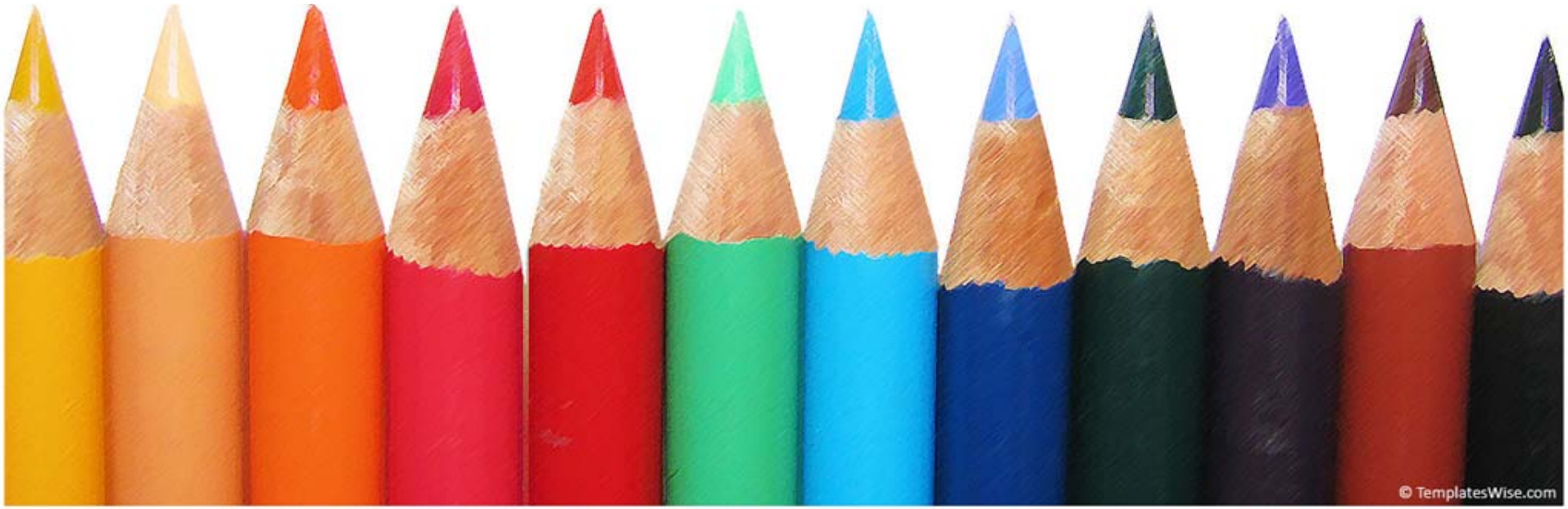
Importance of single nodes for Boolean network dynamics

