WHITE PAPER

# Big Data is Better on Bare Metal

## Make big data performance a priority

## EXECUTIVE SUMMARY

Today, businesses create and capture unprecedented amounts of data from multiple sources in structured and unstructured formats. Storing, processing and pulling value from this 'big data' is no easy task. IT professionals often provision public cloud servers to scale storage and processing power to accommodate this steady stream of data, but those virtualised resources fail to deliver the performance and consistency of equivalent bare metal servers.

IBM® Cloud tested the performance and consistency of big data workloads on virtual servers and bare metal servers to compare the suitability of those platforms for applications that store and process massive amounts of data. With these results, IT professionals can make better decisions when selecting cloud resources for storage- and processor-intensive workloads.

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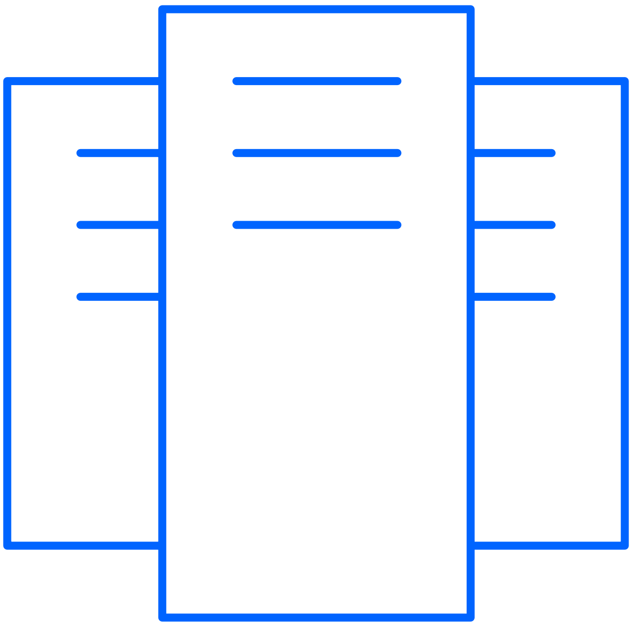
# What is Big Data?

As storage technologies evolve and additional capacity becomes more and more affordable, businesses find new ways to capture and process more information. Within this information, companies find insights with potential business value. The challenge lies in organising and analysing the data to create new business strategies and make organisational decisions.

Until recently, the most prevalent tools for organising and analysing data were relational database management systems (RDBMS) leveraging Structured Query Language (SQL). SQL solutions use structured data sets typically stored and manipulated on a single server. When the size of the data set increases to the capacity ceiling of the existing server, the solution scales up by moving to a larger server with higher processing power and more storage and RAM. Scaling up like this can be time-consuming and lead to a substantial increase in cost.

With data arriving more quickly from many different sources and in myriad schemas, database administrators need to maximise the efficiency and scalability of their solutions. As a result, many have begun leveraging NoSQL (Not Only SQL) databases, which use non-relational and unstructured data sets. This 'big data' architecture allows data to be stored across multiple systems, enabling NoSQL applications to scale out through the incremental addition of commodity systems, achieving on-demand capacity growth and higher cost effectiveness.



**These big data architectures can make sense of huge volumes of data, but to do so, that data has significant infrastructure requirements:**

- Storage to accommodate the volume of data
- RAM to move and load the data as needed
- Processing power commensurate with the level of performance required from the solution
- Network capable of connecting distributed data stores with low latency to enhance performance.

To address those requirements, many businesses leverage cloud computing resources as the underlying infrastructure to horizontally scale their big data environments. The most common building blocks in these environments are virtualised public cloud servers and bare metal servers.

# The **Four Vs** of Big Data

**Volume:** Think petabytes. From web history to public records to private internal documents, businesses store everything.

**Variety:** Large volumes of structured and unstructured data, including email, social media, video, images, weather data, blogs and much more.

**Velocity:** Data is constantly generated with real time queries for meaningful information to be served on demand.

**Value:** Meaningful insights derived from big data that go beyond the results of traditional intelligence querying and reporting. These insights can be transformed into predictive analytics for trends and patterns.

