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## Chapter 9: Virtualization Management: Data Center Automation

A constant challenge in most IT environments is that of finding enough time and resources to finish all the tasks that need to be completed. IT departments find themselves constantly fighting fires and responding to a seemingly never-ending stream of change requests. Although virtualization technology can provide numerous advantages, there are also associated management-related challenges that must be addressed. When these tasks are performed manually, the added overhead can reduce cost savings and can result in negative effects on performance, availability, reliability, and security.

In previous chapters, I have covered a broad array of best practices related to virtualization management. Organizations have the ability to choose from a range of implementation methods, including physical servers, virtual machines, and clustered systems. The tasks have ranged from deployment and provisioning to monitoring virtual systems once they are in production. All of this raises questions related to the best method of actually *implementing* these best practices.

The focus of this chapter is on data center automation. Organizations that have deployed virtual machines throughout their environment can benefit from using enterprise software that has been designed to provide automated control. The goal is to implement technology that can provide for a seamless, self-managing, and adaptive infrastructure while minimizing manual effort. It's a tall order, but certainly one that is achievable by using a combination of best practices and the right tools.

### Goals of Automating Virtualization Management

On the surface, the benefits of automation are easy to envision. By using hardware and software to manage the IT infrastructure, administration costs are often reduced dramatically. As with most IT initiatives, it is important to define the purpose of investing in a particular technology or approach. In this section, I'll describe some of the goals of automating the management of data center environments that include virtualization. These high-level requirements will feed into the next section—a description of automation-related benefits.

### **Supporting Business Processes**

To increase overall efficiency, businesses and IT groups develop processes for managing their physical and virtual data center environments. These processes can include tasks related to deployment, monitoring, and change management. For example, several steps are generally required to complete the process of provisioning and deploying a new physical or virtual machine.

The primary challenge with business processes is that they require coordination and cooperation between different groups of people. For example, a virtual machine configuration change might require approval from end users, business managers, and technical staff. Common problems include delays in reviews and approval or even unintentionally performing changes without going through the necessary steps. Enterprise automation solutions can help make these tasks easier and more effective by simplifying the management of processes.

### **Increasing IT Responsiveness**

IT departments often find themselves working in a reactive model. They try to keep pace with change requests, which seem to be generated almost constantly. Systems administrators and other technical staff tend to spend a large portion of their available time in ensuring that these requests are completed. Even with this added effort, delays in provisioning and deployment can lead to less-than-ideal response times for many of the most common requests. Many changes are relatively simple to perform, so an automated data center solution can help organizations meet goals and reduce costs. Examples include managing performance-related changes such as reconfiguring virtual machine memory settings, balancing resource usage, or relocating virtual machines to different host servers. These are examples of operations that generally involve a fixed sequence of steps that require little manual oversight.

### **Flexibility and Agility**

In an ideal world, an IT organization would be able to build and deploy a data center infrastructure that could meet business needs over long periods of time. In the past, technical departments tended to work alone in planning for which resources and services they would provide to their users. In modern organizations, however, changes are unavoidable. In fact, it is very likely that systems that are deployed today will need to be reallocated or reconfigured in the near future.

The primary driver for these changes is the rapid pace of business goals and strategies. In order to remain competitive, organizations must react quickly to competitive issues and new initiatives. The goal of using automation is to provide a method by which IT deployments can remain flexible. The dynamic allocation of resources for new projects is an important aspect that must be addressed. The overall business goal, however, is to ensure that IT departments remain aligned with the needs of the users and applications that they support.

### ***Dynamic Resource Management***

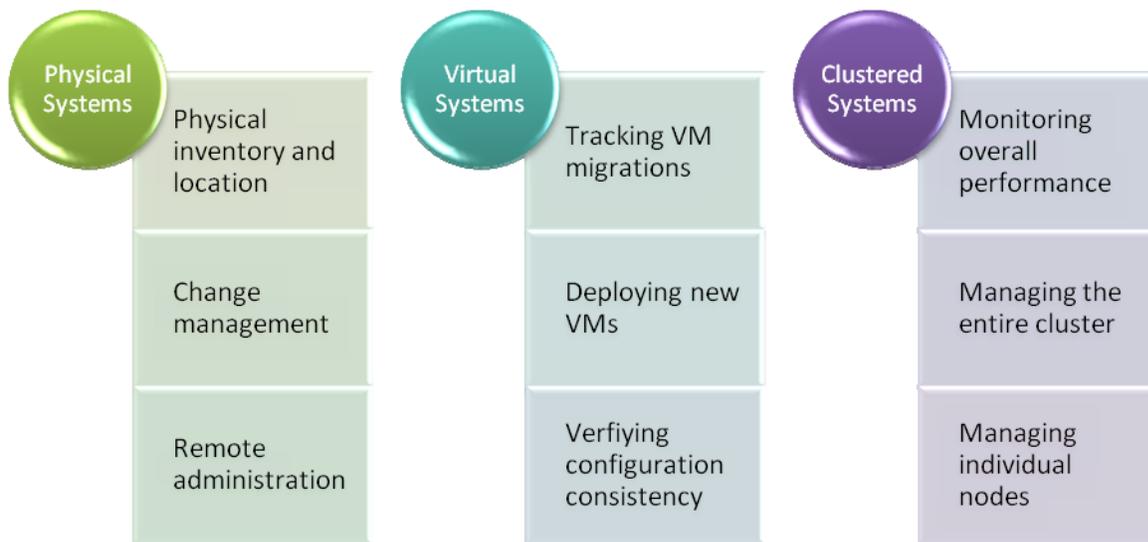
Capacity planning involves attempting to predict future resource usage patterns and to convert that information into system requirements. Even when significant effort is put into determining capacity goals, however, organizations find that their priorities can change quickly and with little warning. For example, a publicly accessible service or application might experience far greater demand than was initially expected. Delays in meeting this demand can result in slow performance or even downtime for users of the applications. The end result is that business goals are not met.

