The Collections Connection Ninth Edition (Really!)

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Goal of Talk

Find true happiness

Achieve world domination with the Java™ Collections Framework

Outline

I. What's New in Tiger? (quick review)

An awful lot! (JSR-14, JSR-201, JSR-166, etc.)

II. What Coming in Mustang?

More cool stuff

Some dull stuff

III. Q & A

Pearls of wisdom from the assembled multitudes

I. What's (Relatively) New in Tiger?

- Three language features
  - Generics, For-each loop, Autoboxing
- Three core collection interfaces
  - **`Queue`**, **`BlockingQueue`**, **`ConcurrentMap`**
- One skeletal implementation
  - **`AbstractQueue`**
- Eleven (!) concrete implementations
  - 2 **`Queue`**, 5 **`BlockingQueue`**, 2 **`Map`**, 2 **`Set`**
- A handful of generic algorithms and such

Language Feature – Generics

- Provides compile-time type safety for collections and eliminates drudgery of casting
  - Tell compiler the element type of collection
  - Compiler inserts casts for you
  - Casts won't fail at runtime
  - “Stronger typing with less typing”

```
// 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();
}
```

Language Feature – For-Each Loop

- Eliminates drudgery, error-proneness of iterators
  - Tell compiler what collection you want to traverse
  - Compiler takes care of iterator or index for you
  - You won't make cut-and-paste errors

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

Language Feature – Autoboxing

- Eliminates the drudgery of manual conversion between primitive types (such as **`int`**) and wrapper types (such as **`Integer`**)

```
public class Freq {
    public static void main(String[] args) {
       Map<String, Integer> m =
            new TreeMap<String, Integer>();

        for (String word : args) {
            Integer freq = m.get(word);
            m.put(word, (freq == null ? 1 : freq + 1));
        }
        System.out.println(m);
    }
}
```

New Interfaces

- **`Queue`** - **`Collection`** that holds elements for processing
- **`BlockingQueue`** - **`Queue`** that allows client to wait for an element to appear (“work queue”)
- **`ConcurrentMap`** - **`Map`** that facilitates concurrent use

Queue Interface extends `Collection`

	Throws exception	*Returns special value*
Insert	`add(e)`	`offer(e)`
Remove	`remove()`	`poll()`
Examine	`element()`	`peek()`

Sample Use of Queue Interface

```
static <E> List<E> heapSort(
        Collection<E extends Comparable<? Super E>> c) {
    Queue<E> queue = new PriorityQueue<E>(c);
    List<E> result = new ArrayList<E>();
    while (!queue.isEmpty())
        result.add(queue.remove());
    return result;
}
```

In practice you should simply call **`Collections.sort`**

BlockingQueue extends Queue

	Exception	*Special-value*	*Blocks*	*Times out*
Insert	`add(e)`	`offer(e)`	`put(e)`	`offer(e,time,unit)`
Remove	`remove()`	`poll()`	`take()`	`poll(time,unit)`
Examine	`element()`	`peek()`	*N/A*	*N/A*

ConcurrentMap Interface

Adds atomic “mini-transactions” to **Map**

```
// Insert entry for key if none present
V putIfAbsent(K key, V value);

// Remove entry for key if mapped to value
boolean remove(Object key, Object value);

// Replace entry for key if present
V replace(K key, V newValue);

// Replace entry for key if mapped to oldVal
boolean replace(K key, V oldVal, V newVal);
```

Queue Implementations

- **`LinkedQueue`** - basic concurrent FIFO queue
- **`PriorityQueue`** - heap-based priority queue
- **`LinkedList`** - retrofitted to implement **`Queue`**
- **`AbstractQueue`** - skeletal implementation

BlockingQueue Implementations

- **LinkedBlockingQueue** - basic FIFO impl
- **ArrayBlockingQueue** - fixed size impl
- **PriorityBlockingQueue** - what you'd expect
- **DelayQueue** - “scheduling” queue
- **SynchronousQueue** - rendezvous mechanism

