DEPLOYMENT GUIDE

INDUSTRY: ALL

Zebra YMS for VMware Infrastructure

Deployment and Technical Considerations Guide

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vmware®

Zebra®

Zebra Enterprise Solutions

Table of Contents

Introduction

This document provides direction to those interested in running the Zebra Yard Management System (YMS) on VMware vSphere™ 4. It provides a basic overview of the Zebra YMS architecture as well as the value of utilizing the VMware® platform to run Zebra YMS. The results of recent testing performed jointly by VMware and Zebra are included, which characterizes the performance and functionality of Zebra YMS running on vSphere 4. Finally, this document outlines some best practices for utilizing the two product sets, Zebra YMS and vSphere 4, together in your datacenter.

Zebra Yard Management System (YMS) Overview

The Zebra YMS is a yard planning, management, and execution solution that leverages wireless location and communication technologies and configurable business rules to optimize yard operations and the systems with which they interface. The YMS was designed for yards that require fast throughput (accomplished through faster gate transactions), efficient parking assignments, fewer yard moves, and greater door turns. While the scheduling system is used for planning expected arrivals and departures, the execution system responds to unplanned events based on business rules that are configured for specific customer operations. The combination of effective planning and exception handling allows the YMS to direct the right trailer to the right door at the right time.

VMware vSphere 4 Overview

VMware vSphere, the industry's first cloud operating system, leverages the power of virtualization to transform datacenters into dramatically simplified cloud computing infrastructures and enables IT organizations to deliver the next generation of flexible and reliable IT services, using internal and external resources, securely and with low risk. Building on the proven power of the VMware virtual infrastructure platform, used by more than 130,000 customers, VMware vSphere dramatically reduces capital and operating costs, and increases control over delivery of IT services while preserving the flexibility to choose between any type of OS, application and hardware, hosted in-house or using external resources. With VMware vSphere providing the foundation for internal and external clouds, using federation and standards to bridge internal and external cloud infrastructures, organizations of all sizes can achieve the full benefits of cloud computing.

VMware's leading virtualization solutions provide multiple benefits to IT administrators and users. VMware virtualization creates a layer of abstraction between the resources required by an application and operating system, and the underlying hardware that provides those resources. A summary of the value of this abstraction layer includes the following:

- Consolidation: VMware technology allows multiple application servers to be consolidated onto one physical server, with little or no decrease in overall performance. For Zebra YMS customers, this can lead to a reduced total cost of ownership (TCO) for running the Yard Tracking and Management System on VMware vSphere virtual machines.
- Ease of Provisioning: VMware virtualization encapsulates an application into an image that can be duplicated or moved, greatly reducing the cost of application provisioning and deployment.
- Manageability: Virtual machines may be moved from server to server with no downtime using VMware vMotion, which simplifies common operations like hardware maintenance and reduces planned downtime.
- Availability: Unplanned downtime can be reduced and higher service levels can be provided to an application. VMware High Availability (HA) ensures that in the case of an unplanned hardware failure, any affected virtual machines are restarted on another host in a VMware cluster.

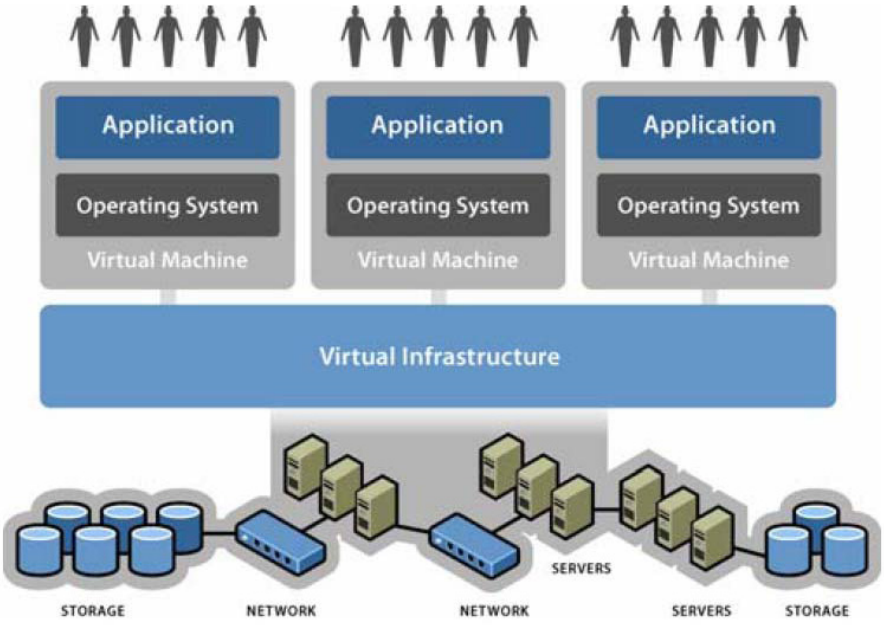

Figure 1. VMware Virtual Infrastructure Solution

Zebra YMS Architecture

Core Zebra Yard Management System (YMS) components include:

- Automatic Yard Inventory – Using the wireless location system, YTMS understands the current location of every tagged trailer and switch tractor, as well as the status of each spot and door. This information is used to optimize the movement of equipment and people within the yard.
- Automatic Door Assignment – Configure rules that select trailers to be pulled to doors when doors become available. Door availability is determined by the location system when RTLS (real time location technology) is used. Rules are configured at the door level. Resulting trailer move requests automatically display on screens inside switch tractors.
- Wireless Switcher Dispatch – Enables wireless communication of trailer move requests to switchers via touch-screen vehicle-mounted terminals. Switchers can map requests, perform trailer inspections, audit yard spots, and complete trailer moves from their on-board computer. Switchers can also receive instant text messages from dispatchers.
- Automatic Parking Assignment – Configure rules that assign yard spots to trailers during check-in and after they are processed at a door. Rules can be configured to minimize driving distance between trailers parked in the yard and the doors that will process them.
- Door Manager – This real-time graphical view of all dock doors shows which doors are empty, which are occupied, which have trailer move requests, which have queued trailers, which rules are associated with doors, trailer damage status, door enabled/disabled status, and trailer age. Queue trailers behind doors that result in automatic trailer move requests when doors become available.
- Saved Reports – Users may create and save their own reports and schedule them to be emailed to one or more recipients. For example, a user may want to create equipment inventory reports and email them to carriers on a daily basis to assist carriers with maintaining proper levels of inventory on site. The system automatically runs and sends the reports as email attachments on days and times that customers specify.
- Check-Out Blocking Rule – Configure rules that prevent trailers from being checked out that should not leave the yard.
- Gate-To-Door Rules – Configure rules that direct selected inbound trailers from the gate to dock doors if the trailers being checked in match the rule criteria for available doors.
- Trailer Inspection – Configure inspection points and assign severities. Prevent specified types of damaged trailers from being pulled to dock doors. Measure the quality of trailers across carriers over time.
- Inbound Scheduling – Create site arrival appointments for inbound expected trailers. Configure time windows for calculating on-time

performance on history reports. Automatically populate trailer check-in forms by pulling information from inbound schedules.

- Outbound Scheduling – Create site departure appointments for outbound expected trailers. Configure time windows for calculating on-time performance on history reports. Automatically populate trailer update forms by pulling information from outbound schedules.
- Easy Dock – Using a stationary or vehicle-mounted touch-screen terminal, dock personnel can quickly view the status of dock doors, change trailer status at doors, and create trailer move requests. Easy Dock can also be extended to include custom plug-in modules such as creating shippers.
- Alerts – Automatically notify key personnel via email when trailers are not where they are supposed to be or if they have remained in a particular status for too long.
- Automatic Pick-up Notification – Configure the system to automatically email carriers when trailers are available for pickup. The system records the notification time and actual pick-up time for each trailer for measuring carrier responsiveness.
- Scheduled Email – Create custom reports and configure the system to automatically send reports to carriers, suppliers, and anyone else on a scheduled basis.
- Vessel Voyage – Assign vessel voyage information to each inbound container to track their origin and process them in FIFO order.
- System Interfaces – The application programming interface (API) allows YTMS and external systems to exchange information. Through the API, external systems are made aware of each inbound and outbound trailer, each trailer that arrives at and departs from a door or spot, each status update, and each schedule change. External systems can also update trailer statuses within YTMS and query any report using the API.
- Directed Task Assignment – YTMS can be configured to optimize the assignment of trailer move requests to switchers based on the locations of available switchers relative to trailers that need to be moved.
- Dynamic Labor Standards – YTMS leverages PathFinder to calculate the length of time required to complete each move request. Expected and actual move times are displayed on reports for productivity comparisons.

