Globus MEDICUS

Standards Based Enterprise Architecture for Medical Image Publication, Discovery, and Archiving in HealthGrids

Stephan G. Erberich, Ann Chervenak, Robert Schuler, Laura Pearlman, Jonathan C. Silverstein, Carl Kesselman

Health Care System

"We don't really have a health care delivery system in this country. We have an expensive plethora of uncoordinated, unlinked, economically segregated, operationally limited micro system, each performing in ways that too often create suboptimal performance both for the overall health care infrastructure and for individual patients."

George Halvorson

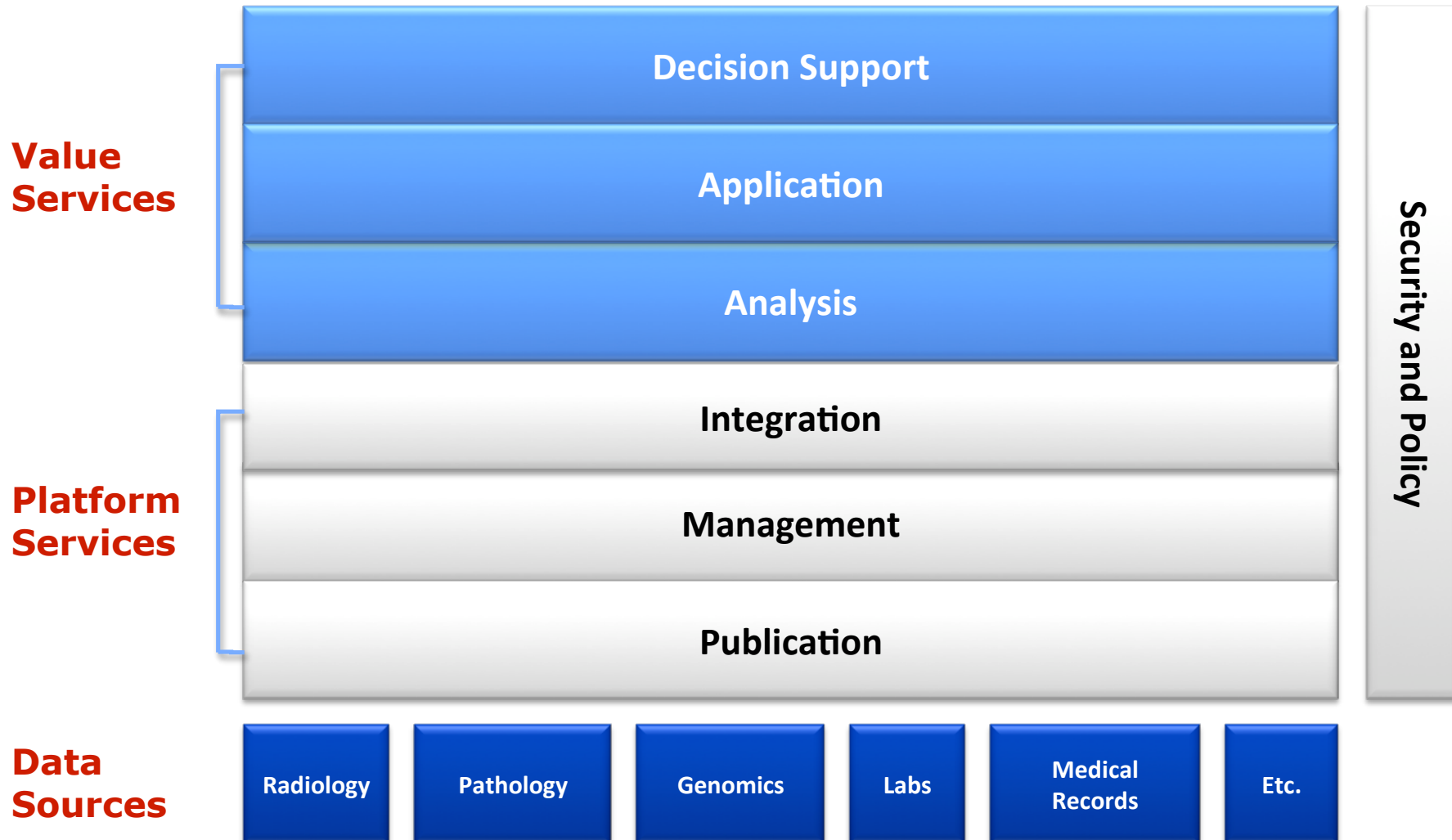*Health Care Reform Now! A Prescription for Change Wiley 2007*

Health Care System

"We have reached the point where both health care delivery and health care financing in America need new directions. The old approach isn't technically broken – because it continuous to function – but it performs at unacceptable and unaffordable levels in far too many ways for far too many people."

George Halvorson

Health Care Reform Now! A Prescription for Change Wiley 2007

Global Health Platform

Value Services
- Decision Support
- Application
- Analysis

Platform Services
- Integration
- Management
- Publication

Security and Policy

Data Sources
- Radiology
- Pathology
- Genomics
- Labs
- Medical Records
- Etc.

the globus alliance
www.globus.org

Globus MEDICUS

- Medical Imaging and Computing for Unified Information Sharing (MEDICUS)
- Use standards Open Grid Service Architecture (OGSA) for Healthcare and Clinical Research
- Vertical integration of existing robust Grid technology
- Addresses Medical Imaging
  - ◆ DICOM image **sharing** within Grids*
  - ◆ DICOM image **processing** (WS)
  - ◆ DICOM image **archiving/management** (Grid PACS)**

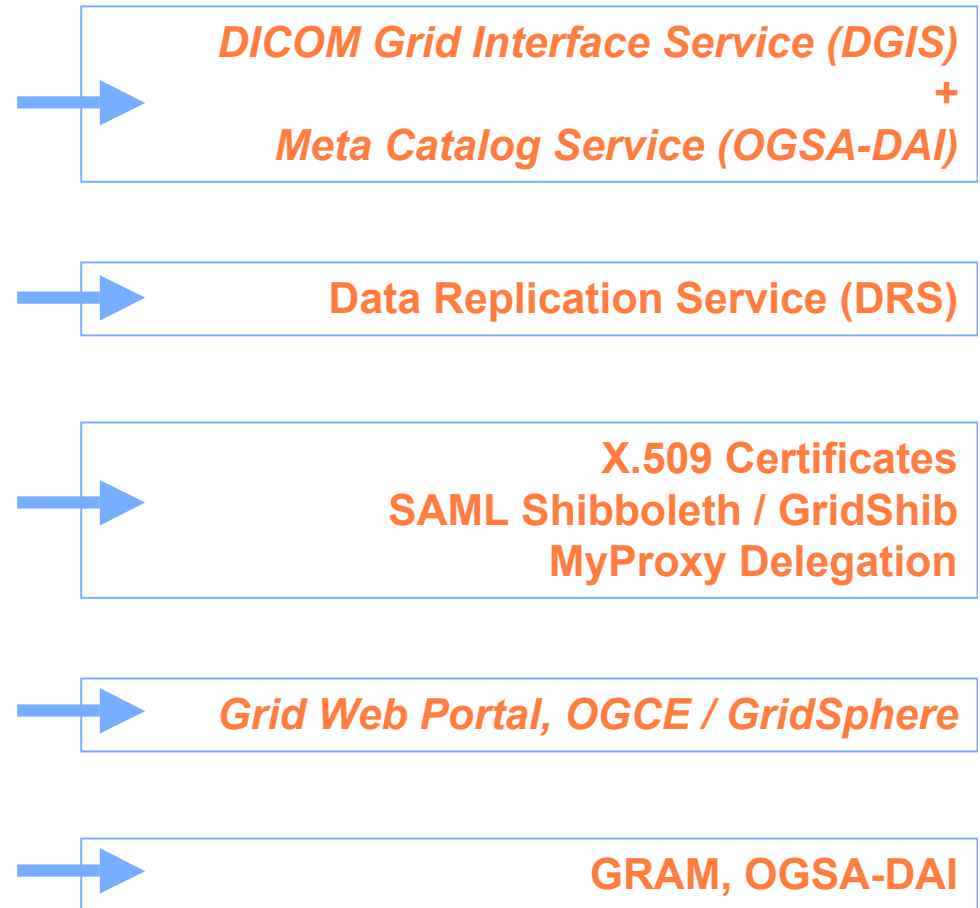*PACS and Imaging Informatics, SPIE Medical Imaging, 6145-32, 2006

**Int Journal of Computer Assistant Radiology and Surgery, 2006, 1:87-105; p100-104, Springer, Heidelberg

Globus MEDICUS Proto-Project @ http://dev.globus.org/wiki/Incubator/MEDICUS

Medical Imaging Grid: Nuts and Bolts

Globus Toolkit Release 4

- DICOM images
  - Send   (publish)
  - Query/Retrieve   (discover)

  → *DICOM Grid Interface Service (DGIS)*
  +
  Meta Catalog Service (OGSA-DAI)

- Grid Archive
  - Fault tolerant
  - Bandwidth

  → **Data Replication Service (DRS)**

- Security
  - Authentication
  - Authorization
  - Cryptography

  → **X.509 Certificates
  SAML Shibboleth / GridShib
  MyProxy Delegation**

- Access
  - Web portal

  → *Grid Web Portal, OGCE / GridSphere*

- Applications
  - Computing
  - Data Mining

  → **GRAM, OGSA-DAI**

the globus alliance
www.globus.org

The Grid is the PACS

- **Meets image exchange needs**
  - Not limited to research use (e.g. BIRN, caBIG)
  - Single architecture for Clinical and Research use
  - Federate image references (Meta Catalog) - IHE XDS model
  - X.509 authentication security model + SAML assertions
  - Hide Grid workflow from user if possible, e.g. DICOM workflow

- **Meets image storage needs**
  - FT and DR by replicas
  - PACS-Grid-PACS too slow for clinical use
  - Integrate hospital PACS
  - Data integrity by CRC checksums

