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Integrating DICOM Objects with a Database Management System

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Agenda

- Background
- Motivation, challenges and design goal
- Our solution: architecture and key concepts
- Example: metadata management
- Summary
Background

• Part of Oracle’s interMedia feature
  A database application development framework for storage, manipulation, management, and indexing of multimedia data in Oracle database

• Provides relational and object interfaces to support:
  • Web publishing
  • Streaming media
  • JDeveloper and Oracle Portal integration
Business Motivation

- Growth of healthcare IT market
- Large increase in digital imaging
- National archives for research and public health
- Healthcare information integration
  - image integrated EHR (electronic healthcare record)
  - DICOM/HL7 integration
The Imaging “Perfect Storm”

Innovation and adoption: new modalities and disciplines

Technology advancement, more powerful hardware

Effective and more frequent utilization of imaging equipment

Share
Archive
Integrate
Motivation for Integrating DICOM with Databases

- Scalability, extremely large data sets
  - Single BLOB of 128 TB, database up to 8 XB
- Ease of development and management
  - Uniform interface for all business data
  - Backup and restore
  - Data migration, integration and remote sharing
  - Information Lifecycle Management
- Search, retrieval and transaction control
  - Reporting, data mining and business activity monitoring
- Security and auditing
Requirements

- Reliable storage and delivery
- Secure data sharing within and across
  - Departments/organizations/regions/nations
- Ease of system integration
- Growth and scalability
- Long term accessibility
Design Objectives

- Open platform capable of managing DICOM content along with all other medical and business information.
- Flexible design to permit the development and customization of applications of different scale, geographical span and business needs.
- Lower cost and complexity of developing, deploying, managing and integrating medical applications.
Challenges of Integrating DICOM: Managing Attributes

- Evolution of the DICOM standard
  - Extension to a particular branch of medicine
  - New imaging modalities
  - New/updated object/attribute definitions
- Non-conformant DICOM objects
- Large number of attributes
  - 2,000 distinct attributes defined so far
- Private attributes
Challenges of Integrating DICOM: Managing Imagery

- Ever growing file size
  - Memory management
  - Processing, encryption, …
- Index and search
- Storage scalability
- Backup and restore
- Database tools
Solution

A model-driven architecture that employs a user-configurable repository to control the behavior of DICOM support in a database

- Tight integration
- Secure
- Scalable
Architecture

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<thead>
<tr>
<th>Applications</th>
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<tr>
<td><strong>Database applications</strong></td>
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<td><strong>Mid-tier Java proxy classes</strong></td>
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<td><strong>SQL and PL/SQL layer DICOM functions</strong></td>
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<td><strong>Oracle interMedia</strong></td>
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<td><strong>Multimedia management</strong></td>
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<td><strong>Java Runtime</strong></td>
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<td><strong>DICOM model repository</strong></td>
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<td><strong>Database LOBs, Object,</strong></td>
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<td><strong>JavaVM, XML DB</strong></td>
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Key Concept: Repository

- Use pluggable model repository to encapsulate the DICOM standard definitions
Repository, Cont.

- Repository stores the data model that defines the behavior of a database instance
- Data model can be customized by a DBA
- Data model defines
  - DICOM data dictionary (part 6)
  - DICOM private attributes
  - DICOM to XML mapping
  - DICOM validation rules (part 3)
  - ...

DICOM
Key Concept: Data Type Definition

- Built-in support and validation for all VRs
- Canonical XML representation for each type of DICOM value representation (VR)
- Strongly typed and coupled to XML
  - Datetime DT ➔ xsd:datetime
  - PersonName PN ➔
    - encoding="unibyte | phonetic | ideographic"
    - Family, Given, Middle, Prefix, Suffix
- Valid XML document ⇔ parseable DICOM object
Key Concept: XML Mapping

• Use a mapping table to determine the XML representation of a DICOM attribute
Key Concept: Constraint

- Separate DICOM metadata content encoding and its constraint definitions

<table>
<thead>
<tr>
<th>Tag</th>
<th>Value</th>
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DICOM Object Constraints
Constraint, Cont.

- Constraint can be grouped into validation rules
  - To verify the conformance of a DICOM object
  - Can be SOP class specific
  - Managed by the model repository
  - Can be disabled or updated at any time
DICOM Support in Databases

- Metadata management
- Indexing
- Image transcoding, processing and compression
- Transfer syntax conversion
- Anonymization
- Extensibility
- ...

Example: Metadata Management

- Interpret and validate DICOM attributes (metadata)
- DICOM Object ➔ XML metadata
- XML metadata + a non-DICOM image ➔ a DICOM image
- Index and search DICOM objects by their metadata
User Defined XML Metadata Schema

Instead of extracting DICOM attributes and encoding them into a predefined XML schema, we extract attributes to fit a user defined XML metadata schema

- Tightly coupled with XML mapping table
- Constraints are defined external to XML
- Follows the XML metadata schema template
User Defined XML Metadata Schema, cont.

- Tuned to a specific application to achieve the best performance, interoperability and readability
- Avoid storing and processing metadata attributes that are irrelevant to an application
- Enforce localized conformance
  - Patient age to be type 1
XML Metadata Schema Template

- Strongly typed metadata attributes
- Two parts:
  - Attributes defined in the mapping document
    - <UserTag>value</UserTag>
    - Tree structure
  - Unmapped attributes
    - <type tag="HHHHHHHH">value</type>
    - Flat list (optional)
Summary

A model driven DICOM solution:

• Invariant to modification of the DICOM standard
• Online upgrade of DICOM repository model
• Supports private attributes
• Lossless XML mapping
• Customizable XML schema
• Customizable conformance validation
QUESTIONS
&
ANSWERS

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