

Lec18 CS241

Graham Cooper

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Grammar Rules

Expressions

Address of

$$\frac{E: \text{int}}{\&E: \text{int}^*}$$

If E has type int, then &E has type int *

Dereference:

$$\frac{E: \text{int}^*}{*E: \text{int}}$$

IF E has type int * then *E has type int

Allocation:

$$\frac{E: \text{int}}{\text{newint}[E]: \text{int}^*}$$

Mult:

$$\frac{E_1: \text{int} \ E_2: \text{int}}{E_1 * E_2: \text{int}}$$

Similarly for /, %

Addition:

$$\frac{E_1: \text{int} \cap E_2: \text{int}}{E_1 + E_2: \text{int}}$$

$$\frac{E_1: \text{int}^* \cap E_2: \text{int}}{E_1 + E_2: \text{int}^*}$$

$$\frac{E_1: \text{int} \cap E_2: \text{int}^*}{E_1 + E_2: \text{int}^*}$$

Substraction:

$$\frac{E_1: \text{int} \cap E_2: \text{int}}{E_1 - E_2: \text{int}}$$

$$\frac{E_1: \text{int}^* \cap E_2: \text{int}}{E_1 - E_2: \text{int}^*}$$

$$\frac{E_1: \text{int}^* \cap E_2: \text{int}^*}{E_1 - E_2: \text{int}}$$

Functions:

$$\frac{\langle f, (\tau_1, \tau_2 \dots \tau_n) \rangle \in \text{procs} \ E_1: \tau_1 \dots E_n: \tau_n}{F(E_1, \dots E_n): \text{int}}$$

Additional Type Constrains

Loops, if statements

while(T) {S}

if (T) {S₁} else {S₂}

Test T should be boolean, not int or int*. But there is not boolean type in WLP4

The grammar ensures that T will be a boolean tests (Expr comparison Expr), so as long as the comparison is well-typed, the if/while will be correct

Any expression that has a type is well-typed.

$$\frac{E:\tau}{\text{well-typed}(E)}$$

Tests:

$$\frac{E_1:\tau \cap E_2:\tau}{\text{well-typed}(E_1 == E_2)}$$

similar with !=

$$\frac{E_1:\tau \cap E_2:\tau}{\text{well-typed}(E_1 < E_2)}$$

Similar with >, >=, <=

Assignment:

$$\frac{E_1:\tau \cap E_2:\tau}{\text{well-typed}(E_1 = E_2)}$$

Print:

$$\frac{E:\text{int}}{\text{well-typed}(\text{println}(E))}$$

Deallocation:

$$\frac{E:\text{int}^*}{\text{well-typed}(\text{delete}[E])}$$

IF:

$$\frac{\text{well-typed}(T) \cap \text{well-typed}(S_1) \cap \text{well-typed}(S_2)}{\text{well-typed}(\text{if}(T)(\{S_1\} \text{else} \{S_2\}))}$$

Loops:

$$\frac{\text{well-typed}(T) \cap \text{well-typed}(S)}{\text{well-typed}(\text{while}(T)\{S\})}$$

Sequences:

$$\frac{}{\text{well-typed}(\epsilon)}$$

$$\frac{well-typed(S_1) \cap well-typed(S_2)}{well-typed(S_1, S_2)}$$

Dcls:

$$\frac{}{well-typed(intid=NUM)}$$

$$\frac{}{well-typed(int*id=NULL)}$$

Procedures:

$$\frac{well-typed(dcls) \cap well-typed(stmts) \cap E:int}{well-typed(INT, ID, (params)\{dcls, stmts, return, E;\})}$$

WAIN:

$$\frac{dcl_2=INT, ID \cap well-typed(dcls) \cap well-typed(stmts) \cap E:int}{well-typed(INT, WAIN(dcl, dcl_2)\{dcls, stmts, return, E;\})}$$

Code Generation

Source \rightarrow Lexical Analysis \xrightarrow{tokens} parsing \rightarrow semantic analysis $\xrightarrow{parsetreeandsymboltable}$
 Code Generation \rightarrow assembly

- By now, the source program is guaranteed to be free of compile-time errors.
- We must now output equivalent MIPS code

There are ∞ many equivalent MIPS programs, which do we choose?

- correct (essential)
- easiest (for cs241)
- shortest
- fastest to run
- fastest to compile

0.1 Example:

```
int wain(int a, int b) { return a;}
```

Convention:

- parameters of wain are in \$1 and \$2
- output will be in \$3

MIPS:

```
add $3, $1, $0
jr $31
```

```
int wain (int a, int b) {return b;}
```

MIPS:

```
add $3, $2, $0
jr $31
```

Parse trees for these programs are the same.

How do we tell one from the other?

Determine which of the two declared ID's the returned ID matches

How do we do that? Use the symbol table.

Add a field to the symbol table to indicate where each symbol is stored

Name	TYpe	Location
a	int	\$1
b	int	\$2

Then when traversing for code gen, look up ID in the symbol table

a \rightarrow \$1

b \rightarrow \$2

Local Declerations?

- cant all be in regs, probably not enough

For simplicity:

- put all local vars on the stack, including params of wain.

```
int wain(int a, int b){return a;}
```

```
sw $1, -4 ($30)
```

```
sw $2, -8($30)
```

```
lis $4  
.word 8  
sub $30, $30, $4  
lw $3, 4($30)  
add $30, $30, $4  
jr $31
```