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DICOM
Digital Imaging and Communications in Medicine

# Analytic Workflow: From Images to Reports


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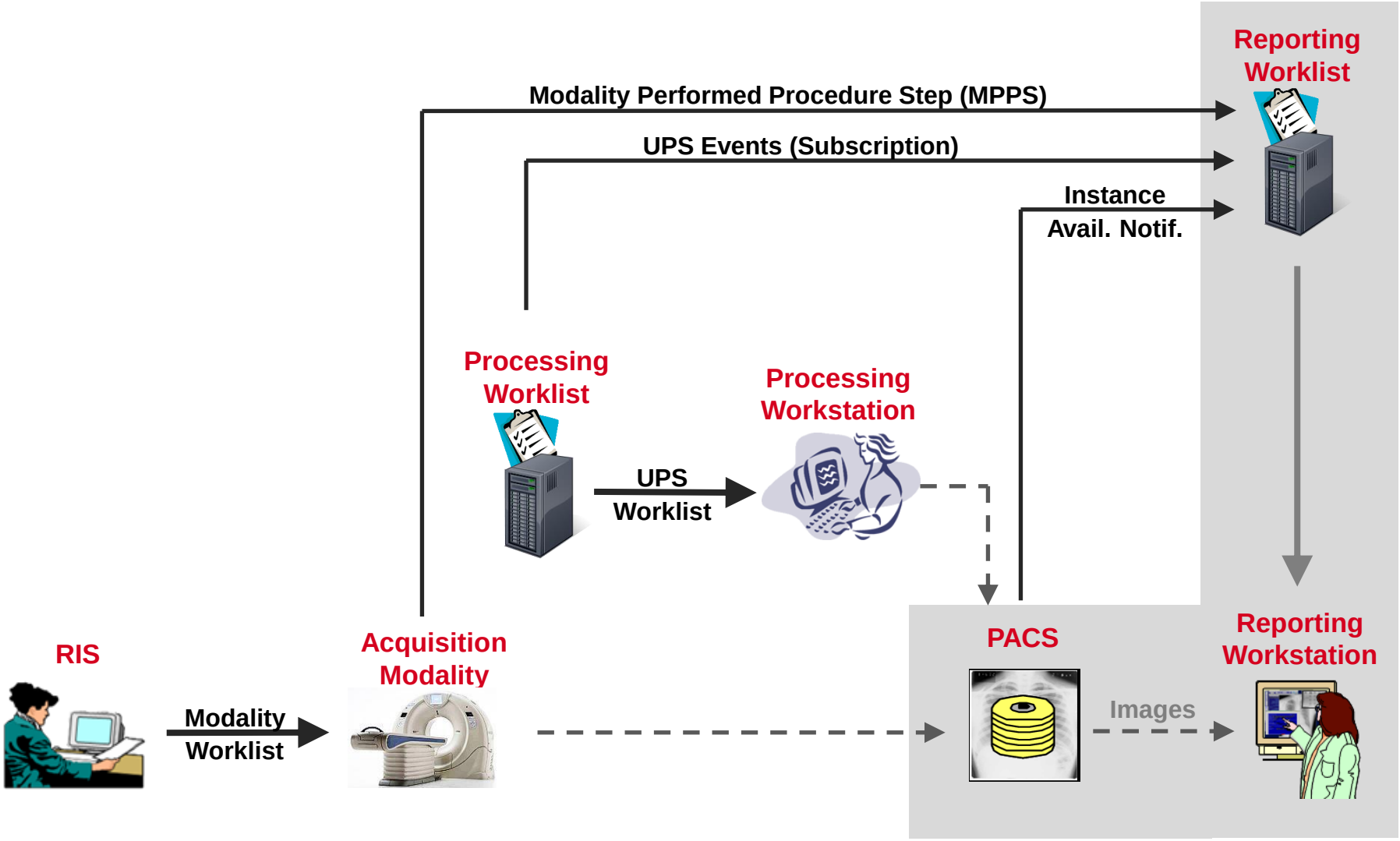
# Dataflow & Workflow



# “Post-Acquisition” Workflow

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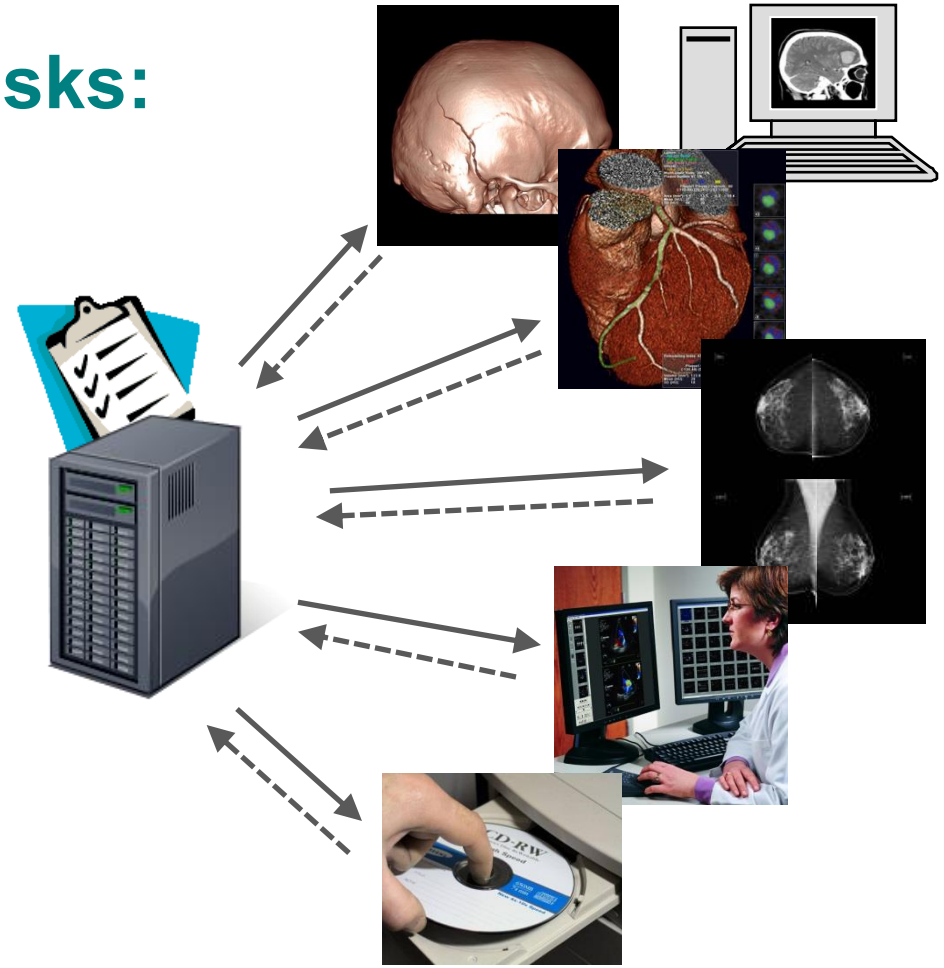
## Example “Workitem” Tasks:

- 3D View Generation
- Computer Aided Detection
- Clinical Applications
- Pre-fetching
- Image Routing
- CD Burning
- Image Importing
- …



# Unified Procedure Step (UPS)

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## Add “Create Workitem” & “Push Workflow”

- Request another system to add item to worklist
- Replacement for implicit workflow (“push to a box and hope for the best”)

