IHIC 2009: "SHOW ME YOUR CDA!" INTEROPERABILITY FORUM

CDA CASE STUDY TEMPLATE

"Show me Your CDA": STRUCTURED REPORT EDITOR FOR THE HIBA MULTIMEDIA EHR

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Summary-

Among the main objectives of the Multimedia EHR of the Hospital Italiano de Buenos Aires (HIBA) is the need to include not only text and images in the reports but also structured clinical information coded using a controlled vocabulary. A structured reporting system was designed to achieve this goal, including the use of macros and templates. The reporting system organizes the radiological information into knowledge trees. Each one of these trees' concepts is represented in the clinical terminological server of the HIBA. The reports are generated and stored as a CDA R2 document including the narrative text, the links to the images, and each finding and observation represented as a CDA R2 coded entry. Also the input of the structured editor as a plug-and-play run-time integrated component is also a CDA R2 document combined with some editor behavior parameters. In this context, we defined as our best solution for the output of the structured editor a CDA R2 document. When we discussed the input for the editor component, we followed the same logic and also used a CDA R2 document for as part of the input. This radiology editor output is based on the RSNA guides and the CDA R2 IG for imaging, and also in HIBA own implementation guide for CDA R2 document used in its EHR. Since this editor is also part of an agreement between the Hospital Italiano de Buenos Aires and UDIAT Parc Taulí– of Catalunya, Spain, it has multi-language capabilities (Spanish, Catalan, or English as user interface language and the same choice of languages as output language (CDA R2 instance language used for text and descriptions inside the narrative sections and entries)

I. Introduction – Business Case

The Hospital Italiano de Buenos Aires is one of the founding members of HL7 Argentina, and has used HL7 standards since 1999. Framed by the process of integrating the information systems for the EHR, Ancillary Services and Patient Services, the Hospital Information Department of the Hospital Italiano de Buenos Aires developed a document repository for clinical documents (consultation notes, discharge reports, etc.) and final reports from ancillary services, using HL7 V2.x messaging and CDA documents to achieve full system interoperability.

In this context, employing HL7 as our messaging standard allowed us to continue using already functional independent departmental systems without being restrained to a particular hardware or software platform. The only problem with the use of messaging for observations as a transfer scheme to the EHR was that V2 messages may present only temporary and partial information, and are not digitally signed or authenticated from the sender. Coping with the EHR needs for signed and validated documents, the HIS information department asked the technical staff to find a transfer and storage standard with some intrinsic properties: authenticable, non-repudiable, independent from the generating applications and flexible. Bringing further integration while leveraging the existing messaging platform, the Hospital Italiano de Buenos Aires used CDA Release 2 documents digitally signed using the XML signature standard to store a fully authenticated history of each patient in a central document repository.

The user community of this project is as follows: all radiologists use the report editor, all physicians inside the hospital and its associated sites have access to the reports, patients can see their reports in

the HIBA Personal Health Record, and the structured entries are leveraged to generate clinical statistics by the Biostatistics section of the HIBA.
This CDA R2 editor allowed us to combine the narrative text, the coded entries and the possibility to link the images from the image archive in the same digitally signed document, improving the workflow of the affected departments, bringing uniformity and structure to the reports and allowing future reuse of the coded entries for statistical purposes.
The use of this tool combined with the implementation of UDIAT PACS solution dramatically changed the workflow of the diagnostic imaging department, lowering the turn-around-time of routine ambulatory radiology reports (from image acquisition to report availability in the EHR) from 96 hours to less than 48 hours average, with partial reports generated on-line, authored by the responsible radiologists, and immediate availability of images inside of the EHR (minutes after acquisition).

II. Implementation, Methodology and Tools

The reporting application is based on SUN GlassFish 9.0 and consists of:

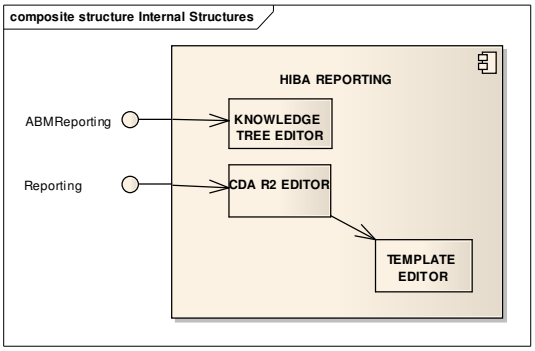
- **Report authoring component**, with some extra integrated capabilities if the calling application provides them (the ability to show previous reports for the same patient, show previous acquired images, send additional images to the PACS server, customized template authoring, etc.)

