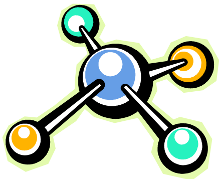
# Generics

Making type-aware classes

EHSDI

eBuzima

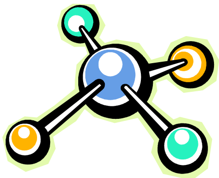
# Java's collection classes



- The JDK contains many useful classes to help you store collections of objects without writing your own storage classes
  - `ArrayList`
  - `HashMap`
  - `LinkedList`
- We can use these in our programs by importing the package `java.util`

```
import java.util.*;

ArrayList list = new ArrayList();
```

# Without generics

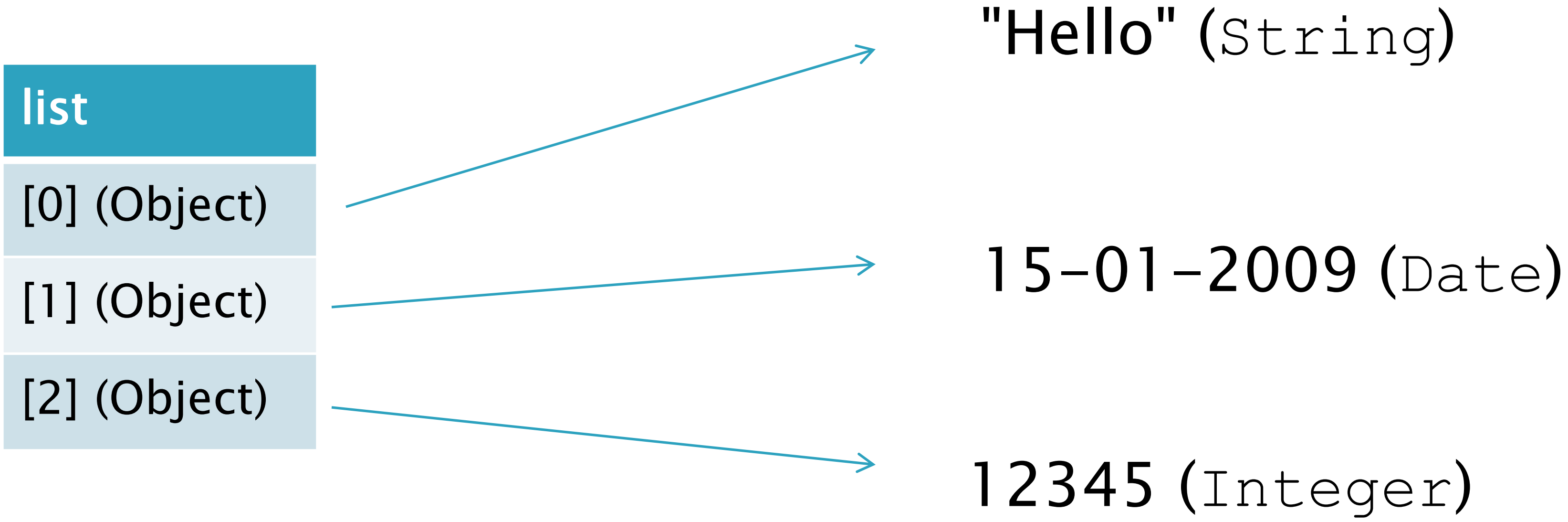


- These classes were developed to store any kind of Java object
- Internally they use references of type `Object` to store each element
- Thus they were not strongly-typed, you had to remember what kind of object you were storing

```
ArrayList list = new ArrayList();
list.add("Hello");
String s = (String)list.get(0);
```

# ArrayList example

```
ArrayList list = new ArrayList();
list.add("Hello");
list.add(new Date());
list.add(12345);
```



list

[0] (Object)

[1] (Object)

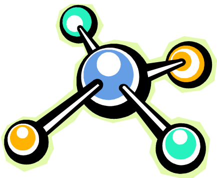
[2] (Object)

"Hello" (String)

