

International Conference on Computational Systems Biology (ISB 2017), Shenzhen, China, August 18-21, 2017.

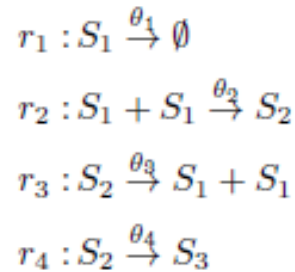
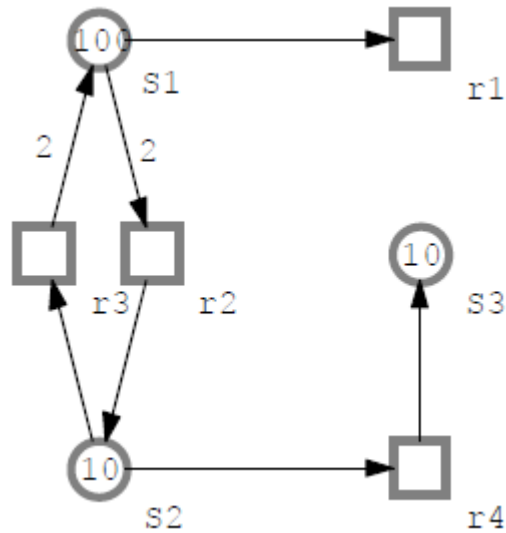
# Modeling Biological Systems with Uncertain Kinetic Data Using Fuzzy Continuous Petri Nets

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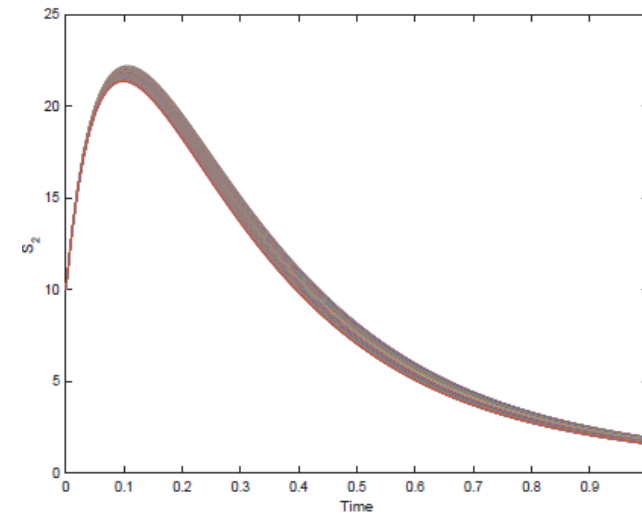
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- ❑ **Modeling methods for Biochemical network**
  - ❑ Qualitative/uncertain: Boolean networks, Petri nets, fuzzy methods, qualitative Petri nets
  - ❑ Quantitative: Differential equations, Bayesian networks, stochastic/continuous Petri nets.
  
- ❑ **How to model a biochemical network with both precise and uncertain kinetic parameters?**
  - ❑ Combine fuzzy methods with quantitative methods
  - ❑ Our approach: **introduce fuzzy logic into continuous Petri nets**
  - ❑ **Fuzzy Continuous Petri Nets (FCPNs)**



$$\begin{aligned}
 dS_1/dt &= 2 * (\theta_3 * S_2) - (\theta_1 * S_1) - 2 * (\theta_2 * S_1^2), \\
 dS_2/dt &= (\theta_2 * S_1^2) - (\theta_3 * S_2) - (\theta_4 * S_2), \\
 dS_3/dt &= (\theta_4 * S_2).
 \end{aligned}$$



