Where Did My Architecture Go?

Preserving and recovering the design of software in its implementation

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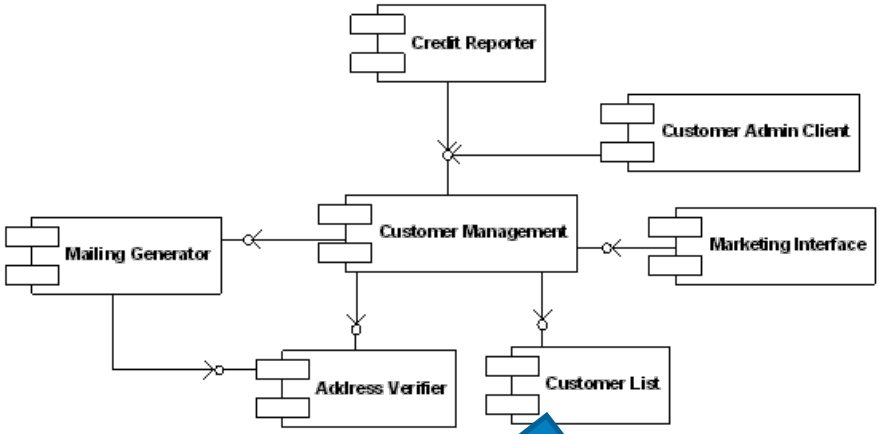
- Losing Design in the Code
- Key Design Constructs
- My Example Application
- Finding and Keeping Design in Code
  - Conventions
  - Dependency analysis
  - Module systems
  - Augmenting the code & checking rules
  - Language extensions
- Summary

Losing Design in the Code

Losing the design in the code

- Good designers talk about many structures that aren't part of mainstream programming languages
  - layers, adapters, proxies, components, brokers, ...
- Yet the code is all that exists at runtime
  - "the code doesn't lie"
- But if we've only got code where does all that design information go?

Losing the design in the code




```
./dda/business/common/controller/DtoManager.java
./dda/business/common/data/cmp/BaseDataSupplierAdapter.java
./dda/business/common/data/cmp/CmpObjectId.java
./dda/business/common/dsi/DataManagerFactory.java
./dda/business/common/dsi/DataManagerIf.java
./dda/business/common/dsi/DataSupplierIf.java
./dda/business/common/dsi/DataSupplierReadMarker.java
./dda/business/common/dsi/DomainObject.java
./dda/business/common/dsi/DomainObjectFactory.java
...
```

Problems with Code as Design

- Only language structures are present
  - language structures are fine grained
- Fine grained nature is very detailed
  - difficult to discern structure from the details
- Design structures don’t exist
  - need to discern design structure from the code
  - a lot of mapping and assumption required
  - relies on well structured and named code

Strengths of Code as Design

- Interpretation by machine
  - searching
  - checking
  - querying
- Certainty with respect to runtime
  - “the code doesn’t lie”
- Integration of different abstraction levels
  - see where a line fits in the overall design

Using Code as our Design Notation

- Need to extend our notion of "code"
  - Extend languages to allow design elements
  - Sapir-Whorf – extend language, influence thinking
- We can create or use new languages
  - e.g. aspect based languages, ArchJava, ...
- Or extend the ones we have
  - comments, annotations, packages, aspects, ...
- Or use tools to visualise and infer design
  - dependency visualisers, rules checkers, ...

Key Design Constructs

What Do We Mean by Design Information?

- Many possible types of "design" information but two broad groups: *static* and *dynamic*
- *Static* information describes structures visible at *design* time
  - packages, classes, components, connectors, ...
- *Dynamic* information describes structures visible at *runtime*
  - invocations, data flow, sequencing, ...

Static Design Information

- Layers
- Modules (or “subsystems”)
- Components (and component types)
- Pattern implementations
- Dependencies
  - e.g. between components or on resources
  - particularly difficult across tiers/technologies
- Hierarchies and containment (e.g. plugins)

Dynamic Design Information

- Run-time invocations & control flow
  - i.e. ***do*** I call X, not ***can*** I call X (and when)
- Size and speed
  - how many times do I do something?
  - how many items are accessed / created / ...
- Design validation
  - does it really do what the design says it should

This session's focus is static information

An Example Application

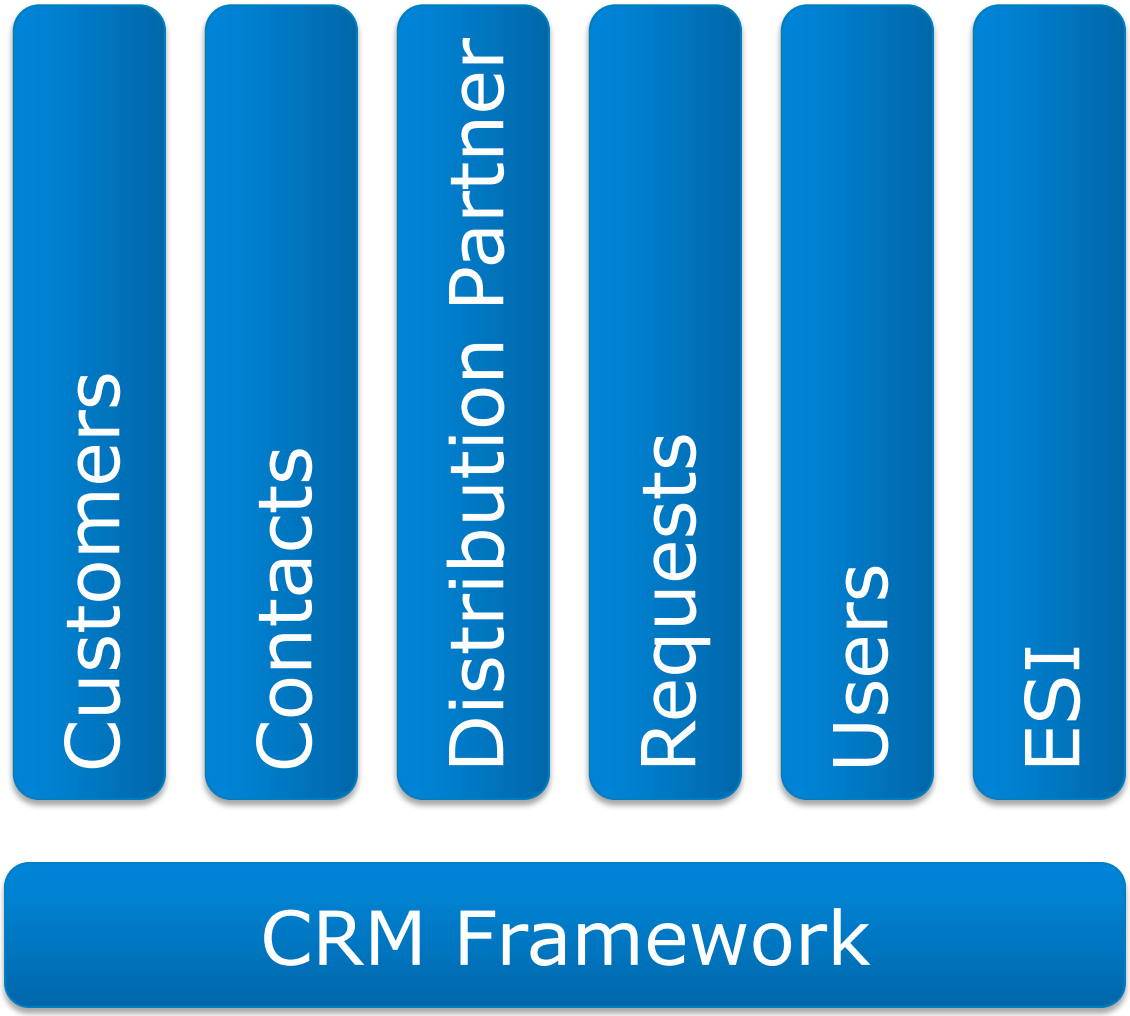
An Example Application

- A very, very basic CRM system server + integration test
- Based on code supplied as a vendor example
- 6 functional modules + a generic framework
  - CRM Framework
  - Contacts
  - Customers
  - Distribution Partners
  - Enterprise Service Integration (ESI – links to other systems)
  - Requests
  - Users
- Code is organised first by module, then by layer
- Small, not trivial: 6.5 KLOC, 20K byte codes, 162 types

