

Individual- and Agent-Based Models: Introduction, Tradeoffs & Tools

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January 11, 2011

Complementary Model Types

- Static Models
 - Models help us understand connections between system components, but don't explicitly represent time
 - Aid reasoning about structure of system
- Dynamic models
 - Aid in understanding dynamic implications (consequences over time) of system structure & choices

Social Network Analysis

- Understanding structural relationship between parties
- Understanding how network position influences patterns of health
- Identifying highly influential or critical parties
- An important enabler for and “synergizer” with dynamic modeling
- (Dynamic extensions are possible)

Dynamic Models

- Simulation models represent hypothesized *causal relationships* between diverse factors
- Models provide a provide a way to examine diverse consequences of changes in one area of the system to the whole system
- Models help us and system actors to understand
 - System vulnerabilities, leverage points
 - Ways of fruitfully changing system structure
 - Improved ways of working together

Analogy: Other Simulators to Improve Performance & Lower Risk

- Pilot decision making: Flight simulators
- Climate policy: Climate simulators
- Process & power plants: Plant simulators
- Driver training: Vehicular simulators
- Street design & traffic flow regulation: Traffic simulators
- Construction coordination: Construction process simulators

Regularities Arise from Underlying *Processes*

- The time series shown are tightly interrelated, not independent
- Many of the features of the time series are driven by the same underlying processes
 - Natural history of infection
 - Demographic change of the population
 - Mechanisms of infection transmission
 - Risk behaviour & risk perception
 - Health system response
- Simulation seeks insight from characterizing *causal structure* of those processes

Understanding Intervention Impact ⇒
Seek to Understand *Causal* Relationships

- Progression of infection
- Immunity
- Response to treatment
- Mixing patterns (e.g. between communities)
- Intergenerational/social network mediated effects
 - Role modelling & Behavior change emulation
- Diversity in contact rates
- Strain interaction
- Diversity in symptoms

Simulation Models: Some Uses

- Make explicit mental models of causality, for discussion and collective refinement
- Assist in management of complex situations
 - Serve as “What if” tool for identifying desirable policies
 - Understand trends & help make sense of interaction of diverse information, processes
 - Prioritizing research/data collection & identifying inconsistencies
 - Understanding commonalities between contexts, infection spread
- Communication (e.g. “learning labs”)

Simulation Models as Dynamic Hypotheses

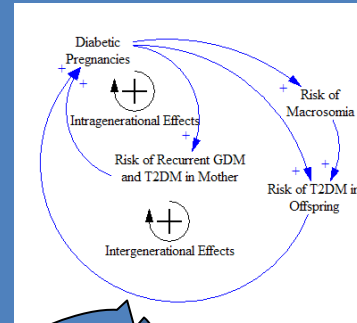
- Explaining drivers for trends or anticipating intervention impact requires understanding processes underlying observables
- A model represents a hypothesis regarding the possible causal interaction of diverse factors often studied in isolation
 - Operationally captures a hypothesis for “how the system works” at certain level of description
- Model parameters: Detailed assumptions for particular epidemiological contexts

Coevolution

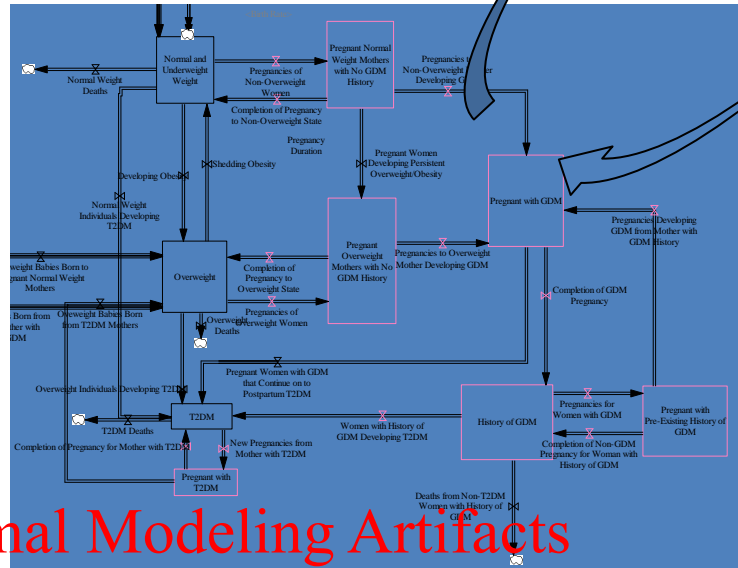
Observation/
Evaluation

External World

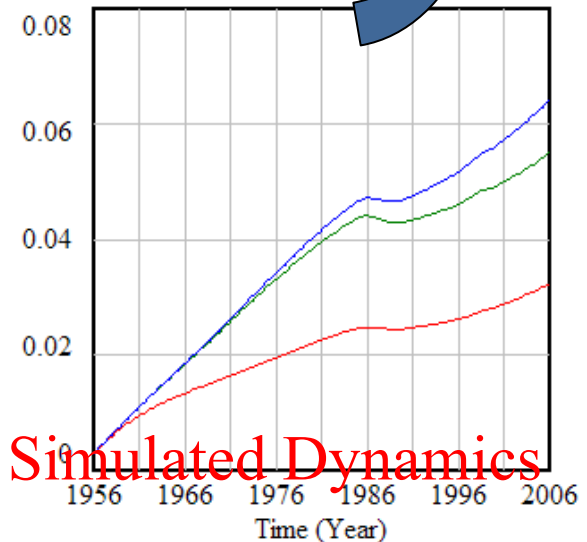
Actions & Choice of
Observations



Mental Model



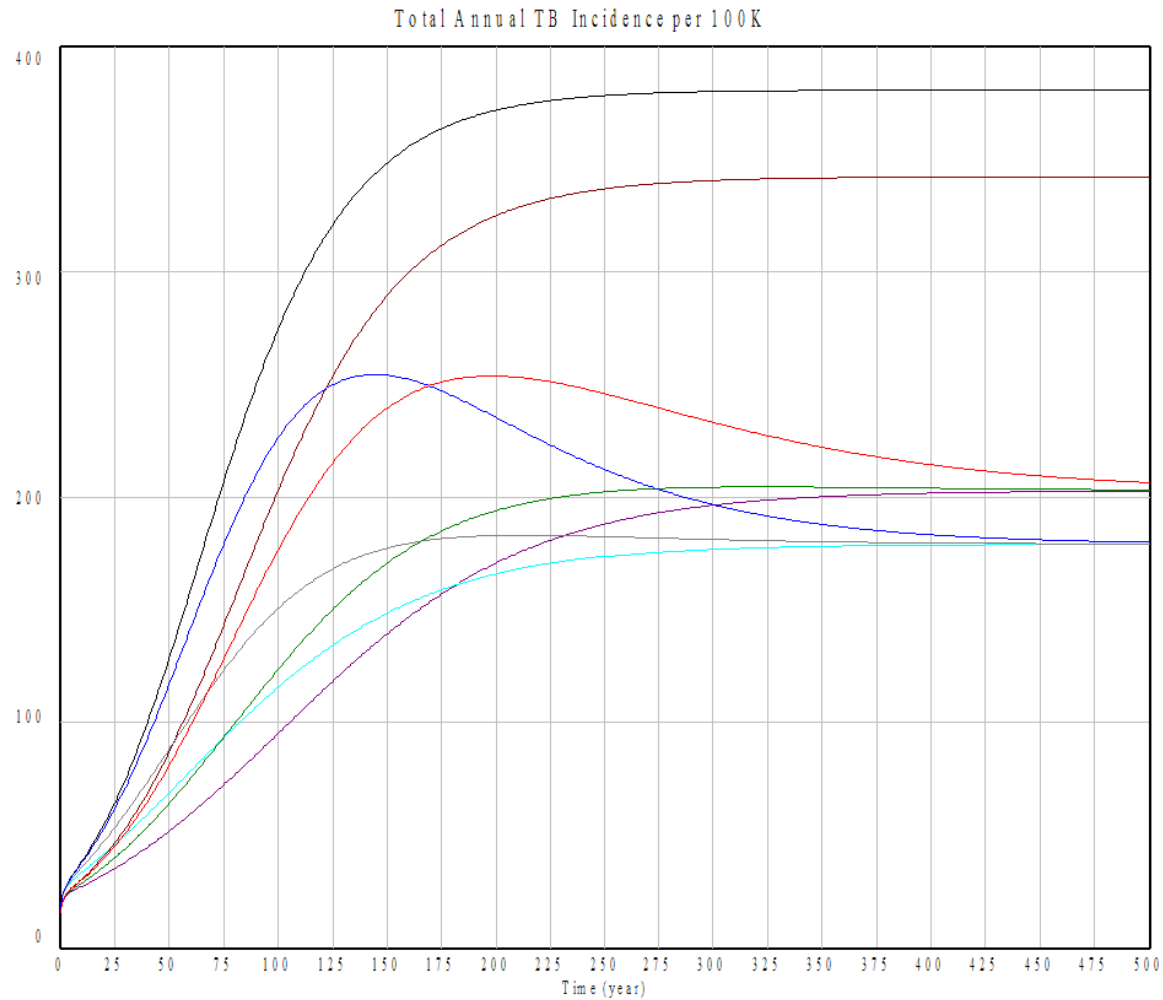
Fractional Prevalence of T2DM



Simulated Dynamics

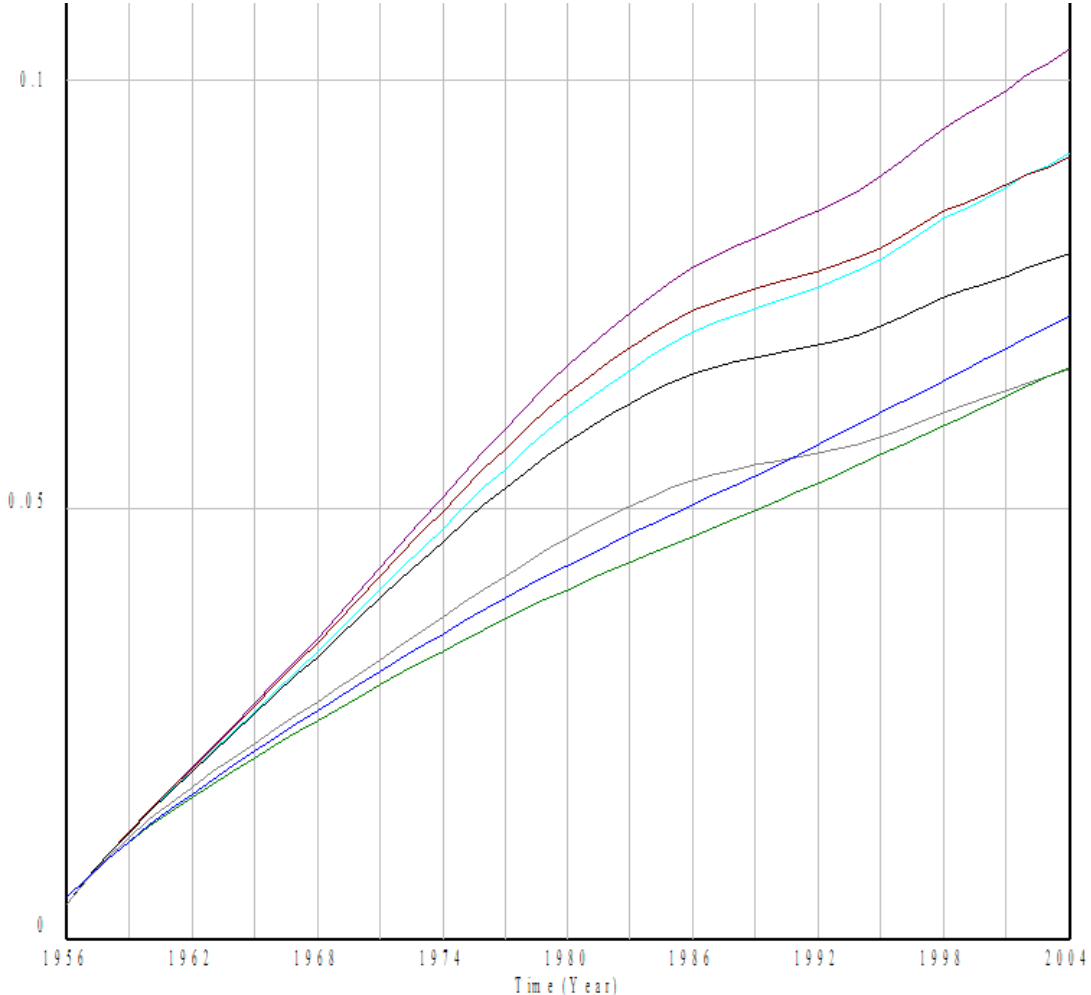
Formal Modeling Artifacts

Scenarios for Understanding How Does X affect System



Total Annual TB Incidence per 100K : 1x Standard Immigration T2DM
 Total Annual TB Incidence per 100K : 1x Standard Immigration No T2DM
 Total Annual TB Incidence per 100K : Half Standard Immigration No T2DM
 Total Annual TB Incidence per 100K : Half Standard Immigration T2DM
 Total Annual TB Incidence per 100K : No Immigration T2DM
 Total Annual TB Incidence per 100K : No Immigration No T2DM
 Total Annual TB Incidence per 100K : Standard Immigration T2DM
 Total Annual TB Incidence per 100K : Standard Immigration No T2DM

