

Envisioning Future Radiology Informatics

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Outline

- Understanding Basic MII
- Challenges
- Paradigm of Future MII
- Current projects

Introduction

- Naming or Identifiers
 - Imaging Informatics
 - Medical Imaging Informatics (MII)
 - Radiology Informatics
- Distinctness
 - Upon the scope of the domain
 - Technically sharing

Characteristics in Radiological Science

- Data-intensive science
- Technology-driven specialty
- Leads Imaging Informatics
- Frontier in cancer diagnostics
- Proliferated applications in
 - oncology, cardiology, dermatology, surgery, gastroenterology, obstetrics, gynecology and pathology, and other frontiers in medical sciences
- Both medical and IT Industries involvements

Objectives

- A subspecialty of radiology that aims to improve **medical imaging related** services within the healthcare enterprise through
 - Accuracy (methodology)
 - Efficiency (workflow)
 - Usability (feasibility or applicability)
 - Reliability (accessibility)
 - **Sustainability**
 - **Cost/performance**
- Its ultimate goal to **improve health care systems**

Subjects

- Study of how medical images (within radiology and/or throughout the medical enterprise) are
 - *Acquired*
 - *Archived*
 - *Retrieved*
 - *Processed*
 - *Analyzed*
 - *Enhanced*
 - *Visualized*
 - *Exchanged*
- *Data, communication, and process*

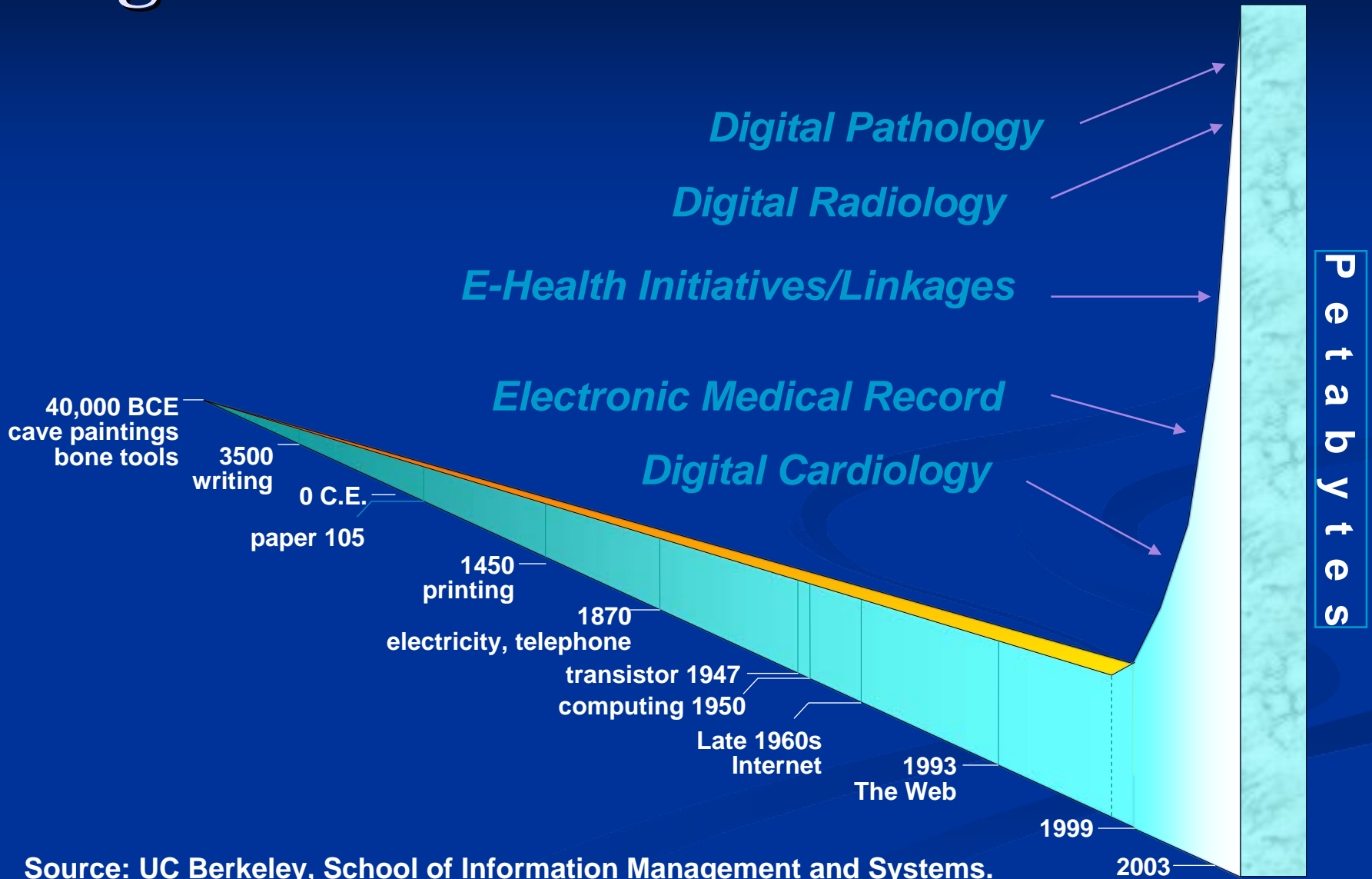
Crossing

- Interdisciplinary
- Multidisciplinary
 - Biological sciences
 - Medical and health sciences
 - Clinical services
 - Information science
 - Medical physics/engineering

Historical Evaluation

- Duration (more than 30 years ago)
- Cultural vision: Computer Applications in Radiology
- Revolution of practical radiology with rapid IT development
 - Demands: data explosion
 - Core technical driving force: digital radiology

