Verilog Size Checking

Expressions

- $\mathcal{A}$ is the set of atoms in an expression. In the AST, they correspond to leaves. In System-Verilog, they refer to what the standard calls an "operand" (variables, integers, function calls, slices of a variable, etc.).
- $\mathcal{R}$ is the set of resizable expressions. It corresponds to the expression whose top level is one of: atom, cast, comparisons, logic operation, reduction, assignments, shift assignments, concatenation, replication and inside operation.
- $\mathcal{E}$ is the set of System-Verilog expressions. We have $\mathcal{A} \subset \mathcal{E}$. An expression either contains an expression or is an atom.

Rules

We use the following notations:

- Γ maps atoms to their size,
- Φ maps lvalues to their size,
- The statement $e \Rightarrow t$ means "e has a size t",
- The statement $e \Leftarrow t$ means "e can be resized to t".

Base case

$$\frac{\Gamma(e) = s \qquad e \in \mathcal{A}}{e \Rightarrow s}\ \text{Atom}\Rightarrow$$

Resize case

$$\frac{e \Rightarrow s \qquad s \leqslant t \qquad e \in \mathcal{R}}{e \Leftarrow t}\ \text{Resize}\Leftarrow$$

Operators

- $\oplus \in \{$`+`, `-`, `*`, `/`, `%`, `&`, `|`, `^`, `^~`, `~^`$\}$:

$$\frac{a \Rightarrow t \qquad b \Leftarrow t}{a \oplus b \Rightarrow t}\ \text{LBinOp}\Rightarrow \qquad \frac{a \Leftarrow t \qquad b \Rightarrow t}{a \oplus b \Rightarrow t}\ \text{RBinOp}\Rightarrow \qquad \frac{a \Leftarrow t \qquad b \Leftarrow t}{a \oplus b \Leftarrow t}\ \text{BinOp}\Leftarrow$$

- $\oplus \in \{$`+`, `-`, `++`, `--`, `~`$\}$:

$$\frac{e \Rightarrow t}{\oplus e \Rightarrow t}\ \text{UnOp}\Rightarrow \qquad \frac{e \Leftarrow t}{\oplus e \Leftarrow t}\ \text{UnOp}\Leftarrow$$

- $\oplus \in \{$`$signed`, `$unsigned`$\}$:

$$\frac{e \Rightarrow t}{\oplus(e) \Rightarrow t}\ \text{Cast}\Rightarrow$$

- $\oplus \in \{$`===`, `!==`, `==?`, `!=?`, `==`, `!=`, `>`, `>=`, `<`, `<=`$\}$:

$$\frac{a \Rightarrow t \qquad b \Leftarrow t}{a \oplus b \Rightarrow 1}\ \text{LCmp}\Rightarrow \qquad \frac{a \Leftarrow t \qquad b \Rightarrow t}{a \oplus b \Rightarrow 1}\ \text{RCmp}\Rightarrow$$

- $\oplus \in \{$`&&`, `||`, `->`, `<->`$\}$:

$$\frac{a \Rightarrow t_a \qquad b \Rightarrow t_b}{a \oplus b \Rightarrow 1}\ \text{Logic}\Rightarrow$$

- $\oplus \in \{$`&`, `~&`, `|`, `~|`, `^`, `~^`, `^~`, `!`$\}$:

$$\frac{e \Rightarrow t}{\oplus e \Rightarrow 1}\ \text{Red}\Rightarrow$$

- $\oplus \in \{\texttt{>>}, \texttt{<<}, \texttt{**}, \texttt{>>>}, \texttt{<<<}\}$:

$$\frac{a \Rightarrow t \quad b \Rightarrow t_b}{a \oplus b \Rightarrow t}\ \text{Shift}\Rightarrow \qquad \frac{a \Leftarrow t \quad b \Rightarrow t_b}{a \oplus b \Leftarrow t}\ \text{Shift}\Leftarrow$$

- $\oplus \in \{\texttt{=}, \texttt{+=}, \texttt{-=}, \texttt{*=}, \texttt{/=}, \texttt{\%=}, \texttt{\&=}, \texttt{|=}, \texttt{\^{}=}\}$:

$$\frac{\phi(l) = t \quad e \Leftarrow t}{l \oplus e \Rightarrow t}\ \text{LAssign}\Rightarrow \qquad \frac{\phi(l) = t \quad e \Rightarrow t_e \quad t < t_e}{l \oplus e \Rightarrow t}\ \text{RAssign}\Rightarrow$$

- $\oplus \in \{\texttt{<<=}, \texttt{>>=}, \texttt{<<<=}, \texttt{>>>=}\}$:

$$\frac{\phi(l) = t \quad e \Rightarrow t_e}{l \oplus e \Rightarrow t}\ \text{AssignShift}\Rightarrow$$

- If expression:

$$\frac{e \Rightarrow t_e \quad a \Rightarrow t \quad b \Leftarrow t}{e\texttt{?}a\texttt{:}b \Rightarrow t}\ \text{LCond}\Rightarrow \qquad \frac{e \Rightarrow t_e \quad a \Leftarrow t \quad b \Rightarrow t}{e\texttt{?}a\texttt{:}b \Rightarrow t}\ \text{RCond}\Rightarrow \qquad \frac{e \Rightarrow t_e \quad a \Leftarrow t \quad b \Leftarrow t}{e\texttt{?}a\texttt{:}b \Leftarrow t}\ \text{Cond}\Leftarrow$$

- Concatenation:

$$\frac{e_1 \Rightarrow t_1 \quad \dots \quad e_k \Rightarrow t_k \quad t = t_1 + \dots + t_k}{\texttt{\{}e_1, \texttt{...}, e_k\texttt{\}} \Rightarrow t}\ \text{Concat}\Rightarrow$$

- Replication:

$$\frac{i \in \mathbb{N} \quad e \Rightarrow t_e \quad t = i \times t_e}{\texttt{\{}i\ e\texttt{\}} \Rightarrow t}\ \text{Repl}\Rightarrow$$

- Inside:

$$\frac{a \Rightarrow t \quad e_1 \Leftarrow t \quad \dots \quad e_k \Leftarrow t}{a\ \texttt{inside}\ \texttt{\{}e_1, \texttt{...}, e_k\texttt{\}} \Rightarrow 1}\ \text{LInside}\Rightarrow$$

$$\frac{i \in \{1, \dots, k\} \quad a \Leftarrow t \quad e_1 \Leftarrow t \quad \dots \quad e_{i-1} \Leftarrow t \quad e_i \Rightarrow t \quad e_{i+1} \Leftarrow t \quad \dots \quad e_k \Leftarrow t}{a\ \texttt{inside}\ \texttt{\{}e_1, \texttt{...}, e_k\texttt{\}} \Rightarrow 1}\ \text{RInside}\Rightarrow$$