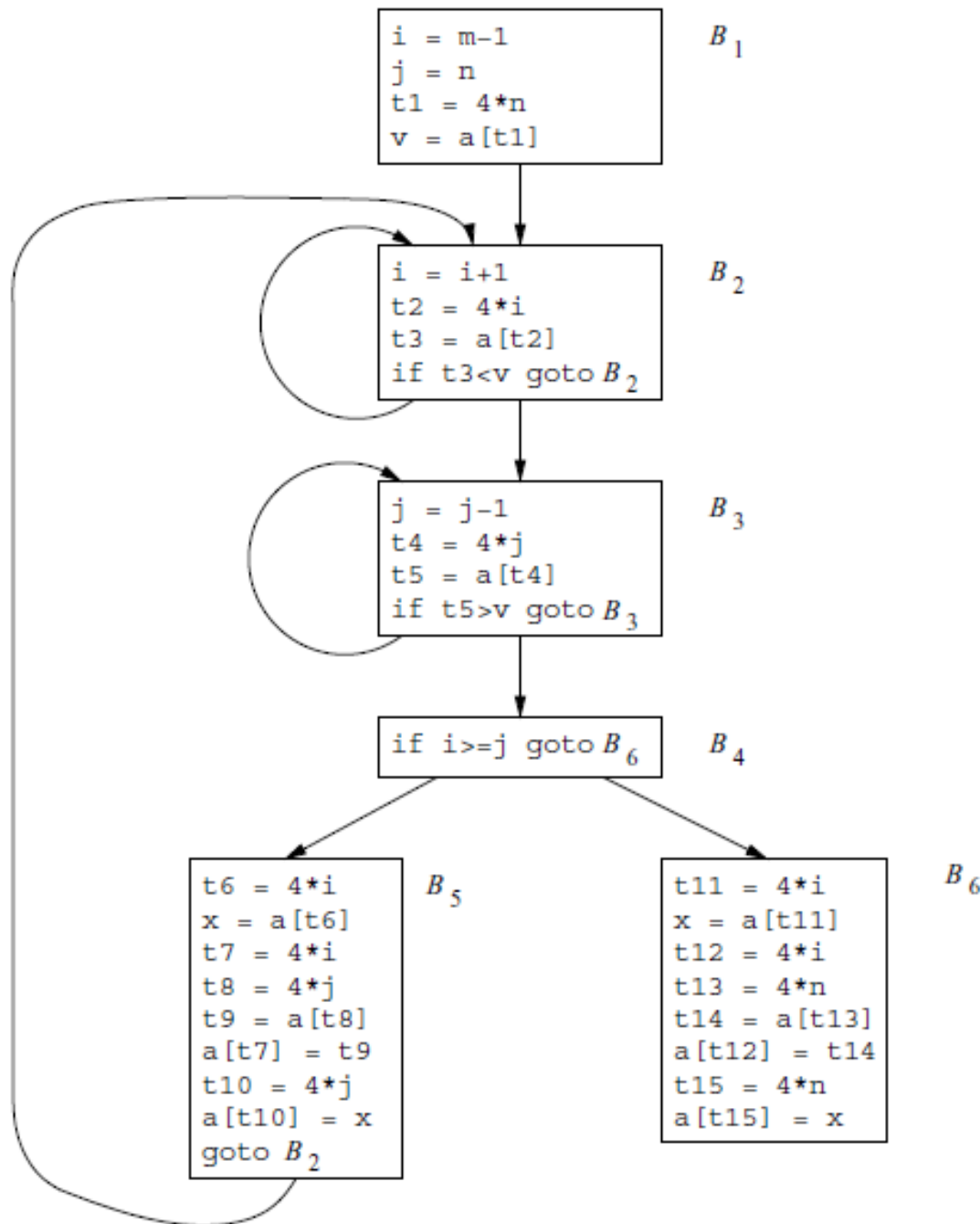


Apply local and global common subexpression elimination to quicksort code flowgraph.



# Apply local and global common sub expression elimination to quicksort code flowgraph

## STEP 1:

apply local common sub expression elimination to all basic blocks

- use AEB algorithm

## STEP 2:

apply global common sub expression elimination

- find  $EVAL(i)$ ,  $KILL(i)$
- Use them to find  $in(i)$  and  $out(i)$  [iterative algorithm]
- Use  $AEin(i)$  for global common sub expression elimination

# Local common sub-expression elimination in B1

1.  $i = m - 1$
2.  $j = n$
3.  $t1 = 4 * n$
4.  $v = a[t1]$

1.  $AEB = \{ \langle 1, m, -, 1, nil \rangle \}$
2.  $AEB = \{ \langle 1, m, -, 1, nil \rangle \}$
3.  $AEB = \{ \langle 1, m, -, 1, nil \rangle, \langle 3, 4, *, n, t1 \rangle \}$
4.  $AEB = \{ \langle 1, m, -, 1, nil \rangle, \langle 3, 4, *, n, t1 \rangle \}$

No change in block

## Local common sub-expression elimination in B2

1.  $i = i + 1$
2.  $t2 = 4 * i$
3.  $t3 = a[t2]$
4. if  $t3 < v$  goto B2

1.  $AEB = \emptyset$
2.  $AEB = \{ \langle 2, 4, *, i, t2 \rangle \}$
3.  $AEB = \{ \langle 2, 4, *, i, t2 \rangle \}$
4.  $AEB = \{ \langle 2, 4, *, i, t2 \rangle, \langle 4, t3, <, v, nil \rangle \}$

No change in block

## Local common sub-expression elimination in B3

1.  $j = j - 1$
2.  $t4 = 4 * j$
3.  $t5 = a[t4]$
4. if  $t5 > v$  goto B3

1.  $AEB = \emptyset$
2.  $AEB = \{ \langle 2, 4, *, j, t4 \rangle \}$
3.  $AEB = \{ \langle 2, 4, *, j, t4 \rangle \}$
4.  $AEB = \{ \langle 2, 4, *, j, t4 \rangle, \langle 4, t5, >, v, nil \rangle \}$

No change in block

# Local common sub-expression elimination in B4

1. if  $i \geq j$  goto B6

1. AEB={<1,  $i \geq j$ , nil>}

No change in block

# Local common sub-expression elimination in B5

1.  $t6 = 4 * i$   
2.  $x = a[t6]$   
3.  $t7 = 4 * i \rightarrow t7 = t6$

4.  $t8 = 4 * j$

5.  $t9 = a[t8]$

6.  $a[t7] = t9$

7.  $t10 = 4 * j \rightarrow t10 = t8$

8.  $a[t10] = x$

9. goto B2

1.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle \}$

2.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle \}$

3.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle \}$

4.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

5.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

6.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

7.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

8.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

9.  $AEB = \{ \langle 1, 4, *, i, t6 \rangle, \langle 4, 4, *, j, t8 \rangle \}$

## Local common sub-expression elimination in B5

1.  $t6 = 4 * i$
2.  $x = a[t6]$
3.  $t7 = 4 * i$
4.  $t8 = 4 * j$
5.  $t9 = a[t8]$
6.  $a[t7] = t9$
7.  $t10 = 4 * j$
8.  $a[t10] = x$
9. goto B2



1.  $t6 = 4 * i$
2.  $x = a[t6]$
3.  $t7 = t6$
4.  $t8 = 4 * j$
5.  $t9 = a[t8]$
6.  $a[t7] = t9$
7.  $t10 = t8$
8.  $a[t10] = x$
9. goto B2



# Local common sub-expression elimination in B5

1.  $t6 = 4 * i$

2.  $x = a[t6]$

~~3.  $t7 = 4 * i$~~

4.  $t8 = 4 * j$

5.  $t9 = a[t8]$

6.  $a[t7] = t9$

~~7.  $t10 = 4 * j$~~

8.  $a[t10] = x$

9. goto B2



1.  $t6 = 4 * i$

2.  $x = a[t6]$

3.  $t8 = 4 * j$

4.  $t9 = a[t8]$

5.  $a[t6] = t9$

6.  $a[t8] = x$

7. goto B2

As, these calculation were not requested explicitly by the programmer, they are **eliminated**.\*

# NOTE:

- *Compilers need to be judicious about the number of temporaries created to hold values.*
- *An excessive number of temporary values creates register pressure possibly resulting in spilling registers to memory, which may take longer than simply recomputing an arithmetic result when it is needed.*

# Local common sub-expression elimination in B6

1.  $t11 = 4 * i$
2.  $x = a[t11]$
3.  $t12 = 4 * i \rightarrow t12 = t11$
4.  $t13 = 4 * n$
5.  $t14 = a[t13]$
6.  $a[t12] = t14$
7.  $t15 = 4 * n \rightarrow t15 = t13$
8.  $a[t15] = x$

1.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle \}$
2.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle \}$
3.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle \}$
4.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$
5.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$
6.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$
7.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$
8.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$
9.  $AEB = \{ \langle 1, 4, *, i, t11 \rangle, \langle 4, 4, *, n, t13 \rangle \}$

## Local common sub-expression elimination in B6

1.  $t11 = 4 * i$
2.  $x = a[t11]$
3.  $t12 = 4 * i$
4.  $t13 = 4 * n$
5.  $t14 = a[t13]$
6.  $a[t12] = t14$
7.  $t15 = 4 * n$
8.  $a[t15] = x$



1.  $t11 = 4 * i$
2.  $x = a[t11]$
3.  $t12 = t11$
4.  $t13 = 4 * n$
5.  $t14 = a[t13]$
6.  $a[t12] = t14$
7.  $t15 = t13$
8.  $a[t15] = x$

