

Due: Thursday, 22 April 2010, 12 noon

Open books, library, internet, notes, ...
Do not contact another human.

1. Consider the following basic block:

$a \leftarrow b + c$

$e \leftarrow c + c$

$f \leftarrow a + c$

$g \leftarrow b + e$

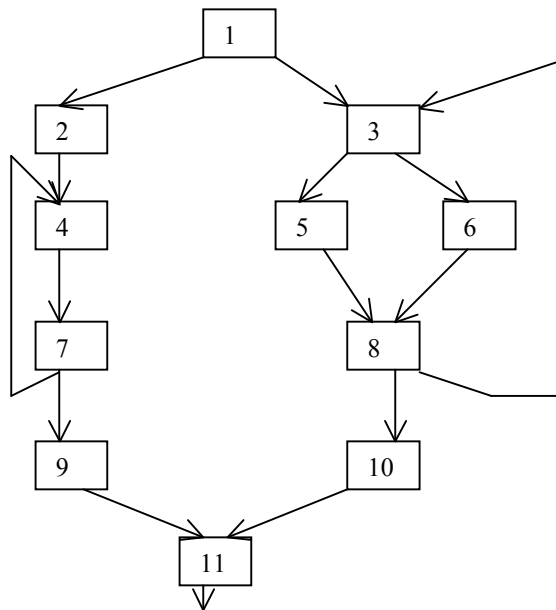
$h \leftarrow b + c$

1. a Build a DAG for that block (using any (unambiguous) standard graph representation, e.g., vertex & node drawing, adjacency matrix, adjacency list).

1. b. What redundancies can be found via the DAG?

1.c. At the end of the block, f and g have the same value. Why would an optimization algorithm have difficulty discovering this fact?

2. Consider this control-flow graph:



2. a. Identify the extended basic blocks in the graph.

2.b. Write a procedure in Java, C, or reasonably unambiguous pseudo-code that might generate this control-flow graph.

3. Show how the code fragment

```
if (c[i] != 0)
    then a[i] := b[i] / c[i];
    else a[i] := b[i];
```

can be represented in an abstract syntax tree, in a control-flow graph, and in an intermediate address (three- or four-address) representation.

4. The following attribute grammar estimates the execution time of a sequence of assignment statements.

<u>Production</u>	<u>Attribution Rules</u>
$Block0 \rightarrow Block1 \text{ Assign}$	$\{Block0.cost \leftarrow Block1.cost + Assign.cost\}$
$Block \rightarrow Assign$	$\{Block0.cost \leftarrow Assign.cost\}$
$Assign \rightarrow \text{ident} = Expr;$	$\{Assign.cost \leftarrow Cost(store) + Expr.cost\}$
$Expr0 \rightarrow Expr1 + Term$	$\{Expr0.cost \leftarrow Expr1.cost + Cost(add) + Term.cost\}$
$Expr0 \rightarrow Expr1 - Term$	$\{Expr0.cost \leftarrow Expr1.cost + Cost(sub) + Term.cost\}$
$Expr0 \rightarrow Term$	$\{Expr0.cost \leftarrow Term.cost\}$
$Term0 \rightarrow Term1 * Factor$	$\{Term0.cost \leftarrow Term1.cost + Cost(mult) + Factor.cost\}$
$Term0 \rightarrow Term1 / Factor$	$\{Term0.cost \leftarrow Term1.cost + Cost(div) + Factor.cost\}$
$Term0 \rightarrow Factor$	$\{Term0.cost \leftarrow Factor.cost\}$
$Factor \rightarrow (Expr)$	$\{Factor.cost \leftarrow Expr.cost\}$
$Factor \rightarrow \text{num}$	$\{Factor.cost \leftarrow Cost(loadInt)\}$
$Factor \rightarrow \text{ident}$	$\{Factor.cost \leftarrow Cost(load)\}$

<u>Operation</u>	<u>Cost</u>
store	3
add	1
sub	1
mult	4
div	4
loadInt	2
load	3

Estimate the cost of the following block of assignments:

```
a = 3;
b = (a + 3) / a;
```

5. The following grammar describes a language of matched parentheses.

Goal $\rightarrow$ Parens

Parens $\rightarrow$ (Parens) Parens
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5.a. Construct the item sets of LR(1) for this grammar

5.b. Derive the Action and GoTo tables.

5.c. Is the grammar LR(1)?