

# Digital Imaging COmmunications in Medicine

## DICOM in a Nutshell

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ICS - ARC

PHILIPS MEDICAL SYSTEMS

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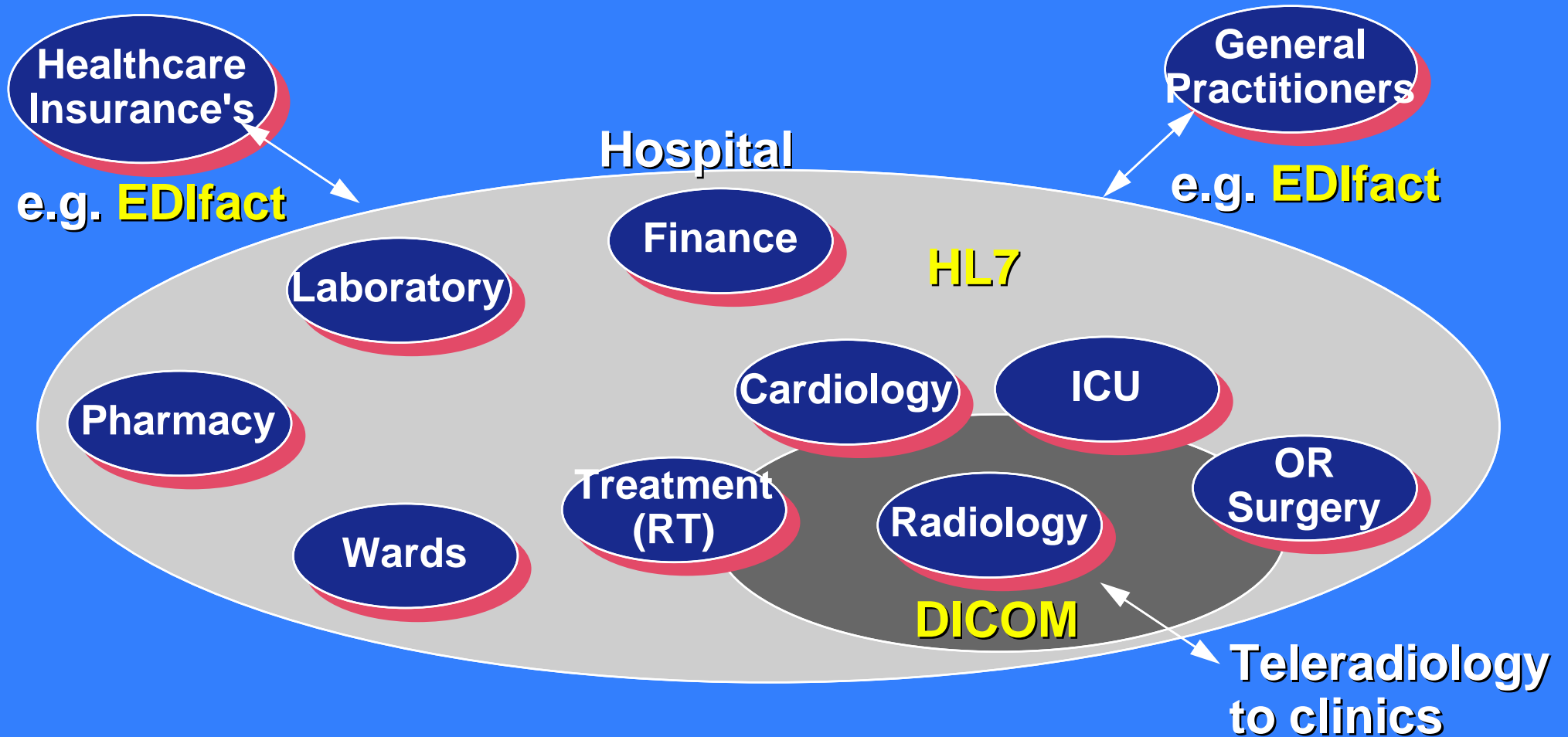
**PHILIPS**

# Presentation Overview

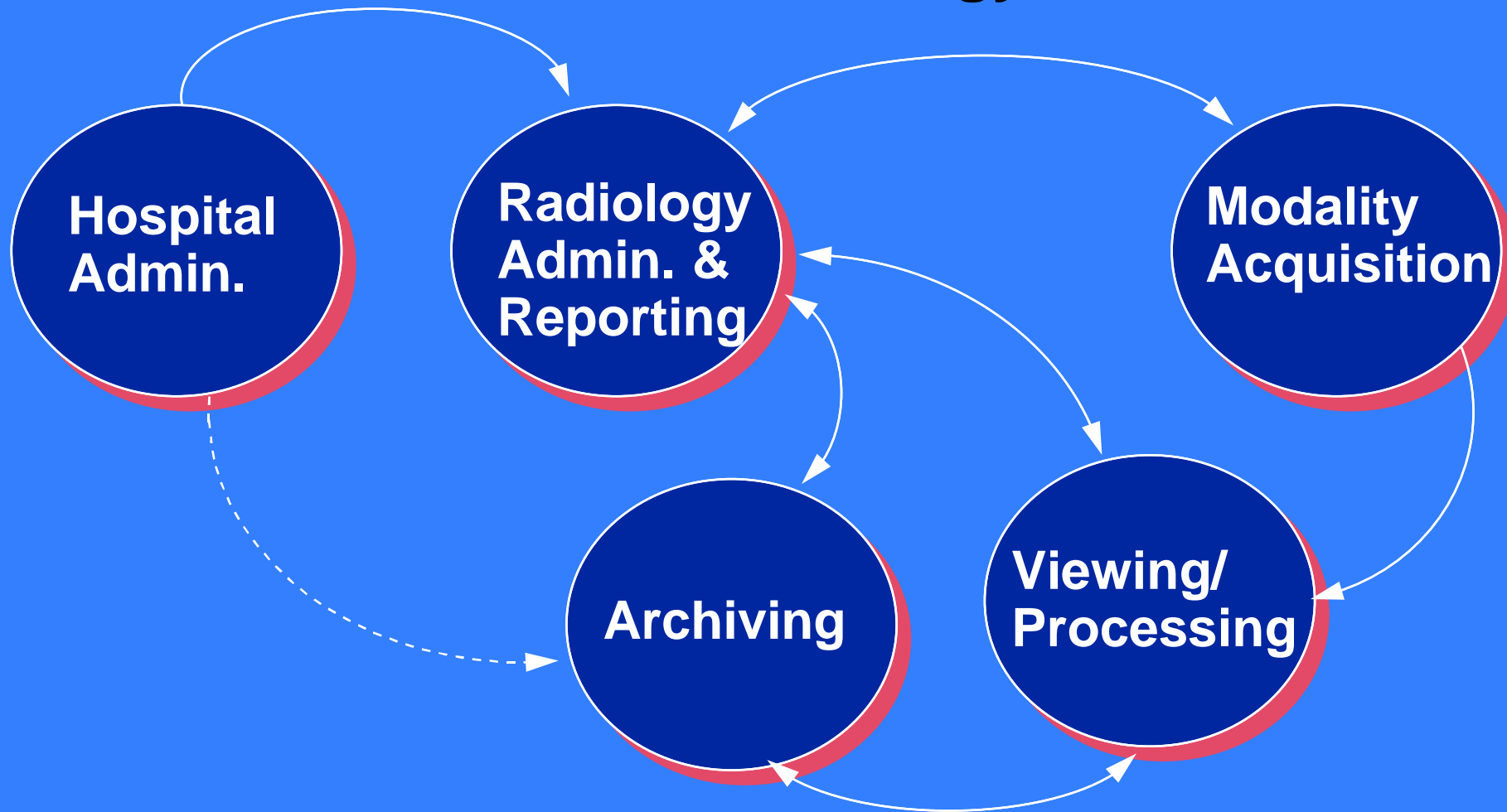
- **Scope and Goal of DICOM**
- **Functionality (Services)**
- **Information Model and Objects**
- **Protocol, Client/Server and Negotiation Aspects**
- **Conformance Statements**
- **RIS Example**
- **Connectivity Versus Interoperability**
- **References**



# Healthcare Communication Standards



# Different Domains in Radiology



# Why DICOM?

- **Need for Digital Image Generation**
- **More need for Digital Transfer/Archiving (PACS)**
- **More need for Post-Processing**
- **More need for Cross-Vendor Compatibility**
- **Need for Communication via Networks/Media**



# DICOM Goals

**By:**

- **Definition of Semantics & Syntax of Digital Images and Messages**
- **Defininition of Conformance Requirements for DICOM Implementations**

**Arrange:**

- **Interchange of Medical Images and Related Data**
- **Create an Open Environment among Vendors**
- **Enable/Facilitate Interoperability**