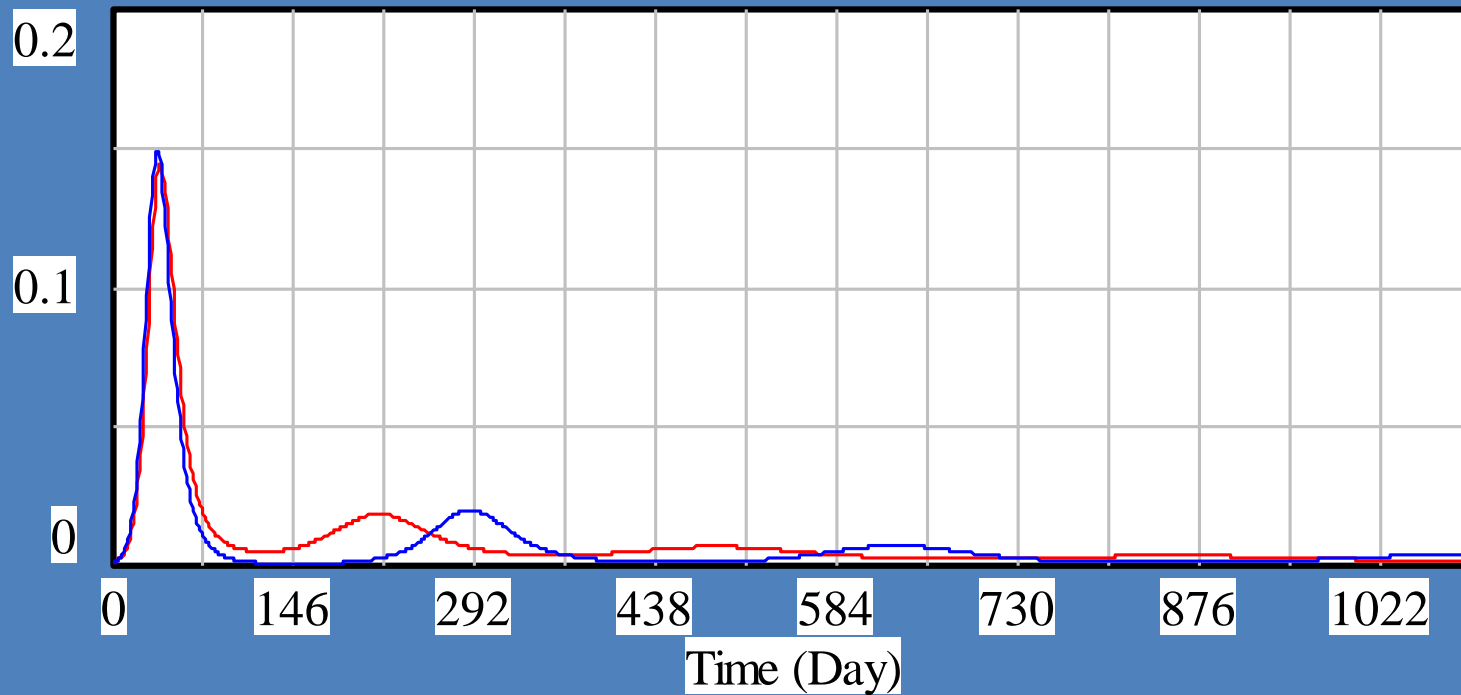
Policy Formulation & Evaluation



Fractional Prevalence of T1DM [Scenario] : Test 1971 GP 15% Controlled GDM T1DM
Fractional Prevalence of T1DM [Scenario] : Test 1971 GP with GDM
Fractional Prevalence of T1DM [Scenario] : Test 1971 GP no GDM
Fractional Prevalence of T1DM [Scenario] : Test 1971 AB No GDM
Fractional Prevalence of T1DM [Scenario] : Test 1971 AB No GDM or T1DM Effect on Child
Fractional Prevalence of T1DM [Scenario] : Test 1971 AB No T1DM Effect on Child
Fractional Prevalence of T1DM [Scenario] : Test 1971 AB No GDM Effect on Child
Fractional Prevalence of T1DM [Scenario] : Test 1971 AB 15% Controlled GDM T1DM

Model Can Be Used to Investigate Scenarios

Fractional Prevalence



Fractional Prevalence : Alternative SIR

Fractional Prevalence : Baseline SIR

Examples of Dynamic Modeling Approaches

- System Dynamics Modeling

- Feedback-centric modeling approach
- Focuses on feedbacks & accumulations
- Spans qualitative & quantitative methods
- Supports rich mathematical analysis
- Interactive model runs

- Agent-Based Modeling

- Captures interactions between individuals within populations
- Captures individual histories & trajectories
- Gracefully represents network connections
- Easier capturing of heterogeneity
- Detailed policy planning

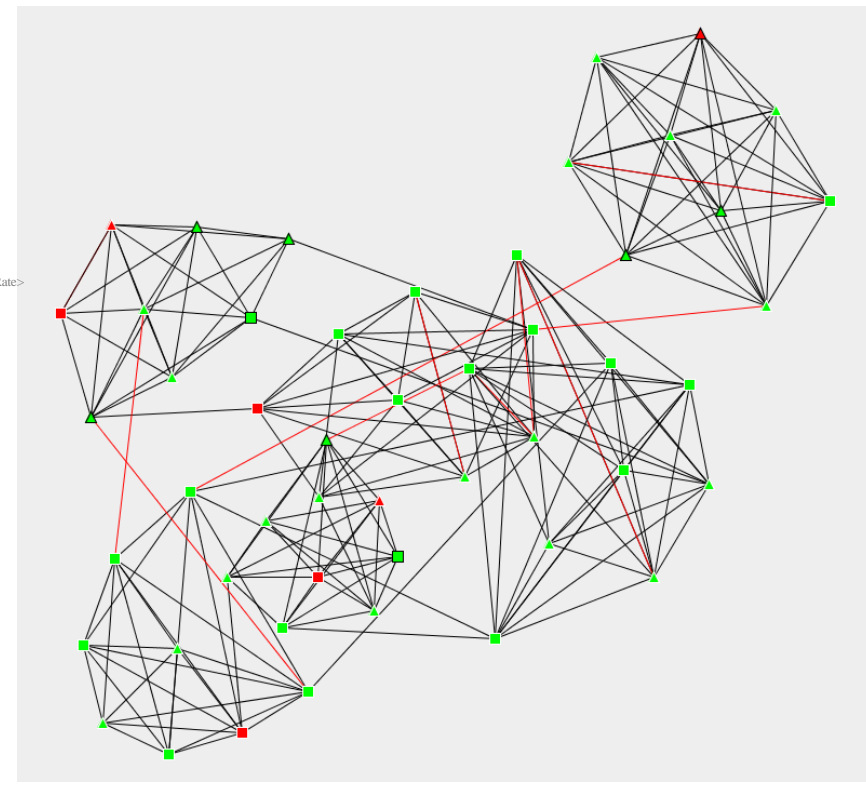
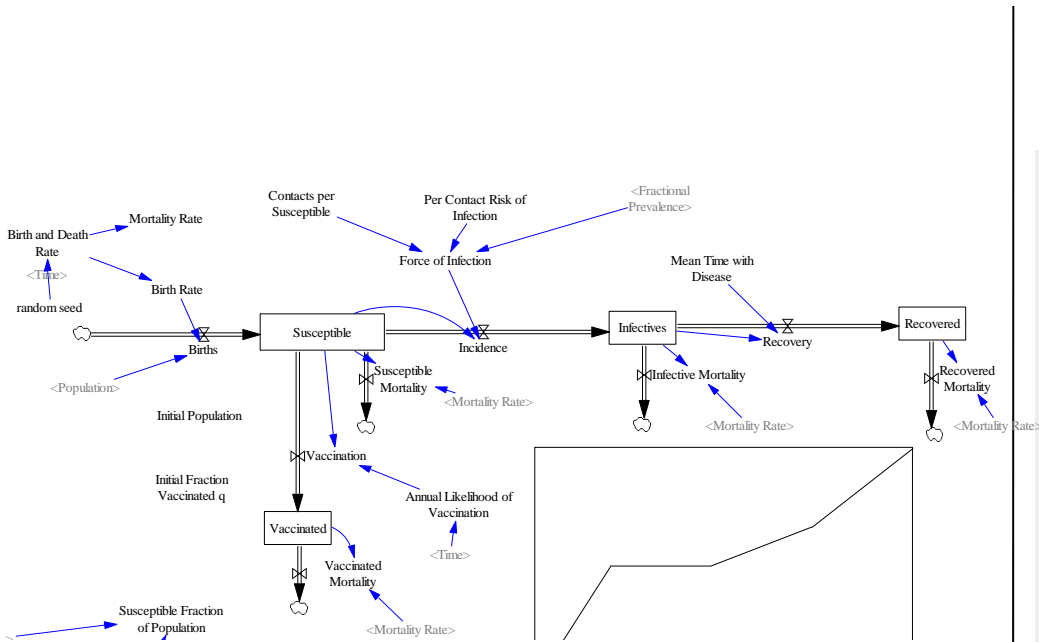
- **Discrete Event Simulation**

Simulates flow of individuals through processes
Captures resource use

Dynamic Models for Health

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

Contrasting Model Granularity



Key Needs Motivating Individual-Based Modeling

- Need to calibrate against information on **agent history**
- Need to capture **progression** of agents **along multiple pathways** (e.g. co-morbidities)
- Wish to characterize **learning by and/or memory** of agents based on experience, or **strong history dependence** in agents
- Need to capture distinct **localized perception** among agents
- Seeking to intervene at points in, change behavior on, explain phenomena over or explain dynamics **across networks**
- Seek **distinct interventions for many heterogenous categories**
- Need to **capture impact** of intervention across **many categories**
- When it is much simpler to **describe behavior at indiv. level**
- Seek **flexibility** in exploring different **heterogeneity dimensions**
- **Needs of stakeholders** to engage with individual-based models
- Want to describe behaviour at **multiple scales**

Agent-Based Modeling

- We can capture individuals in many ways
- I view Agent based models (ABM) as a type of individual-based modeling that encapsulates a given individual as a *software object* with
 - Methods
 - Properties
- Objects provide a convenient abstraction for individuals
- Agent-based models currently require writing at least some code in programming languages
- We can formulate SD models w/i agent-based tools
 - I view such models as simultaneously SD & ABM
- We can follow an SD process to build & use agent-based models

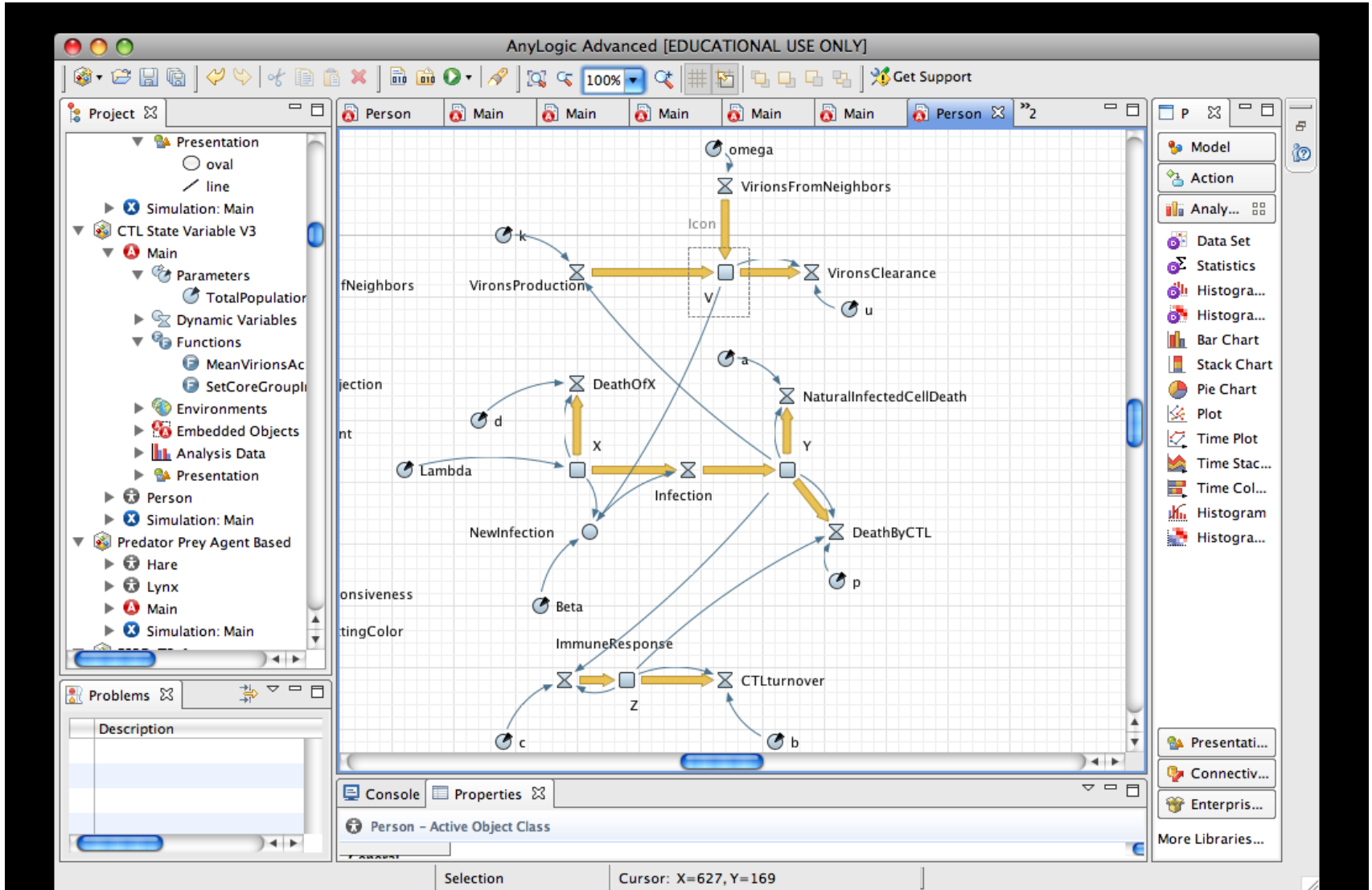
Agent-Based Systems

- Agent-based model characteristics
 - One or more populations composed of individual agents
 - Each agent is associated with some of the following
 - State (continuous or discrete e.g. age, health, smoking status, networks, beliefs)
 - Parameters (e.g. Gender, genetic composition, preference fn.)
 - Rules for interaction (traditionally specified in general purpose programming language)
 - Embedded in an environment (typically with localized perception)
 - Communicate via messaging and/or flows
 - Environment
- Emergent aggregate behavior

