Introduction to DICOM

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Who I am / Where do I work?

Garrett Seeley- Associate Professor of Biomedical Equipment Technology, Texas State Technical College, Waco, Texas.

- Education: MS-Information Technology, BS Biomedical Electronics, USAMEOS Graduate, CompTIA A+ and Network +
- Experience: 12 years in field of Biomedical and Radiology services, 13 years of education at the college level.
- My Employer: TSTC - graduates over 50 technicians annually, 30+ are dual degree, Biomedical and Medical Imaging.
- Students are trained on actual equipment, over 3 million worth of used medical equipment including Ultrasound machines, Mammography, Rad/Fluoro, CT, and MRI systems - Total costs are about $20,000 for 2 years of training.

What Is DICOM?

Digital Imaging and Communications in Medicine

- A **public, open source** communicational standard which allows several different manufacturers to create, store, view, print, and transfer a medical grade image in a common format.
- At the heart of a **Picture Archiving and Communication System**
- A part of the **Electronic Medical Records (EMR)** system
  - Health Level Seven (HL7) is the text side of EHR
  - DICOM is the **picture and video** side of EHR
- Created in part in 1981 by American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA). In 1991 – changed to DICOM

What is DICOM used for

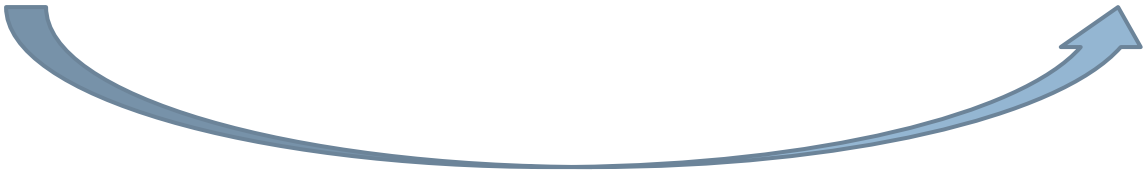
- Was first used for printing from multiple sources. – used by high-end medical imaging
- Later expanded to storage and digital reading of high-end imaging
- Expanded to other modalities, then finally the entire Radiology Department "Went Digital"
- Is still growing to Structured Reporting, Modality Performed Procedure Steps, and Computer Aided Detection

DICOM Communication

How does DICOM work?

Say we want to send a letter from one apartment building to another using the USPS. What is needed?

Name
Street
Address
Apartment #



DICOM Communication Requirements

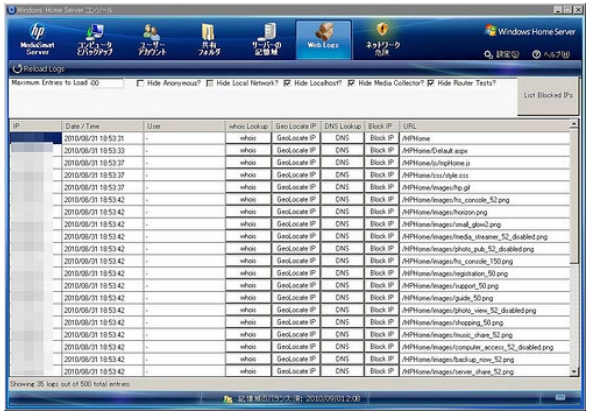
Lets apply the previous information to a DICOM communication.

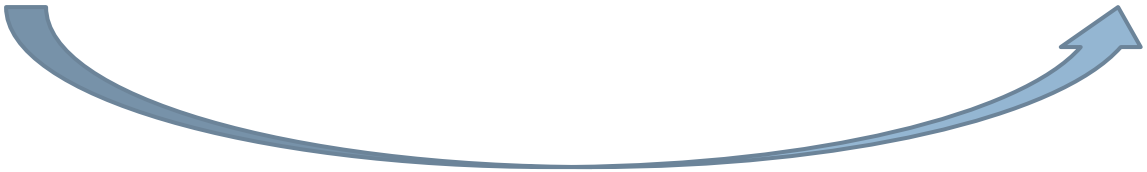
What is needed?

