Design principles

OOD: Lecture 4

Next lecture

- UML: Thursday, Sep 20, at 8:15 am in 1211

Reminder: Readings

- Wirfs-Brock, R., and B. Wilkerson (1989) “Object-oriented design: a responsibility-driven approach”
- *Wikipedia's entry on Object-oriented Design*

“Software rot”

- Increased difficulty to adapt and maintain
- Causes
  - Communication/Documentation breakdown
    - Maintainers not fully familiar with the original design principles -> change works, but…
  - Design is not resilient in the face of change

Symptoms of rotting design

- **Rigidity**
  - Every change causes a cascade of subsequent changes in dependent modules. “2 days -> 2 months”
- **Fragility**
  - Breaks in many places when a change is made
- **Immobility**
  - Reuse is more work than creating from scratch
- **Viscosity**: The law of least resistance when faced with a choice
  - *Design* viscosity: Hacks are easier/faster than preserving the design
  - *Environment* viscosity: Slow cycle time -> fastest choice

Dependency management

- Rigidity, fragility, immobility, and viscosity are all four – arguably – caused by an improper dependency structure
- Three groups of preventive principles / guidelines
  - Class design
  - Package cohesion
  - Package coupling

Principles of object-oriented class design

SOLID:

- **SRP**: The single responsibility principle
- **OCP**: The Open Closed principle
- **LSP**: The Liskov substitution principle
- **ISP**: The interface segregation principle
- **DIP**: The dependency inversion principle

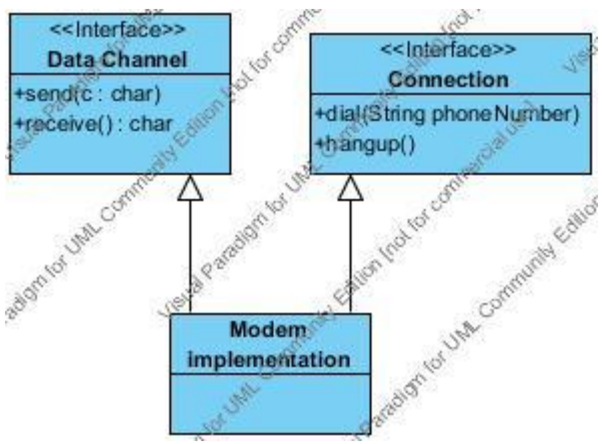
SRP
The single responsibility principle

- *A class should have one, and only one, reason to change.*
- A class should have a single responsibility
- Example

```
interface Modem {    //Modem.java -- SRP Violation
    public void dial(String phoneNumber);
    public void hangup();
    public void send(char c);
    public char receive();
  }
```

SRP continued

- Two responsibilities
  - Connection management: `dial` and `hangup`
  - Data communication: `send` and `receive`
- Better



  - Nothing depends on the modem implementation class

OCP
The Open Closed principle

- *A module should be open for extension but closed for modification.*
  - Ability to change what the module does, without changing its source code
  - Techniques based on abstraction
    - Dynamic polymorphism
    - Static polymorphism

Dynamic polymorphism OCP violation example

```
struct Modem {
    enum Type {hayes, courier, ernie) type;
};
struct Hayes {
    Modem::Type type;
    // Hayes related stuff
};
struct Courier {
    Modem::Type type;
    // Courier related stuff
};
struct Ernie {
    Modem::Type type;
    // Ernie related stuff
};
void LogOn(Modem& m, string& pno, string& user, string& pw) {
        if (m.type == Modem::hayes) {
            DialHayes((Hayes&)m, pno);
        } else if (m.type == Modem::courier) {
            DialCourier((Courier&)m, pno);
        } else if (m.type == Modem::ernie) {
            DialErnie((Ernie&)m, pno)
        // ...
     }
}
```

OCP: Dynamic polymorphism continued

```
class Modem {
  public:
    virtual void Dial(const string& pno) = 0;
    virtual void Send(char) = 0;
    virtual char Recv() = 0;
    virtual void Hangup() = 0;
};

void LogOn(Modem& m, string& pno,
           string& user, string& pw) {
  m.Dial(pno);
  // you get the idea.
}
```

