Improving Your Code with Dependency Injection and Aspect-Oriented Programming

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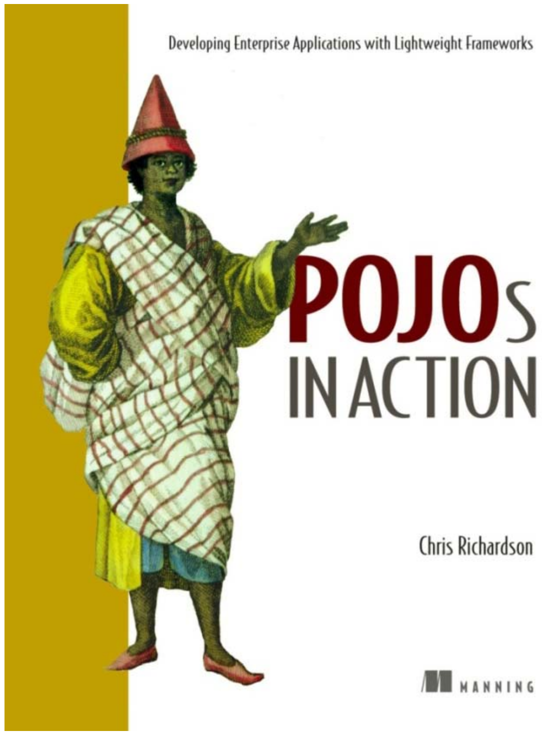
Overall presentation goal

Show how dependency injection, and aspect-oriented programming make code easier to develop and maintain

About Chris


Developing Enterprise Applications with Lightweight Frameworks
POJOs IN ACTION
Chris Richardson
MANNING

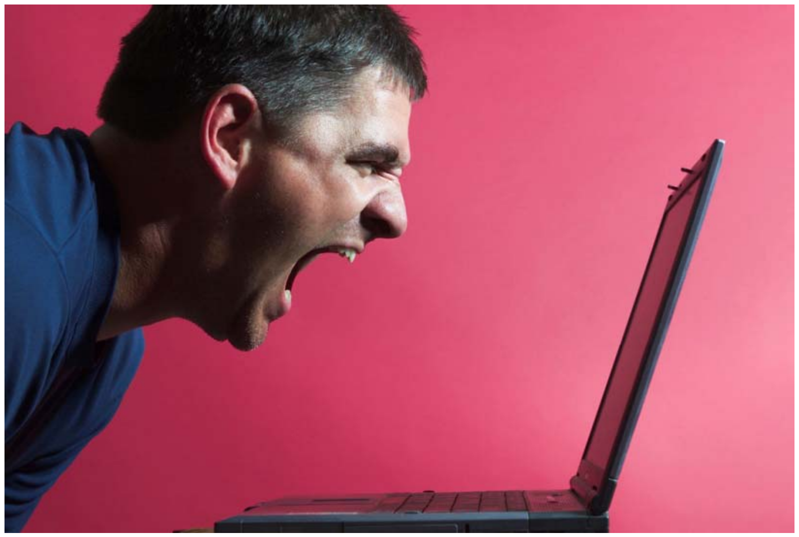
- Grew up in England
- Live in Oakland, CA
- Over twenty years of software development experience
  - Building object-oriented software since 1986
  - Using Java since 1996
  - Using J2EE since 1999
- Author of POJOs in Action
- Speaker at JavaOne, JavaPolis, NFJS, JUGs, ….
- Chair of the eBIG Java SIG in Oakland (www.ebig.org)
- Run a consulting and training company that helps organizations build better software faster

Agenda

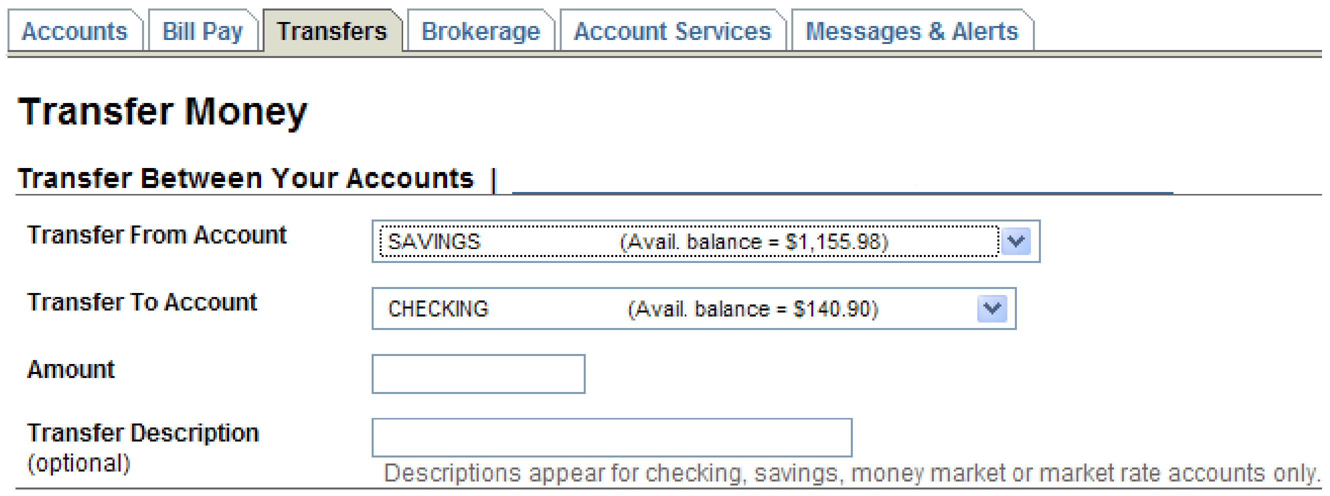
- **Tangled code, tight coupling and duplication**
- Using dependency injection
- Dependency injection with less XML
- Simplifying code with aspects
- Using aspects in the domain model

Code that you hate to change

- Business logic and infrastructure logic are **tangled** together
- Implementation of features is **scattered and duplicated** throughout the application
- Components are **tightly coupled** to one another and the infrastructure



Example banking application



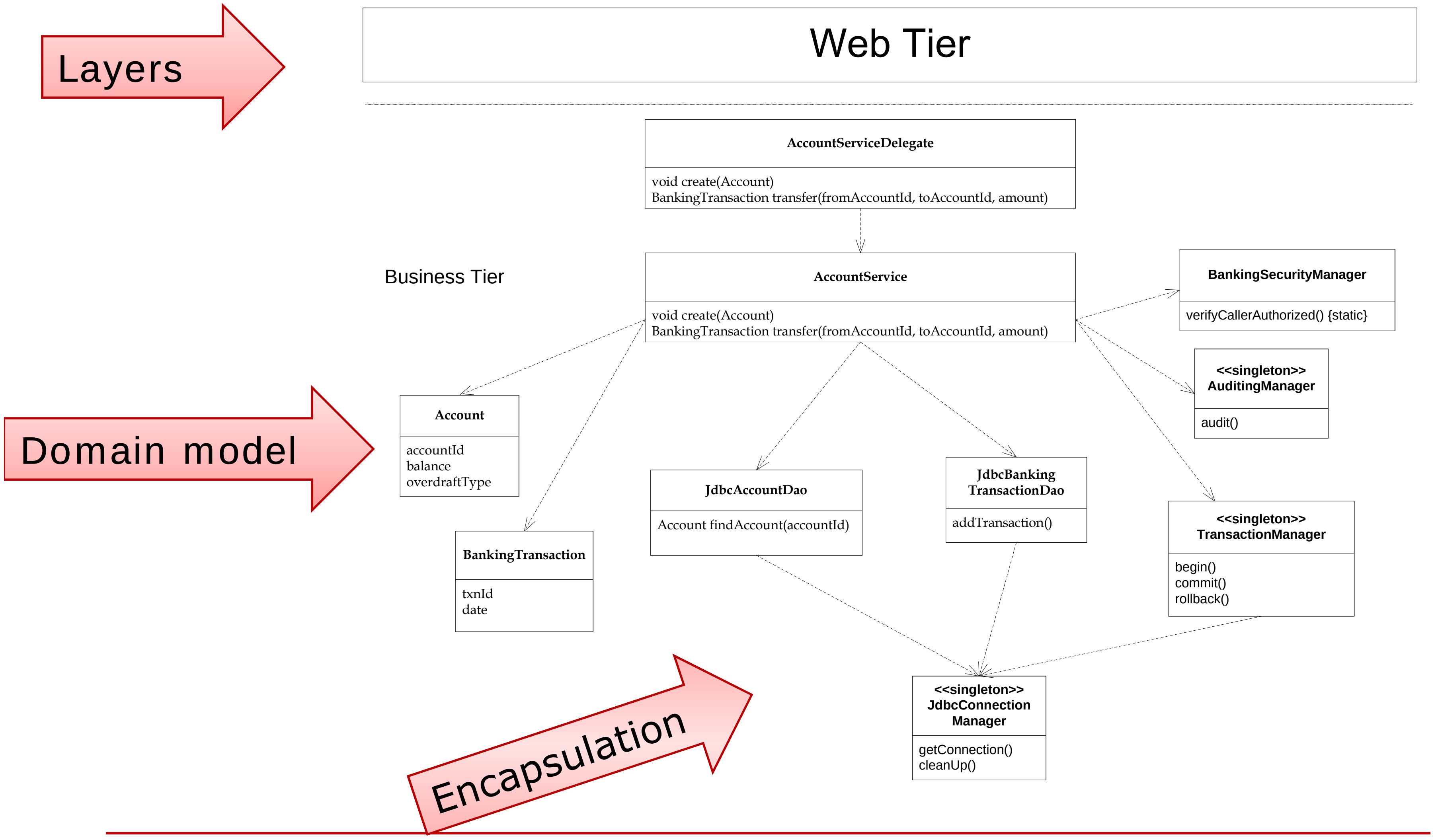
Transfer Money

Transfer Between Your Accounts |

Transfer From Account	SAVINGS (Avail. balance = $1,155.98)
Transfer To Account	CHECKING (Avail. balance = $140.90)
Amount	
Transfer Description (optional)	

Descriptions appear for checking, savings, money market or market rate accounts only.

