

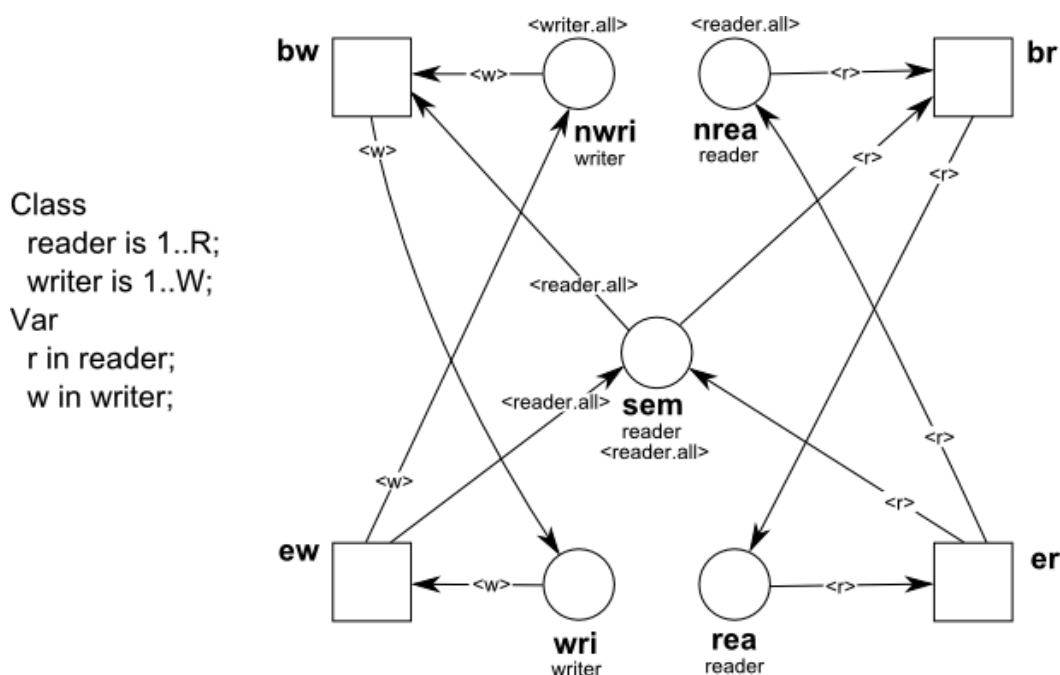
This form is a summary description of the model entitled "Reader/Writer Mutual Exclusion" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models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

Description

The net models a system with readers and writers. Reading can be conducted concurrently whereas writing has to be done exclusively. This is modeled by a number of semaphores (one for each reader) that need to be collected by a writer prior to writing.

Net formalism: This submission contains unfolded versions of the net for a variety of scaling parameters. These nets are given in LoLA low-level format and PNML. The original net has been modeled as an algebraic Petri net in LoLA high-level format, see <http://service-technology.org/files/lola/lola.pdf>.

The model is sketched in the figure. The two sorts R and W model the number of readers and writers, respectively.



References

Wolfgang Reisig. *Elements of Distributed Algorithms. Modeling and Analysis with Petri Nets.*, Springer, 1998.

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
(readers r , writers w)	see description	(10,10), (10,20), (10,50), (10,100), (10,500), (10,1000), (10,2000), (20,10), (100,10), (500,10), (1000,10), (2000,10)

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs
$(r, w) = (10, 10)$	50	40	300
$(r, w) = (10, 20)$	70	60	540
$(r, w) = (10, 50)$	130	120	1260
$(r, w) = (10, 100)$	230	220	2460
$(r, w) = (10, 500)$	1030	1020	12060
$(r, w) = (10, 1000)$	2030	2020	24060
$(r, w) = (10, 2000)$	4030	4020	48060
$(r, w) = (20, 10)$	80	60	560
$(r, w) = (100, 10)$	320	220	2640
$(r, w) = (500, 10)$	1520	1020	13040
$(r, w) = (1000, 10)$	3020	2020	26040
$(r, w) = (2000, 10)$	6020	4020	52040

Structural properties

ordinary — all arcs have multiplicity one	✓
simple 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 an 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)
nested units — places are structured into hierarchically nested sequential units ^(m)	✗

Behavioural properties

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

(a) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(b) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(c) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(d) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(e) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(f) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(g) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(h) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(i) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(j) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(k) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(l) stated by [CÆSAR.BDD](#) version 1.7 on all 12 instances (see aforementioned parameter values).

