VISUALSIM TRAINING

Training: Planning, Modeling, Simulation, Advanced Features

MIRABILIS design

Planning

- Goals & Requirements
- Tasks or Operations
- Workloads or Traffic
- Hardware or Platform
- Collaboration & Sharing
- Data Management
- Support
- Look & feel

Modeling

- Parameters/ Variables/ DS/ Fields
- Flow- System, Beh-Arch, Data flow
- Performance Power Functionality
- Hierarchical/ Class/ DI Blocks
- Traffic/ Results
- Hardware/ Software/ Network
- Abstraction
- Algorithms
- Task Graph
- Checking

Simulation and Analysis

- Types of Studies
- Parameter Ranges
- Graphical/ Batch/ Multi-Core
- Debugging/ Verification
- Requirements
- Post-Simulation
- Types of Plots
- Advanced Studies
- Accuracy
- Compare

Advanced Features

- Failure
- Integration
- Generation
- Encryption

Agenda- Part 2: Modeling

- Parameters/Variables/DS/Fields
- Data Types
- Regex
- Flow- System, Beh-Arch, Data flow
- Hierarchical/ Class/ DI Blocks
- Traffic
- Results
- Abstraction

Variable Vs Parameter Vs Data Structure

Variable

1. 3 types- Block(In Script and Expression List only), Local(One window) and Global (Full Model)
2. Values change during simulation
3. Example: Flag, Statistics

Parameter

1. Fixed for a simulation and modified for next run
2. Example: clock speed, buffer size
3. Used for multi-core and batch simulation

Data Structure

1. Similar to Struct in C with Fields and values
2. Contains specific information for that Transaction or packet
3. Dynamically add and destroy fields

Common

-All standard data types supports by Parameters, Variables and fields

-Viewable by Blocks

Data Structure

Data Structure is similar to “struct” in C

Fields of the Data Structure represent

- Data transmitted through the model
- Represents the Control signal info , frames, packets etc.

Data Structures contain 6 standard header

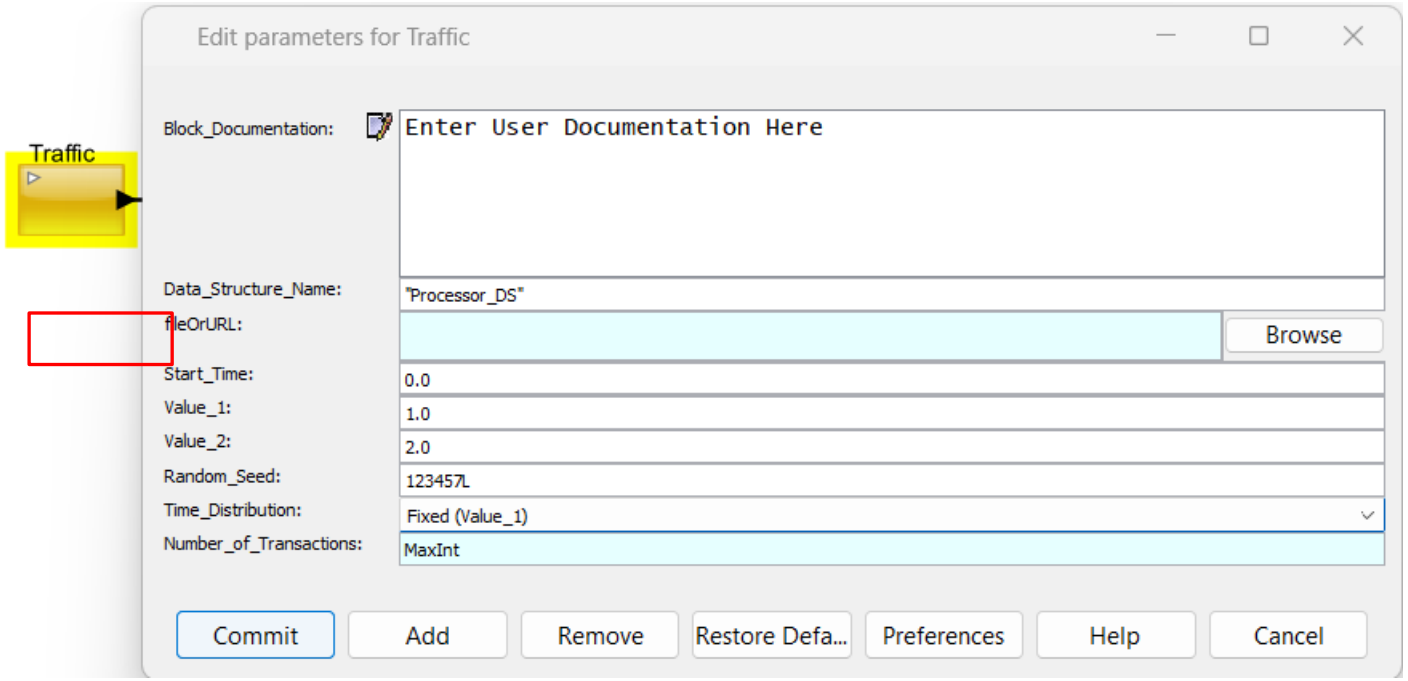
- Block (Source name) and DS_Name (Template name)
- TIME (creation time-stamp) and ID (sequence number)
- INDEX (integer scratch pad) & DELTA (double scratch pad)

```
DISPLAY AT TIME                    ------ 0.0 ps ------
{BLOCK                          = "Traffic",
DELTA                           = 0.0,
DS_NAME                         = "Header_Only",
ID                              = 1,
INDEX                           = 0,
TIME                            = 0.0}
```

Data Structure Templates

- VisualSim Processor, memory -> Processor_DS
- Network modeling -> Task_Class
- Non-Processor Hardware -> Hardware_DS
- Stochastic -> Header

Processor_DS - template

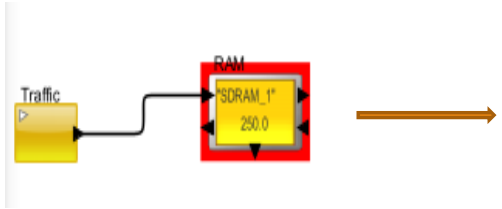


Replacing the default data structure template which can have 50+ fields with a minimal template (Min DS) (~10 fields) will show significant improvement in Run Time of the Models

Necessary Fields in the Data Structure

- A_Source
- A_Destination
- A_Command
- A_Bytes
- A_Bytes_Remaining
- A_Bytes_Sent
- A_Task_Flag

Note: Error message will be thrown when one or more required fields are absent



Block : stochastic_model_0.RAM
Line : Incoming Data Structure does not contain one or more of the necessary fields:
{"A_Source", "A_Destination"}
Error_Number : DRAM_001A
Explanation : Add the required fields listed.
Exception : Incoming Data Structure is missing some fields
in .stochastic_model_0.RAM

Edit parameters for ExpressionList2

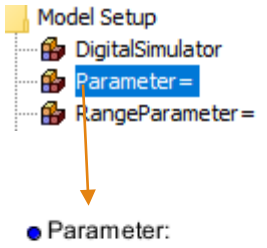
```
   Result_C = MyRegExpression_C_or_None /* Exp
/* Add as many RegEx lines are required */
```

```
/* Template to enter multiple RegEx lines*/
input.A_Source = "Traffic"
input.A_Destination = "SDRAM_1"
input.A_Bytes = 8
input.A_Bytes_Remaining = 4
input.A_Bytes_Sent =4
input.A_Command = "Read"
```

Adding the necessary fields resolves the issue

Parameter

Used to define values which cannot be changed during simulation but can be changed between simulation

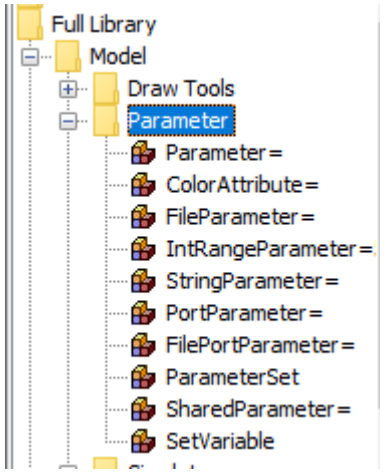


Usage

- Any block in the BDE can access these values
- Export block parameters to link to the BDE parameters

Types

- Generic parameters - Scalar and String
- Expressions
- File names
- Parameter Set

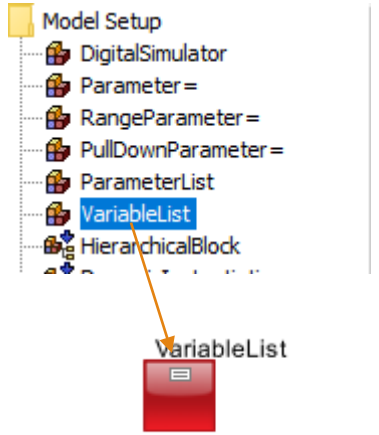


Variable

Variable is a lookup list, variable or register to store data during the simulation

Variable is a named location

- Local- available in the current window only
- Global- available throughout the model
- Block- available within the Script, ExpressionList



Used to communicate between blocks and routing

Defined in VariableList (Global and local), ExpressionList (Block) and Script (Block)

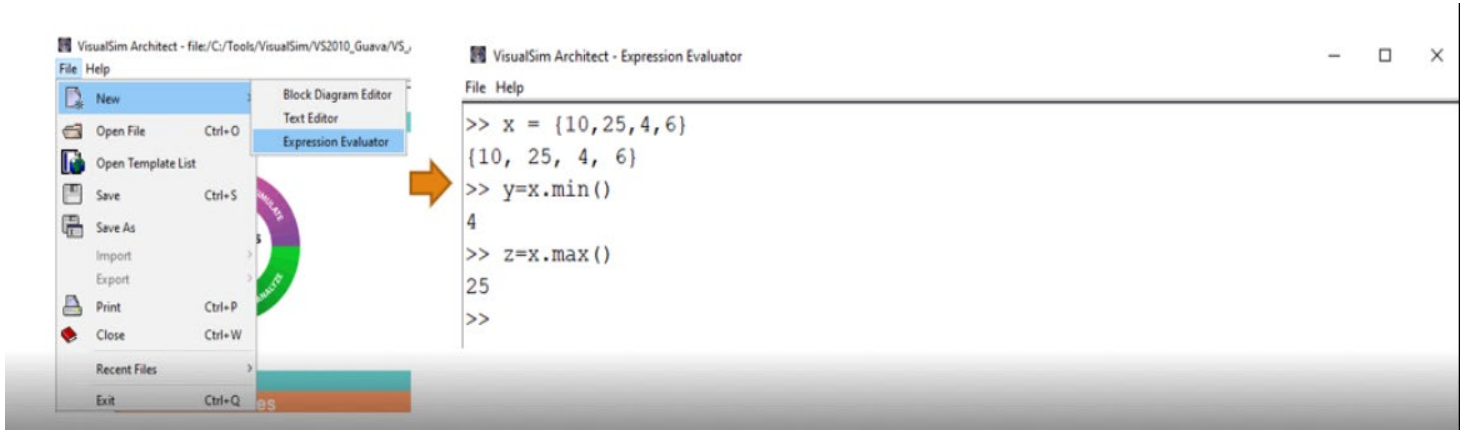
Supports all standard data types

Data Types supported in VisualSim

1. Scalar
   - Integer
   - Double
   - Long
2. String
3. Array
4. Matrix

Note:

- 1/5 will be 0
- 1.0/5 will be 0.2
- 1/5.0 will be 0.2
- 1.0/5.0 will be 0.2



RegEx

- Collection of Mathematical, Logical, Statistical and Algorithm-Specific Functions
- Popular RegEx are used with Array, Queues, Schedulers, Data Structure, Power and Networking
- Usage
  - ✓Parameters
  - ✓Processing, ExpressionList, Script and Queue/Server for defining logic and decisions
  - ✓Can combine parameters, variable and data structure fields

Regex Examples

Hardware Architecture Routing table

addToRoutingTable (String Architecture_Name, String Source_Name, String Destination_Name, String Hop_Name, String Source_Port_Name)	Adds a line to the routing table. This is used to add a specific connection.	addToRoutingTable ("Architecture_1", "IO_2","IO_2", "Bus_Name_1", "Bus_Name_2")
getRoutingTable (String Architecture_Name)	Get Routing Table as a Data Structure.	getRoutingTable(" Architecture_1")

Power Regex

powerManager (String power_table_name)	Gets the complete power table. This will get the details for all devices that are associated with this PowerTable	powerManager ("ARM_Table_Manager ")
stateChange (String power_manager_name, String Device Name String Operating State, String State name)	Changes the state of a device dynamically. See device list above.	stateChange("Manager_1 ", "ARM","Standby","Idle“)

Statistics

addStats (String memory_name, double value)	Updates a statistics memory that is defined using the Statistics block. If the memory exists, then add double value and return true, else returns false.

File I/O

readFile (String filename)	Get the string text contained in the specified file.	readFile("File_Name")
writeFile (String filename, java.lang.Object token)	Write the token to the specified file.	writeFile("File_Name",port_token)

Expression List

Sequence of mathematical expressions

Requires one transaction on all input ports to fire the block

Assign values to fields or variables

- Execution starts when data arrives on all input ports
- Data at each port is identified by the port name
- Queued if multiple values arrive at one port

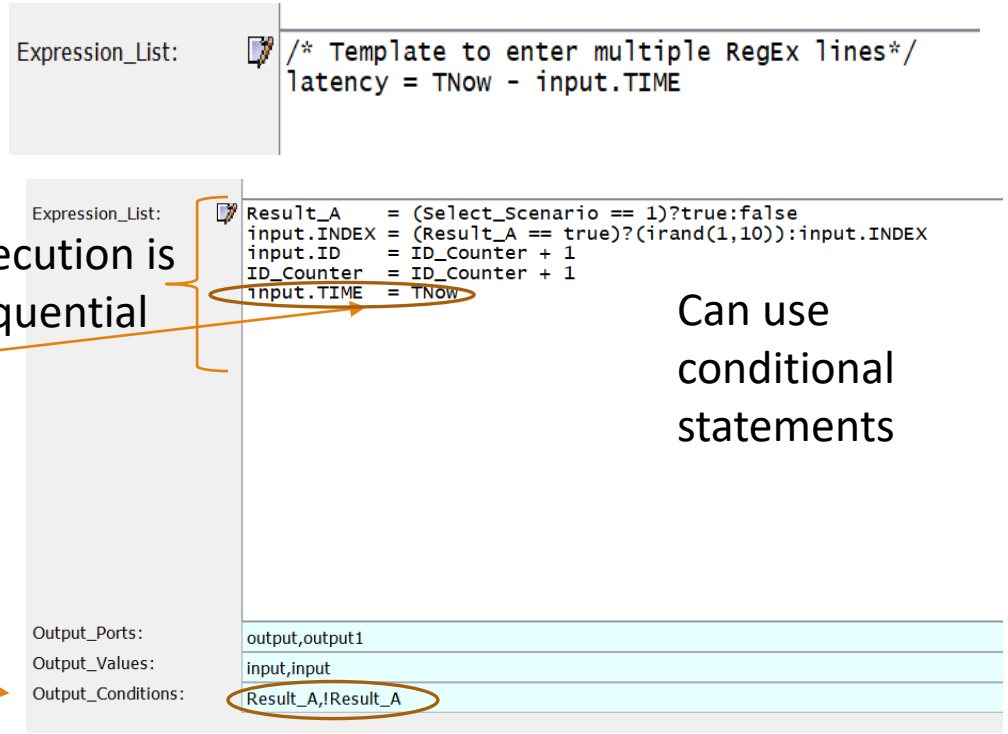
Usage

- input.field_name = value

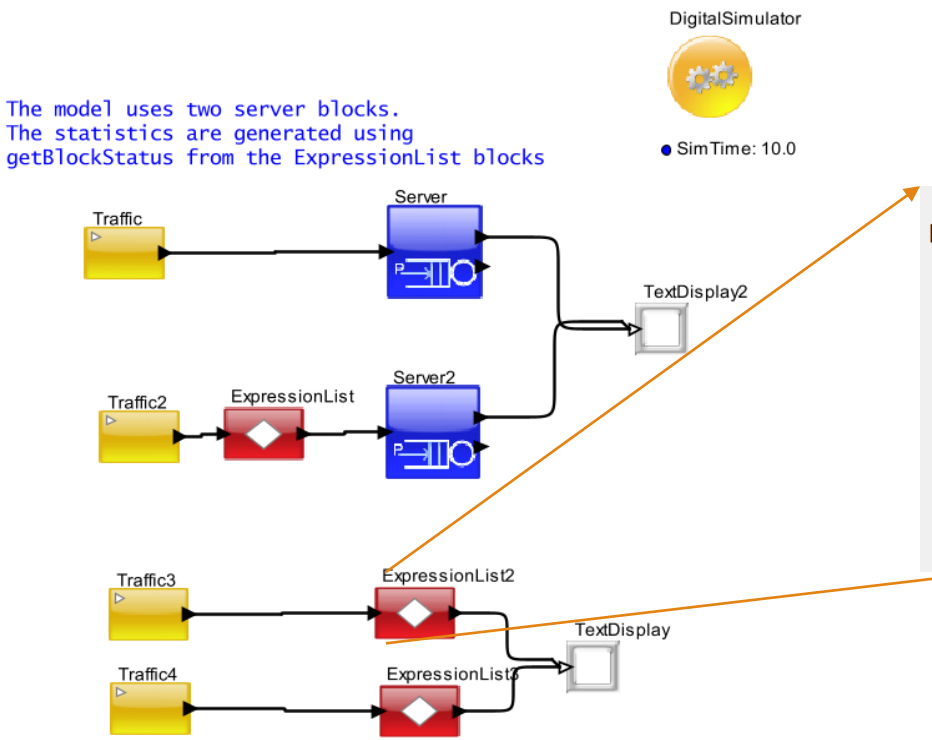
Output

- Condition can use any expression containing fields, variables and logical operators

Some Commonly used Expressions in ExpressionList



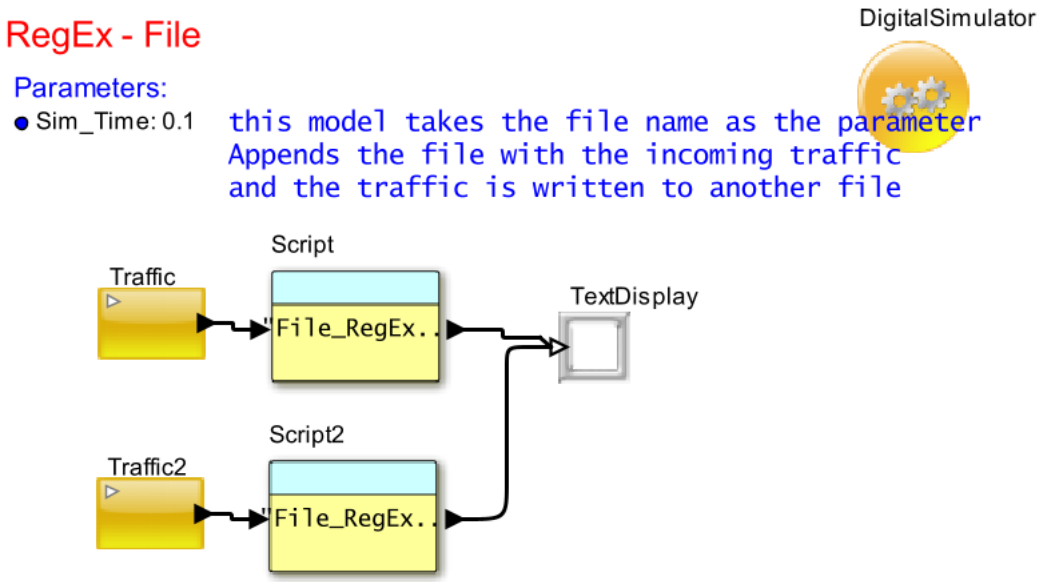
Using Regex in ExpressionList – Demo Model



