Deploying PACS/RIS Healthcare Applications with VMware View and AlwaysOn™ Point of Care

APOC Medical Imaging

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WHITE PAPER
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Introduction

This document provides information on some of the challenges facing PACS (Picture Archiving and Communication System) and RIS (Radiology Information System) end-users in the healthcare space and how VMware View™ and Always On™ Point of Care (APOCH) can help to address them. It is readily apparent that healthcare providers need a better desktop solution to address the ever-changing requirements of radiology professionals, including x-ray technicians, referring physicians, as well as radiologists. Some of the challenges include:

- Inconsistent desktop experience of existing systems, particularly among users who use multiple machines during the course of the day. Multiple logins, different hardware configurations and user experience in the clinic and at home, limited tablet/iPad access options, all contribute to user frustration.
- Cost of managing the desktop environment. In addition to replacing hardware every 2-4 years, managing multiple machines for users due to OS incompatibility can dramatically increase the cost of managing the desktop environment for end users.
- Downtime is a major concern in the radiology space. Maintaining a “dark” inventory of desktop machines may not be a viable solution, and “ghosting” or “imaging” of new desktops still results in downtime. Desktop hardware and software refreshes usually require some downtime and can be a challenging endeavor to carry out in larger organizations.

In this paper, we discuss these challenges and present a strategy that helps address these issues utilizing an architecture that includes VMware APOCH and View and for PACS/RIS client access, which supports the needs of end users and makes it easier for IT staff to manage applications and desktop environments. We first describe PACS and RIS applications and the workflows associated with using these tools in healthcare system environments. The remainder of the paper describes use cases for deploying these applications to workstations using VMware APOCH and VMware View and highlights the benefits that using VMware desktop solutions provides to different target users.

PACS and RIS Healthcare Systems Overview

In medical imaging, PACS is an acronym for Picture Archiving and Communication System. PACS healthcare solutions were developed to facilitate electronic diagnostic imaging workflow and provide economical storage (and archive), rapid retrieval of images, access to images acquired with multiple modalities, and simultaneous access from multiple sites. In laymen’s terms, PACS is the software and hardware that is responsible for displaying, transporting, storing, retrieving and archiving your X-ray, MR (magnetic resonance), and other medical images when you visit a doctor’s office or clinic. PACS uses a standard format for image storage and transfer called DICOM (Digital Imaging and Communications in Medicine), but can also encapsulate non-image data, such as PDF and JPG in DICOM format. Vendor Neutral Archives are also facilitating the distribution, viewing and efficient archive of both DICOM and Non-DICOM studies.

PACS and RIS Components and Features

A PACS solution consists of four major components:

1. Imaging modalities such as CT, mammography, MRI, and X-ray. (These are instruments and various types of equipment which produce images of the body using X-ray, ultrasound, magnetic resonance, or other methods of recording such as gastrointestinal and ophthalmology.)
2. Secured network for the transmission of patient information.
3. Storage and archive of image studies and reports.
4. Workstations used to retrieve, interpret, and review images.
Deploying PACS/RIS Healthcare Applications with VMware APOC and VMware View

The following illustration shows the various components used in providing a PACS solution.

![PACS Components](image1.png)

Figure 1. PACS Components

A PACS solution has four main uses:

1. Replace hard-copy medical images with electronic images.
2. Provide remote access of a patient study (patient information and images) for off-site viewing, which enables tele-radiology or the ability for practitioners in different physical locations to access the same information simultaneously.
3. Create an electronic image integration platform for radiology images that interfaces with other medical automation systems such as Hospital Information System (HIS), Electronic Medical Record (EMR), and Radiology Information System (RIS) to facilitate the diagnostic workflow.
4. Provide Radiology Workflow Management, which is used by radiology personnel to manage the workflow of patient exams.

A RIS solution incorporates a computerized database used by radiology departments to store, manipulate, and distribute patient radiological data and imagery. The system also generally provides patient tracking and scheduling, result reporting, and image tracking capabilities. RIS complements HIS (Hospital Information Systems) as well as PACS (Picture Archive and Communication System) and is critical to providing efficient workflow for radiology practices.