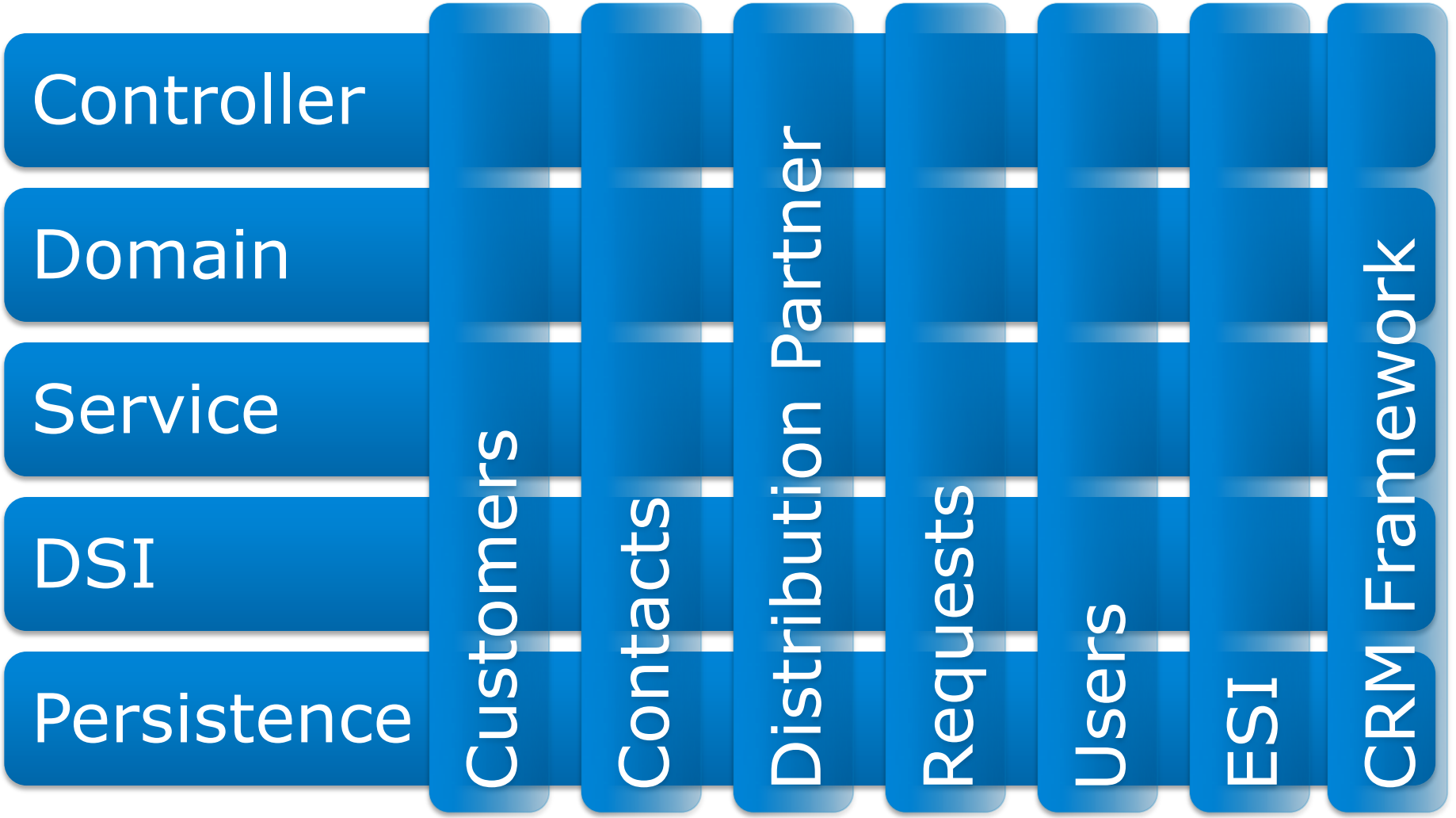
Simple CRM System Layers

- Controller
- Domain
- Service
- Data Service Interface
- Persistence

Simple CRM Modules



Simple CRM Modules



Finding & Keeping Design in Code

Techniques

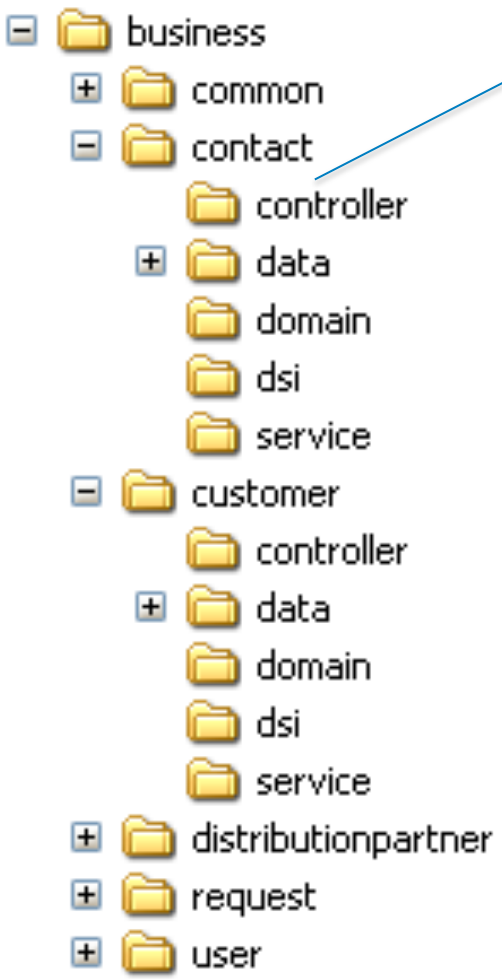
- Naming conventions with code & build structure
- Dependency analysis tools
- Module systems (Spring, Guice, OSGi, ...)
- Augmenting the code (annotations, rules)
  - checking design rules (Architecture Rules, Macker)
- Aspects
  - useful for design constructs and checking
- Special purpose languages (e.g. ArchJava)