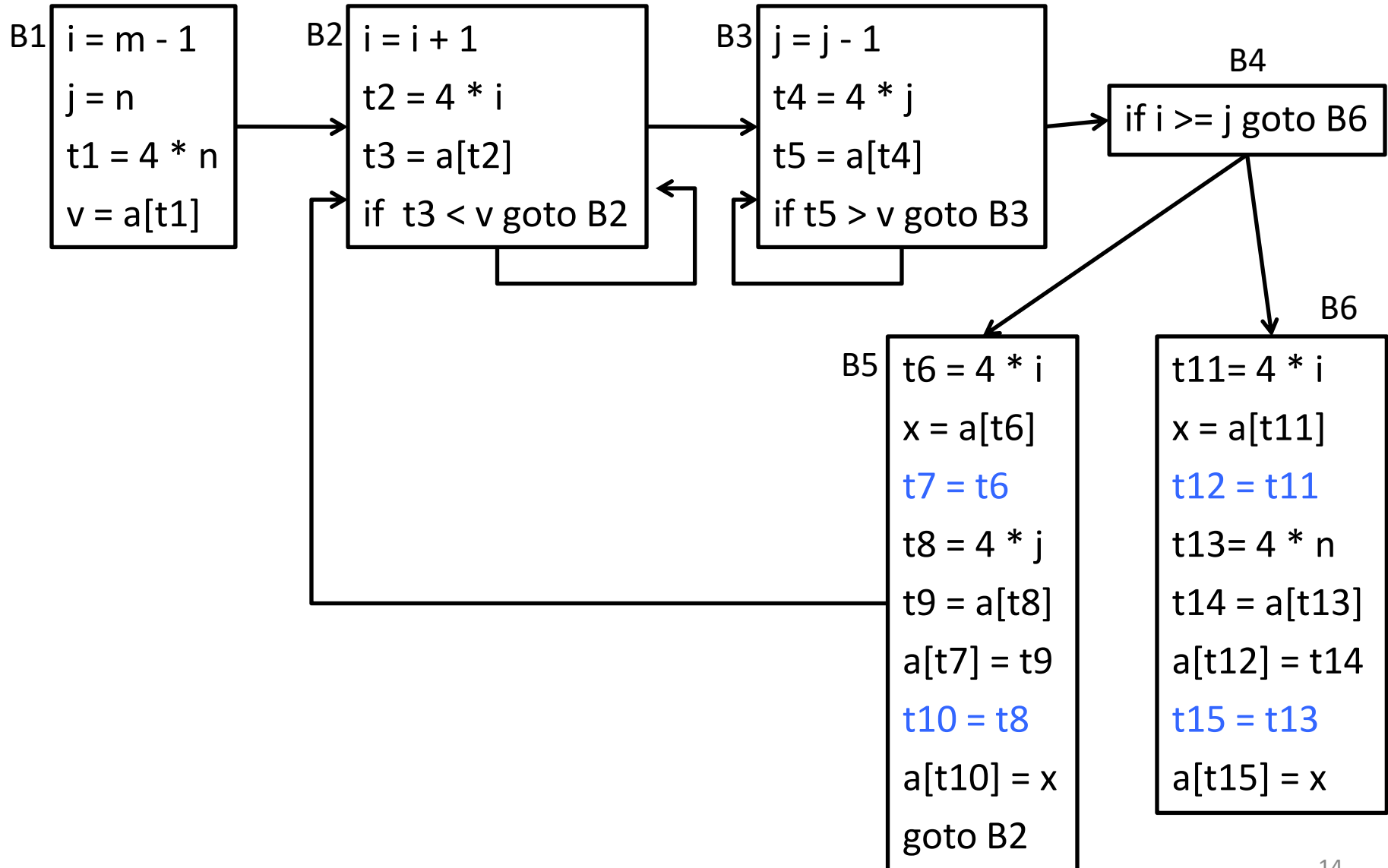
# Local common sub-expression elimination in B6

1.  $t11 = 4 * i$
2.  $x = a[t11]$
- ~~3.  $t12 = 4 * i$~~
4.  $t13 = 4 * n$
5.  $t14 = a[t13]$
6.  $a[t12] = t14$
- ~~7.  $t15 = 4 * n$~~
8.  $a[t15] = x$

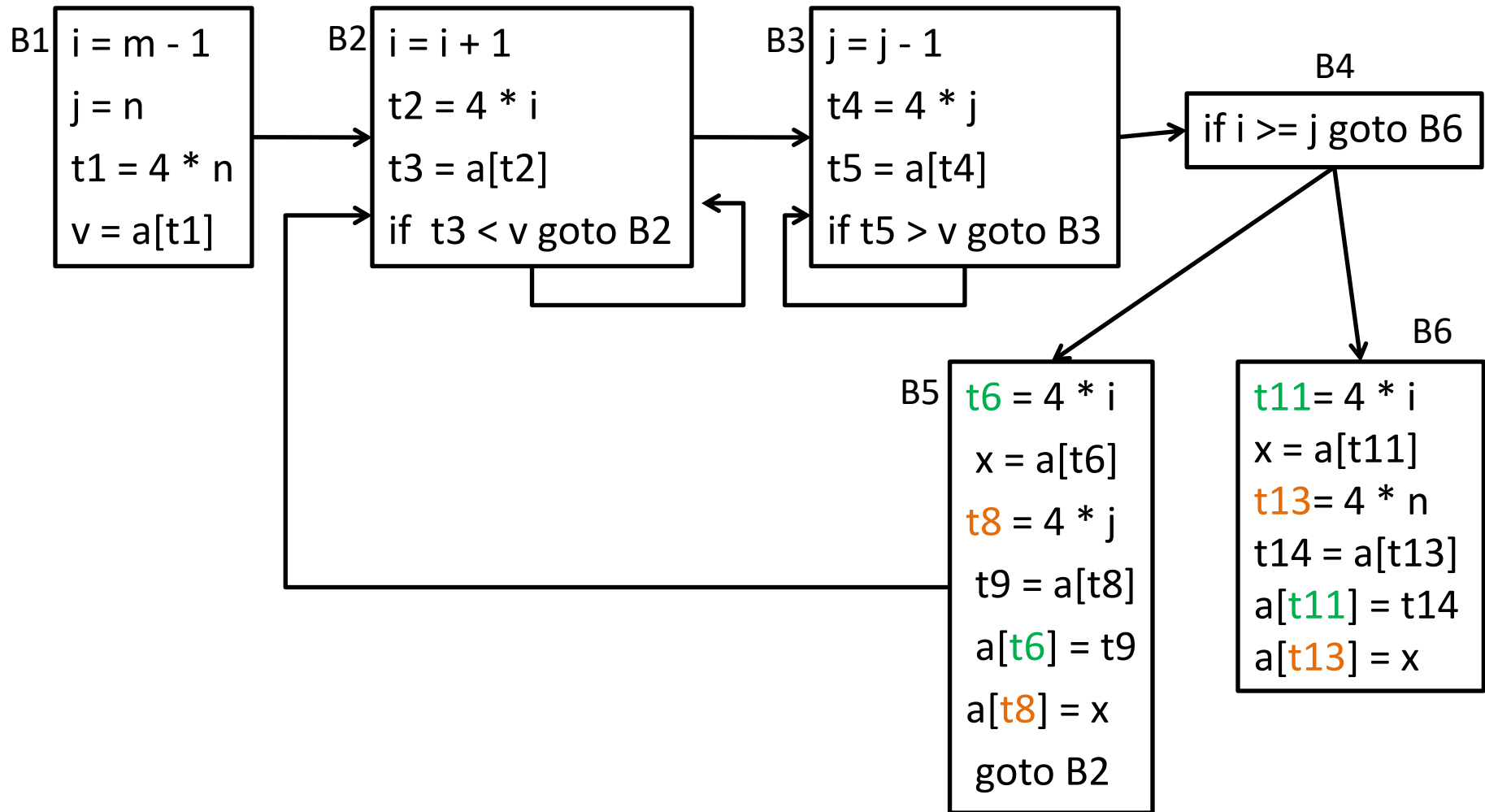


1.  $t11 = 4 * i$
2.  $x = a[t11]$
3.  $t13 = 4 * n$
4.  $t14 = a[t13]$
5.  $a[t11] = t14$
6.  $a[t13] = x$

