New Java Language Features in JDK 1.5

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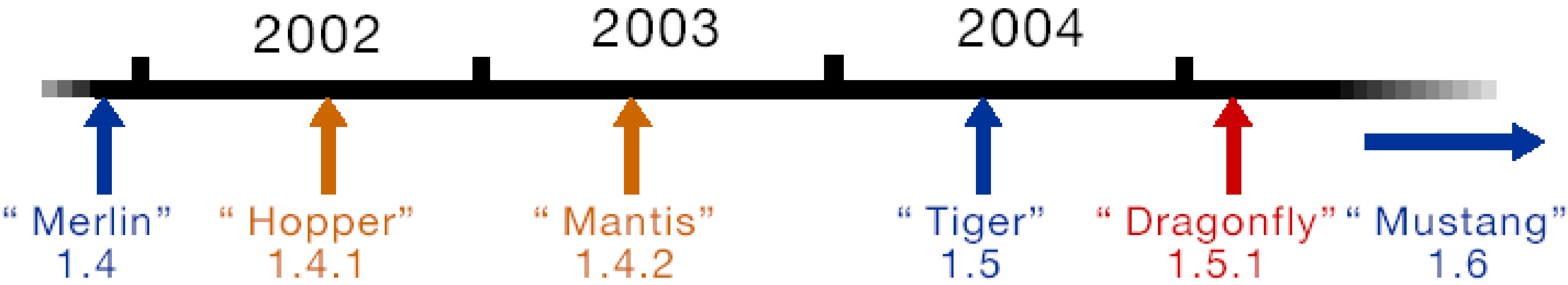
J2SE Roadmap

- Timeline:



1.4 Releases

- 1.4.1: Main focus is on quality improvements
- Over two thousand bug fixes
- New garbage collectors - concurrent mark sweep and parallel young space
- 1.4.2: Same focus (2000 more bug fixes)
- Lots of performance work
- Full Itanium support

Watch out for Tigers

- Java 2 Platform, Standard Edition Release 1.5 (code name Tiger)
- Targeted for summer 2004 (beta Late 2003?)
- The major theme is ease of development.
  - 15 component JSRs for new features
- Better Scalability and performance.

Tiger Componenet JSRs

- 003 JMX™ Management API
- 013 Decimal Arithmetic
- 014 Generic Types
- 028 SASL
- 114 JDBC™ API Rowsets
- 133 New Memory Model
- 163 Profiling API
- 166 Concurrency Utilities
- 174 JVM™ Software
- Monitoring and Mgmt
- 175 Metadata
- 199 Compiler APIs
- 200 Pack Transfer Format
- 201 Four Language Updates
- 204 Unicode Surrogates
- 206 JAXP 1.3

Language Changes in Tiger

I. Generics
II. Enhanced for Loop ("foreach")
III. Autoboxing/Unboxing
IV. Typesafe Enums
V. Varargs
VI. Static Import
VII. Metadata

Major Theme – Developer Friendliness

- Better type safety.
- Easier to code. Better expressiveness.
- Simpler to visualize, more readable.
- Minimize incompatibility
  - No VM changes.
  - All binaries, most sources run unchanged.
  - New keywords kept to a minimum (1)

I. *Generics*

- Generics abstract over Types
- Classes, Interfaces and Methods can be Parameterized by Types
- Generics provide increased readability and type safety.

Why Add Generics?

- When you get an element from a collection, you have to cast
  - Casting is a pain
  - Casting is unsafe. Casts may fail at runtime
- Wouldn’t it be nice if you could tell the compiler what type a collection holds?
  - Compiler could put in the casts for you
  - They’d be guaranteed to succeed.

