



# The Value of Storage Virtualization

A WHITE PAPER

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Abstract: "Virtualization" has become a buzzword in technology circles lately, but what exactly it is—and what it is not—have been variously and vaguely defined. This white paper addresses the specific topic of **storage virtualization**. Presented within a context of related issues in storage networking, storage virtualization is defined, its benefits are presented, and its features detailed.

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## What Virtualization Is...and Isn't

### It is...

**Storage virtualization** is the aggregation of multiple physical storage devices (such as RAID arrays, ATA/SATA disks, high speed disks (HSDs), or tape drives) of various interface protocols (such as SCSI, iSCSI, or Fibre Channel) into a single virtual storage pool from which the creation and provisioning of virtual storage volumes, appearing as locally attached logical devices to their host server, can be performed as needed, when needed from a centralized console. An advanced virtualization solution provides IT administrators the freedom of choice to provision the available storage in the virtual pool as SAN and/or NAS volumes.

In plain English: when storage from the virtual pool is allocated to an application server by an administrator at a centralized console, the server is forced into thinking that an actual SCSI storage device has been physically plugged into it. And that's how it appears on the list of devices attached to the server—for example, as a new F or G drive in Microsoft® Windows servers, or a newly mountable physical device in Unix, Linux®, or Solaris®. Virtualization is like a shield that protects application servers from being affected by the heterogeneous (if not out-and-out chaotic) storage world of arrays, mixed disks, storage controllers, NICs, HBAs, tape drives, etc., that is operating behind the scenes.

### It's not...

Storage virtualization is *not* typically considered to be the implementation of hardware mirroring or RAID by a storage device vendor. Nevertheless, some manufacturers are now blurring virtualization with the functionality of their new RAID controllers, which will accept reconfiguration commands from a metadata manager.

It is also *not* typically considered storage virtualization to mask file systems or allow concurrent file sharing across multiple OS platforms, although some manufacturers try to make this claim.

Since “virtualization” is a hot tech industry buzzword, many companies are trying to jump on the bandwagon, or at least not get left behind in the dust. It is, therefore, important for enterprises to do their research before committing to a solution that simply claims to offer virtualization capability. It will avert some expensive disappointments. Furthermore, it's important to recognize that virtualization all by itself is not enough, as is explained just below and throughout this paper.

### It's valuable when...

To be truly valuable, in addition to unifying management of SAN and NAS resources, an advanced storage virtualization solution should come as part of an industrial-strength storage infrastructure package offering maximum freedom of choice in all areas. The complete solution should be based on open standards, making it independent of device vendors and interfaces, connectivity protocols, and operating system (OS) platforms.

Virtualization should be offered in conjunction with cutting-edge storage management features, such as high availability, automatic failover, snapshot, mirroring, replication, and accelerated backup and recovery. Application-specific optimization capabilities should exist, such as the ability to offload host server tasks like replication and backup. Plus, the solution should be reliable, scalable, secure, easy to deploy and use, as well as being cost-effective.

Sound like a tall order? Yes, but it's not impossible. A sophisticated software solution can achieve these results.

## Technology's Magic Pill

### *Virtualization is valuable because it...*

...makes everyone happy. Which equates with a healthy bottom line. For enterprises, the bottom line is that virtualization saves money and helps make money. For systems operators, the benefit is the light at the end of their workload tunnel. And for end-users, the boon is the ability to remain blissfully unaware of what's going on behind the scenes while reliably having someplace to dump their data.

Below is a collection of notable reasons why a superior virtualization solution substantially increases return on investment (ROI) and reduces total cost of ownership (TCO) of the total storage network infrastructure.

### **Reduces managerial and administrative overhead**

Virtualization really makes IT administrators happy. A storage infrastructure that employs virtualization is considerably easier for IT administrators to manage, saving them a great deal of time and effort. Instead of expending huge chunks of time on hardware modifications—physically attaching, moving around, and configuring devices—they can effortlessly assign, unassign, or reassign virtual volumes from a central location. Not only does this leave administrators with more time to do all of the other things on their plate, it saves enterprises resources as fewer IT staff are needed to manage much larger amounts of storage.

