

CUI
Comsats University Islamabad (Vehari Campus)



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Department: CS

Topic of Assignment:

"Slicing Program"

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Subject:

Software Re-Engineering

Batch: "19"

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Program #1

Solution:

n	Statement	REFs(n)	DEFs(n)	relevant(n)
1	b=1		b	
2	c=2		c	{b}
3	d=3		d	{b}
4	a=d	d	a	{b, d}
5	if (a=3) then	a		{b, d}
6	d=b+d	b, d	d	{b, d}
7	c=b+d	b, d	c	{b, d}
8	else			{b, c}
9	b=b+1	b	b	{b, c}
10	d=b+1	b	d	{b, c}
11	Endif			{b, c}
12	a=b+c	b, c	a	{b, c}
13	print a	a		{a}

Program Slice on <13, a>:

{12, 9, 2, 1}

n	Statement
1	b=1
2	c=2
9	b=b+1
12	a=b+c

Program #1: Detailed Calculation of relevant(n) for Slice <13, a>

Initialization:

- relevant(13) = {a} (from the slicing criterion <13, a>)

Step 1: Calculate relevant(12)

Statement 12: a = b + c
DEF(12) = {a}
REF(12) = {b, c}

$$\begin{aligned}
\text{relevant}(12) &= (\text{relevant}(13) - \text{DEF}(12)) \cup (\text{REF}(12) \text{ if } \text{relevant}(13) \cap \text{DEF}(12) \neq \emptyset) \\
&= (\{a\} - \{a\}) \cup (\{b, c\} \text{ if } \{a\} \cap \{a\} \neq \emptyset) \\
&= \emptyset \cup \{b, c\} \\
&= \{b, c\}
\end{aligned}$$

Step 2: Calculate relevant(11)

Statement 11: Endif

DEF(11) = \emptyset

REF(11) = \emptyset

$$\begin{aligned}
\text{relevant}(11) &= (\text{relevant}(12) - \text{DEF}(11)) \cup (\text{REF}(11) \text{ if } \text{relevant}(12) \cap \text{DEF}(11) \neq \emptyset) \\
&= (\{b, c\} - \emptyset) \cup (\emptyset \text{ if } \{b, c\} \cap \emptyset \neq \emptyset) \\
&= \{b, c\} \cup \emptyset \\
&= \{b, c\}
\end{aligned}$$

Step 3: Calculate relevant(10) (else branch)

Statement 10: $d = b + 1$

DEF(10) = $\{d\}$

REF(10) = $\{b\}$

$$\begin{aligned}
\text{relevant}(10) &= (\text{relevant}(11) - \text{DEF}(10)) \cup (\text{REF}(10) \text{ if } \text{relevant}(11) \cap \text{DEF}(10) \neq \emptyset) \\
&= (\{b, c\} - \{d\}) \cup (\{b\} \text{ if } \{b, c\} \cap \{d\} \neq \emptyset) \\
&= \{b, c\} \cup \emptyset \\
&= \{b, c\}
\end{aligned}$$

Step 4: Calculate relevant(9) (else branch)

Statement 9: $b = b + 1$

DEF(9) = $\{b\}$

REF(9) = $\{b\}$

$$\begin{aligned}
\text{relevant}(9) &= (\text{relevant}(10) - \text{DEF}(9)) \cup (\text{REF}(9) \text{ if } \text{relevant}(10) \cap \text{DEF}(9) \neq \emptyset) \\
&= (\{b, c\} - \{b\}) \cup (\{b\} \text{ if } \{b, c\} \cap \{b\} \neq \emptyset) \\
&= \{c\} \cup \{b\} \\
&= \{b, c\}
\end{aligned}$$

Step 5: Calculate relevant(8)

Statement 8: else

DEF(8) = \emptyset

REF(8) = \emptyset

$$\begin{aligned}
\text{relevant}(8) &= (\text{relevant}(9) - \text{DEF}(8)) \cup (\text{REF}(8) \text{ if } \text{relevant}(9) \cap \text{DEF}(8) \neq \emptyset) \\
&= (\{b, c\} - \emptyset) \cup (\emptyset \text{ if } \{b, c\} \cap \emptyset \neq \emptyset) \\
&= \{b, c\}
\end{aligned}$$

Step 6: Calculate relevant(7) (then branch)

Statement 7: $c = b + d$

$DEF(7) = \{c\}$

$REF(7) = \{b, d\}$

$relevant(7) = (relevant(11) - DEF(7)) \cup (REF(7) \text{ if } relevant(11) \cap DEF(7) \neq \emptyset)$
 $= (\{b, c\} - \{c\}) \cup (\{b, d\} \text{ if } \{b, c\} \cap \{c\} \neq \emptyset)$
 $= \{b\} \cup \{b, d\}$
 $= \{b, d\}$

