Statistical Analysis of Networks

Introduction to Stochastic Actor-Based Models

Learning Goals

- Understand difference between Exponential Random Graph Models and Stochastic Actor-Based Models
- Describe logic of *micro-steps* and simulation of networks using **rate** function.
- Describe logic of *preferences* and simulation of networks using **objective** function.

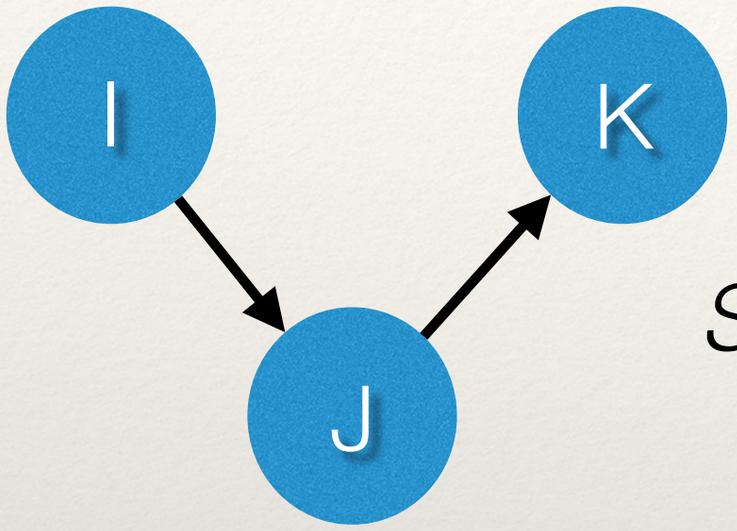
Introduction

- With ERGMs, we asked: "what are the network configurations that generated this network?"
  - We reviewed models that are "edge-based" in the sense that the probability of an edge is dependent (or not) on other edges in the network.

Introduction

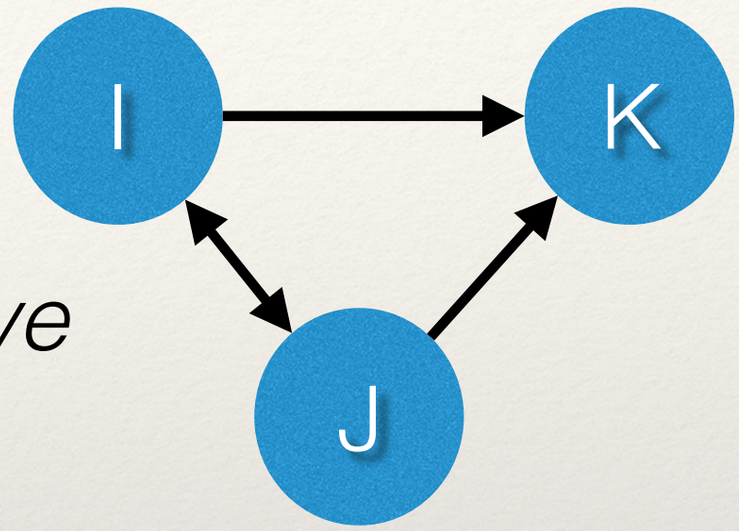
- With *Stochastic Actor-Based Models* (SABM), we can ask a new question:
  - How do networks change? (network dynamics)
    - This introduces a temporal element that was not addressed by ERGMs (*although, it is possible* [see STERGMs]).

Network Dynamics



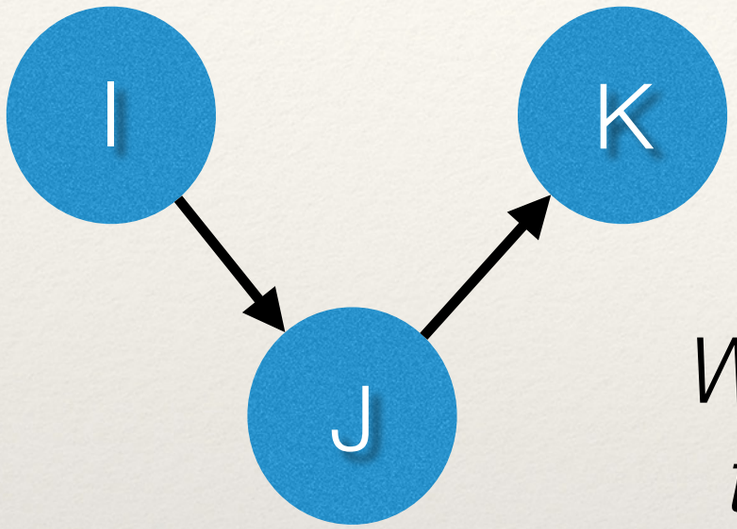
t

Suppose we observe two discrete time points.

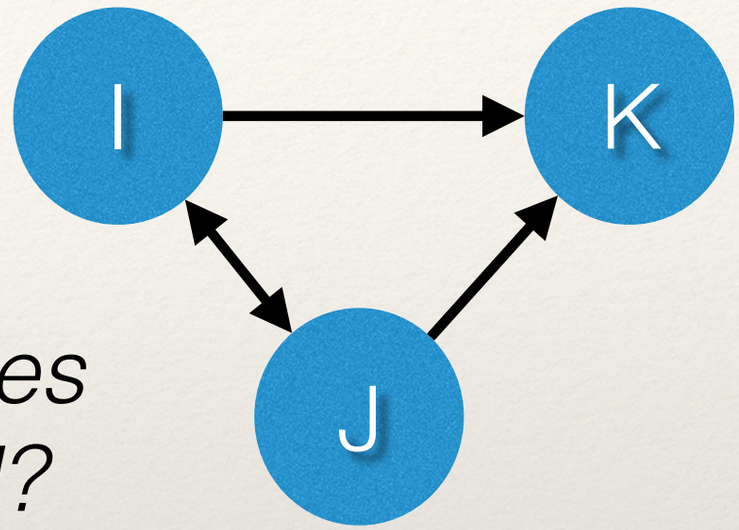


t + 1

Network Dynamics

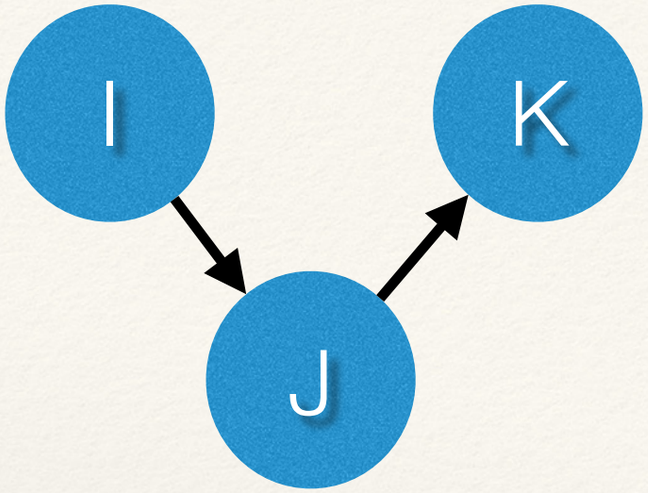


What are the changes that have occurred?