Fakhteh Ghanbarnejad, Konstantin Klemm

arXiv:1111.5334v1

Leipzig, Nov. 2011



Importance of single nodes for Boolean network dynamics

- ON/OFF states
- Networks (interactions)
- Dynamics: Boolean functions

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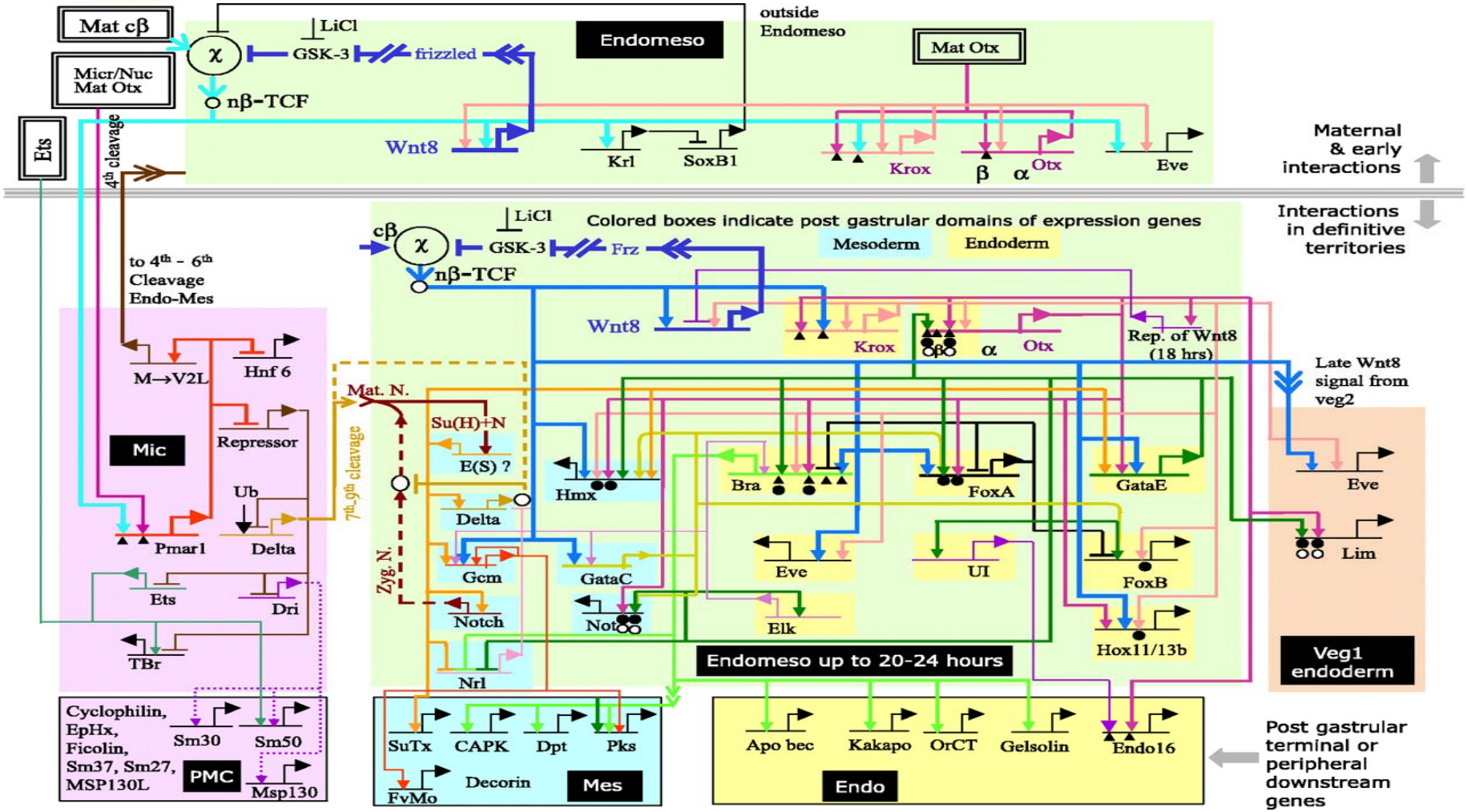
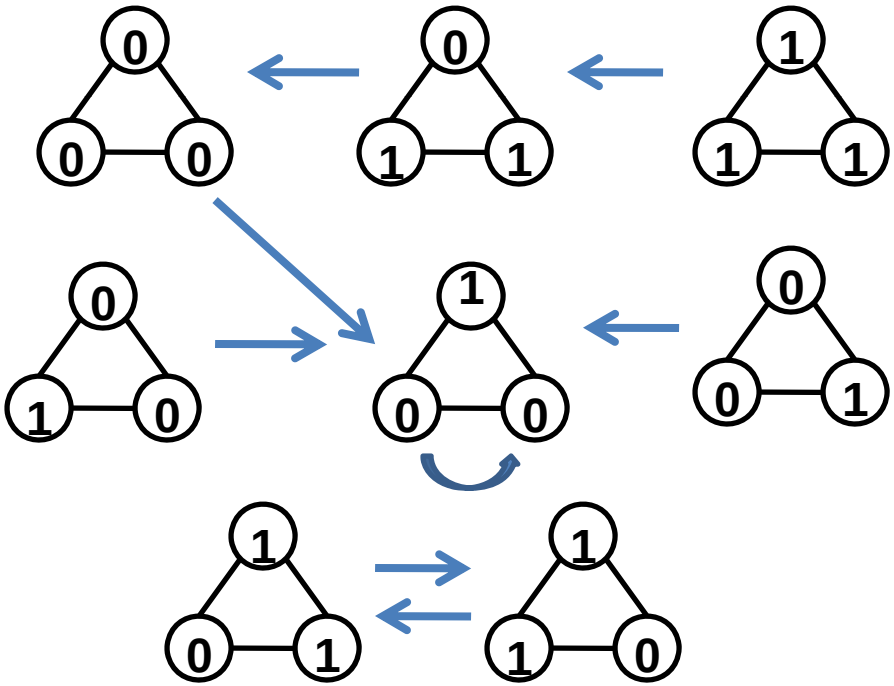
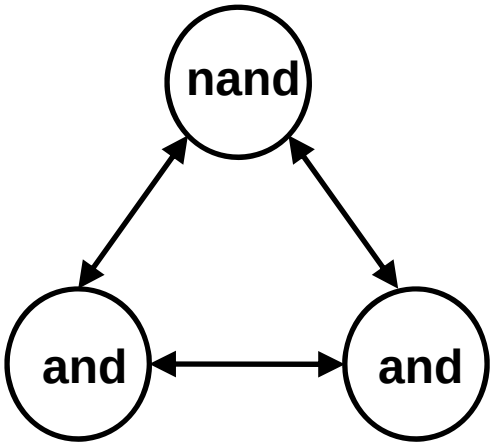
Gene Regulatory Network Controlling Embryonic Specification in the Sea Urchin



