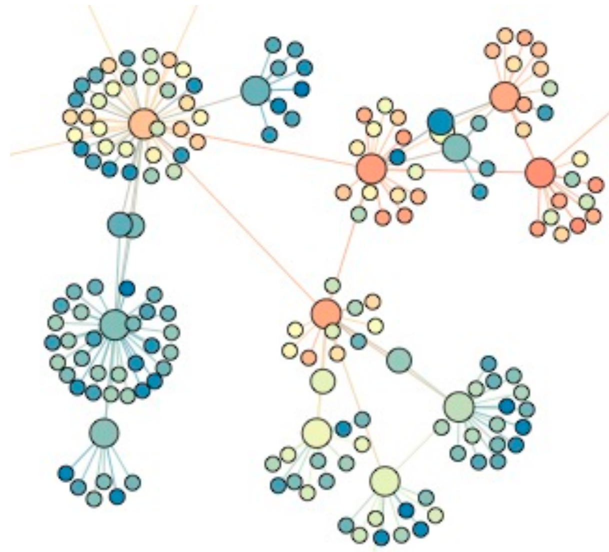


Network models in NetLogo

CS224W

Outline

- Why model? Why with agents?
- NetLogo: the Agent Based Modeling (ABM) language we will be using
- Issues in ABMs:
  - updating
  - robustness/sensitivity
  - reproducibility

Software: NetLogo

- a language built specifically for agent based modeling
- a modeling environment
  - interactively adjust parameters
  - feedback through plots & visualizations

What is a complex system?

- A large population of interacting agents
- No centralized control
- Emergent global dynamics (e.g. coordination) from distributed interactions

Why model?

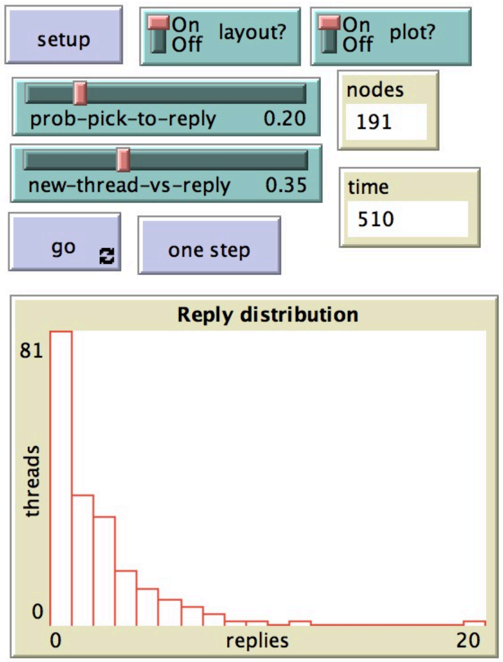
- Gain understanding of system
- Make predictions about what system will do when parameters reach yet-unseen values
- Re-run the past

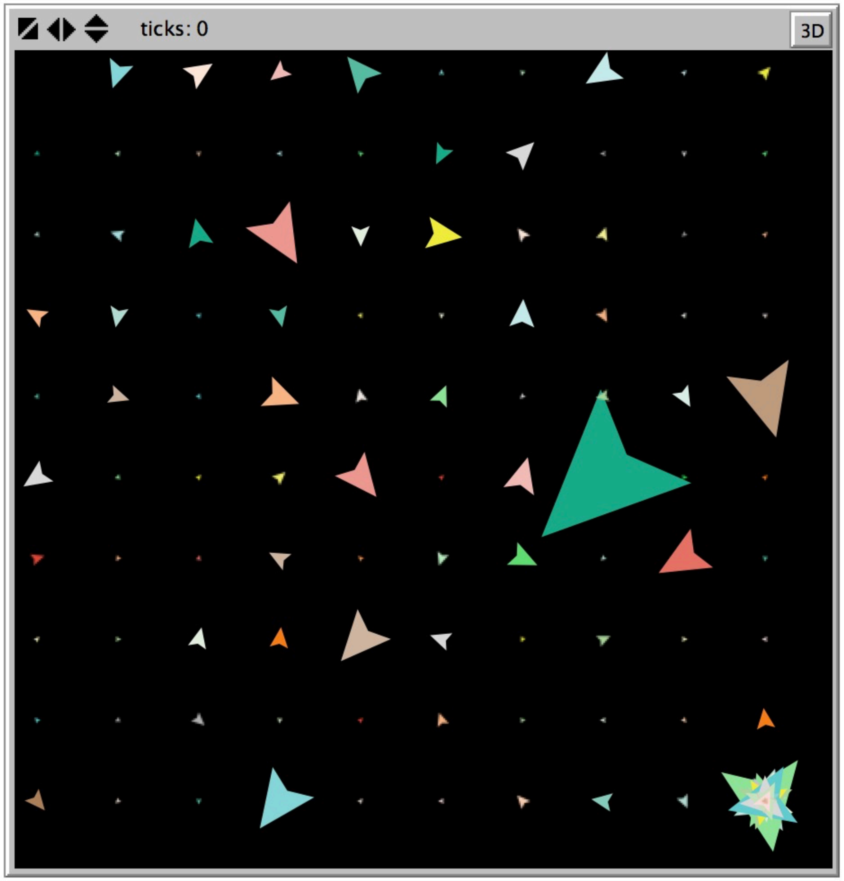
Why model with agents?

- Agents are more cooperative and less expensive than human subjects ☺
- Some systems cannot be solved analytically
  - or the interesting part is the path dependence and not the average behavior
- Flexibility:
  - different agent types, behaviors, constraints

