

Discrete Inter-agent Dynamics, Sending & Receiving Messages

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Using Modeling to Prepare for Changing Healthcare
Needs

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Discrete Agent Coupling via Messages

- Within AnyLogic, agents can be coupled by either discrete (instantaneous and individuated) or continuous (ongoing and gradual) coupling
- The preferred mechanism for discrete coupling is *messages* sent between agents
 - Many types of messages payloads are possible
 - An agent can send a given message to one or more agents
 - Frequently messages are sent locally to neighbors within the environment
 - Neighboring nodes on the network
 - Nearby neighbors in space

Messages & Statecharts

- Messages may be handled in many ways
- One of the most common ways in which messages are handled is by statecharts
 - A transition can be triggered (“guarded” or gated) by a message
 - A transition may be associated with an action that fires off a message to other agents (or to other statecharts within the agent)



Hands on Model Use Ahead



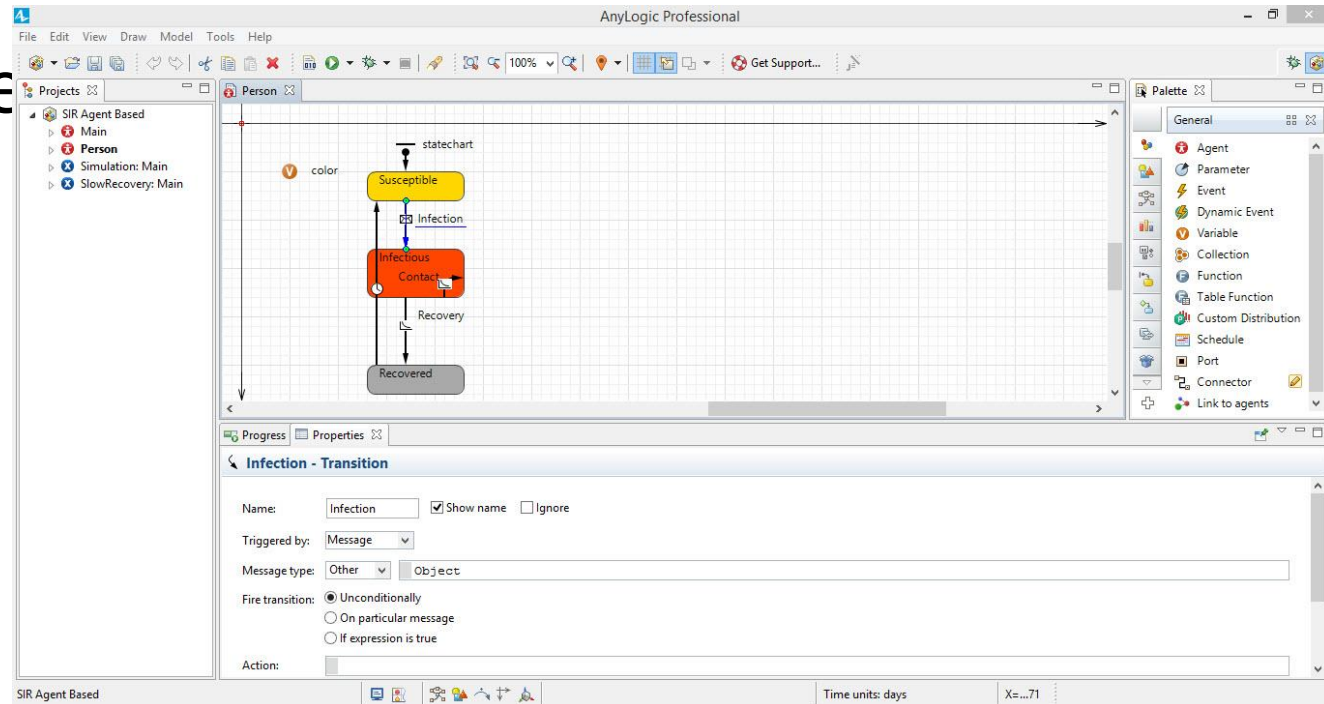
Load Sample model:

SIR Agent Based.alp

Open Up “Person” class

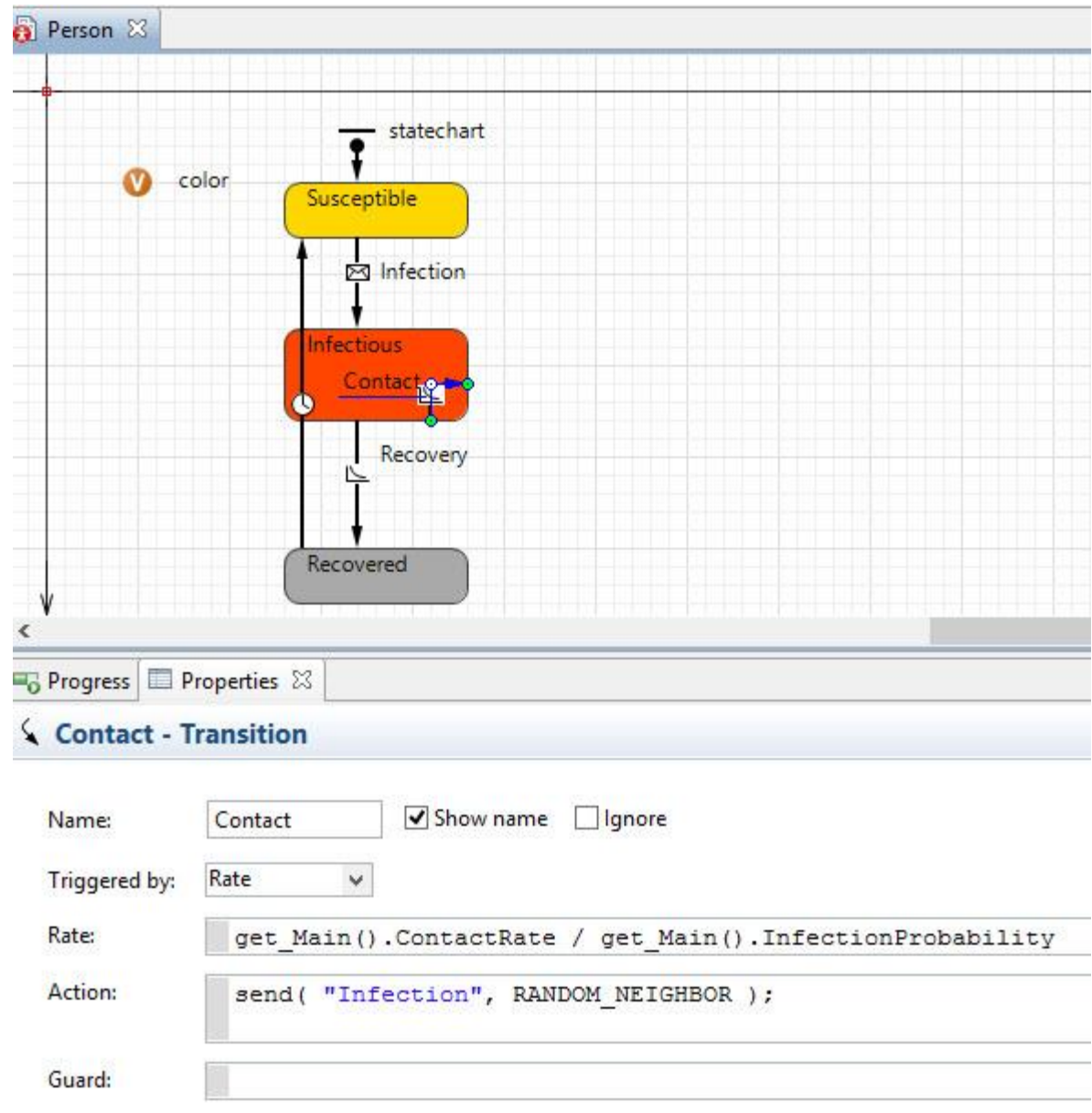
Receiving a Message

- In this case, only 1 message type exists, so the simple fact that a message has been received is sufficient; there is no need to inspect message contents



Sending a Message

- (Self-transition because remains in state)



Message Sending

- Messages may be sent to either
 - A particular, explicitly specified agent
 - An implicitly specified class of agents
 - Neighboring agents in the environment topology
 - Random agents
 - All agents
 - Any connected agents
 - All connected agents
- Mechanism:
 - *send(Message, DestinationObject)*
 - *send(Message, AgentClassId)*

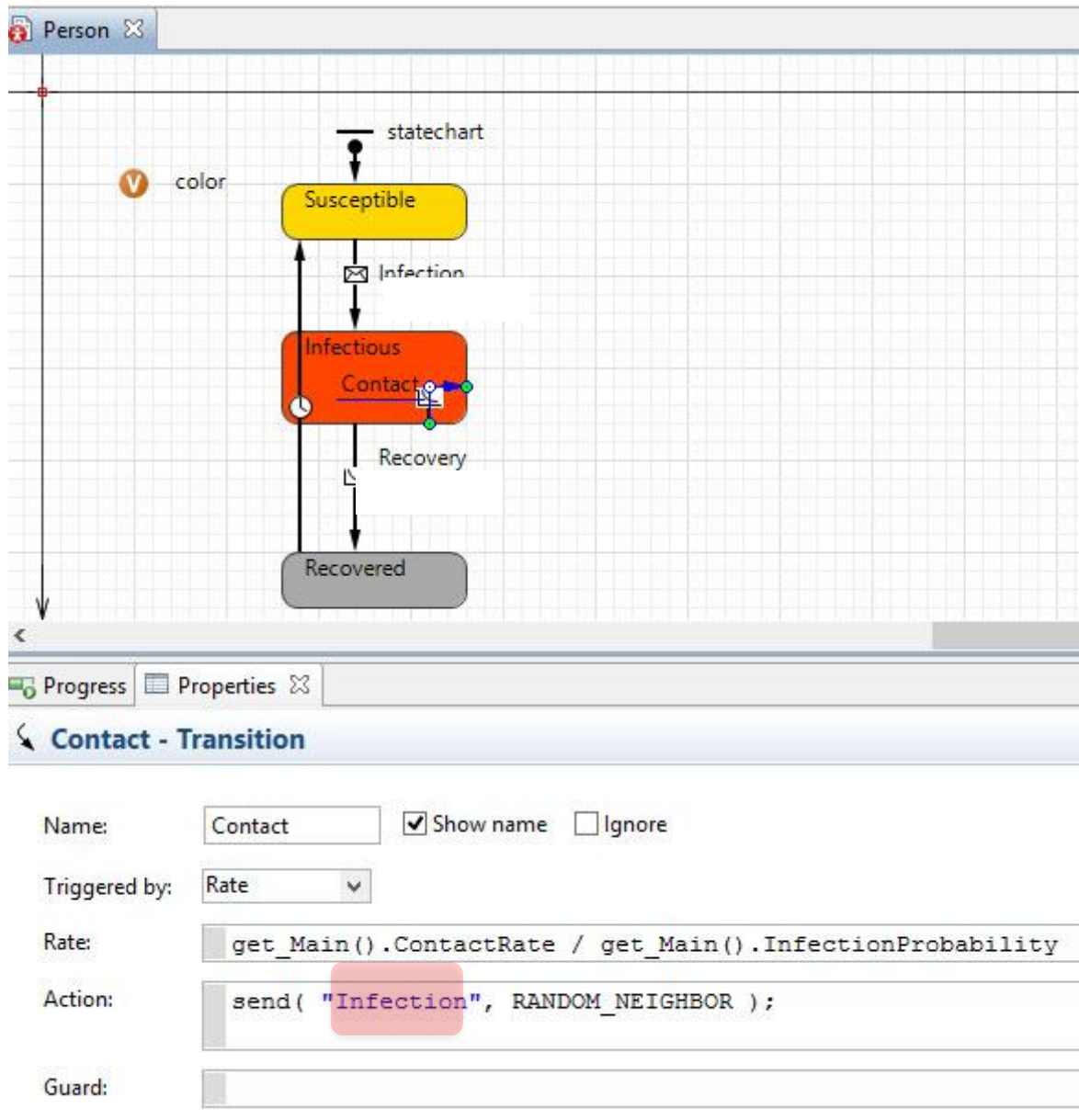
Synchronous vs. Asynchronous Delivery

- Messages may be sent in two ways
 - Via ***send***: Asynchronous (scheduled)
 - Delivery occurs sometime after call to send
 - This is like sending a text message – it can be read later
 - Via ***deliver***: Synchronous (immediately called)
 - Risks infinite loops in delivery (if destination also calls deliver in the reverse direction)
 - This is like calling the other person's phone – you demand their attention immediately

