

Number of Addresses in Machine Instructions

1. Instruction Formats Based on Address Count

- **Three-address instruction:**

$$\text{ADD } Z, X, Y \Rightarrow Z := X + Y$$

This instruction explicitly specifies two source operands and a destination.

- **Two-address instruction:**

$$\text{ADD } X, Y \Rightarrow X := X + Y$$

One operand acts as both source and destination. Fewer operands than the three-address format.

- **One-address instruction:**

$$\text{ADD } X \Rightarrow \text{AC} := \text{AC} + X$$

Uses an implicit accumulator (AC). Operations are always between AC and memory.

2. Expression to Evaluate

We evaluate the following arithmetic expression using different machine formats:

$$X := C \times C + A \times B$$

3. One-Address Machine (Using Accumulator)

```
LOAD A  AC := A
MULTIPLY B  AC := AC × B
STORE T  M(T) := AC  (store intermediate result)
LOAD C  AC := C
MULTIPLY C  AC := C × C
ADD T  AC := AC + T
STORE X  M(X) := AC
```

Explanation:

First computes $A \times B$, stores it in temporary memory T . Then computes $C \times C$, adds T , and stores result in X .

4. Two-Address Machine

MOVE T, A $T := A$
MULTIPLY T, B $T := T \times B$
MOVE X, C $X := C$
MULTIPLY X, C $X := X \times C$
ADD X, T $X := X + T$

Explanation:

Here, each instruction modifies the first operand. Intermediate value $T := A \times B$ is added to $X := C \times C$.

5. Three-Address Machine

MULTIPLY T, A, B $T := A \times B$
MULTIPLY X, C, C $X := C \times C$
ADD X, X, T $X := X + T$

Explanation:

All three operands are explicitly mentioned: destination and two sources. No need for intermediate loads/stores.

6. Summary Comparison Table

| Feature | One-Address Machine | Two-Address Machine | Three-Address Machine |
|---|----------------------------|---------------------|----------------------------------|
| Number of operands per instruction | 1 (with accumulator) | 2 (one destination) | 3 (two source + one destination) |
| Requires accumulator | Yes | No | No |
| Temporary variables needed | Yes (e.g., T) | Yes (T, X) | Optional (T, X) |
| Instruction count for complex expressions | High | Moderate | Low |
| Clarity and simplicity | Less clear, verbose | Moderate | Most readable |
| Efficiency | Lower (more memory access) | Medium | High (fewer steps) |