Design Patterns
Elements of Reusable Object-Oriented Software
Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides
Foreword by Grady Booch
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

CSE503: SOFTWARE ENGINEERING

DESIGN PATTERNS

David Notkin
Spring 2011

History

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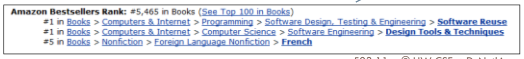
- The Gang of Four (GoF)
  - Erich Gamma, Richard Helm, Ralph E. Johnson, and John M. Vlissides. 1993. Design Patterns: Abstraction and Reuse of Object-Oriented Design. In Proceedings of the 7th European Conference on Object-Oriented Programming (ECOOP '93).
  - Their book, *Design Patterns: Elements of Reusable Object-Oriented Software*, was released at OOPSLA 1994.
  - The book and the authors have won several awards including the Jolt productivity award, the Software Development productivity award, and the SIGSOFT Outstanding Research award

May 1, 2011


Amazon Bestsellers Rank: #5,465 in Books (See Top 100 in Books)
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#1 in Books > Computers & Internet > Computer Science > Software Engineering > **Design Tools & Techniques**
#5 in Books > Nonfiction > Foreign Language Nonfiction > **French**

Pre-history: Christopher Alexander

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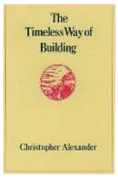
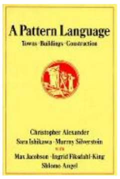
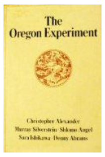
"At the core... is the idea that people should design for themselves their own houses, streets and communities. This idea... comes simply from the observation that most of the wonderful places of the world were not made by architects but by the people."
—Christopher Alexander, *A Pattern Language*

http://en.wikipedia.org/wiki/File:Christopher_Alexander.jpg




A Pattern Language
Towns · Buildings · Construction
Christopher Alexander
Sara Ishikawa · Murray Silverstein
with
Max Jacobson · Ingrid Fiksdahl-King
Shlomo Angel


The Oregon Experiment
Christopher Alexander
Murray Silverstein · Shlomo Angel
Sara Ishikawa · Denny Abrams

bing "design patterns" on 5/2/2011 65.5M hits including…

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- .NET Design Patterns in C# and VB.NET
- Yahoo! Design Pattern Library
- Azure Design Patterns
- ASP.NET Wiki: Architecture: Design Patterns
- SOA patterns
- Design Patterns for Building Flexible and Maintainable J2EE Applications
- Design Patterns and Refactoring
- Design Patterns in Ruby
- Ajax Patterns
- CSS Design Patterns
- PHP Design Patterns
- Train the Trainer Design Pattterns Design Patterns Training
- … and millions more!

ACM Digital Library
Hits on "design patterns" in title

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- 2011
  - Towards studying the performance effects of design patterns for service oriented architecture
  - Architectural patterns to design software safety based safety-critical systems
  - Evaluation of web application security risks and secure design patterns
  - Type design patterns for computer mathematics
- 2010 & 2009
  - Object oriented design pattern decay: a taxonomy
  - Design patterns to guide player movement in 3D games
  - Design patterns for efficient graph algorithms in MapReduce
  - Towards a Comprehensive Test Suite for Detectors of Design Patterns
  - Design patterns in separation logic

What are design patterns?

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- First, your view based on experience, rumor, etc.

What are design patterns?

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- Solutions to commonly arising object-oriented design problems – solutions actually used multiple times by multiple people over time
- Stylized descriptions that include (in part)
  - a motivation (the problem and the context),
  - a design-level description (in terms of interfaces and interconnections),
  - one or more example implementations in a well-known programming language
- "a 'well-proven generic scheme' for solving a recurring design problem"
  - Often overcoming limitations of OO hierarchies
- Idioms intended to be "simple and elegant solutions to specific problems in object-oriented software design"
  - Patterns are a collection of "mini-architectures" that combine structure and behavior
- Gabriel: "Alexander could have written a 1-sentence definition of what a pattern is, or an essay, but instead he wrote a 550-page book to do it. Because the concept is hard."

