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White Paper

IBM Enterprise Linux Server: Superior Virtualization Eliminates x86 Server Sprawl

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Executive Summary

IT executives operating or planning to operate a consolidated data center environment with virtualized Linux servers often view the x86 platform as the most cost-effective solution, based on the lower hardware cost, compared to other platforms. While generally acknowledging the clearly superior architecture, efficiency, manageability, and performance of IBM's System z, they regard a mainframe as overkill, believing they will be paying for more than they need. This may be attributable in part to industry positioning of the x86 platform as able to handle any workload under any condition. Additionally, they mistakenly regard System z as old, proprietary technology, poorly suited to modern applications, and with less support from Linux application Independent Software Vendors (ISVs). They also believe it will be complicated and difficult to manage.

In short, IT executives, familiar and comfortable with the x86 platform, feel it is "good enough," even for their mission-critical, virtualized Linux environments. They should think again. The truth is, virtualizing Linux servers on a System z platform, such as IBM Enterprise Linux Server, can result in:

- Much more efficient operation than Linux on x86-based platforms, with much higher virtual machine (VM) consolidation ratios, and requiring far fewer administrators.
- Dramatically reducing software license costs, both immediately and cumulatively over time, compared to an x86-based solution.
- Possibly saving 50 percent or more in software license and administrative cost alone, with as few as 40 VMs, versus an x86-based solution. The System z solution has the potential of paying for itself in savings from system administrative costs alone within five years.

It is, in fact, the architecture, efficiency, manageability, and performance of the System z platform that generates such surprisingly impressive cost benefits. While a robust platform for virtualized Linux consolidation at a fairly small scale, the virtualized x86 platform has certain inefficiencies and limitations. When scaled to enterprise proportions, these begin to take their toll, in terms of throughput performance, CPU underutilization, and software expenses, as well as in the increased use of resources such as network, power, HVAC, and floor space.

Some of the cost advantages of consolidated Linux virtualized on System z include:

- Vastly greater VM density within a single physical node — approximately 240 VMs as opposed to about 10 on an Intel eight-core system.

- Multiple processors other than the CPUs that are dedicated to specific tasks (such as I/O), letting the CPU cycles be used strictly for workload processing. This affords System z tremendously greater transactional throughput than an x86 platform, while making much more efficient use of application software.
- A share-everything design philosophy underlying the System z server, meaning thousands of VMs can all use a common virtual pool, dwarfing the physical nodes within a scaled-out x86 environment. This lets administrators apply a common set of workload policies across, say, 100 applications under a single workload management system, where spikes and dips in the different workloads level themselves out based on business-driven priorities and objectives.
- A very large internal communications bus that expedites traffic between processors and, again, contributes to comparatively much higher throughput.

Compared to virtualized x86 environments, System z is also unquestionably better suited for mission-critical virtualized workloads. Providing a distributed x86 infrastructure with levels of redundancy and fault tolerance, reliability, and security comparable to those found in a System z would be cost-prohibitive.

For all but the smallest operations, the x86 data center model continues to be scale-out, in which servers, software, facilities, and labor are added over time. As a result, operational and IT costs can be increasingly difficult to track and manage, causing these costs to spiral out of control.

When it comes to running Linux and industry-standard application software, little or no difference exists between the System z and x86-based platforms. In fact, organizations can use common enterprise commercial software such as Oracle, WebSphere, or SAP;1 they can program with Java; and they can use Apache Tomcat, MySQL, or the entire LAMP (Linux, Apache HTTP Server, MySQL, PHP) stack.

[1]IBM has a very large SWG portfolio, with over 7,000 applications (a mixture of business apps, tools, middleware, and management) that run on the System z platform. Refer to the IBM Global Solutions Directory (GSD) found here: http://www-304.ibm.com/partnerworld/gsd/homepage.do

Introduction

Objective

This paper was written to inform the information technology leadership teams within businesses and other organizations of a comparably priced alternative to consolidating virtualized Linux servers on distributed x86-based data center environments — the IBM Enterprise Linux Server. [2]

Audience

This paper will benefit IT systems architects and IT managers who are operating or planning to deploy an enterprise Linux solution, or are planning to take an existing Linux solution to the next level.

Contents of this Report

This white paper contains the following major sections:

- **Virtualized Linux Servers: Solutions and Challenges** — This section discusses the financial aspect of virtualized Linux platforms, the impressive savings IBM Enterprise Linux Server can deliver over an x86 virtualized Linux platform. Also, how different cost structures between the two can obscure true costs, and the issue of virtual server sprawl in the distributed environment.
- **How Linux and System z Virtualization can Benefit Business Organizations** — This section explores the tremendous VM density that can be achieved on System z, how the efficiency of its architecture impacts throughput and the bottom line, and how inefficient utilization of software costs an organization. It also discusses whether a virtualized x86 Linux data center is truly "good enough" for mission-critical needs, and how System z runs industry-standard software.
- **Conclusion** — This section wraps up the paper and sums up the key conclusions.

[2] The IBM Enterprise Linux Server offers a Linux-ready IT infrastructure solution that combines the industry-leading IBM System z and the outstanding IBM z/VM virtualization technologies for workload and server consolidation.

Virtualized Linux Servers: Solutions and Challenges

Consolidating Linux servers by running multiple virtual machines has become the de facto approach to curbing the costs of server hardware sprawl on x86-based servers in the data center. To control such expenditures as equipment purchases and maintenance, underutilization of hardware, energy usage, software licensing, and staff time, IT leaders and data center managers have made virtualized server consolidation one of their foremost business priorities.

