

HIGHLIGHTS

- Performance Troubleshooting Tips
- Heterogeneous DR and Cloning
- Exclusive Early Access:
Performance Management Report (pdf)
VMware ESX 3.0 Best Practices (pdf)
NetApp SE Training Preso: TDPS

The Future of Storage

Dave Hitz, Founder and Executive VP, NetApp

Dave's take on recent storage innovations that have the potential to cause radical changes in the data center.



[More :-](#)

BLOGGING WITH DAVE

Dave Hitz, NetApp Founder and EVP

"If your boss won't buy hardware to experiment with, simulate NetApp storage on Linux®."

• [Dave's Blog](#)

DRILL DOWN

- **FAS3070/V3070 Overview**
A five-minute intro to the newest NetApp midrange SAN option, the 250TB FAS3070.
- **Disk-to-Disk Backup and Recovery: A Global Customer Analysis**
An online virtual trade show.
- **All-in-One Research Guide: SAN**
Expert Q&As, SAN management tips, and info on connectivity and switches.



FEATURED WEBCAST

Simplifying, Scaling, and Streamlining Storage for Exchange Server 2007

ADMIN RESOURCES

- **End-User Review: NTOP**
How one sysadmin uses (and customizes!) NTOP, which combines IP and non-IP traffic for a complete view of network activity.
- **Best Practices: NetApp & VMware ESX with FC, iSCSI, and NFS «Early Access»**
Backup/recovery and thin provisioning options plus a sample hot backup script.

TIPS FROM THE TRENCHES

Six Ways to Minimize Storage Risk

Gary Ono, Strategic Support Manager, NetApp

Even the most savvy IT teams sometimes leave themselves at risk. Are you exposed? Plus, tools for tracking and evaluating bugs and user reviews of five free online monitoring tools.

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Monitor, Troubleshoot, and Improve NetApp Storage Performance

Akshay Bhargava and Mukesh Nigam, Product Engineers, NetApp

Early access to a new 30-page guide to NetApp storage performance management plus practical advice on:

- Storage performance metrics
- A troubleshooting methodology
- Alternatives to system upgrades



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ENGINEERING TALK

Disaster Recovery and Cloning for Heterogeneous Environments

Troy Eberlein, Director of Product Management, NetApp

Working with multiple storage vendors? NetApp TDPS enables an integrated DR and cloning strategy across your entire IT infrastructure.



This technical training session details how TDPS replicates block-level data independent of the underlying server, storage type, or storage interconnect.

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[FEEDBACK](#)



DAVE HITZ

Founder and Executive Vice President, NetApp

As executive vice president, Dave is responsible for the future strategy and direction of Network Appliance. He and James Lau founded Network Appliance in 1992 with a desire to simplify storage the way Cisco simplified networking. Hitz previously worked as a senior engineer at Auspex Corporation and in engineering roles at MIPS Computer. Before starting his career in the computer industry, Dave worked as a cowboy, getting valuable management experience while herding and branding cattle.

The Future of Storage

Podcast transcript: Q&A with Dave Hitz

In a recent NetApp TechTalk podcast, Elisa Steele, NetApp VP of Worldwide Integrated Marketing, asked Dave Hitz about the images materializing in his technology crystal ball. The full interview transcript is available only from Tech OnTap.

Elisa: Dave, what do you think has been the single biggest innovation in storage the last few years?

Dave: I don't think I'd narrow it down to a single innovation, but I'll give you an area. I think the most interesting area has been virtualization. Virtualization really is "How do you take a bunch of stuff and make it look like something different?"

How do you take a storage system with hundreds of disk drives—or in some cases over a thousand—and get rid of having to deal with all of those disk drives? What if you have a thousand disk drives and don't want to deal with "this data goes on this disk drive" or "this data goes on that disk drive" or "how much room is left here" or "how much room is left there?"

That's really what we've done in the Data ONTAP 7G software release, which includes features around virtualization like NetApp FlexVol™ and FlexClone™ technologies. All of these features involve virtualization, and to me they represent the most interesting recent innovation.

Elisa: Let's dive into that. Everybody's talking about virtualization. What's your take on what that really means?

Dave: Virtualization is when you've got one thing and you wish it was something else. Here's an example of virtualization. I wish I had a private wire for my house that I could do my work over. But I don't have a private wire, and I can't afford it because my house is too far away. But I do have the Internet, and using the combination of encryption and tunneling I can build myself a virtual private network. That's virtual.

There are two areas in storage virtualization that I think are especially interesting. The one I think that has been the biggest leap and has had the biggest impact for customers over the past few years has been the question of how I can take all of these disk drives and turn them into virtual pools that I can manage in more convenient ways. The second one that's a really interesting NetApp innovation is all the virtualization we're doing across systems. That's the work that we're doing with Data ONTAP 10G,

TechTalk Podcast Interviews with Dave Hitz

- [The Future of Storage](#)
- [Technologies That Shape Consumer Experience](#)
- [Public Policy and Technology Solutions Address Data Breaches](#)
- [When It Makes Sense to Be an Early Adopter](#)

RELATED INFORMATION

- [Examining the Future: Trends in Storage Technology Adoption](#)
- [Data ONTAP® 7G overview](#)
- [Data Center Proven Webcast series](#)
- [NetApp Podcast library](#)

Dave's Blog

According to Dave, "A big part of my job is listening to smart people who know about storage, digesting what they say and reflecting on it, and then turning that into my own opinion. Then when I share my thoughts, they get distributed randomly to whoever I happen to be talking to. So why am I doing a blog? I figured that if I'm going to be having ideas and sharing them, I might as well collect them in one place."

Dave might call his blogs a mere collection of opinions, but we prefer to think of them as glimpses of genius with a touch of cowboy humor.

Here are some of our favorites from among his recent posts:

- [Thinking Out Loud—10 Years of Vision, from IPO to Fortune 1000](#)
- [Follow-Up on VMware: Both Better and Worse Than I Described](#)
- [Booth Duty at Oracle® Open World: FlexClone Is the Big Hit](#)
- [Simulate NetApp Storage on Linux® \(My Boss Won't Buy Hardware for Me to Play\)](#)

which is the result of the Spinnaker acquisition that we made a few years ago.

Elisa: So virtualization is one of those areas that is really changing the landscape in the data center and how you manage things. What are some of the other fundamental shifts that you see happening in the data center today?

Dave: When I look at corporate data centers, the thing that's most interesting to me about the way that people are changing them is what's going on with VMware. I keep talking to customers who are telling me that they've taken 50 servers and packed them into two or three. One customer that I've talked with took 500 servers and reduced them to 25 with VMware. If you just think of the power savings, the money savings, and the physical space savings in the data center, it's absolutely amazing.

