

$$\begin{aligned} \frac{d\alpha}{dt} &= -v_1 \\ \frac{dSte2}{dt} &= -v_2 + v_3 - v_5 \\ \frac{dSte2_{active}}{dt} &= v_2 - v_3 - v_4 \\ \frac{dSst2_{active}}{dt} &= v_{46} - v_{47} \\ \frac{dG\alpha\beta\gamma}{dt} &= -v_6 + v_9 \\ \frac{dG\alpha GTP}{dt} &= v_6 - v_7 - v_8 \\ \frac{dG\alpha GDP}{dt} &= v_7 + v_8 - v_9 \\ \frac{dG\beta\gamma}{dt} &= v_6 - v_9 - v_{10} + v_{11} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32} \\ &\quad - v_{42} + v_{43} \\ \frac{dSte5}{dt} &= -v_{12} + v_{13} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32} \\ \frac{dSte11}{dt} &= -v_{12} + v_{13} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32} \\ \frac{dSte7}{dt} &= -v_{14} + v_{15} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32} \\ \frac{dFus3}{dt} &= -v_{14} + v_{15} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} - v_{29} \\ &\quad + v_{30} + v_{33} \\ \frac{dSte20}{dt} &= -v_{18} + v_{19} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32} \end{aligned}$$

$$\begin{aligned} v_1 &= \alpha[t] \cdot Bar1_{active}[t] \cdot k_1 \\ v_2 &= Ste2[t] \cdot \alpha[t] \cdot k_2 \\ v_3 &= Ste2_{active}[t] \cdot k_3 \\ v_4 &= Ste2_{active}[t] \cdot k_4 \\ v_5 &= Ste2[t] \cdot k_5 \\ v_6 &= Ste2_{active}[t] \cdot G\alpha\beta\gamma[t] \cdot k_6 \\ v_7 &= G\alpha GTP[t] \cdot k_7 \\ v_8 &= G\alpha GTP[t] \cdot Sst2_{active}[t] \cdot k_8 \\ v_9 &= G\alpha GDP[t] \cdot G\beta\gamma[t] \cdot k_9 \\ v_{10} &= G\beta\gamma[t] \cdot C[t] \cdot k_{10} \\ v_{11} &= D[t] \cdot k_{11} \\ v_{12} &= Ste5[t] \cdot Ste11[t] \cdot k_{12} \\ v_{13} &= A[t] \cdot k_{13} \\ v_{14} &= Ste7[t] \cdot Fus3[t] \cdot k_{14} \\ v_{15} &= B[t] \cdot k_{15} \\ v_{16} &= A[t] \cdot B[t] \cdot k_{16} \\ v_{17} &= C[t] \cdot k_{17} \\ v_{18} &= D[t] \cdot Ste20[t] \cdot k_{18} \end{aligned}$$