## Simplify Implementation

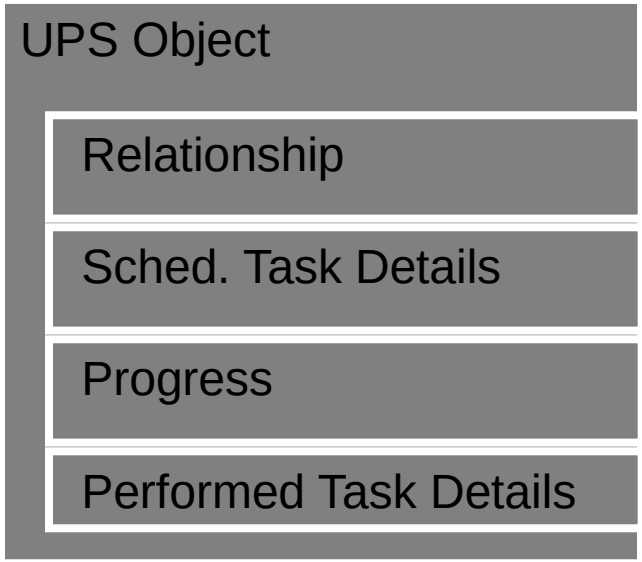
- GPWL had N:M relation of SPS:PPS
- State diagram was very complex

## Improve Status/Result Monitoring

- Getting PPS feed was awkward; required configuration and forwarding

## Both RESTful (UPS-RS) and DIMSE APIs

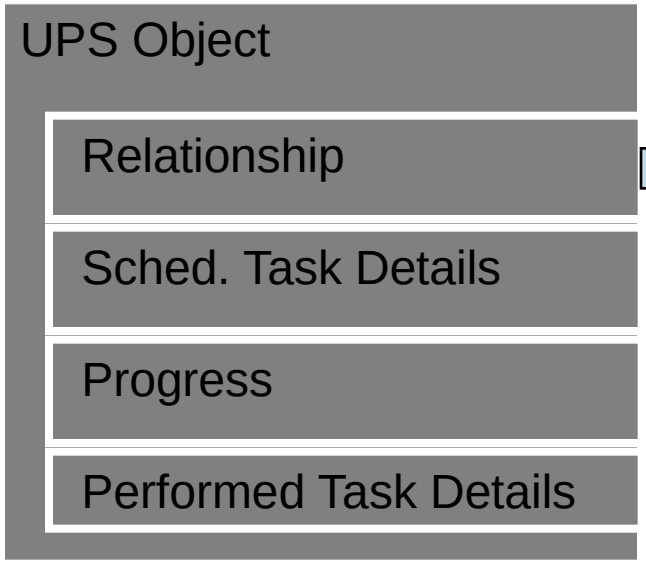
# UPS Workitem Structure




A Workitem has its attributes grouped into 4 Modules:

(this does not affect processing;
just for logical organization)

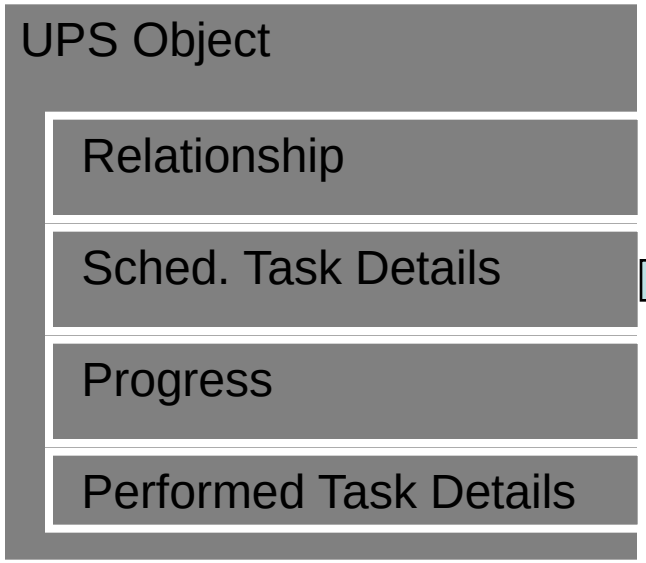
# UPS Workitem Structure




**Relationship Module**

- Patient demographics
- Admission details
    - Order details
    - Requested Procedure
    - Accession #
    - Reason for Requested Procedure
    - Requesting physician/department
    - etc…

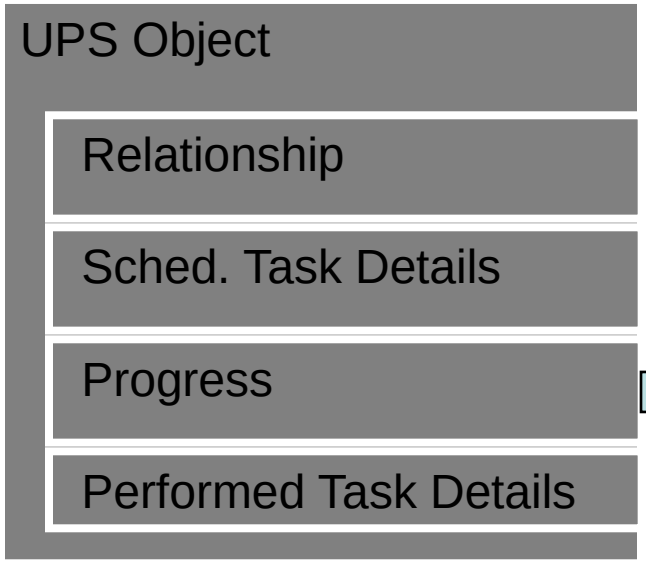
# UPS Workitem Structure




**Scheduled Proc. Info. Module**

- Priority
- Requested perform/completion time
- Requested resources/location
- Requested Procedure descrip./codes
- Requested Processing parameters
- List of Input data IDs & Location
- Input Data Availability Flag
- Requested Output Location
- etc…

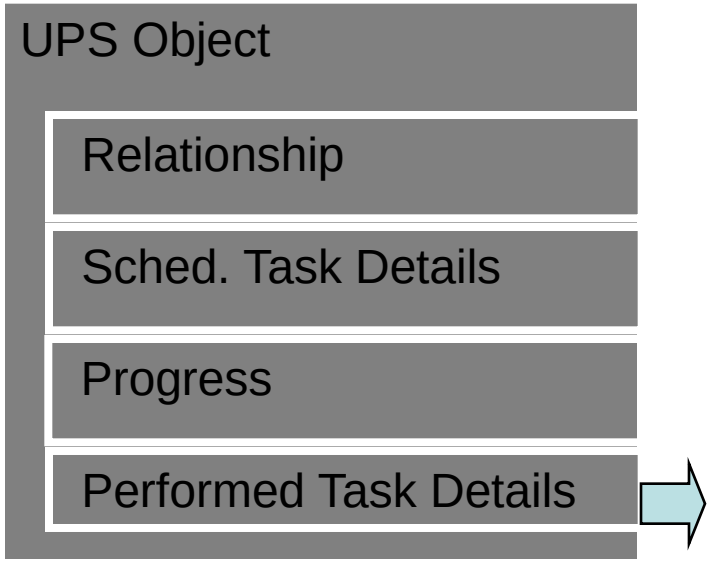
# UPS Workitem Structure




**Progress Module**

- UPS State (Scheduled, In-Progress, Completed, Canceled)
- Progress Status – Numerical (e.g. % complete)
- Progress Status – Description (e.g. Annealing phase complete)
- Contact information for performer (e.g. phone #)
- etc…