The reason this is so interesting to me from a Network Appliance perspective is that once you virtualize your servers, you have to figure out what to do about the storage. If you have virtualized servers in the front end that can be provisioned quickly, you'd better have storage in the back end that's also virtual and can be quickly provisioned. So NetApp and VMware are a very nice combination. That feels like a radical change in data centers to me.

Elisa: How do you think that's impacting how we're deploying business applications in the data center? What are some of the fundamental shifts you see in the way that storage architectures are being developed to support these massive applications?

Dave: Step back and look at the very top-level issues that IT people have. They're always worried about the stuff working and basic availability. If that doesn't happen, then nothing else matters. Given that it'll basically work, they'd like to drive the cost down—never bad to save money. But another big issue that's important is "How fast can I respond if a new business opportunity comes up or I need to deploy a new application?"

From a storage professional's point of view, a customer comes in and says, "Look, I need a new server and I need some storage to go with it. How quickly can I get that?" I think it's all about business agility. When you look at business applications especially, it's all about responding to some problem.

Elisa: Before we move on to other topics, I don't want to miss asking you about other potentially disruptive technologies like iSCSI. What exactly is happening with iSCSI that you think is disruptive and what's the impact going to be on the market?

Dave: If you look at the storage industry big picture, you see that over the past 10 or 15 years the big, big trend has been migrating from direct-attached storage to various forms of storage over a network, either a Fibre Channel network or an Ethernet network, SAN or NAS.

The most interesting thing about that transition is that at the low end we still have so much direct-attached storage. If you look at IDC data for the price bands above \$150,000, almost all of the storage these days is attached to some kind of network, typically Fibre Channel in the very most expensive systems. If you look at the lower price bands below \$50,000 or \$15,000, a very high percentage of storage is still direct attached, often sitting right inside servers.

So where does iSCSI come in? I think iSCSI is going to enable the conversion of the rest of that storage. It's kind of like SAN for the rest of us. You know, that was Apple's model at one point. And I think what iSCSI is going to do is let small and medium businesses and also the stranded servers in large corporations get all of the benefits that large businesses have been getting out of SAN at a price point and a management complexity point that work for them.

Elisa: Are there other disruptive areas or technologies that you think are really changing the landscape in the data center?

"When I look at corporate data centers, the thing that's most interesting to me about the way people are changing them is what's going on with VMware."

Data Center Proven Webcast Series

In this three-part TechTalk series, customers, analysts, and NetApp experts discuss best practices in data center design and management.

- [Part I: Building an Effective Data Center](#)
- [Part II: Effective Data/Storage Manageability](#)
- [Part III: Effective Business Application Management](#)

The Future of Storage

Like any technology, storage adoption generally moves in waves. New technologies emerge in response to the limitations and challenges of existing technology, while other technologies mature and move into decline.

In June, NetApp founder and EVP Dave Hitz outlined his predictions for the next 20+ years of storage technology evolution.



Don't miss [Examining the Future](#).

Dave: One other disruption that I'd say is pretty interesting is what's going on with encryption these days. When people think about the challenges they face with their data, one of the big challenges is that more and more of the data holds important information about somebody, not just company stuff or engineering schematics or abstract stuff. It's Dave's medical records or Dave's personal e-mail.

As soon as you start getting into personal data that means something to people, it raises questions of corporate responsibility. And so I think encryption is going to become much, much more important over the next few years as people grapple with what it means to have such personal data on disk drives.

Elisa: Talk about the disk drive itself. What's happening there?

Dave: One of the most interesting things going on in disk drive technology is the shift from Fibre Channel to ATA drives. Or I should be more explicit when I say "shift." I don't see Fibre Channel disk drives going away any time soon. For high-end enterprise applications that require both the highest performance and the highest reliability, Fibre Channel drives are what people should be using.

But ATA drives create a really interesting opportunity for people to do a couple of things. The first is to save money in situations in which they don't need the absolute highest performance. We've got a lot of people starting to run pretty high-end apps—Exchange, database apps, etc.—using ATA drives, which are a lot less expensive, and just saying, "Hey, I don't need the highest performance here."

ATA drives are so much less expensive than Fibre Channel that people are really starting to think, "Instead of sending all my data to tape immediately, I could just keep it on spinning media for quite a while." That allows you to use the data that would have been backup data in much more interesting ways. You can use it for legal discovery, you can do restores from it more quickly than if you were going to tape, or you can just search around to find stuff that might have been there.

So that whole zone of backup is turning into something more complicated around long-term retention and archival and data that's just convenient to have spinning instead of data on tape. The low price of ATA is really enabling people to think about wholly different ways they can manage their data long term and continue to get value out of it.

Elisa: We can't let you go without talking about storage grids. We did a podcast on storage grids and folks keep talking about it. We'd love to hear your take on the grid future for storage.

Dave: Grid is one of those words like virtualization that has such a broad meaning that it's hard to get your arms around it. I think the most interesting way to think about storage grids is to ask, "What's it for?" Storage grids are to sit behind application grids.

The best way to start is to think about what's going on with grid computing, from the server side, the compute side, and then we can talk about what kind of storage capabilities would be required to satisfy that. If you look at grid computing, there's grid computing for technical applications and there's grid computing for business applications.

I look at those two completely differently, and here's the reason. For technical computing, grid computing is not new and it's not revolutionary. It is the default standard way that people solve these problems. If you look at any environment in which people are doing technical computing—I'm thinking of chip design or software development or even high-end scientific apps like seismic processing or Hollywood movie animation—you will find hundreds if not thousands of nodes of Linux®, sometimes Windows®, just crunching away on the same problem. The kinds of issues that you face there are how to get a storage infrastructure that can serve that many hundreds or thousands of Linux back ends. A lot of the work we've been doing with people in those industries has been work to satisfy that technical grid. When I say it's not revolutionary, it's not that it's not innovative. It's just work that's finished. If you're doing that kind of work and you're not using grid computing, then you really ought to be checking into why you are different and why you couldn't be taking advantage of this stuff.

So what's the idea of business grid computing? The big drivers of business grid

benefits that the tech guys are getting?" Instead of buying super-expensive computers, the tech guys are saying, "I'm just going to buy cheap PCs and run my big stuff there." I think Oracle and SAP have been asking, "Well, why can't we run our stuff on those cheap PCs, too, and somehow make the whole environment good enough to work well?" The issues there are somewhat different from the issues in technical grids. In technical grids it's all about boatloads of CPU and how you can run the same problem on a thousand Linux computers. When you look at business grids, typically they're much smaller.

