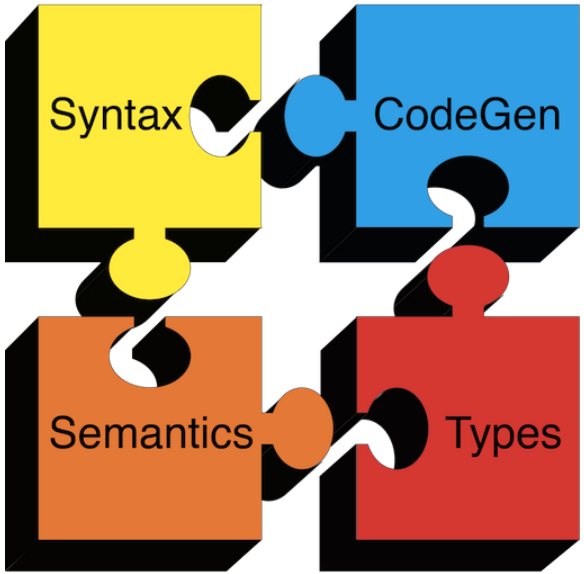
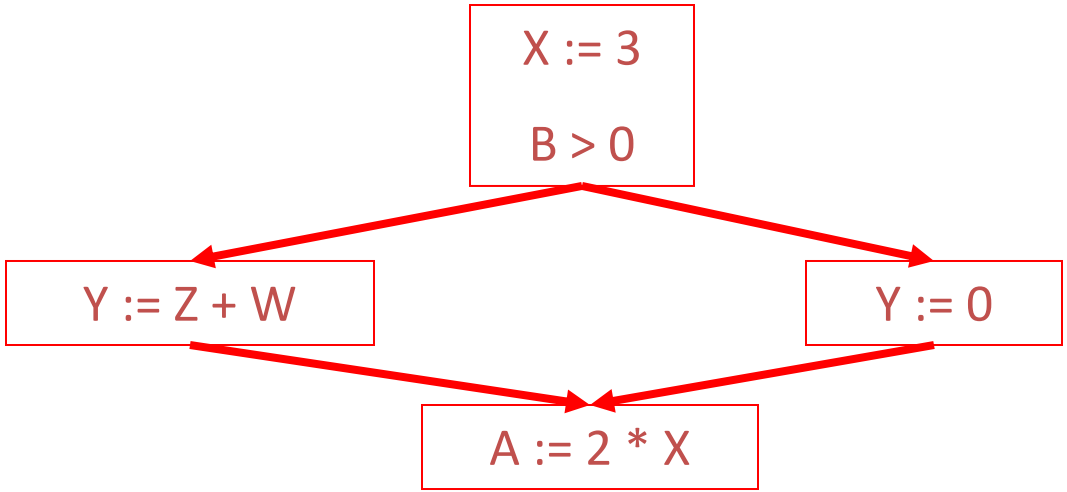


Compilers

Liveness Analysis

Liveness Analysis

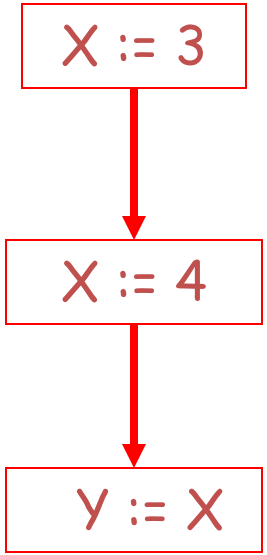
Once constants have been globally propagated, we would like to eliminate dead code



After constant propagation, X := 3 is dead (assuming X not used elsewhere)

Liveness Analysis

- The first value of x is *dead* (never used)
- The second value of x is *live* (may be used)
- Liveness is an important concept



Liveness Analysis

A variable x is live at statement s if

- There exists a statement s' that uses x
- There is a path from s to s'
- That path has no intervening assignment to x

Liveness Analysis

- A statement x := … is dead code if x is dead after the assignment
- Dead statements can be deleted from the program
- But we need liveness information first . . .