Virtualization provides IT departments with a method of improving overall resource utilization. And, as virtual machines are relatively easy to reconfigure and relocate, the environment can easily adapt to changes. The problem, however, is that these operations require time and effort from systems administrators. Allocating resources and provisioning or moving virtual machines can be time consuming and can require many different steps. Another issue is that changes to performance requirements can occur at any time. Systems must be constantly monitored for changes in usage patterns and associated resource problems.

Automated systems should have the ability to make common configuration changes based on system demands in order to provide low response times. The end result is a dynamic resource management—an automated method of ensuring that all physical and virtual systems are configured optimally based on changing conditions.

### ***Support for the Entire Environment***

With the availability of virtualization technology, IT departments have a wide variety of different types of infrastructure components from which to choose. Many organizations have deployed a combination of physical systems, virtual systems, and clustering technology to meet their business and technical needs. With relation to automation, it is important for an enterprise data center management solution to support a broad variety of platforms and implementations. Figure 9.1 provides an example.



**Figure 9.1: Automation and management issues for different types of IT systems.**

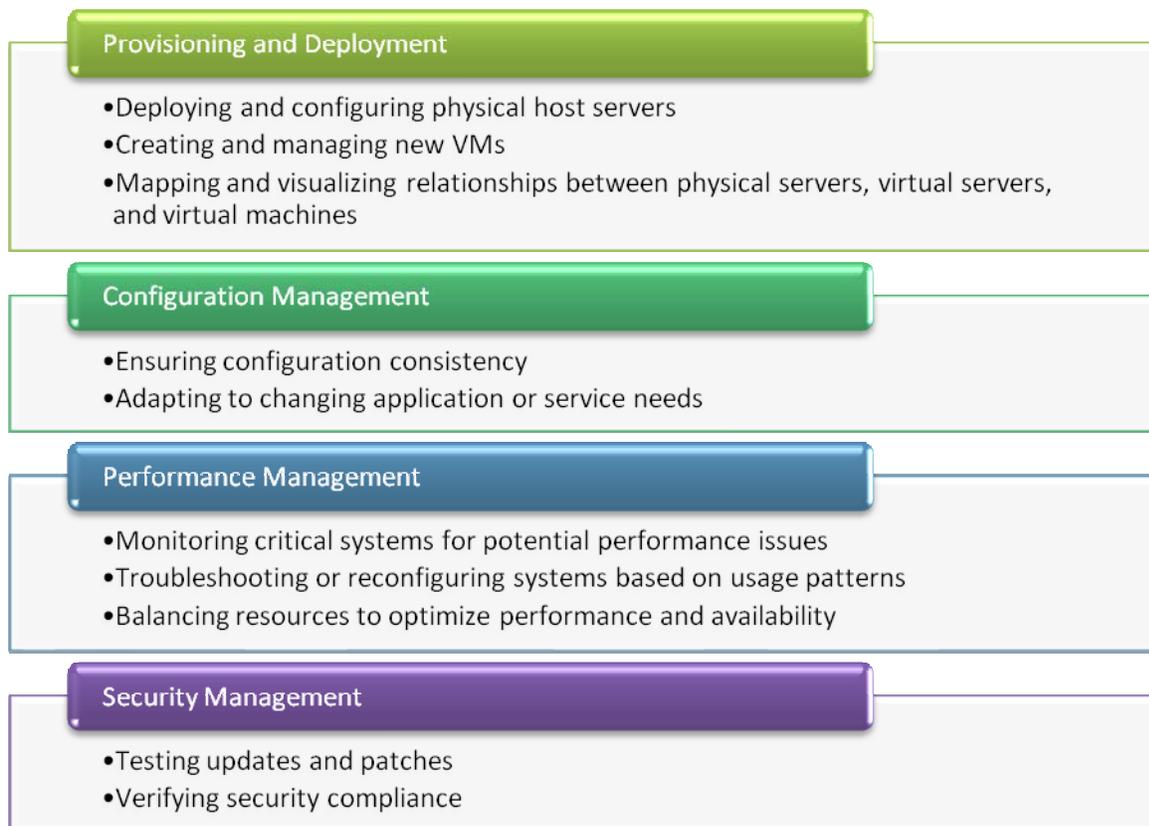
In many environments, the standard deployment for supporting new applications and services involves the use of physical machines. When managing these systems, details such as rack location, network configuration, and operating system (OS) configuration management are important concerns. An automated management solution should have physical inventory capabilities as well as methods for performing change management. Additionally, remote management is a useful feature that allows systems administrators to use a central console to manage even the largest data center environments.

Virtual systems have risen in importance in most corporate data centers. IT teams generally attempt to deploy new applications and services within virtual machines in order to gain improved resource utilization. However, virtualization presents specific challenges from the standpoint of automation. First, because virtual machines are portable, they must be tracked, even when they are moved across physical host servers. Second, the balancing of resources within the host machine to the virtual machines can quickly become a time-consuming task for administrators as they try to ensure that resources are optimized. Also, the process of deploying new virtual machines is one that should require several steps and approvals. Although the technical process of creating or copying a virtual machine is relatively simple, ensuring configuration consistency and compliance with security requirements are important concerns. Overall, the dynamic nature of virtual systems makes them a good candidate for automation. Additionally, automated solutions that are built to manage virtual environments have the ability to clearly depict the relationships between physical and virtual servers and help manage resource usage.

Many enterprise applications and services exceed the capabilities of a single physical server. Requirements such as fault-tolerance, high-availability, and scalability can lead IT departments to implement clustering. In this architecture, multiple physical servers (known as nodes within the cluster) are logically grouped so that they appear as a single system to end users and other programs. When considering the automation of cluster management, it is important to include the management of the entire cluster as well as individual computers that are part of the cluster. Performance can be measured at either of these levels, and automatic corrective actions can help prevent downtime, data loss, or other problems.

### **Improving Human Resource Management**

To lower overall IT costs, virtualization technology helps address the issue of low average hardware resource utilization. Just as important to the “bottom line” for most organizations is the issue of human resource costs. The time and effort that is required to implement and support large numbers of physical and virtual systems can be significant. Figure 9.2 shows some of the tasks that are often performed manually.



