Virtualization Is Not A Silver Bullet

Why and How Virtualization Needs To Be Managed

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The Lure of Virtualization

Virtualization is an important technology. It was introduced to the IT market at the right time, when "off the shelf servers provide far more computer power than the majority of applications need. Moore's Law had run rampant for decades, doubling the capacity and speed of the average server every 18 months. So the time finally arrived when there was a major imbalance between the workload that the typical application presented and the computer power that the typical low-end server provided. Virtualization technology appeared magically, right on cue, when it could be put to excellent use.

Efficiency rates less than 10 percent (in terms of cpu and memory usage) were common and there were many examples of efficiency as low as 2 percent.

Why Virtualization is an excellent technology

Over the past 15 years, the corporate buying pattern for server hardware had two strands:

- High end hardware, powerful Unix clusters or mainframe resources, were purchased for mission critical applications with large workloads.
- Undemanding applications and services were catered for by inexpensive off-the-shelf hardware. Sometimes dubbed "volume servers" they cost $25,000 or less or much less and they are bought on an as-needed basis.

The volume servers typically ran either Linux or Windows. Neither of these OSes were built to run multiple applications. Even though running multiple applications on a single server was possible with these OSes, few data centers cared to try. The policy was "one application per server" and attempting anything else was dangerous.

By 2004 it had become clear that most off-the-shelf servers were running at very low levels of efficiency. Efficiency rates less than 10 percent (in terms of cpu and memory usage) were common and there were many examples of efficiency as low as 2 percent. This was undesirable, but it wasn't the only problem that data centers faced. Indeed, there were a series of problems arising from the inefficient deployment of large numbers of servers.

Moore's Law

What was the underlying cause of this? Moore's Law, the doubling in speed of cpu chips, memory and other computer components, had behaved reliably for decades, regularly delivering reliable improvements in computer performance. But in 2004, the chip industry could no longer deliver that remarkable speed increase in the way that it had been doing.

Chip speeds had been accelerated in two ways:

1. By further miniaturization, allowing more transistors onto the chip.
2. By increasing the clock speed (the electric pulse rate) of the chip.

The second of these mechanisms was no longer practical. As the clock speed moved into the 3-4 Gigahertz range, voltage leaks caused severe heating problems. It was still possible to run the chips a little faster in this way, but they consumed more electricity and they required more cooling. It wasn't worth it. This had a profound impact on data centers.

So the litany of problems that data centers now faced included the following:

- **Server sprawl:** Many data centers were gradually running out of space. Data centers that were built for tens of servers, suddenly needed to accommodate hundreds of servers. Sometimes this meant a whole new data center.
- **Labor costs:** The rise the server population caused a disproportionate rise in support staff.

- **Cooling costs:** Most data centers had not been built with sufficient air conditioning capability to cool the computers they now accommodated. The A/C either needed upgrading or, again, maybe there was a need for a new data center.
- **Electricity costs:** The cost of electricity itself became an issue. It was now a major cost, and the irony was that for every new server added electricity was required both to run it and to cool it. Many servers were running inefficiently, but they needed as much cooling as those that ran efficiently.

As a general guide about 15-20% of servers that are candidates for virtualization can be implemented as virtual servers quickly and with little fuss.

Abracadabra! Server Virtualization

It seemed almost magical that virtualization technology appeared right on schedule to offer a solution to these severe data center problems. For most organizations the nightmare wasn't that their raw data center costs were escalating, awkward though that was. It was that they might be forced to build a whole new data center long before they had expected to.

Data center space is the most expensive "office space" there is. The actual cost varies according many factors, particularly size and capacity, but also proximity to power sources, power distribution and disaster recovery, labor costs, local taxes and so on. And the costs are always substantial; measured in millions or tens of millions or, for very large data centers, even hundreds of millions.

Any technology that deferred such an investment would be welcomed with open arms, and virtualization could do that. It could:

- **Reduce server sprawl:** By consolidating many of the inefficient servers into a much smaller population.
- **Reduce electricity and cooling costs:** Reduce the server population and you reduce electricity and cooling costs.

