COMVIEW MEDICAL SYSTEMS

DICOM SR Implementation

DICOM Structured Reporting: Implementation Experience

David Clunie, MD.

Director of Healthcare Information Systems

ComView Corporation

DICOM SR Implementation

Design Goals

- Cardiology image reporting system
- Multi-modality: Angio (XA) & Echo (US)
- Standards based: facilitate interchange
- Re-use existing components:
  - DICOM image acquire/view/archive
  - Consumer/open-source tools

Existing Tools

- DICOM toolkit
  - Java, Part 10, C-Store, dataset build/parse
- Image viewing application
- Web-browser window available
- Java Server Page (JSP) engine
- XML tools (SAX/DOM parse, XSL-T)

Report Features

- Very structured (especially echo)
  - By anatomic feature
  - By measurement type
- Both technologist & physician input
- Measurements not image-coupled (yet)
- Many specific variants:
  - Adult/pediatric,normal/stress,site-specific

Template Use & Design

- Little need for observation context
- WG 1/12 templates not yet mature
- Coding schemes not yet mature
- Therefore:
  - private templates
  - augment LOINC with private codes
  - generic input, editor and renderer

Design Alternatives

- Hard-coded SR-specific application
- Literal XML instantiation & conversion
  - DOM (slow, flexible) or SAX (fast, XSL-T)
- SR-specific Object Model
  - Limited reusability; support for XSL-T ?
- Virtual XML - simulate SAX events
  - Both DICOM parse & DICOM generate

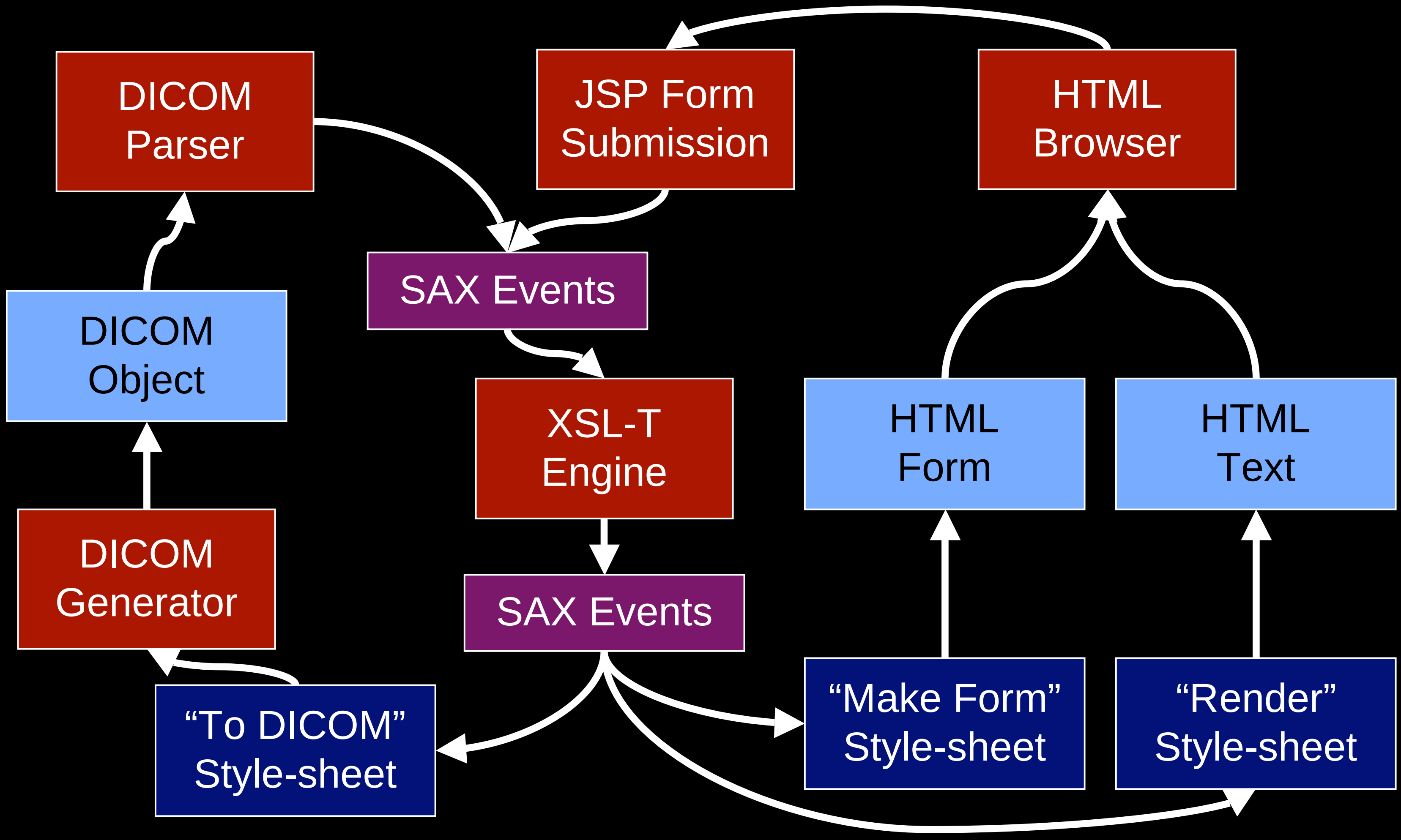
ComView MEDICAL SYSTEMS

DICOM SR Implementation

Architecture: “round-trip”

- Only persistent object is binary DICOM
- DICOM parser returns SAX events
  - i.e. implicit virtual XSML conversion
- SAX events drive XSL-T stylesheet
  - produces HTML form (+CSS for prettiness)
- Browser renders form which user fills in
- Submit -> JSP makes SAX events from form
  - I.e. another implicit virtual XML conversion
- Either: cycle revised form or DICOM C-Store

DICOM SR Implementation



Implementation Specifics - SAX

- SAX API is key interface boundary
  - Producer/consumer model
  - Producer is “document parser”
  - Consumer is “document handler”
- DICOM interface
  - Parser wrapped inside SAX parser
  - Generator wrapped inside SAX handler

Implementation Specifics - HTML

- HTML Pages are only interface to user
- Non-editable information
  - Rendered as non-form elements
- Editable information
  - Rendered as form elements
  - Naming scheme maps to header/SR tree
  - Pre-loaded from images/work-list etc.

