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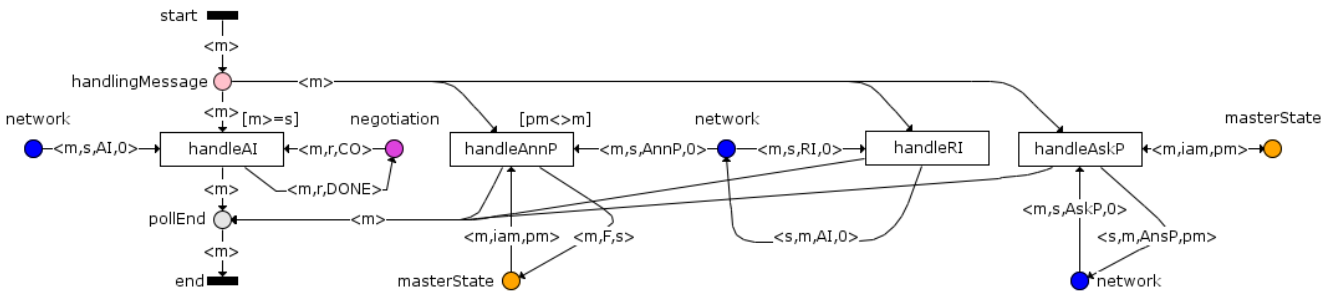
This form is a summary description of the model entitled "Neo election protocol" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are 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.



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, 8, 9, 10

Size of the colored net model

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

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Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs
$N = 2$	438	357	1998
$N = 3$	972	1016	5840
$N = 4$	1830	2340	13565
$N = 5$	3090	4674	27162
$N = 6$	4830	8435	49028
$N = 7$	7128	14112	81968
$N = 8$	10062	22266	129195
$N = 9$	13710	33530	194330
$N = 10$	18150	48609	281402

Structural properties

free choice — *all (different) transitions with a shared input place have no other input place* ✗ (a)
state machine — *every transition has exactly one input place and exactly one output place* ✗ (b)
marked graph — *every place has exactly one input transition and exactly one output transition* ✗ (c)
connected — *there is a undirected path between every two nodes (places or transitions)* ✗ (d)
strongly connected — *there is a directed path between every two nodes (places or transitions)* ✗ (e)
source place(s) — *one or more places have no input transitions* ✓ (f)
sink place(s) — *one or more places have no output transitions* ✓ (g)
source transition(s) — *one or more transitions have no input places* ✗ (h)
sink transitions(s) — *one or more transitions have no output places* ✗ (i)
loop-free — *no transition has an input place that is also an output place* ✗ (j)
conservative — *for each transition, the number of input arcs equals the number of output arcs* ✗ (k)
subconservative — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ✗ (l)

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* ✓ (m)
deadlock — *there exists a reachable marking from which no transition can be fired* ✓ (n)
reversible — *from every reachable marking, there is a transition path going back to the initial marking* ✗ (o)
quasi-live — *for every transition t, there exists a reachable marking in which t can fire* ✗ (p)
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ✗ (q)

(a) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(b) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(c) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(d) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(e) the net is not connected and, thus, not strongly connected.
(f) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(g) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(h) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(i) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(j) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(k) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(l) stated by CÆSAR.BDD version 1.7 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(m) stated by CÆSAR.BDD version 2.0 to be true on 2 instance(s) out of 9, and unknown on the remaining 7 instance(s).
(n) stated by CÆSAR.BDD version 2.0 to be true on 2 instance(s) out of 9, and unknown on the remaining 7 instance(s).
(o) the marking graph has deadlocks and contains more than one reachable marking.
(p) stated by CÆSAR.BDD version 2.0 on all 9 instances (2, 3, 4, 5, 6, 7, 8, 9, and 10).
(q) the net is not quasi-live and, thus, not live.

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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 [r]	?	1	$\in [12, 438]$ [s]
$N = 3$	974 325 [t]	?	1	$\in [24, 972]$
$N = 4$	2.919×10^{11} [u]	?	?	≥ 40 [v]
$N = 5$	?	?	?	≥ 60
$N = 6$	?	?	?	≥ 84
$N = 7$	?	?	?	≥ 112
$N = 8$	?	?	?	≥ 144
$N = 9$	?	?	?	≥ 180
$N = 10$	?	?	?	≥ 220

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.

[r] Computed by alpina, ITS-Tools, marcie, neco, and pnxdd at MCC'2013; confirmed by CÆSAR.BDD 1.8.
[s] lower and upper bounds given by the number of initial tokens and the number of places.
[t] Computed by alpina, ITS-Tools, marcie, and pnxdd at MCC'2013; confirmed by CÆSAR.BDD 1.8.
[u] Computed by greatSPN, ITS-Tools, and pnxdd at MCC'2013.
[v] lower bound given by the number of initial tokens.