

# OPNET/Riverbed Modeler: Configuring and Running Simulations

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Lecture № 6

- 1 Configuring simulations
- 2 Manage scenarios
- 3 Running simulations
- 4 DES Log
- 5 Animation

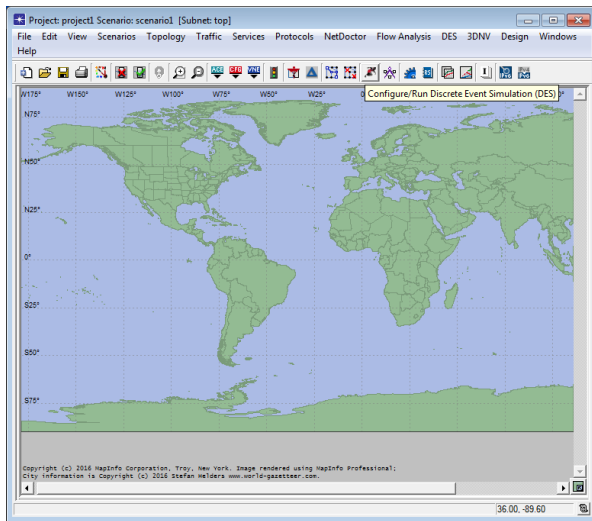
- 1 Configuring simulations
- 2 Manage scenarios
- 3 Running simulations
- 4 DES Log
- 5 Animation

# Configuring Simulations

- Before a simulation can be executed, the statistics of interest must be selected and configured
- After the statistics have been selected, there are additional simulation attributes that must be configured
  - E.g., duration, seed, sim efficiency
- In some situations, the simulation execution may be unsuccessful because of the errors in constructing the model or in configuring the simulation
  - Simple debugging may be done using the **discrete event simulation (DES) Log**

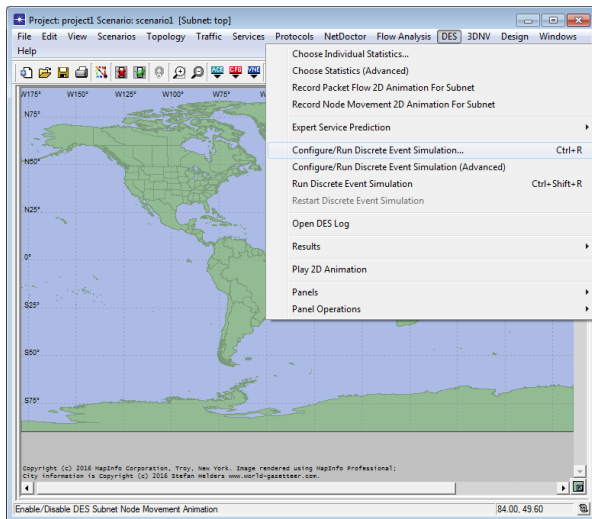
# Configuring Simulations (cont'd)

- Configure/Run Discrete Event Simulation (DES)



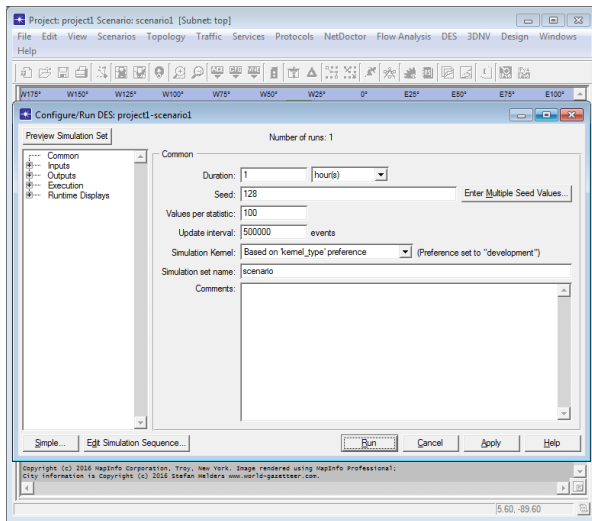
# Configuring Simulations (cont'd)

- DES ⇒ Configure/Run Discrete Event Simulation...



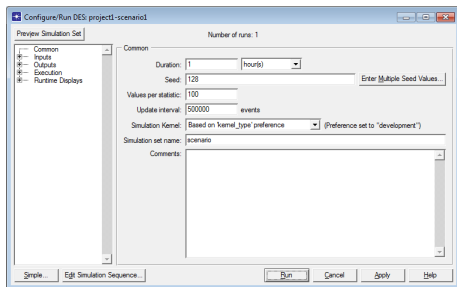
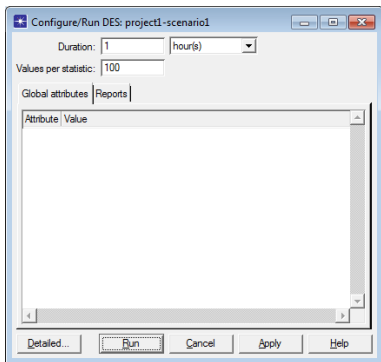
# Configuring Simulations (cont'd)

- Configure/Run DES



# Configuring Simulations (cont'd)

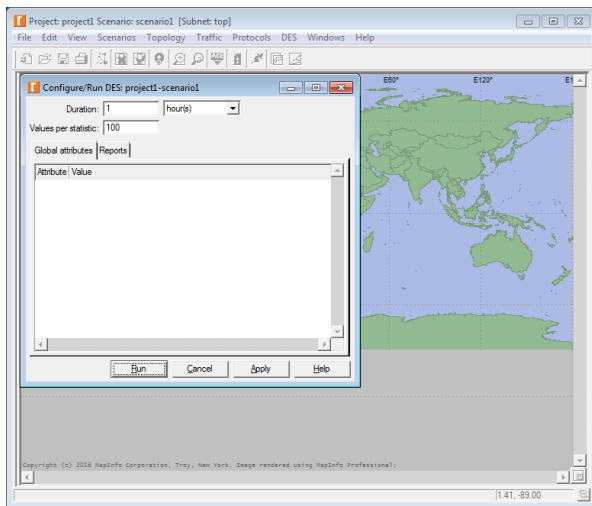
- Configure/Run DES: **Simple...** vs. **Detailed...**
  - Simple mode – allows configuration of only a few key parameters
  - Detailed mode – provides a complete set of configuration controls





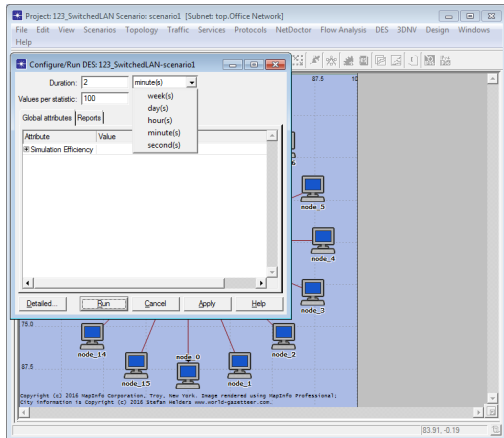
# Configuring Simulations (cont'd)

- **Riverbed Modeler Academic Edition** : no Detailed, only Simple ☹️



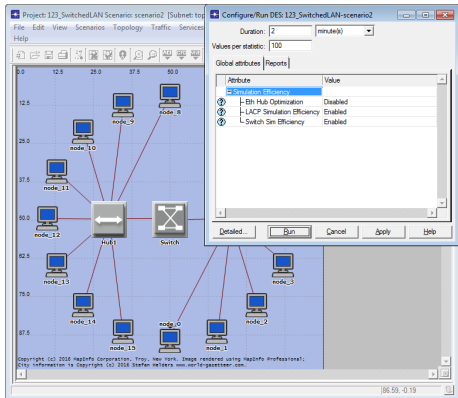
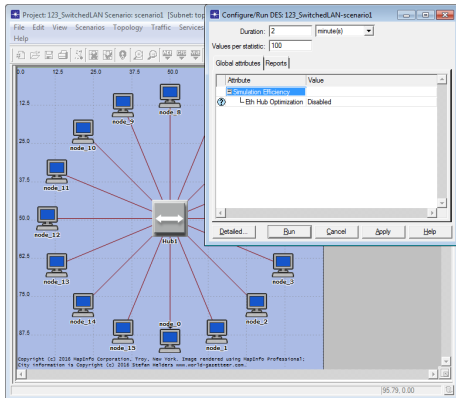
# Configuring Simulations (cont'd)

- **Duration** – sets the duration of the simulation
- **Values per statistic** – sets the maximum number of values recorded for each statistic



# Configuring Simulations (cont'd)

- **Global attributes** – apply to all objects in the simulation study
- **Simulation Efficiency** – specifies whether or not the simulation efficiency (aka 'sim efficiency') mode is used



# Configuring Simulations (cont'd)

- Eth Hub Optimization

Attribute: Eth Hub Optimization

Data type:  Attribute properties:  Private  Public

Symbol map

Symbol	Value
Disabled	disabled
Enabled	enabled

Default value:

Units:

Comments

When set to "Disabled", the hub models in the network behave in the exact same way that the real hubs behave: they forward a received packet to every other port that is in use except the port from which the packet is received.