# After local common subexpression elimination



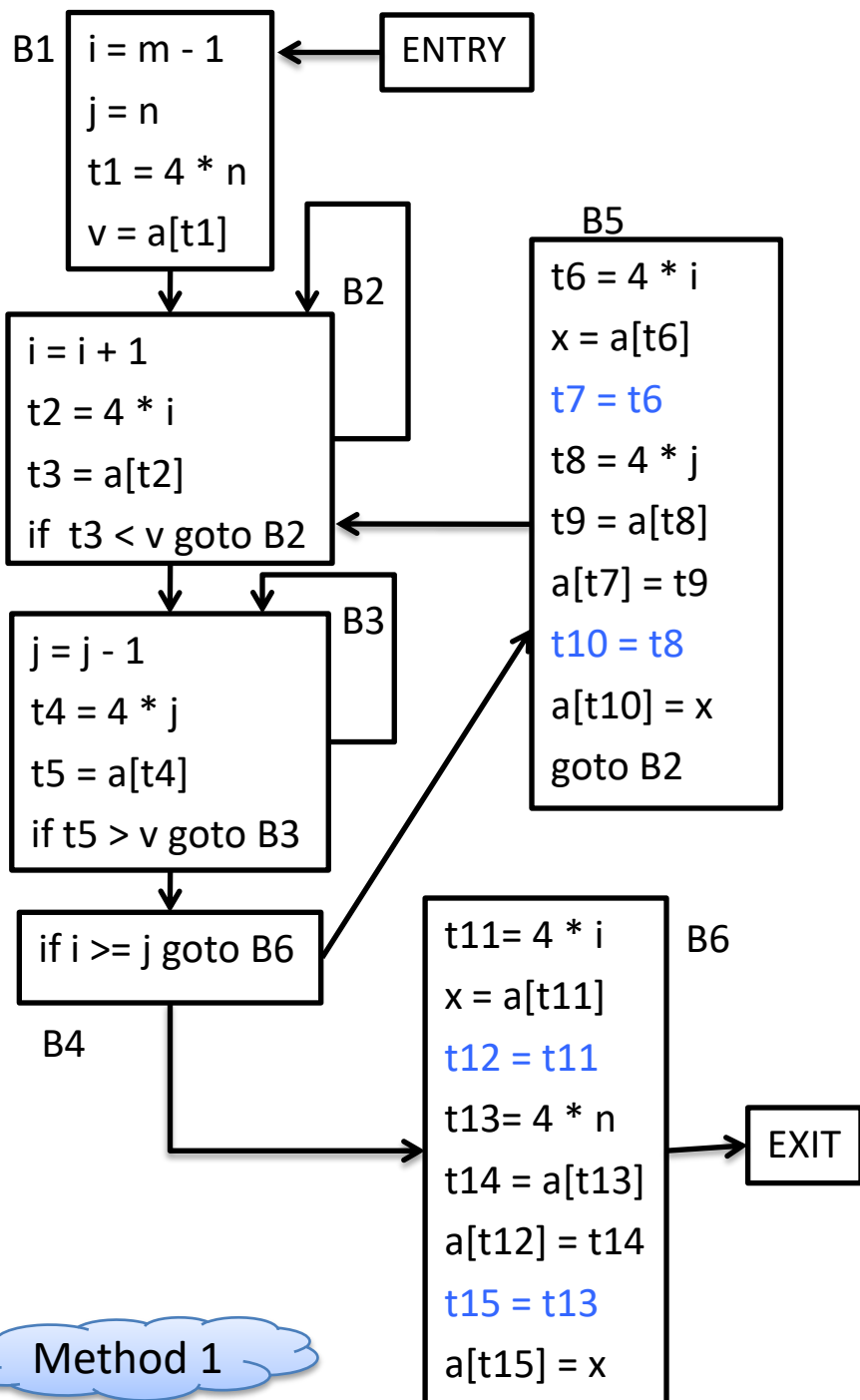
## After local common subexpression elimination



# Global Common subexpression elimination

- Find  $EVAL(i)$ ,  $KILL(i)$
- Use them to find  $in(i)$  and  $out(i)$  [iterative algorithm]
- Use  $AEin(i)$  for global common sub expression elimination





EVAL(ENTRY) =  $\emptyset$

EVAL(B1) =  $\{m-1, 4*n\}$

EVAL(B2) =  $\{4*i, t3 < v\}$

EVAL(B3) =  $\{4*j, t5 > v\}$

EVAL(B4) =  $\{i \geq j\}$

EVAL(B5) =  $\{4*i, 4*j\}$

EVAL(B6) =  $\{4*i, 4*n\}$

EVAL(EXIT) =  $\emptyset$

KILL(ENTRY) =  $\emptyset$

KILL(B1) =  $\{i+1, 4*i, t3 < v, j-1, 4*j, t5 > v, i \geq j\}$

KILL(B2) =  $\{i \geq j, i+1\}$

KILL(B3) =  $\{i \geq j, j-1\}$

KILL(B4) =  $\emptyset$

KILL(B5) =  $\emptyset$

KILL(B6) =  $\emptyset$

KILL(EXIT) =  $\emptyset$

$4 * i$  is not included as it is present in EVAL(B2)

$4 * j$  is not included as it is present in EVAL(B2)

$$\text{EVAL}(\text{ENTRY}) = \emptyset$$

$$\text{EVAL}(\text{B1}) = \{m-1, 4*n\}$$

$$\text{EVAL}(\text{B2}) = \{4*i, t3<v\}$$

$$\text{EVAL}(\text{B3}) = \{4*j, t5>v\}$$

$$\text{EVAL}(\text{B4}) = \{i>=j\}$$

$$\text{EVAL}(\text{B5}) = \{4*i, 4*j\}$$

$$\text{EVAL}(\text{B6}) = \{4*i, 4*n\}$$

$$\text{EVAL}(\text{EXIT}) = \emptyset$$

$$\text{KILL}(\text{ENTRY}) = \emptyset$$

$$\text{KILL}(\text{B1}) = \{i+1, 4*i, t3<v, j-1, 4*j, t5>v, i>=j\}$$

$$\text{KILL}(\text{B2}) = \{i>=j, i+1\}$$

$$\text{KILL}(\text{B3}) = \{i>=j, j-1\}$$

$$\text{KILL}(\text{B4}) = \emptyset$$

$$\text{KILL}(\text{B5}) = \emptyset$$

$$\text{KILL}(\text{B6}) = \emptyset$$

$$\text{KILL}(\text{EXIT}) = \emptyset$$

$$U = U \cup \text{EVAL}(i) = \{m-1, 4*n, 4*i, t3<v, 4*j, t5>v, i>=j\}$$

	Initial	Iteration 1	
	$\text{OUT}(i) = U - \text{KILL}(i)$	$\text{IN}(i) = \cap \text{out}(j) \quad j \in \text{Pred}(i)$	$\text{OUT}(i) = \text{EVAL}(i) \cup (\text{IN}(i) - \text{KILL}(i))$
<b>ENTRY</b>	$\emptyset$	$\emptyset$	$\emptyset$
<b>B1</b>	$\{m-1, 4*n\}$	$\emptyset$	$\{m-1, 4*n\}$
<b>B2</b>	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{m-1, 4*n\}$	$\{4*i, t3<v, m-1, 4*n\}$
<b>B3</b>	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{4*j, t5>v, m-1, 4*n, 4*i, t3<v\}$
<b>B4</b>	U	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$
<b>B5</b>	U	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v, i>=j\}$	$\{4*i, 4*j, m-1, 4*n, t3<v, t5>v, i>=j\}$
<b>B6</b>	U	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v, i>=j\}$	$\{4*i, 4*n, m-1, t3<v, 4*j, t5>v, i>=j\}$
<b>EXIT</b>	U	$\{m-1, 4*n, 4*i, t3<v, 4*j, t5>v, i>=j\}$	not required

$$\text{EVAL}(\text{ENTRY}) = \emptyset$$

$$\text{EVAL}(\text{B1}) = \{m-1, 4*n\}$$

$$\text{EVAL}(\text{B2}) = \{4*i, t3 < v\}$$

$$\text{EVAL}(\text{B3}) = \{4*j, t5 > v\}$$

$$\text{EVAL}(\text{B4}) = \{i \geq j\}$$

$$\text{EVAL}(\text{B5}) = \{4*i, 4*j\}$$

$$\text{EVAL}(\text{B6}) = \{4*i, 4*n\}$$

$$\text{EVAL}(\text{EXIT}) = \emptyset$$

$$\text{KILL}(\text{ENTRY}) = \emptyset$$

$$\text{KILL}(\text{B1}) = \{i+1, 4*i, t3 < v, j-1, 4*j, t5 > v, i \geq j\}$$

$$\text{KILL}(\text{B2}) = \{i \geq j, i+1\}$$

$$\text{KILL}(\text{B3}) = \{i \geq j, j-1\}$$

$$\text{KILL}(\text{B4}) = \emptyset$$

$$\text{KILL}(\text{B5}) = \emptyset$$

$$\text{KILL}(\text{B6}) = \emptyset$$

$$\text{KILL}(\text{EXIT}) = \emptyset$$

$$U = U \cup \text{EVAL}(i) = \{m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v, i \geq j\}$$

	Iteration 1	Iteration 2	
	old_OUT(i)	IN(i) = $\cap$ out(j) $j \in \text{Pred}(i)$	OUT(i) = EVAL(i) $\cup$ (IN(i) - KILL(i))
<b>ENTRY</b>	$\emptyset$	$\emptyset$	$\emptyset$
<b>B1</b>	$\{m-1, 4*n\}$	$\emptyset$	$\{m-1, 4*n\}$
<b>B2</b>	$\{4*i, t3 < v, m-1, 4*n\}$	$\{m-1, 4*n\}$	$\{4*i, t3 < v, m-1, 4*n\}$
<b>B3</b>	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$	$\{4*i, t3 < v, m-1, 4*n\}$	$\{4*j, t5 > v, 4*i, t3 < v, m-1, 4*n\}$
<b>B4</b>	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$	$\{i \geq j, 4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
<b>B5</b>	$\{4*i, 4*j, m-1, 4*n, t3 < v, t5 > v, i \geq j\}$	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$	$\{4*i, 4*j, i \geq j, m-1, 4*n, t3 < v, t5 > v\}$
<b>B6</b>	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$	$\{4*i, 4*n, i \geq j, m-1, t3 < v, 4*j, t5 > v\}$
<b>EXIT</b>	not required	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$	not required

