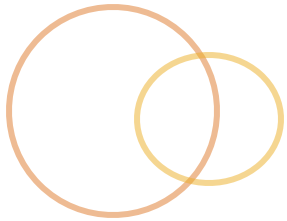
What's New In Java

Advanced Language Features

Presentation Topics



In this section, we will cover:

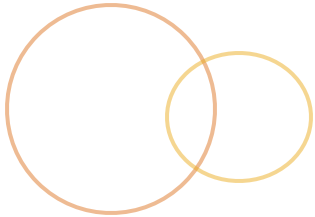
- Type-safe Enumerations
- Generics
- Metadata
- Covariant Returns

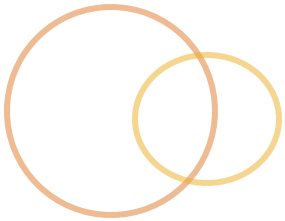
Objectives

When we are done, you should be able to:

- Create a simple enumeration
- Incorporate generics into “legacy” code
- List 2 annotations

Type-Safe Enumerations

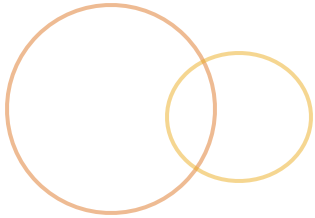


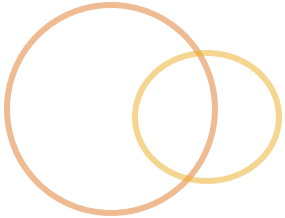


Type-Safe Enumerations

- What is an Enumeration?
  - Comes from mathematical world
  - Represents finite listing of values
- What is a type-safe enumeration?
  - Language-based mechanism to represent finite listing
  - Represents a collection of typed-values
  - Immutable

Enums



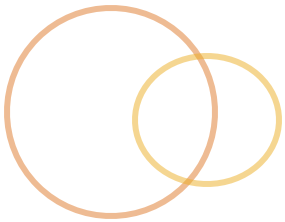


- Why do they exist?
  - Historically implemented using an enum pattern
  - Common problems with enum pattern:
    - Not type-safe
    - No separate namespace (values typically defined as fields)
    - Based on primitive values that may change
  - Laborious to develop using enum pattern
    - Creates code level dependencies
    - Tons of boiler-plate code

Enums [cont.]

- How do they work?
  - Look similar to enumeration support in other languages
  - Considered new type, `enum` type
  - Full-fledged type support:
    - Fields
    - Methods
    - Constructors
  - Support `Object` level functionality like:
    - Comparison
    - Serialization
    - `toString`, `equals`, etc.

Creating an Enum



- Two ways to create an enum
  - Top-level type declaration
  - Inner-class type declaration
- In both cases:
  - Declare enum type
  - Define with “values”

Top-level Enum Example

```
1   package examples.enums;
2
3   /**
4    * Days is a basic illustration of an
5    * enumerated type within the Java language.
6    */
7   public enum Days {
8      SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
9      THURSDAY, FRIDAY, SATURDAY;
10  }
11
```

Inner-class Enum Example

```
1   package examples.enums;
2
3   /**...*/
7   public class Calendar {
8     public enum Days { SUNDAY, MONDAY, TUESDAY,
9                        WEDNESDAY, THURSDAY, FRIDAY,
10                       SATURDAY };
11  }
12
```

