Workload Management and Job Scheduling on Platform Rocks Clusters

Platform Lava, a free and fully functional entry-level workload manager for Platform Rocks, is becoming popular in the high-performance computing community. Platform Lava enables organizations to upgrade to advanced workload managers easily. By understanding the features and benefits of advanced workload managers, administrators can make informed decisions about the migration process—and help advance the dual goal of fair access to and enhanced utilization of shared computing resources.

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High-performance computing (HPC) clusters based on industry-standard computing, storage, and network interconnect components offer attractive price/performance ratios and ease incremental growth. HPC clusters are designed using cost-effective components; however, large clusters—especially those comprising hundreds of servers—require substantial investments. As a result, most HPC clusters are shared among several departments within an organization. Once a cluster is up and running, the challenge for system administrators is to ensure fair access and maximize utilization ratios in order to enhance return on investment. An efficient workload manager is critical for achieving these objectives. Workload managers vary in complexity and features. Some are feature rich but difficult to configure, while others are simple but buggy.

Figure 1 shows the typical components from which a Platform Rocks cluster is built—including everything from the OS to benchmarking tools such as Linpack. A key enabling component of a Platform Rocks cluster is the free Platform Lava workload management software system. Platform Lava is based on Platform Load Sharing Facility (LSF) HPC, which has become the de facto workload manager for many production clusters. Platform Lava enables Platform Rocks users to submit their work easily to the cluster, while providing administrators with enough flexibility and control to help ensure that high-priority jobs complete on time.

1 Platform Rocks includes software developed by the Rocks Cluster Group at the San Diego Supercomputer Center and its contributors.
A critical component of any workload manager is the job scheduler. When users submit jobs, the scheduler combines all requests and decides when and where to execute the jobs. Typically, workload managers have internal job schedulers. However, system administrators can substitute an external scheduler for the internal scheduler to enhance functionality. Platform Lava has a simple but stable first-come, first-served scheduler that is useful in most situations. Platform Lava’s interface is compatible with Platform LSF HPC, providing a clear migration path. Platform Lava can also use external schedulers such as Maui for enhanced features; for example, Maui provides advanced scheduling algorithms that are specifically designed to maximize utilization in policy-driven, heterogeneous HPC environments.

Features of Platform Lava

Platform Lava’s features and capabilities can provide benefits for many cluster environments. Primary among these benefits are ease of installation and use, scalability, reliability, and flexibility and control.

Ease of installation and use. Platform Lava is easy to install on a Platform Rocks cluster. The Platform Lava Roll is installed first on the front-end node, and the necessary configuration files and services are copied, installed, and configured on each compute node as it joins the cluster. For single-user clusters, the default configuration is sufficient. Administrators who need to control access to the cluster or manage multiple groups with different applications on the cluster can easily edit the text-based configuration files using the Platform Lava simple command set. Once the changes are made, the administrator simply notifies the system to reload its configuration files.

Scalability. Platform Lava scales from 1 to 500 nodes with a single Platform Rocks front end. The workload manager also scales with the number of users, jobs queued, and jobs running in the system. Platform Lava is designed to queue up and run jobs from hundreds of users.

Reliability. Platform Lava keeps track of work submitted and maintains accurate job records so that jobs will continue to run as long as the compute nodes running the application do not fail. If the front-end node fails or Platform Lava components fail, Platform Lava is designed to rebuild the state of the system and all jobs running on the system when those failed components are restarted. Even if an application completes or fails when Platform Lava is down, the software is designed to rebuild the state and notify the user that the job has finished or failed once Platform Lava is restarted.

Flexibility and control. For shared cluster resources, manual rules need to be established between users to enforce controlling and modifying the cluster for each user’s needs and applications. In practice, this works when there is a small set of users or when all of the users know each other and effectively police each other. But as the number of users on the cluster grows, more elaborate control features are needed. This is where flexibility and control help the Platform Lava administrator. Platform Lava can be configured to change a cluster’s configuration during different times of the day and to control access to the cluster by user, host, queue, and general Linux* limits. By modifying the text configuration files, the Platform Lava administrator controls work on the cluster.

Benefits of migrating to advanced workload managers

The advantages of migrating from Platform Lava to Platform LSF HPC include enhanced scalability, parallel job control, advanced scheduling features and algorithms, and the ability to link multiple clusters into a single compute resource. Many production environments exceed the capabilities for basic workload managers. Typically, when an environment grows, the complexity of user needs, the capacity and capability of computing resources, and even the ability to connect to other independent clusters become important factors in managing a compute infrastructure. Best practices recommend that complex compute infrastructures be handled with advanced workload managers.

In general, as a compute infrastructure grows in complexity, the emphasis is placed either on high throughput or on high performance. Another way to look at this division is to consider high-throughput computing as capacity computing and high-performance computing as capability computing. The challenge in capacity computing is maximizing the number of serial jobs
that can be pushed through the computer infrastructure. Key concerns are job-priority management and job scheduling without compromising resource utilization. In contrast, high-performance computing maximizes fine-grained parallel processing. Among the many issues that arise in such a capability computing environment, key considerations include the management and monitoring of parallel subtasks and the optimization of scheduling to leave as few gaps in compute utilization as possible. Platform LSF HPC can be an excellent choice for industrial-strength capacity and capability computing.

