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Distributed Simulation Module User's Guide

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Chapter 1 Introduction

The LightTools Distributed Simulation Module allows you to distribute a simulation over multiple computers. To accomplish this, all interactive operations a user performs on a *controller* computer, such as opening files, modifying models, analyzing data, are duplicated on computers running *worker* sessions of LightTools. (See *Terminology* on page 2 for descriptions of the distributed simulation terminology.) The state of the model is constantly synchronized with each of the workers. During a simulation, each worker traces a portion of the total rays. The rays are assumed to be independent from other rays and can be incoherently accumulated into the analysis meshes like a multi-threaded operation. With this method, each worker collects its set of receiver rays, and the binned data is accumulated at the controller. After the simulation, when you make changes to the number of bins or filter settings or ray paths, LightTools first updates the rays on each worker and then re-accumulates the binned data on the controller.

Note: A Distributed Simulation Module license is required for each of the worker sessions, and you must have a floating license.

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- *Terminology* on page 2
- *Assumptions* on page 3
- *Limitations for the Distributed Simulation Module* on page 4
- *Installing the Distributed Simulation Module* on page 7
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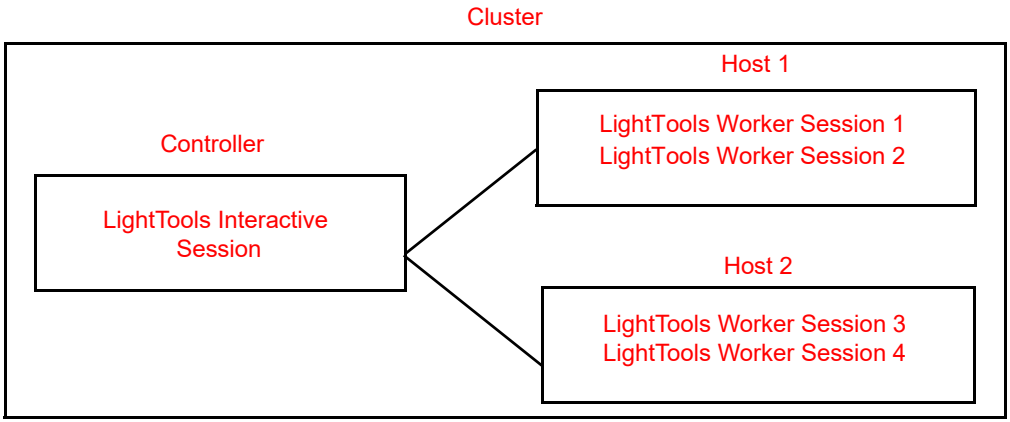
Terminology

The following terms are used describe how the Distributed Simulation Module works.

- Distributed simulation – A process that uses multiple computers to perform a Monte Carlo ray trace of an optical model.
- Controller – An interactive session of LightTools the user interacts with to perform modeling, simulation, and analysis.
- Host - A computer on which one or more worker sessions of LightTools run.
- Worker – A session of LightTools that performs a portion of the simulation, stores partial results, and feeds results back to the controller.
- Cluster – A collection of a controller and one or more workers sharing a simulation task.
- Rank – An ordinal number assigned by the Intel Message Passing Interface (MPI) to each LightTools session in a cluster. The controller is always given a rank of 0.
- Core – Computer cores are equivalent to CPU threads. A LightTools simulation is not significantly increased when running multiples threads per core, such as when hyperthreading is enabled.



Assumptions

The following assumptions are made during for a distributed simulation process.

