

This form is a summary description of the model entitled “Anderson” 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 PT net models Anderson’s queue lock mutual exclusion algorithm for N processes.

The pseudo code of the algorithm is the following:

```
// variables
constant int N := 4;
shared int next := 0;
shared enum slot {has_lock, must_wait} slot[N - 1] := { has_lock, must_wait, ..., must_wait};
local int my_place;

// code for a process p (p in [0..N-1])
01 loop {
02   noncritical_section;
03   my_place := fetch_and_inc(next)
04   if my_place = N - 1 then
05     atomic_add(next, - N)
06   fi
07   my_place := my_place % N
08   await slot[my_place] = has_lock
09   slot[my_place] := must_wait;
10   critical_section;
11   slot[(my_place + 1) % N] := has_lock
12 }
```

References

Shared-memory mutual exclusion: major research trends since 1986. *Distrib. Comput.*, 2003. James H. Anderson and Yong-Jik Kim and Ted Herman

Scaling parameter

| Parameter name | Parameter description | Chosen parameter values |
|----------------|-------------------------------|------------------------------|
| N | Number of processes competing | 4, 5, 6, 7, 8, 9, 10, 11, 12 |

Size of the model

| Parameter | Number of places | Number of transitions | Number of arcs | Number of units | HWB code |
|-----------|------------------|-----------------------|----------------|-----------------|----------|
| $N = 4$ | 105 | 200 | 752 | 7 | 1-6-26 |
| $N = 5$ | 161 | 365 | 1380 | 8 | 1-7-32 |
| $N = 6$ | 229 | 600 | 2280 | 9 | 1-8-43 |
| $N = 7$ | 309 | 917 | 3500 | 10 | 1-9-49 |
| $N = 8$ | 401 | 1328 | 5088 | 11 | 1-10-56 |
| $N = 9$ | 505 | 1845 | 7092 | 12 | 1-11-63 |
| $N = 10$ | 621 | 2480 | 9560 | 13 | 1-12-69 |
| $N = 11$ | 749 | 3245 | 12540 | 14 | 1-13-86 |
| $N = 12$ | 889 | 4152 | 16080 | 15 | 1-14-93 |

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 | ? |
| live — for every transition t , from every reachable marking, one can reach a marking in which t can fire | ? |

(a) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(b) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(c) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(d) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(e) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(f) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(g) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(h) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(i) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(j) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(k) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(l) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

(m) stated by CÆSAR.BDD version 3.7 on all 9 instances (4, 5, 6, 7, 8, 9, 10, 11 and 12).

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

(o) safe by construction – stated by PNML2NUPN 3.2.0.

(p) stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 9, and unknown on the remaining 5 instance(s).

(q) stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 9, and unknown on the remaining 5 instance(s).

(r) stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 9, and unknown on the remaining 5 instance(s).

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 |
|-----------|------------------------------------|------------------------------|---------------------------------|-----------------------------------|
| $N = 4$ | 29,641 ^(s) | 97,516 | 1 | 6 ^(t) |
| $N = 5$ | 689,901 ^(u) | 2,784,245 | 1 | 7 ^(v) |
| $N = 6$ | 18,206,917 | 86,996,322 | 1 ^(w) | 8 ^(x) |
| $N = 7$ | 538,699,029 | ? | 1 ^(y) | 9 ^(z) |
| $N = 8$ | $\geq 1.13251e+08$ ^(aa) | ? | 1 ^(ab) | 10 ^(ac) |
| $N = 9$ | $\geq 1.51217e+08$ ^(ad) | ? | 1 ^(ae) | 11 ^(af) |
| $N = 10$ | $\geq 1.14121e+09$ ^(ag) | ? | 1 ^(ah) | 12 ^(ai) |
| $N = 11$ | $\geq 8.47469e+09$ ^(aj) | ? | 1 ^(ak) | 13 ^(al) |
| $N = 12$ | $\geq 8.42744e+08$ ^(am) | ? | 1 ^(an) | 14 ^(ao) |

Other properties

- State property: at each reachable marking, there is at most one process in the critical section.

$$\sum_{i \in \{0..N-1\}, j \in \{0..N-1\}} cs_{i,j} \leq 1$$

- LTL property: there is infinitely often a process in the critical section.

$$\Box(\langle\langle \sum_{i \in \{0..N-1\}, j \in \{0..N-1\}} cs_{i,j} == 1 \rangle\rangle)$$

^(s) stated by [CÆSAR.BDD](#) version 3.7.

^(t) number of initial tokens, because the net is conservative.

^(u) stated by [CÆSAR.BDD](#) version 3.7.

^(v) number of initial tokens, because the net is conservative.

^(w) stated by [PNML2NUPN](#) 3.2.0.

^(x) number of initial tokens, because the net is conservative.

^(y) stated by [PNML2NUPN](#) 3.2.0.

^(z) number of initial tokens, because the net is conservative.

^(aa) stated by [CÆSAR.BDD](#) version 3.7.

^(ab) stated by [PNML2NUPN](#) 3.2.0.

^(ac) number of initial tokens, because the net is conservative.

^(ad) stated by [CÆSAR.BDD](#) version 3.7.

^(ae) stated by [PNML2NUPN](#) 3.2.0.

^(af) number of initial tokens, because the net is conservative.

^(ag) stated by [CÆSAR.BDD](#) version 3.7.

^(ah) stated by [PNML2NUPN](#) 3.2.0.

^(ai) number of initial tokens, because the net is conservative.

^(aj) stated by [CÆSAR.BDD](#) version 3.7.

^(ak) stated by [PNML2NUPN](#) 3.2.0.

^(al) number of initial tokens, because the net is conservative.

^(am) stated by [CÆSAR.BDD](#) version 3.7.

^(an) stated by [PNML2NUPN](#) 3.2.0.

^(ao) number of initial tokens, because the net is conservative.