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Problem 1 (Graph II and Graph III)

EXERCISES

Section 2.2.3.

1. Below are four graphs, each of which is defined by the sets of nodes, initial nodes, final nodes, edges, and defs and uses. Each graph also contains a collection of test paths. Answer the following questions about each graph.

Graph I.
$N = \{0, 1, 2, 3, 4, 5, 6, 7\}$
$N_0 = \{0\}$
$N_f = \{7\}$
$E = \{(0, 1), (1, 2), (1, 7), (2, 3), (2, 4), (3, 2), (4, 5), (4, 6), (5, 6), (6, 1)\}$
$def(0) = def(3) = use(5) = use(7) = \{x\}$

Test Paths:
$t1 = [0, 1, 7]$
$t2 = [0, 1, 2, 4, 6, 1, 7]$
$t3 = [0, 1, 2, 4, 5, 6, 1, 7]$
$t4 = [0, 1, 2, 3, 2, 4, 6, 1, 7]$
$t5 = [0, 1, 2, 3, 2, 3, 2, 4, 5, 6, 1, 7]$
$t6 = [0, 1, 2, 3, 2, 4, 6, 1, 2, 4, 5, 6, 1, 7]$

Graph II.
$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1, 2), (2, 3), (2, 6), (3, 4), (3, 5), (4, 5), (5, 2)\}$
$def(x) = \{1, 3\}$
$use(x) = \{3, 6\}$ // Assume the use of x in 3 precedes the def
Test Paths:
$t1 = [1, 2, 6]$
$t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]$
$t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]$
$t4 = [1, 2, 3, 5, 2, 6]$

Graph III.
$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1, 2), (2, 3), (3, 4), (3, 5), (4, 5), (5, 2), (2, 6)\}$
$def(x) = \{1, 4\}$
$use(x) = \{3, 5, 6\}$

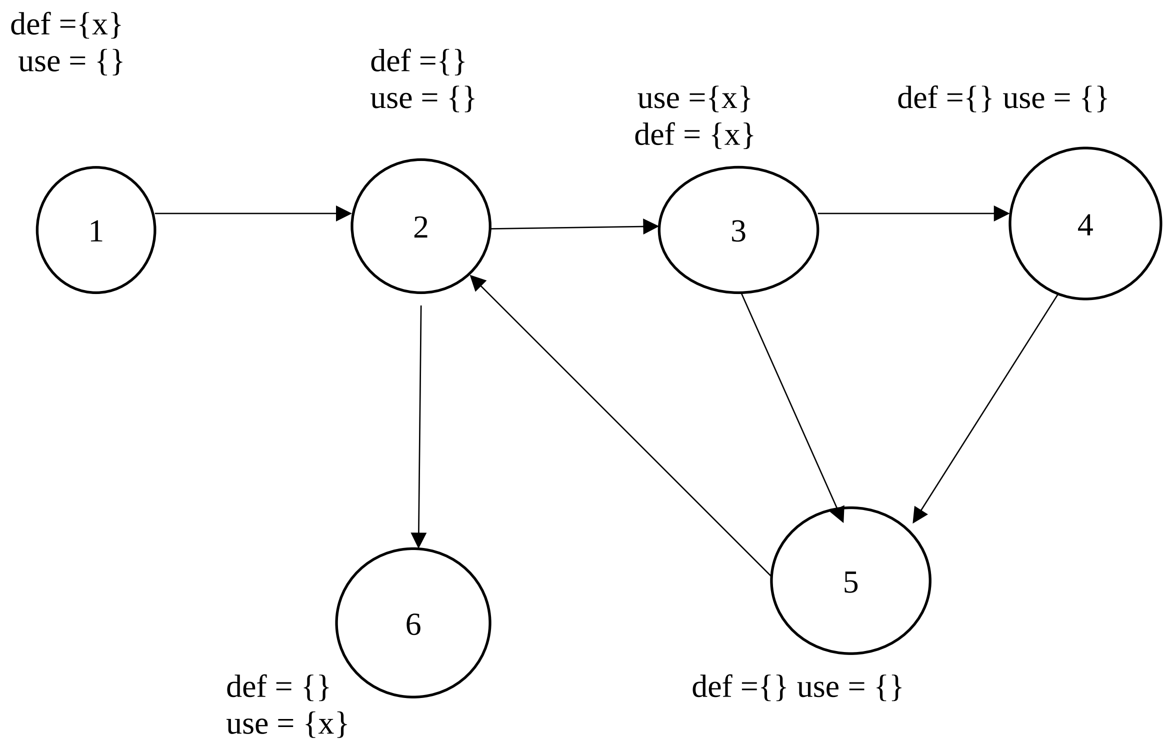
Test Paths:
$t_1 = [1, 2, 3, 5, 2, 6]$
$t_2 = [1, 2, 3, 4, 5, 2, 6]$