$$\text{EVAL}(\text{ENTRY}) = \emptyset$$

$$\text{EVAL}(\text{B1}) = \{m-1, 4*n\}$$

$$\text{EVAL}(\text{B2}) = \{4*i, t3<v\}$$

$$\text{EVAL}(\text{B3}) = \{4*j, t5>v\}$$

$$\text{EVAL}(\text{B4}) = \{i>=j\}$$

$$\text{EVAL}(\text{B5}) = \{4*i, 4*j\}$$

$$\text{EVAL}(\text{B6}) = \{4*i, 4*n\}$$

$$\text{EVAL}(\text{EXIT}) = \emptyset$$

$$\text{KILL}(\text{ENTRY}) = \emptyset$$

$$\text{KILL}(\text{B1}) = \{i+1, 4*i, t3<v, j-1, 4*j, t5>v, i>=j\}$$

$$\text{KILL}(\text{B2}) = \{i>=j, i+1\}$$

$$\text{KILL}(\text{B3}) = \{i>=j, j-1\}$$

$$\text{KILL}(\text{B4}) = \emptyset$$

$$\text{KILL}(\text{B5}) = \emptyset$$

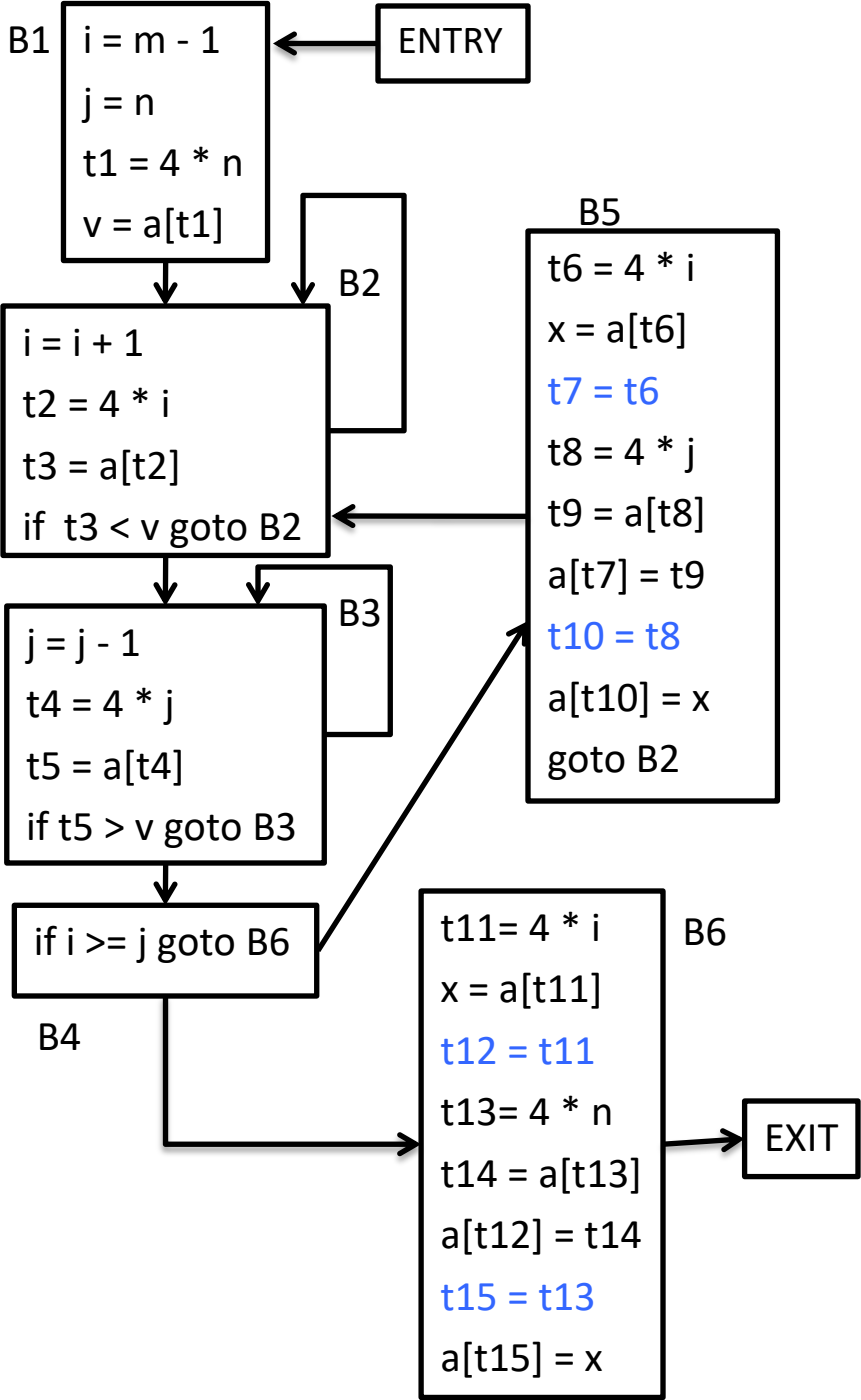
$$\text{KILL}(\text{B6}) = \emptyset$$

$$\text{KILL}(\text{EXIT}) = \emptyset$$

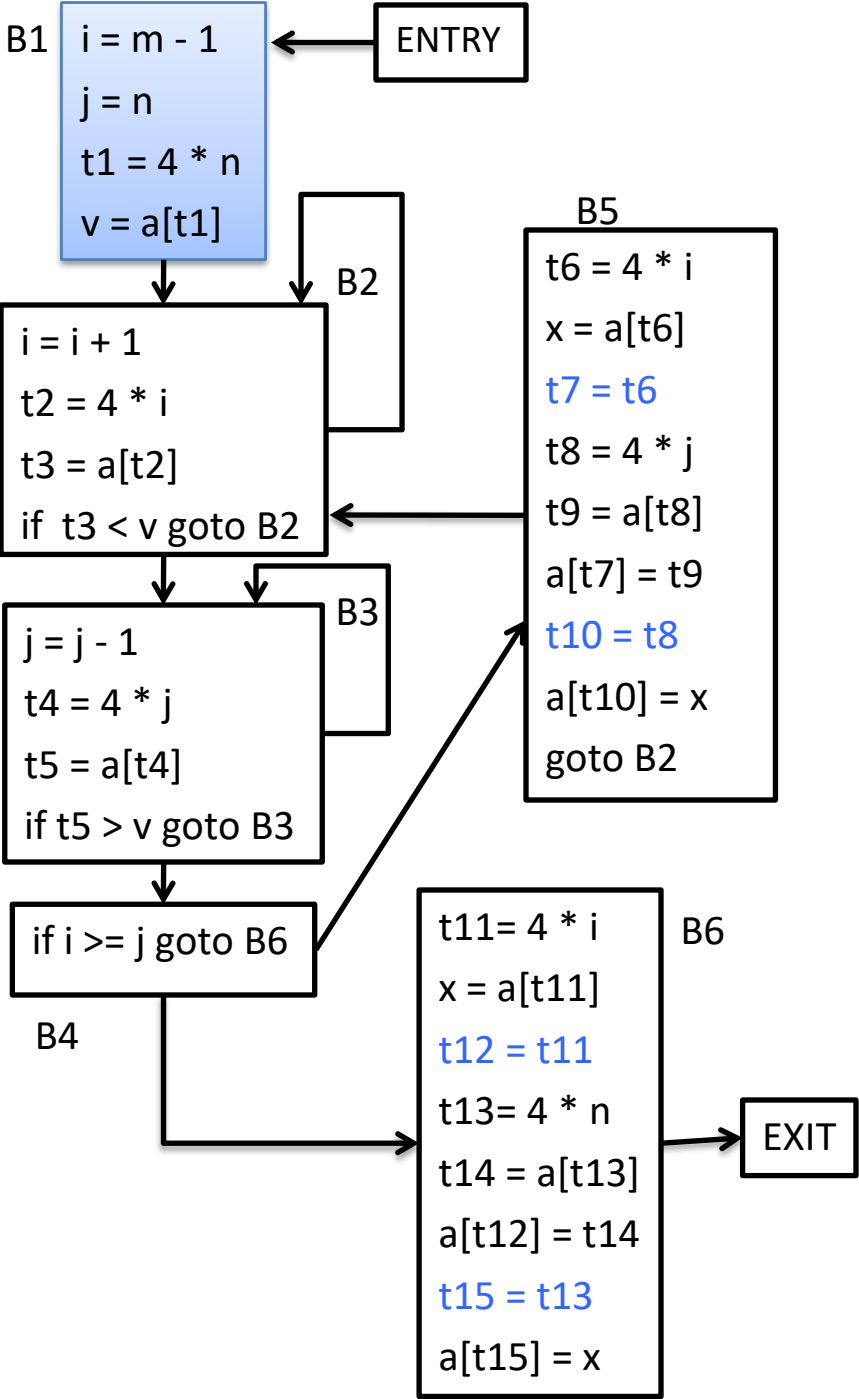
$$U = U \cup \text{EVAL}(i) = \{m-1, 4*n, 4*i, t3<v, 4*j, t5>v, i>=j\}$$

	Iteration 1	Iteration 2	
	old_OUT(i)	IN(i) = $\cap$ out(j) $j \in \text{Pred}(i)$	OUT(i) = EVAL(i) $\cup$ (IN(i) - KILL(i))
<b>ENTRY</b>	$\emptyset$	$\emptyset$	$\emptyset$
<b>B1</b>	$\{m-1, 4*n\}$	$\emptyset$	$\{m-1, 4*n\}$
<b>B2</b>	$\{4*i, t3<v, m-1, 4*n\}$	$\{m-1, 4*n\}$	$\{4*i, t3<v, m-1, 4*n\}$
<b>B3</b>	$\{4*j, t5>v, m-1, 4*n, 4*i, t3<v\}$	$\{4*i, t3<v, m-1, 4*n\}$	$\{4*j, t5>v, 4*i, t3<v, m-1, 4*n\}$
<b>B4</b>	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{4*j, t5>v, m-1, 4*n, 4*i, t3<v\}$	$\{i>=j, 4*j, t5>v, m-1, 4*n, 4*i, t3<v\}$
<b>B5</b>	$\{4*i, 4*j, m-1, 4*n, t3<v, t5>v, i>=j\}$	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{4*i, 4*j, i>=j, m-1, 4*n, t3<v, t5>v\}$
<b>B6</b>	$\{4*i, 4*n, m-1, t3<v, 4*j, t5>v, i>=j\}$	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$	$\{4*i, 4*n, i>=j, m-1, t3<v, 4*j, t5>v\}$
<b>EXIT</b>	not required	$\{4*i, 4*n, m-1, t3<v, 4*j, t5>v, i>=j\}$	not required