### **Lowers investment in human resources**

Gartner Research reports that without virtualization, one person is able to manage only up to 300GB of data; in a well-executed virtualized environment, however, the amount one person can manage jumps to 2+TB(!) Without virtualization, the long-term cost of managing and maintaining traditional data storage infrastructure can radically outweigh the cost of acquiring and installing storage. Moreover, even in today's tighter economic environment, analysts calculate that the available pool of qualified personnel is insufficient to address the anticipated massive surge in storage demand. The sheer volume of storage managed per person will continue to grow at a rate that many organizations have difficulty keeping up with unless they implement a virtualization solution. Storage virtualization helps alleviate these imbalances by simplifying storage management, which translates directly into lower staffing requirements.

### **Enables interoperability with storage hardware**

Another key benefit of virtualization is interoperability. Masking the complexity of various vendors' storage solutions ideally creates an environment where every disk subsystem appears the same to the host server. The actual disk subsystem behind the virtual image can be anything. In a virtualized storage architecture, enterprises can purchase their storage knowing that it can just be plugged in to start working, without complex and time consuming configurations—or a total lack of interoperability—thus significantly decreasing their investment and increasing financial return.

Virtualization can keep enterprises immune to becoming captive to a specific vendor or proprietary technology and the higher initial and recurring costs that this tends to involve. Because virtualized storage is agnostic with respect to vendors and technology, IT administrators are given the freedom to choose the best solution for their organization. This also encourages healthy competition in the storage appliance industry, bringing added benefits over time in the form of technological advances and fine-tunings.

### **Enables efficient allocation of storage resources**

Since virtual volumes can span across multiple physical device boundaries, a virtualized storage environment maximizes storage utilization, helping to avoid idle or unused storage space. Administrators can allocate more storage where it's being used or is almost used up, and less storage where it's not needed. This prevents the common practice of over-allocating storage in an attempt to prevent running out of space, or the equally common under-allocation—and its associated panicked race to buy and install more storage. Virtualization enables administrators to respond *immediately*, rationally, to changing storage needs. In advanced solutions, the response can even be instant—the system can be configured

to monitor itself and add storage capacity automatically when pre-defined thresholds are reached. All of this opens the way for future storage purchases to be chosen from a plethora of available solutions, resulting in better price and capabilities. A practical virtualization solution likewise ensures that all existing and future storage capacities can be fully integrated, realized, and presented in a simple manner and managed with ease as a single virtual volume.

### **Allows easy, effective management of storage network/devices**

A virtualized approach makes it much easier to add and maintain storage devices. An advanced solution applies an intuitive Graphical User Interface (GUI) to visualize storage and then assign and manipulate it as needed. Furthermore, dynamic modification of access permissions to virtual volumes can be performed on the fly. Online and transparent migration of storage devices allows maintenance and upgrade of storage devices without shutting down applications.

### **Supports remote data access, backup, mirroring, replication**

A value-adding storage virtualization solution also enables IT administrators to create backups and mirror space on disks configured virtually anywhere in a system, or across IP networks. It enables disaster recovery services such as replication of data across IP to a remote site and rapid data and system recovery services such as bare metal recovery and online/nearline disk-based backups. This not only eases administration for the local SAN managers, since they can remain at their central location, but also benefits the entire enterprise, since it makes critical data inexpensively available outside a geographically local area. And, of course, it ensures that a business can continue operating in the event of damage or loss of a primary data set.

### **Ensures business continuity**

Virtualization allows for rapid storage growth and reconfiguration, without the downtime that expansion usually entails. This is a vital advantage for today's enterprises, which are increasingly running in fast-paced 24x7x365 mode. Volumes of storage can be allocated to application servers on the fly, without interrupting operation.

In order to truly assure business continuity, an advanced virtualization solution should make it possible to safeguard against all possible single points of failure on storage devices, server hardware, networking hardware, and even complete site failure due to disaster. In an age when businesses can't operate without access to their data, less downtime and disaster protection translate into higher returns for enterprises.

To guard against failure of storage systems, the solution should enable mirroring of virtual drives, and not just within cabinets but also across cabinets, even if they are made by different vendors, and across any distance. To defend against server hardware failure, an advanced virtualization solution should support high availability configurations, enabling full redundancy throughout the entire data path so that there is no single point of failure. To protect against site failure from a variety of disasters, the solution should support remote replication of virtual drives to keep an extra set of data off-site.

