

CHReME: A Web Based Application Execution Tool for using HPC Resources

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Abstract - High Performance Computing (HPC) Systems are used to solve highly challenging, complex, time consuming, and advanced computational problems. HPC has become the workhorse for carrying out research and development activities for scientific and social advancement. For using HPC, scientists and researchers required expertise in Linux and HPC, which posed a serious challenge for the scientists in focusing on their core research area. This meant that the scientist was now burdened with the computational aspects and workings of HPC. Coming to the rescue, the HPC Solutions Group at Centre for Development of Advanced Computing (C-DAC), India developed a web based resource management and monitoring engine **CHReME: C-DAC's HPC Resource Management Engine**. CHReME provides a layer of abstraction to shield the end-user from the complexity of accessing HPC cluster resources while enabling them to concentrate on their core research/scientific area. CHReME's intuitive graphical user interface (GUI) and web based Unix/Linux shell makes clusters of different magnitude easy to use, manage and monitor. CHReME enables the HPC users to access the cluster resources from any remote location using a web browser viz Mozilla Firefox, CHROME, Internet Explorer. The portal is engineered to address the needs of novice as well as expert system users working in different scientific domains.

This paper focuses on CHReME as the cluster resources and job management portal for utilizing High Performance Computing resources. With CHReME in place, the user does not have to learn the computational aspects of HPC thus giving the freedom to focus more on his/her core research area.

Keywords-CHReME, HPC, Portal, C-DAC, Cluster, GUI

1. INTRODUCTION

For the design, analysis and basic research studies, scientists and engineers run compute intensive codes on high-performance computing clusters. In the HPC domain, for optimal resource utilization, various cluster resource managers are widely used. Resource managers are very effective in the case when the cluster size is very high and the tasks to be submitted are complex. Users as well as administrators find it tedious and time-consuming to use the command line utilities to carry out these complex activities on a day-to-day basis. Instead a web based GUI tool would help users and administrators effectively in managing and monitoring jobs and resources on cluster environment. Using CHReME, the user can submit tasks onto the HPC cluster without getting into the intricacies of system commands and usage

1.1 CHReME

CHReME is a HPC resource management portal that manages and tracks resource utilization of HPC Systems. It provides a variety of means for interaction, including command-line interface over the web through 'HTTPS' encryption, web-based graphical user interfaces for easy remote access for users and administrators. CHReME is designed for flexibility, allows accounting & application while supporting a variety of resource managers in the background. CHReME packs in a powerful web interface, enabling HPC users to submit a job irrespective of their location. There is no need for installing any additional software on the client machine where the job is being submitted. With CHReME, the user can submit tasks onto the HPC cluster without getting into the complexities of system commands and thus utilize their quality time in doing their domain research.



Fig 1 CHReME Home Page

1.2 CHReME Workflow

CHReME helps HPC administrators and HPC users to monitor and report on HPC workloads as well as analyzing the associated data. From the user's perspective, this includes a unique and innovative interface that is built on top of a Resource Manager, providing timely results easily. Users can choose from a variety of pre-configured menus for obtaining information regarding the status of their jobs. They can use these menus to monitor the HPC infrastructure for optimal resource planning and utilization. CHReME helps the administrators to monitor & analyze their cluster performance in order to troubleshoot potential issues and analyze usage patterns for better efficiency. Using CHReME, the user can assume the role of an administrator with a little training in running an HPC cluster. CHReME makes this transition easier.

2. TECHNICAL SPECIFICATIONS

CHReME was developed using open source Apache Struts framework which follows Model-View-Controller (MVC) architecture, JSP, XML, HTML, AJAX. CHReME is deployed on Apache Tomcat 6 web server.

Tab 1. Technology Details

Details	
Framework	Apache Struts
Technologies	JSP, XML, HTML, AJAX
System	Linux (shared + Distributed Memory System)
Web Server	Apache Tomcat 6

3. SALIENT FEATURES

- **GUI based Web Interface:** Organizes, simplifies and modularizes the access to various cluster resources through an intuitive graphical web interface for users and administrators.
- **Advanced Reservations:** Provides complete information regarding the availability of cluster resources, thus facilitating the user in utilizing the set of resources which are available at his/her disposal at a particular time. This enables users to plan their jobs and block (if required) a particular resource, for use in the future.