Graph IV.
$N = \{1, 2, 3, 4, 5, 6\}$
$N_0 = \{1\}$
$N_f = \{6\}$
$E = \{(1, 2), (2, 3), (2, 6), (3, 4), (3, 5), (4, 5), (5, 2)\}$
$def(x) = \{1, 5\}$
$use(x) = \{5, 6\}$ // Assume the use of x in 5 precedes the def
Test Paths:
$t1 = [1, 2, 6]$
$t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]$
$t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]$

(a) Draw the graph.
(b) List all of the du-paths with respect to x. (Note: Include all du-paths, even those that are subpaths of some other du-path).
(c) For each test path, determine which du-paths that test path tours. For this part of the exercise, you should consider both direct touring and sidetrips. Hint: A table is a convenient format for describing this relationship.
(d) List a minimal test set that satisfies *all-defs* coverage with respect to x. (Direct tours only.) Use the given test paths.
(e) List a minimal test set that satisfies *all-uses* coverage with respect to x.

(Direct tours only.) Use the given test paths.
(f) List a minimal test set that satisfies *all-du-paths* coverage with respect to x. (Direct tours only.) Use the given test paths.

II a)
G = <N, N0, Nf, E>
Nodes (N): {1, 2, 3, 4, 5, 6}
Node 1: Initial node (N0)
Node 6: Final node (Nf)
Edges (E): {(1, 2), (2, 3), (2, 6), (3, 4), (3, 5), (5, 2)}
def (x) = {1, 3}
use (x) = {3, 6}



b) All the du-paths with respect to x are [1,2,3], [1,2,6], [3, 4, 5, 2, 6] and [3,5,2,6]

c) t1 = [1, 2, 6]
t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6]
t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]
t4 = [1, 2, 3, 5, 2, 6]

Direct
[1,2,6] by t1
[1,2,3] by t2, t3 and t4
[3, 4, 5, 2, 6] by t3
[3,5,2,6] by t4

Sidetrip
[1,2,6] and [3, 4, 5, 2, 6] by t2
[1,2,6] and [3,5,2,6] by t3
[1,2,6] by t4

The test path t1 tours the du paths [1, 2, 6] directly because the du- path is the sub path of the test path t1. In the same manner, the test path t2 tours the du-paths [1, 2, 3], the test path t3 tours [1,2,3] and [3, 4, 5, 2, 6] and the test path t4 tours [3, 5, 2, 6] since they are sub paths of the respective test paths.

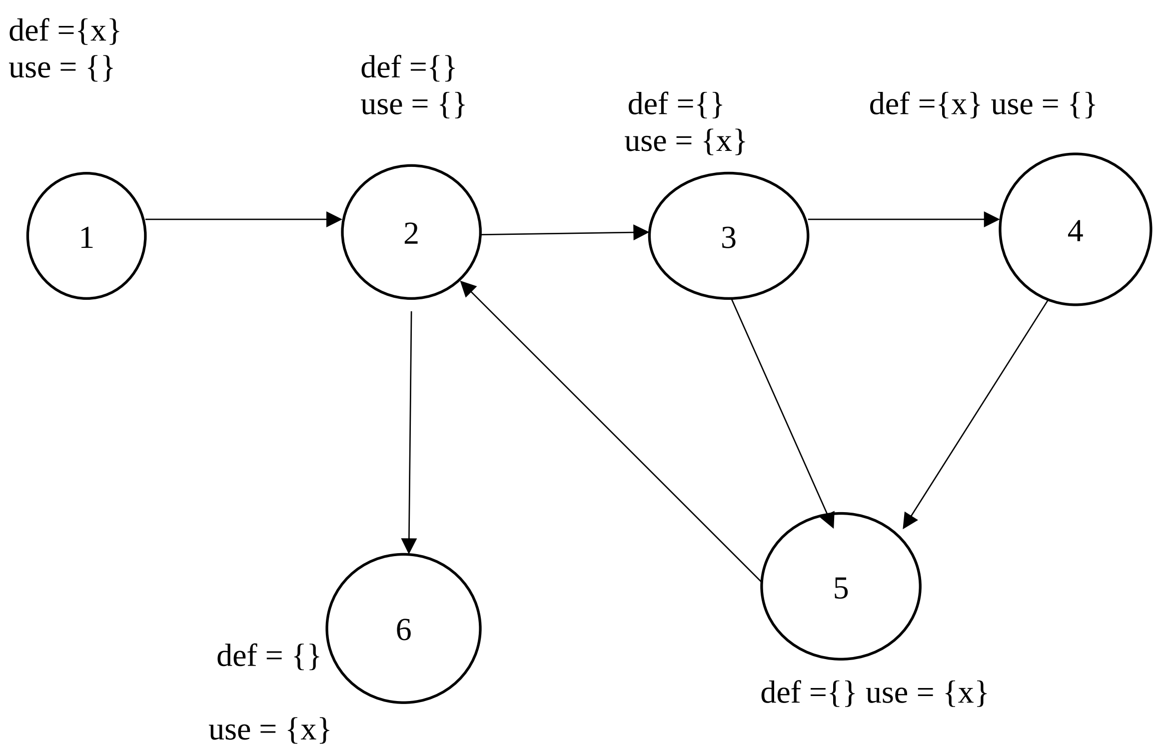
Test path t2 tours the du-paths [1, 2, 6] and [3, 4, 5, 2, 6], t3 tours [1,2,6] and [3,5,2,6] and t4 tours [1,2,6] with sidetrips because every edge in the du-path is not in the test paths in the same order.

