22nd Annual Scientific Meeting Adelaide
Thursday 11th – Friday 12th April 2013

Merging expectations…the reality

Thomas Vargoczky, GM of Mach7 Technologies ANZ

Own, Share and Access Your Imaging Data
• Introduction

• Healthcare IT domain - complexity

• Historical background – how we got here?

• Three examples
  • Canada Infoway
  • MGH research
  • NSW EIR

• Conclusion
Reality of Healthcare IT Complexities

Clinical Imaging & Informatics

Clinical Documentation
- Patient Assessment
- I & O
- Vital Signs
- Flow-sheets
- Kardex
- Task Lists
- Non-MD Orders
- Patient Education
- Interface to Monitors
- Critical Specialty Documents
- Non-MD Evidence Based Documentation

Enterprise Patient Access
- Admission / Registration
- Eligibility Verification
- Request for Authorization
- Enterprise Scheduling
- Consumer Portal
- Technical Denial Management

Health Information Management
- Coding
- Abstracting
- Coding Support
- Chart Tracking Management
- Chart Completion
- Electronic Signature
- Release of Information
- Printing the EMR
- Workflow Tools
- Transcription / Dictation
- MRN Management and Merge
As modern hospitals gain more imaging technology, image management becomes exponentially complex.

Breadth and Complexity Lead to Multiple Modalities
As modern hospitals gain more imaging technology, image management becomes exponentially complex.

### Basic Hospital Workflow Schematic

**Interactive Engine**
- HIS
- RIS
- CVIS
- LIS
- Other IS

**Modalities of Imaging**
- Radiology PACS
- Cardiology PACS
- Pathology PACS
- Dermatology
- Orthopedics
- Oncology
- Dentistry
- Other Imaging

**Radiology**
- Radiology Reading
- Mammography Reading
- Pathology Reading
- Teleradiology

**Cardiology**
- Cardiology Reading
- 3D Image Processing

**Pathology**
- Pathology Reading

**Reporting**
- Mammo Tracking
- MQSA Reporting
- Reporting/ Speech Processing
- Peer Review
- Critical Results Tracking
- DVD/CD Burning
- MGT Reports Productivity

**Diagnostics**
- Transcription
- Computer Assisted Diagnostics (CAD)

**Transcription**
- Computer Assisted Diagnostics (CAD)
- Peer Review
- DVD/CD Burning

### Expectations and Reduction of Complexity

- **High Level of Complexity**
- **Number of Vendors**
- **Hardware**
- **Software**
- **Support Contracts**
- **Upgrades Management**

**Proprietary and Confidential**
The 70’s & 80’s

The Beginning

Image Diagnosis = Proprietary Modality Workstations

1970
1971: Introduction of the Computed Tomography (CT)

1980
1983: ACR/NEMA 1.0 Release Standards for Medical Images
1988: ACR/NEMA 2.0 Release

ACR: American College of Radiology
NEMA: National Electric Manufacturers Association (including Imaging) in America
Image Diagnosis = Multi-Vendor Diagnostic Workstation

1990: At RSNA first commercial sale of Medical devices using ACR/NEMA 2.0 standard.

1990: GE, Siemens, Kodak, and Merge meet at Georgetown University to show integration using ACR/NEMA 2.0.


1993: The DICOM Standards was formed as the 3.0 Release of ACR/NEMA.

1999: PACS Market is Born...

- Picture = Viewer
- Archive = Storage
- Communication = Moving of image data
- System

DICOM (Digital Imaging and Communications in Medicine) is a standard for handling, storing, printing, and transmitting information in medical imaging.
First generation PACS Migrations begin. Challenges with dirty and proprietary image data

Disaster recovery Becomes a hotter Topic as regulations Become more strict

Hospital consolidations, Regional exchanges and sharing of image data Lead to interoperability challenges

EMR Image Enablement becomes A desire and requirement

Storage requirements And specialty silos lead To IT infrastructure Complexity, excessive cost and complications With image enablement

