Annotations and Reflection?

- Features of some languages
- Programmer conveniences
- Useful in checking inheritance
- Alternate development modes

Annotations

- Remember @Override
- Remember JUnit?
  - @Before, @After, @Test
- @ is Java's notation for the start of an annotation
  - like @author for javadoc
- What are they?
  - metadata
  - provide data about a program

What are annotations used for?

- Information for the compiler
  - detect errors
  - suppress warnings.
- Compile-time and deployment-time processing
  - for IDEs and other tools
  - generate code, XML files, etc.
- Runtime processing
  - some annotations are used at runtime.

Annotations can have field names and data

```
@Author(
    name = "Benjamin Franklin",
    date = "3/27/2003"
)
class MyClass()


@SuppressWarnings(value = "unchecked")
void myMethod() { ... }
```

Where can annotations be used?

- Declarations of classes, fields, methods, etc.
- Java SE 8 also has type annotations:
  - Class instance creation expression:

    ```
    new @Interned MyObject();
    ```

  - Type cast:

    ```
    myString = (@NonNull String) str;
    ```

  - implements clause:

    ```
    class UnmodifiableList<T> implements
         @Readonly List<@Readonly T> { ... }
    ```

  - Thrown exception declaration:

    ```
    void monitorTemperature() throws
         @Critical TemperatureException { ... }
    ```

Why do we care about annotations?

- Tools love to use them
  - JUnit
  - Javadoc
  - Web-related Tools:
    - Java Persistence API (JPA)
      - describes the management of relational data in applications
    - Application Servers

