



# WORKFLOW MANAGEMENT FOR RADIOTHERAPY

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## 1. Purpose

The DICOM Standard has successfully been extended to support the needs for Radiotherapy environments. Almost all data needed for the radiotherapy treatment of a patient can now be described by the seven radiotherapy objects (RT Image, RT Structure Set, RT Plan, RT Dose, RT Beam Session Record, RT Brachy Session Record, and RT Summary Record).

Now that the RT objects have been widely implemented by the majority of vendors it becomes obvious that the day-to-day work with these objects is lacking support to manage them efficiently. The workflow and management components for radiotherapy have not been addressed initially *"due to the absence of a consistent process model for a radiotherapy department, especially in an international context. As a result, the radiotherapy information objects contain a large number of conditional and optional data elements. Essentially the objects are intended to be used as "containers" for related radiotherapy data, with data being added as the object flows through the department."* (Supp. 11, 1997)

The purpose of this white paper is to draw specific attention to the difference between the mainly non-image RT objects and 'traditional' image objects. Especially the non-static but rather dynamic character of some of the RT objects introduces the need for version management of those objects.

Further this paper shall outline the issues related to workflow management in a radiotherapy environment and to propose possible extensions and modifications to the DICOM standard.

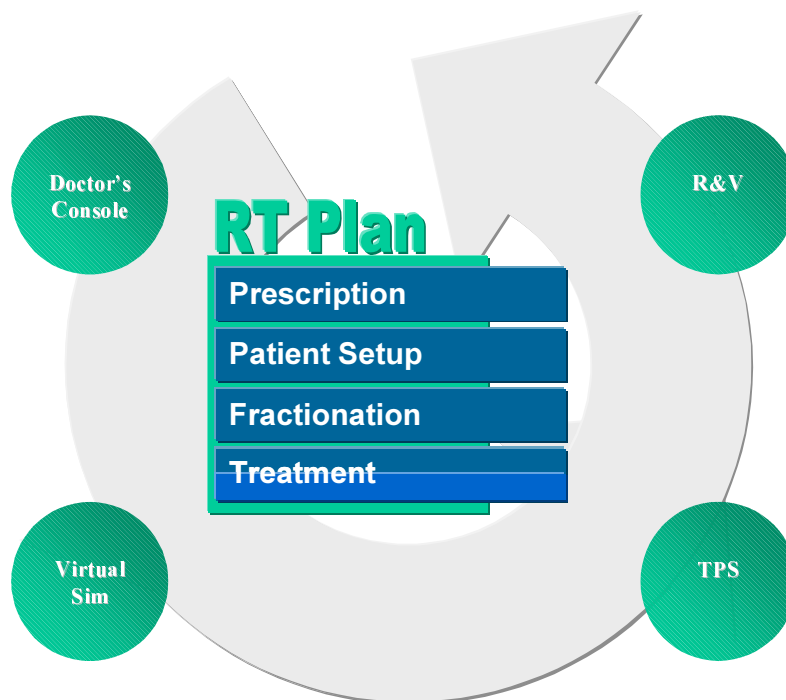
## 2. Dynamic Objects

In contrast to many image based objects in DICOM some of the RT objects contain only non-image information.

Most of the attributes or modules within a RT object are optional. Some of these objects are 'growing' (evolving) over time during the treatment preparation process within a radiotherapy clinic.

A typical example is the RT Plan object that may be created at one application entities and modified – possibly several times – on one or more other application entities.

Throughout this process the RT Plan object shall represent the summary of all modifications done at the individual stages of the process (Fig. 1).



**Figure 1: Different versions of a 'growing' RT Plan object**

Additionally, in Radiotherapy, a particular manufacturer's machine will typically encode some, but certainly not all of the concepts in RT objects.

It is important that all information that is added to the object throughout this process is kept – even though the application entity in question may not be able to deal with certain attributes.

### 3. Request Remote Processing

#### 3.1 General

There are at least two arguments that support the need for a possibility to request processing by a remote application entity:

- There is a need for specialized automated workstations (i.e. without user interaction) from independent vendors, which shall be included in the radiotherapy workflow.
- In large environments it will be more effective that workstations actively request procedures to be done on a specialized automated workstation rather than requiring the specialized workstation to continuously poll for its workload.

The two arguments are not only applicable to a radiotherapy environment but may be useful in any distributed environment.

