

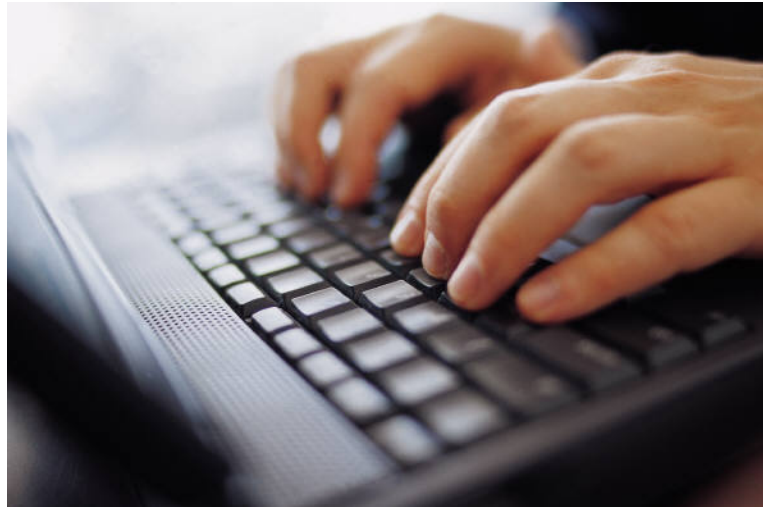
# The Embedded Environment The Network & regular spatial embedding in agent-based modeling

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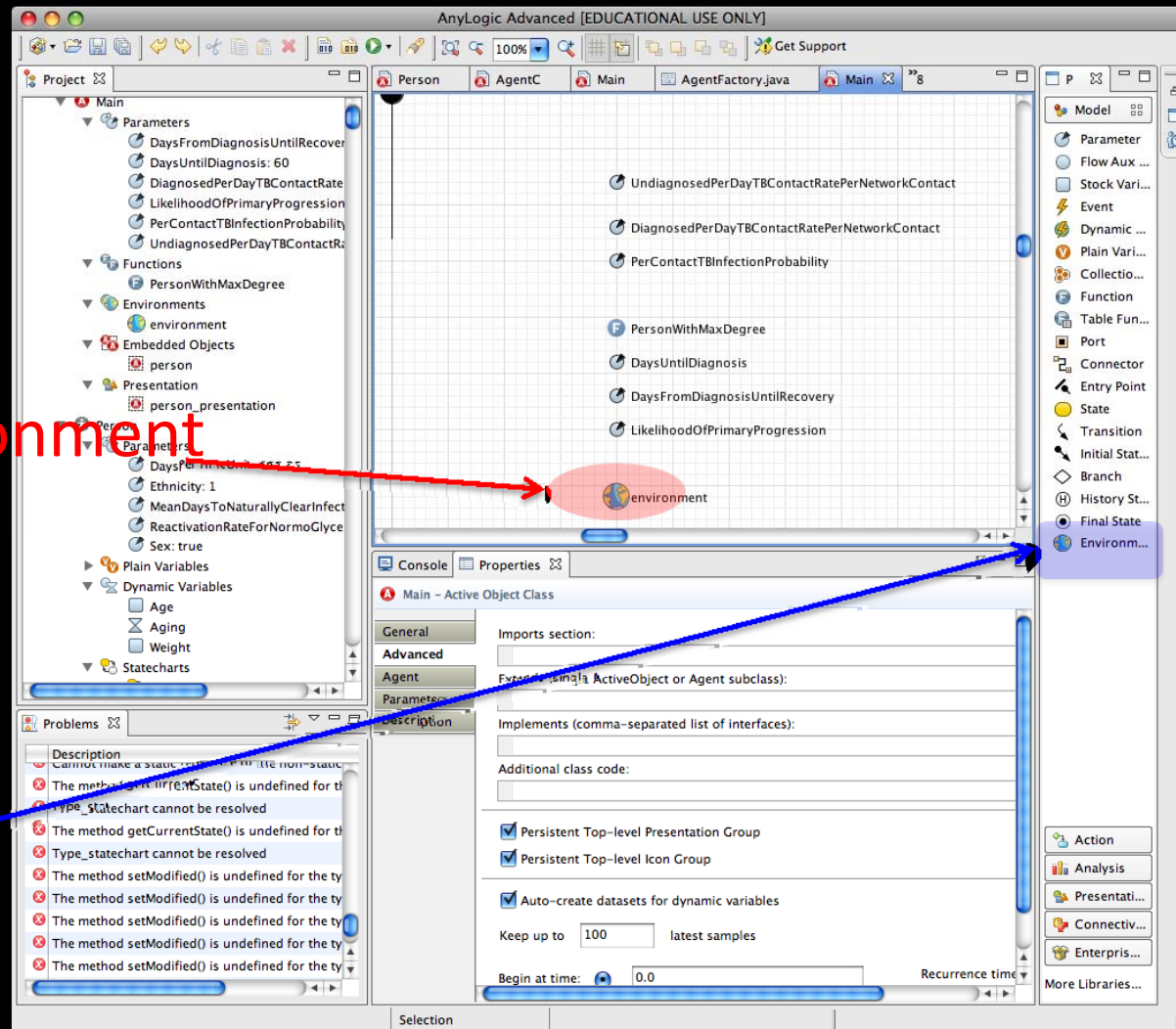
# Hands on Model Use Ahead