- **Comprehensive Monitoring:** Through CHReME the HPC System administrator can collect, monitor, visualize and analyze data pertaining to resource consumption, jobs, etc. Also empowers end user with actionable information.
- **Extensive Runtime Environment:** Provides an extensive HPC runtime environment for parallel applications including compilers, scientific libraries.
- **Security:** Secured credential access on web through HTTPS encryption.
- **Scientific Application Integration:** This allows the end-user to customize the application execution interface and provides flexibility by creating various workflows and associating them to the scientific applications. Workflows make the application execution procedure modular which helps the users to execute only specific workflows.
- **Work stage Management:** Provides the mechanism for saving the workflow execution state and hence provides the user with complete information of the workflow status along with the complete log footprint for various stages of the workflow execution.
- **Workload Manager Integration:** CHReME is integrated with Torque, a resource manager and Maui a cluster scheduler which facilitate the users to have optimal and efficient utilization of cluster resources, thus obtaining the results within the required timeframe.
- **Resource Registry and Management:** Creation, management and monitoring of various cluster resources viz. queue, parallel environment, users, nodes.
- **Alerts and Reporting:** Users can receive automated notification via e-mail, based on events such as job completion, change in resource status, etc.
- **Ease of Credential Management:** Used to create new roles, new users, to assign/un-assign roles to user, and to disable/enable users from HPC system. This is accessible only to the Administrator.
- **Multi-Tasking via GUI based Web shell:** The parallel shell allows simultaneous execution of multiple commands and scripts across the cluster as a whole.
- **Ease of File Manipulation:** Web interface for file uploading and downloading from client machine. Error and output files of the application and job can be downloaded unto the client machine.

4. DESCRIPTION

Web Based Cluster Access Portal provides a menu driven portal that is broadly classified into two key areas namely the User Area and the Admin Area

4.1 User Area

The CHReME portal facilitates the end user with a web based GUI for accessing and managing remote cluster resources from any location using a web browser. For accessing the HPC System, a secure shell login via portal is needed. The portal then transfers control to the login service that uses the User Management service to obtain the User object for the user with the given login name. If successful, the login service invokes the authentication modules depending on the order of priority and tries to authenticate the user. Once authenticated, the user is directed to his/her customized homepage.

CHReME provides following functionalities for user:

- Job Creation and Submission
- Job Monitoring
- Advanced Reservation
- Cluster Resource Monitoring
- Extensive Runtime Environment