# DICOM - ACR-NEMA

## History:

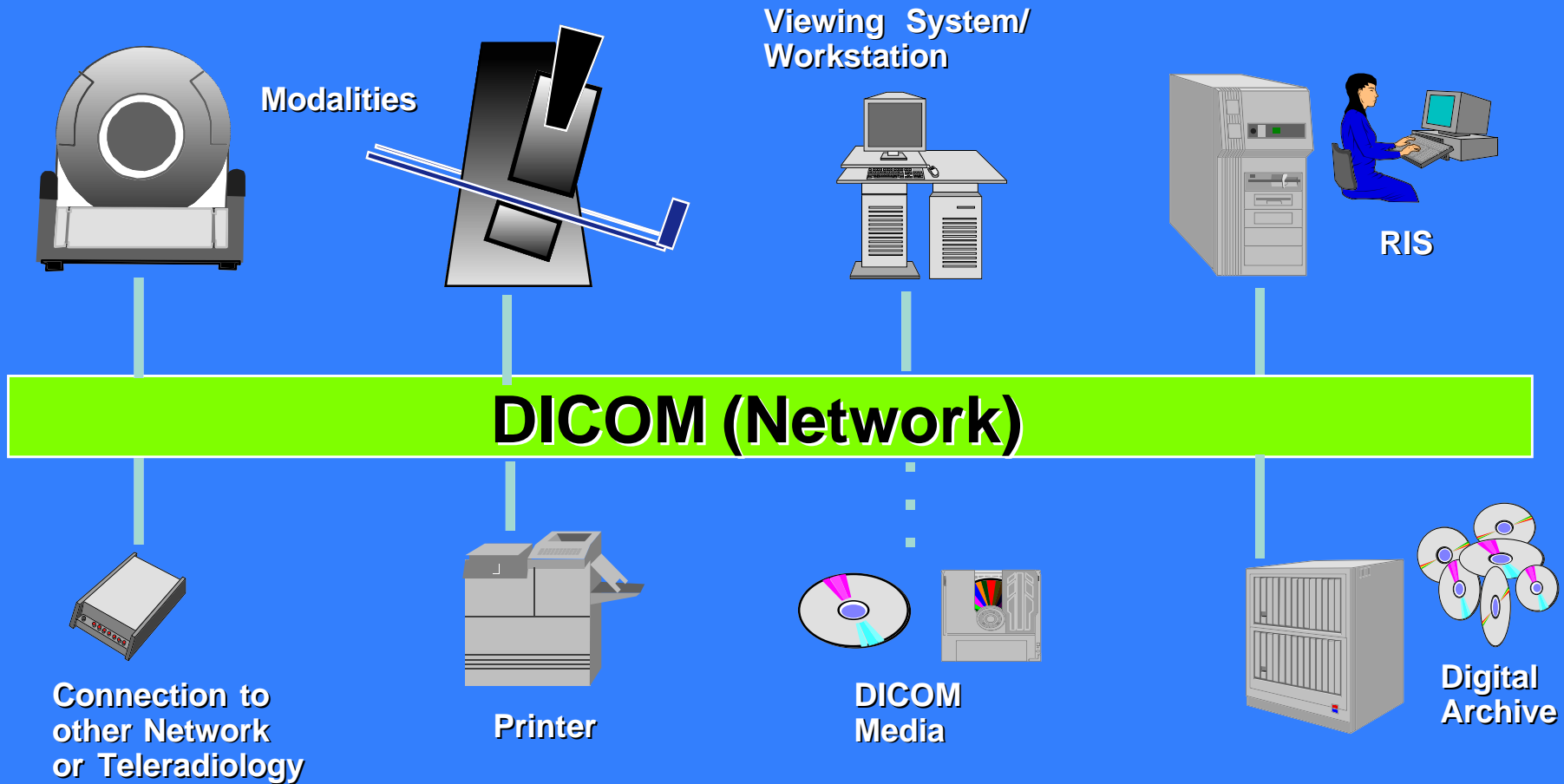
- ACR-NEMA 1.0 and 2.0 in 1985 - 1988
- DICOM (3.0) first parts in 1993
- Continuous Development on DICOM (also with HL7)

## DICOM (3.0) improvements w.r.t. ACR-NEMA 2.0:

- Networking and Connection Negotiation
- More than only Image Transfer
- Formal Conformance Statements
- More Complete/More Acceptance

