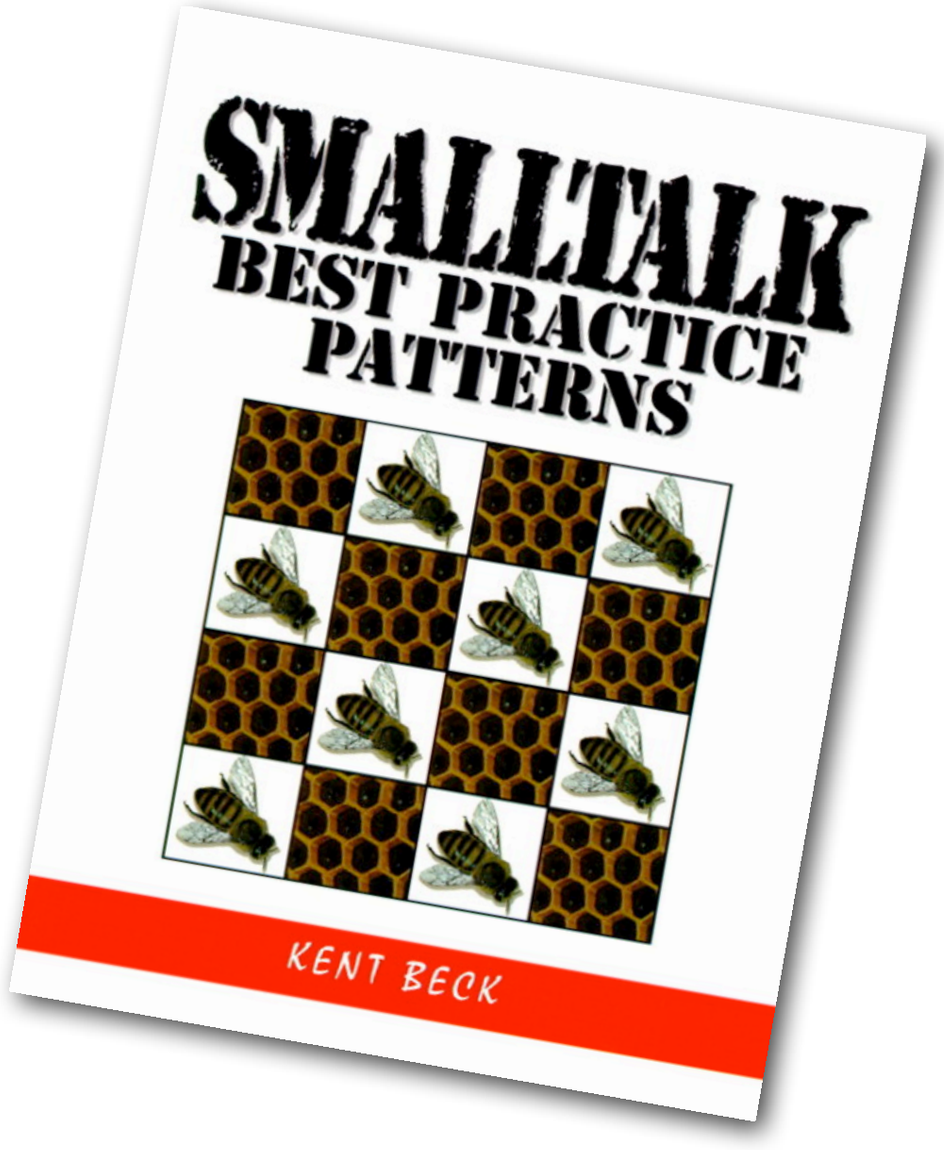
Smalltalk
Best Practice Patterns

Part I

Based on the Book by …

Kent Beck



Based on the Book by …

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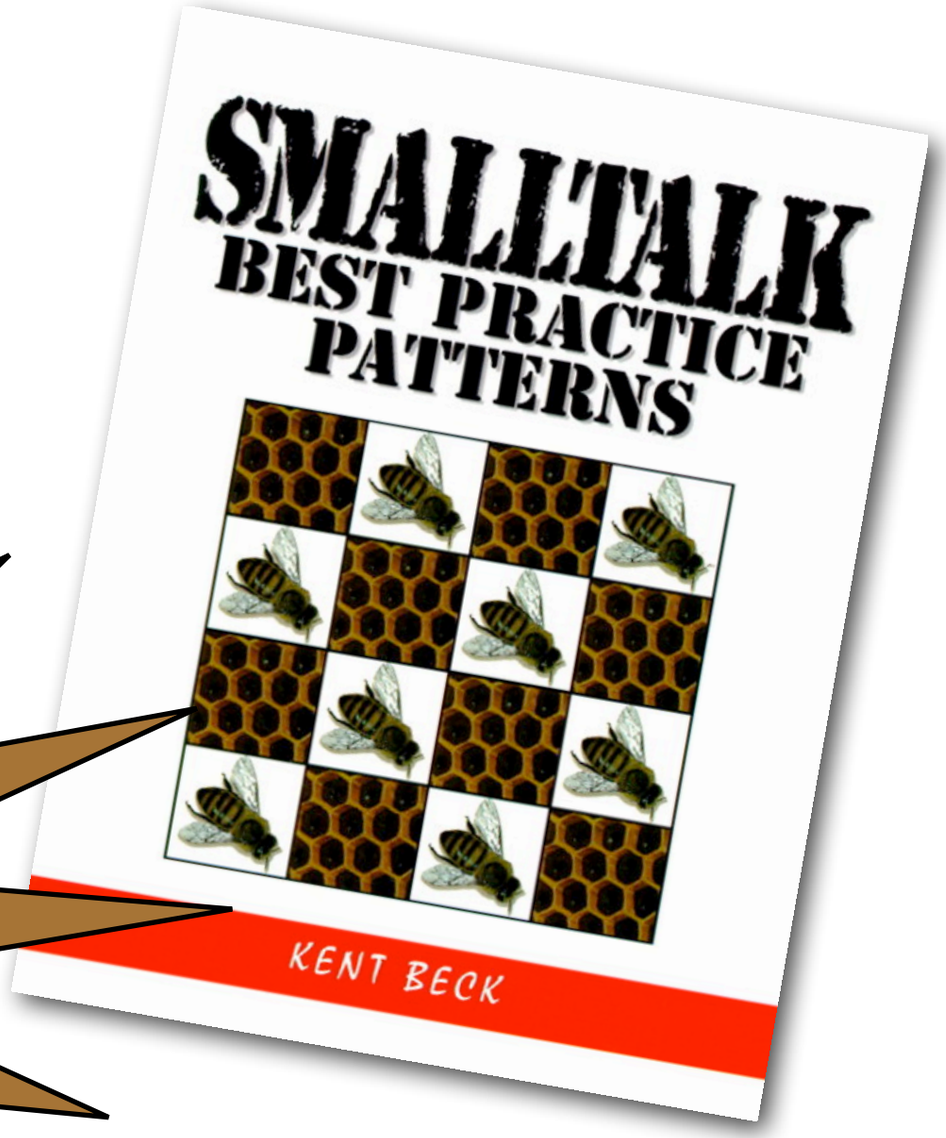

Very little here is Smalltalk-specific

Why Patterns?

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- There are only so many ways of using objects
  - many of the problems that you must solve are independent of the application domain
  - patterns record these problems and successful solutions

Why Patterns?

- There are only so many ways of using objects
  - many of the problems that you must solve are independent of the application domain
  - patterns record these problems and successful solutions
- Remember: the purpose of eduction is to save you from having to think

What's hard about programming?

- Communicating with the computer?
  - not any more!
  - we have made real progress with languages, environments and style

- Communicating with other software developers!
  - 70% of the development budget is spent on "maintenance"
    - discovering the intent of the original programmers

How to improve communication

- Increase bandwidth
  - within the development team
  - between the team and the re-users
- Increase information density
  - say more with fewer bits
  - make our words mean more

A Pattern is:

- A literary form for capturing “best practice”
- A solution to a problem in a context
- A way of packing more meaning into the bytes of our programs

Patterns exist …

- At many levels:
  - Management Patterns
  - Architectural Patterns
  - Design Patterns
  - Programing Patterns
  - Documentation Patterns

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- At many levels:
  - Management Patterns
  - Architectural Patterns
  - Design Patterns
  - **Programing Patterns**
  - Documentation Patterns

Behavioral Patterns

- *Objects Behave!*
  - Objects contain both state and behavior
  - *Behavior* is what you should focus on getting right!

Patterns for Methods

- Composed Method
- Complete Creation Method
- Constructor Parameter Method
- Shortcut Constructor Method
- Conversion
- Converter Method
- Converter Constructor Method
- Query Method
- Comparing Method
- Execute Around Method
- Debug Printing Method
- Method Comment

Composed Method

How do you divide a program into methods?

- ➡ *Each method should perform one identifiable task*
- ➡ *All operations in the method should be at the same level of abstraction*
- ➡ *You will end up with many small methods*

Complete Creation Method

How do you represent instance creation?

