



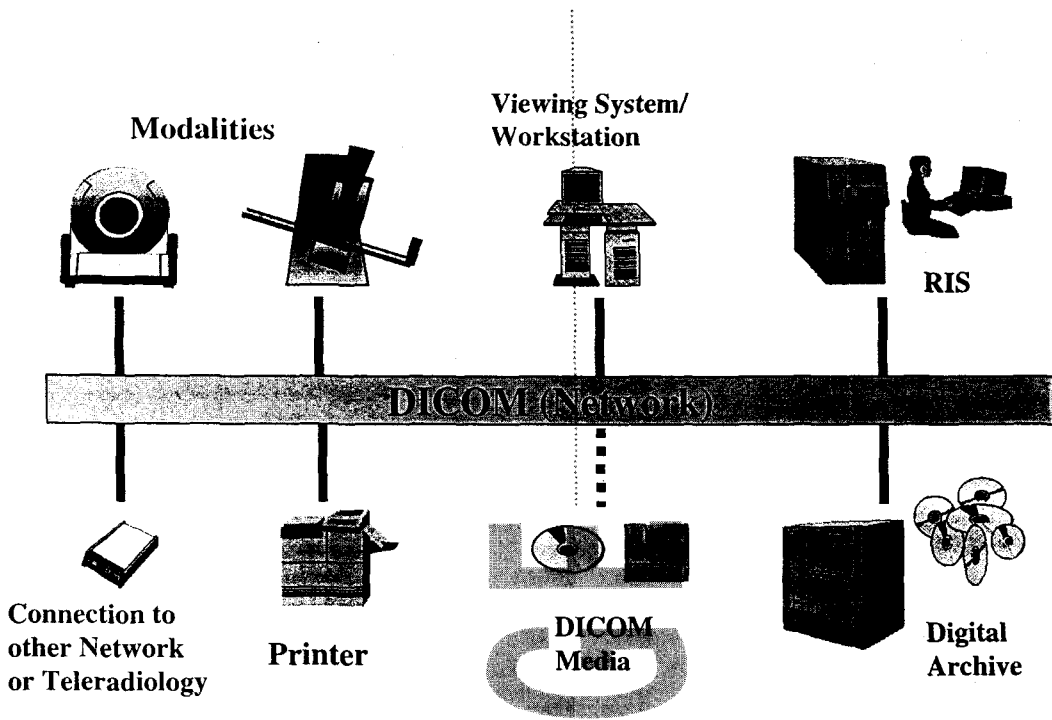
Digital Imaging Communications in Medicine(DICOM)

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■ Presentation Overview

- **DICOM 3.0 History**
- **Network Environment**
- **Object-oriented design**
- **Information Object Definition**
- **DICOM Service Elements**
- **SOP Class**
- **Protocols (DUL for TCP/IP)**
- **Conformance**
- **References**

■ Equipment with DICOM Connection



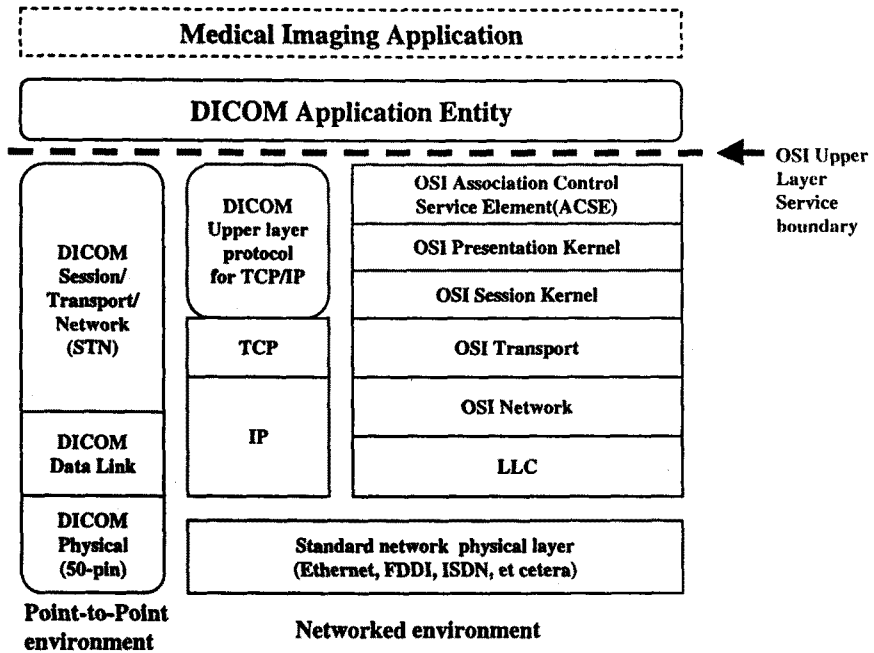
■ DICOM History

- ACR(American College of Radiology) & NEMA(National Electrical Manufactures Association) forms a joint committee (1982)
- ACR-NEMA Version 1.0 (1985)
- ACR-NEMA Version 2.0 (1988)
- DICOM 3.0 (1993) by ACR-NEMA WG VI