Major vendors of x86-based servers offer systems preconfigured for virtualization. The rise in the number of business organizations deploying core business-critical workloads on x86-based systems has roughly paralleled the growth of virtualization, with about half of such workloads running on VMs and more being added every day.

The following graph, from Gartner, shows the percentage of industry workloads running in VMs on the x86 platform from 2005 and projected out seven years from now. It indicates that adoption is expected to continue robust growth well into the future.

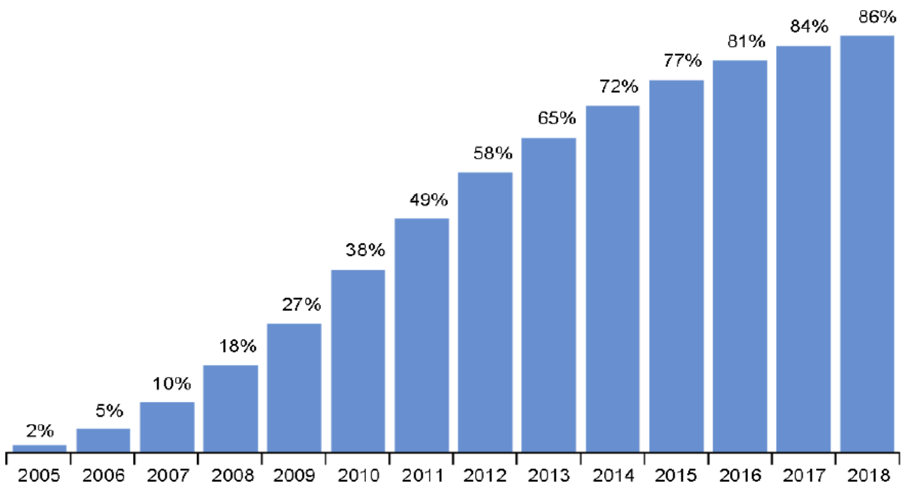
Spotlight on Blue Cross and Blue Shield of Minnesota (BCBSM)

As the largest health plan in the state, Blue Cross and Blue Shield of Minnesota (BCBSM), a not-for-profit healthcare organization, is constantly seeking ways to reduce operational costs and deliver better value to its two million members. It began looking for an alternate environment to support its SAP application when its existing Microsoft Windows and Intel processor-based server landscape began growing too costly to operate and maintain.

BCBSM has consolidated 40 HP Intel x86 architecture servers into a single IBM System z server with IBM Integrated Facility for Linux (IFL) engines. The SAP ERP applications now run in a virtualized SUSE Linux environment. The IBM DB2 database supporting the SAP applications runs under z/OS on the same System z server.

Compared to the cost of a distributed infrastructure, total cost of operations will be reduced significantly over the next five years, including reductions in space, electricity, and cooling requirements. Virtualization has cut server provisioning times by 99 percent, enabling IT staff to respond faster to requests. Availability has improved significantly, and disaster recovery can be achieved 97 per cent faster than before.

Figure 1. Percentage of x86-Architecture Workloads Running in VMs



Source: Gartner (March 2011)

While this projection may hold true, it could be a costly mistake for any IT decision-maker to assume that an x86 server is the best — or even the least expensive —server for their virtualized Linux environment.

Aside from advances in virtualization technology itself, one factor accounting for the steady rise in virtualization on x86 platform has been the incremental improvements and additions to the x86 architecture, making it more mission-critical and enterprise-worthy. Even so, in data centers supporting 40 or more VMs, x86-based environments exhibit certain drawbacks. Issues that arise out of these drawbacks become ever more glaring the more VMs there are. This can result in considerable expenses incurred over time which, when revealed, often take CIOs by surprise.

The Financial Aspect of Virtualized Linux Platforms

The primary appeal of running Linux VMs on x86-servers is one of perceived cost: x86 hardware is at the lowest end of the business-class hardware price scale. The security, open source flexibility, interoperability, and lack of licensing schemes of Linux OS makes it a low-cost option in enterprise data centers, as well. Additionally, the latest x86 architecture offers a design capable of running serial, parallel, and data-oriented tasks in a balanced manner, suitable to enterprise-scale workloads with a fair degree of reliability, availability, and serviceability (RAS).

Therefore, it surprises many systems architects and IT managers to learn that Linux on x86-servers may not be the best solution for their virtualized data center — even in terms of cost. It surprises them even more to learn that, in a data center of 40 or more

VMs, virtualizing on an IBM Enterprise Linux Server is not only cost-competitive with Linux on the x86 servers, it can ultimately prove *less* expensive.

The truth is virtualizing servers using IBM Enterprise Linux Server can result in:

- Much higher VM consolidation ratios, with much more efficient operation than Linux on x86-servers, and requiring far fewer administrators.
- Dramatically reduced software costs, both immediately and cumulatively over time, compared to an x86-based solution.
- Conceivably saving 50 percent or more over an x86-based solution on software and administrative cost alone, with as few as 40 VMs. The virtualized IBM System z environment (exemplified in the IBM Enterprise Linux Server solution) has the potential to pay for itself in five years or less from just the savings on system administrative costs alone. [3]

The IBM Enterprise Linux Server environment offers much higher than average processor utilization levels, so a single Integrated Facility for Linux (IFL)[4] processor is able to handle workloads equivalent to a large number of x86 servers. This is particularly significant for software which is licensed on a per-processor basis, as is the case for many of the company's business-critical applications.

In addition, IBM System z servers (IBM mainframes) bring to the table the proven power, security, and built-in RAS that has made them unchallenged standard for core mission-critical business systems for decades.

IT decision-makers — especially those in mid-sized businesses — frequently dismiss a System z virtualization solution based on perceived expense.