Naming and Conventions

Naming and Conventions

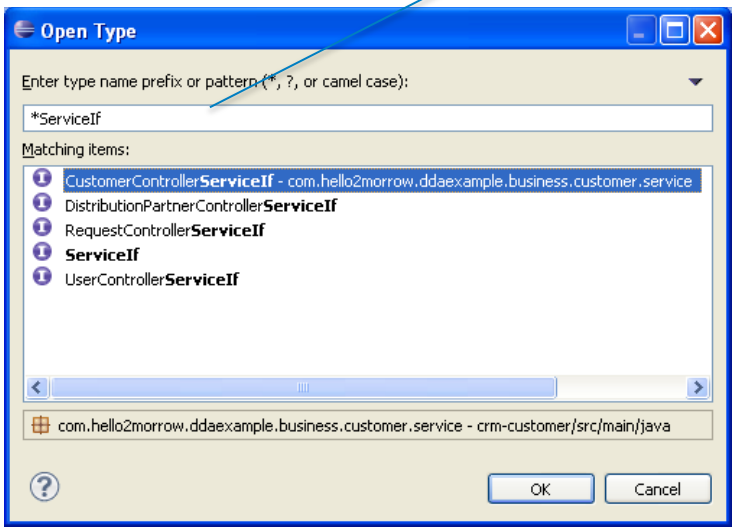
- Code structure
  - classes, packages, ...
- Build system
  - Maven’s module based build
  - dependencies

Naming and Conventions



Functional areas & layers shown by package naming

Identify code element types by name matching



"Simple" stuff but often done badly or not at all

Dependency Analysis

Dependency Analysis

- A key element of design is modularisation
- A key part of modularisation is defining dependencies
- Poorly designed dependencies make software almost un-maintainable
  - well designed dependencies enable change with a minimum of risk and cost
- Dependencies are difficult to visualise, analyse and understand from source code
- A good place to start understanding design and managing design information is dependency analysis

Tools 1 – Structure & Analysers

- Understanding Java code using
  - Maven
  - jDepend
  - ClassCycle
  - Structure 101

Tools1 – Maven and Design

- Maven is a Java project automation system
  - build, tool integration, doc generation, ...
  - a key philosophy is enforcing a set of conventions
  - forces you to consider modularisation & dependencies
- Maven "modules" (code trees) have explicit versioned dependencies on each other
- The structure of a Maven project is almost always comprehensible if you've seen one before

Tools1 - Maven

pom.xml declares structure and dependencies at each level

```
+ pom.xml
+ module1
      - pom.xml
      - src/main/java/ ...
      - src/test/java/ ...
      - target/module1-1.0-SNAPSHOT.jar
+ module2
      - pom.xml
      - src/main/java/ ...
      - src/test/java/ ...
      - target/module2-1.0-SNAPSHOT.jar
```

each module has the same structure

1 module =
1 built target (JAR)

Tools1 - Maven

An example pom.xml module definition file

```
<project ...>
   ...
  <groupId>com.artechra.simplecrm</groupId>
  <artifactId>crm-request</artifactId>
  <packaging>jar</packaging>
  <version>1.0-SNAPSHOT</version>
  <name>CRM User Request Module</name>
  <dependencies>
    <dependency>
        <groupId>com.artechra.simplecrm</groupId>
        <artifactId>crm-framework</artifactId>
        <version>1.0-SNAPSHOT</version>
    </dependency>
    ...
</dependencies>
</project>
```

Explicit dependencies in the build system help to preserve design information

Tools 1 - Maven Dependency Analysis

Generates a dependency tree for the project modules

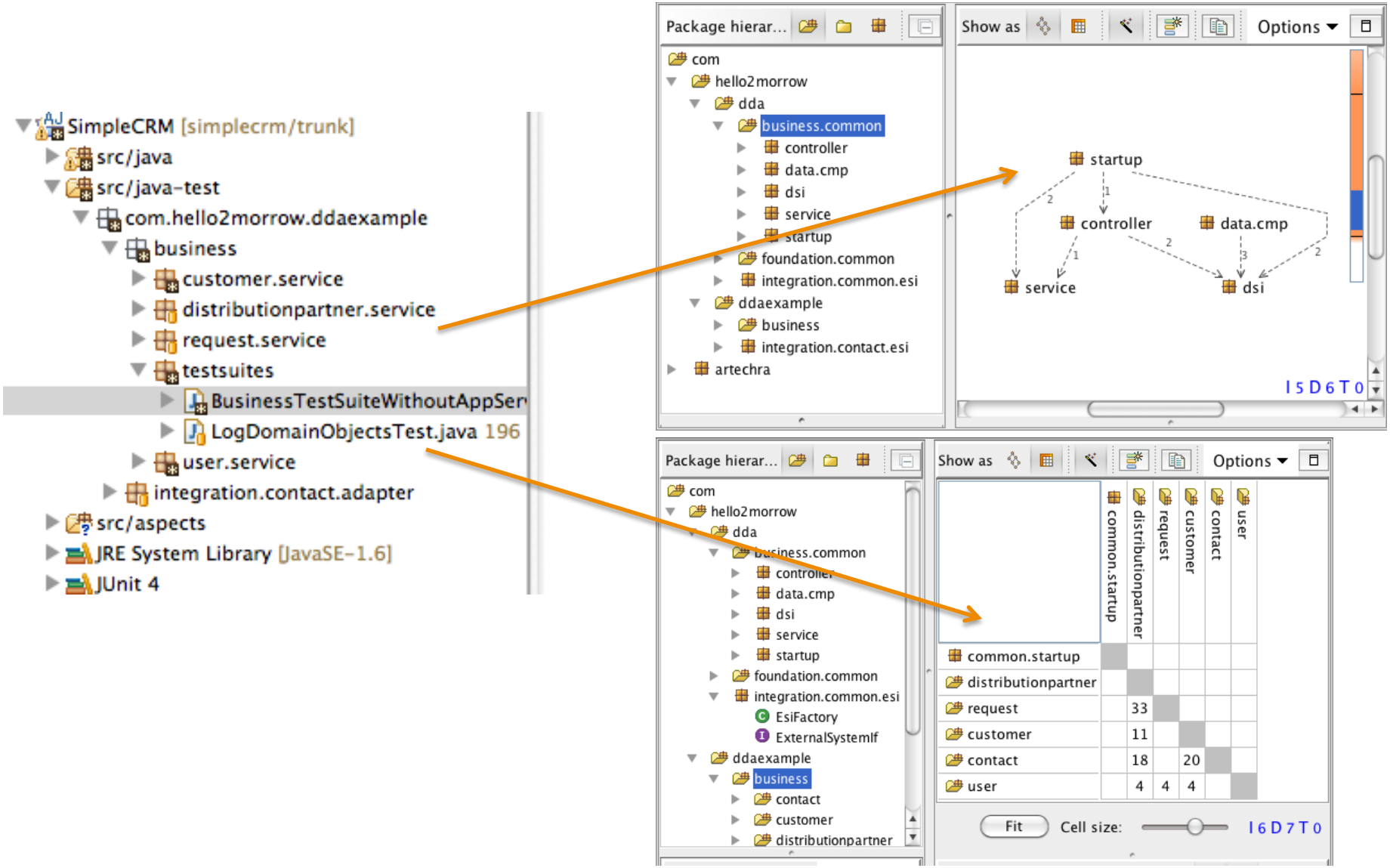
```
$> mvn dependency:tree -Dverbose=true
com.artechra.simplecrm:crm-itest:jar:1.0-SNAPSHOT
+- com.artechra.simplecrm:crm-contact:jar:1.0-SNAPSHOT:compile
|  +- (com.artechra.simplecrm:crm-framework:jar:1.0-SNAPSHOT:compile - …
|  +- (com.artechra.simplecrm:crm-esi:jar:1.0-SNAPSHOT:compile - omitted for duplicate)
|  \- (log4j:log4j:jar:1.2.9:compile - omitted for duplicate)
+- com.artechra.simplecrm:crm-customer:jar:1.0-SNAPSHOT:compile
|  +- (com.artechra.simplecrm:crm-framework:jar:1.0-SNAPSHOT:compile - …
|  +- (com.artechra.simplecrm:crm-contact:jar:1.0-SNAPSHOT:compile - …
|  +- (com.artechra.simplecrm:crm-user:jar:1.0-SNAPSHOT:compile - omitted for duplicate)
|  \- (log4j:log4j:jar:1.2.9:compile - omitted for duplicate)
+- com.artechra.simplecrm:crm-distributionpartner:jar:1.0-SNAPSHOT:compile
|  +- (com.artechra.simplecrm:crm-framework:jar:1.0-SNAPSHOT:compile - …
|  +- (com.artechra.simplecrm:crm-request:jar:1.0-SNAPSHOT:compile - …
[trimmed]
```