Working with an Enum

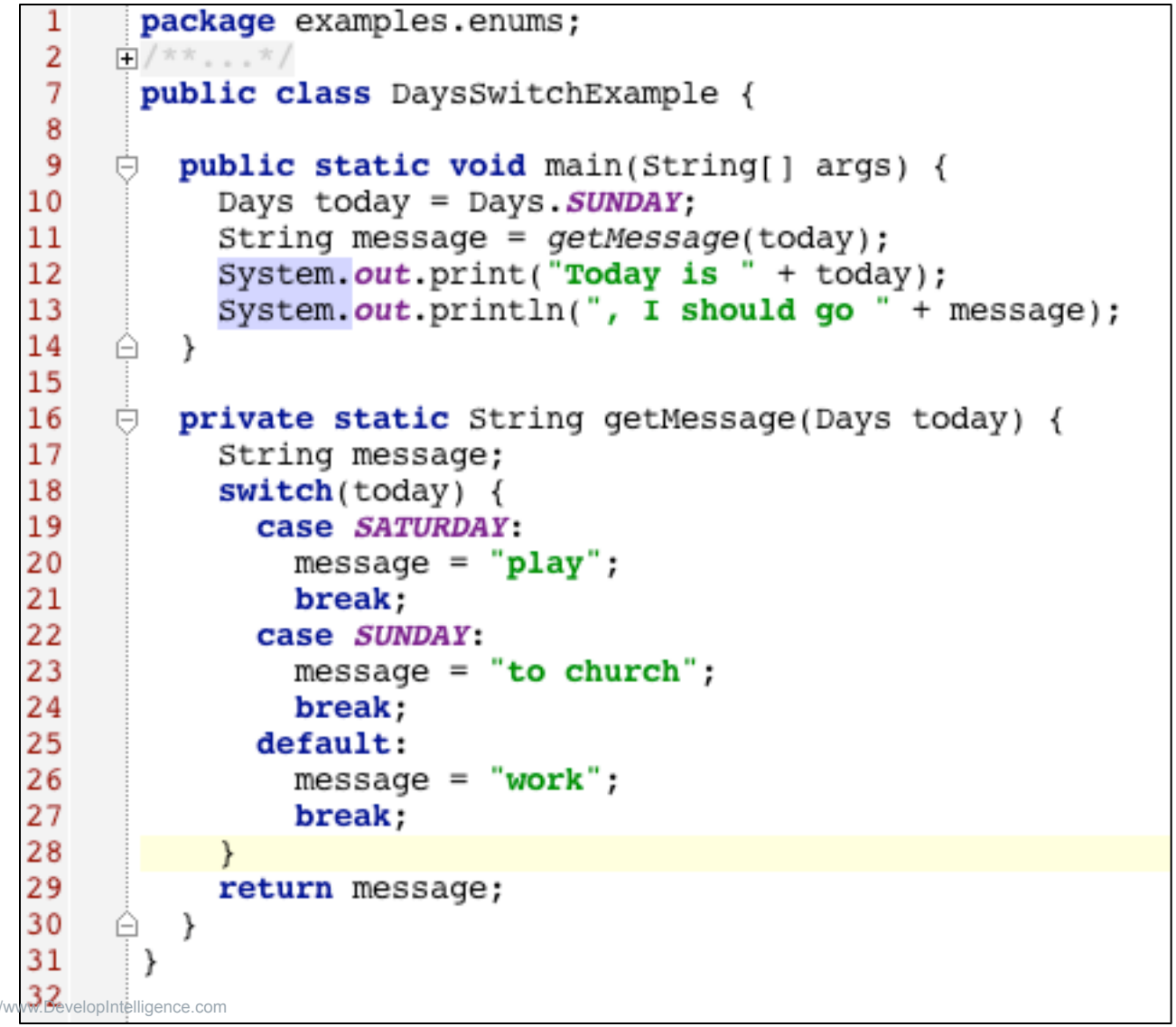
- Enums are types

- Values are instances of an enum type
  - Stored as `static final` fields in type
  - Defined in terms of
    - `name` - stringified representation of field name
    - `ordinal` - position in set
  - Referencable through dot-notation
  - Are switchable

Accessing an Enum Value Example

```
1   package examples.enums;
2
3   /**...*/
7   public class DaysExample {
8
9     public static void main(String[] args) {
10      Days today = Days.SUNDAY;
11      System.out.println("Today is: " + today);
12    }
13  }
14
```

Enum Switch Example



```
1  package examples.enums;
2  /**...*/
7  public class DaysSwitchExample {
8
9    public static void main(String[] args) {
10     Days today = Days.SUNDAY;
11     String message = getMessage(today);
12     System.out.print("Today is " + today);
13     System.out.println(", I should go " + message);
14   }
15
16   private static String getMessage(Days today) {
17     String message;
18     switch(today) {
19       case SATURDAY:
20         message = "play";
21         break;
22       case SUNDAY:
23         message = "to church";
24         break;
25       default:
26         message = "work";
27         break;
28     }
29     return message;
30   }
31 }
32
```

Working with an Enum [cont.]

- Enums have some predefined *static* methods
  - `values` – retrieves all enum instances
  - `valueOf` - transforms `String` value into enum instance
- Have some predefined *instance* methods
  - `name` – upper-case name of enum instance
  - `toString`
  - `equals`
  - `hashCode`

Enum Method Example

```
1   package examples.enums;
2
3   /**...*/
9   public class DaysValuesExample {
10
11    public static void main(String[] args) {
12      for(Days d : Days.values())
13        System.out.println(d.name());
14    }
15
16  }
17
```

Prints:

```
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
```

Working with an Enum [cont.]

- Enums can have methods
- Accessed using dot-notation
- Can have static methods associated with enum
- Can have instance methods associated with enum values

Enum Method Example

```
1   package examples.enums;
2
3   /**...*/
7   enum Days {
8     SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
9     THURSDAY, FRIDAY, SATURDAY;
10
11    public String getReadableName() {
12      //get name as String
13      String nameValue = name();
14
15      //convert it to correct capitalization
16      return nameValue.substring(0, 1) +
17             nameValue.substring(1).toLowerCase();
18    }
19  }
20
```

```
1   package examples.enums;
2   /**...*/
6   public class DaysMethodExample {
7
8     public static void main(String[] args) {
9       Days today = Days.SUNDAY;
10      System.out.println("Today is: " + today.getReadableName());
11    }
12  }
13
```

Enum Lab 1

- **Description**:
  Create an enumeration called `Month` to represent the months of the year. Allow the user to specify their favorite month from the command line. Convert the `String` value for the month to the appropriate `Month` enum value. If an invalid month is specified, notify the user and print off all valid values for `Month`. Once a `Month` is selected, print off a message describing what season the month belongs to.
- **Duration**: 20 minutes

Working With an Enum [cont.]

- Enums support method overriding
  - Enum-defined methods
  - Object methods
- Method over-ridding supported:
  - Across all enum instances
  - Specific instance

Instance Method Overriding Example

```
1   package examples.enums;
2
3   /**...*/
9   public class DaysValuesExample2 {
10
11    public static void main(String[] args) {
12      for(Days d : Days.values())
13        System.out.println(d.getReadableName());
14    }
15
16  }
17
```

```
1   package examples.enums;
2
3   /**...*/
7   enum Days {
8     SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
9     THURSDAY, FRIDAY,
10    SATURDAY { //treat saturday different
11      public String getReadableName() {
12        return name();
13      }
14    };
15
16    public String getReadableName() {
17      //get name as String
18      String nameValue = name();
19
20      //convert it to correct capitalization
21      return nameValue.substring(0, 1) +
22             nameValue.substring(1).toLowerCase();
23    }
24  }
25
```

Enum Method Overriding Example

```
1   package examples.enums;
2
3   /**...*/
7   enum Days {
8     SUNDAY, MONDAY, TUESDAY, WEDNESDAY,
9     THURSDAY, FRIDAY,
10    SATURDAY { //treat saturday different
11      public String getReadableName() {...}
14    };
15
16    public String getReadableName() {...}
24
25    public String toString() {
26      return getReadableName();
27    }
28  }
29
```

```
1   package examples.enums;
2
3   /**...*/
9   public class DaysValuesExample3 {
10
11    public static void main(String[] args) {
12      for(Days d : Days.values())
13        System.out.println(d);
14    }
15
16  }
17
```

Working with an Enum [cont.]

