MODULE *syncCon2*

EXTENDS *Integers*, *Sequences*, *FiniteSets*, *TLC*

CONSTANT N, *FAILNUM*

ASSUME $N \leq 5 \ \land 0 \leq FAILNUM \land FAILNUM \leq 2$

$Nodes \triangleq 1 \,..\, N$

```
--algorithm syncCon2
{
    variable failNum = FAILNUM,
             up = [n ∈ Nodes ↦ TRUE],
             pt = [n ∈ Nodes ↦ 0],
             t = [n ∈ Nodes ↦ FALSE],
             d = [n ∈ Nodes ↦ -1],
             mb = [n ∈ Nodes ↦ {}],

    define {
    SetMin(S) ≜ CHOOSE i ∈ S : ∀ j ∈ S : i ≤ j
    UpNodes ≜ {n ∈ Nodes : up[n] = TRUE}
    }

    macro Maybefail( ) {
        if ( failNum > 0 ∧ up[self] )
            { either
                { up[self] := FALSE ; failNum := failNum - 1 ; }
              or skip ; } ;

    }

    fair process ( n ∈ Nodes )
    variable v = 0, prev_value = 0, Q = {}, prev_mb_count = 0, ctr = 1 ;
    {

P:  while ( up[self] ∧ ctr > 0 ) {

        if ( pt[self] = 0 ) { v := self ; } ;
        else { v := d[self] } ;
        Q := Nodes ;

PS: while ( up[self] ∧ Q ≠ {} ) {
            with ( p ∈ Q ) {
                mb[p] := mb[p] ∪ {v} ;
                Q := Q \ {p} ;
                Maybefail() ;
            } ;
        } ;

        if ( up[self] ) pt[self] := pt[self] + 1 ;
```

"*prev_mb_count*" keeps

"*prev_value*" stores the

"*ctr*" is the round count

next round is executed w

set the v to self for first

```
PR: await (up[self] = TRUE ∧ (∀ k ∈ UpNodes : pt[self] ≤ pt[k])) ;
    {
        prev_value := d[self] ;
        d[self] := SetMin(mb[self]) ;

          New rounds are needed if:
          CASE 1: decision varies between first and last round
          CASE 2: number of messages varies between current and previous round
        if ( prev_value ≠ d[self] ∨ prev_mb_count ≠ Cardinality(mb[self]) ) ctr := 1 ;
        else ctr := ctr − 1 ;

        prev_mb_count := Cardinality(mb[self]) ;
        mb[self] := {} ;

        if ( ctr = 0 ) t[self] := TRUE ;

     }

     }   end_while
     }     end_process
}
```

BEGIN TRANSLATION

VARIABLES $failNum$, up, pt, t, d, mb, pc

define statement

$SetMin(S) \triangleq$ CHOOSE $i \in S : \forall j \in S : i \leq j$

$UpNodes \triangleq \{n \in Nodes : up[n] = \text{TRUE}\}$

VARIABLES v, $prev\_value$, Q, $prev\_mb\_count$, ctr

$vars \triangleq \langle failNum,\ up,\ pt,\ t,\ d,\ mb,\ pc,\ v,\ prev\_value,\ Q,\ prev\_mb\_count,\ ctr\rangle$

$ProcSet \triangleq (Nodes)$

$Init \triangleq$ Global variables

$\land\ failNum = FAILNUM$
$\land\ up = [n \in Nodes \mapsto \text{TRUE}]$
$\land\ pt = [n \in Nodes \mapsto 0]$
$\land\ t = [n \in Nodes \mapsto \text{FALSE}]$
$\land\ d = [n \in Nodes \mapsto -1]$
$\land\ mb = [n \in Nodes \mapsto \{\}]$

Process n

$\land\ v = [self \in Nodes \mapsto 0]$
$\land\ prev\_value = [self \in Nodes \mapsto 0]$
$\land\ Q = [self \in Nodes \mapsto \{\}]$
$\land\ prev\_mb\_count = [self \in Nodes \mapsto 0]$
$\land\ ctr = [self \in Nodes \mapsto 1]$

