Model: Circular Trains
Type: P/T Net
Origin: Academic

since
MCC 2014

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This form is a summary description of the model entitled "Circular Trains" 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

On a circular railroad divided in S sections, $\frac{S}{3}$ trains circulate in the same direction. For security reasons, a segment may never contains more than one train at a time [a]. Traffic lights manage the access to each sections. In the figure below, sections are represented by places Section_$\langle i \rangle$. The presence of a marking in such places means that a train is there. Traffic lights are modeled by places F$\langle i \rangle$, they are marked when they are green. The passage from section $\langle i \rangle$ to $\langle j \rangle$ is done when firing transition t$\langle i \rangle$_to_$\langle j \rangle$.
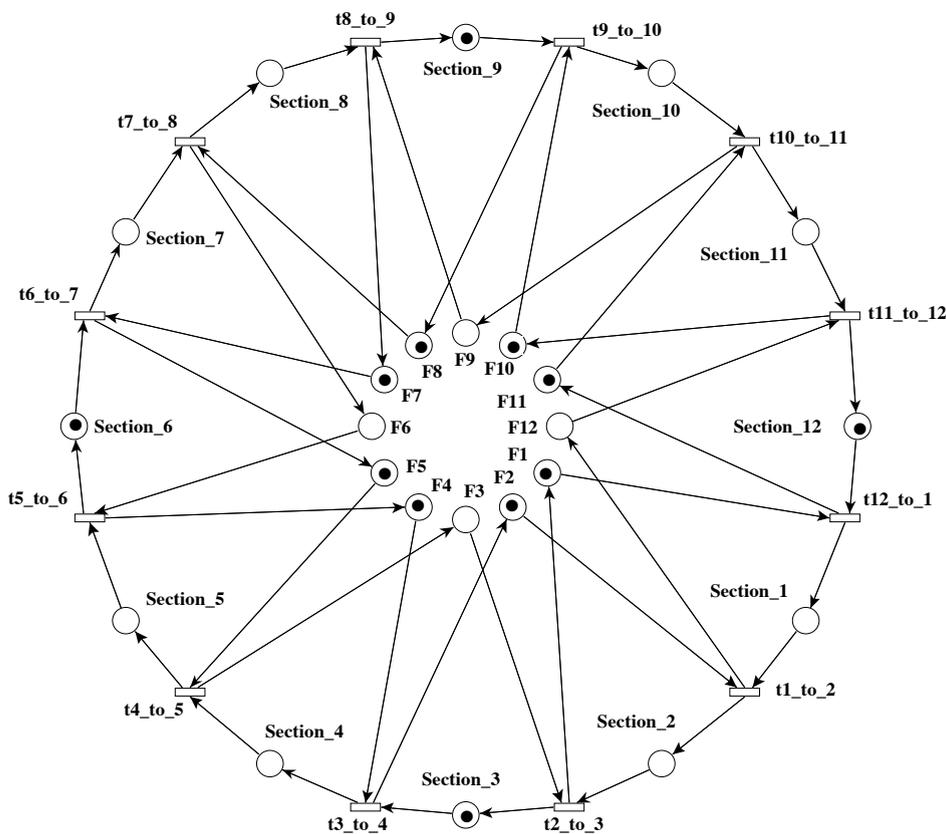
References

The model was originally presented in [1], it was reused as an example in the PetriScript documentation [2].

1. Hartmann Genrich, "Predicate/Transition nets", in Petri Nets: Central Models and their Properties, Advances in PetriNets 1986, Part 1, roc on an advanced course, Bad Honnef, 1986, Springer Verlag, L.N.C.S. 254. pp 207-247

2. A. Hamez and X. Renault, "PetriScript Reference Manual (1.0)", http://www.lip6.fr/cpn-ami-doc/PetriScript_Reference_Manual.pdf, 2005

[a]this is an adaptation of the original problem where these trains could never be located on two contiguous segments (change of the initial marking).