- Enums support constructors
- Constructors are private
- Used to initialize instance variables
- Provide type-safe instance creation

Enum Constructor Example

```
1  package examples.enums;
2
3  /**...*/
7  enum DaysToo {
8    SUNDAY ("Sunday"), MONDAY ("Monday"),
9    TUESDAY ("Tuesday"), WEDNESDAY ("Wednesday"),
10   THURSDAY ("Thursday"), FRIDAY ("Friday"),
11   SATURDAY;
12
13   private String readableName;
14
15   DaysToo() {
16     readableName = name();
17   }
18
19   DaysToo(String s) {
20     readableName = s;
21   }
22
23   public String getReadableName() {
24     return readableName;
25   }
26
27   public String toString() {
28     return getReadableName();
29   }
30 }
31
```

Advanced Enum Features

- Enums are types
  - No enum - enum inheritence chains
  - No class - enum inheritence chains
  - Can implement interfaces
- Two new enumeration oriented collections
  - `EnumMap`– converts enum fields into map keys
  - `EnumSet`– converts enum fields into a set

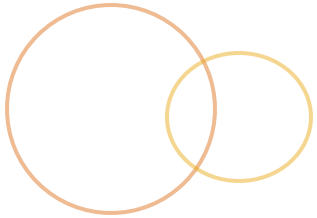
Enum Lab 2

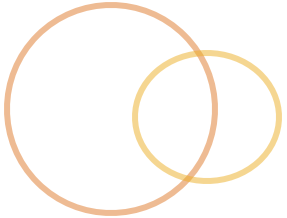
- **Description**:
  Modify Enum Lab 1. Refactor the enumeration implementation, adding a more robust static factory method. Regardless of the case of the `String` passed in, if the `String` matches a `Month`'s name, the `Month` should be returned. Additionally, associate a `Season` with each enum value and make it accessible through a `getSeason` method call. Modify your application to use the enum modifications.
- **Duration**: 20 minutes

Generics

Black and white never tasted so good

Generics





- What are generics?
  - Stands for generic types and generic methods
  - Represent design pattern known as *parameterized types* and methods
  - Allows a type to be defined without specifying all of the other types it uses
  - Were one of most requested features of language

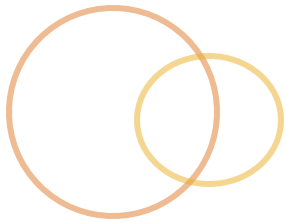
Generics [cont.]

- Why do they exist?
  - Add type-awareness to collections, without breaking flexibility
  - Add type-awareness to other container-like classes, without breaking flexibility
  - Add type awareness to methods
  - Provide compile-time type-safety
    - Remove development-time casting procedures
    - Remove run-time type incompatibilities
    - Remove run-time `ClassCastExceptions`

Using Generics

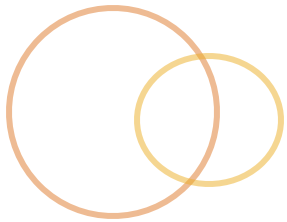
- How do they work?
  - Supports both definition and application
    - Most straightforward is application
    - But application requires understanding definition
  - Use “placeholder” to represent generic type as part of type or method definition
    - Placeholder value is replaced with type in source
    - Placeholder is removed during compilation, replaced with traditional casting (known as type erasure)

Generic Placeholders



- Generic type placeholders
  - Used when defining a parameterized type
  - `<E>` - stands for element; represents element type held within container
  - `<T>` - stands for type
  - `<V>` - stand for value
- Generic method placeholders
  - Used when defining a parameterized method
  - `<E>` – parameterized type
  - `<?>` – wildcard placeholder
  - `<? extends E>` – bounded wildcard placeholder
  - `<? super E>` - bounded wildcard placeholder
- `<E>, <T>, <V>,` etc. naming convention only

Generic Collections



- Collections API has been rewritten to support Generics
  - Provides type safety to collections
  - Applies to *all* classes within Collection API
- Specify the type the collection will hold
  - Inserting type mismatch generates compile-time error
  - Getting / removing element no longer requires cast
- Backwards compatible in *raw type* format
  - May generate compile-time warning
  - Can widen typed collection into raw-type

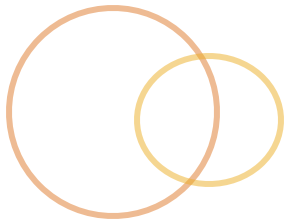
Generic List

- `List` represents an ordered collection
- `List` interface now represents generic type

```
public interface List<E> extends Collection<E> {..}
```

- Read as *List of <type E> elements*
- Certain `List` methods now generic
  - `Iterator<E> iterator();`
  - `boolean containsAll(Collection<?> c);`
  - `boolean addAll(Collection<? extends E> c);`

Generic ArrayList



- Provides type-safe representation of an array-backed list
  - Implementation of `List` interface
  - Subclass of `AbstractList`
  - Common replacement for `Vector`
- Create `ArrayList` using parameterized syntax:
  - `List<String> myList = new ArrayList<String>();`
  - `<String>` replaces placeholder `<E>`
  - Read as *`List` of `String` elements*
  - `myList` can only hold `String` elements

