ESAxioms^{0,22}

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\begin{array}{l}
\mathrm{ESAxioms}(E;T;M;\\
\qquad\qquad loc;kind;val;\\
\qquad\qquad when;after;\\
\qquad\qquad sends;sender;index;\\
\qquad\qquad first;pred;\\
\qquad\qquad causl)\\
\equiv_{\mathrm{def}}\ (\forall e,\ e'{:}E.\ loc(e) = loc(e') \Rightarrow causl(e,e') \vee e = e' \vee causl(e',e))\\
\qquad \& \ (\forall e{:}E.\ first(e) \Leftrightarrow (\forall e'{:}E.\ loc(e') = loc(e) \Rightarrow \neg causl(e',e)))\\
\qquad \& \ (\forall e{:}E.\\
\qquad\quad \neg first(e)\\
\qquad\quad \Rightarrow loc(pred(e)) = loc(e)\ \&\ causl(pred(e),e)\\
\qquad\qquad \& \ (\forall e'{:}E.\ loc(e') = loc(e) \Rightarrow \neg(causl(pred(e),e')\ \&\ causl(e',e))))\\
\qquad \& \ (\forall e{:}E.\ \neg first(e) \Rightarrow (\forall x{:}\mathrm{Id}.\ when(x,e) = after(x,pred(e))))\\
\qquad \& \ (\mathrm{Trans}\ e,e'{:}E.\ causl(e,e'))\\
\qquad \& \ \mathrm{SWellFounded}(causl(e,e'))\\
\qquad \& \ (\forall e{:}E.\\
\qquad\quad \mathrm{isrcv}(kind(e))\\
\qquad\quad \Rightarrow (sends(\mathrm{lnk}(kind(e)),sender(e)))[index(e)]\\
\qquad\qquad =\\
\qquad\qquad \mathrm{msg}(\mathrm{lnk}(kind(e));\mathrm{tag}(kind(e));val(e)))\\
\qquad \& \ (\forall e{:}E.\ \mathrm{isrcv}(kind(e)) \Rightarrow causl(sender(e),e))\\
\qquad \& \ (\forall e,\ e'{:}E.\\
\qquad\quad causl(e,e')\\
\qquad\quad \Rightarrow \neg first(e')\ \&\ causl(e,pred(e')) \vee e = pred(e')\\
\qquad\qquad \vee\ \mathrm{isrcv}(kind(e'))\ \&\ causl(e,sender(e')) \vee e = sender(e'))\\
\qquad \& \ (\forall e{:}E.\ \mathrm{isrcv}(kind(e)) \Rightarrow loc(e) = \mathrm{destination}(\mathrm{lnk}(kind(e))))\\
\qquad \& \ (\forall e{:}E,\ l{:}\mathrm{IdLnk}.\ \neg loc(e) = \mathrm{source}(l) \Rightarrow sends(l,e) = \mathrm{nil})\\
\qquad \& \ (\forall e,\ e'{:}E.\\
\qquad\quad \mathrm{isrcv}(kind(e))\\
\qquad\quad \Rightarrow \mathrm{isrcv}(kind(e'))\\
\qquad\quad \Rightarrow \mathrm{lnk}(kind(e)) = \mathrm{lnk}(kind(e'))\\
\qquad\quad \Rightarrow (causl(e,e')\\
\qquad\qquad \Leftrightarrow\\
\qquad\qquad causl(sender(e),sender(e')) \vee sender(e) = sender(e')\ \&\ index(e)<index(e')))\\
\qquad \& \ (\forall e{:}E,\ l{:}\mathrm{IdLnk},\ n{:}\mathbb{N}_{<\|sends(l,e)\|}\cdot\\
\qquad\quad \exists e'{:}E.\ \mathrm{isrcv}(kind(e'))\ \&\ \mathrm{lnk}(kind(e')) = l\ \&\ sender(e') = e\ \&\ index(e') = n)
\end{array}
$$

clarification:

$$
\begin{array}{l}
\mathrm{ESAxioms}\{\mathrm{i{:}l}\}\\
\qquad\qquad (E;\ T;\ M;\ loc;\ kind;\ val;\ when;\ after;\ sends;\ sender;\ index;\ first;\ pred;\ causl)\\
\equiv_{\mathrm{def}}\ (\forall e{:}E,\ e'{:}E.\ loc(e) = loc(e') \in \mathrm{Id} \Rightarrow causl(e,e') \vee e = e' \in E \vee causl(e',e))
\end{array}
$$