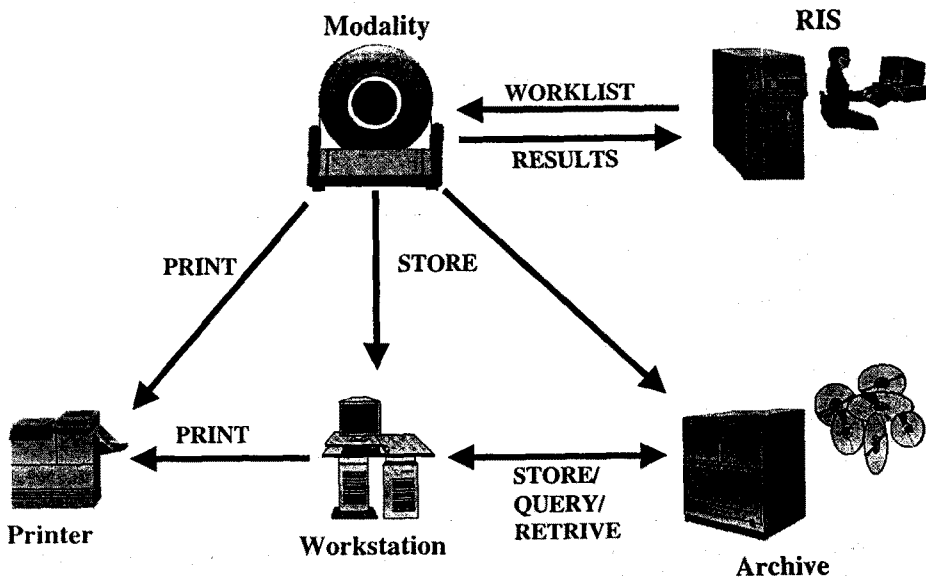
■ DICOM 3.0

- **DICOM is a standard for the communication of medical images and associated information**
- **More than only Image Transfer**
- **Provide an interface for network support**
 - Encourage open systems interconnection of imaging equipment over standard networks (OSI 7 Layer or TCP/IP)
- **Conform fully with ISORM**
- **Conformance Statements**
- **Incorporates the concept of object-oriented design**
 - DICOM relies on explicit and detailed models of how the "things"(patients, images, reports, etc) involved in radiology operations are described and how they are related : Entity-Relationship (E-R Model)

■ DICOM Version 3.0 Protocol Architecture



■ Simple Services Example



■ Object-Oriented Modeling and Design

- Object-orientation is a technique for system modeling (an integrated software and hardware system or an organization)
- Object-oriented modeling and design is a way of thinking about problems using models organized around real-world concepts
- The fundamental construct is the object, which combines both data structure(Attributes) and behavior(Operations) in a single entity
- Using object-orientation as a base, we model the system as a number of discrete objects that interact
- An Object-oriented approach is characterized by identity, classification, polymorphism and inheritance.

■ Object-Oriented Modeling and Design

- Identity means that data is quantized into discrete, distinguishable entities called objects
- Classification means that objects with the same data structure(attribute) and behavior(operations) are grouped into a class
- Polymorphism means that the same operation may behave differently on different classes
- Inheritance is the sharing of attributes and operations among classes based on a hierarchical relationship