Step 7: Calculate relevant(6) (then branch)

Statement 6: $d = b + d$

$DEF(6) = \{d\}$

$REF(6) = \{b, d\}$

$relevant(6) = (relevant(7) - DEF(6)) \cup (REF(6) \text{ if } relevant(7) \cap DEF(6) \neq \emptyset)$
 $= (\{b, d\} - \{d\}) \cup (\{b, d\} \text{ if } \{b, d\} \cap \{d\} \neq \emptyset)$
 $= \{b\} \cup \{b, d\}$
 $= \{b, d\}$

Step 8: Calculate relevant(5)

Statement 5: if $(a=3)$ then

$DEF(5) = \emptyset$

$REF(5) = \{a\}$

$relevant(5) = (relevant(6) - DEF(5)) \cup (REF(5) \text{ if } relevant(6) \cap DEF(5) \neq \emptyset)$
 $= (\{b, d\} - \emptyset) \cup (\{a\} \text{ if } \{b, d\} \cap \emptyset \neq \emptyset)$
 $= \{b, d\}$

Step 9: Calculate relevant(4)

Statement 4: $a = d$

$DEF(4) = \{a\}$

$REF(4) = \{d\}$

$relevant(4) = (relevant(5) - DEF(4)) \cup (REF(4) \text{ if } relevant(5) \cap DEF(4) \neq \emptyset)$
 $= (\{b, d\} - \{a\}) \cup (\{d\} \text{ if } \{b, d\} \cap \{a\} \neq \emptyset)$
 $= \{b, d\}$

Step 10: Calculate relevant(3)

Statement 3: $d = 3$

$DEF(3) = \{d\}$

$REF(3) = \emptyset$

$relevant(3) = (relevant(4) - DEF(3)) \cup (REF(3) \text{ if } relevant(4) \cap DEF(3) \neq \emptyset)$
 $= (\{b, d\} - \{d\}) \cup (\emptyset \text{ if } \{b, d\} \cap \{d\} \neq \emptyset)$
 $= \{b\}$

Step 11: Calculate relevant(2)

Statement 2: $c = 2$

$DEF(2) = \{c\}$

$REF(2) = \emptyset$

$relevant(2) = (relevant(3) - DEF(2)) \cup (REF(2) \text{ if } relevant(3) \cap DEF(2) \neq \emptyset)$

$= (\{b\} - \{c\}) \cup (\emptyset \text{ if } \{b\} \cap \{c\} \neq \emptyset)$

$= \{b\}$

Step 12: Calculate relevant(1)

Statement 1: $b = 1$

$DEF(1) = \{b\}$

$REF(1) = \emptyset$

$relevant(1) = (relevant(2) - DEF(1)) \cup (REF(1) \text{ if } relevant(2) \cap DEF(1) \neq \emptyset)$

$= (\{b\} - \{b\}) \cup (\emptyset \text{ if } \{b\} \cap \{b\} \neq \emptyset)$

$= \emptyset$

Program #2

Solution:

n	Statement	REFs(n)	DEFs(n)	relevant(n)
1	#include <stdio.h>			
2	#include <math.h>			
3				
4	int main(void)			
5	{			
6	Double a, b, c, d, x1, x2;			
7	// Read input data			
8	printf("Enter the variables for the quadratic")			{a, b, c}
9	scanf("%lf%lf%lf", &a, &b, &c);	a, b, c	a, b, c	{a, b, c}
10				{a, b, c}
11	//Perform calculation			{a, b, c}
12	d=sqrt(b * b - 4. * a * c);	a, b, c	d	{a, b, c}
13	x1=(-b + d) / (2. * c);	b, d, c	x1	{b,d, a}
14	x2=(-b - d) / (2. * a);	b, d, a	x2	{b, d, a}

15				{x2}
16	//Display output			{x2}
17	printf("\nx1=%12.3e x2=%12.3e\n", x1, x2);	x1, x2		{x2}
18	return 0;			
19	}			

Program Slice on <17, x2>:

{14, 12, 9}

n	Statement
9	scanf("%lf%lf%lf", &a, &b, &c);
12	d=sqrt(b * b - 4. * a * c);
14	x2=(-b - d) / (2. * a);

Program #2: Detailed Calculation of relevant(n) for Slice <17, x2>

Initialization:

- relevant(17) = {x2} (from the slicing criterion <17, x2>)

Step 1: Calculate relevant(16)

Statement 16: //Display output

DEF(16) = \emptyset

REF(16) = \emptyset

$\text{relevant}(16) = (\text{relevant}(17) - \text{DEF}(16)) \cup (\text{REF}(16) \text{ if } \text{relevant}(17) \cap \text{DEF}(16) \neq \emptyset)$

$= (\{x2\} - \emptyset) \cup (\emptyset \text{ if } \{x2\} \cap \emptyset \neq \emptyset)$