### **Facilitates fast data access**

For all intents and purposes, a virtualized volume mimics an actual physical device. However, *a superior virtualization solution succeeds at generating virtual drives that far surpass their physical cousins in speed and functionality.* In this way, virtualization can significantly improve the performance of a storage network. This is crucial, as speedy access to data is a critical benchmark for modern enterprises whose customers want products fast and demand answers *now.*

Virtualization, in combination with other functionalities, can be particularly beneficial when performing tape backups. Virtual volumes can be staged on disks and later backed up to tapes, thus offloading I/O and processing cycles from the application server. For example, by leveraging IPStor software's delta-based snapshot techniques and/or FalconStor's virtual tape technology, *truly* LAN-free/server-less/windowless backups become a reality.

## Benefits summary

Virtualization greatly enhances the capabilities of storage administrators, whose ability to manage storage with a comprehensive virtualization and storage services toolset significantly drives down storage administration costs. A storage virtualization solution eases the task and cost of storage capacity planning. It allows usage of heterogeneous storage, empowering enterprises to leverage their current infrastructure and to make future purchases based on the best choices available rather than being tied to homogeneous proprietary storage offerings.

Virtualization makes the implementation of enterprise-wide storage management a dream come true. It can provide enterprise-wide manageability, allowing storage systems to be constantly available and scalable to meet future needs. It allows easy storage space reallocation with minimal impact to application servers, diminishing downtime and allowing enterprises to do business at optimum intensity, 24x7. Virtualization is also fundamental to enabling business continuity functionality, such as mirroring and remote backup.

With proper implementation, storage virtualization can yield tremendous cost savings and other vital benefits to today's enterprises.

## The Case for Virtualization

### The wild, wild world of SAN and NAS

In response to the need to warehouse and manage the ever-flourishing jungles of mission critical data, many enterprises have either already implemented a Storage Area Network (SAN) or are considering doing so. The caveat: there is a high degree of complexity inherent in the implementation and subsequent maintenance of a typical SAN solution. There are a variety of reasons for this. The point to remember is that even though basic storage devices may be getting cheaper, **complexity is expensive**.

Another challenge to the designing of a storage network is posed by the existence of Network Attached Storage (NAS) as a storage alternative. Which does a company choose, a SAN or NAS? Both? Each addresses a different need and exercises a different approach to storage management. Though the advantages and disadvantages of SANs and NAS are still debated in technology circles and by vendors, the fact is that both are needed in corporate data centers.

Complicating matters further, the original separation of abilities between SANs and NAS, such as block level access and file level access, respectively, is becoming blurred as the capabilities of storage appliances continue to be enhanced. As a result, an enterprise may invest a tremendous amount in one solution, only to find that another solution might have been better in some way, e.g., more versatile. Only by then it's too late: resources have already been spent. Furthermore, a chosen solution is likely to be incapable of being integrated with any other solution. In these ways, enterprises often find themselves locked into one vendor's proprietary solution, which may be less appropriate to their needs, less technologically advanced, and more expensive than an alternative solution. Or they end up with several different storage solutions that need to be managed separately, requiring more of storage administrators' already limited time and requiring that IT staff have first-hand knowledge of several different devices and modes of connectivity.

One thing is certain: SAN and NAS storage solutions are usually costly and complex to design, implement, and integrate. In addition to these factors, the continual investment in maintaining such solutions once they have been implemented is substantial. This is because for each vendor's specific solution, specialized technical knowledge is required to manage it and future expansion necessitates the purchase of proprietary storage appliances and use of the same method of connectivity, even if alternative methods have developed. These factors have generated a huge demand for a method of managing multiple storage solutions that not only has a unifying and simplifying effect on storage management, but is more cost effective over the long term, as well.

Another factor to bear in mind: mergers, acquisitions, and partnerships today typify the dynamic nature of business. Crucial to the success of such endeavors is the ability to quickly initiate and consistently sustain fast-paced sharing of data, often across corporate-wide computing environments that are national or international in scale. The notion of a single island of storage only available to specific, geographically local departments is rapidly becoming obsolete in today's eBusiness environment. It is imperative, therefore, that whatever other useful features a storage solution may provide, it must above all else do so *without slowing down or in any way impeding the sharing of data*. In fact, a solution that speeds up the consolidation and movement of data is certainly at the top of every enterprise's wish list.