Implementation Specifics - HTML

- Limited HTML features required
  - Forms
  - Cascading Style-Sheets (CSS)
    - Prettiness
    - Customize appearance (e.g. site-specific)
    - Factor out appearance from JSP logic
  - No Javascript necessary (yet)
    - Future use: client-side field validation

Implementation Specifics - JSP

- Form submitted via CGI PUT method
- Type of “submit” dictates next step:
  - Update/render/print/store/sign etc.
- Recurse through named attributes
- Generate SAX events to XSL-T engine
- Pipe XSL-T output to servlet response
- Stateless: no cookies or server state

Implementation Specifics - XSLT

- Two approaches:
  - “pull” values into a specific format
    - always result in pre-defined format
    - ignores “un-pulled” attributes: not general
    - essentially highly template-dependent
  - “rewrite rules” repeatedly applied
    - generic and extensible
    - can recognize “patterns” and optimize

Results of Experience - DICOM

- Existing toolkit re-use:
  - No tag ordering problems
  - No sequence building problems
  - Service/SOP Class/IOD support
- Existing application re-use:
  - No need to re-implement archive/database
  - Image viewer integration (share context)

Results of Experience - Pick-lists

- Codes for Concept Names and values
- Where do lists of codes come from ?
  - Dictionary/lexicon
  - Embedded in style-sheet
- Triggering context group selection
  - *Very useful to keep context group choice encoded in data-set !*

ComView Medical Systems

In-band Context Identifier

Code Value	(0008,0100)	1
Coding Scheme Designator	(0008,0102)	1
Coding Scheme Version	(0008,0103)	1C
Code Meaning	(0008,0104)	1
Context Identifier	*(0008,010F)*	*3*
Mapping Resource	(0008,0105)	1C
Code Set Extension Flag	(0008,0106)	3
…	…	…

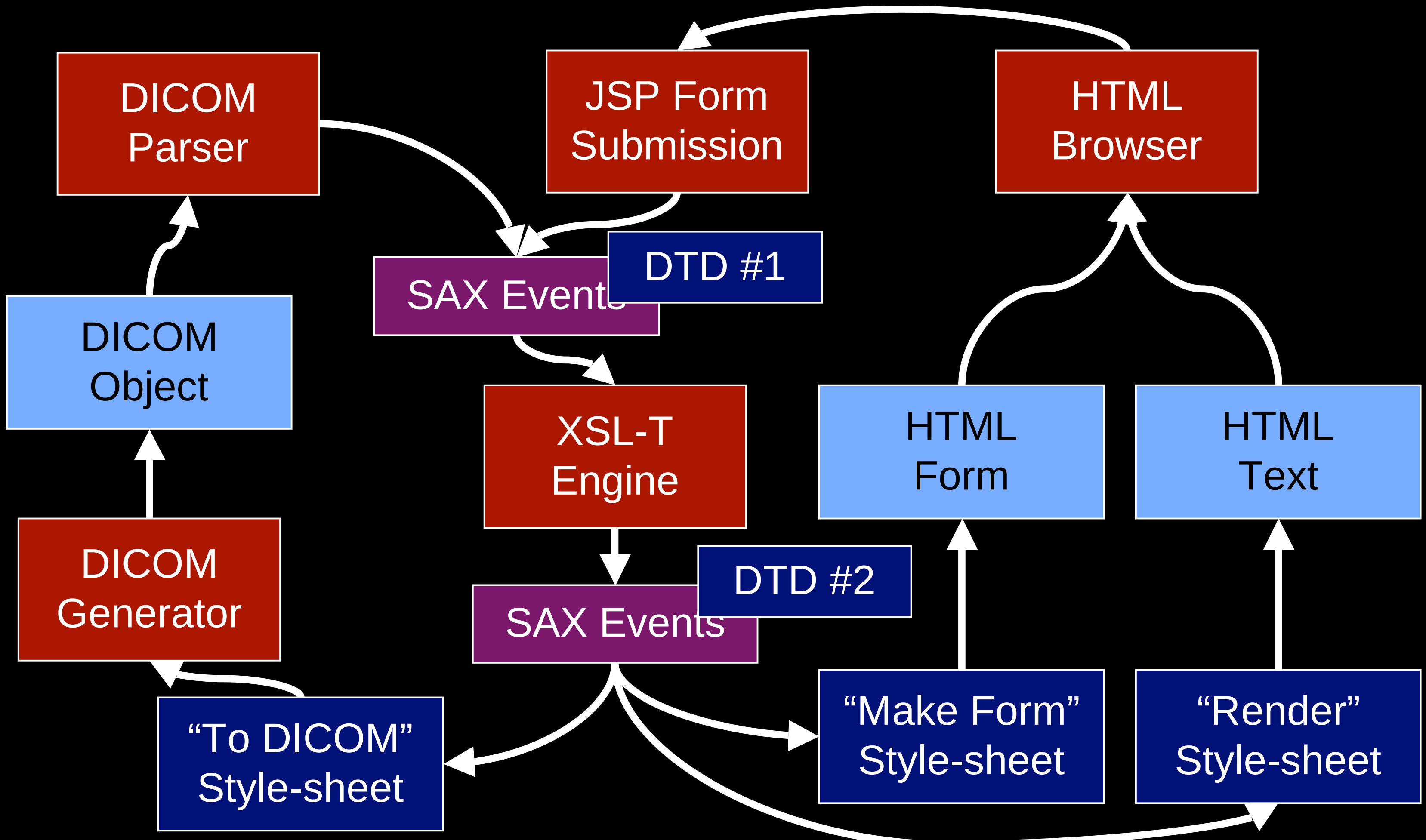
In-band Context Identifier

- Allows style-sheet to trigger pick-list generation locally to content item
- No *a priori* knowledge of template required
- Strategy allows for editable documents in the absence of a template !
- Still need context group itself of-course