Simple List Example [Old way]

```
1   package examples.generics.simple;
2   import ...
6   /**...*/
11  public class OldWayExample {
12
13    public static void main(String[] args) {
14      List myList = new ArrayList();
15      //convert args into a List
16      List argList = Arrays.asList(args);
17      //add Strings to list
18      myList.addAll(argList);
19      //list is not typesafe, can add any object
20      myList.add(new Integer(0));
21
22      Iterator theArgs = myList.iterator();
23
24      //step through list elements
25      while (theArgs.hasNext()) {
26        //will cause class cast
27        // exception with Integer element
28        String nextArg = (String) theArgs.next();
29      }
30    }
31  }
32
```

Simple List Example [New way]

```
1   package examples.generics.simple;
2   import ...
6   /**...*/
10  public class TestExample {
11
12    public static void main(String[] args) {
13      //typesafe List of String elements
14      List<String> myList = new ArrayList<String>();
15
16      //convert args into a List<String>
17      List<String> argList = Arrays.asList(args);
18      myList.addAll(argList);
19
20      //would cause compile-time error
21      //myList.add(new Integer(0));
22
23      //Iterator is now also typesafe
24      Iterator<String> theArgs = myList.iterator();
25      while(theArgs.hasNext()) {
26        String nextArg = theArgs.next();
27      }
28    }
29  }
30
```

Typesafe Collection Advantages

- Adds compile time type safety
  - `OldWayExample` allowed `Integer` to be inserted into collection; discovered problem at run-time
  - `TestExample` prevented `Integer` to be inserted into collection; discovered at compile-time
- Simplified interactions
  - `OldWayExample` required casting when working with collection elements
  - `TestExample` contained specific type; so no casting needed
- No advantages in speed or performance

How Do They Work? [revised]

- Implemented different than other languages
  - Adopt ***type erasure*** mechanism
    - Parameterized placeholder replaced at compile time
    - Code converted from parameterized to generic
    - Compiler “inserts” cast similar to `OldWayExample`
  - Compiler ensures type-safety
    - Only at compile time
    - Run-time relies on traditional mechanism
    - As a result, can still encounter run-time exceptions

Simple List Example [corrupted]

```
1   package examples.generics.simple;
2   import ...
6   /**...*/
10  public class CorruptTestExample {
11
12    public static void main(String[] args) {
13      //typesafe List of String elements
14      List<String> myList = new ArrayList<String>();
15
16      //convert args into a List<String>
17      List<String> argList = Arrays.asList(args);
18      myList.addAll(argList);
19
20      //call third-party api which uses raw types
21      ThirdPartyAPI.addElement(myList);
22
23      //Iterator is now also typesafe
24      Iterator<String> theArgs = myList.iterator();
25      while(theArgs.hasNext()) {
26        String nextArg = theArgs.next();
27      }
28    }
29  }
30
```

Simple List Example [corrupted]

- Third-party API does not utilize type-safe collections
- Causes issues at run-time (adds an Integer)

```
1   package examples.generics.simple;
2
3   import java.util.List;
4
5   /**...*/
11  public class ThirdPartyAPI {
12
13    public static void addElement(List list) {
14      list.add(new Integer(32));
15    }
16  }
17
```

Solidifying Type-safety

- Type erasure can be “stepped” around
- Should be a facility to guarantee type-safety, even with older / third-party APIs
- Collection facility adds wrappers to increase safety
  - Does not guarantee type-safety
  - But prevents insertion of type mismatched objects
  - Encounter `ClassCastException` on insertion instead
  - Theoretically easier to debug

Solidifying Type-safety [cont.]

- Dynamic type-safety support provided by collections class
  - `Collections` class rewritten to support generics
  - New static methods used to create a “checked” collection
    - `public static <E> List<E> checkedList( List<E> list, Class<E> type);`
    - `public static <K, V> Map<K, V> checkedMap( Map<K, V> m, Class<K> keyType, Class<V> valueType);`
  - Similar to other static methods used to create things like synchronized collections

Generics Lab 1

- Description: Use the `Mixer` as your starting point. Refactor the `Mixer` so that the frequency map becomes type safe. The frequency map should contain `<String, Integer>` as its map structure. The `List` should contain `<String>` as its element types. Validate that you have written a type-safe `Mixer` using the `-Xlint` option with the compiler.
- Duration: 15 minutes

Working with Generics

- Generics go beyond type-safe collections
- Can create generic methods
- Can create own generic types

Creating Generic Methods

- Relatively straightforward process
  - Can add generic method support to any class
  - Use when you want to place type constraints on method
  - Simply add generic method nomenclature to method signature
    - Adjust method parameter list
    - Adjust method return signature

Revised Third-party Example

- Can modify method signature to ensure compile-time type-safety
- Only applicable if have “third-party” code

```
1   package examples.generics.simple;
2
3   import java.util.List;
4
5   /**...*/
10  public class TypeSafeThirdPartyAPI {
11
12    public static void addElement(List<String> list) {
13      list.add("Hello Typesafety");
14    }
15  }
16
```

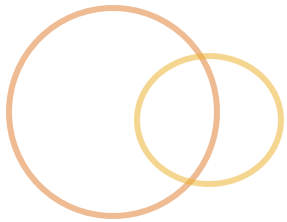
Creating Generic Methods [cont.]

