Orientation & Modeling Types

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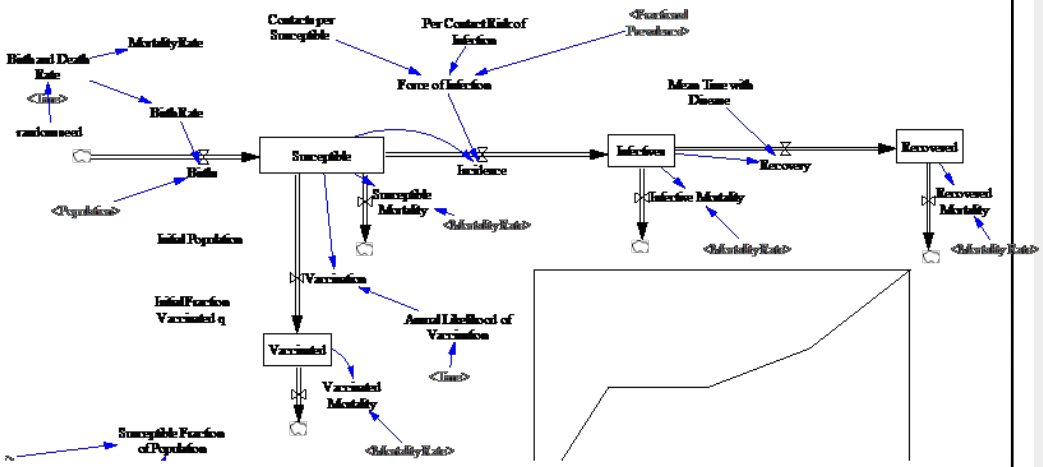
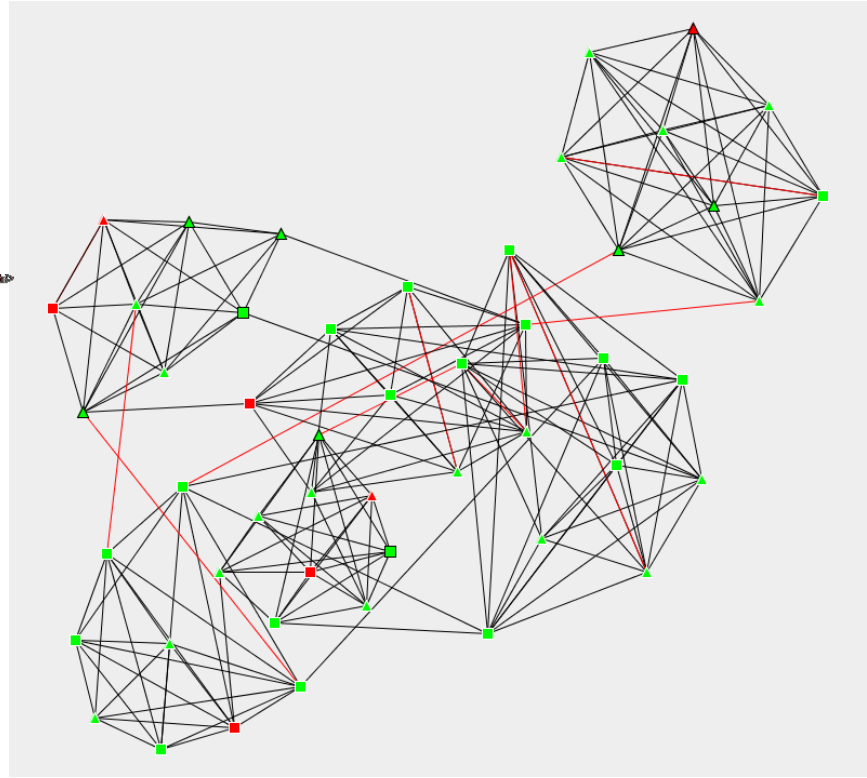
11-5-2009

Dynamic Models for Health

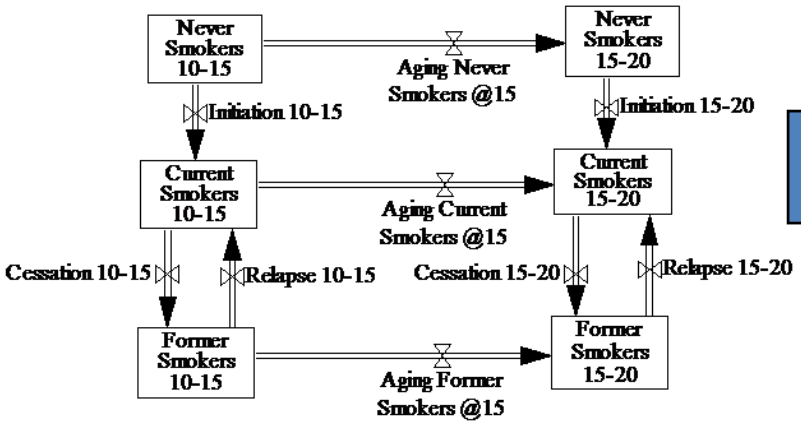
- Classic: Aggregate Models
  - Differential equations
  - Population classified into 2 or more state variables according to attributes
  - |State Variables|,|Parameters| << |Population|
- Recent: Individual-Based Models
  - Governing equations approach varies
  - Each individual evolves
  - |State Variables|,|Parameters| $\propto$ |Population|

