

# From Connectivity to Interoperability: more than 10 years DICOM experience at Philips MRI

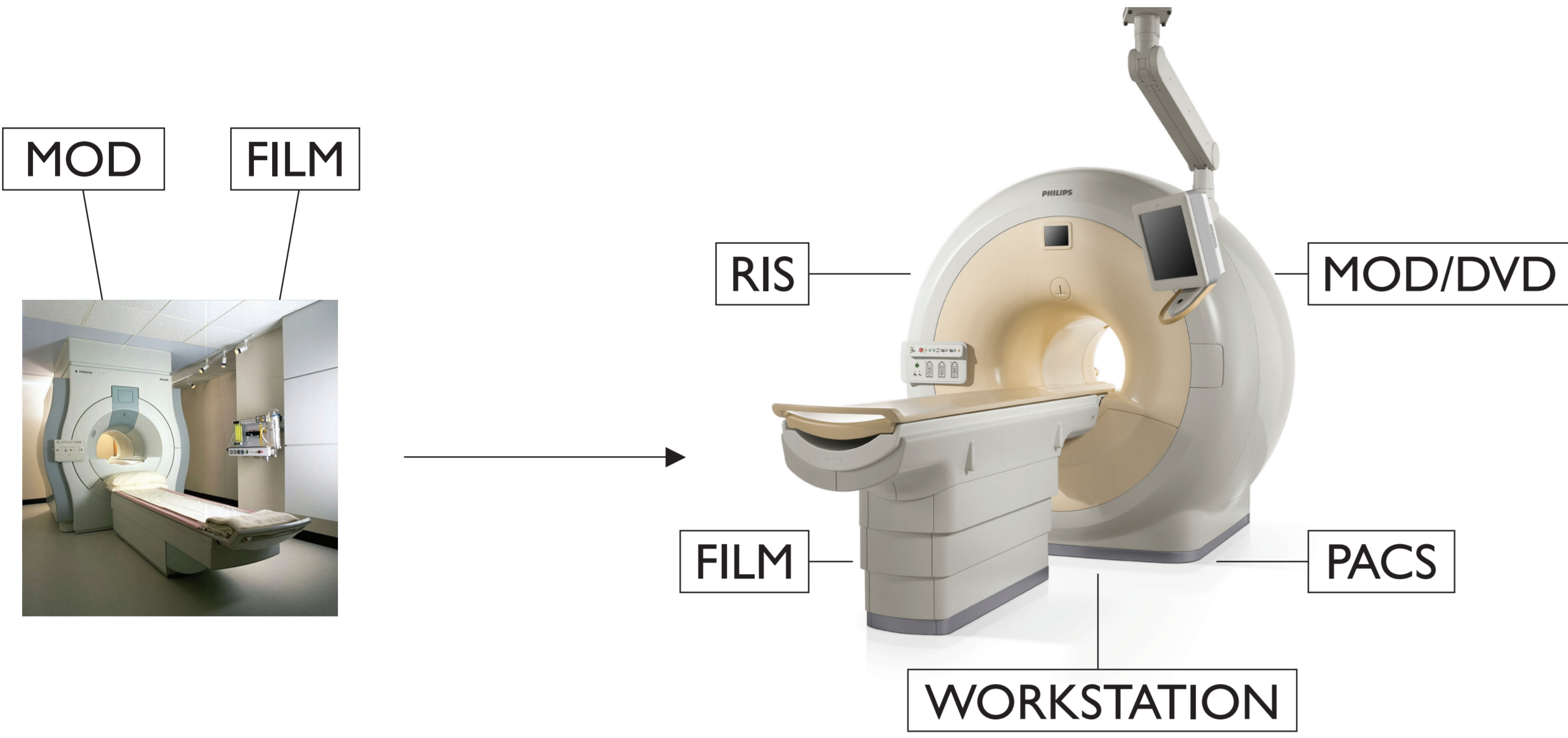
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In 1995 we built our first DICOM export server. This was the start for switching from a private protocol to the standard DICOM protocol for communication with other systems. The first step was only focused on Connectivity (exchange of data). Interoperability (correct use of exchanged data) was at that time less visible. During the following years more and more systems supported the DICOM standard to communicate with other systems. This enabled hospitals to switch to an almost complete digital workflow. This also implies that the focus must shift from just storage of data (Connectivity) to the real usage of the data in a workstation (Interoperability). In practice this means that the MR system has to operate in a complex multi-vendor environment, with different levels of DICOM maturity.