Example: threads

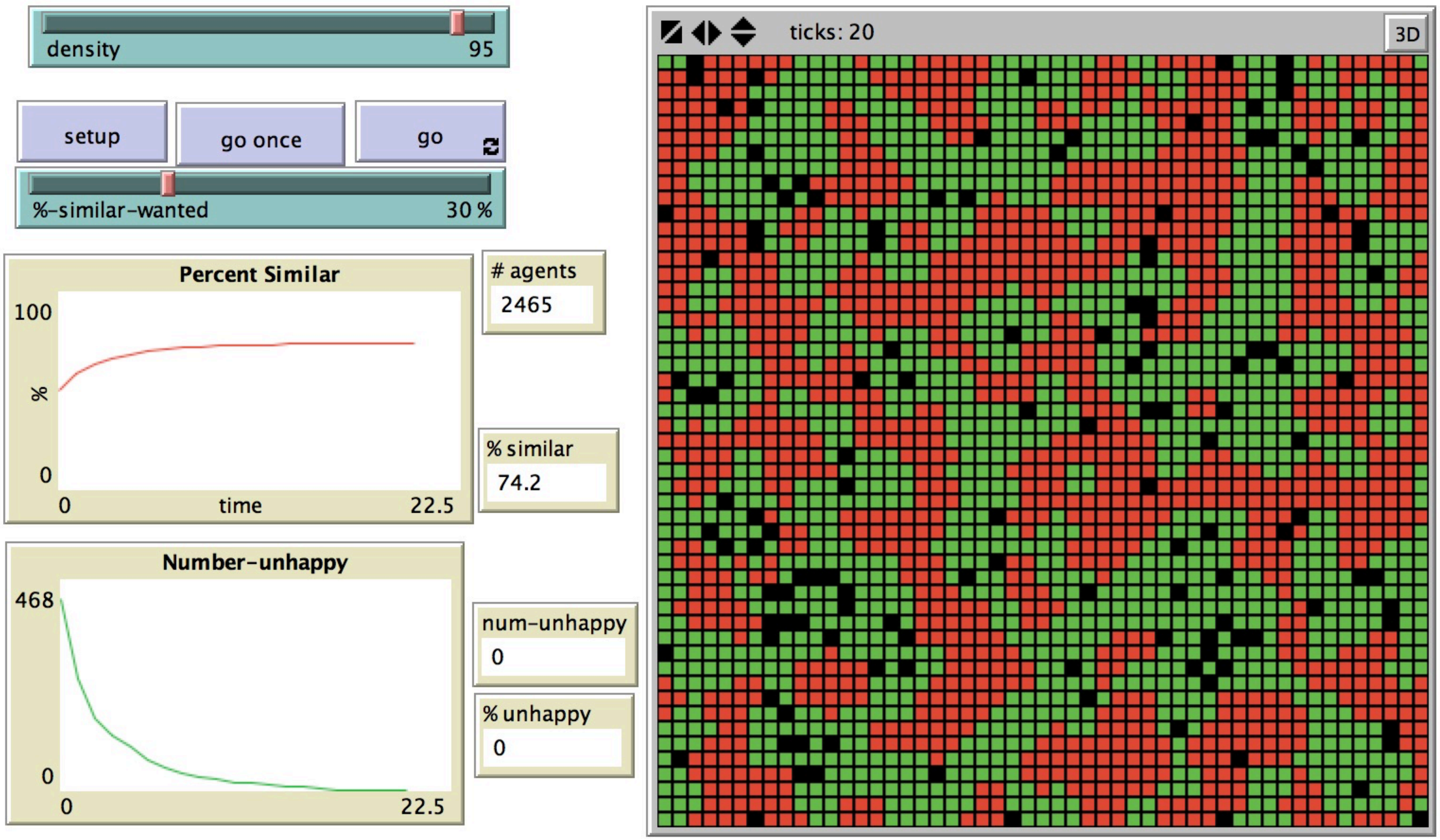
- Colleague asks: why is the distribution of replies per thread so skewed? Are some better than others? Or could it be random?





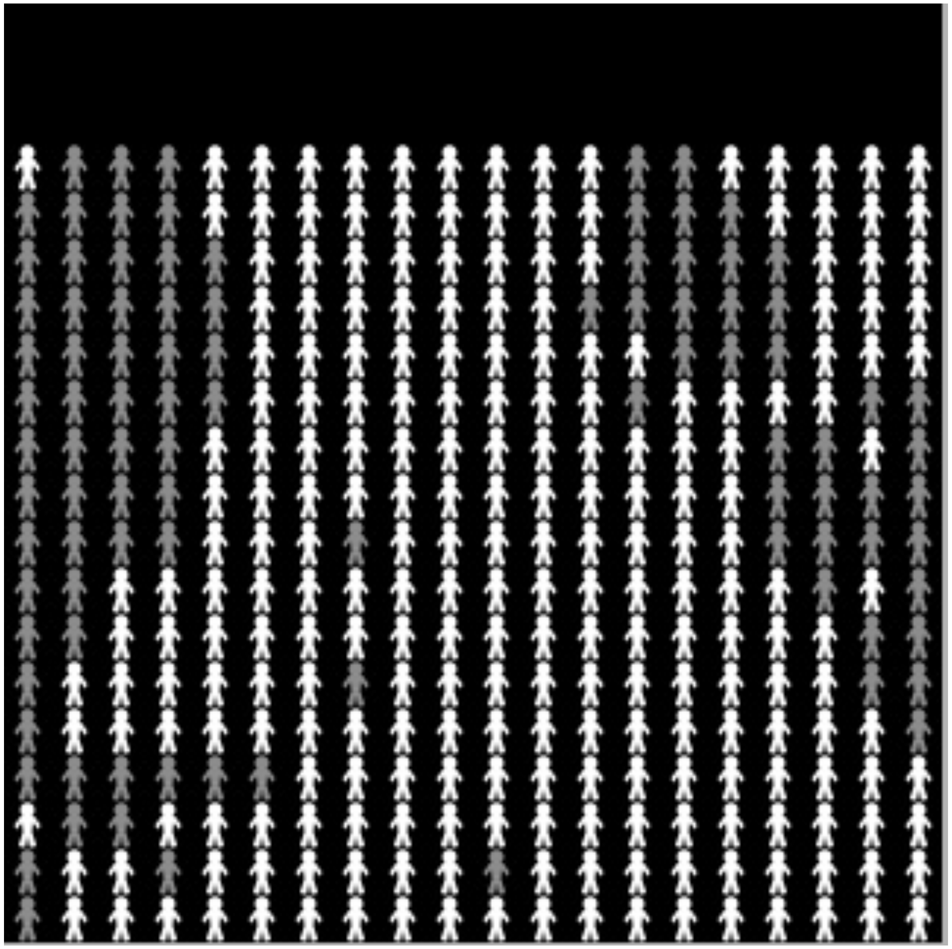
http://web.stanford.edu/class/cs224w/NetLogo/nonnetwork/threads.nlogo