The 2000’s
The first Decade of Age of Specialty Silo’s
Present

The 2010’s

**Standard Base** Storage and Communication

Ophthalmology  
Dermatology

Dental  
Wound Care  
Pathology  

Advance Visualization  
Workstations begin  
Offering 3D + 4D + 2D

2010  

A Vendor Neutral Archive (VNA) trend moves into an Enterprise Imaging Platform Strategy and Solution

2013
Present & Trend

PACS Re-Defined

System

Picture ≈ Advance Visualization Viewer (2D + 3D + 4D)

Clinical Buying Decision

Enterprise Imaging Platform

IT Buying Decision
Canada Infoway – Image enable the EHR
1. Example - Image Enabling the pan-Canadian EHR

- Connect radiologists with DI departments so that all facilities within Canada have access to radiologist coverage.
- Connect physicians with each other so that they can view DI results quickly and seamlessly.
- Create a longitudinal record of DI data so that physicians can see the full DI history, irrespective of where the images were acquired and the report transcribed.

We want to "share images and reports"
EHR Infostructure

JURISDICTIONAL INFOSTRUCTURE

Registries Data & Services
- Client Registry
- Provider Registry
- Location Registry
- Terminology Registry

Ancillary Data & Services
- Outbreak Mgmt
- PHS Reporting

EHR Data & Services
- Shared Health Record
- Drug Information
- Diagnostic Imaging
- Laboratory

Data Warehouse
- Health Information

Data Warehouse
- Security Mgmt
- Privacy Data
- Configuration

Longitudinal Record Services
- Business Rules
- EHR Index
- Message Structures
- Normalization Rules

HIAL
- Communication Bus

Common Services
- Public Health Services
- Pharmacy System
- Radiology Center PACS/RIS
- Lab System (LIS)
- Hospital, LTC, CCC, EPR
- Physician Office EMR
- EHR Viewer

POINT OF SERVICE
- Public Health Provider
- Pharmacist
- Radiologist
- Lab Clinician
- Physician/Provider
- Physician/Provider
Image enabled EHR benefits for non-PACS hospitals

- **Film Operations Savings**
  - Stationary - Master bags, Insert bags, Labels
  - Film
  - Processing chemicals, maintenance
  - Courier/taxi

- **Staff Reductions**
  - Film library staff can be reallocated or reduced through attrition

- **Productivity**
  - 30% increase in Radiologist productivity
  - 25% increase in Technologist productivity
  - 1.75 hour per week for physicians

- **Other Savings**
  - Reduced patient transfer costs -$0.87 per exam
  - Reduced repeat procedures -$1.10 per exam
  - Storage Space -$1.20 per sq foot

~ 55% decrease in $/exam $7.85 to $3.91
Image enabled EHR benefits to the Healthcare System

• $7.4 Billion cost but deliver $9.1 Billion in Health System Benefits over 10 years across Canada

• Avoidable retakes are estimated to cost the Province of Ontario approximately $132M on an annual basis

• Single site implementations cost 51% more than interoperable shared solutions

• Costs for “useable” storage have gone down from $15,000/TB to $5,000/TB by consolidating storage into centralized infrastructures

• Capital acquisition costs have reduced by a factor of 3 through regionalization
MGH* – “DICOM” Image Meta Data Research Platforms
2. Example - Imaging Research Platform

- Emphasis on “Translational Research”
  - “bench to bedside” or “Bedside to Bench”
- More modest goal for images
  - clinical distribution of research tool output
- Clinical systems (Imaging Repositories/PACS Archive(s))
  - all accept DICOM input
  - most will not accept non-DICOM input
  - almost none aware of research formats
  - DICOM encapsulated PDF is an option
A Multi Faceted Research Platform

- Inhouse Research Applications
- Point of Care Appliances
- Data Center(s)
- Hospital(s)
- MOH
- Research/Teaching

- EMR/ Hospital Information Systems
- Data Warehouse
- Data Capture
- Business Intelligence
- Data Mining

- PACS & Image Acquisition Devices/Systems
- Pathology Information Systems
- Registries
- Data Access
- Vendor Neutral Framework
- Standards Based Messaging Services
- Research Query Services
- Terminology Management (SNOMED) (DICOM..etc)
- Security and Auditing