P. Oliveri, E. H. Davidson Current Opinion in Genetics & Development - 2004

Boolean Dynamics





Importance of single nodes for Boolean network dynamics

impact of individual nodes

on dynamics

(short /long term)

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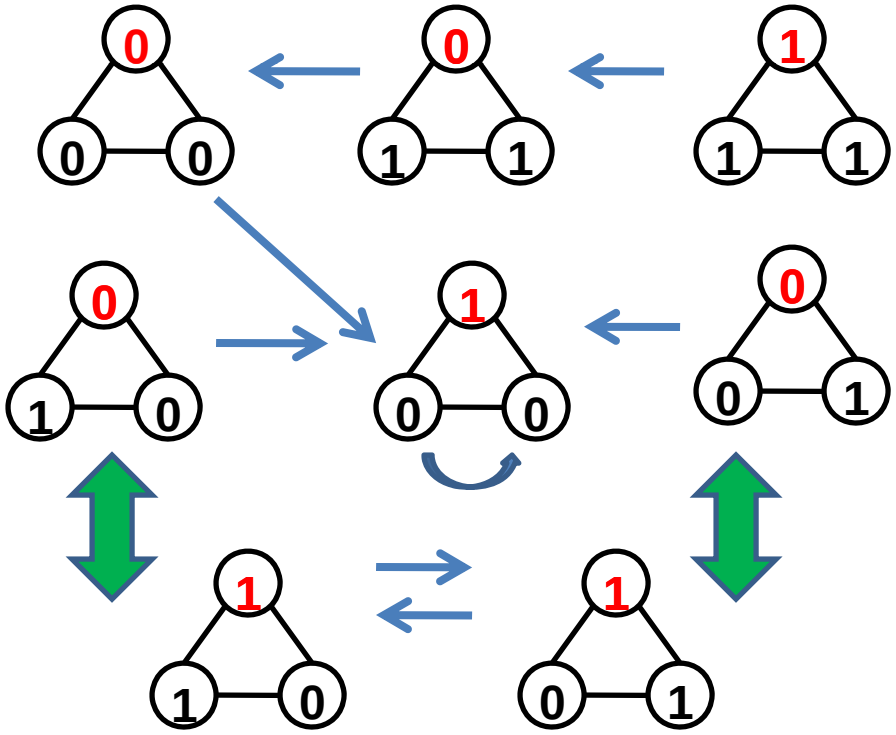
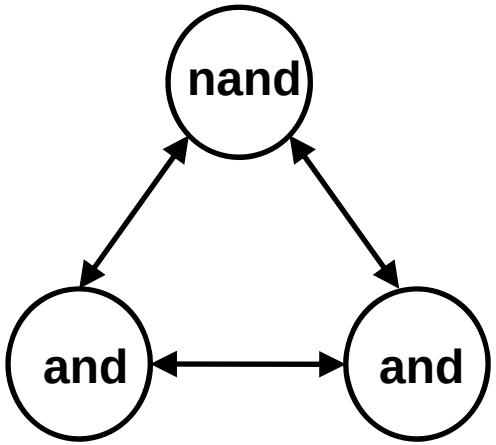
Computing the dynamical impact of nodes



