Extending the Data Center: Lean IT for Remote and Branch Offices

Capable, Simple, Cost-Effective IT for the Extended Enterprise

Overview

Performance, business continuity, and compliance requirements mandate serving key applications and data sets from remote and branch office (ROBO) locations. But “fat branch” IT infrastructure wastes space, power, network bandwidth, and management resources. New “one-box” computing, virtualization, and networking solutions resolve the dilemma, with better utilization of local infrastructure, less application downtime and recovery time, faster application deployments, and lower infrastructure and operating costs.

Introduction

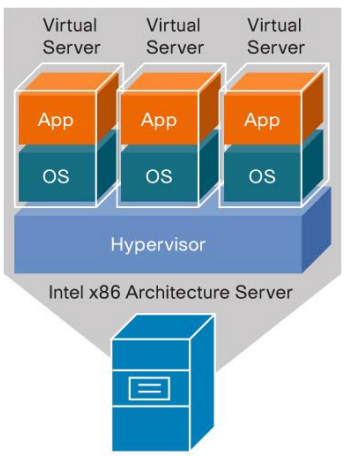
VMware vSphere Virtualization has transformed the corporate data center, raising server and storage utilization; management visibility and control; business agility; and cost effectiveness. Along the way, virtualization has created entirely new cloud-based services, virtual desktops, virtualized disaster recovery sites, and even complete virtual data centers.

Virtualization is now making inroads into remote- and branch-office (ROBO) computing, offering consolidation, energy-saving, and rapid provisioning benefits. But to deliver the most value, virtualization must meet the unique requirements of these locations. The goal of this document is to (1) compare and contrast data center and remote/branch-office virtualization environments, (2) describe how virtualization meets specific branch-office challenges, (3) explain how virtualization technology unlocks new capabilities in the branch office, and (4) describe the new joint VMware and Cisco® one-box computing, virtualization, and networking solution for remote and branch offices.

Beyond the Data Center

Data centers achieve economies of scale by concentrating physical x86 servers along with the infrastructure and staff needed to operate and manage them. But large data centers are also more complex to manage, consume significant amounts of energy, and require sophisticated capacity planning to account for unanticipated loads. Virtualization addresses these challenges by inserting a thin layer of hypervisor software between the server hardware and the operating system, creating containers for operating systems and applications (virtual servers) as shown in Figure 1. These virtual servers can be provisioned more quickly than their physical counterparts; require less space, power, and cooling; and can be cloned, moved, or clustered on demand without service interruption.

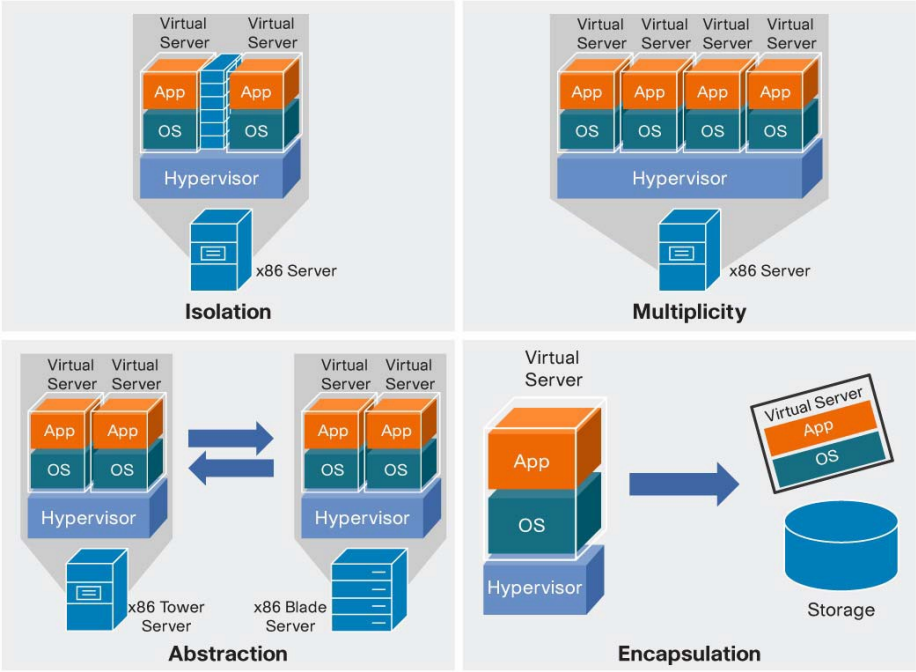
Figure 1. x86 Server Virtualization Architecture