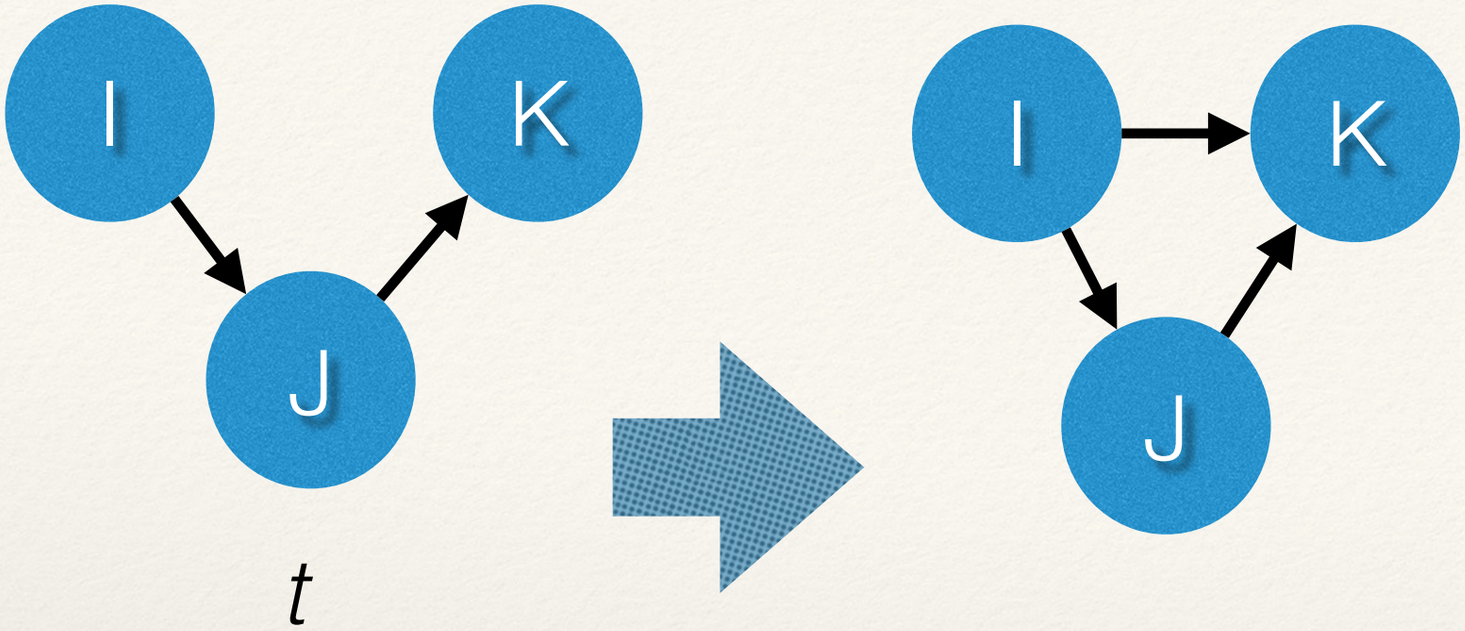


t

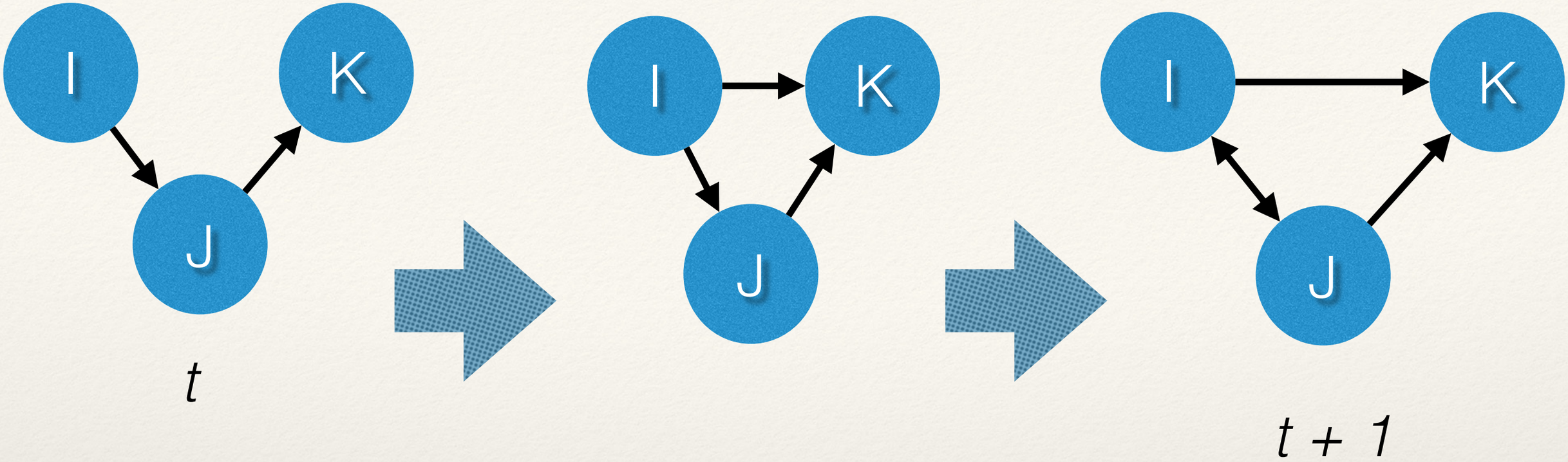
t + 1



t

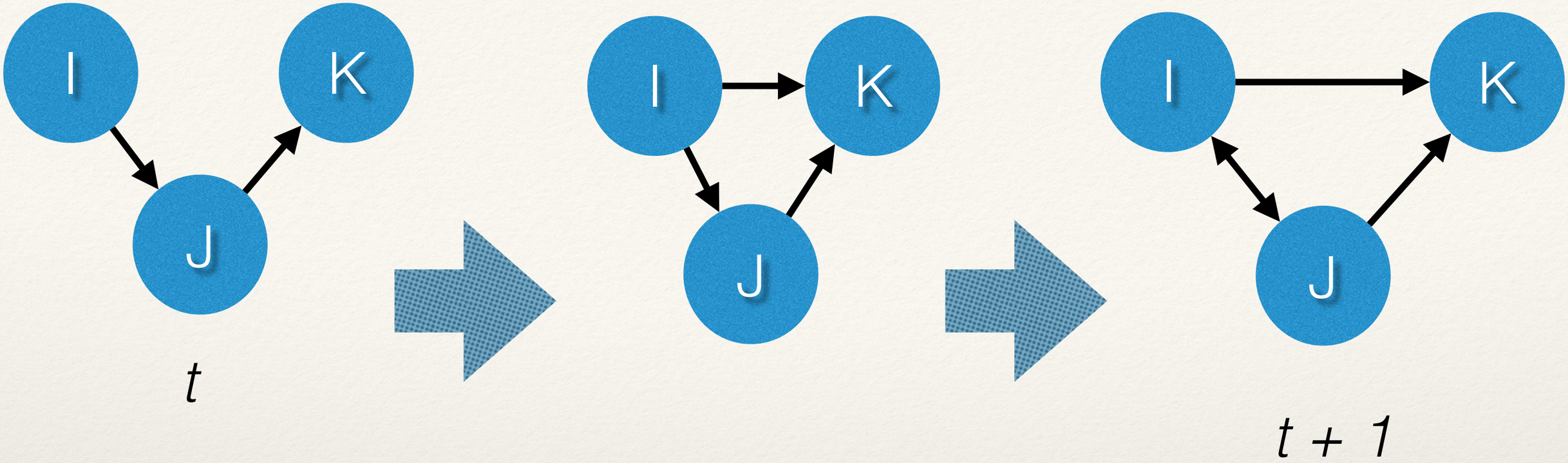


t



t

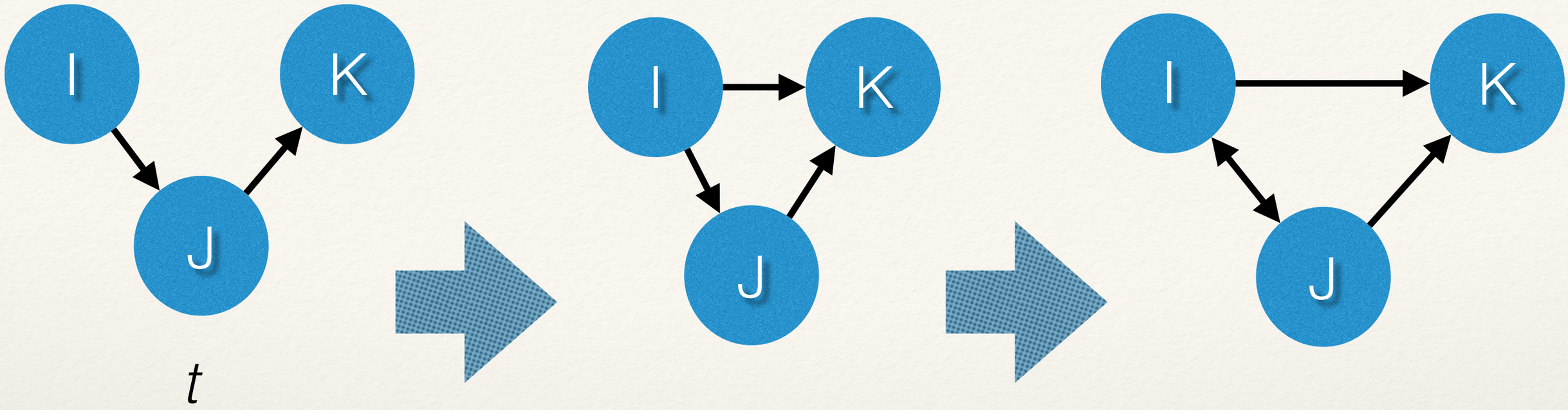
t + 1



t

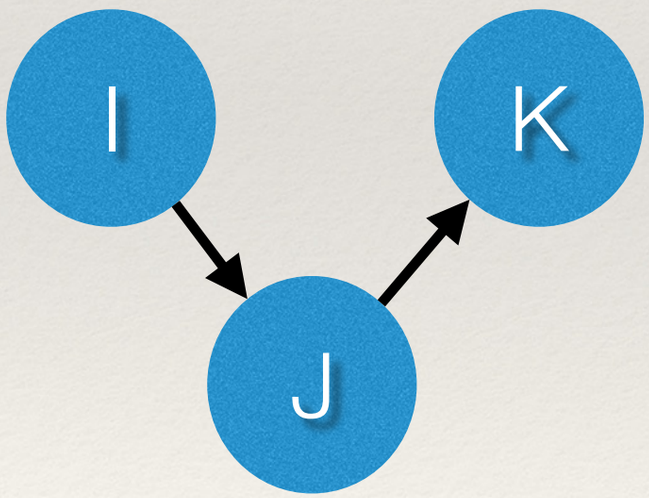
t + 1

Or…

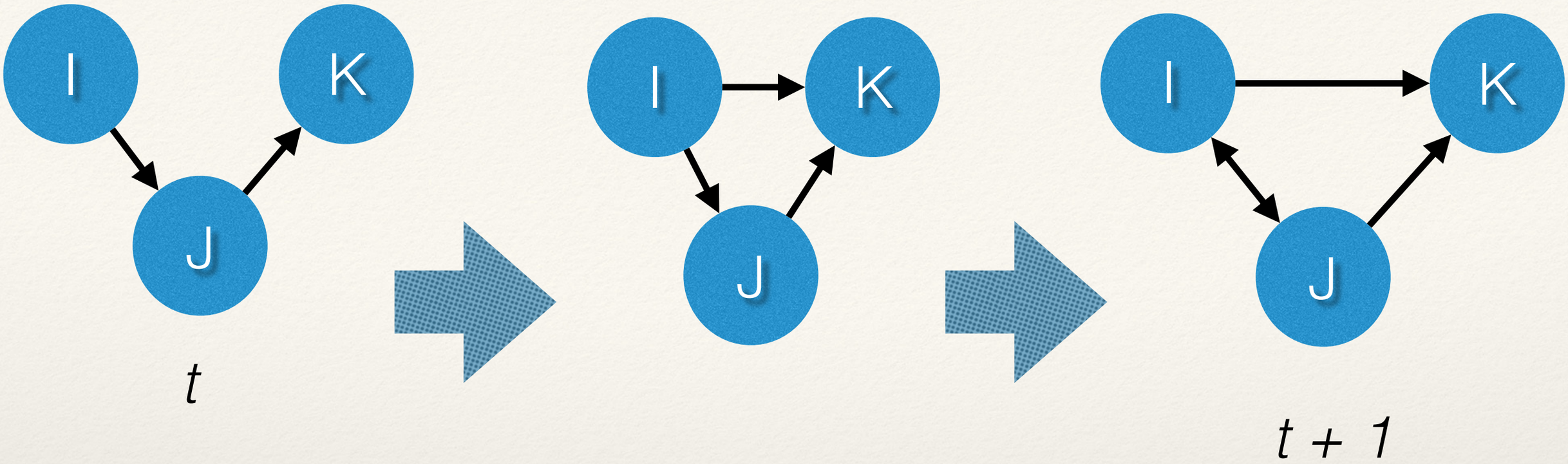


t *t + 1*

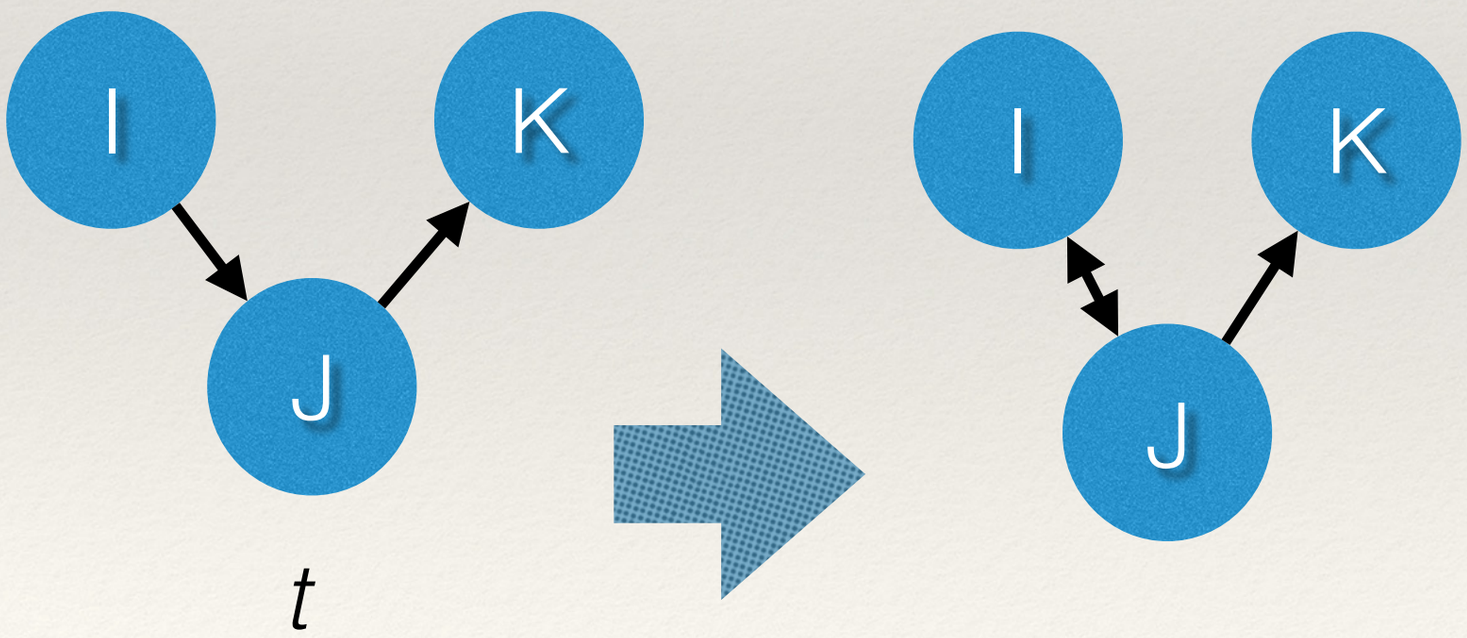
Or…

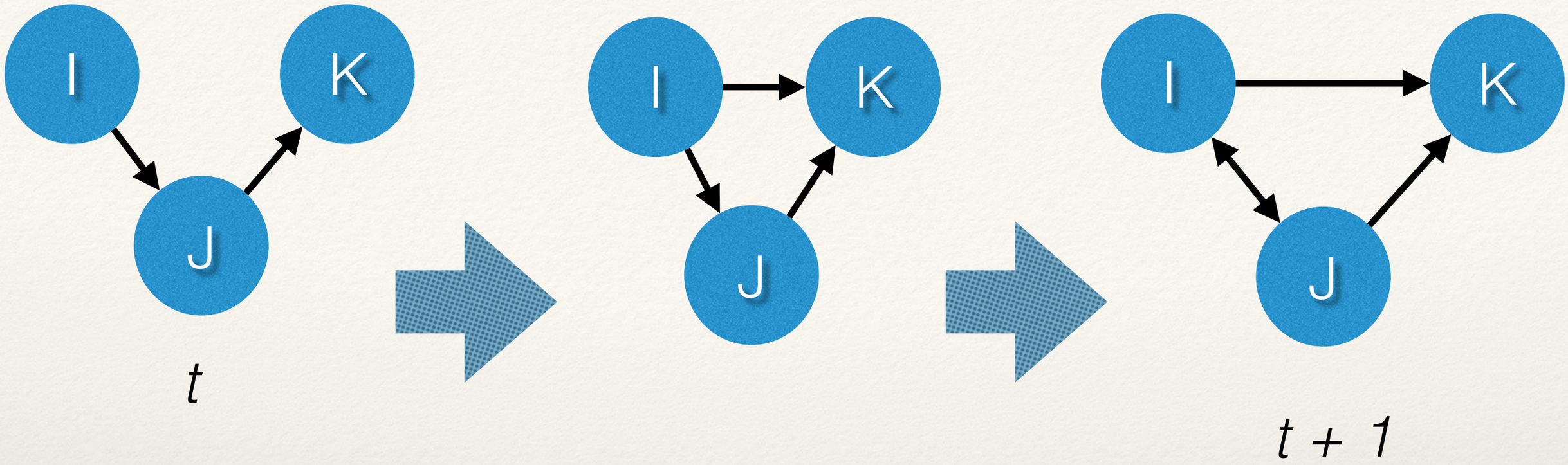


t

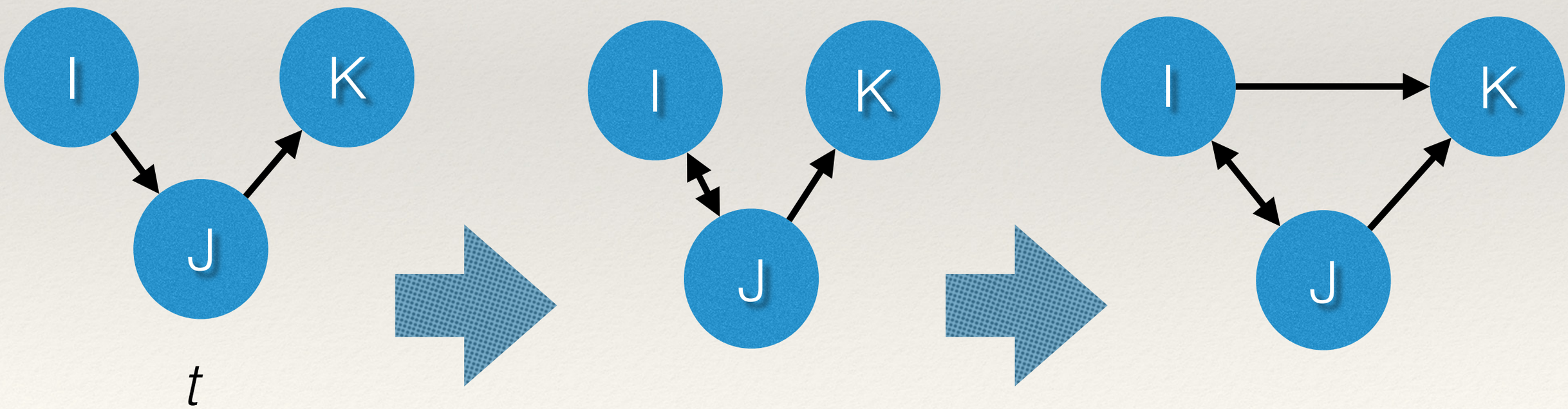


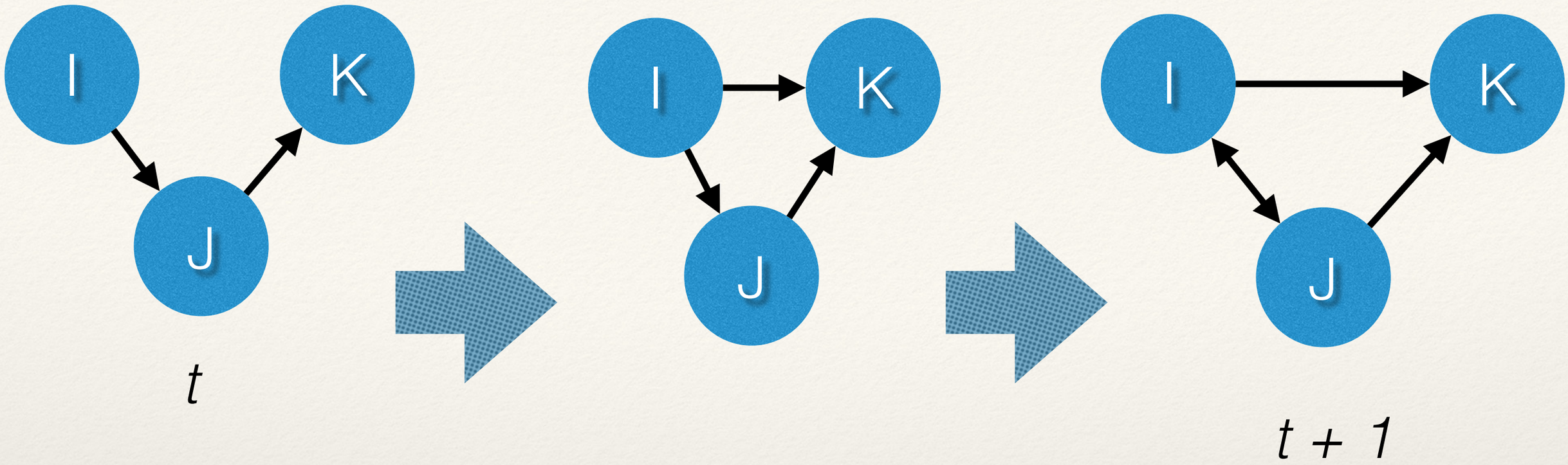
Or…



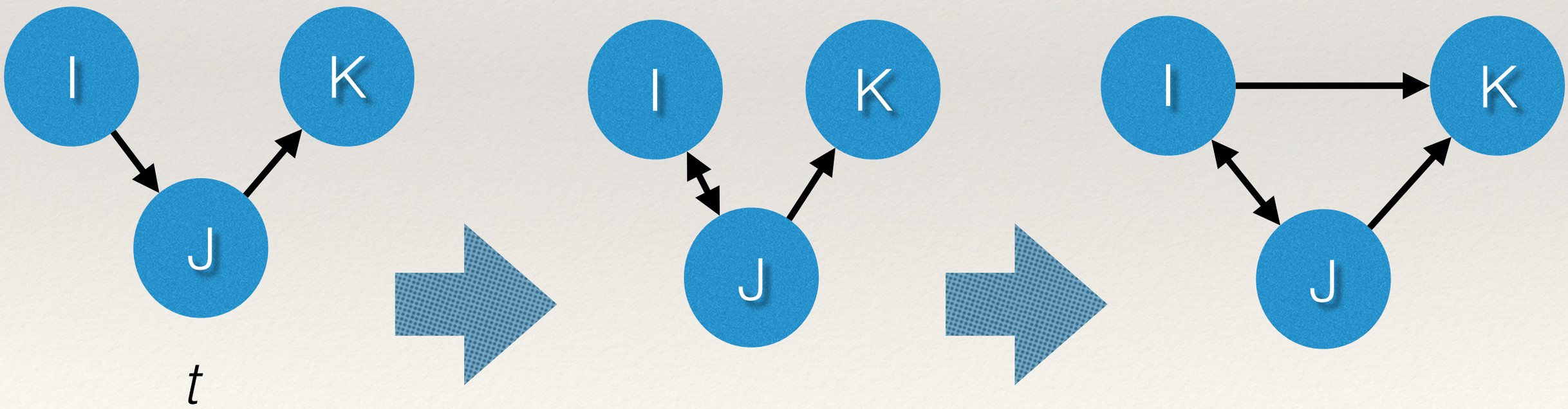


Or…

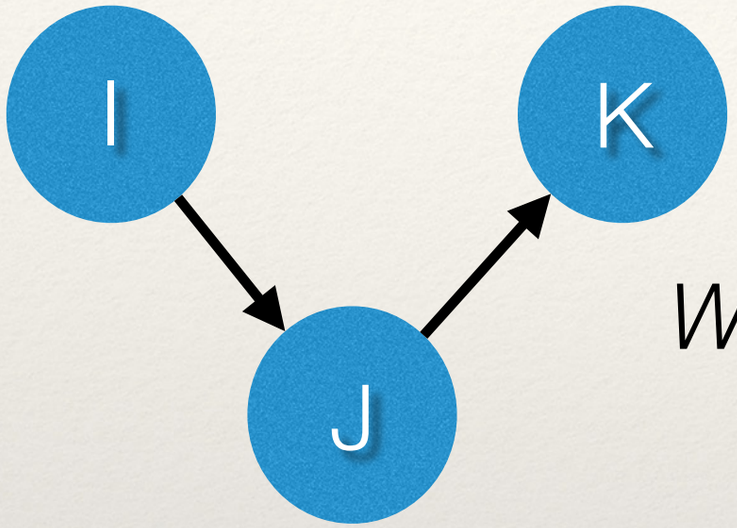




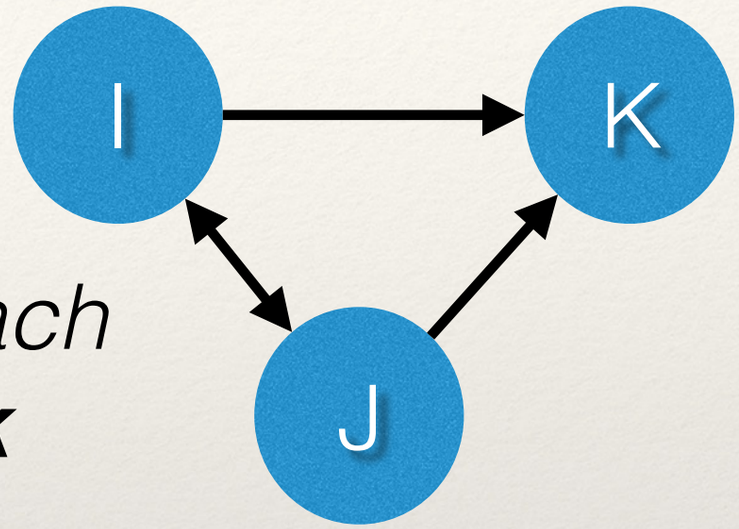
Both are different sequences.



Network Dynamics



