CSCD70 Compiler Optimization

Tutorial #3 Dataflow Analysis

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Abstract

In this tutorial, we will be discussing the following topics:

- Dataflow Analysis Case Study: Available Expressions
- Assignment 1 Q & A

- ► Why do we want to study **Available Expressions**?
 - ► Global Common Subexpressions, e.g.,

```
if (...) {
  x = m + n;
} else {
  y = m + n;
}
z = m + n; // 'm + n' has already been computed,
  therefore is redundant
```

- What happens if m + n is NOT computed in the else branch?
- Need a rigorous way for arguing about "redundancy".
 Available Expressions
- ▶ In Available Expressions, we care about expressions.
 - ⇒ **Domain**: Sets of Expressions

Terminologies

- An expression $x \oplus y$ is **available** at a point p if every path from the entry node to p evaluates $x \oplus y$.
- A block **generates** expression $x \oplus y$ if it definitely evaluates $x \oplus y$ and does not subsequently define x or y.
- A block **kills** expression $x \oplus y$ if it assigns (or may assign) x or y and does not subsequently recompute $x \oplus y$
- ► E.g.,

```
x = y + 1; // generates 'y + 1'
y = m + n; // generates 'm + n', also kills 'y + 1'
```

 \Rightarrow Transfer Function: $f_B := \operatorname{gen}_B \cup (x - \operatorname{kill}_B)$

- ▶ What should be the **Direction** of analysis?
 - ▶ In Available Expressions, we eliminate an expression because it has been computed in the past.
 - ► In Live Variables, we eliminate a variable because it is not going to be used in the future.
 - ⇒ Available Expressions is Forward while Live Variables is Backward.
- **⇒ Direction**: Forward

OUT Equation: $OUT[B] = f_B(IN[B])$

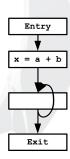
IN Equation: $IN[B] = \wedge_{p \in pred(B)} OUT[p]$

▶ What should be the **Meet Operator** between different paths?

► What should be the **Initial Condition** and **Boundary Condition**?

IC: $OUT[B] = \mathbb{U}$, BC: $OUT[entry] = \emptyset$

- ▶ What does Initial and Boundary mean?
- ► How is this related to the Direction and Meet Operator we have discussed?
- ▶ What happens if we assume different conditions? Will they affect the results?



Available Expressions Dataflow Analysis

Domain	Sets of Expressions
Direction	Forward
Transfer Function	$f_B := \operatorname{gen}_B \cup (x - \operatorname{kill}_B)$
Meet Operator	$\wedge \coloneqq _$
OUT Equation	$OUT[B] = f_B(IN[B])$
IN Equation	$IN[B] = \wedge_{p \in pred(B)} OUT[p]$
Initial Condition	$\mathrm{OUT}[B] = \mathbb{U}$
Boundary Condition	$OUT[entry] = \emptyset$

™ Homework Assignment: Available Expressions