The Medicine Behind the Image

Open Source Software

-

Is it a Viable Alternative for a Healthcare Institution?

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CTO - RadPharm, Inc.

RadPharm
The Imaging Core Lab

Acknowledgements

- Several recent presentations by various PACS luminaries
  - Steve Langer (Mayo)
  - Brad Erickson (Mayo)
  - Paul Nagy (University of Maryland)
  - Steve Horii (University of Pennsylvania)

- Most recent (RSNA 2005) talk at OpenRad
  - http://www.openrad.com/rsnaopensource.pdf

Is Proprietary PACS Viable ?

- Why are PACS much more expensive than the underlying off-the-shelf PC, server and storage hardware ?
- How profitable is PACS for the vendor ?
- Will the vendor fail or be acquired ?
- Will the installed base survive acquisition ?
- Will there be long term support ?
- How long will the current offering last before sites are forced to upgrade ?
- Big vendors are not immune - how many PACS have the they built or acquired then orphaned ?
- Is their pace of innovation sufficient ? It only needs to be “incrementally better than the competition”

Is Open Source Viable ?

- Does it exist for your application ?
- How much hand-holding do you need ?

- Open source deployment is about taking control
- With control comes responsibility

- Requires that you have the necessary expertise to deploy and support - may be out-sourced

What is Open Source Software ?

- Open source software (OSS) licensees are free to:
  - Use software for any purpose
  - Make and distribute copies
  - Create and distribute derivative works
  - Access and use the source code
  - Combine open source and other software (Restated by Rosen, 2004)
- Open Source Initiative (OSI)
  - http://www.opensource.org/docs/definition.php
- Free Software Foundation (FSF)
  - http://www.fsf.org/
  - Adds requirement that any derivative works be redistributed under the same license (i.e., with source code) - “copyleft”, reciprocity

The meaning of “freedom”

- In English, free means (in this context) either
  - At no cost (“gratis”)
  - Without restriction (“libre”)
- FSF principles - the freedom to
  - run the software for any purpose (0)
  - study how the program works and adapt it to your needs (1)
  - redistribute copies so you can help your neighbor (2)
  - improve the program, and release your improvements to the public, so that the whole community benefits (3)
- Access to the source code is a precondition 1 & 3
- Distribution cost does not have to be zero, but freedom 2 implies that anyone (else) may distribute it for nothing
- F/OSS - Free or Open Source Software

Intellectual Property and F/OSS

- There is an “owner” of the “property” that is the code
- Ownership of property is a right to exclude others from using it
- Embodied in copyright and patent law
- Owner may grant rights to others through a license or contract
- F/OSS - the rights granted establish the context for use and distribution
- F/OSS advocates are not “against” property rights - they depend on them to enforce the license
- F/OSS is not “public domain”, i.e., no longer has an owner

(See Rosen, 2004)

Historical Perspective

- Only the F/OSS terminology and formalisms are new
- Programmers have been exchanging software since computers were invented
- Long recognized that some fundamental tools are too important, too complex or too urgently needed to build “in-house”
- Today referred to as “pre-competitive collaboration” (see Weber, 2004)
- 1952 - Project for the Advancement of Coding Techniques (PACT)
- 1955 - SHARE (IBM)
- 1961 - DECUS (Digital Equipment)
- 1973 - Unix distribution outside Bell Labs
- 1978 - First Berkeley (BSD) Unix distribution
- 1985 - FSF founded - Richard Stallman
- 1997 - Cathedral and Bazaar paper - Eric Raymond
- 1998 - Jan - Netscape announces source code release
- 1998 - Feb - “open source” term - less provocative alternative to “free”
- See http://www.opensource.org/docs/history.php for 1998 events

How can OSS exist ?

- Political economic public goods theory of industrial era predicts that it should not:
  - non-rival and non-excludable goods subject to collective provision should encourage free riding and hence unravel backward toward under-provision
  - “non-rival” - if an individual consumes, others have no less
  - “non-excludable” - individuals who have not contributed can use it
  - “collective provision” - requires a lot of contributors
- Therefore, Linux is “impossible”
- Demonstrably, it is not, so need to reassess
  - The motivations of individuals contributing
  - Mechanisms of coordination
  - Implications of complexity for governance

(See Weber, 2004)

Types of F/OSS

- Operating system
  - Linux, BSD variants
- Database
  - MySQL, Postgresql and others
- Web server
  - Apache
- Scripting and languages
  - Perl, PHP, gcc and g++, and others
- Desktop productivity
  - Open Office, GIMP
- Vertical applications
  - Such as PACS, RIS

Linux

- How many in the audience use Linux ?