Zebra Yard Architecture

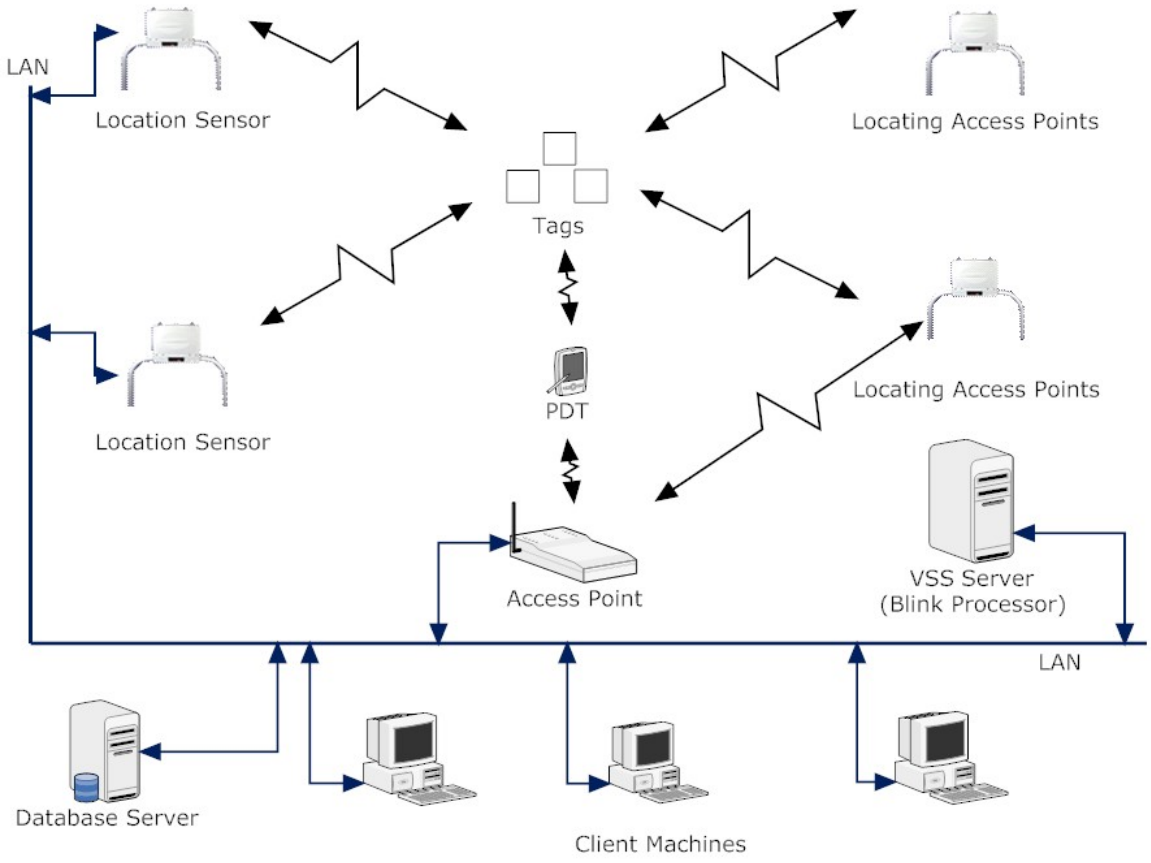

Figure 2. Zebra YMS Architecture

Testing Process and Results

To characterize the performance of the Zebra YMS on VMware vSphere 4, performance tests were carried out jointly by VMware and Zebra. The configuration tested and the results are summarized in the following sections.

Hardware Configuration

Host Servers:

- 1 x HP DL 360 Server running VMware vSphere 4.0 (Build 164009)
- 2 x Quad Intel Xeon L5420 Core 2.5 Ghz CPUs
- 32 GB RAM
- iSCSI HBA cards (HW-based iSCSI initiators)

Storage:

- Network Appliance FAS 3020 with iSCSI protocol over a dedicated 1GB TCP/IP Network with the following LUNs configured on a 28 x 146 GB disk aggregate:
  - 5 x 50 GB LUNs
  - 2 x 100 GB LUNs

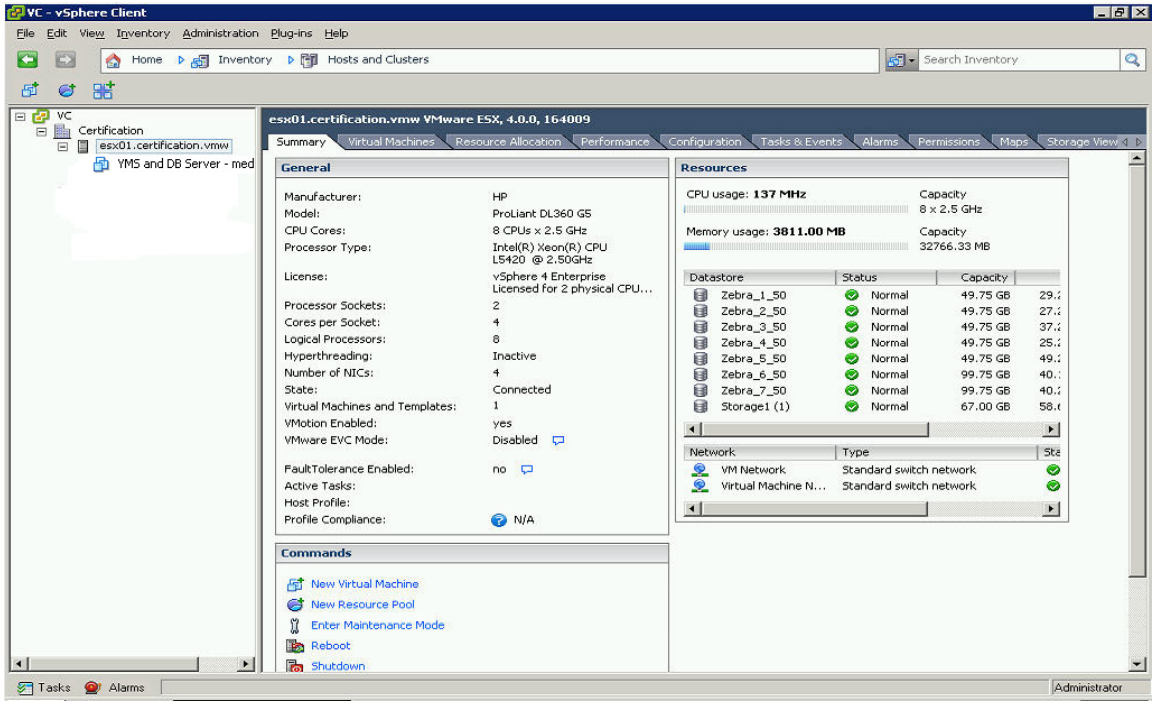

Figure 3. Details of Host ESX01 from VMware vCenter Server 4.0

Virtual Machine Configuration

The following Zebra YMS server configuration was used in medium-size deployment testing:

Configuration 1: YMS Server and DB Server – Windows 2003 Standard Edition – 32 Bit

- 2 vCPU
- 4096 MB RAM
- Connected to 100 GB LUN (20 GB System Disk and 30 GB Data Disk)