Results of Experience - XML

- No XML ever actually instantiated
- “Virtual” XML in SAX events
- Still requires DTD (or Schema)
- Several DTDs
  - One specific to SR structure for round trip
  - One specific to DICOM tags for generation

DICOM SR Implementation



Results of Experience - XML

- Advantage of “non-standard” DTDs
- Multiple DTDs specific to need
- Choose elements vs. attributes as desired
- Extensible to match evolving style-sheets
- Addition of state information to alter user interface:
  - E.g. container expand/collapse, tab view

Results of Experience - XSL-T

- Pure rewriting approach
  - very generic - can render any SR
  - not always the prettiest rendering
- Combination pull and rewrite
  - Pull for:
    - initial creation (e.g. replicating conventional form or wizard)
    - “header” attributes - consistent presence and layout
  - Rewrite for editing/rendering

Results of Experience - XSL-T

- Declarative approach of tree re-writing rules takes some getting used to
- X-PATH syntax for rule and value selection is very useful (esp. access to distant ancestors and descendants)
- HTML (or other text) output is very straightforward
- Include/import mechanism allows tool-generated rules to be added (e.g. code lists)

Results of Experience - SR

- Rule against non-null values
  - “fill in the blanks” objects illegal
  - -> “chicken and egg” problem
- Mandatory units for NUM annoying
- How to (usefully) render different relationship types
- How to render by-reference links

Results of Experience - Templates

- "Headings" == "Containers"
  - Expand/collapse or tab through containers
  - Want everything at top level a container
- Unnecessary containers annoying
  - CONTAINER "cardiac measurement *contains* "stroke volume" = "70" "ml"
- Homogeneous container contents
  - e.g. all NUM -> render as HTML table

Results of Experience - Templates

- Re-usable mini-template “components”
- Achieve consistency of rendering
  - e.g.
    - Numeric tables
    - Normal range
    - Qualitative assessment (hi/lo/normal)

Future Directions

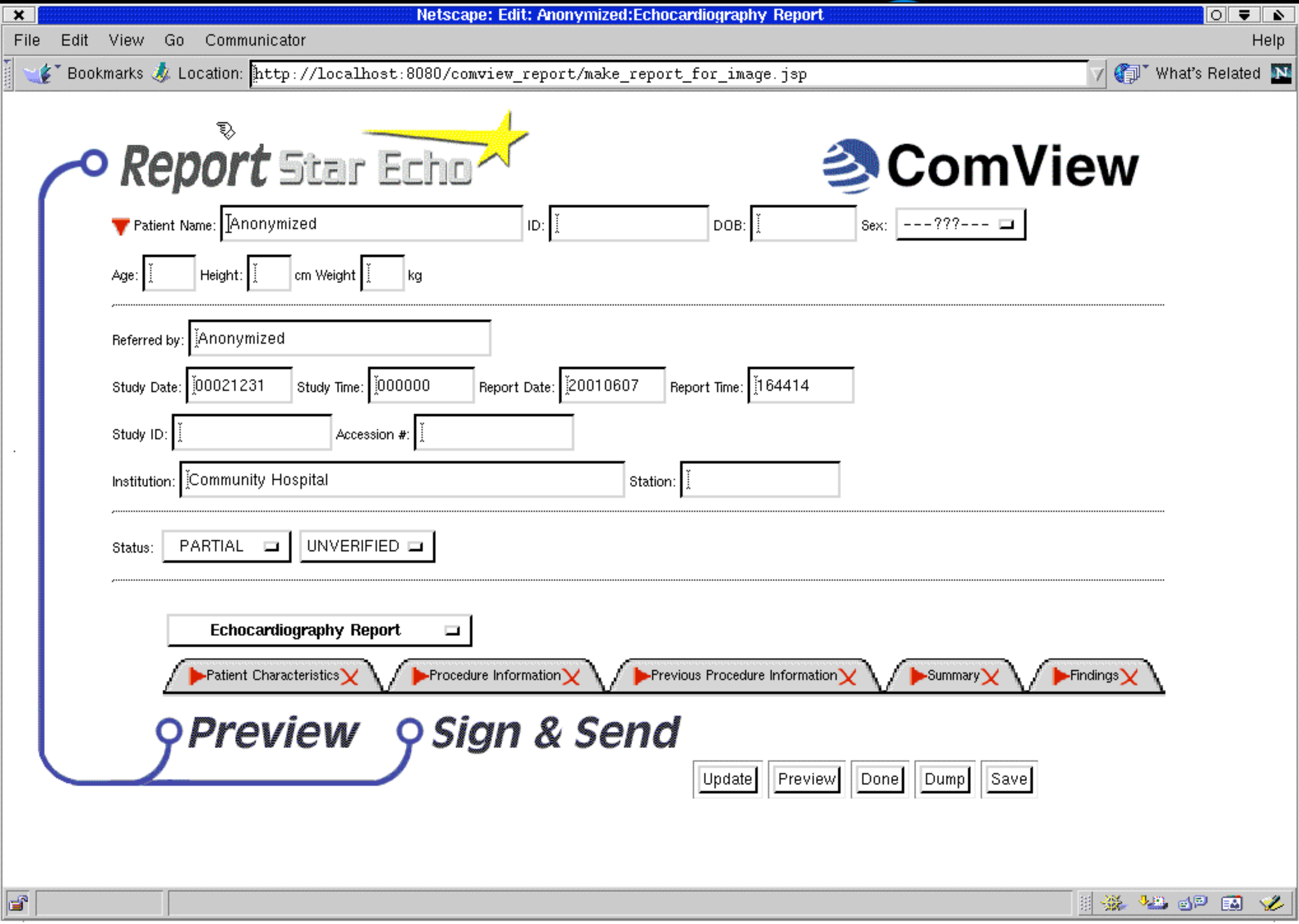
- Adopting standard templates:
  - Easier with generic approach
    - Re-use of common rendering elements
    - Installed base of reports still usable
- Example:
  - Support of ACC 2001 demo CD SR
    - Trivial effort to render (same style-sheet)
    - Editable once context groups added

