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IHE Radiology Technical Framework
White Paper
2004-2005

For Trial Implementation

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Departmental Workflow

15 **IHE-Radiology Technical Committee**

Editors:

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1   Introduction

In order to harmonize, align and further develop the existing Scheduled Workflow with other
Integration Profiles, an overall concept and model covering all the important workflow management
issues on an imaging department level is presented.

This white paper describes IHE's understanding of workflow that underlies the IHE Radiology
Technical Framework (TF). While the concepts described in this paper are derived from radiology it
is believed that they are applicable across most imaging departments. Thus the term "imaging
department" is used within this paper where there is nothing specific to radiology being described.

The paper first provides some background information about the design goals of the workflow model
as well as definition of some key terms. The paper then discusses the workflow concepts as viewed
from outside the imaging department followed by a discussion of those same concepts as seen from
within the imaging department. The paper then relates these concepts to transactions and behavior
specified in the existing TF and how the capabilities of several of the existing integration profiles can
be combined to provide an additional level of integration. The departmental workflow is further
described in terms of behavior and sequencing that would be required to connect the existing IHE
Radiology Integration Profiles as well as presenting a few examples of real-world use cases to
illustrate the points.

It is assumed that the reader has a working knowledge of the integration profiles, actors and
transactions defined within the IHE Radiology Technical Framework.

2   Request for Feedback

The IHE Radiology Planning and Technical Committees request feedback on the concepts described
in this White Paper and the Gaps/ Open Issues identified at the end of the White Paper. Comments
can be submitted via the web discussion forum at http://forums.rsna.org.

3   Design goals

The Integration Profiles in the IHE Radiology Technical Framework enable the seamless use of
relevant imaging data **within** a multi-vendor system environment of a hospital's imaging department.
In most cases, such imaging work is **ordered** from other departments **external** to the imaging
department that provides diagnostic imaging and imaging data access **services** to ordering
departments.

The variability in imaging work practices, mainly arising from differences in patients' health statuses,
enterprise business processes and local policies, demands a highly **flexible** workflow management.
The design of the IHE Workflow Profiles attempts to provide a balanced approach between flexibility
and complex, difficult to align methods addressing the same practice need.

The **Scheduled Workflow Integration Profile** served as central workflow management for
coordinating important work steps necessary to diagnostic imaging. Additionally, there are other
Radiological Workflows that help to manage specific aspects of complex groups of activities such as
post-processing and reporting.   From these existing workflow profiles, generalized and flexible
workflow management is evolved.

Workflow management on a departmental level needs to reliably and timely **connect different
workflow parts** within the department. It also maintains similar relevant connections to workflow
participants outside the imaging department.

4   Definitions

This section defines the terms and concepts used for describing the Departmental Workflow in this
document. These definitions are generic enough to apply to other domains though some examples are
radiology specific.

Order: A part of a managed workflow that corresponds to a service request from an external
department. An order is broken down in one or more Requested Procedures to be fulfilled by one or
more of the Radiological Workflows. Example: request for a CT Head with 3D Reconstruction to be
broken down into CT Head Scan and 3D CT Head Reconstruction.

Requested Procedure: A part of a managed workflow that forms a logical work unit that is a part of
an order. The Requested Procedure can be broken down into elementary procedure steps, whose
individual outputs are used as input to a reporting activity (e.g., for a radiologist). These steps are
distributed to specified workflow participants individually or grouped in worklists. The execution of
these steps may need a certain sequence of execution (Requested Procedure Phases). A Requested
Procedure is a structural view on a managed workflow, ignoring execution timing and scheduling
aspects. Example: Reporting on images acquired for a CT of the neck.

Procedure Step: A part of a managed workflow that is considered an elementary unit of work that is
part of a Requested Procedure that cannot be divided for scheduling purposes. Typically it is
assigned to a human or a machine workflow participant. A Procedure Step can be managed in a
worklist and contributes to fulfilling a Requested Procedure, and generally results in the creation of

85   some sort of output data. Example: CT Abdomen/Pelvis Scan without contrast, Calcium scoring reconstruction of the heart.

Certain procedure steps are not directly associated with acquisition (e.g. injections, treadmill, etc.) though they may be expressed formally as Scheduled Procedure Steps (if these workflow participants support a DICOM Worklist) or informally as an internal procedure step (this is beyond the scope of

90   IHE).

Worklist: A worklist contains scheduled procedure steps or workitems from one or more requested procedures to be performed by a target (e.g., a human, a device, or an application) within an explicit workflow. Worklists do not necessarily prescribe a certain sequence of performing its entries. Example: today's worklist for a technologist at a conventional radiography device.

95   **Worklist Manager:** A workflow participant having the control over a set of worklists that it generates based on information obtained from different workflow participants. Example: Post-Processing Manager actor from the IHE Radiology Technical Framework that provides worklists to post-processing capable participants, or Report Manager actor from the IHE Radiology Technical Framework that provides worklists to Report Creator actors.

100   **Worklist Client:** A workflow participant that obtains worklists from Worklist Managers and performs corresponding procedure steps or workitems from the worklist. The Worklist Client generates work status information. Example: Acquisition Modality actor in the IHE Radiology Technical Framework.

Output Manager: A workflow participant storing, making accessible and managing results that are

105   generated during the execution of procedure steps. It obtains results to be made accessible within the managed workflow from Worklist Clients and may issue availability status information to Worklist Managers. Example: Image Manager/Image Archive and Report Repository in the IHE Radiology Technical Framework.

Service: The sum of processes that is performed in order to fulfill an order or request for service. The

110   requestor provides information to the workflow participants of the service, and obtains the services' outputs. In the context of the IHE Radiology Technical Framework, a Radiology Department provides diagnostic imaging and imaging data access services to other parts of the enterprise.

Workflow: The sequence of processes performed by human or machine workflow participants according to procedural rules in order to fulfill work goals. It may be possible to identify different

115   parts within a workflow, consisting of groups of workflow steps.

In a managed workflow, certain managing actors define, distribute and monitor process steps and related execution statuses in a controlled way to other workflow participants.

Workflow Step: An identified unit of work in an enterprise that contributes to the enterprise's business goals and comprises a set of more detailed process steps. Often called "business process" or

120   "activity". In order to manage the execution of a process, it is translated in requested procedures and procedure steps of a managed workflow. Example: perform a CT scan, print the acquired images on film.

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Explicit workflow: A sequence of workflow steps provided and controlled via a computer-generated worklist that consists of indivisible (elementary) steps. The execution is pre-defined by the healthcare
125   institution and can be completely managed by IHE-capable workflow participants.

Implicit workflow: A sequence of workflow steps that are **not** provided and controlled via a computer-generated worklist. This results in a set of one or more steps that are defined in such a way so that coordination of actor activities is done without using IHE worklist mechanisms. Multiple activities within an actor may be coordinated and managed through a computer-generated worklist.
130   However such activities are not described by IHE because IHE does not describe activities within an actor. Example: Implicit Post-Processing may describe the situation that some post-processing steps are done during the acquisition workflow by the same person on a standalone post-processing workstation that does not receive a separate worklist.

Departmental Workflow Manager: The workflow participant having the overall control over the
135   departmental workflow management, connecting internally and externally managed workflow parts. It receives orders from outside the department, distributes work to departmental workflow participants and notifies statuses back to outside the department. Example: Order Filler actor in the Scheduled Workflow Integration Profile of the IHE Radiology Technical Framework.

Requested Procedure Phase: A set of procedure steps within a workflow that is controlled by a
140   single Worklist Manager and has certain timing characteristics. One Requested Procedure can consist of one or more Requested Procedure Phases that are interdependent and are executed in a certain order: the execution of procedure steps in one phase depends on the results of prior phases and itself may trigger the execution of procedure steps in subsequent phases. One phase may consist of several procedure steps that are scheduled and performed. Example: The post-processing phase can start after
145   sufficient input exists from the acquisition phase.

Instance Availability Notification (IAN): A status message within a managed workflow that is sent by an Output Manager to certain Worklist Managers to inform them about the availability status of certain stored objects.

5   Concepts

5.1   Departmental Workflow - External View
150

An Imaging Department provides a number of services to the enterprise or practice it supports. These services fall into two types of services:

- Diagnostic Services
- Imaging Information Access Services (Reports & Images)

155   In addition, an Imaging Department needs, from the enterprise, a number of services to support its operation such as the Admission, Discharge, Transfer (ADT) Services that provide patient identification and demographics.
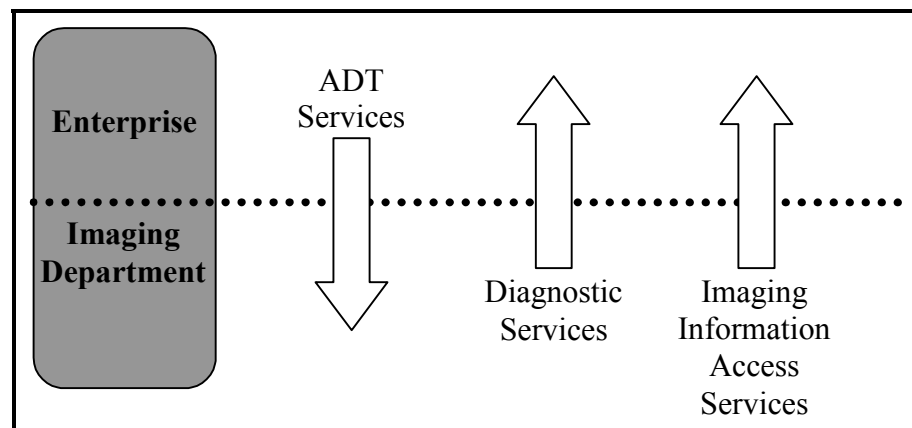
Figure 1: Imaging Department Services

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The Diagnostic Services provide a diagnostic report from the Imaging Department to the Enterprise, most often in response to an Order issued by the Enterprise.

The Imaging Information Access Services provide, to any other authorized external department, access to reports and associated images for their operation. For example, neurosurgery or oncology needs to retrieve images for their therapy planning activities.

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The Admission, Discharge, Transfer (ADT) Services notify the Imaging Department of relevant patients registered, their identifiers and associated demographic information. This will avoid re-entering this information for patients that are examined by the Imaging Department as well as improving the accuracy, reliability and timeliness of the demographic information as it passes through the department.

