Description

Management of resources with the declaration of all resources to be used in a critical section. When process \( p \) enters a critical section (transition \( \text{enter} \)) it locks all the resources needed to be used in the critical section (4 max). Then, it can release a subset of these resources, max 2 at a time (and then stay in the critical section) or exit the critical section, thus releasing all the remaining resources it locks.

```
Class
       Proc is 1..3;
       Res is 1..6;
Domain
       PR is <Proc,Res>;
Var
       p in Proc;
       r1, r2, r3, r4 in Res;
```

```
enter4
```

```
enter3
```

```
enter2
```

```
enter1
```

```
pr_in
```

```
pr_released
```

```
exit
```

```
release1
```

```
release2
```

References

From a book on operating systems by Sacha Krakowiak. The model is presented and explained in the reference below:

Scaling parameter

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Parameter description</th>
<th>Chosen parameter values</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Cardinality of Proc and Res classes)</td>
<td>see description</td>
<td>((n, 2 \times n)) with (n \in {3, 5, 6, 7, 9, 10, 11})</td>
</tr>
</tbody>
</table>

Size of the colored net model

- number of places: 5
- number of transitions: 7
- number of arcs: 29

Size of the derived P/T model instances

<table>
<thead>
<tr>
<th>Parameter (n)</th>
<th>Number of places</th>
<th>Number of transitions</th>
<th>Number of arcs</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 3)</td>
<td>33</td>
<td>4791</td>
<td>38652</td>
</tr>
<tr>
<td>(n = 5)</td>
<td>75</td>
<td>56105</td>
<td>492760</td>
</tr>
<tr>
<td>(n = 6)</td>
<td>102</td>
<td>136662</td>
<td>1226388</td>
</tr>
</tbody>
</table>

Structural properties

- ordinary — all arcs have multiplicity one
- simple free choice — all transitions sharing a common input place have no other input place
- extended free choice — all transitions sharing a common input place have the same input places
- state machine — every transition has exactly one input place and exactly one output place
- marked graph — every place has exactly one input transition and exactly one output transition
- connected — there is an undirected path between every two nodes (places or transitions)
- strongly connected — there is a directed path between every two nodes (places or transitions)
- source place(s) — one or more places have no input transitions
- sink place(s) — one or more places have no output transitions
- source transition(s) — one or more transitions have no input places
- sink transition(s) — one or more transitions have no output places
- loop-free — no transition has an input place that is also an output place
- conservative — for each transition, the number of input arcs equals the number of output arcs
- subconservative — for each transition, the number of input arcs equals or exceeds the number of output arcs
- nested units — places are structured into hierarchically nested sequential units

(a) the net is not ordinary in all its 2 instances (3 and 5).
(b) the net is not ordinary in all its 2 instances (3 and 5).
(c) the net is not ordinary in all its 2 instances (3 and 5).
(d) the net is not ordinary in all its 2 instances (3 and 5).
(e) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(f) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(g) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(h) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(i) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(j) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(k) stated by CÆSAR.BDD version 1.7 on all 2 instances (3 and 5).
(l) stated by PNML2NUPN 1.3.0 on all 2 instances (3 and 5).
(m) stated by PNML2NUPN 1.3.0 on all 2 instances (3 and 5).
(n) 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 ........................................... X

**deadlock** — there exists a reachable marking from which no transition can be fired ........................................... X (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 ......................................... ✔

**live** — for every transition $t$, from every reachable marking, one can reach a marking in which $t$ can fire ......................... ✔

---

Size of the marking graphs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of reachable markings</th>
<th>Number of transition firings</th>
<th>Max. number of tokens per place</th>
<th>Max. number of tokens per marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n = 3$</td>
<td>6320 (p)</td>
<td>116178 (q)</td>
<td>4 (t)</td>
<td>18 (s)</td>
</tr>
<tr>
<td>$n = 5$</td>
<td>1.0660E+8 (u)</td>
<td>?</td>
<td>?</td>
<td>≥ 15</td>
</tr>
<tr>
<td>$n = 6$</td>
<td>2.5725E+10 (q)</td>
<td>?</td>
<td>?</td>
<td>≥ 18</td>
</tr>
<tr>
<td>$n = 7$</td>
<td>8.5698E+12 (v)</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$n = 9$</td>
<td>2.1185E+18 (w)</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

(o) checked by the Crocodile tool in 2012, see reference 1; confirmed at MCC’2014 by GreatSPN, Lola, PNXDD, and Tapaal on one P/T instance ($N = 3$).

(p) computed at MCC’2013 by GreatSPN, ITS-Tools, Marcie, and PNXDD; confirmed at MCC’2014 by GreatSPN on the colored net instance, and by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

(q) computed at MCC’2014 by MArCie.

(t) computed at MCC’2014 by GreatSPN, Marcie, PNMC, and Tapaal.

(u) computed at MCC’2014 by GreatSPN, Marcie, PNMC, and Tapaal.

(v) computed at MCC’2014 by ITS-Tools; confirmed at MCC’2014 by GreatSPN on the colored net instance.

(w) computed at MCC’2013 by ITS-Tools; confirmed at MCC’2014 by GreatSPN on the colored net instance.

(x) computed at MCC’2014 by ITS-Tools; confirmed at MCC’2014 by GreatSPN on the colored net instance.

(y) computed at MCC’2014 by GreatSPN on the colored net instance.

(z) computed at MCC’2014 by GreatSPN on the colored net instance.