

May 2013

# The Cloud-Enabled Data Center

**PANDUIT**<sup>®</sup>

building a smarter,  
unified business foundation

Connect. Manage. Automate.

[www.panduit.com](http://www.panduit.com)

## Introduction

A growing number of organizations are adopting some form of cloud computing to meet the challenges of rapidly deploying their IT services and addressing their dynamic workload environments while maximizing their IT return on investments (ROIs). Cloud computing gives users the ability to access the IT resources faster than traditional and virtual servers. It also provides improved manageability and requires less maintenance. By deploying technology as a service, your users access only the resources they need for a specific task, which prevents you from incurring costs for computing resources not in use. In addition, developing a cloud-enabled data center can improve operational efficiencies while reducing operational expenses by 50%.

Panduit, the leader in Unified Physical Infrastructure offerings, and IBM, a pioneer in delivering cloud computing solutions to clients, have joined forces to deliver optimized, custom and preconfigured solutions for the cloud-enabled data center.

This white paper describes how network, storage, compute and operations are important factors to consider when deploying private and public cloud computing in the data center. Specifically, it examines integrated stack/pre-configured and custom cloud deployments. It also explains the importance of the physical infrastructure as the foundation in successful cloud deployment and maintenance.

Finally, it showcases how IBM's depth of experience in delivering systems and software for cloud solutions when combined with Panduit's physical infrastructure expertise, provides a tremendous impact on room-level data center environmental and new-age topology. Panduit and IBM provide a complete set of capabilities (network, storage, compute, operations and physical infrastructure) to accommodate your cloud computing needs.

## Cloud Computing

Cloud computing allows organizations to reconsider IT and reinvent the way they do business. By adopting cloud philosophies, businesses can rapidly integrate and deliver services across cloud environments, increasing efficiency, improving business agility and lowering costs.

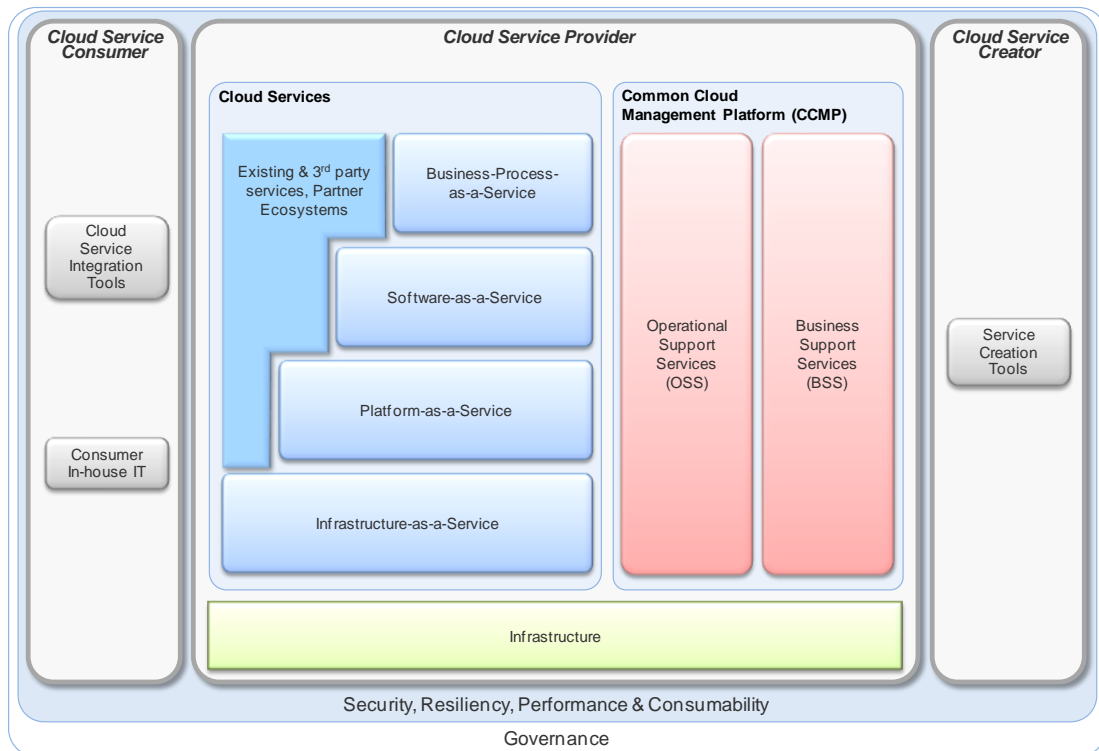
Once businesses recognize that cloud computing can easily address their increasing demands for agility and efficiency, they need to choose the cloud computing option that best fits their business requirements. Private and public clouds are two common deployment models that offer seamless access to applications and data on robust and efficient networks with minimal IT support. Cost reductions, easier implementation and maintenance, and better flexibility are also significant benefits of these cloud deployments. A third deployment model is the hybrid, which many organizations settle on as well. A hybrid cloud is the combination of two or more distinct cloud infrastructures (such as private and public) that remain unique entities, but are bound together by standardized or proprietary technology.

### ***The IBM Cloud Computing Reference Architecture***

Cloud computing can potentially be a disruptive change to the way an enterprise's IT services are delivered. Examining a candidate cloud solution provider's reference architecture should be a standard element of a CIO's cloud vendor evaluation strategy. IBM has created a proven cloud computing reference architecture that is employed in building private clouds for clients, private clouds that house IBM internal applications and the IBM Cloud that supports our public cloud service offerings. This same reference architecture is reflected in the design of

IBM expert integrated systems (bundled hardware and software for cloud implementation) and IBM cloud service management software products.

The reference architecture represents the aggregate experience from hundreds of cloud client engagements and IBM-hosted cloud implementations, based on knowledge of IBM's services, software and system experiences. It provides specifications not only for the physical components of a cloud implementation (network, compute, storage, virtualization), but for the software components required to run operational and business management processes as well. It also defines governance policies tailored for the environment or organization.

