Software methodology and snake oil

- **programming is hard**
  - programs are very expensive to create
  - full of errors
  - hard to maintain
- **how can we design and program better?**
- **a fruitful area for people selling "methodologies"**
  - for nearly 40 years
- **each methodology has the germ of a useful idea**
- **each claims to solve major programming problems**
- **some are promoted with religious fervor**
- **in fact most don't seem to work well**
- **or don't seem to apply to all programs**
- **or can't be taught to others**

- **a few are genuinely useful and should be part of everyone's repertoire**

Examples...

- **modularity, information hiding, coupling, cohesion**
- **structured programming (programming without goto's)**
  - top-down development, successive refinement
  - chief programmer teams, egoless programming
  - structured X: design, analysis, requirements, specification, walkthroughs...
- **CASE tools (Computer Aided Software Engineering)**
  - UML (Unified Modeling Language), message sequence charts, state diagrams
- **formal methods**
  - verification, validation, correctness proofs, model checking
- **object-oriented programming**
  - CRC cards (Class, Responsibilities, and Collaborators)
  - object-oriented everything
    design, analysis, requirements, specification, walkthroughs...
- **RAD (rapid application development)**
  - components, COTS (Components off the Shelf)
  - 4th generation languages, automatic programming, X by example, graphical programming
- **extreme programming, refactoring, agile methods, pair programming, ...**
- **aspect oriented programming**
- **design patterns**
  - patterns of everything

Design patterns

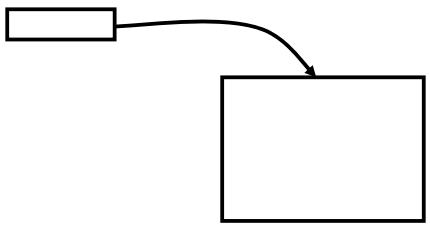
- **"Design patterns ... describe simple and elegant solutions to specific problems in object-oriented software design."**
  - *Design Patterns: Elements of Reusable Object-Oriented Software*, by Gamma, Helm, Johnson, Vlissides (the "Gang of Four"), 1995
- **"idioms for design" or program structure**
  - successful among broad group of programmers
  - widely used to describe software structure
- **three basic categories:**
  - creational: making things
  - structural: organizing things
  - behavioral: operating things

Bridge (or "handle/body") pattern

- **"Decouple an abstraction from its implementation so that the two can vary independently"**
- **C++ string class: separate handle from body**
  - implementation can be changed without changing abstraction of "string"

```
class String {
   private:
        Srep *p;
   public:
        ...

};
class Srep {
        char *sp;  // data
        int   n;   // ref count
        ...
};
```



- **similar examples:**
  - FILE * in C stdio, RE * in regexpr interface, connection in MySQL interface
- **change of implementation has no effect on client**
  - can even switch implementation at run time
- **(in C and C++) hides implementation completely**
  - C: hidden behind opaque type; C++: implementation class is invisible
- **can share implementation among multiple objects without revealing the sharing**
  - e.g., reference counting, sharing of open files in FILE*

Adapter (or Wrapper) pattern

- **"Convert the interface of one class into another interface that clients expect"**

- **maps one interface into another**
  - more or less at the same level

- **e.g., in the C stdio package:**

  fread(buf, objsize, nobj, stream)
  fwrite(buf, objsize, nobj, stream)

  are wrappers around

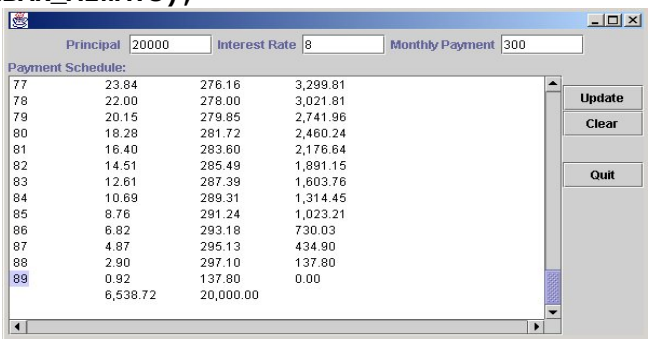
  read(fd, buf, size)
  write(fd, buf, size)