- The system is based on the Intel Message Passing Interface (MPI).
- The controller and workers have a common version of MPI installed.
- The controller and workers have a common version of LightTools installed.
- The controller and workers are on the same subnet of a single domain.
- Continuous load balancing is updated after each simulation to test the ray trace speed of each worker. The fraction of the simulation rays sent to each worker is based on the previous simulation. It is suggested that you start a distributed simulation with a small number of rays to initiate the load balancing and then perform a larger simulation to balance the performance of the selected workers.
- Each worker is able to access a common LightTools system (.lts) model and any required external files with the controller through a universal naming convention (UNC) shared folder.
- The operation requires a floating license. The controller checks out the typical licenses needed for the model, and each worker checks out a worker license from a pool of Distributed Simulation Module licenses.
- Each worker session is licensed for use up to 16 CPU threads; to use all the cores to achieve optimal performance on a 48-core host, three distributed simulation instances of LightTools are needed for three instances of the workers to run on the workstation, each requiring its own license.

Limitations for the Distributed Simulation Module

Distributed simulations are designed to increase simulation speed for models that were defined and set up in a non-distributed version of LightTools. Interactive use and continuous synchronization of the model state between the controller and workers allows you to change receiver filters and mesh settings after the simulation. Other interactive use is limited as described below. Building and modifying models, optimization, and tolerancing are supported, but there are sequences of operations that cause LightTools to lose synchronization and hang the distributed session. If synchronization is lost or when a worker is unresponsive to the controller, LightTools prompts you to save the model and start a new distributed simulation session.

The following limitations are known to exist in this release.

- The LightTools Cluster Startup dialog box is available only in English.
- If files are not accessed from a shared drive (including optical properties and materials), the workers can lose synchronization or hang the processes; this can affect commands that use internal paths such as macro-based geometry creation commands and copy and paste geometry macros.

  Because optical properties must be access from a shared drive, it is not possible to use the Load From Library option in the Optical Properties Manager, because this option attempts to retrieve files on the local file system. To work around this, you can use the Load From File option instead, and navigate to the shared folder to select the desire file.
- If a worker session of LightTools exhausts memory on the host computer, LightTools will hang or crash.
- This version does not provide a way to remove non-responsive cluster nodes from the simulation.
- Tolerance analyses and optimization distribute the simulation, not the individual perturbed models.
- LED Lens and MacroFocal elements cannot be created or modified when running a distributed simulation.
- Hybrid simulations are not supported.
- Photorealistic rendering is not supported.
- Continue Simulation After Interrupt (Interrupt and then Add more rays) is not supported.

- When a simulation includes a large set of rays, exporting receiver rays and saving the model with ray data can require an extensive amount of time.
- The Glass Map is not supported.
- The LightTools SOLIDWORKS Link Module is not supported.
- Ray data can be saved during a distributed simulation but can be opened only when running in single simulation mode upon restoring the .lts file.
- External utility programs may lose synchronization depending on the API functions they call.
- LightTools utilities should connect only to the controller, not the workers.
- The UDVS Logger (which is currently single-threaded) is not supported.
- Support for user-defined optical properties (UDOPs), and other user-defined DLL components is limited to “well-behaved” DLLs; some implementations may cause LightTools to hang.

Chapter 2 Installing the Distributed Simulation Module

To operate LightTools over a network of computers for distributed simulations, you must have:

- LightTools installed on the controller and worker host computers.
- A floating license server with licenses for LightTools, any required modules, and for each worker participating in the simulation.
- Intel Message Passing Interface (MPI) installed on each host running worker sessions that participate in simulations.

Tell me about...

- *Installing the Floating License Manager* on page 7
- *Installing LightTools* on page 7
- *Installing MPI* on page 8

Installing the Floating License Manager

You must have the latest version of the OSG Floating License Manager, which is provided on the SolvNetPlus website on the same Downloads page as the product software. You can install the floating license manager on any computer in the domain accessible to the controller and worker host computers.

For instructions for installing the OSG Floating License Manager, see the *LightTools Installation Guide*, which is available to download on SolvNetPlus and the Synopsys website (https://www.synopsys.com/optical-solutions/support/support-install-lic-overview.html).

Installing LightTools

You must install LightTools on the controller and each worker host computer. We recommend that you run the same version of LightTools on the controller and each host through a shared executable path.