Automated procedures require input information and control information to perform the procedure. The result of a procedure usually is one or more sets of new information and/or modifications of the input information.

Another characteristic of automated procedures is that the requesting workstation wants to be able to get information about the status of the requested procedure or to abort the requested procedure.

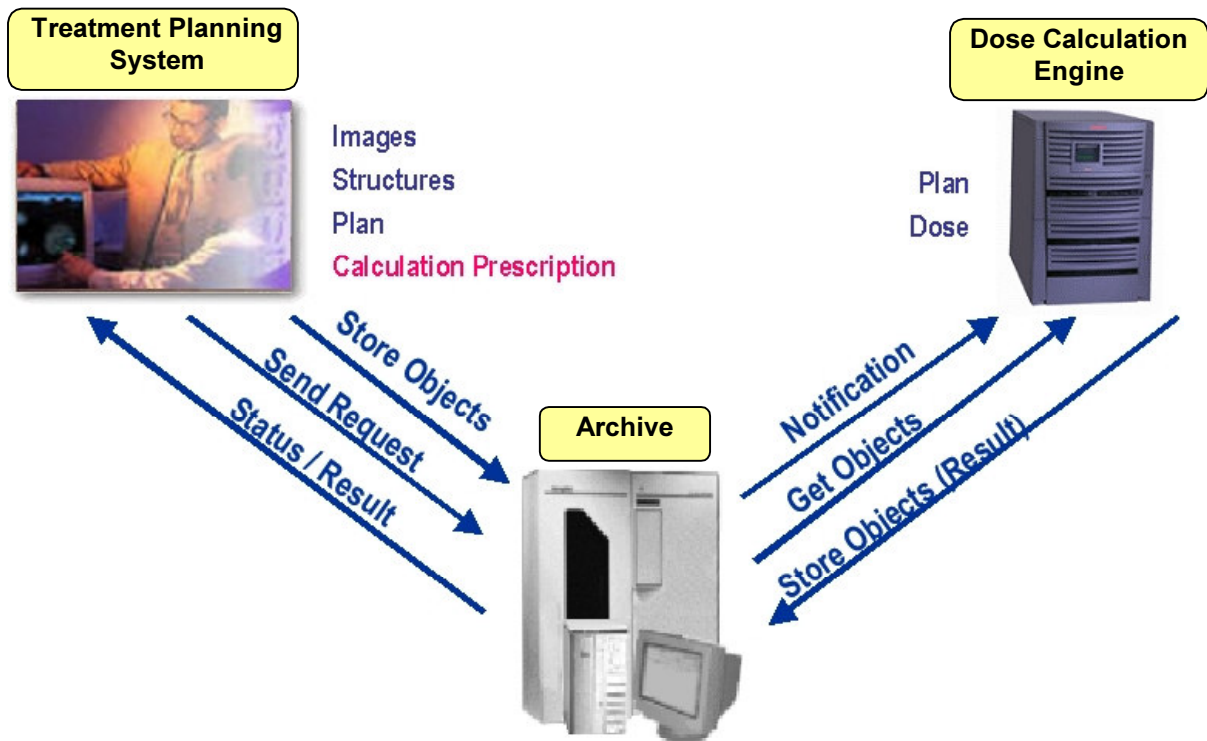


Figure 2: Example of a requested dose calculation in a RT environment

For example, in case we are dealing with optimization and dose calculation of a radiotherapy treatment plan, the following activities occur (Fig. 2):

- The requesting application creates a treatment plan that it would like to get optimized. Additionally the dose distribution for the optimized treatment plan shall be calculated.
- The requesting application stores the treatment plan and control information for the optimization and for the dose calculation.
- It requests the necessary procedures to be done by a specialized application with a certain priority.
- During optimization or dose calculation the requesting application wants to get status information about the progress of the requested procedures. The application or the operator may decide to abort the requested procedure(s) at any time.

### 3.2 General Purpose Worklist SOP Class

The General Purpose Worklist SOP Class supports some of the required functionalities to initiate and control the activities described above.