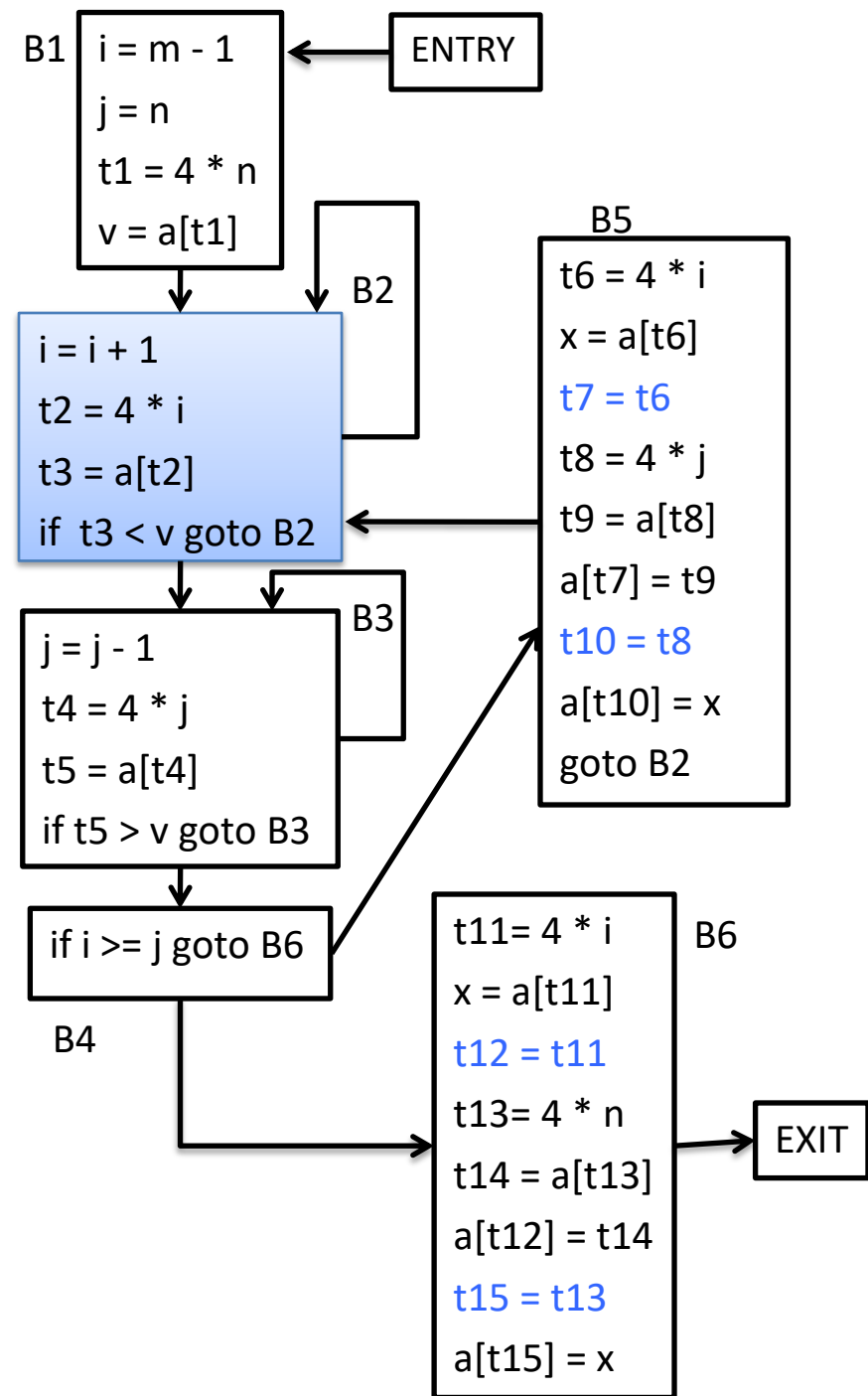
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



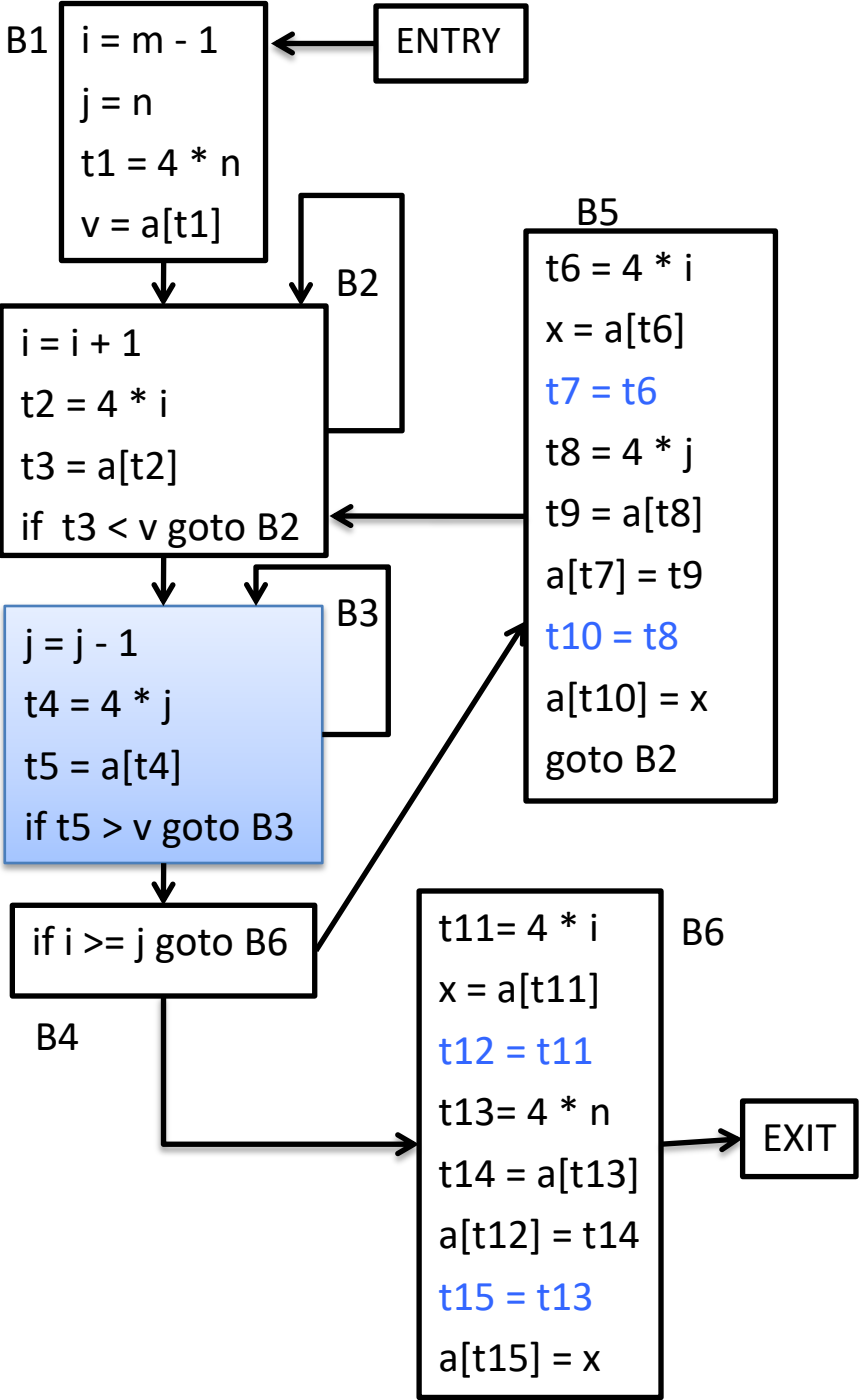
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3<v, m-1, 4*n\}$
B4	$\{4*j, t5>v, m-1, 4*n, 4*i, t3<v\}$
B5	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$
B6	$\{i>=j, m-1, 4*n, 4*i, t3<v, 4*j, t5>v\}$
EXIT	$\{4*i, 4*n, m-1, t3<v, 4*j, t5>v, i>=j\}$