$= \{x2\} \cup \emptyset$

$= \{x2\}$

Step 2: Calculate relevant(15)

Statement 15: (empty line)

DEF(15) = \emptyset

REF(15) = \emptyset

$$\begin{aligned} \text{relevant}(15) &= (\text{relevant}(16) - \text{DEF}(15)) \cup (\text{REF}(15) \text{ if } \text{relevant}(16) \cap \text{DEF}(15) \neq \emptyset) \\ &= (\{x2\} - \emptyset) \cup (\emptyset \text{ if } \{x2\} \cap \emptyset \neq \emptyset) \\ &= \{x2\} \end{aligned}$$

Step 3: Calculate relevant(14)

Statement 14: $x2 = (-b - d) / (2 * a)$
 $\text{DEF}(14) = \{x2\}$
 $\text{REF}(14) = \{b, d, a\}$

$$\begin{aligned} \text{relevant}(14) &= (\text{relevant}(15) - \text{DEF}(14)) \cup (\text{REF}(14) \text{ if } \text{relevant}(15) \cap \text{DEF}(14) \neq \emptyset) \\ &= (\{x2\} - \{x2\}) \cup (\{b, d, a\} \text{ if } \{x2\} \cap \{x2\} \neq \emptyset) \\ &= \emptyset \cup \{b, d, a\} \\ &= \{b, d, a\} \end{aligned}$$

Step 4: Calculate relevant(13)

Statement 13: $x1 = (-b + d) / (2 * c)$
 $\text{DEF}(13) = \{x1\}$
 $\text{REF}(13) = \{b, d, c\}$

$$\begin{aligned} \text{relevant}(13) &= (\text{relevant}(14) - \text{DEF}(13)) \cup (\text{REF}(13) \text{ if } \text{relevant}(14) \cap \text{DEF}(13) \neq \emptyset) \\ &= (\{b, d, a\} - \{x1\}) \cup (\{b, d, c\} \text{ if } \{b, d, a\} \cap \{x1\} \neq \emptyset) \\ &= \{b, d, a\} \cup \emptyset \\ &= \{b, d, a\} \end{aligned}$$

Step 5: Calculate relevant(12)

Statement 12: $d = \text{sqrt}(b * b - 4 * a * c)$
 $\text{DEF}(12) = \{d\}$
 $\text{REF}(12) = \{a, b, c\}$

$$\begin{aligned} \text{relevant}(12) &= (\text{relevant}(14) - \text{DEF}(12)) \cup (\text{REF}(12) \text{ if } \text{relevant}(14) \cap \text{DEF}(12) \neq \emptyset) \\ &= (\{b, d, a\} - \{d\}) \cup (\{a, b, c\} \text{ if } \{b, d, a\} \cap \{d\} \neq \emptyset) \\ &= \{b, a\} \cup \{a, b, c\} \\ &= \{a, b, c\} \end{aligned}$$

Step 6: Calculate relevant(11)

Statement 11: //Perform calculation
 $\text{DEF}(11) = \emptyset$
 $\text{REF}(11) = \emptyset$

$$\begin{aligned} \text{relevant}(11) &= (\text{relevant}(12) - \text{DEF}(11)) \cup (\text{REF}(11) \text{ if } \text{relevant}(12) \cap \text{DEF}(11) \neq \emptyset) \\ &= (\{a, b, c\} - \emptyset) \cup (\emptyset \text{ if } \{a, b, c\} \cap \emptyset \neq \emptyset) \\ &= \{a, b, c\} \end{aligned}$$

Step 7: Calculate relevant(10)

Statement 10: (empty line)
 $\text{DEF}(10) = \emptyset$
 $\text{REF}(10) = \emptyset$

$\text{relevant}(10) = (\text{relevant}(11) - \text{DEF}(10)) \cup (\text{REF}(10) \text{ if } \text{relevant}(11) \cap \text{DEF}(10) \neq \emptyset)$
 $= (\{a, b, c\} - \emptyset) \cup (\emptyset \text{ if } \{a, b, c\} \cap \emptyset \neq \emptyset)$
 $= \{a, b, c\}$

Step 8: Calculate relevant(9)

Statement 9: `scanf("%lf%lf%lf", &a, &b, &c)`
 $\text{DEF}(9) = \{a, b, c\}$
 $\text{REF}(9) = \{a, b, c\}$

$\text{relevant}(9) = (\text{relevant}(10) - \text{DEF}(9)) \cup (\text{REF}(9) \text{ if } \text{relevant}(10) \cap \text{DEF}(9) \neq \emptyset)$
 $= (\{a, b, c\} - \{a, b, c\}) \cup (\{a, b, c\} \text{ if } \{a, b, c\} \cap \{a, b, c\} \neq \emptyset)$
 $= \emptyset \cup \{a, b, c\}$
 $= \{a, b, c\}$