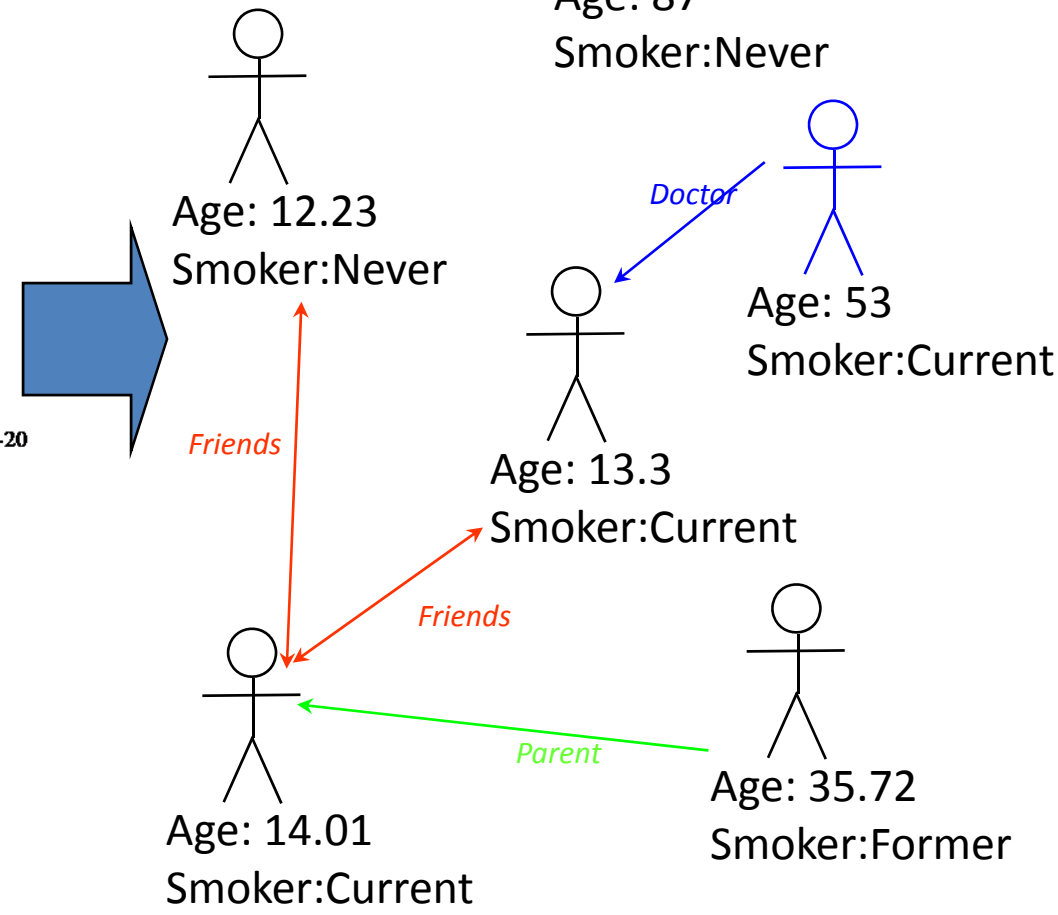
Contrasting Model Granularity



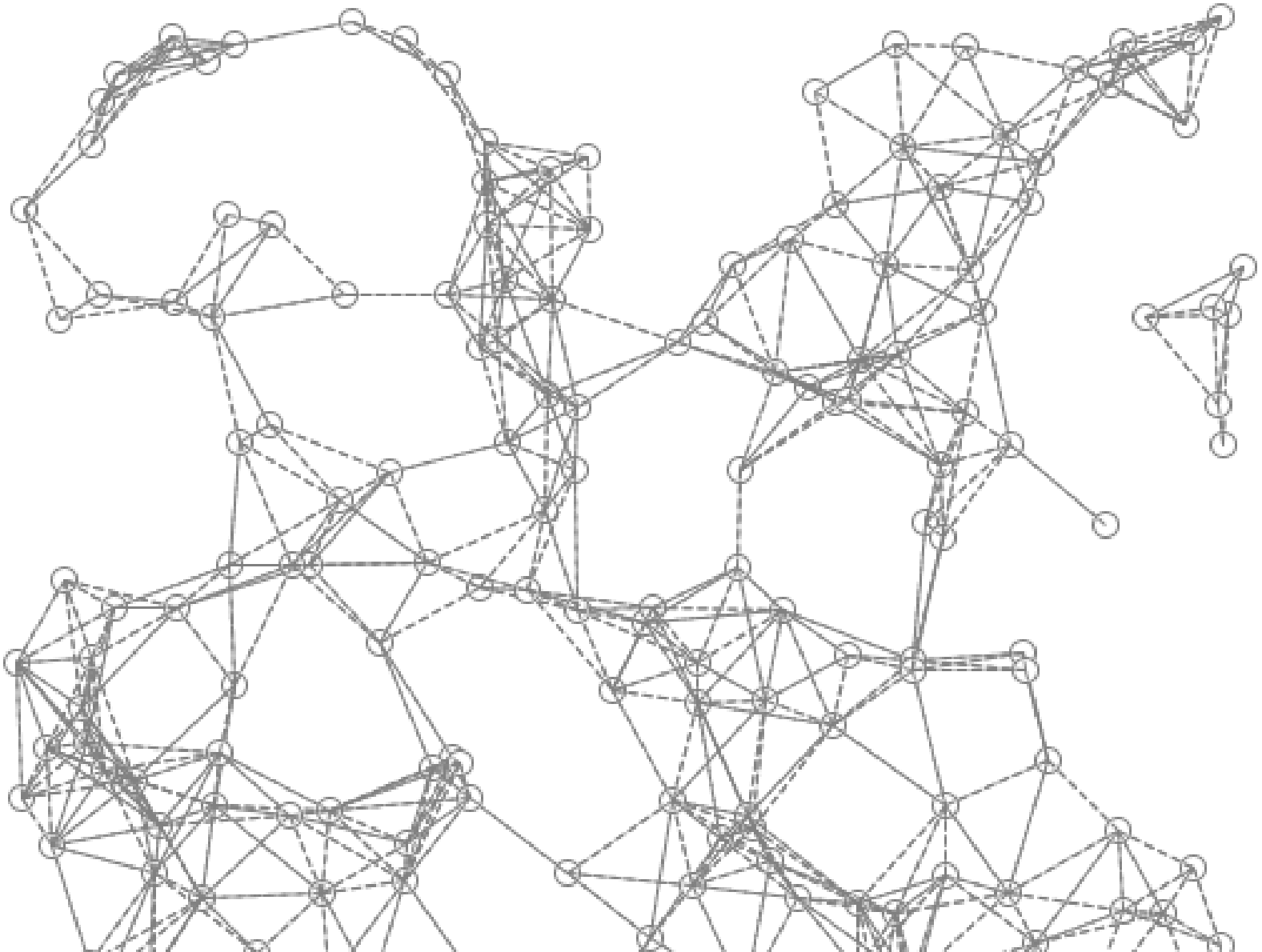


Interacting Individuals



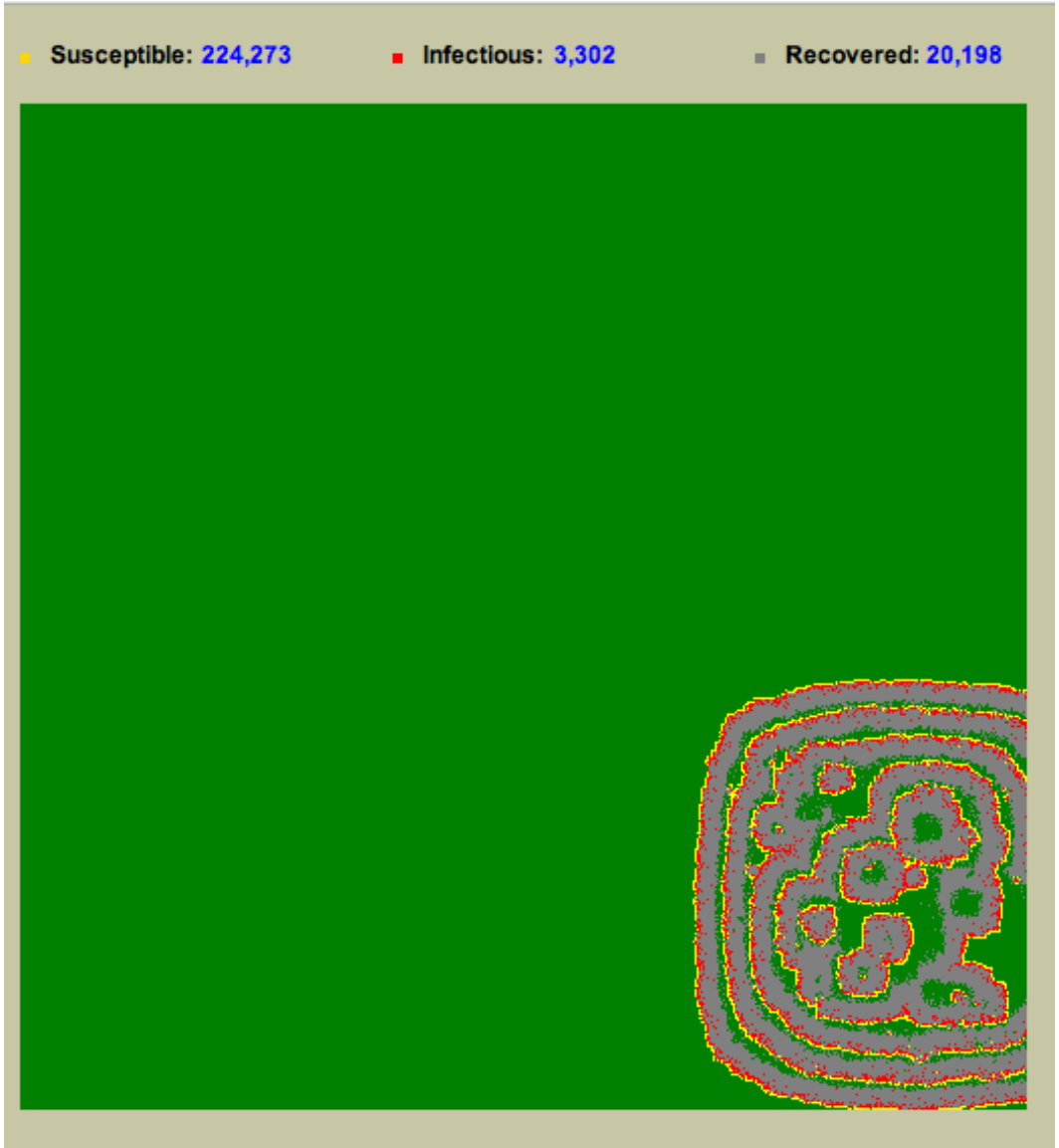


Network Embedded Individuals



Irregular Spatial Embedding & Process Flow

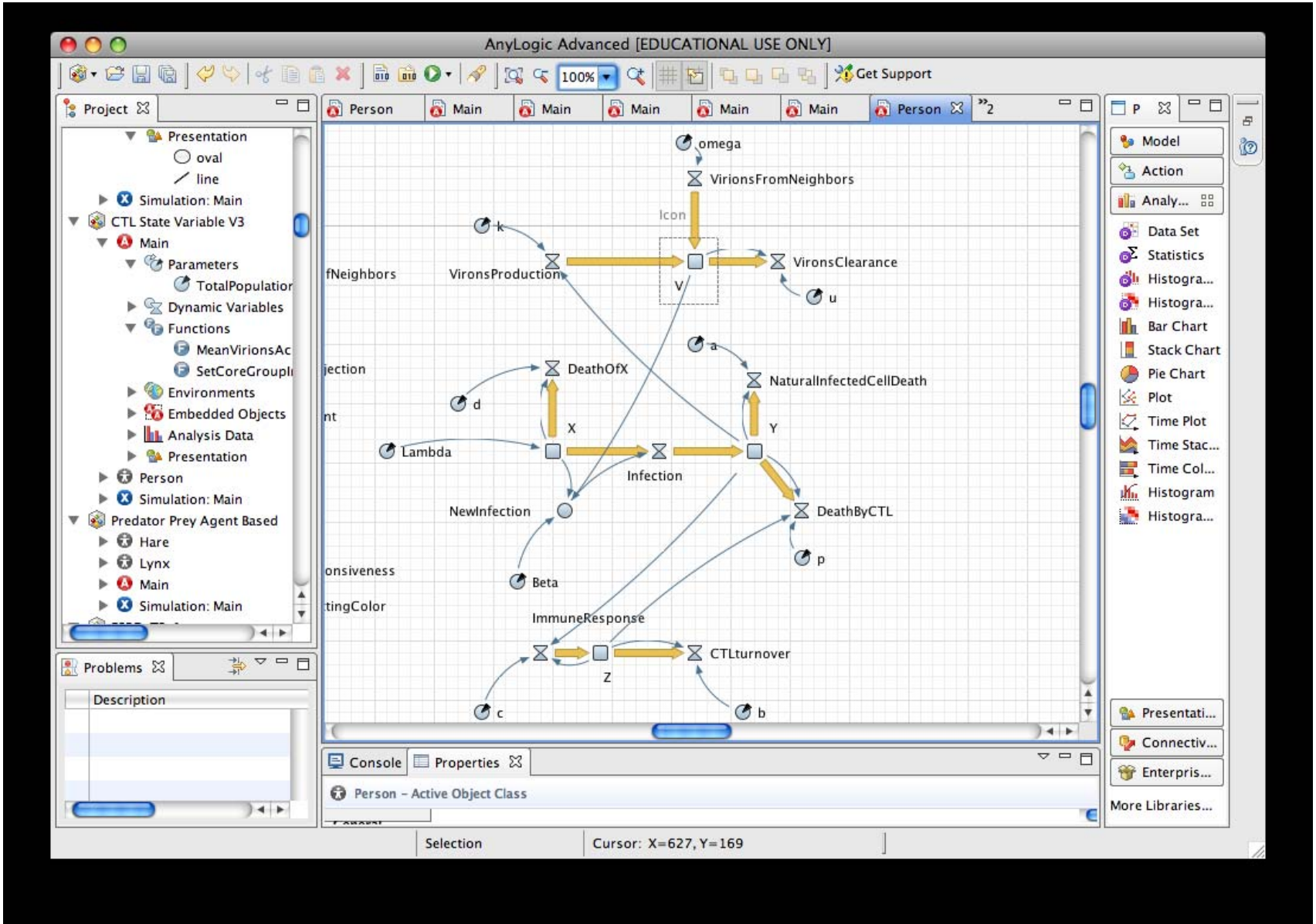
