# Application Program Development

Segment : Generics (Templates)

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# Outcomes

- Understanding of Generics.
  - Parameterized Types
  - Sub-typing
  - Type Erasure
  - Generic Methods
  - Generic Classes & Interfaces

# What is Generics?

- Generics adds stability to your code by detecting bugs on the compile time.
- Generics is the capability to parameterize types.
- Generics enable types to be parameter when defining classes, interfaces and methods.
- We are all familiar with passing arguments in methods, where values travel in those arguments, now with the help of generics we can Pass types as arguments.

# Motivation

Polymorphism promotes **generalization**

```
class Store{
        private Bookmark a;

        public void set(Bookmark a){
                this.a = a;
        }

        public Bookmark get(){
                return a;
        }
}
```

Can only hold **Bookmark** objects or its subtype objects

✓ **Type is hardcoded**

# More Generalized Form

```
class Store{
        private Object a;

        public void set(Object a){
                this.a = a;
        }

        public Object get(){
                return a;
        }
}
```

John:
Store store = new Store();
store.*set*(**new Date()**); // java.util.Date
…
Date date = **(Date)** store.*get*() //Cast

Bob:
store.*set*(**new Date()**); // java.sql.Date

John:
Date date = **(Date)** store.*get*(); //java.util.Date

**ClassCastException**

✓**Too generic**

✓**Explicit Casting**

✓**Runtime Exception**

Generics was introduced to solve this

Generics is purely compile time concept

```
class Store <T>{
        private T a;

        public void set(T a){
                this.a = a;
        }

        public T get(){
                return a;
        }
}
```

John:

```
Store<Date> store = new Store<Date> (); //java.util
store.set(new Date());
Date date = store.get() //no Casting
```

Bob:

```
store.set(new Date()); // java.sql.Date
                //compiler error
```

Mike:

```
Store<Book> store = new Store<Book> ();
store.set(new Book());
```

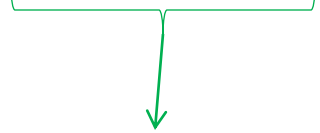
- ✓ **Type safety at compile-time**
- ✓ **cleaner code**
- ✓ **Expressive code**
- ✓ **Generics**

# Generics and Parameterized Types

## Generic Type

Class or Interface with ***type parameters***

class ClassName**<T1, T2, T3, ...>** {… …}



✓ Type of *instance variables*
✓ Type of *parameters, local variables, return types*

```
class Store <T>{
        private T a;

        public void set(T a){
                this.a = a;
        }

        public T get(){
                return a;
        }
}
```

