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Strategic Advisory

Refresh Considerations for Data Center Architecture
(Intel/AMD based Racks/Blades)

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GOAL
This discussion attempts to identify several major quantitative and/or financial factors relevant to making refresh/lifecycle and financing decisions about Intel-based data center systems. The goal is to set forth some base-level evaluation models for use in calculating the effects of technology changes on financial and system performance metrics.

ASSUMPTIONS
This discussion assumes that the data center consists of high-performance rack servers or blade servers, populated with systems composed of Intel Xeon (and AMD equivalents) processors and (optionally) on-board hard disk drives. It further assumes that most units are replaceable in-line (i.e. 'hot swappable'), and that system management and/or provisioning software can redistribute workloads within select pools of servers.

APPROACH
There are two steps in this approach: (1) estimate the impact of shorter refresh cycles on real costs; and (2) estimate the impact of leasing on the investments required to move to shorter cycles.

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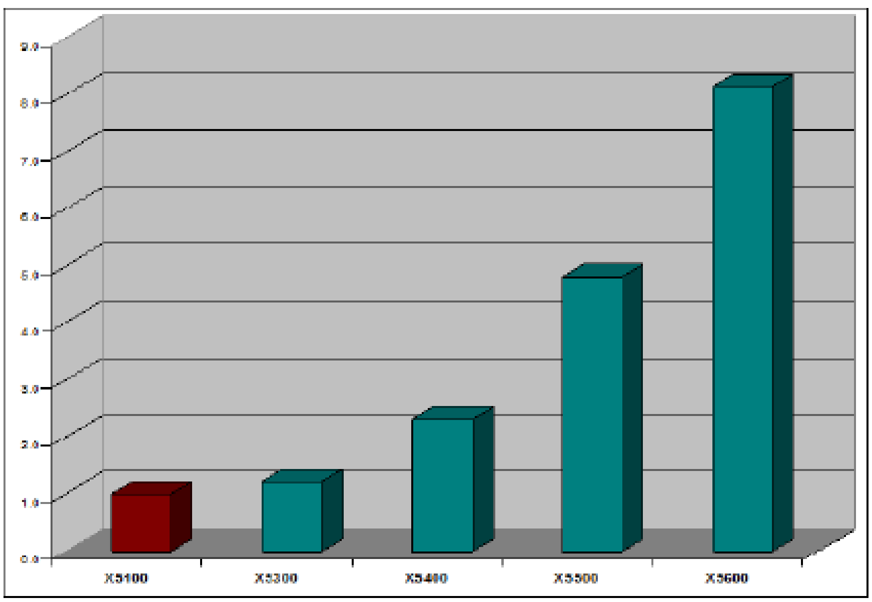
Step 1—Estimation of the financial impact of shorter equipment refresh cycles

Energy Costs

A growing reason to move to shorter refresh cycles today—especially for volume servers—is the steady advance of energy-efficiency technology. The servers available today use only a fraction of the energy used by prior generations of servers, and this can amount to significant savings. Although we have only recently begun to measure performance per watt, all the available data indicated that each successive generation of Intel/AMD servers produces the same computational output for only 60% (and sometimes only 25%) of energy expense.

For example, prior to the creation of the SPECpower_ssj2008 benchmark, one test showed that the Intel Xeon 5160 performed 1.85x the workload per watt as did the prior-generation Xeon 5070. The SPECpower_ssj2008 benchmarks have shown similar results for advances within the Xeon family.

To help size this for financial assessment, if we use the Xeon 5160 (2006 technology) as a base of 1x, then the generation of Xeons which large enterprises installed in 2008 would do 2.45x the work per watt, the newer/2009 Nehalem Xeon 5500s would do 4.8x, and the latest 5600s would do 8.2x . By estimating replacement footprints, we could calculate energy savings.



Server Performance per Watt (Relative to x5100)
(based on SPECpower measurements, www.spec.org)

The estimation process would be fairly simple: build a spreadsheet with approximate numbers of each processor 'layer' (e.g. Xeon 51xx, 53xx, 54xx) and apply the above ratios to calculate a relative energy savings. The watts per system could be taken from vendor spec pages, or more accurately, from representative systems on the SPEC-power website. [Note that this is both relative and 'rough', in that it does not isolate HDD energy, power supply efficiency, etc.]

