Dmitry Zaitsev
daze@acm.org

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

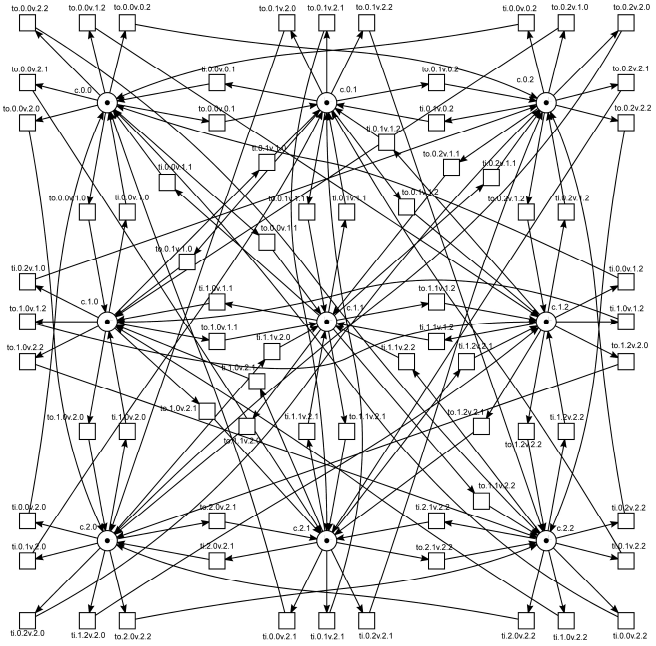
Description

There is a d-dimensional grid of size n indexed with d-tuples having components' range from 0 to $n-1$. A grid cell model is represented with a single Petri net place denoted as "p". Neighboring cells are connected via pairs of dedicated transitions; transitions are denoted as input "ti" and output "to" with respect to a cell with lesser index. A hypertorus is obtained from a hypercube via closing (connecting) opposite facets in each dimension. Indices are printed with '.' separator on dimensions; character 'v' separates two indices in a couple. More complicated cell models can be inserted but the canvas of connections does not change.

In a generalized neighborhood [1], neighbors are situated at Chebyshev distance equal to 1 restricted by a given interval of Manhattan distance r, $1 \le r_1 \le r \le r_2 \le d$. Neighbors are connected via facets which are hypercubes having dimensions from $d-r_1$ to $d-r_2$. Thus, $r_1 = 1$, $r_2 = 1$ gives von-Neumann's neighborhood and $r_1 = 1$, $r_2 = d$ gives Moore's neighborhood.

A program *hmn* [2] that generates models has the following command line: *hmn d n* [*m*] [*e*] [r_1] [r_2] > *hmn_model.net*

where d is the number of dimensions ($d \ge 1$); n is the size of hypertorus or hypercube ($n \ge 1$; for hypertorus $n \ge 3$), actually the size is $n \times n \times n \times ... \times n$ (d times); m is the number of tokens in each node ($m \ge 0$, default 1); e is an edge condition: 't' – hypertorus, 'c' – hypercube (default 't'); r_1 is a lower bound of Manhattan distance (default $r_1 = 1$); r_2 is an upper bound of Manhattan distance (default $r_2 = d$), $1 \le r_1 \le r_2 \le d$.



Graphical representation for $d = 2$, $n = 3$, $m = 1$, $e =' t'$, $r_1 = 1$, $r_2 = 2$

References

[1] Zaitsev D.A. A generalized neighborhood for cellular automata, Theoretical Computer Science. Online 22 November 2016, http://dx.doi.org/10.1016/j.tcs.2016.11.002

[2] Zaitsev D.A. Generators of canvas for Petri net models of hypertorus (hypercube) grid with Moore's, von-Neumann's, and generalized neighborhoods, https://github.com/dazeorgacm/hmn

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Scaling parameter

Parameter name	Parameter description	Chosen parameter values
d, n, m, e, r_1, r_2	d – dimension; n – size; m – initial marking of each place; e – edge condition: 't' – hypertorus, 'c' – hypercube; r_1 – lower Manhattan distance; r_2 – upper Manhattan distance	(2,3,1,'t',1,2), (2,3,1,'c',1,2), (3,3,1,'t',1,1), (4,3,2,'c',2,3), (5,4,1,'t',3,5)

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs
$N = (d, n, m, e, r_1, r_2)$	$P = n^d$	for a hypertorus (e='t'): $T = n^d \cdot \sum_{j=r_1}^{r_2} 2^j C_d^j$; for a hypercube – sum on all the places (cells) the number of a cell neighbors (depending on the dimension of the corresponding edge)	$A = 2T$
(2,3,3,c,1,2)	9	40	80
(2,3,3,t,1,2)	9	72	144
(3,3,3,t,1,1)	27	162	324
(4,3,3,c,2,3)	81	1632	3264
(5,4,4,t,3,5)	1024	196608	393216

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)] ..... ✘

[(a)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(b)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(c)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(d)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(e)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(f)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(g)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(h)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(i)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(j)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(k)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(l)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(m)] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[(n)] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php

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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* ..... ✗
reversible — *from every reachable marking, there is a transition path going back to the initial marking* ..... ✓ [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
d, n, m, e, r_1, r_2	$C^{n^d-1}_{(m+1)n^d-1}$	Sum on all markings, for all places (cells) with nonzero marking, the number of the corresponding cell neighbors	$m \cdot n^d$	$m \cdot n^d$
(2,3,1,c,1,2)	24310	514800	9	9 [t]
(2,3,1,t,1,2)	24310	926640	9	9 [u]
(3,3,1,t,1,1)	973469712824056	?	27	27 [v]
(4,3,2,c,2,3)	C^{80}_{242}	?	162	162 [w]
(5,4,1,t,3,5)	C^{1023}_{2047}	?	1024	1024 [x]

[o] confirmed by CÆSAR.BDD version 2.7 on all 5 instances (see all aforementioned parameter values).
[p] stated by CÆSAR.BDD version 3.3 on all 5 instances (see all aforementioned parameter values).
[q] stated by CÆSAR.BDD version 2.7 to be false on 4 instances out of 5, and unknown on the remaining instance.
[r] stated by CÆSAR.BDD version 2.7 to be true on 4 instances out of 5, and unknown on the remaining instance.
[s] stated by CÆSAR.BDD version 2.7 to be true on 4 instances out of 5, and unknown on the remaining instance.
[t] number of initial tokens, because the net is conservative.
[u] number of initial tokens, because the net is conservative.
[v] number of initial tokens, because the net is conservative.
[w] number of initial tokens, because the net is conservative.
[x] number of initial tokens, because the net is conservative.