CS/SE 6367 Course Project

Timeline

Note that the proposal is due at 11:59pm Feb. 21st.

Submission materials: a 1-2 page proposal using the double-column ACM *sample-sigconf* format (https://www.acm.org/publications/proceedings-template. You can use either word or latex). **Note that you should not change the font size, format, or spacing.** Your proposal should specify the following parts:

1. The members in your group (1-4 students per group)
2. The problem you want to investigate
3. The basics of existing techniques and/or the design of your technique
4. Your implementation/study plan
5. The experimental evaluation subjects and design

Mid-Term progress report is due at 11:59pm March 13th.

Submission materials: a 3-4 page report (extended from your proposal) specifying your results for your 1st phase and further plan for the 2nd phase

Final report is due at 11:59pm May 1st.

Submission materials: a 6-10 page full report (extended from your mid-term report) & code & data

Phase-1 (Due: March 13th)

Use ASM byte-code manipulation framework [1] to build an automated coverage collection tool that can capture the statement coverage for the program under test. Then, apply your tool to 10 real-world Java projects (>1000 lines of code) with JUnit tests (>50 tests) from GitHub [2] to collect the statement coverage for its JUnit tests. Note that your tool should (1) use Java Agent [3] to perform on-the-fly code instrumentation, (2) be able to store the coverage for each test method in the file system, and (3) be integrated with the Maven build system [4] so that your tool can be triggered by simply typing "mvn test" after changing the pom.xml file of the project under test. More implementation details are shown in the appendix.

Phase-2 (Due: May 1st)

Further augment the coverage collection tool implemented in Phase-1 to trace more information about program internal states, e.g., tracing accessible field/variable values for the beginning of each method execution. Then, infer the possible single-variable invariants based on the Daikon technique.

- Reference:
  - https://plse.cs.washington.edu/daikon/
- Evaluate your tool to infer invariants for one real-world library project from Phase-1, such as commons-utils or joda-time.

Or: any other software testing or debugging topics proposed by the student and approved by the instructor by **March 10th**.

Appendix

Java Agent

The code instrumentation way that we learnt in the class has to modify the bytecode file on the file system. There are several limitations for that. First, the time can be wasted when reading and writing back the bytecode files from/to file systems. Second, the bytecode file on the file systems may be changed into a mess. Therefore, Java Agent [1] was proposed to change the bytecode file only in the memory during the JVM load time. Whenever, a Java bytecode file is loaded into JVM (for execution), Java Agent will transform that file and add instrumentations in the memory, leaving the actual bytecode file on file systems unchanged. There is a much cleaner and faster way to do code instrumentation. Java Agent can be directly combined with ASM to do bytecode instrumentation on-the-fly [5].

JUnit Listener

In order to record the coverage information for each JUnit test method, you need to capture the start and end events for each JUnit test method, so that you can start recording when the test starts and stop recording when the test ends. JUnit RunListener provides a direct way to do that. There are plenty of example online [6].

Integration with Maven

Maven [4] is one of the most widely used build system for Java. It enables the users to build Java projects easily without worrying about the 3rd-party libraries, since the Maven build system will automatically download the 3rd-party libraries based on the Maven configuration file (pom.xml). The "mvn test" command is used to execute all the JUnit tests for a Maven project (Note that all the projects in the course project list appendix use Maven projects, and you can use that command to execute the tests that come with the projects). When firing the "mvn test" command, the Maven surefire plugin is used to find and execute all the JUnit tests. You can easily configure your Java Agent and JUnit listener for the surefire plugin in the Maven pom.xml file. Example for integrating Maven with both Java Agent and JUnit listener can be found online [7]. Here is also a simply example for configuring Maven surefire within the project under test's pom.xml:

```xml
<plugin>
        <groupId>org.apache.maven.plugins</groupId>
        <artifactId>maven-surefire-plugin</artifactId>
        <configuration>
                <argLine>-javaagent:[path-to-your-agent.jar]</argLine>
                <properties>
                        <property>
                                <name>listener</name>
                                <value>[YourListener]</value>
                        </property>
                </properties>
        </configuration>
</plugin>
```

Replace [path-to-your-agent.jar] with your java agent jar's absolute path, and replace [YourListener] with your JUnit listener's full name (e.g., edu.utdallas.MyJUnitListener). After your configuration, when firing the "mvn test" command, your Java Agent and JUnit listener will be activated to execute all the tests and record the coverage for each test for the project under test.