$\frac{d\alpha}{dt} = -v_1$	$v_1 = \alpha[t] \cdot Bar1_{active}[t] \cdot k_1$
$\frac{dSte2}{dt} = -v_2 + v_3 - v_5$	$v_2 = Ste2[t] \cdot \alpha[t] \cdot k_2$
$\frac{dSte2_{active}}{dt} = v_2 - v_3 - v_4$	$v_3 = Ste2_{active}[t] \cdot k_3$
$\frac{dSst2_{active}}{dt} = v_{46} - v_{47}$	$v_4 = Ste2_{active}[t] \cdot k_4$
$\frac{dG\alpha\beta\gamma}{dt} = -v_6 + v_9$	$v_5 = Ste2[t] \cdot k_5$
$\frac{dG\alpha GTP}{dt} = v_6 - v_7 - v_8$	$v_6 = Ste2_{active}[t] \cdot G\alpha\beta\gamma[t] \cdot k_6$
$\frac{dG\alpha GDP}{dt} = v_7 + v_8 - v_9$	$v_7 = G\alpha GTP[t] \cdot k_7$
$\frac{dG\beta\gamma}{dt} = v_6 - v_9 - v_{10} + v_{11} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32}$	$v_8 = G\alpha GTP[t] \cdot Ste2_{active}[t] \cdot k_8$
$-v_{42} + v_{43}$	$v_9 = G\alpha GDP[t] \cdot G\beta\gamma[t] \cdot k_9$
$\frac{dSte5}{dt} = -v_{12} + v_{13} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32}$	$v_{10} = G\beta\gamma[t] \cdot C[t] \cdot k_{10}$
$\frac{dSte7}{dt} = -v_{14} + v_{15} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} + v_{32}$	$v_{11} = D[t] \cdot k_{11}$
$\frac{dFus3}{dt} = -v_{14} + v_{15} + v_{17} + v_{21} + v_{23} + v_{25} + v_{27} - v_{29}$	$v_{12} = Ste5[t] \cdot Ste11[t] \cdot k_{12}$
$+v_{30} + v_{33}$	$v_{13} = A[t] \cdot k_{13}$
$\frac{dSte20}{dt} = -v_{18} + v_{19} - v_{20} + v_{22} + v_{24} + v_{26} + v_{28} + v_{31}$	$v_{14} = Ste7[t] \cdot Fus3[t] \cdot k_{14}$
	$v_{15} = B[t] \cdot k_{15}$
	$v_{16} = E[t] \cdot F[t] \cdot k_{16}$
	$v_{17} = C[t] \cdot k_{17}$
	$v_{18} = D[t] \cdot Ste20[t] \cdot k_{18}$

READABILITY ?
 CAUSALITY ?
 UNIQUE STRUCTURE ?

- quantitative model = qualitative model + quantitative parameters

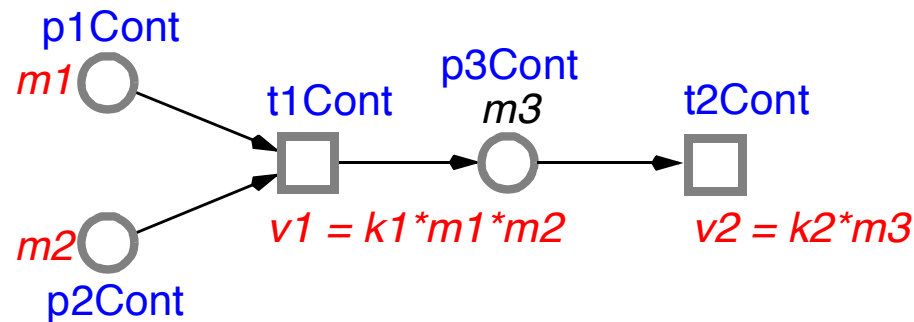
-> *known or estimated quantitative parameters*

