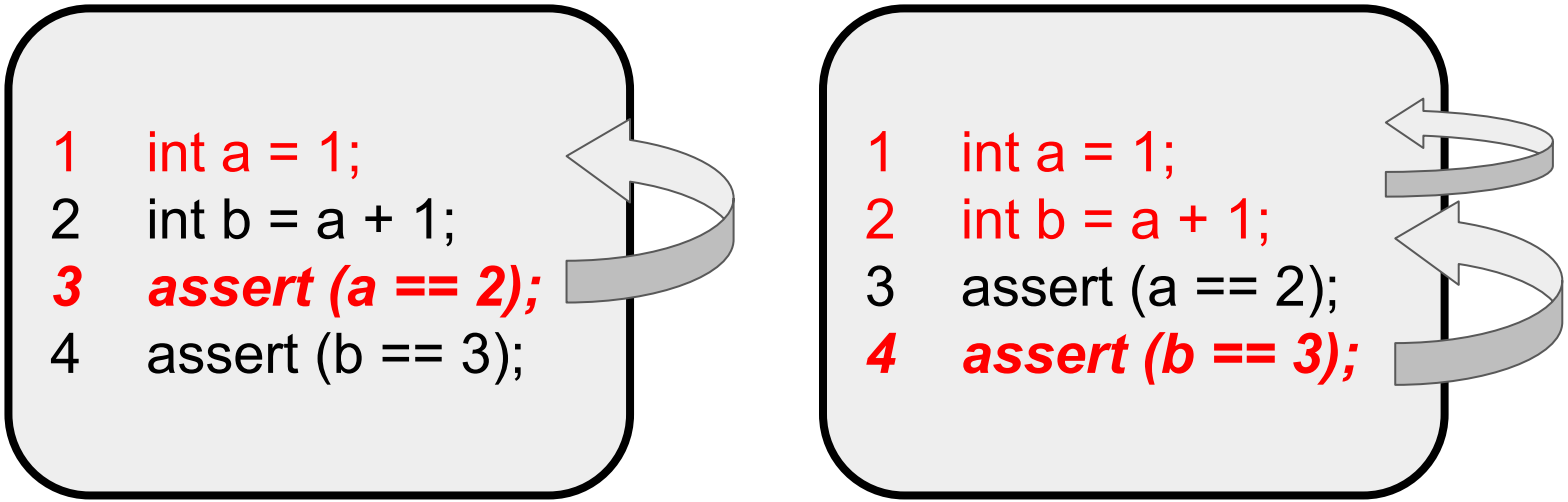
Program Slicing

What is slicing

Definition: The process that finding all statements in a program that directly or indirectly affect the value of a variable occurrence



Algorithm 1: Dynamic slicing algorithm.

```
1  Input : DCFG, c, v_1, ..., v_n
   Output: slice
2  begin
       ▷ Create working set of pairs of statement instances and used
         variables
3      W ← {(c, v_1) ... (c, v_n)}
4      while W ≠ ∅ do
5          (t, v) ← pick and remove from W
6          slice ← slice ∪ {t}
7          t' ← the instance t is control-dependent on
8          if t' not in slice then
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9              W ← W ∪ {(t', v') | v' ∈ use(t')}
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10         t' ← reaching definition of v at t
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12             W ← W ∪ {(t', v') | v' ∈ use(t)}
13     return slice
14 Procedure use(t)
15     return all variables used in t
```

Control Dependencies

```
1    int m = 1;
2    int n = 2;
3    int p = 4;
4    int q = m + 2;
5    if (m == 1) {
6            p = p - 1;
7    }
8    assert(p == 4);
```

If	A can alter the program's control and it determines whether B executes
Then	B is control-dependent on A

➢ 6 is control-dependent on 5

Example statements: ***if*** and ***while***

Control-flow Dependencies

```
1    int m = 1;
2    int n = 2;
3    int p = 4;
4    int q = m + 2;
5    if (m == 1) {
6            p = p - 1;
7    }
8    assert(p == 4);
```

If	B is executed immediately after A in the same execution thread
Then	B is control-flow-dependent on A

- 2 is control-flow-dependent on 1
- 3 is control-flow-dependent on 2
- 4 is control-flow-dependent on 3
- ……