**Simpler is cheaper.** How to simplify and speed up both storage provisioning and data access *and* reduce costs? Virtualization. Use a virtualization solution that is capable of unifying SAN and NAS provisioning and management under one umbrella, one that's straightforward to implement and use. The key is to implement a solution that delivers all the benefits of virtualization *while reducing administrative overhead*, instead of introducing new policies, procedures, and fancy (expensive) devices.

## Buyer Beware

### Virtualization alone doesn't cut it...

Virtualization has emerged as the answer to everyone's wishes. But what good is a functionality unless it comes wrapped in a comprehensive high-performance package? Not much good at all. Virtualization is not all it's cracked up to be without the proper framework.

It is not enough to simply enable a virtualization process. The true value of virtualization can only be realized within a full-featured future-proof storage solution that leverages current IT infrastructure and provides not just virtualization but top performance (fast data storage and access), ease of use, *unified SAN and NAS management*, seamless and simple integration of host-based systems (i.e. servers with direct-attached storage, a.k.a. DAS), virtualization across cabinets (not just within one storage cabinet), and seamless support of heterogeneous storage environments. This can only be achieved with a solution that offers **total freedom of choice** in device vendors, interfaces, connectivity, platforms, and protocols.

### Criteria for choosing a virtualization solution

Tip: if a solution can't leverage an enterprise's current network infrastructure and IT staff's knowledge, doesn't enable the seamless integration of a heterogeneous storage environment, doesn't have the ability to provision storage resources as SAN and/or NAS, and can't integrate machines that have DAS (which most organizations still have around), it's probably time to look for something else.

The key is to find a solution that enables virtualization within a unified mechanism, while simultaneously facilitating rapid sharing of stored data, *and* maximizing ROI on current and future infrastructure purchases. In this matter, not all storage solutions are created equal. The storage market warrants a highly sophisticated, high performance, vendor-neutral solution that works with all management tools, reporting utilities, and maintenance procedures.

Selection criteria for a vendor's virtualization solution should include performance, scalability, high availability, and the cost of installation and maintenance. Additional concerns include ease-of-use and the manufacturer's or vendor's plans for the future (i.e., their support of emerging standards). Solutions that preclude those in charge of the IT treasure chest from making a more cost-effective decision in the future, or limit them to a proprietary technology, introduce heavy overhead. This is undesirable in an ever-changing market.

The real challenge in setting selection criteria is figuring out what an enterprise's business-specific needs are. Factors such as bandwidth, response time, and required physical connections must be determined. Available support staff and technical competency also play critical roles.

At the same time that many companies are struggling to disentangle themselves from proprietary vendor-specific environments, many IT professionals have come to the realization that true virtualization enables the recognition and control of many different vendor's storage devices.

When selecting a **virtualization** solution, enterprises must choose the solution that offers the **most value** to their organization. This, unfortunately, is not always apparent. Virtualization solutions on the market today focus almost solely on the presentation of multiple physical devices to the host servers as logical virtual volumes. The two additional facets that create a truly comprehensive solution should not be overlooked: **connectivity** and **application optimization**. As was explained earlier, freedom of connectivity allows for the integration of storage devices and free expansion of the storage network. Application optimization allows for the offloading of host server tasks like snapshot and backup for faster data throughput.

**Questions to ask** before selecting a solution include:

- Is the solution a hardware and software solution that will require extensive matrix testing across all equipment?
- If a hardware solution, what industry support is there for such hardware?
- Does it require a "black box" which is based upon a proprietary, vendor specific operating system?

Formerly, virtualization was thought of as functioning only within a Fibre Channel SAN. Today's business needs dictate that *storage be dynamically assessable not only intra-SAN, but also inter-SAN*. A comprehensive virtualization solution should also include the ability to connect virtualized volumes across *IP as well as Fibre Channel*. The solution should also allow the seamless incorporation and management of NAS devices. This is usually the point of demarcation for most virtualization solutions on the market today. They provide virtualization intra-SAN only and do not accommodate NAS devices. This negates one of the most important aspects of storage virtualization: *presentation of storage and data outside the SAN*.