Step 9: Calculate relevant(8)

Statement 8: `printf("Enter the variables...")`
 $\text{DEF}(8) = \emptyset$
 $\text{REF}(8) = \emptyset$

$\text{relevant}(8) = (\text{relevant}(9) - \text{DEF}(8)) \cup (\text{REF}(8) \text{ if } \text{relevant}(9) \cap \text{DEF}(8) \neq \emptyset)$
 $= (\{a, b, c\} - \emptyset) \cup (\emptyset \text{ if } \{a, b, c\} \cap \emptyset \neq \emptyset)$
 $= \{a, b, c\}$

Steps 7-1: Earlier statements (1-7)

These are declarations and comments that don't affect the relevant sets.

Complete relevant sets for Program #2:

n	relevant(n)
17	{x2}
16	{x2}
15	{x2}
14	{b, d, a}
13	{b, d, a}
12	{a, b, c}
11	{a, b, c}
10	{a, b, c}
9	{a, b, c}
8	{a, b, c}
1-7	\emptyset

Program #3

Solution:

n	Statement	REFs(n)	DEFs(n)	relevant(n)
1	b=1		b	
2	c=2		c	b
3	d=5		d	b, c
4	a=3		a	b, c
5	While (a < 10)	a		b, c
6	b=b+c	b, c	b	b, c
7	c=c+1	c	c	b
8	a=b	b	a	b
9	EndWhile			a
10	print a	a		a

Program Slice on <10, a>:

{8, 7, 6, 2, 1}

n	Statement
1	b=1
2	c=2
6	b=b+c
7	c=c+1
8	a=b

Program #3: Detailed Calculation of relevant(n) for Slice <10, a>

Initialization:

- $\text{relevant}(10) = \{a\}$ (from the slicing criterion <10, a>)

Step 1: Calculate relevant(9)

Statement 9: EndWhile

$\text{DEF}(9) = \emptyset$

$\text{REF}(9) = \emptyset$

$\text{relevant}(9) = (\text{relevant}(10) - \text{DEF}(9)) \cup (\text{REF}(9) \text{ if } \text{relevant}(10) \cap \text{DEF}(9) \neq \emptyset)$
 $= (\{a\} - \emptyset) \cup (\emptyset \text{ if } \{a\} \cap \emptyset \neq \emptyset)$
 $= \{a\}$

Step 2: Calculate relevant(8)

Statement 8: $a = b$

DEF(8) = {a}

REF(8) = {b}

$$\begin{aligned}\text{relevant}(8) &= (\text{relevant}(9) - \text{DEF}(8)) \cup (\text{REF}(8) \text{ if } \text{relevant}(9) \cap \text{DEF}(8) \neq \emptyset) \\ &= (\{a\} - \{a\}) \cup (\{b\} \text{ if } \{a\} \cap \{a\} \neq \emptyset) \\ &= \emptyset \cup \{b\} \\ &= \{b\}\end{aligned}$$

Step 3: Calculate relevant(7)

Statement 7: $c = c + 1$

DEF(7) = {c}

REF(7) = {c}

$$\begin{aligned}\text{relevant}(7) &= (\text{relevant}(8) - \text{DEF}(7)) \cup (\text{REF}(7) \text{ if } \text{relevant}(8) \cap \text{DEF}(7) \neq \emptyset) \\ &= (\{b\} - \{c\}) \cup (\{c\} \text{ if } \{b\} \cap \{c\} \neq \emptyset) \\ &= \{b\} \cup \emptyset \\ &= \{b\}\end{aligned}$$

Step 4: Calculate relevant(6)

Statement 6: $b = b + c$

DEF(6) = {b}

REF(6) = {b, c}

$$\begin{aligned}\text{relevant}(6) &= (\text{relevant}(7) - \text{DEF}(6)) \cup (\text{REF}(6) \text{ if } \text{relevant}(7) \cap \text{DEF}(6) \neq \emptyset) \\ &= (\{b\} - \{b\}) \cup (\{b, c\} \text{ if } \{b\} \cap \{b\} \neq \emptyset) \\ &= \emptyset \cup \{b, c\} \\ &= \{b, c\}\end{aligned}$$

Step 5: Calculate relevant(5)

Statement 5: While ($a < 10$)

DEF(5) = \emptyset

REF(5) = {a}

$$\begin{aligned}\text{relevant}(5) &= (\text{relevant}(6) - \text{DEF}(5)) \cup (\text{REF}(5) \text{ if } \text{relevant}(6) \cap \text{DEF}(5) \neq \emptyset) \\ &= (\{b, c\} - \emptyset) \cup (\{a\} \text{ if } \{b, c\} \cap \emptyset \neq \emptyset) \\ &= \{b, c\}\end{aligned}$$

