

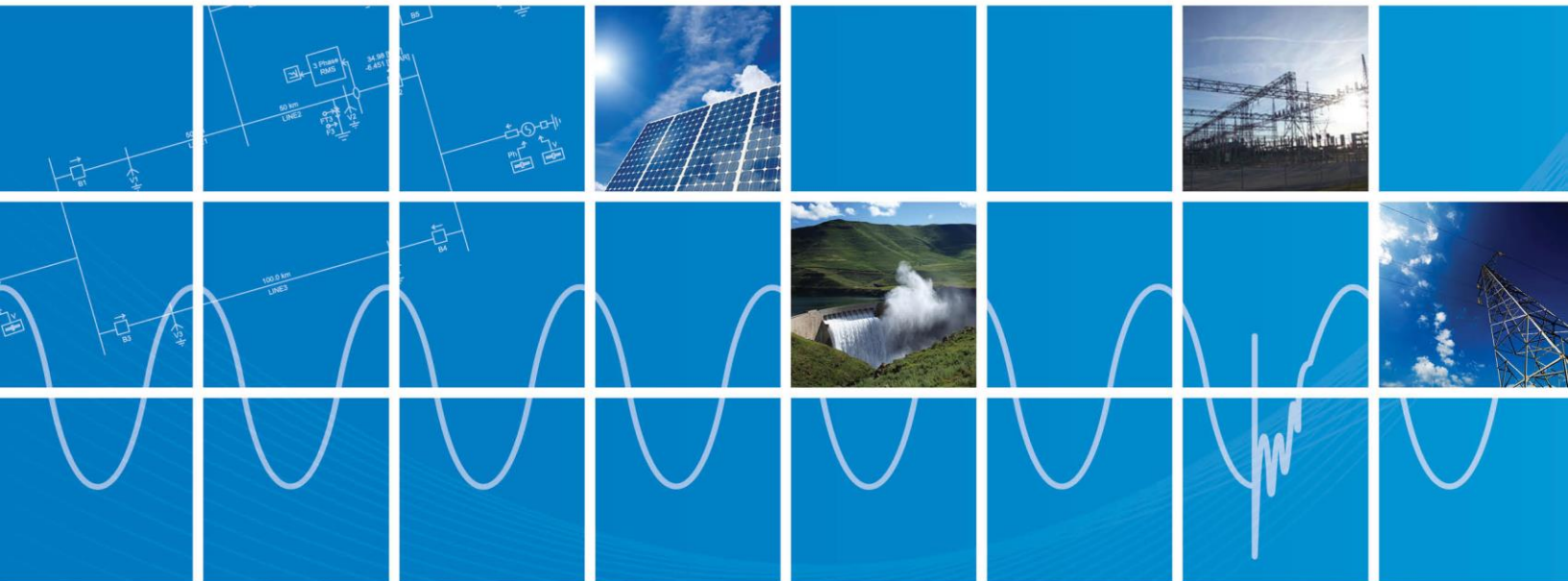


PSCAD™

Setting Up and Using the Cluster Launch System

Written for PSCAD Version 5

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Initial



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1. Background

Traditionally, PSCAD was used to run simulations of small power networks to study localized effects of electromagnetic transients. A single processor/core was sufficient in those times. Over time, with the advancement in power systems and the availability of increased computing power in the form of number of cores in a computer, power systems engineers created sizable networks that surpassed the software's capability of only using one core for running the simulations.

In recent years, PSCAD has evolved to become a Parallel Processing Software for EMT Simulation. With features such as, Parallel Network Interface (PNI), Parallel Multiple Run (PMR) and Intelligent Parallel Multiple Run (PMR-I), PSCAD can now utilize the computing power of multiple cores available at its disposal. It not only utilizes multiple cores on the computer where PSCAD is running, but also can utilize multiple-cores on remote computers connected via a LAN.

