Expressing Architectural Design Intent in Code

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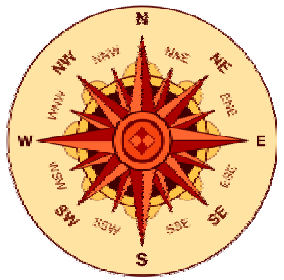
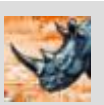
Summary

- **Design intent is lost between design à code**
  - Hard to infer design from code
  - But we can make it easier
- **Hints in code preserve design intent**
  - Easier to encode extensional intent
  - Hard to encode intensional intent (e.g. for all components …)
- **Big idea now – read patterns later**
  - Read the full chapter: http://goo.gl/NYxdy
  - Talk on YouTube

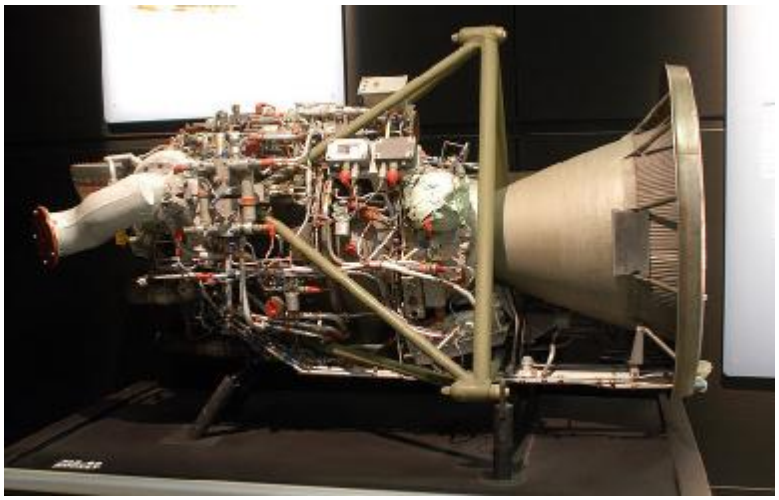


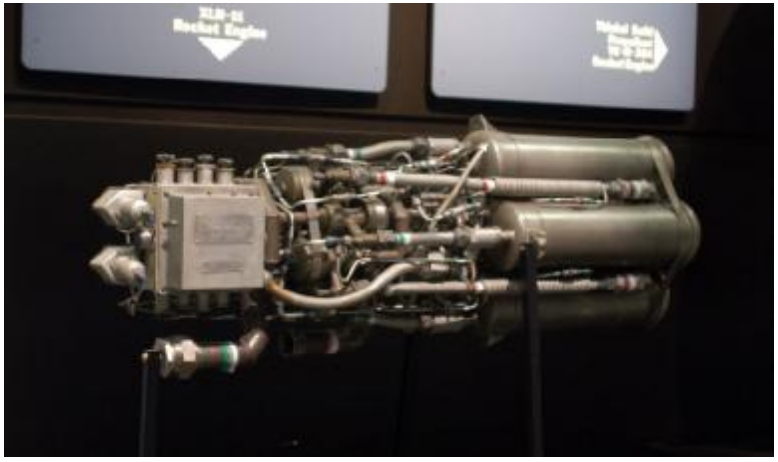


It’s hard to infer design intent

Machines are solutions, not designs

- Why are they lying around?
- Won't bad guys copy them?
- What can you learn by looking at them?
- What knowledge is needed to build your own rocket?
- What is missing from these rockets? I.e., what can't you learn?





These are solutions, not designs

Programs also express solutions

- To a computer, these programs are equally good
- ... but not to a human

```
void primes(int cap, int t, int composite) {
  int i,j;
  i = t / cap;
  j = t % cap;
  if(i <= 1)
    primes(cap,t+1,composite);
  else if(!j)
    primes(cap,t+1,j);
  else if(j == i && !composite)
    (printf("%d\t",i), primes(cap,t+1,composite));
  else if(j > 1 && j < i)
    primes(cap,t+1, composite + !(i % j));
  else if(t < cap * cap)
    primes(cap,t+1,composite);
}

int main() {
  primes(100,0,0);
}
```

