Unified Physical Infrastructure (UPI) Strategies for Data Center Networking

Physical Infrastructure Considerations for Data Center Consolidation

WHITE PAPER

Introduction

Improving the performance of business applications drives all equipment and technology decisions in the data center. Implementing a data center consolidation effort will reduce real estate costs and enable increased energy efficiency through more efficient provisioning of power, cooling, and IT resources. These efforts center on reducing duplicate resources (applications, hardware, infrastructure, labor), and range from deploying the latest consolidated server adapter technologies to eliminating dedicated legacy applications and assets.

Optimizing the physical infrastructure is key to a successful data center consolidation project. Applying Unified Physical Infrastructure (UPI) management principles reduces risk associated with displacement and realignment of IT resources. However, it can take weeks or months to provision the infrastructure, move and track assets, migrate applications, and perform configuration testing, all while containing risk and ensuring the availability of mission-critical business functions.

This paper defines the critical role played by the physical infrastructure to support data center consolidation efforts. It also identifies new infrastructure technologies that enable advanced computing strategies such as server virtualization which can be deployed over consolidated data center assets. Data center stakeholders can use UPI principles in conjunction with consolidation strategies to reduce the operational cost of network, computing, and storage resources within the data center and achieve a better return on infrastructure investment.

Is Your Data Center Ready for Consolidation?

Business management systems require increasingly complex and large-scale database processing capabilities, and the adoption of rich collaboration (i.e., Web 2.0) services for both employees and customers. As a result the complexity of the IT physical infrastructure has a significant impact on overall operational costs.

These capabilities are often met by over-provisioning the data center: dedicated servers are added with the addition of new applications, resulting in an infrastructure that is difficult to manage. Merger and acquisition activities result in further duplication of IT resources, with new and existing server and storage assets often used at 20-25% of their capacity. Additional appliances needed for load balancing and security fill racks quickly, and hundreds to thousands of power and data cables must be managed overhead, underfloor, and within enclosures to prevent network, server, and storage failures from occurring.

In response, organizations are implementing network consolidation techniques to untangle the snarl of applications and assets in several ways: (1) reducing the number of IT assets (servers, storage units, and switches); (2) leveraging those assets more efficiently; (3) lowering real estate costs by reducing both the footprint of the physical infrastructure and the total number of data centers in use; (4) reducing the number of networks and lowering WAN/ISP costs; and (5) reducing power consumption across all systems (including cooling) to increase energy efficiency.

Effective consolidation practices incorporate logical and physical architectures to achieve operational cost savings and maximize return on data center infrastructure investments. Ultimately these practices improve asset utilization and enable greater business agility (see Figure 1).

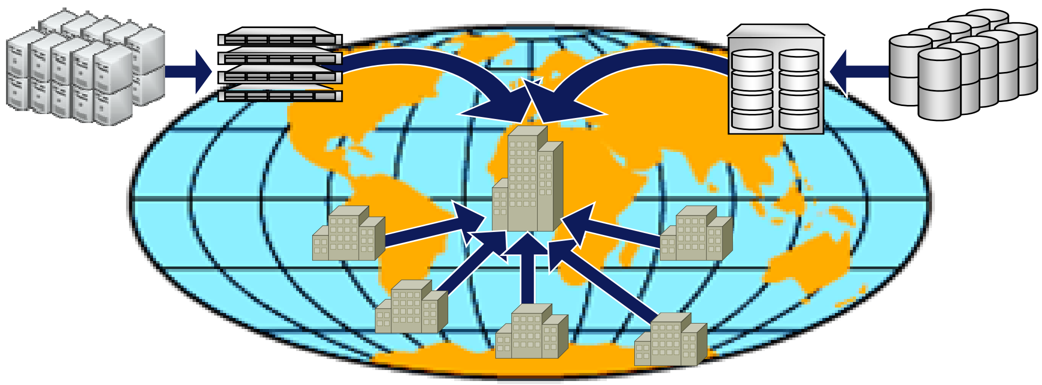


Figure 1. Data center consolidation efforts reduce real estate and energy costs through more efficient provisioning of power, cooling, and server resources.

