The Essential Guide to Server Performance and Benchmark Testing
Introduction

Maintaining high server performance and appropriate scale to keep up with growing computing demands doesn't happen automatically. Data center administrators must continuously track performance and make the most of hardware resources. There are ways in which IT professionals can simplify server management at top performance.

Benchmark testing helps administrators monitor server resources, manage utilization, optimize performance and identify problems before they occur. Simple server configuration tweaks can squeeze more performance out of physical and virtual machines (VMs).

This guide covers best practices for benchmark testing with valuable tips from data center experts on how to improve server performance.
Select the right server

Serving different data center needs

The data center needs to run applications, which means the right servers for the right workloads need to be in place. Just as important as raw performance data is how different server architectures handle tasks.

Why Purpose-built vs. general purpose

While an x86 CISC processor can be used for anything, it's not always the best choice. Simplified and highly integrated purpose-built RISC processors are improving efficiency and power in data centers.

With demand for high computing performance and low power use, systems designers are realizing that the all-encompassing x86 processor, with its complex instruction set, cannot build functionality and efficiency. Performance-built processors can address the computing needs of servers, storage arrays, network devices and other systems.

RISC vs. CISC processors
Today's x86 processor designs are an amalgamation of features and functionality from the last 30 years, right up to today's Intel-VT and AMD-V instructions to support hardware-assisted virtualization.

But there's a problem with this complex instruction set computing (CISC) approach; every new instruction or feature adds tens of thousands of transistors to the processor die, adding power demands and latency even if the instructions are rarely used. The chip is extremely versatile, but it runs hot and sucks power with ever-increasing clock speeds.

Processors run much more efficiently when tailored to a specific task. Reduced instruction set computing (RISC) strips out unneeded features and functionality, and builds on task-specific capabilities. Simpler, more reliable RISC processors provide the same effective computing throughput at a fraction of the power and cooling.

The question in CISC vs. RISC arguments is versatility vs. efficiency. Traditional x86 CISC processors can tackle almost any computing task using an extraordinarily comprehensive instruction set. This made CISC the preferred chip design for general-purpose computing platforms: enterprise servers, desktop PCs and laptop/notebook systems.

Purpose-built RISC processors sacrifice versatility for efficiency. Removing unneeded instructions dramatically reduces the processor's transistor count.
Tackling fewer tasks in hardware means those tasks are performed faster, even at lower clock speeds (less power) than a full x86 CISC counterpart.

Printers, home routers, and even multifunction telephones and remote controls use RISC processors, and the concept is growing dramatically for fully featured computing platforms. A tablet or smartphone's RISC processor can deliver smooth video playback, fast webpage display and a responsive user interface for many hours on a battery charge, with no cooling devices. This same chip design paradigm is systematically finding traction in data center systems.

**Examples of RISC processors**

Chip designers, such as Intel, are forging ahead with RISC processors for data centers and endpoints. Intel's Atom processor family has diversified into numerous purpose-built variants using major parts, but not necessarily all, of the x86 instruction set.

The Atom single-core Silverthorne family for the mobile Internet device (MID) market supports MMX, SSE, SSE2, SSE3, SSSE3 and Enhanced SpeedStep Technology, but not all models support Hyper-Threading or Intel-VT. While an Atom-based system will support most basic x86 applications, it is not intended for virtualization in this case.

The Atom S12x9 family supports a complete system-on-a-chip (SoC) with 40 lanes of PCIe 2.0 for high I/O capacity. It is used in storage systems. The Atom
Avoton is a 64-bit SoC processor that includes an Ethernet controller and is designed for microservers. The Atom Rangeley SoC processor is tailored for handling network traffic and used in entry- to mid-level routers, switches and security devices.

Linux-based multi-core SoC RISC processors like Tilera TILE Gx-8072 provide 72 interconnected RISC cores in the same package. You'll find these in low-power servers, allowing huge complements of processor cores for tasks like network data handling and video transcoding.

A more general expression of RISC processors is the ARMv8 reference design licensed by Advanced RISC Machines (ARM). Tablet processors like Apple's A6 and NVIDIA's Tegra 3 are based on ARM's Cortex A9 RISC processor. The 64-bit Cortex-A57 design supports applications programmed in Linux, Linaro and other open-source languages. AMD will develop a RISC SoC processor for enterprise servers based on the Cortex-A57 design.

---

**Mainframe pronounced relevant again**

The IT landscape has changed, and talk of the mainframe’s benefits is again audible. The mainframe vs. server question comes down to space and facilities costs as well as simplicity of operations.
Remember the mainframe? A few decades ago, with the rise of client-server computing, everyone thought mainframes would quickly disappear from the data center. In the 1990s, when servers grouped in local networks stored files in a central location, there was no need to keep the expensive mainframe. For the price of one mainframe, you could afford to buy a hundred servers.

As the Internet took over, servers became more complex. Often, several servers had to work together to accomplish a specific task. Data centers grew to accommodate more and more servers, which demanded power and cooling resources. Some power providers increased capacity just for data centers, and electricity costs continued to rise. Virtualization and cloud computing trends have influenced the numbers, but server sprawl is still on the rise.

But the mainframe vs. server argument never really went away. And, to the surprise (or dismay) of many, mainframes might be winning the debate.

A large Midwestern U.S. security company replaced more than 200 servers with one big mainframe in 2012, according to the company's data center architect. "We save a fortune on electricity and the mainframe is doing everything our 200-plus servers were doing in the past. And we can reduce the size of the data center, which means that we can save an additional fortune on realty," he explained.

Next-generation mainframes can run an open operating system like Linux, eliminating the cost and inconvenience of proprietary OSes. Major Linux
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

vendors like Red Hat and SUSE have a version of their distribution that runs on mainframe hardware.

"A mainframe is like one very large server that can do anything that multiple servers in a rack are able to do. It's a virtualization platform; its hardware is highly redundant, so it replaces a cluster of servers. And, compared to all the x64 servers, it's not even that expensive," said the data center architect.

Even if mainframes are a tough sell, it is clear that a comeback is in the works. Large companies can even save money on IT infrastructure by replacing hundreds of servers with one huge -- if expensive -- mainframe computer.

### FPGA servers touted as flexible hosting machines

New processors use FPGA chips to accelerate applications, enabling server specialization with flexible programming.
No single processor architecture handles every workload optimally, and the demand for efficiency at scale is pushing new, powerful app-centric servers. In one design, the central processing unit (CPU) offloads tasks to a field programmable gate array (FPGA) component.

Depending on the nature of the application, the tasks and the quality of hardware descriptive language (HDL) coding in the FPGA programming, FPGAs boost performance substantially.

**Specialized servers vs. standard x86**

A server can accelerate an application by reducing the computing instruction set (RISC), which shaves off latencies in the chip, but only works for apps tailored to use those instructions. Another method extends the processor command set to handle new tasks internally -- the opposite of RISC -- for more flexibility. The third option is to offload instructions from the processor to another computing component -- such as moving send/receive tasks to a network interface card -- which accelerates instruction processing.
The latest wrinkle in the server performance push is a new take on the offloading paradigm: pairing an x86 processor with a FPGA. The FPGA is customizable: It is programmed to boost a specific workload's performance, and then reprogrammed to accommodate changing needs in the future.

For example, a properly programmed FPGA could improve the throughput of graphics tasks, similar to co-processing with a CPU and graphics processing unit. With some reprogramming, however, the same FPGA could accelerate database searches. The best applications for acceleration (task offloading in this case) have frequent repetitive tasks or complex task sequences.

**Pros and cons of servers with FPGA processors**

FPGA-accelerated processors like Intel's Xeon E5+FPGA make the most sense when there is a massive quantity of servers running the same accelerated workloads. It's almost never economical to deploy FPGA servers for everyday data centers running a limited number of general business apps. This is mainly because of the work needed to develop the acceleration algorithms in HDL.

Not all FPGAs are equal; the best application performance comes from a larger FPGA with quality HDL coding. This means more logic gates interconnected
most efficiently. A smaller FPGA programmed in a cumbersome manner cannot make as large of a difference for the workload.

The payoff for HDL development work isn't noticeable on an Exchange Server deployment. However, in cloud or Web-scale data centers, boosting performance a few percentage points across thousands of servers could save millions of dollars; consider a 10% faster search, OpenCL or big data analytical performance across 1,000 servers.

Using FPGAs for acceleration also adds a new wrinkle to change management, especially for large-scale data centers, because enterprise tools must track the FPGA algorithm as it is updated.

