Introduction to the Anylogic Interface by Building Up a Simple Networked Model

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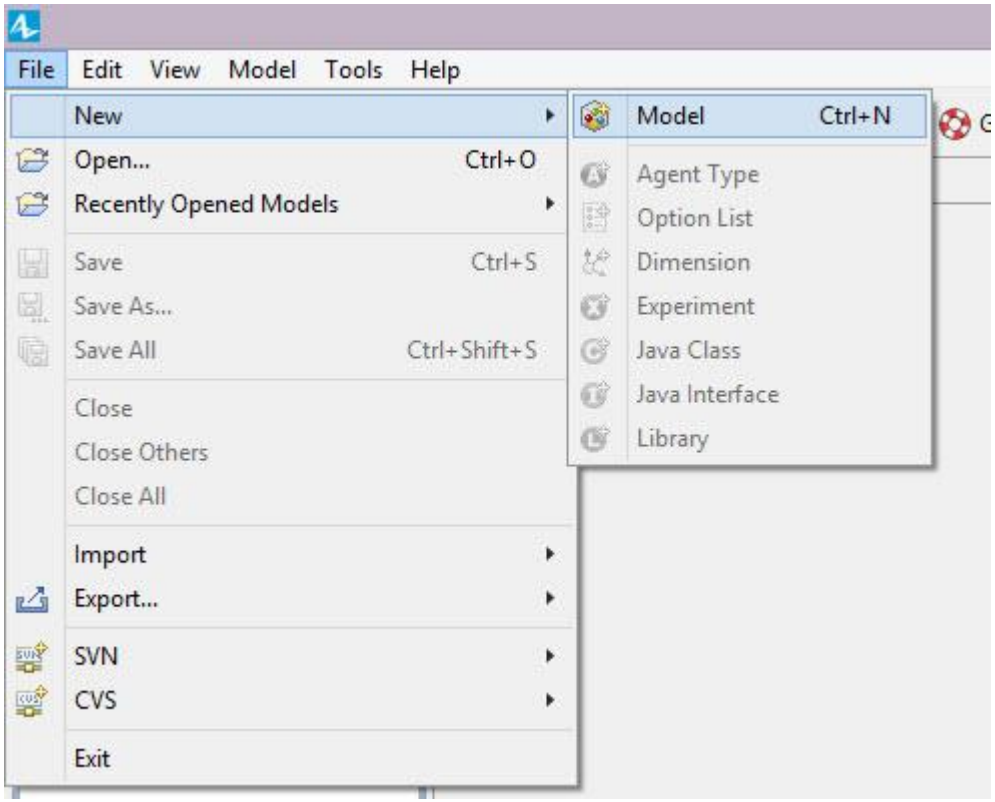
Using Modeling to Prepare for Changing Healthcare Needs

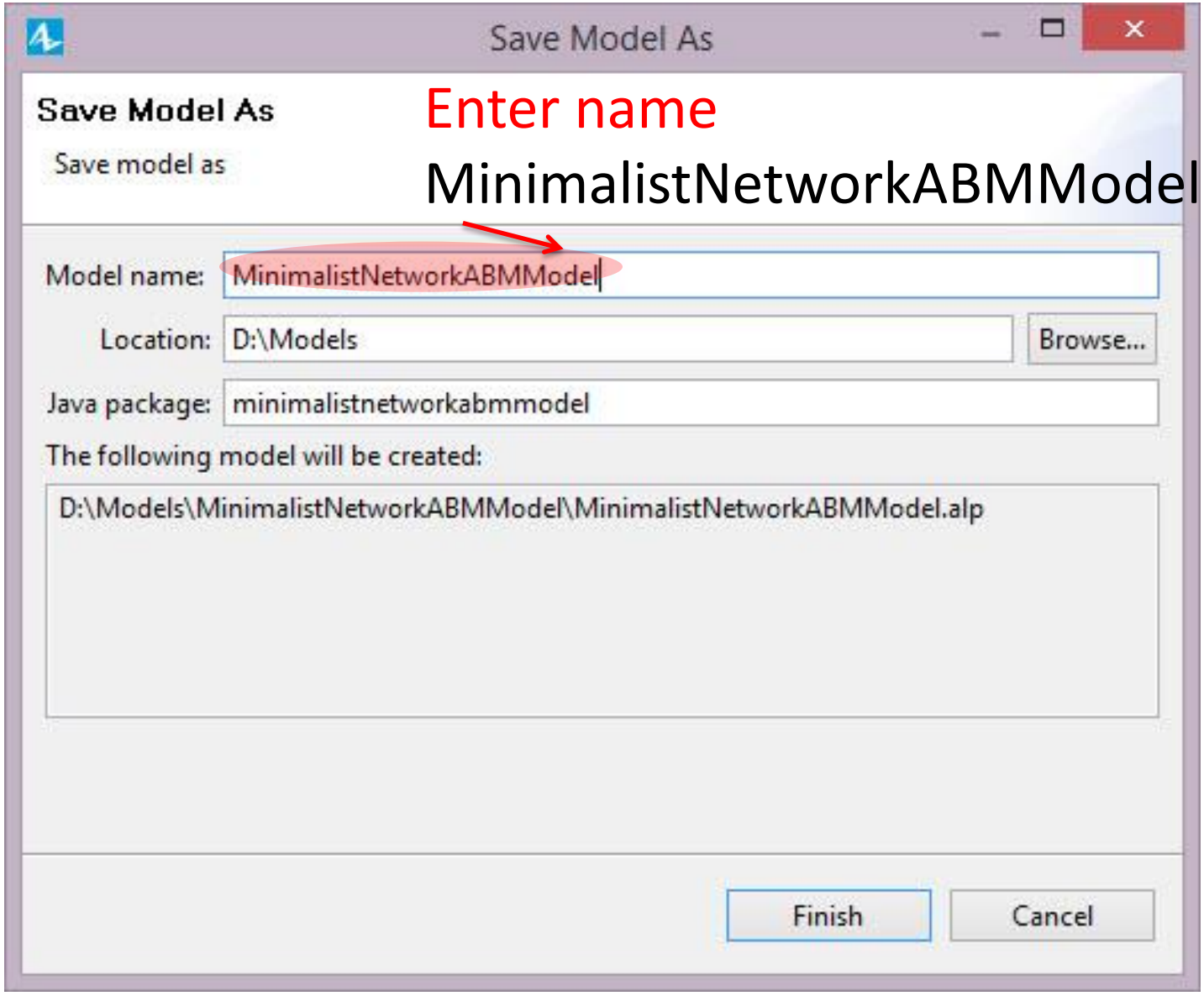
Duke-NUS

April 16, 2014

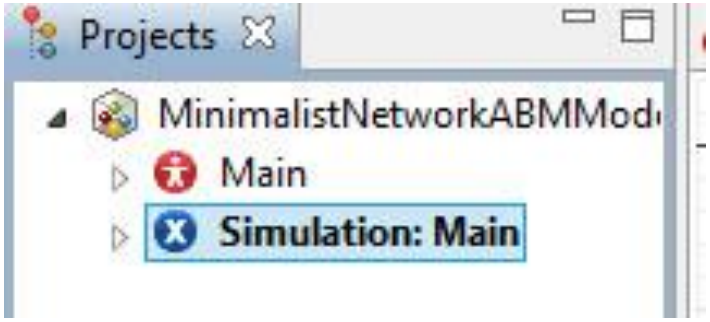
Add a New Model Project



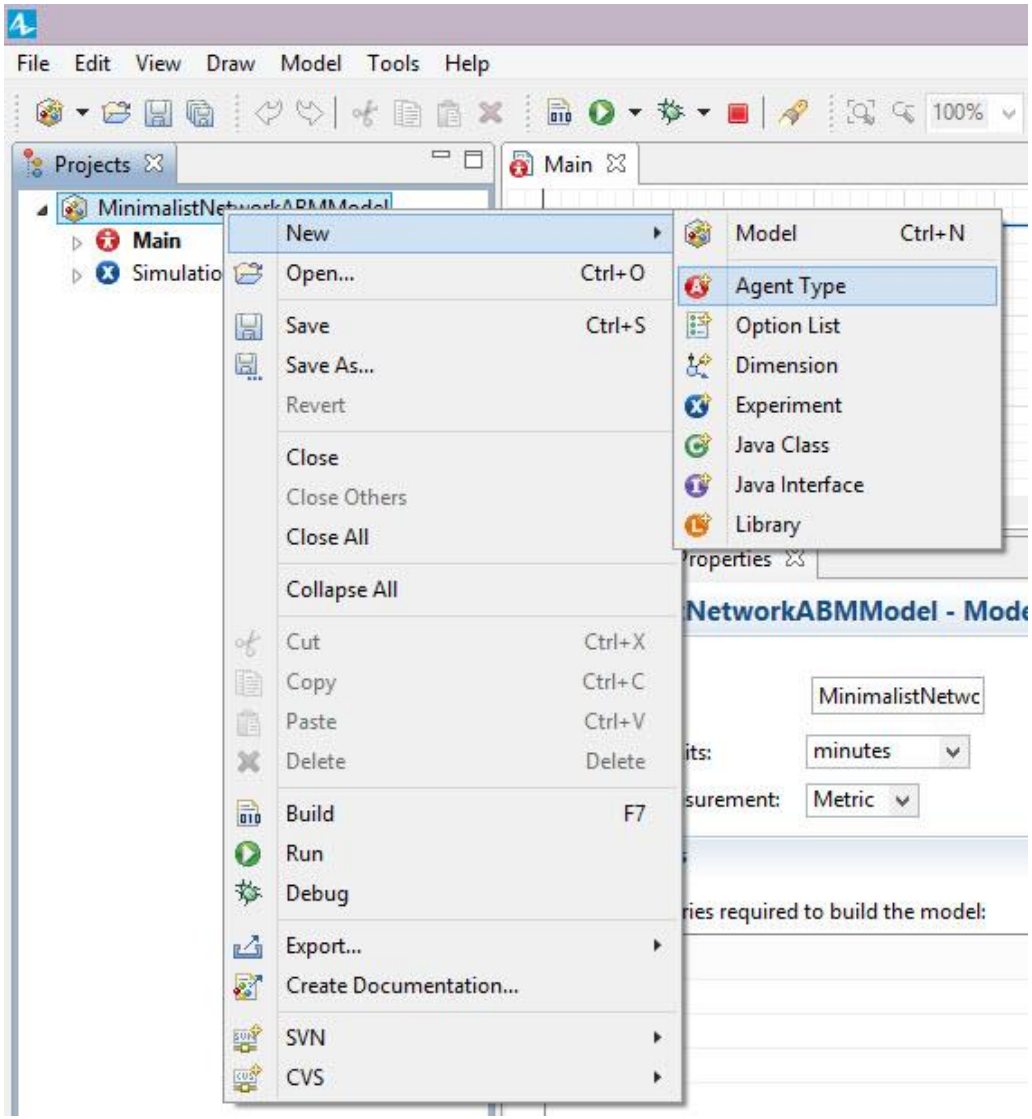
Filling in the Model Project Details



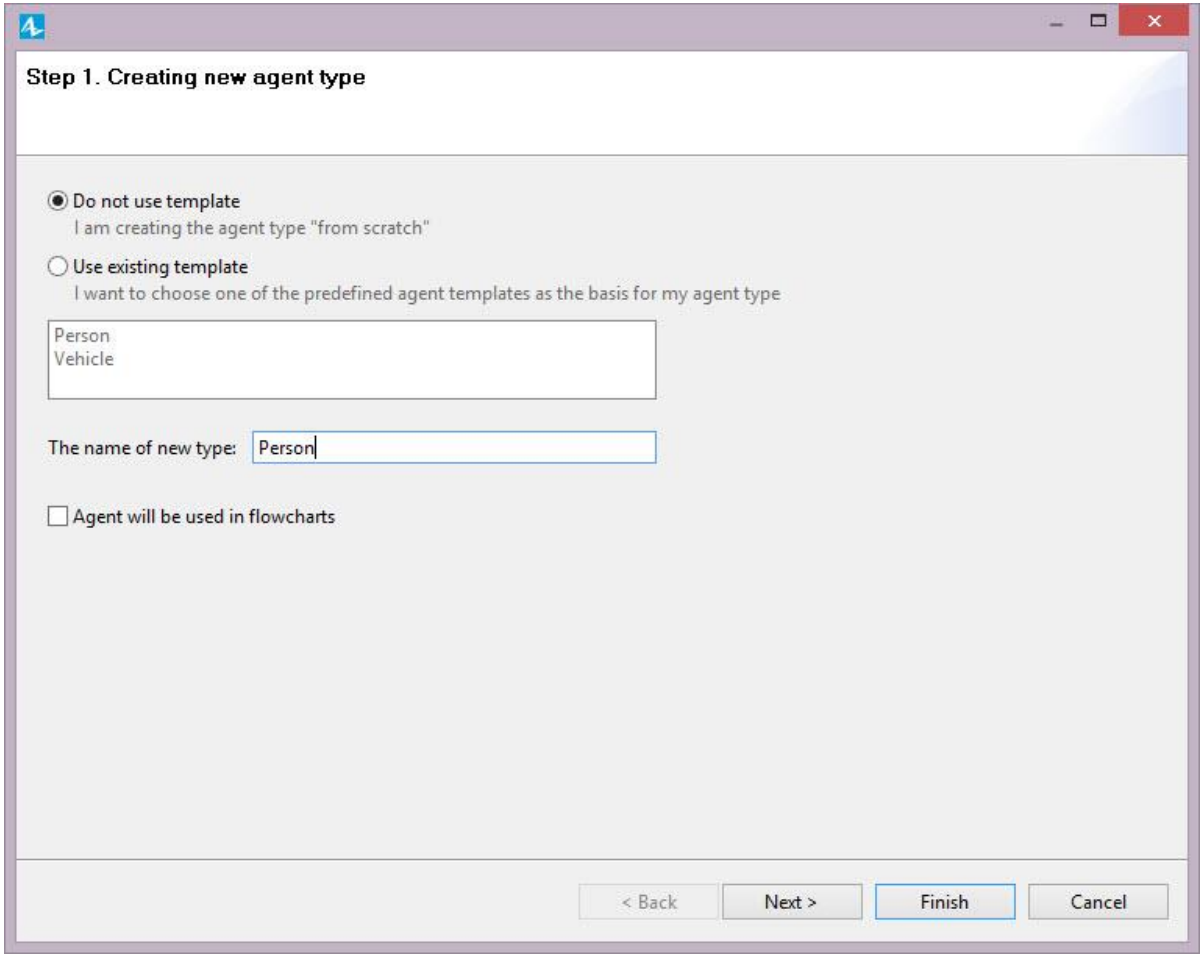
Project Window



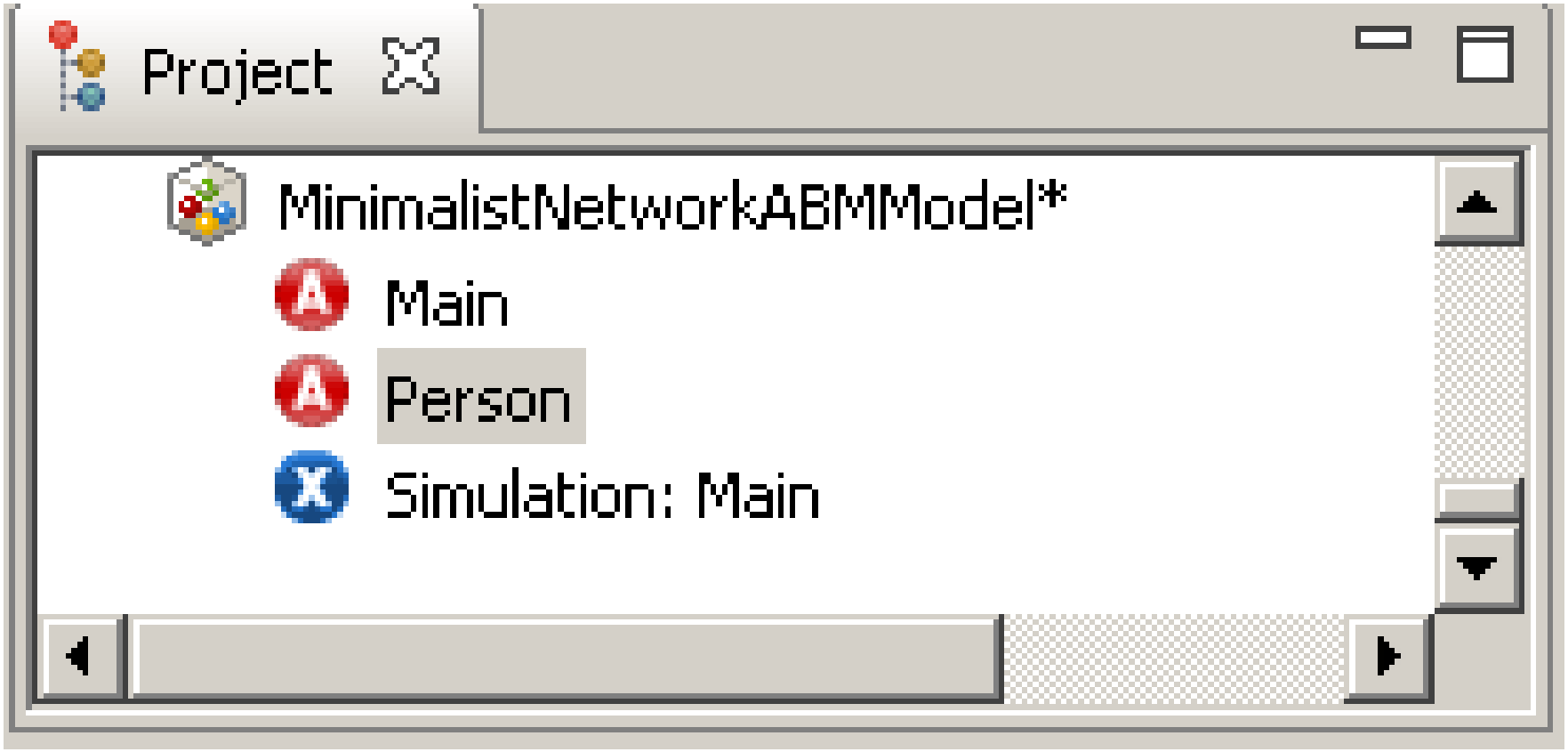
Add an Active Object Class



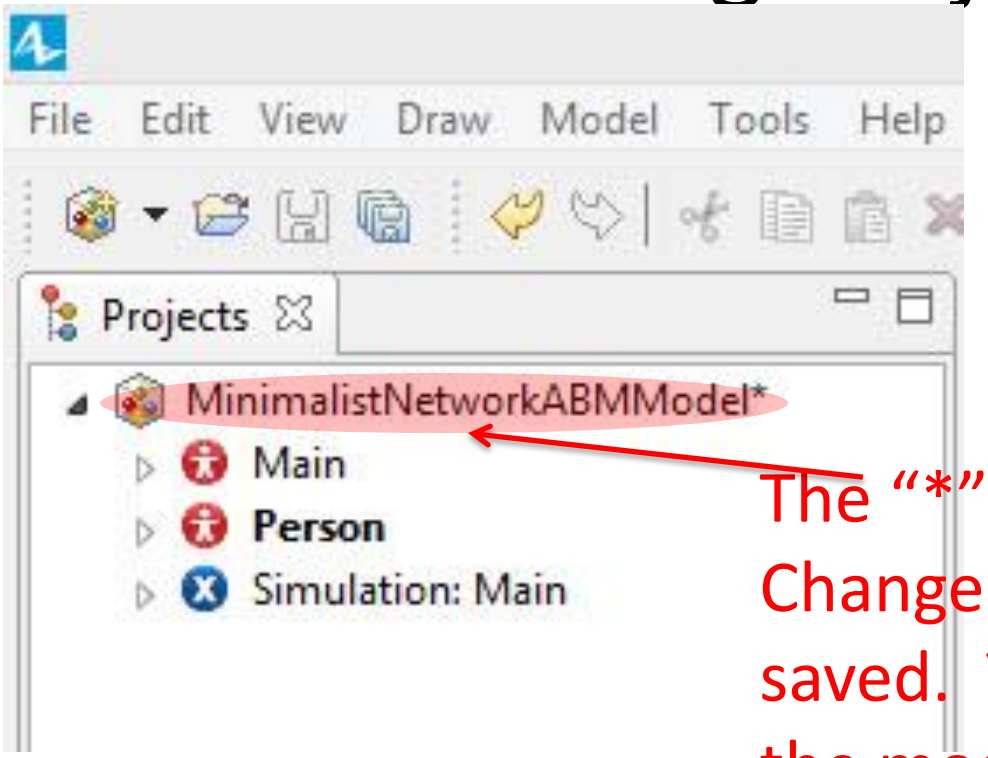
Filling in the Agent Class Details



Updated Project Window



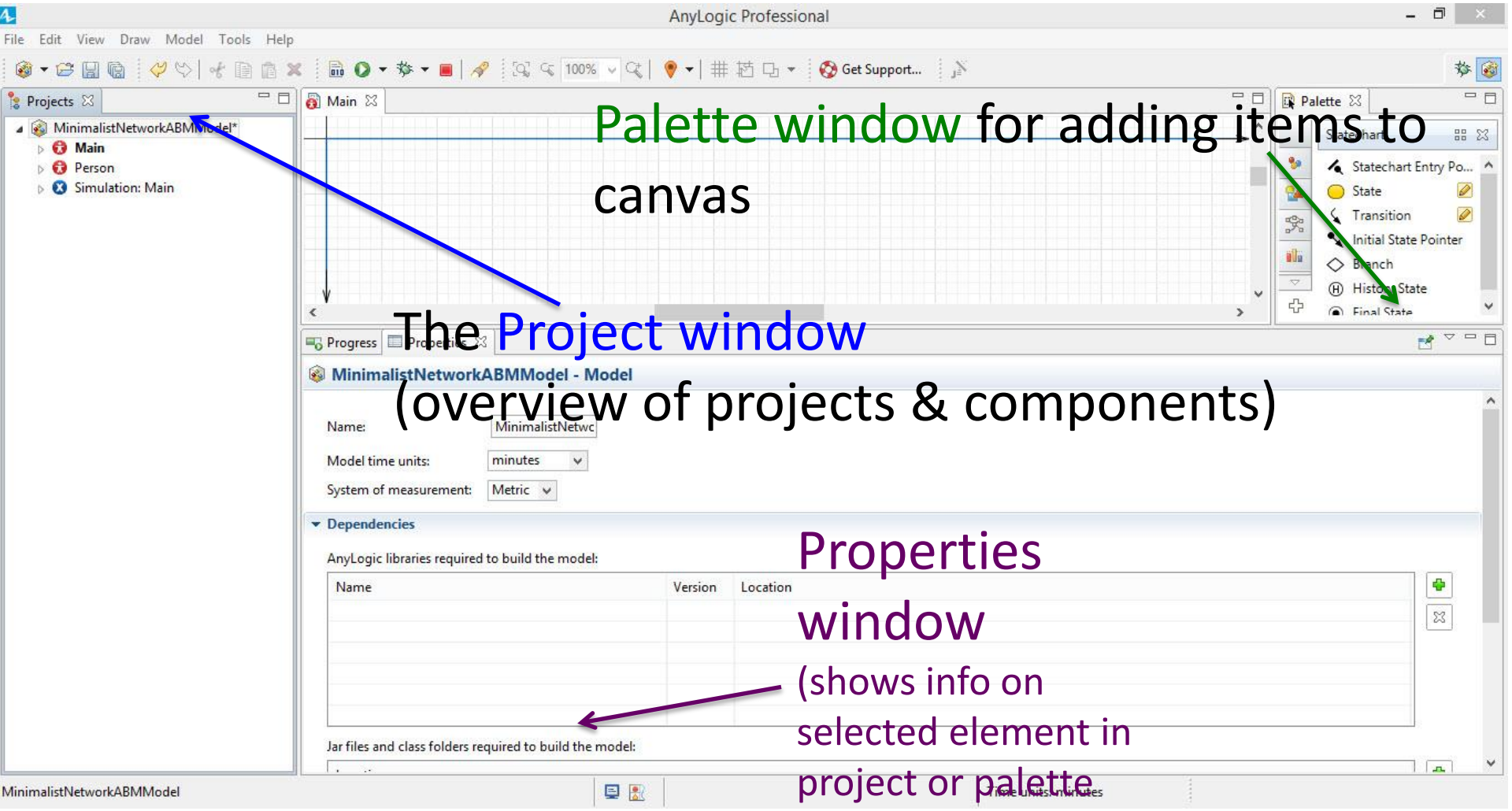
Resulting Project Window



The "*" means that the model has Changed since the last time it was saved. You should consider saving the model when you see this!

