CMSC 132: Object-Oriented Programming II

Generic Programming

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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 $\rightarrow$ A extends B
  2. Type variables $\rightarrow$ <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

```java
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<B> is a subtype of GT<A>

Example

```java
ArrayList<String> strL = new ArrayList<String>();
ArrayList<Object> objL = strL;  // Illegal!
```
Consider what could happen if legal

```java
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

```java
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 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)