The Maven "site report" web sites also have dependency reports

Tools 2 – Dependency Analysers

- Static dependency checkers
  - Structure 101, Lattix, CppDepend, Ndepend
  - jDepend, ClassCycle, Dependency Finder
- Reveal real structures via dependency analysis
  - often with checking for simple user defined rules
- Capabilities and focus vary by tool
  - one common limitation is use of package structure

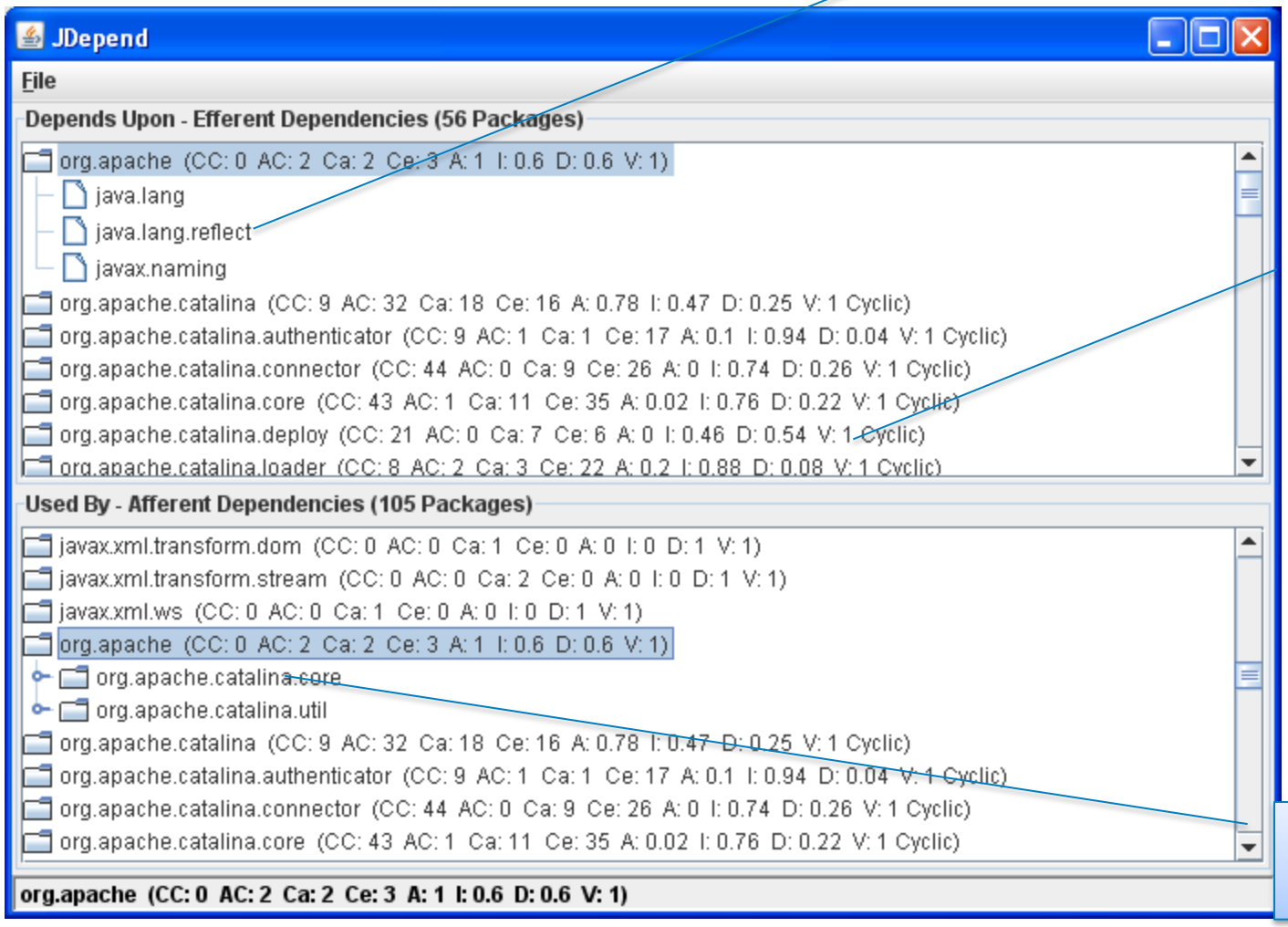
Tools 2 - Dependency Analysers



Tools 2 - JDepend

- Probably the original Java dependency analyzer
  - byte code analysis of coupling and dependencies
  - now extremely stable
  - limited to package level analysis
- Limited GUI feature set
  - afferent and efferent coupling report with metrics
- Primarily a library
  - callable from JUnit, other tools, FITness, Ant, ...
  - comprehensive XML or text report

Tools 2 - JDepend



Depends upon analysis

Coupling metrics

Used by analysis

Tools 2 - ClassCycle

- Similar tool to JDepend
  - extends it with class level dependency analysis
  - adds dependency checking language and engine
  - well documented algorithms
  - a couple of limitations removed
- XML reporting of dependencies
  - command line or Ant plugin
  - Eclipse plugin is available
- Nice dependency checking language