$\land\ pc = [self \in ProcSet \mapsto \text{“P”}]$

$P(self) \triangleq$
$\land\ pc[self] = \text{“P”}$
$\land$ IF $up[self] \land ctr[self] > 0$
THEN $\land$ IF $pt[self] = 0$
THEN $\land\ v' = [v$ EXCEPT $![self] = self]$
ELSE $\land\ v' = [v$ EXCEPT $![self] = d[self]]$
$\land\ Q' = [Q$ EXCEPT $![self] = Nodes]$
$\land\ pc' = [pc$ EXCEPT $![self] = \text{“PS”}]$
ELSE $\land\ pc' = [pc$ EXCEPT $![self] = \text{“Done”}]$
$\land\ pt' = pt$
$\land$ UNCHANGED $\langle v,\ Q\rangle$
$\land$ UNCHANGED $\langle failNum,\ up,\ pt,\ t,\ d,\ mb,\ prev\_value,$
$prev\_mb\_count,\ ctr\rangle$

$PS(self) \triangleq$
$\land\ pc[self] = \text{“PS”}$
$\land$ IF $up[self] \land Q[self] \neq \{\}$
THEN $\land\ \exists\, p \in Q[self]:$
$\land\ mb' = [mb$ EXCEPT $![p] = mb[p] \cup \{v[self]\}]$
$\land\ Q' = [Q$ EXCEPT $![self] = Q[self] \setminus \{p\}]$
$\land$ IF $failNum > 0 \land up[self]$
THEN $\land\ \lor\ \land\ up' = [up$ EXCEPT $![self] = \text{FALSE}]$
$\land\ failNum' = failNum - 1$
$\lor\ \land$ TRUE
$\land$ UNCHANGED $\langle failNum,\ up\rangle$
ELSE $\land$ TRUE
$\land$ UNCHANGED $\langle failNum,\ up\rangle$
$\land\ pc' = [pc$ EXCEPT $![self] = \text{“PS”}]$
$\land\ pt' = pt$
ELSE $\land$ IF $up[self]$
THEN $\land\ pt' = [pt$ EXCEPT $![self] = pt[self] + 1]$
ELSE $\land$ TRUE
$\land\ pt' = pt$
$\land\ pc' = [pc$ EXCEPT $![self] = \text{“PR”}]$
$\land$ UNCHANGED $\langle failNum,\ up,\ mb,\ Q\rangle$
$\land$ UNCHANGED $\langle t,\ d,\ v,\ prev\_value,\ prev\_mb\_count,\ ctr\rangle$

$PR(self) \triangleq$
$\land\ pc[self] = \text{“PR”}$
$\land\ (up[self] = \text{TRUE} \land (\forall\, k \in UpNodes : pt[self] \leq pt[k]))$
$\land\ prev\_value' = [prev\_value$ EXCEPT $![self] = d[self]]$
$\land\ d' = [d$ EXCEPT $![self] = SetMin(mb[self])]$
$\land$ IF $prev\_value'[self] \neq d'[self] \lor prev\_mb\_count[self] \neq Cardinality(mb[self])$
THEN $\land\ ctr' = [ctr$ EXCEPT $![self] = 1]$
ELSE $\land\ ctr' = [ctr$ EXCEPT $![self] = ctr[self] - 1]$
$\land\ prev\_mb\_count' = [prev\_mb\_count$ EXCEPT $![self] = Cardinality(mb[self])]$
$\land\ mb' = [mb$ EXCEPT $![self] = \{\}]$
$\land$ IF $ctr'[self] = 0$

$$
\begin{array}{l}
\quad \text{THEN} \ \ \land\, t' = [t \ \text{EXCEPT} \ ![self] = \text{TRUE}] \\
\quad \text{ELSE} \ \ \land\, \text{TRUE} \\
\qquad\qquad \land\, t' = t \\
\land\, pc' = [pc \ \text{EXCEPT} \ ![self] = \text{“P”}] \\
\land\, \text{UNCHANGED} \ \langle failNum,\ up,\ pt,\ v,\ Q \rangle
\end{array}
$$

$$n(self) \triangleq P(self) \lor PS(self) \lor PR(self)$$

$$
\begin{array}{l}
Next \triangleq (\exists\, self \in Nodes : n(self)) \\
\qquad \lor \ \text{Disjunct to prevent deadlock on termination} \\
\qquad\quad ((\forall\, self \in ProcSet : pc[self] = \text{“Done”}) \land \text{UNCHANGED} \ vars)
\end{array}
$$

$$
\begin{array}{l}
Spec \triangleq \ \land\, Init \land \Box[Next]_{vars} \\
\qquad\quad \land\, \forall\, self \in Nodes : \mathrm{WF}_{vars}(n(self))
\end{array}
$$

$$Termination \triangleq \Diamond(\forall\, self \in ProcSet : pc[self] = \text{“Done”})$$

END TRANSLATION

$$Inv \triangleq \forall\, i, j \in Nodes : (t[i] \land t[j]) \Rightarrow (d[i] = d[j])$$

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