Register Allocation

TEACHING ASSISTANT: DAVID TRABISH

MIPS Architecture

- MIPS has 32 registers:
  - t0, …, t9
  - a0, a1, a3, a4
  - v0, v1
  - sp, fp
  - ra
  - …
- We will work with MIPS32
  - 32-bit registers

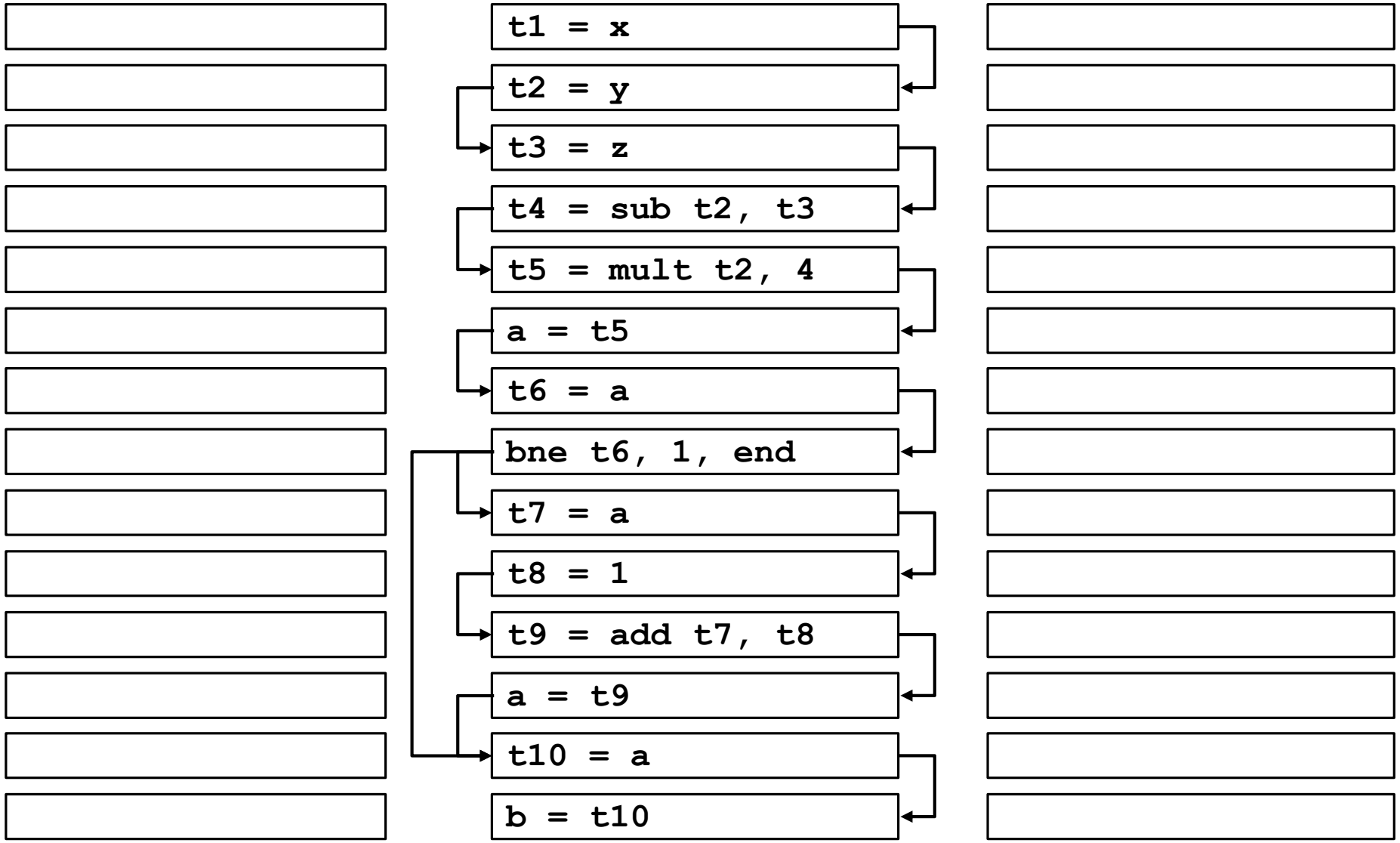
Control Flow Graph

- TODO

Control Flow Graph

```
a = x * (y - z)
if (a) {
  a = a + 1;
}
b = a
```

```
t1 = x
t2 = y
t3 = z
t4 = sub t2, t3
t5 = mult, t1, t4
a = t5
t6 = a
bne t6, 1, end
t7 = a
t8 = 1
t9 = add t7, t8
a = t9
end:
t10 = a
b = t10
```



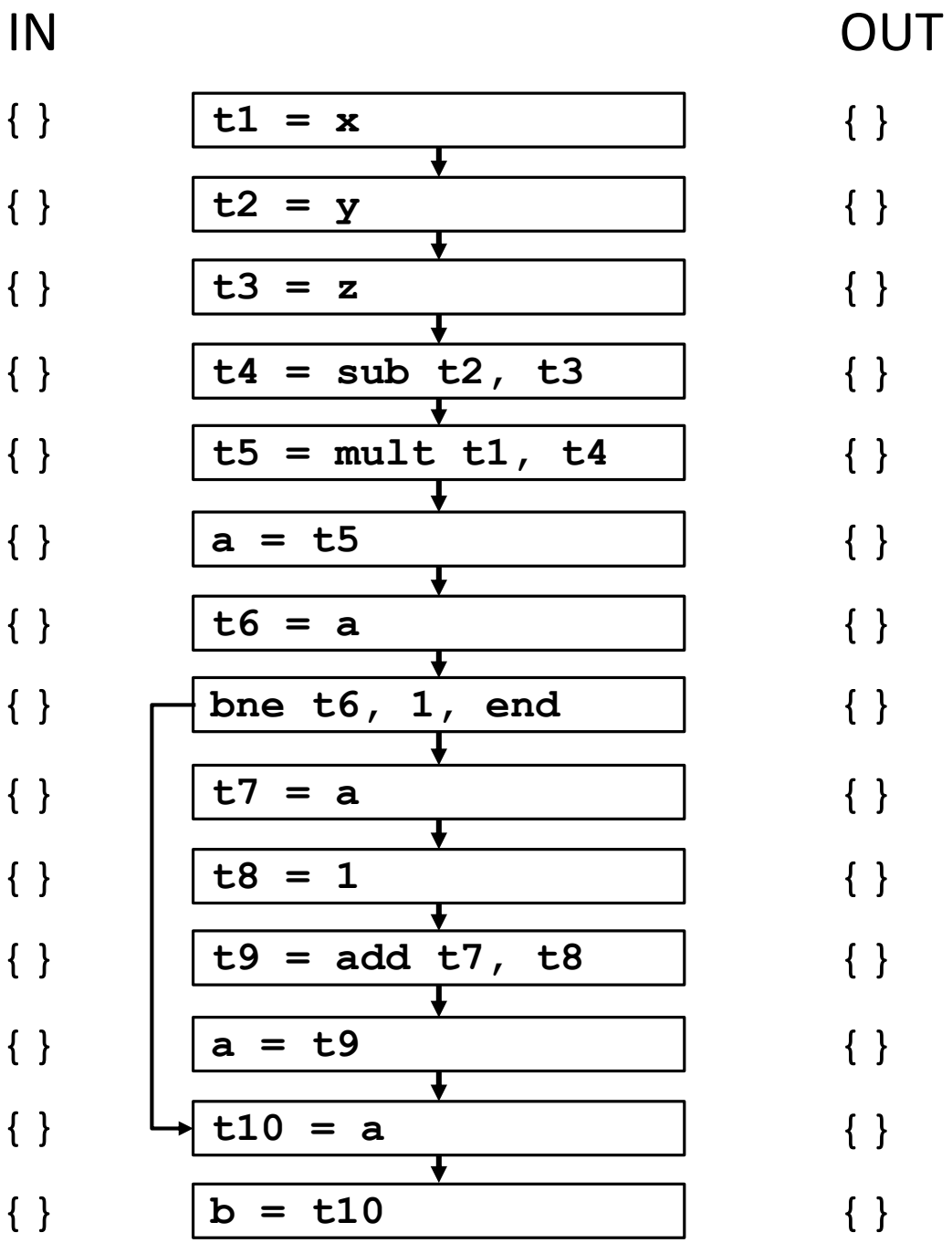

```
t1 = x
t2 = y
t3 = z
t4 = sub t
t5 = mult,
a = t5
t6 = a
bne t6, 1,
t7 = a
t8 = 1
t9 = add t
a = t9
end:
t10 = a
b = t10
```

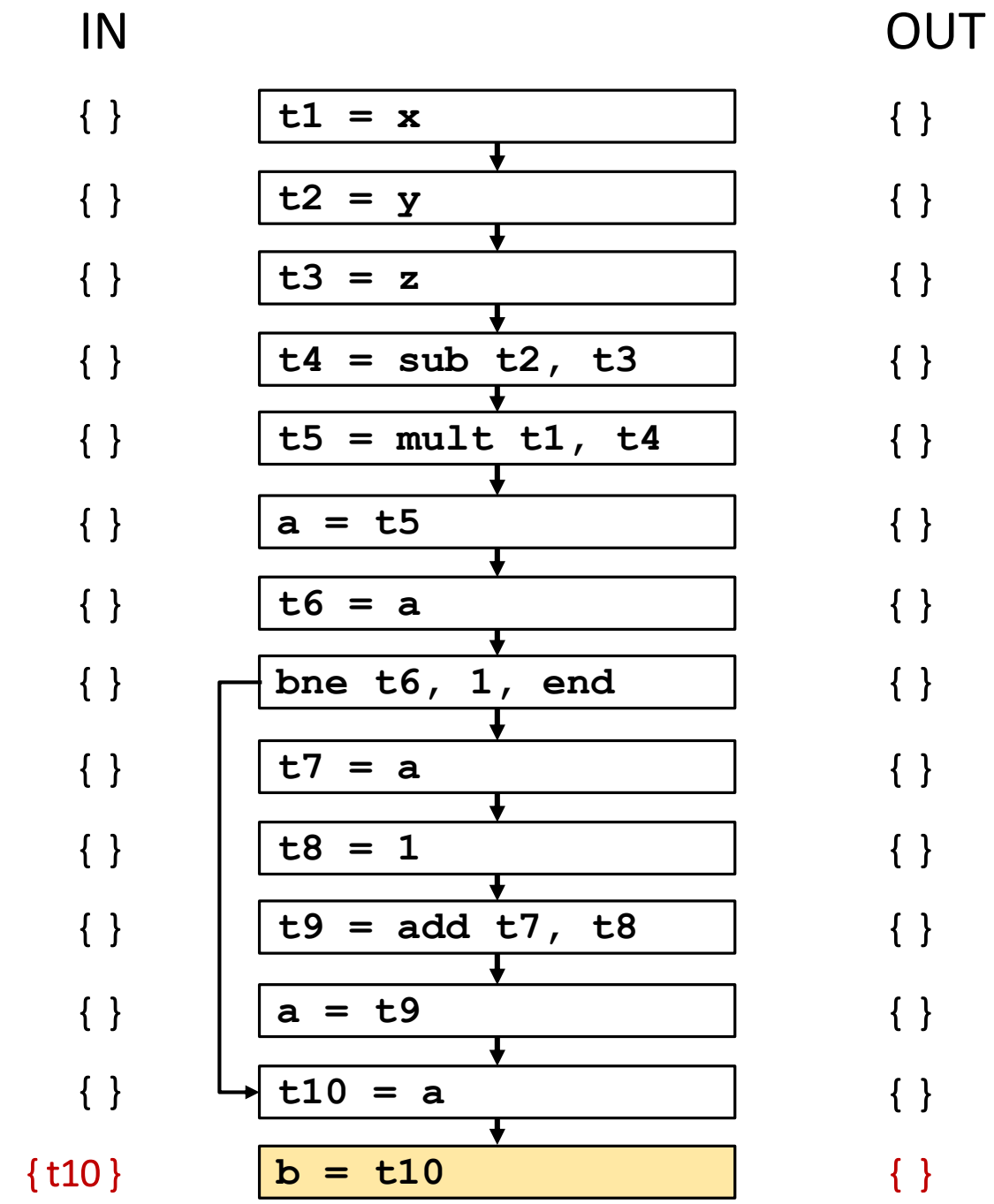
Liveness Analysis

- TODO

Liveness Analysis

- First pass


IN
OUT
{ }
t1 = x
t2 = y
t3 = z
t4 = sub t2, t3
t5 = mult t1, t4
a = t5
t6 = a
bne t6, 1, end
t7 = a
t8 = 1
t9 = add t7, t8
a = t9
t10 = a
b = t10