For details about installing LightTools, see the *LightTools Installation Guide*, which is available to download on SolvNetPlus and the Synopsys website (https://www.synopsys.com/optical-solutions/support/support-install-lic-overview.html).

Installing MPI

You must install MPI on the controller and all worker host computers. The MPI executable is provided on the SolvNetPlus website on the same Downloads page as the product software.

1. Navigate to the folder where the file w_mpi-rt_p_2018.2.185.exe is located.
2. Double-click the file w_mpi-rt_p_2018.2.185.exe and follow the prompts, accepting the default settings.
3. Open a Windows command prompt as administrator.
4. Enter the command:

   ```
   hydra_service -install
   ```
5. Run MPI by entering the following command in the command prompt.

   ```
   mpiexec -n 2 hostname.exe
   ```

   When prompted, enter your user name and Windows password. Tip: See *How to Make MPI Remember Your Credentials* on page 8.

   If the setup is correct, the name of your computer id displayed twice as output.

How to Make MPI Remember Your Credentials

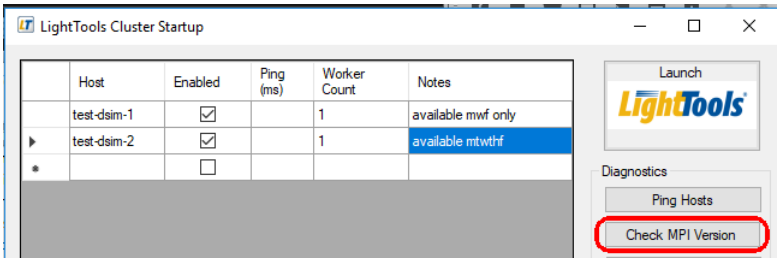
You can register your username and password with MPI so you don't have to enter it every time you run LightTools. This information is stored in the registry as encrypted data.

1. From a command prompt, enter:

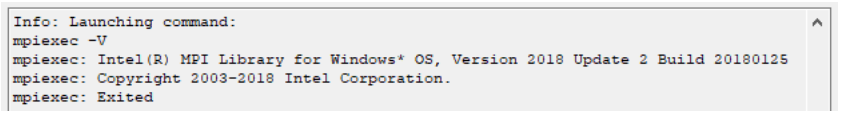
   ```
   mpiexec -register
   ```
2. Enter the domain and username (e.g., DOMAIN\username)
3. Enter your Windows password, and confirm it.

Querying the MPI Version

To query the MPI component installed on the controller, click the Check MPI Version button on the LightTools Cluster Startup dialog box. To open this dialog box, select the Windows Start menu and select **LightTools > Start Distributed Simulation.**



The MPI version number is displayed in the message window.



Chapter 3 Starting and Stopping a LightTools Distributed Simulation

To run a distributed simulation, you first define the location of the LightTools executable, controller, workers, and some command options.You can do this using the LightTools Cluster Startup dialog box or from a command prompt, as described in the following procedures.