Regular Spatial Embedding



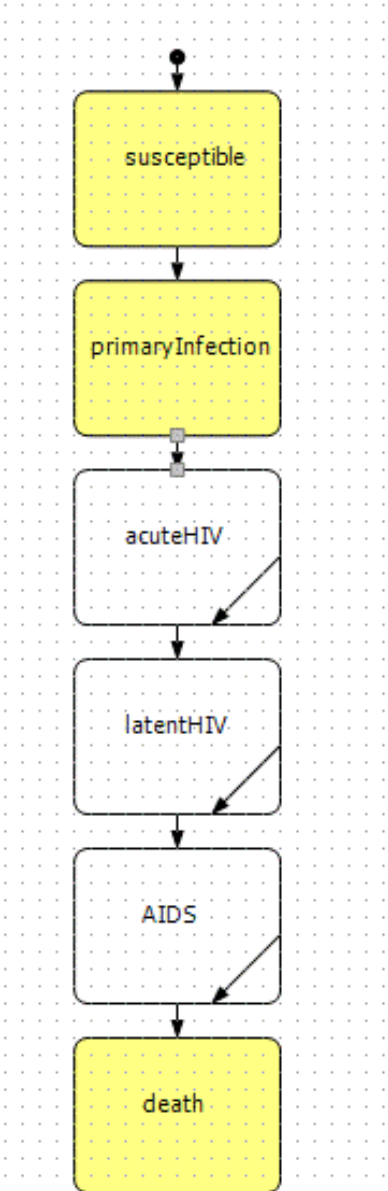
Elements of Individual State

- Example Discrete
  - Ethnicity
  - Gender
  - Categorical infection status
- Continuous
  - Age
  - Elements of body composition
  - Metabolic rate
  - Past exposure to environmental factors
  - Glycemic Level

