Model: PGCD
Type: Colored Net (with derived P/T Nets)
Origin: Academic

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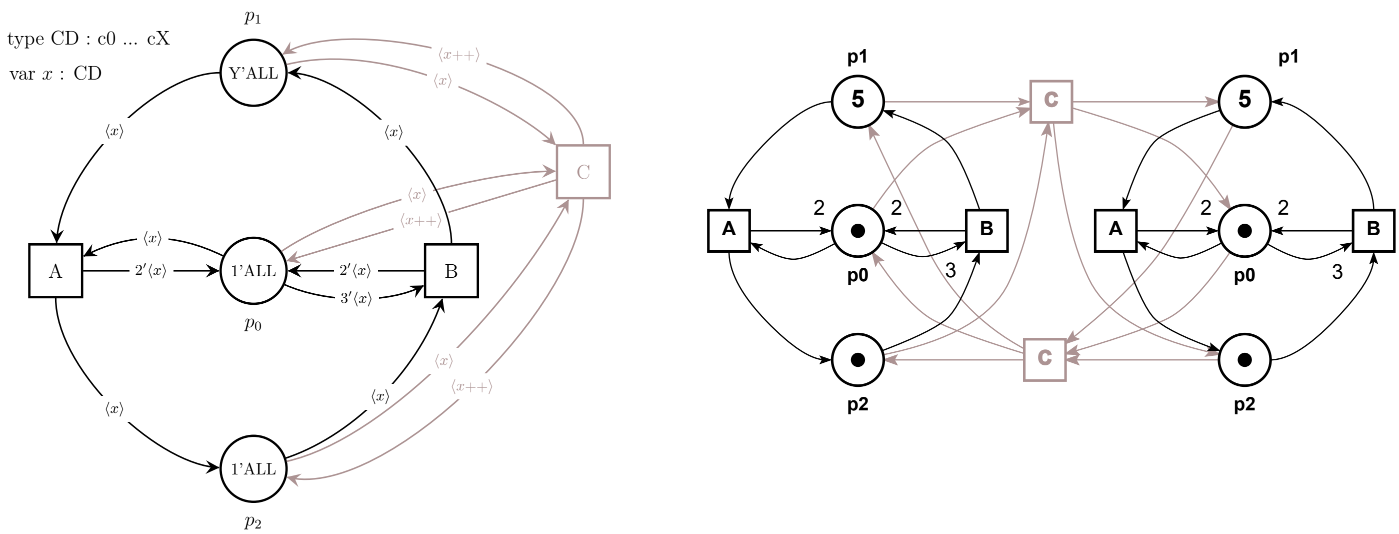
This form is a summary description of the model entitled "PGCD" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together with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

Description

This model is a variation of a very simple benchmark used in [1] to compare the performances of tools for checking reachability problems. In PGCD, transitions A/B can increment/decrement the marking of place p_0 by 1. Nonetheless, due to the choice of weights on the arcs, it must be the case that the number of occurrences of B is always less than the one of A in any feasible firing sequence. This leads to state invariants that cannot be proved by reasoning only on the state equation.

We propose a parametric version of the example given in [1] using $X + 1$ different copies of the same component, arranged into a ring. Also, our model is bounded, whereas the initial example was not. In our case, the size of the state space is controlled by the initial marking of place p_1, denoted Y, which is the second scaling parameter of our model.



Graphical representation of PGCD-COL-DXNY (left) and a derived P/T net (right) for the instance $(1, 5)$

References

1. Amat, N., Dal Zilio, S., & Hujsa, T. (2022). *Property directed reachability for generalized Petri nets*. In International Conference on Tools and Algorithms for the Construction and Analysis of Systems. Springer.

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
(X, Y)	X controls the number of different copies of the basic PGCD component, whereas Y defines the initial marking of place p_1	$(2, 5)$, $(2, 6)$, $(2, 100)$, $(3, 50)$, $(4, 25)$, $(4, 50)$, $(5, 25)$

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Size of the colored net model

number of places:	3
number of transitions:	3
number of arcs:	14

Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs
(X,Y)	$3\,\mathrm{X}+3$	$3\,\mathrm{X}+3$	$14\,\mathrm{X}+14$

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) .... ✗

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)
reversible — *from every reachable marking, there is a transition path going back to the initial marking* .... ? (s)