- **Template authoring component**, allowing each department or specific reporting physician to combine knowledge tree elements to generate predefined reports.

- **Knowledge tree maintenance component**, which allows definition of new kind of reports, sections, branches, and concepts, and tie them to a controlled vocabulary (SNOMED CT, Radlex , etc.)

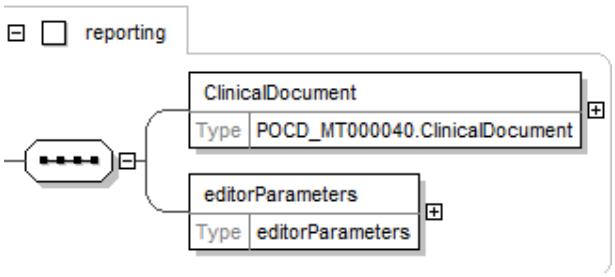
Any of this components can be be integrated with a calling system (radiology information system, cardiology, information system, etc.) just by calling a specific URL with a set of parameters in the form of an XML instance (see Picture 1 – HIBA REPORTING APPLICATION – interfaces)

Picture 1 – HIBA REPORTING APPLICATION INTERFACES



The interface for the Reporting component is basically a CDA R2 compliant document with information about the context and existing narrative of the report, and another element (editorParameters) grouping editor specific behavior information. – See Picture 2 – Reporting XML Interface Schema

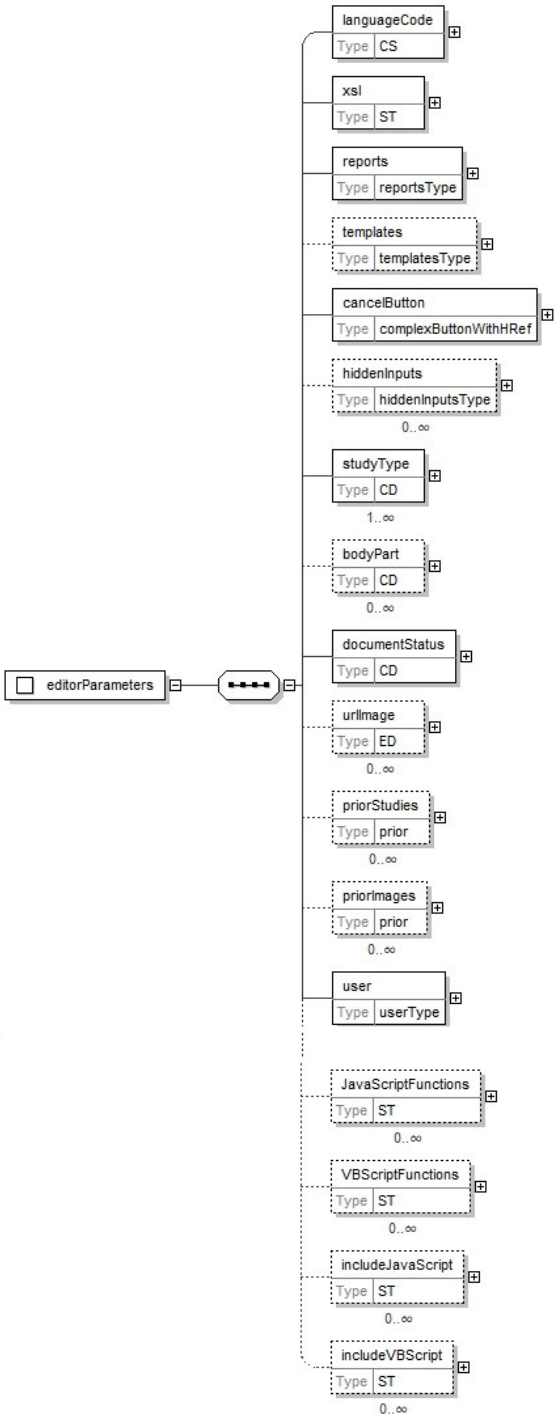
Picture 2 – Reporting XML Interface Schema



The CDA R2 document used for input also can contain coded entries for the findings, so this editor achieves partial report capabilities (edit->save->resume edition->final save and sign, and optional auto-save and resume capabilities) without loosing the previously selected entries of the knowledge tree.

