SBML Model Report

Model name: "Radulescu2008_NFkB-_hierarchy_M_14_25_28_Lipniacky"

May 5, 2016

1 General Overview

This is a document in SBML Level 2 Version 1 format. This model was created by the following two authors: Vijayalakshmi Chelliah[1] and Ovidiu Radulescu[2] at February 27th 2009 at 4:28 p. m. and last time modified at June third 2014 at 1:55 p. m. Table 1 gives an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	2
species types	0	species	24
events	0	constraints	0
reactions	24	function definitions	0
global parameters	31	unit definitions	0
rules	0	initial assignments	0

Model Notes

NFkB model M(14,25,28) - Lipniacky's NFkB model

This is a model of NFkB pathway functioning from hierarchy of models of decreasing complexity,created to demonstrate application of model reduction methods proposed in

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This a model from the article:

Robust simplifications of multiscale biochemical networks.

Radulescu O, Gorban A., Zinovyev A., Lilienbaum. A. BMC Syst Biol2008:2:86 18854041,

Abstract:

BACKGROUND: Cellular processes such as metabolism, decision making in development and differentiation, signalling, etc., can be modeled as large networks of biochemical reactions. In order to understand the functioning of these systems, there is a strong need for general model reduction techniques allowing to simplify models without loosing their main properties. In systems biology we also need to compare models or to couple them as parts of larger models. In these situations reduction to a common level of complexity is needed. RESULTS: We propose a systematic treatment of model reduction of multiscale biochemical networks. First, we consider linear kinetic models, which appear as „pseudo-monomolecular„ subsystems of multiscale nonlinear reaction networks. For such linear models, we propose a reduction algorithm which is based on a generalized theory of the limiting step that we have developed in 1. Second, for non-linear systems we develop an algorithm based on dominant solutions of quasi-stationarity equations. For oscillating systems, quasi-stationarity and averaging are combined to eliminate time scales much faster and much slower than the period of the oscillations. In all cases, we obtain robust simplifications and also identify the critical parameters of the model. The methods are demonstrated for simple examples and for a more complex model of NF-kappaB pathway. CONCLUSION: Our approach allows critical parameter identification and produces hierarchies of models. Hierarchical modeling is important in „middle-out„ approaches when there is need to zoom in and out several levels of complexity. Critical parameter identification is an important issue in systems biology with potential applications to biological control and therapeutics. Our approach also deals naturally with the presence of multiple time scales, which is a general property of systems biology models.

This model is originally proposed by Lipniacki 2004 (Lipniacki T, Paszek P, Brasier AR, Luxon B, Kimmel M.(2004). Mathematical model of NF-kappaB regulatory module. J. Theor. Biol. 228 (2): 195-215. 15094015

The models are provided in CellDesigner v3.5format. The name of the model M(x,y,z) should bedeciphered as following:

x - number of speciesy - number of reactionsz - number of parameters

Simulation protocol:The model can be simulated in CellDesignerdirectly, or in any simulator supportingevents. The simulation period should beset up in 20 hours (t=72000 sec). This model reproduces Figure 3b (M(14,25,28)) of the publication.

For additional information please contactAndrei.Zinovyev at curie.fr

2 Unit Definitions

This is an overview of five unit definitions which are all predefined by SBML and not mentioned in the model.

2.1 Unit `substance`

Notes Mole is the predefined SBML unit for `substance`.

Definition mol

2.2 Unit `volume`

Notes Litre is the predefined SBML unit for `volume`.

Definition l

2.3 Unit `area`

Notes Square metre is the predefined SBML unit for `area` since SBML Level 2 Version 1.

Definition m^2

2.4 Unit `length`

Notes Metre is the predefined SBML unit for `length` since SBML Level 2 Version 1.

Definition m

2.5 Unit `time`

Notes Second is the predefined SBML unit for `time`.

Definition s

3 Compartments

This model contains two compartments.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
`default`			3	1	litre	☑	
`c2`	nucleus		3	1	litre	☑	`default`

3.1 Compartment `default`

This is a three dimensional compartment with a constant size of one litre.

3.2 Compartment `c2`

This is a three dimensional compartment with a constant size of one litre, which is surrounded by `default`.

