Short Course
System Dynamics Modeling of Natural Environments: An Introduction to STELLA
Sunday 11 March 2001

Geological Society of America
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Introduction to Building Models with STELLA

Notes and Information Sheets

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Agenda for this Session

I. Basic STELLA Building Blocks

- definition and discussion of the four (4) basic building blocks of which all STELLA models are comprised. These building blocks are: (a) Stock, (b) Flow and controller, (c) converter, and (d) connector.

II. Basic Structure of STELLA Models

- flow accounting structures and computational structures. Makiing the model structure appear as you view the system.

III. Structural Organization of STELLA

- STELLA is organized in a hierarchial fashion to allow convenient model construction, modification, and interactive use. We will focus on model construction in this session.

IV. Introductory STELLA Models - Building Simple Models

A. Simple Bathtub Model
- placing objects on screen and connecting them; entering algorithms; running the model (RUN menu and time specs); creating tables and graphs. (hours vs days)

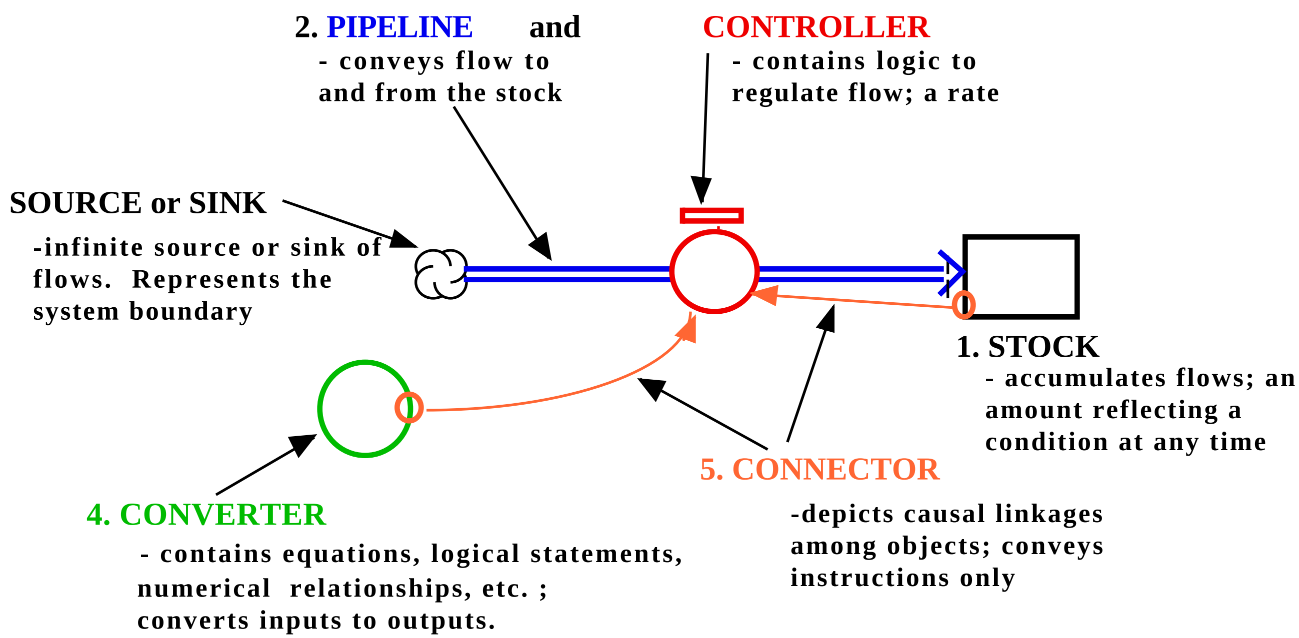
B. Modifications of the Simple Bathtub Model
- modify the Simple Bathtub Model to build a greater reality in the final model.

C. Compound Interest Model
- placing objects on screen and connecting them; entering algorithms; running the model (RUN menu and time specs)(dt and compounding period); sensitivity analysis and comparative outputs.

