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Preface

Welcome to the Developer Manual for Bright Cluster Manager 7.3.

0.1 About This Manual

This manual is aimed at helping developers who would like to program the Bright Cluster Manager in order to enhance or alter its functionality. It is not intended for end users who simply wish to submit jobs that run programs to workload managers, which is discussed in the User Manual. The developer is expected to be reasonably familiar with the parts of the Administrator Manual that is to be dealt with—primarily CMDaemon, of which cmsh and cmgui are the front ends.

This manual discusses the Python API to CMDaemon, and also covers how to program for metric collections.

0.2 About The Manuals In General

Regularly updated versions of the Bright Cluster Manager 7.3 manuals are available on updated clusters by default at /cm/shared/docs/cm. The latest updates are always online at http://support.brightcomputing.com/manuals.

- The Administrator Manual describes the general management of the cluster.
- The Installation Manual describes installation procedures for a basic cluster.
- The User Manual describes the user environment and how to submit jobs for the end user.
- The Cloudbursting Manual describes how to deploy the cloud capabilities of the cluster.
- The Developer Manual has useful information for developers who would like to program with Bright Cluster Manager.
- The OpenStack Deployment Manual describes how to deploy OpenStack with Bright Cluster Manager.
- The Big Data Deployment Manual describes how to deploy Big Data with Bright Cluster Manager.
- The UCS Deployment Manual describes how to deploy the Cisco UCS server with Bright Cluster Manager.
- The Machine Learning Manual describes how to install and configure machine learning capabilities with Bright Cluster Manager.

If the manuals are downloaded and kept in one local directory, then in most pdf viewers, clicking on a cross-reference in one manual that refers to a section in another manual opens and displays that section in the second manual. Navigating back and forth between documents is usually possible with keystrokes or mouse clicks.

For example: <Alt>-<Backarrow> in Acrobat Reader, or clicking on the bottom leftmost navigation button of xpdf, both navigate back to the previous document.

The manuals constantly evolve to keep up with the development of the Bright Cluster Manager environment and the addition of new hardware and/or applications. The manuals also regularly incorporate customer feedback. Administrator and user input is greatly valued at Bright Computing. So any comments, suggestions or corrections will be very gratefully accepted at manuals@brightcomputing.com.
0.3 Getting Administrator-Level Support

If the reseller from whom Bright Cluster Manager was bought offers direct support, then the reseller should be contacted.

Otherwise the primary means of support is via the website https://support.brightcomputing.com. This allows the administrator to submit a support request via a web form, and opens up a trouble ticket. It is a good idea to try to use a clear subject header, since that is used as part of a reference tag as the ticket progresses. Also helpful is a good description of the issue. The followup communication for this ticket goes via standard e-mail. Section 11.2 of the Administrator Manual has more details on working with support.

0.4 Getting Developer-Level Support

Developer support is given free, within reason. For more extensive support, Bright Computing can be contacted in order to arrange a support contract.

0.5 Getting Professional Services

Bright Computing normally differentiates between professional services (customer asks Bright Computing to do something or asks Bright Computing to provide some service) and support (customer has a question or problem that requires an answer or resolution). Professional services can be provided after consulting with the reseller, or the Bright account manager.
This chapter introduces the Python API of Bright Cluster Manager. For a head node `bright72`, the API reference documentation for all available objects is available in a default cluster via browser access to the URL:

https://bright72/userportal/downloads/python

The preceding access is via the User Portal (section 10.9 of the Administrator Manual).

The documentation is also available directly on the head node itself at:

file:///cm/local/docs/cmd/python/index.html

### 1.1 Installation

The Python cluster manager bindings are pre-installed on the head node.

#### 1.1.1 Windows Clients

For windows clients, Python version 2.5.X is needed. Newer versions of Python do not work with the API.

For Windows a redistributable package is supplied in the `pythoncm-dist` RPM package installed on the cluster. The file at `/cm/shared/apps/pythoncm/dist/windows-pythoncm.7.3.r15673.zip`—the exact version number may differ—is copied to the Windows PC and unzipped.

A Windows shell (`cmd.exe`) is opened to the directory where the Python bindings are. The `headnodeinfo.py` example supplied with the unzipped files has a line that has the following format:

```python
cluster = clustermanager.addCluster(<parameters>);
```

where `<parameters>` is either:

- `<URL>'`, `'<PEMauth1>'`, `'<PEMauth2>'`
- or
- `<URL>'`, `'<PFXauth>'`, `'password'`

The `<parameters>` entry is edited as follows:

- the correct hostname is set for the `<URL>` entry. By default it is set to `https://localhost:8081`
- If PEM key files are to be used for client authentication,
2 Bright Cluster Manager Python API

- <PEMauth1> is set to path of cert.pem
- <PEMauth2> is set to the path of cert.key

- If a PFX file is used for client authentication,
  - <PFXauth> is set to path of admin.pfx
  - <password> is set to the password

To verify everything is working, it can be run as follows:
c:\python25\python headnodeinfo.py

1.1.2 Linux Clients
For Linux clients, a redistributable source package is supplied in the pythoncm-dist package installed on the cluster. The file at /cm/shared/apps/pythoncm/dist/pythoncm-7.3-r18836-src.tar.bz2—the exact version number may differ—is copied and untarred to any directory.

The build.sh script is then run to compile the source. About 4GB of memory is usually needed for compilation, and additional packages may be required for compilation to succeed. A list of packages needed to build Python cluster manager bindings can be found in the README file included with the package.

The headnodeinfo.py example supplied with the untarred files is edited as for in the earlier windows client example, for the clustermanager.addCluster line.