2. Cluster Launch System

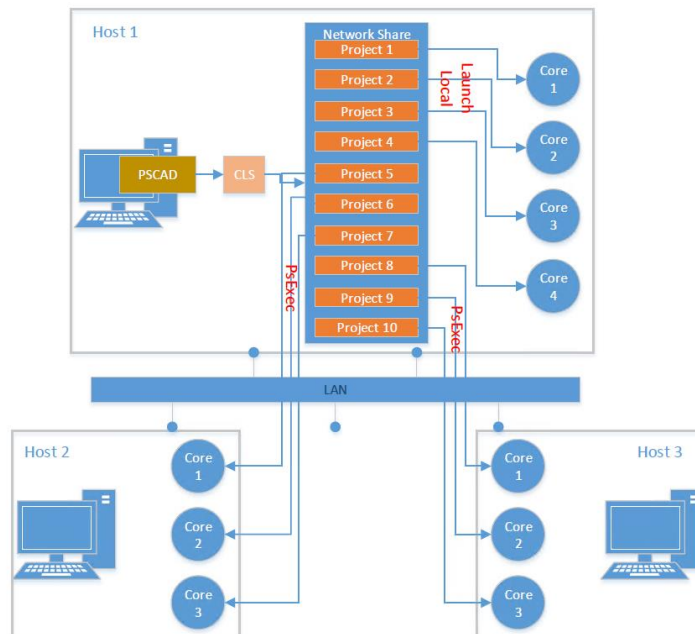
The Cluster Launch System (CLS) is a utility used by PSCAD to launch simulation processes on remote computers. The CLS uses PsExec.exe, available from Windows Sysinternals, to launch simulation processes on remote computers.

2.1. Why Cluster Launch System?

The use of parallel processing features in PSCAD often leads to the requirement of many cores generally exceeding those available in a single computer. In such cases, to prevent performance losses, multiple multi-core computers connected via LAN can be utilized to run simulations. Such a configuration of collection of multi-core computers is called a “computational cluster” and hence the name Cluster Launch System for the utility that can launch simulations on a computational cluster.

2.2. Overview

A high level representation of how Cluster Launch System works is shown in the figure below:



A user wanting to run 10 simulations on a computer (Host 1) comprising of four cores can use the Cluster Launch System to configure a computational cluster and run 10 simulations using several multi-core computers connected via LAN. As shown in the figure above, Host 1 can be treated as the Master computer since PSCAD is running on this computer. PSCAD launches CLS, which is then used to configure



a computational cluster comprising of Host 1, Host 2 and Host 3, all connected with each other via LAN. CLS then launches all 10 simulations. The first four simulations are launched on the local computer and the remaining six simulations are distributed on Host 2 and Host 3.

3. Environment Setup for Cluster Launch System

There are some prerequisites before the Cluster Launch System can be used. The following is the required setup process for CLS to work.

3.1. Admin Privileges on Cluster Nodes

Cluster Launch System uses PsExec.exe to launch simulations on remote computers. This requires administrator privileges for the user on all the computers that are taking part in the cluster.

3.2. PSCAD ComFab .dll Availability

PSCAD in version V5 uses ComFab as the communication library. The comFab .dll is required to be available on all the computers taking part in the cluster. This means that PSCAD must be installed on all the computers. However, only one PSCAD license is required to run the simulations.

3.3. Download the PsExec Utility

PsExec.exe must exist on the computer where PSCAD is running. PsExec.exe is a third party utility and can be downloaded from the following link:

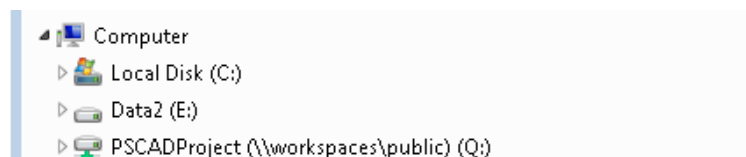
<https://docs.microsoft.com/en-us/sysinternals/downloads/psexec>

PsExec.exe comes as part of PsTools, which is Windows Sysinternals suite of utilities. The downloaded .zip file can be unzipped/extracted to a suitable location of the Master computer. The path to PsExec.exe can then be provided to the CLS application.