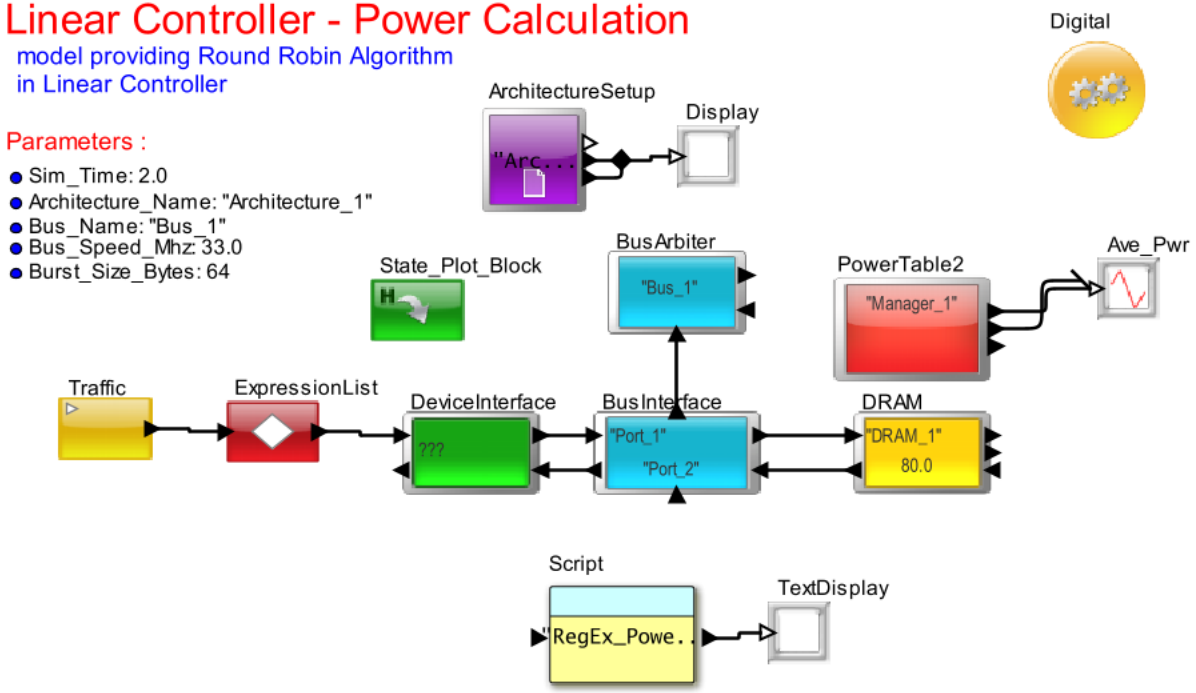
Expression_List:

```
Result_A = getBlockStatus("TimedResource2","XY","length",4,1)
Result_B = getBlockStatus("TimedResource2","XY","stats",4,1)
Result_C = getBlockStatus("TimedResource2","XY","stats",5,1)
Result_D = getBlockStatus("TimedResource2","XY","stats",-4,1)
Result_E = getBlockStatus("TimedResource2","XY","stats",-5,1)
Result_F = getBlockStatus("TimedResource2","XY","copy",4,1)
Result_H = getBlockStatus("TimedResource2","XY","array",1,2)
Result_I = getBlockStatus("TimedResource2","XY","copy.ID",4,1)
```

Demo Models – Regex in script block



$VS/doc/Training_Material/Tutorial/General/RegEx/RegEx_File_Test.xml

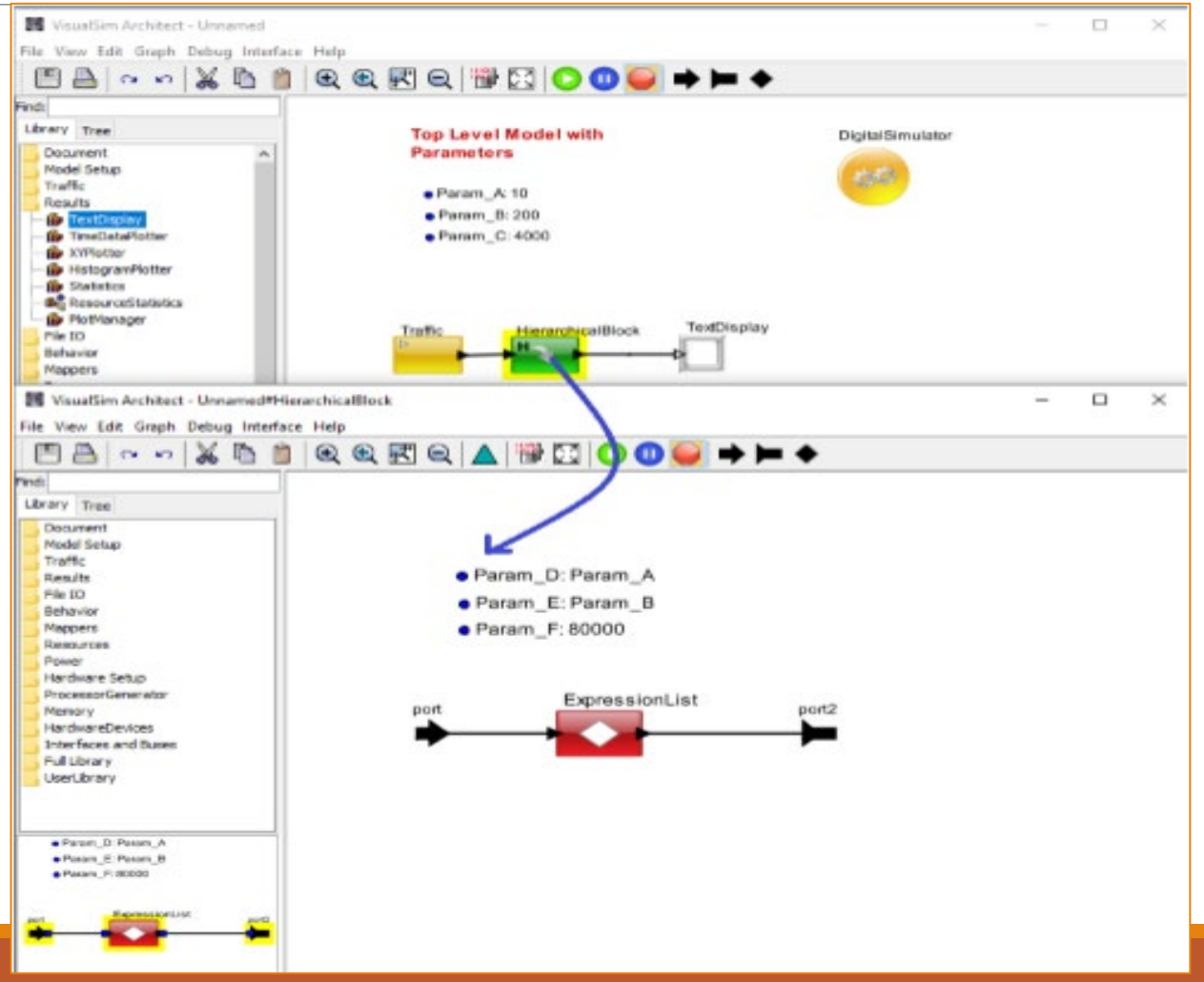


$VS/doc/Training_Material/Tutorial/General/RegEx/RegEx_Power_Test.xml

Hierarchical/ Class/ DI Blocks

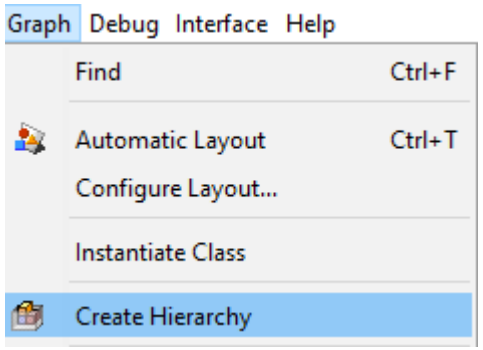
Hierarchical Blocks

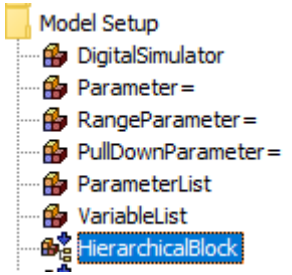
- Grouping a set of functional blocks that combine to define a function or device



Construct Hierarchical Block

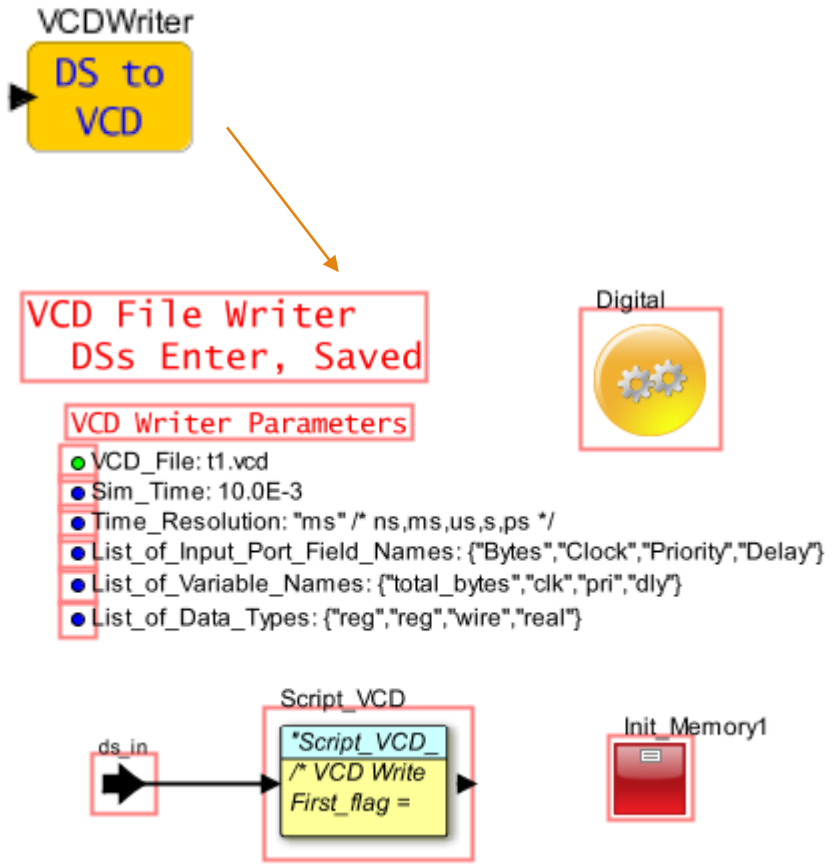
- Select the blocks to be grouped. Select Edit -> Create Hierarchy
- Drag from Model Setup -> HierarchicalBlock
- Add input and output ports, Parameters
- To view inside the Block**, Right click- > Open Block**





Class

- A class is a master version of the block.
- Class is an XML sub-model
- Can be instantiated multiple times in the model.
- Changes made to class block are replicated to all linked instances
- All sub-models need a Simulator

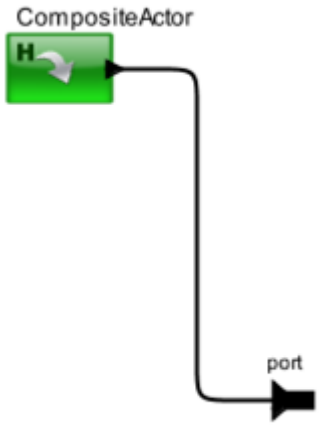


How to construct a Class?

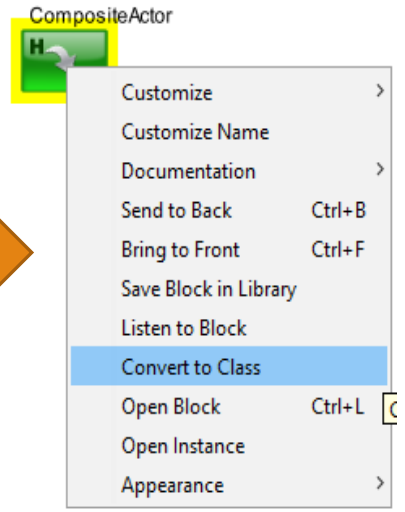
- **Assemble the initial block diagram**
  - ✓Use the library blocks to assemble the model
  - ✓Create a Hierarchical block of this block diagram
- **Create a class**
  - ✓Convert the Hierarchical block into a Class
  - ✓Save as a sub-model
- **Instantiate a new class for use in a model**
  - ✓To use the Class, you need to instantiate the block in the model using Graph> Instantiate. Entity. Make sure the Class is located within the VS_Model_Library directory
- **To test the class**
  - ✓ Test the class by constructing a simple model around it.
- **Save in Library**
  - ✓Right-click the block and select Save Block in Library.

Constructing a class

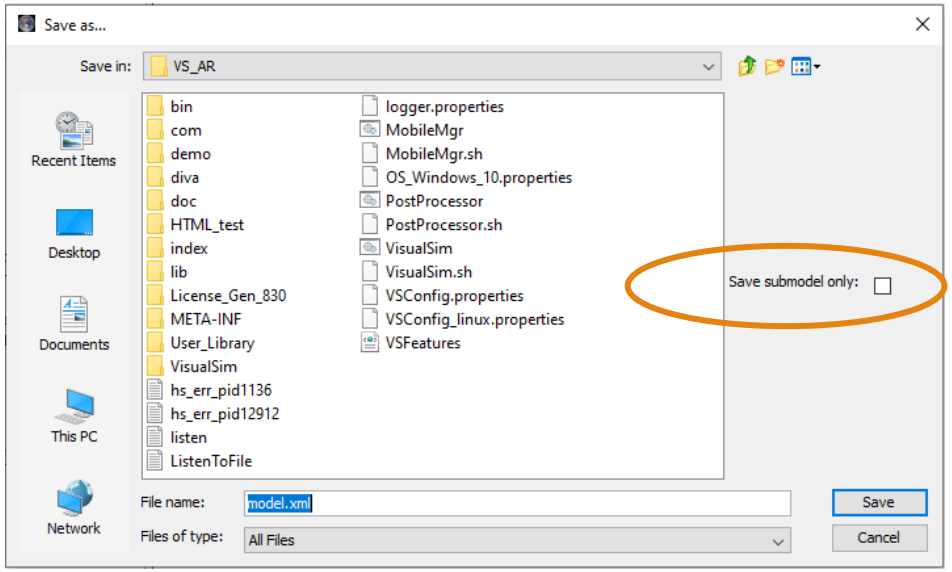
CREATE HIERARCHY



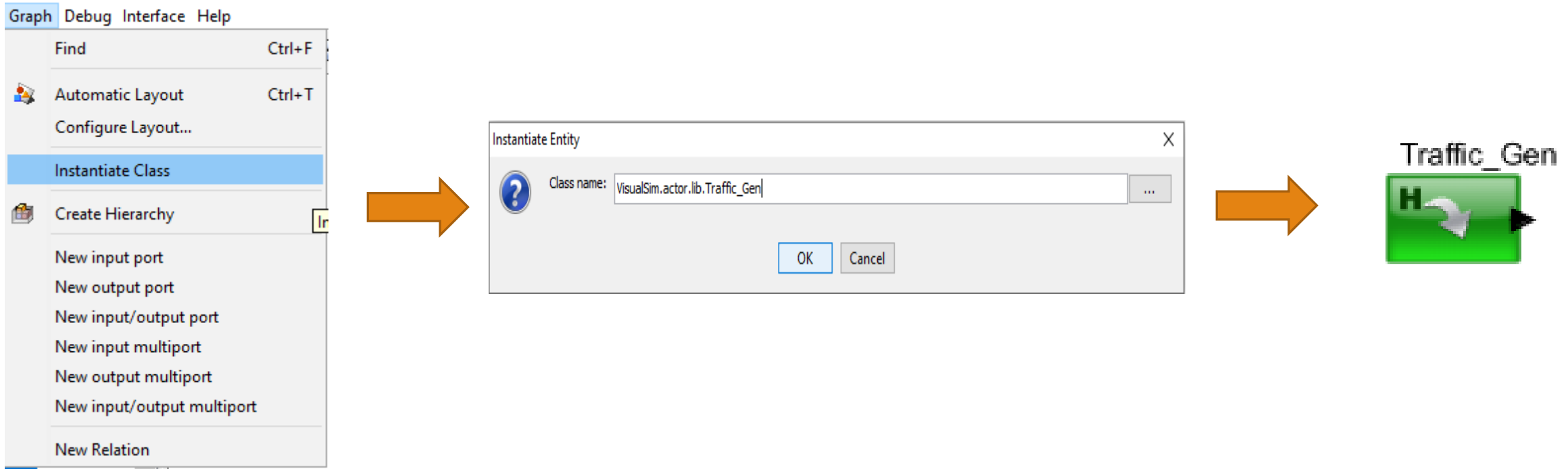
CONVERT TO CLASS



OPEN CLASS AND SAVE AS

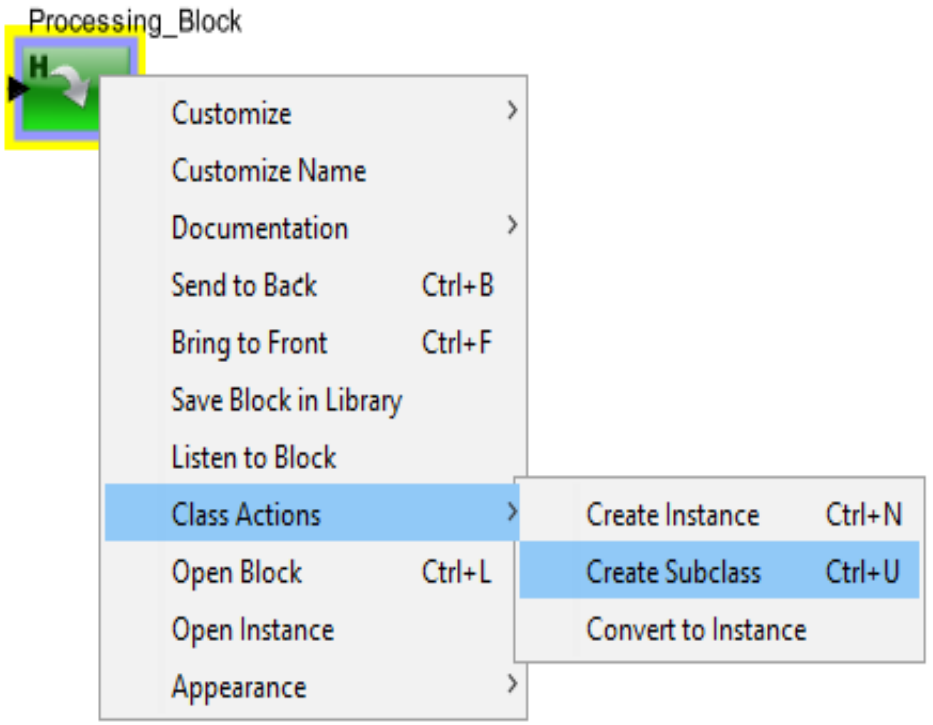


Instantiating the Class



Creating Sub Class

- Right click on the Class Block
- Select **Class Actions > Create Subclass**
- Can add additional parameters and Blocks



Do’s and Don’t for Class Block

Save all class blocks in a common location

Make sure the location is below a Classpath

Organize the Classes in folders under this Classpath

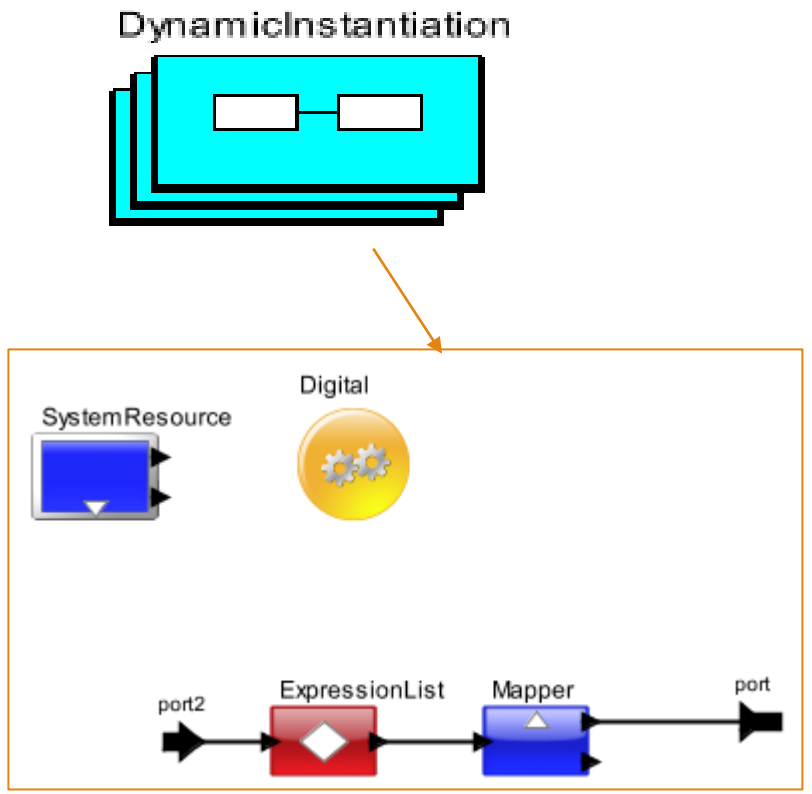
Use the Open Instance for Listen to Block and Listen to Port ONLY

Do not modify any functionality inside the Open Instance.