# UPS Workitem Structure




**Performed Proc. Info. Module**

- Time Performed/completed
- Performing resources/location
- Performed Procedure descrip./codes
- Performed Processing parameters
- List of Output data IDs & Location
- etc…

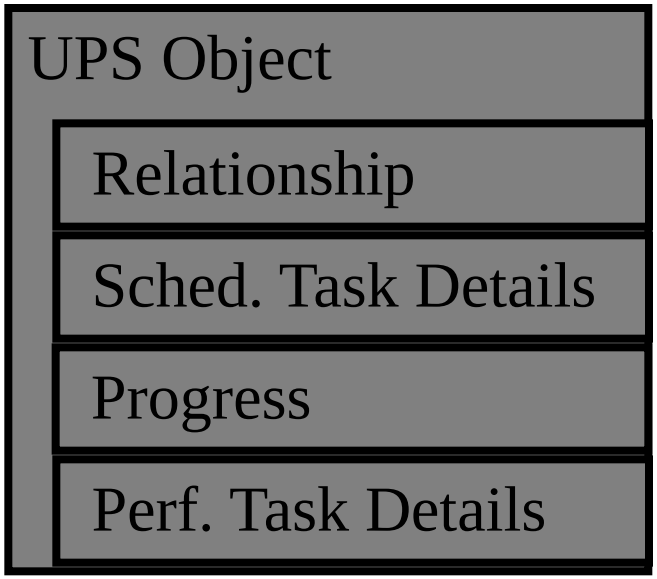
# UPS SOP Classes

A UPS Object is managed by one SCP. (It doesn't move)

**4 SOP Classes** can be used to operate on a UPS object.

Each SOP Class supports a few related operations.

SCU/SCP not *required* to implement all the SOP Classes. Can implement SOP Classes based on the operations it needs.

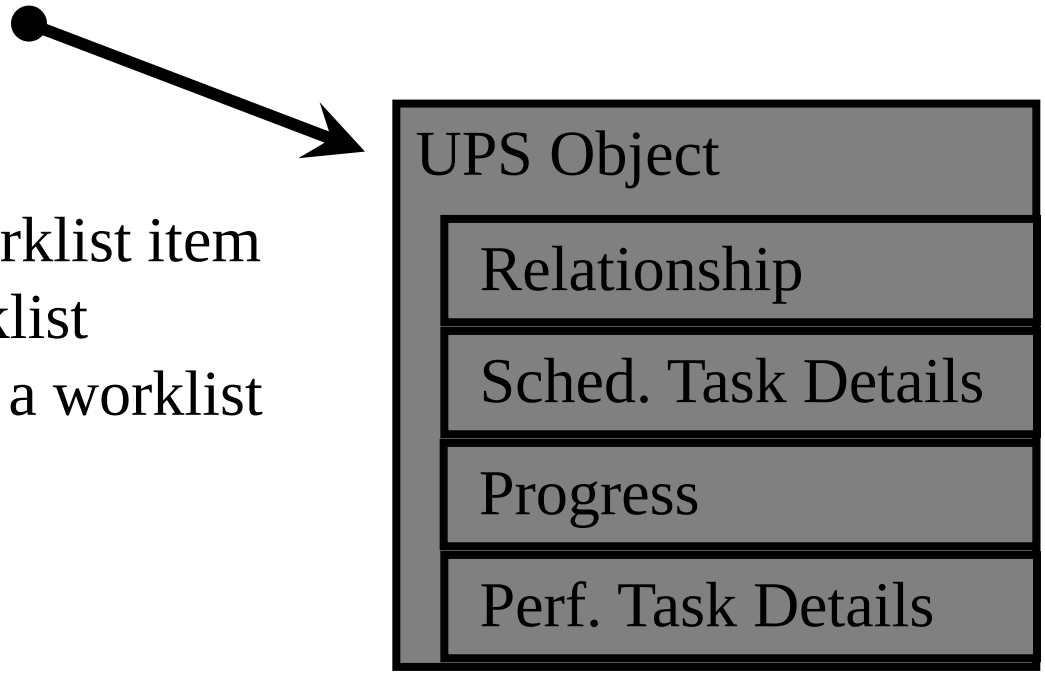


# UPS SOP Classes

**UPS Push SOP Class**

allows SCU systems to:

* ***create (push)*** a new worklist item (i.e. instance) on a worklist
* ***request cancellation*** of a worklist item

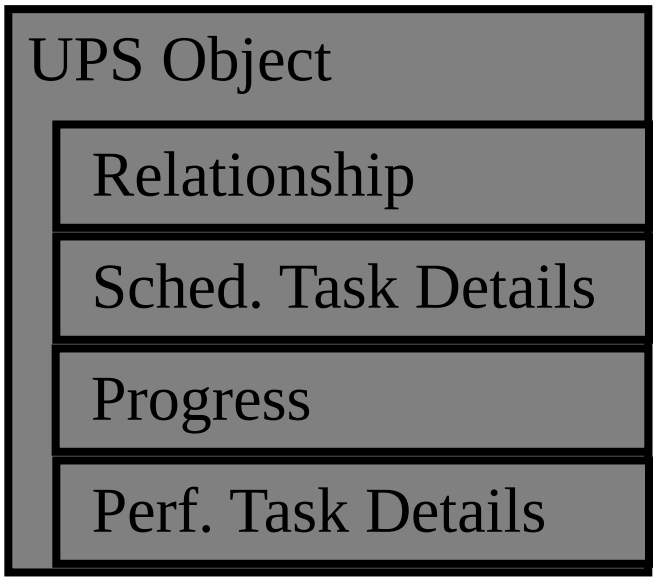


# UPS SOP Classes

**UPS Pull SOP Class**

allows SCU systems to:

* ***query*** a worklist for matching items
* ***get details*** for a worklist item
* ***take ownership/control (pull)*** of a worklist item
* ***modify progress/status/result*** details for the worklist item
* ***finalize*** a controlled worklist item as Completed or Canceled.

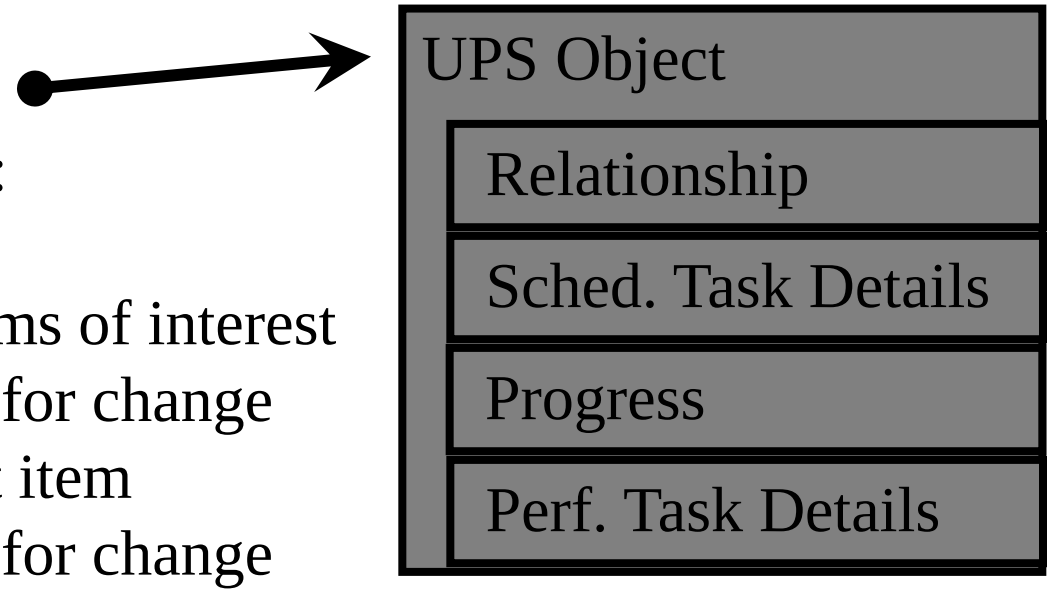


# UPS SOP Classes

**UPS Watch SOP Class**

allows SCU systems to:

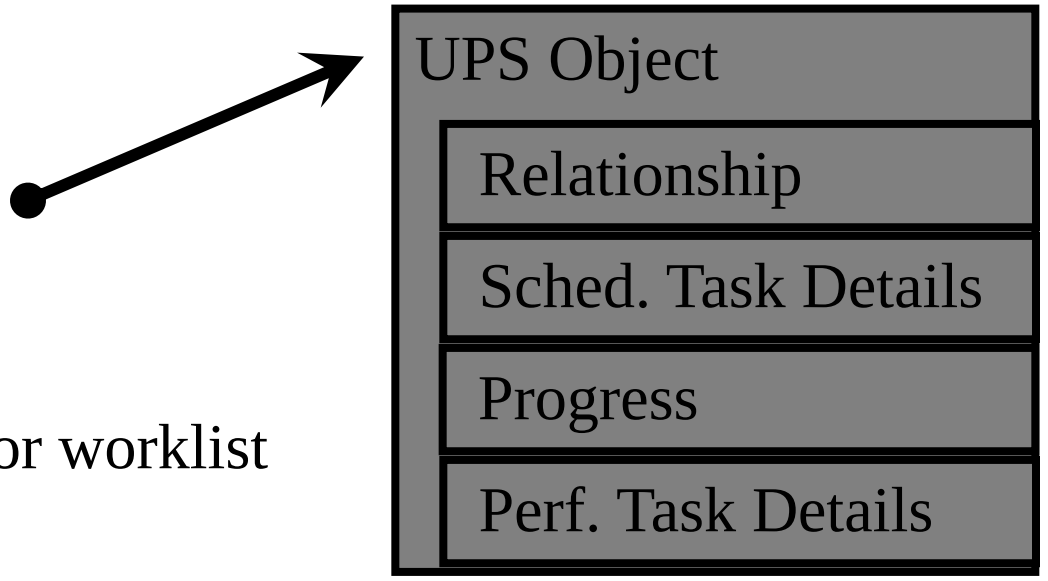
* ***query*** a worklist for items of interest
* ***subscribe/unsubscribe*** for change events for *one* worklist item
* ***subscribe/unsubscribe*** for change events for *all* worklist items
* ***get details*** for a worklist item
* ***request cancellation*** of a worklist item



# UPS SOP Classes

**<u>UPS Event SOP Class</u>**
allows SCU systems to:

* ***<u>receive</u>*** change events for worklist items



# UPS Interfaces: DIMSE and RESTful

## DIMSE (Traditional DICOM Protocol)

- Push/Pull/Watch/Event SOP Classes

## RESTful (New Web Protocol)

- UPS-RS Supplement 171 (Final Text)
- HTTP Interface to UPS Service
- Mostly Request/Response for each DIMSE message
- Uses WebSockets for Events

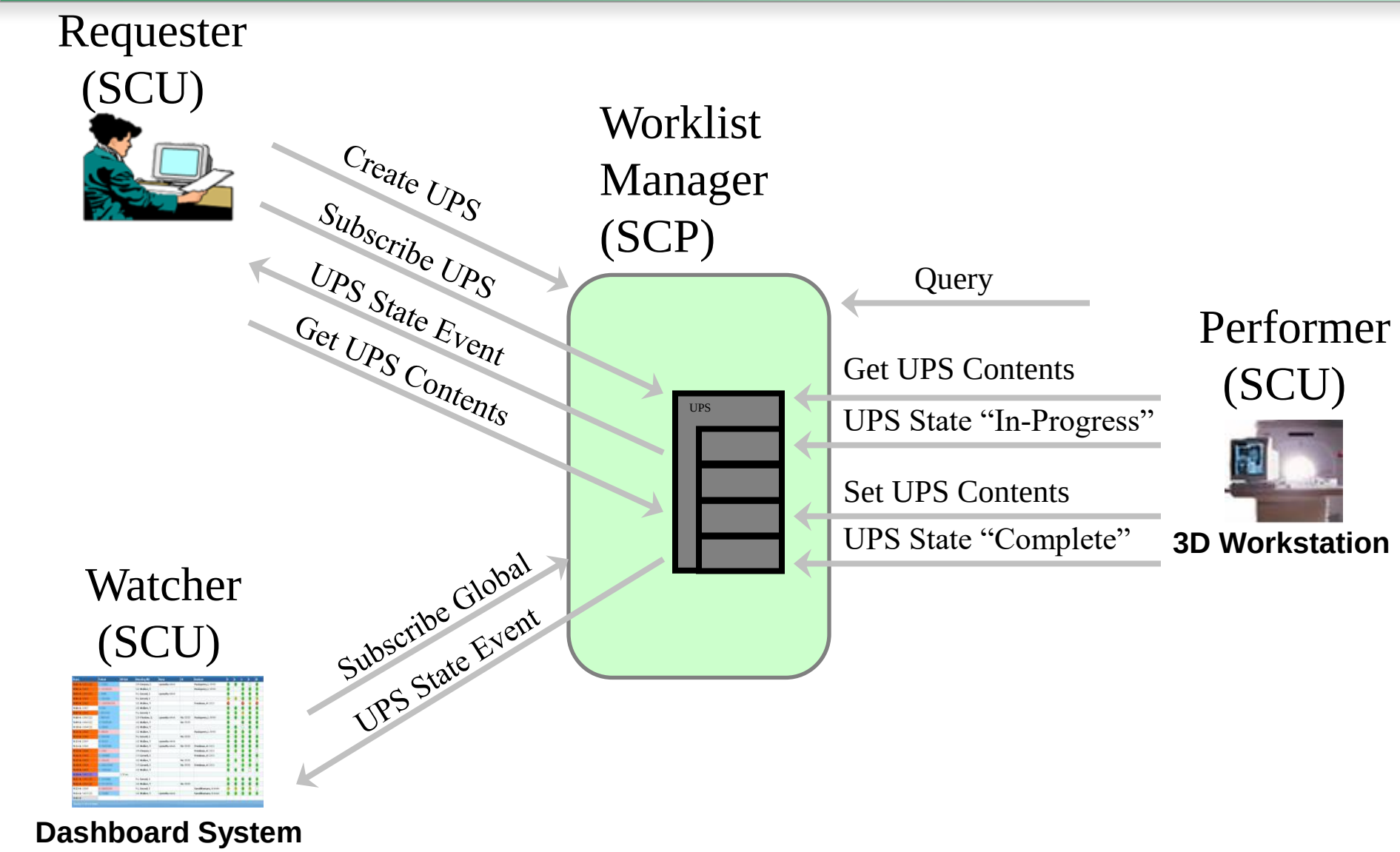
**SCP can serve DIMSE clients & RESTful clients interacting with the same UPS workitems.**