The Low Hanging Fruit

As a rough rule of thumb, in a virtualization-free data center, 75% of the commodity servers (that's usually 60% of the total server population) are candidates for virtualization - because they are inefficient. The other 25% or so will use most of their computer resources efficiently. This will include such applications as email that spread over multiple servers or active BI data marts, where users keep the server busy with stream of complex queries.

For most data centers it is easy to identify some servers that are candidates for virtualization. Servers that are devoted to software testing, for example, are obvious candidates. And, because the primary users of such servers are IT savvy, you can let them create, manage and remove virtual servers themselves.

Once you move beyond those servers, you need to identify production systems that have a very predictable workload. Some applications will have such a workload - but you have to be sure. If an application uses just 5% of a server's resources over a whole day, it still might require 50% of those resources at peak loading time. Some applications, especially Internet facing applications, need a great deal of head room, and others do not.

As a general guide about 15-20% of servers that are candidates for virtualization can be implemented as virtual servers quickly and with little fuss. In many early virtualization projects, data centers simply replaced physical application siloes with virtual application siloes. Because the servers were well chosen, the approach tended to be successful, but as further virtualization was attempted, problems began to arise.

Virtualization Is Not A Silver Bullet

What we have described brings us roughly the point where many organizations find themselves virtualization. Most data centers are now running virtualization projects. Most have virtualized a proportion of their eligible server population. Surveys confirm this. So does the collapse in server sales that began in the last quarter of 2008 and has proceeded through the first two quarters of 2009. According to figures from IDC, server shipments have fallen by about 30% in the first two quarters of the year.

The response of IT departments to the recession has clearly been to cut costs through virtualization. Nowadays 50% of new servers installed will run with virtualized partitions. Virtualization has become the norm and it's working.

Why Virtualization is not a silver bullet

To understand what's going on, it helps to calculate the cost savings of server virtualization in terms of the Total Cost of Ownership (TCO) of a server. The TCO includes the cost of purchase and maintenance, the electricity, cooling and space costs, administration, deployment and support costs. The typical TCO will vary from one data center to another, but it will be a significant multiple of the server cost, probably a factor of 3 or 4.

When you use virtualization technology to replace two servers with one, you save the TCO of almost one whole server, by saving the operational and ***physical support*** costs. On the surface, there appear to be no added costs, except that most server virtualization requires the use of a Storage Area Network (SAN) so that cost needs to be added in. If you can use virtualization to fit 3, 5 or even 10 servers into one, the cost savings multiply up and a pleasing manner.

Now take a look at Intel's future roadmap for its chips. The future looks even more promising. Intel's 8 core Nehalem chips are now available, and they will probably be followed in the future by 16 core chips. More cores means more capacity to virtualize. So as new server hardware appears, there will be a chance to "reduce the costs again", consolidating your applications onto even fewer servers and saving even more server costs. At last, Moore's Law is paying big dividends!

The Devil in the Detail

Unfortunately, it's not that simple. Virtualization easily generates false expectations. It can indeed deliver impressive economies, but there are limits. Virtualization does not remove server sprawl, it just replaces server sprawl with ***virtualized server sprawl***. For virtualization to deliver to its full potential, ***virtualized server sprawl*** needs management. It needs to not sprawl.

Virtualization easily generates false expectations. It can indeed deliver impressive economies, but there are limits. Virtualization does not remove server sprawl, it just replaces server sprawl with virtualized server sprawl.

Here's the problem: While the "management tools" provided by the vendors of virtual platforms only manage the virtual partitions - they do not and cannot manage the applications that run in those partitions. Important management information and control is easily be lost when applications are virtualized. Consider this list:

- **A single comprehensive view of transactions.** This is critical to customer and user experience. Virtualization can interfere with the all-important monitoring software that gathers the data and helps to ensure the service.
- **Integrated performance management.** The ability to perform accurate and timely fault detection and root cause analysis across networks and systems is impaired by unmanaged virtualization.
- **Real-time configuration change detection and notification.** Agents and/or software components that monitor configuration change need to be in the right location. Virtualization can and often does ignore this important detail.