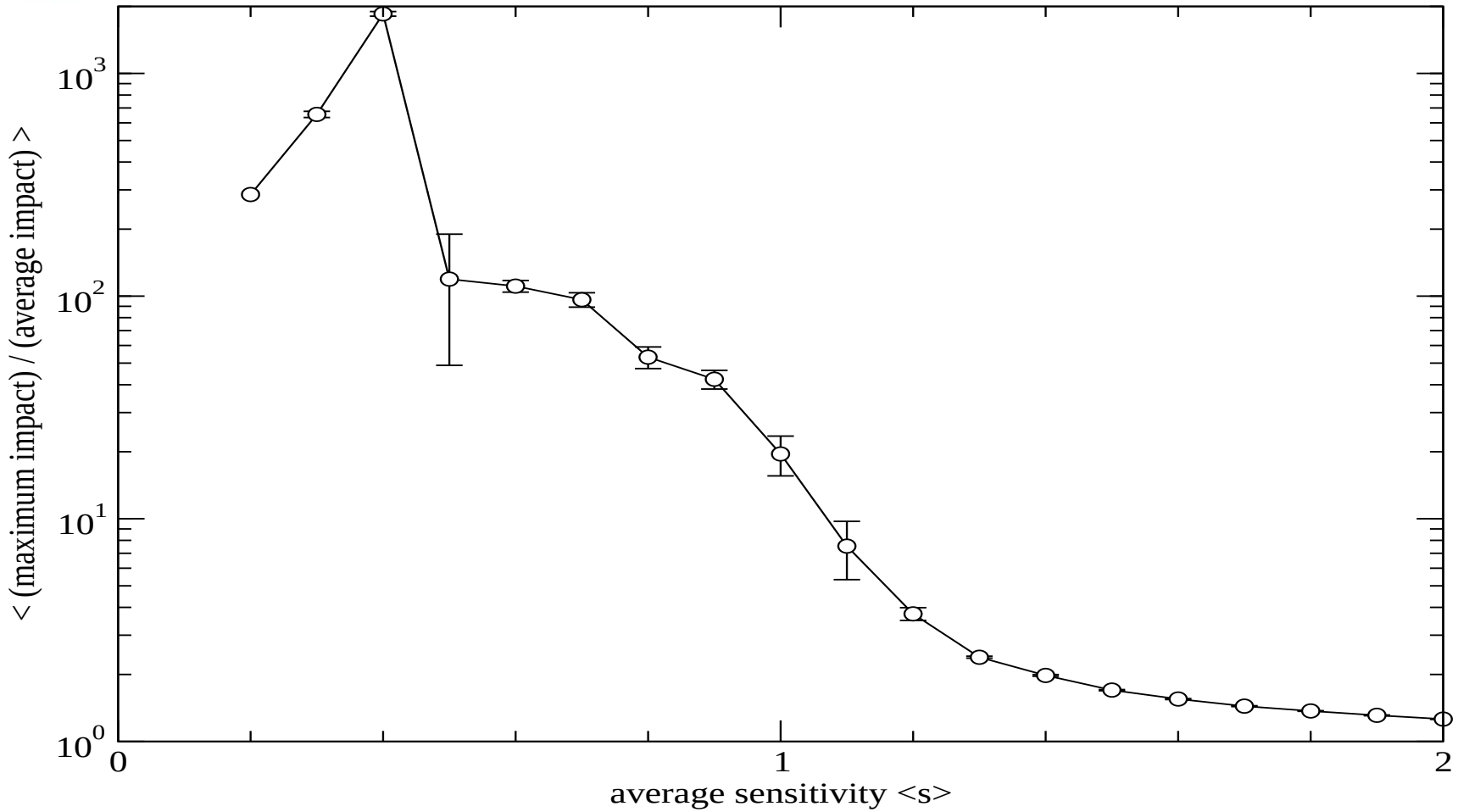


Flip:

0→1

1→0

Variation of dynamical impact across nodes in random Boolean networks



Predicting of dynamical impact

- Why ?
- How ?

