Java Jive

Java Jive
as sung by The Ink Spots

I love coffee, I love tea
I love the java jive and it loves me
Coffee and tea and the jivin' and me
A cup, a cup, a cup, a cup, a cup!

I love java, sweet and hot
Whoops! Mr. Moto, I'm a coffee pot
Shoot me the pot and I'll pour me a shot
A cup, a cup, a cup, a cup, a cup!

Oh, slip me a slug from the wonderful mug
And I cut a rug till I'm snug in a jug
A slice of onion and a raw one, draw one.
Waiter, waiter, percolator!

etc.

James Gosling, Inventor of Java

Photo by Mast Photography

James Gosling received a BSc in Computer Science from the University of Calgary, Canada in 1977. He received a PhD in Computer Science from Carnegie-Mellon University in 1983. He is currently a Distinguished Engineer at Sun Microsystems. He has built satellite data acquisition systems, a multiprocessor version of Unix, several compilers, mail systems and window managers. He has also built a WYSIWYG text editor, a constraint based drawing editor and a version of a text editor called Emacs for Unix systems. More recently he has been the lead engineer for the Java/HotJava system.

http://java.sun.com/people/jag/

Java, an Imperative Language

- Imperative languages often **permit** the use of functional programming.
- Sometimes just say "no" to side-effects.
- Otherwise use functions and side-effects articulately.
- **Best of both worlds!**

Java vs. rex

- The analog to ***function*** in rex is ***method*** in Java. Functions are applied as aFunction(x, y, z), while methods are applied like x.aMethod(y, z).
  principal argument (an object)

- Argument and return **types** must be declared in Java, not in rex.

- Both allow **recursion**.

- All of the underlying functionality in rex is implementable.

- Think of rex lists as your abstraction, use Java to implement it.

The empty Java program

```
class empty ☹
{

public static void main(String arg[ ])
  {
  }

}
```

The empty Java program

The one and only class of this program

```
class empty
{
```

Makes this method accessible from the outside.

```
public static void main(String arg[ ])
  {
  }

}
```

The main method for this class (called at start-up).

External arguments for this method.

Result type of this method (none).

Says that this method depends only on the class, not any specific object.

The “Hello, world” program in Java

```
class Hello ☺
{
public static void main(String arg[])
  {
  System.out.println(”Hello, world!");
  }
}
```

The "Hello, world" program in Java

The empty program + one line.

```
class Hello
{
public static void main(String arg[])
   {
   System.out.println("Hello, world!");
   }
}
```

The print-with-end-of-line method for object System.out.

The standard output stream object, pre-defined in the System class.

The "System" class.

Running Java on turing

- Current version is 1.3.1
- To compile:

UNIX convention for compiler, e.g. javac, cc

```
javac Hello.java
```

- To execute:

No "c" here.

No ".class" here.

```
java Hello
```

Running Java on turing

```
turing 101> ls Hello.*
Hello.java
```

Check what's there.

```
turing 102> javac Hello.java
```

Compile it.

```
turing 103> ls Hello.*
Hello.class    Hello.java
```

Check what's there now.

```
turing 104> java Hello
Hello, world!
```

Run it.

Be astounded by results.

Hacky Shortcuts

Since java is a prefix of javac, this tends to confound using command completion (e.g. `!j` in the Cshell).

In your .cshrc should be the following command definitions:

```
alias jc 'javac \!$.java'                 #compile java
alias je 'java'                            #execute
alias jx 'javac \!$.java ; java \!$'       #compile and execute
```

Example usage:

```
jc Hello            # same as javac Hello.java
je Hello            # same as java Hello
jx Hello            # same as javac Hello.java; java Hello
```

Then use **!jc, !je,** or **!jx** to re-do previous commands of same type.

Java Objects

- Java data items are either:
  - Primitives, such as
    - int, long, float, double, char
  - Objects, such as
    - String, Long, Double
    - Objects you define
    - Arrays are essentially Objects too.

Purposes of Objects

- **Aggregate** various data objects together
- Allow mutation of the **state** of data objects
- Control use and access of data according to specific **disciplines**
- and other good stuff

Immutable Objects

- An Object is **immutable** if it state never changes once it is created.
- **Functional programming** deals with immutable objects *almost* exclusively
  - (exception: delayed evaluation)
- The aggregating and disciplined access properties of Objects are still very useful.

