Tech Note 656
Building Wonderware® Solution Architectures on VMware

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Introduction

This *Tech Note* discusses VMware virtual machine technology, and how it can be utilized to deploy Wonderware Solutions built upon the System Platform.

Application Versions

- VMware ESX 3.5 and 4.0

- **Supported Wonderware Products (see list below)**

Virtual Machine Defined

A virtual machine is a tightly-isolated software container that can run its own operating systems and applications as if it were a physical computer. A virtual machine behaves exactly like a physical computer and contains it own virtual (i.e. software-based) CPU, RAM hard disk and network interface card (NIC).

FIGURE 1: VIRTUAL MACHINE ARCHITECTURE

The operating system doesn't know the difference between a virtual machine and a physical machine, nor do applications or other computers on a network. Even the virtual machine thinks it is a "real" computer. Nevertheless, a virtual machine is composed entirely of software and contains no hardware components whatsoever. As a result, virtual machines offer a number of distinct advantages over physical hardware.

Other Definitions

- **Host System**: Operating System that Runs Virtualization Software to Execute One or More Guest Systems, i.e. VMware ESXi (Physical Machine).

- **Guest System**: Operating System that Runs Within a Host Virtual Environment, i.e. Windows 2003 Server R2 (Virtual Machine).
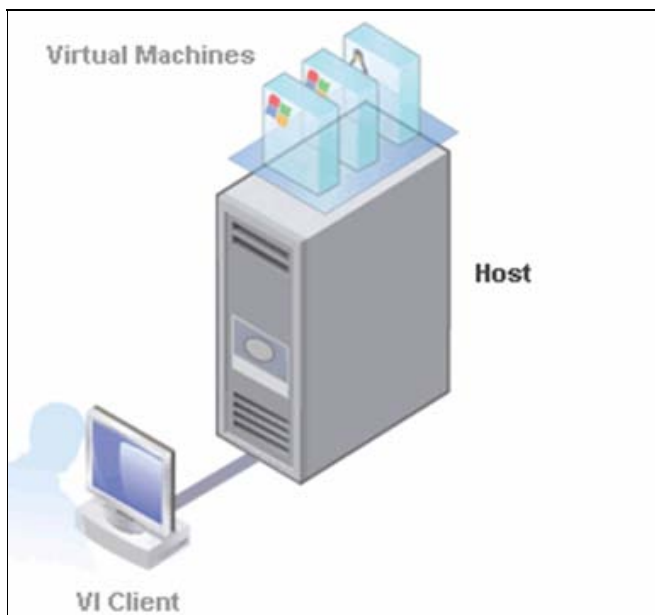

FIGURE 2: HOST AND GUEST SYSTEMS

Other definitions appear in context with VMware product descriptions.

Virtual Machine Advantages

- Hardware Independence

- Fault Tolerance

- Application Load Balancing

- Rapid Disaster Recovery

  (DR)
- Recovery to Non-Identical Hardware

- Ability to Pre-Test OS Patches or Vendor Updates

- Ability to Roll-Back Incompatible OS Patches or Vendor Updates

- Reduced TCO Resulting from Consistent Datacenter Environment

Virtualization Technology Background

Virtualization Technology was first implemented approximately 30 Years ago by IBM, on Mainframe Computers.

Virtualization provided the following benefits:

- Allowed Multitasking.

- Allowed better utilization of (expensive) Mainframe Hardware.

- Mainframes were designed for this type of partitioning.

Virtualization practices were reduced during the 80s and 90s because

- Low cost PC-based solutions were becoming more popular.

- Client-Server Applications were used to distribute computing power.

- Standardization on x86 architectures.

- Many challenges for IT emerged in order to support, maintain, and upgrade distributed systems.

In 1999 VMware introduced virtualization to x86 Systems. This event provided the following benefits:

- Provided general purpose usage from shared hardware Infrastructure.

- Provided Full Isolation.