Load model: TBv1.alp

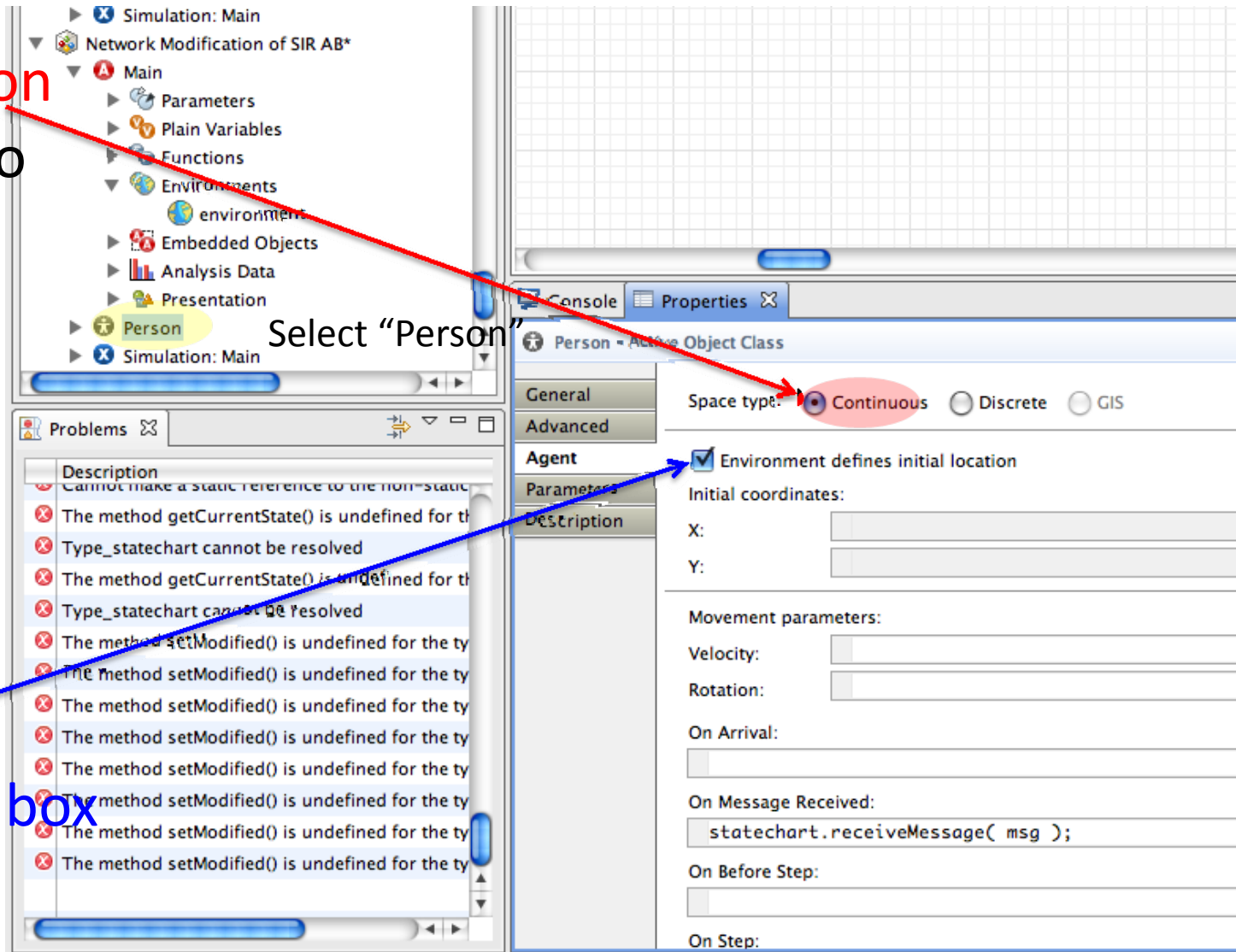
# Environment Objects: The Key to Agent Embedding

This environment  
object  
was  
added  
from  
here



# Agent Needs to “Know about” Environment

This radio button setting needs to Agree with the Space type of the environment!