# Bare Metal Servers vs. Virtual Servers

Think about bare metal servers and virtual servers as two tools in the same toolbox. One isn't inherently better than the other; each has its own strengths and weaknesses.

Bare metal servers provide customers with direct, exclusive access to the raw hardware resources in a server. Virtual servers are independent cloud instances provisioned by a hypervisor on a hardware node that may be public (shared) or private.

## Bare Metal Servers – Raw Horsepower

For processor-intensive and disk I/O-intensive workloads, bare metal servers (sometimes referred to as dedicated servers) are ideal. These servers are single-tenant, so they are completely dedicated to a single customer. That means noisy neighbors won't affect performance.

Additionally, because bare metal servers do not run on top of a hypervisor, workloads do not pay the 'hypervisor tax'— a slight performance degradation caused by a hypervisor serving as a middleman between the operating system and the hardware.

Without a hypervisor to abstract the hardware, bare metal servers typically take much longer to provision and configure than virtual servers. When an infrastructure needs to scale quickly, bare metal is usually avoided. To address that weakness, IBM Cloud designed automated deployment and control of bare metal servers, bringing select configurations online in as little as 20 to 30 minutes and fully customised servers (your choice of processor, cores, RAM, storage, ports, etc.) online in two to four hours.

## Virtual Servers – Flexibility and Scalability

Applications and workloads that vary significantly in size or need to stay nimble in a constantly changing market are ideal for virtual servers. Virtual servers are provisioned on top of a hypervisor in a single- or multi-tenant public cloud environment. Virtual server resources can be deployed in as little as five minutes on monthly or hourly terms, so you can scale horizontally by adding additional servers very quickly.

## Bare Metal and Virtual – Together

IBM Cloud provisions bare metal servers and virtual servers in a single, unified cloud environment to provide customers with choice and control over the resources that will power their widely varying workloads.

**Business needs change. Our offering is designed to allow you to focus on today's needs without worrying what those needs will look like days, weeks, or months down the road.**

**The IBM Cloud platform and infrastructure was designed and built to be completely scalable:**

- Add bare metal and virtual servers on demand
- Scale back when necessary to reduce costs
- Order with hourly or monthly terms to fit different projects' timelines
- No long-term contracts.

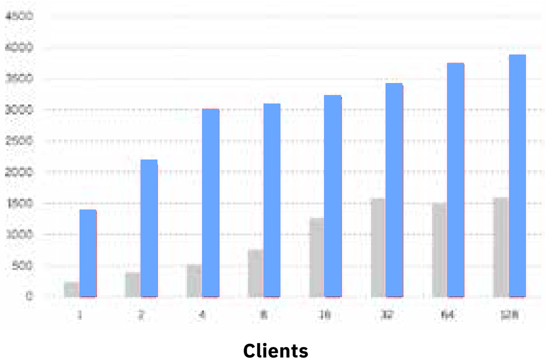
# Big Data - Performance

To determine whether big data applications are better suited to bare metal servers or virtual servers, we set up benchmarking tests to measure the performance and consistency of the two platforms. To accurately measure performance, an IBM Cloud engineer configured equivalent bare metal and virtual test environments to query and update a MongoDB data set using its freely available benchmarking harness (details noted in Appendix A).

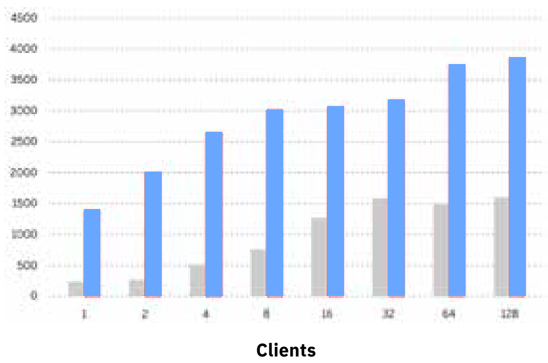
The benchmarking harness recorded the read and write operations per second of each cluster, based on the number of concurrent clients involved. The test results spoke volumes. Every bare metal environment outperformed its virtual server equivalent in terms of average reads and writes.