## **FalconStor's IPStor® Software Rises to the Challenge**

### **Zoom...**

While bearing the aforementioned concerns in mind, a close look at the performance capabilities of The FalconStor® IPStor® software solution puts everything in focus. IPStor not only cuts costs by optimizing usage and management of the storage the hardware an enterprise already has, it improves performance, too. A 'zero-memory-copy' algorithm passes data through the IPStor appliance with minimal processing and without reliance on caching data in memory, to the point that practical benchmark tests show better performance through IPStor than directly attaching storage to each server.

For boundless scalability, IPStor software's architecture specifically allows for a large cluster of IPStor appliances to jointly work together to service a virtually unlimited number of application servers and storage elements at optimal performance.

Moreover, for business whose existing IT infrastructures contain storage devices whose data is mandated to remain *unvirtualized*, IPStor offers a unique *Storage Service Enabler* option which allows these machines to be incorporated seamlessly into an IPStor-managed storage network without being virtualized (as service-enabled devices (SEDs). SEDs can take immediately take advantage of all of IPStor business continuity and disaster recovery services.

### **Lowering costs is the name of the game**

In order to extend SAN connectivity, a device is needed to serve as the bridge between a distance-limited Fibre Channel network and the boundless IP-based network. While certain solutions on the market today can extend the distance limitations imposed by Fibre Channel, they are costly and complicated both to implement and to maintain.

There is a cost-effective and simple alternative: IPStor software, which fully supports intra- and inter-SAN connectivity across IP via the iSCSI standard. IPStor software leverages the ubiquitous IP infrastructure, allowing for standard networking devices to be utilized for presentation of the virtual volumes derived from the SAN storage to a wide community of application servers. It also allows the management of these virtual volumes by a *readily available pool of IP-familiar personnel*.

**With IPStor software, all of the potential cost-savings introduced by the implementation of a virtualization solution are realized.** In particular, the savings are staggering in terms of lower managerial and administrative overhead. In an IPStor-virtualized environment, FalconStor's IPStor storage infrastructure software applies an intuitive Java-based Graphical User Interface (GUI) to visualize storage and then assign and manipulate it as necessary; one administrator can potentially manage an infinite amount of data with ease, instead of the 300GB max imposed by a non-virtualized setting.

Furthermore, dynamic modification of access permissions to virtual volumes can be performed *on the fly* with IPStor. Online and transparent migration of storage devices allows maintenance and upgrade of storage devices *without shutting down applications*. And less downtime equals higher returns for enterprises.

### Access security gets a boost with IPStor

Even when the focus is intra-SAN only, IPStor still has specific advantages.

The problem: In order to accomplish such tasks as flow analysis and snapshot, some metadata solutions must insert themselves into the data path. In short, they pop in-band and out-of-band. These metadata servers must also interface with the Fibre Channel switches in order to properly map paths between the application server(s) and the storage devices. This is accomplished by either standardizing on a specific switch manufacturer (in essence becoming homogenous), or turning off all zoning and LUN masking in the switch. Turning off zoning and LUN masking at the switch opens up a security issue with Fibre Channel. Many low-level utilities can then potentially scan all attached storage since it is now open through the switch.

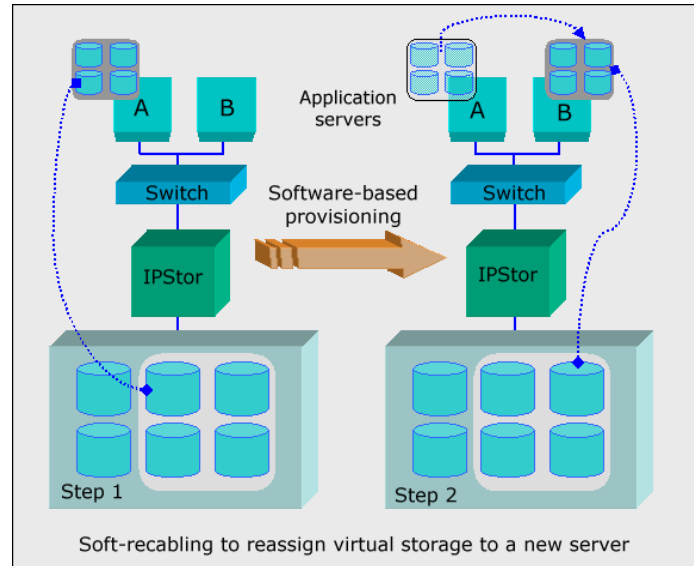
True security cannot be realized unless there is end-to-end intelligence. Some metadata solutions accomplish this by dictating that intelligent adapters be installed in both the servers and storage devices. This is intrusive and often results in a large compatibility test matrix.

