

Appendix B

Random and Exogenous Variation

Random variations play a central role in network simulation. Distributional and Scalar Distributional attributes use random variation as well as traffic generators. In each of these cases you have access to a combo box, such as the one in Figure B.1 labeled “Distribution,” to show the use of the source of variation. If you click on the down arrow, a list that includes the available distributions is displayed.

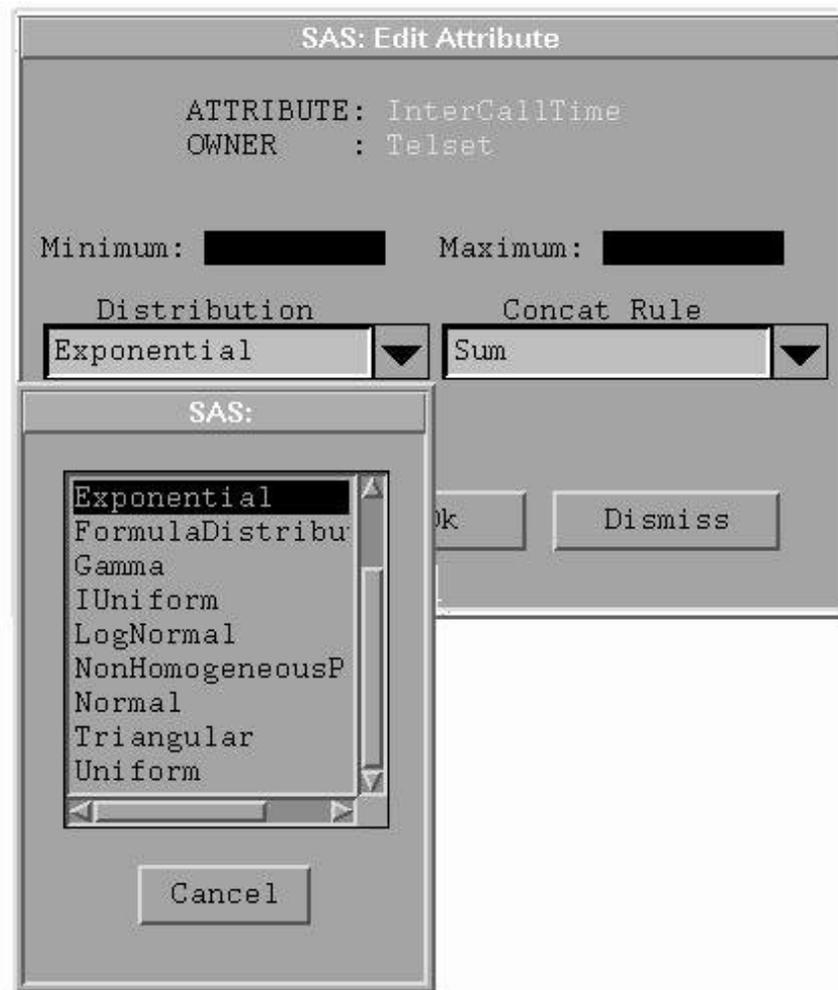


Figure B.1. Source of Variation Combo Box

When you select one of these distributions, the selection is displayed in the text area to the left of the down arrow. For each distribution you select, you can set one or more parameters that further define the choice.

There are two types of sources of variation, random and exogenous. These are not

mutually exclusive. That is, an exogenous source of variation can be randomly generated.

Random Sources of Variation

The random sources of variation are generated using pseudorandom number generators. The netWorks application provides a set of standard generators. These include

- Exponential, with mean $1/\lambda$ and density function

$$f(x) = \frac{1}{\lambda} \exp^{-x/\lambda}, \text{ for } 0 \leq x, 0 \leq \lambda$$

- Nonhomogenous Poisson, with rate parameter $\lambda(t)$ and density function

$$f(x) = \frac{1}{\lambda(t)} \exp^{-x/\lambda(t)}, \text{ for } 0 \leq x, 0 \leq \lambda(t)$$

where $\lambda(t)$ is cyclic and continuous for all $t \geq 0$ with

$$\lambda^* \equiv \sup_{t \geq 0} \lambda(t)$$

- Gamma, with parameters λ and n and density function

$$f(x) = \frac{x^{n-1} \exp^{-x/\lambda}}{\lambda^n \Gamma(n)}, \text{ for } 0 < x, 0 < \lambda, 0 < n$$

- Erlang, with parameters λ and n and density function

$$f(x) = \frac{x^{n-1} \exp^{-x/\lambda}}{\lambda^n \Gamma(n)}, \text{ for } 0 < x, 0 < \lambda, n \in Z^+$$

- Uniform, with parameter U and density function

$$f(x) = \frac{1}{U}, \text{ for } 0 \leq x, 0 \leq U$$

- IUniform, with parameter U and density function

$$f(x) = \frac{1}{[U]}, \text{ for } x \in Z, 0 \leq U$$

- Deterministic, with parameter U and density function

$$f(x) = 1, \text{ for } x = U$$

Each of these generators has a control panel for setting parameters. For example, if you select **Exponential** from the list box in Figure B.1 and then click the **Parameters** button, the exponential control panel in Figure B.2 is displayed. In this window, you set the initial seed value and the mean $1/\lambda$.