![Functional Components of RIS System](image2.png)

Figure 2. RIS Solution Components

Most RIS solutions today support the following features:

- Patient registration, scheduling, tracking, and list management.
- Interface with modality via worklists.
- Request and document scanning.
- Results entry.
- Report, printout, faxing, and emailing of clinical reports.
- Interactive documents and custom reports.
- Modality and material management.
- HL7 interfaces – communication between RIS, HIS/PACS and EMR.
- PACS workflow.
- Radiology department workflow.

Before discussing the integration of PACS and radiology workflow, a review of imaging workflow basics is helpful. In its simplest form, the workflow consists of: order entry; receiving the patient; imaging; evaluating the images; releasing the patient; submitting the images for interpretation; interpreting the images (dictation); transcription of the report; and, finally, signing the report.

**Basic PACS and RIS Workflows**

The basic PACS workflow consists of imaging a patient, sending the studies to PACS in an unread status, and having radiologists interpret the study and then change the study to a read status. At the workstation level, this usually means the radiologist begins the interpretation for a particular study by launching the PACS client/viewer and selecting a study from a “worklist”. A worklist contains a list of all the patients scheduled for an exam during a specific period of time, usually a day. After completing the interpretation of the study, the radiologist will change the status from unread to read or dictated, depending upon the specific PACS system used. The PACS then communicates this change in status to the RIS via HL7 communication on the backend. Changes to the study and its status are all done from within the PACS client.

![Figure 3. PACS Workflow](image)

The basic RIS workflow differs from PACS in that the radiologist first logs into the RIS to begin his workflow and selects a patient from the RIS worklist. From there, the radiologist manages the entire workflow from order entry to transcription and final sign-off of the report. All image functions, from acquisition to interpretation of the study, are provided through integration with the PACS. From within the RIS, a patient record is opened and then the appropriate study for that patient is selected. The link to the appropriate study is dynamically generated, and is usually an URL link that launches the study within the PACS. (This is considered an URL integration from RIS to PACS.) When the radiologist clicks the link to the study, the PACS viewer is launched separately from the RIS. Once the interpretation is complete, the radiologist will change the status of the study, and an HL7 message will be sent back to the RIS with the updated status.
The key differentiator here is the entry point into the RIS/PACS. Different PACS/RIS solutions may use different delivery methods. Depending on workflow, the end user will launch either the PACS or RIS and, via an API or similar integration, have access to the other application. On the backend, HL7 will provide communication between the PACS and RIS. Most hospitals and radiology centers today have an integrated RIS and PACS and will utilize both workflows, depending on the user.

In Figure 4 above, you can see the RIS Client workstation connects to the RIS and subsequently via HL7 provided access into the PACS. The Radiologist workstation connects to the PACS and has access to the RIS via HL7 as well. In most instances, the user will have both applications installed on the same machine. In some instances, a “thick client” is installed locally. Other delivery methods include using a standard Internet browser such as Internet Explorer. In most cases, the delivery uses a combination of a thick client and a browser.

The Current and Specialized Diagnostic Workstation

The current situation of high-end workstations with Graphics Processing Units (GPUs) supporting diagnostic medical imaging becomes more challenging as the operating system changes drive additional effort. Potential for hardware upgrades with driver implications also add to the support challenges. The evolution of the healthcare organizations presents a challenge as there are mergers and acquisitions driving integration requirements and geographic implications. While GPU performance continues to aid in the diagnostic cycle times, there are higher and higher expectations from every part of the organization to improve delivery throughput and quality. If down-times for workstations are able to be reduced and effect the consistency of service levels and performance improve, this adds to the overall effectiveness of the medical imaging diagnostic services. In addition, there is a drive to add remote access with the same features as local access.

Each workstation has the potential to cost between $5,000 to $8,000. There are some organizations that have developed their own workstations. Layer on top of that, the integration of the GPU and the qualification, testing and maintenance of each workstation, this can create yet another challenge for the medical imaging IT organization.

VMware View and APOC MI

VMware View allows for the delivery of rich, personalized virtual desktops as a managed service. With VMware View, coupled with VMware vSphere, customers can manage both servers and desktops from the data center to the cloud. Figure 5 provides a high-level logical architecture of VMware View virtual desktop technology running on the VMware vSphere virtualization platform.
With VMware View, administrators can virtualize operating systems, applications, and user data to deliver modern, flexible, and high-performance desktops to end users. End-users can securely access their personalized virtual desktop from a wide variety of thick, thin or mobile devices—without compromise.
Deploying PACS/RIS Healthcare Applications with VMware APOC and VMware View

VMware APOC complements VMware View by allowing IT organizations to provide applications to end-users without the difficulty or complexity of having to deal with application conflicts and prerequisites or operating system dependencies.

