PRINCIPAL SOURCES OF OPTIMAZATION

Presented by
S.Sivasathya
BP150510

INTRODUCTION

- The code produced by the straight forward compiling algorithms can often be made to run faster or take less space, or both.

This improvement is achieved by program transformations that are traditionally called optimizations.

Compilers that apply code-improving transformations are called optimizing compilers.

- Optimizations are classified into two categories.
- Machine independent optimizations:
- Machine dependant optimizations:

Machine independent optimizations:

- Machine independent optimizations are program transformations that improve the target code
- without taking into consideration any properties of the target machine.

Machine dependant optimizations:

- Machine dependant optimizations are based on register allocation and utilization of special.
- machine-instruction sequences.

The criteria for code improvement transformations:

- Simply stated, the best program transformations are those that yield the most benefit for the least effort.
- Flow analysis is a fundamental prerequisite for many important types of code improvement.

CONT……

- Generally control flow analysis precedes data flow analysis.
- Control flow analysis (CFA) represents flow of control usually in form of graphs, CFA
- constructs such as

  control flow graph

  Call graph
- Data flow analysis (DFA) is the process of ascerting and collecting information prior to program execution about the possible modification, preservation, and use of certain entities (such as values or attributes of variables) in a computer program.

PRINCIPAL SOURCES OF OPTIMIZATION

- A transformation of a program is called local if it can be performed by looking only at the statements in a basic block; otherwise, it is called global.

- Many transformations can be performed at both the local and global levels. Local transformations are usually performed first.

Function-Preserving Transformations

- There are a number of ways in which a compiler can improve a program without changing the function it computes.

Cont……

The transformations:

- Common sub expression elimination,
- Copy propagation,
- Dead-code elimination, and
- Constant folding
- are common examples of such function-preserving transformations.
- The other transformations come up primarily when global optimizations are performed.
- Frequently, a program will include several calculations of the same value, such as an offset in an array. Some of the duplicate calculations cannot be avoided by the programmer because they lie below the level of detail accessible within the source language.

Common Sub expressions elimination:

- An occurrence of an expression E is called a common sub-expression if E was previously computed, and the values of variables in E have not changed since the previous computation. We can avoid recomputing the expression if we can use the previously computed value.
- For example
- t1: = 4*i
- t2: = a [t1]
- t3: = 4*j
- t4: = 4*i
- t5: = n
- t6: = b [t4] +t5

CONT.....

- The above code can be optimized using the common sub-expression elimination as
- t1: = 4*i
- t2: = a [t1]
- t3: = 4*j
- t5: = n
- t6: = b [t1] +t5
- The common sub expression t4: =4*i is eliminated as its computation is already in t1. And value of i is not been changed from definition to use.

Copy Propagation:

- Assignments of the form f : = g called copy statements, or copies for short.
- The idea behind the copy-propagation transformation is to use g for f, whenever possible after the copy statement f: = g.
- Copy propagation means use of one variable instead of another.
- This may not appear to be an improvement, but as we shall see it gives us an opportunity to eliminate x.

Cont.....

For example:

- x=Pi;
- ……
- A=x*r*r;
- The optimization using copy propagation can be done as follows:
- A=Pi*r*r;
- Here the variable x is eliminated

Dead-Code Eliminations:

- A variable is live at a point in a program if its value can be used subsequently; otherwise, it is dead at that point.
- A related idea is dead or useless code, statements that compute values that never get used.
- While the programmer is unlikely to introduce any dead code intentionally ,it may appear as the result of previous transformations.

An optimization can be done by eliminating dead code.

- Example:
- i=0;
- if(i=1)
- {
- a=b+5;
- }

CONT.….

- Here, ‘if’ statement is dead code because this condition will never get satisfied.
- We can eliminate both the test and printing from the object code. More generally,
- deducing at compile time that the value of an expression is a constant and using the
- constant instead is known as **constant folding**.
- One advantage of copy propagation is that it often turns the copy statement into dead
- code.
- For example,
- a=3.14157/2 can be replaced by
- a=1.570 there by eliminating a division operation.

Loop Optimizations:

- We now give a brief introduction to a very important place for optimizations, namely loops, especially the inner loops where programs tend to spend the bulk of their time.
- The running time of a program may be improved if we decrease the number of instructions in an inner loop, even if we increase the amount of code outside that loop.
- Three techniques are important for loop optimization:
- **code motion**, which moves code outside a loop;
- **Induction-variable elimination**, which we apply to replace variables from inner loop.
- **Reduction in strength**, which replaces and expensive operation by a cheaper one, such as a multiplication by an addition.

