

From the Grid to the CPU: Minimizing Operational Expenses in Today's Data Centers

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The operational challenges of today's data centers have become a gloomy issue for IT managers and CIOs around the globe. As hundreds of thousands of servers and storage systems are deployed to keep pace with ever-growing business computing needs, data center managers are faced with increasing operational costs—namely power, cooling and maintenance. Today's data centers spend just 30% of their budget on capital expenditures, while a whopping 70% is consumed by operational expenses.

The natural shift away from antiquated RISC/proprietary Unix-based servers and the movement toward high performance, open architecture, open source solutions has enabled countless data centers to proportionally reduce capital expenditures while increasing overall system performance. But while the price/performance ratio has improved, the cost to operate and maintain all those servers has spiraled out of control.

This white paper examines ways in which today's data centers can improve overall efficiency and reduce operational waste by leveraging unique server and data center-level technologies.

POWER CONSUMPTION

Today's X86 server designs have enabled dramatic improvements in density, with rack-mount systems packing more, ever-faster processors into a cabinet. Advancements such as the half-depth form factor and back-to-back mounting enable density levels as high as 80 1U rack-mount servers per cabinet. The newest multi-core processors from AMD and Intel are enabling never-before-seen CPU core densities, and the introduction of quad-core computing has increased compute levels to an unprecedented 640 processing cores in a cabinet just 7 feet tall and 3 1/2 feet deep.

Density levels that high with all those processing cores in such a small footprint is a necessity for data centers managing mission-critical applications, resulting in exponentially greater compute power in a small amount of space. But higher density comes with a price—a very high price in the form of power, cooling and maintenance. Thus, while delivering the flexibility and scalability that leading Internet and High Performance Computing (HPC) environments are clamoring for, dense server clusters raise power consumption levels and amplify thermal management challenges.

With data centers restricted by how much power can physically be delivered to the site, it is not uncommon for a data center to simply run out of power capacity long before running out of space. Similarly, data centers' HVAC systems are limited in how many BTUs of cooling power can be delivered. In public co-location facilities, a fixed, predetermined level of wattage and heat dissipation is assigned per rack, making this an even greater challenge for companies hosting their servers in a public data center.

Given that data centers have among the highest density of energy-consuming equipment of any modern building and use 100 times the electricity of a typical office building on a per square foot basis, the issue of consumption continues to make headlines.

It is estimated that a typical server rack consumes 100-200 watts of power. This is a significant amount of power, especially when you consider that the cost of electricity after row-level losses can be as high as \$0.10 per kWh, and the cost of cooling can be as high as \$0.05 per kWh.

With the increasing demand for data center space, the vicious cycle of increasing power and cooling costs is becoming a major concern for data center operators.

INSIDE THE DATA CENTER

One of the most common mistakes data center operators make is to specify a power density that is too high for the equipment they are using. This can lead to a power distribution system that is oversized and inefficient, leading to higher power and cooling costs.

At a basic level, data center operators should carefully select the equipment they use, ensuring that it is properly matched to the power and cooling capacity of the data center. This includes selecting equipment that is energy-efficient and has a long life expectancy. Additionally, operators should ensure that the equipment is properly configured and maintained to ensure optimal performance.

For example, if a data center operator specifies a power density of 200 watts per server rack, but the equipment they are using only requires 100 watts, they are oversizing the power distribution system. This can lead to higher power and cooling costs, as the system is not operating at its most efficient point. Additionally, oversizing the system can lead to a shorter life expectancy for the equipment, as it is not being properly matched to the power and cooling capacity of the data center.

Once the proper 'recipe' for a specific server configuration has been identified to match performance and power requirements, the next step is to consider ways to reduce power consumption by choosing high efficiency, lower wattage components. This becomes especially important when selecting processors and power supplies.

CPUs and AC power supplies draw more power than any other components inside a system. Subsequently, they give off significant amounts of heat and are generally the first parts to fail inside a server. The processor drives a server's overall power draw requirement; the fastest processors consume the most power and generate the most heat.

Today's lower wattage CPUs from AMD and Intel continue to achieve high levels of performance with decreased power consumption. Higher CPU clock speeds will require higher wattage draws, which may be necessary in HPC and other compute-intensive environments. Regardless of what CPU is selected, the system should fit within the data center's so-called 'energy footprint' and systems should be designed to be cooled effectively.

Power supplies are the most common cause of server failure. Traditional power supplies are inefficient, meaning they waste a significant amount of power (and heat) while converting AC power to DC power. This inefficiency can result in power supplies consuming 30% and more of the total power drawn by a server. And in the case of a server with a 100W CPU, a 30% inefficient power supply can contribute an additional 30W to the server's internal power draw. This is a significant power efficiency issue, especially in a data center with thousands of servers. Recent advances in power supply technology have resulted in 90% or more efficient power supplies, which can reduce the power consumption of a server by 30% or more. This translates to a significant reduction in the cost of ownership (COO) of a server, as the power supply is a major component of the total cost of ownership. In fact, a 30% reduction in power consumption can result in a 30% reduction in the COO of a server. But what if the power supply is not the only component that is inefficient? What if the power supply is reliable, but the other components are not? This is a common scenario in a data center, where the power supply is often the most reliable component, while the other components are often the least reliable. This can result in a significant portion of the server's power being wasted on inefficient components, which can lead to a significant increase in the COO of the server.

DC POWER AS AN ALTERNATIVE

In 2003, the first distributed DC power technologies became available for large-scale data center server deployments. Long a standard in the telco industry, DC power options provide a more efficient power standard, eliminating the need for wasteful AC-DC power conversion inside a traditional AC power supply at the system level.