# UPS-RS Summary

| Action Type | Section | Method & Resource |
|---|---|---|
| CreateUPS | 6.9.1 | POST {+SERVICE}/workitems{?AffectedSOPInstanceUID} |
| UpdateUPS | 6.9.2 | POST {+SERVICE}/workitems/{UPSInstanceUID}{?transaction} |
| SearchForUPS | 6.9.3 | GET {+SERVICE}/workitems{?query*} |
| RetrieveUPS | 6.9.4 | GET {+SERVICE}/workitems/{UPSInstanceUID} |
| ChangeUPSState | 6.9.5 | PUT {+SERVICE}/workitems/{UPSInstanceUID}/state |
| RequestUPSCancellation | 6.9.6 | POST {+SERVICE}/workitems/{UPSInstanceUID}/cancelrequest |
| CreateSubscription | 6.9.7 | POST {+SERVICE}/workitems/{UPSInstanceUID}/subscribers/{AETitle}{?deletionlock}<br><br>{additional methods omitted for brevity} |
| SuspendGlobalSubscription | 6.9.8 | POST {+SERVICE}/workitems/1.2.840.10008.5.1.4.34.5/<br><br>{additional methods omitted for brevity} |
| DeleteSubscription | 6.9.9 | DELETE {+SERVICE}/workitems/{UPSInstanceUID}/<br><br>subscribers/{AETitle} |
| OpenEventChannel | 6.9.10 | GET {+WSSERVICE}/subscribers/{AETitle} |
| SendEventReport | 6.9.11 | N/A |

See DICOM PS3.18 for details

# UPS Pull Workflow Example

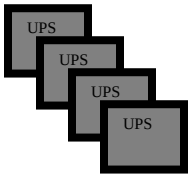


# Pull Workflow

SCP

SCU

**R I S**




**3D Workstation**

Give me a list of tasks that need to be done
(C-FIND)

I will do that one
(N-ACTION Set to IN-PROGRESS)

Record these details in the UPS
(N-SET attribute values)

I am finished
(N-ACTION Set to COMPLETE)

# Push Workflow

SCU

**R I S**

SCP

**3D Workstation**

UPS

Please perform this task
(N-CREATE with these attribute values)

Notify me about progress for that task
(N-ACTION Subscribe)

I have started to do that task
(N-EVENT it is IN-PROGRESS)

I have updated details in the UPS
(N-EVENT)

I am finished
(N-EVENT it is COMPLETE)

Give me the result details of the task
(N-GET these attribute values)

# Watch Workflow

## No central controller

- Workstation watches flow of N-EVENTs: "System X did A", "System Y did B"
- Workstation decides "Hmmm, I think I will do C"
- Workstation creates a UPS for itself
- Interested Subscribers are notified of Workstation activity via N-EVENT; N-GET details as needed

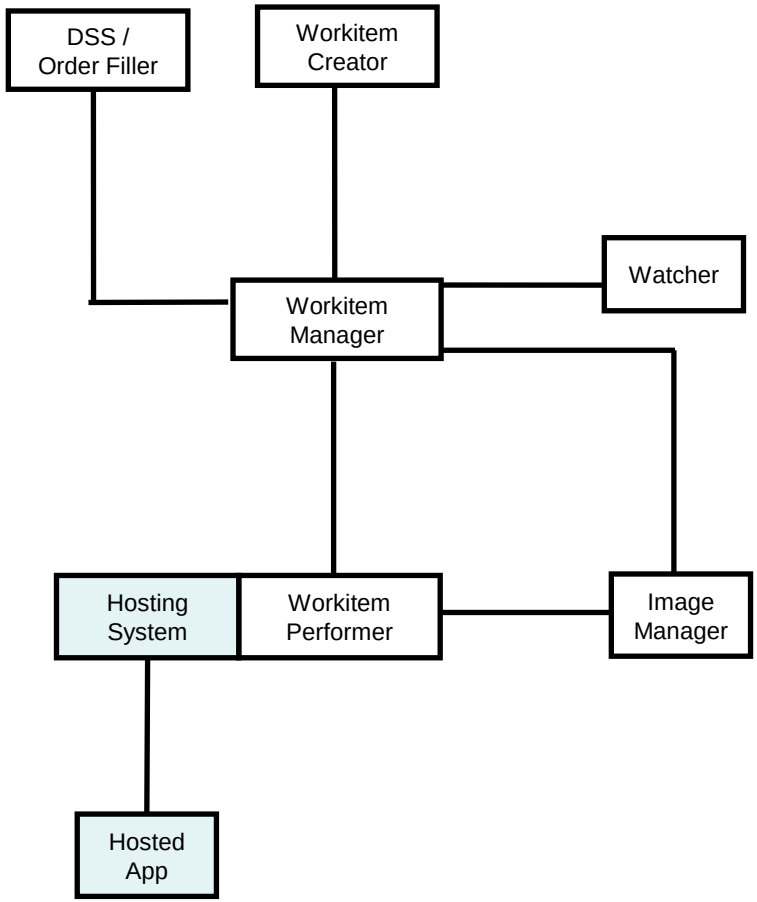
## Similar to Ad hoc/Unscheduled Tasks

## Examples:

- CAD workstation sees N-EVENT that Mammo Acq. is complete; decides to do CAD processing
- Reporting station sees N-EVENT that CAD is complete; decides to queue reading worklist for that study

# IHE Post-Acquisition Workflow

- **IHE PAWF builds on DICOM UPS**
- **Essential Profile Features:**
  - **Worklist managed processing**
    - **Automated & manual**
  - **Progress notifications**
    - **Any interested system (RIS, Billing, Reading Worklist, Dashboard, Analytics)**
    - **Subscription-based**
  - **Cancelation requests**
    - **With reason & contact**
  - **Hosted applications ("DICOM plugins")**



# DICOM Application Hosting

**Separate the application from the infrastructure**

- **Infrastructure (Hosting Systems) move and store data & results, and manage workflow**
- **Applications process and analyze that data, and provide results back to the infrastructure**