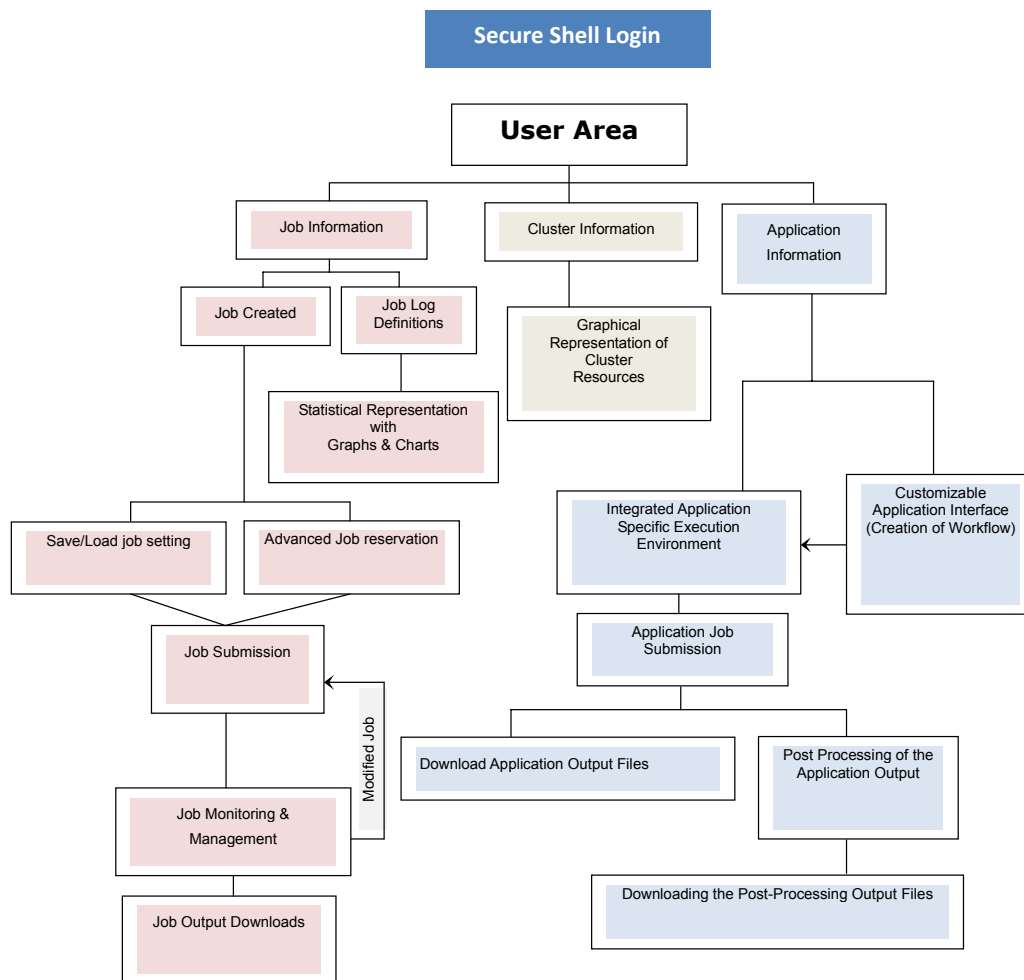


Fig 2 CHReME User Flow Diagram

Job Creation and Submission

It includes Creating Job Scripts, Job Submission, Management and Monitoring.

Creating Job Script

Portal provides interface for creating batch script to be run on HPC System. This contains prerequisites for the particular scheduler, commands, required CPU, memory and the length of time etc.

It also includes scheduler specific directives as comments in the script. In particular, all lines beginning with say #PBS, in case of creating a PBS script are followed by the PBS directives. After the PBS directives is the body of the script that is -- commands which are executed when the script runs. In this way the script is created which is further submitted to the scheduler for submitting to the scheduler.

Job Submission

The process of submitting a script to the scheduler using the scheduler specific commands is referred as Job Submission. Job submission GUI prompts user for script details such as job name, job priority, resource requirement, time frame, email details for error notification, Error& output details.

Job Monitoring

The portal provides user with easy monitoring and managing of the jobs submitted by them. It provides information about the current status of the submitted job. For convenience the portal has the facility to watch jobs which are specific to a particular status. For example, this facility can monitor and display details of all the jobs whose status is *Running*. Similarly it can list all the jobs whose status is *Completed*.

User can manage the jobs with varied status like *Running*, *Queued*, *Exit* and *Completed* with ease. Portal displays information such as JobID, Priority, Job Name, Owner, Status and Queue. User can delete, suspend, resume, hold, release and checkpoint various jobs.

Advanced Reservation

With Advanced Reservation features, the users can specify requirements for compute resources such as selecting the machine for a particular job, the number of processors and quantity of memory required for running a scientific task. Similarly, the users can also use Advanced Reservation to specify a network resource or time slot during which they expect to employ reserve resources.

Access to a given reservation is controlled by a reservation-specific access control list (ACL), which determines usage of the reserved resource.

Cluster Resource Information

Portal provides graphical representation of the cluster resource usage. This facilitates the user in utilizing the set of resources which are available for him at a particular time. The administrator can monitor and analyse the cluster performance which helps in troubleshooting potential issues and analysing usage patterns for better efficiency.