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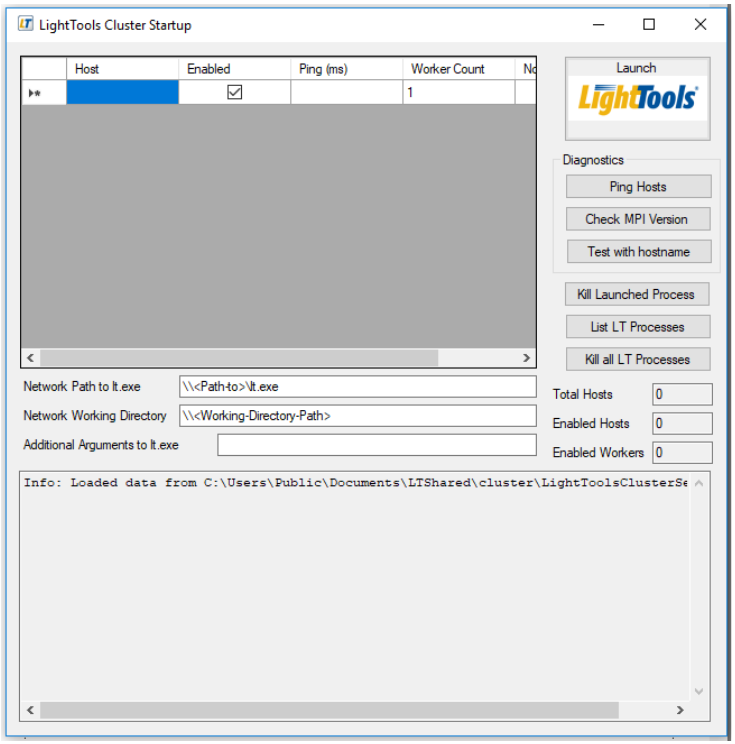
- *Starting a Distributed Simulation* on page 11
- *Stopping a Distributed Simulation* on page 17
- *Troubleshooting* on page 18

Starting a Distributed Simulation

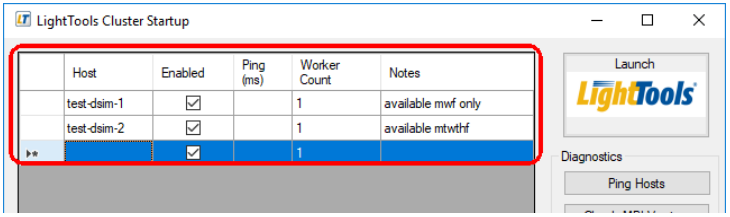
Follow these steps to open the LightTools Cluster Startup dialog box and define and start a distributed simulation session.This dialog box provides a table for specifying hosts and workers, options for specifying controller inputs, diagnostic tools, and a message window.

1. Click the Windows Start menu and select **LightTools > Start Distributed Simulation.**

   The LightTools Cluster Startup dialog box is displayed, shown in the following figure.



2. Specify the hosts and workers in the table at the top of the dialog box.



To specify the workers, you provide a host name and a worker count. You can also control which host is enabled and add notes. The columns for specifying workers are:

– Host: Enter the host name or IP address of the computer on which one or more worker sessions will run. To delete a host, select the row and press the Delete key.

– Enabled: Indicates whether or not the workers on this host participate in a distributed simulation. This option is turned *on* (checked) when you add a host to the list. You can turn it on or off to select a subset of known hosts to participant in the simulation.

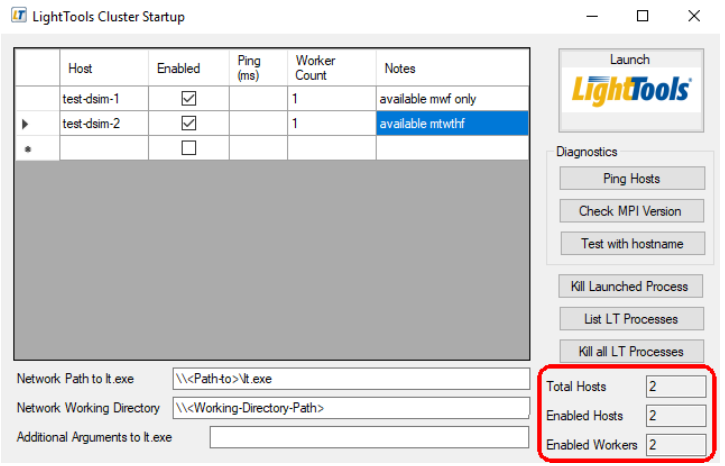
– Ping (ms): This is not an input field. This field displays the results when you click the Ping Hosts button in the Diagnostics section of the dialog box to test the availability of hosts. It shows the time used to connect to each host (in milliseconds); if the host cannot be found, it displays the status **failed**, which indicates that you can disable it for the next simulation.