## History DICOM at Philips MRI

- 1988 ACR-NEMA MOD / GCOM (private)
- 1995 DICOM Export Server 'Simple'
- 1996 RIS Worklist
- 1999 DICOM Export/Import Server 'Full', DICOM Print
- 2002 Support of Secondary Capture, Softcopy Grayscale Presentation State, Storage Commit, MPPS, Query/Retrieve, DICOM File, DICOM MOD, IHE and VA requirements
- 2004 DICOM DVD
- 2005 Support of Enhanced MR Image, MR Spectroscopy & Raw Data Storage

What you see is that we moved from "standalone" to "connected" systems and from printing on hardcopies, via storage on MOD/DVD, to storage of digital images in digital archives. This creates extra requirements on the richness of the image data, since more and more viewing & processing is done on other systems. During this process one first has to solve Connectivity and later the Interoperability issues.



The expectation of users is that new products will work with all other Medical Equipment in the hospital (workflow), since "all understand DICOM".

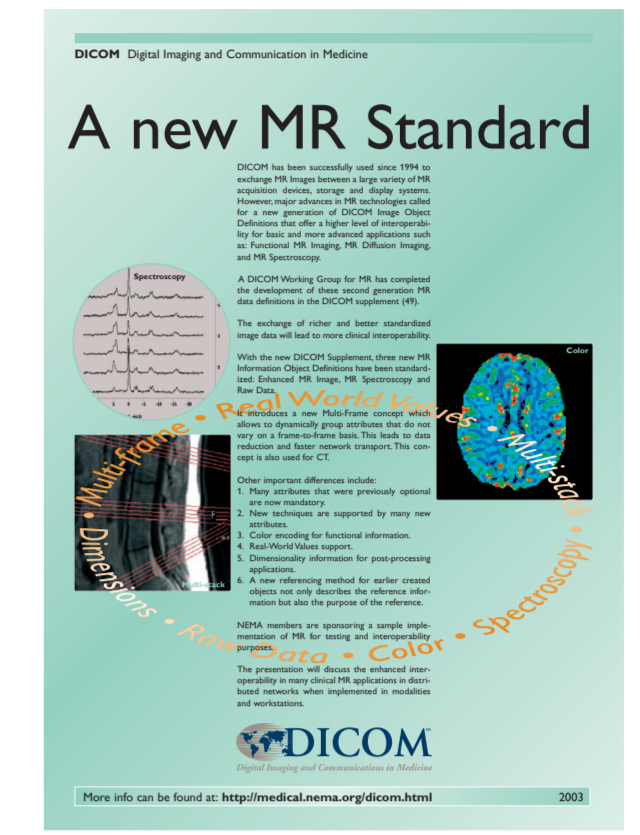
The DICOM standard provided us with a smooth transition from local to remote storage thanks to the fact that standardized data can simply be extended with private attributes and private SOP Classes.

## Enhanced MR Storage SOP Classes

Introducing Enhanced MR (EMR) solves most currently known Interoperability issues for MR.

At first glance it seems hard to add support for these new SOP Classes, but actually it is not! The following advantages of the new Enhanced MR Storage SOP Classes make it straightforward for the vendors to implement it:

- All information of a Series is present in one EMR Object (thus not 'scattered')
- All known attributes are defined for existing applications
- Due to stricter rules (VT) one doesn't need to make compromises (all data will be present)
- Clear relationships through reference mechanism
- Structured: Multi-Frame module with Shared and Non-Shared header parts in Functional Groups
- Context: With Dimension Module no advanced knowledge is needed for the default order to show images.
- Viewers only need to use this module for showing the images in the correct order in a flexible way.