The main differences to the previously existing Basic Worklist Management Service Class are (Fig. 3)

- the worklist can be stored
- each procedure step can have references to objects that contain input data or that are relevant for the procedure step

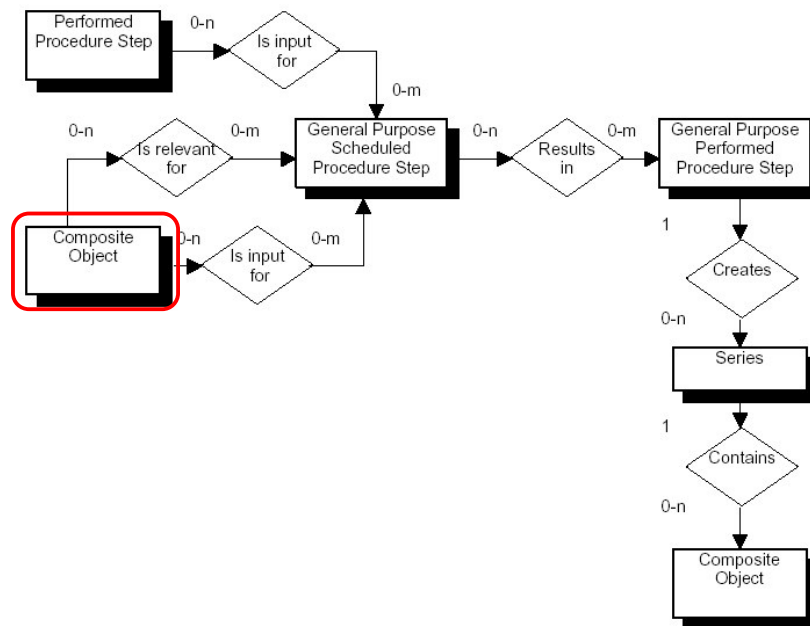


Figure 3: Scheme of the General Purpose Worklist Service Class

The current General Purpose Worklist SOP Class works according to a Pull Model which means that the *Performing Node* (e.g. dose calculation engine) has to query the central node for orders to be performed.

This will create a lot of communication overhead furthermore the *Performing Node* has to ‘know’ all central nodes that may request a service.

The definition of a new Management SOP Class shall extend the existing General Purpose Worklist Service Class by introducing a Push Model. Furthermore the set of radiotherapy objects needs to be extended by one or more new composite objects that will describe the requested procedure and provide the necessary control information

### 3.3 Introduce Push Model

Therefore a new Management SOP Class shall be defined that support a Push model where the requesting node (Host) will request a service from a dedicated *Performing Node* (Fig. 4).

