Machine-independent Optimization

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Loop-invariant code detection

Repeat {
Mark as "invariant" all those statements not previously so marked, all of whose operands are constants, or have all their reaching definitions outside L, or have exactly one reaching definition, and that definition is a statement in L marked "invariant"
} until no new statement are marked "invariant"

Loop-invariant code motion algorithm

1. Find loop-invariant statements
2. For each statement s defining x found in step (1), check that
   2.1 It is in a block that dominates all exits of L

       — A node d of a flow graph dominates a node n, if every path from the entry node to n goes through d

   2.2 x is not defined elsewhere in L
   2.3 all uses in L of x only be reached by the definition x in s
3. Move each statement s found in step (1) and satisfying conditions of step (2) to a newly created preheader
   3.1 provided any operands of s that are defined in loop L have previously had their definition statements moved to the preheader

Loop-invariant code motion

$$\begin{array}{l} \textit{while } c \; \{ \\ \qquad S; \\ \} \end{array} \qquad\qquad \begin{array}{l} \textit{if } \; c\{ \\ \;\; \textit{repeat} \\ \qquad\quad S; \\ \;\; \textit{until } \; \textit{not } \; c \\ \} \end{array}$$

- Loop-invariant expression can be placed just prior to repeat-until construct

Copy propagation

- The idea behind copy propagation transformation is to use v for u, whenever possible after the copy statement $u = v$

$$\begin{array}{l} x = t3 \\ a[t2] = t5 \\ a[t4] = x \end{array} \longrightarrow \begin{array}{l} x = t3 \\ a[t2] = t5 \\ a[t4] = t3 \end{array}$$

Induction variable strength reduction

- A variable x is said to be an "induction variable" if there is a positive or negative constant c such that each time x is assigned, the value increases by c
- The transformation of replacing an expensive operation, such as multiplication, by a cheaper one, such as addition, is known as *strength reduction*
- Often it is possible to eliminate all but one of a group of induction variables

Induction variable strength reduction