"Why purchase a solution based on System z?" they ask. "It's more than what I need."

However, a better question would be: "How much am I *currently* paying for a unit of work on my x86-based data center environment, compared to what I'd pay on an Enterprise Linux Server. And, how much can I expect to pay over the next few years?"

Typically, the IT leadership within an organization lacks an accurate answer. They usually find the real conclusion to be a revelation.

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[3]*The New Alternative for Leveraging the Power of Business Intelligence*, IBM Corporation, 2010

[4]An Integrated Facility for Linux is an attractively priced processor dedicated to Linux workloads on IBM System z servers.

Cost Structures Obscure True Expenses

Historically, hardware costs made up the largest expenditure in an organization's IT environment, with servers the most expensive component of all. Hardware acquisition expenditures have therefore always been closely scrutinized. This led to decades of effort by System z developers dedicated to making those CPUs work consistently at 100 percent utilization. The results of this intense pressure to maximize efficiency include such innovations as multiprocessor computers, and multitasking (later also incorporated into other servers including the x86).

The success of these persistent efforts, along with a steady fall in the prices of hardware generally, has brought about a paradigm shift. Today the most significant portions of an organization's IT budget consist of software expenses and staffing, rather than systems hardware. In order to accurately assess and control expenses in a data center environment, an organization's IT leadership must know:

- Not only the initial purchase cost of any hardware involved, but also all software costs, such as application license fees, as well as any other software required. These may include asset management, patch management, logging and reporting, and time-stamping software (which is often required across servers in a distributed environment for regulatory compliance and/or troubleshooting purposes).
- The time and expense of all personnel devoted to supporting the servers, either full-time or as a portion of their jobs, throughout the organization.
- How the growth of applications and increased usage over the next few years are likely to affect costs.

A scale-up platform such as Enterprise Linux Server, designed to run over 1,000 VMs on a single physical server, centralizes data center operations. This makes costs for infrastructure, software, and administration far easier to ascertain than in an x86 environment. Software costs, for instance, show up as a single bill from ISVs such as IBM, BMC, or CA. This sort of ready visibility into lump-sum costs for both hardware and software contributes to the common perception of mainframe operations being considerably more expensive than x86-based operations. But are they?

In a large scaled-out x86-based virtualized Linux environment, costs are ordinarily distributed across an organization. Frequently they are siloed in unrelated cost centers and departments, and often tracked by separate accounting entities. Scaled-out environments tend to distribute system support, as well. The time and effort that goes into the lifecycle support of any given virtual server can involve not just the Linux administrators in the data center, but network or security administrators, as well. Many

of these people have other primary responsibilities, so they represent fractional head counts when assessing the cost of managing the server environment.
Thus, determining the true cost of an x86-based server environment is difficult for IT leaders to achieve. More often than not, they really do not know what the expenses are at a rolled-up level. This is not much of a problem in smaller virtualized Linux data centers with just a few physical servers. However, as the number of VMs reaches more than 40, and up into the hundreds, organizations can lose sight of and control of costs, amounting to hundreds of thousands to millions of dollars.

Virtual Server Sprawl

One problem that initially gave rise to server virtualization is server sprawl; that is, expansion of scaled-out farms of physical servers was becoming costly and inefficient. Consolidating several virtual servers onto a single physical machine addresses the chronic underutilization of x86 servers to some degree, and also does a lot to reduce hardware expenditures, administration, and maintenance, power costs, and data center floor-space requirements.

As virtualized data centers have gained widespread adoption, however, the number of virtual servers in the typical data center is growing faster than ever. It once took as long as six months to provision a new hardware-based server. VMs, not directly associated to hardware procurement, are so readily obtained that lines-of-business units are requesting new VMs at an unprecedented rate. It is now so easy to create a new VM or clone an existing one that, in many cases, users are doing it themselves.

This “virtual server sprawl” can be difficult to control. More to the point, it is harder to measure and keep track of than physical server sprawl. In fact, ISVs have even sprung up, offering software specifically designed to assist in managing VMware environments.

Though easily generated, virtual servers require the same types of management activity as their physical counterparts – operating system and application patching, anti-virus signature updates, resource monitoring and management, data backup, and planned changes as a result of normal operation. They consume host hardware resources such as memory, processor cycles, disk space, and I/O bandwidth.

Then, there are the costs of the software running within the virtual machine. Depending on the software licensing and support terms for the applications and any software systems management add-ons, there are normally fees and costs paid to each of those vendors for every VM created.

Massive amounts of capital, time, and effort can be wasted on IT projects that were launched in the past by managers who may no longer be on board at the company, or who have moved on to other assignments.

The inefficiency and waste in a large x86-based distributed virtualized Linux operation, due to lack of effective, centralized asset management, can be mind-boggling. Industry analysts have been calling attention to the phenomenon of virtual sprawl and its drawbacks since before 2008. With the increased adoption of virtualization since then, the problem has only gotten worse.

One of the ISVs that develops software to manage virtualized data centers reported finding overspending in more than 95 percent of such environments. In just one relatively small operation of only about 325 VMs, they cited more than $200,000 in overspending on inefficiencies.[5] A 2010 IDC survey of mid-sized and large businesses found that over half of enterprise applications were underutilized, with the number of unused but paid-for licenses ranging anywhere from 25 percent to more than 75 percent.

To sum up, the true cost of VM sprawl in a distributed x86 virtualized Linux environment is often severely underestimated, much of it being unanticipated and difficult to discern. These "hidden" costs are not attributable to the expense of managing the environment. In fact, they are spawned by inefficient management, in the form of wasted resources such as software and personnel.

