Software Components Compatibility Verification Based on Static Byte-Code Analysis

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Agenda

- Compatibility problems of current component based applications
- Proposed solution: Dependencies reconstruction and evaluation
- Classification of incompatibilities that can be discovered
- Approach implementation
- Case-study
- Limitations

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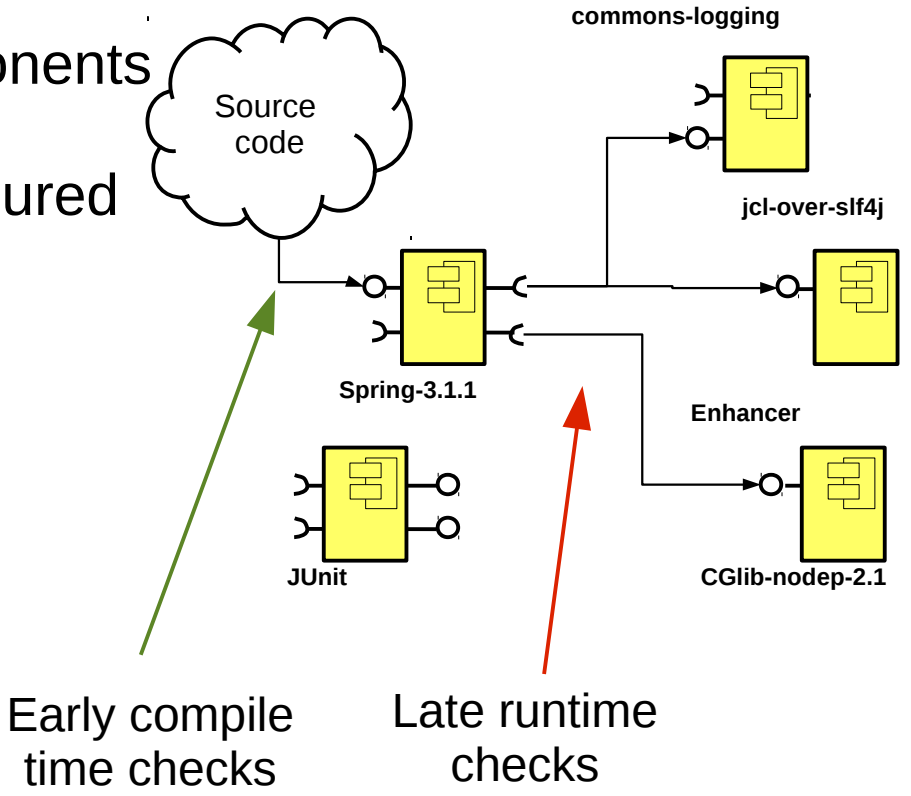
Problem

Applications from preexisting components may contain type incompatibilities

- Type compatibility traditionally ensured by compilation
- Preexisting components already compiled
- Compile time checks skipped
- Other means to ensure type compatibility required



Type errors manifested at runtime

- e.g. LinkageError in Java
  - NoSuchMethodError
  - ClassNotFoundException

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Proposed Solution

- Dependencies reconstruction from binaries
  - Byte-code in Java
- Dependencies' consistency evaluation
  - In terms of binary compatibility
- Compatibility decision
  - Prevents runtime errors
  - “as if compiled by compiler” but working with binary compatibility (differ in Java)

Created Java byte-code analyzer an verification tool

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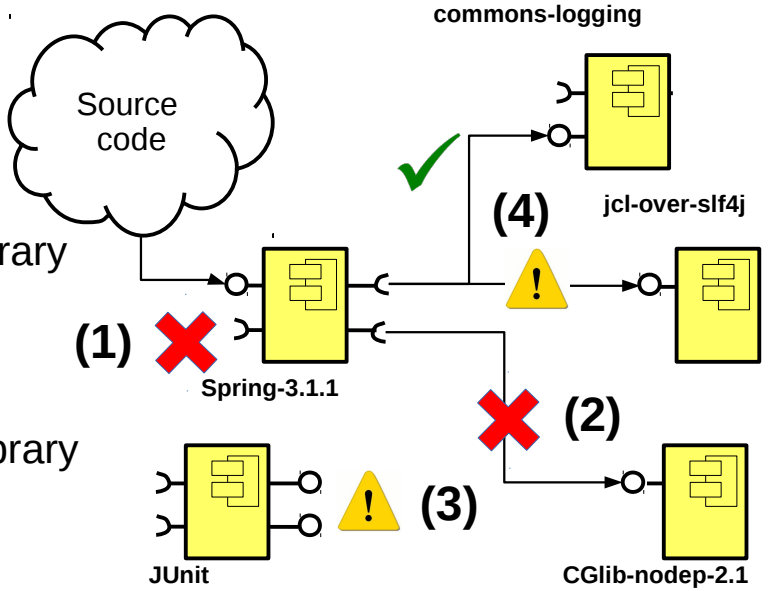
Incompatibilities Classification

