DICOM Traffic Performance and WAAS Application Deployment Guide

This document describes how the Digital Imaging and Communications in Medicine (DICOM) protocol behaves over a wide area network (WAN) within the Cisco Wide Area Application Services (WAAS) environment. The relative performance improvements with WAAS are detailed, along with the component roles and configurations used in the lab environment.

This document is intended for use by system engineers, account managers, and healthcare IT managers who are interested in understanding how the Cisco WAAS can improve DICOM traffic performance over a WAN link.

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Solution Overview

Overview

Cisco WAAS is an application acceleration and WAN optimization solution that optimizes the performance of any TCP-based application operating over a WAN environment. Cisco WAAS uses a combination of TCP optimization techniques and application acceleration features to overcome the most common challenges associated with transporting traffic over a WAN.

The DICOM standard is used in healthcare organizations for the exchange of images (CT, MRI, cat scan, etc).Cisco WAAS can transport DICOM type traffic and allow healthcare organizations to accomplish the following objectives:

- ***Reduce*** the amount of *bandwidth* required to deliver highly dense DICOM images over WANs.
- ***Increase*** the amount of *traffic throughput* experienced by the branch modalities for when storing or receiving DICOM images.
- Allow for ***consolidation*** of backend Picture Archival Communications Systems (PACS) used for the DICOM image storage into centralized data centers.

The Cisco Applications Network Services (ANS) solution is the overriding solution that encompasses the results of DICOM/WAAS traffic. It is recommended that the reader also refer to the ANS deployment guides for more details on Cisco WAAS and enterprise network architecture design.

http://ans.cisco.com.com/locator.com

DICOM Overview

Picture Archival Communications Systems (PACS) are at the core of medical image management. PACS is comprised of a cluster of application, database, and web servers. The PACS architecture dictates the quantity and function of the servers, but they all require high availability, typically greater than 99.99%.

The DICOM standard is used to support image exchange for both senders and receivers in a standard format and the underlying information model and information management services. These images or other DICOM objects can then be exchanged and read by other devices that can read the DICOM format.

A good reference document detailing DICOM can be found at the following URL:

http://www.ringholm.de/docs/02010_en.htm

A sample hypothetical DICOM image file is shown in Figure 1 and Figure 2. In this example, the first 794 bytes are used for a DICOM format header, which describes the image dimensions and retains other text information about the scan. The size of this header varies depending on how much header information is stored. Here, the header defines an image that has the dimensions 109x91x2 voxels, with a data resolution of 1-byte per voxel (so the total image size will be 19838 bytes). The image data follows the header information (the header and the image data are stored in the same file).

Figure 1 Example DICOM Image (1)

```
First 128 bytes: unused by DICOM format
Followed by the characters 'D','I','C','M'
This preamble is followed by extra information e.g.:

0002,0000,File Meta Elements Group Len: 132
0002,0001,File Meta Info Version: 256
0002,0010,Transfer Syntax UID: 1.2.840.10008.1.2.1.
0008,0000,Identifying Group Length: 152
0008,0060,Modality: MR
0008,0070,Manufacturer: MRIcro
0018,0000,Acquisition Group Length: 28
0018,0050,Slice Thickness: 2.00
0018,1020,Software Version: 46\64\37
0028,0000,Image Presentation Group Length: 148
0028,0002,Samples Per Pixel: 1
0028,0004,Photometric Interpretation: MONOCHROME2.
0028,0008,Number of Frames: 2
0028,0010,Rows: 109
0028,0011,Columns: 91
0028,0030,Pixel Spacing: 2.00\2.00
0028,0100,Bits Allocated: 8
0028,0101,Bits Stored: 8
0028,0102,High Bit: 7
0028,0103,Pixel Representation: 0
0028,1052,Rescale Intercept: 0.00
0028,1053,Rescale Slope: 0.00392157
7FE0,0000,Pixel Data Group Length: 19850
7FE0,0010,Pixel Data: 19838
```

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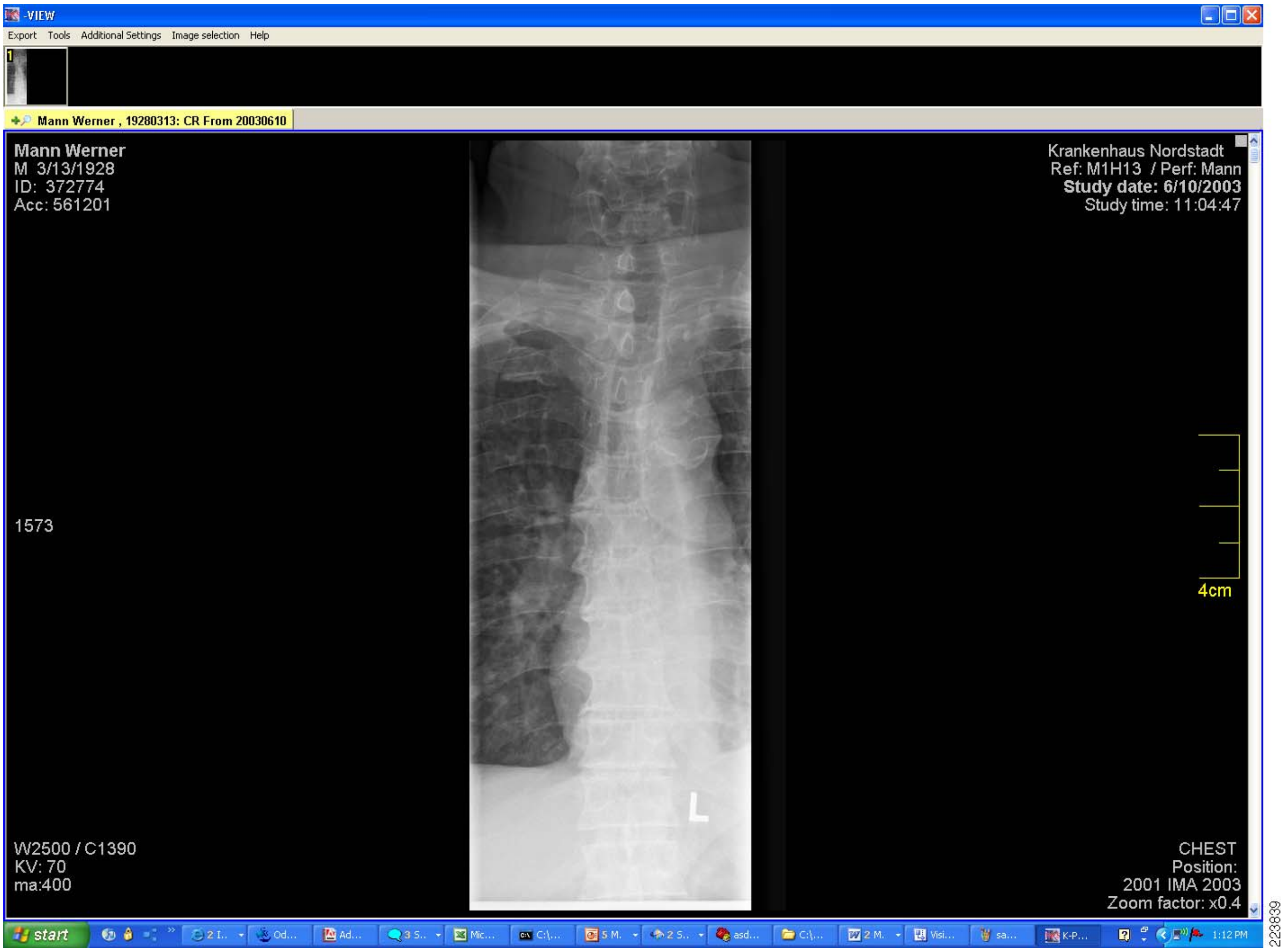
Figure 2 Example DICOM Image (2)

