

# Combination of Cloud Computing and High Performance Computing

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**Abstract:** Cloud Computing is a remote location technology which provides Platform as a Service (PaaS), Software as a Service (SaaS) and Infrastructure as a Service (IaaS). High Performance Computing (HPC) allows scientists and engineers to solve complex science, engineering, and business problems using applications that require high bandwidth, enhanced networking, and very high compute capabilities. The combination of Cloud Computing and High Performance Computing allows you to increase the speed of research by running high performance computing in the cloud and to reduce costs by providing Cluster Compute or Cluster GPU server's on-demand without large capital investments. Tap into unlimited resources to scale your High Performance Computing jobs - analyzing large-scale data, running simulations and financial models and experimenting while reducing time to market. Build your personalized end to end High Performance Computing solution on Cloud which tailored to your organization's needs.

**Keywords:** High Performance Cloud Computing, High Performance Computing, Cloud Computing, Amazon Web Services, Microsoft Azure, IBM Cloud

## I. Introduction

Cloud provides like Amazon Web Services, Microsoft Azure and IBM Cloud provides High Performance Computing solution on Cloud. Cloud Computing is a remote location technology which provides Platform as a Service (PaaS), Infrastructure as a Service (IaaS) and Software as a Service (SaaS). High Performance Computing (HPC) allows scientists and engineers to solve complex science, engineering, and business problems using applications that require high bandwidth, enhanced networking, and very high compute capabilities. The Combination of High Performance Computing and Cloud Computing are known as High Performance Cloud Computing.

### High Performance Computing

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High Performance  
Cloud Computing

Cloud Computing

AWS allows you to increase the speed of research by running high performance computing in the cloud and to reduce costs by providing Cluster Compute or Cluster GPU server's on-demand without large capital investments. You have access to a full-bisection, high bandwidth network for tightly-coupled, IO-intensive workloads, which enables you to scale out across thousands of cores for throughput-oriented applications.

Microsoft Azure breaks free from the overhead and limitations of your on-premises infrastructure. Tap into unlimited resources to scale your High Performance Computing (HPC) jobs - analyzing large-scale data, running simulations and financial models and experimenting while reducing time to market.

IBM Cloud solves complex problems quickly with high-performance computing on cloud. Build your personalized end to end High Performance Computing (HPC) solution tailored to your organization's needs. Organization's can process large volumes of data more economically and quickly with an easily configurable and scalable solution on the IBM Cloud. IBM Cloud provides high speed data transfer, storage that expands to exabytes, and industry-leading workload management software all running on the powerful IBM Cloud infrastructure to help you meet workload demands.

## II. Amazon Web Services for High Performance Computing

High Performance Computing (HPC) allows scientists and engineers to solve complex science, engineering, and business problems using applications that require high bandwidth, enhanced networking, and very high compute capabilities. AWS allows you to increase the speed of research by running high performance computing in the cloud and to reduce costs by providing Cluster Compute or Cluster GPU server's on-demand without large capital investments. You have access to a full-bisection, high

bandwidth network for tightly-coupled, IO-intensive workloads, which enables you to scale out across thousands of cores for throughput-oriented applications.