Step 6: Calculate relevant(4)

Statement 4: $a = 3$

DEF(4) = {a}

REF(4) = \emptyset

$$\begin{aligned}\text{relevant}(4) &= (\text{relevant}(5) - \text{DEF}(4)) \cup (\text{REF}(4) \text{ if } \text{relevant}(5) \cap \text{DEF}(4) \neq \emptyset) \\ &= (\{b, c\} - \{a\}) \cup (\emptyset \text{ if } \{b, c\} \cap \{a\} \neq \emptyset) \\ &= \{b, c\}\end{aligned}$$

Step 7: Calculate relevant(3)

Statement 3: $d = 5$

$DEF(3) = \{d\}$

$REF(3) = \emptyset$

$$\begin{aligned} \text{relevant}(3) &= (\text{relevant}(4) - DEF(3)) \cup (\text{REF}(3) \text{ if } \text{relevant}(4) \cap DEF(3) \neq \emptyset) \\ &= (\{b, c\} - \{d\}) \cup (\emptyset \text{ if } \{b, c\} \cap \{d\} \neq \emptyset) \\ &= \{b, c\} \end{aligned}$$

Step 8: Calculate relevant(2)

Statement 2: $c = 2$

$DEF(2) = \{c\}$

$REF(2) = \emptyset$

$$\begin{aligned} \text{relevant}(2) &= (\text{relevant}(3) - DEF(2)) \cup (\text{REF}(2) \text{ if } \text{relevant}(3) \cap DEF(2) \neq \emptyset) \\ &= (\{b, c\} - \{c\}) \cup (\emptyset \text{ if } \{b, c\} \cap \{c\} \neq \emptyset) \\ &= \{b\} \end{aligned}$$

Step 9: Calculate relevant(1)

Statement 1: $b = 1$

$DEF(1) = \{b\}$

$REF(1) = \emptyset$

$$\begin{aligned} \text{relevant}(1) &= (\text{relevant}(2) - DEF(1)) \cup (\text{REF}(1) \text{ if } \text{relevant}(2) \cap DEF(1) \neq \emptyset) \\ &= (\{b\} - \{b\}) \cup (\emptyset \text{ if } \{b\} \cap \{b\} \neq \emptyset) \\ &= \emptyset \end{aligned}$$

Program #4

Solution:

n	Statement	REFs(n)	DEFs(n)	relevant(n)
1	read(text);	text		text
2	read(n);		n	text
3	lines=1;		lines	n, text
4	chars=1;		chars	n, text
5	subtext = ""		subtext	n, text
6	c= getChar(text);	text	c	Subtext ,n, text
7	while (c!= '\eof')	c		subtext ,c , n
8	If (c== '\n') then	c		subtext ,c , n
9	lines = lines + 1;	lines	lines	subtext ,c , n
10	chars = chars + 1;	chars	chars	subtext ,c , n
11	else chars=chars +1	chars	chars	subtext ,c , n
12	if(n!=0) then	n		subtext ,c , n
13	subtext = subtext ++ c	subtext, c	subtext	subtext ,c , n
14	n=n-1	n	n	subtext , n
15	c= getChar(text);	text	c	subtext
16	write(lines);	lines		subtext
17	write(chars);	chars		subtext
18	write(subtext);	subtext		subtext

Program Slice on <18, subtext>:

{13, 12, 14, 6, 2, 1, 5, 15}

n	Statement
1	read(text);
2	read(n);
5	subtext = ""
6	c= getChar(text);
12	if(n!=0) then
13	subtext = subtext ++ c
14	n=n-1
15	c= getChar(text);

Program #4: Detailed Calculation of relevant(n) for Slice <18, subtext>

Initialization:

- relevant(18) = {subtext} (from the slicing criterion <18, subtext>)

Step 1: Calculate relevant(17)

Statement 17: write(chars)

DEF(17) = \emptyset

REF(17) = {chars}

relevant(17) = (relevant(18) - DEF(17)) \cup (REF(17) if relevant(18) \cap DEF(17) $\neq \emptyset$)
= ({subtext} - \emptyset) \cup (\emptyset if {subtext} $\cap \emptyset \neq \emptyset$)
= {subtext}

Step 2: Calculate relevant(16)

Statement 16: write(lines)

DEF(16) = \emptyset

REF(16) = {lines}

relevant(16) = (relevant(17) - DEF(16)) \cup (REF(16) if relevant(17) \cap DEF(16) $\neq \emptyset$)
= ({subtext} - \emptyset) \cup (\emptyset if {subtext} $\cap \emptyset \neq \emptyset$)
= {subtext}

Step 3: Calculate relevant(15)

Statement 15: c = getChar(text)

