ISSN No. 0976-5697

Volume 8, No. 1, Jan-Feb 2017

International Journal of Advanced Research in Computer Science

RESEARCH PAPER

Available Online at www.ijarcs.info

Cloud Storage Providers and its Metrics

Dr.V.Nethaji
Department of Computer Science,
American Megatrends,
Chennai, Tamilnadu, India.

Dr.M.Durairaj
Department of Computer Science,
Solution Architect, Anuta Networks,
Bangalore, Karnataka, India.

Dr. K.Chidambaram
Department of Computer Science,
Wipro,
Coimbatore, Tamilnadu, India.

Abstract: Cloud Storage Providers (CSPs) delivered over an Exabyte of data under contract. This amazing growth announcers a new period for how storage is delivered and consumed. The CSP market has seen new providers, new functionality, improved platform maturity, increased acceptance in the enterprise and significant price reductions. Amazon's S3 service crossed the 1-trillion-object mark1, a significant indication of platform maturity, and all major CSPs dropped their prices multiple times. As public cloud storage becomes critical to enterprise infrastructure, independent testing and monitoring of these systems is becoming all the more critical to IT. It publishes the report to share the information that we assemble in order to properly evaluate CSPs for our own use. Cloud storage is a key factor of our storage-as-a-service, much like the traditional system vendors leverage commodity hard drives in their storage arrays.

Keywords: Cloud Storage Providers (CSPs), Functionality, Price, Presentation, Availability, Scalability, Benchmark.

INTRODUCTION

Cloud Storage Providers (CSPs) monitor every change, improvement or update within the CSP market, and constantly evaluate which CSPs best enable us to provide the highest quality service to our customers. In report, tests confirmed that Amazon S3 and Microsoft Azure Blob Storage were the two strongest players in the market and that, although other offerings showed potential, they had not yet matured enough for use in enterprise storage solutions. Overall, the CSPs tested demonstrated clear advancements, including improved Presentation and fewer errors. It is clear that the minimum is moving upward, which is excellent news for the cloud storage market as a whole. As more CSPs mature into enterprise-class cloud storage providers, organizations and vendors will be able to leverage competitive progressions in price and technology to improve their overall storage infrastructure.

Comparison Metrics

Cloud Storage Providers to achieve the best possible product at most cost effective price. Organizations considering cloud storage as part of their storage infrastructure should consider these same trade-offs when comparing CSPs. It evaluates three key components of each CSP's offering:

- Functionality
- Price
- Presentation

Functionality

While most interactions that an enterprise has with CSPs consist of simple API commands - GET, PUT and DELETE an organization should consider a broader range of functionality when comparing cloud storage providers [1]. Many companies today are universal operations with offices around the world in wide variety of localities, from major metropolitan areas to remote villages. To serve such users, cloud service providers need to keep access points around the world and support significant cross-geography replication. Two copies of a file in a single data center is not geographic redundancy. In addition, organizations that expect to make meaningful use of cloud storage in their environment should also value features of potential providers such as their API-based account creation and account management processes, accessibility of libraries and software to access data, the complexity of their billing schemes and other aspects that help operations teams to ensure a smooth experience for their users and applications.

Price

Price Cloud storage architecture is fundamentally different from traditional storage; consequently, it is also priced differently from conventional storage. Instead of charging a price per raw TB, most CSPs charge based on GB stored per month. However, pricing is typically more complicated than a simple count of GB per month, often adding compute costs and network costs. While this pricing model is cost effective because it charges customers only for the resources that they use, it makes predicting future costs a complex endeavor due to the changeability of applications and use-cases. Although some vendors offer tools to help estimate costs, every customer's use-case is unique, so one-size-fits-all tools provide poor predictions. Unless the organization is working with a provider that offers a basic pricing scheme, it is best to conduct initial tests with a minimal investment and then extrapolate from those results to develop a more accurate pricing guesstimate model. Price itself is a very small part of a CSP comparison and may be the last part of a decision. Commodity offerings combined with competitive activity are driving costs down rapidly, however functionality and Presentation still differ significantly. When appraising a CSP, remember, price is easy to change and negotiate – functionality and Presentation are not.

Presentation

Presentation is the primary yardstick by which it measures any publicly available CSP, testing the operation and constancy of CSPs over long periods of time. In fact, it has been testing and comparing CSPs. Before considering any CSP for use in a production environment, it must meet minimum Presentation benchmarks across three areas:

II. CSP's BENCHMARK

This simple test measures the raw ability of each CSP to handle thousands of Writes, Reads and Deletes. We test each CSP with files of different sizes:

• 1 KB
• 10 KB
• 100 KB
• 1 MB
• 10 MB
• 100 MB
• 1 GB

Using varying levels of concurrency:

• 1 Thread
• 10 Threads
• 50 Threads
• 100 Threads

The Write/Read/Delete benchmark test runs for twenty four hours, using multiple testing machine instances and several non-serial test runs to reduce the probability that external network issues could bias the results.