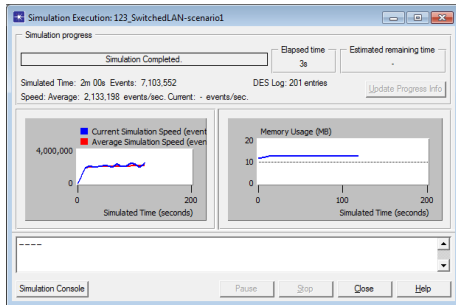
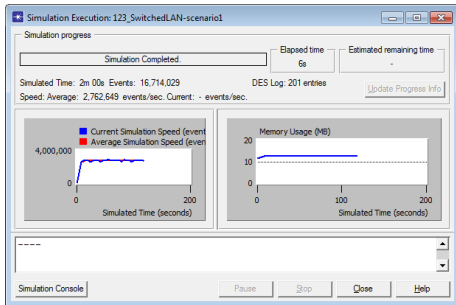
When set to "Enabled", the hubs follow a smarter approach. First they check whether they are directly connected to the final destination of the packet. If this is the case, then the packet is forwarded only to the port connecting to the destination MAC. Otherwise, the packet is forwarded only to the ports that are connecting to other bridge or switch nodes. This approach results in faster simulations due to less number of packets created and events executed without having any effect on simulation results unless MACs of some end-nodes are operating in promiscuous mode.

Allow other values

Close

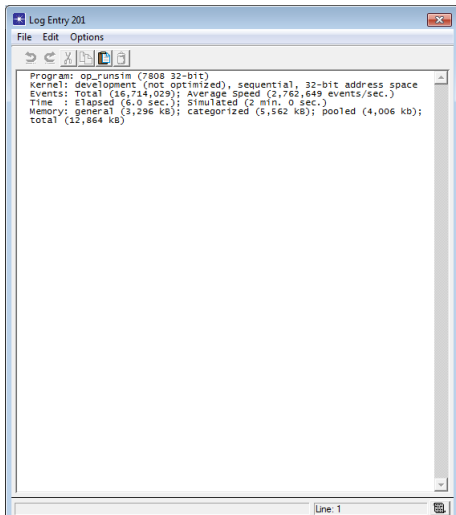
# Configuring Simulations (cont'd)

- Eth Hub Optimization: **Disabled** (default) vs. **Enabled**

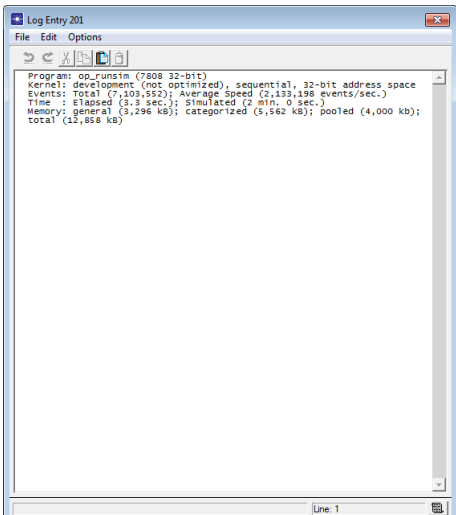


# Configuring Simulations (cont'd)

- Eth Hub Optimization: **Disabled** (default) vs. **Enabled**



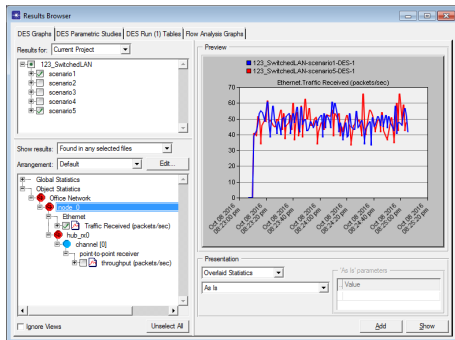
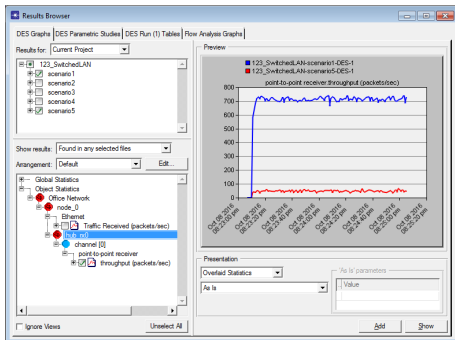
```
Log Entry 201
File Edit Options
Program: op_runsim (7808 32-bit)
Kernel: development (not optimized), sequential, 32-bit address space
Events: Total (16,714,029); Average Speed (2,762,649 events/sec.)
Time : Elapsed (6.0 sec.); Simulated (2 min. 0 sec.)
Memory: general (3,296 kb); categorized (5,562 kb); pooled (4,006 kb);
total (12,864 kb)
```



```
Log Entry 201
File Edit Options
Program: op_runsim (7808 32-bit)
Kernel: development (not optimized), sequential, 32-bit address space
Events: Total (7,103,552); Average Speed (2,133,198 events/sec.)
Time : Elapsed (3.3 sec.); Simulated (2 min. 0 sec.)
Memory: general (3,296 kb); categorized (5,562 kb); pooled (4,000 kb);
total (12,858 kb)
```

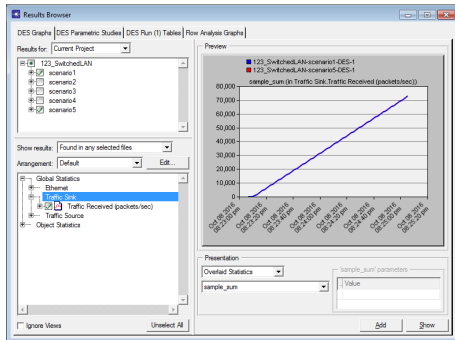
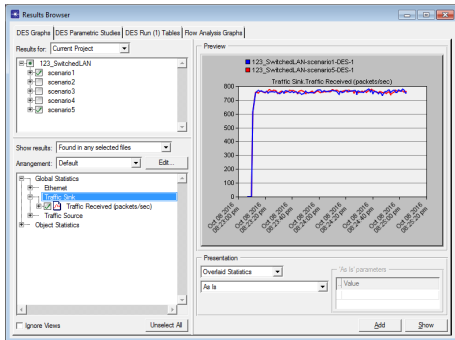
# Configuring Simulations (cont'd)

- Eth Hub Optimization: **Disabled** (default) vs. **Enabled**



# Configuring Simulations (cont'd)

- Eth Hub Optimization: **Disabled** (default) vs. **Enabled**





# Configuring Simulations (cont'd)

- Switch Sim Efficiency

Attribute: Switch Sim Efficiency

Data type:

Attribute properties:  Private  Public

Range

From:  open

To:  open

Symbol map

Symbol	Value
Enabled	1
Disabled	0

Allow other values

Default value

Units

Comments

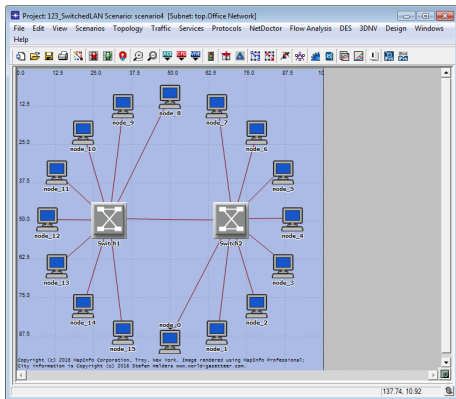
Specifies whether simulation efficiency is desired. When Enabled, the Spanning Tree is never recalculated once it has been set up. When Disabled, the switch periodically updates the spanning tree and sends update messages to neighboring bridges.

This attribute should be set to "Disabled" if node/link failures or recoveries are expected in the bridged network so that the spanning tree can be re-constructed after the topology change.

Close

# Configuring Simulations (cont'd)

## • Switch Sim Efficiency



Configure/Run DES: 123\_SwitchedLAN-scenario4

Duration: 2 minute(s)

Values per statistic: 100

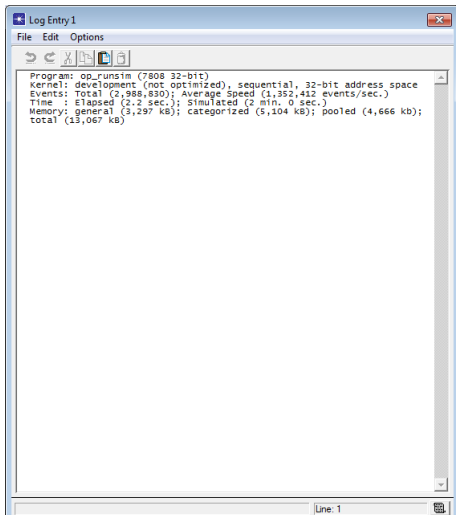
Global attributes | Reports

Attribute	Value
Simulation Efficiency	
LACP Simulation Efficiency	Enabled
Switch Sim Efficiency	Enabled