**Figure 9.2: Common manual tasks for systems administrators.**

Apart from these labor-related “hard costs” are opportunity costs. Systems administrators that spend the majority of their time “fighting fires” have far less time to spend on strategic initiatives. The result is that IT departments end up taking on a passive and reactive role rather than a strategic one within the organization. From a business standpoint, this makes IT appear as more of a cost center than a competitive business enabler.

Many of the most common tasks related to systems management can be better performed using data center automation tools. For example, evaluating, deploying, and verifying security updates are tasks that can be performed using enterprise management tools. Systems administrators can receive reports and notifications whenever manual intervention is required. The result is scalability to support thousands of virtual and physical systems without a corresponding increase in human resource requirements.

## **Benefits of Data Center Automation**

Based on the high-level goals that organizations have defined for data center automation, it is important to consider the many significant benefits of automation. Overall, these features and capabilities can help optimize operations and provide much-needed management and oversight capabilities.

### ***Consistency and Repeatability***

A common source of IT-related problems is change. Modifications to existing systems or the deployment of new ones often leaves room for human error or unforeseen effects. Additionally, without going through the proper approvals, it can be difficult to ensure that IT projects remain aligned with business goals. To avoid common problems, it is important for technical staff to perform operations in a consistent and repeatable fashion. Environments that have implemented best practice approaches can codify these steps so that all administrators have access to the information. Automated solutions can help ensure that defined practices are followed by guiding users through the required steps. Some steps can also be performed automatically, thereby minimizing manual intervention and room for error.

### ***Scalability and Cost Reduction***

The addition of every new server or virtual machine to an IT data center comes with attached management-related costs. Shortly after implementing virtual machines, systems administrators often find that they are supporting hundreds of new systems. Although the deployment process is usually quick and easy, each of the OSs must be managed as if they were physical systems. Automation can help improve data center scalability by providing a method of managing large, complex environments. The end result is that IT organizations can support additional capacity while minimizing the impact to management-related human resources.

### ***Automated Resource Management***

IT organizations are often faced with constantly changing requirements. In some cases, too many resources are deployed for a particular application or service. In others, the existing configuration has a hard time keeping up with unexpected demand. Manually adapting to these requirements can be a significant challenge, and often IT departments cannot make changes quickly enough to avoid issues that are seen by end users.

When managing environments that contain hundreds or thousands of physical and virtual systems, automated resource management is a necessity. Performance monitoring features can help identify potential problems before users notice them. And, basic corrective actions (such as the reconfiguration of a virtual machine) can be performed without requiring administrators' time. Often, resources are unavailable on a particular host server, or specific servers are significantly over-utilized. Additionally, virtual machines can have usage patterns that vary over time and as a result of different numbers of users. In these cases, it's important to balance (or rebalance) the existing workloads over the available physical server infrastructure. Automation is an excellent solution for this process, as it can monitor for potential resource allocation problems and automatically take the necessary corrective actions. Overall, all of these methods help IT departments deal with rapidly evolving requirements while minimizing management overhead.

### ***Supporting Service Desk Automation***

Many types of change requests are relatively simple in nature but still require time and effort to implement. Data center automation solutions can help enable a self-service model that allows end users to directly request certain types of changes. Assuming that the user has appropriate permissions, steps can involve the provisioning and deployment of a new virtual machine. Users can be given the ability to choose from among several configurations that are available in a virtual machine library. They can then specify the purpose of the virtual machine along with any additional requirements. IT management can review and approve the request. Assuming that the changes are allowed, the steps required to deploy the new virtual machine can be performed with little or no effort by systems administrators. The result is a much more responsive provisioning process that is not a burden on IT staff.

Data center automation tools can also be used to shorten the resolution time for common problems. For example, by monitoring virtual and physical system performance, the system can identify potential application issues before they are detected by end users. Some types of changes can be performed automatically, whereas others will require notification of the appropriate staff. Overall, however, proactive monitoring can help prevent problems that affect end users.

## Identifying Candidates for Automation

When discussing data center management, an important consideration is determining which processes or tasks can benefit most from automation. In most cases, some time and expense is required to implement automated solutions. Therefore, organizations should evaluate where they can provide the most significant benefits.

### ***Characteristics of Good Automation Candidates***

There are numerous characteristics that can help IT managers determine which types of tasks are the most appropriate automation candidates. Tasks and processes that organizations should consider automating have the following characteristics:

- Frequently-repeated tasks—Operations that are performed routinely and often are good candidates for automation. In general, the more often a task is performed, the greater will be the benefit from automation. A list of these tasks can usually be obtained by interviewing systems administrators or by reviewing the amount of time spent on specific areas of IT infrastructure management.
- Well-defined processes and steps—Automation works best when there is a well-defined algorithm for reaching a goal. A good test for this is to create a simple sequence of steps or a flowchart for completing the entire process. Workflows that have significant branching or complexity are often not less-than-ideal candidates for automation.
- Time-consuming tasks—Some proportion of IT staff members' time is spent on performing tasks that are fairly simple but are time-consuming. Examples include installing OSs and managing system updates. Tasks that take up significant amounts of time are excellent candidates for automation, as this can free up human resources for focusing on more strategic tasks.
- Many affected systems—The more physical or virtual systems that are affected by a process, the more likely automation is to help. A common example is that of deploying OS updates and security patches. Often, hundreds of systems must be updated using the same or similar processes. Automation can greatly reduce the time required to address each affected system while ensuring that systems are not overlooked.
- Consistency requirements—Consistency is an important component of maintaining overall quality in IT infrastructures. For example, all new deployments should be verified to meet the configuration requirements that are defined in the organization's security policies. Automated solutions follow a clearly defined sequence of steps and can help ensure that no portion of the process is overlooked. This benefit can also be important from a regulatory compliance standpoint or where manual operations are to be avoided for security reasons.
- Scheduling requirements—One of the most dreaded aspects of working in typical IT environments is the need to perform after-hours or weekend work. In order to minimize disruptions in service, IT staff members often need to make these sacrifices. Automated solutions allow administrators to schedule important tasks to occur at any time. Administrators can then review the logs of actions and find exceptions that must be managed manually.