[5] *The Costs of Virtual Sprawl*, Dan Woods, as published on Forbes.com

How Linux and System z Virtualization Can Benefit Business Organizations

The perception that System z servers are more expensive than x86 servers has a basis in fact. The superior technology and powerhouse capacity of the hardware comes at a premium, to be sure. However, hardware is only one cost component in an IT infrastructure and — as pointed out earlier — not even the most substantial one. Linux on System z also has a different cost structure than z/OS does. Organizations deploy consolidated, virtualized Linux data center environments to reduce costs. The cost reductions from virtualizing Linux on System z, with an IBM Enterprise Linux Server, so far outstrip what can be saved with Linux on x86 servers that the difference can often make System z the more economical choice by a considerable margin.

It is well accepted that higher VM density translates into more savings through consolidation. Administrators in x86-based virtualized data centers commonly work with approximately 10 Linux VMs per Intel eight-core system. A System z-based data center running the same workload at the same service level can host 240 VMs. Even relatively small organizations have seen three-year savings of 50 percent with Enterprise Linux Server over x86 virtualized Linux servers running industry-standard workloads — provided those x86 servers supported adequate RAS provisions, on par with industry best practices.

One independent study [6] considered prices for running a heavy I/O workload on 240 VMs. It estimated running that workload on one System z 196 with 32 IFLs, at 70 percent CPU utilization with a high-reliability service-level profile, to be approximately $3,300,00. It estimated running that same workload with the same number of VMs on an equivalent x86 platform (24 Intel Xeon eight-core servers as 24 blades, 192 CPUs) to be approximately $4,800,000.

Customers running approximately a hundred applications on racks of x86 physical servers find it hard to believe that those workloads will all run on four to six processors within a single System z server. The reason? They are accustomed to making allowances for the inefficiencies inherent to the x86 architecture. The System z architecture, as mentioned earlier, was designed to maximize efficiency in utilizing hardware resources.

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[6] *The Mainframe Virtualization Advantage: How to Save Over a Million Dollars Using an IBM System z as a Linux Cloud Server*, Clabby Analytics and IT Market Strategy, 2011.

This extremely efficient architecture is what lays behind the impressive cost-effectiveness of the System z servers.

Efficiency in the Architecture Impacts the Bottom Line

Fundamental differences exist between the System z server architecture and that of an x86 server with VMware. Having roots in the days when every cycle was precious, and where applications had to fit into 64 KB of central storage, System z servers (mainframes) were built from the beginning to wring out the most efficient utilization possible from memory, storage, and peripherals. As an example, System z exploits every interrupt or pause in workload to instantly take the next unit of work awaiting a processor.

With the innovation of Workload Manager — part of the fully integrated System z stack that includes z/VM – IBM enabled technicians to set performance goals (e.g., 40 percent of transactions under two seconds) and let the system automatically assign computing resources to workloads. As a result, today IBM Enterprise Linux Server runs comfortably at over 85 percent utilization of computing resources.

Determining Your CAPEX-Free Cash Budget

If you are an IT system architect or IT manager operating an x86 Linux environment, you can conduct a simple test to determine the CAPEX-free cash budget available for optimizing your data center using a simple collection tool IBM makes available at http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/PRS4325
Ask your management team to estimate the average sustained utilization of your x86 Linux server farm. (If the estimate is higher than 10-30 percent, have them run the collection tool.) Take the utilization figure, invert the amount (1/x), subtract 10 percent, and then multiply it by your software expense for the same environment. The resultant amount is your CAPEX-free cash budget to optimize your data center.

Another critical distinction in System z architecture is the existence of an entire pool of processors other than CPUs, which can take on tasks other than whatever actual application workload — e.g., an Oracle database — the CPU is engaged in running at any given time. Cycles not directly related to running that application, such as network hops or storage calls, are offloaded to entirely separate processors. Figure 2, below, presents a graphic presentation of the System z processor pool.

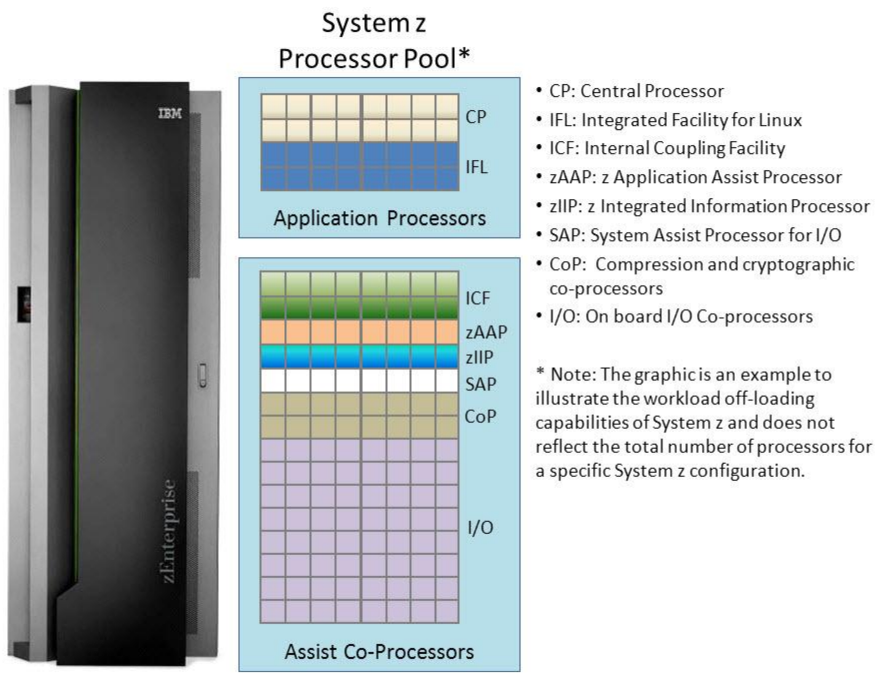

Figure 2: System z Architecture Showing Processor Pool

These processors (of which there may be dozens or hundreds, depending on server configuration) are dedicated to their particular task, such as I/O; they are not also running the Linux OS or any software application. They are strictly data shuttles. More to the point, they are not subject to software charges, as is the CPU. A data center can have its processor running a production workload 24 hours a day while leveraging all those other processors, but the chargeable unit for application software remains the core. For instance, 20 cores of x86 workload can be accommodated by a single System z core.

