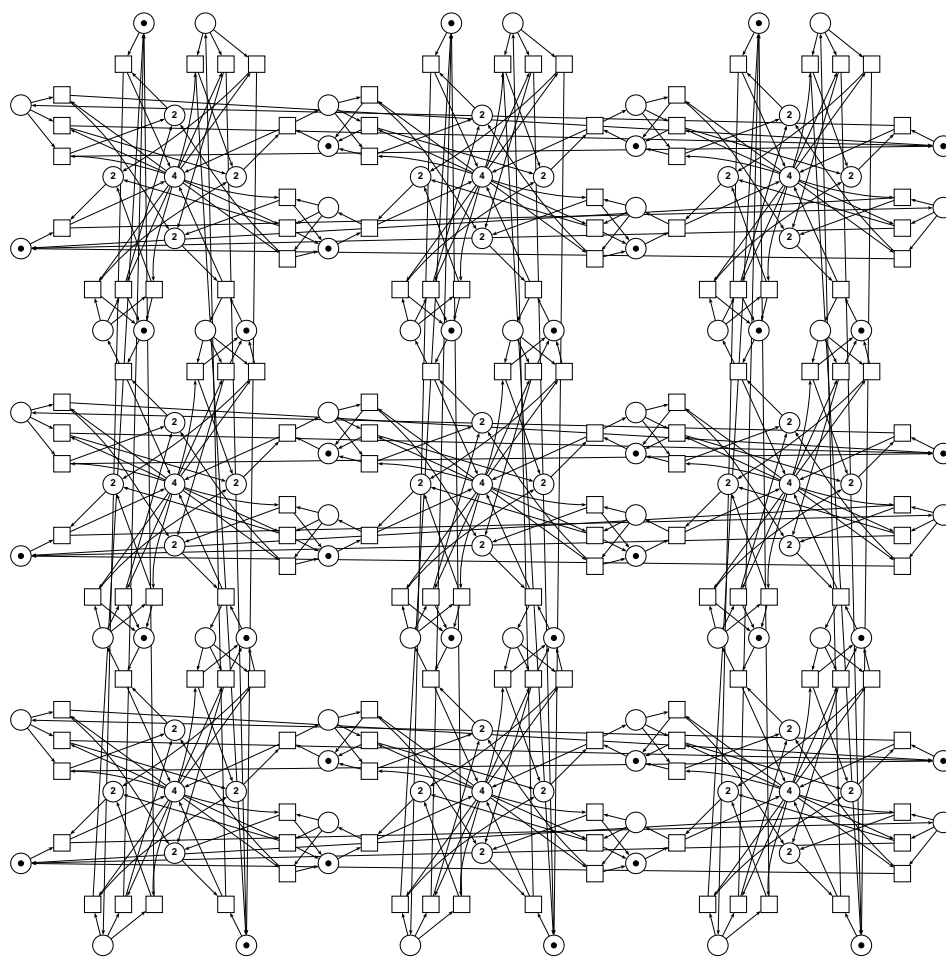


This form is a summary description of the model entitled “HypertorusGrid” proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given 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>

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 b 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>

Behavioural properties

- safe** — *in every reachable marking, there is no more than one token on a place* X ^(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* X
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* X

Size of the marking graphs

Parameter	Number of reach-able markings	Number of tran-sition 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)	?	?	≥ 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.