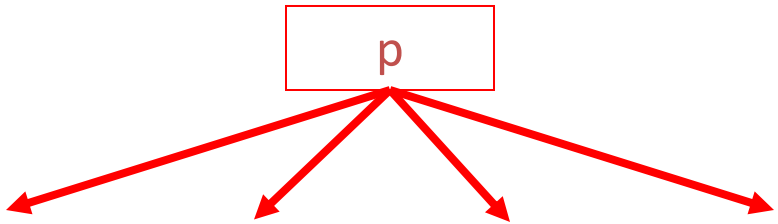
Liveness Analysis

- We can express liveness in terms of information transferred between adjacent statements, just as in copy propagation

- Liveness is simpler than constant propagation, since it is a boolean property (true or false)

Liveness Analysis

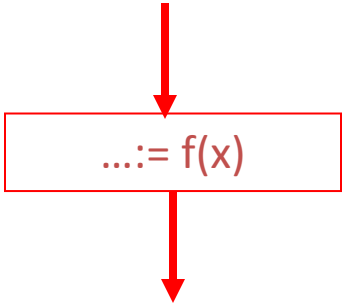
Rule 1



$$L(p, x, out) = \vee \{ L(s, x, in) \mid s \text{ a successor of } p \}$$

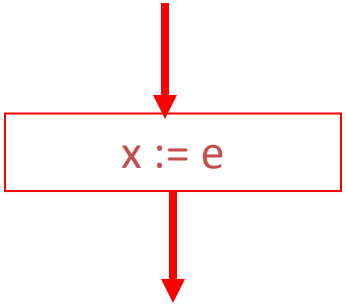
Liveness Analysis

Rule 2



L(s, x, in) = true if s refers to x on the rhs

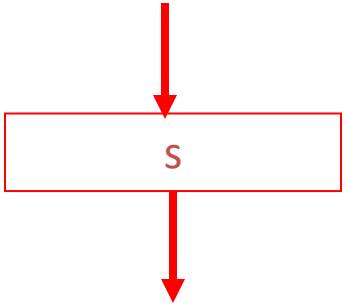
Rule 3



L(x := e, x, in) = false if e does not refer to x

Liveness Analysis

Rule 4



L(s, x, in) = L(s, x, out) if s does not refer to x

Liveness Analysis

1. Let all L(…) = false initially

2. Repeat until all statements s satisfy rules 1-4

   Pick s where one of 1-4 does not hold and update using the appropriate rule

Liveness Analysis

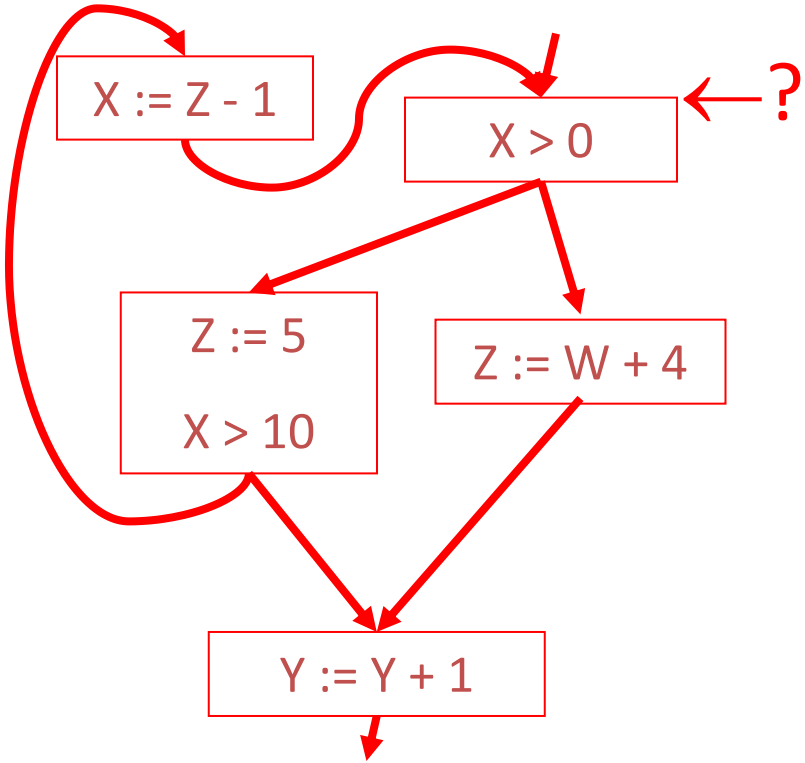
Liveness Analysis

- A value can change from false to true, but not the other way around
- Each value can change only once, so termination is guaranteed
- Once the analysis is computed, it is simple to eliminate dead code

Liveness Analysis

After running the liveness analysis algorithm to completion, which of W, X, Y, and Z are live at the program point labeled at right? Assume all variables are dead on exit.

- ☐ W
- ☐ X
- ☐ Y
- ☐ Z



Liveness Analysis

We've seen two kinds of analysis:

Constant propagation is a *forwards* analysis:
information is pushed from inputs to outputs

Liveness is a *backwards* analysis: information is pushed from outputs back towards inputs

Liveness Analysis

- There are many other global flow analyses
- Most can be classified as either forward or backward
- Most also follow the methodology of local rules relating information between adjacent program points