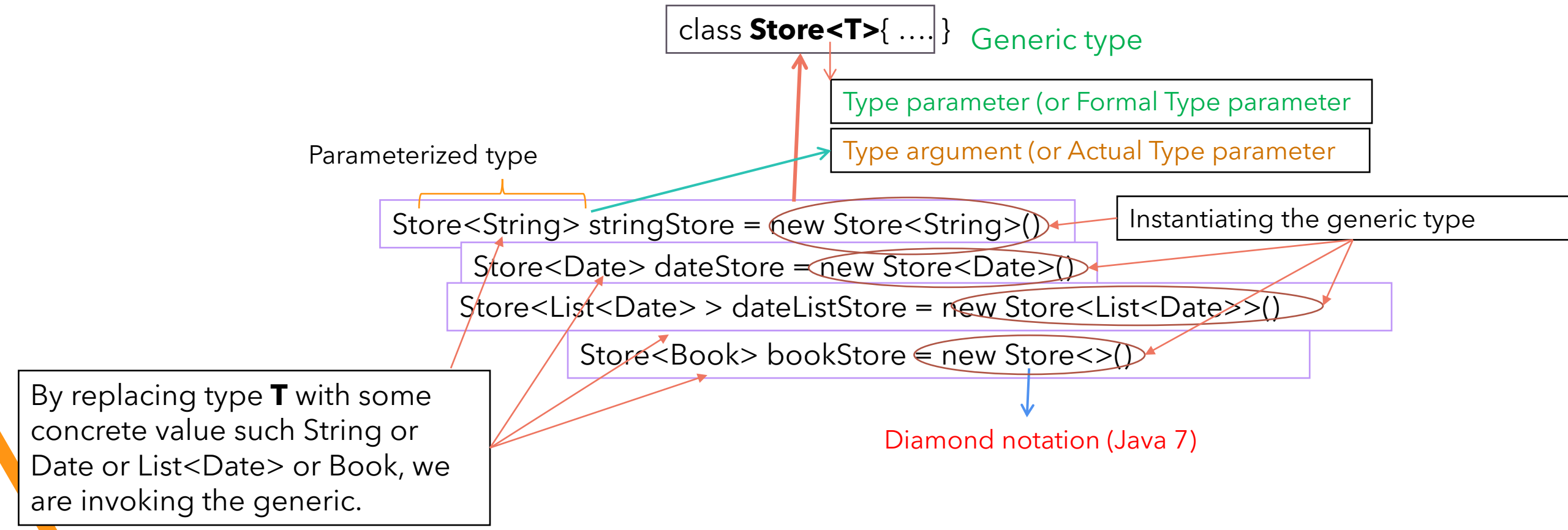
Type parameter

Instance variable

Method parameter

Return type

# Generic Type and Parameterized Type



# Type Parameter Naming Conventions

Use **single, uppercase** letters

**E** – Element (Collections)
**K** – Key, **V** – Value (Maps)
**N** – Numbers
**T** – Type (usually in non-collection)
**S, U, V** – 2nd, 3rd, 4th types

# Subtyping of Generic Types

```
interface Container<T> {
    void set(T a);
    T get();
}
```

```
class Store<T> implements Container<T> {
    private T a;

    public void set(T a) {
        this.a = a;
    }

    public T get() {
        return a;
    }
}
```

Parameterized type

**Container<String>** store = new Store<>();

# Multiple Type Parameters

- You can also have multiple Type Parameters as well. Example

```
public interface Pair<K, V>{
	public K getKey();
	public V getValue();
}
public class OrderedPair<K, V>
implements Pair<K, V>{
	private K key;
	private V value;
	public OrderedPair(K key, V
value){
		this.key = key;
		this.value = value;
	}
	public K getKey() {return key;}
	public V getValue() {return
value;}	}
```

- Instasiation of the OrderedPair class

```
OrderedPair<String, Integer> p1
= new OrderedPair<>("One", 1);
```

```
OrderedPair<String, String> p2
= new OrderedPair<>("Hello",
"world");
```

# Why Generics: Benefits ??

**Stronger Type checking :**

- Fixing Error at run-time or Fixing error at compile time?

```
List<String> list = new ArrayList<String>();
list.add("hello");
list.add(32); //Compile Time Error
```

**Casting can be eliminated:**

- No more object types casting.

**with type cast**

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

**without type case**

```
List <String> list = new ArrayList<String>();
list.add("hello");
String s = list.get(0);    //no cast
```

**Type Safety:**

- Holds only single type of objects, doesn't allow to store other objects.

## Non Generic Example:

```
import java.util.*;
public class ArrayListWithoutGenericsTest {
    public static void main(String[] args) {
        List strLst = new ArrayList();
        strLst.add("alpha"); // String upcast to Object implicitly
        strLst.add("beta");
        strLst.add("charlie");
        Iterator iter = strLst.iterator();
        while (iter.hasNext()) {
         // need to explicitly downcast Object back to String
          String str = (String)iter.next();
          System.out.println(str);
        }
        // Compiler/runtime cannot detect this error
        strLst.add(Integer.valueOf(1234));
        // compile ok, but runtime ClassCastException
        String str = (String)strLst.get(3);
    }
}
```

We could use an **instanceof** operator to check for proper type before down-casting. Again checking will be done on run-time