OCP: Static polymorphism

- Templates/Generics

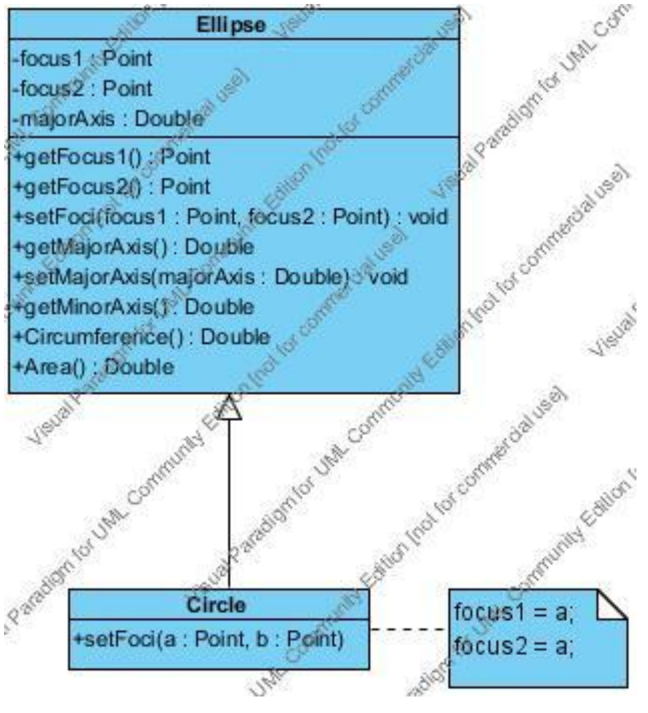
```
template <typename MODEM>
  void LogOn(MODEM& m, string& pno,
                   string& user, string& pw) {
    m.Dial(pno);
    // ...
}
```

LSP
The Liskov substitution principle

- *Derived classes must be substitutable for their base classes.*
- The contract of the base class must be honoured by the derived class
- A derived class is substitutable for its base class if:
  - Its *pre-conditions* are no stronger than the base class method.
  - Its *post-conditions* are no weaker than the base class method.
- Or, in other words, derived methods should expect no more and provide no less.

LSP violation
The Circle/Ellipse dilemma

- A circle `is-an` ellipse



LSP violation 2

- A client code fragment:

```
void f(Ellipse e) {
  Point a = new Point(0, 1);
  Point b = new Point(1, 0);
  e.setFoci(a, b);
  e.setMajorAxis(3);
  assert e.getFocus1() == a;
  assert e.getFocus2() == b;
  assert e.getMajorAxis() == 3;
}
```

LSP violation 3

- Ugly client-side fix

```
void f(Ellipse e) {
  if (e.getClass().equals(
                  Ellipse.class)) {
    //…
  } else {
    throw new Exception(
            "Not a real ellipse");
  }
```

ISP
The interface segregation principle

- *Make fine grained interfaces that are client specific.*
  Or
  Many client specific interfaces are better than one general purpose interface
- [Kent] Do not change interfaces unless absolutely necessary, and especially do not change method signatures

DIP

The dependency inversion principle

- *Depend on abstractions, not on concretions.*
- The primary mechanism of OO design
- No dependency should target a concrete class
  - Non-volatile classes (e.g. Java core library classes) tend to cause less problems

Principles of package cohesion

- **REP**: The release reuse equivalency principle
- **CCP**: The common closure principle
- **CRP**: The common reuse principle

Note that these three exist in a balance. They can’t all three be completely satisfied at the same time

REP
The release reuse equivalency principle

- *The granule of reuse is the granule of release.*
- Package together what would be reused together
- Support and maintain older versions
- Simplifies reuse

CCP
The common closure principle

- *Classes that change together are packaged together.*
- Minimizes configuration management (CM) work
  - I.e. management, test, and release of packages
- Simplifies development and maintenance
- Tends towards big packages

CRP
The Common Reuse Principle

- *Classes that aren't reused together should not be grouped together.*
- Complement of REP
- Avoid forcing unnecessary client re-building
- Simplifies reuse
- Tends to small packages

