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).

### Scaling parameter

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

#### 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	Number of	Number of	Number of	HWB code
	places	transitions	arcs	units	
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

 $<sup>^{\</sup>rm (a)}$  stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>&</sup>lt;sup>(b)</sup> 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).

<sup>(</sup>d) stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 10).

<sup>(</sup>e) stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>&</sup>lt;sup>(f)</sup> stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>&</sup>lt;sup>(g)</sup> stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

 $<sup>^{\</sup>rm (h)}$  stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>&</sup>lt;sup>(i)</sup> stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>(</sup>i) stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

 $<sup>^{(</sup>k)}$  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).

<sup>(</sup>m) stated by CÆSAR.BDD version 2.0 on all 5 instances (2, 4, 10, 20, and 40).

<sup>&</sup>lt;sup>(n)</sup>the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php

## Behavioural properties

safe — in every reachable marking, there is no more than one token on a place	<b>X</b> (o)
dead place(s) — one or more places have no token in any reachable marking $\ldots$	? (p)
dead transition(s) — one or more transitions cannot fire from any reachable marking $\ldots$	<b>X</b> (q)
deadlock — there exists a reachable marking from which no transition can be fired	<b>X</b> (r)
<b>reversible</b> — 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 reach-	Number of tran-	Max. number of	Max. number of
	able markings	sition firings	tokens per place	tokens per marking
N = 2	$153^{(s)}$	$312^{(t)}$	1 <sup>(u)</sup>	$6^{(v)}$
N = 4	$4.71789E + 9^{(w)}$	$3.96972E+10^{(x)}$	1 <sup>(y)</sup>	$20^{(z)}$
N = 10	$\geq 4.24981E + 15^{(aa)}$	?	$1^{(ab)}$	$\in [94, 120]^{(ac)}$
N = 20	?	?	1	$\in [312, 440]^{(ad)}$
N = 40	?	?	1	$\in [120, 1680]^{(ae)}$

<sup>(q)</sup> 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).

<sup>&</sup>lt;sup>(o)</sup> 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. <sup>(p)</sup> 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).

<sup>&</sup>lt;sup>(r)</sup> 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).

<sup>(</sup>s) stated by CÆSAR.BDD version 2.0; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

 $<sup>^{\</sup>rm (t)}$  computed at MCC'2014 by Marcie.

<sup>&</sup>lt;sup>(u)</sup> the unfolded P/T net is safe; confirmed by CÆSAR.BDD version 2.0; confirmed at MCC'2014 by GreatSPN, Marcie, PNXDD, and Tapaal.

<sup>(</sup>v) computed at MCC'2014 by Marcie, PNMC, and Tapaal.

 $<sup>^{(\</sup>mathrm{w})}$  computed at MCC'2014 by Marcie, PNMC, and PNXDD.

<sup>&</sup>lt;sup>(x)</sup> computed at MCC'2014 by Marcie.

<sup>&</sup>lt;sup>(y)</sup> computed at MCC'2014 by Marcie and PNMC.

<sup>&</sup>lt;sup>(z)</sup> computed at MCC'2014 by Marcie and PNMC.

<sup>(</sup>aa) stated by CÆSAR.BDD version 3.5.

 $<sup>^{\</sup>rm (ab)}\,{\rm P/T}$  instances are safe;  $N^2$  for colored instances.

<sup>&</sup>lt;sup>(ac)</sup> upper bound given by the number of leaf units.

<sup>&</sup>lt;sup>(ad)</sup> upper bound given by the number of leaf units.

<sup>&</sup>lt;sup>(ae)</sup> lower bound given by the number of initial tokens and upper bound given by the number of leaf units.