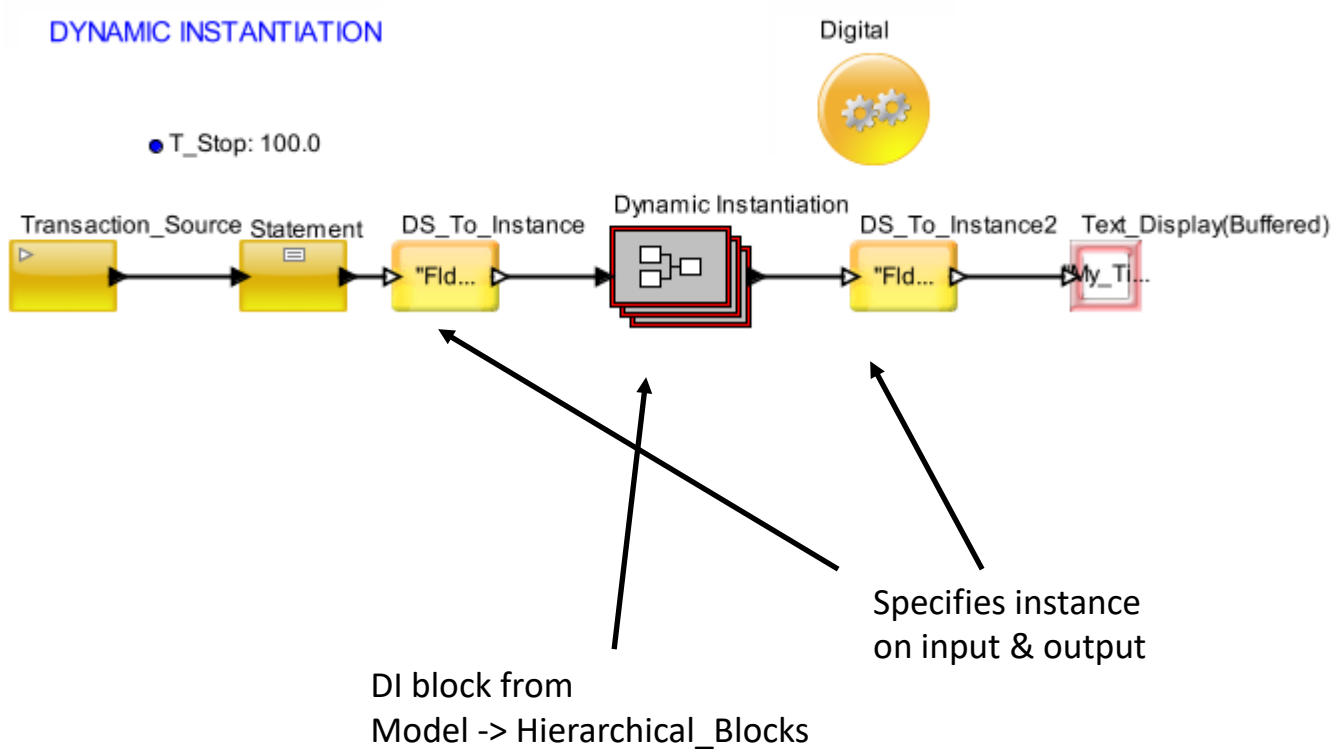
- This will reflect only in that instance of this Class.
- Any changes to the instance is extremely hard to debug.

Dynamic Instantiation

- Creates multiple instances of itself during the preinitialize phase of model execution.
- Each instance of this block behaves exactly like a Hierarchical block.
- Helps significantly in building large designs where the model structure scales.



Example of Dynamic Instantiation



Advantages of Dynamic Instantiation

- Dynamic Instances solves modeling problems where objects are arbitrarily required.

- Examples are:
  - ✓ Mobile units entering, traversing and exiting a coverage area
  - ✓ Creation and deletion of virtual circuits
  - ✓ Peer-to-peer protocol connections

- Above problems are difficult to model using Static Instantiation
  - ✓ Place many copies of a block in a diagram and use block logic to emulate creation and deletion and to branch data to/from the appropriate blocks.
  - ✓ Create a primitive that does all the work.

- Static Instantiation requires over-specification and makes model engineering and presentation difficult.

MIRABILIS design

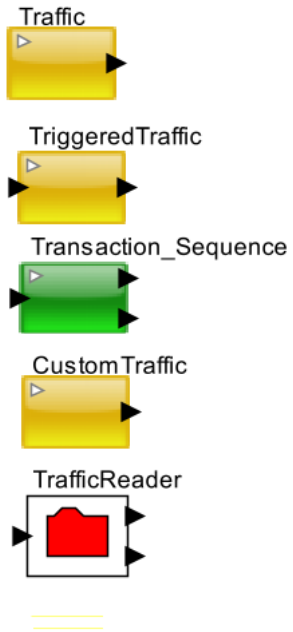
Differences

- Modification in one Hierarchical block does not affect another
- Changes in Open Block of Class block will be reflected at all places were used
- Changes in Instance will only be reflected in that one location
- Open Block for Dynamic Instantiation and Hierarchical Block for Listeners
- Open Instance for Classes for Listeners

Traffic

Data Structure Generation

- Traffic
  - ✓ Time distribution
- TriggeredTraffic
  - ✓ Requires an input trigger to generate DS
- Transaction Sequence
  - ✓ Custom list of operations
- Custom Traffic
  - ✓ Periodic distribution
- Trace
  - ✓ Read from a file
- Using RegEX
  - ✓ **newToken(Value)**

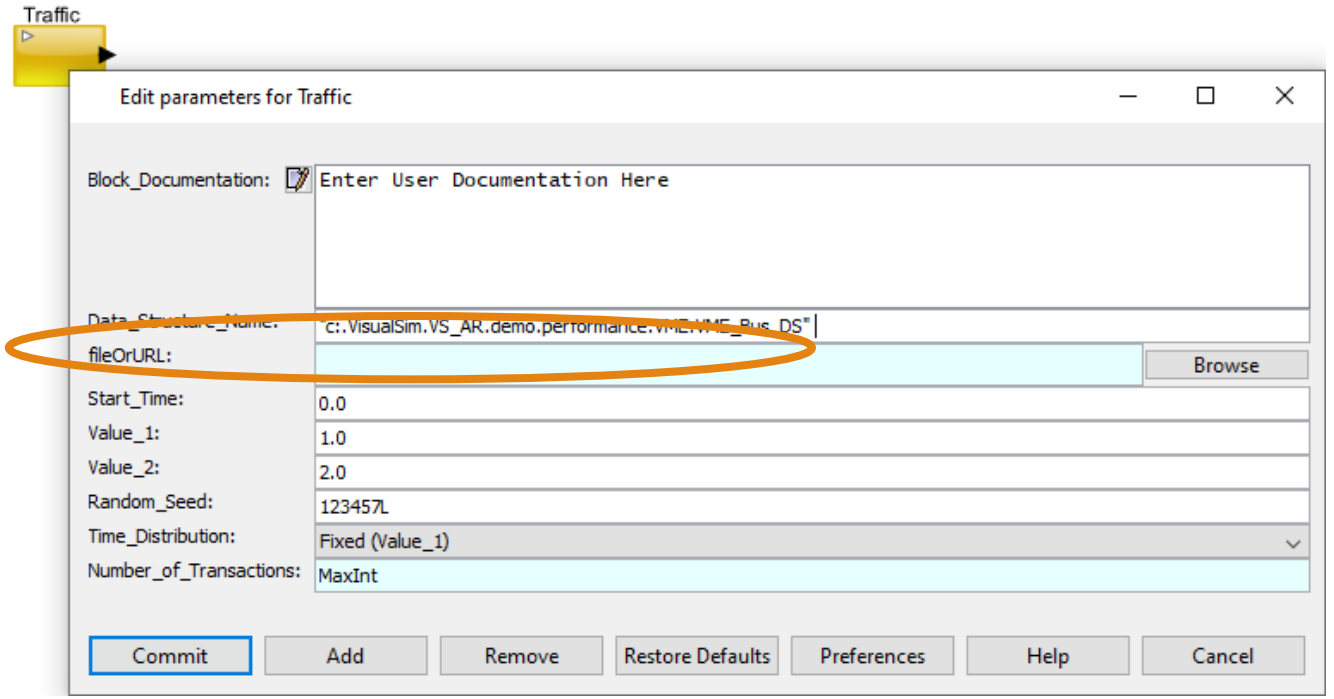


Defining Data Structure in Traffic Blocks

Data Structures template

- .txt can be located anywhere
- .class located in VS_AR/VisualSim/data

- Absolute path is required for accessing files located anywhere.
- File name if located in the $VS/VisualSim/data directory.

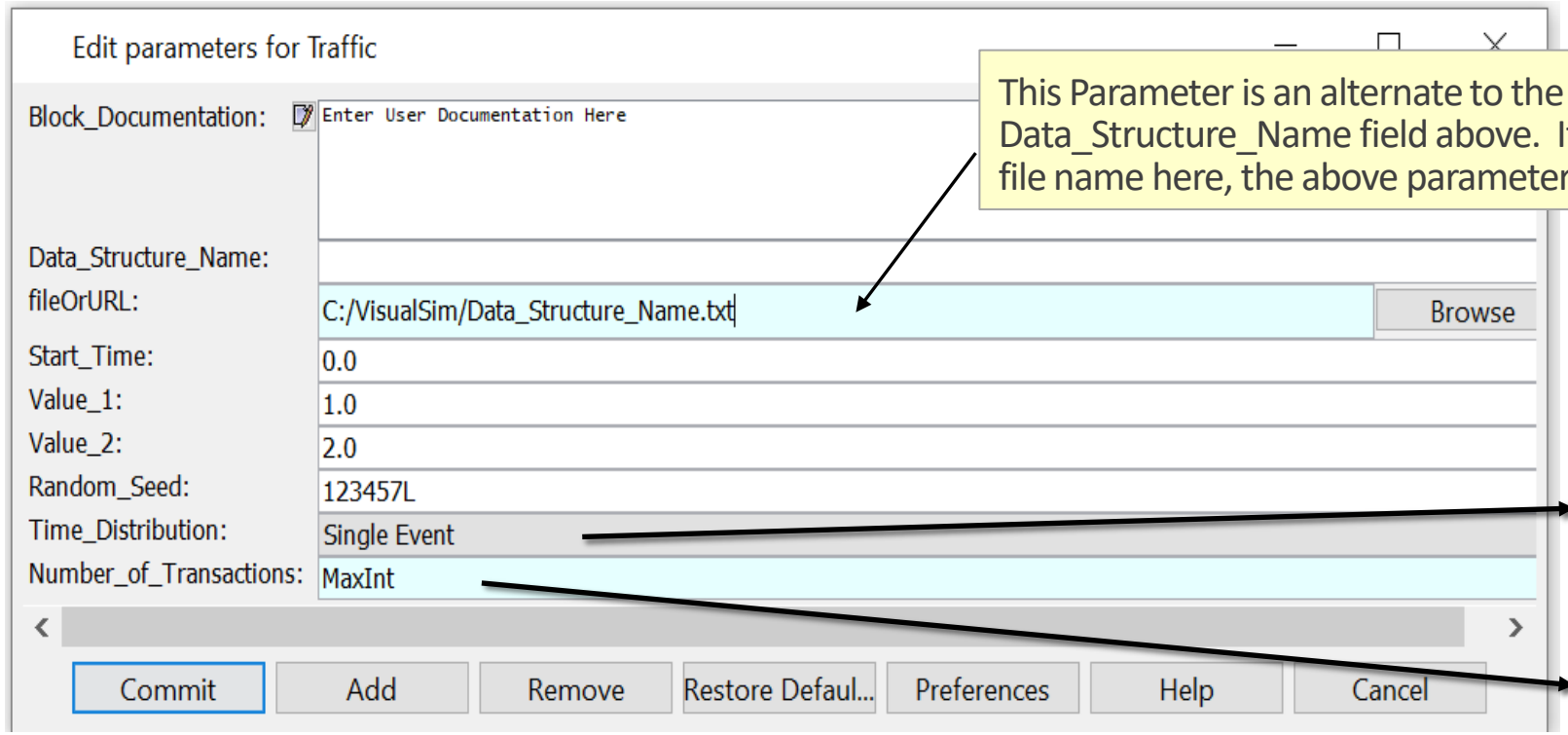


Types

- **Statistics Distribution-** Single request, periodic or fixed, uniform within a range, normal, exponential
- **Custom**- Based on a combination of data size and interface speed. Can also be triggered by external event
- **Trace file-** Existing file from hardware bus, network, software thread execution sequence, instruction order
- **Sequence**- Special case to typically debug with a order such as command of “Read, Write, Write, Read , or packet sizes of “128, 1512, 256”

Traffic

- Double click to configure



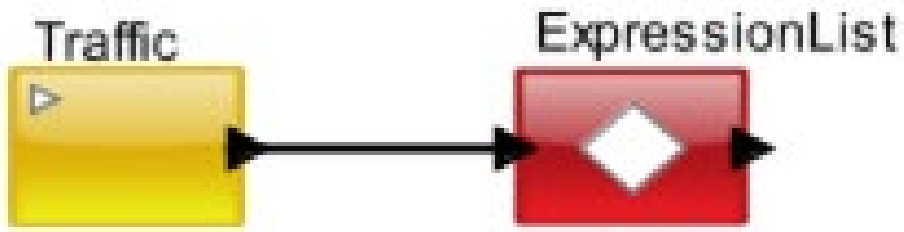
This Parameter is an alternate to the Data_Structure_Name field above. If the user defines a file name here, the above parameter is not considered.

Select the "Time_Distribution" according to design

Restrict the number of transactions

Type I - Statistical

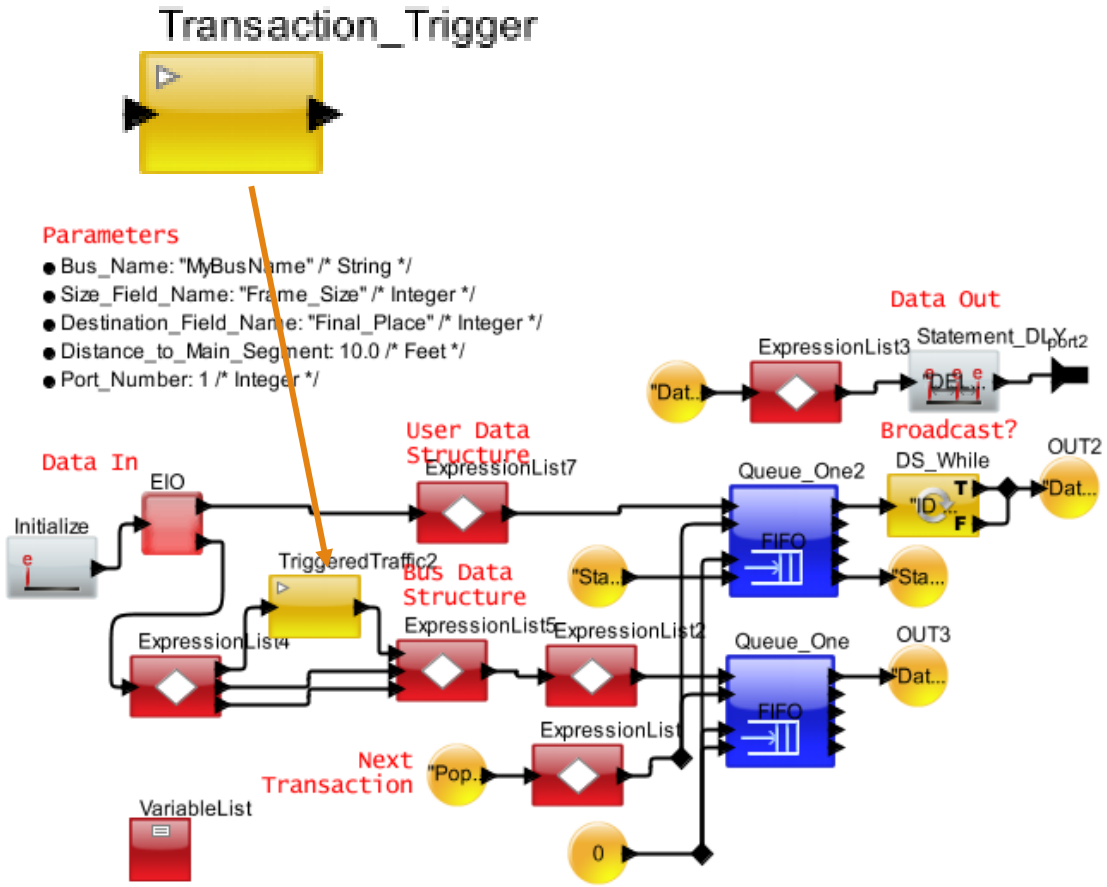
- Define a distribution
- Parameters for mean and standard distribution
- Specify values for the Data Structure fields. It can be source, destination, data, priority or bus delay



Type II - Custom

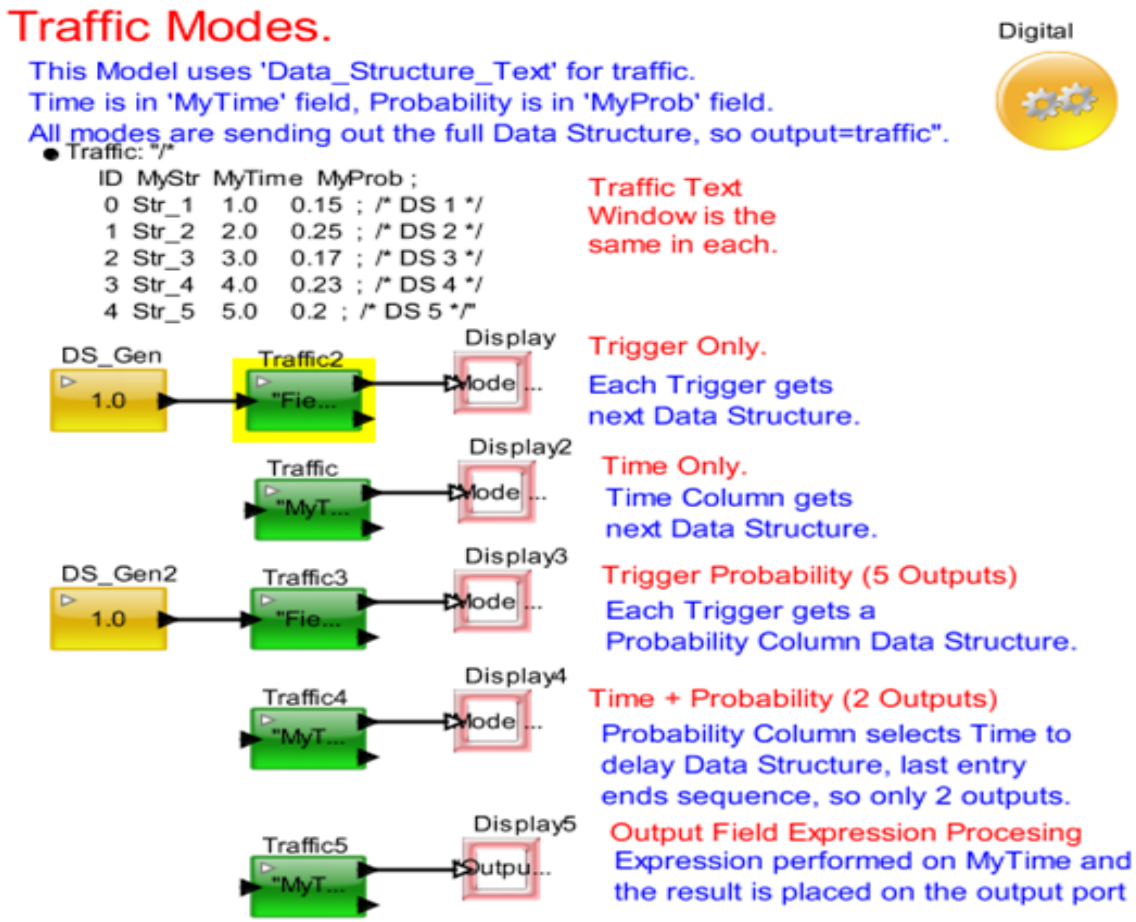
- If a custom distribution is required or the Data Structure is generated as a function of another activity, or triggered during the flow, use the **Triggered Traffic.**