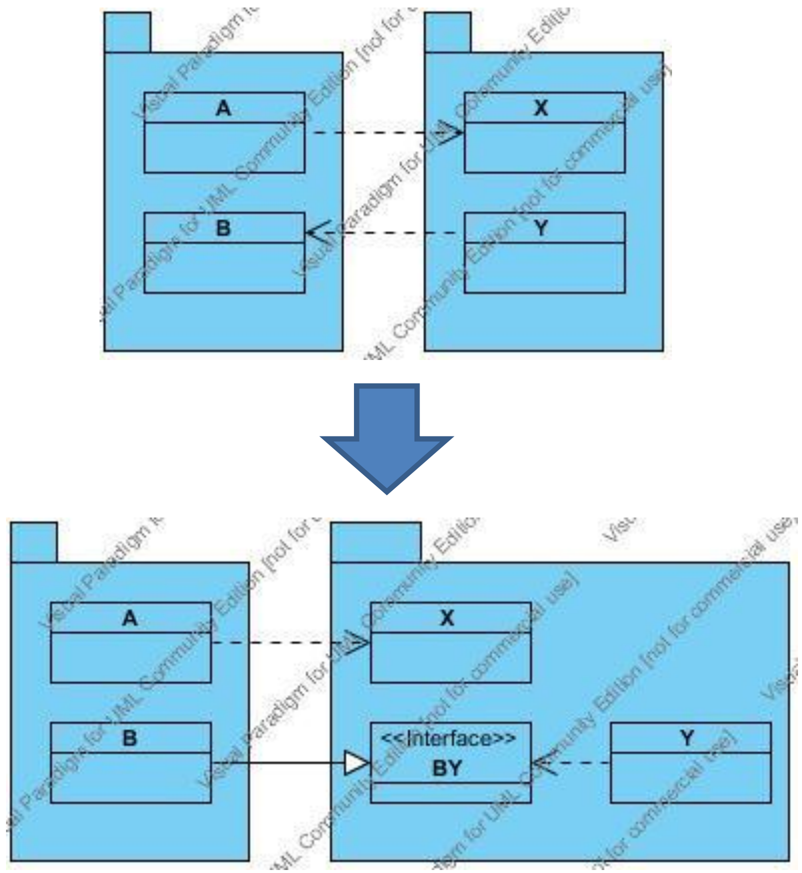
Principles of package coupling

- **ADP**: The acyclic dependencies principle
- **SDP**: The stable dependencies principle
- **SAP**: The stable abstractions principle

ADP
The acyclic dependencies principle

- *The dependency graph of packages must have no cycles.*
- Cycles increase the work to re-build and eventually make every package depend on every other package
- Breaking a cycle
  - New package: Break out of dependency target
  - Apply dependency inversion (DIP) + interface segregation (ISP)

ADP: Breaking a cycle
Applying DIP & ISP



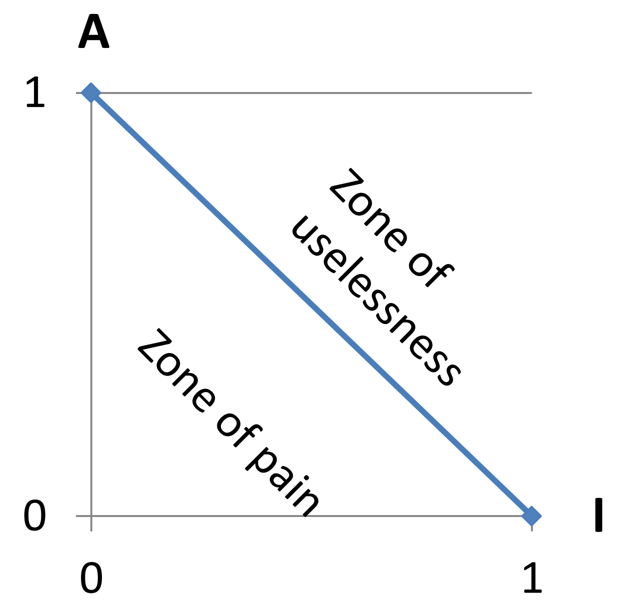
SDP

The stable dependencies principle

- *Depend in the direction of stability.*
- A way of reducing the number of packages that are hard to change because changes would propagate to many other packages
- $Instability = \frac{C_e}{C_a + C_e}$
- Depend upon packages whose Instability metric is lower than yours

SAP
The stable abstractions principle

- *Abstractness increases with stability*
  or
  Stable packages should be abstract packages.
- Can be seen as a re-formulation of dependency inversion (DIP)
- Abstract – stable – easy to extend (OCP)
- Concrete – instable – easy to change



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