Code Motion:

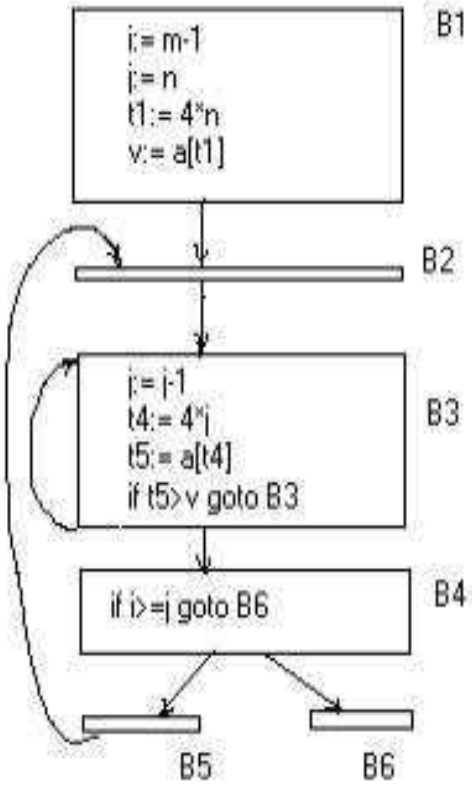
- An important modification that decreases the amount of code in a loop is code motion.
- This transformation takes an expression that yields the same result independent of the number of times a loop is executed (a loop-invariant computation) and places the expression before the loop.
- Note that the notion “before the loop” assumes the existence of an entry for the loop.
- For example, evaluation of limit-2 is a loop-invariant computation in the following while-statement:
- **while (i <= limit-2) /* statement does not change limit*/**
- Code motion will result in the equivalent of
- **t= limit-2;**
- **while (i<=t) /* statement does not change limit or t */**

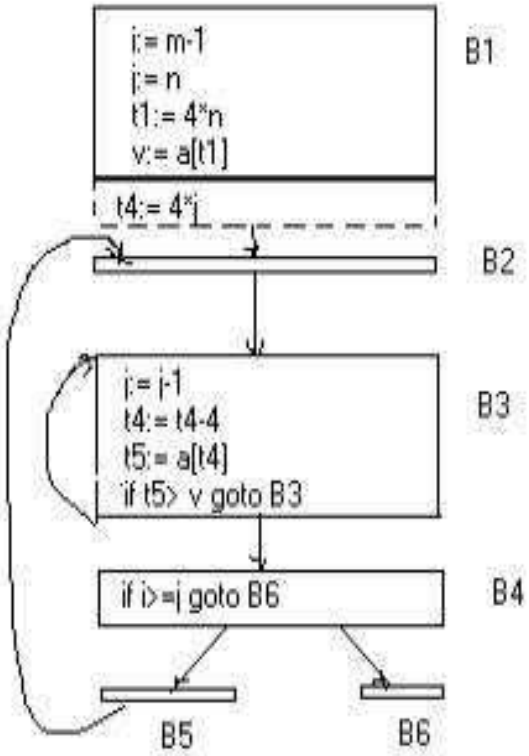
Induction Variables :

- Loops are usually processed inside out. For example consider the loop around B3.
- Note that the values of j and t4 remain in lock-step; every time the value of j decreases by 1, that of t4 decreases by 4 because 4*j is assigned to t4. Such identifiers are called induction variables.
- When there are two or more induction variables in a loop, it may be possible to get rid of all but one, by the process of induction-variable elimination. For the inner loop around B3 in Fig. we cannot get rid of either j or t4 completely; t4 is used in B3 and j in B4.
- However, we can illustrate reduction in strength and illustrate a part of the process of induction-variable elimination.
- Eventually j will be eliminated when the outer loop of B2- B5 is considered.

Example:

- As the relationship t4:=4*j surely holds after such an assignment to t4 in Fig. and t4 is not changed elsewhere in the inner loop around B3, it follows that just after the statement j:=j-1 the relationship t4:= 4*j-4 must hold.
- We may therefore replace the assignment t4:=4*j by t4:= t4-4. The only problem is that t4 does not have a value when we enter block B3 for the first time.
- Since we must maintain the relationship t4=4*j on entry to the block B3, we place an initializations of t4 at the end of the block where j itself is The replacement of a multiplication by a subtraction will speed up the object code if multiplication takes more time than addition or subtraction, as is the case on many machines.


i:= m-1
j:= n
t1:= 4*n
v:= a[t1]
B1
B2
j:= j-1
t4:= 4*j
t5:= a[t4]
if t5>v goto B3
B3
if i>=j goto B6
B4
B5
B6


i:= m-1
j:= n
t1:= 4*n
v:= a[t1]
B1
t4:= 4*j
B2
j:= j-1
t4:= t4-4
t5:= a[t4]
if t5> v goto B3
B3
if i>=j goto B6
B4
B5
B6

Thank You