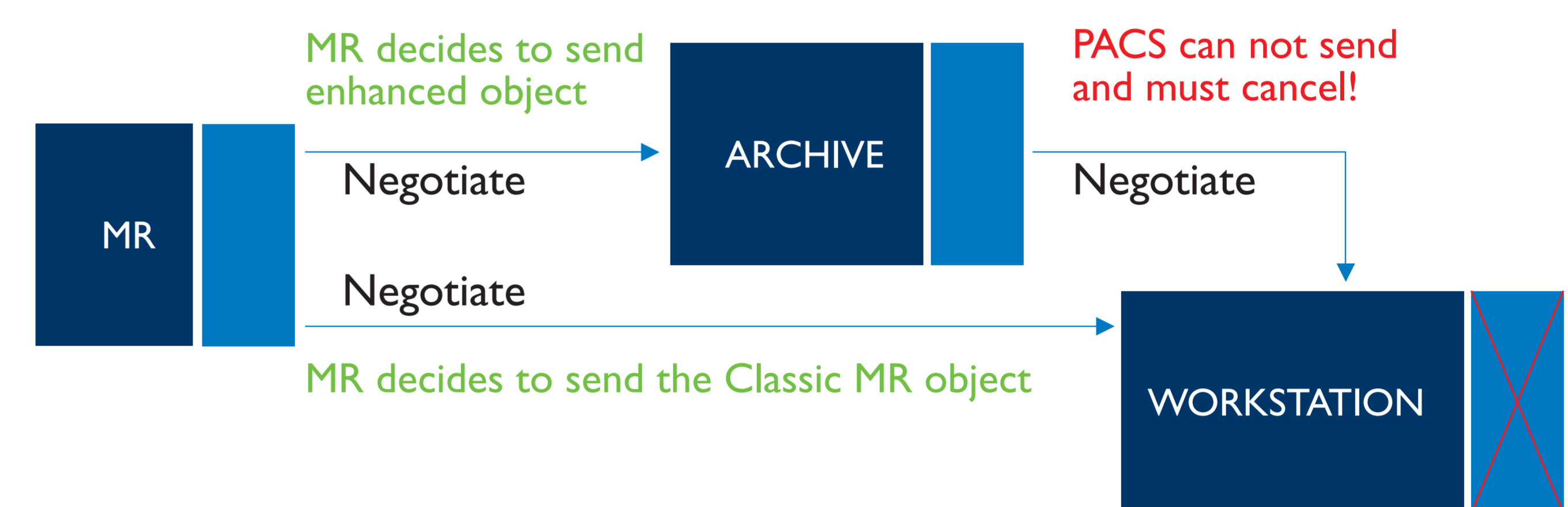


## Introduction of Enhanced MR Storage SOP Classes

It takes a relative long time before the Healthcare Industry understands and accepts new SOP Classes.

Our strategy is to support the 'old' and 'new' SOP Classes in parallel.

The actual SOP Class that will be used for transfer, can be defined either by configuration and/or run-time association behavior (EMR is the default choice).



Benefits of the Enhanced MR Storage SOP Classes, like the much faster data transfer and the storage of MR Spectroscopy, can already be clinically proven during the transition phase.

## Challenges

Up to now our experience is that the use of private attributes causes Connectivity and Interoperability issues. The challenge is to balance perfect Connectivity and sufficient Interoperability.

The classic definition of the MR Image Storage SOP Class (more than 10 years old) had some disadvantages, which are addressed with Supplement 49 for MR (Enhanced MR):

- Not prepared for large datasets => solved with a new Multi-Frame technique
- Not really structured => solved with 'Functional Group' Sequences
- Not very strict, many VT=2 and VT=3 attributes => new SOP Classes are much stricter here
- Lack of attributes for the emerging applications in MR