![Figure 6. VMware APOC Reference Architecture](image)

Figure 6. VMware APOC Reference Architecture

In Figure 6, it is illustrated that the APOC Reference Architecture provides a non-stop capability for desktop operations and services. This is a service-level not provided at the desktop level in the past.

How is medical imaging supported by a virtualized workstation strategy?

PCoIP technology is the result of a breakthrough in display compression for connecting desktops over existing, standard IP networks. PCoIP technology allows all enterprise desktops, from task workers to power users, to be centrally located and managed in the data center, while providing the remote user with an exceptional user experience. The PCoIP protocol compresses, encrypts and encodes the entire computing experience at the data center and transmits it 'pixels only' across any standard IP network to stateless PCoIP zero clients. Your data never leaves the data center. The PCoIP protocol is implemented in silicon for hardware accelerated performance, and in software in VMware View. It supports high resolution, full frame rate 3D graphics and HD media, multiple large displays, full USB peripheral connectivity, and high definition audio, all connected over the corporate LAN or WAN.
On LAN or WAN connections, VMware View with PCoIP delivers a high performance desktop experience, even over high latency and low bandwidth connections. The View Client with Local Mode enables end-users to enjoy secure, offline access to desktops applications and data regardless of network availability. And since desktops are tied to users’ identities and not specific devices, desktops follow the user from device to device for ultimate freedom and mobility.
Traditionally, accessing data and applications with a wider array of devices, and from an increasing range of locations, has been a challenge. VMware View provides a software-to-software implementation of PCoIP that is designed and built for desktops that suit various worker profiles. With the concerns of integrity of the network and security/privacy of data of particular importance in safeguarding patient’s healthcare information, PCoIP promises a comparable LAN and WAN experience while preserving security and administrative control.
GPU considerations with a View Implementation:

VMWare Blog Excerpt

By Aaron Blasius, senior product manager, VMware 5/15/2012

VDI solutions have been available for many years now and are becoming the preferred desktop platform for many market segments. From the enterprise to state, local and education customers and from Health Care to the small and mid-size businesses, organizations are realizing the benefits of delivering desktop workloads to their employees from private clouds enabled via VMware View. Centralization, automated provisioning and additional security are the primary drivers of View hosted solutions. Until recently, customer’s looking to secure their high value workstations assets in hosted solutions has been limited to niche solutions. This is about to change. Virtualizing graphics workloads was not an immediate need for the early adopters of virtualization for the data center. It was the evolution to virtual desktop workloads forced the issue of virtual graphics for the data center. Organizations wanted to bring VDI to more teams and employees demanded the same high fidelity experience from their virtual machines as the one they could find at home.

VMware leveraged the virtual 3D technology developed for the Workstation and Fusion products to ensure the rich graphics experience provided by enterprise software products such as Aero. Software rendered 3D in View 5 was delivered and the use case grew.

At VMworld in Copenhagen last year we Hannounced a technology preview with NVIDIA that enabled a true virtual workstation experience. vSphere virtualization coupled with the full power of the NVIDIA Quadro GPU card securely delivered from the data center to scientist, engineers, artists and manufacturing partners through a View virtual environment. Private clouds will be able to host the organizations most important IP. This provides the ability to more easily and securely leverage their global workforce, distributed supply chains and external partners; the View use case grew.

What’s next?

For me, few end-user scenarios expand the VDI use case more than 3D graphics. Harnessing the tremendous efficiency of the GPU for graphical rendering in a View environment impacts the two major concerns of any VDI initiative: experience and cost. The tremendous power of ESX will be able to virtualize and manage NVIDIA’s hardware based GPU resources. Accelerated 3D rendering provides a better end-user experience and increased efficiency means higher consolidation ratios. Cards like NVIDIA’s next generation VGX GPU cards provide the horsepower to ensure GPU doesn’t have to be limiting resource for graphics hungry power users. Managing this resource with the industry’s leading hypervisor from VMware means customers will continue to manage all their private clouds via vSphere. Multi-monitor use cases, DirectX and OpenGL application, CAD reviewers and diagnosticians are just some of the groups who have struggled with the graphics performance of VDI in the past. But with virtual graphics acceleration, this will no longer be the case.

