Model: Neo election protocol
Type: Colored Net (with derived P/T Nets)
Origin: Industrial (Nexedi)

since
MCC 2012

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This form is a summary description of the model entitled "Neo election protocol" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together with property files (possibly, one per model instance) giving a set of properties to be checked on the model.

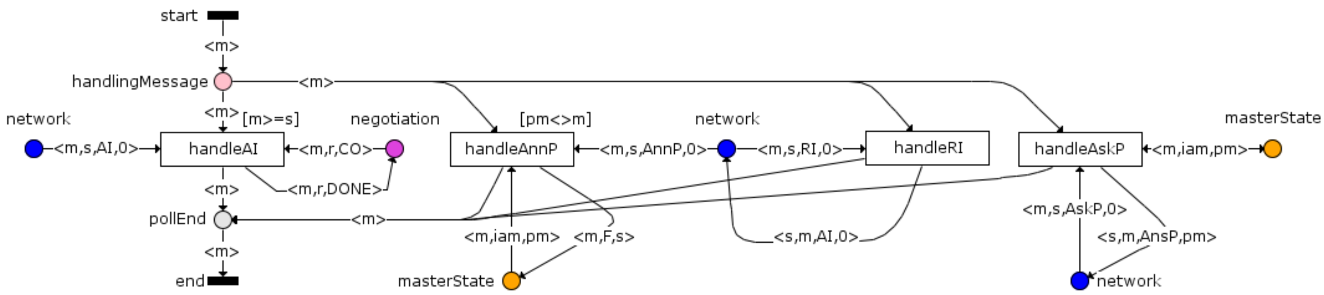
Description

The Neo protocol aims at managing large distributed databases on clusters of workstations. The machines on the cluster may have several roles. This model focusses on master nodes which handle the communications between all nodes, and in particular requests for accessing database objects. Prior to that all master nodes agree on a primary master which will be the operating one, the other master nodes being secondary, waiting to replace the primary master if needed.

The Petri net of this case study models the election protocol which has the particularity of allowing dynamic joining and leaving the cluster. The sub-net represented in the figure models a part of the procedure used by network nodes to handle incoming messages.

A detailed description is given in the referenced paper.

In March 2020, Pierre Bouvier and Hubert Garavel provided a decomposition of three instances of this model into networks of communicating automata. Each network is expressed as a Nested-Unit Petri Net (NUPN) that can be found, for each instance, in the "toolspecific" section of the corresponding PNML file. In April 2021, Pierre Bouvier decomposed all the remaining instances of this model.



References

http://www-lipn.univ-paris13.fr/~petrucci/PAPERS/61280145.pdf

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	number of network nodes participating to the election	2, 3, 4, 5, 6, 7, and 8

Size of the colored net model

number of places:	18
number of transitions:	22
number of arcs:	98

generated on January 2, 2024

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Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 2$	438	357	1998	15	1–14–25
$N = 3$	972	1016	5840	31	1–30–53
$N = 4$	1830	2340	13565	53	1–52–93
$N = 5$	3090	4674	27162	81	1–80–141
$N = 6$	4830	8435	49028	115	1–114–199
$N = 7$	7128	14112	81968	155	1–154–266
$N = 8$	10062	22266	129195	201	1–200–344

Structural properties

ordinary — *all arcs have multiplicity one* ✔
simple free choice — *all transitions sharing a common input place have no other input place* ✗ [(a)]
extended free choice — *all transitions sharing a common input place have the same input places* ✗ [(b)]
state machine — *every transition has exactly one input place and exactly one output place* ✗ [(c)]
marked graph — *every place has exactly one input transition and exactly one output transition* ✗ [(d)]
connected — *there is an undirected path between every two nodes (places or transitions)* ✗ [(e)]
strongly connected — *there is a directed path between every two nodes (places or transitions)* ✗ [(f)]
source place(s) — *one or more places have no input transitions* ✔ [(g)]
sink place(s) — *one or more places have no output transitions* ✔ [(h)]
source transition(s) — *one or more transitions have no input places* ✗ [(i)]
sink transitions(s) — *one or more transitions have no output places* ✗ [(j)]
loop-free — *no transition has an input place that is also an output place* ✗ [(k)]
conservative — *for each transition, the number of input arcs equals the number of output arcs* ✗ [(l)]
subconservative — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ✗ [(m)]
nested units — *places are structured into hierarchically nested sequential units* [(n)] ✔

