MODULE *ABSpec*

EXTENDS *Integers*

CONSTANT *Data* The set of all possible data values.

VARIABLES *AVar*, The last $\langle value, bit \rangle$ pair A decided to send.
BVar The last $\langle value, bit \rangle$ pair B received.

Type correctness means that *AVar* and *BVar* are tuples $\langle d, i \rangle$ where $d \in Data$ and $i \in \{0, 1\}$.

$$TypeOK \triangleq \begin{array}{l} \land\ AVar \in Data \times \{0, 1\} \\ \land\ BVar \in Data \times \{0, 1\} \end{array}$$

It's useful to define *vars* to be the tuple of all variables, for example so we can write $[Next]\_vars$ instead of $[Next]\_\langle \ldots \rangle$

$$vars \triangleq \langle AVar, BVar \rangle$$

Initially *AVar* can equal $\langle d, 1 \rangle$ for any *Data* value d, and *BVar* equals *AVar*.

$$Init \triangleq \begin{array}{l} \land\ AVar \in Data \times \{1\} \\ \land\ BVar = AVar \end{array}$$

When $AVar = BVar$, the sender can "send" an arbitrary data d item by setting $AVar[1]$ to d and complementing $AVar[2]$. It then waits until the receiver "receives" the message by setting *BVar* to *AVar* before it can send its next message. Sending is described by action A and receiving by action B.

$$A \triangleq \begin{array}{l} \land\ AVar = BVar \\ \land\ \exists\, d \in Data : AVar' = \langle d, 1 - AVar[2] \rangle \\ \land\ BVar' = BVar \end{array}$$

$$B \triangleq \begin{array}{l} \land\ AVar \neq BVar \\ \land\ BVar' = AVar \\ \land\ AVar' = AVar \end{array}$$

$$Next \triangleq A \lor B$$

$$Spec \triangleq Init \land \Box[Next]_{vars}$$

For understanding the spec, it's useful to define formulas that should be invariants and check that they are invariant. The following invariant *Inv* asserts that, if *AVar* and *BVar* have equal second components, then they are equal (which by the invariance of *TypeOK* implies that they have equal first components).

$$Inv \triangleq (AVar[2] = BVar[2]) \Rightarrow (AVar = BVar)$$

FairSpec is *Spec* with the addition requirement that it keeps taking steps.

$$FairSpec \triangleq Spec \land \mathrm{WF}_{vars}(Next)$$

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