This unique architecture allows a CPU to work ceaselessly on any workload assigned to it. Contrast this with Linux on the x86 platform. If Oracle, for instance, is running on a VM in an x86-based platform and the processor must access storage, it suspends operation while the data is retrieved. Such innumerable pauses make for inefficiency, with processor contention causing problems in an I/O-intensive environment (such as a database) when the CPU exceeds approximately 55 percent utilization. [7] A System z CPU responsible for transactional workloads, on the other hand, easily continues to run full transactional throughput at 90 percent utilization.

[7] This applies to most typical enterprise workloads; however, it would not be a problem with workloads having almost no I/O, such as animation rendering or geological mapping.

Throughput Should be the Determining Metric

IT decision-makers in an organization, often unaware of the true cost of an x86-based server environment, frequently focus solely on the acquisition price of the hardware. On this basis alone, x86 seems the best available deal. What they should be considering, however, is throughput — that is, how much *work* can actually get done for their investment.

The extreme efficiency of a System z environment (such as offered by IBM Enterprise Linux Server) often more than compensates for the somewhat higher acquisition price of the hardware, relative to a number of racks of Intel x86-based multi-core servers (or nodes), along with their required gear. A node on the scale of a System z has more headroom and thus can be used to create and operate more virtual machines by an order of magnitude.

Over a 24-hour period of operation, each node running VMs on the x86 racks operates at around 50 percent utilization, with 10 percent of that reserved for VMware (due to I/O caching, etc.), leaving perhaps 40 percent throughput, at best. Each of those nodes incurs costs for software — including virtualization software and applications — as well as personnel to maintain it, and the networking infrastructure between it and all the other nodes. The same workloads that can be handled by this environment can be supported within the boundaries of a single System z node, and will run the VMs at 90 percent utilization. That is, it will double the throughput of the x86 environment.

Unused capacity can usefully be viewed as a tax paid by the organization on the total cost of a system. For example, in terms of energy costs, if a system runs at 95 percent CPU utilization, the organization is paying a 5 percent energy tax; at 40 percent the organization is paying a 60 percent tax.

CPU cycles are only one area where the System z model is more efficient, in terms of throughput. Another is in networking. Consider a simple web-serving OLTP environment accessing data at high volume. It consists of a database and a web application server, each running on a separate processor at top capacity. On an x86 platform, approximately 30 percent of the data in the IP datagram traffic used between processors is actual data; the remainder is header information. So a considerable number of cycles are devoted to nothing but IP datagram processing.

With the same workload running in a System z, traffic between processors takes place over the extremely large internal communications bus — on which the traffic can be tuned and which lacks the IP overhead. The response time for the System z as compared to the x86-based environment would be comparable, and in some cases could even slightly favor the latter. However, for the same cost, the System z transactional throughput would be greater by an order of magnitude. Where the System z environment might put out 10,000 transactions per second, the x86 environment might put out anywhere from 500 to 2,000.

Inefficient Utilization of Software is a Major Expense

We have already noted that software costs make up the most significant portion of an organization's IT budget (in addition to staffing). This is also one of the most significant areas where unused capacity amounts to a tax on the overall cost of a virtualized Linux data center platform. ISVs extend no rebates for underutilized hardware system capacity. As with other inefficiencies inherent in the x86 distributed platform, the inefficient use of software becomes increasingly expensive with the growth of the environment.

The massive consolidation ratio System z allows also translates into dramatically reduced software costs. The general licensing model used by nearly all ISVs for industry-standard applications such as WebSphere and Oracle is on a per-core basis. While they do usually adjust pricing for the perceived value in terms of throughput, making application software for System z somewhat more expensive, this typically amounts to something like a 25 percent delta for what really amounts to three or four times the value.

Let us illustrate the software cost savings in a simple scenario. A data center that is paying for 128 cores running an Enterprise Oracle workload on an Intel x86 rack-based environment can reduce the number of those core-based Oracle licenses to six or seven in a System z environment. The following subsection provides cost-based examples of the software savings possible.

Software Costs Calculation Examples[8]

Assuming an environment's software license costs amount to $30,000 and the yearly support costs are $10,000, Example 1 (below) shows the three-year cost when consolidating from six x86 cores to one IFL, and Example 2 shows the three-year costs with a consolidating from 120 x86 cores to 15 IFLs.

[8]Edison does not provide any ISV software prices. The prices in this example do not reflect any real prices; they are used for illustration purposes only.