Statement Coverage Output Specification

When firing "mvn test", your tool should be able to output a file named "stmt-cov.txt" under the project under test (Note that it is faster to store all coverage info in some data structure such as HashSet, and then dump them to file once the test ends). The file should include statement coverage information for each test method. Each line in the file represents a test method or a covered statement, while the test method line will have the [TEST] prefix. Each test method should be followed by the set of statements covered by it (with no duplication). Each test method is represented by the full name of the test class +":"+the test method name, while each statement is represented by the full name of the class +":"+the line number.

The project grading will be based on (1) the efficiency of your tool (i.e., how much time your tool consumes in collecting coverage for a project), (2) the effectiveness of your tool (i.e., is the coverage collected by your tool correct and precise? how much information do you trace?).

The following is an example stmt-cov.txt file:

[TEST] a.b.c.TestA:test1
a.b.c.A:1
a.b.c.A:3
a.b.c.A:4
[TEST] a.b.c.TestA:test2
a.b.c.A:5
a.b.c.A:6
a.b.c.A:7
[TEST] a.b.c.TestB:test1
a.b.c.B:1
a.b.c.B:4
…

References

[1] http://asm.ow2.org/
[2] https://github.com/
[3] https://docs.oracle.com/javase/7/docs/api/java/lang/instrument/package-summary.html
[4] https://maven.apache.org/guides/getting-started/maven-in-five-minutes.html
[5] http://www.tomsquest.com/blog/2014/01/intro-java-agent-and-bytecode-manipulation/

[6] http://memorynotfound.com/add-junit-listener-example/
[7] https://dzone.com/articles/junit-listener

Frequently Asked Questions (FAQs)

I'll keep posting answers for some frequently asked questions to help you prepare for the project:

1. The JUnit Listener was introduced for JUnit 4.x, but joda-time (https://github.com/JodaOrg/joda-time) uses JUnit 3.8. How should I make it work for joda-time?

Answer: Easy, simply change the JUnit version configuration, "<version>3.8</version>", into "<version>4.12</version>" in joda-time's pom.xml. The JUnit 4.x library is compatible for JUnit 3.x tests.

2. Should I instrument all the classes including Java internal classes to trace their coverage?

Answer: No. You simply need to instrument and trace coverage for the classes of the project under test. You can use the package prefix to filter out other classes (e.g., belonging to third-party libraries or Java internal library). For example, for joda-time, you can simply instrument the classes with the "org.joda.time" prefix, while for commons-dbutils (https://github.com/apache/commons-dbutils), you can simply instrument the classes with the "org.apache.commons.dbutils" prefix.

3. Should I exclude the test classes for coverage collection?

Answer: No. You should instrument all the classes for the project under test, e.g., all the classes with the "org.joda.time" package prefix for joda-time.

Feel free to ask me or the TA for any further question.

4. Can I configure Maven surefire to use parallel test execution, e.g., forking JVMs to execute JUnit tests and collect coverage concurrently?

Answer: Of course.

5. Can I have some expected output information to help with the debugging?

Answer: Yes. You should be able to obtain coverage for all the 300 tests of commons-dbutils and (at least) 4203 tests of joda-time. For commons-utils, the generated file size would be around 976K. Here is also the detailed coverage information for one test of commons-dbutils:

org.apache.commons.dbutils.BasicRowProcessorTest:testCheckDataSizes
org.apache.commons.dbutils.BaseTestCase:114
org.apache.commons.dbutils.BaseTestCase:116
org.apache.commons.dbutils.BaseTestCase:117
org.apache.commons.dbutils.BaseTestCase:118
org.apache.commons.dbutils.BaseTestCase:124
org.apache.commons.dbutils.BaseTestCase:130
org.apache.commons.dbutils.BaseTestCase:131
org.apache.commons.dbutils.BaseTestCase:132
org.apache.commons.dbutils.ProxyFactory:50
org.apache.commons.dbutils.ProxyFactory:69
org.apache.commons.dbutils.ProxyFactory:114
org.apache.commons.dbutils.MockResultSet:45
org.apache.commons.dbutils.MockResultSet:49
org.apache.commons.dbutils.MockResultSet:51
org.apache.commons.dbutils.MockResultSet:53
org.apache.commons.dbutils.MockResultSet:55
org.apache.commons.dbutils.MockResultSet:63
org.apache.commons.dbutils.MockResultSet:64
org.apache.commons.dbutils.MockResultSet:65
org.apache.commons.dbutils.MockResultSet:66
org.apache.commons.dbutils.MockResultSet:67
org.apache.commons.dbutils.MockResultSet:68
org.apache.commons.dbutils.MockResultSet:69
org.apache.commons.dbutils.MockResultSet:71

6. Can I have some example GitHub projects to explore?

Answer: Sure, besides the mentioned joda-time and commons-dbutils, there are another 399 GitHub Java projects with JUnit tests (each line shows the project name+commit version+url, separated by ","):

aalto-xml,056b198e932af32d3013cc9b0afd5fe3e85e7aad,https://github.com/FasterXML/aalto-xml
agoncal-application-petstore-ee6,796eaafebd3237a47012927cbfeab617df5d08dd,https://github.com/agoncal/agoncal-application-petstore-ee6
aho-corasick,25eeef5168846d50dc343c1f224a24745f925f5b,https://github.com/robert-bor/aho-corasick
AhoCorasickDoubleArrayTrie,d226eee2ef1426387bc70f8102f5aabf7a2d54f3,https://github.com/hankcs/AhoCorasickDoubleArrayTrie
akela,1bb3413e1b81aca1c69d6e58bb8d71ae54f36d4f,https://github.com/mozilla-metrics/akela
Alternator,fc27a86b22f2648bedcc7e17a802fa4cd9eeac75,https://github.com/mboudreau/Alternator
anomaly-detection,4172db9ab6627e36144c36edea9e03ea53a2753b,https://github.com/tdunning/anomaly-detection
ansj_seg,853b3d0cd11c4ca873fc8ec8dce690e79d67592b,https://github.com/NLPchina/ansj_seg
apgdiff,6e308028fff16c1d404eb0a2f9885b07814e9491,https://github.com/fordfrog/apgdiff
apk-parser,0f1b7ab5637dd8e3463b8d23a6055189149c189f,https://github.com/xiaxiaocao/apk-parser
appengine-guestbook-java,8bb9c6957e454144a90015a875c2d44cbc8f3a9a,https://github.com/GoogleCloudPlatform/appengine-guestbook-java
are-we-consistent-yet,2ea5002b3528ca0faf340af6c63ad05746f67b3f,https://github.com/andrewgaul/are-we-consistent-yet
argparse4j,d2bdbf719714ff15c2fd440c4d06745d779509c2,https://github.com/tatsuhiro-t/argparse4j
asciidoctor-maven-plugin,d79ce38ec4b3ebb733def765b26efc411ecc7096,https://github.com/asciidoctor/asciidoctor-maven-plugin
ashot,fe8e2b09fe83ebb7b4b238fd6f9031cfdbe79883,https://github.com/yandex-qatools/ashot
assertj-core,1b99f507c4bfb78189c28db6434afb97b5b2e77a,https://github.com/joel-costigliola/assertj-core
asterisk-java,96e01b4c01e1e99b3f35ca3121d473fc35035ffc,https://github.com/asterisk-java/asterisk-java