Person objects



Abstract into

Person Class

Attributes
name
age
sex
Operations
walk
talk
sing

Polygon objects



Abstract into

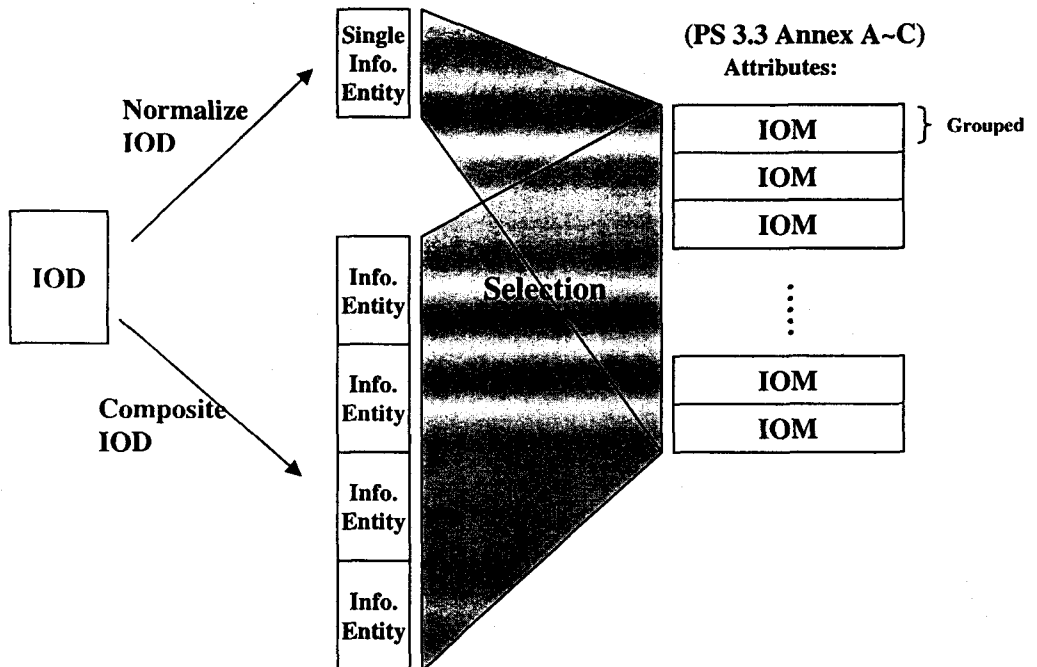
Polygon Class

Attributes
vertices
border color
fill color
Operations
draw
erase
move

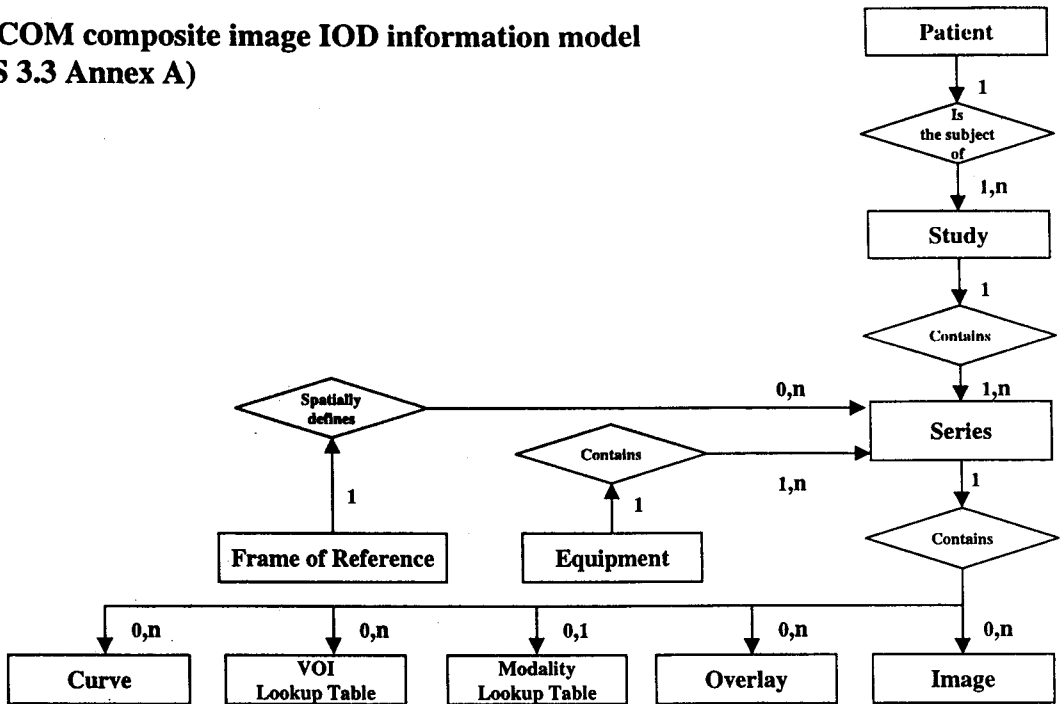
■ Information Object Definitions (IOD)

- **Abstract definition of real-world entities applicable to communication of digital medical images**
- **Derived by E-R Model**
- **Attributes of an IOD describe the properties of a real-world object instance**
(Patient : Patient Name, Age, Sex)
- **Normalized Information Object Definition**
(Attributes inherent in the real-world entity)
- **Composite Information Object Definition**
(Attributes which are inherent in the real-world entity and related to the real-world entity)

■ Relationship between IODs and Attributes



■ **DICOM composite image IOD information model (PS 3.3 Annex A)**



■ **DICOM Message Service Element (DIMSE)**

- Service Elements are the operations allowed on IOD
- DIMSE-C Service are services applicable only to a Composite IOD and provide only operation service
- DIMSE-N Service are services applicable only to a Normalized IOD and provide both operation and notification service

DIMSE	
DIMSE-C	DIMSE-N
C-STORE	N-EVENT-REPORT
C-GET	N-GET
C-MOVE	N-SET
C-FIND	N-ACTION
C-ECHO	N-CREATE
	N-DELETE

■ Service-Object Class Pair (SOP Class)

- A Service-Object Pair (SOP) Class is defined by the union of an IOD and a DIMSE Service Group(DSG)
- Each SOP Class has an UID used for unique identification
- Normalized SOP Classes are defined as the union of a Normalized IOD and a set of DIMSE-N Services
- Composite SOP Classes are defined as the union of a Composite IOD and a set of DIMSE-C Services
- Extended SOP Class, Specialized SOP Class, Private SOP Class by extending IOD

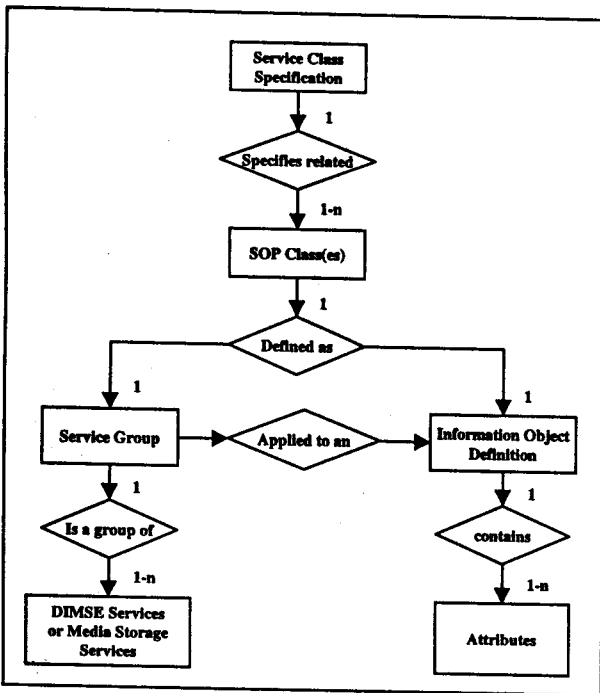
Standard SOP Classes (STORE-C)

SOP Class Name	SOP Class UID
Computed Radiography Image Storage	1.2.840.10008.5.1.4.1.1.1
CT Image Storage	1.2.840.10008.5.1.4.1.1.2
Ultrasound Multi-frame Image Storage	1.2.840.10008.5.1.4.1.1.3
MR Image Storage	1.2.840.10008.5.1.4.1.1.4
Nuclear Medicine Image Storage	1.2.840.10008.5.1.4.1.1.5
Nuclear Medicine Image Storage	1.2.840.10008.5.1.4.1.1.6
Secondary Capture Image Storage	1.2.840.10008.5.1.4.1.1.7
Stand-alone Overlay Storage	1.2.840.10008.5.1.4.1.1.8
Stand-alone Curve Storage	1.2.840.10008.5.1.4.1.1.9
Stand-alone Modality LUT Storage	1.2.840.10008.5.1.4.1.1.10
Stand-alone VOILUT Storage	1.2.840.10008.5.1.4.1.1.11