The editor parameters were defined using the HL7 V3 data-types because they were needed for the CDA R2 element anyway, and there is no better choice available.
A complete reference on the different editor behavior parameters is out of the scope of this paper, but basically it defines the language of graphic interface of the editor, the desired behavior for each button, the user editing the document and its privileges, etc.

Picture 3 – Reporting XML Interface Schema



About the CDA R2 design, we based it on the **HIBA CDA R2 implementation guide** (available in Spanish at **www.ringholm.de/downloads/CDA_R2_samples.zip**) and the **HL7 Standard for CDA Release 2: Imaging Integration Basic Imaging Reports in CDA and DICOM Diagnostic Imaging Reports (DIR) Implementation Guide (Universal Realm) Release 1 document (CDAR2_II_BIMGRPTS_R1_I1_2008MAY)**, although we've got to compromise and adapt some content to the capabilities of our PACS (which not supported WADO by that time) and to the structure of our coded entries for the findings.

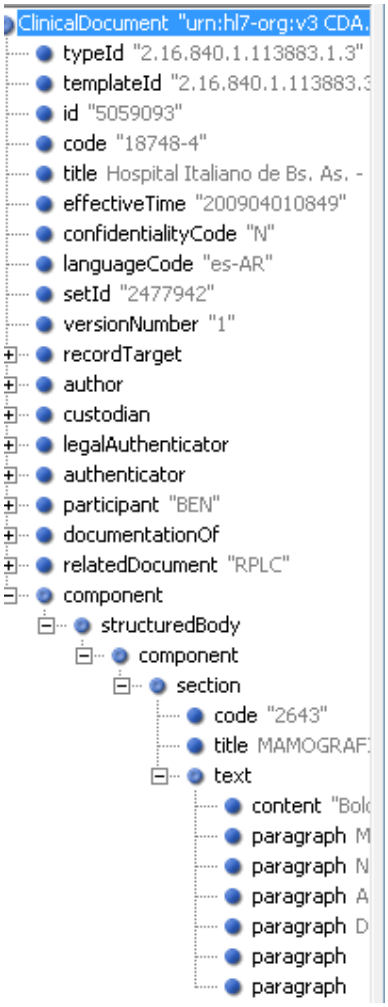
The only document type implemented is **Diagnostic Imaging Report** (LOINC 18748-4), although the specific type of report is included in the CDA Header (DocumentationOf/ServiceEvent).

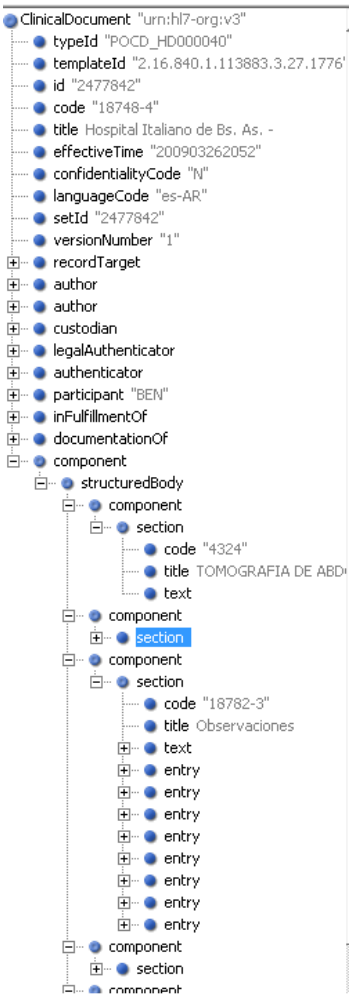
The previous generation of our CDA R2 reporting tools generated just plain text reports without sections, entries or linked DICOM references (see Picture 4 – Comparison of CDA R2 structures).
The reports were generated after transcription of the radiologist dictation by human transcriptionists which gave our workflow almost a 24 hour delay and was possible source of transcription errors.