For most folks I think the real benefit of business grids is the reduction of complexity. Instead of having a few hundred separate machines running all of this stuff, they can grid it down and get their arms around it.

Elisa: Do you have any final words of advice for people trying to simplify all of this in the data center?

Dave: These are complicated applications. In the end I don't think there's going to be any super-simple way to look at them. The question you should be asking, though, is how do you build an infrastructure in your data center that as easily as possible allows you to deploy these things and manage them.

The kind of tools that are going to help, tools of virtualization like VMware or Microsoft Virtual Server, are tools that'll let you deploy a new server more quickly and create the CPU environment to run your applications more flexibly.

Once you've done that on the server side you're going to be asking questions about the storage behind it, and that'll lead you straight to questions of cloning, of thin provisioning, of can you get access over both Ethernet and Fibre Channel. It's going to be complicated, but the more flexible the solutions you have, if they've got virtualization in them to give you more choices of how you deploy them, those are the kinds of things to be looking for.

Top Podcasts of 2006

Grid computing and iSCSI took top billing in our countdown of the most popular podcasts of 2006. If you haven't already checked them out, see for yourself what's been generating all the buzz:

- **Vision for the Grid**

Suresh Vasudevan, senior vice president, NetApp Product Management, and general manager, Decru, summarizes our vision and development road map for storage grid architectures.



- **IP SAN (iSCSI) Discussion with Rich Clifton**

Join Rich Clifton, NetApp VP, Enterprise Data Center and Applications, as he discusses IP SAN and how iSCSI fits into that IP-based technology.



- **De-duplicating Data to Meet Today's Data Growth**

With data growing at a rate of 50% a year, data de-duplication has once again become highly visible in the industry. Manish Goel, VP and GM of Secondary Storage.



- **NetApp Technology Behind Movie Magic**

Michael Thompson, senior systems engineer at Industrial Light and Magic (ILM), describes how NetApp Data ONTAP GX systems keep visual effects on blockbuster films in full production.



[Full NetApp TechTalk Podcast Library](#)



GARY ONO

Strategic Support Manager, Network Appliance™ Global Services

Gary joined NetApp Global Services (NGS) as a Technical Global Advisor in 1998. In this role he helped over 25 top NetApp accounts maximize uptime and assisted with various data migration projects and a full data center move. In his current role, Gary oversees a team of NGS Technical Global Advisors supporting over 8500 systems at 57 accounts worldwide.

Are you Exposed? Six Ways to Minimize Storage Risk

By Gary Ono

The job of a NetApp Technical Global Advisor (TGA) is to help NetApp customers get the best possible performance and availability from their mission critical storage environments. By working closely with customer accounts, TGAs focus on identifying potential risks that might exist and help the customer take steps to eliminate those risks. In short, TGAs obsess and lose sleep so the IT teams don't have to.

In my experience, there are six common areas where even the most savvy customers sometimes leave themselves exposed:

- Not running current or appropriate software levels
- Not monitoring system capacity
- Upgrading without a clear plan
- Insufficient storage resiliency
- Not watching for bugs
- Not subscribing to support communications

In this article, I'll summarize these risks and how to address them in a NetApp environment.

Risk #1: Not Running Current or Appropriate Software Levels

Solution: Upgrade Firmware and OS (But Be Careful!)

About 80% of NetApp support cases result from either a failure to upgrade or encountering a known bug. This may involve the operating system version running on the storage system or firmware levels on disks, shelves, motherboards, etc.

Managing firmware is quite simple. It is a NetApp best practice to have the most current version of firmware installed, so whenever a new version is available you should upgrade.

OS upgrades are trickier because the latest version of an OS may not always be the most appropriate for a given set of storage systems. The starting point to determine the appropriate software versions for your environment is the [interoperability matrix](#) available on the NOW™ (NetApp on the Web) site. Be prepared—it can take a certain amount of research to determine whether the features of a particular OS version are best suited for the environment and the applications being used.

Risk #2: Not Monitoring System Capacity

Solution: Establish Baselines and Thresholds and Monitor Regularly

Scrambling to increase capacity or upgrade a system because you ran out of disk

RELATED INFORMATION

[NetApp TGA Service Overview \(pdf\)](#)

[Architecting Storage for Resiliency](#)

[Tips for a Successful Migration](#)

[NOW Website](#)

Storage Monitoring Tools

Having the right tools can dramatically simplify the process of monitoring your storage systems. NetApp Operations Manager is perfectly suited to aid capacity monitoring and planning. A [guided tour](#) is available.

There are also a variety of free applications and scripts that many customers find helpful. Tools recommended by Tech OnTap members include:

- **MRTG for Filers:** A special version of MRTG tailored to monitor CPU load, disk usage, and more. ([full article](#))
- **Cacti:** Monitor and chart critical storage system data such as volume, quota, CPU, and inode usage. Specify thresholds and receive alerts. ([full article](#))
- **Swatch and Kiwi Syslog:** Monitor storage log files for messages of concern. ([full article](#))
- **ToasterView:** Graphically monitor NetApp disk usage at the volume level. ([full article](#))
- **NTOP:** Combines IP and non-IP traffic for a complete picture of network activity. ([full article](#))

space is a situation you want to avoid. Expanding storage system capacity should always be a well-thought-out and planned event. Haste can lead to costly mistakes that you will pay for either now or later.

You should establish thresholds for volume and inode usage and monitor free storage capacity on each storage system regularly to ensure that set thresholds have not been exceeded. When you see that a storage volume is approaching a threshold, you should then have plenty of time to plan the best way to increase capacity without having to scramble.

NetApp Operations Manager software can aid with capacity monitoring and planning on NetApp storage. NetApp professional services engineers and NetApp customers also use a variety of free tools to monitor storage system capacity. (See sidebar.)

Risk #3: Upgrading without a Clear Plan

Solution: Go Over Every Minute Detail and Develop Contingency Plans

Another large chunk of the technical support cases at NGS are the result of upgrades gone bad. One small command initiated out of sequence can have serious results. Upgrade failures sometimes cause many hours or even days of unplanned downtime.

There's no easy fix, but I can tell you how NetApp TGAs approach these projects. We typically discuss the proposed upgrade with key IT staff and develop a step-by-step upgrade plan. The plan is carefully reviewed by all parties involved prior to implementation. You should not only think about how you are going to upgrade to the new release, you should also have a contingency plan to roll the upgrade back if unforeseen problems arise. Solicit the advice and/or assistance of all the vendors that are directly or indirectly involved in the upgrade. The last thing you want is to find out that the new release you've upgraded to is incompatible with some critical feature of your backup software or business application.