Data-flow Dependencies

```
1    int m = 1;
2    int n = 2;
3    int p = 4;
4    int q = m + 2;
5    if (m == 1) {
6            p = p - 1;
7    }
8    assert(p == 4);
```

If	a). B is control-flow-dependent on A b). v used in B is defined in A and no other statement redefines v between A and B
Then	B is data-flow-dependent on A *i.e.* ***dynamic reaching definition*** *of v in B is A*

- 4 is data-flow-dependent on 1
  - Dynamic reaching definition of **m** in 4 is 1
- 5 is data-flow-dependent on 1
  - Dynamic reaching definition of **m** in 5 is 1
- 6 is data-flow-dependent on 3
  - Dynamic reaching definition of **p** in 6 is 3

Statement & Statement instance

s_i = **Statement**

The statement in line i

t_i^j = **Statement instance**

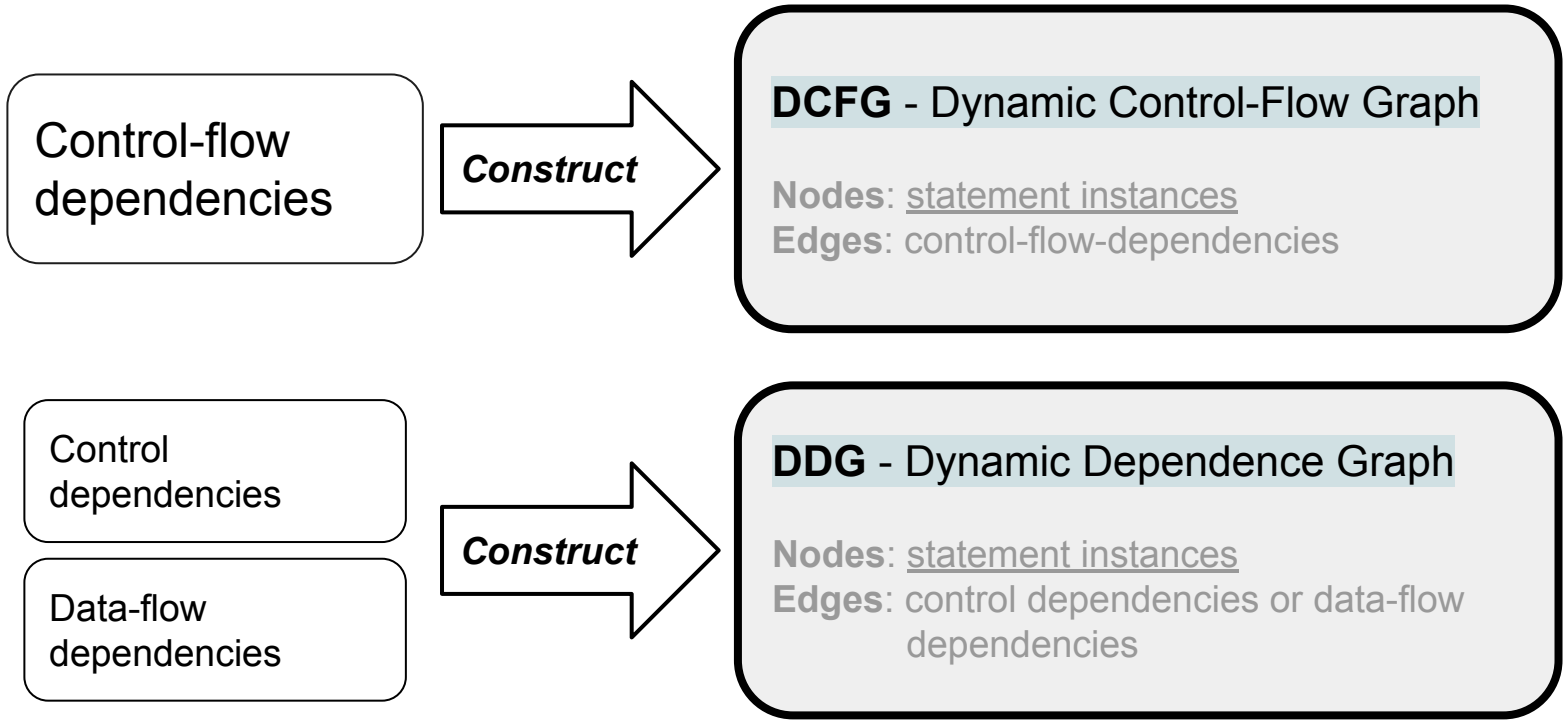
jth execution of statement s_i

```
1    int a = 1;
2    while (a >= 0) {
3        a = a - 1;
4    }
```