- ➡ *Don't: expect your clients to use new and then operate on the new object to initialize it.*
- ➡ *Instead: provide methods that create full-formed instances. Pass all required parameters to them*
  - Put creation methods in a protocol called *instance creation*

Non-example:

➡ *Point new x:10; y:20; yourself*

Example:

➡ *Point x:10 y:20*

Constructor Parameter Method

You have a constructor method with parameters. How do you set the instance variables of the new object?

➡ *Define a single method that sets all the variables. Start its name with "set", and follow with the names of the variables*

- Put constructor parameter methods into the *private* protocol
- Answer **self** explicitly (INTERESTING RETURN VALUE)

Why not use the ordinary setter methods?

- ➡ *Once and Only Once*
- ➡ *Two circumstances:*
  - initialization
  - state-change during computation
- ➡ *Two methods*

Shortcut Constructor Methods

What is the external interface for creating a new object when a Constructor Method is too wordy?

➡ *Represent object creation as a method on one of the arguments.*

- Add no more than three such shortcut constructor methods per system!
- Examples: 20@30, key->value,
  20@30 extent: 10@10
- Put shortcut constructor methods into the *converting* protocol

Conversion

How do you convert information from one object's format to another?

- *Don't: add all possible protocol to every object that may need it*
- *Instead: convert from one object to another*
  - If you convert to an object with similar responsibilities, use a CONVERTER METHOD.
  - If you convert to an object with different protocol, use a CONVERTER CONSTRUCTOR METHOD

Converter Method

How do you represent simple conversion of another object with the same protocol but a different format?

Kent Beck tells a story …

➡ *If the source and the destination share the same protocol, and there is only one reasonable way to do the conversion, then provide a method in the source object that converts to the destination.*

➡ *Name the conversion method "asDestinationClass"*

- examples: Collection ›› asSet,
  Number ›› asFloat, but *not* String ›› asDate

Converter Constructor Method

How do you represent the conversion of an object to another with a different protocol?

➡ *Make a constructor method that takes the object-to-be-converted as an argument*

- Put Converter Constructor Methods in the *instance creation* protocol
- Example: Date class ›› fromString:

Query Method

How do you represent the task of testing a property on an object?

What should the method answer?

What should it be named?

➡ *Provide a method that returns a Boolean. Name it by prefacing the property name with a form of "be"—is, was, will, etc.*

Examples:

➡ *Switch ›› on*
status := #on
Switch ›› off
status := #off

Switch ›› status
^ status

Examples:

➡
```
Switch ›› on
        status := #on
Switch ›› off
        status := #off
Switch ›› status
        ^ status
```

➡
```
Switch ›› turnOn
        status := #on
Switch ›› turnOff
        status := #off
Switch ›› isOn
        ^ status = #on
Switch ›› isOff
        ^ status = #off
```

Comparing Method

How do you order objects with respect to each other?

➡ *Implement < to answer true if the receiver should be ordered before the argument, and = to answer true if the objects are equal.*

- Put comparing methods into a protocol called *comparing*

➡ *Implement* < and = *only if there is a single overwhelming way to order the objects*

Execute Around Method

How do you represent pairs of actions that should be taken together?

- *Open a file — close a file*
- *Acquire a lock — release a lock*

Obvious solution: make both methods part of the protcol

- *File » open Stream » close*
- *Lock » acquire Lock » release*

What's wrong with that?

Clients are responsible for "getting it right"

How should they know?

Solution

Code a method that takes a block as an argument.

Name the method by appending “During: aBlock” to the name of the first method

```
File » openDuring: aBlock
    | s |
    s := self open.
    aBlock value: s.
    s close
```

Solution

Code a method that takes a block as an argument.

Name the method by appending “During: aBlock” to the name of the first method

```
File » openDuring: aBlock
    | s |
    s := self open.
    aBlock value: s.
    s close
```

```
File » openDuring: aBlock
  | s |
  s := self open.
  aBlock value: s
          ensure: [s close]
```

Which protocol?

Put Execute Around methods in the protocol that contains the methods that they encapsulate

➡ *so openDuring: goes in the “opening” protocol, along with open*

Reversing Method

A composed method may be hard to follow because messages are going to too many receivers

- **Point››printOn:** aStream
  x printOn: aStream.
  aStream nextPutAll: '@'.
  y printOn: aStream.

➡ *How do you code a smooth flow of messages?*

- **Point››printOn:** aStream
  x printOn: aStream.
  aStream nextPutAll: '@'.
  y printOn: aStream.

Why isn’t this smooth?