DEF(15) = {c}

REF(15) = {text}

relevant(15) = (relevant(16) - DEF(15)) \cup (REF(15) if relevant(16) \cap DEF(15) $\neq \emptyset$)
= ({subtext} - {c}) \cup ({text} if {subtext} \cap {c} $\neq \emptyset$)
= {subtext} $\cup \emptyset$
= {subtext}

Step 4: Calculate relevant(14)

Statement 14: n = n - 1

DEF(14) = {n}

REF(14) = {n}

relevant(14) = (relevant(15) - DEF(14)) \cup (REF(14) if relevant(15) \cap DEF(14) $\neq \emptyset$)
= ({subtext} - {n}) \cup ({n} if {subtext} \cap {n} $\neq \emptyset$)
= {subtext} \cup {n} (because subtext depends on n)
= {subtext, n}

Step 5: Calculate relevant(13)

Statement 13: subtext = subtext ++ c

DEF(13) = {subtext}

REF(13) = {subtext, c}

relevant(13) = (relevant(14) - DEF(13)) \cup (REF(13) if relevant(14) \cap DEF(13) $\neq \emptyset$)
= ({subtext, n} - {subtext}) \cup ({subtext, c} if {subtext, n} \cap {subtext} $\neq \emptyset$)
= {n} \cup {subtext, c}
= {subtext, c, n}

Step 6: Calculate relevant(12)

Statement 12: if (n != 0) then

DEF(12) = \emptyset

REF(12) = {n}

relevant(12) = (relevant(13) - DEF(12)) \cup (REF(12) if relevant(13) \cap DEF(12) $\neq \emptyset$)
= ({subtext, c, n} - \emptyset) \cup ({n} if {subtext, c, n} $\cap \emptyset \neq \emptyset$)
= {subtext, c, n}

Step 7: Calculate relevant(11)

Statement 11: else chars = chars + 1

DEF(11) = {chars}

REF(11) = {chars}

relevant(11) = (relevant(12) - DEF(11)) \cup (REF(11) if relevant(12) \cap DEF(11) $\neq \emptyset$)
= ({subtext, c, n} - {chars}) \cup (\emptyset if {subtext, c, n} \cap {chars} $\neq \emptyset$)
= {subtext, c, n}

Step 8: Calculate relevant(10)

Statement 10: chars = chars + 1

DEF(10) = {chars}

REF(10) = {chars}

relevant(10) = (relevant(11) - DEF(10)) \cup (REF(10) if relevant(11) \cap DEF(10) $\neq \emptyset$)
= ({subtext, c, n} - {chars}) \cup (\emptyset if {subtext, c, n} \cap {chars} $\neq \emptyset$)
= {subtext, c, n}

Step 9: Calculate relevant(9)

Statement 9: lines = lines + 1

DEF(9) = {lines}

REF(9) = {lines}

relevant(9) = (relevant(10) - DEF(9)) \cup (REF(9) if relevant(10) \cap DEF(9) $\neq \emptyset$)
= ({subtext, c, n} - {lines}) \cup (\emptyset if {subtext, c, n} \cap {lines} $\neq \emptyset$)
= {subtext, c, n}

Step 10: Calculate relevant(8)

Statement 8: If (c == '\n') then

DEF(8) = \emptyset

REF(8) = {c}

relevant(8) = (relevant(9) - DEF(8)) \cup (REF(8) if relevant(9) \cap DEF(8) $\neq \emptyset$)
= ({subtext, c, n} - \emptyset) \cup ({c} if {subtext, c, n} $\cap \emptyset \neq \emptyset$)
= {subtext, c, n}

Step 11: Calculate relevant(7)

Statement 7: while (c != '\eof')

DEF(7) = \emptyset

REF(7) = {c}

$\text{relevant}(7) = (\text{relevant}(8) - \text{DEF}(7)) \cup (\text{REF}(7) \text{ if } \text{relevant}(8) \cap \text{DEF}(7) \neq \emptyset)$
 $= (\{\text{subtext}, c, n\} - \emptyset) \cup (\{c\} \text{ if } \{\text{subtext}, c, n\} \cap \emptyset \neq \emptyset)$
 $= \{\text{subtext}, c, n\}$

Step 12: Calculate relevant(6)

Statement 6: c = getChar(text)

DEF(6) = {c}

REF(6) = {text}

$\text{relevant}(6) = (\text{relevant}(7) - \text{DEF}(6)) \cup (\text{REF}(6) \text{ if } \text{relevant}(7) \cap \text{DEF}(6) \neq \emptyset)$
 $= (\{\text{subtext}, c, n\} - \{c\}) \cup (\{\text{text}\} \text{ if } \{\text{subtext}, c, n\} \cap \{c\} \neq \emptyset)$
 $= \{\text{subtext}, n\} \cup \{\text{text}\}$
 $= \{\text{subtext}, n, \text{text}\}$