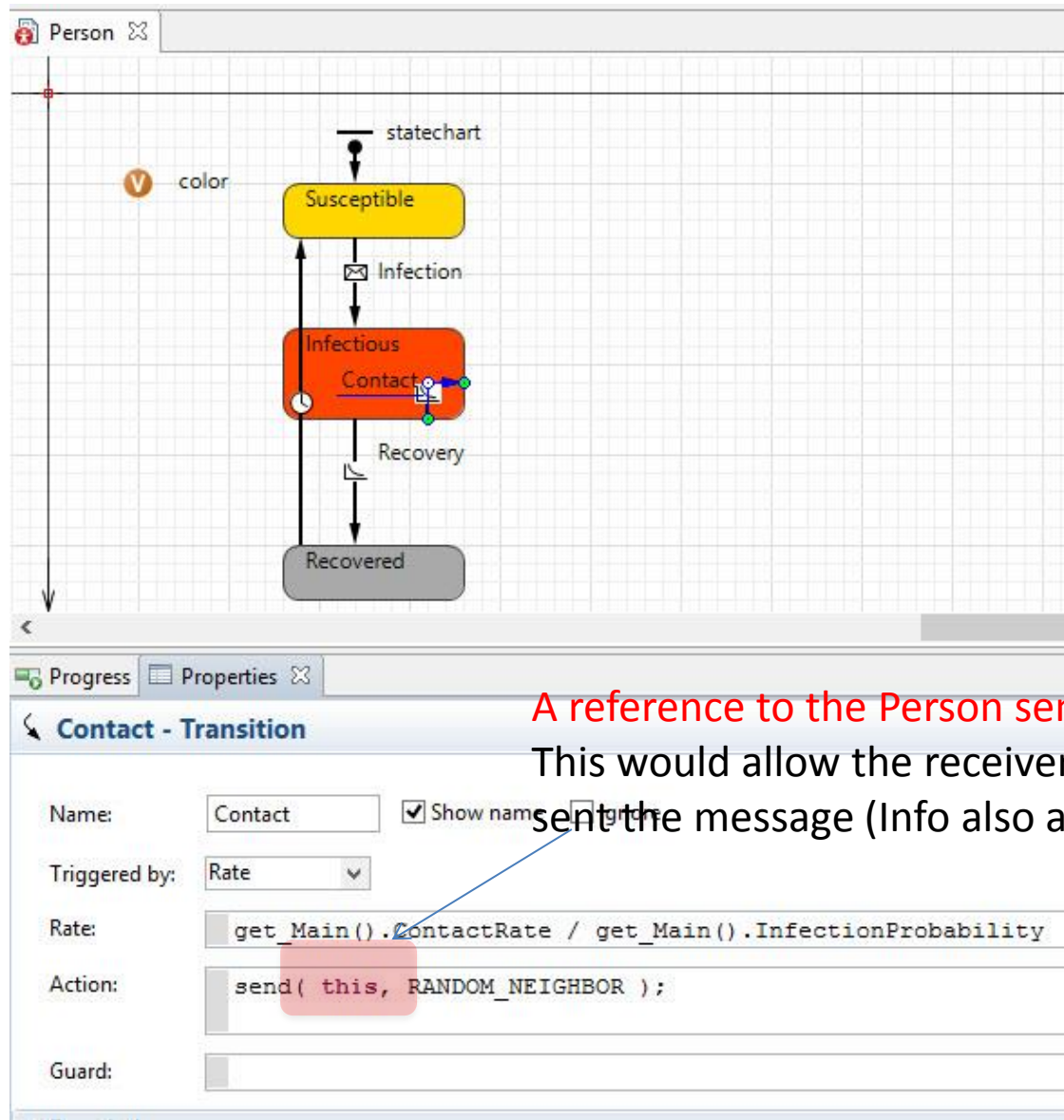
Message Payloads

- Sometimes just the fact that a message has been sent provides us with all of the information we need
- Sometimes just distinguishing different message types is sufficient
- We will sometimes send messages with payloads of data that provide extra information, e.g.
 - The agent that sent the message (eg that is infecting us)
 - Particular parameters
- Can send messages different payload types
 - Boolean/int/double/String/Other (can specify class type)

Sending a Message with a String Payload



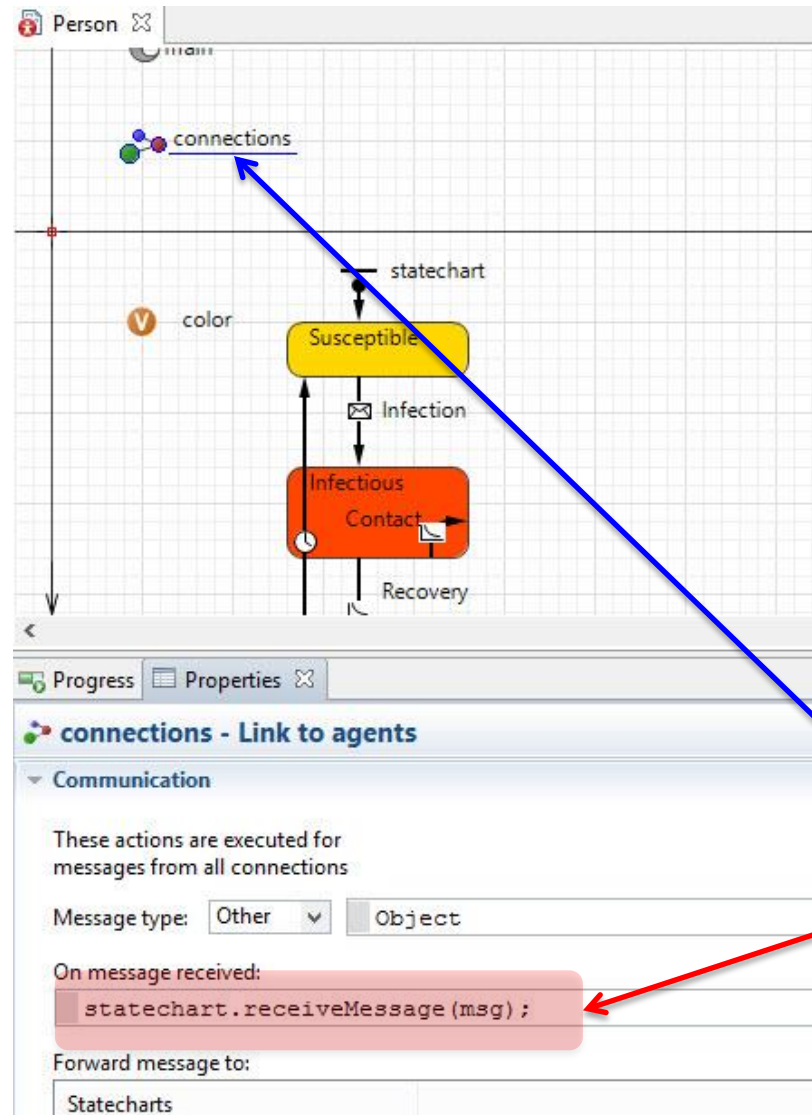
Sending a Message with Object Payload



A reference to the Person sending the message!

This would allow the receiver to know who sent the message (Info also available in other ways)

Receiving a Message: Forwarding Messages on to the Statechart



The **action** for Handling received messages delegates to the **Statechart object**

Receiving a Message

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart for a 'Person' agent. The statechart includes two states: 'Susceptible' (yellow) and 'Infectious' (red). A transition labeled 'Infection' connects the 'Susceptible' state to the 'Infectious' state. The 'Infectious' state has a 'Recovery' transition that leads back to the 'Susceptible' state. The 'Infectious' state also contains a 'Contact' sub-state. The 'Person' agent is connected to a 'connections' object and a 'color' variable. The 'Projects' panel on the left shows a hierarchy: 'SIR Agent Based*' > 'Main' > 'Person' > 'Simulation: Main' > 'SlowRecovery: Main'. The 'Palette' on the right lists various components like Agent, Parameter, Event, etc. The 'Properties' panel at the bottom is titled 'Infection - Transition' and contains the following settings:

- Name: Infection ☒ Show name ☐ Ignore
- Triggered by: Message
- Message type: Other ☐ Object
- Fire transition: ☒ Unconditionally
☐ On particular message
☐ If expression is true
- Action: (empty field)

The bottom status bar indicates 'Time units: days'.