- Allowed flexibility in Operating System choice for applications.

- Introduced many challenges in introducing Virtualization on the x86 platforms.

The result is a high-performance virtual machine that matches the host hardware performance, and maintains total software compatibility. VMware pioneered this technique and is today the leader in virtualization technology. Wonderware announced support for VMware ESX/ESXi in September, 2007 via **Tech Note 499**.

Why IT Departments are Driving Server Virtualization

The IT stakeholders support Server Virtualization for the following reasons:

- Low Infrastructure Utilization.
  - Typical x86 server deployments achieve an average utilization of only 10% to 15% of total capacity .

  - Organizations typically run one application per server to avoid the risk of vulnerabilities in one application affecting the availability of another application on the same server.

- Increasing Physical Infrastructure Costs.
  - The operational costs to support growing physical infrastructure have steadily increased. Most computing infrastructure must remain operational at all times, resulting in power consumption, cooling and facilities costs that do not vary with utilization levels.

- Increasing IT Management Costs.
  - As computing environments become more complex, the level of specialized education and experience required for infrastructure management personnel, and the associated costs of such personnel have increased.

- Insufficient Failover and Disaster Protection.
  - Organizations are increasingly affected by the downtime of critical server applications and inaccessibility of critical end user desktops.

  - The threat of security attacks, natural disasters, health pandemics and terrorism has elevated the importance of business continuity planning for both desktops and servers.

- High Maintenance end-user desktops.
  - Managing and securing enterprise desktops present numerous challenges.

  - Controlling a distributed desktop environment

- Enforcing management, access and security policies without impairing users' ability to work effectively is complex and expensive.

- Numerous patches and upgrades must be continually applied to desktop environments to eliminate security vulnerabilities.

How Manufacturing Benefits from Server Virtualization

- Speeds Commissioning of New Servers.

- Provides the ability to Adjust Server Architecture to Adapt for Growth (Scalability).

- Enables better utilization of Available Physical Assets.

- Provides standardized and consistent IT OS Builds Across the Enterprise.

- Reduces Support Costs; IT Infrastructure Team Owns/Maintains Physical and Virtual Server Environments.

- Provides the ability to isolate applications from each other without having to procure additional physical Server hardware.

- Provides the ability to easily create and maintain a Development & Testing Environment identical to the Production Environment.

VMware Products

VMware ESXi - Host OS for Execution of Virtual Machines
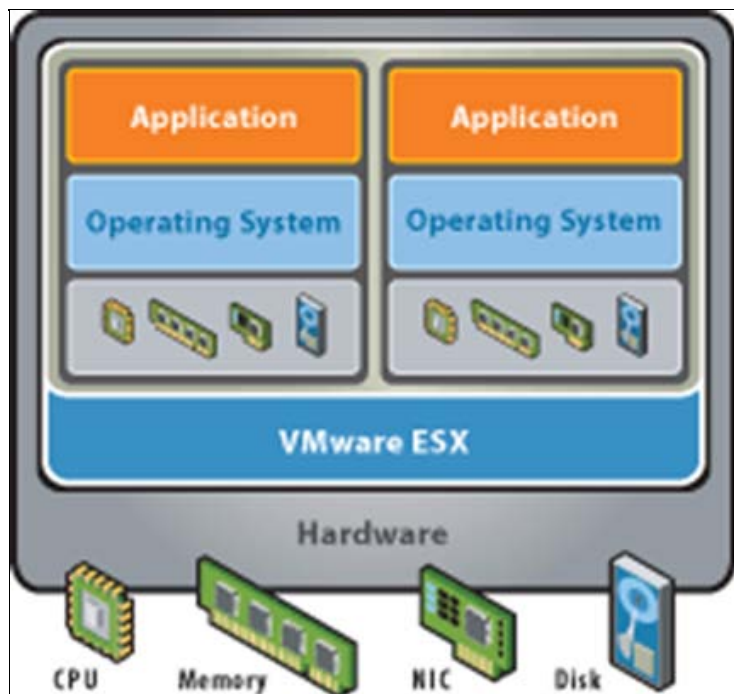
FIGURE 3: VMWARE ESX AND EXSI

VMware ESXi is the bare bones base operating system (hypervisor) for VMware's virtualization technology. This version of the hypervisor can be easily pre-loaded onto servers to be deployed when new capacity is needed. Features of ESXi:

- No general-purpose operating system or parent partition.

