Cerner SkyVue
Cardiology Remote Review with NVIDIA and VMware Horizon

Stuart Jackson
Sr. Technology Architect
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Health care is too important to stay the same.
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Cardiology Diagnostic Imaging
Cardiology Diagnostic Imaging
Framework
Workflow Challenges

- Physicians are looking for ways to do things remotely.
- Hospitals may have physicians that refer patients from their offices to the facility. Once the patient is done, rather than sending the film to the referring physician, the referring physician can view the data through the Horizon View client from a remote office without the need for a high end graphics workstation and having to install and manage code updates to their devices.
- Physicians who are on call need the ability to access image data without having to be physically at the facility.
- The same challenges exist in radiology imaging. In some types of procedures in radiology like Mammo and Chest or bone XRay, the graphic display requirement is more strict as lesions, bone fracture can be as fine as a thread of human hair. Here the display needs to be at least 2K and higher to see the details. This makes it harder to do remote review where the high end monitors are not available.
Workflow Requirements

• In cardiology, being able to see the blood flow through the veins, and arteries in smooth motion is important to identify blockage.

• Seeing the heart function and be able to measure the ejection fraction from the chamber allowing the physician to understand the condition of the patient’s heart.

• In cases where blockage is identified and a graft is put in place to fix the problem area, the physician will acquire images to see the result of the blood flow. All of these workflows require the cine rate to be performant allowing for smooth cine.
Testing Overview

- Performed at the Dell Solution Center in Round Rock, Texas.
- Subject matter experts were provided by Cerner and Dell, covering various areas including desktop virtualization, high performance graphics card technology and clinical imaging.
- Dell provided all hardware, including servers, workstations, WYSE zero-clients and network infrastructure.
- Cerner provided a CareAware Multimedia PACS Archive, staged with several anonymized cardiology data sets, and the SkyVue Cardiology workstation software.
- VMWare Group policy configurations were applied to enable build to lossless images and to optimize the image quality and frame rates.
- Each virtual desktop was staged with the Cerner SkyVue Cardiology workstation software installed by Cerner resources.
- The CareAware Multimedia PACS Archive was deployed on the same local network as the virtual infrastructure environment hosting the virtual desktops.
Testing Overview

- Initial testing was done with no network restrictions on 1 Gigabit connections.
- Cerner SkyVue was launched and various image types were retrieved and displayed from the image archive, including echocardiogram studies (ultrasound) and cardiac catheterization (X-ray Angiography).
- The amount of time it took for the thumbnail bar to populate, image viewports to populate and the beginning of the cine playing were noted as performance indicators.
- Cine was stopped on several multi-frame images and the frames were manually cycled through at a high rate to ensure scrolling was smooth and no frames were skipped.
- Echocardiogram studies were displayed in a 2x2 viewport layout. Sets of 4 images were cycled through rapidly to note the speed at which the viewports populated and began to cine as well as how quickly the thumbnails were displayed in the thumbnail bar.
- Cardiac catheterization studies were viewed in a 1x1 viewport layout.
- Image thumbnails were dragged from the thumbnail bar down to the viewport to note how quickly the image populated in the viewport and cine began to play on the multi-frame images. In both cases, the fluency of the images when in cine mode was noted.
Testing Overview

- The number of CPU cores allocated to each virtual machine was varied to find the most economical configuration.
- Various graphics card configurations using NVIDIA Grid K1 and K2 cards were tested.
- Pass-through configurations of both cards where an entire GPU was allocated to a virtual desktop were tested, as well as various NVIDIA vGPU profiles which allocated physical GPU shares and frame buffer shares.
- The amount of memory allocated to the desktop was consistent at 16 GB for all testing scenarios, set to the Cerner defined standard for SkyVue Cardiology physical workstations.
- Once an optimal virtual desktop configuration was determined, the network characteristics were modified using a hardware WAN emulator. Bandwidth was tested by decreasing available bandwidth incrementally until performance was no longer acceptable.
- Latency and packet loss were tested by increasing the values incrementally to identify the maximum values that still delivered acceptable performance. Acceptable performance was defined by the following factors:
  - The thumbnail bar and viewports populate in a speed consistent with a physical workstation installation of the software
  - Cine loops play smoothly, even on the first pass as the images are rendering
  - Viewports populate an image within 1 second of the thumbnail being dragged from the thumbnail bar to the viewport. If the image is multi-frame, the cine begins to play immediately and consistently.
Testing Network Configuration

vSphere 6.0

VMware Horizon VIEW Connection Broker

Dell 10 Gbe Switch

Dell 1 Gbe Switch

Apposite WAN Emulator

Dell Wyse Zero/Thin Clients

Cerner CareAware Multimedia Archive Server
Testing Scenarios

- **GPU**
  - **GPU Pass-through Configuration**
    - Using a dedicated GPU pass-through configuration per virtual desktop provided acceptable performance. Dedicated GPUs per virtual desktop provided the lowest density of virtual desktops per host server. There was also no observable performance gain for SkyVue Cardiology using this configuration.