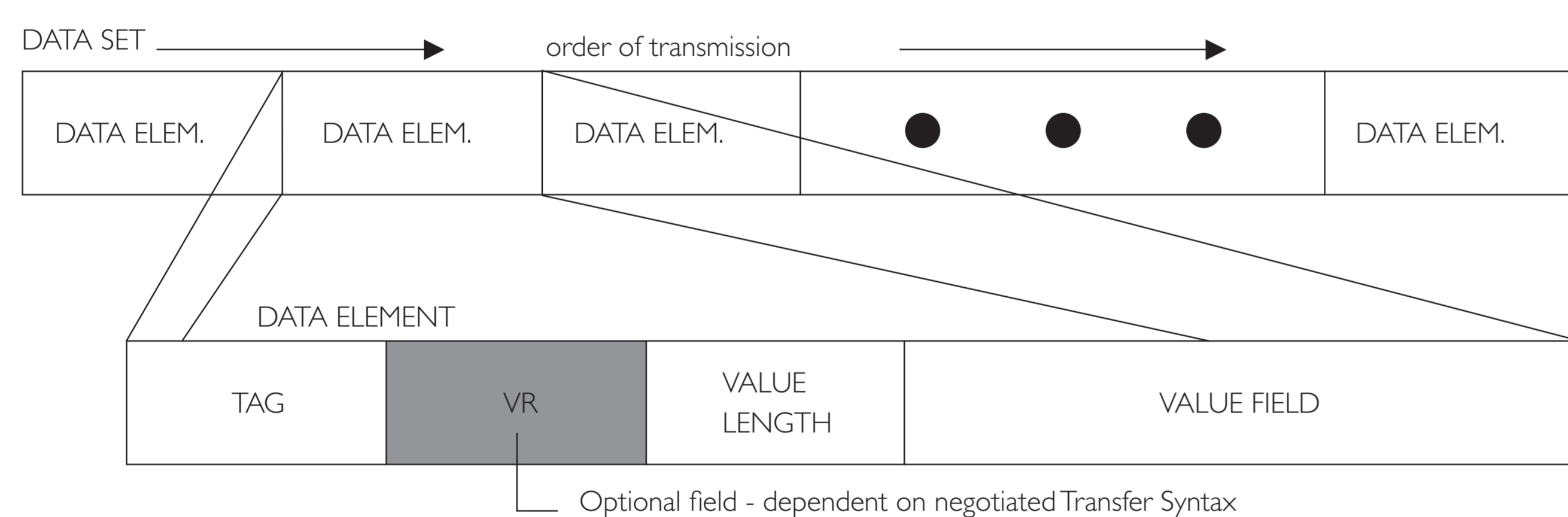
In particular the Value Types (VT) were a problem for Interoperability because the receiver cannot trust that all required data will be present.

## Connectivity

IHE Philosophy: 'Be strict with exporting and flexible with receiving'.  
Observation: "I speak perfect DICOM and now nobody understands me."  
This means that there is still no guarantee that all data will be understood or even accepted.

Philips MR has solved most Connectivity issues with the help of configuration settings like:

- Skipping private SOP Classes (use Raw Data)
- Stripping private attributes (pure DICOM)
- Selecting Transfer Syntaxes (Explicit / Implicit VR)



- Encoding of DICOM Objects (Defined / Undefined Length Sequences)
- Encoding of Group Length Attributes (With / Without)
- Selecting the preferred SOP Class to use (Enhanced MR vs. Classic MR)

Improving Connectivity by sending less data will potentially reduce Interoperability, therefore we had to be careful with our choices. One has to balance Connectivity and Interoperability.

## Interoperability

How to keep up with the modifications of the DICOM Standard?

We live in a fast world where new applications emerge. The data of new applications is at that moment not part of the DICOM standard. However one still needs to store this data. It would be "nice" when the additions are also understood by receiving nodes.