Similar in motivation to PL constructs

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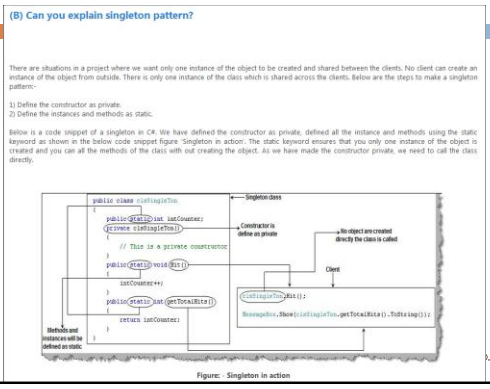
Simple example: singleton pattern
Only one object of the given type exists

```
class Bank {
  private static bank theBank;

  // private constructor
  private Bank() { ... }

  // factory method
  public static getBank() {
    if (theBank == null) {
      theBank = new Bank();
    }
    return theBank;
  }
  ...
}
```

- Pattern isn't explicit in code
- Could be defined by a programming language
- Would appear differently in different languages

http://www.eggheadcafe.com/tutorials/aspnet/280ee727-00a7-497a-84d2-6ebb16df4140/design-pattern-interview.aspx



(B) Can you explain singleton pattern?

There are situations in a project where we want only one instance of the object to be created and shared between the clients. No client can create an instance of the object from outside. There is only one instance of the class which is shared across the clients. Below are the steps to make a singleton pattern:-

1) Define the constructor as private.
2) Define the instances and methods as static.

Below is a code snippet of a singleton in C#. We have defined the constructor as private, defined all the instance and methods using the static keyword as shown in the below code snippet figure 'Singleton in action'. The static keyword ensures that you only one instance of the object is created and you can all the methods of the class with out creating the object. As we have made the constructor private, we need to call the class directly.

```
public class clsSingleTon
{
    public static int intCounter;
    private clsSingleTon()
    {
        // This is a private constructor
    }
    public static void Hit()
    {
        intCounter++;
    }
    public static int getTotalHits()
    {
        return intCounter;
    }
}
```

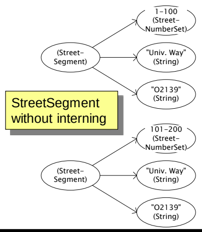
```
clsSingleTon.Hit();

MessageBox.Show(clsSingleTon.getTotalHits().ToString());
```

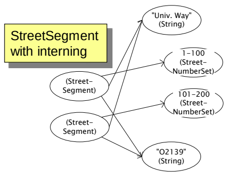
Singleton class
Constructor is define as private
No object are created directly the class is called
Client
Methods and instances will be defined as static

Figure: - Singleton in action

Interning pattern

- Reuse existing objects instead of creating new ones
  - Less space
  - May compare with == instead of `equals()`
- Permitted only for immutable objects





Interning mechanism

- Maintain a collection of all objects
- If an object already appears, return that instead

```
HashMap<String, String> segnames;
String canonicalName(String n) {
  if (segnames.containsKey(n)) {
    return segnames.get(n);
  } else {
    segnames.put(n, n);
    return n;
  }
}
```

- Java builds this in for strings: `String.intern()`
- Two approaches
  - create the object, but perhaps discard it and return another
  - check against the arguments before creating the new object

`java.lang.Boolean` does not use the Interning pattern

```
public class Boolean {
  private final boolean value;
  // construct a new Boolean
   value
  public Boolean(boolean
   value) {
    this.value = value;
  }

  public static Boolean FALSE
   = new Boolean(false);
  public static Boolean TRUE =
   new Boolean(true);
```

```
// factory method that uses
   interning
  public static
   valueOf(boolean value) {
    if (value) {
      return TRUE;
    } else {
      return FALSE;
    }
  }
}
```

Recognition of the problem

- Javadoc for Boolean constructor includes…
- Allocates a Boolean object representing the value argument
  - "Note: It is rarely appropriate to use this constructor. Unless a new instance is required, the `static factory valueOf(boolean)` is generally a better choice. It is likely to yield significantly better space and time performance."
- Josh Bloch (JavaWorld, January 4, 2004):
  - "The Boolean type should not have had public constructors. There's really no great advantage to allow multiple trues or multiple falses, and I've seen programs that produce millions of trues and millions of falses, creating needless work for the garbage collector."
  - So, in the case of immutables, I think factory methods are great."