Make sure this box is checked!

# Spatial Types Supported

- Continuous
  - No interference between agents
  - Continuous movement (via velocity)
  - Only spatial dimensions required
- Discrete
  - Space is tessellated into cells
  - Mutual exclusion of agents from a given cell
  - Space information requires dimension & rows/columns (for count of cells in X & Y location)

# Discrete Space

- Common Built-in methods
  - Finding empty cells
  - Jumping to cells
  - Moving to nearby cells
- Neighborhood models
  - Moore: 4 neighbors (in Cardinal directions)
  - Euclidean: 8 neighbors

# Continuous Space

- Continuous
  - X & Y location
  - Velocity
  - Rotation
- Movement
  - “moveTo” starts agent moving towards a destination (per velocity & shortest path)
  - “jumpTo” directly moves agent to destination

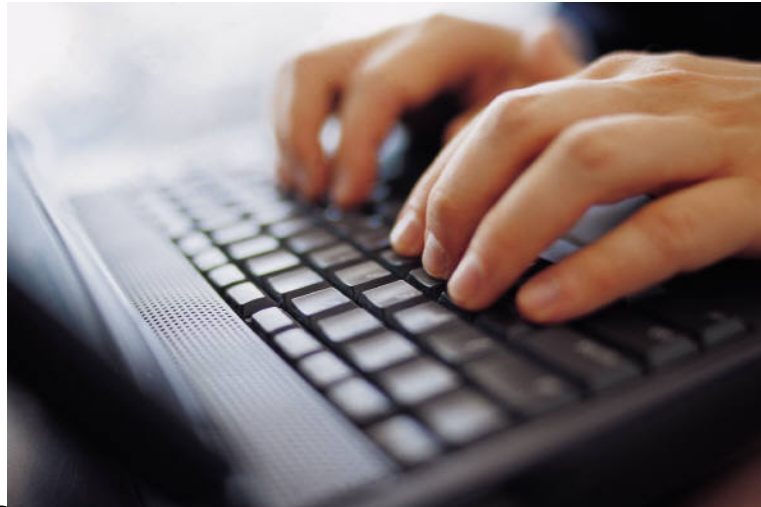
# Networks & Spatial Layouts

- Distinct node attributes: Location & connections
  - Spatial layouts determine where nodes appear in space (and often on the screen)
  - Network type determines who is connected to who
  - For the most part, these characteristics are determined independently
- Network topologies (connectedness) can be defined either *alternative to* or *in addition to spatial layouts*
  - Agents will have spatial locations in either case





## Hands on Model Use Ahead



Load model: Spatial SEIR with  
Waning Immunity.alp

# Network Types

The screenshot displays the AnyLogic Advanced software interface, titled "AnyLogic Advanced [EDUCATIONAL USE ONLY]". The interface is divided into several panes:

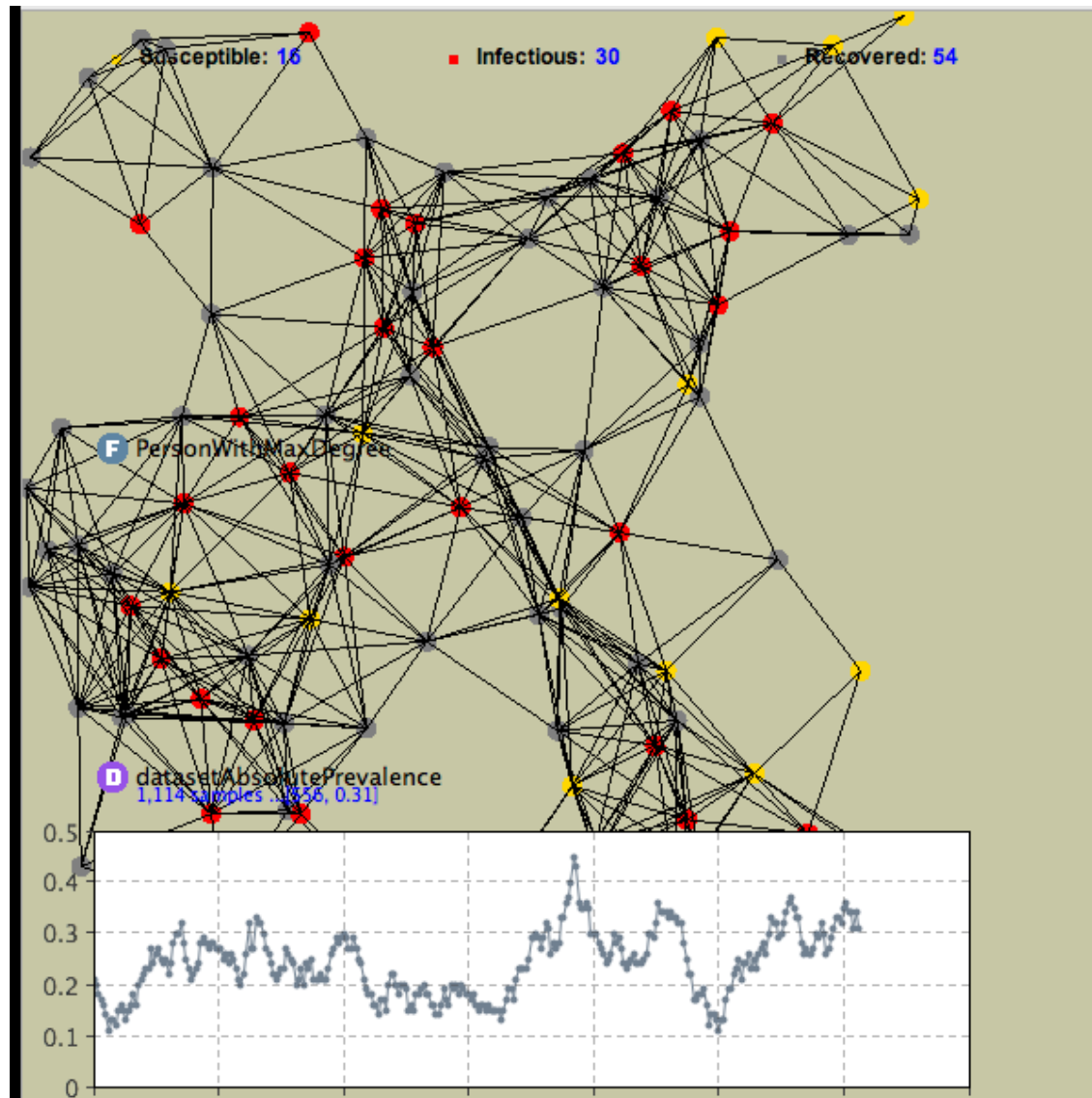
- Project Pane (Left):** Shows a hierarchical tree of the project structure. The "environment" object is highlighted under the "Spatial SEIR with Waning Immunity" > "Main" > "Environments" path.
- Properties Pane (Right):** Displays the properties for the selected "environment" object. The "Advanced" tab is active, showing settings for the network type. The "Space type" is set to "Continuous". The "Width", "Height", "Columns", and "Rows" are all set to 500. The "Neighborhood type" is set to "Euclidean". The "Layout type" is set to "User-defined". The "Network" type is set to "Scale free", and a dropdown menu is open showing other options: "Random", "Ring lattice", "Small world", "Scale free" (selected), and "Distance based". The "Connections per node" is set to 10. The "Connection range" is set to "All". The "Neighbor link function" is set to "M".
- Console Pane (Bottom Left):** Shows a list of errors, including "Cannot make a static reference to the non-static method getState() of the class Person" and "The method getState() is undefined for the type Person".
- Model Canvas (Center):** Shows a grid with several objects, including "ImmunityDuration", "TotalPopulation", "AverageIllnessDuration", "ContactRatePerNetwork", "PerContactInfectionProb", and "nSusceptible".
- Toolbox (Far Right):** Contains various modeling tools such as "Line", "Polyline", "Curve", "Rectan...", "Round...", "Oval", "Arc", "Pixel", "Text", "Image", "Group", "Button", "Check...", "Edit Box", "Radio...", "Slider", "Comb...", "List Box", "File Ch...", "Progre...", "CAD D...", "GIS Map", "Connectiv...", and "Enterpris...".

The text "Select environment" is overlaid on the "environment" object in the Project pane.

# Interaction Between Network & Location 1

- For one type of networks (Distanced Based), whether there is a connection between A and B depends on the distance between A & B
  - This sets connectivity based on location considerations!