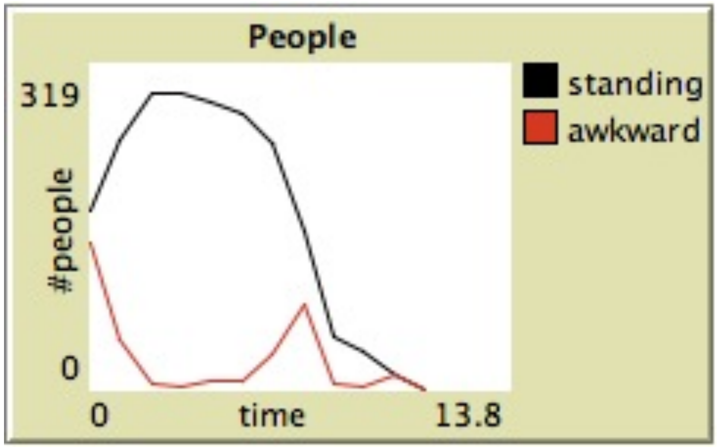
Example: segregation



In models library

Example: standing ovation



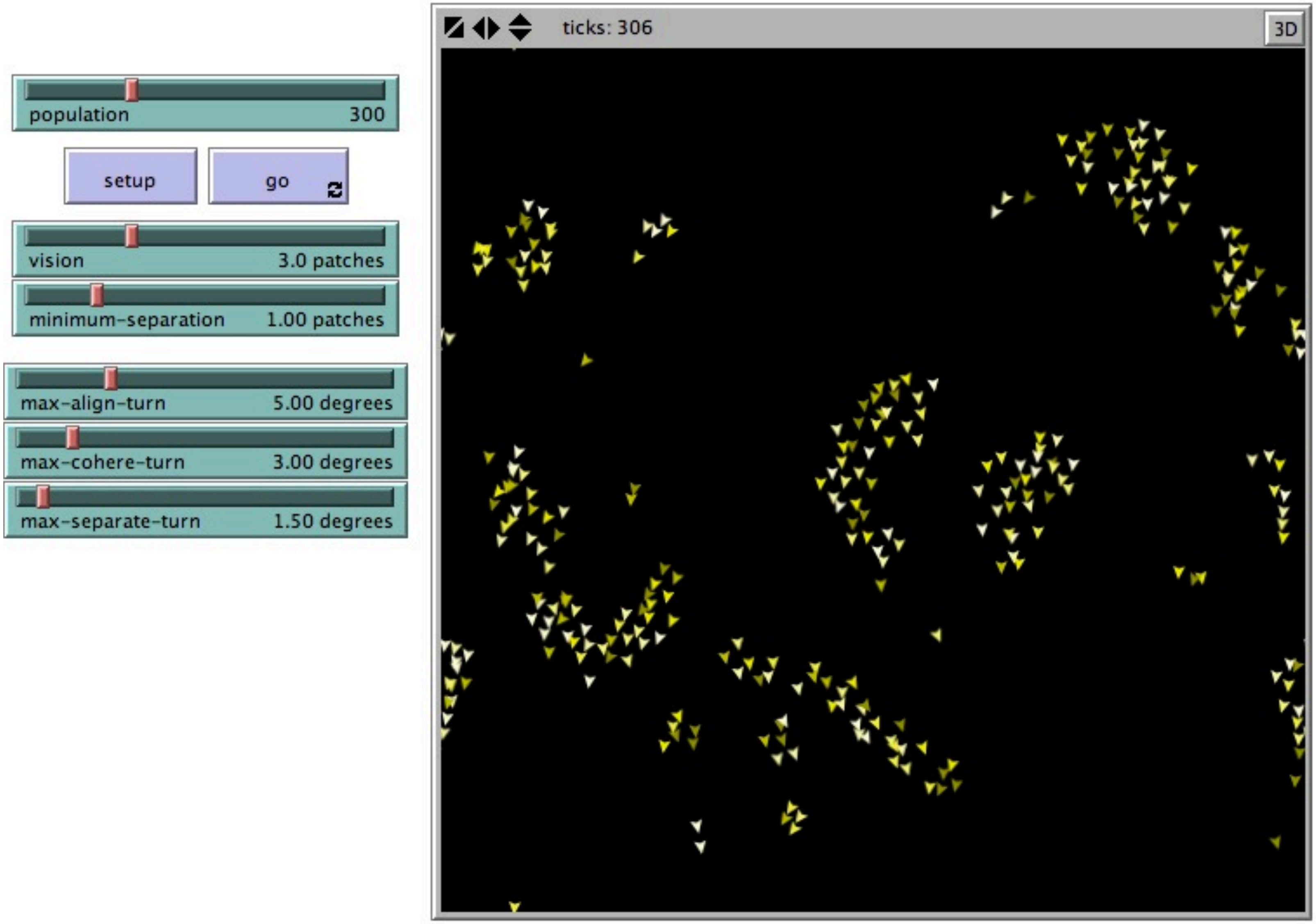


http://web.stanford.edu/class/cs224w/NetLogo/nonnetwork/StandingOvation2.nlogo

model types

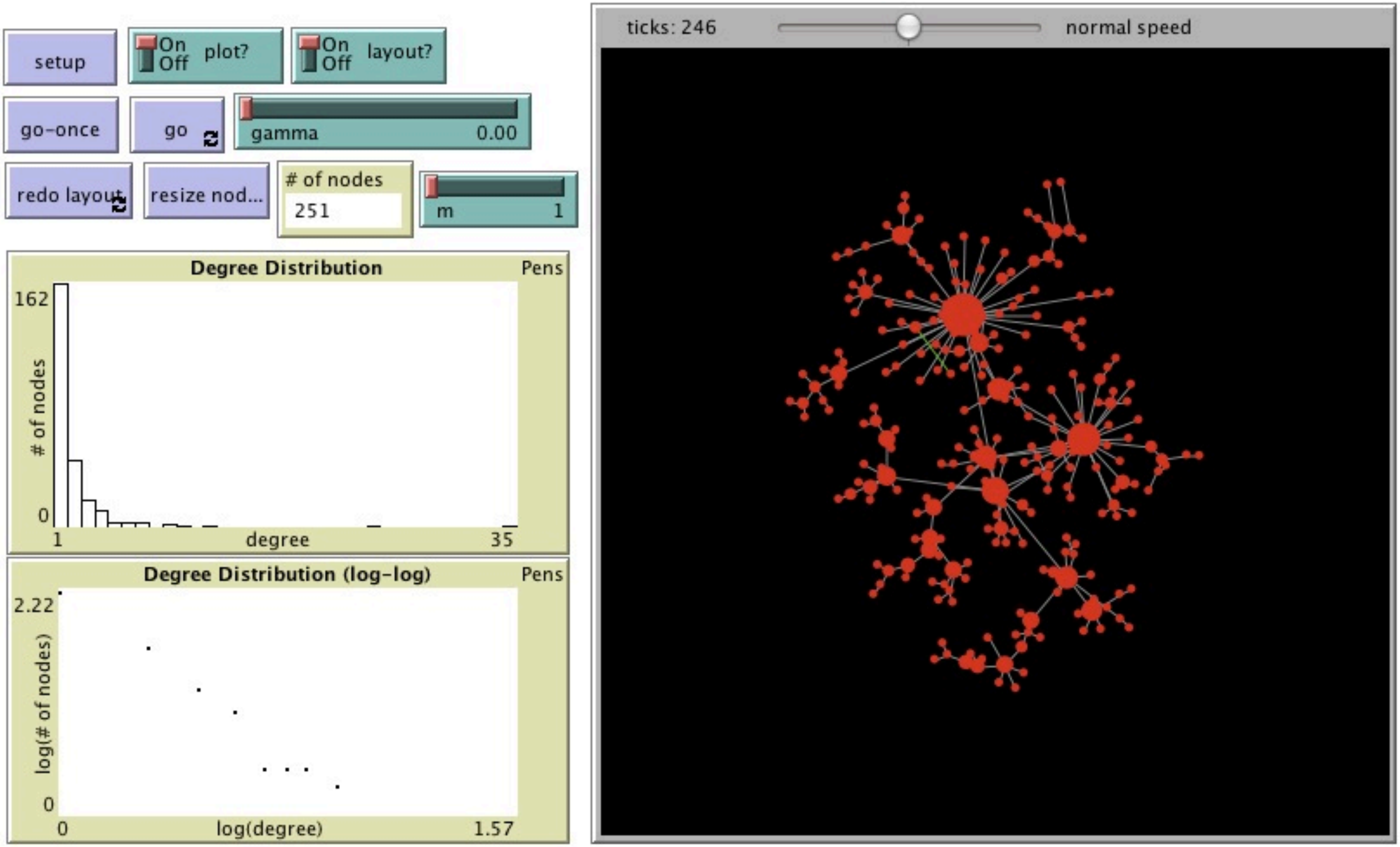
- deterministic
- stochastic (contain randomness)
- evolving

