Server Virtualization and the Cooling Paradox

IT organizations are turning to server virtualization in order to gain greater data center efficiency. By combining workloads onto fewer servers, virtualization enables server consolidation and delivers immediate benefits by increasing server utilization, reducing server footprint, and lowering overall IT energy consumption and cooling requirements. This provides a number of distinct results, most notably lower data center operating expenses.

At the same time, the benefits of server virtualization are not being fully realized by most IT and data center managers. When "racking and stacking," data center managers are often confronted with power and cooling constraints, particularly the limitations that are made evident when attempting to air-cool mid or high-density server racks. The majority of data centers in the United States are more than seven years old, designed and constructed before server virtualization had really taken hold as a trend. Most data center facilities are ill-equipped to support today's virtualized server environments. As IT and facilities managers move toward server virtualization, they should give careful consideration to the capabilities and efficiencies of their cooling infrastructure. By implementing a denser computing environment, combined with high-efficiency liquid cooling solutions, data center owners can achieve better than a 20% improvement in energy cost savings and can decrease space requirements by more than 80%. A sustainable data center cooling strategy is a blueprint for business efficiency and profitability.

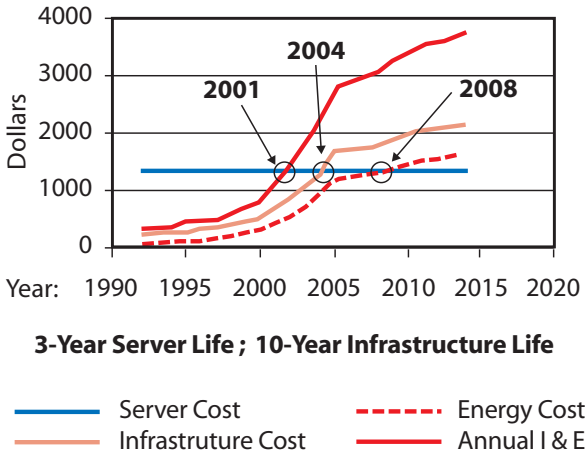
Server Efficiency and Energy Consumption

One of the primary drivers of server virtualization in the data center is underutilized servers. Gartner estimates that typical utilization rates for x86 servers range between 7% and 15% in nonvirtualized environments,[i] and because x86 servers typically host only a single application, their processors may sit idle 85–95% of the time While sitting idle, these servers use nearly as much power as they do when they are active. A recent report by the U.S. Environmental Protection Agency claims that data centers in the U.S. consume 4.5 billion kWh annually, 1.5% of the country's total energy consumption.[ii] With energy costs becoming a larger and larger component of data center operating budgets, it is no wonder that enterprises are embracing the challenge issued by the U.S. Department of Energy to reduce data center energy consumption 10% by 2011.

Virtualization — Increasing Server Utilization and Data Center Efficiency

According to VMware, the average consolidation ratio of servers after virtualization is 10:1, with server utilization increasing on average up to 50%.[iii] By virtualizing servers, IT organizations can greatly increase server processing capacity while lowering costs, minimizing the server/rack footprint and making existing IT infrastructures more flexible. Server virtualization also delivers an immediate savings on power and cooling by eliminating underutilized servers. VMware estimates that by consolidating 500 servers down to 50, the amount of power consumed can be reduced from 86,500 watts to 11,500 watts, representing an energy savings of $75,000 under typical circumstances. Efficiency has become an important criterion in the selection and deployment of server hardware today.

Cost of Power and Cooling Exceeds Cost of IT Equipment within 2 Years



Belady, C., "In the Data Center, Power and Cooling Costs More Than Equipment It Supports," Electronics Cooling Magazine (Feb. 2007)

Virtualization — Driving Rack Densification and Cooling Requirements

Server virtualization projects, if executed well, can lead to dramatic short and long-term savings; however, virtualization has many implementation costs associated with it. For instance, it does not make sense to virtualize workloads on inefficient legacy servers. As a result, in many virtualization projects, enterprises will invest in new hardware, typically a compact form factor of x86 1U or blade servers.

The total wattage consumed per server can be between 380 and 550 watts for a two-CPU, dual-core server. So even though an IT rack may hold only fifteen two-way, dual-core virtualized servers, the power consumed per rack is between 5.7 and 8.25 kW (power and heat have a 1:1 ratio, meaning power consumed equals cooling required). Conventional air-cooled data centers are capable of cooling about 4kW per rack, equivalent to one 7U-9U server blade chassis or approximately ten 1U servers. This approach leaves 32U or more of unused space within a typical 42U rack, a massive waste of vertical real estate and a proportionately wasteful strategy when combined with inefficient air-cooling products. While server virtualization and consolidation do lead to a large reduction in energy use and total cooling requirements, the reduction in total cooling requirements is

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leveraged only through the migration from a low-density to a high-density computer environment. High-density data centers equipped with efficient, space-saving liquid cooling are defining how server virtualization projects can achieve best results for payback.

A typical virtualization project first involves the identification of applications and servers that can be virtualized. A limiting factor is that not each and every application warrants virtualization. Gartner estimates that only 16% of workloads are running on virtual machines today.[v] In a virtualization project, as some percentage of servers are decommissioned and turned off throughout the data center, immediate and long-term savings are gained by reducing the amount of energy consumed for each IT compute.

For example, Table 1[vi] illustrates three scenarios that take different approaches to virtualization and cooling. As shown in "PROJECT A," by virtualizing 160 servers, an energy savings of over $50,000 is recognized in year one alone. But because servers remain populated throughout the data center and in every rack, this dispersed architecture is commonly called "load spreading." As a result, there is no savings in cooling or in square feet of white space occupied.