PACS image sizes can range greatly, but a typical image size is in the order of 1 to 50 MB. Each exam study may have a multitude of many images that make up for large file sizes ranging up to 2GB per exam. In addition, the amount of image traffic can vary greatly depending on the size of the clinic or hospital, and how many modalities are being used at a given time.

Refer to Appendix C: Typical Volumes of DICOM Traffic for information on different image characterizations, such as image file size and amounts of typical DICOM traffic for small, medium, and large size hospitals or clinics. Since large and frequent DICOM traffic are transferred daily, wide area acceleration (WAA) engineering can potentially provide great bandwidth savings and performance increases, if traffic must be traversed over a WAN.

Figure 3 DICOM Image Viewer

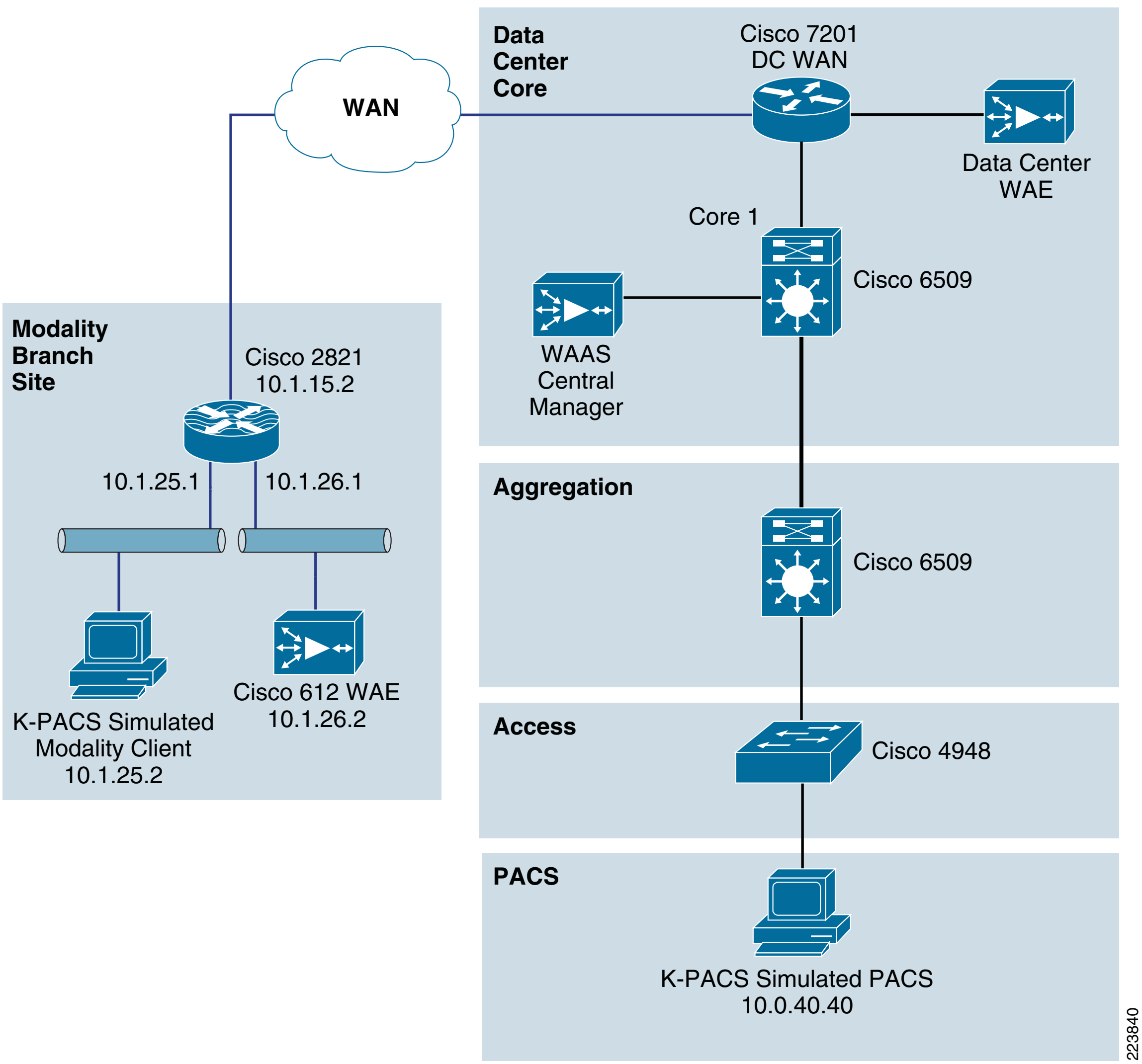


Solution Architecture

Architecture and Topology

The Cisco WAAS and DICOM topology used for the DICOM tests is illustrated in Figure 4. The overall architecture is broken into the functional areas described below.

Figure 4 ***Lab Test Setup***



Modality Branch Office

The modality branch site represents a remote branch office or small clinic that supports the collections of images through x-ray, Cat Scan equipment called *modalities*. The K-PACS application is a standalone, light weight application that was loaded onto a PC at the branch office. This was used to simulate these branch modalities. Several high resolution images were loaded onto the PC. The K-PACS application wraps a DICOM header around each of the images. The K-PACS application is instructed to send one or more images to the PACS storage system at the far-end data center. This PACS was also simulated using a destination K-PACS PC at the data center. The branch K-PACS PC sits on a dedicated VLAN L2 interface (VLAN 300) off the Cisco Integrated Services Router (ISR).

For more information on the K-PACS application, refer to the following URL:

http://www.k-pacs.net/

The Cisco Wide Area Application Engine (WAE) 612 resides on a dedicated VLAN Layer-2 interface (VLAN 301) off the Cisco ISR. The Cisco WAE is used to perform the WAA functions using the following techniques:

- Compression—If data is forwarded or retrieved to/from the server farm, the Cisco WAE performs compression algorithms on the data allowing for the WAN to become more efficient in bandwidth utilization.
- TCP Flow Optimization (TFO)—Scales the window sizing that is used to allow the WAN bandwidth. This more effectively uses the connection by increasing the window size.
- Local Caching—If the data that is being requested is locally cached, the Cisco WAE will respond to the requestor with the cached data and request *only* the required data from the server farm.

