Lecture 19:
Verification, Validation and Testing

Test automation · Test coverage · Bug reporting · Alternatives to testing

INF2-SEPP

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This Lecture

- Test automation with JUnit 5
  - Main components of a JUnit 5 test class
  - Assertion statements in JUnit 5
- Java inline assertions and their alternatives
- Test coverage and tools for it (IntelliJ IDEA)
- Bug reporting and tools for it (Trac, JIRA)
- Alternatives to testing:
  - Reviews / walkthroughs / inspections
  - Static Analysis and tools for it

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- JUnit is a framework for automated testing of Java programs.
- You will use JUnit 5 in Coursework 3.
- Similar frameworks are now available for most programming languages.

Main Components of a JUnit 5 Test Class

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- Contents: code to execute the code under test, assert method(s), usually an informative failure message.

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- @Tag("<TagName>") — tag the test; JUnit 5 allows running tests with a chosen tag.
- @RepeatedTest(<Number>) — repeat a test a specified number of times.

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- All methods accept an optional custom error message String.

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Assertions checking can be switched on/off.

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- Proper exception-based error handling (e.g. throw NegativeArgumentException) is another option.

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public static double sqrt (double x){
   if (x <0){
     throw NegativeArgumentException(”Cannot take the square
     root of a negative number!”);
   }
  /*..*/
}
```

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- Proper exception-based error handling (e.g. throw NegativeArgumentException) is another option.
- Pro: program fails gracefully rather than crashing with AssertionError.
- Con: checking inputs everywhere leads to duplicated code across classes.
- Recommended: validate at the UI boundary; use inline assertions elsewhere to catch internal faults.

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- Other types: basic condition coverage, MC/DC, path coverage …
- This course focuses on statement and branch coverage.

Statement and branch coverage

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void decideGreater(int a, int b){
  if (a>b)
    System,out.println(“a is greater than b”);
}
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a=5; b=4

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- Things can get complicated with nested or complex conditions

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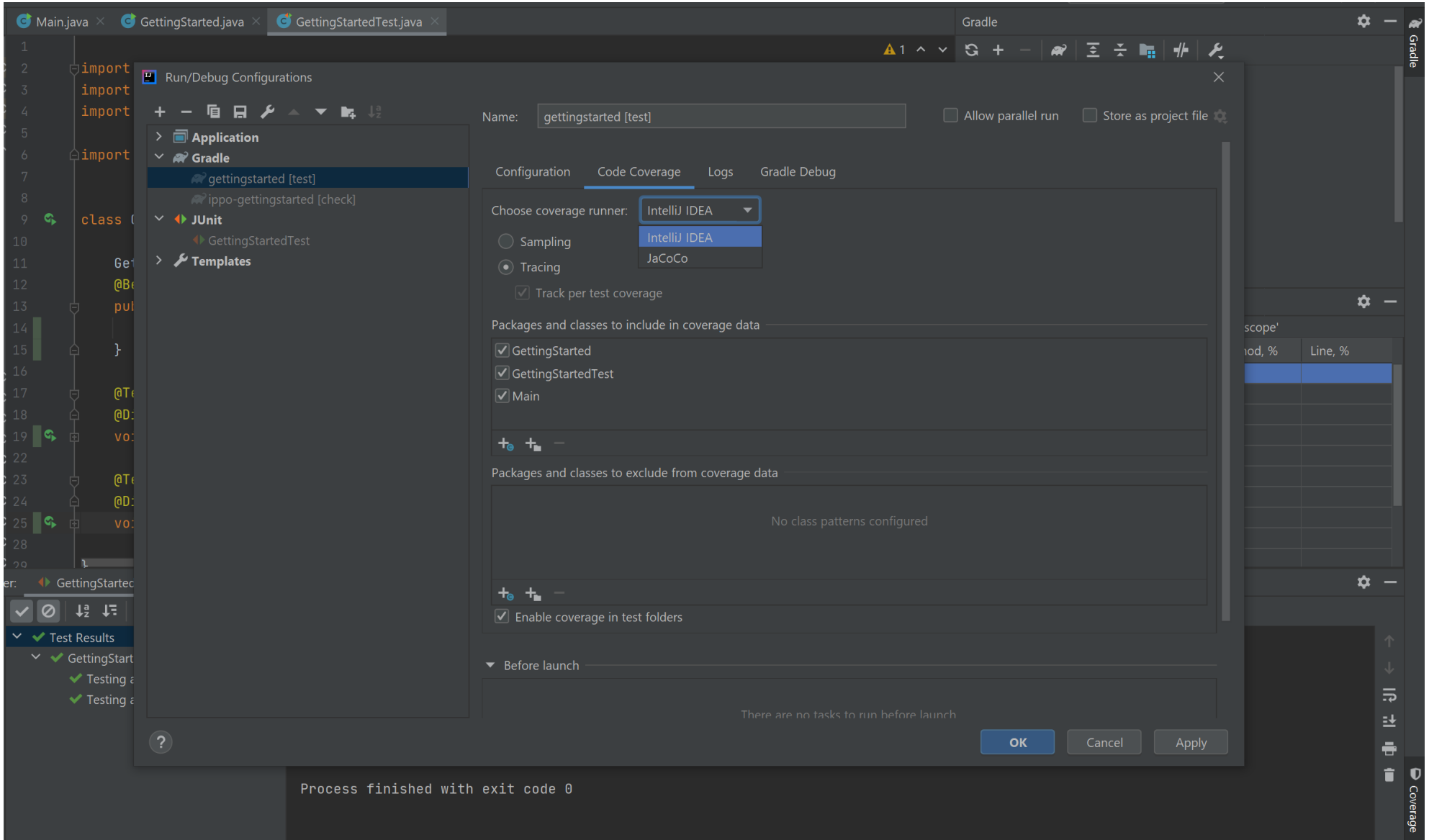
- Path coverage is exponentially more complex.
- Coverage-based (white-box) testing should be combined with black-box testing.

Coverage Tools — General & IntelliJ IDEA

- Open-source tools for Java/JUnit: CodeCover, EMMA, Gretel, JaCoCo, Quilt.
- Commercial tools: Atlassian Clover, Testwell.

Code Coverage in Intellij IDEA



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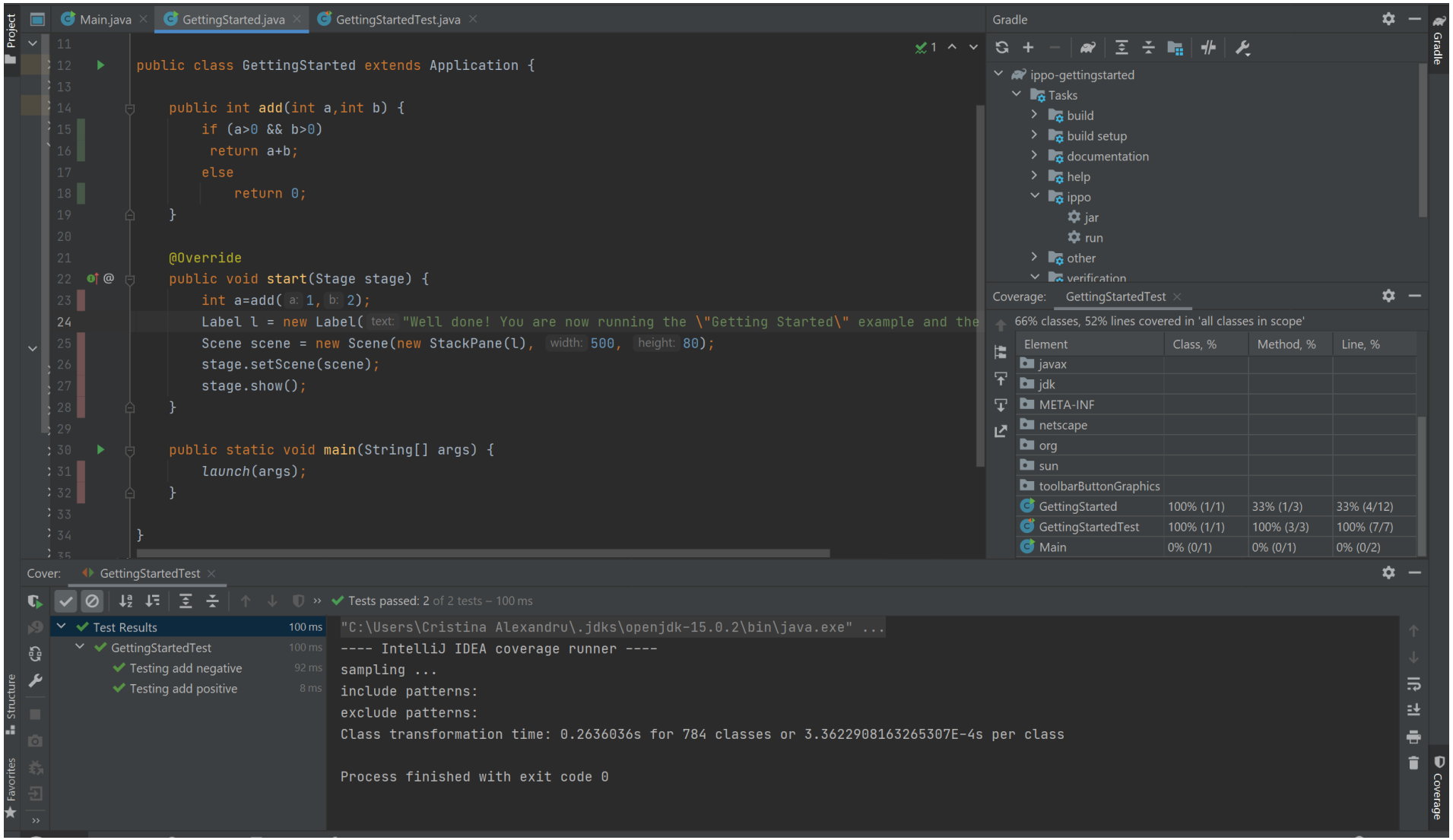

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- Commercial tools: Atlassian Clover, Testwell.
- IntelliJ IDEA has its own coverage runner and integrates JaCoCo and EMMA.
- Run with coverage: Edit Configurations → Code Coverage tab → choose runner (IntelliJ IDEA / JaCoCo).
