

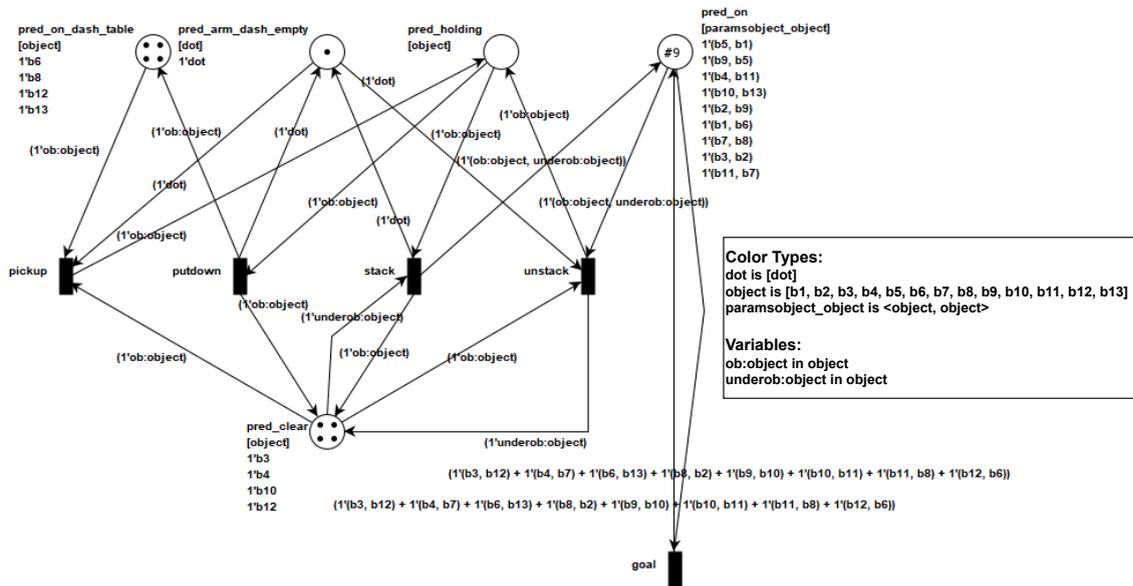
*This form is a summary description of the model entitled “BlocksWorld” proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together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

## Description

Blocks World is originally a classical planning task. The task concerns moving various blocks using a mechanical arm from a starting position to a desired goal position. It is designed to be reminiscent of the real-life problem of calculating a sequence of moves when stacking shipping containers s.t. as little moves as possible are used.

This model has been translated from a classical planning task to a Petri net using a method developed as part of our master’s thesis, supervised by Alvaro Torralba and Jiri Srba at Aalborg University. The places are equivalent to predicates, transitions to actions, colors to objects, and each marking to a state in the original planning task. Therefore, a sequence of transition firings from the initial marking to a desired goal marking is a valid plan in the original planning task.

Twenty instances (numbered with an index  $N$  ranging from 1 to 20) of increasing sizes have been selected, which correspond to the models with different numbers of object colors (namely: 9, 13, 18, 23, 28, 33, 38, 43, 48, 53, 57, 62, 67, 72, 77, 82, 87, 92, 97, and 102).



Graphical representation of the instance  $N = 2$

## References

1. Gupta, N., Nau, D.S.: On the complexity of blocks-world planning. Artificial Intelligence 56(2), 223–254 (1992). [https://doi.org/https://doi.org/10.1016/0004-3702\(92\)90028-V](https://doi.org/https://doi.org/10.1016/0004-3702(92)90028-V)
2. Ginnerup, H., Lassen, S.: Planning via Colored Petri Nets. 9th semester project, Aalborg University (2023).