# Generic Class (Another Example)

**GenericBox.java**

```
public class GenericBox<E> {
    private E content; // Private variable
    public GenericBox(E content) {// Constructor
                this.content = content;
    }
    public E getContent() {
                return content;
    }
    public void setContent(E content) {
                this.content = content;
    }
    public String toString() {
                return content + " (" + content.getClass() + ")";
  } }
```

toString() reveals the actual type of the contents

```
public class TestGenericBox {
   public static void main(String[] args) {

    GenericBox<String> box1 = new GenericBox<>("Hello");
    // no explicit downcasting needed
    String str = box1.getContent();
    System.out.println(box1);

    // autobox int to Integer
    GenericBox<Integer> box2 = new GenericBox<>(123);
    // downcast to Integer, autoboxing to int
    int i = box2.getContent();
    System.out.println(box2);

   // autobox double to Double
   GenericBox<Double> box3 = new GenericBox<>(55.66);
   // downcast to Double, autoboxing to double
   double d = box3.getContent();
   System.out.println(box3);
   }
}
```

```
Hello (class java.lang.String)
123 (class java.lang.Integer)
55.66 (class java.lang.Double)
```

# Type Erasure

- When a generic type is instantiated, the compiler translates  those types by a technique called *type erasure*

- In previous example the compiler replaces all reference to parameterized type E with Object, performs the type check, and insert the required downcast operators.

```
// A dynamically allocated array with generics
public class MyGenericArrayList<E> {
   private int size; // number of elements
   private Object[] elements;
   public MyGenericArrayList() { // constructor
      elements = new Object[10];
    }
   public void add(E e) {
      if (size < elements.length) {
            elements[size] = e;
      }
      else { // allocate a larger array and add the element…. }
      ++size;
   }
   public E get(int index) {
      if (index >= size) throw new IndexOutOfBoundsException("Index: “
                              + index + ", Size: " + size);
          return (E)elements[index];
   }
   public int size() {
          return size;
   }
}
```

```
public class MyGenericArrayListTest {
   public static void main(String[] args) {
     // type safe to hold a list of Strings
     MyGenericArrayList<String> strLst = new MyGenericArrayList<>();
     strLst.add("alpha"); // compiler checks if argument is of type
String
     strLst.add("beta");

     for (int i = 0; i < strLst.size(); ++i) {
           // compiler inserts the downcasting operator (String)
           String str = strLst.get(i);
           System.out.println(str);
      }

    // compiler detected argument is NOT String, issues compilation
error
      strLst.add(new Integer(1234));
   }
}
```

# Raw Types

- *Raw Type* is the name of the a generic class or interface without any type arguments. For example

```
public class Store<T>{
        public void setStore(T t) { /* … */}
        // …
}
Store<String> strStore = new Store<>();
Store rawStore = new Store();
```

Creating a parameterized type store

Creating a ***raw type*** store

- We should avoid raw types. Why?
  - They are not type safe, you possibly get runtime error.
  - They require proper casting
  - They act as normal object instantiation

# Generic method

- Type parameters can also be declared within method and constructor signatures to create *generic method*
- Type parameter's scope is limited to the method in which it is declared.

```
public class GenericsMethods {
   public static <T> boolean isEqual(GenericsType<T> g1, GenericsType<T> g2){
        return g1.get().equals(g2.get()); }
   public static void main(String args[]){
        GenericsType<String> g1 = new GenericsType<>();
        g1.set("hello");
        GenericsType<String> g2 = new GenericsType<>();
        g2.set("hello");
        boolean isEqual = GenericsMethods.<String>isEqual(g1, g2);

    //above statement can be written simply as
        isEqual = GenericsMethods.isEqual(g1, g2);
        //without specifying a type between angle brackets.
   }
}
```

# Restriction ~ Primitives

*Type argument cannot be a primitive*

```
Store<int> intStore = new Store<int>();
```

# Restriction ~ Static Context

*Type argument cannot be used in static context*

*Type of static variables:*

```
public  class Device<T>{
        private static T deviceType;
}

Device<Smartphone> phone = new Device<>();
Device<Pager> pager = new Device<>();
```

T? Smartphone or pager