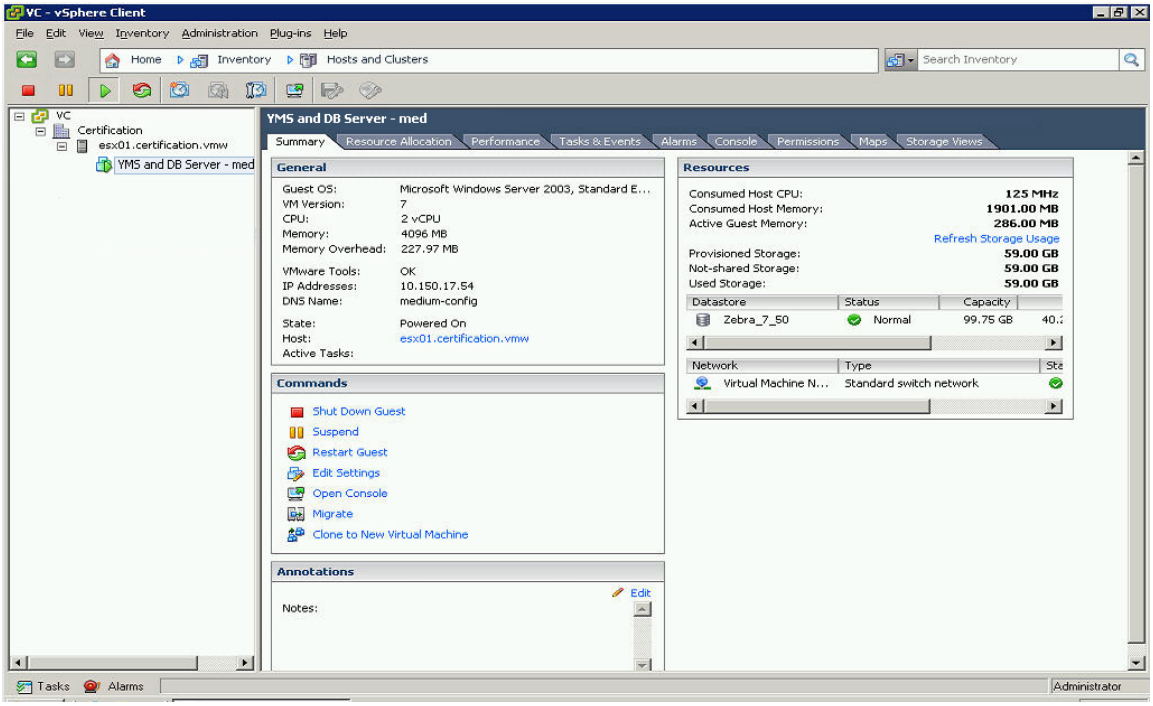

Figure 4 – Details of YMS and DB Server Virtual Machine with 2vCPUs

The following Zebra YMS Server configuration was used in large-size deployment testing:

Configuration 2: YMS Server and DB Server – Windows 2003 Standard Edition – 32 Bit

- 4 vCPU
- 4096 MB RAM
- Connected to 100 GB LUN (20 GB System Disk and 30 GB Data Disk)

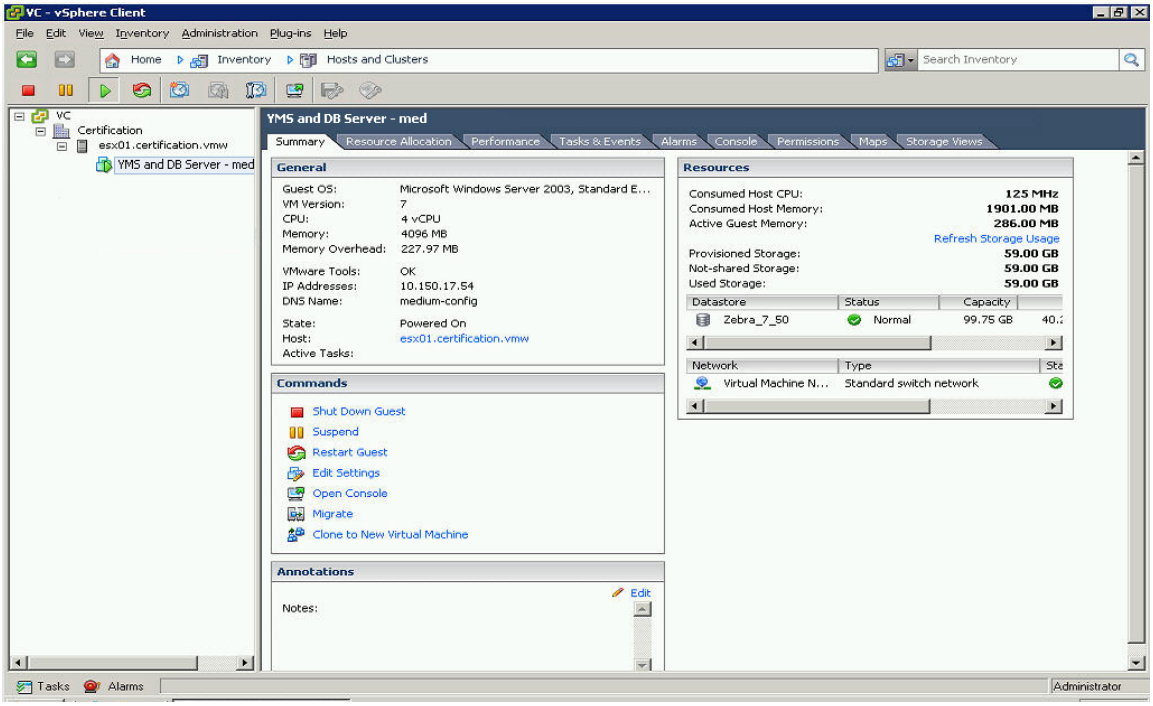

Figure 5. Details of YMS and DB Server Virtual Machine with Four vCPUs

Test Workload Used

Test configurations 1 and 2 supported the same number of YMS transactions and queries, which included 30 concurrent client connections with Resource Manager running multiple queries, Door Manager access and multiple inbound, update, and outbound transactions per client. On average, the YMS load tested was about 1 transaction per second and 5 queries per second. In addition, the tests included over 30 Switcher Dispatch and 30 Easy Dock concurrent connections, each performing move completes and trailer status changes on the average of 1 per second respectively.