Name nucleus

4 Species

This model contains 24 species. The boundary condition of ten of these species is set to `true` so that these species' amount cannot be changed by any reaction. Section 7 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
s121	IKBA	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s122	sa13_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s124	sa12_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s125	mRNAIKBA	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s126	A20	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s127	mRNAA20	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s128	A20	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s129	sa444_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s130	IKKi	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s131	sa19_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s132	IKKa	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s133	IKKn	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s134	sa20_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s135	NFkB:IkB_alpha	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s139	IKKa/IKBa	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s150	IKK	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s152	NFkB/Ikb_alpha/IKKa	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s153	sa96_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s154	sa97_degraded	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	☑	☑
s159	NFkB/IkB_alpha	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s160	IkB_alpha	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
s161	NFkB	default	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s164	NFkB	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟
s167	IkB_alpha	c2	$\mathrm{mol} \cdot \mathrm{l}^{-1}$	⊟	⊟

5 Parameters

This model contains 31 global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
k1			0.003		☑
k2			$1.25 \cdot 10^{-4}$		☑
k3			$2.5 \cdot 10^{-6}$		⊟
k4			0.100		☑
k5			0.002		☑
k6			$1.25 \cdot 10^{-4}$		☑
k7			0.200		☑
k8			0.100		☑
k9			1.000		☑
k10			0.100		☑
k11			$1.25 \cdot 10^{-4}$		☑
k12			$2 \cdot 10^{-5}$		☑
kf13			18.400		☑
kr13			0.000		☑
kf14			18.400		☑
kr14			0.000		☑
kf15			0.003		☑
kr15			0.000		☑
k16			0.500		☑
k17			$4 \cdot 10^{-4}$		☑
k18			$3 \cdot 10^{-4}$		☑
k20			$5 \cdot 10^{-7}$		☑
k19			0.000		☑
k21			10^{-4}		☑
k22			0.500		☑
kf23			0.001		☑
kr23			$5 \cdot 10^{-4}$		☑
k27			$4 \cdot 10^{-4}$		☑
kf28			0.010		☑
kr28			0.000		☑
k26			$5 \cdot 10^{-7}$		☑

6 Reactions

This model contains 24 reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	re44		$s121 \xrightarrow{s164} s125$	
2	re45		$s125 \longrightarrow s124$	
3	re46		$s160 \longrightarrow s122$	
4	re47		$s125 \longrightarrow s160 + s125$	
5	re48		$s126 \xrightarrow{s164} s127$	
6	re49		$s133 \longrightarrow s132$	
7	re52		$s135 \xrightarrow{s132} s161$	
8	re53		$s133 \longrightarrow s131$	
9	re56		$s132 \longrightarrow s134$	
10	re57		$s139 \longrightarrow s132$	
11	re58		$s132 + s135 \longrightarrow s152$	
12	re59		$s152 \longrightarrow s161 + s132$	
13	re60		$s130 \longrightarrow s129$	
14	re61		$s127 \longrightarrow s128 + s127$	
15	re63		$s132 \xrightarrow{s128} s130$	
16	re64		$s150 \longrightarrow s133$	
17	re65		$s160 + s161 \longrightarrow s135$	
18	re66		$s160 + s132 \longrightarrow s139$	
19	re67		$s161 \longrightarrow 5\, s164$	
20	re68		$5\, s159 \longrightarrow s135$	
21	re69		$s164 + s167 \longrightarrow s159$	

№	Id	Name	Reaction Equation	SBO
22	re70		s127 ⟶ s153	
23	re71		s128 ⟶ s154	
24	re72		s160 ⟶ 5 s167	

6.1 Reaction re44

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Reaction equation

$$\text{s121} \xrightarrow{\text{s164}} \text{s125} \tag{1}$$

Reactant

Table 6: Properties of each reactant.

Id	Name	SBO
s121	IKBA	

Modifier

Table 7: Properties of each modifier.

Id	Name	SBO
s164	NFkB	

Product

Table 8: Properties of each product.

Id	Name	SBO
s125	mRNAIKBA	

Kinetic Law

Derived unit contains undeclared units

$$v_1 = \text{k26} \cdot [\text{s164}] \tag{2}$$

6.2 Reaction re45

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\text{s125} \longrightarrow \text{s124} \tag{3}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
s125	mRNAIKBA	

Product

Table 10: Properties of each product.

