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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 *inter*Media feature

  A database application development framework for storage, manipulation, management, and indexing of multimedia data in Oracle database

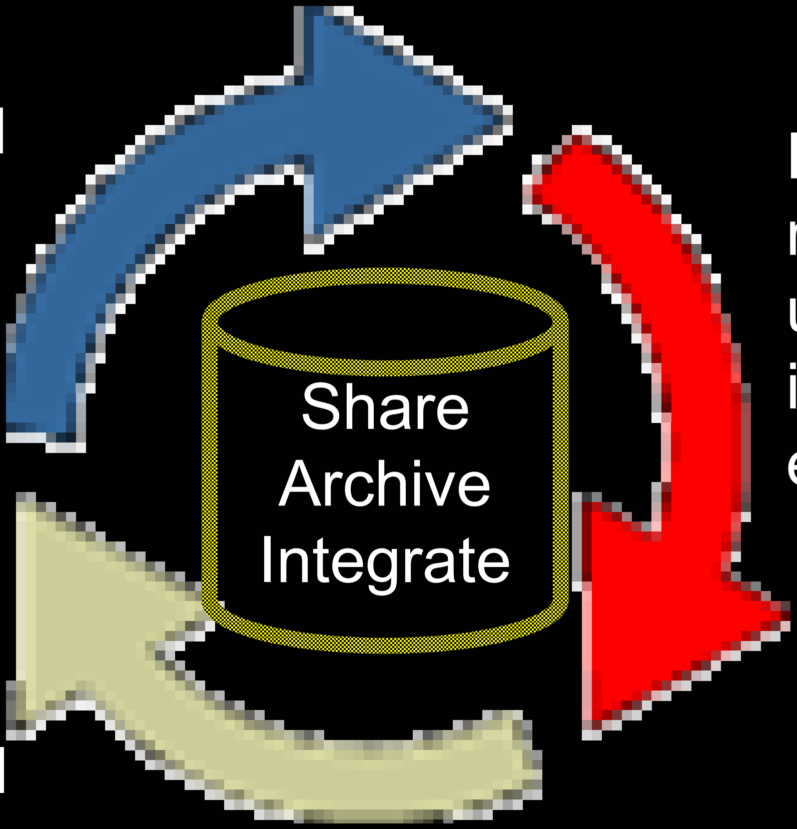
- Provides relational and object interfaces to support:
  - Web publishing
  - Streaming media
  - JDeveloper and Oracle Portal integration

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



Share
Archive
Integrate

Effective and more frequent utilization of imaging equipment

Technology advancement, more powerful hardware

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

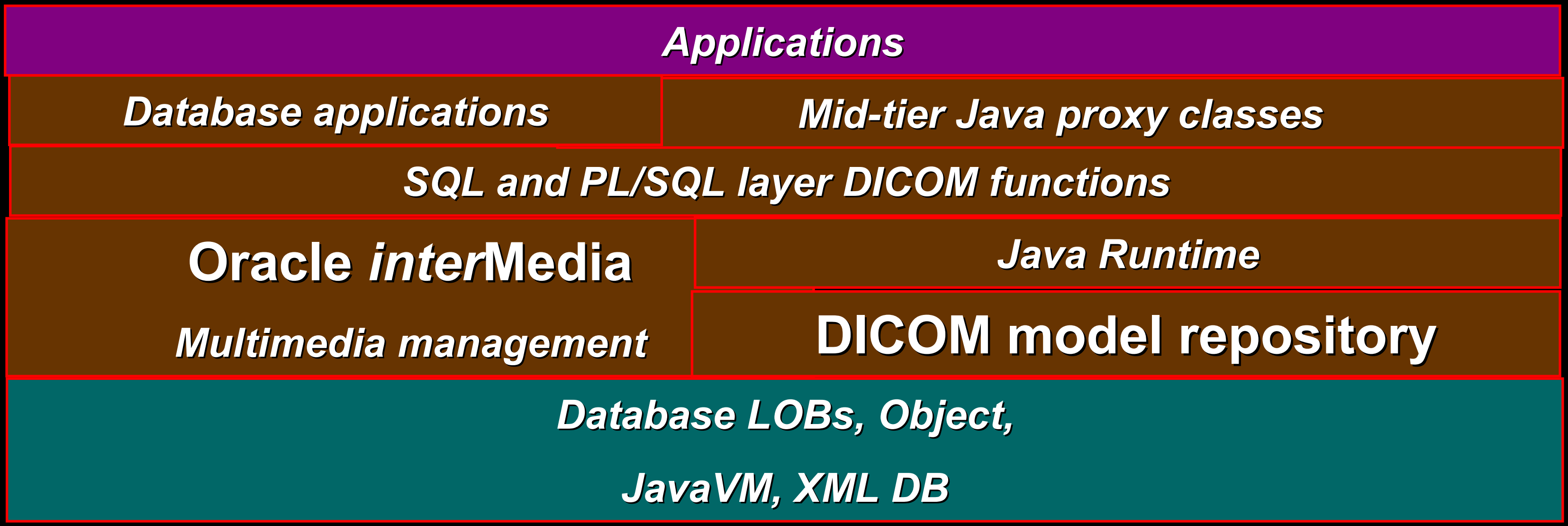
- Ever growing file size
  - Memory management
  - Processing, encryption, …
- Index and search
- Storage scalability
- Backup and restore
- Database tools

