MODULE *Storm*

EXTENDS *TLC*, *Naturals*, *FiniteSets*, *Sequences*

CONSTANTS *Nodes*,
Root,
NarrowEdge,
WideEdges

VARIABLES *state*,
previousStates

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\begin{array}{l}
SInit \triangleq \\
\quad \land\ state = \\
\qquad [n \in 1 \,..\, Nodes \mapsto [credits \mapsto 0,\ totalcredits \mapsto 0]] \\
\quad \land\ previousStates = \langle\rangle \\
\\
SendWide(n) \triangleq \\
\quad \lor \quad \land\ n = Root \\
\qquad \land\ state[n].credits = 0 \\
\qquad \land\ \text{LET } perDevice \triangleq \\
\qquad\quad \text{CHOOSE } c \in 1 \,..\, 1024 : \\
\qquad\qquad \land \exists\, m \in 0 \,..\, 10 : c = 2^m \\
\qquad\qquad \land\ c * Cardinality(WideEdges[n]) < 1024 \\
\qquad\qquad \land \forall\, j \in 1 \,..\, 1024 : \\
\qquad\qquad\quad \land \exists\, m \in 0 \,..\, 10 : j = 2^m \\
\qquad\qquad\quad \land\ j * Cardinality(WideEdges[n]) < 1024 \\
\qquad\qquad\quad \Rightarrow c \geq j \\
\qquad\quad \text{IN} \quad state' = [i \in 1 \,..\, Nodes \mapsto \\
\qquad\qquad \text{IF } i = n \text{ THEN} \\
\qquad\qquad\quad [credits \mapsto 1,\ totalcredits \mapsto \\
\qquad\qquad\qquad 1 + perDevice * Cardinality(WideEdges[i]) \\
\qquad\qquad\quad] \\
\qquad\qquad\quad \text{ELSE IF } i \in WideEdges[n] \text{ THEN} \\
\qquad\qquad\quad [credits \mapsto state[i].credits + perDevice, \\
\qquad\qquad\qquad totalcredits \mapsto state[i].totalcredits \\
\qquad\qquad\quad] \\
\qquad\qquad\quad \text{ELSE } state[n] \\
\qquad\quad] \\
\qquad \land\ previousStates' = Append(previousStates,\ state) \\
\quad \lor \quad \land\ n \neq Root \\
\qquad \land\ state[n].credits \geq Cardinality(WideEdges[n]) \\
\qquad \land\ \text{LET } perDevice \triangleq \text{ CHOOSE } c \in 1 \,..\, state[n].credits : \\
\qquad\quad \land \exists\, m \in 0 \,..\, 10 : c = 2^m
\end{array}
$$

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\begin{array}{l}
\quad \land\ c * \mathit{Cardinality}(\mathit{WideEdges}[n]) \leq \mathit{state}[n].\mathit{credits} \\
\quad \land\ \forall\, j \in 1 \,..\, \mathit{state}[n].\mathit{credits} : \\
\qquad \land\ \exists\, m \in 0 \,..\, 10 : j = 2^m \\
\qquad \land\ j * \mathit{Cardinality}(\mathit{WideEdges}[n]) \leq \mathit{state}[n].\mathit{credits} \\
\qquad \Rightarrow\ c \geq j \\
\text{IN} \quad \mathit{state}' = [i \in 1 \,..\, \mathit{Nodes} \mapsto \\
\quad \text{IF}\ i = n\ \text{THEN} \\
\quad\ [\mathit{credits} \mapsto \\
\qquad \mathit{state}[n].\mathit{credits} - \mathit{perDevice} * \mathit{Cardinality}(\mathit{WideEdges}[i]), \\
\quad\ \mathit{totalcredits} \mapsto \mathit{state}[i].\mathit{totalcredits}] \\
\quad \text{ELSE}\ \text{IF}\ i \in \mathit{WideEdges}[n]\ \text{THEN} \\
\quad\ [\mathit{credits} \mapsto \mathit{state}[i].\mathit{credits} + \mathit{perDevice}, \\
\quad\ \mathit{totalcredits} \mapsto \mathit{state}[i].\mathit{totalcredits}] \\
\quad \text{ELSE}\ \mathit{state}[i] \\
\quad] \\
\land\ \mathit{previousStates}' = \mathit{Append}(\mathit{previousStates},\ \mathit{state})
\end{array}
$$

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\begin{array}{l}
\mathit{SendNarrow}(n) \triangleq \quad \land\ n \neq \mathit{Root} \\
\qquad\qquad\qquad\quad \land\ \mathit{state}[n].\mathit{credits} > 0 \\
\qquad\qquad\qquad\quad \land\ \text{LET}\ \mathit{msgCredits} \triangleq (\mathit{state}[n].\mathit{credits} + 1) \div 2 \\
\qquad\qquad\qquad\qquad \text{IN} \quad \mathit{state}' = [i \in 1 \,..\, \mathit{Nodes} \mapsto \\
\qquad\qquad\qquad\qquad\quad \text{IF}\ i = n\ \text{THEN} \\
\qquad\qquad\qquad\qquad\qquad [\mathit{credits} \mapsto \mathit{state}[n].\mathit{credits} - \mathit{msgCredits}, \\
\qquad\qquad\qquad\qquad\qquad\ \mathit{totalcredits} \mapsto \mathit{state}[i].\mathit{totalcredits}] \\
\qquad\qquad\qquad\qquad\quad \text{ELSE}\ \text{IF}\ i \in \mathit{NarrowEdge}[n]\ \text{THEN} \\
\qquad\qquad\qquad\qquad\qquad [\mathit{credits} \mapsto \mathit{state}[i].\mathit{credits} + \mathit{msgCredits}, \\
\qquad\qquad\qquad\qquad\qquad\ \mathit{totalcredits} \mapsto \mathit{state}[i].\mathit{totalcredits}] \\
\qquad\qquad\qquad\qquad\quad \text{ELSE}\ \mathit{state}[i] \\
\qquad\qquad\qquad\qquad] \\
\qquad\qquad\qquad\quad \land\ \mathit{previousStates}' = \mathit{Append}(\mathit{previousStates},\ \mathit{state})
\end{array}
$$

$$
\begin{array}{l}
\mathit{SNext} \triangleq \quad \exists\, n \in 1 \,..\, \mathit{Nodes} : \lor\ \mathit{SendWide}(n) \\
\qquad\qquad\qquad\qquad\qquad\qquad\quad \lor\ \mathit{SendNarrow}(n)
\end{array}
$$

$$
\mathit{SSpec} \triangleq \mathit{SInit} \land \Box[\mathit{SNext}]_{\langle \mathit{state},\ \mathit{Nodes},\ \mathit{WideEdges},\ \mathit{NarrowEdge},\ \mathit{Root} \rangle}
$$

$$
\begin{array}{l}
\mathit{NoLoop} \triangleq \forall\, i \in 1 \,..\, \mathit{Len}(\mathit{previousStates}) : \\
\qquad\qquad \forall\, j \in 1 \,..\, \mathit{Len}(\mathit{previousStates}) : \\
\qquad\qquad\quad \text{IF}\ i \neq j\ \text{THEN} \\
\qquad\qquad\qquad \mathit{previousStates}[i] \neq \mathit{previousStates}[j] \\
\qquad\qquad\quad \text{ELSE}\ \text{TRUE}
\end{array}
$$