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Basic DICOM Concepts
with Healthcare Workflow

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PACS

MERGE™ Healthcare

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Co-Chair DICOM Standards Committee

Overview

- DICOM Terminology and Functionality!
- HL7 Terminology and Functionality!
- How DICOM & HL7 work together in the Healthcare Workflow?
- How does IHE fit in to this?

DICOM and HL7 have Common Goals

- *They allow electronic healthcare information to be:*
  - exchanged, integrated, shared, and retrieved

- *They support:*
  - clinical practice and management
  - delivery and evaluation of healthcare services

- *They were specifically created to allow:*
  - flexible, cost effective approaches, guidelines, methodologies and related services
  - for interoperability between healthcare information systems

The DICOM Standard

- ***DICOM covers:***
  - Communication protocols over networks
  - Communication via interchangeable media
  - Data content
  - Functional application services
  - Consistent display of images across devices
  - Security and configuration management
  - Physician defined look and feel of display (Hanging Protocols)
  - Identifying and grouping related information (Structured Reports)
  - Etc.

The DICOM Standard

- ***DICOM does not cover:***
  - Anything related to **implementation**
    - Database structure
    - Programming languages
    - Hardware
    - Operating systems
    - etc.
  - How and what data to process
  - Graphical user interface design

DICOM Message/File Content (Information Object Definition – IOD)