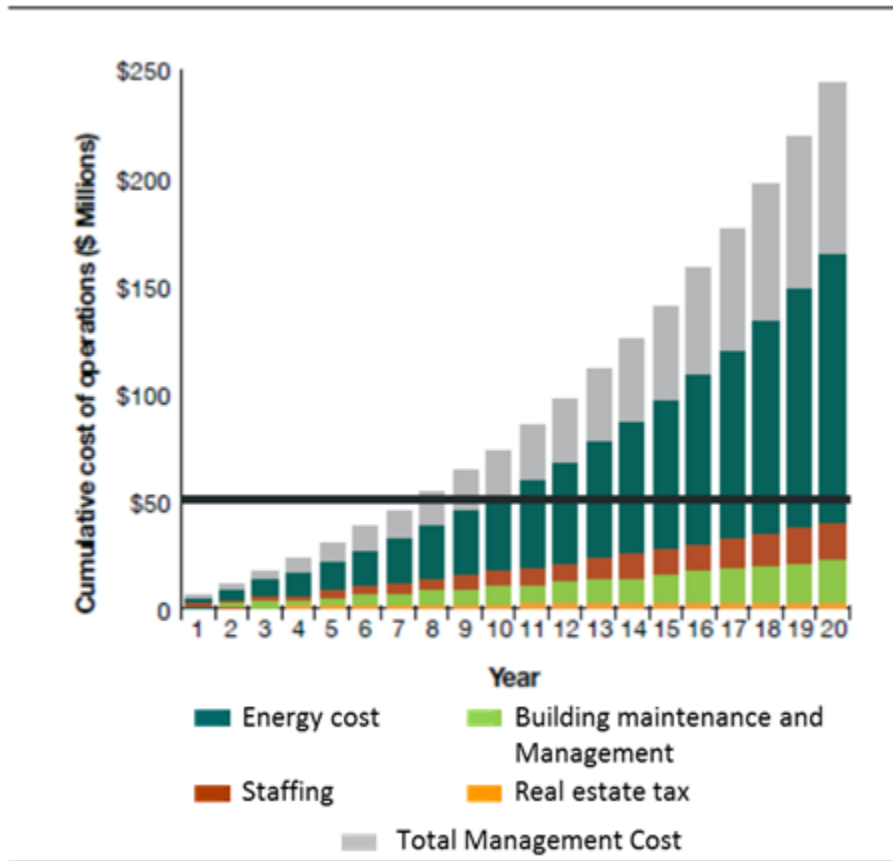


**Figure 1. IBM Cloud Computing Reference Architecture.**

The infrastructure layer of the cloud reference architecture comprises all hardware infrastructure elements needed to provide cloud services. This includes facilities and physical infrastructure as well as the server, storage and network resources and how those resources are deployed and connected within a data center (see Figure 1). It is important to note that in a true cloud environment, significant engineering and considerations must be invested for selecting and deploying these infrastructure elements to achieve minimal costs in combination with optimal performance, scalability, security and resiliency.

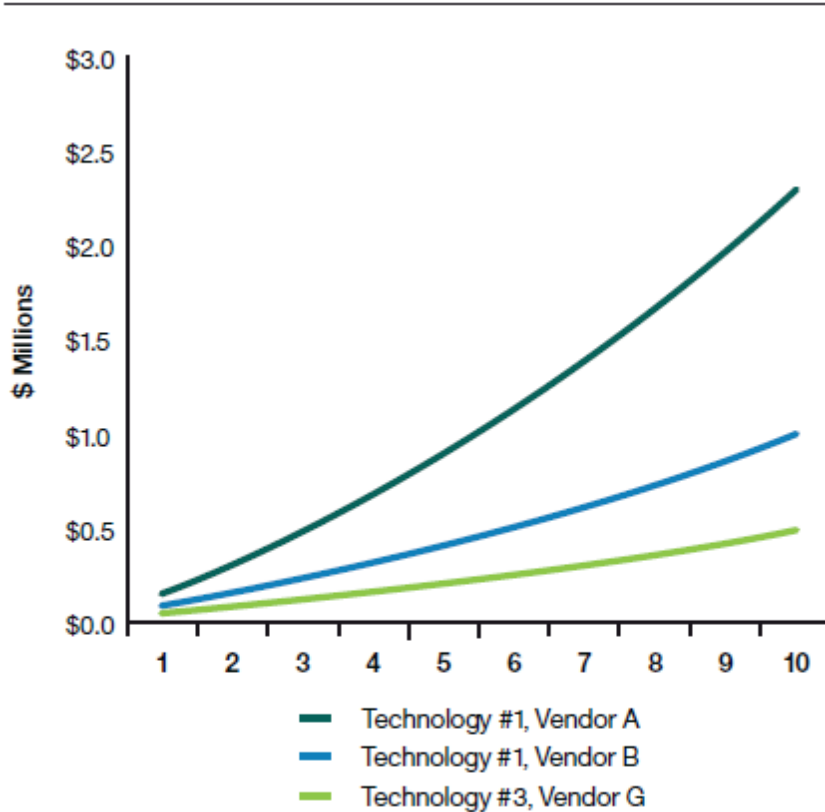
**The Importance of Designing an Optimized Data Center**

Good design and implementation provides a significant benefit for operating costs. It is critical to optimize both capital and operating expenses over the long term, as shown in Figure 2.



**Figure 2. Operating costs can be as much as five times the capital costs; a \$50M data center (black line) will cost about \$250M in operating expenses over its lifetime. Source: IBM estimate.**

One way to improve investment governance is to assess which technology components will cost less to purchase versus which will cost less to operate over the 15-20 year life of the data center, as shown in Figure 3. The least expensive equipment purchase does not always equate to the most effective choice. Making technology and vendor tradeoffs is critical, but if the decision makers are only taking capital costs into consideration, the long term operating costs may be overlooked. In one estimate, IBM found that the equipment costs varied widely, and the size of the capital investment did not always equate to the operating costs over a ten-year period.



Source: IBM estimates

**Figure 3. IBM's analysis shows that the technology that required a \$20,000 higher capital investment (Vendor A) produced a \$15M savings in operating costs over the years, producing better value for the client.**

#### Public Cloud

Public cloud is cloud infrastructure that is made available to the general public or a large industry group through a service provider. Public cloud service providers usually own and operate the infrastructure and offer access only through the Internet.

Top-of-mind concerns that public cloud providers should address for the physical infrastructure are:

*Fast implementation to accommodate rapid growth* – How will you streamline the process of designing, specifying, installing and managing the increasingly complex physical infrastructure necessary to optimize your data center?

*High-density server deployments that exceed available power and cooling supply* – How will your team monitor and manage the available power and cooling for a given server or cabinet?

*Maximize revenue generation per square foot or kilowatt* – How do you ensure that you maximize revenue (such as floor space and vertical space in the cabinet) in your facility?

