IT@Intel White Paper

Intel IT
IT Best Practices
Virtualization and Cloud Computing
February 2011

Applying Factory Principles to Accelerate Enterprise Virtualization

We began 2010 with about 12 percent of the Office and Enterprise environment virtualized; by year's end this rate had more than tripled to 42 percent, and we remain on track to virtualize 75 percent of our environment over the next few years.

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Executive Overview

To create the infrastructure for our private enterprise cloud, Intel IT has set a goal of virtualizing up to 75 percent of our Office and Enterprise computing environment. This presents the challenge of how to rapidly virtualize thousands of servers located across Intel and owned by a variety of Intel business groups.

To address this, we created a standardized, repeatable, high-volume virtualization process analogous to a factory production line, managed by a dedicated operations group within Intel IT. We call this the Virtualization Factory.

It consists of seven clearly defined steps that encompass the entire virtualization process, from identifying physical servers that are virtualization candidates to removing these servers from the environment after migration.

Key learnings include:

- To accelerate virtualization, it was not enough simply to provide technical capabilities: we also needed to create demand among business groups and convince them that we could virtualize applications without impact to the production environment.
- To achieve our goal of virtualizing 75 percent of applications, we needed to remove technical limitations so that we could virtualize mission-critical and externally facing applications in a secure manner.
- Post-conversion technical assistance and tuning were important to help ensure a good customer experience and an efficient production environment.
- Final steps, such as standardizing systems management of the virtualized server and removing the physical servers from the environment, required significantly more work than originally anticipated.

The Intel IT Virtualization Factory has played a key role in successfully accelerating virtualization within Intel's Office and Enterprise IT environment. We began 2010 with about 12 percent of the environment virtualized; by year's end this rate had more than tripled to 42 percent, and we remain on track to virtualize 75 percent of our environment over the next few years. We plan to further drive adoption of virtualization during 2011, while continuing to improve and automate our processes.

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BUSINESS CHALLENGE

In 2009, Intel IT made a strategic decision to transition to a private cloud based on highly virtualized infrastructure. Our goal was to realize cloud computing benefits such as increased agility and reduced cost.

To provide the foundation for this cloud, our ultimate target is to virtualize up to 75 percent of our Office and Enterprise computing environment. This presents a significant challenge: how to rapidly virtualize thousands of servers in order to achieve the full benefits of cloud computing while maintaining or even improving the quality of service provided to business groups.

When we made the decision to build the private cloud, we had already begun implementing virtualization. However, our efforts were on a relatively small scale; virtualization was the exception rather than the rule and was typically undertaken in response to specific requests from business groups. As a result, by the end of 2009, we had virtualized only about 12 percent of the Office and Enterprise environment. Our capacity and capabilities were constrained; due to technical limitations, we were able to virtualize only smaller and less-demanding systems that comprised less than 50 percent of the environment. Also due to technical limitations, some early virtualization experiences were disappointing. Another reason for the slow progress was that although our architecture and engineering groups had designed virtualization solutions, our operations teams were not actively engaging with business groups to explain our plans and encourage them to virtualize.

To help achieve our goal of transitioning to a private cloud, we needed a different approach that could address these challenges and accelerate the pace and proactive use of virtualization within our environment. Three factors helped create the momentum to compel this change.

- **Management mandate.** IT management set a clear mandate to make virtualization a priority. Based on this, we created aggressive goals designed to make virtualization the norm rather than the exception.
- **Expanding technical capabilities.** We built additional virtualization capacity and capabilities that helped to ensure we could expand the scope of our virtualization efforts while maintaining quality of service with no negative impact to the production environment.
- **Business value.** We proactively demonstrated that virtualization delivered significant business value, achieving average consolidation ratios of 15:1 using servers based on the latest Intel® Xeon® processors, and improved agility for business groups consuming services from IT.

VIRTUALIZATION FACTORY

To accelerate the pace of virtualization, we focused on creating a standardized, repeatable process—analogous to a factory production line—that would enable our IT operations group to create demand among business groups and quickly virtualize a large number of servers in a highly efficient, predictable way. A dedicated Intel IT operations group manages this process, which enables us to quickly virtualize servers in an efficient, predictable way. We call this the Virtualization Factory.