– Worker Count: Controls the number of worker sessions that will run on the host. By default, one session will run, but you can enter a value to increase this when the host has many CPUs and sufficient memory to allow multiple LightTools instances. Each worker is designed to allow using 16 threads, so you can increase this when the host supports more than 16 threads. If you want to run multiple worker sessions of LightTools on a host, see *Increasing Desktop Heap Memory on Worker Nodes* on page 16

Note: You must have a Distributed Simulation Module license for every worker session of LightTools that runs on a host computer.

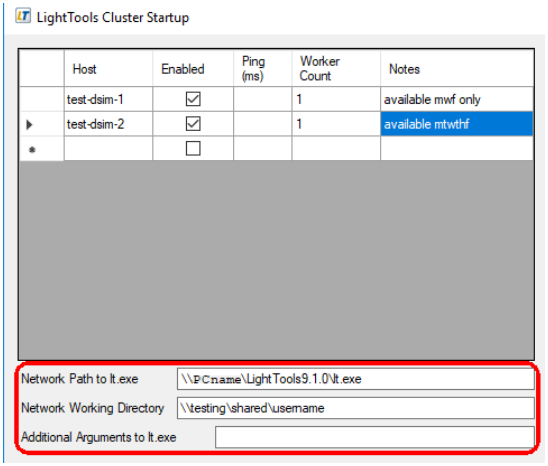
– Notes: You can add information such as when a host is available, what its capabilities are, or other information that is useful to you. Notes are preserved between sessions.

The total number of hosts, total enabled hosts, and enabled workers are displayed on the right side of the dialog box, shown in the following figure.



3. Specify controller inputs.

   Below the table of hosts and workers is a section for defining controller-related inputs for the simulations.



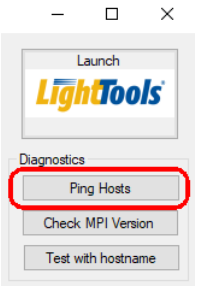
   – Network Path to lt.exe: The distributed simulation is designed to share the same version of LightTools on the controller and workers, and this is the path to the shared LightTools executable.

   – Network Working Directory: Like the LightTools executable, this defines the path that the controller and workers use to access model files and save results. This must be a shared network path.

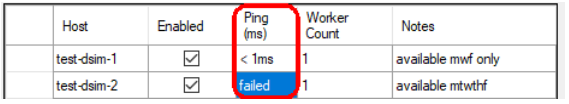
– Additional Arguments to lt.exe: Allows you to enter command line options to use when LightTools starts.

4. Verify that the hosts are available using either of these options:

– Click the **Ping Hosts** button.

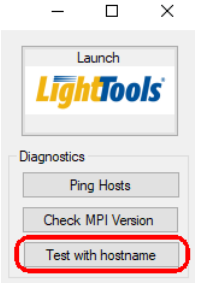


This button initiates a test communication to each host using the Windows ping command and displays the communication time in the Ping (ms) column of the table.

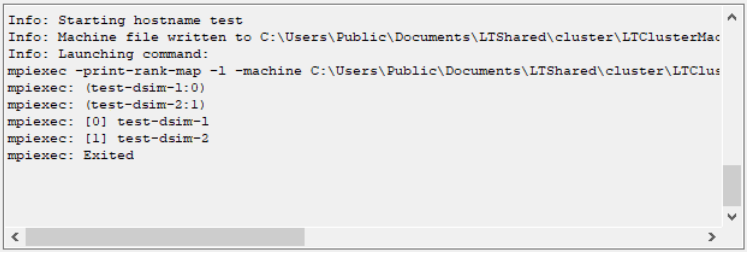


	Host	Enabled	Ping (ms)	Worker Count	Notes
	test-dsim-1	☑	< 1ms	1	available mwf only
	test-dsim-2	☑	failed	1	available mtwthf

– Click the **Test with hostname** button.