## Virtual Servers vs. Bare Metal Servers

**Average Read Operations per Second by Concurrent Client**




**Average Write Operations per Second by Concurrent Client**




Virtual Servers    Bare Metal Servers

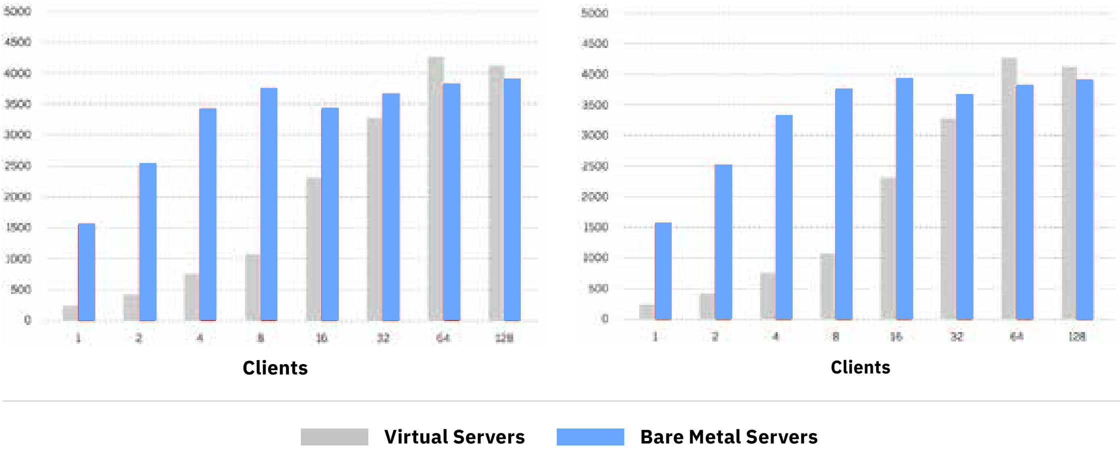
Because the bare metal environment could leverage the server's hardware resources directly and didn't have to compete with other users for resources, bare metal servers delivered up to six times better performance over equivalent virtual servers.

While measuring the average read and write operations per second, the benchmarking harness also recorded the peak performance of each environment and those results are noteworthy as well (for a different reason):

## Virtual Servers vs. Bare Metal Servers

### Average Read Operations per Second by Concurrent Client

### Average Write Operations per Second by Concurrent Client

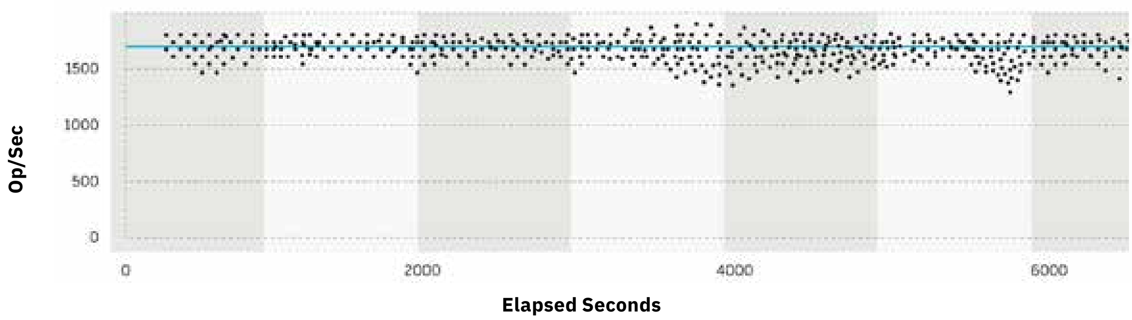



The peak results for read and write operations per second in the bare metal environments were very close to the average read and write operations recorded for that environment, but the peak results were vastly different from the average results in the virtual server environment. In two of the scenarios, the virtual servers actually hit a higher peak than the bare metal servers. When taken in context with the average operations per second recorded by the virtual server environment, the results actually highlight the other key performance indicator for big data workloads: **Consistency.**