- **The mapping of applications and their dependencies to the underlying infrastructure.** This is critical for reducing sprawl, maintaining compliance and ensuring performance in a real-time environment. It's a sobering thought that, by simply moving a virtual partition, an application can suddenly cease to obey a compliance mandate.
- **The information required in order to provisioning and de-provisioning servers efficiently.** This activity is now intimately connected to the deployment of virtual partitions. Physical provisioning needs to be an automated closed-loop real-time activity and for that, a complete knowledge of the workload patterns of the whole environment is required.
- **Coherent security.** IT security (typically an area where compliance is non-negotiable) is no longer a simple perimeter activity. As virtual partitions are created and retired, the appropriate IT security protection has to move in harmony. This applies to all areas of IT security, from user and software access to intrusion prevention, and securing the hypervisors themselves.

In summary, we need to holistically manage both the virtual and physical environments, where previously we only needed to manage a relatively static physical environment. We need up-to-the-second visibility of everything, and we need to be able to monitor any part of it and accommodate any changes that occur. If anything fails, we need to recover the situation.

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In other words, with virtualization, managing the whole environment becomes a great deal more complex.

Consider a Simple Situation

Let's imagine that we have implemented, say, 3 applications on the same server and the server fails. Of course, we will have to recover all three applications at once, and that will probably take longer than recovering just one application. But then the question arises: Where should we put the recovered applications?

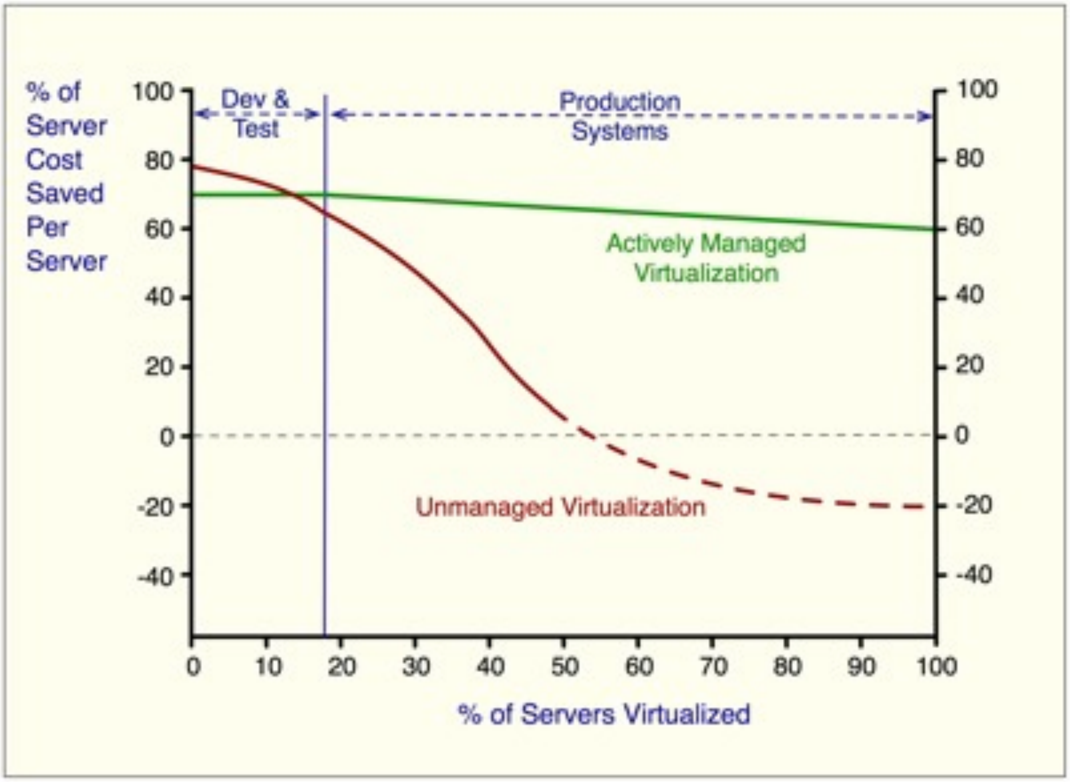
We may need to bring a new server into play from the resource pool or we may be able to fit the three applications onto two or three other servers that are not yet running to capacity. But how will we know what virtual partition can fit where? And how will we know, assuming that the cpu and memory is sufficient, that the network bandwidth of the specific server will be adequate? And then how will we know which monitoring components need to be loaded and where to load them or how to configure them for the new location of the application?