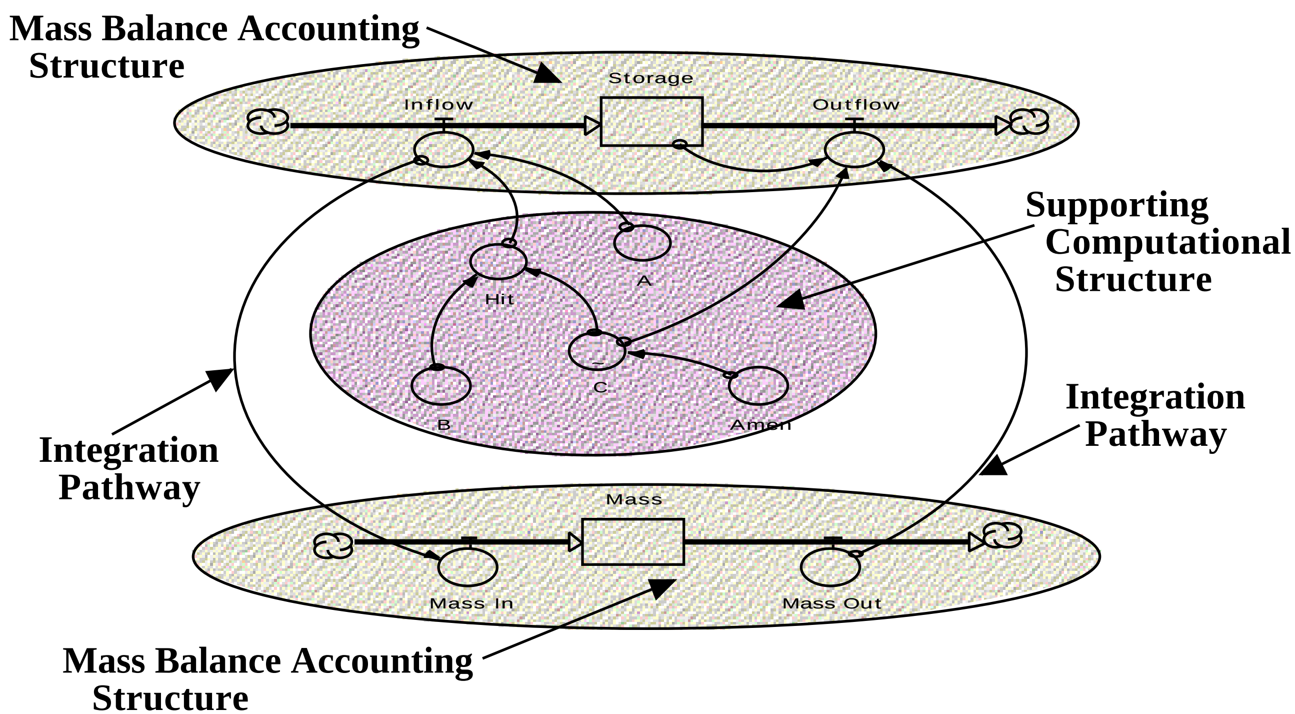
D. Goal Seeking Model
- placing objects on screen and connecting them; entering algorithms; running the model; graphical inputs; scatter plots.

