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1  ---------- MODULE StateSpace ----------
   The graph representation of n-ary ordered state space and 2D state space used in CJupiter and
   XJupiter, respectively.
6  EXTENDS JupiterCtx, GraphsUtil
7  ----------
8  IsSS(G) ≜  A state space is a digraph with labeled edges.
9      ∧ IsGraph(G)  It is a digraph (represented by a record).
10     ∧ G.node ⊆ (SUBSET Oid)  Each node is characterized by its context, a set of operations.
11     ∧ G.edge ⊆ [from : G.node, to : G.node, cop : Cop]  Each edge is labeled with an operation.

13 EmptySS ≜ EmptyGraph
14 ----------
15 Locate(cop, ss) ≜  Locate the (unique) node in state space ss that matches the context ctx of cop.
16     CHOOSE n ∈ ss.node : n = cop.ctx

18 xFormSS(cop, copprime) ≜  Transform cop against copprime on state space.
19     LET u ≜ cop.ctx  Return the extra state space.
20         v ≜ u ∪ {cop.oid}
21         uprime ≜ u ∪ {copprime.oid}
22         vprime ≜ u ∪ {cop.oid, copprime.oid}
23         cop2copprime ≜ COT(cop, copprime)
24         copprime2cop ≜ COT(copprime, cop)
25     IN  [node ↦ {u, v, uprime, vprime},
26          edge ↦ {[from ↦ u, to ↦ v, cop ↦ cop],
27                  [from ↦ u, to ↦ uprime, cop ↦ copprime],
28                  [from ↦ v, to ↦ vprime, cop ↦ copprime2cop],
29                  [from ↦ uprime, to ↦ vprime, cop ↦ cop2copprime]}]

31 xFormCopCopsSS(cop, cops) ≜  Transform cop against cops (a sequence of cops) on state space.
32     LET RECURSIVE xFormCopCopsSSHelper(_, _, _)  Return the extra state space.
33         xFormCopCopsSSHelper(coph, copsh, xss) ≜  xss: the eXtra state space
34             LET u ≜ coph.ctx
35                 v ≜ u ∪ {coph.oid}
36                 uvSS ≜ [node ↦ {u, v}, edge ↦ {[from ↦ u, to ↦ v, cop ↦ coph]}]
37             IN  IF copsh = ⟨⟩ THEN [lss ↦ uvSS, xss ↦ xss ⊕ uvSS]
38                 ELSE LET copprimeh ≜ Head(copsh)
39                          uprime ≜ u ∪ {copprimeh.oid}
40                          vprime ≜ u ∪ {coph.oid, copprimeh.oid}
41                          coph2copprimeh ≜ COT(coph, copprimeh)
42                          copprimeh2coph ≜ COT(copprimeh, coph)
43                      IN  xFormCopCopsSSHelper(coph2copprimeh, Tail(copsh),
44                              xss ⊕ [node ↦ {u, v},
45                                     edge ↦ {[from ↦ u, to ↦ v, cop ↦ coph],
46                                             [from ↦ u, to ↦ uprime, cop ↦ copprimeh],
47                                             [from ↦ v, to ↦ vprime, cop ↦ copprimeh2coph]}])
48     IN  xFormCopCopsSSHelper(cop, cops, EmptySS)
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49 └──────────────────────────────────────────────────────────────────────┘
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