AnyLogic Interface Elements

Note: Double-Clicking on a Tab opens view as Full-Screen

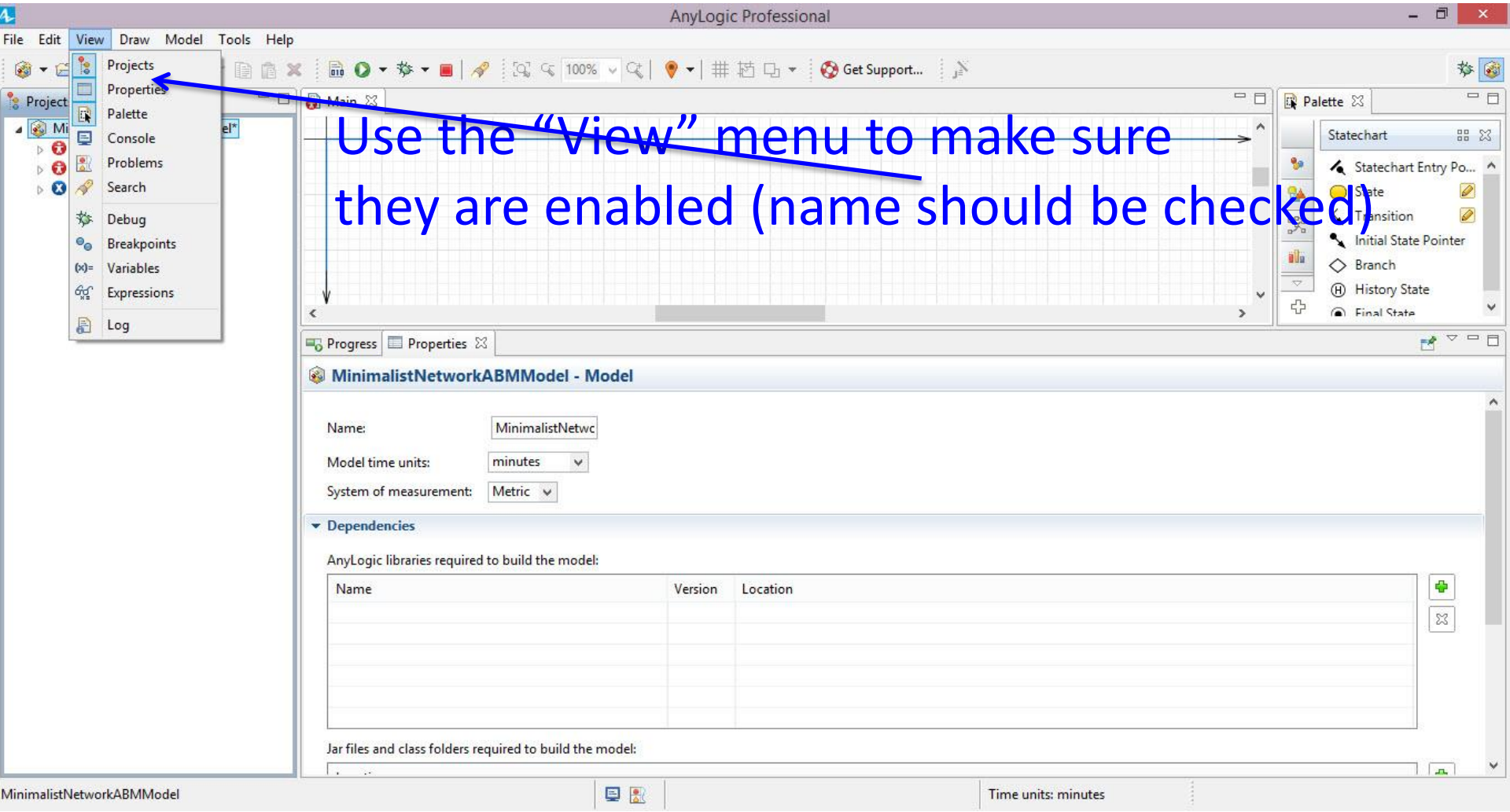


Palette window for adding items to canvas

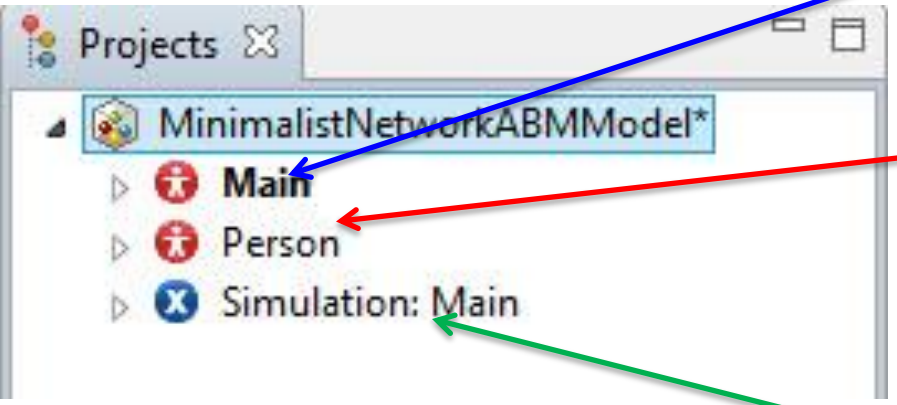
The Project window (overview of projects & components)

Properties window (shows info on selected element in project or palette window)

If Windows are Missing…



The “Project” Window



“Main” class
(Defines the “*Stage*” on which agents circulate)

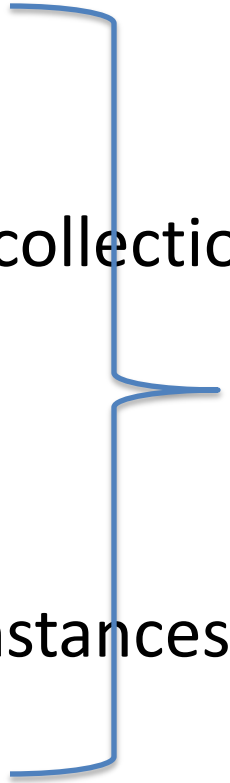
“Agent” classes
(Define the *actors*)

“Experiment” classes
(Define the *Assumptions for Simulation scenarios*)

Key Customized “Classes”

- The structure of the model is composed of certain key user-customized “classes”
- “Main” class
  - Normally just one instance
  - This will generally contain collections of the other classes
- “Agent” classes
  - Your agent classes
  - There are typically many instances (objects) of these classes at runtime
- “Experiment” classes

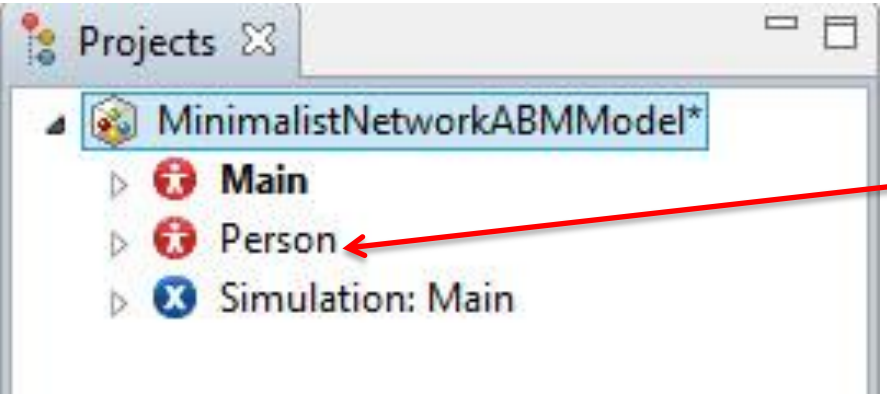
  These describe assumptions to use when running the model



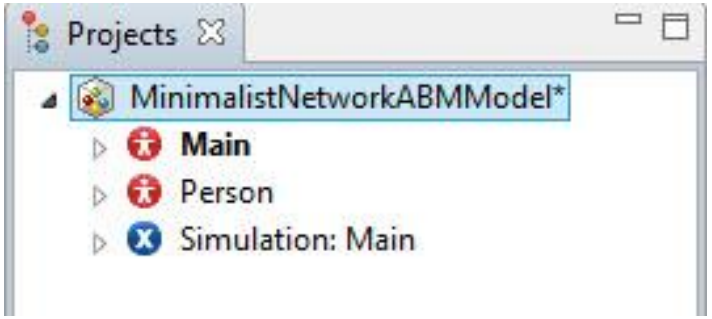
Creating a Visual Representation

- Agents and Main classes can be associated with visual representations
- These representations can give us a clearer sense of agent behavior

Open Up Canvas for “Person”
(In case it is not already open)
this is an Agent class, which defines the Characteristics & Behaviour of Agent Population Members



Agent “Class”



- A particular agent “class” defines “what it means” to be that particular type of agent in our model with respect to characteristics (static [“parameters”], dynamic [“state”]), behaviour & appearance.
  - e.g. a “Person” class defines “Personhood” (“Personness”)
- A given agent “class” will often have many particular representatives (instances) during simulation
  - e.g. While there may be just one “Person” class, there may be many specific People circulating within a model
- Our model may have define types of agents (e.g. Persons, Doctors; Hares & Lynxes), each with one or more accompanying populations

What is a Class?

- A class is like a mold in which we can cast particular objects
  - From a single mold, we can create many “objects”
  - These objects may have some variation, but all share certain characteristics – such as their behaviour
    - This is similar to how objects cast by a mold can differ in many regards, but share the shape imposed by the mould
- In object oriented programming, we define a class at “development time”, and then often create multiple objects from it at “runtime”
  - These objects will differ in lots of (parameterized) details, but will share their fundamental behaviors
  - Only the class exists at development time
- Classes define an interface, but also provide an *implementation* of that interface (code and data fields that allow them to realized the required behaviour)

A Critical Distinction: Design (Specification) vs. Execution (Run) times

- The computational elements of Anylogic support both design & execution time presence & behaviour
  - Design time: Specifying the model
  - Execution time ("Runtime"): Simulating the model
- It is important to be clear on what behavior & information is associated with which times
- Generally speaking, design-time elements (e.g. in the palettes) are created to support certain runtime behaviors

A Familiar Analogy

- The distinction between model design time & model execution time is like the distinction between
  - Time of Recipe Design: Here, we're
    - Deciding what exact set of steps we'll be following
    - Picking our ingredients
    - Deciding our preparation techniques
    - Choosing/making our cooking utensils (e.g. a cookie cutter)
  - Time of Cooking: When we actually are following the recipe
    - A given element of the recipe may be enacted many times
      - One step may be repeated many times
      - One cookie cutter may make many particular cookies

Cooking Analogy to an Agent Class: A Cookie Cutter

- We only need one cookie cutter to bake many cookies
- By carefully designing the cookie cutter, we can shape the character of many particular cookies
- By describing an Agent class at model design time, we are defining the cookie cutter we want to use
  - Just like the shape of one cookie cutter gets reflected in many particular cookies
    - One agent class has many particular “instances” (Persons)
    - The visual representation of that class gets spread around
    - One visual element in the design of a class can become many during simulation

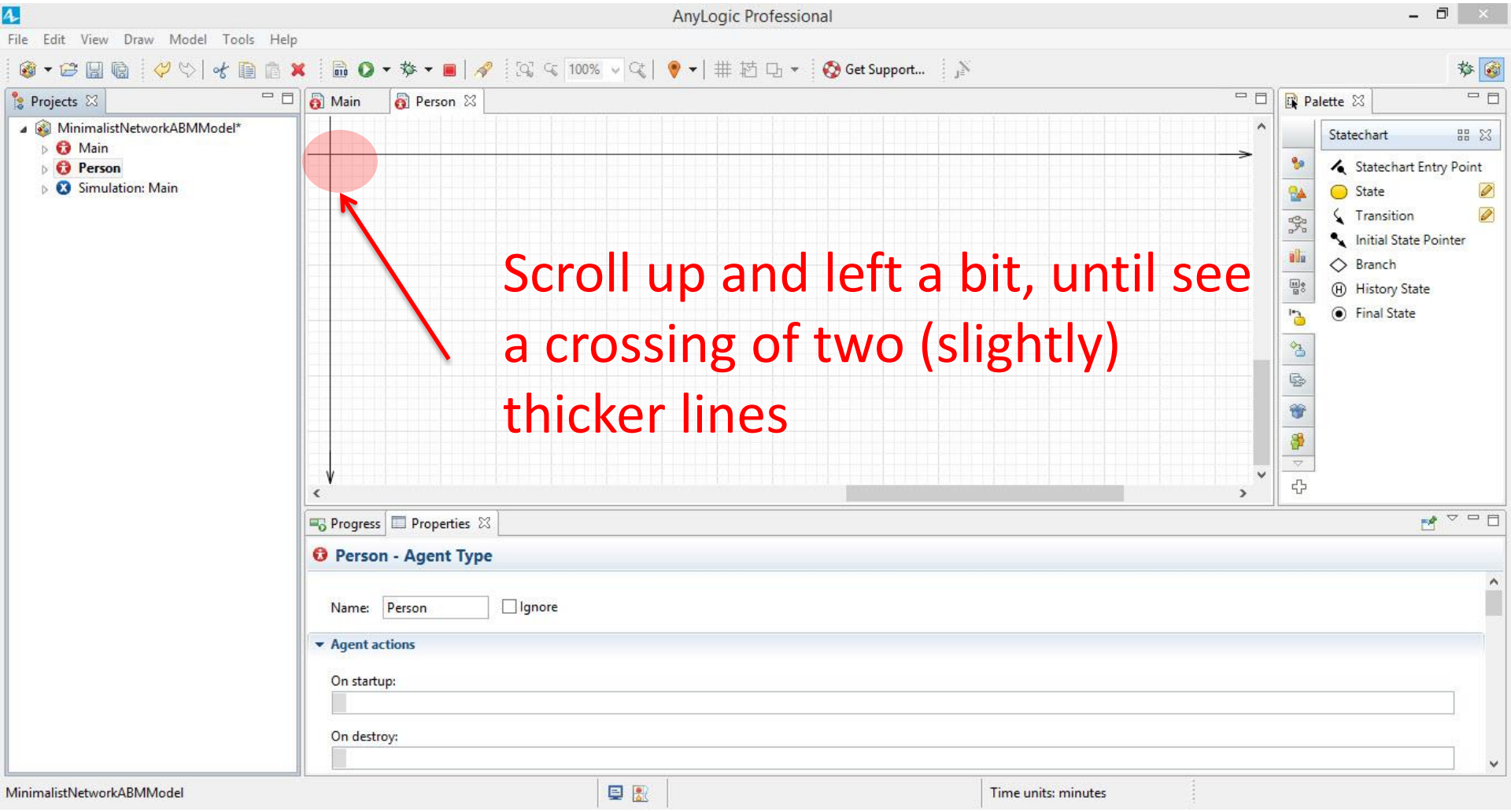
Classes: Design & Run Time Elements

- The AnyLogic interface makes critical use of a hierarchy of *classes (*e.g. *Main, Agent* classes*, Experiment* classes*)*
  - These classes each represent the properties & behaviour of one or more particular objects at runtime
  - We will be discussing this hierarchy more in a later session
- Each of these classes is associated with both
  - Design time interface (appearance at design time)
  - Run time elements (presence of the class object and instances of the class when running the simulation)

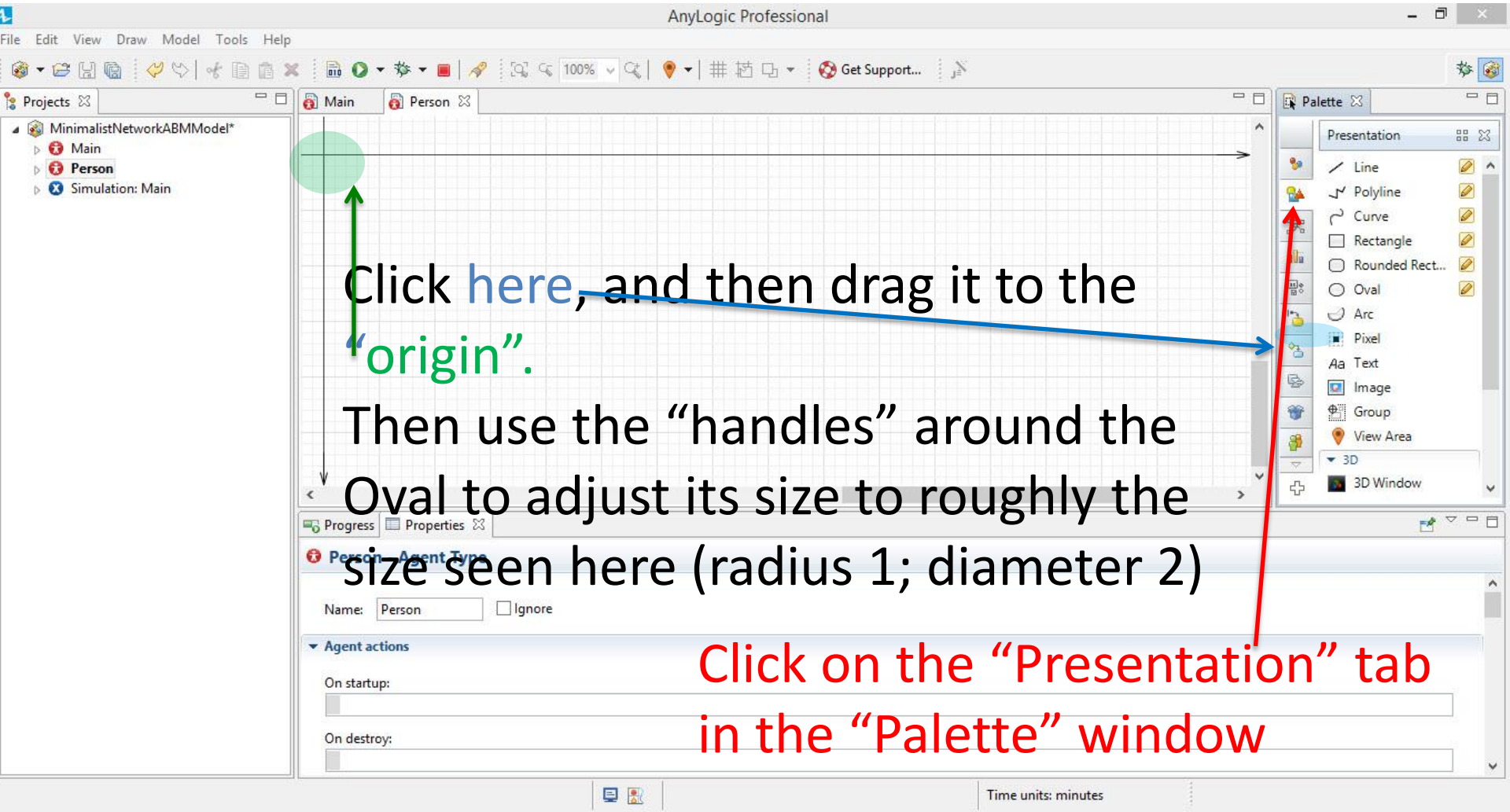
Design Time Components

- Properties for entities
  - Values to use at runtime/Bits of code/Data types/Initial values of state variables/parameter values
- Declaring & manipulating variables, parameters, functions, etc.
- Defining the visual elements to use for each agent
- In an agent-based model, we have only one "class" for each *type* of object (e.g. "Person", "Doctor")
  - The populations of agents are just "instances" of this class

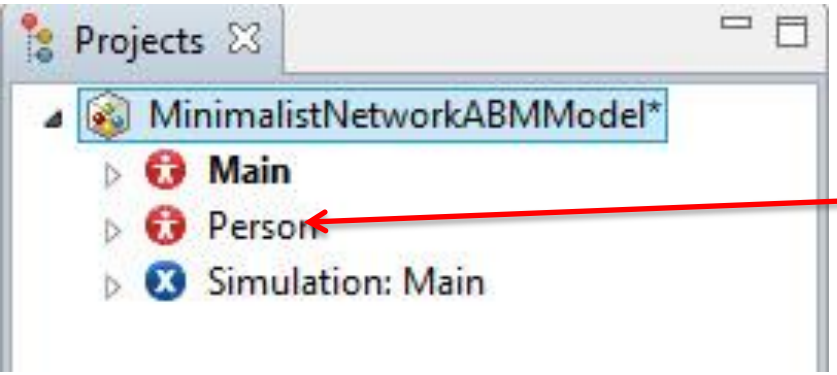
Agent Class Defines the Characteristics & Behaviour of Agent Population Members



Adding an Oval to Represent Agent

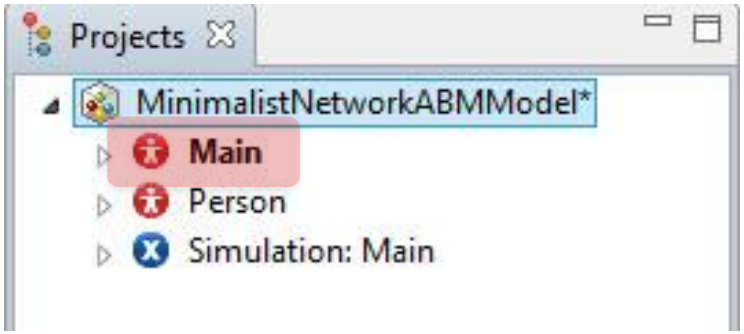


Open Up Canvas for “Main”
(In case it is not already open)