*Ability to meet or exceed Service Level Agreements (SLAs)* – How do physical infrastructure moves, adds and changes impact your ability to meet your SLAs?

**Private Cloud**

Private cloud is cloud infrastructure that is operated solely for a single organization. The organization can access the information from its internal resources, whether managed from within or by a third-party, either on-site or off-site. Two common types of private cloud are integrated stack and custom cloud.

- *Integrated Stack* – a pre-configured combination, which includes the entire necessary physical infrastructure, of scalable network, storage and compute resources along with OS, application, and a management platform that has been pre-tested for performance. Key benefits of an integrated stack include: pre-testing and interoperability to reduce operational risks and faster deployment times as the stack is most often delivered as a single bill of material (BOM).
- *Custom Cloud* – A modular, plug and play approach that allows organizations to build cloud infrastructures in smaller increments, adding capacity when needed. This typically includes network, software and management deployed in a traditional data center layout.

Top-of-mind concerns that should be addressed for the physical infrastructure when migrating to a private cloud are:

*Server and Network Bandwidths* – What demands will virtualization place on the speed and bandwidth of your network? What will increased bandwidth on your existing hardware and network infrastructure mean for your business?

*Network Architecture Impact on Cabling Infrastructure* - How will you manage high cable densities? How will you manage up to three times more cables in each cabinet and in your pathways?

*Power and Cooling* – What steps are you taking to increase the cooling efficiency of your data center? Do you have initiatives to improve your PUE and mean time between failures (MTBF)?

*Integrated Stack Impact on the Data Center* – How will your team account for the thermal management of active equipment with different cooling requirements in a single cabinet? How will your team ensure your data center is ready for an integrated stack deployment? When creating or implementing integrated stack, what is your plan for weight distribution and power balancing per power outlet and unit of equipment? Is your data center ready to scale multiple integral stacks to accommodate growth?

## Physical Infrastructure: The Cloud Foundation

A unified approach to logical and physical systems architecture is imperative to fully address the migration to cloud computing. Panduit has developed the Unified Physical Infrastructure<sup>SM</sup> (UPI) approach to help enterprises align, converge, and optimize critical systems – communication, computing, control, power, and security – to build a smarter, unified business foundation.

Cloud deployment requires a robust and unified physical infrastructure to maximize the benefits of reduced costs and downtime, increased flexibility, and simplified implementation. Therefore, it is important for organizations to consider the physical infrastructure design before adopting cloud architecture. A strong physical infrastructure foundation ensures reliability, agility and security to drive business advantages and overall success. In addition, designing a centrally managed and integrated logical and physical infrastructure is key to avoiding challenges that are typical with the silo-based method of deploying and managing the physical infrastructure, such as downtime and higher operational costs.

### ***Benefits of Infrastructure Planning***

The main benefits of solutions that help prepare the infrastructure for cloud deployment include reduced unplanned outages and infrastructure management costs, which increase time available for strategic activities and ensure faster delivery. Other benefits include decreased infrastructure complexity, better operational control, improved confidence in Layer 1 stability and a documented and approved delivery process. Scalability and improved capacity utilization are also key benefits for effective cloud deployment.

A recent survey of Chief Information Officers (CIOs) indicates that 92% feel that minimizing unplanned outages is critical or very important when preparing their organization's infrastructure for private and/or hybrid cloud deployment. When asked about reduced infrastructure management costs, 89% also feel it is very important.

- **Minimize Unplanned Downtime.** Advanced technologies deployed in a traditional architecture can lead to increased complexity and leave critical systems vulnerable to faults, unexpected downtime and longer Mean Time to Repair (MTTR). This leads to decreased productivity, lost customers and a negative impact on the bottom line. Although downtime can never be completely eliminated, integrated logical to physical architectures enable faster diagnoses to detect the threat of faults such as broken or compromised network performance before downtime occurs.
- **Lower Costs.** Panduit and IBM use proven methodologies and global best practices to provide solutions that allow enterprises to fully leverage assets and reduce costs. This approach allows data center managers to shorten implementation time and costs by removing complications and delivering engineered, tested and validated solutions optimized for IBM technology applications. As a result, cloud deployment can optimize real estate, improve energy efficiency, and reduce complexity.

### ***Important Characteristics for Deployment Success in the Physical Infrastructure***

There are specific characteristics in a physical infrastructure solution that are key to successful cloud performance:

- *Agility* – handle moves, adds and changes for added flexibility and capacity management
- *Sustainability* – maximize real estate utilization and optimize power and cooling efficiency
- *Visibility* – maintain control of data process and real-time visibility into network reliability, bandwidth, IT asset health and capacity when leveraging third-party cloud vendors

## Cloud-Enabled Data Center

When deploying the cloud infrastructure in traditional data centers, it is important to understand that a cloud-enabled data center needs to be able to lay the foundation for a successful virtualized environment, a key component of cloud computing. This requires the data center to have the capability to handle the operational strains that occur as a result of cloud-based applications. Cloud computing changes the landscape of the traditional data center by transforming how businesses process information and manage their IT infrastructure. For example, a successful implementation and integration of a cloud-enabled data center allows an organization to focus on the core business instead of having to plan or manage resources. It may require fewer servers, which reduces capital expense and is an effective way to improve agility, scalability, and sustainability. In addition, cloud computing allows for rapid deployment, improved storage and data accessibility, which all contribute to an optimized data center.

When deploying the cloud infrastructure in traditional data centers, it is also important to consider how the integrated stack affects data center operations because an integrated stack can be a key element of the cloud infrastructure. In a typical data center layout with separate areas for compute servers, network switches and storage gear, a cooling system design that follows industry best practices is essential to the successful deployment of the IT equipment. This is especially critical when you combine these components into a single cabinet or pod of cabinets to create a high performance integrated stack. Not only does the proper cooling design keep the IT equipment safe from unplanned downtime due to overheating, but significant operational expense (OpEx) savings are realized through more efficient energy usage.

A traditional data center is comprised of three main sections:

- Compute - Equipment Distribution Area (EDA)
- Network - Main Distribution Area (MDA)
- Storage - Storage Area Network (SAN)

An integrated stack has all three of these components in a single cabinet.