Server Consolidation

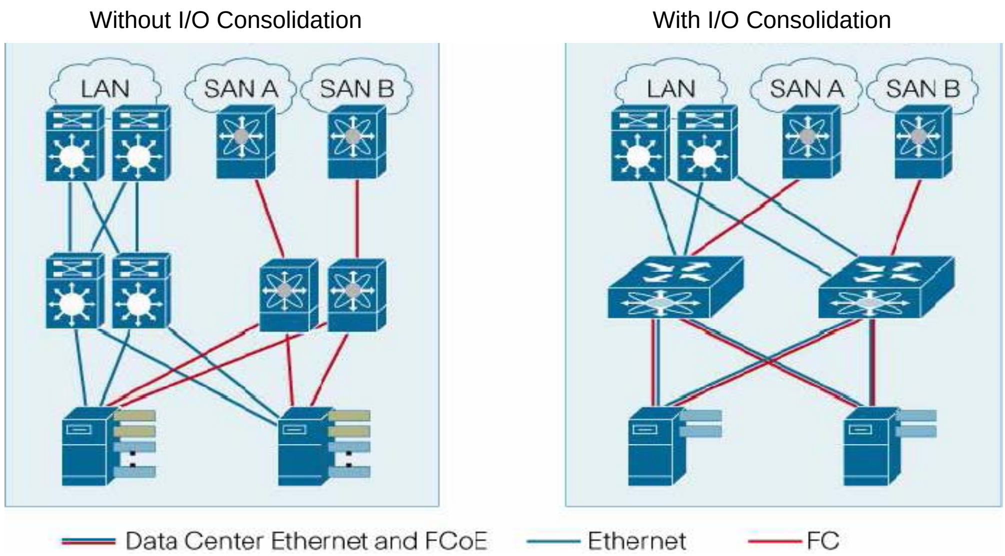
In the server environment, the specific goals are to consolidate business applications onto a reduced number of standardized infrastructure assets and then optimize the utilization of those assets. Specific server area optimization strategies include the following:

- ***Server upgrades.*** Many enterprises take the opportunity of re-provisioning server assets in the data center server environment to achieve greater efficiencies. For example, rack densities may be increased by deploying blade servers and/or servers which feature multi-core processors to obtain more computing power per rack unit (RU).

- ***Server virtualization.*** Virtualization technologies (such as Cisco® VFrame, Microsoft® Virtual Server and Hyper-V™, VMware®, or Xen®) pool resources together in a single "virtual" environment to share processing efforts more evenly across fewer physical servers. This strategy also helps increase the availability of applications by sharing them across multiple virtual machines to maintain user access in the event of planned server maintenance or unplanned downtime.

- ***I/O consolidation*****.** Many data centers operate multiple separate networks: one for IP networking, one for block I/O, and a third for server-to-server protocols used by high-performance computing (HPC) applications. Some of these parallel data streams may be consolidated over the same 10 Gb/s physical infrastructure by employing Converged Network Adapters (CNAs) with Fibre Channel over Ethernet (FCoE) technologies. This approach reduces the need for separate switches, cabling, adapters, and transceivers for each class of traffic (see Figure 2).

Active equipment that supports 10GBASE-T operating over 100 m of Category 6A UTP cabling is expected to be available in 2009. In the meantime, SFP+ copper and fiber cabling assemblies are expected to be adopted for 10 Gb/s consolidation applications in the data center. The advantages of the SFP+ interface include cost and connector backward compatibility: SFP+ active equipment modules require a lower number of components, making SFP+ a cost-efficient alternative to other transceivers. Also, the front connector of optical modules remains an LC connector, which enables reuse of the existing fiber infrastructure in the data center. The *PANDUIT* white paper "Implementing a 10 Gb/s Physical Infrastructure to Achieve I/O Consolidation in the Data Center" addresses this topic in greater depth.