# Distance-Based Layout



# Property for Distance-Based Layout: Distance Threshold

The screenshot shows the 'environment - Environment' properties window in NetLogo. The 'Advanced' tab is selected, and the 'Distance based' network type is highlighted. The 'Apply on startup' checkbox is checked for the network type.

environment - Environment

General

Advanced

Description

Space type: ☒ Continuous ☐ Discrete ☐ GIS

Width: 500

Height: 500

Columns: 500

Rows: 500

Neighborhood type: Euclidean

Layout type: User-defined ☐ Apply on startup

Network: Distance based ☒ Apply on startup

Connections per agent: 20

Connection range: 100

Neighbor link fraction: 0.95

M: 5

# Random Connections

The screenshot shows the 'environment - Environment' dialog box in NetLogo. The 'General' tab is active. The 'Space type' is set to 'Continuous'. The 'Width', 'Height', 'Columns', and 'Rows' are all set to 500. The 'Neighborhood type' is set to 'Euclidean'. The 'Layout type' is set to 'User-defined'. The 'Network' is set to 'Random', which is highlighted with a yellow oval. The 'Apply on startup' checkbox is checked. The 'Connections per agent' is set to 5, 'Connection range' is 100, 'Neighbor link fraction' is 0.95, and 'M' is 5.

