> *This form is a summary description of the model entitled "Philosophers" 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 is the famous model that illustrates an inappropriate use of shared resources generating deadlocks. N philosophers share a table with N plates and sticks. They are thinking and, when they need to eat, they go to the table, grab one stick from one side of their plate, then the second from the other side, then eat, and then go back thinking.

In March 2020, Pierre Bouvier and Hubert Garavel provided a decomposition of six 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 three more instances of this model.
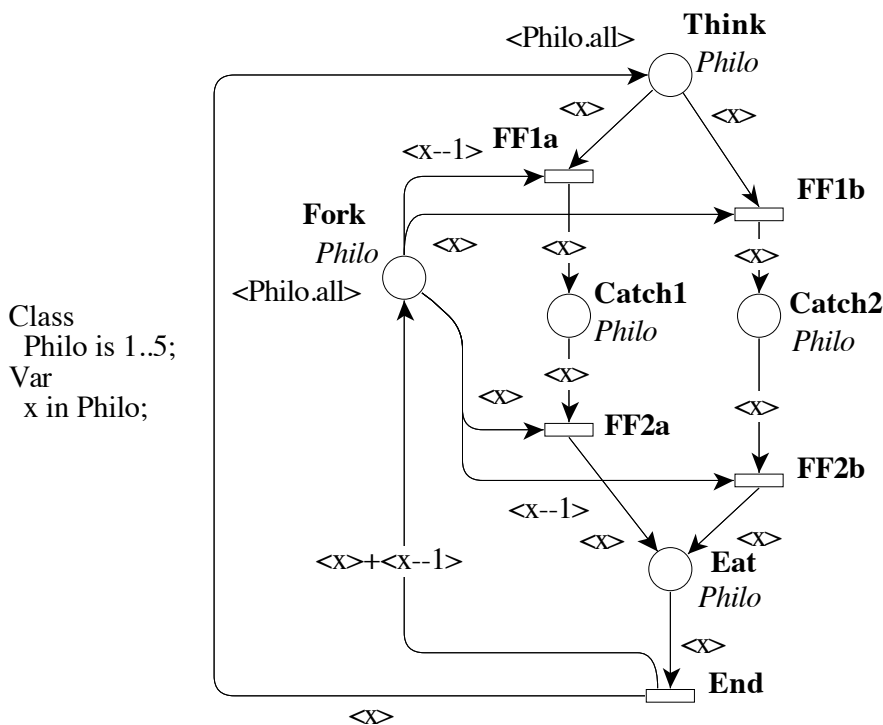
Graphical representation for $N = 5$

References

http://dblp.uni-trier.de/rec/bibtex/journals/acta/Dijkstra71

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	N is the number of dining philosophers. Initial marking of places Think and Fork are impacted.	5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, 10 000, 50 000, 100 000

Model: Philosophers
Type: Colored Net (with derived P/T Nets)
Origin: Academic

since
MCC 2011

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Size of the colored net model

number of places:	5
number of transitions:	5
number of arcs:	15

Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 5$	25	25	80	11	1–10–18
$N = 10$	50	50	160	21	1–20–35
$N = 20$	100	100	320	41	1–40–70
$N = 50$	250	250	800	101	1–100–175
$N = 100$	500	500	1600	201	1–200–350
$N = 200$	1000	1000	3200	401	1–400–700
$N = 500$	2500	2500	8000	1001	1–1000–1782
$N = 1000$	5000	5000	16000	2001	1–2000–3561
$N = 2000$	10000	10000	32000	4001	1–4000–7137
$N = 5000$	25000	25000	80000	–	– –25000
$N = 10000$	50000	50000	160000	–	– –50000

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] .... ? [o]

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[a] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[b] stated by CÆSAR.BDD version 2.6 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[c] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[d] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[e] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[f] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[g] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[h] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[i] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[j] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[k] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[l] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, and 10 000).

[m] stated by CÆSAR.BDD version 1.7 on all 11 instances (5, 10, 20, 50, 100, 200, 500, 1 000, 2 000, 5 000, Land 10 000).

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

[o] stated by CÆSAR.BDD version 3.5 to be true on 9 instance(s) out of 11, and false on the remaining 2 instance(s).

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Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* .... ✔ [(p)]
dead place(s) — *one or more places have no token in any reachable marking* .... ? [(q)]
dead transition(s) — *one or more transitions cannot fire from any reachable marking* .... ? [(r)]
deadlock — *there exists a reachable marking from which no transition can be fired* .... ✔ [(s)]
reversible — *from every reachable marking, there is a transition path going back to the initial marking* .... ✘ [(t)]
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* .... ✘ [(u)]