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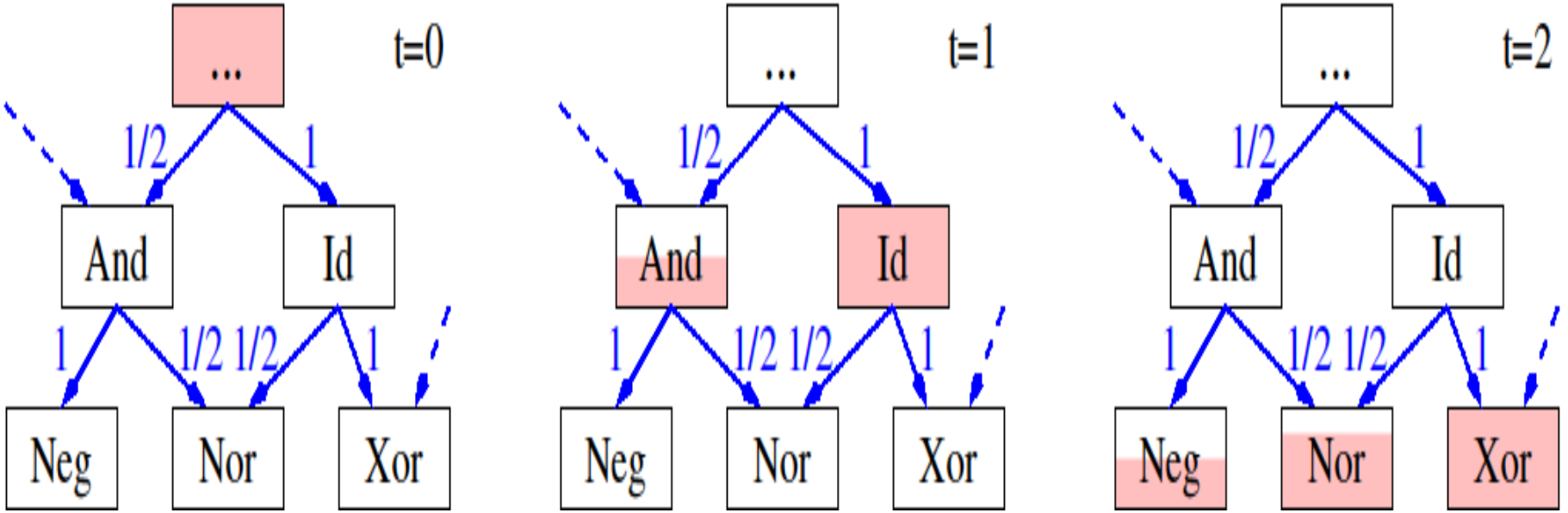
Probabilistic description of damage spreading in a Boolean dynamics



$$p_j(t) \propto \sum_{i-1}^{N} \alpha_{ji} p_i(t-1)$$

$$p(t) = \aleph^{\Gamma} p(t-1)$$

$$p(t) = (\aleph^{\Gamma})^t p(0)$$

Importance of single nodes for Boolean network dynamics

Centrality measures considered as predictors for the dynamical impact

Range	Adjacency matrix	Activity matrix
local	**out-degree**	**strength**
global	**eigenvector**	**eigenvector**

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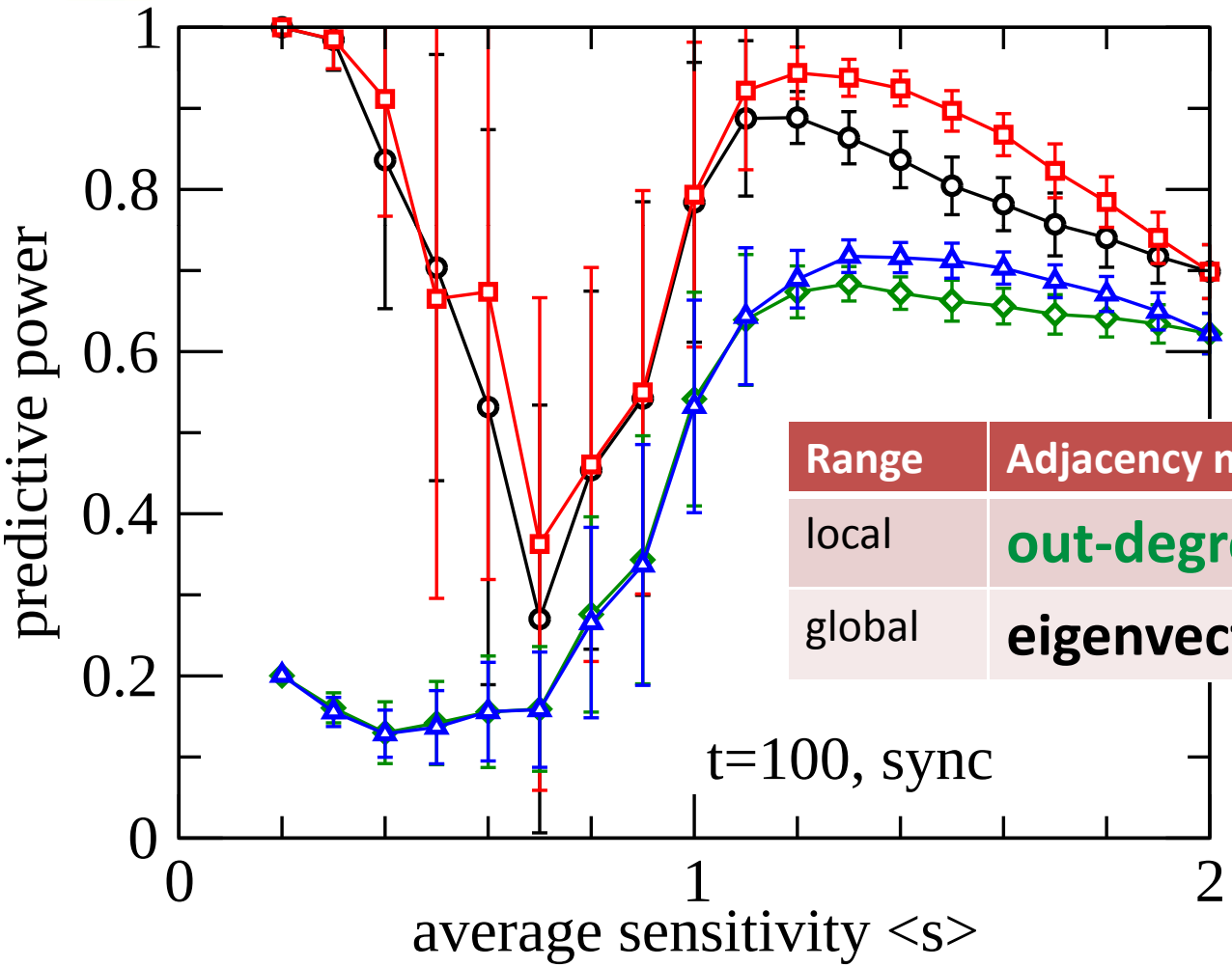
Results for random Boolean networks