WAN Optimization, page 9 describes these acceleration functions in more detail. The Cisco WAE 612 was used in this test bed. Cisco offers many other WAE devices that can be used in the WAAS design. For more information, refer to the following URL:

http://cisco.com/en/US/products/ps6474/index.html

Finally, the Cisco 2821 ISR is used as the remote branch router. The Cisco 2821 was configured as an edge router with VLAN interfaces 300 and 301 for the K-PACS PC and the WAE respectively, and also provides routing to the WAN.

WAN

The WAN connection used is a standard T1 connection from the branch ISR to the data center 7200. The following settings were used:

- Bandwidth (BW) = 1.544 Mbps
- Framing = ESF
- Coding = B8ZS

There was no loss, delay, or jitter inserted into the WAN.

Data Center Core

The data center (DC) follows the design guidelines provided in the *Data Center 2.5 Design Guide* found at the following URL:

http://www.cisco.com/en/US/netsol/ns656/networking_solutions_design_guidances_list.html#anchor3

The DC design consists of a data center WAN router, core, aggregation, access switches, and the server farm (where the PACS application is simulated). The DC WAN router performs the same function as the branch WAN router by redirecting traffic to the DC WAE. The DC WAE performs the following:

- Locally cached—If the data that is being requested is locally cached, the WAE will respond to the requestor with the cached data and request only required data from the branch. This allows the WAN to become more efficient as only the *needed data* is requested.
- New data —If the data is being forwarded to the branch or coming from the branch, the Cisco WAE performs compression algorithms on the data, allowing for the WAN to become more efficient.

Included at the DC is the Cisco WAAS central manager (CM). The Cisco WAAS CM runs on the Cisco WAE appliance. The Cisco WAAS CM provides a centralized mechanism for configuring features, reporting, and monitoring. In addition, it can also manage a topology containing thousands of Cisco WAE nodes. The Cisco WAAS CM is accessed from a web browser using Secure Socket Layer (SSL), allowing management from essentially anywhere.

Note The Cisco ACE module functionality was not included in this particular test bed. DICOM was testing with the Cisco ACE in the *Connected Imaging Performance and Management Design and Implementation Guide*, found at the following URL: http://wwwin.cisco.com/enterprise/iArchitectures/healthcare.shtml

Aggregation and Access

The Cisco Catalyst 6509 switch was used at the aggregation layer and the Cisco 4848 switch used for the access layer to connect the PACS server simulator.

PACS Server

The PACS server farm consisted of a single K-PACS server simulating a PACS.

K-PACS is a windows-based view/client/server package that simulates the most important DICOM service classes (i.e., store, query/retrieve, send and move).

The features used for the solution testing are:

- Query/retrieve Service Class User (SCU) on patient and study.
- Store SCU from local K-PACS database at branch office to target archive at remote data center.
- Store Service Class Provider (SCP) with e-film compliant file organization.

A single workstation using the K-PACS client software was deployed at the branch office. Another workstation using the K-PACS server software was deployed at the data center server farm.

The K-PACS requires the following:

- Windows 2000/XP
- Processor of Pentium II 800Mhz class

- 256Mb RAM
- 10Mbit/s network connection
- DMA33 capable hard disc
- Monitor with 1024x768 pixel resolution

WAN Optimization

WAN optimization is a set of services that overcomes the performance limitations caused by transport protocols, network conditions, and network utilization. Common WAN optimization services employed by the WAA engines include the following.

TCP Flow Optimization

Inherent to TCP is the concept of *TCP slow start*, which allows TCP to identify the amount of network capacity available to a connection and impacts the throughput of the connection. *TCP slow start* hinders the application throughput by first waiting to determine network capacity before data is transmitted.

TCP flow optimization (TFO) scales the window sizing that is used to allow the WAN bandwidth to be more effectively used by the connection, by increasing the window size. This allows a much larger amount of data to be outstanding and unacknowledged in the network.

Data Suppression

Data suppression is a function of WAN optimization that allows accelerators to eliminate the transfer of redundant data across the network. This provides significant throughput and bandwidth savings. Accelerators keep a repository of previously seen patterns of data.

When a redundant data pattern is identified, the pattern is replaced with a unique identifier. The unique identifier is seen by the far-end accelerator and then is used to locate the original larger block of data. The savings is created since the unique identifier is very small in size and can be used to replace the large amount of data.

Compression

Compression is similar to data suppression since it minimizes the amount of data that must traverse the WAN network. Compression algorithms check the data to find areas for consolidation. Compression is beneficial in the first transfer of a data pattern to minimize the amount of bandwidth consumption.

DICOM images usually have large areas of black in relation to the actual image and therefore DICOM image benefit greatly from compression

Object Caching

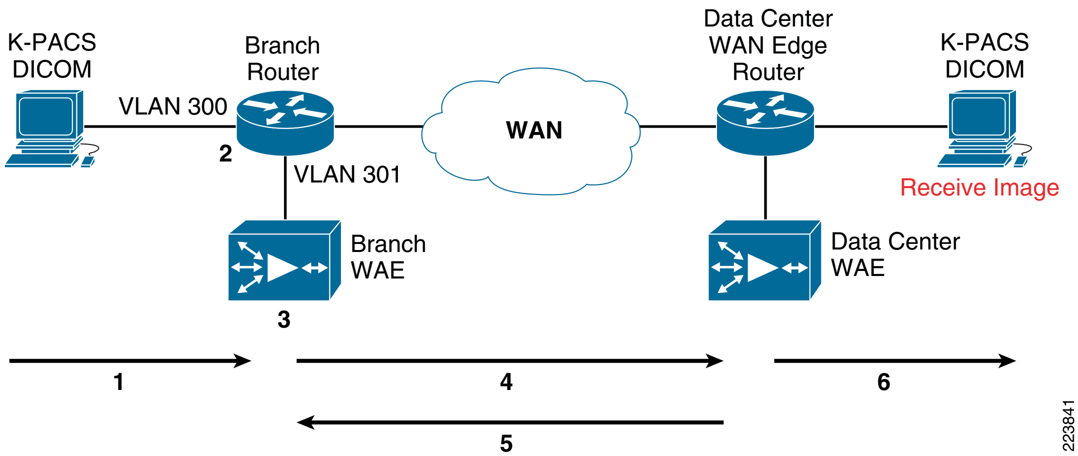
WAA engines also use object caching, by retaining a local copy of objects that have been requested at the far-end. If the object is requested again and verified to be identical to the copy on the origin server, then that local copy can be used.

Object caching eliminates the need for the object to be transferred over the WAN. A large increase of bandwidth (BW) savings is seen when objects are requested the second time over the WAN, since the object has now been cached.

Data Flow Example

Figure 5 shows a summary of the data flow used in the WAAS/DICOM testbed.

Figure 5 Data Flow Example



Step 1 The branch office K-PACS PC attempts to perform a C-STORE on a set of images to the K-PACS PC at the data center.

Step 2 The Cisco ISR uses WCCP to intercept the K-PACS request.