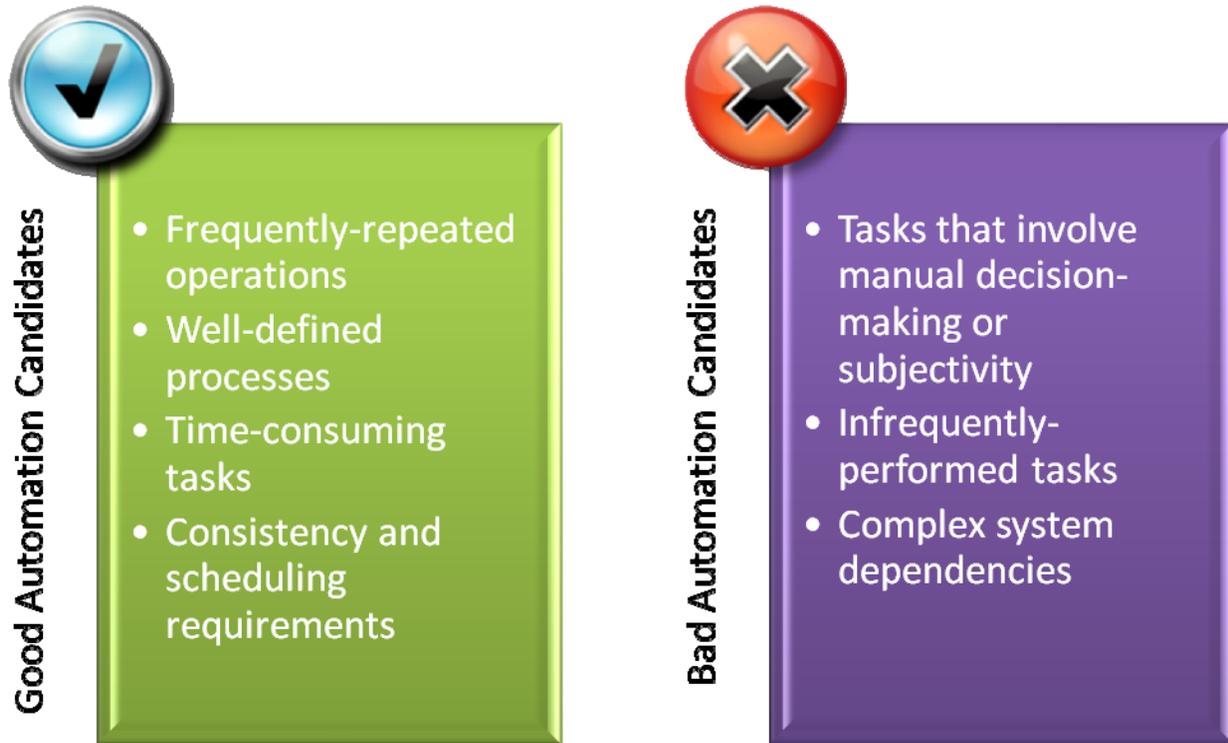
Ideally, a task or process will meet many or all of these characteristics.

### **Characteristics of Poor Automation Candidates**

Conversely, there are several characteristics that make a process a poor choice for automation. These factors involve:

- **Manual judgment and decision-making**—Automated solutions rely upon a set of steps that can be defined and executed reliably. Many IT operations (such as provisioning and configuration management) often follow a sequence of actions. Some operations, however, can be complicated and will require human intervention. For example, the requirements for setting up a mission-critical clustered application would involve input and design decisions from server, storage, network, and data center staff. These types of processes make less-than-ideal candidates for automation.
- **Infrequent operations**—If a task is performed rarely, it might not be worth the time and effort required to implement an automated solution. Often, IT departments have quarterly or annual tasks that are tedious but complicated. When considering the costs of automation, organizations might find that the effort and cost of automation is not justifiable.
- **Few affected systems**—Although consistency is always an important goal in production environments, there are always areas of the IT infrastructure that differ from the rest. For example, a set of virtual machines might be required to run an obscure OS or a legacy application in order to meet specific requirements. It might make more sense to perform these tasks manually because automating them can often take just as long.
- **Complex system dependencies**—Modern IT applications have dependencies on many components of an IT infrastructure. These components include network and storage dependencies as well as specific requirements for physical hosts and virtualization platforms. Tasks that have many inter-dependencies and complex relationships should generally be managed manually. Systems administrators can retain control over changes and configuration decisions by choosing the best process for each system.

Figure 9.3 provides a summary of characteristics that make good and bad automation candidates.



*Figure 9.3: Evaluating characteristics of automation candidates.*

Overall, organizations should develop a list of prioritized candidates for automation. This list can then be used to determine how best to implement a data center automation product to obtain the most value.

## Examples of Automating Virtualization Management

So far, I have focused on the business goals and benefits of implementing data center automation. To help illustrate specific methods by which organizations can use automation in a virtualized environment, the focus of this section is on examples. Although the specific details and value of each type of automation will vary based on organizations' needs, each of these areas should be considered as potential cases for automation.

## Automating Provisioning and Deployment

The ability to quickly and efficiently deploy new virtual machines is a significant advantage over provisioning physical machines. The process is often orders of magnitude faster, making IT organizations much more responsive to business users' needs. However, IT teams are challenged with ensuring configuration consistency and quality for virtual systems. A broad variety of considerations must be taken into account. These range from ensuring that the base OS is supported to verifying that the latest security updates are installed. A best practice recommendation is for organizations to create a virtual machine library—a set of virtual machine images that are designed to be used as the basis for new virtual machine deployments.

Automating solutions can help improve the provisioning and deployment process by simplifying several tasks. For example, self-service features can allow end users to request the creation of new virtual machines using an automated solution. Organizations that have developed a deployment approval process can be assured that the necessary review is performed by business and technical management. Figure 9.4 illustrates typical steps. To ensure that the process runs efficiently, the automated deployment solution can generate emails or other notifications to remind employees of their role in the approval process.

