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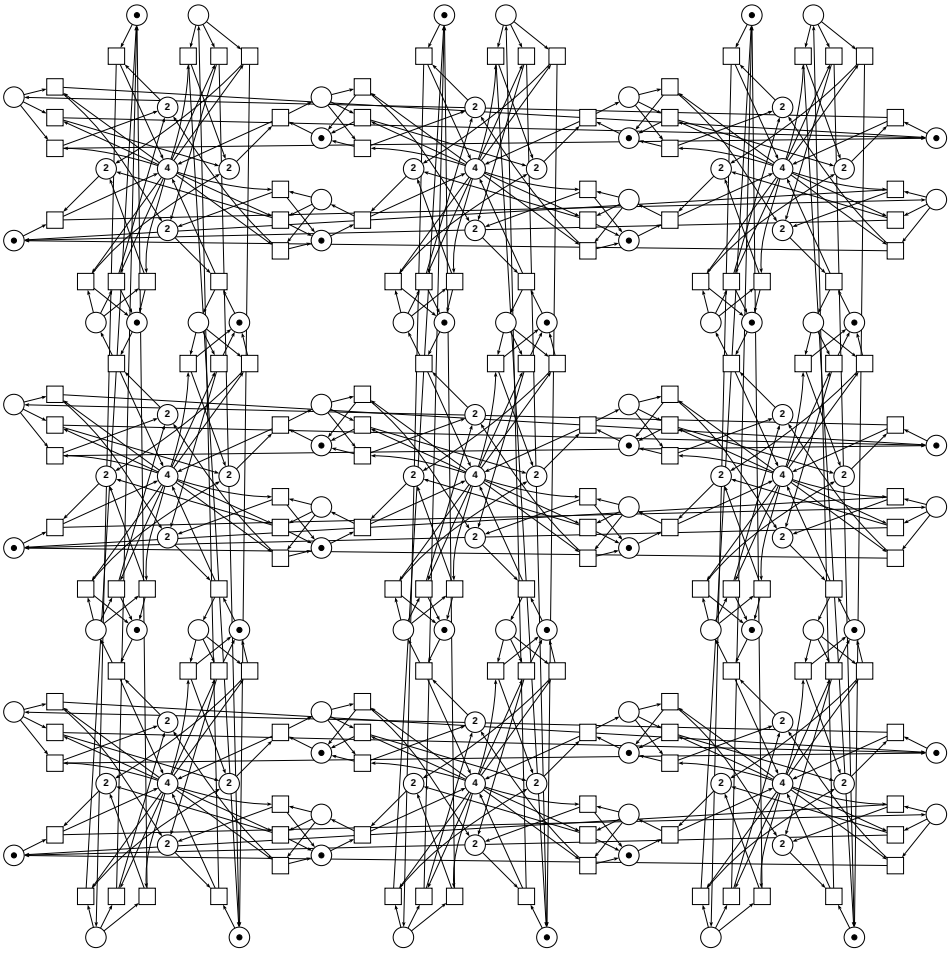
This form is a summary description of the model entitled "HypertorusGrid" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given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

Description

A hypertorus is obtained from a hypercube via closing (connecting) opposite facets in each dimension. A cell of hypertorus grid represents a computing and packet switching device with ports situated on facets of the unit-sized hypercube. A device works in full-duplex mode using store-and-forward principle with limited capacity of buffer. Neighboring cells are connected via merging contact places situated on common facets.



Graphical representation for $d = 2$, $k = 3$, $p = 2$, and $b = 4$.

References

[1] Zaitsev D.A., Zaitsev I.D., Shmeleva T.R. Infinite Petri Nets as Models of Grids. Chapter 19 in Mehdi Khosrow-Pour (Ed.) Encyclopedia of Information Science and Technology, Third Edition (10 Volumes). IGI-Global: USA, pp. 187–204, 2014.

[2] Zaitsev D.A. Verification of Computing Grids with Special Edge Conditions by Infinite Petri Nets, Automatic Control and Computer Sciences, 2013, vol. 47, no. 7, pp.403–412.

[3] Zaitsev D.A. Generator of hypertorus Petri net models. http://github.com/dazeorgacm/htgen

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Scaling parameter

Parameter name	Parameter description	Chosen parameter values
(d, k, p, b)	d – dimension of hypertorus; k – size in each dimension, totally k^d nodes; p – number of packets in each section of the internal buffer; b – available buffer size. d and k influence the Petri net structure while p and d define its initial marking.	(2,1,8,0), (2,2,1,0), (2,3,2,4), (3,3,2,6), (4,3,2,8), (5,3,2,10)

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs
(d, k, p, b)	$6 \cdot d \cdot k^d + k^d$	$4 \cdot d^2 \cdot k^d$	$16 \cdot d^2 \cdot k^d$
$(2, 1, 8, 0)$	13	16	64
$(2, 2, 1, 0)$	52	64	256
$(2, 3, 2, 4)$	117	144	576
$(3, 3, 2, 6)$	513	972	3888
$(4, 3, 2, 8)$	2025	5184	20736
$(5, 3, 2, 10)$	7533	24300	97200

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] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[b] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[c] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[d] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[e] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[f] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[g] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[h] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[i] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[j] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[k] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[l] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[m] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[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]
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* ..... ✗
quasi-live — *for every transition t, there exists a reachable marking in which t can fire* ..... ✓ [p]
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ..... ✗

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
$(2,1,8,0)$	87552	667632	32	36
$(2,2,1,0)$	$\geq$ 7.50898e+08 [q]	?	?	$\geq$ 32 [r]
$(2,3,2,4)$	?	?	?	144 [s]
$(3,3,2,6)$	?	?	?	648 [t]
$(4,3,2,8)$	?	?	?	2592 [u]
$(5,3,2,10)$	?	?	?	9720 [v]

Other properties

To observe a deadlock, there should be enough packets (p) compared to available buffer size (b) to block a couple or more devices [1,2].

Using *htgen* [3], a model in format .net of Tina modeling system (`http://www.laas.fr/tina`) was built for given values of parameters.

[o] stated by CÆSAR.BDD version 2.6 on all 6 instances (i.e., the six quadruples listed above).
[p] stated by CÆSAR.BDD version 2.6 to be true on 2 instance(s) out of 6, and unknown on the remaining 4 instance(s).
[q] stated by CÆSAR.BDD version 2.6.
[r] lower bound given by the number of initial tokens.
[s] number of initial tokens, because the net is conservative.
[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.