Step 13: Calculate relevant(5)

Statement 5: subtext = ""

DEF(5) = {subtext}

REF(5) = \emptyset

$\text{relevant}(5) = (\text{relevant}(6) - \text{DEF}(5)) \cup (\text{REF}(5) \text{ if } \text{relevant}(6) \cap \text{DEF}(5) \neq \emptyset)$
 $= (\{\text{subtext}, n, \text{text}\} - \{\text{subtext}\}) \cup (\emptyset \text{ if } \{\text{subtext}, n, \text{text}\} \cap \{\text{subtext}\} \neq \emptyset)$
 $= \{n, \text{text}\}$

Step 14: Calculate relevant(4)

Statement 4: chars = 1

DEF(4) = {chars}

REF(4) = \emptyset

$\text{relevant}(4) = (\text{relevant}(5) - \text{DEF}(4)) \cup (\text{REF}(4) \text{ if } \text{relevant}(5) \cap \text{DEF}(4) \neq \emptyset)$
 $= (\{n, \text{text}\} - \{\text{chars}\}) \cup (\emptyset \text{ if } \{n, \text{text}\} \cap \{\text{chars}\} \neq \emptyset)$
 $= \{n, \text{text}\}$

Step 15: Calculate relevant(3)

Statement 3: lines = 1

DEF(3) = {lines}

REF(3) = \emptyset

$\text{relevant}(3) = (\text{relevant}(4) - \text{DEF}(3)) \cup (\text{REF}(3) \text{ if } \text{relevant}(4) \cap \text{DEF}(3) \neq \emptyset)$
 $= (\{n, \text{text}\} - \{\text{lines}\}) \cup (\emptyset \text{ if } \{n, \text{text}\} \cap \{\text{lines}\} \neq \emptyset)$
 $= \{n, \text{text}\}$

Step 16: Calculate relevant(2)

Statement 2: read(n)

DEF(2) = {n}

REF(2) = \emptyset

relevant(2) = (relevant(3) - DEF(2)) \cup (REF(2) if relevant(3) \cap DEF(2) $\neq \emptyset$)

= ({n, text} - {n}) \cup (\emptyset if {n, text} \cap {n} $\neq \emptyset$)

= {text}

Step 17: Calculate relevant(1)

Statement 1: read(text)

DEF(1) = {text}

REF(1) = {text}

relevant(1) = (relevant(2) - DEF(1)) \cup (REF(1) if relevant(2) \cap DEF(1) $\neq \emptyset$)

= ({text} - {text}) \cup ({text} if {text} \cap {text} $\neq \emptyset$)

= \emptyset \cup {text}

= {text}

Program #5

Solution:

n	Statement	REFs(n)	DEFs(n)	relevant(n)
1	read(n);		n	
2	i=1;		i	
3	sum=0;		sum	i
4	product=1;		product	i
5	while (i < n) do	i, n		product , i
6	sum= sum +i;	sum, i	sum	Product , i
7	product= product *i	product, i	product	product , i
8	i=i +1;	i	i	Product
9	write(sum);	sum		product
10	write(product);	product		product

Program Slice on <10, product>:

{7, 5, 8, 4, 2, 1}

n	Statement
1	read(n);
2	i=1;
4	product=1;
5	while (i < n) do
7	product= product *i
8	i=i +1;

Program #5: Detailed Calculation of relevant(n) for Slice <10, product>

Initialization:

- relevant(10) = {product} (from the slicing criterion <10, product>)

Step 1: Calculate relevant(9)

Statement 9: write(sum)

DEF(9) = \emptyset

REF(9) = {sum}

$$\begin{aligned} \text{relevant}(9) &= (\text{relevant}(10) - \text{DEF}(9)) \cup (\text{REF}(9) \text{ if } \text{relevant}(10) \cap \text{DEF}(9) \neq \emptyset) \\ &= (\{\text{product}\} - \emptyset) \cup (\emptyset \text{ if } \{\text{product}\} \cap \emptyset \neq \emptyset) \\ &= \{\text{product}\} \end{aligned}$$

Step 2: Calculate relevant(8)

Statement 8: i = i + 1

DEF(8) = {i}

REF(8) = {i}

$$\begin{aligned} \text{relevant}(8) &= (\text{relevant}(9) - \text{DEF}(8)) \cup (\text{REF}(8) \text{ if } \text{relevant}(9) \cap \text{DEF}(8) \neq \emptyset) \\ &= (\{\text{product}\} - \{i\}) \cup (\{i\} \text{ if } \{\text{product}\} \cap \{i\} \neq \emptyset) \\ &= \{\text{product}\} \cup \emptyset \\ &= \{\text{product}\} \end{aligned}$$

Step 3: Calculate relevant(7)