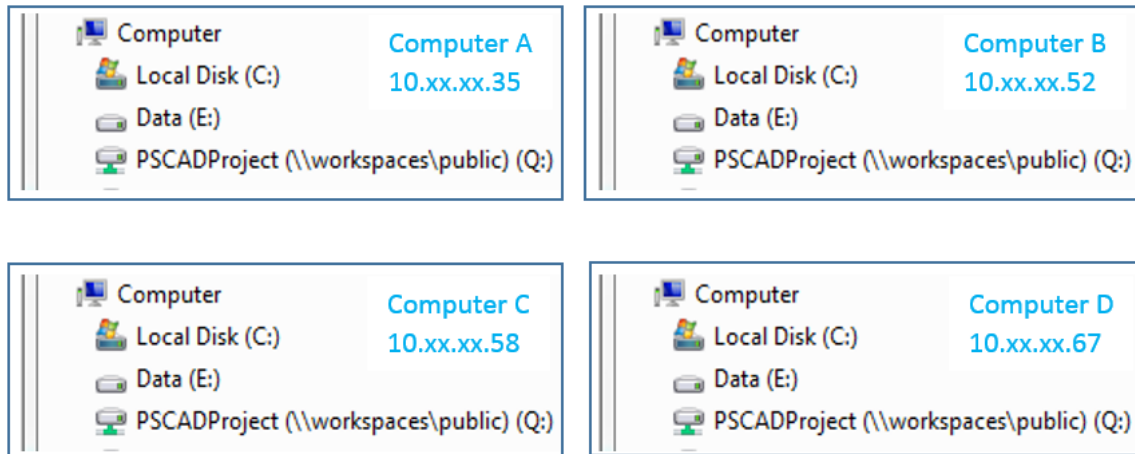
3.4. Configure Shared Network Drive

CLS **can only be used** if all the files corresponding to the simulation projects reside on a shared network drive. This includes the workspace file (.pswx), project files (.pscx) and all other files required by the simulation project. CLS requires the shared network drive to be mapped on to a common drive letter. This drive letter **must** be the same on all the computers participating in running the simulations.

Example:



In the example, the shared network location `\\workspaces\public\PSCADProject` is mapped on to drive letter "Q" on a computer. The drive letter "Q" must be the same drive letter on all the computers in the cluster as shown in the figure below:



3.5. Allow PsExec Access to the Network Drive

PsExec needs to have access to the mapped networked drive on all participating remote computers in the cluster. This can be performed by running a command in the Windows Command prompt ("cmd") of the computer where PsExec is downloaded (the Master computer). The command is as follows:

```
PsExec.exe -s \\<IPAddress> net use P: \\<Network>\<shared>\<folder> /USER:<domain>\<username> <password>
```

Examples:

```
PsExec.exe -s \\<10.xx.xx.35> net use Q: \\workspaces\public\PSCADProject /USER:mhi\joshsmith pwd123
PsExec.exe -s \\<10.xx.xx.52> net use Q: \\workspaces\public\PSCADProject /USER:mhi\johnsmith pwd123
PsExec.exe -s \\<10.xx.xx.65> net use Q: \\workspaces\public\PSCADProject /USER:mhi\johnsmith pwd123
PsExec.exe -s \\<10.xx.xx.78> net use Q: \\workspaces\public\PSCADProject /USER:mhi\johnsmith pwd123
```