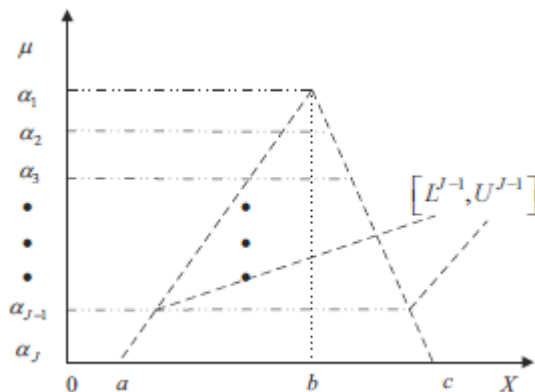
## □ Syntax

- Following the syntax of **Petri nets**

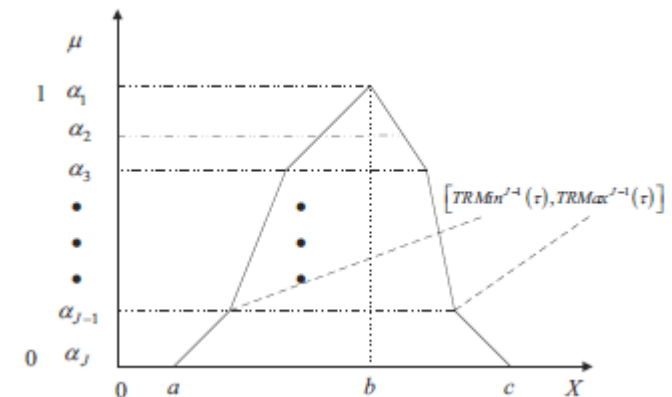
## □ Semantics

- An FCPN is equivalent to a set of **fuzzy differential equations** with fuzzy parameters

- Present a **fuzzy simulation algorithm** for FCPNs
- Compute **uncertain band** of an output from uncertain inputs
- Estimate **membership functions** of an output from uncertain inputs
- Offer an analysis method for addressing large models