Double Click Here

"Main" Class: The "Stage" for Agents



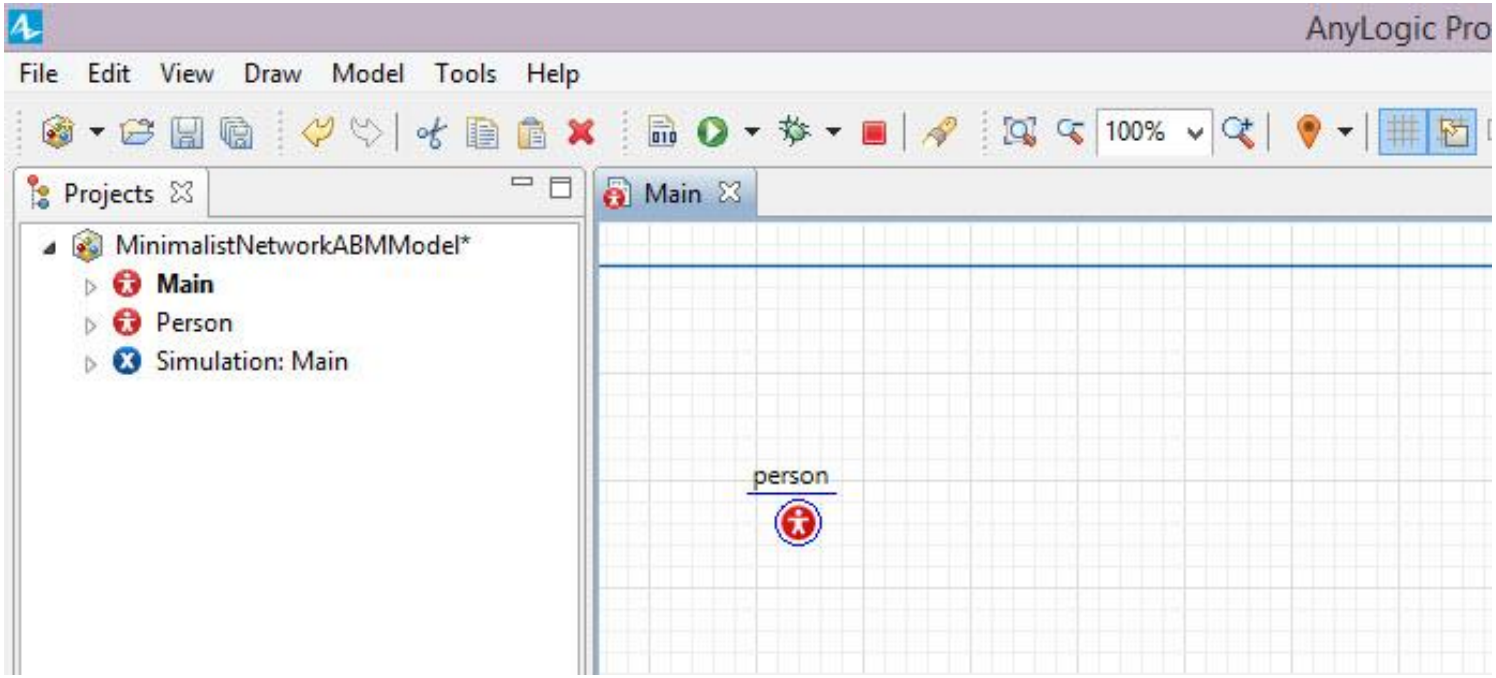
- Defines the environment where agents interact
- Defines interface & cross-model mechanisms
- The Main object normally contains one or more "populations" of "replicated" agents
  - Each population consists of agents of a certain class (or a subclass therefore), e.g.
    - "Hares"
    - "Lynxes"
  - The agent classes are defined separately from the Main class

We will now add an Agent (Person) population to the "Main" Class

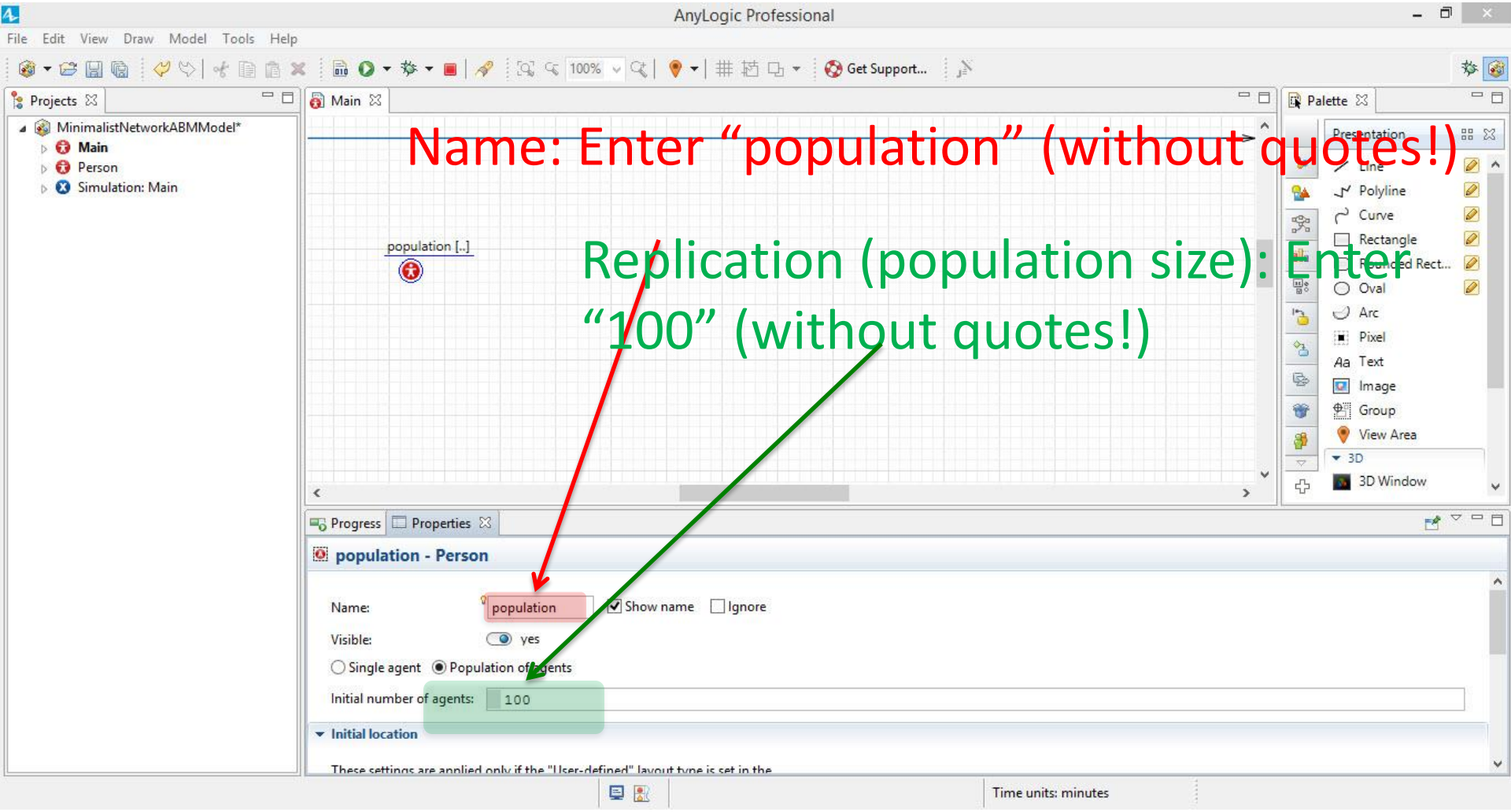
Agent Populations in the Main Class

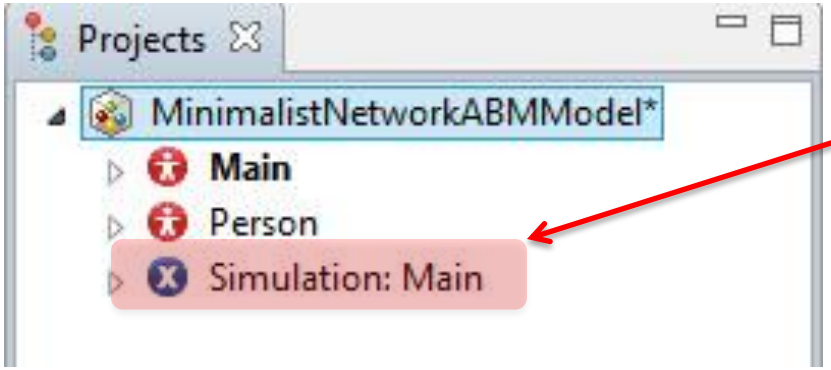
- Through the “Replication” property, the number of these agents can be set
- The “Environment” property can be used to associated the agents with some surrounding context (e.g. Network, embedding in some continuous space, with a neighborhood)
- Statistics can be computed on these agents
- Within the Main class, you can create representations of subpopulations by dragging from an Agent class into the Main class area

To Add an Agent (Person) Population:
Drag From “Person” into the Canvas for “Main”



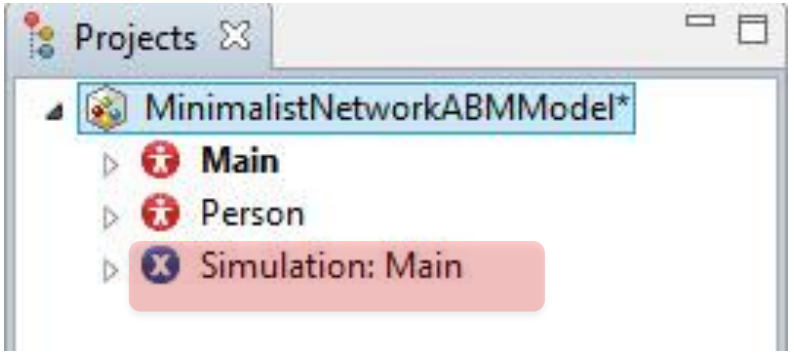
Specifying the Population Name & Size





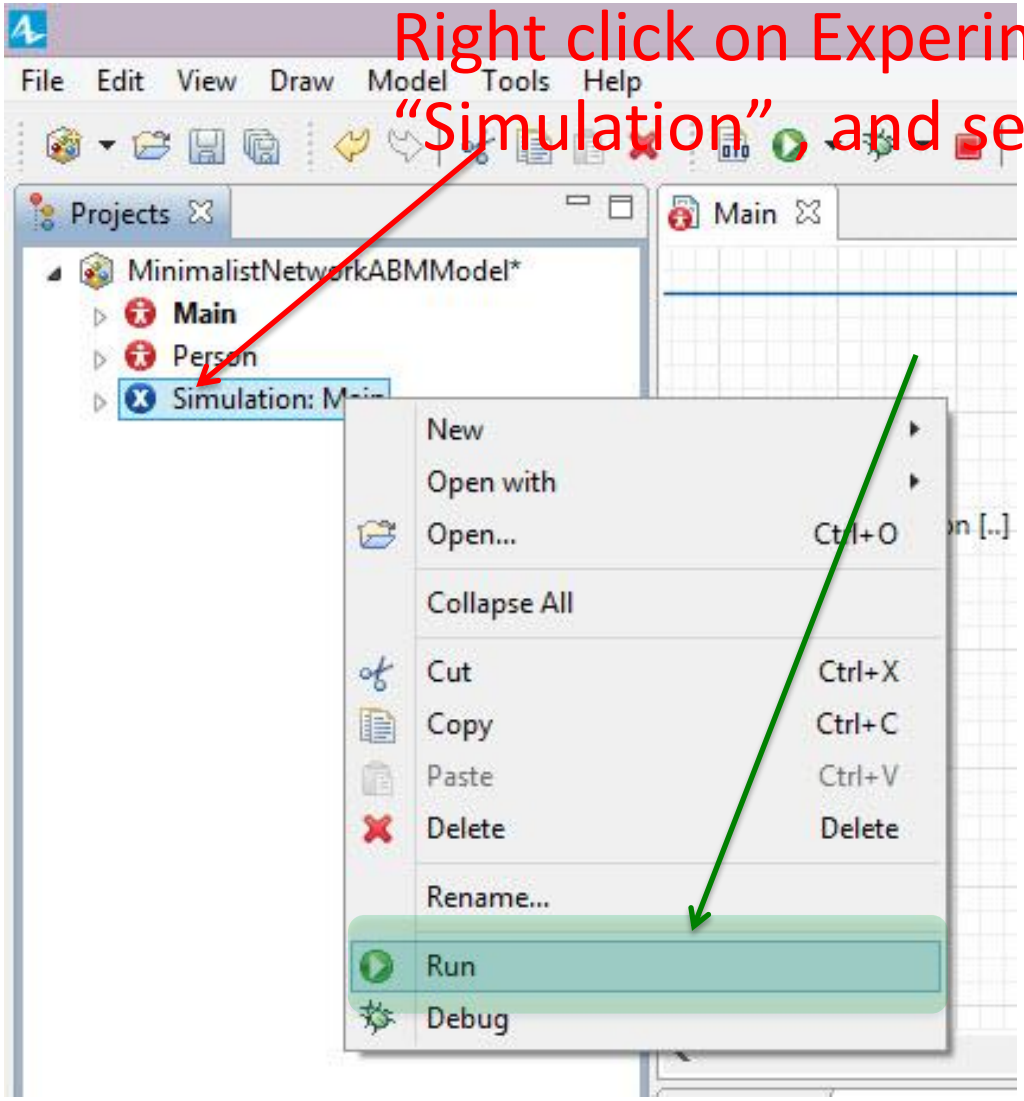
A (default) Experiment Specifies assumptions for a particular scenario (e.g. population size, pathogen contagiousness, etc.)

Experiment Classes

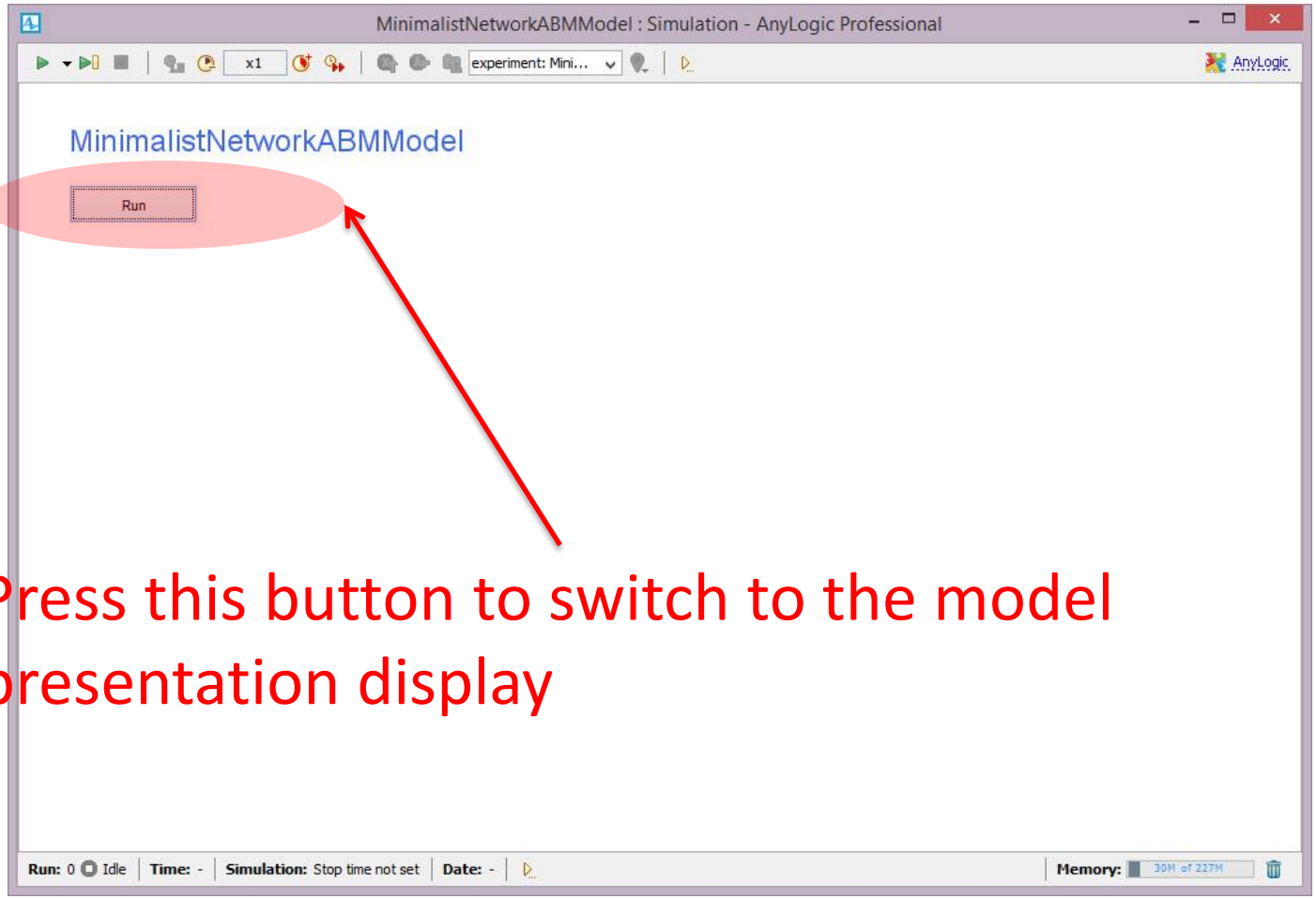


- Experiment classes allow you to define & run scenarios in which global "parameters" (i.e. assumption quantities defined in *Main*) may hold either default or alternative values
- Experiment classes are also used to set
  - The time horizon for a simulation
  - Memory limits (important for large models)
  - Details of simulation run
  - Details on random number generation
  - Virtual machine arguments
- "Parameters" allow one to set the values for each parameter
- Right click on these & choose "Run" to run such a scenario

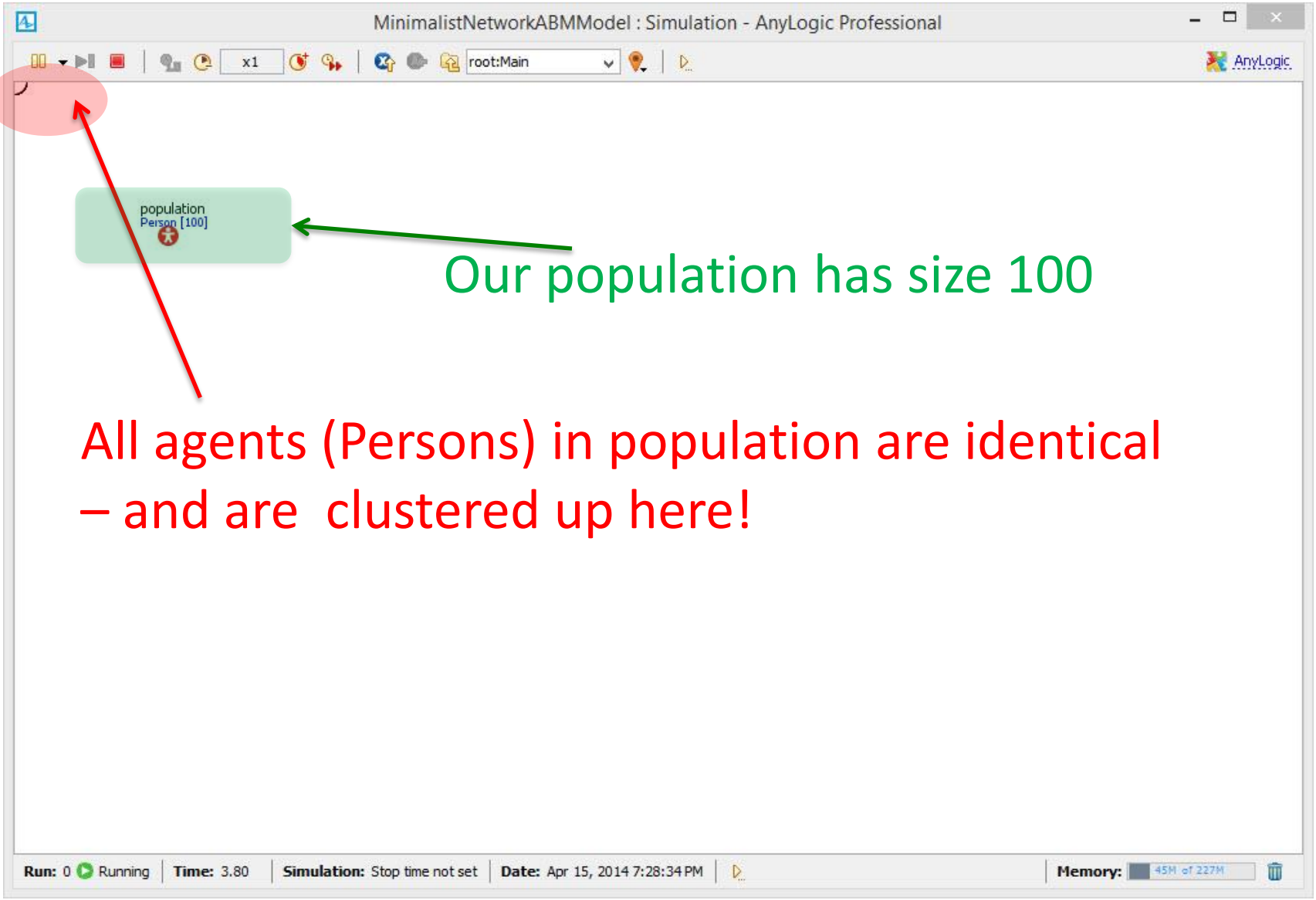
Let's Simulate the Model!



