Health Engine: Image-Enabled Patient Health Records with Oracle Multimedia DICOM

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CIO AdNovum

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Agenda

- Motivation
- Company Presentation
- The Health Engine
- Use of Oracle Multimedia DICOM
- DICOM Performance Measurements
- Outlook
- Conclusions
- Q & A
Motivation

Efficiently manage all patient health records of a large hospital or hospital network including all type of medical images (X-Ray, MRI, CT, etc.) in one place – the Health Engine.
Company Presentation

the i-engineers

- Development and integration of the i-engine system core of the Health Engine
- Since 2002
- 25 employees
- Aarau (Switzerland)
- Customers: Health, Government
- Oracle Partner

AdNovum

- Swiss-Quality High-End Security & Software Engineering
- Since 1988
- 190 employees
- Zurich (HQ, Switzerland), Bern (Switzerland), Budapest (Hungary)
- Customers: Financial, Government, E-Health
- Oracle Partner and Member of Oracle Partner Advisory Board

☑️ The two companies maintain a successful partnership.
☑️ AdNovum offers integration of i-engine solutions into existing IT environments.
The Health Engine

- Universal archive and content management system
- (Virtual) patient dossier containing patient health records
  - medical, administrative, legal and care documents
- Medical record management workflow
- Meet regulatory requirements
  - Full traceability
  - Strict Access Management
- Information life cycle support
  - Audit-proof archive on leading archives (EMC, IBM, HP, Sun)
- Fully integrated into key hospital applications
  - Does not replace other systems
The Health Engine – Swiss Medical Suite

- Integration of hospitals, doctors, pharmaceutical companies
- Secure communication and data exchange of medical, administrative and financial information
- Installed base (Switzerland)
  - 180 hospitals / 6’200 doctors / 70 pharmaceutical companies
  - 50% / 50% / 80% of Swiss market
The Health Engine – Software Infrastructure

Based on Oracle 11g technology

- **Oracle Database 11g**
  - Use of Secure Files for fast storage and retrieval
  - Storage of all data in the database, specifically DICOMS, files, …

- **Oracle Application Server 11g**
  - Java EE application

- Extensive use of **Oracle Multimedia DICOM**
  - Native support of Oracle DICOM (ORDDicom)
  - Extraction of Metadata
  - Conversion of DICOM into Web-friendly formats
The Health Engine – Client GUIs

Technologies: Windows, HTML and Adobe Flex
The Health Engine – Patient Record
The Health Engine – Typical Deployment

SSO-Portal
Intranet / Extranet

Employee

Patient

CIS

Office Email

Domain-specific Applications

PACS

Process Manager (BPEL)
IHE-Processes, Customer Specific Processes

Service Bus (Adapters, Interfaces, …)

Base Services

Patient, Case Dossier
DMS Access-Mgt.

MPI

Signature Service

LDAP AD

Archive ILM Records Management

Storage / Archive

SAN

Centera DR550

Centera DR550

Service Bus

ESB-Infrastructure

Process Manager (BPEL)
IHE-Processes, Customer Specific Processes

External Services

Insurances

Laboratories

Financial Services

Doctors

Specialists

Radiologist

Hospitals

Dossier Registries

Disaster Recovery Sites

AdNovum the i-engineers
The Health Engine – Architectural Overview

- Oracle Application Server
- The Health Engine
- DICOM Node
- Oracle Database 11g
- Oracle Multimedia DICOM Support
- Database Storage

- HTTP(S) / SOAP
- DICOM
- JDBC
- ASM
The Health Engine – Goals

- Include images from PACS systems with other Health Engine patient data
  - Consistent storage of all patient data in one place
- Integration of PACS without media transfers
- Implementation based on well-established DICOM standard
- Transparent handling of DICOM objects within Health Engine
  - Store DICOM information in Health Engine Database

⇒ Use of Oracle Database 11g Multimedia DICOM objects
Use of Oracle Multimedia DICOM

Advantages
- Full DICOM data object support on data-tier level
- Transactional access also on images (1-phase commit)
- Data consistency over all patient data
- Indexing and querying of DICOM metadata
- Sophisticated DB caching and optimizing technologies
- Well established and efficient data backup procedures
- Only database with native DICOM support (ORDDicom)

Challenges
- DICOM communication has to be provided extra
- Performance regarding DICOM object throughput
Use of Oracle Multimedia DICOM

Oracle Multimedia DICOM includes
- ORDDicom object type
- DICOM metadata extraction
- DICOM conformance validation
- DICOM image processing/compression
  - Making DICOM content anonymous
  - Creating content from images/metadata
- A run-time updatable DICOM data model
- User defined extension to standard DICOM model
Use of Oracle Multimedia DICOM

- ORDDicom object type
- DICOM conformance validation
- DICOM metadata extraction
- User defined extension

Base Services

- DICOM image processing

Storage / Archive

- SAN

Process Manager (BPEL)

SSO-Portal
Intranet / Extranet

Domain specific Applications

- CIS
- ERP
- PACS
- Lab
- Office
- Email

The Health Engine

Employee

Patient
Use of Oracle Multimedia DICOM

- Performance was a huge concern on the part of our customers
- A lot of today's DICOM processing systems store DICOM information on proprietary file systems
- Customers challenged that storing DICOM objects in a standard database will meet with their requirements