Example of Continuous Individual State

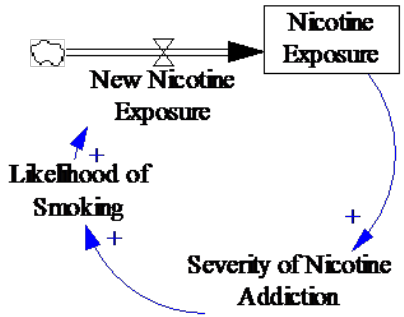


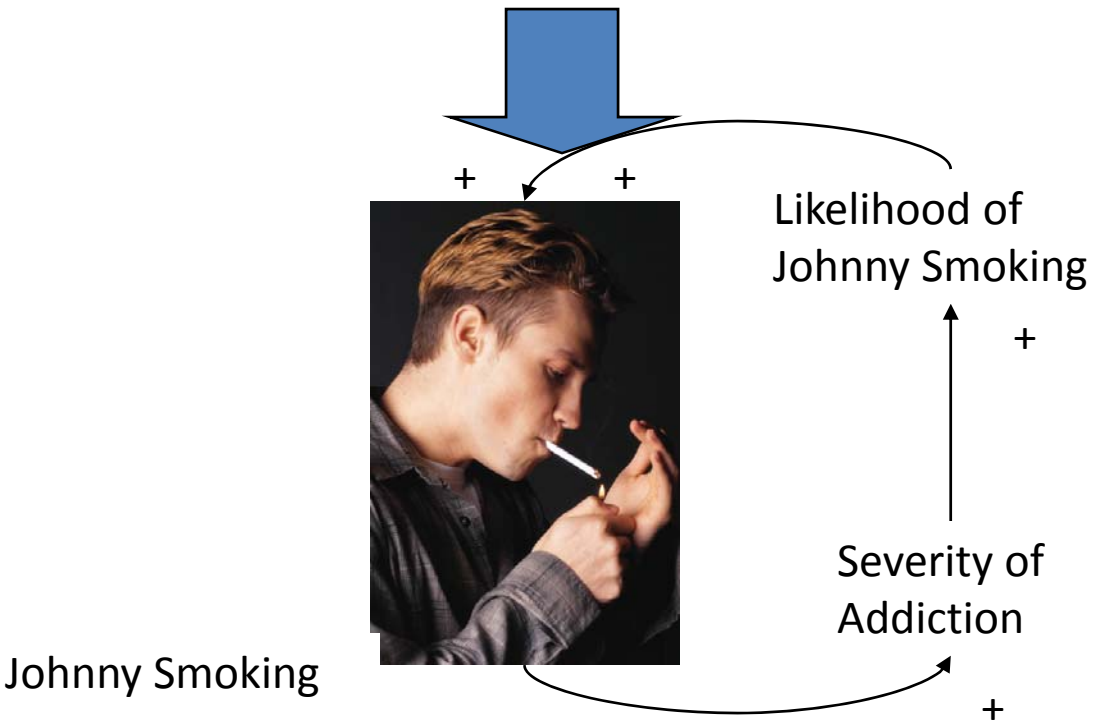
Example of Discrete States
Binary Presence in Discrete State



Feedbacks

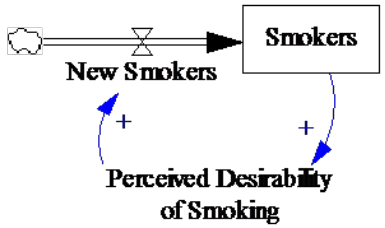
- Some aggregate feedbacks lie within individual agent





Feedbacks

- Many aggregate feedbacks are *between* agents



Aggregate Model

Johnny's
Father's
Smoking

+

Johnny's
Perception
Of Desirability
Of Smoking

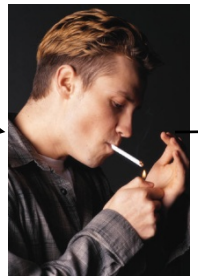
+

Agent-Based Model

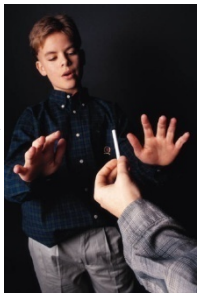
+

+

Timmy's
Perception
Of Desirability
Of Smoking



Johnny
Smoking



Capturing Heterogeneity in Individual-Based vs. Aggregate Models

- Consider the need to keeping track of a independent characteristics on each person (with d values – and possibly progression between them!)
  - E.g. age, sex, ethnicity, education level, strain type, city of residence, stage of many co-morbidities, etc.
- Aggregate Model: Add a subscript
  - This multiplies the model size (number of state variables into which we divide individuals) by *d*!
- Individual based model: Add field (variable/param)
  - If model already has c fields, this will increase model size by a fraction 1/c.

Challenges for Model Formulation: Persistent Interaction

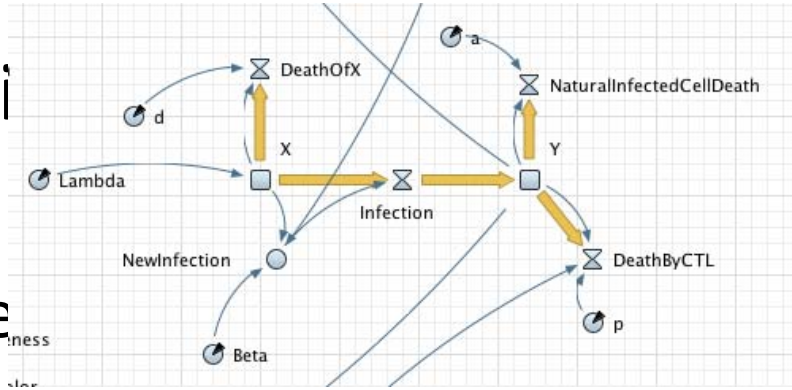
- Network topologies can affect qualitative behavior
- Aggregate representations of network structure are expensive and awkward
- IBM permit expressive, efficient characterization of both dense & sparse networks
- While percolation over many topologies can be simulated in aggregate models, parameter calibration often requires finer-grained simulation

AnyLogic basics

- Multi-platform
- Declarative graphical languages
- Basic language: Java
- Rich library of built-in objects
- Continuous or discrete time/space
- Modeling approaches supported
  - System Dynamics
  - Agent-based
    - Regular & irregular spatial embedding, network embedding
  - Discrete event