Benefits

Our objective was to provide a high-volume migration path that handles the virtualization process from start to finish and creates a seamless experience for our customers—the server and application owners within Intel's business groups.

SCALABILITY, AGILITY, AND AVAILABILITY

The private cloud offers clear benefits to business groups. In the physical environment, business groups are responsible for purchasing and managing their own servers; the process of acquiring and deploying new physical servers can take several months. The private cloud offers much greater agility, with the ability to dynamically scale resources on demand to more quickly meet changing business needs; we have reduced the time required to provision virtual servers to three hours. Other advantages include higher availability without the need for additional hardware.

We provide a range of predefined virtual servers—small, medium, and large, with differing CPU, memory, and disk allocations—to meet the varying needs of business applications, as described in Table 1. This enables us to more efficiently and rapidly allocate resources, and simplifies capacity planning.

With the transition to the cloud model, business groups no longer need to purchase or manage servers; Intel IT offers conversion at no cost, including removal of the original physical server. Our Virtualization Factory process minimizes virtualization risk by converting servers with no changes to data or server configuration.

REDUCED INFRASTRUCTURE COSTS

As we virtualize servers—and remove the original physical servers from the environment—we consolidate them onto fewer, more energy-efficient systems. This reduces IT infrastructure costs and energy consumption.

Process Steps

The Virtualization Factory consists of seven clearly defined steps, as shown in Figure 1. It begins by identifying servers that are candidates for virtualization and creating demand among business groups. These two steps result in identifying physical servers suitable for virtualization within business groups that have committed to virtualize. Each of these servers then undergoes the remaining steps in the Virtualization Factory process, including conversion to a virtual machine (VM). The process culminates in the removal of the physical server from the environment.

1. IDENTIFICATION

We begin our process by applying a systematic method to determine whether each physical server is a candidate for virtualization. Our method is to document all known technical limitations to virtualization and determine how to recognize them on each system down the wire using scripts and system checks. This enables us to quickly analyze our entire infrastructure and determine which systems are candidates for virtualization. It also helps us prioritize where we should focus our efforts to remove technical limitations.

During this stage, we use a technical limiter assessment tool to determine whether servers within the Intel IT environment meet criteria that qualify them as candidates. We then confirm their suitability by communicating with application owners. Our criteria include:

Resource Utilization and Fit with Predefined VMs

Physical servers that have generally low levels of CPU, memory, and disk utilization are considered good candidates because they can be virtualized and consolidated with low risk. We assess whether servers are a good fit for one of our three predefined sizes of VM.

Application Class

This determines whether the application falls within the current scope of the Virtualization Factory. As we remove technical limitations, the scope is continually expanding to include a broader range of more-demanding applications; this is described further in "Creating Demand" below.

Server Age

Older servers, especially those that are out of warranty, are obvious candidates for virtualization and consolidation.

Data Center Location

Data centers at some Intel locations lack virtualization infrastructure such as virtualization host servers. This can restrict our ability to virtualize physical servers located within those data centers. In some cases, it is possible to virtualize these servers and run the resulting VM at a different data center. Occassionally, however, the customer may decide that the ensuing network latency results in unacceptable performance for users at the original location. The customer usually determines whether or not the impact of network latency is acceptable based on the type of application and previous experience.

Table 1. Intel IT Virtual Machine Sizing and Consolidation Ratios

We provide a range of predefined virtual servers with differing CPU, memory, and disk allocations to meet the varying needs of business applications. Using this approach, we have achieved average consolidation ratios of 15:1 on servers based on Intel® Xeon® processor 5500 series.

CPU (up to)	**Memory** (up to)	**Disk** (Includes OS) (up to)	**Virtual Machine Intel® Xeon® processor 5500-based servers**
Small: Applications, Web Basic Server			
1 vCPU	2 GB	100 GB	22:1
Medium: SQL Database Servers and Java* Applications			
2 vCPUs	4 GB	200 GB	11:1
Large: Stacked Applications, Large Applications, Super Servers			
4 vCPUs	8 GB	500 GB	5:1
		Average weighted density ratio:	15:1

Performing the Identification Process

Initial identification of virtualization candidates is essentially an automated process, using an internally developed assessment tool to gather information about individual physical servers in the Intel IT environment and determine whether these servers are a good fit for our criteria and predefined VMs. The information is gathered from databases used for asset management, configuration, and support; provisioning and patch management; and utilization and performance monitoring.