- typical quantitative parameters of bionetworks

-> *compound concentrations* -> *real numbers*

-> *reaction rates / fluxes* -> *concentration-dependent*

- continuous Petri nets



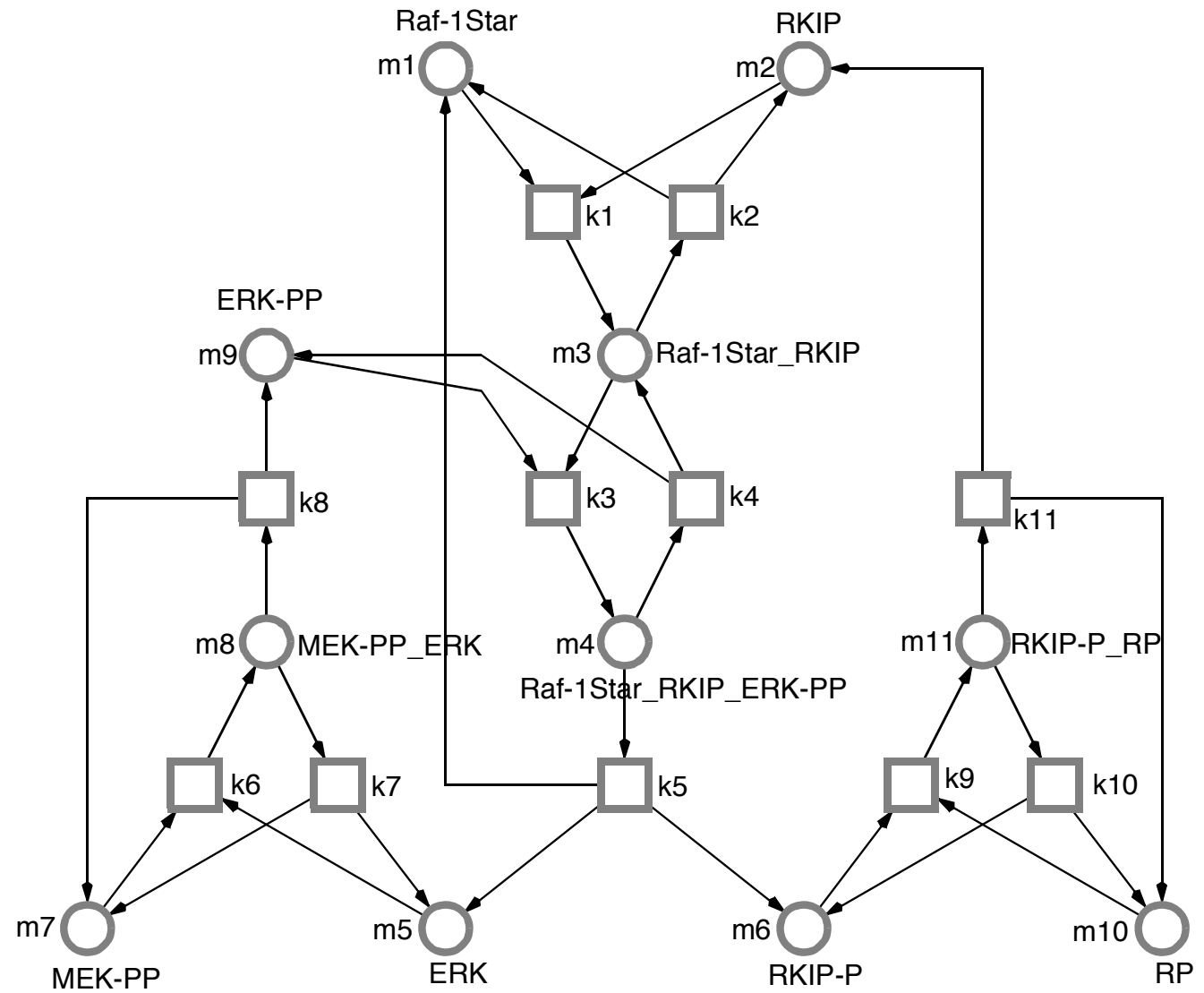
continuous nodes !