The path to the remote cluster manager library is added:

export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:remotecm

To verify everything is working, the following can be run:

python ./headnodeinfo.py

1.2 Examples
A set of examples can be found in /cm/local/examples/cmd/python/ on the head node of the cluster.

1.2.1 First Program
A Python script is told to use the cluster manager bindings by importing pythoncm at the start of the script:

import pythoncm

If not working on the cluster, the administrator needs to set the path where the shared libraries can be found (pythoncm.so in Linux, or python.pyd in windows). This is done by adding the following to the start of the script:

import sys
sys.path.append(".") # path to pythoncm.so/python.pyd

Python cluster manager bindings allow for simultaneous connections to several clusters. For this reason the first thing to do is to create a ClusterManager object:

clustermanager = pythoncm.ClusterManager()

A connection to a cluster can now be made. There are two possible ways of connecting.

The first is using the certificate and private key file that cmsh uses by default when it authenticates from the head node.
cluster = clustermanager.addCluster('https://mycluster:8081',
 '/root/.cm/admin.pem', '/root/.cm/admin.key');

The second way uses the password protected admin.pfx file, which is generated with the cmd -c command. A Python script could ask for the password and store it in a variable for increased security.

cluster = clustermanager.addCluster('https://mycluster:8081',
 '/root/.cm/cmgui/admin.pfx', '', '<password>');

Having defined the cluster, a connection can now be made to it:

isconnected = cluster.connect()
if !isconnected:
    print "Unable to connect"
    print cluster.getLastError()
    exit(1)

If a connection cannot be made, the function cluster.connect() returns false. The function cluster.getLastError() shows details about the problem. The two most likely problems are due to a wrong password setting or a firewall settings issue.

Similar to cmgui and cmsh, the cluster object contains a local cache of all objects. This cache will be filled automatically when the connection is established. All changes to properties will be done on these local copies and will be lost after the Python script exits, unless a commit operation is done.

The most common operation is finding specific objects in the cluster.

active = cluster.find('active')
if active == None:
    print "Unable to find active head node"
    exit(1)
else:
    print "Hostname of the active head node is %s" % active.hostname

If creating an automated script that runs at certain times, it is highly recommended to check if objects can be found. During a failover, for instance, there will be a period over a few minutes in which the active head node will not be set.

It is good practice to disconnect from the cluster at the end of the script.

cluster.disconnect()

When connecting to a cluster with a failover setup, it is the shared IP address that should be connected to, and not the fixed IP address of either of the head nodes.

1.3 Methods And Properties

1.3.1 Viewing All Properties And Methods

All properties visible in cmsh and cmgui are also accessible from Python cluster manager bindings.

The easiest way to get an overview of the methods and properties of an object is to define the following function:

```python
import re
def dump(obj):
    print "--- DUMP ---"
    for attr in dir(obj):
        p = re.compile('^__.*__$')
        if not p.match(attr):
            print "%s = %s" % (attr, getattr(obj, attr))
```

An overview of all properties and methods for the active head node can be obtained with:

```python
active = cluster.find('active')
dump(active)
```
1.3.2 Property Lists

Most properties are straightforward and their names are almost identical to the \texttt{cmsh} equivalent. For instance:

\begin{verbatim}
node.mac = '00:00:00:00:00:00'
category.softwareimage = cluster.find('testimage')
\end{verbatim}

Properties that contain lists, like \texttt{node.roles}, \texttt{node.interfaces}, \texttt{category.fsmounts} and several others, are trickier to deal with. While iterating over a list property is simple enough:

\begin{verbatim}
for role in node.roles:
    print role.name
\end{verbatim}

because of an implementation restriction, adding a new role requires that a local copy of the roles list be made:

\begin{verbatim}
roles = node.roles
provisioningrole = pythoncm.ProvisioningRole() # Create a new provisioning role object
roles.append(provisioningrole)
node.roles = roles # This will update the internal roles list with the local copy
\end{verbatim}

1.3.3 Creating New Objects

Creating a new node can be done with:

\begin{verbatim}
node = pythoncm.Node()
\end{verbatim}

This is valid command, but fairly useless because a node has to be a \texttt{MasterNode}, \texttt{PhysicalNode} or \texttt{VirtualSMPNode}. So to create a normal compute or login node, the object is created as follows:

\begin{verbatim}
node = pythoncm.PhysicalNode()
\end{verbatim}

The first thing to do after creating a new object is to add it to a cluster.

cluster.add(node)

It is impossible to add one node to more than one cluster.

After the node has been added its properties can be set. In \texttt{cmsh} and \texttt{cmgui} this is semi-automated, but in Python cluster manager bindings it has to be done by hand.

\begin{verbatim}
node.hostname = 'node001'
ode.partition = cluster.find('base')
ode.category = cluster.find('default')
\end{verbatim}

Similar to the node object, a \texttt{NetworkInterface} object has several subtypes: \texttt{NetworkPhysicalInterface}, \texttt{NetworkVLANInterface}, \texttt{NetworkAliasInterface}, \texttt{NetworkBondInterface}, and \texttt{NetworkIPMIInterface}.

\begin{verbatim}
interface = pythoncm.NetworkPhysicalInterface()
interface.name = 'eth0'
interface.ip = '10.141.0.1'
interface.network = cluster.find('internalnet')
node.interfaces = [interface]
ode.provisioningInterface = interface
\end{verbatim}

Having set the properties of the new node, it can now be committed.

\begin{verbatim}
cr = node.commit()
\end{verbatim}
If a commit fails for some reason, the reason can be found:

```python
if not cr.result:
    print "Commit of %s failed:" % node.resolveName()
    for j in range(cr.count):
        print cr.getValidation(j).msg
```

1.3.4 List Of Objects

In the following lists of objects:

- Objects marked with (*) cannot be used
- Trees marked with (+) denote inheritance

### Roles

- Role (*):
  - BackupRole
  - BootRole
  - DatabaseRole
  - EthernetSwitch
  - LoginRole
  - LSFClientRole
  - LSFServerRole
  - MasterRole
  - PbsProClientRole
  - PbsProServerRole
  - ProvisioningRole
  - SGEClientRole
  - SGEServerRole
  - SlurmClientRole
  - SlurmServerRole
  - SubnetManagerRole
  - TorqueClientRole
  - TorqueServerRole