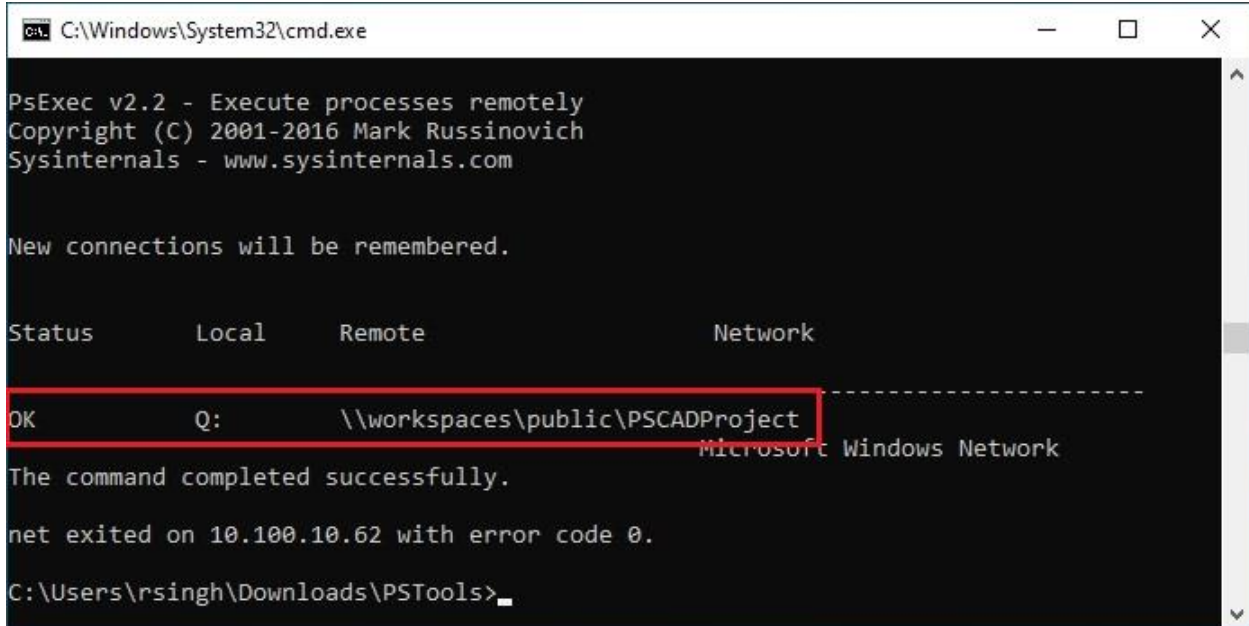
3.6. Verify PsExec's Access Permissions to Network Drive

To verify that the network drives mapped on remote computers are accessible to PsExec (running from the Master computer), run the following command:

```
PsExec.exe -s \\<IPAddress> net use
```

For Example:

```
PsExec.exe -s \\<10.xx.xx.35> net use
```

A screenshot of a Windows command prompt window titled "C:\Windows\System32\cmd.exe". The window has a black background with white text. The text shows the output of the PsExec v2.2 command. It includes the program name, copyright information, a message about connections, a table with columns for Status, Local, Remote, and Network, a row of output data, and a success message. A red rectangle highlights the row of output data. The prompt ends with "C:\Users\rsingh\Downloads\PSTools>".

```
C:\Windows\System32\cmd.exe

PsExec v2.2 - Execute processes remotely
Copyright (C) 2001-2016 Mark Russinovich
Sysinternals - www.sysinternals.com

New connections will be remembered.

Status      Local      Remote      Network
-----
OK          Q:         \\workspaces\public\PSCADProject
                                     Microsoft Windows Network
The command completed successfully.
net exited on 10.100.10.62 with error code 0.
C:\Users\rsingh\Downloads\PSTools>
```

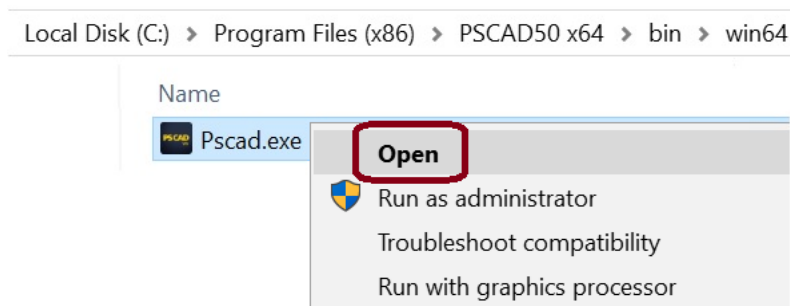
The *Status* must be “OK” for the drive letter that was mapped on all remote computers participating in the cluster.

4. Launching the Cluster Launch System

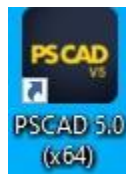
Following are the requirements and modes for CLS when it is launched.