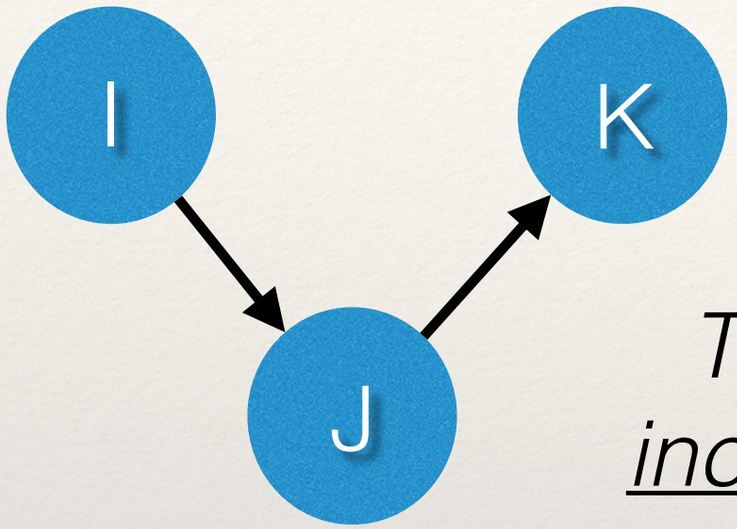
We don't observe each step with ***network panel data***



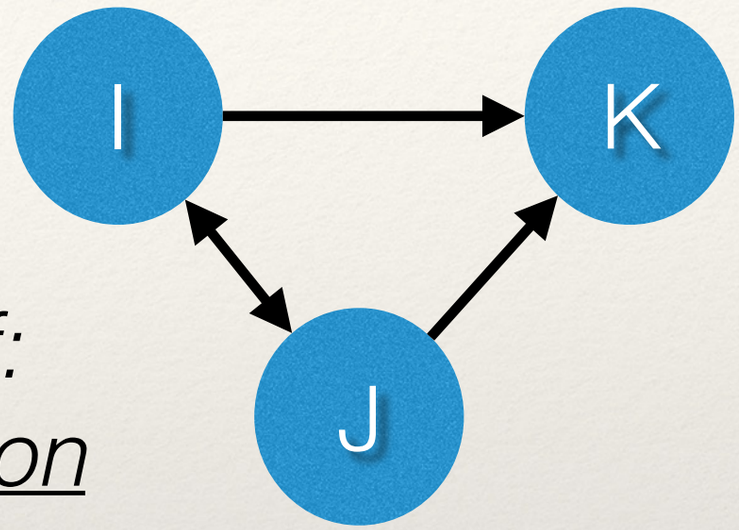
t

t + 1

Network Dynamics



This is a problem of:
<u>incomplete observation</u>
<u>of change</u>



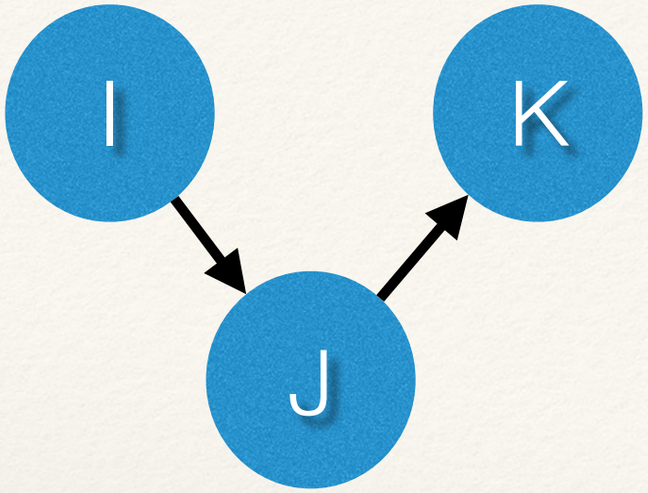
t

t + 1

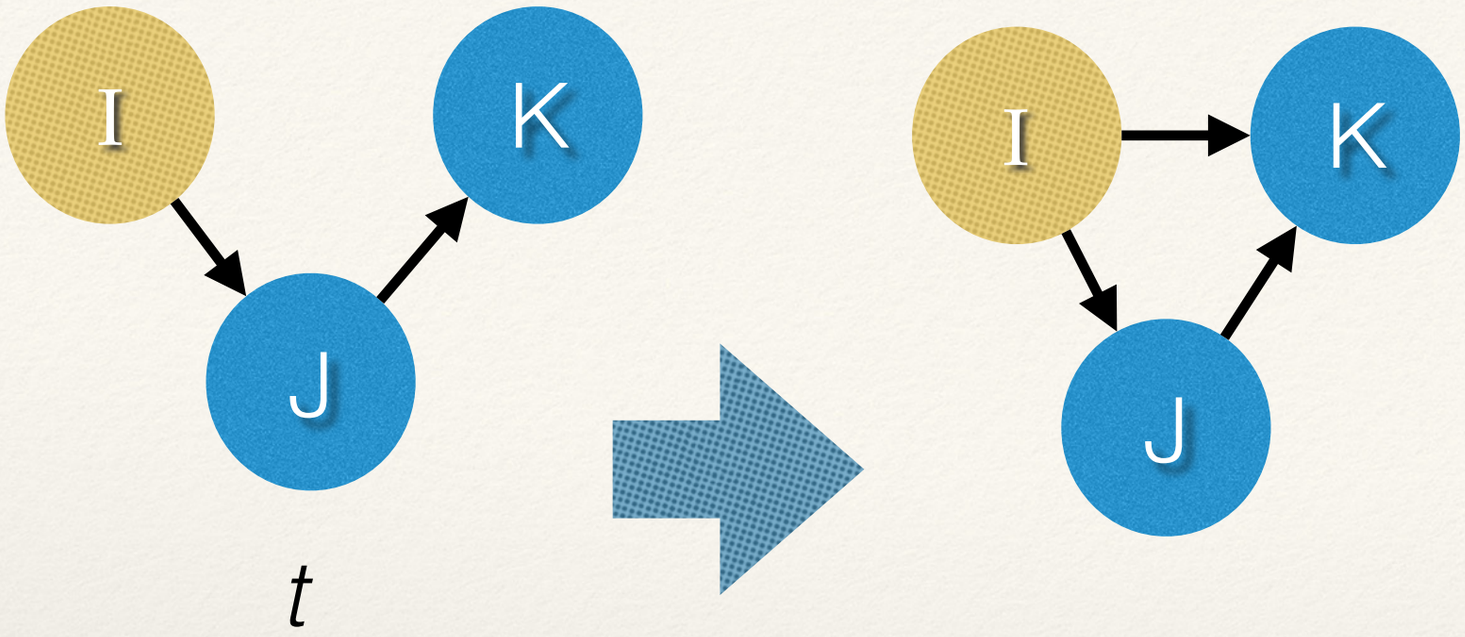
We want to model
these dynamics as
<u>micro steps</u>

Micro-steps

- What is a **micro-step**?:
  - Uniquely identify actors
    - Actors control and decide about the tie variable
      - (*Note the difference from an ERGM*)



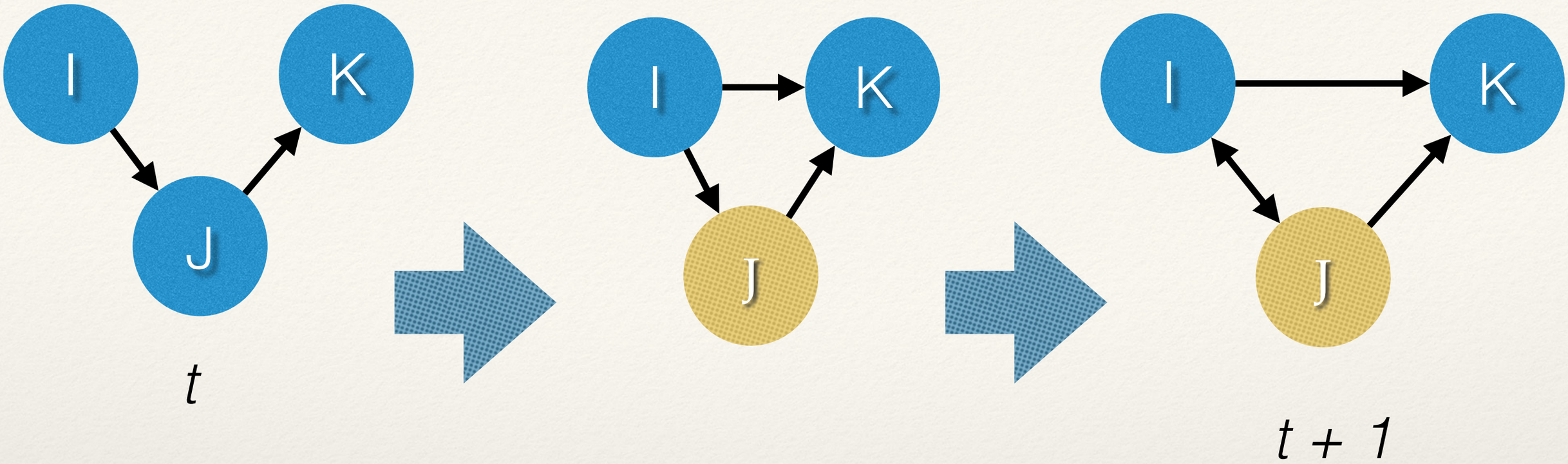
t



t

In the first micro-step, the yellow node makes a decision.

