

Oat v.1 Language Specification

252-0210-00L Compiler Design HS2020

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1 Grammar

The following grammar defines the Oat syntax. All binary operations are *left associative* with precedence levels indicated numerically. Higher precedence operators bind tighter than lower precedence ones.

| | | |
|---------|-------|--|
| $prog$ | $::=$ | $prog$ |
| | | $decl_1 .. decl_i$ |
| $decl$ | $::=$ | global declarations |
| | | $gdecl$ |
| | | $fdecl$ |
| $gdecl$ | $::=$ | global variable declarations |
| | | <code>global id = $gexp$;</code> |
| arg | $::=$ | arg |
| | | $t\ id$ |
| $args$ | $::=$ | args |
| | | $arg_1, .., arg_n$ |
| $fdecl$ | $::=$ | function declaration |
| | | <code>retty $id(args)$ block</code> |
| $block$ | $::=$ | blocks |
| | | $\{stmt_1 .. stmt_n\}$ |
| t | $::=$ | types |
| | | <code>int</code> |
| | | <code>bool</code> |
| | | <code>ref</code> |
| ref | $::=$ | reference types |
| | | <code>string</code> |
| | | $t[]$ |

| | | |
|--------------|---|---|
| <i>F</i> | $::=$ $ \quad (t_0, \dots, t_n) \rightarrow retty$ | function types |
| <i>retty</i> | $::=$ $ \quad \text{void}$ $ \quad t$ | return types |
| <i>bop</i> | $::=$ $ \quad *$ $ \quad +$ $ \quad -$ $ \quad <<$ $ \quad >>$ $ \quad >>>$ $ \quad <$ $ \quad <=$ $ \quad >$ $ \quad >=$ $ \quad ==$ $ \quad !=$ $ \quad \&$ $ \quad $ $ \quad [\&]$ $ \quad []$ | (left associative) binary operations multiplication (precedence 100) addition (precedence 90) subtraction (precedence 90) shift left (precedence 80) shift right logical (precedence 80) shift right arithmetic (precedence 80) less-than (precedence 70) less-than or equal (precedence 70) greater-than (precedence 70) greater-than or equal (precedence 70) equal (precedence 60) not equal (precedence 60) logical and (precedence 50) logical or (precedence 40) bit-wise and (precedence 30) bit-wise or (precedence 20) |
| <i>uop</i> | $::=$ $ \quad -$ $ \quad !$ $ \quad \sim$ | unary operations |
| <i>gexp</i> | $::=$ $ \quad \text{integer}$ $ \quad \text{string}$ $ \quad \text{ref null}$ $ \quad \text{true}$ $ \quad \text{false}$ $ \quad \text{new } t [] \{gexp_1, \dots, gexp_n\}$ | global initializers 64-bit integer literals C-style strings |
| <i>lhs</i> | $::=$ $ \quad id$ $ \quad exp_1 [exp_2]$ | lhs expressions |

| | | |
|------------------|---|--|
| <i>exp</i> | $::=$ <i>id</i> <i>integer</i> <i>string</i> <i>ref null</i> <i>true</i> <i>false</i> <i>exp</i> ₁ [<i>exp</i> ₂] <i>id</i> (<i>exp</i> ₁ , .., <i>exp</i> _{<i>n</i>}) <i>new t []</i> { <i>exp</i> ₁ , .., <i>exp</i> _{<i>n</i>} } <i>new int</i> [<i>exp</i> ₁] <i>new bool</i> [<i>exp</i> ₁] <i>exp</i> ₁ <i>bop</i> <i>exp</i> ₂ <i>uop exp</i> (<i>exp</i>) | expressions 64-bit integer literals C-style strings Explicitly initialized array Default-initialize int array Default-initialize bool array |
| <i>vdecl</i> | $::=$ <i>var id = exp</i> | local declarations |
| <i>vdecls</i> | $::=$ <i>vdecl</i> ₁ , .., <i>vdecl</i> _{<i>n</i>} | decl list |
| <i>stmt</i> | $::=$ <i>lhs = exp</i> ; <i>vdecl</i> ; <i>return exp</i> ; <i>return</i> ; <i>id</i> (<i>exp</i> ₁ , .., <i>exp</i> _{<i>n</i>}) ; <i>if_stmt</i> <i>for</i> (<i>vdecls</i> ; <i>exp</i> _{opt} ; <i>stmt</i> _{opt}) <i>block</i> <i>while</i> (<i>exp</i>) <i>block</i> | statements |
| <i>if_stmt</i> | $::=$ <i>if</i> (<i>exp</i>) <i>block</i> <i>else_stmt</i> | if statements |
| <i>else_stmt</i> | $::=$ ϵ <i>else block</i> <i>else if_stmt</i> | else |

