



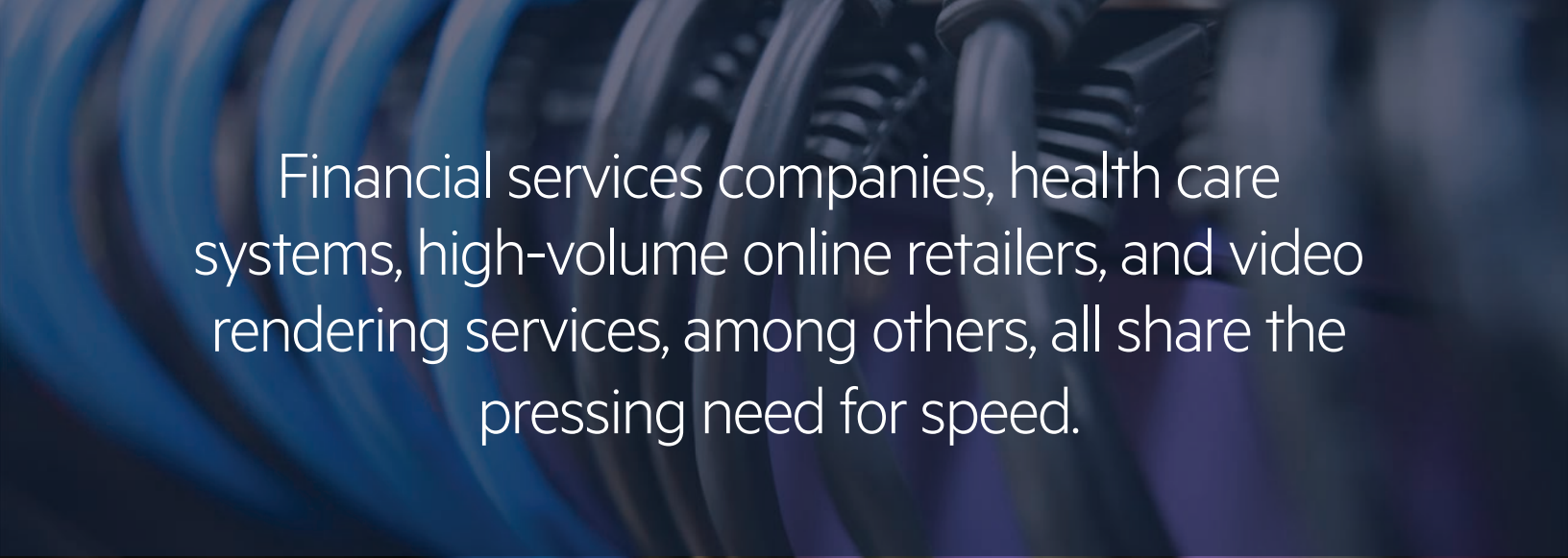
Create More than 55x Faster Hybrid Cloud Solutions with Maximum Security, Availability and Elasticity

WHITE PAPER

A HIGH PERFORMANCE SOLUTION USING NETAPP PRIVATE
STORAGE IN A DIGITAL REALTY DATA CENTER



DIGITAL REALTY



Financial services companies, health care systems, high-volume online retailers, and video rendering services, among others, all share the pressing need for speed.

Overview

Creating a secure, high-performance enterprise storage solution presents a number of challenges. This paper details a high-level process for putting together such a solution with an iterative approach beneficial at both the component level and the system level.

Digital Realty sponsored a study to explore the challenges of creating such a high-performance solution using IBM Cloud Bluemix and NetAPP Storage. The study was implemented by Krystallize Technologies.

Krystallize Technologies set up three different “real world” configurations, using the architecture described in this paper, to design a dedicated, low-latency, private connection between cloud services and customer-provided network equipment, storage, and compute infrastructure that is durable and affordable.

Scope

This paper presents test results showing how a well-designed, well-executed hybrid cloud architecture performs versus one that leverages standard facilities, using connections and an architecture not optimized for application performance.