16 Servers	**Connections**		
	Ethernet	**FC**	**Total**
Adapters*	16	16	32
Switches	2	2	4
Cables	32	32	64

* Using dual port adapters

- Servers have two adapters: one Ethernet dual port NIC and one FC dual-port HBA
- Each adapter uses two cables
- Each server requires four cables
- Each cabinet hosts four switches

16 Servers	**Connections**		
	Ethernet	**FC**	**Total**
Adapters*	16	0	16
Switches	2	0	2
Cables	32	0	32

* Using dual port adapters

- The FC switches have been eliminated
- The FC HBAs in servers have been eliminated
- The Ethernet NICs in servers have been replaced by FCoE CNAs
- Only two cables are needed to connect a server in a redundant deployment design instead of four
- Two more rack positions are freed up for use by servers

Figure 2. Consolidated network topologies leverage 10 Gb/s technologies to optimize the physical infrastructure and maximize asset utilization. (Image source: Cisco)

Storage Consolidation

Consolidated storage environments are designed to provide a centralized location to store, access, and manage mission-critical data. As businesses grow, storage systems evolve from scattered islands to more centralized and/or tiered environments that store data under the control of a single network or file management system. These architectures provide secure, reliable access to mission-critical data, often using high-performance arrays and storage networks to reduce backup times and meet disaster recovery requirements.

Specific storage area optimization strategies include the following:

- ***Centralized architectures.*** Consolidation of scattered Direct-Attach Storage (DAS), Network Attached Storage (NAS) units, and Storage Area Network (SAN) islands into a single physical fabric enables streamlined storage management and more efficient asset utilization. These simplified environments reduce operational costs as they are easier to manage, maintain, and scale. The ability of SANs to replicate data quickly between storage arrays and over long distances makes them preferred over DAS and NAS approaches in larger enterprise environments to meet disaster recovery requirements. (Note: At distances longer than six miles FCoE is a cost-efficient alternative to Fibre Channel, enabling a longer reach with no performance overhead and eliminating the cost of an additional IP gateway.) For more information see the *PANDUIT* white paper "Using Centralized Architectures to Achieve Physically Consolidated Storage Environments".

- ***Storage upgrades.*** Just as with server environments, legacy storage drives can be upgraded to higher-density storage arrays, and multiple switches across SAN islands may be replaced with a smaller number of high port-count director (i.e., core) switches (see Figure 3). Innovative drive technologies feature variable-speed motors and hybrid (i.e., partial solid-state) memory that reduce power consumption in the SAN area.

- ***Storage virtualization.*** Storage virtualization initiatives enable network stakeholders to consolidate equipment and physical space, increase drive utilization, and eliminate redundant business applications. A Virtual Storage Area Network (VSAN) is a collection of ports from a set of connected SAN director switches that form a virtual fabric. Each VSAN is a separate self-contained fabric using distinctive security policies, zones, events, memberships, and name services, with traffic isolated between fabrics. Technologies such as Fibre Channel zoning and N_Port ID Virtualization (NPIV) are available to enhance VSAN security and flexibility.

Next-generation consolidated storage networks are likely to include both FCoE and native Fibre Channel protocols over fiber optic media, and many will leverage consolidated I/O and virtualization technologies to achieve networking and application efficiencies. With the rise in popularity of 4 Gb/s Fibre Channel transceivers and the recent introduction of 8 Gb/s devices, any high-performance storage network deployment should consist of OM3 or higher grade fiber. Low-loss connectivity – patch cords, cassettes, interconnect cables, trunk cable assemblies such as the *PANDUIT*® *QUICKNET*™ Pre-Terminated Cabling System – also enables heightened network flexibility by building more headroom into the channel for patch fields and cross-connects and thereby increasing the number of physical infrastructure topologies available.