2 Typing Rules

$\boxed{\vdash bop_1, \dots, bop_i : F}$

$\frac{}{\vdash +, *, -, <, >, >>, [\&], [!]: (\text{int}, \text{int}) \rightarrow \text{int}} \text{ TYP_INTOps}$

$\frac{}{\vdash ==, !=, <=, >= : (\text{int}, \text{int}) \rightarrow \text{bool}} \text{ TYP_CMPOps}$

$\frac{}{\vdash \&, | : (\text{bool}, \text{bool}) \rightarrow \text{bool}} \text{ TYP_BOOLOps}$

$\boxed{\vdash uop : F}$

$\frac{}{\vdash ! : (\text{bool}) \rightarrow \text{bool}} \text{ TYP_LOGNOT}$

$\frac{}{\vdash \sim : (\text{int}) \rightarrow \text{int}} \text{ TYP_BITNEG}$

$\frac{}{\vdash - : (\text{int}) \rightarrow \text{int}} \text{ TYP_NEG}$

$\boxed{G; L \vdash exp : t}$

$\frac{x:t \in L}{G; L \vdash x : t} \text{ TYP_LOCAL}$

$\frac{}{G; L \vdash n : \text{int}} \text{ TYP_INT}$

$\frac{}{G; L \vdash s : \text{string}} \text{ TYP_STRING}$

$\frac{}{G; L \vdash \text{stringnull} : \text{string}} \text{ TYP_NULLSTR}$

$\frac{}{G; L \vdash t[] \text{ null} : t[]} \text{ TYP_NULLARR}$

$\frac{}{G; L \vdash \text{true} : \text{bool}} \text{ TYP_TRUE}$

$\frac{}{G; L \vdash \text{false} : \text{bool}} \text{ TYP_FALSE}$

$\frac{G; L \vdash exp_1 : t[] \quad G; L \vdash exp_2 : \text{int}}{G; L \vdash exp_1[exp_2] : t} \text{ TYP_INDEX}$

$\frac{f:(t_1, \dots, t_i) \rightarrow t \in G \quad G; L \vdash exp_1 : t_1 \quad \dots \quad G; L \vdash exp_i : t_i}{G; L \vdash f(exp_1, \dots, exp_i) : t} \text{ TYP_CALL}$

$\frac{G; L \vdash exp_1 : t \quad \dots \quad G; L \vdash exp_i : t}{G; L \vdash \text{new } t[] \{exp_1, \dots, exp_i\} : t[]} \text{ TYP_ARRLIT}$

$\frac{G; L \vdash exp_1 : \text{int}}{G; L \vdash \text{new int } [exp_1] : t[]} \text{ TYP_ARRZEROINT}$

$\frac{G; L \vdash exp_1 : \text{int}}{G; L \vdash \text{new bool } [exp_1] : t[]} \text{ TYP_ARRZEROBOL}$

$\frac{\vdash bop : (t_1, t_2) \rightarrow t \quad G; L \vdash exp_1 : t_1 \quad G; L \vdash exp_2 : t_2}{G; L \vdash exp_1 \text{ bop } exp_2 : t} \text{ TYP_BOP}$

$\frac{\vdash uop : (t) \rightarrow t \quad G; L \vdash exp : t}{G; L \vdash uop \text{ exp} : t} \text{ TYP_UOP}$

$$\boxed{G; L_1 \vdash vdecl \Rightarrow L_2}$$

$$\frac{G; L \vdash exp : t \quad x \notin L}{G; L \vdash \text{var } x = exp \Rightarrow L, x : t} \quad \text{TYP_DECL}$$

$$\boxed{G; L_0 \vdash vdecls \Rightarrow L_i}$$

$$\frac{G; L_0 \vdash vdecl_1 \Rightarrow L_1 \quad \dots \quad G; L_{i-1} \vdash vdecl_i \Rightarrow L_i}{G; L_0 \vdash vdecl_1, \dots, vdecl_i \Rightarrow L_i} \quad \text{TYP_VDECLS}$$