Id	Name	SBO
s124	sa12_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_2 = \mathrm{k27} \cdot [\mathrm{s125}] \tag{4}$$

6.3 Reaction re46

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s160} \longrightarrow \mathrm{s122} \tag{5}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
s160	IkB_alpha	

Product

Table 12: Properties of each product.

Id	Name	SBO
s122	sa13_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_3 = \mathrm{k21} \cdot [\mathrm{s160}] \tag{6}$$

6.4 Reaction re47

This is an irreversible reaction of one reactant forming two products.

Reaction equation

$$\mathrm{s125} \longrightarrow \mathrm{s160} + \mathrm{s125} \tag{7}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
s125	mRNAIKBA	

Products

Table 14: Properties of each product.

Id	Name	SBO
s160	IkB_alpha	
s125	mRNAIKBA	

Kinetic Law

Derived unit contains undeclared units

$$v_4 = \mathrm{k22} \cdot [\mathrm{s125}] \tag{8}$$

6.5 Reaction re48

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Reaction equation

$$\mathrm{s126} \xrightarrow{\mathrm{s164}} \mathrm{s127} \tag{9}$$

Reactant

Table 15: Properties of each reactant.

Id	Name	SBO
s126	A20	

Modifier

Table 16: Properties of each modifier.

Id	Name	SBO
s164	NFkB	

Product

Table 17: Properties of each product.

Id	Name	SBO
s127	mRNAA20	

Kinetic Law

Derived unit contains undeclared units

$$v_5 = \mathrm{k19} + \mathrm{k20} \cdot [\mathrm{s164}] \tag{10}$$

6.6 Reaction re49

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s133} \longrightarrow \mathrm{s132} \tag{11}$$

Reactant

Table 18: Properties of each reactant.

Id	Name	SBO
s133	IKKn	

Product

Table 19: Properties of each product.

Id	Name	SBO
s132	IKKa	

Kinetic Law

Derived unit contains undeclared units

$$v_6 = \mathrm{k1} \cdot [\mathrm{s133}] \tag{12}$$

6.7 Reaction re52

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Reaction equation

$$\mathrm{s135} \xrightarrow{\mathrm{s132}} \mathrm{s161} \tag{13}$$

Reactant

Table 20: Properties of each reactant.

Id	Name	SBO
s135	NFkB:IkB_alpha	

Modifier

Table 21: Properties of each modifier.

Id	Name	SBO
s132	IKKa	

Product

Table 22: Properties of each product.

Id	Name	SBO
s161	NFkB	

Id	Name	SBO

Kinetic Law

Derived unit contains undeclared units

$$v_7 = \mathrm{k12} \cdot [\mathrm{s135}] \tag{14}$$

6.8 Reaction `re53`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s133} \longrightarrow \mathrm{s131} \tag{15}$$

Reactant

Table 23: Properties of each reactant.

Id	Name	SBO
`s133`	IKKn	

Product

Table 24: Properties of each product.

Id	Name	SBO
`s131`	sa19_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_8 = \mathrm{k2} \cdot [\mathrm{s133}] \tag{16}$$

6.9 Reaction `re56`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s132} \longrightarrow \mathrm{s134} \tag{17}$$

Reactant

Table 25: Properties of each reactant.

Id	Name	SBO
s132	IKKa	

Product

Table 26: Properties of each product.

Id	Name	SBO
s134	sa20_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_9 = \mathrm{k6} \cdot [\mathrm{s132}] \tag{18}$$

6.10 Reaction re57

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s139} \longrightarrow \mathrm{s132} \tag{19}$$

Reactant

Table 27: Properties of each reactant.

Id	Name	SBO
s139	IKKa/IKBa	

Product

Table 28: Properties of each product.

Id	Name	SBO
s132	IKKa	

Kinetic Law

Derived unit contains undeclared units

$$v_{10} = \mathrm{k8} \cdot [\mathrm{s139}] \tag{20}$$

6.11 Reaction `re58`

This is an irreversible reaction of two reactants forming one product.

Reaction equation

$$\mathrm{s132} + \mathrm{s135} \longrightarrow \mathrm{s152} \tag{21}$$

Reactants

Table 29: Properties of each reactant.