Statement 7: product = product * i

DEF(7) = {product}

REF(7) = {product, i}

$$\begin{aligned} \text{relevant}(7) &= (\text{relevant}(8) - \text{DEF}(7)) \cup (\text{REF}(7) \text{ if } \text{relevant}(8) \cap \text{DEF}(7) \neq \emptyset) \\ &= (\{\text{product}\} - \{\text{product}\}) \cup (\{\text{product}, i\} \text{ if } \{\text{product}\} \cap \{\text{product}\} \neq \emptyset) \\ &= \emptyset \cup \{\text{product}, i\} \\ &= \{\text{product}, i\} \end{aligned}$$

Step 4: Calculate relevant(6)

Statement 6: $\text{sum} = \text{sum} + i$

$\text{DEF}(6) = \{\text{sum}\}$

$\text{REF}(6) = \{\text{sum}, i\}$

$$\begin{aligned}\text{relevant}(6) &= (\text{relevant}(7) - \text{DEF}(6)) \cup (\text{REF}(6) \text{ if } \text{relevant}(7) \cap \text{DEF}(6) \neq \emptyset) \\ &= (\{\{\text{product}, i\} - \{\text{sum}\}\} \cup \{\{\text{sum}, i\} \text{ if } \{\text{product}, i\} \cap \{\text{sum}\} \neq \emptyset\}) \\ &= \{\{\text{product}, i\} \cup \emptyset\} \\ &= \{\{\text{product}, i\}\}\end{aligned}$$

Step 5: Calculate relevant(5)

Statement 5: while ($i < n$) do

$\text{DEF}(5) = \emptyset$

$\text{REF}(5) = \{i, n\}$

$$\begin{aligned}\text{relevant}(5) &= (\text{relevant}(6) - \text{DEF}(5)) \cup (\text{REF}(5) \text{ if } \text{relevant}(6) \cap \text{DEF}(5) \neq \emptyset) \\ &= (\{\{\text{product}, i\} - \emptyset\} \cup (\{i, n\} \text{ if } \{\{\text{product}, i\} \cap \emptyset \neq \emptyset\})) \\ &= \{\{\text{product}, i\} \cup \emptyset\} \\ &= \{\{\text{product}, i\}\}\end{aligned}$$

Step 6: Calculate relevant(4)

Statement 4: $\text{product} = 1$

$\text{DEF}(4) = \{\text{product}\}$

$\text{REF}(4) = \emptyset$

$$\begin{aligned}\text{relevant}(4) &= (\text{relevant}(5) - \text{DEF}(4)) \cup (\text{REF}(4) \text{ if } \text{relevant}(5) \cap \text{DEF}(4) \neq \emptyset) \\ &= (\{\{\text{product}, i\} - \{\text{product}\}\} \cup (\emptyset \text{ if } \{\{\text{product}, i\} \cap \{\text{product}\} \neq \emptyset\})) \\ &= \{\{i\} \cup \emptyset\} \\ &= \{\{i\}\}\end{aligned}$$

Step 7: Calculate relevant(3)

Statement 3: $\text{sum} = 0$

$\text{DEF}(3) = \{\text{sum}\}$

$\text{REF}(3) = \emptyset$

$$\begin{aligned}\text{relevant}(3) &= (\text{relevant}(4) - \text{DEF}(3)) \cup (\text{REF}(3) \text{ if } \text{relevant}(4) \cap \text{DEF}(3) \neq \emptyset) \\ &= (\{\{i\} - \{\text{sum}\}\} \cup (\emptyset \text{ if } \{i\} \cap \{\text{sum}\} \neq \emptyset)) \\ &= \{\{i\}\}\end{aligned}$$

Step 8: Calculate relevant(2)

Statement 2: $i = 1$

$\text{DEF}(2) = \{i\}$

$\text{REF}(2) = \emptyset$

$$\begin{aligned}\text{relevant}(2) &= (\text{relevant}(3) - \text{DEF}(2)) \cup (\text{REF}(2) \text{ if } \text{relevant}(3) \cap \text{DEF}(2) \neq \emptyset) \\ &= (\{\{i\} - \{i\}\} \cup (\emptyset \text{ if } \{i\} \cap \{i\} \neq \emptyset))\end{aligned}$$

$$= \emptyset \cup \emptyset$$

$$= \emptyset$$

Step 9: Calculate relevant(1)

Statement 1: read(n)

DEF(1) = {n}

REF(1) = \emptyset

$$\text{relevant}(1) = (\text{relevant}(2) - \text{DEF}(1)) \cup (\text{REF}(1) \text{ if } \text{relevant}(2) \cap \text{DEF}(1) \neq \emptyset)$$

$$= (\emptyset - \{n\}) \cup (\emptyset \text{ if } \emptyset \cap \{n\} \neq \emptyset)$$

$$= \emptyset$$