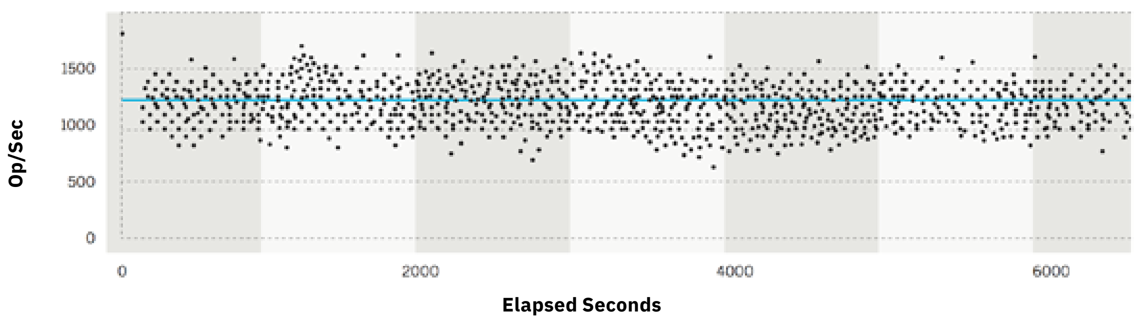
# Big Data - Consistency

Performance is only meaningful when it's consistent. In our performance test, the virtual server environment may have recorded 4,500 read operations per second at its peak, but on average, that environment was delivering 1,500 read operations per second. If an environment's performance varies that significantly from one second to the next, it's extremely difficult to build an environment to handle a growing workload. To compare the consistency of results on bare metal servers against virtual servers, an IBM Cloud engineer configured two five-node Riak clusters and simulated load deployments using Basho Bench (details noted in Appendix B). This test observed and plotted the operations per second over a two-hour period:

**Bare Metal Servers:**
Operations per Second Under Load (2 Hours)




**Virtual Servers:**
Operations per Second Under Load (2 Hours)



The bare metal environment averages higher operations per second throughout the test, but more tellingly, the results are much more tightly condensed around the average. When performance varies significantly from one second to the next in the virtual server environment, capacity planning becomes an issue. What statistic should be used when deciding whether to scale an environment up or down? If you build your environment to accommodate the worst-recorded results, whenever performance is good, you will have over-provisioned resources. Opting to base capacity on the best results will likely result in the environment underperforming. And basing capacity on the average results is a coin-flip between those two alternatives.

Businesses rely on **consistent results** to forecast trends, set budgets and make important decisions. Planning for cloud infrastructure environments should be no exception.

# Big Data Needs Bare Metal

Promises of quick and easy deployment can be hard to resist. While some applications are best suited to run on virtual servers in a public cloud environment, big data is not one of them.

It’s important to note that:

- The two most important characteristics of a cloud environment running high-I/O workloads like big data are **performance** and **consistency**
- Bare metal servers can be configured and optimised to **deliver unparalleled performance results** when serving and **processing huge volumes of data**
- Virtual servers tasked with high-I/O workloads can be **adversely affected by other customers’ resource usage** when multiple users share the same virtual server host node
- Bare metal server **resources are local and are not shared**, so workloads perform much more consistently than they do in shared and/or networked virtual server environments
- Virtual servers can be provisioned quickly and can scale horizontally much faster than bare metal servers, but workloads that do not need burstability benefit from the performance and consistency of bare metal servers.

# What makes IBM Cloud an ideal provider for big data workloads?

**Unmatched technology:** IBM Cloud gives you the highest performing cloud infrastructure available. Whether your big data spans globally or locally, our worldwide data centers and best-in-class bare metal and virtual servers can handle the task.

**Seamless network:** Our fast network integrates public, private and internal management networks to deliver higher speed, which is essential when analysing and transferring big data.

**Full management and automation:** We developed a different kind of cloud solution—an all-in-one automated platform. Every server, storage device and management and security service can be controlled through one management system, all accessible by our API, customer portal and even mobile applications.