### Available Mechanisms:

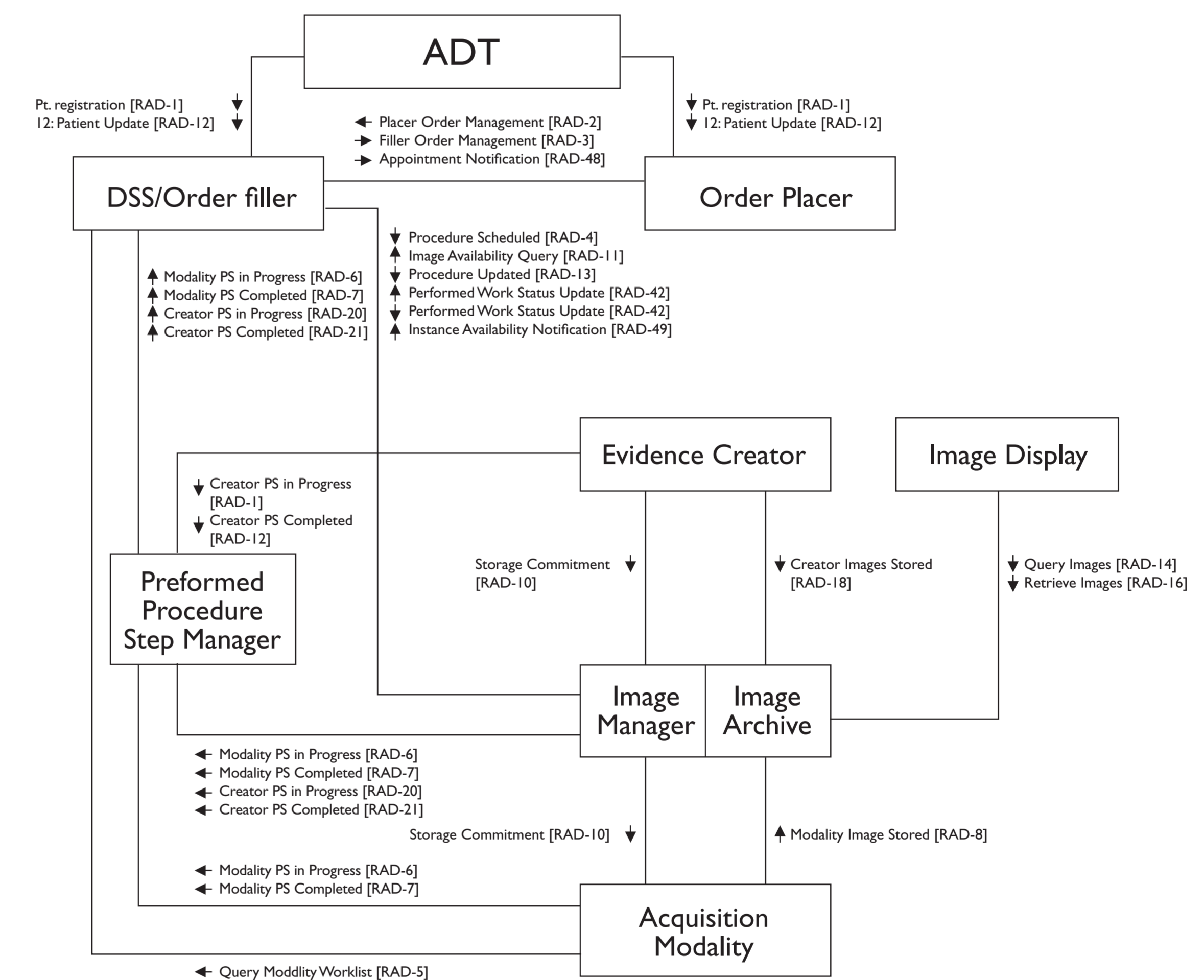
1. Use Private attributes and/or Private SOP Classes and document these in your DCS  
=> Fast introduction possible, but low level of Interoperability (propose also for inclusion into the DICOM standard)
2. DICOM Change Proposals for existing SOP Classes  
=> Relative fast introduction, but no guarantee that receiving stations will accept/use it (standardized, but optional)
3. Propose new SOP Classes  
=> Long lead-time from proposal to DICOM standard and even longer before it is implemented by the Healthcare Industry. Fully Interoperable (standardized).

Our strategy is to support Interoperability by adopting DICOM changes as early as possible.

## Possibilities to Check Implementations

The DICOM Conformance Statement (DCS) should contain all information needed to determine the level of Connectivity and Interoperability. With the help of DICOM validation tools (e.g. DVTK from Philips and DicomImageViewer from PixelMed) you can check your (EMR) DICOM objects for correct syntax.

IHE plays a major role for testing implementations of the DICOM Standard in the Healthcare Industry. At Connectathons we test the supported IHE Profiles against implementations from other vendors. IHE records the results of correctly supported combinations on their Internet site (<http://www.ihe.net>). The successful results can be checked by any user on the Internet.



Our experiences show that most Connectivity and Interoperability issues can be solved by defining a correct configuration on both nodes (source and destination). However this can be a time-consuming process which is not straightforward and not easy due to the many available options.

## Summary

Everyone expects that the Connectivity Software just works. Due to the variety of Medical Equipment, each with their own DICOM implementation, one has to find a flexible way of handling Connectivity problems. We solved this by choosing smart defaults in our Connectivity Configuration and making these choices selectable for the Service Engineer. Solving Interoperability issues is even more challenging. The Enhanced MR Storage SOP Classes have the potential to solve most current known Interoperability issues for MR. However we see a slow adoption of EMR by the Healthcare Industry. For checking your level of Connectivity and Interoperability with other vendors, the IHE Connectathons are a good place to test.

## Conclusion

Connectivity problems must be solved first before even thinking about Interoperability. The real solution for solving Interoperability issues is active contribution to the DICOM standard by proposing changes and contributing to new supplements. A good DICOM implementation strategy should take into account all aspects of the workflow in the hospital.

## References

- DICOM Standard 2008 | IHE Radiology Technical Framework | Philips Healthcare. DICOM Conformance Statement MR Release 2
- Kees Verduin, DICOM Conference 2008: "Enhanced MR Objects address Multi-Vendor Interoperability issues in Clinical Radiology"