Future Directions

- Integration with images & coordinates
  - Shared (bi-directional) context approach
  - Create/edit:
    - HTML form element triggers capture of current image viewer context -> JSP
  - Render:
    - Javascript or anchor in XSL-T-generated-HTML triggers JSP to update viewer context

Future Directions

- Improved rendering
  - To other than HTML
    - e.g. directly to HL7 V2.x. OBX segment
  - Multi-lingual rendering
  - Narrative conversion of code entries


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_report_for_image.jsp
What's Related
Report Star Echo
ComView
Patient Name: Anonymized
ID:
DOB:
Sex: ---???---
Age:
Height:
cm Weight
kg
Referred by: Anonymized
Study Date: 00021231
Study Time: 000000
Report Date: 20010607
Report Time: 164414
Study ID:
Accession #:
Institution: Community Hospital
Station:
Status: PARTIAL
UNVERIFIED
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Preview
Sign & Send
Update
Preview
Done
Dump
Save


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
What's Related
Report Star Echo
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Preview
Sign & Send
Update
Preview
Done
Dump
Save

Netscape: Edit: Anonymized:Echocardiography Report

File Edit View Go Communicator Help

Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp What's Related

Report Star Echo

ComView

Patient Anonymized, ; Study (00021231:000000)

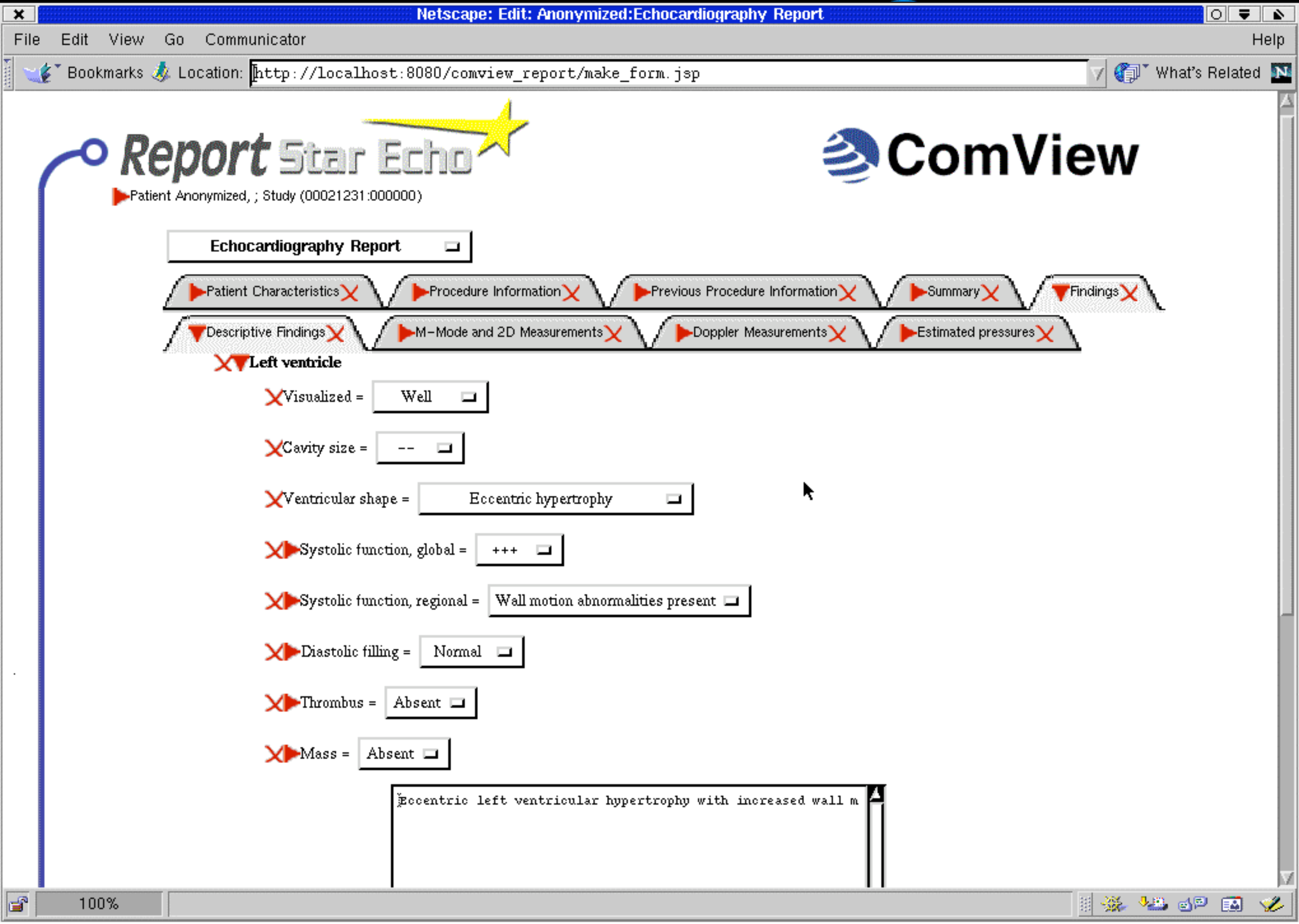
Echocardiography Report

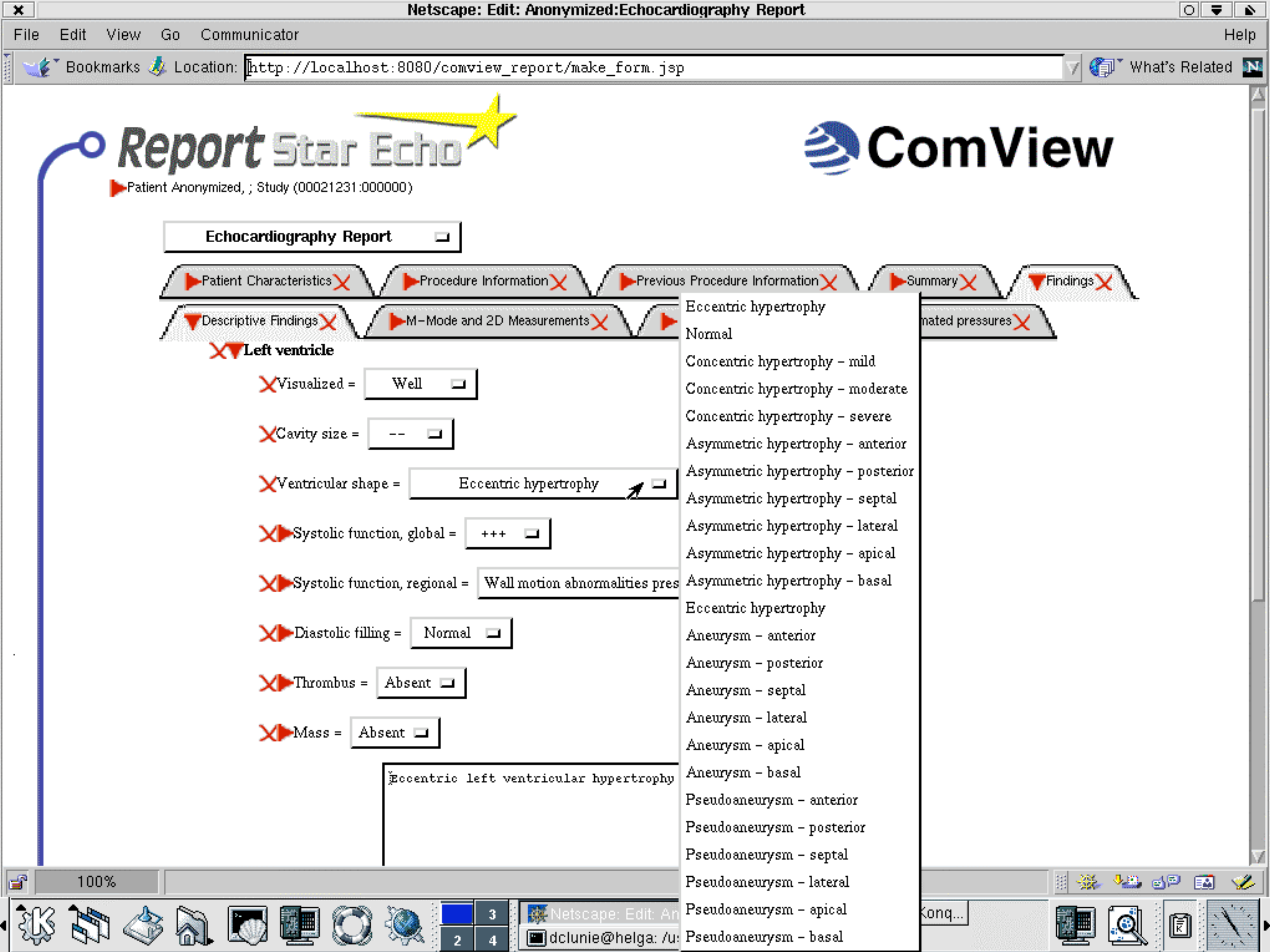
Patient Characteristics | Procedure Information | Previous Procedure Information | Summary | Findings

Descriptive Findings | M-Mode and 2D Measurements | Doppler Measurements | Estimated pressures