A perimeter cooling design for a traditional data center layout is shown in Figure 4. In this design the cooling needs of the rows are provided by the Computer Room Air Handler (CRAH) units on each end of the hot aisles. The servers are located in the EDA and their cooling needs are provided by the CRAH units placed in these areas. Similarly, the storage gear is located in the SAN, the network switches are located in the MDA and at the end of the EDA row of cabinets.

In this design, the airflow requirements and characteristics of servers and switches in the EDA are similar for each cabinet. Therefore, the CRAHs supplying cool air to the EDA can have similar set points for supply temperature and airflow rates. Also, the requirements of the SAN and MDA can be provided by the CRAH units that serve those areas of the data center with the appropriate supply temperature and airflow rate to meet the needs of the SAN and MDA IT equipment.



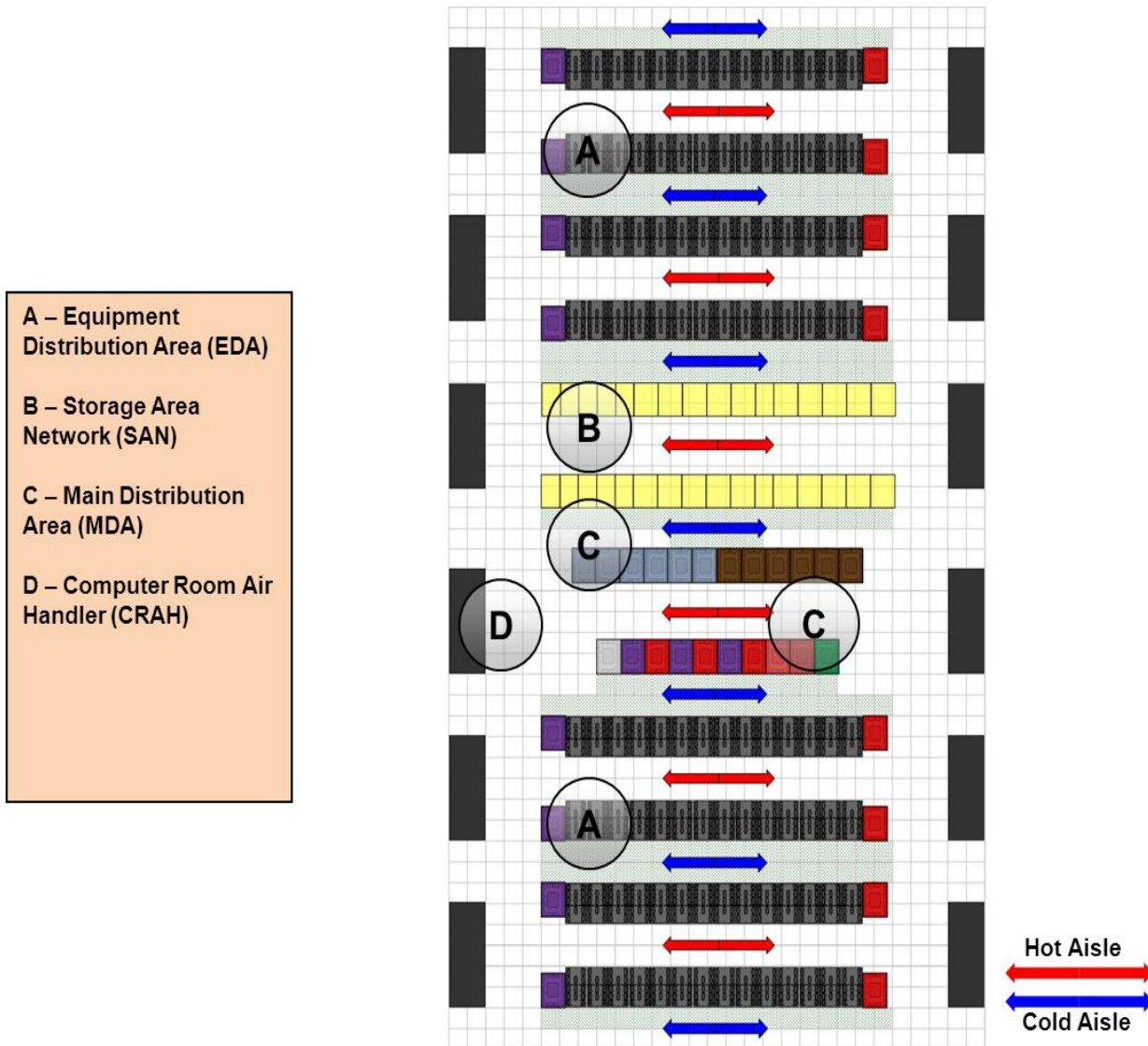


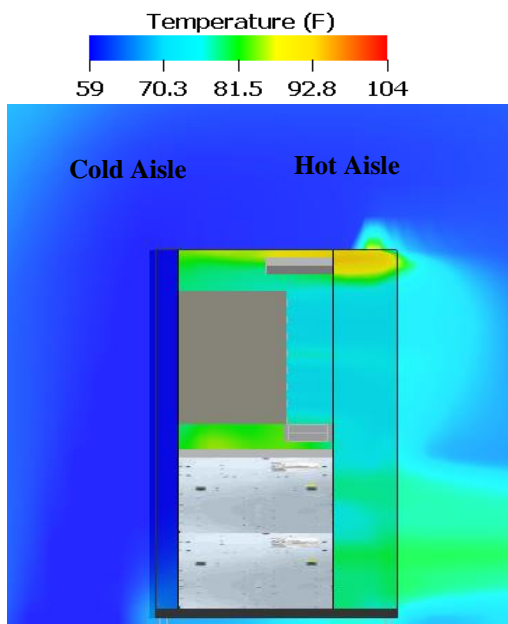
Figure 4. Traditional data center layout.

### Typical Integrated Stack

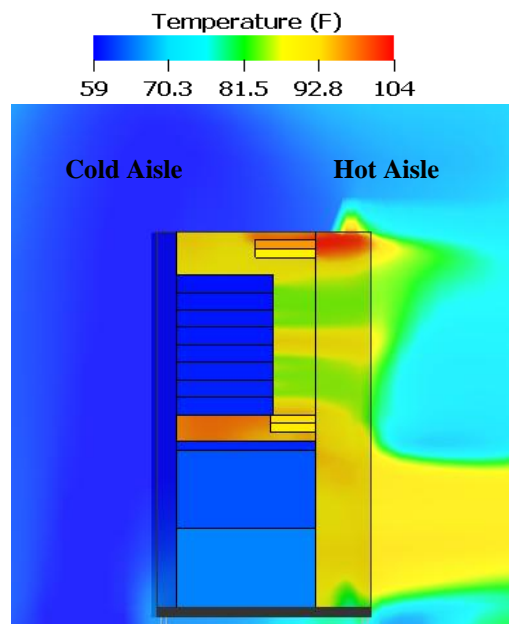
Within the integrated stack, the three main areas of the traditional data center (compute, network and storage) reflect the value of mapping the logical architecture to the physical infrastructure. This logical integration combines all of the above components into one unit that can be deployed into the traditional data center and used to optimize areas such as power, cooling, space, speed and performance. It is also important to note the integrated stack impact on the data center considerations as described in the *Private Cloud* section of this white paper.