A nice architecture …



Layers
Web Tier
AccountServiceDelegate
void create(Account)
BankingTransaction transfer(fromAccountId, toAccountId, amount)
Business Tier
AccountService
void create(Account)
BankingTransaction transfer(fromAccountId, toAccountId, amount)
BankingSecurityManager
verifyCallerAuthorized() {static}
<<singleton>> AuditingManager
audit()
Domain model
Account
accountId
balance
overdraftType
BankingTransaction
txnId
date
JdbcAccountDao
Account findAccount(accountId)
JdbcBanking TransactionDao
addTransaction()
<<singleton>> TransactionManager
begin()
commit()
rollback()
<<singleton>> JdbcConnection Manager
getConnection()
cleanUp()
Encapsulation

… but shame about the code

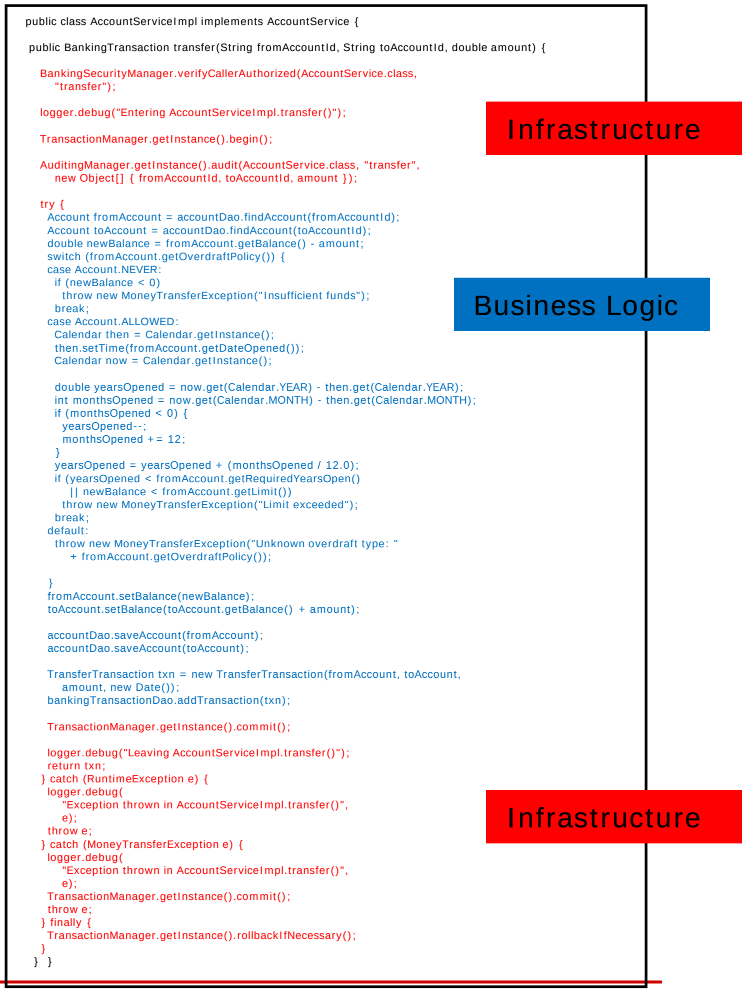
Procedural code

- Anemic Domain Model
  - AccountService = Business logic
  - Account and BankingTransaction = dumb data objects
- Code is more difficult to:
  - Develop
  - Understand
  - Maintain
  - Test
- Solution: That's a whole other talk.

```
public class AccountServiceIImpl
     implements AccountService {

 public BankingTransaction transfer(String
                    fromAccountId, String toAccountId,
                    double amount) {
…
 Account fromAccount =
   accountDao.findAccount(fromAccountId);

 Account toAccount =
    accountDao.findAccount(toAccountId);
 double newBalance = fromAccount.getBalance() –
      amount;

 fromAccount.setBalance(newBalance);
     toAccount.setBalance(toAccount.getBalance() +
                           amount);
….
```

Tangled code

- Every service method contains:
  - Business logic
  - Infrastructure logic
- Violates Separation of Concerns (SOC):
  - Increased complexity
  - Testing is more difficult
  - More difficult to develop
- Naming clash: transaction



```
public class AccountServiceImpl implements AccountService {

 public BankingTransaction transfer(String fromAccountId, String toAccountId, double amount) {

   BankingSecurityManager.verifyCallerAuthorized(AccountService.class,
     "transfer");

   logger.debug("Entering AccountServiceImpl.transfer()");

   TransactionManager.getInstance().begin();

   AuditingManager.getInstance().audit(AccountService.class, "transfer",
     new Object[] { fromAccountId, toAccountId, amount });

   try {
    Account fromAccount = accountDao.findAccount(fromAccountId);
    Account toAccount = accountDao.findAccount(toAccountId);
    double newBalance = fromAccount.getBalance() - amount;
    switch (fromAccount.getOverdraftPolicy()) {
    case Account.NEVER:
     if (newBalance < 0)
      throw new MoneyTransferException("Insufficient funds");
     break;
    case Account.ALLOWED:
     Calendar then = Calendar.getInstance();
     then.setTime(fromAccount.getDateOpened());
     Calendar now = Calendar.getInstance();

     double yearsOpened = now.get(Calendar.YEAR) - then.get(Calendar.YEAR);
     int monthsOpened = now.get(Calendar.MONTH) - then.get(Calendar.MONTH);
     if (monthsOpened < 0) {
      yearsOpened--;
      monthsOpened += 12;
     }
     yearsOpened = yearsOpened + (monthsOpened / 12.0);
     if (yearsOpened < fromAccount.getRequiredYearsOpen()
        || newBalance < fromAccount.getLimit())
      throw new MoneyTransferException("Limit exceeded");
     break;
    default:
     throw new MoneyTransferException("Unknown overdraft type: "
        + fromAccount.getOverdraftPolicy());

    }
    fromAccount.setBalance(newBalance);
    toAccount.setBalance(toAccount.getBalance() + amount);

    accountDao.saveAccount(fromAccount);
    accountDao.saveAccount(toAccount);

    TransferTransaction txn = new TransferTransaction(fromAccount, toAccount,
      amount, new Date());
    bankingTransactionDao.addTransaction(txn);

    TransactionManager.getInstance().commit();

    logger.debug("Leaving AccountServiceImpl.transfer()");
    return txn;
   } catch (RuntimeException e) {
    logger.debug(
      "Exception thrown in AccountServiceImpl.transfer()",
      e);
    throw e;
   } catch (MoneyTransferException e) {
    logger.debug(
      "Exception thrown in AccountServiceImpl.transfer()",
      e);
    TransactionManager.getInstance().commit();
    throw e;
   } finally {
    TransactionManager.getInstance().rollbackIfNecessary();
   }
 } }
```

Duplicated code

```
public class AccountServiceImpl implements AccountService {

 private Log logger = LogFactory.getLog(getClass());

 public BankingTransaction transfer(String fromAccountId, String
   BankingSecurityManager.verifyCallerAuthorized(AccountServic

   logger.debug("Entering AccountServiceImpl.transfer()");

   TransactionManager.getInstance().begin();

   AuditingManager.getInstance().audit(AccountService.class, "tr

   try {
...
    TransactionManager.getInstance().commit();

     logger.debug("Leaving AccountServiceImpl.transfer()");

     return txn;

   } catch (RuntimeException e) {
     logger.debug("Exception thrown in AccountServiceImpl.transf
     throw e;
   } catch (MoneyTransferException e) {
     logger.debug("Exception thrown in AccountServiceImpl.transf
     TransactionManager.getInstance().commit();
     throw e;
   } finally {
     TransactionManager.getInstance().rollbackIfNecessary();
   }
  }
```

```
public void create(Account account) {
    BankingSecurityManager.verifyCallerAuthorized(AccountService.class,
        "create");

    logger.debug("Entering AccountServiceProceduralImpl.create()");

    TransactionManager.getInstance().begin();

    AuditingManager.getInstance().audit(AccountService.class, "create",
        new Object[] { account.getAccountId() });

    try {
      ...
      logger.debug("Leaving AccountServiceProceduralImpl.create()");
    } catch (RuntimeException e) {
      logger.debug("Exception thrown in
AccountServiceProceduralImpl.create()",
         e);
      throw e;
    } finally {
      TransactionManager.getInstance().rollbackIfNecessary();
    }

  }
```

Violates Don’t Repeat Yourself (DRY)

Tightly coupled code

- Service instantiates DAOs
- References to:
  - Singletons classes
  - Static methods
- Consequences:
  - Difficult to unit test
  - Difficult to develop

```
public class AccountServiceImpl
        implements AccountService {

public AccountServiceImpl() {
   this.accountDao = new JdbcAccountDao();
   this.bankingTransactionDao =
               new JdbcBankingTransactionDao();
}

public BankingTransaction transfer(String
                fromAccountId, String toAccountId,
                double amount) {

 BankingSecurityManager
   .verifyCallerAuthorized(AccountService.class,
      "transfer");

 TransactionManager.getInstance().begin();

...
}
```