4.1. Launch CLS with USER Privileges

PSCAD launches Cluster Launch System as an external application. CLS must be launched with Windows USER *privileges* and NOT with ADMIN *privileges*. This is because the network resources are not treated the same as all other resources between ADMIN and USER privileged environments. To launch CLS with USER privileges, PSCAD must be launched with USER privileges, as shown:



Or, by using the PSCAD application shortcut on the desktop

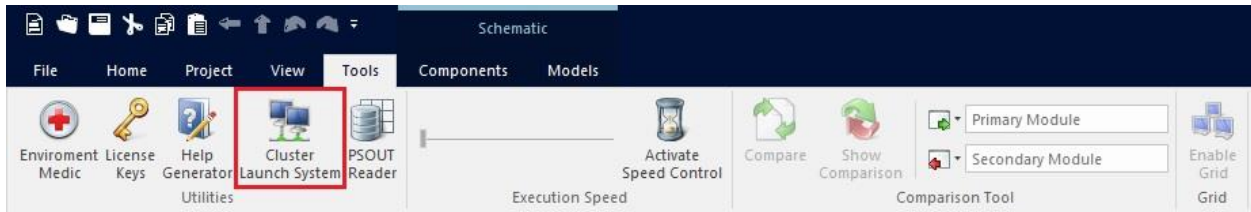


4.2. CLS Launch Modes

CLS can be launched in two modes – Configuration mode and Run mode.

4.2.1. Configuration Mode

The user may choose to launch CLS to configure the cluster and resources. To launch CLS in configuration mode, select "Cluster Launch System" from the *Tools* menu, as shown in the figure below:

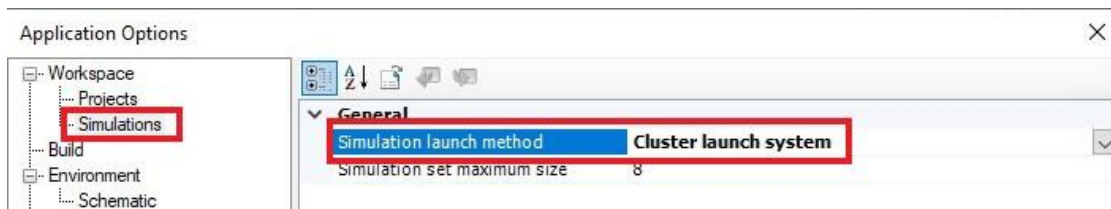


In this mode, the user will not be able to run the simulations.

4.2.2. Run Mode

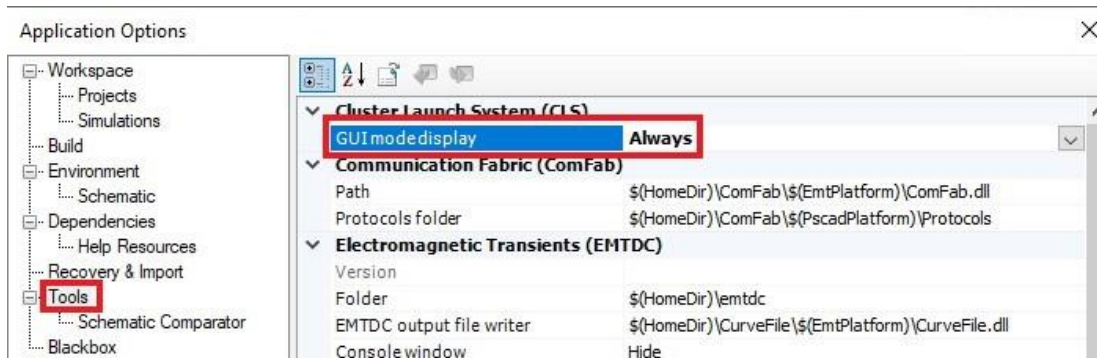
To launch CLS in run mode, the user must enable some settings. Further, in run mode CLS can be launched in two sub-modes – GUI mode and command line mode

- a. From the *PSCAD File* menu, select “Application Options”, then select “Cluster launch utility” from the *Simulation launch method* drop-down menu.