$$s_1, s_2, s_3$$

$$t_1^1, t_2^1, t_3^1, t_2^2, t_3^2, t_2^3$$

Graphs: DCFG and DDG



Graph: CDDG

```
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2    int n = 2;
3    int p = 4;
4    int q = m + 2;
5    if (m == 1) {
6          p = p - 1;
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```
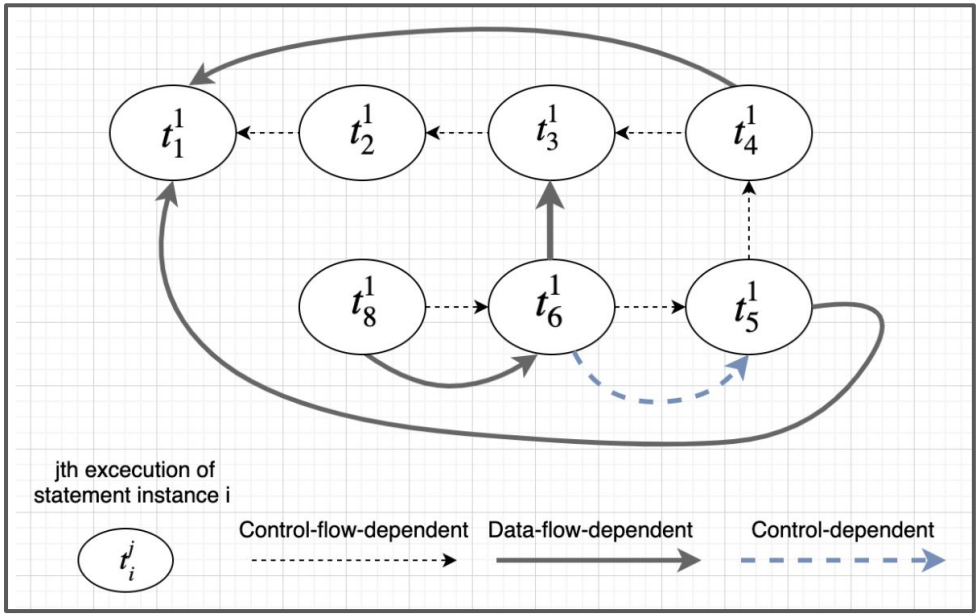

CDDG - Combined Dynamic Dependence Graph

Combination of CDFG and DDG



Input: (c, v)

```
1    int m = 1;
2    int n = 2;
3    int p = 4;
4    int q = m + 2;
5    if (m == 1) {
6            p = p - 1;
7    }
8    assert(p == 4);
```

Slicing Criterion - (c, v)

A statement instance and all variables of interest **used** in this statement instance

Examples: $(t_4^1, m), (t_5^1, m), (t_6^1, p), (t_8^1, p)$

Algorithm 1: Dynamic slicing algorithm.

```
1  Input  : DCFG, c, v_1, ..., v_n
   Output: slice
2  begin
       ▷ Create                                   t instances and used
         variable
3      W ← {(c,
4      while W ≠
5          (t, v)
6          slice
7          t' ←
8          if t' n
               ▷
9              W                                  more than once
                                                  all its used variables
10         t' ←
11         if t' n
12             W
13     return slice
14 Procedure use(t)
15     return all variables used in t
```