170

Based on a detailed understanding of workflow within radiology this white paper describes a model that explains how work gets done based on worklists and status notifications. The model is rich enough to also handle cases where some of the work is not scheduled. This model is believed to be applicable in other areas that have similar workflow characteristics.
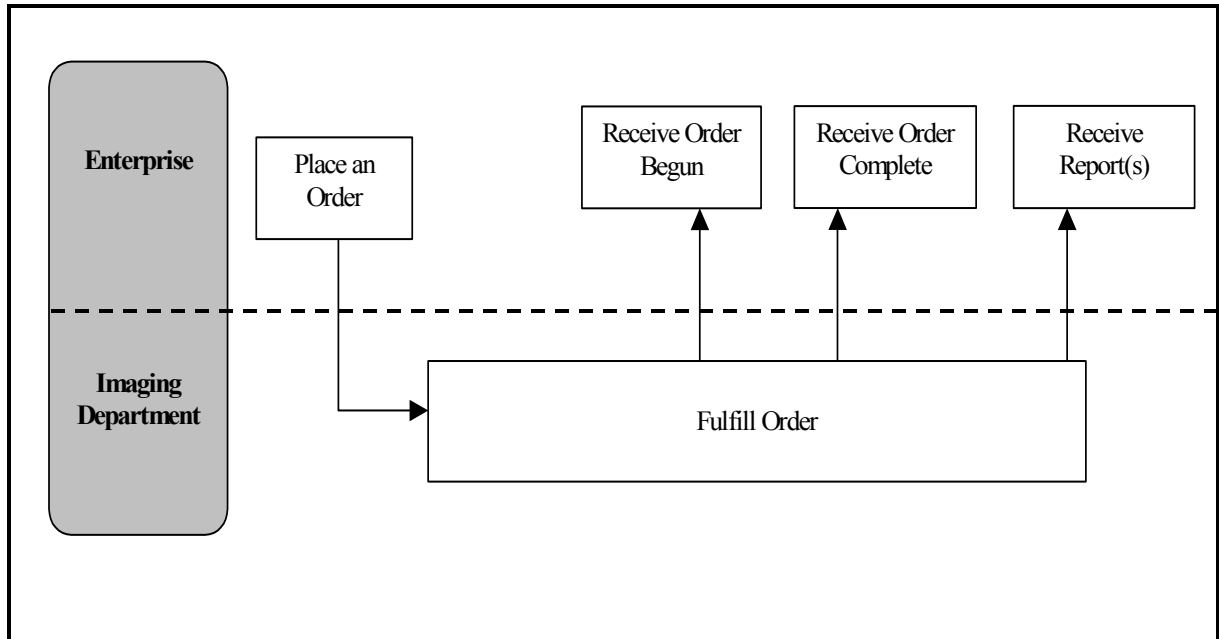
175 **5.1.1   Service Workflow Process Model – External View**

These Services are rendered according to a workflow process model. It defines the sequencing of processes that are managed at the boundary between the Imaging Department and the Enterprise.

There will be a number of processes that are performed within the Imaging Department but that are not directly visible at the service boundary. Such internal processes and their Workflow Process Model will be described later.

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The Diagnostic Services operate according to a workflow process described in Figure 2. An Order is placed by the Enterprise. The Enterprise receives notification that the Order has begun. One or more requested procedures are performed in response to this Order. One or more resulting reports and images are provided by the Imaging Department to the Enterprise upon completion of the Order.

185   Diagramming Note (for Figures 2, 3, 5 - 8): Arrows on these diagrams indicate the sequence of tasks: the flow of work from one step to the next. Arrows entering a step box show the preceding steps necessary for that step to begin. Arrows leaving a step box show any successive steps .

Figure 2: Diagnostic Services

The Imaging Information Access Services operate according to simpler workflow process as described in Figure 3. The enterprise requests access to image information associated with a requested procedure, and is provided with corresponding images, evidence objects or reports.
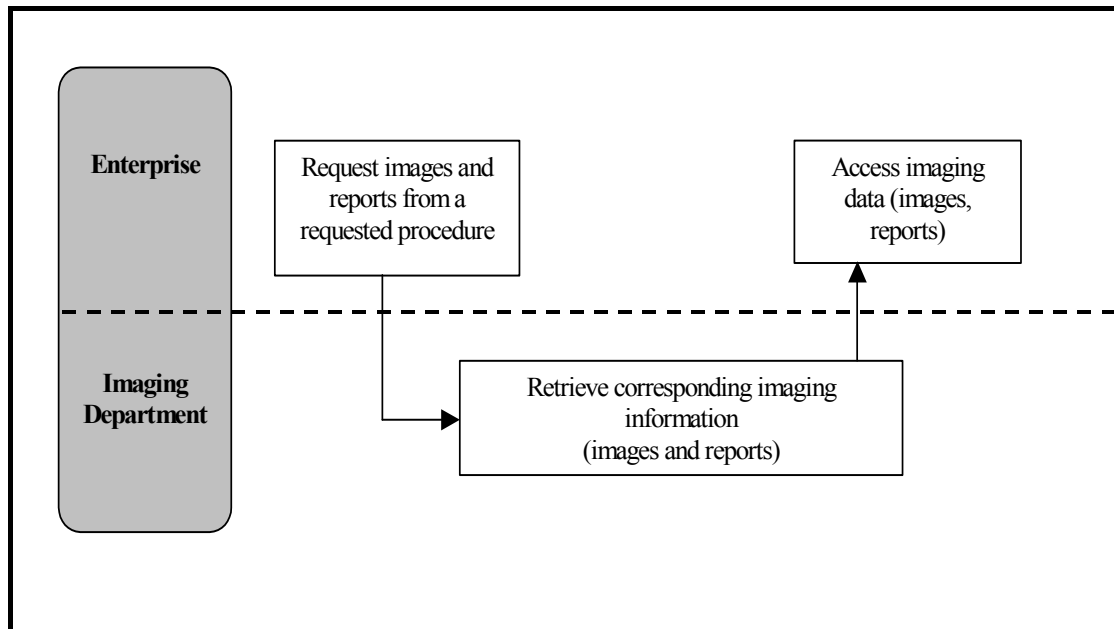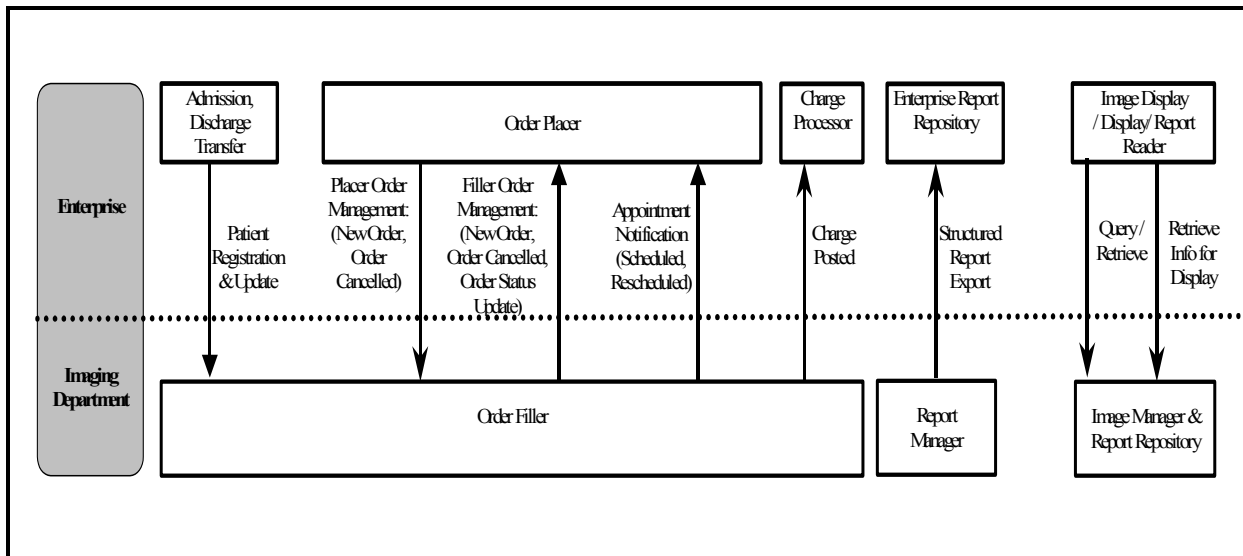
Figure 3: Imaging Information Access Services

5.1.2   Actors and Transaction Model – External View

200   The exchange of information at the boundary of the Imaging Department that supports the Diagnostic
      and the Imaging Information Access Services requires information exchanges initiated by
      information systems that reside either outside or inside of the imaging department. IHE abstracts
      these information systems as one or more Actors that represent a specific collection of functions. The
      information flows to and from these Actors are abstracted as Transactions.

205   Figure 4 provides an overview of some of the IHE Transactions defined by the IHE Radiology and IT
      Infrastructure Technical Frameworks that support the Diagnostic and the Imaging Information Access
      Services. All actors and transactions mentioned here are involved in transactions that cross the
      boundary of the Imaging Department.

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Figure 4: Actors and Transaction Crossing the "Enterprise/ Departmental" Boundary

To illustrate a possible real-world system environment, the following table provides one **example** of how the actors shown above could map to real world hospital IT systems. There are other "mappings"

215   that are equally valid.

Actor	Real World IT System
Admission, Discharge, Transfer	Hospital Information System (HIS)
Order Placer	HIS
Charge Processor	Hospital Billing System
Enterprise Report Repository	EHR Application
Image Display	Oncology Workstation
Display	EHR Application
Report Reader	Oncology Workstation
Order Filler	Radiology Information System (RIS)
Report Manager	Radiology Reporting System
Image Manager & Report Repository	Picture Archive & Communication System (PACS)

In supporting these Services, the Information Systems of the Imaging Department rely on Services provided by enterprise information systems (e.g. HIS) such as the Admission, Discharge, Transfer

220   (ADT) Services.

There are sequencing requirements across these transactions. For example, some charges may not be posted until the Order has been completed and the Report made available. These are not specified in this section, but in the Integration Profiles to which those transactions belong.

5.2   Departmental Workflow - Internal View

225 **5.2.1   Internal Imaging Departmental Workflow Processes**

To generate the diagnostic report for a requested procedure, multiple phases may be involved such as image acquisition, post-processing, and reporting. The image acquisition phase includes scheduling the acquisition steps and performing the acquisition of images. The post-processing phase includes the creation of additional images derived from the acquired ones such as three-dimensional
230 reconstruction. It also includes the creation of evidence documents that encode measurements or computer aided diagnosis performed on the images. The reporting phase includes the creation of the diagnostic report.

In a typical imaging department, the acquisition phase occurs first. The post-processing phase
235 optionally follows acquisition if additional data (such as 3D reconstruction data) is needed. Finally, the reporting phase occurs. In practice, variations in the phase sequencing exist. Some procedures do not require post-processing; others can be urgent in which case the reporting could start as soon as images are available even if the acquisition has not yet ended. Furthermore, some sites may have multiple post-processing phases.