➡ *We want to think of the method as doing three things to aStream. But, that's not what it says!*

- **Point››printOn: aStream**

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x printOn: aStream.
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➡ *We want to think of the method as doing three things to aStream. But, that's not what it says!*

Instead:

- **Point››printOn:** aStream

```
aStream print: x.
aStream nextPutAll: '@'.
aStream print: y.
```

- **Point››printOn: aStream**

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x printOn: aStream.
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y printOn: aStream.
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Why isn't this smooth?

➡ *We want to think of the method as doing three things to aStream. But, that's not what it says!*

Instead:

- **Point››printOn:** aStream

```
aStream
    print: x;
    nextPutAll: '@';
    print: y
```

Method Object

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What do you do when COMPOSED METHOD doesn't work?

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Why doesn't it work?

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What do you do when COMPOSED METHOD doesn't work?

Why doesn't it work?

➡ *many expressions share method parameters and temporary variables*

Beck:

- *“This was the last pattern I added to this book. I wasn't going to include it because I use it so seldom. Then it convinced an important client to give me a really big contract. I realized that when you need it, you really need it”*

The code looked like this:

- **Obligation ›› sendTask:** aTask **job:** aJob
  | notProcessed processed copied executed |
  … 150 lines of heavily commented code …

What happens when you apply COMPOSED METHOD?

- **Obligation ›› sendTask:** aTask **job:** aJob
  | notProcessed processed copied executed |
  … 150 lines of heavily commented code …

Turn the method into a class:

```
Object subclass: #TaskSender
        instanceVariableNames: 'obligation task job
        notProcessed processed copies executed'
```

- *Name of class is taken from original method*
- *original receiver, parameters and temp become instance variables*

new class gets a CONSTRUCTOR METHOD

```
TaskSender class ›› obligation: anObligation task:
aTask job: aJob
    ^ self new
        setObligation:  anObligation
        task: aTask
        job: aJob
```

and the CONSTRUCTOR PARAMETER METHOD

Put the original code in a compute method:

TaskSender››compute

… 150 lines of heavily commented code …

- Change aTask (parameter) to task (instance variable) *etc*.
- Delete the temporaries

Change the original method to use a TaskSender:

◦ **Obligation ›› sendTask:** aTask **job:** aJob

```
^ (TaskSender obligation: self task: aTask job: aJob)
    compute
```

Now run the tests

Now apply COMPOSED METHOD to the 150 lines of heavily commented code.

- *Composite methods are in the TaskSender class.*
- *No need to pass parameters, since all the methods share instance variables*

Beck:

➡ *“by the time I was done, the compute method read like documentation; I had eliminated three of the instance variables, the code as a whole was half of its original length, and I’d found and fixed a bug in the original code.”*

Debug Printing Method

How do you code the default printing method?

- ➡ *Smalltalk provides a way of presenting any object as a String*
- ➡ *printOn: is there for you, the programmer*
  - other clients get their own message

Converting Objects to Strings

There are now four **getters** defined in trait Object for converting an Object to a String:

Show ASCII

```
getter asString(): String      (* for normal use *)
getter asDebugString(): String      (* for debugging; may contain more information *)
getter asExprString(): String      (* when considered as Fortress expression, will equal self *)
getter toString(): String      (* deprecated *)
```

In the trait, all of the other methods are defined in terms of `asString`, so `asString` is the principal method that you should override when you create a new trait. Frequently, programmers write a method that emits more information about the internal structure of an object to help in debugging. If you do that, make it a **getter** and call it `asDebugString`.

`asExprString` is intended to produce a fortress expression that is equal to the object being converted.

Examples

The automatic conversion to String that takes place when an object is concatenated to a String uses `asString`.

The `assert(a, b, m ...)` function uses `asDebugString` to print `a` and `b` when $a \neq b$

Here are the results of using the three getters on the same string:

```
asString:      The word "test" is overused
asExprString:  "The word \"test\" is overused"
asDebugString: BC27/1:
                       J15/0:The word "test"
                       J12/0: is overused
```

Here they are applied to the range 1:20:2

```
asString:      [1,3,5,7,... 19]
asExprString:  1:19:2
asDebugString: StridedFullParScalarRange(1,19,2)
```

Method Comment

How do you comment a method?

- *Communicate important information* that is not obvious from the code *in a comment at the beginning of the method*

How do you communicate what the method does?

- INTENTION-REVEALING SELECTOR

…what the arguments should be?

- TYPE-SUGGESTING PARAMETER NAME

…what the answer is?

- other method patterns, such as QUERY METHOD

…what the important cases are?

