TST JUnit Testing
Software Verification and Validation
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1 Instruction Coverage

1.1 size()

```
public int size() {
   return n; //I1
}
```

Test Case	Values	Expected / Actual	IC
sizeZeroTest	-	0	I1

1.2 contains(String key)

```
public boolean contains(String key) {
   if (key == null) //I1
      throw new IllegalArgumentException("argument to
         contains() is null"); //I2
   return get(key) != null; //I3
}
```

Test Case	Values	Expected / Actual	IC
containsNullKey	null	IAE	I1, I2
containsNonNullKey	"someKey"	false	I1, I3

1.3 get(String key)

```
public T get(String key) {
  if (key == null) //I1
     throw new IllegalArgumentException("calls get() with
        null argument"); //I2
  if (key.length() == 0) //I3
     throw new IllegalArgumentException("key must have
        length >= 1"); //I4
  Node<T> x = get(root, key, 0); //I5
  if (x == null) //I6
    return null; //I7
  return x.val; //I8
}
```

Test Case	Values	Expected / Actual	IC
getNullKey	null	IAE	I1, I2
getEmptyStringKey	""	IAE	I1, I3, I4
getNonExistentKey	“someKey”	null	I1, I3, I5, I6, I7
getExistentKey	“key”	<value>	I1, I3, I5, I6, I8

1.4 put(String key, T val)

```
public void put(String key, T val) {
  if (key == null) //I1
    throw new IllegalArgumentException("calls put() with
       null key"); //I2
  if (!contains(key)) //I3
    n++; //I4
  root = put(root, key, val, 0); //I5
}
```

Test Case	Values	Expected / Actual	IC
putNullKey	null, 1	IAE	I1, I2
putValidNewKey	“someKey”, 1	NoExep	I1, I3, I4, I5

1.5 longestPrefixOf(String query)

```
public String longestPrefixOf(String query) {
  if (query == null) //I1
    throw new IllegalArgumentException("calls
       longestPrefixOf() with null argument"); //I2
  if (query.length() == 0) //I3
    return null; //I4
  int length = 0; //I5
  Node<T> x = root; //I6
  int i = 0; //I7
  while (x != null /*I8*/ && i < query.length() /*I9*/) {
    char c = query.charAt(i); //I10
    if    (c < x.c) /*I11*/ x = x.left; //I12
    else if (c > x.c) /*I13*/ x = x.right; //I14
    else {
      i++; //I15
      if (x.val != null) //I15
        length = i; //I17
      x = x.mid; //I18
    }
  }
  return query.substring(0, length); //I19
}
```

Test Case	Values	Expected / Actual	IC
longestPrefixOfNull	null	IAE	I1, I2
longestPrefixOf EmptyString	""	null	I1, I3, I4
longestPrefixOf AllInstructions	"c"	"c"	I1, I3, I5, I6, I7, I8, I9, I10, I11, I12, I13, I14, I15, I16, I17, I18, I19

1.6 keys()

```
public Iterable<String> keys() {
  Queue<String> queue = new LinkedList<>(); //I1
  collect(root, new StringBuilder(), queue); //I2
  return queue; //I3
}
```

Test Case	Values	Expected / Actual	IC
keysTest	-	Empty Iterator	I1, I2, I3

1.7 keysWithPrefix(String prefix)

```
public Iterable<String> keysWithPrefix(String prefix) {
   if (prefix == null) //I1
      throw new IllegalArgumentException("calls
         keysWithPrefix() with null argument"); //I2
   Queue<String> queue = new LinkedList<>(); //I3
   Node<T> x = get(root, prefix, 0); //I4
   if (x == null) //I5
      return queue; //I6
   if (x.val != null) //I7
      queue.add(prefix); //I8
      collect(x.mid, new StringBuilder(prefix), queue);
         //I9
      return queue; //I10
}
```

Test Case	Values	Expected / Actual	IC
keysWithPrefixNull	null	IAE	I1, I2
keysWithPrefix NonExistentPrefix	"prefix"	Iterator (size 0)	I1, I3, I4, I5, I6
keysWithPrefix ExistentPrefix	"c"	Iterator (size 1)	I1, I3, I4, I5, I6, I7, I8, I9, I10