240 A simple imaging phase sequencing example is shown in

Figure 5. "Phase Completed" notifications from the Acquisition, and Post-processing phases back to the Order Filling Phase have been omitted from the figure to simplify it.
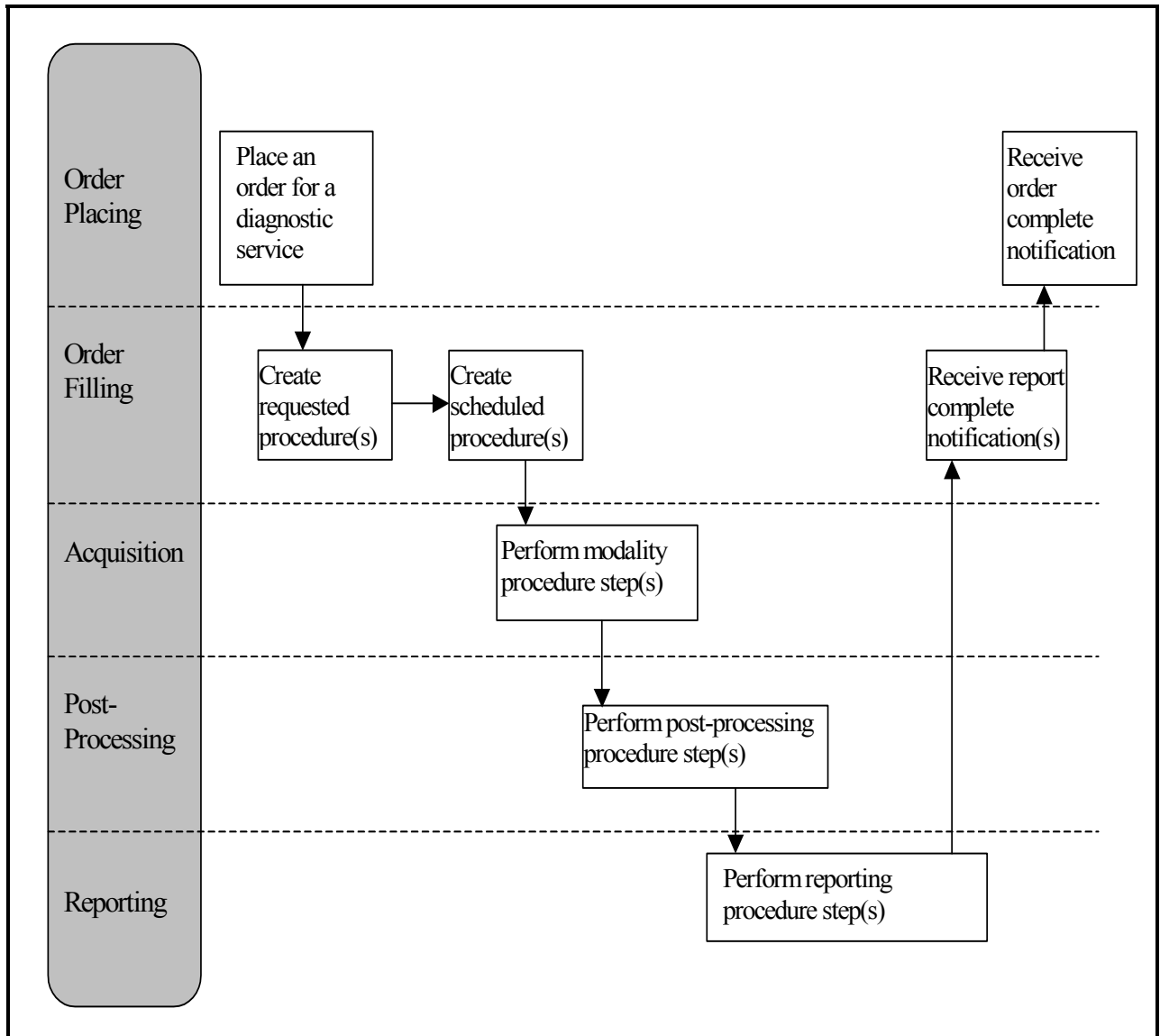
Figure 5: Simple Imaging Phase Sequencing – Including all Phases

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Figure 6 shows a more complex example of imaging phase sequencing. In this case, the sequencing represents the workflow processes associated to an order with 2 requested procedures (e.g.

250   involvement of two radiologists of different sub-specialties is needed). The first requested procedure requires a single acquisition procedure step and two post-processing procedure steps prior to the

reporting step. The second requested procedure requires two acquisition steps but no post-processing prior to reporting. Again, the completion notifications from the acquisition and post-processing phases have been omitted for simplicity. In this example, the post-processing and reporting phases are done based on an "implicit" schedule. In other words, they are not triggered off of an explicit scheduled workitem for post-processing or reporting.
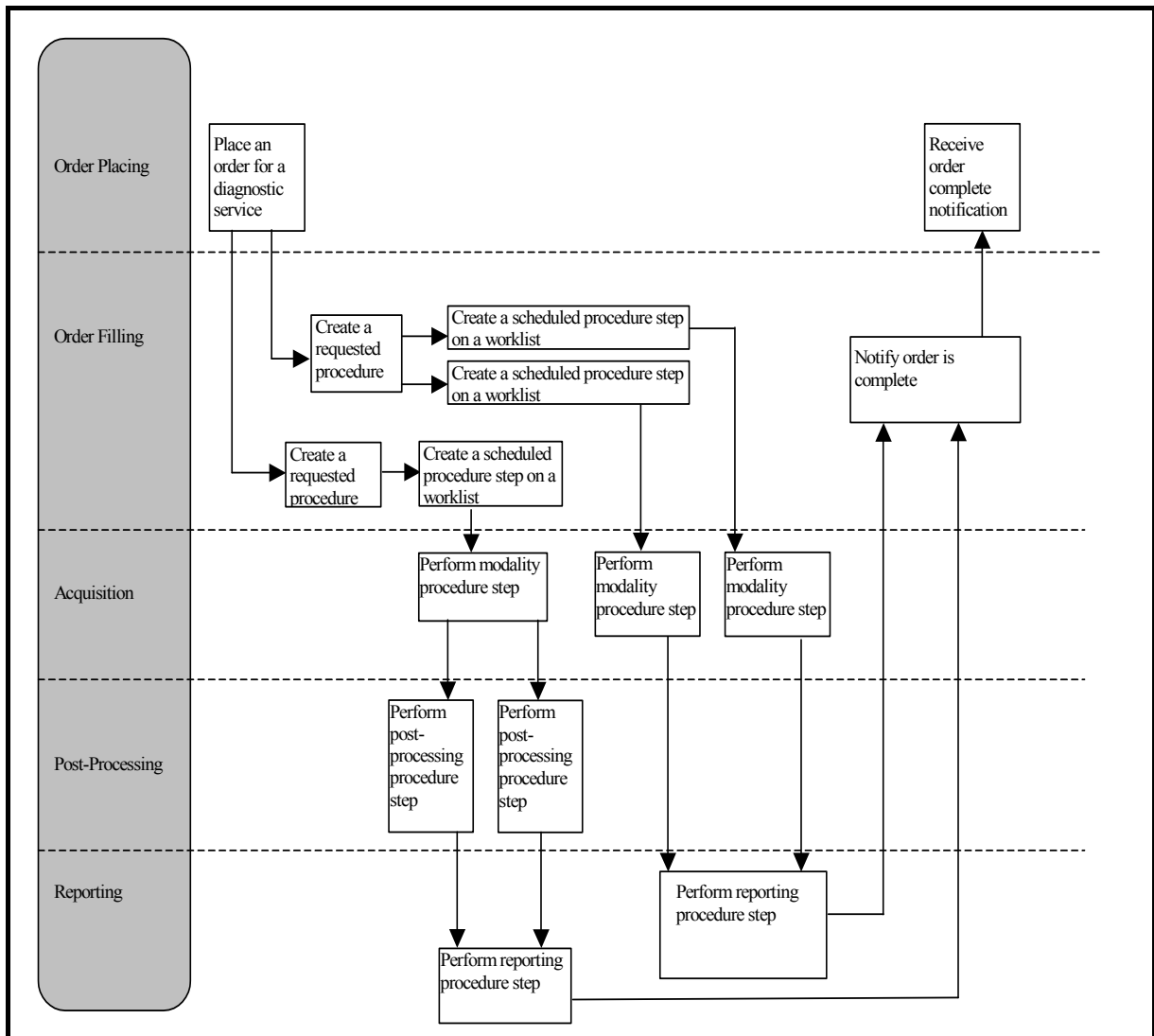
255

Figure 6: Imaging Phase Sequencing – Multiple Requested Procedures
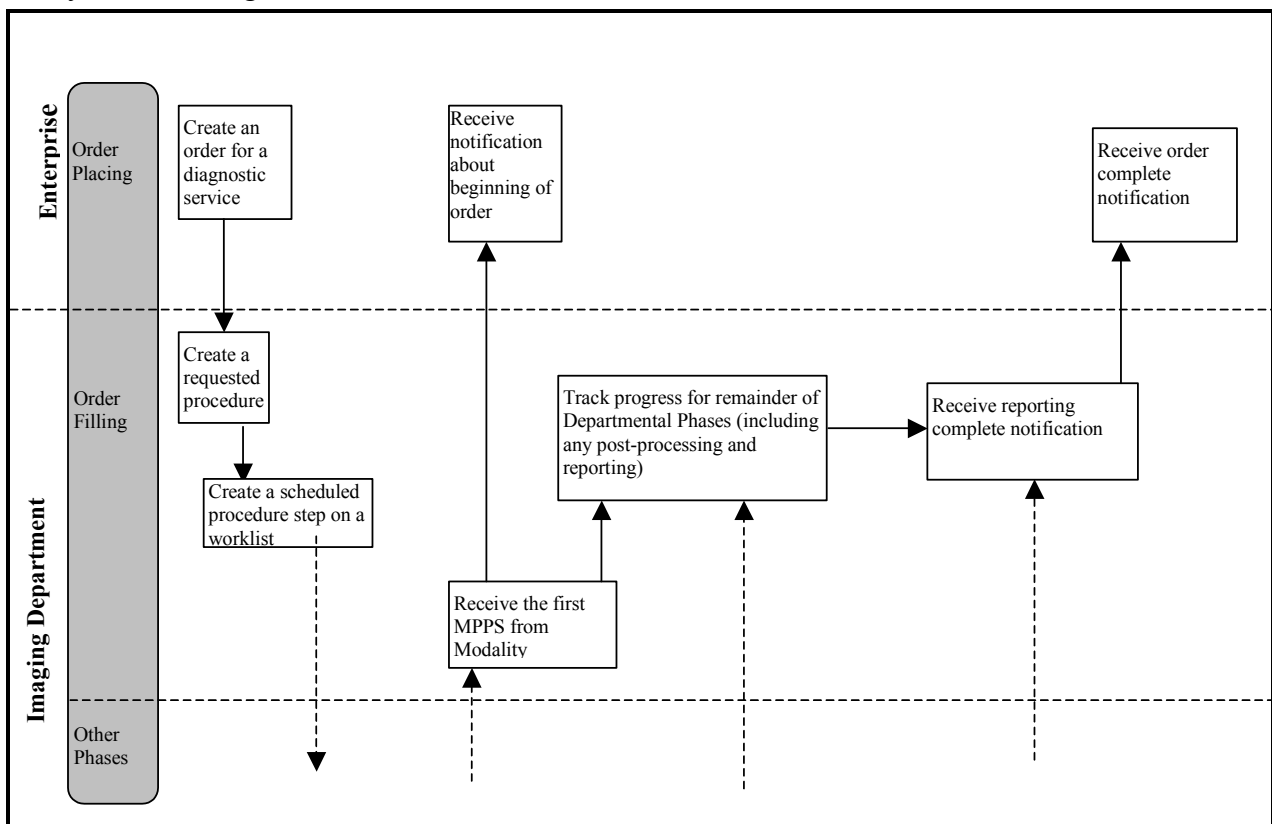
260 **5.2.2   Status Notification to Order Placing Phase**

The Order Filling Phase notifies the Order Placing Phase about the status of the order.

Figure 7 illustrates the flow of key activities involved this notification. Order Filling notifies Order
Placing that the order has started upon receiving the first MPPS message from the acquisition
modality related to a requested procedure of that order. Order Filling notifies Order Placing that the
265   order is complete after receiving the notification that the reporting is complete for all the procedures
of that order.

In order to simplify this figure, it is assumed that the order is composed of only one requested
procedure. In the case where the order is composed of multiple requested procedures, the notification
of the beginning of the order is sent when the first procedure of that order begins; the notification of
270   the completion of the order is sent when the last procedure of that order completes.

Note that this figure shows a view similar to that shown in Figure 2 in section 5.1.1. The main
difference is that this figure includes the next level of detail associated with the "Fulfill Order"
activity shown in Figure 2.

275   **Figure 7: Status Notification to Order Placing**

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5.2.3   Detailed Internal Phase sequencing

280   Requested Procedures generally require two or more phases to be performed in sequence. Commonly, a Requested Procedure (RP) Phase is initiated when the preceding phase, if any, has ended and when all input needed to perform the activities of that RP phase are available. However, a worklist manager can decide to start the work as soon as some input is available even if the preceding phase has not ended or the needed input is not complete.

285   The worklists/ worklist items used to manage the work done within a given phase can be generated or updated any time the worklist manager deems it appropriate based on internal logic. This logic may require input received in the form of notifications regarding previous steps and availability of previous data. For example, a worklist manager may choose to schedule steps based on a variety of input including step notifications, phase completions, and data availability notifications.