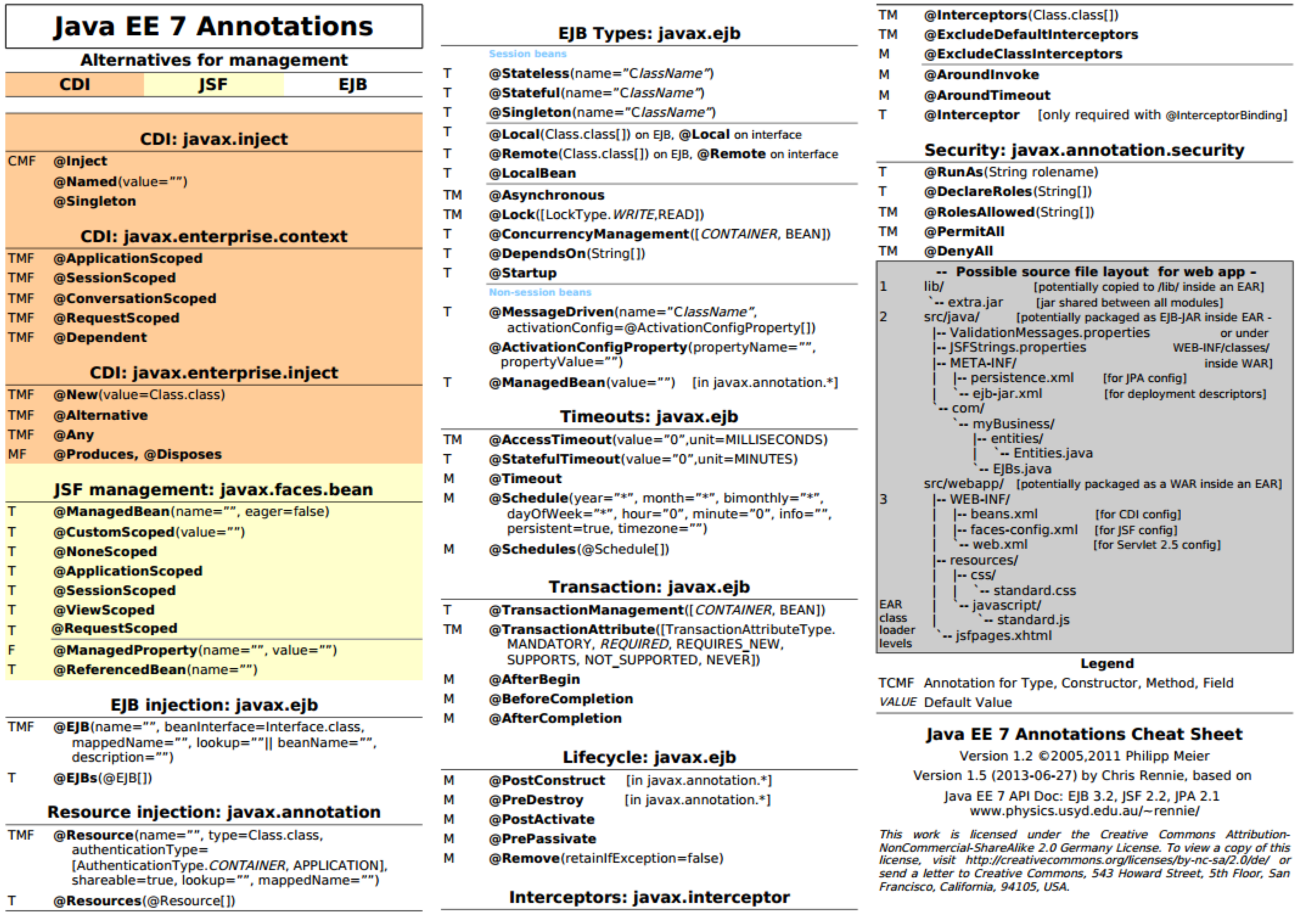
Annotations Look-Up

- Scattered in the Java API. Examples:

http://docs.oracle.com/javaee/8/api/javax/annotation/package-summary.html

http://docs.oracle.com/javaee/8/api/javax/faces/bean/package-summary.html

- Via cheat sheets:



Java EE 7 Annotations

Alternatives for management

CDI	JSF	EJB

CDI: javax.inject

CMF	**@Inject**
	@Named(value="")
	@Singleton

CDI: javax.enterprise.context

TMF	**@ApplicationScoped**
TMF	**@SessionScoped**
TMF	**@ConversationScoped**
TMF	**@RequestScoped**
TMF	**@Dependent**

CDI: javax.enterprise.inject

TMF	**@New**(value=Class.class)
TMF	**@Alternative**
TMF	**@Any**
MF	**@Produces, @Disposes**

JSF management: javax.faces.bean

T	**@ManagedBean**(name="", eager=false)
T	**@CustomScoped**(value="")
T	**@NoneScoped**
T	**@ApplicationScoped**
T	**@SessionScoped**
T	**@ViewScoped**
T	**@RequestScoped**
F	**@ManagedProperty**(name="", value="")
T	**@ReferencedBean**(name="")

EJB injection: javax.ejb

TMF	**@EJB**(name="", beanInterface=Interface.class, mappedName="", lookup=""|| beanName="", description="")
T	**@EJBs**(@EJB[])

Resource injection: javax.annotation

TMF	**@Resource**(name="", type=Class.class, authenticationType=[AuthenticationType.*CONTAINER*, APPLICATION], shareable=true, lookup="", mappedName="")
T	**@Resources**(@Resource[])

EJB Types: javax.ejb

Session beans

T	**@Stateless**(name="C*lassName*")
T	**@Stateful**(name="C*lassName*")
T	**@Singleton**(name="C*lassName*")
T	**@Local**(Class.class[]) on EJB, **@Local** on interface
T	**@Remote**(Class.class[]) on EJB, **@Remote** on interface
T	**@LocalBean**
TM	**@Asynchronous**
TM	**@Lock**([LockType.*WRITE*,READ])
T	**@ConcurrencyManagement**([*CONTAINER*, BEAN])
T	**@DependsOn**(String[])
T	**@Startup**

Non-session beans

T	**@MessageDriven**(name="C*lassName*", activationConfig=@ActivationConfigProperty[])
	@ActivationConfigProperty(propertyName="", propertyValue="")
T	**@ManagedBean**(value="") [in javax.annotation.*]