- Direct Link Colocation Features and Benefits
- Reference Solution for Implementing NetApp Private Storage for IBM Cloud Colocated in a Digital Realty Data Center
- Results of Performance Tests Conducted by Krystallize Technologies

Audience

This document is intended to introduce CIOs, CTOs, cloud strategists and business executives to Direct Link Colocation—a highly secure, highly available, low-latency solution for successful hybrid cloud deployments. The solution couples IBM Cloud enterprise-class automated cloud provisioning, management and services with Digital Realty’s unparalleled global data center footprint and expertise in data center operations for uniquely fast, secure and flexible hybrid cloud implementations. It leverages the IBM Cloud’s residency in Digital Realty properties around the world.

The Business Challenge

Big Data is today's greatest business asset and its biggest IT headache. Just collecting and storing Big Data doesn't drive revenue. In fact, as more data get stored, enterprises are finding it increasingly difficult to extract meaning from them. The cloud solutions that seem to offer instant relief have too often proven to intensify the pain.

Enterprises have spent the last few years grappling with the logistics of moving massive amounts of data to and from the cloud, a forced march around multiple stumbling blocks.¹ Financial services companies, health care systems, high volume online retailers, video rendering services among others all share the pressing need for speed—not just in getting vast amounts of data to cloud applications but in extracting insights from it to drive time-critical business decisions or to meet consumers' real-time performance expectations.

Without a high throughput, low latency connection between your SAN and your cloud compute infrastructure, your business may fail to extract actionable insights in time to make the best decisions.

Latency

For many Big Data workloads, speed is essential. Without a high throughput, low latency connection between your SAN and your cloud compute infrastructure, your business may fail to extract actionable insights in time to make the best decisions.

Data security

Even though cloud governance replaced security as enterprises' biggest point of anxiety about cloud computing in 2015², security continues to rank a close second, especially for companies that store sensitive customer information in their systems of record and are obliged by law to protect its privacy and security. Breaches can be as damaging to a company's reputation as to its bottom line.

Cost

For start-ups and enterprises alike, cloud costs have become a concern. Bandwidth gets expensive fast. Slow networks impact productivity and may cause missed deadlines or disappointed customers. Slow application performance costs more. It's easy to add servers, bare metal or virtual, to your public cloud but businesses today are finding it can be hard to manage those resources, especially when a lot of different business units with a lot of different projects are using the cloud. More and more, companies find they are paying for cloud resources they're not using to capacity³.

¹Gartner's 2013 cloud report.

²RightScale 2016 THE STATE OF THE CLOUD REPORT: Hybrid Cloud Adoption Ramps as Cloud Users and Cloud Providers Mature

³Ibid



Direct Link Colocation enables customers to establish a dedicated, low latency private connection between IBM Cloud Bluemix services and customer-provided network equipment, storage and compute infrastructure within a Digital Realty colocation facility, often just a few feet away. Close physical proximity and a robust business partnership combine to provide the industry's most durable and affordable solution to the challenges of secure high-performance storage and compute.

Direct Link Colocation Features and Benefits **NO WAN IS THE BEST NETWORK**

By eliminating the need for a WAN connection between the customer's data center infrastructure and IBM Cloud Bluemix services, Direct Link Colocation removes several of the obstacles responsible for the high failure rate⁴ of hybrid cloud deployments today. Prominent among these are poor network availability and slow network performance. Direct Link Colocation is architected to maximize throughput and bypass Internet hiccups.

HIGH SECURITY JOINS HIGH PERFORMANCE

Direct Link Colocation solves the business challenge of maintaining control and privacy of data while extracting maximum business value from that data. With Direct Link Colocation, businesses can transfer sensitive data between their private cloud and the IBM Cloud via a redundant, dedicated Layer 1 fiber connection, enjoying industry-leading throughput with no public Internet exposure.

Cloud Quality of Service tests by Krystallize Technologies showed that this solution using Direct Link colocation experiences 1/50 of the latency of the same configuration using the Internet. Application throughput is 55.4 times faster with Direct Link Colo than on the Internet. See detailed test data on pages 12-14 of this document.

PRIVATE CONNECTIVITY ENHANCES PRODUCTIVITY AND LOWERS COST

Creating a private high bandwidth, low latency connection to expedite data migration to and from cloud-based applications maximizes the productivity of computational resources and the human workforce dependent on their output. Increased productivity and improved cloud management dramatically reduce total cost of ownership (TCO).