- Runs in a 32Mb footprint.

- More memory available for Guest Systems.

- Can be upgraded to be part of the vSphere virtual infrastructure system.

VMware vSphere - Virtual Data Center for the VMware Enterprise Application

FIGURE 4: VMWARE VSPHERE

VMware vSphere is the enterprise solution for managing virtual machines across multiple host servers. vSphere has several licensing levels to enable advanced features. Features include:

- **Data Recovery**: Agentless backup for guest machines.

- **Fault Tolerance**: Continuous availability in the event of hardware failure.

- **Hot Add**: Add CPU and memory to guest machines without disruption or downtime.

- **Host Profiles**: Standardize and automates configuration of host servers.

- **Thin provisioning**: Dynamic allocation of storage capacity to allow storage to be added as needed.

- **Advanced Networking**: Allows for interface to third party virtual network switches such as Cisco Nexus 1000v.

VMware VMFS – High Performance Storage File System
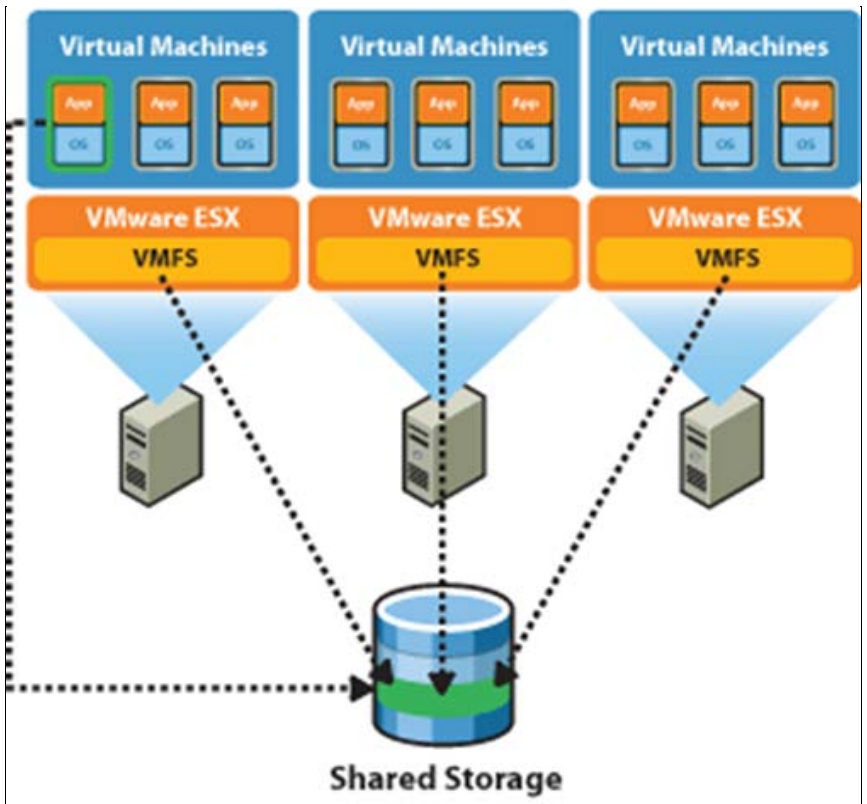
FIGURE 5: VMFS PRODUCT

The VMware vStorage VMFS file system addresses the challenges of machine virtualization. The VMware storage solution allows multiple host systems to access data on a shared storage solution, such as an iSCSI, or Fibre Channel SAN, concurrently. The software stores all information about the virtual machine's state in a central location. This allows for host machines to be clustered, and the virtual machine can be migrated from host-to-host in a seamless manner.