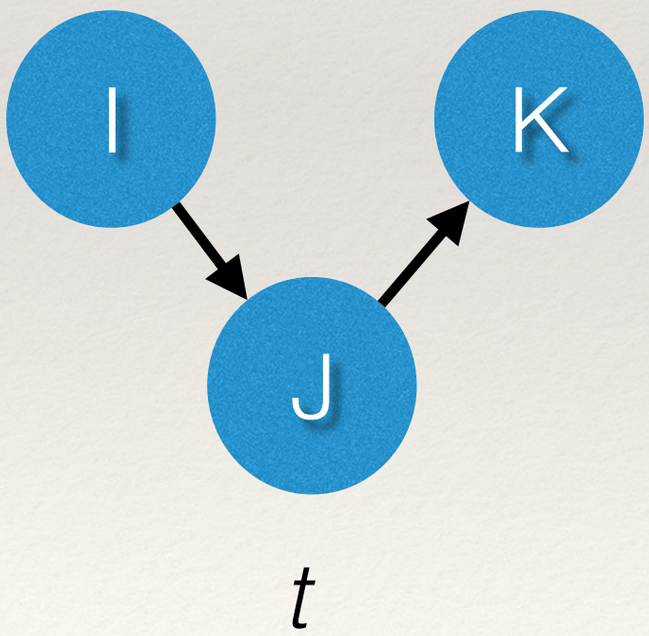
Specifically, drop a tie.



In the second micro-step, the yellow node makes a decision.

Specifically, reciprocate a tie.

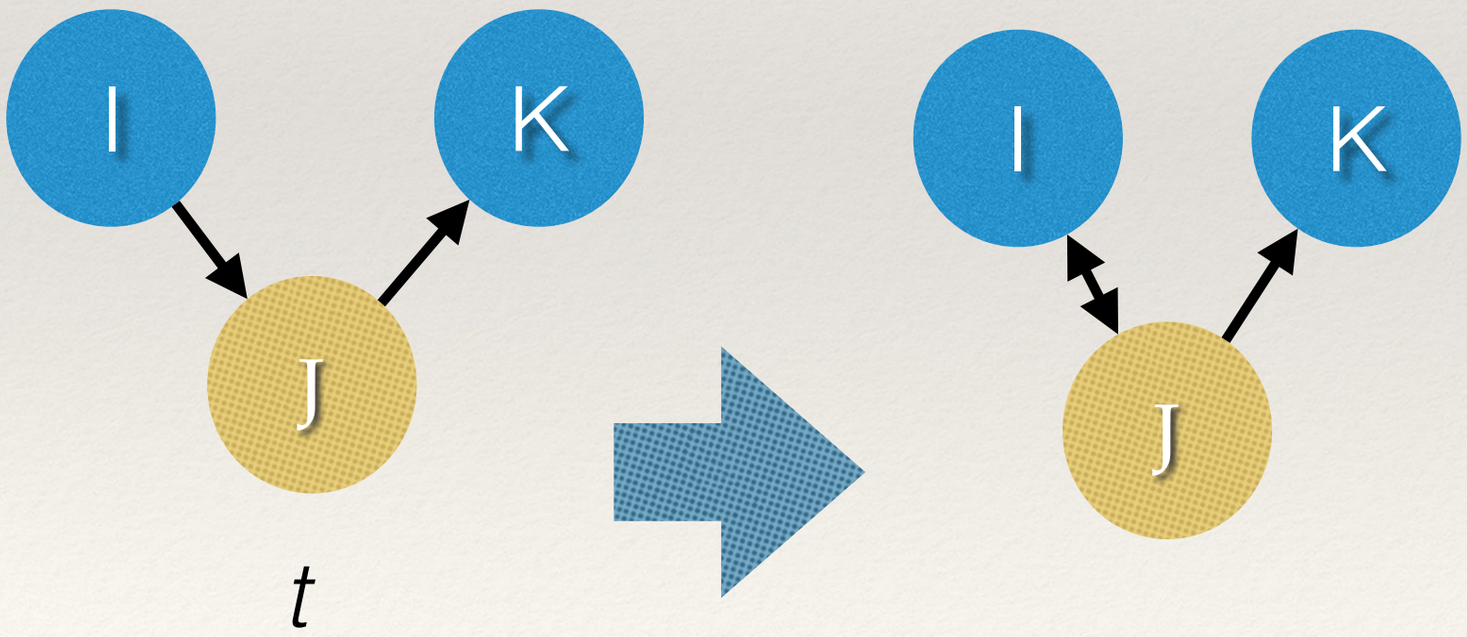
But, there are different ***sequences*** *of decisions that occur by which we would reach the second network.*



t

In the first micro-step,
the yellow node makes
a decision.

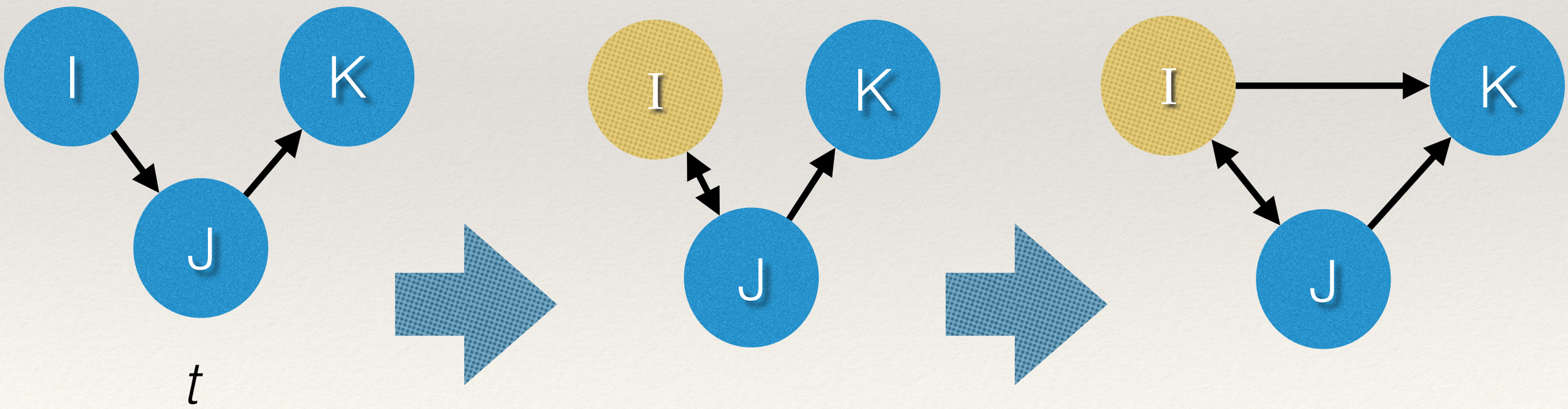
Specifically,
reciprocate a tie.



t

In the second micro-step, the yellow node makes a decision.

Specifically, drop a tie.



t

t + 1

Why 'actor-based'?

- Actors make decisions which drive change in the network (i.e. actor-driven or agent-based model).
- ERGMs are ***edge***-based models in that we parameterize the configurations of edges that characterize the network.

Why ‘actor-based’?

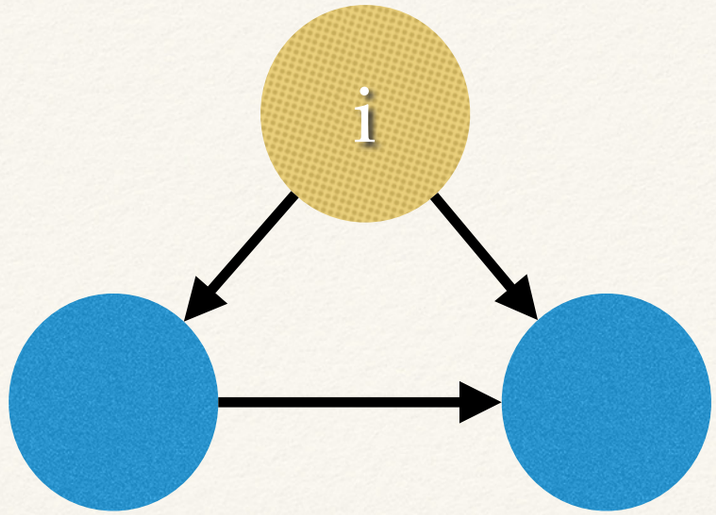
- The SABM has 2 sub-models (called **functions**):
  - When can actor *i* make a decision? (**rate**)
  - Which decision does actor *i* make? (**objective**)

Simulating Network Evolution

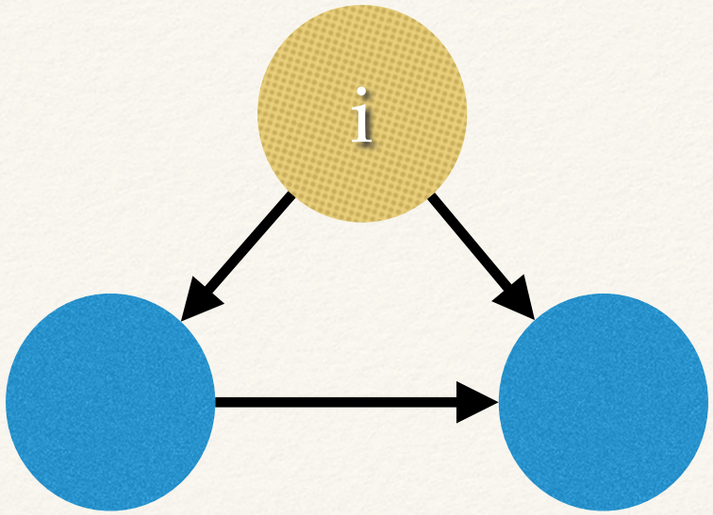
- The SABM logic goes like this:
  - Start with a network at t_0 and run an algorithm to t_1.
  - For all actors, a *waiting time* is sampled according to the *rate function*.
  - Take the actor with the shortest waiting time and allow the actor to set a *micro step*.

Objective Function

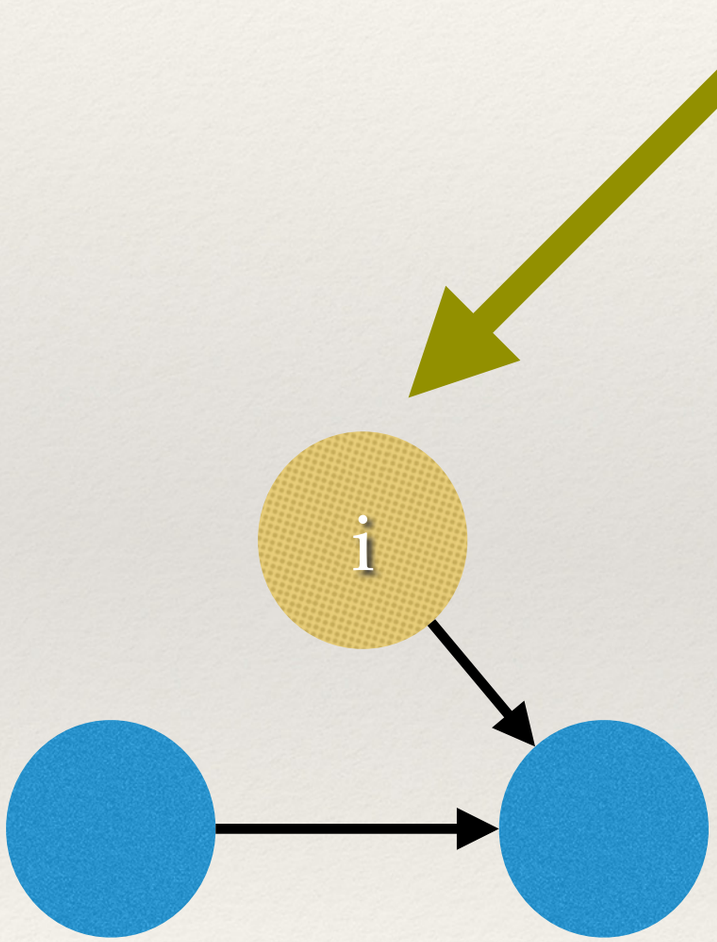
- The **rate** function determines how many decisions actors make.
- The **objective** function expresses how likely it is for an actor to change his/her network in a particular way.
  - Represents the short-term *objectives* of the actor (hence the name).
    - "defined on the set of possible states of the network, as perceived from the point of view of the focal actor" (Snijders et al. 2010).