- Can get fancy with wildcarding
  - Adds flexibility to method signature
  - Can be confusing
    - `<?>` - unknown type
      - unbounded wildcard
      - use when you don't know or care about the value's type; like raw types
    - `<? extends Number>`
      - Upper-bounded wildcard
      - Specified type should be Number or any subclass of Number
    - `<? super Number>`
      - Lower-bounded wildcard
      - Specified type should be a direct subclass of Number

Bounded Third-party Example

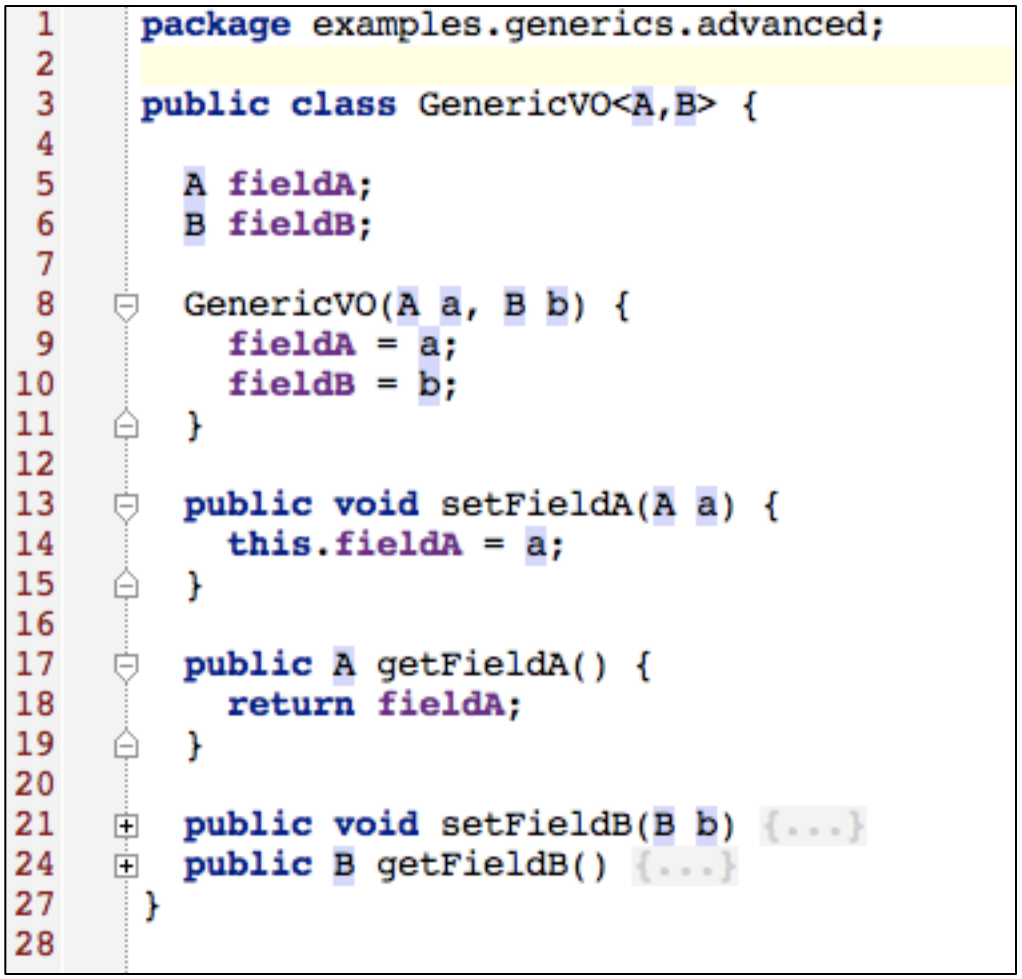
```
1   package examples.generics.advanced;
2
3   import java.util.List;
4
5   /**
6    * The following class represents
7    * a Third-party API that can
8    * maintains a bounded type-safe collection
9    */
10  public class BoundedTypeSafeThirdPartyAPI {
11
12    public static void addElement(List<? super Number > list) {
13      list.add(729);
14      list.add(Math.PI);
15    }
16  }
17
```

Creating Generic Type



- Relatively straight-forward process
  - Create generic type like any type
  - Include generic type nomenclature
  - Reference placeholder within code
  - Have methods support generic type
- Could be used for things like:
  - Custom data structure
  - Generic value object

GenericVO Example



```
1   package examples.generics.advanced;
2
3   public class GenericVO<A,B> {
4
5     A fieldA;
6     B fieldB;
7
8     GenericVO(A a, B b) {
9       fieldA = a;
10      fieldB = b;
11    }
12
13    public void setFieldA(A a) {
14      this.fieldA = a;
15    }
16
17    public A getFieldA() {
18      return fieldA;
19    }
20
21    public void setFieldB(B b) {...}
24    public B getFieldB() {...}
27  }
28
```

GenericVO Example [cont.]

```
1  package examples.generics.advanced;
2
3  public class GenericVOExample {
4
5    public static void main(String[] args) {
6      //create instances of the GenericVO
7      GenericVO<String, String> name =
8              new GenericVO<String,String>("John", "Doe");
9
10     GenericVO<String, Integer> user =
11             new GenericVO<String,Integer>("john_doe123", 123457);
12
13     //get name field <B>
14     String lastName = name.getFieldB();
15     System.out.println("name's field <B> is: " + lastName);
16
17     //get user field <B>
18     Integer userId = user.getFieldB();
19     System.out.println("users's field <B> is: " + userId);
20   }
21
22 }
23
```

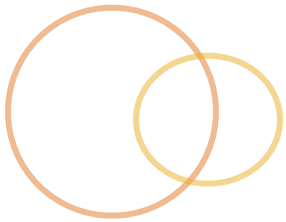
APIs Effected by Generics

- Collections API
- Reflection API
- Concurrency API
- `java.lang` classes - like `Comparable`

Constructing Generics Lab

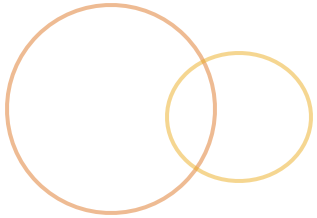
- Description: This is an optional lab to let you further explore using Generics. One suggested lab is to modify the Mixer so that it use a “custom” data structure to hold the word and its frequency count. This custom data structure could be contained in a List parameterized to your type.
- Duration: 30 minutes

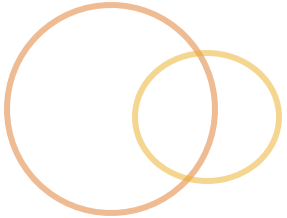
Metadata



Notes on Annotations

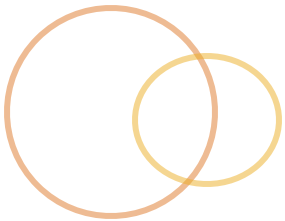
MetaData





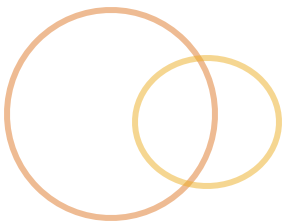
- What is it?
  - Typically described as “data about data”
  - Usually provides additional information about data
  - Basic example - comments in code
  - More complex example - schema
- Why is it needed?
  - Provide additional data about data, outside of data
  - Keeps data clean
  - Can be used by tools to “learn” about the data, without interrogating data

Annotations



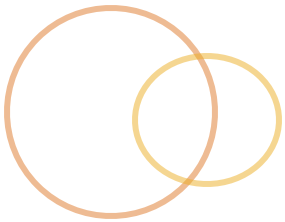
- What are they?
  - Metadata facility for Java
    - Allowing you to provide additional data alongside Java classes
    - Similar to Javadoc “metadata” facility
  - Expanded and formalized mechanism
    - “Competes” with Doclet / XDoclet
  - Recognized by Java compiler and other tools

Annotations



- Why do we need them?
  - Additional data can be read:
    - By the Compiler
    - By source-code generation tools
    - At run-time
  - Additional data can be used to:
    - Generate boiler-plate code
    - Maintain side-file dependencies
    - Mark things for tracking purposes (like TODOs)

Annotations [cont.]

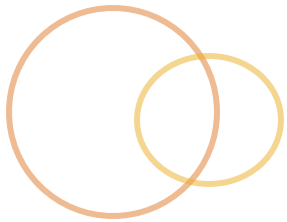


- How do they work?
  - Don’t affect program semantics; aren’t allowed to disrupt execution
  - Represented as a new type within language
  - Have similar syntax to Javadoc
  - Applied like modifiers
  - Have constrained lifespan
  - Detected and interpreted by compiler

Annotation Type

- New type within language
  - `java.lang.annotation.Annotation`
  - Type can be annotated with other annotations
- Type like an interface
  - Use `@interface` instead of interface
  - Support methods
    - Must be declared without arguments
    - Methods can not throw `Exceptions`
  - Support name-value-pairs (NVP)
    - Can not have members; members defined through coding convention
    - Method name + return type define member as NVP
    - NVP can have default values (making it optional)

Annotation Syntax

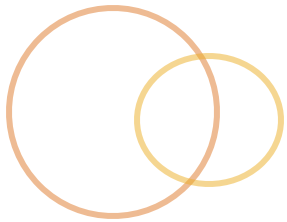


- Syntax similar to Javadoc syntax
  - `@Deprecated` v. `@deprecated`
  - `@` - represents annotation
  - `Deprecated` - represents annotation type
- Syntax more robust than Javadoc syntax
  - Can pass NVP
    - `@SupressWarnings` - no NVP passed
    - `@SuppressWarnings(value={"unchecked, fallthrough"})` - NVP passed
    - `@SuppressWarnings({"unchecked, fallthrough"})` - NVP passed; short-hand
  - Not white-space sensitive

Annotation Example

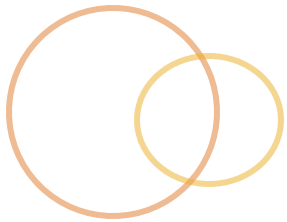
```
@Target({TYPE, FIELD, METHOD, PARAMETER, CONSTRUCTOR, LOCAL_VARIABLE})
@Retention(RetentionPolicy.SOURCE)
public @interface SuppressWarnings {
    /**
     * The set of warnings that are to be suppressed by the compiler in the
     * annotated element.  Duplicate names are permitted.  The second and
     * successive occurrences of a name are ignored.  The presence of
     * unrecognized warning names is <i>not</i> an error: Compilers must
     * ignore any warning names they do not recognize.  They are, however,
     * free to emit a warning if an annotation contains an unrecognized
     * warning name.
     *
     * <p>Compiler vendors should document the warning names they support in
     * conjunction with this annotation type. They are encouraged to cooperate
     * to ensure that the same names work across multiple compilers.
     */
    String[] value();
}
```

Provided Annotations



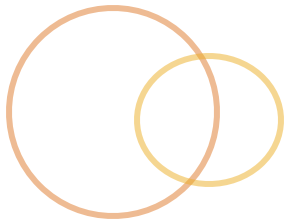
- Two classifications:
  - Meta-annotations
    - Annotate annotations
    - Found in `java.lang.annotation`
    - 4 main meta-annotations
    - Used to define annotation behaviors
  - Annotations
    - Core annotations
    - Found in `java.lang`; automatically imported in source
    - 3 main annotations