FIGURE 6: MULTIPLE VIRTUAL SYSTEMS

Other features of vStorage VMFS Include:

- Adaptive Block sizing allows growing of VMFS Volumes on the fly.

- Automatic discovery and mapping of LUNs to a VMware VMFS volume.

- Optimize disk I/O with with adjustable disk, file and block sizing.

- Reliable and faster recovery of guest machines after a failure with distributed journaling.

- Snapshots allow you to create a point-in-time copy of a virtual machine that can be used for testing, backup, or recovery.
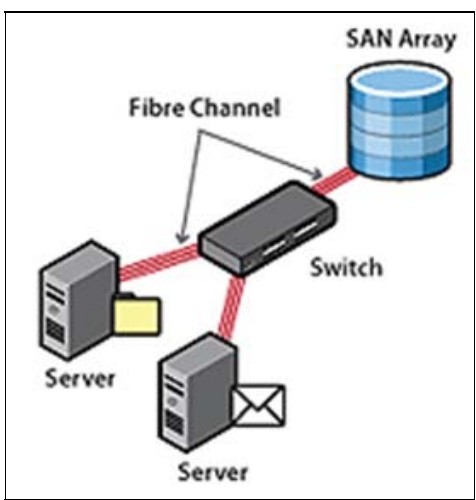
VMFS Best Practices

- Provision Storage to Optimize I/O Performance, then for storage capacity

- Consider I/O Requirements for *all* Guest systems, then size storage solutions accordingly.

- I/O demands of some guest systems may warrant a dedicated storage solution. Examples would be high I/O Database solutions, etc.

- Measure the I/O Workload of existing systems prior to virtualization. Use the aggregate I/O Requirements to determine how your storage solution should be sized, and configured.

- Pooling of resources in a Virtual environment will increase resource utilization. This is desirable to make better use of physical infrastructure, and simplify management. However, during peak demand this practice can have an impact on application performance.

  To mitigate this risk, consider placing guest systems with heavy I/O demands on a separate VMFS Volume (or dedicated disk) to reduce the affects of contention.