The bigger the workloads, the greater the savings an enterprise should expect to realize with this solution. In addition to delivering fast, consistent data-transfer rates, a dedicated private network allows you to directly access your local SoftLayer resources without complicated network address translation (NAT) rules.

EXPAND ON DEMAND WHEN BUSINESS SPIKES

With a permanent private network connection between your private cloud and IBM Cloud Bluemix super-fast, automated Infrastructure-as-a-Service platform, your business can easily add and manage compute and

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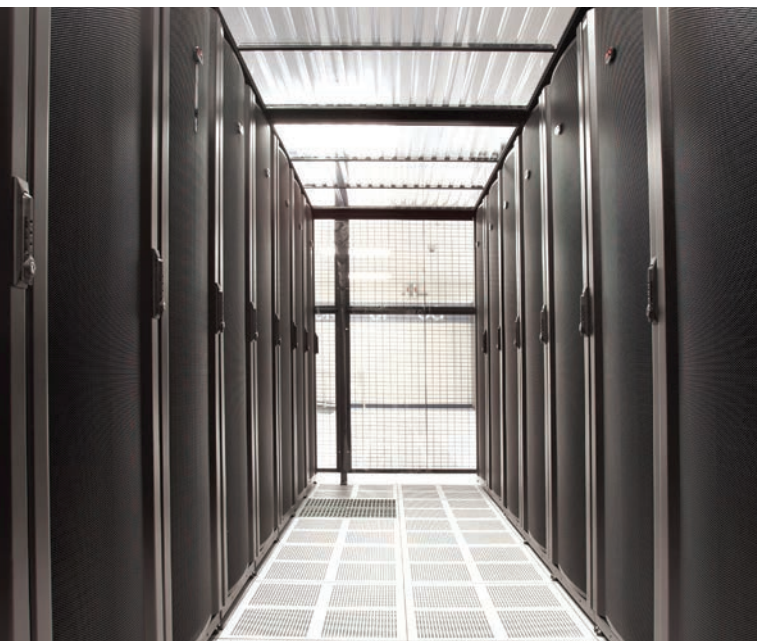


storage to accommodate large workloads and seasonal spikes when you need them, no capital expenditure required.

FIVE-NINES DATA CENTERS SUPPORT FIVE- NINES CLOUD DEPLOYMENTS

If you can't trust your data center, you can't trust your cloud, which, let's be honest, also lives in a data center. Operational excellence in the data center is essential to implementing and maintaining a successful hybrid cloud. Not only does Digital Realty have the industry's best record for uptime⁵ and its largest global footprint, it also hosts more IBM Cloud Bluemix sites than any other data center provider. This strategic cloud partnership is based on solid ground.

⁵<https://esj.com/articles/2014/06/26/cloud-projects-fail.aspx>



Purpose

This solution unites industry-leading physical and virtual technologies via lowest-latency direct fiber connection between on-premise and cloud storage and compute infrastructures. The key to its success is proximity. More IBM Cloud Bluemix deployments are sited in Digital Realty facilities than with any other data center provider. To date, Digital Realty houses 63% of IBM Cloud capacity within its facilities, while the remaining 37% of IBM capacity is divided among 10 or so other providers.

The solution is designed to deliver maximum storage and compute capacity for enterprises, with massive data stores, that need to solve business problems fast without compromising the security of user information. Use cases include but are not limited to the following:

- Financial modeling
- Engineering analysis
- Data warehousing
- Resource exploration
- Semiconductor chip design
- Logistics management

While results will vary, solution components support storage scale-out to more than 17,000 drives and 4M IOPS of performance, with latency between on-premise colocation and cloud infrastructure shown to reach as low as 4 milliseconds in sample deployments. Users should expect to incur lower costs than they would by connecting using the Internet to other public cloud service providers.

COMPONENTS

- NetApp AFF 8020 High-Performance Storage array
- Direct Link Colocation in a Digital Realty data center
- IBM Cloud Bluemix Performance Block Storage
- 10Gbps fiber private connectivity between customer storage and IBM Cloud Bluemix Infrastructure as-a-Service

NetApp AFF 8000 series storage cabinets

Managed by NetApp Data ONTAP®, the AFF 8000 series is the All Flash subset of the FAS8080 product line. It is tightly integrated with Open Stack cloud infrastructure to enable enterprises to implement Service Oriented Architecture, allowing multi-tenancy of applications in a private cloud environment. Find full technical specifications here: <http://www.netapp.com/us/products/storage-systems/all-flash-fas/index.aspx>. In the High-Performance Storage solution, the NetApp storage array resides in a Digital Realty Data Center.