15-01-2009 (Date)

12345 (Integer)

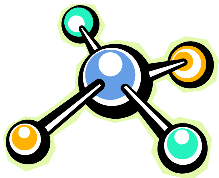
# ArrayList Example



```
ArrayList list = new ArrayList();
list.add("Hello");
list.add(new Date());
list.add(12345);


String s = (String)list.get(0);
Date d = (Date)list.get(1);
int n = (Integer)list.get(2);


String e = (String)list.get(2);
```

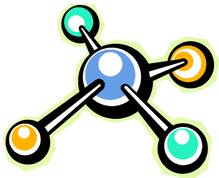
Runtime Error!

# Being strongly typed



- So sometimes it can be useful to not be strongly typed – it means you can store anything
- But its easy to forget what you've stored, and end up with an `ClassCastException`
- Better to have some control over what goes into your `ArrayList` (or other collection class)

# Behold generics

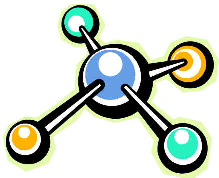


- The new version of these classes support something called generics, which means we can specify a type for our collection
- For example, an `ArrayList` that only accepts strings…

```
ArrayList<String> list = new ArrayList<String>();
list.add("Hello");
list.add("World");

list.add(12345);
```

Compiler error

# How does it work?



- Supposing we have the following simple class

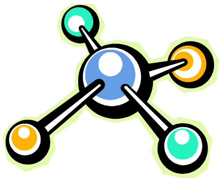
```
class Point {
   protected int x, y;
}
```

- But we want different versions for other data types….

```
class DoublePoint {
   protected double x, y;
}
```

```
class ShortPoint {
   protected short x, y;
}
```

# Going Generic



- We can make our Point class **generic**…

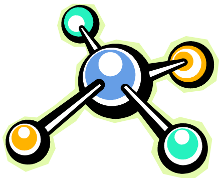
```
class Point<T> {
  protected T x, y;
}
```

- And then specify the data type when we create an instance…

```
Point<Double> p1 = new Point<Double>();
Point<Short> p2 = new Point<Short>();
```

`p1.x` and `p1.y` are now of type `Double`

# Methods of generic classes



- We can define generic methods to work with our generic variables…

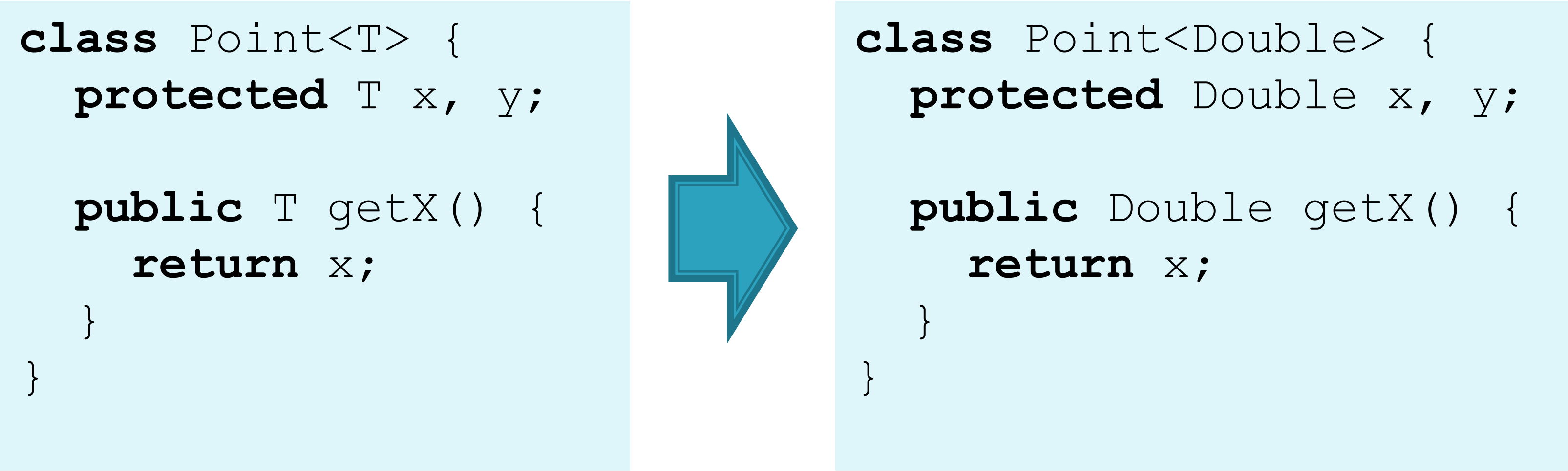
```
class Point<T> {
  protected T x, y;

  public T getX() {
    return x;
  }
  public void setX(T x) {
    this.x = x;
  }
}
```

