

# *A Study of Cloud Computing Environments for High Performance Applications*

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## **Abstract**

High performance applications requires high processing power to compute highly intensive and complex applications for research, engineering, medical and academic projects. In the traditional way, an organization will have to pay very high costs to run an HPC (High Performance computing) application. The organization has to purchase highly expensive hardware for running an HPC application and maintaining it afterwards. The HPC resources on the company premises may not satisfy all the demands of scientific application where resources may not suitable for corresponding requirements. Considering the case of SMEs (small and medium enterprises), an increasing demand is always challenging. Cloud computing is an on-demand, pay-as-you-go model, that offers scalable computing resources, unlimited storage in an instantly available way. In this paper we included requirements of HPC applications in cloud, cluster based HPC applications, types of clusters, Google's HPC Cloud architecture, performance analysis of various HPC cloud vendors and four case studies of HPC applications in cloud.

**Keywords:** *Cloud, HPC, SMEs, EC2, POD Cloud, R-HPC*

## **I. INTRODUCTION**

High Performance Computing (HPC) plays an important role in both scientific advancement and economic competitiveness of a nation - making production of scientific and industrial solutions faster, less expensive, and of higher quality. HPC is a key component in many applications: designing vehicles and airplanes; designing high-rise buildings and bridges; discovery of drugs; discovery and extraction of new energy sources like oil and natural gas; weather forecasting; and many more. HPC requires very high processing power to compute largely complex scientific applications. The advantage of pay-as-you-go computing has been an industry goal for many years starting from main frame, cluster and grid computing. Cloud computing takes grid computing to a whole new level by using virtualization to encapsulate an operating system instance and run it in a cloud whenever they need computational resources. In addition cloud storage can also be used independently with operating system instances. Cloud computing also offers unlimited storage and instantly available and scalable computing resources, all at a

reasonable metered cost. Cloud also having large data centres which is suitable for data-intensive applications.

## **II. HPC APPLICATIONS IN CLOUD**

With increasing demand for high performance, efficiency, productivity, agility and lower cost, since several years, information communication technology are dramatically changing from static silos with manually managing resources and applications, towards dynamic virtual environments with automated and shared services, i.e. from silo-oriented to service oriented architectures[15]. A "traditional" cloud offers features that are attractive to the general public. These services comprise single, loosely coupled instances (an instance of an OS running in a virtual environment) and storage systems backed by service level agreements (SLAs) that provide the end user guaranteed levels of service. These clouds offer the following features:

- Instant availability – Cloud offers almost instant availability of resources.
- Large capacity – Users can instantly scale the number of applications within the cloud.
- Software choice – Users can design instances to suit their needs from the OS up.
- Virtualized – Instances can be easily moved to and from similar clouds.
- Service-level performance – Users are guaranteed a certain minimal level of performance.

Although these features serve much of the market, HPC users generally have a different set of requirements:

- Close to the "metal" – Many man-years have been invested in optimizing HPC libraries and applications to work closely with the hardware, thus requiring specific OS drivers and hardware support.
- User space communication – HPC user applications often need to bypass the OS kernel and communicate directly with remote user processes.

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## **Table of Contents 2014 Ieee Base Paper On Cloud Computing**

1. Understanding the eBook 2014 Ieee Base Paper On Cloud Computing
  - The Rise of Digital Reading 2014 Ieee Base Paper On Cloud Computing
  - Advantages of eBooks Over Traditional Books
2. Identifying 2014 Ieee Base Paper On Cloud Computing
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an eBook Platform
  - User-Friendly Interface
4. Exploring eBook Recommendations from 2014 Ieee Base Paper On Cloud Computing
  - Personalized Recommendations
  - eBook User Reviews and Ratings
  - eBook Bestseller Lists
5. Accessing 2014 Ieee Base Paper On Cloud Computing Free and Paid eBooks
  - eBook Public Domain eBooks
  - eBook Subscription Services
  - eBook Budget-Friendly Options
6. Navigating 2014 Ieee Base Paper On Cloud Computing eBook Formats
  - ePub, PDF, MOBI, and More
  - eBook Compatibility with Devices
  - eBook Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of eBook
  - Highlighting and Note-Taking eBook
  - Interactive Elements eBook
8. Staying Engaged with 2014 Ieee Base Paper On Cloud Computing

- Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers 2014 Ieee Base Paper On Cloud Computing
9. Balancing eBooks and Physical Books 2014 Ieee Base Paper On Cloud Computing
- Benefits of a Digital Library
  - Creating a Diverse Reading Collection 2014 Ieee Base Paper On Cloud Computing
10. Overcoming Reading Challenges
- Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
11. Cultivating a Reading Routine 2014 Ieee Base Paper On Cloud Computing
- Setting Reading Goals 2014 Ieee Base Paper On Cloud Computing
  - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of 2014 Ieee Base Paper On Cloud Computing
- Fact-Checking eBook Content of 2014 Ieee Base Paper On Cloud Computing
  - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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