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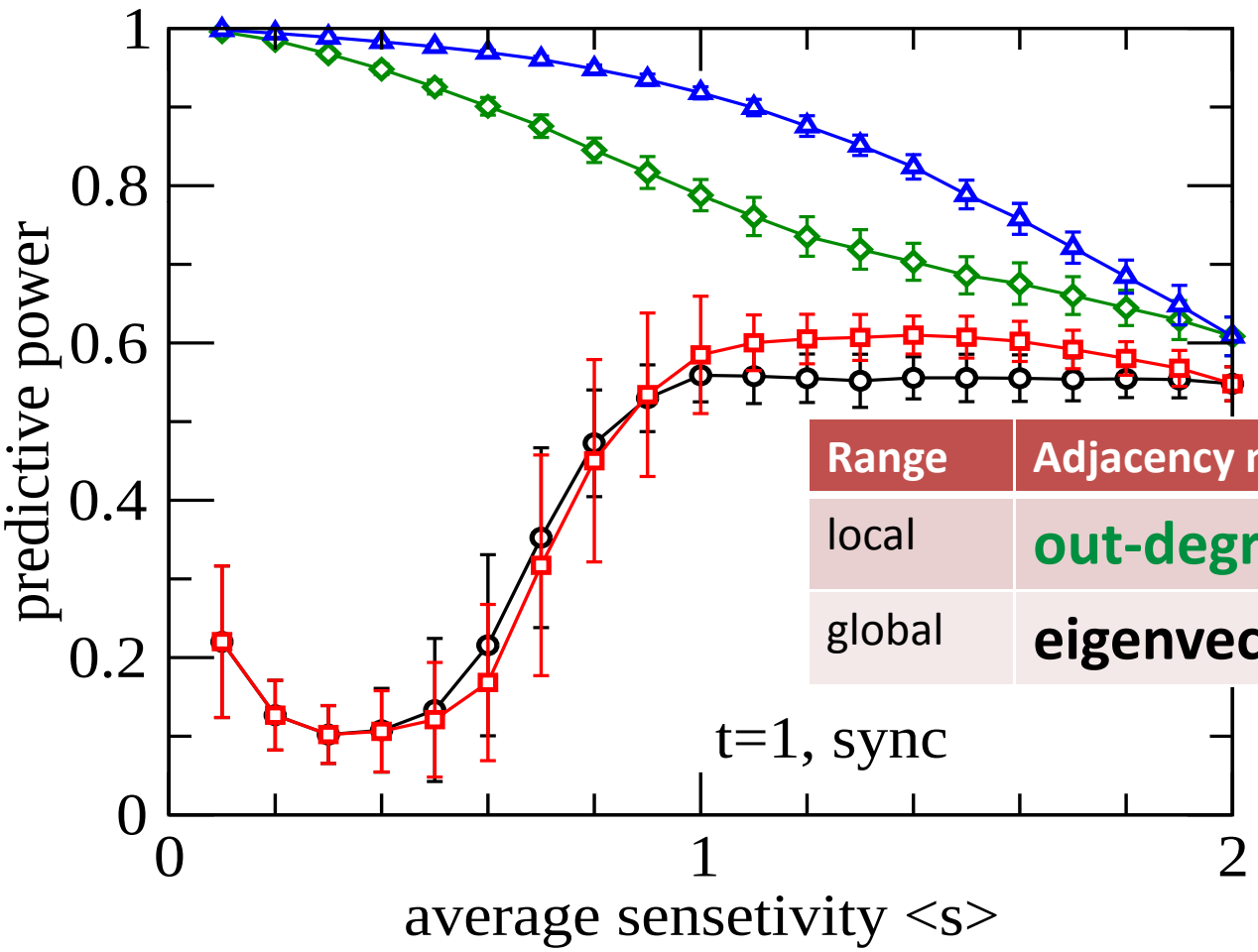
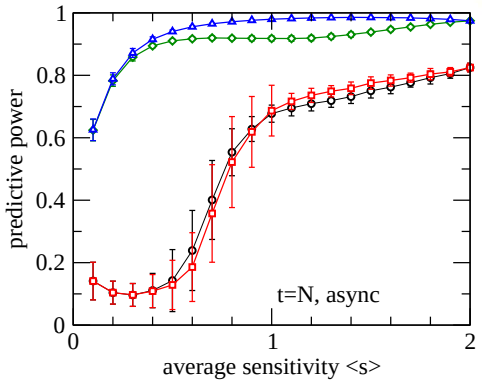
Results for random Boolean networks