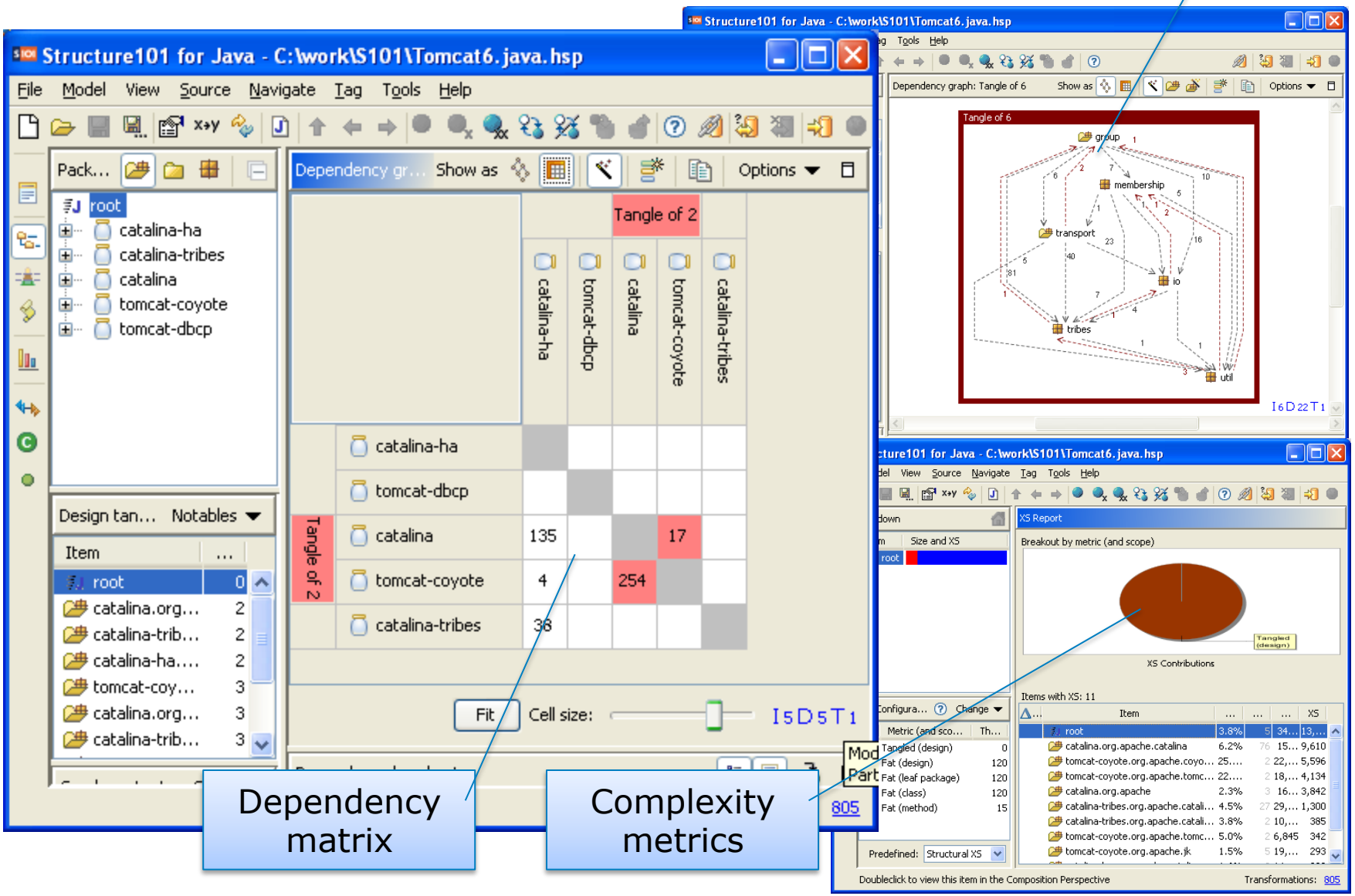
Tools 2 - ClassCycle Example Rules

```
{base-pkg} = com.artechra

[util] = ${base-pkg}.util.*
[non-util] = ${package}.* excluding [util]

check [util] independentOf [non-util]

check absenceOfPackageCycles > 1 in ${package}.*

layer infra = [util] ${base-pkg}.type.*
layer persistence = ${base-pkg}.dao.*
layer domain-logic = ${package}.domain.*
check layeringOf basic persistence domain-logic
```

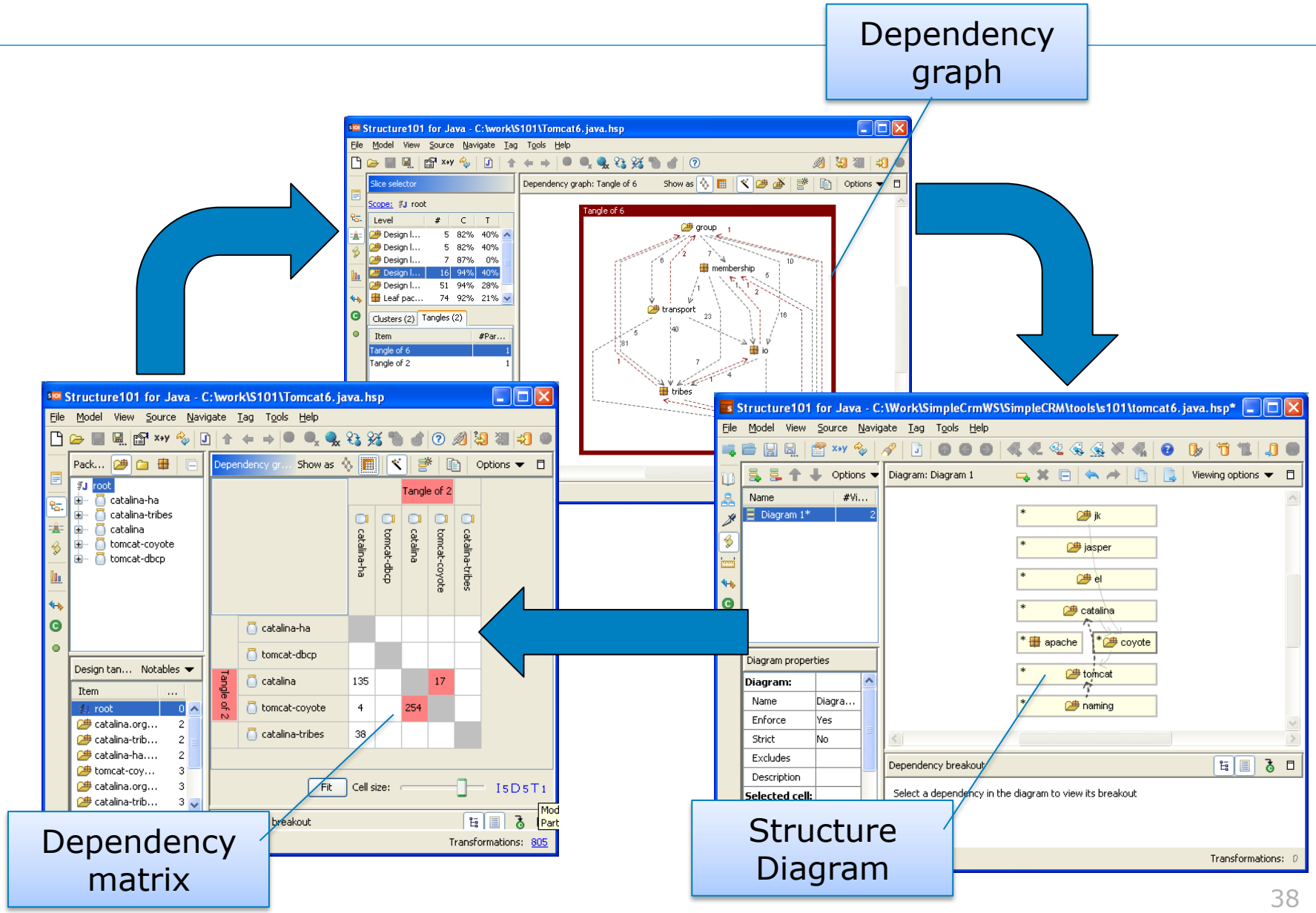
Tools 2 - Structure 101

- Commercial dependency analyser
  - Java, .NET, C/C++ and “generic” versions
- Desktop tool and optional “headless” tools with webapp for history and build integration
- Dependencies, collaborations, metrics
  - basic violation checking via “architecture” view
- Rich UI for navigation and analysis
  - separate IDE integration for IntelliJ and Eclipse