Id	Name	SBO
`s132`	IKKa	
`s135`	NFkB:IkB_alpha	

Product

Table 30: Properties of each product.

Id	Name	SBO
`s152`	NFkB/Ikb_alpha/IKKa	

Kinetic Law

Derived unit contains undeclared units

$$v_{11} = \mathrm{k9} \cdot [\mathrm{s132}] \cdot [\mathrm{s135}] \tag{22}$$

6.12 Reaction `re59`

This is an irreversible reaction of one reactant forming two products.

Reaction equation

$$\mathrm{s152} \longrightarrow \mathrm{s161} + \mathrm{s132} \tag{23}$$

Reactant

Table 31: Properties of each reactant.

Id	Name	SBO
s152	NFkB/Ikb_alpha/IKKa	

Products

Table 32: Properties of each product.

Id	Name	SBO
s161	NFkB	
s132	IKKa	

Kinetic Law

Derived unit contains undeclared units

$$v_{12} = \mathrm{k10} \cdot [\mathrm{s152}] \tag{24}$$

6.13 Reaction re60

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s130} \longrightarrow \mathrm{s129} \tag{25}$$

Reactant

Table 33: Properties of each reactant.

Id	Name	SBO
s130	IKKi	

Product

Table 34: Properties of each product.

Id	Name	SBO
s129	sa444_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_{13} = \mathrm{k11} \cdot [\mathrm{s130}] \tag{26}$$

6.14 Reaction re61

This is an irreversible reaction of one reactant forming two products.

Reaction equation

$$\mathrm{s127} \longrightarrow \mathrm{s128} + \mathrm{s127} \tag{27}$$

Reactant

Table 35: Properties of each reactant.

Id	Name	SBO
s127	mRNAA20	

Products

Table 36: Properties of each product.

Id	Name	SBO
s128	A20	
s127	mRNAA20	

Kinetic Law

Derived unit contains undeclared units

$$v_{14} = \mathrm{k16} \cdot [\mathrm{s127}] \tag{28}$$

6.15 Reaction re63

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Reaction equation

$$\mathrm{s132} \xrightarrow{\mathrm{s128}} \mathrm{s130} \tag{29}$$

Reactant

Table 37: Properties of each reactant.

Id	Name	SBO
s132	IKKa	

Modifier

Table 38: Properties of each modifier.

Id	Name	SBO
s128	A20	

Product

Table 39: Properties of each product.

Id	Name	SBO
s130	IKKi	

Kinetic Law

Derived unit contains undeclared units

$$v_{15} = \mathrm{k5} \cdot [\mathrm{s132}] + \mathrm{k4} \cdot [\mathrm{s132}] \cdot [\mathrm{s128}] \tag{30}$$

6.16 Reaction re64

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s150} \longrightarrow \mathrm{s133} \tag{31}$$

Reactant

Table 40: Properties of each reactant.

Id	Name	SBO
s150	IKK	

Product

Table 41: Properties of each product.

Id	Name	SBO
s133	IKKn	

Kinetic Law

Derived unit not available

$$v_{16} = \mathrm{k3} \tag{32}$$

6.17 Reaction re65

This is an irreversible reaction of two reactants forming one product.

Reaction equation

$$\mathrm{s160} + \mathrm{s161} \longrightarrow \mathrm{s135} \tag{33}$$

Reactants

Table 42: Properties of each reactant.

Id	Name	SBO
s160	IkB_alpha	
s161	NFkB	

Product

Table 43: Properties of each product.

Id	Name	SBO
s135	NFkB:IkB_alpha	

Kinetic Law

Derived unit contains undeclared units

$$v_{17} = \mathrm{kf13} \cdot [\mathrm{s161}] \cdot [\mathrm{s160}] - \mathrm{kr13} \cdot [\mathrm{s135}] \tag{34}$$

6.18 Reaction `re66`

This is an irreversible reaction of two reactants forming one product.

Reaction equation

$$\mathrm{s160} + \mathrm{s132} \longrightarrow \mathrm{s139} \tag{35}$$

Reactants

Table 44: Properties of each reactant.

Id	Name	SBO
`s160`	IkB_alpha	
`s132`	IKKa	

Product

Table 45: Properties of each product.