Deterministic: flocking



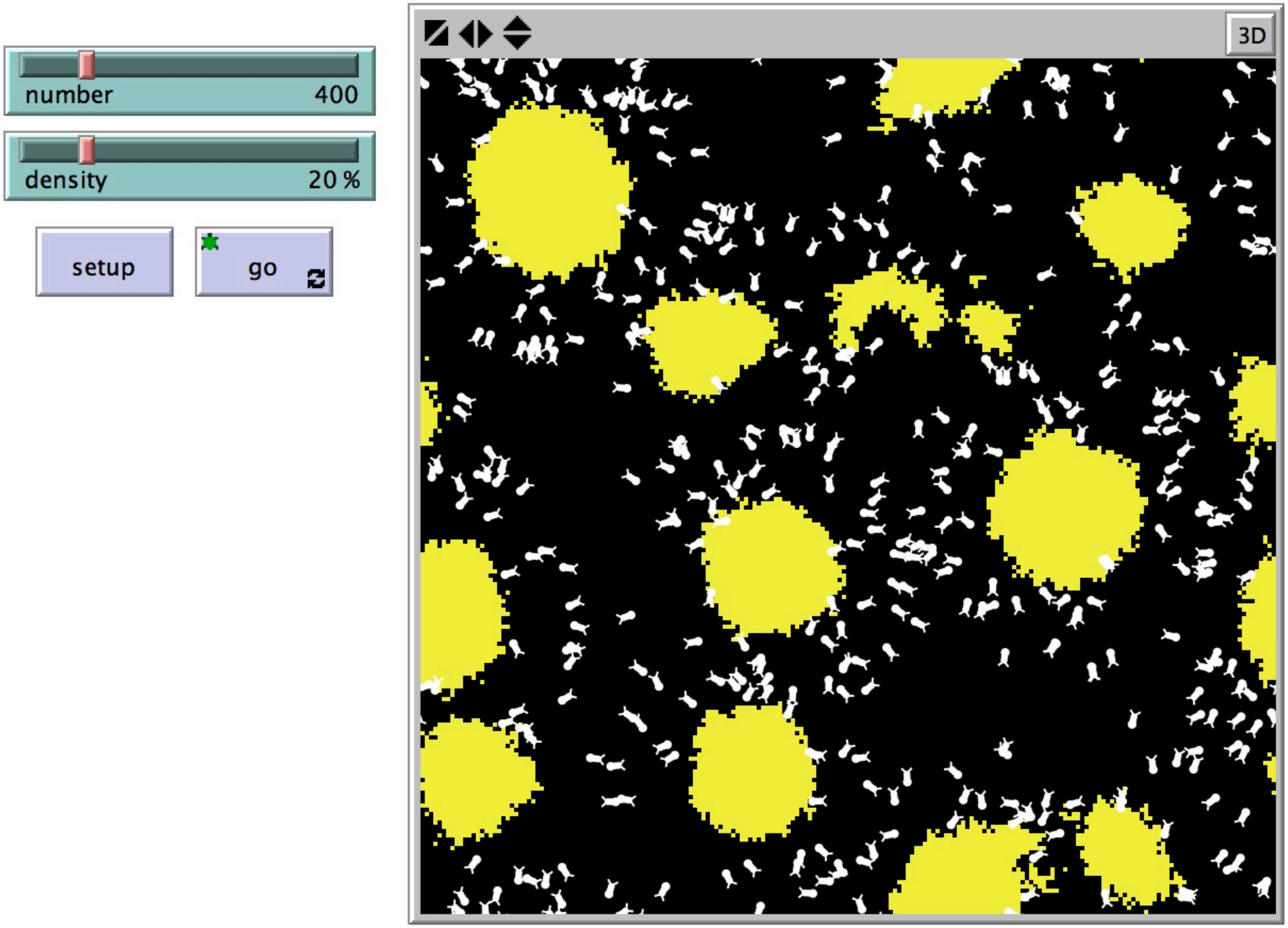
In model library

Stochastic: network growth



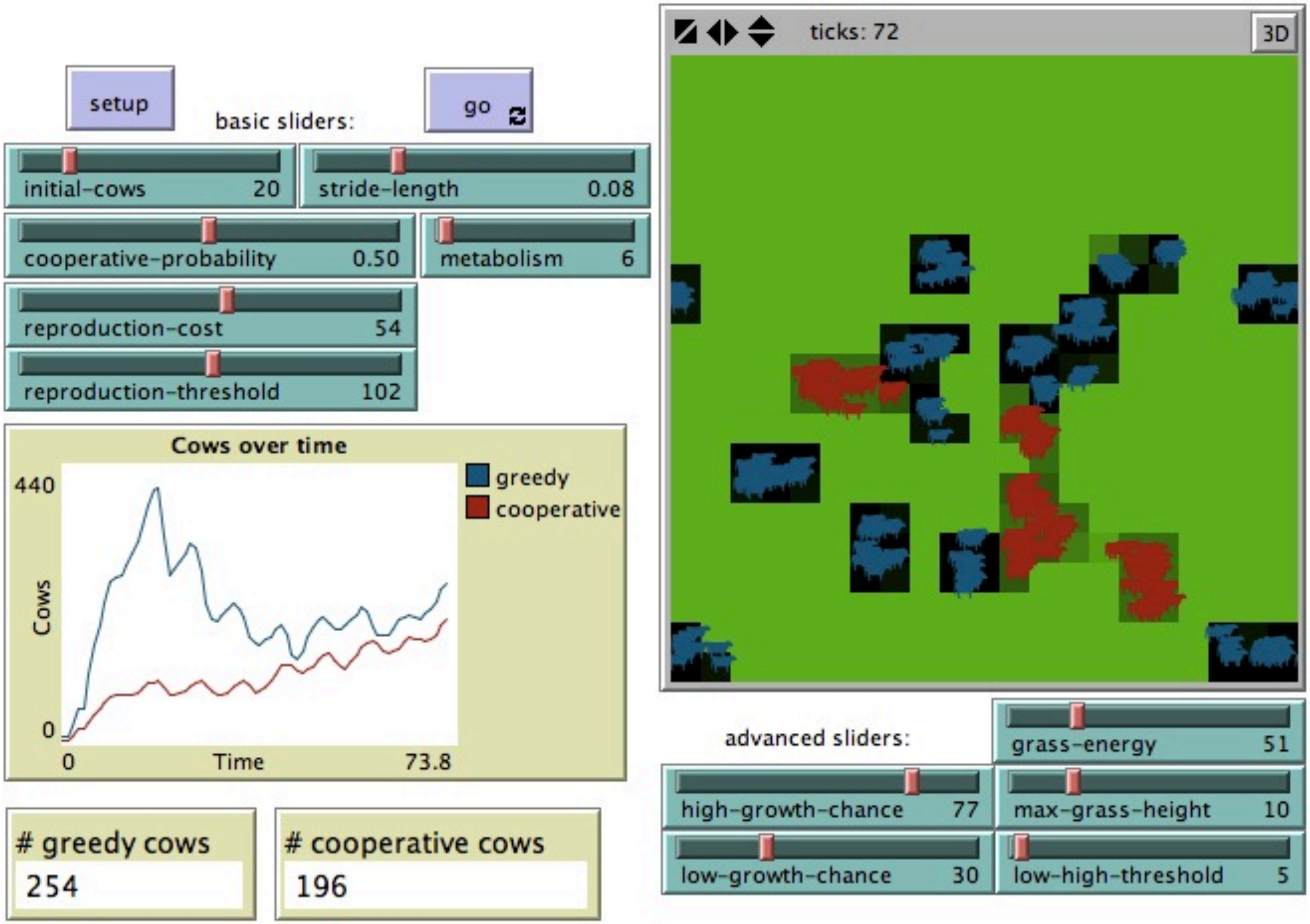
http://web.stanford.edu/class/cs224w/NetLogo/RAndPrefAttachment.nlogo