async-retry,409df80589218c047c99302f5ac14ea37c548f24,https://github.com/nurkiewicz/async-retry
avaje-ebeanorm,3f0dcdb6d13ae468a1b0b1d9f048bdaf1e2b5d1b,https://github.com/ebean-orm/avaje-ebeanorm
batch-import,acc673772c4b0d9a614606c41f5e28cd6a6c1747,https://github.com/jexp/batch-import
BitHub,82c9d21d292772e35ac40c8269001add2aa3e884,https://github.com/WhisperSystems/BitHub
BootsFaces-OSP,3a815026926e84921cc41d39999e2a5bbb55cd95,https://github.com/TheCoder4eu/BootsFaces-OSP
brickhouse,8fce0ac98aef422772ac89de7a620caac47ccc9d,https://github.com/klout/brickhouse
budgetapp,2e64ae46d9024bd2f377fed237368cdc35aa98b5,https://github.com/paukiatwee/budgetapp
Bukkit,f210234e59275330f83b994e199c76f6abd41ee7,https://github.com/Bukkit/Bukkit
byteunits,b9ddb0b3d735938d747d9969f6e551b087b00e75,https://github.com/JakeWharton/byteunits
caesar,45c4fe7032824efa4c63e0e82ea0514d366ef4b2,https://github.com/vbauer/caesar
calculon,7e681dfbebeae1a218d0f2fda28ca8f016d7534b,https://github.com/mttkay/calculon
cascading_ext,2f42e3a9c43ba52def3ac3ceae4c984827e155b8,https://github.com/LiveRamp/cascading_ext
cassandra-reaper,f3e1e8926c1e2f4d3de2bada332d7ded09212581,https://github.com/spotify/cassandra-reaper
cassandra-webconsole,22415f259d825880acc89b8265f16b4c9e426783,https://github.com/suguru/cassandra-webconsole
charts4j,19518f2c21df0408fcd98d15819eb6d67d5e1936,https://github.com/julienchastang/charts4j
checkstyle,18172eab38e9443539633d6ee3a30818c10c7bb1,https://github.com/checkstyle/checkstyle
chromecast-java-api-v2,4bad20e5a03ec09f47aed7ca69de970a28543800,https://github.com/vitalidze/chromecast-java-api-v2
cli-parser,f4ad598c2a4ab421816f49dd9e02725e0f905bcb,https://github.com/spullara/cli-parser
clj-ds,6a45a1ddb253516088c3480ee8ee7796bd72b094,https://github.com/krukow/clj-ds
clojure-maven-plugin,6a6a80de9926e76b2b30b69a0784e37ce0d33568,https://github.com/talios/clojure-maven-plugin
cloudhopper-smpp,4ee6e347cca81cfbeaff08ca536673e1b14268bc,https://github.com/twitter/cloudhopper-smpp
clue,1d58e6f14f41969b6378226948c34e3fa3a78132,https://github.com/javasoze/clue
CodeGlance,494654a8391eef63497409ab6528238e8df45feb,https://github.com/Vektah/CodeGlance
CommandHelper,b1dee3879ab3ef4d7c7b78ff48885b516d0e9931,https://github.com/sk89q/CommandHelper
commons-codec,158d178c58e892ba87d782ecf436d30c038d464e,https://github.com/apache/commons-codec
commons-imaging,5fee7e45d1443b881956ea8a5847a9b6aaacaa10,https://github.com/apache/commons-imaging
commons-io,190ff91777340f14dd1f04d6171013d84dd8a195,https://github.com/apache/commons-io
commons-lang,38e829fb39a05d7f51b2efbec35aa02cf40c5a65,https://github.com/apache/commons-lang
compile-testing,db256e040bdc1dab480a9687f45efb30169ce9a0,https://github.com/google/compile-testing
compress,876fbc1a260980747cfd4591999949599f246013,https://github.com/ning/compress
computoser,a35cff10fa467db5191edc1cc23e7970cdf5e45a,https://github.com/Glamdring/computoser
Confucius,2c3028782eaaf2337bde558b4a700210a10f543e,https://github.com/IvanTrendafilov/Confucius
cors-filter,d86da0e71fbab6cbbc724539dc9b92899b7db32b,https://github.com/eBay/cors-filter
couchdb-lucene,d4f641229e058f0e28869176554bb5b147a5915d,https://github.com/rnewson/couchdb-lucene
coveralls-maven-plugin,20490f660d0501bbce8ce69054e4aed5a07c519b,https://github.com/trautonen/coveralls-maven-plugin
crawler4j,de46d30530f6ebb7805dbb89565445af1e95c566,https://github.com/yasserg/crawler4j
css-selectors,bd04b93b3b7db7de64343531acc710b6983aff7c,https://github.com/chrsan/css-selectors
csv-serde,f315c1ae4b21a8288eb939e7c10f3b29c1a854ef,https://github.com/ogrodnek/csv-serde
cucumber-java-skeleton,14325293b16f9692c3d0d535049b3c05547fcc18,https://github.com/cucumber/cucumber-java-skeleton
cucumber-reporting,7327026542f3cdaeda61927cbaf619545f55d4f5,https://github.com/masterthought/cucumber-reporting