• VMware Converter – Convert Physical Machines to Virtual

VMware Converter enables conversion of physical machines (or images) to VMware Format. The conversion process (P2V) from Physical to Virtual machine allows existing hardware to be decommissioned and migrated into the virtual environment. In addition to the ability to create a virtual image from an existing system, the converter is able to convert images from other virtual machine formats (i.e. MS Virtual PC, MS Virtual Server) or from a backup image (i.e. Norton Ghost, Acronis, or Symantec Backup Exec).
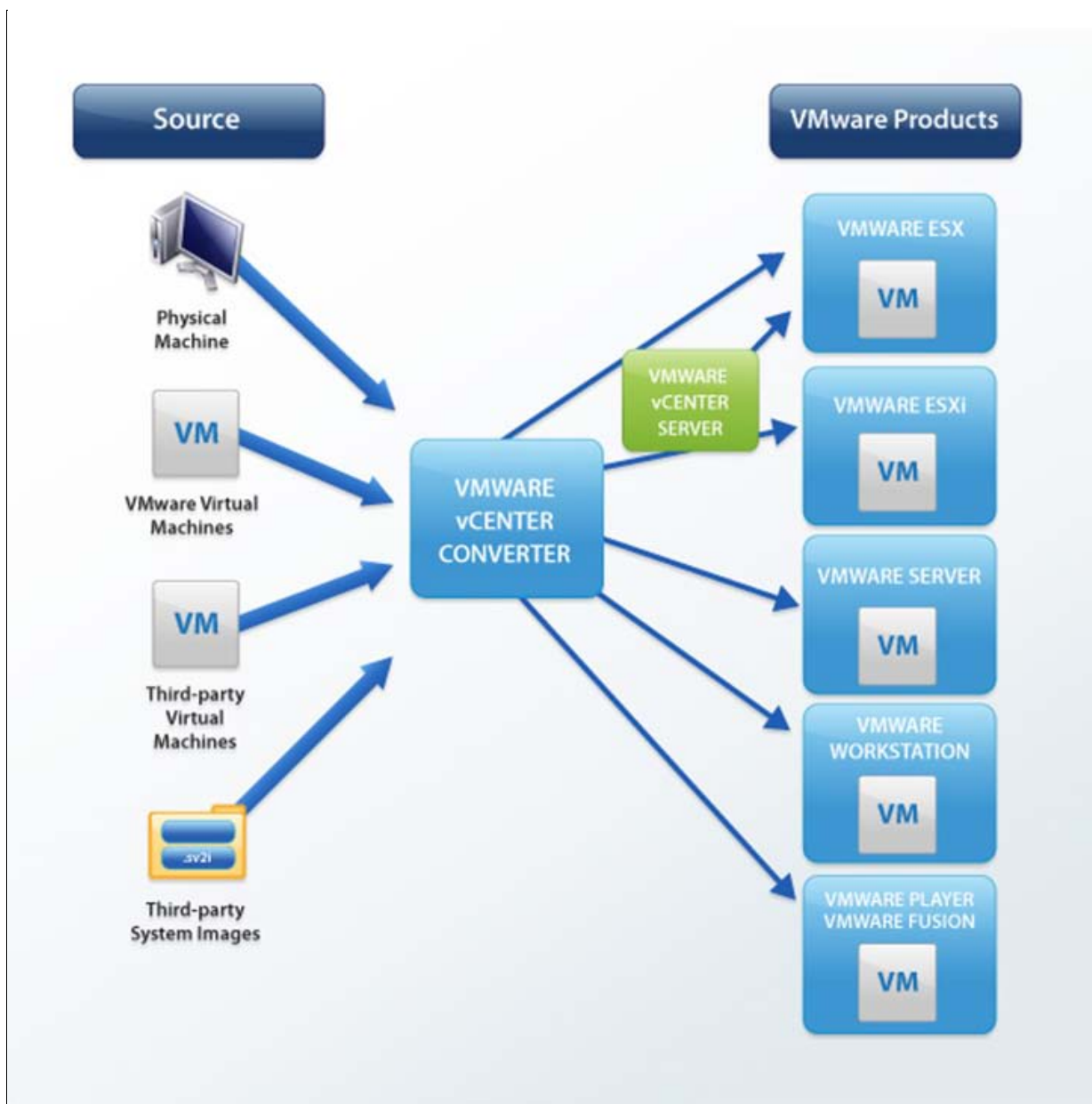
FIGURE 7: MACHINE CONVERSION

The converter can clone and backup machines to virtual images as part of a disaster recovery plan.

Compatibility with Wonderware Applications

Tech Note 499 Wonderware Support for VMware ESX Server 3i states:

"VMware ESX Server is currently the only virtualization technology formally supported by Wonderware in production applications. Other virtualization technology may exhibit more significant drift in the system clock with less control over virtual machine scheduling, making other platforms unsuitable for production use.

"Wonderware Technical Support will not require clients running on VMware ESX to recreate and troubleshoot every issue in a non-virtualized environment; however, Wonderware does reserve the right to request customers to diagnose certain issues in a native operating system environment, operating without the virtual environment. Wonderware will only make this request when there is reason to believe that the virtual environment is a contributing factor to the issue."