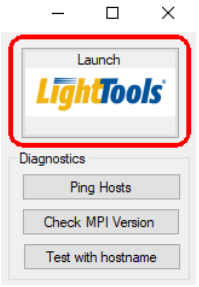


This option performs a more thorough test of the participating hosts, including checking that MPI is installed. Information on the command operation and the status of the hosts is displayed in the message window.



Depending on the results of the host verification, you can enable or disable hosts for the distributed simulation.

5. When you are ready to open a model for the distributed simulation, click the Launch LightTools button.



When you start a simulation, the process is distributed according to the parameters specified in the LightTools Cluster Startup dialog box. The process generates the following two data files during operation.

- LTClusterMachine.txt: Contains a list of the participating hosts and used when a distributed simulation is started.
- LightToolsClusterSetup.xml: Stores the current settings of the program and restores them when the Startup program is started.

Increasing Desktop Heap Memory on Worker Nodes

Workers run in a non-interactive session that has limited Desktop Heap Memory resources available. If you want to run multiple sessions of LightTools on a worker, you need to adjust this value (on each worker) to allow multiple workers on the same workstation by editing the registry value at:

`HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Session Manager\SubSystems\Windows`

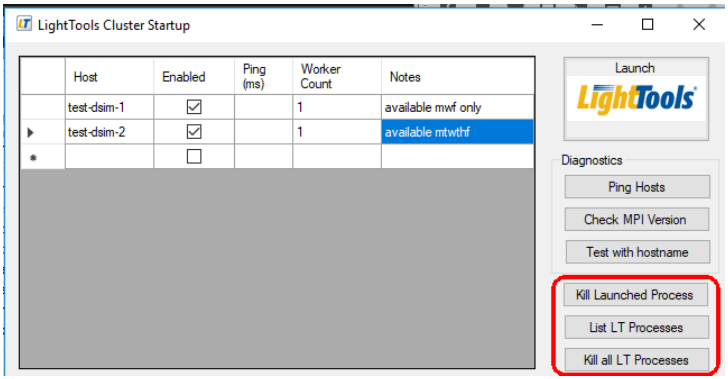
The entry should look something like:

```
%SystemRoot%\system32\csrss.exe ObjectDirectory=\Windows
SharedSection=1024,20480,768 Windows=On SubSystemType=Windows
ServerDll=basesrv,1
ServerDll=winsrv:UserServerDllInitialization,3
ServerDll=winsrv:ConServerDllInitialization,2
ServerDll=sxssrv,4 ProfileControl=Off MaxRequestThreads=16
```

The third number in SharedSection controls the size of Desktop Heap Memory for non-interactive sessions. Increase this value to 8192 or greater. After changing this registry value, reboot.

Stopping a Distributed Simulation

If LightTools becomes unresponsive, you can terminate the distributed process using the following options in the LightTools Cluster Startup dialog box.



- **Kill Launched Process**: Terminates the last command issued when a problem is encountered; for example, if you click **Test with hostname** and one of the hosts is not available, the last command issue for that host would be terminated.
- **List LT Process:** Lists all instances of LightTools that are running.
- **Kill all LT Processes**: Terminates all instances of LightTools that are running, even those that are not part of the distributed simulation.

Troubleshooting

- **`pmi_proxy not found`** error - If you try to run a cluster and get the error pmi_proxy not found on <host>. Set Intel MPI environment variables, it may be because your computer or the host computer has an environment problem.
  - mpiexec -V shows the version. Use this to verify that the same version is installed on all hosts.
  - Problems may be resolved by uninstalling and reinstalling MPI.
- MPI installation should add **`mpiexec`** to the firewall exclusion list. If the test program cannot run on the worker, check the firewall; LightTools may not run from a shared directory until a firewall exclusion is added for LightTools.
- LightTools must be properly licensed for all worker sessions on a host.