We should also note that the vendors improve upon efficiency each year—with greater reductions in some years than others, obviously—with the implication that energy savings could increase every year, if the servers are consistently being refreshed. Here's the model run for 1,000 units of four generations of Xeon chips, with annual kW dollar savings (at 100% utilization):

	Units	Watts	Extended kWs	5600 equiv.	#5600s needed	5600 kW	Freed-up watts	kW costs	Saved Ext kW$
X5100	1,000	258	258	0.12	123	29	229	$0.08	$160,169
X5300	1,000	334	334	0.16	158	38	296	$0.08	$207,445
X5400	1,000	276	276	0.30	301	72	204	$0.08	$142,860
X5500	1,000	237	237	0.59	590	142	95	$0.08	$ 66,825
								Total	**$577,300**

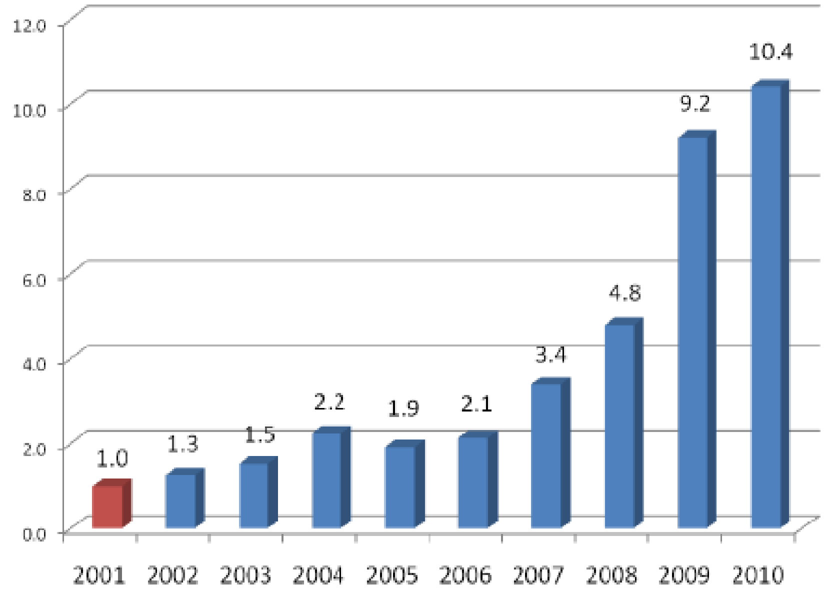
Since each watt of power used for a server also requires 1-2 watts of power to cool the server, the estimated energy savings should be at least doubled (for the HVAC operational cost—excluding the equipment cost of the HVAC units).

Harvesting these savings, however, will typically not be under the control of IT, since utility bills are more frequently placed in the Facilities and/or Physical Plant budgets—and not in IT. This means that IT would see the costs for the new equipment, but not see any reduction in its own budget (since 'Utilities' is not often a line item in the IT budget). The CFO therefore must adjust the budgets of Facilities/Physical Plant to harvest these cash reductions in utility bills. In the cases where IT does have a budget line item for Utilities (e.g. in dedicated, stand-alone data centers), the savings can be harvested within the IT budget, of course.

Cost Avoidance/Consolidation Savings

We have already seen how performance per watt can reduce energy bills, but performance per dollar can also be used to reduce equipment expenses while keeping computing power at the same level. This is a simple reality of incessant technology improvements by vendors.

There are many ways to measure this, but just to use a common benchmark to size this (TPC-C), here's a chart of the computing performance/price for Intel servers over the past few years:



How Much x86 Computing Power does a Dollar Buy? (Relative to 2001)
(based on TPC-C benchmarks, tpc.org)

What this basically means is that a server today (from the "2010" column) can do the same amount of work per dollar as 10 servers from 2001, or two servers from 2008. In other words—all other things being equal—a manager could recover half the space, half the support labor, and at least half the risk of component failure, by replacing servers every 18-24 months or so.

This growth in performance-per-dollar allows us to either (1) buy more computing power for the same budget; or (2) buy the same computing power for less budget—or a little of both.