Example 1: Consolidation of 6 x86 Cores to 1 IFL

	Costs	Comments
1 year	$20,000 savings	• Without consolidation, $60K is required for support • One new license is required, costs are $30K • Support for one IFL costs $10K ► $60K - $30K - $10K = $20K
2 year	$50,000 savings	• Without consolidation,, $60K is required for support • Support for one IFL costs $10K ► $60K - $10K = $50K
3 year	$50,000 savings	• Without consolidation,, $60K is required for support • Support for one IFL costs $10K ► $60K - $10K = $50K
Total savings over 3 years	**$120,000**	

Example 2: Consolidation of 120 x86 Cores to 15 IFLs

	Costs	Comments
1 year	$600K savings	• Without consolidation,, $1.200K is required for support • 15 new licenses are required, costs are $450K • Support for 15 IFLs costs $150K ► $1.200K - $450K - $150K = $600K
2 year	$1,050,000 savings	• Without consolidation, $1.200K is required for support • Support for 15 IFLs costs $150K ► $1.200K - $150K = $1.050K
3 year	$1,050,000 savings	• Without consolidation, $1.200K are required for support • Support for 15 IFLs costs $150K ► $1.200K - $150K = $1.050K
Total savings over 3 years	**$2,700,000**	

Mission Critical: Are Virtualized x86 Data Centers Truly "Good Enough?"

System z servers were developed from their very inception to serve as the computing engine of enterprise organizations. Not so the x86 server; it started life in the form of personal computers developed to serve individuals. It has been incrementally retrofitted with added horsepower and technology to accommodate networking, web capabilities, clustering, and virtualization, as well as more complex and demanding workloads.

Today, servers based on x86 multi-core architecture — capable of running parallel, serial, and data-oriented tasks in a balanced fashion — are impressive business-worthy machines. If providing the massive level of redundancy and fault tolerance, reliability,[9] and security[10] found in a System z were possible in a x86-based infrastructure, it would it be cost-prohibitive to do so. IT leadership in many organizations running mission-critical workloads regard the x86 server as "good enough" to meet their needs. Are they? If an organization's virtualized Linux data center operation does not (and is not expected to) exceed less than half a rack of x86 servers, the answer to that question might be yes. Beyond that point, however, the x86 server begins to yield sharply diminishing returns on performance and value, and does not rise to the level commonly regarded as necessary for mission-critical operations.

Virtualization

It is impossible to imagine operating a System z-based data center without virtualization. IBM's System z servers have incorporated virtual machine technology since 1972. Therefore, virtualization is deeply ingrained in the System z architecture, and is designed with same attention to efficiency as the rest of the system.

In order to grasp a System z server's capacity for virtualization, compare a workload with intensive I/O requirements running on three IBM systems designed for virtualized data centers:

- A 16-core BladeCenter HX5 system.
- An eight-core BladeCenter PS 701 POWER7 system running PowerVM.
- A zEnterprise 196 server running z/VM and with 32 IFLs.

[9] System z has a 35-year Mean Time Between Failure rate.
[10] System z is the only commercially available server to have been awarded Common Criteria Evaluation Assurance Level 5 (EAL5) for security.

Suppose that these servers are to be utilized in running workloads consisting of online banking transactions of 1 MB apiece, with each workload driving 22 transactions per second. The dedicated I/O processors in the System z architecture (discussed earlier), and the flexible scalability and capacity of a common virtual resource pool (discussed below) allow as many as 40 such workloads to run on a single System z 196 with 32 IFLs. It would require as many as 40 of the other two servers to achieve equivalent throughput.

Scalability

System z holds a world record for scalability. [11] The design philosophy underlying a large-scale System z architecture is based on sharing resources. It shares memory, a very large internal communications bus (or "backbone"), CPUs, disks, and other resources, all of which can be made available to a common pool within a single self-contained unit. The size of this node can be as much as 80 cores. If each core consolidates 20 VMs, that amounts to 1,600 VMs, all part of one virtual pool, dwarfing the nodes within a scaled-out x86 environment. It allows an administrator to apply a common set of workload policies across, say, 100 applications under a single workload management system, where the peaks and valleys in all these workloads level themselves out based on business-driven priorities and objectives.

In an x86 scaled-out environment, a single large application may spread across the boundaries of one or more nodes, involving network overhead that can degrade throughput. The much more restricted physical capacity of each node in the environment hampers the ability to shift resources to applications that need them *when* they need them.

Again, fewer throughputs translate to more servers, more software, and more overhead.

Security

The damage done by security breaches is well known even to people uninvolved with IT, due to a number of high-profile cases of data loss and/or theft in some major Fortune 500 corporations. The monetary cost to commercial companies in a recent study ranged from $750,000, for the least expensive, to nearly $31 million to resolve a data breech. [12]

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[11] As part of the world's largest Core Banking Benchmark run by IBM and Financial Network Services (a subsidiary of Tata Consultancy Services) for the Bank of China, System z delivered 9,445 business transactions per second, based on more than 380 million accounts with 3 billion transaction histories.

[12] *Ponemon Study Shows the Cost of a Data Breach Continues to Increase*, Ponemon Institute, November 2011.

As with other improvements designed to make the x86 platform suitable for mission-critical, improvements in the platform's level of security have been made incrementally to a platform that started out inherently inappropriate for sensitive or mission-critical workloads. While improvements have been significant, serious flaws have been discovered and fixed as recently as December of 2011.

The security model that System z uses to provide access control and auditing functionality, Resource Access Control Facility (RACF), is one of the most scalable and mature security monitors available in IT. [13] Able to support extremely granular policy-based permissions, RACF works closely with the underlying System z hardware — for example, protecting digital certificates within tamper-proof cryptographic processors.

Part of each processor in the IBM System z server, the CP Assist for Cryptographic Function (CPACF) presents an interface easily grasped by administrators familiar with today's security systems. It provides a set of cryptographic functions that focuses on the encryption/decryption function of SSL, Virtual Private Network (VPN), and data-storing applications. The CPACF is used by SSL/TLS functions included in the z/VM Lightweight Directory Access Protocol (LDAP) client and server, and by the SSL functions provided by the z/VM SSL server. Any VM can access the functions of the CPACF by using the Message-Security Assist (MSA) extensions of the IBM System z processor architecture. No explicit z/VM authorization or configuration is required.

z/VM can virtualize System z cryptographic devices so they can be shared by many Linux systems. z/VM can balance the workload across multiple cryptographic devices. Should one device fail or be brought offline, z/VM can transparently shift Linux systems using that device to use an alternate cryptographic device without user intervention.