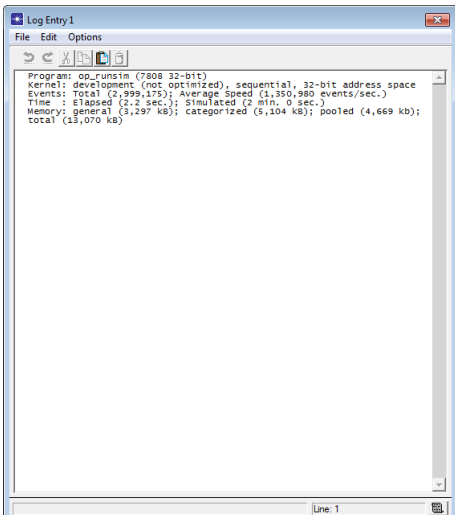
Detailed... Run Cancel Apply Help

# Configuring Simulations (cont'd)

- Switch Sim Efficiency: **Enabled** (default) vs. **Disabled**



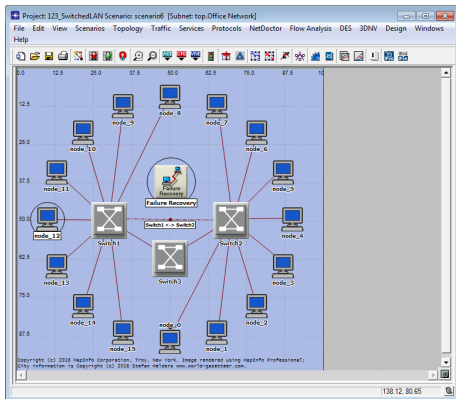
```
Log Entry 1
File Edit Options
Program: op_runsim (7808 32-bit)
Kernel: development (not optimized), sequential, 32-bit address space
Events: Total (2,988,830); Average Speed (1,352,412 events/sec.)
Time : Elapsed (2.2 sec.); Simulated (2 min. 0 sec.)
Memory: general (3,297 kb); categorized (5,104 kb); pooled (4,666 kb);
total (13,067 kb)
```



```
Log Entry 1
File Edit Options
Program: op_runsim (7808 32-bit)
Kernel: development (not optimized), sequential, 32-bit address space
Events: Total (2,999,175); Average Speed (1,350,980 events/sec.)
Time : Elapsed (2.2 sec.); Simulated (2 min. 0 sec.)
Memory: general (3,297 kb); categorized (5,104 kb); pooled (4,669 kb);
total (13,070 kb)
```

# Configuring Simulations (cont'd)

- Let's make it a bit more exciting 😊



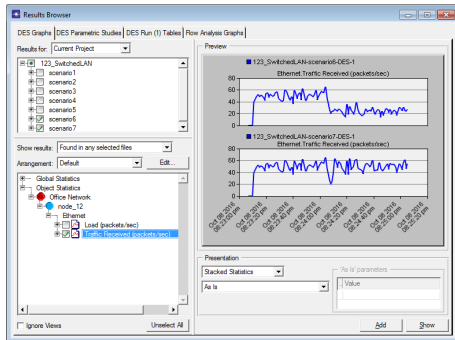
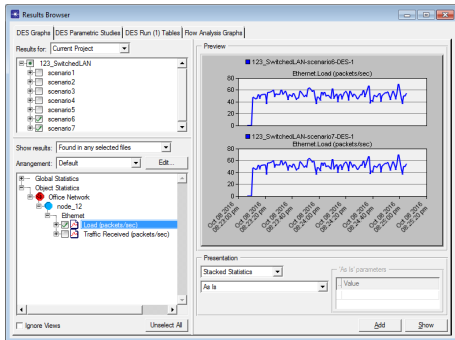
The screenshot shows the "(Failure Recovery) Attributes" dialog box. The "Type" is set to "Utilities". The dialog contains a table of attributes and values:

Attribute	Value
- name	Failure Recovery
- Failure/Recovery Modeling	Enabled
- Link Failure/Recovery Specification	(...)
- Number of Rows	1
Office Network: Switch1 <-> Switch2	
- Name	Office Network: Switch1 <-> Switch2
- Time (seconds)	60
- Status	Fail
- Link Failure/Recovery Specification File	NOT_USED
- Node Failure Mode	Node Only
- Node Failure/Recovery Specification	No Failure/Recovery

At the bottom of the dialog, there is an "Advanced" checkbox (unchecked), an "Apply to selected objects" checkbox (unchecked), an "Exact match" checkbox (unchecked), an "Filter" button, and "OK" and "Cancel" buttons.

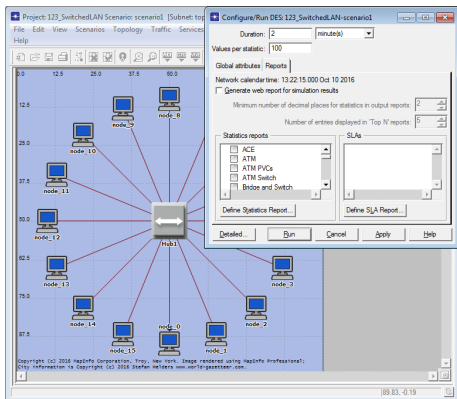
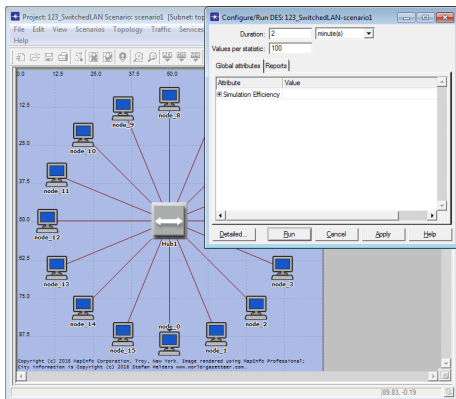
# Configuring Simulations (cont'd)

- Switch Sim Efficiency: **Enabled** (default) vs. **Disabled**



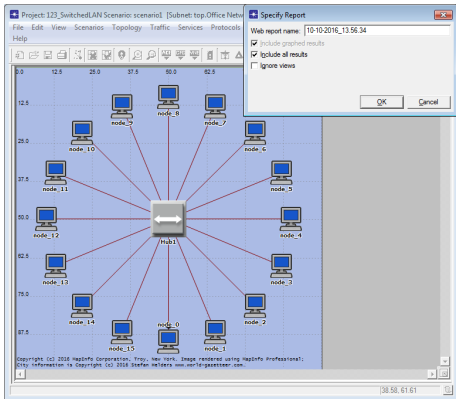
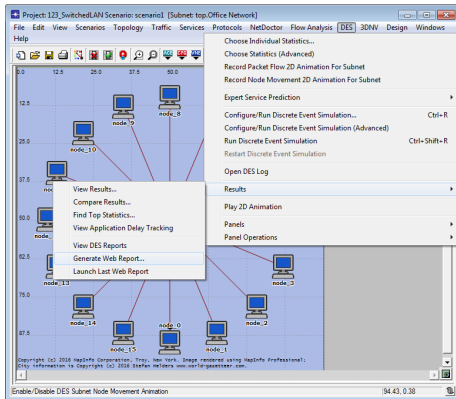
# Configuring Traffic Simulations (cont'd)

- **Reports** – specifies statistics and **service level agreement (SLA)** reports to be collected during the simulation study



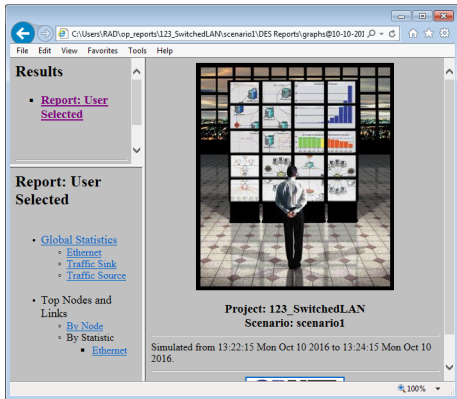
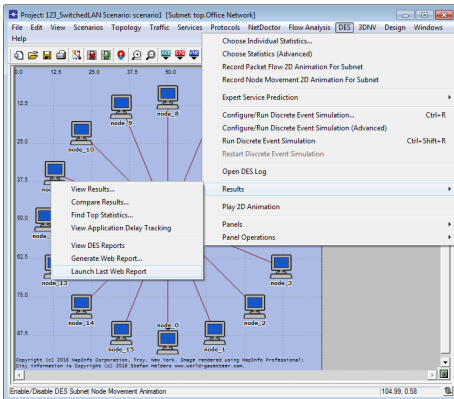
# Configuring Simulations (cont'd)

- DES ⇒ Results ⇒ Generate Web Report... ⇒ OK



# Configuring Simulations (cont'd)

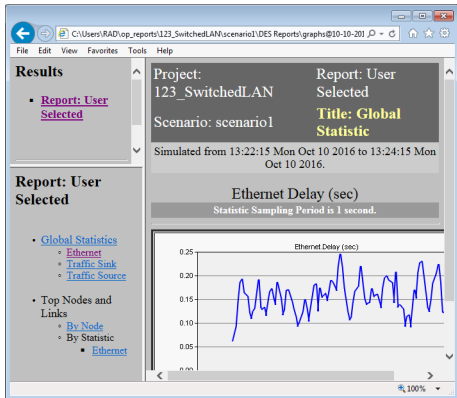
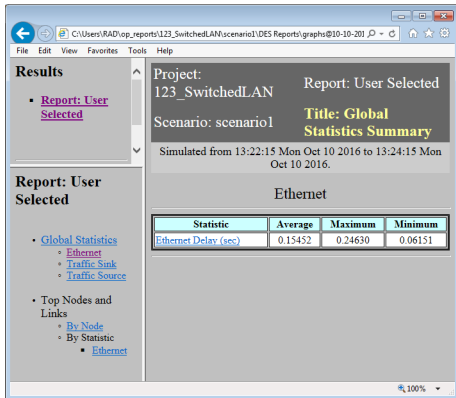
- DES ⇒ Results ⇒ Launch Last Web Report