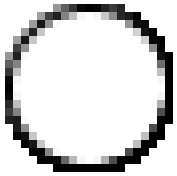
Initial Simulation Screen



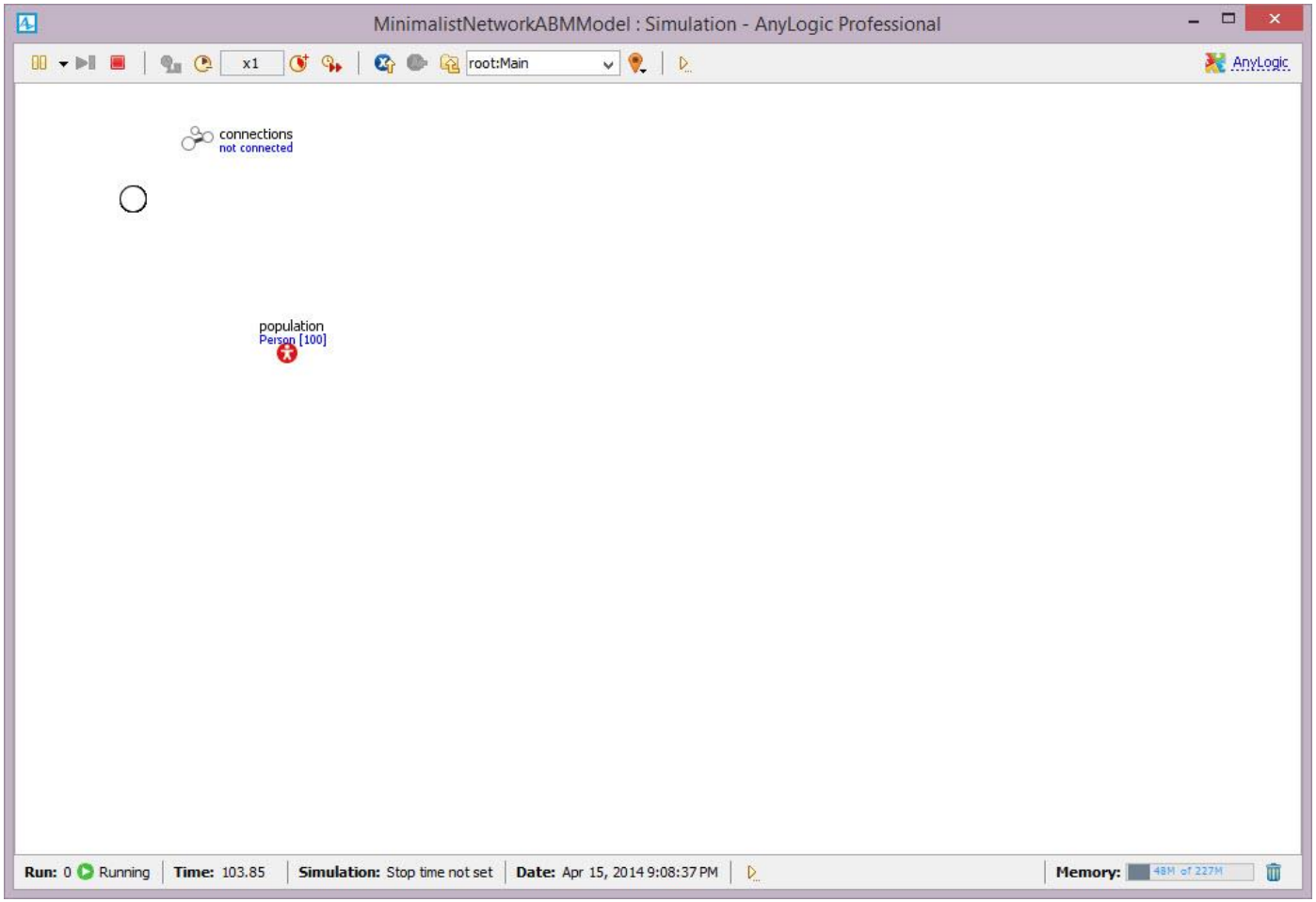
An Uninspiring Display



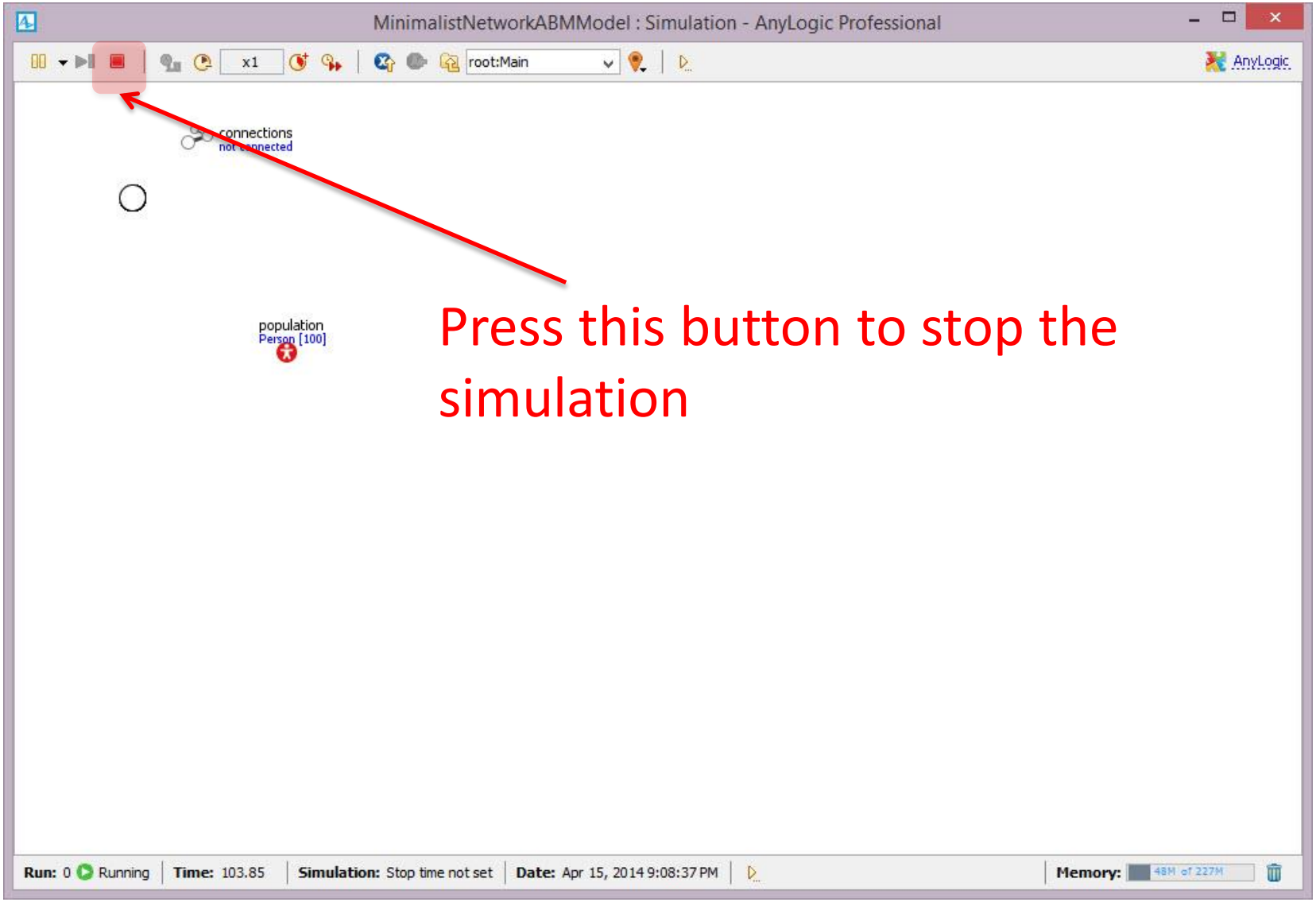
A Magnified View



“Right Click” & Drag to “Pan” (“Pull”) viewer



Stop Simulation



Agent Populations Live in Main Class

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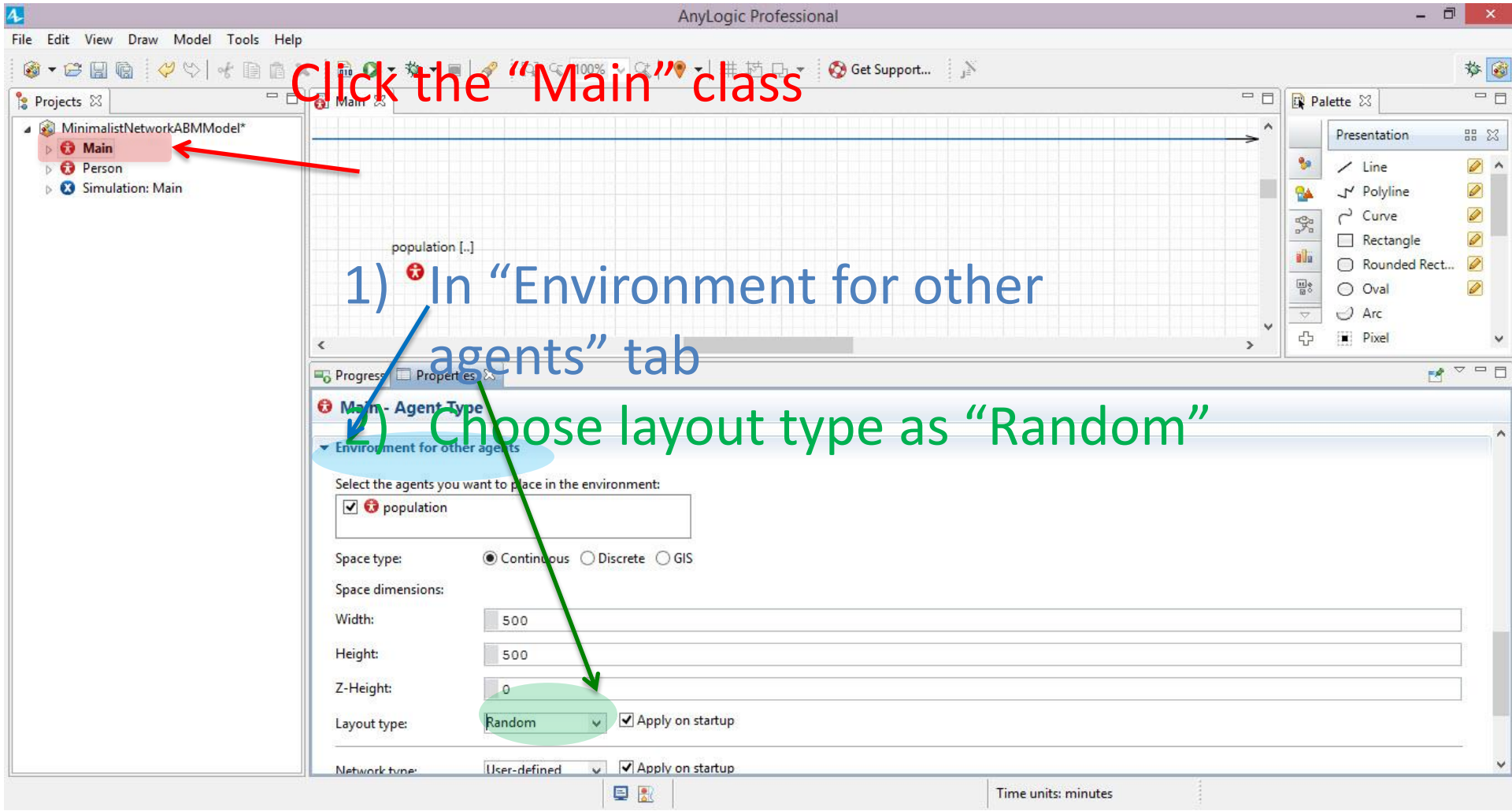
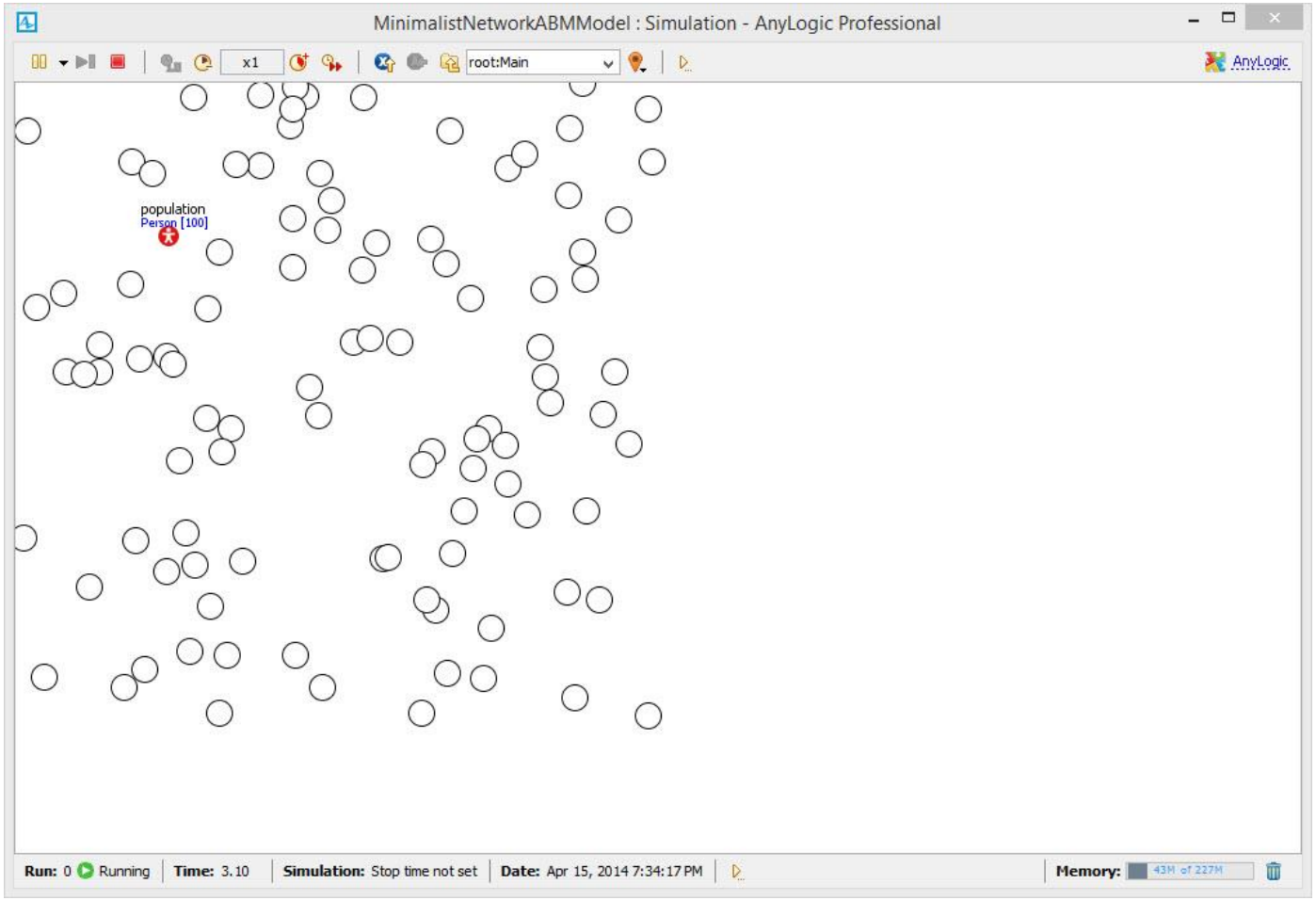
From “General” Area of “Palette” Window Add an “Environment” to the Model



Run the Model: Environment Distributes Agents Around Space



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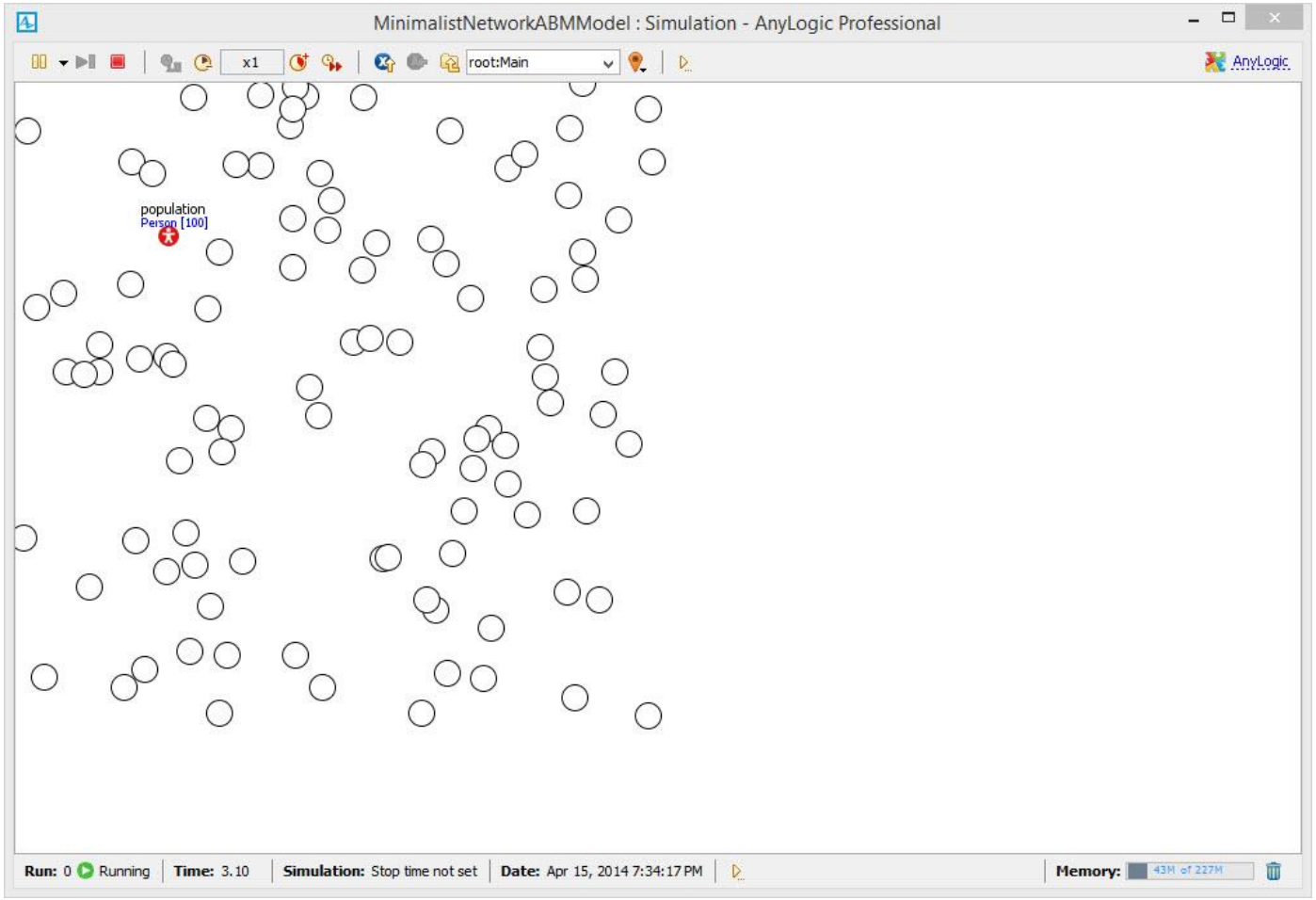


Recall: A Familiar Analogy

- The distinction between model design time & model execution time is like the distinction between
  - Time of Recipe Design: Here, we're
  - Time of Cooking: When we actually are following the recipe

The Notion of a “Build”

- We prepare a fully specified model to run a simulation using a “build”
  - If all goes well, this translates project to executable Java
  - This may alert you to errors in the project
- A “compiler” is a tool to convert from a program’s specification (e.g. state charts, Action diagrams, etc.) to a representation that can be executed
  - Normally a compiler is applied to each of several components of a program (e.g. classes)
  - AnyLogic’s “build” process applies a compiler to the components of the AnyLogic model

Cooking Analogy to “Build”ing: Obtaining & Preparing the Ingredients

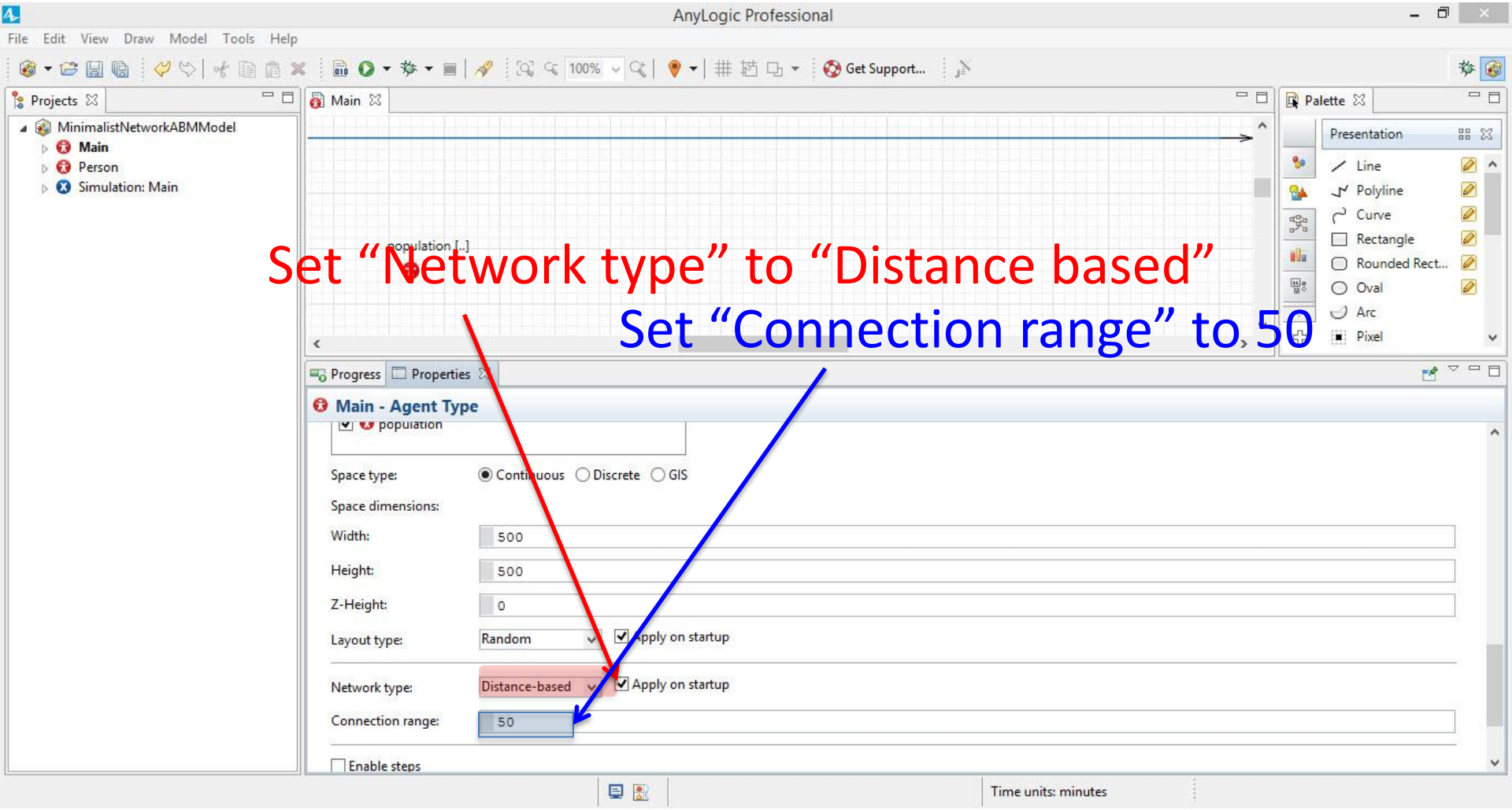
- Before we can actually realize the recipe, we need to go collect & prepare all ingredients
- We’re not yet cooking, but what we are doing makes the cooking possible
- The “cooking” here is running the model

Let’s Place the Agents in a Network

- Steps
  - Tell the Environment that we want to situate the agents in a (here, distance-based) network
  - Specify the attributes of the network (here, the distance threshold up to which agents are considered connected)
  - Give agents a way of appearing visually connected

Setting Network Type in the Environment

Open “Main”, Click on “environment”, and go to the “Advanced” tab in “Properties” window



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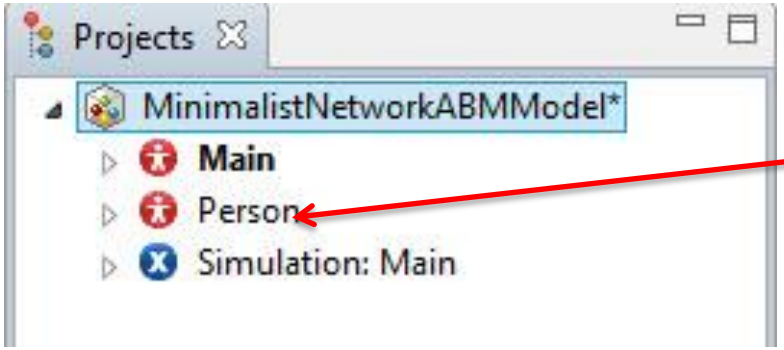
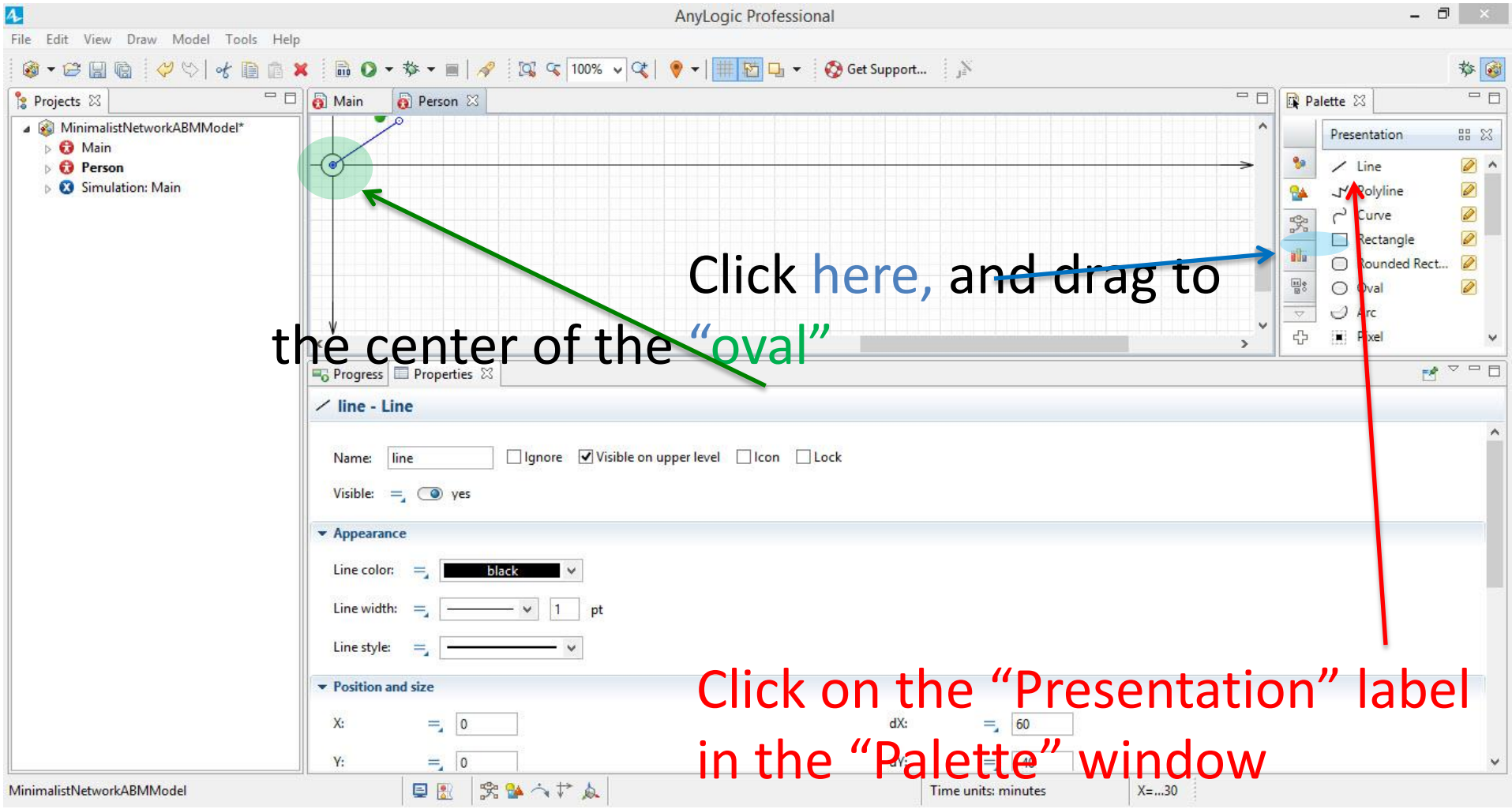
Open Up Canvas for “Person”
(In case it is not already open)



