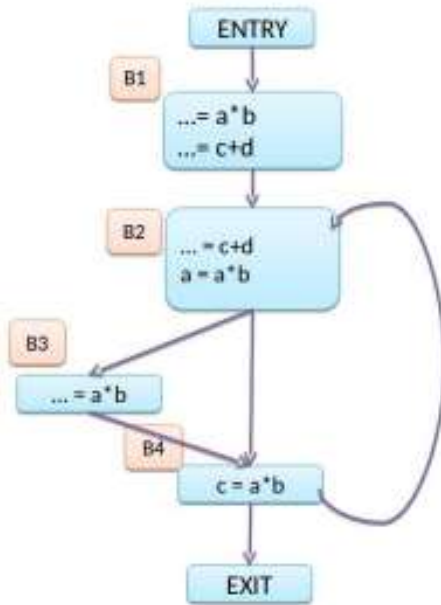


$r2 = r0 + r1$
 $r4 = r2 + r2$

For next two questions: Consider the following CFG



Q150. [MSQ]

Which of the following is/are correct gen and kill sets of basic blocks for Available expression analysis?

- (A) For basic block B1, Gen = {a*b, c + d}, Kill = {}
- (B) For basic block B2, Gen = {c + d}, Kill = {a*b}
- (C) For basic block B3, Gen = {a*b}, Kill = {}
- (D) For basic block B4, Gen = {a*b}, Kill = {c + d}

Answer: a, b, c, d

Solution:

BB	GEN	KILL
B1	{a*b, c+d}	{ }
B2	{c+d}	{a*b}
B3	{a*b}	{ }
B4	{a*b}	{c+d}

Q151. [MSQ]



Which of the following is/are correct IN and OUT sets of basic blocks for Available expression analysis?

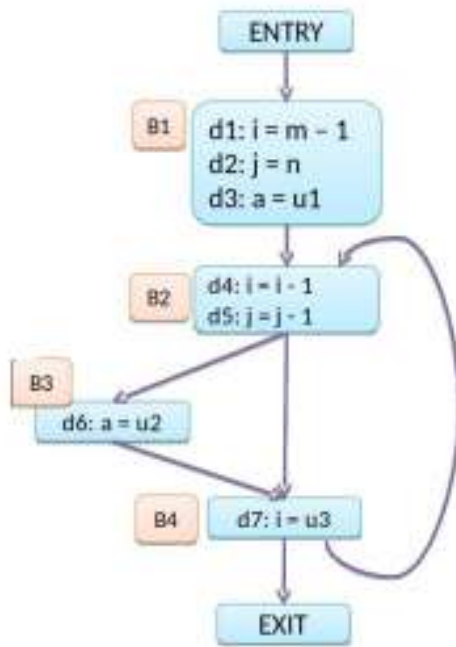
- (A) For basic block B1, $IN = \{\}$, $OUT = \{a*b, c + d\}$
- (B) For basic block B2, $IN = \{a*b\}$, $OUT = \{a*b, c + d\}$
- (C) For basic block B3, $IN = \{c + d\}$, $OUT = \{a*b, c + d\}$
- (D) For basic block B4, $IN = \{c + d\}$, $OUT = \{a*b, c + d\}$

Answer: a, b, c

Solution:

Pass#	Pt	B1	B2	B3	B4
Init	IN	-	-	-	-
	OUT	\mathcal{U}	\mathcal{U}	\mathcal{U}	\mathcal{U}
1	IN	\emptyset	$a*b, c+d$	$c+d$	$c+d$
	OUT	$a*b, c+d$	$c+d$	$a*b, c+d$	$a*b$
2	IN	\emptyset	$a*b$	$c+d$	$c+d$
	OUT	$a*b, c+d$	$c+d$	$a*b, c+d$	$a*b$
3	IN	\emptyset	$a*b$	$c+d$	$c+d$
	OUT	$a*b, c+d$	$c+d$	$a*b, c+d$	$a*b$

For next two questions: Consider the following CFG



Q152. [MSQ]

If Gen (B) and Kill (B) represent the Gen set and Kill set of basic block B, respectively. Which of the following options is/ are correct about gen and kill sets of basics blocks for reaching definition analysis?