Stochastic: termites



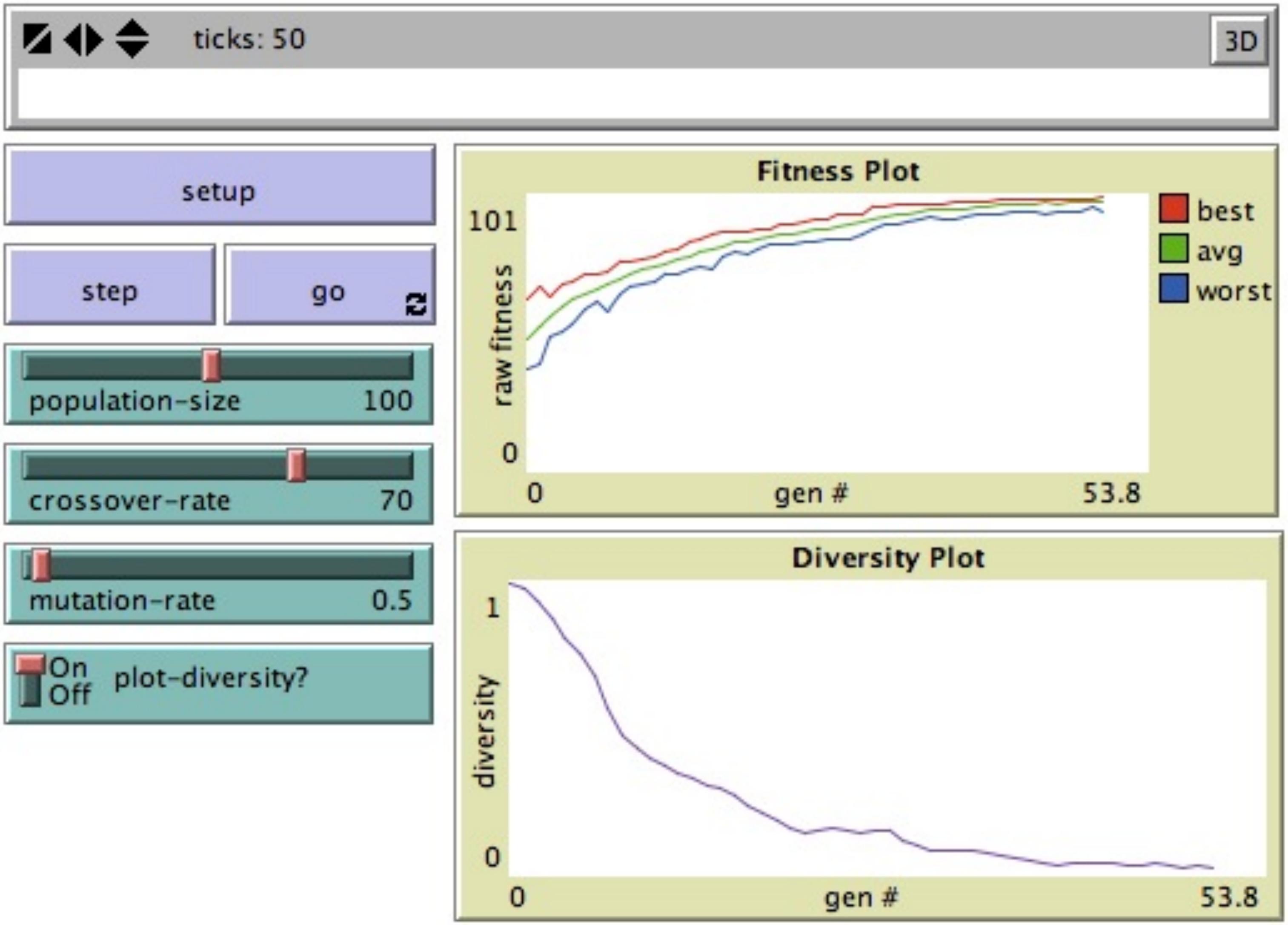
In models library

stochastic: cow cooperation



In models library

Evolving: genetic algorithms



In models library: simple genetic algorithms

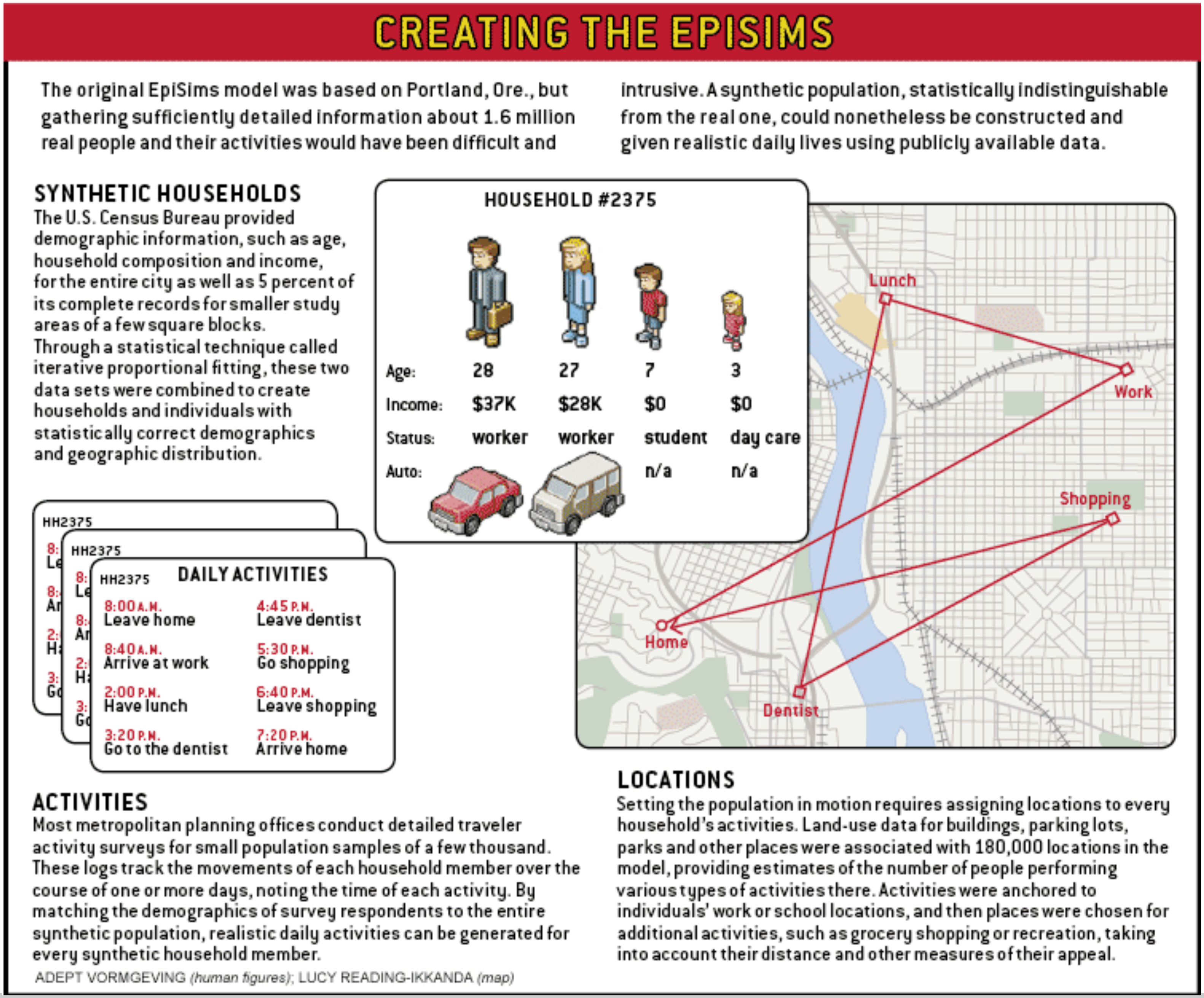
What is a model?

- A simplified mathematical representation of a system.
- Only include features essential to explaining phenomenon of interest

Modeling vs. simulation

- simulation: add detail to make the simulation as *realistic* as possible
- model: *simplify* as much as possible to glean essential behavior of system

example of simulation: Episims



CREATING THE EPISIMS

The original EpiSims model was based on Portland, Ore., but gathering sufficiently detailed information about 1.6 million real people and their activities would have been difficult and intrusive. A synthetic population, statistically indistinguishable from the real one, could nonetheless be constructed and given realistic daily lives using publicly available data.

SYNTHETIC HOUSEHOLDS

The U.S. Census Bureau provided demographic information, such as age, household composition and income, for the entire city as well as 5 percent of its complete records for smaller study areas of a few square blocks. Through a statistical technique called iterative proportional fitting, these two data sets were combined to create households and individuals with statistically correct demographics and geographic distribution.

ACTIVITIES

Most metropolitan planning offices conduct detailed traveler activity surveys for small population samples of a few thousand. These logs track the movements of each household member over the course of one or more days, noting the time of each activity. By matching the demographics of survey respondents to the entire synthetic population, realistic daily activities can be generated for every synthetic household member.

LOCATIONS

Setting the population in motion requires assigning locations to every household's activities. Land-use data for buildings, parking lots, parks and other places were associated with 180,000 locations in the model, providing estimates of the number of people performing various types of activities there. Activities were anchored to individuals' work or school locations, and then places were chosen for additional activities, such as grocery shopping or recreation, taking into account their distance and other measures of their appeal.