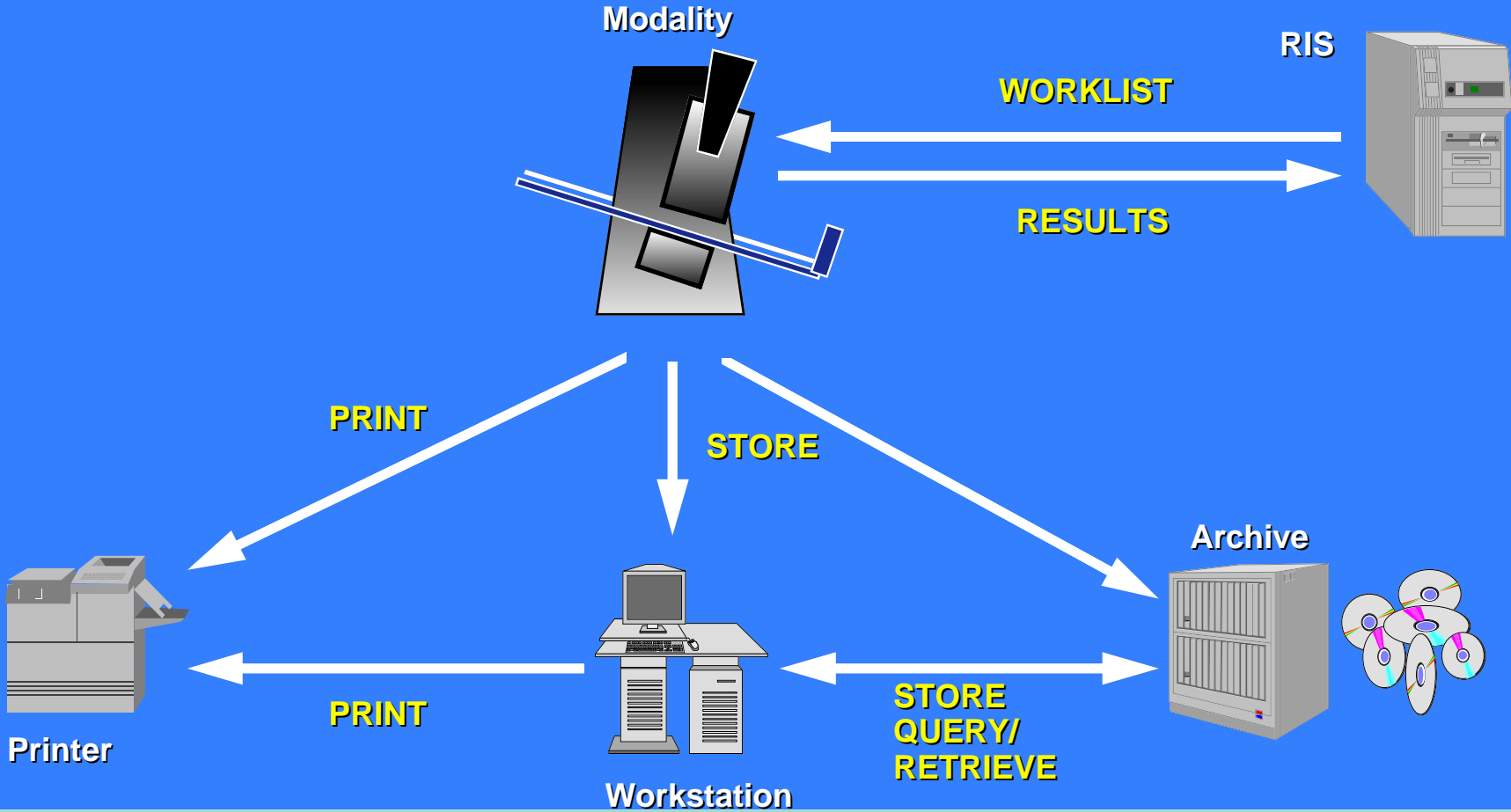


# Example of Equipment with DICOM Connection





# Simple Services Example

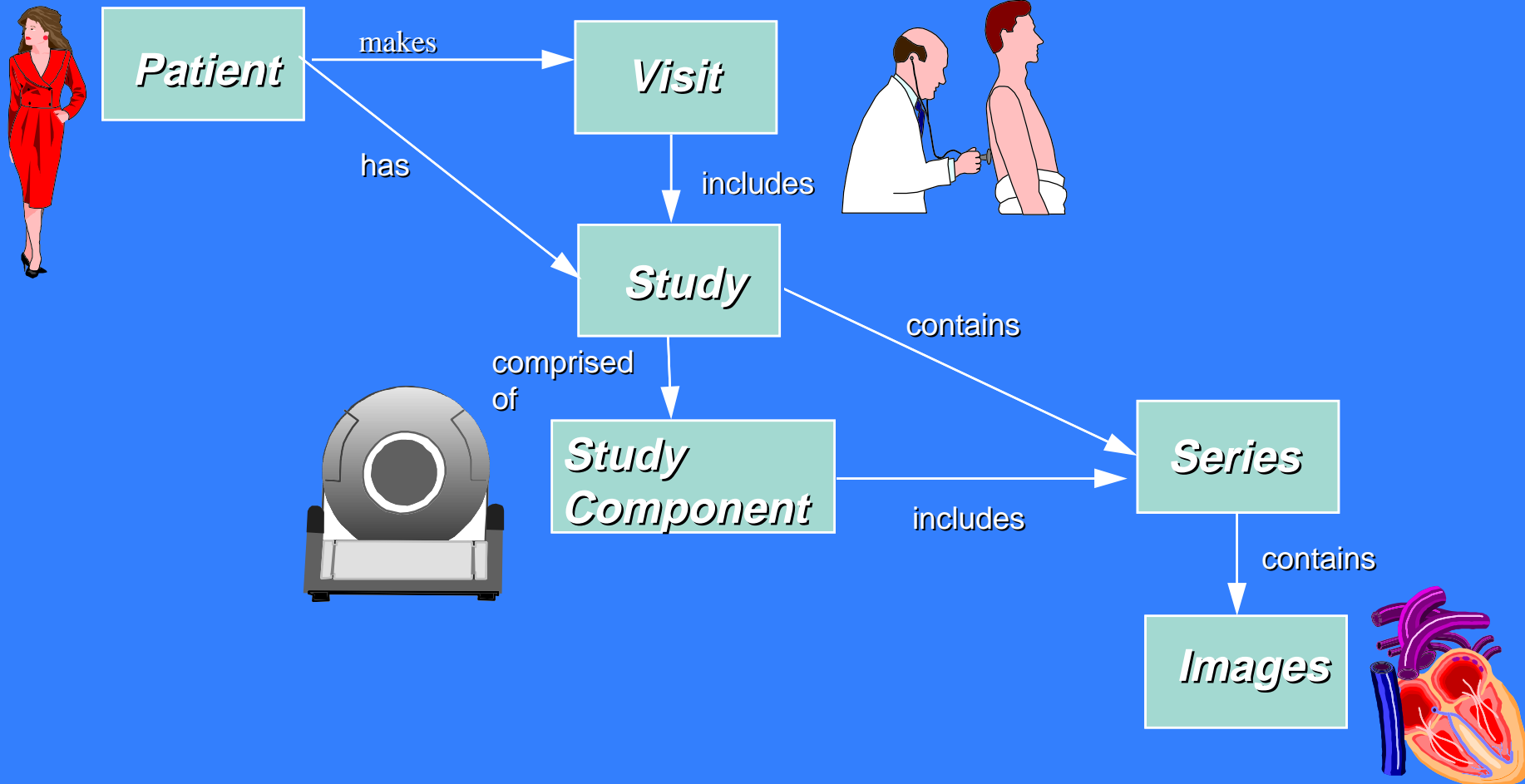


## DICOM Functionality: Service Classes

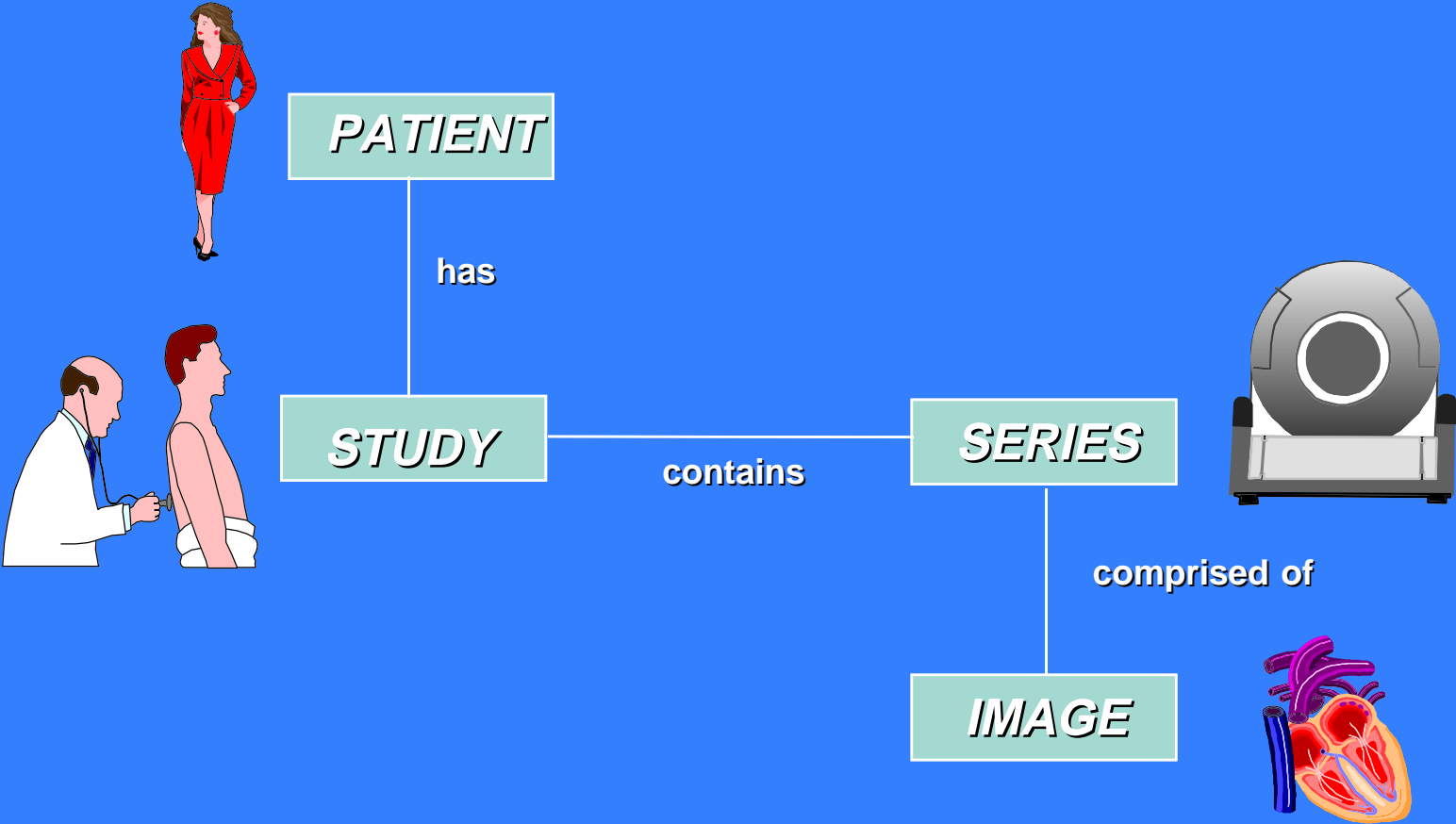
- **Archive/Transfer Images: Store (across network)**
- **Archive/Interchange Images: Media Storage**
- **Query for Information & Retrieve Images**
- **Make Image Hardcopies: Print Management**
- **Patient, Study & Results Management**
- **RIS-Modality: Worklist Management**
- **Test Connectivity: Verification**



# DICOM Application Model (Real World) - Simplified



# DICOM Information Model (simplified)



## Query/Retrieve Models (Image Information)

- **Patient Root** (all levels from Patient downwards)
- **Study Root** (all levels from Study downwards)
- **Patient/Study Only** (all images dealt with implicitly)

Note, for naming in actual service requests:

- **FIND** is used often for Querying Information
- **GET/MOVE** is used often for Retrieving Images



# Attributes

- Patient Name
- Patient ID

**Patient**

.....

- Accession Number
- Study Date

**Study**

.....