The point is that there are things we need to know about the application no matter where we place it in the resource pool.

We need to know:

- What maximum resources (cpu, memory, etc.) the application needs.
- How to monitor the service levels (customer experience)
- How to detect and/or implement configuration changes.
- How to monitor for problems and failures.
- How to provide access to it for users or other applications that connect to it.
- How to secure it.

And we will also need to have full knowledge of the physical and virtual environment and their dependencies, so we can decide where best to place it.



Eventually a point is reached where costs start to go negative and the virtualization is no longer worth pursuing (represented by the dotted line).

Figure 1. A Typical Virtualization Pattern

The Virtualization Project

The graph in Figure 1 illustrates and explains why virtualization is not, on its own, a silver bullet. It is a conceptual representation, assembled from the collective experience of several mature virtualization initiatives in large data centers.

- The x-axis: ***% of Servers Virtualized***, represents the complete population of servers that have been identified as candidates for virtualization in a virtualization project.
- The y-axis: ***% of Server Cost Saved Per Server***, represents the cost saving from virtualizing a single server, measured as a percentage of the TCO of the server that is no longer required. Note that the y axis drops below zero, because, as we shall see, it is possible for virtualization to generate costs as well as to reduce them and even to eliminate the cost advantage of virtualization.
- The green line: ***Actively Managed Virtualization***, represents the cost saving trajectory when virtualized servers are closely managed. The initial benefits in virtualizing "the low hanging fruit" are shown as less because there is the additional cost of the management software that is required. However as more and more servers are virtualized the cost savings diminish only slightly - indicating that this approach scales well, but not perfectly.
- The red line: ***Unmanaged Virtualization***, illustrates what happens as a virtualization project moves from virtualizing the low hanging fruit to virtualizing more complex production which are candidates for virtualization. First management costs begin to emerge, making their presence felt as soon as there are

a significant number of virtual servers to manage, but not becoming severe until attempts are made to virtualize some of the less simple production systems. Eventually a point is reached where costs start to go negative and the virtualization is no longer worth pursuing (represented by the dotted line). Note that we assuming the use of more than just hypervisor software in "unmanaged virtualization". It assumes tools such as VMware's vMotion, which moves virtual partitions between servers but does not keep track of where VMs reside.

- The division between **Dev & Test and Production Systems**. We have split the server population between servers that are used for software development and testing, and those used for production systems (a less than 20: 80 ratio is normal). For Dev & Test, the use of manual scripts and VM tools will normally be adequate for managing the associates server resources.

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The most important point to note is: Experience from large virtualization projects suggests that diminishing returns eventually become negative returns.

Why?

The Management of Virtualization

It's easier to understand the phenomenon of diminishing returns if we distinguish between the four distinct levels of virtualization, illustrated in the adjacent diagram:

1. **Manually Virtualization Management (Level 1):** It is possible to manage virtualized partitions using manually written scripts and VM tools almost in the same way that you can deploy relatively simple applications just using scripts and a few utilities. This is often where Data Centers start out with virtualization and it can be adequate for Dev & Test servers.
2. **Static Virtualization Management (Level 2):** Here virtualization is implemented also for a limited number of production systems. The virtualized servers are monitored for performance across both physical and virtual environments. For example, when it looks as though some virtual server will soon need more resources, the required resources can be configured and delivered before problems arise. This level also requires effective automated provisioning, and change and configuration management.
3. **Active Virtualization Management (Level 3):** This is required for extensive production deployments. It is best to think of it as the automation of the whole virtualized environment and all the resources it contains. It involves a real-time or near real-time gathering of information from all virtual servers. Automatic resource allocation is dynamically provided to meet all needs. There is comprehensive and integrated network management, application performance management, capacity planning, security and compliance, as well as service accounting and chargeback.