Additional advice is available in Will Titherington's article, [Tips for a Successful Migration Project](#).

Risk #4: Insufficient Storage Resiliency

Solution: Cluster Storage and Implement RAID-DP™

Ensuring storage resiliency means providing an appropriate level of protection for both storage heads/controllers and disks. To create a storage environment that is fully resilient to hardware failures, NetApp always recommends clustering storage systems. Other storage vendors may utilize dual controller configurations to achieve a similar result.

Disk resiliency is essential for almost every application. You may be able to live with a controller failure rendering your data briefly unavailable, but losing data is another thing entirely. At minimum for most applications you'll want to take advantage of whatever RAID capabilities your storage systems offer.

You also need to make sure that you have an appropriate number of spare disks in your disk shelves so that RAID volumes can be reconstructed quickly if a failure occurs.

Beyond these things, we almost always recommend that our accounts use the NetApp dual-parity RAID implementation. RAID-DP is a standard NetApp feature that prevents data loss in the event of a second drive failure at minimal incremental cost. For the most mission-critical applications, NetApp also offers SyncMirror®, which combines the disk-mirroring protection of RAID1 with NetApp RAID4 or RAID-DP technology to maintain two online copies of data. This configuration provides protection against all types of hardware outages, including triple disk failures.

For more information, read [How NetApp Protects Against Disk Drive Weaknesses](#).

Risk #5: Not Watching for Bugs

Solution: Leverage NetApp Tools for Monitoring Bugs

The storage goal of all enterprises is stability, which translates to consistent availability with as close to zero downtime as possible. To achieve this, it is critical to evaluate the known bugs in each software release to determine the possible effect on your environment. This should be done prior to installing a new release. New bugs in each

RAID-DP Versus RAID4

RAID-DP significantly increases data protection, with zero to minimal impact on capacity utilization and performance versus RAID4. And, because RAID-DP is an integral part of Data ONTAP®, there are no hidden costs associated with it.

RAID-DP offers:

- Protection against up to two disk failures in the same RAID group
- Protection against single disk failure plus uncorrectable bit error during the reconstruction time frame
- No significant read, write, or CPU consumption differences
- Larger allowable RAID groups, which mean that capacity utilization stays about the same (one in eight disks dedicated to parity)

Learn more about the [NetApp Implementation of RAID Double Parity](#).

GoDaddy.com Leverages NetApp Support

GoDaddy.com is the world leader in domain name registration and management, offering a complete line of web presence tools and management.

In a recent case study, GoDaddy highlighted its NetApp storage infrastructure and the great support it receives from NetApp Global Services as two of the keys to its success.

[Read the case study \(pdf\)](#) to find out more.

software release in use should be monitored periodically. The number of bugs is generally higher when the software is new and decreases as a release matures and bugs are fixed. Also, the number of bugs typically increases as the rate of change in the software increases.

Like all hardware and software developers, NetApp occasionally uncovers bugs in its operating systems, application software, and firmware that may adversely affect customer operations. NetApp TGAs use a variety of tools to evaluate known bugs and to determine the possible impact on my accounts. Tools for monitoring and evaluating bugs that are available on the NetApp NOW Web site include:

- [Bugs Online](#)
- [Bug Watcher](#)
- [Bug Alerts Profiler](#)

Risk #6: Not Subscribing to Support Communications

Solution: Subscribe to (and Read!) Support Communications

Vendor support organizations generally provide bulletins and other communications to notify you of potential problems with hardware, system software and applications. These can be extremely helpful in avoiding problems and ensuring storage stability.

NetApp Global Services offers two types of e-mail communications for NetApp products.

- **Customer Support Bulletins (CSBs)** notify you of urgent and important product information that may affect product performance or reliability. You will only receive customer support bulletins that relate to your NetApp storage systems.
- **Product Communiqués (CPCs)** keep you up to date on software releases, product announcements, and end of availability items.

If you work with NetApp storage, you need to receive NetApp support communications. To ensure that you are subscribed to the appropriate bulletins, check the Field Alerts option of the [NOW subscription center](#).

Next Steps

Paying attention to these areas can have a big impact on storage success. Some risks can be easily addressed—for example, implementing RAID-DP—while others require a significant and continued time investment.

Do you need a TGA? It depends. A TGA relationship can be an excellent enhancement and complement to SupportEdge Premium and SupportEdge Secure for Government service. NetApp customers with anywhere from hundreds to thousands of systems are using TGAs, so it isn't just the size of your implementation that matters.

The key is how hands on you want to be and how much you can afford to offload. If you're the type of super techie person who can't wait for perfstat viewer to be released so you can parse your own files, then it's quite likely you don't need a TGA. But, if you have more than 50 storage systems and don't want to have to worry about keeping track of versions, bugs, alerts, auto supports, etc., a TGA can be a valued member of your team.

Comment on this article



AKSHAY BHARGAVA AND MUKESH NIGAM

Product Engineers, Network Appliance

Akshay Bhargava (left) and Mukesh Nigam (right) are members of the NetApp core system team. Akshay lives and breathes Data ONTAP® and the WAFL® file system. He previously served in a variety of engineering management and software development roles working on distributed computing, clustering, storage virtualization, and network security. Mukesh, a former member of the Data ONTAP kernel and networking engineering team, spends his days (and occasional nights) focused on platforms, performance, and networking. Prior to NetApp, Mukesh held a variety of engineering roles working on storage security, networking, UNIX® internals, and fault tolerance.

Monitor, Troubleshoot, and Improve NetApp Storage Performance

By Akshay Bhargava and Mukesh Nigam

In February NetApp will publish a 30-page technical report that gives readers the knowledge and tools to monitor and manage performance on NetApp storage systems using NetApp Operations Manager. As a Tech OnTap member, you're invited to enjoy early access to the report, [Storage Performance Management](#), and submit your questions to the authors.

Of all the elements in the IT infrastructure, storage is one of the least understood, often resulting in storage systems that are either underconfigured or overconfigured for their dynamic workloads.

This article provides an overview of the three core elements of storage performance management—monitoring, troubleshooting, and solving performance issues—and how to approach each area in a NetApp environment. It also addresses some of the most common questions asked by NetApp customers, including:

- What metrics should I use to track NetApp system performance?
- How do I troubleshoot storage performance problems?
- And, most importantly, how can I correct performance issues?

Performance Monitoring:

Latency Is an Early Indicator of Performance Problems

A little proactive effort can yield big rewards, especially in performance management. The easiest way to know when you've got a performance problem is to understand acceptable performance metrics for your applications, establish baselines for key performance metrics, and monitor your environment regularly.