Virtual servers have other capabilities that physical x86 servers lack (Figure 2):

- **Isolation:** a virtual server confined in its own container is unaware of other virtual servers
- **Multiplicity:** virtual servers share hardware with other virtual servers
- **Abstraction:** virtual servers are hardware-independent and can run on various platforms
- **Encapsulation:** each virtual server stores its complete point-in-time execution state in a file

Figure 2. Fundamental Attributes of Virtualized Server Platform



These attributes are the basis for higher-level capabilities that VMware vSphere Virtualization introduces into the data center.

Driven by virtualization, data-center consolidation has transformed IT infrastructure. For example, consolidated data centers, along with WAN optimization technologies, have reduced the need for local servers at remote and branch offices. But because WAN link speed and reliability limits keep them from relying completely on the home-office data center, even these “lean” offices still deploy a small number of servers locally.

Lean remote- and branch-office server infrastructure is dramatically different from that of a typical headquarters data center. Table 1 outlines some of the most important differences:

Table 1. Comparison of Data Center and Remote- or Branch-Office Infrastructure

	Consolidated Data Center	Lean Remote or Branch Office
Number of x86 servers	Large (tens to thousands)	Small (1 to 2)
Server type	Mid- to high-range	Low-range
CPU type	Multisocket; many cores	Single and dual socket; a few cores
Memory capacity	Large (tens to hundreds of GB)	Small (4 to 16 GB)
Primary storage type	SAN	DAS
Storage capacity	Large (hundreds to thousands of TB)	Limited (GB to single-digit TB)
Server load	Dynamic and fluctuating	Static and predictable
Number of applications	Large (tens to hundreds)	Small (fewer than a dozen)

New application rollouts	Frequent	Infrequent
IT management	Local	Remote
Server uptime	Critical	Critical
Crash recovery time	Critical	Critical
Application response time	Critical	Critical

Compared to the concentration of high-performance, high-capacity server hardware at data centers, most remote and branch offices have only a server or two. As a result, these smaller offices seldom use virtual server mobility, dynamic provisioning, workload balancing, and other advanced features VMware vSphere Virtualization offers: first, because they depend on data-center infrastructure, and second, because they add little value to configurations with so few servers.

In principle, virtual server mobility or clustering could be delivered from the data center into the branch office over a high-bandwidth, low-latency WAN link. But today's typical remote or branch office lacks the bandwidth needed to support such operations. A 4 GB Microsoft Windows Server virtual machine, for example, would take up to 6 hours to transfer on a dedicated T1 link even with no other traffic. WAN optimization cuts transfer time, but not enough to make server mobility or clustering a practical solution.

But despite their infrastructure and bandwidth limitations, there remain compelling technical and business reasons to use VMware vSphere Virtualization at remote and branch offices.

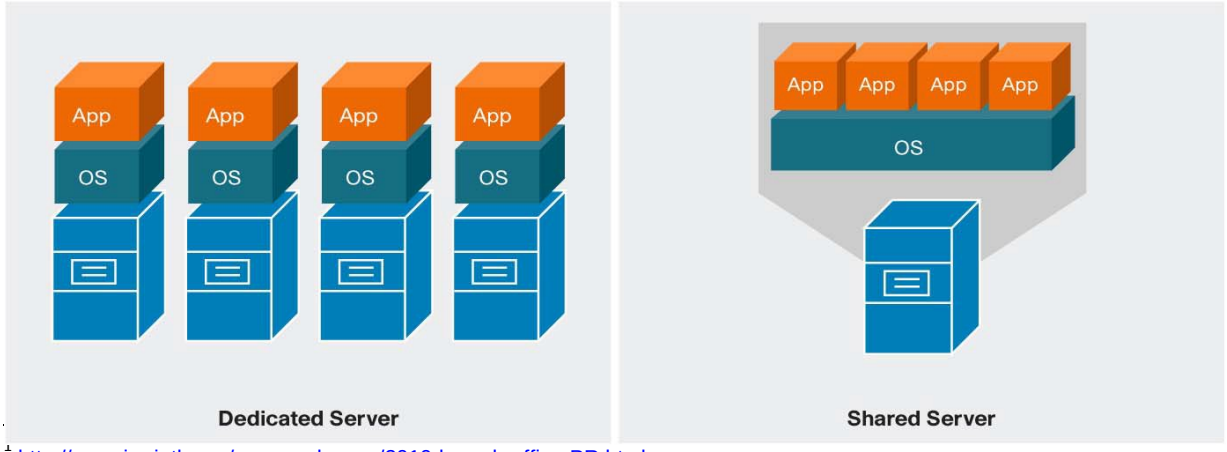
Addressing Current Remote- and Branch-Office Challenges through VMware vSphere Virtualization