290   The common sequencing of acquisition and post-processing is shown in

        Figure 8. Note that in the figure the major workflow phases have been associated with one or more actors responsible for keys steps within those RP phases. In addition, the figure assumes the Performed Procedure Step (PPS) Manager Actor is grouped with the DSS/ Order Filler rather than
295   with the Image Manager/Image Archive. See section 8.2 - Remaining Gaps item #4 for a discussion of this alternative.
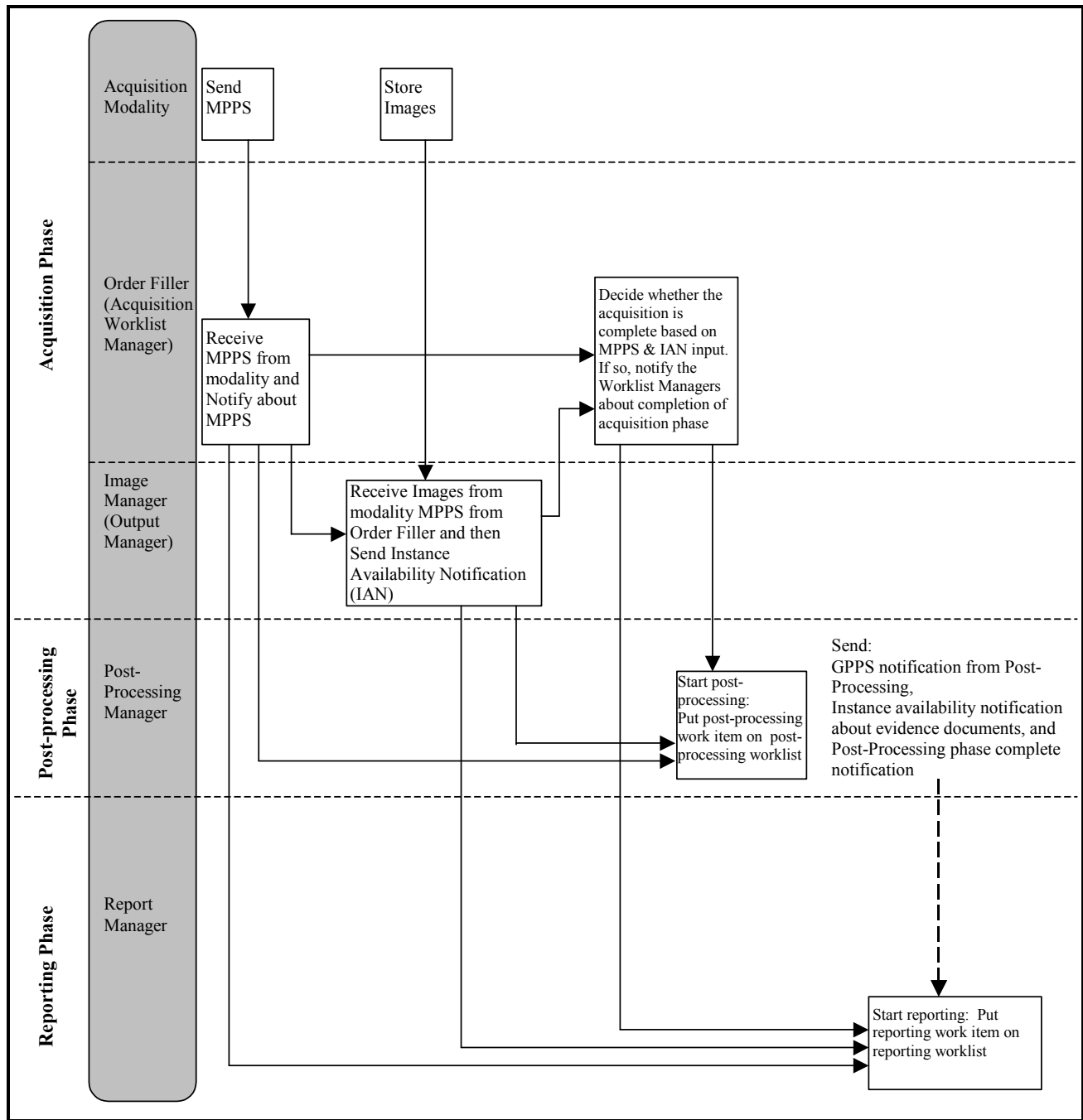
Figure 8: Detailed Internal Phase Sequencing – Acquisition & Post-processing

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5.2.4   Internal Depatmental Phase Combinations (Workflow Chaining)

The scope of work managed by a single worklist manager for a given requested procedure is referred to here as a phase. There are three types of phases that currently exist within the IHE Radiology Technical Framework. They are:

305   1.   Acquisition Phase - The Department System Scheduler/ Order Filler is the worklist manager for the actors involved in the Acquisition Phase as they cooperate to manage and complete any image acquisition associated with the requested procedure that they receive from the Department System Scheduler/ Order Filler. The Acquisition Phase is nearly always the first phase to begin since the other two phases typically require the output from the Acquisition
310   Phase as input.

     2.   Post-processing Phase – The Post-processing worklist manager is either the Post-Processing Manager or the Department System Scheduler/ Order Filler. The actors involved in the Post-processing Phase cooperate to manage and complete any post-processing activities associated with the requested procedure that they receive from the Department System
315   Scheduler/ Order Filler. The Post-processing Phase generally requires information from the Acquisition Phase as input before it can begin.

     3.   Reporting Phase – The Report Manager is the reporting worklist manager. The actors involved in the Reporting Phase cooperate to manage and complete any diagnostic reporting activities associated with the requested procedure that they receive from the Department
320   System Scheduler/ Order Filler. The Reporting Phase generally requires information from the Acquisition Phase and sometimes from the Post-processing Phase as input before it can begin.

Note that other workflows may be considered and described in the future. Examples of such workflows may include: physician conferencing workflows, and patient case review workflows.

325 In general, there are four types of actors key to completing the work within (and between) the Requested Procedure Phases. They are: worklist clients, output managers, worklist managers and a workflow manager. The essential requirements for each actor type follow.

A **Worklist Client** needs to be able to:
- Get a worklist from its worklist manager
330 - Create the necessary content (output) for the given phase
- Send a Performed Procedure Step (PPS) (directly or indirectly) to the worklist manager it gets its worklist from.

An **Output Manager** needs to be able to
- Send Instance Availability Notification (IAN) to at least one worklist manager
335 - Receive output from Worklist Clients

A **Worklist Manager** needs to be able to:

- Create worklist items (either based on notification info or possibly from instructions from the Department System Scheduler/ Order Filler)
- Provide worklists to worklist clients

340
- Receive PPSs (directly or indirectly) from its own worklist clients
- Send client PPSs to registered interested parties (peer Worklist Managers)
- Optionally receive PPS from peer Worklist Managers
- Receive IAN from output managers.
- Receive phase complete status messages from peer worklist managers.

345
- Send phase complete status messages to peer worklist managers or to the Workflow Manager.

A Department System Scheduler/ Order Filler (**Workflow Manager)** needs to be able to:

- Notify Worklist Managers of Requested Procedures
- Receive phase complete status messages from worklist managers

350

Figure 9 shows an example of how the various phases interact with one another and the key transactions needed to coordinate activities between them. The scope of each phase is roughly shown in the figure by a light gray box. The figure also reflects the sequencing associated with Use Case 1- Departmental Workflow: Scheduled Procedure with Post-Processing and Reporting described in
355   section 7.1 below.

[Note 1: the figure shows the DSS/Order Filler actor twice. On the right side showing its primary role of department order workflow manager, and again towards the left showing its additional role as manager of the acquisition worklist. The virtual transactions "between" these systems are shown with dotted lines since they are actually the same system .]

360   [Note 2: the figure assumes the PPS Manager Actor is grouped with the DSS/ Order Filler. See section 8.2 - Remaining Gaps item #4 for a discussion of this alternative.]
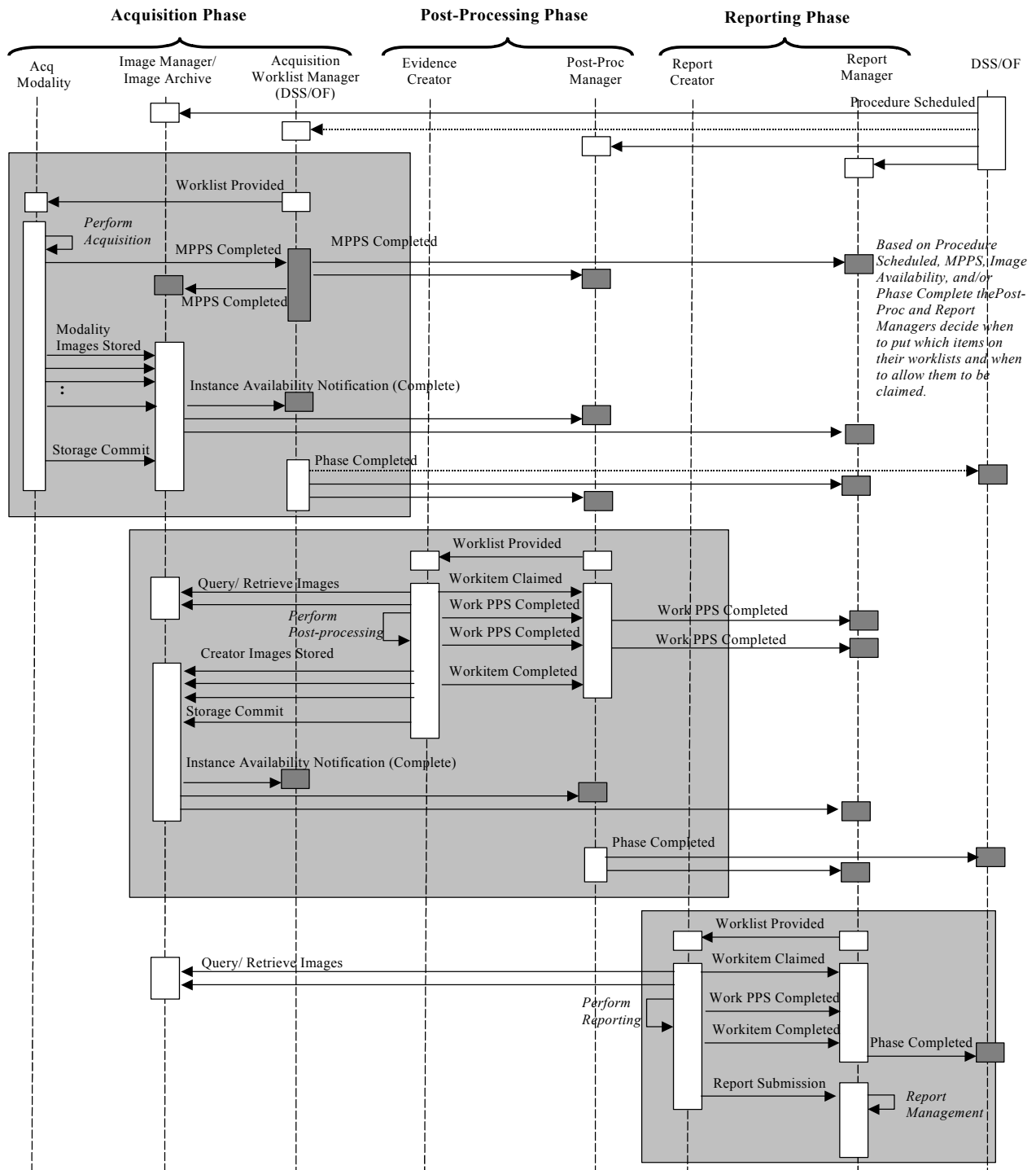

Acquisition Phase   **Post-Processing Phase**   **Reporting Phase**

Figure 9: Phase Combination Sequence Diagram

The event sequence in the previous diagram stops in the reporting phase prior to report storage and distribution. The diagram does **not** show an Instance Availability Notification sent at the end of the reporting phase being initiated by the Report Manager. (See Section 9.2 – Gap #10 for discussion of the use of IAN for reports).

