The long Good-Bye to NullPointerException

Stephan Herrmann

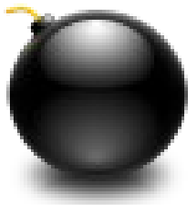
The Road Behind

- 1965 — The billion dollar mistake
  - 1965 Tony Hoare introduced Null references in ALGOL W
- 2006 – 3.2 — Bug 110030 – Provide support for **null reference analysis**
- 2011 – 3.8 — Bug 186342 – Using **annotations** for null checking
  - EclipseCon Europe 2011: “Bye-bye NPE”
- 2013 – 4.3 — Bug 383368 – syntactic null analysis for **field references**
- 2014 – 4.4 — Bug 392099 – Apply null **annotations on types** for null analysis
  - EclipseCon Europe 2014: “A Deep Dive into the Void”
- 2015 – 4.5 — Bug 331651 – Support **external null annotations** for libraries
- Continuous improvement of analysis for:
  - loops, assert, generics, modules, interfacing with “legacy” code
  - injection, well-known libraries

The billion dollar mistake

1965

```
String val;

...

val = null;

...

uc = val.toUpperCase();
```



Null Reference Analysis

2006 – 3.2

```
String val;

...

val = x;

...

if (val != null)
    uc = val.toUpperCase();
else
    lc = val.toLowerCase();
```

- As part of flow analysis
- Only local analysis

Using Annotations for Null Checking

2011 – 3.8

```
String meth(@NonNull String val1, @Nullable String val2)
{
    if (someFlag)
        return val1.toUpperCase();
    else
        return val2.toLowerCase();
}

...

s = meth(“hello”, null);

s = meth(null, “hello”);
```

- Inter-procedural analysis
- Simple “contracts”

Flow Analysis for Fields?

2013 – 4.3

```
class Test {
   @Nullable String f;

    String meth() {
        if (this.f != null) {
          // some code here
            return this.f.toUpperCase();
        }
        return "<don't know>";
    }
}
```

- Unexpected errors
- 3 risks of shared data
  - concurrency
  - aliasing
  - side effects
- Compromise
  - accept minimal risk
  - no sophistication
  - "syntactic analysis"

Null Annotations on Types

```
String meth(@NonNull List<@Nullable Person> val)
{
    return val.get(0).getName();
}

...
```

2014 – 4.4

- Since Java 8
- JSR 308
- @Target(TYPE_USE)
  - Contracts?
  - Extended type system