Information Entities

Patient Information

Study Information

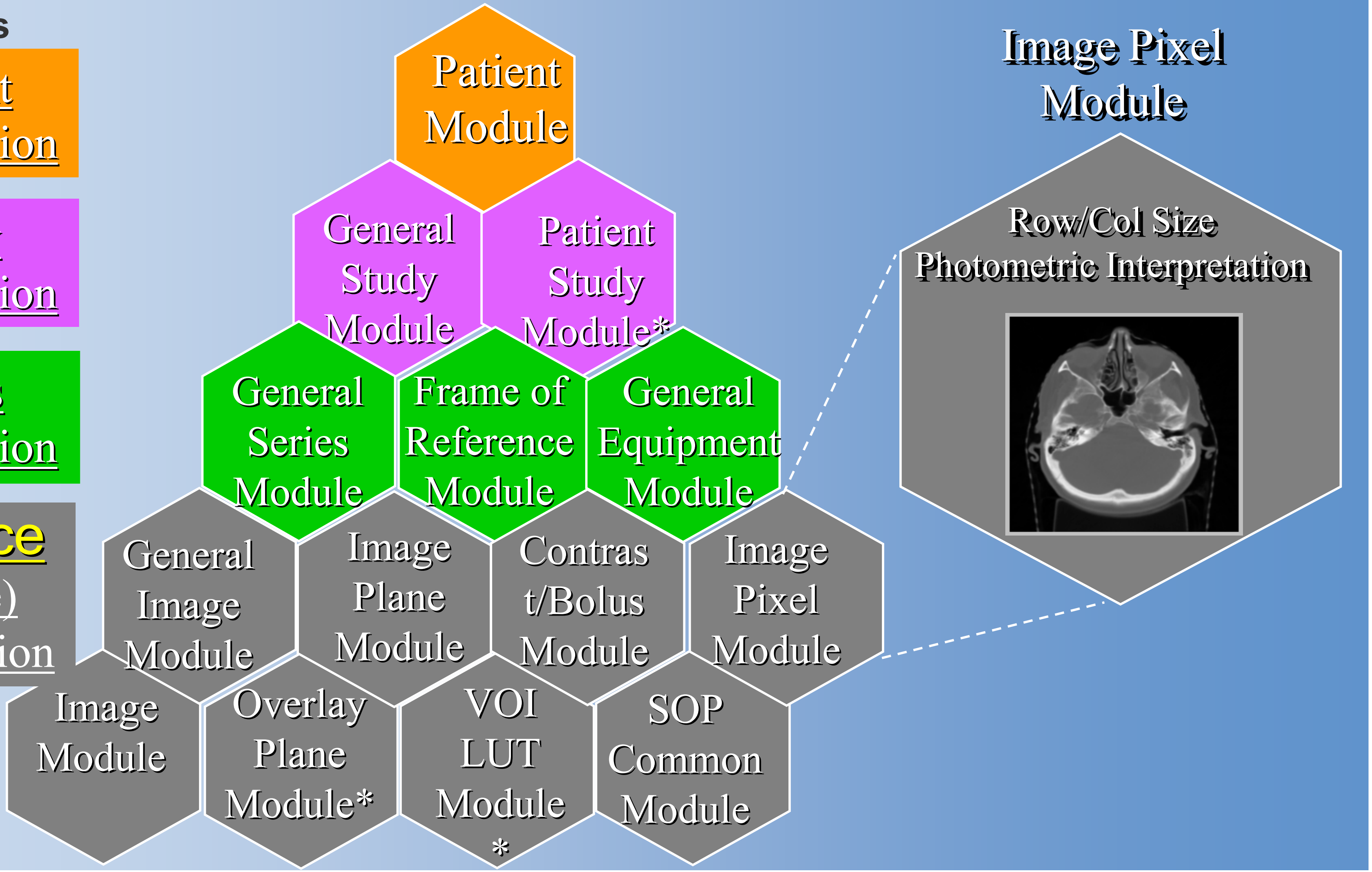
Series Information

Instance (Image) Information

Modules

Attributes

Image Pixel Module



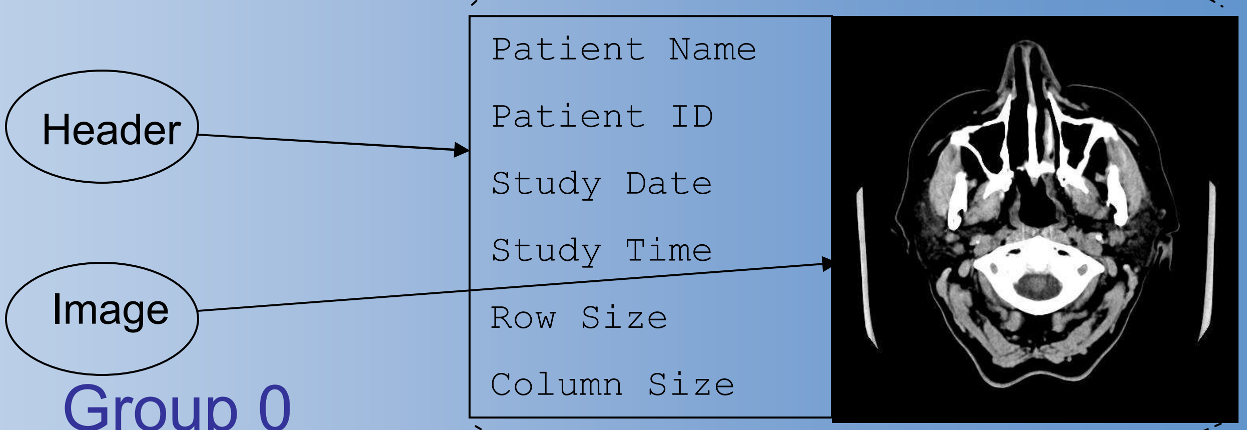
DICOM Transfer via Network or Media

DICOM [. . . . . . . F I L E . . . .]

Media Transfer = Meta Data + Data Set

Group 2

(Describes Data Set)



Group 0

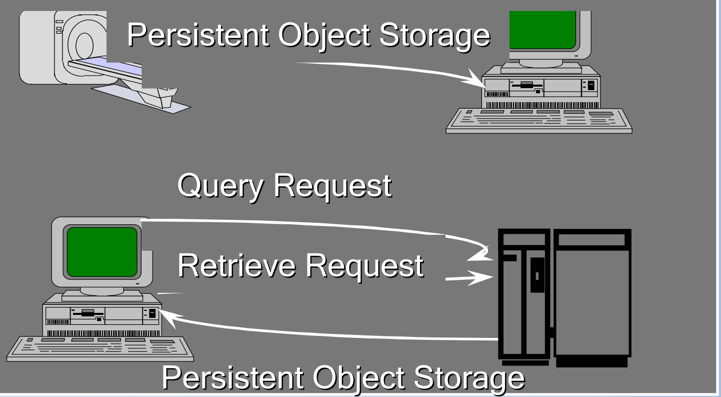
(Describes Service: C-Store)

Network Transfer = Command + Data Set

DICOM [. . . . . . M E S S A G E . . . .]

DICOM Functional Service Groups

Image Related Information Transfer



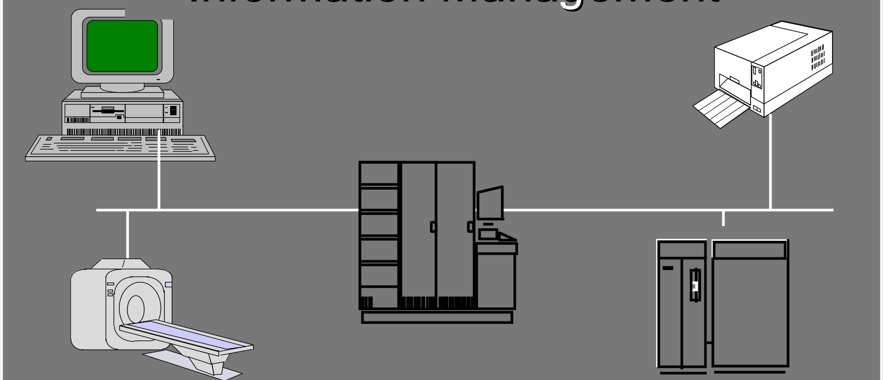
Persistent Object Storage

Query Request

Retrieve Request

Persistent Object Storage

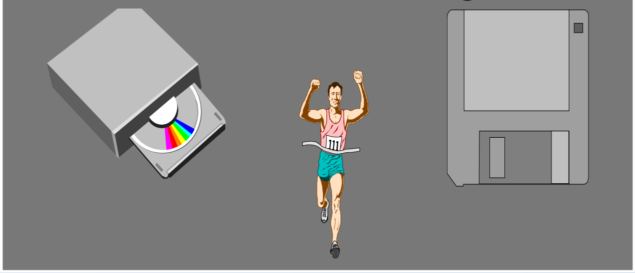
Image Related Workflow and Information Management