Picture 4 – Comparison of structures of our previous and current CDA R2 document instances for the imaging diagnostic department

Before: only one narrative section, no coded entries, no related images

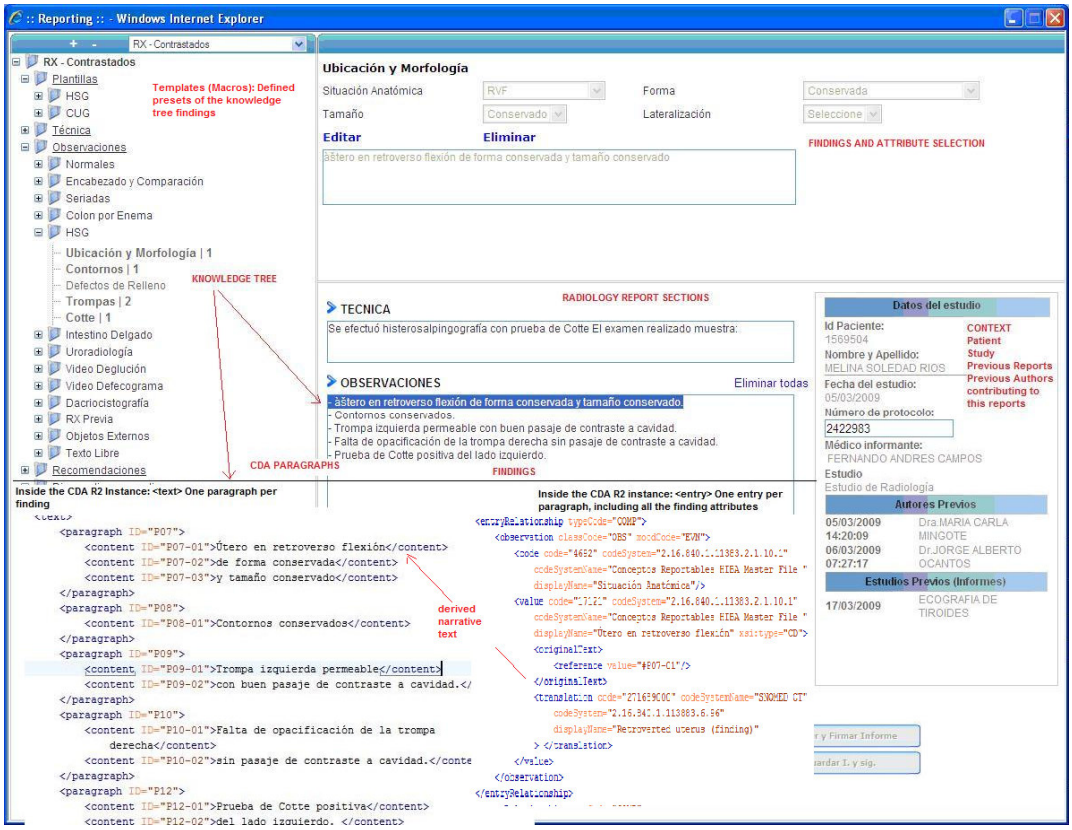
After: standardized sections defined by RSNA, coded entries with controlled vocabulary for findings, access to related images from the PACS





The identifiers used for our CDA R2 documents are those OIDs assigned by HL7 Argentina to the Hospital Italiano de Buenos Aires and its local branches for registries: patients, physicians, departments, orders and studies.

Each finding selected in the knowledge tree of the editor automatically generates the corresponding entries and its derived narrative text.


