

Comparison of Several IaaS Cloud Computing Platforms

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Abstract— Today, the question is less about whether or not to use Infrastructure as a Services (IaaS), but rather which providers to use. Cloud infrastructure services, known as Infrastructure as a Service (IaaS), are self-service models for accessing, monitoring, and managing remote data center infrastructures, such as compute, storage, networking, and networking services. Instead of having to purchase hardware outright, users can purchase Infrastructure as a Service (IaaS) based on consumption, similar to electricity or other utility billing. Most providers offer the core services of server instances, storage and load balancing. When choosing and evaluating a service, it is important to look at issues around location, resiliency and security as well as the features and cost. In order to evaluate which provider best suits requirements.

Key words: Amazon AWS, Benefits of Infrastructure as a Service, Comparison of Infrastructure as a Service, Google Compute Engine, HP Enterprise Converged Infrastructure, IBM SmartCloud Enterprise, Rackspace Open Cloud, Windows Azure

I. INTRODUCTION

Cloud Computing is one of the hot topics of the moment and everyone has an opinion on it. The term 'Cloud' covers a number of deployment scenarios, including PaaS (Platform as a Service), SaaS (Software as a Service) and IaaS (Infrastructure as a Service). The computing resources that we need grown up due to the use of computers in our day-to-day life has increased. It is costly to buy a mainframe computers, it became important to find the alternative ways to get the greatest return on the investment, allowing multiple users to share among both the physical access to the computer from multiple terminals and to share the CPU time, eliminating periods of idleness, which is time-sharing. The origin of the term 'cloud computing' is unclear, but it appears to derive from the way of drawings of stylized clouds to denote networks in diagrams of computing and communications systems. Cloud computing is a paradigm shift in which computing is moved away from personal computers and even the individual enterprise applications to a 'cloud' of computers. "Cloud computing is where data and services reside in massively scalable data centres in the cloud and can be accessed from any connected devices over the internet". In cloud services users are given access to application software and databases. The cloud service offering companies manage the infrastructure and platforms on which the applications run. Software as a services is sometimes referred to as on-demand software and is usually priced on a pay-per-use basis. Providers generally charge price using a subscription fee.

Infrastructure as a Service could be described as the foundation or lowest tier in the Cloud Computing stack. In short, it refers to the deployment of traditional infrastructure components such as servers and storage. Today this usually means virtual infrastructure, as the need to have dedicated servers is diminishing rapidly.

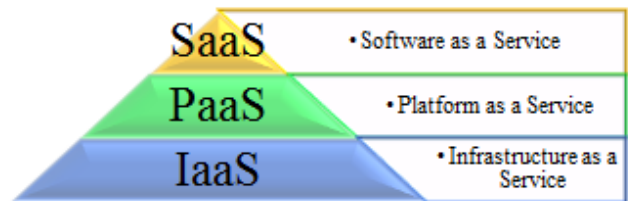


Fig. 1: Stack of Cloud Computing

There are many benefits of using Infrastructure as a Service:

- IaaS reduced environment effect with optimum use of IT resources and system.
- It changes cost form Capital Expenses (Capex) to Operational Expenses (Opex). No need to invest on assets and expenses on related cost.
- Learning new application or programming frameworks is not required because it's with PaaS and SaaS.
- Existing skill sets around server, database and application administration can all be retained and re-used. It provides resources in terms of components they would traditionally deploy in their own data centers.
- It provides a degree of portability between service providers and the customer's own existing infrastructure as deployment takes place on standard platforms such as Windows and Linux.
- Customer has control over the storage of data, including additional encryption and security measures because of isolation of resources at the virtual server level

Infrastructure as a Service (IaaS) is a cloud model which allows organizations to outsource computing equipment and resources such as servers, storage, networking as well as services, such as load balancing and content delivery networks. The IaaS provider owns and maintains the equipment while the organization rents out the specific services it needs, usually on a "pay as you go" basis. It's easy to think of IaaS as a commodity product, that all virtual machines are essentially the same regardless of where they reside. There is some truth in that, however the distinguishing features of each cloud provider, especially around management and specialized services, are what's important to administrators. When evaluating IaaS providers, it's important to look beyond the range of cloud services that are offered and consider management functions, monitoring tools, identity management, service level agreements and customer support.

