ECE450 – Software Engineering II

Today: **Design Patterns I**

The *patterns* ruckus

- We (software people) didn't start the fire
- Christopher Alexander
  - *A Pattern Language*
  - *A Timeless Way of Building*

The *patterns* ruckus (more)

The *patterns* ruckus (even more)

Patterns in the world

- There are some problems that come up over and over again in a domain
  - Architecture: How to provide easy access to an enclosed space selectively?
  - Software: How to allow for open extension of classes without modifying their currently accepted code?
- Each time a similar problem comes up, designers will typically start with something that has worked before
  - But then add a wrinkle inspired by something that works better for their current context
- In the software field, an enthusiastic community has formed around the concept of *design patterns*
  - The "Gang of Four" (I hate that name) *Design Patterns* book really started it all in 1995
  - Architectures and designs are discussed using patterns terminology
  - People won't treat you with respect as a designer anymore if you're not familiar with at least some patterns

A pattern must...

- Solve a problem
  - That is, it must be useful
- Have a context
  - It must describe where the solution can be used
- Recur
  - It must be relevant in other situations
- Teach
  - It must provide sufficient understanding to tailor the solution
- Have a name
  - It must be referred to consistently

Patterns craze

- Beware!
  - It's a sign of **lack of** expertise to think everything can be solved with patterns
  - Or to believe that the more patterns one can stick into one's design, the better
- Not everything is a pattern
- Patterns do not lead to direct code reuse
- Patterns are deceptively simple
- Even experts can disagree
  - (ESPECIALLY experts can disagree)
- Designers' key quality is good judgment
  - Good judgment comes from experience
  - Patterns are *not* a workaround to exercising good judgment

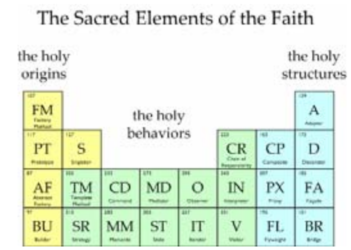
Design Pattern Descriptions

- Name and intent
- Problem and context
  - What is the problem and the context where we would use this pattern?
  - Under what specific conditions should this pattern be used?
- Solution
  - A description of the elements that make up the design pattern
  - Emphasizes their relationships, responsibilities, and collaborations
  - Not a concrete design or implementation; rather an abstract description
- Positive and negative consequences of use
  - The pros and cons of using the pattern
  - Includes impact on reusability, portability, and extensibility

Organizing Patterns

- Organizing by purpose: What a pattern does
  - Creational: Creating, initializing, and configuring classes and objects
  - Structural: Composition of classes and objects
  - Behavioral: Dynamic interactions among classes and objects
- Organizing by scope: What the pattern applies to
  - Class patterns
    - Focus on the relationships between classes and their subclasses
    - Involve inheritance reuse
  - Object patterns
    - Focus on relationships between objects
    - Involve composition reuse
- How would you classify the Template Method pattern?

Organizing Patterns...

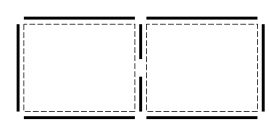


Do I need to master them all?

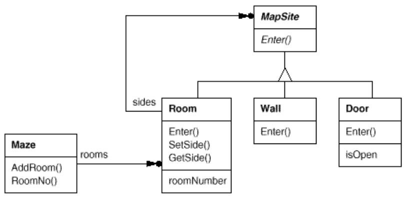
- No –at least not now
- For the final, you're expected to:
  - Superficially know of all of them
  - Master in depth a few of each kind
- The patterns catalog doesn't end with the Gang of Four book
  - There are concurrency patterns, analysis patterns, etc.
  - Unreasonable to know of all of them if they're out of your domain

Maze example

- Building a maze for a computer game
- A maze is a set of rooms
- A room knows its neighbours
  - Another room
  - A wall
  - A door



Maze classes



Maze creation

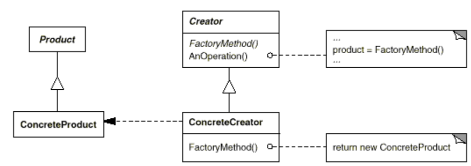
```
public Maze createMaze() {
  Room r1 = new Room(1);
  Room r2 = new Room(2);
  Door d  = new Door(r1, r2);

  r1.setSide(Direction.North, new Wall());
  r1.setSide(Direction.East, d);
  r1.setSide(Direction.West, new Wall());
  r1.setSide(Direction.South, new Wall());

  r2.setSide(Direction.North, new Wall());
  r2.setSide(Direction.East, d);
  r2.setSide(Direction.West, new Wall());
  r2.setSide(Direction.South, new Wall());

  Maze m = new Maze();
  m.addRoom(r1);
  m.addRoom(r2);
  return m;
}
```