Availability:

This test takes place over a 20 days period and measures each CSP's response time to a single W/R/D process at 1 minute intervals [11]:

• Write a randomly generated 1 KB file
• Read a randomly selected formerly written file
• Delete a selected file

Reading and deleting a random file forces each CSP to prove their capability to be responsive to all of the data, all of the time, and not merely to the last piece of cached data [2]. This test calculates the entire time required to complete the three requests, with any required retries. This ensures examination of not only responsiveness but also of CSP reliability and latency.

Scalability:

Similar to availability test, this is also protracted test that measures each CSP's ability to perform consistently as the number of objects under management growths. Presentation under increasing object counts is often the Achilles heel of a cloud storage system, and this test actions each CSP's ability to maintain Presentation levels as the total number of objects are stored in a single container increases to hundreds of millions.

III. METHOLOGY

Due to dynamics in the marketplace, the list of platforms evaluated continues to change every time. The CSPs tested Amazon S3, Microsoft Azure Blob Storage, Google Cloud Storage, Rackspace Cloud and HP Cloud Object Storage Files. While many cloud storage platforms are openly available, currently only these five platforms offer the combination of functionality, market experience and price that it requires for our solution [3].

It engineers conducted all tests using simple virtual machines across most of the major cloud compute platforms. Each CSP was tested by using three "outside" machines spread throughout the eastern region of the United States. Although the use of "inside" machines would likely produce the best possible results for any CSP, we selected not to test such configurations, in order to present a scenario that accurately matches how it uses cloud storage - where it is accessed from outside of the cloud itself. We competed all tests using a variety of times, locations, virtual machines and dates to eliminate external network bias.

CSPs to participate in the evaluation process. The tested companies were allowed to review the preliminary results, discuss the findings and provide feedback to it engineering teams [2]. We learned that in some cases, the CSPs had imposed limits on the machines, limits on container Presentation or had actually upgraded their networks during the testing period – all of which affected the results. For those CSPs that requested it, we re-ran the Presentation tests a second time. However, it did not allow any CSPs to make changes that would not be available at no additional cost to a standard customer[12].

One interesting lesson from the review process was that some CSPs required the making of brand new accounts to take advantage of improved infrastructure. While simple for testing, this is unacceptable in the real world and represents a clear deviation from the traditional Infrastructure-a-Service(IaaS)model.

• **Machine 1**

- RAM: 15-18 GB
- vCPUs: 4
- Operating system: Ubuntu 12.041, 64 bit - Ubuntu12.041 LTS (GNU/Linux 3.2.0-25-virtual x86_64)

• **Machine 2**

- RAM: 5 GB
- vCPUs: 2
- Operating system: Ubuntu 12.041, 64 bit - Ubuntu 12.041 LTS (GNU/Linux 3.2.0-25-virtual x86_64)

The tests are designed to evaluate the Presentation of CSPs under file-server data. The tests use the same distribution of file sizes used by actual It enterprise customers across thousands of installations over several times. Customers primarily use it to replace aging NAS technologies in data-centers and distributed offices – for this reason, the file size distribution matches that of a typical enterprise file server [4]. The exact distribution of file sizes used was:

Table I: File size distribution

1KB	10KB	100KB	1MB	10MB	100MB	1GB
16.8%	24.6%	26.2%	9.7%	22.2%	0.4%	0.1%

CSPs and any other as-a-service vendors should strive to provide their customers with the best possible customer experience, and all upgrades should occur behind the scenes without customer intervention. For organizations planning to use a CSP, it is best to communicate your use case to the suitable provider teams to ensure that you are taking advantage of their most up-to-date offerings.

IV. RESULTS

Write/Read/Delete Benchmark

Benchmark results varied significantly across CSPs, illustrating that parity does not yet exist in this market. Of all the different tests run on the CSPs, this simple test highlighted the differences best. For each test (Write/Read/Delete), the test evaluated 23 combinations of file sizes and thread counts as shown in Table II.

Table II: File size and thread count combinations tested

File Size & Threads Tested		1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
Number of Concurrent Threads	1	✓	✓	✓	✓	✓	✓	✓
	10	✓	✓	✓	✓	✓	✓	
	25	✓	✓	✓	✓	✓		
	50	✓	✓	✓	✓	✓		

The results are averaged based on the weighting of customer file-server data (Table 1) and are then indexed to the Presentation of the top performer. The results, therefore, compare all the CSPs to the Presentation of the top performer across all file sizes and thread counts. This allows hundreds of individual tests to be evaluated using a single benchmark metric [5]. Detailed raw results by CSP are included in the appendix.

The results show that raw write/read/delete Presentation varies significantly as object sizes and thread counts vary. Specifically, small object sizes and smaller thread counts highlight the transactional overhead of any platform. The effect of transactional overhead becomes most noticeable during writes, which contains three steps:

- Preparation
- Transmission
- Acknowledgement

For small files, Transmission is only a small portion of the total transaction, so any inefficiency in the Presentation of Preparation and Acknowledgement has greater impact [11]. Those object stores that are built with efficient Preparation and Acknowledgement steps perform best when handling small files [6].