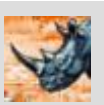
```
void p(int m, int t, int c) {
  ((t / m) <= 1) ? p(m,t+1,c) :
  !(t % m) ? p(m,t+1, t % m) :
  ((t % m)==(t / m) && !c) ?
  (printf("%d\t",(t / m)), p(m,t+1,c)) :
  ((t % m)> 1 && (t % m) < (t / m)) ?
  p(m,t+1,c + !((t / m) % (t % m))) :
  (t < m * m) ? p(m,t+1,c) : 0;
}

int main() {
  p(100,0,0);
}
```

Solution != design intent

Example obfuscated code from Wikipedia

In a nutshell

- A running machine is a valuable thing
- But we would also like to know:
  - How it works
  - Why it works
  - How to evolve and change it
  - The principles it embodies
- It's hard, maybe impossible, to understand these by inspection
- Some machines are easier to understand than others
- Understandable code à saved time

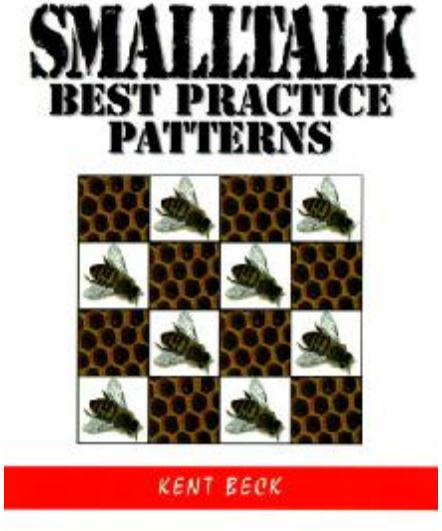


Model in code principle

Expressing design intent

- **Kent Beck: Smalltalk Best Practice Patterns**
- **Intention Revealing Message**
  (i.e., method name)

  "What's going on? Communication. … Intention Revealing Messages are the most extreme case of writing for readers instead of the computer. As far as the computer is concerned, both versions are fine. The one that separates intention (what you want done) from implementation (how it is done) communicates better to a person."



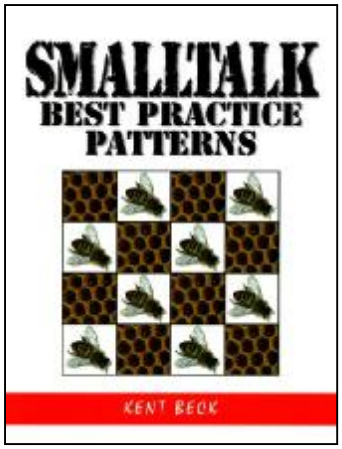
Beck's example

- Obvious solution: invert colors in the callback
- Expressing intent:
  - § Name method "highlight" to show intent
  - § How do we highlight? We invert colors.
  - § So, add another method "invertColors"

Important idea:
Write more code than necessary.
Extra code = hints.

```
doubleClickCallback(Drawable d)
    d.highlight();
```

```
highlight()
    this.invertColors();

invertColors()
    temp = this.getBackgroundColor();
    this.setBackgroundColor( this.getForegroundColor() )
    this.setForegroundColor( temp );
```



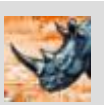
We provide hints all the time

- Class names
  - Airplane, Route
- Method names
  - taxi(), takeoff(), land()
- Variable names
  - fuelRemaining, flapAngle
- Object responsibilities (somewhat)
- Nesting
  - Wing is part of a Plane

So, why does this work?

Model-in-code principle

- **Model-in-code principle:**
  - Expressing models in code helps comprehension and evolvability
- **One kind of model: Domain model**
  - Standard in OO programming (e.g., Booch method)
  - Objects mirror domain concepts
  - Stronger: Domain Driven Design (Eric Evans)
- **So, what about our architecture model in code?**



Architecture in code

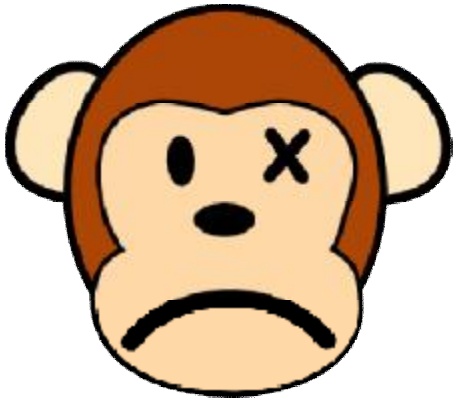
Motivation: Why reveal architecture in code

- When reading code, want to know:
  - Who talks to who
  - Invariants and constraints
  - Styles and patterns
  - Performance requirements or guarantees
  - Data structures used for communication
  - Etc.
- Easy to see in architecture model
- Hard to see in code

Problem: Cannot express all architecture in code

- Source code is good at expressing solutions
- It cannot express all architecture design intent

... why not?