Low-level, error-prone code

- Repeated boilerplate:
  - Opening connections
  - Preparing statements
  - Try/catch/finally for closing connections, etc
- Lots of code to write and debug
- Change a class ⇒ Change multiple SQL statements

```
public class JdbcAccountDao implements AccountDao {

 public Account findAccount(String accountId) {

   Connection con = JdbcConnectionManager
             .getInstance().getConnection();

   PreparedStatement ps = null;
   ResultSet rs = null;
   try {
     ps = con.prepareStatement(...);
     ...
     return account;
   } catch (SQLException e) {
     throw new RuntimeException(e);
   } finally {
     JdbcConnectionManager.getInstance()
         .cleanUp(con, ps, rs);
   }

  }
```

Violates Don’t Repeat Yourself (DRY)

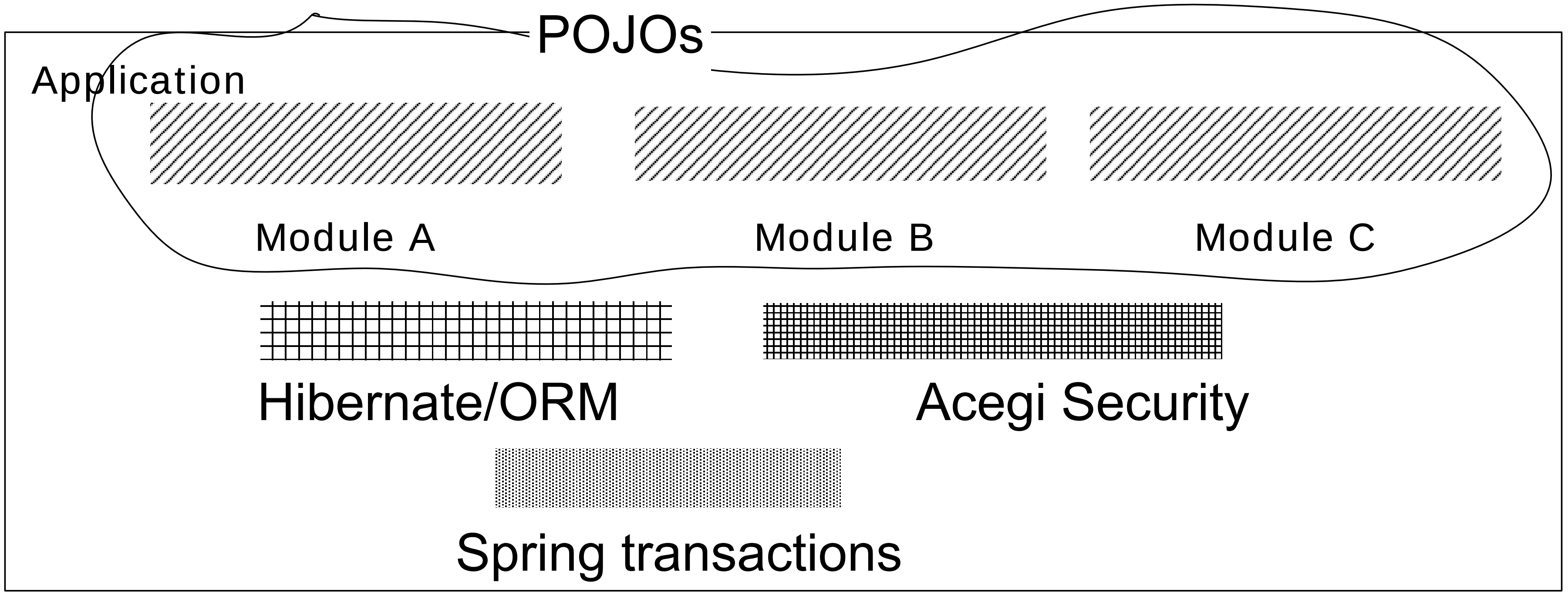
So what? It works!

- Code is difficult to change ⇒ can’t keep up with the needs of the business
- Bad code/obsolete frameworks ⇒ difficult to hire/retain good people
- It’s a downwards spiral
  - Bug fixes and enhancements aren’t done correctly
  - Design continues to degrade

Improving the code

- Dependency injection
  - Decouples components from one another and from the infrastructure code
- Aspect-oriented programming
  - Eliminates infrastructure code from services
  - Implements it one place
  - Ensures DRY SOCs

POJO programming model



Agenda

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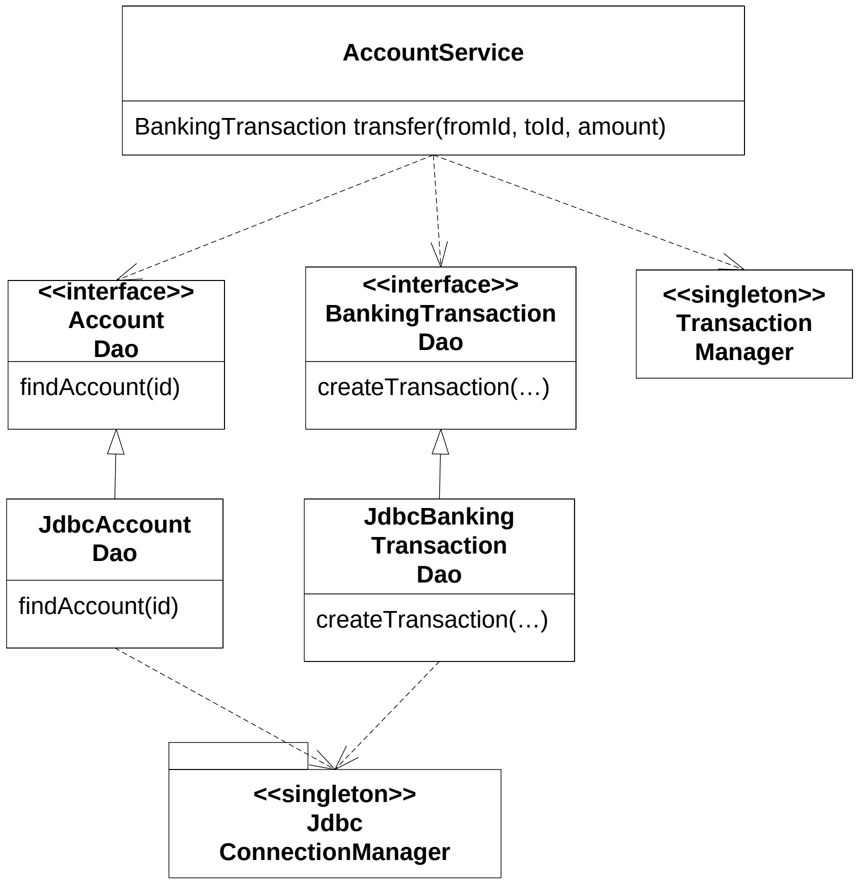
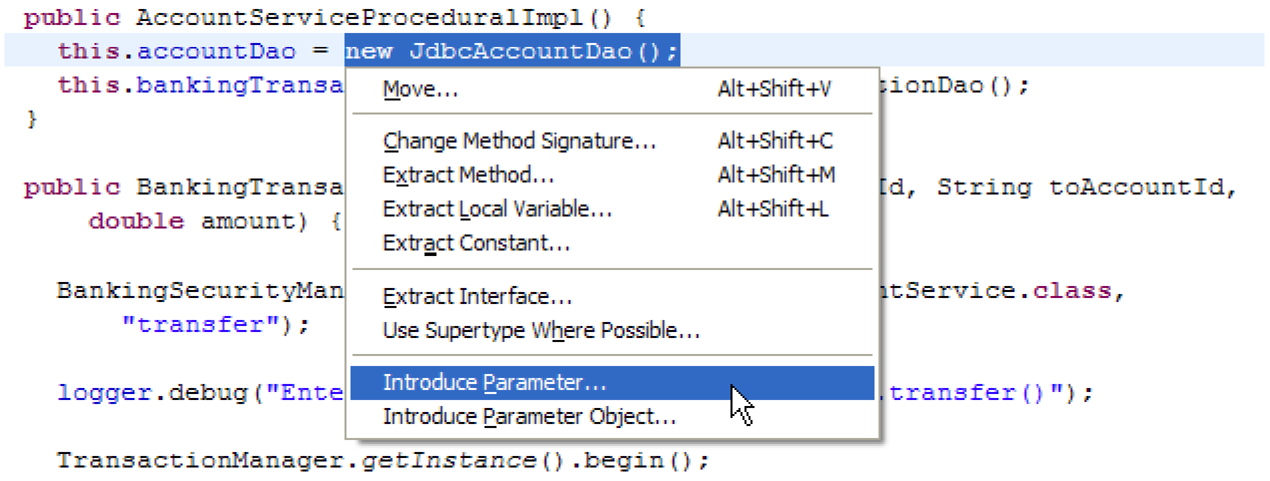
- **Using dependency injection**
- Dependency injection with less XML
- Simplifying code with aspects
- Using aspects in the domain model

Dependency injection


AccountService
BankingTransaction transfer(fromId, toId, amount)
<<interface>> Account Dao
findAccount(id)
<<interface>> BankingTransaction Dao
createTransaction(…)
<<singleton>> Transaction Manager
JdbcAccount Dao
findAccount(id)
JdbcBanking Transaction Dao
createTransaction(…)
<<singleton>> Jdbc ConnectionManager

- Application components depend on:
  - One another
  - Infrastructure components
- Old way: components obtain dependencies:
  - Instantiation using new
  - Statics – singletons or static methods
  - Service Locator such as JNDI
- But these options result in:
  - Coupling
  - Increased complexity
- New way: Pass dependencies to component:
  - Setter injection
  - Constructor injection

Replace instantiation with injection



```
public AccountServiceProceduralImpl() {
  this.accountDao = new JdbcAccountDao();
  this.bankingTransa                                     :ionDao();
}

public BankingTransa                                     Id, String toAccountId,
    double amount) {

  BankingSecurityMan                                     tService.class,
      "transfer");

  logger.debug("Ente                                     .transfer()");

  TransactionManager.getInstance().begin();
```

Move... Alt+Shift+V
Change Method Signature... Alt+Shift+C
Extract Method... Alt+Shift+M
Extract Local Variable... Alt+Shift+L
Extract Constant...
Extract Interface...
Use Supertype Where Possible...
Introduce Parameter...
Introduce Parameter Object...