Filtering a Collection - Today

```
// Removes 4-letter words from c; elements must be strings
static void expurgate(Collection c) {
   for (Iterator i = c.iterator(); i.hasNext(); )
      if(((String) i.next()).length() == 4)
         i.remove();
}
```

Filtering a Collection with Generics

```
// Removes 4-letter words from c
static void expurgate(Collection<String> c) {
   for (Iterator<String> i = c.iterator(); i.hasNext(); )
      if (i.next().length() == 4)
         i.remove();
}
```

Clearer and Safer

- No cast, extra parentheses, temporary variables
- Provides compile-time type checking

Signature Changes

```
interface List<E> {
  void add(E x);
  Iterator<E> iterator();
}
interface Iterator<E> {
  E next();
  boolean hasNext();
}
```

List Usage – without Generics

```
List ys = new LinkedList();
ys.add("zero");
List yss;
yss = new LinkedList();
yss.add(ys);
String y = (String)
    ((List)yss.iterator().next()).iterator().next();
Integer z = (Integer)ys.iterator().next();
// run-time error!
```

List Usage – with Generics

```
List<String> ys = new LinkedList<String>();
ys.add("zero");
List<List<String>> yss;
yss = new LinkedList<List<String>>();
yss.add(ys);
String y =
   yss.iterator().next().iterator().next();
Integer z = ys.iterator().next();
// compile-time error
```

Generic Methods and Sub Types

```
class Collections {
   public static <S,T extends S> void
      copy(List<S> dest, List<T> src){...}
}
class Collection<E> {
   public <T> boolean
      containsAll(Collection<T> c) {...}
   public <T extends E> boolean
      addAll(Collection<T> c) {...}
}
```

Generics Vs. Templates

- Unlike C++, generic declarations are type checked
- Generics are compiled once and for all
  - No code bloat
- Generic source code not exposed to user - No hideous complexity
- No template meta-programming
  - Simply provide compile-time type safety and eliminate need for casts

II. Enhanced *for* loop

- Iterating over collections is a pain
- Often, iterator is unused except to get elements
- Iterators are error-prone
  - Iterator variable occurs three times per loop
  - Gives you two opportunities to get it wrong
  - Common cut-and-paste error
- Wouldn’t it be nice if the compiler took care of the iterator for you?

Applying a Method to Each Element in a Collection - Today

```
void cancelAll(Collection c) {
   for (Iterator i = c.iterator(); i.hasNext(); ) {
      TimerTask tt = (TimerTask) i.next();
      tt.cancel();
   }
}
```

Applying a Method to Each Element in a Collection with Enhanced `for`

```
Void cancelAll(Collection c) {
   for (Object o : c)
      ((TimerTask)o).cancel();
}
```

- Clearer and Safer
- No iterator-related clutter
- No possibility of using the wrong iterator

Enhanced *for* Really Shines When Combined With Generics

```
void cancelAll(Collection<TimerTask> c) {
   for (TimerTask task : c)
      task.cancel();
}
```

- Much shorter, clearer and safer
- Code says exactly what it does

It Works for Arrays too!

```
// Returns the sum of the elements of a
int sum(int[] a) {
   int result = 0;
   for (int i : a)
      result += i;
   return result;
}
```

- Eliminates array index rather than iterator
- Similar advantages

Nested Iteration is Tricky...

```
List suits = ...;
List ranks = ...;
List sortedDeck = new ArrayList();

for (Iterator i = suits.iterator(); i.hasNext(); )
   for (Iterator j = ranks.iterator(); j.hasNext(); )
      sortedDeck.add(new Card(i.next(), j.next()));

// Broken - throws NoSuchElementException!
```

Nested Iteration, cont.

```
// Fixed - a bit ugly
for (Iterator i = suits.iterator(); i.hasNext(); )
   Suit suit = (Suit) i.next();
   for (Iterator j = ranks.iterator(); j.hasNext(); )
      sortedDeck.add(new Card(suit, j.next()));
```

- With enhaced for, it's easy!

```
for (Suit suit : suits)
   for (Rank rank : ranks)
      sortedDeck.add(new Card(suit, rank));
```

III. *Autoboxing/Unboxing*

- You can’t put an int into a collection
  - Must use Integer instead
- It’s a pain to convert back and forth
- Wouldn’t it be nice if compiler did it for you?