**Vendor offerings**

Combining processors and FPGA devices is not new. Intel has done this with the Atom E600C series x86 processors. It includes memory and I/O, and is linked through a single-lane PCIe channel. The Intel Atom system-on-chip processors are used for lightweight Web-hosting servers, while the Xeon Phi is appearing in highly parallel processing tasks.
Juniper Networks is combining Intel Xeon E3-1125C v2 processors with Broadcom switching chips and Altera FPGAs to create a server on switch for the QFX5100-AA switch platform. The goal is to run financial services directly on the switch, which is accelerated by the FPGA.

Hyperscale data center operators are anxious to integrate FPGA capabilities. Microsoft's Catapult project added FPGAs on PCIe cards (not yet on CPUs) to more than 1,600 servers running the Bing search engine. The company's report showed almost double the throughput. Microsoft also added FPGA-enhanced Intel Xeon E5-26000 v3 processors to its second-generation open-source Open CloudServer specification.

Expect FPGA server technology to develop and trickle down to smaller, more general-purpose data centers, as evidenced by Intel's package of Xeon E5-FPGA. Libraries of HDL optimizations may even become available for everyday business apps.
Intel scale-up servers' future

Intel's Haswell-based E7 version 3 processor competes with IBM's POWER8 systems for large, scale-up data center workloads, which used to be the sole domain of mainframes.

The E7 processors target traditionally mainframe workloads: Online transaction processing (OLTP), big data business intelligence (BI) and scientific simulations. These business-critical applications crunch a lot of data, require high I/O throughput and are difficult to segment across separate machines. E7-based servers also consolidate virtualized x86 infrastructures onto a smaller footprint.

The E7 v3 uses the same core and internal dual ring interconnect as the E5 v3, but handles different data center workloads. The E5 series appears primarily in two-socket, scale-out, cloud-native servers. Intel E7 v3's feature set supports scale-up, high-memory, mission-critical workloads. Servers based on the E7 v3 offer concentrated compute in primarily four- to eight-socket systems (the processor can go into systems with up to 32 sockets) with 6 to 12 TB of memory across 96 or 192 memory sockets, respectively.

**Big workload options**

Data center managers typically refresh four- to eight-socket business-critical systems every five years. The E7 v3 will potentially replace Intel Xeon 7400-
based servers and IBM Power servers for these workloads. Intel estimates, for example, that one rack of E7 v3 servers will replace 10 racks of 7400-series Xeons circa-2010 for OLTP workloads.

Enterprises also compare Intel E7 v3 with IBM POWER8 servers. The high-end E7 v3 provides roughly equivalent performance to the POWER8 system, according to as-yet-unpublished Intel benchmarking, at about 10 times lower total cost of ownership, factoring in initial CapEx, power and cooling expenses, and software plus support licenses.

IBM optimized two POWER8 configurations for SAP HANA, which should compete well with a loaded E7 8000 series server. Benchmarks are not yet available from IBM for the systems, which use 24 cores and 1 TB of memory and 40 cores and 2 TB memory, respectively.

The E7 v3 processor core

Intel E7 v3 models sport up to 18 cores sharing 45 MB of last-level cache. This completes Intel's migration to the Haswell architecture. The processor adds features to improve memory performance, power management and I/O throughput. It also includes new transaction-related and crypto-acceleration features, better memory performance on DDR4, and system resiliency from Run Sure and MCA/machine check.
Software licenses, as for OLTP with high fees per core, sometimes cost much more than the underlying hardware. The E7s have segment-optimized processors, which trade off core count for CPU frequency and/or power budget.

Big, consolidated systems running big data applications will make use of a set of reliability, availability and serviceability features. Features include memory mirroring and sparing, recovery from parity errors with DDR4 memory and circuitry that allows firmware to intercept and handle corrected and uncorrected error events.

The E7 v3 enhances transaction throughput via additions and updates to Intel's transaction extensions (TSX) that speed multithreaded database applications using hardware lock elision. A base set of TSX functions were included with the E5 v3 processors, but later disabled due to unspecified bugs. The Haswell E7 fixes and improves the TSX feature set and enables fine-grain locking performance using coarse-grain code. This provides up to six times greater OLTP throughput on workloads such as SAP HANA.

**Flash in the pan**

Creative new flash memory system designs and processor interfaces may mitigate demand for Intel E7 v3 high-memory, scale-up systems.

In-memory databases offer the requisite performance for analytics workloads operating on large data sets -- at a hefty cost. A 1 TB system, using 16GB
DDR4 server DIMMs that run about $200 each, boasts $13,000 of RAM. In contrast, a 960 GB enterprise solid-state drive costs less than $700. This 17:1 price difference is the driving force behind innovative new flash storage designs and interfaces.

IBM uses a high-speed, low-latency CAPI interface to its POWER processors, which makes flash look and perform like internal RAM. At the OpenPOWER Summit 2015, Redis Labs showed comparative results from a large NoSQL app: A system with 90% CAPI flash provided virtually identical performance (200,000 IOPS, sub-millisecond latency) to a 100% in-memory database. It is more than 70% cheaper.

At EMC World 2015, EMC demonstrated a DSSD rack-scale PCIe flash product executing Hadoop queries for a typical analytical app. On synthetic performance benchmarks, the flash array nearly matched native RAM speeds.

**AMD plans data center takeover with x86 chips**

Data center server buyers will soon have a new choice for software-defined and high-performance data analysis workloads, as AMD plans a return to x86 server prominence.
Advanced Micro Devices (AMD) is betting on enterprise and hyperscale IT demand for a choice beyond Intel CPUs. By 2017-2018, AMD's roadmap is to gain customers in enterprise and customized large-scale -- such as cloud service provider -- data centers.

"Server users and OEMs want an alternative to Intel, if only to put competitive pressure on Intel for technology innovation," said Nathan Brookwood, research fellow at Insight 64 in Saratoga, Calif. AMD is the only company other than Intel and Via Technologies that can legally build x86 processors.

The share of data center servers based on AMD chips has shrunk considerably since the company once held about a quarter of that space. In 2006, AMD estimated its server processor market share in the high 20% range. By 2013, analyst firm Gartner put it in single digits.

Analysts say AMD took some wrong turns with data center offerings, including a foray into the server business with SeaMicro that it will shutter in 2015, and a socket-compatible ARM and x86 design -- Skybridge -- that lacked enough end-user support to get off the ground. The company also failed to develop a roadmap that was competitive with Intel, which contributed to the Wintel (Intel-powered, Windows OS servers) domination in today's enterprises. "I don't see users abandoning Intel very quickly," said Charles King, principal analyst of Pund-IT in Hayward, Calif. "Intel has delivered on product innovation and has a clear roadmap ahead at least down to 10nm and probably below that."
AMD representatives also stressed that software and hardware partnerships will further develop its chip architectures. This is a call for openness that IBM also has pursued, by open-sourcing its Power chip architecture, King said.

**AMD's architectural roadmap**

Software-defined everything means that "the server has won," said Forrest Norrod, senior vice president and general manager of AMD's Enterprise, Embedded and Semi-Custom group. AMD will position its x86 and ARM architectures to replace proprietary hardware designs from storage and networking companies, to execute all the commands that were previously hard-wired into hardware.

Brookwood says AMD is in tune with the data center industry, tailoring its new architectures to support the software-defined era. In 2015, AMD will offer the Seattle ARM chip, Opteron A1100, for storage servers and a Hierofalcon ARM chip for embedded designs in networking. The ecosystem for A1100 includes software for Linux OSes, drivers, tool chains and software development kits.

AMD's Zen core microarchitecture for x86 servers will suit data center workloads, such as data analysis and visualization, as well as scalable apps, Norrod said. It targets high-performance computing with a secondary focus on energy efficiency. With simultaneous multi-threading and high-bandwidth memory to use a new cache system, the Zen architecture boasts a 40% improvement in instruction per clock over AMD's existing architecture,
Excavator, and high native I/O capacity. The architecture releases in 2016 with Opteron on Zen. It is designed to solve the problems that virtualization creates on standard hardware, like memory starvation, memory overcommit and so on.

"AMD needs to be in the same performance class [as Intel Xeon processors] to handle software-defined data centers," Brookwood said. He added that it is too soon to tell if AMD can create an architecture to match what's on Intel's roadmap for 2016. AMD declined to share technical details around Zen, but called Intel "a ruthless and strong competitor in x86," a lesson AMD learned all too well in the late 2000s.

The architecture may not be AMD's biggest challenge in the mature x86 server space, according to King, but rather getting server buyers to care about their architecture.

"AMD does have some very interesting technologies, and can blend CPU and GPU capabilities in ways that are very intriguing for higher-end, higher-performance workloads," King said, "But they're almost starting all over again [in x86 servers]."