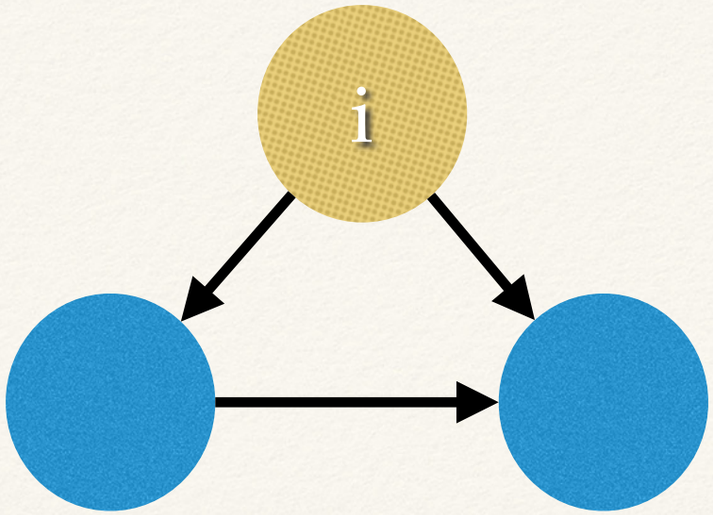
What can *i* do?



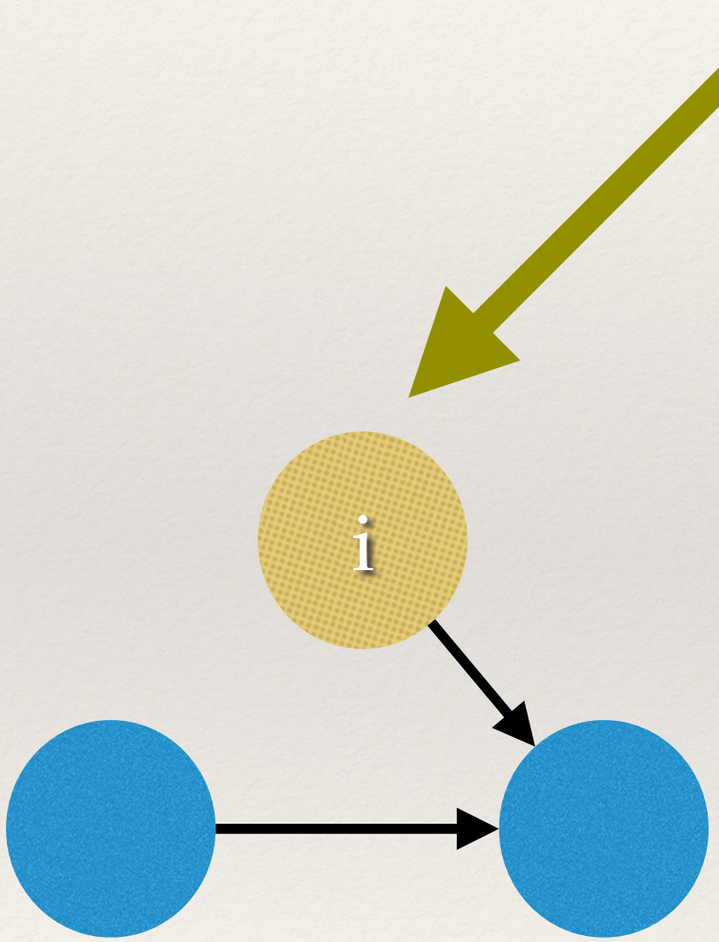
What can *i* do?



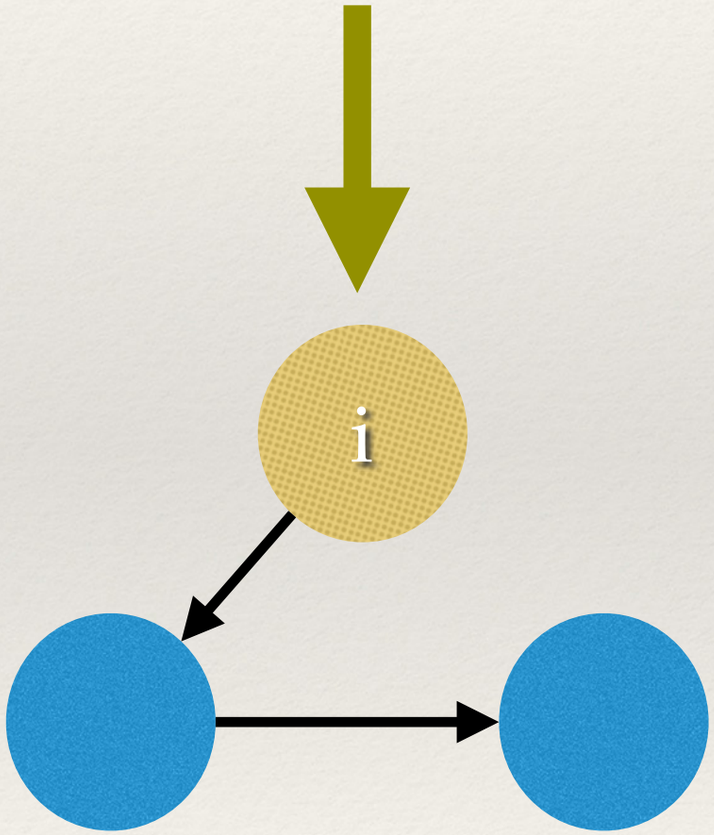
Drop an existing tie



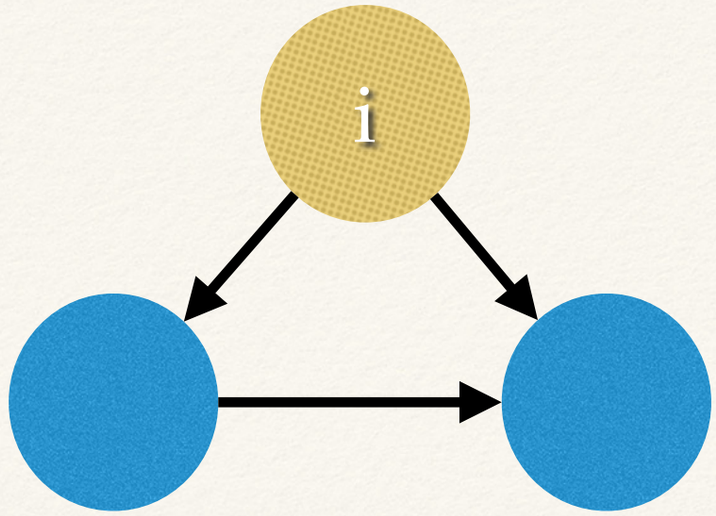
What can *i* do?



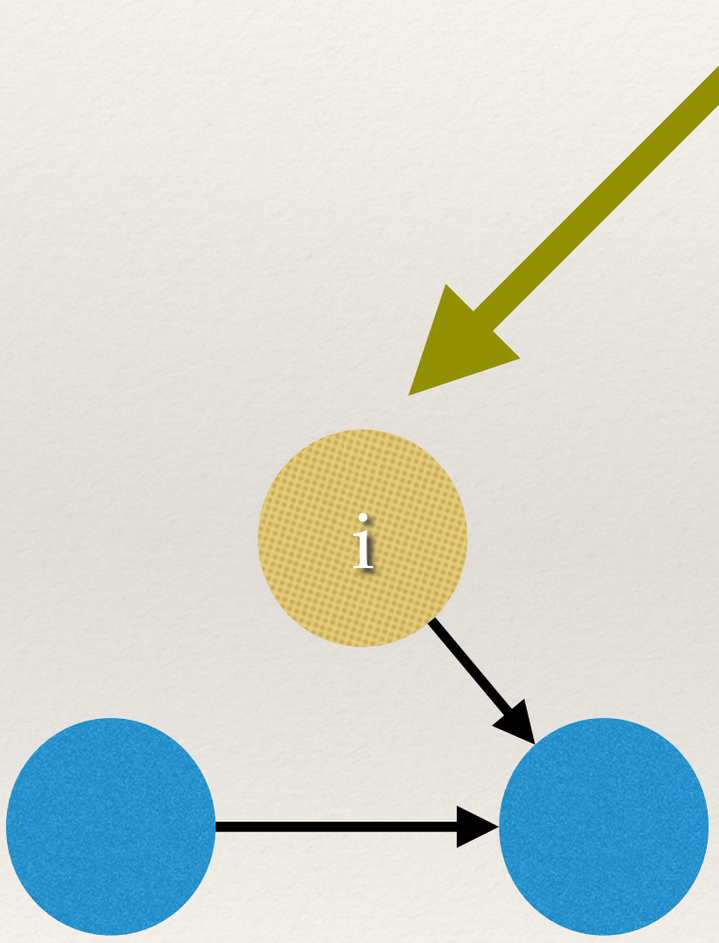
Drop an existing tie



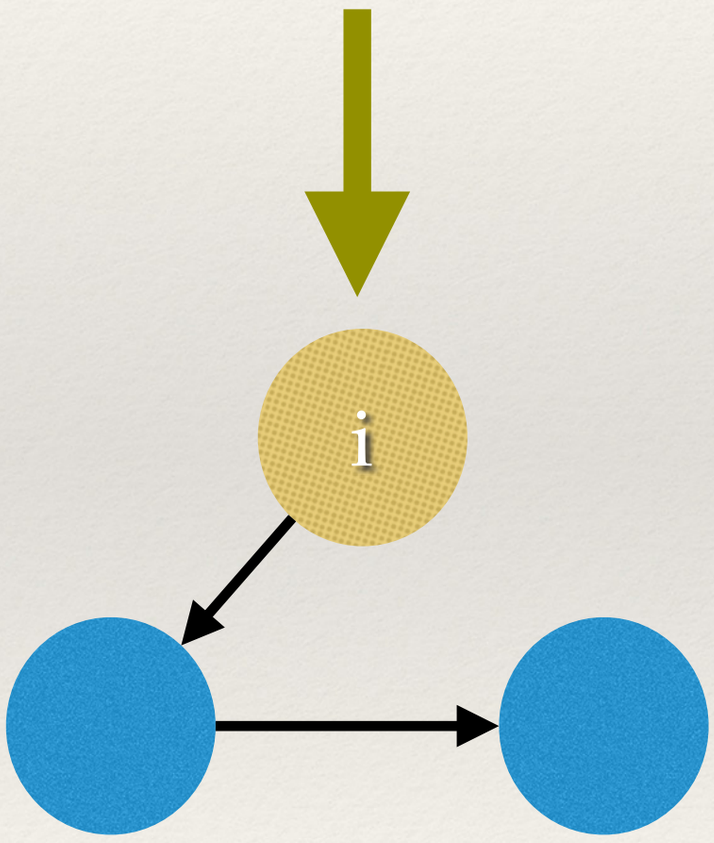
Or…drop a different tie



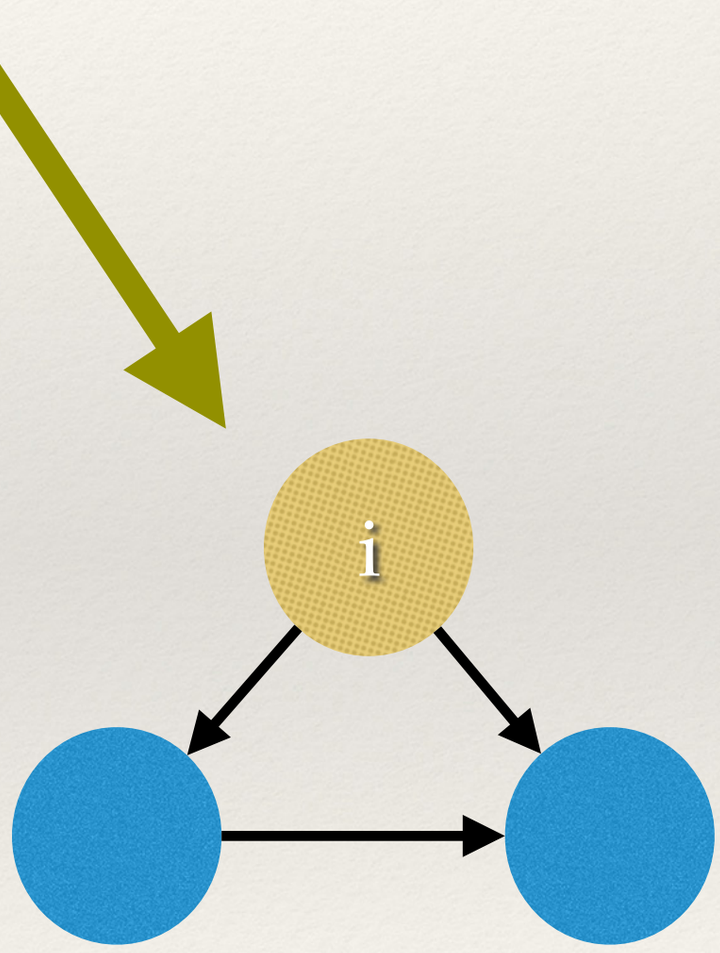
What can *i* do?



