Labeling Guide - Testability Refactoring Patterns

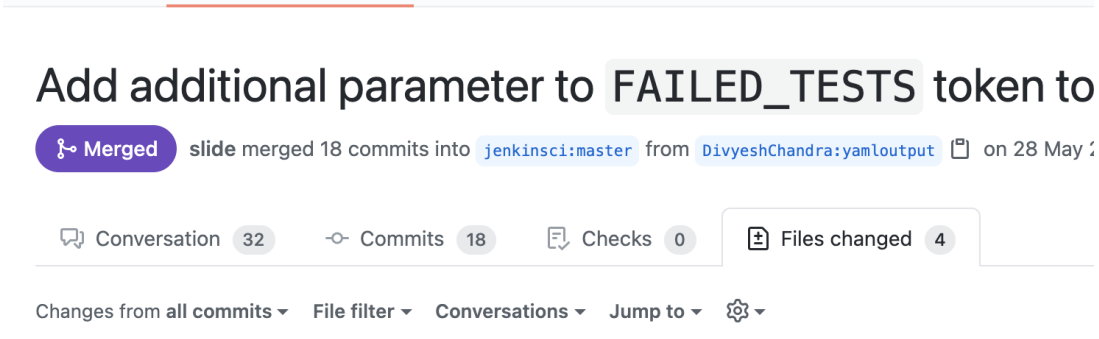
This task is an important step of a scientific study on refactoring for testability. One of the researchers has already labelled several hundreds GitHub Pull Requests (PRs) with common refactoring patterns that are listed below checking whether the specific pattern is present in the Pull Request or not. To ensure that the results are reliable and minimise errors in the labelling process, we need a second (independent) opinion.

Refactoring for testability is essentially about changing the structure of production code without changing its behaviour in order to make it possible to write unit-tests for it or to improve or extend existing unit tests Here two examples of refactoring the production code for the purpose of testablity:
Example 1: It would make sense to inject an instance of the dependent class from a unit-test instead of creating a new instance of the dependent class in the constructor: you can use a fake/mock implementation of the dependent class from the unit-test and therefore control the dependencies of the class under test.
Example 2: a class uses System.currentTimeMillis() to take date/time one hour ago and provides a string formatted in a certain way. You cannot use assertEquals("03:54", timeCalculator.getTimeOneHourAgo()) in a unit-test because system time changes constantly, but you can inject java.time.Clock into the class, use fake implementation of Clock and use fixed time in the unit-test.

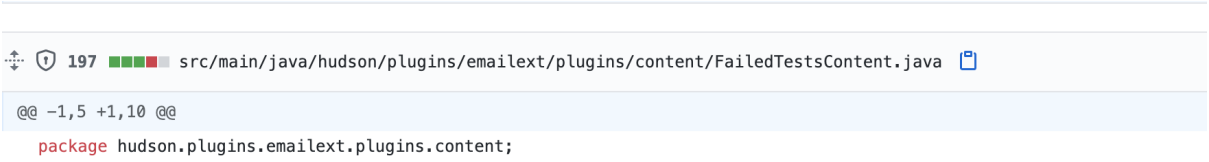
Process

Please carefully read and follow the following process. The validity of the study is dependent on how well you label the data.