IN
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{ }
t1 = x
{ }
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t4 = sub t2, t3
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t5 = mult t1, t4
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a = t5
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t6 = a
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{ }
bne t6, 1, end
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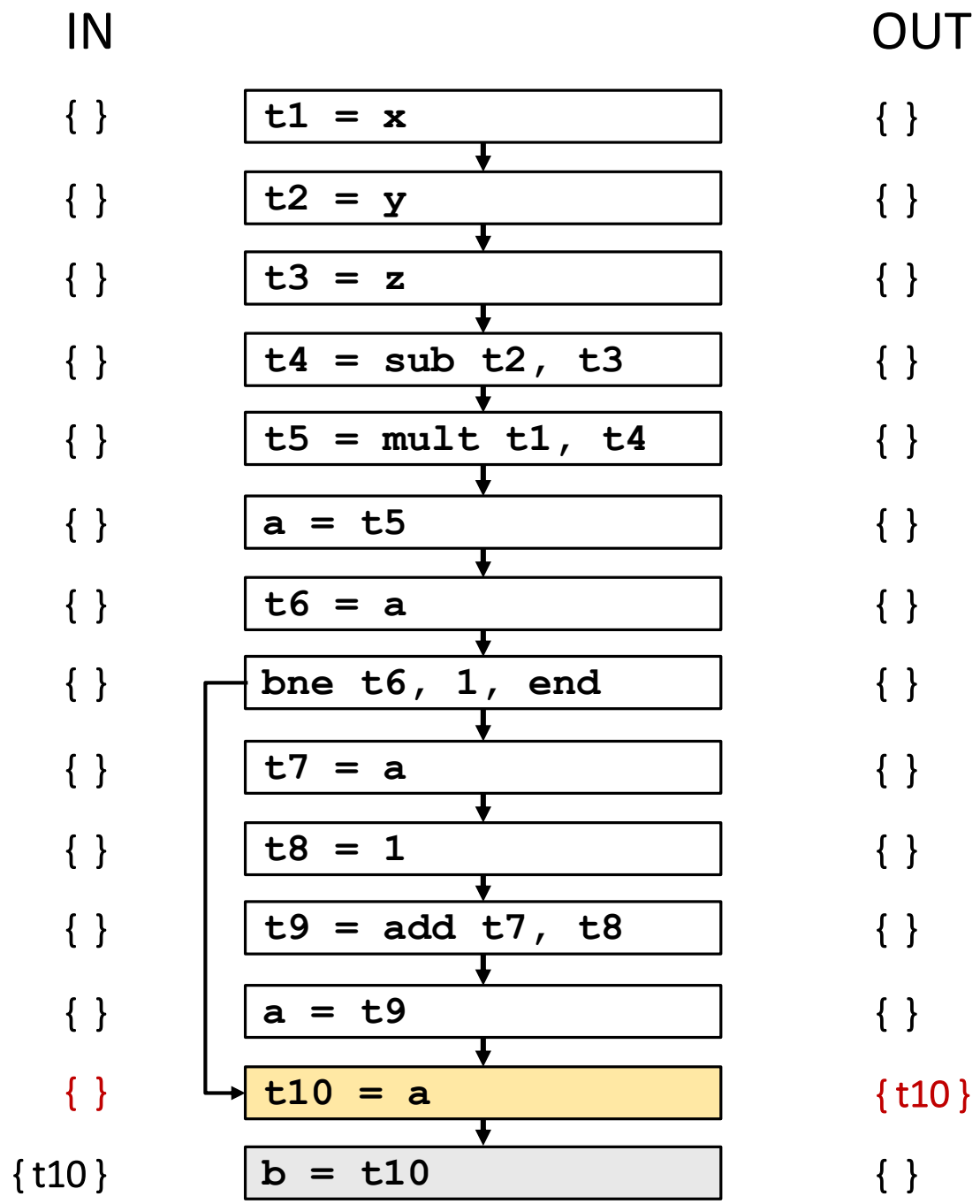
{ }
t7 = a
{ }
{ }
t8 = 1
{ }
{ }
t9 = add t7, t8
{ }
{ }
a = t9
{ }
{ }
t10 = a
{ }
{t10}
b = t10
{ }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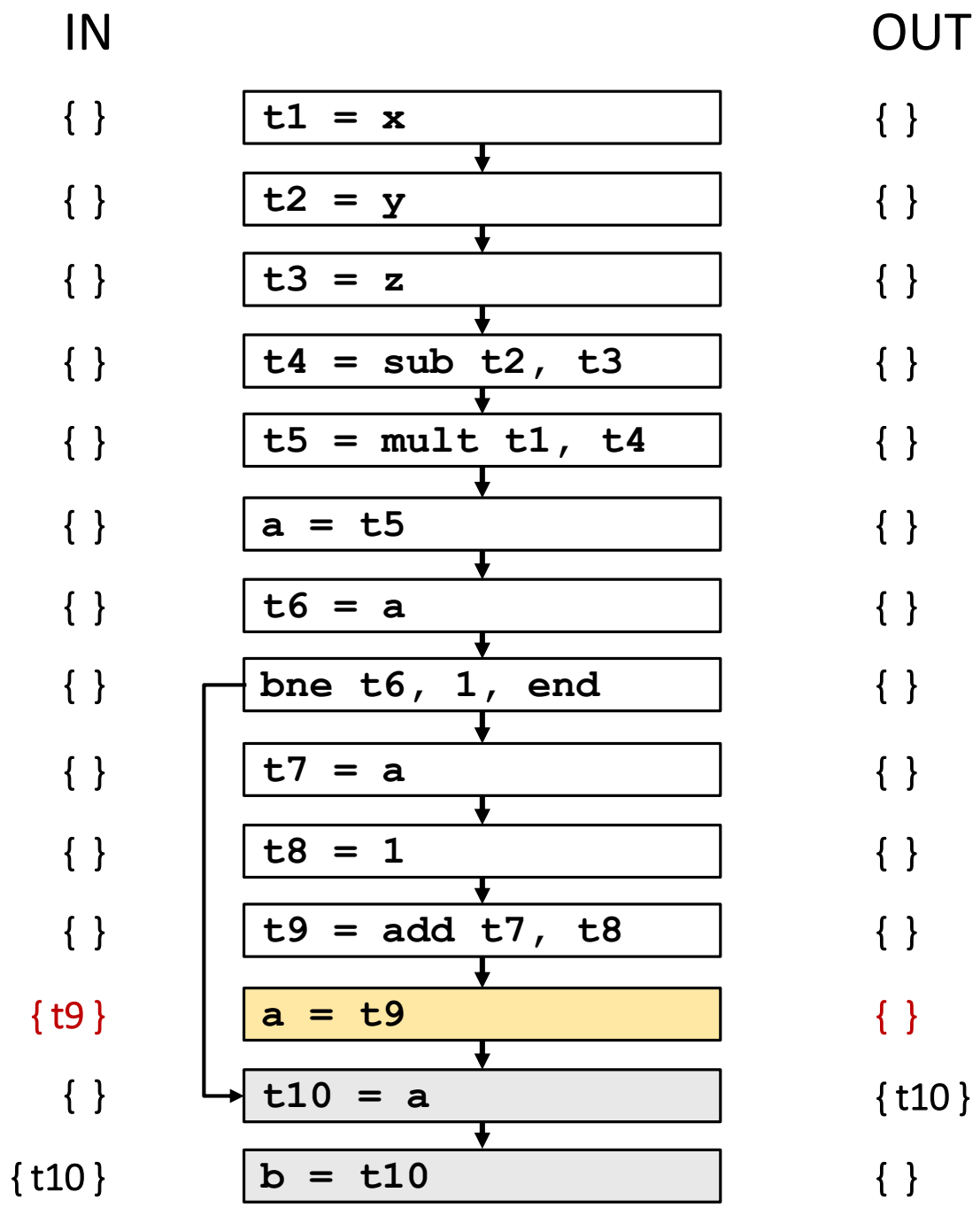
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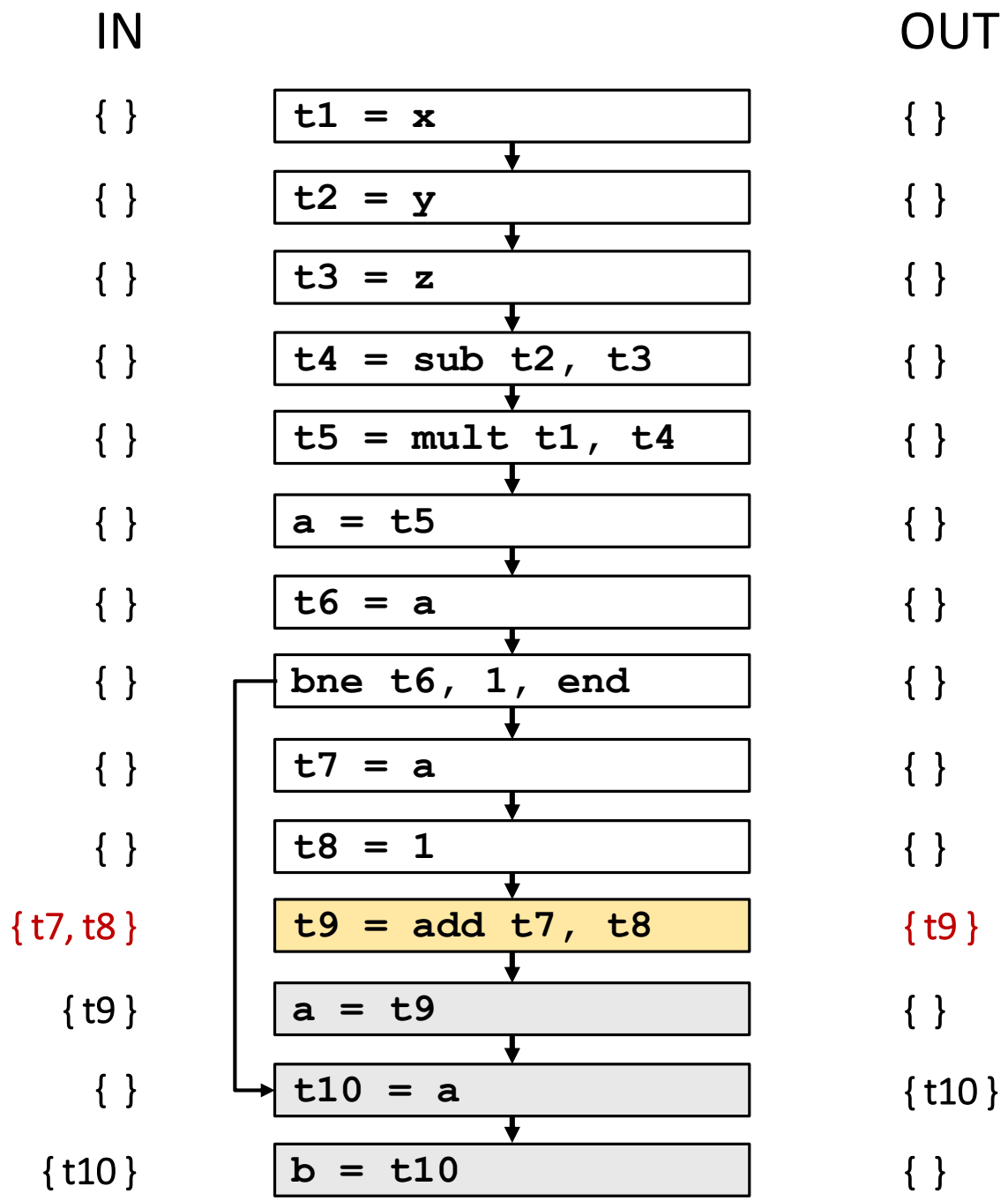
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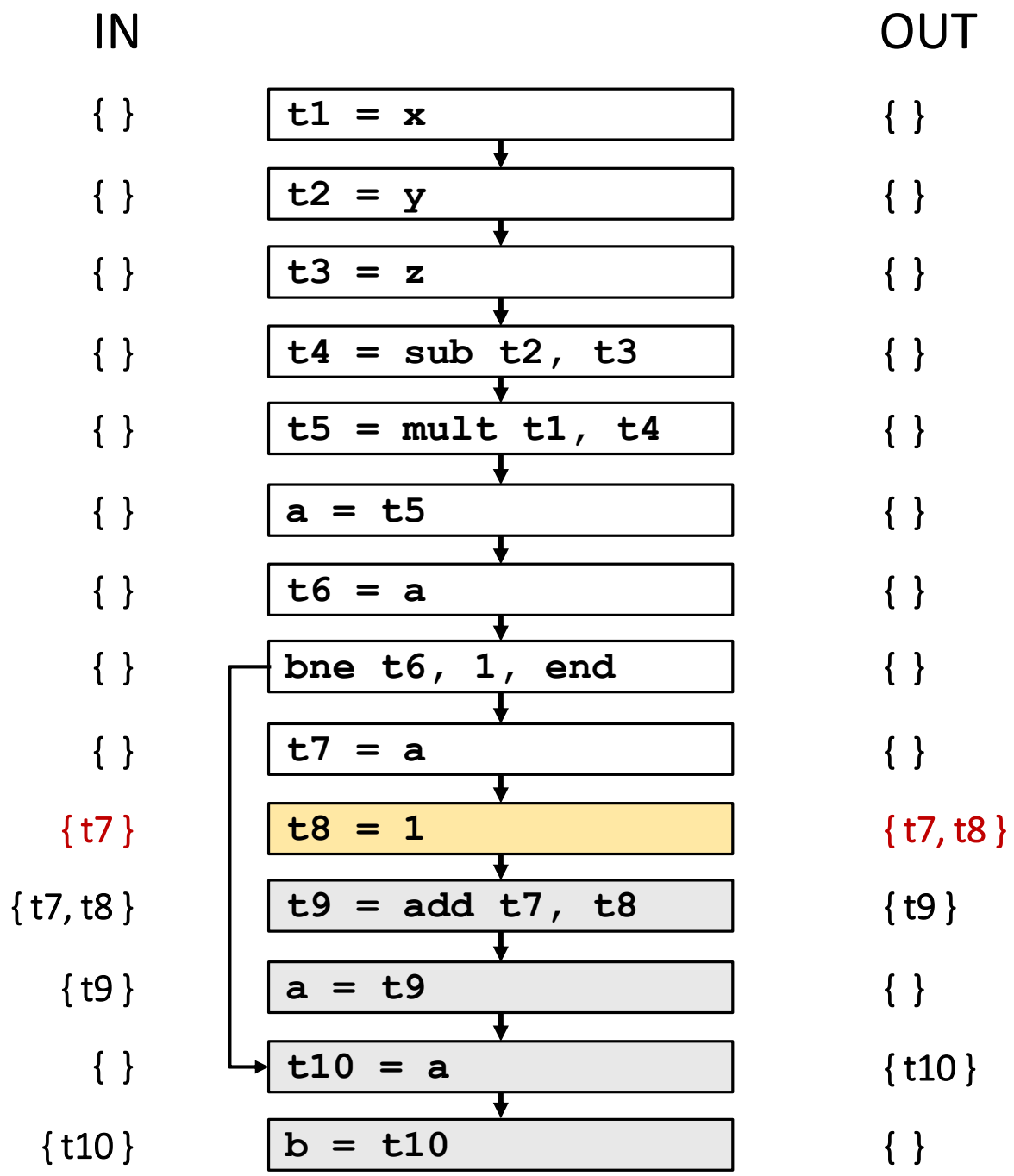