Print Management

Print Images

Media Interchange



Functional DICOM Application Services (SOP Classes)

- DICOM supports many functions over Networks:
  - A CT transferring CT images to a remote archive for Storage
  - An MR workstation sending 12 images and a film layout to a departmental film printer for Printing a hardcopy film
  - An Ultra Sound device querying a Radiology Information System (RIS) for a list of all the patients scheduled for the next 8 hours, along with the procedures to be performed for each of the scheduled patients

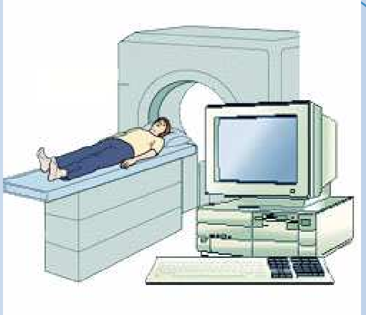
- DICOM supports storage of data for many different applications on Interchangeable Media:
  - A technologist storing a patients Digital X-Ray images on a CD so that the patient can take them to her personal doctor
  - A radiologist sending a Mammography study on a DVD to another radiologist for consultation (no network available)

Service Class

- A Service Class is a group of commonly functioning SOP Classes
  - Storage Service Class
  - Print Management Service Class
  - Study Management Service Class
- A Service Class has Rules and Behaviors that are defined and must be adhered by products that claim to be DICOM Compliant via a DICOM Conformance Statement

Network Addressing with DICOM

Handshake Requirements



ID: CT_AE1
IP: 10.3.253.8
Port: 104

Association / Negotiation

ID: WK_AE1
IP: 10.3.253.9
Port: 4006

CT Config File

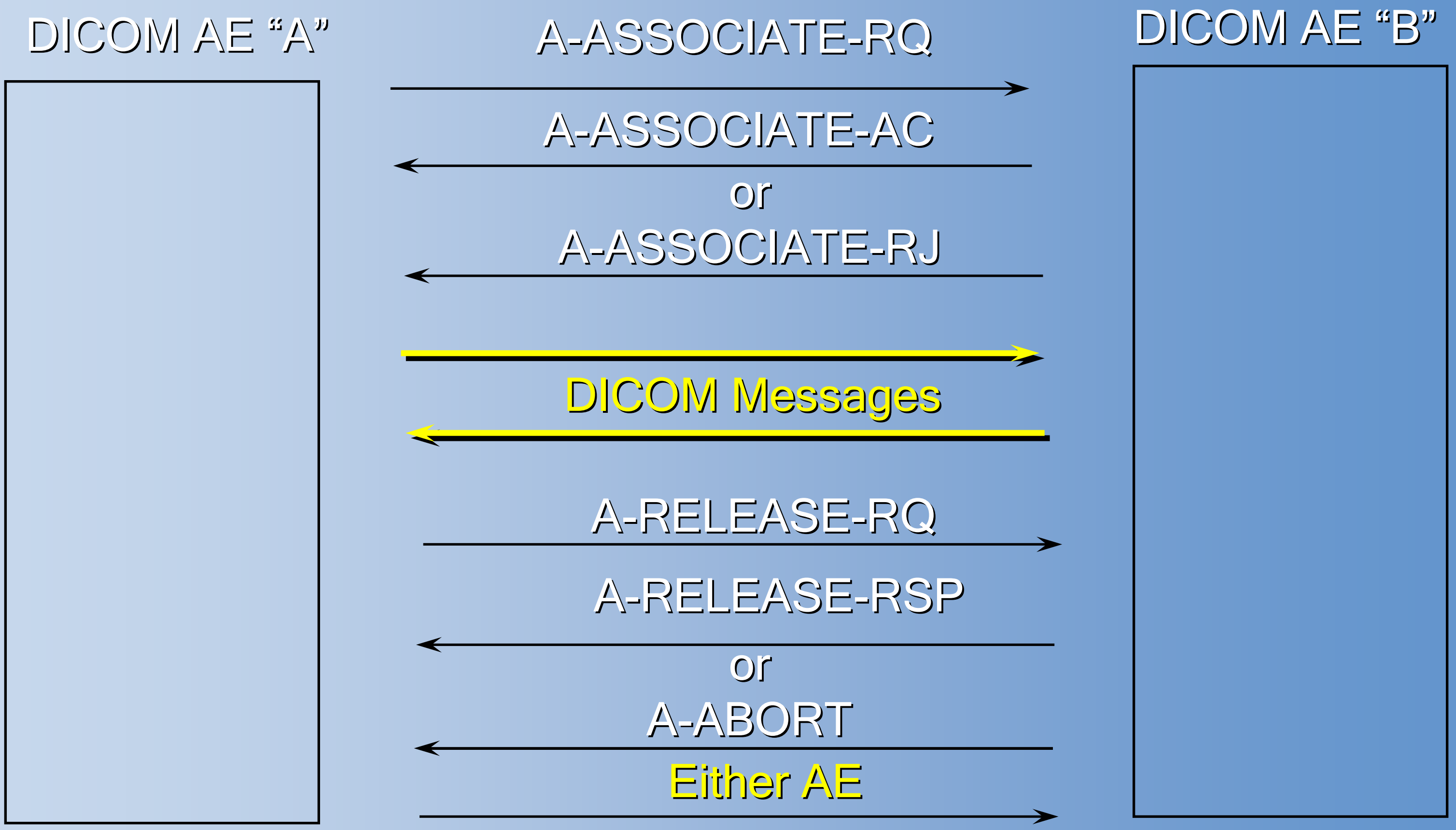
IP Addr	AE Title	Port #
10.3.253.1	Fusion	104
10.3.253.9	WK_AE1	4006