“Double Click Here

Adding a Line to Represent Connections



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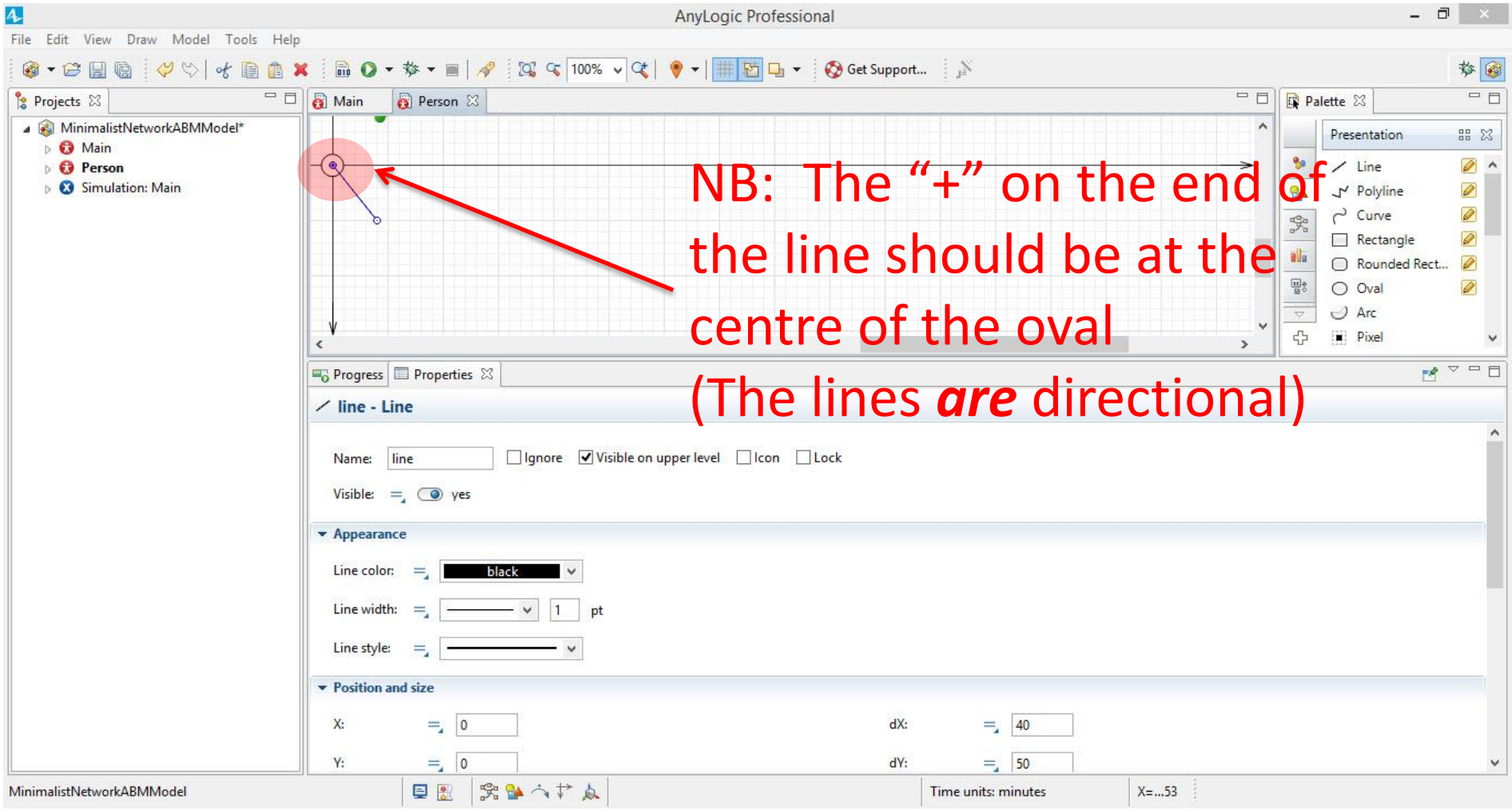
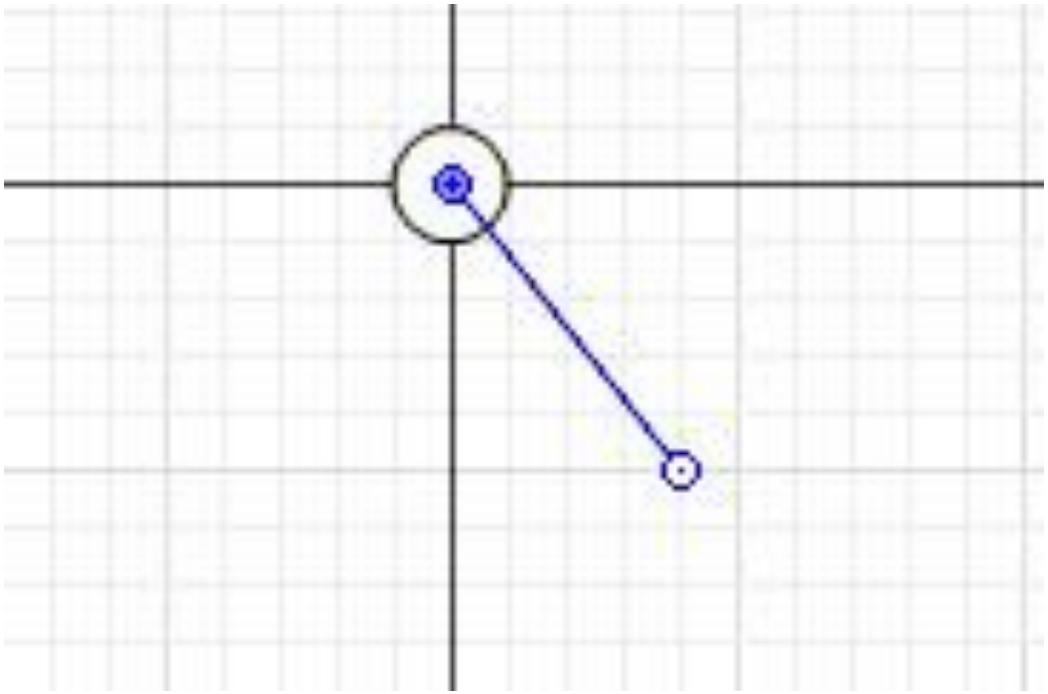
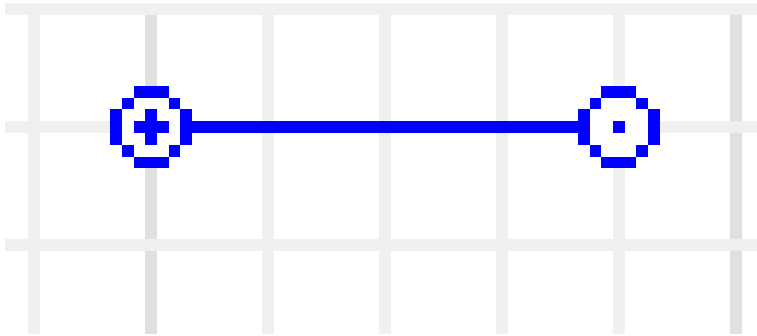


Close-Up

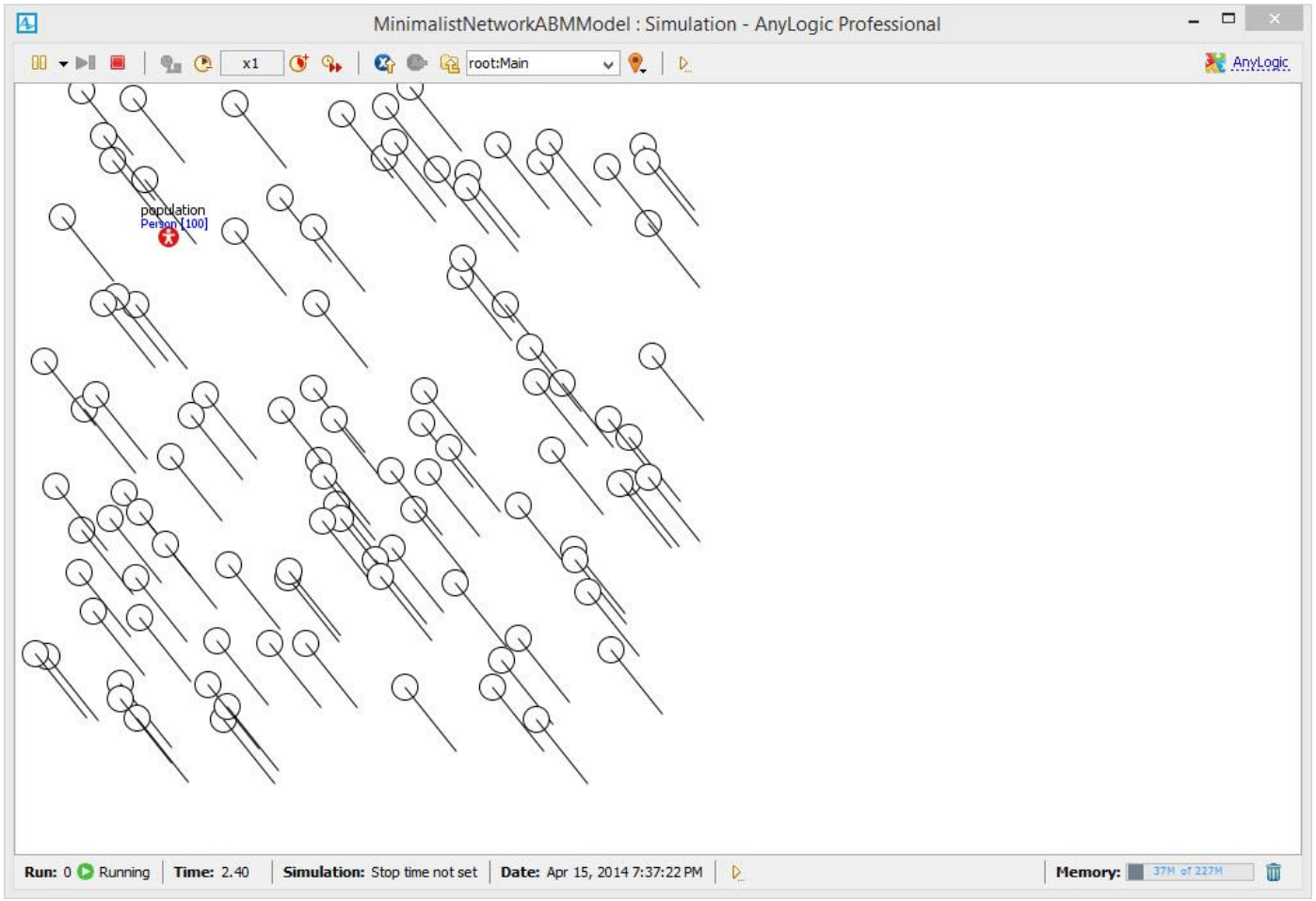


If you are Initially Unsuccessful in Placing the Line in the Circle …

- Place the line on the canvas
- A line looks like this:
  - Pull the end with a small “+” into the very center of the circle
  - The “dotted” end can dangle



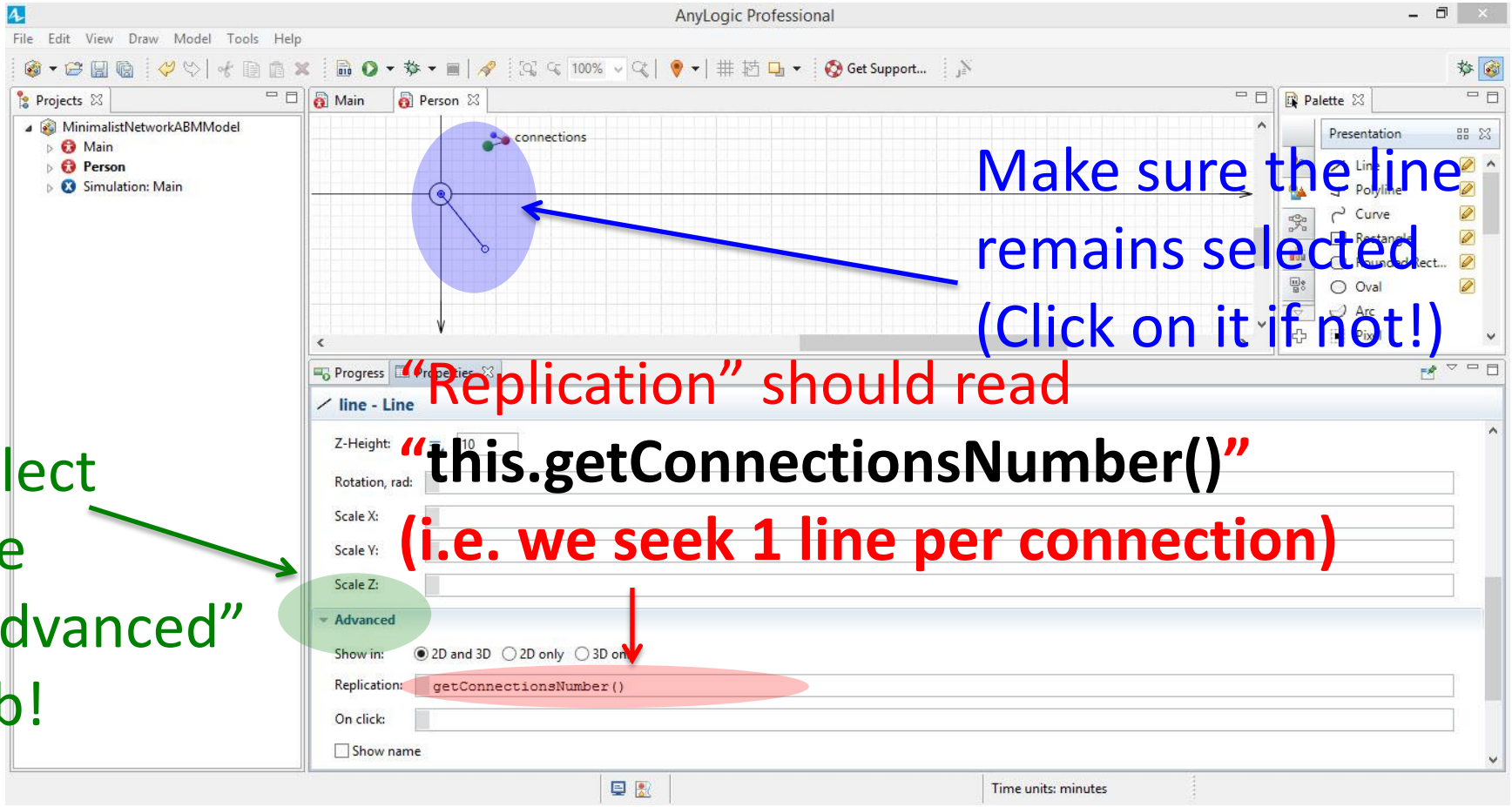
Run the Model: An Uninspiring Sight



We Need to Multiply & Adjust the Lines

- Right now, there is only 1 line per agent
- We need
  - One line per connection between one person and another
  - The lines to connect the two persons

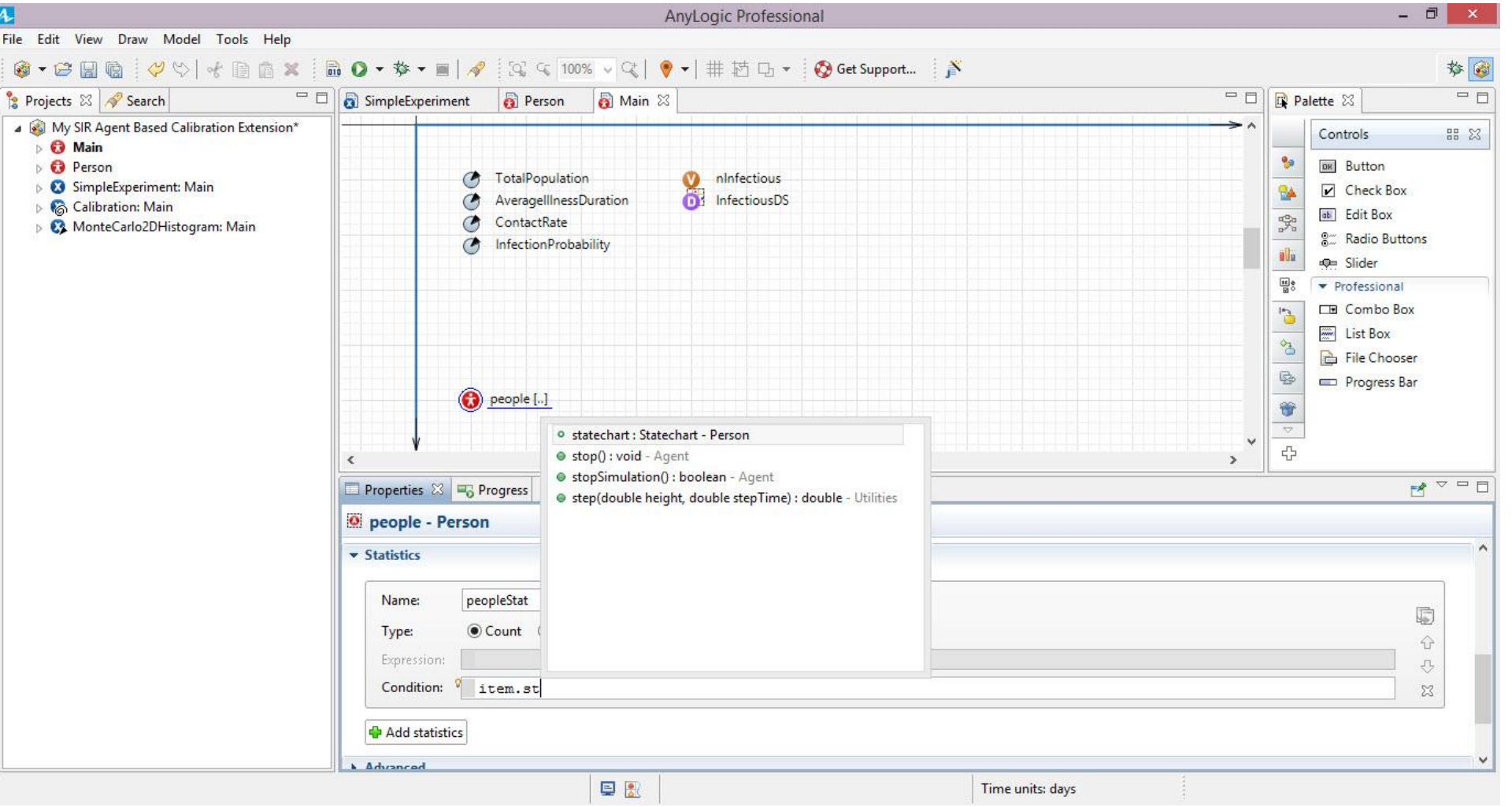
Duplicating the Lines for Each Connection



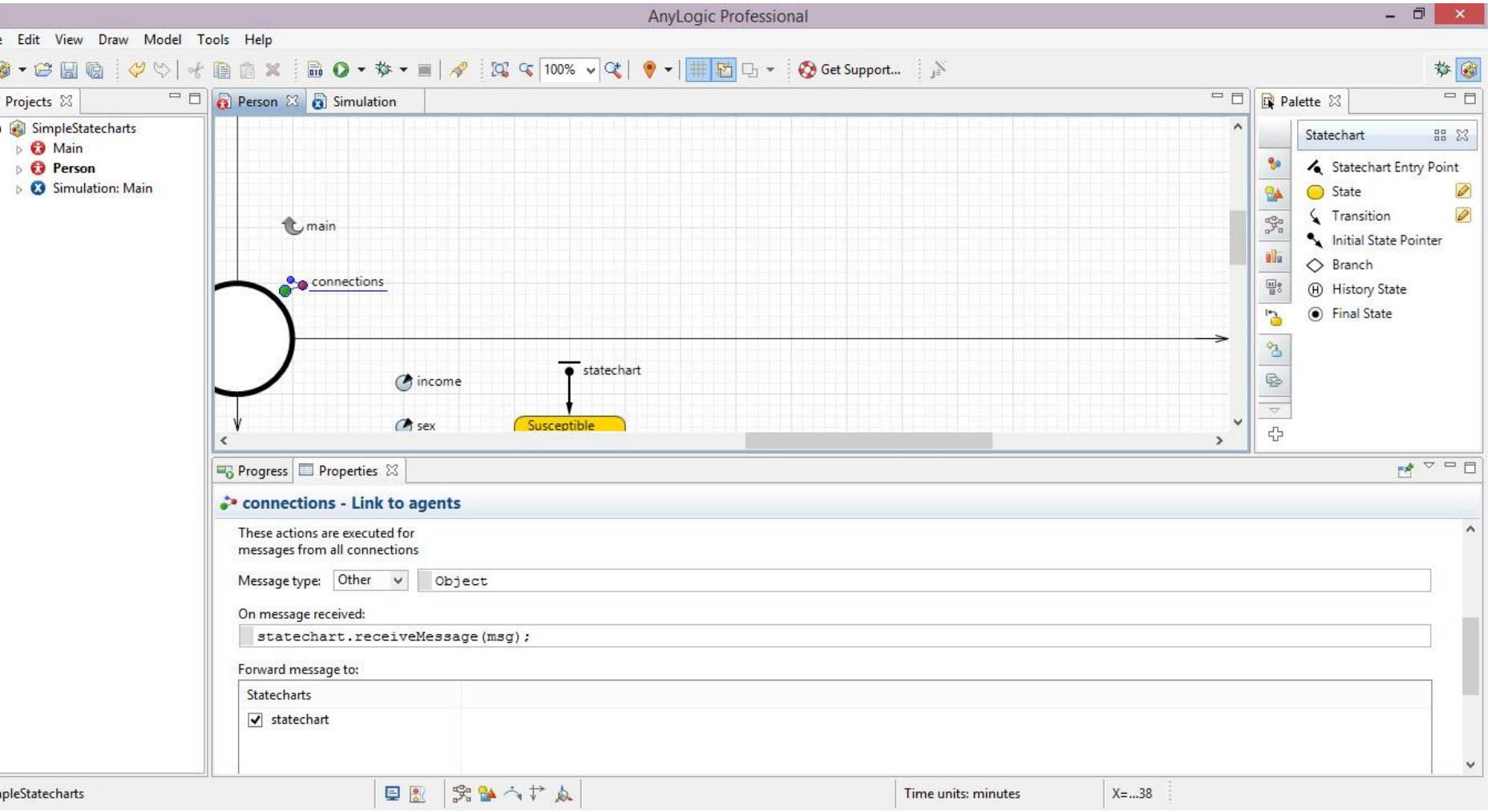
Tips to Bear in Mind While Writing Code

- Click on the “light bulb” next to fields to get contextual advice (e.g. on the variables that are available from context
- While typing code, can hold down the Control key and press the “Space” key to request autocompletion
  - This can help know what parameters are required for a method, etc.
- Java is case sensitive!
- Can press “Control-J” to go to the point in Java code associated with the current code snippet
- Can press “build” button after writing snippet to increase confidence that code is understood

