

Dynamic Transition in Coevolving Networks

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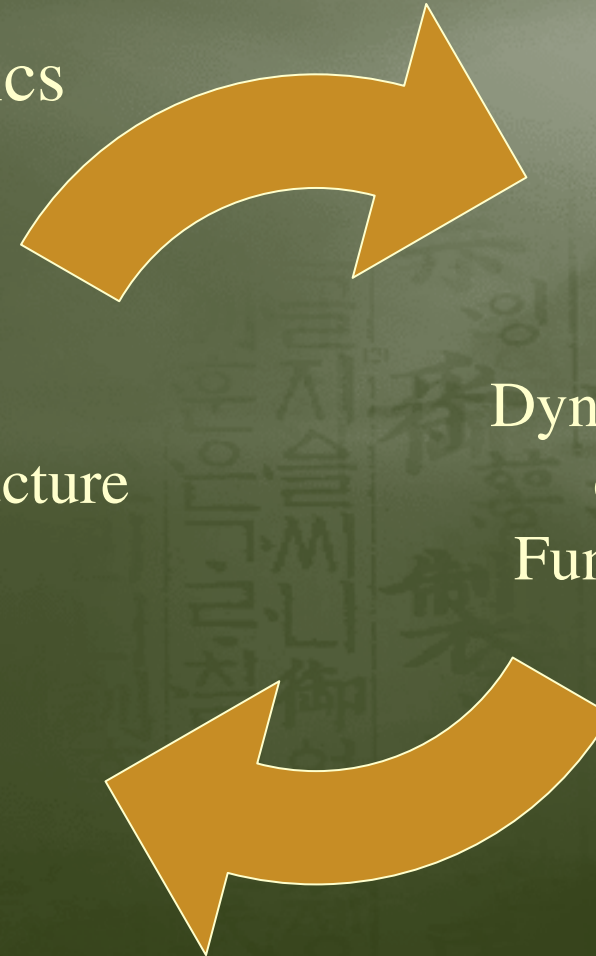
Reference : S.-W. Kim and J.D. Noh, Phys. Rev. Lett. **100**, 118702 (2008)

I. Introduction

- Network : Structure and Dynamics

- Interplay

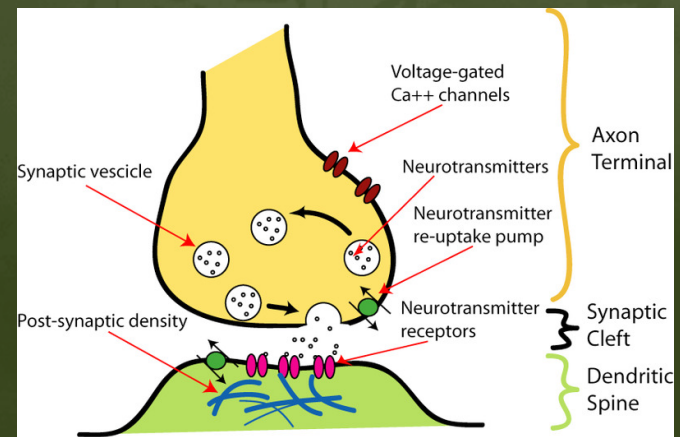
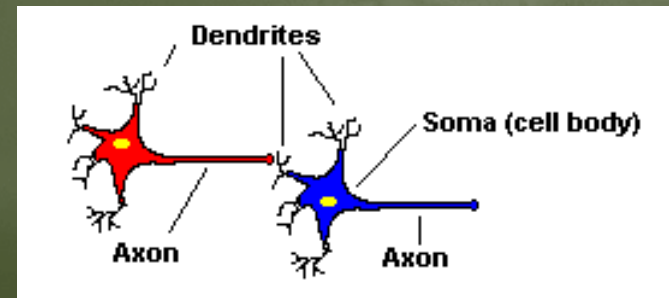
- Question: Emerging property



I. Introduction

- Synaptic plasticity in neural networks

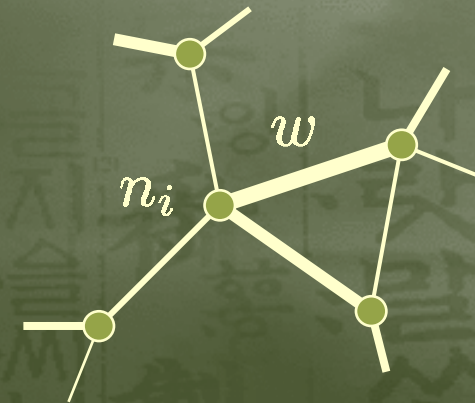
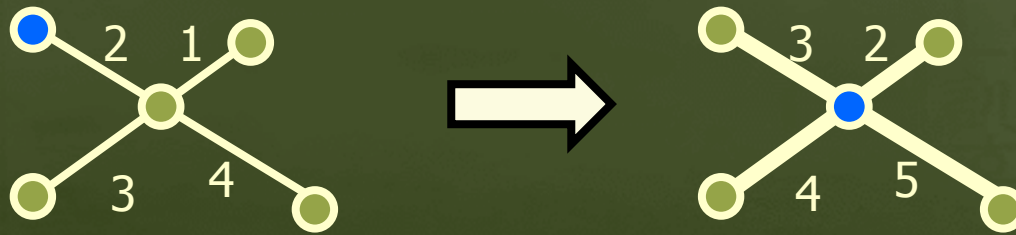
- structure to dynamics
 - signal transmission
- dynamics to structure
 - long term potentiation
 - long term depression
- network evolution