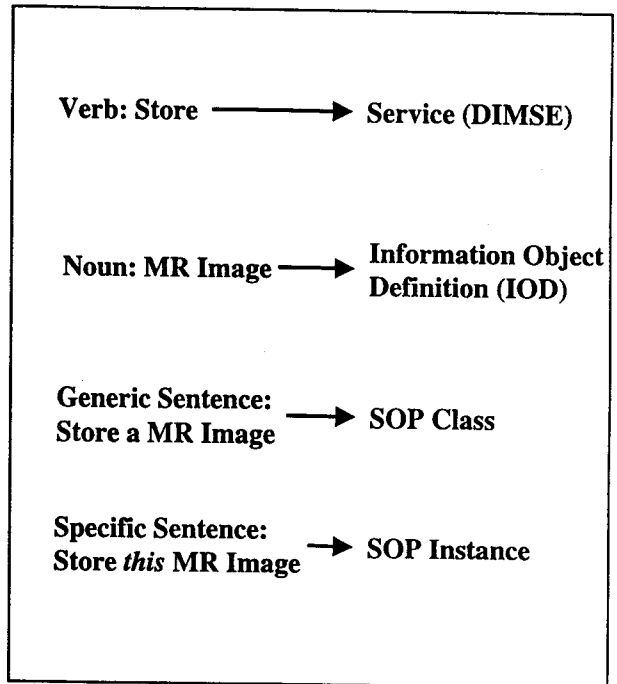
■ Service-Object Class Pair (SOP Class)

- The information object and the service class are the two fundamental components of DICOM
- Information objects define the core contents of medical imaging
- Service classes define what to do with those contents
- The service classes and information objects are combined to form the functional units of DICOM
- The SOP class represents the elemental unit of functionality defined by DICOM
- The SOP Class becomes a SOP instance when the attributes in the information object and the variables (parameters) of the service class are filled in by values
- The process of DICOM communication involves the exchange of SOP instances with use of DICOM messages

■ **DICOM Information Model**

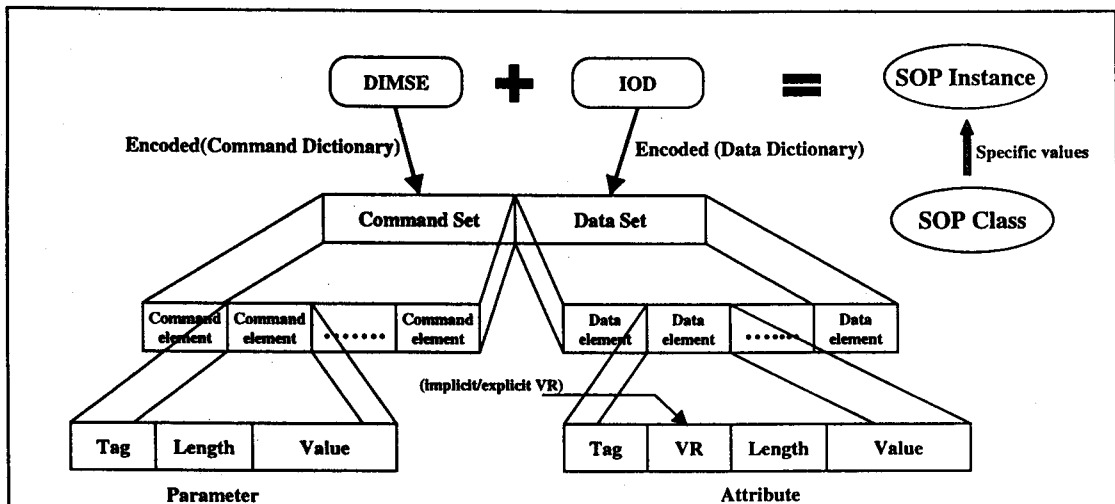


■ **Analogy between constructing a sentence and building a DICOM SOP Class**



■ **DICOM Message**

- The DICOM Message is the communication version of a SOP Class
- A message consists of Command Set and Data Set
- The Command Set uses and provides the specified service
- The Data Set is made up of the properly encoded information object instance
- A DICOM Message is encapsulated into a P-DATA-TF PDU (Protocol)



■ DICOM Message

C-STORE parameters

DIMSE-C Parameter Name	Description
Message ID	Identify this operation
Message ID Being Responded To	Message ID corresponding Req.
Affected SOP Class UID	SOP Class for the storage
Affected SOP Instances UID	SOP Instance UID stored
Priority	LOW, MEDIUM, or HIGH
Move Originator Application Entity Title	DICOM AE Title of C-MOVE
Move Originator Message ID	C-STORE sub-operation
Data Set	Attributes of the SOP Instance stored
Status	Error/success notification

Data Dictionary (Part 6)

Tag	Name	VR	VM
(0080,0000)	Group Length	UL	1
(0080,0012)	Instance Creation Date	DA	1
(0080,0016)	SOP Class UID	UI	1
(0080,0018)	SOP Class Instance UID	UI	1
(0010,0010)	Patient's Name	PN	1
(0010,0020)	Patient ID	LO	1
(0010,0030)	Patient's Birth Date	TM	1
(0010,2154)	Patient's Telephone Numbers	UI	1-n
(0018,0081)	Echo Time	DS	1
(0018,0082)	Inversion Time	DS	1
(0018,2154)	Echo Number(s)	DS	1-n

Command Dictionary (Part 7-Annex E)