My eye-opening experience

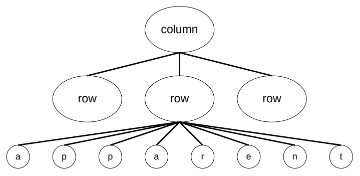
- At Dagstuhl
- With Griswold
- And with Helms and Vlissides
- In the bar
- "How to rethink our design for a program restructuring system?"

Patterns are an example of chunking

- Advanced chess players are in part superior because they don't see each piece individually
  - Instead, they chunk groups of them together
  - This reduces the search space they need to assess in deciding on a move
- This notion of chunking happens in almost every human endeavor
- Such chunking can lead to the use of idioms
  - As it has in programming languages
- The following slides show some parts of a particular pattern: flyweight
  - I won't go through the slides in detail, but they give a feel for people who haven't seen more concrete information on patterns

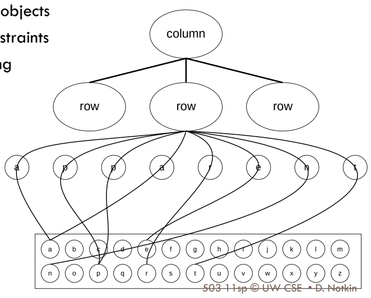
Example: flyweight pattern

- What happens when you try to represent lots of small elements as full-fledged objects?
- It's often too expensive
- And it's pretty common

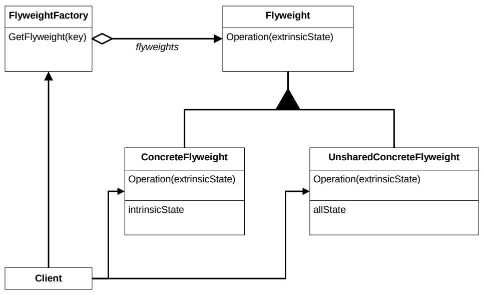


An alternative approach

- Use sharing to support many fine-grained objects efficiently
  - Fixed domain of objects
  - Maybe other constraints
  - Similar to interning



Flyweight structure


FlyweightFactory
GetFlyweight(key)
flyweights
Flyweight
Operation(extrinsicState)
ConcreteFlyweight
Operation(extrinsicState)
intrinsicState
UnsharedConcreteFlyweight
Operation(extrinsicState)
allState
Client

Participants

- Flyweight (**`glyph`** in text example)
  - Interface through which flyweights can receive and act on extrinsic state
- ConcreteFlyweight (**`character`**)
  - Implements flyweight interface, shareable, only intrinsic state (independent of context)
- UnsharedConcreteFlyweight (**`row, column`**)
- FlyweightFactory
  - Creates and manages flyweight objects

Sample code

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```
class Glyph {
public:
  virtual ~Glyph();virtual
  void Draw(…);
  virtual void SetFont(…);
  …
}
class Character : public Glyph {
  Character(char);
  virtual void Draw(…);
private:
  char _charcode;
};
```

- The code itself is in the domain (glyphs, rows, etc.)
- But it's structured based on the pattern
- The client interacts with `Glyph`, `Character`

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A little more code

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```
Character* GlyphFactory::CreateCharacter(char c) {
  if (!_character[c]) {
      _character[c] = new Character();
  }
  return _character[c];
}
```

- Explicit code for each of the elements in the flyweight structure

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Classes of patterns: structural

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- These provide ways to compose interfaces and define ways to compose objects to obtain new functionality
- **`Adapter`** allows classes with incompatible interfaces to work together by wrapping its own interface around that of an already existing class
- **`Bridge`** decouples an abstraction from its implementation so that the two can vary independently
- **`Composite`** composes zero-or-more similar objects so that they can be manipulated as one object
- **`Decorator`** dynamically adds/overrides behavior in an existing method of an object
- **`Facade`** provides a simplified interface to a large body of code
- **`Flyweight`** reduces the cost of creating and manipulating a large number of similar objects
- **`Proxy`** provides a placeholder for another object to control access, reduce cost, and reduce complexity

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Classes of patterns: creational

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- For instantiating classes and objects
  - Class-creation patterns tend to exploit inheritance
  - Object-creation patterns tend to exploit delegation
- **`Abstract Factory`** groups object factories that have a common theme
- **`Builder`** constructs complex objects by separating construction and representation
- **`Factory Method`** creates objects without specifying the exact class to create
- **`Prototype`** creates objects by cloning an existing object
- Singleton restricts object creation for a class to only one instance