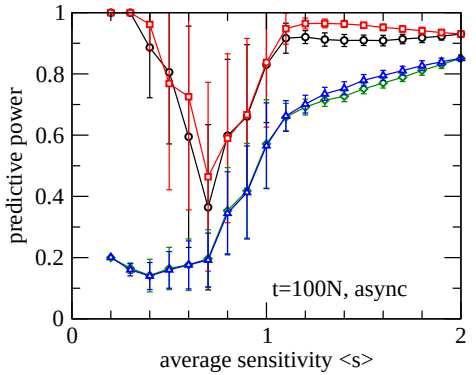


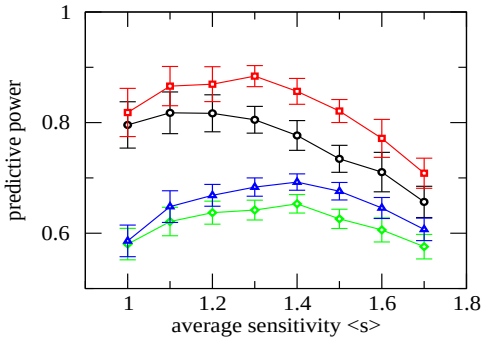
Range	Adjacency matrix	Activity matrix
local	out-degree	strength
global	eigenvector	eigenvector

More cases

- Asynchronous updating
- Attractor switching
- With small perturbations







Dynamical impact in a real network

fibroblast signal transduction

		all nodes			
		$\mathcal{P}_\epsilon$	$\mathcal{P}_e$	$\mathcal{P}_\sigma$	$\mathcal{P}_d$
synchronous	$t = 1$	0.671	0.454	**0.930**	0.455
	$t = 100$	**0.920**	0.734	0.746	0.523
asynchronous	$t = N$	0.706	0.528	**0.904**	0.564
	$t = 100N$	**0.854**	0.694	0.748	0.542
		only core nodes			
		$\mathcal{P}_\epsilon$	$\mathcal{P}_e$	$\mathcal{P}_\sigma$	$\mathcal{P}_d$
synchronous	$t = 1$	0.633	0.467	**0.946**	0.528
	$t = 100$	**0.911**	0.777	0.738	0.611
asynchronous	$t = N$	0.658	0.543	**0.919**	0.656
	$t = 100N$	**0.834**	0.731	0.741	0.631

