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1  |----- MODULE AbsJupiter -----|
   | Abstract Jupiter, inspired by the COT algorithm proposed by Sun and Sun. See their paper |
   | published on TPDS'2009. |
6  | EXTENDS JupiterSerial |
7  |-----|
8  VARIABLES
9      cseq,      cseq[c]: local sequence number at client c ∈ client
10     ds,         ds[r]: document state at replica r ∈ Replica
11     copss       copss[r]: the state space (i.e., a set) of Cops maintained at replia r ∈ Replica
13  vars  $\triangleq$   $\langle \text{intVars}, \text{serialVars}, \text{cseq}, \text{ds}, \text{copss} \rangle$ 
14  |-----|
15  TypeOK  $\triangleq$ 
16       $\wedge$  TypeOKInt
17       $\wedge$  TypeOKSerial
18       $\wedge$  Comm(Cop)! TypeOK
19       $\wedge$  cseq ∈ [Client → Nat]
20       $\wedge$  ds ∈ [Replica → SUBSET Oid]
21       $\wedge$  copss ∈ [Replica → SUBSET Cop]
22  |-----|
23  Init  $\triangleq$ 
24       $\wedge$  InitInt
25       $\wedge$  InitSerial
26       $\wedge$  Comm(Cop)! Init
27       $\wedge$  cseq = [c ∈ Client ↦ 0]
28       $\wedge$  ds = [r ∈ Replica ↦ {}]
29       $\wedge$  copss = [r ∈ Replica ↦ {}]
30  |-----|
31  RECURSIVE xForm(-, -)
32  xForm(cop, r)  $\triangleq$ 
33      LET ctxDiff  $\triangleq$  ds[r] \ cop.ctx THEOREM : cop.ctx ⊆ ds[r]
34      RECURSIVE xFormHelper(-, -, -)
35          xFormHelper(coph, ctxDiff, copssr)  $\triangleq$  'h' stands for "helper"
36          IF ctxDiff = {}
37              THEN  $\langle \text{coph}, \text{copssr} \cup \{\text{coph}\} \rangle$ 
38          ELSE LET foph  $\triangleq$  CHOOSE op ∈ ctxDiff : the first op (specifically, oid) in serial
39                       $\forall \text{opprime} \in \text{ctxDiff} :$ 
40                      opprime ≠ op ⇒ tb(op, opprime, serial[r])
41                      fcophDict  $\triangleq$  {op ∈ copssr : op.oid = foph ∧ op.ctx = coph.ctx}
42                      fcoph  $\triangleq$  CHOOSE op ∈ fcophDict : TRUE THEOREM : Cardinality(fcophDict) = 1
43                      cophx  $\triangleq$  COT(coph, fcoph)
44                      fcophx  $\triangleq$  COT(fcoph, coph)
45                      IN xFormHelper(cophx, ctxDiff \ {foph}, copssr ∪ {cophx, fcophx})
46  IN xFormHelper(cop, ctxDiff, copss[r])

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48  $Perform(cop, r) \triangleq$ 
49   LET  $xform \triangleq xForm(cop, r)$   $\langle xcop, xcopss \rangle$ 
50      $xcop \triangleq xform[1]$ 
51      $xcopssr \triangleq xform[2]$ 
52   IN    $\wedge state' = [state \text{ EXCEPT } ![r] = Apply(xcop.op, @)]$ 
53      $\wedge ds' = [ds \text{ EXCEPT } ![r] = @ \cup \{cop.oid\}]$ 
54      $\wedge copss' = [copss \text{ EXCEPT } ![r] = xcopssr]$ 
55 |-----|
56 | Client  $c \in Client$  issues an operation  $op$ . |
57 |-----|
58  $DoOp(c, op) \triangleq$   $op$ : the raw operation generated by the client  $c \in Client$ 
59    $\wedge cseq' = [cseq \text{ EXCEPT } ![c] = @ + 1]$ 
60    $\wedge$  LET  $cop \triangleq [op \mapsto op, oid \mapsto [c \mapsto c, seq \mapsto cseq'[c]], ctx \mapsto ds[c]]$ 
61   IN    $\wedge Perform(cop, c)$ 
62    $\wedge Comm(Cop)!CSend(cop)$ 
63
64  $DoIns(c) \triangleq$ 
65    $\exists ins \in \{op \in Ins : op.pos \in 1 \dots (Len(state[c]) + 1) \wedge op.ch \in chins \wedge op.pr = Priority[c]\} :$ 
66    $\wedge DoOp(c, ins)$ 
67    $\wedge chins' = chins \setminus \{ins.ch\}$   $\text{We assume that all inserted elements are unique.}$ 
68
69  $DoDel(c) \triangleq$ 
70    $\exists del \in \{op \in Del : op.pos \in 1 \dots Len(state[c])\} :$ 
71    $\wedge DoOp(c, del)$ 
72    $\wedge UNCHANGED chins$ 
73
74  $Do(c) \triangleq$ 
75    $\wedge DoSerial(c)$ 
76    $\wedge \vee DoIns(c)$ 
77    $\vee DoDel(c)$ 
78
79 |-----|
80  $Rev(c) \triangleq$ 
81    $\wedge Comm(Cop)!CRev(c)$ 
82    $\wedge Perform(Head(cincoming[c]), c)$ 
83    $\wedge RevSerial(c)$ 
84    $\wedge UNCHANGED \langle chins, cseq \rangle$ 
85
86 |-----|
87  $SRev \triangleq$ 
88    $\wedge Comm(Cop)!SRev$ 
89    $\wedge$  LET  $cop \triangleq Head(sincoming)$ 
90   IN    $\wedge Perform(cop, Server)$ 
91    $\wedge Comm(Cop)!SSendSame(cop.oid.c, cop)$ 
92    $\wedge SRevSerial$ 
93    $\wedge UNCHANGED \langle chins, cseq \rangle$ 
94
95 |-----|
96  $Next \triangleq$ 
97    $\vee \exists c \in Client : Do(c) \vee Rev(c)$ 

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96       $\vee SRev$ 
97
98       $Fairness \triangleq$ 
99       $WF_{vars}(SRev \vee \exists c \in Client : Rev(c))$ 
100
101       $Spec \triangleq Init \wedge \Box[Next]_{vars} \quad \text{\textcolor{gray}{ $\wedge Fairness$ }}$ 
102  |
    \ * Modification History
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