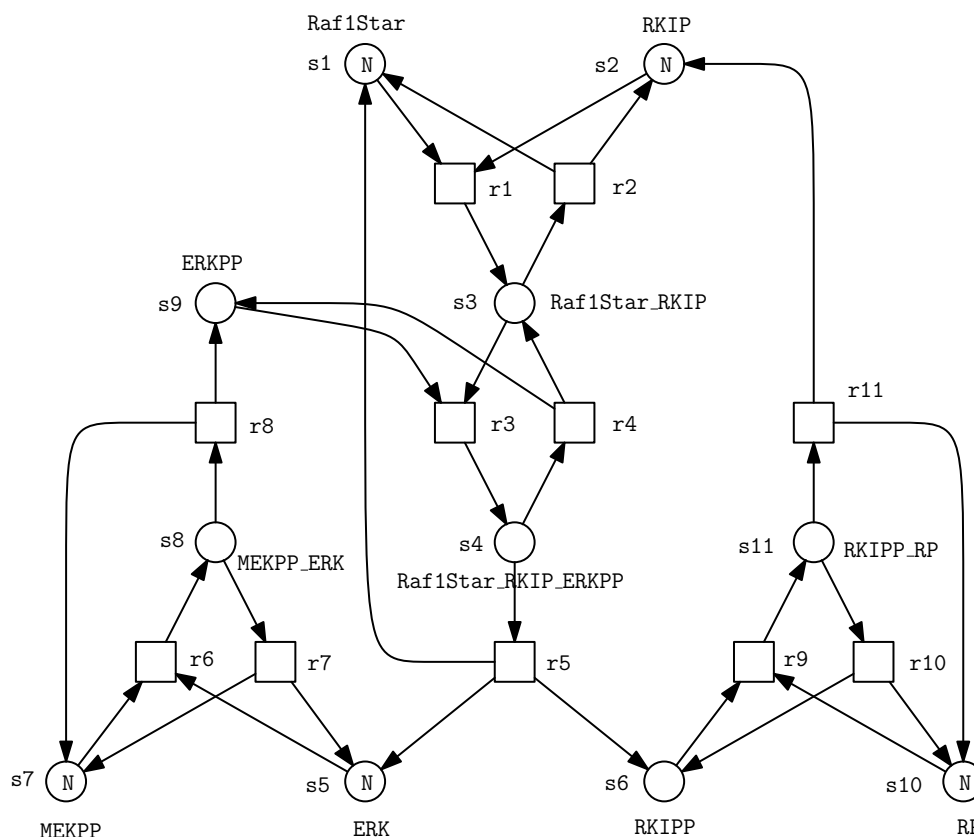


*This form is a summary description of the model entitled “ERK” proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together with 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].



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.

## 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

Although the model is parameterized, its size does not depend on parameter values.

number of places: 11  
 number of transitions: 11  
 number of arcs: 34

## Structural properties

<b>ordinary</b> — all arcs have multiplicity one	✓
<b>simple free choice</b> — all (different) transitions with a shared input place have no other input place	✗ (a)
<b>state machine</b> — every transition has exactly one input place and exactly one output place	✗ (b)
<b>marked graph</b> — every place has exactly one input transition and exactly one output transition	✗ (c)
<b>connected</b> — there is an undirected path between every two nodes (places or transitions)	✓ (d)
<b>strongly connected</b> — there is a directed path between every two nodes (places or transitions)	✓ (e)
<b>source place(s)</b> — one or more places have no input transitions	✗ (f)
<b>sink place(s)</b> — one or more places have no output transitions	✗ (g)
<b>source transition(s)</b> — one or more transitions have no input places	✗ (h)
<b>sink transitions(s)</b> — one or more transitions have no output places	✗ (i)
<b>loop-free</b> — no transition has an input place that is also an output place	✓ (j)
<b>conservative</b> — for each transition, the number of input arcs equals the number of output arcs	✗ (k)
<b>subconservative</b> — for each transition, the number of input arcs equals or exceeds the number of output arcs	✗ (l)
<b>nested units</b> — places are structured into hierarchically nested sequential units <sup>(m)</sup>	✗

## Behavioural properties

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

(a) there is an arc from place “p2” (which has 2 outgoing transitions) to transition “t2” (which has 2 input places).  
 (b) 11 transitions are not of a state machine, e.g., transition “t0”.  
 (c) 11 places are not of a marked graph, e.g., place “p0”.  
 (d) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (e) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (f) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (g) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (h) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (i) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (j) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).  
 (k) 11 transitions are not conservative, e.g., transition “t0”.  
 (l) 7 transitions are not subconservative, e.g., transition “t1”.  
 (m) the definition of Nested-Unit Petri Nets (NUPN) is available from <http://mcc.lip6.fr/nupn.php>  
 (n) stated by CÆSAR.BDD version 2.0 to be true for  $N = 1$ , and false on the remaining 5 instance(s).  
 (o) 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.  
 (p) stated by CÆSAR.BDD version 2.0 on all 6 instances (1, 10, 10<sup>2</sup>, 10<sup>3</sup>, 10<sup>4</sup>, and 10<sup>5</sup>).

## 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 <sup>(q)</sup>	30 <sup>(r)</sup>	$N$ <sup>(s)</sup>	$5 \cdot N$ <sup>(t)</sup>
$N = 10$	47 047 <sup>(u)</sup>	372 372 <sup>(v)</sup>	$N$ <sup>(w)</sup>	$5 \cdot N$ <sup>(x)</sup>
$N = 100$	1.5914E+10 <sup>(y)</sup>	1.68445E+11 <sup>(z)</sup>	$N$ <sup>(aa)</sup>	$5 \cdot N$ <sup>(ab)</sup>
$N = 1\,000$	14 081 614 073 878 351 <sup>(ac)</sup>	?	$N$	$5 \cdot N$
$N = 10\,000$	?	?	$N$	$5 \cdot N$
$N = 100\,000$	?	?	$N$	$5 \cdot N$

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<sup>(q)</sup> confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

<sup>(r)</sup> computed at MCC'2014 by Marcie.

<sup>(s)</sup> confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.

<sup>(t)</sup> confirmed at MCC'2014 Marcie, PNMC, and Tapaal.

<sup>(u)</sup> computed by Marcie on 2013-12-13; confirmed at MCC'2014 by Marcie, PNMC, PNXDD, Stratagem, and Tapaal.

<sup>(v)</sup> computed at MCC'2014 by Marcie.

<sup>(w)</sup> confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.

<sup>(x)</sup> confirmed at MCC'2014 by Marcie, PNMC, and Tapaal.

<sup>(y)</sup> exact value 15 914 114 086 computed by Marcie on 2013-12-13; confirmed at MCC'2014 by Marcie and PNMC.

<sup>(z)</sup> computed at MCC'2014 by Marcie.

<sup>(aa)</sup> confirmed at MCC'2014 by Marcie and PNMC.

<sup>(ab)</sup> confirmed at MCC'2014 by Marcie and PNMC.

<sup>(ac)</sup> computed by Marcie on 2013-12-13.