When we identify a candidate, we notify the server owner and request confirmation that the server can be virtualized. The next steps depend on the server owner's response:

- If the owner confirms that this is a candidate for virtualization, we pass information to the team managing Step 3, scheduling and capacity management.
- If the owner plans to terminate the physical servers without virtualizing them, we pass this information to the team managing Step 7, end of life. This may be the case if the physical servers are no longer in active use.
- If servers are not currently virtualization candidates due to the technical limitations of our current virtualization capabilities, we work with Intel IT engineering groups to remove the limitations, as described in Step 2, creating demand.
- If there are no technical limitations but the server owner or application owner is reluctant to virtualize for other reasons, we move to Step 2, creating demand.

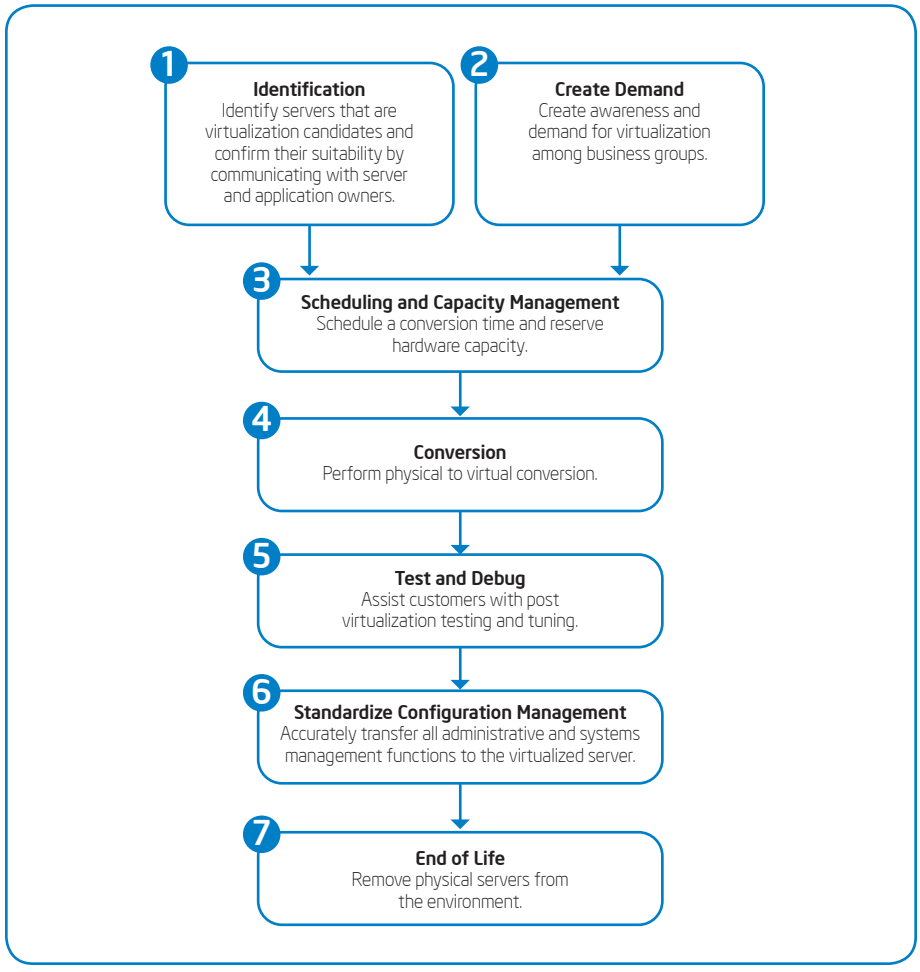

Figure 1. Intel IT's Virtualization Factory consists of a seven-step process that accelerates the adoption of virtualization in our Office and Enterprise computing environment.