**Explore IBM Cloud bare metal and virtual servers at http://ibm.co/bare-metal and learn more about built-to-order big data solutions and application-specific best practices for Riak, Hadoop, MongoDB at http://ibm.co/big-data.**

**Have additional questions? Ask an expert: http://ibm.co/contact-us or call us: 214-442-0600.**

**Run your big data on bare metal servers. Our IBM Cloud experts will help you create a high-performance cloud infrastructure to best meet your big data needs.**

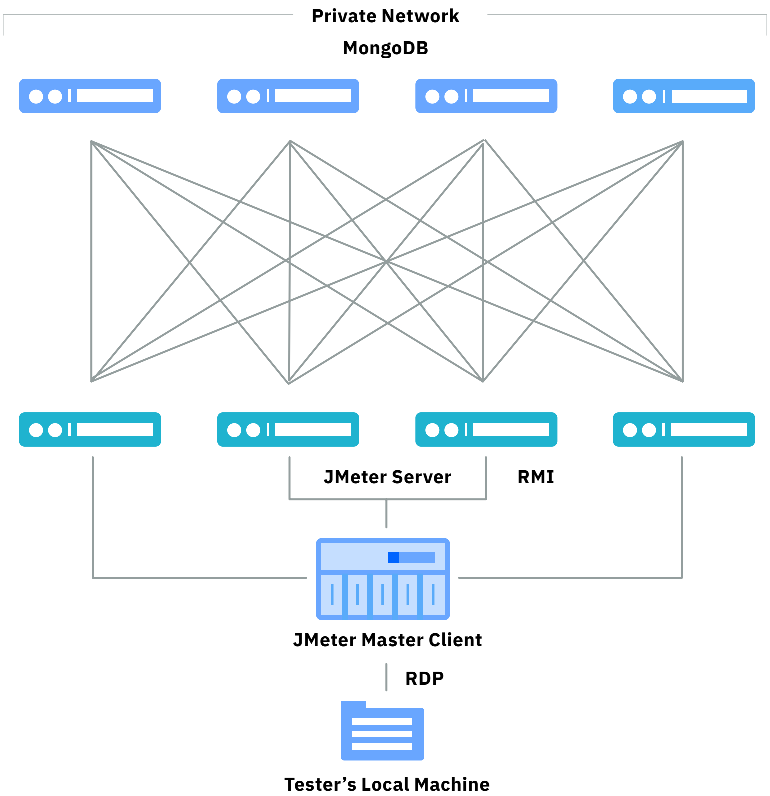
# Appendix A

## Big Data Performance Testing Methodology — MongoDB

Data sets of 512kb (kilobits) documents were preloaded onto single MongoDB instances on each server. The data sets were created with varying size compared to available memory to allow for data sets that were both larger (two times) and smaller than available memory. The test also ensured that the data set was altered during the test run frequently enough to prevent the queries from caching all of the data into memory.

Once the data sets were created, JMeter server instances with 4 cores and 16GB of RAM were used to drive 'benchrun' from the MongoDB benchmarking harness. The diagram below illustrates how we set up the testing environment.

These Jmeter servers function as the clients generating traffic on the MongoDB instances. Each client generated random query and update requests with a ratio of six queries per update (The update requests in the test were to ensure that data was not allowed to fully cache into memory and never exercise reads from disk). These tests were designed to create an extreme load on the servers from an exponentially increasing number of clients until the system resources became saturated and we recorded the resulting performance of the MongoDB application.




### Test Configuration

- Data Set (32GB of .5mb documents)
- 200 iterations of 6:1 query-to-update operations
- Concurrent client connections exponentially increased from 1 to 128
- Test duration spanned 48 hours.

# Appendix A (continued)

Big Data Performance Testing Methodology — MongoDB

## Bare Metal Servers vs. Virtual Servers

| | Bare Metal Server Node | Virtual Server Node |
|---|---|---|
| Core | Dual 6-core Intel 5670 CPUs | 26 Virtual Compute Units |
| Operating System | 64-bit CENTOS | 64-bit CENTOS |
| RAM | 36 GB (Gigabytes) RAM | 30 GB RAM |
| RAID | 2 x 64 GB SSD (Soilid State Drive)<br>RAID1 (Journal Mount) | 2 x 64 GB Network Storage<br>RAID1 (Journal Mount) |
| SAS | 4 x 400 GB SSD<br>RAID10 (Data Mount) | 4 x 300 GB SSD<br>RAID10 (Data Mount) |
| Network | 1 GB Network \| Bonded | 1 GB Network |

