Cool Modes / System Dynamics

Beginners Tutorial

Introduction
At this point, we assume that you have Cool Modes installed and running on your computer. You should be familiar with the basic features of Cool Modes: Adding plugins, creating, deleting, using workspaces, and connecting nodes etc. Additionally, you should have the System Dynamics plugin and the Functions plugin installed in your Cool Modes directory /libs/plugins/.

A very easy example
In this chapter, we will do a very easy example step-by-step: We want to simulate the growth of a population.

1. Start Cool Modes and add the plugins “System Dynamics”, “Function” and “Draw Palette”. Open a workspace.
2. Save the file.
3. Create two stock nodes and a rate node by dragging them into the workspace.
4. Edit a stock node: Open the settings dialog of one of the stocks by right-clicking it and choosing “Settings”. Change the name of the stock to “source” and check the “Infinite stock?” box. Click “OK”. Notice the value of this node changing to “infinite”. This node will resemble the source of our persons – in our simulation, it is “infinite”. This means, we can “create” as much people as we want to.
5. Edit the other stock node: Open the settings dialog of the other stock node (right-click – “Settings”). Name this stock “population”. Change the init-value to 10.0. Click “OK” to confirm this settings. This stock node will count and accumulate the number of persons in our “growth of population”-example. When the settings dialog has closed, click the “Reset”-button in the plugin windows. Notice the value of the “population” node changing to 10.0 – this is the initial value you just entered.
6. Now edit the rate node: Change the name to “births” and enter “5” in the field “calculation rule” and click “OK”. In our first simulation, we add 5 persons to the “population” node each step.
7. Connect these three nodes with two FlowEdges: source -> births -> population. (Notice the rate node becoming dark green – this means something can flow from one stock to another now.)
8. Save your file. Your workspace should now look similar to Figure 1.
Simulating

Let’s do a first simulation. You can control System Dynamics simulations by manipulating the “Step Control” and “Timeline” in the plugin window.

- “Reset” will reset all stock nodes to their initial value. (It is recommended to reset your model before simulating.)
- “1 Step” will do one step in the simulation.
- Use the slider (between “Step” and “Reset”) to set the number of steps that will be done.
- Use the slider “Timeline” to jump directly to a specific number of steps in the simulation.

Now, press “Reset” and “1 Step” five times. You can see how the population increases by 5 each time you press the button, up to 35.0. Notice the value of “source” remaining “infinite”. To change this, uncheck the “Infinite stock?” box in the settings of the “source” node. Pressing “Reset” and five times “1 Step” again in the plugin window, you will see that “source” is decreasing down to -25.0, which is exactly the value added to “population”. Please make “source” an “infinite stock” again.
**Graph display**

To have a nice overview of what has happened in the simulation, you can add a "graph display" to the workspace and connect it with nodes of interest. Switch to the "Functions" plugin (symbolized by a small calculator) and draw the empty graph into the workspace. Click on "Simple Edge" in the same plugin and connect the "births"-node and the "population"-node with this graph node. (If you did a "Reset", simulate five steps again.)

Two lines will appear in the graph display – a horizontal one and and an ascending one. If you cannot see them properly, try zooming out and change the viewport ( + / - and arrow buttons). The horizontal line represents the development of the "births" node, the ascending line shows the development of the "population". Since the number of "births" is constant in our first example, the respective line is horizontal.

Have a look at Figure 2 to see what it should look like.

![Graph display](image)

**Figure 2**
Bringing in more realism: exponential growth

Since a constant growth of a population is not very realistic, we will improve our model and bring in exponential growth.

The number of births usually depends on the number of fertile individuals. So we have to feed this information into the calculation of the number of births. To this purpose, draw an “InfoEdge” from “population” to “births”. An arrowed, bowed, black edge will appear. Create a “Constant” node, name it “birthrate”, set its value to 0.1 and draw another “InfoEdge” from “birthrate” to “births”. This will be our birth rate – a factor needed to calculate the births.

The difference between “InfoEdge” and “FlowEdge” is, that “InfoEdge” only brings in knowledge about the value of one node to another. An “InfoEdge” does never transfer “material”. A “FlowEdge” substracts a value from one stock node and adds this value to another stock node, according to the calculated rate in between.

Enter the settings dialogue of “births” now. In the field “variables”, “birthrate” and “population” will appear, since these nodes are connected to “births” via “InfoEdges”. These variables can be used for calculations, now. Do this by entering “population*birthrate” in the field called “calculation rule”. (You can double-click on a variable to have its name copied into the calculation rule.) Click “OK”. This formula means, that 10% of the value of the population (0.1*population) will be born (and added) each step.

You should see now, how the number of births is calculated according to the values of “population” and “birthrate”: Press “Reset” and do some simulation steps. You will see a more interesting and realistic development in the graph plotter than before. Try changing the birth rate (the value of “birthrate”) and exploring the model…

Births and deaths

To make our model even more realistic, we need people dying. This feature can be added in our model simply by adding another flow to the “population” node. Create another rate node, constant node and another rate node and connect them:

- Rate node: name it “deaths”
- Stock node: name it “graveyard” and set it to “infinite”
- Constant node: name it “deathrate” and enter the value 0.08
- Draw a FlowEdge from “population” to “deaths” and from “deaths” to “graveyard”
- Draw an InfoEdge from “deathrate” to “deaths” and from “population” to “deaths”.
- Enter the calculation rule “deathrate*population” in the Rate node’s settings.

Try to do some simulations: Click “Reset” and do some steps or draw the “Timeline” slider. Notice the lines in the plotter becoming more flat now, since there are people dying now (Figure 3).
Still, the population is increasing, because the birth rate (0.1) is higher than the death rate (0.08). Try to change these values and look at the model's behaviour.

**Foxes and Rabbits**

It is possible to have different populations influencing each other. Imagine a population of rabbits, that is increasing rapidly, because the birth rate is much higher than the death rate. But – there are foxes, that hunt and kill rabbits. So – if there are many rabbits, many foxes will be born, too, and they will hunt and kill even more rabbits. This will decrease the number of rabbits. This will in turn decrease the number of foxes again etc. etc.

What will be the behaviour of this system?

Have a look at Figure 4 and the example file ("fox_and_rabbit.xml") that came together with this tutorial. Explore the model, do some simulations and try to change some constants...
In the “fox and rabbit” example, you will find a rate called “kills” somewhere in the middle of the workspace. This rate is not connected to stock nodes and therefore it is painted light green. This indicates, that this rate node is used to calculate intermediate results, that can be used by other nodes. There are no values shifted between stock nodes by this node. With the help of this “calculation feature” of the rate node it is possible to create rather complex models without loosing the overview.

**Future Versions**

We are currently working on a new version of the System Dynamics for Cool Modes. It will be available (together with a new version of Cool Modes) in August 2004. It will come with a fully operational collaborative mode, with new modelling features (e.g. a “clock”) and with an improved usability.

For questions and remarks, contact Lars Bollen <bollen@collide.info>.

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