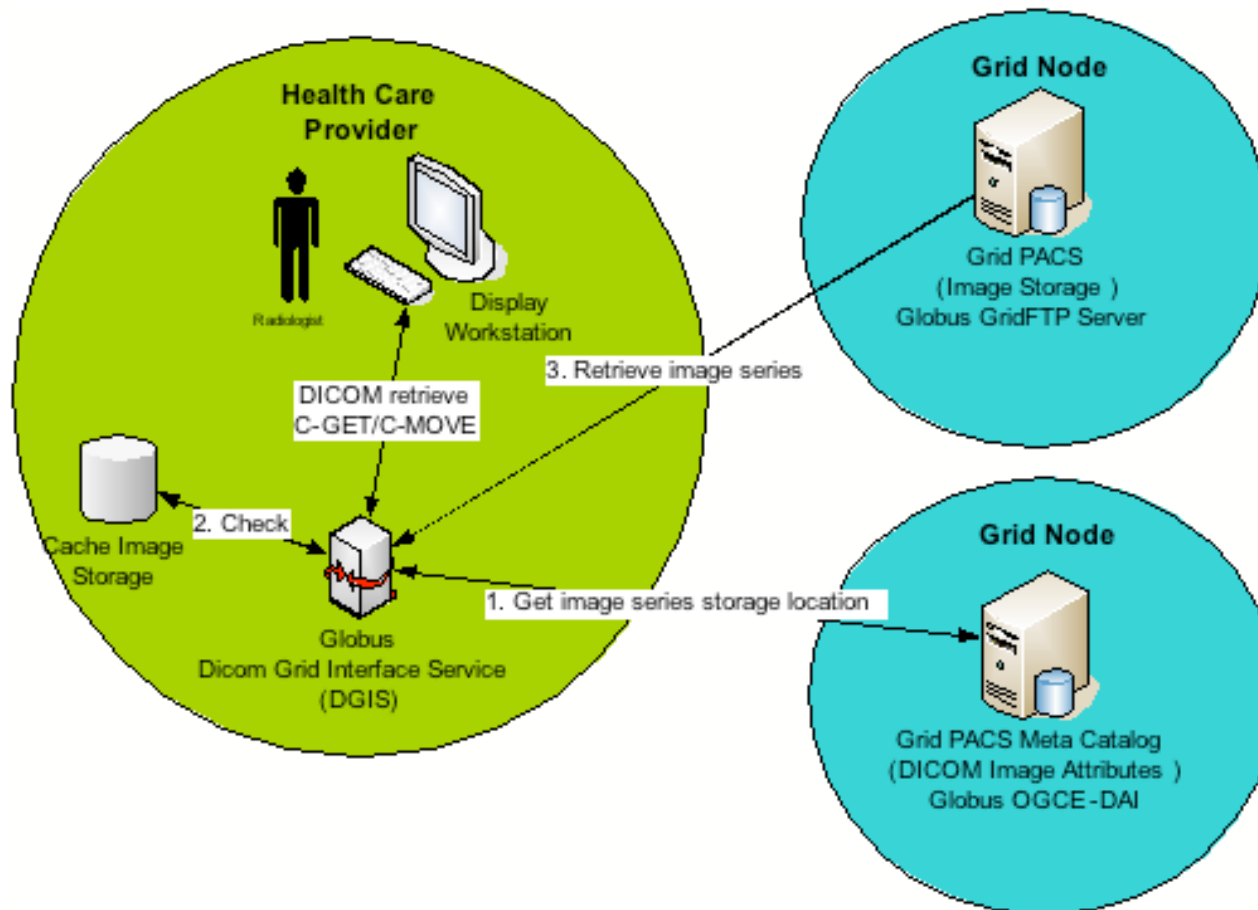# DGIS: Image publication
DICOM C-STORE Operation
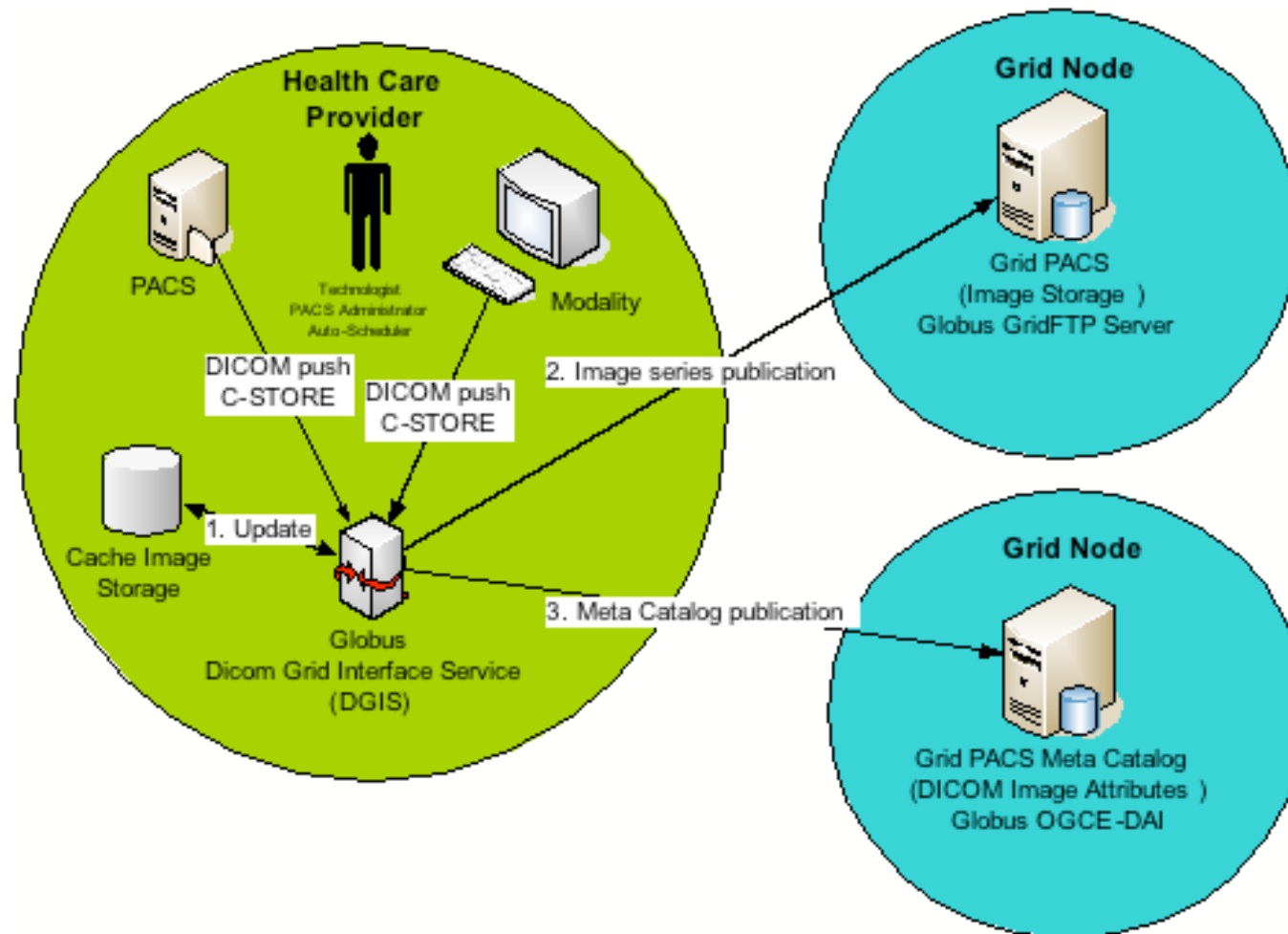
DGIS: Image Discovery
DICOM C-FIND Operation
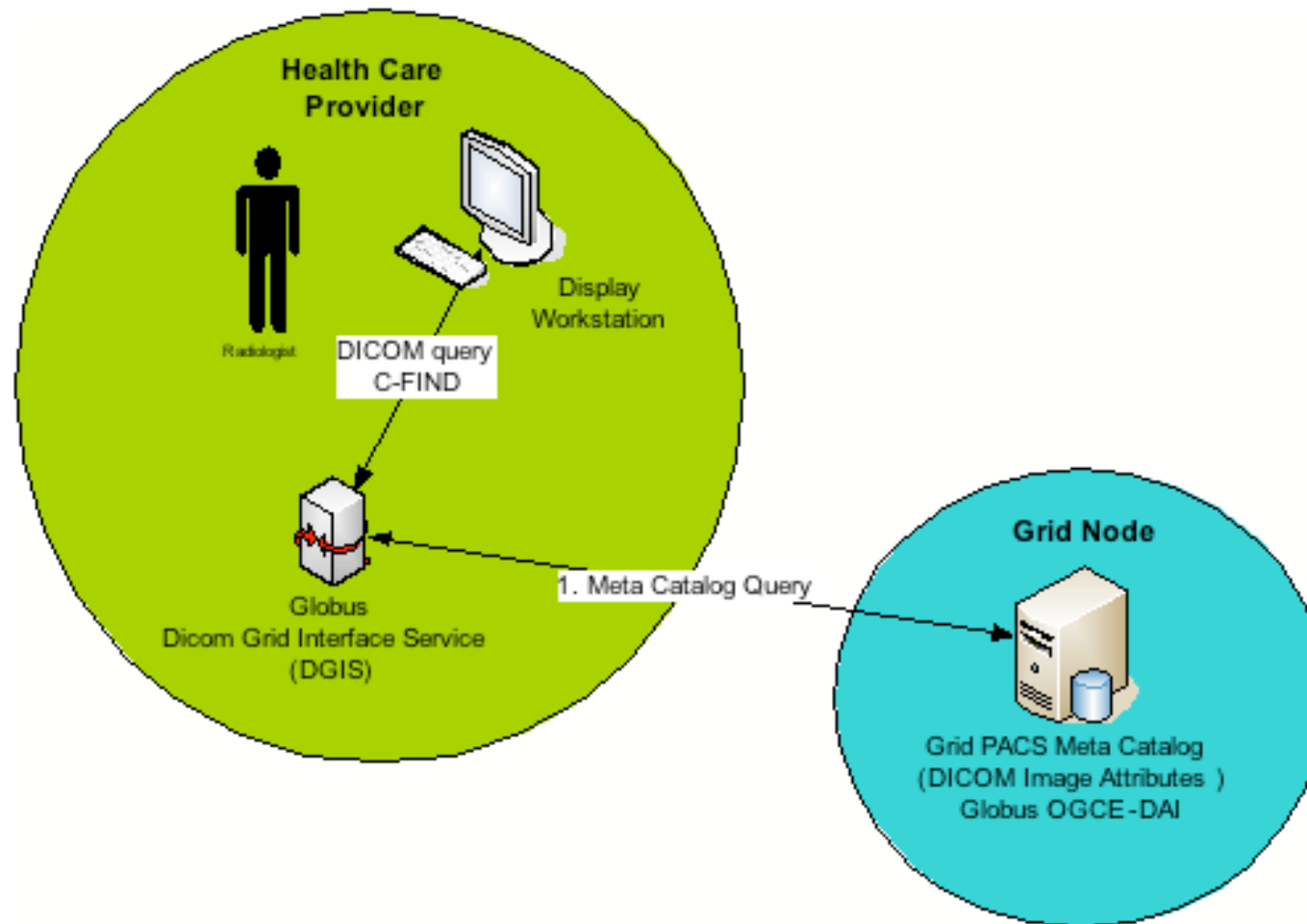
DGIS: Image Delivery
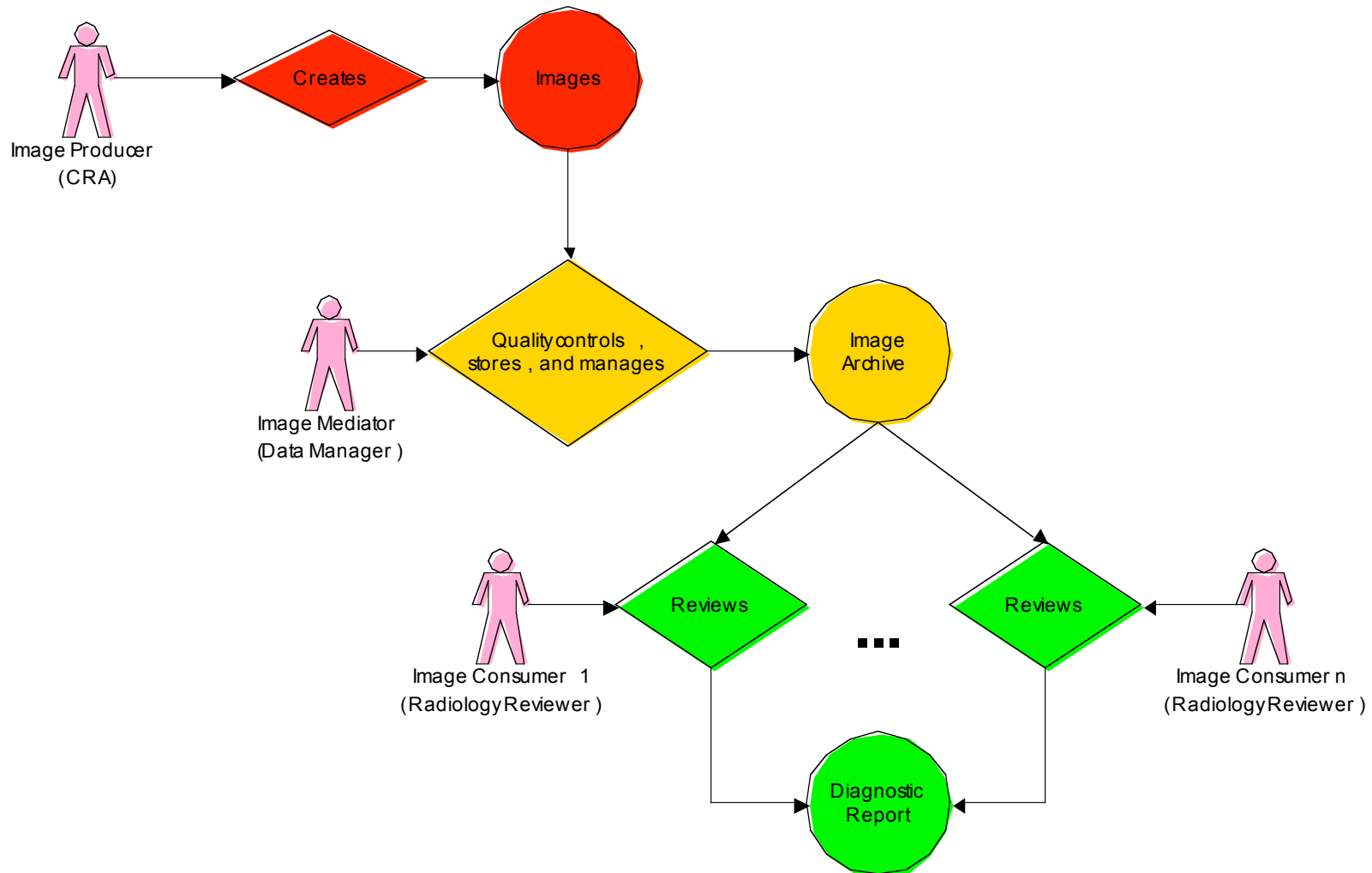# DICOM C-GET/C-MOVE Operations