# Appendix B

## Big Data Performance Testing Methodology — Riak

Five-node clusters with Riak 1.3.1 were created on bare metal servers and on public cloud virtual server. To optimise for Riak performance, tweaks were made at the OS level of each server (running CentOS 64-bit):

**Noatime**

**Nodiratime**

**barrier=0**

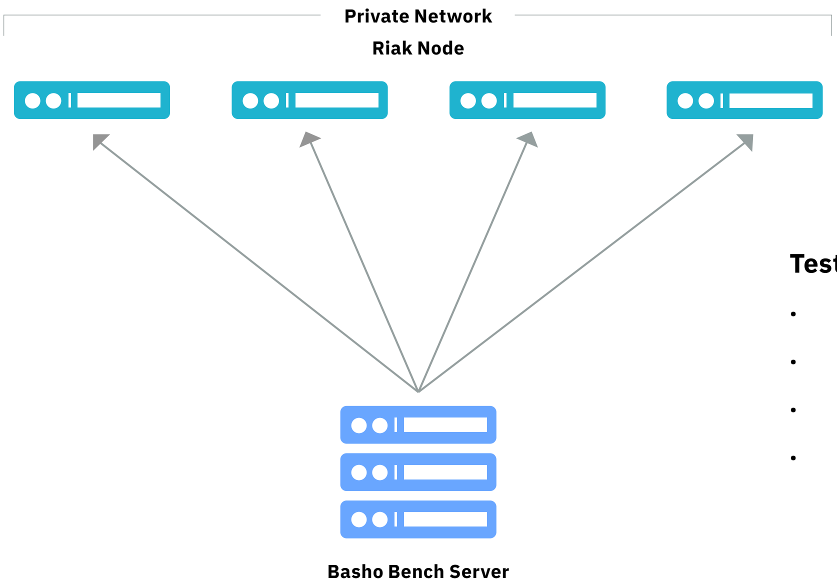
**data=writeback**

**ulimit -n 65536**

The common Noatime and Nodiratime settings eliminate the need for writes during reads to help performance and disk wear. The barrier and writeback settings are a little less common and may not be what you'd normally set. Although those settings present a very slight risk for loss of data on disk failure, remember that the Riak solution is deployed in five-node rings with data redundantly available across multiple nodes in the ring.

With that in mind and considering each node also being deployed with a RAID10 storage array, the minor risk for data loss on the failure of a single disk in the entire solution would have no impact on the entire data set (as there are plenty of redundant copies for that data available). Given the minor risk involved, the performance increases of those two settings justify their use.

With all of the nodes tweaked and configured into clusters, we set up Basho's test harness - Basho Bench - to remotely simulate load on the deployments. Basho Bench allows you to create a configurable test plan for a Riak cluster by configuring a number of workers to utilise a driver type to generate load. It comes packaged as an Erlang application with a config file example that you can alter to create the specifics for the concurrency, data set size and duration of your tests. The results can be viewed as CSV data and there is an optional graphics package that allows you to generate graphs. A simplified graphic of our test environment looks like this:




### Test Configuration

- Data Set: 400GB
- 10:1 Query-to-Update Operations
- 8 Concurrent Client Connections
- Test Duration: 2 Hours

# Appendix B (continued)

Big Data Performance Testing Methodology — Riak

## Riak - Consistency Test

Bare Metal 5-Node Cluster vs Virtual Server 5-Node Cluster

| | **Bare Metal Server Node** | **Virtual Server Node** |
|---|---|---|
| Core | Dual 6-core Intel 5670 CPUs | 26 Virtual Compute Units |
| Operating System | 64-bit CENTOS | 64-bit CentOS |
| RAM | 36 GB RAM | 30 GB RAM |
| RAID | 4 x 300 GB 15K SAS \| RAID10 | 4 x 300 GB Network Storage |
| SAS | 1 GB Network - Bonded | 1 GB Network |

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