Figure 2. Four steps

4. **Dynamically Managed Virtualization (Level 4):** This is full production deployment of virtualization for the enterprise, including outsourced applications

and resources. This means dynamic optimization across all resource pools leading to dynamically managed private, hybrid and even public clouds.

The Virtualization Gotcha's.

The effective management of virtualization is not easy to automate. To see why, we need to consider application dependencies. When an application is implemented in an isolated silo, it runs in a self contained manner. It has few dependencies that are external to that silo - although it may have some.

Unmanaged virtualization will only work in situations where virtualization does not increase the dependencies of an application in any significant way.

When runs in a virtualized server it immediately acquires some dependencies it never previously had. It now has to share resources. It no longer has a physical location, it only has a virtual one. If, for example, the application runs for only 16 hours per day, then it should be taken down when not in use, so that other applications can use the resources it is occupying. But if you take it down, when you put it back up again, you may not be able to put it back exactly where it was. That space may no longer be available.

You may not have thought of users accessing an application as being a dependency, but user access mechanisms, whether through identity management systems or portals, or simply through logins, need to know where to find the application or they cannot connect. User access is a dependency. Unmanaged virtualization will only work in situations where virtualization does not increase the dependencies of an application in any significant way. That means replacing physical siloes with virtual siloes, but going no further.

As soon as you go further than that, the virtualization needs to be managed. You can either do that manually or you can automate some or all of the management activity.

It's worth our providing a list of potential application dependencies, because each one of them, where it has an impact, needs to be catered for. So here's a list:

- **Time dependencies:** These are the driving force of workload management and managing them is one of the keys to workload automation. Ultimately, applications need to meet their service schedule and abide by the schedules of other applications they are dependent on, or which depend on them.
- **Failover dependencies and Backup:** Applications may need to recover automatically should they fail for any reason. As such, failover needs to be automated and resourced in the event that a failure occurs.
- **Disaster recovery:** In a full disaster scenario, the application needs to be able to participate effectively in disaster recovery procedures.
- **Security:** No matter how or where the application runs, it must receive a constant level of protection from an IT Security perspective (Host Intruder Protection System, virus scanning, etc.)
- **Access:** It is not just that users need to have access when required, but any other application that directly connects to this application also needs the ability to make secure access.
- **Management Regime:** The whole of infrastructure management including system management, network management, storage management, database management, etc. needs to know how and where the application is running (for the sake of trouble ticket management, configuration management, patch management, root cause analysis, etc.)
- **Service Level Management:** The application will (presumably) be expected to conform to a specific service level. The service level monitoring software will need to know the location of the virtual server at all times.

- **Testing Model:** The testing procedures for the application need to take account of all application dependencies which can be tested or modeled.