- Every time the input port is triggered the Triggered Traffic block generates a transaction



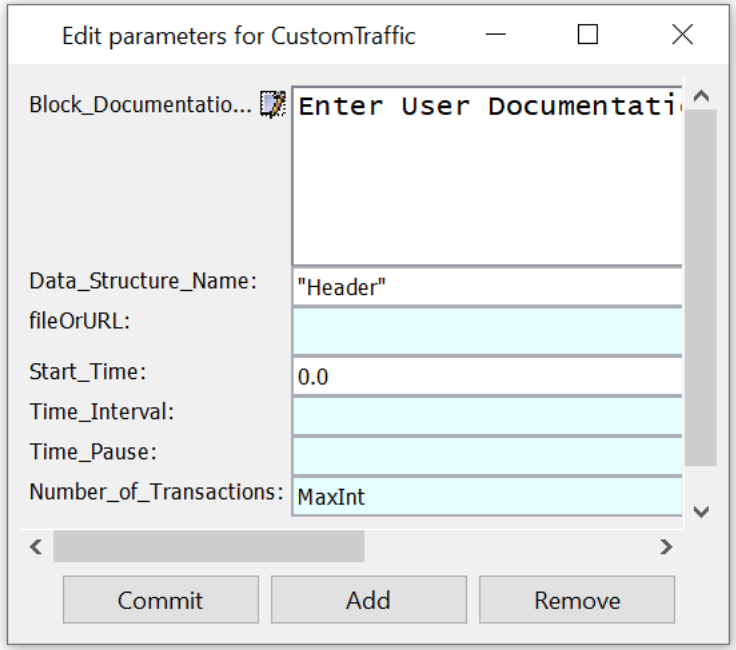
Type III – Transaction Sequence

- Generate transactions or Data Structures in a specific sequence
- Define sequences in the parameter window or specify a file + path
- Time interval between Data Structure is a parameter
- Specify an output processing using the Regular Expression (RegEx) Language



Type IV – Custom Traffic

- Generate data structure during the T_Interval period
- Stalls all transmission during the T_Pause.
- Equally distributes the Number_Of_Transactions during the T_Interval range.



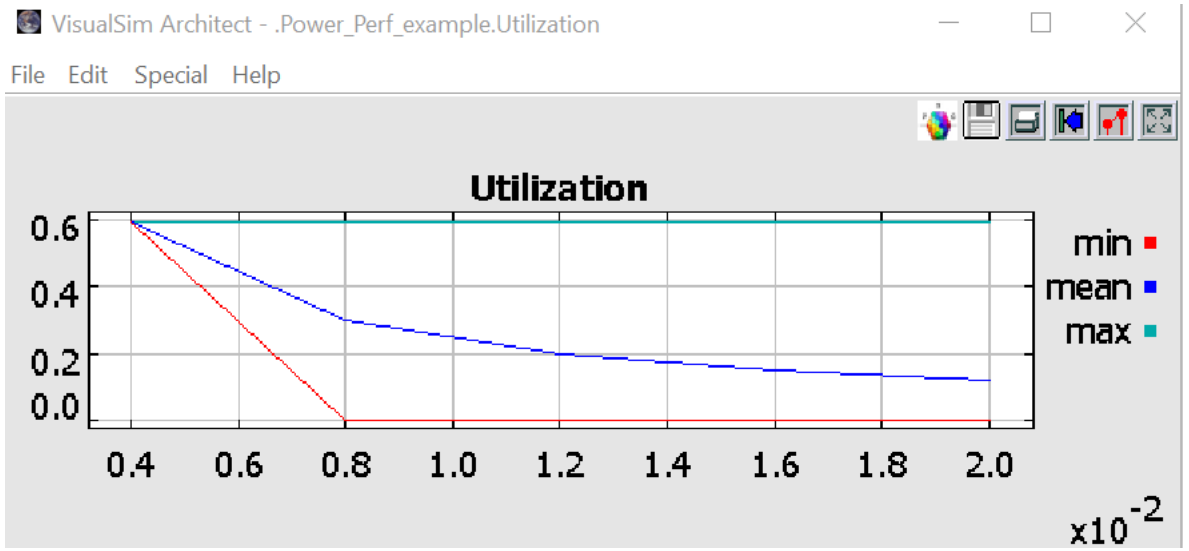
MIRABILIS design

Plotting, Displays and Statistics

Result

- **Statistics**
  - ✓ ResourceStatistics
  - ✓ Statistics blocks to collect statistics at intermediate points
- **Assertions or tests**
  - ✓ High/low value for scalar
  - ✓ Conditional model activity
  - ✓ Model termination
- **Collect data**
  - ✓ Write to screen or to files (Excel, text or XML)
- **Plot data**
  - ✓ Bar, Histogram or XY plots
  - ✓ Special viewers- Matrix, Image, MPEG and speakers
- **3D- Interactive Creation**
  - ✓ Create custom animated views that resemble the system

Using TimeData Plotter

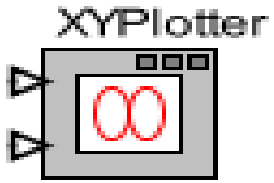


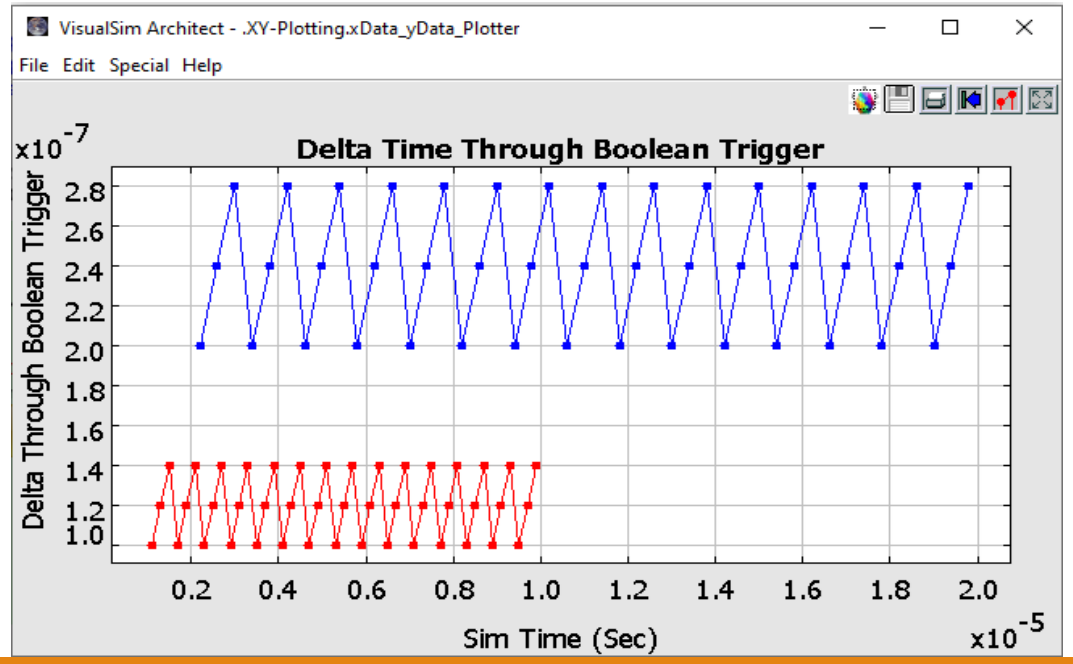
- Plot double values against simulation time
- View or save the results of the simulation in a XY format.
- Used to depict latency, throughput and other variables that vary against time.

X-axis : Sim Time (s), Y-axis : Utilization

XY Plotter

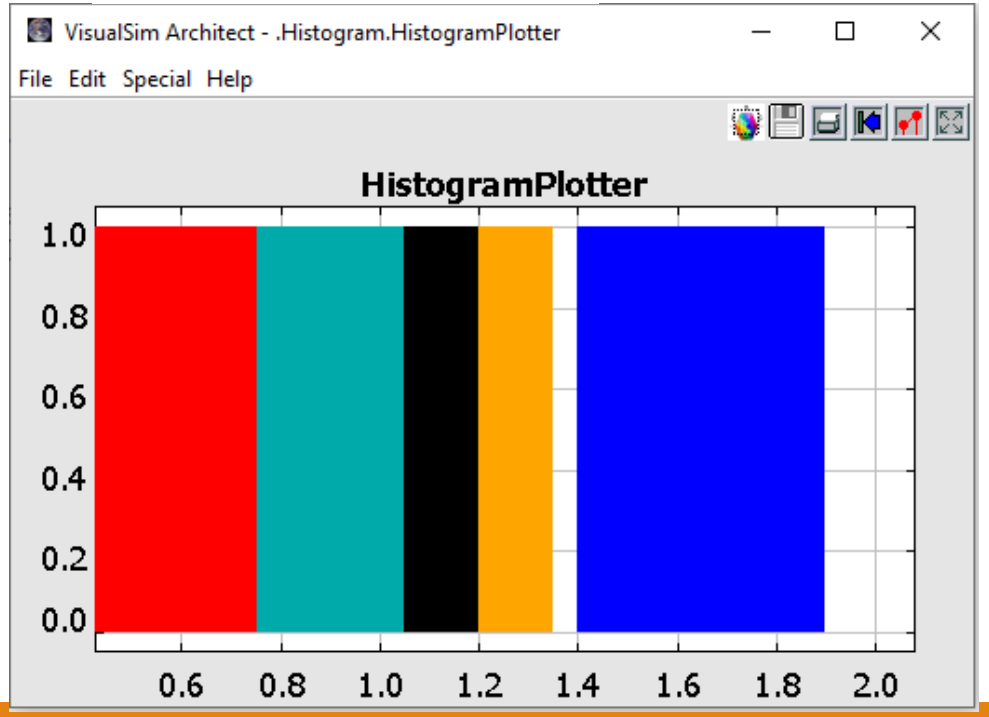
- Any scalar value against any other scalar value. Both values must arrive synchronously.
- The X- and Y-axis can have different data values.
- Plots can be Latency vs. Packet Size or Task Delay vs. Processor Speed.
- The parameters of this block match the fields (or RegEx) of the incoming Data Structure to determine the coordinates, color and trace identifier (Dataset).
- Values, color, legend defined in fields of incoming data structure. Plot similar to XYPlotter



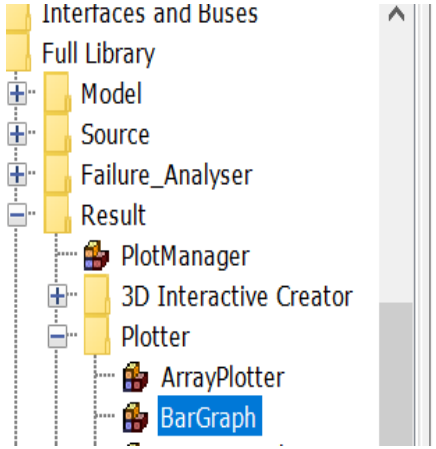


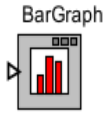
Histogram

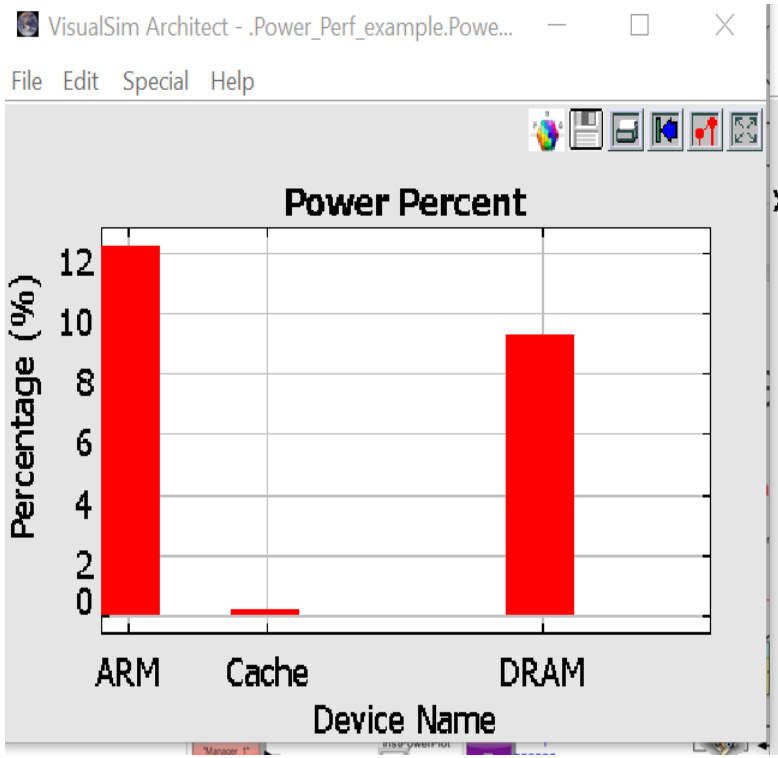
- The plotter accepts data on the input and plots them as a histogram.
- View the plot in real-time or save for future viewing.