Application Entity Title

IP Address

Port #





Communication Requirements

Terms and Definitions - The Big Three!

• Application Entity Title (AE Title) The **name of a software** or module in a computer on a DICOM compatible PACS network.

• Internet Protocol Address (IP Address) The logical location of a computer in a network - **where the machine is** on the network

• Port # - A number from 0 to 65535 that provides a communication access for a software module on a computer. Example Hypertext Transfer Protocol (http) uses port 80 - **The location of the software on that IP**

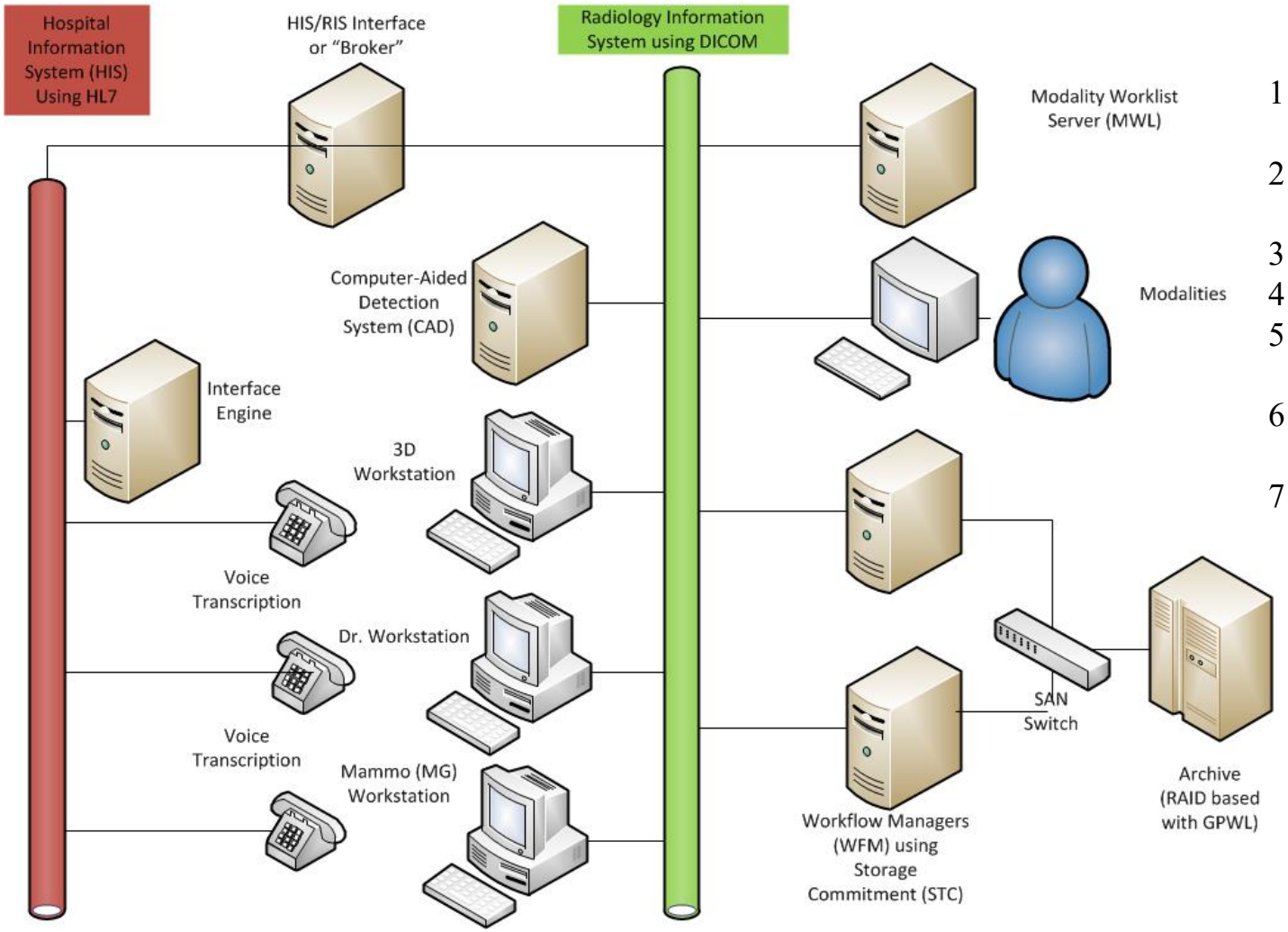
All Three must be present for DICOM to work

