CS 494
Object-Oriented Analysis & Design

Design Patterns

Readings

- Chapter 1 of GoF book
  - Especially pp. 1-10, 24-26
  - I'll get this to you (toolkit, reserve, Web?)
- Eckel's *Thinking in Patterns,* on Web
  - Chap. 1, "The pattern concept"
  - Chap. 5, "Factories"
- Handouts on various patterns

Idioms, Patterns, Frameworks

- Idiom: a small language-specific pattern or technique
  - A more primitive building block
- Design pattern: a description of a problem that reoccurs and an outline of an approach to solving that problem
  - Generally domain, language independent
  - Also, analysis patterns
- Framework:
  - A partially completed design that can be extended to solve a problem in a domain
    - Horizontal vs. vertical

Examples of C++ Idioms

- Use of an Init() function in constructors
  - If there are many constructors, make each one call a private function Init()
    - Init() guarantees all possible attributes are initialized
    - Initialization code in one place despite multiple constructors
- Don't do real work in a constructor
  - Define an Open() member function
    - Constructors just do initialization
    - Open() called immediately after construction
  - Constructors can't return errors
    - They can throw exceptions

Design Patterns: Essential Elements

- Pattern name
  - A vocabulary of patterns is beneficial
- Problem
  - When to apply the pattern, what context.
  - How to represent, organize components
  - Conditions to be met before using
- Solution
  - Design elements: relationships, responsibilities, collaborations
  - A template for a solution that <u>you</u> implement
- Consequences
  - Results and trade-offs that result from using the pattern
  - Needed to evaluate design alternatives

Patterns Are (and Aren't)

- Name and description of a <u>proven</u> solution to a problem
- Documentation of a design decision
- They're not:
  - Reusable code, class libraries, etc. (At a higher level)
  - Do not require complex implementations
  - Always the best solution to a given situation
  - Simply "a good thing to do"

Describing Design Patterns

- The GoF defined a standard format
  - Generally followed
  - Not just a UML diagram!
- Pattern Format (13 sections):
  - Pattern name and classification
  - Intent: what's it do? Rationale?
  - Also known as
  - Motivation
    - A scenario that illustrates a sample problem and how this patterns helps solve it.
  - Applicability
    - For which situations can this be applied?
  - Structure
    - Graphical representation (e.g. UML)

Pattern Format (cont'd)

- Participants
  - Classes and objects, their responsibilities
- Collaborations
  - How participants interact
- Consequences
- Implementation
  - Pitfalls, hints, techniques, language issues
- Sample code
  - Code fragments that illustrate the pattern
- Known uses
  - From real systems
- Related patterns
  - Similar patterns, collaborating patterns

Example 1: Singleton Pattern

- Context: Only one instance of a class is created. Everything in the system that needs this class interacts with that one object.
- Controlling access: Make this instance accessible to all clients
- Solution:
  - The class has a static variable called *theInstance* (etc)
  - The constructor is made <u>private</u> (or protected)
  - Clients call a public operation *getInstance()* that returns the one instance
    - This may construct the instance the very first time or be given an initializer

Singleton: Java implementation

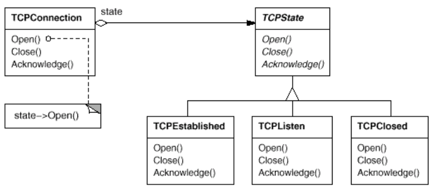
```
public class MySingleton {
  private static MySingleton theInstance =
        new MySingleton();
  private MySingleton() { // constructor
     …
  }

  public static MySingleton getInstance() {
        return theInstance;
  }
}
```

Static Factory Methods

- Singleton patterns uses a *static factory method*
  - Factory: something that creates an instance
- Advantages over a public constructor
  - They have names. Example: BigInteger(int, int, random) vs. BigInteger.probablePrime()
  - Might need more than one constructor with same/similar signatures
  - Can return objects of a subtype (if needed)
- Wrapper class example:
  Double d1 = Double .valueOf("3.14");
  Double d2 = new Double ("3.14");
- More info: Bloch's *Effective Java*

The State Design Pattern

- A connection can be in various states
  - Handles requests differently depending on state
- Connection delegates requests to its state object
  - Which changes dynamically



TCPConnection
Open()
Close()
Acknowledge()
state
TCPState
Open()
Close()
Acknowledge()
state->Open()
TCPEstablished
Open()
Close()
Acknowledge()
TCPListen
Open()
Close()
Acknowledge()
TCPClosed
Open()
Close()
Acknowledge()