As file sizes or thread counts increase, the time associated with transmission increasingly dominates the overall time associated with the transaction. Inefficiencies in Preparation or Acknowledgement become less and less critical. Many CSPs overly focus their efforts to improve the efficiency of the Transmission stage of the transaction and thus perform better under the load of larger object sizes or thread counts. This may be fine for use-cases like media archives, but for file-server data which is often dominated by small files, Presentation on small files is critical.

Write Benchmark

Microsoft was the top write performer. Furthermore, Microsoft outperformed all other CSPs on 14 of the 23 individual combinations tested, making it far and away the optimal write target for file-based data. More so than in any other benchmark-based test, Microsoft shows how strong its updated technology is in this write test. Amazon and HP are the strongest second contenders trailing behind Microsoft (Figure 1).

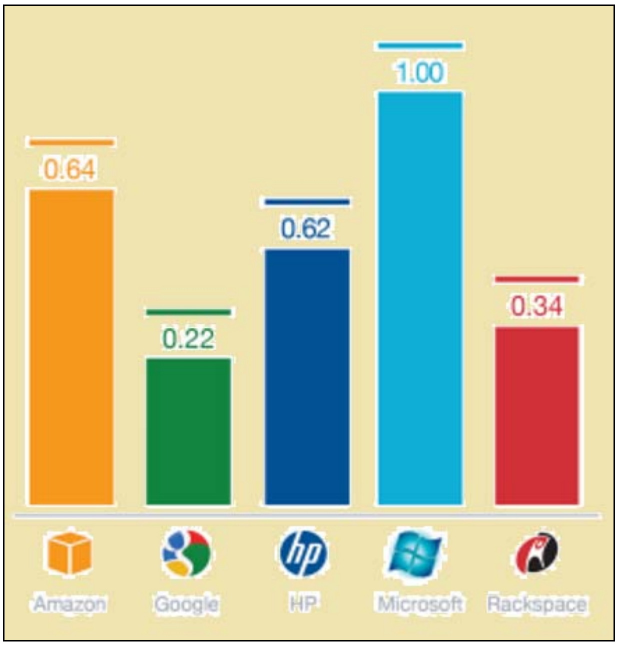

Figure 1: Indexed cloud storage write speed with all file sizes

The results for files larger than 1 MB show how much more closely all of the CSPs perform as transactional overhead becomes less significant than actual data transmission [7]. In Figure 2, Amazon takes the top spot and the remaining providers show relative parity except for Google.

Read Benchmark

Read Presentation again shows Microsoft with a significant lead over its nearest competitor (Figure 3). However, Amazon no longer has the clear second position from the write test. In fact, HP, a relative newcomer, edged out Amazon for the second spot. Even Google and

Rackspace, which struggled by comparison on the write test, show much better relative benchmark Presentation when reading objects.