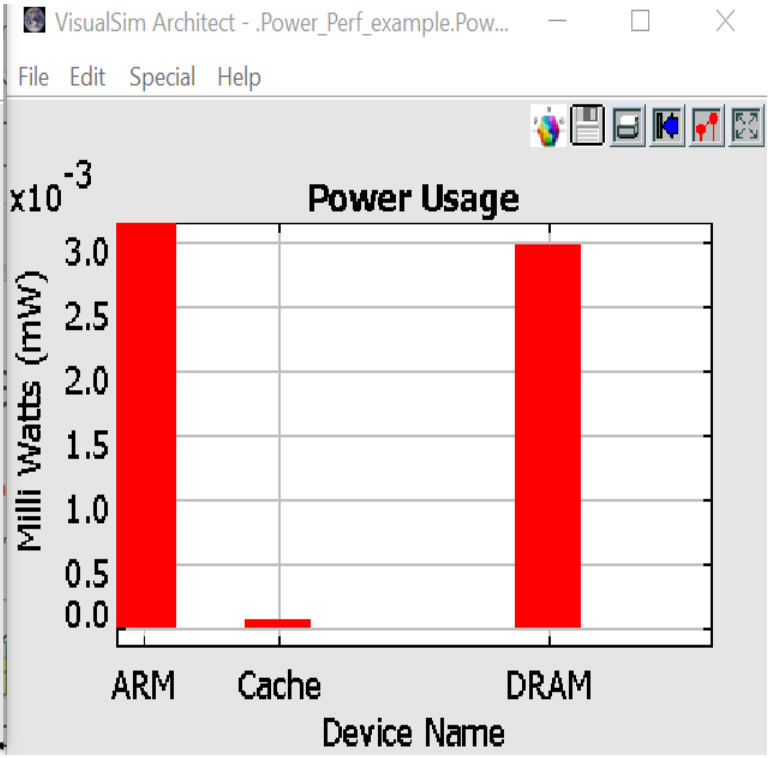


Using Bar Graph



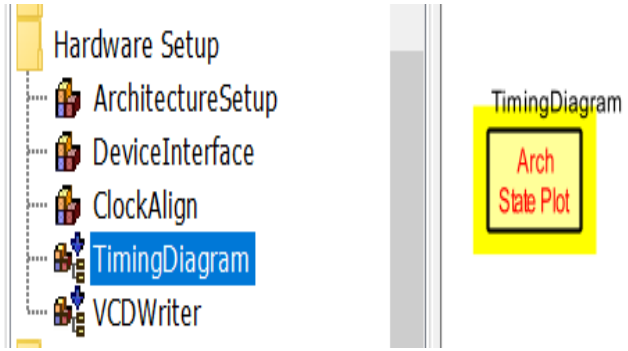


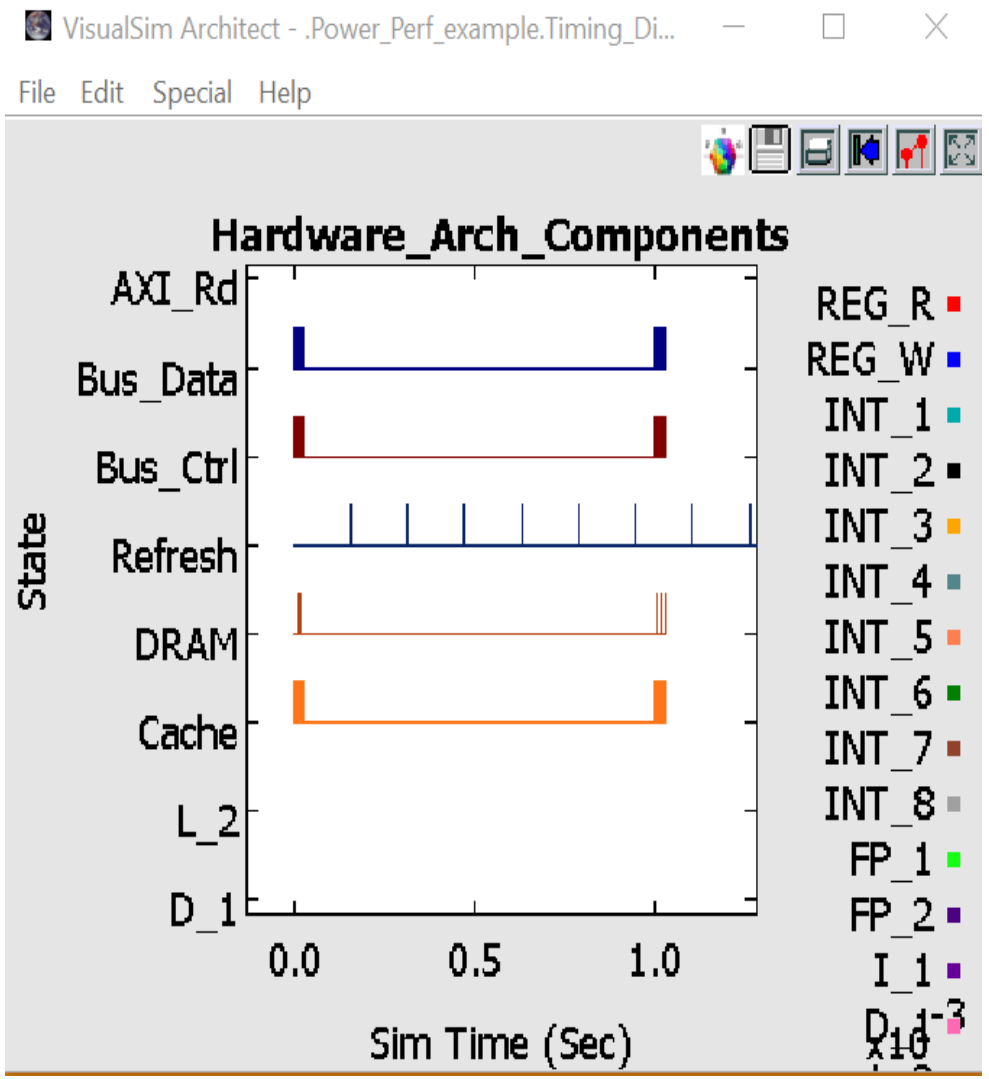




- The bar graph plots series
- The input is an array

Using Timing Diagram

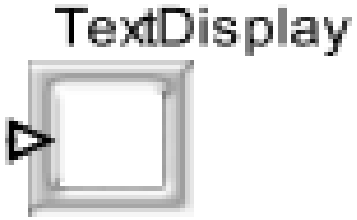


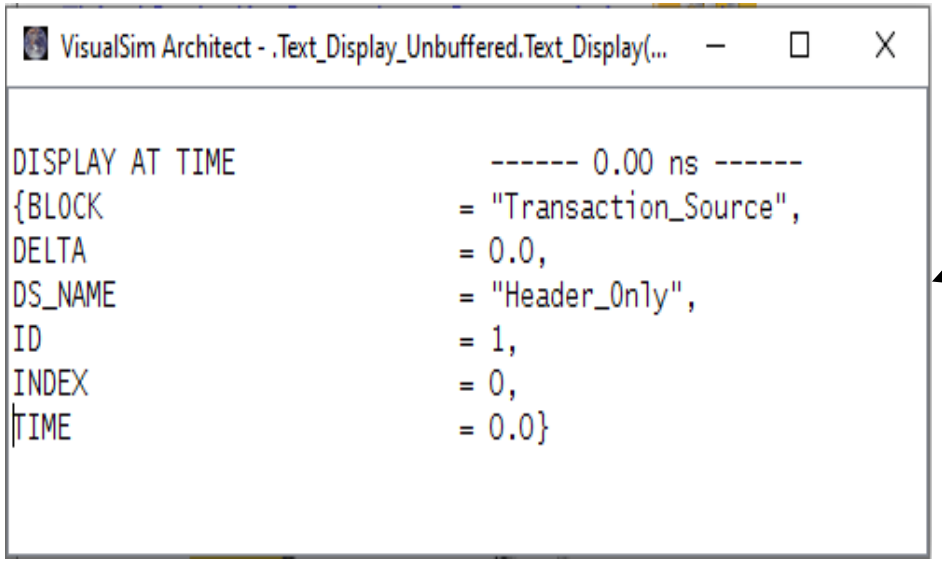


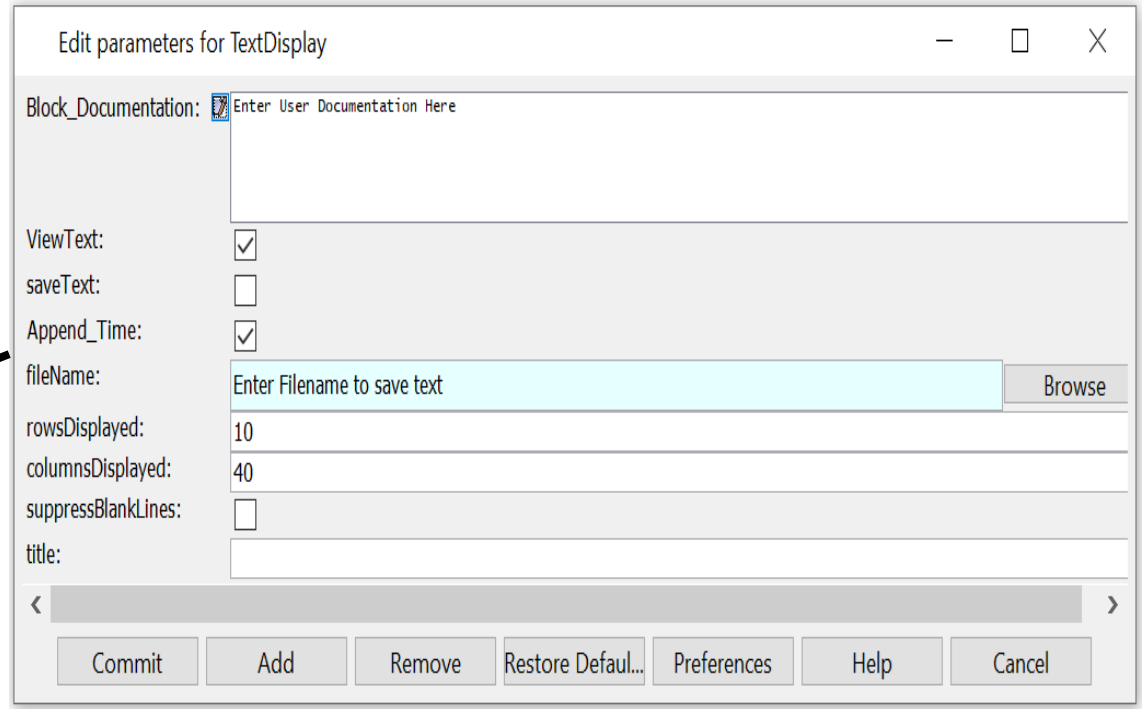
Need to add details

Text Display

- Output to text the data structure and statistics
- The input type can be of any type.
- Can be set to Save/View from Post Processor
- Cannot be viewed from the Post Processor

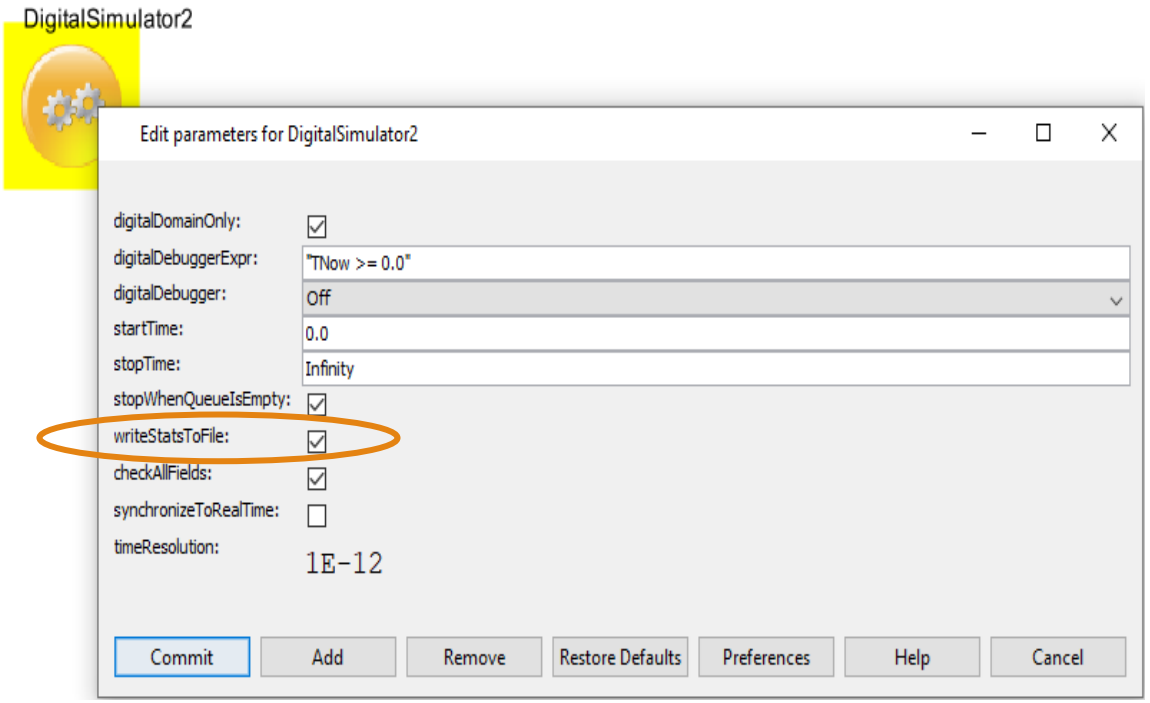






writeStats To File

- Generates Statistics for all the blocks in the model at the end of simulation
- Writes into a Text File in the model directory




```
Queue_Statistics                6.00000000000 sec
{BLOCK                      = "SR_SrExtend_example.SystemResource_Extend",
DELTA                       = 0.0,
DS_NAME                     = "Queue_Common_Stats",
ID                          = 1,
INDEX                       = 0,
Number_Entered              = 7,
Number_Exited               = 1,
Number_Rejected             = 0,
Occupancy_Max               = 6.0,
Occupancy_Mean              = 3.7777777777778,
Occupancy_Min               = 1.0,
Occupancy_StDev             = 1.4740554623802,
Queue_Number                = 1,
TIME                        = 6.0,
Total_Delay_Max             = 4.0,
Total_Delay_Mean            = 4.0,
Total_Delay_Min             = 4.0,
Total_Delay_StDev           = 0.0,
Utilization_Mean            = 0.0}
```

Differences between ArchitectureSetup and Resource Statistics Blocks

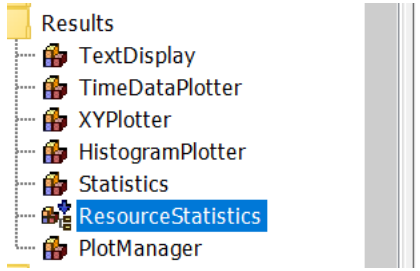
Resource Statistics from Architecture setup – Covers all the hardware Blocks

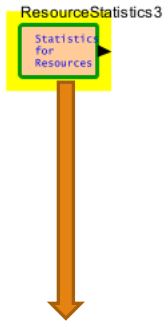
```
DISPLAY AT TIME                ------ 4.00000000 ms ------
{AHB_Bus_Delay_Max            = 7.4000000000081E-8,
AHB_Bus_Delay_Mean            = 4.1460937499999E-8,
AHB_Bus_Delay_Min             = 3.9999999999979E-8,
AHB_Bus_Delay_StDev           = 6.8947470309723E-9,
AHB_Bus_IOs_per_sec_Max       = 256000.0,
AHB_Bus_IOs_per_sec_Mean      = 256000.0,
AHB_Bus_IOs_per_sec_Min       = 256000.0,
AHB_Bus_IOs_per_sec_StDev     = 0.0,
AHB_Bus_Input_Buffer_Occupancy_in_Words_Max      = 4.0,
AHB_Bus_Input_Buffer_Occupancy_in_Words_Mean     = 0.2324853228963,
AHB_Bus_Input_Buffer_Occupancy_in_Words_Min      = 0.0,
AHB_Bus_Input_Buffer_Occupancy_in_Words_StDev    = 0.5308132512572,
AHB_Bus_Preempt_Buffer_Occupancy_in_Words_Max    = 0.0,
AHB_Bus_Preempt_Buffer_Occupancy_in_Words_Mean   = 0.0,
AHB_Bus_Preempt_Buffer_Occupancy_in_Words_Min    = 0.0,
AHB_Bus_Preempt_Buffer_Occupancy_in_Words_StDev  = 0.0,
AHB_Bus_Throughput_MBs_Max    = 3.964,
AHB_Bus_Throughput_MBs_Mean   = 3.964,
AHB_Bus_Throughput_MBs_Min    = 3.964,
AHB_Bus_Throughput_MBs_StDev  = 0.0,
ARM_Context_Switch_Time_Pct_Max          = 0.075375,
ARM_Context_Switch_Time_Pct_Mean         = 0.075375,
ARM_Context_Switch_Time_Pct_Min          = 0.075375,
ARM_Context_Switch_Time_Pct_StDev        = 0.0,
ARM_D_1_Hit_Ratio_Max         = 0.0,
ARM_D_1_Hit_Ratio_Mean        = 0.0,
ARM_D_1_Hit_Ratio_Min         = 0.0,
ARM_D_1_Hit_Ratio_StDev       = 0.0,
ARM_I_1_Hit_Ratio_Max         = 100.0,
ARM_I_1_Hit_Ratio_Mean        = 24.9388753056235,
ARM_I_1_Hit_Ratio_Min         = 0.0,
ARM_I_1_Hit_Ratio_StDev       = 37.8307159101048,
ARM_Stall_Time_Pct_Max        = 0.0,
ARM_Stall_Time_Pct_Mean       = 0.0,
ARM_Stall_Time_Pct_Min        = 0.0,
```

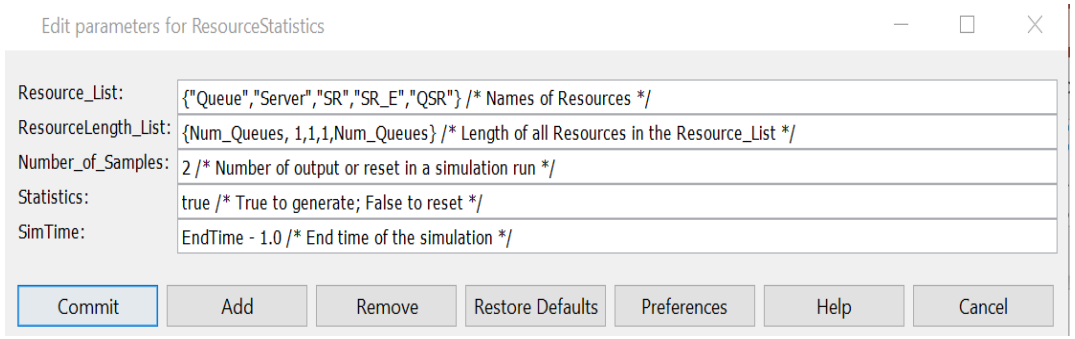
```
BLOCK                         = ".Power_Perf_example.A
Cache_Delay_Time_Max          = 4.8192771084337E-8,
Cache_Delay_Time_Mean         = 4.6380835843373E-8,
Cache_Delay_Time_Min          = 6.0240963855422E-9,
Cache_Delay_Time_StDev        = 8.551245431752E-9,
Cache_Hit_Ratio_Max           = 95.5102040816327,
Cache_Hit_Ratio_Mean          = 95.5102040816327,
Cache_Hit_Ratio_Min           = 95.5102040816327,
Cache_Hit_Ratio_StDev         = 0.0,
Cache_Memory_Used_By_ARM_MB_Max          = 0.01568,
Cache_Memory_Used_By_ARM_MB_Mean         = 0.01568,
Cache_Memory_Used_By_ARM_MB_Min          = 0.01568,
Cache_Memory_Used_By_ARM_MB_StDev        = 0.0,
Cache_Memory_Used_By_RAM_MB_Max          = 7.04E-4,
Cache_Memory_Used_By_RAM_MB_Mean         = 7.04E-4,
Cache_Memory_Used_By_RAM_MB_Min          = 7.04E-4,
Cache_Memory_Used_By_RAM_MB_StDev        = 0.0,
Cache_Memory_Used_By_Total_MB_Max        = 0.016384,
Cache_Memory_Used_By_Total_MB_Mean       = 0.016384,
Cache_Memory_Used_By_Total_MB_Min        = 0.016384,
Cache_Memory_Used_By_Total_MB_StDev      = 0.0,
Cache_Throughput_MBs_Max      = 4.096,
Cache_Throughput_MBs_Mean     = 4.096,
Cache_Throughput_MBs_Min      = 4.096,
Cache_Throughput_MBs_StDev    = 0.0,
DELTA                         = 0.0,
```

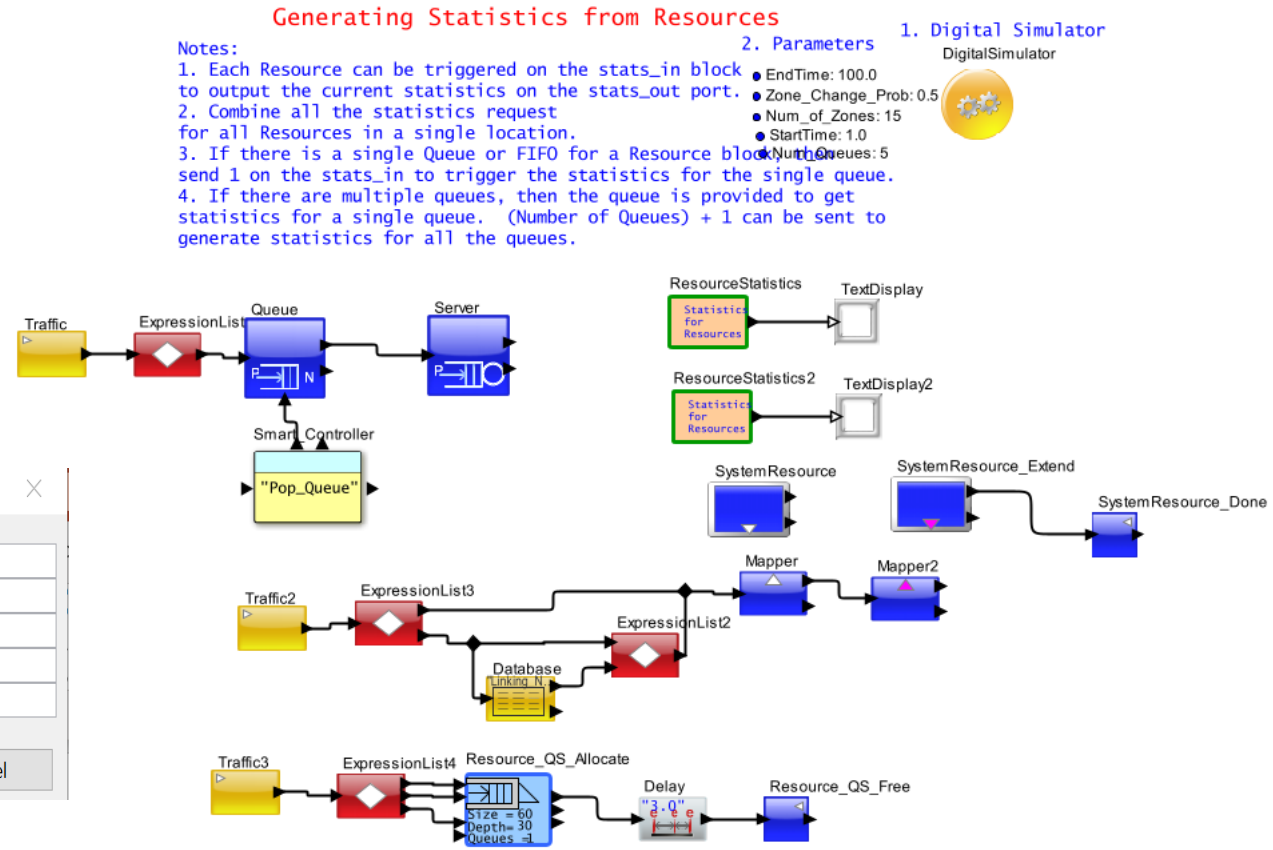
```
RAM_Bus_Delay_Mean            = 4.7999999999962E-8,
RAM_Bus_Delay_Min             = 4.7999999999888E-8,
RAM_Bus_Delay_StDev           = 0.0,
RAM_Bus_IOs_per_sec_Max       = 3000.0,
RAM_Bus_IOs_per_sec_Mean      = 3000.0,
RAM_Bus_IOs_per_sec_Min       = 3000.0,
RAM_Bus_IOs_per_sec_StDev     = 0.0,
RAM_Bus_Input_Buffer_Occupancy_in_Words_Max      = 4.0,
RAM_Bus_Input_Buffer_Occupancy_in_Words_Mean     = 1.6216216216216,
RAM_Bus_Input_Buffer_Occupancy_in_Words_Min      = 0.0,
RAM_Bus_Input_Buffer_Occupancy_in_Words_StDev    = 1.4950612633448,
RAM_Bus_Preempt_Buffer_Occupancy_in_Words_Max    = 0.0,
RAM_Bus_Preempt_Buffer_Occupancy_in_Words_Mean   = 0.0,
RAM_Bus_Preempt_Buffer_Occupancy_in_Words_Min    = 0.0,
RAM_Bus_Preempt_Buffer_Occupancy_in_Words_StDev  = 0.0,
RAM_Bus_Throughput_MBs_Max    = 0.048,
RAM_Bus_Throughput_MBs_Mean   = 0.048,
RAM_Bus_Throughput_MBs_Min    = 0.048,
RAM_Bus_Throughput_MBs_StDev  = 0.0,
RAM_Delay_Time_Max            = 3.8461538461538E-8,
RAM_Delay_Time_Mean           = 2.8846153846154E-8,
RAM_Delay_Time_Min            = 1.9230769230769E-8,
RAM_Delay_Time_StDev          = 9.6153846153846E-9,
RAM_Memory_Used_By_Cache_MB_Max          = 1.92E-4,
RAM_Memory_Used_By_Cache_MB_Mean         = 1.92E-4,
RAM_Memory_Used_By_Cache_MB_Min          = 1.92E-4,
RAM_Memory_Used_By_Cache_MB_StDev        = 0.0,
RAM_Memory_Used_By_Total_MB_Max          = 1.92E-4,
RAM_Memory_Used_By_Total_MB_Mean         = 1.92E-4,
RAM_Memory_Used_By_Total_MB_Min          = 1.92E-4,
RAM_Memory_Used_By_Total_MB_StDev        = 0.0,
RAM_Throughput_MBs_Max        = 0.048,
RAM_Throughput_MBs_Mean       = 0.048,
RAM_Throughput_MBs_Min        = 0.048,
RAM_Throughput_MBs_StDev      = 0.0,
ROM_Bus_Delay_Max             = 4.8000000000105E-8,
ROM_Bus_Delay_Mean            = 4.7999999999988E-8,
ROM_Bus_Delay_Min             = 4.7999999999888E-8,
```