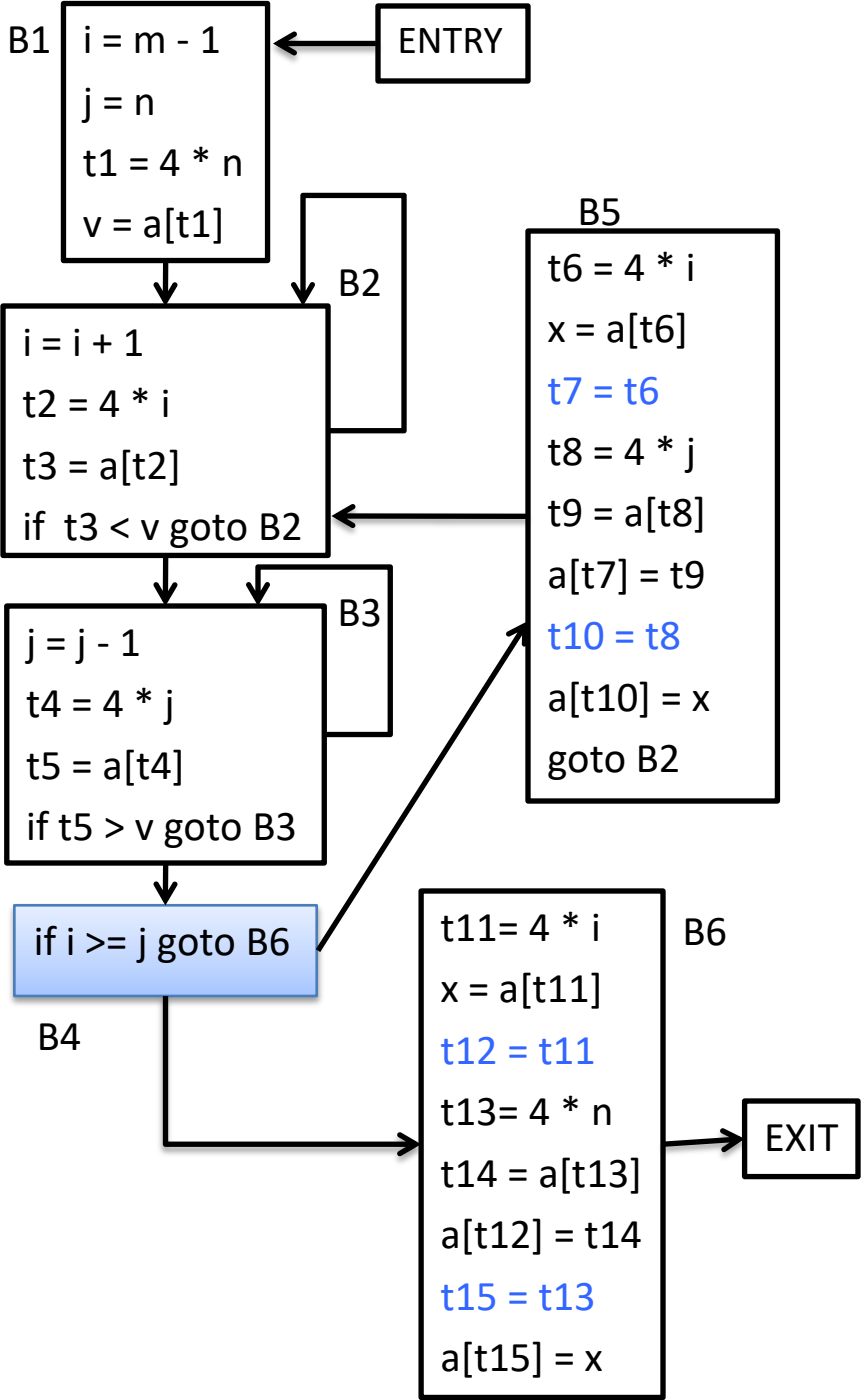


Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$

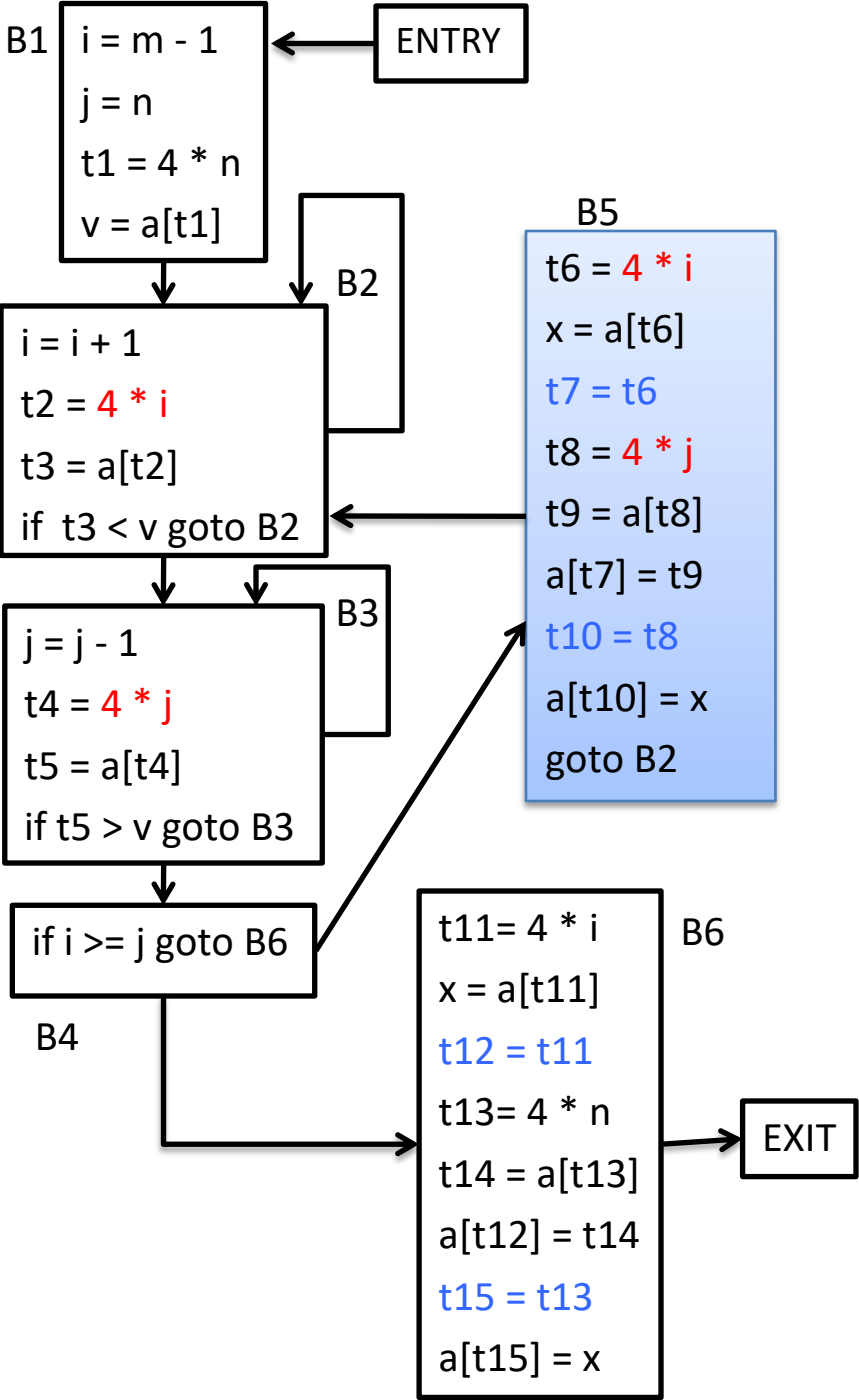




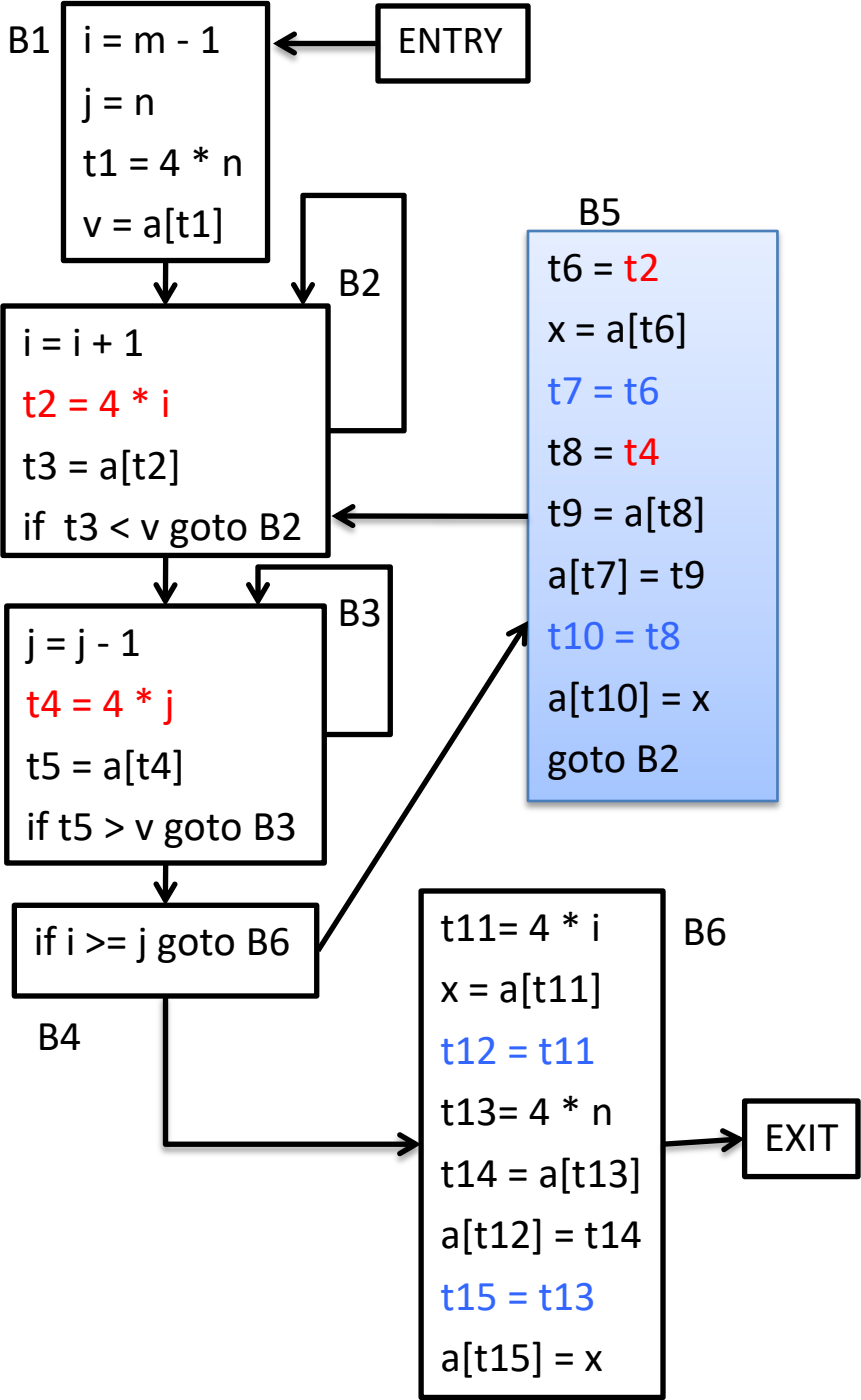
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



