"Modeling and Simulation using ***Stella***"

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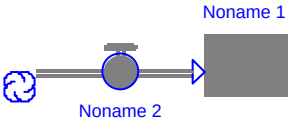
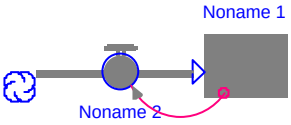
In July of this year I attended a week-long workshop given by the Shodor Foundation on creating models and simulations using a variety of software packages. The purpose of this paper is to provide an introduction to one such package, "*Stella*". This software package can be used to create models and simulations for a wide variety of disciplines. An instructor may use "*Stella*" to either make instructional modules and labs, or to provide a means for students to create and explore their own models.

We will explore two models using "*Stella*", namely, an exponential growth model and a predator-prey model. But first, a few basics. There are icons in a menu bar that can be selected to construct a model. The main icons are described below.

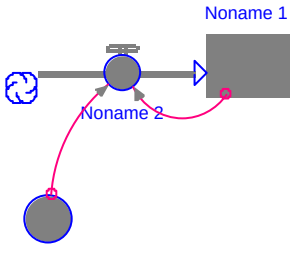
represents a reservoir for a quantity, such as population.



The pump to the left of the reservoir represents the rate of change of the quantity in the reservoir.

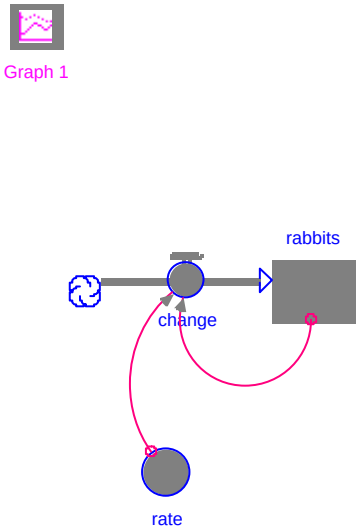


an arrow icon allows for an input into the pump.



Finally, a circular icon represents a constant.

Below is a completed model for a population of rabbits. Note that the graph icon allows for a graphical display of the results. It is also possible to display the results in a table.



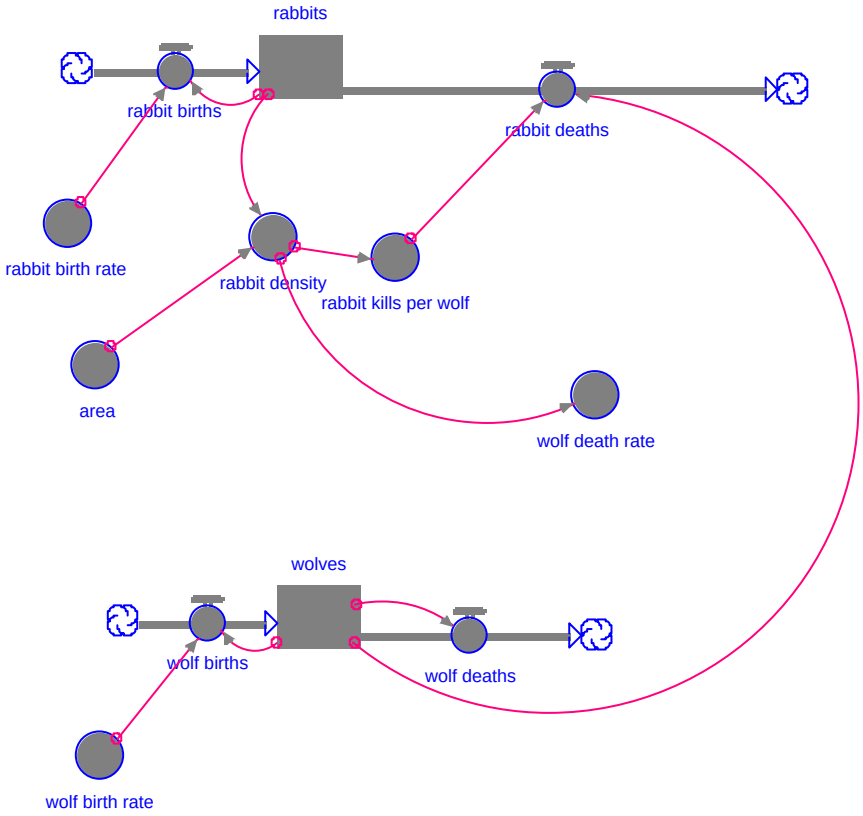
"*Stella*" has several levels. By clicking on a down arrow you can move to the equation level to see the mathematics and structure of the model. For the population growth model above the structure is:

rabbits(t) = rabbits(t-dt) + (change)*dt
INT rabbits = 100 (a specification I choose for this example)
INFLOWS:
change = rate*rabbits
rate = .2 (again, a choice I made)

The default settings for the time is [0,12] in increments of 0.25 time units, e.g., minutes, days, and so on. These, of course, can be changed. Also, you may choose the integration method to be Euler's Method (the default setting), Runge-Kutta 2, or Runga-Kutta 4. The method of integration that you choose can have a significant effect on the results you get.

There are many areas in which "*Stella*" can be used to model and simulate various processes, including business, chemistry, environmental sciences, math, medicine, physics, and social sciences.

The model below simulates a predator-prey environment that takes into account a number of factors that effect the population of rabbits and wolves.



<u>These are the equations in order of execution for Wolf & Rabbits madel.</u>

{ INITIALIZATION EQUATIONS }
area = 1E3
INIT Rabbits = 5E4

rabbit_birth_fraction = 1.25
rabbit_births = Rabbits*rabbit_birth_fraction
INIT Wolf = 1250

rabbit_density = Rabbits/area
rabbit_kills_per_wolf = GRAPH(rabbit_density)
(0.00, 3.89e-305), (50.0, 50.0), (100, 100), (150, 150), (200, 200), (250, 250), (300, 300), (350, 350), (400, 400), (450, 450), (500, 500)
rabbit_deaths = Wolf*rabbit_kills_per_wolf
wolf_birth_fraction = .25
wolf_births = Wolf*wolf_birth_fraction
wolf_death_fraction = GRAPH(rabbit_density)
(0.00, 0.5), (10.0, 0.45), (20.0, 0.4), (30.0, 0.35), (40.0, 0.3), (50.0, 0.25), (60.0, 0.2), (70.0, 0.15), (80.0, 0.1), (90.0, 0.05), (100, 0.005)
wolf_deaths = Wolf*wolf_death_fraction+PULSE(100,2,1E3)

{ RUNTIME EQUATIONS }
Rabbits(t) = Rabbits(t - dt) + (rabbit_births - rabbit_deaths) * dt

Wolf(t) = Wolf(t - dt) + (wolf_births - wolf_deaths) * dt

rabbit_births = Rabbits*rabbit_birth_fraction
rabbit_density = Rabbits/area
rabbit_kills_per_wolf = GRAPH(rabbit_density)
(0.00, 3.89e-305), (50.0, 50.0), (100, 100), (150, 150), (200, 200), (250, 250), (300, 300), (350, 350), (400, 400), (450, 450), (500, 500)
rabbit_deaths = Wolf*rabbit_kills_per_wolf
wolf_births = Wolf*wolf_birth_fraction
wolf_death_fraction = GRAPH(rabbit_density)
(0.00, 0.5), (10.0, 0.45), (20.0, 0.4), (30.0, 0.35), (40.0, 0.3), (50.0, 0.25), (60.0, 0.2), (70.0, 0.15), (80.0, 0.1), (90.0, 0.05), (100, 0.005)
wolf_deaths = Wolf*wolf_death_fraction+PULSE(100,2,1E3)

The website for the publisher of "*Stella*" is http://www.hps-inc.com. Go visit them. Perhaps "*Stella*" is the girl for you!