Adding Type Metadata with Annotations

Jim Wilson

Mobile Solutions Developer & Architect

@hedgehogjim | jwhh.com

Overview

The need for type metadata

Using annotations

Declaring custom annotations

Accessing annotations

Annotation target and retention

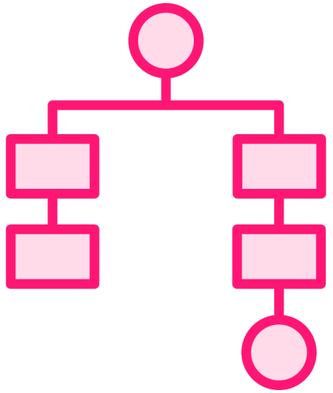
Simplifying element setting

Annotation element types

Class-cross reference

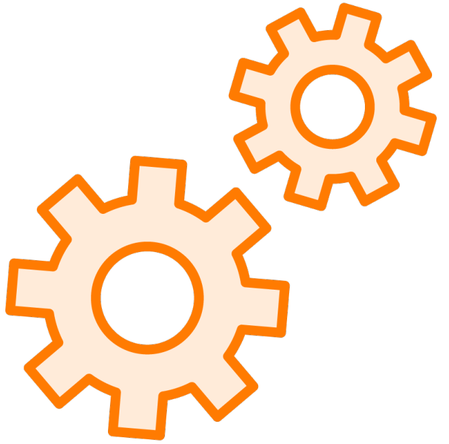
Programs Fit Into a Larger Picture

Incorporate developer's assumptions



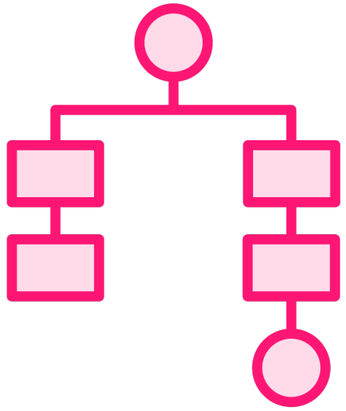
About the type system

About the toolset



About the execution environment

Programs Incorporate Context and Intent



Type system solves much of the issue

But standard type system isn’t enough

Type Expressing Intent

```
public class TxWorker {
  protected BankAccount account;
  protected char txType;
  protected int amt;

  public TxWorker(BankAccount account, char txType, int amt) { . . . }

  public void run() {
    if (txType == ‘w’)
      account.withdrawal(amt);
    else if (txType == ‘d’)
      account.deposit(amt);
  }
}
```