K12, AMD's ARM high-performance core, will debut in 2017. The logic for Zen x86 chips will carry over into the K12 ARM design, designed to make AMD competitive in server designs without a lot of roadmap juggling when ARM interest picks up, Brookwood said. The K12 uses the 2014 ARM v8 chip architecture license and will go into new servers and embedded systems.
AMD's representatives admitted ARM hype cycles are nothing new to data centers, but expect 2017 to be a year of real adoption, which will trickle down from leading-edge IT companies into enterprises and small businesses as workloads are designed to use the alternative architecture.

"ARM will be important over time to the general purpose x86 server market," Norrod said. In the intermediate future, AMD will work to make x86 processors with the capacity to run software-defined data centers.

AMD also sees opportunity for graphic processing units (GPUs) and accelerated processing units (combining CPU and GPU) supporting workstation graphics from the data center and running high-performance computing applications. AMD's GPU developments include energy efficiency improvements, memory compression, graphics virtualization and high-bandwidth memory. High-bandwidth memory -- which stacks the memory on the chip -- uses less power and space on the motherboard than other GPU designs, according to company CTO Mark Papermaster.

These designs will rely on ARM Secure Processor and TrustZone for security, isolating and protecting applications and interfaces.

AMD also envisions its flexible chip design methodology -- which makes some processors more CPU heavy, adding GPU accelerators for other chips -- used in semi-custom hyperscale server designs tailored to the needs of the particular end user. For example, large cloud service providers may work with AMD to
create chips that get the most processing per Watt efficiency based on the workloads it runs. Cloud suppliers have very different needs than the traditional enterprise, Brookwood said, and AMD's semi-custom business has a track record in this area.

Why micro servers failed

Lisa Su, president and CEO of AMD, said that the SeaMicro business unit didn't allow AMD to add differentiation for data center users and that the micro server segment hasn't taken off as quickly as expected.

But the main problem with AMD systems may have been AMD's primary data center customers -- systems OEMs. By offering full servers, AMD competed against its customer base. It was "very tenuous" from the start, Brookwood said, with inherent problems.

Another issue with micro servers was that the processors communicated via a proprietary fabric rather than a standards-based technology like Ethernet, he added. As that held back user interest in micro servers, the SeaMicro experiment became more of a problem.

"We can't cover every space in [the data center]," AMD's Norrod said, "Our strategy isn't centered on broad design points with a general purpose." Instead, he said, AMD will target workloads that Intel will not or cannot effectively support, with innovations and customizations at the chip level.
In the toolbox

Benchmark testing tool choices

Benchmark testing establishes baseline performance expectations, tracks system performance over time, plans virtualization capacity and manages server resources and performance. Benchmarks identify potential performance problems and future capacity needs.

Make needs-based decisions around benchmarks

Selecting a benchmarking tool can be a daunting task because there are dozens of different tools available. Not only does Windows have its own built-in tool for benchmarking (Performance Monitor), but a quick Internet search reveals a wide array of third-party tools, ranging from freeware to expensive commercial products. So how do you know which tool to choose?

Believe it or not, product functionality is often irrelevant when choosing a benchmarking tool. After all, pretty much any of the available tools will tell you how hard your CPU is working or how fast your hard drive is (although it is always a good idea to make sure your tool of choice includes such basic
In this guide

Introduction
Select the right server
In the toolbox
Get useful benchmarks
A well-oiled machine
Getting more PRO+ exclusive content

The key to choosing a benchmarking tool is to look beyond the basics and decide whether or not a tool that you are considering will actually do the job that you need it to do.

Benchmarks and system compatibility

One of the first considerations that you need to take into account is system compatibility. It goes without saying that your tool of choice should work on the operating system that you're using, but there is more to it than that. For instance, you may discover that some older benchmarking tools do not work correctly on 64-bit servers.

And every once in a while, you may find that the tool's system requirements are a bit misleading. A few years ago, for example, I downloaded a freeware benchmarking tool that shall remain nameless. The minimum system requirements stated that you had to have Windows XP and a CD-RW drive. I needed to benchmark a computer that was running Windows XP, so I decided to give the tool a try. As it turned out, the tool wasn't actually designed for Windows XP. Instead, the download consisted of a bootable CD image. It was designed this way because the tool was intended to measure the system's raw capabilities from outside of Windows. As such, there was no way to use the tool to find out how well Windows was performing.

Benchmark's level of technical depth
Another important consideration is the level of technical depth that you require. Over the years, I have seen one or two tools that were so unbelievably complex that they ended up being completely useless to me. On the other hand, the Windows Experience Index is a built-in, consumer-oriented benchmarking tool that assesses various aspects of system performance on a scale from 1.0 to 7.9 (in Windows 7). Although the Windows Experience Index can give you a general idea of how well a system performs, it does not provide nearly enough technical information for it to be taken seriously by most IT pros.

You will find that most of the benchmarking tools on the market fall somewhere between the tools that I have just described. Even so, it is important to look closely at the level of technical depth that the tool actually provides, because some tools are geared more toward consumers while others are geared more toward engineers or IT professionals. Decide what kind of information you require and then verify that the tool actually provides those details in your specific environment.

**Benchmarks and scalability**

Do you need to benchmark one server or a thousand servers? Scalability will be another important factor to consider. The number of servers that you need to benchmark will weigh heavily on the type of benchmarking tool that you should purchase.
For instance, if you need to benchmark a large number of servers, then you probably don’t want to buy a tool that has to be manually installed on each server and that stores the benchmark data locally. A better tool for such environments would be a product that uses agents to send performance data to a central server, where the data is stored in a database. Such a tool would also likely include a central management and reporting console used to manage the data that is being collected. One possible example of such a tool is OpManager from ManageEngine.

On the other hand, if you only have two or three servers to benchmark, you probably don’t want to invest in an enterprise-class product like the one I just described. Such a tool is probably overkill for smaller environments, and the fact that it requires a dedicated server for collecting performance data may render this type of solution cost-prohibitive.

Benchmarks, virtualization and applications

Today, almost every organization uses virtual servers to at least some degree. What a lot of people don’t realize, however, is that it can be extremely difficult to find out how well a virtual server is actually performing. Time-slicing and hardware agnostics cause many of the conventional benchmarking tools to produce results that are way out in left field. Therefore, if you plan to benchmark virtual servers, it is critical for you to make sure that your benchmarking software is virtualization-aware. One free option for benchmarking virtual machines is VMmark from VMware.
Another factor to take into account is the type of benchmarking that you want to do. While there are dozens of general benchmarking tools available, some benchmarking tools are application-specific. For example, there are benchmarking tools that are specifically designed to monitor Exchange servers or SQL servers.

Keep in mind that you do not have to buy an application-specific benchmarking tool. There is no reason why you can't use a general benchmarking tool to monitor your Exchange servers, for example. However, application-specific tools often provide more insight than you can get with a general benchmarking tool. For example, a general benchmarking tool might be able to tell you how hard the volume containing an Exchange database is working, but it probably won't be able to monitor the number of database transactions per second.

Application-specific benchmarking tools are good for capacity planning and for alerting. For example, an Exchange-specific benchmarking tool might be able to alert you to a backup in a message queue (which would indicate mail flow issues), whereas a general tool would not have this capability. A tool like Microsoft's System Center Operations Manager is designed to monitor network servers using Performance Monitor counters. Once again, evaluate a variety of tools and select a product with the features and capabilities that best match your needs.

**Benchmark licensing**
One last consideration that you should take into account is the product’s licensing model. Benchmarking your servers could become cost-prohibitive if the product that you choose requires a separate license for each server. If you are going to use a commercial product, then ideally you should look for one that is licensed in a way that allows you to benchmark as many systems as you like. A perfect example of such a product is PerformanceTest from PassMark Software. If you have difficulty finding such a product, then at least be aware of the licensing costs before you make the purchase.

Look before you leap

Being that there are so many different benchmarking products on the market, it can be difficult to find one that is a good fit for your needs. Thankfully, many vendors offer free trial versions of their wares. Downloading and installing the trial version of a benchmarking product is well worth the effort because doing so will allow you to definitively determine whether or not the product in question will meet your needs before you commit to purchasing it.
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

Pick a server monitoring tool worthy of your data center

In complex modern data centers, performance monitoring is more important than ever, but finding the right server monitoring tool for the job can be a challenge.

Businesses rely on performance monitoring tools to ensure business productivity via application performance and uptime. Your server performance monitoring tool delivers important metrics on server and application performance levels, service levels, and even network issues that create bottlenecks. It also provides a centralized view of the data center's physical servers and virtual machines as well as devices and applications, enabling IT professionals to proactively address failures and improve the user experience.