Clinical Trials

- Clinical Trials become essential part of "forefront" patient care

- Cancer trials often a last resource

- Health Care Systems Solution must support clinical trials, research and patient care at once
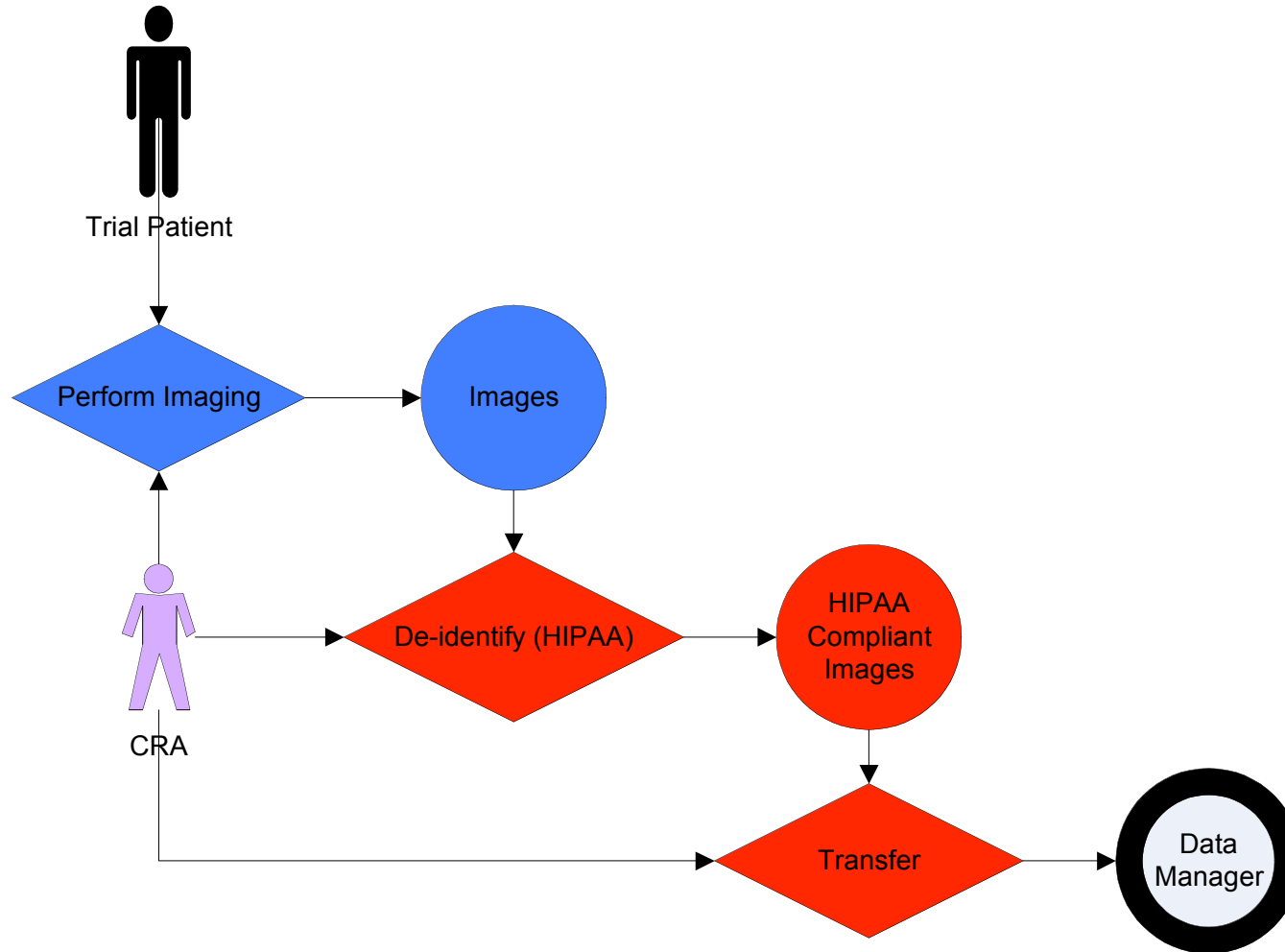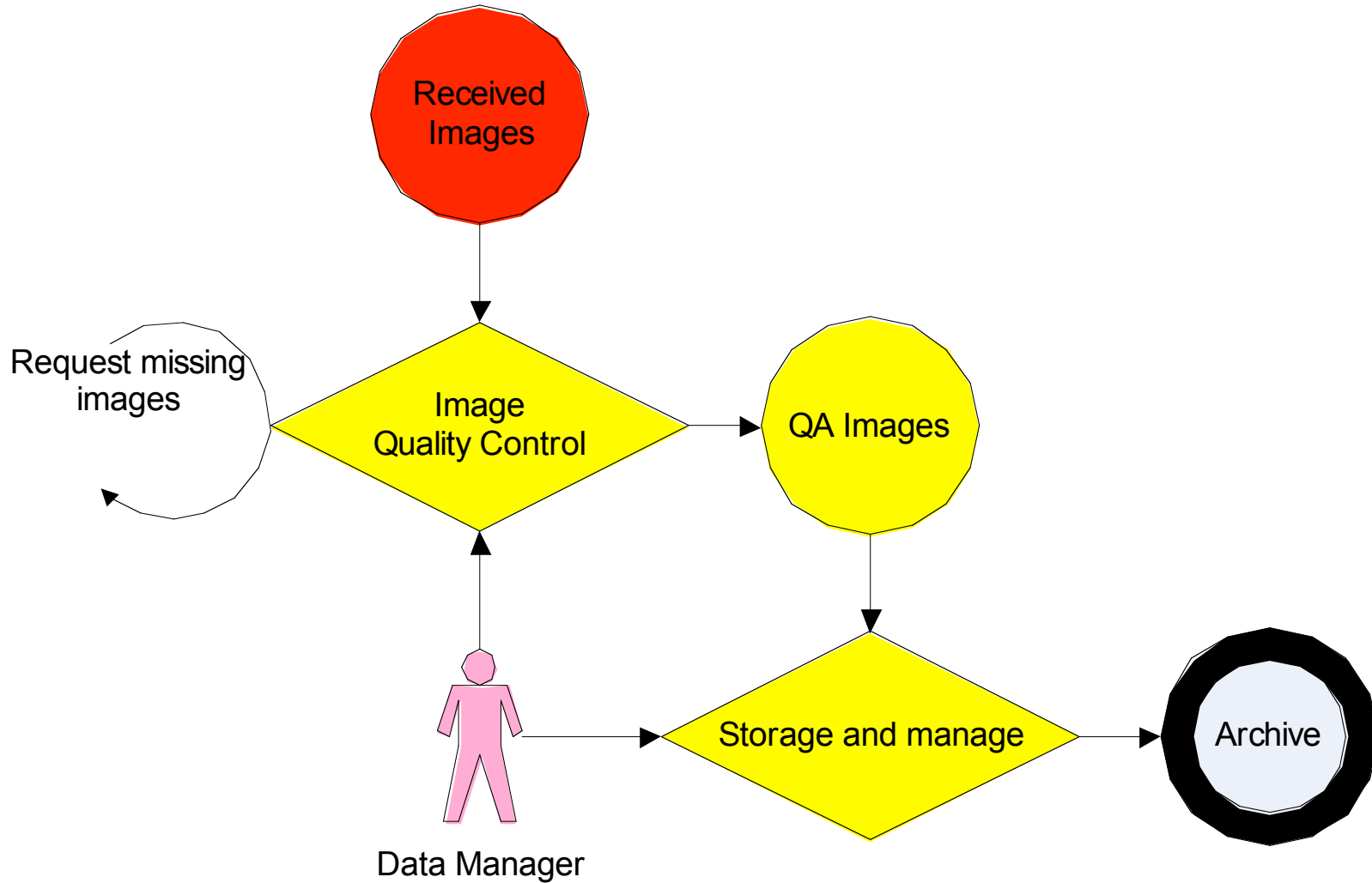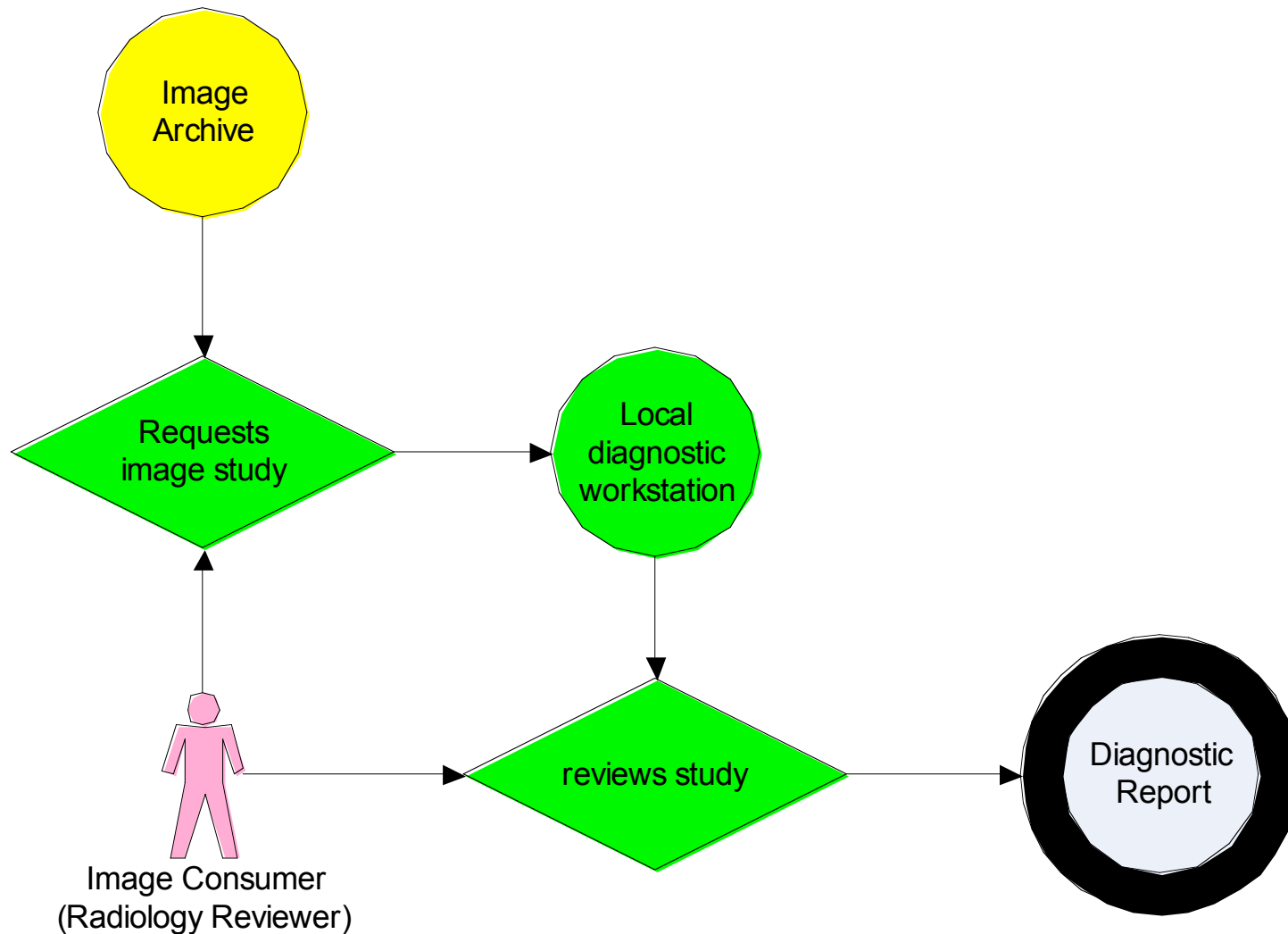
Radiology Workflow

Trial Site

the globus alliance
www.globus.org

QA

Central Review

the globus alliance
www.globus.org

MEDICUS Fault Tolerance and Disaster Recovery

- **FT and DR through replicas**

  - OGSA compliant Replication Location Service (RLS)

  - Index encrypted DICOM keys (study and series UIDs)

  - Index which storage has physical representation of series record

  - Local replica index (RLS)

  - VO replica index (RLS master)

the globus alliance
www.globus.org

Meta Catalog Service for Medical Images

- OGSA-DAI + DB (e.g. MySQL, Derby, Oracle, ..)
- DICOM meta data
    - Patient level (e.g. encrypted name, id, etc.)
    - Study level (e.g. date, time, protocol, etc.)
    - Series level (e.g. imaging type, modality, etc.)
    - Image level (e.g. position, level, exposure, etc.)
- Keys are DICOM UIDs (Study, Series, Image)
- Health meta data
    - Flexible Annotation, e.g. ICD-9

the globus alliance
www.globus.org

Protected Health Information Problem

- **What do we want?**
  - ◆ Use clinical data for research
  - ◆ Share clinical data, make research data available
  - ◆ Reuse same infrastructure
  - ◆ Image exchange between health providers

- **Patient must authorize use of data – consent process**
  - ◆ Intact unmodified DICOM workflow for diagnostics
  - ◆ De-identified DICOM workflow for research (Modality profiles)
 - ◆ Group authorization problem: Patient data–to-User (Physician/Researcher) relationship not manageable!

PHI authorization

- ## MEDICUS v1
  - Single layer GSI security model
  - X.509 proxy certificate standards based
  - Typical use case: Closed VO like Healthcare provider network, Military network, research network, closed R