Wkstn Config File

IP Addr	AE Title	Port #
10.3.253.1	Fusion	104
10.3.253.8	CT_AE1	104

Node Level Security

Typical Network Flow



DICOM AE "A"

DICOM AE "B"

A-ASSOCIATE-RQ

A-ASSOCIATE-AC

or

A-ASSOCIATE-RJ

DICOM Messages

A-RELEASE-RQ

A-RELEASE-RSP

or

A-ABORT

Either AE

Only The AE Which Initiated The Association May Release It
However, Either May Initiate An A-ABORT

Providers and Users of DICOM Functions over the Network

- Service Class Provider (SCP):
  - Application that is Providing the Service for a particular DICOM Function (SOP Class).
  - Therefore, a device that can receive CT images over a network utilizing the DICOM protocol and stores those received CT images in its databases would be called, in DICOM terms:
    - **a CT Image Storage SOP Class**
    - **that plays the network role of an SCP**
    - **and follows the rules of the Storage Service Class.**
- Service Class User (SCU):
  - Application using a particular DICOM Function (SOP Class)

DICOM Network Roles

- Successful communication - products must play “opposite roles”
  - Receive images = Service Class Provider (SCP)
  - Send images = Service Class User (SCU)

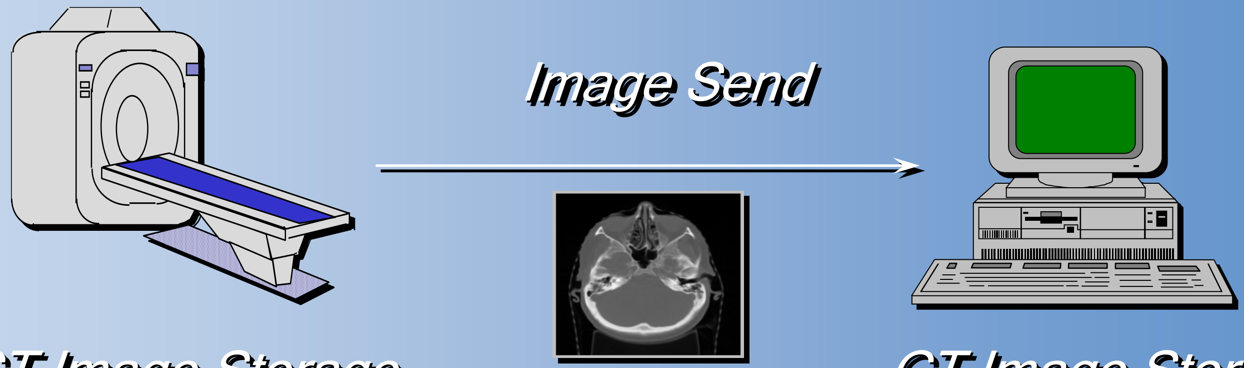
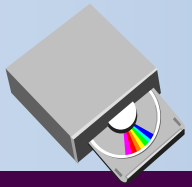


Image Send

CT Image Storage SOP Class (SCU)

CT Image Storage SOP Class (SCP)

Network roles are defined for all DICOM Functions



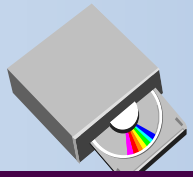
DICOM Media Interchange

DICOMDIR

- A “directory file”, which is required for DICOM Media
- Contains pointers to a list of DICOM files on a CD, DVD, MOD, Flash Memory, etc.
- Used to locate and load DICOM files from a CD, DVD, etc.
- Is a file with a Meta Header (Group 2) + Directory Attributes (Group 4) + Key Attributes for Searching (regular Data Set Attributes)

DICOM File

- Is a file with a Meta Header (Group 2) + a Data Set
- Is pointed to by DICOMDIR
- Has filename of 1-8 Characters with NO extension



DICOM Media Interchange

- Application profiles define a selection of choices applicable to a specific context for exchanging media (e.g. Cardiac profile- 512 X-ray Angio, Lossless JPEG, CD-R)
- The profile “negotiates” the media capabilities
- More than one application profile may exist on a specific media
- A device may support one or more of the following roles:
  - File-Set Creator (FSC) - initialize new media and write SOP instances
  - File-Set Reader (FSR) - read the medical directory and selected SOP instances
  - File-Set Updater (FSU) - read and update the medical directory as well as SOP instances on the media