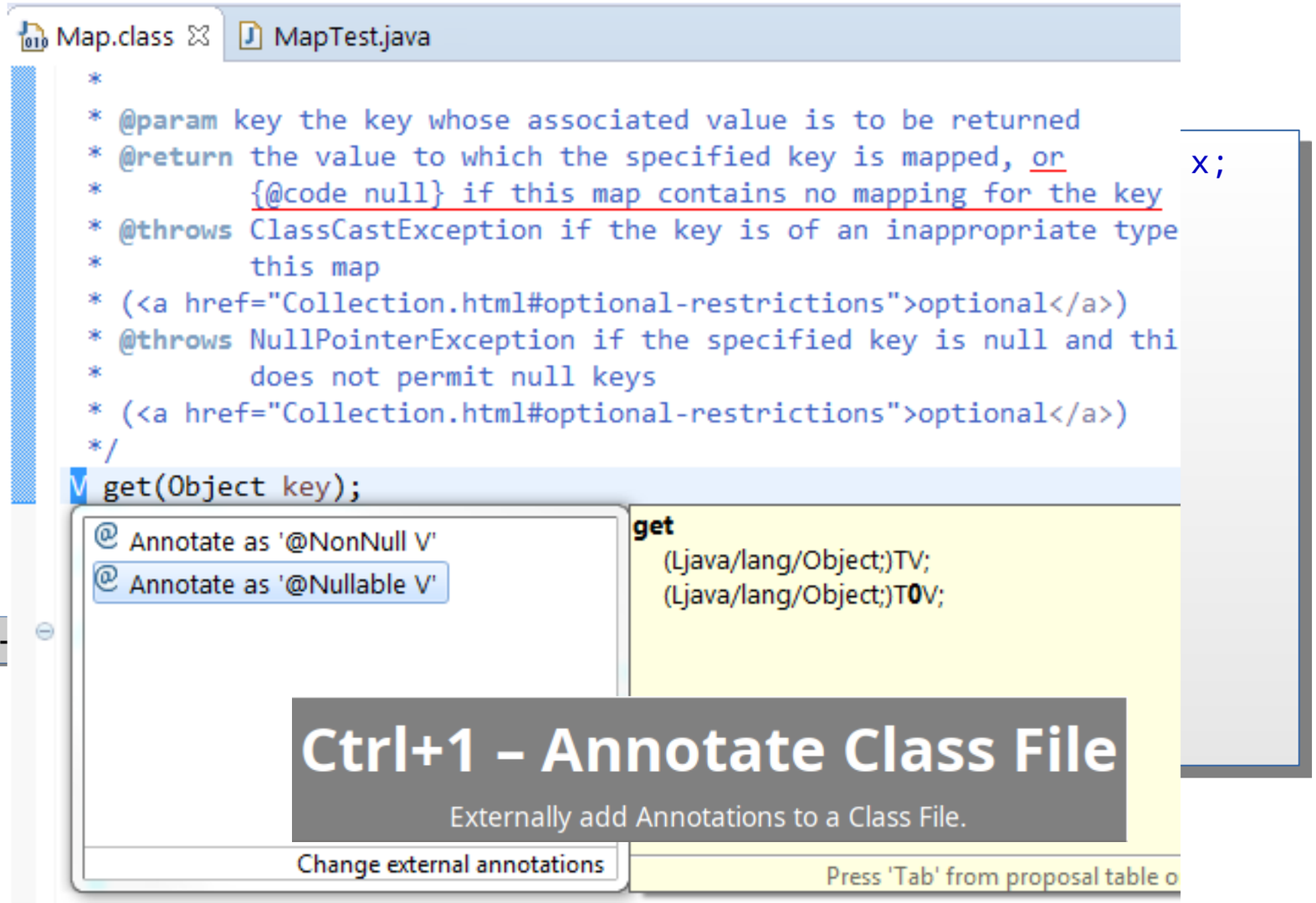
External Null Annotations

```
@NonNull Map<@NonNull String, NonNull Person> val = x;

String name = val.get("Joe").getName();

...
```

- "Legacy" libraries
- Files: *.eea
- Command "Annotate"

2015 – 4.5

External Null Annotations



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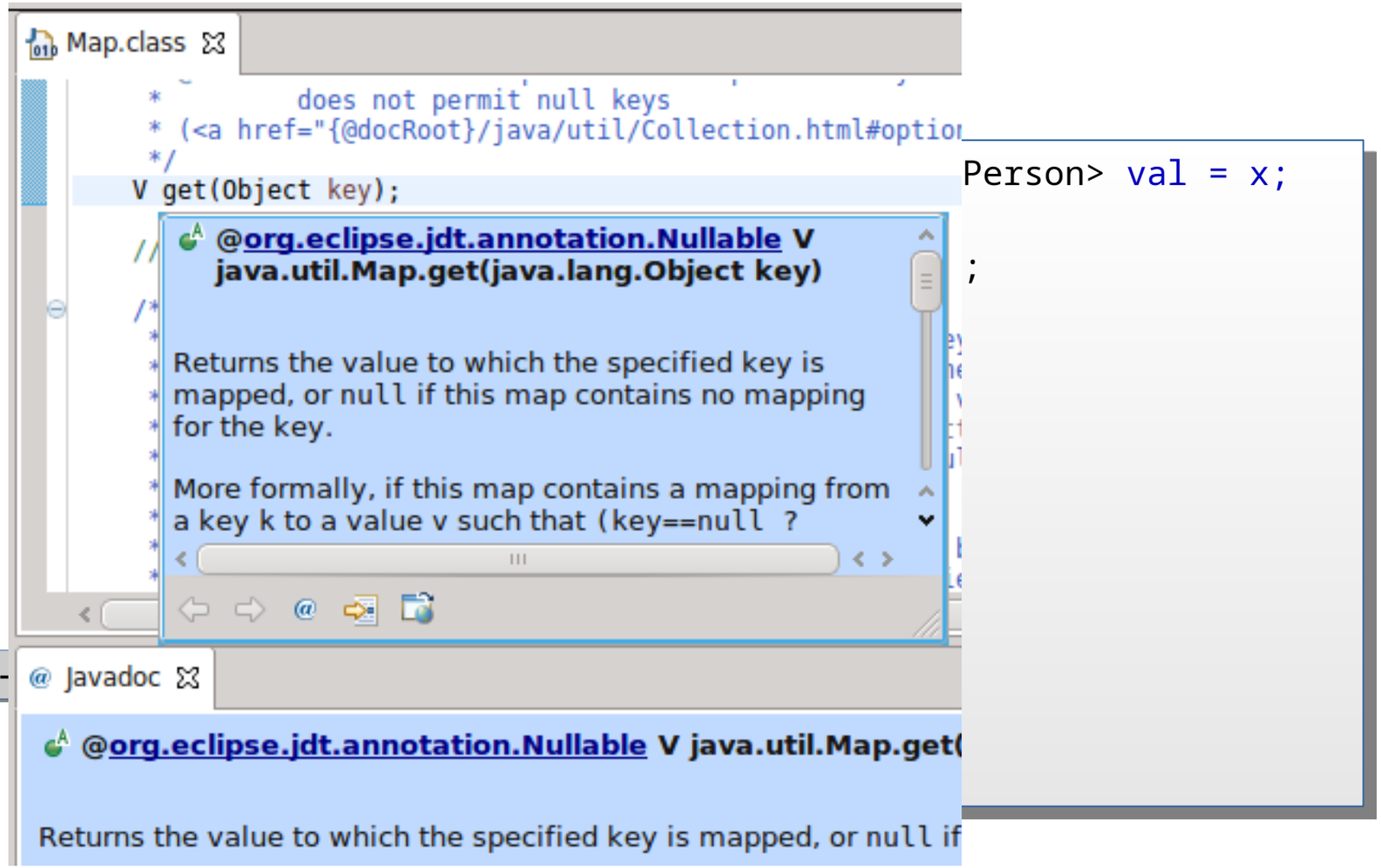

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2015 – 4.5

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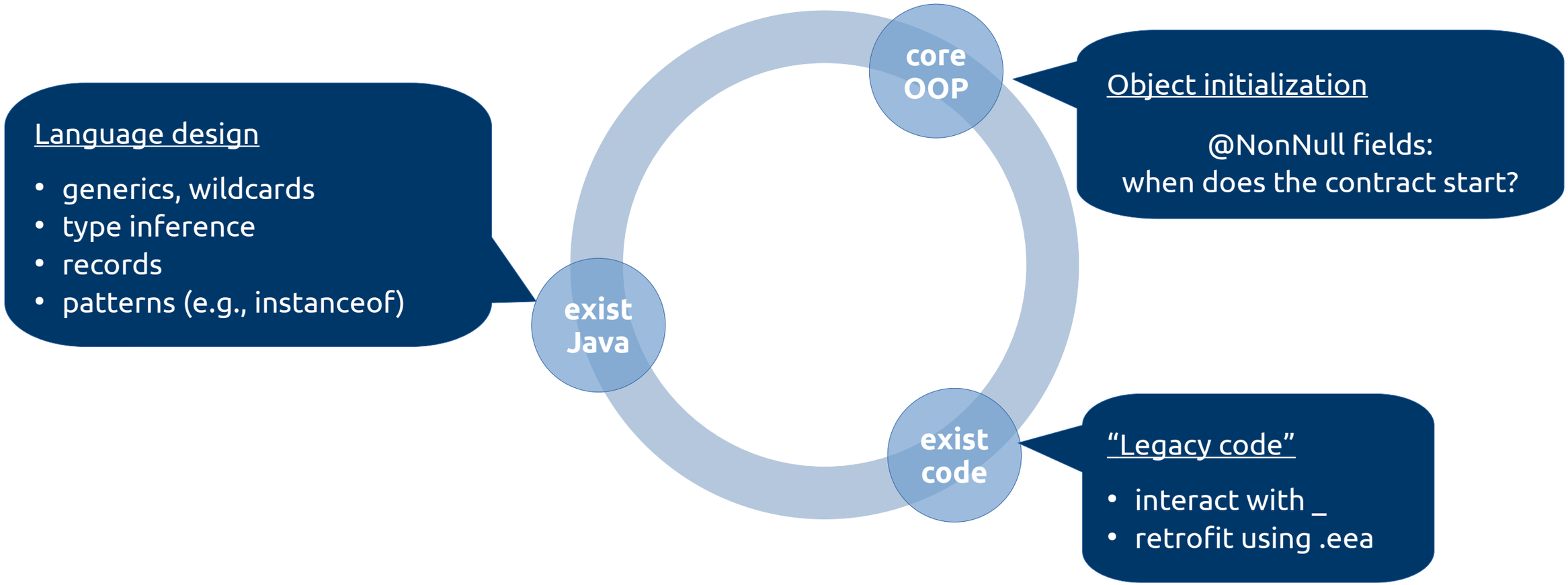
Difficulties

- Adding a core concept interacts with all that's already there



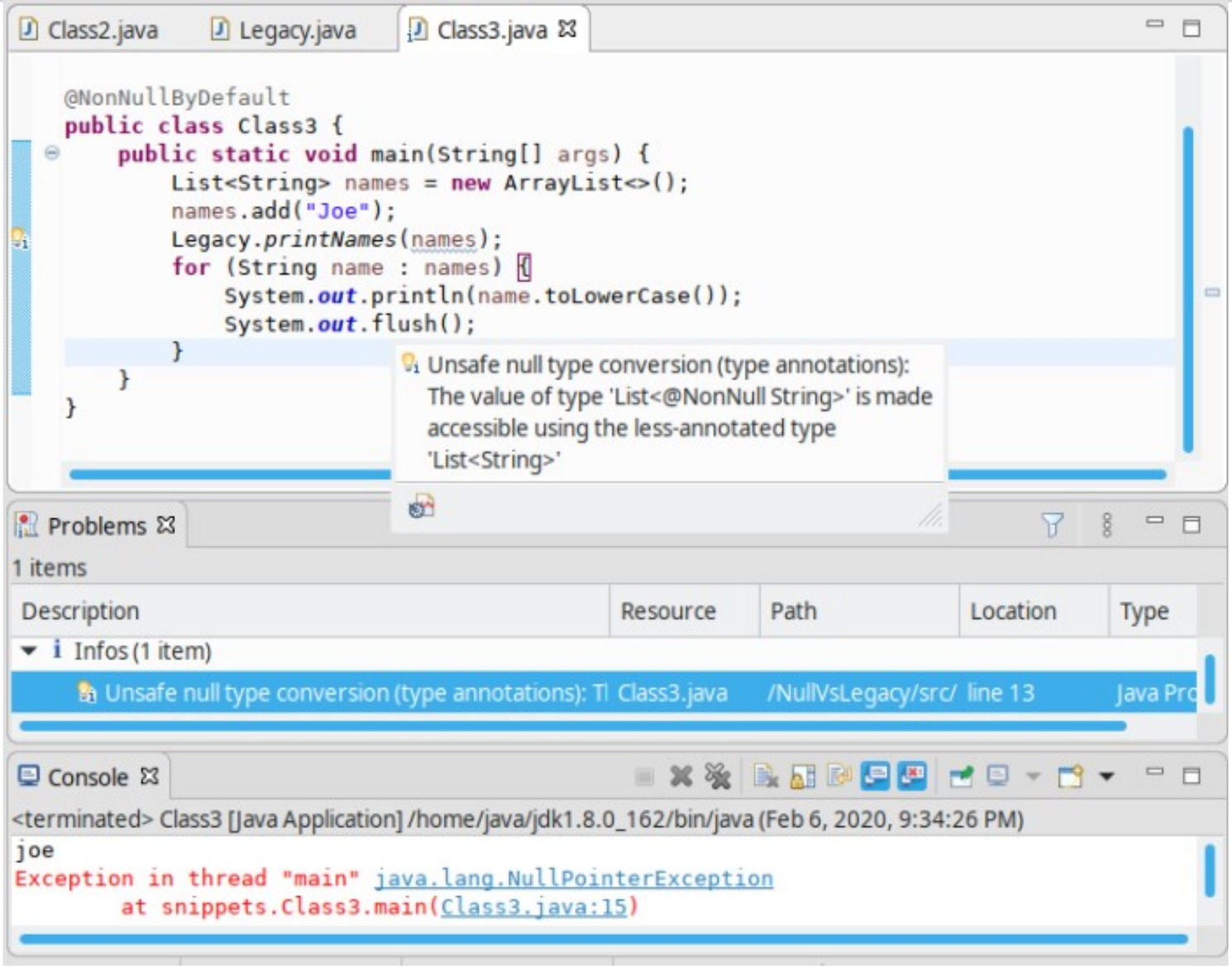
Generics meet Legacy

- Warn when

  legacy code can taint

  null-checked values

2020 – 4.15



Advances concerning **External Annotations**

What “3rd Party” Code?