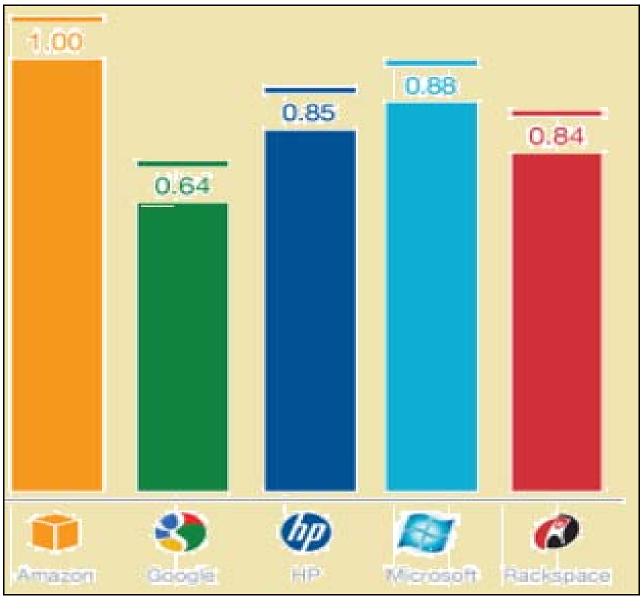

Figure 2: Indexed cloud storage write speed with files > 1MB

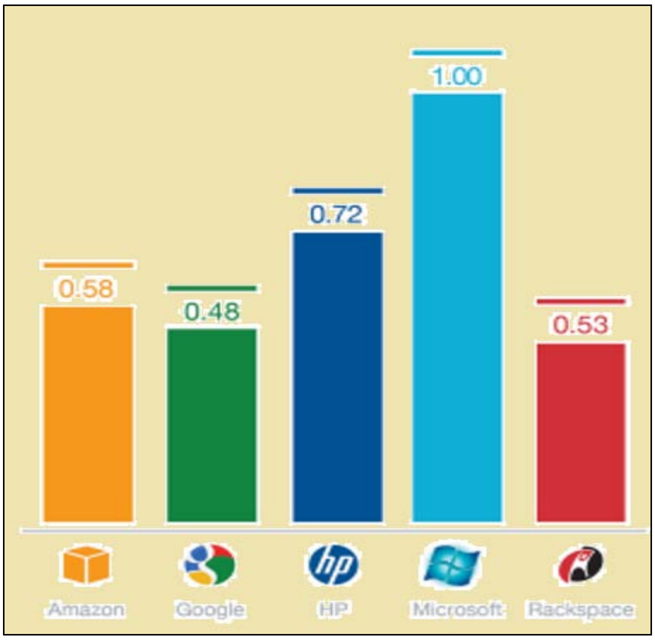

Figure 3: Indexed cloud storage read speed with all file sizes

Unlike the results from the write benchmark, in Figure 4 Microsoft maintains its leadership position even as object sizes increase [8]. While it still outperforms the other CSPs, the other platforms provide much closer Presentation than they do with smaller objects. Surprisingly, Amazon actually falls to fourth place behind both HP and Rackspace.

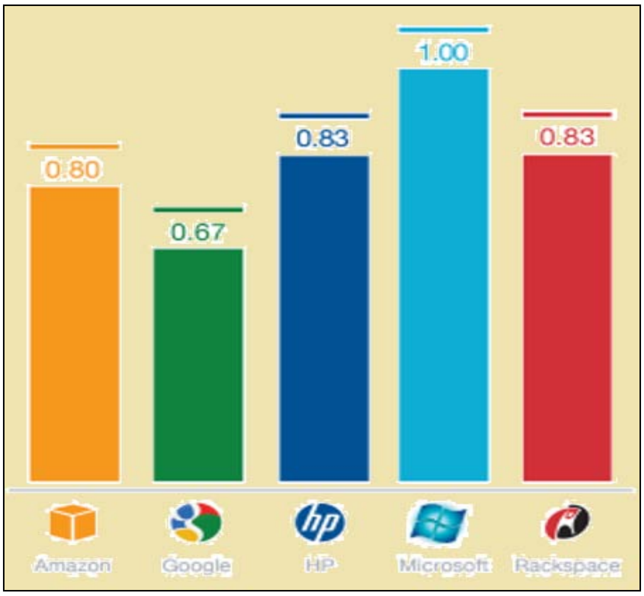

Figure 4: Indexed cloud storage read speed with files > 1MB

Delete Benchmark

Improving on the results from the other Presentation tests, Microsoft is more than twice as fast at deleting files as its nearest competitor. Amazon and HP share second position, well above both Google and Rackspace (Figure 5). Varying file sizes does not vary the results of this benchmark test.

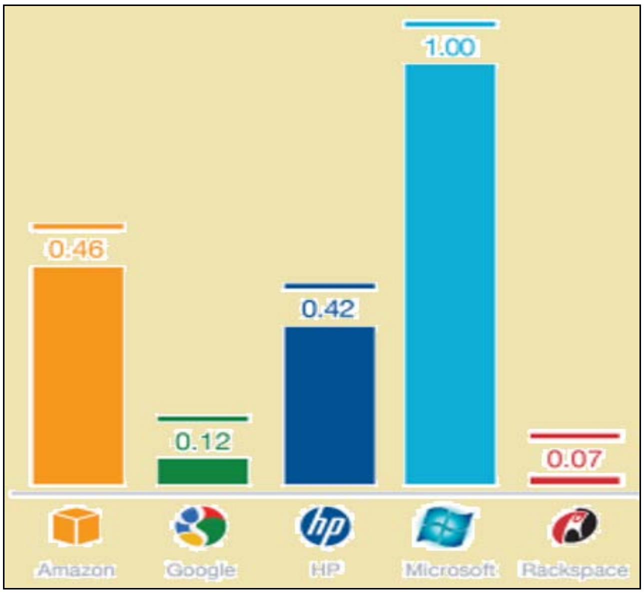

Figure 5: Indexed cloud storage delete speed

Availability is measured using the 'response time' metric that measures each CSP's response time to a single W/R/D process at 60-second intervals. Because 'response time' also includes any time associated with retries or delays, it is a more effective metric for availability than a simple ping test. Microsoft performed the best in this test, averaging a response time of less than 0.5 seconds over a 30- day period [9]. Amazon was the next closest, averaging just under 0.65 seconds, with third-place Rackspace averaging just under 1 second (Figure 6).