Tools 2 - Structure 101



Tools 2 – Structure 101



Module Systems

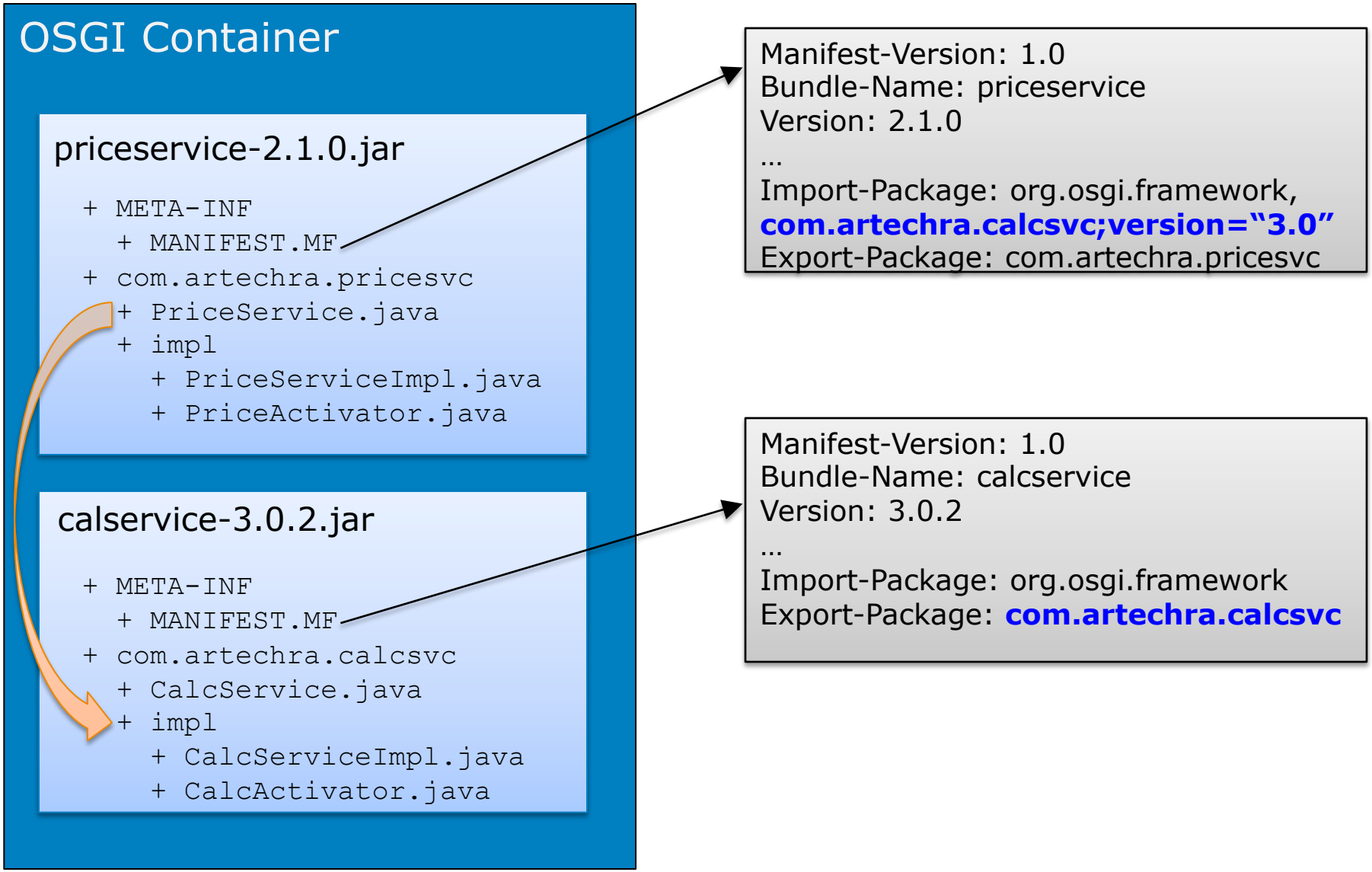
Module Systems & Structuring

- Dependency Injection (IoC) containers
  - Java: Spring, Guice, ...
  - .NET: AutoFac, Spring.NET, ...
  - Containers instantiate components & “wire” together
  - Tendency to end up with very large configurations
  - Tendency to end up with very fine grained “components”
  - Do allow some degree of system structure to be visible
- Full blown module systems like OSGi
  - provides a module system for Java based on JAR files
  - a reasonably high commitment technology to adopt
  - can be complicated in a JEE environment
  - explicit declaration of module’s exports and imports

Java Modules with OSGi

- OSGi is an example of a full-blown module system
  - defines model of modules, their lifecycle and services
  - specifies a runtime container of standard services
  - allows (functional) structure to be clearly seen
  - makes inter module dependencies very clear
- Open standard developed by the OSGi Alliance
- Evolves existing Java technologies
  - JAR files used as the basis of components (“bundles”)
  - Manifest files extended to provide meta-data
  - Bundle services are simply Java interfaces
  - Imports and exports specified by Java packages

Java Modules with OSGi



Augmenting the Code

Augmenting the Code

- Design information meta-data
  - annotations
  - external meta-data (e.g. declarative design rules)
- Rules based tools for validation
  - commercial: Structure 101, SonarJ, ...
  - open source: Macker, Architecture Rules, ...
  - aspect oriented languages: AspectJ, ...

Meta Data in the Code

- A number of meta-data systems exist
  - Java annotations & .NET attributes
  - Doxygen comments
- These can be used to “mark” design elements
  - @Layer(“Persistence”), @Facade
- Current limitation is the lack of tool support
  - except aspects, most tools ignore annotations etc
  - can write own utilities using reflection type APIs
  - feed outputs of proprietary analysis to generic tools

Java Metadata - Annotations

- Annotations allow meta data to be attached to code
  - fields, methods, parameters, classes, interfaces, packages
  - useful information for people, also machine processable
- Annotations are little classes
  - defined as special interfaces using keyword "`@interface`"
  - can contain own data, allowing storage of design information
  - result in objects attached to Java code elements
- Can define annotations for design level information
  - Component types: `@Service`, `@DAO`, `@DomainObject`, …
  - Containers: `@Component`, `@Layer`
- Include in the code as you write it
  - for packages, remember they're in `package-info.java` !