The full set of metrics you choose to monitor may depend on your application, but **NetApp recommends monitoring latency as the primary performance indicator.**

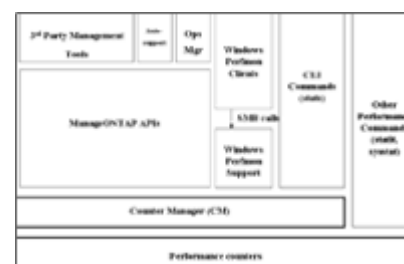
Latency is a highly reliable indicator of changes in performance and is often one of the first indicators of a resource overload. Other parameters such as throughput and transactions per second are important, but regularly monitoring latency can help

RELATED INFORMATION

- [Sneak Peek: Storage Performance Management](#)
- [Workload Prioritization with NetApp](#)
- [NetApp FlexShare Demo](#)
- [Operations Manager Guided Tour](#)

Performance Metrics in Data ONTAP

Data ONTAP has always maintained a wide variety of performance counters for monitoring and troubleshooting. To make these counters more accessible, NetApp provides a Counter Manager layer within Data ONTAP. Counter Manager can be easily queried by Manage ONTAP.



[Click to Enlarge](#)

Manage ONTAP is a collection of application programming interfaces (APIs) for the Data ONTAP operating system. These APIs are used by Operations Manager and AutoSupport and also provide open access to NetApp performance metrics for integration between NetApp solutions and partner solutions, as well as simplified integration with in-house

Sneak Preview



you easily detect potential storage bottlenecks *before* they become a problem. Latency increases that may not yet be large enough to noticeably affect end users or applications often indicate that a storage system is approaching a resource bottleneck.

Command-line tools such as *stats show* can be used to determine latency, as can applications like Windows® Perfmon or other standard third-party tools that integrate with the Manage ONTAP™ API.

NetApp recommends the Performance Advisor Client provided with NetApp Operations Manager (formerly known as DataFabric® Manager, or DFM). The Performance Advisor Client can provide a convenient, graphical view of latency—or virtually any available performance metric—over time. If you use Operations Manager, we suggest creating a graphical view of latency for each critical volume on your storage system and saving a baseline for each volume with acceptable application performance. (See Figure 1 for an example.) In addition to latencies, you should also establish baselines for CPU utilization and throughput on each network interface (including NICs and/or HBAs).

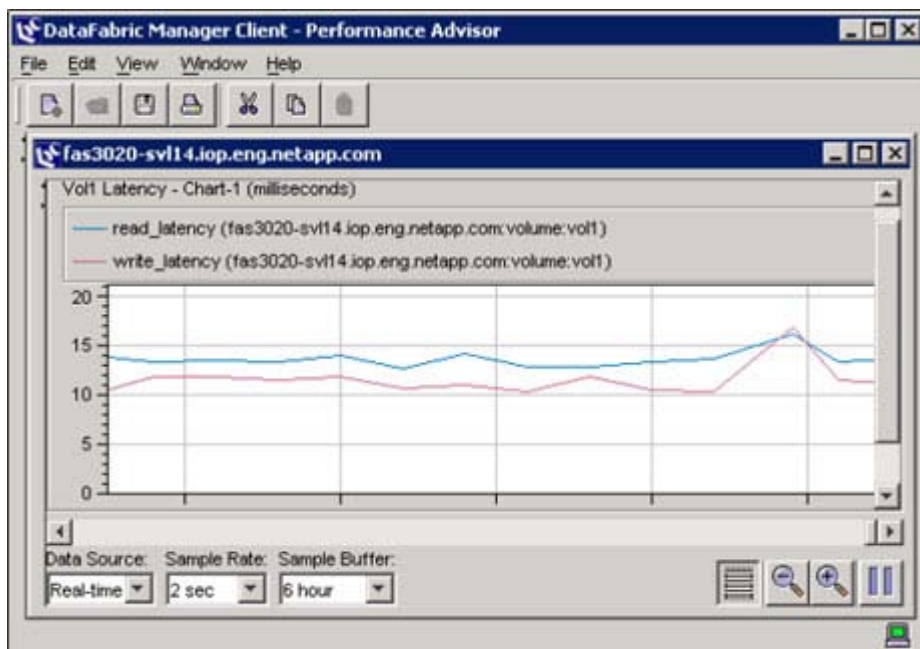


Figure 1) Volume latency.

For example, if a storage system is servicing a critical database plus other noncritical workloads, you should establish a baseline and monitor latency regularly on every database volume. If you notice latency gradually increasing over time and approaching the threshold you deemed acceptable, you should troubleshoot and take corrective action before the problem becomes critical.

Even if an end user reports a problem that was not detected through regular storage system monitoring, having good baselines still provides a basis for comparison that can simplify troubleshooting as you try to determine where the bottleneck is in your IT infrastructure.

Troubleshooting: Rule Out Transient Activities, Then Focus on Utilization

When latency increases, the first step to isolating the cause is to look for transient system activities that might be causing a resource overload. Transient activities such as RAID reconstructions, SnapMirror® transfers, NDMP, and others may affect performance.

If one or more such activities are present:

A brand new technical report on Storage Performance Management will be published in February.

As a Tech OnTap member, you get a sneak preview plus an opportunity to submit comments to the authors!

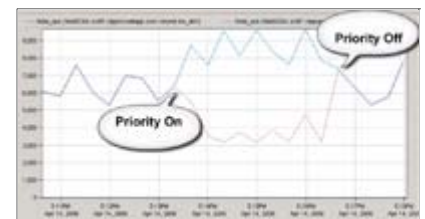
applications.

Manage ONTAP is exposed within Data ONTAP through a variety of interfaces, including SNMP, CLI, RPC, NDMP, and Data ONTAP APIs, so it is relatively easy for your in-house application to monitor important storage metrics.

The Windows Perfmon tool built into Microsoft® Windows can also be used to monitor NetApp performance metrics through calls to the Windows Perfmon support module of Data ONTAP.

FlexShare in Action

The following graph shows how a high-priority application can benefit from FlexShare:



Click to launch the FlexShare demo.

To perform this test:

- A single NetApp system was configured with two identical volumes.
- [SIO](#) (see [related article](#)) was used to simulate an OLTP workload against each volume (R/W 40:60, random: 70%, block size: 8KB).

With FlexShare off, each volume delivered a workload of about 6,000 disk ops per second for a total of 12,000. Priority on one volume was then set to "VeryHigh," while the other was set to "VeryLow."

