CS 898 AE SAM - Quiz 1 Feb, 2021

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1. Who are the available expressions for each instruction in the following program?

L1	a = c
L2	b = a + 1
L3	c = c + b
L4	a = b * 2
L5	if (a < N) goto L2
L6	return c

l	Kill AE (l)	GEN AE (l)
1	∅	∅
2	∅	a + 1
3	c + b	∅
4	{a + 1}	{b * 2}
5	∅	∅
6	∅	∅

Equations

$AE_{entry}(1) = \emptyset$

$AE_{entry}(2) = AE_{exit}(1) \cap AE_{exit}(5)$

$AE_{entry}(3) = AE_{exit}(2)$

$AE_{entry}(4) = AE_{exit}(3)$

$AE_{entry}(5) = AE_{exit}(4)$

$AE_{entry}(6) = AE_{exit}(5)$

$AE_{exit}(1) = AE_{entry}(1)$

$AE_{exit}(2) = AE_{entry}(2) \cup \{a+1\}$

$AE_{exit}(3) = AE_{entry}(4) \cup \{b*2\} / \{a+1\}$

$AE_{exit}(4) = AE_{entry}(5)$

AE ∞

$AE_{exit}(1) = AE_{entry}(1)$

$AE_{exit}(2) = AE_{entry}(2) \cup \{a+1\}$

$AE_{exit}(3) = AE_{entry}(3) / \{a+b\}$

$AE_{exit}(4) = AE_{entry}(4) \cup \{(b*2)\} / \{a+1\}$

$AE_{exit}(5) = AE_{entry}(5)$

$AE_{exit}(6) = AE_{entry}(6)$

Largest Sols.

l	$AE_{entry}(l)$	$AE_{exit}(l)$
1	$\emptyset$	$\emptyset$
2	$\emptyset$	$\{a+1\}$
3	$\{a+1\}$	$\{a+1\}$
4	$\{a+1\}$	$\{b*2\}$
5	$\{b*2\}$	$\{b*2\}$
6	$\{b*2\}$	$\{b*2\}$

2) Who are the reaching definitions for each instruction in the following program?

```
L1   a = 10
L2   b = b + 1
L3   c = c + b
L4   a = b * 2
L5   if (b < N) goto L2
L6   return a
```

Solution

l	KILLen(l)	GENen(l)
1	{(a,?), (a,1) (a,4)}	{(a,1)}
2	{(b,?) (b,2)}	{(b,2)}
3	{(c,?), (c,3)}	{(c,3)}
4	{(a,?) (a,1) (a,4)}	{(a,4)}
5	∅	∅
6	∅	∅

Equations

$RD_{entry}(1) = \{(a,?), (b,?) (c,?)\}$

$RD_{entry}(2) = RD_{exit}(1) \cup RD_{exit}(5)$

$RD_{entry}(3) = RD_{exit}(2)$

$RD_{entry}(4) = RD_{exit}(3)$

$RD_{entry}(5) = RD_{exit}(4)$

$RD_{entry}(6) = RD_{exit}(5)$

$RD_{exit}(1) = (RD_{entry}(1) \setminus \{(a,?)(a,1)(a,4)\}) \cup \{(a,1)\}$

$RD_{exit}(2) = (RD_{entry}(2) \setminus \{(b,?)(b,2)\}) \cup \{(b,2)\}$

$RD_{exit}(3) = (RD_{entry}(3) \setminus \{(c,?)(c,3)\}) \cup \{(c,3)\}$

$RD_{exit}(4) = (RD_{entry}(4) \setminus \{(a,?)(a,1)(a,4)\}) \cup \{(a,4)\}$

$RD_{exit}(5) = RD_{entry}(5)$

$RD_{exit}(6) = RD_{entry}(6)$

Smallest Solution

	$RD_{entry}(1)$	$RD_{exit}(1)$
1	$\{(a,?)(b,?)(c,?)\}$	$\{(a,1),(b,?)(c,?)\}$
2	$\{(a,1)(b,?)(c,?)(a,4)(c,3)(b,2)\}$	$\{(a,1)(c,?),(a,4)(c,3)(b,2)\}$
3	$\{(a,1)(c,?)(a,4)(c,3)(b,2)\}$	$\{(a,1)(a,4)(c,3)(b,2)\}$
4	$\{(a,1)(a,4)(c,3)(b,2)\}$	$\{(a,4)(c,3)(b,2)\}$
5	$\{(a,4)(c,3)(b,2)\}$	$\{(a,4)(c,3)(b,2)\}$
6	$\{(a,4)(c,3)(b,2)\}$	$\{(a,4)(c,3)(b,2)\}$

3 Who are the live variables for each instruction in the following program?

```
L1  x = z
L2  y = 1
L3  x = 1
L4  if (y > x)
L5  then (z = y)
L6  else z = y * y
L7  x = z
```

Solution

l	$kill_{LV}(l)$	$Gen_{LV}(l)$
1	x	z
2	y	ϕ
3	x	ϕ
4	ϕ	x, y
5	z	y
6	z	y
7	x	z

Equations

$LV_{entry}(1) = LV_{exit}(1) \setminus \{x\} \cup \{z\}$
$LV_{entry}(2) = LV_{exit}(2) \setminus \{y\}$
$LV_{entry}(3) = LV_{exit}(3) \setminus \{x\}$
$LV_{entry}(4) = LV_{exit}(4) \cup \{x, y\}$
$LV_{entry}(5) = LV_{exit}(5) \setminus \{z\} \cup \{y\}$
$LV_{entry}(6) = \{LV_{exit}(6) \setminus \{z\} \cup \{y\}$
$LV_{entry}(7) = \{LV_{exit}(7) \setminus \{x\} \cup \{z\}\}$

$LV_{exit}(1) = LV_{entry}(2)$

$LV_{exit}(2) = LV_{entry}(3)$

$LV_{exit}(3) = LV_{entry}(4)$

$LV_{exit}(4) = LV_{entry}(5) \cup LV_{entry}(6)$

$LV_{exit}(5) = LV_{entry}(7)$

$LV_{exit}(6) = LV_{entry}(7)$

$LV_{exit}(7) = \emptyset$

Smallest Sol.

1	$LV_{entry}(\ell)$	$LV_{exit}(\ell)$
1	$\{z\}$	$\emptyset$
2	$\emptyset$	$\{y\}$
3	$\{y\}$	$\{x, y\}$
4	$\{x, y\}$	$\{y\}$
5	$\{y\}$	$\{z\}$
6	$\{y\}$	$\{z\}$
7	$\{z\}$	$\emptyset$