But not all server monitoring tools are created equal. Some may have trouble measuring physical and virtual environments together; some may provide too much information or information that is too granular for data center managers to put to good use. Still others may not be cost-effective or provide only stripped-
down functionality. It's important for IT procurement managers to explore the range of tools and make informed decisions about which server monitor is right for their environment.

With the wide range of offerings and functionalities, choosing the best server performance monitoring tool can be a challenge. These four steps can lead the way to the right selection:

1. **Analyze your environment.** Start by analyzing your applications and the environment in which you run them. Most organizations have a significant on-premises footprint, so the ability to monitor hardware is important. On the other hand, public cloud computing and complex applications will be a part of every IT organization's future (if not its present), so defining requirements in light of extended functionality options also matters. Create a list of current and future performance monitoring requirements and use it to filter potential vendors.

2. **Define your budget.** Your tool options range from free to expensive, with functionality and ease of use likely to improve as costs increase. Examine your budget and estimate what you can invest in performance monitoring. Factor in the cost of any application downtime that could occur without the
right server monitoring tool. That calculation may free up some additional money.

3. **Choose your favored deployment option.** In the past, Software as a Service (SaaS) performance monitoring technologies offered less functionality than their on-premises counterparts. Today, that isn't necessarily true, so the deployment choice comes down to preference. Choosing one deployment option over another will filter out some products and simplify the decision-making process.

4. **Create a shortlist and perform a pilot.** It's almost a given that all products perform well in the vendor's tests and in demo situations, but some will operate differently in the real data center. Test-drive your top three choices. The tools will be difficult to fully deploy; instead, create a scaled-down application and apply each of your shortlisted performance monitoring tools to it. This will help you understand how they work and, critically, compare the monitoring tools' functionality and ease of use.

**Potential challenges**

As you move forward in the selection process, there are a couple of "gotchas" to consider:
• **Future-proof your selection.** Most companies will use public cloud computing, so any product you consider should fully support that transition, even if it isn’t on your short-term roadmap. Consider both today’s and tomorrow’s infrastructure environment.

• **Understand what you are paying for.** With so much competition in the performance-monitoring space, vendors may offer an introductory feature set at rock-bottom prices, holding back important functionality as part of pricey add-on modules. If you expect the full product suite, don’t budget for a base product with extended functionality only available with an additional purchase. For a SaaS server monitoring tool, understand the factors that affect pricing: the number of applications monitored, the number of user accounts registered, the number of components being connected and so forth.

• **Prepare for employee training.** Even if a vendor strives to make its product easy to use, the reality is that complex applications require more complex monitoring tools. Your staff will encounter a learning curve with whatever performance monitoring product you select. Invest in training and you’ll reap the benefits of monitoring as quickly as possible.
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

Ensure adequate virtualization capacity

Virtualization administrators must strike a delicate balance between achieving the highest practical virtual machine density and ensuring that each virtual machine delivers an acceptable level of performance. This balance is not always easy to attain, but it is easy to determine why VM performance might be suffering. Take a look at five of the most common causes of performance bottlenecks.

Hardware resource contention

You can trace the vast majority of VM performance problems to hardware resource contention. The basic idea behind server virtualization is treating the host server's physical hardware as a pool of resources that can be shared among multiple virtual machines. VMs compete for these resources, and performance problems result from resources stretched too thin.

Hardware emulation

When a VM experiences performance problems, you should first make sure that it is not using hardware emulation. Ideally, you should assign physical hardware resources to a VM; however, hypervisors such as Microsoft Hyper-V and VMware vSphere provide emulation features that offer support for older operating systems.
VMware and Hyper-V also offer a collection of services that allow the hypervisor to interact with guest operating systems. In VMware, this collection of services is known as VMware Tools, while Microsoft calls these services Hyper-V Integration Services. Though not directly related to VM performance, performance may suffer if a VM does not have either service installed or if it runs the wrong version.

**Disk I/O**

Resource contention-related performance problems often result from disk I/O complications. In my experience, issues have occurred when numerous VMs were configured to share a common storage array, but collectively, the virtual machines required a higher rate of disk I/O than the storage array could deliver.

Reducing the storage I/O burden might mean purchasing a higher-performance storage array or limiting the number of VMs sharing the array. In some cases, this might not seem like a tall order, but the following two aspects of virtual server storage are easy to overlook.

**Virtual server clustering**

Production VMs are almost always part of a cluster. Both VMware and Microsoft used to require that cluster nodes be connected to a shared storage device. As such, you may be inclined to assume that the cluster's limitations are directly tied to the Cluster Shared Volume's limitations. Hyper-V clusters, however, can...
be attached to multiple Cluster Shared Volumes, which means a single storage array does not have to support the entire cluster. Windows Server 2012 Hyper-V completely eliminates the need for a Cluster Shared Volume, but Microsoft still recommends using one when possible.

The other easy-to-overlook part of virtual server storage is that you are not limited to a single host server cluster. VMware environments commonly have multiple clusters as a way to isolate workloads and reduce resource contention.

In addition to storage I/O, memory, CPU cores and network bandwidth can also cause hardware resource contention. By using performance monitoring, you can determine the specific cause of the bottleneck.

**Incorrect configurations**

Issues related to hardware emulation and resource contention are the most common causes of virtual server performance problems, but they have company in that category. Simple configuration issues can also cause major performance issues.

A few months ago, I encountered a virtualized Exchange 2010 mailbox server that was painfully slow to the point of being unusable. The virtual server took 10 to 20 seconds to respond to a simple mouse click.

In this case, the VM’s virtual network adapter had accidentally been connected to the wrong virtual switch, which connected it to the wrong virtual network.
Exchange Server was then unable to contact a domain controller. Exchange mailbox servers depend strongly on the Active Directory, and its absence led to the performance problems.

Kick the tires on cloud servers too

What's not to like about cloud servers? Deploying a cloud server means there's no more hardware to buy, you can choose the best server size for your needs and you can pay as you go for use. So, what's the problem? Well, only the first of these statements -- no more hardware -- is universally true.

It's important to first carefully compare cloud servers on three points before looking at the performance metrics of the cloud provider choices on your short list.

- How fast is the cloud server's vCPU?
- How quickly do memory and disk respond?
- What is the actual network throughput?

Cloud servers are all "virtual" servers that run on the same physical hardware as physical servers. Virtual server platforms allow administrators to provision
servers by specifying the CPU, memory and disk characteristics those systems will have when each is brought online.

Naturally, cloud providers offer systems that are different "sizes" with regard to power and price. Offerings typically have two key dimensions: CPU and memory. For a basic orientation, it is safe to think of "small" as 1 vCPU and 2 GB of RAM allocated, "medium" as 2 vCPUs and 4 GB of RAM, and "large" as 4 vCPUs and 8 GB of RAM.

Several vendors offer similar technologies, but just use slightly different terminology. For example, Amazon Web Services' price/performance model is based on what it calls the "EC2 Compute Unit." Amazon defines it this way: "One EC2 Compute Unit (ECU) provides the equivalent CPU capacity of a 1.0- to 1.2-GHz 2007 Opteron or 2007 Xeon processor."

For the sake of professional sanity, think of a single ECU as being the equivalent of a single vCPU from other cloud server vendors. Therefore, two ECUs would equal 2 vCPUs from other vendors.

In addition to vCPU and RAM, cloud server providers will also specify the amount of disk capacity available on each server, though the capacity varies too dramatically to make any generalizations. Provisioning additional disks is a standard option as different applications and users can have dramatically different disk requirements.
While every server will have network connectivity, cloud service providers differ on how (or if) they advertise the network bandwidth available to cloud servers of different sizes. You can most likely expect to see a Gigabit Ethernet connection specified.

Remember: All of this is virtual. The virtualized hardware interacts with the cloud server OS in the same way that real hardware does; however, it does not necessarily deliver the same performance as it would if the OS were running on the physical hardware.

Cloud server vendors make provisioning decisions about how many virtual servers to run on a physical server, as well as how many real CPUs and memory that physical server should have. These decisions directly affect their bottom line and your end users' applications' performance.

**Measuring up cloud service providers**

After comparing cloud servers on these three criteria, you're ready to evaluate performance benchmark tests. And there are several ways to benchmark cloud server performance.