As I said, things are about the change and look for VMware to continue to lead the way by providing the most comprehensive graphics strategy in the market, I for one am very excited.

PACS/RIS Client Deployments with VMware APOC MI and View

By deploying VMware View and APOC MI in a PACS/RIS environment, administrators can design and deliver desktop solutions that match each user’s specific needs and requirements. For example, PACS/RIS solutions typically might have the following types or categories of users:

- IT Department members, CTO, and PACS Administrators.
- Radiologists – primary PACS users who use the system for reading and diagnosing images.
- Radiology technologists and technicians who perform examinations using X-ray or MR images; other healthcare specialists may use various other imaging modalities such as computed tomography, magnetic resonance imaging and mammography.
- Clinicians and referring physicians who oversee and manage individual patient care and treatment, and might be remote to the radiology facility.

The following sections describe use cases for these individual groups of users and detail how VMware View and APOC can enhance clinical workflow experience while providing a non-stop clinical desktop environment that is secure, easy to manage, and cost-effective.

Scenario 1: IT Department – Managing Software Versions and Application/Browser Conflicts

Most modern RIS and PACS clients are either thick clients or browser-based and can be used interchangeably, or in combination. However, different browser requirements, or different operating system requirements for individual components, are a cause for concern and can create big headaches for administrators who deploy PACS/RIS solutions and those who configure and manage desktop environments for workstation users that access those systems.

For example, a PACS client might only work with an earlier version of Internet Explorer, while the RIS client may require a later version. This scenario is fairly common in Healthcare IT environments where providers pick “best of breed” applications from different vendors that may not have the same baseline system requirements. Furthermore, with the explosion of alternative end-user devices available, such as smart phones, tablets, “zero clients”, etc., PACS and RIS vendors are increasingly being forced to provide solution support across a whole range of different devices and operating systems. Also, with the introduction of Windows 7 and Internet Explorer 8, new Mac and Linux clients, PACS and RIS vendors may not be adequately prepared when it comes to updating legacy applications to work with all these new devices and in all these new environments. Customers and IT departments are caught between wanting to upgrade devices and software and not having applications that can run on new devices/operating systems.

That’s where using VMware APOC and View can help. With VMware APOC and View, customers can address the need to provide a consistent desktop experience across many different heterogeneous environments, including different operating systems and browser versions, and also provide support for alternative new devices such as tablets and smart phones.
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Accessing clients running on legacy operating systems with VMware View
Using VMware View, an end user can have a consistent desktop experience using the appropriate browser required for any specific application. With VMware View, PACS/RIS vendors can also address any issues arising from the required use of a legacy-version browser by providing access through a virtual desktop using a specific version of the browser and/or thick client.

Running applications that require Internet Explorer 6 on Windows 7
VMware APOC can further ensure a consistent desktop experience for users by allowing operation of disparate browser versions on the same machine—APOC also allows users to run multiple versions of thick client applications on the same desktop, side-by-side, without conflict. APOC leveraged with View provides a more flexible user experience by enabling multiple versions of a browser, for example, running multiple versions of Internet Explorer 6, 7 or 8 to reside on the same desktop, either installed locally or in a View desktop.

Running 32-bit applications on newer operating systems (64-bit or Window 7)
APOC can be leveraged for “migration” of client applications from existing 32-bit platforms to newer 32-bit or 64-bit OS platforms. An example might be a client application that is currently written for and supported on 32-bit Windows XP. Using APOC with this application can enable it to run on Windows XP 64-bit or even Windows 7, in some cases. This provides customers and vendors with an easier operating system migration path without requiring changes to client applications.

Desktop Management from Centralized Location
APOC enables customers to package client applications and distribute them by streaming to endpoints from a network share. At the desktop, all that is needed is a shortcut to the APOC package on a network share. Application updates are as simple as replacing the APOC package/file on the network share or using “side-by-side” updates where users can continue to access older versions of the application and automatically be upgraded when they sign off and re-launch the application. This allows administrators to patch applications at one location instead of having to distribute patches to all the endpoints/desktops simultaneously. APOC provides a completely agent-less application delivery mechanism that allows application upgrades without any downtime to the end user.