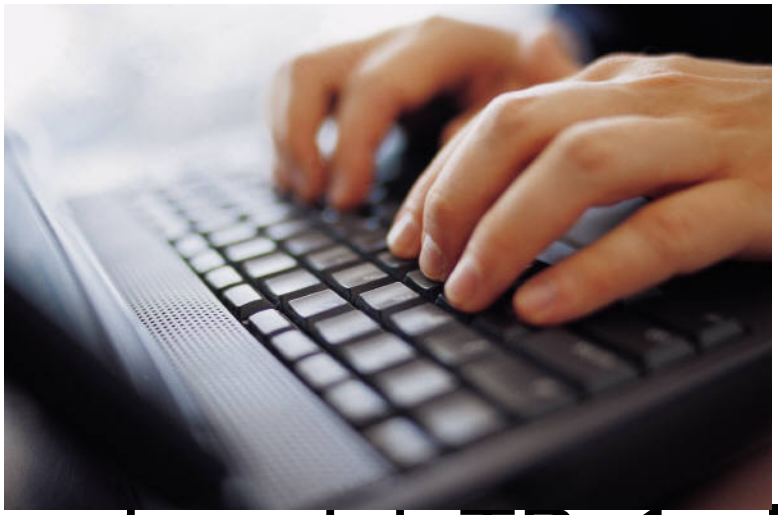
System Dynamics

- Feedback-focus
- Traditional graphical depicti
  - Stocks (state of system)
  - Flows (rates of change to the
  - Continuous variation in state



- Stocks are initialized, are then change according to flows
- Values of flows are determined by stocks & any other variables

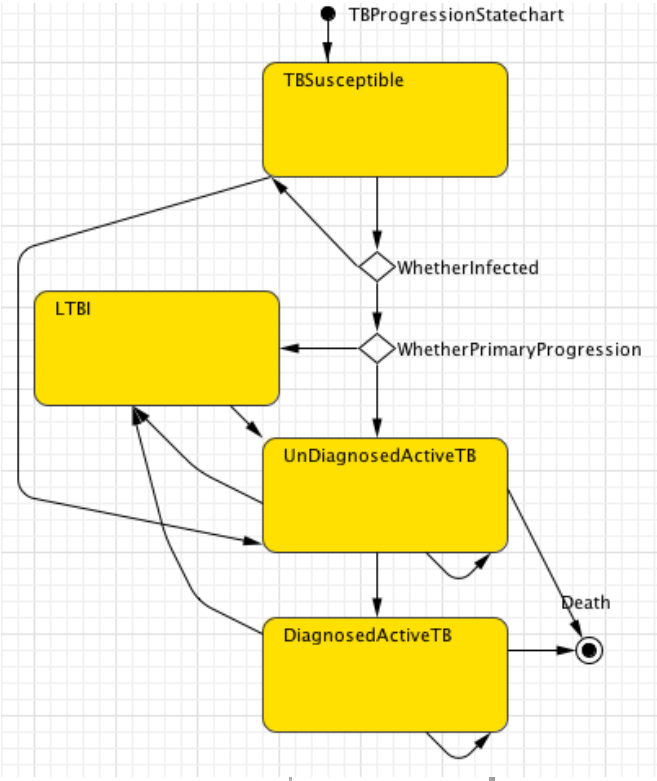
Hands on Model Use Ahead

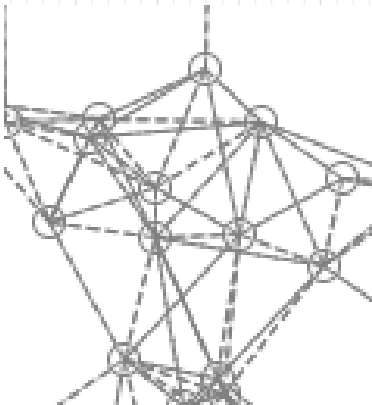


Load model: TBv1.alp

Agent-Based Approaches

- Agent (actor) focused
- Traditional graphical depiction:
  State transition diagram
  - States
  - Transitions
  - Discrete variation in state
- Regular or irregular topologies connect between agents
  - Messages sent via connections





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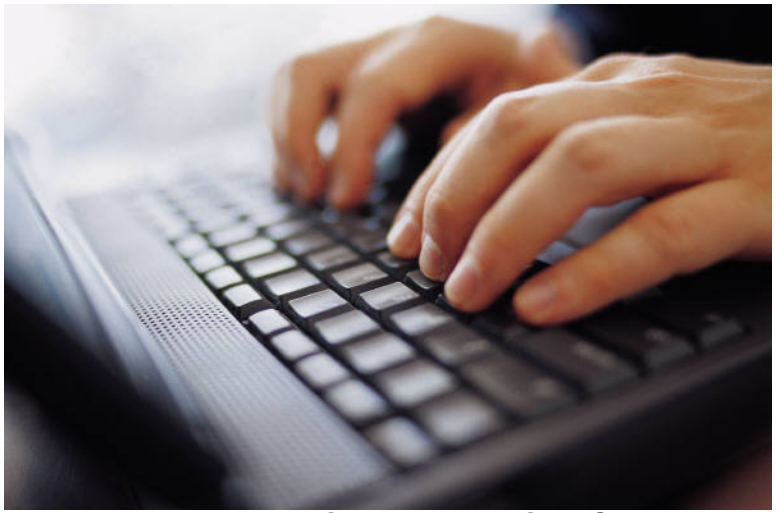
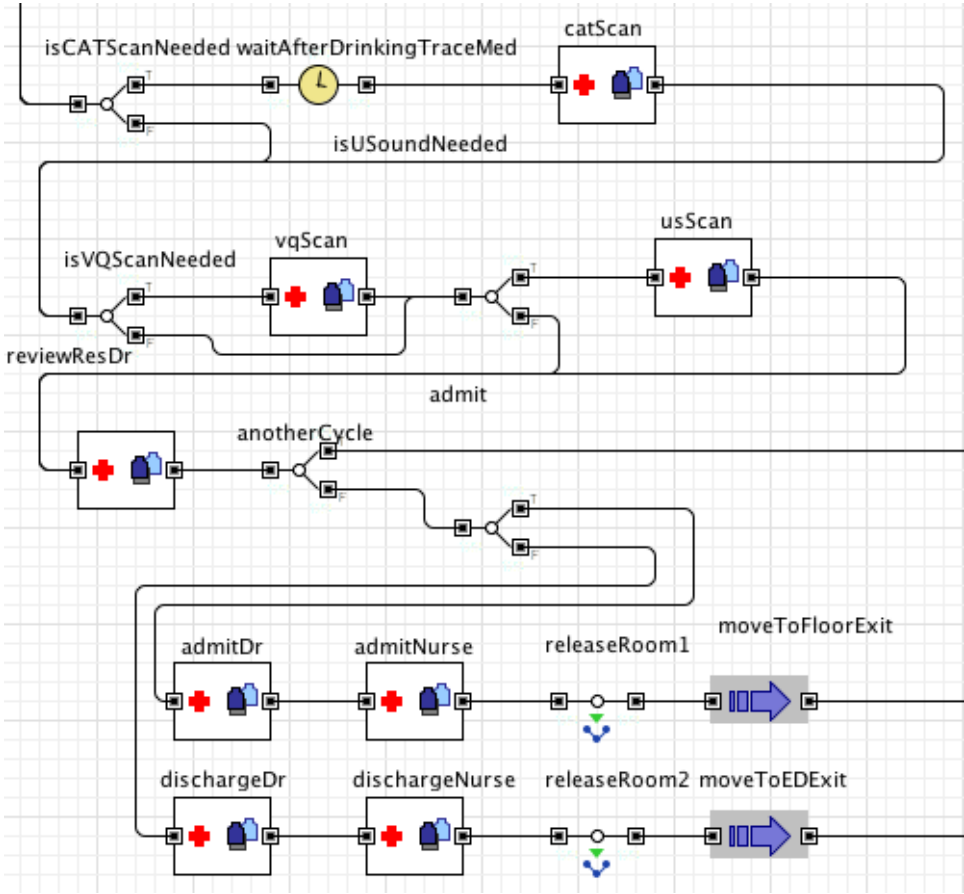