DIGITAL REALTY DATA CENTERS

Digital Realty owns and operates more data centers, comprising more square footage globally than any other provider. For the past 10 years, it has achieved five nines availability, the best uptime record on record. Known for operational excellence, Digital Realty is constantly striving to improve both environmental

⁵Ten consecutive years of 5 nines uptime.

Overview of the high-performance storage solution:

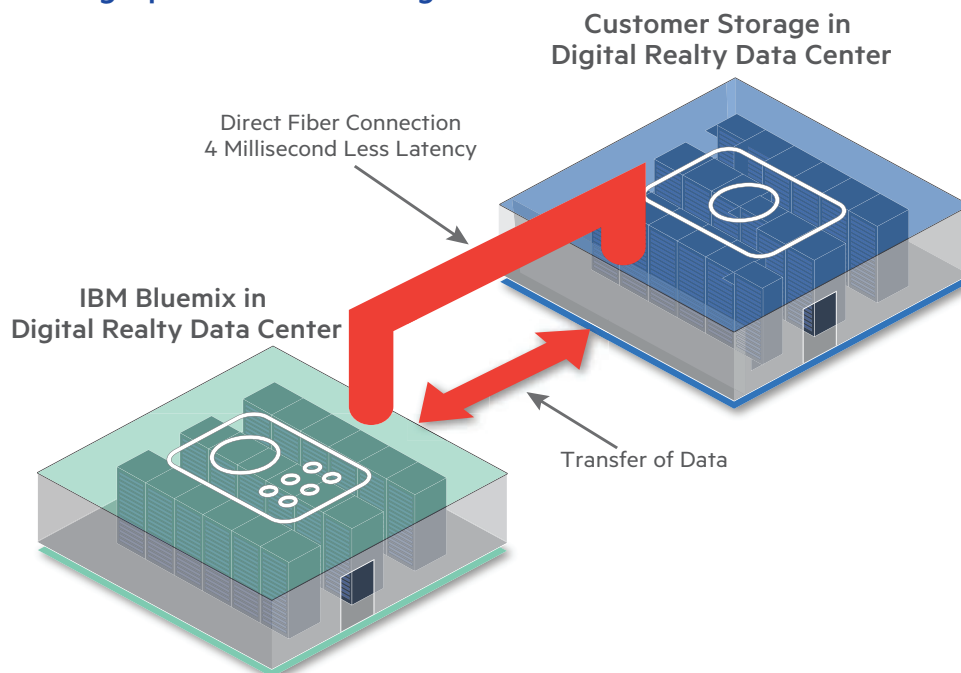


Figure 1 Direct Link Colo private network in red. The solution leverages colocation of IBM Cloud Bluemix services and customer infrastructure in a Digital Realty facility.

stewardship and customer satisfaction. It offers unsurpassed network connectivity and high-speed Metro Connect hubs, as well as 24x7 physical security and remote hands support.

EXISTING CUSTOMERS

Existing customers can engage Direct Link Colocation to IBM Cloud Bluemix services from their Digital Realty deployments.

RACK AND SHIP

Enterprises with systems of record in storage can rack and ship their SAN solution to a Digital Realty data center that offers Direct Colocation, retaining custody of sensitive data while empowering hybrid cloud resources.

NEW DEPLOYMENT

New projects or new businesses can build a private cloud solution in a Digital Realty facility.

A minimum deployment for Direct Link Colocation includes the following:

- Rack: APC NetShelter AR 3100
- Power: 30Amp/208Volt A+B (5kW) single phase
- 1U patch panel & in rack PDU's
- Cross Connects: 2 Single-mode (SM) Fiber included w/ SC Connector (1GB/s or 10GB/s connection)
- Cabinets are offered in 1 cabinet increments and can be leased for 36 months, 24 months, or 12-month terms.

AVAILABILITY

The High-Performance Storage solution is currently available in five Digital Realty data centers and their corresponding IBM Cloud-SoftLayer locations. Because Digital Realty hosts the largest number of IBM Cloud-SoftLayer compute nodes, they are also able to offer more Direct Link Colocation deployments than any other provider.