⇩

```
public AccountServiceImpl(AccountDao accountDao,
    BankingTransactionDao bankingTransactionDao) {
   this.accountDAO = accountDao;
   this.bankingTransactionDAO = bankingTransactionDao;
}
```

Replace singleton with dependency injection

```
class AccountServiceImpl ...

public BankingTransaction transfer(String
       fromAccountId, String toAccountId,
      double amount) {

 TransactionManager.getInstance().begin();
...
}
```

Extract Local Variable

```
BankingTransaction transfer(String
       fromAccountId, String toAccountId,
      double amount) {
    TransactionManager transactionManager =
      TransactionManager.getInstance();
    transactionManager.begin();
    ...
}
```

Convert Local Variable to Field

```
AccountServiceImpl(
      AccountDao accountDao,
      BankingTransactionDao
bankingTransactionDao) {
    this.accountDAO = accountDao;
    this.bankingTransactionDAO =
          bankingTransactionDao;
    transactionManager =
     TransactionManager.getInstance();
  }
```

Introduce Parameter

```
  public AccountServiceImpl(
      AccountDao accountDao,
      BankingTransactionDao
               bankingTransactionDao,
      TransactionManager transactionManager) {
    this.accountDAO = accountDao;
    this.bankingTransactionDAO =
bankingTransactionDao;
    this.transactionManager = transactionManager;
  }
```

Replace static dependency with injection

```
BankingSecurityManager.verifyCallerAuthorized(AccountService.class, "transfer");
```

```
public class BankingSecurityManagerWrapper {

  public void verifyCallerAuthorized(Class<?> targetType, String methodName) {
    BankingSecurityManager.verifyCallerAuthorized(targetType, methodName);
  }

}
```

```
public AccountServiceImpl(
      ...
     BankingSecurityManagerWrapper bankingSecurityWrapper) {
     ...
     this.bankingSecurityWrapper = bankingSecurityWrapper;
 }
```

Who instantiates the objects?

- Clients that instantiate service need to pass in dependencies
- But they could use dependency injection too ⇒ ripples up through the code
- We could use a hand-written factory but that's where Spring comes into play

```
public class AccountServiceDelegate implements AccountService {

  public AccountServiceDelegate() {
    this.service =  new
       AccountServiceImpl(
            new JdbcAccountDao(),
            new JdbcBankingTransactionDao(),
}
```

⇩

```
public class AccountServiceDelegate implements AccountService {
  public AccountServiceDelegate(AccountService service) {
    this.service =  service;
  }
}
```

```
public class SpringAccountServiceTests  extends AbstractSpringTest {

protected void onSetUp() throws Exception {
    super.onSetUp();
    service = new AccountServiceDelegate(
        new AccountServiceImpl(
            new JdbcAccountDao(),
            new JdbcBankingTransactionDao(),
            TransactionManager.getInstance(),
            AuditingManager.getInstance(),
            BankingSecurityManagerWrapper.getInstance()));
  }
```

!

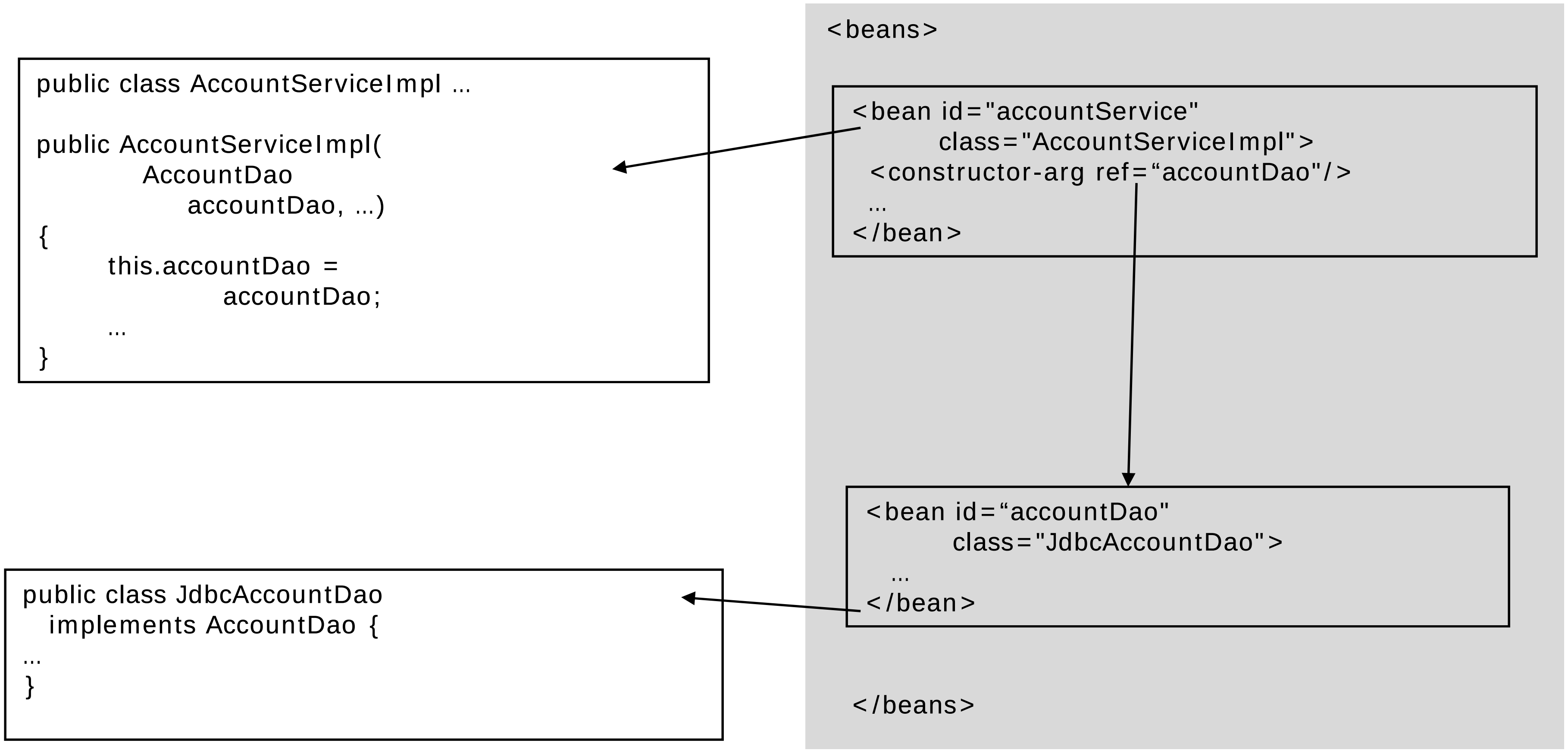
The Spring framework

- Simplicity and power
  - Supports the POJO programming model
  - Dependency injection
  - AOP for handling crosscutting concerns
  - Simplified APIs for many 3rd party frameworks (Hibernate, JDBC, Quartz, JMX, ..)
  - Web frameworks: MVC, WebFlow
- Rapid evolution
  - Spring 2.0 – October 2006
  - Spring 2.5 – December 2007
  - Complete backward compatibility

Spring lightweight container

- Lightweight container = sophisticated factory for creating objects
- Spring bean = object created and managed by Spring
- You write XML that specifies how to:
  - Create objects
  - Initialize them using dependency injection

Spring code example



```
public class AccountServiceImpl ...

public AccountServiceImpl(
        AccountDao
            accountDao, ...)
{
      this.accountDao =
                accountDao;
      ...
}
```

```
public class JdbcAccountDao
  implements AccountDao {
...
}
```

```
<beans>

 <bean id="accountService"
         class="AccountServiceImpl">
   <constructor-arg ref=“accountDao"/>
   ...
 </bean>

  <bean id=“accountDao"
          class="JdbcAccountDao">
     ...
  </bean>

 </beans>
```

Using Spring dependency injection

```
<beans>

 <bean id="AccountServiceDelegate"
   class="net.chris...client.AccountServiceDelegate">
   <constructor-arg ref="AccountService"/>
 </bean>

 <bean id="AccountService"
   class="net.chris...domain.AccountServiceImpl">
   <constructor-arg ref="accountDao"/>
   <constructor-arg ref="bankingTransactionDao"/>
   <constructor-arg ref="transactionManager"/>
   <constructor-arg ref="auditingManager"/>
   <constructor-arg ref="bankingSecurityManagerWrapper"/>
 </bean>



<bean id="accountDao"
   class="net.chris...domain.jdbc.JdbcAccountDao"/>

 <bean id="bankingTransactionDao"
   class="net.chris...domain.jdbc.JdbcBankingTransactionDao"/>

 <bean id="transactionManager" factory-method="getInstance"
   class="net.chris...infrastructure.TransactionManager"/>

 <bean id="auditingManager" factory-method="getInstance"
   class="net.chris...infrastructure.AuditingManager"/>

 <bean id="bankingSecurityManagerWrapper"
   class="net.chris...infrastructure.BankingSecurityManagerWrapper"/>

</beans>
```

```
ApplicationContext ctx =
   new ClassPathXmlApplicationContext(
      "appCtx/banking-service.xml");

service = (AccountService) ctx
      .getBean("AccountServiceDelegate");
```