- Modality Type
- Series Date

**Serie**

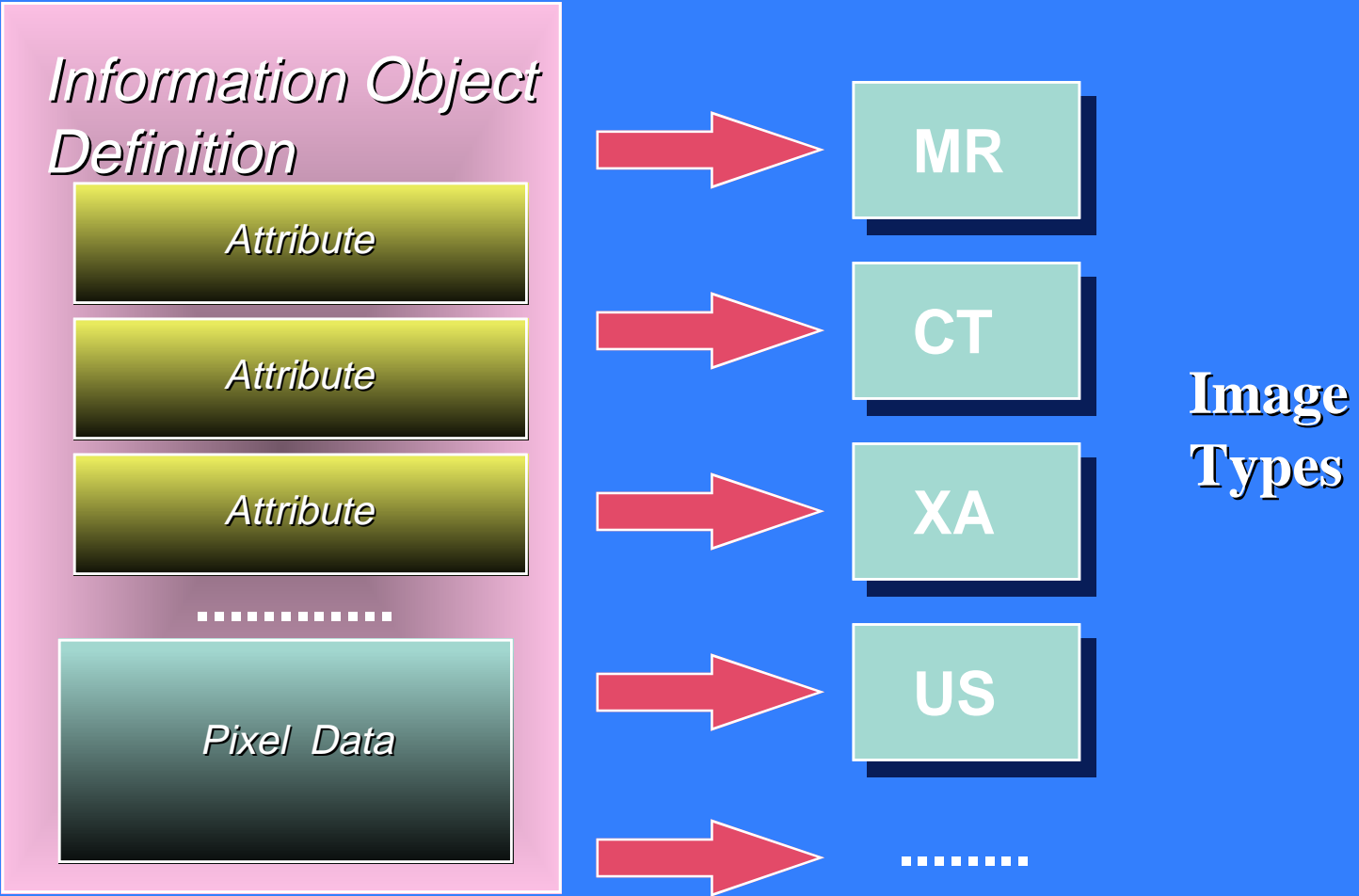
.....

- Image Type
- Rows and Columns
- Pixel Data

**Image**



# Objects Definitions - (e.g. Images)



# Attribute Types

- (1) Mandatory - Always Present with a Value
- (2) Mandatory - But allowed to be Empty
- (1C), (2C) Conditional - Type 1 and 2
- (3) Optional - also allowed to be Empty

Objects (e.g. Different Image Types) can have different Type specifications for the same Attribute. For example:

- X,Y,Z Image Orientation for CT type 1, not in plain X-ray
- Image Type Generic type 3, for XA and CT type 1





## Attribute Definitions (Data Dictionary)

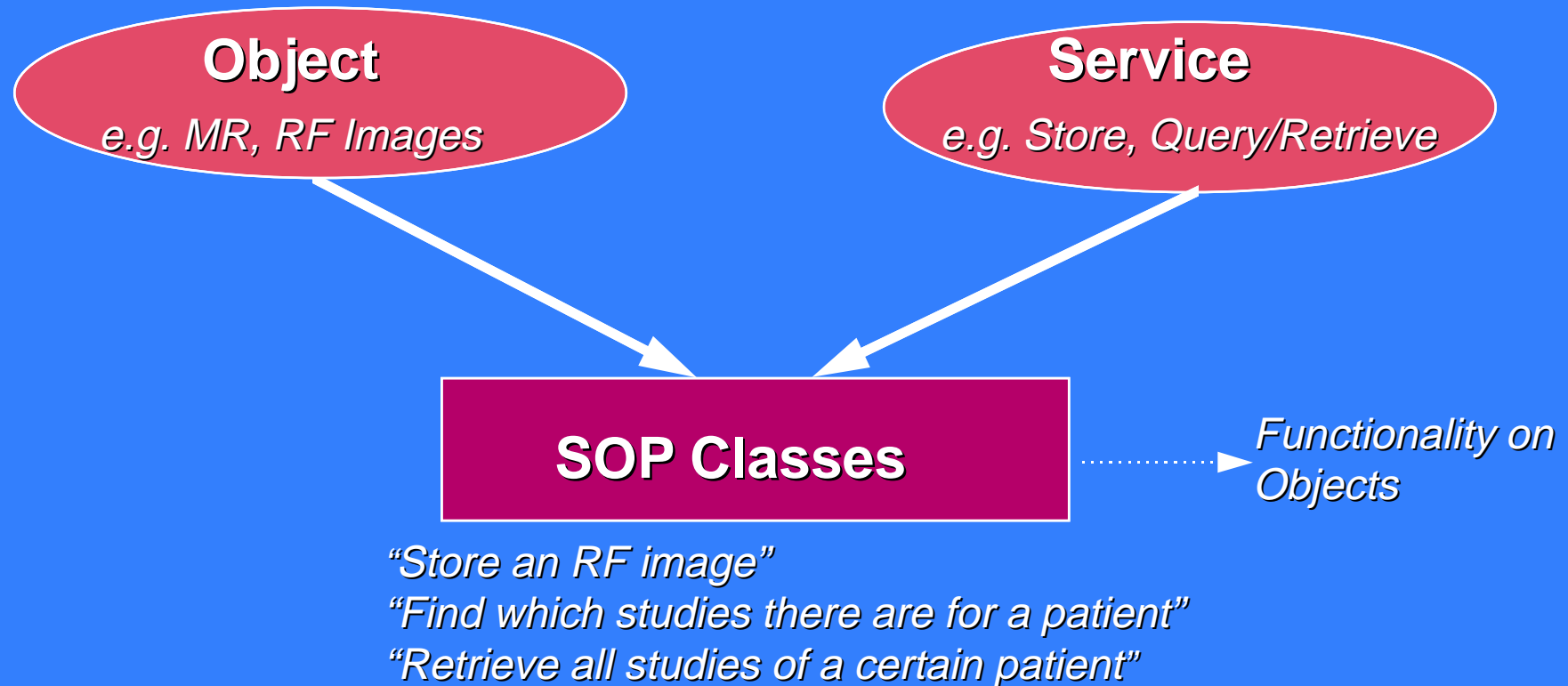
- **Attribute Name**
- **Tag (e.g. 0008,0102) - Hexadecimal**
- **Value Representation (VR): date, integer, patient name, ...**
- **Value Multiplicity: number of values must/may be present**
- **Description: semantics**

**Private Attributes may be defined by vendors, and are always Optional. Conflicts in Tags prevented by DICOM.**



# Services on Objects

**SOP Class: a Method to Operate on an Information Object**



## Unique Identifiers (UIDs)

- Identification Method which is **World-Wide Unique**.
- Unique Identifiers are defined for all **SOP Classes**.  
Important for the Conformance Statement.

Also, a Unique Identifier is given to all:

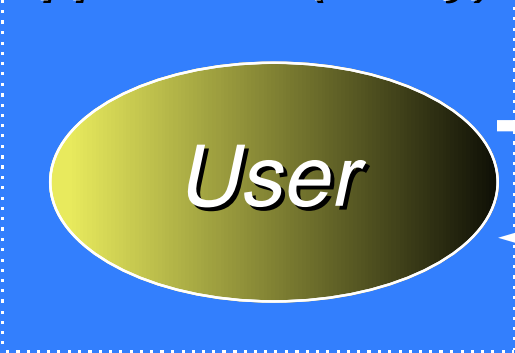
- Studies (Study Instance UID)
- Series (Serie Instance UID)
- Images (SOP Instance UID)

These UIDs are for instance used for Retrieval.