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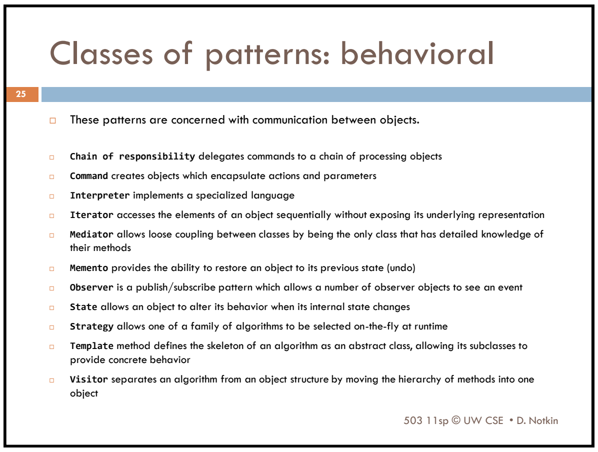

Classes of patterns: behavioral

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- These patterns are concerned with communication between objects.

- `Chain of responsibility` delegates commands to a chain of processing objects
- `Command` creates objects which encapsulate actions and parameters
- `Interpreter` implements a specialized language
- `Iterator` accesses the elements of an object sequentially without exposing its underlying representation
- `Mediator` allows loose coupling between classes by being the only class that has detailed knowledge of their methods
- `Memento` provides the ability to restore an object to its previous state (undo)
- `Observer` is a publish/subscribe pattern which allows a number of observer objects to see an event
- `State` allows an object to alter its behavior when its internal state changes
- `Strategy` allows one of a family of algorithms to be selected on-the-fly at runtime
- `Template` method defines the skeleton of an algorithm as an abstract class, allowing its subclasses to provide concrete behavior
- `Visitor` separates an algorithm from an object structure by moving the hierarchy of methods into one object

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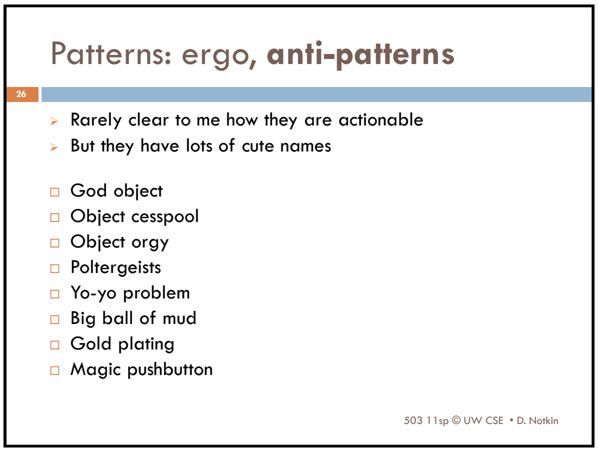

Patterns: ergo, **anti-patterns**

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- Rarely clear to me how they are actionable
- But they have lots of cute names

- God object
- Object cesspool
- Object orgy
- Poltergeists
- Yo-yo problem
- Big ball of mud
- Gold plating
- Magic pushbutton

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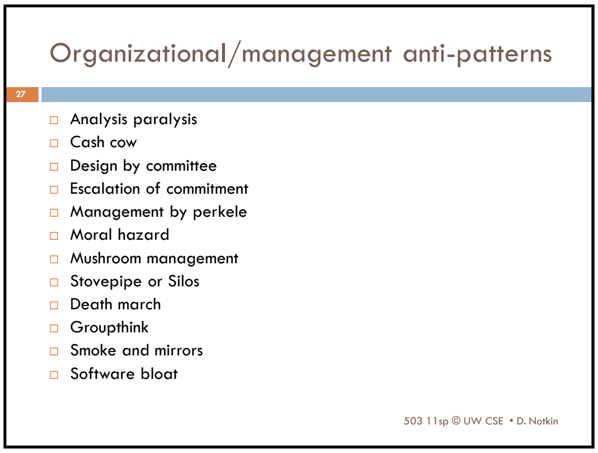

Organizational/management anti-patterns

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- Analysis paralysis
- Cash cow
- Design by committee
- Escalation of commitment
- Management by perkele
- Moral hazard
- Mushroom management
- Stovepipe or Silos
- Death march
- Groupthink
- Smoke and mirrors
- Software bloat