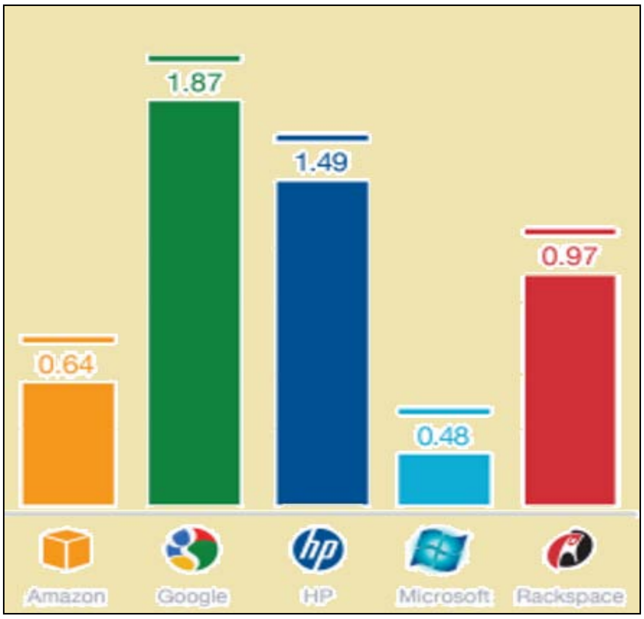

Figure 6: Average availability response time

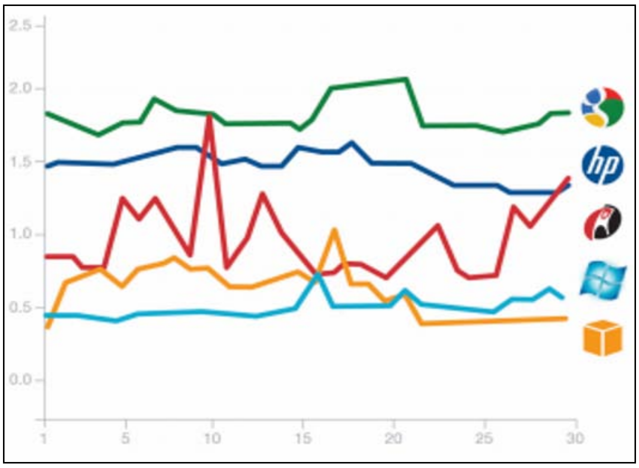

Figure 7: Average daily availability response time

Examining the results over the month of testing also gives some insight into the variability of the numbers [10]. While Microsoft and HP appear stable, Amazon and Google show a greater amount of variance in the results [11]. Rackspace is the most inconsistent of all the CSPs, with meaningful swings visible day over day (Figure 7).

In addition to system and data availability, the test also measures overall uptime or percent of the time that the CSP is reachable. All players showed strong uptime percentages, with newcomer Google sharing the top spot with Amazon at 100 percent over the 30-day period (Figure 8).

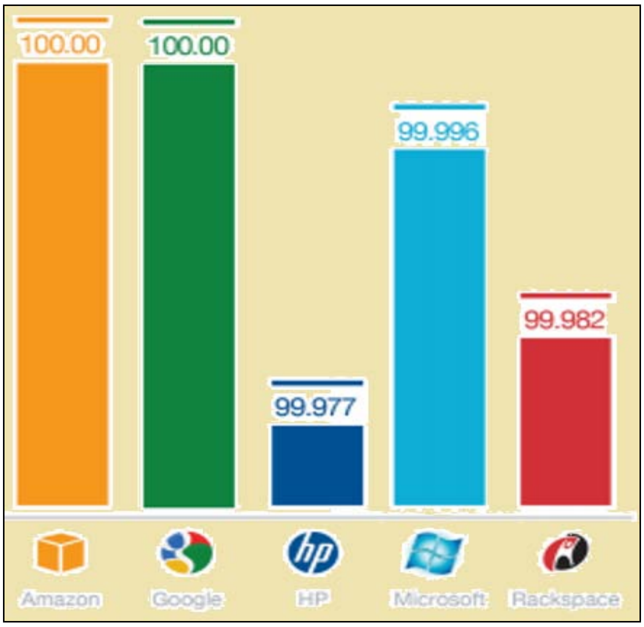

Figure 8: Average uptime

V. SCALABILITY

As object counts increase, the Presentation of some CSPs degrade or becomes variable. Depending on CSP architecture, some systems are designed to scale across containers, not within them. This type of architectural limitation can become a significant bottleneck after months or even years of usage [7]. An ideal scenario for anyone seeking to leverage cloud storage is to partner with a CSP whose Presentation and responsiveness are unchanging regardless of the number of objects under management. Just as with traditional in-house storage, customers expect a consistent level of Presentation.

Under this test, all of the CSPs were loaded with new objects as quickly as possible up to 100 million objects or 30 days, whichever came first. The variance (Figure 9) represents how much the speed of loading objects changed over time, causing inconsistency and variability as objects were loaded.

Amazon, Microsoft and Google showed the lowest levels of variance, proving that no matter how many objects were loaded, Presentation did not depart significantly from their respective mean value. It is interesting to note that the two OpenStack platforms (HP and Rackspace) show the greatest variance as object counts increase. This may hint at architectural limitations, but without further testing and data, it is impossible to point to exactly what caused these elevated levels of variance and instability.