environment - Environment

General

Space type: ☒ Continuous ☐ Discrete ☐ GIS

Width: 500

Height: 500

Columns: 500

Rows: 500

Neighborhood type: Euclidean

Layout type: User-defined ☐ Apply on startup

Network: Random ☒ Apply on startup

Connections per agent: 5

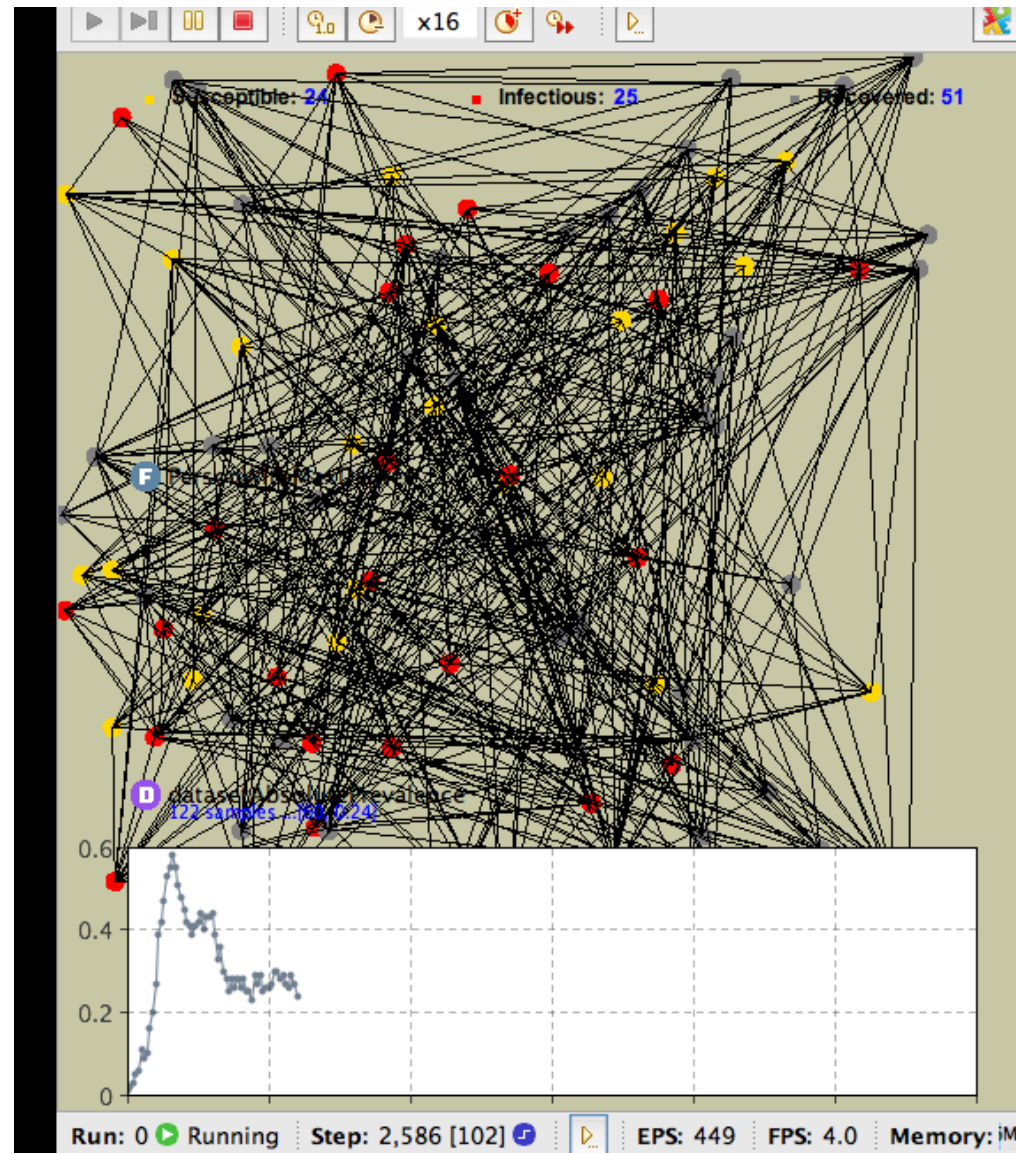
Connection range: 100

Neighbor link fraction: 0.95

M: 5



# With Random Connections



# Scale-Free Network

The screenshot shows the 'Properties' window for an 'environment' in NetLogo. The 'General' tab is selected. The 'Space type' is set to 'Continuous'. The 'Width', 'Height', 'Columns', and 'Rows' are all set to 500. The 'Neighborhood type' is set to 'Euclidean'. The 'Layout type' is set to 'User-defined'. The 'Network' is set to 'Scale free', which is highlighted with a yellow oval. The 'Apply on startup' checkbox is checked. The 'Connections per agent' is set to 5, 'Connection range' is 100, 'Neighbor link fraction' is 0.95, and 'M' is 5.