Hands on Model Use Ahead

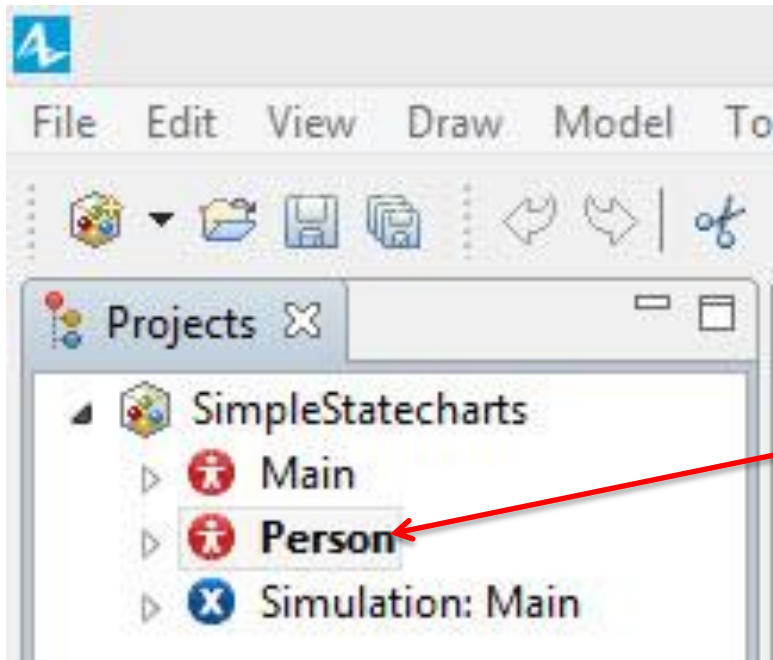


Load Previous Built [& Provided] Model:

SimpleStatecharts

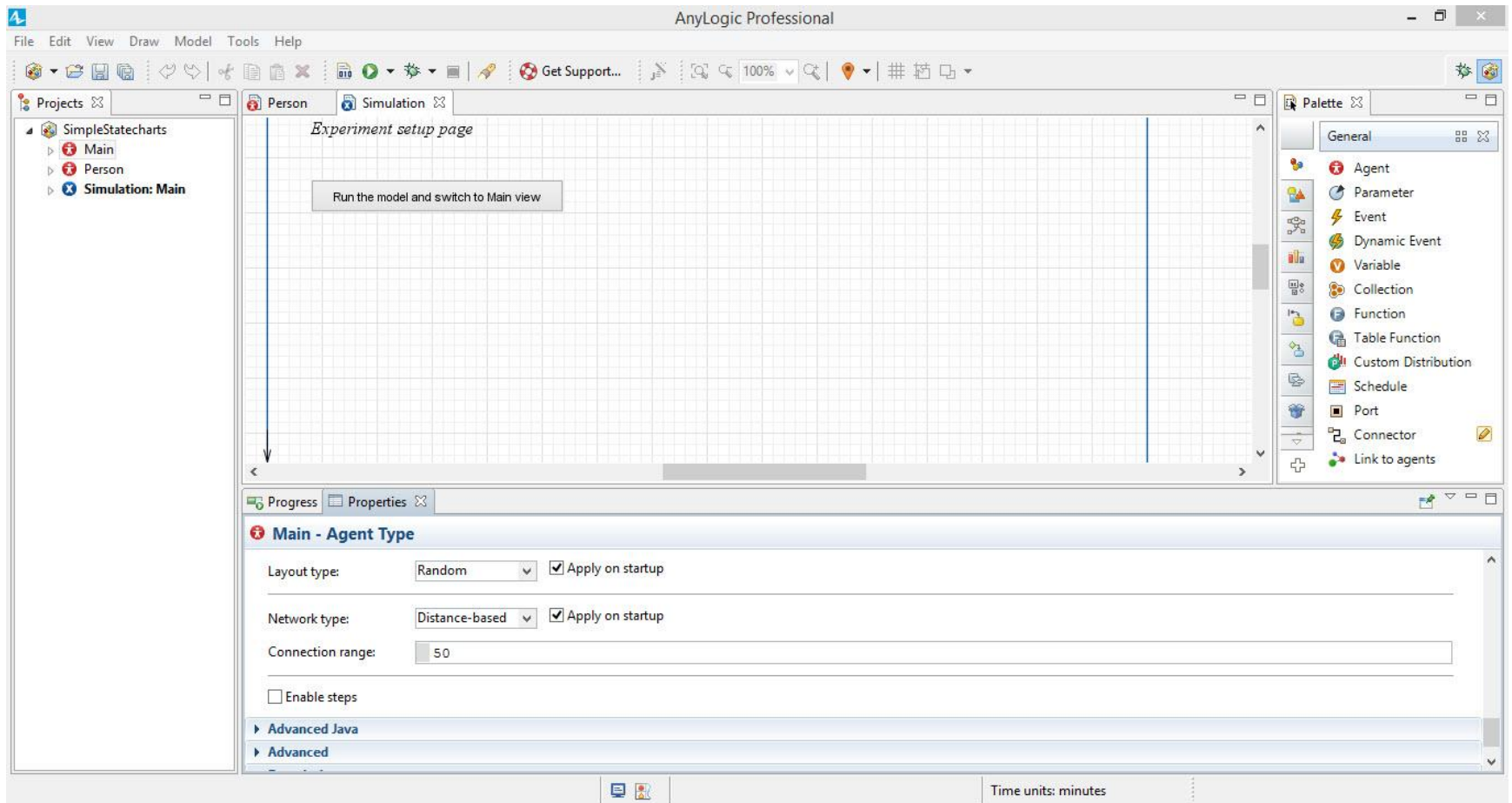
Save as **SimpleNetworkTransmission**

Open Up Canvas for “Main” (In case it is not already open)

