Introduction to Generics in Java

Motivation Example - 1

- Need to deal with a dynamic collection of Dog's in more than one context
- How to solve this?
- Reuse code with Composition

```
public class DogCollection {
  private Dog[] _dogs;
  private int _size;

  public DogCollection(int initialSize) { … }

  private void resize() { … }

  public void add(Dog d) { … }

  public boolean remove(Dog d) { … }

  public Dog get(int idx) { … }
}
```

Motivation Example - 2

- Same needed functionality with Cat's
- Solution

- Problem?
  - Duplication of code
  - Both classes are almost equal!

```
public class CatCollection {
  private Cat[] _cats;
  private int _size;

  public CatCollection(int initialSize) { … }

  private void resize() { … }

  public void add(Cat c) { … }

  public boolean remove(Cat c) { … }

  public Cat get(int idx) { … }
}
```

Motivation Example - 3

- Define a generic collection of Objects

- Advantage
  - Can hold anything

- Disadvantage?
  1. Casting
  2. Type checking

```
public class Collection {
  private Object[] _collection;
  private int _size;

  public Collection(int initialSize) { … }

  private void resize() { … }

  public void add(Object o) { … }

  public boolean remove(Object o) { … }

  public Object get(int idx) { … }
}
```

Disadvantage: Casting

- With DogCollection

```
DogCollection dogs;
dogs  = new DogCollection(5);
Dog d = new Dog("Cão");
dogs.add(d);
Dog myDog = dogs.get(0);
```

- With generic Collection

```
1. Collection dogs;
2. dogs = new Collection(5);
3.  Dog d = new Dog("Cão");
4. dogs.add(d);
5. Dog myDog = dogs.get(0);
```

Which line is wrong?

A. None
B. Line 1
C. Line 4
D. Line 5

Need a cast at line 5

```
(Dog)dogs.get(0);
```

Disadvantage: Type Checking

- With DogCollection

1. DogCollection dogs;
2. dogs = new DogCollection(5);
3. Cat c = new Cat(“Tareco”);
4. dogs.add(c);
5. Dog myDog = dogs.get(0);

What happens?

- Compilation error at line 4

- With generic Collection

1. Collection dogs;
2. dogs = new Collection(5);
3. Cat c = new Cat(“Tareco”);
4. dogs.add(c);
5. Dog myDog = (Dog)dogs.get(0);

What happens now?

- No compilation error
- But execution error
  - At line 5
  - ClassCastException

Better Solution: Generic Types

- Java has syntax for *parameterized data types*
  - Referred to as *Generic Types* in most of the literature
- A *generic type* is a generic class or interface that is parameterized over types
  - Can have one or more *type parameters*
  - *Each type parameter represents a data type*
- When a generic type is instantiated have to specify a type for each parameter type

Generic Types

- Data type parameters declared in class/interface header after name inside **< >**

```
public class Collection<E> {
```

- The `<E>` is the declaration of a data type parameter for the class
  - any legal identifier: `Foo`, `AnyType`, `Element`, `DataTypeThisListStores`
  - Java style guide recommends terse identifiers
  - The data type parameter can be used inside the generic type to refer to a type

- The value E stores will be filled in whenever a programmer declares a variable of type `Collection`

```
Collection<String> li = new Collection<String>(30);
```

Example – Generic Collection

```
public class Collection<E> {
  private E[] _collection; // not exactly true
  private int _size;

  public Collection(int initialSize) { … }

  private void resize() { … }

  public void add(E o) { … }

  public boolean remove(E o) { … }

  public E get(int idx) { … }
}
```

1. Collection<Dog> dogs;
2. dogs = new Collection<Dog>(5);
3. dogs = new Collection<>(5);
4. Dog d = new Dog(“Cão”);
5. dogs.add(d);
6. dogs.add(new Cat());
7. Dog myDog = dogs.get(0);

Generics, Inheritance, and Subtypes

- Given Animal as superclass of Dog and Cat
- Is Collection<Animal> a super type of Collection<Cat> and Collection<Dog)?
- NO!

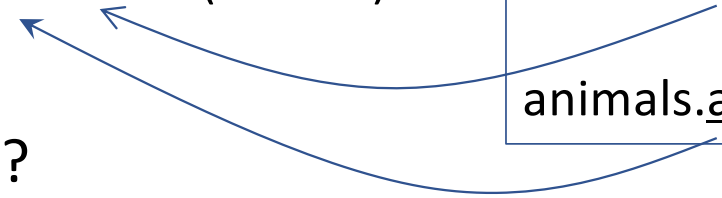
```
public class Collection<E> {
  …
  public void add(E o) { … }
}
```

```
Collection <Dog> dogs = new Collection<>(30);
Collection<Animal> animals = dogs;   ✗

animals.add(new Dog());   ✓

animals.add(new Cat());   ✓
```

Collection<Animal>.add(Animal)



- Problem with code?
  - Dogs now holds two objects, a dog and a **cat**
  - Compilation error for ***animals = dogs***

Restrictions on Generics

- Cannot instantiate generic types with primitive types
- Cannot create instances of type parameters
- Cannot declare static fields whose types are type parameters
- Cannot use casts or *instanceof* with parameterized types
- Cannot create arrays of parameterized types
- Cannot create, catch, or throw objects of parameterized types