:: Reporting :: - Windows Internet Explorer
RX - Contrastados
Plantillas
HSG
CUG
Técnica
Observaciones
Normales
Encabezado y Comparación
Seriadas
Colon por Enema
HSG
Ubicación y Morfología | 1
Contornos | 1
Defectos de Relleno
Trompas | 2
Cotte | 1
Intestino Delgado
Uroradiología
Video Deglución
Video Defecograma
Dacriocistografía
RX Previa
Objetos Externos
Texto Libre
Recomendaciones
Templates (Macros): Defined presets of the knowledge tree findings
KNOWLEDGE TREE
Ubicación y Morfología
Situación Anatómica
RVF
Forma
Conservada
Tamaño
Conservado
Lateralización
Seleccione
Editar
Eliminar
FINDINGS AND ATTRIBUTE SELECTION
útero en retroverso flexión de forma conservada y tamaño conservado
RADIOLOGY REPORT SECTIONS
TECNICA
Se efectuó histerosalpingografía con prueba de Cotte El examen realizado muestra:
OBSERVACIONES
Eliminar todas
útero en retroverso flexión de forma conservada y tamaño conservado.
- Contornos conservados.
- Trompa izquierda permeable con buen pasaje de contraste a cavidad.
- Falta de opacificación de la trompa derecha sin pasaje de contraste a cavidad.
- Prueba de Cotte positiva del lado izquierdo.
CDA PARAGRAPHS
FINDINGS
Datos del estudio
Id Paciente:
1569504
Nombre y Apellido:
MELINA SOLEDAD RIOS
Fecha del estudio:
05/03/2009
Número de protocolo:
2422983
Médico informante:
FERNANDO ANDRES CAMPOS
Estudio
Estudio de Radiología
CONTEXT
Patient
Study
Previous Reports
Previous Authors contributing to this reports
Autores Previos
05/03/2009 14:20:09 Dra.MARIA CARLA MINGOTE
06/03/2009 07:27:17 Dr.JORGE ALBERTO OCANTOS
Estudios Previos (Informes)
17/03/2009 ECOGRAFIA DE TIROIDES
Inside the CDA R2 Instance: <text> One paragraph per finding
<paragraph ID="P07">
<content ID="P07-01">Útero en retroverso flexión</content>
<content ID="P07-02">de forma conservada</content>
<content ID="P07-03">y tamaño conservado</content>
</paragraph>
<paragraph ID="P08">
<content ID="P08-01">Contornos conservados</content>
</paragraph>
<paragraph ID="P09">
<content ID="P09-01">Trompa izquierda permeable</content>
<content ID="P09-02">con buen pasaje de contraste a cavidad.</
</paragraph>
<paragraph ID="P10">
<content ID="P10-01">Falta de opacificación de la trompa derecha</content>
<content ID="P10-02">sin pasaje de contraste a cavidad.</conte
</paragraph>
<paragraph ID="P12">
<content ID="P12-01">Prueba de Cotte positiva</content>
<content ID="P12-02">del lado izquierdo. </content>
derived narrative text
Inside the CDA R2 instance: <entry> One entry per paragraph, including all the finding attributes
<entryRelationship typeCode="COMP">
<observation classCode="OBS" moodCode="EVN">
<code code="4652" codeSystem="2.16.840.1.113883.2.1.10.1"
codeSystemName="Conceptos Reportables HIBA Master File "
displayName="Situación Anatómica"/>
<value code="7.7.2." codeSystem="2.16.840.1.113883.2.1.10.1"
codeSystemName="Conceptos Reportables HIBA Master File "
displayName="Útero en retroverso flexión" xsi:type="CD">
<originalText>
<reference value="#P07-C1"/>
</originalText>
<translation code="271679C0C" codeSystemName="SNOMED CT"
codeSystem="2.16.842.1.113883.6.96"
displayName="Retroverted uterus (finding)"
></translation>
</value>
</observation>
</entryRelationship>
Firmar Informe
Guardar I. y sig.

The controlled terminology involves the use of local concepts structured in knowledge trees but mapped to the Clinical Terminology Server of the HIBA contents.
The CTS serves as a bridge between interface terminology and standardized terminology as SNOMED CT (if available for each attribute of each finding)
So each finding is represented as paragraphs, and has its attributes represented as components.
Each attribute has a code and a value (see paragraph 3.3.9 of CDAR2_II_BIMGRPTS_R1_I1_2008MAY) , both can (code and value) can be expressed with translations to SNOMED CT or RadLex if available – (see Picture 5 –CDA R2 entry for a radiological finding attribute).

This relationship can be defined using the Knowledge Tree Editor component.