## Scaling parameter

Parameter name	Parameter description	Chosen parameter values
$N$	Index of the instance	from 1 to 20

## Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 1$	109	181	896	20	1-19-46
$N = 2$	209	365	1810	28	1-27-66
$N = 3$	379	685	3412	38	1-37-109
$N = 4$	599	1105	5512	48	1-47-139
$N = 5$	869	1625	8110	58	1-57-169
$N = 6$	1189	2245	11210	68	1-67-232
$N = 7$	1559	2965	14810	78	1-77-267
$N = 8$	1979	3785	18910	88	1-87-302
$N = 9$	2449	4705	23506	98	1-97-337
$N = 10$	2969	5725	28602	108	1-107-372
$N = 11$	3421	6613	33052	116	1-115-400
$N = 12$	4031	7813	39042	126	1-125-436
$N = 13$	4691	9113	45542	136	1-135-537
$N = 14$	5401	10513	52548	146	1-145-577
$N = 15$	6161	12013	60038	156	1-155-617
$N = 16$	6971	13613	68044	166	1-165-657
$N = 17$	7831	15313	76536	176	1-175-697
$N = 18$	8741	17113	85538	186	1-185-737
$N = 19$	9701	19013	95042	196	1-195-777
$N = 20$	10711	21013	105048	206	1-205-817

## Structural properties

<b>ordinary</b> — all arcs have multiplicity one .....	yes
<b>simple free choice</b> — all transitions sharing a common input place have no other input place .....	no <sup>(a)</sup>
<b>extended free choice</b> — all transitions sharing a common input place have the same input places .....	no <sup>(b)</sup>
<b>state machine</b> — every transition has exactly one input place and exactly one output place .....	no <sup>(c)</sup>
<b>marked graph</b> — every place has exactly one input transition and exactly one output transition .....	no <sup>(d)</sup>
<b>connected</b> — there is an undirected path between every two nodes (places or transitions) .....	yes <sup>(e)</sup>
<b>strongly connected</b> — there is a directed path between every two nodes (places or transitions) .....	yes <sup>(f)</sup>
<b>source place(s)</b> — one or more places have no input transitions .....	no <sup>(g)</sup>
<b>sink place(s)</b> — one or more places have no output transitions .....	no <sup>(h)</sup>
<b>source transition(s)</b> — one or more transitions have no input places .....	no <sup>(i)</sup>
<b>sink transitions(s)</b> — one or more transitions have no output places .....	no <sup>(j)</sup>
<b>loop-free</b> — no transition has an input place that is also an output place .....	no <sup>(k)</sup>
<b>conservative</b> — for each transition, the number of input arcs equals the number of output arcs .....	no <sup>(l)</sup>
<b>subconservative</b> — for each transition, the number of input arcs equals or exceeds the number of output arcs .....	no <sup>(m)</sup>
<b>nested units</b> — places are structured into hierarchically nested sequential units <sup>(n)</sup> .....	yes

<sup>(a)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(b)</sup> transitions “pickup\_0” and “stack\_0” share a common input place “pred\_clear\_0”, but only the former transition has input place “pred\_on-table\_0”.

<sup>(c)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(d)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(e)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(f)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(g)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(h)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(i)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(j)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(k)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(l)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(m)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 20 instances (i.e., for  $N \in \{1, \dots, 20\}$ ).