Basic STELLA Building Blocks

1. Stock
2. Flow (Pipeline and Controller)
3. Converter
4. Connector

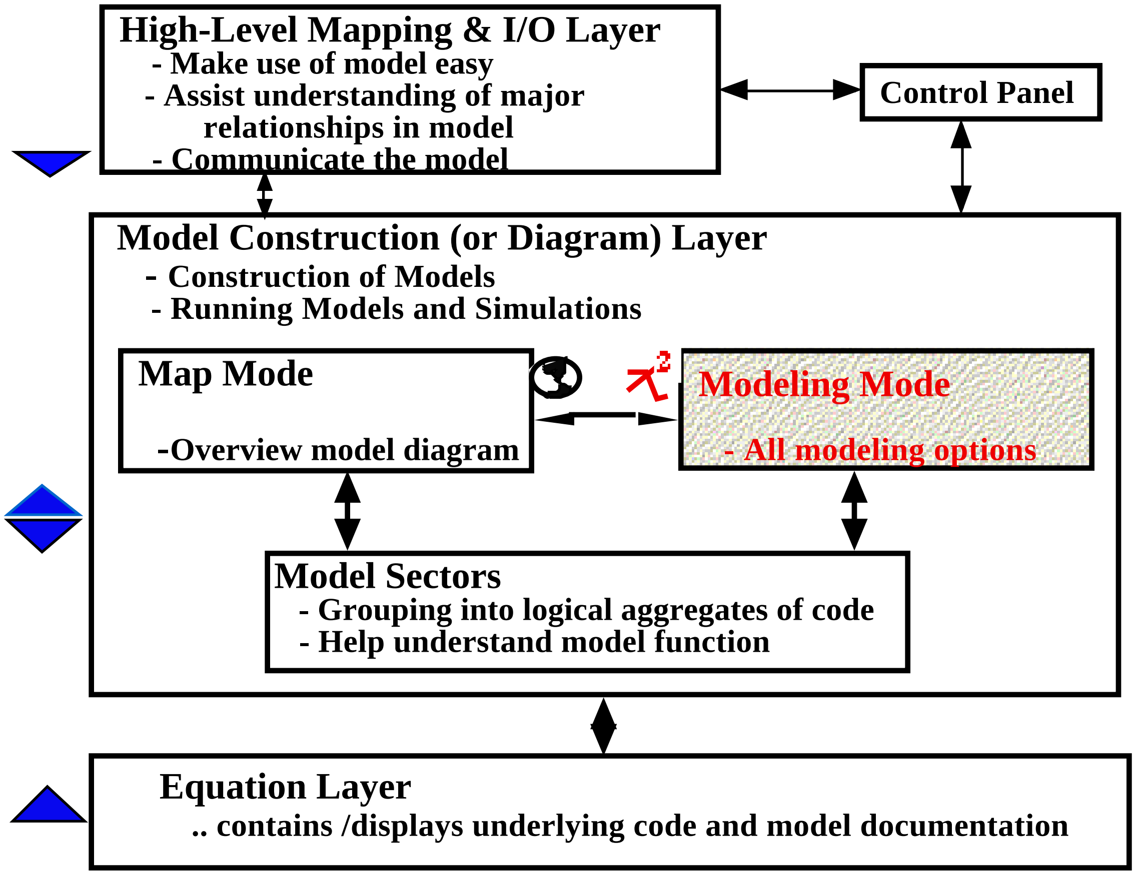


Basic Structure of STELLA models



Unique arrangements of building blocks give unique model structures so that the model possess unique features and capabilities.

Structural Organization of STELLA

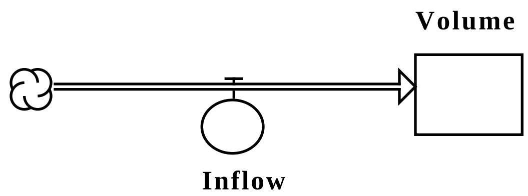


Introductory STELLA Models

The Simple Bathtub Model

1. Navigate to modeling layer
2. Place building blocks on screen (plumbing)

Structural Diagram



3. Enter algorithms
4. View the code (Equation Layer)
5. Run the model (Run Menu & Time Specs)
6. Output Results, i.e. Inflow and Outflow
   (Create tabels & graphs)

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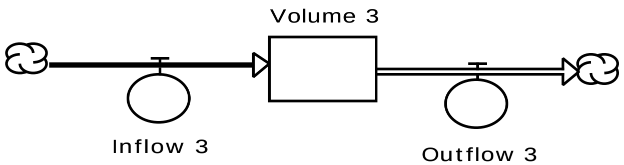
RUN 1 - Run for 50 minutes

RUN 2 - Run for 24 hours

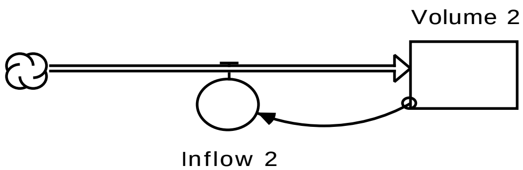
Introductory STELLA Models

The Simple Bathtub Model - Some Modifications

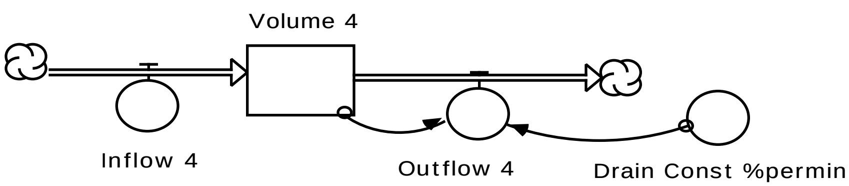
1. Simple Bathtub with Inflow & Outflow



2. Simple Bathtub with Inflow Control



3. Simple Bathtub with Inflow & Control of Outflow

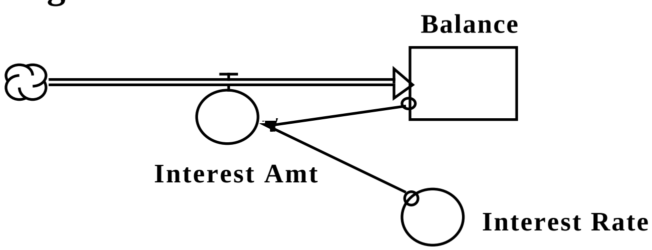


Introductory STELLA Models

The Compound Interest Model

1. Navigate to modeling layer
2. Place building blocks on screen

Structural Diagram



3. Enter algorithms
4. Run the model (Time Specs and dt)
5. Output Results (tables and graphs)
6. Sensitivity to Interest Rate