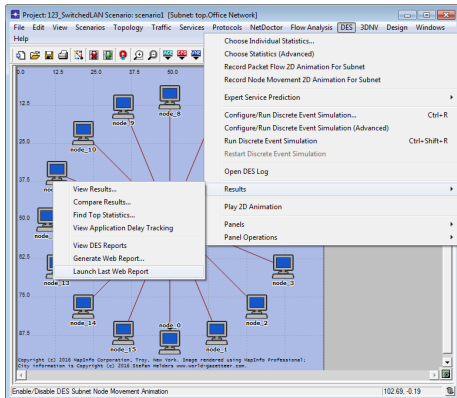
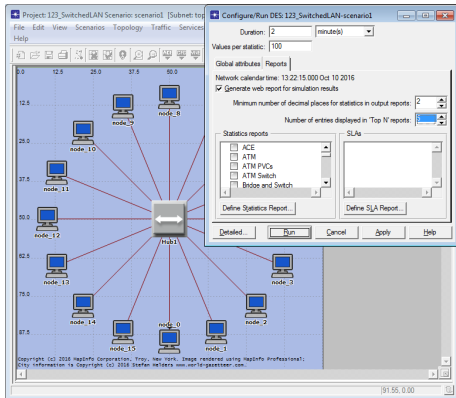
# Configuring Simulations (cont'd)

- Web reports are created in **C:/Users/<user name>/op\_reports/**



# Configuring Simulations (cont'd)

- Web reports can be generated automatically after data collection



# Configuring Simulations (cont'd)

- Define Statistics Report... ⇒ New report ⇒ OK

Project: 123\_SwitchedLAN Scenario: scenariol [Subnet: top  
File Edit View Scenarios Topology Traffic Services Help

Duration: 2 (minute(s))  
Values per statistic: 100

Global attributes Reports

Network calendar time: 13.22.15.000 Oct 10 2016  
 Generate web report for simulation results

Minimum number of decimal places for statistics in output reports: 2  
Number of entries displayed in 'Top N' reports: 5

Statistics reports  
 ACE  
 ATM  
 ATM PVCs  
 ATM Switch  
 Bidcos and Switch

SLAs  
Define SLA Report...

Define Statistics Report...  
Detailed... Run Cancel Apply Help

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[90.79, 0.00]

Project: 123\_SwitchedLAN Scenario: scenariol [Subnet: top  
File Edit View Scenarios Topology Traffic Services Help

Duration: 2 (minute(s))  
Values per statistic: 100

Global attributes Reports

Network calendar time: 13.22.15.000 Oct 10 2016  
 Generate web report for simulation results

Minimum number of decimal places for statistics in output reports: 2  
Number of entries displayed in 'Top N' reports: 5

Statistics reports  
 ACE  
 ATM  
 ATM PVCs  
 ATM Switch  
 Bidcos and Switch

SLAs  
Define SLA Report...

Define Statistics Report...  
Detailed... Run Cancel Apply Help

Define Report: unnamed

Statistic information  
Description:

Draw style:  
Collection mode: Monthly

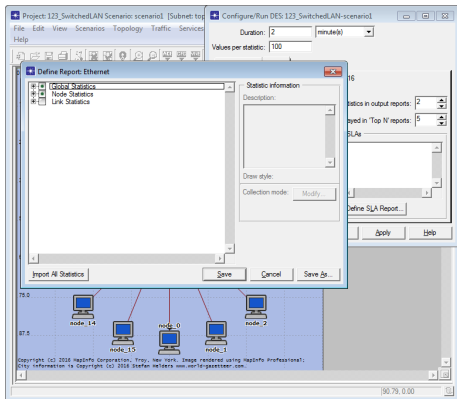
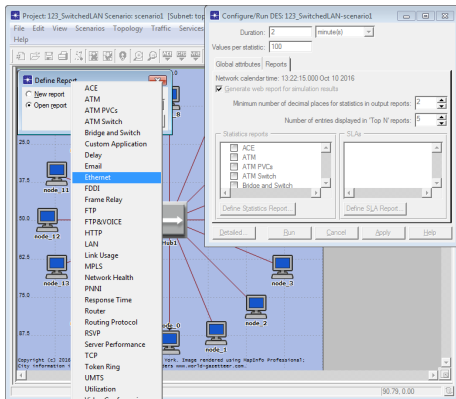
Import All Statistics Save Cancel Save As...

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[90.79, 0.00]

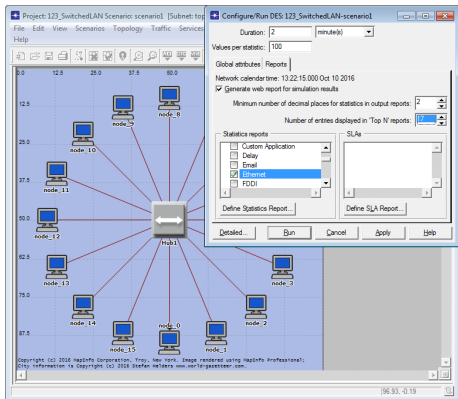
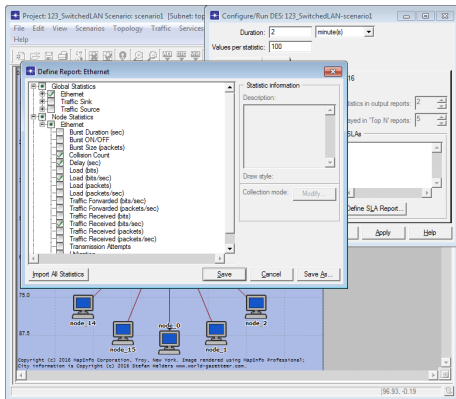
# Configuring Simulations (cont'd)

- Define Statistics Report... ⇒ Open report ⇒ bla-bla-bla ⇒ Save



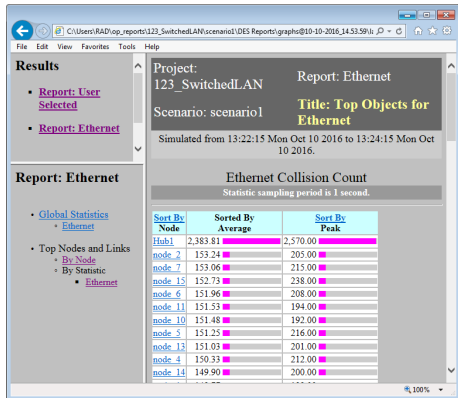
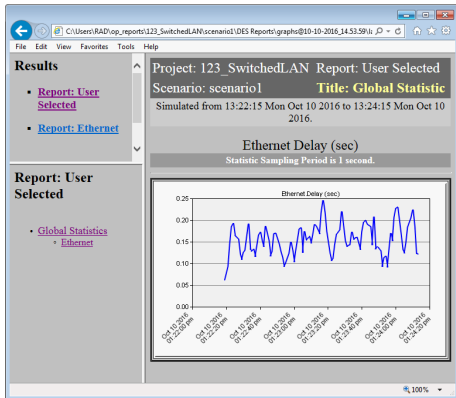
# Configuring Simulations (cont'd)

- To collect the statistics specified in a statistics report, you must associate the report with a scenario
  - When a report is defined, it is not associated with any particular project or scenario



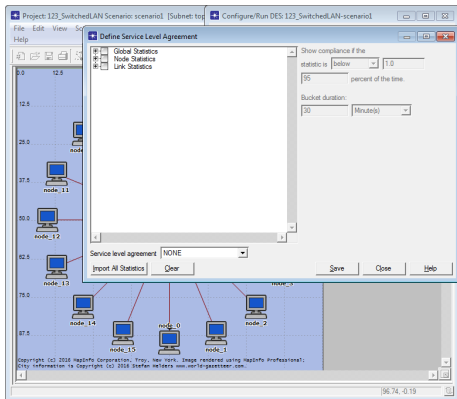
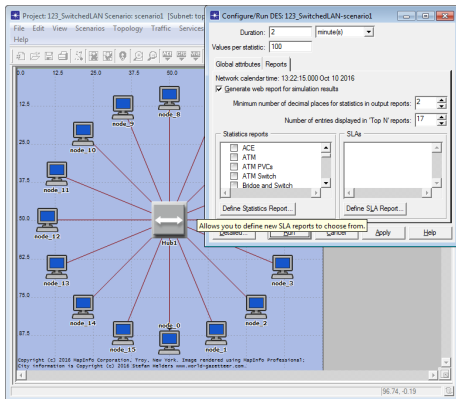
# Configuring Simulations (cont'd)

- Reports: **User Selected** vs. **Ethernet** (default)