Elements of Individual State

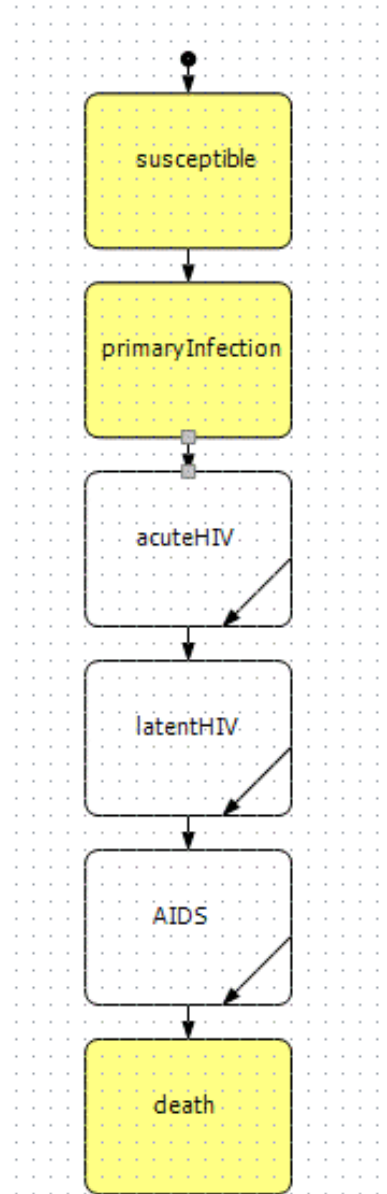
- Example Discrete
 - Ethnicity
 - Gender
 - Categorical infection status
- Continuous
 - Age
 - Elements of body composition
 - Metabolic rate
 - Past exposure to environmental factors
 - Glycemic Level

Example of Continuous Individual State

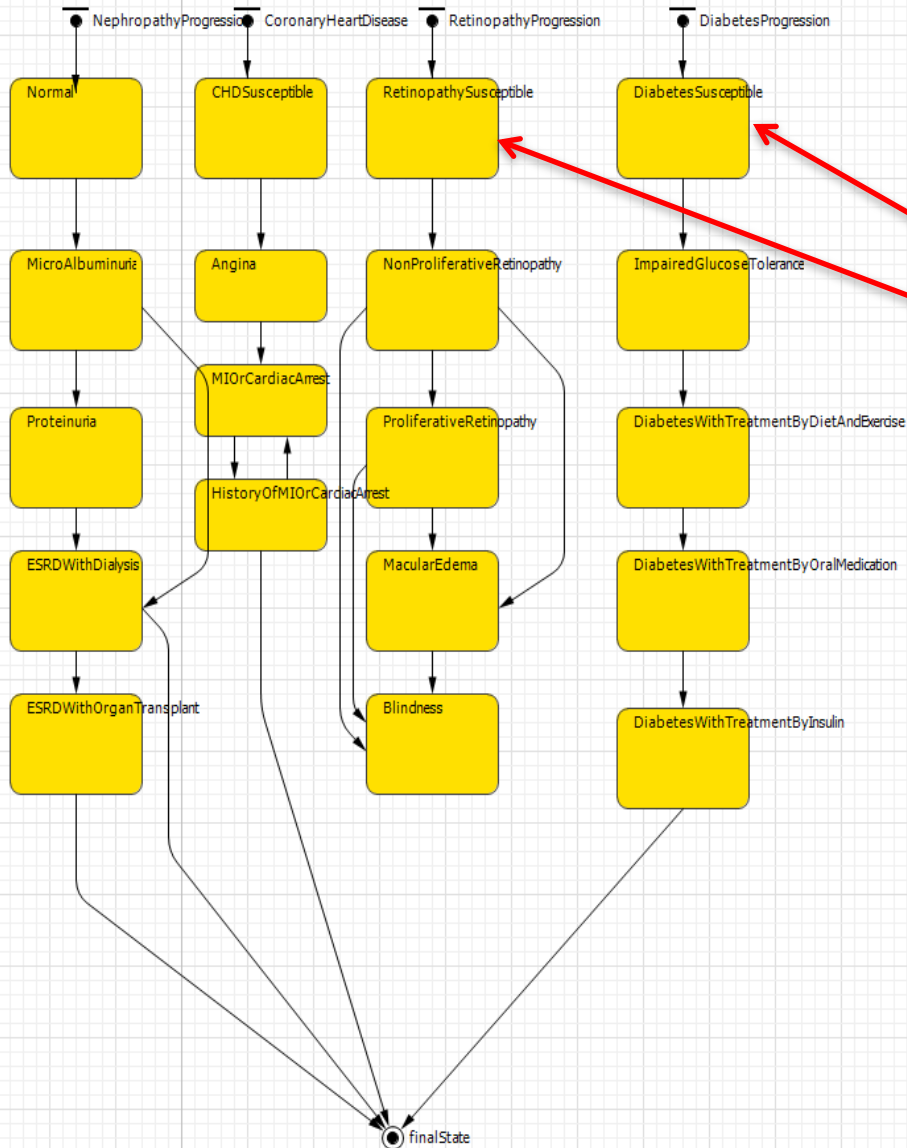


Example of Discrete States

Binary Presence in Discrete State



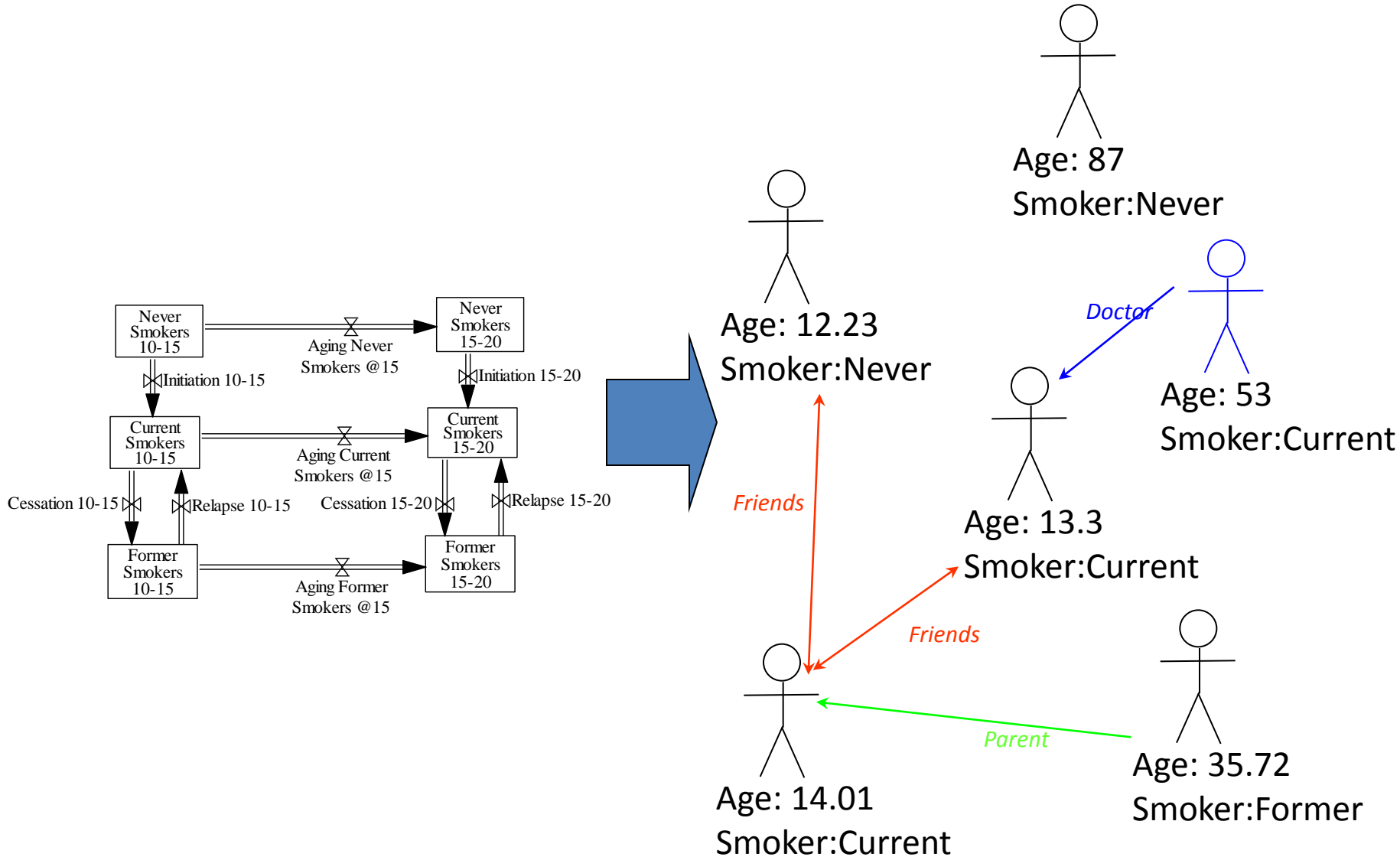
Parallel State Transition Diagrams



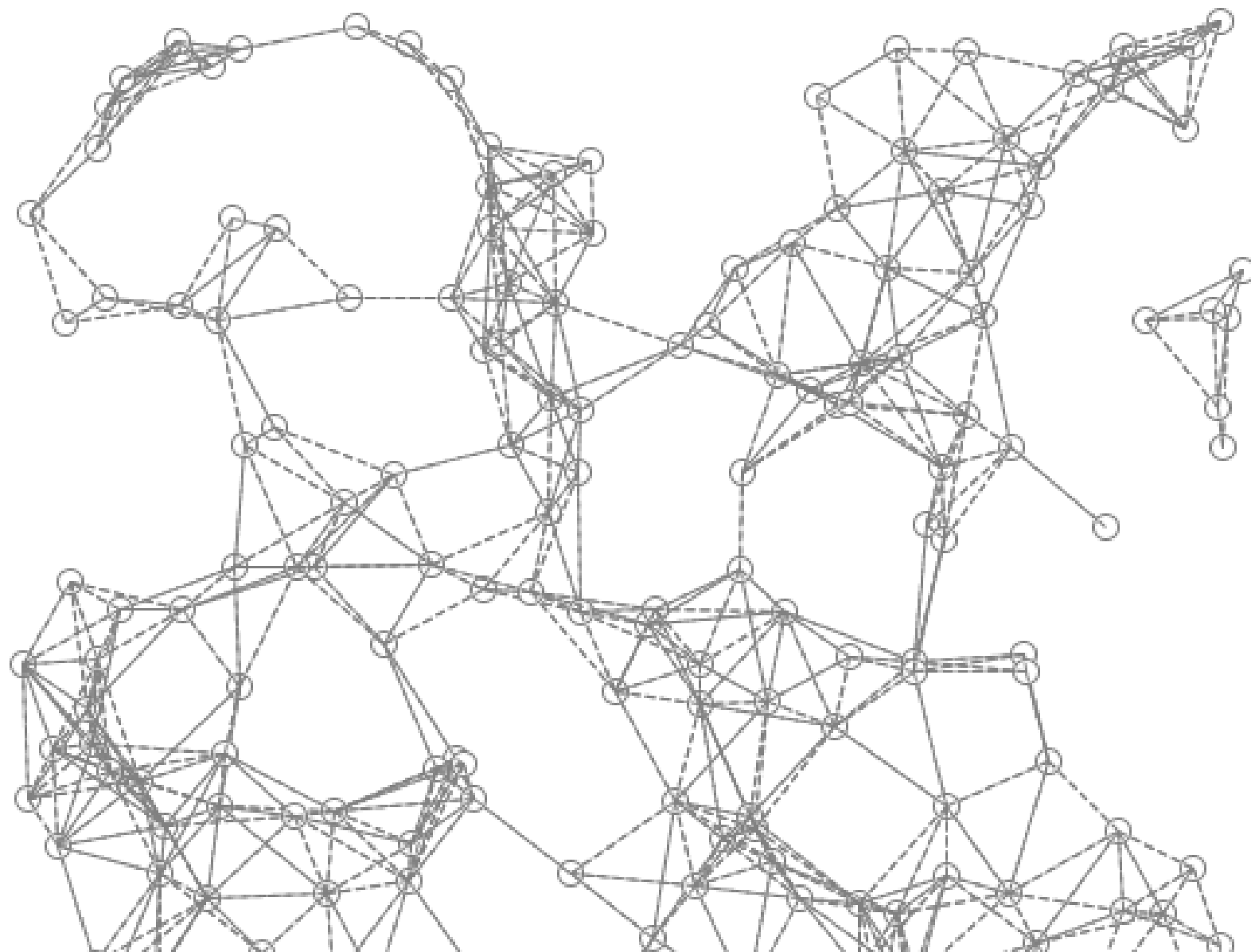
A person is in some particular state with respect to each of these (condition specific) state transition diagrams