In addition to transactions and queries from the YMS client application, configuration 1 was also used to test the “no locates” and “19 locates per second” scenarios. Configuration 2 was also used to test the “25 locates per second” scenario, thus simulating a variety of typical customer workloads.

Results Observed

The recorded response times in the virtual environment are comparable to those observed on native environments and well within threshold limits, without having any significant overhead on the hardware resources.

Three separate tests were performed on the YMS application for different load types: small, medium and large. The three load types Test 1, Test 2, and Test 3 respectively are describe the in detail below.

Test 1 Results

Test 1 focuses on a small sized YMS site with no location data. A small sized site runs on average 1 transaction per second and 1 query per second. The purpose of the test is to validate the VMware configuration for a no locate YMS system.

Table 1. Test Results of No Locate Test

Zebra app/business metric			
Tag State	~2s		
User Resource Status	~2s		
Location History	~2s		
Trailes On Site report	~2s		
Door Manager	all real time events received within 500ms		
30 Switcher Dispatch Responce Time	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
30 Easy Dock Application Response Tir	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
1 API Query Client	see door manager response time		
1 API Update Client	see door manager response time		
Esxtop resource utilization data			
Object: Group Cpu		**Avg**	**MAX**
		VSS and DB server - medium config	VSS and DB server - medium config
	% Ready	0	0
	% Used	30	77
Object: Group Memory			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Active Estimate	10	23
	Memory Size MBytes	4096	4096
	Swapped MBytes	0	0
	Target Size MBytes	2239	2597
	Touched MBytes	670	3809
Object: Network Port			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Outbound Packets Dropped	0	0
	% Received Packets Dropped	0	0
	Packets Received/sec	0	5
	Packets Transmitted/sec	0	6
Object: Physical Cpu			
		_Total	_Total
	% Processor Time	8	20
Object: Physical Disk			
		VSS and DB server - medium config	VSS and DB server - medium config
	Average Driver MilliSec/Command	16	69
	Average Driver MilliSec/Read	2	58
	Average Driver MilliSec/Write	16	69
	Commands/sec	12	591
	Reads/sec	2	372
	Writes/sec	10	459

The table above describes the specific business metrics used within a two hour period. The results show that the CPU and Memory are within design limits for a VMware environment.

Test 2 Results

Test 2 focuses on a medium sized YMS site with location data. A medium sized site runs on average 1 transaction per second and 1 query per second of non location data and 19 locates per second. The purpose of the test is to validate the VMware configuration for a medium sized locate YMS system.

Table 2. Test Results Blink Rate 19

Zebra app/business metric			
Tag State	~2s		
User Resource Status	~2s		
Location History	~2s		
Trailes On Site report	~2s		
Door Manager	all real time events received within 500ms		
30 Switcher Dispatch Responce Time	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
30 Easy Dock Application Response Tir	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
1 API Query Client	see door manager response time		
1 API Update Client	see door manager response time		
Esxtop resource utilization data			
Object: Group Cpu		Avg	MAX
		VSS and DB server - medium config	VSS and DB server - medium config
	% Ready	0	0
	% Used	34	81
Object: Group Memory			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Active Estimate	11	20
	Memory Size MBytes	4096	4096
	Swapped MBytes	0	0
	Target Size MBytes	3016	3096
	Touched MBytes	671	1065
Object: Network Port			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Outbound Packets Dropped	0	0
	% Received Packets Dropped	0	0
	Packets Received/sec	0	6
	Packets Transmitted/sec	0	7
Object: Physical Cpu			
		_Total	_Total
	% Processor Time	9	21
Object: Physical Disk			
		VSS and DB server - medium config	VSS and DB server - medium config
	Average Driver MilliSec/Command	5	37
	Average Driver MilliSec/Read	3	104
	Average Driver MilliSec/Write	5	37
	Commands/sec	33	629
	Reads/sec	2	296
	Writes/sec	32	477

NOTE: The test results are very similar to the small-sized YMS system, indicating that the locate load did not affect average processing time or memory. The location data did affect the maximum processor load and memory; however, the maximum values were still within acceptable VMware limits.

Test 3 Results

Test 3 focuses on a large size YMS site with location data. A large size site runs on average 5 transaction per second and 5 queries per second of non-location data and 25 locates per second. The purpose of the test is to validate the VMware configuration for a large sized locate YMS system.