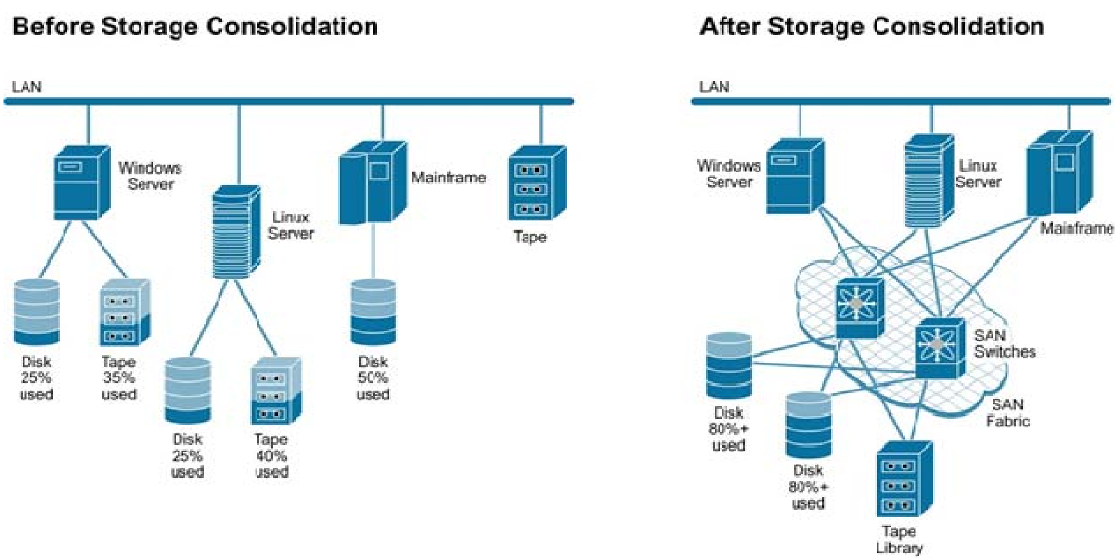


Figure 3. Before storage consolidation, data exists in storage "islands" not accessible to the entire network and storage equipment utilization is low. After storage consolidation, data is accessible to every device on the network and storage array efficiency is greatly improved.

Network Consolidation

Many data centers use multiple interconnect technologies to bridge networks within the overall facility, such as Ethernet for the Local Area Network and Fibre Channel for storage applications. Advancements in 10 Gigabit Ethernet (10 GbE) technologies are making it more attractive (and cost-effective) to consider consolidating these technologies along one high-speed interconnect platform.

One example of this approach is the rapidly developing technology of Fibre Channel over Ethernet (FCoE). The INCITS T11 standards body is finalizing a standard for wrapping Fibre Channel frames within Ethernet headers and trailers, and then using special FCoE switches to transmit Ethernet frames to the conventional LAN switch and send Fibre Channel frames to the Storage Area Network. This consolidation of formerly discrete networks offers several benefits to network stakeholders:

- Server network adapters can be consolidated from a separate Ethernet NIC card and a Fibre Channel Host Bus Adapter (HBA) to a single Converged Network Adapter (CNA).
- Only one cable is now required from the server to the FCoE switch versus the two that used to be required – one for Ethernet traffic and one for the Storage Area Network.
- The reduced overall number of connectors emerging from the server reduces the footprint of the area required for connectors which enables increased server densities. (For example, one of the problems to current adoption of blade servers is the space occupied by all the connectors. The use of the converged adapter improves this situation by reducing the number of required cables and connections for more efficient use of pathway real estate.)
- Further reductions to the total number of servers and server ports can be made by implementing virtualization throughout servers provisioned with converged compute/storage ports (i.e., CNAs).

Coupled with the rapid development of standards for FCoE comes the very recent adoption of smaller form factor for the connectors supporting 10 Gb/s technologies. The SFP+ form factor – originally developed as an optical form factor for 8 Gb/s Fibre Channel and extended to direct attached copper cabling to support 10 Gb/s Ethernet – is an elegant short reach, low power physical layer solution that can be cost effectively implemented. Passive SPF+ copper cable lengths between 5-10 m currently are available with power consumptions of about 1W, which makes these attractive in consolidated data center environments. (Although the IEEE 802.3af standard for 10GBASE-T has been released since June 2006, technology that reduces the overall power consumption of the PHY circuitry remains in development.)

