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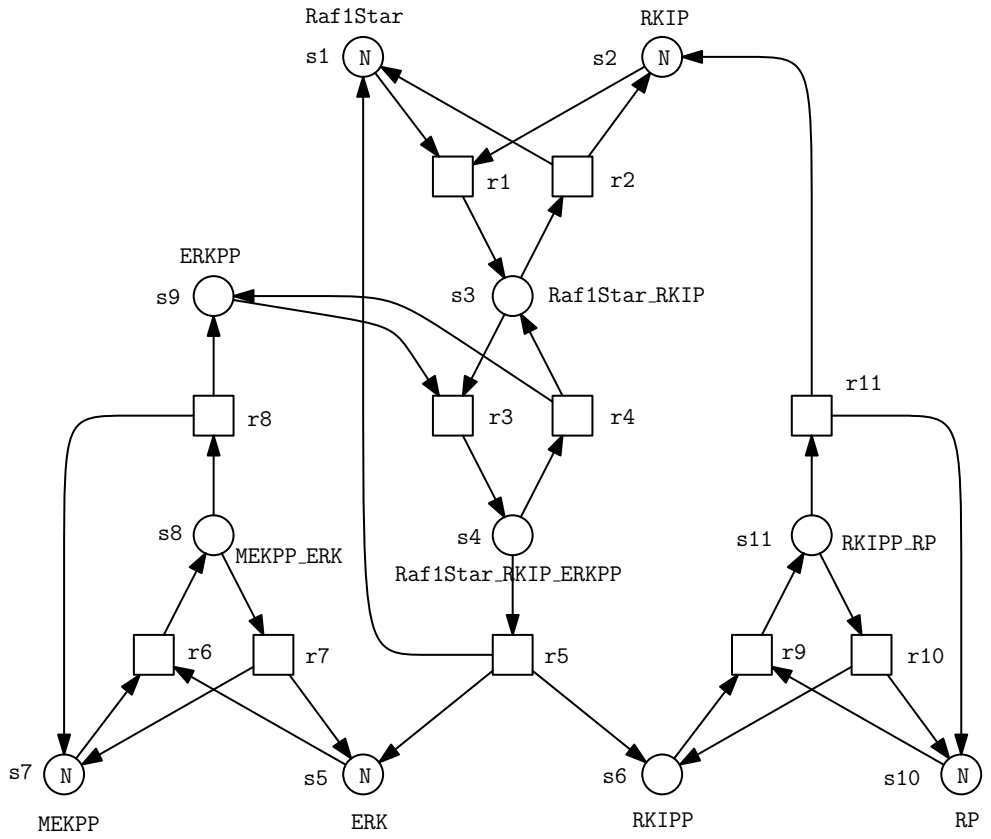
This form is a summary description of the model entitled "ERK" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together with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

Description

ERK is a short name for "RKIP/MEK-ERK signalling pathway". The RKIP inhibited ERK pathway published in [CSK+03], discussed as qualitative and continuous Petri nets in [GH06], and as three related Petri net models in [HDG10].

In March 2020, Pierre Bouvier and Hubert Garavel provided a decomposition of the only one-safe instance of this model into a network of communicating automata. This network is expressed as a Nested-Unit Petri Net (NUPN) that can be found in the "toolspecific" section of the corresponding PNML file.



Graphical representation with parameter N

References

CSK+03 K.-H. Cho, S.-Y. Shin, H.-W. Kim, O. Wolkenhauer, B. McFerran and W. Kolch: Mathematical modeling of the influence of RKIP on the ERK signaling pathway; In CMSB 2003, LNCS 2602, Springer, pages 127–141, 2003.

GH06 Gilbert, D. and Heiner, M.: From Petri nets to differential equations - an integrative approach for biochemical network analysis; In Proc. ICATPN 2006, LNCS 4024, Springer, pages 181–200, 2006.

HDG10 M. Heiner, R. Donaldson and D. Gilbert: Petri Nets for Systems Biology; In Symbolic Systems Biology: Theory and Methods, (MS Iyengar, Ed.), Jones & Bartlett Learning, LCC, pages 61–97, 2010.

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Scaling parameter

Parameter name	Parameter description	Chosen parameter values
N	initial number of tokens on places ERK, MEKPP, Raf1Star, RKIP and RP	1, 10, 100, 1000, 10000, 100000

Size of the model

Parameter	Number of places	Number of transitions	Number of arcs	Number of units	HWB code
$N = 1$	11	11	34	6	1–5–8
$N = 10$	11	11	34	–	––11
$N = 100$	11	11	34	–	––11
$N = 1000$	11	11	34	–	––11
$N = 10000$	11	11	34	–	––11
$N = 100000$	11	11	34	–	––11

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* ..... yes [k]
conservative — *for each transition, the number of input arcs equals the number of output arcs* ..... no [l]
subconservative — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ..... no [m]
nested units — *places are structured into hierarchically nested sequential units* [n] ..... ? [o]

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* ..... ? [p]
dead place(s) — *one or more places have no token in any reachable marking* ..... no [q]

[a] there is an arc from place "Raf1Star_RKIP" (which has 2 outgoing transitions) to transition "r3" (which has 2 input places).
[b] transitions "r3" and "r2" share a common input place "Raf1Star_RKIP", but only the former transition has input place "ERKPP".
[c] 11 transitions are not of a state machine, e.g., transition "r1".
[d] stated by CÆSAR.BDD version 3.3 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[e] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[f] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[g] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[h] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[i] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[j] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[k] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[l] 11 transitions are not conservative, e.g., transition "r1".
[m] 7 transitions are not subconservative, e.g., transition "r2".
[n] the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php
[o] stated by CÆSAR.BDD version 3.3 to be true on 1 instance(s) out of 6, and false on the remaining 5 instance(s).
[p] stated by CÆSAR.BDD version 2.0 to be true for $N = 1$, and false on the remaining 5 instance(s).
[q] stated by CÆSAR.BDD version 3.3 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).

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dead transition(s) — *one or more transitions cannot fire from any reachable marking* ..... no [r]
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
$N = 1$	13 [t]	30 [u]	N [v]	$5 \cdot N$ [w]
$N = 10$	47 047 [x]	372 372 [y]	N [z]	$5 \cdot N$ [aa]
$N = 100$	1.5914E+10 [ab]	1.68445E+11 [ac]	N [ad]	$5 \cdot N$ [ae]
$N = 1\,000$	14 081 614 073 878 351 [af]	?	N	$5 \cdot N$
$N = 10\,000$	?	?	N	$5 \cdot N$
$N = 100\,000$	?	?	N	$5 \cdot N$

[r] stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10^2, 10^3, 10^4, and 10^5).
[s] confirmed by CÆSAR.BDD version 2.0 to be false for $N = 1$, and unknown on the remaining 5 instance(s); confirmed at MCC'2014 by Lola on all 6 instances and Tapaal on 2 instances.
[t] confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.
[u] computed at MCC'2014 by Marcie.
[v] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[w] confirmed at MCC'2014 Marcie, PNMC, and Tapaal.
[x] computed by Marcie on 2013-12-13; confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.
[y] computed at MCC'2014 by Marcie.
[z] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[aa] confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.
[ab] exact value 15 914 114 086 computed by Marcie on 2013-12-13; confirmed at MCC'2014 by Marcie and PNMC.
[ac] computed at MCC'2014 by Marcie.
[ad] confirmed at MCC'2014 by Marcie and PNMC.
[ae] confirmed at MCC'2014 by Marcie and PNMC.
[af] computed by Marcie on 2013-12-13.