4.2 Admin Area

The Administrator homepage contains links to access the various menus. Administrator tasks include the following:

- User Configuration
- Job Management
- Queue Configuration and Management
- Compiler Configuration
- Scheduler Configuration

User Configuration

CHReME provides user management functionality which makes it very easy to add users to the cluster. The user is automatically added to the built-in database. User role manager is used to create new roles, new users, to assign/un-assign roles to user, and to disable/enable users from Web Portal. By default the super user or admin user of the machine enjoy manager privileges. Users have certain access permissions but no cluster or resources management capabilities.

Job Management

Job management allows managing and monitoring all user jobs running on cluster, such as:

- Monitoring status of the job,
- Controlling job status from pre-execution state to execution state
- Priority modification for starving jobs.

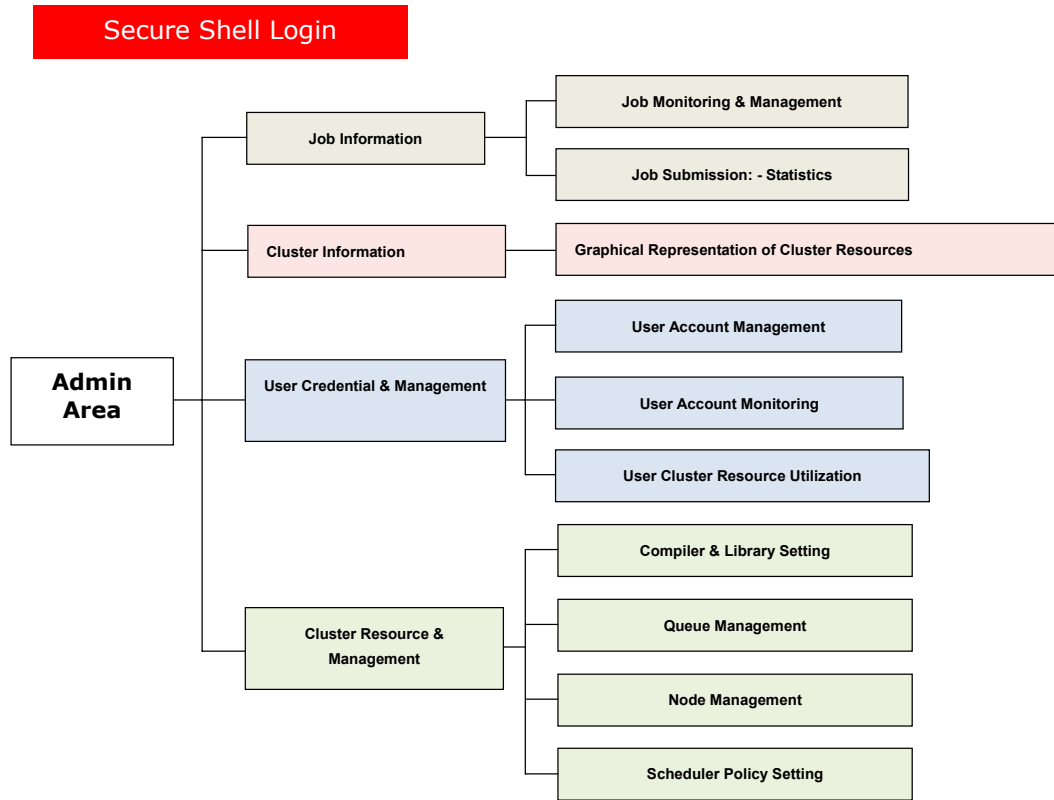


Fig 3 CHReME Administrator Flow Diagram

Queue Configuration and Management

Queue configuration facilitates the administrator in creating classes based on various rules viz max running job, queued job, job prioritization, nodes allocation etc. These classes are associated with the user on the basis of the statistical utilization of the HPC users. The GUI helps in setting up various queue configurations and associating these configurations with the users. In addition to this the GUI makes the queue management viz Queue addition, deletion and alteration process a lot easier.