2. CREATING DEMAND

We realized that to achieve our virtualization goals, it was not enough simply to build virtualization infrastructure capacity and capabilities. We also needed to create awareness and demand for these capabilities among business groups. At the same time, we needed to reassure them that we could virtualize most servers in the environment while continuing to provide the desired performance, reliability, and scalability for their existing solutions. This required a broad range of activities.

Internal Marketing Campaign

We conducted a broad marketing campaign to educate business groups about our plans and the benefits of the private cloud. This included more than 30 presentations to individual groups. We emphasized benefits that directly affected business groups, such as the ability to dynamically scale resources to meet business requirements, higher availability, and the fact that virtualization removed the need for business groups to manage physical servers.

Forging Close Links with Customers

We formed close relationships with business groups to accelerate the virtualization process. Key groups assigned a representative to meet weekly with the Virtualization Factory team; this regular contact helped facilitate progress.

When we identified groups with a sizable number of servers that were good virtualization candidates, we streamlined the virtualization process by enabling direct interaction between the Virtualization Factory team and technical members of the group.

Involving IT Management

We helped ensure the involvement of Intel IT senior management by presenting regular reports that analyzed progress against our overall target, broken down by each manager's area of responsibility.

Table 2. Milestones in Removing Technical Limitations to Virtualization

By removing technical obstacles to virtualization and progressively adding new virtualization capabilities and capacity, we have been able to steadily increase the percentage of virtual servers in our environment.

H1 2010	H2 2010	2011
▪ Virtualization infrastructure in all core/large data centers	▪ Virtualization infrastructure in the demilitarized zone (DMZ) and secure enclaves	▪ Virtualization infrastructure at medium-size sites
▪ Definition of small, medium, and large standardized virtual machines (VMs); option for custom VMs as needed		▪ Support for very large VMs and large databases
▪ Ability to virtualize servers running Microsoft Windows Server 2000*, Microsoft Windows Server 2003*, Microsoft Windows Server 2008*, and Linux*, including 64-bit support	▪ Ability to virtualize externally facing secure applications	
▪ 24x7 support for mission-critical applications	▪ Increased availability: hardware high availability and database clustering	▪ Quality of service for mission-critical applications

Removing Technical Barriers to Virtualization

Until early 2010, our virtualization efforts focused on those applications which are easiest to virtualize and present the lowest risk, including departmental and line-of-business applications. These comprise less than 50 percent of Intel's Office and Enterprise environment. Other applications, including mission-critical and externally facing applications, were initially considered out of scope.

To achieve our goal of virtualizing up to 75 percent of the environment, we needed to remove technical limitations so that we could expand the scope to encompass a broader range of servers, including mission-critical applications with more rigorous performance and availability requirements and externally facing applications with specialized security needs.

During 2010, we progressively added to the breadth and depth of our capabilities. When, during our identification step, we discovered applications that could not be virtualized because we lacked a technical solution, we passed the details to the Intel IT engineering group. The engineering group then developed the appropriate solution.

This removal of technical barriers enabled us to virtualize a greater range of systems, as shown in Table 2. For example, adding 24x7 support and high availability helped enable virtualization of mission-critical applications. We also added virtualization infrastructure at all major sites and intercepted new server landings to help ensure that they were deployed as virtual as opposed to physical solutions. By the end of 2010, we had built capabilities enabling virtualization of up to 80 percent of the servers in our environment. We plan to continue removing technical barriers during 2011.

Building Capacity

For business groups, the key attractions of virtualization are rapid provisioning and dynamic scaling. To provide these capabilities, we need hardware capacity that is available to customers when they need it. Initially, our ability to ramp up virtualization was limited by hardware capacity in some cases. Purchasing and deploying physical virtualization infrastructure within Intel can take months; this meant that we needed to plan and build hardware capacity ahead of demand.

Business Intelligence

We need detailed, accurate data about physical servers in the environment in order to execute our Virtualization Factory process. We devoted considerable time to improving data quality to help ensure we have accurate data such for each server, such as its location, function, and owner. This helps us identify virtualization candidates, discuss plans with business groups, and track progress.

3. SCHEDULING AND CAPACITY MANAGEMENT

Once server owners have confirmed they want to virtualize the server, we need to schedule a time and reserve hardware capacity, as shown on the left in Figure 2, Pre-conversion Workflow. This helps ensure that we can perform a conversion as soon as possible at a time that is acceptable to the owner.