ConcurrentMap Implementation

- **ConcurrentHashMap**
  - Reads never block!
  - Choose write concurrency level at create time
  - Drop-in replacement for **Hashtable***
  - Iterators weakly consistent rather than fail-fast
  - No way to lock entire table
  - Prohibits null keys and values

* in programs that rely on thread safety but not on synchronization details

`Map` and `Set` Implementations

- **`EnumSet`** - element type must be enum
  - Uses bit-vector representation internally
  - **`long`** or **`long[]`** depending on cardinality of enum
  - Bloody fast
- **`EnumMap`** - key type must be enum
  - Uses array representation internally
  - Bloody fast

Type-safety of Generics Has Its Limits

- Generics implemented by *erasure*
- Automatically generated casts may fail when interoperating with legacy (or malicious) clients

```
public class New {
    public static void main(String[] args) {
        List<String> listOfString = new ArrayList<String>();
        Old.putInteger(ls);
        System.out.println(listOfString.get(0).toUpperCase());
    }
}

public class Old {
    public static void putInteger(List list) {
        list.add(new Integer(42));
    }
}
```

New Convenience Implementations – Checked Collection Wrappers

- *Guarantee* runtime type-safety

```
Set<String> s = Collections.checkedSet(
    new HashSet<String>(), String.class);
```

- Wrappers provided for all collection interfaces
- Very useful for debugging

Generic Algorithms

- `frequency(Collection<?> c, Object o)`
  - Counts the number of times **`c`** occurs in **`o`**
- `disjoint(Collection<?> c1, Collection<?> c2)`
  - Determines whether two collections are disjoint
- `addAll(Collection<? super T> c, T... a)`
  - Adds all of the elements in the array **`a`** to **`c`**

```
Collections.addAll(stooges, "Larry", "Moe", "Curly");
```

- `reverseOrder(Comparator<T> cmp)`
  - Returns comparator representing reverse ordering of **`cmp`**

Utility Methods – `java.util.Arrays`

- Content-based **`equals`** present since 1.2
- Added **`hashCode`**, **`toString`** to go along
  - No more **`Arrays.asList`** to print arrays!

```
System.out.println(Arrays.toString(myArray));
```

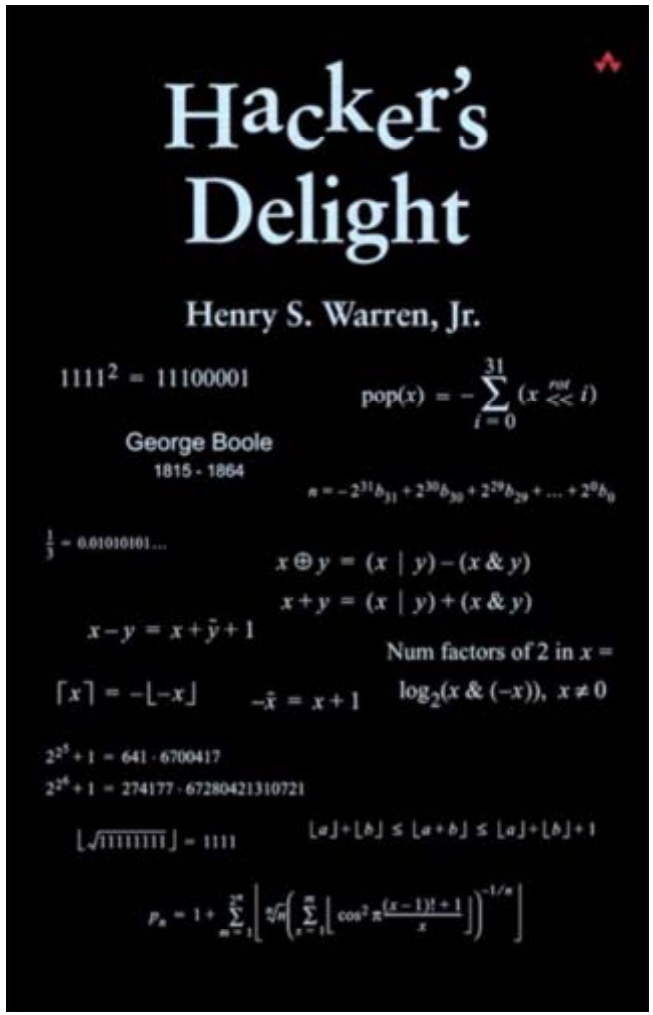
  - Useful for writing **`hashCode`** and **`toString`** methods on classes containing arrays
- For multidimensional arrays: **`deepEquals`**, **`deepHashCode`**, **`deepToString`**

```
System.out.println(
        Arrays.deepToString(myMatrix));
```