```
1    int m = 1;
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8    assert(p == 4);
```

$$c = t_8^1$$

$$v_1 = p$$

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2  begin
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3      W ← {(c, v1) ... (c, vn)}
4      while W ≠ ∅ do
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7          ← the instance t is control-dependent on
8          t′ not in slice then
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9              W ← W ∪ {(t′, v′) | v′ ∈ use(t′)}
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```

$W \leftarrow \{(t_8^1, p)\}$ $\quad slice \leftarrow \{\}$

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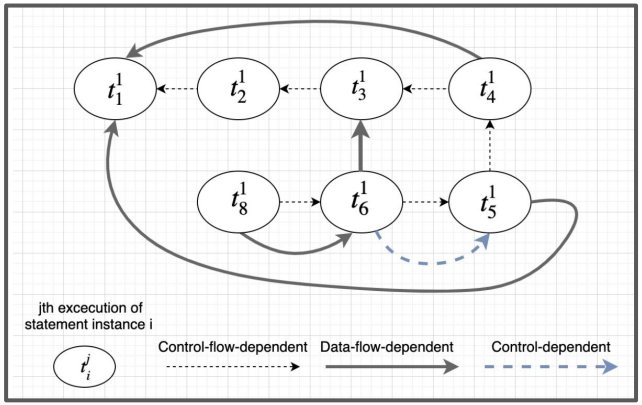

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                     ▷ Add t'  working set with all its used variables