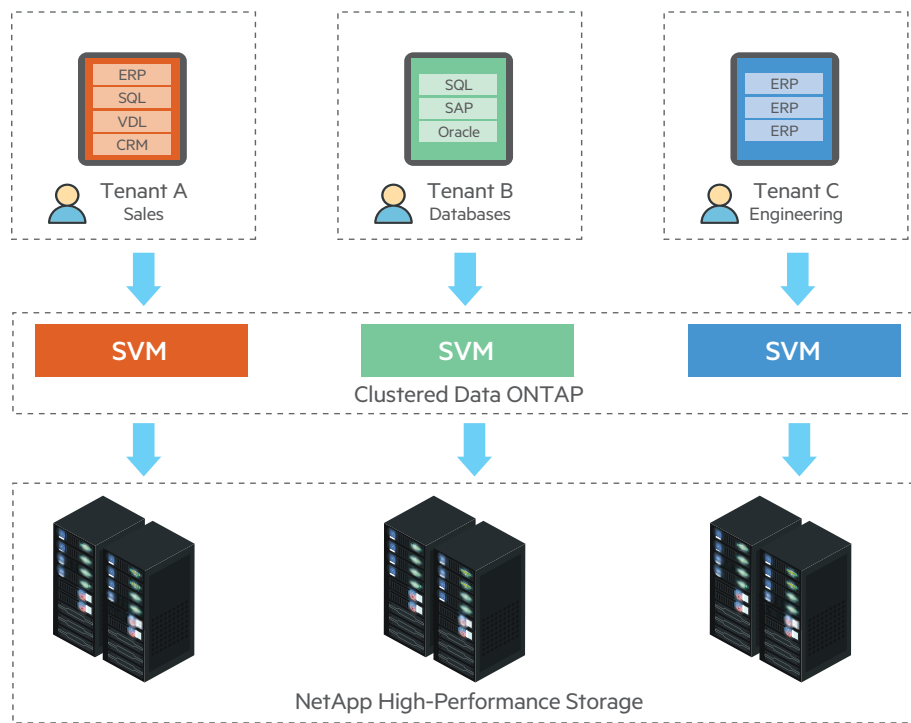


Figure 2 Multi-Tenancy in the on-premise private cloud

IBM CLOUD BLUEMIX HIGH-PERFORMANCE STORAGE

IBM Cloud Bluemix Infrastructure-as-a-Service empowers enterprises to build out High-Performance Storage solutions virtually on the fly when the workloads are big and output is time-critical. Fast server and storage provisioning—from 30 minutes to 2 hours—makes it easy to experiment and fine-tune your storage and compute infrastructure and to expand or contract it as workloads shift.

SINGLE TENANT SCALABILITY

For enterprises with petabytes of data in a new or existing SAN that want to attach to the cloud via a dedicated, single tenant compute and storage solution, IBM Cloud Bluemix provides high input/output and read/write operations at scale for databases and high frequency application servers.

BARE METAL SPEED

Latency is critical to many Big Data workloads. Worker nodes and master nodes in an IBM Biginsights Hadoop cluster work best on a bare metal 10Gbps

network like IBM Cloud Bluemix. Because it provides 10Gbps connectivity to your IBM Bluemix infrastructure, Direct Link Colocation delivers the high throughput you need to ingest data from your SAN.

DATA SECURITY

IBM Cloud Bluemix offers dedicated bare metal compute as well as dedicated virtual servers, allowing

Known for operational excellence, Digital Realty is constantly striving to improve both environmental stewardship and customer satisfaction.