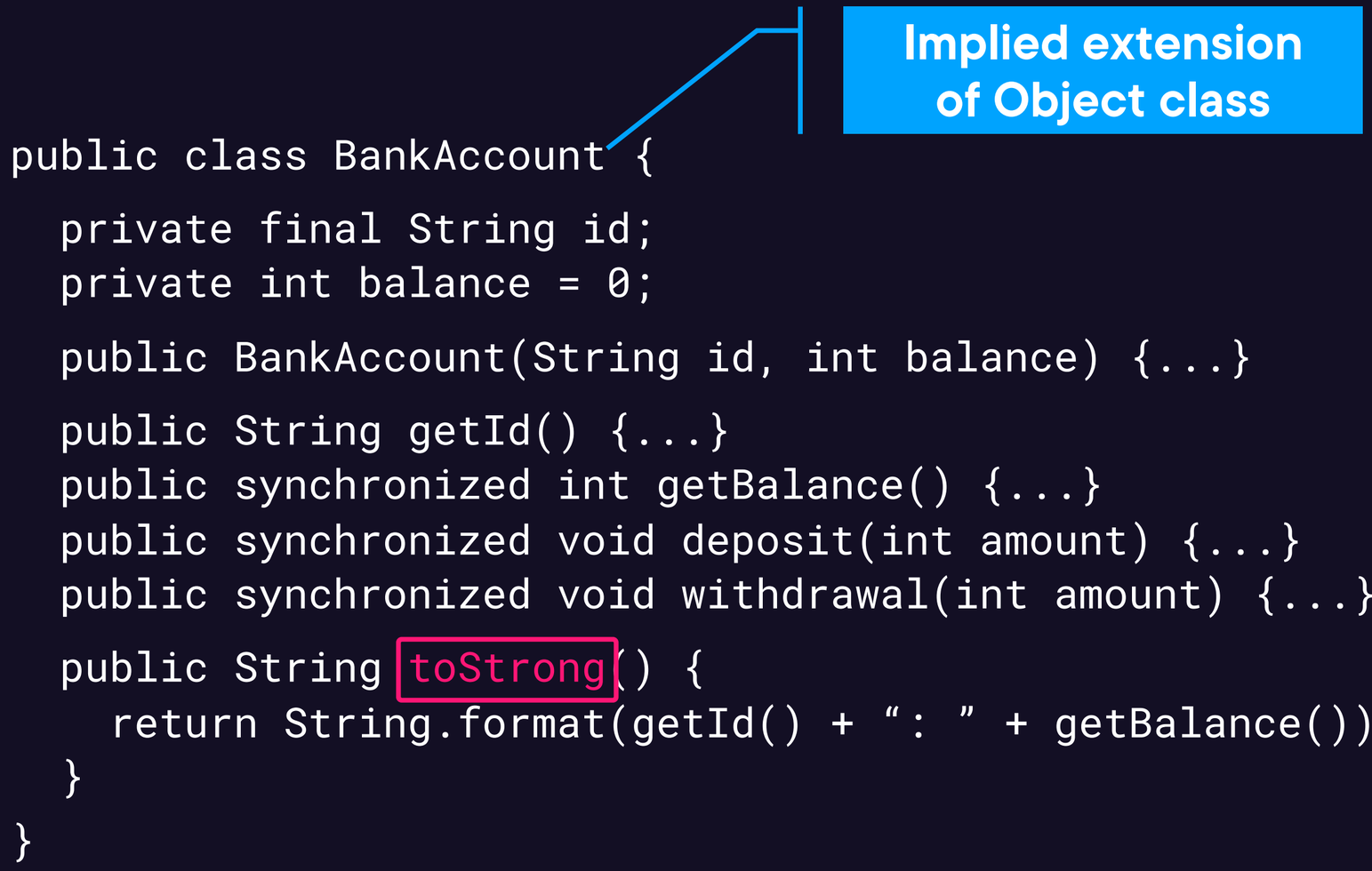
Type Expressing Intent

```
public class TxWorker implements Runnable {
  protected BankAccount account;
  protected char txType;
  protected int amt;

  public TxWorker(BankAccount account, char txType, int amt) { . . . }

  public void run() {
    if (txType == ‘w’)
      account.withdrawal(amt);
    else if (txType == ‘d’)
      account.deposit(amt);
  }
}
```