Step 3 The branch WAE examines the traffic's TCP header and refers to the application policies to determine if the traffic should be optimized. Information in the TCP header (source and destination IP address) allows the WAE to match the traffic to an application policy. If the WAE determines that the traffic should be optimized, information is added to the TCP header to inform the DC WAE to optimize the traffic.

Step 4 The branch WAE passes the client request to the destination K-PACS PC.

Step 5 The data center WAE intercepts the traffic and establishes an optimized connection with the branch WAE.

Step 6 Image is sent to data center K-PACS PC.

Testing Results

Testing Methodology

The basic testing methodology was performed as follows:

Step 1 Initiate a DICOM C-STORE *from* the K-PACS application workstation on the branch segment, *to* the K-PAC workstation located at the data center. The total image size transferred to the server was 43,985,176 byes.

Step 2 Validate that the files were stored correctly at the data center K-PACS.

Step 3 Measure statistics using NetQoS for volume (in MB) and throughput (Kbps) at the edges and the WAN.

Step 4 Run Steps 1 through 3 for the following scenarios:

- **a.** Test 1—WAAS OFF
- **b.** Test 2—WAAS ON, with No Object Caching
- **c.** Test 3—WAAS ON, with Object Caching

The following images were sent from the branch K-PACS PC to the data center K-PACS PC:

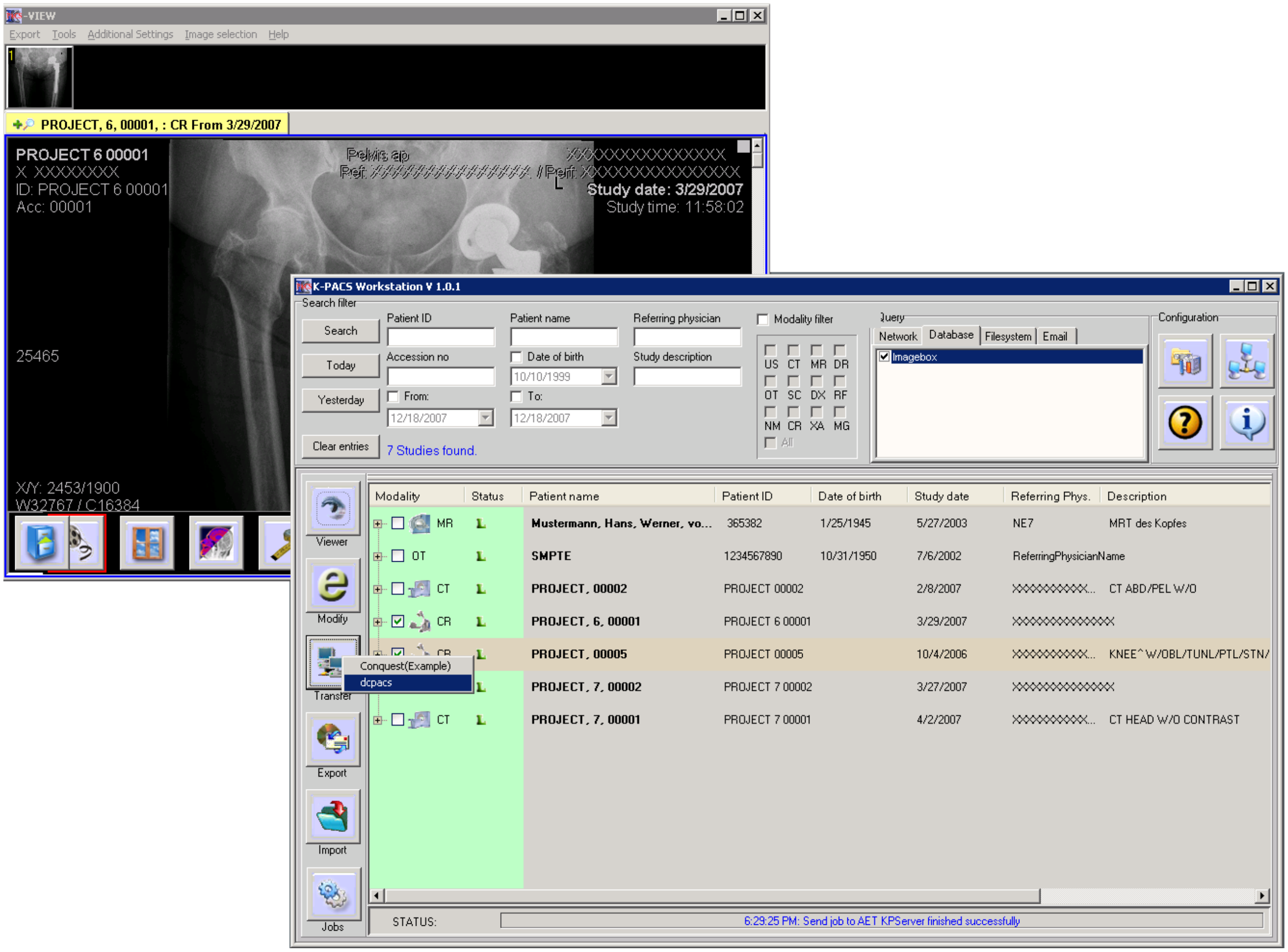
- DICOM image #1, Project 6, 00001, File size = 23.1 MB
- DICOM image #2, Project 7, 00001, File size = 20.8 MB
- Total Volume of files = 43,985,176, bytes = 43.9 MB

Note Test results were recorded for traffic *from* the branch office *to* the data center. A small percentage of reverse traffic was recorded, but not documented in this paper.

K-PAC Application

K-PACS allows a simulation of DICOM traffic and common DICOM operations. The K-PACS application allows for a selection of images to be transferred (i.e., C-STORE) to the far-end system.

Figure 6 K-PACS Application



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Test 1: WAAS OFF

Test 1 was performed with WAAS turned OFF for both the branch and data center WAEs.

Test Results

Data transferred from branch modality to DC PACS server = 43,985,176.

- Location #1: Branch modality to branch WAE
  - Volume = 43.9 MB
  - Average packets per second (pps) = 293 Kbps
- Location #2:Branch WAE to DC WAE (WAN)
  - Volume = 43.9 MB
  - Average pps = 293 Kbps
- Location #3: DC WAE to DC PACS

- Volume = 43.9 MB
- Average pps = 293 Kbps

Summary

The Test 1 results show the baseline volume and throughput of traffic using no WAAS mechanisms (see Figure 7). Note that both volume and throughout are exactly the same in all locations (1, 2, and 3) in the network. This sets the baseline measurements that will eventually be compared with the results obtained from tests 2 and 3.