- ## MEDICUS v2
  - Add second security layer based on patient identity
  - ***Patient Centric Authorization using SAML assertions***
  - Patient advocacy – patient controlled access
  - Logging of "on behalf actor" at Grid Service
  - All patient data on the Grid
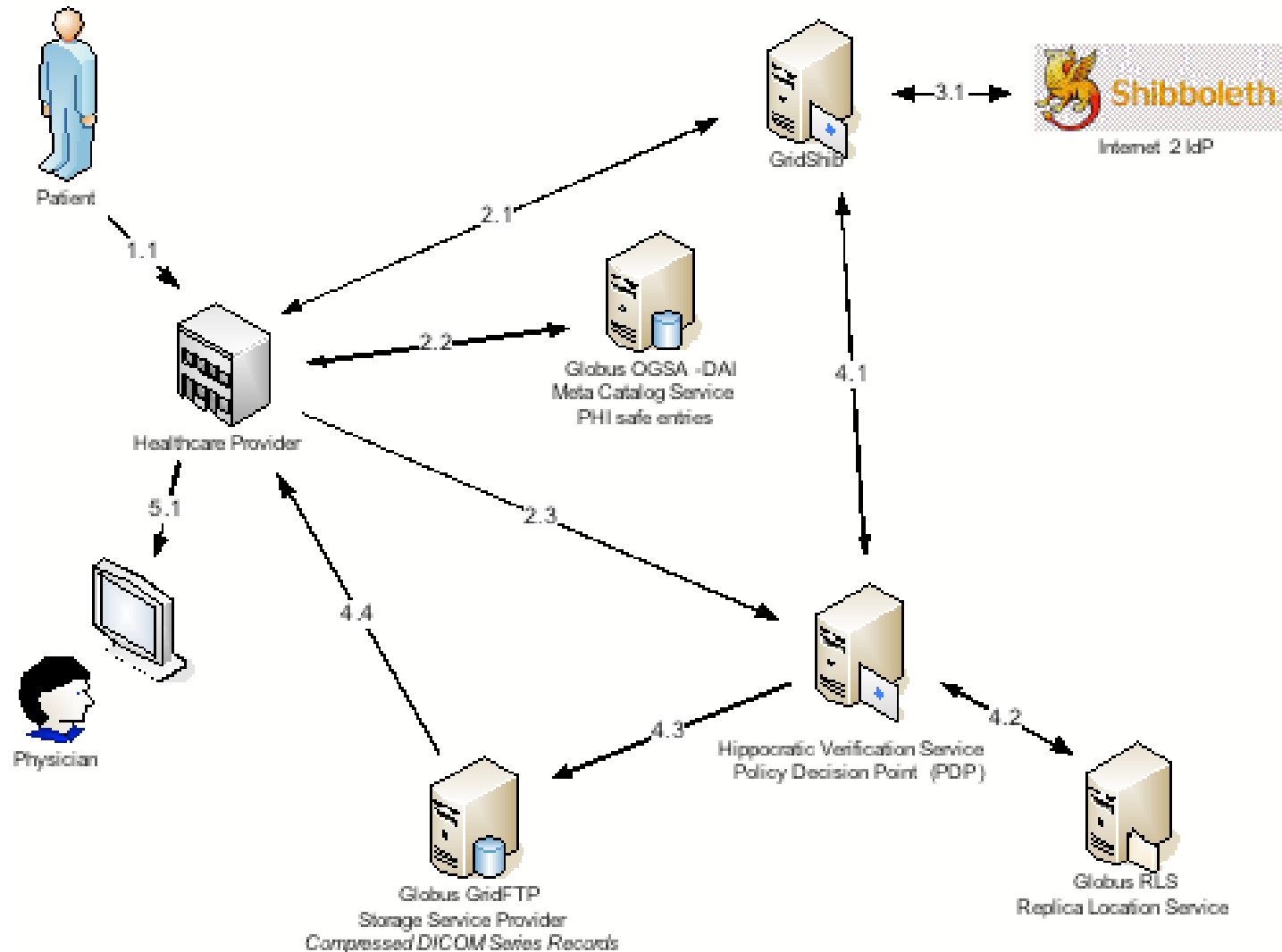 - Typical use-case: SOA of third-party storage, image processing services require no-PHI access to DICOM
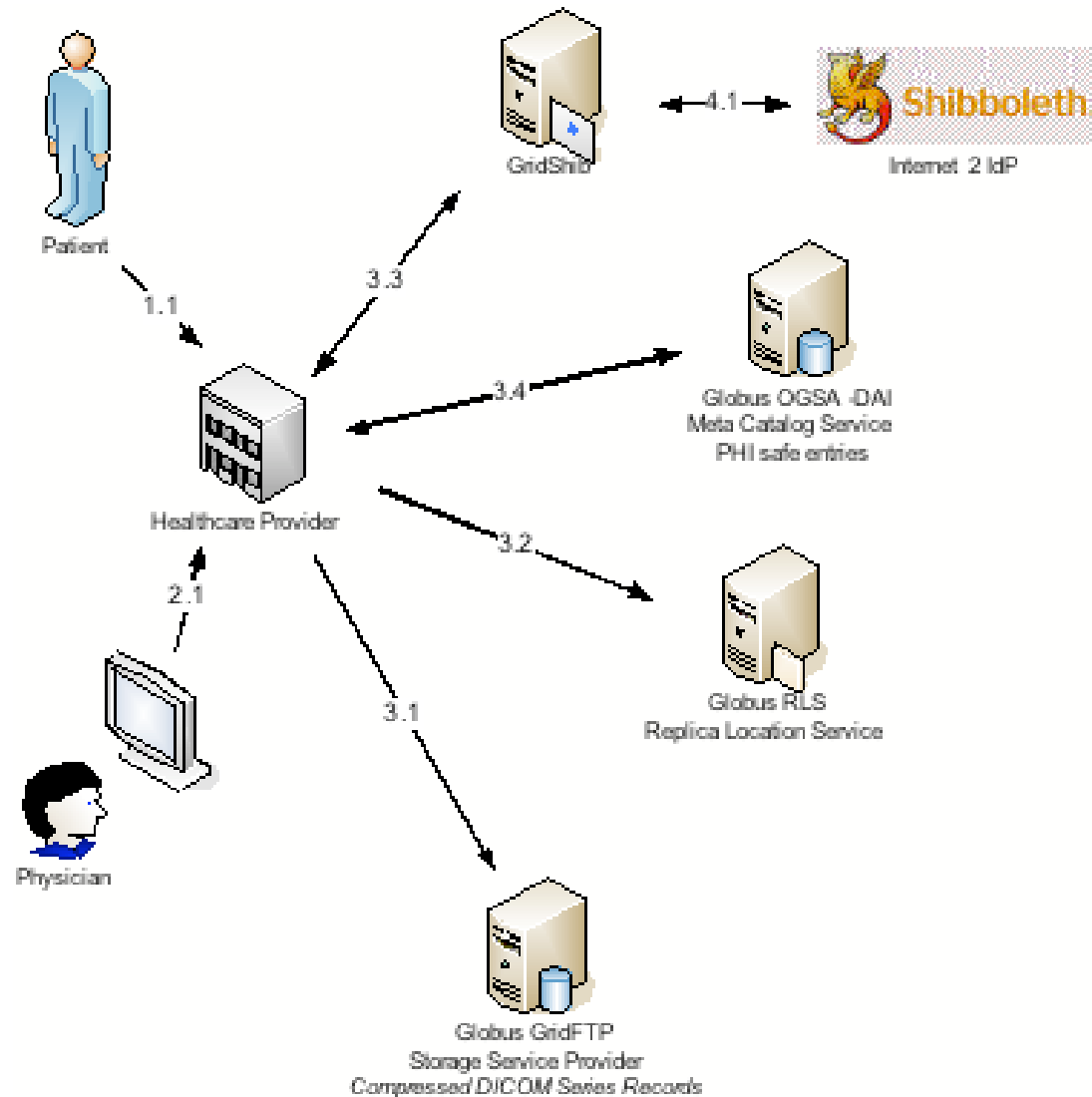
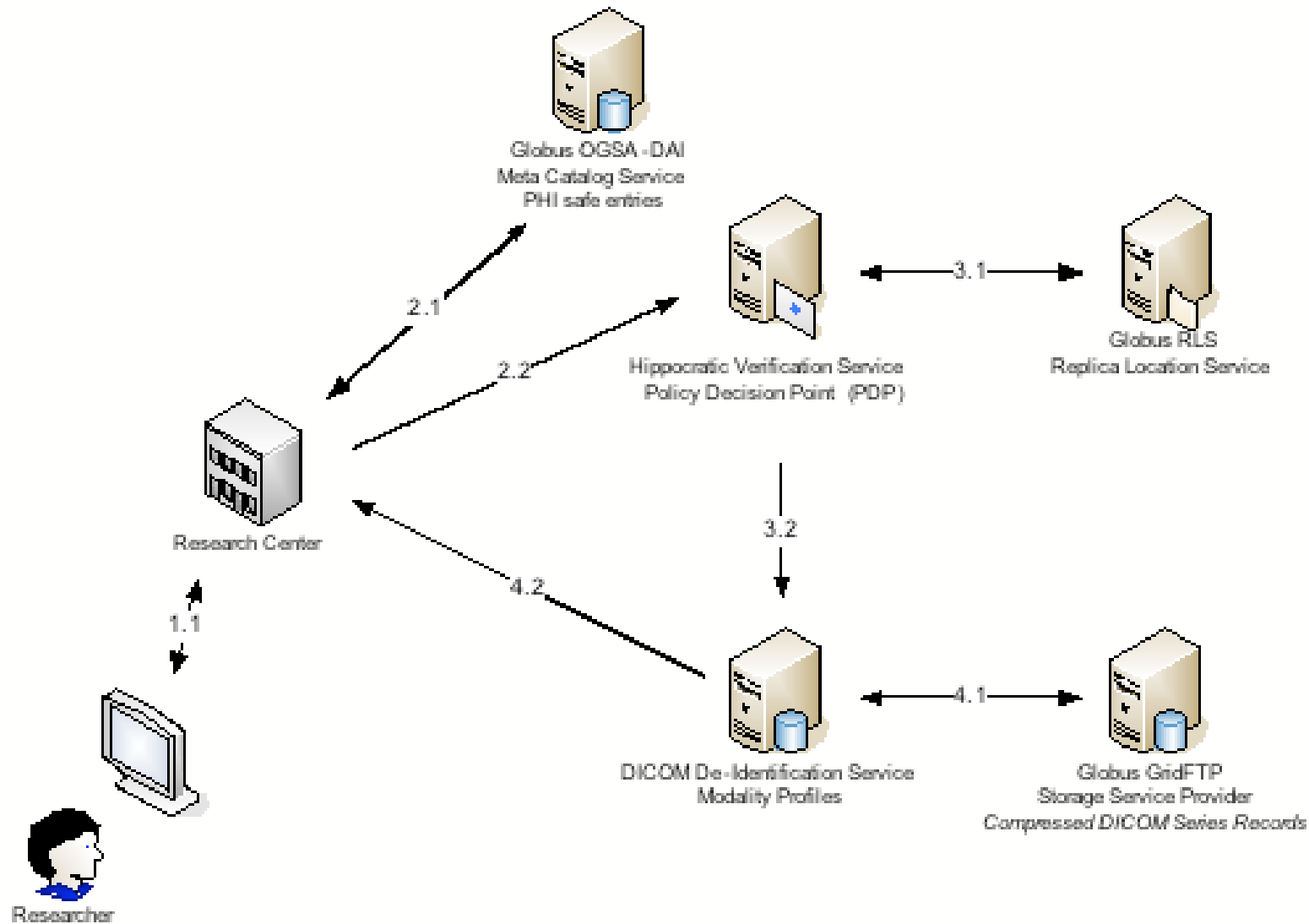# Global Patient Record
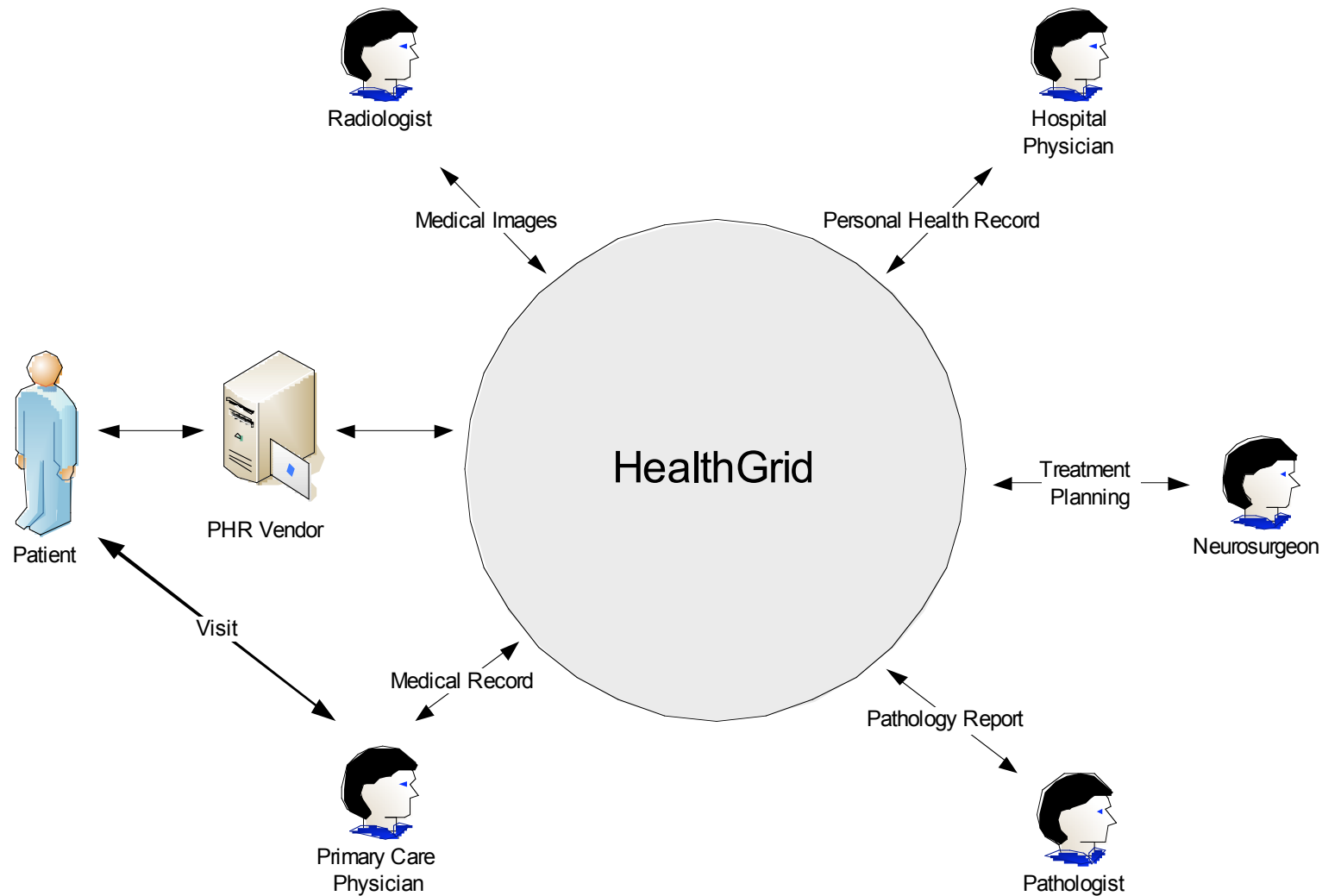
Patient Authorized Grid Image Workflow