Establishing Schedules

For production servers, this means negotiating a window of downtime during which the conversion can take place.

To estimate the length of time required for the conversion, the Virtualization Factory team's scheduler needs to consider other factors such as the number of files to transfer and the cumulative size of all files on the physical computer's hard drives. Typically, a physical-to-virtual conversion within a site requires four to 12 hours.

Additional time may be required if the VM will run at a different data center than the original physical server. In these cases, network latency tends to be high, which impacts the total time required to complete the conversion.

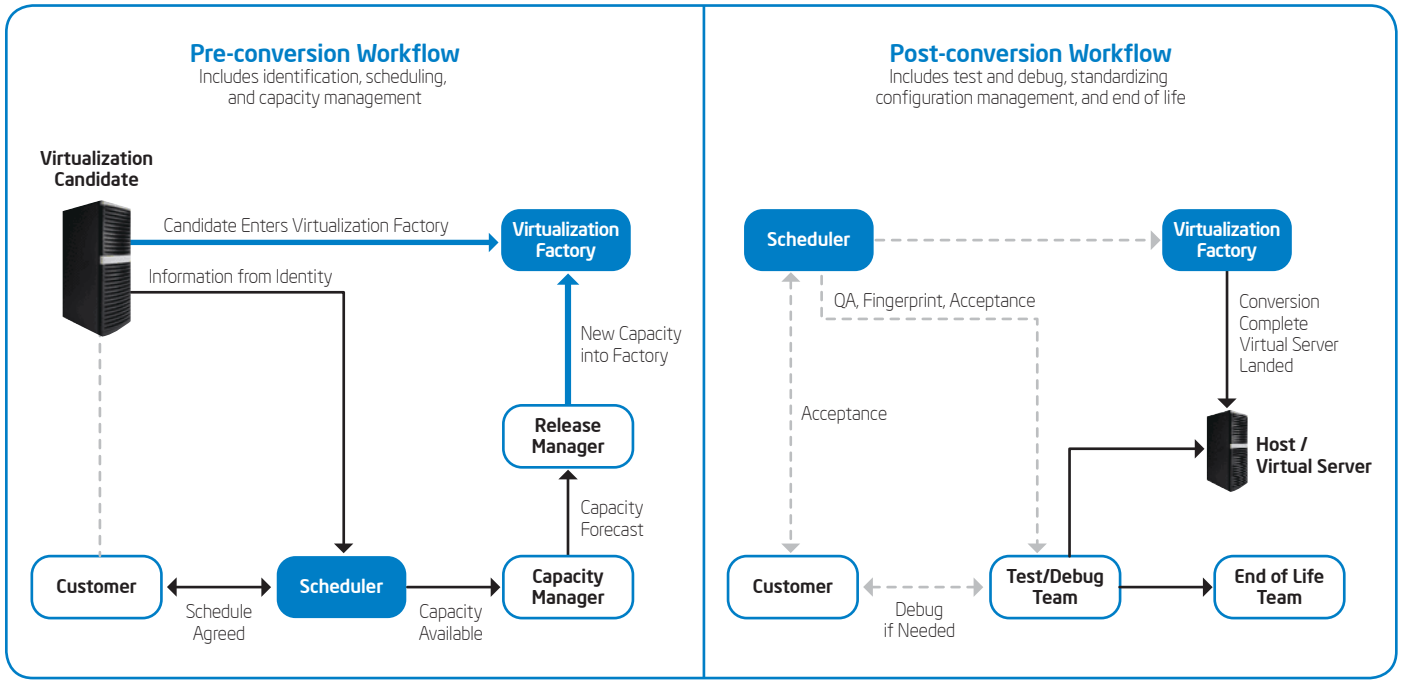

Figure 2. The pre-conversion workflow includes identification, scheduling, and capacity management. Post-conversion workflow includes test and debug, standardizing configuration management, and end of life.

