The C-- Language

1   Concrete Syntax

The concrete syntax of C-- is:

$$
\begin{array}{rcl}
pgm & \to & cmd \\[6pt]
cmd & \to & \texttt{skip} \\
 & | & id \; \texttt{:=} \; exp \\
 & | & {*}id \; \texttt{:=} \; exp \\
 & | & cmd \; \texttt{;} \; cmd \\
 & | & \texttt{if } bexp \texttt{ then } cmd \texttt{ else } cmd \texttt{ end} \\
 & | & \texttt{while } bexp \texttt{ do } cmd \texttt{ end} \\[6pt]
exp & \to & \texttt{readint} \\
 & | & num \\
 & | & exp \; \texttt{+} \; exp \\
 & | & \texttt{-} \; exp \\
 & | & (exp) \\
 & | & id \;\; | \;\; {*}id \;\; | \;\; \&id \\[6pt]
bexp & \to & exp \; \texttt{<} \; exp \\
 & | & exp \; \texttt{=} \; exp \\
 & | & bexp \; \texttt{\&\&} \; bexp \\
 & | & (bexp) \\
num & & number \\
id & & identifiers
\end{array}
$$

1.1   Reserved Words

Reserved words are `skip`, `if`, `then`, `else`, `while`, `do`, `end`, `readint`.

1.2   Numbers

Numbers are integers, optionally prefixed with - for negative integer: -?[0-9]+.

1.3   Identifiers

Alpha-numeric identifiers are [a-zA-Z][a-zA-Z0-9]*.Identifiers are case sensitive.Reserved words cannot be used as identifiers.

1.4 Precedence and Associativity

The precedence of symbols in C-- is listed in descreasing order.Symbols in same set have identical precedence.Symbols with subscript L (respectively R) are left (respectively right) associative.

$$\{-_{unary}\}_R$$
$$\{+\}_L$$
$$\{<\}_L$$
$$\{=\}_L$$
$$\{\&\&\}_L$$
$$\{;\}_L$$

1.5 Comments

A comment is a character sequence within the comment block /* */ or a character sequence from // to the end of the line.Comment blocks can be nested.

2 Standard Semantics of `C--`

2.1 Abstract Syntax

The abstract syntax of `C--`is:

$$
\begin{array}{rcl}
C & \to & \texttt{skip} \\
& | & x \texttt{ := } E \mid *x \texttt{ := } E \\
& | & C \texttt{ ; } C \\
& | & \texttt{if } B \; C \; C \\
& | & \texttt{while } B \; C \\
E & \to & \texttt{readint} \mid \texttt{n} \; (n \in \mathbb{Z}) \\
& | & E \texttt{ + } E \\
& | & \texttt{-}E \\
& | & x \mid *x \mid \&x \\
B & \to & E \texttt{ < } E \mid E \texttt{ = } E \mid B \texttt{ \&\& } B
\end{array}
$$

2.2 Semantic Domain

The semantics of `C--`is defined over following domains

$$
\begin{array}{rcccl}
x & \in & & Var & \\
x & \in & Loc & = & Var \\
v & \in & Val & = & \mathbb{Z} + Loc + \mathbb{B} \\
M & \in & Memory & = & Loc \xrightarrow{\text{fin}} Val \\
n & \in & & \mathbb{Z} & \\
b & \in & & \mathbb{B} & = \{true, false\}
\end{array}
$$

2.3 Semantic Judgement

Semantic judgement for command C is $M \vdash C \Rightarrow M'$

$$
\overline{M \vdash \texttt{skip} \Rightarrow M}
$$

$$
\frac{M \vdash E \Rightarrow v}{M \vdash x \texttt{ := } E \Rightarrow M\{x \mapsto v\}}
$$

$$
\frac{M \vdash E \Rightarrow v}{M \vdash *x \texttt{ := } E \Rightarrow M\{M(x) \mapsto v\}}
$$

$$
\frac{M \vdash C_1 \Rightarrow M_1 \quad M_1 \vdash C2 \Rightarrow M2}{M \vdash C_1 \texttt{ ; } C_2 \Rightarrow M_2}
$$

$$
\frac{M \vdash B \Rightarrow true \quad M \vdash C_1 \Rightarrow M'}{M \vdash \texttt{if } B \; C_1 \; C_2 \Rightarrow M'}
$$

$$
\frac{M \vdash B \Rightarrow false \quad M \vdash C_2 \Rightarrow M'}{M \vdash \texttt{if } B \; C_1 \; C_2 \Rightarrow M'}
$$

$$
\frac{M \vdash B \Rightarrow false}{M \vdash \texttt{while } B \; C \Rightarrow M}
$$

$$
\frac{M \vdash B \Rightarrow true \quad M \vdash C \Rightarrow M_1 \quad M_1 \vdash \texttt{while } B \; C \Rightarrow M_2}{M \vdash \texttt{while } B \; C \Rightarrow M_2}
$$

Semantic judgement for expression E is $M \vdash E \Rightarrow v$.

$$\overline{M \vdash \texttt{readint} \Rightarrow n}$$

$$\overline{M \vdash \texttt{n} \Rightarrow n}$$

$$\frac{M \vdash E_1 \Rightarrow v_1 \quad M \vdash E_2 \Rightarrow v_2}{M \vdash E_1 \texttt{ + } E_2 \Rightarrow v} \qquad v = v_1 + v_2$$

$$\frac{M \vdash E \Rightarrow v}{M \vdash \texttt{ - } E \Rightarrow v'} \qquad v' = -v$$

$$\overline{M \vdash x \Rightarrow M(x)}$$

$$\overline{M \vdash \texttt{*}x \Rightarrow M(M(x))}$$

$$\overline{M \vdash \texttt{\&}x \Rightarrow x}$$

Semantic judgement for boolean expression B is $M \vdash B \Rightarrow b$.

$$\frac{M \vdash E_1 \Rightarrow v_1 \quad M \vdash E_2 \Rightarrow v_2}{M \vdash E_1 \texttt{ < } E_2 \Rightarrow true} \qquad v_1 < v_2$$

$$\frac{M \vdash E_1 \Rightarrow v_1 \quad M \vdash E_2 \Rightarrow v_2}{M \vdash E_1 \texttt{ < } E_2 \Rightarrow false} \qquad v_1 \geq v_2$$

$$\frac{M \vdash E_1 \Rightarrow v_1 \quad M \vdash E_2 \Rightarrow v_2}{M \vdash E_1 \texttt{ = } E_2 \Rightarrow true} \qquad v_1 = v_2$$

$$\frac{M \vdash E_1 \Rightarrow v_1 \quad M \vdash E_2 \Rightarrow v_2}{M \vdash E_1 \texttt{ = } E_2 \Rightarrow false} \qquad v_1 \neq v_2$$

$$\frac{M \vdash B_1 \Rightarrow false}{M \vdash B_1 \texttt{ \&\& } B_2 \Rightarrow false}$$

$$\frac{M \vdash B_1 \Rightarrow true \quad M \vdash B_2 \Rightarrow false}{M \vdash B_1 \texttt{ \&\& } B_2 \Rightarrow false}$$

$$\frac{M \vdash B_1 \Rightarrow true \quad M \vdash B_2 \Rightarrow true}{M \vdash B_1 \texttt{ \&\& } B_2 \Rightarrow true}$$