System z is also inherently immune to exploits that work by bridging a memory boundary in the x86 environment by way, for example, of a memory leak. This is because in the System z architecture memory is always assigned to a task virtually, so there are no memory blocks for a rogue program to address.

Manageability

Being a centralized, scale-up environment, the System z platform is more manageable by design than a scaled-out x86 environment. We already mentioned the way workloads are managed within a single large resource pool according to business-driven objectives. This is accomplished by very few people, reducing the need for administrative staff.

[13] With Common Criteria Evaluation Assurance Level 5 (EAL5) awarded by International Standards Organization, System z has the highest security rating or classification for any commercially available server. z/VM has also separately received EAL certification.

Additionally, the simpler, superior manageability of a centralized model prevents the sort of out-of-control, unseen expenses described earlier as a common drawback of scaled-out x86 environments. In that scenario a developer, for instance, might purchase any number of low-cost server units without concern for software costs or the utilization efficiency of the hardware.

Why Deploy an Entirely New and Different Platform?

When running Linux and application software on System z, few, if any differences exist, compared to other Linux-supporting environments. That is the case even though the System z server differs significantly in its architecture (giving it superior throughput, manageability, and reliability).

Industry-Standard Software

The view of mainframe software as something arcane and proprietary has been inaccurate for many years now. The combined attributes of the System z server design and virtualization stack, along with low-cost processors embodied by the Integrated Facility for Linux (IFL), constitute an energy-efficient platform that can run the widest array of modern application workloads, including open source.

Organizations can use common commercial enterprise software such as Oracle, WebSphere, or SAP. They can program with Java. They can use Apache Tomcat, MySQL, or the entire LAMP stack. Through its partner programs, IBM provides the support and infrastructure to give

Transzap Tackles Growing Pains with System z

A small software service company servicing the oil and gas industry, Transzap nevertheless runs a lot of transactions — an estimated 130 billion over the past year. The company also has experienced extreme growth and appeared on the Inc 5000 list of fastest-growing companies.

This growth brought along challenges, however; and Transzap's distributed x86-based Linux data center began encountering some major issues involving services outages. This threatened to damage the company's reputation, and — with an SLA policy to refund fees for outages beyond a certain duration — cost the company substantially. Finger-pointing was rife between hardware providers, disk providers, database provider, and Linux support provider.

In the course of due diligence in search of a server platform to provide adequate scalability and reliability, the Transzap team learned that a platform based on IBM System z9 business class would provide stable 40-year MTBF reliability. More immediately, the reduced software licensing costs would deliver all the ROI needed to justify its purchase.

Three and a half years ago Transzap moved its entire database onto a virtualized Linux platform running on z/VM on System z. Ever since, the company regularly meets its SLAs. Plans are in the works to upgrade to a System z 114, and it is reported that the platform has proven to have many benefits for a small shop like Transzap.

ISVs software and capacity to develop their applications for System z. [14]

Adoption of Linux on System z has seen growth in the triple digits. Linux running on System z is the same as Linux running on any other platform. The APIs do not change at the kernel or the package level. In nearly every case, moving Linux VMs from an x86 servers to System z involves a few hours' worth of recompiling, along with an error check. The same is largely true for ISV applications; in some cases, there may have been code written to exploit a hardware feature in the platform — however, those are easily identified and dealt with. [15] It is no different or worse than performing any migration between platforms.

Skill Sets Easily Transferable

Because Linux and any business applications running on System z are no different in operation from those running on a x86 server, no new skill sets are required for staff accustomed to operating those applications in a distributed environment. In fact, having been used to a much less efficient system, administrators may receive requests for more resources — such as memory – than a given business unit may actually require.

From the systems management standpoint, managing the System z infrastructure is not appreciably more difficult than managing an x86-based blade infrastructure. For administrators familiar with virtualized Linux in the x86 environment, much of the learning involves functionality that is nonexistent on that platform, and that delivers value up to the full capacity of the system.

For example, System z has the ability to either expand or contract — that is, processors, memory, and I/O can be both added and removed from a running VM without disrupting servers. This is a powerful advantage in flexibility over Linux on x86, which requires a reboot for any such resources to be removed. The ability to move virtual memory wherever needed is another example of a functionality unavailable in the x86 environment which administrators must learn to use.

[14] IBM has a very large SWG portfolio, with over 7,000 applications (a mixture of business apps, tools, middleware, and management) that run on the System z platform. Refer to the IBM Global Solutions Directory (GSD) found here: http://www 304.ibm.com/partnerworld/gsd/homepage.do

[15] In fact, System z is so intolerant of code errors, such as memory leaks, that ISVs have identified them when compiling for System z, which allowed them to locate and fix the errors in the code for the other platforms they support.

IBM Financing

Having one of the world's largest financing businesses, IBM offers creative financing packages that align an organization's capital expenses with the progress of their project. For example, if a business plans to move a hundred cores (a rack or two) of an x86-based virtualized data center operation over to a System z, IBM's financing options allow that business to defer payment until the workloads have been moved. So, a data center can benefit from taking a variety of Linux workloads that are occupying a lot of floor space, put them all into one tightly knit, highly virtualized and highly efficient environment. IBM allows the organization to pay for it as the return on investment is realized.