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
$N = 5$	243 [(v)]	945 [(w)]	1 [(x)]	10 [(y)]
$N = 10$	59 049 [(z)]	459 270 [(aa)]	1 [(ab)]	20 [(ac)]
$N = 20$	3.4868E+9 [(ad)]	5.4239E+10 [(ae)]	1 [(af)]	40 [(ag)]
$N = 50$	7.1790E+23 [(ah)]	2.7918E+25 [(ai)]	1 [(aj)]	100 [(ak)]
$N = 100$	5.154E+47 [(al)]	4.008E+49 [(am)]	1 [(an)]	200 [(ao)]
$N = 200$	2.6561E+95 [(ap)]	4.1318E+97 [(aq)]	1 [(ar)]	400 [(as)]
$N = 500$	3.6360E+238 [(at)]	1.4140E+241 [(au)]	1 [(av)]	1000 [(aw)]
$N = 1000$	1.3221E+477 [(ax)]	1.0283E+480 [(ay)]	1 [(az)]	2000 [(ba)]
$N = 2000$	1.7479E+954 [(bb)]	?	1 [(bc)]	4000 [(bd)]
$N = 5000$	?	?	?	≥ 10000 [(be)]
$N = 10000$	?	?	?	≥ 20000 [(bf)]

[(p)] stated by CÆSAR.BDD version 3.5 to be true on 9 instance(s) out of 11, and unknown on the remaining 2 instance(s).

[(q)] stated by CÆSAR.BDD version 3.3 to be false on 8 instance(s) out of 11, and unknown on the remaining 3 instance(s).

[(r)] stated by CÆSAR.BDD version 2.0 to be false on 5 instance(s) out of 11, and unknown on the remaining 6 instance(s).

[(s)] stated by CÆSAR.BDD version 2.0 to be true on 4 instance(s) out of 11, and unknown on the remaining 7 instance(s); confirmed at MCC'2014 by Helena on 6 colored instances, and by Lola on all P/T instances.

[(t)] the marking graph has deadlocks and contains more than one reachable marking.

[(u)] the net has at least one transition and its marking graph has deadlocks.

[(v)] computed at MCC'2013 by Alpina, GreatSPN, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by CÆSAR.BDD version 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)] computed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.

[(x)] confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

[(y)] computed at MCC'2014 by Marcie, PNMC, and Tapaal.

[(z)] computed at MCC'2013 by Alpina, GreatSPN, ITS-Tools, Marcie, Neco, and PNXDD; confirmed by CÆSAR.BDD version 1.8; confirmed at MCC'2014 by Helena on the colored net instance, and by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal on the P/T net instance.

[(aa)] computed at MCC'2014 by Helena on the colored net instance, and by Marcie on the P/T net instance.

[(ab)] confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal on the P/T net instance.

[(ac)] computed at MCC'2014 by Marcie, PNMC, and Tapaal.

[(ad)] computed at MCC'2013 by Alpina, GreatSPN, ITS-Tools, Marcie, and PNXDD; confirmed by CÆSAR.BDD version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Stratagem.

[(ae)] computed at MCC'2O14 by Marcie.

[(af)] computed at MCC'2014 by GreatSPN, Marcie, and PNMC on the P/T net instance.

[(ag)] computed at MCC'2014 by Marcie and PNMC on the P/T net instance.

[(ah)] computed at MCC'2013 by Alpina, GreatSPN, ITS-Tools, Marcie, and PNXDD; confirmed by CÆSAR.BDD version 1.8; confirmed by CÆSAR.BDD version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Stratagem.

[(ai)] computed at MCC'2O14 by Marcie.

[(aj)] computed at MCC'2014 by GreatSPN, Marcie, and PNMC on the P/T net instance.

[(ak)] computed at MCC'2014 by Marcie and PNMC on the P/T net instance.

[(al)] computed at MCC'2013 by Alpina, GreatSPN, ITS-Tools, Marcie, and PNXDD; confirmed by CÆSAR.BDD version 1.8; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, and Stratagem.

[(am)] computed at MCC'2O14 by Marcie.

[(an)] computed at MCC'2014 by GreatSPN, Marcie, and PNMC on the P/T net instance.

[(ao)] computed at MCC'2014 by Marcie and PNMC on the P/T net instance.

[(ap)] computed at MCC'2013 by GreatSPN, ITS-Tools, Marcie and, PNXDD; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, and PNXDD.

[(aq)] computed at MCC'2O14 by Marcie.

[(ar)] computed at MCC'2014 by GreatSPN, Marcie, and PNMC on the P/T net instance.

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(as) computed at MCC'2014 by Marcie and PNMC on the P/T net instance.

(at) computed at MCC'2013 by ITS-Tools, Marcie, and PNXDD; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, and Stratagem.

(au) computed at MCC'2O14 by Marcie.

(av) computed at MCC'2014 by GreatSPN, Marcie, and PNMC on the P/T net instance.

(aw) computed at MCC'2014 by Marcie and PNMC on the P/T net instance.

(ax) computed at MCC'2014 by Marcie, PNMC, and Stratagem.

(ay) computed at MCC'2014 by Marcie.

(az) computed at MCC'2014 by Marcie and PNMC.

(ba) computed at MCC'2014 by Marcie and PNMC.

(bb) computed at MCC'2014 by PNMC.

(bc) computed at MCC'2014 by PNMC.

(bd) computed at MCC'2014 by PNMC.

(be) lower bound given by the number of initial tokens.

(bf) lower bound given by the number of initial tokens.

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