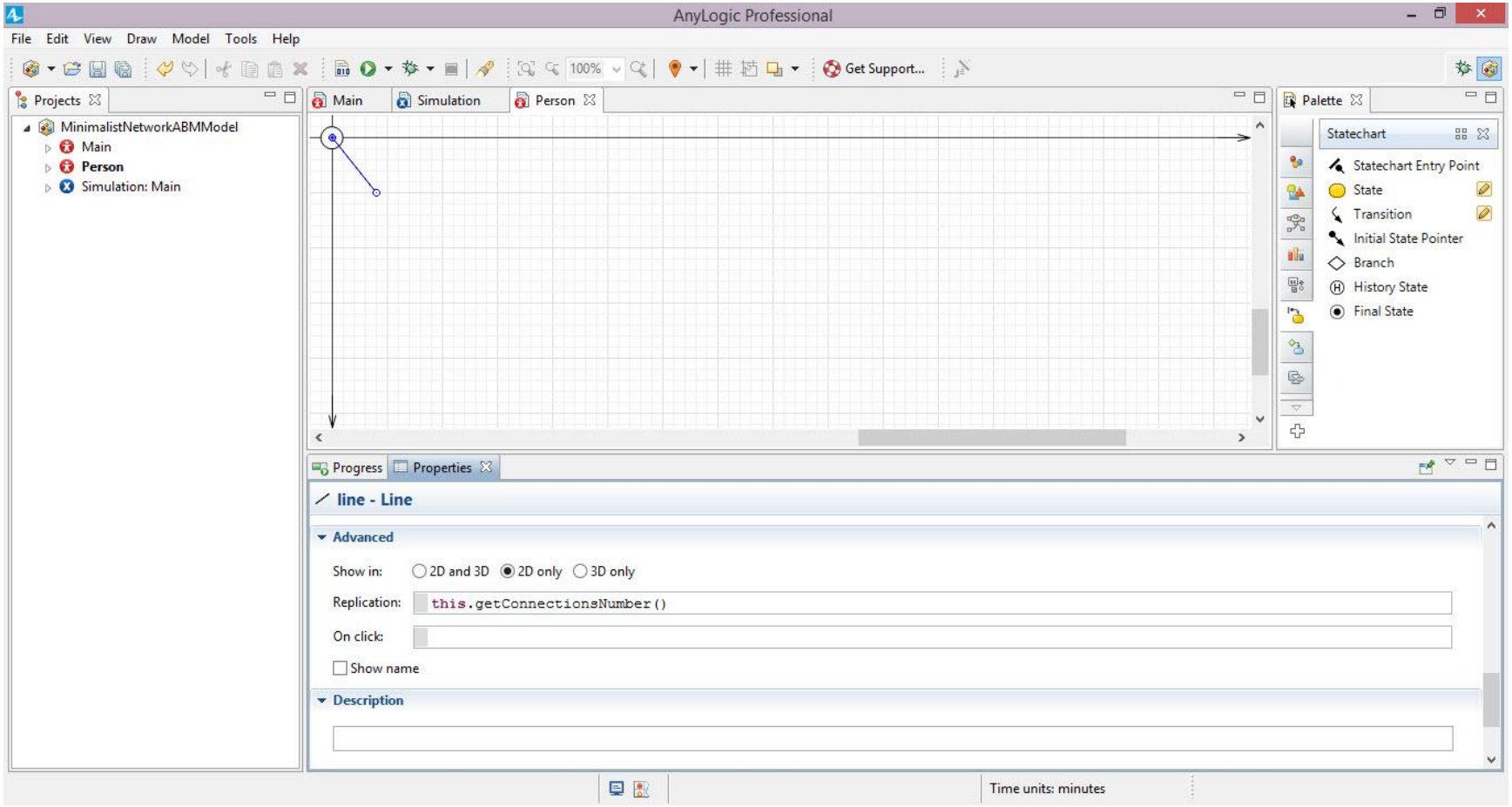
Example of Contextual Information



Autocompletion Info (via Control-Space)



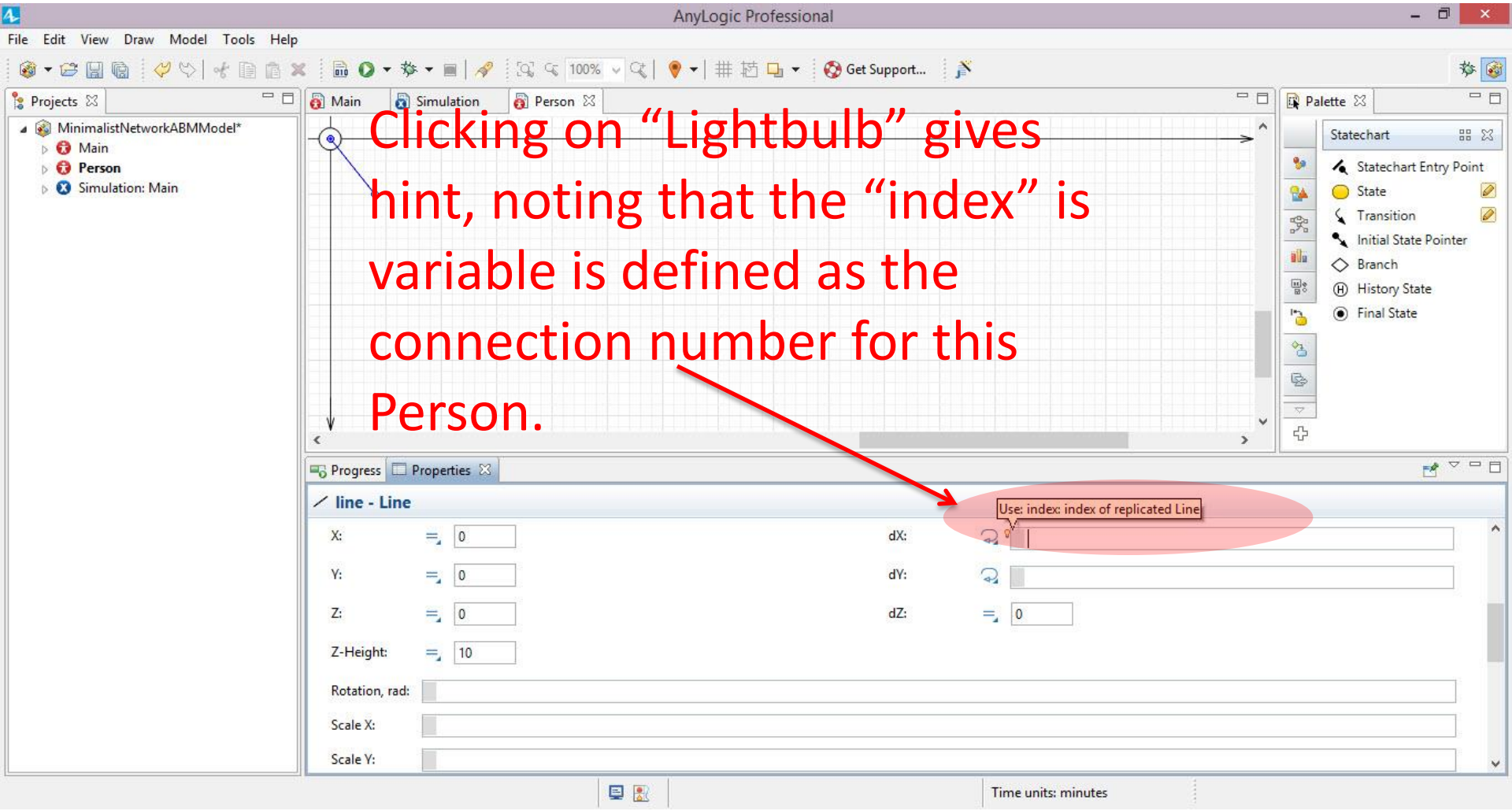
Known AnyLogic Bug – Save, Quit & Restart AnyLogic



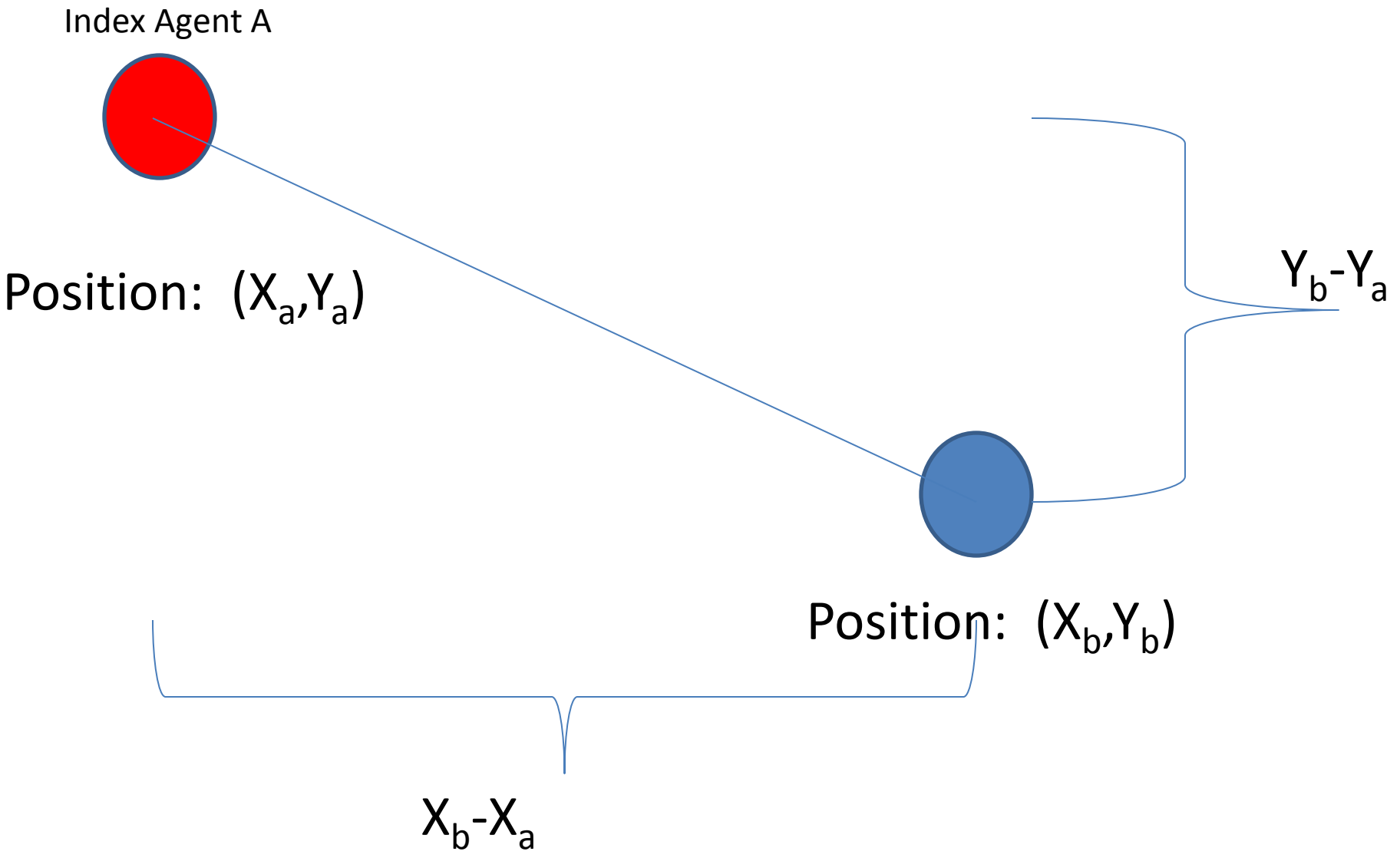
We need to Multiply & Adjust the Lines

- Right now, there is only 1 line per agent
- We need
  - √ One line per connection between one person and another
  - – The lines to connect the two persons
    - This requires *each line* (i.e. the line associated with *each connection*) to be adjusted so that it goes between the position of the current agent (Person) and the position of the other person to whom the connection relates

Scroll Down to “dX” Property



Geometry to Connect Agents

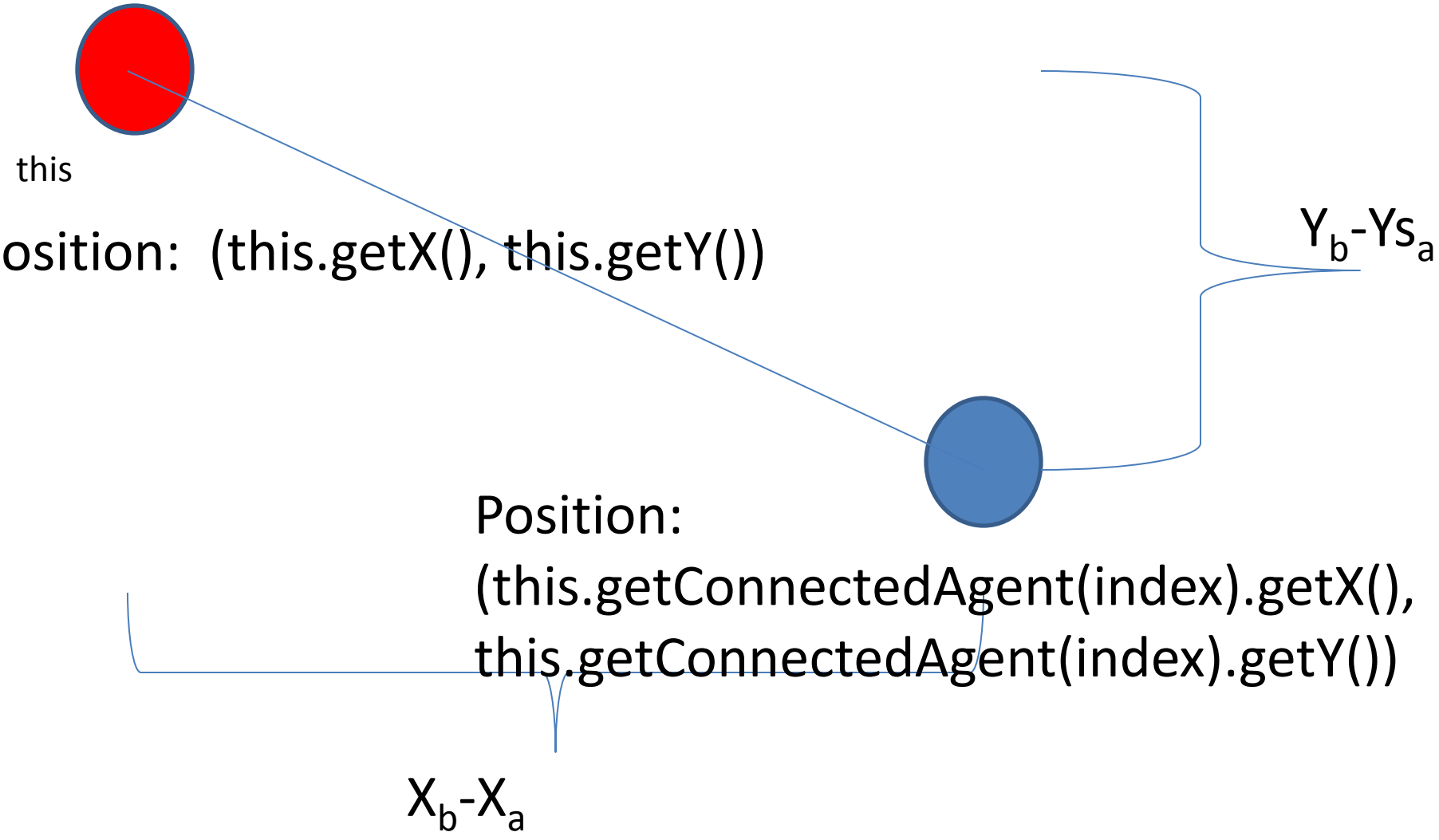


A Few Useful Points

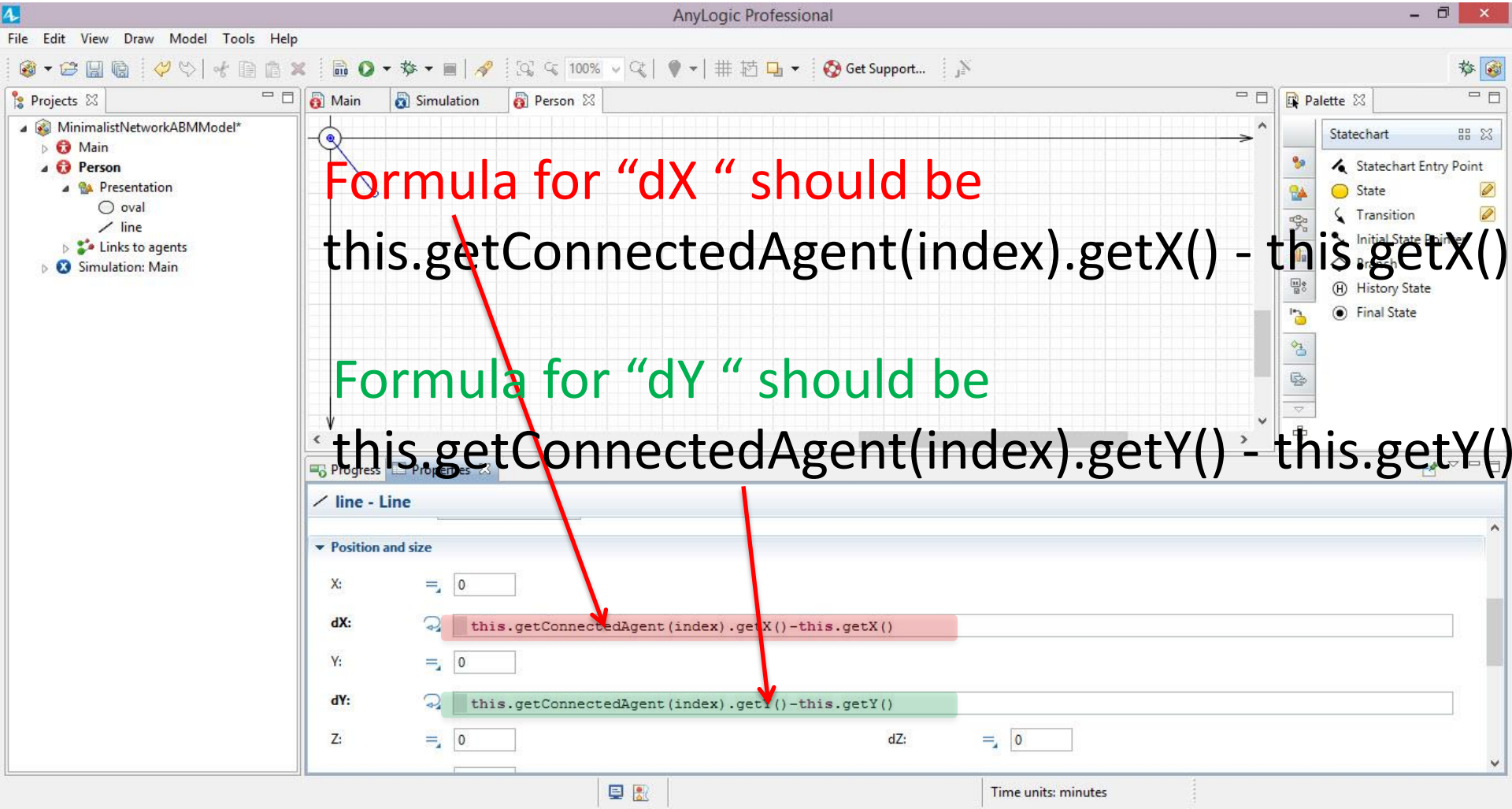
- Agents are “objects” in Java (self-contained structures with state & behavior)
- The reference to the current agent is called “this”
- If we have a reference, we can request information from it by “calling” a method on it
- To get a reference to the i^{th} person connected to “this”, we call “this.getConnectedAgent(i)”
- To get the X or Y position of “this”, we “call”

  “this.getX()” or “this.getY() ”, respectively

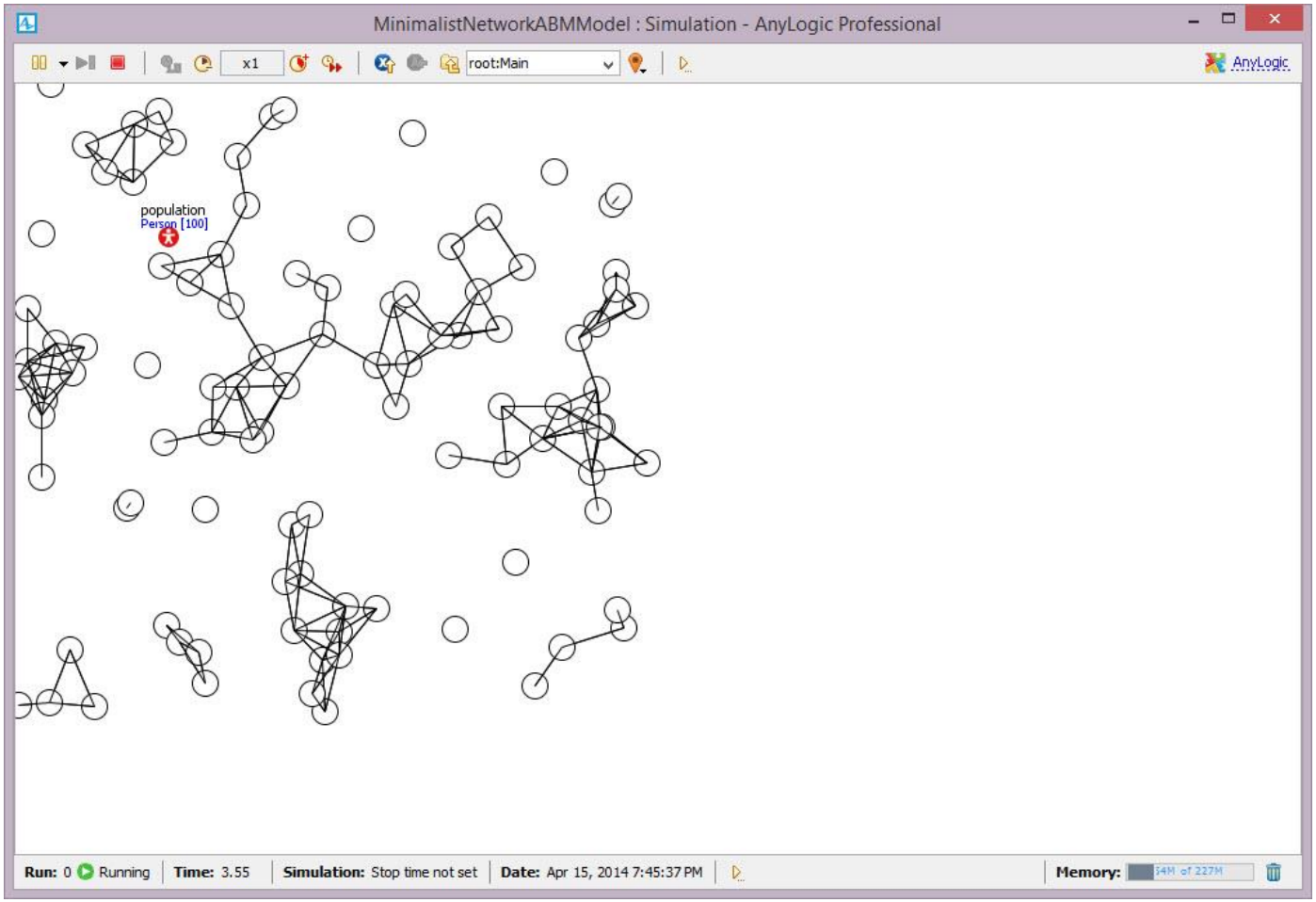
Geometry to Connect Agents



Setting Per-Instance Additional Properties



Result of Running the Model



AnyLogic: Above & Below the "Hood"