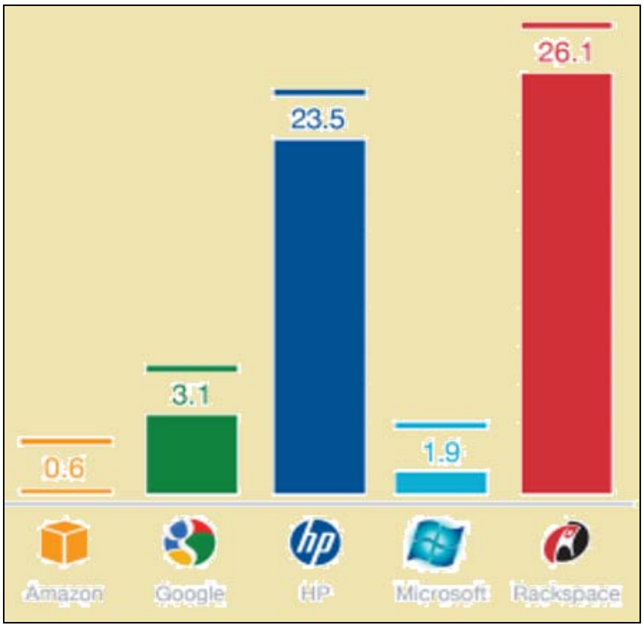

Figure 9: Variance during object scaling test

Compared with results, write and read error rates during scalability testing decreased significantly. While last results showed some error rates ranging from 1% - 60%, this result numbers were all well below 1%.

During 100 million write attempts, Amazon, Microsoft and Google did not show a single write error. Rackspace had an error rate of 0.000001% and HP 0.000017% (Figure 10).

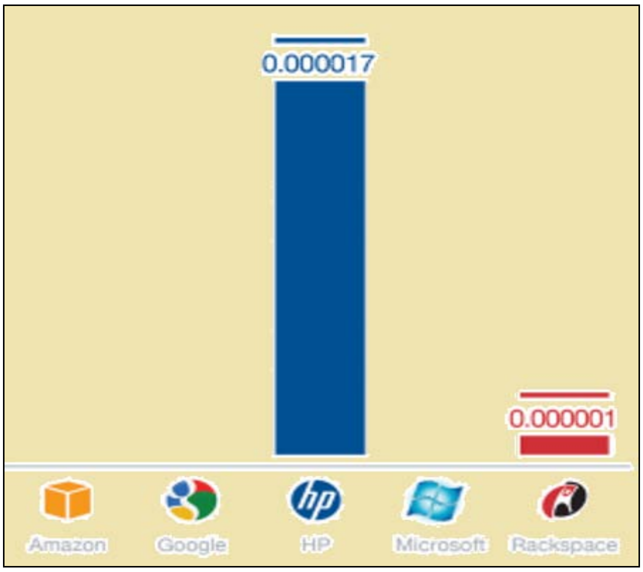

Figure 10: Percentage of write errors

During read attempts, only Microsoft resulted in no errors. Rackspace took the second spot with a read error rate of 0.0012% – significantly lower than rate of 59%. HP had the highest read error rate, but was still below 0.01% (Figure 11).

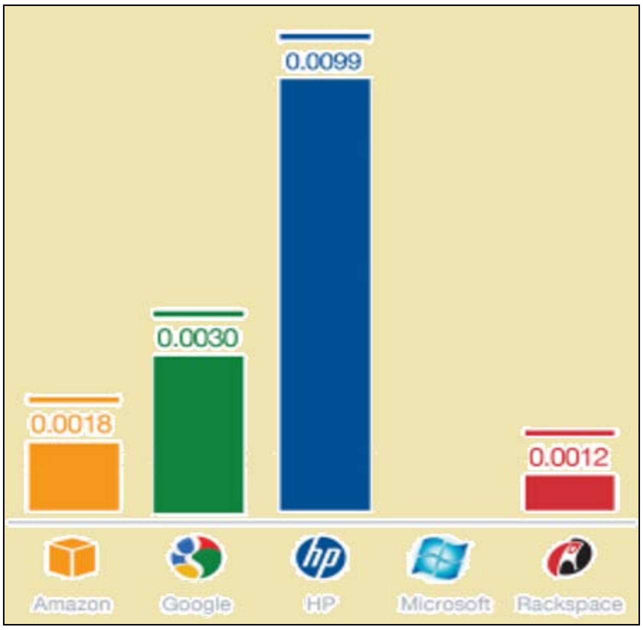

Figure 11: Percentage of read errors

In figure 12 depicts our test bed. Its core component is the testing application that orchestrates experiments and records network traffic. Two or more test computers run the application-under test. For simplicity, we consider only two test computers here, although our methodology is generic and supports multiple clients as well. Our testing application receives benchmarking parameters describing the sequence of operations to be performed [3]. Then, the testing application

acts remotely on Test Computer 1 by means of a FTP server, generating workloads in the form of file batches. Once the application-under-test detects that files have changed, it starts to synchronize them to the cloud. The application-under-test running on Test Computer 2 detects modifications and downloads the new content. Exchanged traffic is recorded during all steps and processed to compute Presentation metrics.