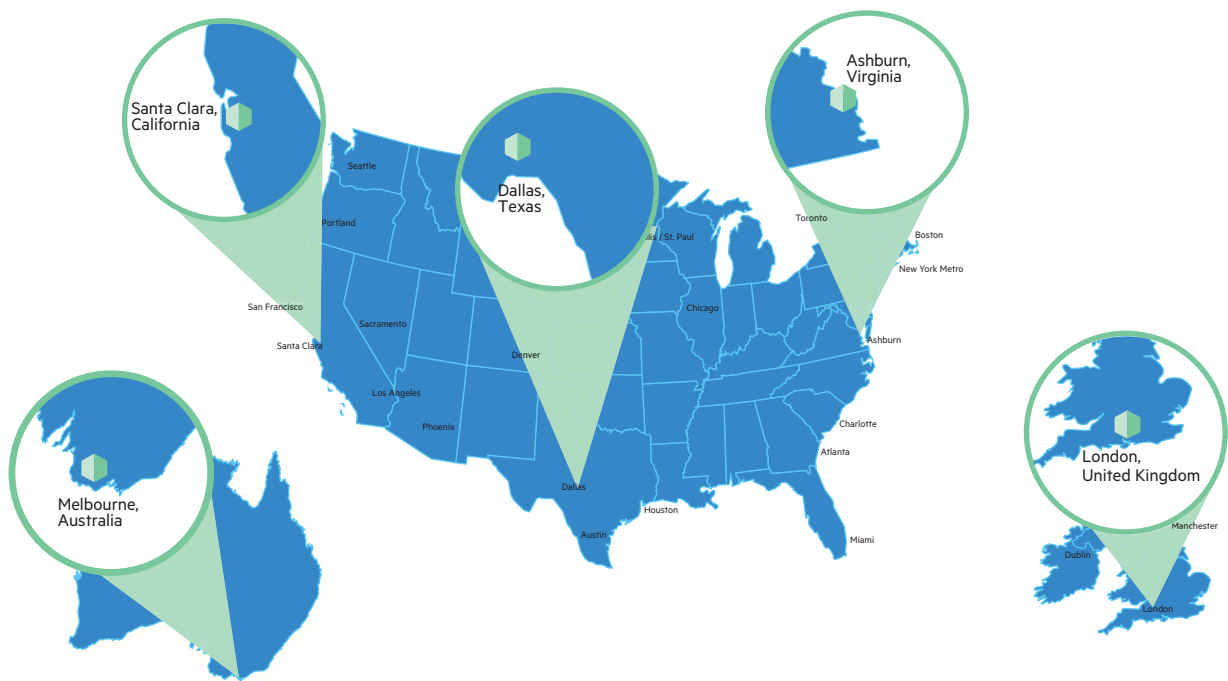


Figure 3 Digital Realty Data Center Locations offering IBM Cloud-Softlayer

you to maintain full control over the cloud-based devices that can access your data stores in the colocation facility.

THREE NETWORK STRUCTURE

IBM Cloud Bluemix's three-network structure is designed to provide maximum connectivity, data security, and control.


Because Digital Realty hosts the largest number of IBM Cloud-SoftLayer compute nodes, they are also able to offer more Direct Link Colocation deployments than any other provider.

Public Network

Every data center and network PoP has multiple 10Gbps connections to top-tier transit and peering network carriers. Network traffic from anywhere in the world will connect to the closest network PoP and it will travel directly across our network to its data center, minimizing the number of network hops and handoffs between providers. Inside the data center, we offer up to ten gigabits per second of bandwidth to individual servers to meet even the most demanding network-intensive workloads.

Private Network

All IBM Cloud Bluemix data centers and PoPs are connected by our private network backbone. This private network is separate from the public network, and it enables you to seamlessly connect your services in IBM Cloud data centers around the world. Move data between servers at no cost, and take advantage of our update and patch servers, software repositories, backend services, and more without interfering with public network traffic.



IBM Cloud Bluemix
Infrastructure-as-a-
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Management Network

In addition to public and private networks, each IBM Cloud Bluemix server is connected to an out-of-band management network. This management network, accessible via VPN, allows access to your server independently of its CPU, firmware and operating system for maintenance and administration purposes.

COST CONTROL

IBM Cloud Bluemix and Direct Link Colocation can help enterprises contain costs by providing on demand compute, with billing based on consumption. Bringing your storage into the colocation rack space allows you to leverage a monthly reporting and billing model, with your critical business data in your own SAN.

API INTEGRATION

NetApp API integration allows you to off load certain capabilities onto the NetApp device from your compute.

COMMON HIGH-PERFORMANCE USE CASES

These solutions are especially well suited to meet the needs of Big Data and of IBM Cloud customers whose online businesses generate vast amounts of data every minute of every day.