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



Applications

Database applications

Mid-tier Java proxy classes

SQL and PL/SQL layer DICOM functions

Oracle *inter*Media

Multimedia management

Java Runtime

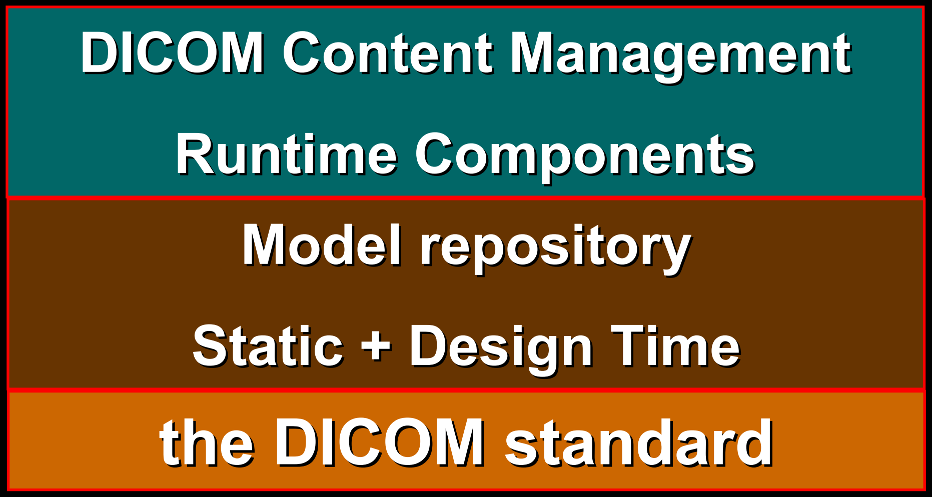
DICOM model repository

Database LOBs, Object,

JavaVM, XML DB

Key Concept: Repository

- Use pluggable model repository to encapsulate the DICOM standard definitions



DICOM Content Management

Runtime Components

Model repository

Static + Design Time

the DICOM standard

Repository, Cont.