- (A) $\text{Gen}(B2) = \text{Kill}(B2) \cup \text{Kill}(B3) \cup \text{Kill}(B4)$
- (B) $\text{Gen}(B1) - (\text{Kill}(B2) \cup \text{Kill}(B3) \cup \text{Kill}(B4)) = \emptyset$
- (C) $\text{Kill}(B2) \cap \text{Kill}(B1) = \text{Gen}(B4) - \text{Kill}(B4)$
- (D) $\text{Kill}(B1) = \text{Gen}(B2) \cup \text{Gen}(B3) \cup \text{Gen}(B4)$

Answer: b, c, d

Solution

BB	GEN	KILL
B1	{d1, d2, d3}	{d4, d5, d6, d7}
B2	{d4, d5}	{d1, d2, d7}
B3	{d6}	{d3}
B4	{d7}	{d1, d4}

Q153. [MSQ]

If IN (B) and OUT (B) represent the IN set and OUT set of basic block B, respectively. Which of the following options is/ are correct about IN and OUT sets of basics blocks for reaching definition analysis after 3rd Pass?

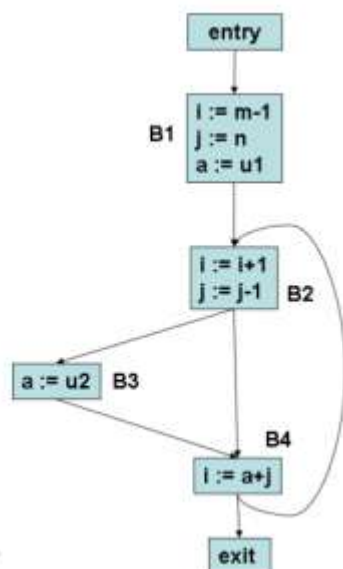
- (A) $|\text{OUT}(B2) \cap \text{OUT}(B3)| = |\text{OUT}(B4) - \text{OUT}(B1)|$
- (B) $\text{IN}(B3) = \text{IN}(B4)$
- (C) $\text{OUT}(B3) = \text{IN}(B4)$
- (D) $\text{IN}(B2) \cup \text{IN}(B1) = \{d1, d2, d3, d5, d6, d7\}$

Answer: A, B, D

Solution:

Pass#	Pt	B1	B2	B3	B4
Init	IN	-	-	-	-
	OUT	\emptyset	\emptyset	\emptyset	\emptyset
1	IN	\emptyset	d1, d2, d3	d3, d4, d5	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5	d4, d5, d6	d3, d4, d5, d6, d7
2	IN	\emptyset	d1, d2, d3, d5, d6, d7	d3, d4, d5, d6	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5, d6	d4, d5, d6	d3, d4, d5, d6, d7
3	IN	\emptyset	d1, d2, d3, d5, d6, d7	d3, d4, d5, d6	d3, d4, d5, d6
	OUT	d1, d2, d3	d3, d4, d5, d6	d4, d5, d6	d3, d4, d5, d6, d7

For next Eight questions: Consider the following CFG



Q154. Which of the following is correct use and define sets of basics block B1 for live variable analysis?

