

Introduction to Cloud for HPC

In this paper we discuss the core concepts behind cloud computing and how they can be applied to High Performance Computing. We then look at Moab HPC Suite - Enterprise Edition and Moab Cloud Suite to see how these fit the traditional cloud model and see how these can benefit HPC users.



Introduction

Traditional High Performance Computing (HPC) has been a key resource for many companies over the years to help resolve a broad range of problems that need large amounts of computing resources. These systems are usually tailored to address a specific task which can in itself present potential issues surrounding their limited application by a small subset of those within an organization. This has contributed to difficulties in justifying the total cost of ownership of these systems.

In the last 20 years or so this has started to change. Universities, for example, have seen more and more departments start to take advantage of what High Performance Computing has to offer them. This is key in expanding HPCs role within these institutions and showing an increase on their return on investment.

This expansion also creates new challenges: as HPC grows, it needs to cater to a wider audience who are not familiar with these technologies.

Four key areas that need to be addressed:

- 1. User interface cannot be a barrier to entry
- 2. Support for a growing range of applications and operating systems
- 3. Tracking utilization of the environment between users and departments
- 4. Ability to automatically respond to events and issues

Another recent trend has emerged in recent years called Cloud Computing. This faces the same challenges as HPC. In order for it to be used by a wider audience it needs to deliver a simple user experience for a vast range of applications. HPC can benefit from the cloud, but the first important question to answer is "What is Cloud Computing?"

What's Cloud Computing?

The term cloud computing is used to define such a broad range of computing solutions that it no longer has a single meaning. Gartner defines five attributes that any cloud service offering should adhere to. By using these attributes, it is possible to see how strongly a cloud solution (or service) adheres to the cloud computing model;

Service-Based: Consumer concerns are abstracted from provider concerns through service interfaces that are welldefined. The interfaces hide the implementation details and enable a completely automated response by the provider of the service to the consumer of the service. The service could be considered "ready to use" or "off the shelf" because the service is designed to serve the specific needs of a set of consumers, and the technologies are tailored to that need rather than the service being tailored to how the technology works. The articulation of the service feature is based on service levels and IT outcomes (availability, response time, performance versus price, and clear and predefined operational processes), rather than technology and its capabilities. In other words, what the service needs to do is more important than how the technologies are used to implement the solution.

Scalable and Elastic: The service can scale capacity up or down as the consumer demands at the speed of full automation (which may be seconds for some services and hours for others). Elasticity is a trait of shared pools of resources. Scalability is a feature of the underlying infrastructure and software platforms. Elasticity is associated with not only scale but also an economic model that enables scaling in both directions in an automated fashion. This means that services scale on demand to add or remove resources as needed.

Shared: Services share a pool of resources to build economies of scale. IT resources are used with maximum efficiency. The underlying infrastructure, software or platforms are shared among the consumers of the service (usually unknown to the consumers). This enables unused resources to serve multiple needs for multiple consumers, all working at the same time.

Metered by Use: Services are tracked with usage metrics to enable multiple payment models. The service provider has a usage accounting model for measuring the use of the services, which could then be used to create different pricing plans and models. These may include pay-as-you go plans, subscriptions, fixed plans and even free plans. The implied payment plans will be based on usage, not on the cost of the equipment. These plans are based on the amount of the service used by the consumers, which may be in terms of hours, data transfers or other use-based attributes delivered.

Uses Internet Technologies: The service is delivered using Internet identifiers, formats and protocols, such as URLs, HTTP, IP and representational state transfer Web-

the foundation for Internet-based services. Google's Gmail, Amazon.com's book buying, eBay's auctions and Lolcats' picture sharing all exhibit the use of Internet and Web technologies and protocols.

Some of these concepts are already very familiar with a traditional HPC environment. One could make the argument the HPC is by its nature service-based as it provides its users with a service platform. This platform has traditionally been static. In most cases a HPC platform will be designed around a very specific need and once deployed will remain in that same state until it is eventually decommissioned. Should its user's requirements change during its life cycle it does not have the ability to adapt without manual intervention.

To be considered a cloud environment, computing resources must be able to change dynamically in response to the user's request. This can include a node or host's operating system, installed applications, storage devices and network setup.

In order to enable this, a provisioning layer needs to be introduced. This needs to be an automated process in order to minimize the time a computing resource spends idle while it is being provisioned.