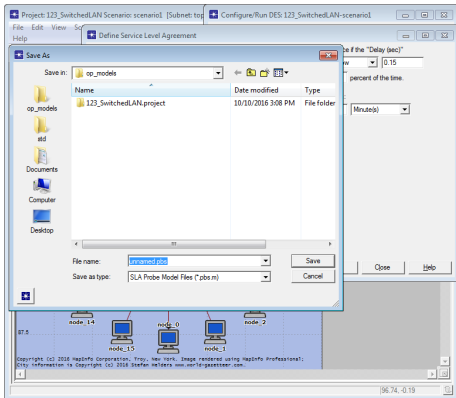
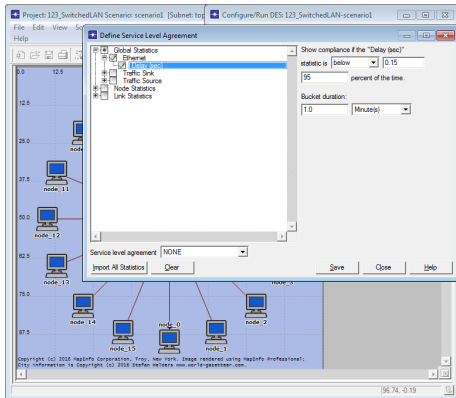
# Configuring Simulations (cont'd)

- **SLAs** – define the thresholds that will be applied against the results collected during the simulation study



# Configuring Simulations (cont'd)

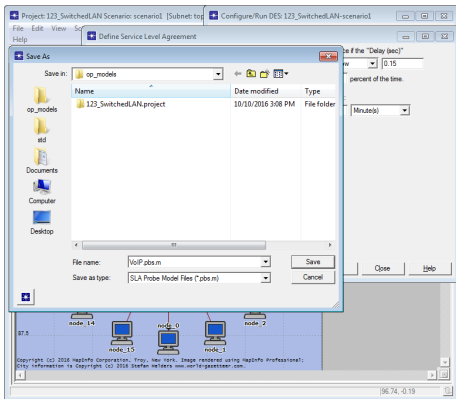
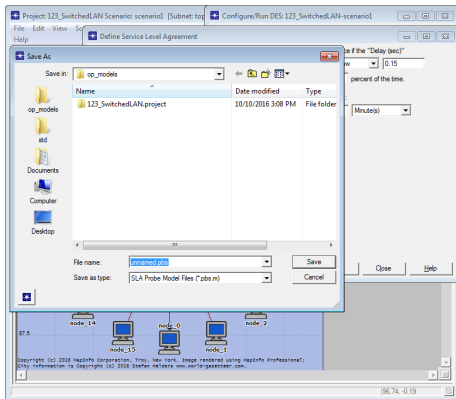
- Define SLA Report... ⇒ bla-bla-bla ⇒ Save





# Configuring Simulations (cont'd)

- Save as <file name>.pbs.m, not just <file name>.pbs



# Configuring Simulations (cont'd)

## • Done!

Project: 123\_SwitchedLAN Scenario: scenariol [Subnet: top] Configure/Run DES: 123\_SwitchedLAN-scenariol

Define Service Level Agreement

Global Statistics

- Ethernet
- Link Statistics
- Traffic Sink
- Traffic Source
- Node Statistics
- Link Statistics

Show compliance if the "Delay (sec)" statistic is below 0.15

95 percent of the time.

Bucket duration: 1.0 (Min,Sec)

Service level agreement: VoIP

Import All Statistics Clear Save Close Help

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Wrote File: C:\Users\RAD\op\_model\VoIP.pbsm [96.74, -0.19]

Project: 123\_SwitchedLAN Scenario: scenariol [Subnet: top] Configure/Run DES: 123\_SwitchedLAN-scenariol

Duration: 2 (minute(s))

Values per statistic: 100

Global attributes Reports

Network calendar time: 13:22:15.000 Oct 10 2016

Generate web report for simulation results

Minimum number of decimal places for statistics in output reports: 2

Number of entries displayed in "Top N" reports: 17

Statistics reports

- ACE
- ATM
- ATM PVCs
- ATM Switch
- Bidoe and Switch

SLAs

- VoIP

Define Statistics Report... Define SLA Report...

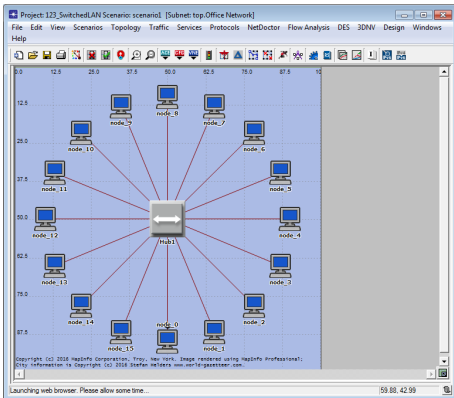
Detailed... Run Cancel Empty Help

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Wrote File: C:\Users\RAD\op\_model\VoIP.pbsm [96.74, -0.19]

# Configuring Simulations (cont'd)

• Let's see... 😊



File Edit View Favorites Tools Help

### Results

- [SLA: VoIP](#)
- [Report: User Selected](#)

**Project: 123\_SwitchedLAN**  
**Scenario: scenario1**

Simulated from 13:22:15 Mon Oct 10 2016 to 13:24:15 Mon Oct 10 2016.

**OPNET**  
Modeling, Performance and Application Partner

100%

# Configuring Simulations (cont'd)

- SLA violation: Global Ethernet Delay was above the SLA limit of 0.15 seconds for more than 5% of packets in each period

The screenshot shows a web browser window displaying a simulation report. The main content area is titled 'Global Statistics' under the 'SLA: VoIP' section. It contains the following text: 'Global Ethernet Delay (sec) was above the SLA limit of 0.15. During the worst period (of 60 seconds), it was above the limit 42% of the time. Furthermore, during 1 other period, it was above the limit at least 5% of the time.'

Project: 123\_SwitchedLAN SLA: VoIP  
Scenario: scenario1 Title: Violations Text Summary  
Simulated from 13:22:15 Mon Oct 10 2016 to 13:24:15 Mon Oct 10 2016.

Global Statistics

Global Ethernet Delay (sec) was above the SLA limit of 0.15. During the worst period (of 60 seconds), it was above the limit 42% of the time. Furthermore, during 1 other period, it was above the limit at least 5% of the time.

The screenshot shows a web browser window displaying a simulation report. The main content area is titled 'Global Statistics' under the 'SLA: VoIP' section. It contains a table with the following data:

Status	Statistic	% of Violations During Worst Period	% of Violations During Entire Simulation	Number of Periods in Violation	Average	Maximum	Min
●	Ethernet Delay (sec)	42	40	2.0000	0.1545	1.4332	0

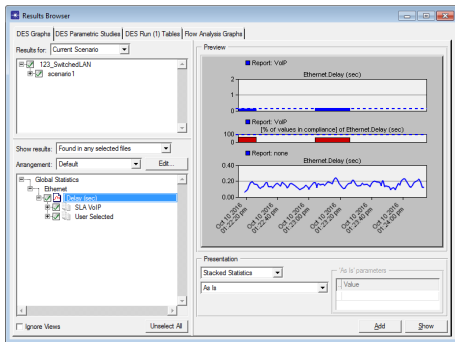
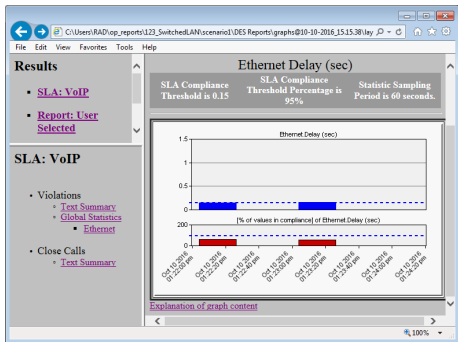
● Denotes Service Level Agreement Violation

Project: 123\_SwitchedLAN SLA: VoIP  
Scenario: scenario1 Title: Global Statistics Violations Summary  
Simulated from 13:22:15 Mon Oct 10 2016 to 13:24:15 Mon Oct 10 2016.

Ethernet

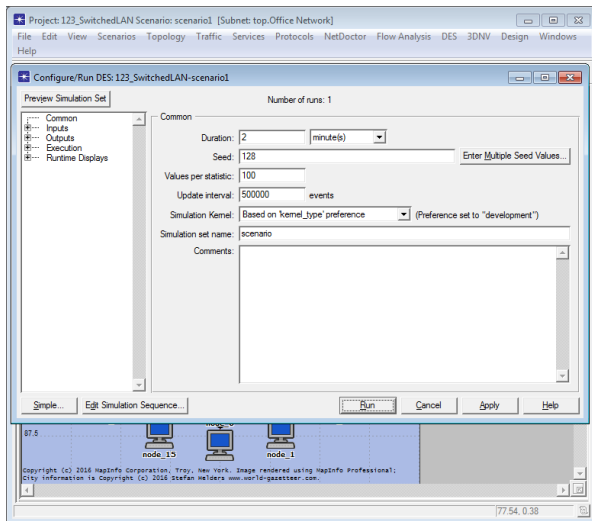
# Configuring Simulations (cont'd)

- **Statistic graph** – statistic threshold, sample mean, min/max values, standard deviation, and sample count (total number of values)
- **Percent compliance graph** – percentage of values in each period that comply with the statistic threshold



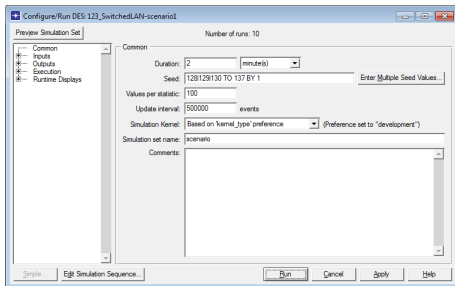
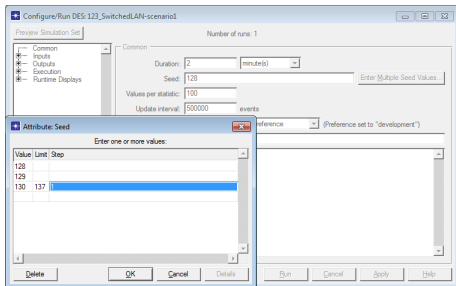
# Configuring Simulations (cont'd)