The dark shaded boxes in the above sequence diagram indicate the distribution (receipt) of workflow status synchronization messages.

It should be noted that nothing prevents the DSS/ Order Filler from accepting the basic activity events within each phase and the worklist managers can be configured to include the DSS/ Order Filler in their notification lists. The figure above assumes that that level of monitoring is not necessary in general since the phase notifications provide a compilation of the relevant details. Similarly, worklist managers are not shown receiving notifications from other worklist managers "upstream" in the workflow (for example, the post-processing manager is not notified of activities in the reporting phase). The worklist managers are capable of receiving such messages if they are added to the notification lists of the other worklist manager.

5.3   Summary of Departmental Workflow Concepts

The IHE Departmental Workflow concept that has been presented in this section is centrally monitored by the Department System Scheduler/ Order Filler, but its execution may be managed by distributing further control into two levels.

The first is a set of one or more Worklist managers that are responsible for management of worklist items used to control the activities within a certain phase of a requested procedure. Worklist Managers are also responsible for conveying phase status and information availability to the Workflow Manager and other peer Worklist Managers. The Worklist Manager's method to generate worklist items is not explicitly described by IHE. Currently it is assumed that a Worklist Manager uses internal logic to generate worklist items. Generation of worklist items directly triggered by an actor other than the Worklist Manager is not defined in this concept paper, and would require additional communication between this other actor and the Worklist Manager.

The second level is a set of workflow participants that are entirely in charge of performing specific procedure steps. This level is defined in detail in the existing individual workflow profile already included in the IHE Radiology Technical Framework and is not described further in this paper.

6   Proposed Departmental Workflow Requirements

The following requirements describe general requirements that are needed to support a robust Departmental Workflow Model. These requirements are in addition to the requirements described in the existing Technical Framework. The "subjects" of the requirements are often a category of IHE actors as defined in section 4 Definitions (e.g., worklist managers, output managers, etc). These additional requirements are candidates for future extension of the IHE Radiology Technical Framework.

400
- A worklist manager should avoid including references to "non-available" instances in the worklist entries it makes available. For example if a worklist manager has not received an instance availability notification including instance A, then instance A should not be referenced in a worklist entry. Worklist references made to "un-available instances" need to be handled as exceptions.

405
- An output manager shall maintain a list of destinations to which it sends Instance Availability Notification (IAN). This list shall include the controlling worklist manager and may include other worklist managers interested in the availability of instances from that output manager. It is recognized that this will create configuration management issues. See section 8.2 - Remaining Gaps (item #8)

410
- Status notifications initiated by either Worklist clients, such as MPPS and GP-PPS transactions, shall not be delayed when forwarded by the controlling Worklist Manager (or the Image Manager/Image Archive when grouped with the MPPS Manager Actor) to other Worklist Mangers. [Note: It has been proposed that the Acquisition Output Manager (Image Manager/Archive) be responsible for distributing the MPPS messages in the case of acquisition

415
  workflow. This is contrary to the assumption made throughout most of the rest of this paper that the existing PPS Manager Actor is grouped with the DSS/ Order Filler for the "Acquisition Phase (i.e., the Scheduled Workflow Integration Profile). See section 8.2 - Remaining Gaps (item #4) for a discussion of this alternative.]

- Unscheduled MPPS, GP-PPS or IAN messages may occur after the Requested Procedure Phase to
420
  which they belong is declared complete. IHE requires that the worklist managers and departmental workflow manager be capable of dealing with this situation.

- GP-PPS sent from the Post-processing Manager (worklist manager in the Post-processing Workflow Integration Profile) to the Order Filler may also be forwarded to the Report Manager (worklist manager in the Reporting Workflow Integration Profile) to enable chaining of the
425
  requested procedure phases managed by the two workflow profiles.

- Selection of instances associated with relevant prior studies is the responsibility of the worklist manager that needs those priors to create a worklist item.

- The following rules describe the requirements for determining when a Requested Procedure Phase is completed and what gets sent from the worklist manager managing the phase to other
430
  worklist managers and the departmental workflow manager to indicate completion:

  - The worklist manager decides if the Requested Procedure Phase it manages has been completed or discontinued.

  - The worklist manager is not required to gate the "Requested Procedure Phase completed notification" on the availability of relevant instances, but can be configured to do so. The
435
    receivers of the "Requested Procedure Phase completed notification" shall be able to handle both cases.

  - The "Phase Completed notification" shall contain a list of output for all the associated requested procedure phase procedure steps. (Note: Under certain circumstances it may be that not all generated output instances are referenced in the "requested procedure status

440   notification". For example, local policy may dictate that instances created that are deemed
           of insufficient diagnostic quality are not included in the notification.)

- The performed protocol codes included in the requested procedure status notification (GP-PPS) shall be the concatenation of the list of MPPS or GP-PPS codes generated by the content creator. The Phase Completion Status is the aggregate status of all performed
445   steps in the phase, thus all codes in the individual performed steps are included. (Note: concatenation of the list of codes allows for duplicate codes to be included).

- A worklist manager may issue a "replacement requested procedure phase completed". This may occur in "append case" situations. The receiving worklist manager or departmental workflow manager shall be able to handle this "replacement" completion
450   notification along with any erroneous instance notifications received prior to the replacement.

7   Example Departmental Workflow Use Cases

These use cases represent real-world examples of how procedures may be performed within the Department (Radiology). The main purpose of these use cases is to show how the workflow
455   capabilities introduced in the previous sections provide the flexibility needed to address a broad range of imaging needs..

In some cases external input may have initiated the process (e.g.. HL-7 feed with Patient Orders), or may be required prior to the initiation of the Procedure Steps (e.g. Lab results or Pharmacology order).

460   ## 7.1   Use Case 1 – Departmental Workflow: Scheduled Procedure with Post-Processing and Reporting

This Use Case is meant to demonstrate the full Departmental Workflow case where Acquisition, Post-processing and Reporting Workflows are all chained together.

The following Scheduled CT Angio with 3D reconstruction of the Circle of Willis' for 'aneurysm' Use
465   Case portrays how departmental workflow may work in this case.

- The admitting staff registers the patient on the ADT.

- The referring physician places an order for a CT Angio with 3D reconstruction of the Circle of Willis' for 'aneurysm' on the Order Placer.

- The Order is received by the Order Filler, a Scheduled Procedure Step is created and is selected
470   via a worklist by the Technologist on a CT.

- The technologist performs the acquisition, and the quality of the images is checked prior to the releasing of the patient from Radiology. (Upon completing the acquisition, the images are automatically sent to the Image Manager).

- The reporting Radiologist sees a new work item appear on their worklist (indicating that some
475   images are available) but noticing that the "partial data" flag is set (since the 3D images are not yet available) decides not to start work on that item yet.

20

- The Order Filler system now possesses the information that the acquisition portion of the Order has been completed.

480
- The processing technologist sees a new work item appear on their worklist (indicating that the CT Angio images are available for processing).

- The processing technologist selects the worklist item and produces the required 3D Reconstruction of the Circle of Willis images and stores them to the Image Manager.

- The Order Filler system now possesses the information that the post-processing portion of the Order has been completed.

485
- The reporting Radiologist sees that the "partial data" flag on the work item is no longer set (indicating that both the CT Angio Images and the post-processed 3D Reconstruction of Circle of Willis Images are available for reporting).

- The reporting Radiologist selects the worklist item and produces a Final Report on the Report Creator/Workstation.

490
- The Order Filler system now possesses the information that the Order has been completed.

- The referring physician reviews the report for the Patient's CT Angio with 3D reconstruction of the Circle of Willis for 'aneurysm' from the Enterprise Report Repository.

The figure below defines an example of the work breakdown of a "CT Angio with 3D reconstruction of the Circle of Willis for 'aneurysm'" Order in the case that Acquisition, Post-Processing and
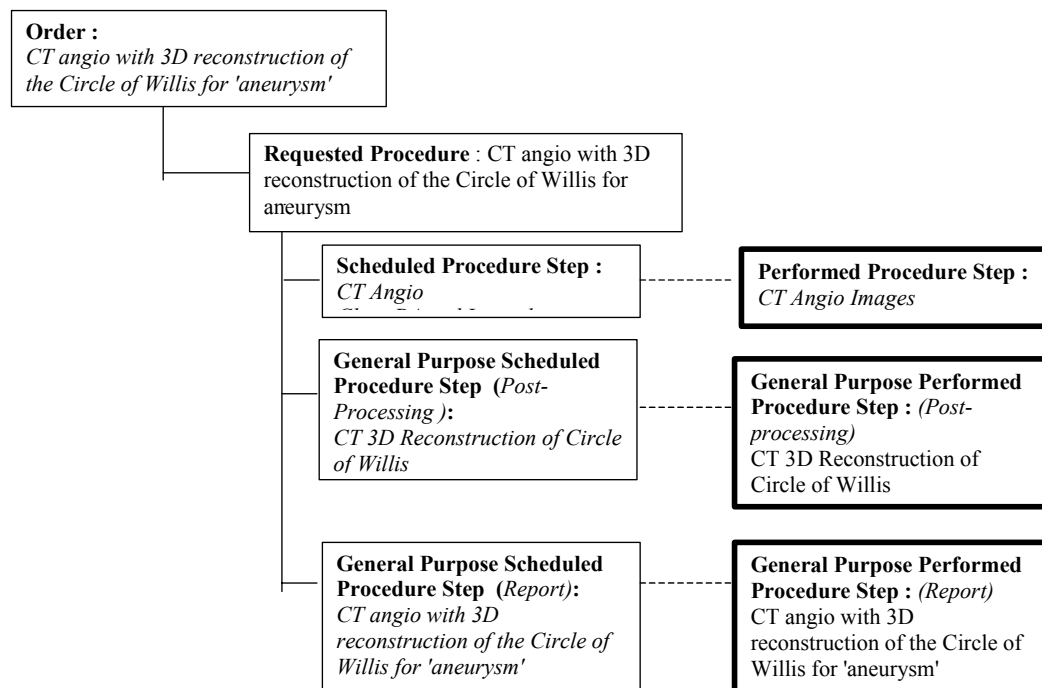495   Reporting are done explicitly.

Figure 10: Order breakdown - Use Case 1

The detailed sequence diagram for this case is the same as the general example presented in Figure 9 in section 5.2.4 above.