(A) Use = { m, n}, Def = {i, j, a }

(B) Use = { m, n, u1}, Def = {i, j }

(C) Use = {m, n }, Def = {i, j }

(D) Use = { m, n, u1 }, Def = { i, j, a }

Answer :-D

Q155.	Which of the following is correct use and define sets of basics block B2 for live variable analysis? (A) Use = {i,j }, Def = {i,j } (B) Use = { i,j}, Def = {i } (C) Use = {i,j }, Def = { } (D) Use = {i,j }, Def = {j } Answer :-C
Q156.	Which of the following is correct use and define sets of basics block B3 for live variable analysis? (A) Use = {u2 }, Def = {a } (B) Use = {u2 }, Def = {u2,a } (C) Use = { a,u2}, Def = {a } (D) Use = {a }, Def = { u2} Answer :-A
Q157.	Which of the following is correct use and define sets of basics block B4 for live variable analysis? (A) Use = {a, j, i }, Def = {i } (B) Use = { a, j}, Def = {i } (C) Use = {a, j, i }, Def = {a, j, i } (D) Use = {a, j, i }, Def = { i, j} Answer :-B
Q158.	Which of the following is correct in and out sets of basics block B1 for live variable analysis? (A) In = {m,n,u1}, Out = {i,j,u2,a} (B) In = {m,n}, Out = {i,j,u2,a} (C) In = {m,n,u1}, Out = {i,j,u2} (D) In = {m,n}, Out = {i,j,u2} Answer :-A
Q159.	Which of the following is correct in and out sets of basics block B2 for live variable analysis? (A) In = {i,j,a}, Out = {a,j,u2} (B) In = {i,j,a,u2}, Out = {a,j,u2} (C) In = {i,j,a}, Out = {a,j,u1} (D) In = {i,j,a,u1}, Out = {a,j,u2} Answer :-B
Q160.	Which of the following is correct in and out sets of basics block B3 for live variable analysis?

- (A) In = {j,u2}, Out = {a,j,u2}
- (B) In = {i,u2}, Out = {a,j,u2}
- (C) In = {i,j,u2}, Out = {a,j,u2}
- (D) In = {i,j}, Out = {a,j,u2}

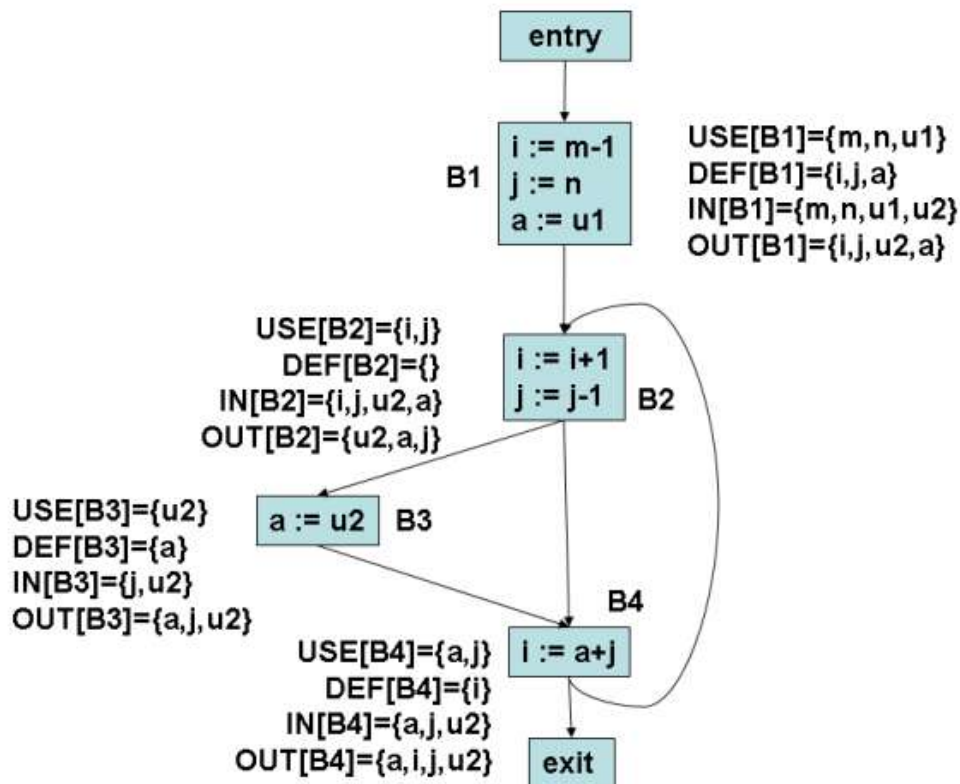
Answer :-A

Q161. Which of the following is correct in and out sets of basic block B4 for live variable analysis?

- (A) In = {a,j,u2}, Out = {a,j,u2}
- (B) In = {a,j,u2}, Out = {a,i,j,u2}
- (C) In = {a,j,u2}, Out = {a,i,u2}
- (D) In = {a,i,u2}, Out = {a,i,j,u2}

Answer :-b

Solution



For next two questions: Consider the following basic block for live variables:


```
b = a
d = b
a = c
e = d
a = e
```

Q162. What is USE for the basic block?