Miscellany – Bit Twiddling

- Common bit-manipulation operations for primitives **`Integer`**, **`Long`**, **`Short`**, **`Byte`**, **`Char`**
- **`highestOneBit, lowestOneBit`**
- **`numberOfLeadingZeros, numberOfTrailingZeros`**
- **`bitCount`**
- **`rotateLeft, rotateRight`**
- **`reverse, reverseBytes`**
- **`signum`**

If You Love Bit Twiddling, Buy This Book!



Collections in Java SE 6 ("Mustang")

Bidirectional collections

- Deques
- Navigable collections

Fewer features, but…

- More bug-fixing
- More accurate API docs
- More community involvement

Focus on Bug-fixing

Our favorite bug fix

5045582: binarySearch fails when size() greater than 1**30

```
- int mid = (low + high) >> 1;
+ int mid = (low + high) >>> 1;
```

Interface `Deque` `extends` `Queue`

	First Element (Head)		Last Element (Tail)	
	exception	*special value*	*exception*	*special value*
Insert	`addFirst(e)`	`offerFirst(e)`	`addLast(e)`	`offerLast(e)`
Remove	`removeFirst()`	`pollFirst()`	`removeLast()`	`pollLast()`
Examine	`getFirst()`	`peekFirst()`	`getLast()`	`peekLast()`

Deque - Queue Equivalents

Queue Method	Equivalent Deque Method
`offer(e)`	`offerLast(e)`
`add(e)`	`addLast(e)`
`poll()`	`pollFirst()`
`remove()`	`removeFirst()`
`peek()`	`peekFirst()`
`element()`	`getFirst()`

Using a Deque as a Stack

Stack Method	Equivalent Deque Method
`push(e)`	`addFirst(e)`
`pop()`	`removeFirst()`
`peek()`	`peekFirst()`

Interface BlockingDeque extends BlockingQueue

	First Element (Head)	
	Block	*Time out*
Insert	`putFirst(e)`	`offerFirst(e,time,unit)`
Remove	`takeFirst()`	`pollFirst(time,unit)`

	Last Element (Tail)	
	Block	*Time out*
Insert	`putLast(e)`	`offerLast(e,time,unit)`
Remove	`takeLast()`	`pollLast(time,unit)`

`Deque` and `BlockingDeque` Implementations

- **`ArrayDeque`** - basic **`Deque`** implementation
  - Very fast (implemented as circular buffer)
  - Stack and queue of choice
  - (Perhaps in dolphin) **`List`** of choice?
- **`LinkedBlockingDeque`** - highly concurrent **`BlockingDeque`** implementation
- **`LinkedList`** - retrofitted to implement Deque

Deque Example

- McDonalds Drive-Thru
  - (and no, I don't eat there)
- You arrive at the end of the line
- You leave from the beginning of the line…
- …Unless the line is too long, in which case you can leave from the end (but not the middle!)
- (Many more serious uses as well)

Navigable Collections

- Add methods that should have been there in the first place
- **`NavigableSet`** extends **`SortedSet`**
- **`NavigableMap`** extends **`SortedMap`**
- Use **`NavigableXxx`** in place of **`SortedXxx`** in new work

- **`ConcurrentNavigableMap`** extends **`ConcurrentMap`** and **`NavigableMap`**
  - Takes advantage of covariant returns for **`Map`** views

