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This form is a summary description of the model entitled "BusinessProcesses" 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.

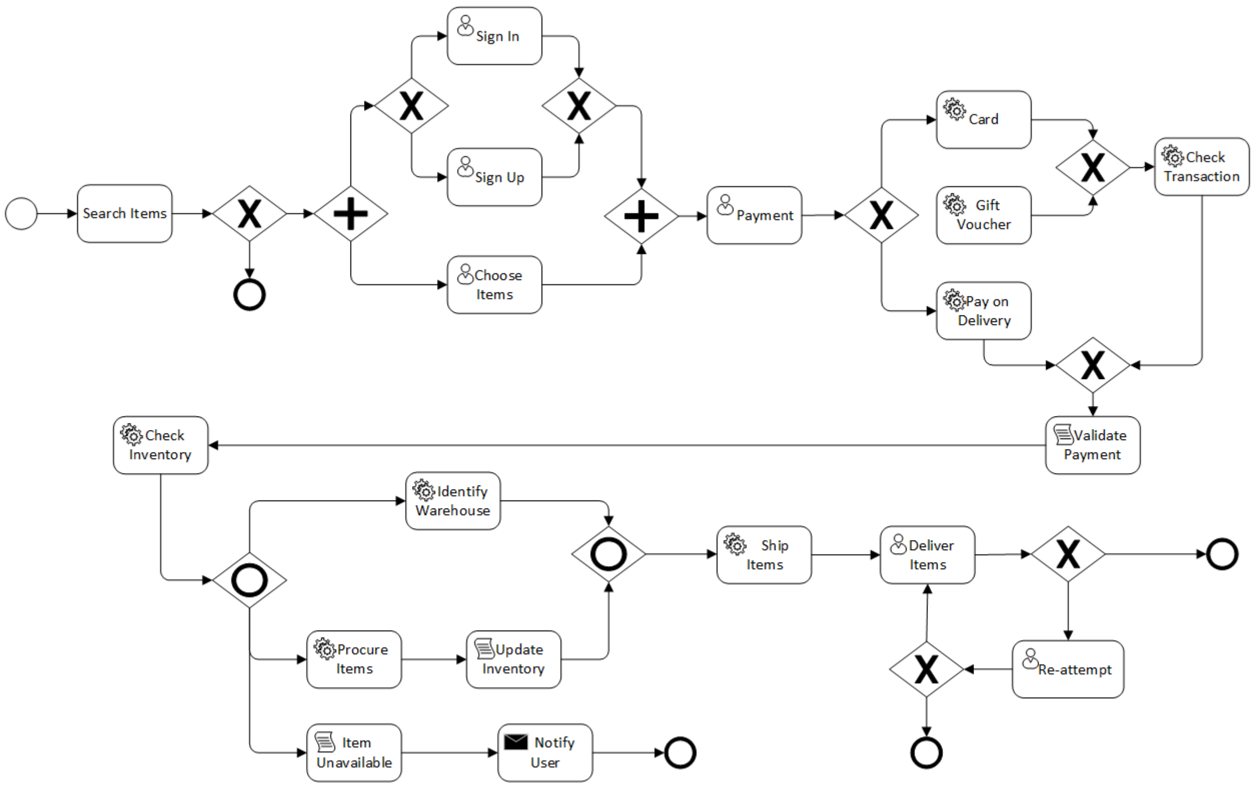
Description

A business process consists in a set of tasks and activities to perform a certain business goal. The Business Process Model and Notation (BPMN) is a widely adopted standard with good tooling support for modelling business processes. Broadly, a process model consists of an initial event, end events, gateways, tasks, and flows. Convergence and divergence of flows are defined using different kinds of gateways.

The NUPN models presented here were obtained as part of our efforts to build a formal verification framework for BPMN [1]. We developed a collection of business processes (specified in BPMN), which represent specific activities carried out by various organizations (e.g., required steps for opening a bank account or publishing a book).