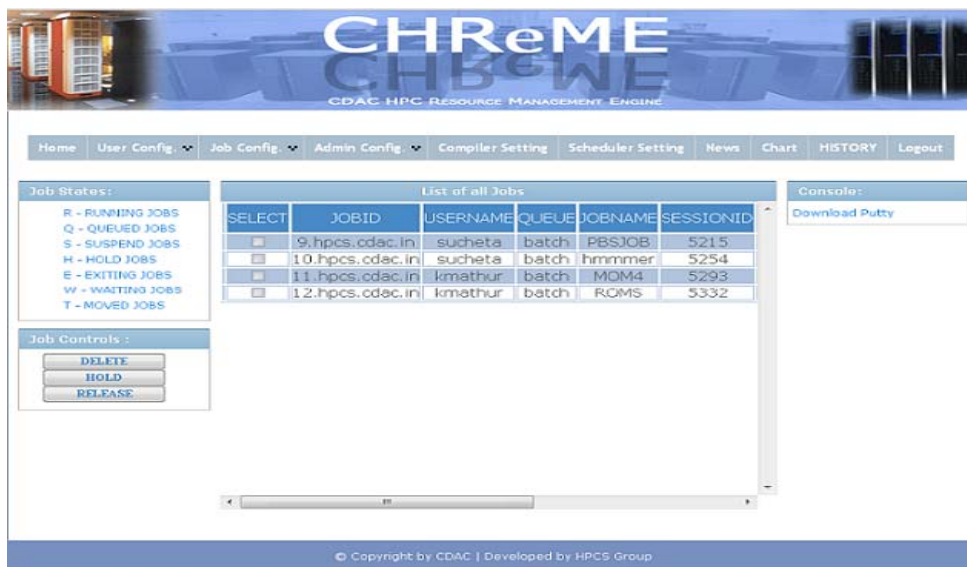


Fig 4 Job Management Page

Compiler Configuration

Compiler & Library Configuration is used to add new compilers & libraries to the cluster. Benefit of this configuration is that the user on cluster need not bother about how to set the compiler and/ library path to their bashrc profile in accordance to their application requirement.

Scheduler Configuration

Scheduler manages incoming jobs and tasks, allocates resources, dispatches tasks to nodes, and monitors the status of jobs, tasks, and nodes. The Scheduler Configuration dialogue permits the setting of scheduler specific policy according to resource utilization. It helps a system administrator to easily configure a scheduler policy such that the performance objectives for various classes of users in the system as well as other system-level performance objectives can be satisfied.

5. CONCLUSION

High Performance Computing (HPC) applications are common in many scientific domains. However, HPC is still complex and hard to use for researchers from domains other than Computer Science. This paper described CHReME, a web based portal for resource allocating, data management, resource monitoring and management. CHReME frees users from remembering a lot of commands and their syntax, and it also provides more active context information or hints as compared to command-line tools.

From the user perspective, CHReME provides them the convenience of accessing their projects and data from a remote location. At the same time CHReME also empowers the administrator with centralized management of all cluster resources. The user is guided by CHReME, throughout the execution, by providing a layer of abstraction which hides the complexities involved therefore freeing the users from learning tedious commands for smooth execution. CHReME saves the various workflow stages of execution thereby assisting the user to continue execution beyond the *Saved* state. It also provides a mechanism to track and re-run various execution stages when an error occurs in a module.

Basically CHReME serves as the interface tool which allows the scientists and researchers to utilize their HPC system optimally for their research without expending any energy towards the detailed workings of HPC. With CHReME in place, the researcher is not burdened with the 'How' and 'Why' of running the HPC system.

6. FUTURE WORK

- Integrating Gold Allocation Manager functionality with CHReME to track and charge job resource usage, providing greater control over who is using the HPC resources.
- Integrating Authentication and Authorization mechanism by implementing Lightweight Directory Access Protocol or LDAP.
- Adding new functionalities for updating the complete job execution footprints in timely manner to user through e-mail, Configuring and Job setting on handhelds. Based on this report the user can take immediate action like configuring the job etc irrespective of his/her location.
- Automating the Cluster monitoring and management process for facilitating the administrator by setting up the HPC resource metrics rules.
- Adding Job Checkpoint feature in the Job Management and Monitoring module.

7. REFERENCES

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