CS & IT Engineering

Compiler Design

Intermediate Code & Code Optimization

Deva sir

Lecture: 3

Topics to be covered:

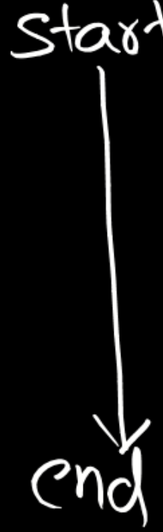
- Data Flow Analysis
  - Live variable Analysis
  - Reaching Definitions Analysis

Data Flow Analysis

- To analyze program
- To understand each variable
- Lattices can be used to analyze data
- Control Flow Graph can help to analyze data.

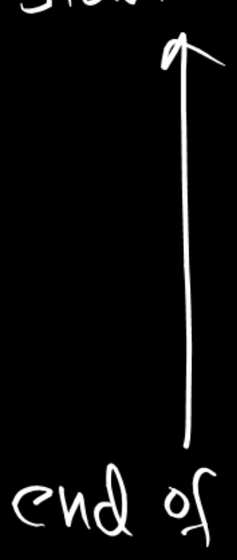
Data Flow Analysis

Forward Analysis



Example:
Reaching Definitions
Available Expressions Analysis

Backward Analysis



Example:
Live variables Analysis

Live variable Analysis [Liveness Analysis]:

- What is LIVE variable ? ✓
- How to compute Live variables at any statement ? ✓
- Backward Analysis:
  - Compute GEN(USE) & KILL(DEF) for each Basic Block.
  - Compute IN and OUT for each BB.

Live variable :

x is live valiable at statement S_i

iff

I) There exist statement S_j that reads x

II) There exist a path from S_i to S_j

III) There is no assignment into x before S_j

no write

no definition

Remember → Blind

↓

understand → Mind

↓

Apply → Mind + Heart

↓

Analyze → Time

↓

evaluate → cross check

↓

create → confidence

At Statement

(Just before statement)

$$\underbrace{x}_{\text{write}} = \underbrace{a}_{\text{read}} + \underbrace{b}_{\text{read}}$$

Find live variables at statement 1

1. $x = a + b$ — x, y, a ✓, b ✓, c ✓

$1 \to 1$ $\quad 1 \to 1$ $\quad 1 \to 2$ OR $1 \to 2 \to 3 \to 4$

2. $y = x * c$

3. $a = x + y$

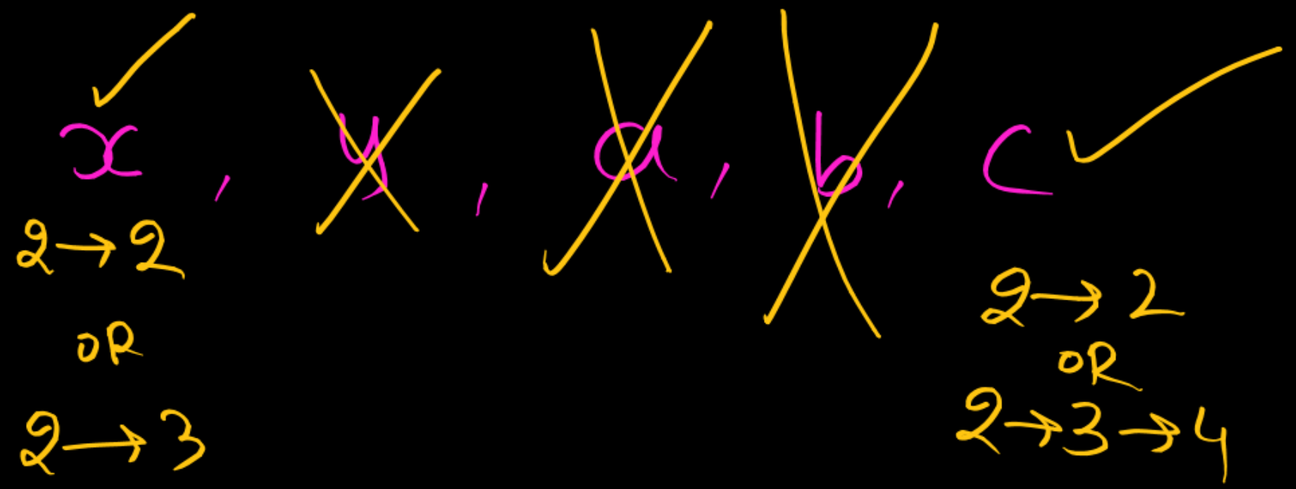
4. $b = a - c$

Why 'a' is live at 1 ?