NavigableSet Interface - Navigation

```
// Returns least element >= to given element, or null
E ceiling(E e);

// Returns least element > given element, or null
E higher(E e);

// Returns greatest element <= given element, or null
E floor(E e);

// Returns greatest element < given element, or null
E lower(E e);

// Gets and removes the first (lowest) element, or null
E pollFirst();

// Gets and removes the last (highest) element, or null
E pollLast();
```

NavigableSet Interface - Views

```
// Returns descending view of set
NavigableSet<E> descendingSet();

// Returns view: fromElement -> toElement
NavigableSet<E> subSet(E fromElement, boolean fromInc,
                       E toElement,   boolean toInc);

// Returns view: <beginning> -> toElement
NavigableSet<E> headSet(E toElement, boolean inclusive);

// Returns view: fromElement -> <end>
NavigableSet<E> tailSet(E fromElement, boolean inclusive);

// Returns iterator in descending order
Iterator<E> descendingIterator();
```

A Small Example Use of NavigableSet

- Words from **`"cat"`** to **`"dog"`** (inclusive)
  - Before: **`sortedSet.subSet("cat", "dog" + '\0')`**
  - After: **`navigableSet.subSet("cat", true, "dog", true)`**
- BigDecimals from 1 to 10 (inclusive)
  - Before: Not Possible!!
  - After: **`navigableSet.subSet(1, true, 10, true)`**
- NavigableSet fixes many other deficiencies in SortedSet as well

NavigableMap Interface Obvious Analogue of NavigableSet

- `ceilingEntry(K key), ceilingKey(K key)`
- `higherEntry(K key), higherKey(K key)`
- `floorEntry(K key), floorKey(K key)`
- `lowerEntry(K key), lowerKey(K key)`
- `firstEntry(), pollFirstEntry()`
- `lastEntry(), pollLastEntry()`
- `descendingMap(), descendingKeySet()`
- `subMap(K, boolean, K, boolean),`
  `headMap(K toKey, boolean inclusive),`
  `tailMap(K fromKey, boolean inclusive)`

Navigable Collection Implementations

- **`TreeSet`** retrofitted for **`NavigableSet`**
- **`TreeMap`** retrofitted for **`NavigableMap`**
- **`ConcurrentSkipListSet`** implements **`NavigableSet`**
- **`ConcurrentSkipListMap`** implements **`ConcurrentNavigableMap`**

Arrays.copyOf

Before:

```
int[] newArray = new int[newLength];
System.arraycopy(oldArray, 0, newArray, 0,
                 oldArray.length);
```

After:

```
int[] newArray = Arrays.copyOf(a, newLength);
```

Collections.newSetFromMap

The JDK does not provide an **`IdentityHashSet`** class, but…

```
Set<Object> identityHashSet =
    Collections.newSetFromMap(
        new IdentityHashMap<Object, Boolean>());
```

AbstractMap.SimpleEntry (finally)

- Writing your own **`Map`** used to be a pain
  - You had to roll your own **`Map.Entry`** from scratch
  - Not any more!
- **`AbstractMap.SimpleEntry`** is a fully functional, concrete **`Map.Entry`** implementation
- Not earthshaking, but a real convenience

Josh's Java 7 ("Dolphin") Wish List

- `Builder<T>`
- `ReferenceMap/Cache`
- `Multiset`
- `Multimap`
- `BiMap`
- `Forwarding{Collection,Set,List,Map}`
- `AbstractIterator`
- `Fast String Collections / Algorithms`

Martin's Java 7 ("Dolphin") musings

- **`ScalableArrayDequeList?`**
  - ArrayList **`get(int)`** very fast, but …
  - **`remove(int), add(int),`** wasted space O(n)
- **`ValueWeakIdentityHashMap?`**
- **`CopyOnWriteArrayHashSet?`**
- **`ScalableIntSet?`**
  - **`BitSet`** too specialized, name is misleading