Figure 7 Test 1: Without WAAS

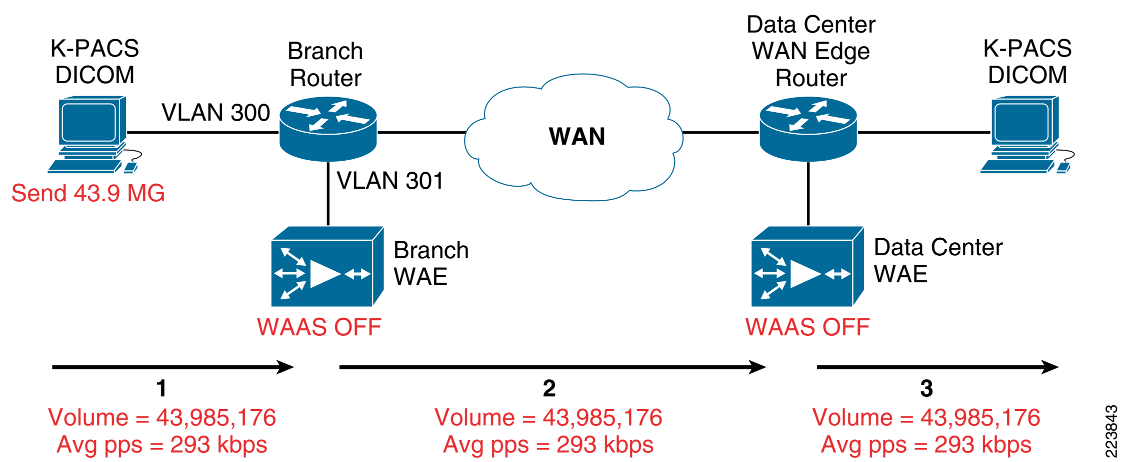

Figure 8 shows the NetQoS volume measurements taken at location #2 (WAN) when WAAS was turned OFF. Volume was measured for 43.9MB in the "To Bytes" column.

Figure 8 NetQoS Results for Test 1

Traffic Table
per 5 minute intervals

Time	To Bytes	From Bytes	Rtrns Bytes	Byte Loss	To Pkts	From Pkts	Rtrns Pkts	Pkt Loss	To Byte Rate (bytes/sec)
12/18/2007 4:30:00 PM PST	236	366	602	100.00%	158,969	158,272	4	0.00%	1
12/18/2007 4:35:00 PM PST	28,146,416	710	17,874,704	63.50%	20,571	10,294	13,060	42.31%	93,821
12/18/2007 4:40:00 PM PST	8,956,360	5,660	6,354,592	70.91%	6,675	3,411	4,710	46.70%	29,855
12/18/2007 4:45:00 PM PST	6,882,164	4,615	3,707,802	53.84%	5,131	2,623	2,759	35.58%	22,941
12/18/2007 4:50:00 PM PST	0	0	0	0.00%	0	0	0	0.00%	0
Total	43,985,176	11,351	27,937,700	NA	191,346	174,600	20,533	NA	NA
Average	10,996,294	2,838	6,984,425	63.50%	47,837	43,650	5,133	5.61%	36,654

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Test 2: With WAAS On, No Caching

Test 2 was performed with WAAS turned ON and object caching turned OFF for both the branch and data center WAEs.

Test Results

Data transferred from branch modality to DC PACS server = 43,985,176.

- Location #1: Branch modality to branch WAE
  - Volume = 43.9MB
  - Average pps = 391 Kbps
- Location #2: Branch WAE to DC WAE (WAN)
  - Volume = 27.9 MB
  - Average pps = 186 Kbps
- Location #3: DC WAE to DC PACS
- Volume = 27.9 MB
- Average pps = 186 Kbps

Summary

The Test 2 results show that the volume of traffic has dropped down to 27.9 M due to the WAEs performing compression and TCP flow optimization (see Figure 9). This results in a WAN utilization savings of 36.5% when WAAS is turned ON. Interestingly, the branch PC is able to perform more work during Test 2, as the average pps has now increased to 391 Kbps from Test 1.

Figure 9 Test 2: With WAAS, No Object Caching

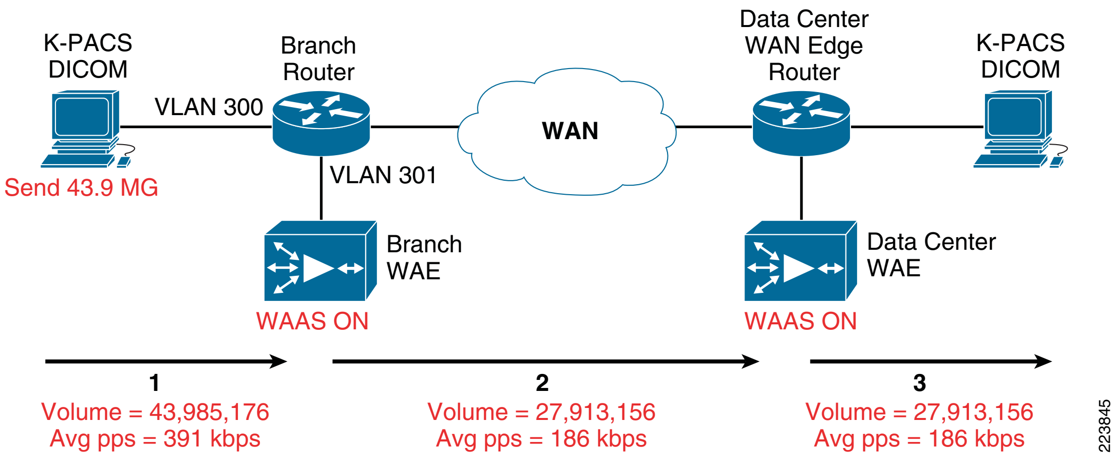

Figure 10 shows the total volume measured at location #2 (WAN) with WAAS turned ON. Volume was measured at 27.9 MB in the “To Bytes” column. This reflected a WAN volume savings of 36.5%.

Figure 10 NetQoS Results for Test 2

Traffic Table
per 5 minute intervals

Time	To Bytes	From Bytes	Rtrns Bytes	Byte Loss	To Pkts	From Pkts	Rtrns Pkts	Pkt Loss
12/18/2007 5:00:00 PM PST	0	0	0	0.00%	0	0	0	0.0
12/18/2007 5:05:00 PM PST	86,168	5,346	40	0.04%	341	263	4	0.6
12/18/2007 5:10:00 PM PST	22,352,810	18,272	30	0.00%	15,774	14,208	3	0.0
12/18/2007 5:15:00 PM PST	3,931,095	13,002	190	0.00%	3,058	2,004	19	0.3
12/18/2007 5:20:00 PM PST	1,543,083	6,188	90	0.01%	1,233	806	9	0.4
12/18/2007 5:25:00 PM PST	0	0	0	0.00%	0	0	0	0.0
Total	27,913,156	42,808	350	NA	20,406	17,281	35	
Average	[illegible]	10,702	88	0.00%	5,102	4,320	9	0.0

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Test 3: WAAS ON, Object Caching On

Test 3 was performed with Cisco WAAS and object caching ON for both the branch and data center WAEs. This test was first run to allow the DC WAE to cache the image files. The test was performed again, and volume and throughput were recorded.