In addition to this, a virtualized layer is often used to make the environment more flexible. Having computing resources contained within a virtual environment decouples them from their physical hosts. This allows the resources to move around the environment, increasing overall system utilisation. Virtual computing resources can be increased, decreased on demand and moved between different physical hosts.

What is HPC Cloud?

HPC Cloud is the continuation of clouds main philosophy with one key difference. As virtualization is not suitable for all workloads, HPC Cloud must support both virtualized and direct access computing resources. This allows workloads that can be virtualized to be scaled with demand without interfering with other physical hosts.

Virtualization gives HPC a flexibility it has not had before. As the processing core density of computer nodes increases a single operating system starts to make less sense. With virtualization a single node can run multiple operating systems at the same time to allow multiple users to use the same resource. This allows the HPC infrastructure to have a higher utilization from users within its organization and just its continued investment.

Virtualization has another key benefit in decoupling a user's job from the physical resource running it. Should there be a fault detected on that physical host the user's job can be moved to another host without interruption rather than being stopped and restarted.

Moab HPC Suite Enterprise Edition

Moab HPC Suite - Enterprise Edition is Adaptive Computing's first cloud product tailored for an HPC



audience. It introduces new technologies such as a new web portal, web services API and chargeback system.

The entire suite is built around the battle-tested and patented Moab intelligence engine to automatically balance the complex, mission-critical workload priorities of enterprise HPC systems. As services are requested, Moab's intelligence engine is able to allocate the available resources and re-provision others to meet the user's requirements. This layer of automation is extremely important in allowing complex environments to be setup without overloading the systems admins.

Simplified User Experience

One the most important components of any cloud/HPC solution is its user interface. For new users this will be their first impression of the service and must be intuitive to use. Moab HPC Suite – Enterprise Edition includes its own web based portal, called Moab Viewpoint, for both job submission and administration. This gives users a simple GUI interface from which to submit their work. Job submissions use a simple web form where resources can be selected from several pull down menus. The contents of these menus can be customized by the administrator to ensure that are job submissions are valid.

As Moab Viewpoint is web based, it can be used by anyone within an organization without the need to install or maintain additional software. This is crucial in enabling HPC resources to be available to as wide an audience as possible.

Once a job has been submitted, a user can check on the status of it through the same interface. This information is pulled directly from Moab's intelligence engine and then cached. This prevents multiple users from querying Moab's intelligence engine directly for the same information which can lead to unnecessary overhead.

Usage Accounting/Charge Mngmt

With the expansion of HPC Cloud comes an increasing emphasis on tracking and charging for utilized computing resources. Moab HPC Suite – Enterprise Edition includes its own chargeback system called Moab Accounting Manager. This gives the administrator the ability to attach a cost to the services they are providing. This charge can be based on each individual components that are used (i.e. processors, GPU's, licences), a total cost, or a combination of the two. Administrators can then distribute usage budgets to different users, departments or projects to manage access.

When a user submits a job, Moab Accounting Manager will be able to supply them with an estimate of how much the job is going to cost, allowing the user to make an informed decision, before submitting their work. Various payment models are supported: funds can be deducted once the user's job has been completed or periodically as it is runs. Moab Accounting Manager provides usage reporting, including costs for the usage, which can be organized by user, group, class or project. This chargeback data can then be integrated with other billing and accounting systems.

This flexibility to provide detailed usage reporting and pay-for-use charging allows both users and administrators to have full visibility and control over the amount of resources they use.

Moab Accounting Manager is built into the Moab Viewpoint portal to allow all cloud and HPC services to be centrally managed.

Dynamic Scaling for HPC Resources

In order to allow resources to scale in response to user demand, Moab HPC Suite – Enterprise Edition has the ability to re-provision nodes within its environment. This allows a higher utilization of the underlying resources as they can be adapted on the fly.

When a user submits a job through the Moab Viewpoint portal, they can select the operating system that is required for the job. This is then passed down to Moab's intelligence engine. The first step Moab will take is to review all computing resources that fit the user's requirement that are not utilized by other work. From this short list, it will then find one that matches the user's desired operating system. Should one be available it will start the user's job immediately. If there is not a match, Moab will call out to its provisioning manager to reinstall the node. Moab will then check on the node until it is back online before submitting the user's job to it.

This ability to switch between operating systems allows for a single computing resource to scale to support a broad range of different job types.