(a) the net is not ordinary.
(b) the net is not ordinary.
(c) the net is not ordinary.
(d) the net is not ordinary.
(e) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(f) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(g) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(h) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(i) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(j) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(k) stated by CÆSAR.BDD version 3.7 on all 7 instances.
(l) stated by PNML2NUPN 3.2.0 on all 7 instances.
(m) stated by PNML2NUPN 3.2.0 on all 7 instances.
(n) the definition of Nested-Unit Petri Nets (NUPN) is available from `http://mcc.lip6.fr/nupn.php`
(o) the initial marking is not safe when $Y \geq 2$, which is the case in all our instances.
(p) all places are marked in the initial marking when $Y \geq 1$, which is the case in all our instances.
(q) this is false when $Y \geq 2$, which is the case in all our instances.
(r) model $(2,5)$ has 3 dead states, even though most of the instances are deadlock free. For instance $(2,6)$ has no deadlocks. Checked by TINA version 3.7.0 on January 2023.
(s) some instances have deadlocks, such as $(2,5)$, even though most of the instances are reversible. For instance, $(2,6)$ is both live and reversible. Checked by TINA version 3.7.0 on January 2023.

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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
$(X = 2, Y = 5)$	8 484 (u)	43 344 (v)	18 (w)	36 (x)
$(X = 2, Y = 6)$	15 670 (y)	48 408 106 836 (z)	19 (aa)	42 (ab)
$(X = 2, Y = 100)$	5 588 167 526 (ac)	23 405 636 097 113 (ad)	301 (ae)	606 (af)
$(X = 3, Y = 50)$	417 214 571 243 (ag)	4 627 552 444 956 (ah)	201 (ai)	408 (aj)
$(X = 4, Y = 25)$	2 573 637 642 576 (ak)	32 995 388 117 120 (al)	130 (am)	260 (an)
$(X = 4, Y = 50)$	9.3348E+14 (ao)	1.2914E+16 (ap)	251 (aq)	510 (ar)
$(X = 5, Y = 25)$	1.5855E+15 (as)	2.4327E+16 (at)	156 (au)	312 (av)

Other properties

Since we always have more occurrences of transition A than B on all execution, then place p_2 should never be empty. This can be expressed by the following state invariant.

$$\text{INV} \;:\; \text{AG}\,(p_2 \geq 1)$$

(t) some instances have deadlocks, such as $(2, 5)$, even though most of the instances are reversible. For instance, $(2, 6)$ is both live and reversible. Checked by TINA version 3.7.0 on January 2023.
(u) computed by TINA version 3.7.0 on January 2023.
(v) computed by TINA version 3.7.0 on January 2023.
(w) computed by TINA version 3.7.0 on January 2023.
(x) computed by TINA version 3.7.0 on January 2023.
(y) computed by TINA version 3.7.0 on January 2023.
(z) computed by TINA version 3.7.0 on January 2023.
(aa) computed by TINA version 3.7.0 on January 2023.
(ab) computed by TINA version 3.7.0 on January 2023.
(ac) computed by TINA version 3.7.0 on January 2023.
(ad) computed by TINA version 3.7.0 on January 2023.
(ae) computed by TINA version 3.7.0 on January 2023.
(af) computed by TINA version 3.7.0 on January 2023.
(ag) computed by TINA version 3.7.0 on January 2023.
(ah) computed by TINA version 3.7.0 on January 2023.
(ai) computed by TINA version 3.7.0 on January 2023.
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(ak) computed by TINA version 3.7.0 on January 2023.
(al) computed by TINA version 3.7.0 on January 2023.
(am) computed by TINA version 3.7.0 on January 2023.
(an) computed by TINA version 3.7.0 on January 2023.
(ao) computed by TINA version 3.7.0 on January 2023. The exact value is 933 481 841 500 756.
(ap) computed by TINA version 3.7.0 on January 2023. The exact value is 12 914 467 131 143 055.
(aq) computed by TINA version 3.7.0 on January 2023.
(ar) computed by TINA version 3.7.0 on January 2023.
(as) computed by TINA version 3.7.0 on January 2023. The exact value is 1 585 536 525 017 640.
(at) computed by TINA version 3.7.0 on January 2023. The exact value is 24 327 669 297 954 672.
(au) computed by TINA version 3.7.0 on January 2023.
(av) computed by TINA version 3.7.0 on January 2023.