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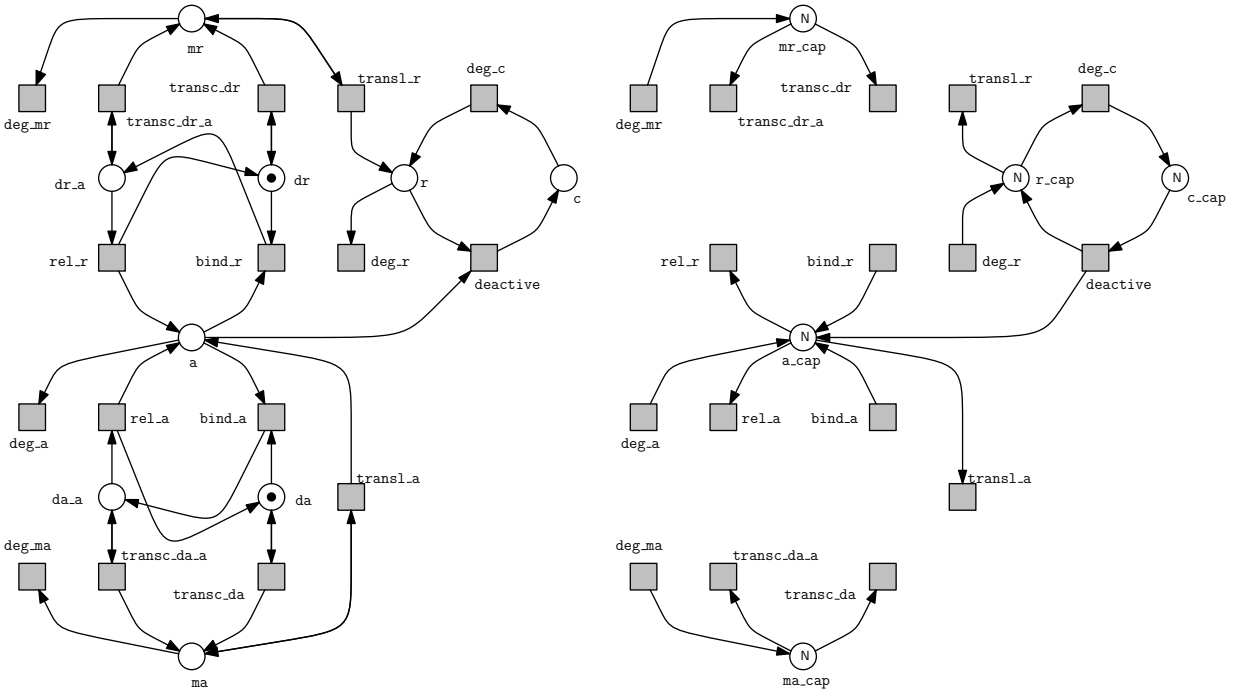
This form is a summary description of the model entitled "CircadianClock" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given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

Description

The abstract circadian clock model of Barkei and Leiber [BL00] shows circadian rhythms which are widely used in organisms to keep a sense of daily time. The stochastic Petri net of the circadian clock is based on the ODE model of [Vilar2002]. The bounded version of the net was used in [SH2009] and the unbounded version in [Rohr2010].

In March 2020, Pierre Bouvier and Hubert Garavel provided a decomposition of the only one-safe instance of this model into a network of communicating automata. This network is expressed as a Nested-Unit Petri Net (NUPN) that can be found in the "toolspecific" section of the corresponding PNML file.



Graphical representation with parameter N. The left hand side represents the unbounded model from [Vilar2002]. It was made bounded using capacity places on the right hand side. The gray coloured transitions are logic/fusion transitions.

References

BL00 N. Barkai and S. Leibler. Biological rhythms: Circadian clocks limited by noise. Nature, 403(6767):267– 268, 2000.

Vilar2002 J. Vilar et al. Mechanisms of Noise-Resistance in Genetic Oscillators Proc. National Academy of Sciences of the United States of America, 99(9):5988-5992, 2002.

SH2009 M. Schwarick and M. Heiner. CSL model checking of biochemical networks with interval decision diagrams. LNBI, 5688:296–312, 2009.

