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

since
MCC 2014

Benoît Barbot
barbot@lsv.ens-cachan.fr

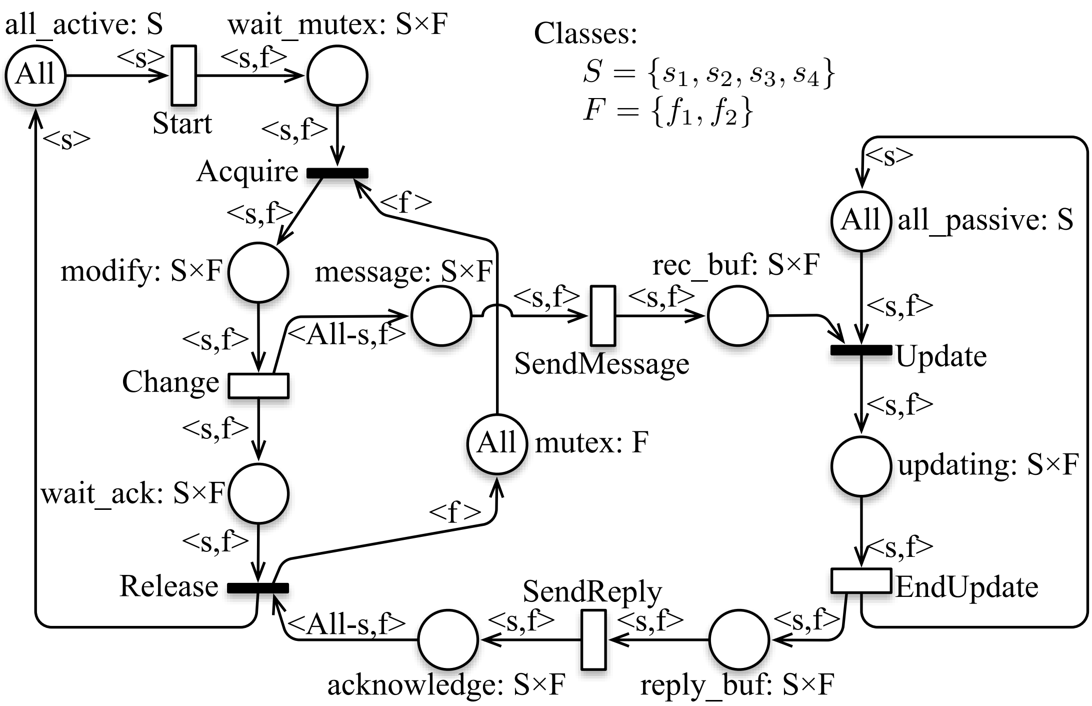
This form is a summary description of the model entitled "DatabaseWithMutex" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given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

Description

This model is an extension of the well-known distributed database example. A database containing files is distributed among different servers; when a file is modified the database must synchronized on all servers. This model adds atomic transitions (in black in the figure) and global mutex for each file. This model is particularly interesting in performance evaluation context, where atomic transitions are supposed to be instantaneous, whereas other requires time.

The colored-net instances of this model have been patched in March 2015 because they contained mistakes that have been detected and reported by Yann Thierry-Mieg; in particular, these mistakes led to diverging answers between the colored nets and the P/T nets for the safety properties. The P/T-net instances have been kept unchanged.

In March 2020, Pierre Bouvier and Hubert Garavel provided a decomposition of two instances of this model into networks of communicating automata. Each network is expressed as a Nested-Unit Petri Net (NUPN) that can be found, for each instance, in the "toolspecific" section of the corresponding PNML file. In April 2021, Pierre Bouvier decomposed all the remaining instances of this model.



Graphical representation with four servers and two files

References

This model is described in:
E. G. Amparore, B. Barbot, M. Beccuti, S. Donatelli, and G. Franceschinis. Simulation-based verification of hybrid automata stochastic logic formulas for stochastic symmetric nets. In Proceedings of the 2013 ACM SIGSIM conference on Principles of advanced discrete simulation, SIGSIM-PADS '13, pages 253–264, New York, NY, USA, 2013. ACM.

And is an extension of a classical example which can be found in Sect. 1.3 of
K. Jensen. Coloured Petri Nets: Basic Concepts, Analysis Methods and Practical Use, Monographs on Theoretical Computer Science, vol. 1:Basic Concepts. Springer-Verlag, Berlin (1997).

Benoît Barbot
barbot@lsv.ens-cachan.fr

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	The model has two natural parameters: The number of servers on which the database is distributed and the number of files in the database. To obtain a single scaling parameter, these two parameters are set to N	2, 4, 10, 20, 40

Size of the colored net model

number of places:	11
number of transitions:	8
number of arcs:	22

Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 2$	38	32	88	7	1–6–14
$N = 4$	140	128	416	25	1–24–70
$N = 10$	830	800	3800	121	1–120–390
$N = 20$	3260	3200	23200	441	1–440–1420
$N = 40$	12920	12800	156800	1681	1–1680–5320

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 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[b] stated by CÆSAR.BDD version 2.6 on all 5 instances (2, 4, 10, 20, and 40).
[c] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[d] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[e] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[f] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[g] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[h] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[i] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[j] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[k] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[l] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[m] stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).
[n] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php

Benoît Barbot
barbot@lsv.ens-cachan.fr

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* .... ✔
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
$N = 2$	153 [s]	312 [t]	1 [u]	6 [v]
$N = 4$	4.71789E+9 [w]	3.96972E+10 [x]	1 [y]	20 [z]
$N = 10$	$\geq$ 4.24981E+15 [aa]	?	1 [ab]	$\in$ [94, 120] [ac]
$N = 20$	?	?	1	$\in$ [312, 440] [ad]
$N = 40$	?	?	1	$\in$ [120, 1680] [ae]

(o) false for the colored net, true for its unfolded P/T nets; the latter was confirmed by CÆSAR.BDD version 3.5 to be true on all 5 instance.
(p) stated by CÆSAR.BDD version 3.3 to be false on 3 instance(s) out of 5, and unknown on the remaining 2 instance(s).
(q) stated by CÆSAR.BDD version 2.0 to be false on 2 instance(s) out of 5, and unknown on the remaining 3 instance(s).
(r) stated by CÆSAR.BDD version 3.5 to be false on 2 instance(s) out of 5, and unknown on the remaining 3 instance(s); confirmed at MCC'2014 by GreatSPN on 1 P/T instance ($N = 2$), and by Lola and Tapaal on 2 P/T instances ($N = 2$ and $N = 4$).
(s) stated by CÆSAR.BDD version 2.0; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.
(t) computed at MCC'2014 by Marcie.
(u) the unfolded P/T net is safe; confirmed by CÆSAR.BDD version 2.0; confirmed at MCC'2014 by GreatSPN, Marcie, PNXDD, and Tapaal.
(v) computed at MCC'2014 by Marcie, PNMC, and Tapaal.
(w) computed at MCC'2014 by Marcie, PNMC, and PNXDD.
(x) computed at MCC'2014 by Marcie.
(y) computed at MCC'2014 by Marcie and PNMC.
(z) computed at MCC'2014 by Marcie and PNMC.
(aa) stated by CÆSAR.BDD version 3.5.
(ab) P/T instances are safe; N^2 for colored instances.
(ac) upper bound given by the number of leaf units.
(ad) upper bound given by the number of leaf units.
(ae) lower bound given by the number of initial tokens and upper bound given by the number of leaf units.