#### Features:

- **High performance computing in the cloud:** High Performance Computing (HPC) on Amazon Elastic Compute Cloud (EC2) is enabled by the Cluster Compute-optimized and GPU instance types (virtual machines). You can use them just like other EC2 instances, but they also have been specifically engineered to provide high performance networking and you can scale to tens of thousands of instances on-demand.
- **Announcing the Amazon EC2 C4 instance type:** C4 instances are designed for compute-bound workloads, such as high-traffic front-end fleets, MMO gaming, media processing, transcoding, and High Performance Computing (HPC) applications. C4 instances are available in five sizes, offering up to 36 vCPUs. C4 instances are based on Intel Xeon E5-2666 v3 (codename Haswell) processors that run at a base frequency of 2.9 GHz, and can deliver clock speeds as high as 3.5 GHz with Intel® Turbo Boost. Each C4 instance type is EBS-optimized by default and at no additional cost. This feature provides 500 Mbps to 4,000 Mbps of dedicated throughput to EBS above and beyond the general purpose network throughput provided to the instance.
- **GPU-compute powered by P2:** P2 instances are ideally suited for machine learning, engineering simulations, computational finance, seismic analysis, molecular modeling, genomics, rendering, high performance databases, and other GPU compute workloads. P2 instance offers 16 NVIDIA K80 GPUs with a combined 192 Gigabytes (GB) of video memory, 40,000 parallel processing cores, 70 teraflops of single precision floating point performance, over 23 teraflops of double precision floating point performance, and GPUDirect technology for higher bandwidth and lower latency peer-to-peer communication between GPUs. P2 instances also feature up to 732 GB of host memory, up to 64 vCPUs using custom Intel Xeon E5-2686 v4 (Broadwell) processors, dedicated network capacity for I/O operation, and enhanced networking through the Amazon EC2 Elastic Network Adaptor. P2 instances allow customers to build and deploy compute-intensive applications using the CUDA parallel computing platform or the OpenCL framework without up-front capital investments.
- **3D processing made easy with G2:** G2 instances are ideally suited for high performance graphical applications, including 3D modeling and simulation, medical and geospatial imaging, and video content delivery.
- **Create high-throughput networks with Placement Groups:** Cluster instances can be launched within a Placement Group. All instances launched within a Placement Group have low latency, full bisection, 10 Gbps bandwidth between instances. Like many other Amazon EC2 resources, Placement Groups are dynamic and are elastically scalable as needed. You can also connect multiple Placement Groups to create very large high performance computing clusters for massively parallel processing.
- **Enhanced networking with SR-IOV:** AWS currently supports enhanced networking capabilities using SR-IOV (Single Root I/O Virtualization) for the C3 and I2 instance types. SR-IOV is a method of device virtualization that provides higher I/O performance and lower CPU utilization compared to traditional implementations. For supported Amazon EC2 instances, this feature provides higher packet per second (PPS) performance, lower inter-instance latencies, and very low network jitter.
- **Big compute meets big data:** Data has gravity; as datasets grow larger it becomes easier to move the compute closer to the data to reduce latency and increase throughput. With AWS big data storage and database services, such as Amazon S3, Amazon Redshift, Amazon DynamoDB, and Amazon RDS, you have the perfect place to host your data for your high performance computing cluster. Furthermore, with Amazon Elastic Block Store (EBS) you can create large scale parallel file systems to meet the high volume, performance, and throughput requirements of your HPC workload.
- **Optimize time and cost with Spot Instances:** You can save time and money by leveraging Spot Instances for your HPC workloads. Spot Instances is a pricing model that enables you to bid on unused Amazon EC2 capacity at whatever price you choose. When your bid exceeds the Spot price, you gain access to the available Spot Instances and run as long as the bid exceeds the Spot Price. Historically, the Spot price has been 50% to 93% lower than the on-demand price.
- **Launch popular HPC software with AWS Marketplace:** AWS Marketplace is an online store that provides an easy way for developers and IT professionals to discover and use software to run in the AWS Cloud. You can find a selection of high performance computing software ready to run in your cluster, such as the Univa Grid Engine resource management system or the Intel Lustre HPC file system, with just a few clicks directly from the AWS Marketplace.

### III. Microsoft Azure for High Performance Computing

Microsoft Azure breaks free from the overhead and limitations of your on-premises infrastructure. Tap into unlimited resources to scale your High Performance Computing (HPC) jobs - analyzing large-scale data, running simulations and financial models and experimenting while reducing time to market.

#### Benefits:

- **Scale on demand, stay on budget:** When the amount of data you have to ingest and process grows, tap into cloud resources for elastic extension of compute capabilities. Scale cost-effectively with the high performance computing (HPC) capabilities of Azure.
- **Democratize access to achieve fast results:** As scientific experiments drive an explosion in data growth, the need to share, process, and protect that data grows too. Bring collaborative, scalable, and secure access from anywhere, at any time, to all users.
- **Reduce time to market:** Add flexible compute resources to deliver more granularity and improved results faster. Ultimately, you'll finish more projects and get more done.
- **Disrupt the market with new products:** Whether re-inventing classic lines of business apps, re-architecting proven scenarios, or taking data-driven into overdrive, you need fast and flexible architectures. Use Azure to build architectures that expand, adapt, and shrink with the demand of customers.

### IV. IBM Cloud

IBM Cloud solves complex problems quickly with high-performance computing on cloud. Build your personalized end to end High Performance Computing (HPC) solution tailored to your organization's needs. Organization's can process large volumes of data more economically and quickly with an easily configurable and scalable solution on the IBM Cloud. IBM Cloud provides high speed data transfer, storage that expands to exabytes, and industry-leading workload management software all running on the powerful IBM Cloud infrastructure to help you meet workload demands.

### V. Conclusion

High Performance Cloud Computing allows scientists and engineers to solve complex science, engineering, and business problems using Cloud Computing which provides high bandwidth, enhanced networking, and very high compute capabilities. It allows you to increase the speed of research by running high performance computing in the cloud and to reduce costs by providing Cluster Compute or

Cluster GPU server's on-demand without large capital investments. Tap into unlimited resources to scale your High Performance Computing (HPC) jobs - analyzing large-scale data, running simulations and financial models and experimenting while reducing time to market. Organization's can process large volumes of data more economically and quickly with an easily configurable and scalable solution on the Cloud.

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