OpenList class

- This is a class you will construct and own.
- It will allow you to solve the Unicalc problem in Java, as well as other things.
- Think of rex lists as the abstraction. Use Java to implement.

Using Your OpenList to Implement Unicalc Functionality

- We want to represent Unicalc Quantities.
- In Java, instead of using a *list* of 3 things, we will add a little more structure:

```
public class Quantity
{
private double Factor;
private OpenList Num;
private OpenList Denom;
        ...  more stuff to come  ...
}
```

Object Creation

- Objects are created using **constructors.**
- For a given Class of Objects, there can be *multiple* types of constructors, each providing different types of parameters to define the creation of an object.

Constructors for Quantities

- Constructors always take the same name as their Class.

- Therefore, all constructors for class `Quantity` will be called (you guessed it)

  `Quantity`

- Constructors will differ depending on types.

- One constructor of a class can call another.

Basic Quantity Constructor

- To define a quantity, we need to give values to all three internal variables:

```
public class Quantity
{
            ... stuff you already saw ...
 public Quantity(double Factor, OpenList Num, OpenList Denom)
   {
   this.Factor = Factor;
   this.Num    = Num;
   this.Denom  = Denom;
   }
            ... more stuff to come ...
 }
```

Variables in red represent values in *this* Quantity.
Variables in green represent values local to this constructor.
The latter go away when the constructor is left.

Convenience Quantity Constructor where the denominator is empty

```
public class Quantity
{
```

... stuff you already saw ...

```
 public Quantity(double Factor, OpenList Num)
   {
   this(Factor, Num, OpenList.nil);
   }
```

... more stuff to come ...

```
 }
```

Variables in green represent values local to this constructor.

this(...) means "call the constructor of this class with the indicated arguments.

Convenience Quantity Constructor

where both numerator and denominator are empty

```
public class Quantity
{
                  ... stuff you already saw ...
Quantity(double Factor)
  {
  this(Factor, OpenList.nil, OpenList.nil);
  }
                  ... more stuff to come ...
 }
```

Variables in green represent values local to this constructor.

this(…) means "call the constructor of this class with the indicated arguments.

Convenience Quantity Constructor

where the numerator is a single unit and denominator is empty

```
public class Quantity
{
                    ... stuff you already saw ...
Quantity(double Factor, String NumUnit)
   {
   this(Factor, OpenList.list(NumUnit), OpenList.nil);
   }
                    ... more stuff to come ...
 }
```

Variables in green represent values local to this constructor. **`this(…)`** means "call the constructor of this class with the indicated arguments.

Getters

- Attributes of objects should never be accessed within an object simply by referring to them:

```
Quantity x = new Quantity(…);
…
System.out.println(x.Num);
```

BAD

- **except** possibly for debugging purposes.
- Instead, use a **getter** method:

```
int getNum()
{
return Num;
}
...
System.out.println(x.getNum());
```

GOOD

Reasons?

Static?

- What is *Static* all about?
- In Java, a method may or may not depend on a specific Object:
  - methods that do *not* depend on this state should be annotated as **`static`**

Static can only call Static

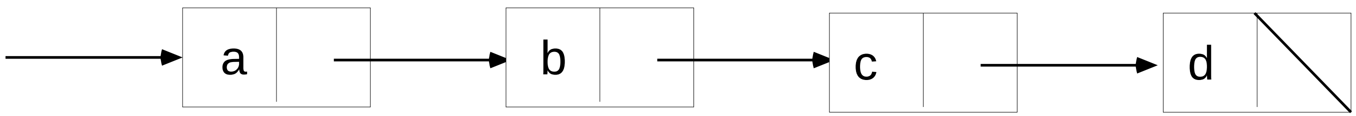
- A static method can only depend on
  - variables declared as static
  - other static methods
- A static method, therefore, **cannot** depend on:
  - variables not declared as static
  - other methods not declared as static
- The compiler will tell you, but maybe in a cryptic way.