To estimate the savings from displacing these servers, one would need to estimate the displaceable "carrying costs" of these units (e.g. cost of real estate, per unit labor/support costs, cabling costs, and other related asset costs such as insurance, security), and apply these to estimates of the installed base (again layered by time). The cost calculation needs to be a 'net reduction' calculation, of course, accounting for the new 'carrying costs' associated with the new units. Here's the model run for 1,000 units of various ages/years of life:

	Units	Carrying Cost$	Extended Carry$	5600 equiv.	#5600s needed	Net Unit Reduction	Extended Net Reduction
In 5th Year	1,000	$250	$250,000	0.12	123	877	$219,325
In 4th Year	1,000	$250	$250,000	0.16	158	842	$210,429
In 3rd Year	1,000	$250	$250,000	0.30	301	699	$174,847
In 2nd Year	1,000	$250	$250,000	0.59	590	410	$102,454
						Total	**$707,055**

Drive Failures

By far, the biggest operational issue for this type of data center is the pattern of on-board hard drive failures. Numerous studies in the 2007-2008 time frame (e.g., by Carnegie Mellon University, Google, University of Illinois) documented that HDDs have both a high 'infant mortality' (failure rate in the first 3 months for high-usage systems) and a high failure rate in years 3-5. Here are the charts from the Google study:

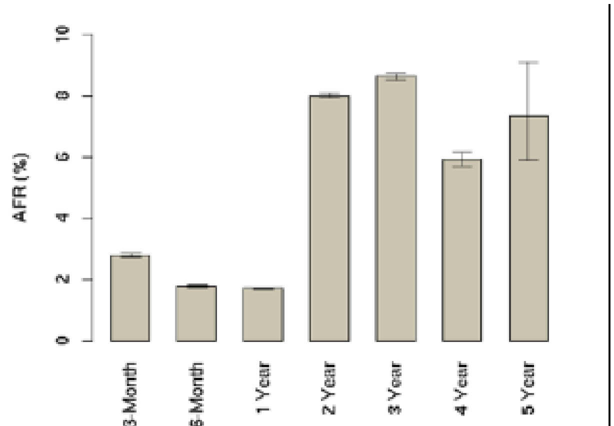


Figure 2: Annualized failure rates broken down by age groups

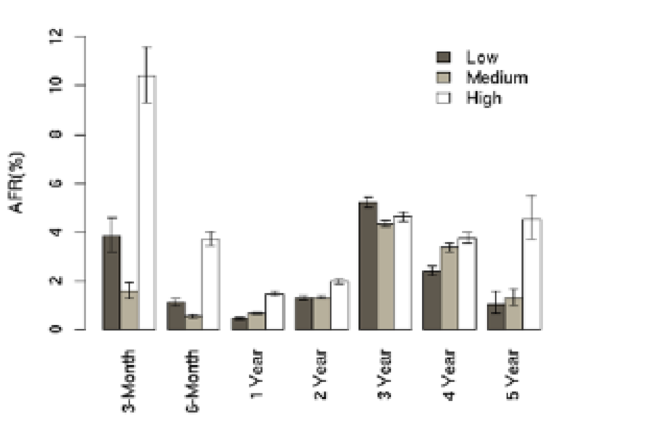


Figure 3: Utilization AFR

Annualized Failure Rates, by Year and by Usage
("Failure Trends in a Large Disk Drive Population", Google study, pages 4-5)

If 6-8% of all HDDs are going to fail in the 3rd year, and another 4-6% in the 4th year, then it is a simple matter to calculate how many replacements should be expected, based on the age of the equipment. Calculating the cost per replacement has two variants: a failure within the warranty period and a failure after warranty expiration. Depending on how service is performed on the units (e.g. self-maintenance, substitute-and-ship), the cost will always have a labor cost, but the replacement equipment cost can be zero (under warranty) or non-zero (for out of warranty).

An argument can be made (and the impact calculated somewhat) that it is more cost-effective to refresh the systems (motherboard and storage together) sometimes during year three—**before** the AFR increases dramatically. If such a refresh program is implemented, then the unit is only 'touched' once (at decommissioning), prior to the HDD failure. If, on the other hand, the HDD is replaced upon failure in years 3 or 4 (one touch), the unit will still have to be touched a second time when some other component eventually fails (e.g. ports, motherboard, memory, power supply) later. Since at least one of these other components will fail by the end of year 5, a fix-in-place strategy will double the labor costs involved in maintaining the units (2 touches versus 1 touch).