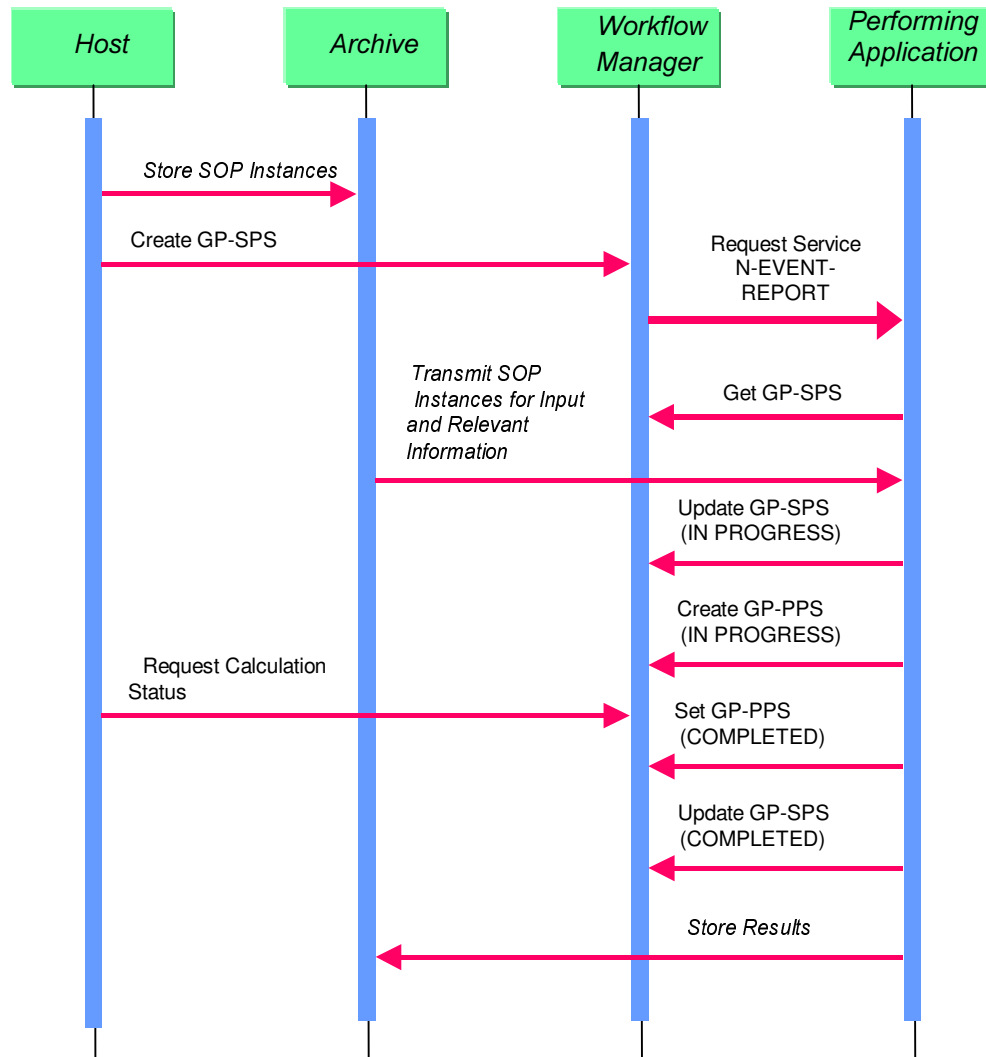


Figure 4: Schematic workflow when requesting remote processing

The Push model will complement the existing General Purpose Worklist SOP Class. It will remove the need for the *Performing Node* to know about the potential sources for a processing request which it would need to poll continuously for new requests..

Within the Push model the requesting node (Host) becomes the active part that is initiating a process that shall be performed on the *Performing Node*.

### 3.4 Introduce new Composite Object(s)

The current RT extensions of DICOM do not contain data structures to prescribe a treatment or to request a dose calculation.

For example it cannot be described,

- where to calculate dose (specification of dose calculation grid)
- which dose calculation algorithm shall be used
- if density corrections shall be applied and which density correction
- how the DVH constraints look that shall be used for optimisation

## 4. Extended Query / Retrieve

The characteristics of most of the RT objects are that they are non-image objects carrying their information within the object/image level attributes.

The current Query/Retrieve models provided by the DICOM standard do not oblige applications to support any attributes on the object/image level for querying (Fig. 5).

**Table C.6-4**  
COMPOSITE OBJECT INSTANCE LEVEL KEYS FOR THE PATIENT  
ROOT QUERY/RETRIEVE INFORMATION MODEL

Description	Tag	Type
Instance Number	(0020,0013)	R
Overlay Number	(0020,0022)	O
Curve Number	(0020,0024)	O
LUT Number	(0020,0026)	O
SOP Instance UID	(0008,0018)	U
All Other Attributes at composite object instance Level		O

**Figure 5: Patient Root Query/Retrieve Information Model**

When working with Query/Retrieve on RT objects it is essential to be able to select one or more desired objects based on their object/image level attribute values. For example it is helpful to select

- RT Plan based on  
RT Plan Label, RT Plan Date, RT Plan Time, Treatment Sites

- RT Image based on  
RT Image Label, Image Type, Radiation Machine Name, Referenced Beam Number
- RT Structure Set based on  
Structure Set Label, Structure Set Date, Structure Set Time
- RT Dose based on  
Dose Comment, Dose Summation Type
- RT Beam Session Record and RT Brachy Session Record based on  
Treatment Machine Name, Referenced Fraction Group Number
- RT Treatment Summary Record based on  
Current Treatment Status, Treatment Status Comment, First Treatment Date, Most Recent Treatment Date

Therefore there is a need for an extended Query/Retrieve support for RT objects.

The difficulty arising when defining a new Query/Retrieve model for RT is due to the fact that many of the attributes that might be of interest are Type 3 (optional).

## 5. Profiles

Under WG6 advice at the time when the RT objects were defined, it was decided to use a relatively small number of SOP classes to encapsulate the data from machines having these various modes of operation. A much larger number of SOP classes could have been used to enhance interoperability, but a number of possibly incorrect assumptions about how devices operate and how the field would evolve would have been necessary.

A much more workable solution seems to retain general-purpose objects, but develop a set of profiles describing requirements and limitations for an intended use scenario. Development of a formal framework for specification of these profiles would greatly aid interoperability. Traditionally this work has been undertaken by external entities (such as IHE), but it may be preferable to have a DICOM framework for working groups to develop these profiles.