II. Model

Co-evolving Network Model

- Weighted undirected network + diffusing particles
- Particles dynamics : random diffusion
- Weight dynamics [LTP]



- Link dynamics [LTD]: With probability $1/w_e$, each link e is removed and replaced by a new one

Dynamic Instability

- Particles tend to be condensed at high degree nodes

- visiting frequency of a random walker $f_i \propto k_i$

[Noh&Rieger, PRL `04]

- macroscopic condensate at high degree nodes

[Noh&Shim&Lee, PRL `05]

- Stronger nodes attract more links ← LTP and LTD

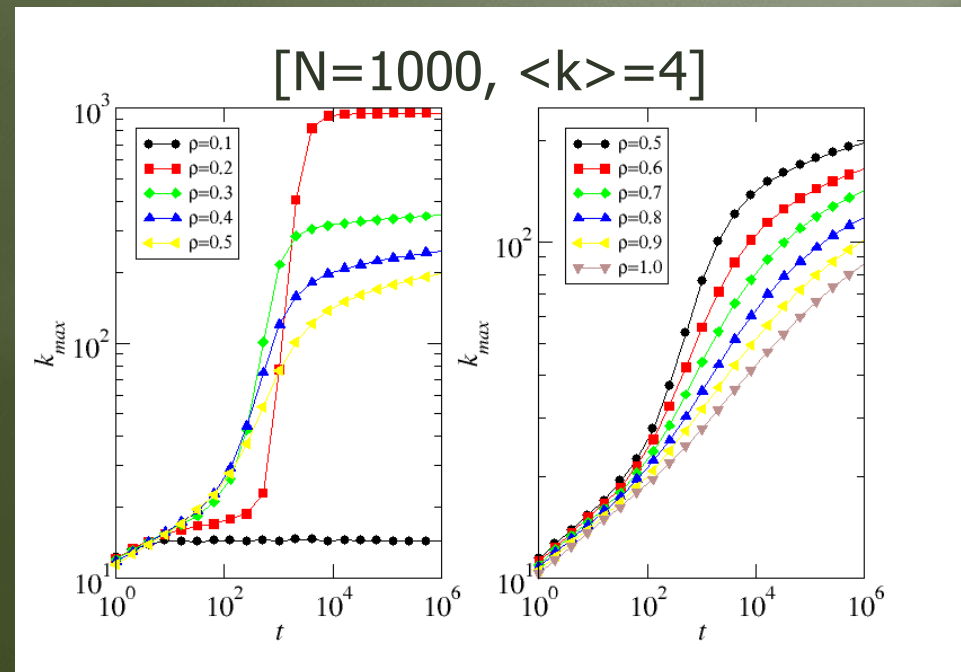
- Positive feedback → dynamic instability toward the formation of hubs



III. Numerical & Analytic Results

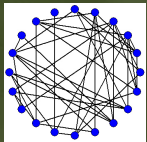
Maximum Degree

- Dynamic instability
- Dynamic phase transition
 - linear growth
($\rho < \rho_c$)
 - sub-linear growth
($\rho < \rho_c$)