$1 \longrightarrow 1$

Find live variables at statement 2

1. $x = a + b$
2. $y = x * c$
3. $a = x + y$
4. $b = a - c$



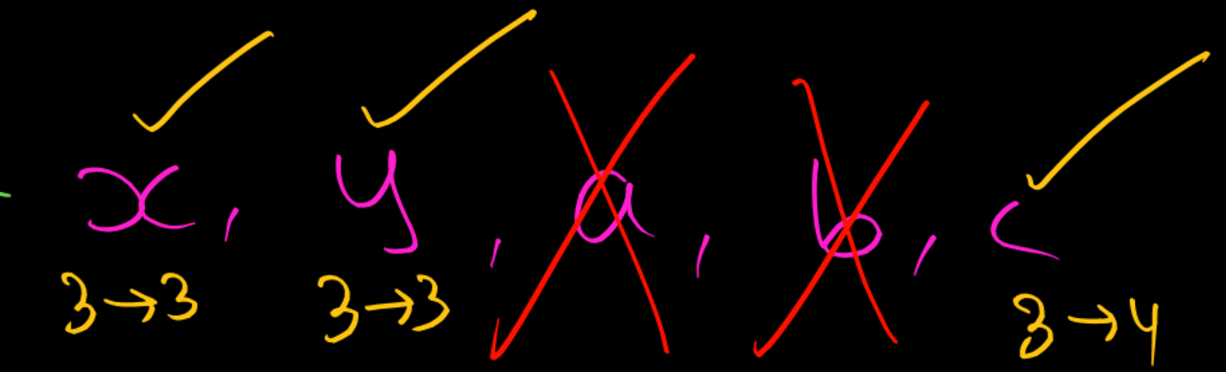
Find live variables at Statement 3

1. $x = a + b$

2. $y = x * c$

3. $a = x + y$

4. $b = a - c$



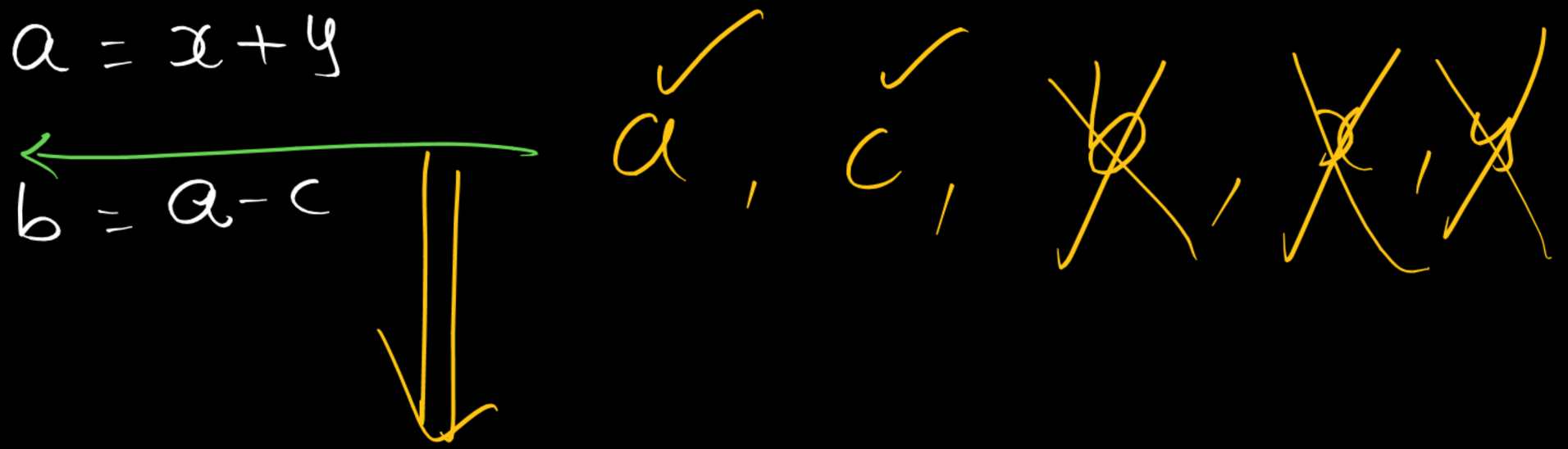
Find live variables at statement 4

1. $x = a + b$

2. $y = x * c$

3. $a = x + y$

4. $b = a - c$



1. a = a + b

2. b = a + b

3. c = b + a

At 1: a ✓ (1→1), b ✓ (1→1, 1→2), ✗

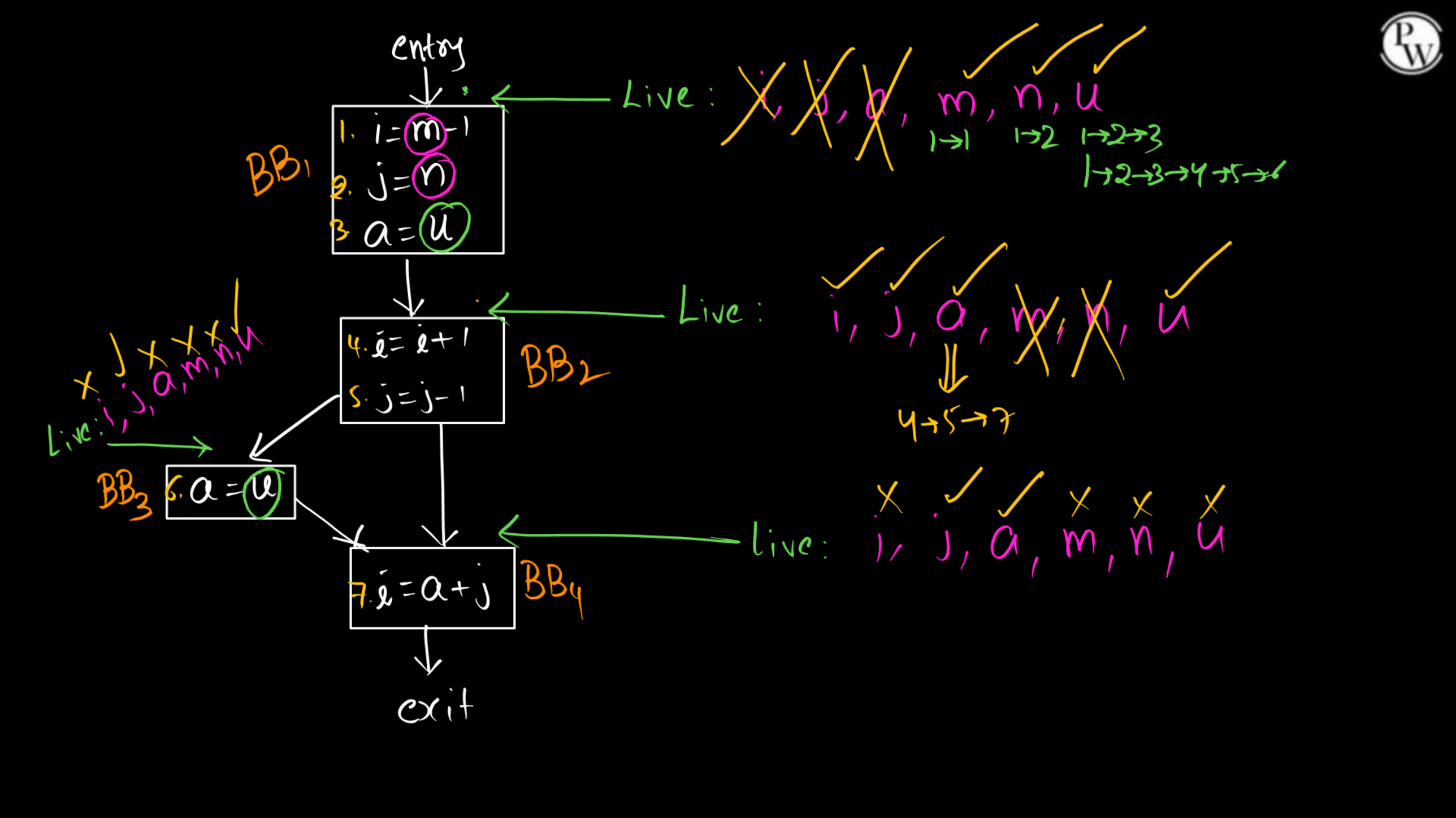
At 2: a ✓ (2→2, 2→3), b ✓ (2→2), ✗

At 3: a ✓ (3→3), b ✓ (3→3), ✗

$$a = a + b \Bigg\} \Longrightarrow$$

$$t_1 = \overset{read}{a} + b$$

$$\underset{write}{a} = t_1$$


entry
BB1
1. i = m - 1
2. j = n
3 a = u
Live : i, j, a, m, n, u
1→1 1→2 1→2→3
1→2→3→4→5→6
BB2
4. i = i + 1
5. j = j - 1
Live : i, j, a, m, n, u
4→5→7
BB3
6. a = u
Live : i, j, a, m, n, u
BB4
7. i = a + j
Live : i, j, a, m, n, u
exit

Summary

- Live variable ✓
- Finding Live variable at particular statement.

Next:

GEN & KILL Set for each BB

Backward Analysis { IN & OUT Set for each BB


Thank you
PW
Soldiers