Using Resource Statistics – Generates Stats for Stochastic Blocks like queues, servers , system resources









Model Location:
$VS/doc/Training_Material/Tutorial/General/Statistics_Plotting/Resource-Statistics.xml

Resource Statistics Block output – Covers all the Blocks in Resource_List

VisualSim Architect - .Resource_Statistics.TextDisplay2

```
DISPLAY AT TIME                 ------ 100.00000000000 sec ------
{BLOCK                        = "Resource_Statistics.Queue",
DELTA                         = 0.0,
DS_NAME                       = "Queue_Common_Stats",
ID                            = 6,
INDEX                         = 0,
Number_Entered                = 28,
Number_Exited                 = 12,
Number_Rejected               = 0,
Occupancy_Max                 = 16.0,
Occupancy_Mean                = 6.9487179487179,
Occupancy_Min                 = 0.0,
Occupancy_StDev               = 4.9091683871895,
Queue_Number                  = 1,
TIME                          = 100.0,
Total_Delay_Max               = 36.7702549507,
Total_Delay_Mean              = 11.326260376275,
Total_Delay_Min               = 0.0,
Total_Delay_StDev             = 10.7856784211654,
Utilization_Mean              = 0.0}

DISPLAY AT TIME                 ------ 100.00000000000 sec ------
{BLOCK                        = "Resource_Statistics.Server",
DELTA                         = 0.0,
DS_NAME                       = "Queue_Common_Stats",
ID                            = 2,
INDEX                         = 0,
```

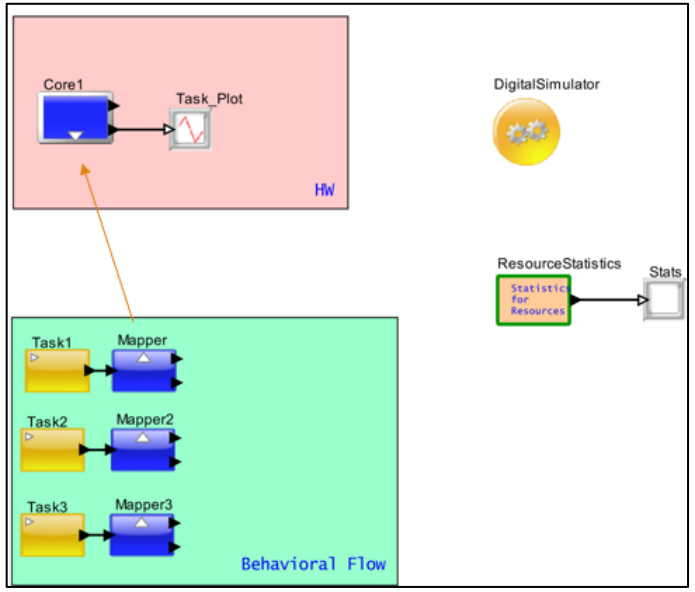
```
DISPLAY AT TIME                 ------ 100.00000000000 sec ------
{BLOCK                        = "Resource_Statistics.SR",
DELTA                         = 0.0,
DS_NAME                       = "Queue_Common_Stats",
ID                            = 2,
INDEX                         = 0,
Number_Entered                = 34,
Number_Exited                 = 8,
Number_Rejected               = 0,
Occupancy_Max                 = 26.0,
Occupancy_Mean                = 13.28,
Occupancy_Min                 = 1.0,
Occupancy_StDev               = 6.9542504987957,
Queue_Number                  = 1,
TIME                          = 100.0,
Total_Delay_Max               = 69.0917283037,
Total_Delay_Mean              = 38.556557421775,
Total_Delay_Min               = 10.24,
Total_Delay_StDev             = 18.6203711290027,
Utilization_Mean              = 90.0917283036515}

DISPLAY AT TIME                 ------ 100.00000000000 sec ------
{BLOCK                        = "Resource_Statistics.SR_E",
DELTA                         = 0.0,
DS_NAME                       = "Queue_Common_Stats",
ID                            = 2,
INDEX                         = 0,
```

MIRABILIS design

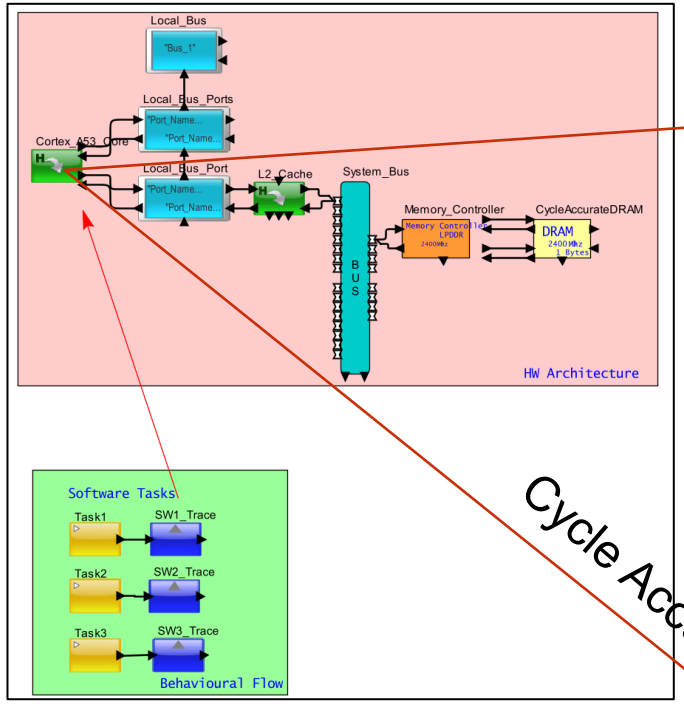
Abstraction

Multiple Levels of Abstraction
Stochastic vs Hybrid vs Cycle Accurate

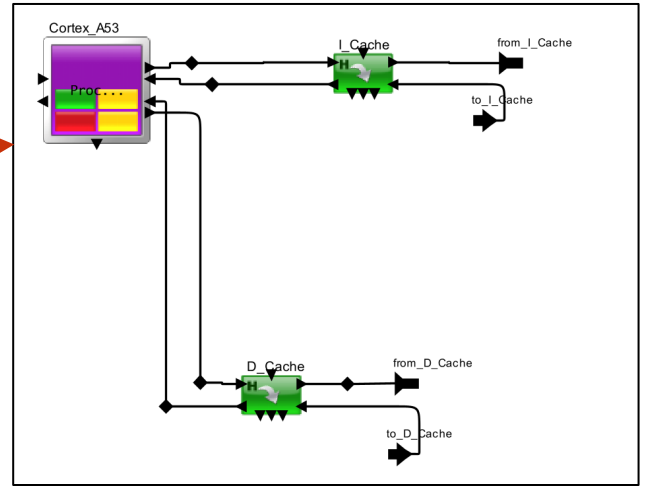


Stochastic

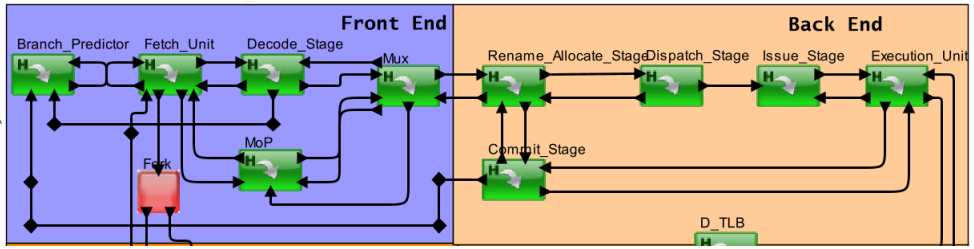
- Easy to build the target SoC/System (Starting version)
- Stochastic subsystems can be replaced with more accurate blocks as required
- Get an early estimate on Power and Performance metrics



Hybrid



Cycle Accurate



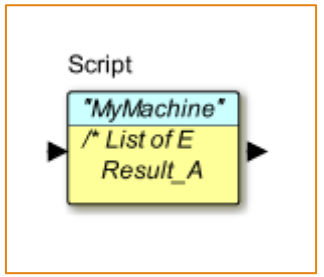
Hybrid – More detailed than stochastic, focus on the application than on the processor micro architecture
Cycle Accurate – Very detailed implementation, focus on processor micro architecture

Algorithms - Adding Custom Block

Script

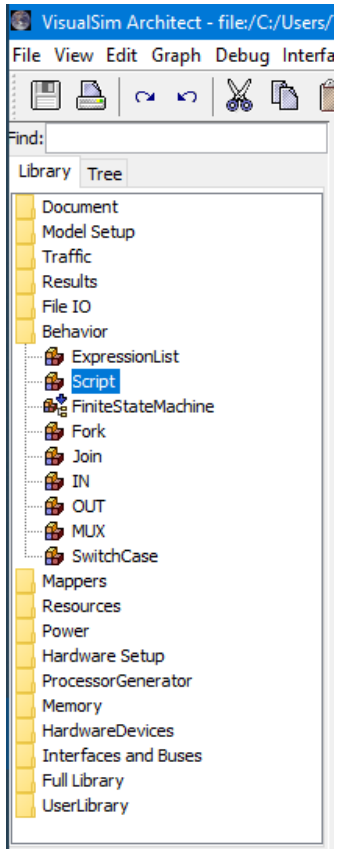
- Used for :
  - Custom logic
  - Scheduling algorithm
  - Arbitration algorithm
  - Statistics and plot generation

A VERY POWERFUL MODULE



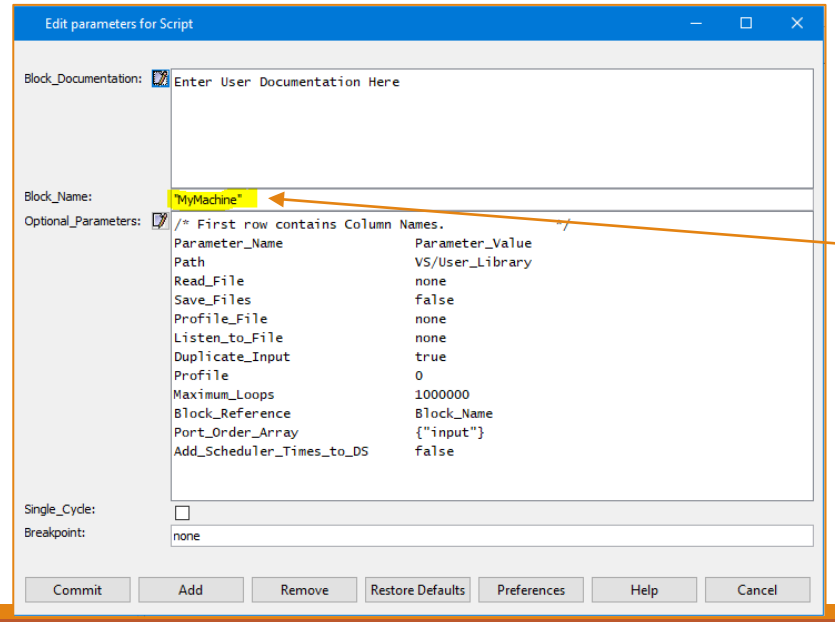
- Can be used to define Resources, Cycle-accurate hardware components and algorithmic behaviors
- Can use if, else-if, else, while, for, SWITCH/CASE/BREAK
- Can implement dependencies, Task Graphs etc.

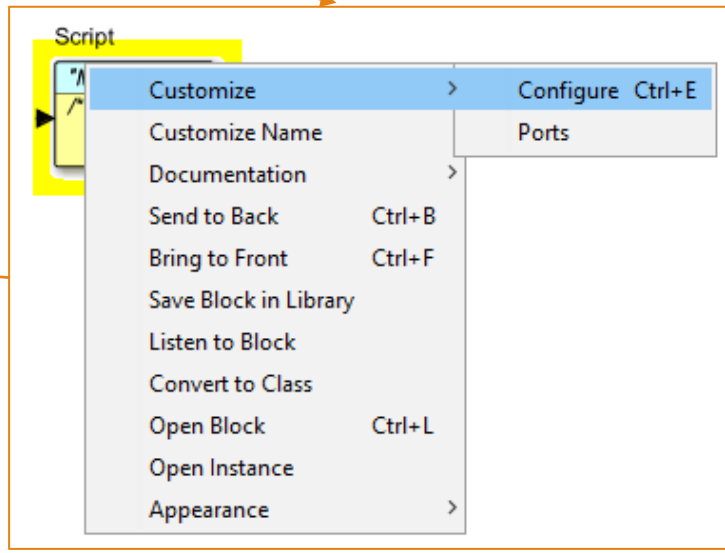
Getting Started with Script



1. Drag and drop the Script block from the library

2. Right Click on script -> Customize -> configure ; give a unique Block Name





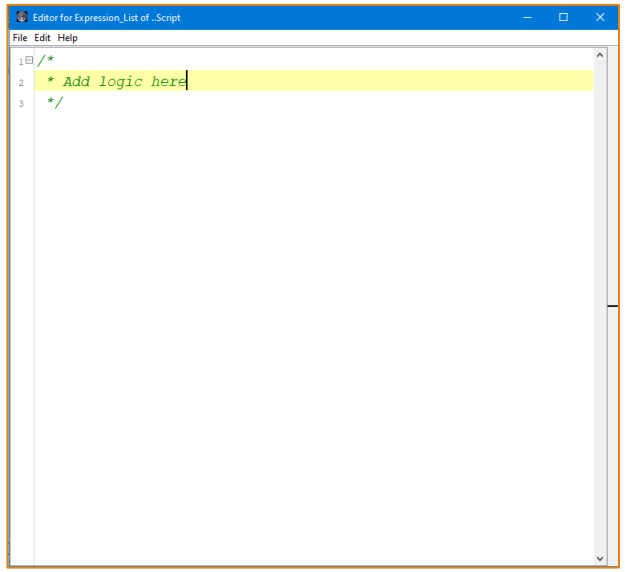
Getting Started with Script

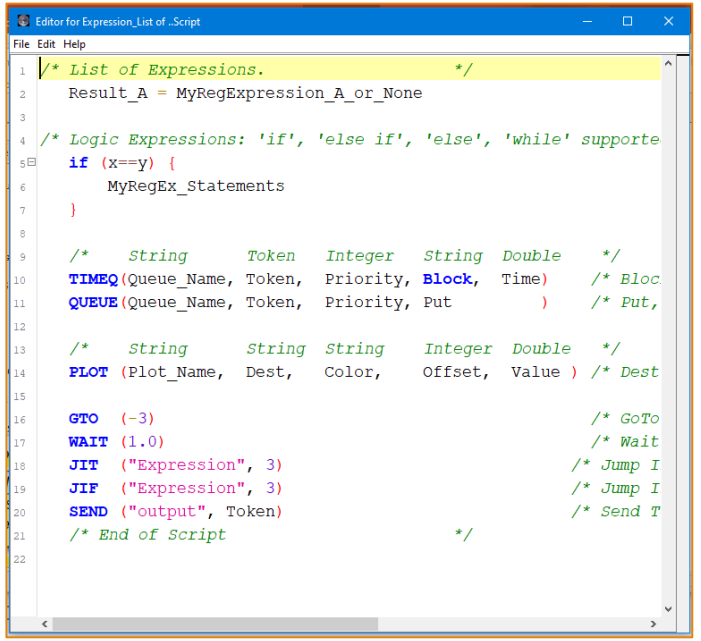
3

Double click on Script; It already has default contents. Delete them

4

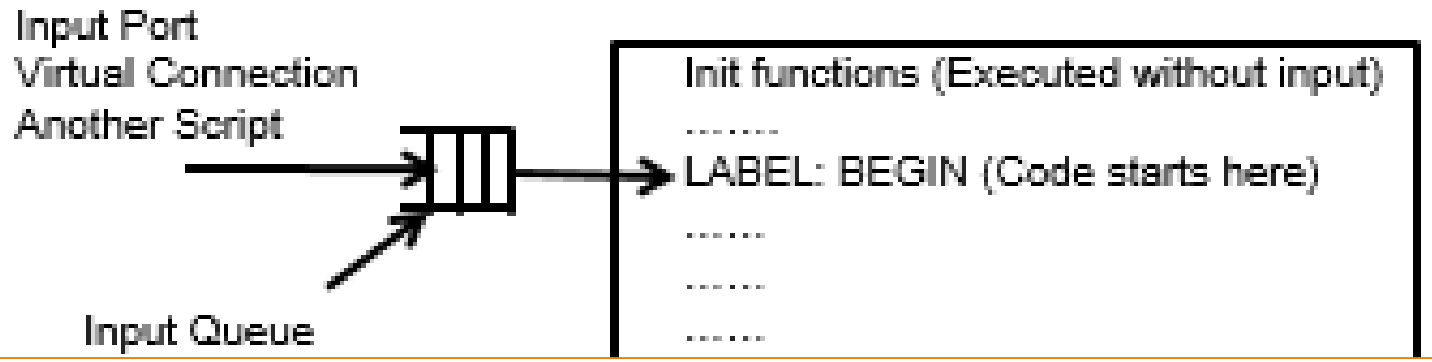
Now we can add our logic here.





NOTE
Model has to be saved before running a model which has script

How Does Script block work?



Even if the script has multiple input ports, the script doesn't have to wait for all input ports to have data to start execution

- When the packets comes into the script, they will be put into a queue called Input Queue
- If a script was idle and a packet comes, then it will be processed immediately.
- If a script was busy executing a packet and another packet comes into the script, then the latest packet will be in the Input Queue until the current execution finishes/stops.
- until the current execution finishes, it can also start the next one when the block DS stalls at a TIMEQ.

The Input Queue is a Virtual Queue

Script Overview

1. port_token is the pointer to the currently executing data structure.

2. Do not use the port name to identify the data structure.

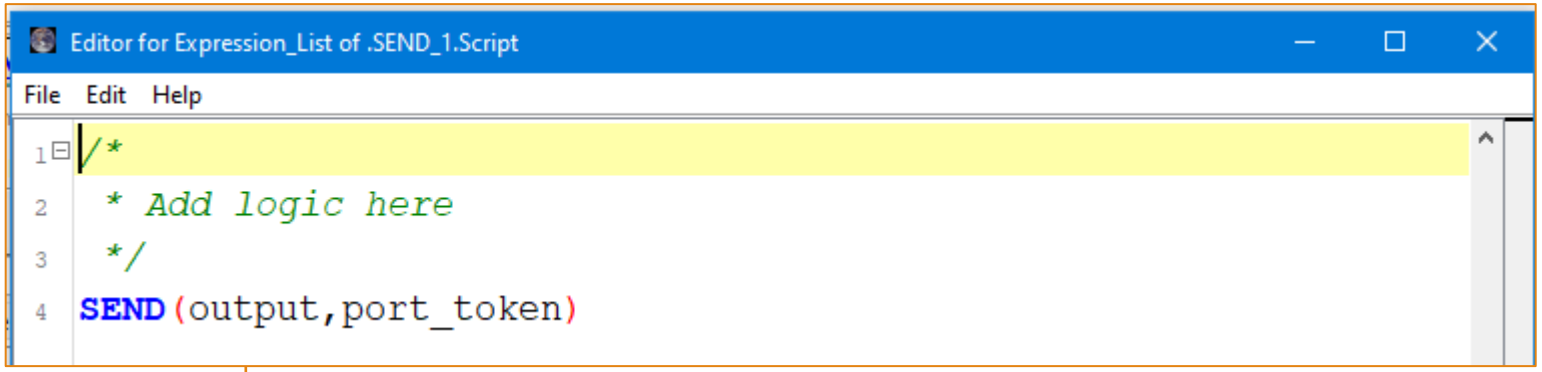
3. Script block maintains the currently executing Data Structure at each line.