d) The minimal test set that satisfies all –Defs coverage with respect to x would be t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6] and t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6]. They both tour at least one path to at least one use.

e) The minimal test set that satisfies all-Uses coverage with respect to x would be {t1 = [1, 2, 6] , t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6], t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6] t4 = [1, 2, 3, 5, 2, 6]} the test paths directly tour the du-paths. They tour at least one path for every def-use pair and all the 4 du-paths are toured.

f) The minimal test set that satisfies all-DU-Paths coverage would be {t1 = [1, 2, 6], t2 = [1, 2, 3, 4, 5, 2, 3, 5, 2, 6], t3 = [1, 2, 3, 5, 2, 3, 4, 5, 2, 6], t4 = [1, 2, 3, 5, 2, 6]}
This is because there is just one du-path for every du-pair. The test set tours every du- path.

III a)
G = <N, N0, Nf, E>
Nodes (N): {1, 2, 3, 4, 5, 6}
Node 1: Initial node (N0)
Node 6: Final node (Nf)
Edges (E): {(1, 2), (2, 3), (3, 4), (4, 5), (5, 2), (2, 6)}
def (x) = {1, 4}
use (x) = {3, 5, 6}



b) All the du-paths with respect to x are [1,2,3], [1,2,3,5], [1,2,6], [4,5], [4,5,2,3] and [4,5,2,6]

c) *t*1 = [1, 2, 3, 5, 2, 6]
*t*2 = [1, 2, 3, 4, 5, 2, 6]

Direct
[1,2,3], [1,2,3,5] by t1
[1,2,3], [4,5] and [4,5,2,6] by t2

Sidetrip
[1,2,6] by t1and t2

The test path t1 tours the du paths [1, 2, 3] and [1, 2, 3, 5] directly because the du- paths are a sub path of the test path t1. In the same manner, the test path t2 tours the du-paths [1, 2, 3], [4, 5] and [4, 5, 2, 6] since they are sub paths of the test path t2.

The test paths t1 and t2 tour the du-path [1, 2, 6] with sidetrips because every edge in the du-path is also in the test paths in the same order.

d) The minimal test set that satisfies all –Defs coverage with respect to x would be *t*2 = [1, 2, 3, 4, 5, 2, 6]. It tours at least one path to at least one use.

e) The minimal test set that satisfies all-Uses coverage with respect to x would be { *t*1 = [1, 2, 3, 5, 2, 6], *t*2 = [1, 2, 3, 4, 5, 2, 6], [1, 2, 6], [1, 2, 3, 4, 5, 2, 3, 5, 2, 6] }
we added new tests in order to have a path to directly tour [1,2,6] and [4, 5, 2, 3] these tour at least one path for every def-use pair and all the 6 du-paths are toured.

f) The minimal test set that satisfies all-DU-Paths coverage would be {*t*1 = [1, 2, 3, 5, 2, 6] , *t*2 = [1, 2, 3, 4, 5, 2, 6], [1, 2, 6], [1, 2, 3, 4, 5, 2, 3, 5, 2, 6] }. This is because there is just one du-path for every du-pair. The test set tours every du-path.