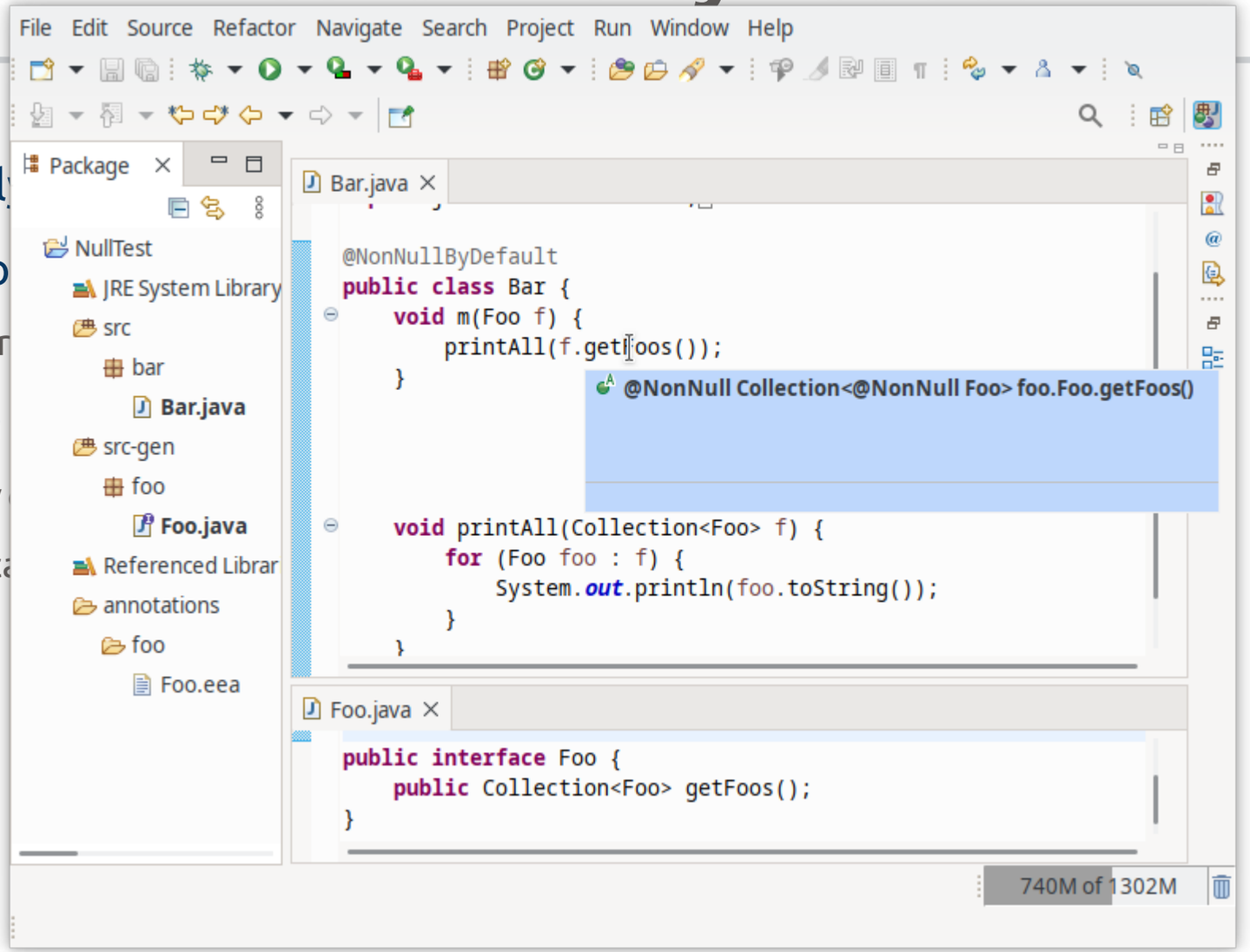
- Originally: overlays for jars
- Other code that cannot be annotated:
  - Generated code (if you don't own the code generator)!
- Solution
  - *Every* classpath entry can refer to external annotations
  - EEA can be superimposed even on sources