A rough way to estimate the cost range of this is to build a spreadsheet of the 'layers' of technology in the data center—based on age. In the absence of hard data, management could simply start with known/approximate unit counts from a recent year, and extrapolate backwards. Then, using the failure rates from the above charts, the predicted failures could be time-lined and labor costs estimated. For the units expected to fail within the 5 year planning horizon, labor costs (and equipment costs, if the failure is expected after the warranty period) should be calculated and this number would be the labor savings from moving to a within-3-years refresh. [In older gear, replacement HDDs may not actually be available, or price-feasible.]

Then, the replacement equipment costs (for those units outside of warranty) would be added to the labor figure, to get a ballpark idea of the additional costs incurred by not moving to a three-year refresh cycle. Here's the model run for 1,000 units in each year (note: since the installed base likely contains units from each year/row in this table, the annual figure would be the total of the 5 rows):

	Units	Failure%	Failures	Labor Cost	HDD$	Equip$	Extended
In 5th Year	1,000	7.00%	70	$250	$250	$17,500	$35,000
In 4th Year	1,000	5.90%	59	$250	$250	$14,750	$29,500
In 3rd Year	1,000	8.20%	82	$250			$20,500
In 2nd Year	1,000	7.80%	78	$250			$19,500
In 1st Year	1,000	3.00%	30	$250			$ 7,500
						TOTAL	**$112,000**

Notice that these costs are bare-bones for drives only (we logically would need to do one version of this table for all types of failures in rack servers: power supply, ports, memory, NIC), and also do not represent the significantly greater cost of business disruption.

Software Licenses

There is a significant savings possible (via basic consolidation) from the reduction of software and software support licenses. Although not strictly a linear function, consolidating **ten** servers into **one** also generally reduces the number of software/support licenses from ten to one. For ten servers, the server OS and utility software can easily represent $5K-$10K in annual contracts, and a reduction to one-tenth of this would net savings around $4,500-9,000 for every ten servers consolidated.

In our hypothetical case, with a net reduction of over 2,500 servers (above under “Consolidation Savings”), the savings could be considerable: a net of 2.5K servers displaced, at $500 annual software maintenance fees, could yield at least $1.25M savings per year.

This reduction in software license and support fees is NOT present in situations where the consolidation is done by means of typical virtualization technologies. When we convert ten physical machines (PMs) into ten Virtual Machines (VM’s) – and run them on one larger physical server—we still have to pay for the software licenses inside the individual VM’s plus the software for the larger host server (OS, utilities, management software, etc). Often, software vendor pricing can be reduced via negotiations and/or ‘virtual use’ pricing tiers, but these reductions are much, much less than those under traditional server consolidation. [Of course, the higher costs for virtualization are due to its higher value: we often use virtualization as a tool to enable consolidation, to increase server utilization, to increase manageability and reliability, and other important tasks.]

But, often a data center will ‘mix-and-match’ consolidation approaches—some virtualized, some not. So, we might very conservatively estimate our savings in this category at slightly more than a third of what we could achieve without virtualization: $450,000.

Other Issues

There are many other cost factors which should be included, mostly from the TCO studies (e.g. cost of maintaining multiple BIOS levels, multiple patch levels, wasting network ports by older servers, the move to SSDs) and there are many architectural issues which should be considered (e.g. ratio of Virtual Machines to Physical Machines, use of auto-provisioning and load-balancing systems to reduce refresh labor costs, higher density to reduce back-end decommissioning costs). But, the main issues discussed above would provide the baseline metrics for analyzing the financial aspects of (and needs for) a regular refresh of an Intel-based data center server infrastructure.

Assessments

Apart from other benefits, the estimates above make a strong case for a shorter refresh cycle for data center Intel/AMD servers. A quick table of the possible savings shows this clearly:

Savings Category	Savings Amount$
Energy/Utilities	$577,300
Consolidation Savings	$707,055
HDD Failures	$112,000
Software Licenses	$450,000
TOTAL	**$1,846,355**

Leasing and shorter refresh cycles: Cash-out-the-door savings

Step 2—Estimation of the financial impact of leasing

All of the above savings argue for (1) faster refresh and/or (2) server replacement/consolidation, but all of these require either replacing existing equipment or implementing a faster refresh on all future server acquisitions.