10         t' ← reaching definition o  at t
11         if t' not in slice then
12             W ← W ∪ {(t', v') | v' ∈  e(t)}
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```

$W \leftarrow \{\}$

$slice \leftarrow \{t_8^1\}$

$t \leftarrow t_8^1,\ v \leftarrow p$

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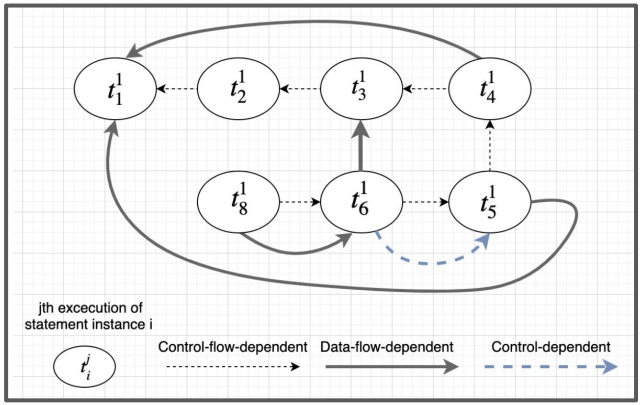

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t' is empty (intra-method slicing)

Note: t' is the method containing t in inter-method slicing

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$t \leftarrow t_8^1,\ v \leftarrow p$

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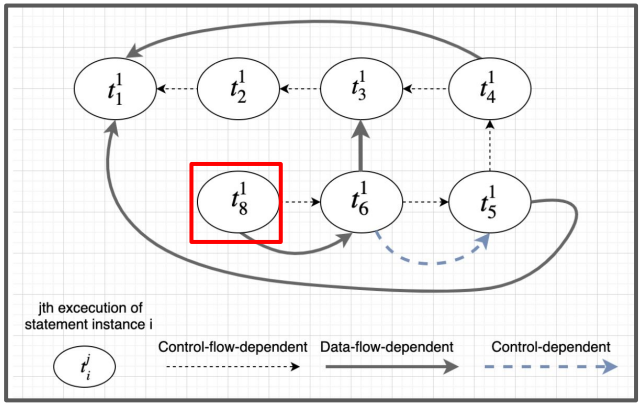

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$t' \leftarrow t_6^1$

$t \leftarrow t_8^1,\ v \leftarrow p$

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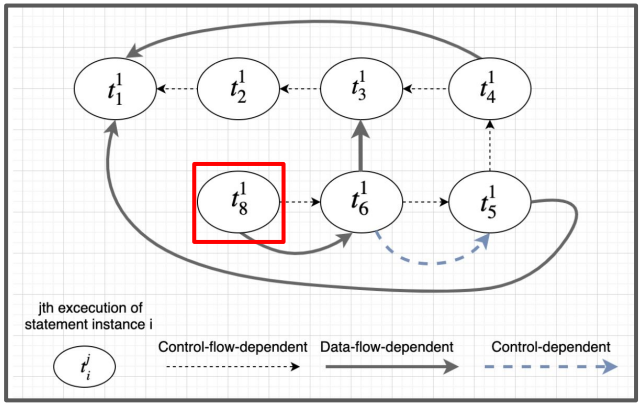