Java Metadata - Annotations

```
@Retention(RetentionPolicy.RUNTIME)
@Target(ElementType.PACKAGE)
public @interface Layer {
   enum LAYERS {PERSISTENCE, WEBUI, DOMAIN,
                INTEGRATION, SERVICE} ;

   LAYERS layer() ;
}
```

Package layer annotation with a "layer" attribute

```
@Layer(layer=Layer.LAYERS.DOMAIN)
package com.artechra.simplecrm.business ;
import com.artechra.Layer ;
```

package-info.java

Applies the annotation to the package meta-data

```
Package p = Package.getPackage(pkgName) ;
if (p.isAnnotationPresent(Layer.class)) {
   Layer l = p.getAnnotation(Layer.class) ;
   if (l.layer() == Layer.LAYERS.SERVICE) {
      // ...
   }
}
```

Reflection allows you to write utilities that see this design information
(you can also use aspects or add annotation processors to your build via javac)

Checking Design Rules

Rules Based tools

- Earlier we saw dependency analysers
  - primarily for extracting dependencies
  - some with interactive analysis
  - most provide basic checking
- Another approach are the rules checking tools
  - provide a rules language and checking engine
- Examples for Java are
  - Architecture Rules and Macker (open source)
  - Semmle ODASA and SonarJ (commercial)

Tools 3 - Macker

- Macker is a rules-based structural analyser
  - open source GPL project, analyses Java byte code
- Rules are described in an XML based language
  - wildcards, inclusion/exclusion, quantifiers, ...
- Macker is a command / Ant target / library to check the rules against a set of classes
  - output to XML or HTML reports or the console
- Real strength is flexibility and the rule language

Tools 3 – Macker Enforcing Rules

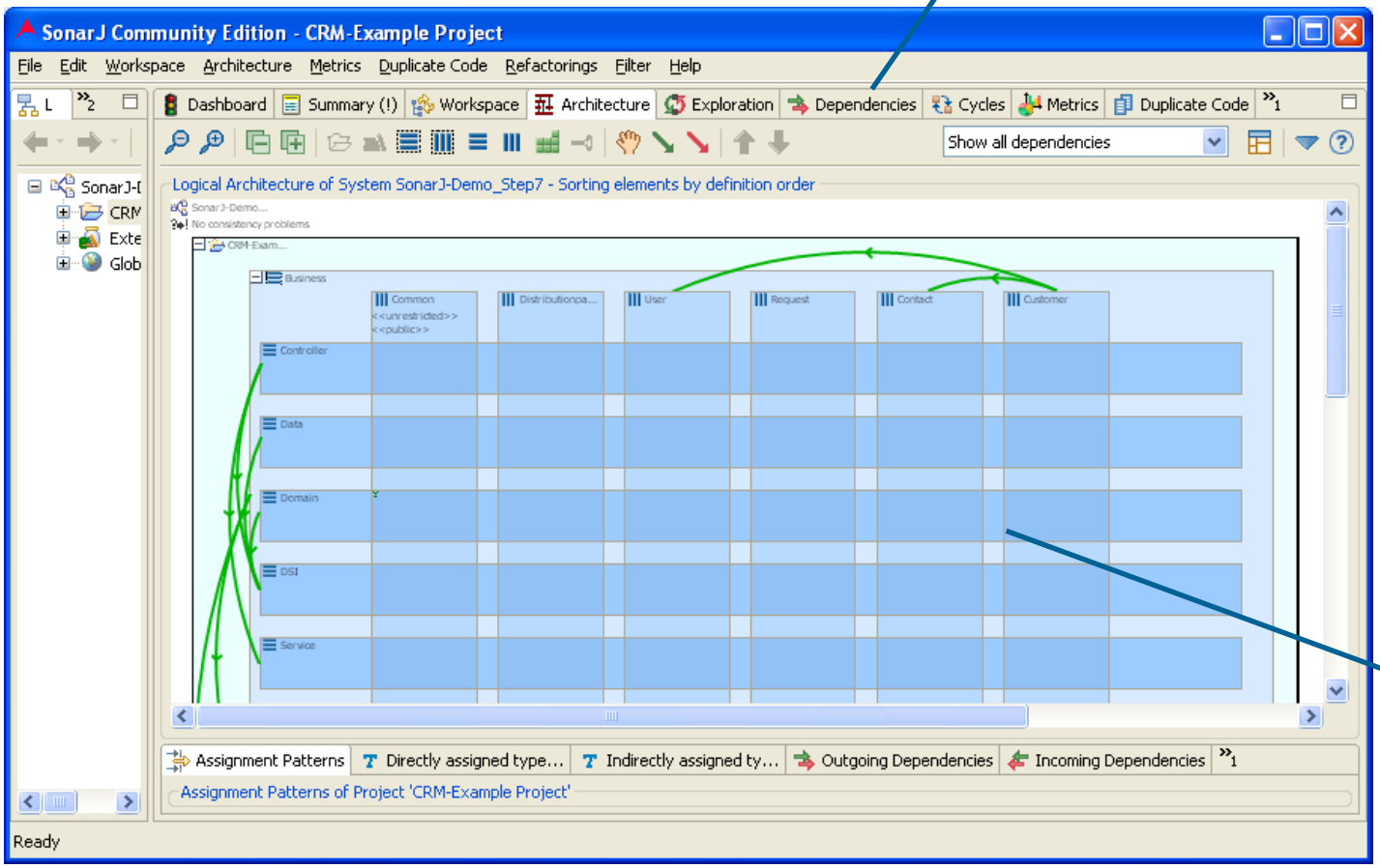
```
<ruleset>
  <var name="base-pkg" value="com.artechra.simplecrm" />
  <foreach var="module"
           class="(${base-pkg}.module.*).**">
    <pattern name="api" class="${module}.*" />
    <pattern name="inside" class="${module}.**" />
    <pattern name="outside">
      <exclude pattern name="inside" />
    </pattern>
    <access-rule>
      <message>${from} must access ${module} via its API</message>
      <deny>
        <from pattern="outside"/><to pattern="inside" />
      </deny>
      <allow><to pattern="api" /></allow>
    </access-rule>
  </foreach>
</ruleset>
```

Tools 3 - SonarJ

- Commercial code analysis tool
  - dependency analysis, metrics, refactoring
  - reporting against a quality model
  - processes Java source code and byte code
- GUI, command line, Ant and Maven options
  - database option for storing results
- Allows fine grained dependency rules
  - provision for layering *and* partitioning

Tools 3 - SonarJ

Metrics, dependency analysis, code duplication checks, ...



Architecture slices and layers

Extending Programming Languages

Extending the Language

- Sapir-Whorf hypothesis: language affects thought
  - we do see this with software developers
  - implementation language drives vocabulary
  - Design level language == design level thinking?
- Aspects
  - split code into design oriented “slices”
  - generate errors and warnings based on structure
- Special purpose languages
  - Arch Java

Aspect Orientation

- AOP provides two possibilities
  - change the way the code is structured
  - check the code using warning/error advice
- AOP separates code into modules that are applied across the codebase
  - “advice” is the code to apply
  - “point cuts” specify where to put it
  - special AspectJ advice just creates warnings when point cuts match

Aspect Orientation

- A common code pattern:

```
public Person getEmployee(String empId) {
        log.entering("HRService", "getEmployee", empId) ;
        if (!SecMgr.checkAccess(Ctx.getCaller(),
                  new Resource(PERSON, empId), READ)) {
                throw new AuthorizationException(…) ;
        }
        Person ret = empRepo.getPersonByRole(empId,Role.EMPLOYEE);
        log.exiting("HRService", "getEmployee", ret) ;
        return ret ;
}
```

The one line of business logic !

It’s difficult to see your design when so many concerns are tangled together

Aspect Orientation

AOP allows us to untangle the concerns ...

```
public aspect LoggingAspect {
    Logger _log = Logger.getLogger("MyAppLogger") ;

    pointcut loggedCall() : execution(@LogPoint * *.*(..)) && !within(LoggingAspect);
    before() : loggedCall() {
        Signature sig = thisJoinPointStaticPart.getSignature();
        Object arg = (thisJoinPoint.getArgs().length > 0 ?
                      thisJoinPoint.getArgs()[0] : null) ;
        _log.entering(sig.getDeclaringType().getName(), sig.getName(), arg);
    }
    after() returning (Object ret): loggedCall() {
        Signature sig = thisJoinPointStaticPart.getSignature();
        _log.exiting(sig.getDeclaringType().getName(), sig.getName(), ret) ;
    }
}
```

... this can then be applied to code where needed ...