This requires representing combinations of possibilities in an aggregate model

Interacting Individuals

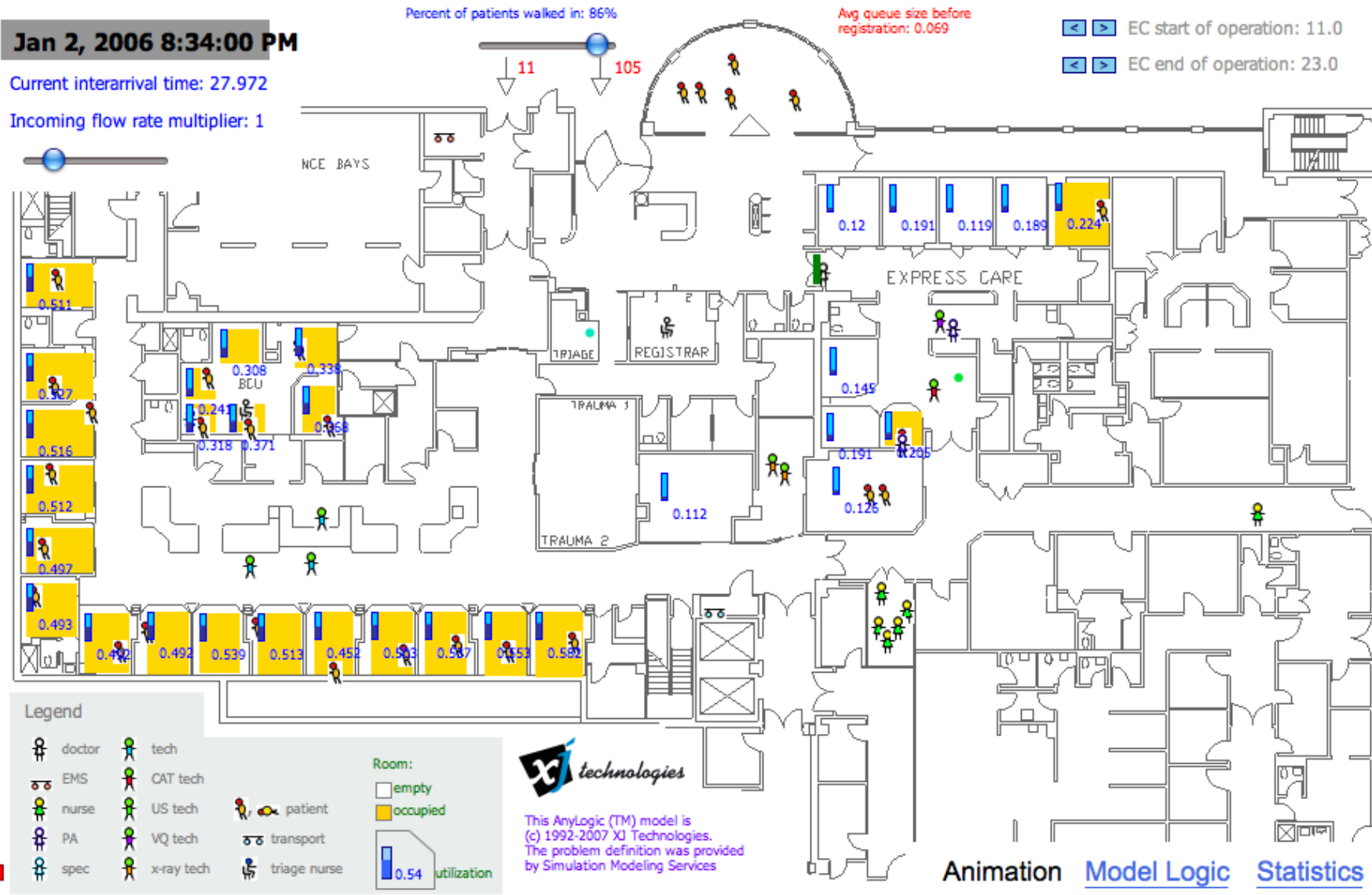


Network Embedded Individuals

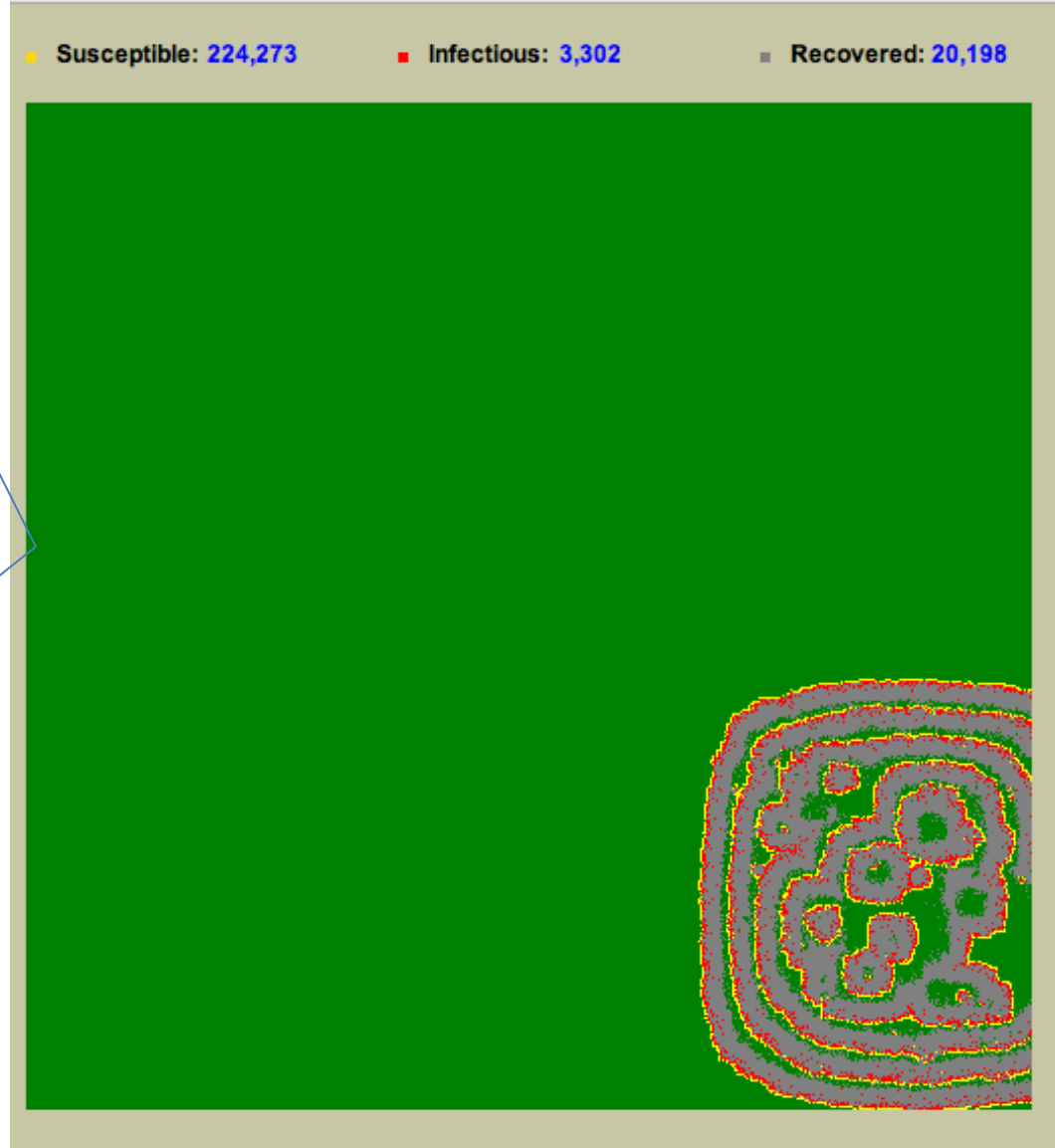
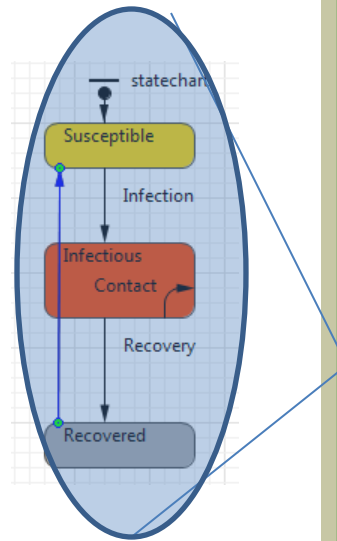


Irregular Spatial Embedding

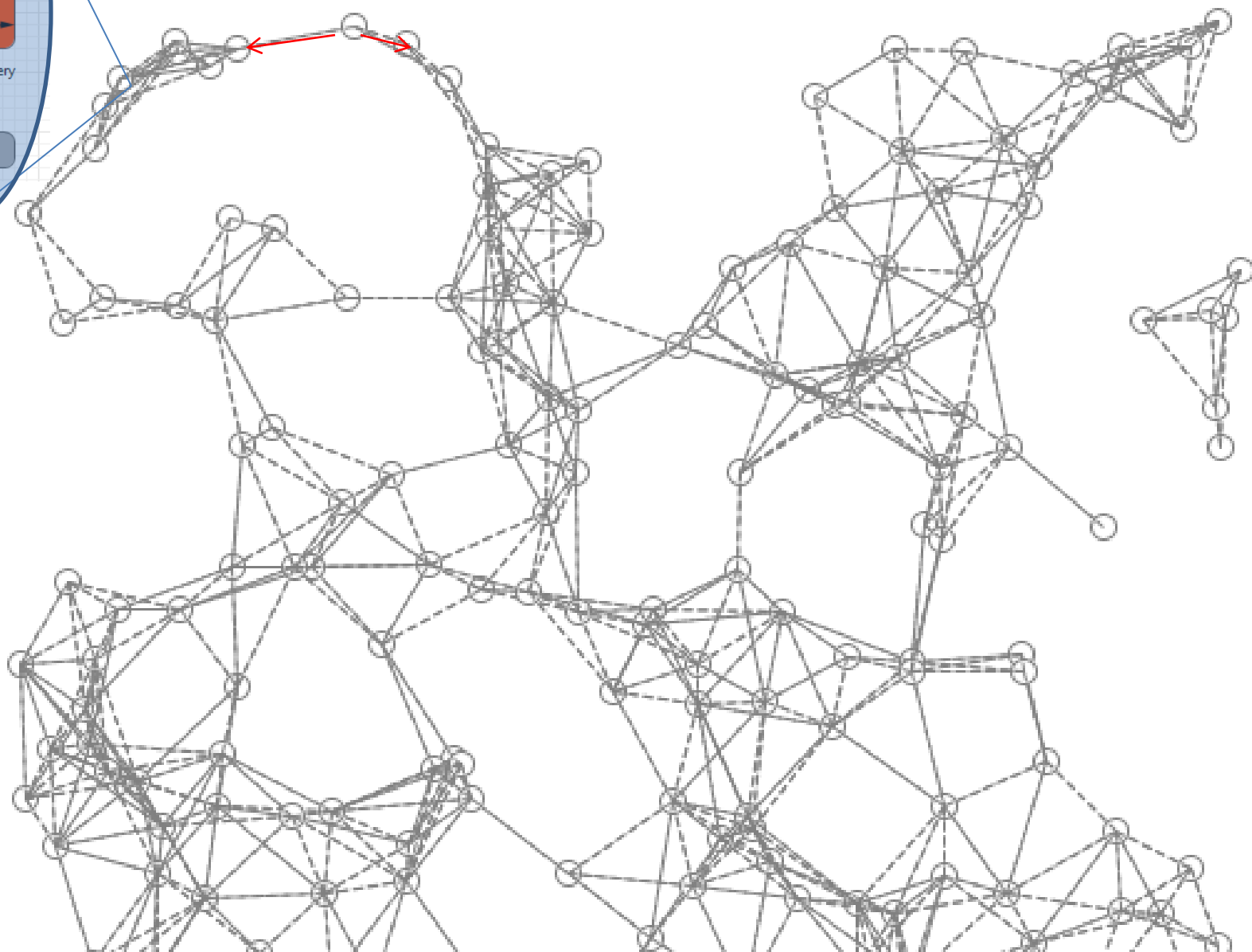
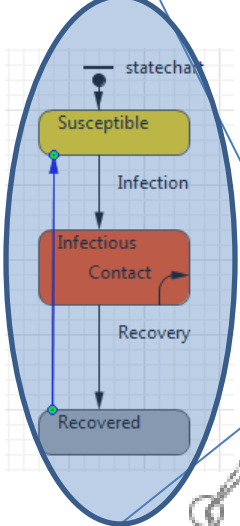
Emergency Department



Example of Emergence: Waves in Regular Spatial Embedding



Network Embedded Individuals



Dynamic Complexity: Oscillations (Damped & Otherwise)