The current reach of the SFP+ passive copper assembly can be exploited by adoption of modular server / switch architectures. One such modular design is the Top of Rack (TOR) model, in which the server switch architecture makes use of edge switches that are often, but not necessarily, mounted at the top of the cabinet. These edge switches are fed by a specified number of servers within the same rack, or perhaps an adjacent one, using shorter lengths of copper cabling from servers to switch. Fiber optic cables are then used to feed from the edge switches to centrally-located core switches; choice of fiber media grade is based on reach, topology (i.e., total number of connectors), and application requirements (i.e., 4-8 Gb/s Fibre Channel and/or 10 Gb/s Ethernet).

Infrastructure Consolidation: Supporting Reduced Real Estate, Increased Equipment Density

Effective consolidation requires a disciplined project management approach that leverages the expertise of the application, storage, network, and facilities teams. The first step taken by management to reduce data center cost and complexity is to identify whether the sheer number of business applications they possess are necessary. Over time, the number of applications that companies develop and deploy increases to meet their dynamic business needs. However, many of these applications either outlive their usefulness or spawn additional applications that render them redundant.

As applications are reduced, removed, or otherwise streamlined, these decisions have a pronounced impact on the layout of all data center infrastructure elements, including servers, storage, power, cooling, and structured cabling. Specifically, changes made to logical system architectures reduce data center real estate by increasing equipment densities throughout the room, which often leads to consolidation of entire data center facilities.

For example, an organization may currently operate 20 data centers that average 5,000 ft^2 (465 m^2) in size, for a total of 100,000 ft^2 (9,300 m^2), and which are scattered across multiple locations, each with different power rates and real estate taxations. An efficiency analysis of these facilities might determine that network storage and compute resources can be centralized into two newly sited 25,000 ft^2 (2,300 m^2) facilities to achieve operational and real estate cost savings. Once the decision is made on how many facilities will be sited, the next goal is to optimize the use of real estate at both room level and within enclosures.

Thermal Management in Dense Data Center Environments

Although equipment consolidation efforts result in a smaller data center footprint, they also lead to increased heat loads and cabling densities within a reduced number of enclosures. Effective thermal management in the data center is achieved by controlling the movement of cool air through the strategic layout of computer room air handling (CRAH) units and physical infrastructure elements, including power and data cabling.

Depending on server number, power consumption, and form factor, heat loads can rise significantly – to 30 kW per cabinet and beyond. Raised floor cooling systems typically deliver enough air to disperse 7-8 kW of heat per cabinet, provided that CRAH units have enough capacity and best practices are employed (e.g., hot aisle/cold aisle equipment layout, 24-36 inch [60-90 cm] raised floor height, 25% opening through perforated tiles, proper return airflow path, and the use of rack filler panels and floor sealing grommets).

For hot spots that develop over the consolidation project, or for very high loads throughout the entire room, cooling capacity can scale in several ways to cool 30+ kW per cabinet. Passive heat removal options include increasing tile open area (from 25% to 40-60%) and deploying rear plenum direct vents (i.e., chimney assisted cooling) on select cabinets to route hot server exhaust air to ceiling plenum spaces. Active options include boosting CRAH capacity and deploying supplemental devices such as rear door heat exchangers (i.e., water-cooled technology) and overhead cooling units.

Both passive and active thermal management techniques allow data center cooling capacity to scale over time as business requirements change and grow, enabling organizations to consolidate servers with minimal, as-needed investment in the physical infrastructure. (Download the following *PANDUIT* white papers for more information on data center cooling efficiency and facilities planning at room level.)

Cabinets and Enclosures

At the enclosure level, consolidation of equipment requires the effective management of very dense cabling environments to support thermal management goals and reduce risk of equipment failure. Switch- and server-specific cabinets work in conjunction with cable management systems to optimize airflow and effectively route, manage, and protect cabling to achieve greater equipment and cabling densities.