Type Unable to Express Intent

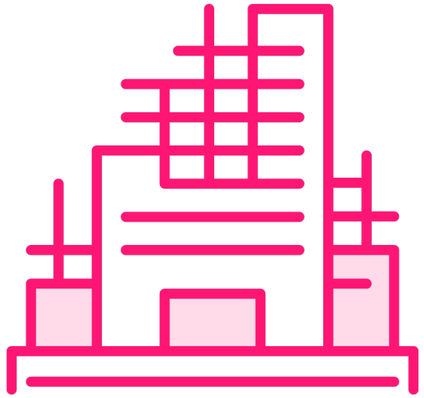


We Often Manually Supplement Type System

Code comments

Documentation

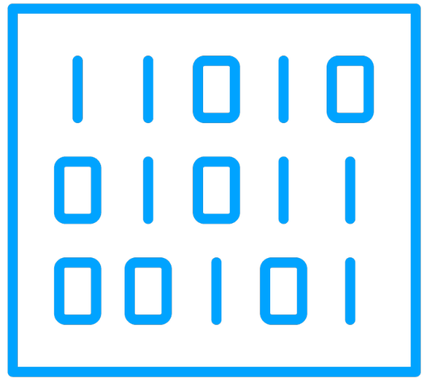
We Need a Better Way



Need a structured way to express context and intent

Allow tools and other code to act on context and intent

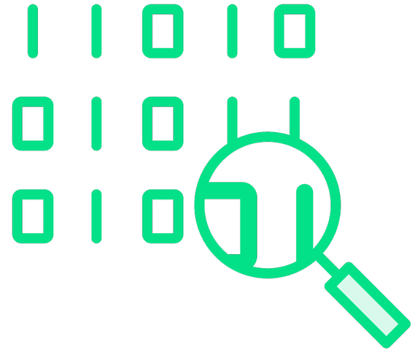
Using Annotations



Special types that act as metadata

Applied to a specific target

No direct affect on target behavior



Must be interpreted

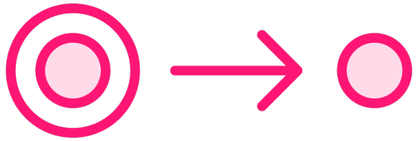
Tools

Execution environments

Any program

Annotations in code

Annotation always preceded by @



Placed directly before the target

Allowable targets vary with annotation

Expressing Intent with Override Annotation

```
public class BankAccount {
  private final String id;
  private int balance = 0;
  public BankAccount(String id, int balance) {...}
  public String getId() {...}
  public synchronized int getBalance() {...}
  public synchronized void deposit(int amount) {...}
  public synchronized void withdrawal(int amount) {...}
  @Override
  public String toStrong() {
    return String.format(getId() + ": " + getBalance());
  }
}
```

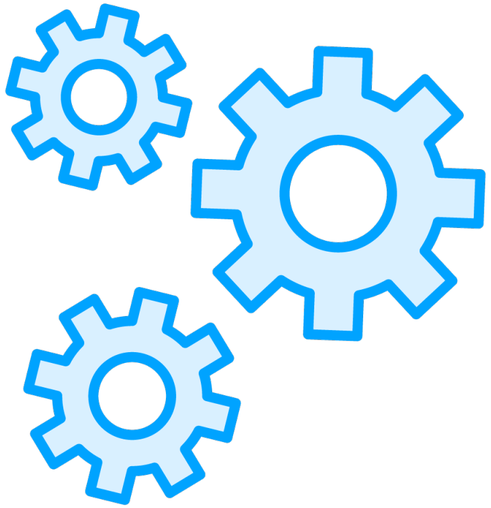
Compiler looks for methods marked with this annotation

Verifies there is a method with matching signature that can be overridden

Using Annotations

Core Java Platform

Provides types for creating annotations
Has only a few annotations



Widely used by other tools/environments

Java EE / Jakarta EE
XML processors such as JAXP
Your code

Common Java core platform annotations

- Override
- Deprecated
- SuppressWarnings

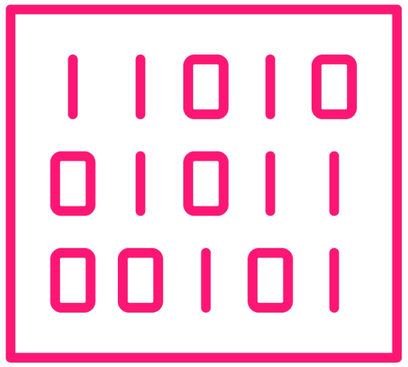
Using Annotations

```
class Doer {
  @Deprecated
  void doItThisWay() { ... }
  void doItThisNewWay() { ... }
}
```

```
@SuppressWarnings("deprecation")
class MyWorker {
  @SuppressWarnings("deprecation")
  void doSomeWork() {
    Doer d = new Doer();
    d.doItThisWay();
  }
  @SuppressWarnings("deprecation")
  void doDoubleWork() {
    Doer d1 = new Doer();
    Doer d2 = new Doer();
    d1.doItThisWay();
    d2.doItThisWay();
  }
}
```