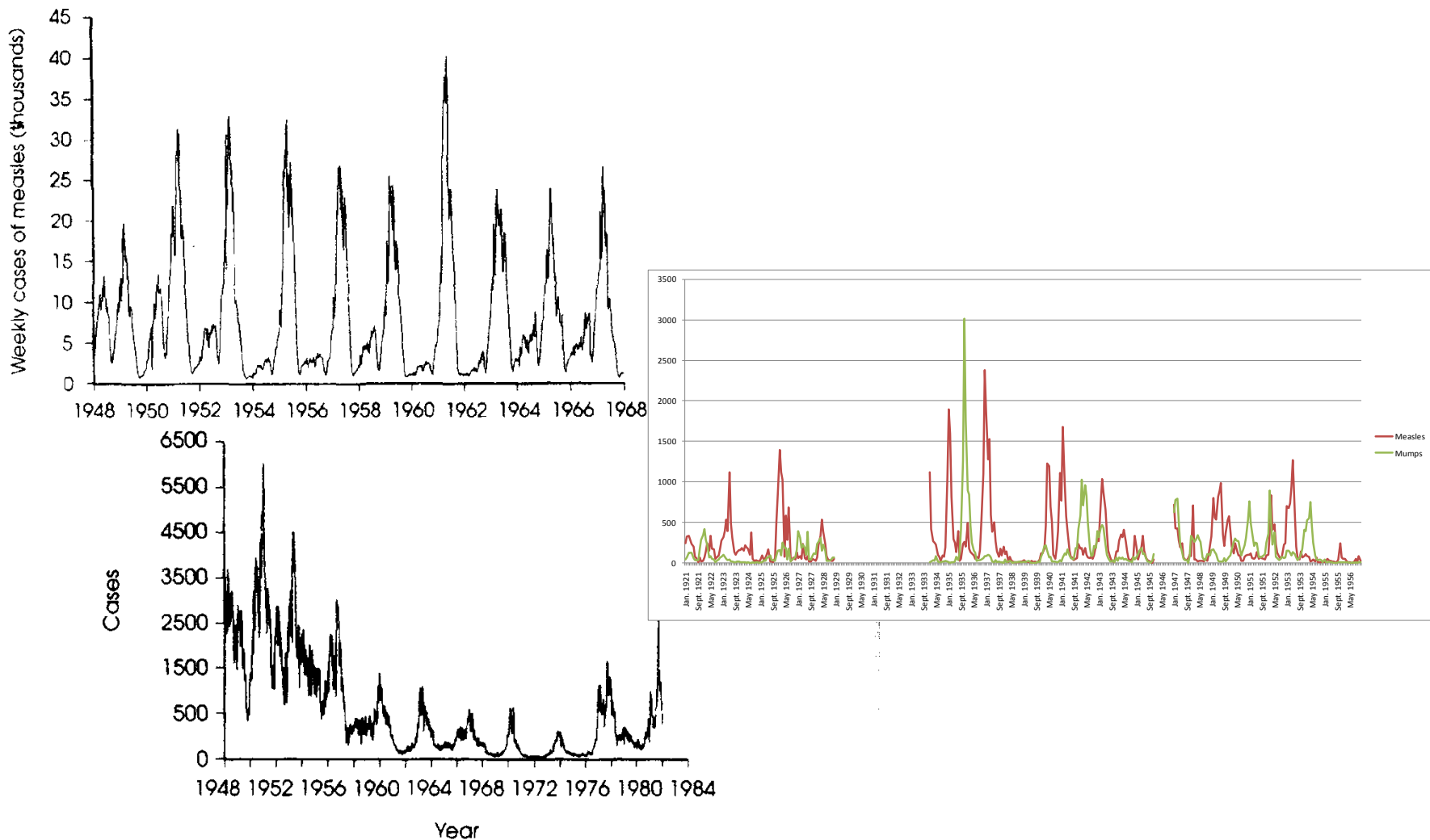


Fig. 6.8. Weekly case notifications of pertussis (whooping cough) in England and Wales for the time period 1948–82. Mass vaccination was introduced in 1956.

Emergence

- Interaction of very simple components can lead to surprising “emergent” dynamic patterns in the behaviour of a given component over time
- The patterns that are seen are quite different than what would be expected through any single component of the system
- These often relate to variables in the underlying system in complex ways

Observation & Change

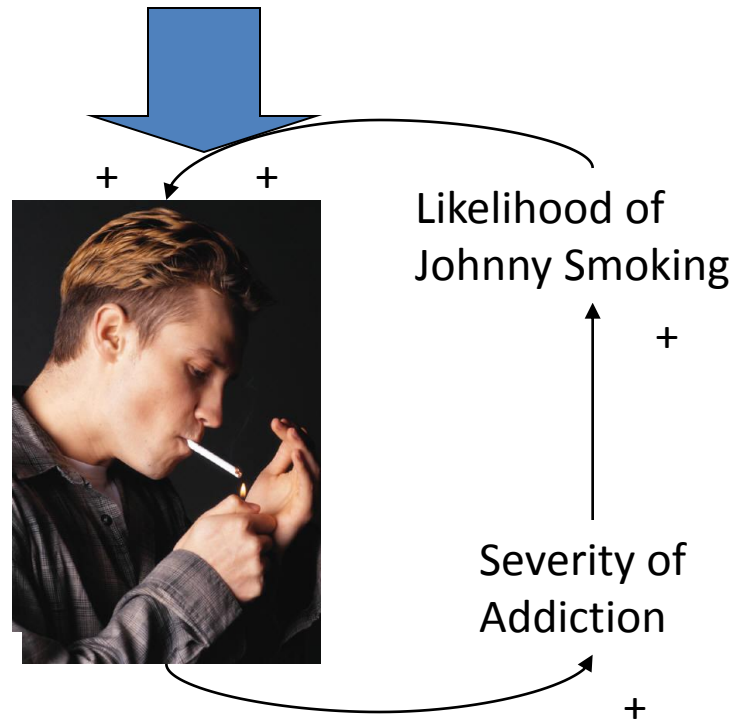
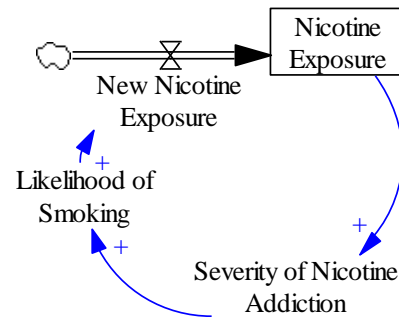
- What we observe most directly in the world are emergent properties of the system
- Changes to these emergent patterns must be accomplished by changing the underlying system
 - The emergent behaviours can change significantly with changes in model structure¶meter values
- Models help with understanding how
 - The emergent patterns reflect the characteristics of the underlying system
 - Changes in the underlying causal factors yield changes in the results

Emergent Behaviour & Modeling Types

- We see emergent behaviour in both System Dynamics and Agent-Based models
 - Agent-based models: Especially in interaction of multiple agents & higher level patterns of behaviour
 - System Dynamics: Especially in interaction of multiple stocks & flows
- Agent-based modeling particularly emphasizes multi-level emergence – how distinctive patterns can emerge at different levels of the system
 - Ability to look at high-level emergence reflects the presence of many individual agents within one model
- The emergent behaviours can change significantly with changes in model structure & parameter values

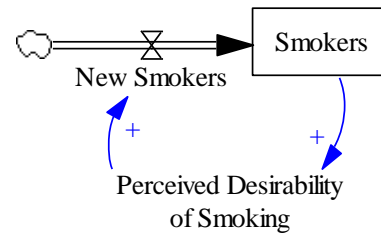
Feedbacks

- 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

Johnny
Smoking



Timmy's
Perception
Of Desirability
Of Smoking



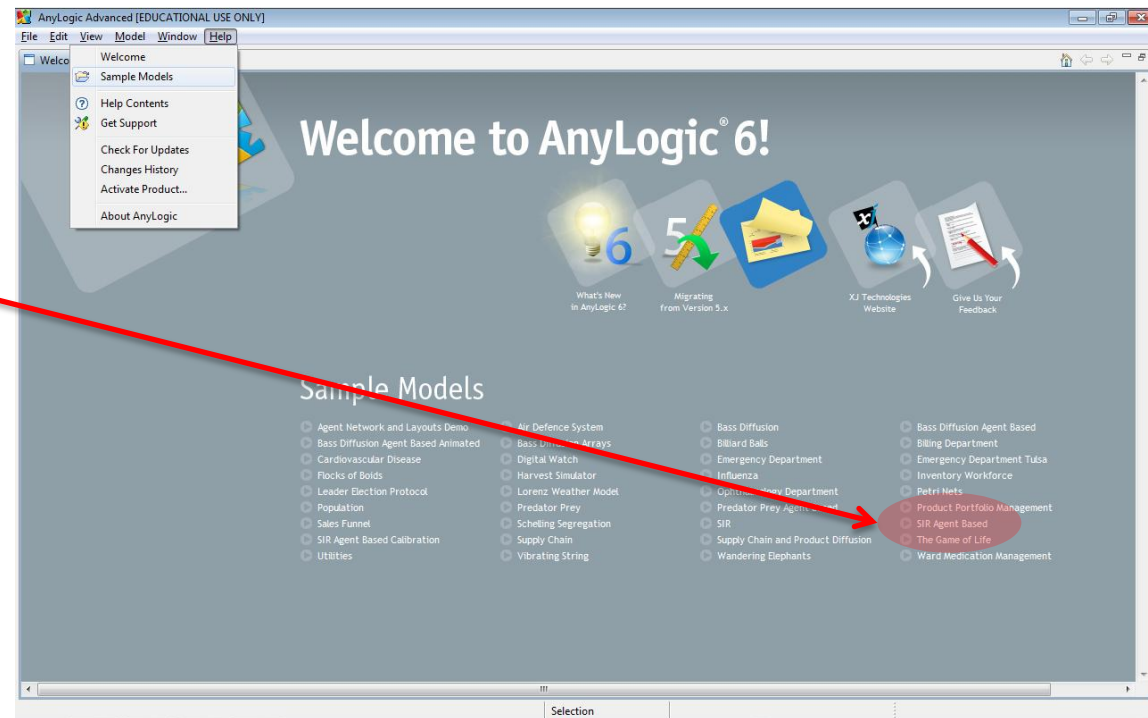
Agent-Based Model

Limitations of Agent-Based Methods

- Inability to mathematically analyze & generalize behaviour beyond a single run
- Long ensemble run times \Rightarrow lack of interactivity, opportunity cost
- Calibrating yields no unique interpretation
- Requirement of some software engineering in building, modifying
- Achieving model transparency is difficulty
- Lack of defined modeling process or qualitative modeling artifacts

Hands on Model Use Ahead: First Glimpse of Agent-Based Modeling

“SIR Agent-Based” is Located here



Load model: SIR Agent-Based from AnyLogic Sample Models (via “Help” menu)

Viewing the Model Structure

Double click on "Person" to see the associated state transition diagram

The screenshot displays the AnyLogic Advanced [EDUCATIONAL USE ONLY] interface. The main window shows a statechart for the 'Person' agent, which is highlighted with a blue oval. The statechart consists of four states: 'Susceptible' (yellow), 'Infectious Contact' (red), 'Recovered' (grey), and 'Recovered' (grey). Transitions are labeled 'Infection' and 'Recovery'. A red arrow points from the text 'Double click on "Person"' to the 'Person' folder in the Project Explorer. A blue arrow points from the text 'to see the associated state transition diagram' to the statechart.

The Project Explorer on the left shows the model structure:

- SIR Agent Based
 - Main
 - Person
 - Simulation: Main

The Properties window at the bottom shows the 'Person - Active Object Class' configuration:

- Name: Person
- Ignore:
- Agent: Agent Generic
- Startup Code:
- Destroy Code:

The Palette on the right lists various model elements:

- Model
 - Parameter
 - Flow Aux Variable
 - Stock Variable
 - Event
 - Dynamic Event
 - Plain Variable
 - Collection Variable
 - Function
 - Table Function
 - Port
 - Connector
 - Entry Point
 - State
 - Transition
 - Initial State Pointer
 - Branch
 - History State
 - Final State
 - Environment
- Action
- Analysis
- Presentation
- Connectivity
- Enterprise Library
- More Libraries...

Press this button to start model execution

The screenshot displays the AnyLogic software interface for an SIR model simulation. The main window is titled "SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]". The simulation area shows three states: "Susceptible" (yellow), "Infectious" (red), and "Recovered" (grey). A red arrow points to a button labeled "Run the model and switch to Main view" located below the "Infectious" state. The statechart area on the right shows a grid with various model elements. The bottom status bar indicates the simulation is in "Idle" mode, with "Step: 0 [0]", "EPS: 0", "FPS: 0.0", and "Memory: 7M of 297M".

Example of Emergent Behaviour

The screenshot displays the AnyLogic simulation environment. The main window, titled "SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]", shows a simulation in progress. At the top, the status bar indicates the following counts: Susceptible: 236,782 (yellow dot), Infectious: 6,167 (red dot), and Recovered: 7,051 (grey dot). The simulation area is a large yellow rectangle representing the susceptible population. In the bottom right corner, a dense, circular cluster of red and grey dots represents the infectious and recovered populations, respectively, illustrating emergent behavior. The interface includes a toolbar with various simulation controls, a palette on the right with categories like Model, Action, Analysis, Presentation, Connectivity, and Enterprise Library, and a status bar at the bottom showing "Run: 0 Running", "Step: 687,896 [14,322]", "EPS: 247,415", "FPS: 1.0", and "Memory: 1 of 297".