Aspect Orientation

- The result of using aspects:

Cross cutting code replaced with annotations

```
@LogPoint
@AuthorizationCheck(type=PERSON, access=READ)
public Person getEmployee2(String empId) {
  Person ret = empRepo.getPersonByRole(empId,
                                       Role.EMPLOYEE) ;
  return ret ;
}
```

- Non-functional code factored out to be dealt with separately
  - two aspects, one for logging one for security
  - worth noting that the security one is quite complicated

Checking Rules with Aspects

- As well as applying code, aspects can be used to check code structures and dependencies
- AspectJ's "warning" and "error" advice keywords

```
declare error <pointcut> : "error message"

declare warning <pointcut> : "warning msg"
```

- Create a library of pointcuts that allow the error and warning declarations to be read easily
- Better suited to some sorts of checks than others
  - e.g. "don't call X from Y" is easy to do
  - e.g. "If I have an X I should have a Y" is difficult to express

Example Rule Checking Aspect

- We don't want any classes calling JDBC unless it's part of the DAO layer
- We do this by creating pointcuts to define the JDBC layer and JDBC calls and combining them

```
public aspect StructureCheckingAspect {
  pointcut inDao() : within(com.myorg.myapp.dao.*) ;

  pointcut callsJdbc() : call(* java.sql.*.*(..)) ||
                         call(* javax.sql.*.*(..)) ;

  declare error : !inDao() && callsJdbc() :
      "Only call JDBC from DAOs" ;
}
```

Arch Java

- Arch Java is a research project from CMU
  - Created as part of Jonathan Aldrich's PhD in 2003
  - Development continued to 2005, but largely dormant now
  - Not a practical proposition, but a glimpse at the future
- Seamless extension to Java to add design ideas
  - first class components and connectors
  - provides a compiler to compile to vanilla .class files
- While not practical for project use, Arch Java does illustrate extending code for design concepts
  - can only hope that an open source project does something similar!

Arch Java Syntax

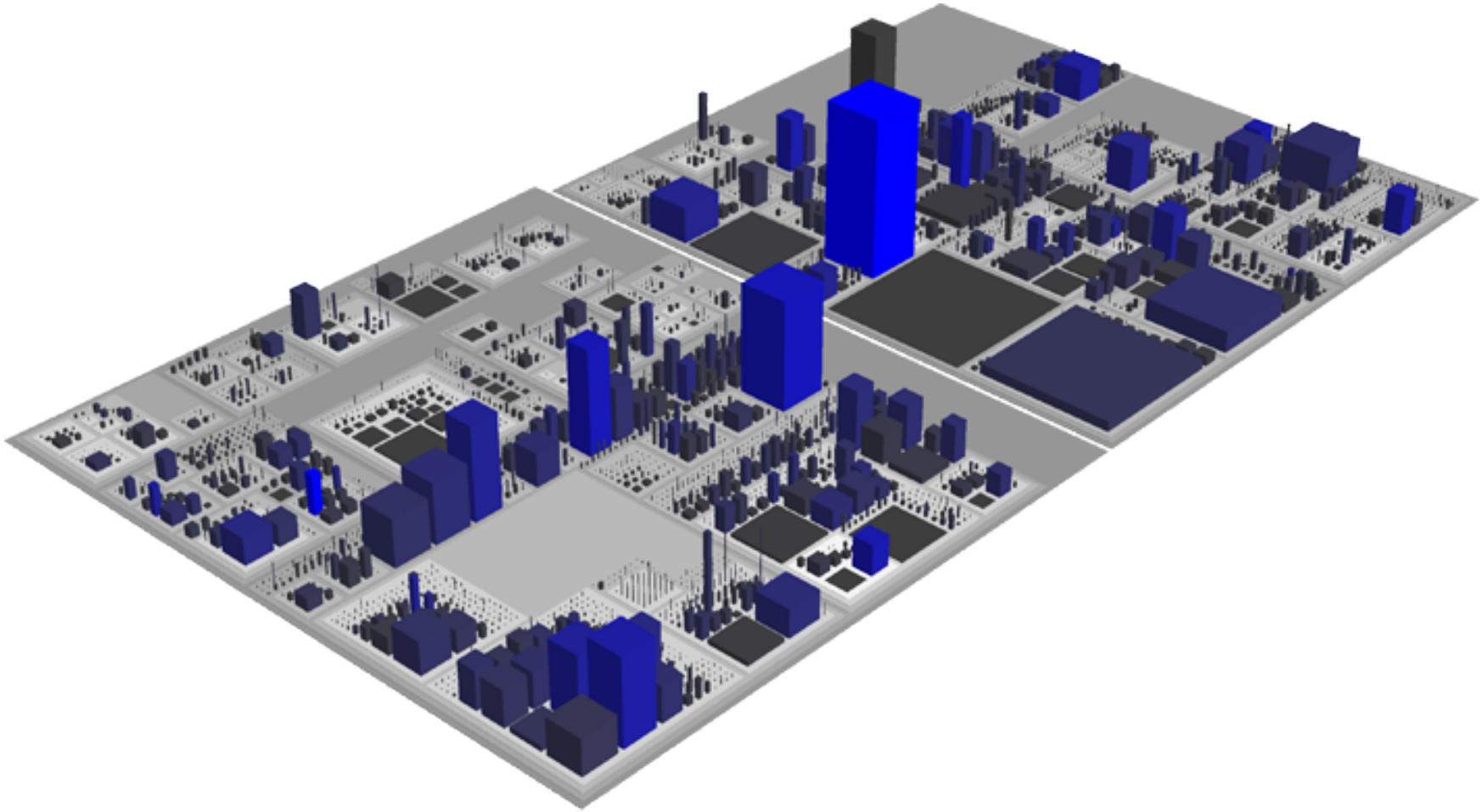
New keywords added to Java

Vanilla Java syntax still used

```
public component class MasterSlave {

  private final Master master = new Master();

    connect pattern Master.Request, Slave.Service
                with AsynchronousConnector {

        // connection constructor called to connect to a slave
        connect(Master sender, int id) {

        // create a new slave component
        Slave slave = new Slave(id);

        // create and return an async connection master to slave
        return connect(sender.Request, slave.Service)
                    with new AsynchronousConnector(connection);

    }

  }

}
```

Design concepts introduced into the code as executable statements

A Final Tool – Code City Visualisation



This is Code City primarily showing metrics rather than structure
http://www.inf.usi.ch/phd/wettel/codecity.html

Summary

Summary

- A lot of valuable design gets lost when you move to code
- Most mainstream tools don't help to prevent this
- We *can* keep, check & recover design
  - careful structuring, modularisation and naming
  - dependency analysis and rules checking
  - external design meta-data
  - new code structuring technologies (e.g. aspects)
- Much of this is new or niche
  - how many projects to do you know with messy design?!
- Use a combination of tools to maintain, check and retrieve design information in/from code
  - integrate tools into the build as well using them interactively

A final Thought …

It's late …
do you know where
your design is?? ☺

Questions and Comments?

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