White Paper

Recording Server Virtualization

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Introduction

Founded on a vision of using IP technology for video surveillance, Milestone Systems developed and introduced the first open platform IP video management software (VMS) in the world. Today, as the global industry leader in open platform IP VMS, the company continues to make new advancements in IP video management software for video surveillance and video enabling business processes.

Saving money is of interest to any organization implementing video surveillance. One way to reduce costs in a video surveillance system is to increase the number of cameras that can be handled by a recording server. Such servers can be expensive to buy and operate. In recent years, more and more organizations have optimized server costs through virtualization. Virtualization is the partitioning of a server into multiple “virtual” servers (also known as virtual machines or VMs). This gives each virtual server the appearance and capabilities of running as a full-fledged server, essentially turning one server into many.

Until recently, virtualization wasn't recommended for recording servers. These servers process all the incoming video from cameras and then stream that video on demand to clients. This is a high resource-demanding service that puts a considerable load on a server's CPU, memory, network, and storage system.

Recent advances in server technology (such as multi-core processors) now enable the purchase of commercial-off-the-shelf (COTS) servers that are powerful enough to perform as multiple recording servers through platform virtualization. By consolidating what would normally be the workloads of many recording servers onto a single physical machine, virtualization can enable organizations to do more with less hardware and help them reduce energy, software, and IT administrative costs.

Milestone Systems XProtect® Corporate video management software is an ideal VMS product for larger surveillance system installations requiring the kind of high scalability that calls for the use of virtualized recording servers. This powerful, IP video management software is designed for large-scale, multi-site installations and can support an unlimited number of cameras, users and sites. XProtect Corporate’s powerful distributed server architecture is well suited to virtualization and scaling to keep up with an organization's growth.
Target audience and white paper purpose

The primary audience for this white paper is surveillance system architects/designers, and large scale surveillance project consultants, as well as companies, organizations, universities, and governments with large scale surveillance projects/installations.

The purpose of this white paper is to provide the results of a test demonstration of the performance and effectiveness of running the Milestone XProtect Corporate platform in a virtual environment on an advanced IBM server platform. The white paper assumes the reader has a general understanding of virtualization and large scale, IP video surveillance systems and VMS solutions such as Milestone XProtect Corporate.

Test objectives

The goal of this demonstration was to validate the Milestone XProtect Corporate v3.1 platform’s performance running in a virtual environment on an IBM System x3850 X5 server platform. Primary performance metrics measured include CPU, RAM and virtual memory consumption per each virtual machine and at the hardware layer.

Since storage performance capabilities are well known and predictable in a Milestone Corporate environment, this study placed less emphasis on testing this component. It was measured and monitored though to ensure no bottlenecks imposed negative results on other areas of testing.

Test environment

The test setup consisted of a single IBM System x3850 X5 with 5 IBM blade servers (4 of which were to be used for running camera emulations), plus an IBM DS5300 Storage Area Network (SAN), an IBM DS4800 SAN, a 10Gb Ethernet switch and an 8GB Fibre Channel switch. IBM System x3850 X5 workload-optimized systems are turnkey solutions configured for high-performing database or virtualization environments. The x3850 X5 server allows freedom of choice with extremely flexible configurations, plus memory expansion capabilities. A modular building block design enables customization for current needs while providing the ability to react to changing workloads.

Physical and Logical Equipment Configurations

- IBM System x3850 X5
- 4 CPU sockets populated with Intel® Xeon® x7560 8-Core 2.27GHz processors for a total of 32 processor cores
- 262GB RAM
- 1Gb Ethernet connection
• Dual 8GB Fibre Channel connections

Software Configuration
• VMware ESXi v4.1 running 14 virtual machines (VMware ESX is a “bare-metal” hypervisor architecture, meaning it installs directly on top of the physical server and partitions it into multiple virtual machines that can run simultaneously, sharing the physical resources of the underlying server. Each virtual machine represents a complete system, with processors, memory, networking, storage and BIOS, and can run an unmodified operating system and applications.)
• Each VM running Microsoft® Windows® Server 2008 Standard R2 x64 with Milestone XProtect Corporate v3.1 Recording Server installed with a single recording service instance