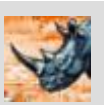


Extensional and intensional

Source: Eden and Kazman

- **Definitions**
  - **Extensional: elements that are enumerated**
    - **E.g., "The system is composed of a modules A, B, and C"**
  - **Intensional: elements that are universally quantified**
    - **E.g., "All filters can communicate via pipes"**

Intensional / Extensional	Architecture model element	Translation into code
Extensional (defined by enumerated instances)	Modules, components, connectors, ports, component assemblies	These correspond neatly to elements in the implementation, though at a zoomed-out higher level of abstraction (e.g., one component corresponds to multiple classes)
Intensional (quantified across all instances)	Styles, invariants, responsibility allocations, design decisions, rationale, protocols, quality attributes and models (e.g., security policies, concurrency models)	Implementation will conform to these, but they are not directly expressed in the code. Architecture model has general rule, code has examples.

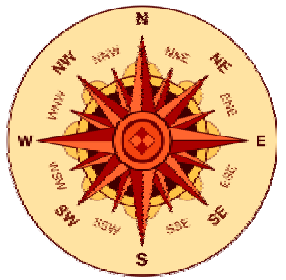


Catalog of patterns

Pattern catalog

- Organizing a catalog of patterns is hard
  - § Let's organize it in slices

- Slice 1: Module dependencies
- Slice 2: Package structure
- Slice 3: Module à Runtime
- Slice 4: Visible components
- Slice 5: Visible connectors
- Slice 6: Properties, styles, patterns



Slice 1: Module dependencies

- Desire: Express/enforce dependencies between modules

- Pattern: use tool to express dependencies
  - Option: VerifyDesign Ant task
  - Option: Framework, like .Net assemblies, OSGi bundles
  - Option: Murphy and Notkin “Reflexion”; Dean Sutherland module system; Halloran enforcing module layers (research)

- These allow you to specify dependencies
- Maybe to check them

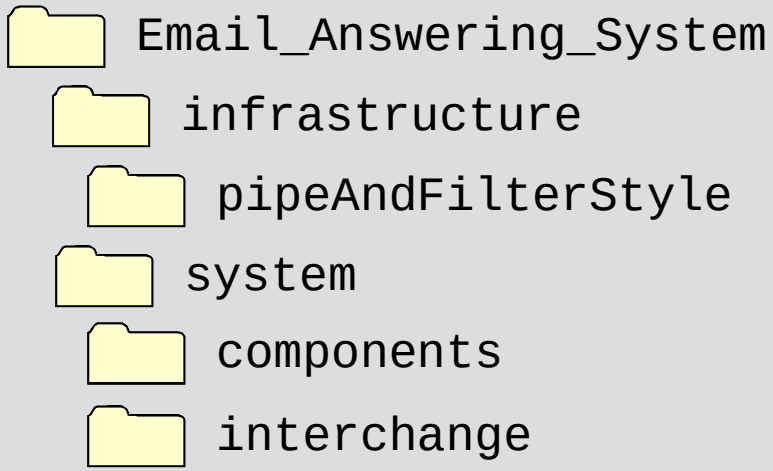
- Some allow “do not depend on” specifications

Slice 2: Package structure

- **Desire: Components visible in code**

- **Modules and components**
  - **No required alignment**
    … but easier if they do align

- **Example of alignment:**
  - **modules A+B+C à component Y**
  - **modules B+D+E à component Z**



- **Pattern: align module and component boundaries**
  - **1:1 module-component alignment?**