## Computational Fluid Dynamics Analysis Results

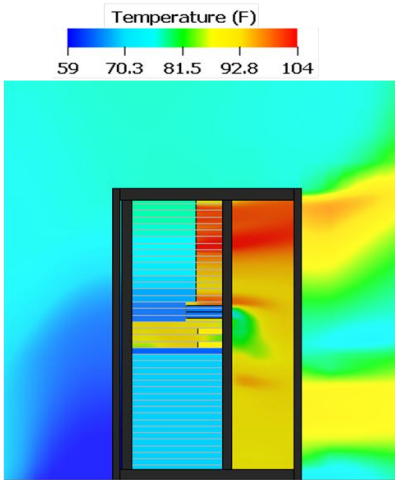
The results of a Computational Fluid Dynamics (CFD) analysis on the integrated stack of equipment at an idle condition are shown in Figure 5. Figure 6 is a CFD analysis with the IT equipment at an average utilization, which increases the IT equipment heat load to 10.4 kW. The combination of these illustrations show that with the IT equipment at this utilization, the storage fabric switches mounted at the top of the rack are approaching their maximum operating temperature of 104°F. Figure 7 shows the improved inlet temperature after the storage fabric switches are relocated to the center of the rack and an inlet duct is installed on the two SAN24B storage fabric switches.



**Figure 5.** Cross-sectional view of temperature distribution through the center line of the cabinet with the integrated stack set at idle. SAN24B storage fabric maximum operating temperature is 104° F.

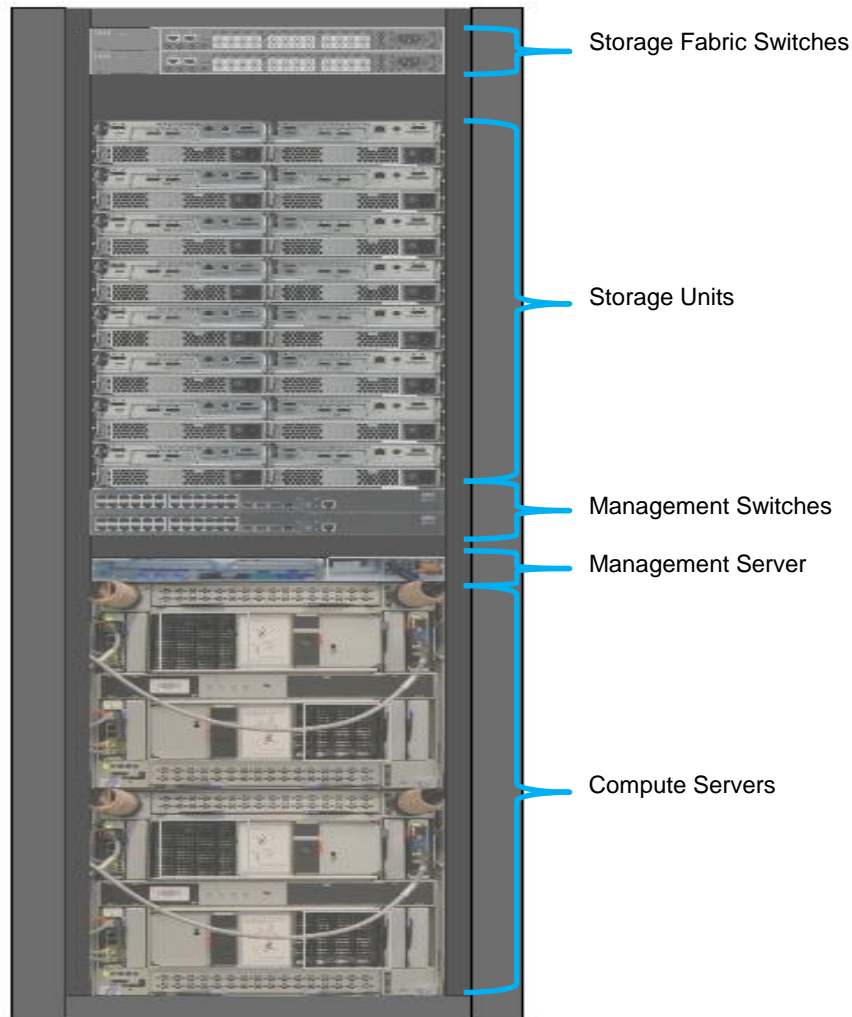


**Figure 6.** Cross-sectional view of temperature distribution through the center line of the cabinet with an integrated stack at a usual utilization. The IT equipment is colored with the maximum inlet temperature for each device. The temperature range is scaled from the minimum ASHRAE allowable inlet temperature to the manufacturer allowable SAN storage fabric switch inlet operating temperature, 104°F.



**Figure 7: Cross-sectional view of temperature distribution through the center line of the cabinet with an integrated stack. The SAN storage fabric switches were relocated to the center of the cabinet and fitted with an inlet duct but they could have remained at the top RU with the inlet duct installed.**

As explained in the CFD analysis section above, when combining network, storage and compute into a single cabinet or pod of cabinets to create a high performance integrated stack, it is essential to consider airflow management for a successful IT deployment. The cooling airflow management is unique for integrated stack configurations due to the varied cooling airflow inlets of network switches and their mounting location in the cabinet (Figure 8). For example, an integrated stack of IBM equipment (Blade Center H servers; DS3524 System Storage; SMC Management Switches and SAN24B-4 switches) requires 6 kW of cooling and 1165 cfm of airflow at an idle condition. For average operating conditions, the SAN storage fabric switches require inlet ducts to keep their inlet air temperatures within their allowable range. *Once equipped with an inlet duct, the SAN storage fabric switches can be placed at any RU position, if desired.* For simpler network cabling, the switches are mounted to the rear rail of the cabinet with the inlets for the switches placed on the hot exhaust side of the cabinet.



