

Lab 3 Report

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1 Test Plan

1.1 Test requirements

The Lab 3 requires to (1) select 6 methods from 6 classes of the SUT (GeoProject), (2) design Unit test cases by using **basis path or graph coverage** technique for the selected methods, (3) develop test scripts to implement the test cases, (4) execute the test scripts on the selected methods, (5) report the test results, and (6) specify your experiences of designing test cases systematically using the graph coverage technique.

In particular, based on the target coverage criteria (i.e., statement, branch, or others), the **test requirements** for Lab 3 are to design test cases *with **graph coverage technique** for each selected method so that “each statement and branch (or path) of the method under test will be covered by at least one test case and the both minimum statement (node) and branch (edge) coverage are greater than those of Lab 2 and 75%, respectively.”*

1.2 Test Strategy

To satisfy the test requirements listed in Section 1, a proposed strategy is to

- (1) select **3 methods that were chosen in Lab1 or Lab2** and **3 new methods** that are NOT selected previously. The selected methods **MUST** contain **predicate** and/or **loop** structures (as many as possible).
- (2) set the objective of the minimum statement or branch (or path) coverage to be greater than that of Lab 2 and adjust the test objective (e.g., 90%, 95% or 100%) based on the time available (if necessary).
- (3) design the test cases for those selected methods by using the **basis path or graph coverage** testing technique.

1.3 Test activities

To implement the proposed strategy, the following activities are planned to perform.

No.	Activity Name	Plan hours	Schedule Date
1	Study GeoProject	2	2023.04.20
2	Learn basis path and	4.5	2023.04.26

	graph coverage		
3	Design test cases for the selected methods	6	2023.04.30
4	Implement test cases	2.5	2023.05.06
5	Perform tests and check code coverage. If not satisfy, design more test cases...	3	2023.05.09
6	Complete Lab3 report	2	2023.05.10

1.4 Design Approach

The **basis path and graph coverage** technique will be used to design the test cases. Specifically, the control flow graph (CFG) of each selected method shall be drawn first, and the possible test paths that satisfy the test requirements (i.e., **statement (node), branch (edge), or path coverage**) shall be derived from the CFG. The possible **inputs** and **expected outputs** for the derived test paths shall be computed from the specification of SUT for each method under test. *Add more test cases by considering to satisfy other coverage criteria, such as edge-pair, all-use, or prime-path coverage criteria.*

1.5 Success criteria

All test cases designed for the selected methods must pass (or 80% of all test cases must pass) and both statement and branch (or path) coverage should have achieved at least 80%, respectively.

2 Test Design

To fulfill the test requirements listed in section 1.1, the following methods are selected and corresponding test cases are designed.

No.	Class	Method	Source Code Links	CFG Links	Test Paths	Inputs	Expected Outputs
1	Base32	encodeBase32(long i, int length)	https://course.selab.ml/stv-gitlab/11159806/6/GeoProject/blob/master/LabReport/Lab3/Base32_encodeBase32	https://course.selab.ml/stv-gitlab/11159806/6/GeoProject/blob/master/LabReport/Lab3/Base32_encodeBase32	P1: {n1, n3, n5, n6}, P2: {n1, n2, n3, n5, n7}, P3: {n1, n3, n4, n3, n5, n6}, P4: {n1, n2, n3, n4, n3, n5, n7}	T1:{i=75324, length=4}, T2:{i=-75324, length=4}, T3:{i=16, length=1}, T4:{i=-16, length=1}	T1:{"29jw"}, T2:{"-29jw"}, T3:{"h"}, T4:{"-h"}