Make Sure Model Time is Visible

SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]

■ Susceptible: 193,137 ■ Infectious: 9,635 ■ Recovered: 47,228

statechart

```
graph TD; Start(( )) --> Susceptible; Susceptible -- Infection --> InfectiousContact; InfectiousContact -- Recovery --> Recovered; InfectiousContact --> InfectiousContact;
```

Run: 0 Running Step: 2,922,431 [19,269] EPS: 218,350 FPS: 0.0 Memory: 4 of 297M

If no model time is visible on the bottom of the window, press **this button** to add a “model time” output

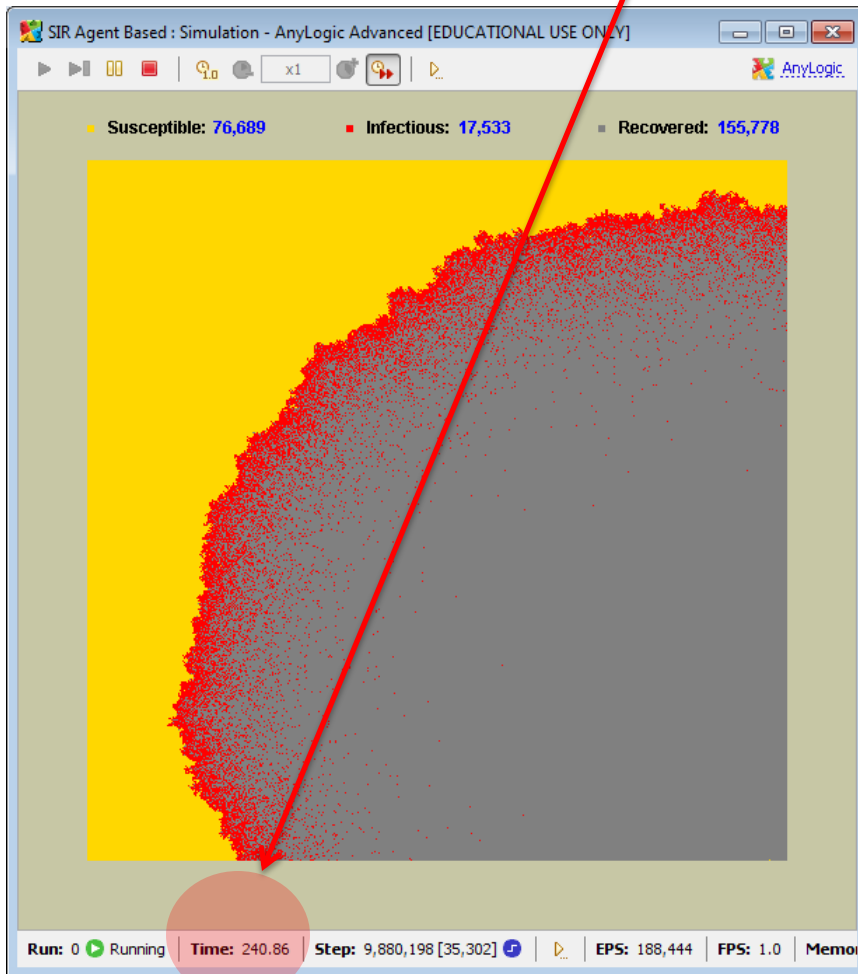
Select "Model Time" here (so a check mark appears)
(If a checkmark is already present, just click back on the

output window)

The screenshot shows the AnyLogic simulation interface. At the top, it displays the status of the simulation: Susceptible: 166,449, Infectious: 11,499, and Recovered: 72,052. Below this is a large graph with a yellow background and a red, irregularly shaped area representing the population distribution. A red arrow points from the text above to the 'Model time' option in a settings menu that is open at the bottom of the graph. The menu includes options like Status, Model time, Model step, Experiment, Simulation, Model date, Events per second, Frames per second, Memory, and Real time. The 'Model time' option is currently unchecked. At the bottom of the window, it shows 'Run: 0 Running' and 'Step: 4,656,702 [23,534]'. The system tray at the very bottom shows 'Slide 16 of 56', 'Office Theme', and 'English (Canada)'.

The screenshot shows a Microsoft PowerPoint window titled 'Modeling, What and Why.pptx'. The ribbon is set to 'Drawing' and includes options like 'Text Direction', 'Align Text', 'Convert to SmartArt', 'Paragraph', 'Drawing', 'Shape Fill', 'Shape Outline', 'Shape Effects', 'Find', 'Replace', and 'Select'. The main slide area is a white grid with a blue background. It contains a title placeholder 'Click to add title' and a text placeholder 'Click to add text'. Below the text placeholder are several icons representing different content types: a calendar, a folder, a document, a photo, a video, and a film strip. The system tray at the bottom shows '50%' zoom level and other standard icons.

The Updated Window Should Include a Model Time Output



Click to add title

Click to add text

Click to add notes

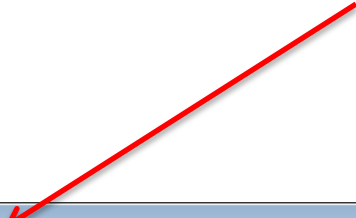
Slide 16 of 56 Office Theme English (Canada) 50%

The figure shows a Microsoft PowerPoint slide with a simulation window embedded. The slide has a blue background and a grid. The simulation window is titled 'SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]' and shows the same SIR model statistics and spatial plot as the first figure. A red arrow points from the text 'Model Time Output' to the 'Time: 240.86' value in the status bar. The status bar at the bottom of the slide shows 'Slide 16 of 56', 'Office Theme', 'English (Canada)', and '50%'.

Stylized Measurement 1

- How Long Does it Take for The Infection to Reach the Top or Left Boundaries?
- We'll compare this to the situation with other parameter assumptions

Press this button to stop model execution



SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]

Terminate execution

- Susceptible: 108,303
- Infectious: 15,284
- Recovered: 126,213

Run: 0 Running Step: 8,209,157 [31,847] EPS: 378,072 FPS: 1.0 Memory: 9M of 297M

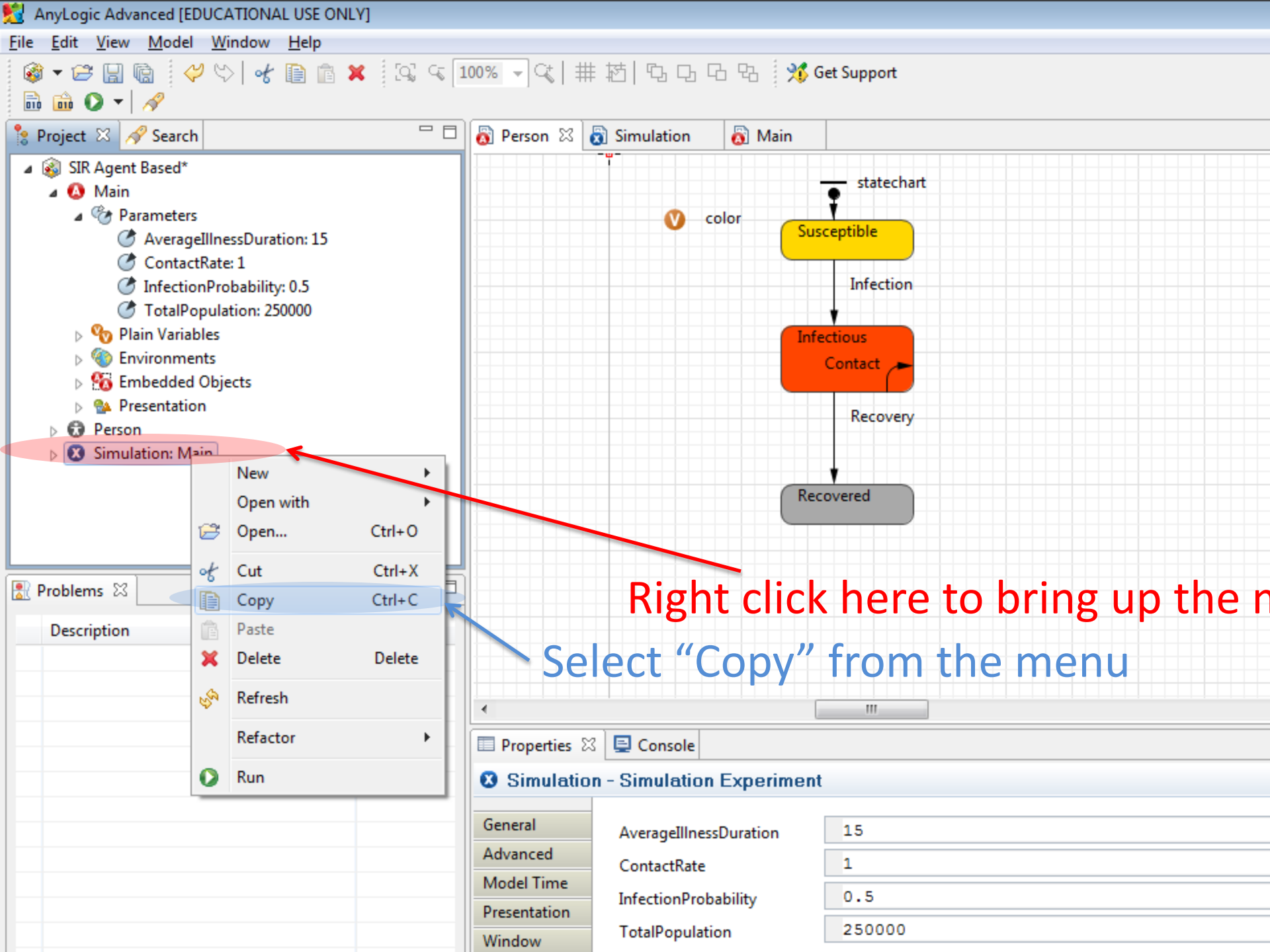
Microsoft PowerPoint

Developer Nuance OCR Acrobat Format

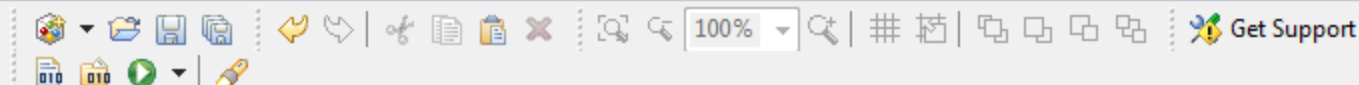
Paragraph Drawing Editing

on to start model

Run: 0 Idle Time: 0.00 Simulation: Stop time not set Memory: 7M of 63M 0.0 sec



Right click here to bring up the menu
Select "Copy" from the menu



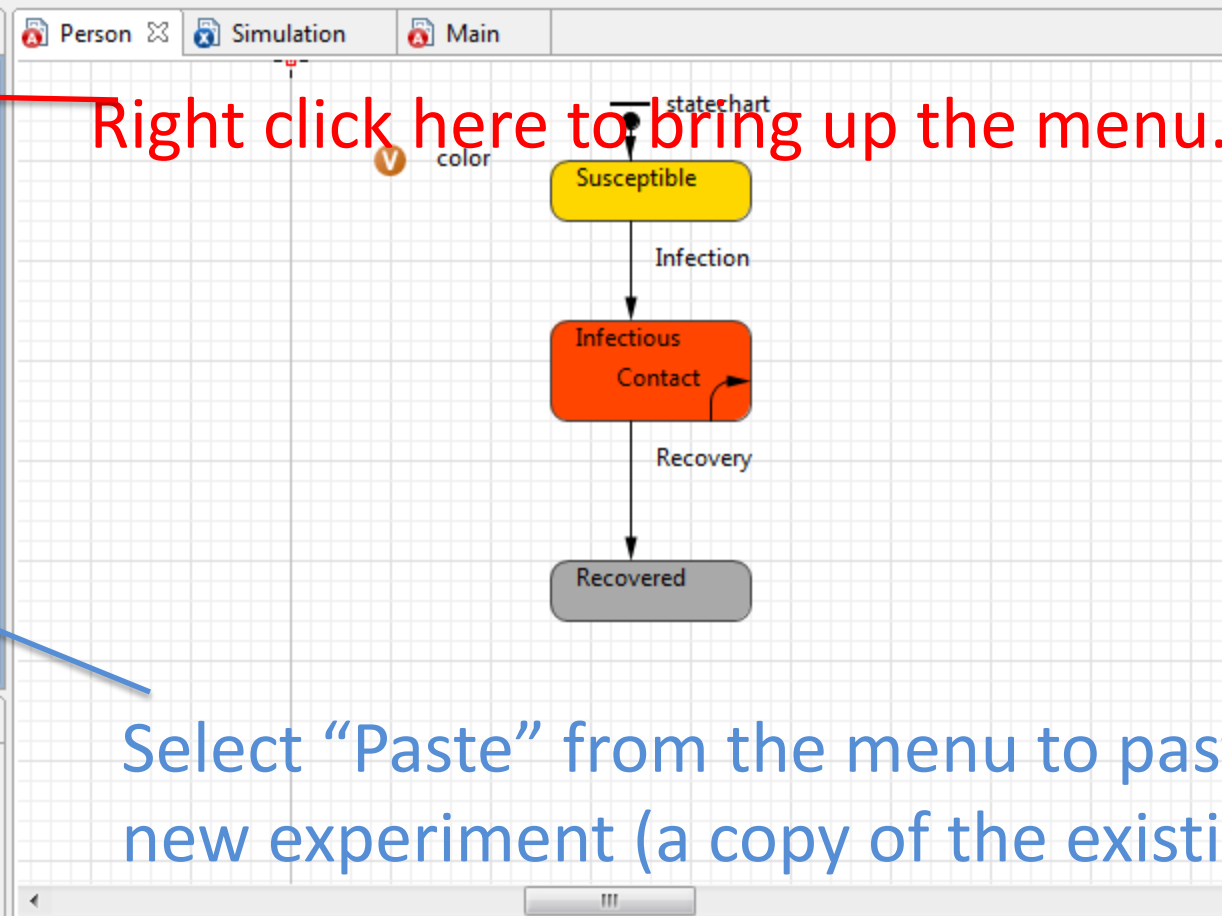
Project Search

- SIR Age
- Ma
- Sim

File menu:

- New
- Open... Ctrl+O
- Save Ctrl+S
- Save As...
- Revert
- Close
- Close Others
- Close All
- Cut Ctrl+X
- Copy Ctrl+C
- Paste
- Delete Delete
- Refresh
- Build F7
- Export...
- Team

Right click here to bring up the menu.