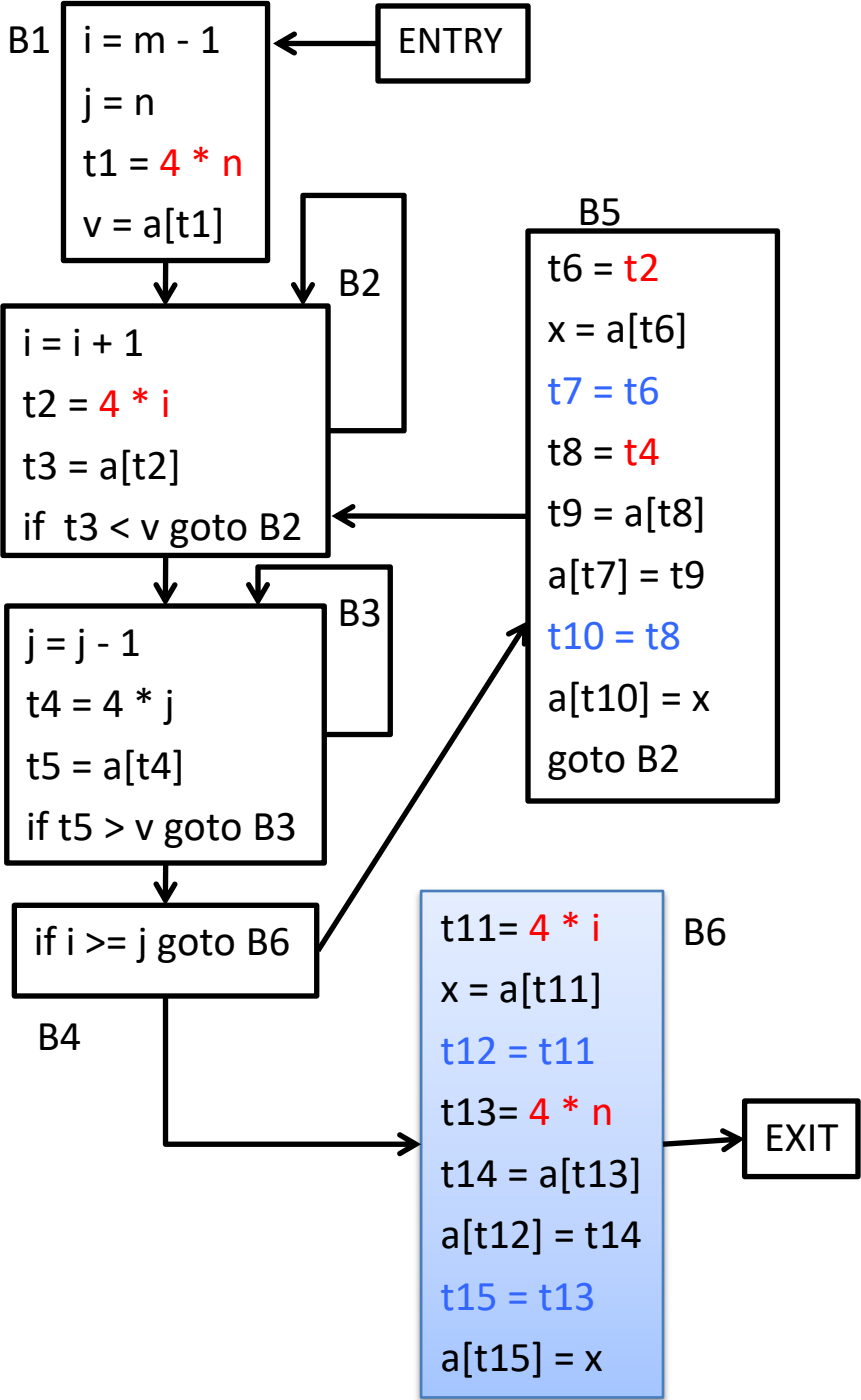
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



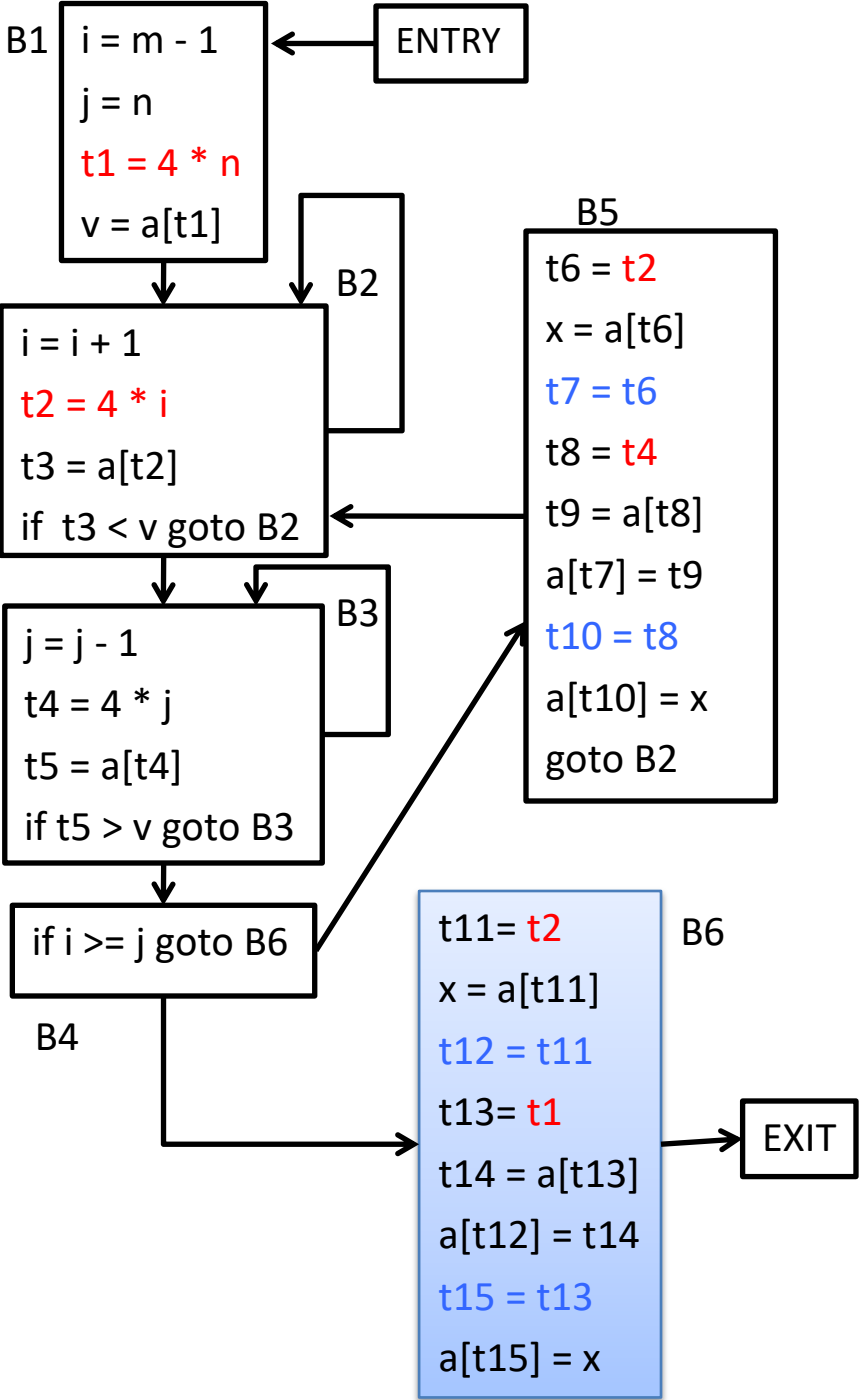
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



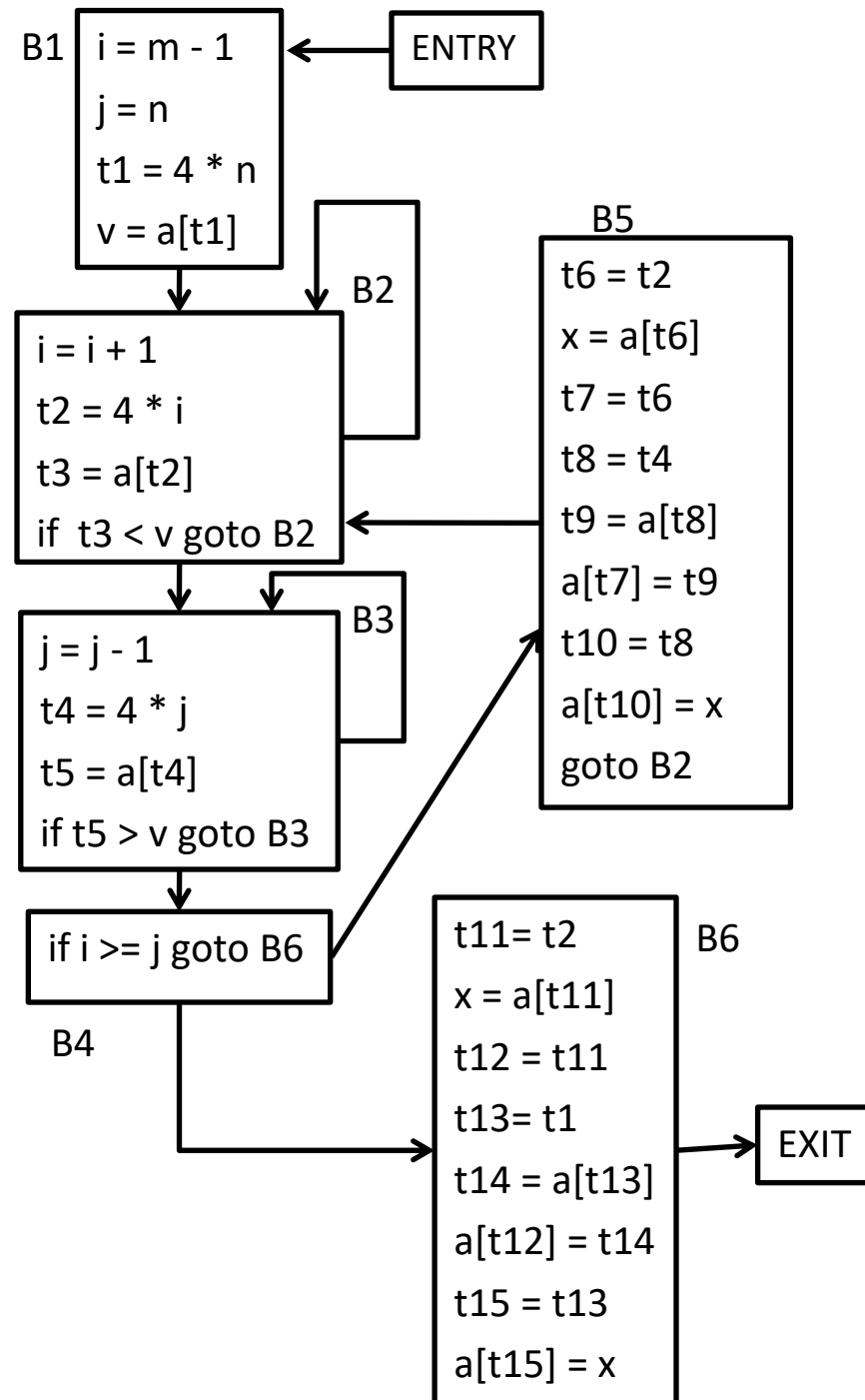
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