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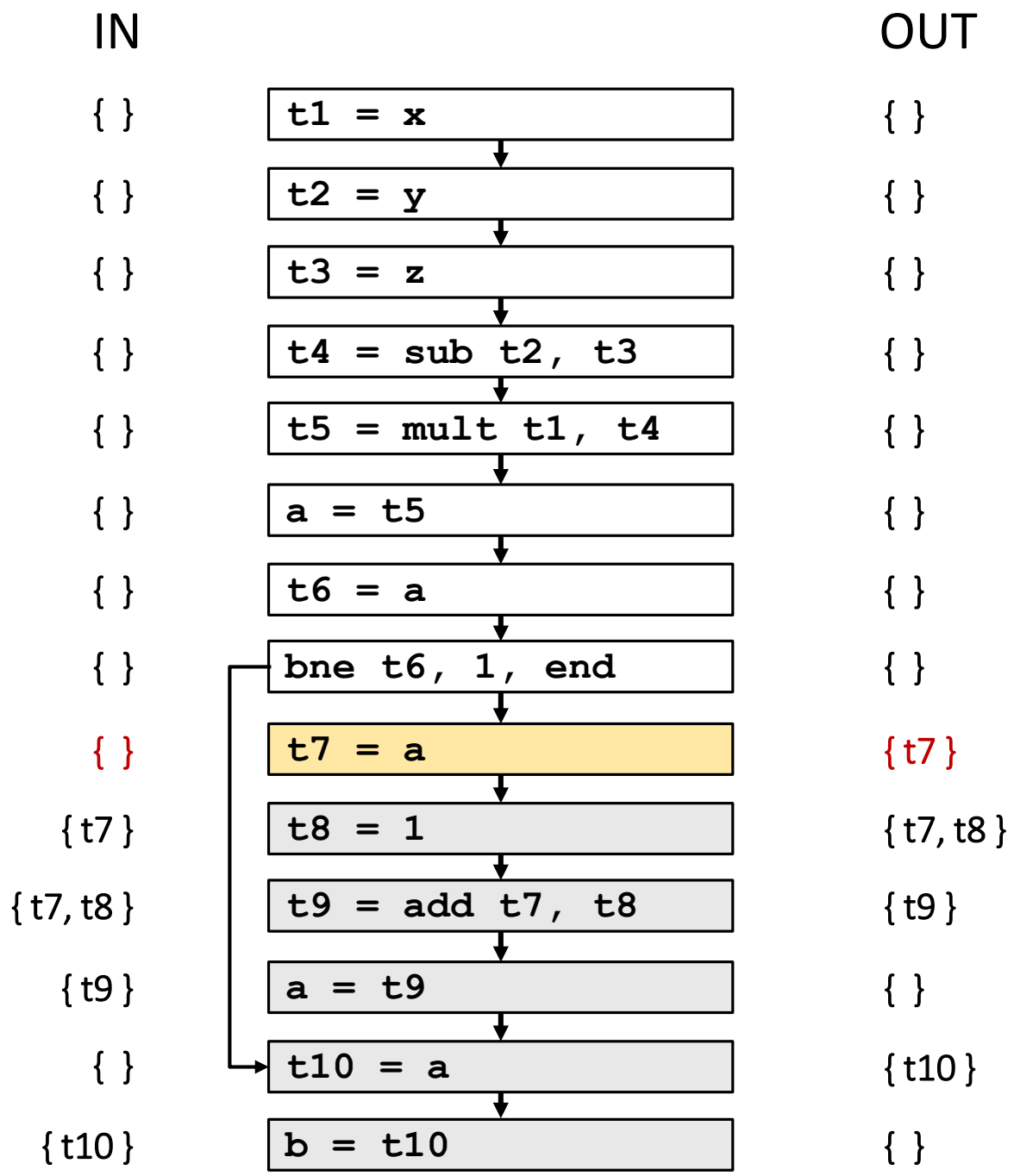
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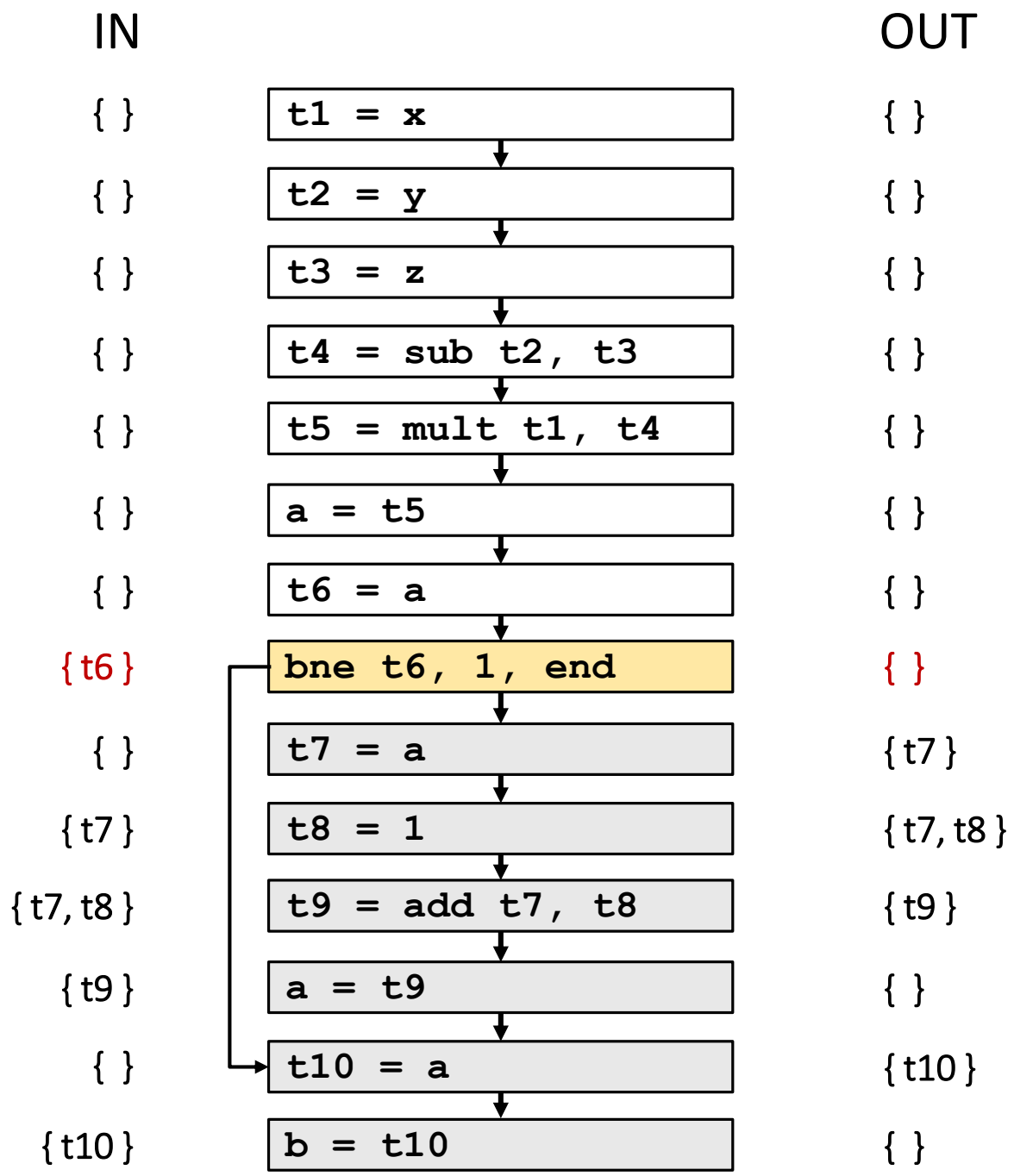
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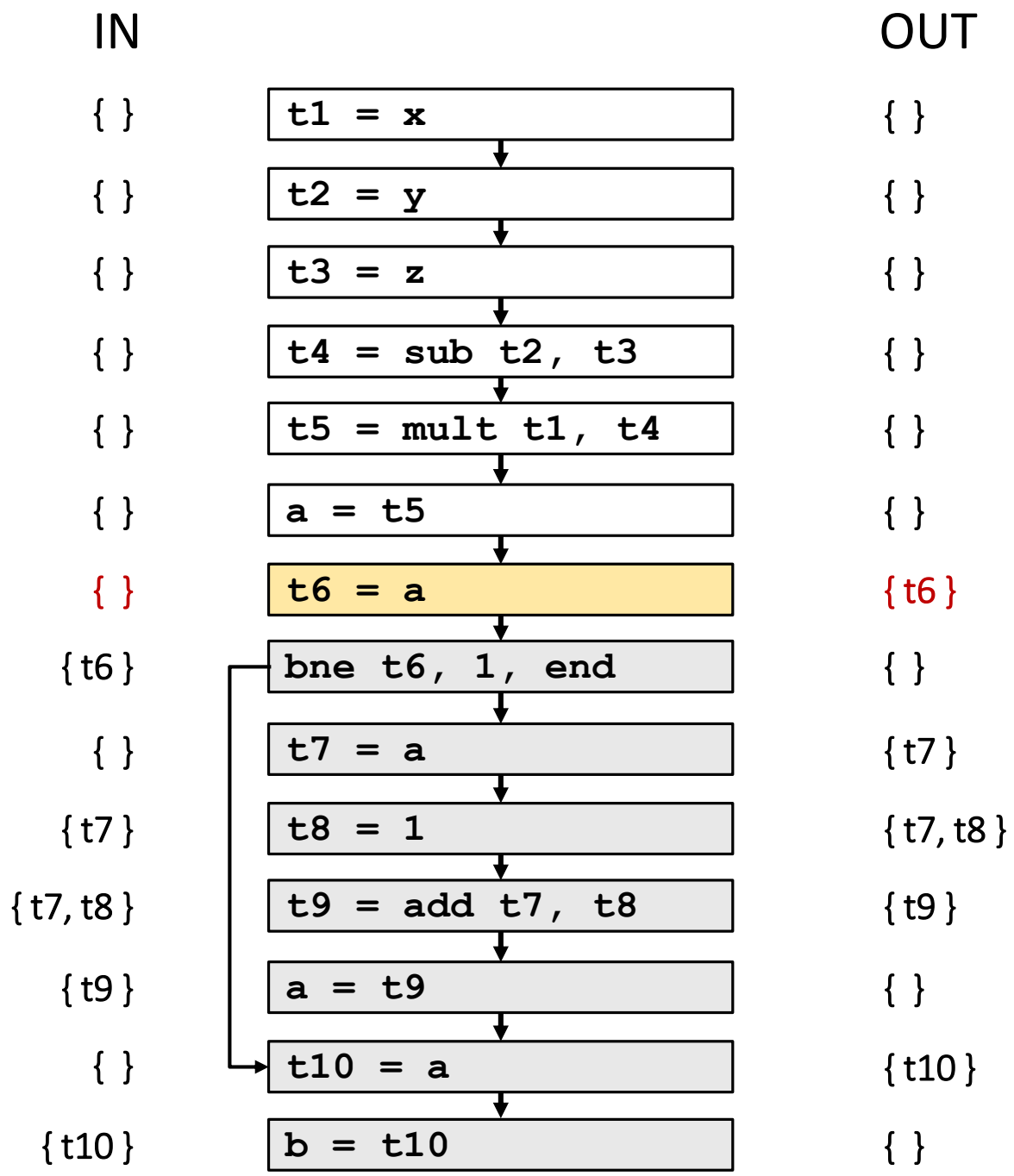
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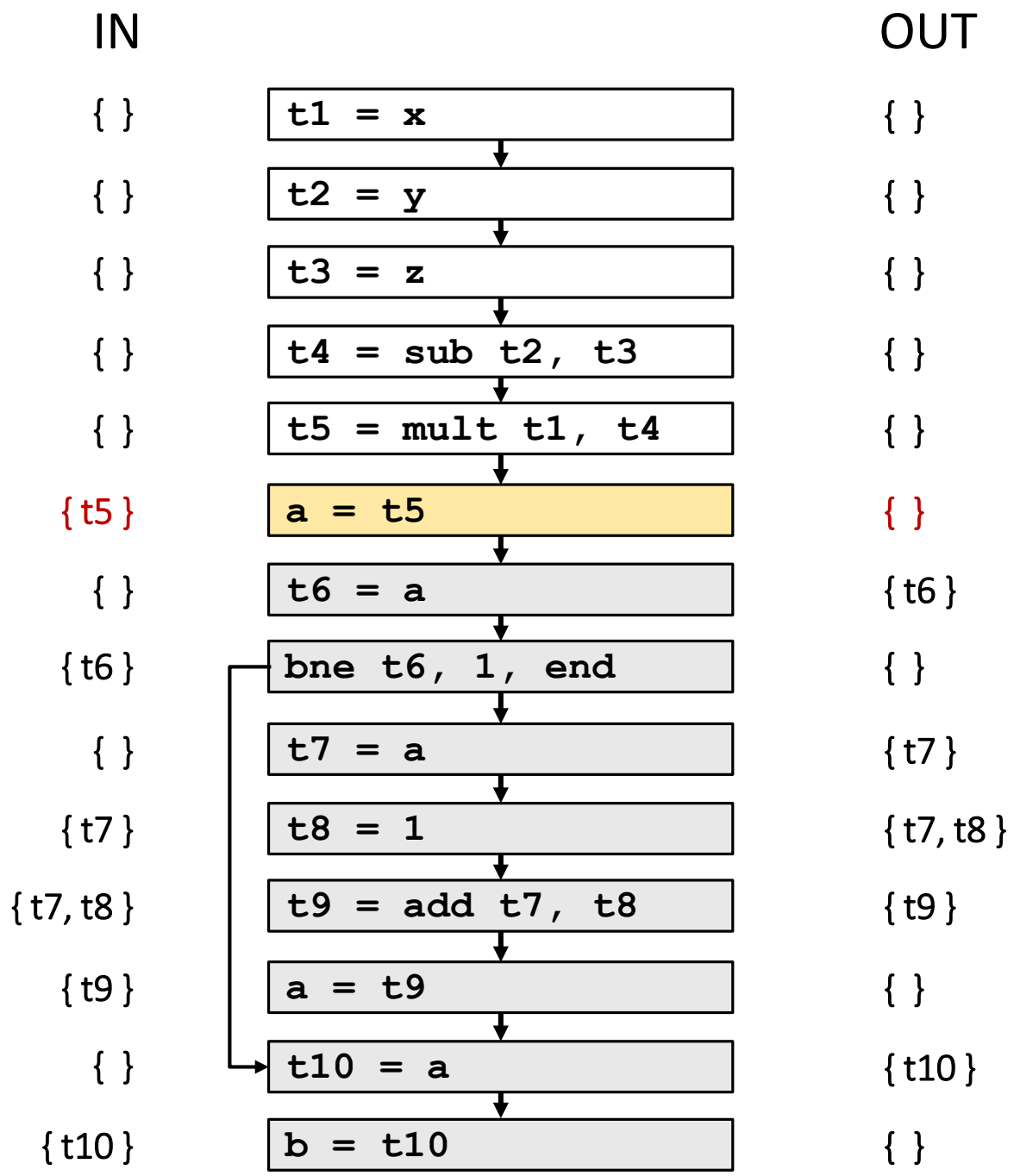
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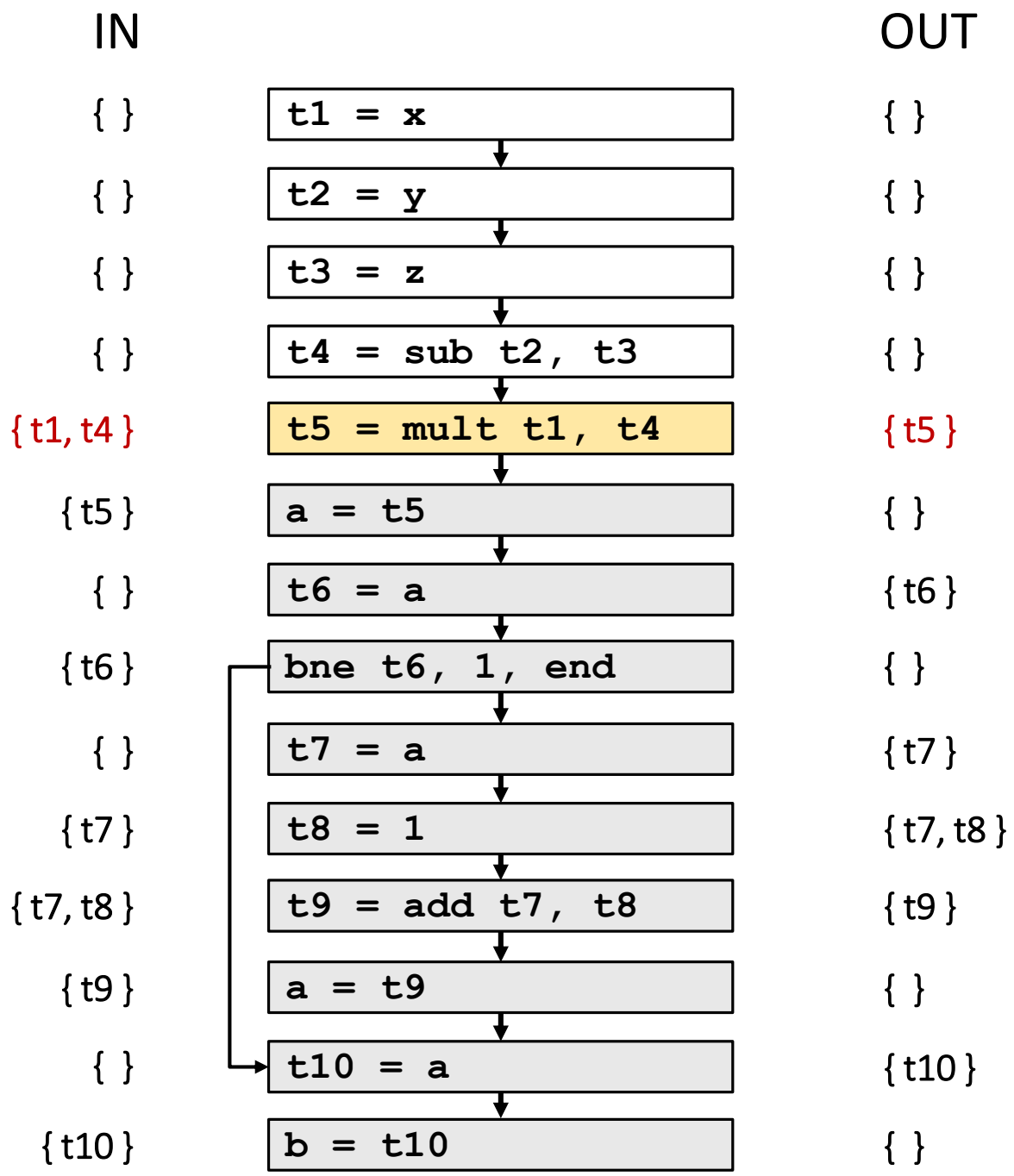
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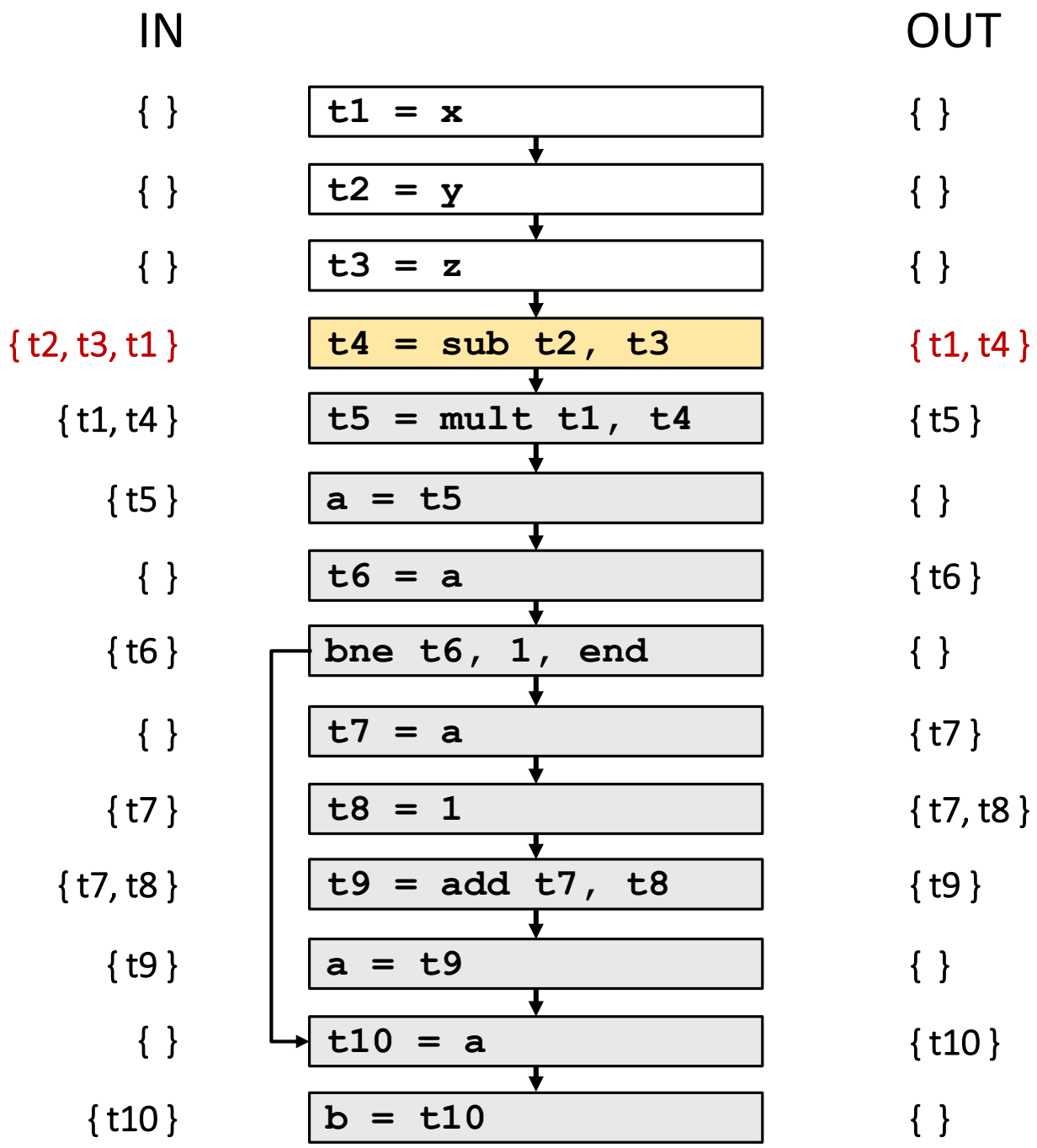
IN
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{ }
t1 = x
{ }
{ }
t2 = y
{ }
{ }
t3 = z
{ }
{ t2, t3, t1 }
t4 = sub t2, t3
{ t1, t4 }
{ t1, t4 }
t5 = mult t1, t4
{ t5 }
{ t5 }
a = t5
{ }
{ }
t6 = a
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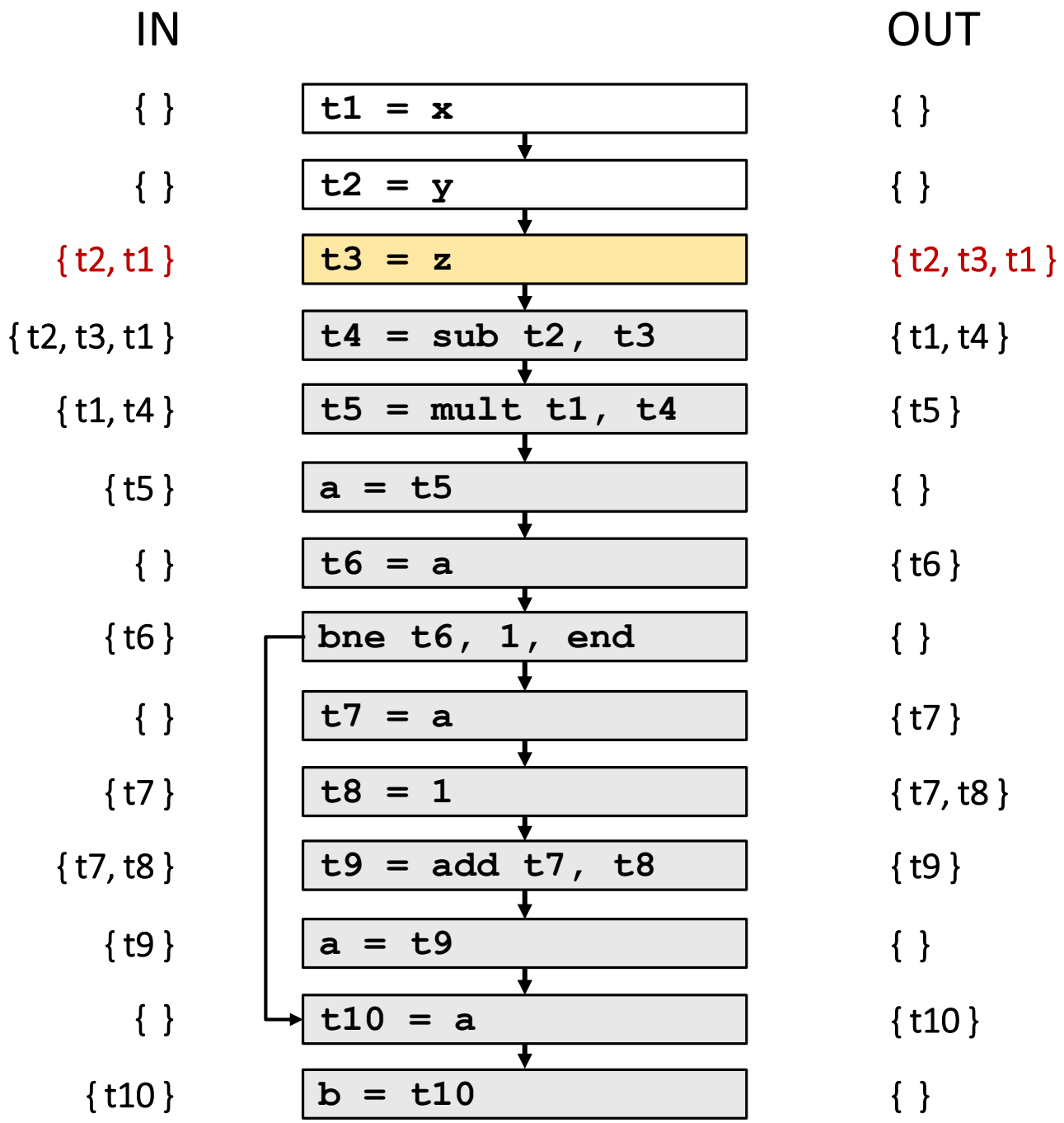
IN
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t1 = x