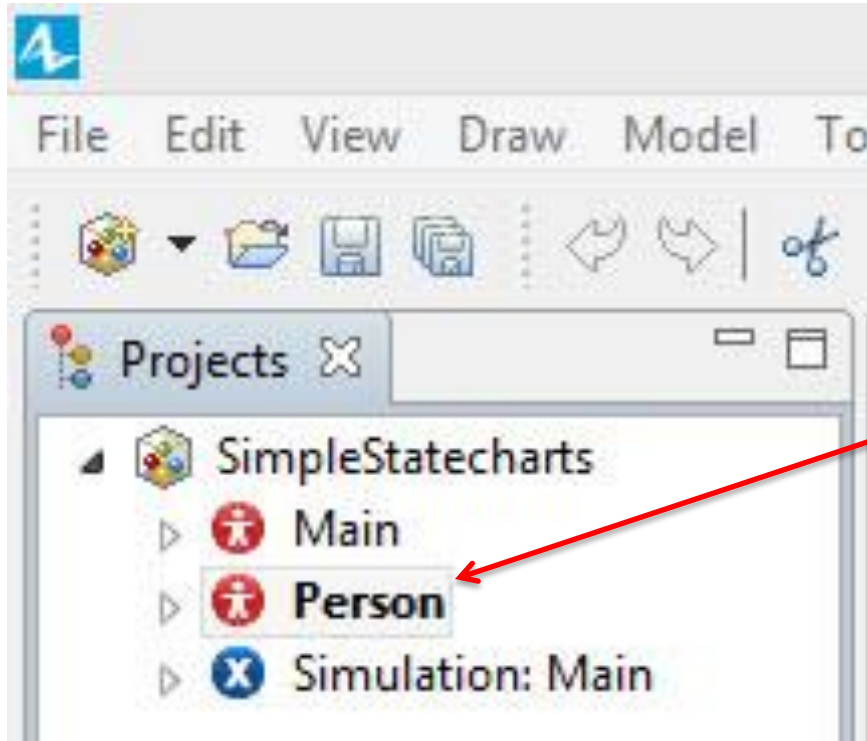


Double Click Here

Place Agents in a Distance Based Network



Open Up Canvas for “Person” (In case it is not already open)



Double Click Here

Set Persons's Representation Radius to 50 (If inner circles overlap, in network contact)

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart for a 'Person' agent. The statechart has two states, 'Susceptible' and 'Infective', represented by yellow rounded rectangles. A transition arrow points from 'Susceptible' to 'Infective', and another points from 'Infective' back to 'Susceptible'. To the left of the statechart, there are three variables: 'income' (blue circle), 'sex' (blue circle), and 'color' (orange circle). The 'Person' agent is also connected to a 'Simulation' agent. The 'Properties' panel at the bottom shows the 'oval - Oval' properties. Under the 'Position and size' section, the 'Type' is set to 'Circle'. The 'Radius' is set to 50. The 'X', 'Y', and 'Z' coordinates are all set to 0. The 'Rotation' is set to 0.0 degrees. The 'Radius Y' is set to 10, and the 'Z-Height' is set to 10. The 'Time units: minutes' label is visible at the bottom right.

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts
 - Main
 - Person
 - Simulation: Main

Person Simulation

income

sex

color

statechart

Susceptible

Infective

Progress Properties

oval - Oval

Position and size

Type: ☒ Circle ☐ Oval

X: 0

Y: 0

Z: 0

Rotation, °: 0.0 degrees

Radius: 50

Radius Y: 10

Z-Height: 10

Time units: minutes

Sending Messages

Using a “Contact” Event to Spread Infection

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts*
- Main
- Person
- Simulation: Main

Person Simulation

income

sex

color

statechart

Susceptible

Infective

Add this transition

transition - Transition

Name: transition ☐ Show name ☐ Ignore

Triggered by: Rate

Rate: 2

Action: `send("Infection", MessageDeliveryType.RANDOM_CONNECTED);`

Guard:

Description

Time units: minutes

Making Infection Depend on a Message (Using a Message Triggered Transition)

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts
 - Main
 - Person
 - Simulation: Main

Person Simulation

income

sex

color

statechart

Susceptible

Infective

Make sure you have selected the transition by clicking on it!

Palette

Statechart

- Statechart Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State

Progress Properties

Infection - Transition

Name: Infection ☐ Show name ☐ Ignore

Triggered by: Message

Message type: Other ☐ Object

Fire transition:

- ☒ Unconditionally
- ☐ On particular message
- ☐ If expression is true

Action:

Guard:

Time units: minutes

Run the Model

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart model for a person. The statechart has two states: 'Susceptible' and 'Infective'. Transitions are labeled with events and actions. The 'Susceptible' state has an initial state pointer and a transition to 'Infective' labeled 'infect' with the action 'color = red'. The 'Infective' state has a transition back to 'Susceptible' labeled 'heal' with the action 'color = blue'. The 'Infective' state also has a final state pointer. The model is connected to a 'Person' object, which has properties like 'income', 'sex', and 'color'. The 'Person' object is also connected to a 'Simulation' object. The 'Properties' panel at the bottom shows the properties of the selected 'oval' object, including its name, visibility, and appearance (fill color, line color, and line width).

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts
 - Main
 - Person
 - Simulation: Main

Person Simulation

connections

income

sex

color

statechart

Susceptible

Infective

Palette

Statechart

- Statechart Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State

Progress Properties

oval - Oval

Name: oval ☐ Ignore ☒ Visible on upper level ☐ Icon ☐ Lock

Visible: ☒ yes

Appearance

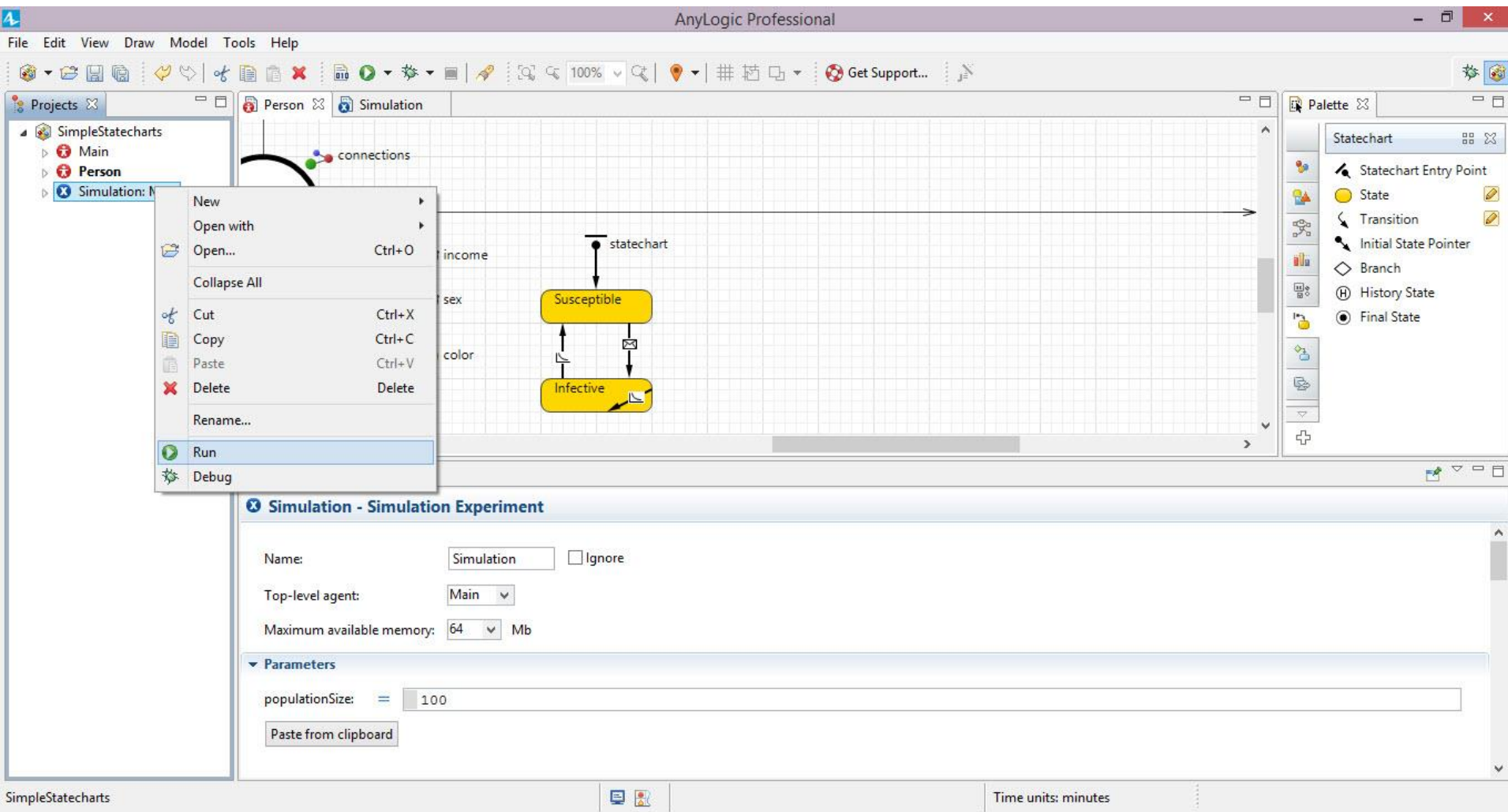
Fill color:

Line color:

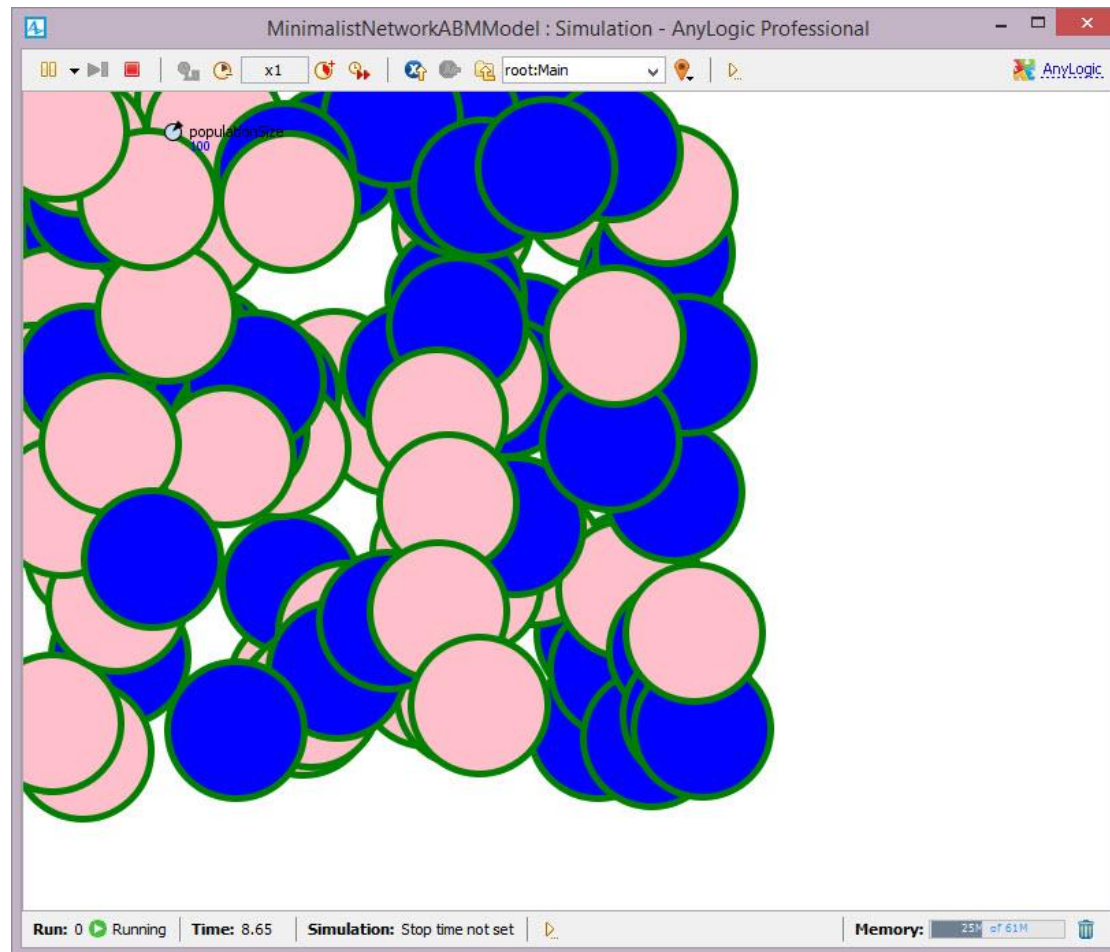
Line width: pt

Time units: minutes

Run the Model



Why No Infection?



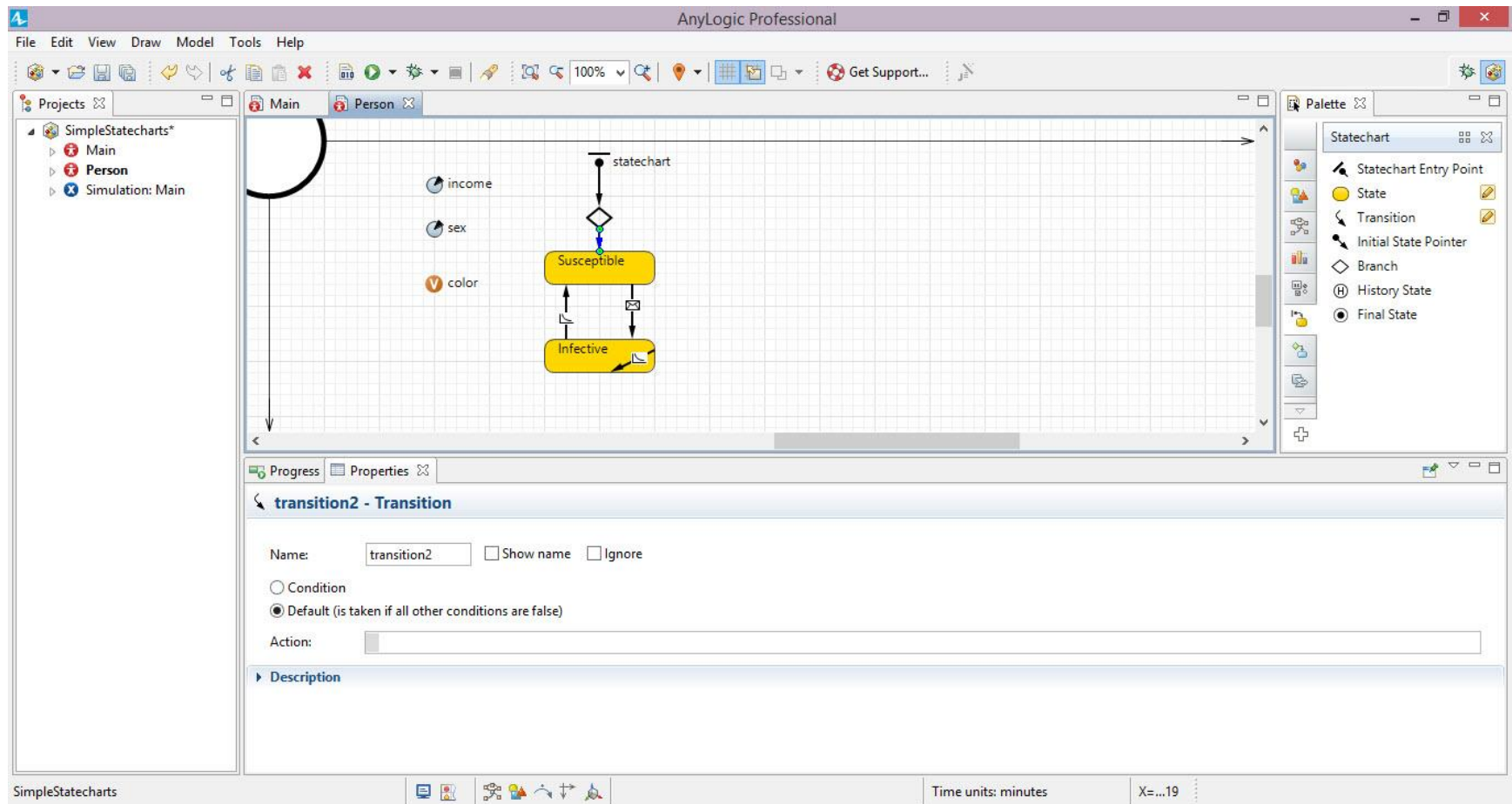
Making the Initial Population Include Some Infectives: Adding a Branch