$$dm1 / dt = dm2 / dt = - v1$$

$$dm3 / dt = v1 - v2$$

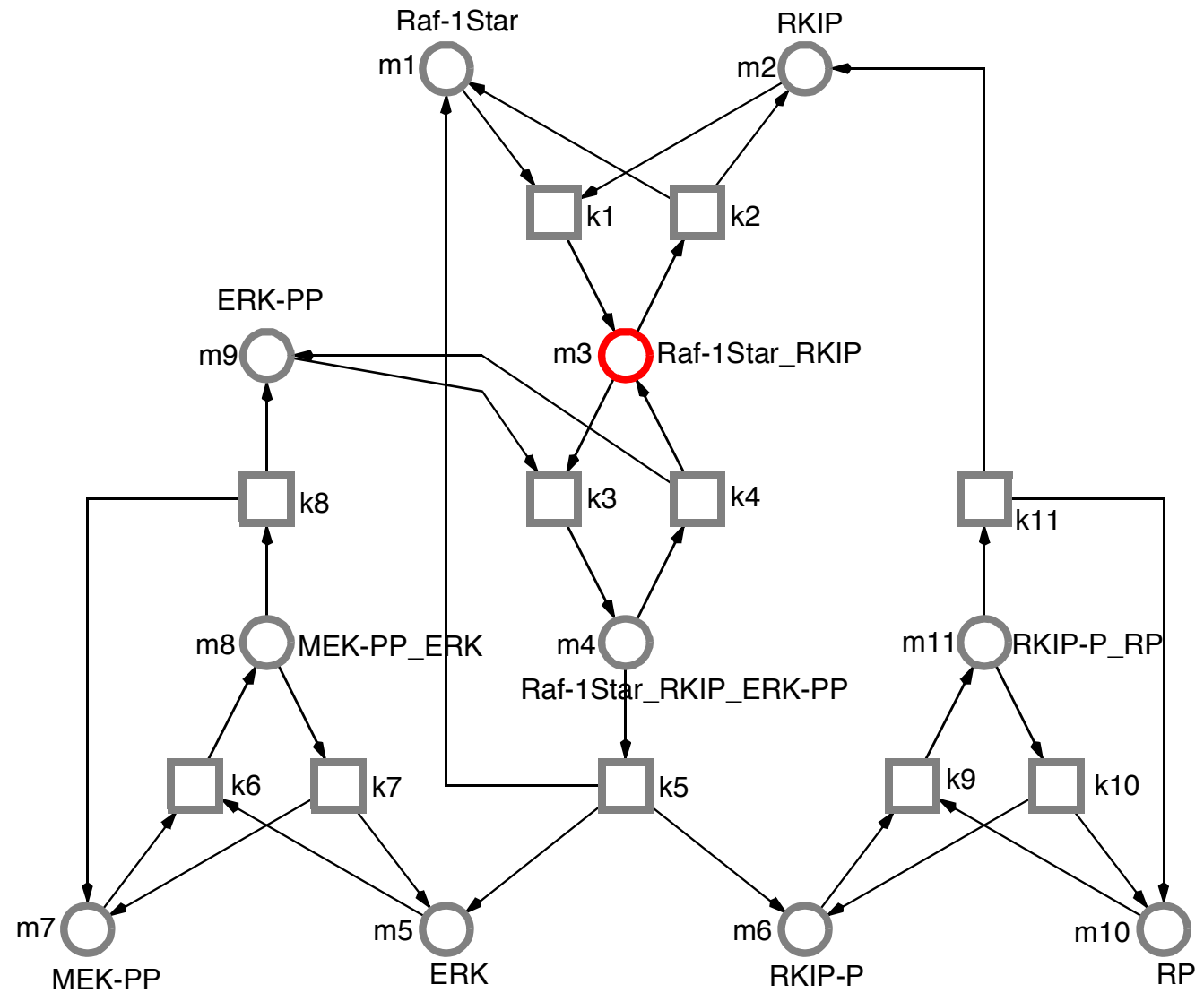
} ODEs

THE RKIP PATHWAY, CONTINUOUS PETRI NET



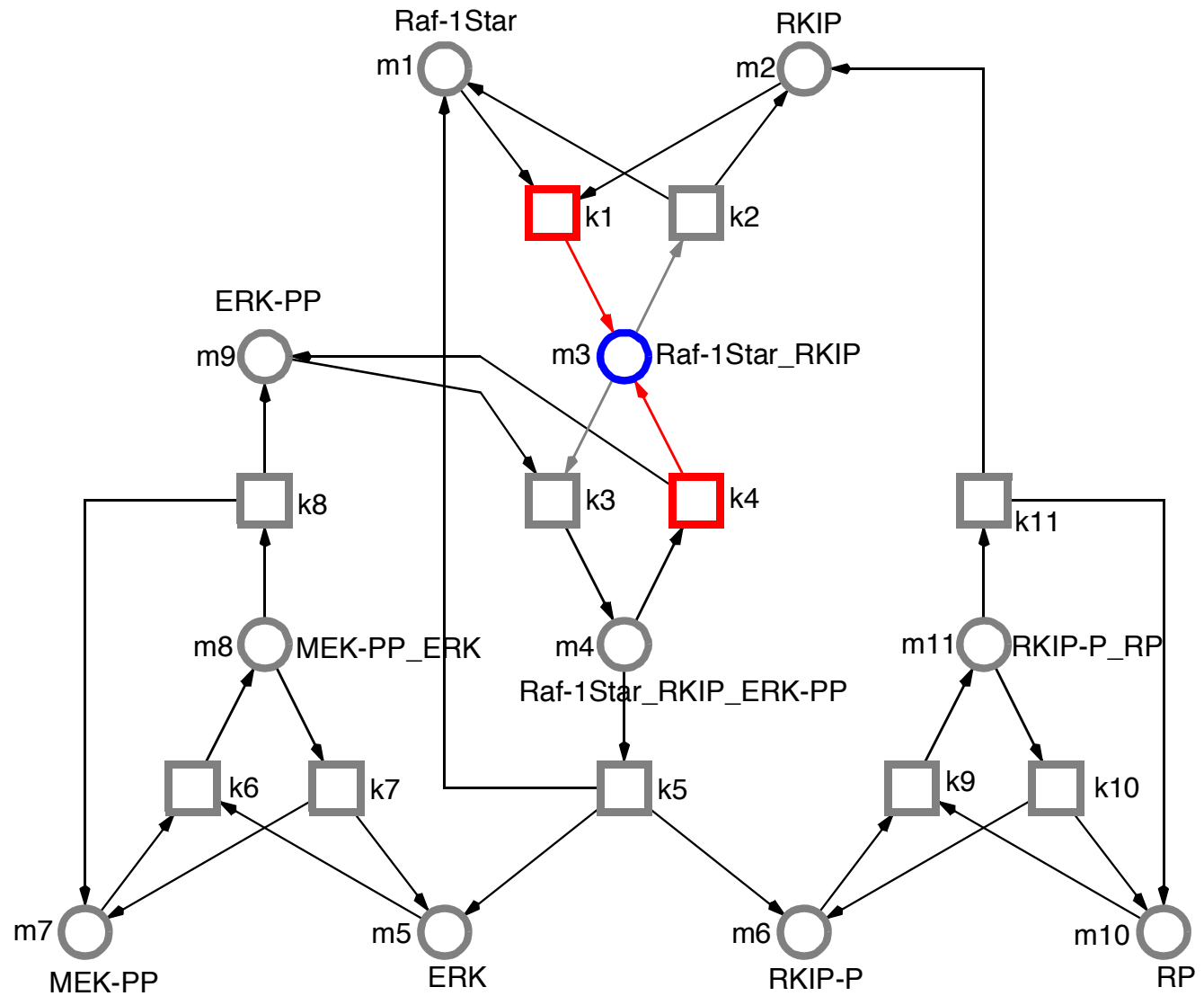