(m) the definition of Nested-Unit Petri Nets (NUPN) is available from <http://mcc.lip6.fr/nupn.php>

(n) stated by [CÆSAR.BDD](#) version 2.0 to be true on 7 instance(s) out of 12, and unknown on the remaining 5 instance(s).

(o) stated by [CÆSAR.BDD](#) version 2.0 to be false on 7 instance(s) out of 12, and unknown on the remaining 5 instance(s); confirmed at MCC'2014 by Cunf, Lola, and Tapaal on all 12 instances, and by GreatSPN on fewer instances.

(p) stated by [CÆSAR.BDD](#) version 2.0 to be true on 7 instance(s) out of 12, and unknown on the remaining 5 instance(s).

live — for every transition t , from every reachable marking, one can reach a marking in which t can fire

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
$(r, w) = (10, 10)$	1034 ^(q)	10 260 ^(r)	1 ^(s)	30 ^(t)
$(r, w) = (10, 20)$	1044 ^(u)	10 280 ^(v)	1 ^(w)	40 ^(x)
$(r, w) = (10, 50)$	1074 ^(y)	10 340 ^(z)	1 ^(aa)	7 ^(ab) 0
$(r, w) = (10, 100)$	1124 ^(ac)	10 440 ^(ad)	1 ^(ae)	120 ^(af)
$(r, w) = (10, 500)$	1524 ^(ag)	11 240 ^(ah)	1 ^(ai)	520 ^(aj)
$(r, w) = (10, 1000)$	2024 ^(ak)	12 240 ^(al)	1 ^(am)	1020 ^(an)
$(r, w) = (10, 2000)$	3024 ^(ao)	?	1 ^(ap)	2020 ^(aq)
$(r, w) = (20, 10)$	1.0486E+6 ^(ar)	2.0972E+7 ^(as)	1 ^(at)	50 ^(au)
$(r, w) = (100, 10)$	1.2677E+30 ^(av)	?	1 ^(aw)	$\in [210, 320]$
$(r, w) = (500, 10)$	3.2734E+150 ^(ax)	?	1 ^(ay)	≥ 1010
$(r, w) = (1000, 10)$	1.0715E+301 ^(az)	?	1 ^(ba)	≥ 2010
$(r, w) = (2000, 10)$?	?	?	≥ 4010

^(q) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by [C/ESAR.BDD](#) version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

^(r) computed at MCC'2014 by Marcie.

^(s) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(t) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

^(u) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by [C/ESAR.BDD](#) version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

^(v) computed at MCC'2014 by Marcie.

^(w) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(x) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

^(y) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by [C/ESAR.BDD](#) version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

^(z) computed at MCC'2014 by Marcie.

^(aa) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(ab) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

^(ac) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by [C/ESAR.BDD](#) version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

^(ad) computed at MCC'2014 by Marcie.

^(ae) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(af) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

^(ag) computed at MCC'2013 by ITS-Tools, Marcie, Neco, and PNXDD; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Tapaal.

^(ah) computed at MCC'2014 by Marcie.

^(ai) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(aj) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

^(ak) computed at MCC'2013 by ITS-Tools, Marcie, Neco, and PNXDD; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Tapaal.

^(al) computed at MCC'2014 by Marcie.

^(am) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(an) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

^(ao) computed at MCC'2013 by ITS-Tools; confirmed at MCC'2014 by PNMC, PNXDD, and Tapaal.

^(ap) computed at MCC'2014 by PNMC and Tapaal.

^(aq) computed at MCC'2014 by PNMC and Tapaal.

^(ar) computed at MCC'2013 by Marcie, Neco, and PNXDD; confirmed by [C/ESAR.BDD](#) version 1.8; exact value: 1 048 586; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Tapaal.

^(as) computed at MCC'2014 by Marcie.

^(at) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and PNXDD.

^(au) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and PNXDD.

^(av) computed by [C/ESAR.BDD](#) version 1.8.

^(aw) computed at MCC'2014 by GreatSPN.

^(ax) computed at MCC'2014 by GreatSPN.

^(ay) computed at MCC'2014 by GreatSPN.

^(az) computed at MCC'2014 by GreatSPN.

^(ba) computed at MCC'2014 by GreatSPN.

Other properties

A mutual exclusion violation (two concurrent writers) can be checked using a CTL formula like

$$\forall i \neq j: \mathbf{EF} (\text{wri}.i \wedge \text{wri}.j)$$

This formula is given for the unfolded low-level models.