2021 – 4.19

What “3rd Party” Code?

- Originall
- Other co
  - Gener
- Solution
  - *Every*
  - EEA c

2021 – 4.19



What “3rd Party” Code?

- Orig
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  -
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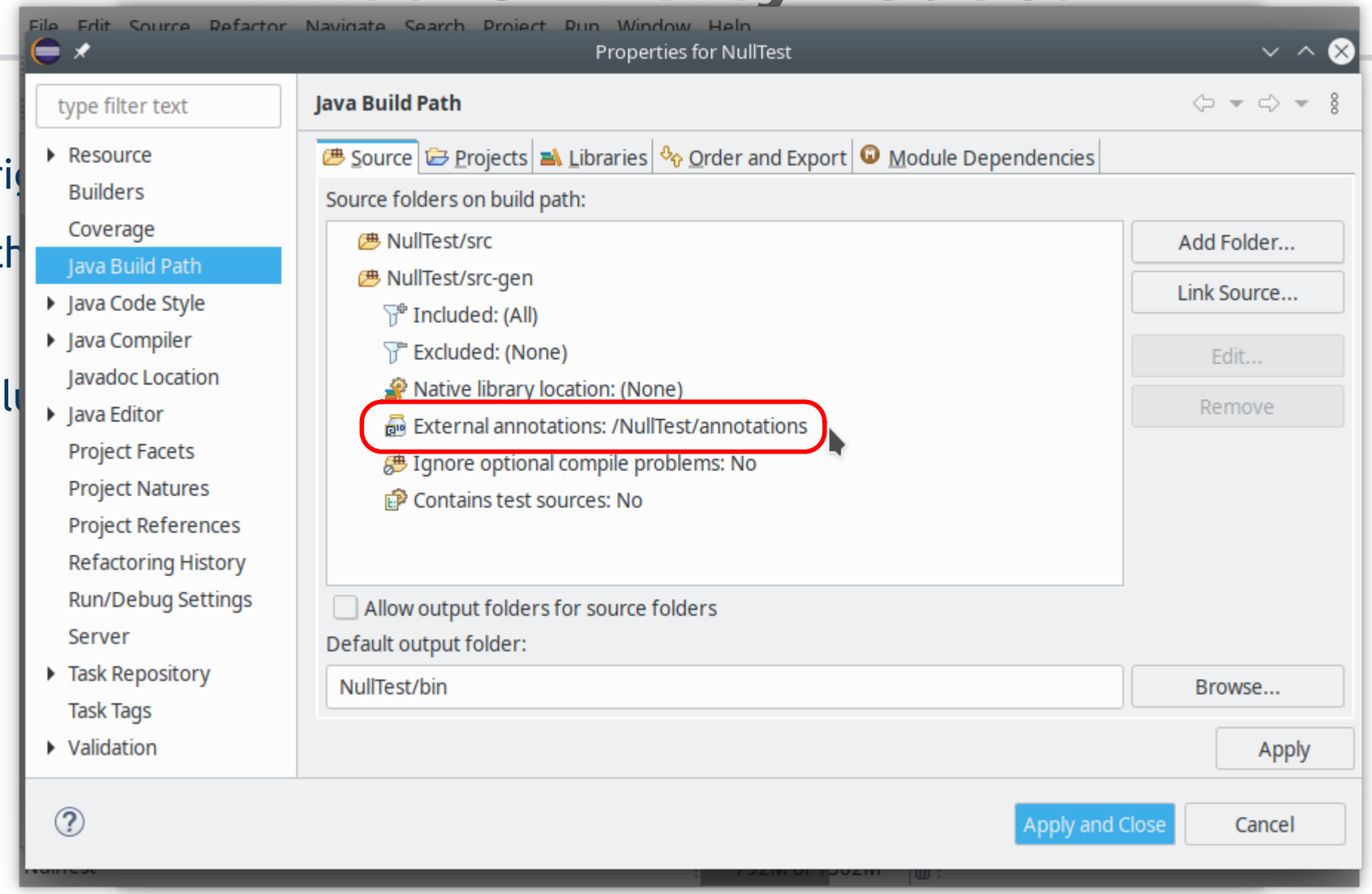
2021 – 4.19