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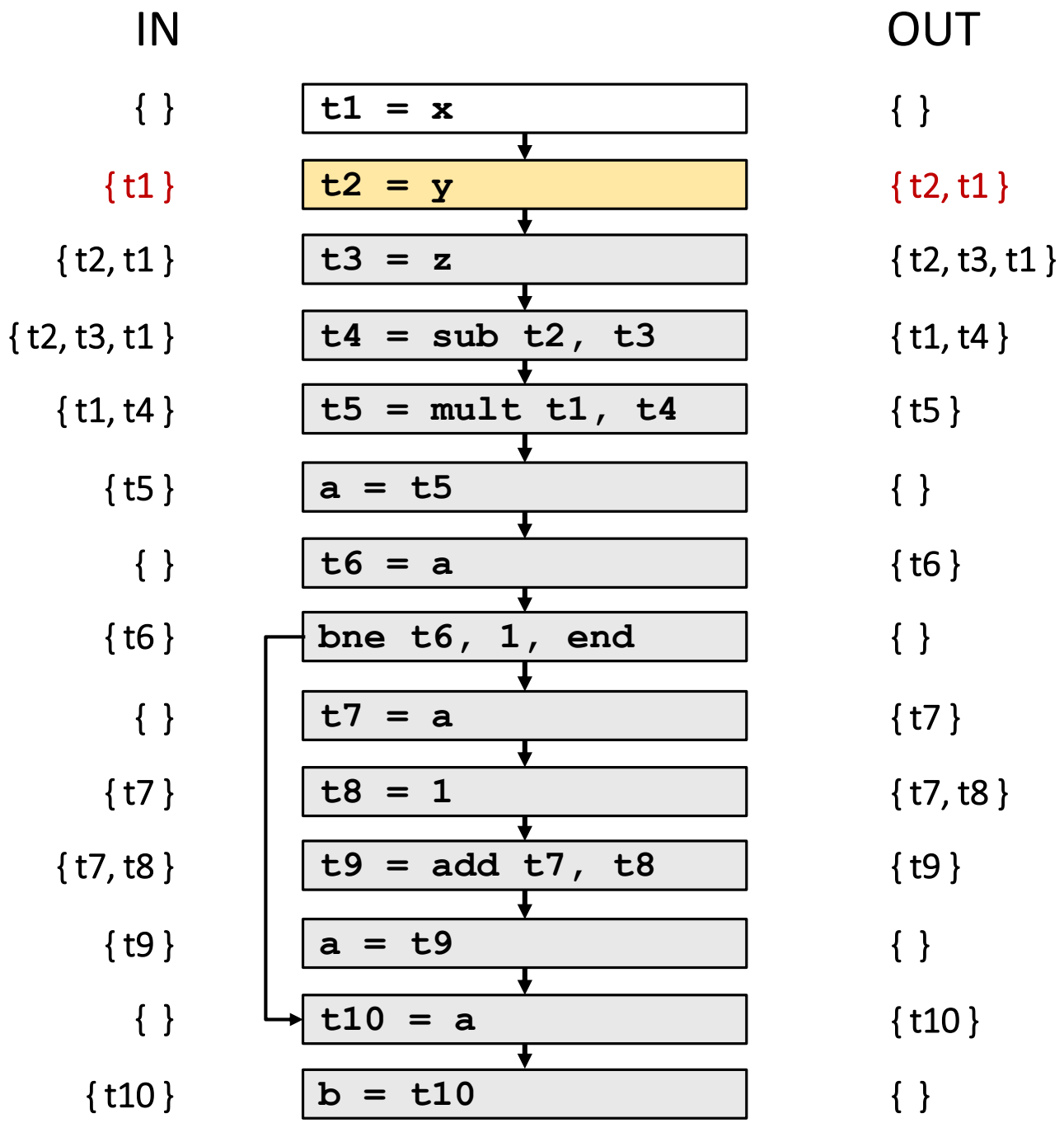
IN
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{ }
t1 = x
{ }
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
{t2, t3, t1}
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{t1, t4}
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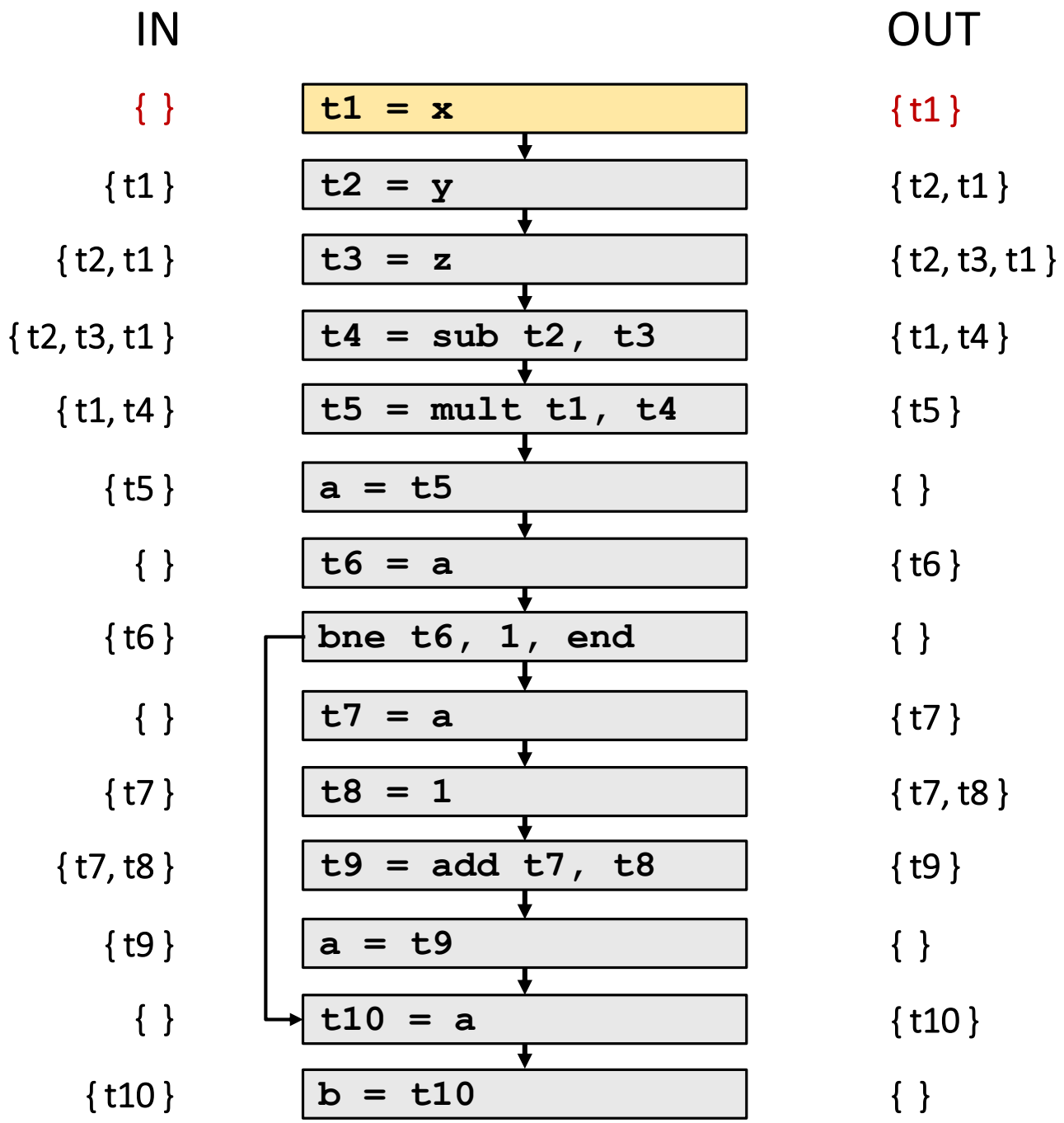
IN
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{ }
t1 = x
{t1}
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{t2, t1}
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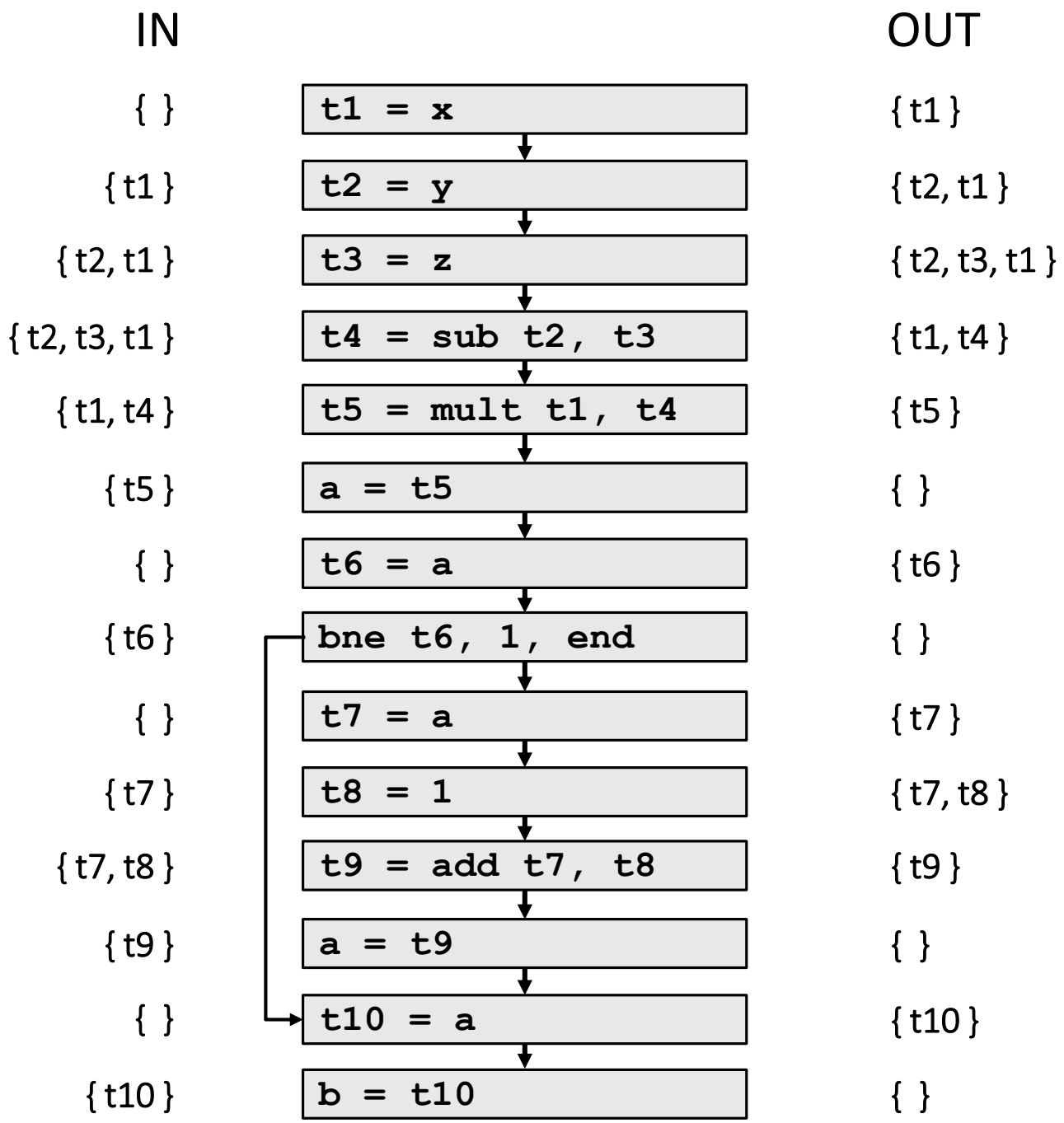
IN
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{ }
t1 = x
{ t1 }
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t2 = y
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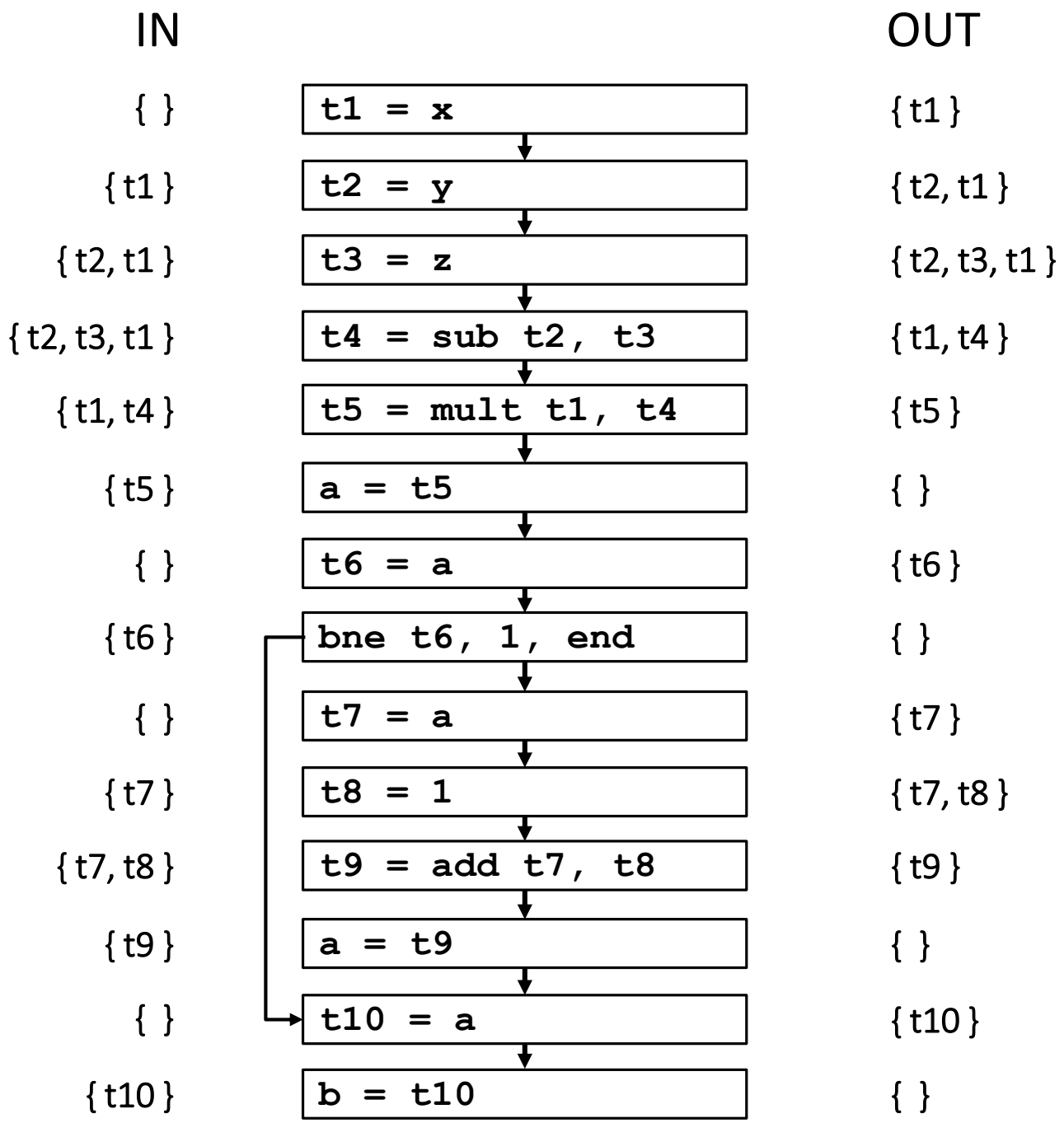
{ t9 }
{ t9 }
a = t9
{ }
{ }
t10 = a
{ t10 }
{ t10 }
b = t10
{ }