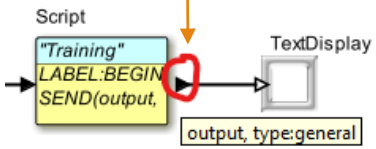
SEND

FORMAT

SEND(destination , data)

destination can be a port or a virtual connection like another script



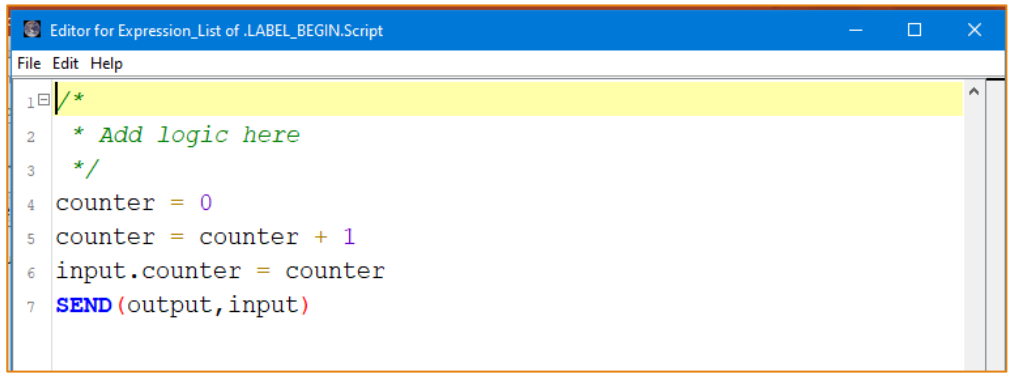


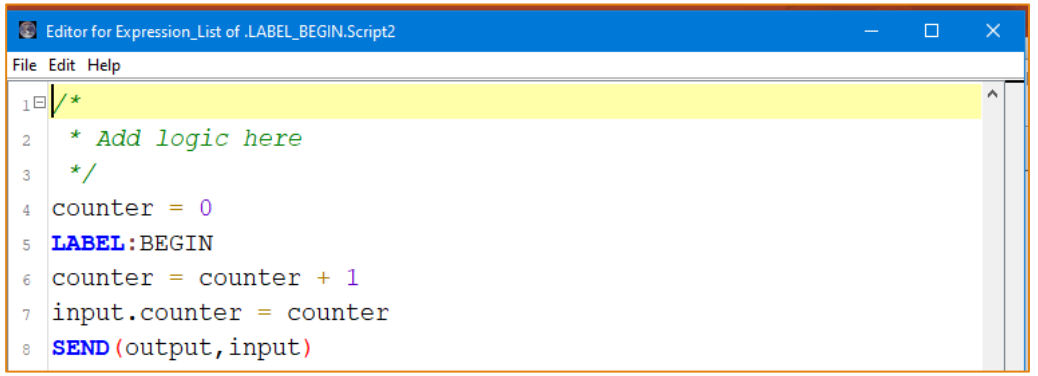
What is happening here?

Here, the data coming to the script is send out through the output port

LABEL:BEGIN

Implementing counter logic: Left or Right





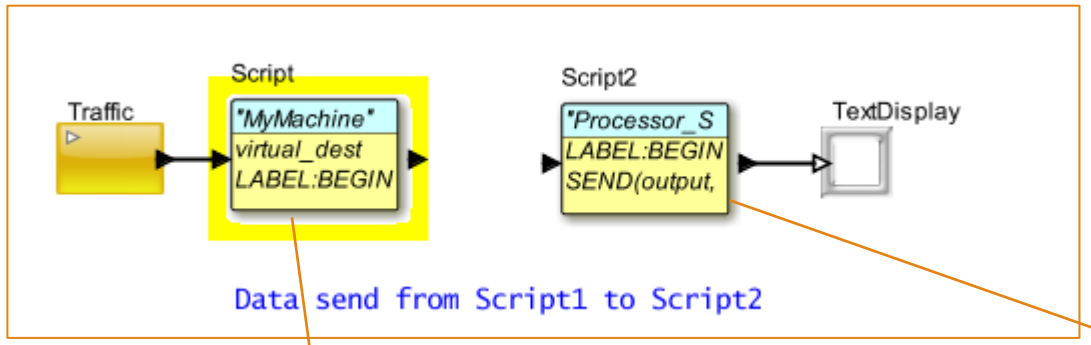
Counter = 0 is executed every time script is triggered

Counter = 0 is only executed once during initialize

All lines of code defined before LABEL:BEGIN is executed at initialize and all lines of code after LABEL:BEGIN are executed when an input comes to script

Can we use “SEND” to send packet to another Script block?

YES




```
DISPLAY AT TIME          ------ 0.0 ps ------
{BLOCK                         = "Traffic",
DELTA                          = 0.0,
DS_NAME                        = "Header_Only",
ID                             = 1,
INDEX                          = 0,
TIME                           = 0.0,
X                              = 250.0}
```

Editor for Expression_List of .Virtual_Connection.Script

File Edit Help

```
1  virtual_dest     =    "Processor_Script"
2  LABEL:BEGIN
3  port_token.x=100.0*5/6*irand(1,6)
4  SEND(virtual_dest,port_token)
5
```

Editor for Expression_List of .Virtual_Connection.Script2

File Edit Help

```
1  LABEL:BEGIN
2  SEND(output,port_token)
```

Packet comes into the second script through a port_name called “virtual”

GTO

Editor for Expression_List of .port_token.Script2

File Edit Help

```
1  /*
2   * Add logic here
3   */
4  counter = 0
5  LABEL:BEGIN
6  counter = counter + 1
7  GTO(END)
8  port_token.counter = counter
9  SEND(output,port_token)
```

GTO -> Go To
GTO(END) -> finish script execution at this line
So script execution stops at line 7.

Line 8 and 9 not executed

FORMAT

GTO(LABEL NAME)

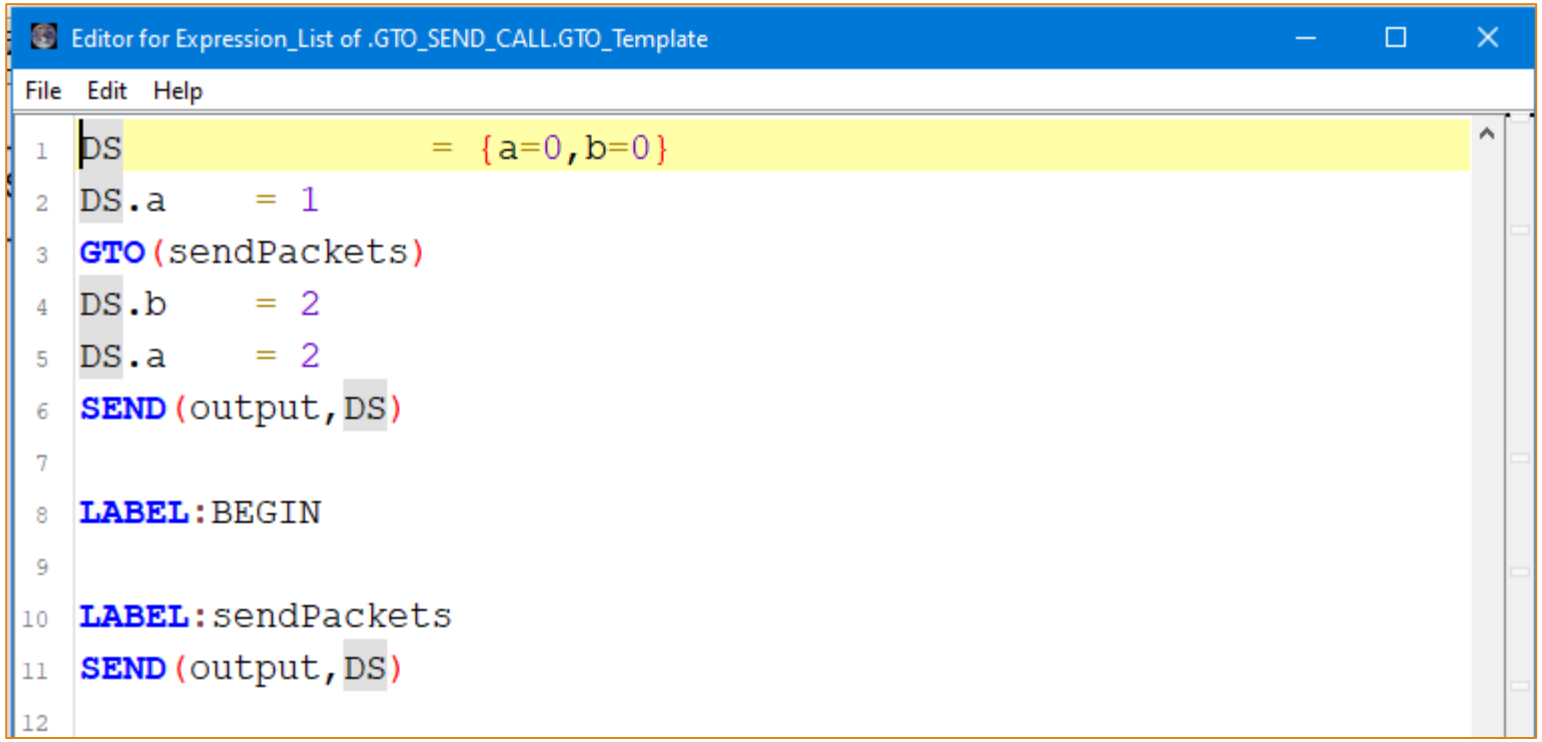
Editor for Expression_List of .GTO.Script2

File Edit Help

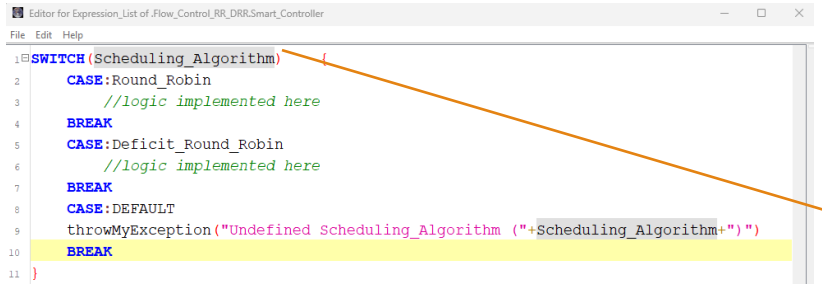
```
1  /*
2   * Add logic here
3   */
4  counter = 0
5  LABEL:BEGIN
6  counter = counter + 1
7  GTO(send_packet)
8  port_token.counter = counter
9  LABEL:send_packet
10 SEND(output,port_token)
```

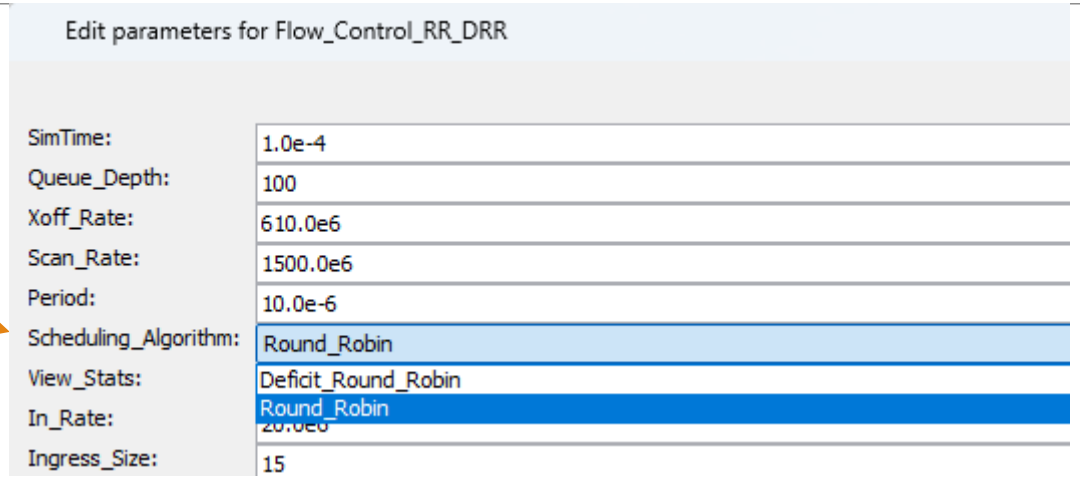
GTO(LABEL name) -> sends the execution to that LABEL
Line 7 to Line 9.
Line 8 wont be executed.

What happens here?



SWITCH





By using a SWITCH CASE logic, we select appropriate operation as per the parameter value.

FORMAT

```
SWITCH(Variable Name) {
  CASE:
  BREAK
  CASE:DEFAULT
}
```

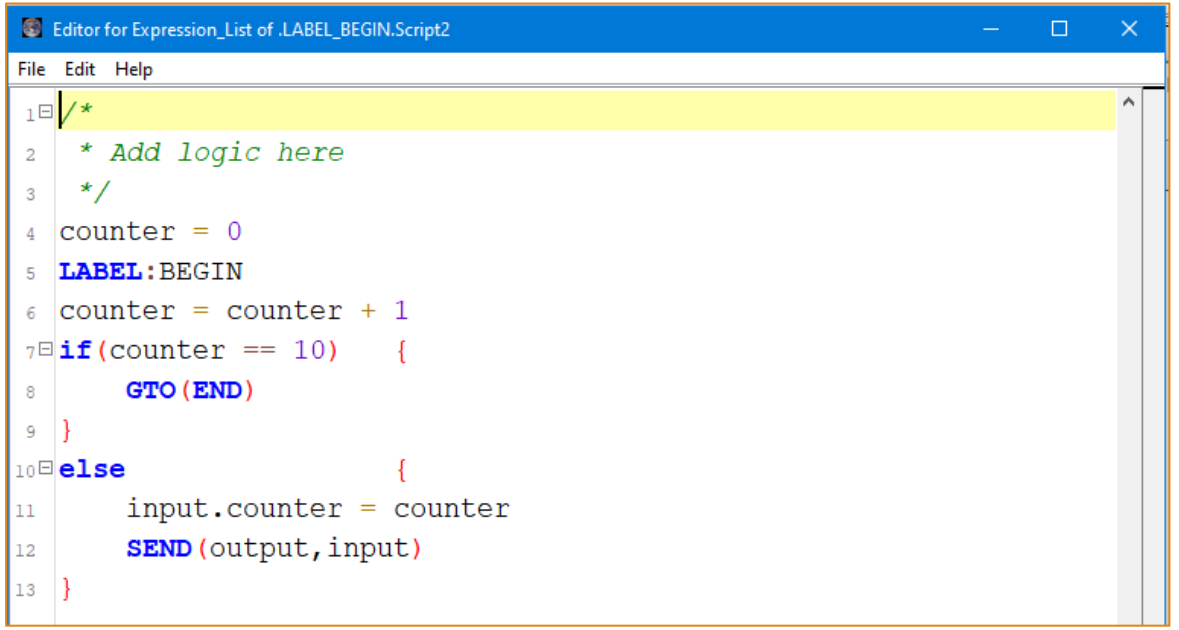
Note: Switch always requires a case (default)

if – else

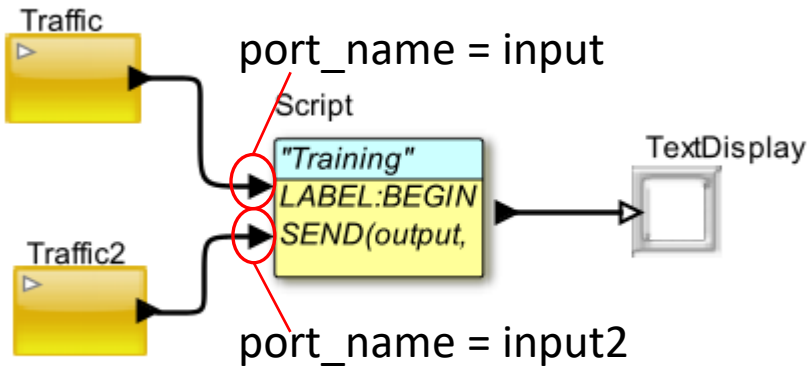
FORMAT

```
if( condition ) {
  <at least one line of code>
}
```

Here, when the counter value reaches 10, we stop the script execution. Otherwise, we send the output.



port_name



When a packet comes into the script, the port through which it came in will be the port_name.