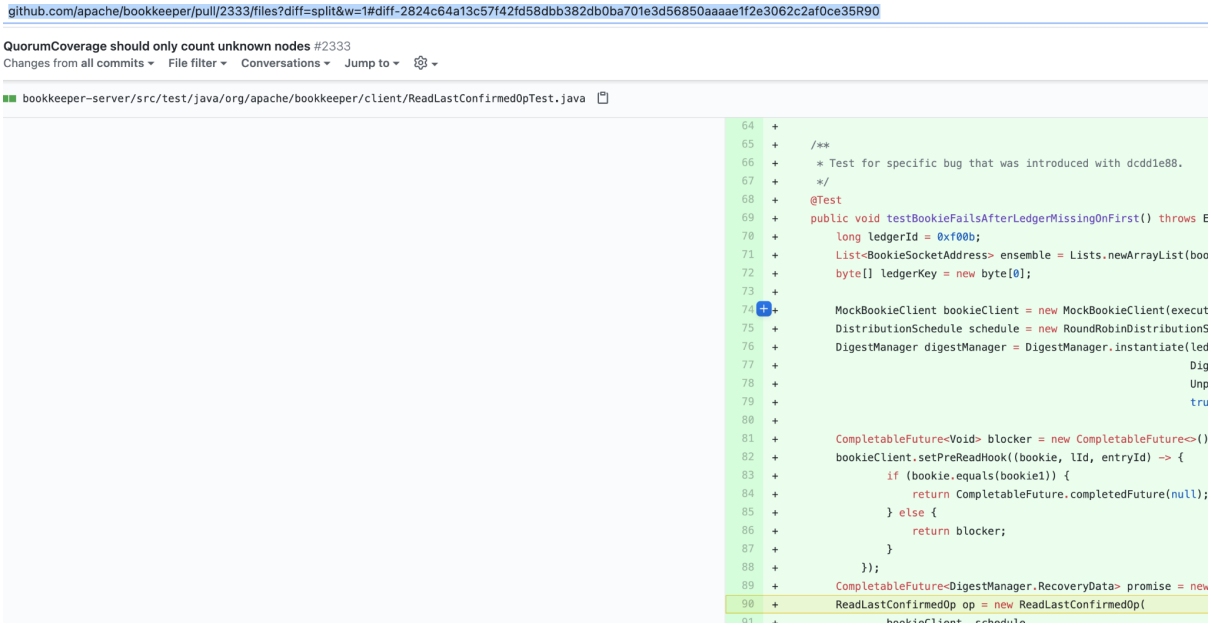
1. Take a PR from the spreadsheet provided to you.
2. If you haven't done labelling of PRs with refactoring patterns for testability before, you can label 10 PRs and ask the researchers for feedback.
3. The URL of the PR provided to you in the spreadsheet in the **url** column, will open the **Files** corresponding to the PR: for example https://github.com/jenkinsci/email-ext-plugin/pull/207/files?diff=split&w=1



4. Please open the Conversation of the the PR in a separate browser tab (with URL https://github.com/jenkinsci/email-ext-plugin/pull/207) and navigate between Files/Conversation tabs to better understand the changes/their context.
5. Every PR can contain none, one or eventually more refactoring patterns for testability.
6. It helps sometimes to read the description of the PR (in Conversation tab). But be aware that it will not always provide much information about what exactly has been refactored to improve testability.
7. Every PR needs to be labelled in the **pr_group** column as irrelevant/**incl**_ref_for_test/**only**_ref_for_test, see **Types of PRs** below. If the PR contains more than one refactoring for testability, all rows in the table should have the same pr_group (or empty for second
8. PRs that are relevant (incl_ref_for_test/only_ref_for_test) should contain refactoring patterns from the list of **Testability refactoring patterns**. If you think the PR includes a refactoring pattern that is not listed below, you can write **others** and mention in the **comment** column why you think it is a pattern.
9. In the **prod_file** column you can mention the filename of the production class (system under test) that has been modified, you can click on the clipboard icon next to the filename.



10. In the **test_location** column you can mention the location of the test code that uses the refactored prod code: invokes it or overrides/mocks it, etc.. Die URL endet auf R[0-9]+, wie im Beispiel unten R90 fuer die Zeile 90 der Testdatei.



11. In the **comment** column you can provide brief details that support your labeling decision: method XX made protected so it is overridden in junit, etc.
12. A PR can contain more than one refactoring pattern, in which case you can insert a new line in the spreadsheet with the same url and details of the second (or third, etc). refactoring: **ref_pattern, prod_file, location, comment.**