DICOM Workflow Flow

- A communication is called an **Association**
- The **source** of an image (modality) is called a **Service Class User- SCU**
- The **destination** of an image (PACS Archive) is called a **Service Class Provider- SCP**
- Associations are exchanged as a software communication (OSI Layer 7) over TCP/IP

Remember: DICOM is a Software Module

DICOM Workflow Flow



1. HL7 Interface Engine Request
2. HIS/RIS HL7 to DICOM
3. MWL
4. Modality
5. WFM with STC to Archive
6. WFM to Workstation
7. Transcription to HL7

DICOM Setup Home Lab

- In your own experimenting at home, try to set up a DICOM network. You can do this on the same machine if you want, just use different port numbers. Try to experiment with the settings we discuss.
- Recommended software:

  Workstation - KPACS - https://image-systems.biz/products/free-dicom-pacs-tools/k-pacs/

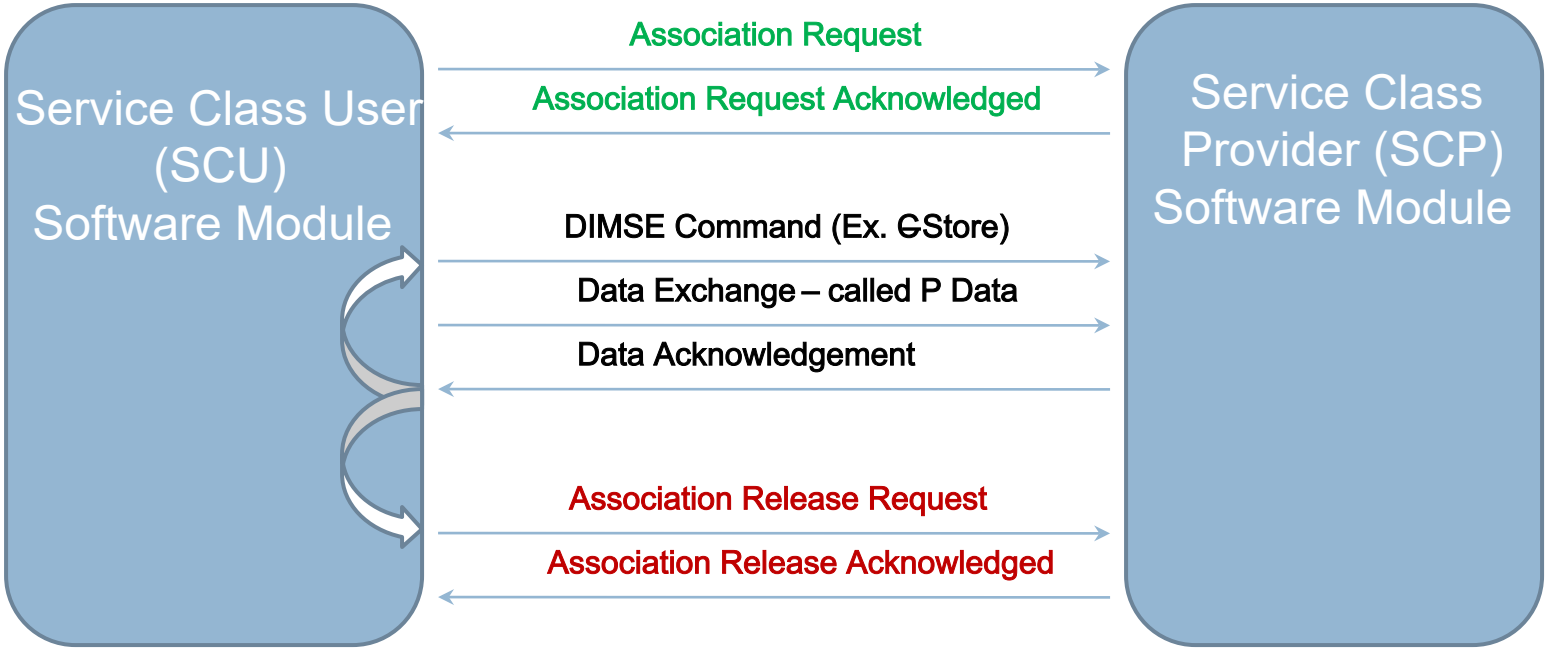
  Workstation - GinkGo CADx - http://ginkgo-cadx.com/en/