II. IAAS CLOUD COMPUTING PLATFORMS PROVIDERS

A. Amazon AWS

Amazon Web Services is a dynamic, growing business unit within Amazon.com. Amazon Web Services offers a full range of compute and storage offerings, including on-demand instances and specialized services such as Amazon Elastic Map Reduce (EMR) and Cluster GPU instances, as well as Elastic Block Storage (EBS) and high performance

SSDs on the storage side. It offers a broad set of global compute, storage, database, analytics, application, and deployment services that help organization move faster, lower IT costs, and scale application. Additionally, the IaaS offers infrastructure services such as workflows, message passing, archival storage, in-memory caching services, search services, both relational and NoSQL databases and more.



B. Windows Azure

Windows Azure provides Virtual Machine and Virtual Network Capabilities which enable users to deploy and run durable VMs in the cloud. VMs can be created from an Image Gallery of pre-populated templates built into the Windows Azure Management Portal or user can upload and run own customer-built VHD images. Windows Azure IaaS offers ready access to virtual networks, service buses, message queues, and non-relational storage platforms as well.



C. Google Compute Engine

Google Compute Engine is a service that provides virtual machines that run on Google infrastructure. Google Compute Engine offers scale, performance and value that allows to easily launch large compute clusters on Google's infrastructure. There are no upfront investments and user can run up to thousands of virtual CPUs on a system that has been designed from the ground up to be fast, and to offer strong consistency of performance. Google Compute Engine is well suited for big data, data warehousing, high performance computing and other analytics-focused applications. It is well integrated with other Google services, such as Google Cloud Storage, Google BigQuery and Google Cloud SQL.



D. Rackspace Open Cloud

The Rackspace open cloud is built on the open-source Open Stack framework, founded by Rackspace and NASA in July 2010. Rackspace offers core cloud computing services with web application hosting or platform as a services, cloud storage, virtual private server, load balancers, databases, backup, and monitoring. User can choose from a variety of operating systems, including Linux and Windows Server. And for an extra fee, can easily create basic monitoring checks, like ping or HTTP checks.



E. IBM SmartCloud Enterprise

IBM SmartCloud Enterprise is a set of cloud computing services for business offered by the information technology company IBM. IBM SmartCloud Enterprise offers core compute and storage services in a 5-tier model along with an asset catalog of IBM and non-IBM software. The IaaS is ideal for enterprises managing a large number of developers and testers who need to deploy virtual machines and allocate storage as efficiently as possible. User can manage administrator and user roles, set limits on resources users can deploy and readily report on user activity. IBM Clouds provides infrastructure as a services, platform as a service and software as a service through public, private and hybrid cloud delivery models.



F. HP Enterprise Converged Infrastructure

HP Enterprise Converged Infrastructure are purpose-built and designed to handle workload requirements with speed and efficiency. Integration across server, storage and networking make these systems easy to buy, deploy and manage and ultimately reduce costs and risks for faster time-to-value. HP's cloud is built on OpenStack and its IaaS service is part of the company's Converged Cloud Solutions for public, hybrid and private clouds. HP offers Windows and Linux command line interfaces in addition to the dashboard as well as a RESTful API so user can use cURL for low level access to HP's cloud functions. HP cloud also offers simple access to its content distribution network (CDN), particularly useful for companies with a global customer and/or user base.



III. CONSIDERATIONS TO WEIGHT IAAS CLOUD COMPUTING PLATFORMS

Infrastructure as a Service provides an easy way to start using Cloud Computing. Most providers offer the core services of server instances, storage and load balancing. When choosing and evaluating a service, it is important to look at issues around location, resiliency and security as well as the features and cost. In order to evaluate which provider best suits requirements, there are a number of considerations to weigh.

A. IaaS Location

Cloud Computing is provided through the Internet, but at some point there are physical servers, storage and networking equipment installed in a data center on to which

service will run. Therefore latency can be an issue, depending the application are deploying. Most Infrastructure as a Services providers operate from multiple locations. If they don't then they are probably not worth considering because operating out of a single data center presents issues around availability.

B. IaaS Redundancy and Availability

One benefit of providing multiple locations is that of increased availability. The question of course, is how that availability is implemented. These are physically separate data centers in separate locations, between which data is replicated. Deploying across multiple regions or locations can increase availability.

Infrastructure providers are offer services to enable the automated failover and management of applications, therefore it's unavoidable for customer to look at how geographic resiliency can be implemented.

C. IaaS Features

There are two features that almost all IaaS providers offer and both should be considered essential to offering a cloud-based infrastructure service. They are server/compute and load balancing.