$$
\begin{array}{l}
\& \ (\forall e{:}E.\ \mathit{first}(e) \Leftrightarrow (\forall e'{:}E.\ \mathit{loc}(e') = \mathit{loc}(e) \in \mathrm{Id} \Rightarrow \neg \mathit{causl}(e',e))) \\
\& \ (\forall e{:}E. \\
\quad \neg \mathit{first}(e) \\
\quad \Rightarrow \mathit{loc}(\mathit{pred}(e)) = \mathit{loc}(e) \in \mathrm{Id}\ \&\ \mathit{causl}(\mathit{pred}(e),e) \\
\qquad \&\ (\forall e'{:}E.\ \mathit{loc}(e') = \mathit{loc}(e) \in \mathrm{Id} \Rightarrow \neg(\mathit{causl}(\mathit{pred}(e),e')\ \&\ \mathit{causl}(e',e)))) \\
\& \ (\forall e{:}E.\ \neg \mathit{first}(e) \Rightarrow (\forall x{:}\mathrm{Id}.\ \mathit{when}(x,e) = \mathit{after}(x,\mathit{pred}(e)) \in T(\mathit{loc}(e),x))) \\
\& \ (\mathrm{Trans}\ e,e'{:}E.\ \mathit{causl}(e,e')) \\
\& \ \mathrm{strongwellfounded}(E;\ e,e'.(\mathit{causl}(e,e'))) \\
\& \ (\forall e{:}E. \\
\quad \mathrm{isrcv}(\mathit{kind}(e)) \\
\quad \Rightarrow (\mathit{sends}(\mathrm{lnk}(\mathit{kind}(e)),\mathit{sender}(e)))[\mathit{index}(e)] \\
\qquad = \\
\qquad \mathrm{msg}(\mathrm{lnk}(\mathit{kind}(e));\mathrm{tag}(\mathit{kind}(e));\mathit{val}(e)) \\
\qquad \in \mathrm{Msg}(M)) \\
\& \ (\forall e{:}E.\ \mathrm{isrcv}(\mathit{kind}(e)) \Rightarrow \mathit{causl}(\mathit{sender}(e),e)) \\
\& \ (\forall e{:}E,\ e'{:}E. \\
\quad \mathit{causl}(e,e') \\
\quad \Rightarrow \neg \mathit{first}(e')\ \&\ \mathit{causl}(e,\mathit{pred}(e'))\ \vee\ e = \mathit{pred}(e') \in E \\
\qquad \vee\ \mathrm{isrcv}(\mathit{kind}(e'))\ \&\ \mathit{causl}(e,\mathit{sender}(e'))\ \vee\ e = \mathit{sender}(e') \in E) \\
\& \ (\forall e{:}E.\ \mathrm{isrcv}(\mathit{kind}(e)) \Rightarrow \mathit{loc}(e) = \mathrm{destination}(\mathrm{lnk}(\mathit{kind}(e))) \in \mathrm{Id}) \\
\& \ (\forall e{:}E,\ l{:}\mathrm{IdLnk}.\ \neg \mathit{loc}(e) = \mathrm{source}(l) \in \mathrm{Id} \Rightarrow \mathit{sends}(l,e) = \mathrm{nil} \in \mathrm{Msg_sub}(l;M)\ \mathrm{List}) \\
\& \ (\forall e{:}E,\ e'{:}E. \\
\quad \mathrm{isrcv}(\mathit{kind}(e)) \\
\quad \Rightarrow \mathrm{isrcv}(\mathit{kind}(e')) \\
\quad \Rightarrow \mathrm{lnk}(\mathit{kind}(e)) = \mathrm{lnk}(\mathit{kind}(e')) \in \mathrm{IdLnk} \\
\quad \Rightarrow (\mathit{causl}(e,e') \\
\qquad \Leftrightarrow \\
\qquad \mathit{causl}(\mathit{sender}(e),\mathit{sender}(e')) \\
\qquad \vee\ \mathit{sender}(e) = \mathit{sender}(e') \in E\ \&\ \mathit{index}(e) < \mathit{index}(e'))) \\
\& \ (\forall e{:}E,\ l{:}\mathrm{IdLnk},\ n{:}\{0..\|\mathit{sends}(l,e)\|^{-}\}. \\
\quad \exists e'{:}E. \\
\quad \mathrm{isrcv}(\mathit{kind}(e')) \\
\quad \&\ \mathrm{lnk}(\mathit{kind}(e')) = l \in \mathrm{IdLnk}\ \&\ \mathit{sender}(e') = e \in E\ \&\ \mathit{index}(e') = n \in \mathbb{Z})
\end{array}
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http://www.cs.cornell.edu/Info/Projects/NuPrl/FDLcontent/p0_286125_/p38_114359_{ESAxioms}.html