Liveness Analysis

- Second pass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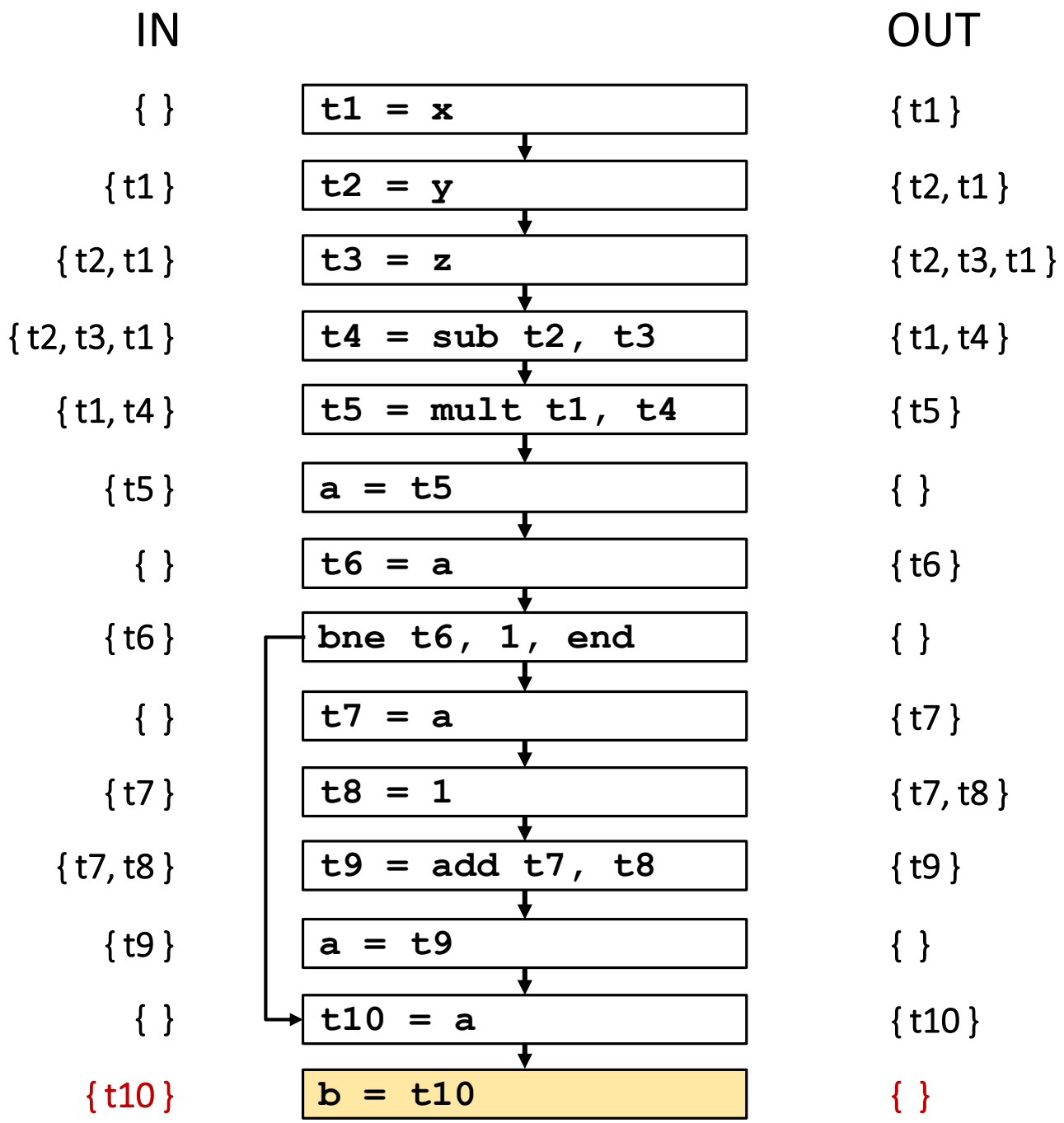
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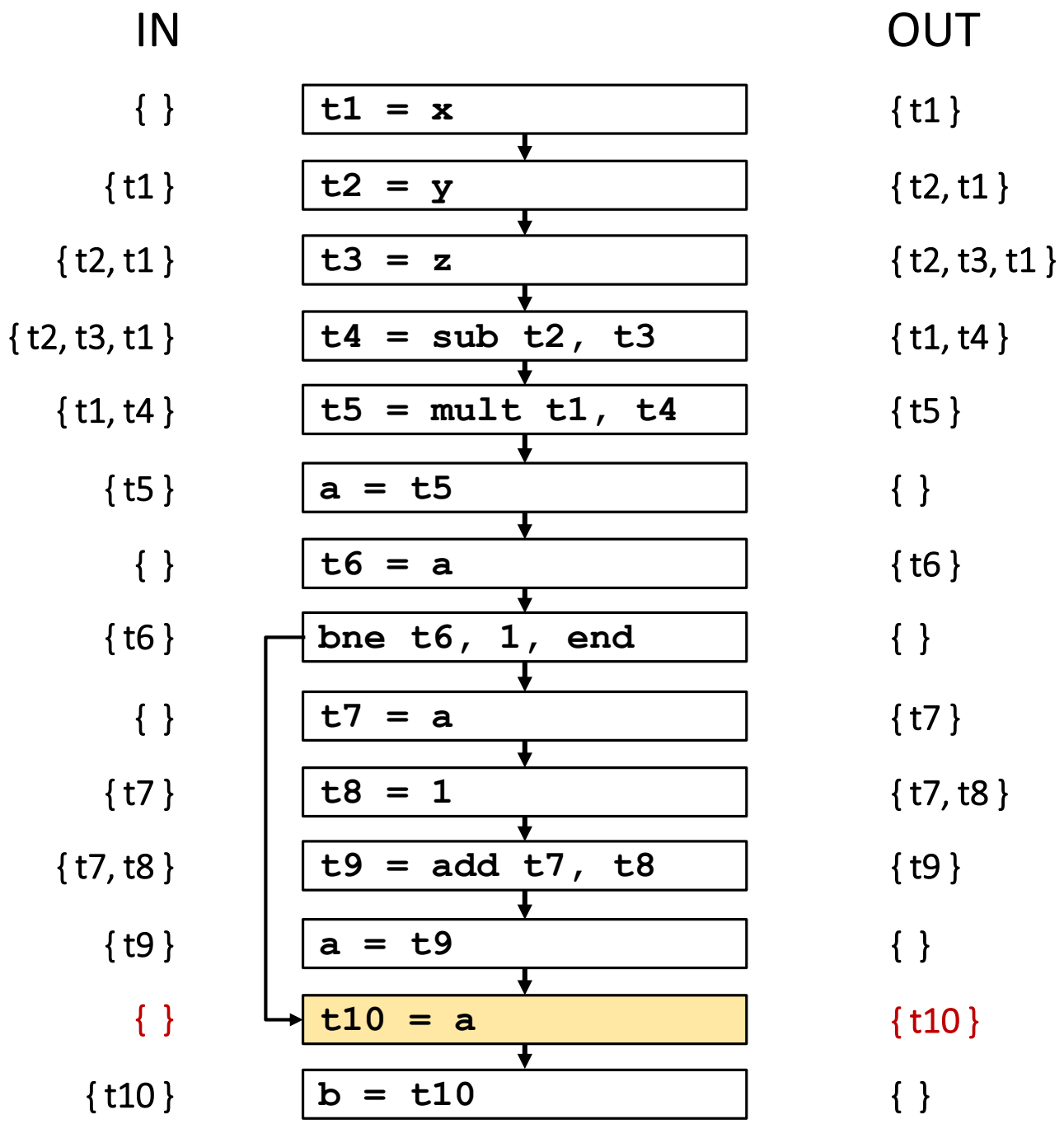
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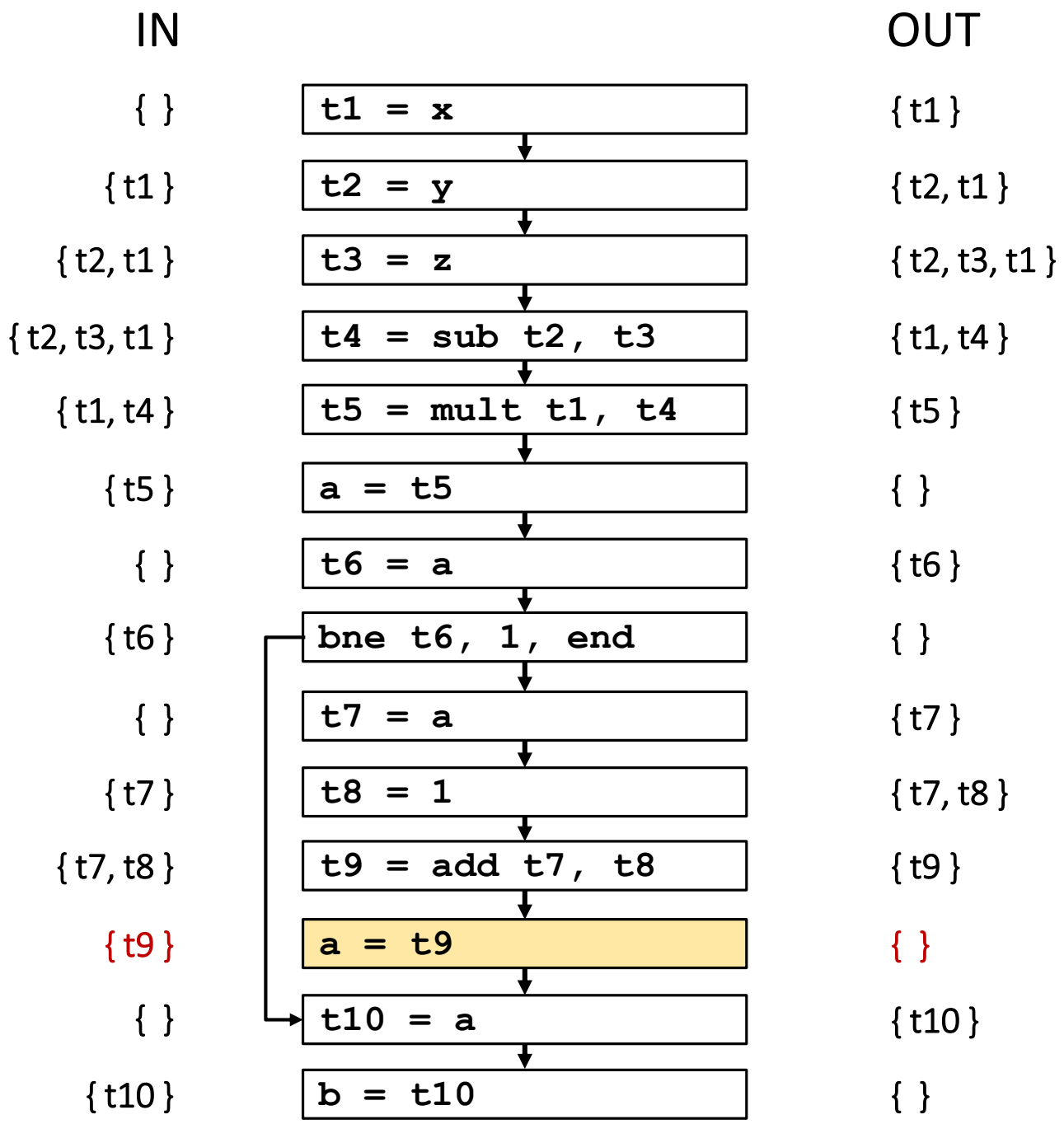
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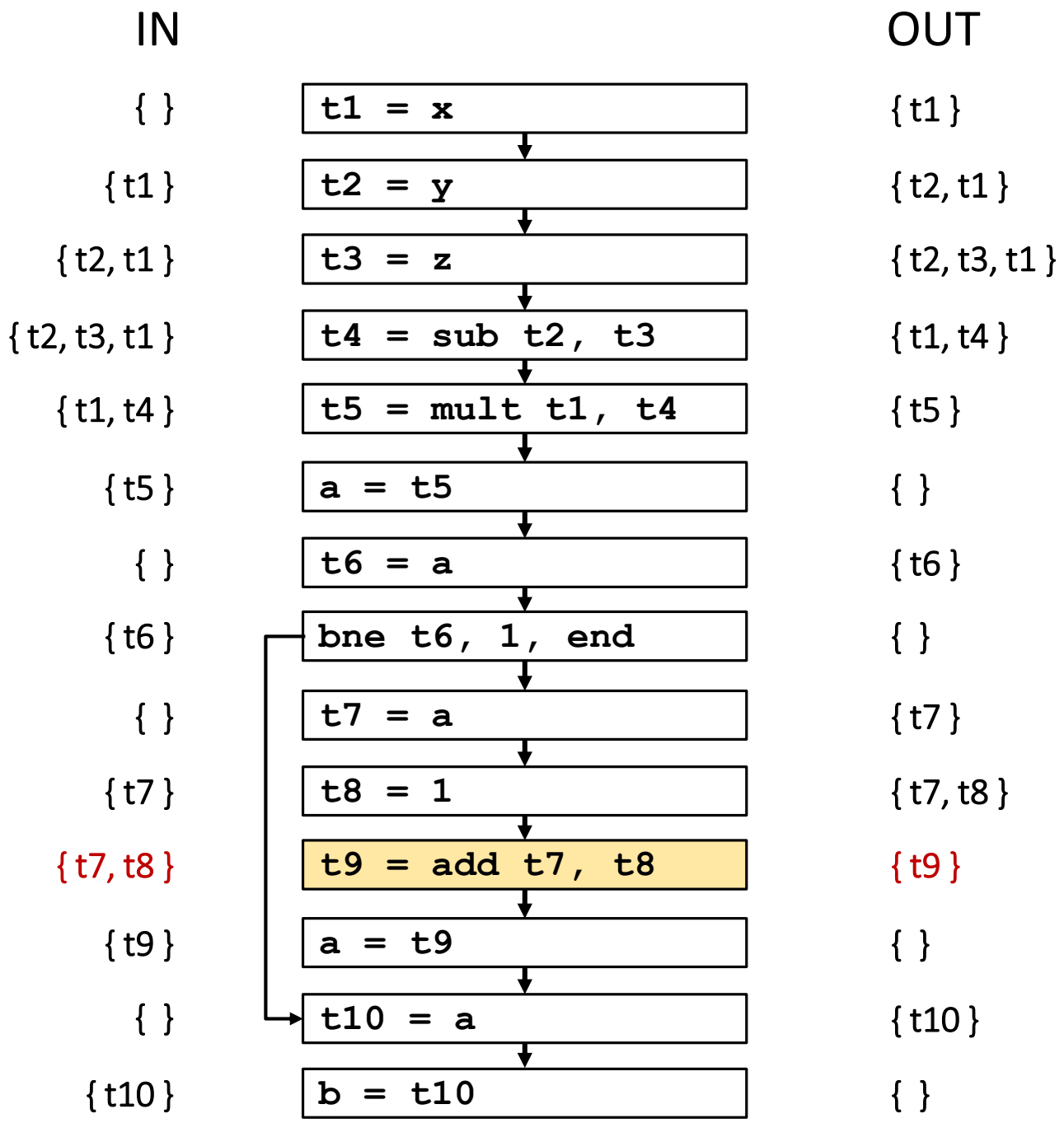
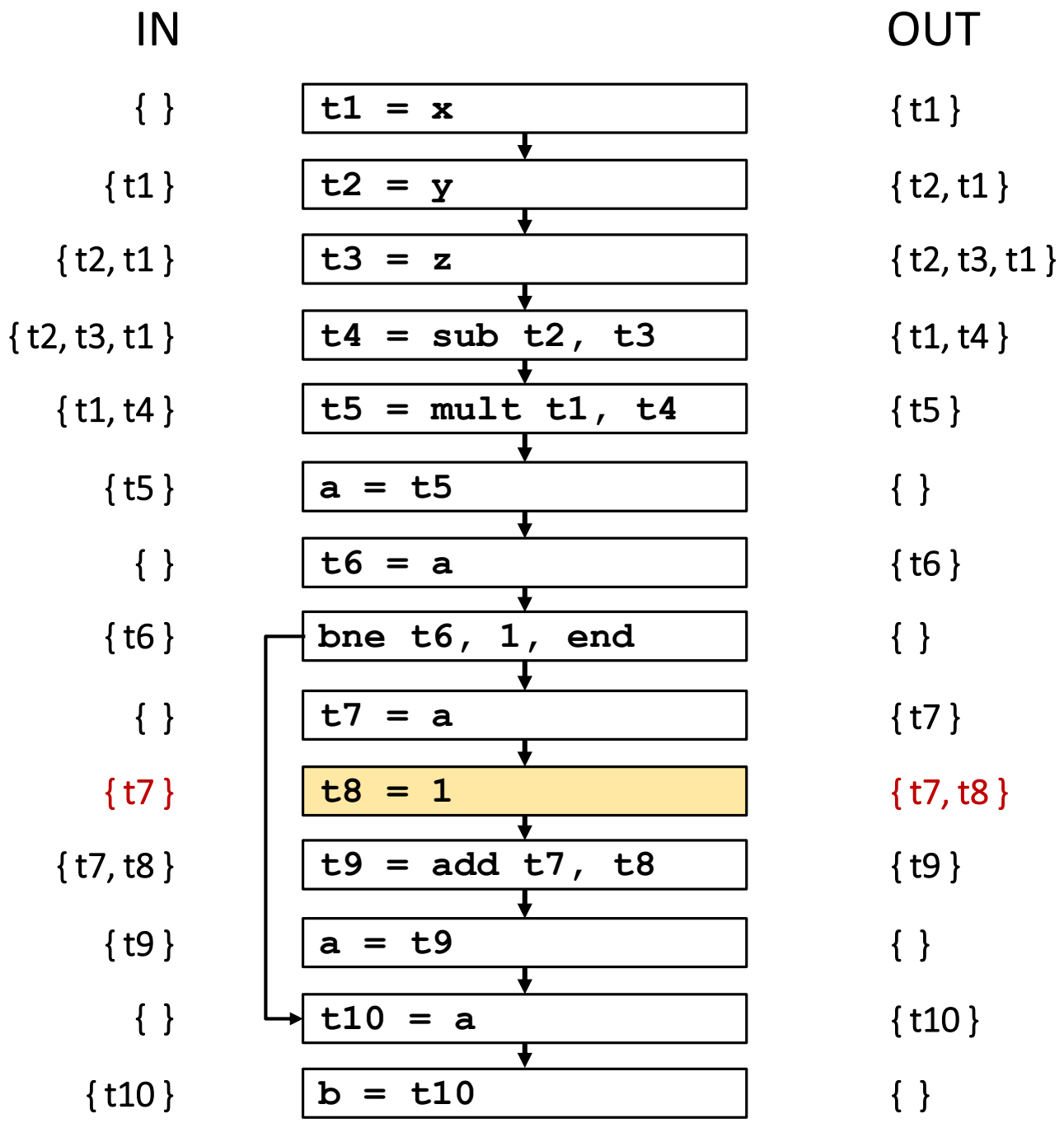
t2 = y
{ t2, t1 }
{ t2, t1 }
t3 = z
{ t2, t3, t1 }
{ t2, t3, t1 }
t4 = sub t2, t3
{ t1, t4 }
{ t1, t4 }
t5 = mult t1, t4
{ t5 }
{ t5 }
a = t5
{ }
{ }
t6 = a
{ t6 }
{ t6 }
bne t6, 1, end
{ }
{ }
t7 = a
{ t7 }
{ t7 }
t8 = 1
{ t7, t8 }
{ t7, t8 }
t9 = add t7, t8
{ t9 }
{ t9 }
a = t9
{ }
{ }
t10 = a
{ t10 }
{ t10 }
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
{t2, t3, t1}
t4 = sub t2, t3
{t1, t4}
{t1, t4}
t5 = mult t1, t4
{t5}
{t5}
a = t5
{ }
{ }
t6 = a
{t6}
{t6}
bne t6, 1, end
{ }
{ }
t7 = a
{t7}
{t7}
t8 = 1
{t7, t8}
{t7, t8}
t9 = add t7, t8
{t9}
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
{t2, t3, t1}
t4 = sub t2, t3
{t1, t4}
{t1, t4}
t5 = mult t1, t4
{t5}
{t5}
a = t5
{ }
{ }
t6 = a
{t6}
{t6}
bne t6, 1, end
{ }
{ }
t7 = a
{t7}
{t7}
t8 = 1
{t7, t8}
{t7, t8}
t9 = add t7, t8
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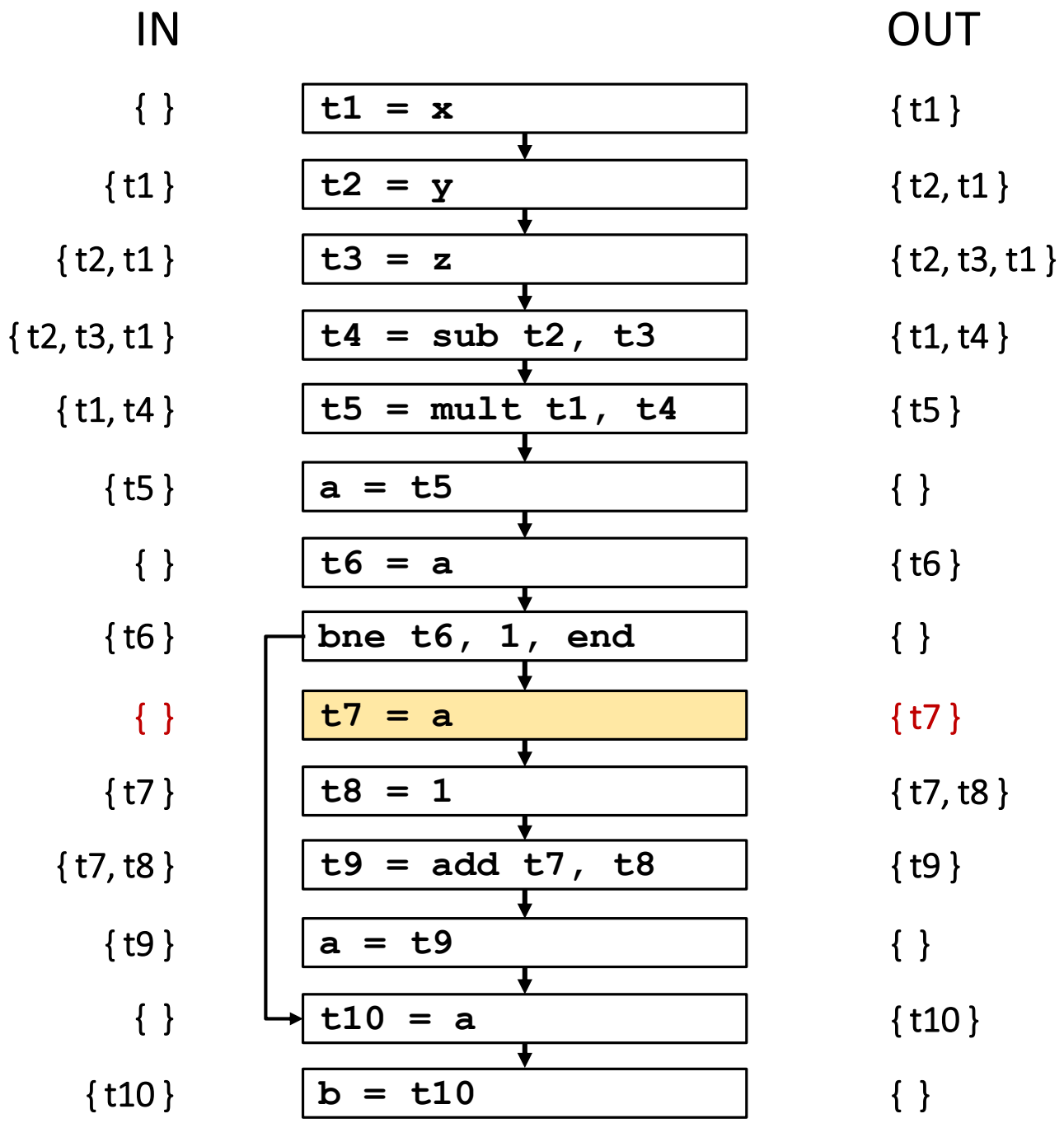
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
{t2, t3, t1}
t4 = sub t2, t3
{t1, t4}
{t1, t4}
t5 = mult t1, t4
{t5}
{t5}
a = t5
{ }
{ }
t6 = a
{t6}
{t6}