Experience of Businesses that have Made the Switch

Here are brief overviews of two actual IBM customers who have benefitted by switching from x86-based virtualized Linux data centers to IBM Enterprise Linux Server.

Financial Services Company

This company is an established leader in business consulting, smart card solutions, e-payment networks, and the integration of financial transaction processing systems. It faced challenges when offering clients a payment switch technology, delivered as a license or a cloud service.

The offering, an innovative Java solution, had grown exponentially. The data center infrastructure underlying the solution consisted of many HP blade servers on many racks, running many instances of the Oracle database. As the solution took off, managers faced increasing difficulty understanding where inefficiencies lay: underutilized servers, poorly utilized storage devices, excessive numbers of routers and switches, and/or other network infrastructure devices.

The infrastructure also lacked the security the company required, making it difficult to comply with the banking industry's PCI compliance standards. Further, the data center was using separate servers for each of its client's development, production, and availability requirements. The costs of electricity, cooling, and of physically expanding with the addition of each new client, were becoming cost prohibitive. The company realized it could not continue to grow without consolidating and virtualizing in some manner, and having the scalability and elasticity to go forward.

The organization's IT staff perceived IBM System z as having a very high cost of ownership and suitable only for much larger organizations. But an in-depth analysis of the combined costs of blade server purchase and required Oracle licenses revealed that an IBM System z solution could reduce the company's overall cost by 30 to 35 percent.

The organization implemented the z10 Business Class mainframe, with tightly integrated IBM z/OS, DB2, and WebSphere software, to support the development of new business channels for the solution, running on Linux-on-z. The platform provides the organization with the high availability needed to support its payments business, which includes solutions for secure transaction processing, issuing credit cards, and ATM transactions. The IBM technology was also chosen for its ability to support PCI compliance with the highest level security and unmatched scalability.

By running on the IBM System z mainframe, the company's payment switch can process up to 5,000 transactions per second (TPS) at a volume of millions of transactions every month.

A principle of the company reports that the payback is multifold and goes beyond eliminating the redundancy of too many servers and programs doing the same thing. They have realized secondary and third-order benefits in operational efficiency and ease-of-management, the lack of which had formerly been so problematic and costly.

Governmental Public Health Management Provider

A local government-funded public health organization, responsible for the management and administration of all aspects of public health over a territory populated by 280,000 people, was struggling with the burden of its operating costs. It sought a way to reduce its IT expenditures without reducing services, while accommodating future growth.

The organization's original data center operation, composed of four HP dual-core servers (eight cores), had become very expensive and was not performing satisfactorily. The year-over-year cost of related Oracle licenses and hardware maintenance was only growing. Limited scalability and related costs made consolidation and optimization impossible.

Seeking a solid, innovative, and scalable infrastructure as well as controlling costs, the organization evaluated three IBM solutions, based on System x (x86-based), Power, and System z (Enterprise Linux Server). To their surprise, the analysis revealed that the System z-based solution promised the lowest cost by a substantial margin of the proposed solutions, projected over a three-year period, and would cost less than half of the existing solution over the same span of time.

The solution implemented consisted of a System z10 Enterprise Linux Server with 1 IFL engine, 16 GB RAM, z/VM, and Red Hat Linux for System z, with the midrange IBM Storwize V7000 storage system having 16 450Gb 2.5 inch disks (7.2 TB) and two-switch FC.

The ROI for the solution began accruing immediately with the reduction from nine Oracle licenses to one, while making it easier to manage the environment with a solid and consolidated database infrastructure. The scalability of the solution will continue to improve as the organization grows and/or consolidates more workloads.

Conclusion

CIOs or other IT decision-maker considering approaches to consolidating Linux servers in a virtualized data center operation would be remiss not to consider IBM's System z-based Enterprise Linux Server. High-end Intel-based servers can support a robust virtualized Linux platform. But, the overall x86 architecture, when scaled to enterprise proportions, begins to show its limitations — efficiency limits, limitations scaling well beyond a single hardware node, and in the cumulative amount of overhead required for each VM on a node.

The x86 architecture was not originally intended to be an enterprise platform. It lacks the sophistication of virtualization, workload management, and architecture between memory, CPU, and I/O, and networking that the System z offers. Any advantage of lower-cost hardware is outweighed by the of cost of all the management and application software, as well as networking gear needed to achieve an acceptable degree of redundancy, availability, fault tolerance, and manageability. That is especially true for an x86-based environment of over a hundred servers, with hundreds of cores.

By contrast, the System z architecture was built to support enterprise workloads from the start, and was designed for maximum efficiency. It becomes an increasingly better value proposition the larger the virtualized data center grows. Moreover, it can be surprisingly cost-competitive, even compared with modest x86 systems, especially over time as the considerable savings gained from far superior efficiency and considerably greater workload throughput begin to accumulate.

The savings in software costs — the most significant portion of an IT budget (next to staff) —are simple to grasp. For example, a data center that is paying for 128 cores running an Enterprise Oracle workload on an Intel x86 rack-based environment can reduce the number of those core-based Oracle licenses to six or seven in a System z environment. And it can run those workloads at near 100 percent processor utilization.

Edison suggests that CIOs or other IT managers consider the full cost of their existing distributed x86 virtualized Linux environment, if one currently exists. Consider the potential growth of a deployed environment; if deploying a new application, consider how that might grow over the next few years. Look at the needs of testing and development — *all* the environments, not merely what a production environment requires. If a planned virtualized Linux environment involves consolidating 100 cores, System z can certainly offer a compelling value proposition. If the projected three-year plan is to scale to 200 cores on x86, nothing else IBM offers can compare with Linux on System z.