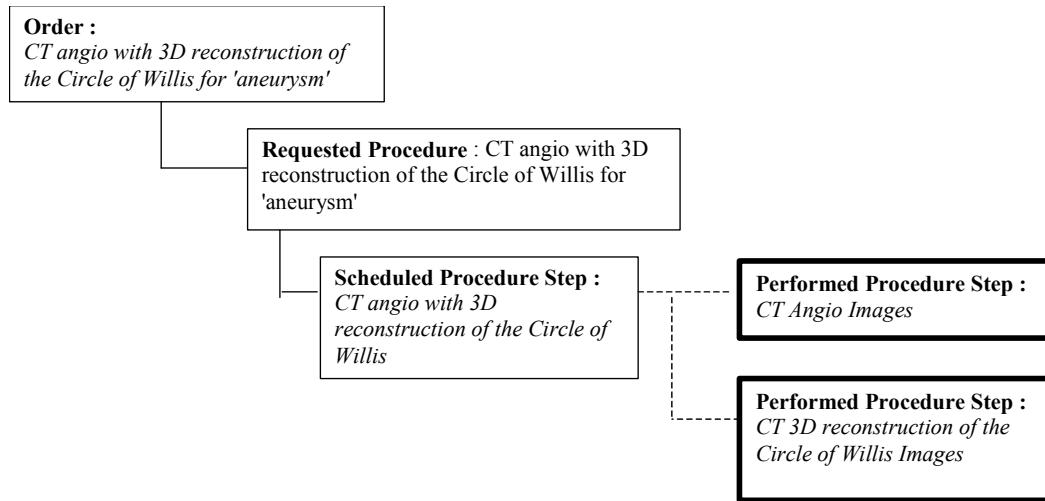## 500 7.2 Use Case 2 – Departmental Workflow: Scheduled Procedure with implicit Post-Processing and implicit Reporting

This Use Case is meant to demonstrate the Departmental Workflow case where both Post-processing and reporting are done implicitly based on the scheduled acquisition procedure step. It demonstrates how the same order as the previous use case may be performed with a different workflow (implicit
505   scheduling of post-processing and reporting).

The following Scheduled CT Angio with 3D reconstruction of the Circle of Willis for 'aneurysm' Use Case portrays how departmental workflow may work in this case.

- The admitting staff registers the patient on the ADT.

- The referring physician places an order for a CT Angio with 3D reconstruction of the Circle of
510   Willis for 'aneurysm' on the Order Placer.

- The Order is received by the Order Filler, a Scheduled Procedure Step is created and is selected via a worklist by the CT Technologist.

- The technologist performs the acquisition, and the quality of the images is checked prior to the releasing of the patient from Radiology. (Upon completing the acquisition, the images are
515   automatically sent to the Image Manager).

- The technologist goes over to the 3D Reconstruction Workstation (or the PACS Workstation with 3D capabilities) where the CT Angio Images have been sent produces the required 3D Reconstruction of the Circle of Willis images and stores them to the Image Manager.

- The Order Filler system now possesses the information that the acquisition and post-processing
520   for the Order has been completed.

- The reporting radiologist uses the RIS to produce the Final Report.

- The Order Filler system now possesses the information that the Order has been completed.

- The referring physician reviews the report for the Patient's CT Angio with 3D reconstruction of the Circle of Willis for 'aneurysm' from the Enterprise Report Repository.
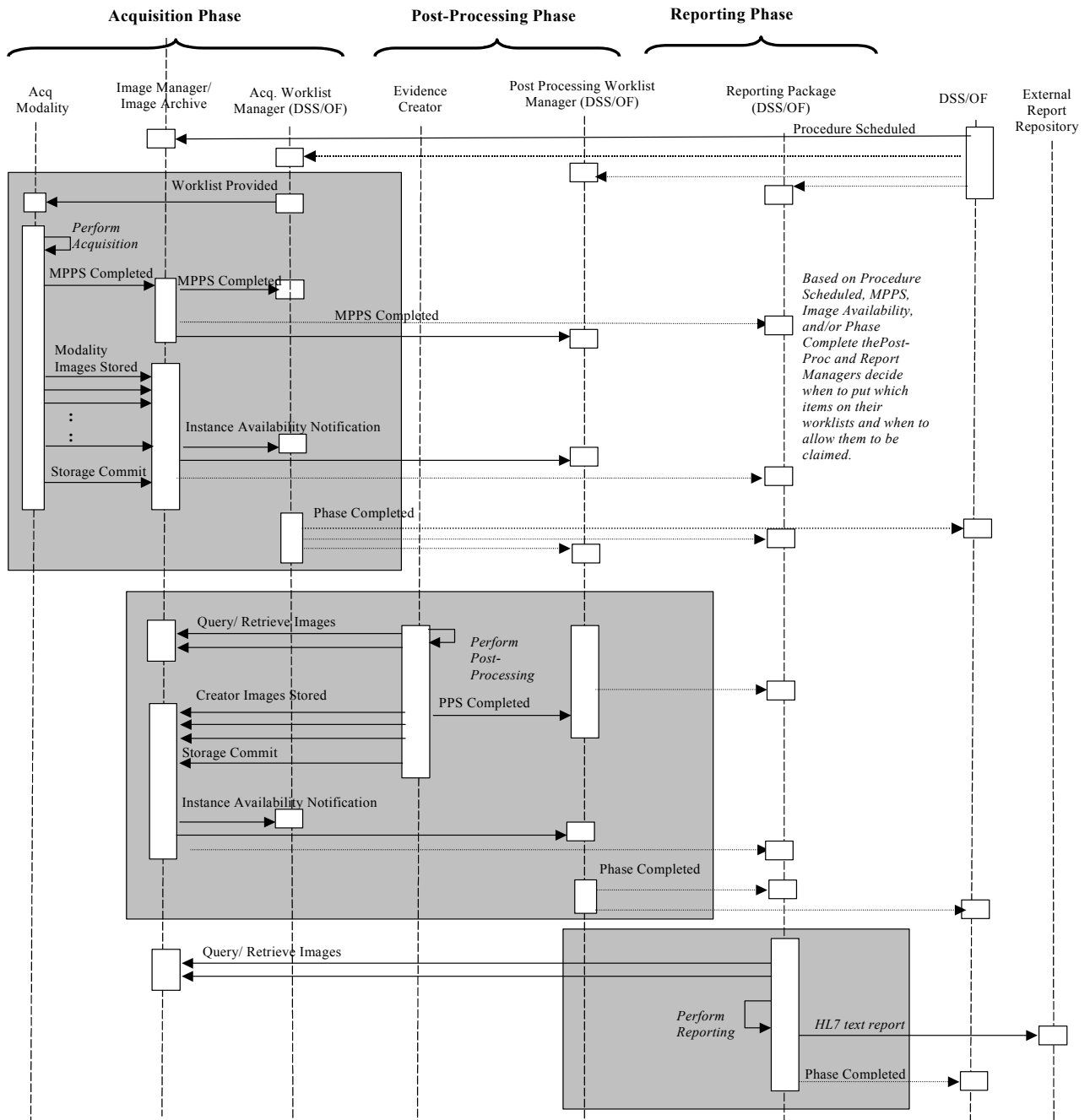
525   Figure 11 defines an example of the breakdown of a "CT Angio with 3D reconstruction of the Circle of Willis for 'aneurysm'" Order in the case that Post-Processing and Reporting are done implicitly as part of Scheduled Workflow.

Figure 12 shows the sequencing of key transactions associated with this use case.

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Figure 11: Order breakdown – Use Case 2

Figure 12: Sequence Diagram - Use Case 2

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7.3   Use Case 3 – Departmental Workflow: Unscheduled Procedure With Implicit Reporting

540   This Use Case is meant to demonstrate the Departmental Workflow case where only Scheduled Workflow is used for acquisition, and reporting is performed internally to the IHE Actors.

The following unscheduled Chest X-Ray Procedure Use Case portrays how departmental workflow may work in this case.

- The admitting staff registers the patient on the ADT.

545   - The patient provides the technologist with an order from the referring physician for a Chest X-Ray.

- The technologist performs the unscheduled acquisition, and the quality of the images is checked prior to the releasing of the patient from Radiology. (Upon completing the acquisition, the images are sent to the Image Manager).

- The Order Filler creates a Requested Procedure/Order on the RIS

550   - The reporting radiologist uses the RIS to produce the Final Report (Patient Information Reconciliation has occurred prior to the start of reporting).

- The Order Filler system now possesses the information that the Order has been completed.

- The referring physician reviews the report for the Patient's Chest X-Ray Procedure from the Enterprise Report Repository.

555   Figure 14 shows the sequencing of key transactions associated with this use case.

The following figure shows the breakdown of the Order into the Requested Procedures then into the corresponding scheduled and performed procedure steps:
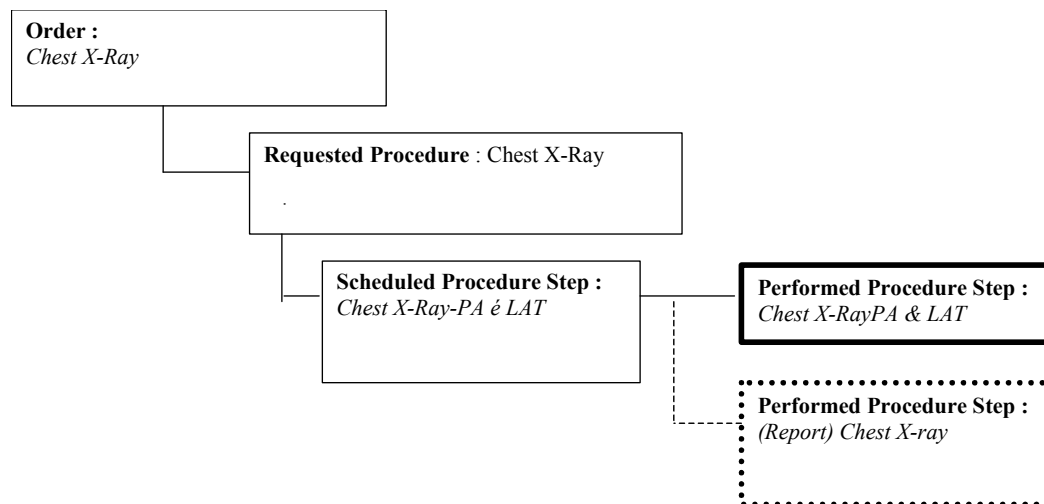

Figure 13: Order breakdown – Use Case 3
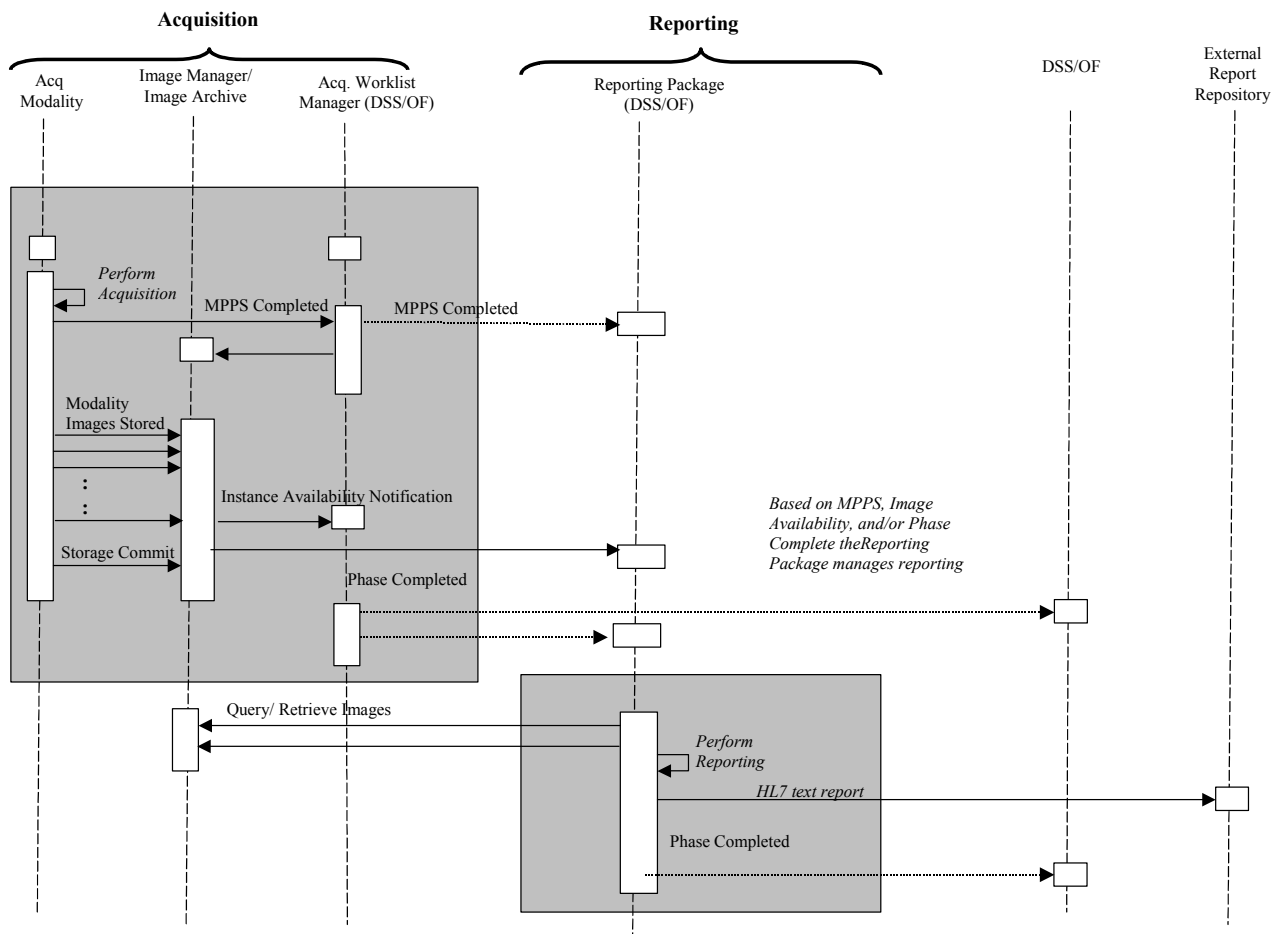
560

