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 Section_\(i\). The presence of a marking in such places means that a train is there. Traffic lights are modeled by places F_\(i\), they are marked when they are green. The passage from section \(i\) to \(j\) is done when firing transition \(t_{i\to j}\).

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>$S = 384$</td>
<td>384</td>
<td>192</td>
<td>768</td>
</tr>
<tr>
<td>$S = 768$</td>
<td>1536</td>
<td>768</td>
<td>3072</td>
</tr>
</tbody>
</table>

Structural properties

- free choice — all (different) transitions with a shared input place have no other input place (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 a 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)

Behavioural properties

- safe — in every reachable marking, there is no more than one token on a place (n)
- deadlock — there exists a reachable marking from which no transition can be fired (o)
- reversible — from every reachable marking, there is a transition path going back to the initial marking (p)
- quasi-live — for every transition $t$, there exists a reachable marking in which $t$ can fire (q)
- live — for every transition $t$, from every reachable marking, one can reach a marking in which $t$ can fire (r)

(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 2.0 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) by construction.
(p) 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).
## 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 ($q$)</td>
<td>496 ($q$)</td>
<td>?</td>
<td>$\geq 12$ ($q$)</td>
</tr>
<tr>
<td>$S = 24$</td>
<td>86,515 ($t$)</td>
<td>411,680 ($w$)</td>
<td>?</td>
<td>$\geq 24$</td>
</tr>
<tr>
<td>$S = 48$</td>
<td>$2.3974 \times 10^{10}$ ($v$)</td>
<td>?</td>
<td>?</td>
<td>$\geq 48$</td>
</tr>
<tr>
<td>$S = 96$</td>
<td>$2.5913 \times 10^{21}$ ($w$)</td>
<td>?</td>
<td>?</td>
<td>$\geq 96$</td>
</tr>
<tr>
<td>$S = 192$</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>$\geq 192$</td>
</tr>
<tr>
<td>$S = 384$</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>$\geq 384$</td>
</tr>
<tr>
<td>$S = 768$</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>$\geq 768$</td>
</tr>
</tbody>
</table>

$q$: computed by Prod and PNXDD on January 2014.
$t$: computed by Prod on January 2014.
$s$: lower bound given by the number of initial tokens.
$v$: computed by Prod and PNXDD on January 2014.
$w$: computed by Prod on January 2014.
$u$: computed by PNXDD on January 2014.
$w$: computed by PNXDD on January 2014.