### Devices

- Device (*):
  - Chassis
  - GpuUnit
  - GenericDevice
  - PowerDistributionUnit
  - Switch (+):
    - EthernetSwitch
    - IBSwitch
    - MyrinetSwitch
  - Node (*):
    - FSExport
    - FSMount
    - MasterNode
    - SlaveNode (+):
      - PhysicalNode
      - VirtualSMPNode

### Network Interfaces

- NetworkInterface (+)
  - NetworkAliasInterface
  - NetworkBondInterface
+ NetworkIpmiInterface
+ NetworkPhysicalInterface
+ NetworkVLANInterface

**Information Objects**
ClusterSetup
GuiClusterOverview
GuiCephOverview
GuiHadoopHDFSOverview
GuiOpenStackOverview
GuiOpenStackTenantOverview
GuiGpuUnitOverview
GuiNodeOverview
GuiNodeStatus
LicenseInfo
SysInfoCollector
VersionInfo

**Monitoring Configuration Objects**
MonConf
ConsolidatorConf
MonHealthConf
HealthCheck
MonMetricConf
ThreshActConf
ThreshAction
Threshold

**LDAP Objects**
User
Group

**Category Objects**
Category
FSExport
FSMount

**Miscellaneous Objects**
SoftwareImage

KernelModule

Network

NodeGroup

Partition
+ BurnConfig
Rack
1.3 Methods And Properties

1.3.5 Useful Methods

For The Cluster Object:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>find(&lt;name&gt;)</td>
<td>Find the object with a given name, &lt;name&gt;</td>
</tr>
<tr>
<td>find(&lt;name&gt;, &lt;type&gt;)</td>
<td>Because it is possible to give a category and node the same name, sometimes the type &lt;type&gt; of the object needs to be specified too</td>
</tr>
<tr>
<td>getAll(&lt;type&gt;)</td>
<td>Get a list of all objects of a given type: e.g., device, category</td>
</tr>
<tr>
<td>activeMaster()</td>
<td>Get the active master object</td>
</tr>
<tr>
<td>passiveMaster()</td>
<td>Get the active master object</td>
</tr>
<tr>
<td>overview()</td>
<td>Get all the data shown in the cmgui cluster overview</td>
</tr>
<tr>
<td>add(&lt;object&gt;)</td>
<td>Add a newly created object &lt;object&gt; to the cluster. Only after an object is added can it be used</td>
</tr>
<tr>
<td>pexec(&lt;nodes&gt;, &lt;command&gt;)</td>
<td>Execute a command &lt;command&gt; on one or more nodes</td>
</tr>
</tbody>
</table>

For Any Object:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>commit()</td>
<td>Save changes to the cluster</td>
</tr>
<tr>
<td>refresh()</td>
<td>Undo all changes and restore the object to its last saved state</td>
</tr>
<tr>
<td>remove()</td>
<td>Remove an object from the cluster</td>
</tr>
<tr>
<td>clone()</td>
<td>Make an identical copy. The newly created object is not added to a cluster yet</td>
</tr>
</tbody>
</table>

For Any Device:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>close()</td>
<td>Close a device</td>
</tr>
<tr>
<td>open()</td>
<td>Open a device</td>
</tr>
<tr>
<td>powerOn()</td>
<td>Power on a device</td>
</tr>
<tr>
<td>powerOff()</td>
<td>Power off a device</td>
</tr>
<tr>
<td>powerReset()</td>
<td>Power reset a device</td>
</tr>
<tr>
<td>latestMonitoringData()</td>
<td>Return a list of the most recent monitoring data</td>
</tr>
</tbody>
</table>

For Any Node:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>overview()</td>
<td>Get the data displayed in the cmgui node overview tab</td>
</tr>
<tr>
<td>sysinfo()</td>
<td>Get the data displayed in the cmgui node system information tab</td>
</tr>
<tr>
<td>pexec(&lt;command&gt;)</td>
<td>Execute a command</td>
</tr>
</tbody>
</table>

1.3.6 Useful Example Program

In the directory /cm/local/examples/cmd/python are some example programs using the python API.
One of these is `printall.py`. It displays values for objects in an easily viewed way. With `all` as the argument, it displays resource objects defined in a list in the program. The objects are 'Partition', 'MasterNode', 'SlaveNode', 'Category', 'SoftwareImage', 'Network', 'NodeGroup'. The output is displayed something like (some output elided):

**Example**

```
[root@bright72 ~]# cd /cm/local/examples/cmd/python
[root@bright72 python]# ./printall all
Partition base
  +- revision ......................
  | name .......................... base
  | clusterName .................. Bright 7.3 Cluster
  ...
  | burnConfigs
  |   +- revision ..................
  |   | name ...................... default
  |   | description ............... Standard burn test.
  |   | configuration ............. < 2780 bytes >
  |   +- revision ..................
  |   | name ...................... long-hpl
  ...
  | provisioningInterface ........ None
  | fmounts ........................ < none >
  | fsexports
  |   +- revision ..................
  |   | name ...................... /cm/shared@internalnet
  |   | path ...................... /cm/shared
  |   | hosts ........................ !17179869185!
  ...
Category default
  +- revision ......................
  | name .......................... default
  | softwareImage .................. default-image
  | defaultGateway ................. 10.141.255.253
  | nameServers ................... < none >
  ...
```

The values of a particular resource-level object, such as `softwareimage`, can be viewed by specifying it as the argument:

**Example**

```
[root@bright72 python]# ./printall.py softwareimage
softwareimage default-image
  +- revision ......................
  | name .......................... default-image
  | path .......................... /cm/images/default-image
  | originalImage .................. 0
  | kernelVersion .................. 2.6.32-431.11.2.el6.x86_64
  | kernelParameters ............... rdblacklist=nouveau
  | creationTime ................... 1398679806
  | modules
  |   +- revision ..................
  |   | name ........................ xen-netfront
  ...
```
1.4 The Workload Management API

The workload management API allows the submission of jobs, the retrieval of information on jobs and queues, and the management of jobs and queues. The methods described in this section are a part of the cmjob service. They can also be accessed via the Cluster object, with exception of the getParentJobs and getJobsSlice methods.