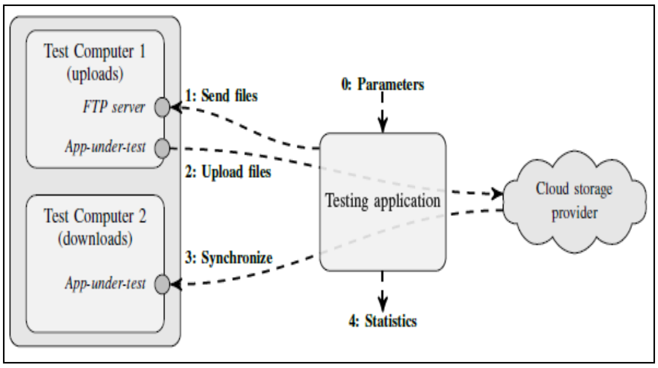

Figure 12: Test bed and workflow of Benchmarks

VI. Benchmark Results by Cloud Service Providers

Amazon Cloud storage:

Write Benchmark Results

Write Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.02	0.13	1.10	5.82	12.29	13.80	13.05
10	0.15	1.34	10.48	52.00	58.01	66.80	
25	0.28	2.82	22.72	73.08	82.66		
50	0.27	2.84	25.57	80.94	89.07		

Read Benchmark Results

Read Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.03	0.25	2.17	7.01	14.81	21.17	20.35
10	0.29	2.70	21.51	66.82	100.76	101.33	
25	0.76	6.89	45.46	83.72	102.11		
50	0.97	8.97	54.75	93.64	105.02		

Delete Benchmark Results

Delete Benchmark Results (Obj/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	30.33	33.32	34.70	35.43	34.64	36.82	14.16
10	350.31	331.70	378.30	375.02	248.54	195.02	
25	882.54	859.70	842.66	714.40	524.87		
50	1,000.86	991.70	1,041.73	976.58	411.72		

Google Cloud storage:

Write Benchmark Results

Write Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.00	0.01	0.07	0.68	4.42	12.53	16.22
10	0.01	0.08	0.68	6.58	41.11	59.30	
25	0.02	0.19	1.73	16.35	80.82		
50	0.04	0.37	3.48	31.73	107.36		

Read Benchmark Results

Read Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.02	0.24	1.28	7.36	24.31	33.01	35.14
10	0.24	2.21	12.24	55.33	72.29	69.19	
25	0.56	5.21	34.47	69.17	69.11		
50	0.99	8.74	51.20	65.47	66.77		

Delete Benchmark Results

Delete Benchmark Results (Obj/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	7.25	7.66	7.65	7.83	7.34	7.42	5.57
10	79.88	79.29	78.79	70.94	66.08	49.50	
25	180.63	180.06	186.16	174.77	161.10		
50	337.62	338.64	352.24	334.03	246.26		

HP Cloud Storage

Write Benchmark Results

Write Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.02	0.16	2.85	10.72	13.41	13.69	13.95
10	0.14	1.95	17.55	47.69	47.13	49.24	
25	0.20	2.03	20.63	59.01	62.60		
50	0.22	2.26	21.44	58.75	49.41		

Read Benchmark Results

Read Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.09	0.20	4.08	8.89	14.63	15.61	16.29
10	0.78	1.97	38.20	77.88	101.82	93.13	
25	1.75	4.92	64.58	97.99	103.15		
50	1.65	9.71	73.08	101.12	100.51		

Delete Benchmark Results

Delete Benchmark Results (Obj/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	48.67	57.40	48.13	52.97	42.29	20.28	5.65
10	358.17	393.95	383.88	402.42	391.55	115.81	
25	615.40	572.10	607.75	733.75	727.77		
50	760.65	752.52	743.79	913.45	674.31		

Microsoft Azure Blob Storage

Write Benchmark Results

Write Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.08	0.72	3.83	10.51	19.20		
10	0.38	3.60	23.62	53.94	42.31		
25	0.57	5.33	33.25	51.89	53.49		
50	0.67	6.40	25.60	56.34	59.17		

Read Benchmark Results

Read Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.22	1.76	8.77	13.74	29.30		
10	1.61	11.08	44.92	74.93	102.97		
25	2.04	12.10	41.59	77.46	123.56		
50	1.89	12.81	42.76	92.58	145.73		

Delete Benchmark Results

Delete Benchmark Results (Obj/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	122.67	111.14	117.40	111.76	121.32		
10	880.85	872.91	882.55	841.09	607.20		
25	1,745.40	1,666.60	1,576.07	1,632.35	772.31		
50	1,671.51	1,713.77	1,567.42	1,306.09	867.50		