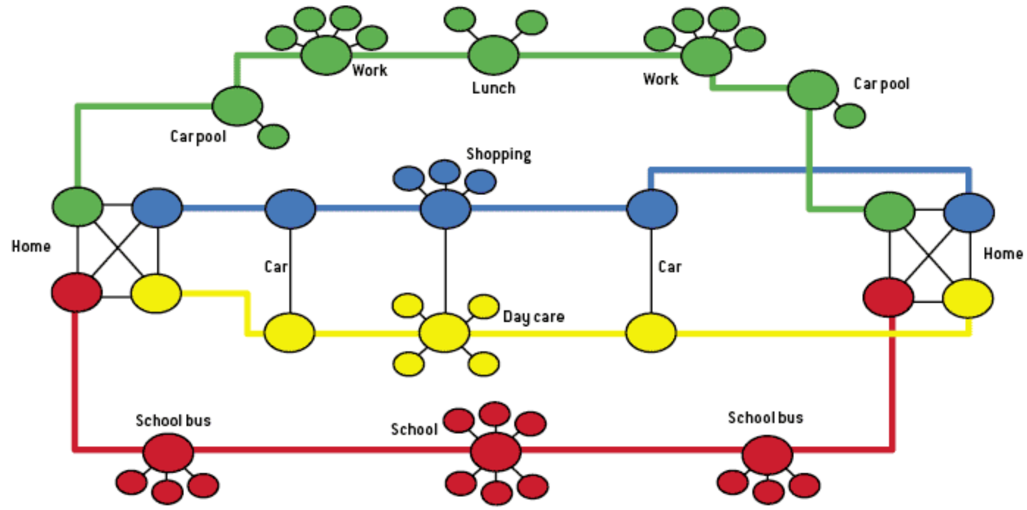
ADEPT VORMGEVING *(human figures)*; LUCY READING-IKKANDA *(map)*

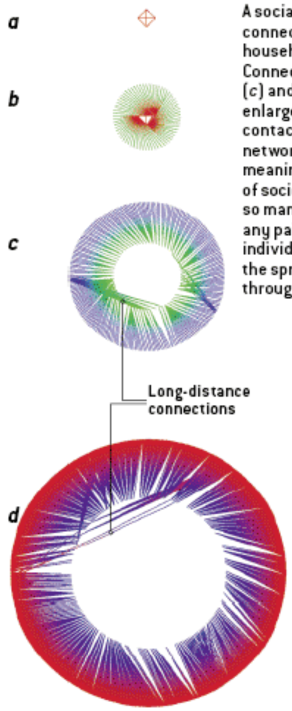
BUILDING SOCIAL NETWORKS

TYPICAL HOUSEHOLD'S CONTACTS

Constructing a social network for a household of two adults and two children starts by identifying their contacts with other people throughout a typical day.

This diagram shows where the household members go and what they do all day but reveals little about how their individual contacts might be interconnected or connected to others.



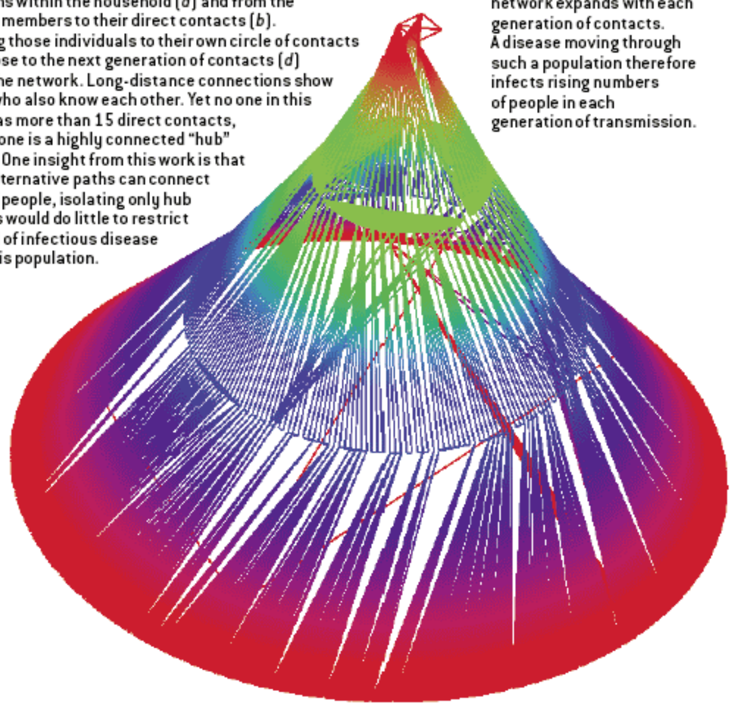


LOCAL SOCIAL NETWORK

A social network emerges by drawing lines to represent connections within the household (*a*) and from the household members to their direct contacts (*b*). Connecting those individuals to their own circle of contacts (*c*) and those to the next generation of contacts (*d*) enlarges the network. Long-distance connections show contacts who also know each other. Yet no one in this network has more than 15 direct contacts, meaning none is a highly connected "hub" of society. One insight from this work is that so many alternative paths can connect any pair of people, isolating only hub individuals would do little to restrict the spread of infectious disease through this population.