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart for a 'Person' entity. The statechart includes a 'statechart' entry point, a 'Susceptible' state, and an 'Infective' state. Transitions are shown between these states. A 'branch' element is being added to the initial state. The bottom panel shows the 'branch - Branch' configuration window with the following fields:

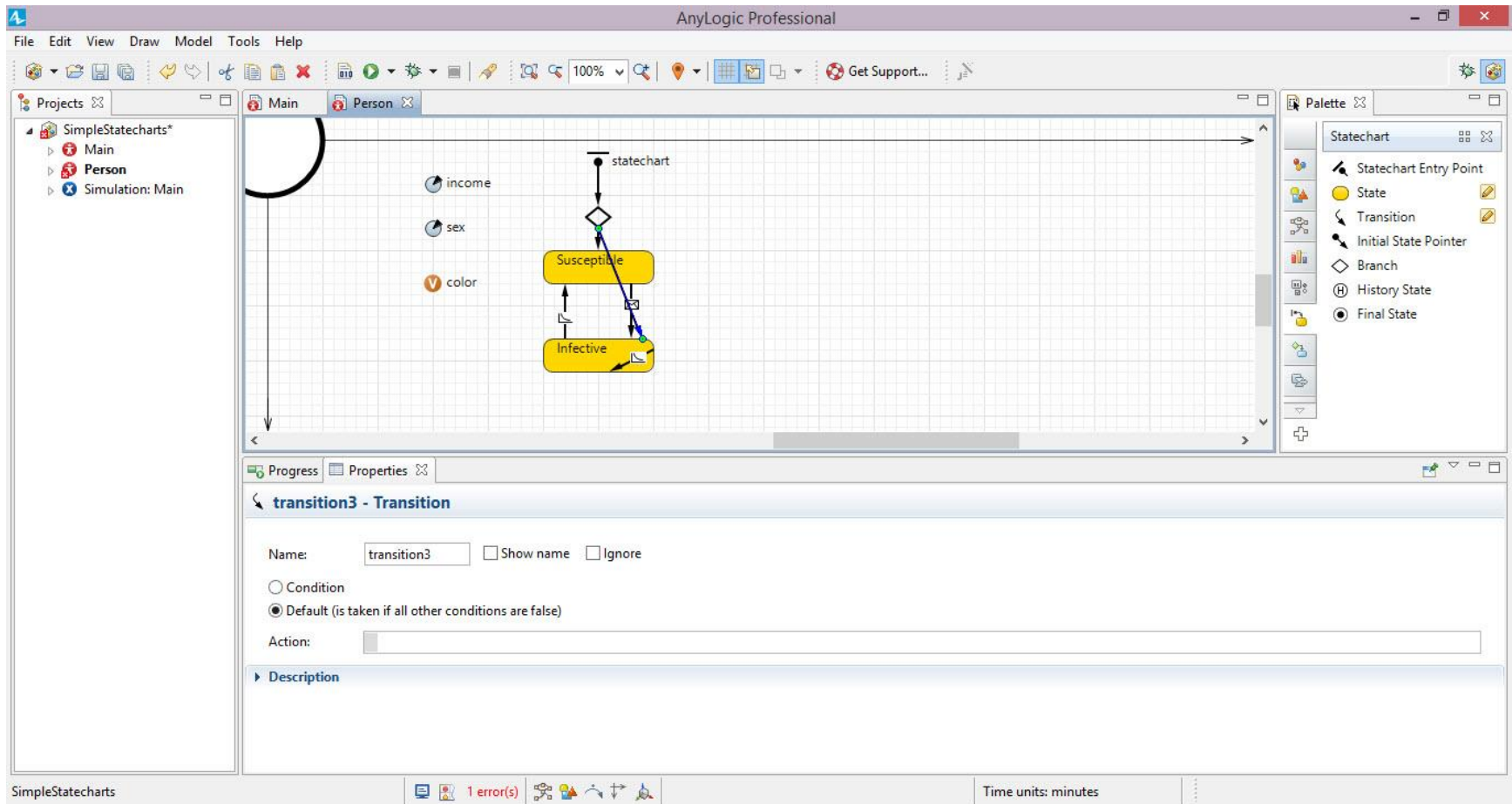
- Name:
- Show name: ☐
- Ignore: ☐
- Action:
- Description:

The status bar at the bottom indicates 'SimpleStatecharts', '6 error(s)', 'Time units: minutes', and 'Autosaving in progress...'.

Making the Initial Population Include Some Infectives: Default is Susceptible



Transition So 5% of the Population Starts Infective



Prettifying: Double-Click on Transition to Add an Extra “Handle” to Shape Transition

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart diagram with two states, 'Susceptible' and 'Infective', connected by a transition. A double-click action is being performed on the transition, which has opened the 'initialInfective - Transition' properties window. This window is currently set to the 'Condition' tab, showing a condition of 'randomTrue(0.05)'. The 'Name' field is set to 'initialInfective'. The 'Description' tab is also visible. The 'Palette' on the right lists various statechart elements: Statechart Entry Point, State, Transition, Initial State Pointer, Branch, History State, and Final State. The 'Properties' window at the bottom shows the 'initialInfective - Transition' properties, including the 'Condition' tab with the condition 'randomTrue(0.05)' and the 'Action' tab. The 'Description' tab is also visible. The 'Time units: minutes' is displayed at the bottom right.