Remote- and branch-office infrastructure has always raised challenges for IT departments, some specific to a company's line of business, others common across industries. They include the cost of deploying new applications, impacts of inadequate environmental controls on equipment, security and regulatory constraints, performance of centralized applications, support for critical uptime requirements, and more. The challenges increase as offices multiply – and a 2010 study by the Internet Research Group (IRG) estimates that U.S. firms maintain 21 percent more branch offices than they did a decade ago.[2] No product or technology can cure all branch office headaches, but vSphere Virtualization addresses some of the most difficult issues.

A typical lean remote or branch office runs four to six applications, for example print services, Dynamic Host Configuration Protocol (DHCP), Domain Name System (DNS), Microsoft Active Directory Domain Services, and performance-critical line-of-business applications. Applications and servers are provisioned according to one of two scenarios (see Figure 3):

- **A dedicated physical server for each application:** this setup isolates applications from each other for organizational, security, performance, or application availability reason, but increases equipment and operating costs
- **Multiple applications share a physical server:** this setup reduces the total cost, but creates access control, operational efficiency, application availability, and time-to-deployment complexity

Figure 3 Application Provisioning Options on Physical Servers

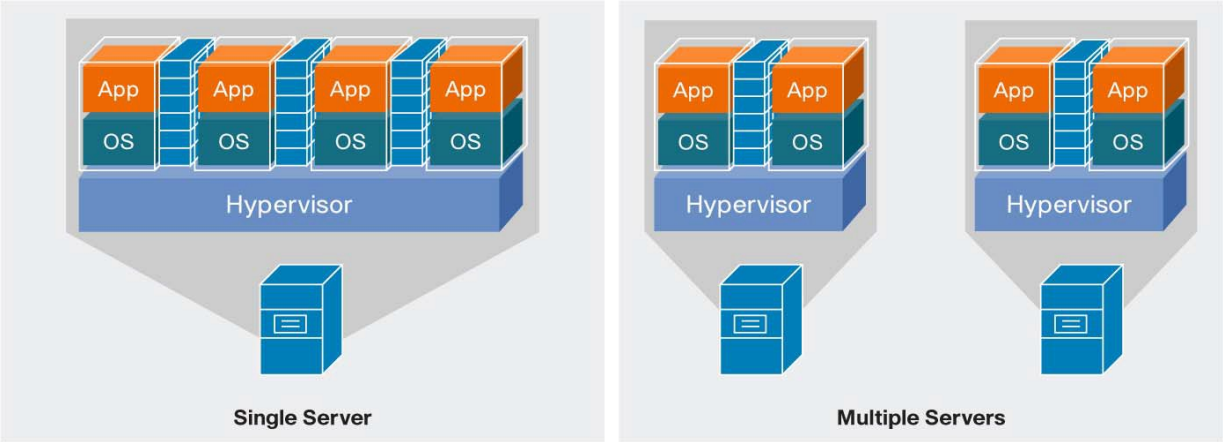


[1] http://www.irg-intl.com/press_releases/2010-branch-office-PR.html

Virtualization supports either deployment scenario and eliminates its major drawbacks. Specifically, the Isolation and Multiplicity attributes of virtual servers support (see Figure 4):

- **A dedicated virtual server for each application, hosted on a single physical server:** this setup isolates applications from each other, while reducing costs, increasing application availability, strengthening access control, and improving time-to-deployment for new applications
- **A dedicated virtual server for each application, hosted on multiple physical servers:** this setup delivers all the benefits listed above, and improves application availability and disaster recovery for a small increase in cost

Figure 4 Application Provisioning Options on Physical Servers



Either provisioning option delivers multiple benefits:

- **Lower infrastructure and operating costs:** consolidating multiple applications on a single physical server eliminates unnecessary servers and increases utilization of the remaining servers, reducing hardware capital expense and operational expenses for:
  - **Equipment and facilities:** fewer physical servers mean lower requirements for Ethernet ports, power supplies, patch panels, surge protectors, cabling, rack space, and floor space powered and cooled to IT requirements.
  - **Lower energy and support costs:** the remaining servers require less energy to power and cool, fewer hardware support contracts, and less time spent on provisioning.
- **Less application downtime and guaranteed responsiveness:** isolation means actions by one application don't affect the rest of the system, so dedicating a virtual server to each application results in:
  - **Shorter planned and unplanned downtime:** maintenance patches, updates, upgrades, and reboots can be carried out independently on each virtual machine, and a misbehaving application doesn't affect any others.
  - **Explicit allocation of hardware resources:** the hypervisor allocates to each application hardware resources that other applications can't steal, so every application delivers a guaranteed minimum level of responsiveness.
- **Faster application deployment:** applications contained in individual virtual machines don't interact or compete the way they can when they share an operating system instance. So virtualization speeds up application deployment, patching, upgrade, and update processes by reducing requirements for coordination, planning, and testing.

Tables 2 through 4 outline the specifics associated with each set of benefits, using scenarios in which physical servers supporting one or more applications each are replaced by virtual machines. In these examples, virtual machines run on new Cisco UCS E-Series x86 blades housed in the Integrated Services Router (ISR G2) platform, using VMware vSphere Cloud Infrastructure hypervisor and management software:

Table 2. Lower Infrastructure and Operating Costs Benefit Details

Current setup	Dedicated physical server for each application
Challenges	• Excess capital expense from underutilized[2] servers, cabling, power supplies, rack space, switch ports, patch panels, surge protectors, physical space, operating system licenses, and equipment spares • Excess operating expenses to power and cool larger-than-necessary infrastructure, extra per-server hardware support costs, and added administrative costs to provision, configure, and maintain multiple servers
New setup	Dedicated virtual server for each application, all hosted on a single physical UCS E-Series server blade
Results	• Smaller infrastructure footprint • Optimized energy consumption • Faster server provisioning, configuration, and maintenance
Benefits	• Cost savings from infrastructure optimization: combining multiple applications onto a single, highly utilized server blade cuts capital expenses by using: o Fewer CPUs, physical network interface cards (NICs), hard disk drives, and less memory o Fewer power supplies, patch panels, switch ports, surge protectors, and less cabling o Less rack and physical space o In many cases, fewer OS licenses[3] • Cost savings from smaller footprint: combining multiple applications onto a single, highly utilized server blade cuts operating expenses by requiring: o Less energy consumption for power and cooling o Lower annual per-server hardware support services o Less administrative time spent provisioning, configuring, and maintaining servers • Virtual NICs and switches available at no additional cost.
Costs	Hypervisor and virtual environment management software

Table 3. Less Application Downtime and Quicker Response Time Benefit Details

Current setup	Multiple applications share one physical server.
Challenges	• One misbehaving application may affect all other applications or take down the entire operating system environment. • One application may consume hardware resources and degrade performance or responsiveness of other applications; in the worst case, an application can starve other applications of all resources • Changes to one application, or deployment of a new application, may require taking the entire server and all hosted applications offline for an extended period of time
New setup	Dedicated virtual server for each application, all hosted on a single physical UCS E-Series server blade

[2] According to one McKinsey and Company study, data center server utilization rarely exceeds 6%. For branch-office servers, average utilization may be even lower because they host services with low resource requirements such as DHCP, DNS, or print servers. http://www.mckinsey.com/clientservice/bto/pointofview/pdf/Revolutionizing_Data_Center_Efficiency.pdf.

[3] Many operating systems allow running multiple instances per license: for example, Microsoft Windows Server 2008 Enterprise Edition allows up to four running instances per license on one physical server. http://download.microsoft.com/download/F/C/A/FCAB58A9-CCAD-4E0A-A673-88A5EE74E2CC/Windows_Server_2008_Virtual_Tech-VL_Brief-Jan_09.docx.