Select "Paste" from the menu to pas
new experiment (a copy of the existi

Properties Console

SIR Agent Based - Model

General

Name: SIR Agent Based

Dependencies

Description

Package: sir_agent_based

File: C:\Program Files (x86)\AnyLogic 6\plugins\com.xj.anylogic.examples_6.2.2.200806

Your Screen Should Look as Follows

The screenshot displays the AnyLogic Advanced software interface, titled "AnyLogic Advanced [EDUCATIONAL USE ONLY]". The main workspace shows a statechart for a "Person" agent. The statechart starts at a "statechart" entry point, leading to a yellow "Susceptible" state. A transition labeled "Infection" leads to an orange "Infectious" state, which also includes a "Contact" sub-state. A transition labeled "Recovery" leads to a grey "Recovered" state. A "color" variable is also visible in the workspace.

The interface includes several panels:

- Project:** Shows a tree view for "SIR Agent Based*" with sub-items like "Main", "Parameters", "Plain Variables", "Environments", "Embedded Objects", "Presentation", "Person", "Simulation: Main", and "Simulation1: Main".
- Palette:** Lists various modeling elements such as "Parameter", "Flow Aux Variable", "Stock Variable", "Event", "Dynamic Event", "Plain Variable", "Collection Variable", "Function", "Table Function", "Port", "Connector", "Entry Point", "State", "Transition", "Initial State Pointer", "Branch", "History State", "Final State", and "Environment".
- Problems:** A table with columns "Description" and "Location".
- Properties and Console:** Panels for viewing agent properties and simulation output.

At the bottom left, it indicates "0 items selected".

Changing the Name of the Experiment

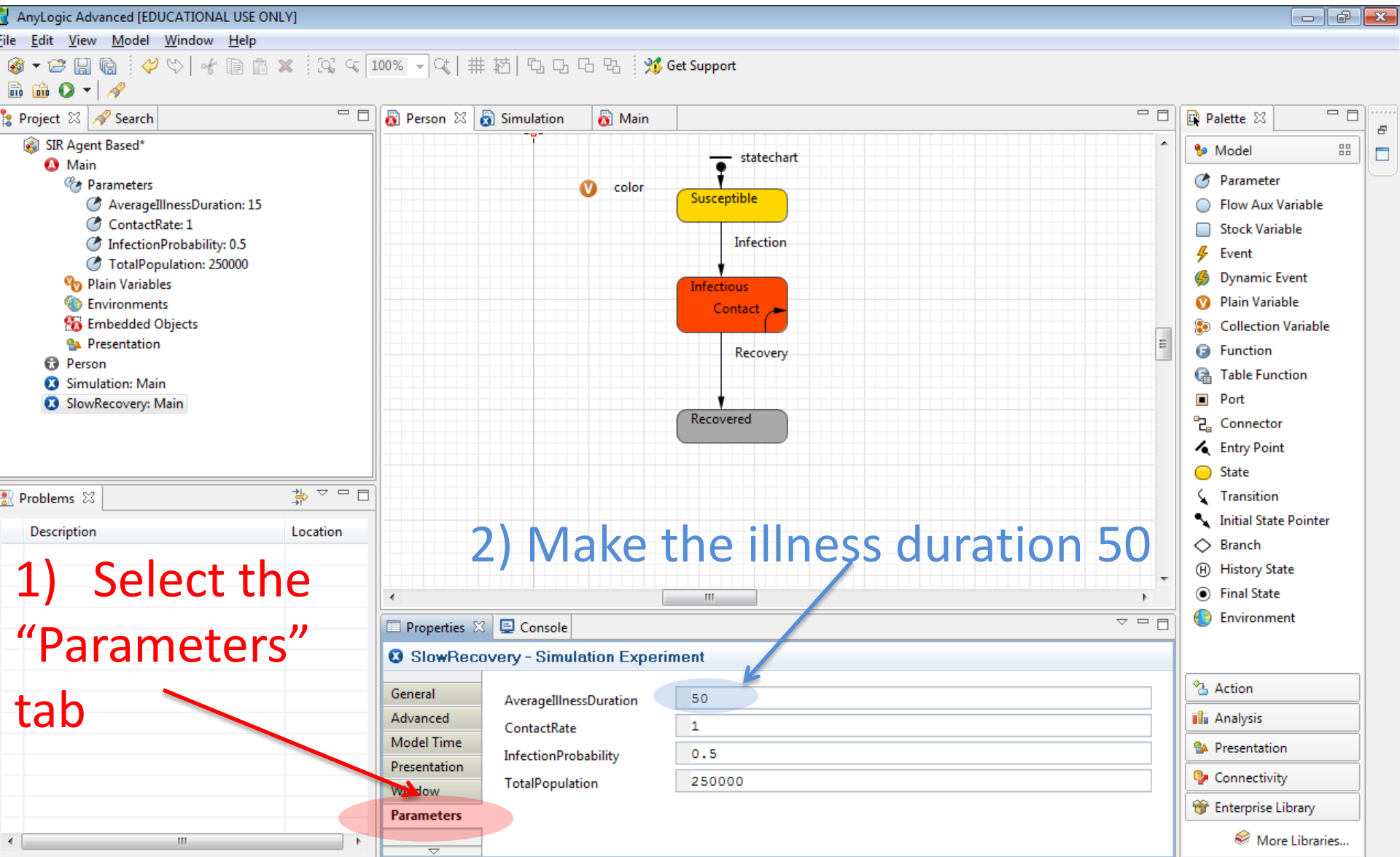
1) Select here (the new experiment) so we can edit its properties (characteristics)

2) Select the "General" tab

3) Type the name "SlowRecovery" for the new experiment

Properties - Simulation Experiment
Name: SlowRecovery
Main active object class (root): Main

Random number generation:
 Random seed (unique simulation runs)
 Fixed seed (reproducible simulation runs) Seed Value: 1



1) Select the "Parameters" tab

2) Make the illness duration 50

Run the Model (via the “Run” button)

The screenshot displays the AnyLogic Advanced software interface. The main workspace shows a statechart with three states: Susceptible (yellow), Infectious (orange), and Recovered (grey). Transitions are labeled 'Infection' and 'Recovery'. A 'color' variable is also visible. The Project Explorer on the left shows a 'Recent Experiment' menu with 'SIR Agent Based / SlowRecovery' selected. The Properties window at the bottom shows the configuration for the 'SlowRecovery - Simulation Experiment'.

2) Be sure to select the “SlowRecovery Experiment for running!

General	Value
AveragellnessDuration	50
ContactRate	1
InfectionProbability	0.5
TotalPopulation	250000

You Should See Something Like This

SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]

Get Support

statechart

- Susceptible
- Infectious Contact
- Recovered

Transition: Infection (Susceptible to Infectious Contact), Recovery (Infectious Contact to Recovered)

Simulation Status:

- Susceptible: 109,925
- Infectious: 87,812
- Recovered: 52,263

Run: 0 Running | Time: 201.45 | Step: 31,562,999 [175,702] | EPS: 143,862 | FPS: 1.0 | Men

es (x86)\AnyLogic 6\jre\bin\javaw.exe (Jul 11, 2010 6:47:45 PM)

Palette

- Model
- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment

Action

Analysis

Presentation

Connectivity

Enterprise Library

More Libraries...

Adding a Transition

The screenshot displays the AnyLogic Advanced interface. The central workspace shows a statechart with three states: 'Susceptible' (yellow), 'Infectious' (orange), and 'Recovered' (grey). Transitions are labeled 'Infection' and 'Recovery'. A 'color' variable is also visible. The 'Palette' on the right contains various modeling elements, with 'Transition' highlighted in a red oval and a red arrow pointing to it. The 'Properties' panel at the bottom shows the console output: '<terminated> anylogic config [Java Application] C:\Program Files (x86)\AnyLogic 6\jre\bin\javaw.exe (Jul 11, 2010 6:54:30 PM)'. The 'Problems' panel is empty.

Select "Transition" on the Palette so we can add a transition to the state chart

Connecting the Two States

2) While holding down the mouse button, drag the mouse to here and only then Release the mouse button

1) Click here first to start the transition

Properties Console

transition - Transition

General Name: transition Show Name Ignore Public Show At Runtime

Description

Triggered by: Timeout

Timeout: 1

Action:

Selection Cursor: X=145, Y=110

Description	Location

- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment
- Action
- Analysis
- Presentation
- Connectivity
- Enterprise Library
- More Libraries...

Give the Transition a Name

The screenshot displays the AnyLogic Advanced interface for an SIR Agent Based model. The main workspace shows a statechart with three states: Susceptible (yellow), Infectious (orange), and Recovered (grey). Transitions are labeled 'Infection' (Susceptible to Infectious), 'Recovery' (Infectious to Recovered), and 'Contact' (Infectious to Infectious). A red arrow points from the text 'Type the name ("waningImmunity") here' to the 'Name' field in the Properties window, which is currently set to 'waningImmunity'. The Properties window also shows 'Triggered by: Timeout' and 'Timeout: 1'. The left sidebar shows the Project tree with 'SIR Agent Based*' and 'Main' selected. The right sidebar shows the Palette with various model elements like Parameter, Flow Aux Variable, Stock Variable, Event, Dynamic Event, Plain Variable, Collection Variable, Function, Table Function, Port, Connector, Entry Point, State, Transition, Initial State Pointer, Branch, History State, Final State, and Environment.

Type the name ("waningImmunity") here

transition - Transition

Press Ctrl+Enter to perform refactoring (replace name occurrences)

General

Name: waningImmunity

Show Name Ignore Public Show At Runtime

Description

Triggered by: Timeout

Timeout: 1

Action:

Setting the Duration Until Immunity Wanes

The screenshot shows the AnyLogic Advanced interface. On the left, a project tree shows 'SIR Agent Based*' with sub-items like 'Main', 'Parameters', and 'Plain Variables'. The main workspace displays a statechart with three states: 'Susceptible' (yellow), 'Infectious' (orange), and 'Recovered' (grey). Transitions are labeled 'Infection' (Susceptible to Infectious), 'Contact' (Infectious to Infectious), and 'Recovery' (Infectious to Recovered). A variable 'color' is also shown. On the right, a palette lists various modeling elements like 'Parameter', 'Flow Aux Variable', 'Stock Variable', etc. At the bottom, the 'Properties' window for the 'waningImmunity - Transition' is open. It shows the transition is triggered by 'Timeout' and has a 'Timeout' value of 100. A red arrow points to the 'Triggered by' dropdown, and a blue arrow points to the 'Timeout' input field.

1) Make sure this is set to "Timeout"

2) Set the waning time To 100

Use the Run Button and select the Original Experiment

The screenshot displays the AnyLogic Advanced software interface. The main workspace shows a statechart with three states: Susceptible (yellow), Infectious (orange), and Recovered (grey). Transitions are labeled 'Infection' and 'Recovery'. A 'waningImmunity' transition is highlighted in the Properties panel, showing a timeout of 100. The Project Explorer on the left shows a tree structure with 'SIR Agent Based / Simulation' selected. A red arrow points to the Run button in the toolbar.