- Switch cabinets contain dense quantities of copper and fiber cabling, and several techniques can be used to increase switch densities in support of data center consolidation efforts. The use of an inset structural frame creates a large and accessible vertical cable pathway to manage cables within the enclosure. Modular cable management can be placed where needed to route cables away from airflow pathways, and side ducting can be used to shift hot switch exhaust air directly into the hot aisle (see Figure 4),

- Server cabinets can maximize the useable rack unit space by vertically orienting patch panels and Power Outlet Units (POUs). An inset structural frame provides patch panel and POU mounting locations next to the servers (see Figure 5), which increases usable rack units within the cabinet to provide an expansion path for future server growth. Bringing connectivity and power outlets to the rack also minimizes cord lengths and reduces cable slack.

- Server densities at rack level also can result in very dense patching environments. The use of angled modular patch panels in racks and cabinets maximizes cabling density by eliminating the need for horizontal cable managers while facilitating proper cable bend radius, enabling 48 copper or fiber optic port connections per rack unit (see Figure 6). High-density angled modular patch panels can be used with high capacity vertical cable managers to deploy and manage thousands of data center links while conserving valuable real estate and maximizing system performance. The modular design of pre-terminated copper and fiber assemblies simplifies the installation of the cabling infrastructure, allowing quick and scalable deployment of permanent links in the data center for reduced total cost of ownership.

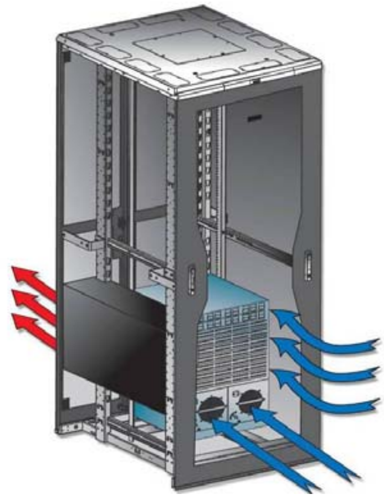


Figure 4. Passive side ducting promotes proper side-to-side airflow through network switches and protecting cables.

Figure 5. POU mounting locations help keep air exhaust pathways behind servers clear to provide maximum airflow and enhance equipment cooling.

Figure 6. *PANDUIT*® *QUICKNET*™ Angled Modular Patch Panels and Cabling Assemblies reduce deployment times and optimize space in dense patching environments.

Physical Infrastructure Management

The use of integrated server and switch architectures promotes a consolidation model which incorporates a defined upgrade path, whether through capacity increases within existing enclosures and patch fields or via straightforward addition of more enclosures, patch panels, racks, and/or cabinets without costly physical migration, cut-over activities, or "rip-and-replace" schemes. Upgrades are made easier with the use of Physical Infrastructure Management (PIM) software and the complementary *PANDUIT*® *PANVIEW iQ*™ System (see Figure 7), which provide real-time monitoring and visibility into dense physical layer connectivity.

PIM systems are designed to increase the speed of configuring consolidated assets and applications, and to identify and resolve problems or security threats in real-time for quick resolution. LC fiber optic and RJ45 copper structured cabling connections can be automatically tracked through the patch field; all other point-to-point physical connections (i.e., InfiniBand, Twinax SFP+) can be manually mapped into the configuration database. By continuously monitoring all patch field connections, a PIM system instantly identifies any interruption or disconnection and immediately notifies a network administrator of the event. These actions help to ensure that any inadvertent disconnections are remedied, minimizing downtime. Likewise, disruptions caused by potential security breaches are instantly identified for quicker response.

Information recorded in the PIM configuration database may be leveraged in several ways. First, the automated documentation of all configuration events can be used to track hardware assets (servers, switches) for commissioning/decommissioning purposes. The data also may be used to meet the reporting requirements of industry regulations or to meet established SLAs, and to provide a "snapshot" of the newly consolidated network to restore connectivity as part of an emergency or disaster recovery measures.