Example

```
class myBad
{
int x;

myBad(int x)
  {
  this.x = x;
  }

int getX()
  {
  return x;
  }

static int test()
  {
  getX() > 0;
  }
}
```

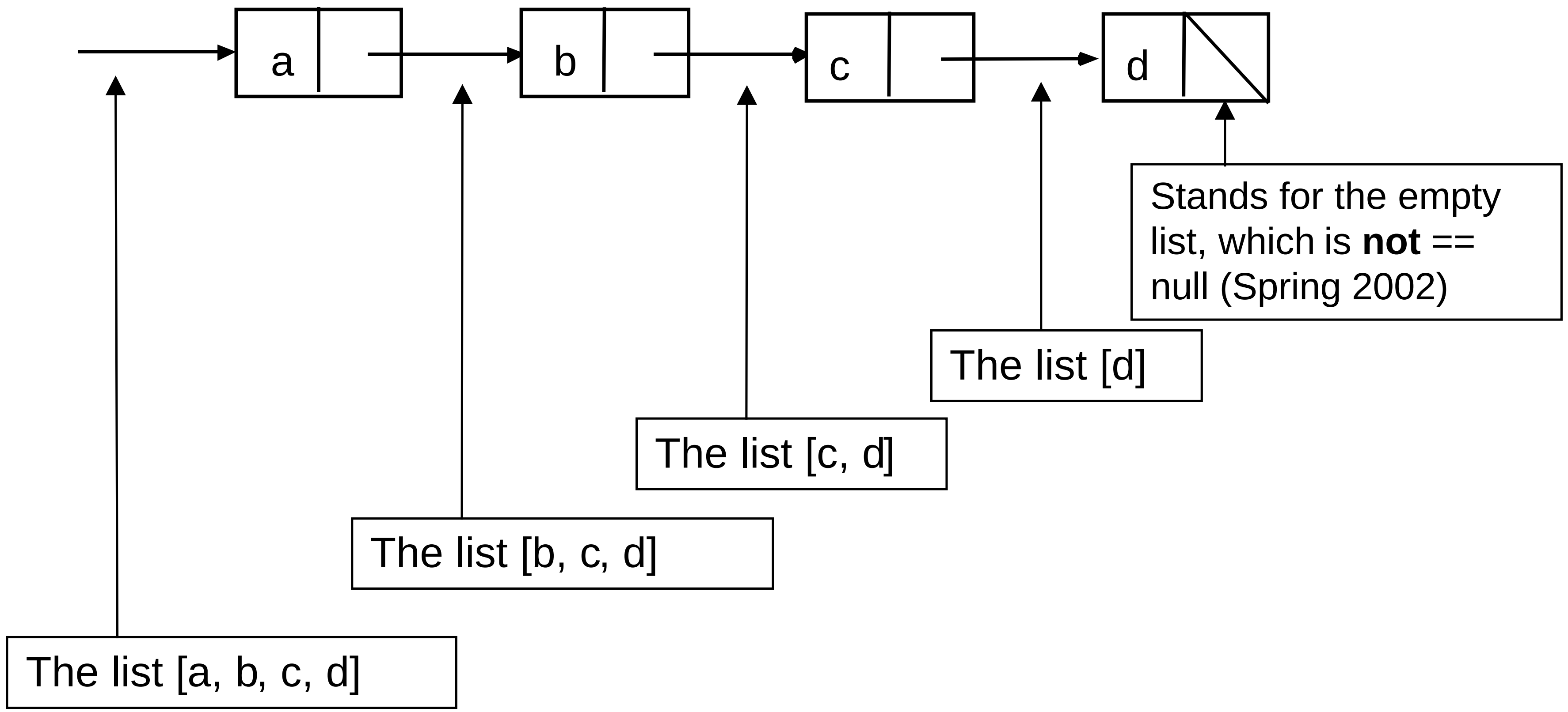
Illegal:
static depends on non-static

An Open List



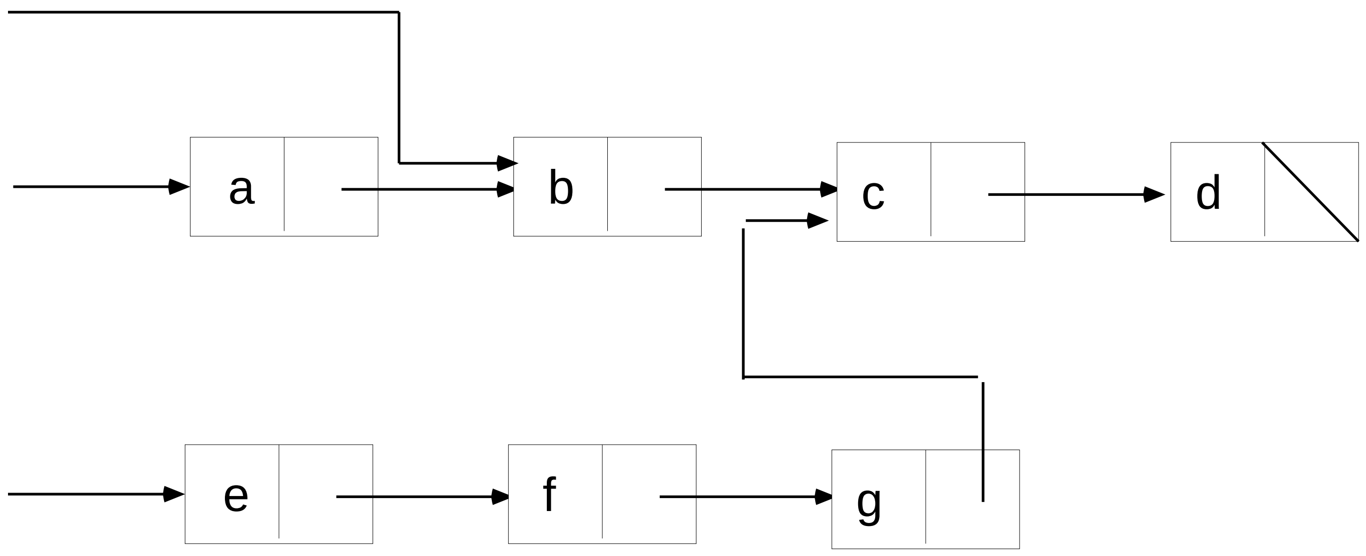
- Each list element begins a list in its own right.
- A list is **identified with** a reference to its first element.