One way to benchmark CPU, RAM and disk use (among other things) is through a third-party tool. The open source Phoronix Test Suite (PTS), for example, runs on all major OS platforms -- including Windows and Linux.
While the selection of available tests PTS offers is so vast it can be mind-boggling, a basic installation includes some core tests of CPU, RAM and local file services. The C-Ray benchmark is a compute-intensive benchmark for CPU. The RAMSpeed benchmark stresses the memory/RAM operation, and PostMark exercises the file performance of the local server disk. These tools can quickly show the differences between various vendor offerings.

If your cloud server supports external clients -- either in the same cloud data center or across the Internet -- you will be driving the Ethernet adapter. You'll want to know how much actual throughput you can expect from your virtual adapter.

One way to determine this is to use Iperf, another open source benchmarking tool that's hosted at Google Code. Combining PTS and Iperf gives enterprises a straightforward way to benchmark the essential elements of a cloud server.

Because cloud servers allow you to pay as you go, booting the server turns on the meter. When you don't need the server, which may be the case in a test-and-development scenario, shut it down and stop the clock. With some cloud service providers, however, this may not be the case.
An example of server chassis benchmarks

Buying a chassis server once meant you were buying a server that slotted into a chassis. That's no longer the case.

A chassis server commits its user to the physical, plug-in architecture of a particular server vendor. In recent years, vendors have broadened this scope to include network communication architecture.

Chassis computing lets network designers and architects think with respect to how servers communicate with one another and with other communication partners in the network. Today's chassis servers from Cisco Systems and IBM/Lenovo come bundled with each vendor's server networking architecture. Buy vendor X's server chassis and server blades, and you get vendor X's networking architecture -- like it or not.

A server blade has two communication requirements: intra-chassis communication -- with another system in the same chassis -- or extra-chassis communication -- with a system located in another chassis.
Servers conduct north/south traffic out of and into the chassis through a top-of-rack (ToR) switch, which essentially works like a traditional local-area network switch, but services a rack of servers. Conversely, east/west traffic goes between server blades in the same chassis.

The differences in network connections across vendors are hardly trivial. Cisco and IBM's choices in their architectural blueprints lead to dramatic differences in theoretical network performance over the architecture's lifetime, as well as practical differences in network performance of current-generation chassis servers.

All together now

Cisco UCS chassis servers handle both types of traffic in the same way, while IBM treats each traffic pattern differently.

Cisco's UCS switch network architecture is switch-centric, unsurprising for a company that grew in the switch industry. Like everything else, architecture is political and technical, and one can assume Cisco's switch group holds great sway over designs.
Any server that needs to communicate to any partner system via the network sends packets through the ToR switch. Whether a blade server needs to communicate with a client across the globe, a server in another chassis, or a server in the adjacent slot one inch away (up to 8 per chassis), the information travels north/south.

With IBM’s Flex System design, network traffic between a server and a partner outside the chassis (north/south) travels through a ToR switch, similar to Cisco’s architecture. However, in Flex Systems, switching capacity is built into the chassis for traffic that originates and terminates in a single chassis (east/west across up to 14 blade servers). For intra-chassis communication, no traffic leaves to transit the ToR switch.

Since the study of the IBM and Cisco server architectures upon which this article is based*, Lenovo acquired the IBM Flex System chassis server line.

**Scalable server architecture**

How a chassis server handles network communications has significant ramifications on bandwidth available for applications and, ultimately, system performance.
IBM commissioned Tolly to benchmark VMware vMotion (the migration of a running virtual machine from one physical host server to another) scenarios on the Cisco UCS servers and IBM's Flex System chassis.

To benchmark total network capacity to blades within the same chassis, the tests used Cisco's highest capacity switch available -- the 6296UP ToR switch -- with Cisco's fabric extender 2208XP FEX modules to communicate with the switch.

A single Cisco 2208 FEX module provides 80 Gbps of bandwidth between the fabric and ToR switch. A single chassis can run with two FEX modules maximum, enabling 160 Gbps between a UCS chassis and the ToR switch.

To benchmark the network capacity of the IBM chassis, Tolly engineers loaded up servers with traffic generation software that rang across servers in the same chassis. Tolly measured 438 Gbps of network traffic (with zero load on the ToR switch due to the chassis architecture). Theoretically, the IBM chassis server offers 2.7 times higher maximum capacity.

To test the real-world application impact of chassis server architecture, the engineers increased the background traffic and measured the time required to
complete a VMware vMotion server migration task. The Flex System showed faster completion, including no competing traffic.

When background traffic increased to the maximum, modeling what an application might encounter in a busy data center, the differences were even more significant.

With Cisco, the maximum background traffic achieved to and from the Cisco UCS chassis was 90.3 Gbps; the IBM Flex System handled 438 Gbps. When run at these levels, IBM completed the VMware migration of nine virtual machines (one vApp tile) in 39 seconds, while Cisco required 99 seconds -- about 2.5 times more time.

**Specifying servers**

Architecture matters in the real world, so understand the benefits and limitations of whatever systems you choose for your organization.

From a networking perspective, IBM's chassis design provides dramatically more bandwidth (and demonstrable performance benefits) for traffic that moves between colocation blades. If applications demand intra-chassis networking performance, then the choice is clear.
IBM's off-chassis networking is the same as Cisco's, in that traffic also passes through the ToR switch.

Of course, there are other reasons to choose one vendor over another that are unrelated to network scalability. If you are running a data center where the chassis servers' bandwidth limits are not stressed, then the potential benefits may be of less importance than vendor streamlining or other factors. For example, e-commerce transactions typically have low bandwidth demands. In a 100% Cisco shop running this type of application, bandwidth limitations are trivial compared to training or licensing costs.
Get useful benchmarks

Benchmark testing strategies, best practices

When conducted properly and consistently, good benchmark testing can provide valuable information that admins can use to improve server performance.

Benchmark tests for a specific workload

Today's servers come in a variety of flavors, performance levels and prices, but figuring out value to your specific operations poses a difficult question for admins.

A challenge for any data center administrator is figuring the return on investment on a server. Will a 16-core server run my application fast enough to justify the steep price compared to fewer-core models?

This is a tough question. A server's performance isn't just driven by core count and gigahertz: Memory size, cache size and disk I/O have a major influence on performance, as does network speed in many use cases. A server benchmark
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

In this guide

enables better side-by-side comparisons of real-world performance than datasheets from competitive vendors.

Assuming we know what we need to benchmark -- usually an existing application used by the business -- the hard part is finding a server to run tests on.

The first step is to check if you need to run your own server benchmark. Software vendors, especially in high-performance computing, like to know what their applications can achieve in terms of performance, and may already recommend server configurations complete with benchmark results.

For popular apps, the server vendor may already have a set of numbers from its own benchmarking lab. Compare these results from as evenly matched benchmark tests on competitive systems as possible. On most x64 machines, the processors derive from the same Intel/AMD reference design, so the same configuration benchmarks almost identically. In this case, the benchmark can come from a different server vendor than the one with the best deal.

Without vendor benchmarks, you need to get a server or cluster. The vendor might provide a loaner system for benchmark tests if your total purchase is priced high for a low volume of systems, such as a server loaded with solid-state direct-attached storage. If you're buying just a handful of average-cost servers, consider calling upon a long-standing relationship with the vendor or their channel representative.
Beyond a physical machine to benchmark, the cloud is an obvious place to look. High-core count instances are hard to find on cloud hosts, and the likelihood of finding the exact server model that you want to buy is low. If current-generation machines that are close to your prospective purchase are available as cloud instances, use one of those and extrapolate from the results. For example, Nvidia’s GPU instances are available as a service.

**Skip the mistakes**

Even numerous commercial products, your server benchmarking results are only going to be valid if you adhere to some recommended best practices. Let’s take this opportunity to talk about some common benchmarking mistakes and how those mistakes can affect the results.

**Benchmarks must test the right elements**

Early in my IT career, I took a Microsoft certification class where the instructor taught me a lesson that I will never forget. The class had just spent the better part of the morning learning about the Performance Monitor and all of the various counters that come with it. After lunch, the instructor informed us that he had just connected some client computers to each of our lab servers, and that
our job was to use the Performance Monitor to find out if the end users were experiencing an acceptable level of performance.

Putting my new knowledge to work, I used Performance Monitor to check for various hardware bottlenecks. I diligently checked the CPU, disk and memory performance before concluding that the load that the end users were placing on the server was indeed acceptable.

The problem was that my benchmarking was right, but I was looking at the wrong thing. I concluded that the server load was acceptable when the original question was whether or not the end-user experience was acceptable. While those questions may sound like one in the same, they had very different outcomes. The end-user experience was unacceptable because of a network bottleneck that would have been undetectable from the server. Had I taken the time to actually benchmark a client machine instead of only checking the server, I would have known that. The lesson was that benchmarking tools can provide valuable information, but the information only helps you if you use the benchmarking tool in the appropriate manner.