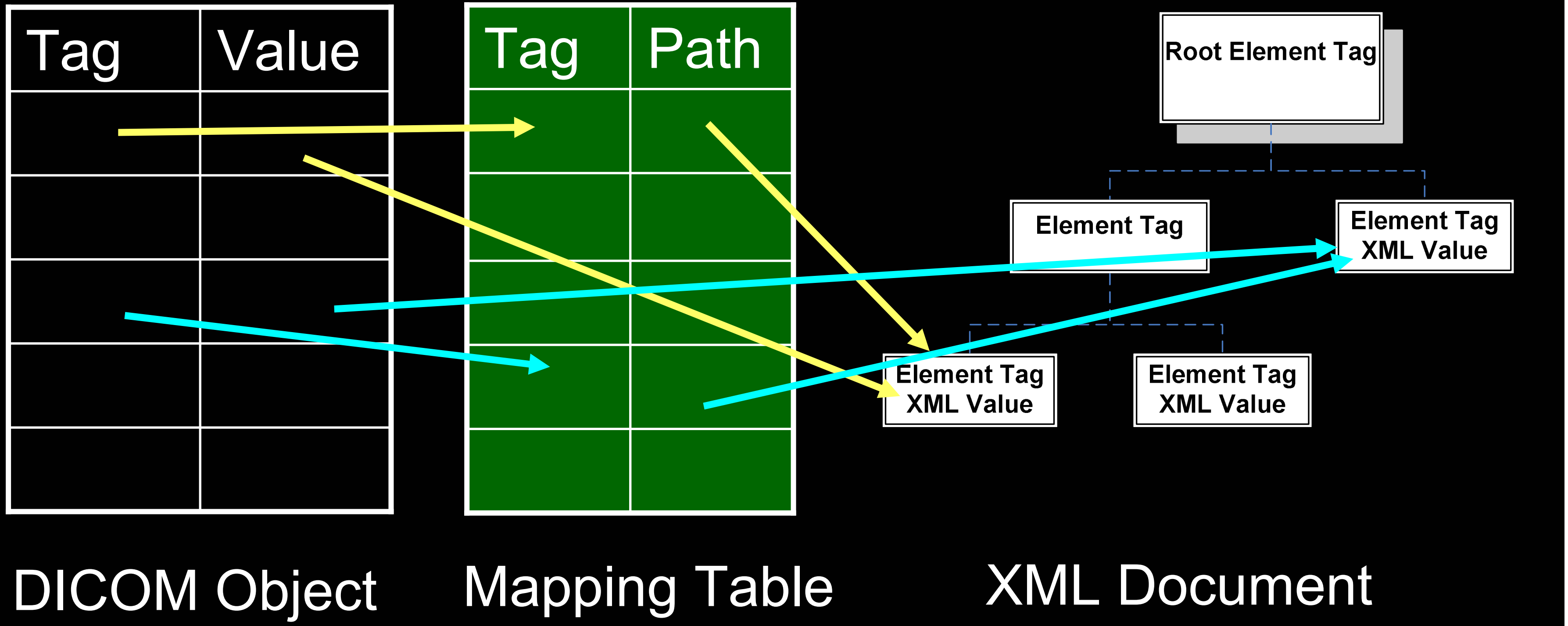
- Repository stores the data model that defines the behavior of a database instance
- Data model can be customized by a DBA
- Data model defines
  - DICOM data dictionary (part 6)
  - DICOM private attributes
  - DICOM to XML mapping
  - DICOM validation rules (part 3)
  - …

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:datatime
  - PersonName PN →
    - encoding="unibyte |phonetic | ideographic"
    - Family, Given, Middle, Prefix, Suffix
- Valid XML document ⇔ parseable DICOM object

