

Parallels® Virtuozzo Containers

White Paper

Greener Virtualization

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Operating system virtualization by Parallels Virtuozzo Containers from Parallels is more efficient than hypervisor-based approaches. The benefits? Less energy consumed and lower ownership costs.

Executive Summary

Green, or environmentally friendly, computing is an idea whose time has come. Besides harming the environment, energy-inefficient datacenters can hurt the bottom line and lead to serious competitive disadvantages. A common inefficiency is server sprawl, the explosive growth of underutilized, overprovisioned servers across the enterprise. Server consolidation through virtualization improves energy efficiency via the decommissioning of unneeded physical servers and higher utilization of the remaining, more energy-efficient servers.

There are several approaches to server virtualization, but the greenest is operating system virtualization, as provided by Virtuozzo from Parallels. Because Virtuozzo is more efficient than hardware virtualization or paravirtualization solutions, it achieves the highest server consolidation ratios. As a result, Parallels Virtuozzo Containers – powered virtualization delivers maximum energy efficiency and all the environmental and ancillary benefits of a green computing initiative.

Main Story

WHY GREEN COMPUTING?

Minimizing the environmental impact of datacenter operations isn't always a priority for IT and business executives. However, it should be.

The environmental impact and costs of excessive energy consumption are among the leading concerns today. According to the U.S. Environmental Protection Agency, datacenters used 61 billion kilowatt-hours of electricity in 2006 at a cost of \$4.5 billion. This accounts for 1.5 percent of all power consumed in the U.S. Unless enterprises take action, datacenter usage is predicted to double by 2011.

Such massive expenditures to power datacenters not only damage the environment, but they affect the bottom line of organizations that waste money on powering, cooling and managing inefficient infrastructure. There are also other risks. As recently reported in eWeek, Gartner analyst Simon Mingay notes that "Failure to [go green] risks incurring unnecessary costs, the potential loss of competitive position, or becoming the target of unwanted attention by environmental pressure groups, the media and politicians."

What's more, our current path is unsustainable. According to The Green Grid consortium, "Power consumption is rising faster than the average datacenter can accommodate. It's not just a matter of building out space to house new servers. IT also needs to add additional electrical capacity and cooling systems."

Many organizations do not have the space or the funds for costly expansions, yet their need for additional computing capacity continues to escalate.

The solution to this dilemma dovetails nicely with the goals of environmentally friendly computing: The greenest datacenter is the one never built and the greenest server is the one never needed. The environmentally responsible thing to do – and the smart business decision – is to maximize the potential of existing datacenters.

HOW VIRTUALIZATION HELPS

A key area of datacenter inefficiency relates to server sprawl. During the last two decades, enterprises have experienced explosive growth in IT infrastructure, both in number of servers and in the complexity of configurations. The typical organization currently has hundreds or thousands of servers distributed across the enterprise, many dedicated to a single application or department.

These dedicated servers are usually overprovisioned, meaning that they operate at only 10 percent to 30 percent of capacity – an inefficiency that leads to excessive costs for electricity and datacenter real estate. According to the Lean & Green consortium, “For every kilowatt of energy consumed by a server, roughly another kilowatt must be expended to cool that machine. By 2008, the power costs of a server are forecast to exceed the cost of the server itself.” Reducing server sprawl through consolidation is a bedrock principle of green computing and datacenter efficiency.

That’s the appeal of server virtualization. By allowing a single server to securely run multiple applications as virtual machines or virtual environments, virtualization enables IT staff to consolidate physical servers and their workloads onto fewer, more highly utilized servers. Green computing benefits include:

- Less electricity used to power and cool servers through the decommissioning of unneeded physical servers and higher utilization of the more energy-efficient servers that remain
- Less real estate required in the datacenter, therefore lowering overall energy consumption
- Less hardware to manage and dispose of

Virtualization is so green that some utility companies, such as Pacific Gas & Electric, provide credits to businesses that incorporate virtualization into their datacenters. “Virtualization technology is helping our customers realize significant energy and cost savings, while addressing critical datacenter capacity issues,” explains Helen Burt, senior vice president and chief customer officer for Pacific Gas & Electric. “By providing financial support, we hope to increase industry adoption of this technology.”