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Scaling parameter

Parameter name	Parameter description	Chosen parameter values
S	The number of sections in the railway	12, 24, 48, 96, 192, 384, 768

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs
S	$2 \times S$	S	$4 \times S$
$S = 12$	24	12	48
$S = 24$	48	24	96
$S = 48$	96	48	192
$S = 96$	192	96	384
$S = 192$	384	192	768
$S = 384$	768	384	1536
$S = 768$	1536	768	3072

Structural properties

ordinary — *all arcs have multiplicity one* .... yes

simple free choice — *all transitions sharing a common input place have no other input place* .... yes [b]

extended free choice — *all transitions sharing a common input place have the same input places* .... yes [c]

state machine — *every transition has exactly one input place and exactly one output place* .... no [d]

marked graph — *every place has exactly one input transition and exactly one output transition* .... yes [e]

connected — *there is an undirected path between every two nodes (places or transitions)* .... yes [f]

strongly connected — *there is a directed path between every two nodes (places or transitions)* .... yes [g]

source place(s) — *one or more places have no input transitions* .... no [h]

sink place(s) — *one or more places have no output transitions* .... no [i]

source transition(s) — *one or more transitions have no input places* .... no [j]

sink transitions(s) — *one or more transitions have no output places* .... no [k]

loop-free — *no transition has an input place that is also an output place* .... yes [l]

conservative — *for each transition, the number of input arcs equals the number of output arcs* .... yes [m]

subconservative — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ...... yes [n]

nested units — *places are structured into hierarchically nested sequential units* [o] .... no

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* .... no [p]

dead place(s) — *one or more places have no token in any reachable marking* .... ? [q]

dead transition(s) — *one or more transitions cannot fire from any reachable marking* .... no [r]

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[b] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[c] stated by CÆSAR.BDD version 2.6 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[d] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[e] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[f] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[g] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[h] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[i] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[j] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[k] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[l] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[m] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[n] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[o] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php

[p] stated by CÆSAR.BDD version 2.0 on all 7 instances (12, 24, 48, 96, 192, 384, and 768).

[q] stated by CÆSAR.BDD version 3.3 to be false on 4 instance(s) out of 7, and unknown on the remaining 3 instance(s).

[r] stated by CÆSAR.BDD version 2.0 to be false on 3 instance(s) out of 7, and unknown on the remaining 4 instance(s).

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deadlock — *there exists a reachable marking from which no transition can be fired* ....no [s]

reversible — *from every reachable marking, there is a transition path going back to the initial marking* ....yes

live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ....yes

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
$S = 12$	195 [t]	496 [u]	2 [v]	12 [w]
$S = 24$	86 515 [x]	411 680 [y]	2 [z]	24 [aa]
$S = 48$	2.3974×10^{10} [ab]	2.2124×10^{11} [ac]	2 [ad]	48 [ae]
$S = 96$	2.5913×10^{21} [af]	4.7121×10^{22} [ag]	?	96 [ah]
$S = 192$	4.2702×10^{43} [ai]	1.532×10^{45} [aj]	2 [ak]	192 [al]
$S = 384$	?	?	?	384 [am]
$S = 768$	?	?	?	768 [an]

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[s] by construction; confirmed at MCC'2014 by Lola on 5 instances, and by GreatSPN and Tapaal on 2 instances.

[t] computed by Prod and PNXDD on January 2014; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

[u] computed by Prod on January 2014; confirmed at MCC'2014 by Marcie.

[v] computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

[w] number of initial tokens, because the net is conservative.

[x] computed by Prod and PNXDD on January 2014; confirmed at MCC'2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

[y] computed by Prod on January 2014; confirmed at MCC'2014 by Marcie.

[z] computed at MCC'2014 by GreatSPN, Marcie, PNMC, and Tapaal.

[aa] number of initial tokens, because the net is conservative.

[ab] computed by PNXDD on January 2014; confirmed at MCC'2014 by Marcie, PNMC, and PNXDD.

[ac] computed at MCC'2014 by Marcie.

[ad] computed at MCC'2014 by Marcie and PNMC.

[ae] number of initial tokens, because the net is conservative.

[af] computed by PNXDD on January 2014; confirmed at MCC'2014 by Marcie and PNXDD.

[ag] computed at MCC'2014 by Marcie.

[ah] number of initial tokens, because the net is conservative.

[ai] computed at MCC'2014 by Marcie.

[aj] computed at MCC'2014 by Marcie.

[ak] computed at MCC'2014 by Marcie.

[al] number of initial tokens, because the net is conservative.

[am] number of initial tokens, because the net is conservative.

[an] number of initial tokens, because the net is conservative.

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