- Detailed mode of Configure/Run DES has multiple pages of controls



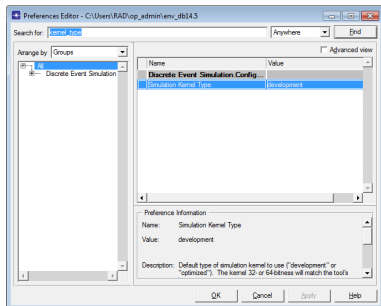
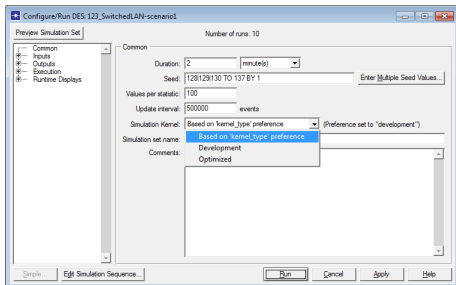
# Configuring Simulations (cont'd)

- **Common** – allows specification of commonly used parameters
- **Seed** – the seed value for the random number generator
- **Enter Multiple Seed Values...** – allows you to specify multiple seeds
  - Varying the random number seed across a family of simulations helps ensure statistical validity



# Configuring Simulations (cont'd)

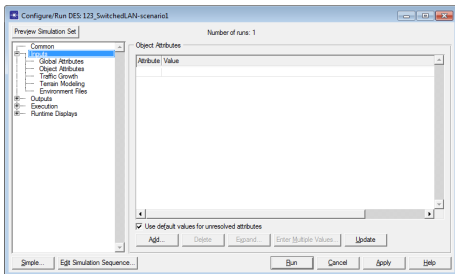
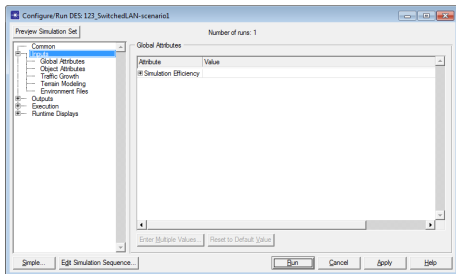
- **Update interval** – determines the frequency with which simulation progress reports are displayed in the simulation console
- **Simulation Kernel** – specifies the type of simulation kernel
  - **Development** – allows close monitoring and debugging of the simulation
  - **Optimized** – optimizes the code for fast execution





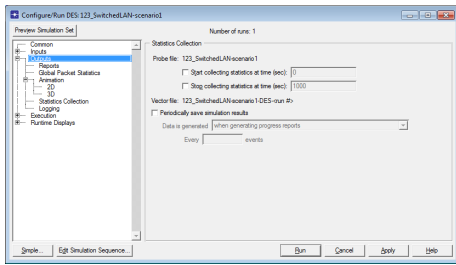
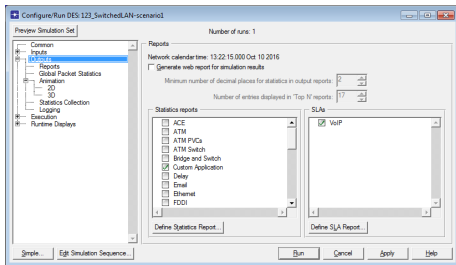
# Configuring Simulations (cont'd)

- **Inputs** – contains several subcategories that can be used to specify configuration items such as global attributes, promoted object attributes, traffic growth, terrain modeling, and environment files



# Configuring Simulations (cont'd)

- **Outputs** – contains several subcategories that allow configuring reports to be created upon simulation completion, the time period for collecting simulation statistics, simulation log data collection, animation, etc.

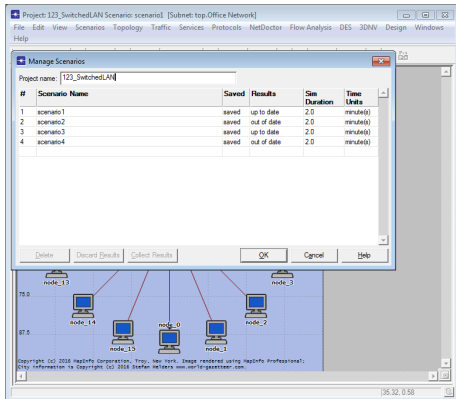
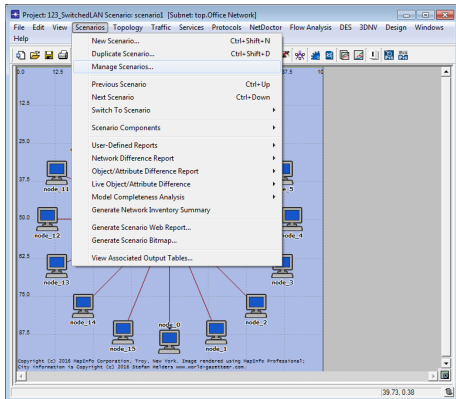


# Outline

- 1 Configuring simulations
- 2 Manage scenarios**
- 3 Running simulations
- 4 DES Log
- 5 Animation

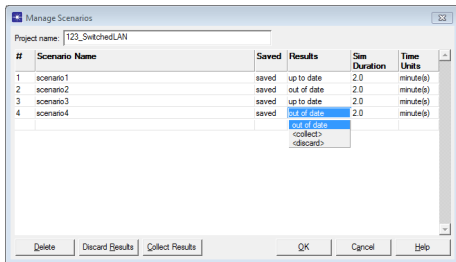
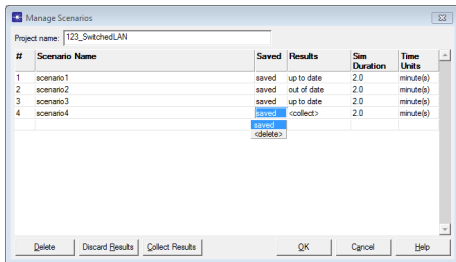
# Manage Scenarios

- **Manage Scenarios** – organizes all scenarios within the project in the form of a table
- Scenarios  $\Rightarrow$  Manage Scenarios...



# Manage Scenarios (cont'd)

- **OK** – saves all the changes, plus all scenarios marked to <collect> or <recollect> the results will automatically begin executing in the order of their scenario numbers
- **Cancel** – discards all the changes and closes the window

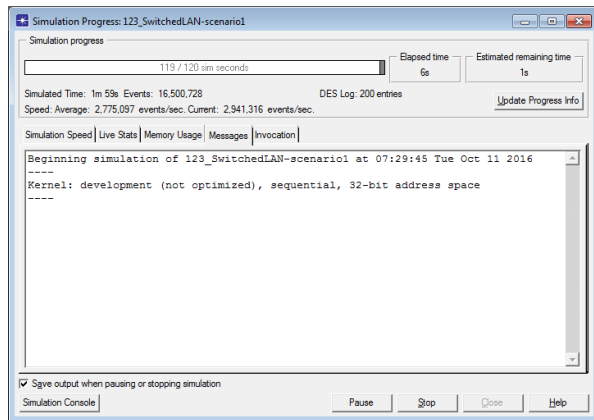


# Outline

- 1 Configuring simulations
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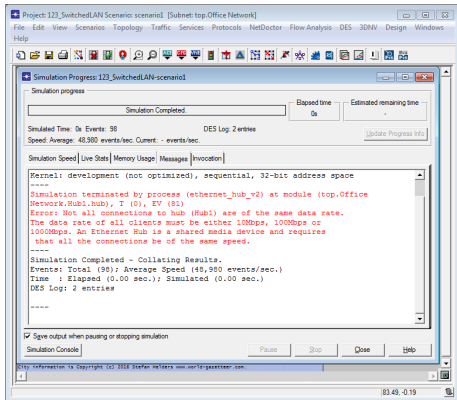
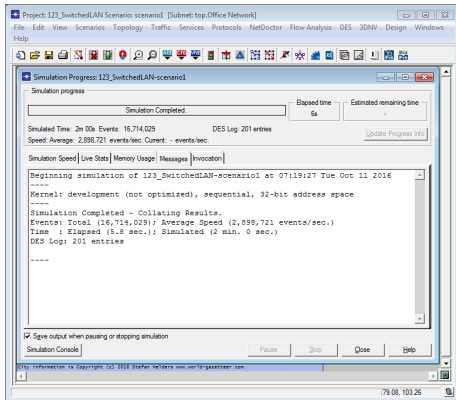
# Running Simulations

- **Pause** – suspends simulation execution
- **Resume** – resumes simulation execution
- **Stop** – terminates simulation execution, resulting in only partial simulation results being collected