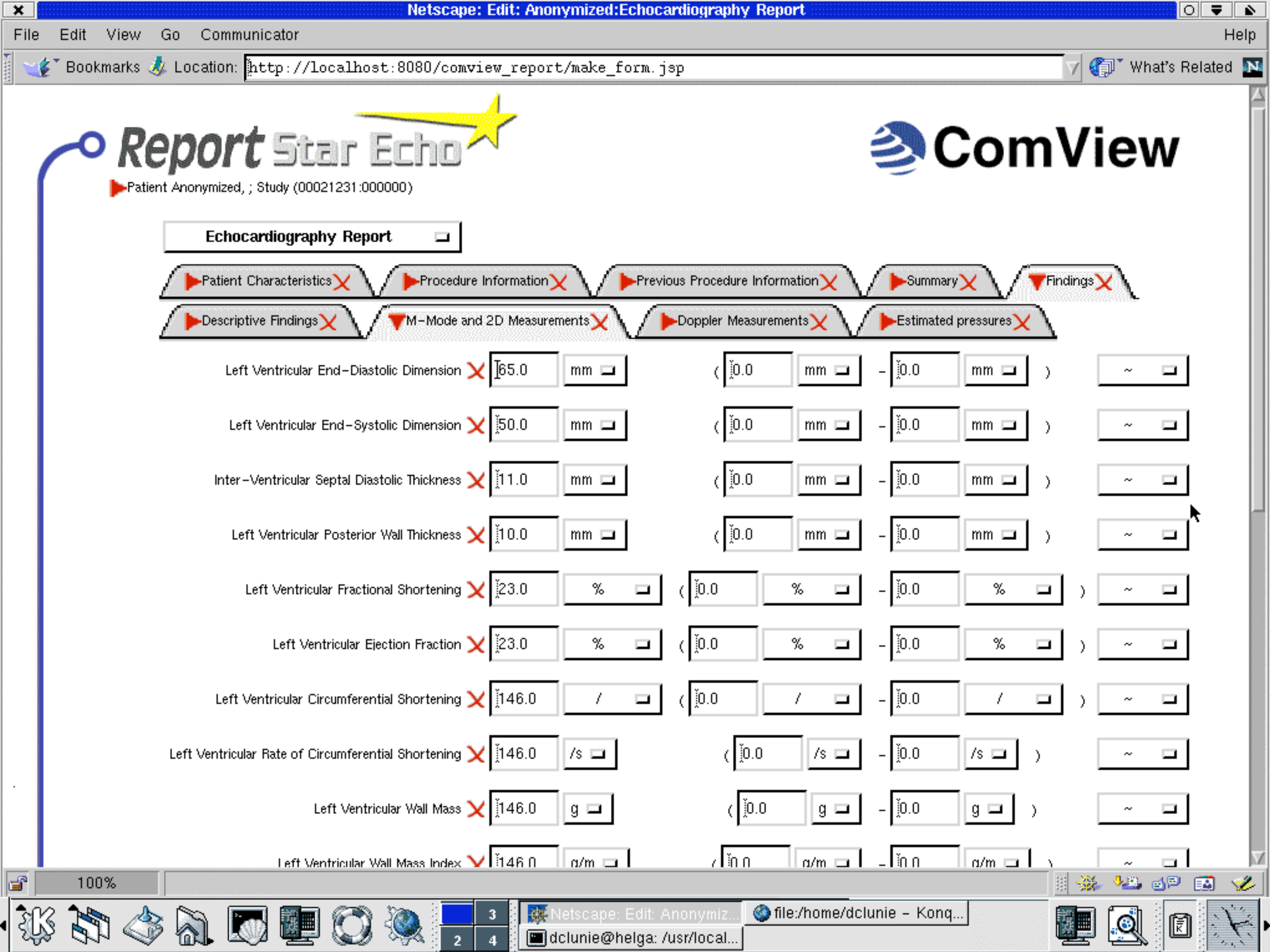
Preview Sign & Send

Update Preview Done Dump Save


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
What's Related
Report Star Echo
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Descriptive Findings
M-Mode and 2D Measurements
Doppler Measurements
Estimated pressures
Left ventricle
Visualized = Well
Cavity size = --
Ventricular shape = Eccentric hypertrophy
Systolic function, global = +++
Systolic function, regional = Wall motion abnormalities present
Diastolic filling = Normal
Thrombus = Absent
Mass = Absent
Eccentric left ventricular hypertrophy with increased wall m
100%



Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
What's Related
Report Star Echo
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Descriptive Findings
M-Mode and 2D Measurements
mated pressures
Left ventricle
Visualized = Well
Cavity size = --
Ventricular shape = Eccentric hypertrophy
Systolic function, global = +++
Systolic function, regional = Wall motion abnormalities pres
Diastolic filling = Normal
Thrombus = Absent
Mass = Absent
Eccentric left ventricular hypertrophy
Eccentric hypertrophy
Normal
Concentric hypertrophy – mild
Concentric hypertrophy – moderate
Concentric hypertrophy – severe
Asymmetric hypertrophy – anterior
Asymmetric hypertrophy – posterior
Asymmetric hypertrophy – septal
Asymmetric hypertrophy – lateral
Asymmetric hypertrophy – apical
Asymmetric hypertrophy – basal
Eccentric hypertrophy
Aneurysm – anterior
Aneurysm – posterior
Aneurysm – septal
Aneurysm – lateral
Aneurysm – apical
Aneurysm – basal
Pseudoaneurysm – anterior
Pseudoaneurysm – posterior
Pseudoaneurysm – septal
Pseudoaneurysm – lateral
Pseudoaneurysm – apical
Pseudoaneurysm – basal
100%
Netscape: Edit: An
dclunie@helga: /u
Konq...


Netscape: Edit: Anonymized:Echocardiography Report
File Edit View Go Communicator Help
Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp
What's Related
Report Star Echo
ComView
Patient Anonymized, ; Study (00021231:000000)
Echocardiography Report
Patient Characteristics
Procedure Information
Previous Procedure Information
Summary
Findings
Descriptive Findings
M-Mode and 2D Measurements
Doppler Measurements
Estimated pressures
Left Ventricular End-Diastolic Dimension 65.0 mm (0.0 mm - 0.0 mm) ~
Left Ventricular End-Systolic Dimension 50.0 mm (0.0 mm - 0.0 mm) ~
Inter-Ventricular Septal Diastolic Thickness 11.0 mm (0.0 mm - 0.0 mm) ~
Left Ventricular Posterior Wall Thickness 10.0 mm (0.0 mm - 0.0 mm) ~
Left Ventricular Fractional Shortening 23.0 % (0.0 % - 0.0 %) ~
Left Ventricular Ejection Fraction 23.0 % (0.0 % - 0.0 %) ~
Left Ventricular Circumferential Shortening 146.0 / (0.0 / - 0.0 /) ~
Left Ventricular Rate of Circumferential Shortening 146.0 /s (0.0 /s - 0.0 /s) ~
Left Ventricular Wall Mass 146.0 g (0.0 g - 0.0 g) ~
Left Ventricular Wall Mass Index 146.0 g/m (0.0 g/m - 0.0 g/m) ~
100%
Netscape: Edit: Anonymiz...
file:/home/dclunie - Konq...
dclunie@helga: /usr/local...