1) Server/Compute

Servers or "instances" represent the main compute resource in IaaS. They will usually be instances of a virtual server running a standard operating system such as Windows or a Linux variant. The underlying virtualization technology used to support the servers isn't significant, although some service providers make a virtue of highlighting the hypervisor they use. When a new instance is created, the boot disk on which the instance runs can be persistent or transient. Persistent disks are retained when an instance is destroyed; transient disks last only as long as the instance itself. Separating the instance from its boot disk is beneficial in a number of ways, as it can be replicated and moved around independently. Not all service providers offer persistent boot images and it is worth checking what features are offered in order to backup or snapshot the image in case recovery is needed.

2) Load balancing

A load balancer provides a virtual IP network connection and distributes connection requests across a number of instances of an application. This feature used to spread load across a number of server instances or to add a degree of resiliency and availability to an application. An additional server instance can be created and added for the duration of the web application has periods of high demand. The temporary instance can then be decommissioned when demand subsides.

D. IaaS Security

Security sits high on everyone's list. In a Cloud environment both logical and physical security is a concern. Poor physical controls can result in data breaches or worse, including prolonged outages. Logical security should ensure that unauthorized access can't be achieved in what is a multi-tenant environment. Security features of Cloud provider must meet standards or compliance rules.

E. IaaS Management

The definition on Cloud Computing from NIST states "minimal management effort" as a service goal. Use of web interfaces displaying dashboards and control panels helps service providers to achieve minimal management effort feature. Web-based management should be simple and easy to use but is unlikely to provide the features needed to deploy cloud infrastructures at scale.

Application Programming Interfaces (APIs) enable Cloud computing to be integrated into existing business processes, including change control, provisioning and billing. For organizations that already run their IT operations as a service to internal business customers, this will be mandatory. When multiple providers are used, APIs enable a common interface to be established, irrespective of where the computing resources are located.

F. IaaS Cost

Every provider will do differentiated pricing, including the costs of some services as part of the package and charging for others. It's important to get full details of what cost model is and more importantly how that translates into any Service Level Agreements (SLA) if the service is unavailable or performs poorly.

IV. COMPARISON OF IAAS CLOUD COMPUTING PLATFORMS

Key Features	
Amazon	Rich set of services and integrated monitoring tools.
Microsoft	Easy-to-use administration tool.
Google	Google infrastructure backing it up, this IaaS is designed to scale.
Rackspace	Easy to use control panel, and strong customer service.
IBM	A good combination of management, software and security features for enterprise cloud administrators.
HP	A good solution for enterprises wanting to integrate their existing IT infrastructure with public cloud services and investing in a hybrid cloud.

Table I Key Features

Limitations	
Amazon	AWS is a complex mixture of services. As workflows become more complex and use of more services can be difficult to project expenses. However, Amazon offers a monthly calculator to help estimate costs.
Microsoft	Minimal, easy-to-use portal interface may not be so appealing to command line gurus.
Google	Lacks ease of administration features. Running Hadoop on Google Compute Engine, for example, requires more from users; because it's not integrated you have to download the Hadoop package, a patch for Hadoop and a set of JDK packages along with several other steps to deploy a Hadoop cluster.
Rackspace	No messaging or specialized services (like Amazon Simple Queue Service and DynamoDB), although there are alternatives (like RabbitMQ and MongoDB or CouchDB) that can run, on slight management.
IBM	May find difficulty distinguishing itself from other OpenStack providers, at least among non-IBM customers.
HP	HP is still relatively new in the IaaS space with a limited track record and feature set compared to more seasoned providers.

Table II Limitations

Pricing	
Amazon	Instances range from \$0.113/hour to \$6.82/hour, with volume discounts available for reserved instances. Storage prices range from \$0.095/GB/month to \$0.125/GB/month. Additional charges for application services and data egress may apply.
Microsoft	\$0.02 to \$1.60 per hour. Storage prices range from \$0.07/GB/month to \$0.12/GB/month, depending on level of redundancy.
Google	Instances range from \$0.019/hour to \$1.659/hour. Provisioned storage is \$0.04/GB/month; snapshot storage is \$0.125/GB/month.
Rackspace	Instances start at \$0.04/hour and go up to \$5.44/hour. File storage starts at \$0.10/GB/month and block storage is \$0.12/GB/month.
IBM	Hourly and monthly pricing available, however numbers are not disclosed. Contact IBM for details.
HP	Instances range from \$0.03/hour to \$3.40/hour. Block storage is \$0.10/GB/month while object storage costs \$0.09/GB/month.