- (A) {a}
- (B) {b,c}
- (C) {e, d}
- (D) { a, c }

Answer:- D

Solution

Use(B)={a,c}

Def (B)={b,d,e,a}

Q163. What is DEF for the basic block?

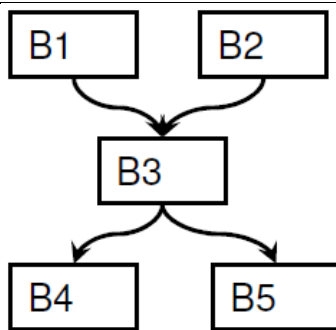
- (A) {a,b,d}
- (B) {c, d, b}
- (C) { a, b, d, e }
- (D) {a, c}

Answer:- C

Solution

Def(B)={a,b,d,e}

Consider the following control flow graph for next three questions



Assume you are given IN/OUT for B1, B2, B4, B5, and GEN/KILL for B3.

Q164. What is the forward data-flow problem for available expression for basic block B3?

- (A) $IN(B3) = OUT(B1) \wedge OUT(B2)$, $OUT(B3) = GEN(B3) \cap (IN(B3) - KILL(B3))$
- (B) $IN(B3) = OUT(B1) \vee OUT(B2)$, $OUT(B3) = GEN(B3) \cup (IN(B3) - KILL(B3))$
- (C) $IN(B3) = OUT(B1) \wedge OUT(B2)$, $OUT(B3) = GEN(B3) \cup (IN(B3) - KILL(B3))$
- (D) $IN(B3) = OUT(B1) \vee OUT(B2)$, $OUT(B3) = GEN(B3) \cap (IN(B3) - KILL(B3))$

164) Answer C

~~out~~ in available expression

$$out(B) = gen(B) \cup \{ in(B) - kill(B) \}$$

$in(B) = \bigcap out(P_i)$ predecessor

$$in(B3) = out(B1) \wedge out(B2)$$

$$out(B3) = gen(B3) \cup \{ in(B3) - kill(B3) \}$$

Q165. What is the forward data-flow problems for reaching definition for basic block B3 ?

- (A) $IN(B3) = OUT(B1) \wedge OUT(B2)$, $OUT(B3) = GEN(B3) \cap (IN(B3) - KILL(B3))$
- (B) $IN(B3) = OUT(B1) \vee OUT(B2)$, $OUT(B3) = GEN(B3) \cup (IN(B3) - KILL(B3))$
- (C) $IN(B3) = OUT(B1) \wedge OUT(B2)$, $OUT(B3) = GEN(B3) \cup (IN(B3) - KILL(B3))$
- (D) $IN(B3) = OUT(B1) \vee OUT(B2)$, $OUT(B3) = GEN(B3) \cap (IN(B3) - KILL(B3))$

165) Answer 9
in reaching definition

$$\text{out}(B) = \text{gen}(B) \cup \{ \text{In}(B) - \text{kill}(B) \}$$

$$\text{In}(B) = \bigcup \text{out}(P_i)$$

$$\therefore \text{out}(B_3) = \text{gen}(B_3) \cup \{ \text{In}(B_3) - \text{kill}(B_3) \}$$

$$\text{In}(B_3) = \text{out}(B_1) \cup \text{out}(B_2)$$

Q166. What is the backwards data-flow problems for B3 ?

(A) $\text{OUT}(B_3) = \text{IN}(B_4) \vee \text{IN}(B_5)$, $\text{IN}(B_3) = \text{USE}(B_3) \cup (\text{OUT}(B_3) - \text{DEF}(B_3))$

(B) $\text{OUT}(B_3) = \text{IN}(B_4) \wedge \text{IN}(B_5)$, $\text{IN}(B_3) = \text{USE}(B_3) \cap (\text{OUT}(B_3) - \text{DEF}(B_3))$

(C) $\text{OUT}(B_3) = \text{IN}(B_4) \vee \text{IN}(B_5)$, $\text{IN}(B_3) = \text{USE}(B_3) \cap (\text{OUT}(B_3) - \text{DEF}(B_3))$