13. PRs with only added code **do not** include refactoring.
14. Very few PRs may contain code in scala/Kotlin/clojure since classes written in any JVM-based language can interact with each other. Try to understand the code changes, especially if you think they are relevant to refactoring for testability. It is fine to proceed to the next PR if you don't understand some of the scala/etc. code.
15. Sometimes a PR contains (relevant for us) refactorings for testability without test code, it is however less common than a PR with general refactorings in production code. If you identify refactorings for testability without relevant test code, just write **none/none relevant** in **test_location** column.
16. Try to not spend more than 10min per PR (or 30min for the few large PRs with more than 10 files). You would usually see patterns sooner than later, if there are any. You can scroll the source code back-and-forward, often it helps to look at the test code first.
17. Feel free to use prefix **borderline** or **unsure** in the comment section if the changes in the PR are not so obvious.
18. Some PRs/projects may have been deleted meanwhile, please write **irrelevant** in pr_group und **deleted** in comment section.
19. Column **java_files_count** tells how many java files have been changed in the PR and gives you an estimate how large the PR is.
20. Go to step 1 if you have time for another PR :)

Types of PRs

A. **only_ref_for_test (only refactorings for testability)**: such PRs contain *only* refactoring in classes under test aka production classes (under src/main/java and similar) and relevant test classes. Refactoring in such PRs should be relevant to testability: make it possible to unit-test a piece of functionality, improve code coverage, make it simpler to unit-test.
B. **incl_ref_for_test**: same as above, but may also include additional bugfixes, new features, and other functional changes in production code.
C. **irrelevant**: PRs that do not contain refactorings for testability. This category also includes bugfixes with relevant unit-tests, for which no production code has been refactored.

Testability refactoring patterns

The following testability refactoring patterns have been identified and can be used for categorisation based on the following rules/examples. A single PR can contain multiple refactoring patterns in the same or different production classes.

1. extract_method_for_override

In this testability refactoring pattern, a section of code is extracted into a method that is defined as protected/package/public and is then overridden in a subclass defined in a unit-test/near unit-test (in src/test/java and similar directories) or using Mockito.when(classUnderTest.getExtractedMethod()).thenReturn(mockedObject).

Examples:

1. https://github.com/apache/incubator-heron/pull/536/files#diff-a053ee8dc2fc86c17a5f5a900a7b1d0de8763658f4068b603c3779e85c28a83aR73 Here startExecutorProcess method is overridden using Mockito
2. https://github.com/apache/incubator-heron/pull/691/files#diff-9e584d73f147296cc864a9a993a8bfbc8527e71c7d9b8e83b741c42a89605af0R117 here callRuntimeManagerRunner has been overridden using Mockito7
3. From the same PR, but another method: https://github.com/apache/incubator-heron/pull/691/files#diff-9e584d73f147296cc864a9a993a8bfbc8527e71c7d9b8e83b741c42a89605af0R109 here getSchedulerClient method is overridden.
4. A more unusual case: https://github.com/codice/ddf/pull/433/files#diff-a5b614fe548edd0534f140f085578dda6dd0d3e41382197e89e049f2010efeb1R228 here a section of code has been replaced with FileUtils.forceMkdir and then overridden using PowerMockito to emulate an IOException thrown

2. extract_method_for_invocation

In this pattern a method is extracted in order to test it from a unit-test. It would also include a method that sets an attribute in a class under test to bring it into a state necessary for testing.

Examples:
1. https://github.com/CIRDLES/Topsoil/pull/162/files#diff-7b9bf92f128762a2fad88b40bf74c65572d54460dd6a7ec7a135fe04c46ab59cR62 Here writeSVGToOutputStream method was extracted from save() method in order to test it separately from a unit-test.
2. https://github.com/hmcts/idam-web-public/pull/196/files#diff-c155b5d2e77d82406ac20d0180b9f4a68371814c3671cb36d4a471c5692b73faR1499 here makeCookieSecure method is extracted and then the result of invocation validated using assertThat.
3. https://github.com/kiegroup/kie-wb-common/pull/367/files#diff-723a9b8d886a2a19624adcf31c8857c22d33200a86b7105f6b9a9dae45529565R44 here get() method was extracted and invoked from junit.
4. A trickier, borderline case: https://github.com/GoogleCloudPlatform/google-cloud-eclipse/pull/1969/files?diff=split&w=1#diff-eeb575b530450ac30e8b3cc876ee53da8e03b9a77da6c8765e4f885e85f68da8R59 here findLocationField() has been extracted instead of accessing attributes of the class under test.
5. https://github.com/pentaho/pentaho-platform/pull/2793/files#diff-80ca59ef80434e0f56b69ddd3f60ae731636696ac952675cc909e5d232ed7e13R50 here addHandlerParamJson has been extracted and commented as // visible for testing purposes. Similar comments or @VisibleForTesting annotation are relatively common.

