MODULE *FarmerPuzzle*

EXTENDS *FiniteSets*, *Naturals*

VARIABLES *LeftSideContents*, *RightSideContents*, *BoatContents*, *EmbarkSide*

$$AllObjects \triangleq \{\text{"Wolf"}, \text{"Goat"}, \text{"Cabbage"}, \text{"Farmer"}\}$$

$$\begin{aligned} WolfEatsGoat \triangleq\ & \lor \{\text{"Wolf"}, \text{"Goat"}\} \subseteq LeftSideContents \land \text{"Farmer"} \notin LeftSideContents \\ & \lor \{\text{"Wolf"}, \text{"Goat"}\} \subseteq RightSideContents \land \text{"Farmer"} \notin RightSideContents \end{aligned}$$

$$\begin{aligned} GoatEatsCabbage \triangleq\ & \lor \{\text{"Goat"}, \text{"Cabbage"}\} \subseteq LeftSideContents \land \text{"Farmer"} \notin LeftSideContents \\ & \lor \{\text{"Cabbage"}, \text{"Goat"}\} \subseteq RightSideContents \land \text{"Farmer"} \notin RightSideContents \end{aligned}$$

$$Safe \triangleq \neg WolfEatsGoat \land \neg GoatEatsCabbage$$

$$\begin{aligned} TypeOK \triangleq\ & \land Cardinality(LeftSideContents) + Cardinality(BoatContents) + Cardinality(RightSideContents) \\ & \land Cardinality(BoatContents) \leq 2 \\ & \land LeftSideContents \subseteq AllObjects \\ & \land BoatContents \subseteq AllObjects \\ & \land RightSideContents \subseteq AllObjects \\ & \land EmbarkSide \in \{\text{"Left"}, \text{"Right"}\} \end{aligned}$$

$$\begin{aligned} Init \triangleq\ & \land LeftSideContents = AllObjects \\ & \land RightSideContents = \{\} \\ & \land BoatContents = \{\} \\ & \land EmbarkSide = \text{"Left"} \end{aligned}$$

$$\begin{aligned} PutOnBoat(obj) \triangleq\ & \land Safe \\ & \land Cardinality(BoatContents) = 0 \lor Cardinality(BoatContents) = 1 \\ & \land BoatContents \subseteq AllObjects \\ & \land \text{IF } EmbarkSide = \text{"Right"} \text{ THEN} \\ & \qquad \land obj \in RightSideContents \\ & \qquad \land RightSideContents' = RightSideContents \setminus \{obj\} \\ & \qquad \land \text{UNCHANGED } LeftSideContents \\ & \quad \text{ELSE} \\ & \qquad \land obj \in LeftSideContents \\ & \qquad \land LeftSideContents' = LeftSideContents \setminus \{obj\} \\ & \qquad \land \text{UNCHANGED } RightSideContents \\ & \land BoatContents' = BoatContents \cup \{obj\} \\ & \land \text{UNCHANGED } \langle EmbarkSide \rangle \end{aligned}$$

$$\begin{aligned} Disembark \triangleq\ & \land Safe \\ & \land \text{"Farmer"} \in BoatContents \\ & \land Cardinality(BoatContents) = 1 \lor Cardinality(BoatContents) = 2 \\ & \land BoatContents \subseteq AllObjects \\ & \land BoatContents' = \{\} \\ & \land \text{IF } EmbarkSide = \text{"Left"} \\ & \quad \text{THEN } \land EmbarkSide' = \text{"Right"} \end{aligned}$$

$$
\begin{array}{ll}
 & \land\ RightSideContents' = RightSideContents \cup BoatContents \\
 & \land\ \text{UNCHANGED}\ \langle LeftSideContents \rangle \\
\text{ELSE} & \land\ EmbarkSide' = \text{“Left”} \\
 & \land\ LeftSideContents' = LeftSideContents \cup BoatContents \\
 & \land\ \text{UNCHANGED}\ \langle RightSideContents \rangle
\end{array}
$$

$$LoadFromLeft \triangleq EmbarkSide = \text{“Left”} \land \exists\, obj \in LeftSideContents : PutOnBoat(obj)$$

$$LoadFromRight \triangleq EmbarkSide = \text{“Right”} \land \exists\, obj \in RightSideContents : PutOnBoat(obj)$$

$$
\begin{array}{ll}
Next \triangleq & \lor\ LoadFromLeft \\
 & \lor\ LoadFromRight \\
 & \lor\ Disembark
\end{array}
$$

$$Spec \triangleq Init \land \Box[Next]_{\langle LeftSideContents,\, RightSideContents,\, BoatContents,\, EmbarkSide \rangle}$$

* Modification History
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