T. Helikaret al; PNAS 105, 1913 (2008)

Importance of single nodes for Boolean network dynamics

- Linear algebra
- Random Boolean networks
- Empirical Boolean networks

Range	Adjacency matrix	Activity matrix
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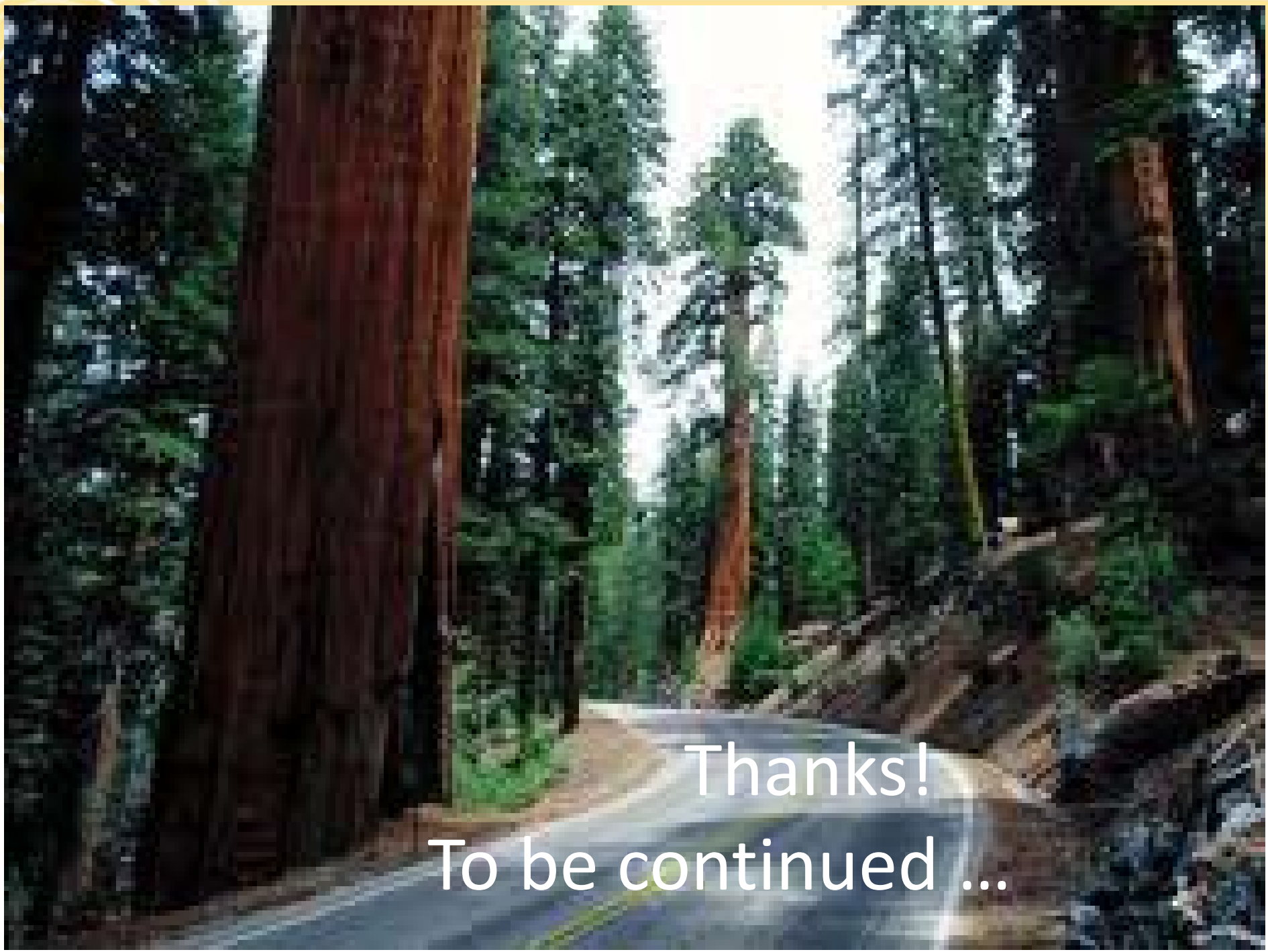
Thanks!
To be continued …

Fakhteh Ghanbarnejad

Konstantin Klemm

Impact of individual nodes in Boolean network dynamics

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Stability of Boolean and continuous dynamics

Phys. Rev. Lett. 107.188701