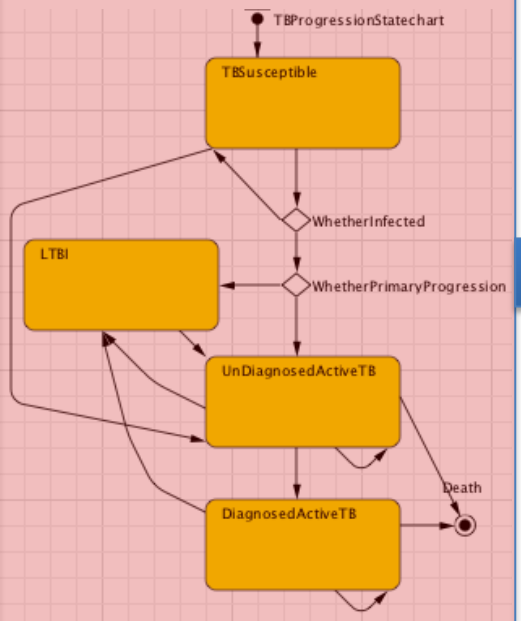
- One of AnyLogic's greatest strengths is the presence of diverse & powerful *declarative* mechanisms for building models
  - These let you focus on the "what" you are modeling, rather than "how" it will be implemented
  - AnyLogic will take care of figuring out the "*how*"
  - This is in contrast to writing code in a general purpose computer language, which generally requires specifying more of the *how*
- For Anylogic, declarative mechanisms include statecharts, stock & flow diagrams, "action" flow charts & process maps
- Other familiar declarative mechanisms include spreadsheet formulas and stock & flow diagrams.
- For most interactions with AnyLogic, you will be able to specify your intentions using these declarative mechanisms
- On occasion, you will need to write & look at Java code

A Bit on “Java”…

- “Java” is a popular cross-platform “object oriented” programming language introduced by Sun Microsystems
- Anylogic is written in Java and turns models into Java
- AnyLogic offers lots of ways to insert snippets (“hooks”) of Java code
- You will need these if you want to e.g.
  - Push AnyLogic outside the envelop of its typical support
    - e.g. Enabling a network with diverse Agent types
  - Exchange messages between Agents
  - Put into place particular initialization mechanisms
  - Collect custom statistics over the population

Stages of the Anylogic Build

Modification Possible



Modification Not Possible

Java Code

Main | Main | Person | Main.java

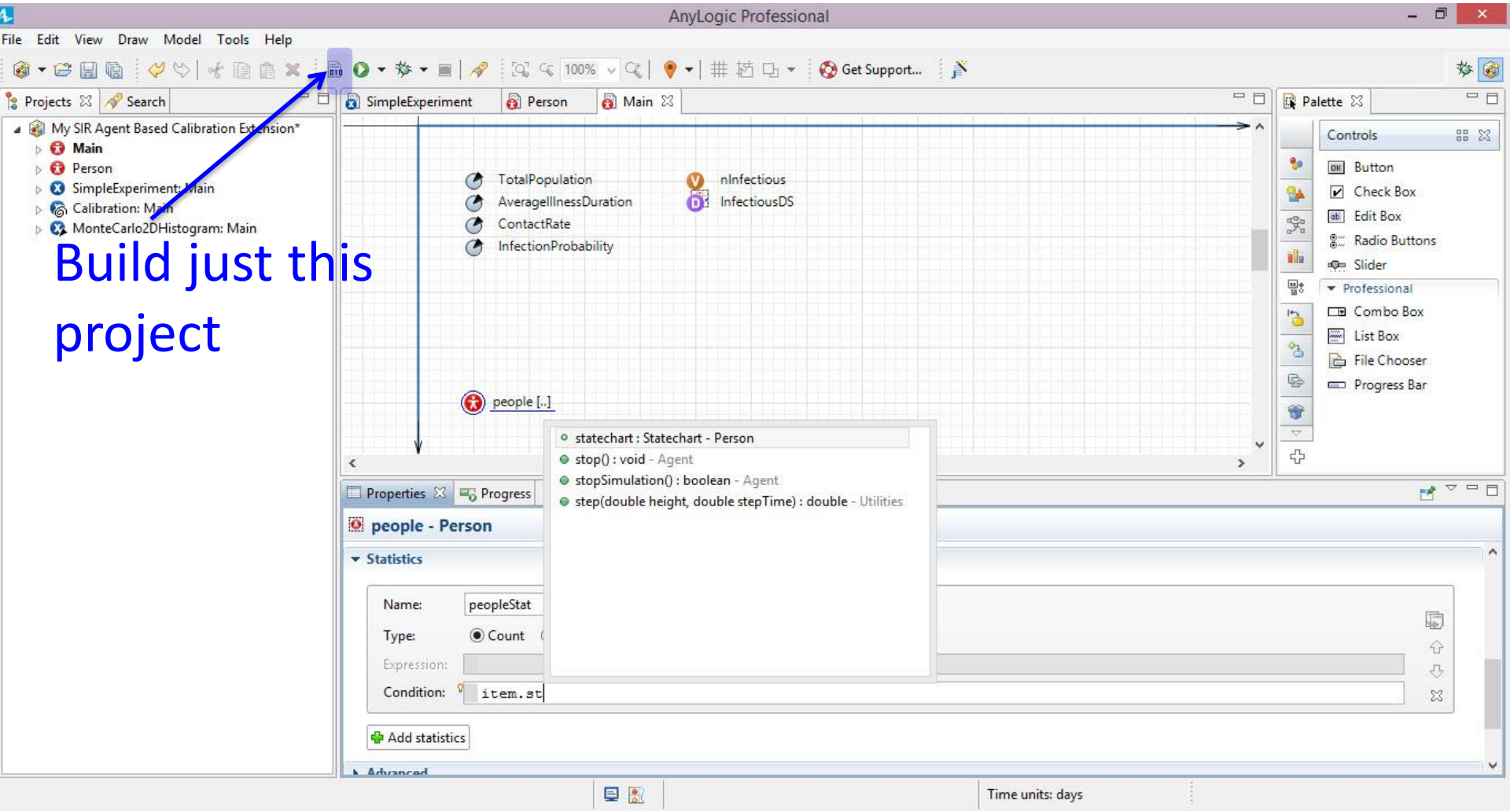
```
double  initialPrevalenceOfInfection ) {
    if (initialPrevalenceOfInfection == this.initialPrevalenceOfIn
      return;
    }
    this.initialPrevalenceOfInfection = initialPrevalenceOfInfecti
    onChange_initialPrevalenceOfInfection();
    onChange();
  }

  void onChange_initialPrevalenceOfInfection() {
    int index;
    index = 0;
    for ( Person object : Population ) {
      object.set_isInitiallyInfected((uniform() < initialPrevalenc
      index++;
    }
```

JVM Byte Code

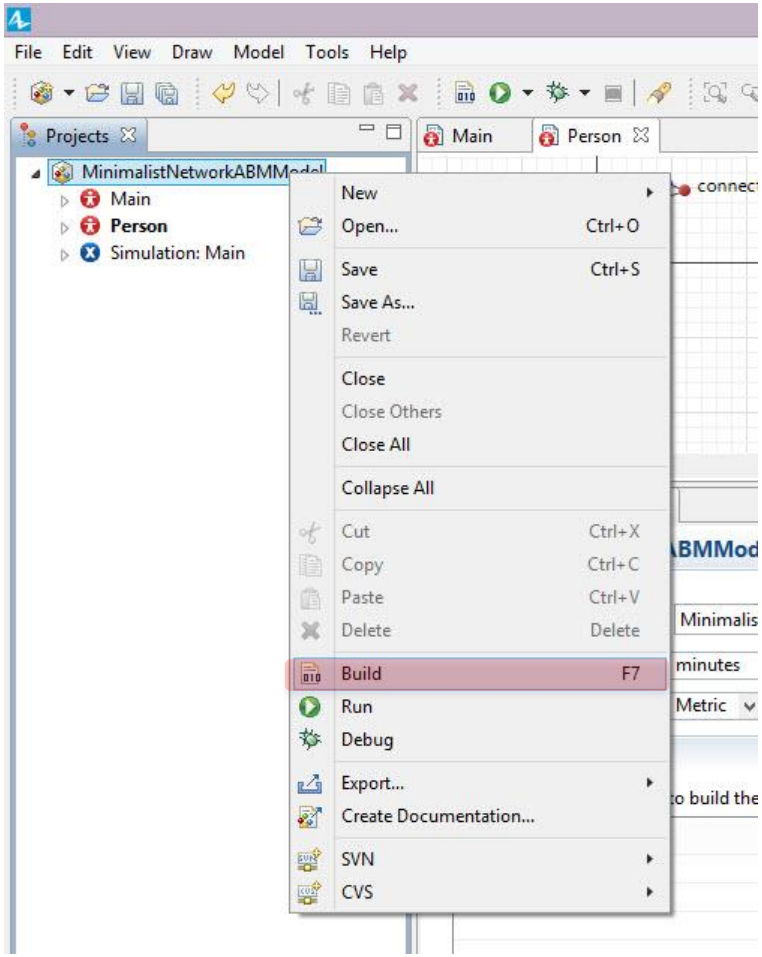
Person.class

“Build” Buttons

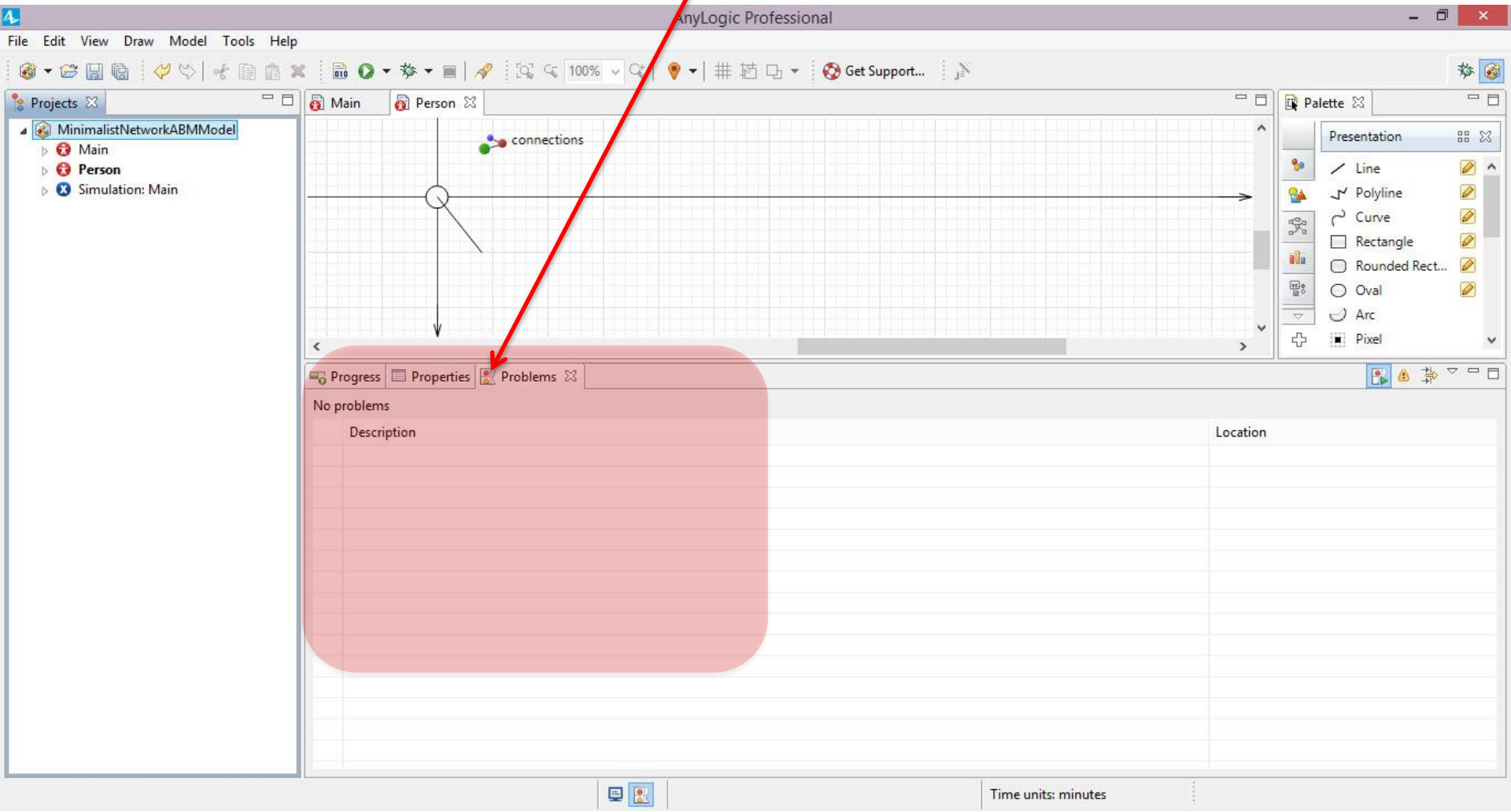
(One just for this project, one for all projects)



Alternative: Building via Context Menu



Builds Gone Bad: The “Problems View”

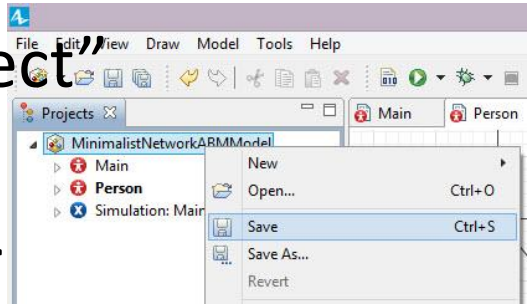


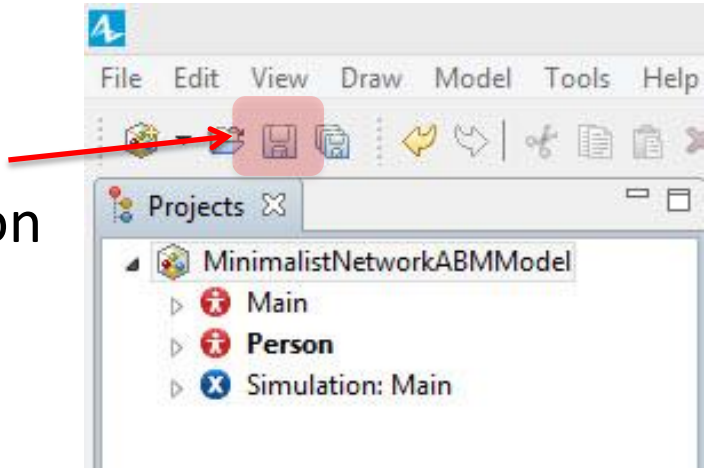
Builds Gone Good: Model Execution

- The simulation is running
- Time is advancing in steps or as necessary to handle events
- Each agent class will typically have many particular agents in existence
  - Each agent will have a particular state
  - This population may fluctuate
- Variables will be changing value
- Presentation elements will be knit together into a dynamic presentation

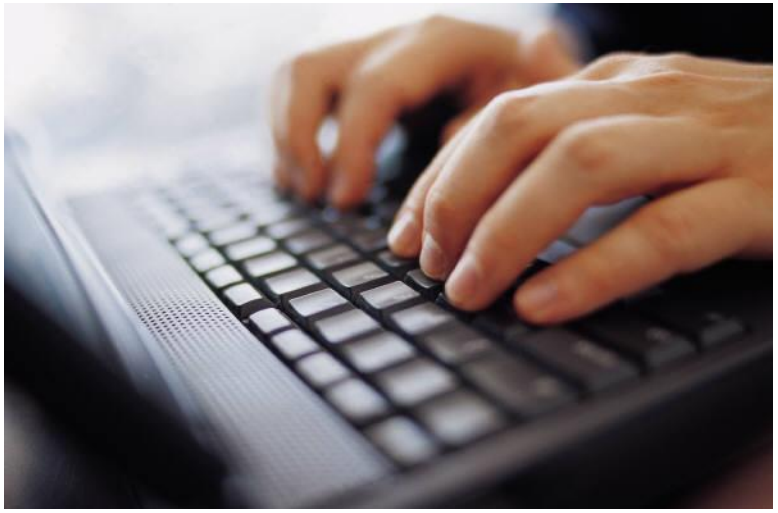
Save Away Your Model

- Multiple ways
  - Right click on project name in "Project" window, and choose "Save"
  - If you are currently working on your project, either
    - Press "disk" icon
    - Use "Save" item on "File" menu





Hands on Model Use Ahead

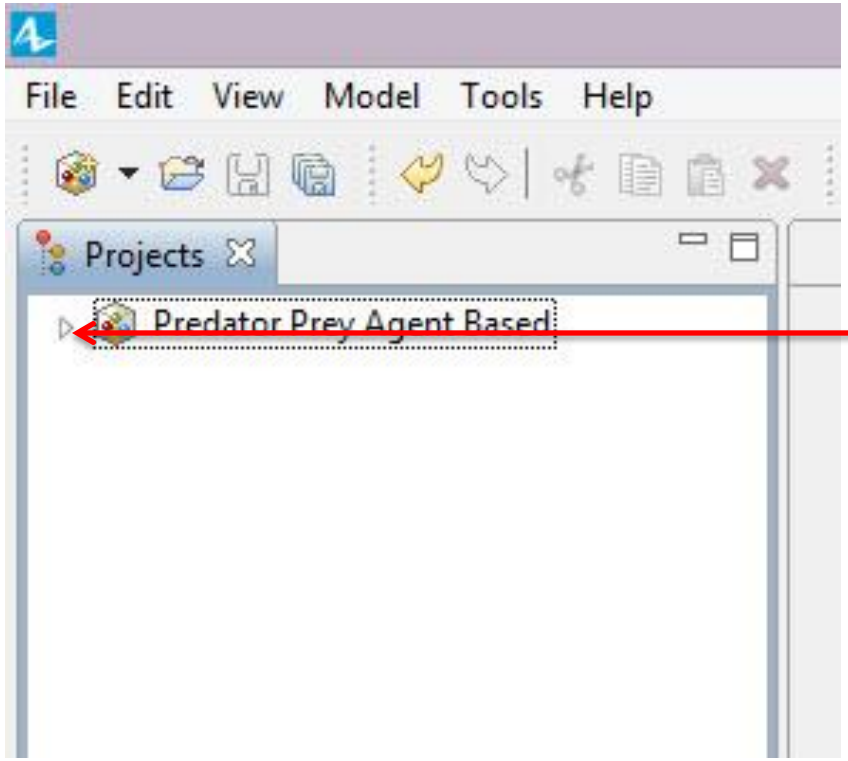


Load Sample Model:

Predator-Prey Agent Based

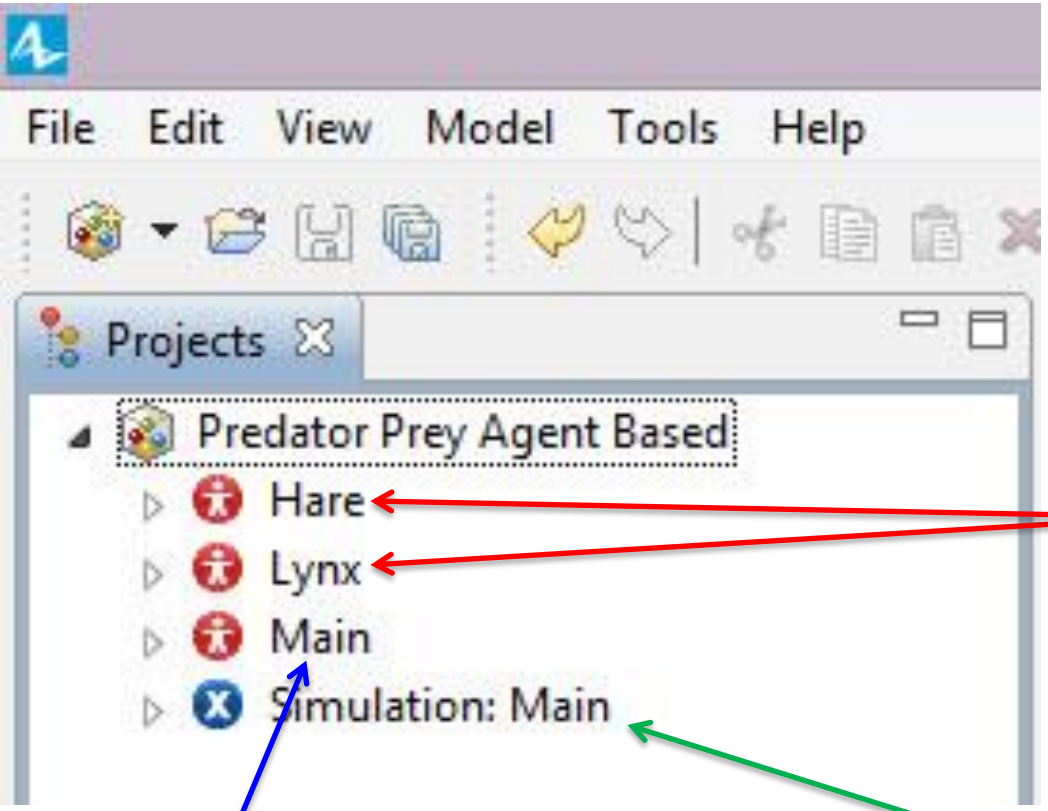
(Via “Example Models” under “Help” Menu)

After Loading in Model



Click on “+” to expand Project details for New model

Example “Classes”



“Agent” classes
(Define the *actors*)