Supported Wonderware Products

- Wonderware Application Server 3.1 SP2

- Wonderware InTouch® 10.1 SP2

- Wonderware Historian 9.0, 10.0

- Wonderware ActiveFactory 9.2

- Wonderware Historian Client 10.0

- Wonderware Information Server 3.0, 3.1, 4.0

- Wonderware InBatch 9.0

- Wonderware Factelligence 3.4, 3.5

- Wonderware MES Operations and Performance Software 4.0

- Equipment Operations Module 2.0, 2.1

- Wonderware Manufacturing Execution Module 1.0

- Production Events Module 2.0, 2.1

- Wonderware Formula Management Module 1.0, 1.1

- QI Analyst 8.0

- Wonderware DA Servers using a DASEngine with build 780.0401 or later. This includes ABTCP 1.5 and SIDirect 1.5.

Supported VMWare Products

- ESX 3.0, 3.5

- EsXi 4.0

- Vsphere 4.0

- **Vsphere Exceptions**
  - FT: Fault Tolerance

  - HA: High Availability (VMOTION during Runtime)

  - DR: Disaster Recovery

  - Hot Add, Add CPU and Memory during runtime.

  - Advanced Networking, 3rd party support for Virtual Switches

  - Pooling of resources, Scheduler.

  - Load Balancing during Runtime.

Supported VMWare Technologies

- Snapshots for testing backup and recovery.

Note: VMWare Workstation is NOT supported for production environments.

Best Practices

- Target Server CPU Utilization at 50% or Less.

- Use the VMware ESX Server Console to configure CPU and Memory Reservations.

- Virtual Machines Configured with a Single Processor Make the ESX Server's Scheduling Simpler.

- Monitor System Clocks for Excessive Drift.

- Monitor the Scan Overruns in each AppEngine.

- **High-Speed Processing**: To ensure proper timing functions of critical applications do not over-commit resources and keep processor affinity locked. For example, if a physical unit was going to be 2 cores and 2GB of RAM, dedicate this to the virtual machine as well and make it the minimum.

- Avoid Time Synch Contentions - Use Only a Single Mechanism - VMware Tools Time Synch.

- Improve Virtual Memory Performance - Use the VMware Memory Control Driver.

- Improve Clock Reliability - Use VMware Tools Descheduled Time Accounting Option - VMDesched.

Architecture Examples

The following examples provide implementation information in the form of short case studies.

Case Study # 1

A large manufacturing facility wishes to utilize VMware technology in order to virtualize all applications. Their manufacturing automatioin is based on Wonderware System Platform. The application architecture consists of

- A Galaxy Repository Server,

- Two servers for InTouch Terminal Servers, and

- 3 Application Servers.

- In addition to the production floor servers, front office servers will be included in the virtual infrastructure.

FIGURE 8: HOSTS AND THEIR VIRTUAL MACHINES

A single virtual data center is configured with 7 host servers, supporting 31 virtual machines.

Note: Not all Virtual Machines are powered on. Some are available for application testing, etc.

FIGURE 9: HOSTS BASELINE STATUS DATA

Host machines are configured as a cluster in VMware. The resulting server architecture allows for the Wonderware software solution to run in a robust environment, independent of the actual hardware. Key benefits include:

- Fault tolerance

- Virtual Machines can migrate to any of the host servers in the event of a hardware failure

- New server hardware can be deployed into the cluster quickly

- Load Balancing: Load can be managed to better utilize physical infrastructure

- Server upgrades can be brought online to improve performance with no downtime• Disaster Recovery

- Backups can be performed while servers are operating, with no agents installed on the guest systems• Upgrades and Patching