Figure 14: Sequence Diagram - Use Case 3

7.4   Use Case 4 – Departmental Workflow: Scheduled Procedure with multiple Requested Procedures

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This Use Case is meant to demonstrate the full Departmental Workflow case where multiple Requested procedures are used. A combination of Acquisition, Post-processing and Reporting Workflows are all chained together.

570 The following Scheduled Nuclear Med R/O Embolism Use Case portrays how departmental workflow may work in this case. (For a more complete description of how Nuclear Medicine workflow "maps" to IHE workflow concepts please refer to Appendix E in the NM Image Profile Supplement).

• The admitting staff registers the patient on the ADT.

- The referring physician places an order for a Nuclear Med R/O Embolism on the Order Placer. The procedure plan for this order requires that a Chest X-ray be performed prior to the Nuclear Medicine imaging procedures.

- The Order is received by the Order Filler, a Scheduled Procedure Step for the Chest X-ray is created and is selected via a worklist by the X-ray Technologist.

- The technologist performs the acquisition, and the quality of the images is checked prior to the releasing of the patient from the modality. (Upon completing the acquisition, the images are sent to the Image Manager).

- The Order Filler system now possesses the information that the Chest X-Ray portion of the acquisition portion of the Order has been completed.

- The reporting Chest Radiologist sees a new work item appear on their worklist.

- The reporting Chest Radiologist selects the worklist item and produces a Final Report on the Report Creator/Workstation for the Chest X-Ray. The Radiologist decides to allow the ventilation/perfusion to continue (otherwise the NM Ventilation and Perfusion scheduled procedure steps would have been discontinued).

- The Order Filler system now possesses the information that the Chest X-Ray portion of the Order has been completed.

- The technologist checks their worklist on the NM Modality and selects the first scheduled procedure for the NM Ventilation Perfusion Procedure, namely the NM Ventilation Step. (Newly created and scheduled by the Department Scheduler/Order Filler when it sees the successful completion of the X-Ray procedure). [Note that the ordering and coordination of the isotopes from the Lab is out of scope for IHE Radiology.]

- The technologist performs the acquisition for the first scheduled procedure step of the NM Ventilation Perfusion Procedure, and the quality of the images is checked prior to the releasing of the patient to the waiting room. (Upon completing the acquisition, the images are sent to the Image Manager).

- The technologist checks their worklist on the NM Modality and selects second NM Ventilation Perfusion Step, namely the scheduled Perfusion Step. (The second acquisition is done after a given delay.).). [Note that the ordering and coordination of the isotopes from the Lab is out of scope for IHE Radiology.]

- The technologist performs the acquisition for the second scheduled procedure step of the NM Ventilation Perfusion Procedure, and the quality of the images is checked prior to the releasing of the patient from Radiology. (Upon completing the acquisition, the images are sent to the Image Manager).

- The Order Filler system now possesses the information that the NM Ventilation Perfusion portion of the acquisition portion of the Order has been completed.

- The processing technologist sees a new work item appear on their worklist (indicating that the NM Ventilation Perfusion images are available for processing).

- The processing technologist selects the worklist item and performs the required analysis and stores them to the Image Manager.

615
- The Order Filler system now possesses the information that the post-processing portion of the Order has been completed.

- The reporting Nuclear Medicine Physician sees that the "partial data" flag on the work item is no longer set (indicating that both sets of NM Ventilation Perfusion Images as well as the Chest X-Ray images are available).

620
- The reporting Nuclear Medicine Physician selects the worklist item and produces a Final Report on the Report Creator/Workstation.

- The Order Filler system now possesses the information that the Order has been completed.

- The referring physician reviews the report for the Patient's Nuclear Med R/O Embolism from the Enterprise Report Repository.

The following figure shows the breakdown of the Order into the Requested Procedures then into the
625   corresponding scheduled and performed procedure steps:

Figure 15: Order breakdown – Use Case 4

The workflow sequence diagram in this case may be found in Figure 16. The shaded blocks in the diagram identify the Requested Procedure Phases but do not describe the internal detail of the phase. Since the activities within each of the phases are identical to the full Departmental Workflow with explicit Acquisition, Post-Processing and Reporting shown in earlier diagrams, only transactions important to the chaining of the Radiological Workflows for this multi-scheduled procedure are shown.. See Figure 9 for the detailed transactions within each of the individual workflow phases.

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Figure 16: Sequence Diagram - Use Case 4
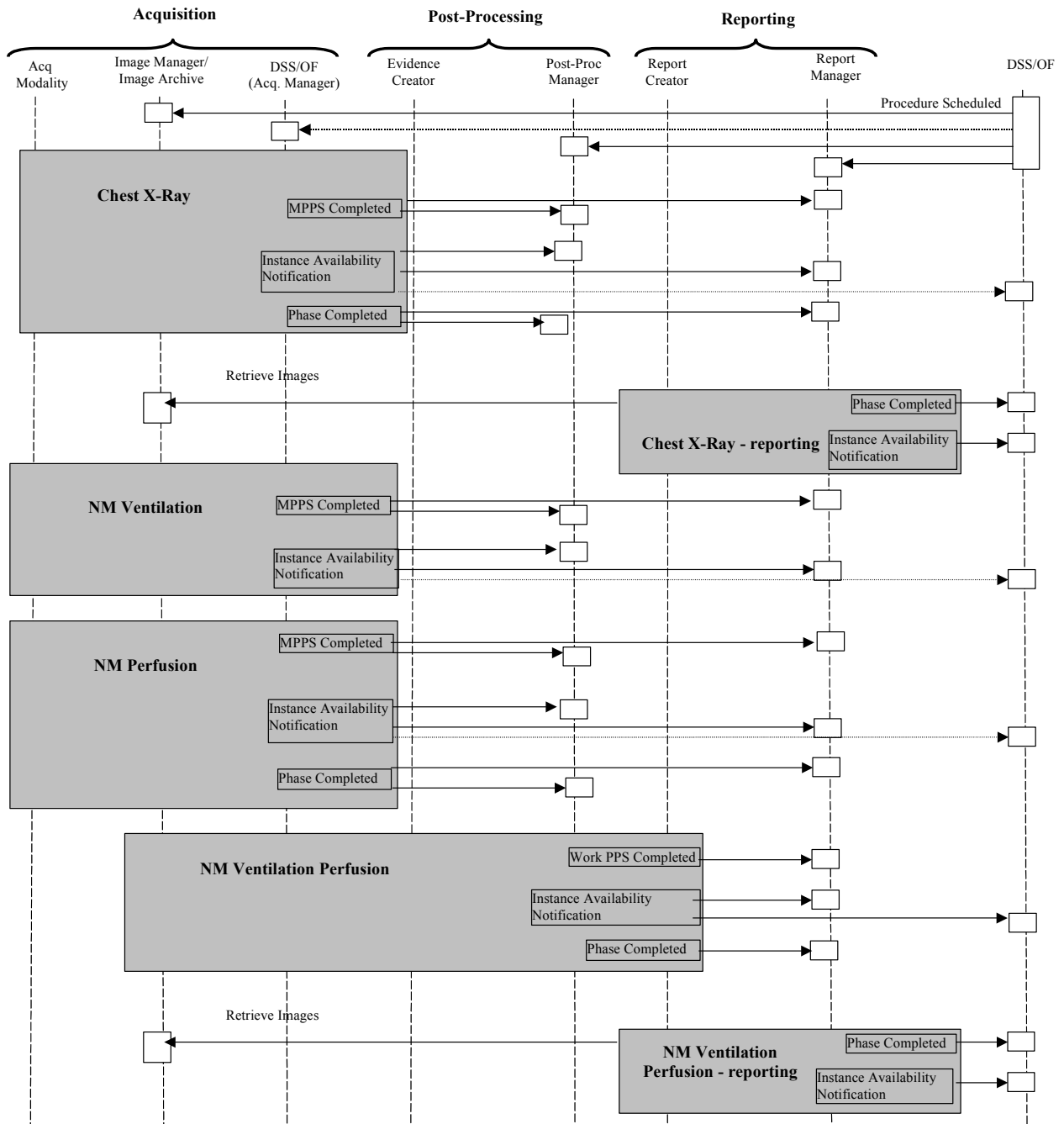
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8   Gaps and Open issues

The following sections list "gaps" that exist in the current IHE Radiology Technical Framework (v5.5 – Final Text) that hinder the ability to implement the concept of a Departmental Workflow as described in this white paper. The gaps addressed by Technical Framework Supplements in the current IHE cycle are identified in section 8.1, while other known remaining gaps are listed in section 8.2.

8.1   Gaps addressed in TF Supplements for 2004

1. Instance Availability Notification:

Although the IHE TF defines an Image Availability Query (transaction 11), this relates to querying an Image Manager. While this transaction is helpful for many scenarios, especially synchronizing or querying outside a specific image creation or prefetching process, a notification of an Output Manager storing any DICOM objects can more timely report such workflow statuses back, enabling subsequent actors to start work earlier. This new transaction has been added as an option in the Scheduled Workflow Integration Profile. For more details on what is/ isn't included in the Instance Availability Notification Supplement, see section 8.2 (items #6, 7, 10 and 11) and section 8.3 below.

2. Appointment Management:

An external department having ordered diagnostic procedures from the imaging department might be interested in getting to know details on the scheduling of this procedure (e.g. date and time). This status information, sent back from the Order Filler, may support the ordering department organizing their workflow (external workflow from the imaging department perspective). The transaction describing this scheduling status notification has been added as an option to the Scheduled Workflow Integration Profile and is described in the Appointment Notification Supplement.

8.2   Remaining Gaps or Issues

3. Text Report Export:

In existing implementations, simple (unstructured) text reports are created and intended to be made available to the enterprise. IHE Radiology currently does only the textual export of DICOM SR objects. In order to enable completion of a requested procedure by a simple text report, it should be possible to export such a report to an Enterprise Report Repository either via simple text or more "structured" text (e.g., HL7 Clinical Document Architecture (CDA)). It must be possible to query, retrieve and display the text report for internal and external workflow processes.