Network and Media Interchange

- Common Image Types
  - Single image, monochrome
  - Single image, color
  - Multiframe
    - Multiple image frames embedded into pixel data
    - One data set (message / file) can contain multiple images
    - Can be monochrome or color
- Data Set Encoding
  - Uncompressed Pixel Data (Transfer Syntax = Implicit VR Little Endian (Default for Network Only), Explicit VR Little Endian and Explicit VR Big Endian)
  - Compressed Pixel Data Only with Explicit VR Little Endian encoding
    - JPEG Lossless
    - JPEG Lossy
    - RLE (Run Length Encoded)
    - JPEG 2000 (Wavelet based)
  - Compressed Data Set
    - Deflated Explicit VR Little Endian (Public Domain “ZIP” format)

DICOM Transfer over Network & Media

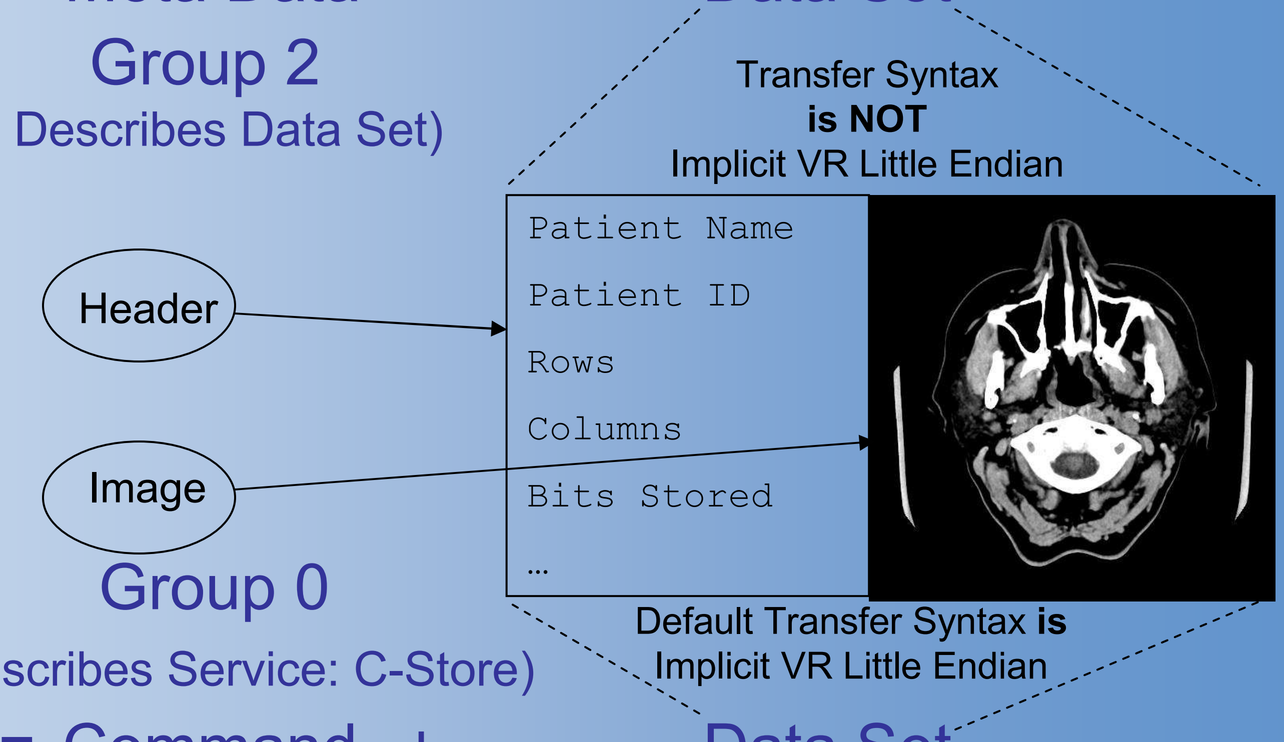
DICOM [.......FILE..........]

Media Transfer = Meta Data + Data Set

Group 2

(Describes Data Set)

Transfer Syntax
is NOT
Implicit VR Little Endian



```
Patient Name
Patient ID
Rows
Columns
Bits Stored
…
```

Group 0

(Describes Service: C-Store)

Default Transfer Syntax **is**
Implicit VR Little Endian

Network Transfer = Command + Data Set

DICOM [.....MESSAGE.......]

DICOM Conformance Statement

- ***It is Required!***
- ***It is a Public Document***
- *It Conveys a Product's DICOM Functionality*
- *It is Based on DICOM Vocabulary*
  - Abstract Syntaxes (SOP Classes), Transfer Syntaxes, SCU/SCP…..
- *It is Used to Compare Connectivity*
- *It is most Often on the Web @ Vendor Site*
- *It Does Not Address All of an Application's Capabilities, but should Address All of the Application's DICOM ones*

A Major Step Towards Interoperability

The HL7 Standard

Health Level Seven Text based Messages

- Messages are sent when an **Event** occurs
  - Patient gets registered for exam
  - Order is issued for exam
  - Patient arrives at hospital
  - Exam complete (Ready for Billing)

- How messages get where they are needed
  - Normally via a Network (TCP/IP over Ethernet or any of the hardware communication protocols, including wireless)
  - Probably via an Interface Engine
    - An intermediate application that can map HL7 messages from one interpretation to another and also route it to all the destinations that need it