Picture 5 – CDA R2 entry for a radiological finding

```
<entryRelationship typeCode="COMP">
    <observation classCode="OBS" moodCode="EVN">
        <code code="4692" codeSystem="2.16.840.1.11383.2.1.10.1"
            codeSystemName="Conceptos Reportables HIBA Master File "
            displayName="Situación Anatómica"/>
        <value code="17121" codeSystem="2.16.840.1.11383.2.1.10.1"
            codeSystemName="Conceptos Reportables HIBA Master File "
            displayName="Útero en retroverso flexión" xsi:type="CD">
            <originalText>
                <reference value="#P07-01"/>
            </originalText>
            <translation code="271689000" codeSystemName="SNOMED CT"
                codeSystem="2.16.840.1.113883.6.96"
                displayName="Retroverted uterus (finding)"
            > </translation>
        </value>
    </observation>
</entryRelationship>
```

Finding (concept in HIBA terminology server)

Translation of the concept in SNOMED CT, provided by the HIBA CTS.

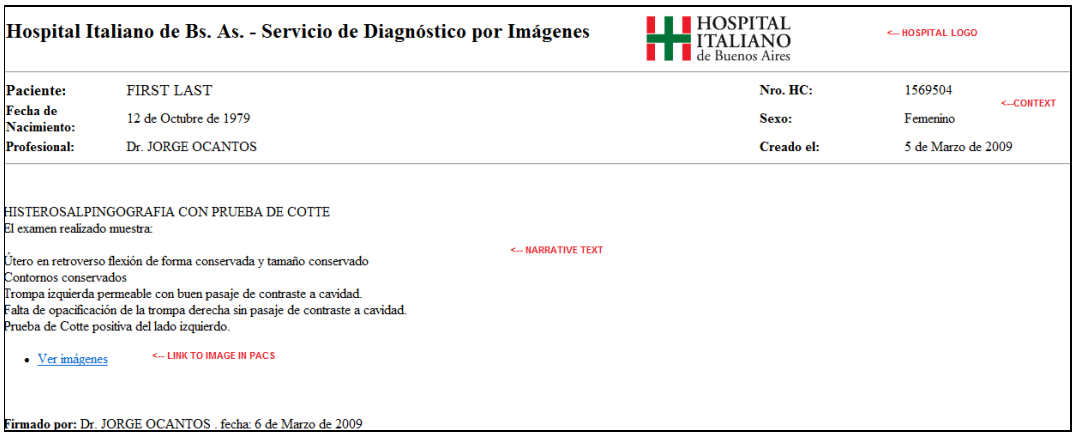
The CDA R2 instances are reused in many ways: as a partial report (HIBA is a teaching hospital and staff radiologists oversee, edit and authenticate the reports previously generated by residents), as a final report for clinical use among all the HIBA clinicians and as part of the EHR of each patient , and as a source of epidemiological information for biostatistics.
We used a simple code/value structure
Software tools used were Java J2EE 6 running on a Sun Application Server with an Oracle database for the knowledge tree, but the software also runs under Glassfish for Windows or any other Java app server, and using Oracle or MS-SQL databases

III. CDA in Use

The editor integrated with the RIS, PACS and EHR is running and generating CDA R2 documents for CR, CT and interventionism (Ultrasound/Angiography) since September 2008. Since its implementation this structured editor was responsible for approximately 35000 reports monthly (30% of the ancillary service reports generated in the Hospital). It is used for report generation by more than 100 radiologists including staff and residents.
Each CDA R2 instance has an associated stylesheet, which allows for stylesheet versioning.
This does not preclude the same document to be seen with the standard CDA.XSL defined by HL7 without loosing clinical content and context should the original stylesheet be unavailable.

Picture 6 below shows a sample of the CDA R2 instance rendered with the ad-hoc stylesheet selected by the imaging radiology department.

Picture 6 – HIBA Reporting CDA R2 rendered with the HIBA defined style/sheet



Picture 7 shows the same instance rendered with a generic CDA.XSL developed by Alexander Henket (replacing the original CDA.xsl)

Picture 7 – HIBA Reporting CDA R2 rendered with the standard CDA.XSL stylesheet

For use of physicians outside of the HIBA, included in the DICOM CD-ROM with the images is a PDF rendering of the CDA R2 repot, generated using a special XSL-FO style-sheet.
The radiologists were trained in the use of the reporting tool using the HIBA moodle platform, and also with personalized, face-to-face education for each radiologist.
The new CDA R2 instances with coded entries uses an average of 18 to 25 kbytes per document, which compared to the previous 6-8 Kbytes average is a huge increase, but this is a very small storage requirement overall compared with the imaging storage impact.