IBM Blade Center
• 5 blade servers of various capacities (4 of which were for running camera emulations) and 10gbps Ethernet

Software Configuration for IBM Blade Center
• VMware ESXi v4.1 installed on all servers
• Four blades configured with 4 virtual servers each for a total of 16 virtual servers, all running Windows Server Standard 2008 R2 x64 and Axis Virtual Camera 3
• Each server loaded with 2 unique H.264 video files and 4 unique MJPEG files
• Fifth blade server running only a single virtual server loaded with Windows Server Standard 2008 R2 x64 and Milestone XProtect Corporate v3.1 Management Server with SQL Server Express 2005 for configuration and logging databases

IBM DS5300 SAN
• Configured with 4 physical arrays
• Three 16-drive arrays configured for RAID 0 with 16 15K 146GB Fibre Channel drives with 2.13TB usable capacity each
• One 16-drive array configured for RAID 0 with 16 15K 73GB Fibre Channel drives for 950GB usable capacity

IBM DS4800 SAN
• 2TB usable capacity
• Dedicated for virtual machine boot volumes to ensure availability of all resources on the DS5300 for video recording
Test procedure

The primary goal of this test was to validate the total number of cameras that could be run on a single server platform with a high degree of total stability in a test environment closely replicating a production system.

One of the most challenging components of video surveillance system testing is delivering a stable simulation of video images with a consistent frame rate at various resolution and codec settings and with a varying degree of image complexity. To accomplish this, we used a total of 16 virtual servers each running the Axis Virtual Camera 3 emulation software. Each virtual server was able to deliver up to 2 unique H.264 video streams and 4 unique MJPEG video streams simultaneously. The video files were NOT shared across the virtual cameras, so each video was effectively a unique video input with non-synchronized bitrate patterns (for cameras that were not started at the same time). This allowed us to feed each of the virtual recording servers with large numbers of video streams from these 16 virtual server and maintain a pretense of uniqueness.

The recording servers were programmed to request up to a total of 80 virtual camera streams from the virtual camera servers (configured as 5 streams per virtual camera server). This ensured a delivery of at least 32 unique video streams to each recording server when testing h.264, and 64 unique video streams for MJPEG tests. Combining this with camera groups and rules, it was possible to achieve a high rate of seemingly unique video streams by varying the start times of each stream and thereby leveling the overall bitrate patterns as would be seen in a full production installation.

The virtual recording servers were assigned storage volumes of 256GB. In this instance, VMware had been installed using a 4KB cluster size which restricted the total volume capacities to this 256GB level. Each of the three 2.1TB volumes were presented to four virtual recording servers total and covered the capacity for virtual recording servers 1-12. Virtual recording server 13 and 14 were each presented with storage from the 950GB array. Some issues with disk I/O were realized due to this configuration which minimized the testing capabilities (primarily with H.264). The details of this limitation and recommendations for a production environment can be viewed in the summary at the conclusion of this paper.

The environment was capable of testing a total of 1,120 cameras (80 virtual cameras assigned to each of the 14 servers) though the testing did not go this high. Instead, more focus was placed on testing varying frame rates and resolutions at fixed quantities to determine the predictability of system scaling. Given the limited amount of time the equipment was available, the bulk of the testing focused on 640x480 (VGA) resolutions, with additional time dedicated to 1280x800 (1 megapixel) resolutions for comparison purposes and to better understand the impact of resolution in system scaling.

It was also important to test the additional CPU load placed on the system when using Video Motion Detection (VMD). Some environments (e.g., a casino) may not benefit from...
VMD due to the high percentage of motion and requirements to record 100% of the images. Other applications (such as those that only need to record intrusions or other action-based activities) save considerable amounts of storage space through the use of VMD.