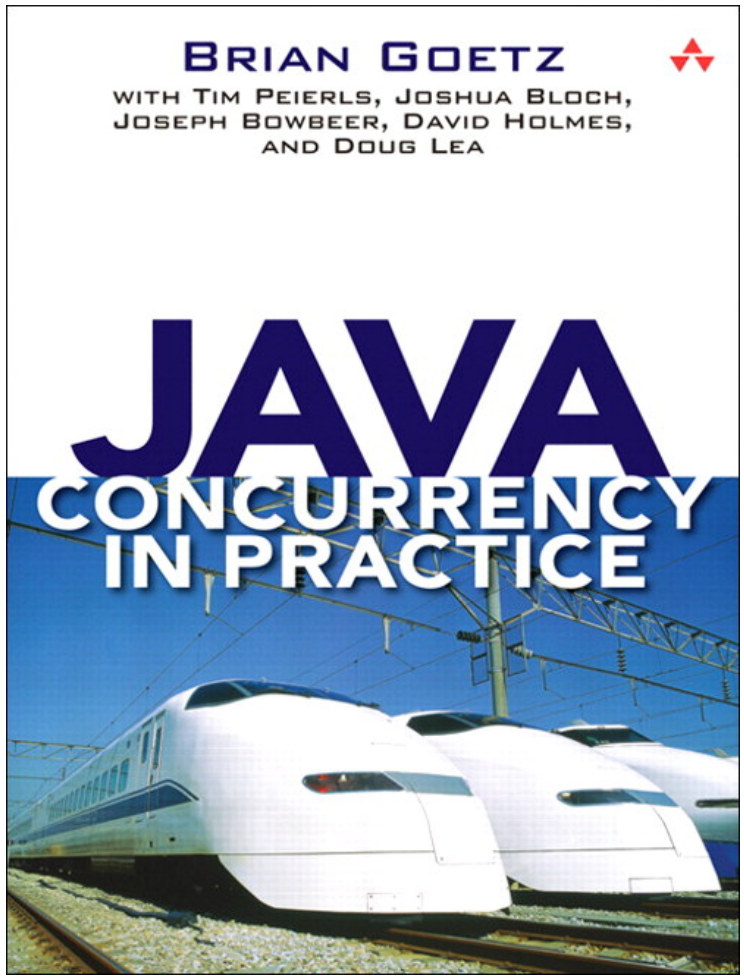
Useful URLs

- Collections framework enhancements in Tiger
  - http://java.sun.com/j2se/5.0/docs/guide/collections/changes5.html
- Collections API, Tutorial, etc.
  - http://java.sun.com/j2se/5.0/docs/guide/collections
- Mustang Collections
  - http://gee.cs.oswego.edu/dl/concurrency-interest
  - http://download.java.net/jdk6/docs/api

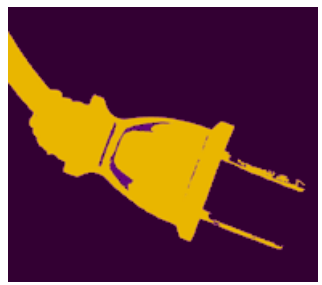
Community Shout-Out

- Props to these homies
  - **Doug Lea**
  - David Holmes (Now at Sun)
  - Jason Mehrens
  - Tom Hawtin
  - Holger Hofstätte
  - Anyone we forgot

