Current and Future Storage Requirements for Healthcare

Waterloo Health Informatics Think Tank
Health Data Storage Decision

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Speaker Declarations

- Clinical Advisory Board and Consultant to:
    - Bycast, Inc.
    - eRAD/ImageMedical
    - InSiteOne, Inc.
- Consultant on RIS/PACS to Healthcare Industry

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Working in an Integrated Digital Healthcare Enterprise

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Presented by

Department of Radiology

University of Rochester School of

Medicine & Dentistry
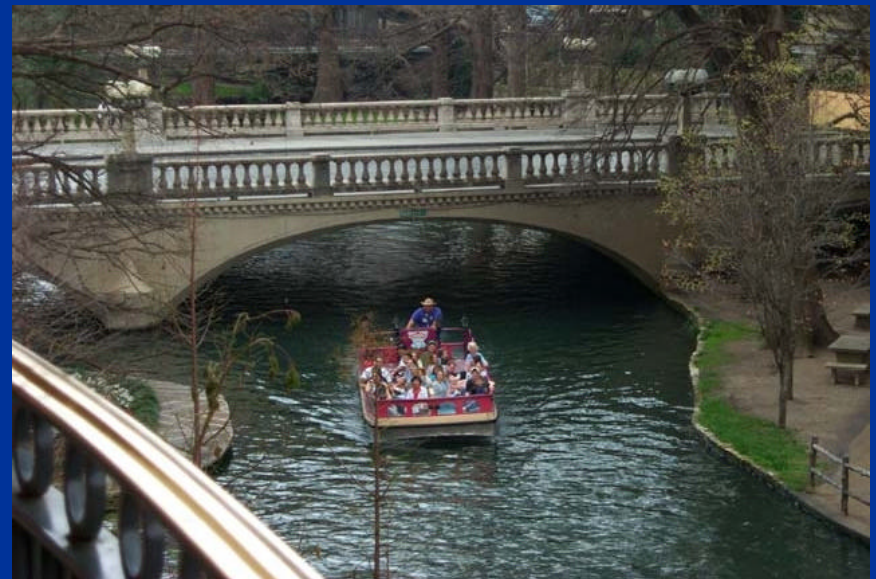
PACS 2004

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Alphabet Soup

- HIS – **H**ospital **I**nformation **S**ystem
- RIS – **R**adiology **I**nformation **S**ystem
- HL7 – **H**ealth **L**evel **7**
- PACS – **P**icture **A**rchiving and **C**ommunications **S**ystem
- DICOM – **D**igital **I**maging and **CO**mmunications in **M**edicine
- IHE – **I**ntegrating the **H**ealthcare **E**nvironment
- HIPAA – **H**ealth **I**nsurance **P**ortability and **A**ccountability **A**ct

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Objectives of the Digital Healthcare Environment

- Reduce costs and remain competitive
- Improve patient care while reducing length of hospital stay
- Reduce errors
- Improve productivity of all healthcare personal
- Increase utilization of resources
- Minimize the use of film and paper

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Requirements

- Images and data must be available **within seconds** any where and at any time
- HE archive must provide essentially **100% uptime** for a filmless and paperless HE
  - A critical trauma patient in ED
  - A patient on the table in the OR
- Images and data must be maintained
  - Secure- never accidentally lost or deleted
  - Private
  - In original and unmodified condition

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Outline

- **IT and infrastructure requirements**
- **Integrated digital Healthcare Enterprise (HE) archive**
- **Storage requirements for variable and fixed content files**
- **Regulatory requirements**
  - Health Insurance Portability and Accountability Act (HIPAA)
  - Personal Information Protection Electronic Document Act (PIPEDA)
- **Retention of Medical Records**

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IT and Infrastructure Requirements

- IT must be
  - **Directly involved** with developing
    - Enterprise archive strategy
    - Fault tolerance strategy
    - Disaster recovery paradigm
  - Made aware of the
    - **Size**
    - **Time sensitivity – 2 to 3 seconds**
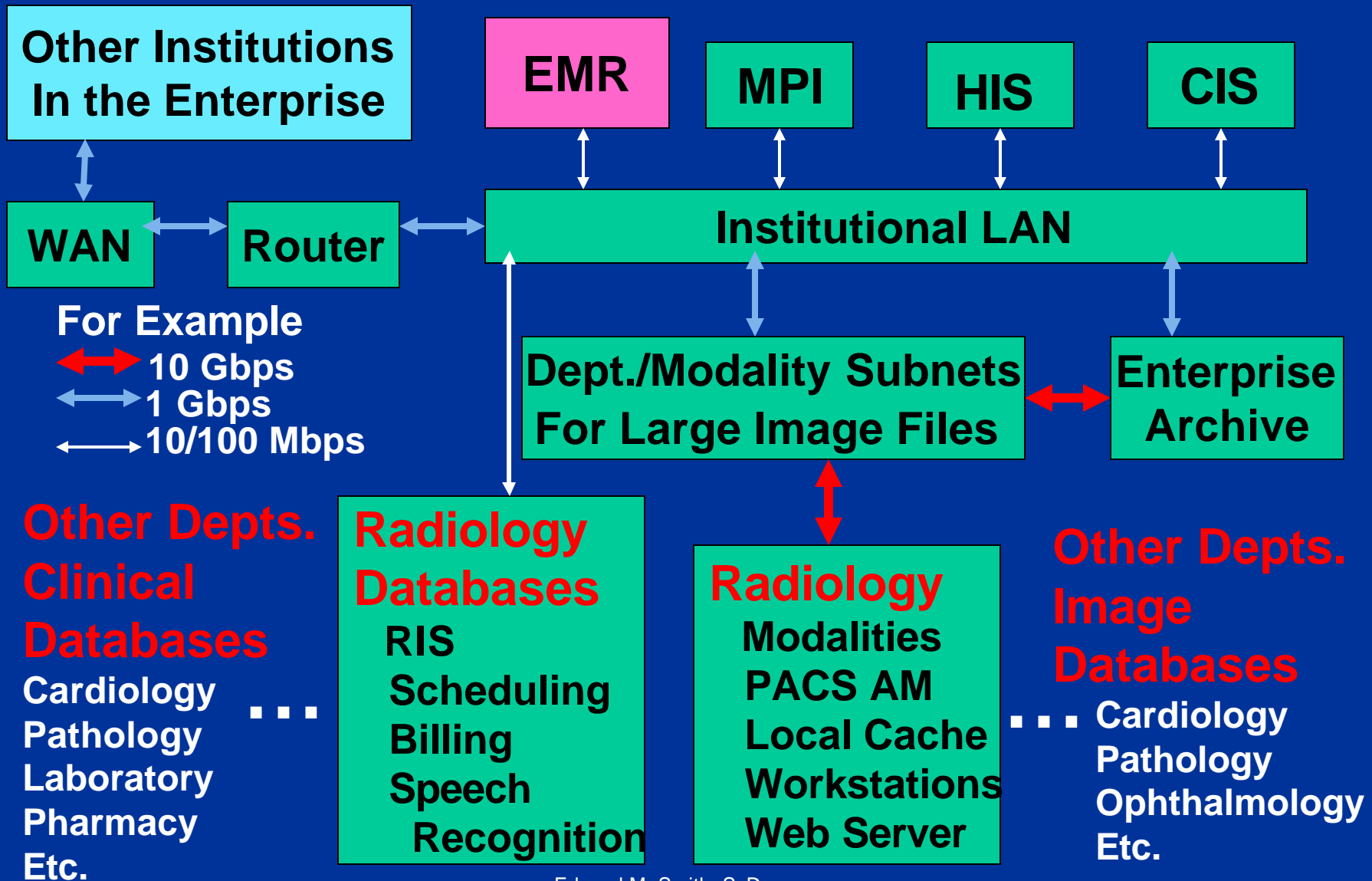   of clinical data and images

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IT and Infrastructure Requirements (cont 1)

- 7 day by 24 hr responsibility – response time in **minutes not hours**

- Infrastructure must be highly available – **99.999%**
    - **LAN**
    - **WAN**

- HIS, RIS, speech recognition, MPI, EMR, CIS must be integrated and data available on the desktop

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IT and Infrastructure Requirements (cont 2)

- Division of responsibilities
  - IT – infrastructure, archive and applications outside of clinical departments, i.e. radiology, cardiology, etc.
  - Clinical departments – clinical applications

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The Integrated HE Archive

Other Institutions In the Enterprise

EMR

MPI

HIS

CIS

WAN

Router

Institutional LAN

For Example

→ **10 Gbps**
→ **1 Gbps**
→ **10/100 Mbps**

Dept./Modality Subnets For Large Image Files

Enterprise Archive

Other Depts. Clinical Databases

Cardiology
Pathology
Laboratory
Pharmacy
Etc.

. . .

Radiology Databases

RIS
Scheduling
Billing
Speech
Recognition

Radiology

Modalities
PACS AM
Local Cache
Workstations
Web Server

Other Depts. Image Databases

. . . Cardiology
Pathology
Ophthalmology
Etc.

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Integrated Digital HE Archive (cont 1)

- The archive is a resource of the HE
- **Interfaced** vs **Integrated** vs **Merged** HIS/RIS/PACS
- "**Fixed** content" vs "**Variable** content" files
- "**On-Demand**" versus "**Rules-Based**"
- "**Thin**" vs "**Fat**" or "**Thick**" client
- First image within 3 seconds

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Integrated Digital HE Archive (cont 2)

- Centralized archive and databases vs distributed archive (cache) and databases
- The HE archive will store:
  - DICOM Part 10 images, waveforms and structured reports (fixed content files)
  - Variable content files containing medical and business information
  - Other fixed and variable content files as required

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Integrated Digital HE Archive (cont 3)

- The archive consists of the
  - Archive manager (AM) or equivalent
  - Storage hardware and storage management software
- The archive must be fault tolerant (highly available) – **99.99%**
- HIPAA
  - All information must be **secure**, **retrievable** and **protected from integrity impairment (corruption)**
  - Disaster Recovery is **MANDATORY**

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Storage Requirements – Radiology

- CT multi-slice systems
  - Increased number and thinner slices
  - 512 x 512 **>** 1024 x 1024
  - 3-D applications
- MR – number of slices and sequences per study increasing
  - Additional applications – MRfn, MRA & MRs
  - 256 x 256 **>** 512 x 512
- CR – image contains 10 MB

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Storage Requirements – Radiology (cont 1)

- Film Digitizer – image contains 10MB or greater
- DR – image contains 18 MB
- Radiology Angiography
- Nuclear Medicine
- US – 3-D US will increase storage requirements
- Digital Fluoroscopy

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Storage Requirements – Radiology (cont 2)
Typical Image and Study Size by Modality

Modality	Image Size			Per Study Basis			
				No. of Images		MB of Storage	
	"X"	"Y"	"Z"	Ave	Range	Ave	Range
CR	2000	2500	2	3	2 to 5	30	20 to 50
DR	3000	3000	2	3	2 to 5	54	36 to 90
CT	512	512	2	60	40 to 300	32	21 to 157
Multi-Slice CT*	512	512	2	1200	400 to 3000	630	210 to 1,600
MR	256	256	2	160	80 to 1000	21	11 to 131

* 16-slice CT, 1mm slice thickness – JHMI

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Storage Requirements – Radiology (cont 3)
Typical Image and Study Size by Modality

Modality	Image Size			Per Study Basis			
				No. of Images		MB of Storage	
	"X"	"Y"	"Z"	Ave	Range	Ave	Range
US	640	480	2*	30	20 to 60	18	12 to 37
Nuclear Medicine	256	256	2	10	4 to 30	1.3	0.5 to 3.8
Film Digitizer	2000	2500	2	3	2 to 5	30	20 to 50
Digital Fluoro	1024	1024	1	20	10 to 50	20	10 to 50
Rad Angio	1024	1024	1	15	10 to 30	15	10 to 30

* **Average of two bytes**

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Storage Requirements – Radiology (cont 4)
Typical Storage Requirements/100,000 Studies/yr

Modality	% of Studies	Ave. MB per study	GB/year per 100,000 studies
Angio	3	20	60
CR & DR	64	35	2,240
CT	20	32	640
MR	5	21	105
NM	3	1.3	3.9
US	5	18	90
Total TB per 100,00 studies			3.1 TB

Excluding Multi-slice CT, 3T MR and Mammography

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Storage Requirements – Digital Mammography

Vendor	Pixel Size (Micron)	FOV (cm)	Matrix Size	MB/Image Uncom-pressed	Com-pression
Fuji	50	18x24 or 24x30	3540x4740x10 b 4728x5928x10 b	35 to 55	Lossless JPEG, 5 to 1 ratio
GE	100	19x23	1900x2300x14 b	8.7	None
Hologic	70	18x24 or 24x29	2560x3328x14 b 3328x4096x14 b	16 to 28	2 to 1 hardware
Orex	50	24x30	4000x5000x12 b	40	Lossless JPEG, Not 510k
Fischer	50/25	21x29 or 11x15	4096x5625x12 b	46	3 to 1 lossless

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Storage Requirements – Digital Mammography (cont 1)

- 9 to 55 MB per image uncompressed
- Typically 4 images/study
- 36 to 220 MB/study uncompressed
- 36 to 220 GB/1,000 studies/yr uncompressed
- If retained 7 years
  - 0.25 to 1.5 TB at 1,000 studies per year
  - 1.25 to 7.5 TB at 5,000 studies per year
- Lossless compression – 2 to 5

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Cardiac Angiography

- Image (frame) size
  - 512 x 512 x 1 Byte
  - 1024 x 1024 x 1 Byte
- Frame rate – 7.5 to 60 frames per second
- Duration of sequence – 5 to 15 sec
- Number of sequences – 3 to 10
- Study size **(uncompressed)**
  - 512 x 512 – 90 to 240 MB
    - **Typical – 200 MB**
  - 1024 x 1024 – 360 to 960 MB
    - **Typical – 800 MB**

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Echo Cardiography

- Image (frame) size 640 x 480 x 1 (monochrome) or 3 bytes (color)
- Frame rate – 15 to 60 per sec.
  - Typical – 30 frames per sec.
- Duration of loop – 1 to 5 sec
- Number of loops – 10 to 20
  - Typical – 15 loops per study
- Study size – 50 to 600 MB or greater **(uncompressed)**
  - **Typical – 300 to 400 MB**

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Storage Requirements – Cardiology (cont 4)
Typical Cardiology Studies Storage Requirements

Study	Acquisition Matrix	Frames per Sec	Duration of Acquisition (Sec)	Loops per Study	Storage per Study (MB)
Angiogram	1024x1024x 1	15	3	5	235
Angioplasty	1024x1024x 1	15	5	5	395
Peripheral Vascular	1024x1024x 1	15	10	3	475
Echo Cardio	640x480x2	30	3	15	830

Assume 4 to 6 GB of uncompressed storage required per cardiac cath lab per day plus echo cardio

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3-D and 4-D Ultrasound

- Store as DICOM US multi-frame – no DICOM 3-D US service class
- 3-D (static) versus 4-D (real-time)
- Store reconstructed
  - 32 to 128 frames (images) – limited by system memory
  - 480 x 640 x 1 or 3 bytes
  - Storage requirements
    - **10 MB** (32 frames - 1B) to
      118 MB (128 frames x 3B)
- Store raw data – 50 to 100 MB

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Digital Pathology*

- Digital pathology is a relatively new application that will require enterprise storage
- Automated scanning microscope can scan and digitize 900 to 1200 slides per day
- Acquisition matrix as large as 1300x1030x3
- Storage requirements per scanning microscope per
  - Day up to 300 GB
  - Year up to 75 TB
- 3-D application will require even more storage

Storage Requirements (cont 7)

- It is difficult to estimate the future storage requirements for a specific modality let alone a specific application

- What will the next application be that requires electronic storage

- Storage requirements will definitely increase with time for all modalities and applications

- The legal requirements for retention of medical records will only amplify the issue

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Regulatory Requirements

- HIPAA
  - Privacy – April 14, 2003
  - Transactions – October 16, 2003
  - Security – April 21, 2005
    - Security in the HE
    - Information must be secure, accessible and protected against corruption
    - Disaster recovery
    - Retention of medical records

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Regulatory Requirements (cont 1)
Disaster Recovery

- Restoration-of-Service (RoS)
- Continuation-of-Business (CoB)
- Disaster Recovery Plan (DRP)
  - Justification
    - Operational
    - Financial
    - Patient care

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Disaster Recovery (cont 1)

- Disaster Recovery Plan (DRP) (cont 1)
  - Components of the DRP
    - DRP Manual – living document
    - Applications and data covered
    - Personnel
    - Alternative operational site – ASP or SSP option
    - Infrastructure and contractual commitments
    - Procedures
    - Test the DRP at least once per year, e.g. when was the last time a database was restored

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Regulatory Requirements (cont 3)
Retention of Medical Records

- There is a maze of federal and state laws dealing with various types of medical records
- Medicare 42 CFR 482.24 – hospitals must maintain **medical records** in their **original or legally produced form** for a period of 5 years
- Conservative approach
    - Retain all medical records for 7 years after last treatment
    - Retain medical records of minors for 7 years after patient reaches age of majority
- Potential economic benefit – data mining

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Summary – Issues To Consider

- A single HE digital archive for all medical information

- Compression of medical information
  - Legal implications
  - Impact on storage requirements

- Future advances in storage technology

- More efficient storage management software

- Impact of HIPAA and PIPEDA on the HE and electronic storage industry

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