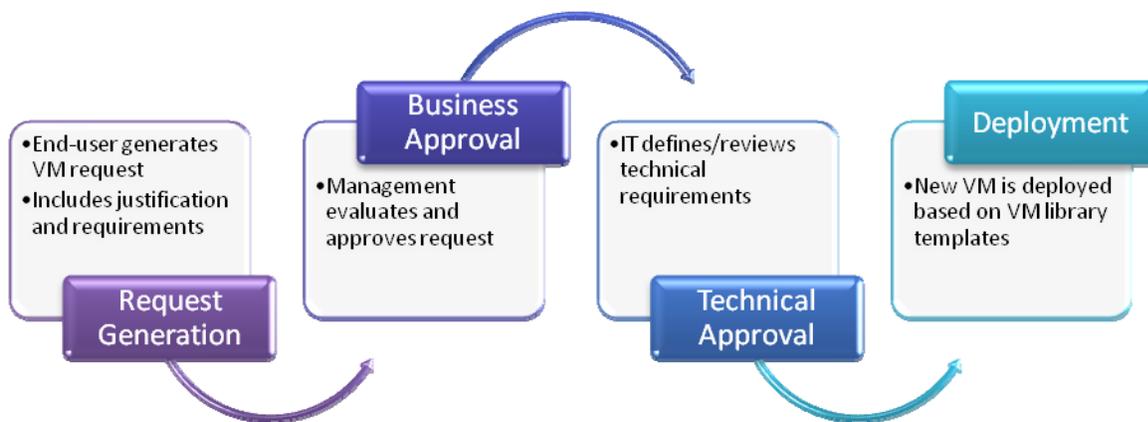


Figure 9.4: Typical steps in an automated provisioning and deployment solution.

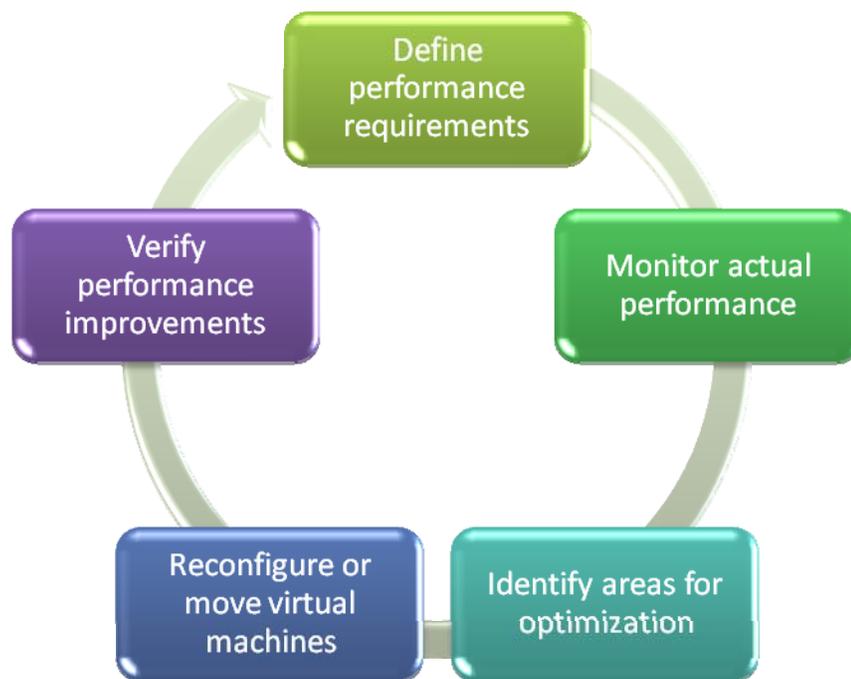
Web-based user interfaces are usually the most accessible and convenient method of implementing workflow processes. Users can simply log on to the system to see which items are awaiting their attention.

Deployment management decisions can be fairly difficult to perform manually. Systems administrators must identify to which host servers their virtual machines should be deployed based on performance and resource requirements. The physical host infrastructure is often rapidly changing; the use of performance-related data can be very helpful in making the best choice. Automated systems can use this information to make better deployment decisions.

### ***Automating Virtual Performance Management***

Optimizing performance can often seem like a never-ending process. There will always be areas for improvement in the IT infrastructure and surprises based on unexpected usage patterns can cause significant disruptions in service. When performed manually, the tasks associated with monitoring production systems and tracking potential performance issues can be time consuming and tedious. It is often too easy to overlook one or a few systems until the problems become noticeable to end users.

Data center automation tools can help dramatically improve resource allocation settings for physical and virtual servers. The first step in implementing an automated performance management approach is to define a process. Figure 9.5 illustrates the major overall approach.



**Figure 9.5: Steps in automated virtualization performance management.**

## Defining Performance Requirements

The process begins with defining performance requirements. In some limited cases, it is possible for the IT department to define acceptable characteristics and thresholds without end-user input. More often, however, it is important to solicit feedback from the business. Common questions that should be asked include:

- Which operations and actions are the most resource-intensive?
- What is the expected response time for common transactions?
- What types of performance problems have been experienced in the past?
- Is there an accurate way to regularly test for performance problems? Examples include load simulation or test transaction capabilities.
- Which related applications do users depend on to complete their job tasks?

The overall goal is to focus on the end-user experience. For example, Web-based applications often provide a simple method of performing test transactions and measuring the time it takes to complete them. All too often, details such as CPU and memory utilization are considered without determining the overall impact on applications and services. By collecting business-level input, organizations can ensure that their systems are meeting overall requirements.

## Monitoring Actual Performance

Once the specific requirements have been defined, an automated solution can routinely test against business and technical requirements. Figure 9.6 provides examples of these metrics.

