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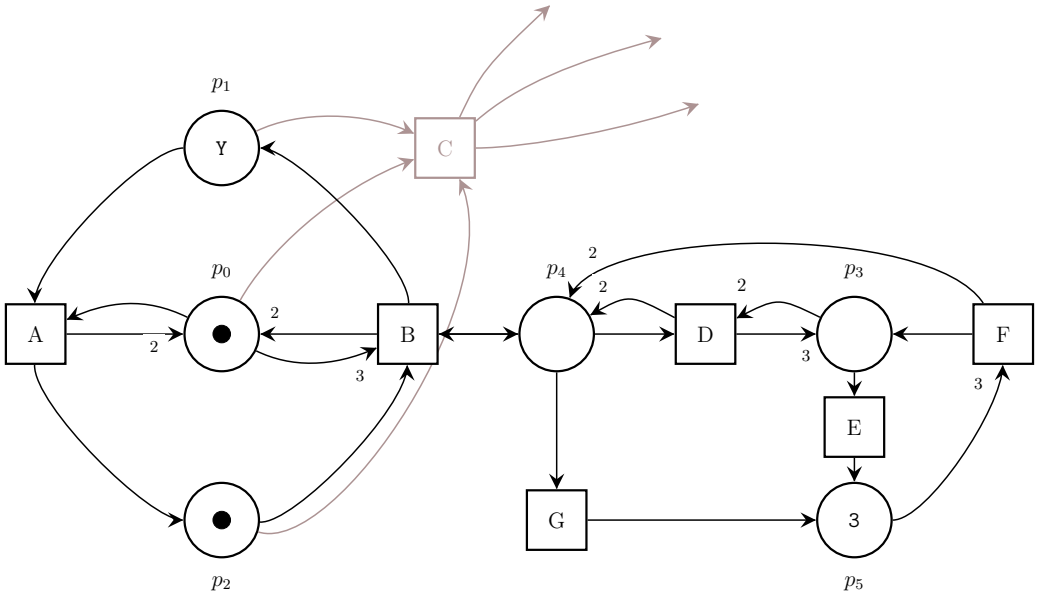
This form is a summary description of the model entitled "Murphy" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together 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 benchmark used in [1] to compare the performances of tools for checking reachability problems. We propose a parametric version of the example given in [1] using $X + 1$ different copies of the same component (see the figure below), arranged into a ring, with successive components connected through transition C. 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.

We called this model Murphy because it was built from a combination of several elements that are supposed to challenge methods for checking reachability formulas. So Murphy was built with the hope that everything that can go wrong will go wrong. The main component of Murphy is the result of the composition of two nets, connected through place p_4. The first net is the component already used with the PGCD model (places p_0, p_1, p_2). The second net (places p_3, p_4, p_5) includes a dead transition (D) that will never be enabled, although the state equation ensures at least one possibility of firing it.



Graphical representation of the main subcomponent in Murphy-COL-DXNY

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 Murphy component, whereas Y defines the initial marking of place p_1	$(1, 10)$, $(2, 50)$, $(2, 100)$, $(3, 50)$, $(4, 25)$, $(4, 50)$

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Size of the colored net model

number of places:	6
number of transitions:	7
number of arcs:	27

Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs
(X, Y)	$6\,\mathrm{X} + 6$	$7\,\mathrm{X} + 7$	$27\,\mathrm{X} + 27$

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 6 instances.
[f] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[g] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[h] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[i] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[j] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[k] stated by CÆSAR.BDD version 3.7 on all 6 instances.
[l] stated by PNML2NUPN 3.2.0 on all 6 instances.
[m] stated by PNML2NUPN 3.2.0 on all 6 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 since place p_5 has 3 tokens in the initial marking.
[p] the only places places that are not marked in the initial marking are p_3 and p_4. We can mark these places by firing transition F which is enabled initially.
[q] the model was built so that transition D is dead. Checked by TINA version 3.7.0 on January 2023 on all the proposed instances.
[r] checked by TINA version 3.7.0 on January 2023 on all the proposed instances.
[s] we have been able to check that $(1, 10)$ is reversible, and so are other small instances. We conjecture that the same is true on all instances.

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
$(X = 1, Y = 10)$	39 780 [u]	267 984 [v]	21 [w]	50 [x]
$(X = 2, Y = 50)$	41 538 421 296 [y]	475 243 407 792 [z]	151 [aa]	315 [ab]
$(X = 2, Y = 100)$	1 207 044 185 616 [ac]	14 135 173 542 432 [ad]	301 [ae]	615 [af]
$(X = 3, Y = 50)$	5.4071E+14 [ag]	8.2295E+15 [ah]	201 [ai]	420 [aj]
$(X = 4, Y = 25)$	2.0012E+16 [ak]	3.6279E+17 [al]	130 [am]	275 [an]
$(X = 4, Y = 50)$	?	?	?	≥ 275 [ao]

Other properties

By construction, place p_2 should always be marked and transition D should be dead. This can be expressed by the following two invariants.

$$\text{INV}_\text{s} \ : \ \text{AG}\ (p_2 \geq 1) \qquad \text{and} \qquad \text{INV}_\text{t} \ : \ \text{AG}\ \neg\, \text{is\_fireable}(D)$$

[t] transition D is dead in all the instances. 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. The exact value is 540 710 084 330 928.
[ah] computed by TINA version 3.7.0 on January 2023. The exact value is 8 229 559 032 648 576.
[ai] computed by TINA version 3.7.0 on January 2023.
[aj] computed by TINA version 3.7.0 on January 2023.
[ak] computed by TINA version 3.7.0 on January 2023. The exact value is 20 012 606 308 670 976.
[al] computed by TINA version 3.7.0 on January 2023. The exact value is 362 794 818 098 718 720.
[am] computed by TINA version 3.7.0 on January 2023.
[an] computed by TINA version 3.7.0 on January 2023.
[ao] lower bound given by the number of initial tokens.