CSE 130: Programming Languages – Principles and Paradigms Fall 2000

Problem Set 1

Instructor: Daniele Micciancio | Sept. 27, 2000

General guidelines: This homework covers the material taught in the first two weeks of classes. It is due on October 9 at the beginning of class; no late submissions will be accepted. Please note that you should NOT work in groups on this homework; doing otherwise will be considered cheating. Finally, when submitting the homework, make sure to PRINT your name clearly on each page of the submission.

Problem 1 (10 points)

In class we defined the following simple grammar for arithmetic expressions with $+, -, *$ and $/$ operations:

$$
\begin{aligned}
E &\rightarrow T + E \mid T \\
T &\rightarrow F * T \mid F \\
F &\rightarrow 0 \mid 1 \mid ... \mid 9 \mid (E)
\end{aligned}
$$

a. Modify the grammar to include also an exponentiation operation $\uparrow$. The new operation should have highest precedence, and associate to the right.

b. Give parse trees and leftmost derivations for the following strings:

$$3 * 4 \uparrow 2 + 1$$

$$2 \uparrow (3 + 5) \uparrow 7 * 4$$

Problem 2 (10 points)

Consider the simple imperative language defined in class. We defined the operational semantics of the `for` V `from` E_1 `to` E_2 `do` S `end`

a. Give an alternative semantics where expression E_2 is re-evaluated at each iteration.

b. Give an example program that produces different results depending on the semantics of the `for` statement. Your program should terminate in both cases, but with different results.

c. Describe the computations defined by the two operational semantics, showing that the final result is different.

Problem 3 (10 points)

a. Use the axiomatic semantics of the simple imperative language we described in class to compute the weakest precondition of the following program fragment:

```
a := 2*b + 1;
b := a - 3;
```
$\{b < 0\}$

b. The "division theorem" says that for every two integers $x \geq 0$ and $y > 0$, there exists two integers q (the *quotient*) and r (the *remainder*) such that $x = yq + r$ and $0 \leq r < y$. Prove the partial correctness of the following program to compute q and r using the axiomatic semantics. What can you say about its total correctness? Discuss partial correctness and total correctness if the precondition is weakened.

$\{x \geq 0, y > 0\}$
```
q:=0;
r:=x;
while (y ≤ r) do
begin r:=r-y;
      q:=q+1;
end;
```
$\{x = qy + r, 0 \leq r < y\}$