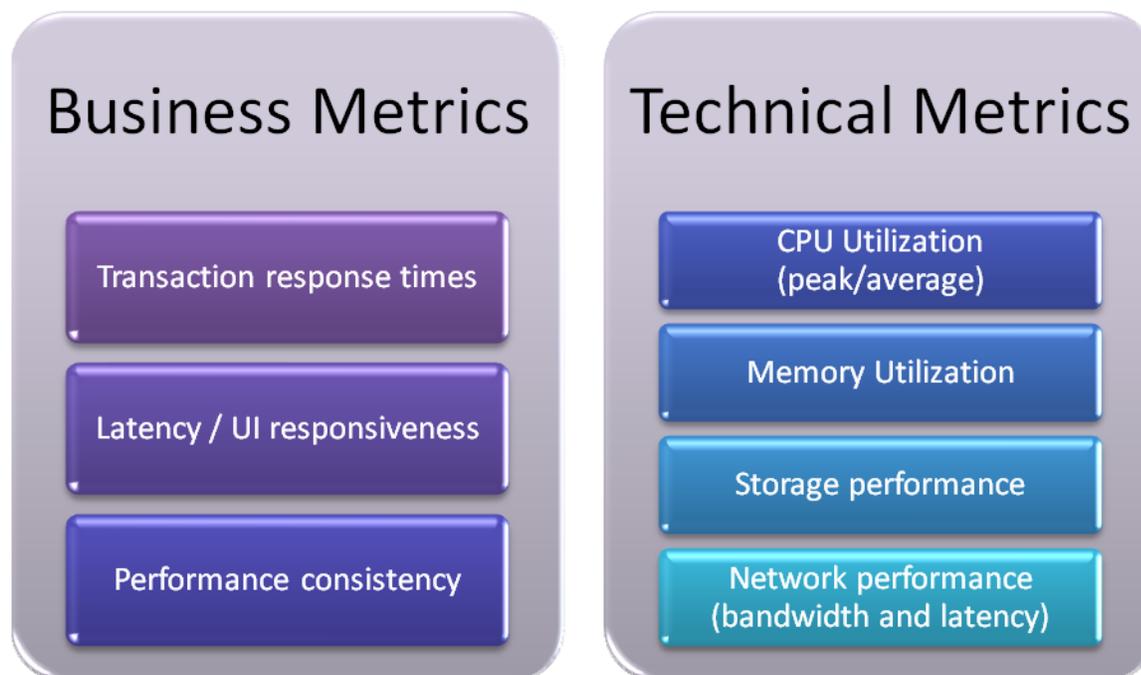


Figure 9.6: Comparing typical business and technical performance metrics.

In general, the business metrics should be considered more important. Although details such as CPU and memory utilization are often easier to measure, it is their effects on the end-user experience that IT should be managing. Of course, the metrics are usually related. For example, high transaction response times might be linked to periods of high memory utilization or paging. In this case, a typical response is to reconfigure the virtual machine to use additional memory.

It is also useful to measure when resources are being left underutilized. For example, if a virtual machine rarely uses the full amount of memory that it has been allocated, these resources can be reclaimed and assigned to other virtual machines.

## Optimizing Performance

Once goals have been defined, an automated system can periodically test production workloads to ensure that they are meeting requirements. When potential problems are discovered, there are two main approaches for taking corrective actions:

- Reconfiguring virtual hardware settings—Common virtual machine settings such as CPU weighting and memory allocation can be quickly and easily modified based on changing needs. Some changes can be performed without any downtime, whereas others might require small disruptions in service.
- Relocating virtual machines—Unlike physical workloads, it is fairly simple to move virtual machines to other host servers in the environment. Some virtualization platforms allow for “live migration” of a running virtual machine, whereas others might require some downtime.

In general, it is best to attempt to reconfigure virtual machine settings if resources are available. IT departments that target a specific amount of resource utilization per host generally leave some “slack” space in memory, CPU, storage, network, and other subsystems. This additional capacity can be added to virtual machines with minimal disruptions and risk. In some cases, however, virtual machines will outgrow the physical capabilities of their host servers. When it is necessary to move virtual machines, a data center automation solution can schedule and perform the necessary steps.

## Verifying Performance Effects

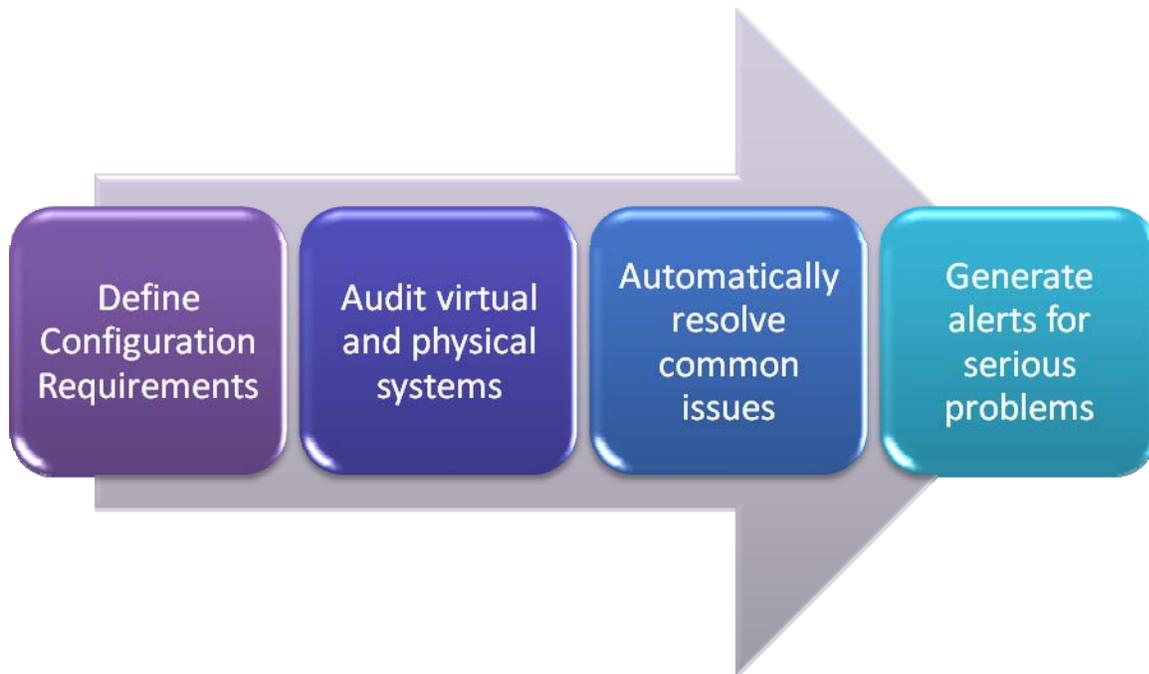
Once changes have been made to production systems, it is important to continue to monitor them. Usually, the effects of specific changes are predictable. For example, adding more memory to a virtual machine should decrease memory utilization. And, this should ultimately improve the business metrics that were defined initially. If changes did not have the intended effect, it might be necessary to take additional actions. For example, changes to CPU resource allocations might not be helpful on a server that is already over-utilized. In that case, moving the virtual machine to another system is the most appropriate response.

