

*This form is a summary description of the model entitled "Lamport's fast mutual exclusion algorithm" 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 net models Lamport's fast mutual exclusion algorithm designed for multi-processor architectures with a shared memory. The pseudo code of this algorithm is given in file `code.pdf`. Each transition of the net has a name of the form XXX\_N where XXX is a description of the statement executed and N is the corresponding line number of the statement in the pseudo-code of the algorithm.

## References

J.B. Jorgensen and L.M Kristensen. *Computer aided verification of Lamport's fast mutual exclusion algorithm using colored Petri nets and occurrence graphs with symmetries*. In *IEEE Transactions on Parallel and Distributed Systems*, Volume 10, Issue 7. IEEE Computer Society, 1999.

## Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	Number of processes competing to access the critical section.	2,3,4,5,6,7,8

## Size of the colored net model

number of places: 18  
 number of transitions: 17  
 number of arcs: 68

## Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs
$N = 2$	69	96	402
$N = 3$	100	156	664
$N = 4$	135	230	990
$N = 5$	174	318	1380
$N = 6$	217	420	1834
$N = 7$	264	536	2352
$N = 8$	315	666	2934

## Structural properties

**ordinary** — all arcs have multiplicity one ..... ✓  
**simple free choice** — all (different) transitions with a shared input place have no other input place ..... ✗ (a)  
**state machine** — every transition has exactly one input place and exactly one output place ..... ✗ (b)  
**marked graph** — every place has exactly one input transition and exactly one output transition ..... ✗ (c)

(a) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).

(b) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).

(c) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).

- connected** — *there is an undirected path between every two nodes (places or transitions)* ..... ✓ (d)
- strongly connected** — *there is a directed path between every two nodes (places or transitions)* ..... ✗ (e)
- source place(s)** — *one or more places have no input transitions* ..... ✓ (f)
- sink place(s)** — *one or more places have no output transitions* ..... ✓ (g)
- source transition(s)** — *one or more transitions have no input places* ..... ✗ (h)
- sink transitions(s)** — *one or more transitions have no output places* ..... ✗ (i)
- loop-free** — *no transition has an input place that is also an output place* ..... ✗ (j)
- conservative** — *for each transition, the number of input arcs equals the number of output arcs* ..... ✗ (k)
- subconservative** — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ..... ✗ (l)
- nested units** — *places are structured into hierarchically nested sequential units<sup>(m)</sup>* ..... ✗

## Behavioural properties

- safe** — *in every reachable marking, there is no more than one token on a place* ..... ✓ (n)
- deadlock** — *there exists a reachable marking from which no transition can be fired* ..... ✗ (o)
- reversible** — *from every reachable marking, there is a transition path going back to the initial marking* ..... ✗
- quasi-live** — *for every transition  $t$ , there exists a reachable marking in which  $t$  can fire* ..... ✗ (p)
- live** — *for every transition  $t$ , from every reachable marking, one can reach a marking in which  $t$  can fire* ..... ✗ (q)

## 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
$N = 2$	380 <sup>(r)</sup>	716 <sup>(s)</sup>	1 <sup>(t)</sup>	8 <sup>(u)</sup>
$N = 3$	19 742 <sup>(v)</sup>	58 272 <sup>(w)</sup>	1 <sup>(x)</sup>	14 <sup>(y)</sup>
$N = 4$	1.9148E+6 <sup>(z)</sup>	9.0461E+6 <sup>(aa)</sup>	1 <sup>(ab)</sup>	22 <sup>(ac)</sup>
$N = 5$	5.3068E+8 <sup>(ad)</sup>	?	1 <sup>(ae)</sup>	32 <sup>(af)</sup>
$N = 6$	$\geq 3.0E+8$ <sup>(ag)</sup>	?	?	$\geq 14$
$N = 7$	$\geq 5.1E+11$ <sup>(ah)</sup>	?	?	$\geq 16$
$N = 8$	?	?	?	$\geq 18$

(d) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (e) from place “P-start.1.1” one cannot reach place “P-wait.0.0”.  
 (f) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (g) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (h) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (i) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (j) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (k) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (l) stated by [CÆSAR.BDD](#) version 1.7 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (m) the definition of Nested-Unit Petri Nets (NUPN) is available from <http://mcc.lip6.fr/nupn.php>  
 (n) stated by [CÆSAR.BDD](#) version 2.0 to be true on 3 instance(s) out of 7, and unknown on the remaining 4 instance(s).  
 (o) stated by [CÆSAR.BDD](#) version 2.0 to be false on 3 instance(s) out of 7, and unknown on the remaining 4 instance(s); confirmed at MCC'2014 by Helena on 3 colored instances ( $N = 2$ ,  $N = 3$ , and  $N = 4$ ) and by GreatSPN and Lola on the 3 corresponding P/T instances.  
 (p) stated by [CÆSAR.BDD](#) version 2.0 on all 7 instances (2, 3, 4, 5, 6, 7, and 8).  
 (q) the net is not quasi-live and, thus, not live.  
 (r) computed by Alpina, ITS-Tools, Marcie, Neco, and PNXDD at MCC'2013; confirmed by [CÆSAR.BDD](#) 1.8; confirmed at MCC'2014 by GreatSPN and Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal on the P/T net instance.  
 (s) confirmed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.  
 (t) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal on the P/T net instance.  
 (u) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal on the P/T net instance.  
 (v) computed at MCC'2013 by Alpina, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by [CÆSAR.BDD](#) 1.8; confirmed at MCC'2014 by GreatSPN and Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal on the P/T net instance.  
 (w) confirmed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.  
 (x) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.  
 (y) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.  
 (z) computed at MCC'2013 by ITS-Tools, and PNXDD; confirmed by [CÆSAR.BDD](#) 1.8; confirmed at MCC'2014 by GreatSPN and Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, and PNXDD on the P/T net instance.

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<sup>(aa)</sup> confirmed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.  
<sup>(ab)</sup> computed at MCC'2014 by GreatSPN, Marcie, and PNMC.  
<sup>(ac)</sup> computed at MCC'2014 by GreatSPN, Marcie, and PNMC.  
<sup>(ad)</sup> computed at MCC'2013 by ITS-Tools, and PNXDD; confirmed at MCC'2014 by PNMC and PNXDD.  
<sup>(ae)</sup> computed at MCC'2014 by PNMC.  
<sup>(af)</sup> computed at MCC'2014 by PNMC.  
<sup>(ag)</sup> stated by [CÆSAR.BDD](#) version 2.0.  
<sup>(ah)</sup> stated by [CÆSAR.BDD](#) version 2.0.