IV. Evaluation/Assessment

This project's original goals were:

1. Integration of the structured report to the EHR.
2. Inclusion of links to the DICOM associated images - especially KINs: a few (5-50) remarkable images selected by the radiologist (sometimes a complete CT study includes more than 3000 images) for the referring physician.
3. Seamless integration with the RIS, without losing componentization of the editor
4. Changes of the reporting workflow including direct reporting by the radiologists, reduction of transcriptionist staff, and less turnaround time.

Additional goals developed during implementation were:

5. Immediate availability of images for the EHR.
6. Ability of the radiologist to customize the report templates
7. Use of the report editor for other hospital's areas, including the possibility of sending DICOMized images to the PACS.
8. Contingency auto-save and store capability of the report editor, in case of EHR document repository failure or even radiology workstation failure.

Method of Evaluation and Results

- **Integration of the structured report to the EHR**
  Each report is automatically send as a CDA R2 document to the EHR repository.
- **Inclusion of links to the DICOM associated images - especially KINs**
  Our radiologists select key images for all complex studies, and the link in the CDA R2 document points to that restricted set of images in the DICOM server / The referring physician also can ask for the complete study.
- **Seamless integration with the RIS, without losing componentization of the editor**
  The editor is a plug-and-play component for our RIS, integrated (invisibly for the user)

- **Changes of the reporting workflow including direct reporting by the radiologists, reduction of transcriptionist staff, and less turnaround time.**

a. TAT= Hours from study start to final report

TAT	Jan 2008	Jan 2009
(Sample n=1500)	**Avg. time**	**Avg. time**
Radiology	>96 hours	<48 hours
Comp.Tomography	>60 hours	<48 hours

b. Transcriptionist staff reduction

	March 2008	March 2009	% reduction
Radiology	8	4	50%
Comp.Tomography	4	2	50%

- Immediate availability of images for the EHR.
  As soon as the image is available from the modality, a new CDA R2 containing a fixed text and a link to the image is sent to the EHR, enabling the referring physician to see the images as soon as possible within the patient EHR context.

Feedback to next CDA release 3

We need

a) The capability to include multiple legalAuthenticator elements, since some of our reports are co-signed with equal authority by two or three radiologists (multiple areas CT)
We are currently using multiple authenticator elements and only one legalAuthenticator, but this doesn't represent our reality.

b) The inclusion of xmldsig namespace INSIDE of the CDA standard. We are using a local extension to the CDA R2 spec right now. This can be also attained by including the signatureText as an optional element for every participant of the CDA R2 document.

V. Future Plans

The project will include the use of the editor and PACS imaging for all other modalities in the Imaging Diagnostic department during this year 2009: magnetic resonance, interventionist radiology, ultrasound, PET, mammography and peripheral angiography, with more than 700K studies/year.