- The high-priority volume climbed to an average of around 9,000 ops, 50% more than without FlexShare and 3X the low-priority volume.
- The low-priority volume dropped to an average of about 3,000 ops.

Total operations remained at 12,000, indicating that FlexShare has no significant system overhead.

Watch the [FlexShare demo](#).
Read [Workload Prioritization for Optimized Performance](#).
Read the [FlexShare Design and Implementation Guide](#). ([pdf](#))

- See if turning the activities off or throttling them improves performance. (Be sure that turning off or throttling the activities won't adversely affect critical operations.)
- For one-time or infrequent activities such as RAID reconstruction, consider the tradeoffs. It might be better to live with the performance impact.
- For regular activities such as Snapshot™, SnapMirror, NDMP, and SnapVault®, consider altering the schedule so that the activity occurs when the system is less loaded.

Once you rule out transient activities, the next step is to drill into each system resource, comparing current utilization levels against your established baselines. We suggest following this order: CPU, disk, networking when drilling into resources. Even if a potential source of a problem has been found, it's a good idea to continue through the other resources to make sure nothing is overlooked.

Keep in mind, of course, that the storage subsystem is only one component in the IT infrastructure that can impact user/application latency. Other factors, such as network, host OS, or application performance, can also impact performance and are important to troubleshoot in isolating a performance issue.

Let's take a look at an example to see how this methodology works.

Case Study: Troubleshooting a CPU Bottleneck

Here's a troubleshooting example based on a workload that generates sequential, read-intensive I/O. The following baseline data was created using the Performance Advisor Client:

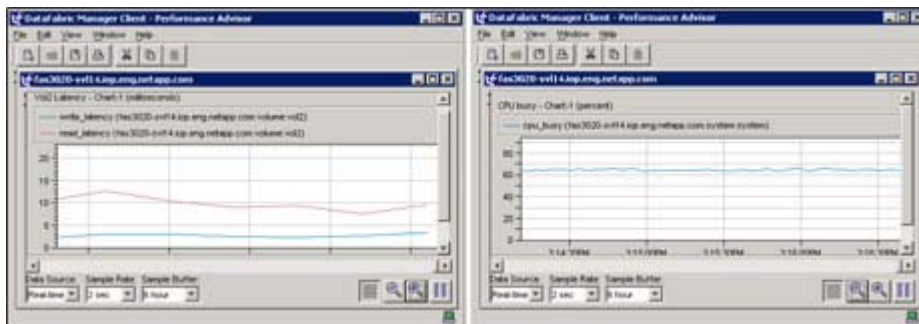


Figure 2) Baseline volume latency and CPU utilization.

Increasing the number of clients created an overload. Note that both read latency and write latency more than double from the baseline.

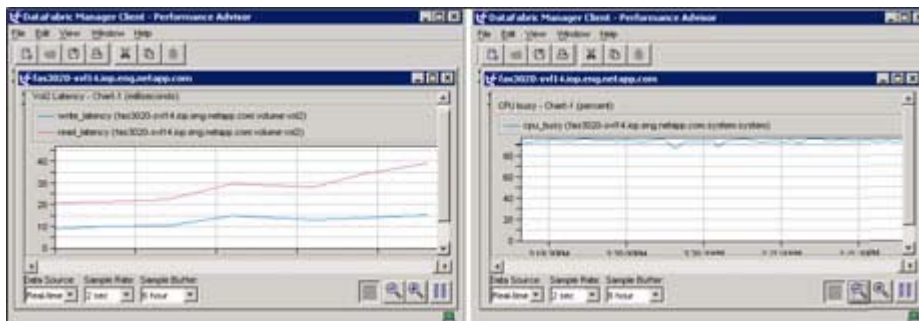


Figure 3) Volume latency and CPU utilization with an increased number of clients.

Following the methodology just discussed, the first step is to check for transient activities. None were found, so we moved on to CPU and quickly discovered that the CPU was pegged. Typically you want to keep CPU utilization under 90%. This example consistently exceeds that threshold. Notice the substantial change from the CPU baseline as well.

Don't forget that CPU overload may be a symptom, not a cause. Some other overloaded system resource could trigger high CPU utilization. For this reason, in this example we went on to check disk and network utilization. The **sysstat** command showed that total disk I/O utilization was 30%, indicating that disk I/O was unlikely to be a problem. Similarly, network utilization on all NICs and HBAs was well below the limits of the installed hardware, and there were no errors, confirming that no other resource

Having the right tools can dramatically simplify the process of monitoring your storage systems. NetApp Operations Manager is perfectly suited to aid capacity monitoring and planning. A [guided tour](#) is available.

There are also a variety of free applications and scripts that many customers find helpful. Tools recommended by Tech OnTap members include:

- **MRTG for Filers:** A special version of MRTG tailored to monitor CPU load, disk usage, and more. ([full article](#))
- **Cacti:** Monitor and chart critical storage system data such as volume, quota, CPU, and inode usage. Specify thresholds and receive alerts. ([full article](#))
- **Swatch and Kiwi Syslog:** Monitor storage log files for messages of concern. ([full article](#))
- **ToasterView:** Graphically monitor NetApp disk usage at the volume level. ([full article](#))
- **NTOP:** Combines IP and non-IP traffic for a complete picture of network activity. ([full article](#))

overload existed and concluding that the CPU was the source of the problem in this case.

Correcting Performance Problems: Upgrading Isn't the Only Option

Customers often think that if the problem involves CPU overload, their only option is to upgrade to a more capable storage system. There are a number of less drastic corrective actions to consider first:

- Utilize NetApp FlexShare (Data ONTAP 7.2 and higher) to give higher priority to critical workloads and low priority to nonessential workloads
- Spread the workload across multiple storage systems to better balance the load
- Stagger jobs during the course of the day

Upgrading should only be necessary if these options are not feasible at your site. Similar corrective actions exist for other common types of overload.

The Goal: Reliable, Predictable Operations

When it comes to storage system performance, achieving reliable, predictable operation should be your primary goal. Establishing baselines and thresholds for each application and instituting a regular monitoring program are the best things you can do to achieve predictability. With those in place, you can detect performance issues before they become critical, quickly determine whether or not storage is the source of a user-reported performance problem, and troubleshoot any problems that might arise.

Sneak Preview

For detailed information on storage performance monitoring and troubleshooting in NetApp environments, check out [Storage Performance Management](#). This report is currently available only to Tech OnTap members.

Storage Performance Management Best Practice	
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[Click here](#) to read the full report.