bne t6, 1, end
{ }
{ }
t7 = a
{t7}
{t7}
t8 = 1
{t7, t8}
{t7, t8}
t9 = add t7, t8
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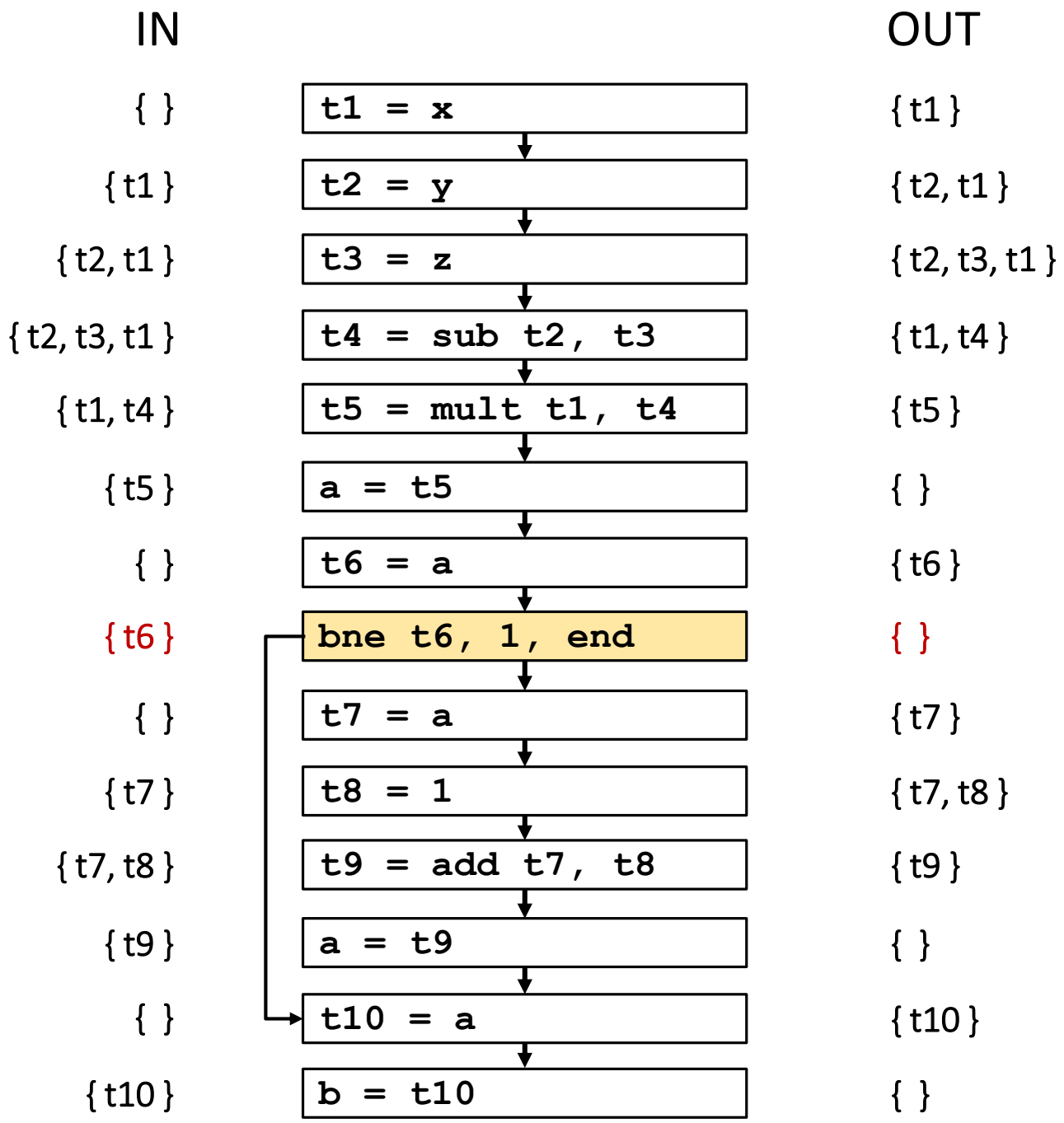
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{ t1 }
{ t1 }
t2 = y
{ t2, t1 }
{ t2, t1 }
t3 = z
{ t2, t3, t1 }
{ t2, t3, t1 }
t4 = sub t2, t3
{ t1, t4 }
{ t1, t4 }
t5 = mult t1, t4
{ t5 }
{ t5 }
a = t5
{ }
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t6 = a
{ t6 }
{ t6 }
bne t6, 1, end
{ }
{ }
t7 = a
{ t7 }
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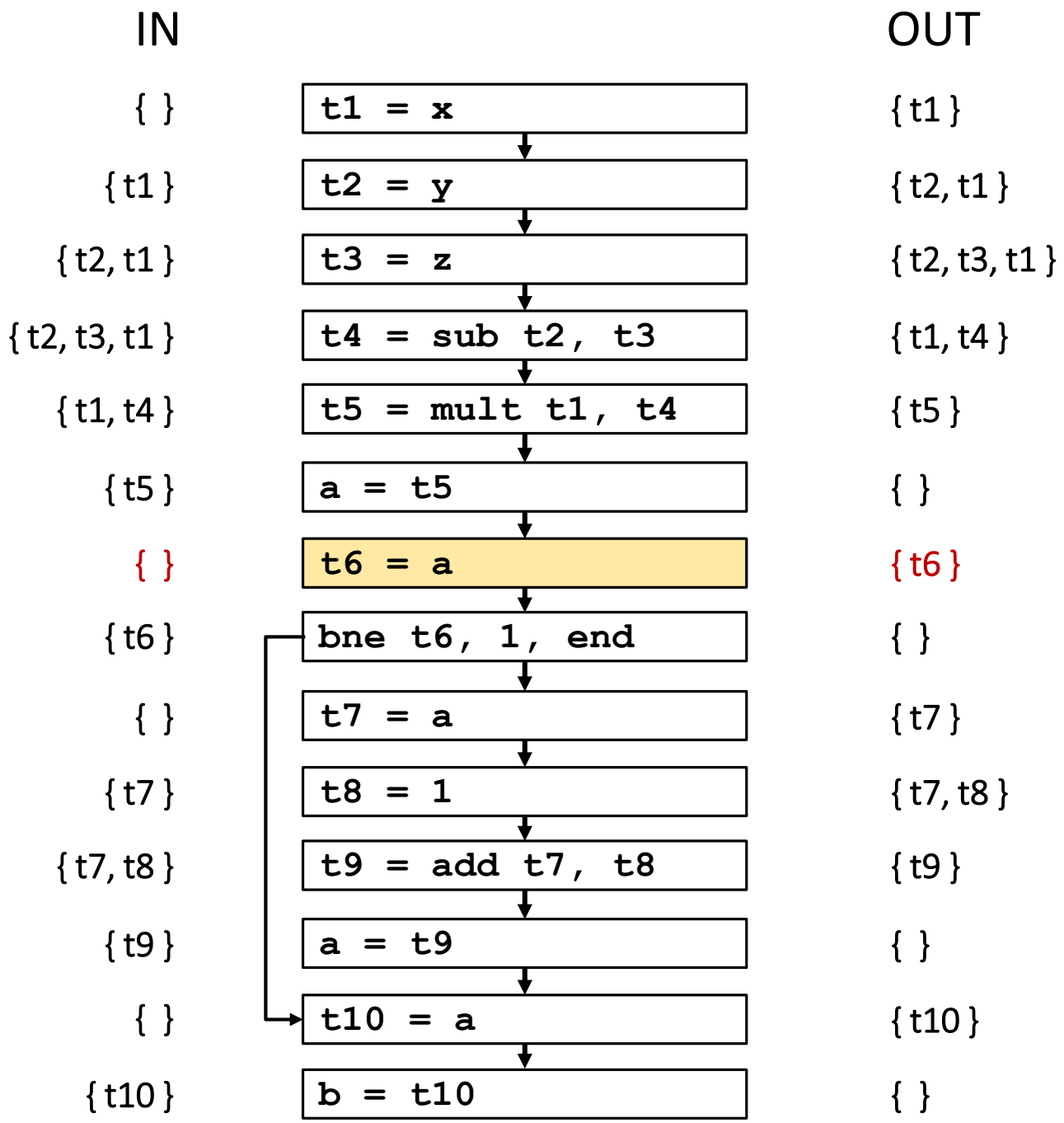
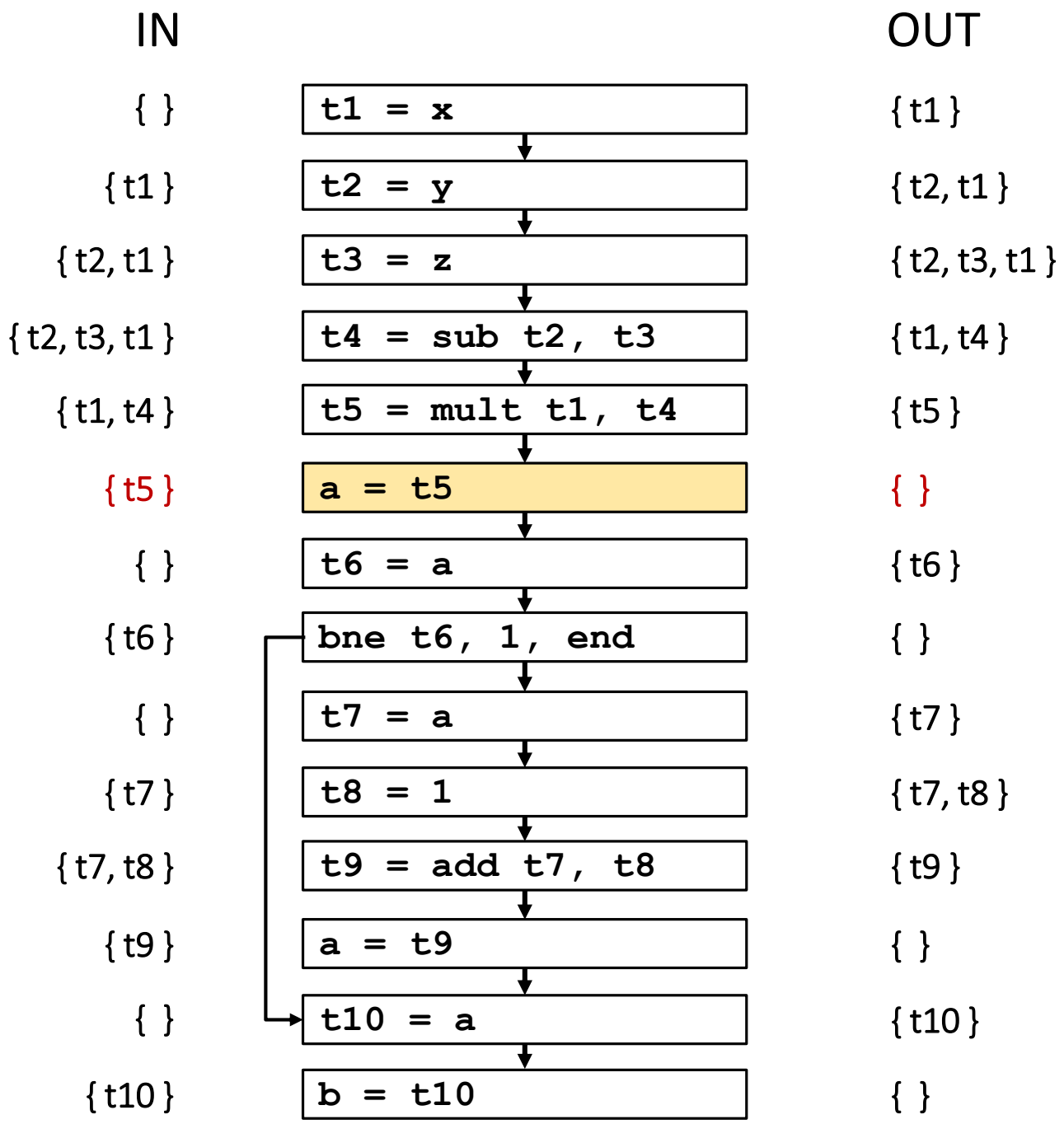
{ t7, t8 }
{ t7, t8 }
t9 = add t7, t8
{ t9 }
{ t9 }
a = t9
{ }
{ }
t10 = a
{ t10 }
{ t10 }
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
{t2, t3, t1}
t4 = sub t2, t3
{t1, t4}
{t1, t4}
t5 = mult t1, t4
{t5}
{t5}
a = t5
{ }
{ }
t6 = a
{t6}
{t6}
bne t6, 1, end
{ }
{ }
t7 = a
{t7}
{t7}
t8 = 1
{t7, t8}
{t7, t8}
t9 = add t7, t8
{t9}
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{ t1 }
{ t1 }
t2 = y
{ t2, t1 }
{ t2, t1 }
t3 = z
{ t2, t3, t1 }
{ t2, t3, t1 }
t4 = sub t2, t3
{ t1, t4 }
{ t1, t4 }
t5 = mult t1, t4
{ t5 }
{ t5 }
a = t5
{ }
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t6 = a
{ t6 }
{ t6 }
bne t6, 1, end
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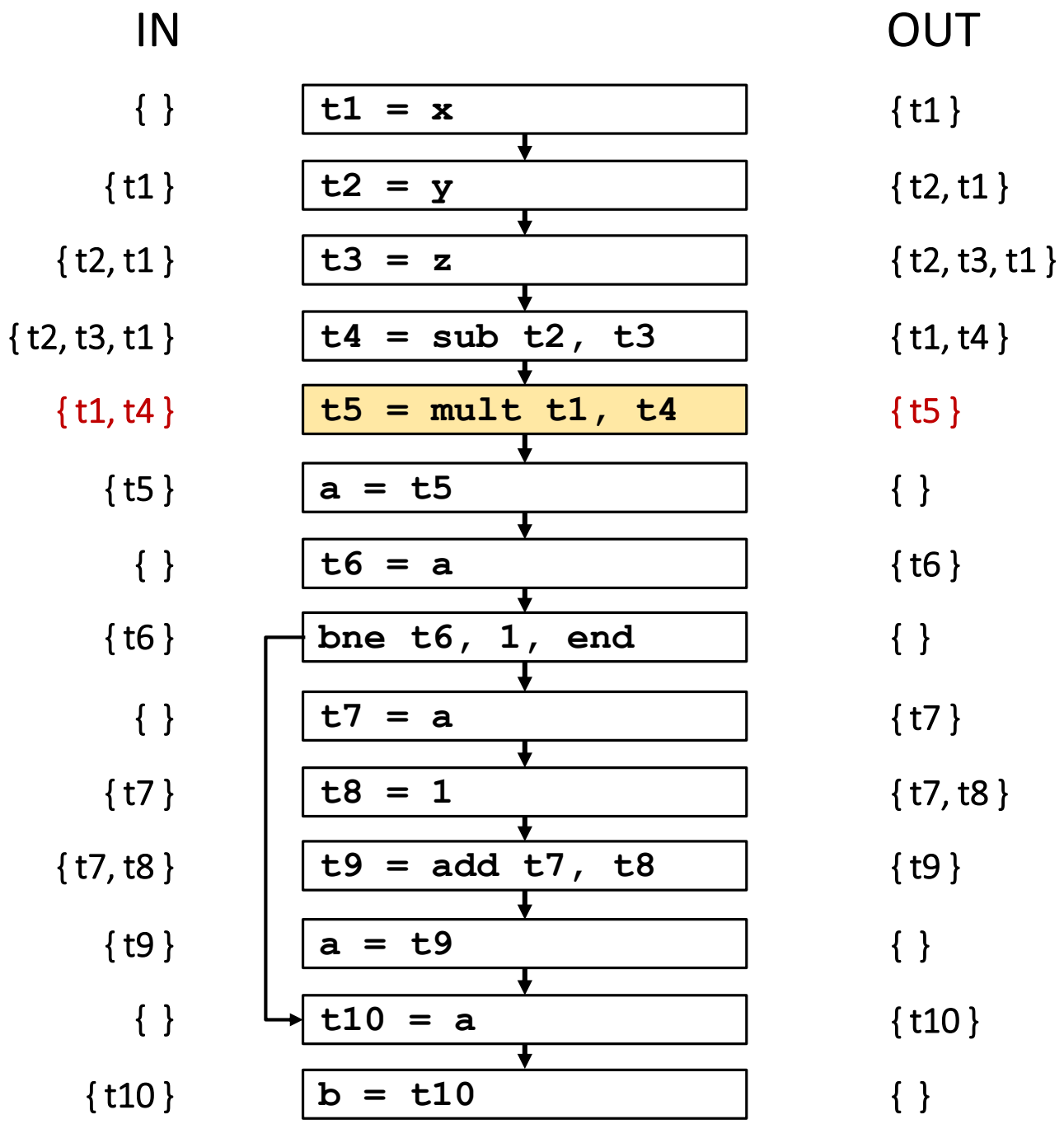
t7 = a
{ t7 }
{ t7 }
t8 = 1
{ t7, t8 }
{ t7, t8 }
t9 = add t7, t8
{ t9 }
{ t9 }
a = t9
{ }
{ }
t10 = a
{ t10 }
{ t10 }
b = t10
{ }