- Missing dependencies **(1)**
  - Produce runtime exceptions (NoSuchMethodEx, ClassNotFoundEx, ...)
  - e.g. missing libraries, forgotten transitively dependent library
- Inconsistent dependencies **(2)**
  - Produce runtime exceptions (LinkageError, ...)
  - e.g. incompatible method signatures caused by wrong library version
- Redundant dependencies **(3)**
  - No error, but increased application size
  - e.g. forgotten test libraries in production code (JUnit)
- Duplicated dependencies **(4)**
  - Application may misbehave (two libraries provide the same API, differ in function)
  - e.g. two different implementation of logging



Dependency Reconstruction

Java byte-code analyser

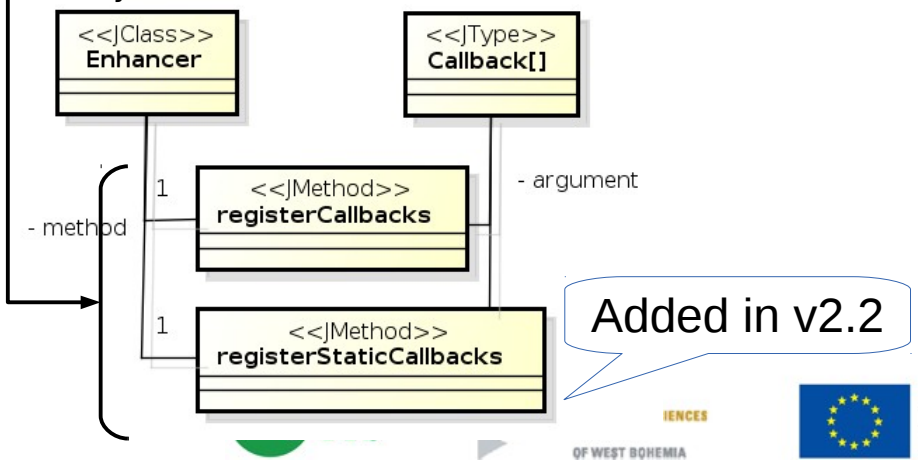
Component API (e.g. CGlib)

```
public class Enhancer {

public static void
  registerCallbacks(
    Class generatedClass,
    Callback[] callbacks) { … }

public static void
   registerStaticCallbacks(
     Class generatedClass,
     Callback[] callbacks) { … }

}
```



API invocation (e.g. Spring)

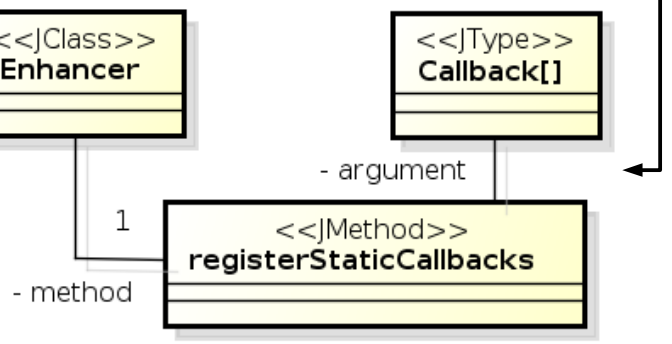
```
class ConfigurationClassEnhancer {

  private Class<?>  createClass(
    Enhancer enhancer) {

      Class<?> subclass =
            enhancer.createClass();

      Enhancer.registerStaticCallbacks(
        subclass, this.callbackInstances);

    return subclass;
  }
}
```