Don't mix server benchmarking tools
Of course there is more to benchmarking than just knowing what to measure. Being consistent with the way that you take your measurements is equally important.

Imagine, for example, that your boss tells you the data drive on a file server has historically had a disk utilization of 97% during business hours (which is way too high). In order to alleviate some of the stress on the server, the organization has recently implemented an identical file server. The data is being replicated across both servers, and a load-balancing solution was put in place to distribute user requests evenly across the two servers. The IT department has invested quite a bit of money in this new solution and now your boss is being asked by upper management to quantify the project's success. Consequently, you are asked to benchmark both servers to find out how heavily the disk is being utilized.

This is where the need for consistency comes into play. There are dozens of server benchmarking tools that could tell you how heavily the server’s disk is being used (including Performance Monitor, which is built into Windows). The problem is that the odds of any two of these tools giving you exactly the same results are slim.
There is a law of science that states that you cannot measure something without affecting it to some degree. This law was originally created for physics and chemistry, but it also applies to computer benchmarking. Any benchmarking tool -- no matter how efficient it is -- places some load on the system being tested. This load skews the results that are reported by the tool because the tool includes its own impact on the system within the reported benchmark data. This is why consistency is so important.

So consider the file server described above and imagine what might happen if you chose a random server benchmarking tool that wrote performance data to disk in real time. Such a tool would increase the server's disk usage (while the tool is running), thus skewing the results. If the tool had a big enough impact on the server's disk resources or if it used a different algorithm to measure the disk utilization, it could potentially report that the disk utilization has gone up, not down. If that happened, then management would likely interpret the result as the project being a colossal failure rather than just a reporting error.

In a situation like this, the only way to get reliable results is to find out which server benchmarking tool was used to take the original measurements and use that same tool. You will notice that I used the phrase "reliable results," not "accurate results." That's because every benchmarking tool will give you results
that are skewed based on the tool's overhead. What is important, however, is to be consistent in the tools that you use so that each measurement is skewed by the same amount.

**Use server benchmarking tools consistently**

Of course, being consistent in your tool selection alone does not guarantee reliable results. You must also be sure that you are consistently using the tool in the same way. For example, if you take one set of measurements during peak hours and another set of measurements during off-peak hours, you will probably get very different results even if you use the same tool for both measurements. Likewise, if you change the server benchmarking tool's sampling frequency or alter various aspects of the system's performance from one measurement to the next, you are changing the amount of overhead that the benchmarking tool places on the system, thereby impacting the results.

**Use virtualization-aware server benchmarking tools**

One last best practice is to distinguish between physical and virtual servers in your benchmarking reports. Due to the way that hardware calls are passed through the hypervisor, accurately benchmarking a virtual server can be
extremely difficult. There are products on the market that are specifically designed for virtual server benchmarking, such as VMmark or VMbench. The problem is that these specific tools are designed specifically for virtual machines, and aren't really appropriate for benchmarking physical servers. Tools such as Windows Performance Monitor can benchmark both physical and virtual servers, but you are likely to see wildly different results from a virtual server than from a comparably configured physical server. For right now there really isn't anything that you can do about this discrepancy other than to be aware of it, and to classify physical and virtual machines separately in your server benchmarking reports.

**Conclusion**

There are a number of different factors and common oversights that can affect the accuracy of server benchmarking. Because these factors can be difficult or impossible to eliminate, it is critically important to perform benchmarking in a consistent manner. In other words, you should use the same server benchmarking tool each time and make sure that the tool is configured the same way each time you use it. You should also try to take measurements at the same time of day or load conditions if possible, since the load that the end users are placing on the server will affect the accuracy of your results.
Four benchmarking guidelines

Server benchmark testing succeeds or fails on the IT staff's approach to the process.

IT professionals have always relied on benchmarks to gauge performance in the data center. But server benchmarks are only as accurate as the people who use them and the measurement circumstances. Too often, the wrong benchmarks are deployed, they don't reflect real operating conditions, or they are deployed carelessly or for the wrong reasons. Follow these five key steps when working with server benchmarks.

1. Lay out your server benchmark goals

Though you can evaluate diverse operating parameters, this kind of comprehensive benchmark process is time-consuming for an IT staff already burdened with heavy workloads and tight budgets.

Administrators must first recognize the problem they want to solve. It may be as simple as verifying a vendor's performance claims before purchasing a next-generation server, looking for underutilized system resources to consolidate, or
even grappling with a suspected performance problem. With a clear goal in mind, you'll know what parameters to measure -- the CPU utilization may be interesting, but offers little value to resolve an issue with network I/O, for example.

2. Identify the right benchmarking tool

There are many server benchmark tools on the market, and each typically does a very specific job. Once you determine the parameters to benchmark, focus on selecting a tool that will best measure what you need to know.

The Standard Performance Evaluation Corporation (SPEC) produces a range of benchmarks routinely used in IT environments. For example, SPEC CPU2006 measures the performance of compute-intensive workloads, while SPECjbb2013 benchmarks Java application performance. Use the latest version of the appropriate benchmark to ensure current hardware is identified and measured accurately.

As a rule, avoid vendor-provided server benchmarking tools due to vendor bias; you can hardly be surprised if a benchmark tool from "vendor X" reports their server is better.
3. Perform server benchmark testing under real load conditions

Benchmarks only provide accurate information when the server is running under actual load conditions. It isn't always possible to deploy a benchmark in a working production server. Instead, benchmarks are often run in a test-and-development or other simulated environment that may not properly mimic CPU, workload, storage and network traffic patterns.

A classic case is benchmarking a CPU that isn't running any workloads other than the OS and benchmark. Of course it will have plenty of spare capacity then. Many organizations with formal server benchmarking processes in place use a test setup that includes transaction scripting or load generators to simulate real working conditions. Performance can be affected by factors like load balancing and even the placement of data on disks, so IT professionals must consider every element of the server's deployment when acquiring benchmark data.

4. Test under varied time and usage conditions

Most data center servers don't maintain a constant load. A Web server workload may see more network and disk access usage during business hours, while a
payroll application may only be used for a few days each month. This means a single point-in-time snapshot of the server's performance is not an accurate picture. Run the benchmark continuously or run several tests as workload conditions change. This helps identify conditions that cause unexpectedly poor performance, as well as opportunities for improvement via upgrades or workload rebalancing.

5. Document test conditions and be consistent

Lack of documentation is a major oversight in server benchmark testing -- especially not recording test setups and load conditions. Without established parameters test-to-test, you can have unexpected differences between results when testing different systems or when testing the same system multiple times. By documenting the test setup, scripts, load generator data sets and other factors, administrators can achieve more repeatable, objective results. Reviewing the documentation can also help validate benchmark results.

Server benchmarks allow data center administrators to measure key attributes of system performance, make informed evaluations of performance over time, and compare different servers. Most benchmark tools are quickly and easily deployed, but meaningful results will depend on a goal or goals, selecting the
right tools, testing under real load conditions (or as close as possible) and over a period of time, and maintaining copious documentation for future reference and validation.

Integrate performance troubleshooting

Compatibility planning and proper use of APIs simplify IT infrastructure monitoring and management tool integration projects.

Data center operators idealize the "single pane of glass" that promises ubiquitous management across the IT infrastructure. Most IT organizations are heterogeneous facilities with a mix of hardware and software, and use multiple tools for monitoring, management and system troubleshooting. These tools are not necessarily designed to work together; interoperability requires costly and time-consuming initiatives.

Set integration goals

Establish the scope of integration early on. If you go into a project looking for that vendor-promised single pane of glass, you'll be disappointed. Start with a reasonable goal: What data, views, logs or other output do you need to
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

Integrate? Resist the temptation to expand and tinker with the project scope as you discover new ways to access and import data from other tools. "Scope creep" delays and complicates integration. Instead, open a new project once the first one has been completed successfully.

Investigate each tool's source data. Knowing whether source data is available as comma separated values, a busy SQL database or some other format will make it easier to implement the right mechanism to locate and import the data into another IT infrastructure monitoring tool. Proprietary data sources are difficult to access and import without APIs or vendor-specific plug-ins.

Understand native compatibility

If your monitoring tool is designed for broad integration, it will handle many different data sources and tools. Nagios XI, for example, can gather information from systems across the enterprise through outside email alerts, simple network management protocol (SNMP) messaging, wizards, agents, components and plug-ins.