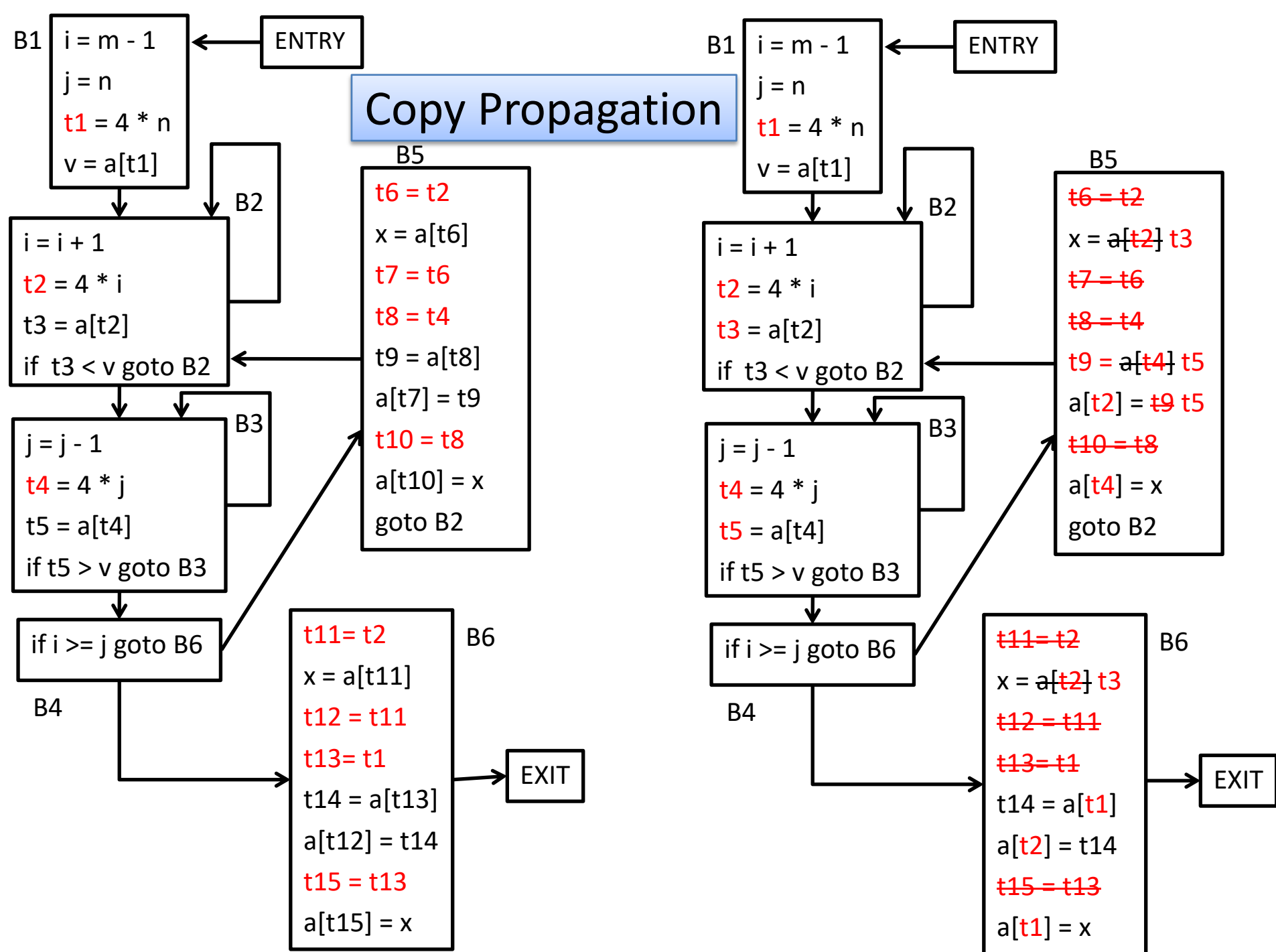
Basic Block	AEin(i)
ENTRY	$\emptyset$
B1	$\emptyset$
B2	$\{m-1, 4*n\}$
B3	$\{4*i, t3 < v, m-1, 4*n\}$
B4	$\{4*j, t5 > v, m-1, 4*n, 4*i, t3 < v\}$
B5	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
B6	$\{i \geq j, m-1, 4*n, 4*i, t3 < v, 4*j, t5 > v\}$
EXIT	$\{4*i, 4*n, m-1, t3 < v, 4*j, t5 > v, i \geq j\}$



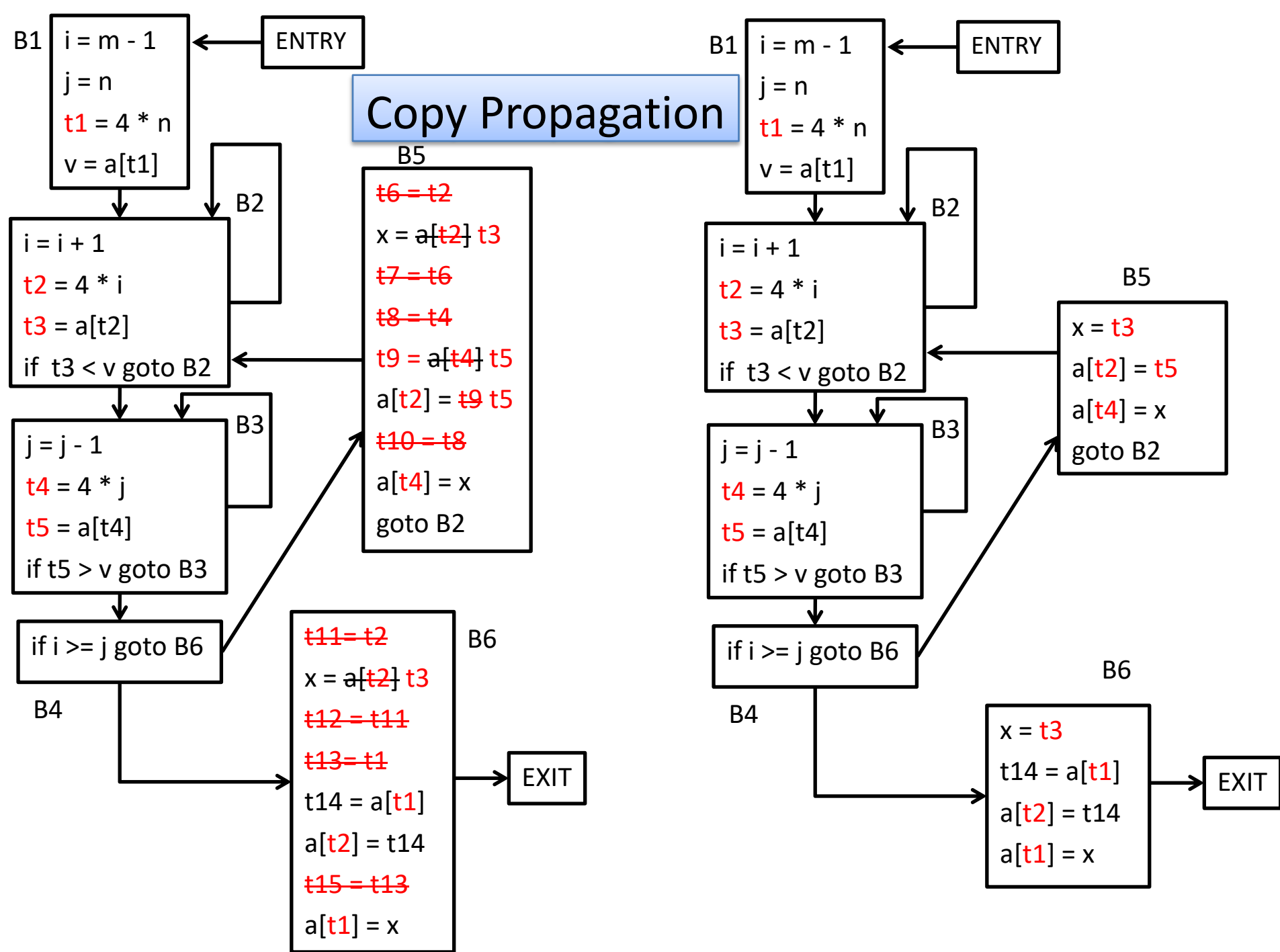
After global common  
subexpression elimination



# Copy Propagation



# Copy Propagation





After Common  
Subexpression  
Elimination and  
Copy Propagation