Workload management examples for a particular workload manager <wlm> in Python can be found on the head node in the directory:

/cm/local/examples/cmd/python/workload<-wlm>.py

Here, <wlm> can take the values torque, slurm, sge, pbspro, openlava, or lsf. The examples define a job, with different job properties associated with different workload managers. With the right properties set, the job can be submitted and the submitted job outputs are printed to STDOUT.

Details of entities and their properties can be found in the CMDaemon API reference.

1.4.1 Job Submission

Job submission is performed with the submitJob method. Its only argument is the Job entity that provides the properties and resource requirements of the job that is submitted.

Each workload manager uses its own job properties format, although they usually behave in a similar way. The following table shows the correspondence between Job entity parameters and the submission parameters for each workload manager.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Slurm</th>
<th>PBS Pro</th>
<th>LSF openlava</th>
<th>UGE OGS (SGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue</td>
<td>-p</td>
<td>-q</td>
<td>-q</td>
<td>-q</td>
</tr>
<tr>
<td>jobname</td>
<td>-J</td>
<td>-N</td>
<td>-J</td>
<td>-N</td>
</tr>
<tr>
<td>Parameter</td>
<td>Slurm</td>
<td>PBS Pro</td>
<td>LSF</td>
<td>UGE</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------</td>
<td>---------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>account</td>
<td>-A</td>
<td>-A</td>
<td>N/A</td>
<td>-A</td>
</tr>
<tr>
<td>project</td>
<td>N/A</td>
<td>-P</td>
<td>-P</td>
<td>-P</td>
</tr>
<tr>
<td>rundirectory</td>
<td>-D</td>
<td>-w</td>
<td>N/A</td>
<td>-wd</td>
</tr>
<tr>
<td>username</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Job script is submitted by this user</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>groupname</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Job script is submitted with group permissions of this user</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>priority</td>
<td>--nice</td>
<td>-p</td>
<td>-sp</td>
<td>-p</td>
</tr>
<tr>
<td>stdinfile</td>
<td>-i</td>
<td>N/A</td>
<td>-i</td>
<td>-i</td>
</tr>
<tr>
<td>stdoutfile</td>
<td>-o</td>
<td>-o</td>
<td>-o</td>
<td>-o</td>
</tr>
<tr>
<td>stderrfile</td>
<td>-e</td>
<td>-e</td>
<td>-e</td>
<td>-e</td>
</tr>
<tr>
<td>dependencies</td>
<td>-d</td>
<td>-W</td>
<td>--hold_jid</td>
<td>-w</td>
</tr>
<tr>
<td>mailNotify</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enables passing other email options, not used directly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mailOptions</td>
<td>--mail-type</td>
<td>-m</td>
<td>-B</td>
<td>-m</td>
</tr>
<tr>
<td>mailList</td>
<td>--mail-user</td>
<td>-M</td>
<td>-u</td>
<td>-M</td>
</tr>
<tr>
<td>resourceList</td>
<td>-C</td>
<td>-l</td>
<td>-R</td>
<td>-l</td>
</tr>
</tbody>
</table>

...continues
...continued

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Slurm</th>
<th>PBS Pro Torque</th>
<th>LSF openlava</th>
<th>UGE OGS (SGE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>maxWallClock</td>
<td>-t</td>
<td>-l walltime</td>
<td>-c</td>
<td>-l h_rt=</td>
</tr>
<tr>
<td>maxNodes</td>
<td>-N</td>
<td>-l select=</td>
<td>-R span[hosts=]</td>
<td>N/A</td>
</tr>
<tr>
<td>nodes</td>
<td>-w</td>
<td>-l select=</td>
<td>-m</td>
<td>-l hostname=</td>
</tr>
</tbody>
</table>

**environmentVariables** All additional environment variables are passed to the job

**commandLineInterpreter**  
Interpreter path is added as a first line into the jobscript

**executable** Added as a command at the end of a new created jobscript.

**arguments** Appended to executable line

**modules** Module files will be added to job script environment

**userdefined** These lines are added into the jobscript before the executable line

**scriptFile** If scriptfile is specified, then only is it submitted

**debug** Return debug info (without submission), including generated script

---

**Notes:**

1. In the case of LSF and OpenLava, the rundirectory parameter of the job entity is converted into a cd command line, that is added to the job script before any commands.

2. The executable file path and its arguments are translated to a single line in the job script. If more complex commands are required then the parameter userdefined should be used instead of executable and arguments. If userdefined is not an empty list, then executable and arguments are ignored.
1.4.2 Job Information And Management

For job manipulation the following functions are used. In these functions, the parameter `<scheduler>` is the name of the workload manager that the operation is applied to, and takes a value of `slurm`, `uge`, `sge`, `openlava`, `lsf`, `torque` or `pbspro`. The parameter `<JobID>` is a string in a format related to that particular workload manager.

**getJobs**(`<scheduler>`): returns Job entities for the specified scheduler. This function triggers a call to the workload manager utility. The workload manager utility is, for example, `qstat` in the case of SGE or Torque, and `scontrol` in the case of Slurm. In profiles (section 6.4 of the Administrator Manual), `GET_JOB_TOKEN` is needed to be able to get all the jobs, while `GET_OWN_JOB_TOKEN` is needed to get just all the jobs belonging to the user making the call.

**getJob**(`<scheduler>`), `<JobID>`): returns a job by job ID. `GET_JOB_TOKEN` is needed to be able to get any job, and `GET_OWN_JOB_TOKEN` is needed to be able to get just the job belonging to the user making the call.

**removeJob**(`<scheduler>`), `<JobID>`): removes the job by job ID and returns the result of job removal. `UPDATE_JOB_TOKEN` is needed to be able to remove any job, and `UPDATE_OWN_JOB_TOKEN` is needed to be able to remove just the job belonging to the user making the call.