Each of these BPMN models was then translated to the LNT language, a modern successor of LOTOS, using our approach for an automatic model-to-model transformation of BPMN models to LNT with preservation of the execution semantics [2]. Each LNT specification was translated to LOTOS, and then to an interpreted Petri net using the CADP toolbox. From each LOTOS specification, a P/T net was obtained by stripping out all data-related information (variables, types, assignments, guards, etc.) from the interpreted Petri net, leading to a NUPN (Nested-Unit Petri Net) model translated to PNML using the CÆSAR.BDD tool.

We only kept the NUPNs generated before applying all the structural and data-flow optimizations of the CÆSAR compiler for LOTOS, because such optimizations appear to be quite effective for business processes and lead to NUPNs that are often too small for the Model Checking Contest. In the collection of NUPNs generated this way, we carefully selected 20 models of high complexity, which we sorted by the increasing number of places.



Sample business process for online shopping

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References

[1] Ajay Krishna, Pascal Poizat, and Gwen Salaün. *VBPMN: Automated Verification of BPMN Processes.* Proc. of the 13th International Conference on Integrated Formal Methods (iFM 2017), Torino, Italy, LNCS 10510, Springer, September 2017.

[2] Pascal Poizat, Gwen Salaün, and Ajay Krishna. *Checking Business Process Evolution.* Proc. of the International Conference on Formal Aspects of Component Software (FACS 2016), Besançon, France, LNCS 10231, Springer, October 2016.

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	N is the number of threads	from 1 to 20

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 1$	200	178	487	43	12–22–87
$N = 2$	262	219	576	63	18–32–127
$N = 3$	274	237	632	61	18–31–128
$N = 4$	288	283	916	65	13–40–125
$N = 5$	368	319	854	81	24–41–168
$N = 6$	376	297	830	111	22–56–199
$N = 7$	386	360	1110	91	19–53–175
$N = 8$	393	344	911	87	26–44–185
$N = 9$	403	374	1148	95	20–55–183
$N = 10$	518	471	1415	123	27–69–238
$N = 11$	567	508	1512	137	30–76–265
$N = 12$	586	525	1560	141	31–78–272
$N = 13$	593	536	1582	139	32–77–271
$N = 14$	624	564	1657	145	34–80–284
$N = 15$	630	566	1666	147	34–81–287
$N = 16$	638	578	1694	147	35–81–290
$N = 17$	650	580	1709	155	35–85–300
$N = 18$	717	642	1860	165	40–89–329
$N = 19$	772	685	1981	181	43–98–357
$N = 20$	782	697	2011	181	43–98–358

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)

(a) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
(b) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
(c) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
(d) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
(e) stated by CÆSAR.BDD version 2.7 to be true on 19 instance(s) out of 20, and false on the remaining 1 instance(s).
(f) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
(g) stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).

