CSCI 742 - Compiler Construction

Lecture 25

More Type Rules

Instructor: Hossein Hojjat

March 31, 2017

Recap: Type Judgments and Type Rules

$$\boxed{\Gamma \vdash e : T}$$

If the (free) variables of e have types given by the type environment gamma, then e (correctly) type checks and has type T

$$\boxed{\frac{\Gamma \vdash e_1 : T_1 \qquad \cdots \qquad \Gamma \vdash e_n : T_n}{\Gamma \vdash e : T}}$$

If e_1 type checks in Γ and has type T_1
and ...
and e_n type checks in Γ and has type T_n
then e type checks in Γ and has type T

Type Rules for Block

$$\frac{\overbrace{\Gamma \oplus \{(x_1, T_1), \cdots, (x_n, T_n)\}}^{\Gamma_1} \qquad \Gamma_1 \vdash s_1 : \texttt{void} \qquad \cdots \qquad \Gamma_1 \vdash s_n : \texttt{void}}{\Gamma \vdash \{T_1\ x_1; \cdots; T_n\ x_n; s_1; \cdots; s_n\} : \texttt{void}}$$

Type Rules for Block

Empty:

$$\frac{}{\Gamma \vdash \{\} : \texttt{void}}$$

Single Statement:

$$\frac{\Gamma \vdash s : \texttt{void}}{\Gamma \vdash \{s\} : \texttt{void}}$$

$$\frac{\Gamma \oplus \{(x, T)\} \vdash \{t_2; \cdots ; t_n\} : \texttt{void}}{\Gamma \vdash \{T\ x\ ;\ t_2; \cdots ; t_n\} : \texttt{void}}$$

declaration is first

$$\frac{\Gamma \vdash s_1 : \texttt{void} \qquad \Gamma \vdash \{t_2; \cdots ; t_n\} : \texttt{void}}{\Gamma \vdash \{s_1\ ;\ t_2; \cdots ; t_n\} : \texttt{void}}$$

statement is first

Type Rule for Method Definitions

$$\frac{\Gamma \oplus \{(a_1, T_1)\ , \cdots\ ,\ (a_n, T_n)\} \vdash e : T_r}{\Gamma \vdash \Big(T_r\ \texttt{fun}\ (T_1\ a_1, \cdots, T_n\ a_n)\ \{\texttt{return}\ \ e\}\Big)\quad : \texttt{void}}$$

Type Rule for Method Call

```
class T0 {
  // ...
  T m (T1 x1,...,Tn  xn) {
    // ...
  }
  // ...
}
```

$$\frac{\Gamma \vdash x : T_0 \qquad \Gamma_{T_0} \vdash \mathtt{m} : T_1 \times \cdots \times T_n \to T \qquad \forall i \in \{1, \cdots, n\}.\ \Gamma \vdash e_i : T_i}{\Gamma \vdash \left(x.\mathtt{m}(e_1, \cdots, e_n) \right) \ : T}$$

Type Checking Expression in a Body

$\Gamma_0 = \{$

```
class World {
  int value;                                  (value, int),
  String info;                                (info, String),
  int m(int x , int y) {                      (m, int × int → int),
    return x + y - 1;
  }
  int n(int x) {                              (n, int → int),
    if (info == "") return m(x + 1,0);
      else return 1;
  }
  boolean p(int r) {                          (p, int → boolean)
    int k = r + 2;
    return m(k, n(value)) > 1;
  }
}
```

$\}$

Γ_0 — $\Gamma_1 = \Gamma_0 \oplus \{(\texttt{r}, \texttt{int})\}$ — $\Gamma_2 = \Gamma_1 \oplus \{(\texttt{k}, \texttt{int})\}$

$$\dfrac{\dfrac{\Gamma_2 \vdash \texttt{k} : \texttt{int} \qquad \dfrac{\Gamma_2 \vdash \texttt{value:int} \qquad \Gamma_2 \vdash \texttt{n:int} \to \texttt{int}}{\Gamma_2 \vdash \texttt{n(value)} : \texttt{int}} \qquad \Gamma_2 \vdash \texttt{m:int} \times \texttt{int} \to \texttt{int}}{\Gamma_2 \vdash \texttt{m(k,n(value))} : \texttt{int}} \qquad \dfrac{}{\Gamma_2 \vdash \texttt{1} : \texttt{int}}}{\Gamma_2 \vdash \texttt{m(k,n(value))} > \texttt{1} : \texttt{boolean}}$$

Exercise

- Type check the `if`-expression

```
class World {
  boolean z;
  int u;
  int f(boolean y) {
    z = y;
    if (u > 0) {
      u = u - 1;
      int z;
      z = f(!y) + 3;
      u = z + z;
    }
    else {u = 0;}
    return u
  }
}
```

Arrays

- Using array as an expression, on the right-hand side

$$\frac{\Gamma \vdash \texttt{a} : T\texttt{[]} \qquad \Gamma \vdash i : \texttt{int}}{\Gamma \vdash \texttt{a[i]} : T}$$

- Assigning to an array

$$\frac{\Gamma \vdash \texttt{a} : T\texttt{[]} \qquad \Gamma \vdash i : \texttt{int} \qquad \Gamma \vdash e : T}{\Gamma \vdash \big(\texttt{a[i]} = e\big) : \texttt{void}}$$

Exercise

- Type check the body of function

```
void next(int[] a, int k) {
  a[k] = a[a[k]];
}
```