It is important to keep in mind that performance optimization is a continual process. Instead of using performance management as a reactive solution for addressing user complaints, automated solutions should continuously monitor the entire infrastructure. In summary, although these steps could be performed manually, it would be time consuming and have limited scalability. Automation ensures that all systems are proactively monitored.

## Verifying Security Configurations and Regulatory Compliance

Ensuring that physical and virtual production systems meet organizational requirements can be a tremendous challenge. For example, OS and application patches are released frequently by a variety of vendors. In addition, changes to security or regulatory compliance requirements can involve frequent auditing and monitoring of the entire infrastructure. Fortunately, this is a good example of where automating can help simplify the process.

Data center automation solutions have the ability to monitor and collect information from a wide variety of different types of workloads. Large numbers of systems can be automatically monitored to ensure that their configuration meets the IT department's requirements. The first step in automating security and compliance management is to develop an overall process. Typical steps are shown in Figure 9.7.



*Figure 9.7: Steps in an automated compliance management solution.*

### Defining Requirements

IT managers should begin by defining the desired configuration of their systems. The details should be based on input from the business as well as technical details. Examples of requirements include:

- All OSs should be up-to-date with the latest available patches
- Login failures on production applications should be logged
- Notifications should be sent when changes are made to the Human Resources database
- All virtual machines should run under at least a minimal security context
- Firewalls should be enabled on all production virtual machines and physical servers

The specific requirements should include all the business and technical details that are relevant to the environment. In some cases, exceptions might be necessary. For example, publicly accessible servers might have different regulatory compliance requirements from internal applications and workloads.

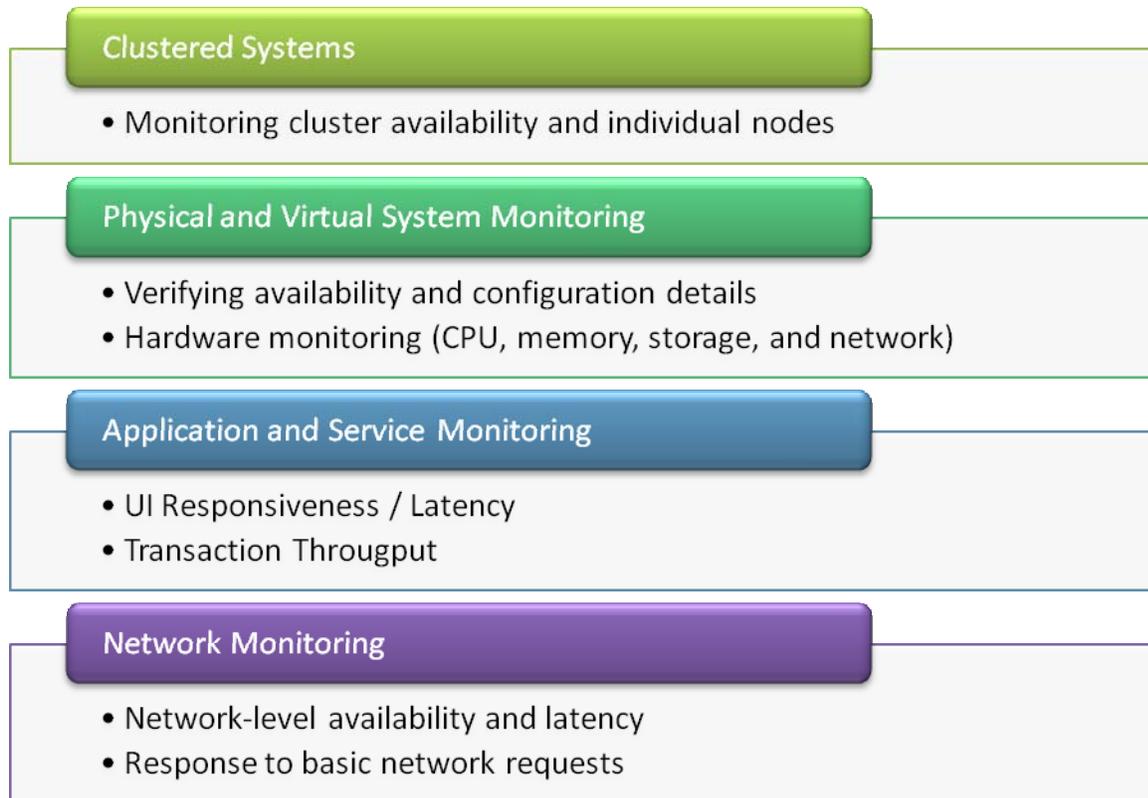
### **Auditing Production Systems**

Once the requirements have been defined, a data center automation solution can connect to and verify the configuration of physical and virtual machines. The specific details will vary based on the type of OS and application. Ideally, the solution will include a database that can translate the requirements into technical details for each target platform.

When configuration issues are detected, there are two main types of responses. For some types of settings, it might be possible to automatically resolve the issue. For example, if logging is disabled at the OS level or a firewall is incorrectly configured, the data center automation solution can take corrective actions. For other types of issues, manual intervention might be required. In those situations, automated alerts can be generated and communicated to the necessary business or technical staff.

