

CMSC 132: Object-Oriented Programming II



Generic Programming

Department of Computer Science
University of Maryland, College Park

Generic Programming

■ Generic programming

- Defining constructs that can be used with different data types
- I.e., using same code for different data types

■ Implemented in Java through

1. Inheritance → A extends B
2. Type variables → <A>

Generic Programming Examples

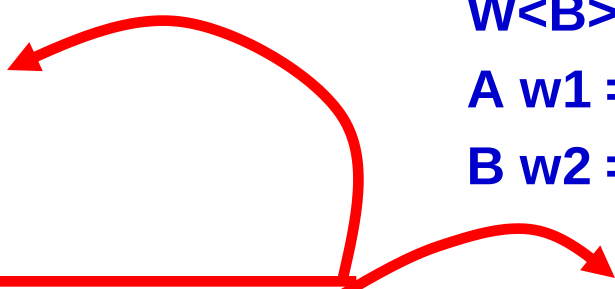
■ Inheritance

```
Class A {  
    doWork( A x ) { ... }  
}  
Class B extends A { ... }
```

```
A w1 = new A( );  
B w2 = new B( );
```

```
w1.doWork( w1 );  
w2.doWork( w2 );
```

**doWork() applied to objects
of both class A and B**



■ Type Variables

```
Class W<T> {  
    doWork( T x ) { ... }  
}  
Class A { ... }  
Class B { ... }
```

```
W<A> x1 = new W<A>( );  
W<B> x2 = new W<B>( );  
A w1 = new A( );  
B w2 = new B( );
```

```
x1.doWork( w1 );  
x2.doWork( w2 );
```

Generic Class

- Class with one or more type variables

- Example → `class ArrayList<E>`

- To use generic class, provide an actual type

- Valid types

- Class → `ArrayList<String>`

- Interface → `ArrayList<Comparable>`

- Invalid types

- Primitive type → `ArrayList<int>`

- (use wrappers) → `ArrayList<Integer>`

Defining a Generic Class

- Append type variable(s) to class name
 - Use angle brackets → `ClassName<type variable>`
- Can use any name for type variable
 - But typically single uppercase letter → E, K, V, etc...
- Use the type variable to define
 - Type of variables
 - Type of method parameters
 - Method return type
 - Object allocation
- Arrays
 - Type of an array object may not be a type variable or a parameterized type, unless it is an unbounded wildcard type
 - How to define arrays?
 - `T[] data = (T[]) new Object[size];`

Example Generic Class

■ Example

```
public class myGeneric<T> {  
    private T value;  
    public myGeneric( T v ) { value = v; }  
    public T getVal( ) { return value; }  
    public void setVal( T newV ) { value = newV; }  
}
```

■ Additional Examples (See code distribution)

Generics and Subtyping

- In general if B is a subtype of A, and GT is a generic type declaration it is not the case that GT is a subtype of GT<A>

- Example

```
ArrayList<String> strL = new ArrayList<String>();  
ArrayList<Object> objL = strL; // Illegal!
```

Generics and Subtyping

■ Consider what could happen if legal

```
class A { ... }  
class B extends A { ... } // B is subtype of A  
List<B> bL = new ArrayList<B>();  
List<A> aL = bL;  
aL.add(new A());  
B b = bL.get(0); // runtime exception
```

■ Using String Class

```
ArrayList<String> sL = new ArrayList<String>();  
ArrayList<Object> oL = sL; // Illegal, but let's assume is valid  
oL.add(new Integer(10));  
String entry = sL.get(0); // Problem!!
```

Subtyping and Arrays

■ Subtyping works for arrays

```
class A { ... }  
class B extends A { ... } // B is subtype of A  
A a = new B();    // B can be used where A expected  
B[] bB = new B[1];  
A[] aB = bB;  
bB[0] = a; // won't compile
```

■ Using String Class

```
Object value = new String("HI");  
String[] sS = new String[1];  
Object[] oO = sS; // Legal  
sS[0] = value; // It will not Compile
```

Wildcards

- ? (unknown)
 - Collection<?>
 - Collection whose element type matches anything
- Bounded Wildcard
 - Example: ArrayList<? extends Shape>
 - Unknown type that is Shape or subtype of Shape
- Summary
 - <?> → unknown type
 - <? extends *typeExpression*> → unknown type that is *typeExpression* or a subtype of *typeExpression*
 - <? super *typeExpression*> → unknown type that is *typeExpression* or a supertype of *typeExpression*.
 - *typeExpression* can involve further occurrences of wildcard type expressions
- Example (WildCard class in code distribution)