**getJobsSlice**(`<scheduler>`), `<start>`, `<maxCount>`, `<parentID>`, `<allUsers>`): returns jobs at the position `<start>` in the global list (sorted by job ID), but only up to `<maxCount>` items. That is, if the value of the parameter `<start>` is a number `n`, then jobs starting from the `n`th item in the global list are returned, up to `<maxCount>` times. `<parentID>` is a method to group jobs by a keyword in the comment string of the jobs. `<allUsers>` specifies, using the value `True` or `False`, whether the jobs of all users should be considered—a value of `False` means that only the jobs owned by the requestor are considered. `GET_JOB_TOKEN` is needed to get any job slice, while `GET_OWN_JOB_TOKEN` is needed to get just the job slices belonging to the user making the call.

**getParentJobs**(`<scheduler>`), `<start>`, `<maxCount>`, `<parentID>`, `<allUsers>`): returns parentJob entities at the position `<start>` in the global list (sorted by parent job ID), but only up to `<maxCount>` items. That is, if the value of the parameter `<start>` is a number `n`, then jobs starting from the `n`th item in the global list are returned, up to `<maxCount>` times. `<parentID>` is a method to group jobs by a keyword in the comment string of the jobs. By default it has an empty value passed to it. If `<parentID>` is given a parent ID value, then the parent job is treated as owned by particular user if and only if all jobs with this tag (parent id) are submitted by that user. Setting `<allUsers>` specifies, using the value `True` or `False`, whether the jobs of all users should be considered—a value of `False` means that only the jobs owned by the requestor are considered. `GET_JOB_TOKEN` is needed to get any job slice, while `GET_OWN_JOB_TOKEN` is needed to get just the job slices belonging to the user making the call.

**requeueJob**(`<scheduler>`), `<JobID>`): requeues job and returns the result of this operation as a string. `REQUEUE_JOB_TOKEN` is needed to be able to requeue any job, while `REQUEUE_OWN_JOB_TOKEN` is needed to be able to requeue just the job belonging to the user making the call.

**holdJob**(`<scheduler>`), `<JobID>`): holds the job and returns the result of this operation as a string. `HOLD_JOB_TOKEN` is needed to be able to hold any job, while `HOLD_OWN_JOB_TOKEN` is needed to be able to hold just the job belonging to the user making the call.
suspendJob(<scheduler>, <jobID>): suspends the job and returns the result of this operation as a string. SUSPEND_JOB_TOKEN is needed to be able to suspend any job, while SUSPEND_OWN_JOB_TOKEN is needed to be able to suspend just the job belonging to the user making the call.

generateJob(<scheduler>, <jobID>): resumes the job and returns the result of this operation as a string. RESUME_JOB_TOKEN is needed to be able to resume any job, while RESUME_OWN_JOB_TOKEN is needed to be able to resume just the job belonging to the user making the call.

releaseJob(<scheduler>, <jobID>): releases the job and returns the result of this operation as a string. RELEASE_JOB_TOKEN is needed to be able to release any job, while RELEASE_OWN_JOB_TOKEN is needed to be able to release just the job belonging to the user making the call.

updateJob(<scheduler>, <jobID>): updates the job and returns the result of this operation as a string. UPDATE_JOB_TOKEN is needed to be able to update any job, while UPDATE_OWN_JOB_TOKEN is needed to be able to update just the job belonging to the user making the call.

isNodeAllocatedForUser(<scheduler>, <username>, <hostname>): returns true if at least one job owned by the user, as specified by the value of <username> allocates the host, as specified by the value of <hostname>.

Parent job is an entity introduced in Bright 7.3 and serves a goal of jobs clusterization. The jobs can be united by a tag surrounded by square brackets (for example "[workflow1]"). The tag is parsed by CMDaemon from the job comment line. The first entry of such a tag in the job comment is considered as the parent job ID. CMDaemon caches parent jobs, and an API client can request all the parent jobs or just some particular one. This allows the client to unite jobs by some user-defined property in a workflow, even if the workload manager does not support the workflow.

1.4.3 Queue Information And Management
For queue manipulation the following functions are used.

getJobQueues(): retrieves all JobQueue entities. Requires GET_JOBQUEUE_TOKEN.

getJobQueue(<queueName>): retrieves a particular JobQueue entity. Here <queueName> is a string. Requires GET_JOBQUEUE_TOKEN.

getParallelEnvs(<scheduler>): retrieves a list of ParallelEnvironment entities associated with a particular workload manager. Requires GET_PE_TOKEN.

getJobQueueStates(): retrieves a list of JobQueueStat entities. Requires GET_JOBQUEUE_TOKEN.

updateJobQueue(<jobQueue>, <force>): updates job queue properties defined by JobQueue entity. Parameter <force> is ignored for now. Requires UPDATE_JOBQUEUE_TOKEN.

addJobQueue(<jobQueue>, <force>): adds a new job queue to workload manager. If <force> has the value True, then the existing queue is recreated. Requires ADD_JOBQUEUE_TOKEN.

removeJobQueue(<queueKey>, <force>): removes queue by key. The key can be retrieved from the JobQueue entity requested by the getJobQueue method. Parameter <force> is ignored for now. Requires UPDATE_JOBQUEUE_TOKEN.
**drainNodes**(<scheduler>, <queue>, <nodes>, <drain>): drains nodes (as defined by a list of hostnames or uniqueKeys) or a particular queue (if supported by the workload manager) in the workload manager. If <drain> has the value 1, then the nodes will be drained, otherwise they are undrained. Returns a list of DrainResult entities. Requires DRAIN_TOKEN.

**drainOverview**(<scheduler>, <nodes>): returns DrainResult entities with current drain state of the nodes. The nodes are defined by a list of hostnames or uniqueKeys. Requires DRAIN_OVERVIEW_TOKEN.
This chapter gives details on metric collections.