- The empty list is identified with a special value.

Open Lists Identified with References



Sharing in Open Lists

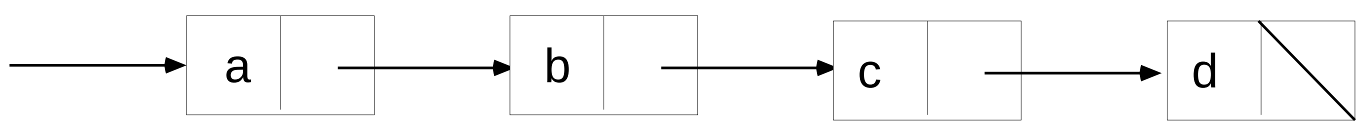
Display the list identified with each reference.



Why is list mutation discouraged?

Passing an Open List as an Argument to a Function

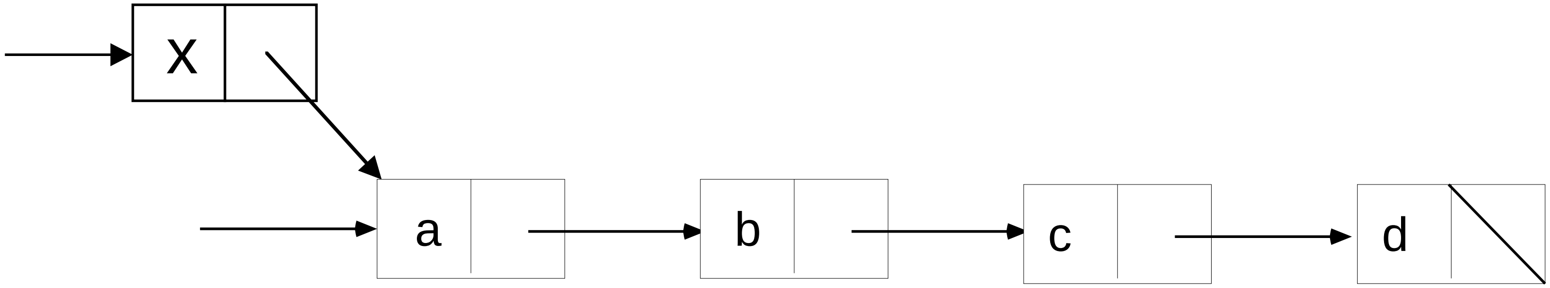
- To pass an open list as an argument, we simply pass its *reference*.
- The list is **not** literally copied.