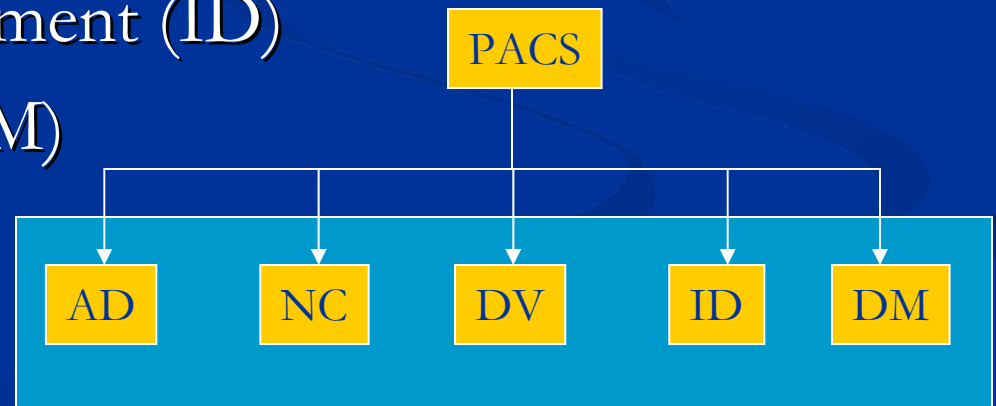
Digitization In Medical Sciences



Source: UC Berkeley, School of Information Management and Systems.

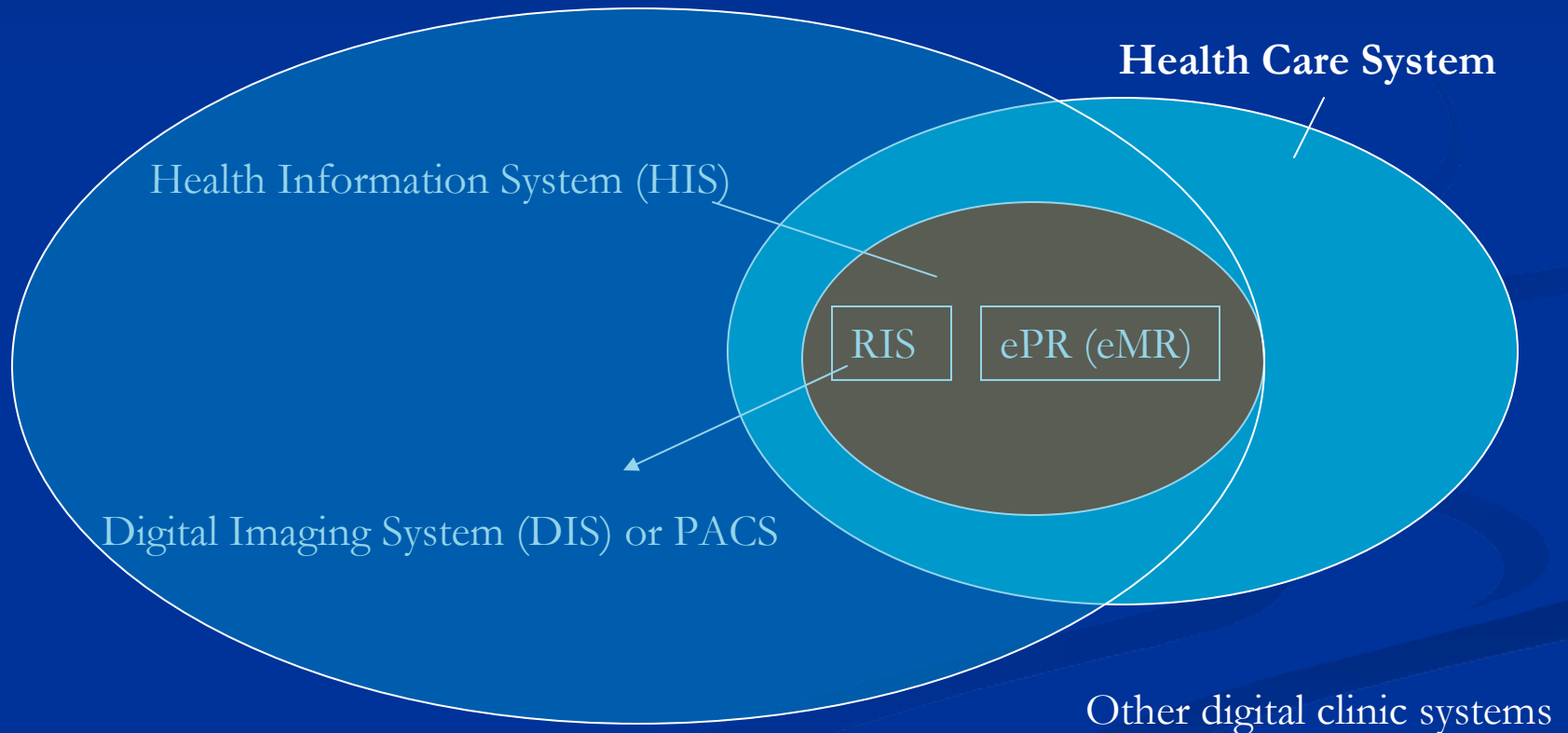
Major Technical Components

- PACS (Picture Archiving and Communication System) --- Core of MII
 - Acquisition and Digitalization (AD)
 - Networking and Communication (NC) --- Workflow
 - Display and Visualization (DV)
 - Information Management (ID)
 - Decision Making (DM)



Relationships

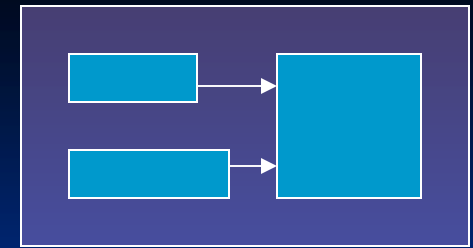
- Organizational Health Care System (HCS)