Table III Pricing

Bonus	
Amazon	New users can get 750 hours, 30GB storage and 15GB bandwidth for free with AWS's Free Usage Tier.
Microsoft	Free 30-day trial with a limit of up to \$200 is available for new users.
Google	Google charges by the minute after a minimum of 10 minutes in an hour.
Rackspace	Rackspace is currently offering a \$100 credit on your first month bill.
IBM	Free cloud server for one month from IBM's SoftLayer.
HP	Free 90-day trial with a \$100 credit for each of your first three HP Public Cloud monthly invoices.

Table IV Bonus

Cloud Promises												
Providers	Cost Reductions / Optimizations					Scalability and Automation				Choice and Flexibility		
	Variety of Pricing Plans	Average Monthly Price	Cost of Data Transfer - out (/GB)	Cost of Data Transfer - in (/GB)	Storage costs (/GB)	Scale Up	Scale Out	APIs	Monitoring	Datacenters	Instance Types	Supported O/S
Amazon	Pay-as-you-go, reserved, spot	\$66.43	\$0.120	\$0.00	\$0.19	Yes	Yes	Yes	Extensive	8	17	4
Microsoft	Pay-as-you-go, semester, year	\$65.70	\$0.155	\$0.00	\$0.13	Yes	Yes	Yes	Average	8	5	6
Google	Pay-as-you-go	\$42.42	\$0.120	\$0.00	\$0.10	Yes	Yes	Yes	Poor	11	22	2
Rackspace	Pay-as-you-go	\$116.80	\$0.120	\$0.00	\$0.10	Yes	Yes	Yes	Average	9	8	4
IBM	Pay-as-you-go, year, semester	\$211.70	\$0.150	\$0.15	\$0.20	No	No	No	Poor	7	5	3
HP	Pay-as-you-go	\$87.60	\$0.120	\$0.00	\$0.12	Yes	Yes	Yes	Poor	3	6	4