IN
OUT
{ }
t1 = x
{ t1 }
{ t1 }
t2 = y
{ t2, t1 }
{ t2, t1 }
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t7 = a
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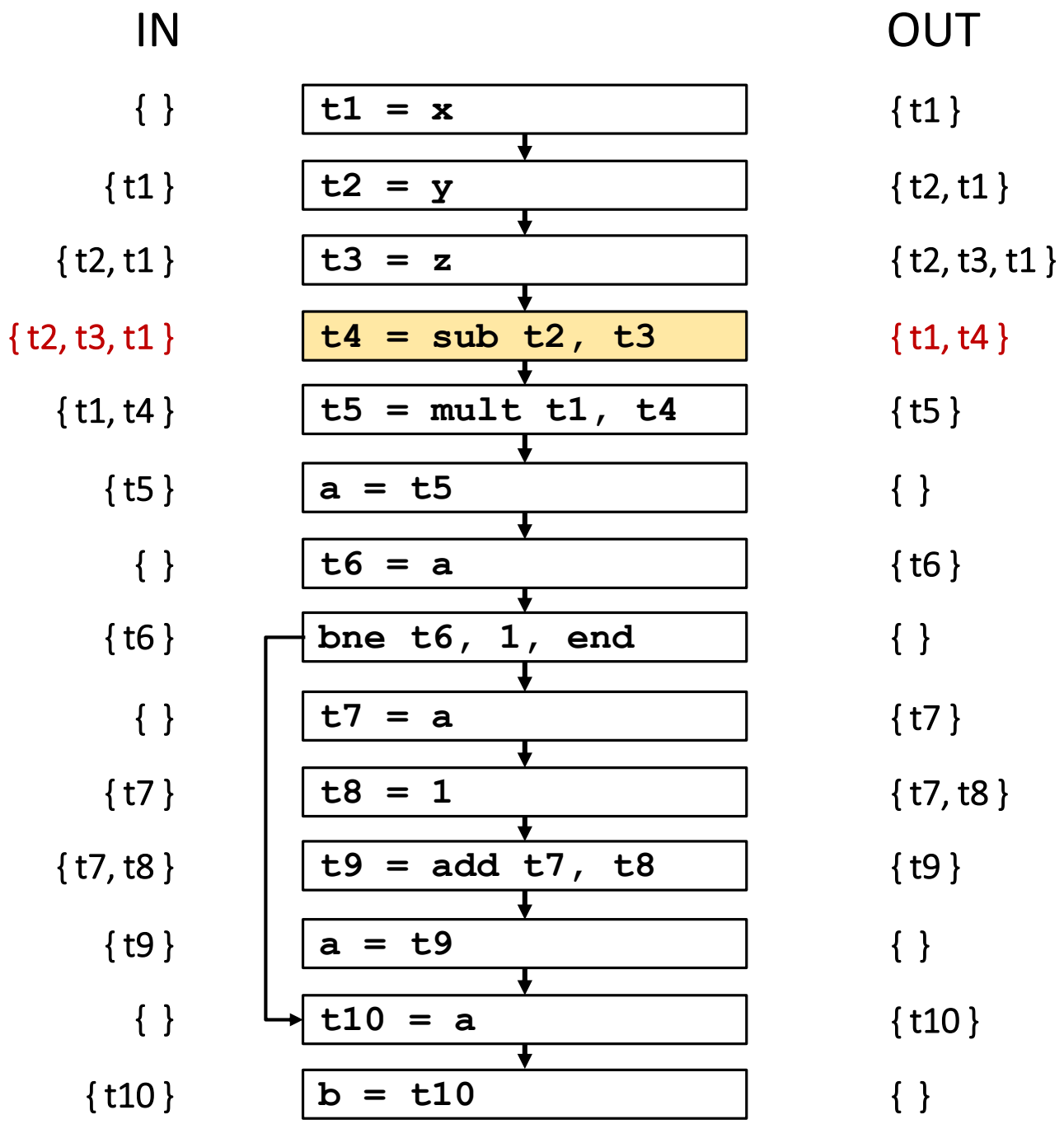
a = t9
{ }
{ }
t10 = a
{ t10 }
{ t10 }
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
{t2, t1}
{t2, t1}
t3 = z
{t2, t3, t1}
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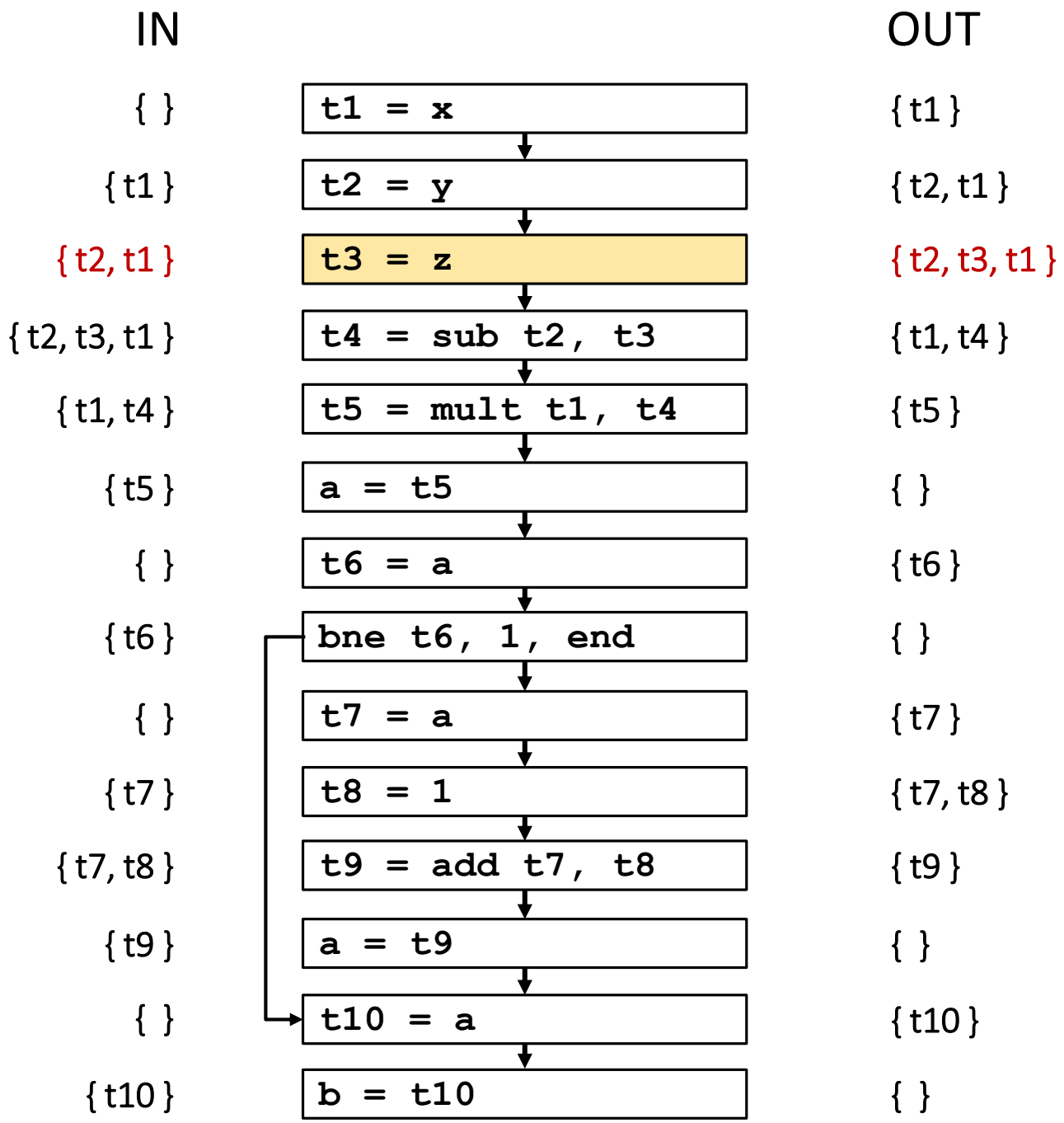
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{ t1 }
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t2 = y
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t3 = z
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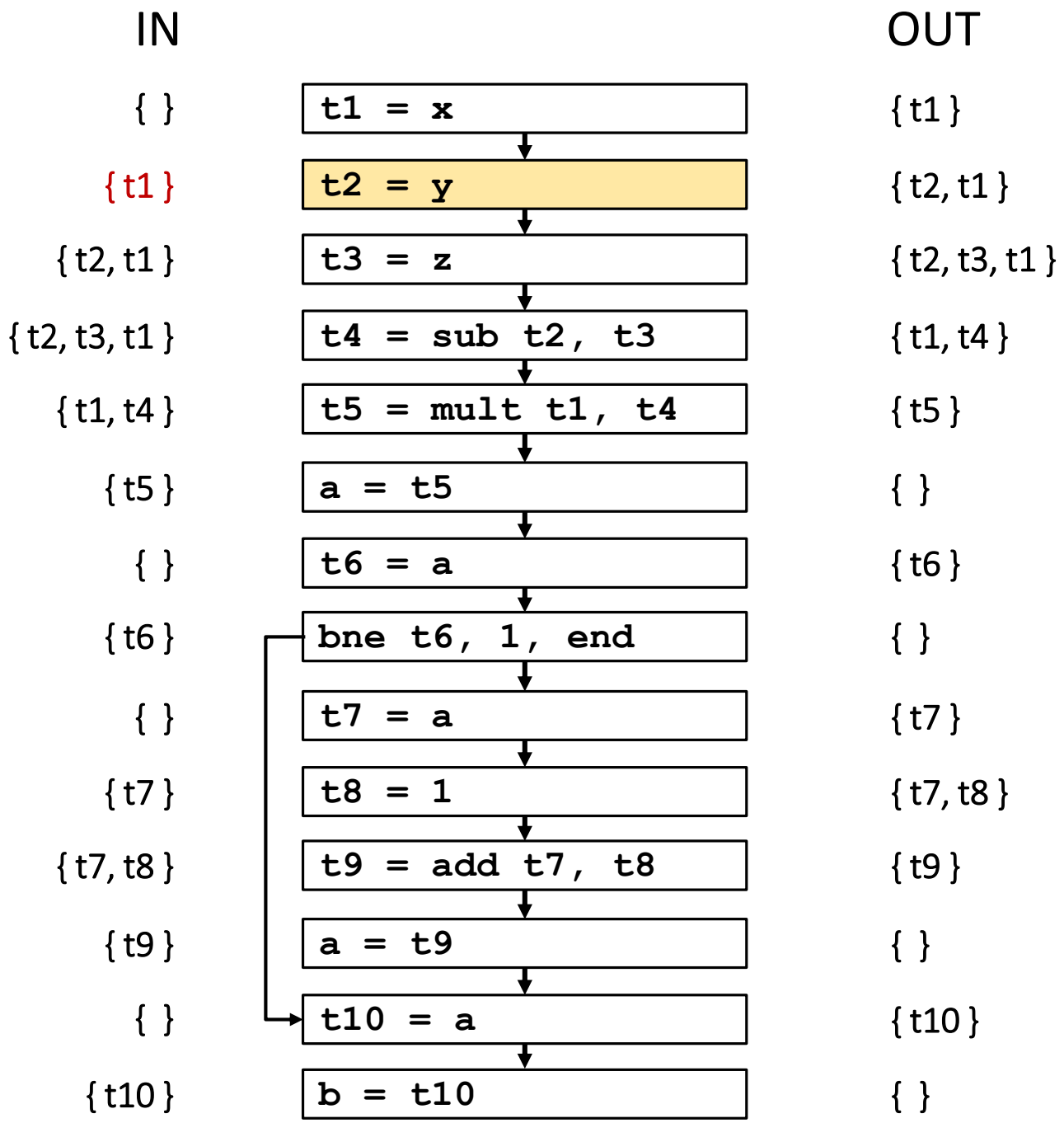
{t9}
a = t9
{ }
{ }
t10 = a
{ t10 }
{t10}
b = t10
{ }