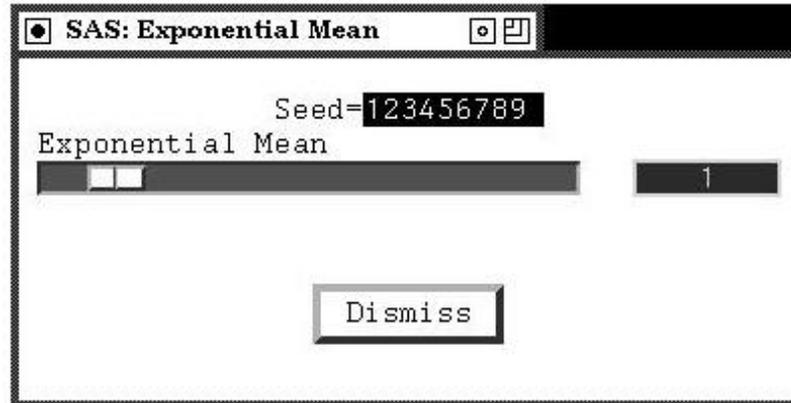


Figure B.2. The Exponential Control Panel

The seed value for each distribution is initialized from a data set of seed values provided with the application. When a new distribution is created, it retrieves the next seed value from the seed data set. You can explicitly change this value if you want to use another seed for the random variable.

Note also that, by default, the Exponential mean in Figure B.2 is set to 1. You can change the mean with the slider. The slider has a range of 0 to 10 for this parameter. If 10 is not large enough for the mean, you can increase it by pointing the cursor at the slider and clicking the right mouse button. This displays a pop-up menu with the entry **Attributes**.

Selecting **Attributes** displays the window in Figure B.3.



Figure B.3. The Slider Attributes Window

In this window you can change various parameters of the slider including the minimum and maximum values. To change the maximum value that an Exponential mean can have, enter a maximum value for the Exponential mean slider and click the **Ok** button. Now the slider can be moved to any value up to that maximum.

You can also change a parameter value by positioning the cursor over the field displaying the parameter value and clicking the left mouse button. You then enter the new value and press the Return/Enter key, and the parameter value is updated.

FormulaDistribution

The netWorks application provides a general function writing capability with the FormulaDistribution selection, shown in the combo box in Figure B.1. If you select **FormulaDistribution** and then click the **Parameters** button, a Formula Manager window (as shown in Figure B.4) is displayed.