Message Field	Tag	VR	VM	Description of Field
Group Length	(0000,0000)	UL	1	The even number of bytes from the end of the value field to beginning of the next group
Affected SOP Class UID	(0000,0002)	UI	1	The affected SOP Class UID associated with the operation
Requested SOP Class UID	(0000,0003)	UI	1	The requested SOP Class UID associated with the operation
Command Field	(0000,0100)	US	1	0001H(C-STORE-RQ), 8001H(C-STORE-RSP) 0010H(C-GET-RQ), 8010H(C-GET-RSP) 0020H(C-FIND-RQ), 8020H(C-FIND-RSP) 0030H(C-ECHO-RQ), 8030H(C-ECHO-RSP) 0120H(N-SET-RQ), 8120H(N-SET-RSP)
Message ID	(0000,0110)	US	1	Implementation-specific value which distinguishes this message from other message
Message ID Being Responded To	(0000,0120)	US	1	Shall be set to the value of the Message ID used in associated request Message
Priority	(0010,0030)	US	1	LOW(0002H), MEDIUM(0000H), HIGH(0001H)

■ DIMSE Services and DIMSE Protocols

DIMSE-C and Protocol

Service	Protocol
C-STORE	C-STORE-RQ, C-STORE-RSP
C-FIND	C-FIND-RQ, C-FIND-RSP, C-CANCEL-FIND-RQ
C-GET	C-GET-RQ, C-GET-RSP, C-CANCEL-GET-RQ
C-MOVE	C-MOVE-RQ, C-MOVE-RSP, C-CANCEL-MOVE-RQ
C-ECHO	C-ECHO-RQ, C-ECHO-RSP

DIMSE-N and Protocol

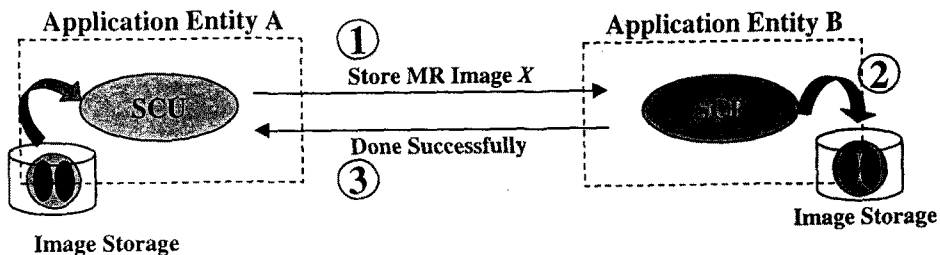
Service	Protocol
N-EVENT-REPORT	N-EVENT-REPORT-RQ, N-EVENT-REPORT-RSP
N-GET	N-GET-RQ, N-GET-RSP
N-SET	N-SET-RQ, N-SET-RSP
N-ACTION	N-ACTION-RQ, N-ACTION-RSP
N-CREATE	N-CREATE-RQ, N-CREATE-RSP
N-DELETE	N-DELETE-RQ, N-DELETE-RSP

■ Application Entity(AE)

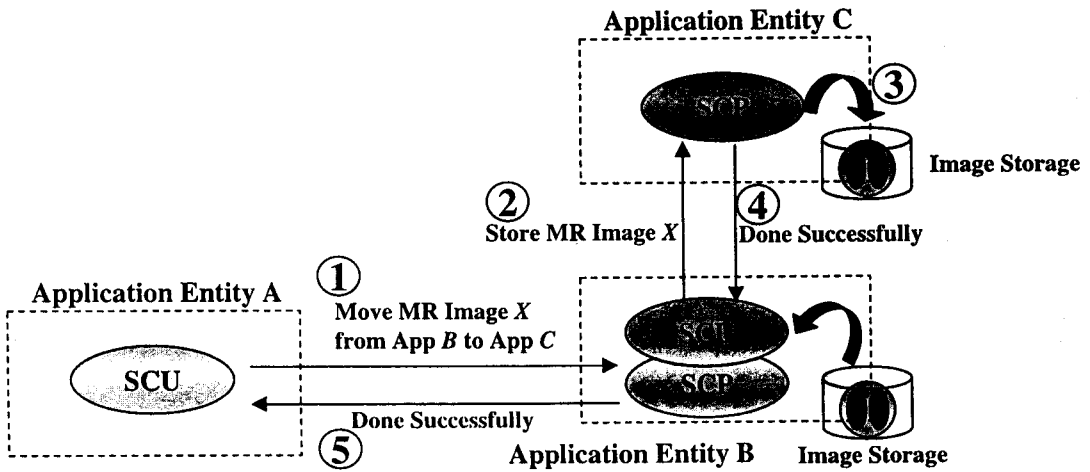
- AE is a part of a process that deals with the communication
- AE has a Application title (Symbolic Name)
- An Association between AEs is established before exchanging information
- The Association is used to negotiate the type of data to be exchanged, and how data will be encoded
- Parameters for the Association :
 1. Application Context (UID = 1.2.840.10008.3.1.1.1)
 2. Presentation Context(Abstract syntax : SOP Class UID+ Transfer syntax (VR, Byte ordering, Compression format) : UID)
 3. User Information
 - a) Maximum Length of PDV in byte
 - b) Implementation UID (required)
 - c) Implementation Version Name (optional)
 - d) SCP/SCU role (optional)