Netscape: Preview: Anonymized:Echocardiography Report

File Edit View Go Communicator Help

Bookmarks Location: http://localhost:8080/comview_report/make_form.jsp What's Related

Patient Name: Anonymized ***ID:*** ***DOB:*** ***Sex:***
Age: ***Height:*** cm ***Weight:*** kg

Referred by:
Study Date: 00021231 ***Study Time:*** 000000 ***Report Date:*** 20010607 ***Report Time:*** 164414
Study ID: ***Accession #:***
Institution: Community Hospital ***Station:***

Status: PARTIAL UNVERIFIED

- ***Echocardiography Report.***
  - ***Patient Characteristics.***

Height	= 74.0 inch
Weight	= 74.0 pound
BSA	= 1.98 square meter
Heart Rate	= 73.0 per minute
Systolic Blood Pressure	= 123.0 mmHg
Diastolic Blood Pressure	= 123.0 mmHg

  - ***Procedure Information.***
    - ***Operator***=Harry
    - ***Study Type***=Transthoracic echocardiogram
    - ***Study Quality***=Technically adequate
    - ***Indication***=Assess LV function
  - ***Previous Procedure Information.***
    - ***Study Type***=None
  - ***Summary.***
    - ***Answer to question posed***=Left ventricular dimension was moderately increased with mildly to moderately reduced systolic performance. Anterior and septal hypokinesis was the main finding. Despite ECG changes, the inferior and posterior walls appeared to move well.
  - ***Findings.***
    - ***Descriptive Findings.***
      - ***Left ventricle.***
        - ***Visualized***=Well
        - ***Cavity size***=Mildly to moderately decreased
        - ***Ventricular shape***=Eccentric hypertrophy
        - ***Systolic function, global***=Moderately increased

inferred from ***Ejection fraction***	= 35.0 Percent
inferred from ***Fractional shortening***	= 45.0 Percent

        - ***Systolic function, regional***=Wall motion abnormalities present
          - ***Basal anterior segment***=Hypokinetic (ASE 2)
          - ***Basal lateral segment***=Normal (ASE 1)
          - ***Basal posterior segment***=Normal (ASE 1)
          - ***Basal inferior segment***=Normal (ASE 1)

- ☐ ***Right atrium.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=Right atrial size was normal.
- ☐ ***Vena cavae.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=The IVC was moderately dilated. Respirophasic change in IVC caliber was blunted, suggesting increased central venous pressure.
- ☐ ***Pulmonic valve.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=Normal.
- ☐ ***Pulmonary artery.***
  - ☐ ***Visualized***=Poorly
  - ☐ ***Narrative finding***=Pulmonary artery dimensions appeared to be normal.
- ☐ ***Pericardium.***
  - ☐ ***Visualized***=Well
  - ☐ ***Narrative finding***=No pericardial effusion.