- Each case becomes a separate method

What's left for the method comment?

Method Comment

How do you comment a method?

- ➡ *Communicate important information* that is not obvious from the code *in a comment at the beginning of the method*

Between 0% and 1% of Kent's code needs a method comment.

- ➡ *use them for method dependencies, to-do's,* reason *for a change*

But:

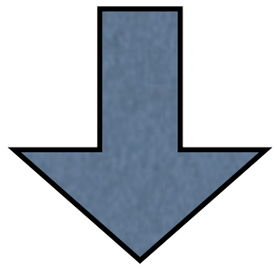
- ➡ *method dependencies can be represented by an EXECUTE-AROUND METHOD*
- ➡ *to-do's can be represented using the self flag: message*

Useless Comment

show

(self flags bitAnd: 2r1000) = 1 "am I visible"

ifTrue: […]



isVisible

^ (self flags bitAnd: 2r1000)

show

self isVisible ifTrue: […]

Message Patterns

Message

- Conditional code:
  - do this or do that, depending
- Encapsulation:
  - do that code over there
- Message-send
  - do this code over there, or that code over yonder, I don’t really care

Message-send replaces conditional

- You are building a complex tool. You find that it behaves the right way for “green” objects, but not for “blue” objects.
- What to do?

```
target isGreen
    ifTrue: [ target doExistingThing ]
    ifFalse: [ target doNewThing ]
```

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~~ifFalse: [target doNewThing]~~

Message-send replaces conditional

- You are building a complex tool. You find that it behaves the right way for “green” objects, but not for “blue” objects.
- What to do?

```
target doAppropriateThing

Green » doApproriateThing
    self doExistingThing

Blue » doApproriateThing
    self doNewThing
```

This is the most important lesson of the quarter

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Take this lesson to heart

- Whenever you discover that a method is making a choice, ask yourself
  - is it doing a single abstract action?
- If so, invent a name for that action
  - a message
- tell an object to do it
  - send that message to the object
- respond appropriately
  - code methods on the receiving objects

Example

```
BrowserNameMorph » onClick
    self representedClass showDefinition
```

Example

Example

```
BrowserNameMorph » onClick
    self representedClassOrTrait showDefinition
```

Example

```
BrowserNameMorph » onClick
    self representedClassOrTrait showDefinition
```

- Problem: showDefinition is the right behavior if I represent a class, but not if I represent a trait.

Wrong Solution

```
BrowserNameMorph » onClick
    | ct |
    ct := self representedClassOrTrait.
    ct isClass
        ifTrue: [ ct showDefinition ]
        ifFalse: [ ct showSubtraits ]
```

Right Solution: Choosing Message

- Think of a good name for what is to be done
  - send that message
  - implement two methods in the receiving classes

```
BrowserNameMorph » onClick
    self representedClassOrTrait showStructure

ClassMorph » showStructure
    self showDefinition

TraitMorph » showStructure
    self showSubtraits
```

- Sometimes even when beginners have several kinds of objects they still resort to conditional logic:

```
responsible := (anEntry isKindOf: Film)
                    ifTrue: [anEntry producer]
                    ifFalse: [anEntry author]
```

- Code like this can always be transformed into communicative, flexible code by using a Choosing Message:

```
Film»responsible ^self producer

Entry»responsible ^self author
```

- Now you can write:

```
responsible := anEntry responsible
```

- but you probably don't need the EXPLAINING TEMPORARY VARIABLE any more.

Decomposing Message

- Send messages to self to break a computation into little pieces
- Most Smalltalk methods are 3 or 4 lines long — certainly less than 10
- Why?
  - Smalltalk's development tools allow programmers to be productive with small code fragments
  - Smalltalk gives the programmer higher-level abstractions

- don’t write:

```
sum := 0.
1 to: collection size
    do: [ : i | sum := sum + (collection at: i)]
```

- write:

```
collection sum
```

Intention Revealing Message

- You are sending a message to invoke a *really simple* computation. How do you communicate your intent?
- Send a message that communicates *what* you want to do (*not* how it is accomplished)

collection isEmpty

number reciprocal

color darker

Intention Revealing Message

- Write a simple method to implement your message

```
Collection » isEmpty
        ^ self size = 0

Number » reciprocal
        ^ 1 / self

Color » darker
        ^ self adjustBrightness: -0.08
```

Intention Revealing Selector

- How do you name a method?
  - Name it after *how* it accomplishes its task
  - Name it after *what* it is supposed to accomplish
    - leave the “how” for the body of the method
  - Examples:

    Array»linearSearchFor:
    Set»hashedSearchFor:
    BTree»treeSearchFor:

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Intention Revealing Selector

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  - Name it after *how* it accomplishes its task
  - Name it after *what* it is supposed to accomplish
    - leave the “how” for the body of the method
  - Examples:

~~Array»linearSearchFor:~~
~~Set»hashedSearchFor:~~
~~BTree»treeSearchFor:~~

Collection»includes:

- Not so easy to apply when you have just one implementation
  - Imagine a second, very different implementation
    - Would you give it the same name?
      - if so, the name is probably “sufficiently abstract” — for now

Programming Patterns for Reuse

Review: Complete Creation Method

Review: Complete Creation Method

- Suppose:
  - Someone likes your class!
  - How to make it easy for her to *use* it!

Review: Complete Creation Method

- Suppose:
  - Someone likes your class!
  - How to make it easy for her to *use* it!

- Provide methods that create well-formed instances.
  - Put them in the “instance creation” protocol on the class side
  - Name them with intention-revealing selectors

Review: Complete Creation Method

- Examples:
  - Point x: 4 y: 3
  - Point r: 20 degrees: 36.8
  - SortedCollection new
  - SortedCollection
    sortBlock: [:a :b | a name <= b name]

Once and Only Once

Once and Only Once

- This means: if you have one thing to say, say it in one place

Once and Only Once

- This means: if you have one thing to say, say it in one place
- It also means: if you have more than one thing to say, don't say it all in one place!
  - Example: if the initialization of an instance variable is different from the setting of that instance variable, write *two* methods!

Example

Example

Window class » **withTitle:** aTextOrString
    ↑ Window new title: aTextOrString;
      yourself

Example

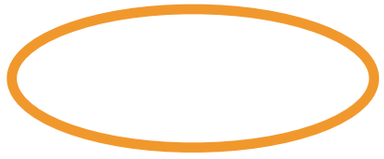
```
Window class » withTitle: aTextOrString
    ↑ Window new title: aTextOrString;
      yourself
```

```
Window » title: aTextOrString
    initializing ← title isNil.

    title ← aTextOrString.

    initializing ifFalse: [self changed: #title]
```

Example (continued)



Example (continued)

```
Window class » withTitle: aTextOrString
    ↑ Window new setTitle: aTextOrString;
      yourself
```

Example (continued)

```
Window class » withTitle: aTextOrString
    ↑ Window new setTitle: aTextOrString;
      yourself
```

```
Window » setTitle: aTextOrString
    title ← aTextOrString.
```

Example (continued)

```
Window class » withTitle: aTextOrString
    ↑ Window new setTitle: aTextOrString;
      yourself
```

```
Window » setTitle: aTextOrString
    title ← aTextOrString.

Window » title: aTextOrString
    title ← aTextOrString.
    self changed: #title
```

Dispatched Interpretation

- How can two objects cooperate when one wishes to conceal its representation
  - Why *would* one wish to conceal its representation?
- Conceal the representation behind a *protocol*
  - *e.g.,* Booleans with *ifTrue: ifFalse:*

But what if the representation is more complicated?

- pass an *interpreter to* the encoded object
- Beck's example:
  - a geometric shape
    - encoded as a sequence of line, curve, stroke and fill commands

- ShapePrinter » **display:** aShape
    | interp |
    interp := anInterpreter writingOn: self canvass.
    aShape sendCommandsTo: interp.

- Shape » **sendCommandsTo:** anObject
    self components do:
        [:each | each sendCommandTo: anObject]

- How does the component know how to send a command to the interpreter?

- If the components are objects, subclasses of the general case:
  - each one knows what command to send for itself. *e.g.*,
  - LineComponent » **sendCommandTo:** anObject

```
self fromPoint printOn: anObject.
' ' printOn: anObject.
self toPoint printOn: anObject.
' line' printOn: anObject
```

- If the components are represented as symbols:
  - each Shape object will need a case statement …

- Why is this called “Dispatched Interpretation”?
  - the encoded object (Shape) dispatches a message to the client
  - the client interprets the message
  - You will have to design a *mediating protocol* between the objects. (Beck page 57)

- Note: all of the internal iterators are very simple examples of dispatched interpretation

  aComplexObject withSomeComponentsDo: aBlock

- aBlock is an interpreter of a very simple protocol

  value: anArgument

Tell, Don’t Ask

(Sharp Ch. 9)

- Tell objects what to do.
- Don’t:
  - ask a question about an object’s state,
  - make a decision based on the answer, and
  - tell the object what to do
- Why?