■ SCU/SCP Roles

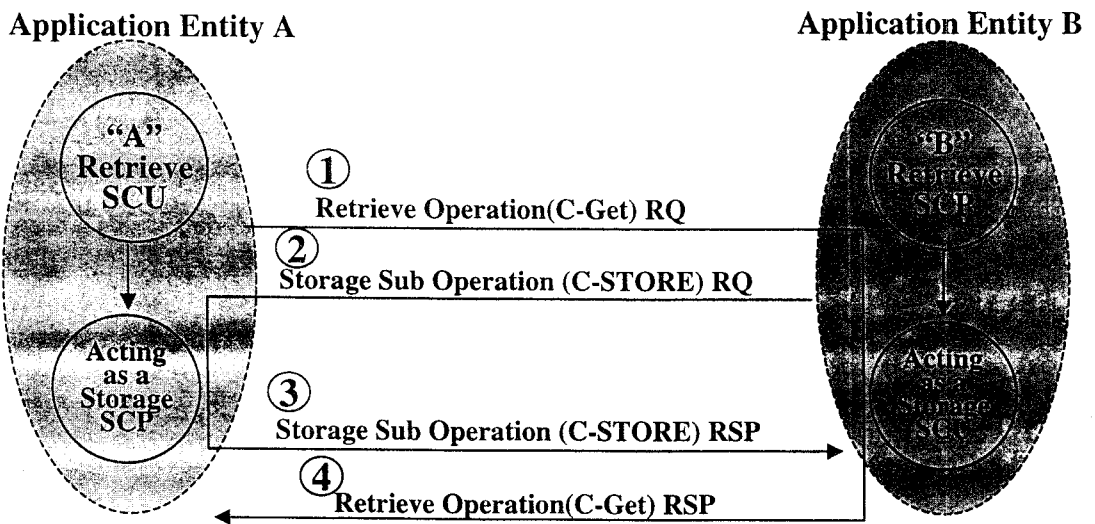
- An AE acting as a Client is Called SCU(Service Class User)
- An AE acting as a Server is Called SCP(Service Class Provider)
- The AE is not limited to 1 role but it can be both SCU and SCP



■ SCU/SCP Role Combined



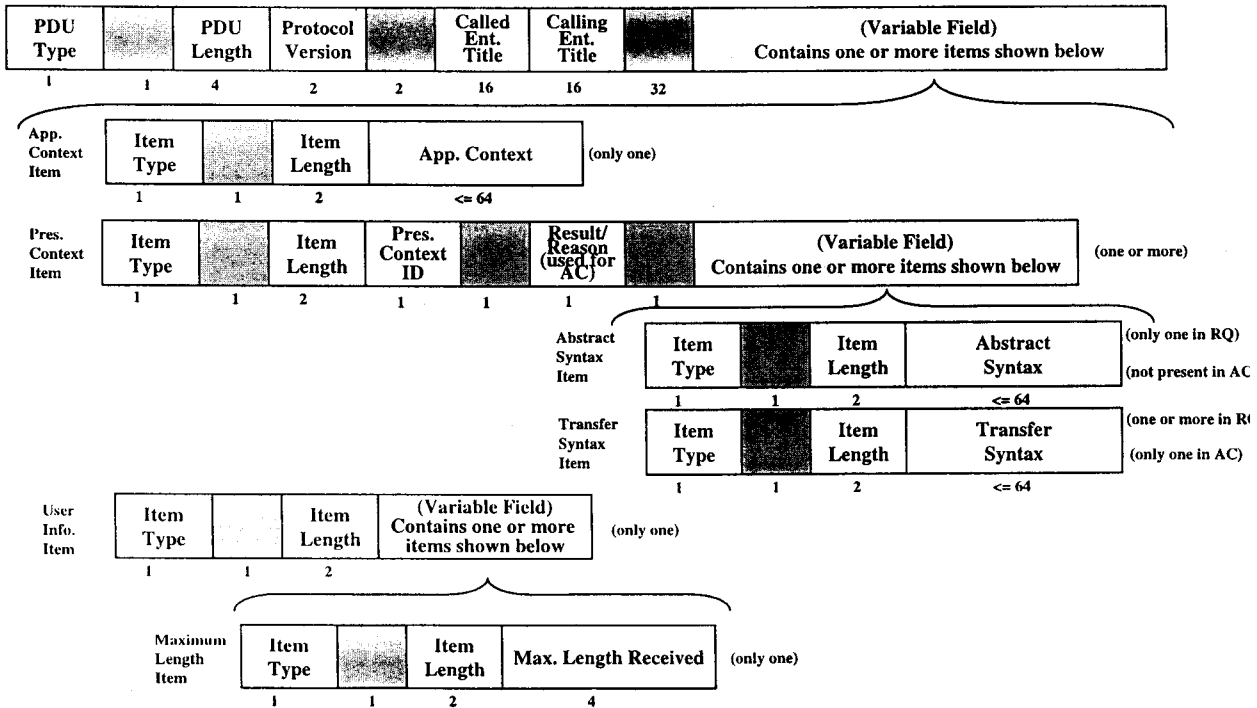
■ SCU/SCP Role Combined



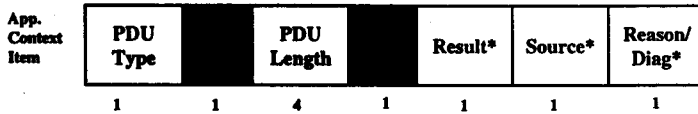
■ DICOM Upper Layer Protocol for TCP/IP

- a) A-ASSOCIATE-RQ PDU
- b) A-ASSOCIATE-AC PDU
- c) A-ASSOCIATE-RJ PDU
- d) P-DATA-TF PDU
- e) A-RELEASE-RQ PDU
- f) A-RELEASE-RP PDU
- g) A-ABORT PDU