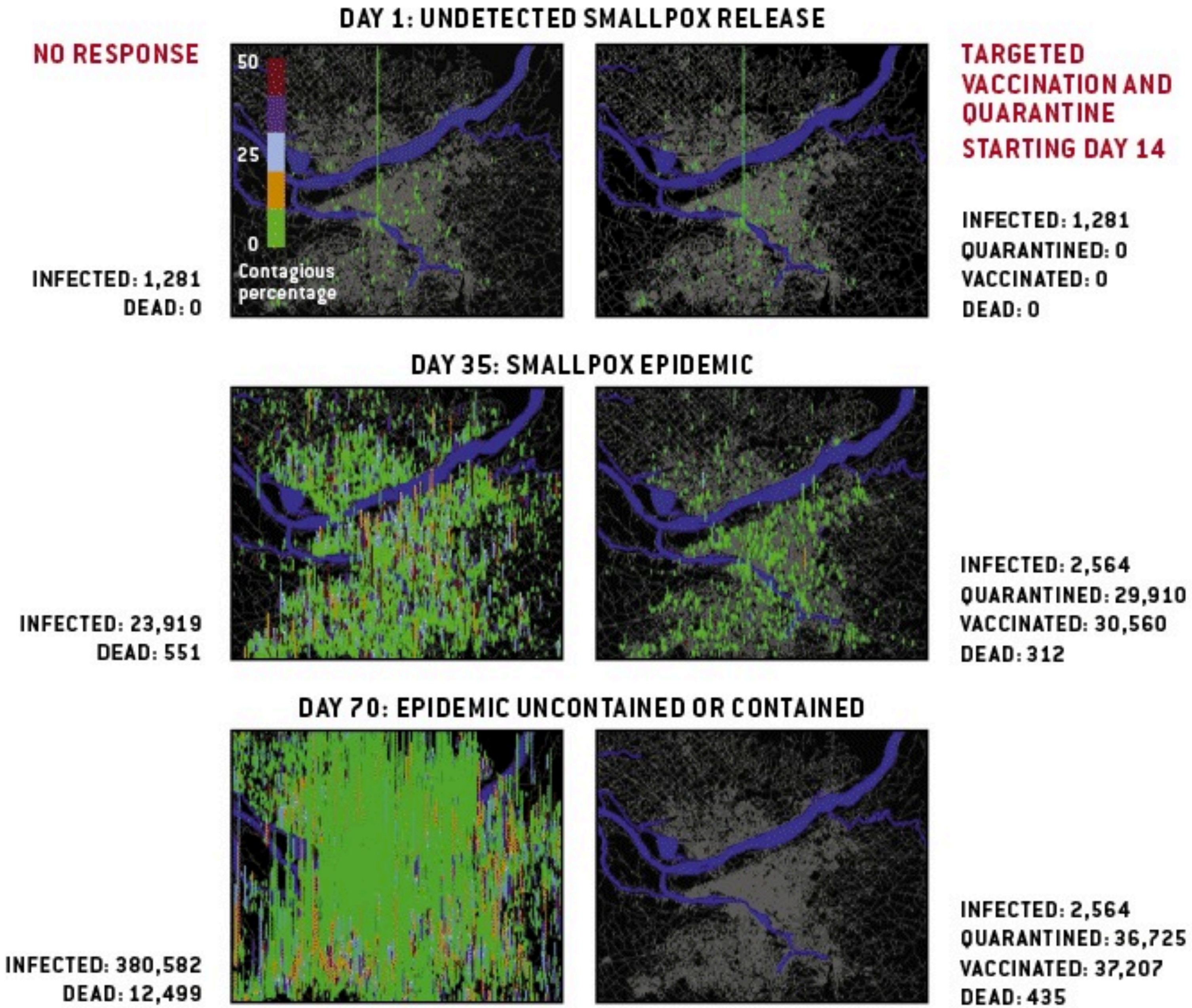
EXPANDER GRAPH

The shape of this small network expands with each generation of contacts. A disease moving through such a population therefore infects rising numbers of people in each generation of transmission.

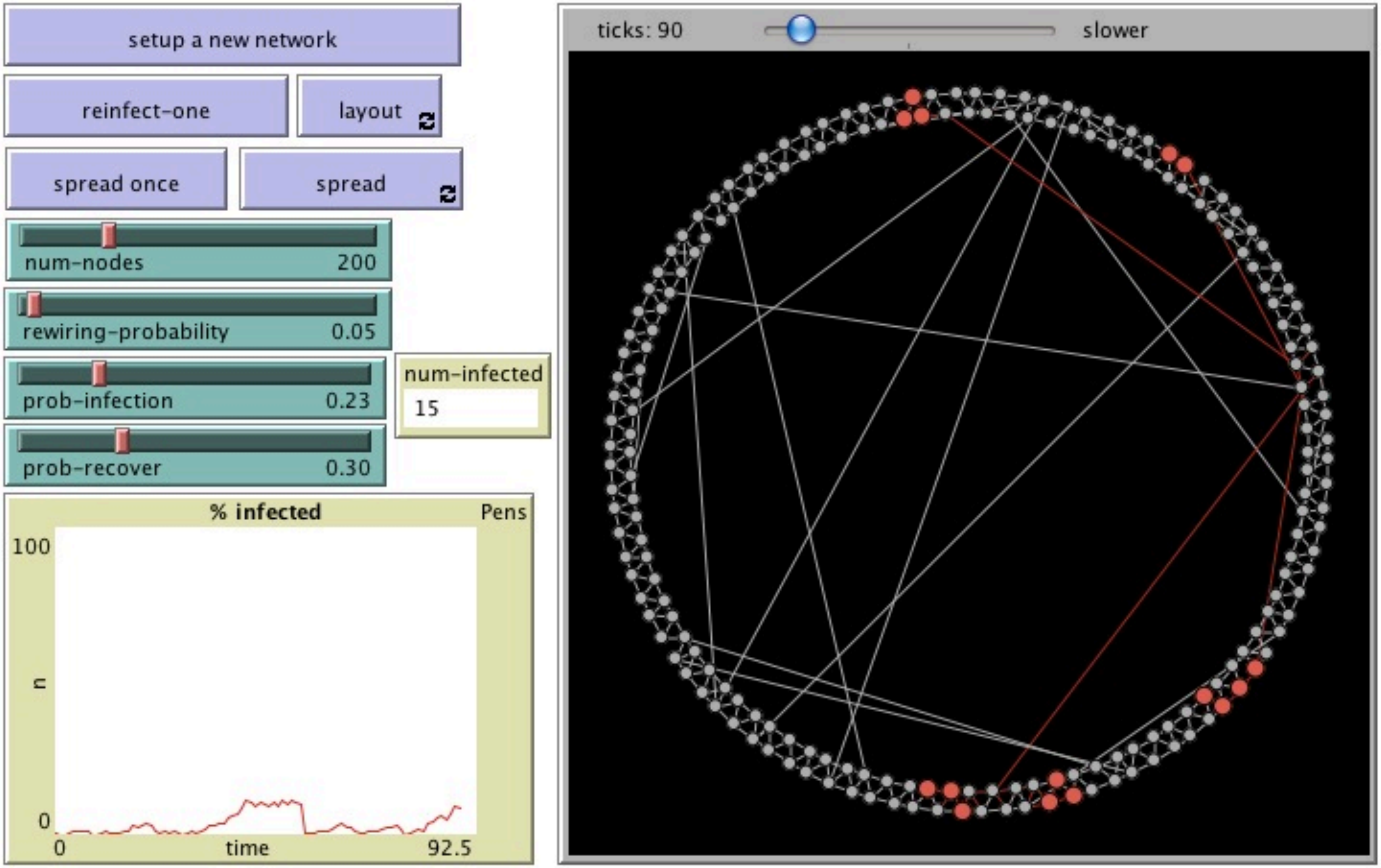


LUCY READING-IKKANDA *(top)*, STEPHEN G. EUBANK *(bottom)*

Using Episims to model a smallpox outbreak in Portland, OR



What a model in NetLogo looks like



other example applications

- urban models
- opinion dynamics
- consumer behavior
  - network effects and lock-in
  - market for lemons
- networks of firms
- supply chain management
- electricity markets

wrap up

- complex networks are complex systems
- modeling lets you get to the heart of the matter (or the complex system) cheaply
- you specify simple micro rules and gain an understanding of the target macro behavior