Id	Name	SBO
`s139`	IKKa/IKBa	

Kinetic Law

Derived unit contains undeclared units

$$v_{18} = \mathrm{k7} \cdot [\mathrm{s132}] \cdot [\mathrm{s160}] \tag{36}$$

6.19 Reaction `re67`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s161} \longrightarrow 5\,\mathrm{s164} \tag{37}$$

Reactant

Table 46: Properties of each reactant.

Id	Name	SBO
s161	NFkB	

Product

Table 47: Properties of each product.

Id	Name	SBO
s164	NFkB	

Kinetic Law

Derived unit contains undeclared units

$$v_{19} = \mathrm{kf15} \cdot [\mathrm{s161}] - \mathrm{kr15} \cdot [\mathrm{s164}] \tag{38}$$

6.20 Reaction re68

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$5\,\mathrm{s159} \longrightarrow \mathrm{s135} \tag{39}$$

Reactant

Table 48: Properties of each reactant.

Id	Name	SBO
s159	NFkB/IkB_alpha	

Product

Table 49: Properties of each product.

Id	Name	SBO
s135	NFkB:IkB_alpha	

Kinetic Law

Derived unit contains undeclared units

$$v_{20} = \mathrm{kf28} \cdot [\mathrm{s159}] - \mathrm{kr28} \cdot [\mathrm{s135}] \tag{40}$$

6.21 Reaction `re69`

This is an irreversible reaction of two reactants forming one product.

Reaction equation

$$\mathrm{s164} + \mathrm{s167} \longrightarrow \mathrm{s159} \tag{41}$$

Reactants

Table 50: Properties of each reactant.

Id	Name	SBO
`s164`	NFkB	
`s167`	IkB_alpha	

Product

Table 51: Properties of each product.

Id	Name	SBO
`s159`	NFkB/IkB_alpha	

Kinetic Law

Derived unit contains undeclared units

$$v_{21} = \mathrm{kf14} \cdot [\mathrm{s164}] \cdot [\mathrm{s167}] - \mathrm{kr14} \cdot [\mathrm{s159}] \tag{42}$$

6.22 Reaction `re70`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s127} \longrightarrow \mathrm{s153} \tag{43}$$

Reactant

Table 52: Properties of each reactant.

Id	Name	SBO
s127	mRNAA20	

Product

Table 53: Properties of each product.

Id	Name	SBO
s153	sa96_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_{22} = \mathrm{k17} \cdot [\mathrm{s127}] \tag{44}$$

6.23 Reaction re71

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s128} \longrightarrow \mathrm{s154} \tag{45}$$

Reactant

Table 54: Properties of each reactant.

Id	Name	SBO
s128	A20	

Product

Table 55: Properties of each product.

Id	Name	SBO
s154	sa97_degraded	

Kinetic Law

Derived unit contains undeclared units

$$v_{23} = \mathrm{k18} \cdot [\mathrm{s128}] \tag{46}$$

6.24 Reaction `re72`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{s160} \longrightarrow 5\,\mathrm{s167} \tag{47}$$

Reactant

Table 56: Properties of each reactant.

Id	Name	SBO
`s160`	IkB_alpha	

Product

Table 57: Properties of each product.

Id	Name	SBO
`s167`	IkB_alpha	

Kinetic Law

Derived unit contains undeclared units

$$v_{24} = \mathrm{kf23} \cdot [\mathrm{s160}] - \mathrm{kr23} \cdot [\mathrm{s167}] \tag{48}$$

7 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

Identifiers for kinetic laws highlighted in gray cannot be verified to evaluate to units of SBML `substance` per `time`. As a result, some SBML interpreters may not be able to verify the consistency of the units on quantities in the model. Please check if

- parameters without an unit definition are involved or

- volume correction is necessary because the `hasOnlySubstanceUnits` flag may be set to `false` and `spacialDimensions`> 0 for certain species.