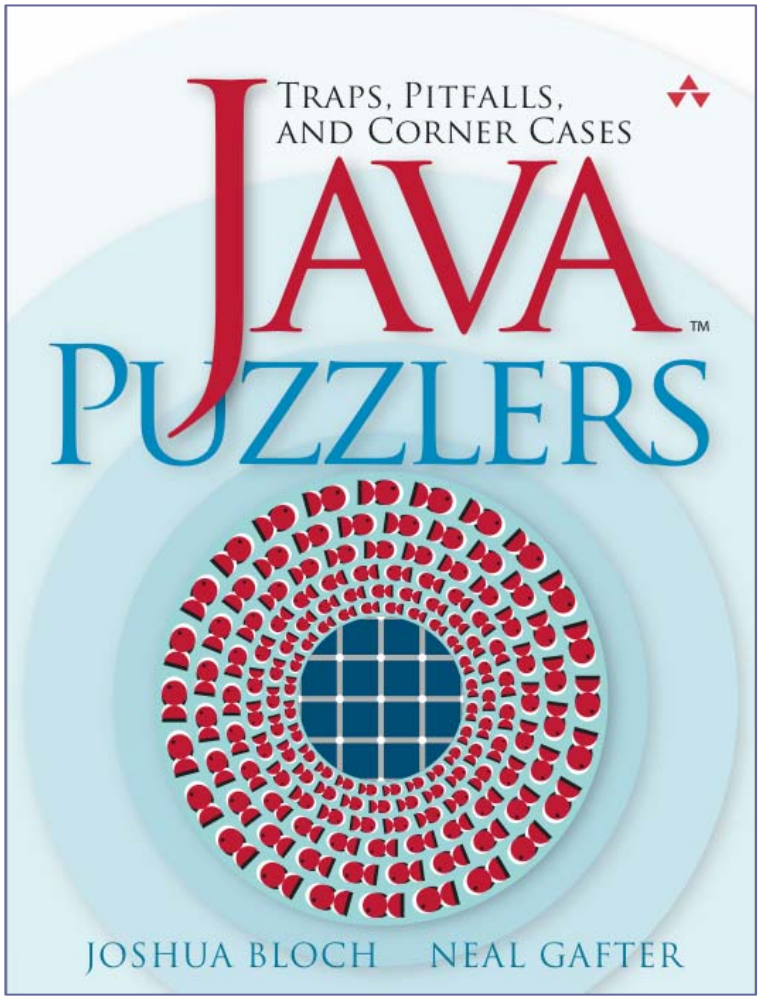
A book from some friends



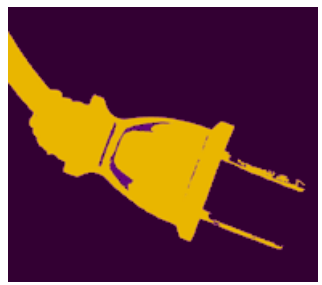
- Collections and Concurrency are inseparable
- The practical Java concurrency book
- From the folks who brought you **`java.util.concurrent`**



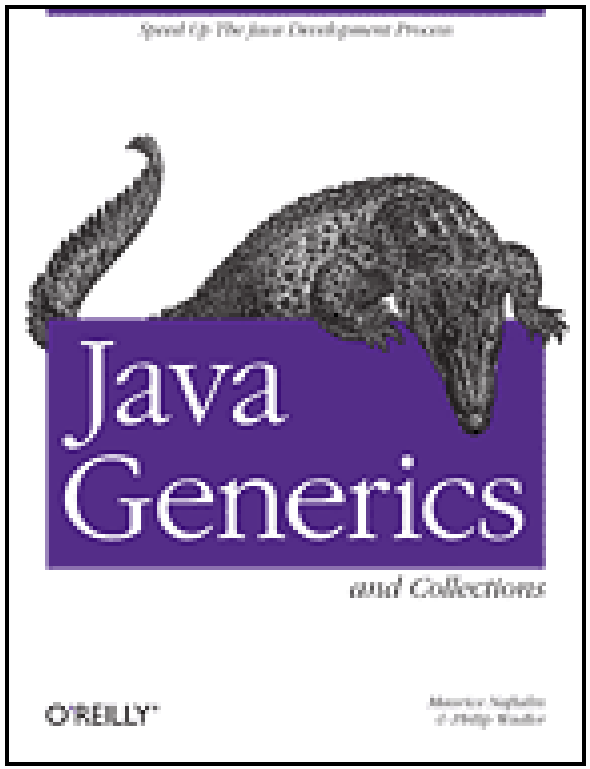
Not just for fun



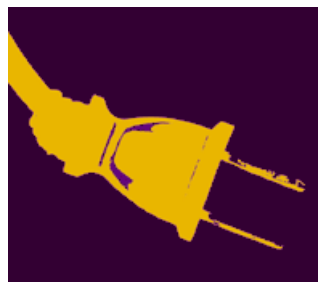
- 95 Puzzles
- 52 Illusions
- Collections



