MODULE *Config*

EXTENDS
Northbound,
Transaction,
Proposal,
Configuration,
Southbound

INSTANCE *Naturals*

INSTANCE *FiniteSets*

INSTANCE *Sequences*

LOCAL INSTANCE *TLC*

$vars \triangleq \langle transaction, proposal, configuration, mastership, target \rangle$

Formal specification, constraints, and theorems.

$Init \triangleq$
$\land\ InitTransaction$
$\land\ InitProposal$
$\land\ InitConfiguration$
$\land\ InitNorthbound$
$\land\ InitSouthbound$

$Next \triangleq$
$\lor\ \land\ NextTransaction$
$\quad\land$ UNCHANGED $\langle configuration, target, mastership \rangle$
$\lor\ \land\ NextProposal$
$\quad\land$ UNCHANGED $\langle transaction \rangle$
$\lor\ \land\ NextConfiguration$
$\quad\land$ UNCHANGED $\langle transaction, proposal \rangle$
$\lor\ \land\ NextNorthbound$
$\quad\land$ UNCHANGED $\langle proposal, configuration, target, mastership \rangle$
$\lor\ \land\ NextSouthbound$
$\quad\land$ UNCHANGED $\langle transaction, proposal, configuration \rangle$

$Spec \triangleq Init \land \Box[Next]_{vars} \land \mathrm{WF}_{vars}(Next)$

$Order \triangleq$
$\forall\, t \in$ DOMAIN $proposal :$
$\forall\, i \in$ DOMAIN $proposal[t] :$
$\land\ \land\ proposal[t][i].phase = ProposalCommit$
$\quad\land\ proposal[t][i].state\ = ProposalInProgress$

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        ⇒ ¬∃ j ∈ DOMAIN proposal[t] :
                ∧ j > i
                ∧ proposal[t][j].phase = ProposalCommit
                ∧ proposal[t][j].state  = ProposalComplete
    ∧ ∧ proposal[t][i].phase = ProposalApply
      ∧ proposal[t][i].state  = ProposalInProgress
      ⇒ ¬∃ j ∈ DOMAIN proposal[t] :
                ∧ j > i
                ∧ proposal[t][j].phase = ProposalApply
                ∧ proposal[t][j].state  = ProposalComplete

Consistency ≜
  ∀ t ∈ DOMAIN target :
    LET
        Compute the transaction indexes that have been applied to the target
      targetIndexes ≜ {i ∈ DOMAIN transaction :
                          ∧ i ∈ DOMAIN proposal[t]
                          ∧ proposal[t][i].phase = ProposalApply
                          ∧ proposal[t][i].state  = ProposalComplete
                          ∧ t ∈ DOMAIN transaction[i].targets
                          ∧ ¬∃ j ∈ DOMAIN transaction :
                                ∧ j > i
                                ∧ transaction[j].type = TransactionRollback
                                ∧ transaction[j].rollback = i
                                ∧ transaction[j].phase = TransactionApply
                                ∧ transaction[j].state  = TransactionComplete}
        Compute the set of paths in the target that have been updated by transactions
      appliedPaths  ≜ UNION {DOMAIN proposal[t][i].change.values : i ∈ targetIndexes}
        Compute the highest index applied to the target for each path
      pathIndexes   ≜ [p ∈ appliedPaths ↦ CHOOSE i ∈ targetIndexes :
                                ∀ j ∈ targetIndexes :
                                  ∧ i ≥ j
                                  ∧ p ∈ DOMAIN proposal[t][i].change.values]
        Compute the expected target configuration based on the last indexes applied
        to the target for each path.
      expectedConfig ≜ [p ∈ DOMAIN pathIndexes ↦ proposal[t][pathIndexes[p]].change.values[p]]
    IN
      target[t] = expectedConfig

Isolation ≜
  ∀ i ∈ DOMAIN transaction :
    ∧ ∧ transaction[i].phase = TransactionCommit
      ∧ transaction[i].state  = TransactionInProgress
      ∧ transaction[i].isolation = Serializable
      ⇒ ¬∃ j ∈ DOMAIN transaction :
```

$\land\ j > i$
$\land$ DOMAIN $transaction[j].targets \cap$ DOMAIN $transaction[i].targets \neq \{\}$
$\land\ transaction[j].phase = TransactionCommit$

$\land\ \land\ transaction[i].phase = TransactionApply$
$\land\ transaction[i].state\ = TransactionInProgress$
$\land\ transaction[i].isolation = Serializable$
$\Rightarrow \neg\exists\, j \in$ DOMAIN $transaction :$
$\land\ j > i$
$\land$ DOMAIN $transaction[j].targets \cap$ DOMAIN $transaction[i].targets \neq \{\}$
$\land\ transaction[j].phase = TransactionApply$

$Safety \triangleq \Box(Order \land Consistency \land Isolation)$

THEOREM $Spec \Rightarrow Safety$

$Terminated(i) \triangleq$
$\land\ i \in$ DOMAIN $transaction$
$\land\ transaction[i].phase \in \{TransactionApply,\ TransactionAbort\}$
$\land\ transaction[i].state\ = TransactionComplete$

$Termination \triangleq$
$\forall\, i \in 1\,..\,Len(transaction) : Terminated(i)$

$Liveness \triangleq \Diamond Termination$

THEOREM $Spec \Rightarrow Liveness$

* Modification History
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