- Keystone Suite X
- External Warehouse
- Imaging & Clinical Data Repository
- Keystore Engine
- Keystore Archive
Clinical versus Research

- DICOM is everywhere in clinical imaging
  - undeniable, unavoidable
  - medical IS folks get over it
- Not the same acceptance in research
  - whiners say DICOM is
    - too big, complicated, expensive, limited, slow, …
    - not XML
- Missing an opportunity
  - to leverage huge base of codified expertise & tools
- Still unavoidable for a lot of research
Sophisticated Image Management - Simplified

Other attributes

Shared Functional Groups Sequence
- Functional Group A Macro
- Functional Group K Macro

Per-frame Functional Groups Sequence
- Item 1 (Frame 1)
  - Functional Group B Macro
  - Functional Group C Macro
  - Functional Group M Macro
- Item 2 (Frame 2)
  - Functional Group B Macro
  - Functional Group C Macro
  - Functional Group M Macro
- Item n (Frame n)
  - Functional Group B Macro
  - Functional Group C Macro
  - Functional Group M Macro

Functional Group Macros
shared for all frames

Sequence of repeating
Functional Group Macros for
each individual frame

Pixel Data
- Frame 1
- Frame 2
- Frame n
Temporal Position Index

Trigger Delay Time

48 ms

Stack ID = 1

Space (2)

Time (1)

Dimension Index Values

Dimension Index Pointers:
1. Temporal Position Index
2. Stack ID
3. In-Stack Position
**Research Data Mining – expectations & reality**

- **Archive & Registry search capabilities**

- **Launch images and reports instantly with a web based viewer**

- **Summary of archived and registered artifacts**

- **Tag, move, and anonymize interesting cases to your teaching and/or research archive segment**

- **Identify if an image and report are local to your diagnostic reading solution and move them there if they are not.**

- **Users can configure their own “relevant prior” rules to more quickly identify exams for comparison**

### Imaging Studies

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<th>Accession</th>
<th>Study Desc.</th>
<th>Modality</th>
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<tbody>
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<td>GHI456</td>
<td>ES_LWREGI</td>
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### Diagnostic Reports

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</table>
NSW EIR – Building a State wide Imaging Platform
3. Example - EIR Guiding Principle - Storage

Storage of DICOM Objects and Structure Report

1. Data will be stored in the IR as was originally acquired by the IR from AHS PACS and will be coerced upon retrieval. (The coercion rules will be discussed in guiding principles 17-20 under Dicom Data Coercion)

2. AHS PACS will support Third-Party Archiving, where possible, such that the AHS PACS will retain pointers to each study archived in the IR by that AHS PACS. Where it is not possible, the AHS PACS will route a copy of data to the IR and the AHS PACS will retain the original copy per that AHS PACS retention rules.

3. HL-7 ORUs will be sent from the RIS to the IR with the exception where SR (structured radiology report) are sent from the AHS PACS.
EIR Solution – Production Mapping
Next release and Upgrade will include Data Mining applications and tools

Direction to provide solution to Meta Data mining and linking images from EIR to Clinical Research including Clinical Trials

Too early to speculate on exact scope

Using MapReduce for Large-scale Medical Image Analysis

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University of Applied Sciences Western Switzerland (HES-SO), Business Information Systems, Sierre, Switzerland

I. INTRODUCTION

The growth of the amount of medical image data produced on a daily basis in modern hospitals forces the adaptation of traditional medical image analysis and indexing approaches towards scalable solutions [1]. The number of images and their dimensionality increased dramatically during the past 20 years. Recent progress in image processing and machine learning makes it possible to assist clinicians in the detection and characterization of important events in large image series. However, the process of extracting intrinsic features from large datasets of 3D/4D images, as well as training machine learning algorithms and global system optimization are extremely demanding in terms of computation time, storage capacity and network bandwidth [2]. The MapReduce framework is a distributed computing framework and has recently been used for large-scale image description and analysis [3]. In this work, MapReduce is used to speed up and make possible three large-scale medical image processing use-cases: (i) parameter optimization for lung texture classification using support vector machines (SVM), (ii) content-based medical image indexing, and (iii) three-dimensional directional wavelet analysis for solid texture classification.