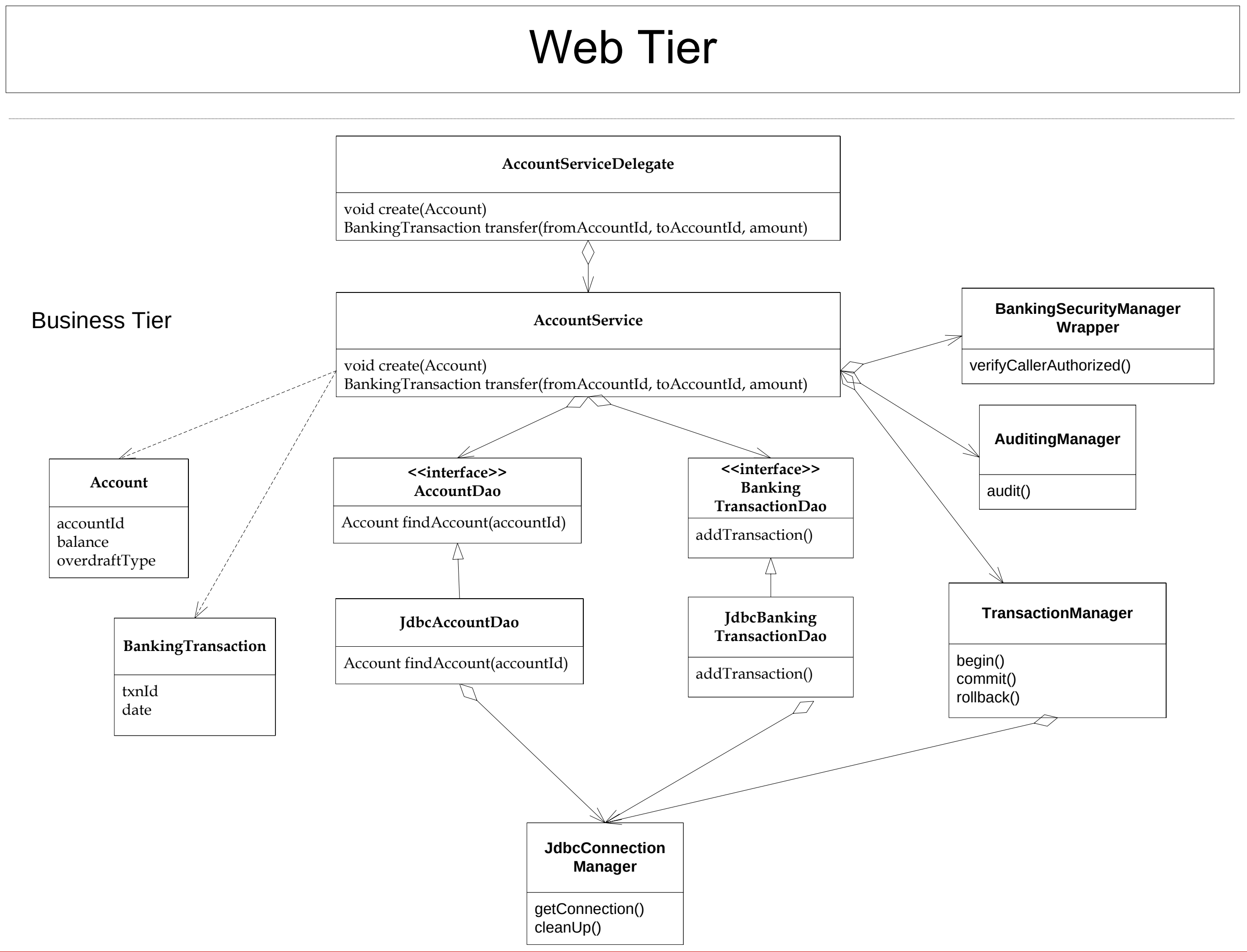
Eliminating Java singletons

- Spring beans are singletons (by default)
- Spring can instantiate classes such as the TransactionManager (if all of its client's use Spring)

```
public class TransactionManager {

public TransactionManager() {
}

public void begin() {…}
```

```
 <beans>

….
<bean id="transactionManager"
      ~~factory-method="getInstance"~~
class="net.chrisrichardson.bankingExample.infras
tructure.TransactionManager"/>

<bean id="auditingManager"
  ~~factory-method="getInstance"~~
class="net.chrisrichardson.bankingExample.infras
tructure.AuditingManager"/>


</beans>
```

Revised design

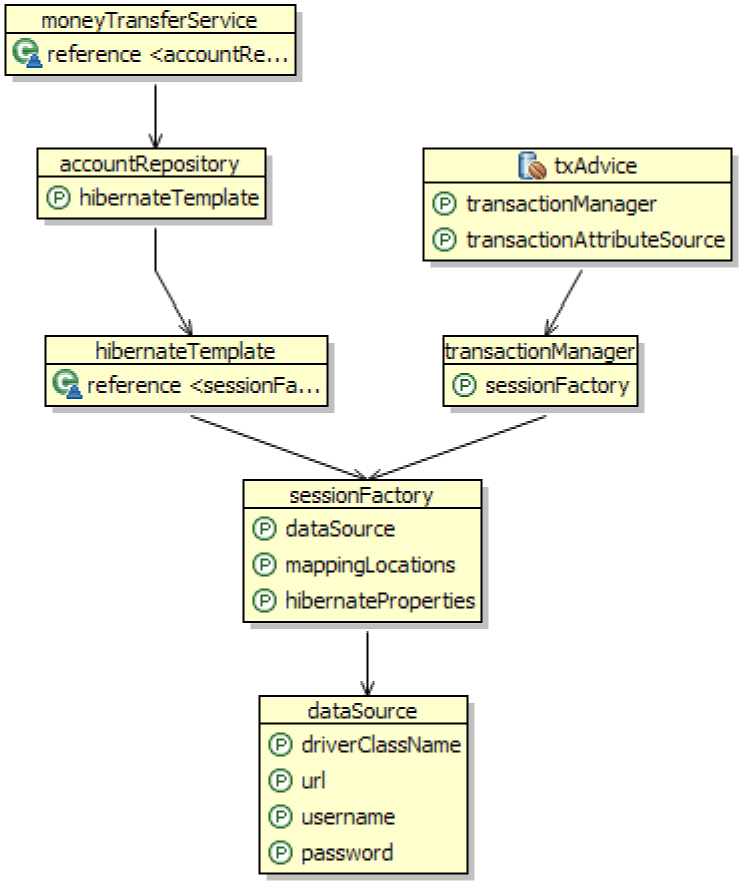


Fast unit testing example

```
public class AccountServiceImplMockTests extends MockObjectTestCase {

 private AccountDao accountDao;
 private BankingTransactionDao bankingTransactionDao;
 private TransactionManager transactionManager;
…

protected void setUp() throws Exception {
   accountDao = mock(AccountDao.class);
   bankingTransactionDao = mock(BankingTransactionDao.class);
   transactionManager = mock(TransactionManager.class);
…
   service = new AccountServiceImpl(accountDao, bankingTransactionDao, transactionManager, auditingManager,
                                                      bankingSecurityWrapper);

 }

 public void testTransfer_normal() throws MoneyTransferException {
   checking(new Expectations() {{
     one(accountDao).findAccount("fromAccountId"); will(returnValue(fromAccount));
     one(accountDao).findAccount("toAccountId"); will(returnValue(toAccount));
     one(transactionManager).begin();
     …
   }}
   );

   TransferTransaction result = (TransferTransaction) service.transfer("fromAccountId", "toAccountId", 15.0);

   assertEquals(15.0, fromAccount.getBalance());
   assertEquals(85.0, toAccount.getBalance());
    …
   verify();

 }
```

Create mock dependencies and inject them

Spring beans in practice



Configuring Spring beans in an application

- Web application
  - ApplicationContext created on startup
  - Web components can call AppCtx.getBean()
  - Some frameworks can automatically inject Spring beans into web components
- Testing
  - Tests instantiate application context
  - Call getBean()
  - Better: Use AbstractDepdendencyInjectionSpringContextTests for dependency injection into tests

```
<web>

 <context-param>
   <param-name>contextConfigLocation</param-name>
   <param-value>appCtx/banking-service.xml
   </param-value>
 </context-param>
 …
</web>
```

```
ApplicationCtx ctx =
  WebApplicationContextUtils.
        getWebApplicationContext(ServletContext)

 AccountService   service = (AccountService) ctx
        .getBean("AccountServiceDelegate");
```

```
public class SpringAccountServiceTests extends
   AbstractDependencyInjectionSpringContextTests {

  private AccountService service;
  …

@Override
  protected String[] getConfigLocations() {
    return new String[] { "appCtx/banking-service.xml" };
  }

  public void setAccountServiceDelegate(AccountService service) {
    this.service = service;
  }

…
}
```

Demo

- Let’s walk through the revised code

Benefits of dependency injection

- Simplifies code
- Promotes loose coupling
- Makes testing easier

Agenda

- Tangled code, tight coupling and duplication
- Using dependency injection
- **Dependency injection with less XML**
- Simplifying code with aspects
- Using aspects in the domain model

Dependency injection with less XML

- Spring 2.5
  - Annotation-based configuration
  - Class path component scanning
- Spring JavaConfig
  - Java-based configuration of Spring beans
- Arid DAO
  - Minimal XML
  - Automatically generated finders

Annotation-based configuration

```
public class MoneyTransferServiceImpl implements MoneyTransferService {

private final AccountRepository accountRepository;

private final BankingTransactionRepository bankingTransactionRepository;

@Autowired
public MoneyTransferServiceImpl(AccountRepository accountRepository
                                                    BankingTransactionRepository
bankingTransactionRepository) {
   this.accountRepository = accountRepository;
   this.bankingTransactionRepository = bankingTransactionRepository;
}
```

```
public class HibernateAccountRepository
  implements AccountRepository {

  private HibernateTemplate hibernateTemplate;

  @Autowired
   public HibernateAccountRepository(HibernateTemplate template) {
     hibernateTemplate = template;
}
```

```
<beans>

  <context:annotation-config/>

  <bean
name="moneyTransferService"
class="MoneyTransferServiceImpl"
  />

 <bean name="accountRepository"
class="HibernateAccountRepository
"
  />

</beans>
```

Annotation-based dependency injection

- @Autowire annotation on
  - Setters
  - Fields
  - Constructors
  - Methods
- Qualifiers for selecting one of multiple candidates to autowire:
  - @Qualifier("mainCatalog")
  - Bean definition contains <qualifier>

Auto-detection of beans

```
@Component
public class MoneyTransferServiceImpl
      implements  MoneyTransferService {
...
}
```

```
@Component
public class HibernateAccountRepository
                        implements AccountRepository {
...
}
```

```
<beans>

 <context:component-scan base-
package="net.chrisrichardson.bankingExample"/>

</beans>
```

Very little XML!