PHI and Medical Record Publication

HIPAA Compliant Research Access

Globus OGSA -DAI
Meta Catalog Service
PHI safe entries

2.1

2.2

Hippocratic Verification Service
Policy Decision Point (PDP)

3.1

Globus RLS
Replica Location Service

Research Center

1.1

3.2

4.2

DICOM De-Identification Service
Modality Profiles

4.1

Globus GridFTP
Storage Service Provider
Compressed DICOM Series Records

Researcher

the globus alliance
www.globus.org

I2 Shibboleth – Identify Federation

Gartner

Research

Publication Date: 28 November 2006   ID Number: G00144216

Findings: Higher Education Institutions Should Prepare for Identity Federation

Jan-Martin Lowendahl, Gregg Kreizman, Michael Zastrocky, Marti Harris

The global nature of higher education research includes funding from national and international bodies. These bodies are streamlining their application processes by electronic means, demanding digital identities from the applicants.

- *I2 announcement 01/17/2007: .. Both the US National Science Foundation (NSF) and National Institutes of Health (NIH) are moving in this direction. The report states that "the federation model with the most momentum is Shibboleth".*
- GridShib using Shibboleth
- OASIS standards based SAML assertions
- GT4 - X.509 certificates with embedded SAML assertions

Federal X.509
Health Provider Certification – US case
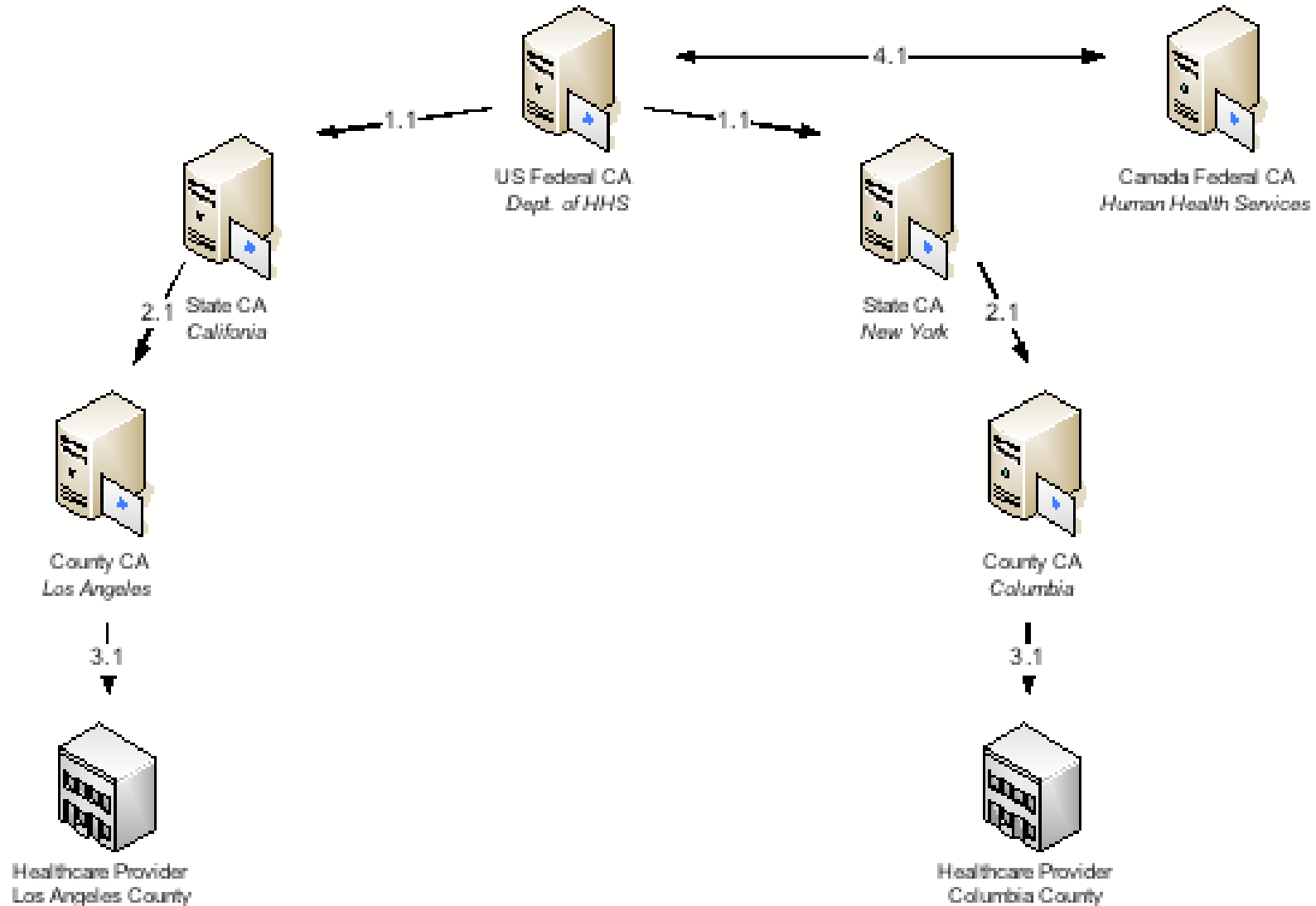
PHI save workflow with PCA