II. METHODS

A cluster of heterogeneous computing nodes was set up in our institution using Hadoop allowing for a maximum of 42 concurrent map tasks. The majority of the machines used are desktop computers that are also used for regular office work. A minimum of two logical cores were not allocated to the Hadoop TaskTracker process, ensuring that common daily tasks could still be run smoothly.

III. RESULTS

Parallel grid search for optimal SVM parameters was carried out on the Hadoop cluster. A map task was defined for each coupled value of $(C, \sigma)$. A clear link between the runtime of a map task and the resulting classification accuracy was observed: most of the tasks with long runtimes resulted in poor classification accuracies. The interruption of such map tasks allowed a reduction of the total runtime from 50th to 9th minute, while keeping all coupled values $(C, \sigma)$ leading to best classification performance. A sequential execution would require 90% approximatively on a desktop computer.

Two approaches for content-based image indexing were compared and implemented in the MapReduce framework: component-based versus monolithic indexing. The former is convenient to separately optimize feature extraction and the index but does not require to run the whole pipeline for each optimization. However, it requires to write the features to a very large CSV (Comma-Separated Values) file of approximately 100 GB for 100,000 images. This resulted in an unexpectedly long runtime for the feature extractor with the MapReduce framework in the component-based approach.

The result is consistent with previous work that showed that MapReduce was not performing well with input-output (IO)-intensive tasks [4]. The monolithic strategy showed to be well-suited for MapReduce, which allowed indexing 100,000 images in about one hour using 24 concurrent tasks.

The parallelization of solid texture processing based on non-separable three-dimensional Riesz wavelets allowed to reduce a total runtime from more than 130h to less than 6h, while keeping the code in the original Matlab/Octave programming language with Hadoop streaming.

IV. DISCUSSIONS AND CONCLUSIONS

Overall Hadoop has shown its utility for large scale medical image computing. The three use-cases reflect the various challenges of processing medical visual information in clinical routine: parameter optimization, indexation of image collections with hundreds of thousands images, and multi-dimensional medical data processing. In all tasks very positive results could be obtained helping the projects to scale with limited local resources available and moderate efforts to adapt the software.

REFERENCES


Conclusion
Expectations

- Advanced visualization workstations
- Consolidating specialty storage silos
- Standards based storage and communications
- Single integration to image enable EMR across all specialties
- Universal viewer (zero foot-print)
Digital Pathology: (Next Frontier)

In the digitized format, the annual production of about 400,000 glass slides will consume 300 terabytes of storage each year.

By Labmedica International staff writers
Posted on 29 Dec 2011

Digital Pathology opportunities estimate 3 – 4 X bigger than Radiology ... but needs investment

- Cardiology
- Bronchoscopy
- Gastrointestinal Endoscopy
- Hematology
- Surgery
- Nuclear Medicine
- Dental
- Dermatology
- Ophthalmology
- Podiatry
- Vascular
- Urology
- Nursing
- Electrocardiography
- Scanned Documents
- Medical Photography
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<td><strong>Departments / Modalities</strong></td>
<td>Radio logy</td>
<td>Cardiology</td>
<td>Pathology</td>
<td>Endoscopy</td>
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<td>Other</td>
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<td>1. Scheduling/Order Entry</td>
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<td>2. Registration/Check-In</td>
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<td>3. Image Acquisition Specimen Collection</td>
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<td>4. Exam Interpretation &amp; Reporting</td>
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<td>5. Final Report Distributed/Clinical Use</td>
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<td>6. Clinical Access to Image &amp; Information</td>
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**Reality?** Workflow Oriented Solutions

Enterprise Clinical Image Management - Simplified

Workflow & Optimization Focus
Goal

Multispecialty Platform
THANK YOU

www.mach7t.com