Inevitably, as organizations change over time, so do their HPC requirements. Platform Lava offers support for organizational growth. However, when administrators must manage demanding workloads across a large cluster, Platform LSF HPC may be required. Because they share the same code base, Platform Lava easily integrates with Platform LSF HPC. The configuration files and functionality of Platform Lava are a subset of those of Platform LSF HPC. Dell and Platform Computing support a clear upgrade path from Platform Lava to Platform LSF HPC.

Advanced scheduling features in Platform LSF HPC can address the issues posed by HPC environments by employing advanced algorithms such as hierarchical fair share and multiple configurable policies. Effective configuration of scheduling policies can enhance resource utilization. Once business policies have been defined to identify critical projects, users, or groups, those policies can be included in the scheduler configuration. This approach enables the scheduler to make decisions dynamically regarding the priority of individual jobs—allowing for equitable and efficient division of resources based on the assigned policies.

Platform LSF HPC helps support scalability into the range of 5,000 nodes, with 100,000 active and queued jobs in the cluster. Multicluster features built into Platform LSF HPC help extend scalability by integrating geographically dispersed clusters. These tools are designed to enable clusters not only to import and export compute jobs, but also to share resources between clusters automatically and transparently. In addition, jobs can be forwarded and resources leased to remote clusters.

The steps required to migrate from Platform Lava to Platform LSF HPC are basic. To install on Platform Rocks 4.0.0, administrators perform a “front-end upgrade” and select the Platform LSF HPC Roll instead of the Platform Lava Roll. On a Platform Rocks 4.0.0 cluster, the ability to add and remove Rolls is built into the infrastructure. Platform Lava can be removed as a Roll, and then Platform LSF HPC can be added. At this point, Platform LSF HPC can be configured to take advantage of the specialized features that are desired. To make use of the parallel management capabilities, administrators simply use prebuilt parallel job launchers that are part of the Platform LSF HPC distribution.

Upgrading does not require code changes in the applications running under the workload manager. Under Platform, multicluster jobs can be passed back and forth between clusters based on send and receive policies. An additional advantage of upgrading from Platform Lava is that Platform LSF HPC includes a GUI.

Key features of advanced workload managers
In production environments, job scheduling can be complex because multiple factors need to be considered. The quality of a schedule depends on the sophistication of the scheduling algorithms employed. Advanced scheduling algorithms use techniques such as advanced reservation and backfill.

Advanced reservation of resources is a technique used by Platform LSF HPC. Jobs that require a large portion of the available resources or have very long anticipated runtimes can use advanced reservation to have a predictable starting time. Advanced reservation of high-priority jobs helps deliver the required quality of service (QoS). Backfill is a common technique that can enhance the quality of the schedule generated. Given a schedule with advanced-reserved, high-priority jobs and low-priority jobs, a backfill algorithm tries to fit the small jobs into scheduling gaps. This allocation does not alter the sequence of jobs previously scheduled but helps improve system utilization by running low-priority jobs between high-priority jobs.

Platform LSF HPC provides a dynamic scheduling decision mechanism, which uses the processing load to make scheduling decisions. Based on these decisions, jobs can be migrated among compute nodes or rescheduled. Loads can also be balanced among compute nodes in heterogeneous environments. In addition, Platform LSF HPC can dynamically migrate jobs among compute nodes. Furthermore, Platform LSF HPC can apply multiple scheduling algorithms to different queues simultaneously.

Platform LSF HPC is targeted toward parallel HPC applications. It offers parallel job control and HPC-specific job scheduling features. In HPC clusters, the scheduling of parallel jobs requires special attention because parallel jobs comprise several subtasks. Each subtask is assigned to a unique compute node during execution, and nodes constantly communicate among themselves during execution. The manner in which the subtasks are assigned to processors is called mapping. Because mapping
affects execution time, the scheduler must map subtasks carefully. To achieve high resource utilization for parallel jobs, both job efficiency and advanced scheduling are required. Platform LSF HPC can make intelligent scheduling decisions based on the features of advanced interconnect networks, thus enhancing process mapping for parallel applications.

Platform LSF HPC can interface with external schedulers like Maui, which may have complementary features. For example, Maui can further enhance the utility of compute resources by considering jobs submitted from all queues concurrently. Internally, Maui is based on a single unified queue. This scheduler offers a variety of QoS settings to system administrators and access levels to users and jobs. Maui can stop a job during execution—a task called preemption—under several conditions, including submission of a higher-priority job.

Workload management for production HPC environments
Platform Lava is a full-featured workload manager that is available at no charge—providing an excellent opportunity for organizations deploying HPC clusters to evaluate it. Dell’s HPC clusters offer a supported and dependable upgrade path to industry-leading workload managers. The principal benefits of upgrading include enhanced scalability; advanced scheduling that can lead to optimal resource utilization; tight job control; multilevel fault tolerance; and topology-aware scheduling. Furthermore, the upgrade does not require any code changes in applications.

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