IN
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{ }
t1 = x
{ t1 }
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t2 = y
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t10 = a
{ t10 }
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b = t10
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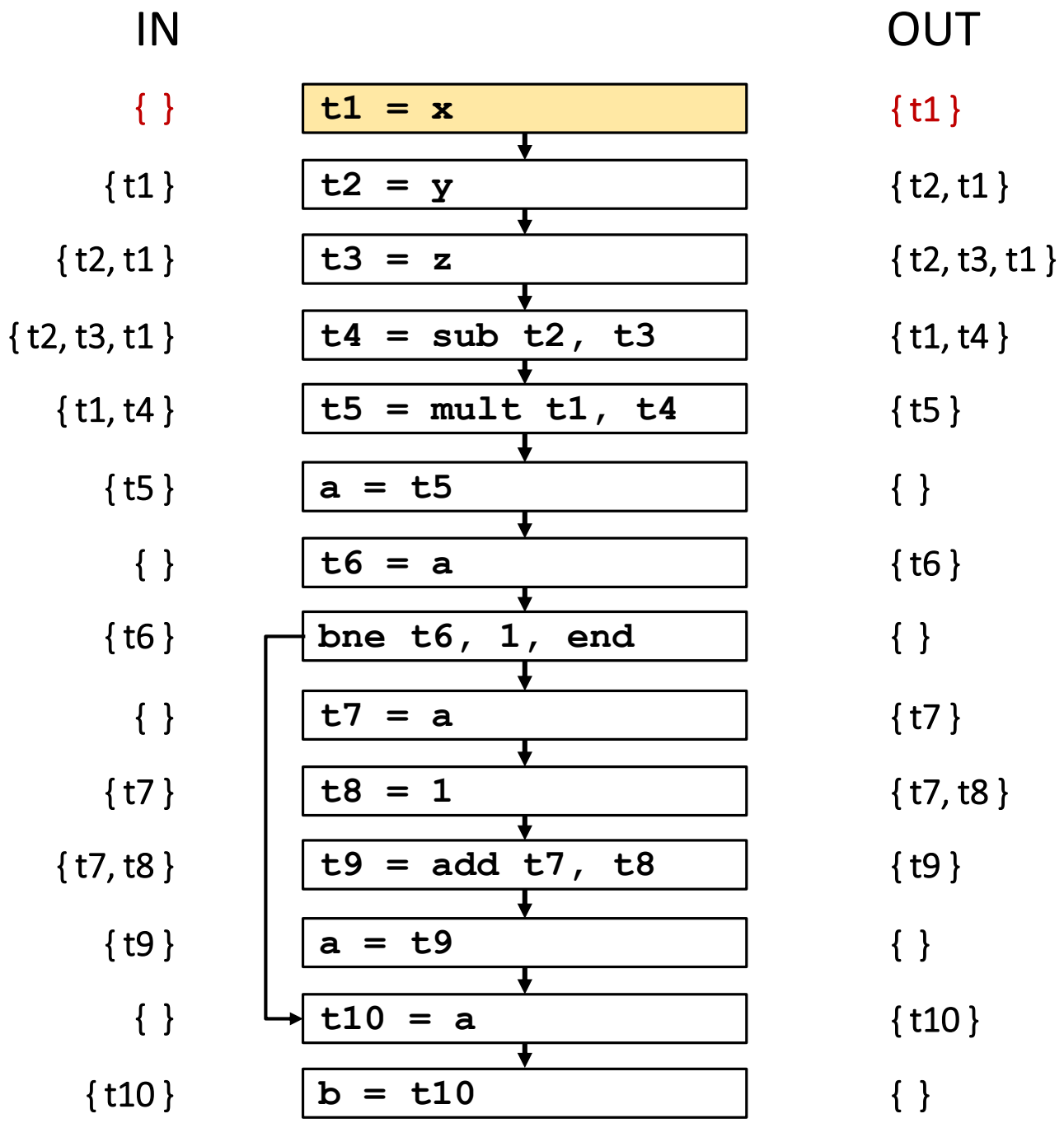
IN
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{ }
t1 = x
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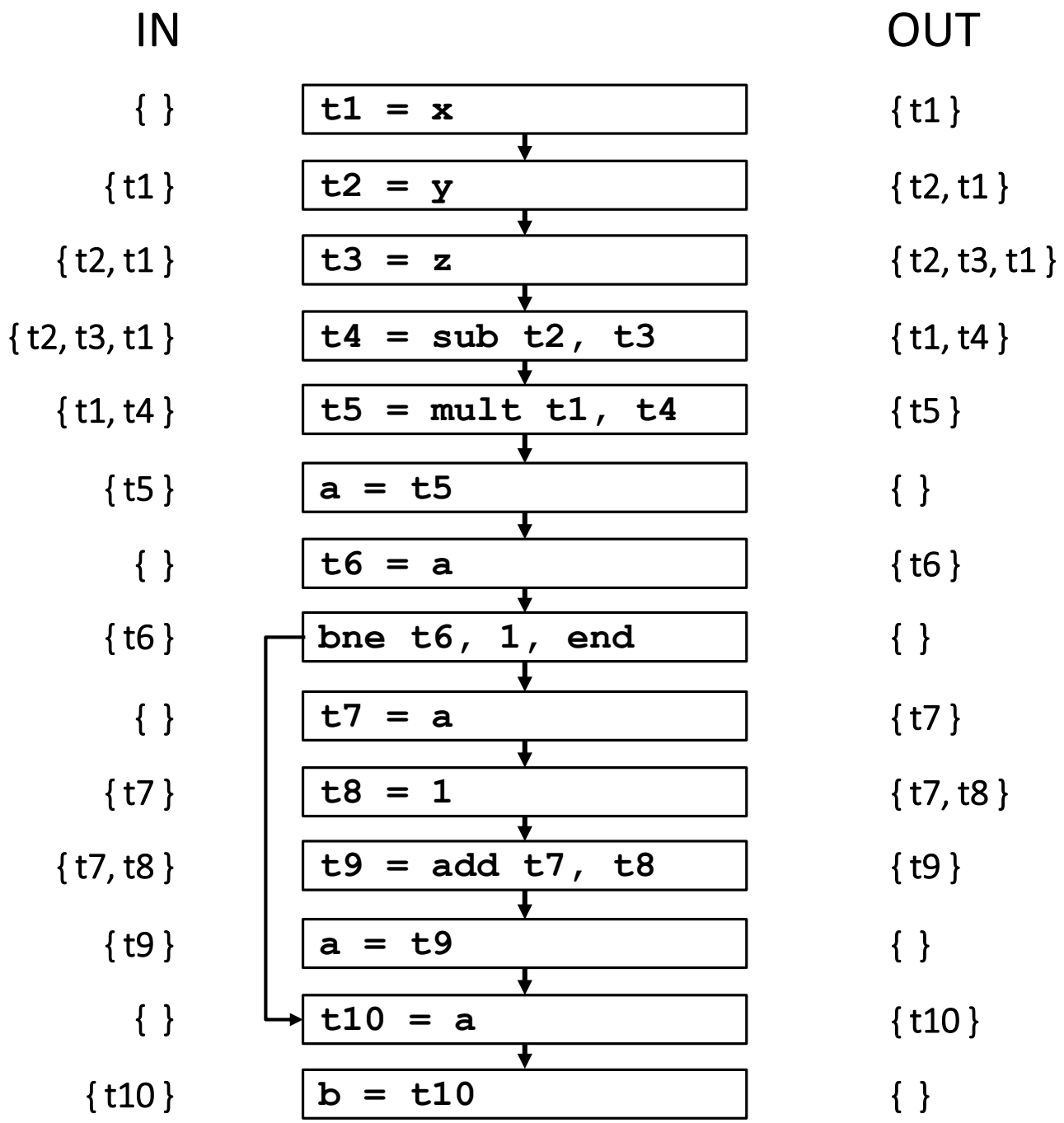
{t9}
a = t9
{ }
{ }
t10 = a
{t10}
{t10}
b = t10
{ }


IN
OUT
{ }
t1 = x
{t1}
{t1}
t2 = y
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{t2, t1}
t3 = z
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{ }
t10 = a
{t10}
{t10}
b = t10
{ }

Graph Coloring

- TODO