A more optimal virtualization project consolidates virtualized servers by racking and stacking. By doing so, rack positions are freed up for other use. However, the degree of consolidation is entirely limited by the cooling capacity of the data center, most often described as "kW of cooling per rack." Air-cooled data centers providing only 4kW of cooling per rack permit only limited consolidation of assets, and in most cases, the data center will still require all air-handling units in operation to provide proper air pressurization throughout the space. "PROJECT B" quantifies this approach. Although the overall rack position space requirement is reduced marginally, no savings in cooling costs or further energy savings is recognized.

High-efficiency and space-effective liquid cooling provides a host of savings opportunities in the virtualized operating environment. **A passive water-cooled Rear Door Heat Exchanger solution provides the greatest efficiency of any comparable modular liquid cooling solutions.**[iv] As quantified in "PROJECT C," this approach allowed densification to 16kW per rack and eliminates all air-handler fan power from the data center. The air-handler fan power is replaced by pumping units that are typically three to five times more efficient than blowers. The result in this example shows an incremental annual energy savings approaching $40,000 per year, or over $90,000 saved per year with the combined reduction in IT power consumption and cooling requirements. Also notable is the space savings; in the virtualized environment supported by liquid cooling, the white space footprint is reduced by nearly 80%.

Table 1. Virtualization & Cooling Project Scenarios

Case Examples	Legacy Data Center	PROJECT A Typical Virtualization w/o Rack & Stack	PROJECT B Typical Virtualization w/Limited Rack & Stack	PROJECT C Optimized Virtualization w/Liquid Cooling
# of Nonvirtualized Applications	1,000	840	840	840
# of Nonvirtualized Servers	1,000	840	840	840
# of Applications Targeted for Virtualization	0	160	160	160
# of 1U Servers Running Virtualized Applications	0	16	16	16
Total # 1U Servers	1,000	856	856	856
IT Power (kW)	400	342.4	342.4	342.4
# 30-Ton Computer Room Air Conditioners (CRAC)	6	6	6	0
Total CRAC Fan Power (kW)	52.8	52.8	52.8	0
# 150kW Coolant Distribution Units (CDU)	0	0	0	3
Total CDU Pump Power (kW)	0	0	0	7.5
Total Combined Power for IT & Cooling (kW)	452.8	395.2	395.2	349.9
Energy Savings (kW)	0	57.6	57.6	102.9
Energy Savings per Year ($s)	$0	$50,492	$50,492	$90,202
Servers per Rack	10	10	10	40
# of Racks	100	100	86	21
Space Required for Rack Positions (sq. ft.)	2,250	2,250	1,926	482
Space Savings	0%	0%	14%	79%
Add'l Savings per Year at Hosted Site Based on Consolidation	0%	$0	$58,320	$260,010

Notes:
1. Assumes 85kW delivered sensible cooling capacity per CRAC unit; 25% N+1 redundancy
2. Assumes 22.5sf per rack position, including aisles
3. Assumes 400W per server
4. Cooling power includes indoor units only (ex. not primary chiller plant); no reheat or humidification
5. Assumes 1 application running on each non-virtualized server
6. Assumes virtualized servers are running 10 individual applications each
7. Assumes 16% of existing software applications can be virtualized
8. Assumes $0.10 kW/hr commercial electricity rate
9. Assumes $180 per square foot, per year

Liquid Cooling Enables Maximum Virtualization and Data Center Optimization

For enterprises to maximize the benefits of server virtualization, aggressive consolidation is encouraged. Consolidation leads to densification of power and heat loads, providing the opportunity to replace inefficient air-cooling products with state-of-the-art liquid cooling solutions such as Coolcentric's LiquiCool® Rear Door Heat Exchanger.

Benefits include:

- 90% or better energy savings
- Up to 80% space savings
- Elimination of air-handler fans, hot aisle containment, cold aisle containment, air-delivery ducting, air-return ducting
- No moving parts, no electrical connections
- No requirement for condensate drains
- Installs in minutes — can be deployed while IT systems or other mechanical systems are running
- Can be installed in any type of data center rack configuration (example: hot aisle/cold aisle or classroom style)
- Payback in less than 1 year
- Scalable — "pay as you grow" vs. sunken cost
- Flexible — fits over 80% of industry-standard IT enclosures
- Sustainable and green

Liquid cooling allows enterprises to fully optimize virtualization projects for maximum return on investment. Coolcentric's solutions provide a dramatic, immediate improvement in server virtualization project results.

About Coolcentric

Coolcentric delivers the world's most energy and space-efficient cooling solutions for reducing data center costs. Coolcentric's LiquiCool products for rack-level cooling, combined with services for integration, deployment and sustainability of data center thermal solutions, allow customers to optimize their data centers for maximum performance and return on investment. For additional information, contact Coolcentric at +1 508.203.4690 or visit **www.coolcentric.com**

References

[i] Data Center Efficiency and Capacity: A Metric to Calculate Both, Gartner, September 18, 2009

[ii] EPA Report to U.S. Congress on Data Center Energy Efficiency, July 2007

[iii] Using Virtualization to Improve Data Center Efficiency, The Green Grid, 2009

[iv] https://microsite.accenture.com/svlgreport/Documents/pdf/case%20study_sun_modularv2.pdf

[v] Gartner Press Release, October 21, 2009

[vi] Coolcentric, 2010

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