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 contain 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 $\text{Section}_i$. The presence of a marking in such places means that a train is there. Traffic lights are modeled by places $\text{F}_i$, they are marked when they are green. The passage from section $\langle i \rangle$ to $\langle j \rangle$ is done when firing transition $t_{i,j}$.\(^{(a)}\)

References

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


\(^{(a)}\) this is an adaptation of the original problem where these trains could never be located on two contiguous segments (change of the initial marking).
Scaling parameter

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Parameter description</th>
<th>Chosen parameter values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
<td>The number of sections in the railway</td>
<td>12, 24, 48, 96, 192, 384, 768</td>
</tr>
</tbody>
</table>

Size of the model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of places</th>
<th>Number of transitions</th>
<th>Number of arcs</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
<td>( 2 \times S )</td>
<td>( S )</td>
<td>( 4 \times S )</td>
</tr>
<tr>
<td>( S = 12 )</td>
<td>24</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>( S = 24 )</td>
<td>48</td>
<td>24</td>
<td>96</td>
</tr>
<tr>
<td>( S = 48 )</td>
<td>96</td>
<td>48</td>
<td>192</td>
</tr>
<tr>
<td>( S = 96 )</td>
<td>192</td>
<td>96</td>
<td>384</td>
</tr>
<tr>
<td>( S = 192 )</td>
<td>384</td>
<td>192</td>
<td>768</td>
</tr>
<tr>
<td>( S = 384 )</td>
<td>768</td>
<td>384</td>
<td>1536</td>
</tr>
<tr>
<td>( S = 768 )</td>
<td>1536</td>
<td>768</td>
<td>3072</td>
</tr>
</tbody>
</table>

Structural properties

- **ordinary** — all arcs have multiplicity one
- **simple free choice** — all transitions sharing a common input place have no other input place
- **extended free choice** — all transitions sharing a common input place have the same input places
- **state machine** — every transition has exactly one input place and exactly one output place
- **marked graph** — every place has exactly one input transition and exactly one output transition
- **strongly connected** — there is an undirected path between every two nodes (places or transitions)
- **source place(s)** — one or more places have no input transitions
- **sink place(s)** — one or more places have no output transitions
- **source transition(s)** — one or more transitions have no input places
- **sink transitions(s)** — one or more transitions have no output places
- **loop-free** — no transition has an input place that is also an output place
- **conservative** — for each transition, the number of input arcs equals the number of output arcs
- **subconservative** — for each transition, the number of input arcs equals or exceeds the number of output arcs
- **nested units** — places are structured into hierarchically nested sequential units

Behavioural properties

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

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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](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) by construction; confirmed at MCC’2014 by Lola on 5 instances, and by GreatSPN and Tapaal on 2 instances.
quasi-live — for every transition $t$, there exists a reachable marking in which $t$ can fire

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

Size of the marking graphs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of reachable markings</th>
<th>Number of transition firings</th>
<th>Max. number of tokens per place</th>
<th>Max. number of tokens per marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S = 12$</td>
<td>195 ($^t$)</td>
<td>496 ($^t$)</td>
<td>2 ($^t$)</td>
<td>12 ($^t$)</td>
</tr>
<tr>
<td>$S = 24$</td>
<td>86 515 ($^w$)</td>
<td>411 680 ($^x$)</td>
<td>2 ($^y$)</td>
<td>24 ($^z$)</td>
</tr>
<tr>
<td>$S = 48$</td>
<td>$2.3974 \times 10^{10}$ ($^{aa}$)</td>
<td>$2.2124 \times 10^{11}$ ($^{ab}$)</td>
<td>2 ($^{ac}$)</td>
<td>48 ($^{ad}$)</td>
</tr>
<tr>
<td>$S = 96$</td>
<td>$2.5913 \times 10^{21}$ ($^{ac}$)</td>
<td>$4.7121 \times 10^{22}$ ($^{ad}$)</td>
<td>? ($^{ae}$)</td>
<td>96 ($^{ag}$)</td>
</tr>
<tr>
<td>$S = 192$</td>
<td>$4.2702 \times 10^{43}$ ($^{ab}$)</td>
<td>$1.532 \times 10^{45}$ ($^{ab}$)</td>
<td>2 ($^{ac}$)</td>
<td>192 ($^{ak}$)</td>
</tr>
<tr>
<td>$S = 384$</td>
<td>? ($^{ac}$)</td>
<td>? ($^{ac}$)</td>
<td>? ($^{ac}$)</td>
<td>384 ($^{alm}$)</td>
</tr>
<tr>
<td>$S = 768$</td>
<td>? ($^{ac}$)</td>
<td>? ($^{ac}$)</td>
<td>? ($^{ac}$)</td>
<td>768 ($^{am}$)</td>
</tr>
</tbody>
</table>

$^t$ stated by CÆSAR.BDD version 2.0 to be true on 3 instance(s) out of 7, and unknown on the remaining 4 instance(s).

$^w$ computed by Prod and PNXDD on January 2014; confirmed at MCC’2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

$^x$ computed by Prod on January 2014; confirmed at MCC’2014 by Marcie.

$^y$ computed at MCC’2014 by GreatSPN, Marcie, PNMC, and Tapaal.

$^z$ number of initial tokens, because the net is conservative.

$^w$ computed by Prod and PNXDD on January 2014; confirmed at MCC’2014 by GreatSPN, Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

$^x$ computed by Prod on January 2014; confirmed at MCC’2014 by Marcie.

$^y$ computed at MCC’2014 by GreatSPN, Marcie, PNMC, and Tapaal.

$^z$ number of initial tokens, because the net is conservative.

$^{aa}$ computed by PNXDD on January 2014; confirmed at MCC’2014 by Marcie, PNMC, and PNXDD.

$^{ab}$ computed at MCC’2014 by Marcie.

$^{ac}$ computed at MCC’2014 by Marcie and PNMC.

$^{ad}$ number of initial tokens, because the net is conservative.

$^{ae}$ computed by PNXDD on January 2014; confirmed at MCC’2014 by Marcie and PNXDD.

$^{af}$ number of initial tokens, because the net is conservative.

$^{ag}$ computed at MCC’2014 by Marcie.

$^{ah}$ computed at MCC’2014 by Marcie.

$^{ai}$ number of initial tokens, because the net is conservative.

$^{aj}$ number of initial tokens, because the net is conservative.

$^{ak}$ number of initial tokens, because the net is conservative.

$^{ai}$ number of initial tokens, because the net is conservative.

$^{am}$ number of initial tokens, because the net is conservative.