Making a Frequency Table Today

```
Public class Freq {
   private static final Integer ONE = new Integer(1);
   public static void main(String[] args) {
      // Maps word (String) to frequency (Integer)
      Map m = new TreeMap();
      for (int i=0; i<args.length; i++) {
         Integer freq = (Integer) m.get(args[i]);
         m.put(args[i], (freq==null ? ONE :
         new Integer(freq.intValue() + 1)));
      }
      System.out.println(m);
   }
}
```

Making a Frequency Table with *Autoboxing*, *Generics*, and Enhanced *for*

```
public class Freq {
   public static void main(String[] args) {
      Map<String, Integer> m = new TreeMap<String,
         Integer>();
      for (String word : args)
         m.put(word,
            Collections.getWithDefault(m, word)+1);
      System.out.println(m);
   }
}
```

IV. Typesafe *Enums*

Standard approach - int enum pattern

```
public class Almanac {
   public static final int SEASON_WINTER = 0;
   public static final int SEASON_SPRING = 1;
   public static final int SEASON_SUMMER = 2;
   public static final int SEASON_FALL = 3;
   ... // Remainder omitted
}
```

Disadvantages of int *Enum* Pattern

- Not type safe
- No namespace - must prefix constants
- Brittle – constants compiled into clients
- Printed values uninformative

Current Solution - Typesafe *Enum* Pattern

From *"Effective Java Programming Language Guide"* by J. Bloch

- Basic idea – class that exports self-typed constants and has no public constructor
- Fixes all disadvantages of int pattern
- Other advantages
  - Can add arbitrary methods, fields
  - Can implement interfaces

Typesafe *Enum* Pattern Example

```
import java.util.*;

import java.io.*;

public final class Season implements Comparable, Serializable {

  private final String name; private static int nextOrdinal =0;

  private final int ordinal = nextOrdinal++;

  public String toString() { return name; }

  private Season(String name) { this.name = name; }

  public static final Season WINTER = new Season("winter");

  public static final Season SPRING = new Season("spring");

  public static final Season SUMMER = new Season(”summer");

  public static final Season FALL = new Season("fall");

  public int compareTo(Object o) { return ordinal -
  ((Season)o).ordinal;}
```



```
...
```

Disadvantages of Typesafe *Enum* Pattern

- Verbose
- Error prone - each constant occurs 3 times
- Can't be used in switch statements
- Wouldn't it be nice if compiler took care of it?

Typesafe *Enum* Construct

- Compiler support for Typesafe Enum pattern
- Looks like traditional enum (C, C++, Pascal)
  - `enum Season {winter, spring, summer, fall}`
- Far more powerful
  - All advantages of Typesafe Enum pattern
  - Allows programmer to add arbitrary methods, fields
- Can be used in switch/case statements
- Can be used in *for* loops.

Enums + *Generics* + Enhanced *for*

```
enum Suit {clubs, diamonds, hearts, spades}
enum Rank {deuce, three, four, five, six, seven,
   eight, nine, ten, jack, queen, king, ace}

List<Card> deck = new ArrayList<Card>();
for (Suit suit : Suit.VALUES)
   for (Rank rank : Rank.VALUES)
      deck.add(new Card(suit, rank));

Collections.shuffle(deck);
```

- Would require pages of code today!

Enum With Field, Method and Constructor

```
Public enum Coin {
    penny(1), nickel(5), dime(10), quarter(25);
    Coin(int value) { this.value =   value; }
    private final int value;
    public int value() { return value; }
}
```

Sample Program Using Coin Class

```
public class CoinTest {
   public static void main(String[] args) {
      for (Coin c : Coin.VALUES)
         System.out.println(c + ": \t"
            + c.value() +"¢ \t" + color(c));
   }
   private enum CoinColor { copper, nickel, silver }
   private static CoinColor color(Coin c) {
      switch(c) {
         case penny: return CoinColor.copper;
            case nickel: return CoinColor.nickel;
            case dime:
            case quarter: return CoinColor.silver;
            default: throw new AssertionError("Unknown
coin: " + c);
      }
   }
}
```

Output of Sample Program

```
Penny:    1¢   copper
nickel:   5¢   nickel
dime:     10¢  silver
quarter:  25¢  silver
```

V. *Varargs*

- To write a method that takes an arbitrary number of parameters, you must use an array
- Creating and initializing arrays is a pain
- Array literals are not pretty
- Wouldn't it be nice if the compiler did it for you?
- Essential for a usable *printf* facility.

