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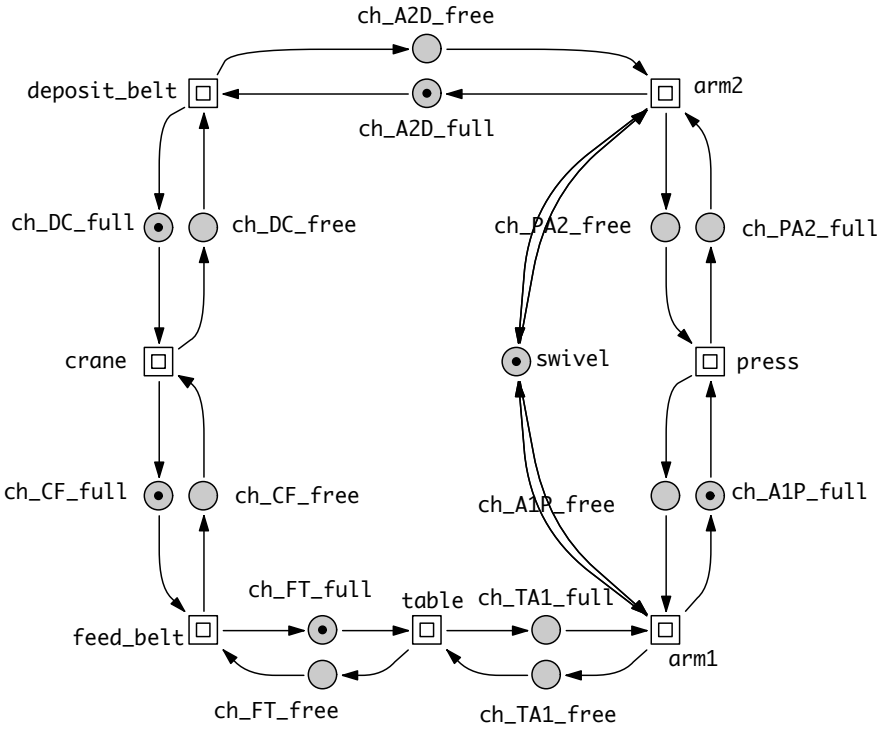
*This form is a summary description of the model entitled "ParamProductionCell" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are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

## Description

The Production cell has been introduced in [LL1995] as a case study to compare different formal methods with respect to their modelling and analysis features. It comes along with a specification of safety and progress properties, which the control software to be developed is expected to fulfil. The production cell sequentially processes plates, at an expected high throughput. The original (open) version of the production cell consists of two belts, a table, a robot with two arms, and a press. A crane has been artificially added, making the system self-contained and thus yielding a closed system. The closed systems differ by the number of plates circulating in the cell.

The Petri net has been first presented in [HD1995], and later published in [HDS1999]. At this time, we were not able to compute the complete marking graph for some versions of this model. Instead, partial order methods have been used to show liveness and for on-the-fly LTL model checking.




*Graphical representation of top layer of the closed system with 5 plates. In the open system, the crane is replaced by a producer and consumer process, modelling the plates' inflow and outflow.*

## References

**HD1995** M. Heiner, P. Deussen: Petri Net Based Qualitative Analysis - A Case Study; Technical report I-08/1995, Brandenburg University of Technology Cottbus, Department of Computer Science, December 1995. http://www-dssz.informatik.tu-cottbus.de/publications/btu-reports/btuReport1995_08_production_cell.pdf.

**HDS1999** M. Heiner, P. Deussen and J. Spranger: A Case Study in Design and Verification of Manufacturing Systems with Hierarchical Petri Nets; The International Journal of Advanced Manufacturing Technology, volume 15, pages 139–152, 1999. http://www-dssz.informatik.tu-cottbus.de/publications/papers/1999_heiner_deussen_spranger_journalAN productionCell.pdf

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**LL1995** C. Lewerentz, T. Lindner: Formal Development of Reactive Systems – Case Study Production Cell; Springer LNCS 891, 1995.

## Scaling parameter

| Parameter name | Parameter description | Chosen parameter values |
|---|---|---|
| $N$ | Initial number of plates in the production cell. For the open system, the initial number is zero. For the closed system, the number is fixed. | 0, 1, 2, 3, 4, 5 |

## Size of the model

| Parameter | Number of places | Number of transitions | Number of arcs |
|---|---|---|---|
| $N = 0$ | 198 | 176 | 730 |
| $N = 1, 2, 3, 4, 5$ | 231 | 202 | 846 |

## 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)
**deadlock** — *there exists a reachable marking from which no transition can be fired* ✘ (p); confirmed at MCC'2014 by Lola

(a) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(b) transitions "t61" and "t67" share a common input place "p14", but only the former transition has input place "p88".
(c) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(d) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(e) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(f) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(g) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(h) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(i) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(j) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(k) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(l) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(m) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(n) the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php
(o) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).
(p) stated by CÆSAR.BDD version 2.0 on all 6 instances (0, 1, 2, 3, 4, and 5).

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and Tapaal on all 6 instances
**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* ..... ? [q]
**live** — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ..... ? [r]

## 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 |
|---|---|---|---|---|
| $N = 0$ | 2,776,936 [s] | 1.3152E+7 [t] | 1 [u] | 32 [v] |
| $N = 1$ | 25,632 [w] | 96 722 [x] | 1 [y] | 36 [z] |
| $N = 2$ | 349,874 [aa] | 1.3807E+6 [ab] | 1 [ac] | 36 [ad] |
| $N = 3$ | 1,465,206 [ae] | 5.9227E+6 [af] | 1 [ag] | 36 [ah] |
| $N = 4$ | 2,409,739 [ai] | 9.8277E+6 [aj] | 1 [ak] | 36 [al] |
| $N = 5$ | 1,657,242 [am] | 6.7464E+6 [an] | 1 [ao] | 36 [ap] |

## Other properties

CPI (Covered by P-Invariants), CTI (Covered by T-Invariants). There are meaningful CTL/LTL properties available, documented in [HD1995].

[q] stated by CÆSAR.BDD version 2.0 to be false for $N = 1$ and true on the remaining 5 instance(s).
[r] true except for N=1.
[s] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, and PNXDD.
[t] computed at MCC'2014 by Marcie.
[u] confirmed at MCC'2014 by Marcie and PNMC.
[v] confirmed at MCC'2014 by Marcie and PNMC.
[w] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, PNXDD, and Tapaal.
[x] computed at MCC'2014 by Marcie.
[y] confirmed at MCC'2014 by Marcie, PNMC, and PNXDD.
[z] computed at MCC'2014 by Marcie, PNMC, and PNXDD.
[aa] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, PNXDD, and Tapaal.
[ab] computed at MCC'2014 by Marcie.
[ac] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ad] computed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ae] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, PNXDD, and Tapaal.
[af] computed at MCC'2014 by Marcie.
[ag] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ah] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ai] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, and PNXDD.
[aj] computed at MCC'2014 by Marcie.
[ak] confirmed at MCC'2014 by Marcie and PNMC.
[al] computed at MCC'2014 by Marcie and PNMC.
[am] computed by Marcie on 2013-12-14; confirmed by CÆSAR.BDD version 2.0; computed at MCC'2014 by Marcie, PNMC, PNXDD, and Tapaal.
[an] computed at MCC'2014 by Marcie.
[ao] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ap] computed at MCC'2014 by Marcie, PNMC, and Tapaal.