- We defined a *performance measurement setup*
  - Use of commodity hardware found at our client’s
  - Focus on image throughput and write performance
  - The goal is to be able to handle standard peak loads of a large (Swiss) hospital, which means storing approx. 300’000 images/hour
# Performance Measurements – Configuration

## Application and Database Server

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>HP ProLiant 585</td>
</tr>
<tr>
<td>Processor</td>
<td>4 x AMD Opteron, 2.4 GHz</td>
</tr>
<tr>
<td>Memory</td>
<td>32 GB</td>
</tr>
<tr>
<td>Controller</td>
<td>2 x Emulex 4GB PCI-e FC</td>
</tr>
<tr>
<td>Network</td>
<td>2 PCI Express 2.5GB/s Intel Pro / 1000 (4 ports)</td>
</tr>
<tr>
<td>OS</td>
<td>Redhat Server 5, 64-bit Linux 2.6.18-128.el5</td>
</tr>
<tr>
<td>Database</td>
<td>Oracle Database 11g Release 1 (11.1.0.7) Enterprise Edition</td>
</tr>
</tbody>
</table>

## Database Storage

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server</td>
<td>HP StorageWorks EVA 8000</td>
</tr>
<tr>
<td>Disk</td>
<td>32 x 300GB FC 15k RPM HD</td>
</tr>
<tr>
<td>RAID</td>
<td>5</td>
</tr>
<tr>
<td>Cache</td>
<td>8192 MB</td>
</tr>
<tr>
<td>Interface</td>
<td>2 x 2GB FC ports</td>
</tr>
</tbody>
</table>
Performance Measurements – Setup

Oracle Application Server (10.1.3.4)

The Health Engine

DICOM Node

Oracle Database Server Release 1 (11.1.0.7)

HP ProLiant DL585

JDBC Thin

DICOM

JDBC Thin

Test Client

Database Storage

HP EVA8000

ASM

2GB/s FC

2GB/s FC
Performance Measurements – Scenarios

- Test scenarios
  - 1: JDBC direct insert of BLOBS
  - 2: JDBC direct insert of ORDDicom objects
  - 3: DICOM node insert of ORDDicom objects
  - 4: DICOM node insert of ORDDicom objects (optimized)

- Test data
  - Small: 512kB medical images
  - Large: 13MB medical images

- Load generation
  - Multithreaded, no think time
Performance Measurements – Scenario 1

- JDBC direct insert of DICOM objects as BLOBS

- Results
  - Acceptable throughput with 512kB and 13MB images
  - Close to direct I/O of attached SAN
  - Good-natured scaling behavior up to 200 parallel threads
  - > 2 Mio images / hour (512kB) resp. 113’000 images / hour (13MB)
Performance Measurements – Scenario 2

- JDBC direct insert of DICOM images as ORDDicom objects (without metadata extraction)

- Results
  - 1.3 Mio images / hour (512kB) resp. 73’000 images / hour (13MB)
  - Still good-natured scaling behavior
  - Significantly lower performance (512kB) due to DICOM overhead
Performance Measurements – Scenario 3

- DICOM node insert of DICOM images as ORDDicom objects (with and without metadata extraction)

- Results
  - 658’000 images / hour (512kB) resp. 86’000 images / hour (13MB)
  - Dramatically reduced throughput with metadata extraction
    - only **227’000 images/hour** (512kB) resp. 62’400 images/hour (13MB)
    - **-66%** (512kB) resp. **-28%** images / hour (13MB)
Performance Measurements – Scenario 4

- Optimized writing of ORDDicom objects
Performance Measurements – Scenario 4

- Optimized DICOM node insert of DICOM images as ORDDicom

- Results
  - 1.3 Mio images / hour (512kB) resp. 68'000 images / hour (13MB)
  - 5.8 x faster (512kB) compared to non-optimized ORDDicom write
  - Excellent combination of BLOB performance and ORDDicom convenience
Outlook

- Customers are performance aware; push performance optimizations for fast DICOM write operations further
- Repeat performance tests with Oracle Database 11g Release 2
- Plan tests on new Exadata V2 system
- Enable Oracle Application Server to act as a DICOM node
- Go about business cases asking for large DICOM archives, such as:
  - Consolidated repositories for hospital networks
  - ASP/SAAS repositories serving several clients
Conclusions

- Position *Health Engine* as Meta-PACS/DICOM universal archive
- Showed key role of Oracle Multimedia DICOM
  - Position Oracle Database 11g as DICOM-Storage
- Functionality and easy use of ORDDicom object
- Verified performance when using Oracle Multimedia DICOM
- (Temporary) performance optimization for DICOM writes

⇒ Oracle Multimedia DICOM provides a crucial piece of technology to build large scale, integrative patient dossier systems like the *Health Engine*. 
Questions?

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More Health Engine and Oracle Multimedia DICOM

| DEMOgrounds | Enterprise Multimedia Management and Medical Imaging | Moscone West W-021 |