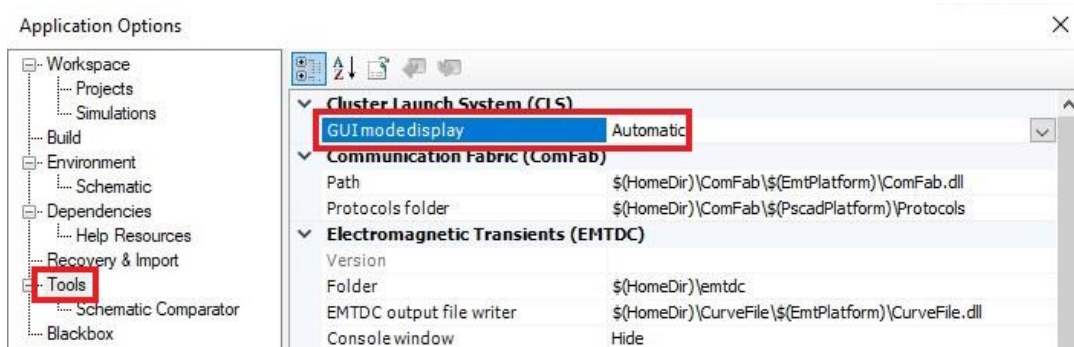
Selecting this option instructs PSCAD to not launch the simulations and to use CLS to launch the simulations.

- b. In *Tools & Utilities*, the user may choose to set “GUI mode display” to “Always” or “Automatic”:
 - o GUI mode display (Always) – this mode allows user the control over cluster configuration and resource settings. It also shows any errors and messages in the GUI window.



This will always display the GUI of CLS when running the simulations.

- GUI mode display (Automatic) – selecting this option will let CLS decide whether to bring up the GUI of CLS application or run in command line. If all system settings are valid, CLS may choose to run in command mode transparent to the user. Whereas, if some parameter is missing or not configured, it will bring up the GUI so users can provide the missing information.



5. Using the Cluster Launch System

The Cluster Launch System is primarily used for launching simulations of multiple multi-core computers connected via LAN.

5.1. Inputs to the Cluster Launch System

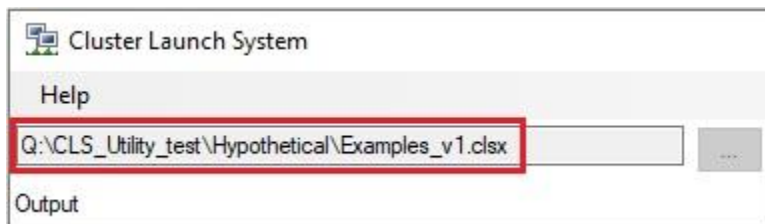
The Cluster Launch System operates on two files – a Simulation task description file and a Configuration file.

5.1.1. Simulation Task Description File

A simulation task description file (with extension “.clsx”) is an XML file generated by PSCAD when a Simulation set is run and “Cluster launch utility” is chosen as Simulation launch method under PSCAD->Application Options->Workspace->Simulations.

The “.clsx” file is generated in the project folder (where workspace file is saved). The filename corresponds with the workspace file. For example, if the workspace name is “Examples_v1.pswx”, then the simulation task description file name will also be named “Examples_v1.clsx”.

The path of the task description file is supplied by PSCAD as an argument to the Cluster Launch System application and does not need to be selected by the user, as shown in the figure below:



An example of a “.clsx” file is given below:

```

<simulation>
  <task namespace="Z1">
    <paramlist>
      <param name="call" value="C:\PROGRA~2\INTELS~1\COMPIL~1.246\windows\bin\IFORTV~1.BAT ia32" />
      <param name="pushd" value="Q:\CLS_Utility_test\Hypothetical\Z1.if15_x86\" />
      <param name="executable" value="Z1.exe" />
      <param name="version" value="-v5" />
      <param name="config" value="Z1_1.config" />
    </paramlist>
  </task>
  <task namespace="Z2">
    <paramlist>
      <param name="call" value="C:\PROGRA~2\INTELS~1\COMPIL~1.246\windows\bin\IFORTV~1.BAT ia32" />
      <param name="pushd" value="Q:\CLS_Utility_test\Hypothetical\Z2.if15_x86\" />
      <param name="executable" value="Z2.exe" />
      <param name="version" value="-v5" />
      <param name="config" value="Z2_1.config" />
    </paramlist>
  </task>
  <task namespace="Z3">
    <paramlist>
      <param name="call" value="C:\PROGRA~2\INTELS~1\COMPIL~1.246\windows\bin\IFORTV~1.BAT ia32" />
      <param name="pushd" value="Q:\CLS_Utility_test\Hypothetical\Z3.if15_x86\" />
      <param name="executable" value="Z3.exe" />
      <param name="version" value="-v5" />
      <param name="config" value="Z3_1.config" />
    </paramlist>
  </task>
</simulation>
    
```

5.1.2. Configuration File

A configuration file (with extension “.cfg”) is an XML file that describes the cluster configuration and resource settings. This file is located in AppData of the Master computer:

C:\Users\johnsmith\AppData\Local\Manitoba HVDC Research Centre\CLSDData\config.cfg

This file is generated by the Cluster Launch System after the user has entered the required information.

An example of “.cfg” file is given below:

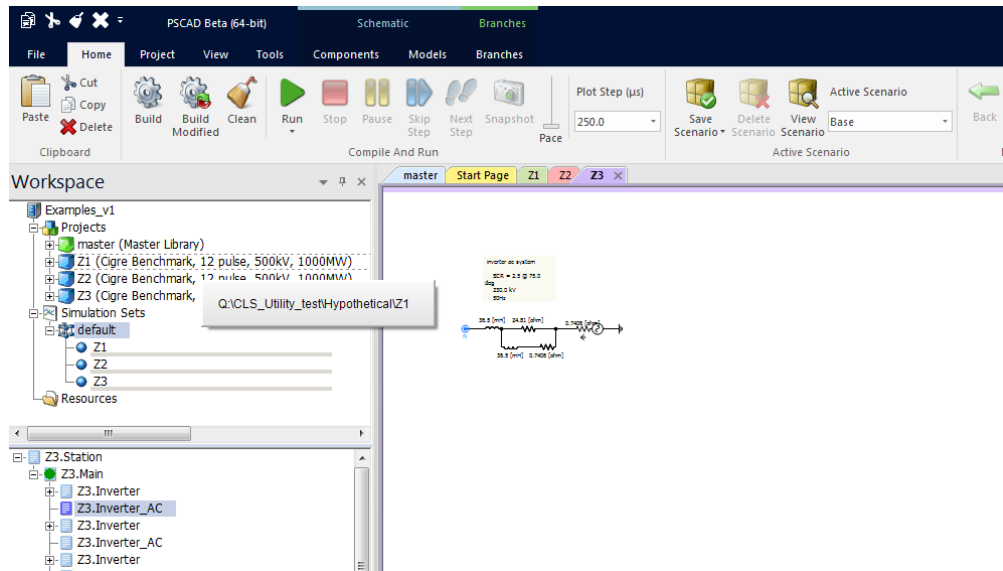
```

<!--Replace IPAddress with machine's IPAddress
Replace corecount value with number of cores in the machine
Add more machines to the cluster by copying above line and filling information-->
<cluster>
  <hostlist>
    <host ipaddress="10.100.8.35" core="2" />
    <host ipaddress="10.100.8.52" core="2" />
  </hostlist>
  <settings>
    <paramlist>
      <param name="psexec" value="C:\Downloads\PSTools\Psexec.exe" />
      <param name="netpath" value="\\workspaces\public\PSCADProject" />
      <param name="drivemap" value="Q:\" />
    </paramlist>
  </settings>
</cluster>
    
```