**Minimize ‘reinvention of the wheel’.**

**(See DICOM PS3.19)**

# One App, Many Hosts

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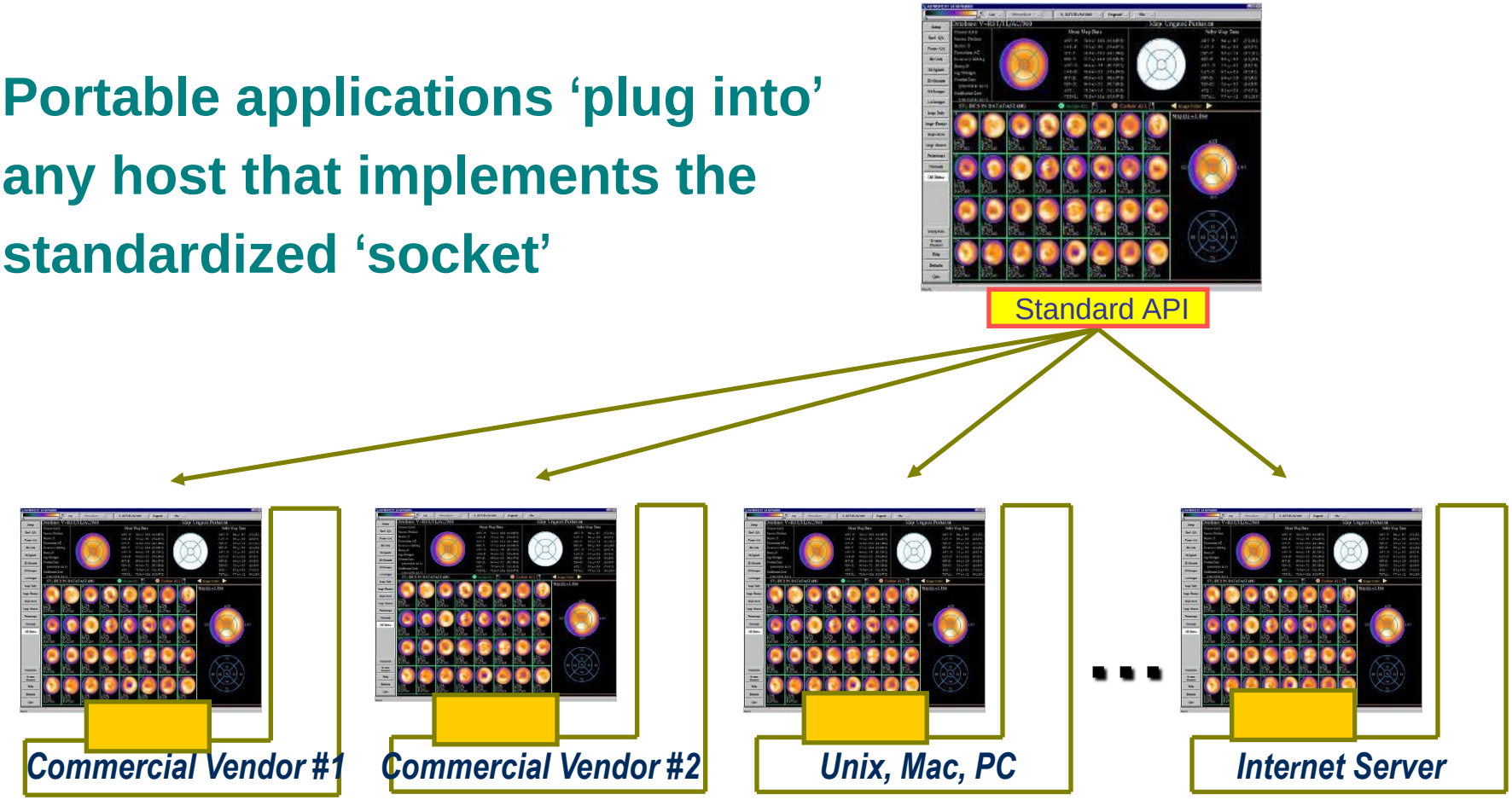
**Portable applications 'plug into' any host that implements the standardized 'socket'**



# Benefits of Application Hosting

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**Users**
- **One workstation supports any needed functionality**
- **Mix and Match applications from multiple providers**

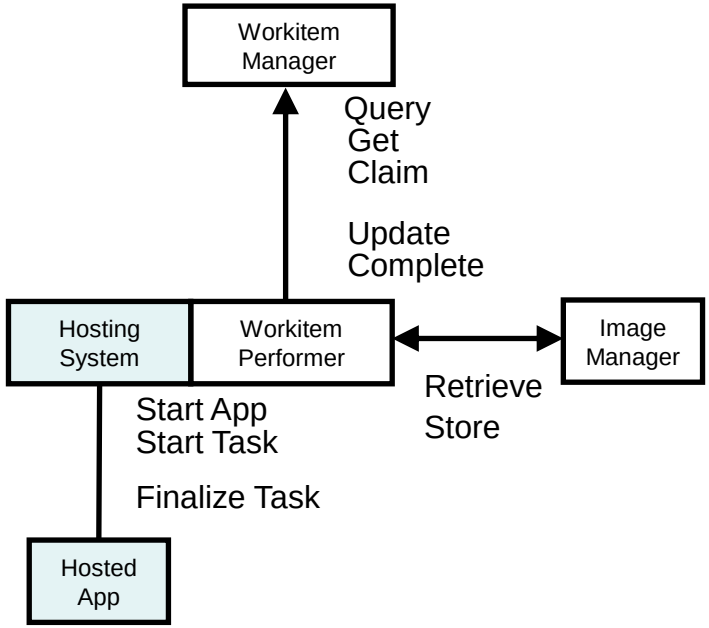
**IT Administrators**
- **Tired of changing infrastructure to accommodate new workstations simply to add functionality**

**Application Developers**
- **Don’t have to re-write applications for dozens of workstations in the market**

**Workstation Vendors**
- **Expand their list of offered applications without development effort**

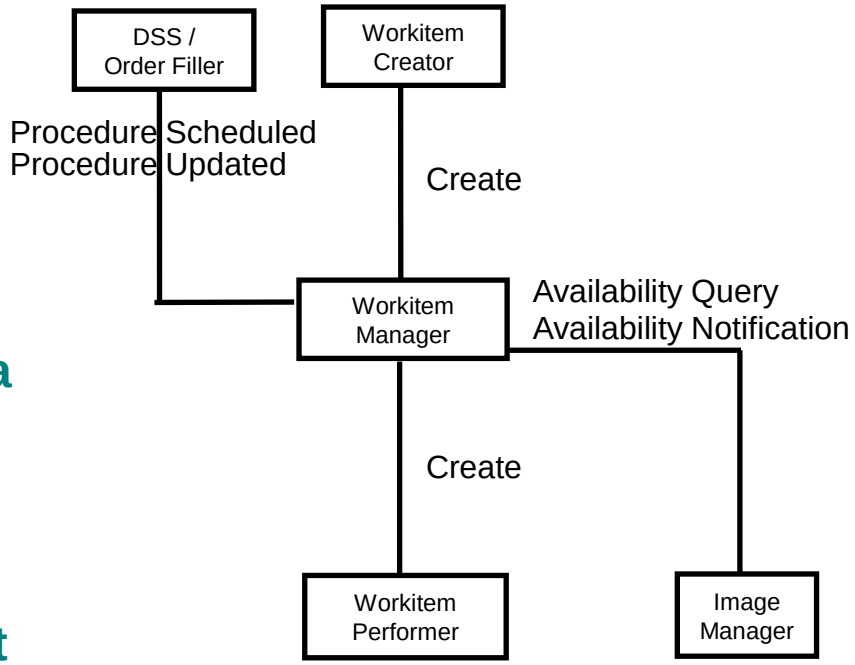
# Perform UPS Workitems

- **Typical Pull Workflow**
  - **Query, Claim, Update, Complete**
- **Input / Output References**
  - **Local to Performer;**
    **Local Image Manager;**
    **Other Image Manager**
- **Hosted applications (plugins)**
  - **Performer may choose to be a Hosting System**
  - **Apps may be 3rd party**