  Server - ConQuest - https://ingenium.home.xs4all.nl/dicom.html

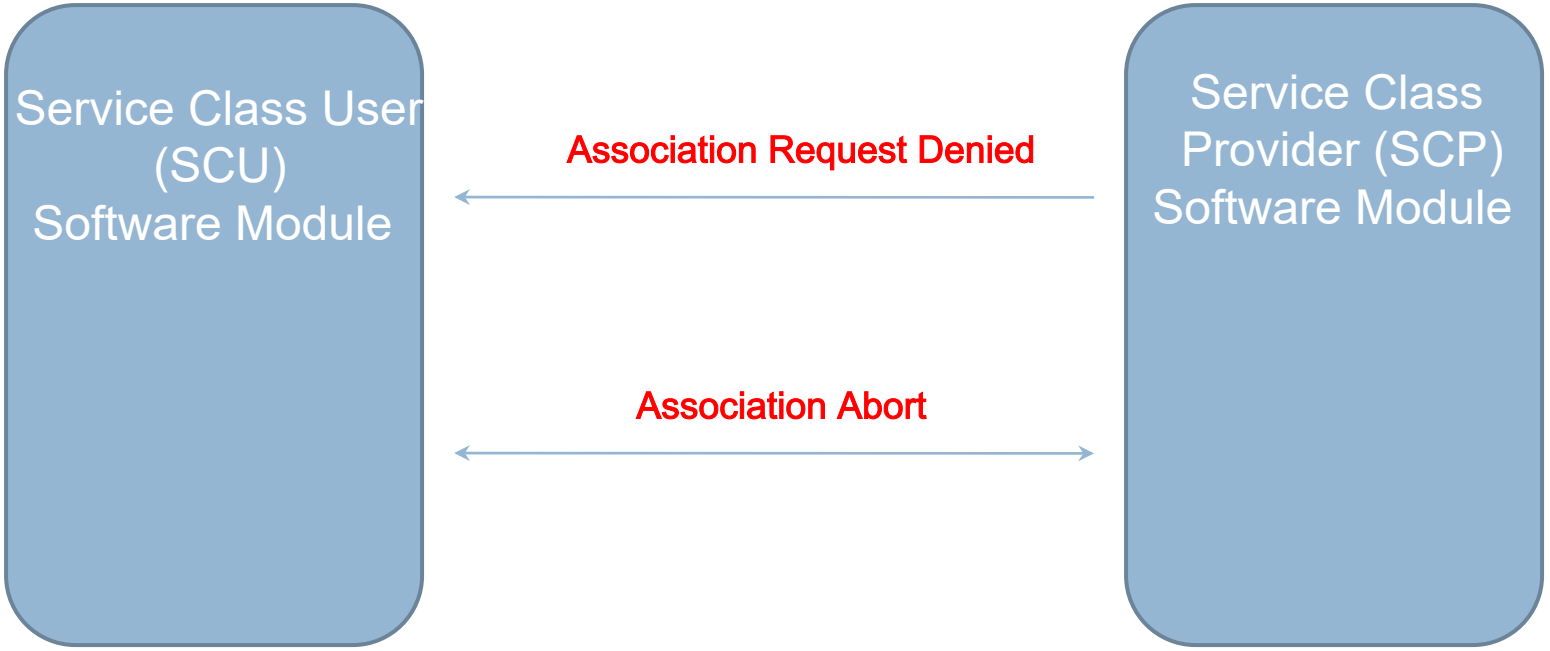
Things to look for in lab

- Look for the 3 main settings: **AE title, IP, Port**
- Try a **DICOM Ping** – Also called a Validation or **Echo**, Look at Pushes (**Store**), and Pulls (**Query / Retrieve**), Look up the term **Stale Data**
- Look for a debug or communication log
  - Watch the protocol data units, or **PDU** exchange on information and the establishing of a communication. It is in 7 steps. These are the steps you look for when troubleshooting. **Request, Acknowledge, P-Data, Release Request, Release Acknowledge**
  - May see **Request Denied** or **Abort**

Association Flow Diagram



DICOM Association Errors



What DICOM Does

- Picture / Video Archive Storage and Retrieval
- Reading of Radiological Images for Diagnosis
- Worklist imports from an HL7 EHR system
- Printing and Teleradiology Services
- Allow for image QA/QC – less repeats
- Reduced Costs when compared to film
- Complete institutional compliance to EHR