Editor for Expression_List of .TStop.Script2

File Edit Help

```
/*
 * Add logic here
 */
LABEL:BEGIN
if(port_name == "input")     {
    port_token.Flag = true
}
else                         {
    port_token.Flag = false
}
SEND(output,port_token)
```

```
DISPLAY AT TIME                 ------ 9.0000000000000 sec ------
{BLOCK                        = "Traffic2",
DELTA                         = 0.0,
DS_NAME                       = "Header_Only",
Flag                          = true,
ID                            = 10,
INDEX                         = 0,
TIME                          = 9.0}

DISPLAY AT TIME                 ------ 9.0000000000000 sec ------
{BLOCK                        = "Traffic",
DELTA                         = 0.0,
DS_NAME                       = "Header_Only",
Flag                          = false,
ID                            = 10,
INDEX                         = 0,
TIME                          = 9.0}
```

TNow and TStop

Editor for Expression_List of .TStop.Script2

File Edit Help

```
1  /*
2   * Add logic here
3   */
4  LABEL:BEGIN
5  TextMessage = "Pkt ID = "+port_token.ID+" . Current TIME = "+TNow+" and Simulation stop time = "+TStop
6  SEND(output,TextMessage)
```

TNow -> gives the current time in simulation
Tstop -> gives the simulation stop time

TStop is obtained from the top level Digital Simulator

VisualSim Architect - .TStop.TextDisplay2

```
DISPLAY AT TIME                  ------ 0.0 ps ------
Pkt ID = 1 . Current TIME = 0.0 and Simulation stop time = 10.0

DISPLAY AT TIME                  ------ 1.0000000000000 sec ------
Pkt ID = 2 . Current TIME = 1.0 and Simulation stop time = 10.0

DISPLAY AT TIME                  ------ 2.0000000000000 sec ------
Pkt ID = 3 . Current TIME = 2.0 and Simulation stop time = 10.0

DISPLAY AT TIME                  ------ 3.0000000000000 sec ------
Pkt ID = 4 . Current TIME = 3.0 and Simulation stop time = 10.0

DISPLAY AT TIME                  ------ 4.0000000000000 sec ------
Pkt ID = 5 . Current TIME = 4.0 and Simulation stop time = 10.0
```

WAIT

Editor for Expression_List of .TStop.Script2

File Edit Help

```
1  /*
2   * Add logic here
3   */
4  WAIT(TStop)
5  Msg = "Message after WAIT . Current TIME = "+TNow+" and Simulation stop time = "+TStop
6  SEND(output,Msg)
7  LABEL:BEGIN
8  TextMessage = "Pkt ID = "+port_token.ID+" . Current TIME = "+TNow+" and Simulation stop time = "+TStop
9  SEND(output,TextMessage)
```

During the delay period, entire script is locked up. No other line or transaction can be executed

WAIT(time) -> Provides delay for the time specified
Until the delay is over, script cannot execute other transactions

FORMAT

WAIT(time)

VisualSim Architect - .TStop.TextDisplay2

```
DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Message after WAIT . Current TIME = 10.0 and Simulation stop time = 10.0

DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Pkt ID = 1 . Current TIME = 10.0 and Simulation stop time = 10.0

DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Pkt ID = 2 . Current TIME = 10.0 and Simulation stop time = 10.0

DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Pkt ID = 3 . Current TIME = 10.0 and Simulation stop time = 10.0

DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Pkt ID = 4 . Current TIME = 10.0 and Simulation stop time = 10.0

DISPLAY AT TIME                ------ 10.0000000000000 sec ------
Pkt ID = 5 . Current TIME = 10.0 and Simulation stop time = 10.0
```

TIMEQ

Editor for Expression_List of .TStop.Script2

File Edit Help

```
1  /*
2   * Add logic here
3   */
4  TIMEQ("stat_Queue",port_token,1,TStop)
5  Msg = "Message after TIMEQ . Current TIME = "+TNow+" and Simulation stop time = "+TStop
6  SEND(output,Msg)
7  LABEL:BEGIN
8  TextMessage = "Pkt ID = "+port_token.ID+" . Current TIME = "+TNow+" and Simulation stop time = "+TStop
9  SEND(output,TextMessage)
```

With TIMEQ, the current port_token is stored in the Queue and a new one can be read from the input queue to start executing from LABEL:BEGIN

FORMAT

TIMEQ(Queue Name, data_structure, 1, delay expression)

With TIMEQ, we get line number 5 to execute at simulation stop time while other Data Structures (DS) will be executed

```
DISPLAY AT TIME                 ------ 5.0000000000000 sec ------
Pkt ID = 6 . Current TIME = 5.0 and Simulation stop time = 10.0

DISPLAY AT TIME                 ------ 6.0000000000000 sec ------
Pkt ID = 7 . Current TIME = 6.0 and Simulation stop time = 10.0

DISPLAY AT TIME                 ------ 7.0000000000000 sec ------
Pkt ID = 8 . Current TIME = 7.0 and Simulation stop time = 10.0

DISPLAY AT TIME                 ------ 8.0000000000000 sec ------
Pkt ID = 9 . Current TIME = 8.0 and Simulation stop time = 10.0

DISPLAY AT TIME                 ------ 9.0000000000000 sec ------
Pkt ID = 10 . Current TIME = 9.0 and Simulation stop time = 10.0

DISPLAY AT TIME                 ------ 10.0000000000000 sec ------
Message after TIMEQ . Current TIME = 10.0 and Simulation stop time = 10.0
```

getBlockStatus

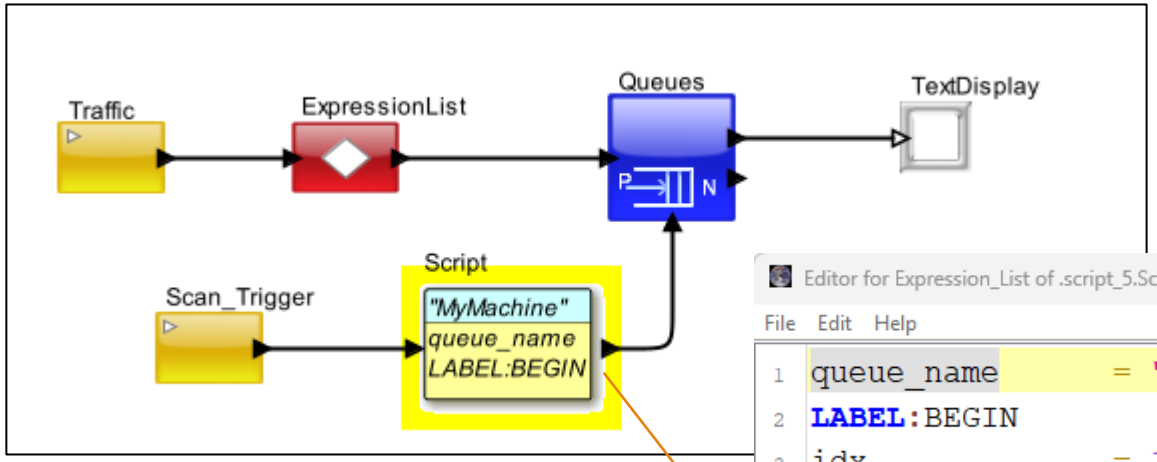
```
while (Queue_Num        <= Ingress_Size)   {
   Buffer_occupancy   = getBlockStatus(Queue_Name,"length",Queue_Num)
   if (Buffer_occupancy > 0 ) {
```

FORMAT

getBlockStatus(Queue Name, <keyword>,Queue Number)

Keyword can be any of the following:
“length” -> gives us the current buffer occupancy (no need to specify Queue Position)
“copy” -> gives us the copy of the packet present in the specified Queue
“pop” -> pop the Specified Queue virtually

Arbitration algorithm : Queue + Script



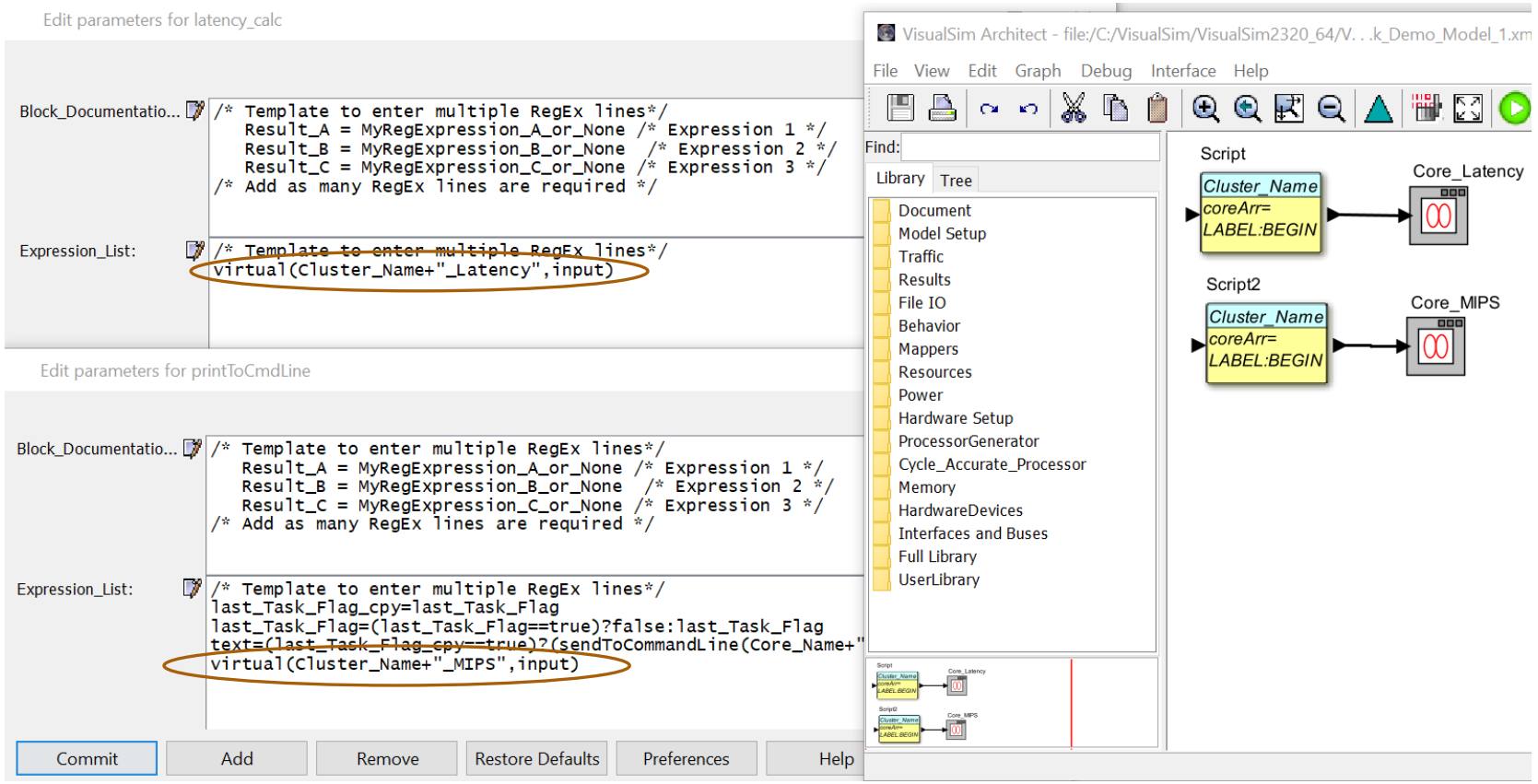
Editor for Expression_List of .script_5.Script

File Edit Help

```
1  queue_name      = "Ingress_Queue"
2  LABEL:BEGIN
3  idx             = 1
4  while(idx       <= Number_Of_Queues)    {
5      qLen        = getBlockStatus(queue_name,"length",idx)
6      if(qLen     > 0)        {
7          SEND(output,idx)
8          GTO(END)
9      }
10     idx         = idx + 1
11 }
12
```

Using regex to send data to script Virtually

Virtual (<script_block_name>, <data_to_be_sent>)



Task Graph Modeling

Blocks Required To Model a Basic Task Graph in VisualSim

Traffic Block – Explained in the Section Traffic

Traffic Generator – Explained in the next section

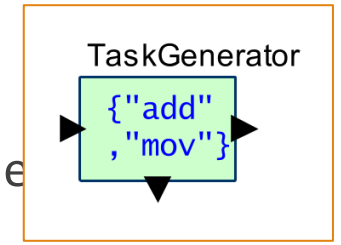
Trace Mapper – Explained in the next section

Mapper Blocks – Explained in the Library Blocks Power Point

System Resource or Processor to represent the hardware on which the task graph will be executed - Explained in the Library Blocks Power Point

Task Generator Module

- Custom Task generator – number of instructions, type of instructions, order of tasks (loop, random) can be set
- More dynamic and distributed traffic profile can be generated
- “n” number of Software tasks can be defined
- In case software development hasn’t started yet, we can use this module to gene
  instruction traces



Task Generator – Config File (Instruction Mix Table)

```
Task_Name           Relative_Time(double)_or
                    Number_Instructions(int) Type Pct  Type Pct  Type Pct   Type Pct   Type Pct    Type Pct   Type Pct   Type Pct   Type Pct   */

Call_Fn_Low                 276              IFU  25.0   BU  5.72      SU   10.0     LU   15.0    PU   0.43     LDU  25.0    STU  15.0      ETC  3.85   ;
Call_Fn_High                573              IFU  40.0   BU  11.36     SU   3.8      LU   15.1    PU   0.85     LDU  12.2    STU  6.1       ETC  10.59  ;
Sensor                      150              IFU  39.7   BU  10.20     SU   7.2      LU   0.0     PU   0.76     LDU  23.6    STU  10.9      ETC  7.64   ;
Read_Frame                  100              IFU  57.0   BU  10.22     SU   0.0      LU   0.0     PU   0.76     LDU  14.4    STU  0.2       ETC  17.42  ;
Decode_Frame                160              IFU  20.6   BU  11.5      SU   16.9     LU   0.0     PU   0.86     LDU  16.2    STU  7.9       ETC  26.04  ;
Video_Post_Proc             200              IFU  20.6   BU  11.5      SU   16.9     LU   0.0     PU   0.86     LDU  16.2    STU  7.9       ETC  26.04  ;
Render_Frame                500              IFU  33.9   BU  9.65      SU   2.6      LU   10.5    PU   0.72     LDU  21.7    STU  18.1      ETC  2.83   ;
Format_Conversion           100              IFU  35.8   BU  18.68     SU   11.4     LU   8.6     PU   1.40     LDU  16.1    STU  4.9       ETC  3.12   ;
Rotate_Frame                1000             IFU  45.1   BU  6.23      SU   13.0     LU   20.5    PU   0.46     LDU  7.1     STU  6.7       ETC  0.91   ;
Display                     100              IFU  2.00   BU  6.00      SU   12.0     LU   10.0    PU   0.00     LDU  35.0    STU  35.0      ETC  0.0    ;
```

Software tasks

Number of instructions per task

The Total Number of instructions are made up of instructions of different types. The percentages of each type of instruction is specified here.

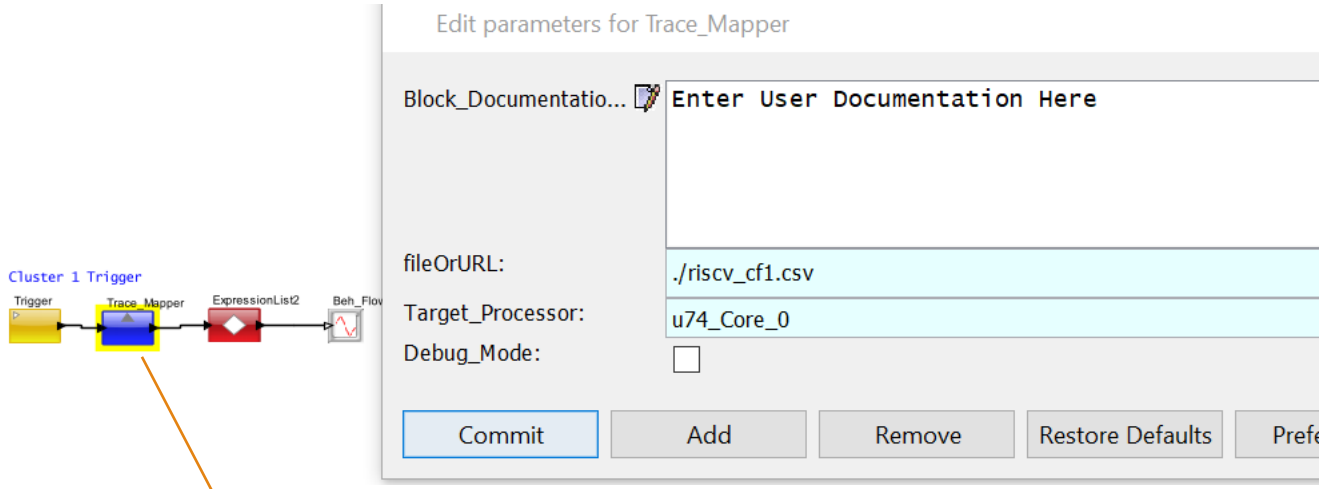
Task Generator - Config File (Instruction Mix Table)

```
Desription          Type (used below)        Mnemonic List   */

Int_Float                IFU                     add sub sbcs ccmn eon eor cmps andhi addgt dmb;
Branch_Unit              BU                      b br beq bcc bge tbnz;
Shift_Unit               SU                      movs movw mvn asrv;
Logic_Unit               LU                      and add orn bics csel ands subne bichi ;
Mispredict_Unit          PU                      *b                          ;
Load_Unit                LDU                     ldr ldrsw prfm ldur ldurb ldurh ldursb ;
Store_Unit               STU                     stur sturb      sturh   str strb ;
Others                   ETC                     casa stxr uqadd16 shsub8 smulls umaal   sdiv udiv       ;
```

This type descriptor is used in the previous slide. User can specify the percentage of each type of instruction for each software operation

Trace Mapper and structure of CSV File containing traces

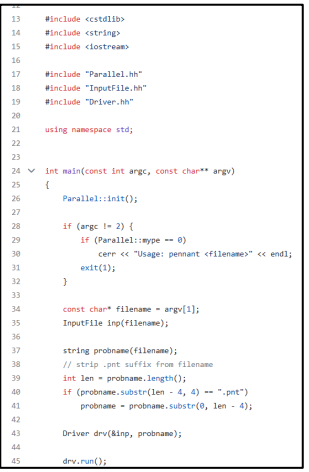



```
1  I_Cache_Address,A_Instruction,D_Cache_Address
2  array,array,array
3  {"0x00000000","0x0000005c",...},{"ldr","mrc",...},{"0x00000020","0x00",...}
```

Note: File name to be specified in CSV format only

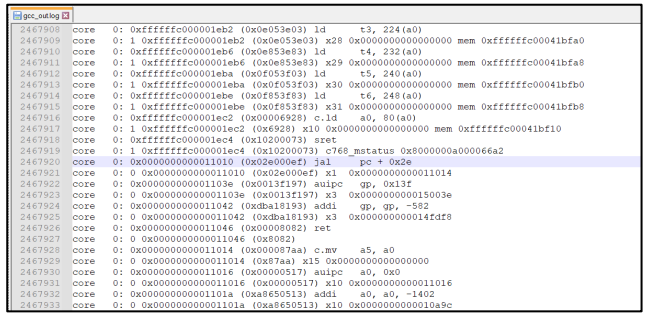
Trace Generation using GEM5 or other simulators compatible with VisualSim

Source Code → Compile → Run on Spike → Generate log → Parse log – remove pk overhead → Gen. data in csv format → Load into the model



riscv64-unknown-elf-gcc ./Source_Code/main.c

./riscv-isa-sim/build/spike -l --log-commits --isa=RV64IMAC ./riscv-pk/build/pk a.out 2>gcc_out.log



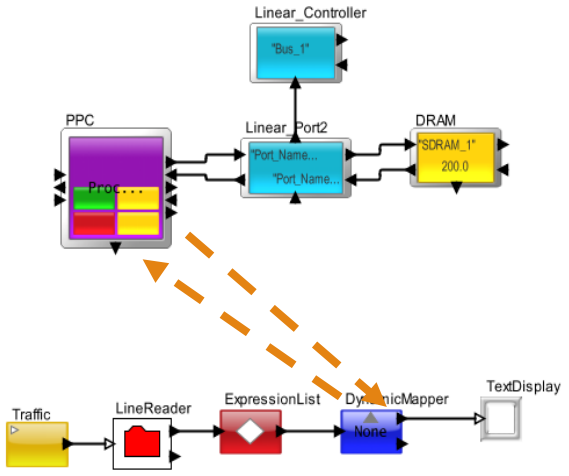
CSV

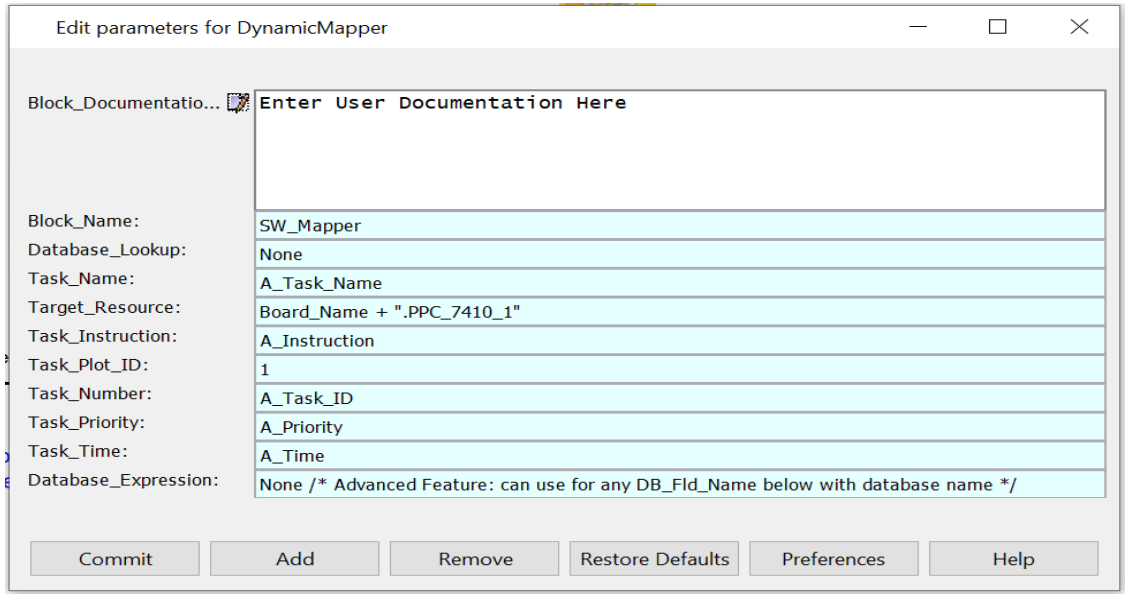
VisualSim Architect

Dynamic Mapper

Mapping of tasks on

- Target processor,
- SystemResource
- SystemResource_Extend





Model Showcasing the usage of TraceMapper and Task generator