Drop an existing tie



Or…drop a different tie



Or…stay the same

Objective Function

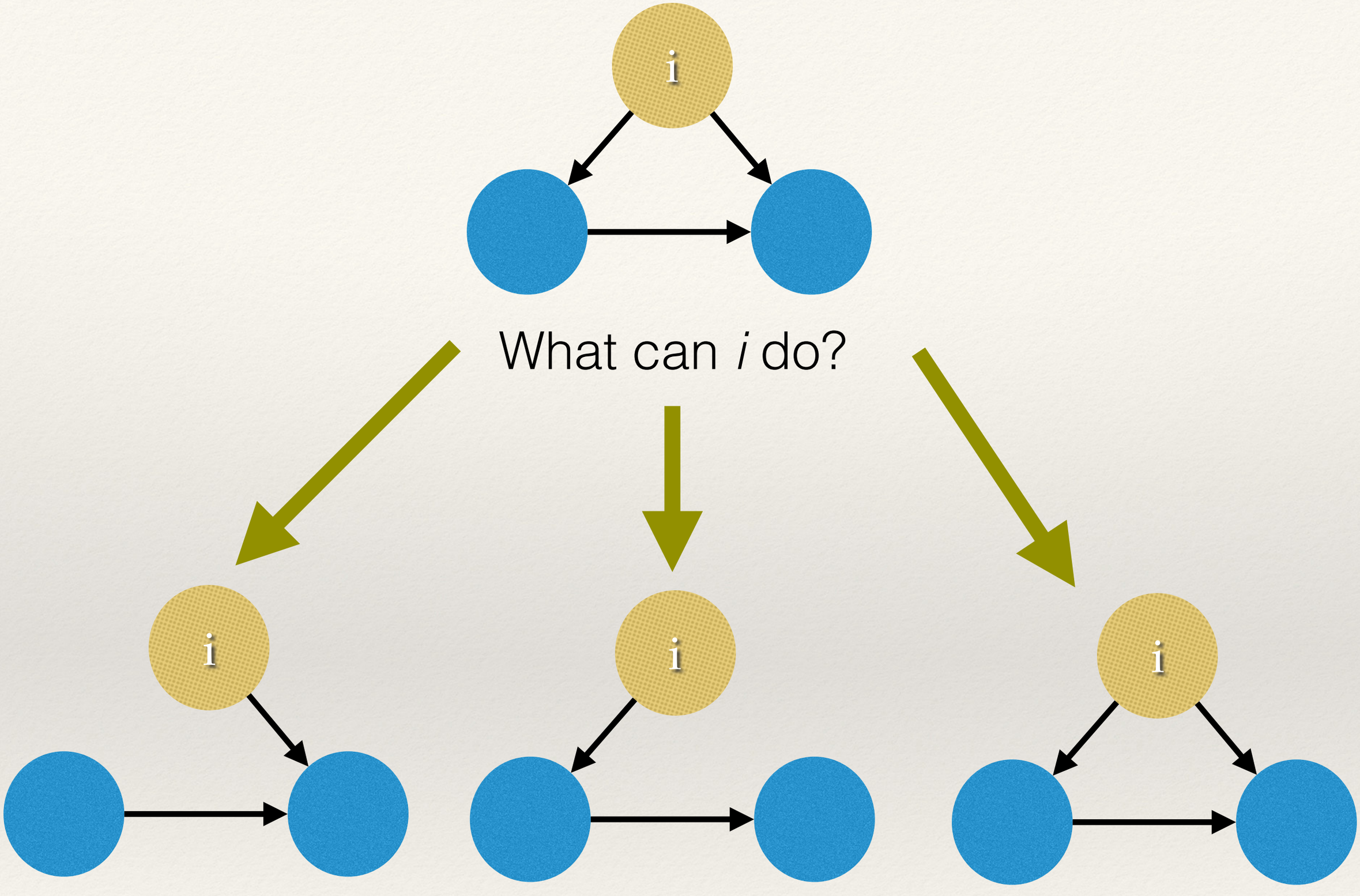
- The SABM simulates networks and compares them to the observed network.
- Basically, optimizing a random utility function.
  - Take an actor, evaluate what he/she can do, determine which is most likely.

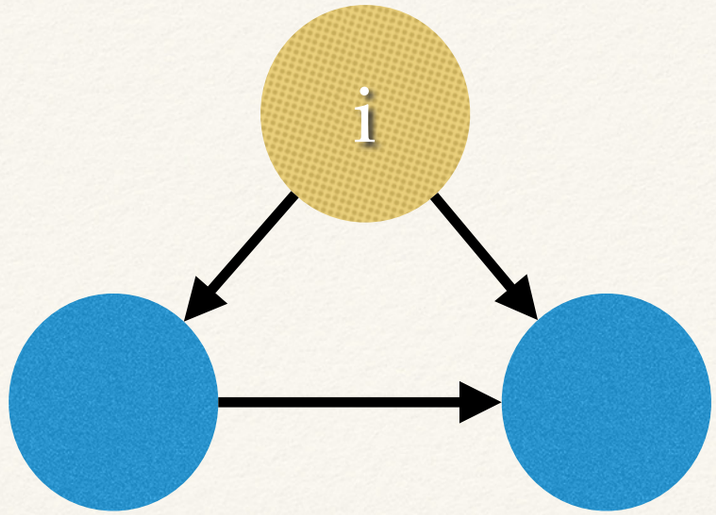
Objective Function

- The estimated model then yields estimates about actors' preferences
  - **Positive** effects that are large and significantly different from zero indicate a preference over available alternatives for that particular configuration.
  - The opposite for **negative** effects that are large and significantly different from zero.

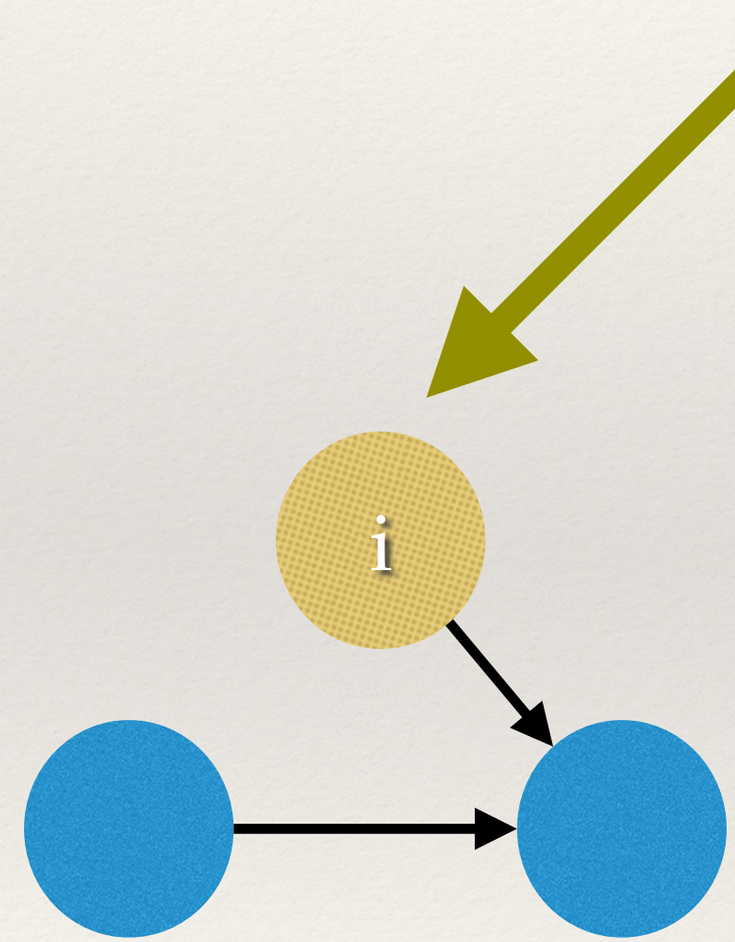
Objective Function

- As with ERGMs, network configurations operationalize the process in which we are interested.
- Thus, we can test hypotheses regarding actor-based mechanisms.

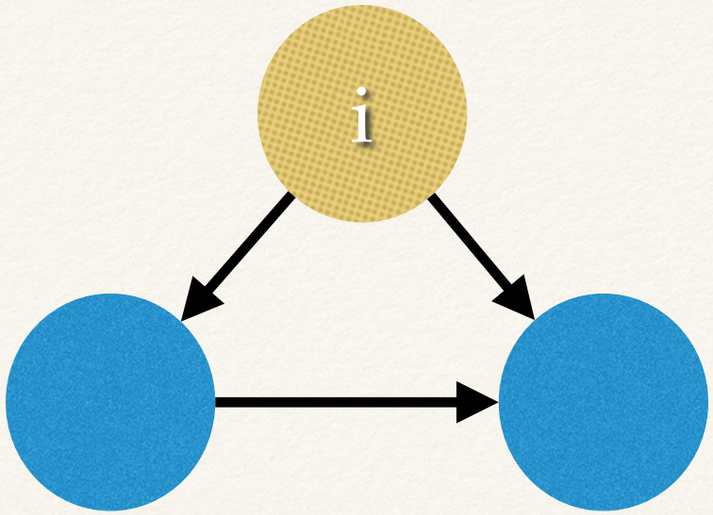

i
What can *i* do?
i
i
i



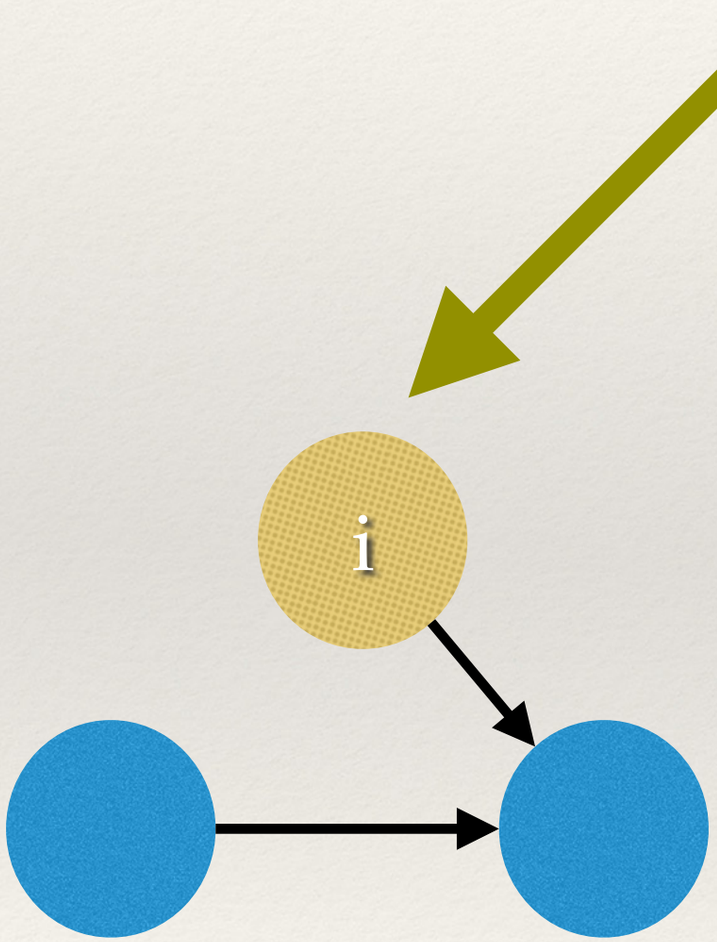
What can *i* do?



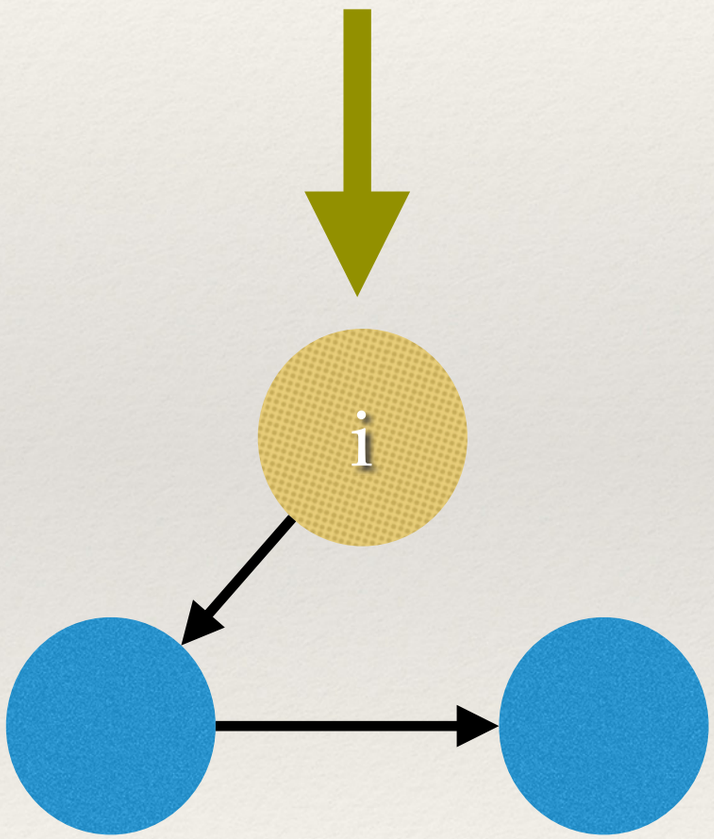
Drop ties to unpopular others



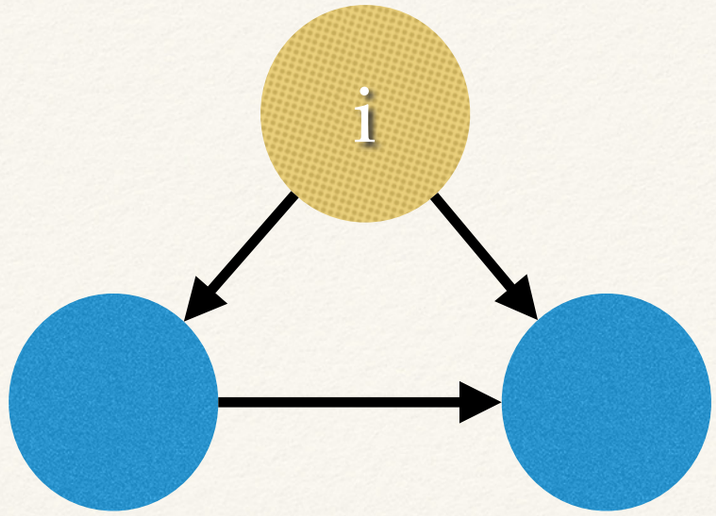
What can *i* do?