1.8 keysThatMatch(String pattern)

```
public Iterable<String> keysThatMatch(String pattern) {
   Queue<String> queue = new LinkedList<>(); //I1
   collect(root, new StringBuilder(), 0, pattern, queue);
      //I2
   return queue; //I3
}
```

Test Case	Values	Expected / Actual	IC
keysThatMatchTest	"pattern"	Iterator (size 0)	I1, I2, I3

2 Edge Coverage

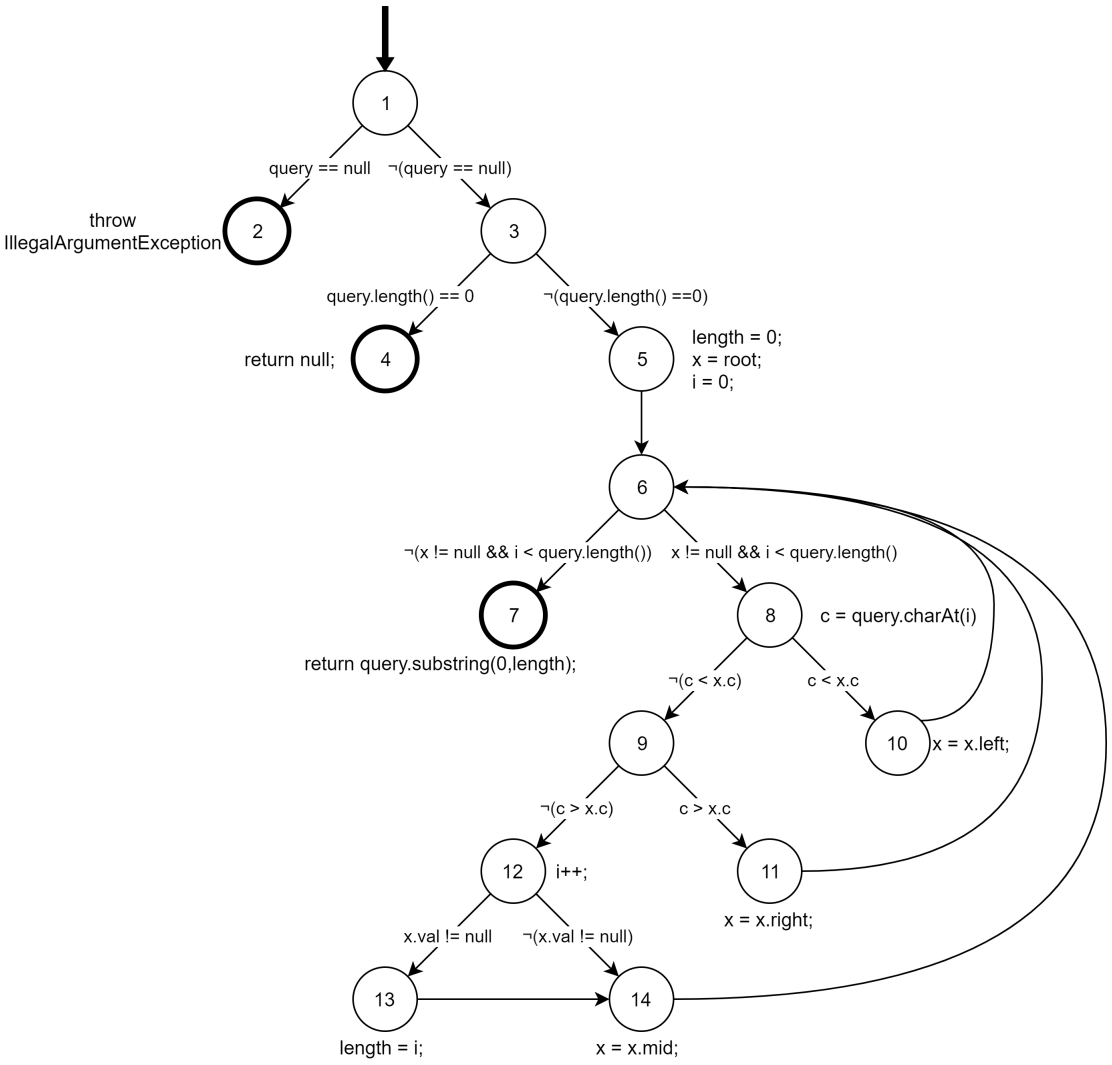

Figure 1: longestPrefixOf's Graph

3 Prime Path Coverage

4 All-Uses Coverage

nodes & edges : I	**def(I)**	**use(I)**
1	{root, query}	{}
(1,2), (1,3)	{}	{query}
3	{}	{}
(3,4), (3,5)	{}	{query}
4	{}	{}
5	{length, x, i}	{root}
(5,6)	{}	{}
6	{}	{}
(6,7), (6,8)	{}	{x, i, query}
7	{}	{query, length}
8	{c}	{i}
(8,9), (8,10)	{}	{c, x}
9	{}	{}
10	{x}	{x}
(10,6), (11,6), (14,6)	{}	{}
(9,11), (9,12)	{}	{c, x}
12	{x}	{x}
12	{i}	{i}
(12,13), (12,14)	{}	{x}
13	{length}	{i}
14	{x}	{x}

var	node	du(node,var)
query	1	[1,2], [1,3], [1,3,4], [1,3,5], [1,3,5,6,7], [1,3,5,6,8]
root	1	[1,3,5]
length	5	[5,6,7]
	13	[13,14,6,7]
x	5	[5,6,7], [5,6,8], [5,6,8,10], [5,6,8,9], [5,6,8,9,11] [5,6,8,9,12], [5,6,8,9,12,13], [5,6,8,9,12,13,14], [5,6,8,9,12,14]
	10	[10,6,7], [10,6,8], [10,6,8,10], [10,6,8,9], [10,6,8,9,11], [10,6,8,9,12], [10,6,8,9,12,13] [10,6,8,9,12,13,14], [10,6,8,9,12,14]