- Results shown inline (green/red gutter) and in a Coverage summary panel showing Class %, Method %, Line %.

Example

Emma is working on building a library system (contains classes such as Book, BookCopy, User, LibraryMember etc). She wants to check if her code handles borrowing books well. Specifically, she wants to test the following situation: if a LibraryMember has already borrowed 12 items, they cannot borrow more, unless 2 or more of the borrowed items are journals. This functionality should only be available for a LibraryMember, not a regular user.

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- JIRA is very popular; free for teams smaller than 10.

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- Each ticket has a detail page: priority, keywords, description, workarounds, attachments.

Bug Tracking: Trac

Ticket	Summary	Component	Version	Milestone	Type	Owner	Status	Created
#3292	OOS on rejoin with new pathfinder	Core engine		Alpha 19	defect		new	Jun 13, 2015
#3471	Units not detecting invalid path.	Core engine		Alpha 19	defect		new	Sep 30, 2015
#3505	Pathfinder - Units in formation stuck frequently	Core engine		Alpha 19	defect		new	Oct 8, 2015
#3551	[PATCH] Prohibit developer overlay cheats in rated games	UI & Simulation		Alpha 19	defect		new	Oct 26, 2015
#3549	Secure authentication - prevent joins as a different player	Core engine		Alpha 20	defect		new	Oct 24, 2015
#3255	[PATCH] Prevent replay overwrites by using date and sequential ID	Core engine		Alpha 19	defect	elexis	new	May 20, 2015
#3271	OOS on rejoin - different mirage order	Core engine		Alpha 19	defect		new	May 27, 2015
#3526	Build a tower in enemy territory	UI & Simulation		Alpha 19	defect		new	Oct 14, 2015
#3545	[PATCH] Crash the game using cheats	UI & Simulation		Alpha 19	defect	stanislas69	assigned	Oct 23, 2015