- Snapshots can be taken prior to major upgrades to capture system state. In the event an upgrade fails, the image can be reverted to the snapshot.
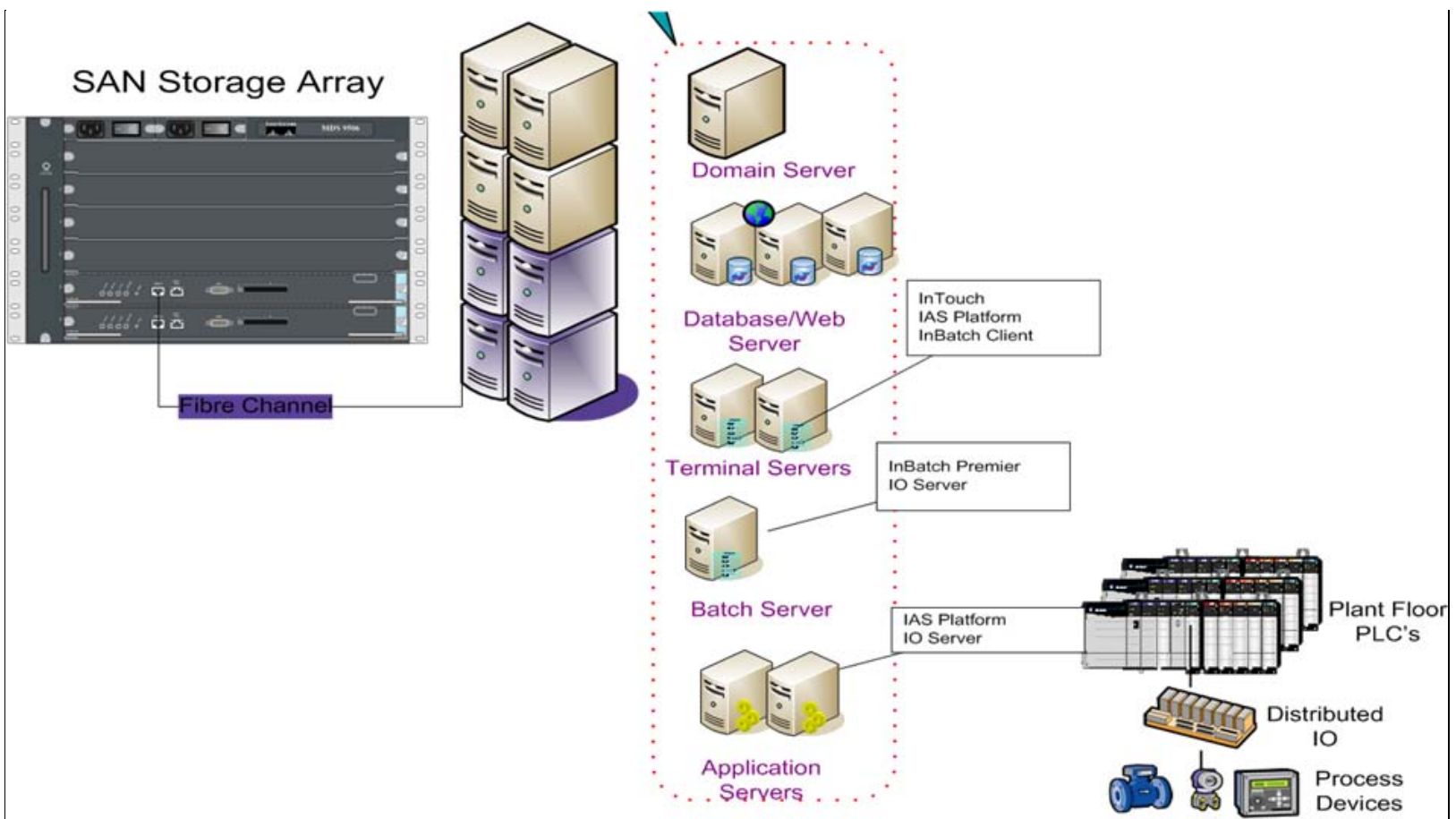
FIGURE 10: VIRTUAL DOMAIN AND INFRASTRUCTURE