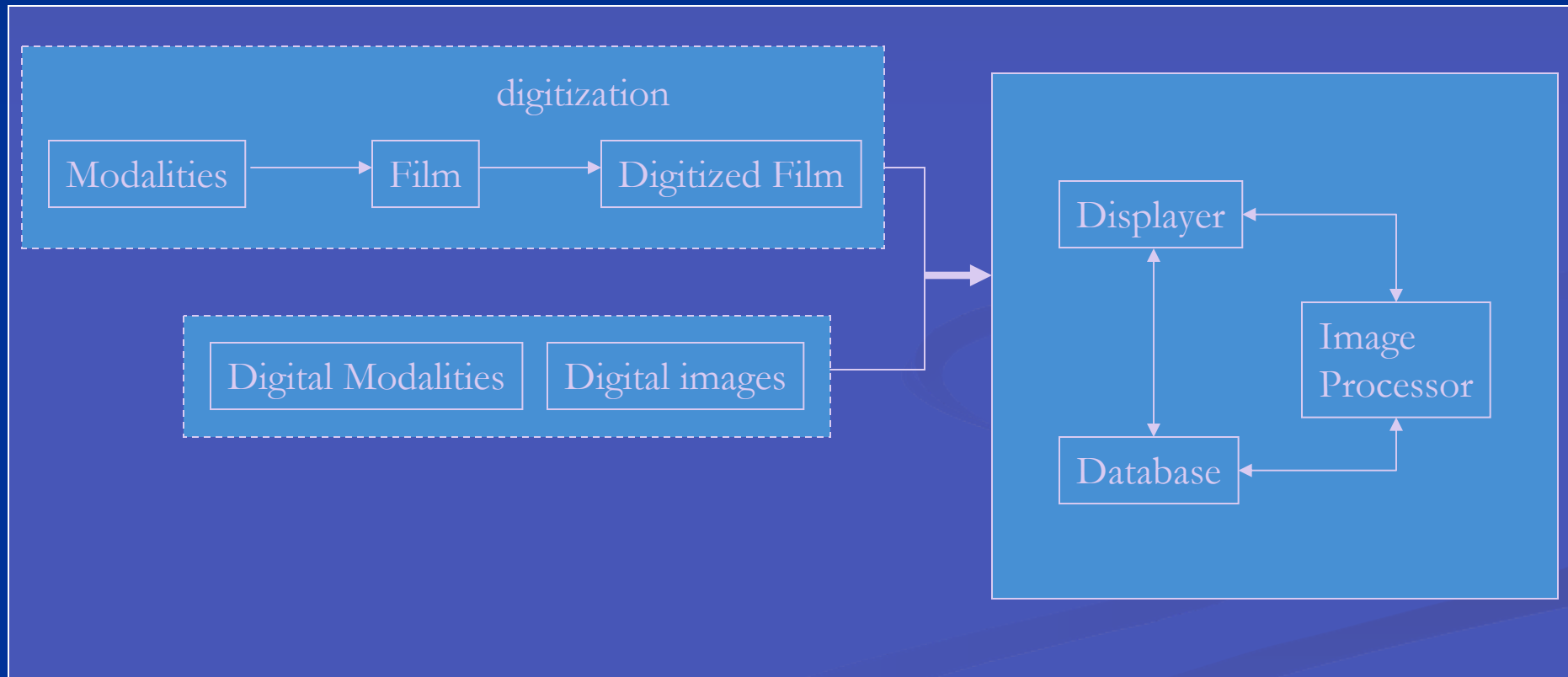
PACS Challenges

- Different regions or enterprises define different PACS specifications with different visions
- Different professionals deploy/implement different interface and prototypes
- Standardization
 - DICOM, HL7, Other IT standards
- Image Digitalization

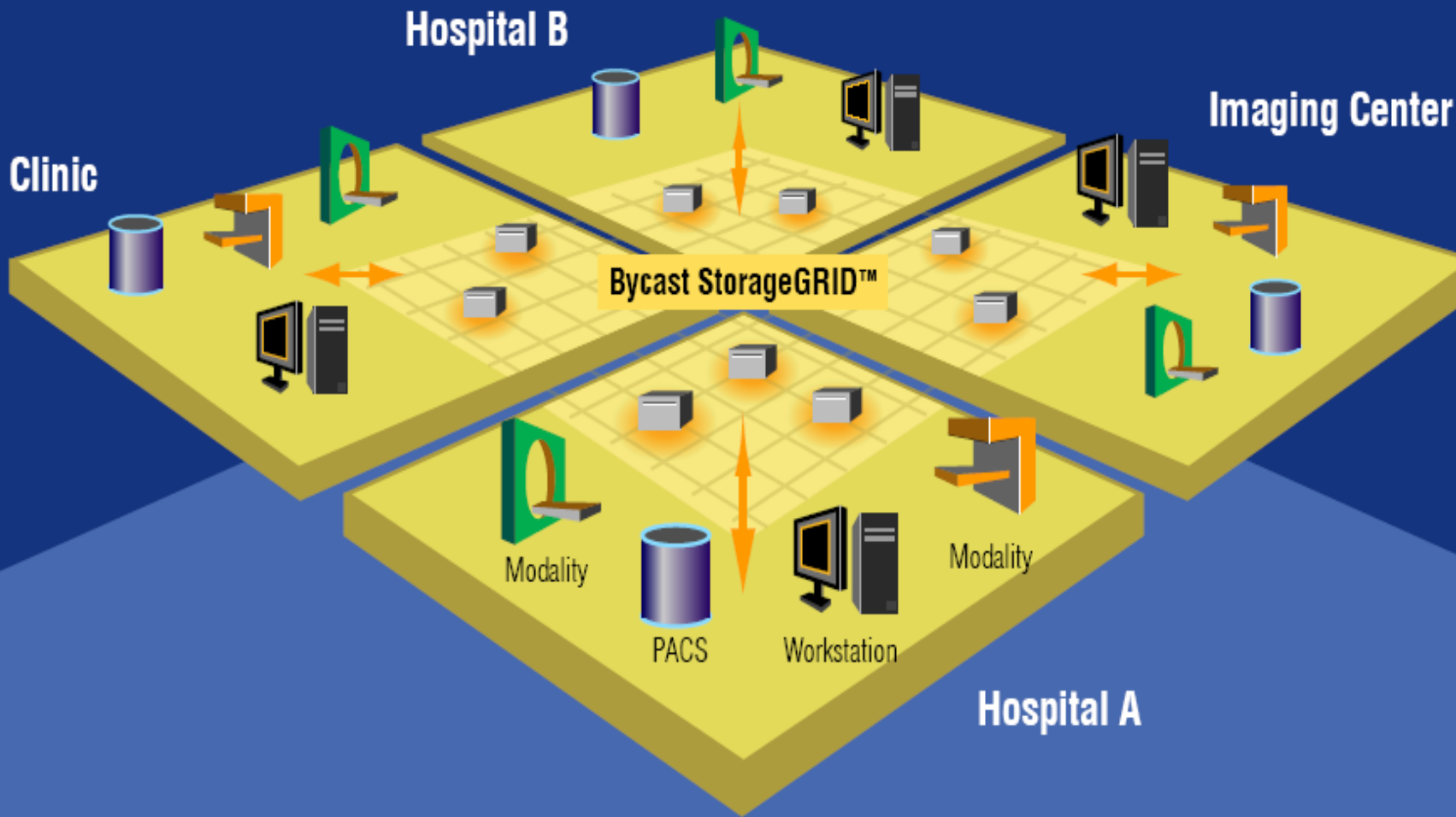
PACS Scaling



- Medium scale (multiple module-based):