T is the **type variable**

We can call it anything, uppercase T is just a convention

# Just like a template

- You can think of a generic class as a template for creating new more specific classes

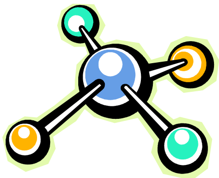


```
class Point<T> {
  protected T x, y;

  public T getX() {
    return x;
  }
}
```

```
class Point<Double> {
  protected Double x, y;

  public Double getX() {
    return x;
  }
}
```

```
Point<Double>d=new  Point<Double>();
```

# Multiple Type Variables



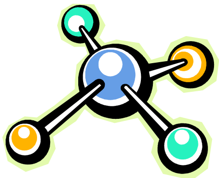
- You are not limited to just one type variable..

```
class PolarPoint<T, R> {
  protected T angle;
  protected R radius;

  public T getAngle() {  return angle; }
  public R getRadius() { return radius; }
}
```

```
PolarPoint<Double, Integer> p
                = new PolarPoint<Double, Integer>();
```

```
PolarPoint<Float, Integer> p2
                = new PolarPoint<Float, Integer>();
```

# Generic methods

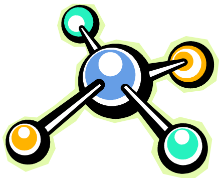


- Any class can have generic methods…

```
class EqualityTest {
  public static <T> boolean test(T o1, T o2) {
    return o1.equals(o2);
  }
}
```

Note that type variable comes just before the return type

# Generic methods



- The compiler tries to infer the type variable from the parameters...

```
EqualityTest.test("Same", "Same");
```

- .. but we can also explicitly declare the type variable as follows…

```
EqualityTest.<String>test("Same", "Same");
```

# Generic types as parameters

- Supposing we have a function which expects a `ArrayList<Integer>` as its only parameter…

```
public void func(ArrayList<Integer> list) { ... }
```

```
ArrayList<Integer> list1 = new ArrayList<Integer>();
ArrayList<String> list2 = new ArrayList<String>();

func(list1);
func(list2);
```

Compiler error

# Wildcard type parameters

- If we want our function to accept an `ArrayList` with any type parameter, we can use the **?** wildcard

```
public void func(ArrayList<?> list) { ... }
```

```
ArrayList<Integer> list1 = new ArrayList<Integer>();
ArrayList<String> list2 = new ArrayList<String>();

func(list1);    // No problem
func(list2);    // No problem
```

# Bounded type parameters

- We can limit the accepted types using the **extends** keyword…

```
public void func(ArrayList<? extends Number> list) {}
```

```
ArrayList<Integer> list1 = new ArrayList<Integer>();
ArrayList<Double> list2 = new ArrayList<Double>();
ArrayList<String> list3 = new ArrayList<String>();

func(list1);
func(list2);
func(list3);
```

Compiler error

# Bounded types

- We can also limit which types are used with our generic classes and methods…
- **extends** is used to limit types to subclasses of the specified class…

```
class Point<T extends Number> {
  T x, y;
}
```

```
public <T extends MyClass> void print(T obj) {
   // We can only print instances of MyClass
   // and its subclasses
}
```