The solution: when the IPStor appliance is located between the host application server(s) and the storage devices, true end-to-end intelligence and complete security can be maintained. Low-level scan utilities are prevented from spoofing storage devices. Public Key Infrastructure (PKI) is also used to maintain host server security. A shared secret key is established when a host server is configured and attached to a virtual volume. This ensures that only that particular client can access its corresponding virtual volume assignments.

Security-conscious users can also appreciate FalconStor's commitment to furnishing cutting-edge access security. IPStor provides **strict built-in authorization policies** to ensure that unauthorized users do not gain access to storage resources on an IPStor storage network. Security for the management console is the same for all connectivity types. IPStor's Java-based console provides **centralized access control** to the storage network, possible as a result of the aggregation and virtualization of storage resources. Only an authenticated administrator is permitted to manage physical devices, create and manage virtual drives, define storage management policies, perform end-to-end diagnostics, and generate reports. IPStor is also the industry's only storage solution to utilize a **key-based authentication** process to create a supplementary shield against snooping and spoofing.

## Soft re-cabling

IPStor's virtualized storage model also allows for **soft re-cabling** of hosts: the ability to logically re-deploy storage from one host to another *without moving any physical cables*. All re-assignments are handled by the software, with simple point and click functionality. For example, an existing data set residing on virtual storage can be switched from a test server to a production server *in seconds* via software reassignment. IPStor's methodology is far simpler than the complex Fibre Channel switch reconfigurations and zoning topologies usually understood as soft re-cabling.



**Figure 1. IPStor-managed soft re-cabling greatly simplifies storage administration by providing a software-only means to move storage from one server to another**

## High availability

High availability is also high on the wish list of enterprises. By implementing the Failover option, IPStor can be deployed in a two-node, symmetric or asymmetric cluster configuration, where two IPStor appliances are configured to monitor each other's health. Should one fail, the other automatically assumes the failed appliance's workload. The DynaPath<sup>®</sup> option maintains consistent connectivity between application servers and the IPStor appliances via sophisticated multipathing and load balancing mechanisms. These are a few of the integral parts of the IPStor advanced virtualization solution's robust support of high availability configurations, with **full redundancy throughout the entire data path** so that there is no single point of failure. Mirroring can also be set up between the clustered IPStor appliances and their attached storage devices. This results in a highly redundant virtual storage solution with 24x7 availability.

## Total freedom of choice

FalconStor's IPStor storage infrastructure software offers **total freedom of choice** in device vendors, interfaces, connectivity, platforms, and protocols. Enterprises are empowered to virtualize across drive, cabinet, protocol, and vendor boundaries with just-in-time (**Capacity-On-Demand™**) space management.

IPStor is **platform independent**. The IPStor software itself runs on either a standard SUSE Linux server (which means that its platform is open and has substantial and growing support from the technology industry) or on a Sun Solaris platform. IPStor is not based upon any proprietary operating system, as do the "black box" solutions on the market today. Future expandability and additional functionality therefore

remain open. Furthermore, IPStor integrates with Windows 2000, Windows 2003, Windows NT, Solaris, Caldera<sup>®</sup>, Redhat<sup>®</sup>, HP-UX<sup>®</sup>, IBM<sup>®</sup> AIX<sup>®</sup>, and Tru64<sup>®</sup>, and is continually being developed to support even more client server OS possibilities. When using Fibre Channel without the optional IPStor Client, IPStor supports any OS, such as Macintosh<sup>®</sup> and NetWare<sup>®</sup>.

IPStor is **connectivity protocol independent**. It robustly and natively supports Fibre Channel (intra- and inter-Fibre Channel SAN), IP, iSCSI, CIFS, NFS, HTTPS, and emerging standards such as Infiniband.