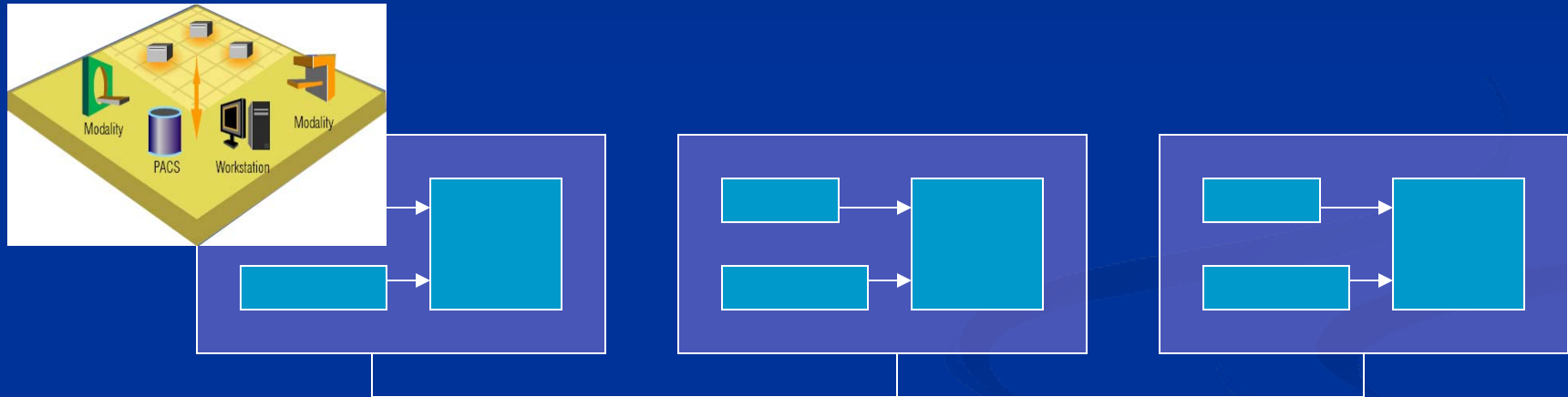
Module with individual health service (hospital or clinic)



IBM Healthcare and Life Sciences Grid Medical Archive Solution

PACS Scaling

- Large scale (multiple module-based):