### **Monitoring Availability**

Ensuring uptime and availability of production systems is an important concern for any IT environment. All too often, IT staff will wait until users report a downtime issue or related problems before investigating the system. In many cases, proactive monitoring could help resolve the problem without any disruption to end-user activities. Data center automation tools have the ability to monitor a large number of systems within an IT infrastructure. Figure 9.8 provides an example of the different types of monitoring that might be required for various types of systems.



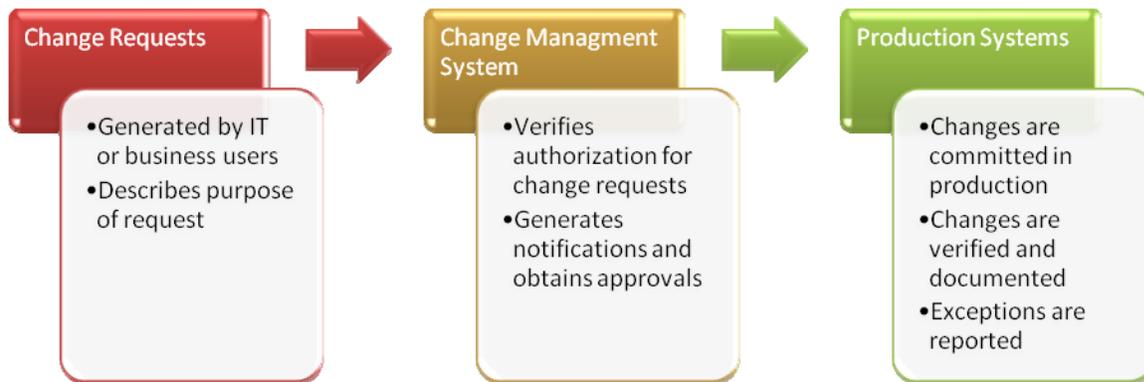
**Figure 9.8: Monitoring availability at numerous layers.**

As mentioned earlier in this section, monitoring requirements should be based on the end-user experience. Specific technical statistics will vary based on the application and underlying OS. However, it is usually easy for systems administrators to define thresholds and metrics for their critical applications.

When availability-related issues occur, some corrective actions can be taken automatically. Simple examples include restarting a service if an application stops responding or rebooting a virtual machine that has stopped unexpectedly. By performing these tasks automatically, response times are decreased dramatically. In other cases, alerts can be generated and communicated to IT staff. This is often required for complex systems where automated responses are not possible. Overall, however, this allows systems administrators to focus their time on important issues rather than routine troubleshooting. Automated solutions can also generate overall availability reports to help determine potential areas for improvement.

### **Change and Configuration Management**

Change is inevitable for modern IT organizations. Modifications to business priorities and technical requirements are common issues that must be addressed. Many organizations use a manual system of handling change requests. Often, users will directly ask a systems administrator to make a change. Although this process can sometimes be efficient, configuration changes can often be the cause of problems. Automated systems can help minimize these risks by using an organized process that involves input from all affected users. Figure 9.9 provides an overview.



**Figure 9.9: Steps in an automated change management process.**

The process starts with a change request that includes information about the purpose and reason for the request. The request is then managed automatically by the automated system. Generally, approvals are required as part of the overall process. The change management system can send notifications to the appropriate employees and allow them to add their comments and decisions on the change. Finally, once the request has been approved, modifications can be automatically deployed into production. For simple actions, the entire sequence can be performed within a few minutes. More complex or risky changes might require scheduling and additional approvals.

Automated systems provide numerous advantages over a manual process. First, the change requests are accurately logged in a centralized system—a step that is often overlooked by overworked systems administrators. Details related to the purpose are also documented. Other IT and business staff can later review this information if further changes are required. With automation, the same type of change can be made consistently across hundreds of systems. They can be scheduled to occur at off-peak times to minimize service disruptions. And, any exceptions (such as a failed change) can be reported to administrators. Overall, these features help ensure that changes are actually managed, instead of being performed in an ad-hoc and reactive fashion.

## Supporting Service Level Agreements and Charge-Backs

Over time, organizations have increasingly made IT decisions a part of their overall corporate strategies. Rather than being relegated to an infrastructure implementation role, IT departments can define and meet strategic objectives. Service Level Agreements (SLAs) can be used to help make the entire organization responsible for defining technology priorities.

 For more information about defining SLAs, see Chapter 6.

An important component of implementing SLAs is the ability to generate accurate reports of resource usage and other details. Details include:

- Application usage by department
- Workload uptime and data protection requirements
- Number of configuration change requests per application
- Required time to resolve typical issues
- Overall hardware resource requirements per application (including CPU, memory, network, and storage subsystems)

This type of information can be difficult to compile manually, as all areas of the overall infrastructure must be considered. However, with the use of data center automation, IT departments can collect usage and performance statistics. The information can be used to generate reports and to help identify the major sources of costs. Some organizations will choose to implement charge-backs—an accounting mechanism that makes departments pay for the resources they use. Overall, this information can help enable the entire organization to make better decisions about their IT infrastructure.

## Summary

Virtualization technology can help organizations meet important business and technical goals, ranging from cost reductions to creating a highly adaptable and efficient infrastructure. The actual realization of these benefits, however, can come at the price of administration. In this chapter, I presented ways in which data center automation tools can help address many of the most common issues. Initially, I described some of the typical goals that businesses have when considering the implementation of data center automation. Examples include enabling flexibility, agility, and dynamic resource management. Next, I described some important benefits of data center automation, including cost reductions.

Organizations will need to determine which types of tasks should be automated. I presented details related to characteristics that should be considered to prioritize the value of data center automation. In general, well-defined, repeatable tasks are the best choices. Finally, I presented numerous examples of ways in which automation can simplify the management of mixed virtual and physical environments. Specific areas include provisioning, deployment, performance management, security configuration, and security.

Overall, data center automation is a powerful method of implementing best practices related to virtualization management. In the final chapter, you'll learn about specific features you should look for when evaluating virtualization management tools and solutions.

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