# Extending Java Generics for Optimal Reuse

Damith C. Rajapakse, Hamid Abdul Basit and Stan Jarzabek {damithch, hamidabd, stan}@comp.nus.edu.sg

## 1. Generics

- Basic Theme : Reuse through parameterization
- Common Usage : Type-safe polymorphic containers
- Java Generics : planned inclusion in Java 1.5 (as proposed by JSR-14)
- Our case study shows:
  - situations in which Java generics fail to provide effective generic solutions
  - a meta-level extension of generics for optimal reuse

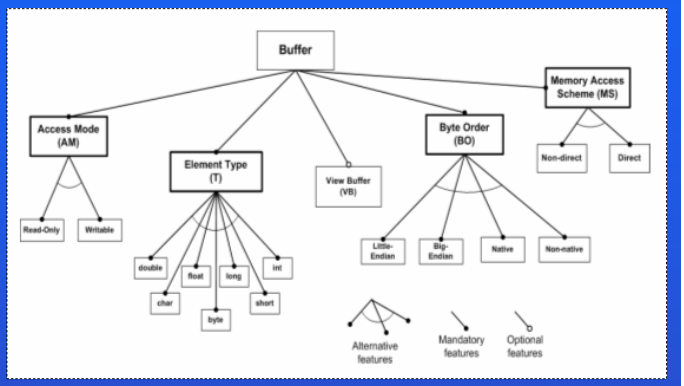
```
public class IntList {
    ...
}
```

```
public class FloatList {
    ...
}
```

```
public class List<T> {
    ...
}
```

## 2. Buffer Library

- Part of java.nio.* package in JDK 1.4.1
- Variability / Feature dimensions in Buffer Library
- Each legal combination of these feature dimensions yields a unique buffer class
  - E.g., DirectIntBufferRS, represents the combination ET = int, AM = read-only, MS = direct, BO = non-native, VB = false
- 74 classes in the Buffer library playing essentially the same role !
- Seven groups of similar buffer classes, much redundant code!
- Can we use generics to solve the problem ?




## 3. Generics-unfriendly variations in buffer classes

- Only three buffer groups were generics-friendly and could be replaced by 3 generic classes
- This solution still relies on wrapper classes for primitive types (since parameterization of primitive types is not allowed)
- only **27%** of code could be eliminated from the Buffer library.
- Many redundancies could not be removed due to various generic-unfriendly situations
- Following types of generic-unfriendliness were noted
  - o Restrictions on type parameters
  - o Non-type parametric variations
  - o Non-parametric variations
  - o Coupling

```
public ByteOrder order() {
  return ((ByteOrder.nativeOrder() ==
     ByteOrder.BIG_ENDIAN)? ByteOrder.LITTLE_ENDIAN
                           : ByteOrder.BIG_ENDIAN);
}
```

```
public ByteOrder order() {
  return ((ByteOrder.nativeOrder() !=
     ByteOrder.BIG_ENDIAN)? ByteOrder.LITTLE_ENDIAN
                           : ByteOrder.BIG_ENDIAN);
}
```

```
public int get(int i) {
    return Bits.swap(unsafe.getInt(ix(checkIndex(i))));
}
```

```
public double get(int i) {
    return Bits.swap(unsafe.getDouble(ix(checkIndex(i))));
}
```

```
private long ix(int i) {
    return address + (i << 2);
}
```

```
private long ix(int i) {
    return address + (i << 3);
}
```

```
...
public abstract class CharBuffer
  extends Buffer implements Comparable, CharSequence{
...
```

```
...
public abstract class DoubleBuffer
    extends Buffer implements Comparable {
...
```

Department of Computer Science, School of Computing, National University of Singapore

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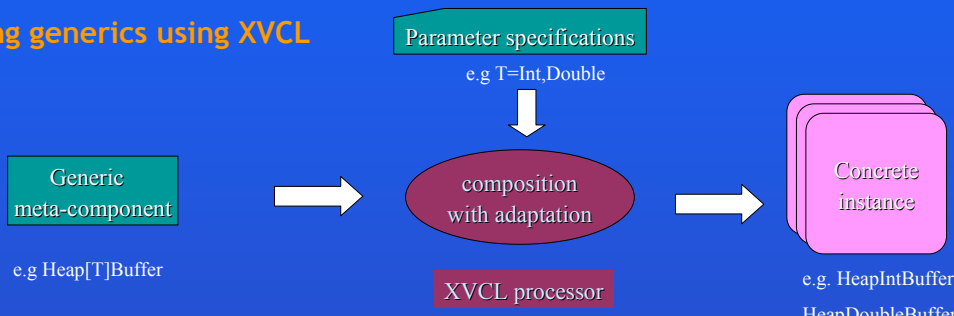
## 4. What is XVCL?

