

Data Flow II

DOM and LIVE

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Course page: <http://www.cs.rochester.edu/drupal/u/cding/csc-255455-advanced-programming-systems-spring-2014>

Review of Last Class

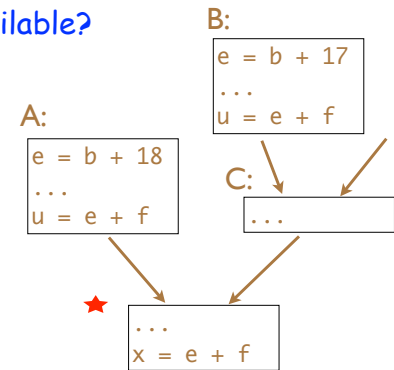
- What is the purpose of data flow analysis?
 - why is it called a framework?
- What are the three steps?
- What are the local sets computed for AVAIL?
- What is the data flow equation for AVAIL?
- Can you draw the two basic cases of control flow merge?
- Define the following for avail analysis
 - expression e , program point p
 - e is available/kill at point p
 - Avail equation
 - how many unknowns

14

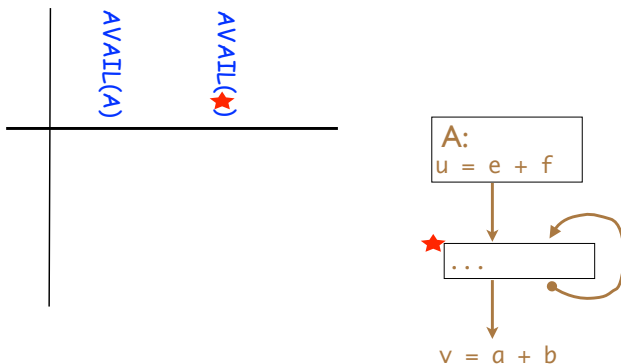
Data Flow Framework

1. Build control flow graph (single function)
2. Compute local information, e.g. ExprKill
3. Iterative solution
 1. initialize the MOP sets
 2. changed = true
 3. while changed
 1. changed = false
 2. for each block x , re-compute the MOP sets
 3. changed = true if any result differs

15

★ Is $e+f$ available?

AVAIL(★) =



- How many choices for initial AVAIL(n)?
- What are the implications for the resulting fixed point?

	init 1		init 1		2
Avail(A)	ϕ	ϕ	ϕ	ϕ	ϕ
Avail(★)	ϕ	ϕ	Ω	$\{e+f\}$	$\{e+f\}$

Computing DOM

- **Dominator**
 - x dominates y iff every path from the root to y includes x
 - $\text{DOM}(y)$ includes x
- **Equation**
 - $\text{DOM}(y) =$
- **Initialization**

19

LIVE Analysis

- **Local sets**
 - $\text{UEVar}(n)$: variables used in n before any re-definition in n
 - $\text{VarKill}(n)$: variables defined in n
- **MOP set**
 - $\text{Live}(n)$: variables live **at the end** of block n
 - v is in $\text{Live}(n)$ iff there is a path from the end of n to a user of v along which v is not redefined.
 - used by a compiler to find un-initialized uses
- **Comparison with AVAIL**
 - live is a property of variables
 - availability is a property of expressions
 - live variables are used in some succeeding path
 - available expressions are defined in all preceding paths

20

Local info for Live

- **Local sets**
- $\text{UEVar}(n)$: variables used in n before any re-definition in n
- $\text{VarKill}(n)$: variables defined in n

for $i \leftarrow 1$ to number of operations
assume op_i is " $x \leftarrow y \text{ op } z$ "

if $i \in \text{Leader}$ then
 $b \leftarrow$ block number for i
 $\text{UEVAR}(b) \leftarrow \emptyset$
 $\text{VARKILL}(b) \leftarrow \emptyset$
if $y \notin \text{VARKILL}(b)$ then
 $\text{UEVAR}(b) \leftarrow \text{UEVAR}(b) \cup \{y\}$
if $z \notin \text{VARKILL}(b)$ then
 $\text{UEVAR}(b) \leftarrow \text{UEVAR}(b) \cup \{z\}$
 $\text{VARKILL}(b) \leftarrow \text{VARKILL}(b) \cup \{x\}$

Gathering Initial Information

21

A: $\begin{matrix} a = b + c \\ d = a \end{matrix}$

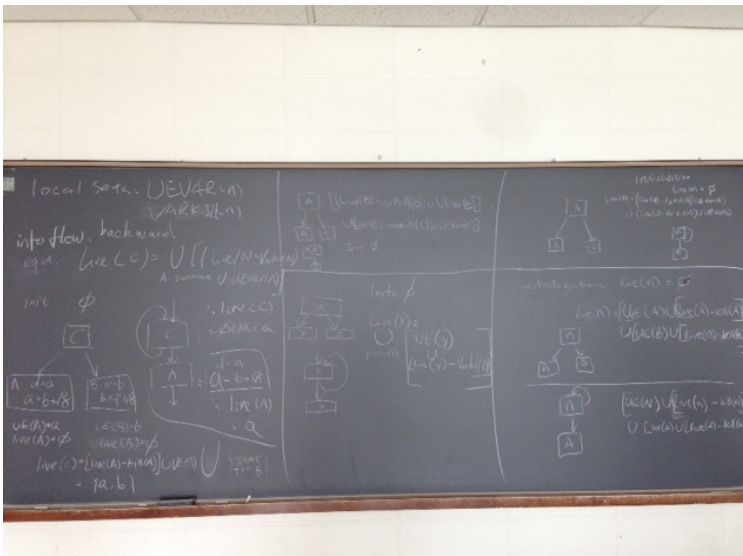
B: $\begin{matrix} d = a \\ a = b + c \end{matrix}$

source: EAC figure 8.8

Comparison

MOP set	Avail(n)	Live(n)
info flow		
local sets		
2 examples		
equation		
initialization		
algorithm		

22



Review Questions

- What is data flow analysis?
- What are the steps of data flow analysis?
- Give the following for AVAIL analysis
 - expression e , program point p
 - e is available at program p
 - AVAIL equation
 - AVAIL algorithm (initialization)
- Give the following for DOM and LIVE analysis
 - local information sets
 - equations
 - initialization
- Define forward and backward data flow analysis

24