HL7 Message

for Admitting a Patient as an In-Patient

```
MSH|^~\&|ADMIN|MCM|LABADT|MCM|198808181126|SECURITY|ADT^A01|MSG00001|P|2.4|<cr>
EVN|A01|198808181123||<cr>
PID|1||PATID1234^5^M11^ADT1^MR^MCM~123456789^^^USSSA^SS||JONES^WILLIAM^A^III||
19610615|M-||C|1200 N ELM STREET^^GREENSBORO^NC^27401-1020|GL|(919)379-1212|
(919)271-3434||M||PATID12345001^2^M10^ADT1^AN^A|123456789|9-87654^NC|<-cr>
NK1|1|JONES^BARBARA^K|WI^WIFE||||NK^NEXT OF KIN<cr>
PV1|1|I|2000^2012^01||||004777^LEBAUER^SIDNEY^J.|||SUR||-||ADM|A0-|<cr>
```

Patient William A. Jones, III was admitted on August 18, 1988 at 11:23 a.m.
To be attended by doctor Sidney J. Lebauer (#004777) for surgery (SUR).
He has been assigned to room 2012, bed 01 on nursing unit 2000.
His wife, Barbara K. Jones is a related family member (next of kin).

Encoding Requirements of Previous Message - ADT^A01 v2.4

Extracted From HL7 v2.4 3.3.1

This is a Message defined by Segments

ADT^A01^ADT_A01	ADT Message	Chapter
MSH	Message Header	2
EVN	Event Type	3
PID	Patient Identification	3
[PD1]	Additional Demographics	3
[{ ROL }]	Role	12
[{ NK1 }]	Next of Kin / Associated Parties	3
PV1	Patient Visit	3
[PV2]	Patient Visit - Additional Info.	3
[{ ROL }]	Role	12
[{ DB1 }]	Disability Information	3
[{ OBX }]	Observation/Result	7
[{ AL1 }]	Allergy Information	3
[{ DG1 }]	Diagnosis Information	6
[DRG]	Diagnosis Related Group	6
[{		
PR1	Procedures	6
[{ ROL }]	Role	12
}]		
[{ GT1 }]	Guarantor	6
[{		
IN1	Insurance	6
[IN2]	Insurance Additional Info.	6
[{ IN3 }]	Insurance Additional Info - Cert.	6
[{ ROL }]	Role	12
}]		
[ACC]	Accident Information	6
[UB1]	Universal Bill Information	6
[UB2]	Universal Bill 92 Information	6
[PDA]	Patient Death and Autopsy	3

= Required
[ ] = Optional
{ } = Repeatable

PID - Patient ID Segment Table (partial)