			2.jpg	2.jpg		}	
2	Base32	decodeBase32(String hash)	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_decodeBase32.jpg	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_decodeBase32.jpg	P1:{n1,n2,n4,n5,n7,n9}, P2:{n1,n3,n4,n5,n6,n5,n7,n8,n9}	T1:{hash=""}, T2:{hash="-1"}	T1:{0}, T2:{-1}
3	Base32	getCharIndex(char ch)	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_getCharIndex.jpg	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_getCharIndex.jpg	P1:{n1,n2,n3}, P2:{n1,n2,n4}	T1:{ch='a'}, T2:{ch='0'}	T1:{not a base32 character: a"}, T2:{0}
4	Base32	padLeftWithZerosToLength(String s, int length)	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_padLeftWithZerosToLength.jpg	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_padLeftWithZerosToLength.jpg	P1:{n1,n2,n3,n4,n3,n6}, P2:{n1,n6}	T1:{s="29jw",length=4}, T2:{s="29jw",length=5}	T1:{29jw"}, T2:{029jw"}}
5	Direction	opposite()	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_padLeftWithZerosToLength.jpg	https://course.selab.ml/stv-gitlab/111598066/GeoProject/blob/master/LabReport/Lab3/Base32_padLeftWithZerosToLength.jpg	P1: {n1, n2}, P2: {n1, n3, n4}, P3: {n1, n3, n5, n6}, P4: {n1, n3, n5, n7}	T1:{Direction.LEFT}, T2:{Direction.RIGHT}, T3:{Direction.LEFT}, T4:{Direction.BOTTOM}	T1:{Direction.LEFT}, T2:{Direction.RIGHT}, T3:{Direction.TOP}, T4:{Direction.BOTTOM}

			eport/La b3/Direc tion_op posite.jp g	eport/La b3/Direc tion_op posite.jp g		ction.TO P}	
6	Coverage	getHash Length()	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Cove rage_get HashLen gth.jpg	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Cove rage_get HashLen gth.jpg	P1:{n1,n 2}, P2:{n1,n 3}	T1:{hash es=""} T2:{hash es="29j w"}	T1:{0} T2:{4}
7	GeoHash	fromLon gToStrin g(long hash)	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Geo Hash_fr omLong ToString. jpg	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Geo Hash_fr omLong ToString. jpg	P1:{n1, n2, n4}, P2:{n1, n2, n3, n4}, P3:{n1, n2, n3, n5, n6, n7, n6, n8}	T1:{hash =12}, T2:{hash =0}, T3:{hash =1}	T1:{"invali d long geohash 12"}, T2:{"invali d long geohash 0"}, T3:{"0"}
8	GeoHash	heightD egrees(i nt n)	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Geo Hash_he ightDegr ees.jpg	https://c ourse.se lab.ml/st v- gitlab/1 1159806 6/GeoPr oject/bl ob/mast er/LabR eport/La b3/Geo Hash_he ightDegr ees.jpg	P1:{n1,n 2}, P2:{n1,n 3}	T1:{n=0} } T2:{hash es=13}	T1:{180} T2:{0}

The details of the design are given below:

Lab3 (Graph Coverage test case design).xlsx

3 Test Implementation

The design of test cases specified in Section 2 was implemented using JUnit 4. The test scripts of 3 selected test cases are given below. The rest of the test script implementations can be found in the [link](#) (or JUnit files).

No.	Test method	Source test code
1	opposite()	<pre> public Direction direction, expected; @RunWith.Parameters.class public class CollectionOfSpecs { public static Collection<Object[]> data() { return Arrays.asList(new Object[] { Direction.NORTH, Direction.LEFT, Direction.LEFT, Direction.RIGHT, Direction.BOTTOM, Direction.TOP, Direction.TOP, Direction.BOTTOM }); } @Test public void directionTest(Direction d, Direction e) { this.direction = d; this.expected = e; } @Test public void opposite() throws Exception { direction = direction.opposite(); assertEquals(direction, expected); } </pre>
2	heightDegrees(int n)	<pre> @Test public void heightDegrees() throws Exception { assertEquals(expected: 180, GeoHash.heightDegrees(n: 0), delta: 0.001); assertEquals(expected: 0, GeoHash.heightDegrees(n: 13), delta: 0.001); } </pre>
3	getHashLength()	<pre> @Test public void getHashLengthUseGraph() throws Exception { Set<String> word = new HashSet<String>(); Coverage c = new Coverage(word, ratio: 0); int length = c.getHashLength(); assertEquals(expected: 0, length); word.add("29jw"); c = new Coverage(word, ratio: 4); length = c.getHashLength(); assertEquals(expected: 4, length); } </pre>
4	padLeftWithZerosToLength(String s, int length)	<pre> @Test public void padLeftWithZerosToLength() throws Exception { assertEquals(expected: "29jw", Base32.padLeftWithZerosToLength(s: "29jw", length: 4)); assertEquals(expected: "029jw", Base32.padLeftWithZerosToLength(s: "29jw", length: 5)); } </pre>
5	getCharIndex(char ch)	<pre> @Test(expected = IllegalArgumentException.class) public void getCharIndex() throws Exception { assertEquals(expected: 0, Base32.getCharIndex('0')); Base32.getCharIndex('A'); } </pre>