7.1 Species `s121`

Name IKBA

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a reactant in `re44`), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s121} = 0 \tag{49}$$

7.2 Species `s122`

Name sa13_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in `re46`), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s122} = 0 \tag{50}$$

7.3 Species `s124`

Name sa12_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in `re45`), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s124} = 0 \tag{51}$$

7.4 Species s125

Name mRNAIKBA

Initial amount 0 mol

This species takes part in four reactions (as a reactant in re45, re47 and as a product in re44, re47).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s125} = v_1 + v_4 - v_2 - v_4 \tag{52}$$

7.5 Species s126

Name A20

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a reactant in re48), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s126} = 0 \tag{53}$$

7.6 Species s127

Name mRNAA20

Initial amount 0 mol

This species takes part in four reactions (as a reactant in re61, re70 and as a product in re48, re61).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s127} = v_5 + v_{14} - v_{14} - v_{22} \tag{54}$$

7.7 Species s128

Name A20

Initial amount 0 mol

This species takes part in three reactions (as a reactant in re71 and as a product in re61 and as a modifier in re63).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s128} = v_{14} - v_{23} \tag{55}$$

7.8 Species s129

Name sa444_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in re60), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s129} = 0 \tag{56}$$

7.9 Species s130

Name IKKi

Initial amount 0 mol

This species takes part in two reactions (as a reactant in re60 and as a product in re63).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s130} = v_{15} - v_{13} \tag{57}$$

7.10 Species s131

Name sa19_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in re53), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s131} = 0 \tag{58}$$

7.11 Species s132

Name IKKa

Initial amount 0 mol

This species takes part in eight reactions (as a reactant in re56, re58, re63, re66 and as a product in re49, re57, re59 and as a modifier in re52).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s132} = v_6 + v_{10} + v_{12} - v_9 - v_{11} - v_{15} - v_{18} \tag{59}$$

7.12 Species s133

Name IKKn

Initial amount 0 mol

Charge 0

This species takes part in three reactions (as a reactant in re49, re53 and as a product in re64).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s133} = v_{16} - v_6 - v_8 \tag{60}$$

7.13 Species s134

Name sa20_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in re56), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s134} = 0 \tag{61}$$

7.14 Species s135

Name NFkB:IkB_alpha

Initial amount 0.06 mol

Charge 0

This species takes part in four reactions (as a reactant in re52, re58 and as a product in re65, re68).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s135} = v_{17} + v_{20} - v_7 - v_{11} \tag{62}$$

7.15 Species s139

Name IKKa/IKBa

Initial amount 0 mol

This species takes part in two reactions (as a reactant in re57 and as a product in re66).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s139} = v_{18} - v_{10} \tag{63}$$

7.16 Species s150

Name IKK

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a reactant in re64), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s150} = 0 \tag{64}$$

7.17 Species s152

Name NFkB/Ikb_alpha/IKKa

Initial amount 0 mol

This species takes part in two reactions (as a reactant in re59 and as a product in re58).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s152} = v_{11} - v_{12} \tag{65}$$

7.18 Species s153

Name sa96_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in re70), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s153} = 0 \tag{66}$$

7.19 Species s154

Name sa97_degraded

Initial amount 0 mol

Charge 0

This species takes part in one reaction (as a product in re71), which does not influence its rate of change because this constant species is on the boundary of the reaction system:

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s154} = 0 \tag{67}$$

7.20 Species s159

Name NFkB/IkB_alpha

Initial amount 0 mol

This species takes part in two reactions (as a reactant in re68 and as a product in re69).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s159} = v_{21} - 5\,v_{20} \tag{68}$$

7.21 Species s160

Name IkB_alpha

Initial amount 0 mol

This species takes part in five reactions (as a reactant in re46, re65, re66, re72 and as a product in re47).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s160} = v_4 - v_3 - v_{17} - v_{18} - v_{24} \tag{69}$$

7.22 Species s161

Name NFkB

Initial amount 0 mol

This species takes part in four reactions (as a reactant in re65, re67 and as a product in re52, re59).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s161} = v_7 + v_{12} - v_{17} - v_{19} \tag{70}$$

7.23 Species s164

Name NFkB

Initial amount 0 mol

This species takes part in four reactions (as a reactant in re69 and as a product in re67 and as a modifier in re44, re48).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s164} = 5\,v_{19} - v_{21} \tag{71}$$

7.24 Species s167

Name IkB_alpha

Initial amount 0 mol

This species takes part in two reactions (as a reactant in re69 and as a product in re72).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{s167} = 5\, v_{24} - v_{21} \tag{72}$$

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