# Subclasses vs generic subtypes

- Recap: `Integer` and `Double` inherit from (extend) `Number`, therefore we can say
  - Integer **is a** Number
  - Double **is a** Number
- …and so the following code works…

```
Number n = new Integer(4);
Double d = new Double(2.3);

ArrayList<Number> list = new ArrayList<Number>();
list.add(n);
list.add(d);
list.add(new Float(2.0f));
```

# Subclasses vs generic subtypes

- However `ArrayList<Integer>` does not inherit from `ArrayList<Number>`, so this doesn't work…

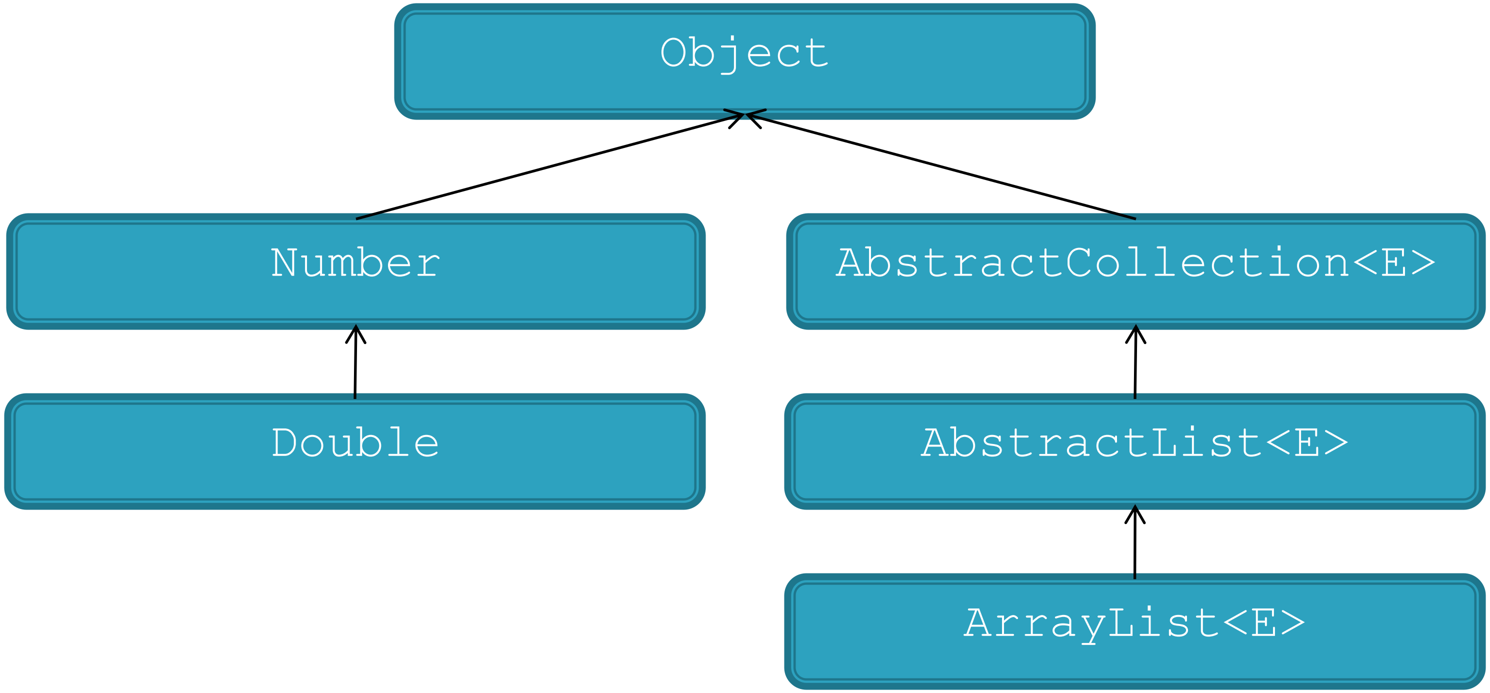
```
public void func(ArrayList<Number> list) { ... }
```

```
ArrayList<Number> list1 = new ArrayList<Number>();
ArrayList<Integer> list2 = new ArrayList<Integer>();
ArrayList<Double> list3 = new ArrayList<Double>();

func(list1);
func(list2);
func(list3);
```