How do clients see my code?

- Internally, .eea have become part of generated sources
- Clients of those classes should see the same API!
- PDE supports new directive in MANIFEST.MF
  - Ensure .eea are included in deployed jar (build.properties)
  - Eclipse-ExportExternalAnnotations: true
  - PDE will do the rest behind the scenes
    - Resolved elements of **Plug-in Dependencies** will have proper **annotationpath**
- Useful for
  - Plug-in projects with ...
  - … generated source ...
  - … superimposed with .eea

2022 – 4.24

How to Manage .eea?

- Text files
  - Initially expected **inside** each project using a legacy library
- Should each project maintain its own set of .eea?
  - Shareable as jar files / artifacts
- Brute force:
  - Search all classpath locations for .eea
- Bad impact on IDE performance

see also: **lastnpe.org**
addresses such issues by extending m2e

The challenge for EEA in the IDE

- JDT should precisely know where to find .eea
  - But now .eea are **artifacts** needing **dependency** management
- Dependency management is handled by your **build system**
- JDT doesn't know *any* build system
  - But JDT knows about **classpath containers**
    - Plug-in Dependencies
    - Maven Dependencies
    - …
- Solution
  - Specify annotation location relative to a classpath container:
  - annotationpath=**org.eclipse.pde.core.requiredPlugins**/org.example.annotations
  - If annotation artifact is in your dependencies* then JDT will find it for eea lookup

2022 – 4.24

IDE vs. CI Builds

- IDE “knows” about .eea
  - Annotation path is configured via **.classpath**
    - .classpath may depend on Eclipse-specifics (like classpath containers)
  - Read .eea:
    - compiler
    - hover
  - Write .eea:
    - **Ctrl+1** Annotate
- Build tools don't know about **.classpath**
  - Add .eea artifacts to your dependencies
  - Catch all: -annotationpath CLASSPATH

```
<plugin>
    <groupId>org.eclipse.tycho</groupId>
    <artifactId>tycho-compiler-plugin</artifactId>
    <configuration>
        <useProjectSettings>true</useProjectSettings>
        <compilerArgs>
            <compilerArg>-annotationpath</compilerArg>
            <compilerArg>CLASSPATH</compilerArg>
        </compilerArgs>
    </configuration>
</plugin>
```

Summary

- Did I promise too much in 2011?
  - Yes
- Is treatment of null a reason to abandon Java?
  - No
- Is it possible to create provably NPE-free code?
  - Yes, but only in green field, clean room development.
- Which TYPE_USE annotations?
  - ~~Not “JSR 305”!~~
  - org.checkerframework.checkers.nullness ?
  - org.eclipse.jdt.annotation_2.2.x ?
  - org.jspecify ?