# Client/Server Concept

*Application (Entity) A*

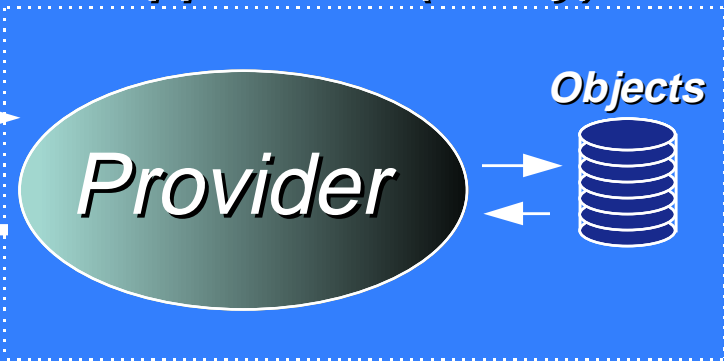


*“Store this Image Please”*

**Service Request**

**Response**

*Application (Entity) B*

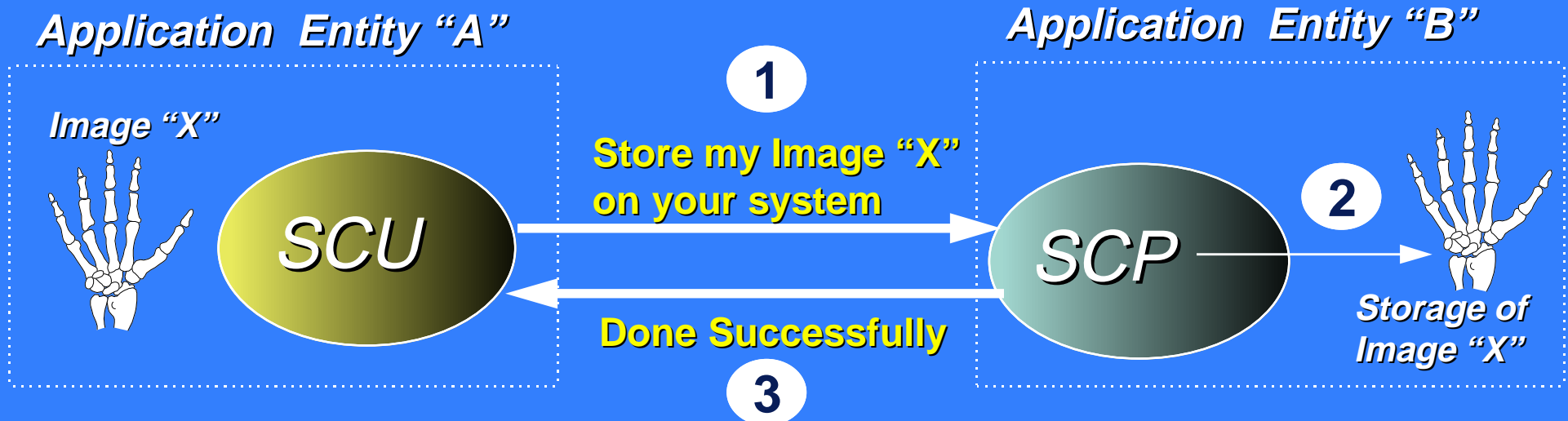


*“Image has been stored”*



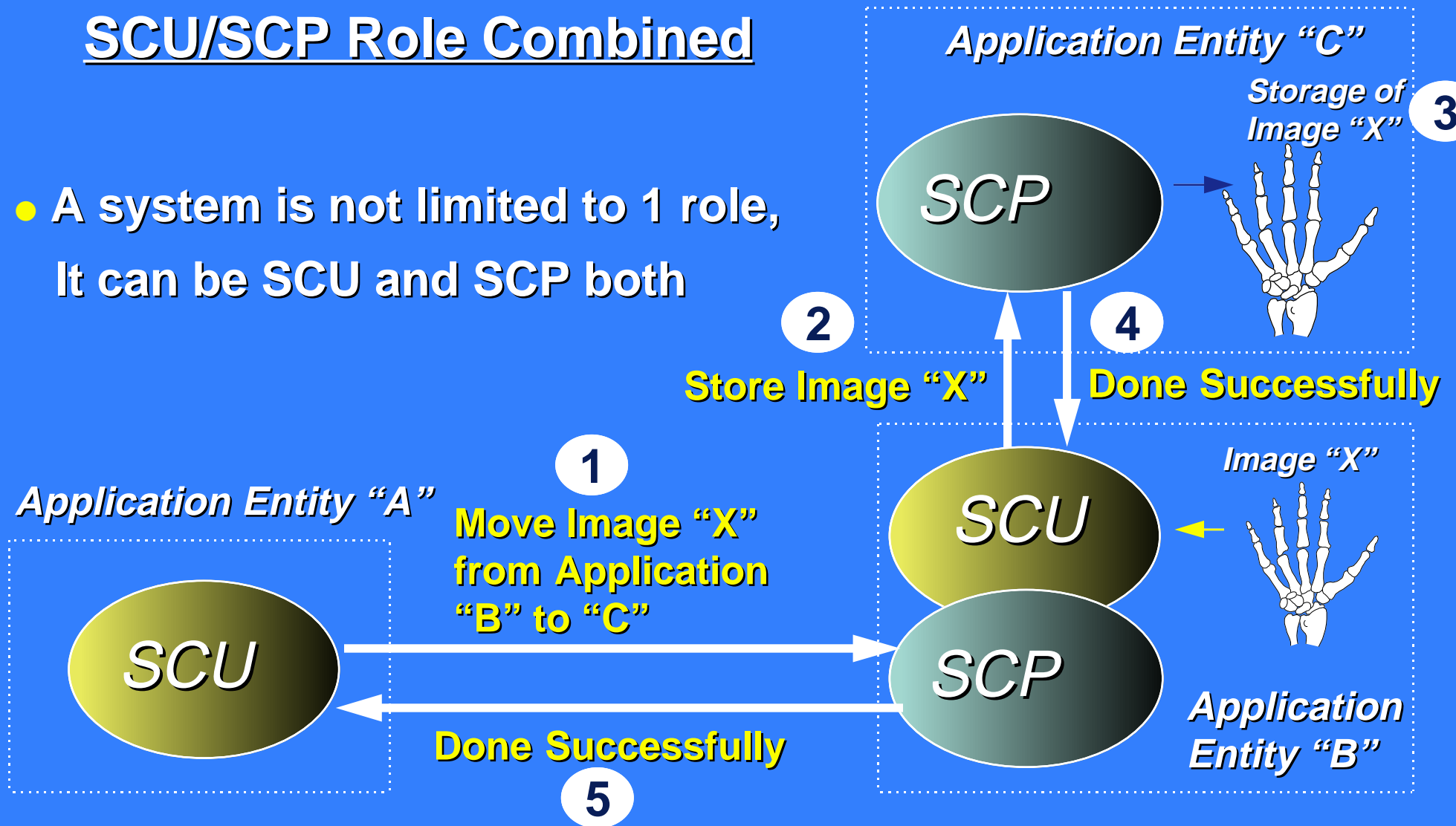
# SCU/SCP Roles

- Client is called “SCU” (Service Class User)
- Server is called “SCP” (Service Class Provider)