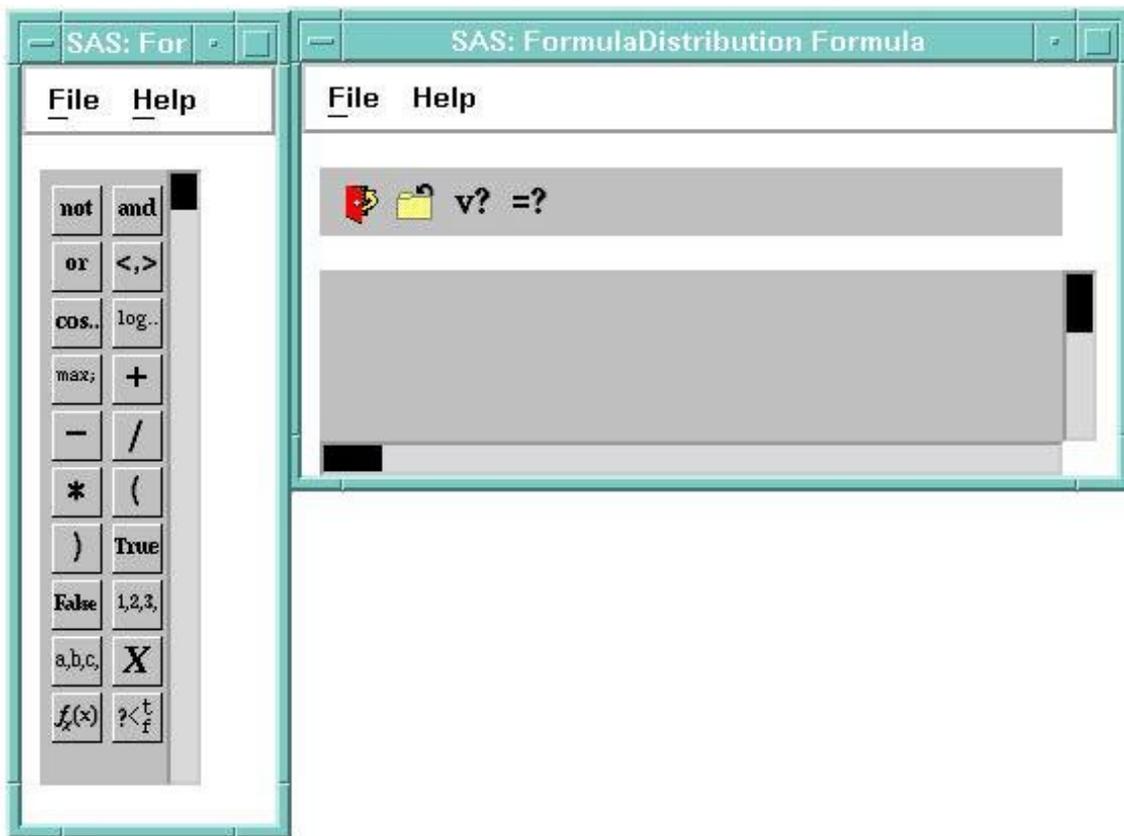


Figure B.4. FormulaDistribution Manager and Palette

From this window, you can write a function that returns a number that is used as the sample from the FormulaDistribution. For example, suppose you wanted a mixture distribution with density function

$$f(x) = .5f_1(x) + .5f_2(x)$$

where $f_1(x)$ is exponential with parameter λ and $f_2(x)$ is a user-defined formula. Figure B.5 shows a portion of the four windows needed to express this.

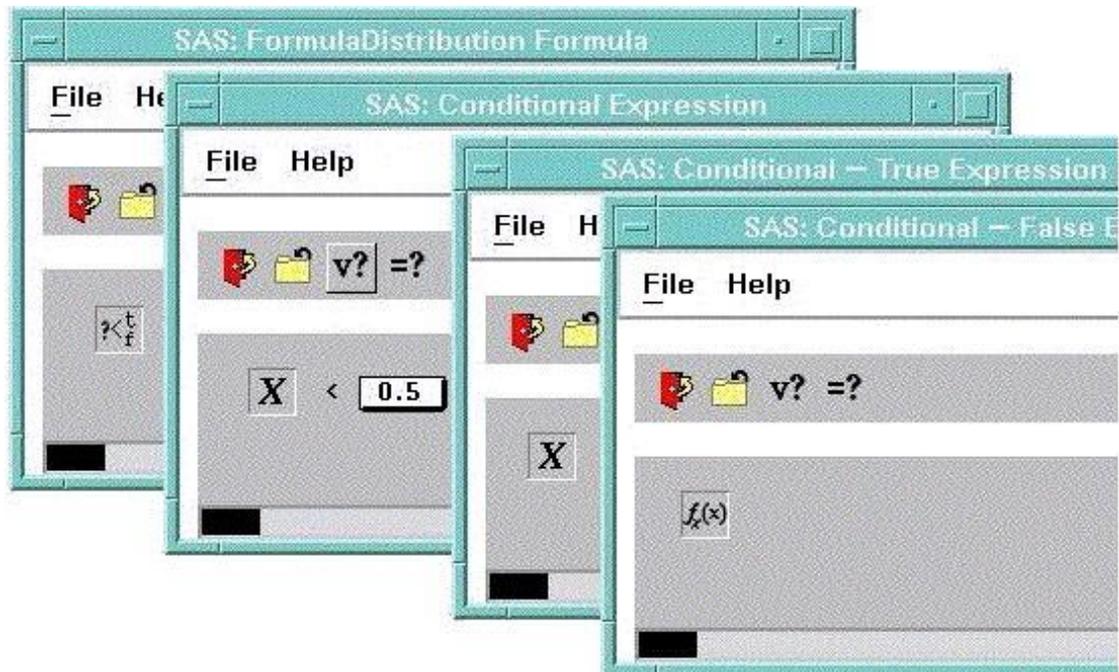


Figure B.5. An Example of a Mixture Distribution

The bottom-most window is the FormulaDistribution Formula window, and it contains the conditional element $\begin{matrix} ? < t \\ f \end{matrix}$. Editing this element provides you with the capability to specify the condition $X < 0.5$.

If the condition evaluates to TRUE, it returns a value from the formula in the True Expression window X , which is the appropriate exponential random variable. If it evaluates to FALSE, it returns a value from the user-defined formula in the False Expression window $f(x)$.

DataSource

You have another opportunity to customize the source of variation with the DataSource selection shown in Figure B.1. With this choice, you can select a SAS data set and a numeric variable. Whenever a sample is needed from a DataSource, an observation is read from the data set and the value of the selected variable is used as the sample value. You choose the data set by clicking the **Parameters** button, which displays the DataSource Control window shown in Figure ??.

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