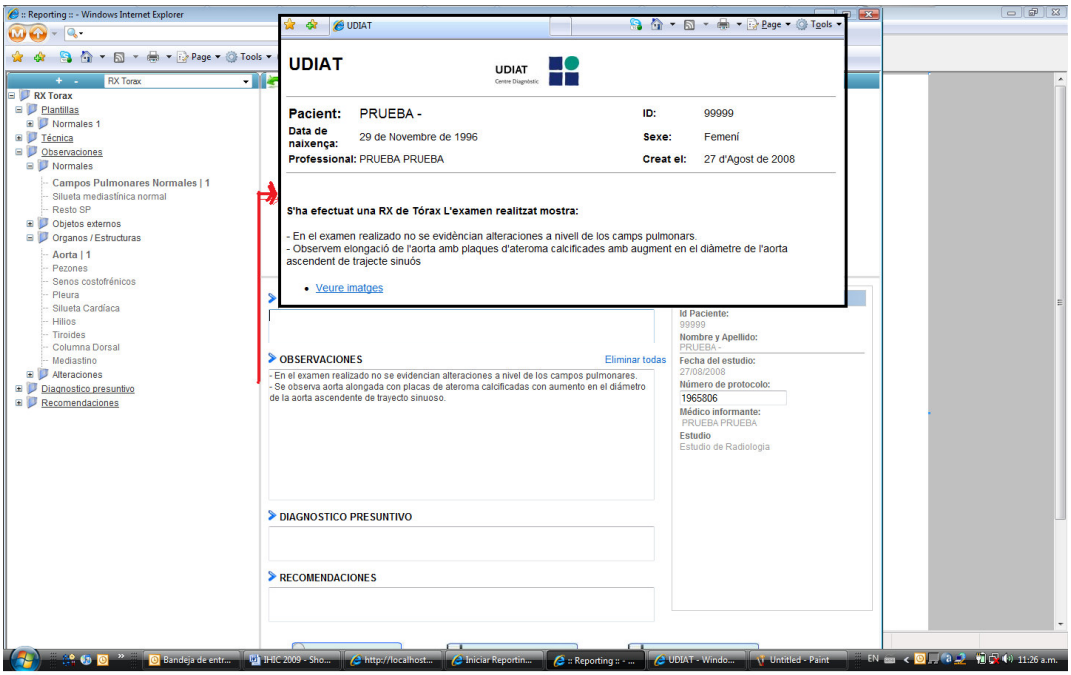
After finishing with this department, we will include during this and next year cardiology and angiography, and all other departments of the Hospital involving structured reports and multimedia objects (dermatology, ophthalmology, central angiography and endoscopy)

One of the main challenges is our PACS' provider planned change in the web delivery through the web: they are changing the proprietary URL call to a WADO standardized invocation, which is the correct path to go. The problem is that the we have included the image invocation through an URL as a link in the CDA R2 documents, and the CDA R2 documents stored in the repository are immutable and are signed digitally, so we plan on having a proxy to transform the old image invocation into the new WADO format.

Other issues for us to look after in the future are
- the possibility of integrating some kind of voice recognition to the editor
- reduce the use of free text by the radiologists

The other challenge will be integration of this component with UDIAT's RIS, which will be the proof of its capability of integrating with other provider's systems, and functioning in more than one language (so far, we've only tested and implemented thoroughly the Spanish GUI/Spanish report version).
We've tested this feature with some basic examples, but we will need more input from UDIAT in order to fine-tune these capabilities. (see Picture 8 – Editor GUI in Spanish, CDA R2 output in Catalan)

Picture 8 – HIBA Reporting CDA R2 GUI and tree in Spanish, output with narrative text in Catalan



VI. Conclusions and Lessons Learned

From the viewpoint of the EHR, any format other than CDA R2 is not acceptable, because of non-standardization and lack of context information given by other XML or non-XML formats.

CDA R2 is all we needed for our report structure: narrative text, coded entries, link to the images, but a good and simple standard for the behavioral parameters will surely be a good initiative. We analyzed CCOW and it turned out to be very much overhead and incomplete for our needs.

CDA R2 also proved its capabilities enabling evolutionary semantic interoperability: we were able to add more information into our reports without changing our repository or the standard used or even our tooling, and we essentially leveraged all our previous efforts.

One of the bigger issues in this project was the human factor: radiologists' training and acceptation of the tools, preparation of the knowledge trees, and discussion with the ordering physicians about the delivery of the reports and images.

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VIII. Included CDA R2 samples

File Name	*Description*
HIBA_REPORTING_CDA_SAMPLE.XML	*Sample CDA R2 Instance from the Structured Reporting Editor, in Spanish, XML Format*
HIBA_REPORTING_CDA_SAMPLE_WITH_CDAXSL.HTML	*Sample CDA R2 Instance from the Structured Reporting Editor, in Spanish, HTML Format, rendered with CDA.XSL*
HIBA_REPORTING_CDA_SAMPLE.HTML	*Sample CDA R2 Instance from the Structured Reporting Editor, in Spanish, HTML Format, rendered with HIBA XSL*
HIBA_REPORTING_CDA_SAMPLE_CAT.XML	*Sample CDA R2 Instance from the Structured Reporting Editor, in Catalan, XML Format*
HIBA_REPORTING_CDA_SAMPLE_CAT.HTML	*Sample CDA R2 Instance from the Structured Reporting Editor, in Catalan, HTML Format, rendered with CDA.XSL*