Results	• Applications are isolated from each other, so operating system failures caused by one application have no effect on other applications • Applications can be guaranteed CPU, memory, and storage resources that other applications cannot take away • New or changed applications are restricted to one virtual server, which can be taken offline without taking the physical server offline
Benefits	• Improved overall system and individual application uptime • Reduced system mean time between failures (MTBF) and mean time to repair (MTTR) metrics • Control over resource sharing based on each application's performance or other business requirements
Costs	• Hypervisor and virtual environment management software • Total application hypervisor and operating system requirements may exceed resources of the existing physical server, requiring upgrade or replacement • Operating systems for applications may increase operating system license costs – the four running instances permitted for Microsoft Windows Server 2008 Enterprise Edition[3] are sufficient for most lean branch offices

Table 4. Faster Time to Deploy Applications Benefits Details

Current setup	Multiple applications share one physical server.
Challenges	• Applications require periodic security patches, maintenance updates, and functional upgrades. When multiple teams are responsible for applications that share a physical server, any change to any one application must be coordinated across all teams, adding coordination and planning processes that delay rollout, introduce additional testing, and may trigger unnecessary changes in the other applications. • Application changes may require security patches, maintenance updates, or even a host operating system upgrade, affecting other applications whether or not they require the change, and introducing coordination issues discussed above. • High performance, fast response time, high availability, or other business needs may require a new application to be hosted locally in the branch office. Rollout of the new application must be coordinated to prevent adverse effects on existing applications or the host operating system.
New setup	Dedicated virtual server for each application, all hosted on a single physical UCS E-Series server blade
Results	• Applications are isolated from each other, and therefore a change in one application or its host operating system has no impact on the other applications. • A new application is provisioned in a new virtual server and deployed on the hypervisor without affecting the other applications.
Benefits	• Faster rollout of application or host operating system patches, updates, or upgrades. • Less time spent on cross-functional coordination required to plan and test application changes. • Improved ability to respond to security risks, application defects, or business requests to add new features or applications.
Costs	• Hypervisor and virtual environment management software • Total application hypervisor and operating system requirements may exceed resources of the existing physical server, requiring upgrade or replacement • Operating systems for applications may increase operating system license costs.

In summary, branch-office virtualization using VMware vSphere increases the speed of application deployment, improves

application uptime and performance guarantees, and reduces equipment and operating costs. But VMware vSphere Virtualization can do much more, with a rich set of features that can enable new capabilities in remote and branch offices.

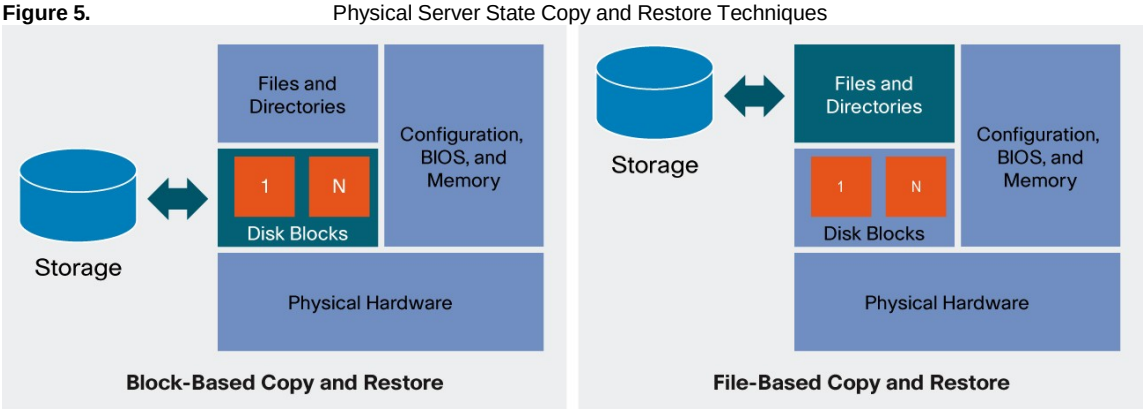
Enabling New Capabilities in Remote and Branch Offices through VMware vSphere Virtualization

vSphere brings capabilities to the data center that traditional servers cannot provide -- live virtual server migration, dynamic resource allocation, live CPU and memory increases, and distributed software switches. Lean branch offices, with their limited hardware footprints, have limited the use of such features. Nonetheless, a number of new capabilities offered by vSphere can improve server uptime and failure recovery time and automate server provisioning in remote and branch offices.