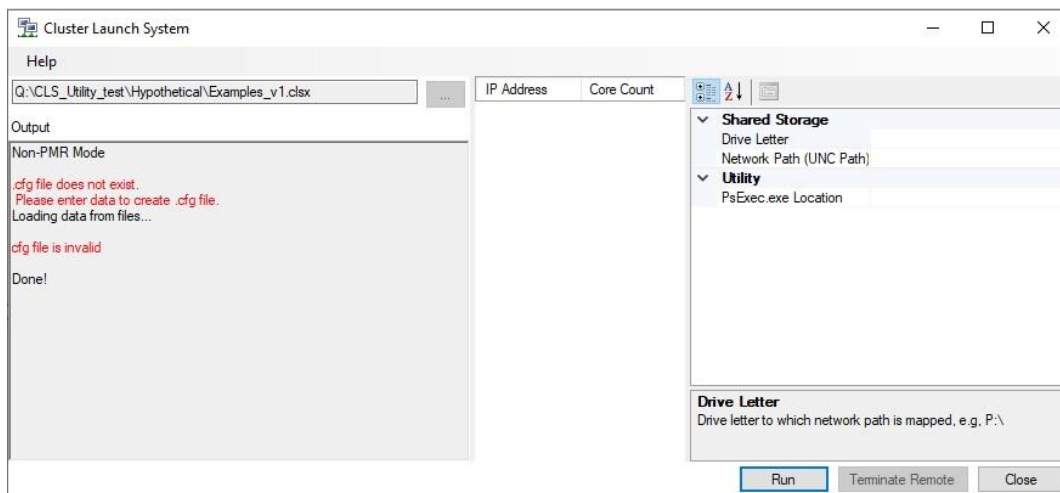
6. Configure CLS and Run Simulations

The Cluster Launch System requires the user to input cluster information (IP Address and Core Count) and Resources Settings the first time it is launched. When the user enters this information, it is saved in the “config.cfg” file. This information is then retrieved and used/shown in the GUI when CLS is launched next time.

A Parallel Network Interface (PNI) example is shown in the figure below:



When we run the simulation set named “default”, the CLS is launched as shown below:



Notice that cluster information (IP Address, Core Count) and Resource Settings (Shared Storage and Utility) are empty. This is because CLS is launched the first time and there was no “config.cfg” file from where the settings could be loaded. Also, “.clsx” file is already present, as we have launched CLS in run mode.

On the first time use of CLS, the user may be required to fill in some information, such as IP Address and Cores of the computers taking part in the execution environment, shared network drive information and PsExec.exe location.

6.1. Configure the Cluster

The user must fill in the “IP Address” of the computers (both local and remote) that are part of the computational cluster. Under “Core Count”, the user must enter the number of cores to be utilized on that particular computer.

For Example:

IP Address	Core Count
10.100.8.35	2
10.100.8.52	2

6.2. Resource Settings

Specify the shared storage network path information and the PsExec.exe path as shown below:

Shared Storage	
Drive Letter	Q:\
Network Path (UNC Path)	\\workspaces\public\PSCADProject
Utility	
PsExec.exe Location	C:\Downloads\PSTools\PsExec.exe

6.3. Saving the Settings

Cluster configuration information and Resource Settings are saved in the “config.cfg file”.

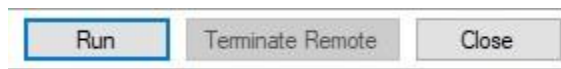
C:\Users\johnsmith\AppData\Local\Manitoba HVDC Research Centre\CLSDData\config.cfg

The user may save the entered information by pressing the Run or Close button on the CLS application. If changes are detected in the form, the user will be prompted to save the information.

When the user launches CLS, the application looks for the "config.cfg" file and loads the configuration and settings in the form.

6.4. Launching the Simulations

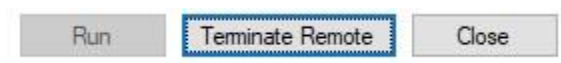
Once the information is filled in on the Cluster Launch System forms, press "Run" button to launch the simulations:



After the simulations have finished running, the user must "Close" the CLS Utility to exit back to PSCAD.

6.5. Terminating the Launched Simulations

If the simulations do not terminate properly, then "Terminate Remote" will terminate all the simulations launched by CLS.





DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	28/Feb/2020