Where DICOM is growing

- More Computer Aided detection in multi-modality diagnosis via CAD systems
- Increase internal communication to HL7 via MPPS with structured reporting
- Better Integration of Voice Transcriptions for faster dictation and reporting
- Expand to other areas such as lab and surgery

Do we need a break?

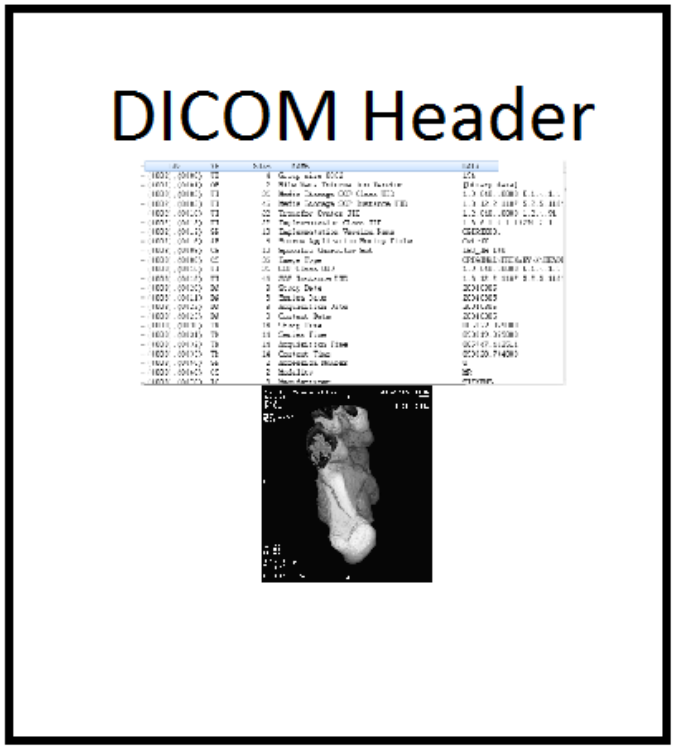
Do you have any questions?

Recall that DICOM...

- Is a public, open source, imaging platform for the pictures and video side of an **EHR**
- Requires setups on both ends of the communication; **SCU** – is the user or client, **SCP** is the server. This is a role the software plays. **Software** can do SCU, SCP, or both.
- Needs a **AE title**, **IP**, and **Port** setup on both ends! SCU & SCP
- Communications are called **Associations** – look in logs for the exchanges - look for the **PDU** exchanges
- Logs Association requests and agreed SOP's. We will study it's transfer syntax, implicit vs explicit VR and other settings now.
- We will focus on Headers and Conformance Statements.