IPStor is **vendor neutral and interface independent** with respect to storage devices. It fully supports and makes sense of heterogeneous storage environments. As noted earlier, storage devices have different performance characteristics. IPStor incorporates a feature that reports a device's throughput capabilities so that proper grouping of storage devices into virtual volumes can be achieved. Statistical analysis of data flow can then be routinely monitored for saturation and capacity planning. IPStor generates a storage pool to which physical storage can be added without affecting the existing logical allocation of resources.

Once virtual volumes are created by a storage administrator, read/write permissions can be applied and assignments of **SAN and/or NAS** resources can be made to the appropriate hosts. Volumes can also be dynamically added, removed, mirrored, and the permissions can be altered.

Since permission is given at the *volume level*, **file formats are no longer an issue**. That is left to client operating systems to manage. Complementary with other vendors' file management solutions, IPStor does not interfere with file system access.

## **An Industrial Powered Virtualization Solution**

A sophisticated virtualization solution can yield tremendous value for an enterprise, playing a major role in business continuity, increased return on investment (ROI), and lower total cost of ownership (TCO) of storage infrastructure. However, it cannot accomplish this without being a part of a complete, open, high-performance storage infrastructure solution that also offers excellent data security. Unlike a purely hardware solution, a software solution can accomplish the requisite level of flexibility and feature-richness, especially if it is highly advanced software and based on open standards.

IPStor software meets and exceeds these criteria. FalconStor's innovative enterprise data protection and storage network infrastructure software is a proven top-performance solution that includes **virtualization** functionality in an **easy-to-use** package combining **speed, security, reliability, interoperability, and scalability**—while enabling all the **latest data management features** and **performance enhancers**.

Mission-critical IPStor storage services include:

- **Continuous Data Protection (CDP), TimeMark<sup>®</sup> point-in-time (PiT) snapshot, Synchronous & Asynchronous Mirroring, and Adaptive Remote Replication** provide rapid data recovery for nonstop business continuity and reliable disaster recovery functionality.
- Application-aware **FalconStor Snapshot Agents** minimize quiesce time during backups and other snapshot-based operations (TimeMark, Replication, CDP, etc.) and *ensure transactional integrity/consistency* of databases and message stores for *fast time-to-recovery*. Available for IBM<sup>®</sup> DB2<sup>®</sup> UDB, Informix<sup>®</sup>, Microsoft<sup>®</sup> SQL Server, Oracle<sup>®</sup>, Pervasive.SQL<sup>®</sup>, Sybase<sup>®</sup>, IBM Lotus Notes<sup>®</sup>/Domino, Microsoft Exchange, Microsoft VSS, Novell<sup>®</sup> GroupWise<sup>®</sup>, and many file systems.
- Storage provisioning occurs in a just-in-time fashion with IPStor's **Capacity-on-Demand (COD)** capability. COD monitors disk space consumption at the application appliance and proactively ensures constant availability of storage to sustain business operations. COD can free up disk space by compressing infrequently used files and/or relocating them to an overflow storage pool. If necessary, COD can expand the file system to meet the storage needs of the application in real time, without user intervention.

- **DynaPath** maximizes data availability for IPStor storage systems and provides peak performance across the SAN, performing Fibre Channel and iSCSI HBA load-balancing and delivering transparent failover, and fail-back services that creating parallel active storage paths that transparently reroute server traffic without interruption in the event of a storage network problem.
- **ZeroImpact Backup** and **HyperTrac Backup** options, plus tight integration with FalconStor's industry-leading **VirtualTape Library** solution, eliminate the backup window and render backups highly reliable and efficient.

IPStor offers enterprises the **total freedom of choice** necessary to maximize utilization of their current IT infrastructure, allowing them to leverage what they have now as needs and opportunities for expansion develop. IPStor is based upon a non-proprietary operating system that is open and allows for not only storage virtualization, but also storage over IP (via the industry standard iSCSI) or Fibre Channel. It allows for application optimization, as well, such as the offloading of host server tasks such as replication and backup. To ensure that IPStor remains future-proof, FalconStor's developers are committed to staying on top of and integrating advanced technologies, such as Infiniband.

The proven and flexible IPStor virtualization solution brings tremendous value to enterprises in an increasingly network-centric and data-centric market. It is also an immensely practical and commonsense partner to virtual machine solutions that virtualize and consolidate servers, such as VMware®. In addition to the cost savings it generates as a result of its deployment, IPStor is also cost-effective to deploy.

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