Problem Set 3: Functions and Type-checking [Solutions]
Due October 16, 2020

Part I: Functions
For the following problem, consider the following program:

```c
void main() {
    int x;
    float y;
    float f;
    ... //some computations
    f = foo(x + y);
    f += bar(x, y);
    ... //some computations
}

float foo(int a) {
    float g;
    g = bar(a, a);
    return g;
}

float bar(int r, int s) {
    float h;
    float q;
    q = 2.0;
    h = 1.0 * (r + s);
    if (r == s) {
        h = h * q;
    }
    return h;
}
```

1. Assume your program is running on a machine with 4 registers, using callee saves. Assume floats and ints are 4 bytes, and addresses are 4 bytes. Draw the complete stack (i.e., the stack including all active activation records) for the program right after foo has called bar, and before bar returns. For each slot in the stack, indicate what is stored there, and how much space that slot takes up.
Part II: Type checking

For this part, consider the same code as in Part I.

1. Using the AST structure we developed for the course project, draw the AST for the line of code `h = 1.0 * (r + s)` and show on the AST you drew how type information is assigned to each node.
Answer:

\[
\begin{align*}
    h & = r * 1.0 + s \\
    & = [\text{float} = \text{float}] \\
    & = \text{BinOp: } * \\
    & = \text{FloatLit: 1.0} \\
    & = \text{BinOp: } + \\
    & = \text{VarNode: } r \\
    & = \text{VarNode: } s
\end{align*}
\]

In UCL, this would actually be a type error, but in a language like C, the operation would produce a float due to type conversion.

The original solutions mistakenly had \( r \) and \( s \) as floats

2. Repeat that process for the line \( g = \text{bar}(a, a) \)

Answer:

\[
\begin{align*}
g & = \text{bar}(a, a) \\
& = [\text{float} = \text{float}] \\
& = \text{CallNode: } \text{bar} \\
& = [\text{int x int -> float}] \\
& = \text{VarNode: } a \\
& = \text{VarNode: } a
\end{align*}
\]

3. Suppose the second parameter of \( \text{bar} \) was a \texttt{float} instead of an \texttt{int}. Mark with a star where type checking would fail in the previous problem.

Answer: [Problem node marked in red]
\[
g (\text{float}) = \text{CallNode: bar} (\text{int} \times \text{float} \to \text{float}) \left( \text{VarNode: a} (\text{int}), \text{VarNode: a} (\text{int}) \right)
\]