Declaring Annotations

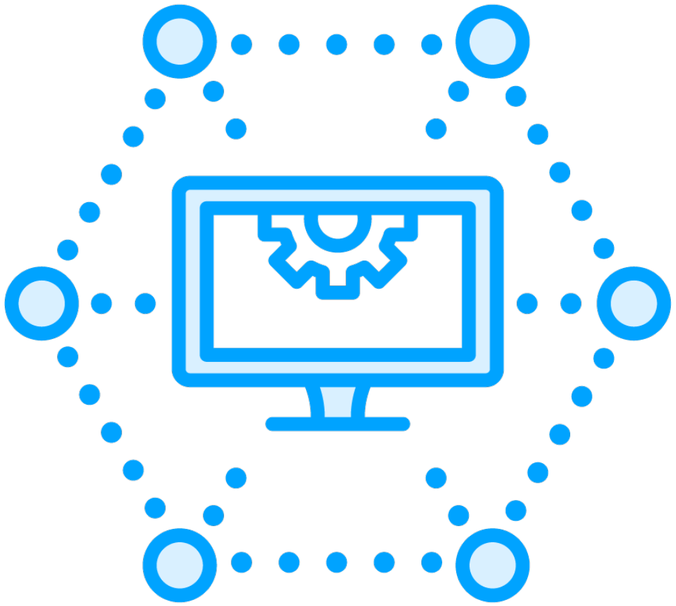
Can create custom annotations



Acts as custom metadata

Same capabilities as built-in annotations

Declaring Annotations



Flexible work dispatch system

- Executes worker classes against targets

Worker type requirements

- Has a no-argument constructor
- Implements TaskWorker interface

Worker threading requirements

- Can create own thread
- Can be run on app's thread pool
- Preference indicated with annotation

Declaring Annotations

Annotations are a special kind of interface

- Usage is much more restricted
- Can’t be explicitly implemented
- Implicitly extend Annotation interface
- Interface behavior not initially apparent

Declaring Annotations

Declaring annotations similar to interfaces

- Use interface keyword
  - Preceded by an @ symbol
- Declarations allow same modifiers
- Declarations allowed in same places

```
@interface

}
```

Declaring Annotations

Annotations can optionally have elements

- Associate values within annotation
- Declared as methods
- Setting is similar to fields

```
public @interface WorkHandler {
    boolean useThreadPool();
}
```

Declaring Annotations

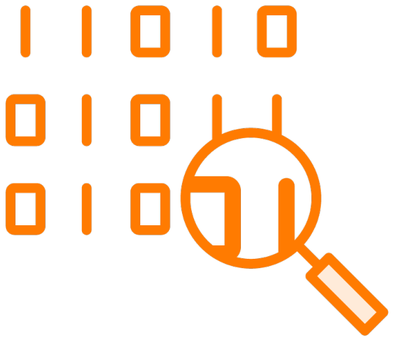
```
@WorkHandler(                        )
public class AccountWorker implements Runnable, TaskWorker {
  BankAccount ba;
  public void setTarget(object target) { ... }

  public void doWork() {
    Thread t = new Thread(
      HighVolumeAccount.class.isInstance(ba) ? (HighVolumeAccount)ba : this);
    t.start();
  }

  public void run() {...}
}
```

Accessing Annotations

Annotations available through reflection



Call getAnnotation on target

Pass annotation class info

Has requested annotation

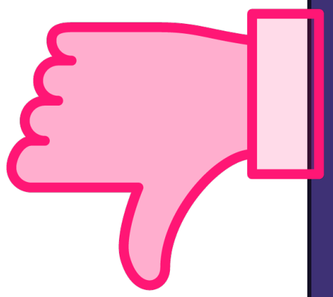
Returns reference to annotation instance

Does not have requested annotation

Returns null

Accessing Annotations

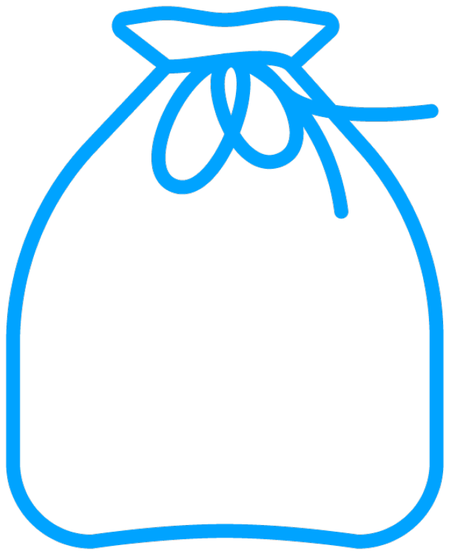
```
ExecutorService pool = Executors.newFixedThreadPool(5); // member variable
```



```
void startWork(String workerTypeName, Object workerTarget) throws Exception {
  Class<?> workerType = Class.forName(workerTypeName);
  TaskWorker worker = (TaskWorker) workerType.newInstance();
  worker.setTarget(workerTarget);

                    workerType
  if(wh == null)
    // throw exception
  if(wh                    )
    pool.submit(
      public void run() {
        worker.doWork();
      }
    });
  else
    worker.doWork();
}
```