<sup>(n)</sup> 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* .....? (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* .....? (s)  
**live** — *for every transition  $t$ , from every reachable marking, one can reach a marking in which  $t$  can fire* .....? (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
$N = 1$	$8.14573e+06$ <sup>(t)</sup>	?	1	$\in [12, 19]$ <sup>(u)</sup>
$N = 2$	$\geq 3.97298e+06$ <sup>(v)</sup>	?	?	$\geq 18$ <sup>(w)</sup>
$N = 3$	$\geq 1.24693e+07$ <sup>(x)</sup>	?	?	$\geq 25$
$N = 4$	$\geq 2.3874e+06$ <sup>(y)</sup>	?	?	$\geq 28$
$N = 5$	$\geq 3.91549e+06$ <sup>(z)</sup>	?	?	$\geq 36$
$N = 6$	$\geq 1.05139e+07$ <sup>(aa)</sup>	?	?	$\geq 39$
$N = 7$	$\geq 1.53568e+07$ <sup>(ab)</sup>	?	?	$\geq 47$
$N = 8$	$\geq 2.00771e+06$ <sup>(ac)</sup>	?	?	$\geq 50$ <sup>(ad)</sup>
$N = 9$	$\geq 2.11611e+06$ <sup>(ae)</sup>	?	?	$\geq 53$
$N = 10$	$\geq 2.47533e+06$ <sup>(af)</sup>	?	?	$\geq 60$ <sup>(ag)</sup>
$N = 11$	$\geq 5.16663e+06$ <sup>(ah)</sup>	?	?	$\geq 67$ <sup>(ai)</sup>
$N = 12$	$\geq 5.43635e+06$ <sup>(aj)</sup>	?	?	$\geq 70$
$N = 13$	$\geq 2.55427e+06$ <sup>(ak)</sup>	?	?	$\geq 77$
$N = 14$	$\geq 248617$ <sup>(al)</sup>	?	?	$\geq 80$
$N = 15$	$\geq 64173$ <sup>(am)</sup>	?	?	$\geq 84$
$N = 16$	$\geq 6.00032e+06$ <sup>(an)</sup>	?	?	$\geq 93$
$N = 17$	$\geq 33073$ <sup>(ao)</sup>	?	?	$\geq 96$
$N = 18$	$\geq 548753$ <sup>(ap)</sup>	?	?	$\geq 104$ <sup>(aq)</sup>
$N = 19$	$\geq 2.69453e+06$ <sup>(ar)</sup>	?	?	$\geq 106$ <sup>(as)</sup>
$N = 20$	$\geq 327489$ <sup>(at)</sup>	?	?	$\geq 113$ <sup>(au)</sup>

- (o) stated by CÆSAR.BDD version 3.7 to be true on 1 instance(s) out of 20, and unknown on the remaining 19 instance(s).  
(p) stated by CÆSAR.BDD version 3.7 to be true on 9 instance(s) out of 20, and unknown on the remaining 11 instance(s).  
(q) stated by CÆSAR.BDD version 3.7 to be true on 1 instance(s) out of 20, and unknown on the remaining 19 instance(s).  
(r) stated by CÆSAR.BDD version 3.7 to be false on 1 instance(s) out of 20, and unknown on the remaining 19 instance(s).  
(s) stated by CÆSAR.BDD version 3.7 to be false on 1 instance(s) out of 20, and unknown on the remaining 19 instance(s).  
(t) stated by CÆSAR.BDD version 3.7.  
(u) lower bound given by the number of initial tokens and upper bound given by the number of leaf units.  
(v) stated by CÆSAR.BDD version 3.7.  
(w) lower bound given by the number of initial tokens.  
(x) stated by CÆSAR.BDD version 3.7.  
(y) stated by CÆSAR.BDD version 3.7.  
(z) stated by CÆSAR.BDD version 3.7.  
(aa) stated by CÆSAR.BDD version 3.7.  
(ab) stated by CÆSAR.BDD version 3.7.  
(ac) stated by CÆSAR.BDD version 3.7.  
(ad) lower bound given by the number of initial tokens.  
(ae) stated by CÆSAR.BDD version 3.7.  
(af) stated by CÆSAR.BDD version 3.7.  
(ag) lower bound given by the number of initial tokens.  
(ah) stated by CÆSAR.BDD version 3.7.  
(ai) lower bound given by the number of initial tokens.  
(aj) stated by CÆSAR.BDD version 3.7.  
(ak) stated by CÆSAR.BDD version 3.7.  
(al) stated by CÆSAR.BDD version 3.7.  
(am) stated by CÆSAR.BDD version 3.7.

## Other properties

The goal transition and the arcs connected to it represent the original planning goal of this particular task. To solve the planning task, check if there exists a reachable marking in which the goal transition is enabled. The goal is encoded s.t. firing the transition does not change the marking.

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<sup>(an)</sup> stated by [CÆSAR.BDD](#) version 3.7.

<sup>(ao)</sup> stated by [CÆSAR.BDD](#) version 3.7.

<sup>(ap)</sup> stated by [CÆSAR.BDD](#) version 3.7.

<sup>(aq)</sup> lower bound given by the number of initial tokens.

<sup>(ar)</sup> stated by [CÆSAR.BDD](#) version 3.7.

<sup>(as)</sup> lower bound given by the number of initial tokens.

<sup>(at)</sup> stated by [CÆSAR.BDD](#) version 3.7.

<sup>(au)</sup> lower bound given by the number of initial tokens.