Meta-Annotations



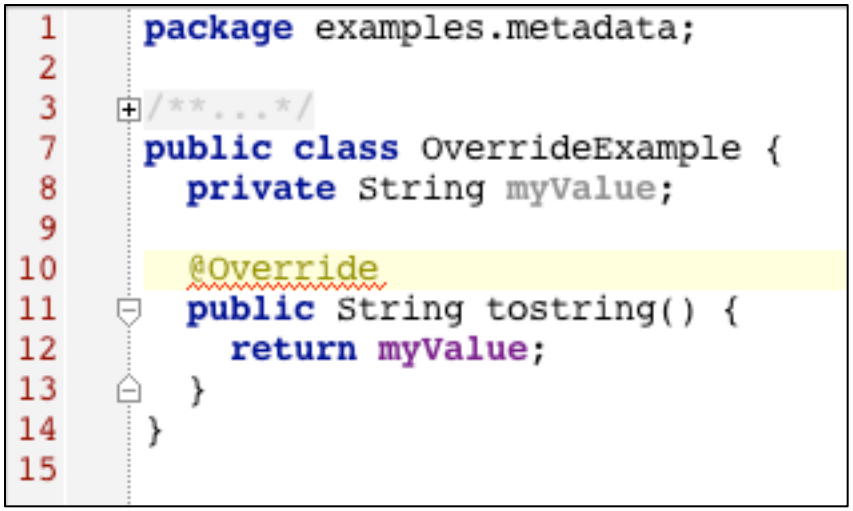
- `Target`
  - Identifies element applicability
  - Default / no value means applies to all elements
  - Possible values defined in `ElementType`
- `Retention`
  - Identifies lifespan of annotation
  - Three lifespans defined in `RetentionPolicy`:
    - `RetentionPolicy.SOURCE` - source only
    - `RetentionPolicy.CLASS` - source and class; not runtime
    - `RetentionPolicy.RUNTIME` - source, class, and runtime
  - Default / no value causes source only retention
- `Documented` - something that should be documented
- `Inherited` - annotation should be carried through inheritence

Core Annotations



- `@Override`
  - Used to notify compiler that method is overridden representation of inherited method
    - Causes compiler to validate overridden signature
    - Generates compiler errors if not in sync
  - `@Target(ElementType.METHOD)`
  - `@Retention(RetentionPolicy.SOURCE)`

@Override Example



```
1   package examples.metadata;
2
3   /**...*/
7   public class OverrideExample {
8     private String myValue;
9
10    @Override
11    public String tostring() {
12      return myValue;
13    }
14  }
15
```

```
 > javac OverrideExample.java
OverrideExample.java:10: method does not override a method from its superclass
  @Override
   ^
1 error
 >
```

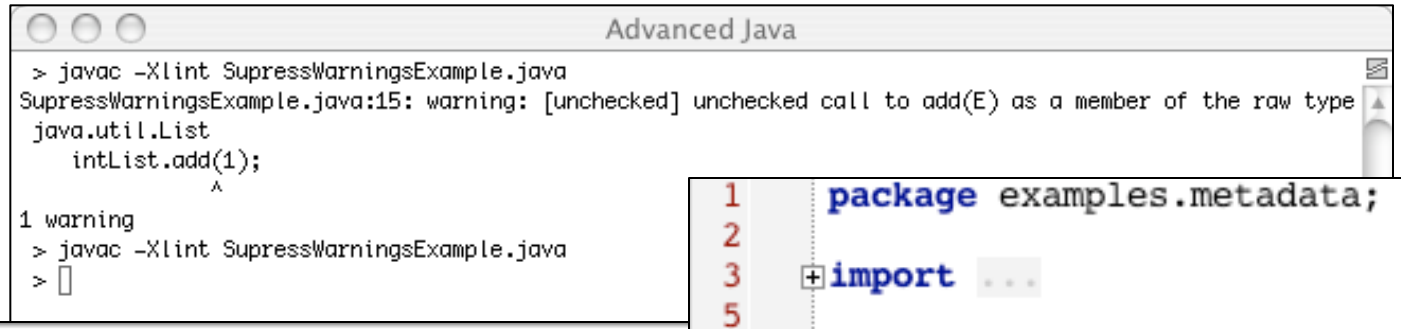
Core Annotations [cont.]

- `@Deprecated`
  - Marker annotation similar to `@deprecated` in Javadoc
  - Used to notify compiler that use of `@Deprecated` element is discouraged
  - No `@Target` specified
  - `@Retention(RetentionPolicy.RUNTIME)`

Core Annotations [cont.]

- `@SupressWarnings`
  - Used to selectively turn off compiler warnings
  - Code-level alternative to `-Xlint` compiler flag
  - No Enum defining which warnings can be selected
  - Works in “hierarchical” manner
  - `@Target({TYPE, FIELD, METHOD, PARAMETER, CONSTRUCTOR, LOCAL_VARIABLE})`
  - `@Retention(RetentionPolicy.SOURCE)`

@SuppressWarnings Example



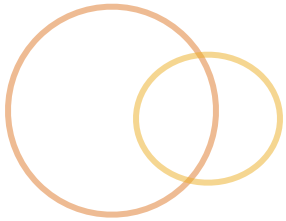

```
1   package examples.metadata;
2
3   import ...
5
6   /**...*/
11  public class SupressWarningsExam
12
13    public List buildList() {
14      List intList = new ArrayList
15      intList.add(1);
16      return intList;
17    }
18
19  }
20
```

```
1   package examples.metadata;
2
3   import ...
5
6   /**...*/
11  public class SupressWarningsExample {
12
13    @SuppressWarnings({"unchecked"})
14    public List buildList() {
15      List intList = new ArrayList();
16      intList.add(1);
17      return intList;
18    }
19
20  }
21
```