#3241	[PATCH] Kick / ban players from a match	UI & Simulation		Alpha 19	enhancement	elexis	new	May 10, 2015
#1791	Units command queue is reset when they enter new formation	UI & Simulation		Alpha 20	defect		new	Dec 19, 2012
#2001	Melee units with big maximum range can attack through walls	UI & Simulation		Alpha 20	defect		new	Jun 24, 2013
#2303	Update tutorials and increase their visibility	UI & Simulation		Alpha 20	defect		new	Dec 8, 2013
#2427	[PATCH] AtlasUI does not open on on commandline Mavericks 10.9	Atlas editor		Alpha 20	defect	trompetin17	new	Feb 8, 2014

Bug Tracking: Trac

#3471 new defect

Opened 5 weeks ago
Last modified 2 days ago

Units not detecting invalid path.

Reported by:	stanislas69	Owned by:	
Priority:	Release Blocker	Milestone:	Alpha 19
Component:	Core engine	Keywords:	pathfinding
Cc:	Itms		

Description (last modified by elexis) Δ

We played a match today with elexis and ffm, and we noticed that units would often try to go from a point 'a' to a point 'b' without realising they wouldn't be able to reach it. So they just walk into the void.

The only we could workaround it, is by cancelling orders, and removing formations (setting it to none)

FFM stated formation should be disabled whereas I think it should be set to none by default.

▶ **Attachments** (6)

Bug Tracking: JIRA

- Widely-used commercial issue tracker by Atlassian.
- Issue list view shows: type, key, summary, assignee, reporter, priority, status, created date.
- Individual issue view: description, attachments, environment, original estimate, time tracking, due date, priority.
- Supports comments, history, work log, sub-tasks, and linked issues.

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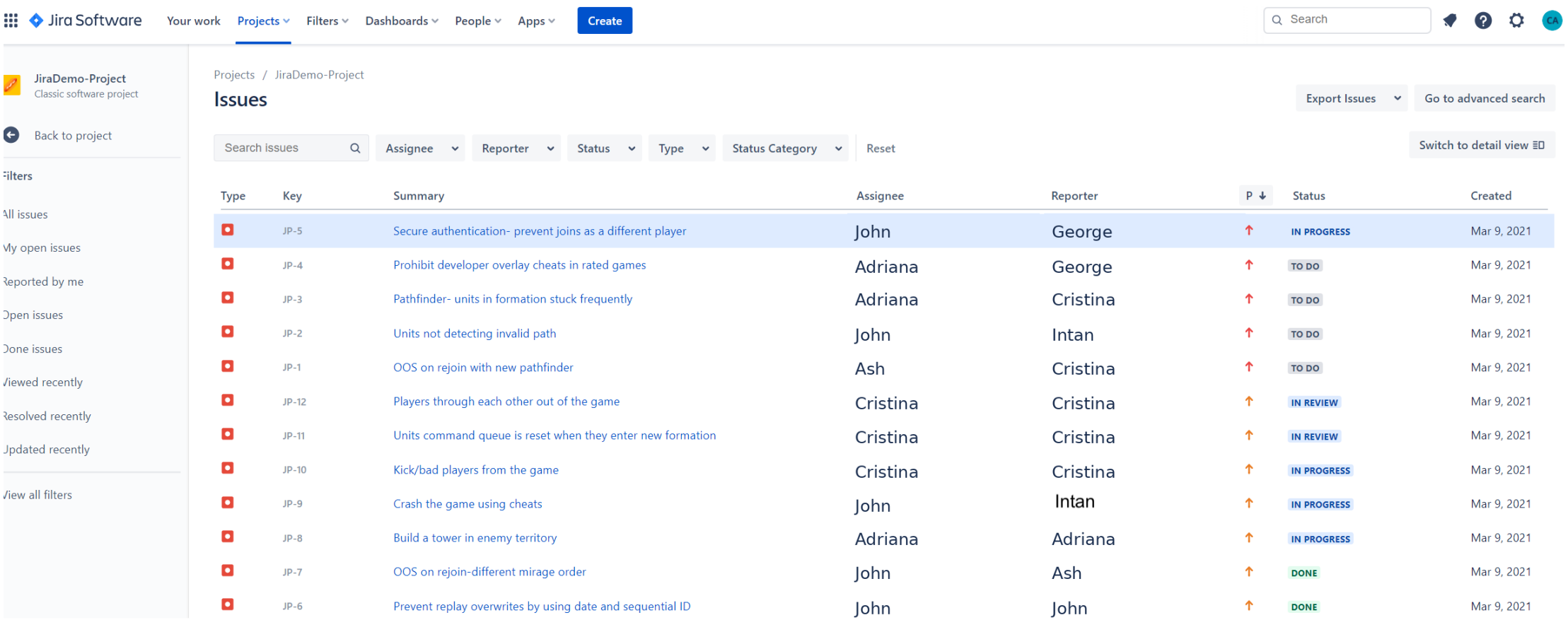