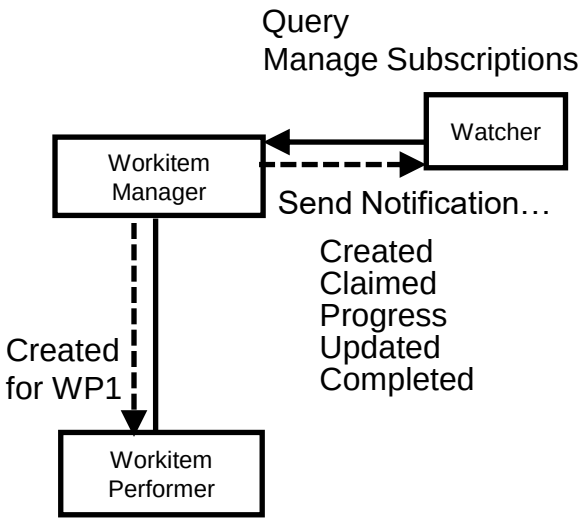
# Create UPS Workitems

- **By Workitem Manager**
  - **Internal logic**
  - **Triggered by DSS/Order Filler scheduling**
  - **Triggered by Image Manager Data**
- **By Workitem Creator**
  - **Explicit create request**
  - **Can be grouped with any relevant system**
- **By Workitem Performer**
  - **Explicit create request**
  - **"Unscheduled"/Self-scheduled/Ad Hoc**



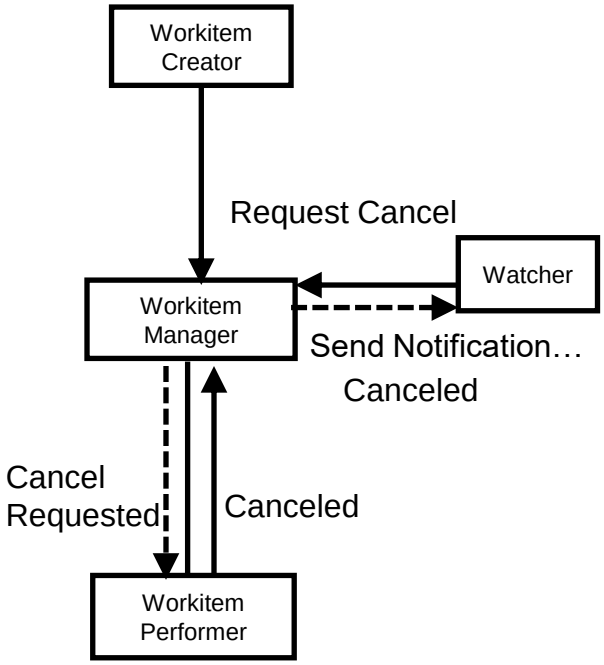
# Monitor UPS Workitems

- **Subscribe / Unsubscribe**
  - **Globally or for Individual Workitems**
- **Applications/Usage**
  - **Schedule subsequent tasks**
  - **Report progress**
  - **Bill for performed tasks**
  - **Populate reading worklist**
  - **Drive dashboard**
  - **Analyze dept. performance**
  - **Claim assigned workitems**

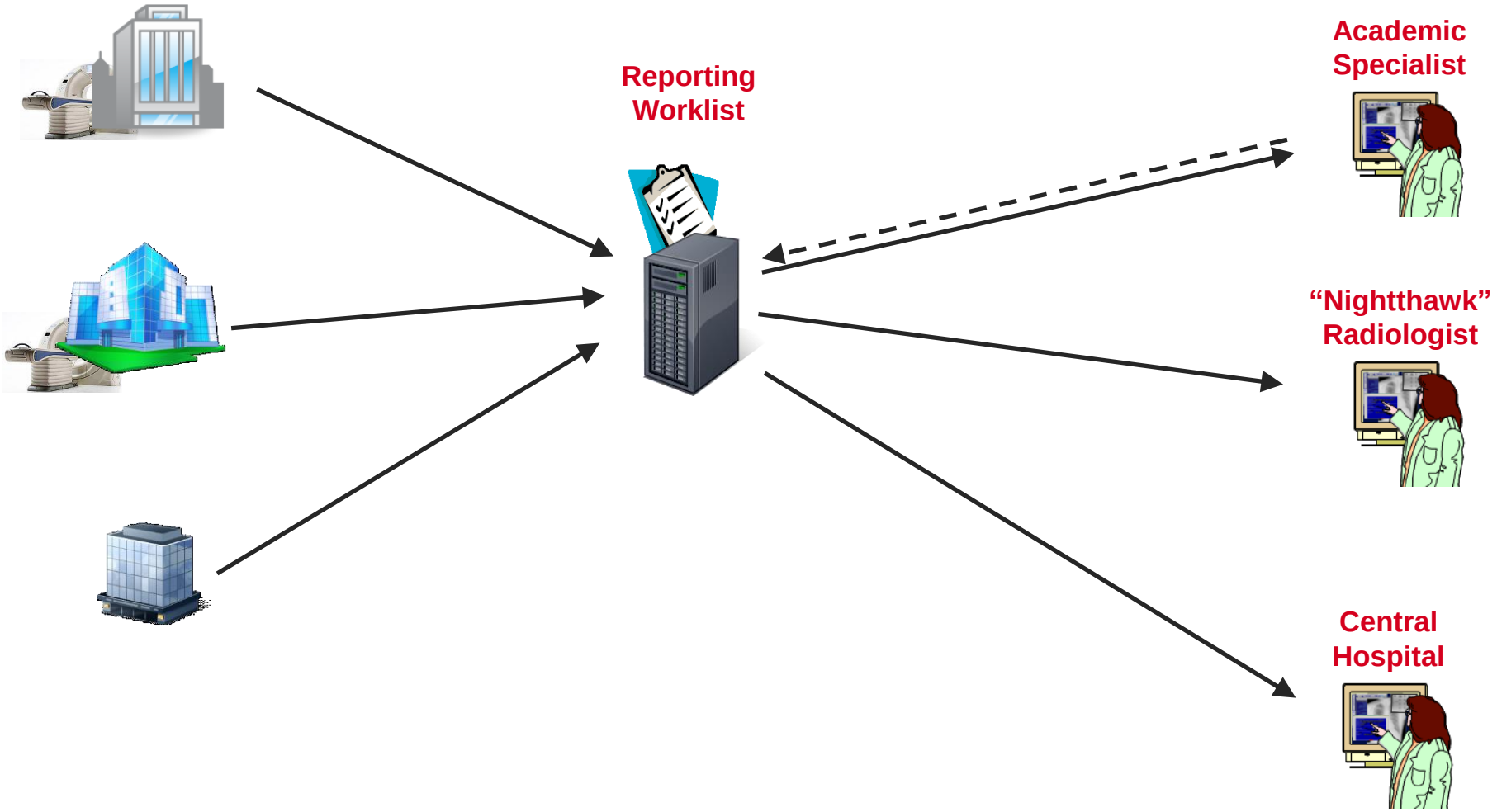


# Cancel UPS Workitems

- **Workitem Manager**
  - **Can directly cancel unclaimed workitems**
  - **Otherwise notifies Performer**
- **Workitem Performer**
  - **Cancels at its own discretion**
- **Watcher**
  - **Waits for Notification task was either Completed or Canceled**