Scenario 2: Radiologist and Radiology Technicians Workstations and View also Diagnostic Display Systems
Using radiologists as an example, these individuals’ workstations are a critical enterprise service, as the Radiology departments in most hospitals provide one of their most critical functions. Additionally, radiologist workstations typically require additional hardware above and beyond standard IT-issued desktops. Most, if not all, radiologist workstations require at least one color monitor and two high-resolution, medical-grade, grayscale monitors. In some instances, certain radiologists will have up to four gray-scale monitors with a single color monitor.

VMware View is particularly well-suited to meet the radiologist’s workstation needs and can first provide them a consistent, highly available, high-performance PACS desktop environment that is managed from the datacenter. VMware View also provides the following capabilities to meet the radiologist’s workstation requirements:

- Supports up to four monitor displays; true multi-monitor support – not stretched.
- Endpoint flexibility – access anywhere and anytime; “Follow Me” Desktop functionality to switch from desktop to laptop, to iPad, and so on.
- USB redirection – allows for USB peripheral use.
- Print Optimization – location awareness helps direct print jobs to an appropriate printer.
• Multimedia Redirection – for viewing cine loops and cardio films.
• PCoIP display protocol used to meet the most challenging requirements of medical imaging.

In addition, packaging the RIS and/or PACS client with APOC and deploying on the View desktop ensures a consistent, compatible PACS/RIS client that is easily updated. It also doesn’t require any downtime and allows the radiologist to run multiple instances of the same client, without issue, during a PACS/RIS upgrade.

Scenario 3: Referring Physicians and View or Clinical View Systems

Referring physicians make up a large portion of a PACS user environment. While the referring physician’s desktop requirements may not be as stringent as the radiologist’s, the PACS experience should be the same in terms of performance and quality. Most referring physicians will also access a PACS system remotely, so performance over a WAN link is important.

Security is another primary concern for these referring physicians, as they are in essence accessing a hospital/radiology clinic’s database and images. VMware View is well suited to meet the referring physician’s needs by providing a secure, high performance virtual desktop environment for viewing PACS images. VMware View uses PCoIP to deliver near-linear performance for image viewing, and by leveraging the VMware View Security Server, which provides secure access to virtual desktops that the physicians can use to view the PACS application and images. The security server architecture lets providers allow encrypted remote access to virtual desktops without the need for any additional VPN software. Since these virtual desktops can be hosted on the same network/datacenter as the PACS application and images, image retrieval and display can be faster than downloading an image over a WAN connection. In addition to using View Security Server, packaging the PACS application using VMware APOC offers additional security for the application itself, including Active Directory integration and securing the application in an .EXE format that cannot be modified, but can be easily upgraded or replaced.

The Clinical Viewing capability opens many possibilities such as secure remote access, wider use of clients such as iOS and/or Android, emerging Windows tablets, MAC and Non-Diagnostic PCs.

Additional Features and Benefits

By integrating VMware View and APOC, IT organizations, including those deploying PACS/RIS solutions, can benefit from easy-to-manage and scalable desktops, and being able to provide end-users with additional flexibility and mobility and the same personalized experience they enjoy with a physical desktop. Depending on the organization, PACS/RIS support may be provided by a larger IT organization such as a hospital IT department, or it may have its own dedicated IT staff and resources. Radiology clinics generally have their own IT staff or outsource the bulk of their IT operations.

In summary, some key concerns that VMware View and APOC address across the organization include:

• Cost to manage desktop – radiologists and other highly-valued personnel have limited tolerance for downtime due to billing losses that may occur:
  – VMware View can provide a consistent, easily-managed, and highly-available desktop solution at a much lower cost than typical desktop machines provisioned with physical hardware.
  – Solutions can grow to meet needs today and into the future.