A typical lean office implements disaster recovery either by storing backups on local storage devices with periodic archives to tape, or by sending them to a data center for storage and tape archival. A growing number of remote and branch offices implement continuous data protection by replicating, snapshotting, or mirroring data to local storage devices. Regardless of where the data resides and how frequently it is backed up, two fundamental techniques are used to copy and restore the data (Figure 5):

- **Block-based disk copying with full-system restoration:** this approach provides the fastest full-system backup and restore operations, with low performance overhead during backup, and full recovery of the server. But it is an all-or-none approach that requires large storage capacity, individual files cannot be restored, and the restore target must be identical to the original server.
- **File-based file system copying with data and configuration restoration:** This method provides backup and restore operations at the individual file level, platform-independent restoration, and flexibility to adapt the configuration to the restoration target. But backup and restore operations take longer, performance overhead is higher during backup, and servers can't be fully recovered.

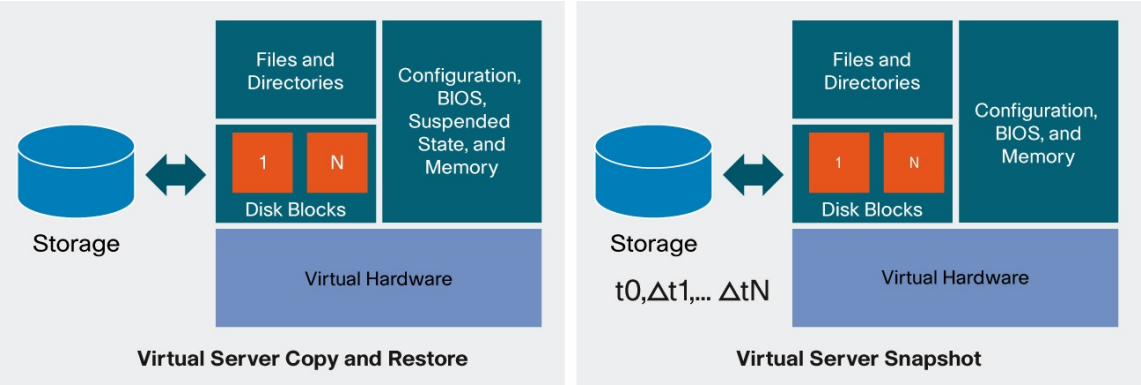
Figure 5. Physical Server State Copy and Restore Techniques



vSphere Virtualization provides new options for capturing point-in-time server states, which are then stored in several files. The abstraction and encapsulation attributes described previously facilitate the following approaches (Figure 6):

- **Virtual server copy and restore:** this option copies the entire persistent state of the virtual server, including the disk, memory, log, configuration, suspended state and snapshot data, NIC teaming, and BIOS. It allows complete restoration of the server, although the server must be powered off during the copy operation.
- **Virtual server snapshot:** this option, performed on a running server, saves the entire persistent and running state of a virtual server at a point in time and allows the server to return to this state.

Figure 6. Virtual Server State Copy and Restore and Snapshot Techniques



The ability to capture the entire server state in a few files provides these benefits to ROBO IT:

- **Less application downtime and faster recovery from failures:** Traditional backup and recovery procedures only copy the server state as it is written to disk. Encapsulating the full state of a virtual server in a set of files facilitates preservation of the entire state at a chosen point in time, as well as changes over time. As a result, saving or snapshotting the virtual server state results in:
  - **Faster recovery of the server during hardware migration or after a server failure:** The hypervisor can restart the virtual server from saved files, files can be exported for backup purposes, and virtual server files can be quickly imported to another hypervisor with the same or a different hardware configuration
  - **Faster rollback to a stable configuration if an application becomes unstable:** The virtual server can be rolled back to a point in time, reversing any unwanted changes

Table 5 provides in-depth explanations of each benefit, assuming the same infrastructure changes discussed in the previous section.