**Figure 8: Rear view of an integrated stack cabinet configuration.**

## Power and Cooling Considerations for Cloud Deployment

Once the physical infrastructure design has been determined, power, cooling, space and performance considerations should be addressed for optimized cloud enablement. The unique deployment of an integrated stack in a cloud-enabled data center requires special consideration for power and cooling designs.

### Power

Equipment power requirements and deployment densities dictate the voltage and amperage of the power distribution system. Two key areas that contribute to sustaining equipment power requirements are power balancing and redundancy.

- *Power Balancing* - This balancing is achieved by obtaining the maximum current draw of each device to be installed in the cabinet from the manufacturers' data sheets, then calculating the total for the entire cabinet. Power balancing also includes distributing the power between the circuits and if three phase, the phases as well.

- **Redundancy** - To ensure the risk of downtime is minimized, the entire load of the cabinet should be met with only one power feed. For example, if the “A” side power is lost, the “B” side power should be able to handle the power requirements of the installed equipment. This system design avoids downtime, productivity loss and achieves high reliability and customer satisfaction.

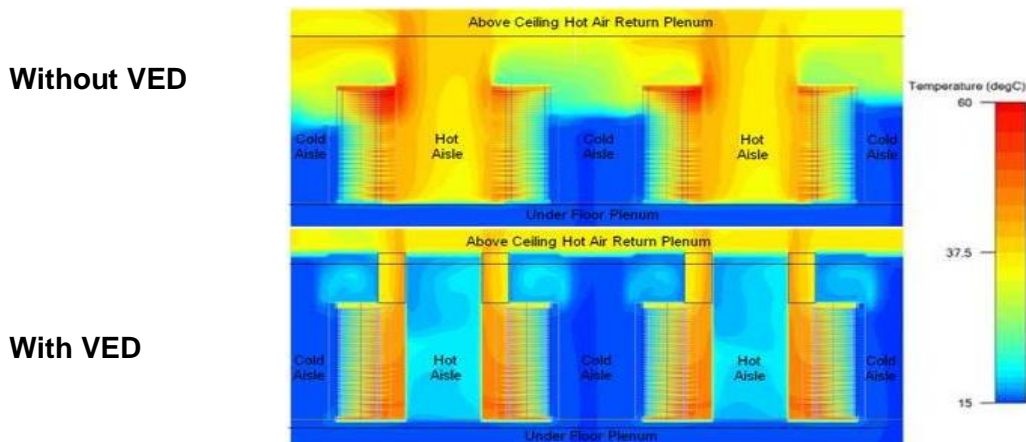
## Cooling

Proper cooling keeps all of the IT equipment functioning well, ensuring higher levels of application uptime. For maximum cooling efficiency, the data center design should prevent equipment from drawing heated air. This can be achieved by utilizing proven design best practices and using effective passive cooling technologies complemented by practical active cooling strategies. Within the cabinet, when hot exhaust air returns above or below the equipment and back into the intake, the possibility exists for hot exhaust air to be recycled into the equipment air intake. When using an integrated stack with a multi-use cabinet, ensure that you are achieving total hot/cold air separation to prevent hot exhaust air recirculation. To address this situation, Panduit’s Net-Access™ Cabinets improve sealing by up to 20%, optimizing hot and cold air separation, resulting in as much as \$800 in energy savings per cabinet annually.<sup>1</sup>

### Benefits of In-Cabinet Thermal Ducting and Cable Management

- Direct exhaust air to hot aisle
- Optimized cable lengths for unobstructed airflow and reduced slack, which mitigates cable congestion

The addition of the Panduit® Net-Contain™ Vertical Exhaust Duct (VED) System separates the hot exhaust air from the cool air and routes the hot exhaust directly from the cabinet into a return plenum. This eliminates recirculation of hot air to cabinet inlets and results in cooling efficiency and significant energy cost reduction that allows data centers to operate at higher supply air set point temperatures (see Figure 9).<sup>2</sup>



**Figure 9. Top view: illustrates un-separated hot and cold air which does not provide the optimum thermal performance to the cabinet equipment, nor does it provide the energy efficiency to the CRAH unit because they are not segregated.**

**Bottom view: CFD analysis shows separated hot and cold air. The hot air exhaust has a direct path to the CRAH unit which provides higher return air temperature, resulting in energy savings.**

<sup>1</sup> For more information about achieving effective cabinet sealing, please refer to Panduit White Paper RKAT01—WW-ENG: *Maximizing Cooling Energy Efficiency with Effective Cabinet Sealing*.

<sup>2</sup> For more information about increasing the cooling efficiency of data centers, please refer to Panduit White Paper WW-CPWP-20: *Impact of Air Containment System*.

## Cabling Systems

In a traditional data center, fiber and copper are the primary cabling systems. However, in an integrated stack, fiber, copper and fabric solutions are all utilized. Moving to server virtualization to support public and private clouds is driving the demand for higher bandwidth connections and greater network capacity. Systems need to scale quickly and support implementations of new equipment. Panduit Physical Infrastructures for cloud ready systems include comprehensive fiber and copper cabling systems that offer ease of deployment and proven performance to ensure availability, reliability and scalability.

### ***Fiber***

Panduit is the leading provider of high performance, high bandwidth fiber optic cabling systems that meet and exceed the demanding requirements of today's data centers. Panduit Fiber Optic Cabling Systems feature low loss, high performance connectivity for added flexibility, performance and scalability, assuring lower total cost of ownership and greater return on investment. Panduit's MPO cassettes support non-disruptive transition from 10 Gb/s Ethernet to 40/100 Gb/s Ethernet networks.

### ***Copper***

Panduit also provides copper solutions for mission-critical data center applications that accommodate storage, compute and networking requirements. Through a deep understanding of data center architecture and customer needs, Panduit is able to select from our wide product portfolio to create configured packages that provide optimal performance and efficiency. Using our best-in-class copper connectivity for 1/10/40G Ethernet, Panduit provides appropriate cabling for pre-configured solutions.