3. widen_access_for_invocation

In this pattern access to an existing method, attribute or class is widened: from private to protected/public/package, from protected to package/public. A method/other member can also be made static in order to avoid instantiation of the class under test: MyClass.calculateSomething() instead of new MyClass().calculateSomething(). The purpose of such refactoring is to invoke the method from a unit-test.

Examples:
1. https://github.com/OryxProject/oryx/pull/164/files#diff-e549a3311dcd3be5ddec5d29777121cc8bf7b9a1b45cb75fdf903fa71d96c7f6R68 here access to calcSilhouetteCoefficient is widened from private to package.
2. https://github.com/pentaho/pentaho-platform/pull/3696/files#diff-aecd0c60cb6460753c921ec554d7998e1814b17af14684aa1c62f9d89a816686R112 here setEnvironmentVariablesFolder is widened from private to public in order to invoek from junit.
3. https://github.com/jenkinsci/gitlab-plugin/pull/335/files#diff-26725b448b0d698fc3c3c3e1be7cc88015138cb25d6bb9bb89eba969364d8296R167 here access to NoOpAction has been widened from private static to package static in order to access it from instanceOf in the junit.
4. https://github.com/apache/druid/pull/2102/files?diff=split&w=1#diff-b9e00c64528c1ed053a08b2a9f8eafce558d3ddc75f503bd16ae6054180936dbR73 here access to attribute CacheMonitor::cache has been widened from private to package in order to read it from a unit-test.
5. https://github.com/Alluxio/alluxio/pull/1629/files?diff=split&w=1#diff-05f6d61b3485c9cae64cdb03bd18f3fadf5edc4c7eeb0a00846545fbe323dea1R89 a pretty unusual case of creating a package-accessible PrivateClass class that provides access to private members of BlockMaster, such as private final mLostWorkers. Unusual, but it achieves the goal of widen_access_for_invocation.

4. widen_access_for_override

In this pattern, access to an existing method, attribute or class is widened from private to protected/public/package or from protected to package/public. Same as above, but for the purpose of overriding the member from a unit-test.

Examples:
1. https://github.com/Netflix/hollow/pull/219/files#diff-bebff128a4d63e213c3189cfd6488a2035f161c712870be19d80e13448d24a4eR213 here publish() method has been widened to protected in order to override its behaviour by throwing a RuntimeException using Mockito.doThrow.

2. https://github.com/OpenRefine/OpenRefine/pull/2839/files#diff-367c88cfad59847336f818d4276255a5c1c23cf155073ae8a5511d8521c3eeeaR59 here access to findValues method has been widened in order to override it using Mockito.thenReturn.
3. https://github.com/getodk/collect/pull/2489/files#diff-23f43ece96723536aea91a0b0073574fb4423e01eed6b2bc15214083e93a4cf8R29 here access to checkForRequiredSensors widened from private to public and overridden in MockBearingWidget subclass.
4. https://github.com/grpc/grpc-java/pull/3029/files?diff=split&w=1#diff-daee08ff4a4ba923599b66efc890057364c2e38046e102a5c968ffb72ea772dbR194 a more unusual case: a builder is extracted and builder.executorPool is overridden.
5. https://github.com/kiegroup/drools-wb/pull/184/files?diff=split&w=1#diff-90c28778706543a6f5e6929d07852b712a1238915f521944180de88c4dc9620fR102 access to ConstraintValueEditor::wrap method has been widened to package and overridden from an anonymous subclass in a junit.

5. extract_class_for_invocation

In this pattern, a piece of existing functionality is usually extracted into a (smaller) class that can be unit-tested.