Rackspace Cloud Storage

Write Benchmark Results

Write Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.00	0.03	0.23	1.68	6.79	17.23	19.64
10	0.03	0.27	2.09	15.75	53.67	58.86	
25	0.07	0.64	5.20	37.38	98.63		
50	0.10	1.00	9.58	59.06	108.37		

Read Benchmark Results

Read Benchmark Results (MB/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	0.02	0.19	1.44	8.09	21.29	34.09	35.99
10	0.19	1.87	13.87	57.64	80.75	74.99	
25	0.44	4.60	33.58	90.86	103.34		
50	0.87	8.58	63.63	100.50	119.24		

Delete Benchmark Results

Delete Benchmark Results (Obj/s)							
Threads	File Sizes						
	1 KB	10 KB	100 KB	1 MB	10 MB	100 MB	1 GB
1	8.59	8.79	8.26	8.31	8.72	9.47	6.27
10	76.32	77.56	70.02	77.05	73.63	47.62	
25	96.61	99.21	98.00	98.34	86.10		
50	98.31	96.17	94.80	98.63	83.70		

VII. CONCLUSION

Microsoft steadily performed better than the other CSPs in the tests, delivering the best Write/ Read/Delete speeds across a variety of file sizes, the fastest response times and the least errors. Not only did Microsoft outperform the competition meaningfully during the raw Presentation tests, it was the only cloud storage platform to post zero errors during 100 million reads and writes. In those groups where Microsoft was not the top performer (uptime and scalability variance), it was a close second.

For these reasons, Microsoft has replaced Amazon to accomplish the top performer position. Cloud storage is a hastily evolving market with new providers and new offerings entering all the time. The results in this report demonstrate that product parity does not yet exist in this market. While offering "cloud storage" is relatively easy, delivering a high performing, reliable and scalable solution needs significant focus, advanced technology and continuous investment.

While Microsoft has protected the leadership position, it is quite possible that things could change again. In this report has been published, there was a dissimilar leader each time. As presented in this paper, Amazon is still a strong player in this market, and is well positioned to continue to improve their platform producing better results. In addition, HP, a relative stranger to the CSP market, showed strong Presentation in write and read tests, suggesting that improvements in stability could make them a key player.

VIII. REFERENCES

[1] R. Gracia-Tinedo, M. S. Artigas, A. Moreno-Martinez, C. Cotes, and P. G. Lopez, "Actively Measuring Personal Cloud Storage," in Proceed-ings of the CLOUD, 2013, pp. 301–308.

[2] W. Hu, T. Yang, and J. N. Matthews, "The Good, the Bad and the Ugly of Consumer Cloud Storage," SIGOPS Oper. Syst. Rev., vol. 44, no. 3, pp. 110–115.

[3] Z. Li, C. Jin, T. Xu, C. Wilson, Y.Liu,L.Cheng, Y.Liu,Y.Dai,andZ.L.Zhang,"TowardsNetwork Level Efficiency for Cloud Storage Services," in Proceedings of the IMC, 2014.

[4] I. Drago, E. Bocchi, M. Mellia, H. Slatman, and A. Pras, "Benchmarking Personal Cloud Storage," in Proceedings of the IMC, 2013, pp. 205–212.

[5] I. N. Bermudez, S. Traverso, M. Mellia, and M. M. Munaf `o, "Exploring the Cloud from Passive Measurements: The Amazon AWS Case," in INFOCOM, 2013, pp. 230–234.

[6] I. Poese, S. Uhlig, M. A. Kaafar, B. Donnet, and B. Gueye, "IP Geolocation Databases: Unreliable?" SIGCOMM Comput. Commun. Rev., vol. 41, no. 2, pp. 53–56, 2011.

[7] I. Drago, "Understanding and Monitoring Cloud Services," Ph.D. dissertation, University of Twente, 2013.

[8] S. Liu, X. Huang, H. Fu, and G. Yang, "Understanding Data Characteristics and Access Patterns in a Cloud Storage System," in Proceedings of the CCGrid, 2013, pp. 327–334.

[9] Z. Li, C. Wilson, Z. Jiang, Y. Liu, B. Y. Zhao, C. Jin, Z.-L. Zhang, and Y. Dai, "Efficient Batched Synchronization in Dropbox-Like Cloud Storage Services," in Proceedings of the Middleware,2013, pp. 307–327.

[10] P. Amrehn, K. Vandenbroucke, T. Hossfeld, K. D. Moor, M. Hirth, R. Schatz, and P. Casas, "Need for Speed? On Quality of Experience for Cloud-based File Storage Services," in Proceedings of the PQS, 2013, pp. 184–190.

[11] P.Jack, Steve wagh, The Nasuni cloud storage blog, 2012, pp.5-8.

[12] W.Jack, Anderson K Rich VORMETRIC CLOUD ENCRYPTION GATEWAY, Enabling Security and Compliance of Sensitive Data in Cloud Storage, 2013.