Test Results

Data transferred from branch modality to DC PACS server = 43,985,176

- Location #1: Branch modality to branch WAE
- Volume = 43.9MB
- Average pps = 586 Kbps
- Location #2: Branch WAE to DC WAE (WAN)
- Volume = 1.79 MB
- Average pps = 23.9 Kbps
- Location #3: DC WAE to DC PACS
- Volume = 1.79 MB
- Average pps = 23.9 Kbps

Summary

The Test 3 results show that the volume of traffic across the WAAS has dropped considerably, down to 1.79 M due to the WAEs performing object caching, *plus* due to compression and flow optimization (see Figure 11). This results in a bandwidth savings of 95.9%. Note that the branch PC is now able to perform even more work than in the case of Test 2, as the average pps has now increased even further to 586 kbps.

Figure 11 Test 3: With WAAS, With Object Caching

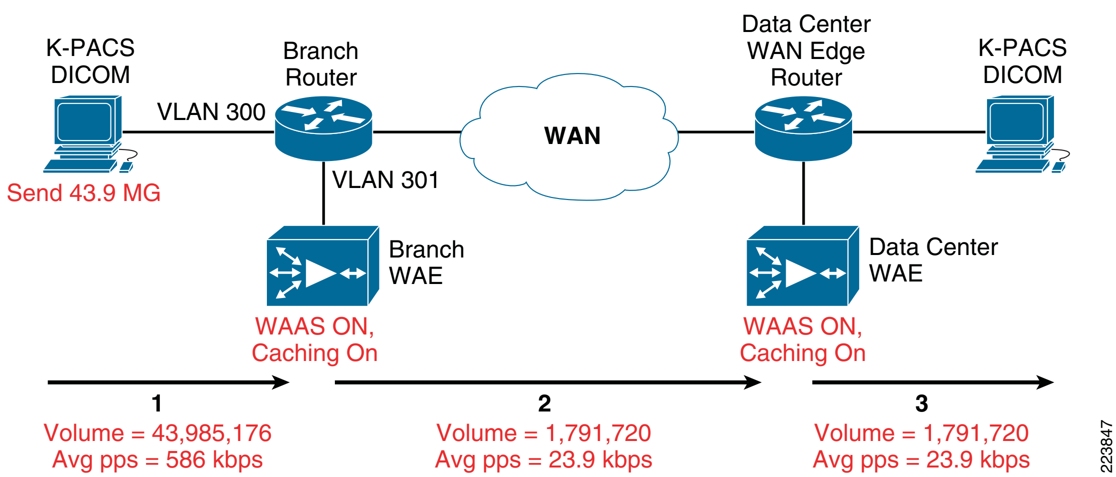

Figure 12 shows the total volume measured at location #2 (WAN) with *both* WAAS and object caching turned ON. Volume was measured at 1.79 MB in the "To Bytes" column. This reflected a WAN volume savings of 95.9%.

Figure 12 NetQoS Results for Test 3

Traffic Table
per 5 minute intervals

Time	To Bytes	From Bytes	Rtrns Bytes	Byte Loss	To Pkts	From Pkts	Rtrns Pkts	Pkt Loss	To Byte Rate (bytes/sec)	From Byte Rate (bytes/sec)	Rtrns Byte Rate (bytes/sec)	To Pkt Rate (pkts/sec)	From Pkt Rate (pkts/sec)
12/18/2007 5:30:00 PM PST	0	0	0	0.00%	0	0	0	0.00%	0	0	0	0	0
12/18/2007 5:35:00 PM PST	1,553,555	73,517	170	0.01%	3,359	3,474	17	0.25%	5,179	245	1	11	12
12/18/2007 5:40:00 PM PST	238,165	17,137	140	0.05%	1,058	878	14	0.72%	794	57	0	4	3
12/18/2007 5:45:00 PM PST	0	0	0	0.00%	0	0	0	0.00%	0	0	0	0	0
Total	1,791,720	90,654	310	NA	4,417	4,352	31	NA	NA	NA	NA	NA	NA
Average	[illegible]	45,327	155	0.02%	2,209	2,176	16	0.35%	2,986	151	1	7	7

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Conclusions

Summary

Table 1 summarizes the percentage (%) increased level of performances for WAN efficiency and client throughput.

Table 1 Percentage Increases in Performance

	WAN Volume Traffic Savings	Client Traffic Throughput Increase
WAAS OFF	No change	No Change
WAAS ON – No Caching	+ 36.5%	+ 33.4%
WAAS ON – With Caching	+ 95.9%	+ 100%

In summary, the Cisco WAAS works effectively with DICOM traffic. If images are required to traverse over slower WAN links, the Cisco WAAS can significantly reduce the amount of traffic across the WAN, while improving the throughput experienced by the edge modality.

From the tests performed, the following conclusions can be made when using the Cisco WAAS:

- The first time an image is stored or retrieved between a modality and a PACS, an expected WAN savings averages +36.5%, and boosts the modality throughput by 33.4%.
- When that same image is stored or retrieved subsequent times after, an expected WAN savings averages +95.9% and boosts modality throughput by +100%.

Ultimately, this translates directly into more effectively managing WAN bandwidth costs for healthcare IT departments. Equally as important, radiologists and x-ray technicians will experience greater throughput speeds when storing or retrieving images to the PACS. This will enable them to perform more work and spend less time waiting for storing or retrieving images.

Appendix A: Configurations

The following are sample configurations for the devices used in the testing for this document.

ISR

```
health-p-m#isr



User Access Verification

Username: cisco
Password:
ISR#sh run
Building configuration...

Current configuration : 33
```

```
!
! Last configuration change at 01:05:16 UTC Wed Dec 19 2007 by cisco

! NVRAM config last updated at 01:05:17 UTC Wed Dec 19 2007 by cisco

!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec
no service password-encryption
!
hostname ISR
!
boot-start-marker
boot system flash:c2800nm-adventerprisek9-mz.124-16.bin

boot system flash:c2800nm-ipbase-mz.123-8.T11.bin

boot-end-marker
!
logging buffered 51200 warnings
!
no aaa new-model
ip wccp 61 password cisco
ip wccp 62 password cisc
!
!
ip cef
!
!
no ip domain lookup
ip domain name yourdomain.com
ip host ISR 99.1.1.1
!
!
voice-card 0
 no dspfarm
!
!
!
!
!
!
!
!
!
!
!
!
!
!
username cisco privilege 15 secret 5 $1$Vfdr$KexEfp8r/kFsyR1XOuo54/

!
!
!
!
!
!
!
interface Loopback0
 ip address 10.1.6.51 255.255.255.255
!
interface GigabitEthernet0/0
```

```
 no ip address
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
!
interface FastEthernet0/3/0
 description ImageTest PC
 switchport access vlan 300
!
interface FastEthernet0/3/1
 description WAE
 switchport access vlan 301
!
interface FastEthernet0/3/2
 shutdown
!
interface FastEthernet0/3/3
 shutdown
!
interface Serial0/0/0
 ip address 10.1.15.2 255.255.255.0
 ip wccp 62 redirect in
 ip flow egress
!
interface Analysis-Module1/0
 no ip address
 shutdown
 hold-queue 60 out
!
interface Vlan1
 no ip address
!
interface Vlan300
 ip address 10.1.25.1 255.255.255.0
 ip wccp 61 redirect in
!
interface Vlan301
 ip address 10.1.26.1 255.255.255.0
!
router eigrp 10
 network 10.1.15.0 0.0.0.255
 network 10.1.25.0 0.0.0.255
 network 10.1.26.0 0.0.0.255
 network 10.0.0.0
 auto-summary
!
ip route 0.0.0.0 0.0.0.0 10.1.15.1
!
ip flow-export source Loopback0
ip flow-export version 5
ip flow-export destination 10.1.70.10 9995
!
ip http server
ip http access-class 23
ip http authentication local
no ip http secure-server
ip http timeout-policy idle 60 life 86400 requests 10000

!
snmp-server community ANSwerLab RO
```

```
snmp-server enable traps tty
!
!
!
!
control-plane
!
!
!
!
!
!
!
!
!
banner login ^C
-----------------------------------------------------------------------


-----------------------------------------------------------------------

^C
alias exec sb sh ip int brief
!
line con 0
 login local
line aux 0
line 66
 no activation-character
 no exec
 transport preferred none
 transport input all
 transport output all
line vty 0 4
 access-class 23 in
 privilege level 15
 login local
 transport input telnet
line vty 5 15
 access-class 23 in
 privilege level 15
 login local
 transport input telnet
!
scheduler allocate 20000 1000
ntp clock-period 17180097
ntp server 10.1.6.20
!
end

ISR#
```