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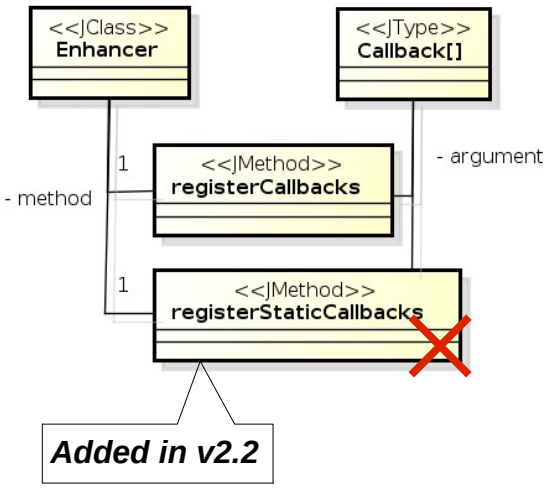
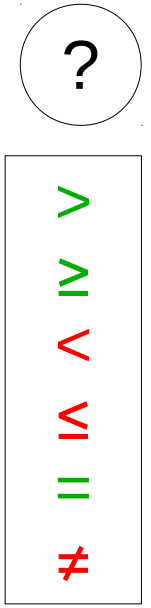
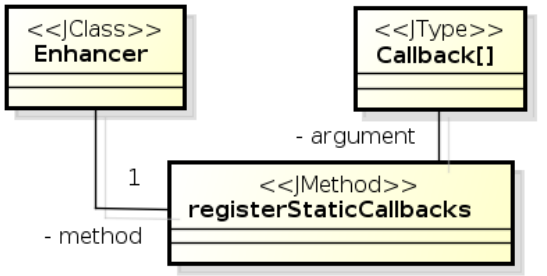
Dependency Evaluation

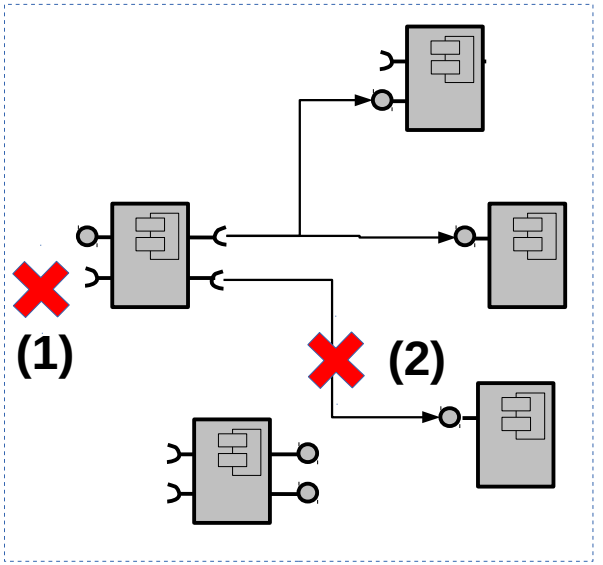
Component API





API invocation





- Two models compared
  - Missing dependencies **(1)**
  - Inconsistent dependencies **(2)**
  - Redundant dependencies **(3)**
  - Duplicated dependencies **(4)**