Tell, don’t Ask — How to do it

Tell, don’t Ask — How to do it

- Rectangle » displayOn: aPort
  aPort isMemberOf: DisplayPort
    ifTrue: ["code for displaying on DisplayPort"].
  aPort isMemberOf: PrinterPort
    ifTrue: ["code for displaying on PrinterPort"].
  aPort isMemberOf: RemotePort
    ifTrue: ["code for displaying on RemotePort"].

Tell, don’t Ask — How to do it

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aPort isMemberOf: DisplayPort
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```

- What’s wrong with this?

Tell, don’t Ask — How to do it

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- What’s wrong with this?
  - How can we add new kinds of graphical object, like Ellipse?

Tell, don’t Ask — How to do it

- Rectangle » displayOn: aPort

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aPort isMemberOf: DisplayPort
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aPort isMemberOf: RemotePort
    ifTrue: ["code for displaying on RemotePort"].
```

- What’s wrong with this?
  - How can we add new kinds of graphical object, like Ellipse?
  - How can we add new kinds of Port?

Tell, don’t Ask — How to do it

```
Rectangle» displayOn: aPort
    aPort displayRectangle: self

Oval» displayOn: aPort
    aPort displayOval: self

Bitmap» displayOn: aPort
    aPort displayBitmap: self
```

... and similarly for the other graphical objects.

How to do it

- DisplayPort » displayRectangle: aRect
    "code to display a rectangle on a displayPort"
  DisplayPort » displayOval: aRect
    "code to display an oval on a displayPort"
  DisplayPort » displayBitmap: aRect
    "code to display a bitmap on a displayPort"
  ... and similarly for the other graphical objects,

- PrinterPort » displayRectangle: aRect
    "code to display a rectangle on a printerPort"
  PrinterPort » displayOval: aRect
    "code to display an oval on a printerPort"
  PrinterPort » displayBitmap: aRect
    "code to display a bimmp on a printerPort"
  ... and similarly for the other graphical objects

- similarly for the other display port classes.

How to do it: Double Dispatch

- Dispatch once on the graphical object:

```
Rectangle» displayOn: aPort
    aPort displayRectangle: self
```

  - remember the result by using an intention-revealing selector
- Dispatch again on what was the argument