Reserve Resources

Once the downtime window is defined, the team's capacity manager reserves the resources—CPU, memory, and disk space—required for the VM. To be able to commit these resources and decide where the VM can be landed, the capacity manager needs continuous updates regarding the capacity available at all sites. To obtain this view, we built tools that gather information from virtualization server clusters and SAN storage within the environment.

Notification and Schedule Confirmation

Once capacity has been reserved, the capacity manager communicates with:

- The server owner, confirming the conversion date and time, and providing information such as the physical and virtual server details and the member of the conversion team that will manage the conversion. The capacity manager also explains any pre-conversion activities required of the server owner.
- The conversion team, to notify them that the candidate is ready for conversion.

4. CONVERSION

This step encompasses the physical to virtual conversion of the server. It creates an exact copy of a physical server in a fully functional VM, during the downtime window scheduled in the previous step. At the end of this stage, the VM becomes the live production system.

Preparation

Before the conversion, the server owner needs to perform several activities to prepare the server, as specified at the end of the previous step in the Virtualization Factory process. These activities include freeing disk space on the source system server by removing unnecessary applications and files such backups and installers, granting access to the Virtualization Factory team to perform the conversion, checking disks to help ensure they are error-free, and defragmenting disks.

The conversion team members then perform several activities to complete the preparation. We create a local account with administration rights, make sure the network adapter is configured properly, and shut down any OS services that could interfere with the conversion.

Customer Notification

We also inform the customer that the conversion is about to begin. To avoid potential problems, we check details such as the planned conversion time and source server.

Physical to Virtual Migration

At this point, we begin the conversion by installing the conversion agent on the physical server and then configure the conversion job to start cloning the physical machine. Once the conversion job completes, we perform final configuration steps on the VM to make it available on the network so it can replace the source server.

Functional Test

Immediately after the conversion has completed, we check that Web sites, databases, and application services all start without issues. This usually takes a few minutes during the scheduled conversion time window.

At this point, the VM is running the production workload. We then pass the VM to the server owner for acceptance testing. The subsequent steps are shown on the right in Figure 2, Post-conversion Workflow.

5. TEST AND DEBUG

We found that it is important for the Virtualization Factory team to provide continuing technical assistance after the conversion step. This helps ensure a good customer experience and, by solving technical issues, makes it easier for the data center operations team to begin managing the newly migrated systems. The Virtualization Factory test and debug step is designed to provide this technical assistance.

This step occurs simultaneously with the customer's validation and acceptance testing of the virtualized live production application, which can take from a few hours to several days to weeks depending on the number of VMs and how critical the application is to the customer. Production systems are typically validated immediately, whereas it can take weeks or even months to validate large development servers that are stacked with multiple applications.

The test and debug team maintains contact with the customer throughout this period. The team is staffed with engineers skilled at general system troubleshooting, performance analysis, and system tuning.

This step ends with the customer's formal acceptance of the virtualized production system. Key test and debug activities include:

Post-conversion Quality Check

As soon as possible after the conversion, we check that the VM is configured correctly. This provides an additional opportunity to address any areas that may have been missed during earlier stages. This includes removal of any hardware-specific services and drivers.

Remediation of Technical Issues

Issues may not appear to be directly related to conversion. For example, there can be lingering issues that require investigation with network tracing tools—such as hard-coded IP addresses or host names, and Domain Name System (DNS) settings. To solve these, engineers need a good understanding of the IT infrastructure as well as troubleshooting skills.

Fingerprinting

We initially size virtualized servers based on the requirements identified during the initial identification step. In most cases, this sizing is correct. However, in some cases, the initial allocation may not accurately reflect the everyday requirements of the production system. For example, the initial scan may have been performed during a period of low activity. Development systems, in particular, tend to experience long periods of relative inactivity interspersed with short periods of intense use.

To optimize performance and utilization of the virtualized server, we monitor and analyze its use of processor, memory, and disk resources in the production environment, typically over a period of about one week. Based on this analysis, we adjust these resources if necessary. We call this process "fingerprinting."

If our monitoring shows that it is necessary to change the configuration, we schedule downtime with the customer and adjust the number of virtual CPUs, memory, or storage allocated to the VM.

Tuning Assistance

In the physical server environment, many applications run on dedicated physical servers. As long as the application performs well, tuning the application for efficient resource use is not a priority, because the servers usually have spare CPU or memory capacity.