4 Test Results

4.1 JUnit test result snapshot

✓ Test Results	95 ms
> ✓ com.github.davidmoten.geo.Base32Test	7 ms
> ✓ com.github.davidmoten.geo.CoverageLongsTest	6 ms
> ✓ com.github.davidmoten.geo.CoverageTest	28 ms
> ✓ com.github.davidmoten.geo.DirectionTest	4 ms
> ✓ com.github.davidmoten.geo.GeoHashTest	36 ms
> ✓ com.github.davidmoten.geo.LatLongTest	14 ms

Test Summary

92
tests

0
failures

0
ignored

0.095s
duration

100%
successful

Packages

Classes

Package	Tests	Failures	Ignored	Duration	Success rate
com.github.davidmoten.geo	92	0	0	0.095s	100%

4.2 Code coverage snapshot

- Coverage of each selected method under test

✓ java	78% classes, 80% lines covered
✓ com.github.davidmoten.geo	78% classes, 80% lines covered
✓ mem	0% classes, 0% lines covered
Geomem	0% methods, 0% lines covered
Info	0% methods, 0% lines covered
> util	100% classes, 62% lines covered
Base32	85% methods, 95% lines covered
Coverage	100% methods, 100% lines covered
CoverageLongs	100% methods, 100% lines covered
Direction	100% methods, 100% lines covered
GeoHash	91% methods, 90% lines covered
LatLong	100% methods, 100% lines covered
package-info.java	
Parity	100% methods, 100% lines covered

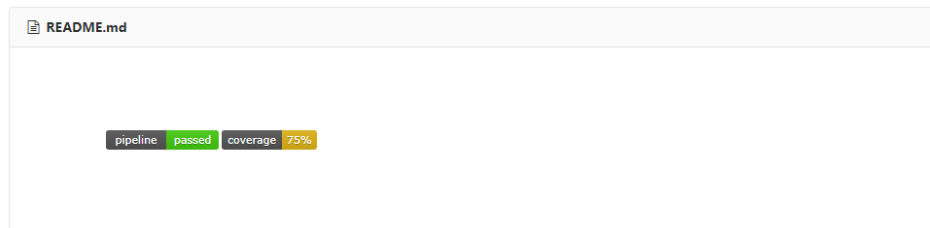
- Total coverage

geo

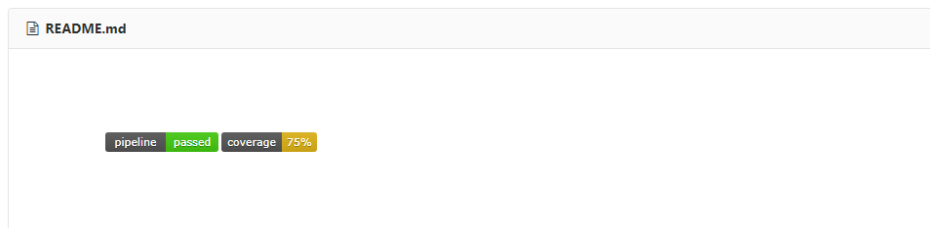
Element	Missed Instructions	Cov.	Missed Branches	Cov.	Missed Cxty	Missed Lines	Missed Methods	Missed Classes
com.github.davidmoten.geo	<div><div></div></div>	94%	<div><div></div></div>	84%	25 149	17 348	1 68	0 10
com.github.davidmoten.geo.mem	<div><div></div></div>	0%	<div><div></div></div>	0%	30 30	61 61	20 20	3 3
com.github.davidmoten.geo.util	<div><div></div></div>	68%	<div><div></div></div>	75%	1 4	1 6	0 2	0 1
Total	447 of 2,326	80%	46 of 186	75%	56 183	79 415	21 90	3 14