• Migration to Windows 7 – can be limited due to support requirements for PACS/RIS legacy products:
  – Using VMware APOC allows end users to run on the latest operating systems without being hindered by legacy PACS/RIS operating system and browser requirements.
  – Using VMware View allows PACS users to migrate seamlessly to Windows 7 while maintaining their legacy desktops.
Deploying PACS/RIS Healthcare Applications with VMware APOC and VMware View

- **Patching and Upgrading** – typically creates downtime issues for radiologists and other highly-valued personal:
  - APOC agent-less architecture does not require any client code to be installed. Applications can be quickly deployed with a single click, reducing time and eliminating installation conflicts for PACS IT Administrators and Staff.
  - Upgraded/patched View desktops can be provisioned quickly to update out-of-date software and operating systems.
  - With APOC, multiple PACS and RIS versions can co-exist on same View desktop to speed rollout and upgrade time. End users can test new versions of software without requiring tedious installation or reinstallation.

- **Cost of Desktop Management** – CAPEX, OPEX:
  - Reduces requirements for helpdesk support by eliminating application conflicts; fully-isolated APOC images do not introduce any changes to the OS or interfere with other applications.
  - PACS and RIS versions can co-exist on the same machine. End users can test new versions of software without requiring installation or reinstallation.
  - Provides opportunity for savings on storage costs for desktops when deployed with View and using View Composer to manage OS and application images; fewer desktop images required.

- **Scalability**:
  - Optimized for desktop workloads – easy to roll out new View desktops and APOC applications for radiologists and clinicians.
  - Demand-based generation – VMware View scales well for rapidly growing radiology centers.
  - Add resources on demand – provision new radiology View desktops in minutes, not hours or days. APOC applications can be delivered automatically and updated for View desktop or mobile users.

- **Availability**:
  - VMware FT – can be used to protect clinician desktop availability.
  - VMware HA – ensures radiologist desktop availability in the event of a host failure.
  - VMware SRM – can be used for desktops too!

- **Reliability**:
  - VMware vMotion – ensures radiologist desktop availability.
  - Storage vMotion – allows for migration of radiology desktops to optimized storage with zero downtime.

- **Seamless fit into any management framework** – single file .MSI and .EXE generated from APOC integrates into any existing management framework for a “single-pane-of-glass” console experience.
  - IT and PACS administrators can deploy MSI packages at any point during a RIS/PACS upgrade without fear of conflict. Speeds client installation and upgrade times.

- **Built in security** – APOC packages run in user-mode only and do not require administrator privilege to install or run. This eases the deployment requirements for even the most difficult packages to “locked-down” PCs and allows users to run applications without compromising security.
  - Prevents incorrect configuration and ensures consistency across PACS/RIS applications; consistent configuration for every user.

- **Deliver application mobility** – Applications can be delivered automatically and provide updates to desktop or mobile users.
  - Reduces downtime during upgrades of RIS/PACS for end users; applications can be upgraded automatically and transparently to end users.

The figure below positions the selection of a deployment strategy based on the use case or needs.
Consideration needs to be given based on the graphic needs of the workstation. While not always required, multi-monitor applications will perform more consistently when Graphics Processing Units are used to offload the primary processors. Complex medical imaging applications such as protein folding and post processing will also drive a decision to deploy GPUs. An advantage to offset the cost of GPUs is the ability to provide more dense Virtual Desktop deployments.

**Virtual Desktop User Segmentation**

![Virtual Desktop Segmentation Diagram]

*Figure 8: Virtual Desktop Segmentation*
Summary

The healthcare radiology space provides a tremendous opportunity for VMware customers to leverage VMware View and APOC offerings to improve Medical Imaging capability. Understanding the components of PACS and RIS as well as workflows and end-user requirements is critical to making the best use of VMware View and APOC in a customer’s environment. Every environment has its own set of challenges to address. However, VMware View and APOC are robust and flexible enough to address almost any challenge and ensure a successful deployment for healthcare applications in a specific environment, exceeding end user requirements and reducing CAPEX and OPEX.

Additional Resources

Customers can find more information about VMware and PACS/RIS healthcare products via the links listed below.

VMware APOC and View Resources

- VMware official website:
  http://www.vmware.com/
- VMware View product Web site:
  http://www.vmware.com/products/view/
- VMware Always On™ Point of Care Web site/Resources:

PACS/RIS Healthcare Solution Resources

- VMware Healthcare Solutions:
  http://www.vmware.com/solutions/industry/healthcare/
- FUJIFILM Medical Systems website:
  http://www.fujimed.com
- McKesson website:
  http://www.mckesson.com
- GE Healthcare website:
  http://www.gehealthcare.com
- Siemens Worldwide Healthcare website:
  http://www.medical.siemens.com