Annotation Retention



Annotations can specify availability

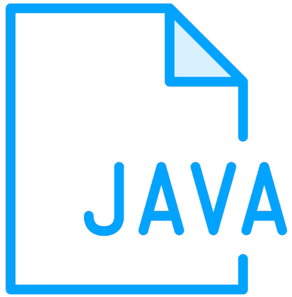
- Part of annotation declaration

Indicated with Retention annotation

- Accepts RetentionPolicy value

```
@Retention( . . . )
public @interface WorkHandler { . . . }
```

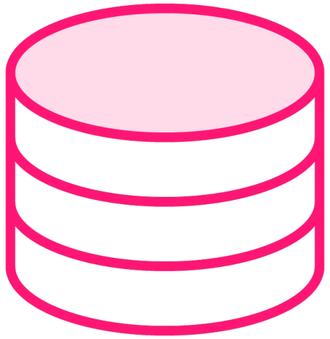
RetentionPolicy Values



SOURCE

Exist only in source file

Discarded by compiler



CLASS

Compiled into class file

Discarded by runtime

Default retention policy

RUNTIME

Loaded into runtime

Accessible with reflection

Annotation Retention

```
@Retention(                          )
public @interface WorkHandler {
  boolean useThreadPool();
}
```

Accessing Annotations

```
ExecutorService pool = Executors.newFixedThreadPool(5); // member variable
```

```
void startWork(String workerTypeName, Object workerTarget) throws Exception {
  Class<?> workerType = Class.forName(workerTypeName);
  TaskWorker worker = (TaskWorker) workerType.newInstance();
  worker.setTarget(workerTarget);
  WorkHandler wh = workerType.getAnnotation(WorkHandler.class);
  if(wh == null)
    // throw exception
  if(wh                  )
    pool.submit(
      public void run() {
        worker.doWork();
      }
    });
  else
    worker.doWork();
}
```

Annotation Target

```
@WorkHandler(useThreadPool = false)
public class AccountWorker implements Runnable, TaskWorker {
  @WorkHandler(useThreadPool = false)
  BankAccount ba;
  @WorkHandler(useThreadPool = false)
  public void setTarget(object target) { ... }
  public void doWork() {
    @WorkHandler(useThreadPool = false)
    Thread t = new Thread(
      HighVolumeAccount.class.isInstance(ba) ? (HighVolumeAccount)ba : this);
    t.start();
  }
  public void run() {...}
}
```

Annotation Target

Annotations can narrow allowable targets

- Part of annotation declaration

Indicated with Target annotation

- Accepts ElementType value

Can support multiple targets

- Use array notation

```
Target(ElementType.CONSTRUCTOR)
```

```
Target( { ElementType.TYPE, ElementType.METHOD } )
```

Annotation Target

```
@Target(                    )
@Retention(RetentionPolicy.RUNTIME)
public @interface WorkHandler {
  boolean useThreadPool();
}
```

Annotation Target

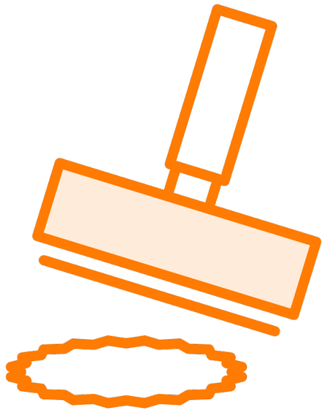
```
@WorkHandler(useThreadPool = false)
public class AccountWorker implements Runnable, TaskWorker {
  @WorkHandler(useThreadPool = false)
  BankAccount ba;
  @WorkHandler(useThreadPool = false)
  public void setTarget(object target) { ... }
  public void doWork() {
    @WorkHandler(useThreadPool = false)
    Thread t = new Thread(
      HighVolumeAccount.class.isInstance(ba) ? (HighVolumeAccount)ba : this);
    t.start();
  }
  public void run() {...}
}
```