- **Pattern: module for interchange types**

Slice 3: Module à Runtime

- Centralized startup code
  - Creation
  - Assembly
  - Initialization
- Alternative:
  - Scattered creation
  - Scattered assembly
- Aids comprehension
- Aids analysis

```
…
public static void main(String[] args) {
   createPipes();
   createFilters();
   startFilters();
   …
}
protected static void createPipes() {
   pipeCleanupToTagging = new Pipe<EmailMessage>( );
   pipeTaggingToMux = new Pipe<EmailMessage>( );
   …
}
protected static void createFilters() {
   filterCleanup = new InputCleanupFilter();
   filterTagging = new TaggingFilter();
   …
}
protected static void startFilters() {
   filterCleanup.run();
   filterTagging.run();
   …
}
```

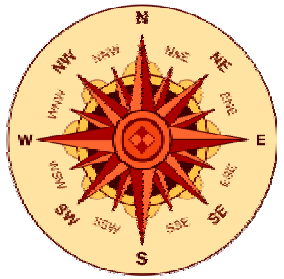
... or use a configuration language

- **Pattern: hoist initialization and configuration**
  - Write in declarative language (e.g., XML)
  - Code reads config file, then creates, attaches, initiates
  - E.g., Struts, EJB, OSGi/Eclipse

Pattern catalog

- **Organizing a catalog of patterns is hard**
  - **Let's organize it in slices**

- **Slice 1: Module dependencies**
- **Slice 2: Package structure**
- **Slice 3: Module à Runtime**
- **Slice 4: Visible components**
- **Slice 5: Visible connectors**
- **Slice 6: Properties, styles, patterns**



Slice 4: Visible components

- **Desire: Components visible in code**
- **Pattern: Abstract class for a Filter, a kind of component**
  - **Differentiates components from other classes**
  - **Standardizes startup with run() and work() template pattern**
- **Find in IDE via class hierarchy**
  - **Show all subclasses of Filter or Component**

```
package infrastructure.pipeAndFilterStyle;

import infrastructure.Component;

abstract public class Filter extends Component
        implements Runnable {
    public void run() {
        try {
            this.work();
        } catch (Exception e) {
            System.exit(1);
        }
    }
    abstract protected void work()
        throws InterruptedException;
}
```

Slice 5: Visible connectors

- **Desire: Connectors visible in code**

- **Pattern: Final class for Pipe, a kind of Connector**
  - § **No subclasses**

- **Hoists concurrency concern**
  - § **Discuss: how?**

- **Find in IDE**

```
package infrastructure.pipeAndFilterStyle;

import infrastructure.Connector;
import java.util.concurrent.BlockingQueue;
import java.util.concurrent.LinkedBlockingQueue;

public final class Pipe<T> extends Connector {
   private BlockingQueue<T> myPipe = new LinkedBlockingQueue<T>();
   private boolean isClosed = false;

   public T blockingRead() throws InterruptedException {
      if ( myPipe.isEmpty() ) return null;
      T t = myPipe.take();
      return t;
   }
   public void blockingWrite(T t) throws InterruptedException {
      if ( isClosed() ) throw new IllegalStateException();
      myPipe.put( t );
   }
   public void close() throws InterruptedException { this.isClosed = true; }
   public boolean isClosed() { return isClosed ; }
   public boolean isClosedAndEmpty() {
      if ( isClosed() && myPipe.isEmpty() ) return true;
      else return false;
   }
}
```

Slice 6: Properties, styles and patterns

- **Desire: make properties, styles, and patterns visible**

- **Pattern: express properties with names**
  - E.g., asynchronousWrite()
  - E.g., readOnlyProvidedInventoryPort
- **Pattern: express properties with annotations**
  - E.g., @asynchronous write()
  - E.g., @readonly providedInventoryPort
  - Enables machine checkability
- **Pattern: express styles/patterns with names**
  - E.g., InventoryFacade, ASTVisitor
  - E.g., TaggingFilter, LyricsServer, VOIPPeer

Summary

- **Design intent is lost between design à code**
  - Hard to infer design from code
  - But we can make it easier
- **Hints in code preserve design intent**
  - Easier to encode extensional intent
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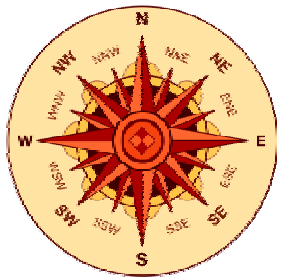

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