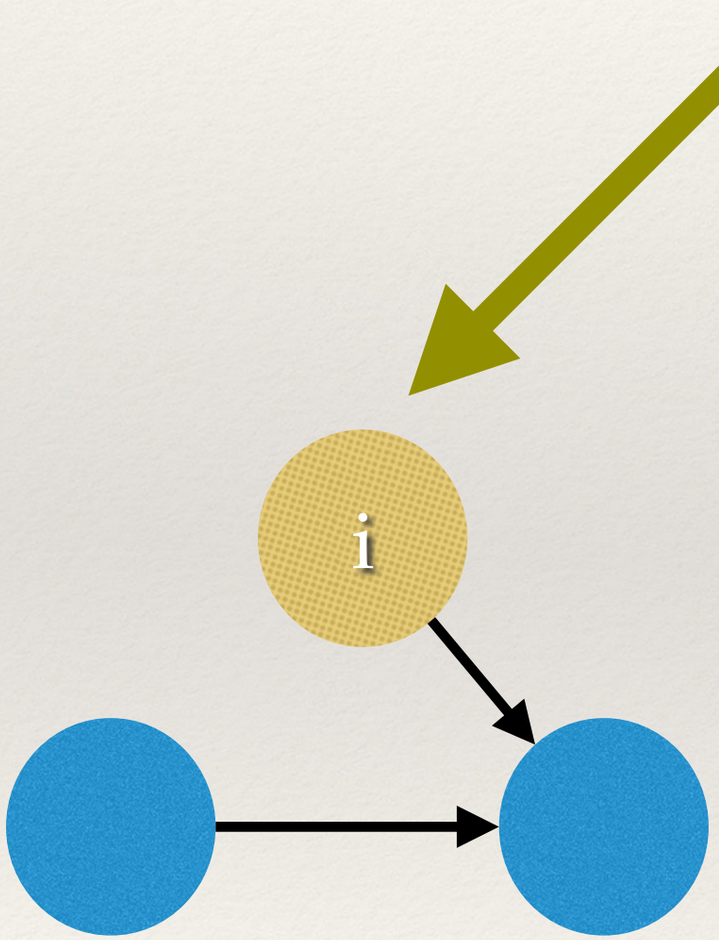
Drop ties to unpopular others



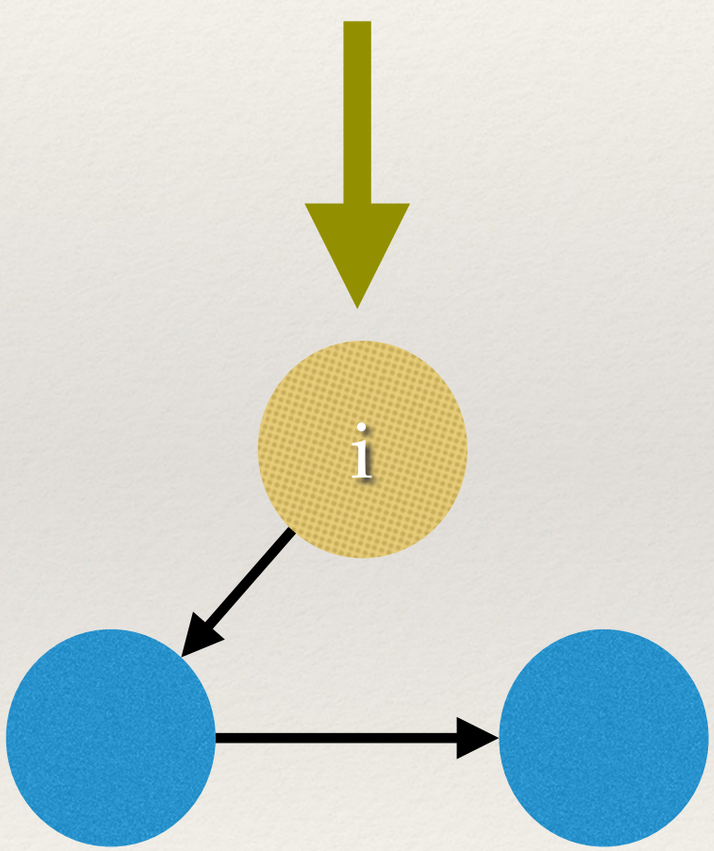
Drop ties to popular others



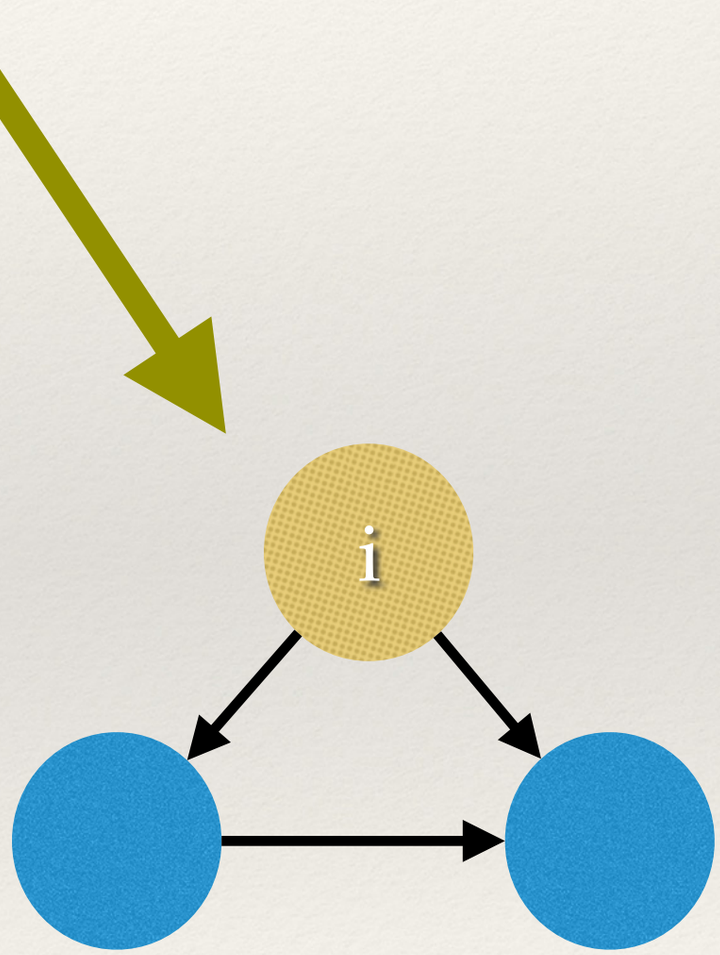
What can *i* do?



Drop ties to unpopular others



Drop ties to popular others



Be happy with 2 friends :)

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference
			to form ties

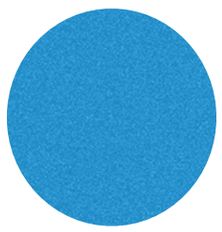
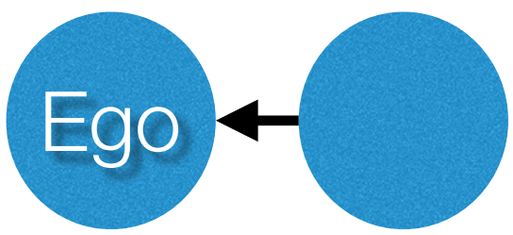
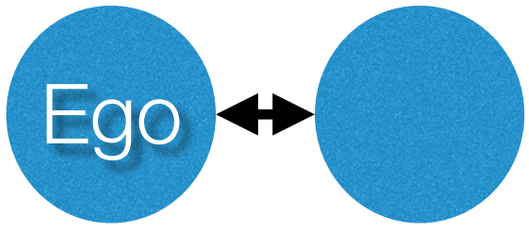
Basic Effects

Effect (RSiena term)	Preference
Outdegree (default)	to form ties

Basic Effects

Effect (RSiena term)	Preference
Outdegree (default)	to form ties
	to reciprocate ties

Basic Effects

t	*t+1*	Effect (RSiena term)	Preference
		Outdegree (default)	to form ties
		Reciprocity (default)	to reciprocate ties

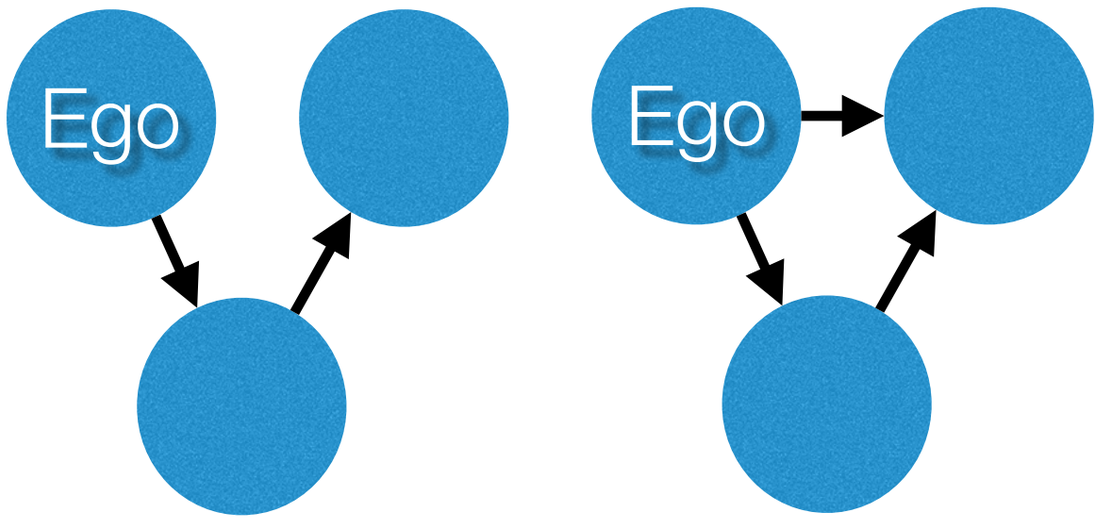
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference

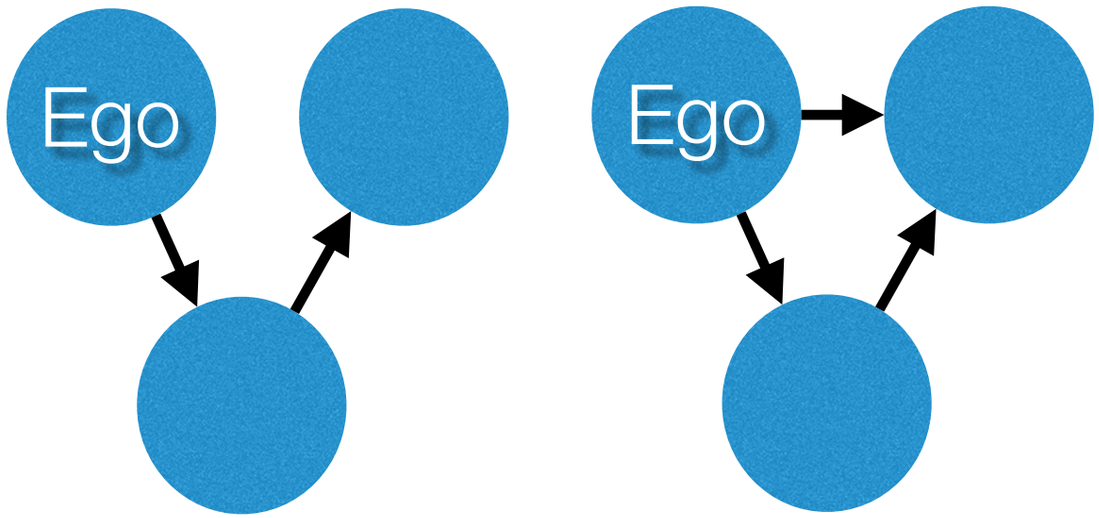
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
			for being friend of the friend's friends

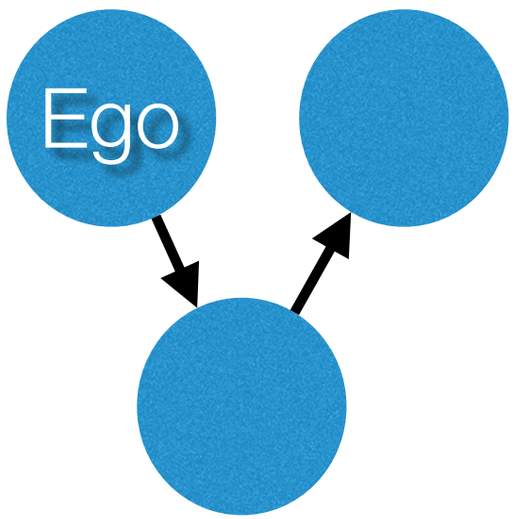
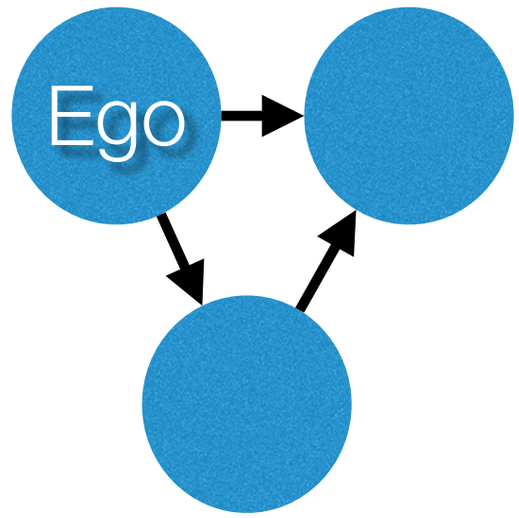
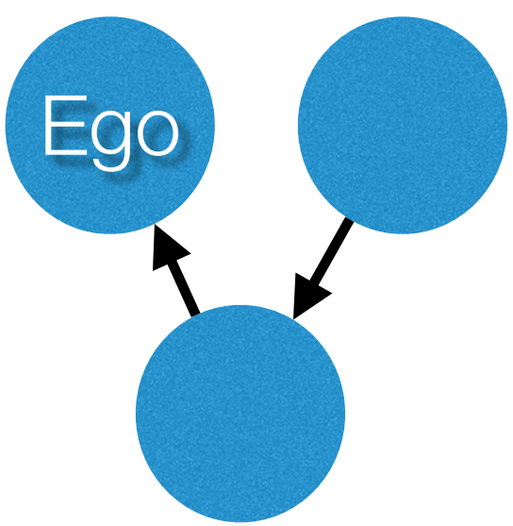
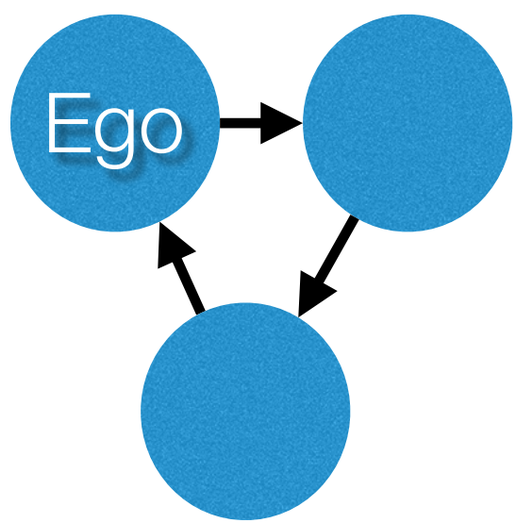
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Transitive Triplets (transTrip)	for being friend of the friend's friends

Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Transitive Triplets (transTrip)	for being friend of the friend's friends
			for forming cycles

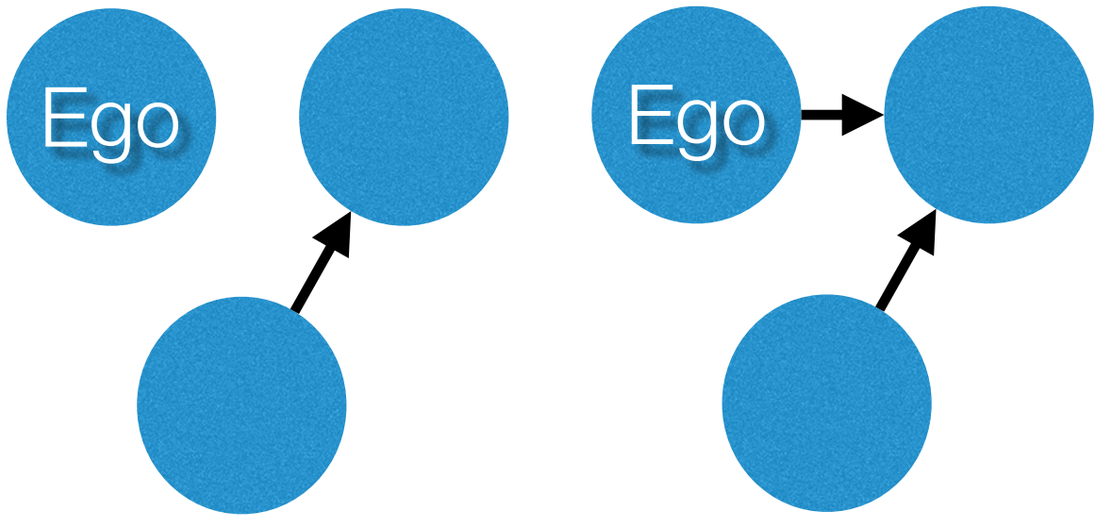
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Transitive Triplets (transTrip)	for being friend of the friend's friends
		Cyclical Triad (cycle3)	for forming cycles

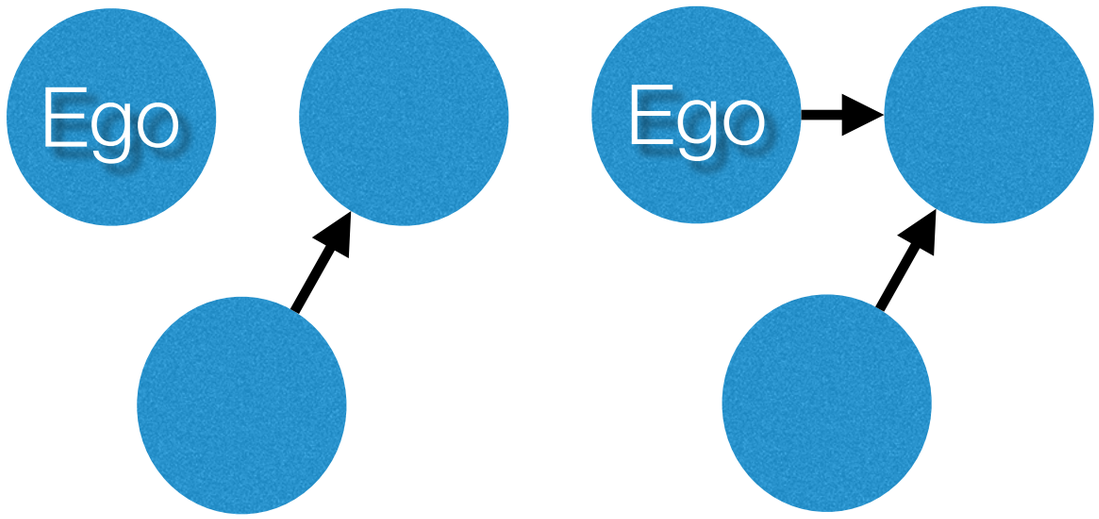
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
			for being friend of popular alters

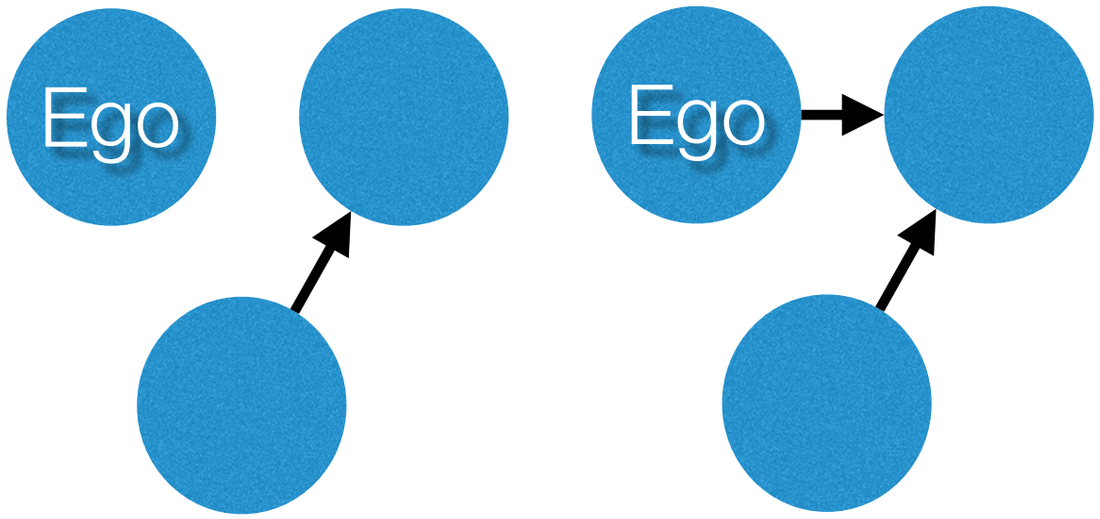
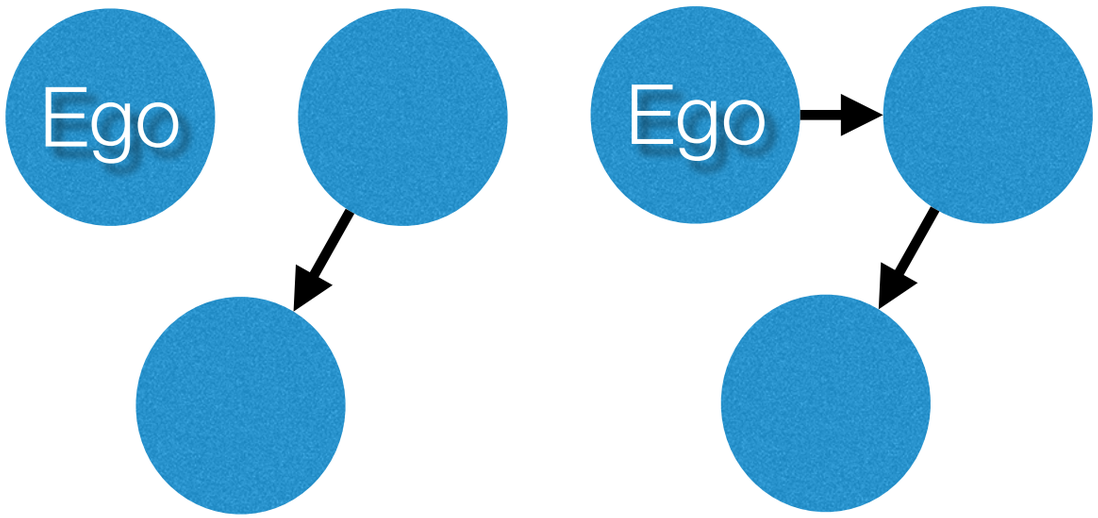
Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Popularity (inPop)	for being friend of popular alters

Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Popularity (inPop)	for being friend of popular alters
			for being friend of active alters

Additional Effects

t	*t+1*	Effect (RSiena term)	Preference
		Popularity (inPop)	for being friend of popular alters
		Activity (outPop)	for being friend of active alters

Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference

Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
			for ties to similar alters

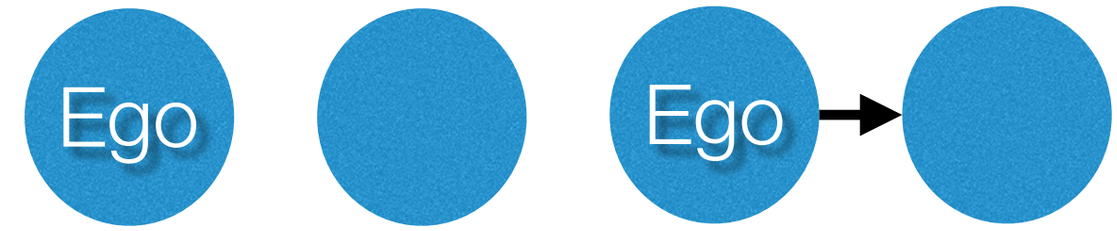
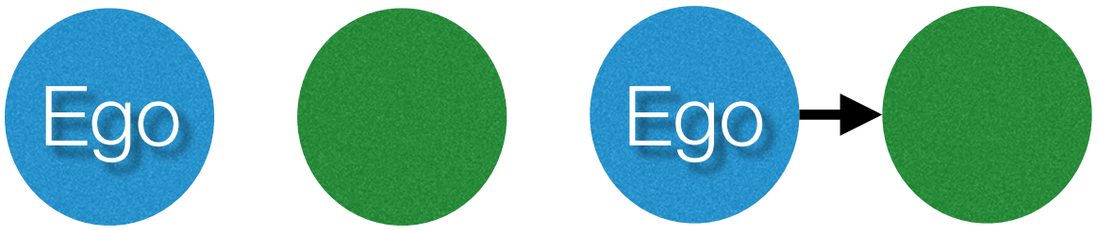
Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
		Similarity (sameX or simX)	for ties to similar alters

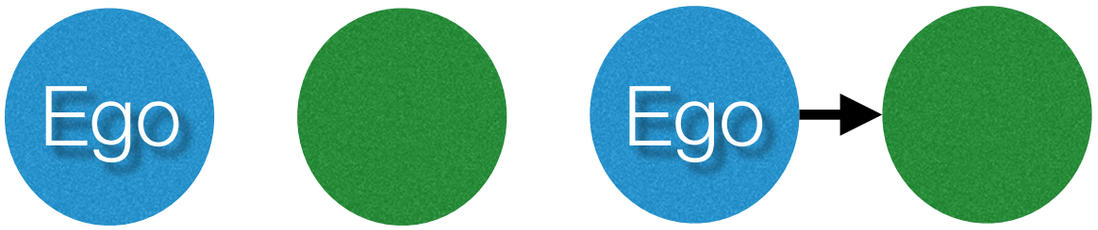
Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
		Similarity (sameX or simX)	for ties to similar alters
			ego's covariate effect on preference

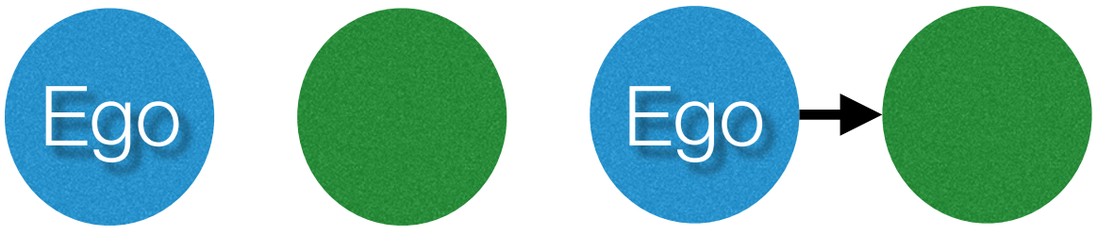
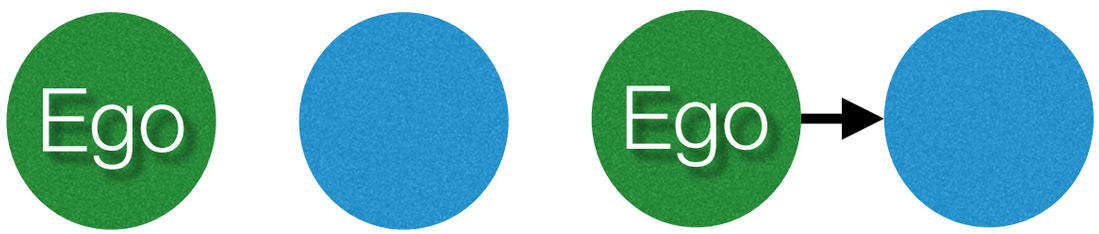
Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
		Similarity (sameX or simX)	for ties to similar alters
		Behavior Ego (EgoX)	ego's covariate effect on preference

Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
		Similarity (sameX or simX)	for ties to similar alters
		Behavior Ego (EgoX)	ego's covariate effect on preference
			alter's covariate effect on preference

Interactions w/ Covariates

t	*t+1*	Effect (RSiena term)	Preference
		Similarity (sameX or simX)	for ties to similar alters
		Behavior Ego (EgoX)	ego's covariate effect on preference
		Behavior Alter (AlterX)	alter's covariate effect on preference

Learning Goals

- Understand difference between Exponential Random Graph Models and Stochastic Actor-Based Models
- Describe logic of *micro-steps* and simulation of networks using **rate** function.
- Describe logic of *preferences* and simulation of networks using **objective** function.

Questions?