Section 10.4.4 of the Administrator Manual introduces metric collections, and describes how to add a metric collections script with cmgui.

This chapter covers how to add a metric collections script with cmsh. It also describes the output specification of a metric collections script, along with example outputs, so that a metric collections script can be made by the administrator.

2.1 Metric Collections Added Using cmsh

A metric collections script, responsiveness, is added in the monitoring metrics mode just like any other metric.

Example

[bright72]% monitoring metrics
[bright72->monitoring->metrics]% add responsiveness
[...[responsiveness]]% set command /cm/local/apps/cmd/scripts/metrics/sample_responsiveness
[...*[responsiveness*]]% set classofmetric prototype; commit

For classofmetric, the value prototype is the class used to distinguish metric collections from normal metrics.

2.2 Metric Collections Initialization

When a metric collections script is added to CMDaemon for the first time, CMDaemon implicitly runs it with the --initialize flag. The output is used to define the collections table header structure. The structure is composed of the component metrics in the collections script, and the resulting structure is placed in the CMDaemon monitoring database. After the initialization step, data values can be added to the collections table during regular use of the script.

The displayed output of a metric collections script when using the --initialize flag is a list of available metrics and their parameter values. The format of each line in the list is:

metric <name[:parameter]> <unit> <class> "<description>" <cumulative> <min> <max>

where the items in the line are:

- metric: A bare word.
- <name[:parameter]>: The name of the metric, with for certain metrics a parameter value. For example, the metric AlertLevel can have the parameter sum assigned to it with the “:” character.
• `<unit>`: The unit of measurement that the metric uses.

• `<class>`: Any of:
  
  – ceph,
  – cgroups/blkio,cgroups/cpu,cgroups/memory,cgroups/network,
  – cluster,
  – cpu,
  – dellness,
  – disk,
  – env,
  – gpu,
  – hadoop/dfs, hadoop/mapred, hadoop/metricsystem, hadoop/rpcdetailed, hadoop/ugu
  – internal,
  – lustre,
  – madoop/rpc,
  – mem,
  – misc
  – net,
  – os,
  – prototype,
  – workload.

• `<description>`: This can contain spaces, but should be enclosed with quotes.

• `<cumulative>`: Either yes or no. This indicates whether the metric increases monotonically (e.g., bytes received) or not (e.g., temperature).

• `<min>` and `<max>`: The minimum and maximum numeric values of this metric are determined dynamically based on the values so far.

Example

[root@myheadnode metrics]# ./sample_responsiveness --initialize
metric util_sda % internal "Percentage of CPU time during which I/O requests were issued to device sda" no 0 100
metric await_sda ms internal "The average time (in milliseconds) for I/O requests issued to device sda to be served" no 0 500

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2.3 Metric Collections Output During Regular Use

The output of a metric collection script without a flag is a list of outputs from the available metrics. The format of each line in the list is:

```
metric <name [:parameter]> <value> [infomessage]
```

where the parameters to the `metric` bare word are:

- `<name [:parameter]>`: The name of the metric, with optional parameter for some metrics.
- `<value>`: The numeric value of the measurement.

**Example**

```
[root@myheadnode metrics]# ./sample_responsiveness
metric await_sda 0.00
metric util_sda 0.00
[root@myheadnode metrics]#
```

If the output has more metrics than that suggested by when the `--initialize` flag is used, then the extra sampled data is discarded. If the output has fewer metrics, then the metrics are set to NaN (not a number) for the sample.

A metric or health check inside a metric collection appears as a check when viewing metrics or healthcheck lists. Attempting to remove such a check specifically using cmsh or cmgui only succeeds until the node is updated or rebooted. It is the metric collection itself that should have the check removed from within it, in order to remove the check from the list of checks permanently.

Setting a node that is UP to a CLOSED state, and then bringing it out of that state with the `open` command (section 5.5.4 of the Administrator Manual) also has CMDaemon run the metric collections script with the `--initialize` flag. This is useful for allowing CMDaemon to re-check what metrics in the collections can be sampled, and then re-configure them.

2.4 Metric Collections Error Handling

If the exit code of the script is 0, CMDaemon assumes that there is no error. So, with the `--initialize` flag active, despite no numeric value output, the script does not exit with an error.

If the exit code of the script is non-zero, the output of the script is assumed to be a diagnostic message and is passed to the head node. This shows up as an event in cmsh or cmgui.

For example, the `sample_ipmi` script uses the `ipmi-sensors` binary internally. Calling the binary directly returns an error code if the device has no IPMI configured. However, the `sample_ipmi` script in this case simply returns 0, and no output. The rationale here being that the administrator is aware of this situation and would not expect data from that IPMI anyway, let alone an error.

2.5 Metric Collections Consolidator Syntax

Metric collections can have a consolidator format defined per metric. The consolidator definition must be placed as an output in the line immediately preceding the corresponding metric initialization output line. The consolidator definition line can take the following forms:

```
consolidators default
consolidators none
consolidators CONSOLIDATORNAME FORMAT SPECIFICATION
```

The meanings of the texts after `consolidators` are as follows:
• **default**: The metrics follow the default consolidator names and interval values (section 10.7.4, page 426 of the *Administrator Manual*). That is, consolidator names take the value of Hour, Day, Week, while the interval values are the corresponding durations in seconds.

• **consolidators none**: No consolidation is done, only raw data values are collected for the metrics.

• **CONSORTIATORNAME FORMAT SPECIFICATION**: This has the form:

  \(<name:\interval[::\kind[::\tablelength]]>\ldots\>

  - **name**: the consolidator name. A special feature here is that it can also define a new consolidator if the name does not already exist. Multiple consolidators can be defined in each consolidator definition line, with name separated from any preceding definition on the same line by a space.

  - **interval**: the duration in seconds, between consolidation, for the consolidator.

  - **kind**: an optional value of min, max, or average. By default it is average.