Case Study # 2

A company needs to maintain a second system identical to their Wonderware-based solution. The system is to be used for user training, and as a development environment to test changes before they are implemented in the production environment. Maintaining two sets of identical systems has proven difficult to keep applications Synchronized.Utilizing VMware a solution could be setup where the production environment is occasionally cloned into a lab environment.
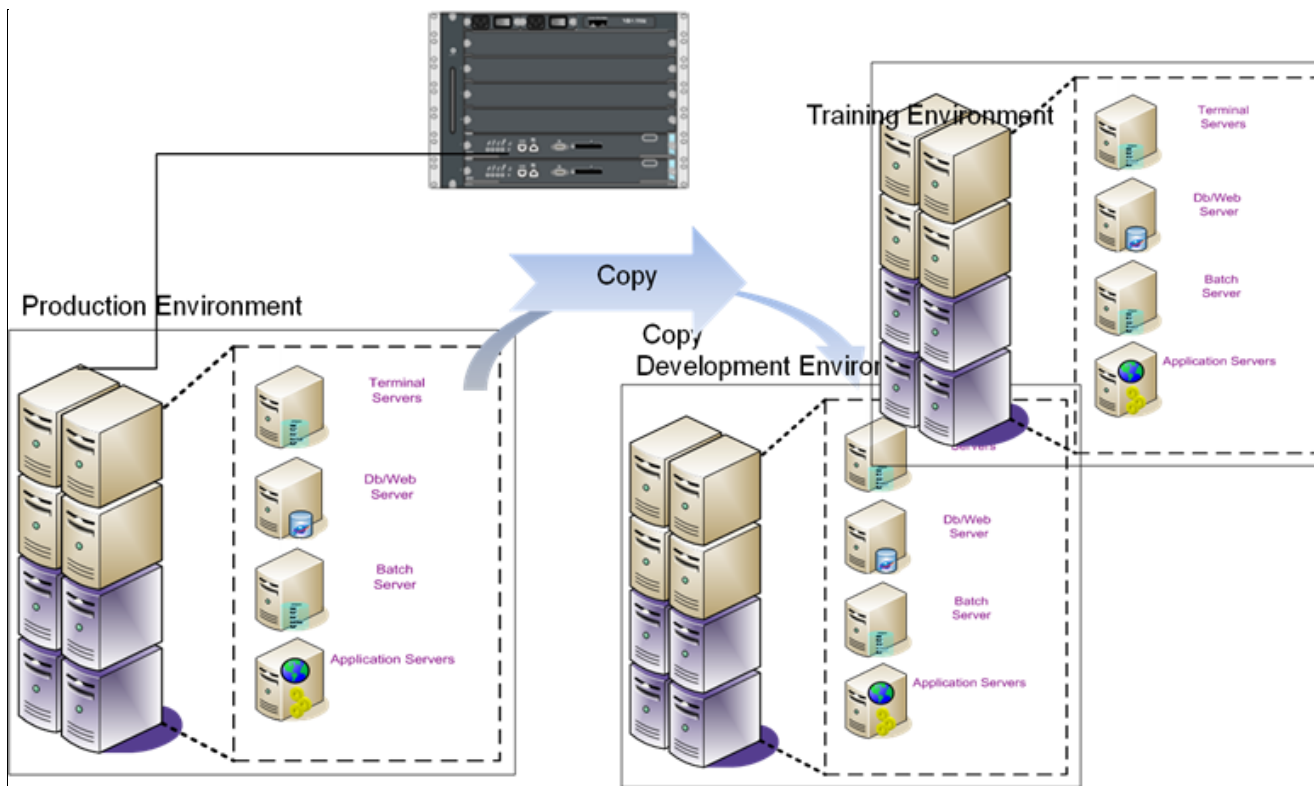
FIGURE 11: CLONING THE VIRTUAL SYSTEM

Conclusions

Wonderware System Platform coupled with VMware virtual infrastructure is an extremely powerful solution with many significant benefits. Solution architectures based on VMware adds more capability and scalability to a Wonderware System Platform Implementation. As with most applications, careful consideration should be given to performance needs when choosing the system architecture.

References

- **www.wonderware.com**

- **www.vmware.com**

- **www.stonetek.com**

B. Humphreys, Stone Technologies & M. Aguinaldo

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