The following diagram illustrates the test setup.
Results

All test results (with exception of virtual memory) listed here refer to the actual hardware we were testing. Test results were extracted from the reporting statistics available through the VMware vSphere Client. Virtual guest OS resource utilization was also monitored to ensure there were no bottlenecks present and to record if there were any errors that were related to potential lost media.

The first test consisted of all cameras running H.264, 640x480 resolution with frame rates of 5, 15 and 30 frames per second (FPS). All tests were first run with motion detection turned on and then again with the motion detection settings turned off. The 5 FPS test consisted of only a single run of 832 cameras, while the 15 and 30 FPS tests measured various camera counts scaling from 416 to 832 devices.

**FPS comparison with VMD enabled**

The following graphs show the results from the 15 and 30 FPS tests at various camera quantities and with video motion detection enabled. The single 5 FPS test is also represented at the 832 camera count.
FPS comparison with VMD disabled

The next set of results compare the above data with test data when the video motion detection is disabled. Disk I/O loads remained mostly unchanged and so those results are not provided here.
Resolution comparison with VMD enabled

Several samples recording in 1280x800 resolution were gathered, but not to the extent of the testing done with VGA resolutions. The primary goal with these tests was to record sample data points that could then be used to better understand the overhead requirement difference between the two resolutions. Below are results comparing data between the two resolution recording in H.264 with video motion detection enabled.

| CPU Utilization Comparison - 640x480 compared to 1280x800 - h.264 - VMD On |
|-----------------------------|-----------------------------|
|                            | 416 - 15 FPS                |
|                            | 832 - 5 FPS                 |
| 640x480                    | 60%                         |
| 1280x800                   | 40%                         |

| RAM Comparison - 640x480 compared to 1280x800 - h.264 - VMD On |
|-----------------------------|-----------------------------|
|                            | 416 - 15 FPS                |
|                            | 832 - 5 FPS                 |
| 640x480                    | 10 GB/Sec                   |
| 1280x800                   | 5 GB/Sec                    |

| Virtual Memory Comparison - 640x480 compared to 1280x800 - h.264 - VMD On |
|-----------------------------|-----------------------------|
|                            | 416 - 15 FPS                |
|                            | 832 - 5 FPS                 |
| 640x480                    | 1.5 GB/Sec                  |
| 1280x800                   | 1 GB/Sec                    |

| Disk Throughput Comparison - 640x480 compared to 1280x800 - h.264 |
|-----------------------------|-----------------------------|
|                            | 416 - 15 FPS                |
|                            | 832 - 5 FPS                 |
| 640x480                    | 140 MB/Sec                  |
| 1280x800                   | 40 MB/Sec                   |
Resolution comparison with VMD disabled

Several samples comparing recording in 1280x800 and 640x480 resolution with VMD disabled were also gathered. The goal with these tests was to record sample data points to compare overhead requirement differences between the two resolutions when video motion detection is not in use.
Conclusions

In a traditional Milestone XProtect Corporate environment, the recording server runs as a 32-bit Windows application and is limited in the amount of memory resources it can use. With XProtect Corporate, it is possible to run multiple instances of the recording server service without the use of third-party virtualization technologies and gain better utilization of the underlying hardware, particularly increased utilization of memory resources. While this is an effective way to run many cameras on a given system, this presents some design challenges, specifically since there is no complementary solution to accommodate multiple recording server instances on a failover server. This makes the use of multiple recording service instances only a partially effective solution.

Running XProtect Corporate in a VMware virtual environment solves this failover issue by allowing a one-to-one relationship of failover and recording servers, plus has many other advantages, particularly in regards to the underlying control of memory and CPU resources. For example, when comparing guest OS memory utilization with host server memory utilization, the totals do not add up. In all the tests, the guest OS memory utilization never went above 2.2GB, yet the total memory utilization of VMware in that particular test was 42GB. This is significantly higher than the 30.8GB you would assume with 14 guest OS's running at 2.2GB. In this case, VMware was able to allocate additional memory resources to drive higher memory bandwidth to the processor cores thereby fully taking advantage of CPU resources. Assuming that we were running several recording service instances directly on the host under Windows, it is likely that we would have seen underused memory resources and a lower total camera count at the top end.