Open List Consing

- To "cons" an element to an open list, we simply put the element in a new cell and hook the cell to the original list:
- consing x to the front [x | [a, b, c, d]] yields

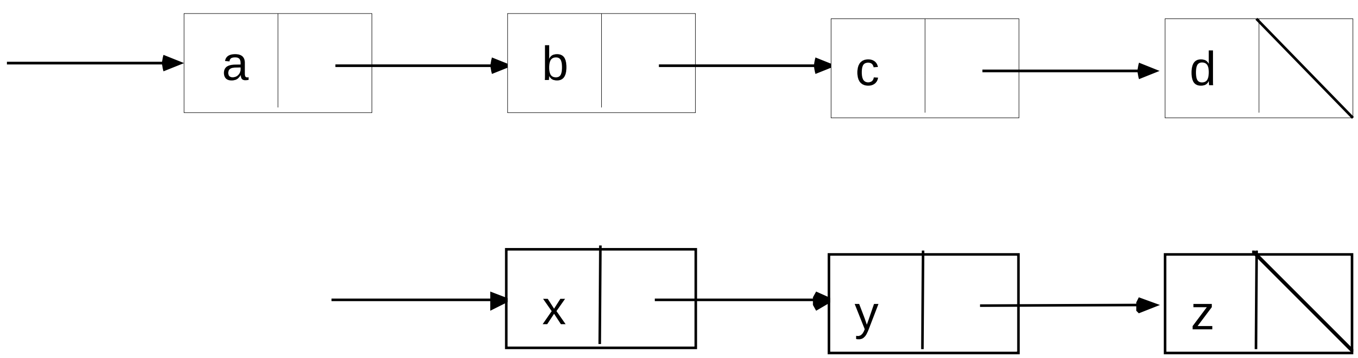
caution: rex, not Java, notation



Appending Open Lists

- What happens when we append one open list to another, as in

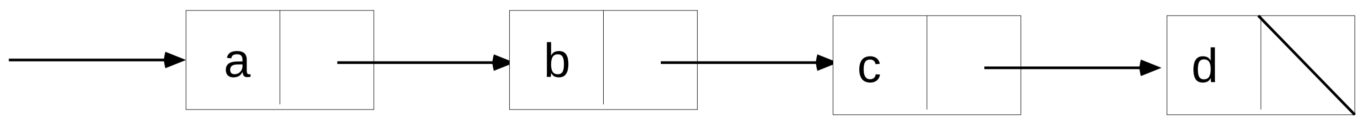
```
L.append(M)?
```



Reversing an Open List

- What happens when we reverse an open list?

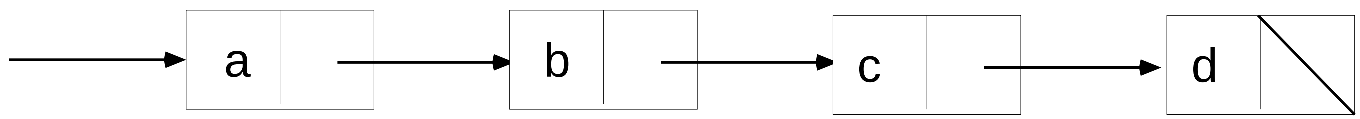
```
L.reverse()
```



Mapping an Open List

- What happens when we map over an open list?

```
L.map(fun)
```



OpenList Basics

- `OpenList(Object First, OpenList Rest)`
- `L.first()`
- `L.rest()`
- `L.isEmpty()`
- `L.cons(Object First)`

Java Code for OpenList

- ```
  public class OpenList
  {
   private Object First;
   private OpenList Rest;
  ```
- ```
   // The unique empty list
   public static OpenList nil = new OpenList();
  ```
- ```
   // Empty-list constructor (use only once)

   private OpenList() { }
  ```
  ```

Java Code for OpenList (2)

- ```
  // Constructor

  public OpenList(Object First, Object Rest)
     {
     ...
     }
  ```

- ```
  // Get first element of a non-empty list.

  public Object first()
     {
     ...
     }
  ```

Java Code for OpenList (3)

- ```
  // Get rest of a non-empty list.

  public OpenList rest()
      {
      ...
      }
  ```

- ```
  // pseudo-constructor or "factory" for
  // non-empty list

  public OpenList cons(Object First)
      {
      ...
      }
  ```

Java Code for OpenList (4)

- ```
  // emptiness test

  public boolean isEmpty()
    {
    ...
    }
  ```
  ```

Java Code for OpenList (5)

- `// pseudo-constructor or “factory” for`
  `// non-empty list`

- ```
  public OpenList cons(Object First)
      {
      ...
      }
  ```
  ```

Static Methods (closer to rex-style)

- ```
  public static OpenList
  cons(Object First, OpenList First)
      {
      ...
      }
  ```
- `public static Object first(OpenList L)`
- `public static OpenList rest(OpenList L)`
- `public static boolean isEmpty(OpenList L)`
  ```

Wrappers for Primitives

- Items in a OpenList must be Objects.
- Primitives (ints, longs, floats, doubles, chars ...) are not Objects in Java.
- The constructor **`Long( )`** makes an Object for any long by creating a "wrapper" which is an object.
- Other wrappers: **`Integer()`**, **`Float()`**, **`Double()`**, **`Boolean()`**, Snoop, Ice-T, ...