This flexibility enables a high level of integration with many tools, applications and systems in the data center. Using agents, it can monitor Windows, Solaris,
In this guide

- Introduction
- Select the right server
- In the toolbox
- Get useful benchmarks
- A well-oiled machine
- Getting more PRO+ exclusive content

Linux, AIX or other desktop and server OSes. Downloadable plug-ins grab data on applications like Apache Tomcat. Widgets like the Nagios Exchange dashlets show traffic reports or other specific information in the interface. Components offer optional extensions to handle new notifications, interface improvements and other features. One popular component is the Active Directory Integration that allows AD to act as an authentication source for Nagios.

Tools, such as open source Zabbix, also collect data by using agents. A native Zabbix agent runs on Linux, Windows and UNIX, collecting details on processor, memory, storage and I/O use. Zabbix natively supports text logs, so it gathers real-time Windows server information via the Windows Event Log and Windows Management Instrumentation. SNMP agents monitor almost any device on the network: uninterruptible power supply systems, printers, network attached storage arrays and so on. An Intelligent Platform Management Interface agent allows Zabbix to gather server processor temperatures, fan speeds, operating voltages and more. The tool also collects data from databases like SQL Server or MySQL, and can use custom scripts when needed.

Use API and SDK features
Software developers typically provide a rich suite of API routines that other software can access. For example, Amazon Web Services' APIs give developers precise control over Elastic Compute Cloud and Virtual Private Cloud services. Nagios supports a range of add-on APIs for file systems, scripting and protocols. Similarly, software development kits (SDKs) supply templates to use those outside services or application APIs.

Infrastructure monitoring tools that come with APIs and SDKs allow sophisticated and efficient integration between platforms. APIs also let developers apply complex rule sets to a large number of devices, which isn't practical through the regular interface. Some APIs enable two-way sharing between tools in the data center infrastructure monitoring ecosystem.

APIs and SDKs require expertise to develop and maintain any code for tool integration. The required skill set might have to come from software development staff or outside consultants.
A well-oiled machine

Optimize server performance

Fine-tuning server configurations and eliminating bottlenecks can lead to substantial performance gains with minimal expense. Ensuring that systems are set up correctly is especially important with virtualized infrastructures. Performance options sometimes come with trade-offs, such as cooling problems or increased energy consumption.

Tune servers for virtualization success

IT professionals often use sophisticated tools to monitor and report virtual server performance, ensuring that the appropriate computing resources are provisioned to each workload and verifying that each system is operating within established parameters. But just because a hardware platform is running properly is no guarantee that the workloads on that platform are delivering an adequate level of service to users. As businesses gain greater appreciation for the importance of each application the focus is slowly shifting from systems management to service management.

The importance of application performance management
Application performance management is an emerging data center discipline designed to ensure that workloads are delivering an appropriate level of performance to end users and to assist IT professionals in diagnosing the causes of workload performance issues.

Application performance management (sometimes called business service management or monitoring) is based on the realization that system hardware performance is relatively easy to monitor, but hardware performance does not always translate to workload performance. The server may have the proper resources, yet workloads may still experience bottlenecks, conflict with one another or otherwise under perform.

The result is a poor user experience, which can lead to diminished productivity and work quality, lost sales opportunities or unnecessary support calls.

Application performance management helps IT professionals understand the behaviors of each enterprise workload and the way those workloads interact across data center servers, storage and networking infrastructures.

**Pinpointing problems in a virtual data center**

Before virtualization, it was relatively simple to troubleshoot application problems on the corresponding server. In most cases, admins could resolve the problem by reconfiguring, upgrading or patching the server.
Unfortunately, virtualization produced an entirely new layer of complexity to application performance. It is certainly beneficial to improve a server’s utilization by running multiple workloads, but shared hardware resources can sometimes result in unforeseen consequences that affect workload performance in unexpected ways.

As an example, suppose a database server and media server share the same physical host server. There are ample resources on the server to handle the requirements of both workloads, and under normal use patterns, both workloads deliver adequate performance. Now suppose that from time to time, users report poor performance in database queries. IT technicians will typically act on those complaints by inspecting the database server VM, expecting to find a configuration change or resource shortage. But the database server checks out. The only glitch appears to be heavy local disk activity during periods of slow database performance, but the disk activity is not related to the database VM. However, another technician realizes that the company just posted video of a new product line, and additional investigation shows that the media server VM was servicing heavy requests for streaming video during periods of poor database response.

In this example, even though the database server VM was experiencing user performance problems, it was caused by spikes in activity from the local media server VM. Thus, the performance of one VM can have an adverse effect on another local VM. Virtualization can complicate root cause troubleshooting...
because VMs can easily be migrated (and resources adjusted) without regard for other workloads on a particular system. In order to troubleshoot such problems effectively, IT professionals need business service management tools that can identify the physical locations of VMs and the applications running within each VM.

**Diagnostic capabilities for application performance management**

Examples of workload performance monitoring tools include ManageEngine's Applications Manager, Dell's Foglight, BMC Software's Application Performance Management and APM from IBM. But, regardless of the product choice, the next generation of virtual machine (VM) performance monitoring and management tools must offer an intelligent and holistic view of the virtualized environment that reaches to endpoint devices.

For example, tools must allow IT staff to see the entire virtual infrastructure overlaid on the physical systems. Tools must also track the computing resources each VM uses against automatic performance baselines and report any performance problems before they affect workload performance. This combination of features allows tools to correlate cause-and-effect behaviors between multiple workloads to allow for better root cause problem analysis. It's a major challenge, but it will emerge as an important step in data center development.
From a value perspective, better tools with root cause analytical capabilities can potentially recover the deployment cost by saving unnecessary expenses. For example, an IT technician unable to examine the behavior relationships between VMs can waste considerable time trying to correct workload problems by migrating VMs, upgrading servers, replacing servers or reallocating resources. While those tactics might alleviate the immediate problem, it does not address the underlying cause nor prevent subsequent problems.

The goal of business IT is to provide services to employees, partners and customers of the business. Ensuring that every workload is available and providing adequate user performance will be a vital part of tomorrow’s data center management. The proper tools not only prevent user problems before they start, but can also speed troubleshooting when VM interactions cause unexpected problems for workloads that are otherwise configured and operating properly. Application performance monitoring tools are available, but the features and functionality are still evolving to provide better insight and decision-making information to IT professionals.
Perfect benchmarks, but poor performance?

Within the data center, there still may be several hops between the user and the application. Even with an infinite number of servers with unlimited capacity, an intelligent decision is still required to determine where traffic should be directed and thus reduce application performance problems. This is the task for load balancers (and their slightly pretentious cousins, application delivery controllers).

Load balancers provide a couple of very useful functions. They can transparently balance traffic across multiple servers to ensure a request is served by the most available server -- the one best able to respond to the request. Even relatively basic load balancers have a major impact on performance by offloading tasks such as Transmission Control Protocol (TCP) handshaking and secure socket layer/transport layer security encryption from the application servers. This is important as it removes CPU load from the target onto a dedicated, lightweight system optimized for high throughput. Load balancers equipped with dedicated silicon can further offload processor-intensive tasks and yield lower latency than software or virtualized platforms. If you are not counting every millisecond of latency, virtualized load balancers can offer greater flexibility since you can spin them up and down with the virtual machines that support them.
Application delivery controllers (ADCs) differ from load balancers in the same way that cars differ from sport cars; performance and features are irrelevant unless they are driven (deployed) optimally. The key difference between an ADC and a load balancer is centered about advanced Layer 7 controls. Web applications suffer particularly badly under the effects of latency, and application delivery controllers use several techniques to address this. For example, HTTP compression and caching optimization can save precious bytes on every HTML object and further remove load from the servers. Optimizing how objects are loaded on end users' devices also improves users' experiences, especially when users are in low-bandwidth or high-latency scenarios.

Maximizing server performance helps diagnose application performance problems

Many features can cause poor server performance. Issues with CPU and RAM use, network interface bandwidth, disk latency and queue lengths are all relatively easy to diagnose and even easier to fix. (The answer is usually "throw money at it.") Additionally, servers that are apparently idle may still display the symptoms of poor application performance; there are many small details which can impact performance that are not visible to the naked eye.

Some classic examples:

1. Broken domain name system resolution causing forward and reverse lookup to timeout or otherwise fail.
2. Incorrect duplex/speed negotiated between client and server. This is reflected where traffic is faster in one direction by an order of magnitude.

3. Disk(s) failed in a striped RAID array.

When the application itself causes the problem

For most network administrators, the responsibility for the application stops at the TCP socket; this makes application issues difficult to diagnose. Tools from ExtraHop Networks and SolarWinds, among other vendors, can shine a light into most applications, but the reality is you may need to roll up your sleeves and start digging to find the root cause. Assuming there are genuinely no resource issues and the host network is apparently healthy, it's time to sit down with the application team to understand what is happening when a user hits "submit."