### ***Fabric***

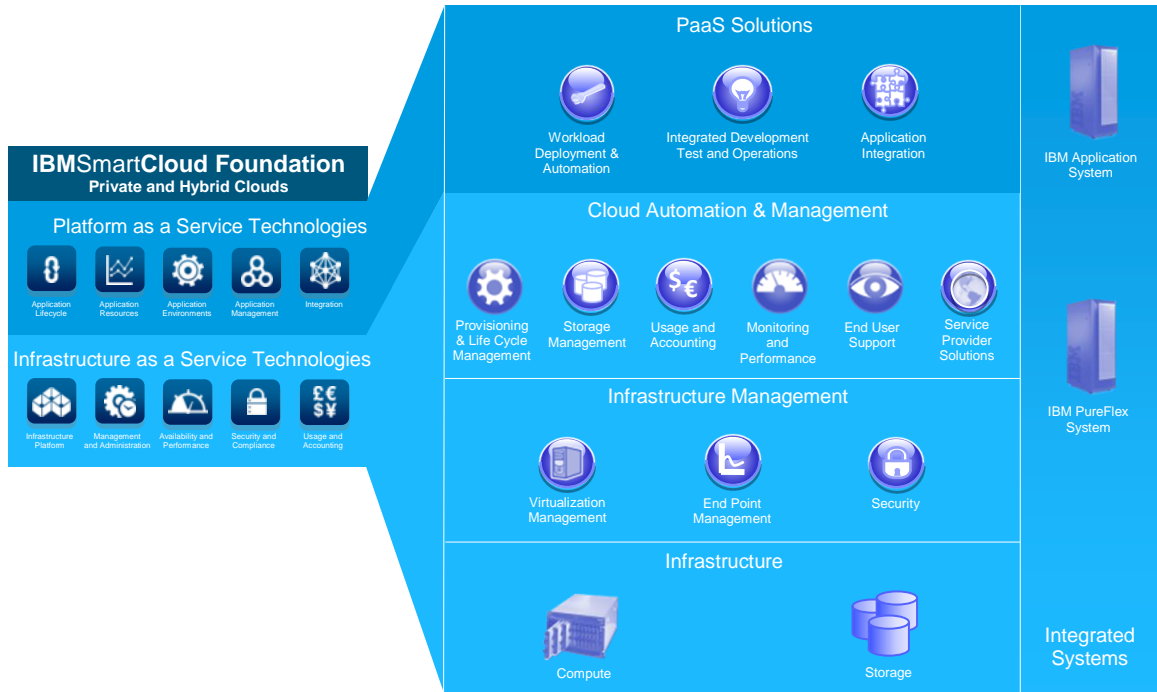
With fabric-based architectures, the physical infrastructure is no longer divided between high-performance mission-critical information and lower-speed, non-priority data. The need for a high-performance physical layer is especially critical for virtual environments, where multiple virtual machines are run over the same physical link, demanding full channel bandwidth in order to maximize network efficiency and port utilization. When deploying I/O fabrics, the physical infrastructure must be able to grow with data storage and information exchange requirements, and must have the ability to easily apply network reconfigurations as business needs change.

Panduit's 10Gig SFP+ and QSFP+ Direct Attach Copper (DAC) passive cable assemblies meet the needs for faster processing speeds, lower power, low latency, server inter-connect and I/O consolidation deployments. A superior performance margin assures data integrity because these assemblies are 100% production tested. Factory terminated connectors provide excellent signal integrity and specification margins. In addition, the robust latching/de-latching mechanism and enhanced strain relief facilitate proper cable management, improved airflow, cooling, and ease of deployment.

## IBM SmartCloud Foundation

The IBM SmartCloud Foundation (shown in Figure 10) is an integrated set of platform capabilities based on open standards and the IBM Cloud Computing Reference Architecture. The Infrastructure as a Service technologies provide a policy-based scalable environment for managing the delivery of computing resources and cloud services "on demand". Platform as a Service technologies deliver an integrated pool of abstracted

application services to build and run cloud services. Clients may choose to build cloud computing environments with expert integrated systems, such as IBM PureFlex or IBM PureApplication Systems. These systems are delivered with IBM SmartCloud Entry software, making it easy for clients to begin building private clouds.



**Figure 10. IBM SmartCloud Foundation.**

For clients with multi-tenancy requirements, IBM has infrastructure solutions such as IBM SmartCloud Provisioning and IBM Service Delivery Manager. Managed Service Providers, and other cloud service providers will benefit from the Managed Service Provider editions of IBM PureFlex, providing the opportunity to maximize value to clients while lowering total cost of ownership with reference configurations to include the infrastructure, cloud service delivery, and managed IT solutions.

Clients may choose to build custom cloud solutions, and IBM SmartCloud offerings are built to integrate and interoperate with many systems and management solutions, from IBM and other vendors, providing the flexibility to adapt initial cloud implementations in an existing data center when required. In addition to IBM PureSystems implementations, IBM has built and deployed thousands of cloud systems, many of them on IBM System x, IBM BladeCenter, IBM Power Systems, and IBM System z servers.