Branch WAE

```
ISR#
WAE CONFIG

WAE-DICOM#sh run
! WAAS version 4.0.13 (build b12 Aug  9 2007)
!
```

```
device mode application-accelerator
!
!
hostname WAE-DICOM
!
!
clock timezone US/Pacific -8 0
!
!
!
!
!
primary-interface GigabitEthernet 1/0
!
!
!
interface GigabitEthernet 1/0
 ip address 10.1.26.2 255.255.255.0
 exit
interface GigabitEthernet 2/0
 shutdown
 exit
!
!
!
ip default-gateway 10.1.26.1
!
no auto-register enable
!
! ip path-mtu-discovery is disabled
!
!
ip route 0.0.0.0 0.0.0.0 10.1.26.1
!
!
ntp server 10.1.20.2
!
!
wccp router-list 1 10.1.26.1
wccp tcp-promiscuous router-list-num 1 password ****

wccp version 2
!
!
!
username admin password 1 bVmDmMMmZAPjY
username admin privilege 15
usernameadminprint-admin-password129D5C31BFF3D8D25AAD3B435B51404EE7D891AB40


2CAF2E89CCDD33ED54333AC
!
!
!
!
authentication login local enable primary
authentication configuration local enable primary

!
!
!
!
!
central-manager address 10.1.21.2
```

```
cms enable
!
!
!
flow monitor tcpstat-v1
flow monitor tcpstat-v1 enable
!
tfo tcp optimized-send-buffer 512
tfo tcp optimized-receive-buffer 512
!
!
no adapter epm enable
!
!
policy-engine application
   name Authentication
   name Backup
   name CAD
   name Call-Management
   name Conferencing
   name Console
   name Content-Management
   name Directory-Services
   name Email-and-Messaging
   name Enterprise-Applications
   name File-System
   name File-Transfer
   name Instant-Messaging
   name Name-Services
   name P2P
   name Printing
   name Remote-Deskto
   name Replication
   name SQL
   name SSH
   name Storage
   name Streaming
   name Systems-Management
   name VPN
   name Version-Management
   name WAFS
   name Web
   name NetQoS
   name Dicom
   classifier AFS
      match dst port range 7000 7009
   exit
   classifier AOL
      match dst port range 5190 5193
   exit
   classifier Altiris-CarbonCopy
      match dst port eq 1680
   exit
   classifier AppSocket
      match dst port eq 9100
   exit
   classifier Apple-AFP
      match dst port eq 548
   exit
   classifier Apple-NetAssistant
      match dst port eq 3283
   exit
   classifier Apple-iChat
      match dst port eq 5297
```

```
      match dst port eq 5298
   exit
   classifier BFTP
      match dst port eq 152
   exit
   classifier BGP
--More--
classifier Dicom
      match dst port eq 104
      match src port eq 104
   exit
```

Appendix B: DICOM Header information

The DICOM elements required depends on the image type, and are listed in part 3 of the DICOM standard. For example, this image modality is 'MR' (see group: element 0008:0060), so it should have elements to describe the MRI echo time. The absence of this information in this image is a violation of the DICOM standard. In practice, most DICOM format viewers (including MRIcro and ezDICOM) do not check for the presence of most of these elements, extracting only the header information which describes the image size.

The NEMA standard preceded DICOM, and the structure is very similar, with many of the same elements. The main difference is that the NEMA format does not have the 128-byte data offset buffer or the lead characters 'DICM'. In addition, NEMA did not explicitly define multi-frame(3D) images, so element 0028,0008 was not present.

Of particular importance is group: element 0002:0010. This defines the DICOM standard. This value reports the structure of the image data, revealing whether the data has been compressed. Note that many DICOM viewers can only handle uncompressed raw data. DICOM images can be compressed both by the common lossy JPEG compression scheme (where some high frequency information is lost) as well as a lossless JPEG scheme that is rarely seen outside of medical imaging (this is the original and rare Huffman lossless JPEG, *not* the more recent and efficient JPEG-LS algorithm). These codes are described in Part 5 of the DICOM standard (see ftp://medical.nema.org/medical/dicom/2000/draft/). An introduction to this the transfer syntax is provided at www.barre.nom.fr.

Table 2 Transfer Syntax UID

Transfer Syntax UID	Definition
1.2.840.10008.1.2	Raw data, Implicit VR, Little Endian
1.2.840.10008.1.2.x	Raw data, Eplicit VR x = 1: Little Endian x = 2: Big Endian
1.2.840.10008.1.2.4.xx	PEG compression xx = 50-64: Lossy JPEG xx = 65-70: Lossless JPEG
1.2.840.10008.1.2.5	Lossless Run Length Encoding

Note that as well as reporting the compression technique (if any), the Transfer Syntax UID also reports the byte order for raw data. Different computers store integer values differently, so called 'big endian' and 'little endian' ordering. Consider a 16-bit integer with the value 257, the most significant byte stores the value 01 (=255) and the least significant byte stores the value 02. Some computers would save this value as 01:02, while others will store it as 02:01. Therefore, for data with more than 8-bits per sample, a DICOM viewer may need to swap the byte-order of the data to match the ordering used by your computer.

In addition to the Transfer Syntax UID, the image is also specified by the Samples Per Pixel (0028:0002), Photometric Interpretation (0028:0004), the Bits Allocated (0028:0100). For most MRI and CT images, the photometric interpretation is a continuous monochrome (e.g., typically depicted with pixels in grayscale). In DICOM, these monochrome images are given a photometric interpretation of 'MONOCHROME1' (low values=bright, high values=dim) or 'MONOCHROME2' (low values=dark, high values=bright). However, many ultrasound images and medical photographs include color, and these are described by different photometric interpretations (e.g., Palette, RGB, CMYK, YBR, etc). Some color images (e.g., RGB) store three-samples per pixel (one each for red, green, and blue), while monochrome and paletted images typically store only one sample per image. Each images store 8-bits (256 levels) or 16-bits per sample (65,535 levels), though some scanners save data in 12-bit or 32-bit resolution. So a RGB image that stores three samples per pixel at 8-bits per can potentially describe 16 million colors (256 cubed).