By replacing a standard AC power supply with a 93% efficient DC power card inside each server, power losses at the server level are instantly reduced. Instead of converting AC power to DC power inside the server, the conversion happens at the cabinet-level via redundant AC-to-DC rectifiers. By converting the power within the external rectifiers—which have an MTBF of 250,000 hours a

piece—20-40% less heat is dissipated within the servers themselves. The subsequent efficiency gain results in power savings while increasing overall system reliability.

In this rectified DC scenario, AC power is brought to the server cabinet through standard power distribution mechanisms. Rectifiers within the cabinet, which take up a mere 2U of rack space in a 44U cabinet populated with 80 systems mounted back-to-back, distribute redundant DC power to each system via DC bus bars housed inside the cabinet. Power savings of 10% and higher are achieved with rectified DC solutions, which can amount to millions of dollars in savings each year alone for a large-scale Web farm.

While the power savings achieved using DC solutions are certainly compelling, the real operational advantages are realized when the DC power is distributed directly to the server racks, coupled with the use of DC power distribution units (PDUs) and DC server cards, which ensure that the power is delivered directly to the server components. This ensures that the power is delivered directly to the server components, which is a significant improvement over the traditional AC distribution structure. The DC solution also allows for a more efficient power distribution structure, which can result in significant savings in power costs.

REDUCING

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In a typical data center, the power is delivered to the server racks through a series of AC-to-DC conversions. This process is inefficient, as it results in significant power loss. By using DC power distribution, the power is delivered directly to the server components, which is a significant improvement over the traditional AC distribution structure. The DC solution also allows for a more efficient power distribution structure, which can result in significant savings in power costs.

New technologies are being developed that will allow for a more efficient power distribution structure. By leveraging large-scale rectifiers and exterior DC power converter units, AC-to-DC conversion is reduced to just two points on the electrical path, culminating in data center-wide DC power distribution directly to DC-based servers.

The increasing popularity of easily deployed rectified DC solutions and the even greater efficiencies achieved via data-center level DC power distribution have prompted IT leaders to consider DC as the new data center standard. New, 'greenfield' data centers are increasingly being built with DC input power—in lieu of AC—in order to achieve the highest possible efficiency and lowest possible power loss from the doorstep to the servers.

BETTER COOLING STRATEGIES

Reducing power consumption at both the server and data center levels clearly impacts operational expenditures. Reduced power consumption means lower power bills and less heat at the component level. Less heat in the chassis means greater system reliability and lifespan. And greater reliability means less human capital and money wasted on maintenance and repair.

But after all that attention on lower wattage components and better power distribution techniques, heat will naturally be a by-product of any machine, and remains the number one killer of systems in a data center. Effective heat evacuation will help reduce the burden on HVAC infrastructure while increasing server life expectancy.

Traditional rack-mount systems have a tendency to push heat back into the aisle, where it has to be dealt with by the inadequate HVAC infrastructure to cool these hot spots. The result is increasing the ambient temperature of the data center.

With coolable components, the electric power portion of the total power requirement is reduced, and the heat load is reduced.

One best practice is to use the cabinet as a chimney. The heat from the cabinet is drawn up and out of the top of the cabinet. This reduces the heat load on the data center HVAC system.

Some X86 systems have a direct connection to the cooling framework. This allows the heat to be directed downward—toward the floor—and evacuated through in-floor cooling devices. Some data centers leveraging these unique heat evacuation techniques actually re-circulate the carefully contained hot air to warm office space during the winter months.

PUTTING IT ALL TOGETHER

The data center, the site of computing innovation for four decades, is continually challenged by ever-increasing operational costs driven by business demands for increased compute performance. With the rapid expansion of rack-mount, X86 systems, many data center managers are struggling to survive within their existing power envelope while keeping data center labor costs to a minimum.

Facilities built as little as two years ago are ill-equipped to hold today's high-density server configurations, largely due to inherent limitations in their power distribution and cooling infrastructure that very visibly impact the bottom line in any budget.

As reducing power consumption, lowering heat output and increasing system reliability become key factors for IT purchasing decisions, every data center needs to consider ways to optimize existing infrastructure and streamline operations:

Consider the power draw of the system. Do my servers contain any unnecessary, extraneous components (all of which, of course, draw power and expel heat)? Has my server provider selected low wattage components that fit within my energy footprint? Do I have enough power per square foot in my data center to support the growing number of servers I have populated?

Choose wisely. Do I have the most efficient server components? Do I have the most efficient power supplies? Do I have the most efficient processors?

Calculate. Do I have the most efficient cooling system? Do I have the most efficient rectified power supply? Do I have the most efficient power distribution system? Do I have the most efficient losses and waste?

Don't forget. Do I have the most efficient cabinet? Do I have the most efficient floor? Do I have the most efficient air conditioning? Do I have the most efficient pollution control system?

Finally, Do I have the most efficient systems? Do I have the most efficient inefficiencies? Do I have the most efficient cost of ownership?

The operational challenges of today's data centers are not new. As energy costs continue to rise, data centers are being forced to eliminate the inefficiencies of today's infrastructure. The adoption of energy-efficient technologies is spreading rapidly in the world's leading data centers, but careful consideration must be given to the growing post-purchase challenges as the sheer volume of deployments continues to rise. Data centers squarely focused on solutions that reduce power, cooling and maintenance costs will reap the benefits time and time again.