Examples:

1. https://github.com/jmxtrans/jmxtrans/pull/171/files#diff-d97fe6da56ad6b50374f4cbe77acdfb7b6db47e30070cb54936ca8638fcee6d3R191 here JmxResultProcessor class has been extracted and invoked from a unit-test.
2. https://github.com/jmxtrans/jmxtrans/pull/291/files#diff-55a66325a926dfab96b606daf8b70a2d6f74d11b744519b5c98d116186a39cf1R22 here convertToDouble method has been extracted into a separate class ObjectToDouble and tested separately from ObjectToDoubleTest.
3. https://github.com/azkaban/azkaban/pull/1765/files?diff=split&w=1#diff-d06231180a58579f8eedec31b2fa3cd65820a1dfb6917ac1be50cd1bb3cc7bf4R68 here code from shutdownAndAwaitTermination extracted into ExecutorServiceUtils and it is mocked (its behaviour overridden) in a unit-test.

6. extract_class_for_override

In this pattern, a class is extracted in order to override it from a unit-test.

Examples:

1. https://github.com/dropwizard/metrics/pull/516/files?diff=split&w=1#diff-77404fc98b2af4ff4f2d91472bb0cd19f1b6f5c86be4ce61acd1922638f6d54cR105 here ObjectNameFactory has been extracted in order to supply a pre-created ObjectName from a unit-test, instead of creating an ObjectName from JmxReporter::createName.
2. https://github.com/firebase/firebase-android-sdk/pull/217/files?diff=split&w=1#diff-c7d337444

4dbf8d5868c2367b77fd52fe7608c08880160b817b272fe396cf9e6R75 here ConnectivityMonitor interface has been extracted and subclassed as FakeConnectivityMonitor in a unit-test.

7. add_constructor_param

In this pattern an additional constructor is created or an extra parameter is added to an existing constructor to supply a dependency from a unit-test.

Examples:
1. https://github.com/kiegroup/kie-wb-common/pull/277/files#diff-195b466598b765a6a5b7d806b12c6a434c4134715caad6a538ce10daee14b015R52 here lockRequired is supplied from a unit-test instead of injecting it via spring or other dependency injection framework.
2. https://github.com/openmrs/openmrs-contrib-android-client/pull/349/files#diff-21e6dfb384292a19172eb526ff517140445ff7d3b3172b95eab5808b63db773fR48 a typical example of replacing new XXXDependency() inside a constructor with an object supplied from a unit-test.

8. create_constructor

In this pattern a constructor is created in order to supply dependencies from a unit-test. It is frequently used with @Autowired and in spring context.

Examples:
1. https://github.com/dhis2/dhis2-core/pull/2892/files#diff-755ce64247e7039b26560990d290fe0bbd03bcc0ce6ed7cb9f65ba0ae7b73134R118 here SmsMessageSender constructor has been created and used from a unit-test. In production code it would be called by spring/other dependency injection framework.
2. https://github.com/apache/incubator-heron/pull/691/files#diff-9e584d73f147296cc864a9a993a8bfbc8527e71c7d9b8e83b741c42a89605af0R45 Constructor RuntimeManagerMain created to inject config and runtime.

9. override_system_time

It is a rather rare pattern. Here developers usually try to override System.currentTimeMillis() or date returned by new Date by using java.time.Clock or supplier of time.
Examples:

1. https://github.com/firebase/firebase-android-sdk/pull/1333/files#diff-329ea845fe9ddff6aa413e47e733c53cba6df39b0905223ee9890badf53a4e5fR154 here Clock interface is created with one real and one fake implementation, the latter is used in the unit-test to override system time.
2. https://github.com/azkaban/azkaban/pull/1975/files#diff-871283916aae52436d516c9da613d7b527846a89210fc110c36da3879a0ec81eR103 here joda DateTimeUtils is

used to set current time and production code uses DateTime.now() instead of System.currentTimeMillis().

10. extract_attribute_for_assertion

This is another rare pattern. In this example https://github.com/apache/druid/pull/2878/files#diff-bc33bf93f99de2070d9fb82b3a60de86a7f7b1a19a41bd992c6b6f6d412430cdR1224 a getter is added for a private member attribute to expose it to a unit-test.

11. Other

Other testability patterns are possible and acceptable, please mark them as ref_pattern=other and write in comment why the changes in a PR are relevant to testability.