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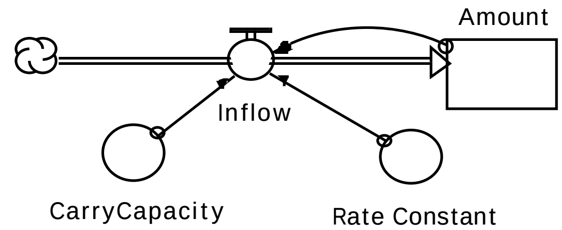
RUN 1 - Interest compounded annually
RUN 2 - Interest compounded quarterly
RUN 3 - Sensitivity Analysis

Introductory STELLA Models

A Goal Seeking Model

1. Navigate to modeling layer
2. Place building blocks on screen

Structural Diagram



3. Enter algorithms
5. Run the model (Time Specs and dt)
6. Output Results (tables and graphs)

Some Comments on EQUILIBRIUM and STEADY STATE

Modeling GOALS AND GOAL SETTING*

Over time many natural systems approach a condition, or goal, called equilibrium or steady-state. Although most systems never reach their goal their dynamics are influenced by how they seek the goal. These goals can change suddenly or evolve gradually so that the system may seek different conditions of equilibrium or steady-state over time.

A goal is fundamental to system thinking in that we compare a transient condition to some standard state or known truth. A systems model adjusts itself over time so that the difference between the standard state (goal) and the immediate condition of the system is minimized. As a result, when goals are incorporated into models they determine the behavior of the system and thus artificially limit its dynamics. Incorporating goals are often useful but, as with other modeling decisions, they should be applied with caution. Whether the system is actually goal seeking or goal constrained is something that has to be evaluated on a case-by-case basis because some systems may not be goal constrained whereas others may be.

In dynamic models goals define upper limits and lower limits for accumulations (stocks). There are basically 4 different ways of creating goals in dynamic models. They are:

A. Difference Method - For upper limits (goal-stock) where goal > stock. For lower limits (stock-goal) where stock > goal. Because these expressions are multiplied by the parameters in the flow, they must be multiplied by a time adjustment factor so that the units of flow are units/time. In calculating the changes in a stock, this method often overshoots the goal by an amount that is dependent on the value of **dt.** Thus small **dt**s are the order of the day.

B. Ratio Method ("Control" Method) - For upper limits {(goal-stock)/goal} where goal>stock Alternatively, (1-stock/goal). For lower limits {(stock-goal)/stock} where stock is > goal. An alternative way of expressing this is (1-goal/stock). The value of these ratios vary from 1 to 0. These expressions are then multiplied by the other parameters to define the flows upon which the attached stocks depend. These expression can either be multiplied within the flow proper or held outside a flow in a separate converter that is then multiplied by the other parameters in the model. One advantage of the "control" method is the dependent stock is not as sensitive to the time step **dt** as it is in the Difference Method.

C. Logic Statement Method - This method is very deterministic in that the flow or a converter which is in turn multiplied by parameters in the flow contain a logic statement such as (**if** stock is < than goal **then** 0 **else** 1). It is best to place the statement into a converter called "control" and direct it into the flow. In this way you always can identify which flows are controlled by goal functions. This method can be used for both upper and lower limit goals.

As with the Difference Method above this method may overshoot the goal by an amount that is dependent on the value of **dt.**

D. Graphical Method - In this method the decay factor which is connected to the exit flow from the stock is converted into a graphical function. One approach is to plot **stock/goal** along the X axis. Because this ratio can vary from 0 to a value of 1, the scale is set from 0 to 1. Along the Y axis is plotted the decay factor which also varies from 0 to 1. Note that there are various ways to establish graphical controls.

* Adapted from the notes of the late Dr. Rolf Stanley, Prof. of Geology, Univ. of Vermont