the globus alliance
www.globus.org
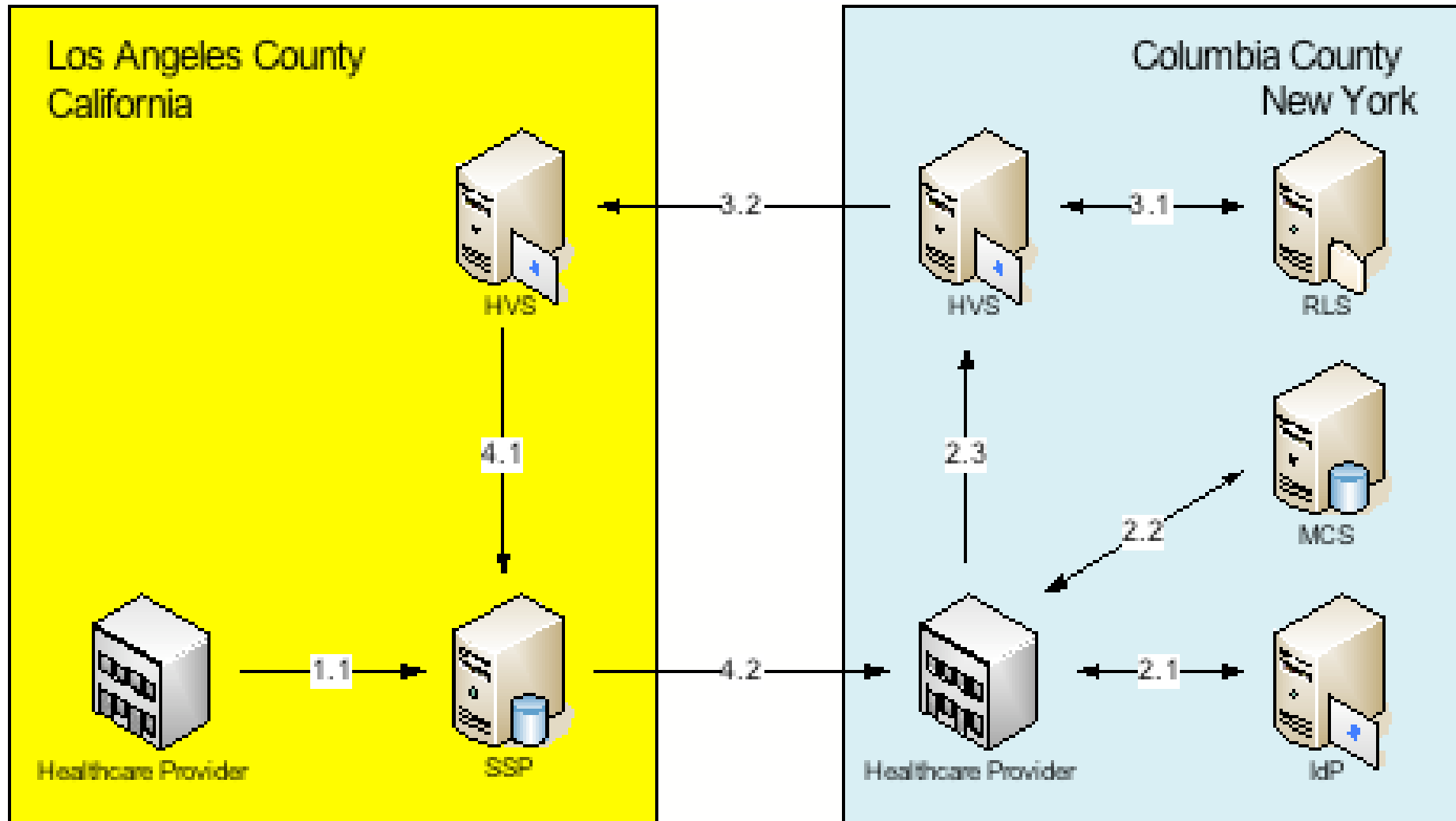
Globus MEDICUS Use-Cases

- **Multi-center clinical trials**
  - Children's Oncology Group Phase-I
    28 international medical centers (since 09/2003)
  - NANT Cancer Foundation
    13 national medical centers (since 12/2005)
- **Off-site Medical Image Storage**
  - Enterprise PACS / Grid PACS
  - FT and DR by replication using Globus Data Replication Service (DRS)
- **Medical Image Federation**
  - Enterprise Hospital VO
  - Military VO
  - Community Practices VO
  - Etc.

MEDICUS use cases: Childrens Oncology Group and Neuroblastoma Cancer Foundation Grids

the globus alliance
www.globus.org
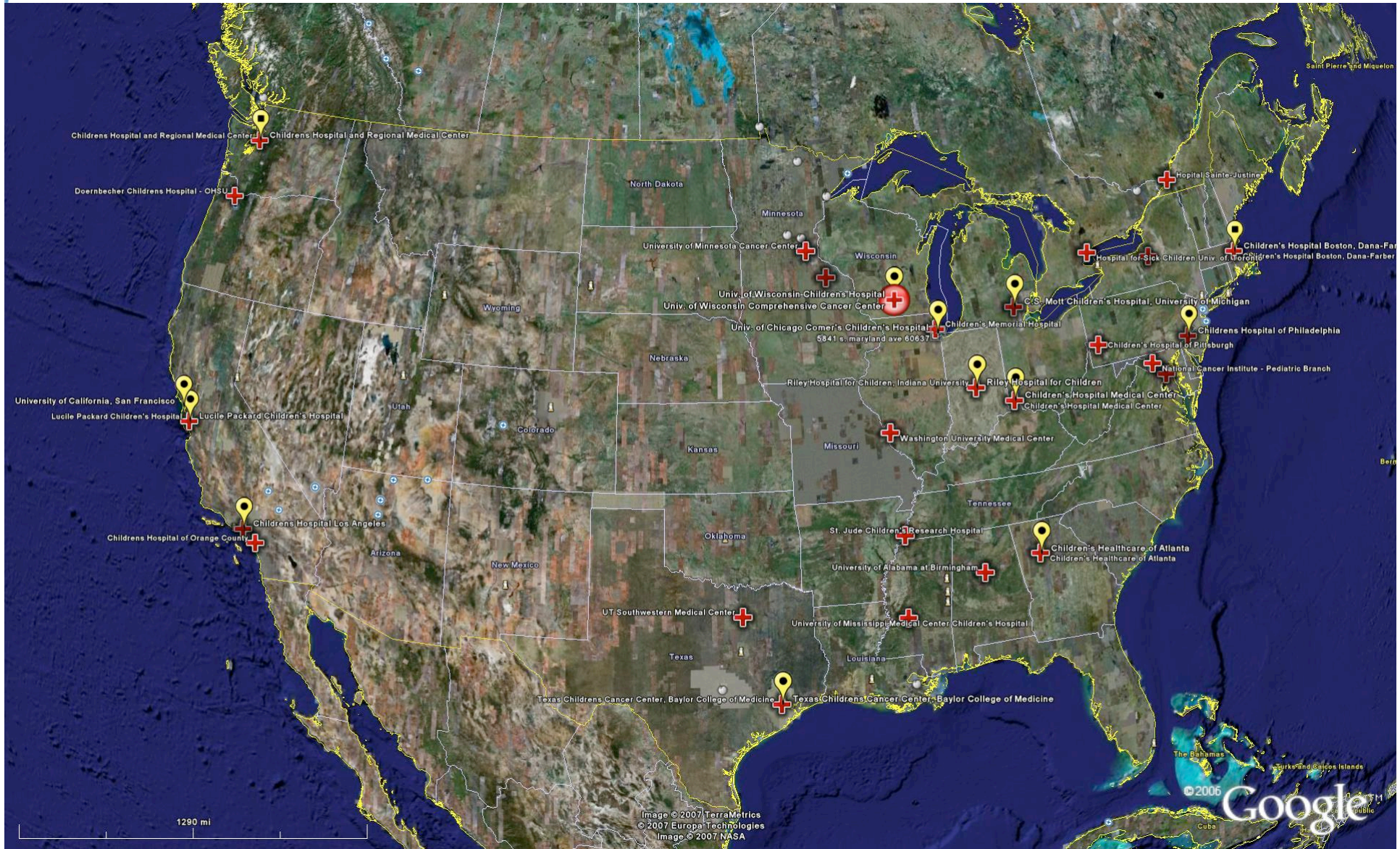
Thalassemia use-case

- Thalassemia is the most common inherited disease in the world, with particularly high prevalence in the Middle and Far East.

- Patients are chronically anemic and many require tri-weekly blood transfusions (2-3 Units apiece) for survival.

- One unit of blood carries as much iron as a patient would absorb from the gut in one year; the body cannot eliminate excess iron.

- Iron accumulation in the endocrine glands and heart are universally fatal if untreated.

Monitoring Iron Removal Therapy

- Oral and parenteral drugs exist to remove iron but therapy must be monitored closely.

- MRI has been used to quantitate iron in the liver, heart, pancreas, kidney, and pituitary.

- Iron estimates by MRI require dedicated personal and software for accurate assessments.

- Smaller imaging centers are unlikely to invest the necessary time and effort.

the globus alliance
www.globus.org

Pilot Demonstration Project
October 2008

- **Thalassaemia Conference, Oct 2008, Singapore**
  - ◆ Organizer: KK Woman's and Children's Hospital
  - ◆ SingHealth participation
  - ◆ Thalassaemia community