In addition, for installations with a single server, most customers would usually not be comfortable running with higher than 50-60% average CPU utilization. They would want to ensure the system has the overhead to accommodate workload spikes that might drive processor utilization higher. In the virtual environment, because the load is distributed across many CPUs equally, it can more comfortably run at a higher overall average processor utilization without concern of such spikes overwhelming the system. In this environment, average CPU utilizations of 70-75% may be comfortable because of the sheer number of processor cores available and how the load is distributed. The test results show a very consistent processor utilization across all tests with only a 5-8% difference between minimum and maximum processor utilization.

Conclusions can also be drawn that the CPU resources scale in a fairly linear fashion as the frame rates are increased. With video motion detection enabled, there is a significant processing requirement to accommodate the video decode.
Virtual memory resource utilization is also an important aspect to deploying a stable video recording environment. Because the Milestone XProtect Corporate software on the recording server is a 32-bit application, the recording service is only capable of addressing 4GB of virtual memory on a 64-bit Windows OS and is limited to 2GB on a 32-bit OS. The conclusion from these tests indicate that the primary drivers for virtual memory utilization are the number of enabled devices, the resolution of these devices, and the codec used. Codec and resolution are the more important factors. Enabling and disabling video motion detection and increases in frame rates had a negligible effect. The highest virtual memory utilization (2.1GB) was recorded while running a total of 832 cameras at 1280x800 resolution at 5 frames per second. This equates to 64 cameras per recording server and would be above the acceptable range for a 32-bit OS but well within the capabilities of a 64-bit operating system.

It should be noted that, although not published in this paper, some comparison benchmark testing was done using MJPEG. When video motion detection was enabled, the CPU utilization percentage was almost identical to comparable camera quantities and resolution in H.264, although the virtual memory consumption was significantly less. The conclusion is that while MJPEG takes less processing power to decode for VMD, it takes considerably more processing power to move the data due to the size of images. Disabling VMD setting has a much more profound impact on the reduction of CPU resources with H.264 than it does with MJPEG.

**Suggestions for a production environment**

The ideal production environment would present each server with its own physical disk array, thereby minimizing the impact of latency in random I/O that is generated by sharing each of the disk arrays between multiple servers. Multiple disk arrays with lower capacities would be recommended for the live database in a production environment to lessen the impact of random I/O, reduce the resulting disk latency, and thus improve disk throughput capacities.

VMware is currently limited to presenting guest operating systems with a maximum LUN size of 1.9TB if the storage is either direct attached or attached via Fibre Channel. In environments of this size, several 1.9TB Windows volumes will have to be configured to accommodate video archiving, making the setup and management of the system much more complex. Using either an iSCSI or NAS target attached directly to the Windows guest will help in mitigating this since Windows is capable of addressing much larger than 2TB volumes. This will significantly decrease setup time and management complexity.

Combining XProtect Corporate with VMWare features such as VMotion and High Availability will provide more options for zero downtime maintenance and quick recovery from catastrophic hardware failure, while providing best utilization of the attached SAN storage.

**Note on Milestone® XProtect® Corporate 4.0**
At the time of testing XProtect Corporate 3.1b was the most current release available. Since the conclusion of this test and prior to release of this white paper, Milestone released XProtect Corporate 4.0. Based on preliminary test results from XProtect Corporate 4.0, the overall concepts and results presented here will also apply to the current release. It should be noted however that efficiency and performance improvements made to the Video Motion Detection engine and video database would likely further improve the results reported in this paper.
About Milestone Systems

Founded in 1998, Milestone Systems is the global industry leader in true open platform IP video management software. The XProtect™ platform delivers powerful surveillance that is easy to manage, reliable and proven in thousands of customer installations around the world. With support for the widest choice in network hardware and integration with other systems, XProtect provides best-of-breed solutions to ‘video enable’ organizations – reducing costs, optimizing processes, protecting people and assets. Milestone software is sold through authorized and certified partners. For more information please visit www.milestonesys.com

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