operations at run-time
  - Implementation dependency between parent and subclasses (breaks encapsulation)
    A change in parent's implementation often forces change in subclass implementation

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- Object composition

  Advantages

  - Defined dynamically at run-time through object references
  - Object must respect each other's interfaces (doesn't break encapsulation)
  - Objects of same type can be replaced at run-time
  - Fewer implementation dependencies

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  Disadvantages

  - Interfaces must be designed carefully
  - Can lead to system design with more objects

Favoring object composition over class inheritance helps keep classes encapsulated and focused on one task

Design based on object composition keeps the system's behavior dependent on object interrelationships

Delegation I

- Can make composition as powerful for reuse as inheritance
- Example:

- Instead of `Window` being a `Rectangle` (inheritance), `Window` has a `Rectangle`
- Delegates rectangle behavior to it, e.g. `[rectangle area];`

Delegation II

- Why use delegation instead of inheritance?
  - Easy to compose behavior at run-time (could make window circular if desired, as long as `Circle` and `Rectangle` have same type)
- Disadvantages
  - Harder to understand than static code
  - Run-time inefficiencies

Use only when it simplifies more than it complicates