dashboard-demo,c99d5275cc6e7e28ec0af4765865602a6149ea1a,https://github.com/vaadin/dashboard-demo
ddd-cqrs-sample,fa98ebd8ba326bb944be05e65af1d747286bad6d,https://github.com/BottegaIT/ddd-cqrs-sample
deft,f29869d57f6670318c7e926e76e18d76439888b7,https://github.com/rschildmeijer/deft
dictomaton,50d2ff4064f37e7985fda2ae7f1b7523e51f4425,https://github.com/danieldk/dictomaton
DiskLruCache,3aa62867b2f4f4d91798dff1bdec565fee2194c9,https://github.com/JakeWharton/DiskLruCache
disruptor_thrift_server,8a200f4c856b4ef7f77a12dcf4c9b568ccc8b986,https://github.com/xedin/disruptor_thrift_server
docker-java,26b4069bb1985a8c293a016aaf9b56979771d75b,https://github.com/kpelykh/docker-java
docker-maven-plugin,06f314141e598c141aa454b39cccd86036f28d5c,https://github.com/wouterd/docker-maven-pluginn
DotCi,c616426df0c67be10b6207426ab9b9ff71763924,https://github.com/groupon/DotCi
dropwizard-configurable-assets-bundle,1bc5cbb0f0feaafe5a47c780c5783cc69ca630e4,https://github.com/bazaarvoice/dropwizard-configurable-assets-bundle
dropwizard-guice,e5aee78633b290f23cf4a03b0236a4f248fad538,https://github.com/HubSpot/dropwizard-guice
dropwizard-quartz,38a7f5f6b427db0821495f99ec750924aaa9b91d,https://github.com/jaredstehler/dropwizard-quartz
druid,dcf1ee4605a76b0446b3392a6559083021eaca47,https://github.com/alibaba/druid
dynalink,f524803f1c3e88bba274295329d6ff879769b501,https://github.com/szegedi/dynalink
EasyFlow,21af23d462dcd83e5c9a23707f02de49f8a75ec0,https://github.com/Beh01der/EasyFlow
effective-java-examples,77d193e266abd397b0929d7fc1354d95d028753e,https://github.com/marhan/effective-java-examples
efflux,2642218e2030b4d5826705b90b4e733d6918ca8a,https://github.com/brunodecarvalho/efflux
elasticsearch-action-updatebyquery,9ba3d3ad72761a9a110c390e222475ff5d8cb2d3,https://github.com/yakaz/elasticsearch-action-updatebyquery
elasticsearch-analysis-combo,0deefdb95ee75e88fcf02277455efb0b58bd9e3f,https://github.com/yakaz/elasticsearch-analysis-combo
elasticsearch-analysis-icu,23a59dbaee4afb583eb15e98a0040a06f21cfec5,https://github.com/elastic/elasticsearch-analysis-icu
elasticsearch-analysis-kuromoji,938c0f9285e3dcf9653ea72a12960ae6337ea207,https://github.com/elastic/elasticsearch-analysis-kuromoji
elasticsearch-analysis-phonetic,07d3bb6023fc267932ad0a90858d46d15851f790,https://github.com/elastic/elasticsearch-analysis-phonetic
elasticsearch-analysis-pinyin,2271c8fa03d4962550eff3ed9b8e67d60941b33d,https://github.com/medcl/elasticsearch-analysis-pinyin
elasticsearch-analysis-smartcn,f384eef5d27738f348cdbced779a2ad04a4e67a3,https://github.com/elastic/elasticsearch-analysis-smartcn
elasticsearch-entity-resolution,8bfcf551e15385d1b4ab0b45bc67dc8900e00470,https://github.com/YannBrrd/elasticsearch-entity-resolution
elasticsearch-gatherer,290c5f3a52b55b6544257329530846cf24075377,https://github.com/jprante/elasticsearch-gatherer
elasticsearch-jdbc,bb702ae11da87422c38037da3dd5883456f53f1d,https://github.com/jprante/elasticsearch-jdbc
elasticsearch-jetty,1f8463aaf993966e76f8065293b8e0e15198c089,https://github.com/sonian/elasticsearch-jetty
elasticsearch-knapsack,4a48056641ca2faee8e4a4475eceee28e94ee38e,https://github.com/jprante/elasticsearch-knapsack
elasticsearch-readonlyrest-plugin,481186a3296d9087d6250c7b6c58460c3069c351,https://github.com/sscarduzio/elasticsearch-readonlyrest-plugin
elasticsearch-redis-river,08ee12890d72654fce90f06d38e1b89de4190a92,https://github.com/leeadkins/elasticsearch-redis-river
elasticsearch-reindex,d70a89346eee53d332cdd29ca19f25ae5153f16a,https://github.com/karussell/elasticsearch-reindex
elasticsearch-river-mysql,d5972be6a1bd2524886d9fb79aaaa2caf96dcbf7,https://github.com/scharron/elasticsearch-river-mysql
elasticsearch-river-redis,ab1331136cd7ee180ed9cb43b650f1f8ae070a7e,https://github.com/sksamuel/elasticsearch-river-redis
elasticsearch-river-web,230694d856b64c44a931592134a3b32f81da454e,https://github.com/codelibs/elasticsearch-river-web

