Analytic Workflow: From Images to Reports

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Dataflow & Workflow

- **RIS**
  - Modality Worklist
  - **Modality**
  - **Acquisition Worklist**
  - **UPS Worklist**

- **UPS Events (Subscription)**
- **Instance Avail. Notif.**

- **Modality Performed Procedure Step (MPPS)**

- **Processing Worklist**

- **Processing Workstation**

- **PACS**
  - **Images**

- **Reporting Worklist**

- **Reporting Workstation**
“Post-Acquisition” Workflow

Example “Workitem” Tasks:

- 3D View Generation
- Computer Aided Detection
- Clinical Applications
- Pre-fetching
- Image Routing
- CD Burning
- Image Importing
- …
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
A **Workitem** has its attributes grouped into 4 Modules:

<table>
<thead>
<tr>
<th>UPS Object</th>
<th>Relationship</th>
<th>Sched. Task Details</th>
<th>Progress</th>
<th>Performed Task Details</th>
</tr>
</thead>
</table>

(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…
**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**

**UPS Object**
- Relationship
- Sched. Task Details
- Progress
- Performed Task Details

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**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…
**Perfomed Proc. Info. Module**
- Time Performed/completed
- Performing resources/location
- Perfomed Procedure descrip./codes
- Perfomed Processing parameters
- List of Output data IDs & Location
- etc…
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 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 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 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 Event SOP Class** allows SCU systems to:

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

See DICOM PS3.18 for details
UPS Pull Workflow Example

Requester (SCU)
- Create UPS
- Subscribe UPS
- UPS State Event
- Get UPS Contents

Watcher (SCU)
- Subscribe Global
- UPS State Event

Worklist Manager (SCP)
- Query
- Get UPS Contents
- UPS State “In-Progress”
- Set UPS Contents
- UPS State “Complete”

Performer (SCU)
- 3D Workstation

Dashboard System
Pull Workflow

SCP

R I S

UPS

UPS

UPS

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)

SCU

3D Workstation
Push Workflow

SCU

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

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

SCP

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)
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 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”)
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

Portable applications ‘plug into’ any host that implements the standardized ‘socket’
Benefits of Application Hosting

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

L. Tarbox - Analytic Workflow: From Images to Reports
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)
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
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 Profile
- Post-Acquisition Workflow Profile
- Remote Radiology Reporting Workflow Profile
- and many more…
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