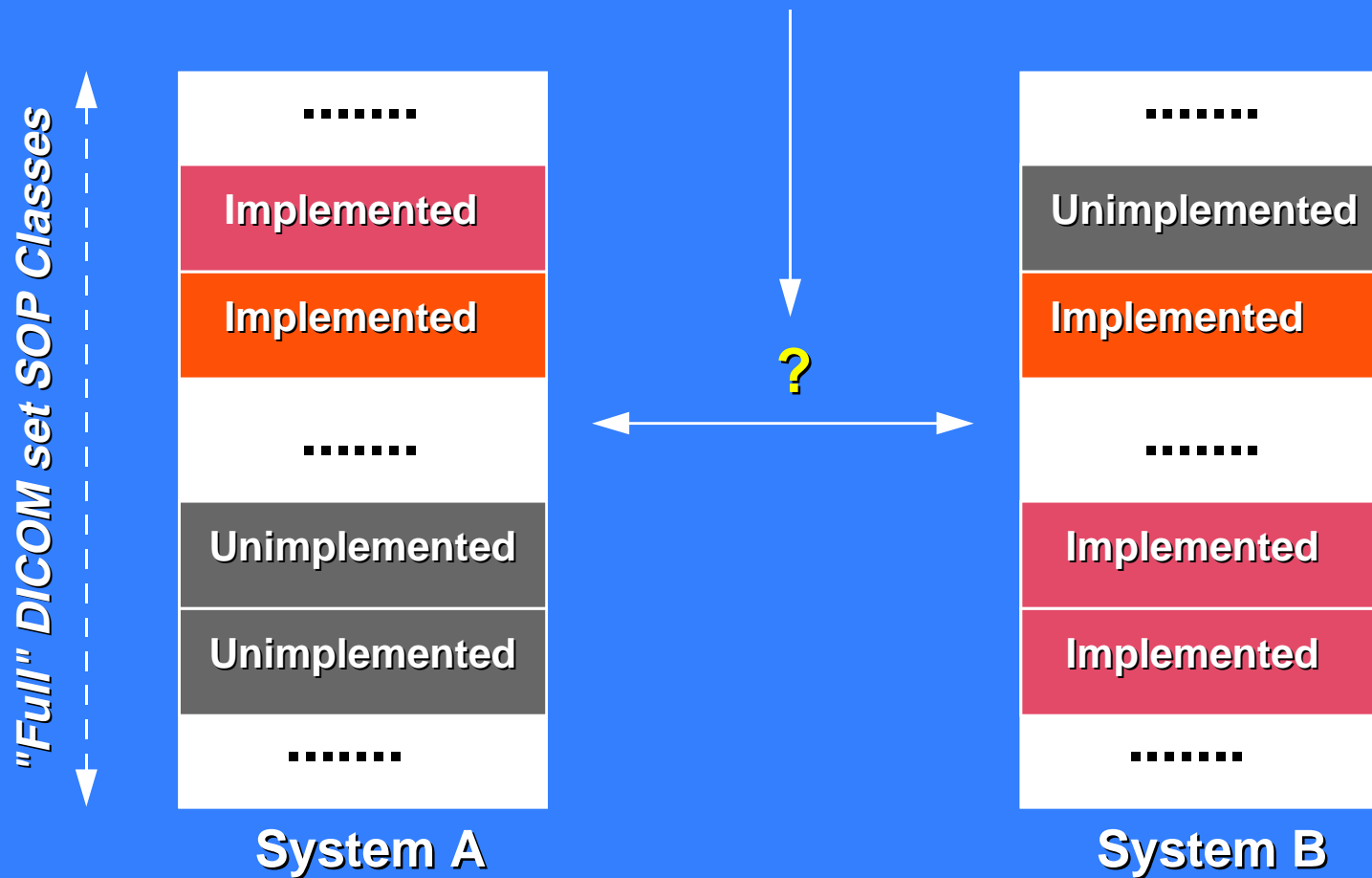


# SCU/SCP Role Combined

- A system is not limited to 1 role, It can be SCU and SCP both



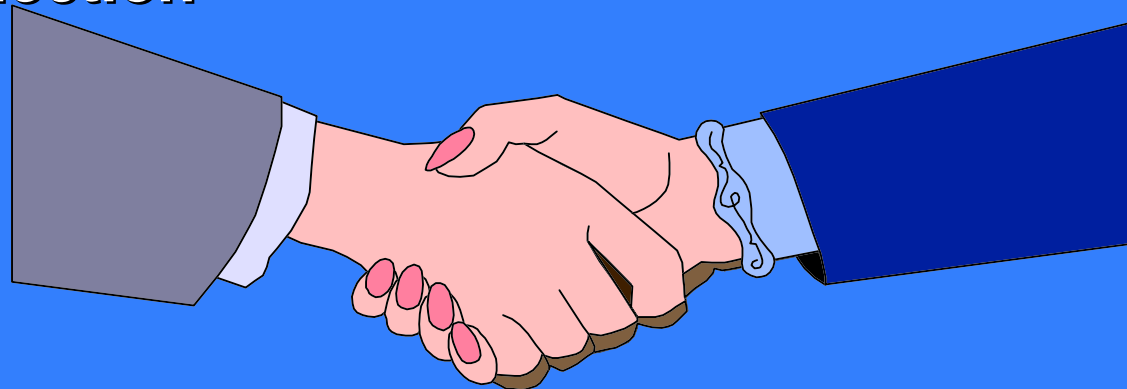
# DICOM - Can we Communicate?



# Association Handling

**First:**

- **Initiate a Connection**

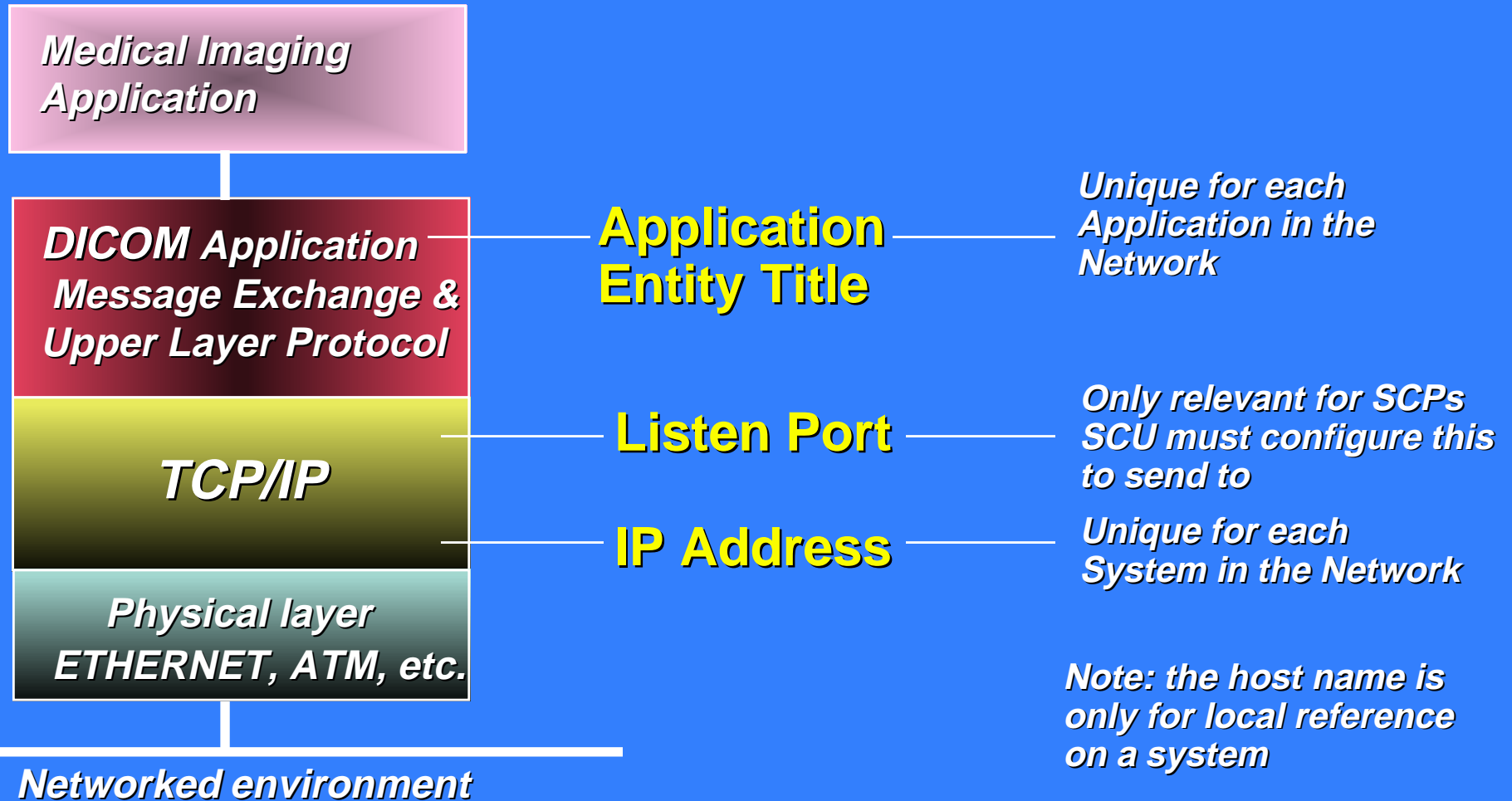


**Then Agree on:**

- **Which SOP Classes are to be used**
- **Client and Server Roles (SCU/SCP)**
- **Encoding (Transfer Syntax)**
- **Other Communication Parameters**



# Connection Identification required per Layer



# Association Handling

- Which SOP Classes are supported by each system
- Client and Server Roles (SCU/SCP)
- Encoding (Transfer Syntax's)
  - Implicit Little Endian (DICOM default)
  - Explicit Little Endian (attribute type added)
  - Explicit Big Endian (byte swapped if necessary)
  - JPEG Lossless
  - JPEG Lossy (information loss)
- Maximum Package Size to be used
- Number of Associations Supported (by SCU and SCP)



# Conformance Statement

- **Mandatory Document for all DICOM compliant systems**  
**Request the document for all systems to connect with**
- **Used to Check if/what level of Connectivity is possible**  
**Compare list of Supported SOP Classes**  
**Compare list of Supported Transfer Syntax's**  
**BEFORE actual installation**
- **Retrieve Connection and Configuration Information**  
**of the systems to connect to**
- **Check for Extensions and Limitations**



# Conformance Statement - Example

## *SOP Classes supported as SCU*

MR Image Storage	1.2.840.10008.5.1.4.1.1.4
CT Image Storage	1.2.840.10008.5.1.4.1.1.2
Patient Root Model Query	1.2.840.10008.5.1.4.1.2.1.1
.....	.....