The Automation of Virtualization

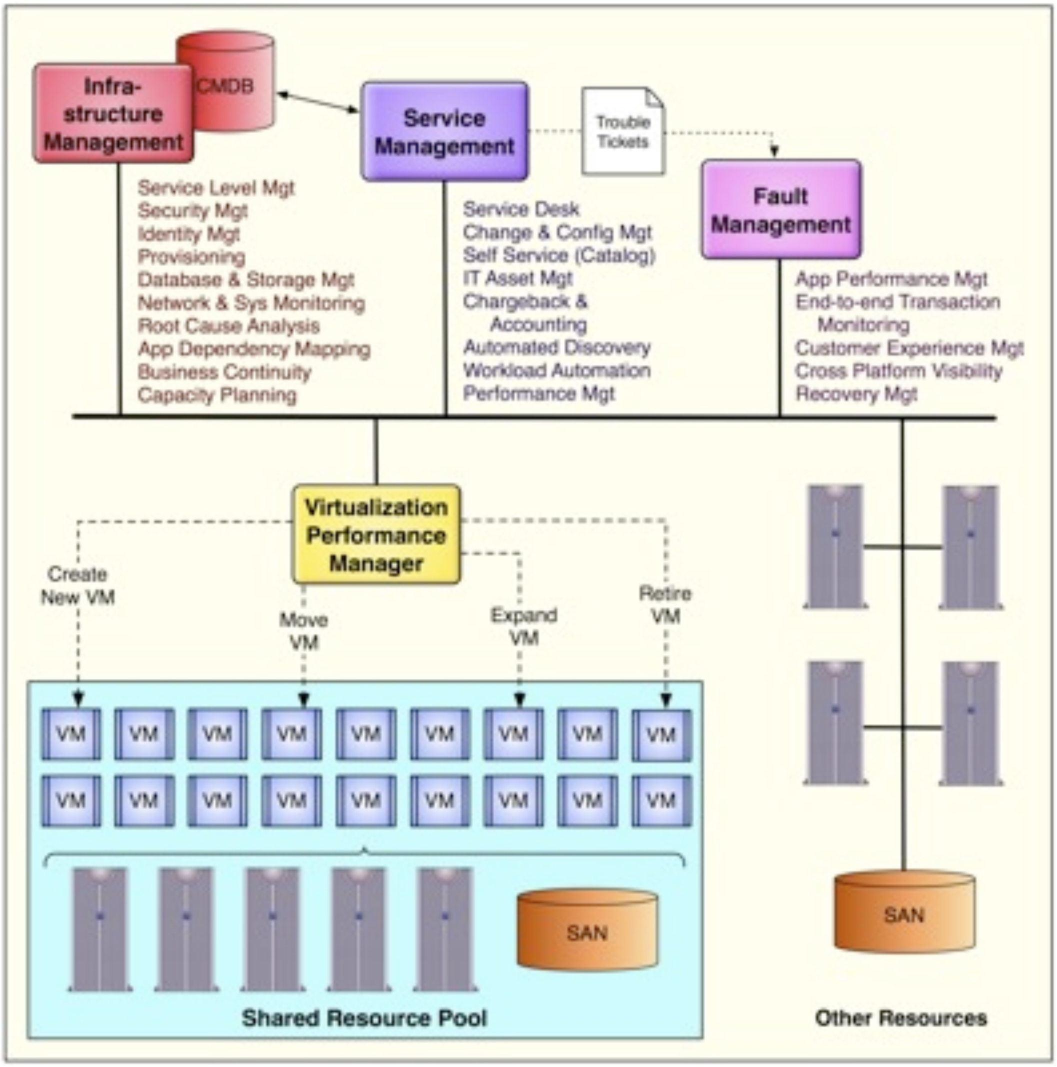

Figure 3. Physical and Virtual Infrastructure

You don't need to consider this illustration for long before you realize how many data center activities are impacted by virtualization.

The illustration in Figure 3 reveals how complex the management of virtualization can be. You don't need to consider this illustration for long before you realize how many data center activities are impacted by virtualization.

As can be seen, the primary function of the **Virtualization Performance Manager** is to preside over the population of virtual machines (VMs). It manages that extensive and extensible environment in the same way that an operating system manages a computer.

You can think of each VM as having a lifecycle. It is created. In time, it may be expanded to give if more resources, if there is a need. Or it may contract to return some of the resources it is not using to the resource pool. At times it may be necessary to move it from one physical server to another, either because one of the VMs it is sharing resources with needs more resource or because it needs more resources itself. And finally, when a VM is no longer needed, the Virtualization Manager retires it.