Local networked

Module 1

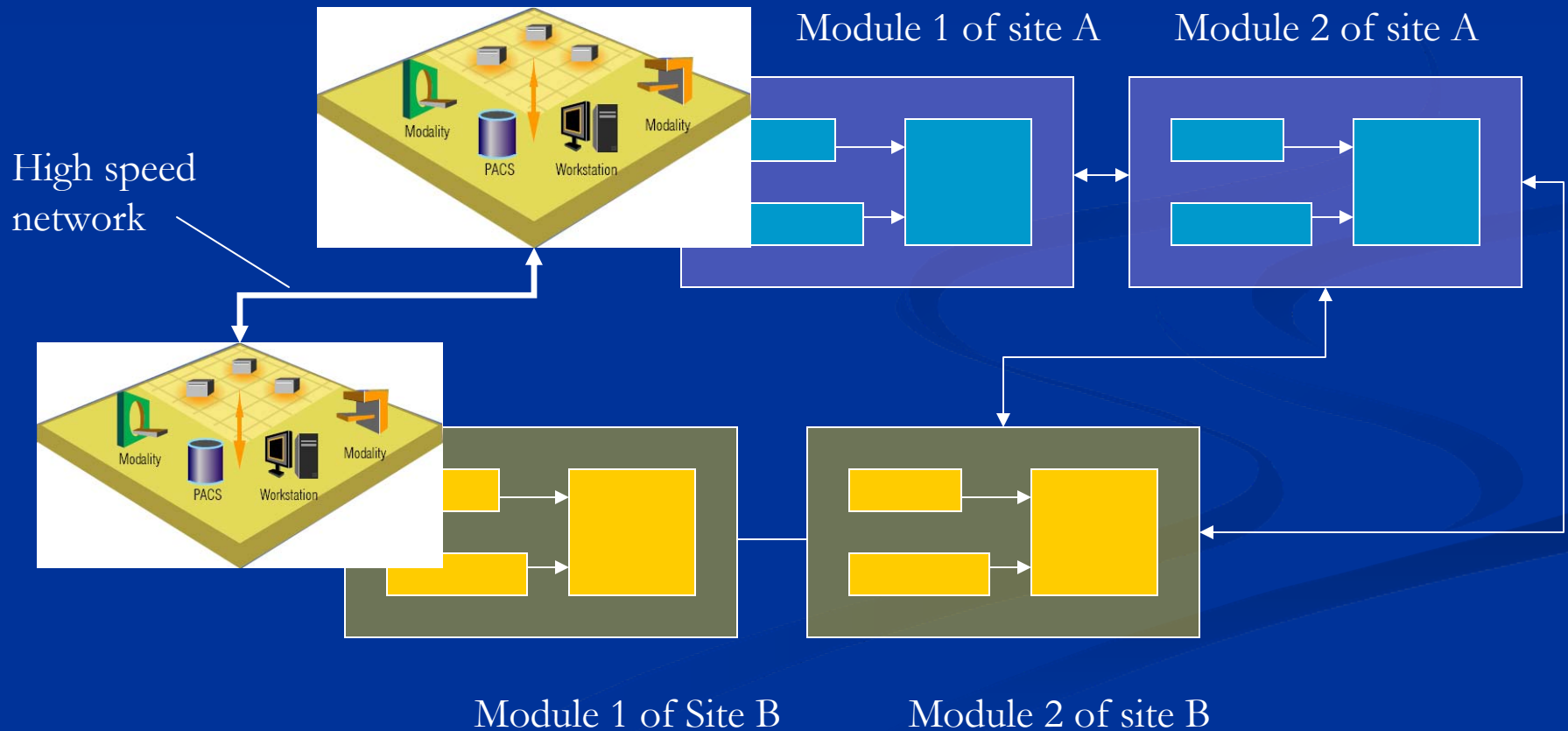
Module 2

Module 3

Distributed multiple- modules within multiple services units; but with single health organization

PACS Scaling

- Super scale (enterprise-, cyberinfrastructure-, heterogeneous, distributed grid-based, cross organization, or even globally):