What does a DICOM file look like

- DICOM uses a **.dcm** file format – like a .txt, or .mp3
- DICOM files are a JPG encapsulated by a header
- The **Header** has the PHI text data from the patient record and from the imaging modality
- The JPG holds the image, but the image data is at the end of the header text data.

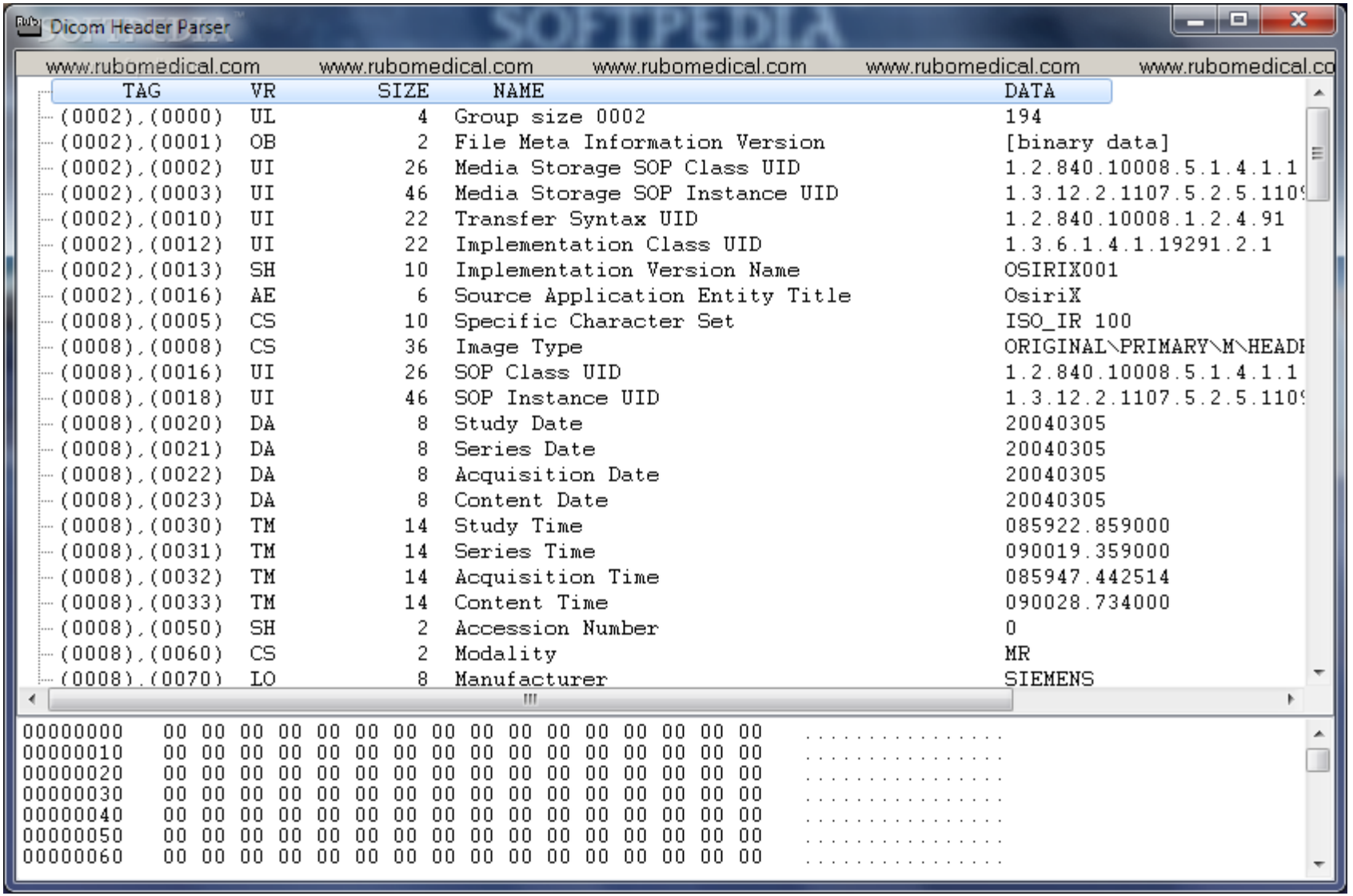


DICOM Terms

More terms used in DICOM- most often during setup

- Service - Object Pairs and Unique Identifiers
  - **SOP** tells what type of modality sent / made the file
  - **UID** is one of a kind identifier for the file and the source
- **Transfer Syntax– Big Endian vs. Little Endian**
  - Little Endian is the most common – smallest bit goes first Also, **Implicit** vs. **Explicit**.
  - Implicit = implied, Explicit = explained.
    - Implicit is flexible where Explicit is more compatible.
- Value Representation (**VR**)– Type of data
- Value Multiplicity (**VM**) – How many times the same data appears

What does a Header look like?



What type of data is in the header?

- Different tags represent different categories and items of data. Follow the link below for a listing of elements.
  http://www.sno.phy.queensu.ca/~phil/exiftool/TagNames/DICOM.html
- Headers Elements (called Tags) are in a (####,####) format. For example:
  - (0002,####) is File transfer information
  - (0008,####) is Study Information
  - (0010,####) is Patient Information
  - (0018,####) is Acquisition Information
  - (0020,####) is Series Information
  - (0028,####) is Image Display and Printing Information
- Keep in mind private data. Ex. (0009,####)

What other info is in a header?

- Remember all of the transfer syntaxes, VR and VM?
  - They are now all very important
- VR – Value Representation will tell you what type of data the header element contains
  - You can often gen the data field length with the VR Ex. The "date" VR data type is 8 numbers yyyymmdd
- VM is used to tell if there are more than one copy of each data type.

Do Headers have problems?

- Sure they do. Sometimes devices want to see specific elements, called **Required Tags**. Sometimes an element is missing and the software rejects the image
- Can we repair this?