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* ✔ [(o)]
dead place(s) — *one or more places have no token in any reachable marking* ✔ [(p)]
dead transition(s) — *one or more transitions cannot fire from any reachable marking* ✔ [(q)]
deadlock — *there exists a reachable marking from which no transition can be fired* ✔ [(r)]

[(a)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(b)] transitions "T-startNeg__send_1" and "T-sendAnnPs__send_1" share a common input place "P-masterList_0_1_0", but only the former transition has input place "P-negotiation_0_0_NONE".
[(c)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(d)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(e)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(f)] the net is not connected and, thus, not strongly connected.
[(g)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(h)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(i)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(j)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(k)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(l)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(m)] stated by CÆSAR.BDD version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(n)] the definition of Nested-Unit Petri Nets (NUPN) is available from `http://mcc.lip6.fr/nupn.php`
[(o)] stated by CÆSAR.BDD version 3.5 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(p)] stated by CÆSAR.BDD version 3.3 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(q)] stated by CÆSAR.BDD version 2.0 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).
[(r)] stated by CÆSAR.BDD version 2.0 to be true on 2 instance(s) out of 7, and unknown on the remaining 7 instance(s); confirmed at MCC'2014 by Helena on all colored instances, and by Lola and Tapaal on (almost) all P/T instances.

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reversible — *from every reachable marking, there is a transition path going back to the initial marking* .... ✗ [(s)]
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* .... ✗ [(t)]

Size of the marking graphs

Parameter	Number of reachable markings	Number of transition firings	Max. number of tokens per place	Max. number of tokens per marking
$N = 2$	241 [(u)]	448 [(v)]	1 [(w)]	14 [(x)]
$N = 3$	974 325 [(y)]	3.5991E+6 [(z)]	1 [(aa)]	30 [(ab)]
$N = 4$	2.9191E+11 [(ac)]	?	1 [(ad)]	52 [(ae)]
$N = 5$	6.3570E+18 [(af)]	?	1 [(ag)]	80
$N = 6$	$\geq$ 531441 [(ah)]	?	1 [(ai)]	114
$N = 7$	$\geq$ 128 [(aj)]	?	1 [(ak)]	154
$N = 8$	$\geq$ 256 [(al)]	?	1 [(am)]	200

Other properties

When analyzing the unfolded place-transition nets, the CÆSAR.BDD tool found a high number of source places, of sink places, of places that never get a token in any reachable marking, and of transitions that are not quasi-live. This is due to the particular tool that has been used to produce these unfolded nets.

(s) the marking graph has deadlocks and contains more than one reachable marking.
(t) the net has dead transitions.
(u) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by CÆSAR.BDD 1.8; confirmed at MCC'2014 by Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, PNXDD; Stratagem, and Tapaal on the P/T net instance.
(v) computed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.
(w) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.
(x) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.
(y) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, and PNXDD; confirmed by CÆSAR.BDD 1.8; confirmed at MCC'2014 by Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, and PNXDD on the P/T net instance.
(z) computed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.
(aa) computed at MCC'2014 by GreatSPN, Marcie, and PNMC.
(ab) computed at MCC'2014 by GreatSPN, Marcie, and PNMC.
(ac) computed at MCC'2013 by GreatSPN, ITS-Tools, and PNXDD; confirmed at MCC'2014 by PNMC and PNXDD.
(ad) computed at MCC'2014 by PNMC.
(ae) computed at MCC'2014 by PNMC.
(af) computed at MCC'2014 by PNMC.
(ag) the P/T instance is safe.
(ah) stated by CÆSAR.BDD version 3.5.
(ai) the P/T instance is safe.
(aj) stated by CÆSAR.BDD version 3.5.
(ak) the P/T instance is safe.
(al) stated by CÆSAR.BDD version 3.5.
(am) the P/T instance is safe.