hospital



registration



order exam



waiting room



final report on RIS



Traditional Genetic Radiology Workflow



modality



exam operation



radiologist review



Fetch report to HIS



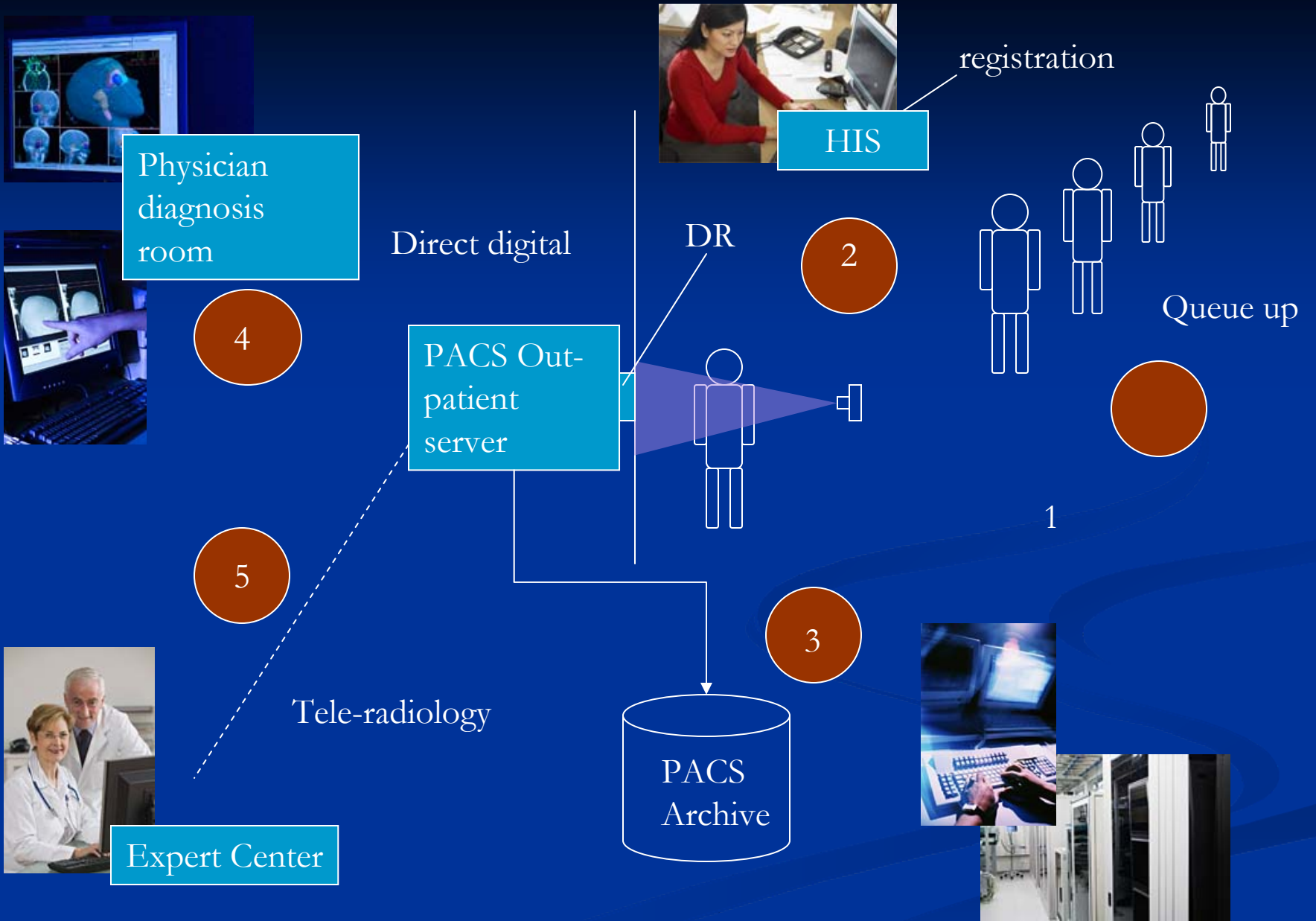
Radiologist preview



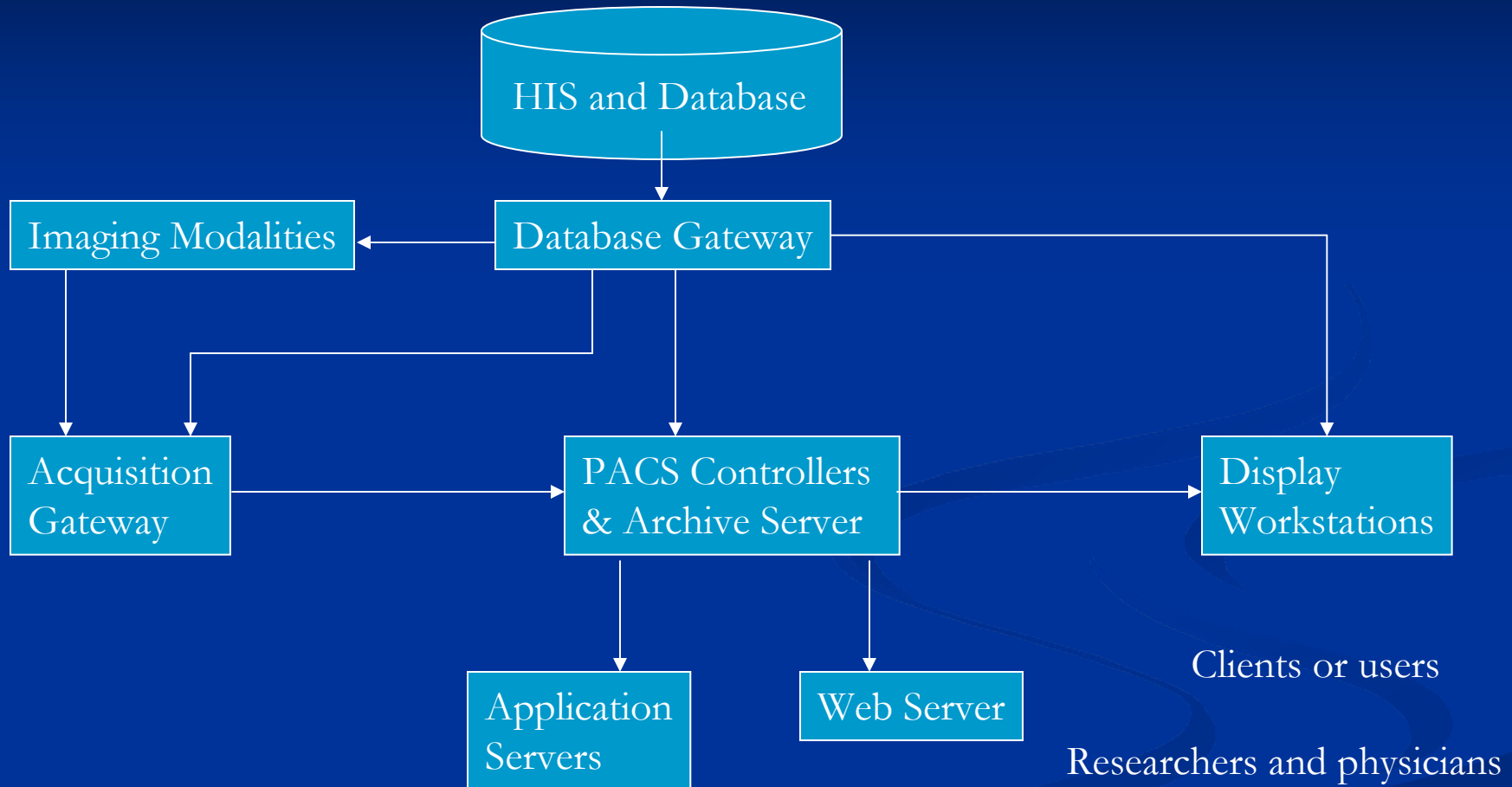
Paperwork film package



send to office

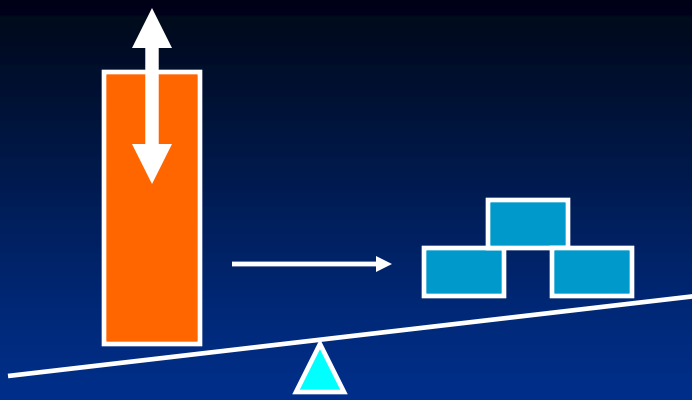


Generic PACS Architecture

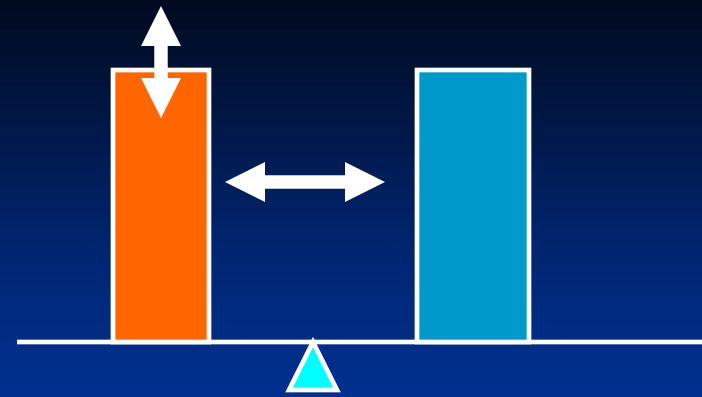


Design Models

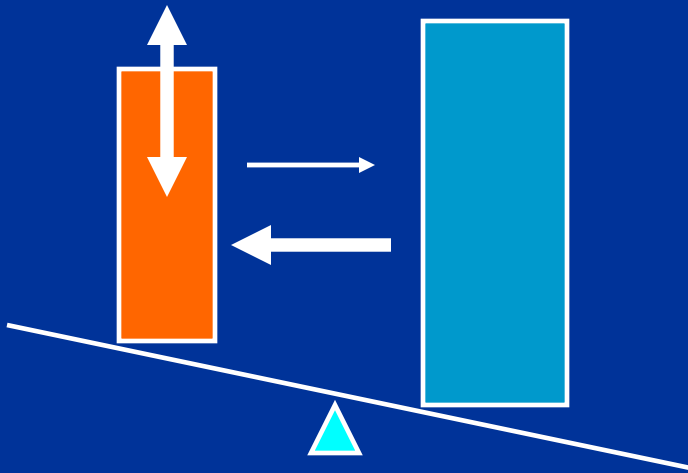
- Loosely classified into five models
 - Home-grow model
 - Two team model
 - Turnkey model
 - Partnership model
 - Application service provider (ASP) model