Component scanning in the classpath

- Configurable filters
  - Annotation
  - Regex
  - AspectJ
  - Regex
- Naming beans:
  - @Component("myService")
  - name-generator="MyNameGenerator"
- @Scope("prototype")

Using Spring JavaConfig 1

```
@Configuration
public abstract class AppConfig {

  @Bean
  public MoneyTransferService moneyTransferService() {
    return new MoneyTransferServiceImpl(accountRepository(),
        bankingTransactionRepository());
  }

  @Bean
  public AccountRepository accountRepository() {
    HibernateAccountRepository repo = new HibernateAccountRepository();
    repo.setSessionFactory(sessionFactory());
    return repo;
  }

  @Bean
  public BankingTransactionRepository bankingTransactionRepository() {
    HibernateBankingTransactionRepository repo = new HibernateBankingTransactionRepository();
    repo.setSessionFactory(sessionFactory());
    return repo;
  }

  @ExternalBean
  public abstract SessionFactory sessionFactory();

}
```

Using Spring JavaConfig 2

```
<bean>

  <bean class="net.chrisrichardson.bankingExample.javaconfig.AppConfig"/>

   <bean class="org.springframework.config.java.process.ConfigurationPostProcessor" />

</beans>
```

Even simpler DAOs with Arid

```
<beans>

 <arid:define-beans
    package='org.jia.ptrack.domain'
     pattern='net.chrisrichardson.arid.domain.GenericDao+'
    ...
</arid:define-beans>


...
</beans>
```

```
public interface AuditEntryRepository extends
     GenericDao<AuditEntry, Integer> {

   List<AuditEntry>  findByUserNameAndDateBetween(String username,
                                                   Date fromDate, Date toDate)
}
```

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- Dependency injection with less XML
- **Simplifying code with aspects**
- Using aspects in the domain model

Crosscutting concerns

- Every service method:
  - Manages transactions
  - Logs entries and exits
  - Performs security checks
  - Audit logs
- Tangled and duplicated code
- OO does not enable us to write this code in one place

```
public class AccountServiceImpl implements AccountService {

 public BankingTransaction transfer(String fromAccountId, String toAccountId, double amount) {

   BankingSecurityManager.verifyCallerAuthorized(AccountService.class,
      "transfer");

   logger.debug("Entering AccountServiceImpl.transfer()");

   TransactionManager.getInstance().begin();

   AuditingManager.getInstance().audit(AccountService.class, "transfer",
      new Object[] { fromAccountId, toAccountId, amount });

   try {
    Account fromAccount = accountDao.findAccount(fromAccountId);
    Account toAccount = accountDao.findAccount(toAccountId);
    double newBalance = fromAccount.getBalance() - amount;
    switch (fromAccount.getOverdraftPolicy()) {
    case Account.NEVER:
     if (newBalance < 0)
      throw new MoneyTransferException("Insufficient funds");
     break;
    case Account.ALLOWED:
     Calendar then = Calendar.getInstance();
     then.setTime(fromAccount.getDateOpened());
     Calendar now = Calendar.getInstance();

     double yearsOpened = now.get(Calendar.YEAR) - then.get(Calendar.YEAR);
     int monthsOpened = now.get(Calendar.MONTH) - then.get(Calendar.MONTH);
     if (monthsOpened < 0) {
      yearsOpened--;
      monthsOpened += 12;
     }
     yearsOpened = yearsOpened + (monthsOpened / 12.0);
     if (yearsOpened < fromAccount.getRequiredYearsOpen()
        || newBalance < fromAccount.getLimit())
      throw new MoneyTransferException("Limit exceeded");
     break;
    default:
     throw new MoneyTransferException("Unknown overdraft type: "
        + fromAccount.getOverdraftPolicy());

    }
    fromAccount.setBalance(newBalance);
    toAccount.setBalance(toAccount.getBalance() + amount);

    accountDao.saveAccount(fromAccount);
    accountDao.saveAccount(toAccount);

    TransferTransaction txn = new TransferTransaction(fromAccount, toAccount,
      amount, new Date());
    bankingTransactionDao.addTransaction(txn);

    TransactionManager.getInstance().commit();

    logger.debug("Leaving AccountServiceImpl.transfer()");
    return txn;
   } catch (RuntimeException e) {
    logger.debug(
      "Exception thrown in AccountServiceImpl.transfer()",
      e);
    throw e;
   } catch (MoneyTransferException e) {
    logger.debug(
      "Exception thrown in AccountServiceImpl.transfer()",
      e);
    TransactionManager.getInstance().commit();
    throw e;
   } finally {
    TransactionManager.getInstance().rollbackIfNecessary();
   }
 } }
```

Infrastructure

Business Logic

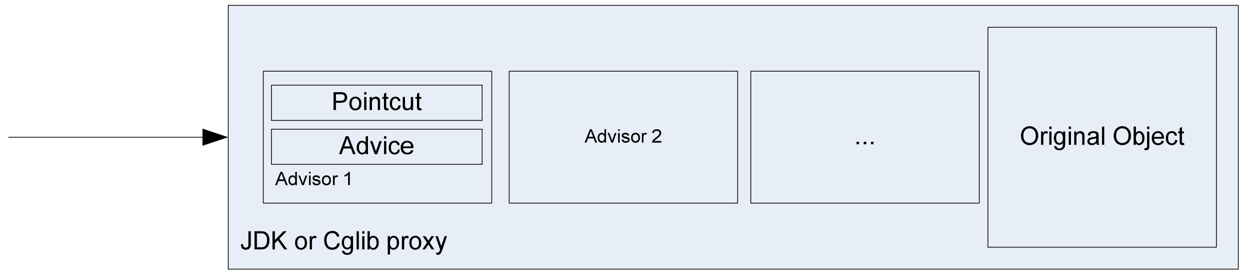
Infrastructure

Aspect-Oriented Programming (AOP)

- AOP
  - enables the modular implementation of crosscutting concerns
  - i.e. eliminates duplicate code
- Aspect
  - Module that implements a crosscutting concern
  - Collection of pointcuts and advice
- Join point
  - Something that happens during program execution
  - e.g. execution of public service method
- Pointcut
  - Specification of a set of join points
  - E.g. All public service methods
- Advice
  - Code to execute at the join points specified by a pointcut
  - E.g. manage transactions, perform authorization check

Spring AOP

- Spring AOP = simple, effective AOP implementation
- Lightweight container can wrap objects with proxies
- Proxy masquerades as original object
- Proxy executes extra advice:
  - Before invoking original method
  - After invoking original method
  - Instead of original method



Transaction Management Aspect

```
public class AccountServiceImpl ...

 public BankingTransaction transfer(
     String fromAccountId,
     String toAccountId, double amount) {
...
  transactionManager.begin();
  ...
  try {
     ...

     transactionManager.commit();
     ...
   } catch (MoneyTransferException e) {
     ...
     transactionManager.commit();
     throw e;
    } finally {
     transactionManager.rollbackIfNecessary();
    }
  }
```

```
@Aspect
public class TransactionManagementAspect {

  private TransactionManager transactionManager;

 public TransactionManagementAspect(TransactionManager
                          transactionManager) {
   this.transactionManager = transactionManager;
  }

  @Pointcut("execution(public *
                    net.chrisrichardson..*Service.*(..))")
  private void serviceCall() {
  }

  @Around("serviceCall()")
  public Object manageTransaction(ProceedingJoinPoint jp)
                     throws Throwable {
   transactionManager.begin();

   try {
     Object result = jp.proceed();
     transactionManager.commit();
     return result;
   } catch (MoneyTransferException e) {
     transactionManager.commit();
     throw e;
   } finally {
     transactionManager.rollbackIfNecessary();
   }
  }

}
```

Spring configuration

```
<beans>

 <aop:aspectj-autoproxy />

  <bean id="transactionManagementAspect"
          class="net.chrisrichardson.bankingExample.infrastructure.aspects.TransactionManagementAspect">
      <constructor-arg ref="transactionManager" />
  </bean>

</beans>
```