Table I Cloud Promises

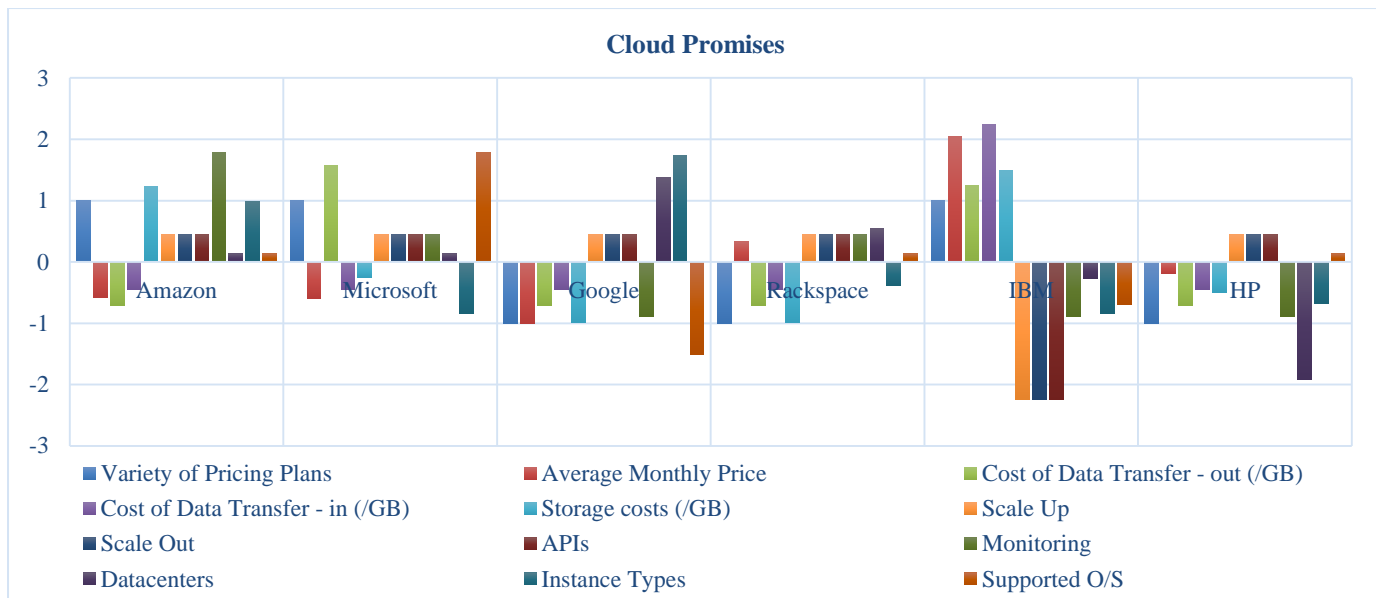


Fig. 2: Cloud Promises

User Concerns							
Providers	Security Features		Ease of Migration		Reliability		
	Certifications	Protection	Standards	VM Upload	Service Age	SLA	Support
Amazon	Yes	Medium	Proprietary	Yes	5+ Years	99.95%	Poor
Microsoft	Yes	Medium	HyperV	Yes	1 - 2 Years	99.95%	Average
Google	Yes	Medium	Proprietary	No	1 - 2 Years	99.95%	Poor
Rackspace	Yes	Medium	OpenStack	No	5+ Years	100.00%	Extensive
IBM	Yes	Medium	No	Yes	1 - 2 Years	99.95%	Poor
HP	No	Medium	OpenStack	No	1 - 2 Years	99.95%	Extensive

Table VI Users Concerns

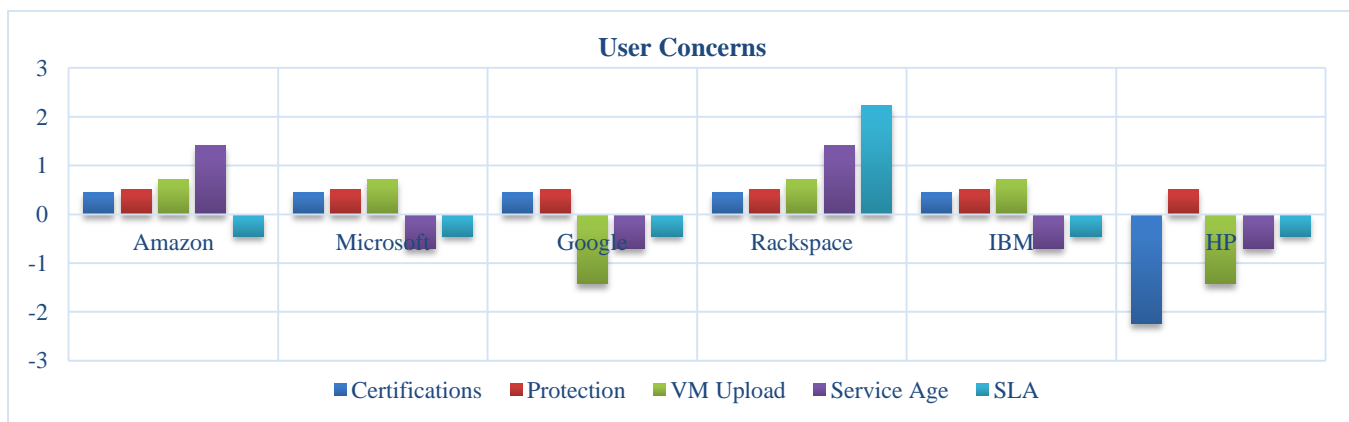


Fig. 3: User Concerns

V. CONCLUSION

Cloud Computing is the promising paradigm for delivering IT services as computing utilities. As there are many

vendors, Providers like Amazon AWS, Google Compute Engine, HP Enterprise Converged Infrastructure, IBM SmartCloud Enterprise, Rackspace Open Cloud, and Windows Azure are considered for enhancing from different

dimensions. As a Service market, however, to prove one of the most exciting ones in the cloud space, and there have been several important factors, such as changes in Pricing strategies, Compatibility operating Systems and languages, supporting services and the entrance of some technology heavy weights. It's important to confirm service providers that can provide services in region and the business continuity they provide for those locations. Infrastructure providers are offer services to enable the automated failover and management of applications; therefore it's unavoidable to look at how geographic resiliency can be implemented. The major IaaS providers all offer load balancing as a feature. Server/Computer and Load balancing are very important feature offered by IaaS providers and both should be considered essentially. Web-based management and Application Programming Interfaces (APIs) enable Cloud computing both are important in IaaS Management in different scenario. In a Cloud environment both logical and physical security is a concern. Cost compression is most imported element for any Individual, Business, or Organization. There exist many frameworks which provides infrastructure as a service. This paper focuses on a comparison between the features of various IaaS Platforms. Thus this study allows the users to select the platform based on the requirements.

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