Compiler errors

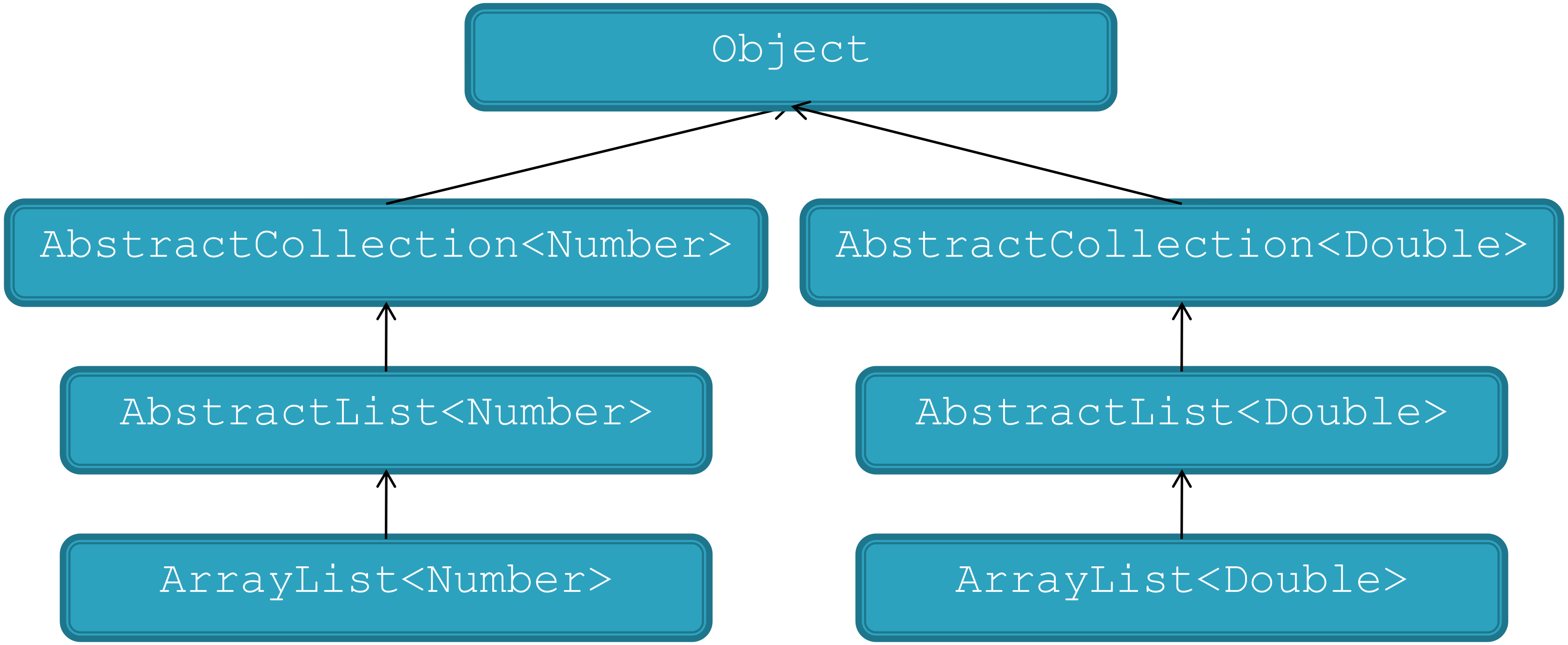
# Subclasses vs Generic Subtypes

- Looking at the inheritance diagrams makes this clear…



# Subclasses vs Generic Subtypes

- `ArrayList<Number>` is not even a cousin of `ArrayList<Double>`!



# References

- Generics in Sun's Java Tutorials at http://java.sun.com/docs/books/tutorial/java/generics