Timeouts: javax.ejb

TM	**@AccessTimeout**(value="0",unit=MILLISECONDS)
T	**@StatefulTimeout**(value="0",unit=MINUTES)
M	**@Timeout**
M	**@Schedule**(year="*", month="*", bimonthly="*", dayOfWeek="*", hour="0", minute="0", info="", persistent=true, timezone="")
M	**@Schedules**(@Schedule[])

Transaction: javax.ejb

T	**@TransactionManagement**([*CONTAINER*, BEAN])
TM	**@TransactionAttribute**([TransactionAttributeType. MANDATORY, *REQUIRED*, REQUIRES_NEW, SUPPORTS, NOT_SUPPORTED, NEVER])
M	**@AfterBegin**
M	**@BeforeCompletion**
M	**@AfterCompletion**

Lifecycle: javax.ejb

M	**@PostConstruct** [in javax.annotation.*]
M	**@PreDestroy** [in javax.annotation.*]
M	**@PostActivate**
M	**@PrePassivate**
M	**@Remove**(retainIfException=false)

Interceptors: javax.interceptor

TM	**@Interceptors**(Class.class[])
TM	**@ExcludeDefaultInterceptors**
M	**@ExcludeClassInterceptors**
M	**@AroundInvoke**
M	**@AroundTimeout**
T	**@Interceptor** [only required with @InterceptorBinding]

Security: javax.annotation.security

T	**@RunAs**(String rolename)
T	**@DeclareRoles**(String[])
TM	**@RolesAllowed**(String[])
TM	**@PermitAll**
TM	**@DenyAll**

-- Possible source file layout for web app -

```
1        lib/                  [potentially copied to /lib/ inside an EAR]
          `-- extra.jar         [jar shared between all modules]
2        src/java/          [potentially packaged as EJB-JAR inside EAR -
           |-- ValidationMessages.properties                  or under
           |-- JSFStrings.properties                    WEB-INF/classes/
           |-- META-INF/                                   inside WAR]
           |    |-- persistence.xml      [for JPA config]
           |    `-- ejb-jar.xml          [for deployment descriptors]
           `-- com/
                `-- myBusiness/
                     |-- entities/
                     |    `-- Entities.java
                     `-- EJBs.java
         src/webapp/  [potentially packaged as a WAR inside an EAR]
3          |-- WEB-INF/
           |    |-- beans.xml           [for CDI config]
           |    |-- faces-config.xml    [for JSF config]
           |    `-- web.xml             [for Servlet 2.5 config]
           |-- resources/
           |    |-- css/
           |    |    `-- standard.css
EAR        |    `-- javascript/
class      |         `-- standard.js
loader     `-- jsfpages.xhtml
levels
```

Legend

TCMF	Annotation for Type, Constructor, Method, Field
VALUE	Default Value

Java EE 7 Annotations Cheat Sheet

Version 1.2 ©2005,2011 Philipp Meier

Version 1.5 (2013-06-27) by Chris Rennie, based on

Java EE 7 API Doc: EJB 3.2, JSF 2.2, JPA 2.1
www.physics.usyd.edu.au/~rennie/

Annotations

- Annotation Types Used by the Java Language
  - The predefined annotation types defined in java.lang are @Deprecated, @Override, and @SuppressWarnings.
    - @Deprecated annotation indicates that the marked element is deprecated and should no longer be used.
      - The compiler generates a warning whenever a program uses a method, class, or field with the @Deprecated annotation.

```
// Javadoc comment
/**
 * @deprecated
 * explanation of why it was deprecated
 */
@Deprecated
static void deprecatedMethod() { ... }
```

Annotations

- @Override annotation informs the compiler that the element is meant to override an element declared in a superclass.

```
// mark method as a superclass method
// that has been overridden
@Override
int overriddenMethod() { ... }
```

- @SuppressWarnings annotation tells the compiler to suppress specific warnings that it would otherwise generate.

```
// use a deprecated method and tell
// compiler not to generate a warning
@SuppressWarnings("deprecation")
void useDeprecatedMethod() {
     // deprecation warning
     // - suppressed
     objectOne.deprecatedMethod();
}
```