  - **tablelength**: an optional value for the length of the table, if kind has been specified. By default it is 1000.

### 2.6 Metric Collections Environment Variables

The following environment variables are available for a metric collection script, as well as for custom scripts, running from CMDaemon:

**On all devices:**

CMD\_HOSTNAME: name of the device. For example:

CMD\_HOSTNAME=myheadnode

**Only on non-node devices:**

CMD\_IP: IP address of the device. For example:

CMD\_IP=192.168.1.33

**Only on node devices:**

Because these devices generally have multiple interfaces, the single environment variable CMD\_IP is often not enough to express these. Multiple interfaces are therefore represented by these environment variables:

• **CMD\_INTERFACES**: list of names of the interfaces attached to the node. For example:

  CMD\_INTERFACES=eth0 eth1 ipmi0 BOOTIF

• **CMD\_INTERFACE\_<interface>\_IP**: IP address of the interface with the name <interface>. For example:

  CMD\_INTERFACE\_eth0\_IP=10.141.255.254
  CMD\_INTERFACE\_eth1\_IP=0.0.0.0

• **CMD\_INTERFACE\_<interface>\_TYPE**: type of interface with the name <interface>. For example:
CMD_INTERFACE_eth1_TYPE=NetworkPhysicalInterface
CMD_INTERFACE_ipmi0_TYPE=NetworkBmcInterface

Possible values are:
- NetworkBmcInterface
- NetworkPhysicalInterface
- NetworkVLANInterface
- NetworkAliasInterface
- NetworkBondInterface
- NetworkBridgeInterface
- NetworkTunnelInterface
- NetworkNetMapInterface

- CMD_BMCUSERNAME: username for the BMC device at this node (if available).
- CMD_BMCPASSWORD: password for the BMC device at this node (if available).

To parse the above information to get the BMC IP address of the node for which this script samples, one could use (in Perl):

```perl
my $ip;
my $interfaces = $ENV{"CMD_INTERFACES"};
foreach my $interface ( split( " ", $interfaces ) ) {
    if( $ENV{"CMD_INTERFACE_" . $interface . "_TYPE"} eq "NetworkBmcInterface" ) {
        $ip = $ENV{"CMD_INTERFACE_" . $interface . "_IP"};
        last;
    }
}
# $ip holds the bmc ip
```

A list of environment variables available under the CMDaemon environment can be found by running a script under CMDaemon and exporting the environment variables to a file for viewing. For example, the /cm/local/apps/cmd/scripts/healthchecks/testhealthcheck script can be modified and run to sample on the head node, with the added line: set>/tmp/environment. The resulting file /tmp/environment that is generated as part of the healthcheck run then includes the CMD_* environment variables.

**Example**

CMD_BMCPASSWORD
CMD_BMCUSERNAME
CMD_CLUSTERNAME
CMD_CMDSTARTEDTIME
CMD_DEVICE_TYPE
CMD_EXPORTS
CMD_FSEXPORT__cm__SLASH_shared_AT_internalnet_ALLOWWRITE
CMD_FSEXPORT__cm__SLASH_shared_AT_internalnet_HOSTS
CMD_FSEXPORT__cm__SLASH_shared_AT_internalnet_PATH
CMD_FSEXPORT__home_AT_internalnet_ALLOWWRITE
CMD_FSEXPORT__home_AT_internalnet_HOSTS
CMD_FSEXPORT__home_AT_internalnet_PATH
CMD_FSEXPORT__var__SLASH_spool__SLASH_burn_AT_internalnet_ALLOWWRITE
CMD_FSEXPORT__var__SLASH_spool__SLASH_burn_AT_internalnet_HOSTS

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2.7 Metric Collections Examples

Bright Cluster Manager has several scripts in the `/cm/local/apps/cmd/scripts/metrics` directory. Among them are the metric collections scripts `testmetriccollection` and `sample_responsiveness`. A glance through them while reading this chapter may be helpful.

2.8 Metric Collections On iDataPlex And Similar Units

IBM’s iDataPlex is a specially engineered dual node rack unit. When the term iDataPlex is used in the following text in this section, it also implies any other dual node units that show similar behavior.

This section gives details on configuring an iDataPlex if IPMI metrics retrieval seems to skip most IPMI values from one of the nodes in the unit.

When carrying out metrics collections on an iDataPlex unit, Bright Cluster Manager should work without any issues. However, it may be that due to the special paired node design of an iDataPlex unit, most IPMI metrics of one member of the pair are undetectable by the `sample_ipmi` script sampling on that particular node. The missing IPMI metrics can instead be retrieved from the second member in the pair (along with the IPMI metrics of the second member).
2.8 Metric Collections On iDataPlex And Similar Units

The output may thus look something like:

**Example**

```
[root@master01 ~]# cmsh
[master01]% device latestmetricdata node181 | grep Domain
Metric       Value
------------- -----
Domain_A_FP_Temp  23
Domain_A_Temp1   39
Domain_A_Temp2   37
Domain_Avg_Power 140
Domain_B_FP_Temp 24
Domain_B_Temp1   40
Domain_B_Temp2   37
[master01]% device latestmetricdata node182 | grep Domain
Metric       Value
------------- -----
Domain_A_FP_Temp no data
Domain_A_Temp1  no data
Domain_A_Temp2  no data
Domain_Avg_Power 170
Domain_B_FP_Temp no data
Domain_B_Temp1  no data
Domain_B_Temp2  no data
[master01]%
```

Because there are usually many iDataplex units in the rack, the metrics retrieval response of each node pair in a unit should be checked for this behavior.

The issue can be dealt with by Bright Cluster Manager by modifying the configuration file for the sample_ipmi script in /cm/local/apps/cmd/scripts/metrics/configfiles/sample_ipmi.conf. Two parameters that can be configured there are chassisContainsLeadNode and chassisContainsLeadNodeRegex.

- Setting **chassisContainsLeadNode** to **on** forces the sample_ipmi script to treat the unit as an iDataPlex unit.