# Running Simulations (cont'd)

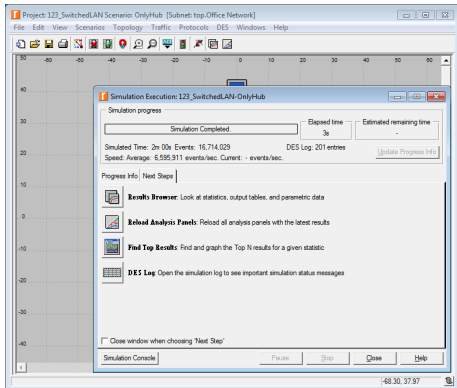
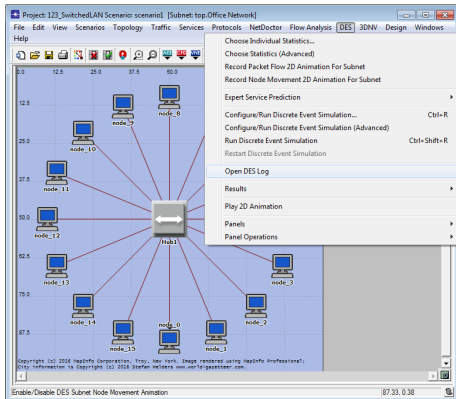
- Once the simulation completes, the simulation progress pane will display the message 'Simulation Completed' and will have the 'Close' button enabled





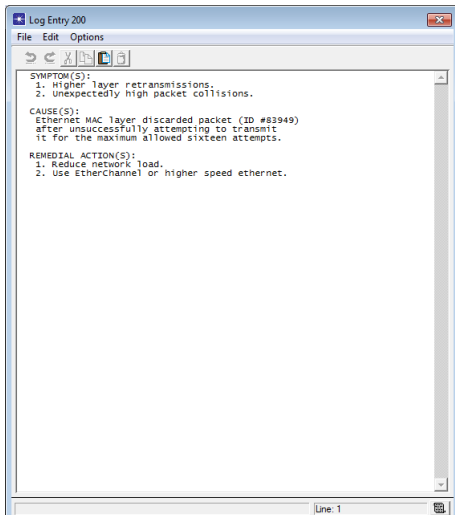
- 1 Configuring simulations
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- 4 DES Log**
- 5 Animation

- **DES Log** – records all important events that occur during the simulation study
- DES  $\Rightarrow$  Open DES Log

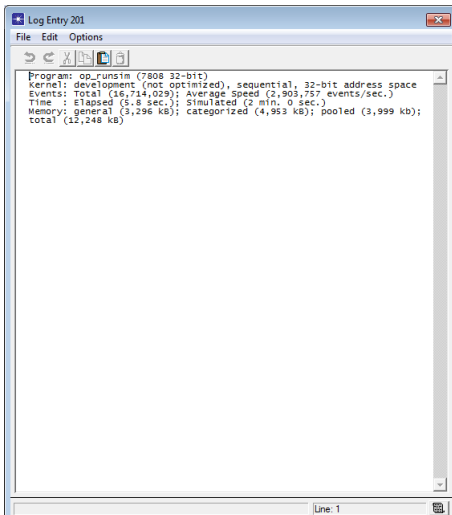




- Each simulation run results in at least one DES Log message generated



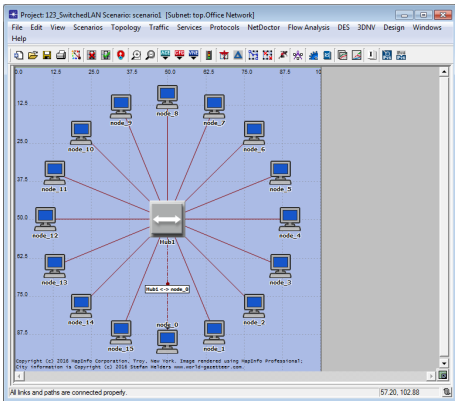
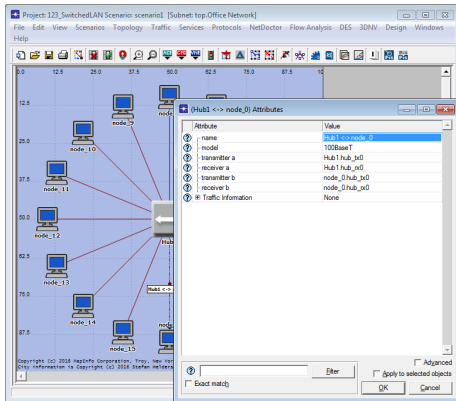
```
Log Entry 200
File Edit Options
SYMPTOM(S):
1. Higher layer retransmissions.
2. unexpectedly high packet collisions.
CAUSE(S):
Ethernet MAC Layer discarded packet (ID #83949)
after unsuccessfully attempting to transmit
it for the maximum allowed sixteen attempts.
REMEDIAL ACTION(S):
1. Reduce network load.
2. Use EtherChannel or higher speed ethernet.
Line: 1
```



```
Log Entry 201
File Edit Options
Program: op_runsim (7808 32-bit)
Kernel: development (not optimized), sequential, 32-bit address space
Events: Total (16,714,029); Average Speed (2,903,757 events/sec.)
Time : Elapsed (5.8 sec.); Simulated (2 min. 0 sec.)
Memory: general (3,296 kb); categorized (4,953 kb); pooled (3,999 kb);
total (12,248 kb)
Line: 1
```

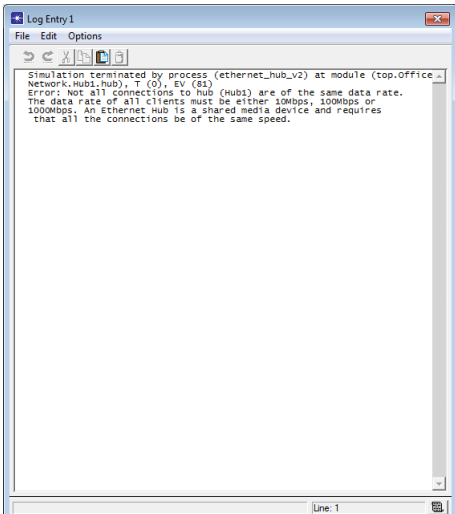
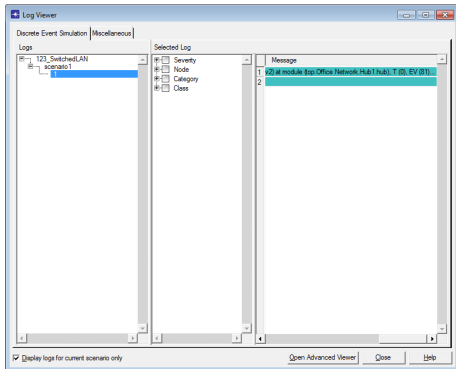
# DES Log (cont'd)

- 'All links and paths are connected properly.' Oh really? 😊



# DES Log (cont'd)

- Let's see... 😊



# Outline

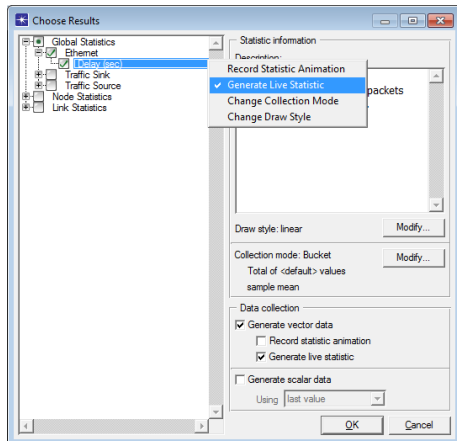
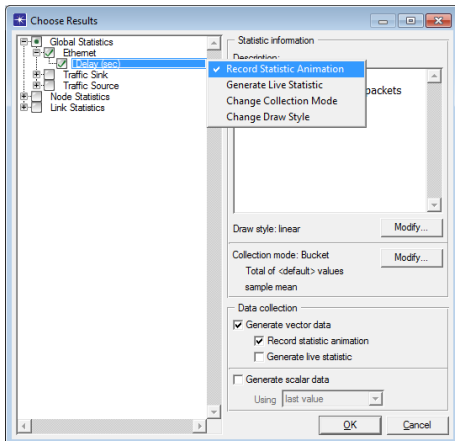
- 1 Configuring simulations
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- 5 Animation**

- 3 types of animation:
  - **Statistic Animation** – shows a graph illustrating the value of a given statistic
  - **Packet Flow Animation** – shows the network as it is represented in the scenario, with packets traversing the links
  - **Node Animation** – shows how nodes operate or move during a simulation study



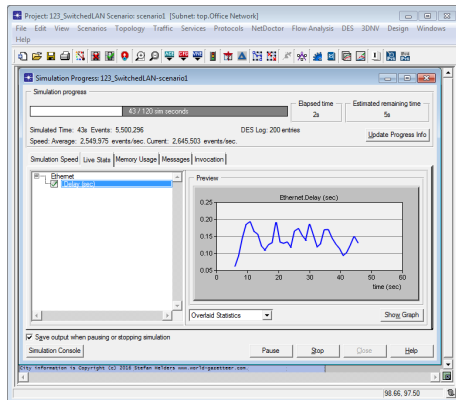
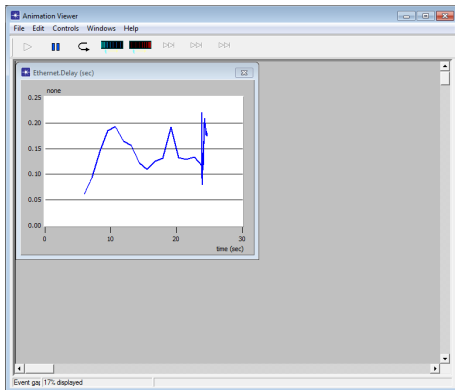
# Animation (cont'd)