All of this activity could be carried out manually, but it far better that all of these VM activities are handled automatically, or with minimal manual intervention. We explained earlier that there are 4 levels of sophistication with virtualization. The first **Manual Virtualization Management (Level 1)** is simply to create virtual siloes. If this is done well there will be no need for much of the activity we just described, except when hardware failure forces the recreation of a VM on a new physical server. However, the level of resource efficiency will be low, cost savings meagre and only a small percentage of servers will be virtualized.

When we move to **Static Virtualization Management (Level 2)**, we can no longer manage the resource pool simply using scripts and VM tools. Consider the activity involved here. The resource pool will contain many servers of different capability (cpu type, cpu speed, available memory, bus speed, I/O channel, network connections, etc.) and also network devices and storage devices. The applications that have to share this resource, if they don't run 24 x 7, will run in different time windows and during those time windows their resource needs will vary.

Rather than individual applications being managed, the whole resource pool is managed with VM's being shuffled from one place to another to make the best use of resources. This is not easily achieved. It requires an accurate map of all the physical resources in the resource pool and their connectivity, an up-to-date map of the location and resources allocated for all VMs and full information about the resource requirements and the dependencies of the applications running in those VMs. Change and configuration management also needs to be part of the mix.

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Given that these capabilities are provided, the **Virtualization Performance Manager** can create a kind of "Run Book" for the whole resource pool and manage it proactively. This is far too complex for anyone to manage manually.

Active Virtualization Management (Level 3) is the next level. This can be viewed as the realitic end target for a virtualization strategy, but it will take time to get there. At the top of the diagram in Figure 3. we show three distinct activities:

- **Infrastructure Management:** Those activities aimed at managing the infrastructure including its security and managing access to it.
- **Service Management:** Those activities that try to ensure that application users receive the level of service that has been mandated for them.
- **Fault Management:** Those activities aimed identifying problems, diagnosing the cause and rectifying the situation where outright failure has occurred.

What we have added to Level 2 here is more complexity. Now we are catering for user self-service; not just IT developers requisitioning virtual servers for testing purposes, but users requesting virtual servers to run some of their applications "on demand". We have added moment to moment service level management. We are expecting the **Virtualization Performance Manager** to directly compensate (if possible) for all faults, whether hardware or software glitches, as they arise. We expect Virtualization Management to work hand-in-hand with Security Management, to be aware of the whole network rather than just the resource pool it is managing and, through the use of discovery software, to have a real time picture of the disposition of all software and hardware. We are expecting Virtualization Management to respond to any eventuality in real time.

Dynamic Virtualization Management (Level 4) is what data centers should aspire to. It is the final level, with virtualization management taking place at the enterprise level and contributing to the real-time management and optimization of all resources used by the corporation.

The Goals of Virtualization Management.

Ultimately, the goal of Virtualization Performance Management is to oversee the virtualization resource pool as if it were a single computer. It is the operating system for that environment, dealing with all failures and anomalies that occur within the environment and ensuring that the applications run as intended.

It compensates for all the disruption that virtualization imposes. For example, consider the issue of compliance. Compliance rules vary from sector to sector. They include security mandates and technical mandates that cover anything from performance and recovery procedures to archiving. Virtualization can disrupt any of these things if it is not adequately managed and it could thus cause a Data Center to be out of compliance.

The **Virtualization Performance Manager** needs to ensure the implementation of of all such policy. Similarly, it needs know and implement all internal policy whether it relates to service levels, security or whatever.

As we noted, for most sites about 75% of the applications running on Intel servers are candidates for virtualization. There is no reason why an organization should not target the virtualization of all of these applications over time.

As data centers vary considerably in the types of applications they run, it's unreasonable to suggest an overall target figure for cost reductions at that level, but it's worth noting that in sites where Static Virtualization Management (Level 2) has been achieved, permanent cost reductions (for that population of servers) have been in a range between 40 to 70%.