## Physical Infrastructure Manager™ (PIM™) / Tivoli Integration

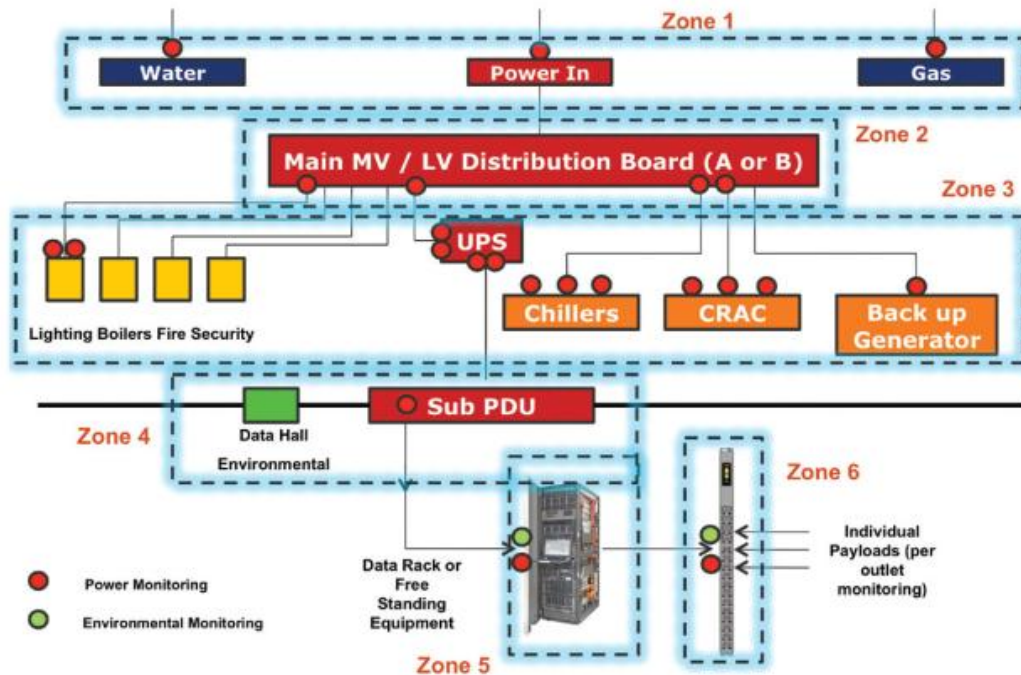
Monitoring of both the physical infrastructure and the cloud infrastructure in the data center is important. IBM SmartCloud Monitoring provides information about the cloud stack and systems. IBM Tivoli Monitoring reaches beyond the cloud stack to the physical infrastructure. The Panduit Physical Infrastructure Manager™ (PIM™) Software Platform can provide comprehensive operations and physical infrastructure management system tools to enhance an existing IBM Tivoli system with timely and actionable information on events within the data center. PIM™ software integrates seamlessly with IBM Tivoli to provide critical information about power, cooling and connectivity states at the rack level. This allows users to monitor the data center environment, accurately control any planned or unforeseen network events, and remotely determine exact root causes of physical infrastructure issues. Work orders can be generated and confirmed complete, and any MTTR metrics from the PIM™ software can be automatically reported to the relevant departments. Hardware provisioning and installation within the PIM™ software are also automated, and the results feed directly into IBM Tivoli. The outcome is a faster change management and/or problem resolution time which can have a direct and positive impact on business processes, revenue and overall OpEx.

With the PIM™ integration, IBM Tivoli users can benefit from increased functionality and enriched data without disrupting existing operations, or needing to switch between or monitor multiple programs. In general, the integration enables collection, correlation and supplementation of PanView iQ™ (PViQ™) System Hardware and PIM™ software events, displayed through the IBM Tivoli graphical user interface (GUI).

Panduit SmartZone™ Solutions expand the existing PIM™ offering and technology roadmap for data center infrastructure management (DCIM) through its launch of the first truly consolidated management platform. This enables IT and Facilities Management to work together to ensure effective monitoring, understanding and management of the data center facility. From the building point of entry to individual server payload, a 6 Zone methodology uses appliances, instrumentation and an intelligent software platform to deliver IT and Facilities Managers a consolidated, holistic and real time view of the entire data center facility, including its energy and environmental status. This consolidation of accurate granular information and monitoring accuracy provides unprecedented control and energy and capacity management (see Figure 11).

The combination of IBM and Panduit SmartZone™ physical infrastructure management systems increases the business agility and efficiency of trouble-shooting by allowing a more targeted time and cost efficient approach to repairs. This approach lowers the overall risk of challenges by enabling proactive monitoring and integrated management.





**Figure 11. Panduit SmartZone™ physical infrastructure systems deliver more effective capacity management and control.**

## Conclusion

Panduit and IBM have developed the industry's most comprehensive approach to an intelligent data center solution that includes advisory and design services, DCIM software and hardware, high-speed data transport (HSDT), energy-efficient cabinets, preconfigured infrastructures and a physical infrastructure foundation, which are all cloud ready. Panduit's solution streamlines the process of designing, specifying, installing and managing the increasingly complex physical infrastructure required for cloud computing.

Panduit Infrastructure Design Services are based on a deep understanding of your logical IT architecture as well as your business objectives. IBM delivers a real-world cloud computing experience using industry-leading, open technologies that provide the most complete portfolio of offerings to customers. As a result, Panduit and IBM deliver a comprehensive physical infrastructure based on industry expertise, reference architecture and best practices developed with leading global technology partners. These factors are the framework with which we develop the optimal physical infrastructure for your data center, merging the physical systems – power, cooling, cabinets, pathways, cabling, bonding and identification – with the IT equipment they support – servers, switches, storage and monitoring.

## Referenced Documents

ASHRAE's "2011 Thermal Guidelines for Data Processing Environments" white paper and its temperature ranges for various environmental classes was prepared by a committee exclusively comprised of engineers from commercial IT equipment manufacturers. The ASHRAE Thermal Guidelines are recognized and followed throughout the IT and data center industries.

- 2012. IDG Research Services. "Designing the Physical Infrastructure to Maximize Cloud Benefits."
- 2012. Gartner, Internap Webcast, "Top 10 Data Center Strategy Success Criteria."
- 2013. IBM. Smarter Data Center Services. Retrieved February 20, 2013 from <http://www-935.ibm.com/services/us/igs/smarterdatacenter-ab-test.html>.

## About Panduit

Panduit is a world-class developer and provider of leading-edge solutions that help customers optimize the physical infrastructure through simplification, increased agility and operational efficiency. Panduit's Unified Physical Infrastructure™ (UPI)-based solutions give enterprises the capabilities to connect, manage and automate communications, computing, power, control and security systems for a smarter, unified business foundation. Panduit provides flexible, end-to-end solutions tailored by application and industry to drive performance, operational and financial advantages. Panduit's global manufacturing, logistics, and e-commerce capabilities along with a global network of distribution partners help customers reduce supply chain risk. Strong technology relationships with industry leading systems vendors and an engaged partner ecosystem of consultants, integrators and contractors together with its global staff and unmatched service and support make Panduit a valuable and trusted partner.

[www.panduit.com](http://www.panduit.com) · [cs@panduit.com](mailto:cs@panduit.com)

## About IBM

As the manager of over eight million square feet of data center space worldwide and with over 100 years in business, IBM can be a vital partner to help you save energy, cut costs, improve utilization, adapt to change, and make your data centers smarter. IBM delivers a comprehensive set of data center and cloud capabilities to provide clear economic value and help clients work through the right mix of delivery models and choices by workload to reap the maximum benefit in a cloud enabled data center. Along with a proven, common cloud computing reference architecture, IBM provides the technology, tools, and skilled resources to help clients plan, build and deliver cloud services. IBM has taken a leadership role in developing standards for cloud computing built on industry and open standards, and has delivery centers around the world.

[www.ibm.com/smartcloud](http://www.ibm.com/smartcloud)