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts
 - Main
 - Person
 - Simulation: Main

Main

Person

income

sex

color

statechart

Susceptible

Infective

Palette

Statechart

- Statechart Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State

Progress

Properties

initialInfective - Transition

Name: ☐ Show name ☐ Ignore

☒ Condition

☐ Default (is taken if all other conditions are false)

Condition:

Action:

Description

Time units: minutes

Prettifying: Drag New Handle to Right, to Route around “Susceptible” State

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart diagram with two states: "Susceptible" and "Infective". A transition labeled "initialInfective" is being edited. The "Properties" panel for this transition is visible, showing the name "initialInfective", a condition of "randomTrue (0.05)", and an empty action field. The "Palette" on the right lists statechart elements: Statechart Entry Point, State, Transition, Initial State Pointer, Branch, History State, and Final State. The "Projects" panel on the left shows a tree structure with "SimpleStatecharts*", "Main", "Person", and "Simulation: Main". The status bar at the bottom indicates "Time units: minutes" and "X=...20".

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts*
- Main
- Person
- Simulation: Main

Main Person

statechart

income

sex

color

Susceptible

Infective

Palette

Statechart

- Statechart Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State

Progress Properties

initialInfective - Transition

Name: initialInfective ☐ Show name ☐ Ignore

☒ Condition

☐ Default (is taken if all other conditions are false)

Condition: randomTrue (0.05)

Action:

Description

SimpleStatecharts

Time units: minutes

X=...20

Add Another Handle, Further Down

The screenshot displays the AnyLogic Professional interface. The main workspace shows a statechart for a 'Person' object. The statechart has two states: 'Susceptible' and 'Infective'. A transition labeled 'initialInfective' leads from the 'Susceptible' state to the 'Infective' state. The transition is currently selected, and its properties are shown in the bottom panel.

Statechart Diagram:

```
graph TD; Start(( )) --> Susceptible; Susceptible --> Infective; Infective --> Susceptible; Infective --> End((( )));
```

Transition Properties Panel:

initialInfective - Transition

Name: ☐ Show name ☐ Ignore

☒ Condition
☐ Default (is taken if all other conditions are false)

Condition:

Action:

Description

The bottom status bar shows 'SimpleStatecharts', 'Time units: minutes', and 'X=...12'.

By Dragging New Handle Further Shape Transition

The screenshot shows the AnyLogic Professional interface for editing a statechart. The main workspace displays a statechart with two states, 'Susceptible' and 'Infective', connected by a transition. A new handle is being dragged from the transition line to the right, extending the transition shape. The left sidebar shows a project tree with 'SimpleStatecharts*' and 'Person'. The right sidebar shows a palette with statechart symbols. The bottom panel shows the 'initialInfective - Transition' properties, including a condition 'randomTrue(0.05)'.

AnyLogic Professional

File Edit View Draw Model Tools Help

Projects

- SimpleStatecharts*
- Main
- Person
- Simulation: Main

Statechart

- Statechart Entry Point
- State
- Transition
- Initial State Pointer
- Branch
- History State
- Final State

initialInfective - Transition

Name: ☐ Show name ☐ Ignore

☒ Condition
☐ Default (is taken if all other conditions are false)

Condition:

Action:

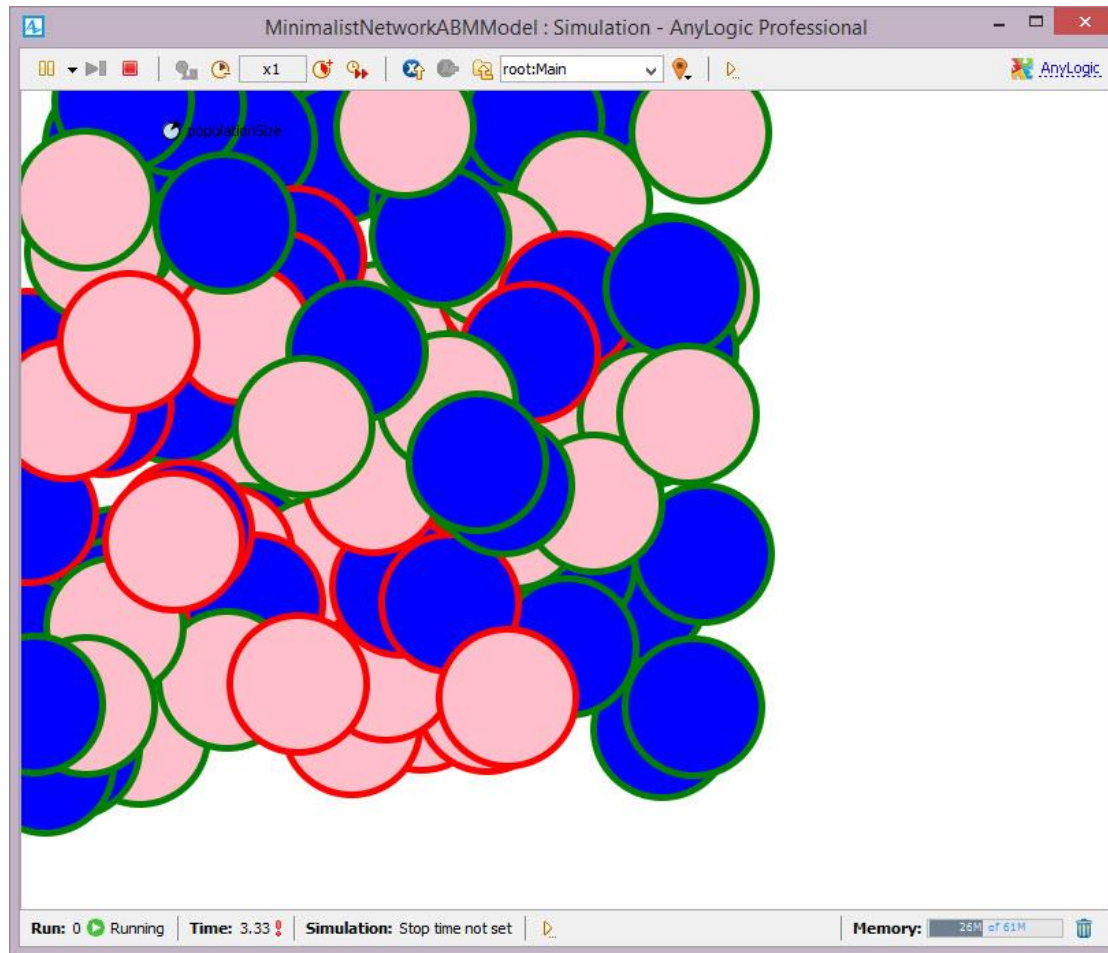
Description

SimpleStatecharts

Time units: minutes

X=...87

Infection Spread in the Network



Infection Percolation over the Network