(D) $\text{OUT}(B_3) = \text{IN}(B_4) \wedge \text{IN}(B_5)$, $\text{IN}(B_3) = \text{USE}(B_3) \cup (\text{OUT}(B_3) - \text{DEF}(B_3))$

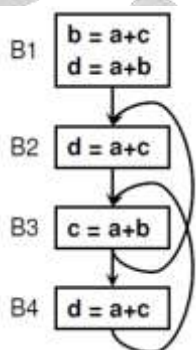
166) Answer A

$$\text{out}(B) = \bigcup \text{In}(S_i) \quad \text{if successor}$$

$$\text{out}(B_3) = \text{In}(B_4) \vee \text{In}(B_5)$$

$$\text{In}(B_3) = \text{use}(B_3) \cup \{ \text{out}(B_3) - \text{def}(B_3) \}$$

Consider the following control flow graph for available expressions



Q167. Calculate GEN/KILL for each basic block. Which of the following option is true?

(A)

	GEN	KILL
B1	$a+c.a+b$	$a+b$
B2	$a+c$	ϕ
B3	$a+b$	$a+b$
B4	$a+c$	ϕ

(B)

	GEN	KILL
B1	$a+c.a+b$	$a+b$
B2	$a+c$	ϕ
B3	$a+b$	$a+c$
B4	$a+c$	ϕ

(C)

	GEN	KILL
B1	$a+c.a+b$	$a+c$
B2	$a+c$	ϕ
B3	$a+b$	$a+c$
B4	$a+c$	ϕ

(D)

	GEN	KILL
B1	$a+c.a+b$	$a+b$
B2	$a+c$	ϕ
B3	$a+b$	$a+c$
B4	$a+c$	$a+c$

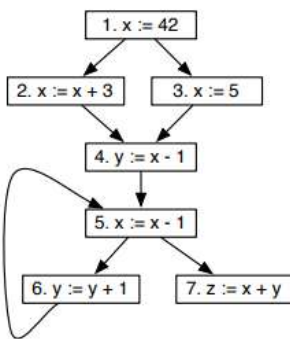
Answer: B

Solution

$IN[B] = \cap P$ a predecessor of B $OUT[P];$

$OUT[B] = gen[B] \cup [(IN[B] - kill[B]);$

For next two questions consider the control-flow graph with numbers for each statement:



Q168. What are the sets of live variables at the beginning of each statement?

[Note: Write \emptyset for the empty set, if necessary]

(A) 1 - \emptyset , 2 - $\{x\}$, 3 - $\{x\}$, 4 - $\{x\}$, 5 - $\{x, y\}$, 6 - $\{x, y\}$, 7 - $\{x, y\}$

(B) 1 - \emptyset , 2 - $\{x\}$, 3 - \emptyset , 4 - $\{x\}$, 5 - $\{x, y\}$, 6 - $\{x, y\}$, 7 - $\{x, y\}$

(C) 1 - \emptyset , 2 - \emptyset , 3 - \emptyset , 4 - $\{x\}$, 5 - $\{x, y\}$, 6 - $\{x, y\}$, 7 - $\{x, y\}$

(D) 1 - \emptyset , 2 - $\{x\}$, 3 - \emptyset , 4 - $\{x\}$, 5 - $\{y\}$, 6 - $\{x, y\}$, 7 - $\{x, y\}$

Answer: B

Solution:

Stmt	Live variables at beginning of stmt
1	\emptyset
2	x
3	\emptyset
4	x
5	x,y
6	x,y
7	x,y

Q169. What are the sets of reaching definitions at the end of each statement?
 [Note: Write \emptyset for the empty set, if necessary]

(a)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3
5	4, 5, 6
6	5, 6
7	4, 5, 6, 7

(b)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	4, 5, 6
6	4, 5, 6
7	4, 5, 6, 7

(c)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	4, 5, 6
6	5, 6
7	4, 5, 6, 7

(d)

statement	Reaching Definition
1	1
2	2
3	3
4	2, 3, 4
5	5, 6
6	5, 6
7	4, 5, 6, 7

169) Answer e

Block Statement	gen(B)	kill(B)	in(B)	out(B)
1	1	2, 3, 5	ϕ	1
2	2	1, 3, 5	1	2
3	3	1, 2, 5	1	3
4	4	6	2, 3	2, 3, 4
5	5	1, 2, 3	4, 6	4, 5, 6
6	6	4	5	5, 6
7	7	ϕ	5, 4, 6	4, 5, 6, 7

Q170. What is the live range for each variable (x, y, z, w & v) in the following program?

```

0: ....
1: x = y + 1
2: z = x + y
3: w = load(x)
4: v = f(z, w) // v is used later
5: ....