Project Explorer:

- SIR Agent Based / Simulation
- SIR Agent Based / SlowRecovery
- Parameters
 - AverageIllnessDuration: 15
 - ContactRate: 1
 - InfectionProbability: 0.5
 - TotalPopulation: 250000
- Plain Variables
- Environments
- Embedded Objects
- Presentation
- Person
- Simulation: Main
- SlowRecovery: Main

Statechart:

```
statechart
    state Susceptible
    state Infectious
    state Recovered
    Susceptible -->|Infection| Infectious
    Infectious -->|Recovery| Recovered
    Recovered -->|waningImmunity| Susceptible
```

Properties Panel: waningImmunity - Transition

General: Name: waningImmunity, Show Name: , Ignore: , Public: , Show At Runtime:

Description: Triggered by: Timeout, Timeout: 100, Action: [Empty]

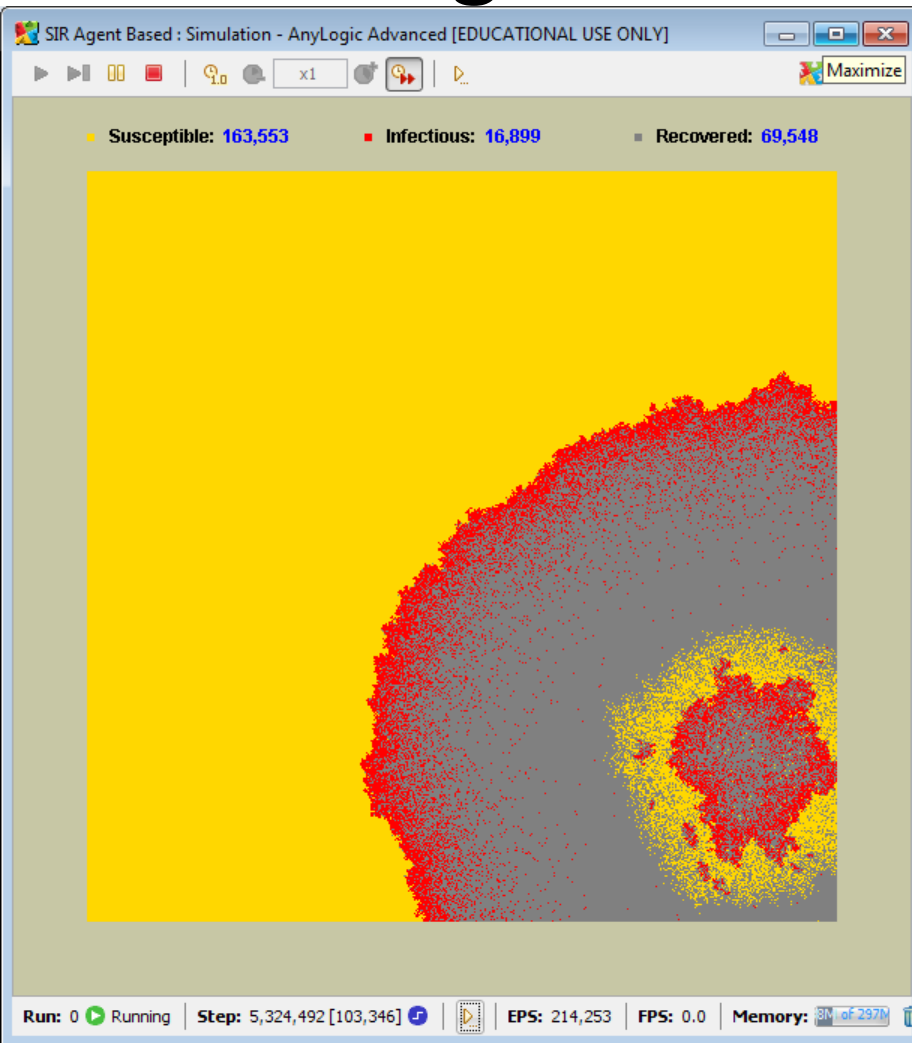
Palette:

- Model
- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment
- Action
- Analysis
- Presentation
- Connectivity
- Enterprise Library
- More Libraries...

Problems Table:

Description	Location
-------------	----------

After Starting the Model, You Should See Something Like This. What Happens as Time Progresses?



Let's Run the Revised Model!

Slide 32 of 63 Office Theme English (Canada)

- When it is much simpler to describe behavior at indiv. level
- Seek flexibility in exploring different heterogeneity dimensions
- Needs of stakeholders to engage with individual-based models
- Want to describe behaviour at multiple scales

Click to add notes

What Happens as Time Progresses?

The screenshot displays the AnyLogic Advanced interface for an SIR Agent Based Simulation. The main window shows a statechart with three states: Susceptible (yellow), Infectious Contact (red), and Recovered (grey). The simulation is running, and the status bar indicates the following metrics:

- Run: 0 Running
- Step: 17,514,034 [229, 125]
- EPS: 137,195
- FPS: 1.0
- Memory: 10M of 297M

The statechart diagram shows the following transitions:

- Initial State Pointer to Susceptible
- Susceptible to Infectious Contact (Infection)
- Infectious Contact to Recovered (Recovery)
- Recovered to Susceptible (Recovery)

The right-hand side of the interface features a Palette with various modeling elements:

- Model
- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment

At the bottom, there are buttons for Action, Analysis, Presentation, Connectivity, and Enterprise Library, along with a link to More Libraries...

Use the Run Button & select the "SlowRecovery" Experiment

The screenshot displays the AnyLogic Advanced (EDUCATIONAL USE ONLY) interface. A red arrow points to the Run button in the toolbar. The Project Explorer on the left shows the project structure, with 'SIR Agent Based / SlowRecovery' selected. The main workspace shows a statechart with three states: Susceptible (yellow), Infectious Contact (orange), and Recovered (grey). Transitions are labeled 'Infection' and 'Recovery'. The Console at the bottom shows a terminated message.

AnyLogic Advanced [EDUCATIONAL USE ONLY]

File Edit View Model Window Help

100%

Get Support

Project: SIR Agent Based / Simulation

- SIR Agent Based / SlowRecovery
- Parameters
 - AverageIllnessDuration: 15
 - ContactRate: 1
 - InfectionProbability: 0.5
 - TotalPopulation: 250000
- Plain Variables
- Environments
- Embedded Objects
- Presentation
- Person
- Simulation: Main
- SlowRecovery: Main

statechart

color

Susceptible

Infectious Contact

Recovered

statechart

Infection

Recovery

Palette

- Model
- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment
- Action
- Analysis
- Presentation
- Connectivity
- Enterprise Library

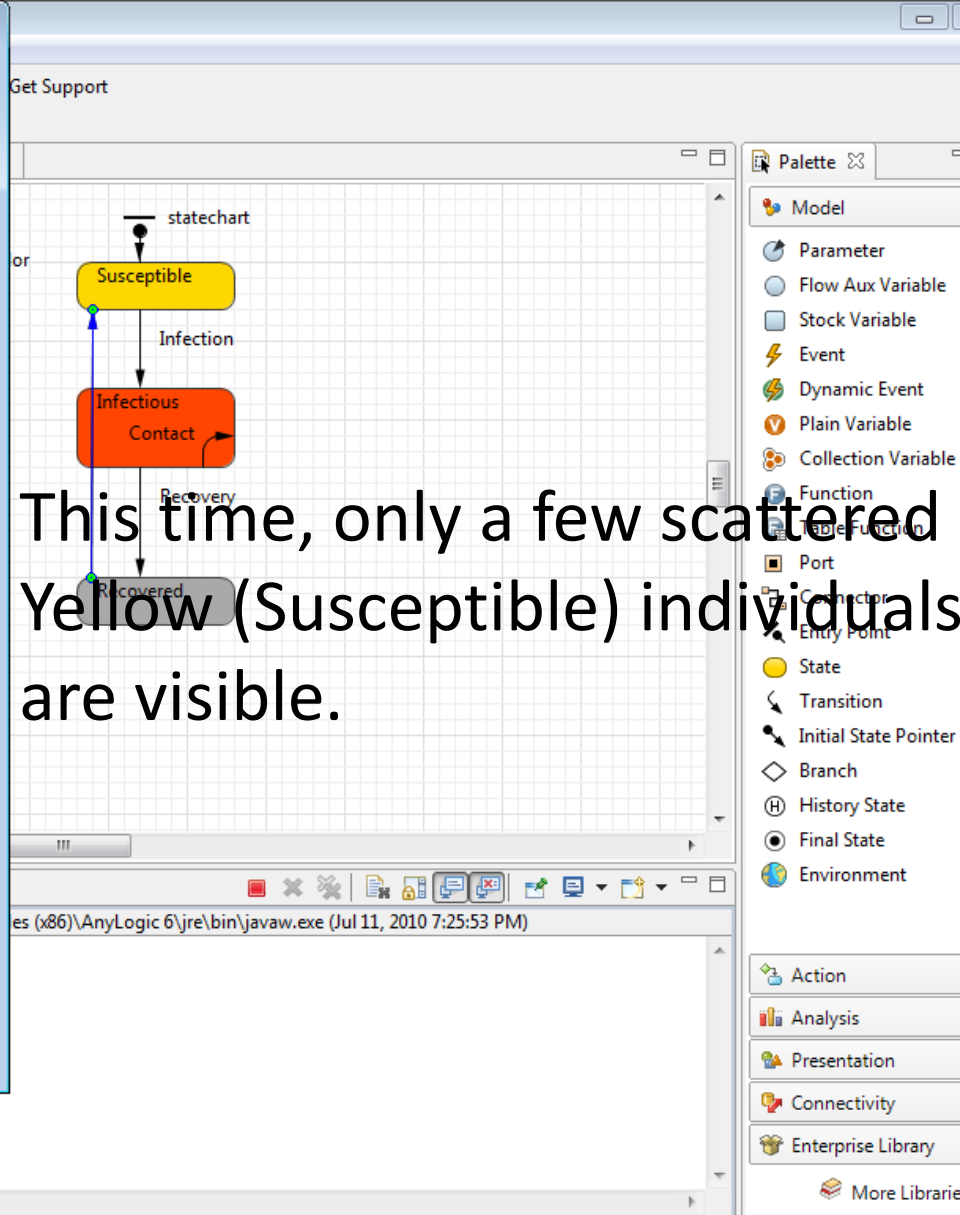
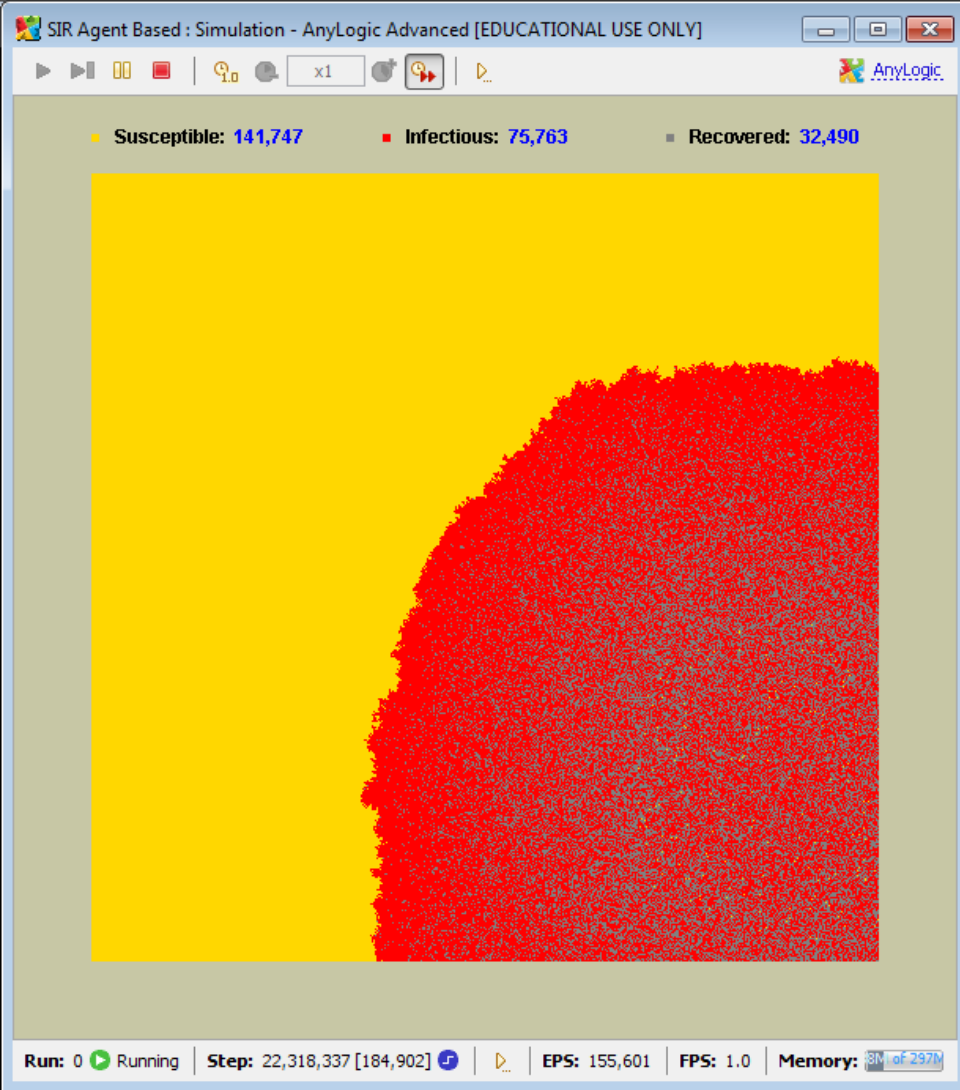
Problems

Description	Location
-------------	----------

Properties Console

<terminated> anylogic config [Java Application] C:\Program Files (x86)\AnyLogic 6\jre\bin\javaw.exe (Jul 11, 2010 7:28:39 PM)

Slow Recovery Results



This time, only a few scattered Yellow (Susceptible) individuals are visible.

As Time Progresses, Little Internal Structure – Why?

SIR Agent Based : Simulation - AnyLogic Advanced [EDUCATIONAL USE ONLY]

■ Susceptible: 50,155 ■ Infectious: 134,360 ■ Recovered: 65,485

statechart

```
graph TD; Start(( )) --> Susceptible; Susceptible -- Infection --> InfectiousContact; InfectiousContact -- Recovery --> Recovered; Recovered --> Susceptible;
```

Model

- Parameter
- Flow Aux Variable
- Stock Variable
- Event
- Dynamic Event
- Plain Variable
- Collection Variable
- Function
- Table Function
- Port
- Connector
- Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State
- Environment

es (x86)\AnyLogic 6\jre\bin\javaw.exe (Jul 11, 2010 7:45:17 PM)

Run: 0 Running Step: 56,894,173 [334,467] EPS: 134,267 FPS: 1.0 Memory: 18M of 297M

Stylized Measurement 2

- How Long Does it Take for The Infection to Reach the Top or Left Boundaries?
- How does this compare with the earlier experiment with a shorter duration of immunity?
- **Bonus question:** What would an aggregate (random mixing) model have predicted?

Project Possibilities

- Gonorrhea
- CWD
- TB
- Diabetes & ESRD
- HPV & Smoking?
- MRSA
- Smoking