The number of traffic flows that are spawned by an apparently simple application will amaze you. Furthermore, you may reach the moment where you'll need to acknowledge that the application is as well optimized as a dog on roller skates. Depending on what you find, you may have to shift some network components around to improve the user experience. Moving databases to the correct side of WAN links, optimizing firewall policies to support long sessions and increasing the capacity of uplinks all may have an impact, even if none of the other areas have.
Ultimately, your response to application performance problems will differ according to the root cause. For any resolution to be effective, you must fully understand what's going on. By following this strategy, when money does need to be spent, it can be spent wisely.

After all is said and done, poor performance may well be a series of small issues that have combined to create a bigger one. In addition, fixing one issue may reveal another; removing a CPU bottleneck may immediately reveal another problem on the disk I/O subsystem.

The moral of this story is that managing application performance is a continuous process, not another black box that you plug into your network. To get the best from your applications and to positively impact the user experience, be cognizant of each end-to-end process involved in your business applications. In my experience -- outside of very latency-sensitive operations like high-frequency market trading -- very few organizations truly realize how their applications are screwed together and where the pitfalls may lie. I've addressed some common issues that can occur, but there are plenty of recessed corners in which other culprits may inhabit.
Tweak BIOS settings, improve system performance

Maximizing your investment in server hardware often means configuring the machine to deliver the best possible performance. One way to maximize a server's performance is to adjust the BIOS settings. This tip explains which BIOS settings are most important to configure to optimize system performance and improve power management.

A few disclaimers on BIOS settings

Of course, if it is possible to get better performance by adjusting a few BIOS settings, then that raises the question of why the manufacturer did not design the machine to use the best possible BIOS settings by default. In some cases, high-performance settings may affect the server’s stability. In other cases, improving performance may increase the server’s temperature, energy consumption, or both. In any case, you should always remember that additional performance may come at a price.

Before I discuss BIOS settings that can be adjusted, I need to point out that every server is different. The make, model, architecture and age of a server all affect the BIOS settings that are available. As such, the settings that I will point out may not be available on every server.

Non-uniform memory access
Non-uniform memory access (NUMA) is a technology that links a series of nodes together via a high-speed interconnect. The basic idea is that each CPU has its own built-in memory controller that directly links to memory that is considered to be local to that CPU. A CPU can access memory within its own node (local) or within another node (remote). Local memory access is faster than remote memory access, because remote memory access requires data to be transferred across a NUMA interconnect.

A technology called node interleaving offsets the performance hit associated with remote memory access by striping data across both memory controllers. Some systems enable node interleaving by default within the system BIOS, but servers acting as virtualization hosts usually perform better with memory interleaving disabled.

**Power management**

Few BIOS settings have as big of an affect on overall performance as the power management settings. Unfortunately, many power management settings are vendor specific, so you may have to check your server vendor’s website for their recommendations.

The first power management feature that you should look for is demand-based scaling (DBS). DBS automatically adjusts the processor’s clock speed to increase performance when additional processing power is needed and saves power during periods of low CPU usage.
Many servers control DBS through power management profiles. The default behavior is usually to let the operating system (OS) control the processor frequency scaling, but doing so requires a bit of CPU overhead. Not all OSes support this type of power management, which can be especially problematic for servers running low-level hypervisors. If you are trying to get the best possible server performance, then look for a power management profile geared toward performance rather than power conservation.

**Simultaneous multithreading**

Many servers with Intel Corp.’s Xeon processors support simultaneous multithreading technology (SMT). SMT is an Intel feature that tricks the OS into thinking that the CPU has twice as many cores as it actually does. SMT treats each physical core as two logical cores.

While Intel claims that SMT improves performance by as much as 30%, SMT may actually hurt performance if the server is used as a virtualization host. This is particularly true for VMs that are only allocated a single logical processor or for environments in which CPU cores are overcommitted.

Most servers that support SMT have this feature enabled by default, but it can be disabled at the BIOS level. You might consider benchmarking your server with SMT enabled, and then with it disabled, to determine which setting yields the best performance.
Core speed

There are a few different BIOS features that affect the speed of a server’s CPU cores. One such feature is Turbo Boost, which is found on some Intel Xeon servers. Turbo Boost works similar to overclocking, in that it allows CPU cores to run faster than their base frequency.

Turbo Boost, which is sometimes disabled by default, tends to be a safe feature to use because it will only increase CPU core frequency if the CPU is consuming less than its rated power and is operating below its rated temperature.

The actual amount of additional processing power that Turbo Boost will yield depends on the number of CPU cores that are active, but often provides two to three frequency steps. In any case, all of the active cores within the CPU will run at the same frequency.

If you are considering using Turbo Boost, you should check to make sure that the BIOS C-state feature is disabled. C-state is a power-saving feature found on some Intel Xeon servers. It works by dropping the voltage of CPU cores, thereby reducing the core frequency. When the frequency of a core is reduced, the frequencies of all the active cores on a CPU are reduced. Therefore, if you are trying to get the maximum processing power from your server, you should avoid any configuration that could result in a cores running at a reduced frequency.
As you can see, there are a number of different BIOS settings that can be configured to optimize a server's performance. Of course, note that doing so may increase power consumption and cause the server to run at a higher temperature.

### Adjust the BIOS for energy-efficient operation

Optimizing server BIOS settings for a server's workload will help balance performance with cooling requirements.

Few servers perform at their maximum possible levels, so they should not be run on their highest performance settings. Server BIOS settings can control performance modes to meet the demands of a given workload. You can conserve energy and data center cooling resources by optimizing how cooling fans operate in conjunction with servers' processors and memory.

**DIMM temperature throttling**

IT professionals rarely think about controlling the heat associated with memory modules, but modern servers can include hundreds of gigabytes of memory spread across more than a dozen high-density dual in-line memory modules
(DIMMs). Modern servers use airflow components and thermal sensors to intelligently direct memory cooling based on the system's available components.

Dynamic closed-loop thermal throttling is the most intelligent thermal-control mode; the server adjusts fan speed to regulate temperature that DIMMs sensors report. Technicians can adjust the thermal set point; if the DIMMs get warmer, the on-device temperature sensor alerts the server to increase fan speed. As DIMMs cool, the fan speed decreases.

In contrast, static closed-loop thermal throttling lacks set-point adjustability for its closed-loop system of sensors and fan control. And static open-loop thermal throttling means constant-speed cooling is applied to the memory components without temperature intelligence. By default, a server's BIOS often selects the most intelligent thermal throttling mode based on components it detects.

**Fan profile characteristics**

Modern servers include 10 or more adjustable-speed fans. Adjusting the fan characteristics can enhance system cooling. BIOS fan profile settings can switch the system's cooling between performance and acoustic modes.

In performance mode, a server uses fans aggressively to cool the overall system. Servers should use performance mode while processing demanding workloads, but most servers select performance mode as the default. This drives the fans harder than may be needed, and it's noisy.
Acoustic mode tells the system to first throttle back computing resources, if possible, to mitigate heat output without ramping up fans. Acoustic mode can degrade server performance, so disable it while processing critical workloads.

**Additional fan settings**

Server BIOS settings usually default to no fan offset, but you can tweak this. Use a fan offset to increase fan speed, addressing slightly elevated system heating issues.

In data centers with very cool ambient air, consider quiet or idle fans. Instead of defaulting to a minimum speed, cooling fans turn off entirely at a set temperature. Infrequent bursts of fan activity keep servers cool while saving significant amounts of energy, especially when the number of fans is multiplied across dozens even hundreds of physical servers. If you're also using a fan offset, be aware that this could keep the fans running at a reduced -- but not stopped -- rate.

Default thermal settings are fine for typical deployments. But with intelligent systems onboard and IT pros who understand their options, server behavior can be tailored to balance power, performance and noise for any data center situation. As with any production server changes, adjust only one setting at a time and then test to measure the effects of any changes.
In this guide

Introduction
Select the right server
In the toolbox
Get useful benchmarks
A well-oiled machine
Getting more PRO+ exclusive content

Getting more PRO+ exclusive content

This e-guide is made available to you, our member, through PRO+ Offers—a collection of free publications, training and special opportunities specifically gathered from our partners and across our network of sites.

PRO+ Offers is a free benefit only available to members of the TechTarget network of sites.

Take full advantage of your membership by visiting http://pro.techtarget.com/ProLP/

Images; Fotalia

© 2016 TechTarget. No part of this publication may be transmitted or reproduced in any form or by any means without written permission from the publisher.