Strings

- In contrast to `long`, `int`, `float`, etc. `Strings` are already objects.

- Consequently, `Strings` do not need extra wrappers.

- `OpenLists` are also Objects.

Getters for Wrappers

- These can be applied to any Object derived from class **`Number`**, which includes **`Long`**, **`Integer`**, …:

  `longValue()`, **`intValue()`**, …

- Use the on-line javadoc pages on the web to find info:

  [**http://java.sun.com/j2se/1.3/docs/api/**](http://java.sun.com/j2se/1.3/docs/api/)

Conversion to String

- Class **String** includes the following static methods (not constructors):

```
valueof(double d)
valueof(long x)
        ...
```

- Each returns a **String**.

Cheap Conversion to String

- "Adding" a number to a string will convert the number to a string, then **concatenate** it:

```
String s = "" + 31415;
```

Conversion **from** String

- Use the appropriate static method in the class **to which** you wish to convert, e.g.
  - **`Long.parseLong(String nm)`**
  - **`Double.parseDouble(String nm)`**

- (Don't use **`getLong`**, which has a different meaning entirely.)

Type Discrimination

- The type of an Object can be discriminated using the **`instanceof`** operator:

```
Object ob = L.first();
if( ob instanceof Long ) ...
if( ob instanceof OpenList ) ...
```

Equality Checking

- To check whether two Objects are *equal*, **DO NOT USE ==**. This only checks whether the **references** to those objects are identical. The Objects could be equal, but be different Objects. This applies for **`Strings`**, for example.

- **DO** USE **`equals`**:

```
if( ob1.equals(ob2) )
```

A Recursive List Pattern (without using map)

- ad-hoc map-like operations, build list **outside-in**, using recursion:

```
static OpenList scale(long factor, OpenList L)
  {
  if( L.isEmpty() )
    return OpenList.nil;

  long first = ((Long)L.first()).longValue();

  Long result = new Long(factor*first);

  return cons(result, scale(factor, L.rest()));
  }
```

unwrap

wrap

recurse

An Iterative List Pattern

- build list **inside-out**, using ordinary iteration and an accumulator

```
static OpenList scaleAndReverse(long factor, OpenList L)
  {
  OpenList result = OpenList.nil;

  for( ; L.nonEmpty() ; L = L.rest() )
    {
    long first = ((Long)L.first()).longValue();

    result = cons(new Long(factor*first), result);
    }

  return result;
  }
```

unwrap

wrap

An Iterative Reduce Pattern

- collapse list into a value using ordinary iteration

```
static long sum(OpenList L)
  {
  long result = 0;

  for( ; L.nonEmpty() ; L = L.rest() )
    {
    long first = ((Long)L.first()).longValue();

    result += first;
    }

  return result;
  }
```

unwrap

An Recursive Merge Pattern

- merge two lists of Longs in increasing order

```
static OpenList merge(OpenList L, OpenList M)
  {
  if( L.isEmpty() )
    return M;

  if( M.isEmpty() )
    return L;

  long firstL = ((Long)L.first()).longValue();

  long firstM = ((Long)M.first()).longValue();

  if( firstL <= firstM )
    return merge(L.rest(), M).cons(L.first());
  else
    return merge(L, M.rest()).cons(M.first());
  }
```

unwrap

Try this

- determine whether an Object occurs in a OpenList

```
static boolean member(Object Ob, OpenList L)
  {





  }
```

If you used recursion, try it with iteration, and vice-versa

- determine whether an Object occurs in a OpenList

```
static boolean member(Object Ob, OpenList L)
  {








  }
```

Open vs. Closed Lists

- Two list models are described in the text:
  - Open lists:
    - Elements and sublists can be shared
    - Mutation of lists is discouraged
    - Mathematically elegant
  - Closed lists:
    - Sharing generally not done
    - Mutation of lists is ok, because they are encapsulated
    - Mathematically less attractive
  - Closed lists can be built by wrapping open lists