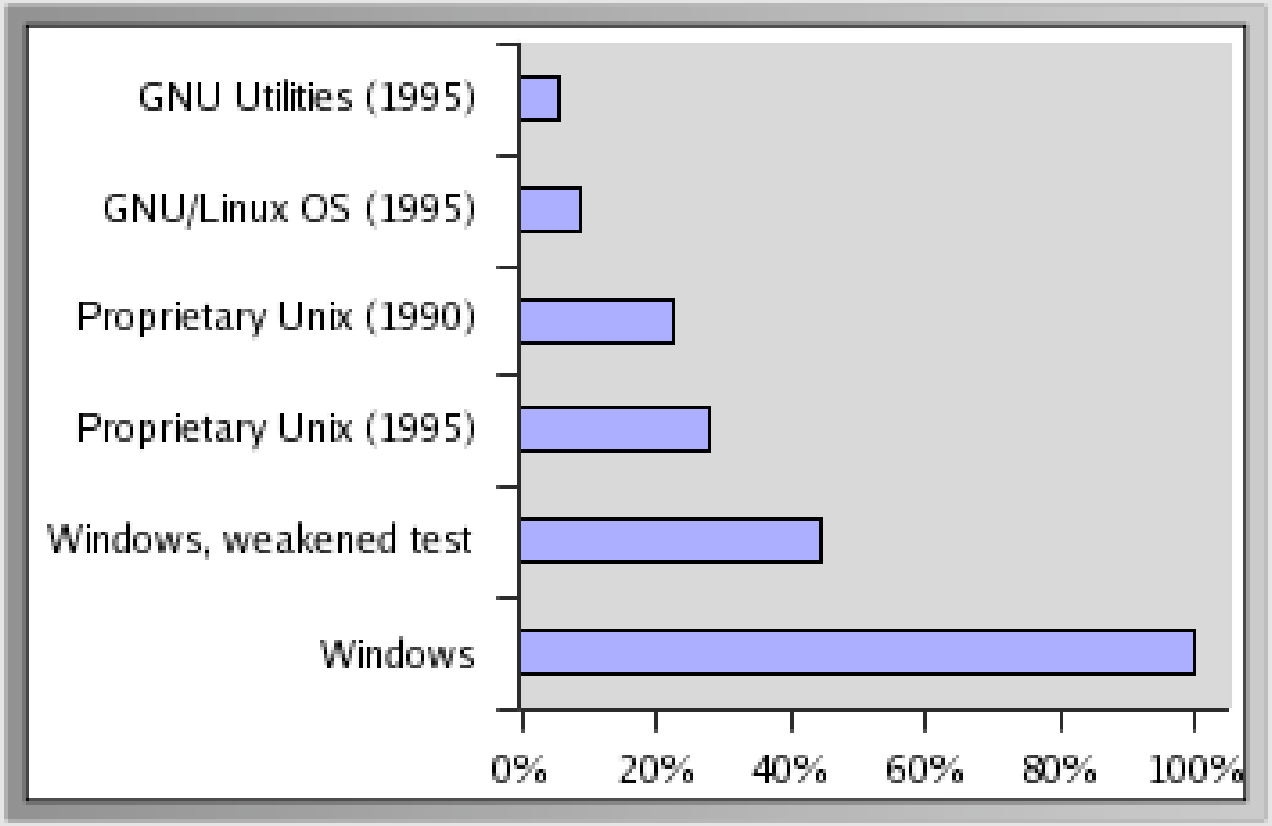
Linux

- How many in the audience use Linux ?
- How many in the audience use Google ?