Rohr2010 C. Rohr. Simulative CSL model checking of Stochastic Petri nets in IDD-MC. In Proc. 17th German Workshop on Algorithms and Tools for Petri Nets (AWPN 2010), volume 643 of CEUR Workshop Proceedings, pages 88–93. CEUR-WS.org, October 2010.

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Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	initial number of tokens on places	1, 10, 100, 1000, 10000, 100000

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 1$	14	16	58	8	1–7–7
$N = 10$	14	16	58	–	– – 14
$N = 100$	14	16	58	–	– – 14
$N = 1000$	14	16	58	–	– – 14
$N = 10000$	14	16	58	–	– – 14
$N = 100000$	14	16	58	–	– – 14

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] ..... ? [o]

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* ..... ? [p]
dead place(s) — *one or more places have no token in any reachable marking* ..... ✗ [q]

[a] 23 arcs are not simple free choice, e.g., the arc from place "a" (which has 4 outgoing transitions) to transition "bind_a" (which has 2 input places).
[b] transitions "bind_a" and "bind_r" share a common input place "a", but only the former transition has input place "da".
[c] 12 transitions are not of a state machine, e.g., transition "bind_a".
[d] 12 places are not of a marked graph, e.g., place "a".
[e] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[f] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[g] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[h] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[i] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[j] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[k] 6 transitions are not loop free, e.g., transition "transc_da".
[l] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[m] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[n] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php
[o] stated by CÆSAR.BDD version 3.3 to be true on 1 instance(s) out of 6, and false on the remaining 5 instance(s).
[p] stated by CÆSAR.BDD version 2.0 to be true for $N = 1$, and false on the remaining 5 instance(s).
[q] stated by CÆSAR.BDD version 3.3 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).

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dead transition(s) — *one or more transitions cannot fire from any reachable marking* ..... ✗ [r]
deadlock — *there exists a reachable marking from which no transition can be fired* ..... ✗ [s]
reversible — *from every reachable marking, there is a transition path going back to the initial marking* ..... ? [t]
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ..... ✔ [u]

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
$N = 1$	128 [v]	624 [w]	N [x]	7 [y]
$N = 10$	644 204 [z]	6.7663E+6 [aa]	N [ab]	52 [ac]
$N = 100$	4.2040E+10 [ad]	4.9743E+11 [ae]	N [af]	502 [ag]
$N = 1\,000$	4.0200E+15 [ah]	4.8172E+16 [ai]	N [aj]	5002 [ak]
$N = 10\,000$	400 200 040 004 000 200 004 [al]	?	N	50 002 [am]
$N = 100\,000$	?	?	N	500 002 [an]

[r] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 100, 1000, 10000, and 100000).
[s] checked by Marcie on 2013-12-13; confirmed at MCC'2014 by Lola and Tapaal on 2 instances ($N = 1$ and $N = 10$).
[t] true for $N = 1$ and false for $N > 1$ – checked by Marcie on 2013-12-13.
[u] checked by Marcie on 2013-12-13.
[v] confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.
[w] computed at MCC'2014 by Marcie.
[x] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[y] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[z] computed by Marcie on 2013-12-13; confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.
[aa] computed at MCC'2014 by Marcie.
[ab] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ac] number of initial tokens, because the net is conservative.
[ad] computed by Marcie on 2013-12-13; exact value: 42 040 402 004; confirmed at MCC'2014 by Marcie, PNMC, and PNXDD.
[ae] computed at MCC'2014 by Marcie.
[af] confirmed at MCC'2014 by Marcie and PNMC.
[ag] number of initial tokens, because the net is conservative.
[ah] computed by Marcie on 2013-12-13; exact value: 4 020 040 040 020 004; confirmed at MCC'2014 by Marcie and PNMC.
[ai] computed at MCC'2014 by Marcie.
[aj] confirmed at MCC'2014 by Marcie and PNMC.
[ak] number of initial tokens, because the net is conservative.
[al] computed by Marcie on 2013-12-13.
[am] number of initial tokens, because the net is conservative.
[an] number of initial tokens, because the net is conservative.