# IHE Remote Radiology Reporting Workflow (RRR-WF)



# UPS-RS for Reporting

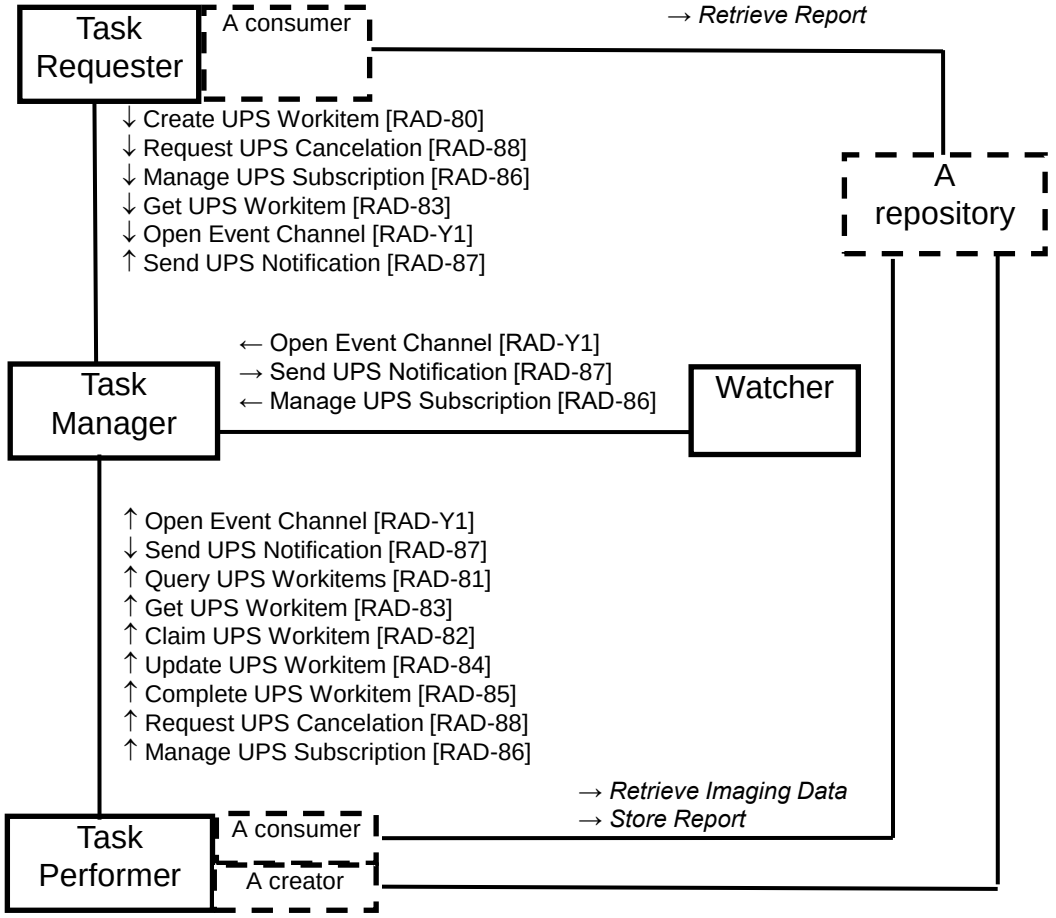
## Remote Radiology Reporting Workflow (RRR-WF)

### Worklist model

- Scheduled tasks
- Relationship to Patient, Order, Workflow
- Lists of inputs and outputs
- Notification of Progress/completion

### Data flow can use:

- XDS, XDS-I
- DICOMweb WADO, STOW
- DICOM C-STORE, C-MOVE



# UPS-RS for Reporting

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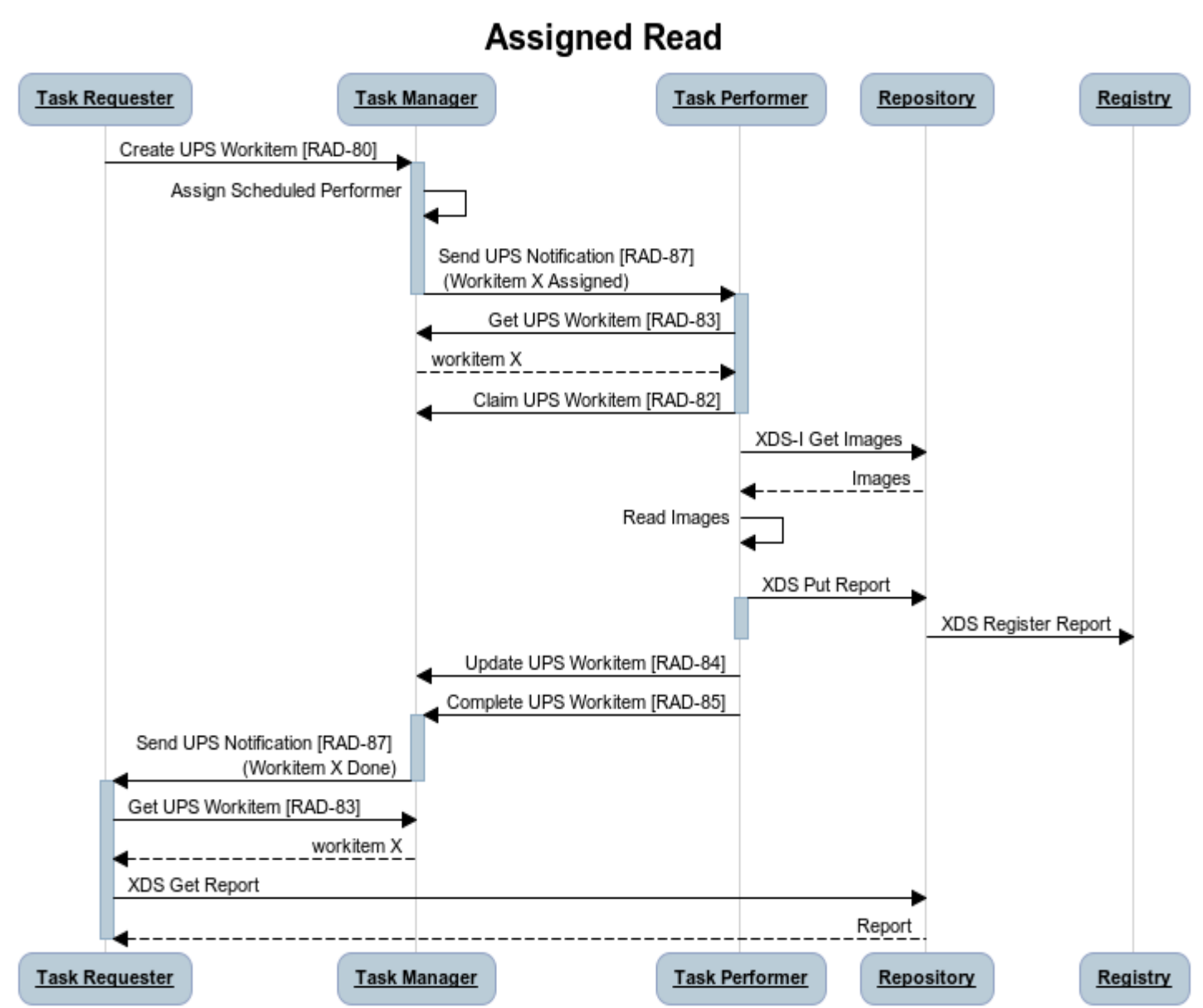

# References

## dicom.nema.org -> The DICOM Standard

- Part 4, Annex CC
- Part 3, C.30
- Part 17, Annex BBB

## www.ihe.net -> Technical Frameworks

- Scheduled Workflow.b Profile
- Post-Acquisition Workflow Profile
- Remote Radiology Reporting Workflow Profile
- and many more…

# SWIM

## UPS are transient but can be locked/logged

- Time scheduled
- Time started
- Time completed
- Even intermediate progress for some tasks

## Track various activities

- Image import, special reconstructions, automated processing, QC, image export