Besides energy efficiency, virtualization offers advantages in IT flexibility and agility, ease of server provisioning and management, and business continuity, making it a hot technology in the enterprise. Goldman Sachs reports that a “virtualization wave... is enabling IT shops to consolidate servers and increase server utilization... Capacity utilization rates are on the rise as server virtualization is finding traction in the enterprise.”

OS VIRTUALIZATION: A BETTER WAY

All virtualization technology is not the same, however. The three main approaches are hardware or hypervisor-based virtualization; paravirtualization; and operating system (OS) virtualization. Each technology has its merits, but when evaluating energy efficiency, special consideration should be given to the server consolidation ratio. The more virtual applications that can reside on a physical server, the fewer servers will be needed.

By this criterion, the greenest technology is OS virtualization, as provided by Virtuozzo from Parallels. To understand why, let’s consider the three approaches:

Hardware or hypervisor-based virtualization

This solution includes products from VMware, Parallels and Microsoft, all of which are designed to run multiple OSes on the same server. Based upon a hypervisor software layer, it virtualizes server hardware resources in order to manage and dedicate them to guest virtual machines, in effect recreating the work of the hardware and OS vendors. Inside each guest virtual machine is a complete copy of an additional OS and the residing workloads or applications. The advantages of hypervisor-based virtualization include the flexibility of running different OSes side by side on the same server. However, high overhead and inefficiencies in memory management consume server resources, slowing response times and reducing the consolidation ratio.

Paravirtualization

Similar to hardware virtualization, paravirtualization is designed to support multiple OSes on a single server. Implemented by the Xen open source project, paravirtualization customizes each OS to be virtualized. This does improve processing efficiency, but paravirtualization still suffers from high overhead and inefficiencies compared to OS virtualization.

OS virtualization

Virtuozzo by Parallels and Sun's Solaris Containers use this approach. The concept is to create isolated partitions or virtual environments (VEs) on a single physical server and OS instance. This provides a leaner, more efficient architecture. Because OS virtualization does not support multiple OSes on the same server, it is intended for enterprises that are consolidating to multiple virtual servers running a single Windows, Linux or Solaris operating system. (Virtuozzo supports both Linux and Windows. Virtuozzo for Linux supports multiple Linux distributions in the guest virtual servers.)

Parallels Virtuozzo Containers is the greenest virtualization by virtue of its low overhead and high efficiency. Para- and hardware virtualization virtualize the server from the hardware up to the OS for every virtual machine, whereas OS virtualization sits on top of the OS, virtualizing a single instance on a server and leveraging all the underlying hardware technology. As a result, para- and hardware virtualization suffer the most performance degradation, while OS virtualization delivers close to native performance. Its efficient architecture enables many more Containers to be supported with adequate processing power on a single physical server, which delivers significantly higher useful server utilization and consolidation ratios. The result is excellent energy efficiency, performance/price ratios and return on investment.

INSIDE PARALLELS VIRTUOZZO CONTAINERS

As a high-efficiency OS virtualization solution, Parallels Virtuozzo Containers not only enables more Containers than hardware-based virtualization. It also shines when used to virtualize resource-intensive applications such enterprise databases and e-mail servers. Virtuozzo's has the same functionality of other virtualization solutions with the following capabilities:

- **Intelligent partitioning** divides a server into as many as hundreds of Containers with full server functionality. While Virtuozzo uses only a single instance of an operating system, each Container has links back to it, making the Container footprint very small and associated operations very fast.
- **Complete isolation** ensures that the Containers are secure and isolated in terms of function, fault tolerance and performance.
- **Dynamic resource allocation** of key system resources, such as CPU, memory, network, disk and I/O, enables near real-time changes without affecting the Container or its workload. Resources can be controlled with simple minimum, maximum, shares or more sophisticated allocations that allow for specified overages.

- **Live migration** and other business continuity capabilities ensure data is available and recoverable. Migrating a Container to another piece of x86 hardware is simple and fast, as long as Virtuozzo is the underlying infrastructure.
- **Server management** is simplified. With Virtuozzo, there's only one OS to manage, update and patch per physical server. And Virtuozzo has a full suite of tools and templates for automated, multi-VE and multi-server administration. Capabilities include conversion, provisioning, monitoring, backing up, recovering, analyzing, troubleshooting, repairing and migrating Containers.
- **The consolidation ratio** is high. Virtuozzo's efficiency is helped by several factors, including a single OS that takes only a single space of memory; one copy of the OS on the hard drive rather than one OS in each environment; and potentially one copy of an application on the host, accessed by each of the virtual environments.