☐ ***M-Mode and 2D Measurements.***

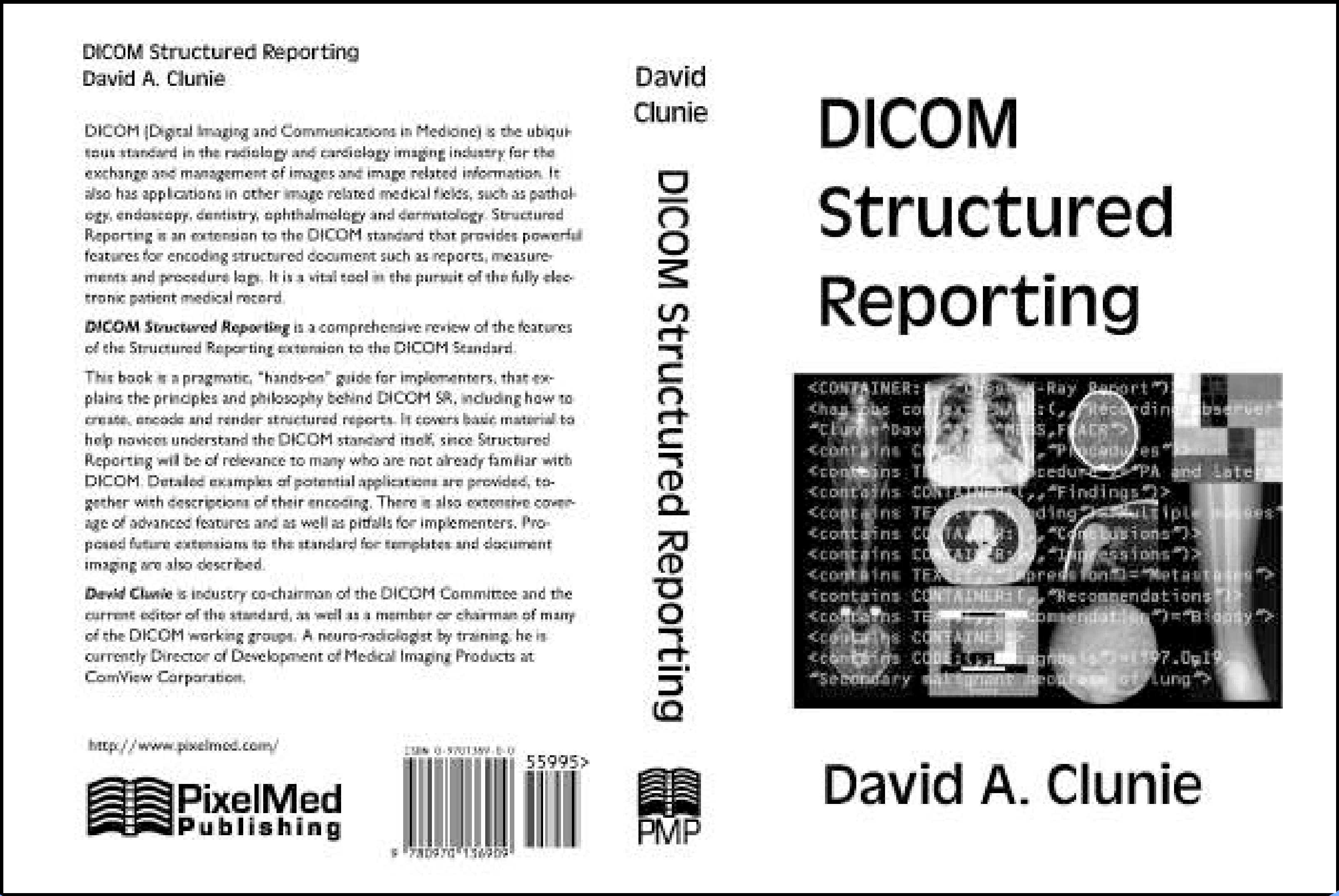
Left Ventricular End-Diastolic Dimension	= 65.0 mm	*(0.0 mm – 0.0 mm) [Normal]*
Left Ventricular End-Systolic Dimension	= 50.0 mm	*(0.0 mm – 0.0 mm) [Normal]*
Inter-Ventricular Septal Diastolic Thickness	= 11.0 mm	*(0.0 mm – 0.0 mm) [Normal]*
Left Ventricular Posterior Wall Thickness	= 10.0 mm	*(0.0 mm – 0.0 mm) [Normal]*
Left Ventricular Fractional Shortening	= 23.0 %	*(0.0 % – 0.0 %) [Normal]*
Left Ventricular Ejection Fraction	= 23.0 %	*(0.0 % – 0.0 %) [Normal]*
Left Ventricular Circumferential Shortening	= 146.0 /	*(0.0 / – 0.0 /) [Normal]*
Left Ventricular Rate of Circumferential Shortening	= 146.0 /s	*(0.0 /s – 0.0 /s) [Normal]*
Left Ventricular Wall Mass	= 146.0 g	*(0.0 g – 0.0 g) [Normal]*
Left Ventricular Wall Mass Index	= 146.0 g/m	*(0.0 g/m – 0.0 g/m) [Normal]*
Left Atrial Systolic Dimension	= 32.0 mm	*(0.0 mm – 0.0 mm) [Normal]*
Aortic Root Diastolic Diameter	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Aortic Annulus Diameter	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Aortic Valve Cusp Separation	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Left Ventricular Outflow Tract Systolic Diameter	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Mitral Valve Diastolic E-F Slope	= 32.0 cm/s	*(28.0 cm/s – 34.0 cm/s) [Normal]*
Mitral Valve Excursion	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Mitral Valve E Septal Separation	= 32.0 mm	*(28.0 mm – 34.0 mm) [Normal]*
Right Ventricular End-Diastolic Dimension	= 65.0 mm	*(0.0 mm – 0.0 mm) [Normal]*

☐ ***Doppler Measurements.***

Aortic Valve Peak Systolic Velocity	= 0.0 cm/s	*(0.0 cm/s – 0.0 cm/s) [Normal]*
Aortic Valve Time Velocity Integral	= 0.0 cm	*(0.0 cm – 0.0 cm) [Normal]*
Aortic Valve Maximum Instantaneous Systolic Gradient	= 0.0 mmHg	*(0.0 mmHg – 0.0 mmHg) [Normal]*
Aortic Valve Mean Systolic Gradient	= 0.0 mmHg	*(0.0 mmHg – 0.0 mmHg) [Normal]*
Aortic Valve Area (by Velocity)	= 0.0 cm2	*(0.0 cm2 – 0.0 cm2) [Normal]*

COMVIEW MEDICAL SYSTEMS

DICOM SR Implementation



DICOM Structured Reporting
David A. Clunie

DICOM (Digital Imaging and Communications in Medicine) is the ubiquitous standard in the radiology and cardiology imaging industry for the exchange and management of images and image related information. It also has applications in other image related medical fields, such as pathology, endoscopy, dentistry, ophthalmology and dermatology. Structured Reporting is an extension to the DICOM standard that provides powerful features for encoding structured document such as reports, measurements and procedure logs. It is a vital tool in the pursuit of the fully electronic patient medical record.

DICOM Structured Reporting is a comprehensive review of the features of the Structured Reporting extension to the DICOM Standard.

This book is a pragmatic, "hands-on" guide for implementers, that explains the principles and philosophy behind DICOM SR, including how to create, encode and render structured reports. It covers basic material to help novices understand the DICOM standard itself, since Structured Reporting will be of relevance to many who are not already familiar with DICOM. Detailed examples of potential applications are provided, together with descriptions of their encoding. There is also extensive coverage of advanced features and as well as pitfalls for implementers. Proposed future extensions to the standard for templates and document imaging are also described.

David Clunie is industry co-chairman of the DICOM Committee and the current editor of the standard, as well as a member or chairman of many of the DICOM working groups. A neuro-radiologist by training, he is currently Director of Development of Medical Imaging Products at ComView Corporation.

http://www.pixelmed.com/

PixelMed Publishing

55995>

David Clunie

DICOM Structured Reporting

PMP

DICOM Structured Reporting

David A. Clunie