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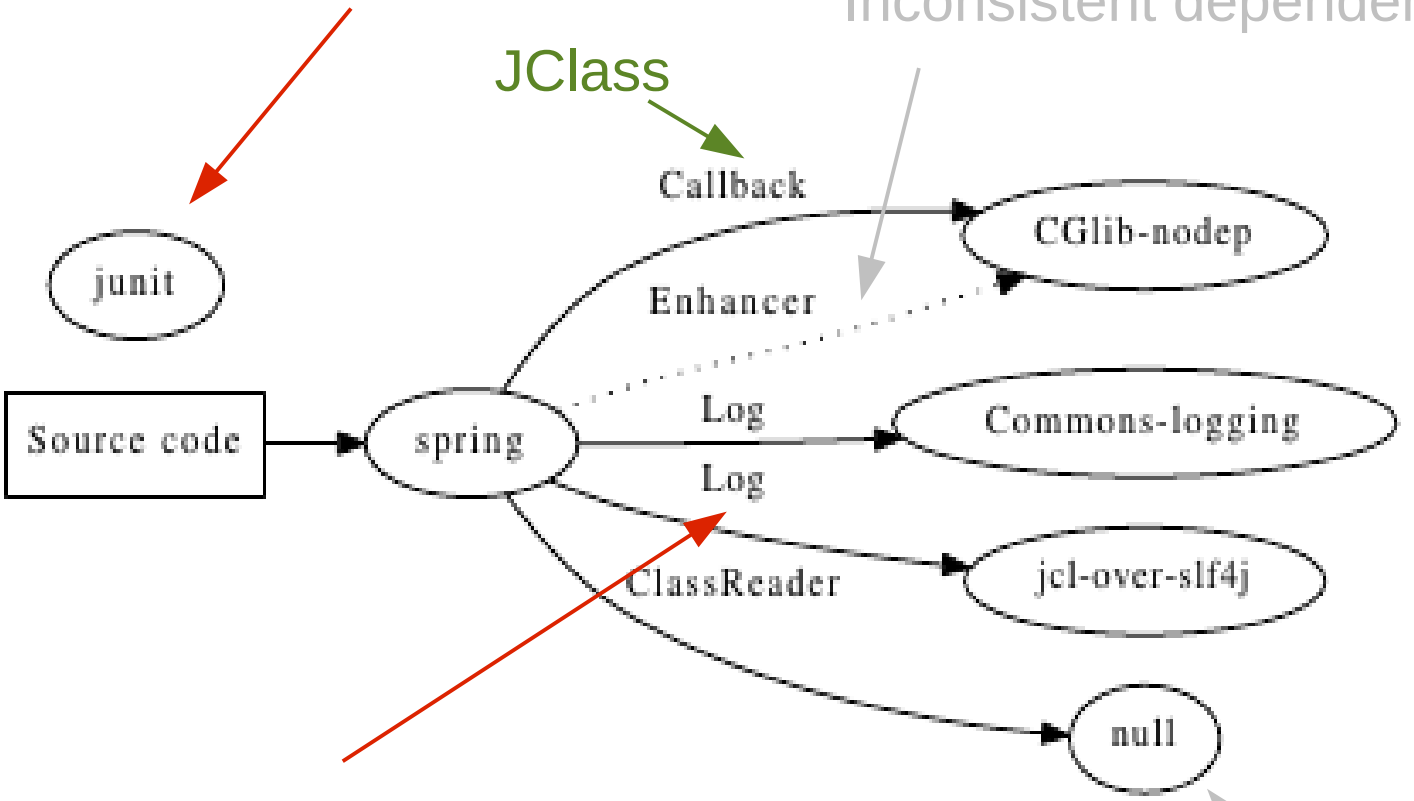
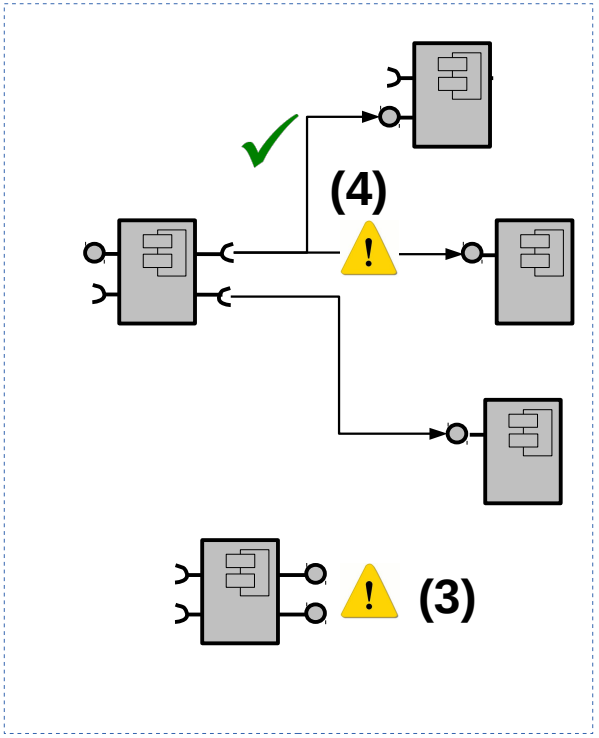
Compatibility Decision

Redundant dependencies **(3)**

Inconsistent dependency **(2)**





Duplicated dependencies **(4)**

Missing dependency **(1)**

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Case-study

- Analysed JEE application
  - Spring, OrientDB, FreeMarker, ... (50 libraries)
  - Build by maven
- Developed Maven plugin to run evaluation
  - Invoked on build (verify phase)
- Discovered problems:
  - Inconsistent dependency: wrong CGlib version (v2.1 instead of v2.2)
    - Caused runtime exception
  - Duplicated dependency: logging: jcl-over-slf4j and commons-logging)
    - Required two configuration files
  - Redundant dependency: JUnit in production code

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Limitations

- Approach limited to static types in permanent byte-code
  - Analyses also API invocations in code that is never invoked (death code)
  - Byte-code generated at runtime, Java Reflection ignored
    - But common in current Java frameworks
- In Case-study
  - Migration to Tomcat 5.5
    - runtime JSTL definition loading not detected (NoClassDefFoundError:javax/el/ValueExpression)
  - Missing JSON parser
    - runtime classpath scanning not detected (exception on AJAX request invocation)

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Conclusion

- Static incompatibilities not detected by compilers in current software
- Proposed byte-code analyser to fill this gap
- Implemented as Maven plugin
- Shown on JEE application
- Usable in development process
  - By Maven plugin

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Thank you for your attention

Questions?

Find us:

Static compatibility tool (JaCC)

https://www.assembla.com/spaces/jacc/

Maven plugin (CCP3)

https://www.assembla.com/spaces/ccp3/

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