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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]
reversible — *from every reachable marking, there is a transition path going back to the initial marking* .... ? [q]
quasi-live — *for every transition t, there exists a reachable marking in which t can fire* .... ? [r]
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
$N = 1$	2.4161e+10 [t]	?	1	$\in$ [2, 22] [u]
$N = 2$	3.14315e+12 [v]	?	1	$\in$ [2, 32] [w]
$N = 3$	1.4794e+13 [x]	?	1	$\in$ [2, 31] [y]
$N = 4$	$\geq$ 5.60577e+10 [z]	?	1 [aa]	$\in$ [2, 40] [ab]
$N = 5$	2.38391e+17 [ac]	?	1	$\in$ [2, 41] [ad]
$N = 6$	$\geq$ 1.69097e+15 [ae]	?	1 [af]	$\in$ [2, 56] [ag]
$N = 7$	$\geq$ 1.56175e+14 [ah]	?	1 [ai]	$\in$ [2, 53] [aj]
$N = 8$	4.94e+17 [ak]	?	1	$\in$ [2, 44] [al]
$N = 9$	$\geq$ 5.84345e+14 [am]	?	1 [an]	$\in$ [2, 55] [ao]
$N = 10$	$\geq$ 6.82096e+17 [ap]	?	1 [aq]	$\in$ [2, 69] [ar]
$N = 11$	$\geq$ 2.65431e+19 [as]	?	1 [at]	$\in$ [2, 76] [au]
$N = 12$	$\geq$ 3.3391e+20 [av]	?	1 [aw]	$\in$ [2, 78] [ax]
$N = 13$	$\geq$ 2.67038e+21 [ay]	?	1 [az]	$\in$ [2, 77] [ba]
$N = 14$	$\geq$ 3.07953e+21 [bb]	?	1 [bc]	$\in$ [2, 80] [bd]
$N = 15$	$\geq$ 1.65335e+21 [be]	?	1 [bf]	$\in$ [2, 81] [bg]
$N = 16$	$\geq$ 4.14724e+22 [bh]	?	1 [bi]	$\in$ [2, 81] [bj]
$N = 17$	$\geq$ 5.14152e+21 [bk]	?	1 [bl]	$\in$ [2, 85] [bm]
$N = 18$	$\geq$ 4.13695e+23 [bn]	?	1 [bo]	$\in$ [2, 89] [bp]
$N = 19$	$\geq$ 1.93579e+25 [bq]	?	1 [br]	$\in$ [2, 98] [bs]
$N = 20$	$\geq$ 5.5722e+24 [bt]	?	1 [bu]	$\in$ [2, 98] [bv]

[h] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[i] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[j] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[k] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[l] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[m] stated by CÆSAR.BDD version 2.7 on all 20 instances (20 values of N).
[n] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php
[o] safe by construction – stated by the CÆSAR compiler.
[p] stated by CÆSAR.BDD version 2.7 to be true on 5 instance(s) out of 20, and unknown on the remaining 15 instance(s).
[q] stated by CÆSAR.BDD version 2.7 to be false on 5 instance(s) out of 20, and unknown on the remaining 15 instance(s).
[r] stated by CÆSAR.BDD version 2.7 to be false on 17 instance(s) out of 20, and unknown on the remaining 3 instance(s).
[s] stated by CÆSAR.BDD version 2.7 to be false on 17 instance(s) out of 20, and unknown on the remaining 3 instance(s).
[t] stated by CÆSAR.BDD version 2.7.
[u] lower and upper bounds given by the number of initial tokens and the number of leaf units.

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(v) stated by CÆSAR.BDD version 2.7.
(w) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(x) stated by CÆSAR.BDD version 2.7.
(y) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(z) stated by CÆSAR.BDD version 2.7.
(aa) stated by the CÆSAR compiler.
(ab) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(ac) stated by CÆSAR.BDD version 2.7.
(ad) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(ae) stated by CÆSAR.BDD version 2.7.
(af) stated by the CÆSAR compiler.
(ag) lower and upper bounds given by the number of initial tokens and the number of leaf units.
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(al) lower and upper bounds given by the number of initial tokens and the number of leaf units.
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(an) stated by the CÆSAR compiler.
(ao) lower and upper bounds given by the number of initial tokens and the number of leaf units.
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(aq) stated by the CÆSAR compiler.
(ar) lower and upper bounds given by the number of initial tokens and the number of leaf units.
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(au) lower and upper bounds given by the number of initial tokens and the number of leaf units.
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(bo) stated by the CÆSAR compiler.
(bp) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(bq) stated by CÆSAR.BDD version 2.7.
(br) stated by the CÆSAR compiler.
(bs) lower and upper bounds given by the number of initial tokens and the number of leaf units.
(bt) stated by CÆSAR.BDD version 2.7.
(bu) stated by the CÆSAR compiler.
(bv) lower and upper bounds given by the number of initial tokens and the number of leaf units.