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This form is a summary description of the model entitled "StigmergyCommit" 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 describes a system of N workers and one coordinator, which perform a variation of a two-phase commit protocol. In this variation, we exploit an indirect communication mechanism based on stigmergy variables [1]. When an agent assigns a value to such a variable, the value receives a timestamp marking the time of assignment.

Agents asynchronously broadcast values after performing an assignment, and receivers will replace their own value with the received one if the latter is newer (i.e., it has a higher timestamp). Specifically, workers agree to commit a transaction by increasing a counter stored in a stigmergy variable. When the counter reaches N, the coordinator confirms the commit. Notice that the workers in this model always agree to commit.

This collection of P/T nets was derived from an initial specification of the system (parameterized by the number N of agents), which was described in LAbS [1], a language that natively supports stigmergy variables. Each instance of this specification, for a given value of N, was then automatically translated into an LNT model by means of the SLiVER tool [2] [3].

Each LNT model was then translated to LOTOS, and then to an interpreted Petri net using the CADP toolbox. Finally, a P/T net was obtained by stripping out all data-related information (variables, types, assignments, guards, etc.) from the interpreted Petri net, leading to a NUPN (Nested-Unit Petri Net) model translated to PNML using the CÆSAR.BDD tool.

Each instance is also parameterized by its version V, which specifies how the NUPN has been produced from the LOTOS specification. V is either equal to "a" if the NUPN has been generated *after* applying all the structural and data-flow optimizations of the CÆSAR compiler for LOTOS, or to "b" if the NUPN has been generated *before* these optimizations.

References

[1] R. De Nicola, L. Di Stefano, and O. Inverso, "Multi-agent systems with virtual stigmergy," Sci. Comput. Program., vol. 187, p. 102345, 2020, doi: 10.1016/j.scico.2019.102345.

[2] L. Di Stefano, F. Lang, and W. Serwe, "Combining SLiVER with CADP to Analyze Multi-agent Systems," in 22nd International Conference on Coordination Models and Languages (COORDINATION), Valletta, Malta, Jun. 2020, vol. 12134, pp. 370–385. doi: 10.1007/978-3-030-50029-0_23.

[3] SLiVER tool: https://github.com/labs-lang/sliver

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
(N, V)	N is the number of agents and V is the version defined above	$\{2...11\} \times \{a, b\}$

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Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 2, V = a$	112	204	693	5	2–4–20
$N = 2, V = b$	928	1040	2439	7	4–4–35
$N = 3, V = a$	148	332	1538	6	2–5–26
$N = 3, V = b$	1231	1476	4168	9	5–5–45
$N = 4, V = a$	184	592	4011	7	2–6–32
$N = 4, V = b$	1534	2136	8601	11	6–6–55
$N = 5, V = a$	220	1212	11640	8	2–7–38
$N = 5, V = b$	1837	3460	22362	13	7–7–65
$N = 6, V = a$	256	2816	35321	9	2–8–44
$N = 6, V = b$	2140	6760	67803	15	8–8–75
$N = 7, V = a$	292	7108	108222	10	2–9–50
$N = 7, V = b$	2443	15956	219500	17	9–9–85
$N = 8, V = a$	328	18744	330279	11	2–10–56
$N = 8, V = b$	2746	42776	723933	19	10–10–95
$N = 9, V = a$	364	50444	999956	12	2–11–62
$N = 9, V = b$	3049	122340	2389246	21	11–11–105
$N = 10, V = a$	400	136960	3002181	13	2–12–68
$N = 10, V = b$	3352	359880	7847007	23	12–12–115
$N = 11, V = a$	436	373236	8944506	14	2–13–74
$N = 11, V = b$	3655	1070836	25615632	25	13–13–125

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] ..... ✔

[a] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[b] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[c] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[d] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[e] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[f] from place 1 one cannot reach place 0.
[g] place 0 is a source place.
[h] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[i] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[j] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[k] stated by CÆSAR.BDD version 3.7 to be true on 10 instance(s) out of 20, and false on the remaining 10 instance(s).
[l] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[m] stated by CÆSAR.BDD version 3.7 on all 20 instances (10 values of N × 2 values of V).
[n] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php

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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]
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
$N = 2, V = a$	695 [u]	?	1	4
$N = 2, V = b$	1.92125e+08 [v]	?	1	4
$N = 3, V = a$	4055 [w]	?	1	5
$N = 3, V = b$	3.52484e+10 [x]	?	1	5
$N = 4, V = a$	25867 [y]	?	1	6
$N = 4, V = b$	6.52057e+12 [z]	?	1	6
$N = 5, V = a$	171115 [aa]	?	1	7
$N = 5, V = b$	$\geq$ 1.0671e+15 [ab]	?	1 [ac]	7
$N = 6, V = a$	1.1535e+06 [ad]	?	1	8
$N = 6, V = b$	$\geq$ 1.31925e+17 [ae]	?	1 [af]	8
$N = 7, V = a$	7.86822e+06 [ag]	?	1	9
$N = 7, V = b$	$\geq$ 2.05905e+19 [ah]	?	1 [ai]	9
$N = 8, V = a$	5.40987e+07 [aj]	?	1	10
$N = 8, V = b$	$\geq$ 2.68409e+21 [ak]	?	1 [al]	10
$N = 9, V = a$	3.73997e+08 [am]	?	1	11
$N = 9, V = b$	$\geq$ 4.55802e+23 [an]	?	1 [ao]	11
$N = 10, V = a$	2.5953e+09 [ap]	?	1	12
$N = 10, V = b$	$\geq$ 4.43795e+23 [aq]	?	1 [ar]	12
$N = 11, V = a$	1.80569e+10 [as]	?	1	13
$N = 11, V = b$	?	?	1 [at]	13

[o] safe by construction – stated by the CÆSAR compiler.
[p] stated by CÆSAR.BDD version 3.7 to be false on 13 instance(s) out of 20, and unknown on the remaining 7 instance(s).
[q] stated by CÆSAR.BDD version 3.7 to be false on 13 instance(s) out of 20, and unknown on the remaining 7 instance(s).
[r] stated by CÆSAR.BDD version 3.7 to be true on 3 instance(s) out of 20, false on the remaining 10 instance(s), and unknown on the remaining 7 instance(s).
[s] stated by CÆSAR.BDD version 3.7 to be false on 3 instance(s) out of 20, and unknown on the remaining 17 instance(s).
[t] stated by CÆSAR.BDD version 3.7 to be false on 3 instance(s) out of 20, and unknown on the remaining 17 instance(s).
[u] stated by CÆSAR.BDD version 3.7.
[v] stated by CÆSAR.BDD version 3.7.
[w] stated by CÆSAR.BDD version 3.7.
[x] stated by CÆSAR.BDD version 3.7.
[y] stated by CÆSAR.BDD version 3.7.
[z] stated by CÆSAR.BDD version 3.7.
[aa] stated by CÆSAR.BDD version 3.7.
[ab] stated by CÆSAR.BDD version 3.7.
[ac] stated by the CÆSAR compiler.
[ad] stated by CÆSAR.BDD version 3.7.
[ae] stated by CÆSAR.BDD version 3.7.
[af] stated by the CÆSAR compiler.
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[al] stated by the CÆSAR compiler.

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