The following information is from http://www.sph.sc.edu/comd/rorden/dicom.html and is provided for informational purposes.

Appendix C: Typical Volumes of DICOM Traffic

Anticipated Volumes of DICOM traffic

Table 3 through Table 5 provide examples of the volume of network traffic that you will see in a given hospital or clinic. You can use these tables as a reference to determine what type of traffic patterns you will see and need to plan for given a particular size clinic; or you can use the tools available from Acuo Technologies to perform a more complete capacity plan including data storage necessary for the Acuo products.

Table 3 Small Hospital or Remote Clinic

# of Scanners	Modality	Matrix			Bits Stored	Image Capture	MB/ Image	Images / Exam	MB/ Exam	Exams/ Year	Exam/ Day	Images/ Day	MB/ Day	MB/ Year
	DSA	1,024	X	1,024	16	DICOM	2		0		0	0	0	0
1	NUCLEAR	256	X	256	24	DICOM	0	10	2	3,000	8	82	16	5,898
2	ULTRASOUND 12bit	512	X	512	16	DICOM	1	30	16	7,000	19	575	302	110,100
	ULTRASOUND 12bit	512	X	512	16	DICOM	1		0		0	0	0	0
1	CT - Standard	512	X	512	16	DICOM	1	60	31	8,000	22	1,315	689	251,658
1	MRI	256	X	256	16	DICOM	0	160	21	10,000	27	4,384	575	209,715
	Digitizer	2,048	X	2,560	16	DICOM	10		0		0	0	0	0

Table 3 Small Hospital or Remote Clinic (continued)

3	Comp. Rad (CR)	2,048	X	2,560	16	DICOM	10	3	26	65,000	178	445	4,668	1,703,936
1	CT 16-Slice	512	X	512	16	DICOM	1	200	105	4,000	11	2,192	1,149	419,430
	CT 64-Slice	512	X	512	16	DICOM	1		0		0	0	0	0
	XA	512	X	512	16	DICOM	1		0		0	0	0	0
	MRI	512	X	512	16	DICOM	1		0		0	0	0	0
	Digital Mammo	4,096	X	5,624	16	DICOM	46		0		0	0	0	0
	Cath Lab	1,024	X	1,024	16	DICOM	2		0		0	0	0	0
1	Special Procedures	1,024	X	1,024	16	DICOM	2	15	31	1,000	3	41	86	31,457
1	Echo's	512	X	512	16	DICOM	1	130	68	2,000	5	712	373	136,315
11										100,000	274	9,747	7,859	2,868,511

Table 4 Mid-Size Hospital or Large Clinic

# of Scanners	Modality	Matrix			Bits Stored	Image Capture	MB/ Image	Images/ Exam	MB / Exam	Exams/ Year	Exams / Day	Images / Day	MB / Day	MB/ Year
	DSA	1,024	X	1,024	16	DICOM	2		0		0	0	0	0
3	NUCLEAR	256	X	256	24	DICOM	0	10	2	9,000	25	247	48	17,695
4	ULTRASOUND 12bit	512	X	512	16	DICOM	1	30	16	18,000	49	1,479	776	283,116
	ULTRASOUND 12bit	512	X	512	16	DICOM	1		0		0	0	0	0
	CT - Standard	512	X	512	16	DICOM	1		0		0	0	0	0
3	MRI	256	X	256	16	DICOM	0	160	21	27,000	74	11,836	1,551	566,231
	Digitizer	2,048	X	2,560	16	DICOM	10		0		0	0	0	0
6	Comp. Rad (CR)	2,048	X	2,560	16	DICOM	10	3	26	180,000	493	1,233	12,928	4,718,592
2	CT 16-Slice	512	X	512	16	DICOM	1	200	105	24,000	66	13,151	6,895	2,516,582
1	CT 64-Slice	512	X	512	16	DICOM	1	2,000	1,049	12,000	33	65,753	34,474	12,582,912
1	PET	512	X	512	16	DICOM	1	90	47	6,000	16	1,479	776	283,116
	XA	512	X	512	16	DICOM	1		0		0	0	0	0
	MRI	512	X	512	16	DICOM	1		0		0	0	0	0
2	Digital Mammo	4,096	X	5,624	16	DICOM	46	4	184	9,000	25	99	4,544	1,658,585
2	Cath Lab	1,024	X	1,024	16	DICOM	2	70	147	6,000	16	1,151	2,413	880,804
2	Special Procedures	1,024	X	1,024	16	DICOM	2	15	31	3,000	8	123	259	94,372
2	Echo's	512	X	512	16	DICOM	1	130	68	6,000	16	2,137	1,120	408,945
28										300,000	822	98,688	65,783	24,010,949

Table 5 Large Hospital / Multiple Clinics

# of Scanners	Modality	Matrix			Bits Stored	Image Capture	MB / Image	Image/ Exam	MB / Exam	Exams / Year	Exams / Day	Images / Day	MB / Day	MB / Year
	DSA	1,024	X	1,024	16	DICOM	2		0		0	0	0	0
9	NUCLEAR	256	X	256	24	DICOM	0	10	2	30,000	82	822	162	58,982
8	ULTRASOUND 12bit	512	X	512	16	DICOM	1	30	16	60,000	164	4,932	2,586	943,718
	ULTRASOUND 12bit	512	X	512	16	DICOM	1		0		0	0	0	0
	CT - Standard	512	X	512	16	DICOM	1		0		0	0	0	0
10	MRI	256	X	256	16	DICOM	0	160	21	90,000	247	39,452	5,171	1,887,437
	Digitizer	2,048	X	2,560	16	DICOM	10		0		0	0	0	0
20	Comp. Rad (CR)	2,048	X	2,560	16	DICOM	10	3	26	600,000	1,644	4,110	43,092	15,728,640
8	CT 16-Slice	512	X	512	16	DICOM	1	200	105	80,000	219	43,836	22,982	8,388,608
3	CT 64-Slice	512	X	512	16	DICOM	1	2,000	1,049	40,000	110	219,178	114,912	41,943,040
4	PET	512	X	512	16	DICOM	1	90	47	20,000	55	4,932	2,586	943,718
	MRI	512	X	512	16	DICOM	1		0		0	0	0	0
6	Digital Mammo	4,096	X	5,624	16	DICOM	46	4	184	30,000	82	329	15,147	5,528,617
6	Cath Lab	1,024	X	1,024	16	DICOM	2	70	147	20,000	55	3,836	8,044	2,936,013
6	Special Procedures	1,024	X	1,024	16	DICOM	2	15	31	10,000	27	411	862	314,573
6	Echo's	512	X	512	16	DICOM	1	130	68	20,000	55	7,123	3,735	1,363,149
86								2,712		1,000,000	2,740	328,959	219,278	80,036,495