Table 3. Test Results Blink Rate 25

Zebra app/business metric			
Tag State	~2s		
User Resource Status	~2s		
Location History	~2s		
Trailes On Site report	~2s		
Door Manager	all real time events received within 500ms		
30 Switcher Dispatch Responce Time	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
30 Easy Dock Application Response Tim	this is simulated in the scripts and the real time events were received within 500ms, all queries were within 1s		
1 API Query Client	see door manager response time		
1 API Update Client	see door manager response time		
Esxtop resource utilization data			
Object: Group Cpu		Avg	MAX
		VSS and DB server - medium config	VSS and DB server - medium config
	% Ready	0	1
	% Used	21	67
Object: Group Memory			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Active Estimate	11	20
	Memory Size MBytes	4096	4096
	Swapped MBytes	0	0
	Target Size MBytes	2496	2869
	Touched MBytes	733	3809
Object: Network Port			
		VSS and DB server - medium config	VSS and DB server - medium config
	% Outbound Packets Dropped	0	0
	% Received Packets Dropped	0	0
	Packets Received/sec	0	5
	Packets Transmitted/sec	0	6
Object: Physical Cpu			
		_Total	_Total
	% Processor Time	11	34
Object: Physical Disk			
		VSS and DB server - medium config	VSS and DB server - medium config
	Average Driver MilliSec/Command	2	23
	Average Driver MilliSec/Read	3	79
	Average Driver MilliSec/Write	2	25
	Commands/sec	41	888
	Reads/sec	2	326
	Writes/sec	39	561

The table above describes the specific business metrics used within a two hour period for a large YMS system. The results show that the CPU and Memory are within design limits for a VMware environment. The number of CPUs used was increased for this test compared to the other 2 tests. While the average load was much higher during the two hour test period it is still with the VMware limits.

Deployment Best Practices

Best practices for deploying VMware virtual infrastructure solutions are outlined within the VMware documentation available at:

http://www.vmware.com/support/pubs/.

VMware also offers specific documents on vSphere 4 performance enhancements, networking and storage performance, best practices for VMware VMFS, and resource management with VMware DRS. Here are some additional specific recommendations for VMware virtual infrastructure deployments:

- Make sure that the host server and storage that you will be using to deploy VMware ESX is listed on the VMware *Systems and Storage Hardware Compatibility List (HCL)* available at:

  http://www.vmware.com/resources/compatibility/

- For best performance, it is highly recommended that you run Zebra YMS Server on the latest available version of VMware ESX. For tests described in this document, vSphere 4.0 was used.
- Disconnect unused or unnecessary devices on both guest and host machines, that is, COM ports, LPT ports, floppy drives, CD-ROM drives, and USB adapters. Disabling devices on hosts frees IRQ resources and eliminates IRQ sharing conflicts that can cause performance problems.
- Make sure that you are running the latest version of VMware Tools in the guest operating system of virtual machines.
- Do not set resource reservations and limits unless required. Set the limit as “unlimited”, which is the VMware default setting.
- To establish a network between two virtual machines that reside on the same ESX host, connect both virtual machines to the same virtual switch. If the virtual machines are connected to different virtual switches, traffic will go through “wire” and incur extra unnecessary CPU and network overhead.
- Using a SAN device for storage is recommended to best meet I/O requirements for applications and also leverage all VMware virtual infrastructure features and capabilities. Using iSCSI or NFS, respectively, provide the next best storage performance. If Zebra VSS is deployed onto an iSCSI array or NFS server, VMware recommends you have at least a 1 Gbps connection. If local disks must be used, VMware recommends placing the VMware ESX operating system on disks separate from the VMFS file system where the virtual machines reside.
- When provisioning disks, use the “eager zero thick disk” setting for better performance. (Data blocks are cleared (zeroed) out when the virtual disks are created.) Even though it may take longer to initially create the virtual disks, this formatting method is preferred for file, database or messaging servers, as it does not suffer the subsequent performance penalty as with ZeroedThick disks. Note that EagerZeroedThick virtual disks can only be

created from the ESX console using the vmkfstools –d eagerzeroedthick command.

- Use separate vSwitches (and consequently separate physical network adapters) to avoid contention between service console, VMkernel, and virtual machines, and between virtual machines running heavy networking workloads.
- Ensure that heavily-used virtual machines do not all access the same VMFS volume concurrently and that they are spread across multiple VMFS volumes. (Typically a VMFS volume will span a single LUN, but this is not always true.) When a large number of virtual machines access the same VMFS volume concurrently, heavy SAN I/O loads can cause poor disk performance.
- Follow best practices for partition alignment of the VMFS volumes and NTFS formatted VMDK disks as described in the following document:

  http://www.vmware.com/pdf/esx3_partition_align.pdf

Licensing

A customer may use Zebra YMS for their internal use solely for the number of "sites" for which they have paid the applicable license fee.

Note: A "site" is defined as a Zebra system consisting of a single instance of Yard per physical customer location. A Yard instance may be installed on a dedicated server, or on a virtual machine, within a hypervisor environment.

Technical Support

Zebra offers standard and enhanced support programs based on customer needs. Both programs include support for Zebra applications deployed in virtual environments. Zebra operates regional support offices in several countries, each of which has its own contact information as specified in the Zebra Customer Support Handbook. Contact information is available online at www.zebra.com/zes, click on Support Login and go to the "Regional Support tab".

Conclusions

As our test results show, you can successfully virtualize Zebra YMS using VMware vSphere 4, and maintain good performance. The majority of Zebra YMS deployments are good candidates for virtualization and can benefit from the many additional features offered by a virtualized infrastructure — such as improved management, availability, and scalability — thus reducing overall TCO.

VMware virtual infrastructure makes it simpler and less expensive to provide higher levels of availability for Visibility Server Software (VSS). Taking advantage of key VMware virtual infrastructure features as vMotion, VMware DRS, and VMware HA, you can eliminate planned downtime, reduce unplanned downtime, and recover rapidly from component or system outages.