HPC Cloud Bursting

As we have seen, Moab HPC Suite – Enterprise Edition provides more elastic flexibility within a set of local computing resources. When a job or HPC service request is received, Moab HPC Suite – Enterprise Edition has the ability to change the resources available to match what is required. The next question to be addressed is *what can be done if no local resource is available?*

Cloud bursting is an application deployment model in which an application runs in a private cloud or data center and bursts into a public cloud when the demand for computing capacity spikes.

Moab HPC Suite – Enterprise Edition supports the ability for new HPC resources to be provisioned within another external cluster or public cloud if no local resources are available. These new resources are then assigned to the job in question in order for it to start. This can be done upon the jobs inception, as a result of a spike in resource demand, or in response to failing local resources. For example, should a single HPC job or service require more resources than were initially requested Moab HPC Suite – Enterprise Edition can respond to this request by provisioning new resources in an external cluster or public cloud (bursting) and then assigning them to the specific job.

Moab Cloud Suite

Moab[®] Cloud Suite takes Moab HPC Suite - Enterprise Edition core concepts ia step further by introducing a new virtualization layer for a full enterprise cloud that maximize benefits and ROI. Moab Cloud Suite is an intelligent cloud management end-to-end platform. It provides touchless cloud service optimization across the full cloud service lifecycle. Moab Cloud Suite uses the patented Moab intelligence engine to automate service requesting, provisioning, modification, and management based on multi-dimensional policies. Moab Cloud Suite supports both cloud and direct access workload models allowing HPC administrators to expand their existing HPC offerings to new users without having to dedicate resources to them.

Service Catalogs

With Moab Cloud Suite, the Moab Viewpoint portal can be tailored to provide different service offerings to different users so it can support a wide range of different needs to any organization.

Administrators can use Moab Viewpoint's own service catalog to build different service offerings. These can take different components like processors, memory, and operating systems and group them together into a single service which is made available to its users. The administrator can either have this as a static HPC service or allow users to modify certain components before submitting their jobs. This is important as it prevents novice users from selecting the wrong resource set for the job but also gives the flexibility to more advance users to tailor their request.

Consider the example of an organization's finance department wanting to use some HPC resources to generate an end of year analysis report. They have no understanding of what physical resources or software they need to achieve this, so giving them any control over these would likely be a bad idea. The administrator of the system can use Moab Viewpoint to create a new service offering for them where each component is pre-selected. This creates a simple one-click solution for the end user.

Each component that the administrator has selected is registered within Moab Cloud Suite. Moab Cloud Suite has an understanding of what is being requested and which resource manager it will need to communicate with to setup the desired infrastructure and run the job.

Diverse Environments

Although most user's work is suitable for running within a virtualized environment, some is not. Moab Cloud Suite allows users to submit jobs to both physical and virtualized resources. An administrator can simply create a separate service offering for each type within Moab Viewpoint for their users to choose. Users will still be able to select what type of physical resources they require in the same way as a virtual machine. Moab's intelligence engine will then search the physical resources it has available and optimally allocate the users job to one. It can re-provision an existing node if the operating system does not match the requested one to maximize utilization of the underlying cluster. In this scenario hypervisors such as VMware's ESX platform can be re-provisioned to match the incoming work, allowing all resources within the cluster to support all job types.

Migrating Workloads

Within an Enterprise Cloud environment we can see that both virtual and direct access workloads can be supported and run side-by-side. Moab Cloud Suite takes this a step further by automatically migrating live jobs based on existing workload and external events.

For example if a node is running as a hypervisor but no virtual machine is running, it will be re-provisioned so that another user's job can use it. However, in this same scenario, if one virtual machine is running on the node then it cannot be re-provisioned even if it is only using 10% of the resources on that node. To address this, Moab Cloud Suite has the ability to condense all running virtual machines into as few hypervisors as possible. This maximizes utilization and available capacity of the cluster. This can be either a manual or automatic policy-based process. Moab Cloud Suite has the ability to migrate workloads based on other external factors. Should a subset of nodes within the cluster become too overburdened, the auto-VM migration overcommit policies, set by the administrator, will automatically migrate the workloads from the effected nodes to balance the workload and maintain performance. Moab Cloud Suite can also automatically migrate workloads if nodes have pre-failure conditions, like being too hot, with trigger policies that both migrate the workload and even create a reservation of the affected nodes to prevent future work from being scheduled to them until they are in good health.

For more information on Moab HPC Suite - Enterprise Edition or to request a solution demonsgtration, contact us today or visit www.adaptivecomputing.com

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