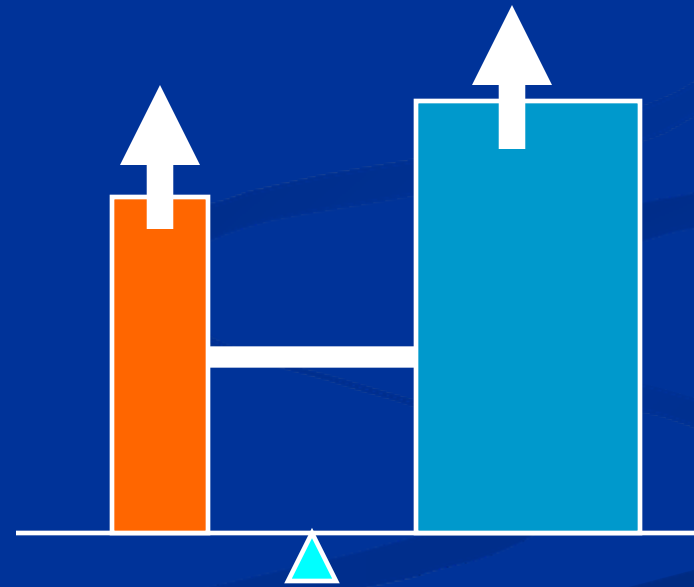
Home-grow (build own car)



Two-teams (special order)



Turn-key (car dealer sale)

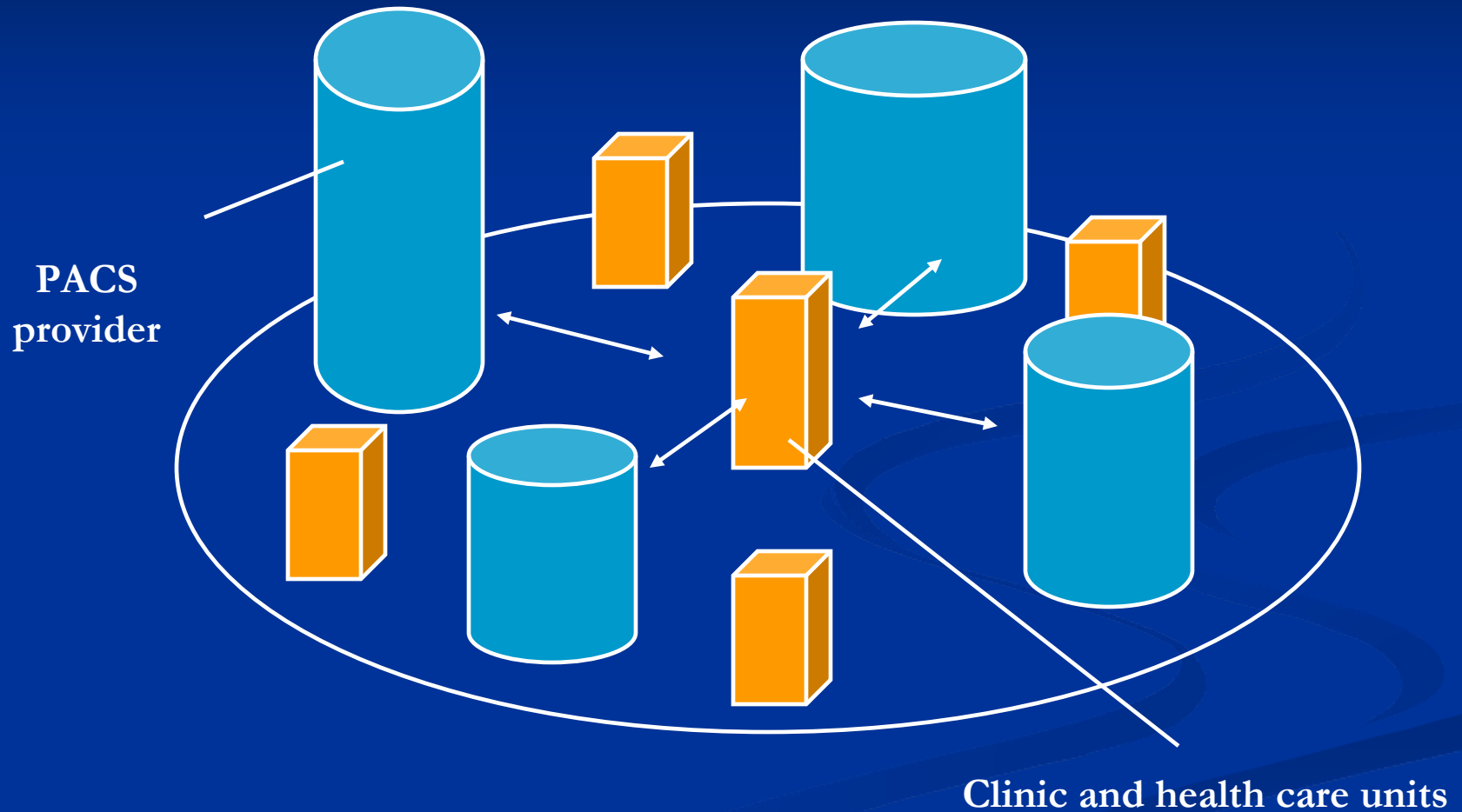


Partnership (renting service)

PACS Concerns

- System expansion
 - upgrade and extension services
- Data Expansion
- Data Migration
 - back-up archive
 - fault-tolerance
 - integration with legacy systems
 - fast wide-area networks

Cyber-enabled, service-oriented PACSs with thin technologies



MII Challenges

- Lack generic MII ontology
 - To systematically defines entity, logical relations, and clasification
- No standard protocols
 - To facilitate the interoperation and communication among globally-distributed MII resources
 - To deploy concurrent hardware and software solutions
 - To utilize cyber-enabled high-speed networks
- Short of education/training programs
 - To foster the next generation in digital health care systems
 - Technologists, radiologists, etc.