In the shared virtualized environment, it becomes more important to tune applications for efficient resource use. This helps ensure that customers continue to experience good performance, while maximizing utilization of the shared environment. We work with server owners to help them tune these applications.

In some cases, we are able to identify problems by monitoring resource utilization. We have found that many applications can be tuned to work very efficiently with fewer vCPUs and less memory than originally allocated. For example, some Java* applications spawn many processes and use more memory than necessary.

6. STANDARDIZING CONFIGURATION MANAGEMENT

Our initial virtualization experiences revealed that standardizing and updating systems management of the VM is an important area that is sometimes overlooked. As a result, we created this step to make sure that all the physical server's administration and systems management functions are accurately transferred to the virtualized server.

Asset Management

We validate the asset management record for the new VM to make sure it is registered with the appropriate contact and includes accurate information about the application running on the server. We double-check network aliases and any other information required for application or infrastructure support.

Backup and Recovery

We engage the backup management team to make sure that backup agents are installed and correctly configured on the new VM, and that backups are no longer performed on the old physical system.

Server Monitoring

We verify that the previous physical server's monitoring configuration has been transferred correctly to the new VM. We do not add monitoring if the source physical server was not previously monitored, unless the customer requests it.

Security Patching

We check with the Intel IT security patching team that the new VM has been correctly enrolled to receive new patches. If no enrollment exists, we add the new VM to the patching database with default values.

7. END OF LIFE

We have found that the removal of old physical servers involves significantly more work than originally anticipated, requiring a series of approval and removal tasks that involve multiple stakeholders. Without this step, we cannot realize many of the benefits

of virtualization, such as more-efficient use of costly data center space and reduced energy consumption.

The end-of-life team acts as the central point of contact for dropping off servers and driving server retirement efforts. After conversion, a physical server may be removed from the environment altogether, or reused by the same or a different group.

In each case, many of the process steps are the same. We need to gain approval from the server owner to remove the server and require similar signoffs from security, storage, and backup and restore teams.

Intel IT already uses multiple tools to manage server assets and server end-of-life processes. These tools allow us to gather the control data required to correctly identify each asset that needs to be decommissioned. The process then includes a number of operational steps:

- Reclaiming SAN space where appropriate.
- Removing backup settings and verifying that existing backups meet retention policy guidelines.
- The network team removes directory entries such as the primary IP and network aliases.
- The IT monitoring team removes monitoring configurations and alerts.
- The security patching team removes the server from the patching control database.
- Finally, the data center operations team completes the removal by taking the server off the rack.

CONCLUSION AND NEXT STEPS

The Virtualization Factory is successfully enabling Intel IT to increase the pace of virtualization within our Office and Enterprise environment. We began 2010 with about 12 percent of the environment virtualized; by year's end this rate had more than tripled to 42 percent, and we are on track to virtualize 75 percent of our environment over the next few years.

To date, we have learned:

- To accelerate virtualization, we needed to provide more than technical capabilities. We needed to create demand among business groups and convince them that we could virtualize applications without impact to the production environment.
- To achieve our goal of virtualizing 75 percent of our environment, we needed to remove technical limitations so that we could securely virtualize mission-critical and externally facing applications.
- Post-conversion technical assistance and tuning is important to help ensure a good customer experience and an efficient production environment.
- Final steps, such as standardizing systems management of the virtualized server and removing the physical servers from the environment, require significantly more work than originally anticipated.

During 2011, we plan to continue to drive adoption of virtualization across Intel IT, and further tune the efficiency of the Virtualization Factory through automation and improved business intelligence.

FOR MORE INFORMATION

Visit www.intel.com/IT to discover additional IT@Intel white papers and briefs about our private enterprise cloud:

- "Implementing On-Demand Services Inside the Intel IT Private Cloud"
- "Implementing and Expanding a Virtualized Environment"
- "Analyzing the Virtualization Deployment Advantages of Two- and Four-Socket Server Platforms"
- "An Enterprise Private Cloud Architecture and Implementation Roadmap"

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ACRONYMS

DMZ	demilitarized zone
DNS	Domain Name System
VM	virtual machine

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