Simplifying Element Setting

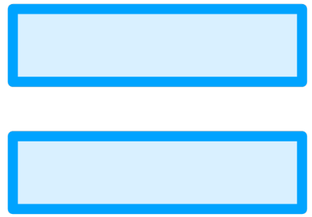
Elements can be setup to simplify setting

- Handle common cases
- Element default values
- Element assignment shorthand

Element Default Values



Use default keyword



Can still set if desired

Element Default Values

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface WorkHandler {
  boolean useThreadPool()
}
```

```
@WorkHandler
public class AccountWorker implements Runnable, TaskWorker { ... }
```

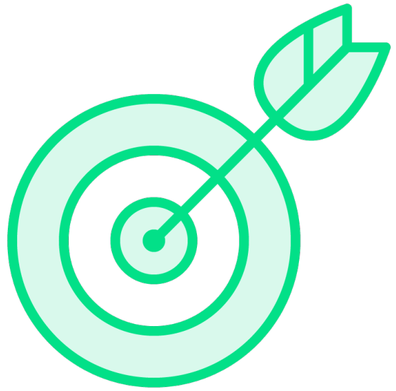
Element Default Values

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface WorkHandler {
  boolean useThreadPool()
}
```

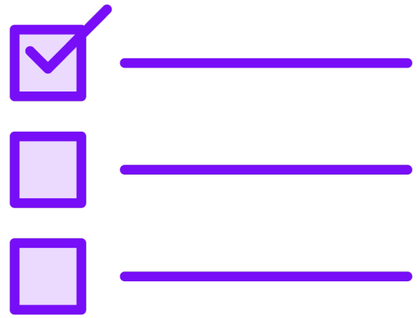
```
@WorkHandler(useThreadPool = false)
public class AccountWorker implements Runnable, TaskWorker { ... }
```

Unnamed Assignment

Can exclude element name when setting



Element must be named value



Must only be setting the value element

Element Default Values

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface WorkHandler {
  boolean useThreadPool() default true;
}
```

```
@WorkHandler
public class AccountWorker implements Runnable, TaskWorker { ... }
```

Element Default Values

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface WorkHandler {
  boolean          value() default true;
}
```

```
@WorkHandler
public class AccountWorker implements Runnable, TaskWorker { ... }
```

Valid Annotation Element Types

Can also be an array of any of these types

Primitive type

String

Enum

Annotation

Class<?>

Annotation Class<?> Element

```
BankAccount acct1 = new BankAccount();
startWork(                                  );
```

```
@ProcessedBy(                          )
public class BankAccount {
  public BankAccount(String id) {...}
  public BankAccount(String id, int balance) {...}
  // other members elided
}
```

```
BankAccount acct1 = new BankAccount();
startWorkSelfContained(     );
```

Annotation Class<?> Element

```
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface ProcessedBy {
  Class<?> value();
}
```

```
@ProcessedBy(AccountWorker.class)
public class BankAccount {
  public BankAccount(String id) {...}
  public BankAccount(String id, int balance) {...}
  // other members elided
}
```

Annotation Class<?> Element

```
BankAccount acct1 = new BankAccount();
startWorkSelfContained(acct1);
```

```
void startWorkSelfContained(Object workerTarget) throws Exception {
  Class<?> targetType = workerTarget.getClass();
                        targetType.getAnnotation(ProcessedBy.class);
                                   pb.value();
  TaskWorker worker = (TaskWorker) workerType.newInstance();
  // Remainder of code just like startWork method . . .
  // . . .
  // . . .
}
```

Summary

Programs incorporate context and intent

- Standard type system isn't always enough
- Sometimes need metadata

Annotations act as metadata

- Annotations are a special kind of interface
- Do not change target behavior
- Must be interpreted

Summary

Can declare custom annotations

- Similar to declaring interfaces
- Use interface keyword preceded by @
- Set retention to control availability
- Set target to narrow use

Annotations accessed with reflection

- Use getAnnotation method of target

Summary

Annotations can optionally have elements

- Associate values with annotation
- Declared as methods
- Setting is similar to fields
- Can associate a default value
- Element name value provides shorthand