$$\boxed{G; L_1; retty \vdash stmt \Rightarrow L_2}$$

$$\frac{G; L_1 \vdash vdecl \Rightarrow L_2}{G; L_1; t \vdash vdecl; \Rightarrow L_2} \quad \text{TYP_SDECL}$$

$$\frac{G; L \vdash lhs : t \quad G; L \vdash exp_2 : t}{G; L; t \vdash lhs = exp_2; \Rightarrow L} \quad \text{TYP_ASSN}$$

$$\frac{f : (t_1, \dots, t_i) \rightarrow \text{void} \in G \quad G; L \vdash exp_1 : t_1 \quad \dots \quad G; L \vdash exp_i : t_i}{G; L; t \vdash f(exp_1, \dots, exp_i); \Rightarrow L} \quad \text{TYP_SCALL}$$

$$\frac{G; L \vdash exp : \text{bool} \quad G; L; t \vdash block_1 \quad G; L; t \vdash block_2}{G; L; t \vdash \text{if}(exp) block_1 \text{ else } block_2 \Rightarrow L} \quad \text{TYP_IF}$$

$$\frac{G; L \vdash exp : \text{bool} \quad G; L; t \vdash block}{G; L; t \vdash \text{while}(exp) block \Rightarrow L} \quad \text{TYP_WHILE}$$

$$\frac{G; L_1 \vdash vdecls \Rightarrow L_2 \quad G; L_2 \vdash exp : \text{bool} \quad G; L_2; t \vdash stmt \Rightarrow L_3 \quad G; L_2; t \vdash block}{G; L_1; t \vdash \text{for}(vdecls; exp_{opt}; stmt_{opt}) block \Rightarrow L_1} \quad \text{TYP_FOR}$$

$$\frac{G; L \vdash exp : t}{G; L; t \vdash \text{return } exp; \Rightarrow L} \quad \text{TYP_RETT}$$

$$\frac{}{G; L; \text{void} \vdash \text{return}; \Rightarrow L} \quad \text{TYP_RETVoid}$$

$$\boxed{G; L; t \vdash block}$$

$$\frac{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i}{G; L_0; t \vdash \{stmt_1 \dots stmt_i\}} \quad \text{TYP_BLOCK}$$

$$\boxed{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i}$$

$$\frac{G; L_0; t \vdash stmt_1 \Rightarrow L_1 \quad \dots \quad G; L_{i-1}; t \vdash stmt_i \Rightarrow L_i}{G; L_0; t \vdash stmt_1 \dots stmt_i \Rightarrow L_i} \quad \text{TYP_STMTS}$$

$$\boxed{G_0 \vdash decl \Rightarrow G_1}$$

$$\frac{x \notin G \quad \cdot; \cdot \vdash gexp : t}{G \vdash \text{global } x = gexp; \Rightarrow G, x : t} \quad \text{TYP_VDECL}$$

$$\frac{f \notin G}{G \vdash t f(t_1 x_1, \dots, t_i x_i) \text{ block} \Rightarrow G, f : (t_1, \dots, t_i) \rightarrow t} \quad \text{TYP_FDECL}$$

$$\boxed{G_0 \vdash decl_1 .. decl_i \Rightarrow G_i}$$

$$\frac{G_0 \vdash decl_1 \Rightarrow G_1 \quad \dots \quad G_{i-1} \vdash decl_i \Rightarrow G_i}{G_0 \vdash decl_1 .. decl_i \Rightarrow G_i} \quad \text{TYP_GLOBAL_CTXT}$$

$$\boxed{G \vdash decl}$$

$$\frac{G; x_1 : t_1, \dots, x_i : t_i; t \vdash \text{block}}{G \vdash t f(t_1 x_1, \dots, t_i x_i) \text{ block}} \quad \text{TYP_GFUN}$$

$$\frac{\cdot; \cdot \vdash gexp : t}{G \vdash \text{global } x = gexp;} \quad \text{TYP_GVAR}$$

$$\boxed{\vdash prog}$$

$$\frac{G_0 \vdash decl_1 .. decl_i \Rightarrow G \quad G \vdash decl_1 \quad \dots \quad G \vdash decl_i}{\vdash decl_1 .. decl_i} \quad \text{TYP_PROG}$$