Load model:

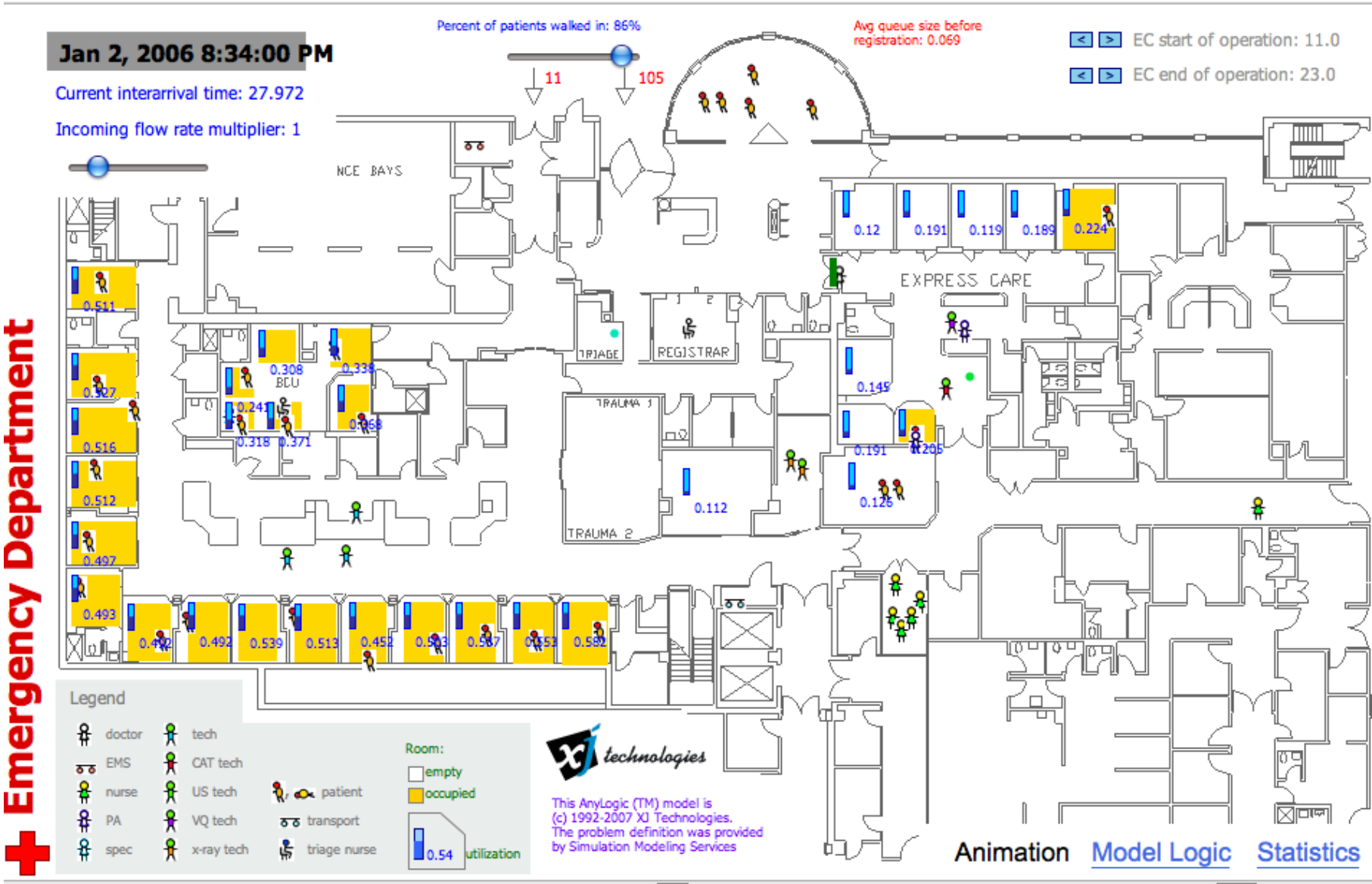
Emergency Department Tulsa.alp

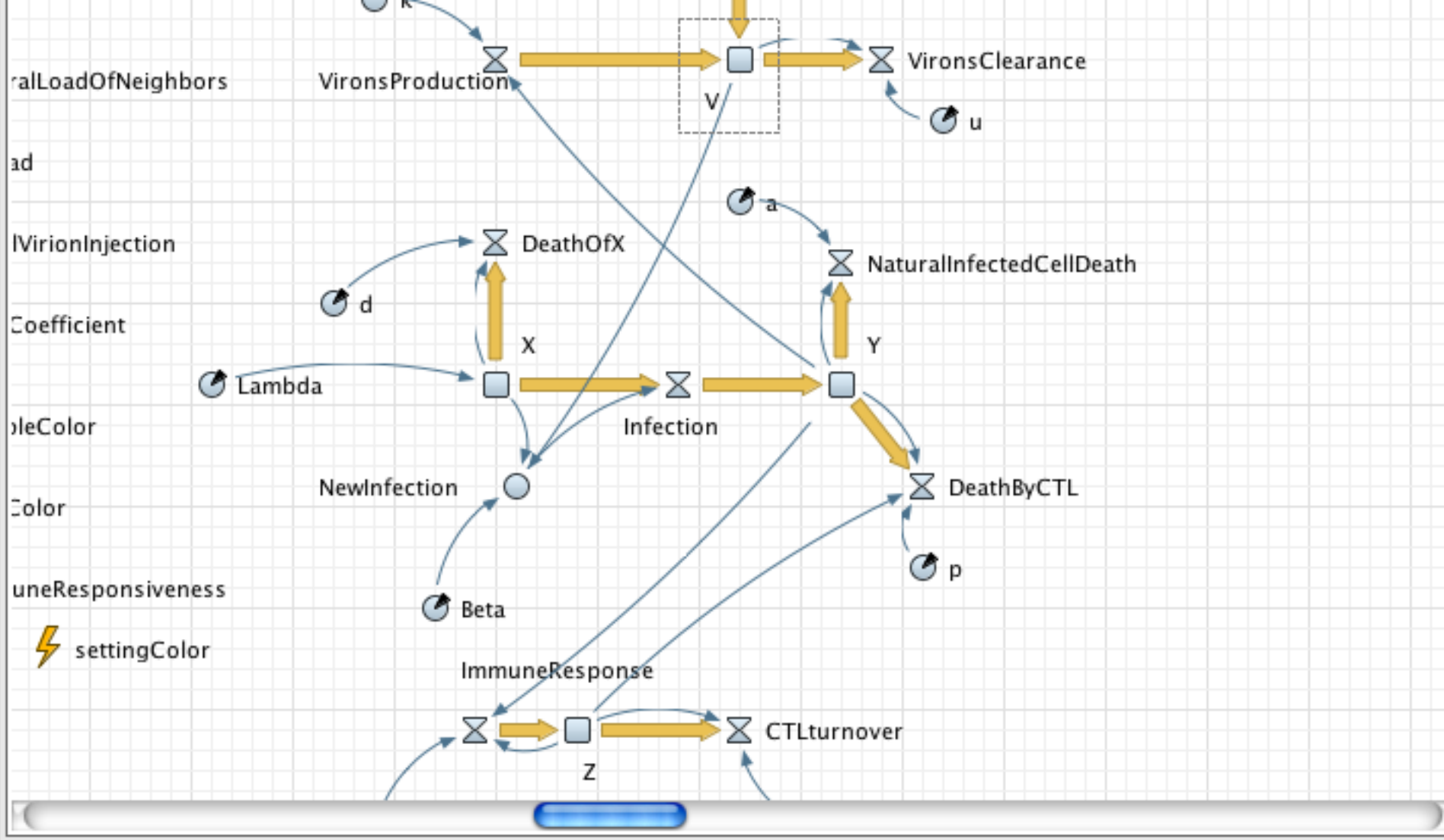
Discrete Event Modeling

- Resource-based modeling
  - Queues
  - Processes
  - Flow charts
  - Capacitated resource pools
  - Send to
  - Attachment/detachment