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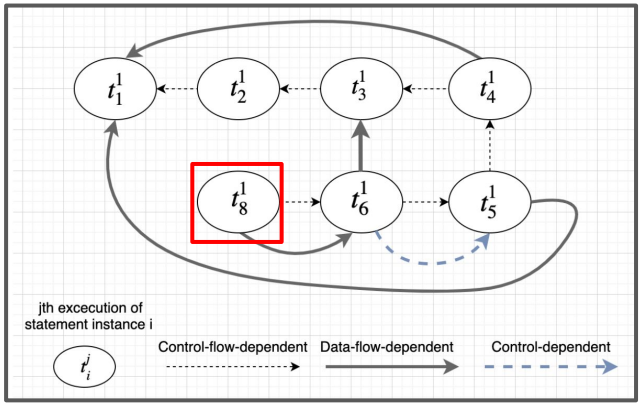

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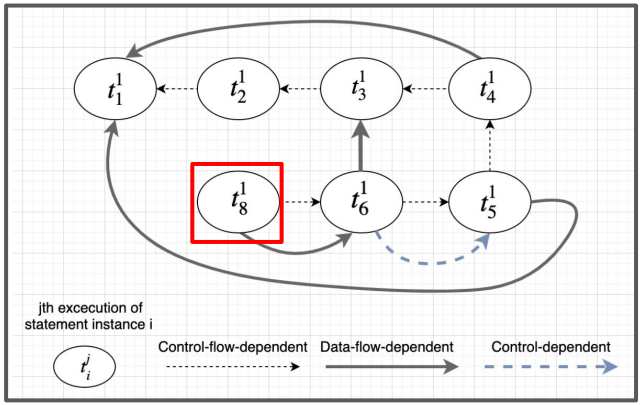

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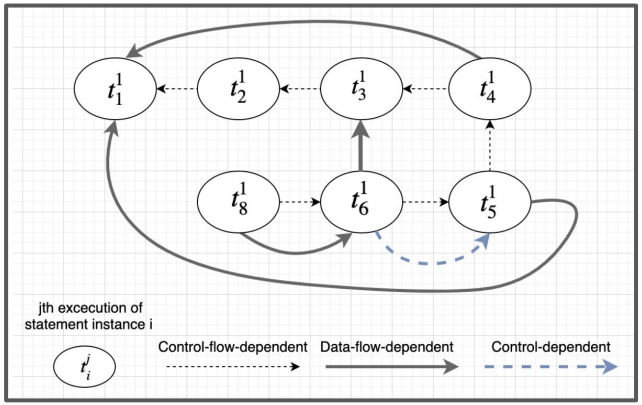

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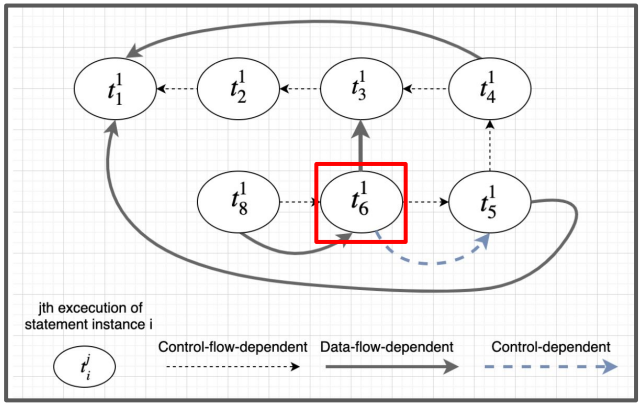

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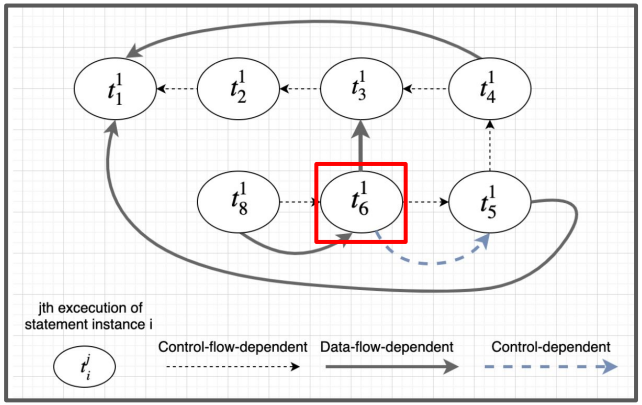

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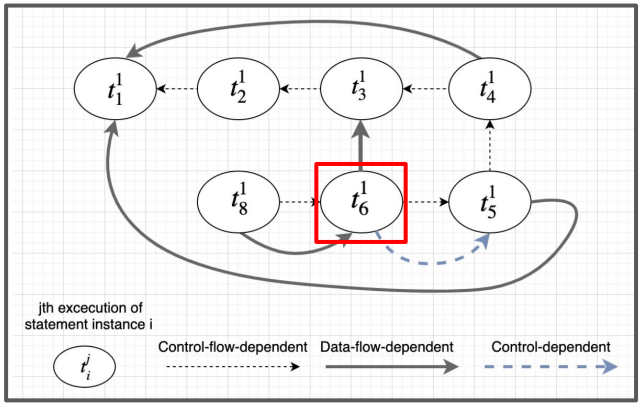

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$W \leftarrow \{(t_5^1, m), (t_3^1, p)\}$ $\quad slice \leftarrow \{t_8^1, t_6^1\}$

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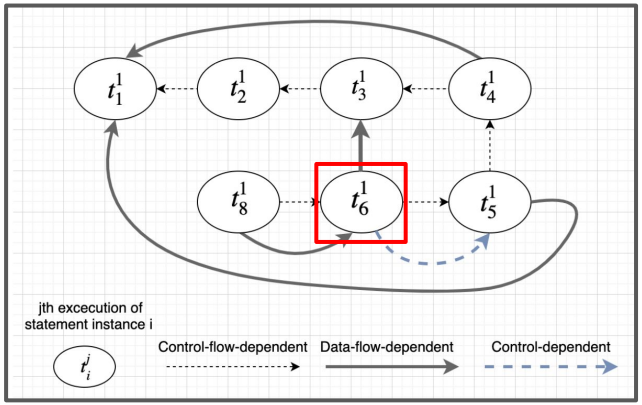