■ A-ASSOCIATE-RQ/A-ASSOCIATE-AC PDU

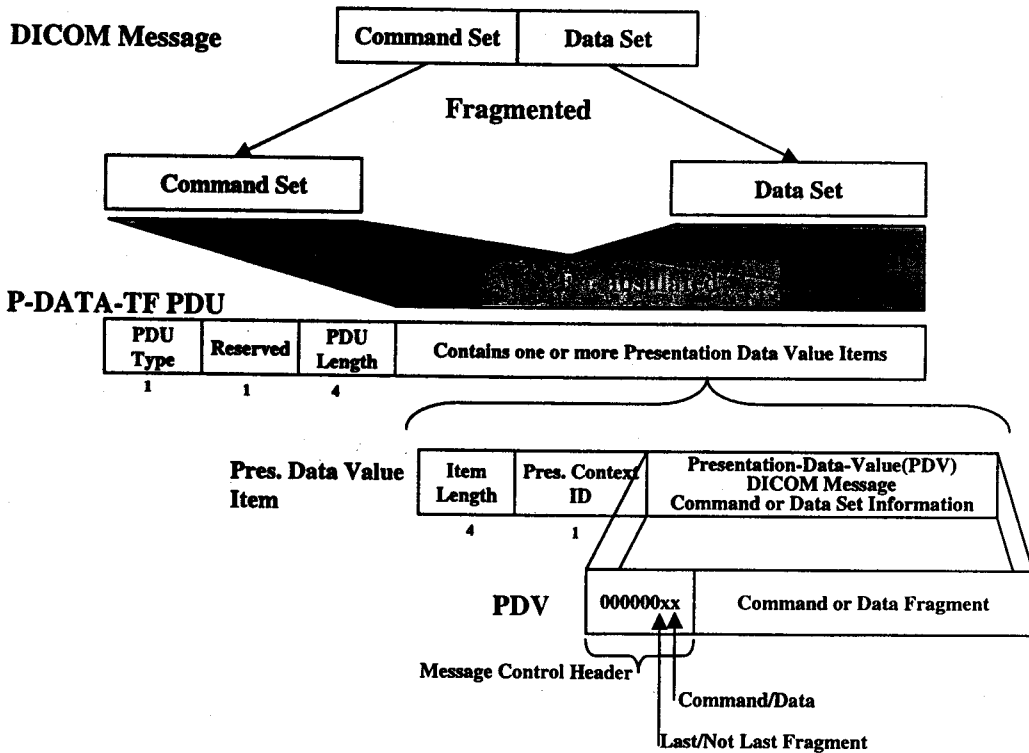


■ A-ASSOCIATE-RJ/A-RELEASE-RQ/ A-RELEASE-RP/A-ABORT PDUS

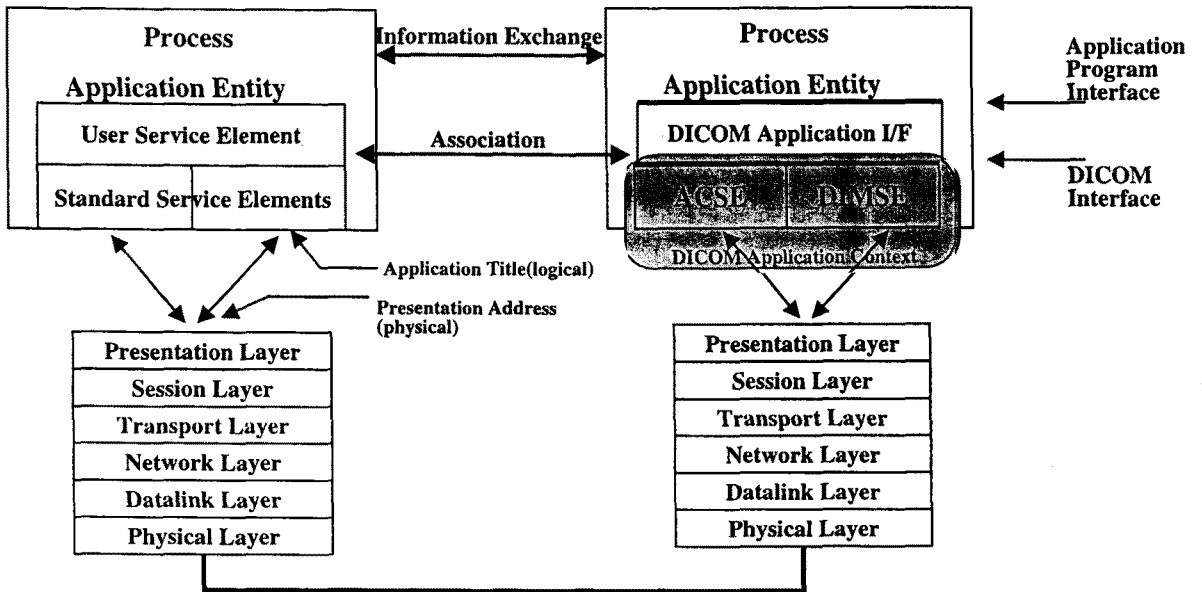


*NOTE : Depending on the specific PDU this field may be used or reserved

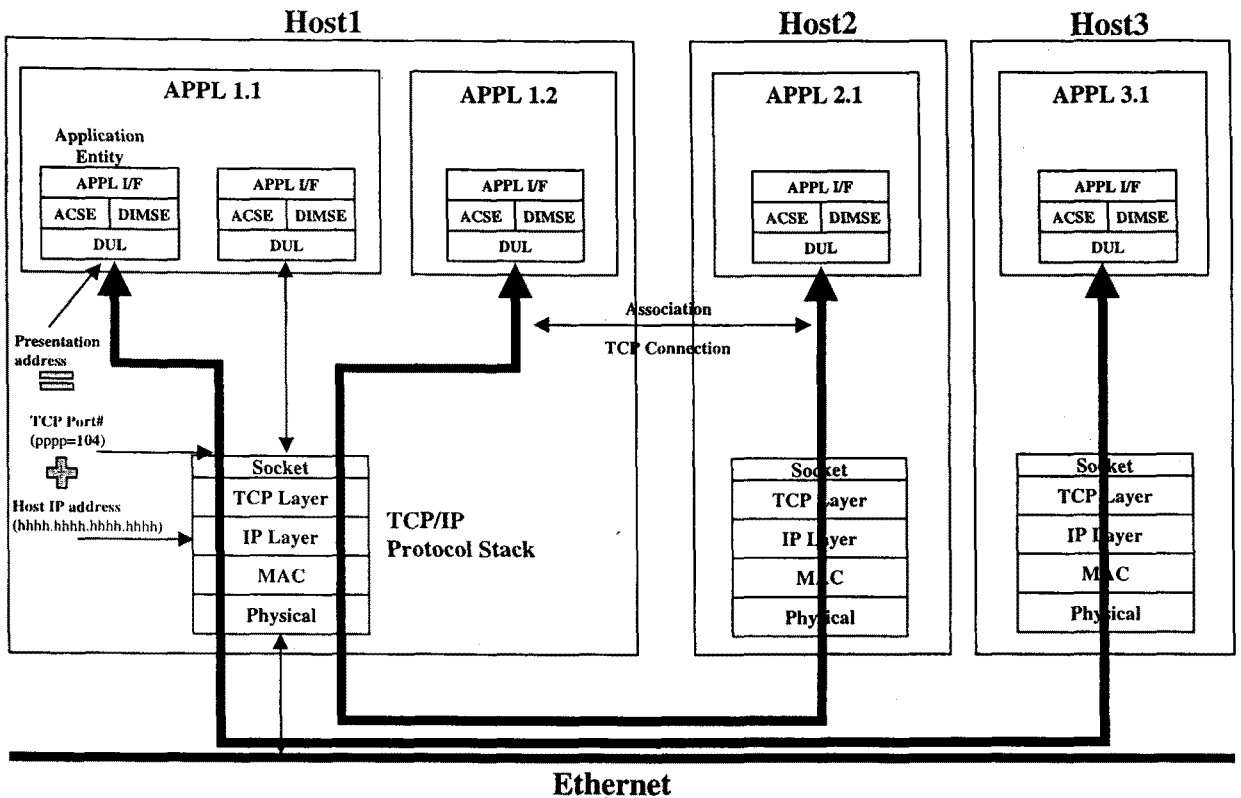
■ P-DATA-TF PDU



■ AE with OSI 7 Layer



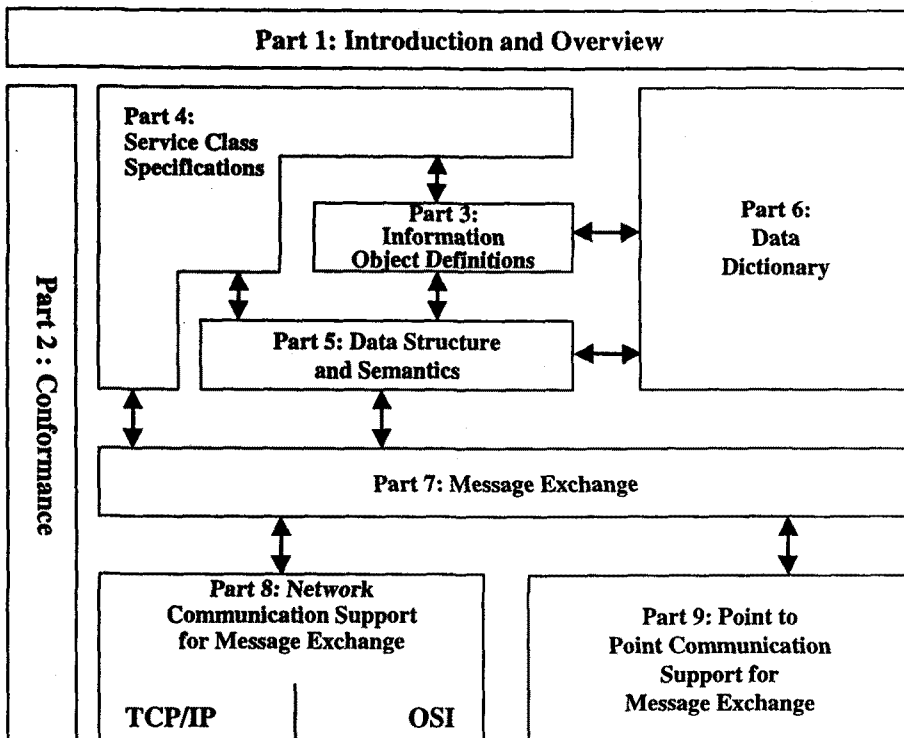
■ AE with TCP/IP



■ Conformance

- DICOM can support many different types of images, transfer syntaxes, service roles, and the like
- Conformance is voluntary
- Conformance Statement describes exactly how a device or a software conforms to the standard
- A conformance statement follows a standard structure
- The Conformance Statement includes
 - a) the implementation model of the application
 - b) the presentation context to be used
 - c) the manner in which associations are to be handled
 - d) the SOP classes to be supported
 - e) the communication profiles to be used
 - f) any extension, specialization, or privatization to be used
- GE SIGNA PROFILE (ID/Net v3.0)

■ Relationships of Parts 1-9 of the DICOM Standard



■ References

- **DICOM 3.0 (Part1~Part13)**
- *http://www.xray.psu.edu/dicom/dicom_home.htm*
- *<http://www.merge.com>*
- *RadioGraphics*
- **Object-Oriented Modeling and Design:**
James Rumbaugh
Prentice-Hall International, Inc.