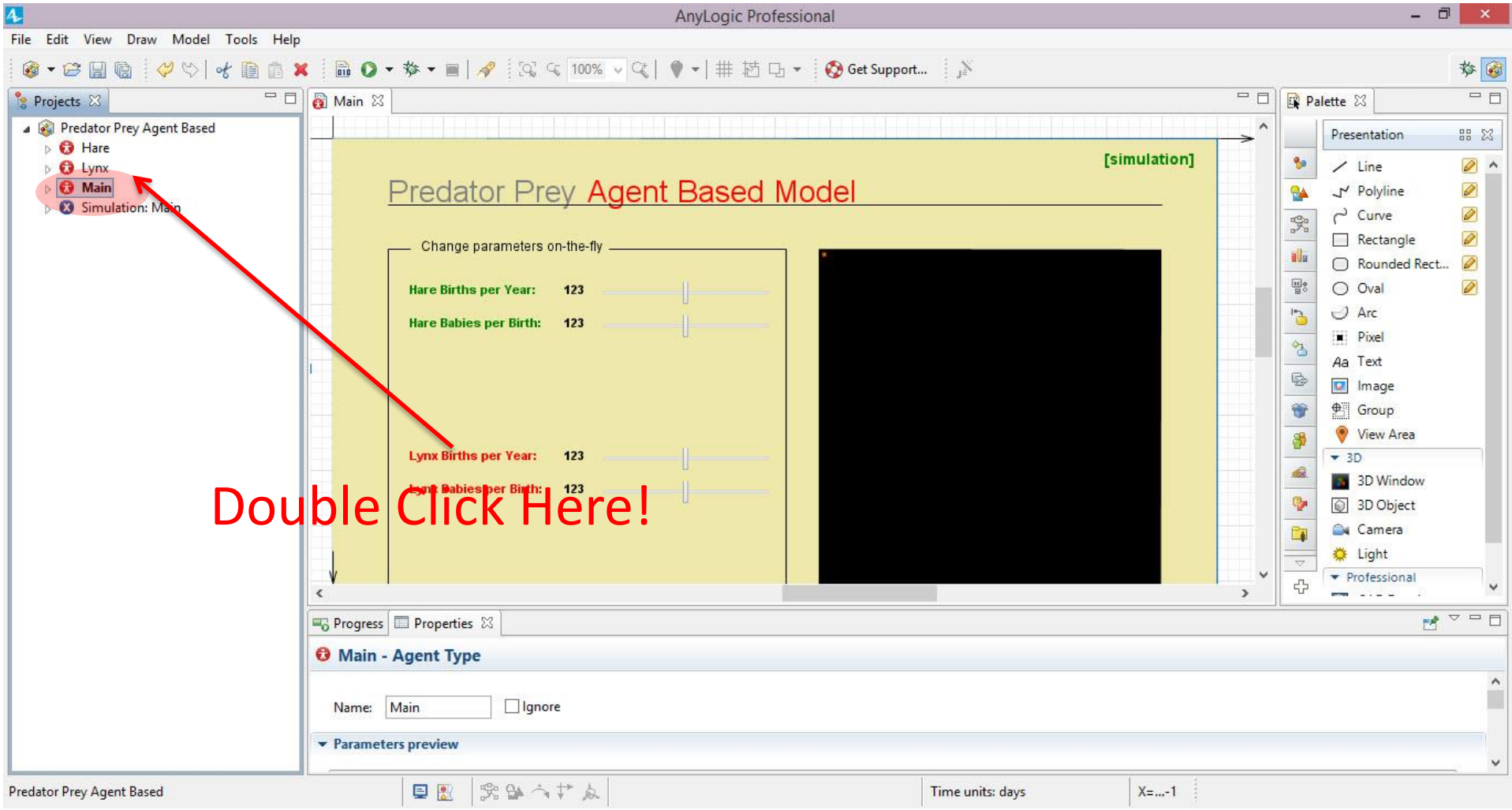
“Main” class
(Defines the “*Stage*” on which agents circulate)

“Experiment” classes
(Define the *Assumptions for Simulation scenarios*)

Multiple Agent Classes

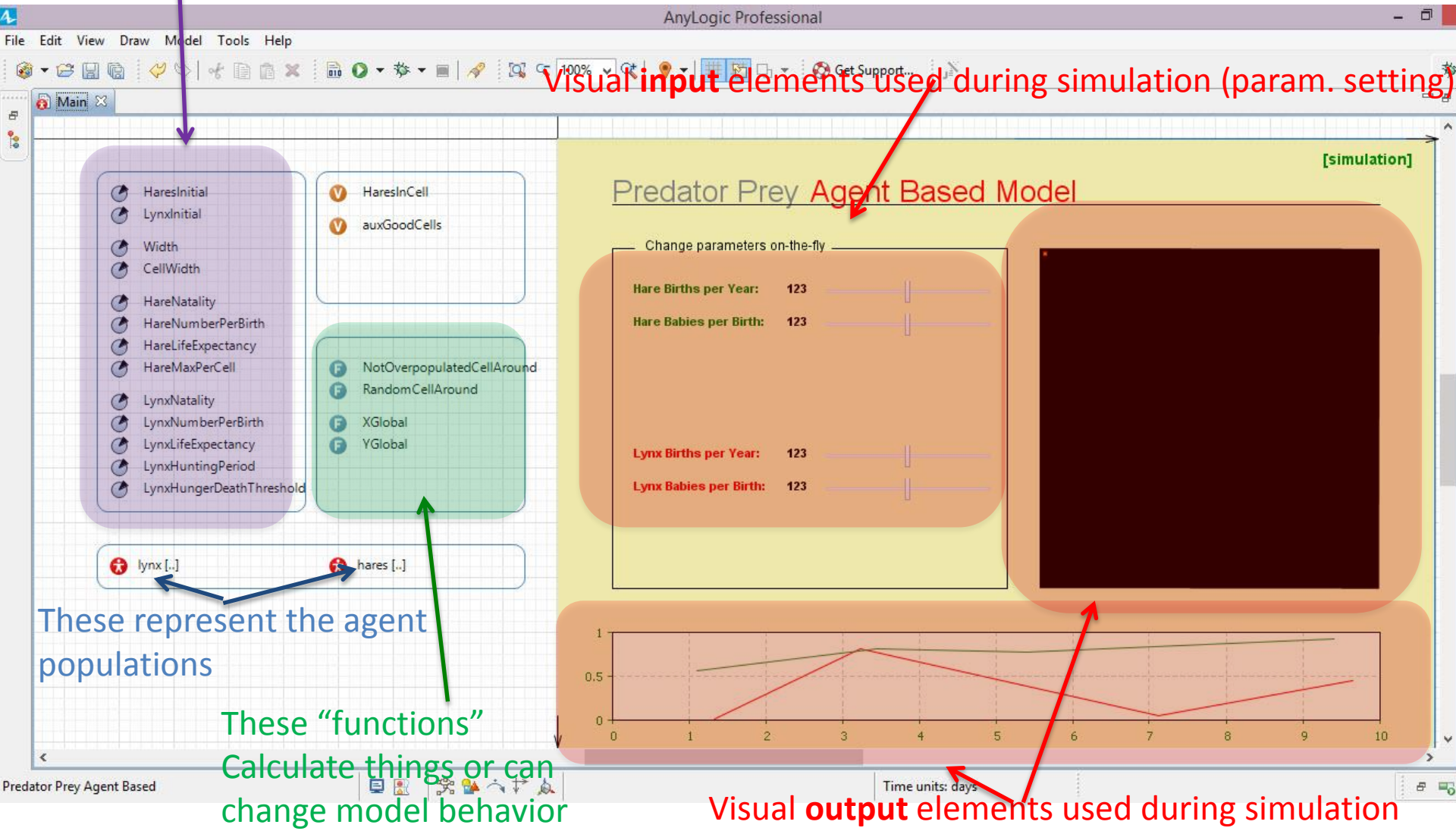
- Frequently we will seek to have multiple types of agents, each with differing types of behavior
- Sometimes these agents – while interacting – will have radically different factors that affect them
  - Cf "PredatorPrey" model, with Lynx & Hare
- Sometimes these agents – while distinctive –will be closely related in many ways
  - Here, we may wish to accomplish this through *subclasses of some common custom agent "superclass"*
  - The common features of the agents would be captured in the superclass

Double Click on “Main” Class Name to View this Class (Should Appear on Top Tab)



(Scroll to Left) Elements of a “Main” Class

These “parameters” specify
static model-wide characteristics



Visual **input** elements used during simulation (param. setting)

These represent the agent populations

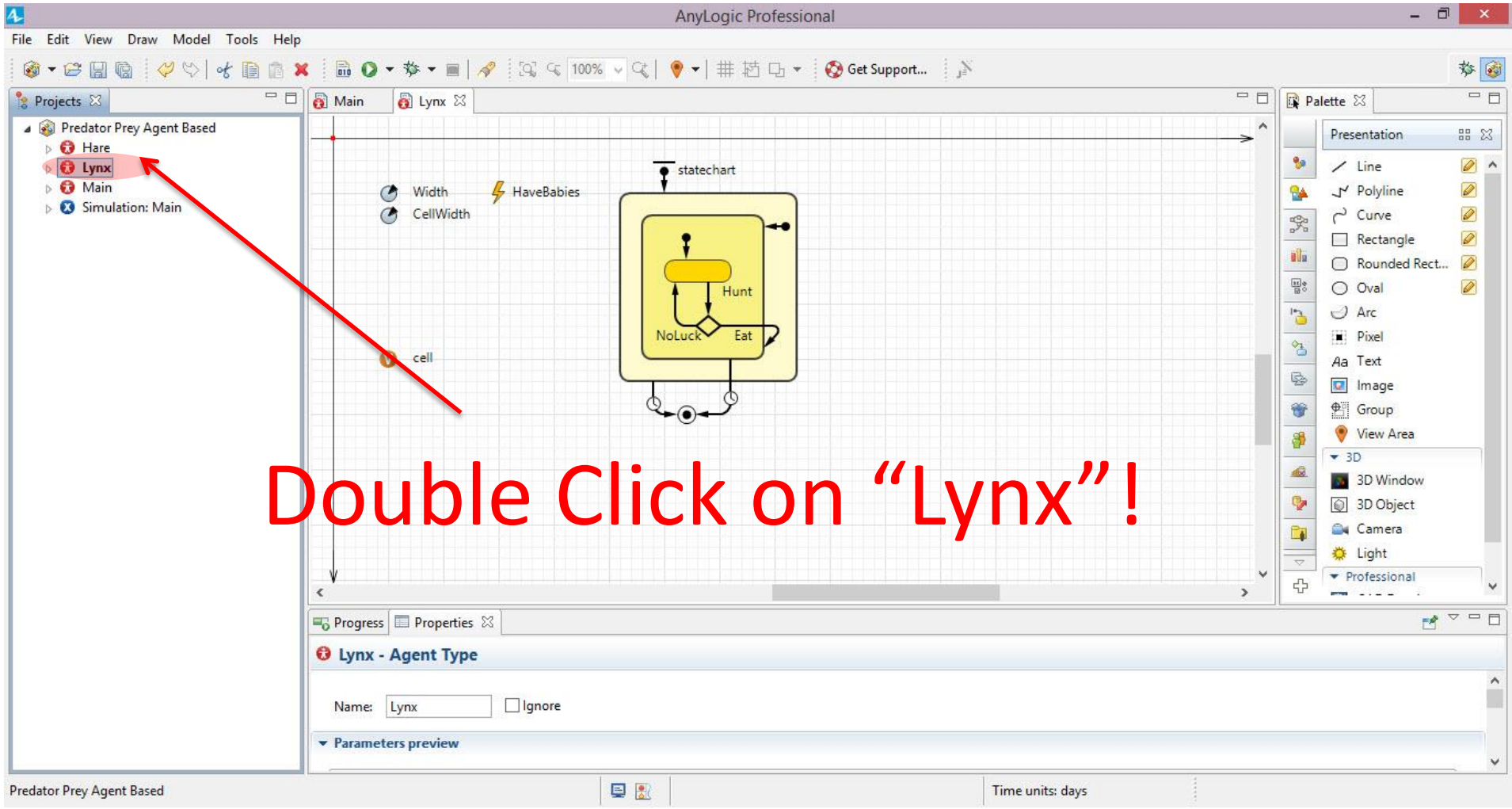
These “functions” Calculate things or can change model behavior

Visual **output** elements used during simulation

Recall: “Main” Class

- Defines the environment where agents interact
- Defines interface & cross-model mechanisms
- The Main object normally contains one or more populations of “replicated” agents
  - Each population consists of agents of a certain class (or a subclass therefore), e.g.
    - “Hares”
    - “Lynxes”
  - The agent classes are defined separately from the Main class

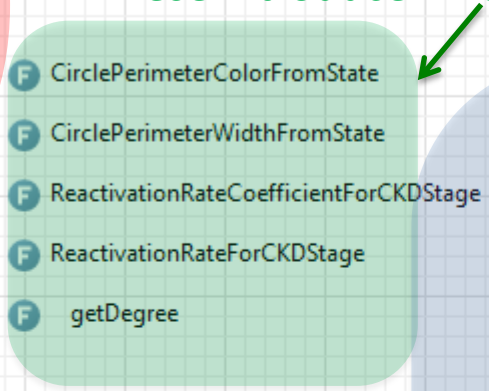
Agent Class Defines the Characteristics & Behaviour of Agent Population Members

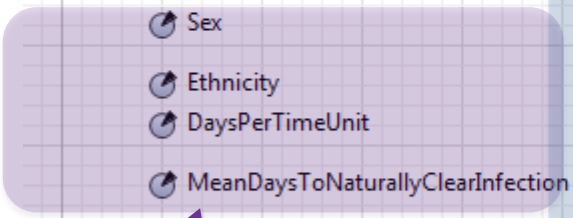


This defines the visual elements to be used for this object when it is displayed at runtime.

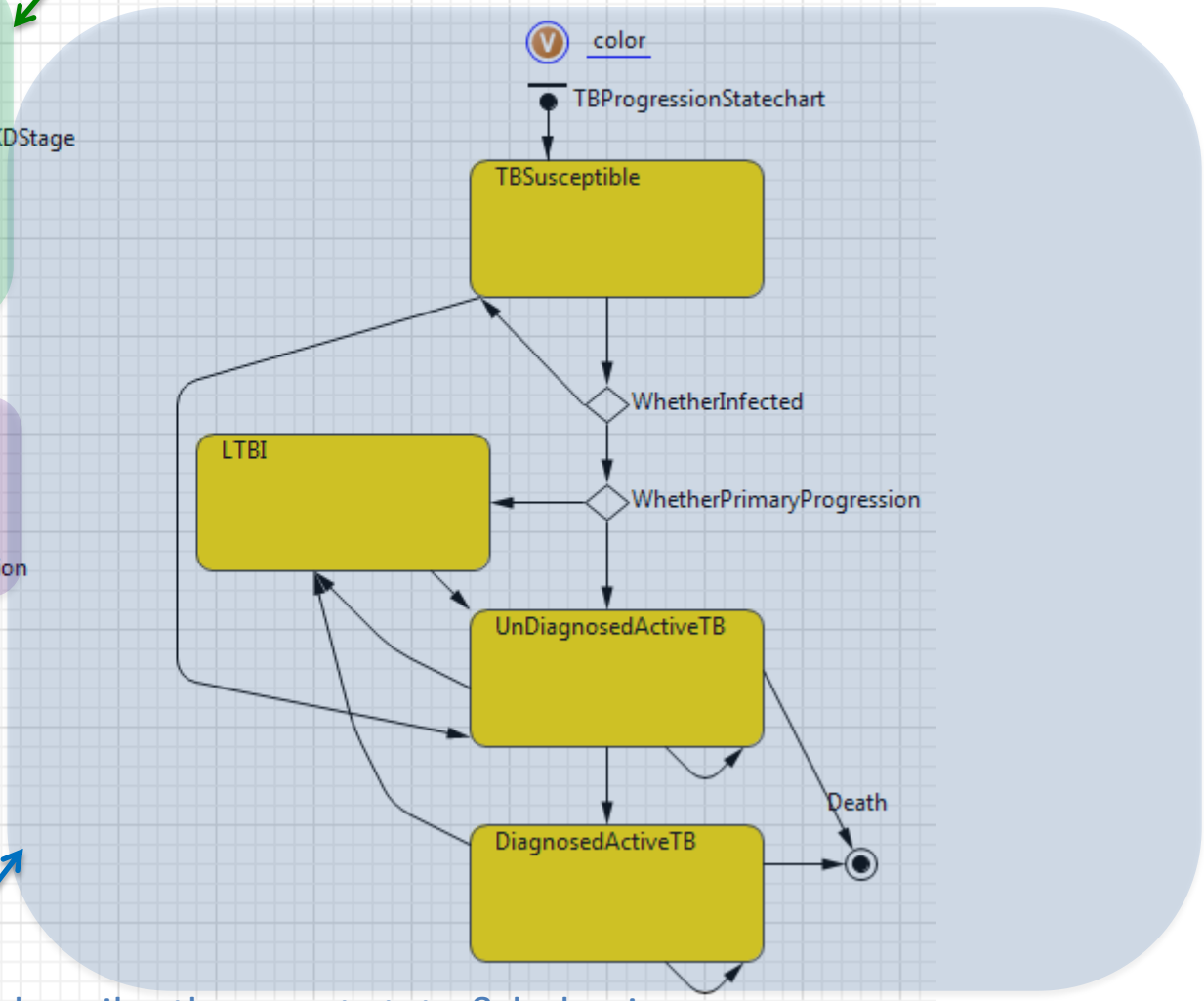
Common Agent-Class Elements

These introduce “methods” (“functions”) that include some Java code





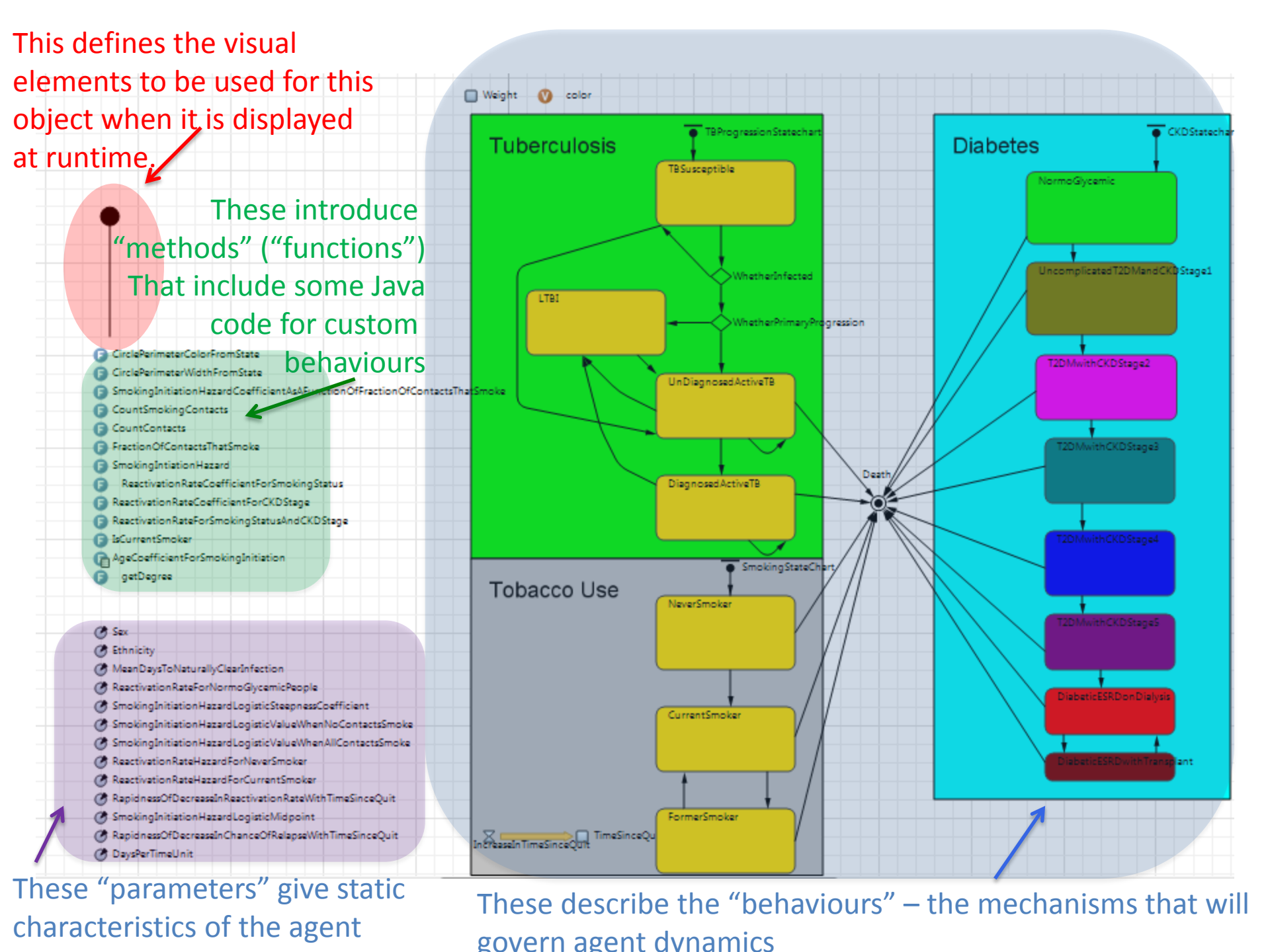
These “parameters” specify static agent characteristics



These describe the agent state & behaviour – the mechanisms that will govern agent dynamics

This defines the visual elements to be used for this object when it is displayed at runtime.

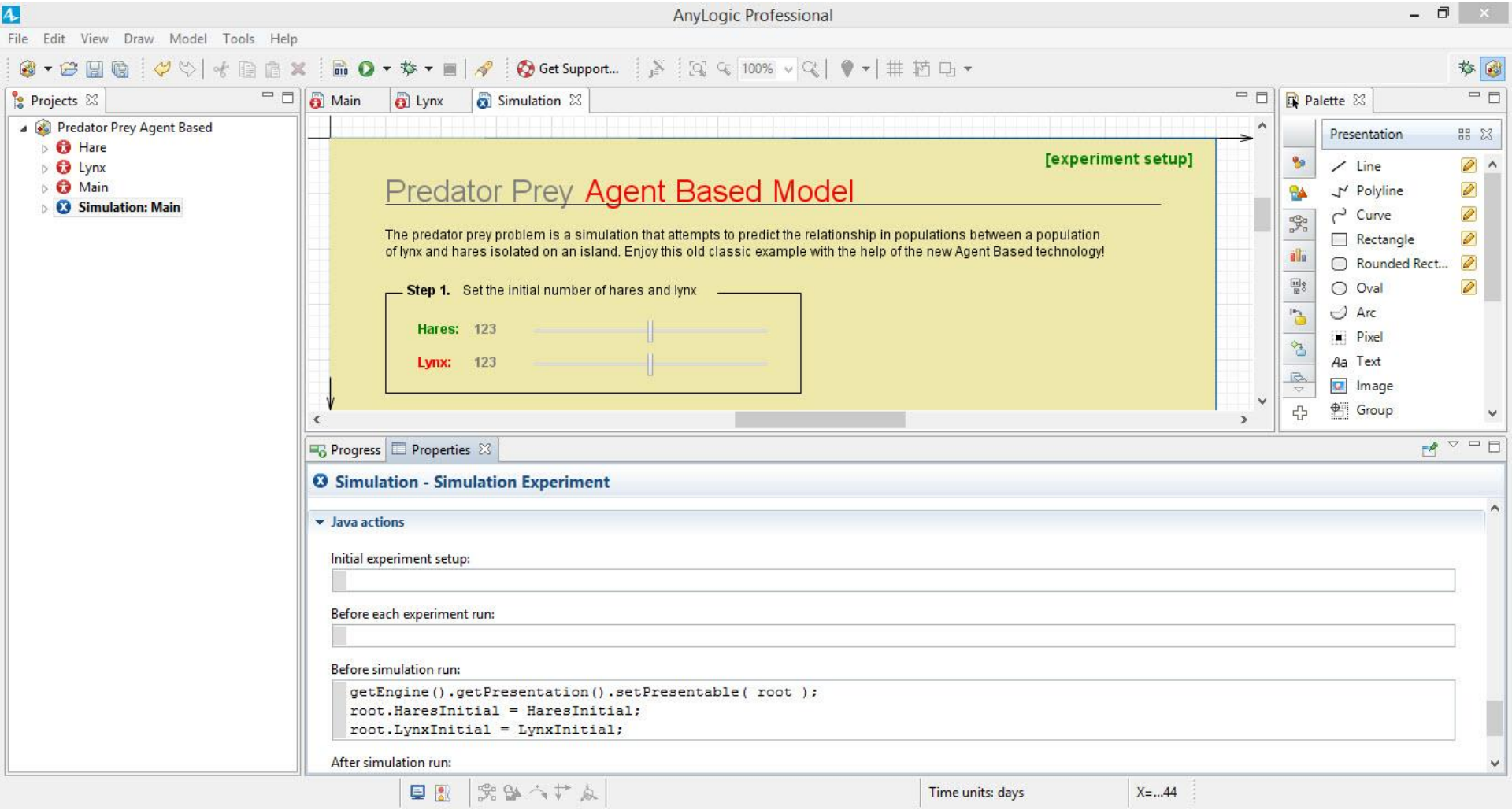
These introduce "methods" ("functions") That include some Java code for custom behaviours



These "parameters" give static characteristics of the agent

These describe the "behaviours" – the mechanisms that will govern agent dynamics

Setting Memory
& Virtual Machine Arguments



Close “Predator-Prey” Model

Right Click on project name (“Predator Prey Agent Based”) & select “Close”