THE RKIP PATHWAY, CONTINUOUS PETRI NET

$$\frac{dm_3}{dt} =$$



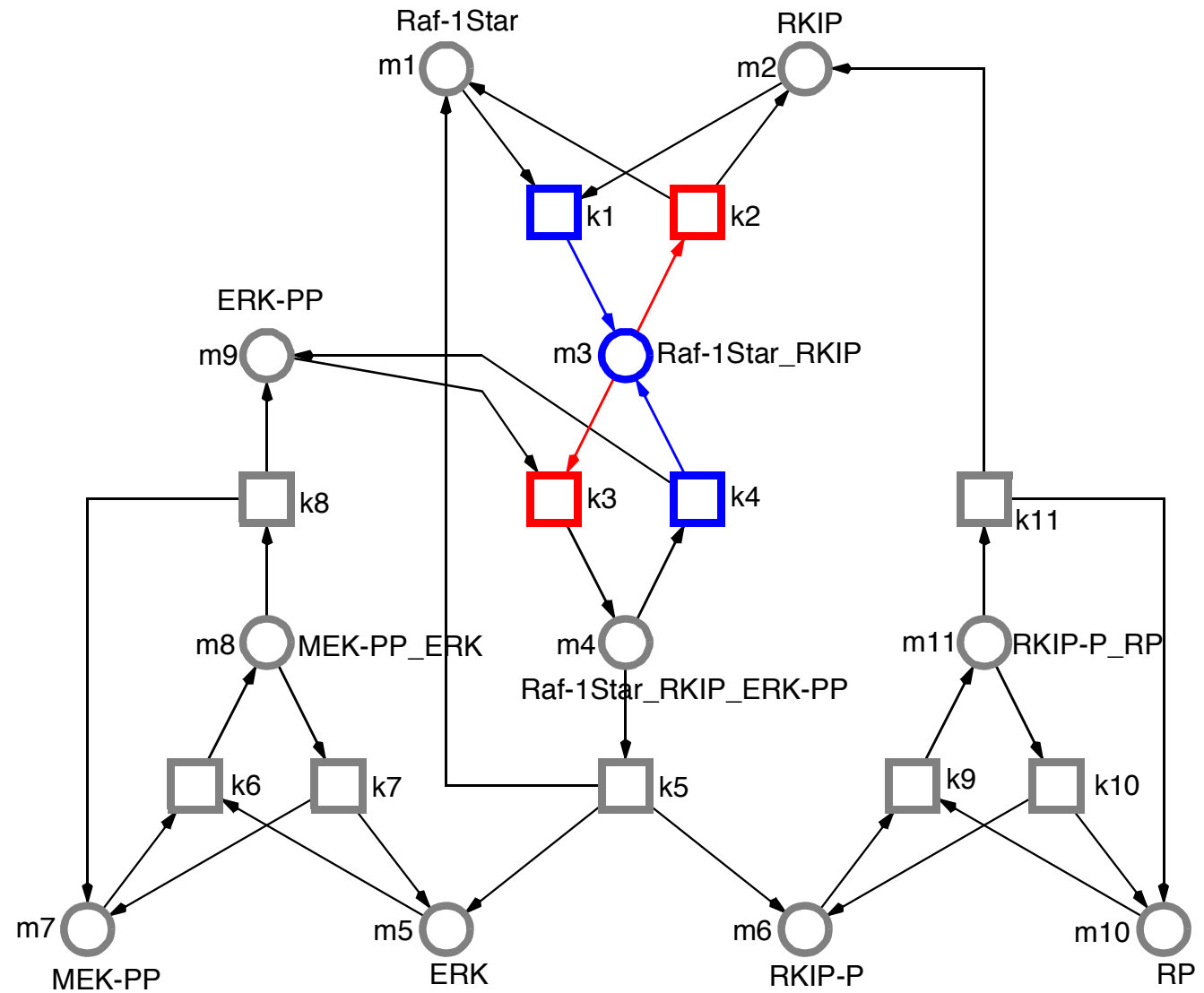
THE RKIP PATHWAY, CONTINUOUS PETRI NET