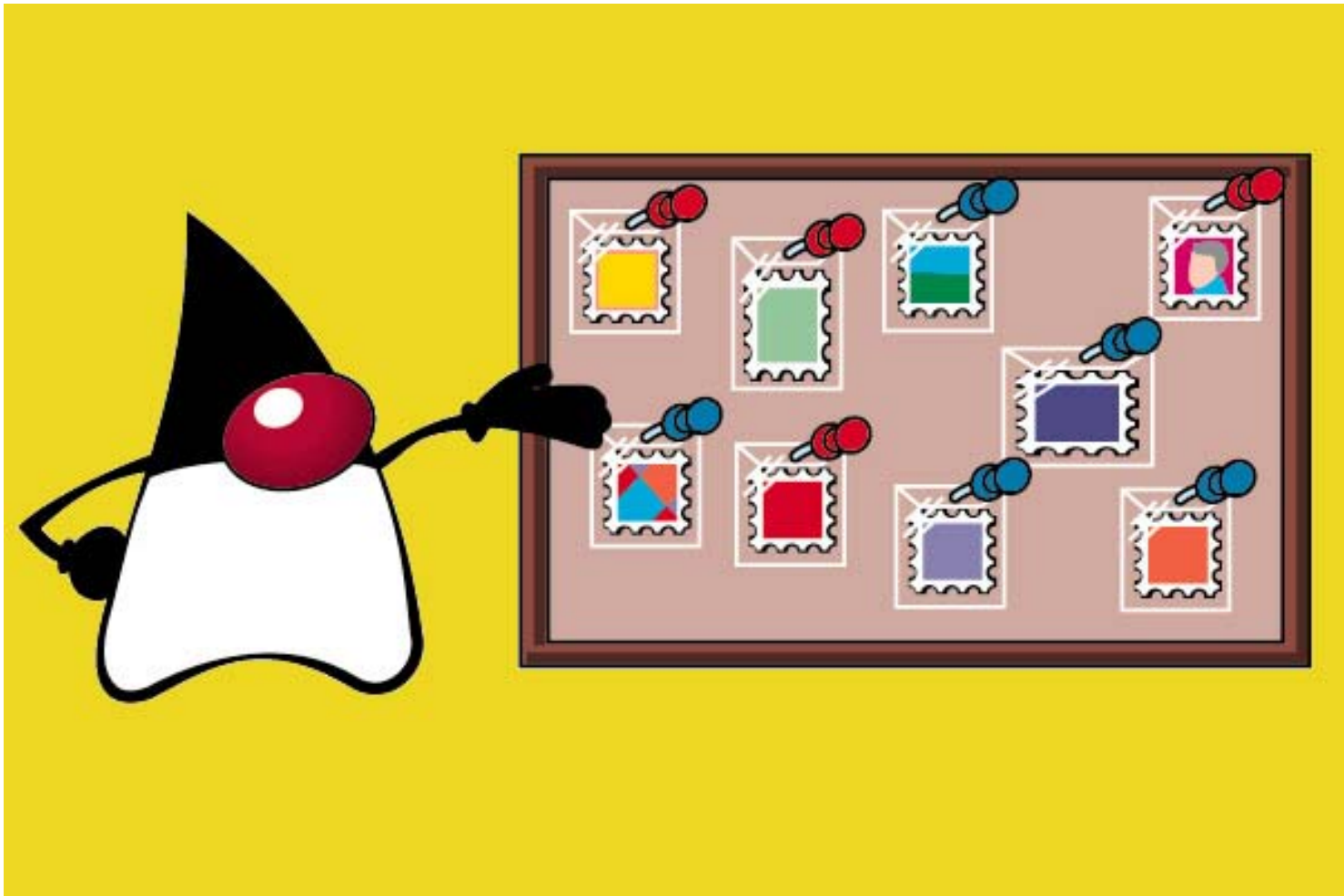
Coming soon (?)



- Collections and Generics are inseparable
- The practical Java Generics book
- From some of the folks who designed Java Generics



Obligatory Graphic



Q&A

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Our Imaginary Friend Herbert

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