Once we move to Active and Dynamic Virtualization Management, we are no longer thinking simply in terms of server costs savings, we are delivering an extremely high level of flexibility. We are also enabling global optimizations to deliver global cost savings in a range of different areas from cloud-sourcing through to power management.

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The Emerging Horizon

In the world of software development Web Services, SOA, Social Networks, Mashups and user scripting capabilities are increasing the level of connectivity between applications. To add to that, technology continues to speed towards a fully mobile always-on real-time world. As a technology, virtualization arrived just in time, to free up huge amounts of IT resource that we had been squandering but nevertheless it faces challenges.

Virtualized servers and virtualized environments are becoming the norm. Currently 50% of Intel servers being purchased are being installed as virtualized resources. Additionally, all the major Unix platforms (Solaris, AIX and HP-UX) support virtualization technology. There is now a choice of hypervisor technology, from VMware, Citrix (with the Open Source Xen) Microsoft (with Viper) and Red Hat with KVM - and that's just for the Intel x86 environment.

The Fragmentation of Virtualization.

There has been a good deal of talk about the idea of "private clouds" although the term is probably a misnomer - the only thing that distinguishes the virtualized environments we have described in this paper and "the private cloud" is the words "private cloud." But, there's nothing wrong with people describing a virtualized resource pool as a private cloud; a rose by any other name would smell as sweet.

From "private clouds" some commentators and marketeers have moved on to talk about "hybrid cloud" where internal "private cloud" resources and external cloud resources are harnessed to work together. Well, if such an arrangements are be created and to operate coherently, they will need a Virtualization Performance Manager. Indeed, they will need one more capable than the Level 3 Virtualization manager we described. It will have to integrate with foreign management environments and it will have to make deployment decisions based on calculating the true cost of the service.

It is difficult to avoid the conclusion that virtualization management will become a central point, if not the central point, in the trend towards cloud computing. The cloud is beguiling and it looks very much like it will deliver cost savings, but the question is:

Can we manage it?

The Optimized Data Center

Virtualization can provide valuable cost savings through consolidating compute workloads and provide greater business agility and lower risk. But virtualization holds the potential to do more. It can also serve as the foundation for a new operating paradigm for your data center. With the necessary management, the virtualization investment can become a cornerstone for transforming the data center into a true utility. It can enable you to deliver the appropriate resources wherever and whenever they are needed, automatically and transparently. In other words, virtualization management can carve out the path to cloud computing.

In the internal cloud model, all resource pools, physical or virtual, can be managed and provisioned in the same way, according to the same set of business goals and policies, regardless of environment, operating system, or type of resource. Applications and users have the prioritized resources they need, regardless of circumstances. And, exactly the right amount of resources are allocated to each job, at each moment, with no resources wasted.

This vision is compelling, and it is one that businesses can begin implementing today, employing the principles and capabilities of leading virtualization platforms. However, virtualization platforms can only accommodate this evolution when they are incorporated into a comprehensive management solution, controlled by the service-level goals and requirements of the business. Providing service-level automation, dynamic scaling, comprehensive management, increased availability, and faster deployment, virtualization management maximizes the value of your virtualization investment today, while providing a building block for even greater efficiencies and capabilities in the future.

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We have already mentioned "dependency escalation"; the reality that Web Services, SOA, Social Networks, VoIP and Mashups are all increasing the level of connectivity between applications, and in doing so, making the management of virtualized environments more difficult. We have also observed that the established move to increasingly large numbers of processor cores per cpu chip has made the use of virtualization inevitable rather than optional. Let us add in the fact that with the move to VoIP and integrated telephony, the service levels that data centers will be expected to provide will escalate - as standard service levels for voice circuits are very high.

It is useless to deny that each year the data center is expected to support more applications than it did the year before. The number of workloads neither falls nor stabilizes.

Virtualization Is Not A Silver Bullet

We started out discussing the management of virtualization, but it is hard to avoid making the link between it and the global management of the data center. As the workloads in the data center become more complex and interdependent and virtualization pervades every hardware platform, virtualization management and data center optimization may well become synonymous.