Logging Aspect

```
public class AccountServiceImpl ...

 private Log logger =
                    LogFactory.getLog(getClass());

 public BankingTransaction transfer(
     String fromAccountId,
     String toAccountId, double amount) {
...
 logger.debug("Entering
             AccountServiceImpl.transfer()");
      ...
  try {
      ...
      logger.debug("Leaving
            AccountServiceImpl.transfer()");
 } catch (RuntimeException e) {
      logger.debug(
          "Exception thrown in
AccountServiceImpl.transfer()",
          e);
      throw e;
  }
```

```
@Aspect
public class LoggingAspect implements Ordered {

  @Pointcut("execution(public *
                    net.chrisrichardson..*Service.*(..))")
  private void serviceCall() {
  }

  @Around("serviceCall()")
  public Object doLogging(ProceedingJoinPoint jp) throws
Throwable {

    Log logger = LogFactory.getLog(jp.getTarget().getClass());

    Signature signature = jp.getSignature();

    String methodName = signature.getDeclaringTypeName()
+ ".“ + signature.getName();

    logger.debug("entering: " + methodName);

    try {
      Object result = jp.proceed();

      logger.debug("Leaving: " + methodName);

      return result;
    } catch (Exception e) {

      logger.debug("Exception thrown in " + methodName, e);
      throw e;

    }
  }
```

Auditing Aspect

```
public class AccountServiceImpl ...

public BankingTransaction transfer(String
fromAccountId, String toAccountId,
     double amount)  {
...

auditingManager.audit(AccountService.class,
"transfer", new Object[] {
       fromAccountId, toAccountId, amount });
```

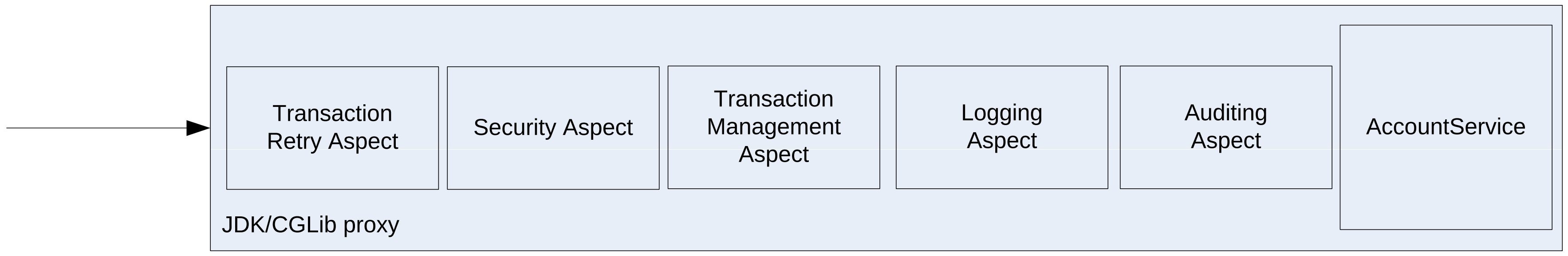
```
@Aspect
public class AuditingAspect  {

private AuditingManager auditingManager;

 public AuditingAspect(AuditingManager auditingManager) {
   this.auditingManager = auditingManager;
 }

 @Pointcut("execution(public *
                   net.chrisrichardson..*Service.*(..))")
 private void serviceCall() {
 }

 @Before("serviceCall()")
 public void doSecurityCheck(JoinPoint jp) throws Throwable
{

   auditingManager.audit(jp.getTarget().getClass(),
jp.getSignature()
      .getName(), jp.getArgs());
 }

}
```

Security Aspect

```
public class AccountServiceImpl ...

 public BankingTransaction transfer(
     String fromAccountId,
     String toAccountId, double amount) {
...
 public BankingTransaction transfer(String
fromAccountId, String toAccountId,
      double amount) throws
MoneyTransferException {


  ...
bankingSecurityWrapper.verifyCallerAuthorized(
AccountService.class,
        "transfer");
...
```

```
@Aspect
public class SecurityAspect {

private BankingSecurityManagerWrapper
bankingSecurityWrapper;


  public SecurityAspect(BankingSecurityManagerWrapper
bankingSecurityWrapper) {
    this.bankingSecurityWrapper = bankingSecurityWrapper;
  }

  @Pointcut("execution(public *
                    net.chrisrichardson..*Service.*(..))")
  private void serviceCall() {
  }

  @Before("serviceCall()")
  public void doSecurityCheck(JoinPoint jp) throws Throwable
{

bankingSecurityWrapper.verifyCallerAuthorized(jp.getTarget()
.getClass(), jp.getSignature().getName());
  }

}
```

In pictures


Transaction Retry Aspect
Security Aspect
Transaction Management Aspect
Logging Aspect
Auditing Aspect
AccountService
JDK/CGLib proxy

Simpler AccountService

```
public class AccountServiceImpl implements
   AccountService {

public AccountServiceImpl(
     AccountDao accountDao,
     BankingTransactionDao bankingTransactionDao) {
   this.accountDao = accountDao;
   this.bankingTransactionDao = bankingTransactionDao;
  }

  public BankingTransaction transfer(String fromAccountId, String toAccountId,
     double amount) throws MoneyTransferException {

   Account fromAccount = accountDao.findAccount(fromAccountId);
   Account toAccount = accountDao.findAccount(toAccountId);
   assert amount > 0;
   double newBalance = fromAccount.getBalance() - amount;
   switch (fromAccount.getOverdraftPolicy()) {
   case Account.NEVER:
     if (newBalance < 0)
   ....
  }

...
```

Fewer dependencies

Simpler code

It's a POJO

Simpler mock object test

```
public class AccountServiceImplMockTests extends MockObjectTestCase {


 public void testTransfer_normal() throws MoneyTransferException {
   checking(new Expectations() {
     {
       one(accountDao).findAccount("fromAccountId");
       will(returnValue(fromAccount));
       one(accountDao).findAccount("toAccountId");
       will(returnValue(toAccount));
       one(accountDao).saveAccount(fromAccount);
       one(accountDao).saveAccount(toAccount);
       one(bankingTransactionDao).addTransaction(
           with(instanceOf(TransferTransaction.class)));
     }
   });

   TransferTransaction result = (TransferTransaction) service.transfer(
       "fromAccountId", "toAccountId", 15.0);
...
}
```

Fewer dependencies to mock

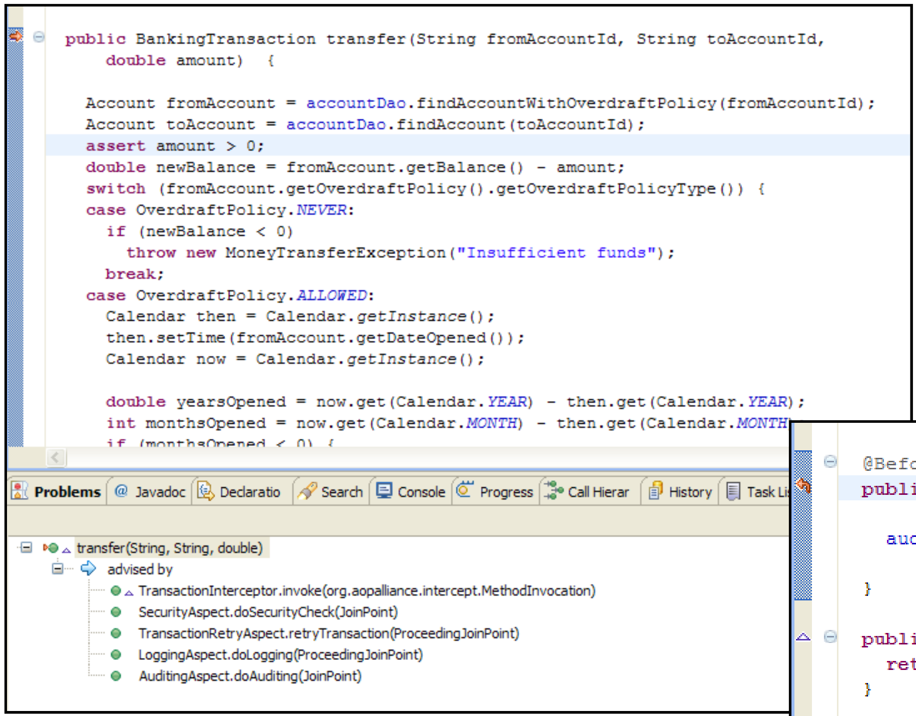
Transaction Retry Aspect

```
public class AccountServiceDelegate {

  private static final int MAX_RETRIES = 2;

  public BankingTransaction transfer(String
fromAccountId, String toAccountId,
      double amount) throws
MoneyTransferException {
    int retryCount = 0;
    while (true) {
      try {
        return service.transfer(fromAccountId,
toAccountId, amount);
      } catch (ConcurrencyFailureException e) {
        if (retryCount++ > MAX_RETRIES)
          throw e;
      }
    }

  }

}
```

```
@Aspect
public class TransactionRetryAspect  {

  private Log logger = LogFactory.getLog(getClass());
  private static final int MAX_RETRIES = 2;

  @Pointcut("execution(public *
                        net.chrisrichardson..*Service.*(..))")
  private void serviceCall() {
  }

  @Around("serviceCall()")
  public Object retryTransaction(ProceedingJoinPoint jp)
throws Throwable {
    int retryCount = 0;
    logger.debug("entering transaction retry");
    while (true) {
      try {
        Object result = jp.proceed();
        logger.debug("leaving transaction retry");
        return result;
      } catch (ConcurrencyFailureException e) {
        if (retryCount++ > MAX_RETRIES)
          throw e;
        logger.debug("retrying transaction");
      }
    }
  }

}
```