That wasn't fun

- Fairly complex member just to create a maze with two rooms
- Obvious simplification
  - Room could initialize sides with four new `Walls`
  - That (kind of) just moves the code elsewhere
- Problem lies elsewhere: *inflexibility*
  - Hard-codes the maze creation
  - Changing the layout can only be done by rewriting, or overriding and rewriting
- Plan for evolution
  - Want to make the maze more flexible
    - Easy to change the components of the game
  - What to do about `DoorNeedingSpell` or `EnchantedRoom`?
    - How can you change `createMaze()` so that it creates mazes with these different kinds of classes?
    - Biggest obstacle is hard-coding of class names

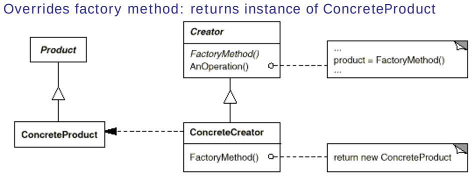
Design pattern: Factory method

- Use when:
  - A class can't anticipate the kind of objects to create
  - Hide the secret of which helper subclass is the current delegate



Factory method (structure)

- Product
  - Defines the interface of objects the factory method creates
- ConcreteProduct
  - Implements the Product interface
- Creator
  - Declares the factory method which returns a Product type
  - Defines a default implementation
  - Calls the factory method itself
- ConcreteCreator
  - Overrides factory method: returns instance of ConcreteProduct



Sample code

```
public class MazeGame {
  public static void main(String[] args) {
    Maze m = new MazeGame().createMaze();
  }

  private Maze makeMaze() { return new Maze(); }
  private Wall makeWall() { return new Wall(); }
  private Room makeRoom(int r) { return new Room(r); }
  private Door makeDoor(Room r1, Room r2) {
    return new Door(r1, r2);
  }

  public Maze createMaze() {
    // do what's needed
  }
}
```


Sample code (cont)

```
public Maze createMaze() {
   Room r1 = makeRoom(1);
   Room r2 = makeRoom(2);
   Door d  = makeDoor(r1, r2);

   r1.setSide(Direction.North, makeWall());
   r1.setSide(Direction.East, d);
   r1.setSide(Direction.West, makeWall());
   r1.setSide(Direction.South, makeWall());

   r2.setSide(Direction.North, makeWall());
   r2.setSide(Direction.East•, makeWall());
   r2.setSide(Direction.West, d);
   r2.setSide(Direction.South, makeWall());

   Maze m = makeMaze();
   m.addRoom(r1);
   m.addRoom(r2);
   return m;
 }
```


Sample code (cont 2)

```
public class BombedMazeGame extends MazeGame {
  private Wall makeWall() {
    return new BombedWall();
  }
  private Room makeRoom(int r) {
    return new RoomWithABomb(r);
  }
}

public class EnchantedMazeGame extends MazeGame {
  private Room makeRoom(int r)
    {  return new EnchantedRoom(r, castSpell());  }
  private Door makeDoor(Room r1, Room r2)
    {  return new DoorNeedingSpell(r1, r2);  }
  private Spell castSpell()
    {  return new Spell();  }
}
```

Sample code (cont 3)

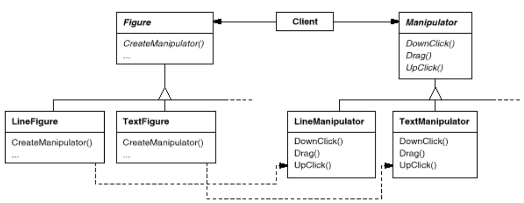
```
public static void main(String[] args) {
  Maze m = new EnchantedMazeGame().createMaze();
}

public static void main(String[] args) {
  Maze m = new BombedMazeGame().createMaze();
}
```


Consequences

- Advantage
  - Eliminates the need to bind specific implementation classes
  - Can work with any user-defined ConcreteProduct classes
- Disadvantage
  - Uses an inheritance dimension
  - Must subclass to define new ConcreteProduct objects
  - Interface consistency required

Other consequences

- Provides hooks for subclasses
  - Always more flexible than direct object creation
- Connects parallel class hierarchies
  - Localizes knowledge of which classes belong together



Implementation

- Two major varieties
  - Creator class is abstract
    - *Requires* subclass to implement
  - Creator class is concrete: provides a default implementation
    - *Optionally allows* subclass to re-implement
- Parameterized factory methods
  - Generic make() method takes class id as parameter
- Naming conventions
  - Use makeXXX() names
- Return object of class to be created
  - Or store as member variable