4.3 CI result snapshot (3 iterations for CI)

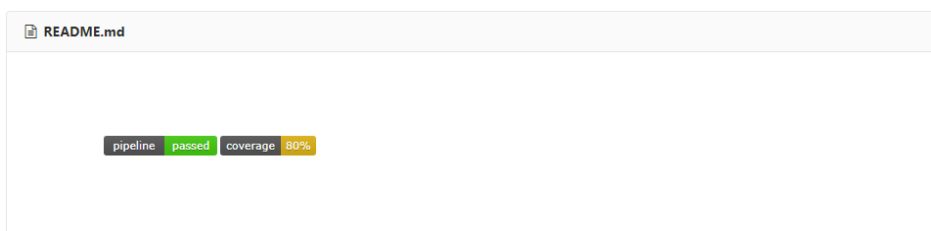
- CI#1



- CI#2



- CI#3



- CI Pipeline

The screenshot shows the 'GeoProject' CI Pipelines page. On the left is a sidebar with navigation links: Overview, Repository, Issues, Merge Requests, CI / CD, Pipelines (selected), Jobs, Schedules, Environments, Charts, Cluster, and Wiki. The main content area displays a table of pipeline runs with columns for Status, Pipeline, Commit, Stages, and a timestamp. The table lists five completed pipeline runs, each with a green '已就绪' (Ready) status icon and two green checkmarks in the Stages column.

Status	Pipeline	Commit	Stages	Timestamp
已就绪	#4223 by [user]	P master - 4b11881d Lab 3 V	✓✓	0001:12 3 minutes ago
已就绪	#4275 by [user]	P master - 27c18f9 Lab 3 IV	✓✓	0001:09 21 hours ago
已就绪	#4274 by [user]	P master - 42a7b68c Lab 3 III	✓✓	0001:16 21 hours ago
已就绪	#4273 by [user]	P master - 351e884a Lab 3 II	✓✓	0001:08 21 hours ago
已就绪	#4272 by [user]	P master - 8a59f2ef Lab 3 I	✓✓	0001:10 21 hours ago

5 The Coverage Comparison

The code coverage of Lab1 (and/or Lab2) and Lab3 are listed in the below Table. The results show that the statement and branch coverage are increased from 80% to 100% in Lab3.

No.	Test method	Lab1 (or Lab2)		Lab3	
		statement coverage	branch coverage	statement coverage	branch coverage
1	opposite()	100%	100%	100%	100%
2	heightDegrees(int n)	80%	81%	100%	100%
3	getHashLength()	100%	100%	100%	100%
4	padLeftWithZerosToLength(String s, int length)	100%	100%	100%	100%
5	getCharIndex(char ch)	100%	100%	100%	100%

6 Summary

In Lab 3, **8** test cases have been designed and implemented using JUnit and the basis path/graph coverage technique. The test is conducted in **3** CI and the execution results of the 6 test methods are **all passed**. The total statement and branch coverage of the test are **94%** and **84%**, respectively. Thus, the test requirements described in Section 1 are satisfied.

在 Lab 3 的 Graph Coverage 的練習，繪製出程式的路徑，來讓我們找到一些測試中可能被忽略的語句，並藉由此發現修正測試以提升測試覆蓋率讓測試能夠更完整，透過這次 Lab 令我收穫許多。