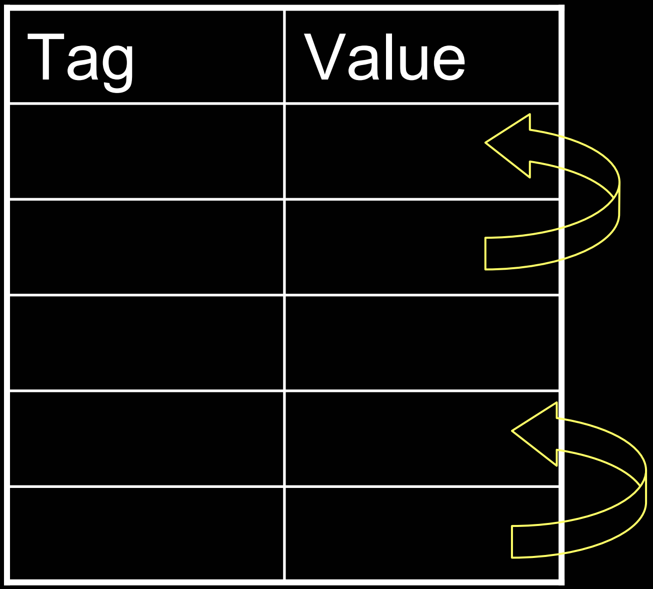
Key Concept: XML Mapping

- 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



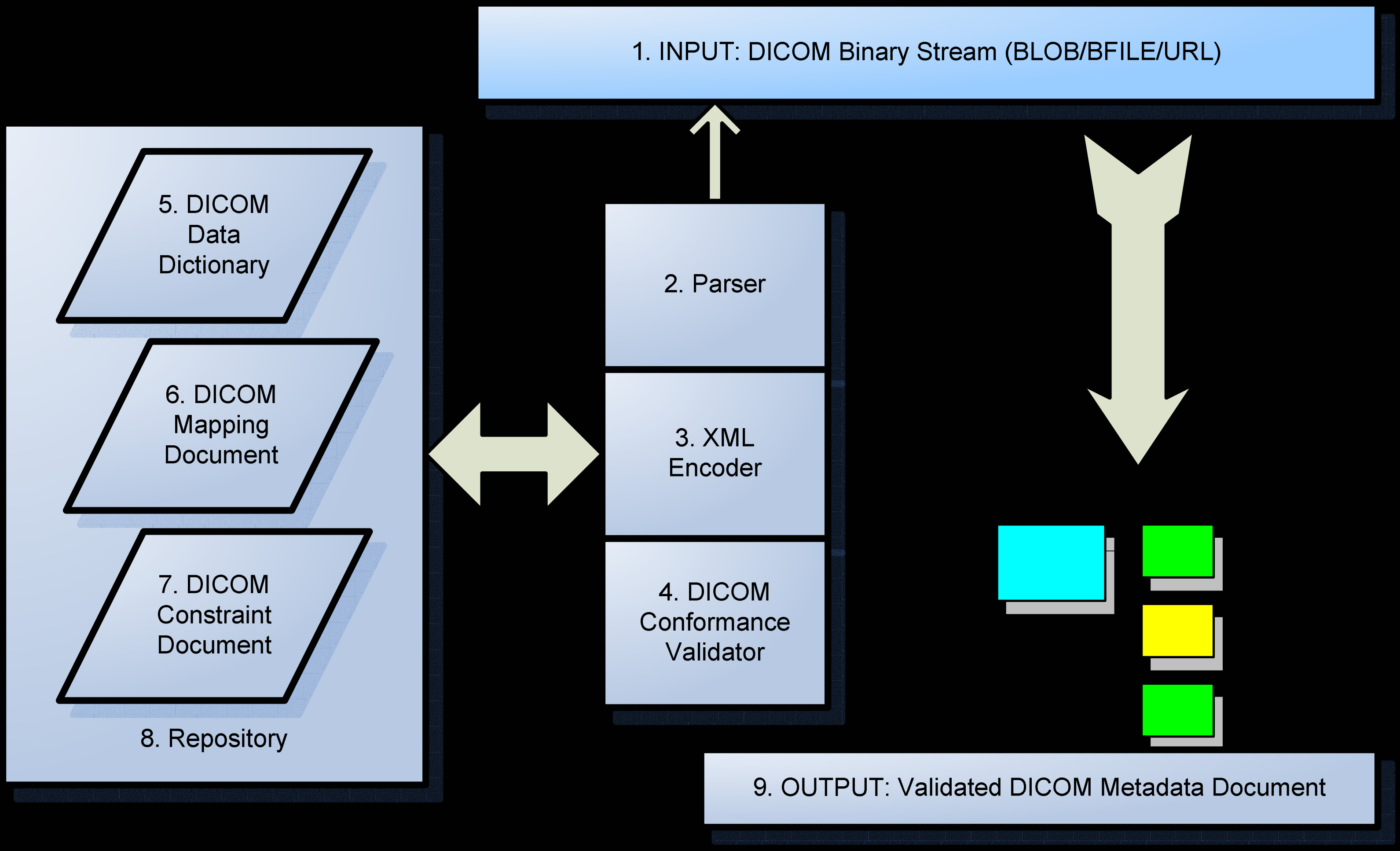
Tag	Value

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

Putting It All Together


1. INPUT: DICOM Binary Stream (BLOB/BFILE/URL)
5. DICOM Data Dictionary
6. DICOM Mapping Document
7. DICOM Constraint Document
8. Repository
2. Parser
3. XML Encoder
4. DICOM Conformance Validator
9. OUTPUT: Validated DICOM Metadata Document

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=“HHHHHHH”>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