	11	[11,6,7], [11,6,8], [11,6,8,10], [11,6,8,9], [11,6,8,9,11], [11,6,8,9,12], [11,6,8,9,12,13] [11,6,8,9,12,13,14], [11,6,8,9,12,14]
	14	[14,6,7], [14,6,8], [14,6,8,10], [14,6,8,9] [14,6,8,9,11], [14,6,8,9,12], [14,6,8,9,12,13] [14,6,8,9,12,13,14], [14,6,8,9,12,14]
i	5	[5,6,7], [5,6,8], [5,6,8,9,12], [5,6,8,9,12,13]
	12	[12,13], [12,13,14,6,7], [12,13,14,6,8] [12,13,14,6,8,9,12], [12,14,6,7], [12,14,6,8], [12,14,6,8,9,12]
c	8	[8,9], [8,10], [8,9,11], [8,9,12]

Test	put ops	Values	Expected	Test Path
1	{}	null	IAE	[1,2]
2	{}	""	null	[1,3,4]
3	{}	"query"	""	[1,3,5,6,7]
4	{sea}	"a"	""	[1,3,5,6,8,10,6,7]
5	{sea}	"t"	""	[1,3,5,6,8,9,11,6,7]
6	{sea, s, e, a}	"sea"	"sea"	[1,3,5,6,8,9,12,13,14,6,8,9,12,14,6,8,9,12,13,14,6,7]
7	{sea, t, a}	"set"	""	[1,3,5,6,8,9,12,14,6,8,9,12,14,6,8,9,11,6,7]
8	{sea, ball, c}	"c"	"c"	[1,3,5,6,8,10,6,8,9,11,6,8,9,12,13,14,6,7]
9	{sea, cat, b}	"b"	"b"	[1,3,5,6,8,10,6,8,10,6,8,9,12,13,14,6,7]
10	{sea, up, w}	"w"	"w"	[1,3,5,6,8,9,11,6,8,9,11,6,8,9,12,13,14,6,7]
11	{sea}	"sd"	""	[1,3,5,6,8,9,12,14,6,8,10,6,7]
12	{sea}	"su"	""	[1,3,5,6,8,9,12,14,6,8,9,11,6,7]
13	{sea, w}	"t"	""	[1,3,5,6,8,9,11,6,8,10,6,7]

5 Logic-based Coverage

References

[1] SiLK - CERT NetSA https://tools.netsa.cert.org/silk/docs.html

[2] List of TCP and UDP port numbers https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers