IBM’s Vision of the Future

Richard S. Bakalar, M.D.
Chief Medical Officer
IBM Healthcare & Life Sciences

June 9, 2007

Digital Imaging is transforming Pathology
“Healthcare 2015: Win-win or lose-lose?” is IBM’s point-of-view on the global healthcare industry.

Countries that successfully transform their healthcare systems (i.e., “win-win” scenario) will witness three changes.
Agenda

• Business Drivers for Healthcare Transformation
• Lessons Learned from the Radiology Experience
• Innovations in Information Technology
  – Enterprise Storage Solutions
  – E-Collaborative Medical Outreach
  – Image Analysis and Decision Support
• Summary for the future
Transformation of Medicine accelerated by a combination of revolutionary technologies and evolutionary practices

- Translational Medicine
- Personalized Health Care
  - Lifetime Treatment
  - Pre-symptomatic Treatment
  - Cancer Diagnosis
- Molecular Medicine
- Clinical Genomics
  - Genetic Predisposition Testing
- Digital Imaging
- Episodic Treatment
- Electronic Health Records
- Artificial Expert Systems

Non-specific (Treat Symptoms)  Organized (Error Reduction)  Personalized (Targeted Treatment)
More Data Over the Last 3 Years Than Previous 40,000 years Combined

- Digital Pathology
- Digital Radiology
- E-Health Initiatives/Linkages
- Electronic Medical Record
- Digital Cardiology

Source: UC Berkeley, School of Information Management and Systems.
Clinical Solution Architecture (Overview)

Knowledge Access
- Researchers
- Rules Officer
- Providers
- Patients

Clinical Knowledge Access - Collaborative Portal
- Clinical Intelligence
  - Evidence Generation, Data Mining & Medical Collaboration
- CDI Repository
  - Evidence & Rules Management
- Decision Support
  - Rules-based Report & Alert Generation

Medical Information Repository
- Security, Anonymization, Auditing, Privacy, Federation, Warehousing, Curation, and Master Registries (Patients, Providers and Locations)

Data Entry & Validation
- External Data
  - Medline, Genomics, Disease Data, Clinical Guidelines, Clinical Trials, Adverse Drug Reaction, etc.
- Internal Data
  - EMR, Ambulatory, Lab, Pharmacy, Imaging, Financial, Admin, Etc.

*Consumer Alternate Points of Care, e.g. home, work, nursing home, shopping mall
Evolution of Telemedicine – Past – Present - Future

Recent and Future Healthcare Advancements in Telemedicine

Technologies
- Interactive voice, data (chat) and video conferencing
- Digital medical content and asynchronous collaboration
- Health portals, integrated health devices and system interoperability

Clinical Business Models
Access — Quality — Cost

First Wave
Virtual Encounter

Second Wave
Digital Consultation

* Third Wave
Electronic Health Coach
(Inform, Advise, and Motivate)
Empowered Consumer-Patient

American Telemedicine Association 2007

I: Virtual Encounter – Video teleconferencing
II: Digital Consultation – Medical images and reports
III: Electronic Health Coach – Personal On-line Health Portal
Lessons Learned from Radiology

- Enterprise Solutions
  - Workflow, display and storage
  - Information Technology support and sustainment

- What is “thought flow”?
  - Enhanced decision support

- Digital Diagnostics on demand
  - Data Analytics – CAD, 3D, and Image Fusion

- Clinical, Operational & Technical Standards
  - Quality Image Display and Digital Tools
  - Reimbursement and Technical Support
  - System Interoperability & High Availability
Analog to Digital PACS Conversion

- Data Capture – Image, metadata & reports
- Workstation Display and Digital Tools
- Local Data Storage – Cache (High Performance)
- Study Distribution and Workflow
- Long Term Archive
Enterprise Storage Solutions
Medical Imaging Storage Challenge

• “Always-On” Archive
  – *Mission Critical - Clinical Performance*
• Reliable Data Integrity and Security
• Easy to Manage and Administer
• Easy Migration to new hardware
• Automated Recovery
• Affordable and Scalable

*Digital Pathology Slide*
Over 1 GB with compression
Conceptual Architecture Options

- Department Hospital Local Storage
  No Redundancy

- Archive and Central Storage
  Physical Redundancy

- Grid and De-Centralized Storage
  Virtual Redundancy
What is a Grid Storage System?

"Siloed" Traditional architecture:
- Difficult & expensive to administer
- Low utilization of hardware & storage
- Vulnerable to failure and downtime
- Bandwidth inefficient
  - Block level replication

"Virtualized" Grid infrastructure:
- Smaller, shared & more cost effective storage environment
- Adaptive, self healing & self managing
- High availability & speed
- Enables infrastructure to be managed independent of the application
PACS and Imaging Architecture

Fixed Content Data has unique & specific requirements
Three Tier System Architecture

APPLICATION LAYER
Clinical Function Image Access

IMAGE MGMT LAYER
Aggregation & Interoperability

STORAGE LAYER
Data Protection, ILM Replication, Encryption Resiliency & Speed

Grid Medical Archive System – GMAS (an IBM Solution)
Centralized Management

- Web-based administration
  - Proactive monitoring
  - Fault detection & alerts
  - Real time and historical reports

- Multi-tier and multi-site mgmt
  - Across all storage tiers
  - Enterprise wide

Single operational dashboard for medical image storage across the enterprise
Medical Enterprise Storage Requirements

✓ High Performance
  ✓ Fast access to data
✓ Reliable & Protected
  ✓ Continuous operation in the presence of faults
✓ Open and Interoperable
  ✓ Support heterogeneous PACS environment
✓ Massively Scalable
  ✓ Very large, rapidly growing data sets
✓ Long Retention Times
  ✓ Data outlives hardware and media
✓ Multi-Facility
  ✓ Secure and Scalable to other regions and disciplines
✓ Simple Administration
  ✓ Easy to manage & operate
✓ Cost Effective
  ✓ Affordable today & tomorrow

Address Requirements Today and Tomorrow
B.C. Cancer Agency Image Distribution Network

- 8 PACS Systems
- 200 workstations and 1000+ users
- 10 remote hospitals across the province
- 24 Terabytes of Storage
- Interfaces with legacy imaging and HIS systems and workstations (DICOM)
e-Collaboration Medical Outreach
Dr. James is a cancer specialist.

He works in a team of clinicians and other specialists covering a wide geographic area.
And to enable them to make clinical decisions the system provides the ability to access, organize and share high resolution diagnostic images.
e-Collaboration Medical Outreach Demonstration: Solution Overview

Clinical Activity or Educational Process Workflow

- Hospital
- Clinic
- Lab
- Physician Office

Video Conference Interface

PC/Web Interface

Video Communications Platform

Video Information Management Platform

Core Information Management Platform

Clinical Information Management Platform

PAS/HIS

PACS

Other Data

CAP Foundation

Futurescape of Pathology
Spatiotemporal Epidemiological Modeler (STEM)
Image Analysis and Decision Support
Hardware and Middleware stack to support Medical Analytics

Medical Image Analytics Application

Server Blades, Cell Blades, Storage & Networking

Physician

Review Old & New study
Run comparison between Imaging Studies
(CMO provides the content management
Cell runs the image analytics
BCU runs the structured Analytics)
Goal: Develop an automated computational method that segments images of immunohistochemically stained cell.

Quantification of immunohistochemistry is performed through human visual inspection and it produces subjective results.

Processing time for our method shall be equal or less than time spent by pathologists. The quality of our results shall be equivalent to that of pathologists.

Cell nuclei classification and segmentation are key techniques.

Immunohistochemically stained cell nuclei
Cell Nuclei Classification & Segmentation

Original Image
Number of cell nuclei = 9

(a)

Foreground Classification

(b)

Touching cell nuclei
Number of foreground objects = 5

(c)

Morphology

(d)

Distance Transform

(e)

Output Image
(separated nuclei)
Number of foreground objects = 9

(f)

Watershed Transform

h-minima Transform

(e)
## Preliminary Results

<table>
<thead>
<tr>
<th></th>
<th>Stained Nuclei</th>
<th>Total Nuclei</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Counted Results</td>
<td>5</td>
<td>276</td>
<td>0.018</td>
</tr>
<tr>
<td>Our Preliminary Results</td>
<td>7</td>
<td>282</td>
<td>0.024</td>
</tr>
</tbody>
</table>
Summary

- Healthcare has unique and challenging Storage, Health Analytics and Information Integration requirements

- Traditional approaches are not scalable, affordable and reliable

Enterprise proven technology with proven results