  - Yes, but its hard. We have to repair each file using a command line program or a script language
  - PACS admins have to do this– sometimes to 150 related files in a study
  - Sometimes MIT techs have to update software to handle new elements
  - This is a compliance issue– consult the conformance statement for more information

DICOM Header Home lab

- At home, open a DICOM file editor. Examine the header and discuss some of the elements
- Use the DICOM validation toolkit
  https://www.dvtk.org/dicom/editor/
- Download anonymized DICOM files from the internet. People post some images.
- Look at the file header to see the data on the created file.

Conformance Statements

- Conformance statements are online for each machine. **Match requirements before purchase**
- They show 7 things:
  - The **product description** and intended use.
  - The compatible **SOP**'s of the device
  - **SCU and SCP** roles and in when the unit performs them
  - The **maximum** number of simultaneous **Associations**
  - The default **Endian Transfer syntaxes**
  - **Required header elements** and accepted VR's or VM's
  - The **TCP/IP compatibility** of the device ex. 10baseT

Sample Conformance Statement

Table 1-2 below outlines the DICOM Network and Media services that DICOMIZER supports.

SOP Classes	User of Service (SCU)	Provider of Service (SCP)
Verification:	Yes	Yes
Query/Retrieve:		
Study Root Information Model FIND	Yes	No
Study Root Information Model MOVE	Yes	No
Transfer:		
Storage (see Table 3-6: Storage SOP Classes)	Yes	Yes
Storage Commitment Push Model	Yes	No
Worklist Management:		
Modality Worklist Information Model - FIND	Yes	No
Modality Performed Procedure Step	Yes	No

TABLE 1-1 NETWORK SERVICES

Conformance Statements

- They are :
  - They are posted online from the manufacturer – This is a "Best practices" thing – not a legal requirement
  - They can be quite lengthy – 80 to 200 pages in length
  - They are supposed to be looked at and matched up to the hospital environment before installing a device
  - They are often overlooked when planning a network expansion
  - They can change with software revisions.
  - **Home Lab:** Go online and look up conformance statements.

That is good start to DICOM

Do you have any questions?