## *Proposed Presentation Contexts*

MR Image Storage	1.2.840.10008.5.1.4.1.1.4	Implicit Little Endian	1.2.840.10008.1.2
MR Image Storage	1.2.840.10008.5.1.4.1.1.4	Explicit Little Endian	1.2.840.10008.1.2.1
.....	.....	.....	.....

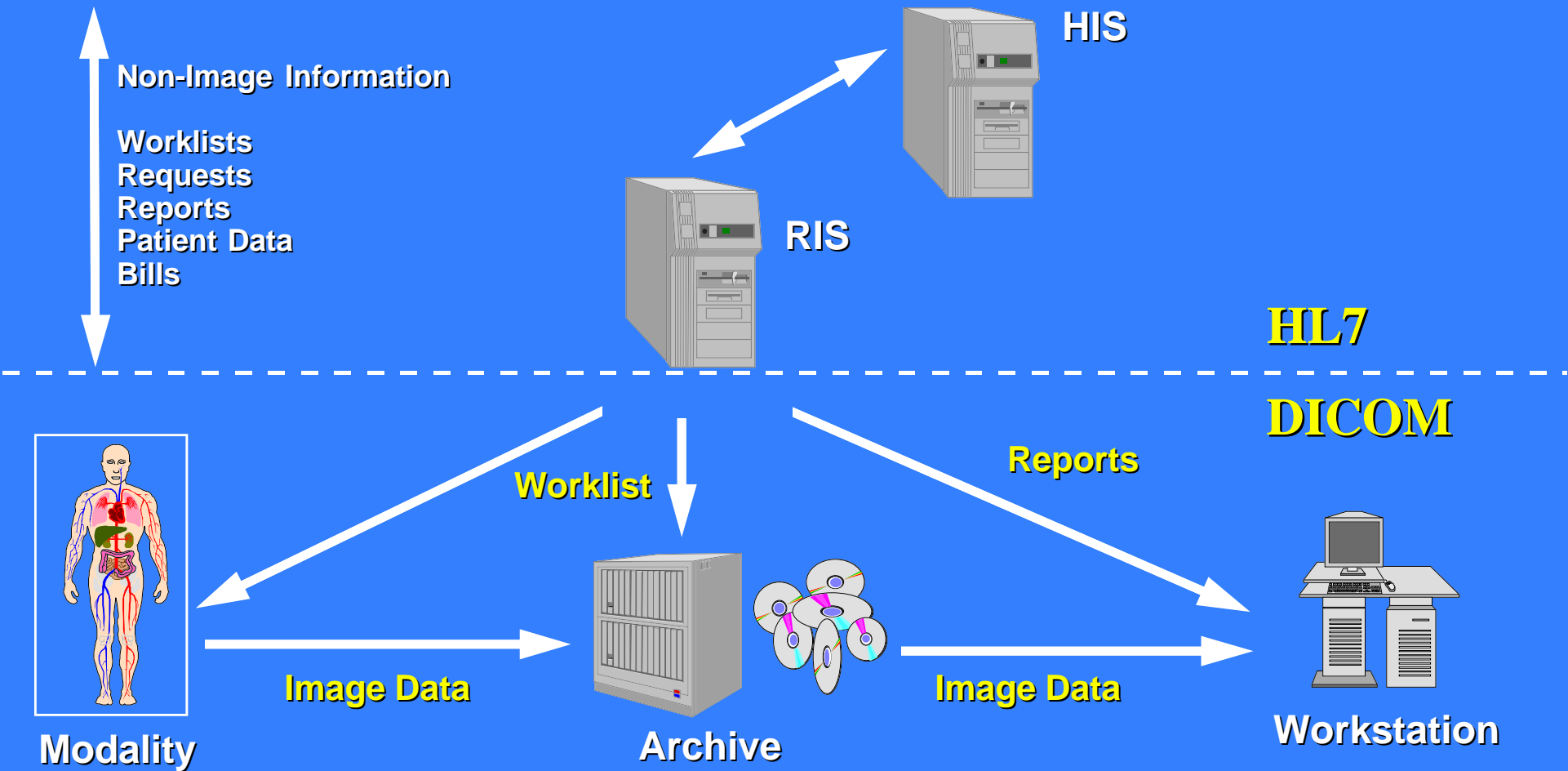


# DICOM Developments

- Security
- Reporting
- Storage Commit
- Print Storage
- New Image SOP Classes (e.g. RT and endoscopy)
- Extension of Standardization of Data Elements
- Display Standards (Image Quality)
- More focus on Interoperability
- Coupling with HIS/RIS World (e.g. HL7)

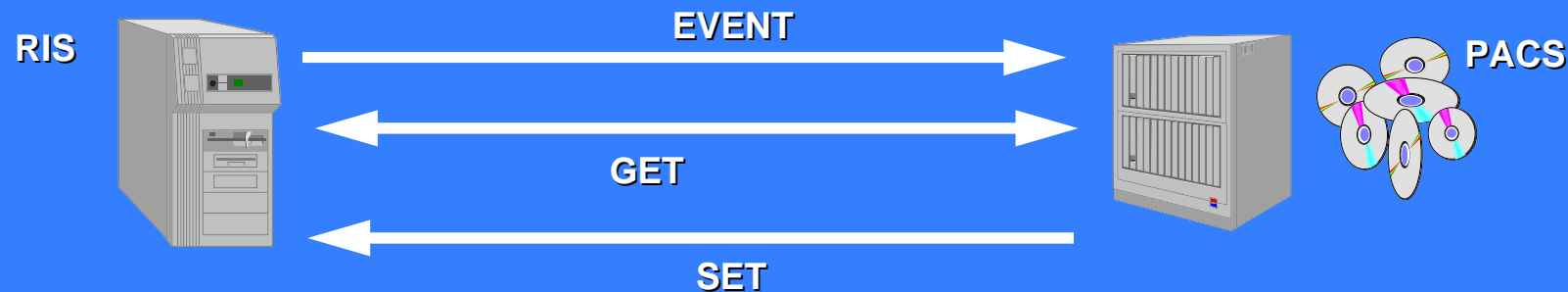


# An Example - RIS Connection



# RIS Connection Models - 1

- **RIS Controlled** Connection (e.g. RIS-PACS)
  - Events by RIS (e.g. with UID values)
  - GET by e.g. PACS detailed information from RIS



- **Detached Patient/Study/Results Management SOP Classes**

## RIS Connection Models - 2

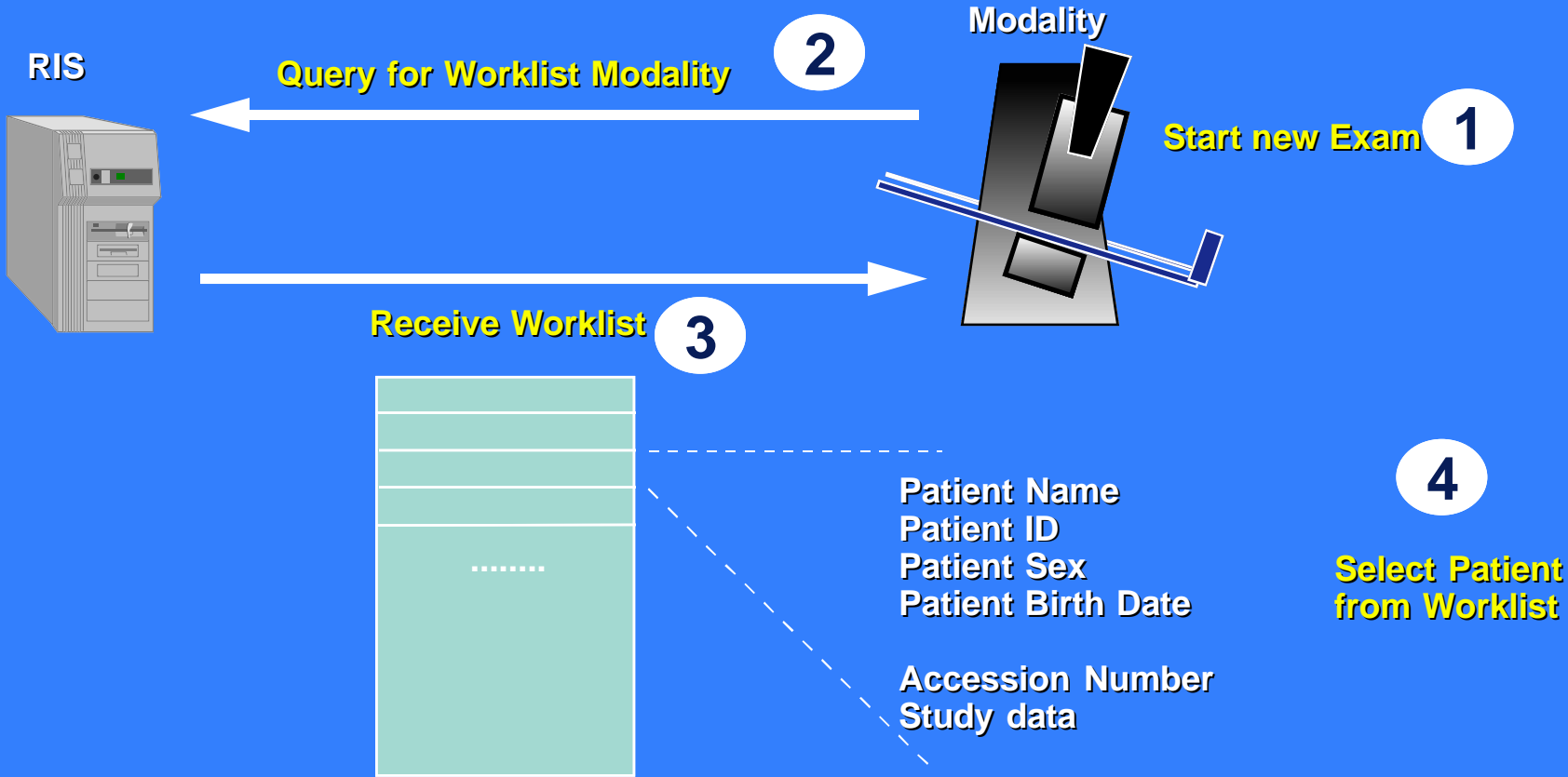
- **Modality Initiated** Information Retrieval
  - Query by Modality
  - RIS provides information in Query Response



