

Auklet:

$\langle \text{expr} \rangle ::= 0 \mid 1 \mid -1 \mid \dots$

$\mid \text{after}(\langle \text{expr} \rangle) \mid \text{before}(\langle \text{expr} \rangle)$

$\mid \langle \text{expr} \rangle + \langle \text{expr} \rangle \mid \langle \text{expr} \rangle - \langle \text{expr} \rangle \mid \langle \text{expr} \rangle * \langle \text{expr} \rangle$

$\mid \text{let } \langle \text{var} \rangle = \langle \text{expr} \rangle \text{ in } \langle \text{expr} \rangle \mid \langle \text{var} \rangle$

Bluebird:

① Syntax $\langle \text{expr} \rangle ::= \dots \mid \text{true} \mid \text{false}$

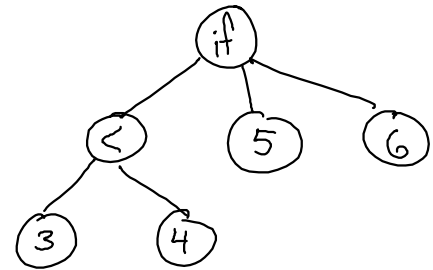
$\mid \langle \text{expr} \rangle \&\& \langle \text{expr} \rangle \mid \langle \text{expr} \rangle \parallel \langle \text{expr} \rangle$

$\mid \text{if } \langle \text{expr} \rangle \text{ then } \langle \text{expr} \rangle \text{ else } \langle \text{expr} \rangle$

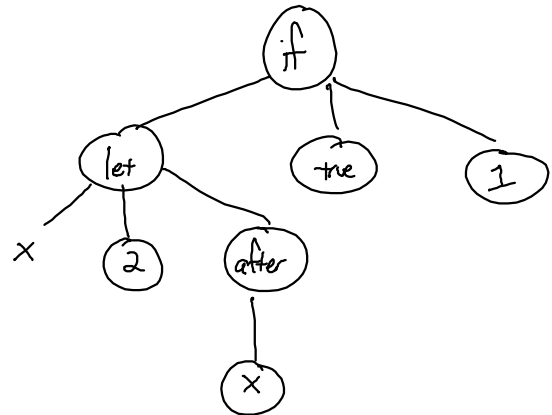
$\mid \langle \text{expr} \rangle = \langle \text{expr} \rangle \mid \langle \text{expr} \rangle < \langle \text{expr} \rangle \mid \langle \text{expr} \rangle > \langle \text{expr} \rangle$

$\mid \text{isbool}(\langle \text{expr} \rangle) \mid \text{isint}(\langle \text{expr} \rangle)$

if $3 < 4$ then 5 else 6



if let $x = 2$ in after(x) then true else 1



② Semantics

$$4 < 3 \Rightarrow \text{false}$$

$$\text{if true then 1 else true} \Rightarrow 1$$

$$\text{let } k = \text{false in } k \parallel k \Rightarrow \text{false}$$

$1 + \text{true} \Rightarrow$
 $\swarrow \searrow$
 $\text{true} \quad 2$
 what C does $\rightarrow$ **error**
 unspecified behavior

bool and int are different

$$\text{isbool}(\text{false}) \Rightarrow \text{true}$$

$$\text{isbool}(0) \Rightarrow \text{false}$$

we will assume that programmer is responsible for type correctness

③ Binary Representation

In Auklet

sign bit

"64-bit signed integer"

5 $\rightarrow$ 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000101
 true $\rightarrow$ X

In Bluebird

sign bit

"63-bit signed integer"

tag bit

In lecture form (not lab)

1 $\rightarrow$ 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
 true $\rightarrow$ 00000000 00000000 00000000 00000000 00000000 00000000 00000000 10000000
 false $\rightarrow$ 00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000

after(2) $\begin{matrix} \text{mov rax, 4} \\ \text{add rax, 2} \end{matrix}$

Consider a function $R(n)$ that takes a BB number and returns representation. (bb-int $\rightarrow$ asm-int)

$$R(a) + R(b) =$$

$$2a + 2b = 2(a+b) = R(a+b)$$

$$R(5) - R(3) = 10 - 6 = 4 = R(2)$$

$$\text{X } R(5) * R(3) = 10 * 6 = 60 = R(30)$$

$$R(5) + R(3) = 10 + 6 = 16 = R(8) = R(5+3)$$

```

mov rax, 10
mov [rsp-8], rax
mov rax, 6
mov [rsp-16], rax
mov rax, [rsp-8]
sar rax, 1
imul rax, [rsp-16]
  
```

BB binary rep

Lecture only

$\left\{ \begin{array}{l} \text{true} \rightarrow 000 \dots \dots \overbrace{1000}^8 \overbrace{0001}^1 \\ \text{false} \rightarrow 000 \dots \dots 00000001 \end{array} \right.$

$N \rightarrow N * 2 \quad (-16, \{ b \mapsto [rsp-8] \})$

if b then 4 else 8

$\begin{array}{l} \text{mov rax, [rsp-8]} \quad \{ \text{1st expr} \\ \text{cmp rax, 0x81} \quad \{ \text{choose then or else} \\ \text{je then_5} \\ \text{mov rax, 16} \quad \{ \text{else expr} \end{array}$

$\begin{array}{l} \text{jmp end_6} \\ \text{then_5:} \\ \quad \text{mov rax, 8} \quad \{ \text{then expr} \\ \text{end_6:} \end{array}$



base 16 $\left\{ \begin{array}{c} F \\ E \\ D \\ C \\ B \\ A \\ 9 \\ 8 \\ 7 \\ 6 \\ 5 \\ 4 \\ 3 \\ 2 \\ 1 \\ 0 \end{array} \right.$ 1000