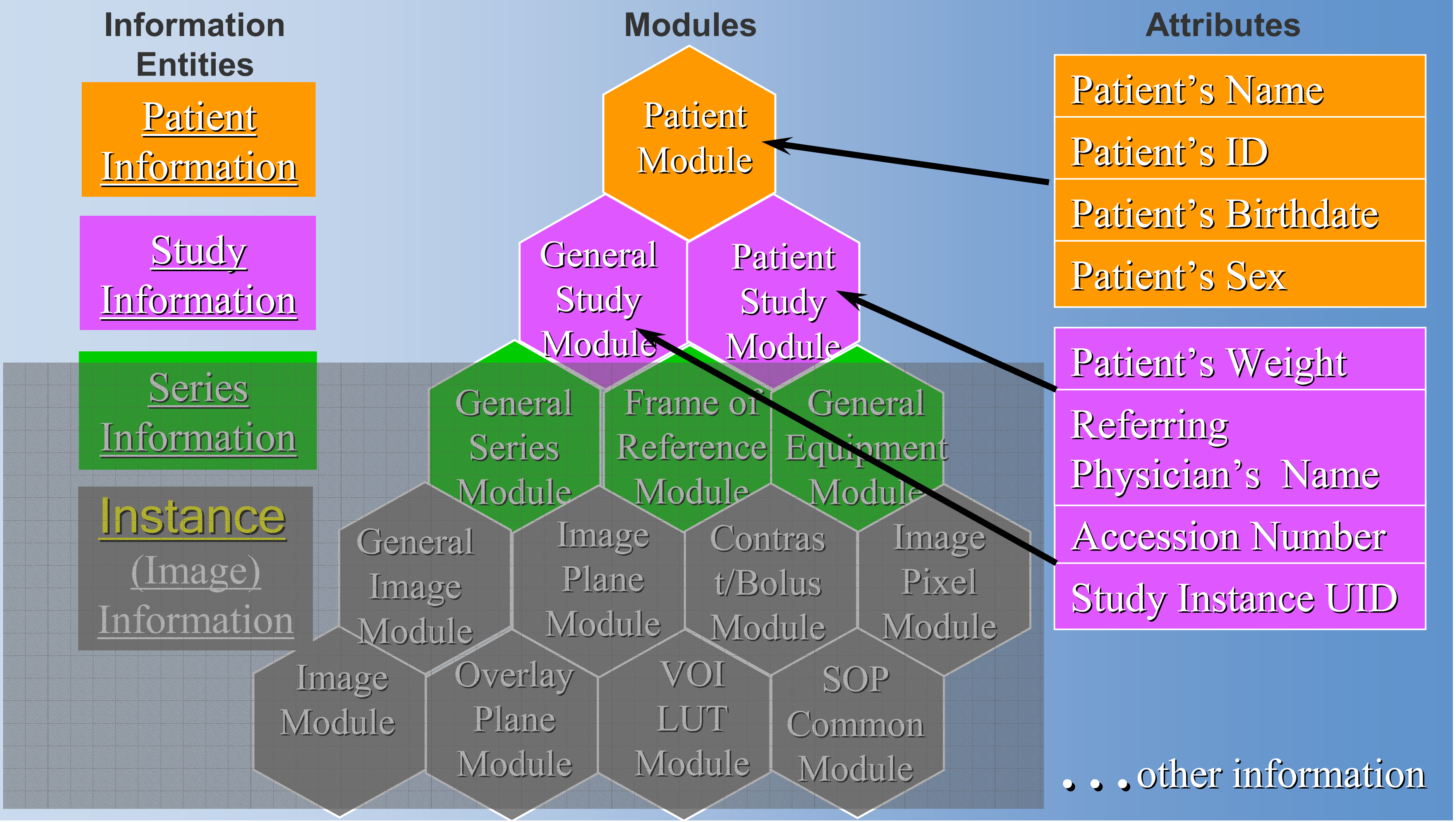
SEQ	LEN	DT	OPT	RP/#	TBL#	ITEM#	ELEMENT NAME
1	4	SI	O			00104	Set ID - Patient ID
2	20	CX	O			00105	Patient ID (External ID)
3	20	CX	R	Y		00106	Patient ID (Internal ID)
4	20	CX	O	Y		00107	Alternate Patient ID - PID
5	48	XPN	R	Y		00108	Patient Name
6	48	XPN	O			00109	Mother’s Maiden Name
7	26	TS	O			00110	Date/Time of Birth
8	1	IS	O		0001	00111	Sex
9	48	XPN	O	Y		00112	Patient Alias
10	1	IS	O		0005	00113	Race
11	106	XAD	O	Y		00114	Patient Address
12	4	IS	O			00115	County Code
13	40	XTN	O	Y		00116	Phone Number - Home

```
MSH|^~\&|ADMIN|MCM|LABADT|MCM|198808181126|SECURITY|ADT^A01|MSG00001|P|2.4<cr>
EVN|A01|198808181123<cr>
PID|1||PATID1234^5^M11^ADT1^MR^MCM~123456789^^^USSSA^SS||JONES^WILLIAM^A^III||
19610615|M-||C|1200 N ELM STREET^^GREENSBORO^NC^27401-1020|GL|(919)379-1212|
(919)271-3434||M||PATID12345001^2^M10^ADT1^AN^A|123456789|9-87654^NC|<-cr>
NK1|1|JONES^BARBARA^K|WI^WIFE||||NK^NEXT OF KIN<cr>
PV1|1|I|2000^2012^01||||004777^LEBAUER^SIDNEY^J.|||SUR||-||ADM|A0-|<cr>
```

Primary HL7 Messages used for PACS

- ADT – Admit, Discharge, Transfer Message
  - Used for registering a patient for a specific exam
  - Used for admitting a patient into the hospital
  - Used for discharging a patient from the hospital
- ORM – Order Message
  - Used for ordering a specific exam
- ORU – Report Message
  - Used to send a report to a place where it is needed