To deploy Zebra YMS successfully on VMware virtual infrastructure, you should first clearly understand your organization's needs and operational requirements — both business and technical, for implementing Zebra YMS. It is also critical that you follow best practice guidelines specific to Zebra YMS as well as those applicable to VMware virtual infrastructure. In general, best practices for physical environments also apply to deployments on VMware virtual infrastructure.

Resources

Customers can find more information about VMware and Zebra YMS products via the links listed below:

- VMware official Web site:

  http://www.vmware.com/

- Zebra Enterprise Solutions Web site:

  http://zes.zebra.com/index.jsp

- Zebra Yard Management Solutions

  http://zes.zebra.com/products/application-software-solutions/manufacturing-operations/yard-tracking-management.jsp

- VMware Infrastructure 3 and vSphere 4 Product Web site:

  http://www.vmware.com/products/data_center.html

- VMware download Web site:

  https://www.vmware.com/download/

- VMware support Web site:

  http://www.vmware.com/vmtn/

- What's new in VMware vSphere 4 Performance Enhancements:

  http://www.vmware.com/files/pdf/vsphere_performance_wp.pdf

- System Compatibility Guide for a complete list of compatible hardware:

  http://www.vmware.com/resources/compatibility/pdf/vi_systems_guide.pdf

- Storage/SAN Compatibility Guide for a complete list of compatible storage devices:

  http://www.vmware.com/resources/compatibility/pdf/vi_san_guide.pdf

- I/O Compatibility Guide for a complete list of compatible networking devices:

  http://www.vmware.com/resources/compatibility/pdf/vi_io_guide.pdf .

Appendix A. Typical Deployment Architecture

This appendix provides information regarding typical deployment architectures for physical deployment of the Zebra YMS application. Testing method used was to simulate load by replaying actual transaction and query from production sites.

Zebra YMS Customer Sizes: Small, Medium and Large

The size of a Zebra YMS system is typically determined by the settings of the following parameters:

- Blink Rate: This is the number of incoming tag blinks (network packets) per second that the Zebra DA and DB services have to be able to process. The processed packets are then sent to the database for further processing and storage. The Blink Rate will have an impact in the amount of CPU used by the DA service and the database.

  Note: Zebra DA is a module that runs as a Windows service. It filters and adds additional information (such as zone names) to blink packets before sending them downstream to the database.

  The Zebra DB is Microsoft SQL 2005 and in Zebra YMS solutions contains all application business logic for the Zebra YMS.

- Number of Tagged Trailers: This is the number of different tag ID's and Trailers stored in the database. Large number of tags and trailer in the database may impact the response time of some reports in Resource Manager (client app to view and filter database data), may lead to intermittent locking of database tables, and may affect the number of blinks persecond that the DA service and the database are able to process.

  Note: The DA service will process and send blinks to the database only as fast as the database is able to consume them. The database, and not the DA service, is typically the bottleneck that limits the rate of blink processing due to application business logic for the Zebra YMS.

- Tag and Trailer History: This is the amount of history stored in the database. Tag location and other trailer information changes are stored in the database table. This can have the most severe effect on performance. Large amounts of data in TBT_LocHist will impact the response time of some reports in Resource Manager, lead to intermittent locking of database tables, and affect the number of blinks per second that the DA service and the database are able to processs.

- Rate of Database Queries and Trailer Transactions: This is the number of queries and transactions per second run against the Zebra YMS database that originate from refreshing reports in Resource Manager, Switcher Dispatch and Easy Dock clients, and from queries placed through the YMS API. Generally speaking, the YMS database was designed to support about two queries per second and two transactions per second. An excessive number of queries will significantly increase SQL Server CPU usage, lead to the locking up of database tables, increase response times, and decrease

the number of blinks per second that the DA service and the database can process. These transactions include Inbound, Outbound, and Update Trailer transactions.

The following table defines small, medium, and large YMS systems based on settings of the three parameters described above.

Table 4. Small, Medium, and Large YMS System Workloads

Site Size	Blink Rate (blinks/sec)	# of Tags/Trailers (# of records in TBT_Tag)	Tag/Trailer History (# of records)	Rate of db Queries/Tx (queries/s)
Small	0	0 - 1000	0 – 10000	0 – 0.1
Medium	10-50	1000 - 5000	10000 - 100000	0.1 – 0.5
Large	50-200	5000 - 50000	100000 – 500000	0.5 – 5

Zebra YMS Server Deployments

Zebra YMS servers are deployed in either a single tier or two-tier configuration:

- Single tier configuration: YMS Services and YMS Database running on a single server
- Two tier configuration: YMS Services and YMS Database running on separate servers

The table below shows typical server size and deployment for different sites sizes.

Table 5. Server Deployment Configurations

Site Size	Tier	Minimum Server Specification
Small	Single	2 GHz, 2 GB RAM, 20 GB disk
Medium	Single	Dual CPU, 2 GHz, 4 GB RM, 40 GB disk
Large	Two-tier	YMS server: 4 CPU, 2 GHz, 4 GB RAM, 40 GB disk DB server: Quad CPU, 2 GHz, 4 GB, 40 GB disk

OS and Database Servers

Operating systems supported include:

- Microsoft Windows 2000, Windows 2003

Database servers supported include:

- Microsoft SQL Server 2000, SQL Server 2005

Test Workloads for Small, Medium, and Large Sites

Test workloads corresponding to a small, medium, and large site are shown in Table 6.