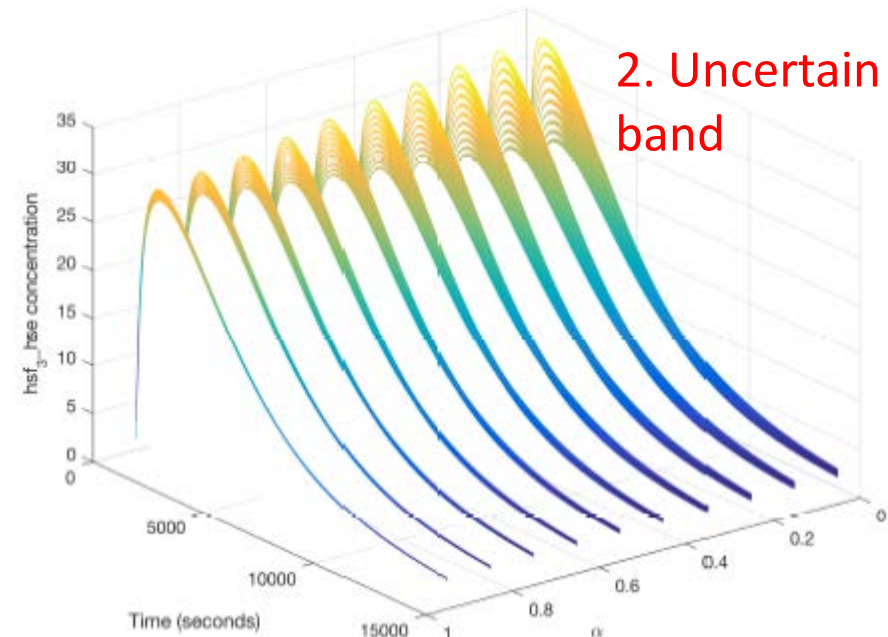
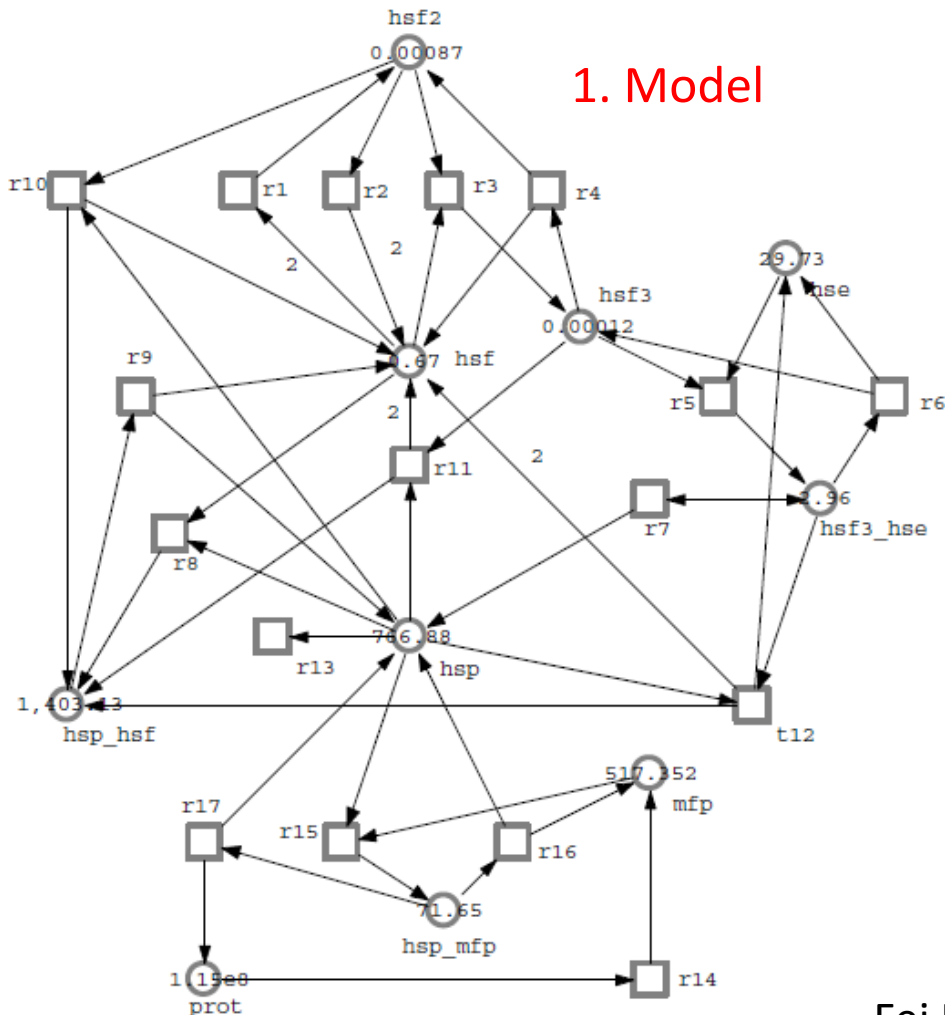


Simulation

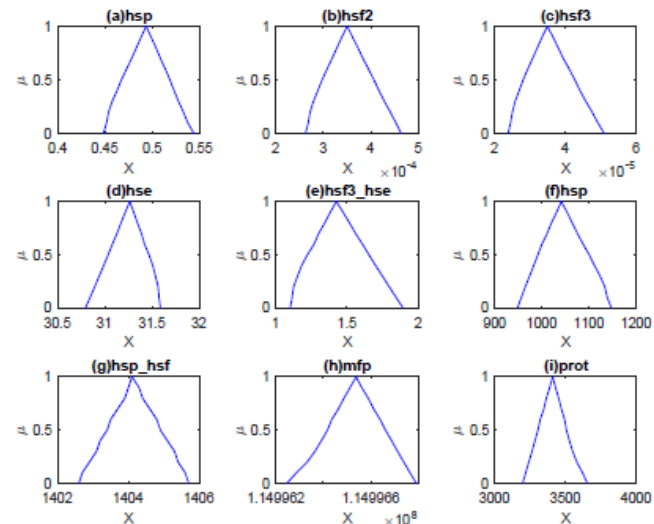


## Heat shock response

1. Model



2. Uncertain band



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3. Membership function



**Thank you for your attention !**