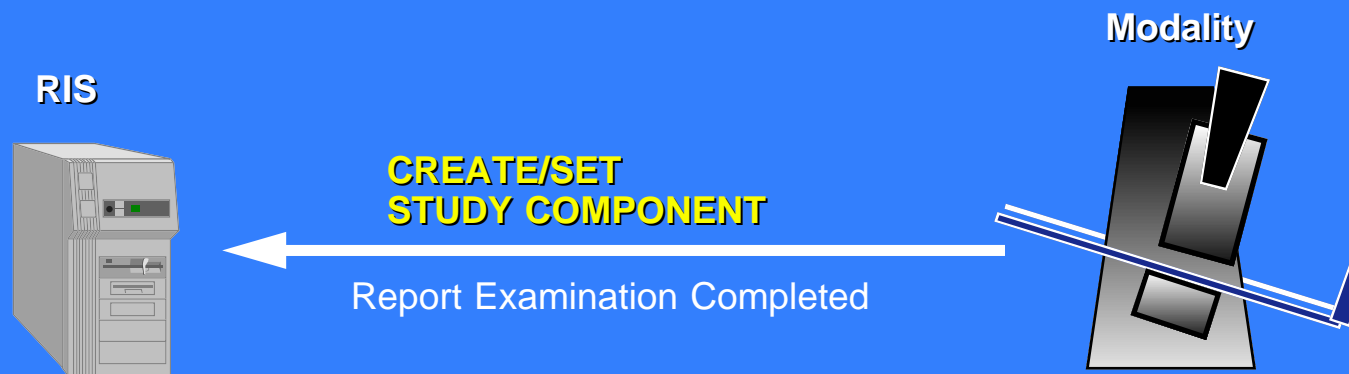
- **Worklist Management SOP Class**



# Worklist Management - Query



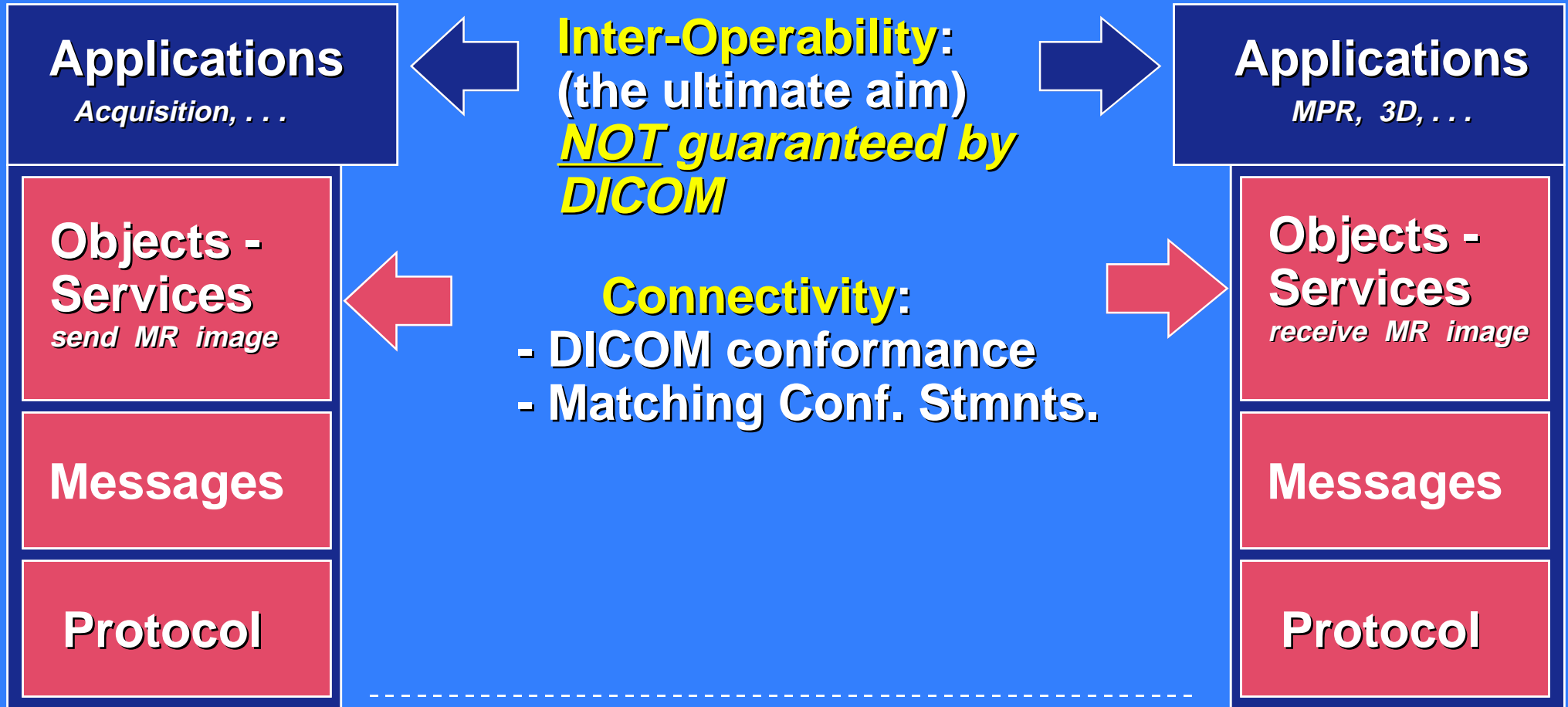
# Results Management



**Study Component: contains produced image as reference  
(no image data)**

**New “Performed Procedure Step” (extension Study Comp.)  
also includes X-ray dose, material used, contrast used, etc.**

# Connectivity Vs. Interoperability



# Application Interoperability Check

Applications can **Require (!)**:

- Optional Attributes
- Private Attributes (not in DICOM Standard)
- Private SOP Classes (not in DICOM Standard)
- Special Semantics of Attributes/Special Rules for Usage

Thus, we need a **Detailed Description** of:

- Required Application Functionality
- Required Attributes for this

to **Verify Interoperability** on before-hand



# DICOM Standard about Interoperability

## DICOM Part P.S. 3.1 - “Goals of the DICOM Standard”:

“Even though the DICOM Standard has the potential to facilitate implementations of PACS solutions, use of the standard alone does not guarantee that all the goals of a PACS will be met.

This standard facilitates Interoperability of systems claiming conformance in a Multi-Vendor environment, but does not, by itself, guarantee Interoperability”



## Further Information

### Internet Sites for more General DICOM Information:

- <http://www.nema.org/nema/medical/dicom>
- <news://comp.protocols.dicom>
- [ftp://ftp.philips.com/pub/ms/dicom/DICOM\\_Information](ftp://ftp.philips.com/pub/ms/dicom/DICOM_Information)

### Philips Medical Systems specific Information:

- <http://www.philips.com/ms/solution/connect>
- [ftp://ftp.philips.com/pub/ms/dicom/Medical\\_Images](ftp://ftp.philips.com/pub/ms/dicom/Medical_Images)
- [ftp://ftp.philips.com/pub/ms/dicom/Conformance\\_Stmnts](ftp://ftp.philips.com/pub/ms/dicom/Conformance_Stmnts)