Table 6. Small, Medium, and Large Site Workloads

Workload	Blink Rate (blinks/sec)	# of Tags (# of records in TBT_Tag)	Tag/Trailer History	Rate of DB Queries (queries/sec)	Rate of DB Tx (queries/sec)
Small	0	0	5000	0.1	0.1
Medium	30	3000	50000	0.3	0.3
Large	100	30000	300000	3	3

- Prior to testing, the Blink Sender tool is used to populate the TBT_Tag and TBT_LocHist tables to the desired level. This tool generates a stream of tag blinks and sends them to the DA service across the network.
- During testing, the Blink Sender tool is used to send tag blinks to the DA service at the required rate.
- Queries are generated using the "30 Resource Manager" client application in auto-refresh mode, 30 Switcher Dispatch clients, 30 Easy Dock Clients, and one API client. The report to be auto-refreshed is the User Resource Status report.
- Transactions can be executed by Resource Server replay or the Zebra YMS DB replay tool.
- The Blink Rate listed in Table 6 is the blink rate generated by the Blink Sender tool. Testing will determine whether the DA service and the database can actually handle the load from specified blink rates.

Measuring Performance

Parameters to Be Measured

System performance is evaluated by measuring the following parameters:

- Processed Blink Rate: As indicated in the previous section, the Blink Sender tool is used to send a stream of tag blinks to the DA accross the network at the rate required in a specific workload or test case. (See Table 3.) However, the DA and the database may or may not be able to process all the blinks coming in, in which case blinks will be "dropped" or lost at the input of the DA service, once the DA input buffer gets full. Given that the DA will process and send blinks to the database only as fast as the database can consume or process those blinks, the blink rate being processed by the DA service is the same as the blink rate being processed by the database. The actual blink rate being processed by the DA is measured using the WT Meter tool.

- DA CPU usage: The amount of CPU used by the DA service is measured using Window's Task Manager or Performance Monitor.
- SQL Server CPU usage: The amount of CPU used by SQL Server is measured using Window's Task Manager or Performance Monitor.
- DA Memory usage: The amount of memory used by the DA service is measured using Window's Task Manager or Performance Monitor.
- SQL Server Memory usage: The amount of memory used by SQL Server is measured using Window's Task Manager or Performance Monitor.
- 30 Resource Manager Client Response Time: The time required to refresh the following reports in Resource Manager is measured: Tag State, User Resource Status, Location History, Trailers On Site report, and Door Manager
- 30 Switcher Dispatch Responce Time: The time required to receive move request updates.
- 30 Easy Dock Application Response Time: The time required to receive dock door update information such as door is occupied, trailer is being pulled, etc.
- One API Query Client: Using the WhereSoft Yard API to query the Trailers On Site report
- One API Update Client: Using the WhereSoft Yard API to update a trailer in the Yard

Test Results for Small, Medium, and Large Sites

Typical results obtained for testing of physical servers for the workloads or test cases listed in Table 6, using the server deployments indicated in Table 7, are provided in the following table.

Table 7. Physical Server Test Results

Workload	Processed Blink Rate (blinks/sec)	DA CPU/Mem Usage	SQL CPU/Mem Usage	Response Times (sec)
Small	100% of incoming flow (5 blinks/sec)	CPU < 5% Mem < 0.1 GB	CPU < 20% Mem < 0.5 GB	Tag State < 3 sec User Resource St. < 3 sec Location History < 3 sec
Medium	100% of incoming flow (30 blinks/sec)	CPU < 5% Mem < 0.1 GB	CPU < 30% Mem < 0.5 GB	Tag State < 3 sec User Resource St. < 3 sec Location History < 3 sec
Large	100% of incoming flow (30 blinks/sec)	CPU < 5% Mem < 0.1 GB	CPU < 50% Mem < 0.5 GB	Trailers On Site < 15 sec Location History < 5 sec History Reports < 5 sec

Typical results from testing of VMware Workstation virtual servers for the workloads or test cases listed in Table 6, using the server deployment configurations indicated in Table 5, are provided in the following table.

Table 8. VMware vSphere Server Test Results

Workload	Processed Blink Rate (blinks/sec)	DA CPU/Mem Usage	SQL CPU/Mem Usage	Response Times (sec)
Small	100% of incoming flow (5 blinks/sec)	CPU < 5% Mem < 0.1 GB	CPU < 20% Mem < 0.5 GB	Tag State < 3 sec User Resource St. < 3 sec Location History < 3 sec
Medium	100% of incoming flow (30 blinks/sec)	CPU < 5% Mem < 0.1 GB	* (see comment below table)	* (see comment below table)
Large	100% of incoming flow (30 blinks/sec)	CPU < 5% Mem < 0.1 GB	* (see comment below table)	* (see comment below table)

* While the measurments often coincided with those on a physical server, occasionally SQL Server used large amounts of CPU for long periods of time for unexplained reasons, leading to unacceptable performance.

Typical results obtained for testing on VMware ESX 3.5 virtual servers, for the workloads or test cases in Table 6, and using the server deployment sizes indicated in Table 5, are as follows:

Table 9. Workload Test Results

Workload	Processed Blink Rate (blinks/sec)	DA CPU/Mem Usage	SQL CPU/Mem Usage	Response Times (sec)
Small	100% of incoming flow (5 blinks/sec)	CPU < 5% Mem < 0.1 GB	CPU < 20% Mem < 0.5 GB	Tag State < 3 sec User Resource St. < 3 sec Location History < 3 sec
Medium	Not measured yet	Not measured yet	Not measured yet	Not measured yet
Large	Not measured yet	Not measured yet	Not measured yet	Not measured yet