The solution is designed to deliver maximum storage and compute capacity for enterprises with massive data stores that need to solve business problems fast without compromising the security of user information.

FULL HYPERVERSOR COMPATIBILITY

NetApp supports all major hypervisor vendors like VMware and Citrix Xen. This allows you to schedule snapshots as well as take on demand snapshots of your infrastructure to the SAN.

SURGE IOPS

Let's say you plan all your IOPS on a nominal IOPS level, but are then presented with a workload that is overwhelming your allocation. With Surge IOPS you can either dynamically or on demand allocate IOPS where needed.

SINGLE TENANCY

Running on dedicated hardware and a dedicated SAN, you can trust your data is secure within your SoftLayer compute layer as well as in your Direct-Link-Colo-attached NetApp storage.

10 GB/S DIRECT LINK CONNECTIVITY

This dedicated low-latency fiber connection between the private cloud and IBM Cloud Bluemix is the heart of this high-performance hybrid cloud solution.

Direct Link Colo Performance Tests and Results

THE QUESTION: How can enterprise IT design a Hybrid Cloud deployment that takes advantage of the latest Public Cloud technologies, maintains direct control of critical stored data, and unites both in a seamless, fast and cost-effective solution?

WHAT WE TESTED

To find the answer, Digital Realty recently sponsored a study to explore that question in depth. With the support of NetAPP Storage and IBM Cloud Bluemix, Krystallize Technologies set up three different hybrid cloud configurations to demonstrate how a well-designed, well-executed hybrid cloud architecture will perform versus one that leverages standard facilities, connections and architecture not optimized for application performance. Three test scenarios were designed to be 'real world' configurations while limiting the variables to ensure that the differences in results are based on location/latency and no other factors. The purpose of the tests was to demonstrate to potential customers in advance of implementation what results they could expect to experience from each configuration.

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BASELINE TEST (TEST 1)

Execute transactions between Public Cloud Compute to Private Cloud Storage leveraging Internet

- Test 1 IBM Cloud Bluemix over Public Internet (.301) IBM Cloud Bluemix Baseline: San Jose / NetAPP storage Dallas / Internet (1Gb)

HYBRID CLOUD METRO (TEST 2)

Execute transactions between Public Cloud Compute to Private Cloud Storage over dedicated MAN network

- Test 2 –IBM Cloud Bluemix over Direct Link (.088) IBM Cloud Bluemix N. Dallas / NetAPP Storage S. Dallas/ Dedicated Metro Link (1Gb)

HYBRID CLOUD COLO (TEST 3)

Execute transactions between Public Cloud Compute to Private Cloud Storage over direct network connection

- Test 3 –IBM Cloud Bluemix over Direct Link: (.004) IBM Cloud Bluemix S. Dallas / | NetAPP Storage S. Dallas / Direct Link (1Gb)

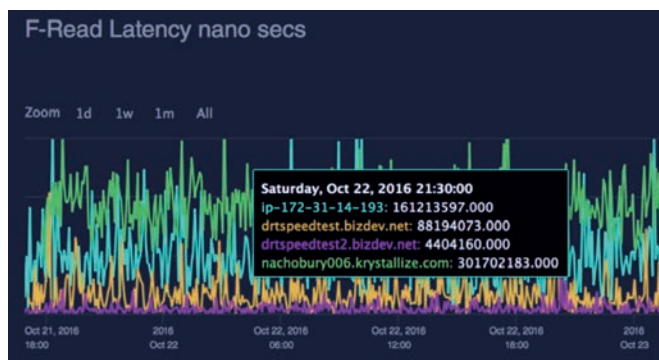


Figure 4 File-Read Latency Measures, Krystallize Technologies

As noted above, in all cases effort was made to limit variables through the use of the a common storage array, a common workload profile performance test and the same Compute Resource configuration in all 3 tests to ensure the results are directly the result of location/latency.

Our Findings

FILE-READ LATENCY

First, it's important to understand File-Read Latency. An application requests data and the file system requests that data from storage system. File Latency is the time it takes for each packet requested to be transmitted and arrive back at the file system. This includes the impact of all of the service layers, including compute, storage, network, and operating system working together to deliver on the storage request. As noted in the above chart, File-Read Latency is measured in Nano seconds. We have converted these to seconds for clearer understanding. Thus latency for IBM Cloud Bluemix over Internet is 0.301 while the direct link cross connect delivers on average 1/50 the latency of the Internet.

