MODULE *sema*

sema - available initially

for process 1 and 2

```
0 : while(true){
1 :     //Non − critical section
2 :     Request(sema)
3 :     //Critical section
4 :     Release(sema)
5 : }

Request(sema){
   while(True){
      if(sema ≜ available){
         sema = busy;
         break;
      }
   }

//if statement till break is atomic

Release(sema){
   sema = available
}
```

EXTENDS *Integers*
VARIABLES $s0$, $s1$, *sema*

$Init0 \triangleq$
$\land\ sema =$ "available"
$\land\ s0 = 0$

$Init1 \triangleq$
$\land\ sema =$ "available"
$\land\ s1 = 1$

$Init \triangleq Init0 \land Init1$

$P01 \triangleq$
$\land\ s0 = 0$
$\land\ s0' = 1$
$\land$ UNCHANGED *sema*

$P12 \triangleq$
$\land\ s0 = 1$
$\land\ s0' = 2$
$\land$ UNCHANGED *sema*

$P22 \triangleq$
$\land\ s0 = 2$

$\land\ s0' = 2$
$\land\ sema = \text{“busy”}$
$\land\ sema' = \text{“busy”}$

$P23\ \triangleq$
$\land\ s0 = 2$
$\land\ s0' = 3$
$\land\ sema = \text{“available”}$
$\land\ sema = \text{“busy”}$

$P34\ \triangleq$
$\land\ s0 = 3$
$\land\ s0' = 4$
$\land\ \text{UNCHANGED}\ sema$

$P45\ \triangleq$
$\land\ s0 = 4$
$\land\ s0' = 5$
$\land\ sema' = \text{“available”}$

$P50\ \triangleq$
$\land\ s0 = 5$
$\land\ s0' = 5$
$\land\ \text{UNCHANGED}\ sema$

$Next0\ \triangleq$
$\lor\ P01$
$\lor\ P12$
$\lor\ P22$
$\lor\ P23$
$\lor\ P34$
$\lor\ P45$
$\lor\ P50$

$Q01\ \triangleq$
$\land\ s1 = 0$
$\land\ s1' = 1$
$\land\ \text{UNCHANGED}\ sema$

$Q12\ \triangleq$
$\land\ s1 = 1$
$\land\ s1' = 2$
$\land\ \text{UNCHANGED}\ sema$

$Q22\ \triangleq$
$\land\ s1 = 2$
$\land\ s1' = 2$

$\land\ sema = \text{“busy”}$
$\land\ sema' = \text{“busy”}$

$Q23 \triangleq$
$\land\ s1 = 2$
$\land\ s1' = 3$
$\land\ sema = \text{“available”}$
$\land\ sema = \text{“busy”}$

$Q34 \triangleq$
$\land\ s1 = 3$
$\land\ s1' = 4$
$\land\ \text{UNCHANGED}\ sema$

$Q45 \triangleq$
$\land\ s1 = 4$
$\land\ s1' = 5$
$\land\ sema' = \text{“available”}$

$Q50 \triangleq$
$\land\ s1 = 5$
$\land\ s1' = 5$
$\land\ \text{UNCHANGED}\ sema$

$Next1 \triangleq$
$\lor\ Q01$
$\lor\ Q12$
$\lor\ Q22$
$\lor\ Q23$
$\lor\ Q34$
$\lor\ Q45$
$\lor\ Q50$

$SLOGP \triangleq \text{UNCHANGED}\ s0$
$SLOGQ \triangleq \text{UNCHANGED}\ s1$

$Next \triangleq (Next0 \land \text{UNCHANGED}\ s1) \lor (Next1 \land \text{UNCHANGED}\ s0) \lor SLOGP \lor SLOGQ$

Video 9 for Justice conditions
The terminology in the video is, Weak Fairness (in TLA+ world, not exactly Justice Conditions)

Justice conditions

$J \triangleq$
$\land\ \neg(s0 = 0)$
$\land\ \neg(s0 = 3)$
$\land\ \neg(s0 = 4)$
$\land\ \neg(s0 = 5)$

$\land \neg(s1 = 0)$
$\land \neg(s1 = 3)$
$\land \neg(s1 = 4)$
$\land \neg(s1 = 5)$
$\land \neg(s0 = 2 \land sema = \text{“available”})$
$\land \neg(s1 = 2 \land sema = \text{“available”})$

but the problem with this is bounded weight need not be satisfied only with the first 10 justice conditions
ie, one process can starve even if we assume fair scheduler

hence we need compassion conditions

$P0 \triangleq s0 = 2 \land sema = \text{“available”}$
$Q0 \triangleq s0 \neq 2$

$P1 \triangleq s1 = 2 \land sema = \text{“available”}$
$Q1 \triangleq s1 \neq 2$

with this compassion condition, we can show no starvation occurs
$i.e$ if $P0$ wants to enter critical section ($i.e$ it performs $request(sema)$, then
eventually, $P0$ will be allowed in critical section

Similarly for $P1$

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