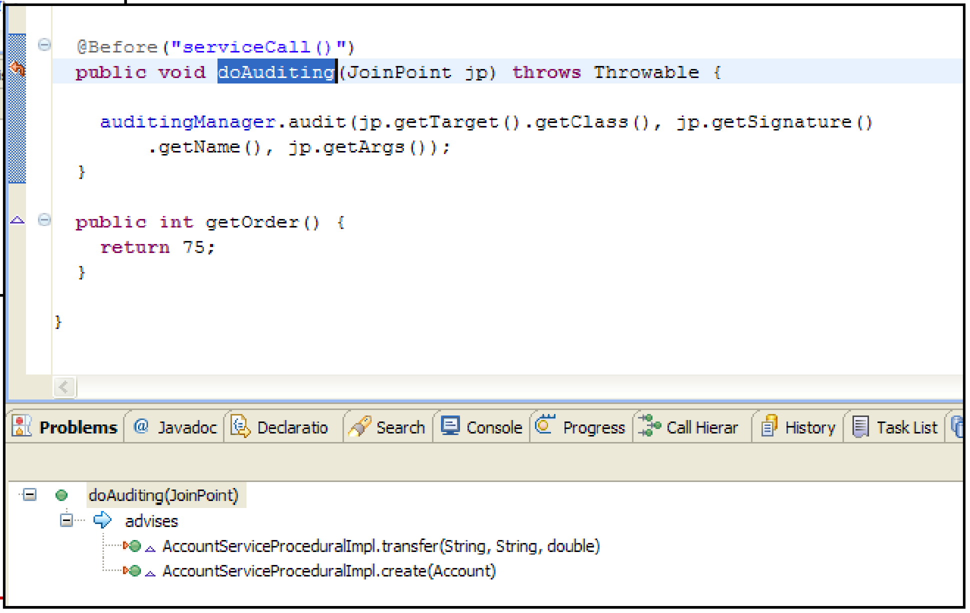
We can delete the delegate class!

Spring IDE for Eclipse



```java
public BankingTransaction transfer(String fromAccountId, String toAccountId,
    double amount)  {

  Account fromAccount = accountDao.findAccountWithOverdraftPolicy(fromAccountId);
  Account toAccount = accountDao.findAccount(toAccountId);
  assert amount > 0;
  double newBalance = fromAccount.getBalance() - amount;
  switch (fromAccount.getOverdraftPolicy().getOverdraftPolicyType()) {
  case OverdraftPolicy.NEVER:
    if (newBalance < 0)
      throw new MoneyTransferException("Insufficient funds");
    break;
  case OverdraftPolicy.ALLOWED:
    Calendar then = Calendar.getInstance();
    then.setTime(fromAccount.getDateOpened());
    Calendar now = Calendar.getInstance();

    double yearsOpened = now.get(Calendar.YEAR) - then.get(Calendar.YEAR);
    int monthsOpened = now.get(Calendar.MONTH) - then.get(Calendar.MONTH
    if (monthsOpened < 0) {
```

```
transfer(String, String, double)
  advised by
    TransactionInterceptor.invoke(org.aopalliance.intercept.MethodInvocation)
    SecurityAspect.doSecurityCheck(JoinPoint)
    TransactionRetryAspect.retryTransaction(ProceedingJoinPoint)
    LoggingAspect.doLogging(ProceedingJoinPoint)
    AuditingAspect.doAuditing(JoinPoint)
```



```java
@Before("serviceCall()")
public void doAuditing(JoinPoint jp) throws Throwable {

  auditingManager.audit(jp.getTarget().getClass(), jp.getSignature()
      .getName(), jp.getArgs());
}

public int getOrder() {
  return 75;
}

}
```

```
doAuditing(JoinPoint)
  advises
    AccountServiceProceduralImpl.transfer(String, String, double)
    AccountServiceProceduralImpl.create(Account)
```

Demo

- Step through the code

Spring provided aspects

- Spring framework provides important infrastructure aspects
- Transaction Management
  - TransactionInterceptor
  - PlatformTransactionManager
- Spring Security a.k.a Acegi Security
  - MethodSecurityInterceptor

Agenda

- Tangled code, tight coupling and duplication
- Using dependency injection
- Simplifying code with aspects
- Dependency injection with less XML
- **Using aspects in the domain model**

Using Aspects in the Domain Model

- Spring AOP works well for the service layer
- But it has limitations:
  - Objects must be created by Spring
  - Can only intercept calls from outside
  - Only efficient when method calls are expensive
- Inappropriate for domain model crosscutting concerns:
  - E.g. tracking changes to fields of domain objects

Introduction to AspectJ

- What is AspectJ
  - Adds aspects to the Java language
  - Superset of the Java language
- History
  - Originally created at Xerox PARC
  - Now an Eclipse project
- Uses byte-code weaving
  - Advice inserted into application code
  - Done at either compile-time or load-time
  - Incredibly powerful: E.g. intercept field sets and gets

Change tracking problem – old way

```
public class Foo {

  private Map<String, ChangeInfo> lastChangedBy
                                 = new HashMap<String, ChangeInfo>();

  public void noteChanged(String who, String fieldName) {
     lastChangedBy.put(fieldName, new ChangeInfo(who, new Date()));
  }

  public Map<String, ChangeInfo> getLastChangedBy() {
    return lastChangedBy;
  }

  private int x;
  private int y;

  public void setX(int newX) {
    noteChanged(determineCallerIdentity(), "x");
    this.x = x;
  }
```

- Put in a base class
- Unless you run into single-inheritance restriction

- Call noteChanged() whenever a field value is changed.
- Tangled code
- Error prone – too easy to forget

Change tracking problem – AOP way

```
@Observable
public class Foo {


  @Watch
  private int x;

  private int y;

  public void setX(int newX) {
     this.x = x;
  }
```

Now it's a simple POJO again

Change tracking aspect

```
public aspect ChangeTrackingAspect {

  declare parents: (@Observable *) implements Trackable;

  private Map<String, ChangeInfo> Trackable.lastChangedBy
             = new HashMap<String, ChangeInfo>();

  private void Trackable.noteChanged(String who, String fieldName) {
   lastChangedBy.put(fieldName, new ChangeInfo(who, new Date()));
  }

  public Map<String, ChangeInfo> Trackable.getLastChangedBy() {
    return lastChangedBy;
  }
…
```

Adds the Trackable interface to all classes annotated with **`@Observable`**

Adds these members to all classes that implement the Trackable interface

Tracking field sets

```
…
  private SecurityInfoProvider securityInfoProvider;

  pointcut fieldChange(Trackable trackable, Object newValue) :
    set(@Watch * Trackable+.*)  && args(newValue) && target(trackable);

  after(Trackable trackable, Object newValue) returning() :
                             fieldChange(trackable, newValue) {
    FieldSignature signature =
               (FieldSignature)thisJoinPointStaticPart.getSignature();
    String name = signature.getField().getName();
    String who = provider.getUser();
    trackable.noteChanged(who, name);
  }
```

```
<bean id="changeTracker"
   class="net.chrisrichardson.aopexamples.simple.ChangeTrackingAspect"
    factory-method="aspectOf">
    <property name="provider" ref="securityInfoProvider"/>
</bean>

<bean id="securityInfoProvider"
     class="net.chrisrichardson.aopexamples.simple.SecurityInfoProvider“
/>
```

```
Foo foo = new Foo();
foo.setX(1);
foo.setY(2);

Trackable trackable = foo;
…
```

Benefits of AOP

- Incredibly powerful
  - Modularizes crosscutting concerns
  - Simplifies application code
  - Decouples application code from infrastructure
- Two options:
  - Spring AOP – simple but less powerful
  - AspectJ – powerful but with a price

Drawbacks of AOP

- Cost of using AspectJ
  - Compile-time weaving – changes build
  - Load-time weaving – increases startup time
- Not everyone’s idea of simplicity
  - Code no longer explicitly says what to do

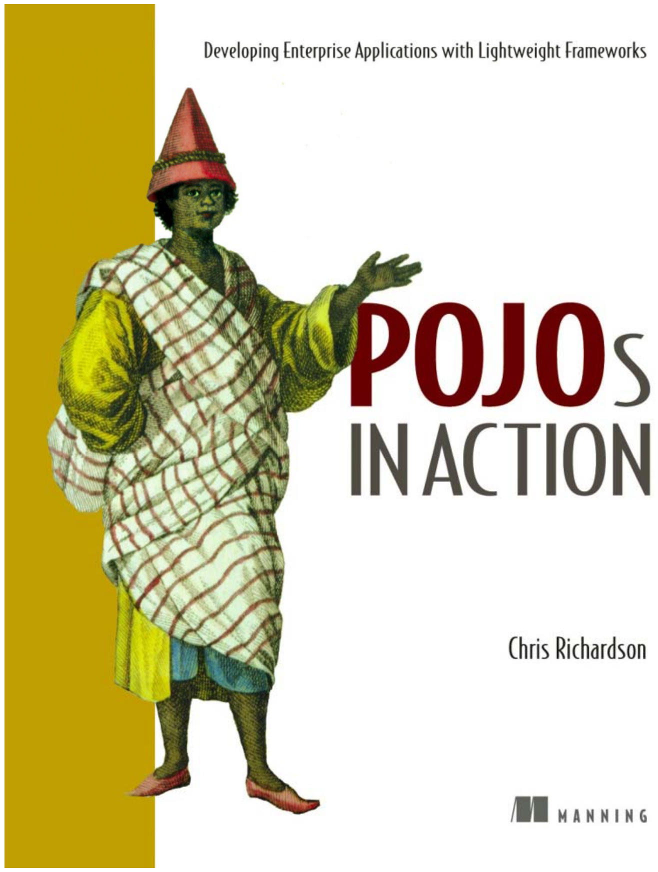
Summary

- Dependency injection
- Aspect-oriented Programming
- Object/relational mapping

→

- Improved SOC
- DRY code
- Simpler code
- Improved maintainability
- Easier to develop and test
- Let’s you focus on the core problem

For more information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