Decorator pattern

- **"Attach additional responsibilities to an object dynamically"**

- **decorator conforms to interface it decorates**
  - transparent to clients
  - forwards some requests
  - usually does some actions of its own before or after
- **e.g., Java Swing JScrollPane class**

```
JTextArea tpay = new JTextArea(15, 45);
JScrollPane jsp = new JScrollPane(tpay,
  JScrollPane.VERTICAL_SCROLLBAR_ALWAYS,
  JScrollPane.HORIZONTAL_SCROLLBAR_ALWAYS);
```



Decorator pattern (2)

```
FileInputStream fin = new FileInputStream(args[0]);
FileOutputStream fout = new FileOutputStream(args[1]);

BufferedInputStream bin = new BufferedInputStream(fin);
BufferedOutputStream bout = new BufferedOutputStream(fout);
```

- **responsibility for buffering attached dynamically**
- **interface remains unchanged**
- **transparent to clients**

Other structural patterns

- **Composite: "Compose objects into tree structures to represent part-whole hierarchies."**
  - can treat individual objects and composition of objects uniformly
  - e.g., window systems
- **Facade: "Provide a unified interface to a set of interfaces in a subsystem."**
  - provides a higher-level interface to something underneath that remains visible and accessible
  - graphics interfaces (e.g., X widgets -> X toolkits -> X intrinsics -> Xlib)
  - simplified socket package (Perl and others)
  - …
- **Proxy: "Provide a surrogate or placeholder for another object to control access to it."**
  - smart pointers, scoped pointers
  - proxy servers for web
  - …

Creational patterns

- **Abstract Factory: "Provide an interface for creating families of related or dependent objects." (also Builder and Factory)**
  - DOM and SAX builder factories
- **Singleton: "Ensure a class only has one instance"**
  - Java System, Runtime, Math classes
- **Prototype: "Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype."**
  - Javascript objects

Behavorial patterns

- **Observer: "Define a one-to-many dependency between objects so that when one object changes state, all its dependents are notified and updated automatically"**
- **Java ActionListener mechanism:**

  `button.addActionListener(this)`
  - tells **button** to notify **this** container when event happens
  - usually called by container that contains object that will get the event
  - can have more than one listener

  `void actionPerformed(ActionEvent e) { … }`
  - called when event occurs
  - determines type or instance that caused event
  - handles it

Behavorial patterns (2)

- **Iterator: "Provide a way to access the elements of an aggregate object sequentially without exposing its underlying representation"**
  - the basis of algorithms in C++ STL

```
Map hs = new TreeMap();
for (Iterator it : hs.keySet()) {
      String n = (String) it.next();
      Integer v = (Integer) hs.get(n);
      ...
```

- **Visitor: "Represent an operation to be performed on the elements of an object structure"**
  - almost any tree walk that does some evaluation at each node
  - draw() where one kind of "Shape" is an entire picture made of Shapes
- **Memento: "Without violating encapsulation, capture and externalize an object's internal state so that the object can be restored to this state later"**
  - Java serialization
  - JSON, XML, ...

Behavioral patterns (3)

- **Interpreter: "Given a language, define a representation for its grammar along with an interpreter that uses the presentation to interpret sentences in the language"**
- **regular expression processors**
- **eval(…) or execute(…) in many languages**
- **printf format strings?**
- **domain-specific / application-oriented languages**
  - JSON, XML, HTML, CSS, etc.
  - Makefiles
  - find command
  - Shell, Awk, ...
  - AMPL, R, ...
  - TEX et al

Summary

- **design patterns:**
  - a useful idea
  - a way to think about, organize, talk about programming
  - likely to still be around in 10 years

  - worth knowing the idea
  - worth recognizing some of the common ones
  - will help you to look alert in an interview

- **methodologies more broadly:**
  - usually a germ of a good idea
  - enthusiasm, initial success in a small sample
  - leads to unwarranted generalization
  - thus oversold or hyped

  - healthy skepticism is warranted