```
PrinterPort » displayRectangle: aRect
    "code to display a rectangle on a printerPort"
```

  - Revealed in a famous paper: “A Simple Technique for Handling Multiple Polymorphism” by Ingalls, OOPSLA ’86

Inheritance

- Kent Beck wrote (and then thought better of) in SBPP:
  - How do you design inheritance hierarchies?
    - Make all of your classes subclasses of Object at first. Create a superclass to hold common code of two or more existing classes.
- Why not start by designing the inheritance hierarchy?

What's Inheritance for?

1. AI folks: classification (is-a hierarchy)
   - a *Car* is-a *Vehicle*, *Mammal* is-an *Animal*
2. In programming languages: inheritance shares implementation
   - A *CodeEditor* is-implemented-like a *TextEditor*
3. C++, Java and Eiffel say: inheritance specifies subtyping (and 2 above)
   - a LinkedList can-be-substituted-for a Collection

What's Inheritance For?

- What's a programmer to do?
  - If you start by designing the is-a hierarchy, you will find that it conflicts with code sharing.
  - You can't start with code sharing, because you don't yet have any code
  - Ignore code sharing?
- Kent's advice: write code, then refactor

Inheritance ≠ Subtyping

- Specializing a class though inheritance does not in general produce a subtype (substitutable type)
  - Adding methods is OK
  - Specializing results is OK
  - Specializing arguments is *not* OK
- What's a programmer to do?

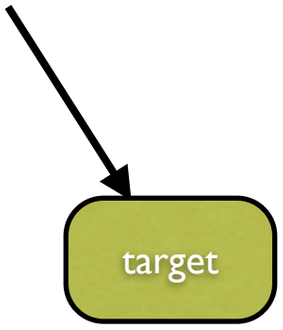
Delegation

- Delegation allows you to share implementation without inheritance
- Pass part of your work on to another object. Put that object in one of your instance variables
  - e.g., a *Path* contains an inst var *form*, the bit mask responsible for actually drawing on the display.
  - e.g., a *Text* contains a *String*

What about **self**?

- When you delegate, the receiver of the delegating message is no longer the target
  - Does it matter? Does the delegate need access to the target? Does the delegate send a message back to the client?
- If it doesn’t matter, delegate messages unchanged

What about **self**?



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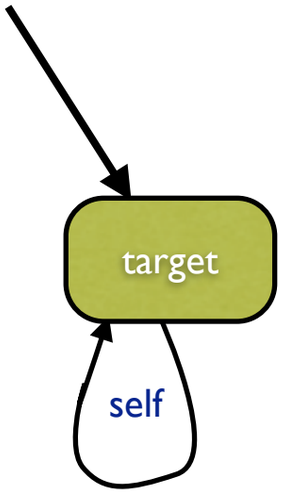

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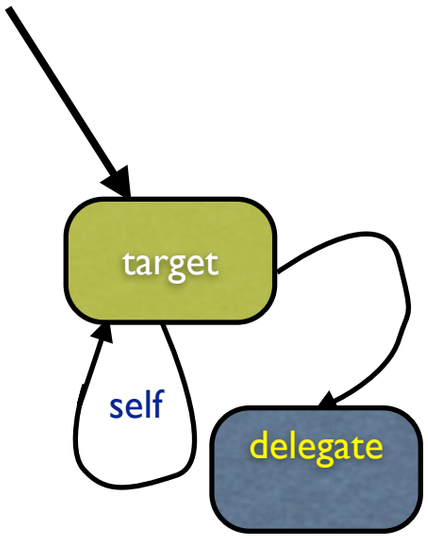

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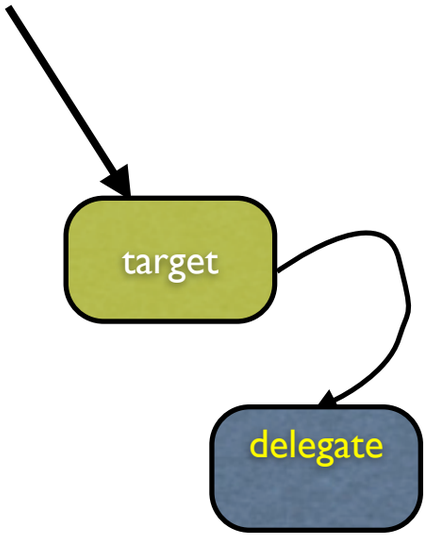

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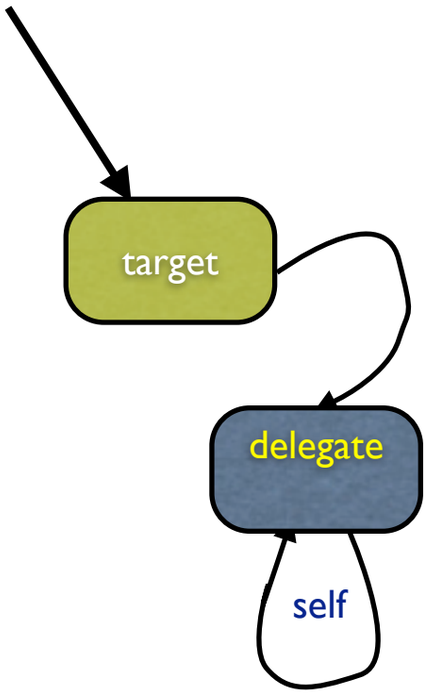

Simple Delegation Example

- Path » **do:** aBlock
  collectionOfPoints do: aBlock

- Path » **collect:** aBlock
  | newPath |
  newPath ← self species new: self size.
  newPath form: self form.
  newPath points:
  (collectionOfPoints collect: aBlock).
  ↑newPath

Self Delegation

- When the delegate *needs* a reference to the delegating object…
- Pass along the delegating object as an additional parameter.

Self Delegation Example

```
Dictionary»at: keyObject put: valueObject
        self hashTable
          at: keyObject
          put: valueObject
          for: self
HashTable»at: keyObject put: valueObject for: aCollection
        | hash |
        hash ← aCollection hashOf: keyObject.

Dictionary»hashOf: anObject
        ↑anObject hash
IdentityDictionary»hashOf: anObject
        ↑anObject basicHash
```

Pluggable Behavior

- Usually, instances of a class
  - share the same behavior…
  - but have different state

- Pluggable Behavior lets them have different behavior:

```
PluggableButtonMorph » performAction
        self model perform: self actionMessage
```

Pluggable Behaviour

ActionButton
... instanceVariableNames: ' … action … '

This class represents a button that gives a user the opportunity to define an action associated with the mouseDown event.

```
ActionButton » action: aBlock
    action ← aBlock

ActionButton » mouseDown: anEvent
    action value
```

Pluggable Block Example

- Cannon » initialize

```
fireButton := ActionButton
        withAction: [self loadAndFire]
        andLabel: 'Fire'
```