Comment on this article



Troy Eberlein

Director of Product Management, NetApp

Troy Eberlein has over 10 years of experience in the storage industry. In January of 2005 he joined Topio and assumed sole responsibility for product management for the Topio Data Protection Suite (TDPS). He led integration projects between NetApp Data ONTAP® and TDPS and joined NetApp when Topio was acquired by the company in December of 2006. Troy previously worked at Candera and Legato Systems.

Disaster Recovery and Cloning in Heterogeneous Environments

By Troy Eberlein

In December 2006 NetApp acquired Topio, a leading supplier of software for enterprise-class data replication and cloning in heterogeneous environments. The potential to simplify heterogeneous environments using TDPS has triggered substantial interest in the NetApp user community.

With that in mind, Tech OnTap is pleased to bring its readers a rare exclusive: an internal technical training session designed to educate NetApp and channel partner systems engineers on TDPS features and functionality.

This presentation is *not* a marketing pitch (probably best not to mention it to the marketing guys, as a matter of fact). It runs about 17 minutes, or you can easily navigate to any section of interest.

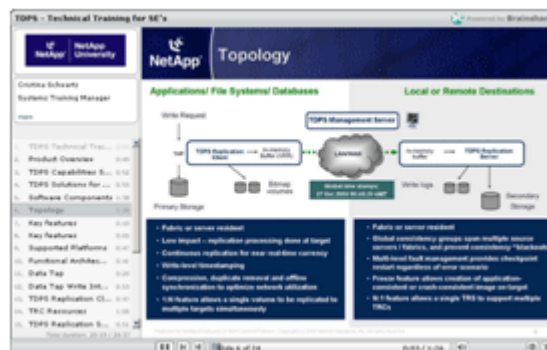
If you're not familiar with TDPS, here's some quick background.

What is TDPS?

TDPS is a software solution that provides nondisruptive data replication of block data across any distance. It is used primarily for disaster recovery and cloning data sets for production support purposes, such as application development and testing, reporting, and analytics. TDPS can replicate block-level data independent of the underlying server, storage type, or storage interconnect. This means that you can deploy a single solution to meet all of your disaster recovery, replication, or data cloning needs instead of a different solution for each major application or each type of storage.

For disaster recovery, the combination of TDPS and NetApp storage allows you to implement a tiered storage strategy and avoid the expense of having to duplicate expensive production storage at your target site. NetApp storage systems have a broad range of capacity and performance levels and all run the same architecture, so you can put each data set on the type of storage that makes the most economic sense and manage it using proven NetApp tools.

You can also replicate production data from expensive primary storage to NetApp storage systems and take advantage of NetApp FlexClone™ to make as many copies of your data set as necessary for development, testing, etc. FlexClone consumes



[Click to view the presentation](#)

RELATED INFORMATION

- [TDPS Product Overview](#)
- [Data Replication and Recovery over Any Distance Ensuring 100% Data Consistency \(pdf\)](#)
- [TDPS Host Edition CPU Benchmark \(pdf\)](#)

TDPS versus Open Systems SnapVault®

The addition of TDPS raises some obvious questions about how the new product fits with the rest of the NetApp software lineup. One of the most frequently asked questions is how TDPS compares to the open systems capabilities of NetApp SnapVault (OSSV).

While both products provide support for a wide range of platforms, OSSV is intended primarily for remote office backup; it saves multiple versions of a file over time to allow restores of a previous file version or of an entire file system to a previous point in time.

TDPS, on the other hand, provides continuous replication of live production data in order to address the demanding requirements of disaster recovery and cloning for production support.

More information:

- [TDPS Product Overview](#)
- [SnapVault Product Overview](#)

storage capacity only as cloned volumes change. TDPS integrates directly with FlexClone so you can manage the whole process centrally.

A lot of vendors—including NetApp—offer replication solutions. What makes the TDPS solution different?

One of the key things that differentiates TDPS from other replication solutions is its ability to support virtually any environment. As soon as you have to add another replication solution to provide DR for an application that's not covered by your primary solution, the complexity of your DR infrastructure goes way up. The same goes for cloning. TDPS covers virtually all types of block-based disk storage, including Fibre Channel SAN, IP SAN, direct-attached storage (DAS), and even internal and system disks.

Other replication solutions are designed to work at either the host level, the fabric level, or the storage array level. Host-level solutions are usually limited in terms of operating system and cluster support. Array-level solutions are typically limited to support for a single vendor.

TDPS gives you a choice of either fabric-level or host-level replication for the broadest possible coverage. At the host level, the software supports all popular operating systems and clusters. With the broad capabilities of TDPS you can create a highly scalable, integrated DR strategy that encompasses your entire IT infrastructure or quickly replicate production data sets to less expensive storage and then clone it as many times as necessary for development, testing, etc.

TDPS can even maintain data consistency across any number of replicating nodes across servers, SAN fabrics, and storage devices. With other solutions, data consistency is limited to individual servers, replication appliances, or appliance clusters, sacrificing scalability to maintain recoverability.

What does the Topio acquisition mean for existing NetApp customers?

In a perfect world (at least according to NetApp!), your IT environment would be based solely on NetApp storage—but that isn't reality in most data centers. TDPS reduces the complexity of disaster recovery and cloning in multivendor environments and enables IT teams to benefit from tiered storage with proven NetApp manageability.

[View the training presentation](#) to learn about TDPS technology, including:

- TDPS capabilities and typical uses
- Software architecture
- Centralized management
- Supported platforms

Benchmarking TDPS Impact on Host Performance

One of the biggest concerns with host-based replication software is that the additional burden the software places on the host may steal too many CPU cycles and impact application performance.

To assess the impact of TDPS running at host level, tests were executed using a variety of I/O workloads with and without the TDPS client software. These tests show that even under the most stringent I/O, TDPS increased CPU utilization by only 3%. For more typical I/O workloads, the TDPS client software had negligible CPU impact.

[View the complete report. \(pdf\)](#)

The information in this article is useful to me.

Strongly Disagree ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 Strongly Agree

What other types of information would you like to see included in this article?

Additional comments:

Thanks!

TECH ONTAP HOME PAGE



Drew Breese
Systems Administrator

Drew has been working in IT for eight years and with NetApp storage for the last four years. Six years ago he started at Onyx—recently acquired by CapitalOne—as a help desk technician and quickly moved into a network operations role. He later worked as a network administrator, gaining hands-on experience keeping his company's networks up and running. He then switched companies and now serves as a systems administrator. When he's not sitting in front of a computer or troubleshooting a network, Drew is an avid snowboarder and is pursuing a helicopter pilot's license.