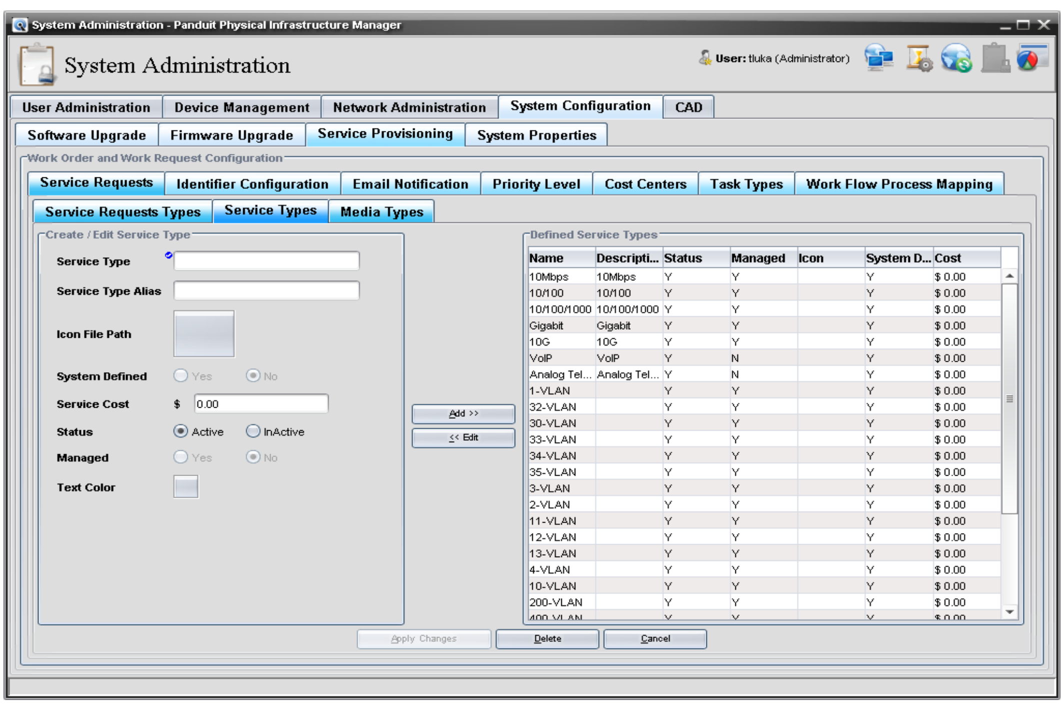


Figure 7. PIM systems optimize a consolidation strategy and improve business agility by achieving better port utilization through superior management of network ports and IT assets.

Conclusion

Successful network consolidation efforts start with the elimination of legacy applications and the adoption of a standardized reference architecture to map the physical infrastructure onto the logical network layer. As a result IT stakeholders manage a simplified, unified infrastructure with fewer adapter cards, cables, and ports, reducing the expense associated with specialist labor and freeing staff for more productive tasks and ultimately reducing operating costs.

- At the level of the data center, consolidation efforts reduce real estate costs and enable increased energy efficiency through more efficient provisioning of power, cooling, and server resources.
- At the network level, viable I/O consolidation is achieved by leveraging virtualization technologies and converged compute/storage ports with a 10 Gb/s copper and fiber infrastructure to reduce total port count and simplify network management.
- Switch- and server-specific cabinets work in conjunction with cable management systems to support thermal management goals and reduce risk of equipment failure in dense consolidated environments.
- Physical infrastructure management (PIM) systems provide on-site and remote management of consolidated networks through intelligent asset identification and tracking of the physical layer.

PANDUIT data center solutions enable server, storage, and data center consolidation with scalable, modular systems that reduce cabling footprint, improve thermal management, and simplify infrastructure complexity for high-density deployments. Innovative physical infrastructure designs based on UPI principles help network stakeholders achieve their goal of reducing IT assets and applications and streamlining management and maintenance tasks to achieve operational cost efficiencies. By mapping consolidated data center and network systems onto a robust physical infrastructure, organizations can mitigate risk across the network to build a smarter, unified business foundation.

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.

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