

CS738: Advanced Compiler Optimizations

Overview of Optimizations

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Recap

► Optimizations

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- ▶ Optimizations
 - ▶ To improve efficiency of generated executable (time, space, resources, ...)

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 - ▶ Maintain semantic equivalence
- ▶ Two levels
 - ▶ Machine Independent
 - ▶ Machine Dependent

Machine Independent Code Optimizations

Machine Independent Optimizations

- ▶ Scope of optimizations

Machine Independent Optimizations

- ▶ Scope of optimizations
 - ▶ Intraprocedural

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- ▶ Simplify global/interprocedural optimizations

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 - ▶ Time consuming

A Catalog of Code Optimizations

Compile-time Evaluation

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- ▶ **When should we NOT apply it?**

Compile-time Evaluation

- ▶ Constant Propagation
 - ▶ Replace a variable by its “constant” value

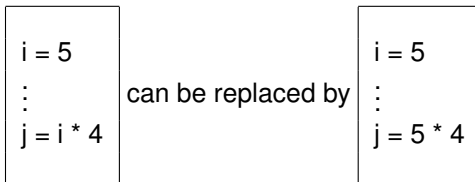
```
i = 5
```

```
⋮
```

```
j = i * 4
```

Compile-time Evaluation

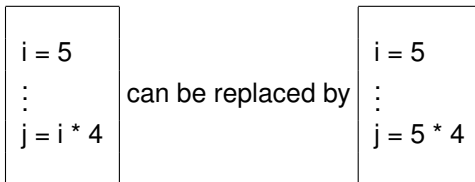
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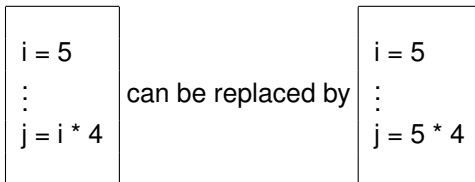


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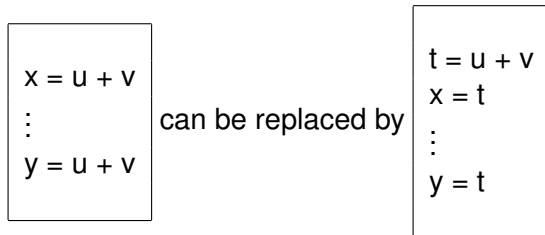
Common Subexpression Elimination

- ▶ Reuse a computation if already “available”

$$\begin{array}{l} x = u + v \\ \vdots \\ y = u + v \end{array}$$

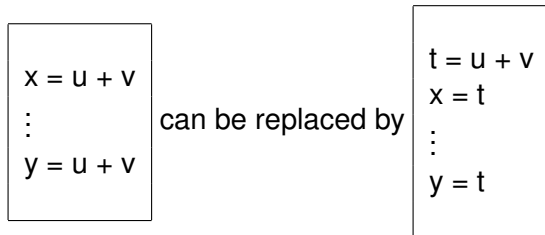
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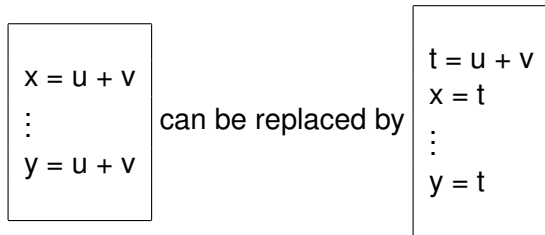
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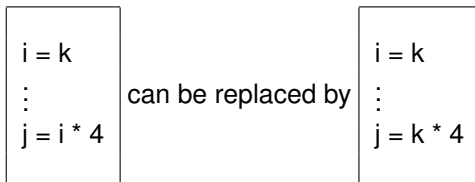
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- ▶ Replace (use of) a variable by another variable
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```

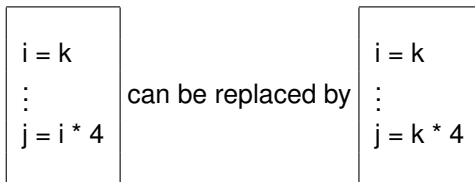
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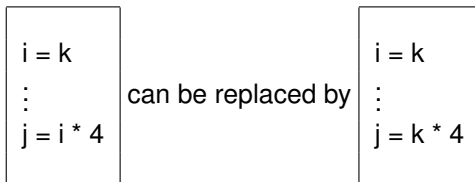
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- ▶ How to find out which code to move?

Code Movement

- ▶ Code size reduction
 - ▶ Suppose the operator \oplus results in the generation of a large number of machine instructions. Then,

```
if (a < b)
    u = x $\oplus$ y
else
    v = x $\oplus$ y
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Code Movement

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 - ▶ Suppose the operator \oplus results in the generation of a large number of machine instructions. Then,

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if (a < b)
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can be replaced by

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t = x $\oplus$ y
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    u = t
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- ▶ Execution frequency reduction

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- Move loop invariant code out of the loop

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for (...) {  
    ...  
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Code Movement

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Code Movement

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Profitability of code motion

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 - ▶ Use of *low strength* operators in place of *high* strength ones.
 - ▶ $i * i$ instead of $i * * 2$, $\text{pow}(i, 2)$
 - ▶ $i << 1$ instead of $i * 2$
 - ▶ Typically performed for integers only – Why?

Agenda

- ▶ Static analysis and compile-time optimizations

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- ▶ For the next few lectures

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 - ▶ Components

Assumptions

- ▶ Intraprocedural: Restricted to a single function

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- ▶ Input in 3-address format

Assumptions

- ▶ Intraprocedural: Restricted to a single function
- ▶ Input in 3-address format
- ▶ Unless otherwise specified

3-address Code Format

► Assignments

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$x = y \text{ op } z$

3-address Code Format

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- ▶ Jump/control transfer

3-address Code Format

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goto L

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- ▶ Statements can have label(s)

L: ...

- ▶ Arrays, Pointers and Functions to be added later when needed