elasticsearch-skywalker,dda56934dee485893f59b2df9aeea6a9b1389dea,https://github.com/jprante/elasticsearch-skywalker
elasticsearch-taste,a42edaa36222bcc411633218da8789bef258465d,https://github.com/codelibs/elasticsearch-taste
elasticsearch-test,90c5f45f7c40c10e10d652f2c019e85e40df8141,https://github.com/tlrx/elasticsearch-test
elasticsearch-timefacets-plugin,4791348273dc0a3fda1c5149fa300f8caecce094,https://github.com/crate/elasticsearch-timefacets-plugin
elasticsearch-transport-websocket,83ee67f65099e273abae954e70c54717fbb77525,https://github.com/jprante/elasticsearch-transport-websocket
embedded-redis,ada2e56d282db59878990c7dc40762ab8a834703,https://github.com/kstyrc/embedded-redis
embedmongo-maven-plugin,ae9513131347c764951b27b65e1799376e21d175,https://github.com/joelittlejohn/embedmongo-maven-plugin
emite,594ab408c689fd4db857451a216da07628f1fce7,https://github.com/EmiteGWT/emite
encog-java-core,d8b979d6d44e10996f327c384405e3e238365c45,https://github.com/encog/encog-java-core
evernote-sdk-java,5dee1cdfe93df6605b9246f8ae80eedde4513cb4,https://github.com/evernote/evernote-sdk-java
evo-inflector,2726279d86b105505782f57625005905f92835c9,https://github.com/atteo/evo-inflector
ews-java-api,f06c90b3396b55780b2eb333c9ddfff1e538a630,https://github.com/OfficeDev/ews-java-api
exp4j,2c7795f0ee55e1eae58784a09453018aaa316e2f,https://github.com/fasseg/exp4j
expiringmap,38414dfe6b8abf7238fed404fc4b8701b521be51,https://github.com/jhalterman/expiringmap
facebook-recommender-demo,df812b4bc9acccbda2c662deef3476cadaf7093f,https://github.com/ManuelB/facebook-recommender-demo
FakeSMTP,f3ceb636dd47bf6833196668242d4c240e6e2759,https://github.com/Nilhcem/FakeSMTP
fast-cast,a7dcb411199586f4b9e8b0bfbbac88b525c40d60,https://github.com/RuedigerMoeller/fast-cast
fastweixin,a5dbcab89665007ac196982930d4bbff1968f483,https://github.com/sd4324530/fastweixin
faunus,1eb8494eeb3fe3b84a98d810d304ba01d55b0d6e,https://github.com/thinkaurelius/faunus
first-stories-twitter,efce1dd343ef2cb13f336934106b5ddc62a49b04,https://github.com/mvogiatzis/first-stories-twitter
fjord,e4acdda6681d162567cb817c49674d3050dd7d75,https://github.com/penberg/fjord
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