FILE-READ THROUGHPUT

Throughput is a measure of actual kilobytes of storage transmitted per second. Actual throughput is impacted by latency as noted above, but is also impacted by

file size, storage caching and a number of other elements. However, as this study used the same CloudQoS workload simulation, the demand was exactly the same. Given that the study used the same storage array to connect to, the storage was the same. Finally, given that the baseline was on IBM Cloud Bluemix, Direct Link Cross Connect used the same compute and the same configurations in all cases, the only variables being distance and latency.

The File-Read Throughput Kbytes/sec chart shown here represents the actual throughput measures collected at the same time as the latency figures above. As noted in the latency figures, the IBM Cloud Bluemix baseline service with the highest latency in the earlier chart had the lowest throughput of 413 KB per second, whereas the IBM Cloud

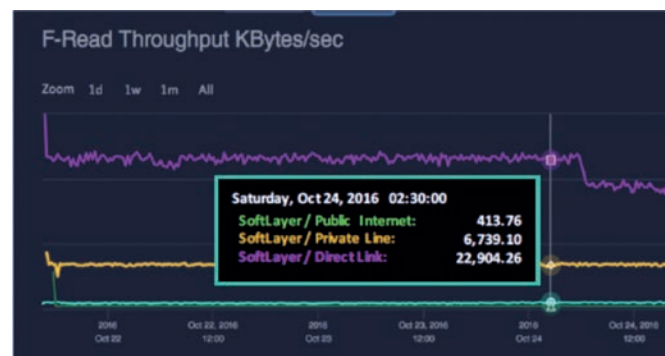


Figure 5 File-Read Throughput Measures, Krystallize Technologies

Bluemix with the Direct that had the lowest latency had the highest throughput of 22,904 KB per second. That is, IBM Cloud Bluemix with Private Line delivered 55.4X better throughput.

APPLICATION PERFORMANCE

The net effect of file read and file throughput is seen in how applications actually perform in the tested configurations. Let's assume that the application we want to put in place is a large

File-Read Latency Test Results: For a non-optimized application:

Solution	Total Data	Payload	Roundtrips	Latency/MS	Seconds to render page
IBM Cloud Bluemix over Internet	5.5MB	64K	86	301	25.8
IBM Cloud Bluemix over X-Connect	5.5MB	64K	86	4	0.3

File-Read Throughput Test Results: In the best case scenario, using full caching and parallel processing:

Solution	Total Data	Throughput	Seconds to render page
IBM Cloud Bluemix over Internet	5.5MB	415KB	13.3
IBM Cloud Bluemix over X-Connect	5.5MB	22,904KB	0.2

web service where the web servers are in the Public Cloud. Finally, the storage will be pulled serially from the storage system per transaction. Network packets have a payload size of 64k bytes per round trip. From here it is simple math: Total Data requested / payload size = total round trips to move the data. Total round trips x latency per round trip = total time to render web page.

Conclusion

Direct Link Colocation is the best and only viable way to build and run the state-of-the-art High-Performance Storage solution outlined in this paper. This solution is one of several leveraging the partnership between Digital Realty and IBM Cloud Bluemix to realize the promise and the necessity of hybrid cloud computing to solve today's complex business challenges. Though other solutions are less secure, slower, less scalable and/or more expensive.

Other data center providers lack the space and power to provision the computational power and high throughput required for business success.

Without dedicated, persistent low-latency connectivity these results become unattainable. It becomes impossible to guarantee the security and privacy of customer data or to meet the government standards for its sanctity integrity.

By following the technology guidelines proposed here, your business, whether startup or enterprise, will be able to achieve the business results described in this paper.

These solutions are especially well suited to meet the needs of Big Data and of IBM Cloud Bluemix customers whose online businesses generate vast amounts of data every minute of every day.



About Digital Realty

Digital Realty Trust, Inc. supports the data center and colocation strategies of more than 2,300 firms across its secure, network-rich portfolio of data centers located throughout North America, Europe, Asia and Australia. Digital Realty's clients include domestic and international companies of all sizes, ranging from financial services, cloud and information technology services, to manufacturing, energy, gaming, life sciences and consumer products.

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