Table 5. Less Application Downtime and Faster Failure Recovery Time Benefits Details

Current setup	Block- or file-based backup and restore of server state
Challenges	• Block-based backup and restore mechanisms require nearly identical hardware configurations for disaster recovery or server migration • File-based backup and restore mechanisms require a multistep process for disaster recovery or server migration, and do not offer the benefits of full-state preservation • Rolling back a misconfigured, defective, or compromised application to a stable server state requires a long multistep restore process and may lead to data loss. Continuous data protection mechanisms with snapshotting offer full rollback capabilities but cost more, consume more processing power, and require more storage capacity than traditional backups. Troubleshooting corrupted applications requires complex and time-consuming restoration of the most recent backup to a spare server.
New setup	A virtual server dedicated to each application, supported by snapshot-and-copy, restore, import, and export operations
Results	• A “golden” fail-safe image of the virtual server is stored alongside the running instance • A snapshot of the virtual server is taken whenever application patches, updates, or upgrades are deployed • When migrating to new server hardware, production instances of virtual servers are exported from existing hypervisors, then imported to hypervisors on different host hardware • The most recent copies of virtual servers are exported from existing hypervisors, stored on backup devices, then imported to hypervisors running on the same or different host hardware when servers are restored after a catastrophic failure. (Note: A number of backup and restore solutions automate this process for virtualized infrastructure.)

Benefits	• Faster recovery from catastrophic hardware failure • Faster migration to new server hardware • Faster rollback of an unstable application to a known state • Capability to troubleshoot unstable applications on backup replicas of virtual servers while the primary instance is rolled back to an earlier state
Costs	• Hypervisor and virtual environment management software • Optional backup and restore solution for virtualized infrastructure

In summary, the capability to copy and restore the entire state of a virtual server to a specific point in time accelerates recovery after server failure, migration to new server hardware, and rollback of unstable applications to a fail-safe state.

VMware and Cisco Remote- and Branch-Office Server Virtualization Solution

Cisco Unified Computing System E-Series Server (UCS® E-Series) brings data-center-class virtualization-ready blade servers to the branch office. Cisco UCS E-Series Servers are high-density single-socket blade servers designed to balance simplicity, performance, and application density even while operating in energy-efficient environments. These small but powerful x86 64-bit blade servers are housed within Cisco Integrated Services Routers Generation 2 (ISR G2) networking platforms, and designed to host essential infrastructure services and mission-critical business applications in the lean branch office.

This solution is best suited for multisite organizations with centralized IT infrastructure that wish to host a small number of essential applications at local offices. Compared to standalone x86 servers with or without virtualization, Cisco UCS E-Series provides more agile, simpler, and lower-cost infrastructure integrated into a single device. And unlike appliance-based virtualization products, Cisco UCS E-Series combined with VMware's vSphere Hypervisor provides enterprise-class virtualization hosted on high-performance, feature-rich hardware.

Depending on the model, the Cisco ISR G2 can host one or more E-Series blades, allowing deployment of one or more physical servers with just 160W per blade added power consumption and no increase in rack space or cabling,. Cisco E-Series blades communicate with each other and the router over a multigigabit fabric backplane, eliminating the need for external cables. IP addresses, switch-port assignment, and routing services such as Network Address Translation (NAT), firewall, and intrusion prevention system (IPS) can be added dynamically as required with no need to physically re-cable the blades.

Data center consolidation has triggered centralization of branch-office applications, but some applications still need to be deployed remotely, for reasons that include:

- **Performance:** applications that require fast response times or transmit large amounts of data can't tolerate WAN links' latency and bandwidth limitations– examples include software distribution, performance monitoring, and interactive applications
- **Availability:** applications that require continuous availability can't tolerate the unreliability of WAN links -- for example DNS or DHCP servers, Microsoft Active Directory Domain Services, print services, and point-of-sale applications
- **Compliance:** some applications must meet security, regulatory, or internal policy requirements that prohibit hosting outside the local office, prohibit export of data outside the local jurisdiction, or require retention of a local copy of data – examples include the Payment Card Industry Data Security Standard (PCI DSS), Health Insurance Portability and Accountability Act (HIPAA), and Sarbanes-Oxley regulations.

Cisco E-Series blades have been designed to help organizations provide data-cemter services to lean remote and branch offices. On-demand application provisioning helps them deploy networking and computing services to remote locations at any time, eliminating costly onsite visits and infrastructure modifications when performance, availability, or compliance considerations require local application deployments. Deploying Cisco E-Series with Cisco ISR G2 removes the burden of having to decide at the outset which services have to be provisioned in the branch office, and it provides the flexibility to change service placement decisions in the future, eliminating costly infrastructure lock-in.