In either case, leasing will prove to be less cash-expensive than purchase and this cost saving is **incremental** to the above savings. There are other operational and financial advantages of leasing, of course, but even a simple buy-versus-lease payment comparison illustrates the cost advantage clearly. [Note that there are ways of flexing these numbers a couple of points in either direction.] Using $1,000 for a base comparison amount, here are typical cash-out-the-door savings for the various refresh terms:

Months	LeasePMT$	Savings$	Savings%
12	$721.80	$278.20	28%
18	$808.11	$191.89	19%
24	$862.80	$137.20	14%
36	$966.60	$ 33.40	3%
42	$1,050.42	$(50.42)	-5%

This represents savings on equipment invoices, over and above the savings from refresh/consolidation. As a means to actually lower the equipment cost (the “I” in ROI), this will accordingly raise the return (the “R” of ROI) as well.

This element is easy to estimate: simply apply the percentage savings above to the purchase price of new servers for the appropriate term.

This means that to the extent the Data Center implements a shorter refresh cycle (to reduce costs), to that same extent, leasing will prove to be the fiscally preferred financing vehicle (to reduce further costs).

Leasing and other considerations

The leasing payment model above is a simple, easy-to-understand model, but there may be other operational and financial reasons to lease—apart from equipment or technology-based reasons. These other factors might involve strategic use of capital, improved asset management practices, reduction of asset redundancies, risk mitigation, disaster recovery capabilities, etc. Although some of these may be difficult to quantify, the business effects of not addressing them adequately can sometimes be modeled or estimated.

Conclusion

Significant savings can be harvested by leasing servers on a faster refresh cycle

As one can tell from the HDD failure rates alone, volume-based servers are meant to be ‘used hard and retired early’. And, technology advances in hardware management and energy management are creating a compelling **financial** story for adoption of the vendors’ latest-and-greatest. Although it would be difficult (if not impossible) to calculate the exact financial savings of moving to a tighter refresh, rough-cut modeling of the tiers (by year and by type) of the server layers would argue that significant decreases in replacement labor, replacement equipment, energy costs, software licenses, and even server spend could be harvested under such a program.

When **combined with various types of leasing structures from Macquarie Equipment Finance**, even more savings can be achieved—while implementing improved asset management practices and insuring that future cost savings are more easily harvested.

[Original white paper published November 2009]

For Further Research

“Performance per Watt: Dempsey and Woodcrest” (David Kanter); http://www.realworldtech.com/page.cfm?ArticleID=RWT110706025321&p=1

SPECpower_ssj2008 results: http://www.spec.org/power_ssj2008/results/power_ssj2008.html

Server Performance Summary – Intel Xeon Processor http://www.intel.com/performance/server/xeon/summary.htm

“Updated: Seagate 1TB Drives Biting the Dust”, Gavin Stacy, Jan 15/2009: http://www.tomshardware.com/news/seagate-7200.11-failing,6844.html

SPECjbb2005 page: http://www.spec.org/jbb2005/

“Failure Trends in a Large Disk Drive Population”, Pinheiro/Weber/Barroso (Google), Feb 2007: http://labs.google.com/papers/disk_failures.pdf

“Disk failures in the real world: What does an MTTF of 1,000,000 hours mean to you?”, Bianca Schroeder/Garth Gibson (Carnegie Mellon University), presented at the 5th USENIX conference (ca. 2007); http://www.usenix.org/events/fast07/tech/schroeder/schroeder_html/index.html

“Vendor disk failure rates: Myth or metic?”, Mary Brandel, Computerworld, April 4 2008; http://www.computerworld.com/action/article.do?command=viewArticleBasic&articleId=9073158

“Are Disks the Dominant Contributor for Storage Failures? A Comprehensive Study of Storage System Failure Characteristics”; Jiang/Hu/Zhou/Kanevsky (Univ. of Ill): http://www.usenix.org/event/fast08/tech/full_papers/jiang/jiang_html/index.html

TPC-C benchmarks: http://www.tpc.org/tpcc/