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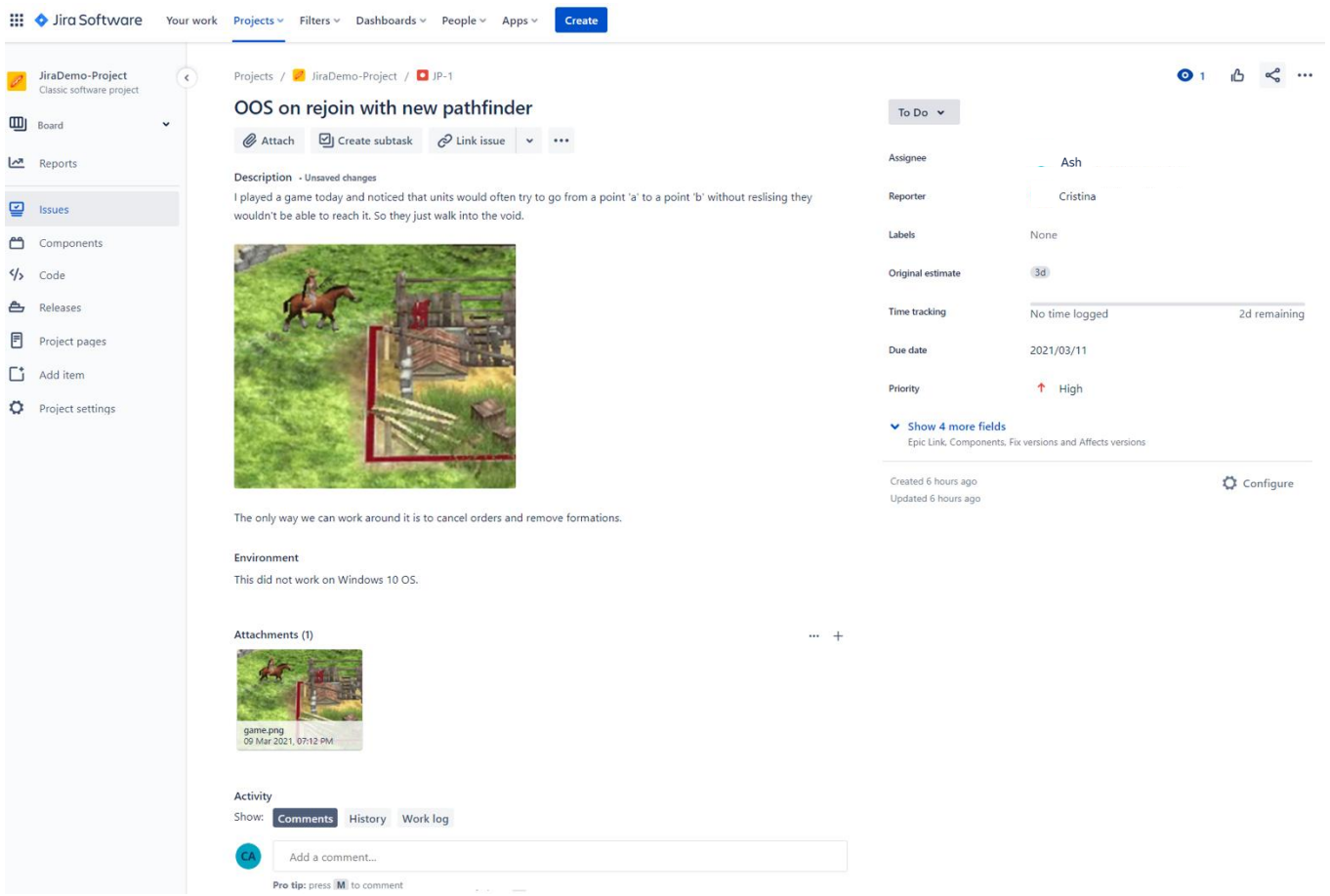

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- Outside views complement the author's own perspective.
- Reviews, walkthroughs, and inspections are treated as equivalent in this course ('Review').

Alternatives to Testing: Static Analysis

- Automatically inspecting code to determine properties without running it — very active research area.
  - Type-checking during compilation is a basic form of static analysis.
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- More automated / large-scale tools: may flag false positives and miss some bugs.
- Think of them as bug-hunting aids, not correctness guarantors.

Static Analysis Tools for Java

- SpotBugs (formerly FindBugs) — looks for bug patterns and incorrect code idioms; widely used.
- ThreadSafe (Contemplate, Informatics spin-out) — focuses on concurrency bugs.
- Infer (Meta/Facebook) — lightweight analysis scaling to 10^6+ LOC; finds null pointer and concurrency issues.
- Give SpotBugs or Infer a try!

Reading & Resources

- JUnit 5: http://www.junit.org
- JUnit Tutorial: vogella.com/articles/JUnit/article.html
- JUnit 5 Assertions API: petrikainulainen.net (JUnit 5 tutorial series)
- Writing tests in IntelliJ IDEA: jetbrains.com/help/idea/tests-in-ide.html
- Inline assertions in Java (Preconditions, Postconditions, Invariants): docs.oracle.com/javase/7/docs/technotes/guides/language/assert.html
- Statement & branch coverage: guru99.com/code-coverage.html
- Unit testing & coverage in IntelliJ IDEA (video): youtube.com/watch?v=QDFI19lj4OM
- JIRA bug tracking: atlassian.com/software/jira/bug-tracking
- SpotBugs: spotbugs.github.io | Infer: fbinfer.com