$$\frac{dm_3}{dt} = +r_1 + r_4$$



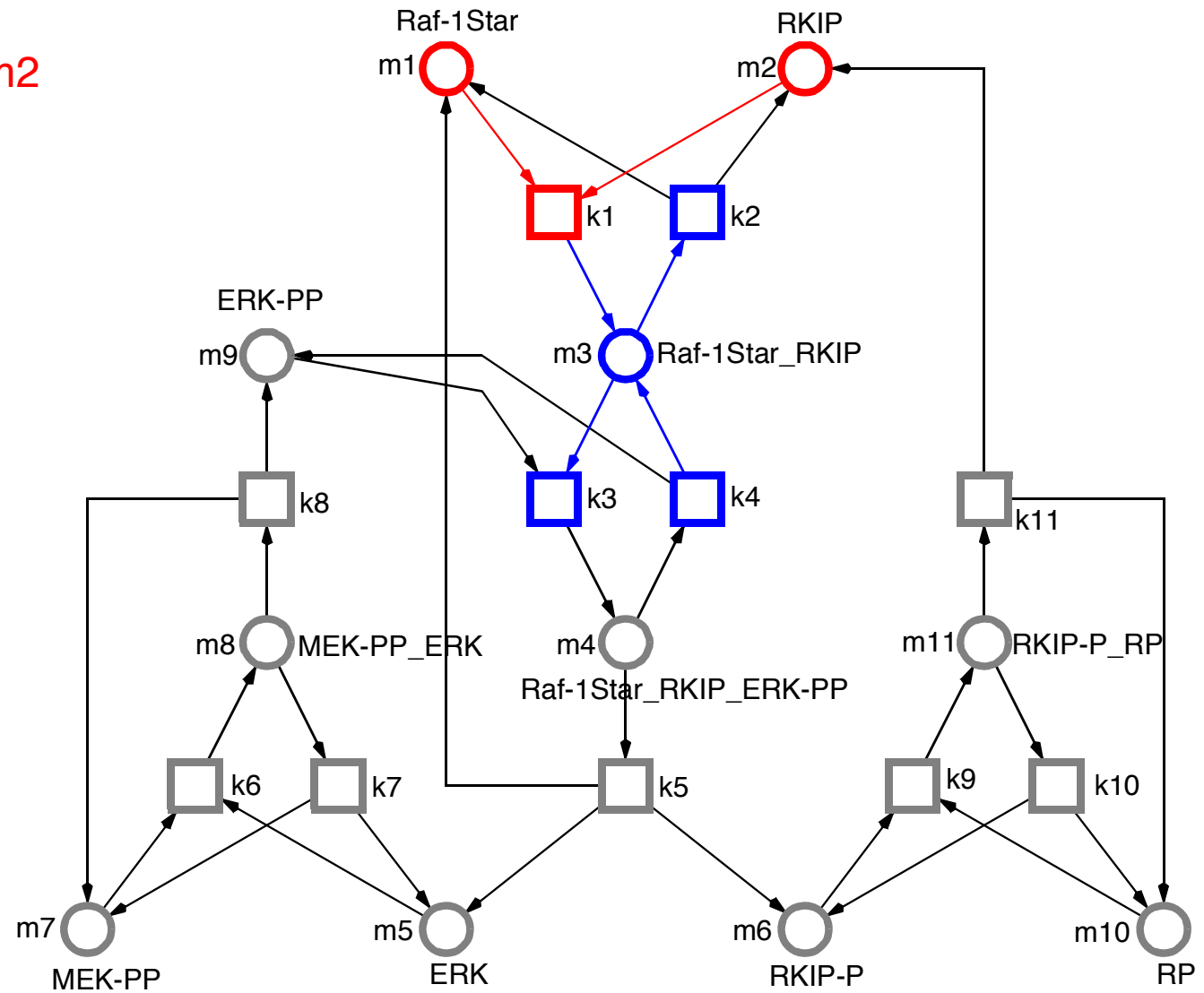
THE RKIP PATHWAY, CONTINUOUS PETRI NET

$$\frac{dm_3}{dt} = +r_1 + r_4 - r_2 - r_3$$