Tool of the Month: NTOP

Every month, Tech OnTap showcases a free tool that just might make your life a little easier. [Recommend a tool](#) and get a FREE NetApp jacket.

What it is: NTOP (network top) displays a list of hosts that are currently using a network and reports information concerning the traffic generated by each host. It provides a simple, graphical display that makes it easy to see that Network Appliance™ storage and other network devices are behaving as expected.

How it works: NTOP is a hybrid layer 2/layer 3 network monitoring application that runs on its own machine (like a Linux® box). By default it uses both layer 2 Media Access Control (MAC) addresses and layer 3 TCP/IP addresses. NTOP associates the two so that IP and non-IP traffic are combined for a complete picture of network activity. The tool will monitor almost any network interface: loopback, Token Ring, Ethernet, Fibre Channel, etc. Since it is Open Source it can easily be modified if you know a little bit about programming.

NTOP is written in C and the source code has support for a number of different platforms, including Linux, FreeBSD, Windows®, Solaris™, HP-UX, and AIX.

Why it's cool: NTOP is just a wonderful, free piece of software. It's one of my favorite tools because it's clean and easy to use and you can show the output to anyone and he or she can follow it. I don't do a lot of programming, but it was easy to go into the source code and modify it to give me exactly what I wanted and then create the graphs I needed for management.

Another nice thing about NTOP is that it doesn't care what sort of network device it is monitoring. It is designed to run on a system and give you details of the network traffic of that system. Or you can modify your switch configurations and use it like a sniffer. You can have it sniff all of your network, a couple of hosts, or just one host. I have done all three.

How Drew uses NTOP: I started using NTOP at my previous company soon after the purchase of several NetApp storage systems. I modified the NTOP source code to define the protocols that were interesting to us, including NFS, Oracle® on the UNIX® machine, and a couple of proprietary programs. Once we started running NTOP we were able to filter out the things that weren't of interest and focus specifically on the traffic to and from the NetApp systems. This included the number of connections, who was talking to the system the most, and who was pushing the most data. This enabled me to prove to management that the new machines were a good investment and that they were really cranking out data versus the systems they replaced.

We also used NTOP for troubleshooting. At one point, an Oracle database that accessed its data via NFS from one of the NetApp storage systems started to go down periodically. Since NetApp was new to the architecture, management was immediately



RELATED INFORMATION

- **NOW Tools Discussion Forum**
(NOW user login required)
- **Official NTOP Website**
- **Previously Featured Tools:**
 - [Toasters](#)
 - [Swatch and Kiwi](#)
 - [Firefox](#)
 - [Cacti](#)
 - [MRTG for Filers](#)
 - [Nagios](#)
 - [SIO](#)
 - [ToasterView](#)

Sample NTOP Output



This image illustrates some of the customizations I have made to NTOP. I created a monitor called "Sniffer" to represent the local NTOP traffic. You can add many more monitors that are specific to what you're looking for. For example, Port 1521 could be added with the name "Oracle" or "Database." The default install includes Port 137, 138, 139 (NetBios/CIFS) and has most protocols related to NFS. The

pointing a finger at it. By using NTOP to watch the NFS traffic between the Oracle machine and storage, in combination with copies of the switch counters/logs, we were able to prove that the NetApp system was doing exactly what it was supposed to be doing.

We started by simply watching the NetApp storage system, then moved on to the UNIX machine, then watched them both at the same time. This was all done by changing switch configurations. The problem was ultimately determined to be a configuration error on the UNIX host that the database was attached to, and not the NetApp system.

My current company just purchased its first NetApp system, so I'll be using NTOP to monitor the new system to prove to management what it is capable of and how it compares to the system it replaced.

How does NTOP differ from other network tools?

In addition to NTOP, I also used to use MRTG to monitor our routers. (See the [previous tool feature on MRTG](#), Editor.) MRTG uses SNMP to read information from network devices that support the protocol, while NTOP looks at network traffic by reading packets directly. As a result, MRTG is good for monitoring multiple networks and lots of devices while NTOP is more focused on presenting a picture of activity on a single network. We actually ran both tools on the same box and used a separate interface for each tool so that NTOP wouldn't see MRTG traffic.

Caveats: NTOP can use a lot of memory. You will need a beefy machine if you plan to use it to watch a bunch of NetApp storage systems or other network devices simultaneously.

NTOP only monitors the traffic it can see. Therefore, you will need access to your switch to put the port in monitoring mode. You have to configure the switch to mirror traffic on the ports used by NetApp systems to the port used by NTOP.

🔗 [NTOP news, downloads and more](#)

What do YOU think?

Ask questions, share feedback, and nominate your own favorite tools on the [NOW tools forum](#) (NOW user login required)

In Tech OnTap's annual survey, nearly half of members asked for NetApp-sponsored forums. NetApp Global Services is now assessing the existing NOW forums and partnering with Tech OnTap to collect feedback and functionality suggestions. Our goal is to encourage widespread interactive discussions on the NOW forums, and we're starting with tools.

Sample forum comments:

- As Drew points out in his article, NTOP needs some resources and memory to run well. Because of the work it has to pull, especially in a production environment, a dedicated machine is probably the best. However, the fact that NTOP operates on layer 2 and 3 and relies on switch capabilities to monitor the relevant ports makes it less suitable for larger networks.

We use Cacti to trace the network performance of our NetApp storage systems (and other hosts), although it is admittedly not as real-time as NTOP can be. I use nethogs for that, which gives a net top per process... but it won't work on NetApp storage as it is a *nix utility. If problems arise and you're using Cacti/SNMP, at least you still have the option to run tcpdump/wireshark to debug the traffic. [Cor Kuin, Netherlands]

- I use NTOP (Linux version) quite a bit. It is a nice Web interface to real-time network stats. NTOP also works with Netflow data and raw capture files. [Paul Skokan, NetApp IT Network Management Engineer]
- NTOP looks very interesting. To test it out I installed the win32 demo version, which is Open Source—you can compile your own version. If you want the precompiled win32 version, you have to register and donate something, which is perfectly reasonable. Installing NTOP also installs winpcap (an Open Source tool for monitoring network traffic on Windows). After installing, I had to start the NTOP service manually (it might have started automatically if I had rebooted) and its Web interface became usable and started showing some non-zero numbers. It seems to work just fine and provide interesting and useful information. [Tim Thompson, NetApp Engineering]

graph at the bottom is a bar graph showing which protocols are being used most.



This image shows throughput in a manner similar to MRTG. Instead of breaking traffic down by protocol, it simply shows the raw amount of network data being moved, which is useful for showing how much data a NetApp storage system is handling.