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$t \leftarrow t_5^1,\ v \leftarrow m$

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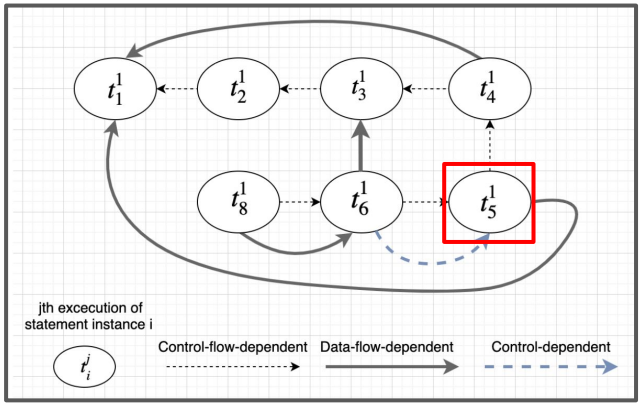

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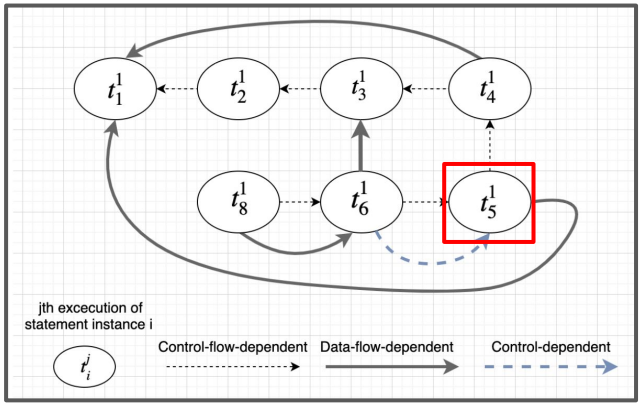

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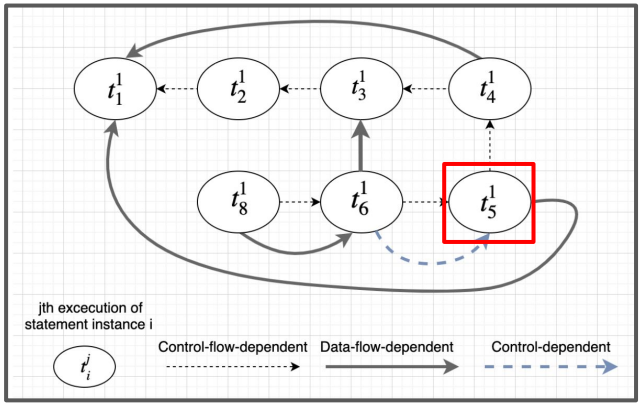

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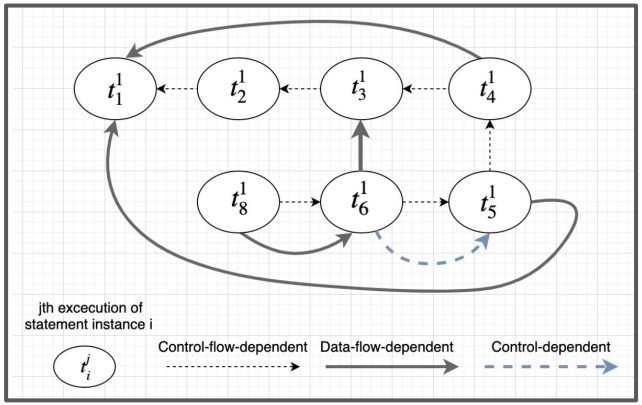

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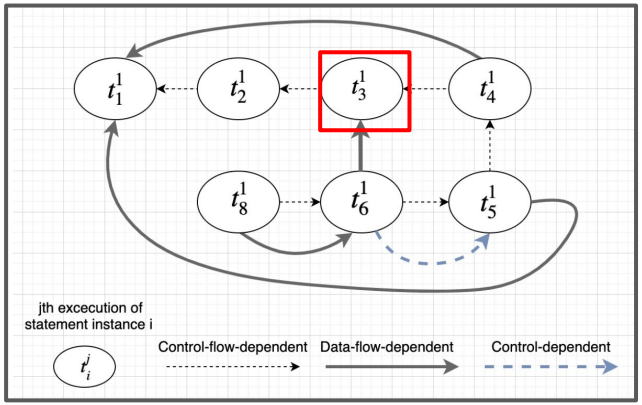

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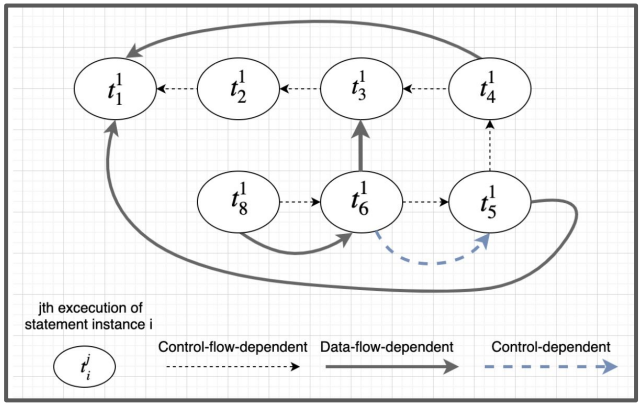

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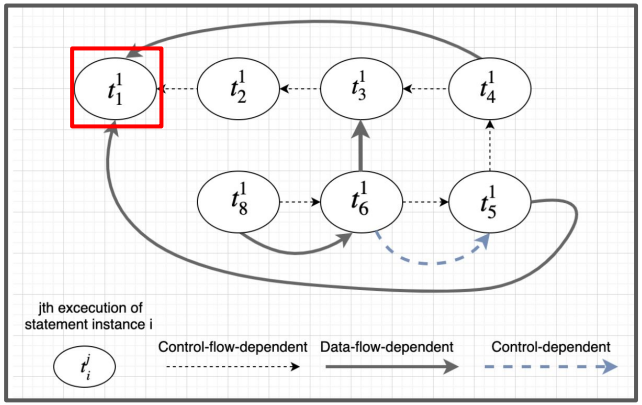

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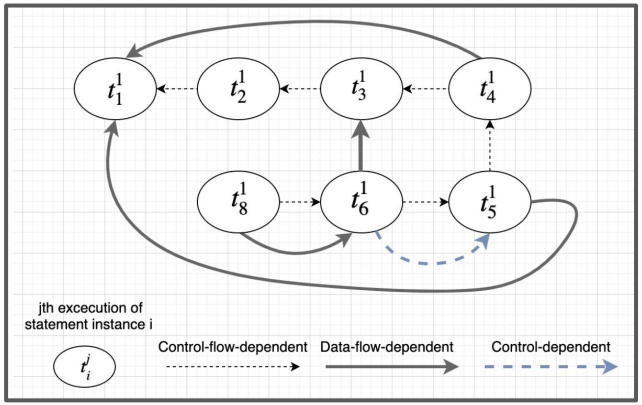

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