- XVCL is a meta-programming technique and tool for effective reuse
- XVCL uses "composition with adaptation" rules to generate a specific program from generic, reusable meta-components
- XVCL is based on Bassett's frames, a technology that has achieved substantial gains in industry, therefore, the underlying principles of the XVCL have been thoroughly tested in practice
- unlike original frames, XVCL blends with contemporary programming paradigms and complements other design techniques

## 5. "Composition with adaptation"

- XVCL adapts meta-components into components of custom programs
- Any location or structure in a meta-component can be a designated variation point, available for adaptation by ancestor meta-components
- an x-framework is a meta-component architecture designed and "normalized" to eliminate redundancies and to enhance reuse
- program generation rules are 100% transparent to a programmer, who can fine-tune and re-generate code without losing prior customizations
- meta-components can evolve as needed without ever forcing retrofits

## 6. Extending generics using XVCL




## 7. XVCL solution for Buffer library

- composition via <adapt>
- insert code at break points

```
SPC name : [T]Buffers_SPC
set   packageName = "java.nio"
set   ElementName =<Byte, Char, Double, Float, Int, Long, Short>
set   ElementType =<byte, char, double, float, int, long, short>
set   ElementSize =<0, 1, 3, 2, 2, 3, 1>
while using-items-in ElmentName, ElementType, ElementSize
  select option="ElementType"
    Byte       adapt  [T]Buffer
               insert moreMethods
               adapt  methodsForByteBuffer
    Char       adapt  [T]Buffer
               insert-after moreInterfaces
               text   ,CharSequence
               insert toString
               text   Public String toString()
                      { return toString(
                        position(),limit());
                      }
    otherwise  adapt  [T]Buffer
```

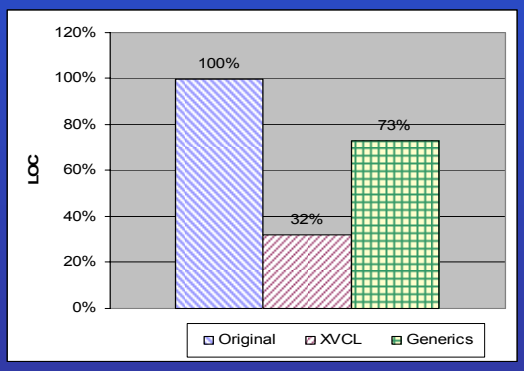
```
meta-component name: [T]Buffer  outfile:@ElementNameBuffer.java
text    public abstract class @ElementNameBuffer extends
          Buffer implements Comparable
break   moreInterfaces
text    {
adapt   commonAttributes
break   moreAttributes
adapt   commonConstructors
break   moreConstructors
adapt   commonMethods
break   moreMethods
break   toString
text    public String toString() {
          StringBuffer sb = new StringBuffer();
          sb.append(getClass().getName());
          sb.append("[pos="+ position());
          sb.append(" lim="+ limit());
          sb.append(" cap="+ capacity());
          Return sb.toString();  }
text    }
```

- generic names: meta-variables and meta-expressions

- select code among many given options
- code generation (loops)

```
Meta-component name: commonMethods
comments  This meta-component contains the definitions of the methods
          all [T]Buffer classes
text      ...../other omitted methods
text      public final @ElementType [] array() {
            if (hb == null)   throw new UnsupportedOperationEx
            if (isReadOnly)   throw new ReadOnlyBufferExcept
            return hb;
          }
text      ...../other omitted methods
```

## 8. Comparison of results




Other applications of XVCL achieved code reductions of:

- 68% in n-tier application (C#)
- 61% in MS ADO wrapper (Java)
- 59% in CORBA Activation IDL library (Java)

We envision many other applications of XVCL in software and non-software domains.