MAKING THE GREEN CHOICE

Energy efficiency of server infrastructure is a special concern at hosting datacenters. ServInt of McLean, Va., for example, provides customers with managed, dedicated servers. However, as ServInt's customer base grew, electricity costs became onerous, as did the complexity of server management. Parallels Virtuozzo Containers provided the perfect solution. By implementing Virtuozzo to supply customers with virtualized servers, ServInt was able to reduce power consumption, deliver new customer offerings and improve manageability. Power consumption dropped 85 percent because 15 or more customers could share a single Virtuozzo server.

"ServInt saw a market need for customers to be 'master of their own domain' by having root access to a server," says Christian Dawson, vice president of operations at ServInt. "Virtualization provides us with a way to offer root access without wasting power and space associated with a dedicated server."

Similarly, Host Europe, a leading ISP and hosting provider based in Cologne, Germany, uses virtualization as part of its green computing initiative. Noticing that 80 percent of its servers were underutilized, Host deployed Virtuozzo to virtualize and consolidate servers. With Virtuozzo, customers receive equal performance due to sharing idle CPU and memory cycles and higher reliability due to better server management tools. Overall power consumption has been reduced by up to 63 percent, providing a greener hosting experience.

As we have seen, server consolidation through virtualization is an essential element of a green computing strategy. In addition to environmental benefits, green initiatives can lead to a better bottom line and a competitive edge. When deciding on a virtualization platform for green computing, consider Virtuozzo from Parallels. Its low-overhead OS virtualization technology is likely to deliver the greatest gains in energy efficiency, server consolidation and ease of management – just what green-minded executives are looking for.

OS VIRTUALIZATION AND HARDWARE VIRTUALIZATION: A HEAD-TO-HEAD COMPARISON

To compare consolidation ratios (and hence energy efficiency) between Parallels Virtuozzo Containers and hardware virtualization solutions such as VMware, consider the following hypothetical situation: An enterprise has 1,000 physical servers, each with 2GB of physical memory and running a Windows Server operating system. The servers have dual 1-GHz CPUs, with average CPU utilization at 10 percent. A hypothetical enterprise application is using 300MB of memory of the 2GB, with the rest being used by the operating system. Reference hardware for the virtualization platform is a quad-core dual 3-GHz server with 8GB of memory.

To calculate the consolidation ratio from hardware virtualization, let's first define how much memory to dedicate to the virtual machines (VMs). The application footprint is 300MB. The operating system needs some memory for the kernel, as does the file system cache, so it is unlikely it could be stripped down to less than 768MB. (Later, the memory paging activity in a VM will show if the decision was correct.)

Of the 8GB of physical memory, 7GB is reserved for use by the VMs. Even assuming a 30 percent of memory over commitment, this would result about 12 VMs per server. Bumping memory up to 16GB would give a consolidation ratio closer to 24 to 1. Note that with eight cores and 24 GHz of bandwidth, there's plenty of processing power, but the solution is memory bound.

Now let's explore Virtuozzo. Some of the 8GB of memory would be needed for the operating system. Since the operating system serves all the applications, let's give it a lavish 2GB. That leaves 6GB for the applications. Each application will be running in a separate virtual environment with its own memory footprint, anywhere from 30MB to 50MB, so let's settle on 40MB.

The total application footprint is 340MB. However, resource sharing needs to be factored in. Part of this footprint is coming from the shared libraries (dll), or application own images, and will be shared among multiple Containers, decreasing the application's memory footprint. Another rarely used part can be safely stored in the swap file. Conservative sharing assumptions will bring the footprint down to the original 300MB.

Now let's calculate the consolidation ratio. 6GB/300MB means 20 Containers per server, with plenty of CPU power per application. With 16GB of memory and 3GB reserved for the OS, the consolidation ratio is about 43 Containers per server.

In summary, hardware virtualization delivers a consolidation ratio of 12 to 1 or 24 to 1 depending on server memory. Virtuozzo delivers 20 to 1 or 43 to 1. All else being equal, Virtuozzo is more energy efficient.