Declaring an Annotation Type

- Define the annotation type:

```
@interface ClassPreamble {
   String author();
   String date();
   int currentRevision() default 1;
   String lastModified() default "N/A";
   String lastModifiedBy() default "N/A";
   // Note use of array
   String[] reviewers();
}
```

Declaring an Annotation Type

- After the annotation type is defined, you can use annotations of that type:

```
@ClassPreamble (
    author = "John Doe",
    date = "3/17/2002",
    currentRevision = 6,
    lastModified = "4/12/2004",
    lastModifiedBy = "Jane Doe",
    // Note array notation
    reviewers = {"Alice", "Bob", "Cindy"}
)
public class Generation3List extends List2{
   // class code goes here
}
```

Declaring an Annotation Type

- To make the information in @ClassPreamble appear in Javadoc-generated documentation, when you define the annotation:

```
// import this to use @Documented
import java.lang.annotation.*;
@Documented
@interface ClassPreamble {

   // Annotation element definitions

}
```

Reflection

- A powerful programming feature
  - requires the ability to examine or modify the runtime behavior of applications running in the Java virtual machine.
- i.e. dynamically examine classes and objects
- Should be used only by developers who have a strong grasp of the fundamentals of the language.
- Can enable applications to perform operations which would otherwise be impossible.

Reflection

- Call methods at runtime that you didn’t know existed at compile time.
- Isn’t that polymorphism?
  - No, polymorphism uses inheritance and knows the overridden method signatures
- At runtime:
  - ask a Class what methods it has
  - call one of those methods

Reflection Uses

- Extensibility Features
  - dynamically use classes not known at compile time
  - plug-ins, add-ons, etc.
  - complete flexibility
- Class Browsers and Visual Development Environments
  - i.e. display class properties
    - think the visual debugger
- Debuggers and Test Tools
  - Watch class values change

Reflection

- It all starts with the **`Class`** class:
  - Every object in Java is a member of a class.
  - How do we get an object's **`Class`**?
  - **`getClass()`** method inherited from Object. Ex:

    ```
    Class c = "Hello".getClass();
    ```
  - Using **`Class.forName`** and a string. Ex:

    ```
    Class c2 = Class.forName("java.lang.String")
    ```
    - can throw **`ClassNotFoundException`**
- Other methods:
  - **`getSuperclass`**
  - **`getDeclaredClasses`**
    - returns an array of Class object members declared by the class, but excludes inherited classes

    ```
    Class cls = Class.forName("ClassDemo");
    Class[] classes = cls.getDeclaredClasses();
    ```
  - **`getEnclosingClass`**
    - Returns the outer class of an inner class (or null if none)

The `Class` class has useful methods

Class Methods for Locating Fields

`Class` API	List of members?	Inherited members?	Private members?
`getDeclaredField()`	no	no	yes
`getField()`	no	yes	no
`getDeclaredFields()`	yes	no	yes
`getFields()`	yes	yes	no

Class Methods for Locating Methods

`Class` API	List of members?	Inherited members?	Private members?
`getDeclaredMethod()`	no	no	yes
`getMethod()`	no	yes	no
`getDeclaredMethods()`	yes	no	yes
`getMethods()`	yes	yes	no

Class Methods for Locating Constructors

`Class` API	List of members?	Inherited members?	Private members?
`getDeclaredConstructor()`	no	N/A[1]	yes
`getConstructor()`	no	N/A[1]	no
`getDeclaredConstructors()`	yes	N/A[1]	yes
`getConstructors()`	yes	N/A[1]	no

Fields

- Has a type and value
- Type is a **`Class`**
- Get/Set data via **`get/set`** methods
- Other useful classes
  - **`Method`**
  - **`Constructor`**

Drawbacks of Reflection

- Performance Overhead
  - dynamic type resolution is expensive
  - certain Java virtual machine optimizations skipped
  - should be avoided in hot spots
- Security Restrictions
  - requires a runtime permission which may not be present when running under a security manager.
    - can't be used with **`Applet`**s
- Exposure of Internals
  - allows code to perform operations that would be illegal in non-reflective code
    - accessing private fields and methods
  - can result in unexpected side-effects