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
  - Example: stack operations the same regardless of stack element type
- Implemented in Java through
  - Inheritance $\rightarrow$ A extends B
  - 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 );

• **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 );

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

• Example
  ```java
  public class myGeneric<T> {
      private T value;
      public myGeneric(T v) { value = v; }
      public T getVal() { return value; }
  }
  ```
• Append type variable(s) to class name using angle brackets `ClassName<type variable>`
• Can use any name for type variable (but typically single uppercase letter → E, K, V, etc…)
  - [http://download.oracle.com/javase/6/docs/api/java/util/Map.html](http://download.oracle.com/javase/6/docs/api/java/util/Map.html)
• Use the type variable to define type of variables, type of method parameters, method return type and 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: Queue.java
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!
  ```
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
  ```java
  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
  ```java
  Object value = new String("HI");
  String[] sS = new String[1];
  Object[] oO = sS;  // Legal
  sS[0] = value;  // It will not Compile
  ```

- Example: Fruit.java, TropicalFruit.java
Wildcards

• ? (unknown)
  • Collection噤?
    • Collection whose element type matches anything
• Bounded Wildcard
  • Example: ArrayList噤? extends Shape噤>
    • Unknown type that is Shape or subtype of Shape
    • Notice the meaning of extends in this context
• Summary
  • 呔?> \rightarrow unknown type
  • 呔? extends typeExpression噤> \rightarrow unknown type that is typeExpression or a subtype of typeExpression
  • 呔? super typeExpression噤> \rightarrow unknown type that is typeExpression or a supertype of typeExpression.
  • typeExpression can involve further occurrences of wildcard type expressions
• Example: WildCard.java