Model: Eisenberg-McGuire
Type: P/T Net
Origin: Academic

since
MCC 2023

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This form is a summary description of the model entitled "Eisenberg-McGuire" 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

This PT net models Eisenberg-McGuire's algorithm for N processes mutual exclusion problem.

The pseudo code of the algorithm is the following:

```
//  variables
constant int N := 4;
shared enum states {IDLE, WAITING, ACTIVE} flag[N - 1] := { IDLE, ..., IDLE};
shared int turn := 0;
int i; //  not shared

// code for a process p (p in [0..N-1])
01 loop {
02   repeat {
03     // announce that we need the resource
04     flag[p] := WAITING;
05     //  scan processes from the one with the turn up to ourselves.
06     //  repeat if necessary until the scan finds all processes idle
07     i := turn;
08     while( i != p) {
09       if(flag[i] != IDLE)
10         i := turn;
11       else
12         i := i + 1 mod N;
13     }
14     //  now tentatively claim the resource
15     flag[p] := ACTIVE;
16     //  find the first active process besides ourselves, if any
17     i := 0;
18     while (i < n and (i == p or flag[i] != ACTIVE)) {
19       i := i + 1;
20     }
21     //  if there were no other active processes, AND if we have the
22     //  turn or else whoever has it is idle, then proceed.
23     //  Otherwise, repeat the whole sequence.
24   }
25   until (i >= n and (turn == p or flag[turn] == IDLE));
26   //  claim the turn and proceed
27   turn := p;
28   //  critical section
29   ...
30   //  find a process which is not IDLE
31   //  (if there are no others, we will find ourselves)
32   i := turn + 1 mod n;
33   while (flag[i] = IDLE) {
34     i := i + 1 mod n;
35   }
36   //  give the turn to someone that needs it, or keep it
37   turn := i;
38   //  we're finished now
39   flag[p] := IDLE;
40 }
```

Places are named `pXX` where `XX` is a line number in the code. Same for transitions. Exceptions are places modeling shared variables and the critical section.

References

Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	Number of processes competing	3, 4, 5, 6, 7, 8, 9, 10

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Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 3$	117	216	900	10	2–8–29
$N = 4$	196	448	1952	12	2–10–37
$N = 5$	295	800	3600	13	1–12–50
$N = 6$	414	1296	5976	15	1–14–58
$N = 7$	553	1960	9212	17	1–16–67
$N = 8$	712	2816	13440	19	1–18–75
$N = 9$	891	3888	18792	23	2–21–90
$N = 10$	1090	5200	25400	25	2–23–105

Structural properties

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

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

extended free choice — *all transitions sharing a common input place have the same input places* .... no [b]

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

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

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

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

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

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

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

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

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

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

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

nested units — *places are structured into hierarchically nested sequential units* [n] .... yes

Behavioural properties

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

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

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

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

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

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

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[a] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[b] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[c] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[d] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[e] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[f] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[g] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[h] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[i] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[j] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[k] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[l] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

[m] stated by CÆSAR.BDD version 3.7 on all 8 instances (3, 4, 5, 6, 7, 8, 9, 10, and 11).

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

[o] safe by construction – stated by PNML2NUPN 3.2.0.

[p] stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 8, and unknown on the remaining 6 instance(s).

[q] stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 8, and unknown on the remaining 6 instance(s).

[r] stated by CÆSAR.BDD version 3.7 to be false on 2 instance(s) out of 8, and unknown on the remaining 6 instance(s).

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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
$N = 3$	31,265 [s]	93,795	1	7 [t]
$N = 4$	1,762,378 [u]	7,049,512	1	9 [v]
$N = 5$	114,106,399	570,531,995	1 [w]	11 [x]
$N = 6$	$\geq$ 7.46519e+08 [y]	?	1 [z]	13 [aa]
$N = 7$	$\geq$ 1.4107e+09 [ab]	?	1 [ac]	15 [ad]
$N = 8$	$\geq$ 1.64208e+10 [ae]	?	1 [af]	17 [ag]
$N = 9$	$\geq$ 6.6762e+10 [ah]	?	1 [ai]	19 [aj]
$N = 10$	$\geq$ 4.96501e+10 [ak]	?	1 [al]	21 [am]

Other properties

- State property: at each reachable marking, there is at most process in critical section.

  $\sum_{i \in \{0..N-1\}} critical\_section_i <= 1$

- LTL property: there infinitely often is a process in critical section.

  $[](<> (\sum_{i \in \{0..N-1\}} critical\_section_i == 1))$

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[s] stated by CÆSAR.BDD version 3.7.
[t] number of initial tokens, because the net is conservative.
[u] stated by CÆSAR.BDD version 3.7.
[v] number of initial tokens, because the net is conservative.
[w] stated by PNML2NUPN 3.2.0.
[x] number of initial tokens, because the net is conservative.
[y] stated by CÆSAR.BDD version 3.7.
[z] stated by PNML2NUPN 3.2.0.
[aa] number of initial tokens, because the net is conservative.
[ab] stated by CÆSAR.BDD version 3.7.
[ac] stated by PNML2NUPN 3.2.0.
[ad] number of initial tokens, because the net is conservative.
[ae] stated by CÆSAR.BDD version 3.7.
[af] stated by PNML2NUPN 3.2.0.
[ag] number of initial tokens, because the net is conservative.
[ah] stated by CÆSAR.BDD version 3.7.
[ai] stated by PNML2NUPN 3.2.0.
[aj] number of initial tokens, because the net is conservative.
[ak] stated by CÆSAR.BDD version 3.7.
[al] stated by PNML2NUPN 3.2.0.
[am] number of initial tokens, because the net is conservative.

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