4. Performed Procedure Step Manager:

The Performed Procedure Step (PPS) Manager has different responsibilities in distributing process status information to other Worklist Managers The current Scheduled Workflow Integration Profile allows the PPS Manager Actor to be grouped either with an Image Manager/Image Archive or a Department System Scheduler (DSS)/ Order Filler. Certain diagrams and transaction flows within

this white paper often show the PPS Manager grouped with the DSS/ Order Filler. Some show it grouped with the Image Manager/Image Archive, in order to highlight that the case selected in these example is arbitrary. A change to the existing Technical Framework PPS Manager grouping rules remains an open issue as both make use of the PPS Complete transaction: the Image Manager/Image

675   Archive (for triggering the sending of the IAN, linking images with Requested Procedures, etc.) and DSS/Order Filler (step completion, dose and consumables tracking). The varieties of real-world configurations (multiple PACS for one RIS, Multiple RIS with one PACS, legacy modalities without PPS support, etc) require further analysis before a fixed grouping of the PPS Manager may be decided.

680   .

    5.   Requested Procedure Phase Completed / Performed Work Status Update:

There is a need to align the "Phase Completed Notification" transaction described in this white paper with the existing "Performed Work Status Update" transaction. This may require clarification/ extension of the current transaction. In this white paper, a Worklist Manager receiving process status

685   information input from Worklist Clients, other Worklist Managers or the Departmental Workflow Manager, may have internal logic to determine when a workflow phase is terminated. In order to inform subsequent Worklist Managers or the Workflow Manager of this, the handling of this information flow needs to be further specified.

    6.   Connect Instance Availability Notification transaction to Workflow Profiles:

690   The Instance Availability Notification is included as an option on the existing Scheduled Workflow Profile in the IHE Radiology Technical Framework. In the future it will be necessary to incorporate this transaction into the other existing IHE Radiology Workflow Profiles (Post-processing Workflow and Reporting Workflow) along with the requisite behavior and rules within those profiles. (See also items #10 and #11 in this section).

695   7.   Image Manager's determination of Instance Availability in Post-processing Workflow Profile

In Scheduled Workflow, the Image Manager/ Image Archive can determine when it has received all of the instances associated with a performed procedure step in order to trigger the Instance Availability Notification. This is possible since the Image Manager receives the MPPS notification with the list of instances associated with the given procedure step. In the current Post-processing

700   Workflow Profile, performed procedure step information (GP-PPS) is not fully distributed. Specifically, the Image Manager does NOT receive performed procedure step information (GP-PPS) indicating the list of instances associated with a given performed step, thus it has no clear way to know when to trigger the sending of the Instance Availability Notification as required by the IAN Supplement. This gap could be addressed by allowing the Image Manager/ Archive to receive GP-

705   PPS notifications in the Post-processing Workflow Profile.

    8.   Need for a Configuration Management Profile:

There is a need for a Configuration Management Profile to manage a number of "configuration requirements" identified as necessary to support the departmental workflow concepts described in this paper. For example, this paper describes the need for Output Managers (e.g., Image

710   Manager/Archive) to maintain a configurable list of destinations for Instance Availability
        Notifications. One aspect of such a profile that was suggested during the public comment phase was
        use of about a configuration component that acts as a central proxy for all Notification Messages
        between the different Manager actors.

        9. Analyze the Relationship of Patient Information Reconciliation (PIR) with Departmental
715   Workflow:

        There is a need for a thorough analysis of the necessary interaction between the Departmental
        Workflow concepts described in this paper and the existing PIR Integration Profile to ensure data
        integrity is preserved in cases where multiple existing workflow profiles are cooperating as part of a
        Departmental Workflow scenario.

720   10. Instance Availability Notification – Availability of Reports

        It is not clear is output managers as repository of reports need to issue Instance Availability
        Notifications. Whether other Worklist managers actually need such notifications is not clear. In
        addition, sending the report may be sufficient.

        11. Instance Availability Notification – Intermediate Notifications and other uses:

725   There is currently no explicit endorsement made within the Instance Availability Notification
        Supplement for the sending of intermediate instance availability notifications, though it is not
        prohibited by the supplement either.

        There are a number of use cases not specifically analyzed that might be served by the Instance
        Availability Notification. One such use case is indication of prefetch results.

730   Pre-fetching or pre-loading pro-actively moves images and other objects from an off-line or near-line
        storage to an on-line storage for fast access to the information. It is usually done before information is
        needed and preferable in a period of little other activities on the system (e.g. night hours). Pre-
        fetching involves the DSS/OF as initiator and receiver, and the Image Manager/ Image Archive as
        instance accessing part.

735   Ordered pre-fetching involves the DSS/OF sending an order to the Image Manager/Image Archive.
        This needs to be done appropriately before the expected pre-fetch action in order to allow preparing
        off-line media or human information selection based on patient history, clinical procedures, etc.

        Pre-fetch ordering can be done in different ways:

        1. Use the existing Procedure Scheduled transaction and let the Image Manager/Image
740   Archive actor determine what and when to pre-fetch. A successfully finished pre-fetch
                activity is indicated to the DSS/OF by an Instance Availability Notification.
                Note: Knowledge of procedures and information relevance needs to be available at the
                Image Manager/Image Archive. Otherwise, selection may be insufficient and superfluous,
                non-relevant patient information may be retrieved.

745   2. Use a new transaction that contains selection data necessary for the Image Manager/Image
                Archive for pre-fetching the relevant imaging information. The DSS/OF has the role of a
                selector and the Image Manager/Image Archive executes the ordered pre-fetch activity at

a time that it controls itself. A successfully finished pre-fetch activity is indicated to the DSS/OF by an Instance Availability Notification.

750   Note: A DICOM General Purpose Worklist Management/ Preformed Procedure Step handshake is a candidate for such a new pre-fetch order transaction. The GP-PPS would report success or failure and completion of the request itself. IAN, when and if instances become available, at an arbitrary level of granularity, would indicate actual availability.

3.   Use a new transaction that gives the DSS/OF actor complete control on the pre-fetch
755   activity and specifies not only the contents but also the point in time of the pre-fetch activity. No human user activity is expected, except for off-line storage systems that require handling of media.
        Note: A DICOM C-MOVE that initiates the exchange of objects between DICOM AE's can be a candidate for such a transaction. However it forces implementers to distinguish
760   separate and unique AE-Title, which mostly is not the case in today's IHE and real life systems.

Conclusions: A considerable amount of the pre-fetching activity will remain implementation-specific. Method no. 1 is sufficient to realize pre-fetching without introducing new transaction/ messages. Method no. 2 flexibly enables a distributed responsibility of pre-fetch functionality, decoupling pre-
765   fetch ordering and execution, but requires a new transaction/ message.

12. Enterprise Scheduling

The only scheduling model currently supported by IHE is scheduling done at the departmental level. This was re-emphasized with the addition of the Appointment Notification Option to Scheduled Workflow. A suggestion has been made to include enterprise scheduling as a possible extension to
770   the existing IHE scheduling. This extension would require cross-domain coordination with at least IHE ITI.

13. Departmental Workflow Exception Management (E.g., Request Cancellation)

There is no information how to cancel a request and how this will propagate to all the affected worklist managers. Additional analysis is required to adequately specify this exception behavior.

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Other gaps or issues may be identified in the future.

8.3   Instance Availability Notification and Departmental Workflow

A Supplement to the IHE Radiology Technical Framework has been written introducing an Instance Availability Notification transaction.

780   Several IHE Integration Profiles may leverage this transaction. It is intended to allow the Department System Scheduler/Order Filler, the Report Manager and/or Post-Processing Manager of the workflow management Integration Profiles (e.g.) to be informed about the availability status of SOP instances associated with activities that result in changing the availability of instances (images, evidence documents, presentation states, key image notes, etc.). Such activities may be controlled by

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785   corresponding performed procedure steps (Modality PPS, Post-Processing GP-PPS, Reporting GP-PPS) or not (e.g. archiving, pre-fetching, media import, etc.).

The communication of availability information allows to make timely workflow decisions about launching subsequent workflow steps based on the availability of the expected instances as well possessing the current storage location for retrieval of these SOP instances.

790   The Image Manager and Report Repository are assumed to be the primary source of such availability information. Such a notification transaction is to be used when use of the current Image Availability Query is not efficient or desirable. (E.g. to avoid excessive polling).

The IHE Technical Committee in the course of the development of this White Paper is considering three broad categories of activities. The first one is addressed by the current Instance Availability
795   Notification supplement. The other two remain to be analyzed in further details.

1.   **Acquisition PPS related**. In these cases, an acquisition Procedure Step is being performed with in-Progress and Completion notified to the output manager. When instances referenced in that Procedure Step have been stored onto the Image Manager/Image Archive, this actor uses the Instance Availability Notification to communicate that such instances are
800   available for retrieve from a specific AE-Title. In this case IHE requires that the notification be triggered when the complete set of instances referenced in the PPS are available. Sending IAN when a partial set of instances is available is not excluded. This is an area of open discussion (See section 8.2 item #11).
There are several examples of when notification of partial results may be clinically useful.
805   The Radiology "wet read", Ultrasound procedures and the radiation therapy planning process outside Radiology make extensive use of incomplete partial results.
In the radiation therapy planning process, the supercomputer that is doing simulations normally provides occasional partial results (images and evidence documents) to the requesting site. It is also normal for the requesting site to be a different enterprise than the
810   supercomputer site, so the Image Manager/Image Archive that receives these images will not be grouped with the worklist manager that handles the queue for the supercomputer. For many simulations these partial results are examined to evaluate the progress of the simulation and to adjust simulation parameters. If the simulation converges more rapidly than expected, they may lead to the requestor terminating the simulation early.
815   Cardiology, Ophthalmology, and Dentistry have rather different relationships between orders and performed procedures. Typically what is scheduled is an "exam", and then a variety of different systems in the exam room perform various procedures that are not explicitly scheduled. If one system needs results from another system they might use IAN, or they might simply poll until the results are available.

820   2.   **Post-Processing or Reporting PPS related**. In these cases, a GP-Procedure Step is being performed with in-Progress and Completion notified to the Image or Reporting Managers. When instances referenced in that Procedure Step have been stored onto the Image Manager/Image Archive or Report Repository, this actor may use the Instance Availability Notification to communicate that such instances are available for retrieve from a specific

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825   AE-Title. It is not clear at this time whether the use of Instance Availability Notification in order to track reporting output is appropriate.

    3.   **Non-PPS Related.** In this case, the change of availability of instances results for some activity within the output manager (e.g. archive, pre-fetch, media import, etc.). As these instances are made available (on-line or near-line) or non-available the Image
830   Manager/Image Archive (or possibly the Report Repository) may use the Instance Availability Notification to communicate that such instances are available (or no longer available) for retrieve from a specific AE-Title. In this case, if such activities operate on a set of instances, which is generally the case, the need to notify In-Progress needs to be reviewed. A number of alternatives may be considered:

835   • Alternative A: Issues a DICOM Instance Availability Notification SOP Class with the list of instances intended to be made available by listing these in a non-available status. This will provide the Order Filler/Workflow Manager a pre-notification of availability. Other notification with an increasing list of available instances may also be considered.

840   • Alternative B: In the case of pre-fetching, it uses a DICOM Unscheduled GP-PPS to notify of a "pre-fetching procedure step" IN-PROGRESS and COMPLETE for the Image manager/Archive to communicate to the Order Filler/Workflow Manager the start and completion of a pre-fetching operation. The GP-PPS COMPLETE contains the list of pre-fetched instances and the location where they are available.