Actor-Based Models for Network Dynamics

COMM 645: Communication Networks
Annenberg School of Communication
University of Southern California

Actor-based models of network dynamics

We use actor-based models of network dynamics when:

- We have network data captured at two or more points in time.
- We want to make inferences about the mechanisms that drive network change over time – or capture the network dynamics that drive actor behavior over time.
- The network size is reasonable: networks with less than 20 nodes or ones with more than a few thousand nodes may be problematic.
- There is enough (and not too much) change in the network between time points. We need to observe change to model the mechanisms driving network dynamics - we cannot do that if our network stays the same.
- While we can model symmetric networks, this approach is used more often (and is easier to interpret) with directed networks.

Some assumptions of the approach

- Actors are seen as **having agency** allowing them to change:
  - Their **outgoing links** (create new ones, dissolve existing ones, do nothing)
  - Their **attributes** (increase/decrease/keep levels, change/keep categories)
- All actors have **full knowledge** about the network & attributes of others.
- Ties are not transient events, but are interpreted as **states**, relatively stable with a tendency to endure over time.
- The changing network is seen as an outcome of a **Markov process**: the current state of the network (not past ones!) probabilistically predicts its next state.
- Continuous time parameter **t** observed at **K** discrete moments t_1, t_2… t_K
- The first observation is not modeled – it is considered the process starting value.
- At any given moment, one probabilistically selected actor gets the opportunity to change an outgoing tie (add new, drop existing, do nothing).

Basics of the approach

- Assume we have a network of size **n** observed at **k** points in time.
- What are the **mechanisms** driving the **network change** over time?
  How does the network structure influence actor characteristics over time?
- Given those mechanisms, what are the **effects** we should include:
  structure (e.g. transitivity), covariates (e.g. homophily), behavior (e.g. influence)
- **Simulate networks** based on initial parameter values. Compute statistics for the simulated networks and compare with those from the observed networks. Update parameter values to make the average of simulated statistics as close as possible to the statistics obtained from the observed network.
- Generate networks based on our final parameter estimates.
  Use those to check that the average statistics are close to the observed (target) values. Calculate a **convergence t-ratio** for deviation between the two.
- We can check **goodness of fit** with regard to **auxiliary statistics** – ones that were not included in our model. If the model is good, the simulated networks will be similar to the observed one. We want to see no significant difference.

Change determination model

- Network evolution modeled in small units: micro-steps
  (one actor, one tie change).

- The change depends on two functions:
  - **Rate function** – when (how often) can actor **i** make a decision?
    Models the speed with which the dependent variable will change.
  - **Objective function** – what decision will actor **i** make?
    Tells us how likely an actor is to change their network in a particular way.

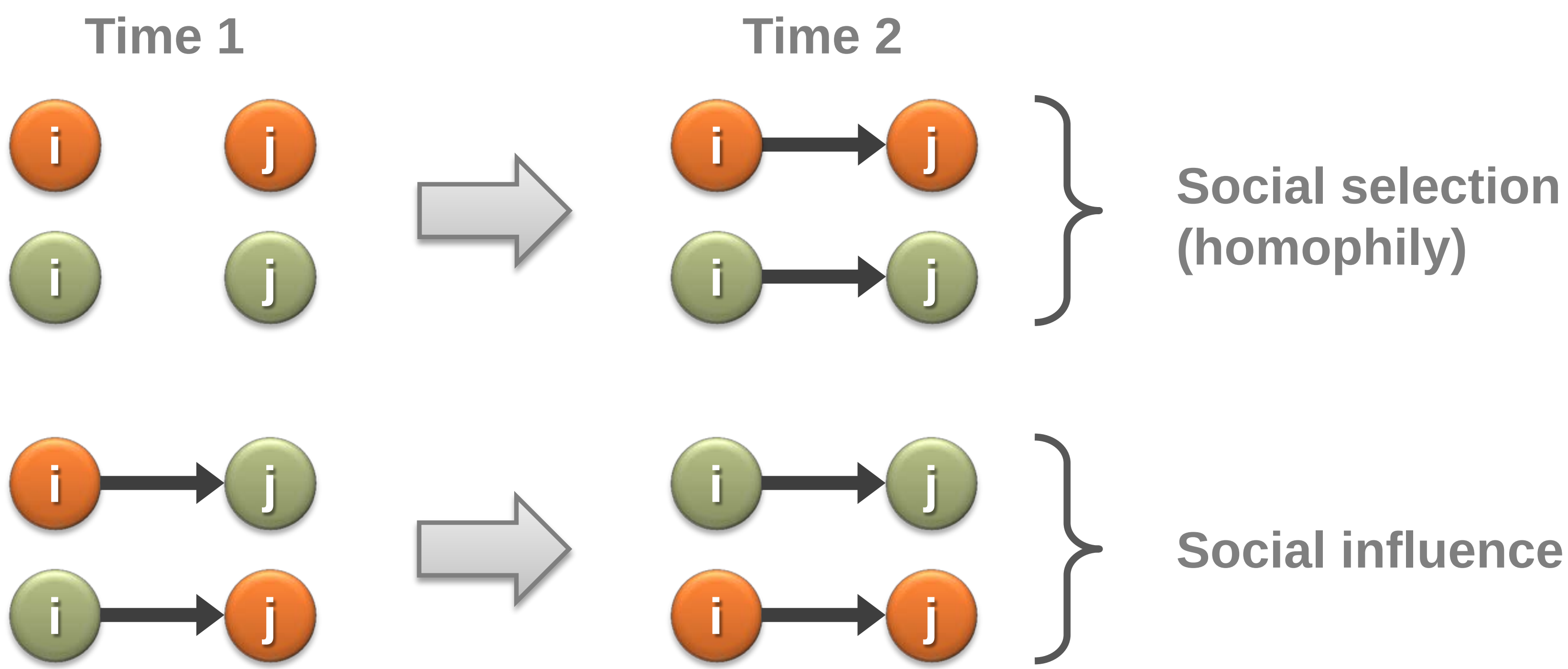
- The **Objective function** can be defined as the sum of:
  - **Evaluation Function** – evaluate the network resulting from **adding** a tie
  - **Endowment function** – evaluate the network resulting from **dissolving** a tie

  *(Usually we see the dissolution of a tie as the opposite of creating one.
  But there may be differences – e.g. the benefit of creating a reciprocal ties
  could be smaller than the loss associated with dissolving a reciprocal tie)*

Social Selection and Social Influence

Social selection: I become your friend because we share certain characteristics
Social influence: I come to share your characteristics because we are friends

The two are very difficult to distinguish looking at a single point in time.



Siena and RSiena Online

The home of Siena: www.stats.ox.ac.uk/~snijders/siena

Maintained by Tom Snijders, University of Oxford

- RSiena Manual
- RSiena sample scripts
- RSiena package on CRAN
- RSienaTest on R-Forge