Link HIS/RIS Data Into Images



Information Entities

Patient Information

Study Information

Series Information

Instance (Image) Information

Modules

Patient Module

General Study Module

Patient Study Module

General Series Module

Frame of Reference Module

General Equipment Module

General Image Module

Image Plane Module

Contrast/Bolus Module

Image Pixel Module

Image Module

Overlay Plane Module

VOI LUT Module

SOP Common Module

Attributes

Patient's Name

Patient's ID

Patient's Birthdate

Patient's Sex

Patient's Weight

Referring Physician's Name

Accession Number

Study Instance UID

. . . other information

The e-Health Workflow

- Referrals / Orders
- Reimbursement

External

Patients

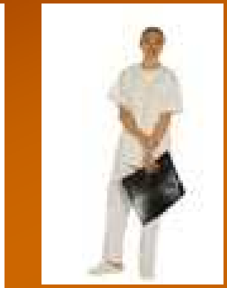
Referring Physicians

Payers

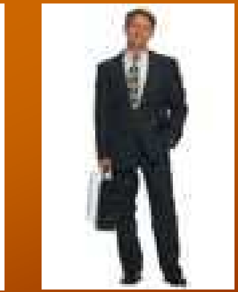
WORKFLOW

Internal

Admin


Tech

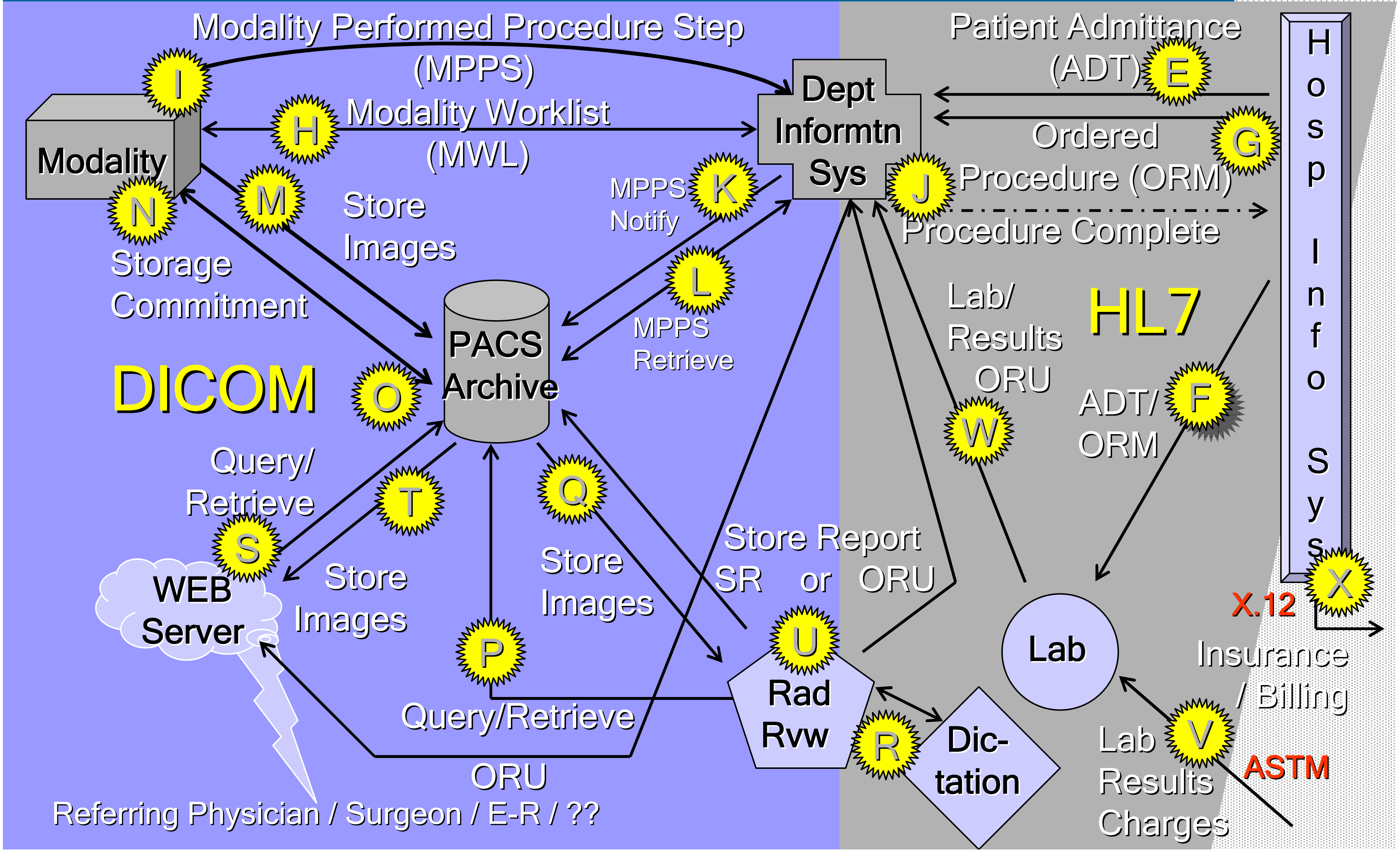
Radiologist


Finance

- Images
- Reports
- Claims

A Sample Workflow

MERGE eFILM



IHE

Integrating the **H**ealthcare **E**nterprise

Initiative promoting and supporting the integration of systems in the healthcare enterprise

Improve the efficiency and effectiveness of clinical practice by improving information flow

IHE information partially extracted from slides of SCAR2003 IHE presentations

What is IHE?

- Standards based communication between healthcare systems
  - **HL7** and **DICOM** are two of these standards
- **Actors:** perform communications roles between systems
- **Transactions:** messages sent between systems
- **Integration Profiles:** grouping of actors and transactions to perform specific workflows

Usage of IHE

- Integration Profiles
  - Integrated solutions that support specific workflows in Radiology, Information Technology, Cardiology, Laboratory, Radiation Oncology, etc.
- User and Vendor Communications
  - Integration Profiles provide common language for discussion
    - To help specify which specific clinical functions are needed within a product
    - To help identify what kind of information must be sent or received to accomplish those clinical functions

IHE brings Reality to the Healthcare Workflow

- It is not a standard, but utilizes Standards.
- It is really a blueprint trying to solve tricky workflow problems.
- There is enormous intellectual property in IHE and extremely thorough solutions to problems.
- Tapping into the experience and knowledge is free.
- In many ways IHE is the lessons learned from all those who have tried to go soft-copy in the past decade and ran into stumbling blocks, plus much more.

DICOM Does Not Stand Alone!

Many standards and initiatives work together to help us implement the electronic information workflow within our healthcare environments.

DICOM is just one of those standards.