- **vGPU Configuration**
  - Using a vGPU configuration allows multiple virtual desktops to share a single physical GPU, providing the highest density of virtual desktops per host server. Several profile configurations were available to choose from.

- **140Q Profile (Recommended)**
  - The K1 K140Q profile allowed for each GPU to support 4 virtual desktops and provided a 1024 MB frame buffer per desktop. Our testing revealed acceptable performance using this profile. This allowed for 16 users per NVIDIA GRID K1 card. With two cards per server a density of 32 virtual desktops per host is possible.
Testing Scenarios

- **vCPU**
  - We tested 4 different vCPU configurations to determine optimal configuration.
  - The 6 vCPU and 8 vCPU configurations provided acceptable performance. There was no observable performance difference between 6, 8 or 12 vCPU's. The recommended configuration is 6 vCPU's from a single physical core.

- **Network Configuration**
  - The network configuration supported gigabit connections. Bandwidth, latency and packet loss characteristics were modified using the Apposite WAN Emulator to determine acceptable performance thresholds for Cerner SkyVue Cardiology. These metrics were measured from the endpoint to the virtual desktop session running the Cerner SkyVue Cardiology viewer.

- **Bandwidth**
  - 10 Mbps in both directions was determined to be the minimum bandwidth requirement per connection.

- **Latency**
  - 100 ms cumulative latency was determined to be the maximum threshold requirement per connection.

- **Packet Loss**
  - Cumulative packet loss of less than .5% was determined to be the maximum requirement per connection.

- **PCoIP**
  - VMware Group policy configurations were applied to enable build to lossless images and to optimize the image quality and frame rates.
Remote Review Architecture
Remote Review ESX Host Architecture

• Host Configuration

• Dell PowerEdge R730 Rack Server
• 2x Intel Xeon E5-2695 v3, 2.3GHz, 14 Core CPUs
• 256GB RAM, 2133MHz
• 2 400GB 12GB SAS SSDs in a RAID 0 (RAID 10 or SAN recommended for production)
• NVIDIA GRID K1
  • 4 Kepler GPUs (Supports up to 8 users per GPU, 32 per card)
  • 768 CUDA Cores
  • 8 GB DDR5 Memory for Frame Buffer
Remote Review Desktop Architecture

- Virtual Desktop Configuration (Recommended)
  - 6 vCPU (6 Core x 1 Socket)
  - 16 GB RAM
  - 150 GB Hard Disk (Solid State Virtual Disks)
  - NVIDIA GRID vGPU
    - Grid_k140q Profile
      - 1024 MB Frame Buffer
      - 2 Virtual Display Heads
      - 2560x1600 Max Resolution
      - 4 vGPUs per GPU
      - 16 total vGPUs per Board
  - Windows 7 64 bit O/S
    - Cerner SkyVue Cardiology Viewer Application installed
Conclusions

• Cerner SkyVue Cardiology was successfully deployed for remote review using VMware Horizon View on a VMware ESX 6 infrastructure.
• This was the first validated virtual technology configuration that can be deployed by Cerner clients today.
• The key technologies enabling this successful validation are NVIDIA GRID vGPU hardware and VMware ESX 6 host infrastructure software.
• The combination of these technologies deployed using the Cerner recommended configurations on appropriate server hardware provided acceptable performance for clinical use in a VMware Horizon View virtual desktop.
• The benchmark by which acceptable performance was determined in the virtual desktops was the concurrent testing performed against a physical high performance graphic workstation.
• If there was no observable difference between the physical high performance graphic workstation and the virtual desktop, performance was deemed acceptable.
Benefits of Remote Review

• Less complex method for the physician to access images remotely
• Meets the image resolution and performance requirements for acceptable use
• Remote desktop infrastructure allows pooled resources to be shared to a larger audience at unlimited remote locations
• Remote desktop infrastructure vastly reduces code management and costs associated with deploying and maintaining high end graphic workstations at remote locations