New Paradigm and Envisioning

- Capacity for handling massive data
- Integration and interoperation among various hospital/clinic systems
- Expansion of MII domain scope

Medical Imaging Informatics Scopes

- Integration
 - Picture Archiving and Communication System (PACS) with other Component Systems
 - Imaging Informatics for the Enterprise
 - Image-Enabled Electronic Medical Records or Electronic Patient Records

Medical Imaging Informatics Topics

- Ontology and W3C Semantic Web
 - Define entity
 - Develop vocabularies and ontological terminology
 - Cataloging entities, and establish their relations
 - Deploy intelligent neural network based workflow
 - Develop data mining and AI-based CAD
 - Implement standards
 - Define semantics
 - Medical communication language
 - Semantics networks

Medical Imaging Informatics Topics

- Unified Medical Language System (UMLS) 2008AA version, (NLM) with three components
- <http://umlsks.nlm.nih.gov>
 - Specialist lexicon
 - Lexical resources, 200k
 - Meta-thesaurus
 - Terminological resources, 5M names, 1M concepts, and 16M relations
 - Semantic network
 - Ontological resources, 135 high-level categories, 7k relations among them

Medical Imaging Informatics Topics

■ Facilitation

- Imaging Facilities Design
- Digital Imaging
 - Digital Radiography
 - Modalities: Computed tomography (CT or XCT), Nuclear medicine (NM), Positron emission tomography (PET), Single-photon emission computed tomography (SPECT), Ultrasound (US), Magnetic resonance imaging (MRI), Digital fluorography (DF), Digital subtraction angiography (DSA), etc.
- Data Acquisition
- Digital imaging
- Archive/Retrieve Integrity and Security
- Image Data Compression

Medical Imaging Informatics

Topics (cont.)

- Processing
 - Image Processing and Enhancement
 - 2D, 3D, 4D, Visualization and Multi-media
 - Speech, Text, Image (Signature) Recognitions
 - Documentations

Medical Imaging Informatics Scopes (Cont.)

- Knowledge Specification
 - Terminology, Methodology, System Dictionary, and Ontology
 - Anatomic knowledge-based system
 - Transforming the Radiological Interpretation Process (TRIP)
 - Radiology Informatics Education

Medical Imaging Informatics Scopes (Cont.)

■ Standardization

- Digital Imaging and Communications in Medicine (DICOM)
- Health Level 7 (HL7)
- Distributed Computing Protocols (W3C, Web Services)

Medical Imaging Informatics Scopes (Cont.)

- Communication
 - Networking
 - Security (network security and patient confidentiality, legal policies)
 - Workflow and optimal data transformation

Medical Imaging Informatics Scopes (Cont.)

- Interaction
 - Radiological Science
 - Knowledge refreshing
 - Modality updating
 - Digital equipments
 - Health care policy
 - ...

Medical Imaging Informatics Scopes (Cont.)

- Informatics
 - Medical Informatics
 - Bioinformatics
 - Health Informatics
 - Nursing Informatics
 - ...

Medical Imaging Informatics Scopes (Cont.)

- Interaction (cont.)
 - Computer Science
 - Algorithms
 - System architecture
 - Software engineering
 - Networking
 - Database architecture
 - High performance computing and distributed computing

Medical Imaging Informatics Scopes (Cont.)

- Interaction (cont.)
 - Information Science (Information Management System)
 - Decision making
 - Optimization
 - Operation research
 - MII system management
 - Market and policy

Medical Imaging Informatics

Scopes (Cont.)

- Interaction (cont.)
 - Information technology
 - Information system implementation
 - Hardware/software acquisition
 - System ordering, maintaining and updating
 - Information
 - Collaborative tools (Tele-conference, meeting)
 - Instructional tools
 - Accessible tools
 - ...

Medical Imaging Informatics

Scopes (Cont.)

- Application
 - Computer-Aided Detection and Diagnosis (CAD)
 - Computer-aided surgery (CAS) or image-guided surgery (IGS)
 - Services assessment (quality assurance and reliability analysis, cost/performance estimation, system measurement)
 - Services-based medical imaging system
 - Teleradiology/Telemedicine

Medical Imaging Informatics Scopes (Cont.)

- Computation
 - Data-mining from medical image databases
 - Artificial Intelligence in medical imaging
 - Process modeling and simulation
 - System radiology

Projects

- Medical Imaging & Radiology Informatics (MIRI)
 - Hawkeye Radiology Informatics (HRI)

<http://www.uiowa.edu/~hri/>

- Radiology Informatics Domain Ontology (RIDO)
 - Formal and logical representations and definitions of concepts, terms, and relationships between MII in radiology and biomedical informatics domains, and other medical science domains.
- Cyberinfrastructure-enabled Radiology Informatics (CIRI)
- Radiology Informatics Education and Training (RIET)

<http://www.uiowa.edu/~hri/education.html>

Projects

- Parallel Computing in Medical Imaging (PCMI)
 - http://www.uiowa.edu/mihpclub/projects_pcmi.html
- Parallelism of Medical Imaging Processing
 - CT Reconstruction
 - Segregation
 - Registration
 - Texturing and classification
 - Enhancement
 - Image compression
 - Image data mining
 - ...

Projects

- Modeling Biotransport in Biophysical System (MBBS)
http://www.uiowa.edu/mihpclub/projects_mbbs.html
 - Hyperthmia
 - Tumor growth and dynamics
- Optical Imaging Tomography and Applications (DITA)
http://www.uiowa.edu/mihpclub/projects_oita.html
- Image Stereology and Clinic Applications (ISCA)
http://www.uiowa.edu/mihpclub/projects_isca.html
- Couple Diffusions for Image Enhancement (DDIE)
http://www.uiowa.edu/mihpclub/projects_cdie.html

Acknowledgements

- NIH
- NSF
- Intel
- Microsoft

Reference

- **ACR** (American Collage of Radiology)
- **RSNA** (Radiology of North American)
- **SIIM** (SCAR, Society of Imaging Informatics in Medicine)
- **CARS** (Assisted Radiology and Surgery), International
- **ABII** (American Board of Imaging Informatics) offers a national certification program that defines the standard for demonstrated knowledge and competence in medical imaging informatics.
 - It was founded by SIIM and the American Registry of Radiologic Technologists (ARRT).

Thanks

Q & A