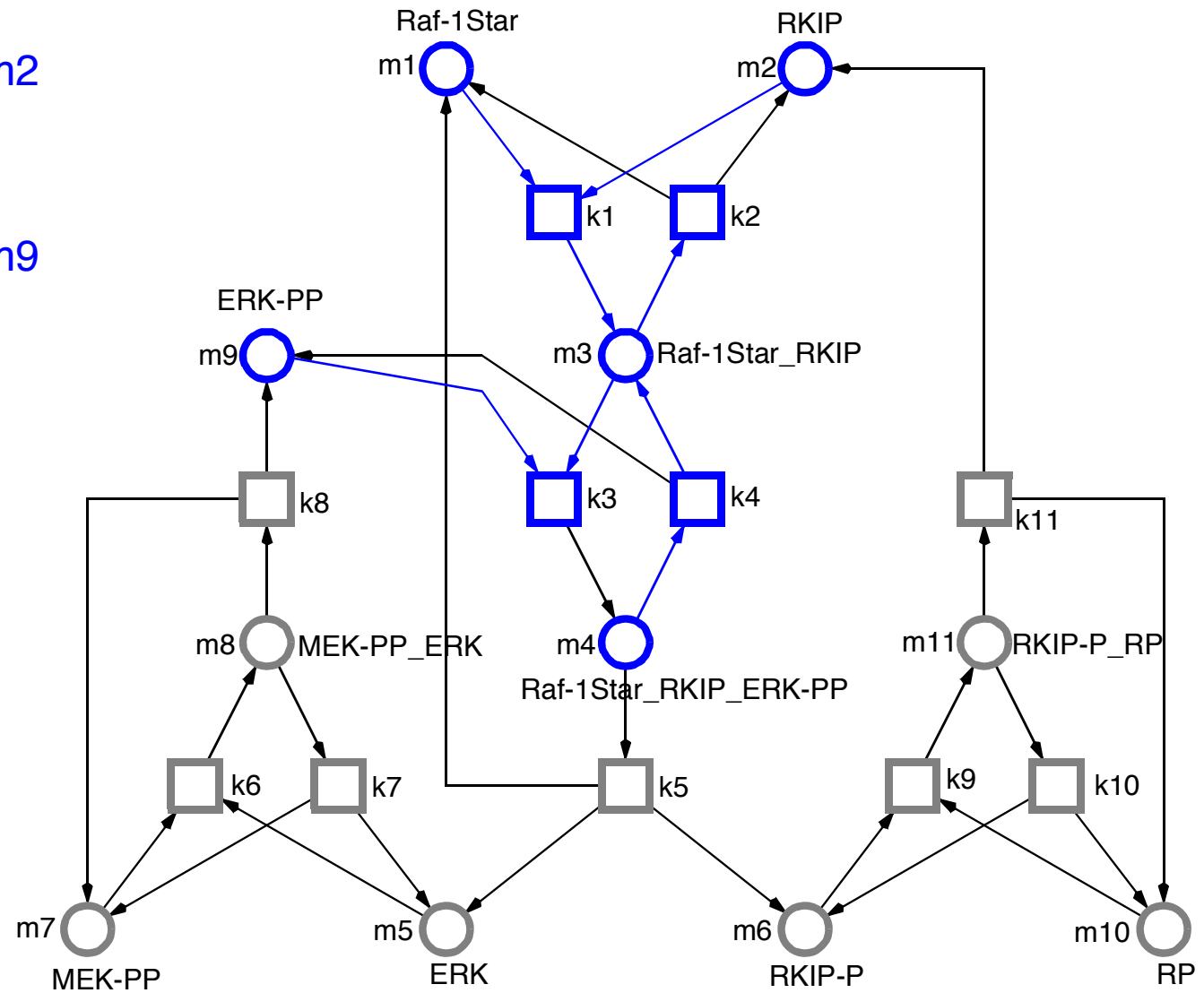
THE RKIP PATHWAY, CONTINUOUS PETRI NET

$$\frac{dm_3}{dt} = +k_1 * m_1 * m_2 + r_4 - r_2 - r_3$$



THE RKIP PATHWAY, CONTINUOUS PETRI NET

$$\frac{dm_3}{dt} = +k_1 * m_1 * m_2 + k_4 * m_4 - k_2 * m_3 - k_3 * m_3 * m_9$$



**THE QUALITATIVE MODEL
BECOMES
THE STRUCTURED DESCRIPTION
OF THE QUANTITATIVE MODEL !**