Using java.text.MessageFormat Today

```
Object[] arguments = {
   new Integer(7),
   new Date(),
   "a disturbance in the Force"
};

String result = MessageFormat.format(
   "At {1,time} on {1,date}, there was {2} on planet "
   + "{0,number,integer}.", arguments);
```

Using MessageFormat With *Varargs*

```
String result = MessageFormat.format(
   "At {1,time} on {1,date}, there was {2} on planet "
   + "{0,number,integer}.",
   7, new Date(), "a disturbance in the Force");
```

Varargs Declaration Syntax

```
public static String format(String pattern,
    Object... arguments)
```

- Parameter type of arguments is Object[]
- Caller need not use varargs syntax

VI. *Static Import* Facility

Classes often export constants:

```
public class Physics {
    public static final double AVOGADROS_NUMBER =
        6.02214199e23;
    public static final double BOLTZMANN_CONSTANT =
        1.3806503e-23;
    public static final double ELECTRON_MASS =
        9.10938188e-31;
}
```

Clients must qualify constant names:

```
double molecules = Physics.AVOGADROS_NUMBER * moles;
```

Wrong Way to Avoid Qulifying Names...

```
// "Constant Interface" antipattern - do not use!
public interface Physics {
   public static final double
      AVOGADROS_NUMBER=6.02214199e23;
   public static final double
      BOLTZMANN_CONSTANT = 1.3806503e-23;
   public static final double
      ELECTRON_MASS = 9.10938188e-31;
}
public class Guacamole implements Physics {
   public static void main(String[] args) {
      double moles = ...;
      double molecules = AVOGADROS_NUMBER * moles;
      ...
   }
}
```

Problems With “Constant Interface”

- Interface abuse does not define type
- Implementation detail pollutes exported API
- Confuses clients
- Creates long-term commitment
- Wouldn’t it be nice if compiler let us avoid qualifying names without sub typing?

Solution - *Static Import* Facility

- Analogous to package import facility
- Imports the static members from a class, rather than the classes from a package
- Can import members individually or collectively
- Not rocket science

Importing Constants With *Static Import*

```
import static org.iso.Physics.*;

public class Guacamole {

   public static void main(String[] args) {

      double molecules = AVOGADROS_NUMBER * moles;

      ...

   }

}
```

`org.iso.Physics` now a class, not an interface

Can Import Methods as Well as Fields

- Useful for mathematics
- Instead of: `x = Math.cos(Math.PI * theta);`
- Say: `x = cos(PI * theta);`

Static Import Works With *Enums*...

```
import static gov.treasury.Coin.*;

class MyClass {

   public static void main(String[] args) {

      int twoBits = 2 * quarter.value();

      ...

   }

}
```

VII. *Metadata*

- Many APIs require a fair amount of boilerplate
  - Example: JAX-RPC web service requires paired interface and implementation
- Wouldn’t it be nice if language let you annotate code so that tool could generate boilerplate?
- Many APIs require side files to be maintained
  - Example: bean has BeanInfo class
- Wouldn’t it be nice if language let you annotate code so that tools could generate side files?

JAX-RPC Web Service - Today

```
public interface CoffeeOrderIF extends java.rmi.Remote {
   public Coffee [] getPriceList()
      throws java.rmi.RemoteException;
   public String orderCoffee(String name, int quantity)
      throws java.rmi.RemoteException;
}
public class CoffeeOrderImpl implements CoffeeOrderIF {
   public Coffee [] getPriceList() {
      ...
   }
   public String orderCoffee(String name, int quantity) {
      ...
   }
}
```

JAX-RPC Web Service With Metadata

```
import javax.xml.rpc.*;
public class CoffeeOrder {
   @Remote public Coffee [] getPriceList() {
      ...
   }
   @Remote public String orderCoffee(String name,
      int quantity) {
      ...
   }
}
```

Conclusion

- Language has always occupied a sweet spot
  - But certain omissions were annoying
- "Tiger" intends to rectify these omissions
- New features were designed to interact well
- Language will be more expressive
  - Programs will be clearer, shorter, safer
- This will not sacrifice compatibility

Would You Like to Try it Out?

- All features (except metadata) are available in early access 1.5 compiler
  - http://developer.java.sun.com/developer/earlyAccess/adding_generics
  - Use the compiler as a drop in replacement for javac.
  - Try it out and send feeback!
- For documentation, see JSRs 14, 201, 175
  - http://www.jcp.org
  - http://java.sun.com/features/2003/05/bloch_qa.html

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