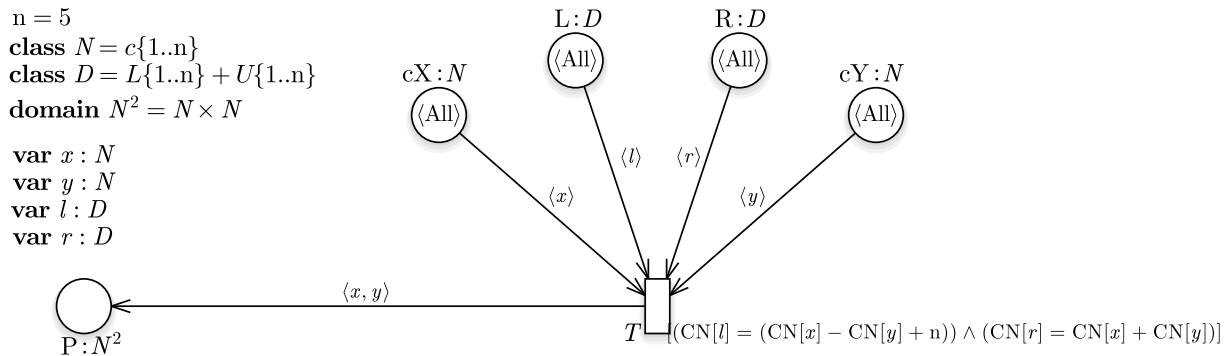


*This form is a summary description of the model entitled “NQueens” proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together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

## Description

The model represents the classical  $n$ -queens problem. The Petri net represents a  $n \times n$  chessboard where the player must position  $n$  queens so that no two queens threaten each other. The model works by positioning one queen at a time, until either a valid solution is found (i.e. all  $n$  queens are placed), or some constraint is violated. Place  $P$  represents the chessboard. Places  $cX$  and  $cY$  represent the constraints of having at most one queen for each row/column. Places  $L$  and  $R$  represent the constraints of having at most one queen for each left/right diagonals. Transition  $T$  models the process of putting a new queen piece to the chessboard in position  $x, y$ . The number of solutions is found by counting all reachable states where  $\sum_{i=1}^n \sum_{j=1}^n cX_i = 0 \wedge cY_i = 0$ .



Graphical representation for  $n = 5$  in the colored version of the model

## Scaling parameter

Parameter name	Parameter description	Chosen parameter values
$n$	The size of the chessboard.	5, 8, 10, 15, 20, 25, 30

## Size of the model

Parameter	Number of places	Number of transitions	Number of arcs
$n$	$n^2 + 6n$	$n^2$	$5n^2$

## 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 ..... ?
- connected** — there is an undirected path between every two nodes (places or transitions) ..... ?
- strongly connected** — there is a directed 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 .....X
- 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<sup>(a)</sup> .....X

### 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 .....X
- 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 .....X

### 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
$N = 5$	462	1.295	1	30
$N = 8$	118.969	564.880	1	48
$N = 10$	?	?	1	?
$N = 12$	?	?	1	?
$N = 15$	?	?	1	?
$N = 20$	?	?	1	?
$N = 25$	?	?	1	?
$N = 30$	?	?	1	?

<sup>(a)</sup>the definition of Nested-Unit Petri Nets (NUPN) is available from <http://mcc.lip6.fr/nupn.php>