environment - Environment

General

Advanced

Description

Space type: ☒ Continuous ☐ Discrete ☐ GIS

Width: 500

Height: 500

Columns: 500

Rows: 500

Neighborhood type: Euclidean

Layout type: User-defined ☐ Apply on startup

Network: Scale free ☒ Apply on startup

Connections per agent: 5

Connection range: 100

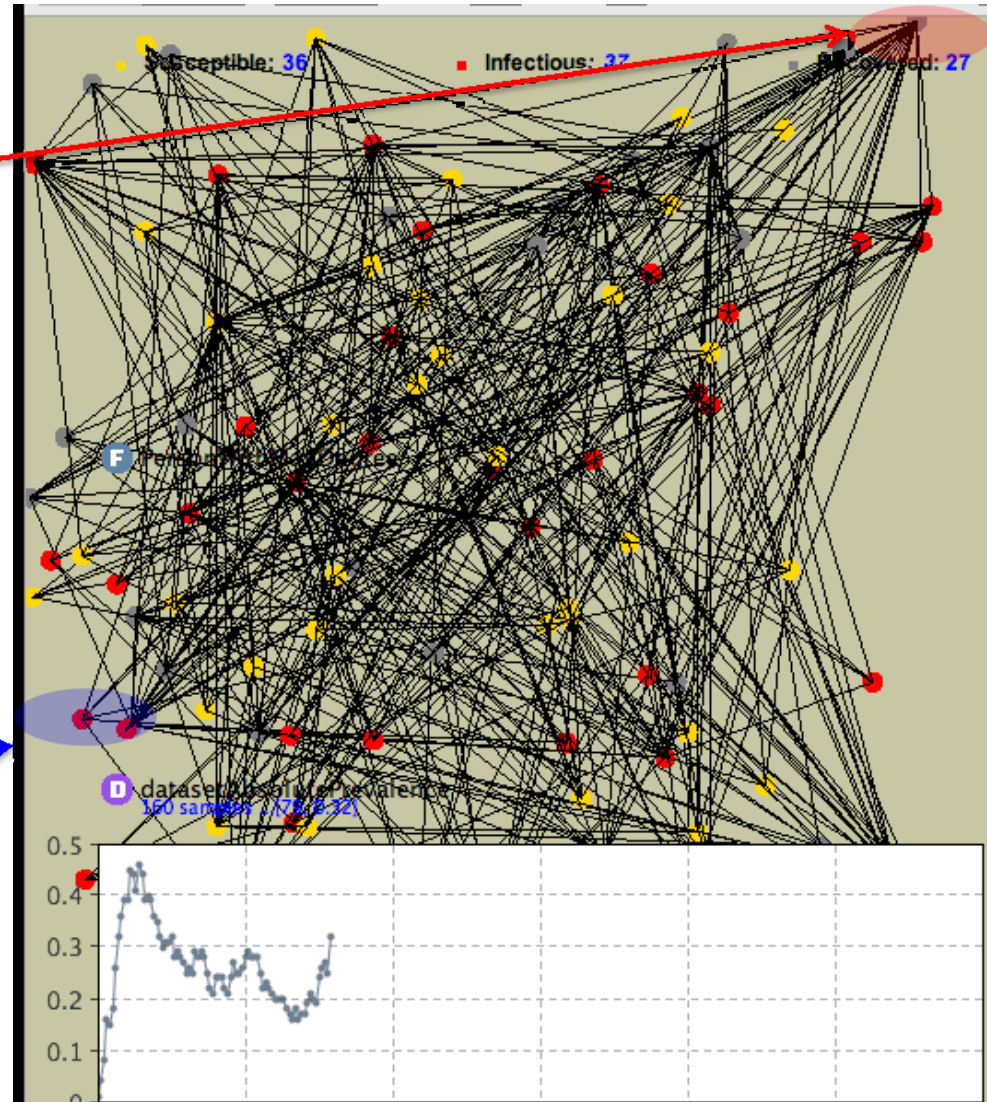
Neighbor link fraction: 0.95

M: 5



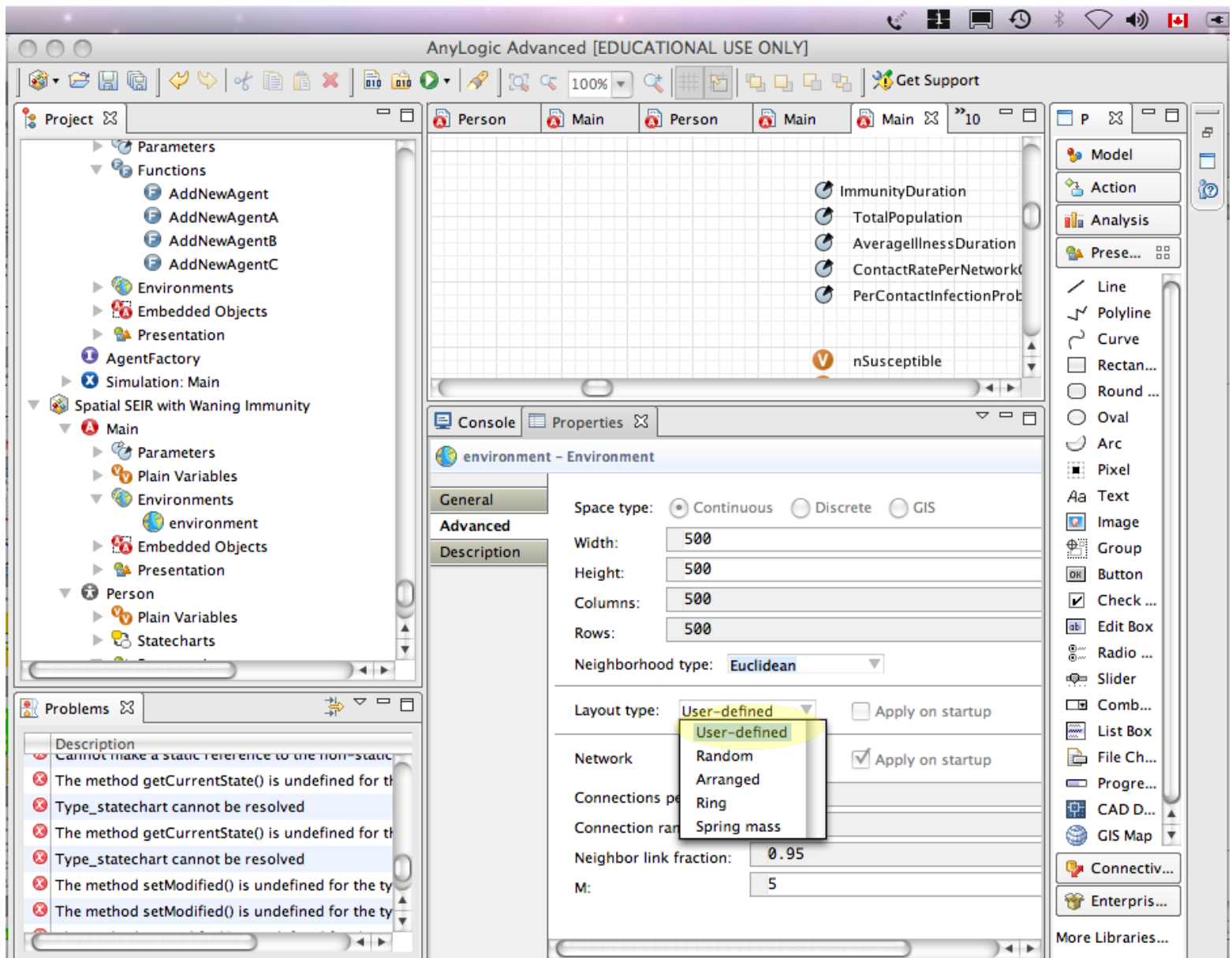
# Scale-Free Network

High degree node



Low degree node

# Layout Types



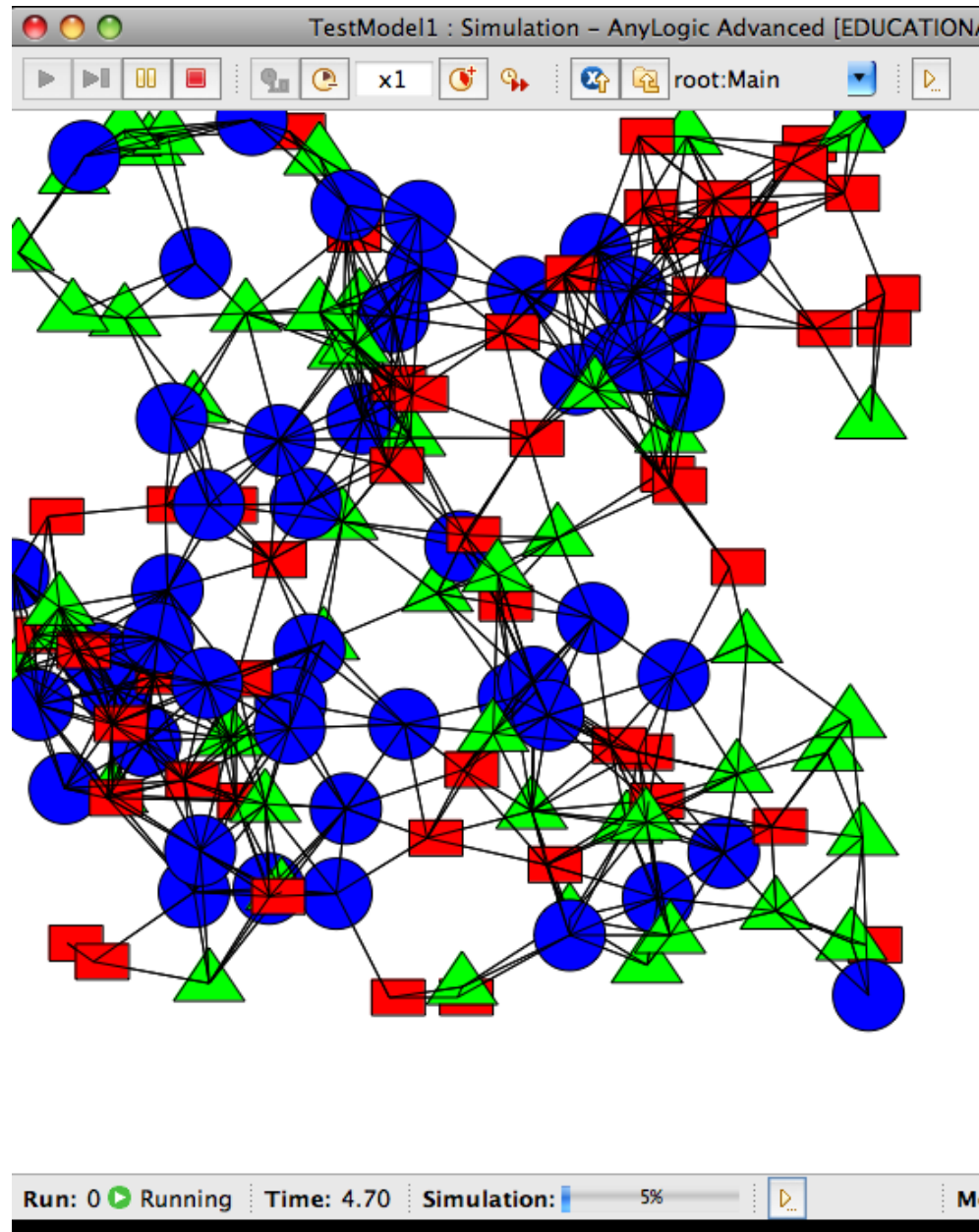
# Layout Type

- **Random:** Uniformly distribute X and Y position of nodes
- **Arranged:** Set node locations in a regular fashion (normally in a 2D grid)
- **Ring:** Set node locations in periodically spaced intervals around a ring shape
- **Spring Mass:** Adjust node locations such that node locations that are most tightly connected tend to be closer together
  - (Sets location based on network!)

# Interaction Between Network & Location 2

- In a Spring-mass layout, the nodes that are highly connected will tend to be clustered
- Here, we are determining the location based on the connectivity!

# Network with Multiple Agent Classes



# Realizing Multiple Agent Classes Sharing Same Network

- Create an agent superclass
- Create multiple subclasses of that superclass
  - In “Properties”
    - indicate that “Extends” superclass
    - Provide constructor to associate with agent population & Main class
- For the Agent population, use a replication of 0
- Create Startup code for “Main” that adds the various types of agents to the model
  - This uses code adopted from Java code output by build