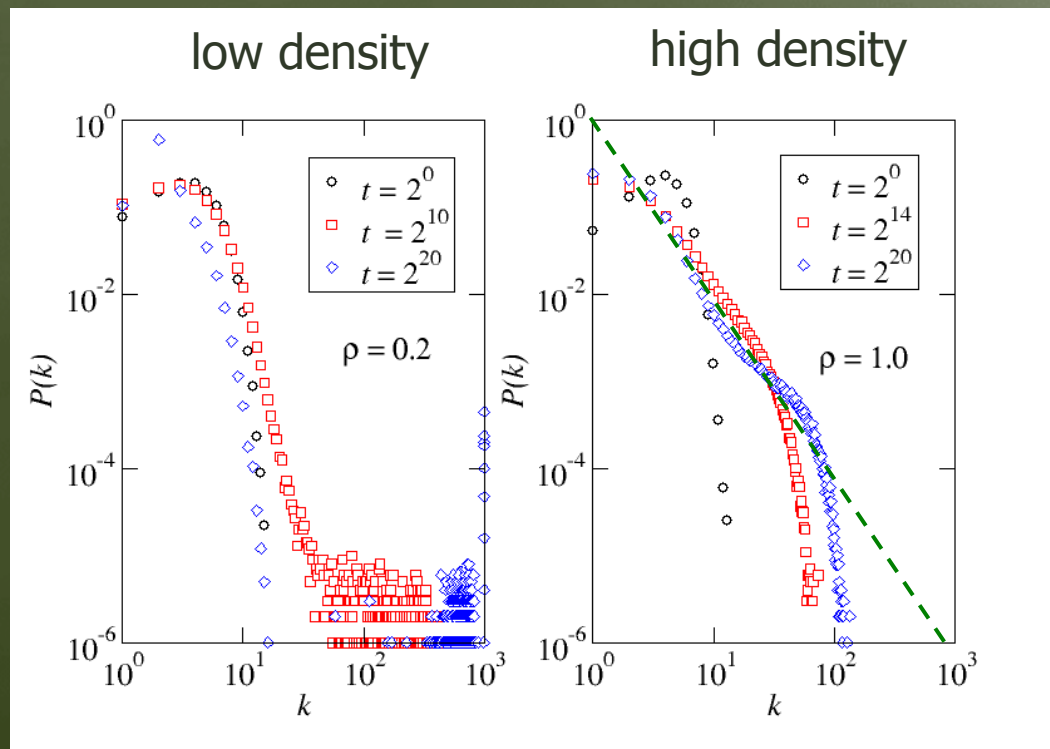
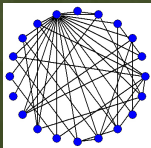
Degree Distribution

Poissonian



+

Poissonian
+
Isolated hubs



Poissonian

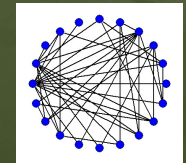


+

Fat-tailed



...



Analytic Theory

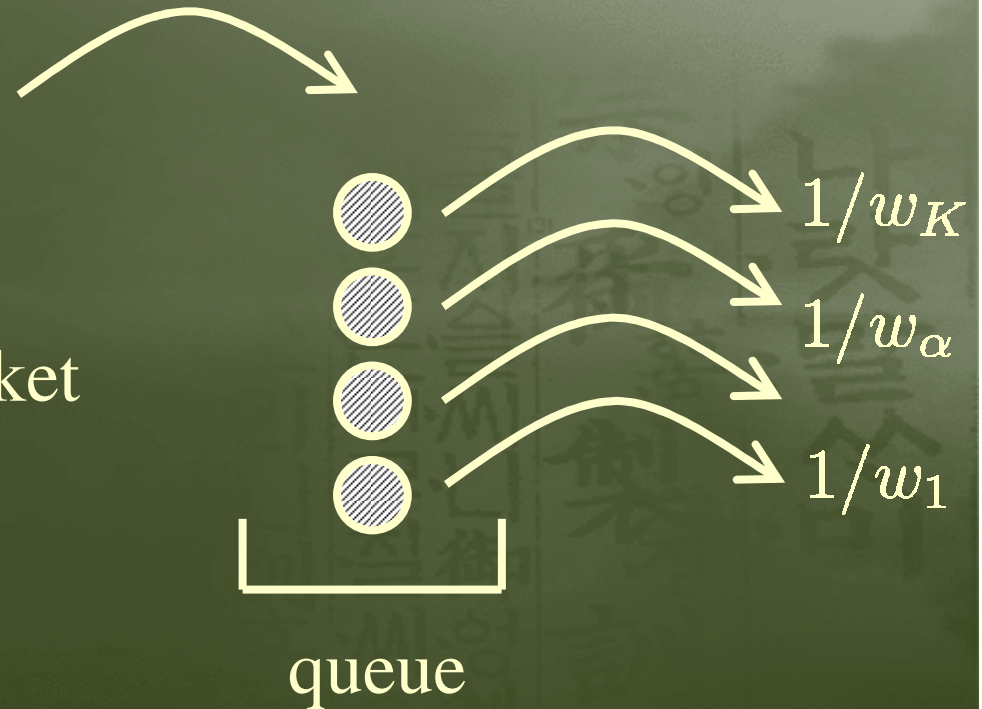
- Separation of time scales
 - particle dynamics : fast
 - network dynamics : slow
- Effective network dynamics
 - : Non-Markovian queueing process

Non-Markovian Queueing Process

- node \$ queue
- edge \$ packet
- degree \$ queue size

- Sitting probability of a packet

$$w_\alpha(t) = 1 + \lambda \sum_{t'=t_\alpha}^t K(t')$$



Analytic Results

- Low density phase
 - $t < \tau$: all queues are occupied by a few packets
→ random network regime
 - $t > \tau$: a certain queue grows spontaneously and ballistically → hub formation
- High density phase
 - All queues grow immediately and simultaneously
 - Queues are competing → scale-invariance

Summary

- Coevolving network model
: interplay of structure and dynamics
- Positive feedback
- Dynamic instability toward the formation of hubs
- Dynamic phase transition

Thank you!!!