Annotation Lab

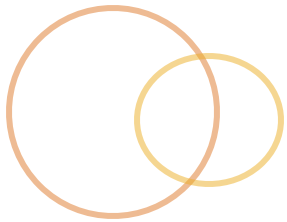
- Description: Add a `tostring` method to the `Month` enumeration. The `tostring` method should return a title-case version of the month name (December). Apply the `@Override` annotations to `tostring` method. `tostring` is not a valid method to override. You should see compiler errors. Clear up any compile errors by changing `tostring` to `toString`.
- Duration: 15 minutes

Covariant Returns



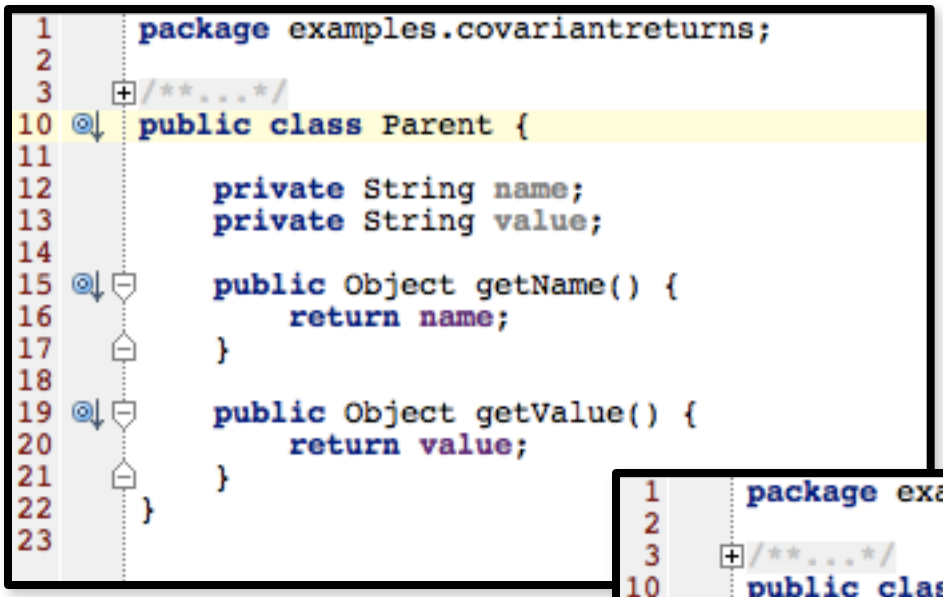
Simplifying Type-safe Returns

Covariant Returns

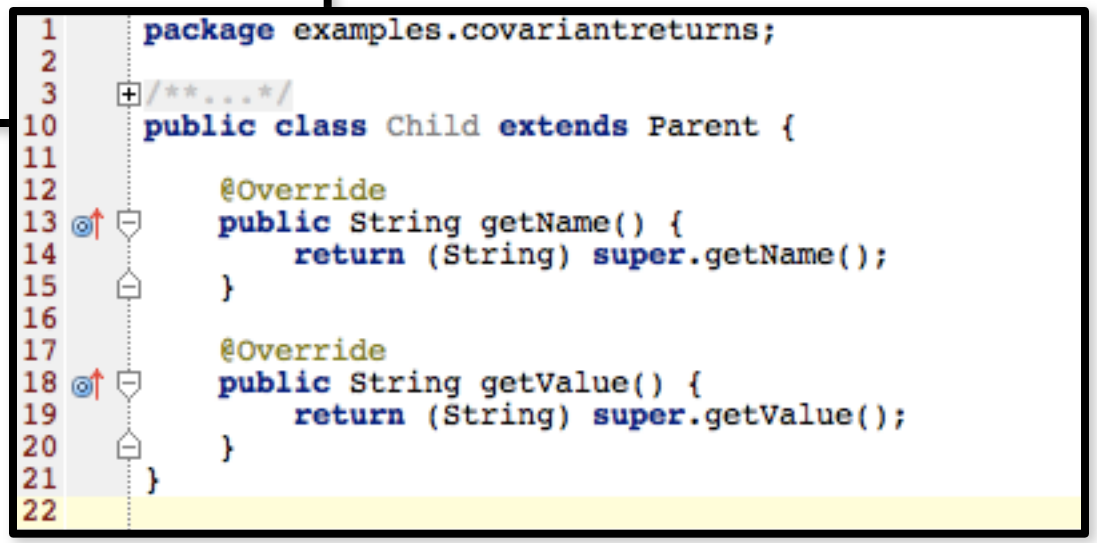


- What are they?
  - Mechanism added to language
  - Allowing return type of inherited method to be narrowed
  - Applies to method over-riding *not* over-loading
- Why do they exist?
  - Needed to support generics mechanism
  - Removes narrowing cast on polymorphic returns
  - Prevents run-time `ClassCastExceptions` on returns
  - Provides compile-time type dependency checking

Covariant Return Example



```
1   package examples.covariantreturns;
2
3   /**...*/
10  public class Parent {
11
12      private String name;
13      private String value;
14
15      public Object getName() {
16          return name;
17      }
18
19      public Object getValue() {
20          return value;
21      }
22  }
23
```



```
1   package examples.covariantreturns;
2
3   /**...*/
10  public class Child extends Parent {
11
12      @Override
13      public String getName() {
14          return (String) super.getName();
15      }
16
17      @Override
18      public String getValue() {
19          return (String) super.getValue();
20      }
21  }
22
```

Summary

Five advanced language enhancements

- **Enums** - type supporting Enumeration Pattern
- **Generics** - mechanism for creating parameterized types and methods
- **Annotations** - mechanism to define additional information without effecting execution
- **Covariant returns** - mechanism to narrow return type