- **Demonstration: iron-load Thalassaemia screening**
  - ◆ Globus MEDICUS Grid-based iron-load MR image management
  - ◆ Globus GRAM Grid-based iron-load image processing
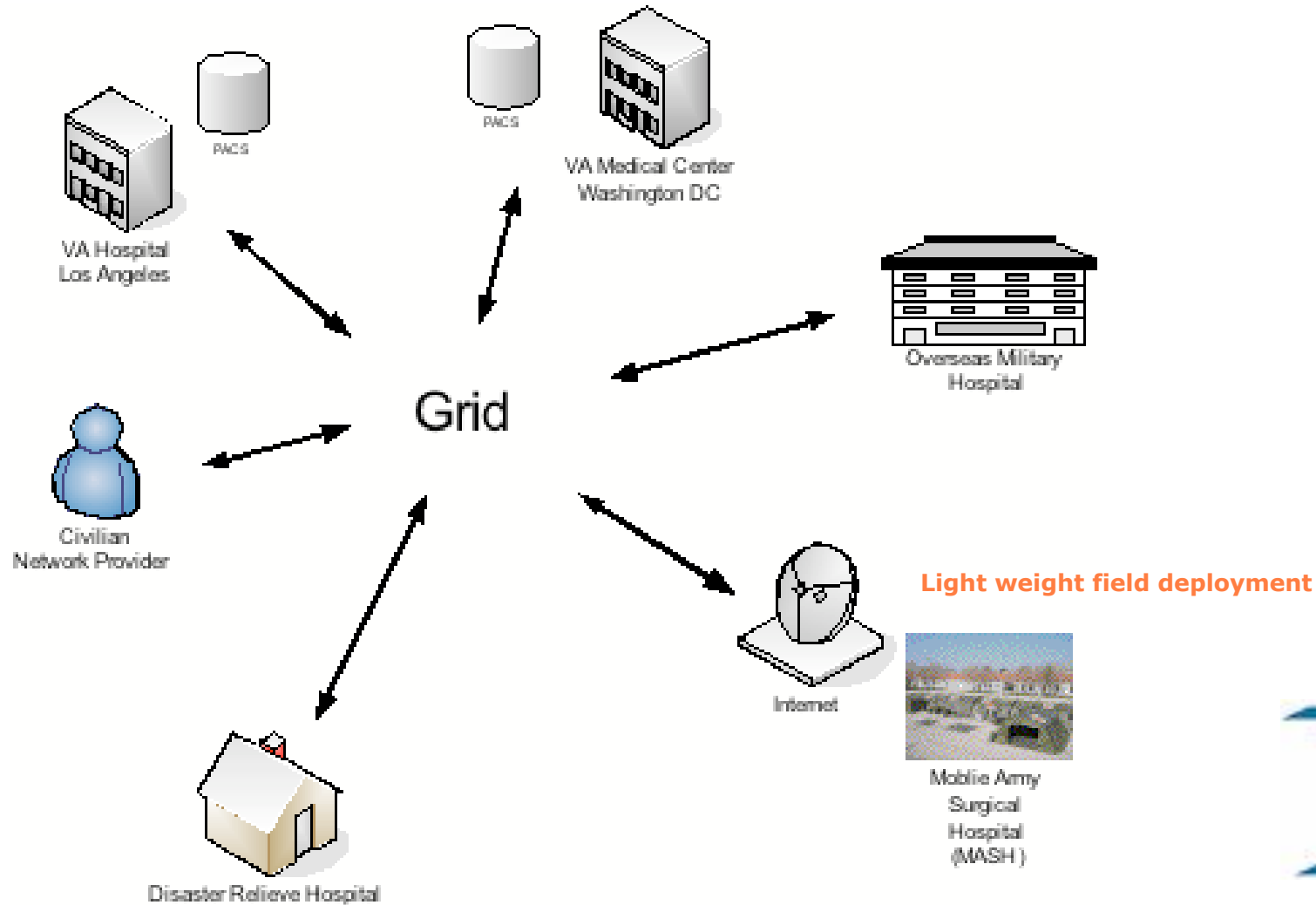 - ◆ Live Grid access to iron-load results
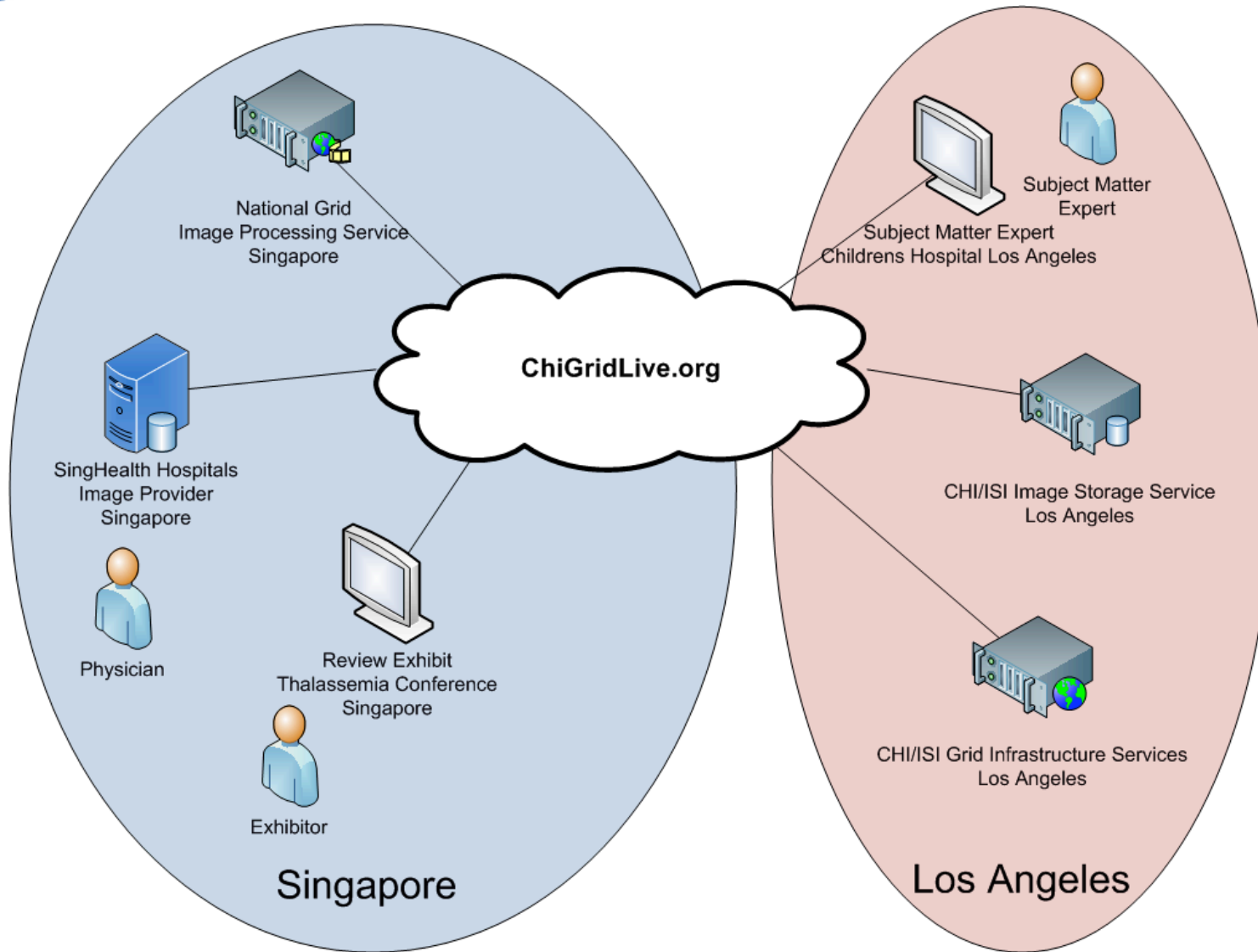
Clinical and Research
Image Management, Processing & Review
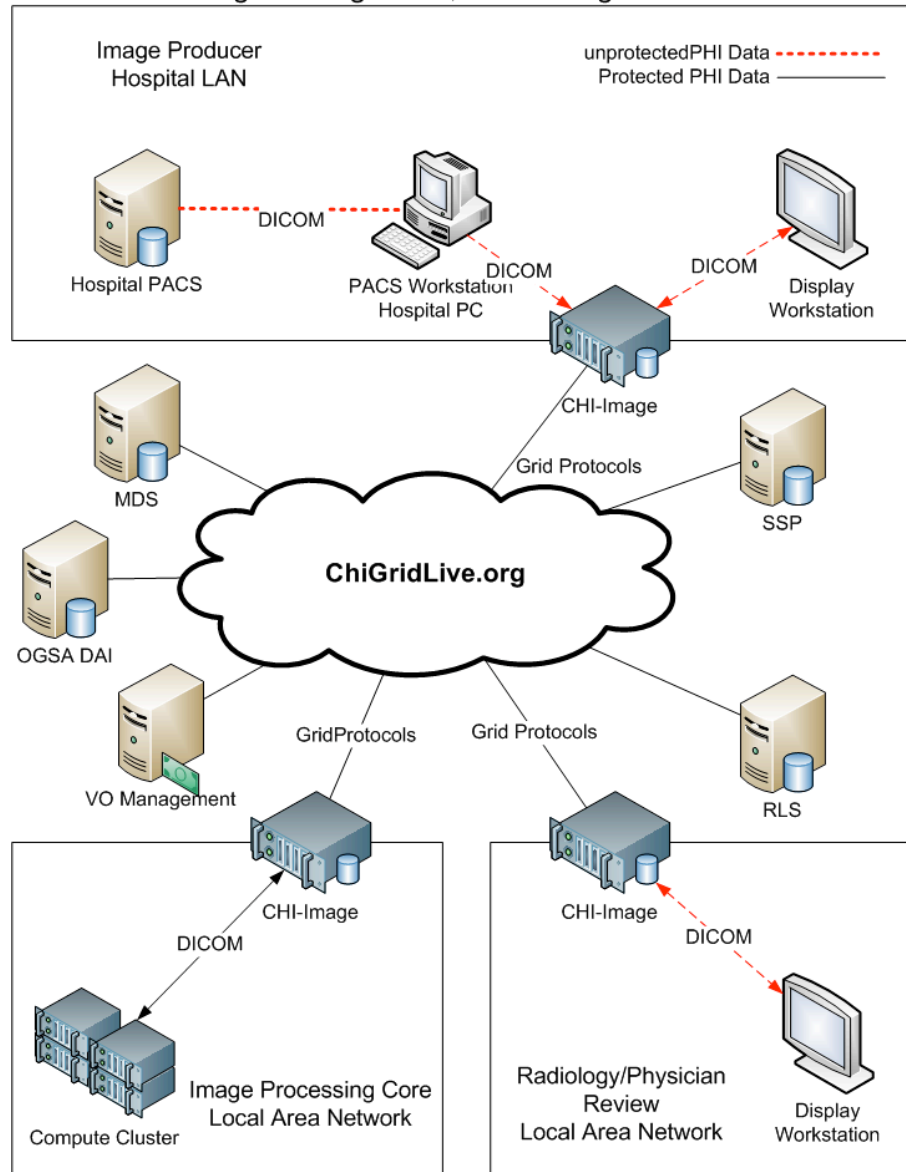
TATRC use-case: Warfighters Healthcare, VA system, Disaster Relieve

the globus alliance
www.globus.org

Summary

- MEDICUS vertically integrates existing standards based GT4 components – no research specific layer
- Fast and efficient DICOM off-site storage
- Integrates with hospital PACS + FT and DR
- Transparent image workflow for Physician
- Flexible and cost efficient deployment using open-source (~ $500 per TB)
- PHI protected at patient level
- Single HealthGrid solution for Clinical and Research use of same images

Conclusion

- MEDICUS present one piece to HealthGrid puzzle

- Modular SOA design ideal for collaborative extension, e.g. image processing web services using DICOM image resources on the Grid

- Open-source (Apache license), part of the Globus Toolkit Development release:
  You are invited to contribute your field of expertise
  dev.globus.org/wiki/Incubator/MEDICUS

- Roadmap: Standards based PHR, Workstation Grid plug-in, IHE XDS/-I WebServices

Acknowledgment

http://dev.globus.org/wiki/Incubator/MEDICUS

Horizon Award Winner 2007

Information Science Institute

IDEA Award

Winner 2007