“Network Modeling”
Irregular Spatial Embedding





Properties | Console

Person – Active Object Class

General

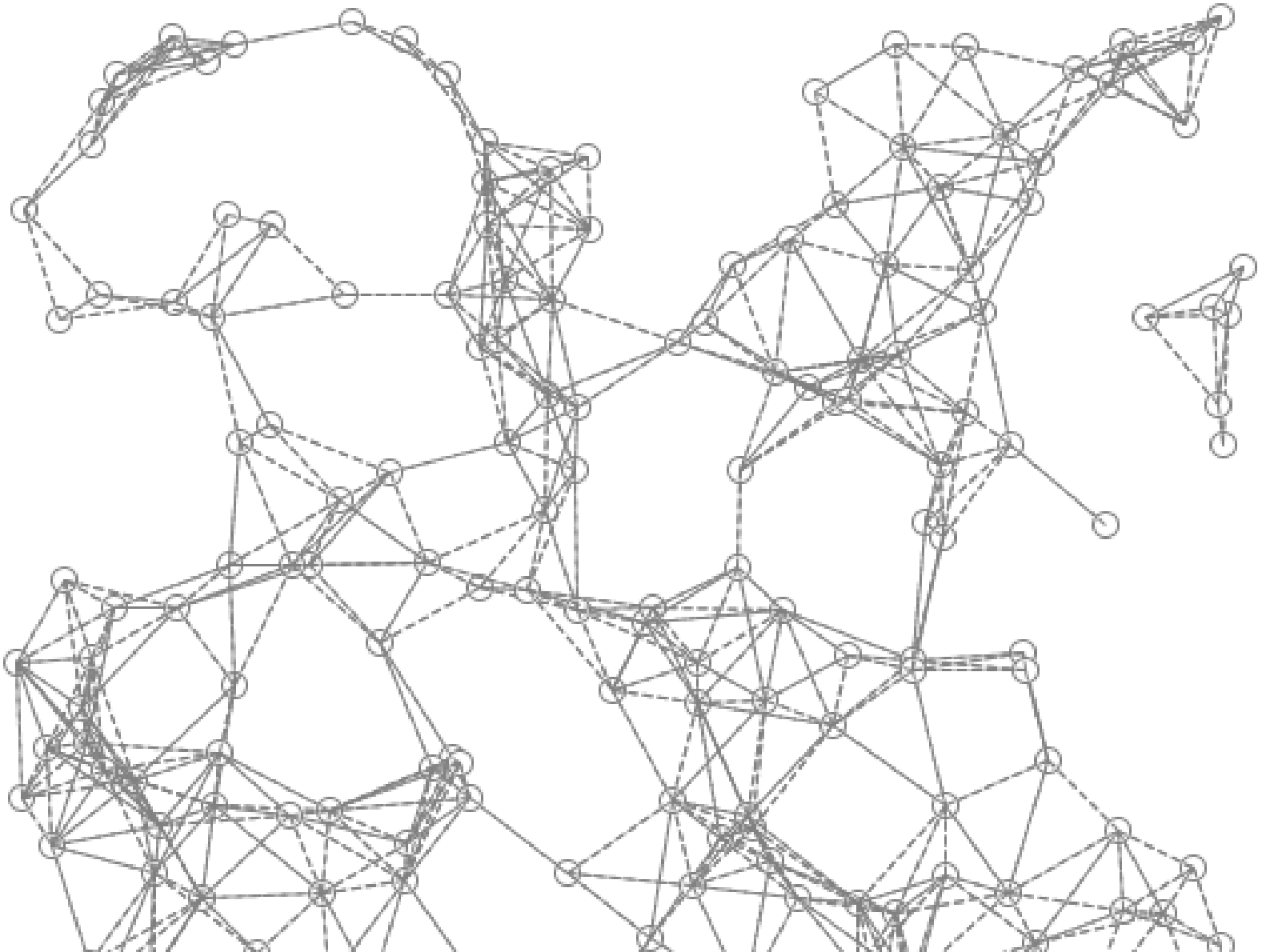
Advanced

Agent

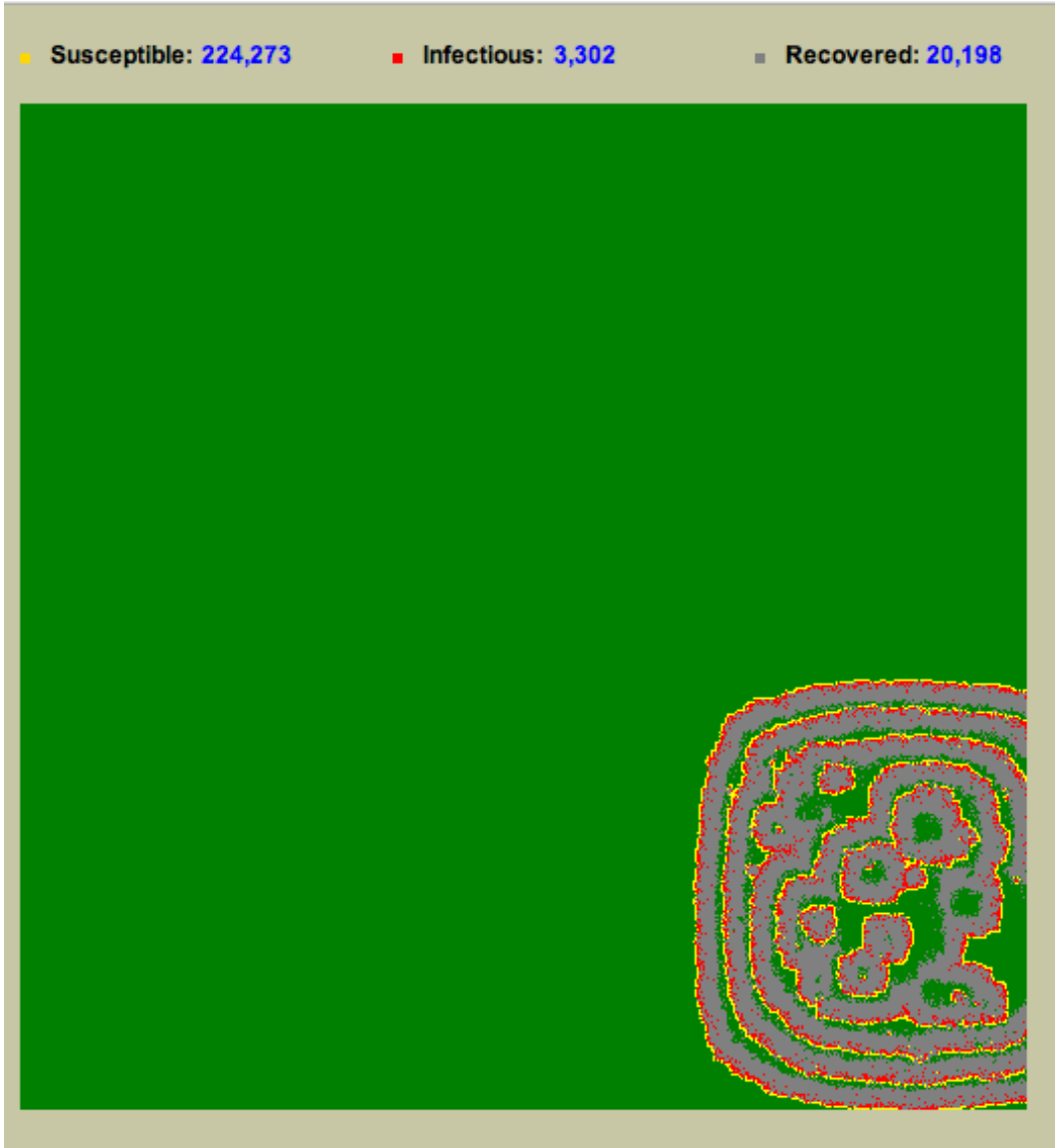
Name: Person

Ignore

Network Embedded Individuals



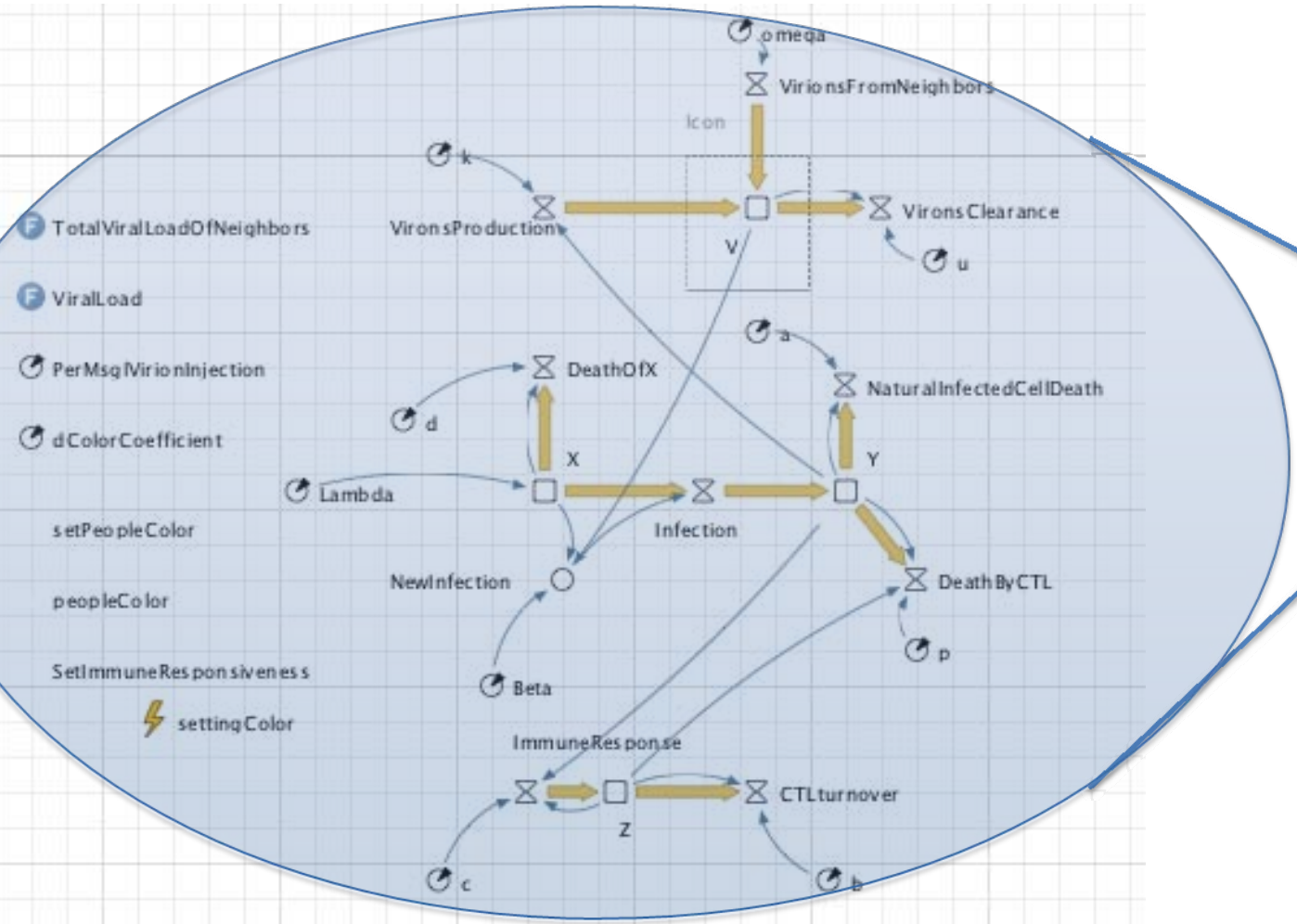
Regular Spatial Embedding

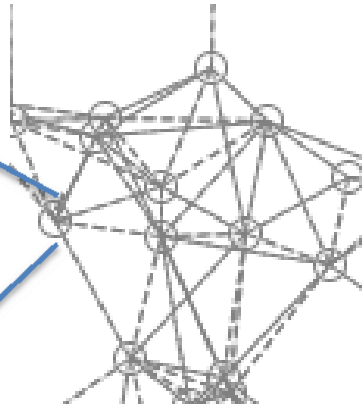


Hybrid Models

- Much of the power of AnyLogic lies in its ability to integrate multiple types of modeling in a single model
- Attractive schemes
  - Agent-based using system dynamics for continuous agent state (c.f. age)
  - System dynamics using agent-based to determine flows
  - Agent-based using system dynamics for global dynamics
  - Agents entering into process-based health services

Example Hybrid Model





Advantages of AnyLogic
(as compared to other Agent-Based Modeling Software)

- Primarily declarative specification
- Less code
- Great flexibility
- Access to Java libraries
- Support for multiple modeling types
- Support for mixture of modeling types

Painful Sides of AnyLogic Education/Advanced

- Export of model results: Lack of trajectory files
- Lack of debugger
- Need for bits of Java code
- Many pieces of system