```

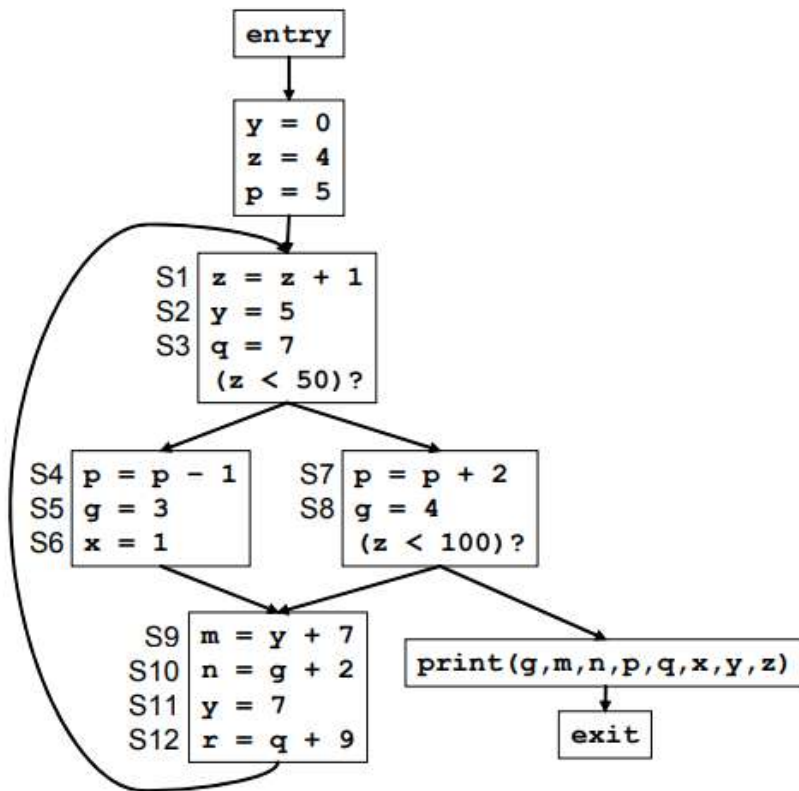
- (A) x: 0-3, y: 0-2, z: 0-4, w: 0-4, v: 0-4
- (B) x: 1-3, y: 1-2, z: 2-4, w: 3-4, v: 4-4
- (C) x: 1-3, y: 0-2, z: 2-4, w: 3-4, v: 4-5
- (D) None of the above

170) Answer C

As x define in 1, then live range of x = 1 to 3
 y is already live in 0, as it being used in 1
 \therefore live range of y = 0 to 2
 z is define in 2, \therefore live range = 2 to 4
 w is define in 3, \therefore live range = 3 to 4
 v define in 4, and will be used later \therefore live range = 4 to 5

Q171. [MSQ]

For the following code, find the loop invariant instruction(s) which can be moved to the pre-header by a loop-invariant code motion pass?



- (A) S2 : `y = 5`
- (B) S3 : `q = 7`
- (C) S6: `x = 1`
- (D) None of these

171) Answer B

a) $s2 \equiv y = 5$, we can't put this outside loop, as y is changing in iterations.

b) $s3 \equiv q = 7$ loop invariant, as it ^{does} ~~cannot~~ get updated in loop.

c) $s6 \equiv x = 1$, this can't be loop invariant because there exist a path in which this value is not assigned to x and gets printed $s1 \rightarrow s2 \rightarrow s3 \rightarrow s7 \rightarrow s8 \rightarrow \text{print}$.

d) false.