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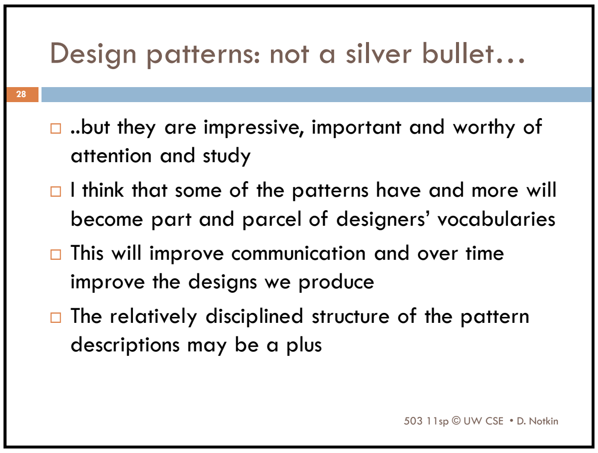

Design patterns: not a silver bullet…

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- ..but they are impressive, important and worthy of attention and study
- I think that some of the patterns have and more will become part and parcel of designers' vocabularies
- This will improve communication and over time improve the designs we produce
- The relatively disciplined structure of the pattern descriptions may be a plus

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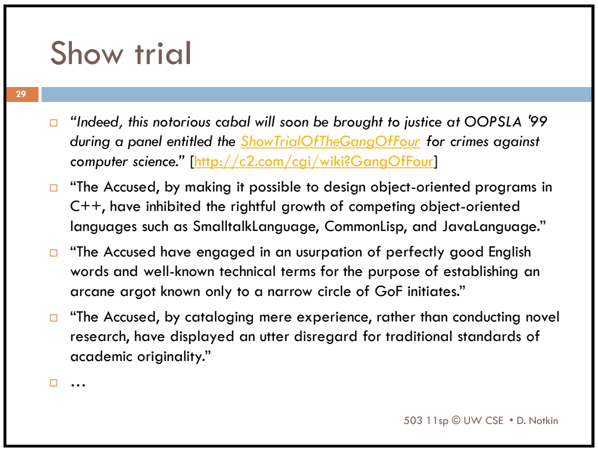

Show trial

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- *"Indeed, this notorious cabal will soon be brought to justice at OOPSLA '99 during a panel entitled the ShowTrialOfTheGangOfFour for crimes against computer science."* [http://c2.com/cgi/wiki?GangOfFour]
- "The Accused, by making it possible to design object-oriented programs in C++, have inhibited the rightful growth of competing object-oriented languages such as SmalltalkLanguage, CommonLisp, and JavaLanguage."
- "The Accused have engaged in an usurpation of perfectly good English words and well-known technical terms for the purpose of establishing an arcane argot known only to a narrow circle of GoF initiates."
- "The Accused, by cataloging mere experience, rather than conducting novel research, have displayed an utter disregard for traditional standards of academic originality."
- …

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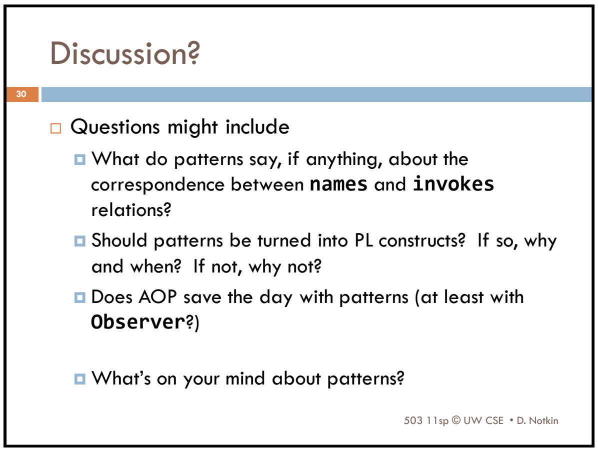

Discussion?

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- Questions might include
  - What do patterns say, if anything, about the correspondence between **`names`** and **`invokes`** relations?
  - Should patterns be turned into PL constructs? If so, why and when? If not, why not?
  - Does AOP save the day with patterns (at least with **`Observer`**?)

  - What's on your mind about patterns?

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