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  →  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 );

**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
  
  \[\text{Example} \rightarrow \text{class ArrayList}\langle\text{E}\rangle\]

To use generic class, provide an actual type

- Valid types
  
  - Class  \[\rightarrow \text{ArrayList}\langle\text{String}\rangle\]
  
  - Interface  \[\rightarrow \text{ArrayList}\langle\text{Comparable}\rangle\]

- Invalid types
  
  - Primitive type  \[\rightarrow \text{ArrayList}\langle\text{int}\rangle\]
    (use wrappers)  \[\rightarrow \text{ArrayList}\langle\text{Integer}\rangle\]
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!
```
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)