## 1 Record Statistic Animation vs. Generate Live Statistic



## 1 Record Statistic Animation vs. Generate Live Statistic

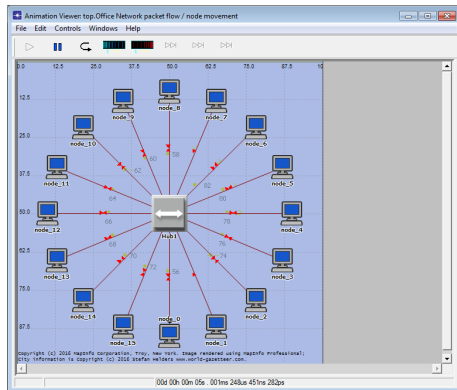
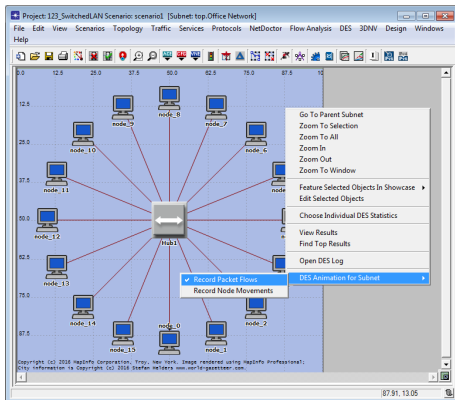
- DES  $\Rightarrow$  Play 2D Animation
- DES  $\Rightarrow$  Configure/Run Discrete Event Simulation...  $\Rightarrow$  Run  $\Rightarrow$   
 $\Rightarrow$  Live Stats



# Animation (cont'd)

## 2 Packet Flow Animation

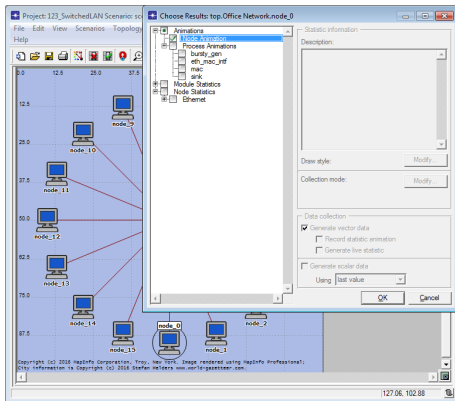
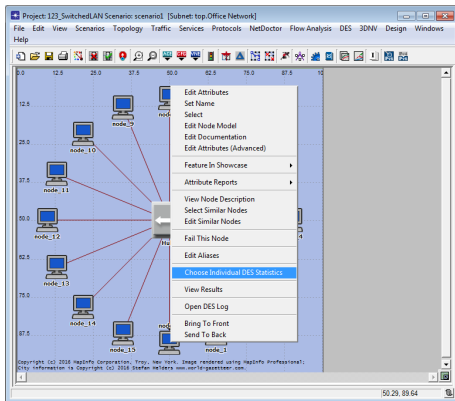
- DES Animation for Subnet  $\Rightarrow$  Record Packet Flows
- DES  $\Rightarrow$  Configure/Run Discrete Event Simulation...  $\Rightarrow$  Run
- DES  $\Rightarrow$  Play 2D Animation



# Animation (cont'd)

## 3 Node Animation

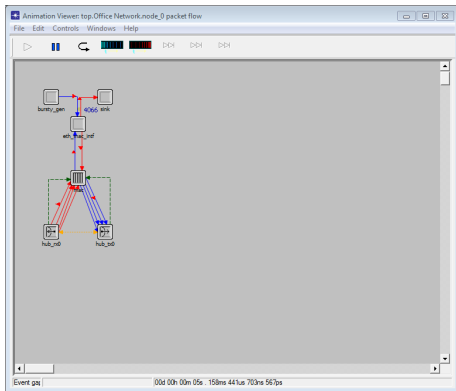
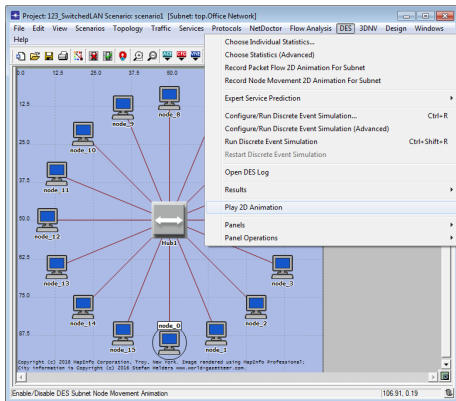
- Choose Individual DES Statistics  $\Rightarrow$  Animations  $\Rightarrow$  Node Animation  $\Rightarrow$  OK



# Animation (cont'd)

## 3 Node Animation

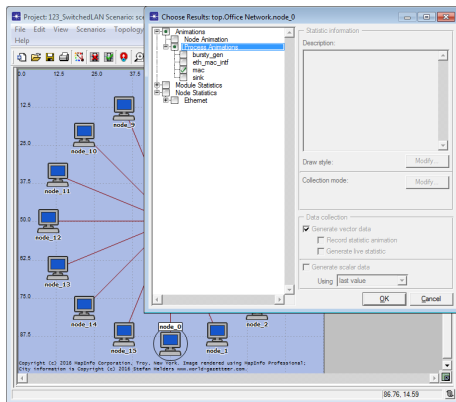
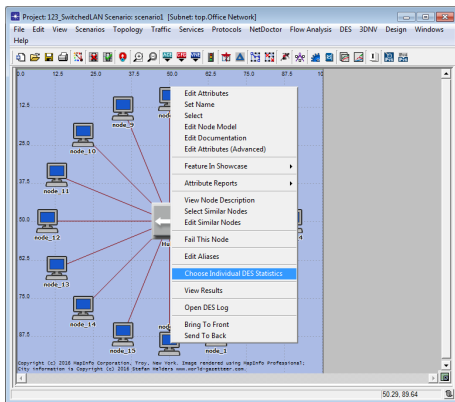
- DES ⇒ Configure/Run Discrete Event Simulation... ⇒ Run
- DES ⇒ Play 2D Animation



# Animation (cont'd)

## 3 Node/Process Animation

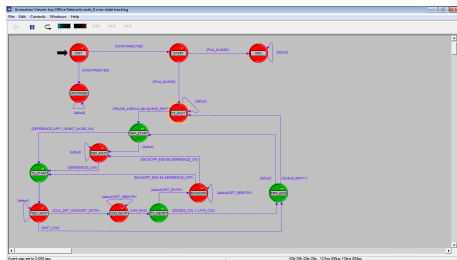
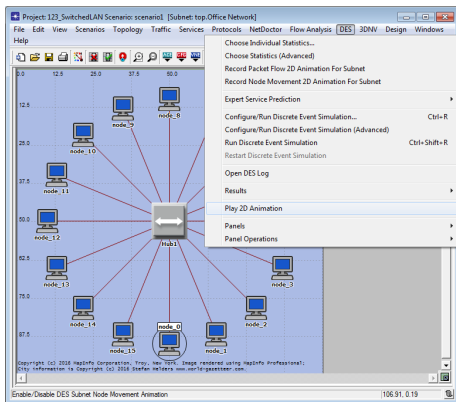
- Choose Individual DES Statistics  $\Rightarrow$  Animations  $\Rightarrow$   
 $\Rightarrow$  Process Animation  $\Rightarrow$  bla-bla-bla  $\Rightarrow$  OK



# Animation (cont'd)

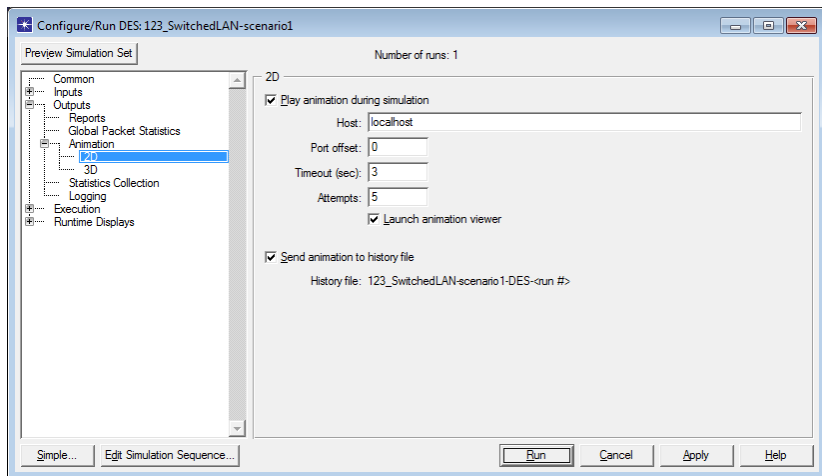
## 3 Node/Process Animation

- DES  $\Rightarrow$  Configure/Run Discrete Event Simulation...  $\Rightarrow$  Run
- DES  $\Rightarrow$  Play 2D Animation



# Animation (cont'd)

- DES ⇒ Configure/Run Discrete Event Simulation... ⇒ Outputs ⇒ Animation ⇒ 2D ⇒ Play animation during simulation





# Animation (cont'd)

- **Riverbed Modeler Academic Edition** : no Animation Viewer ☹
  - 123\_SwitchedLAN-OnlyHub-DES-1.ah : ~ 161 MB