  In particular:

  - **auto** (recommended) means the unit is checked by the IPMI metric sample collection script for whether it behaves like an iDataPlex unit.

  - **on** means the unit is treated as an iDataplex node pair, with one node being a lead node that has all the IPMI metrics.

  - **off** means the unit is treated as a non-iDataplex node pair, with each node having normal behavior when retrieving IPMI metrics. This setting may need to be used in case the default value of **auto** ever falsely detects a node as part of an iDataPlex pair.

- The value of **chassisContainsLeadNodeRegex** can be set to a regular expression pattern that matches the system information pattern for the name, as obtained by CMDaemon for an iDataPlex unit (or similar clone unit). The pattern that it is matched against is the output of:

  ```
  cmsh -c 'device ; sysinfo master | grep "^System Name"'
  ```

  If the pattern matches, then the IPMI sample collection script assumes the unit behaves like an iDataPlex dual node pair. The missing IPMI data values are then looked for on the lead node.

  The value of **chassisContainsLeadNodeRegex** is set to iDataPlex by default.
3

Bright Cluster Manager JSON API

This chapter gives an alphabetical list of the JSON API services and entities available for Bright Cluster Manager. The API reference documentation for all available services and entities is available on the head node at:

/cm/local/docs/cmd/json/index.html.

Some examples of JSON use are given in section 3.3

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3.1.2 ceph
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3.3 JSON Examples

complete.sh
#!/bin/bash

URL=https://localhost:2081/json/
user=koen
pass=koen

echo "========== login ==========="
curl -c curl.cookiest.txt -i -k -X POST -d '{"service":"login", "username":"koen", "password":"$pass"}' $URL; echo
echo "========== master =========="
curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"cm
device","call":"getNode","arg":"master"}' $URL; echo
echo "========== logout ==========

curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"logout"}' $URL; echo
echo "========== denied ==========
curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"cm
device","call":"getNode","arg":"master"}' $URL; echo
curl.sh

# !/bin/bash

source url
if [ -z "$1" ]; then
  pass=koen
else
  pass=$1
fi
read -p "pass: " -s -a $pass

curl -c curl.cookiest.txt -i -k -X POST -d '{"service":"login", "username":"koen", "password":"$pass"}' $URL

curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"cm
device","call":"getLastEvents","args":[0,256]}' $URL

curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"cm
device","call":"getProfile"}' $URL

curl --cookie curl.cookiest.txt -i -k -X POST -d '{"service":"cm
device","call":"getSubjectName"}' $URL

devices.sh

# !/bin/bash

source url
if [ "$1" == "gzip" ]; then

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3.3 JSON Examples

```bash
wget --load-cookies cookie.txt --header='Accept-Encoding: gzip'
   --no-check-certificate --server-response -qO- $URL --post-data="{"service":"cmdevice","call":"getDevices"}"
else
wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL --post-data='{"service":"cmdevice","call":"getDevices"}"
fi

loadone.sh

#!/bin/bash
source url

# not perfect but gets the job done
function jsonval {
    temp='echo $json | sed 's/\\//\//g' | sed 's/[{}]/\|/g' | awk
    -v k="text" '{n=split($0,a,","); for (i=1; i<=n; i++) print a[i]}'
    | sed 's/"\":/\|/g' | sed 's/\[\]/ /g' | sed 's/\"/\|/g' | grep -w $prop'
    r=$(echo ${temp##*|} | tr ']' ' ' | tr ' ' '
    | sort -n)
    echo $(echo $r | cut -d' ' -f 1)
}

prop='uniqueKey'
node=master
json='wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL --post-data='{"service":"cmdevice","call":"getDevice","arg1":"'$node'"}''
nkey=$(jsonval)
if [ -z $nkey ]; then
    echo $json
    exit 1
fi
    echo "$node.uniqueKey = $nkey"

json='wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL --post-data='{"service":"cmmon","call":"getMetric","arg1":"loadOne"}''
mkey=$(jsonval)
    echo "loadone.uniqueKey = $mkey"
now=$(date +%s)
day=$((now-86400))
```

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```
# "begTime":'$day',"endTime":'$now'},
# "intervalNum":0}
#
# echo ---------------------------------------------------------
wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL \
--post-data='{"service":"cmmon","call":"readDataByIntervalNum", 
"args":
[
{"baseType":"ReadMonDataId","uniqueKey":0,"modified":false,"toBeRemoved":false,"childType":", "devId":'$nkey','metricId':"$mkey", "begTime":'$day',"endTime":'$now']}],0}'}
# echo
# echo -----------------------------------------------------------
# data='{"service":"cmmon","call":"readDataByIntervalNum", 
# "args":
[
{"baseType":"ReadMonDataId","uniqueKey":0,"modified":false,"toBeRemoved":false,"childType":", "devId":'$nkey','metricId':"$mkey", "begTime":'$day',"endTime":'$now']}],0}'}
# rm loadone.txt.gz
# echo $data > loadone.txt
# gzip -n loadone.txt
# len=$(wc -c loadone.txt.gz | cut -d " " -f1)
# wget --load-cookies cookie.txt --no-check-certificate --header "Content-Length: $len" --header 'Content-Encoding: gzip' --server-response -O- $URL \
# --post-file=loadone.txt.gz

login.sh

#!/bin/bash
source url
user=$USER
pass=$user
wget --keep-session-cookies --save-cookies cookie.txt --no-check-certificate --server-response -qO- $URL \
--post-data='{"service":"login","username":"$user","password":"$pass"}'}

logout.sh

#!/bin/bash
source url
wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL \
--post-data='{"service":"logout"}'}
rm cookie.txt

node001.sh

#!/bin/bash
source url
```

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if [ -z "$1" ]; then
    node=node001
else
    node=$1
fi

wget --load-cookies cookie.txt --no-check-certificate --server-response -qO- $URL --post-data='{"service":"cmdevice","call":"getDevice","arg1": "$node"}'}