Cisco UCS E-Series powered by VMware vSphere enhances the Cisco E-Series on-demand application-provisioning model with the capability to host any application in the Cisco ISR G2 while taking advantage of all the benefits provided by virtualization as described in this document

Cisco UCS E-Series combined with Cisco ISR G2 creates a unique solution for hosting all branch-office applications and services such as routing, switching, security, voice, video, wireless, computing, storage access, VMware vSphere Virtualization, Microsoft Windows core services, and line-of-business applications. This “ROBO in a box” solution provides the following benefits:

- **Cost savings:** the multiservice Cisco ISR G2 is the lowest total cost solution for branch-office services.[4] Cisco E-Series blades deployed on the Cisco ISR G2 save even more by eliminating onsite visits and infrastructure changes, reducing energy consumption, and attaching Cisco E-Series blade hardware support services to the Cisco ISR G2 at no additional cost.
- **Consolidation:** providing all branch-office services and Microsoft Windows applications in a single device simplifies and reduces the footprint of branch-office infrastructure. With fewer servers and appliances, less cabling, fewer Ethernet ports, fewer power supplies, and less rack and physical space, a hard-wired physical infrastructure that needs frequent onsite support is replaced by a soft-wired virtual infrastructure that is easier to manage remotely.
- **Integration:** The Cisco UCS E-Series platform is connected to the rest of the branch-office network and other Cisco ISR G2 service modules through a multigigabit backplane switch. Virtual servers running Microsoft Windows Server can now directly take advantage of router and switch features such as VLANs, security zones, access control lists (ACLs), and firewall with no impact on performance. By unifying routing, switching, computing, and storage access, the Cisco ISR G2 provides more flexibility, more granular control over security, and higher performance.

Cisco UCS E-Series Use Case 1: Core Windows WAN Edge Services

An organization decides to implement Microsoft Active Directory Domain Services, DHCP server, and DNS server locally in the branch office for:

- **WAN reliability:** The WAN is unavailable from time to time, and the cost of a backup link is prohibitive; or a second service provider is not available in the specific geographic area.
- **WAN performance:** Latency between the branch office and the nearest data center is significant, and branch- office users constantly generate queries to Microsoft Active Directory Domain Services, DHCP server, and DNS server.

The branch office experiences productivity slowdown when these services are slow or unavailable. With Cisco UCS E-Series, core Windows services can be implemented in the following ways:

- Each service can be run as a dedicated virtual server.
- A group of services can be co-located and run on a virtual server.

Actual implementation depends on individual requirements. This solution also decreases the infrastructure footprint at the remote office.

Cisco UCS E-Series Use Case 2: Bank Teller Line-of-Business Applications

A retail bank cannot tolerate any business-hours interruption of its branch-office teller application. The organization implements a thin in-office control point (IOCP) as a standby system for a centrally hosted teller server. Under normal conditions, the branch-office teller client interacts with the central teller system. But if the WAN connection is disrupted or degraded, the local IOCP takes over, serving requests from the teller client. Once the WAN connection is restored, the IOCP synchronizes in-office transactions and returns control to the central teller system. With Cisco UCS E-Series, the IOCP can run on a dedicated virtual server hosted in the Cisco ISR G2, providing higher availability for a business critical application.

Cisco UCS E-Series Use Case 3: Virtualized Network Appliances

A number of appliances that network-level functions -- firewall, wireless LAN controller, private branch exchange, and WAN

[4] http://cio.cisco.com/en/US/prod/collateral/routers/ps5855/prod_white_paper0900aecd805898e5.html

optimization controllers -- continue to be deployed in remote and branch offices. All such devices can be virtualized and hosted on the Cisco UCS E-Series, reducing complexity of remote infrastructure and supporting remote management.

Summary

A typical lean branch office has a significantly different server infrastructure than a data center, but despite the differences, multisite organizations have much to gain by deploying VMware vSphere Virtualization in their remote and branch offices. The virtualization technology helps meet common branch-office challenges, and it introduces new capabilities not available with traditional servers. The main benefits of virtualization in the branch office include:

- Lower infrastructure and operating costs
- Less application downtime and faster response time and failure recovery time
- Faster time to deployment for applications

Cisco UCS E-Series with VMware virtualization offers a powerful, compact, easy-to-administer solution for remote and branch office applications.

For more information visit: http://www.cisco.com/go/ucse/.

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