Linux

- How many in the audience use Linux ?
- How many in the audience use Google ?
- All of the latter use a cluster of > 10,000 Linux servers (Weber, 2004)

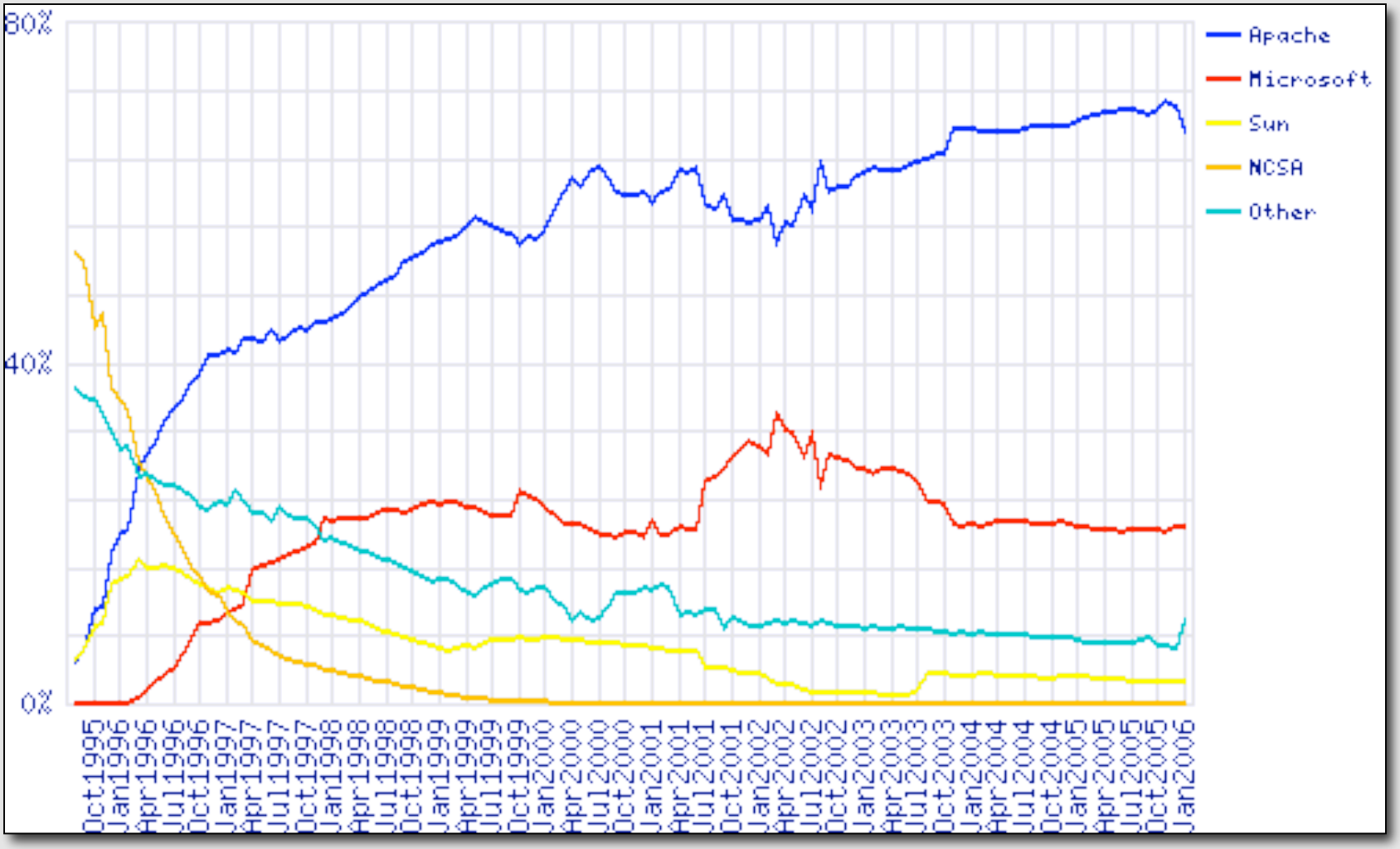
Linux Reliability



Fuzz test - type random characters and see what crashes
Wheeler, 2005 http://www.dwheeler.com/oss_fs_why.html

Apache Web Server

- Has dominated since mid-nineties
- Runs 67% of all web servers
- Non-profit Apache Software Foundation
  - Created as “a more coherent and structured organization that would shield individuals from potential legal attacks”
  - Administered as a meritocracy
- “Scratch the itch” - project began by NCSA users who were no longer supported by original developers (who had lost interest)
- Note that early on there were few if any commercial web servers either - filled a void and became “market leader”
- Has diversified into many infrastructure sub-projects, each useful in their own right beyond web servers



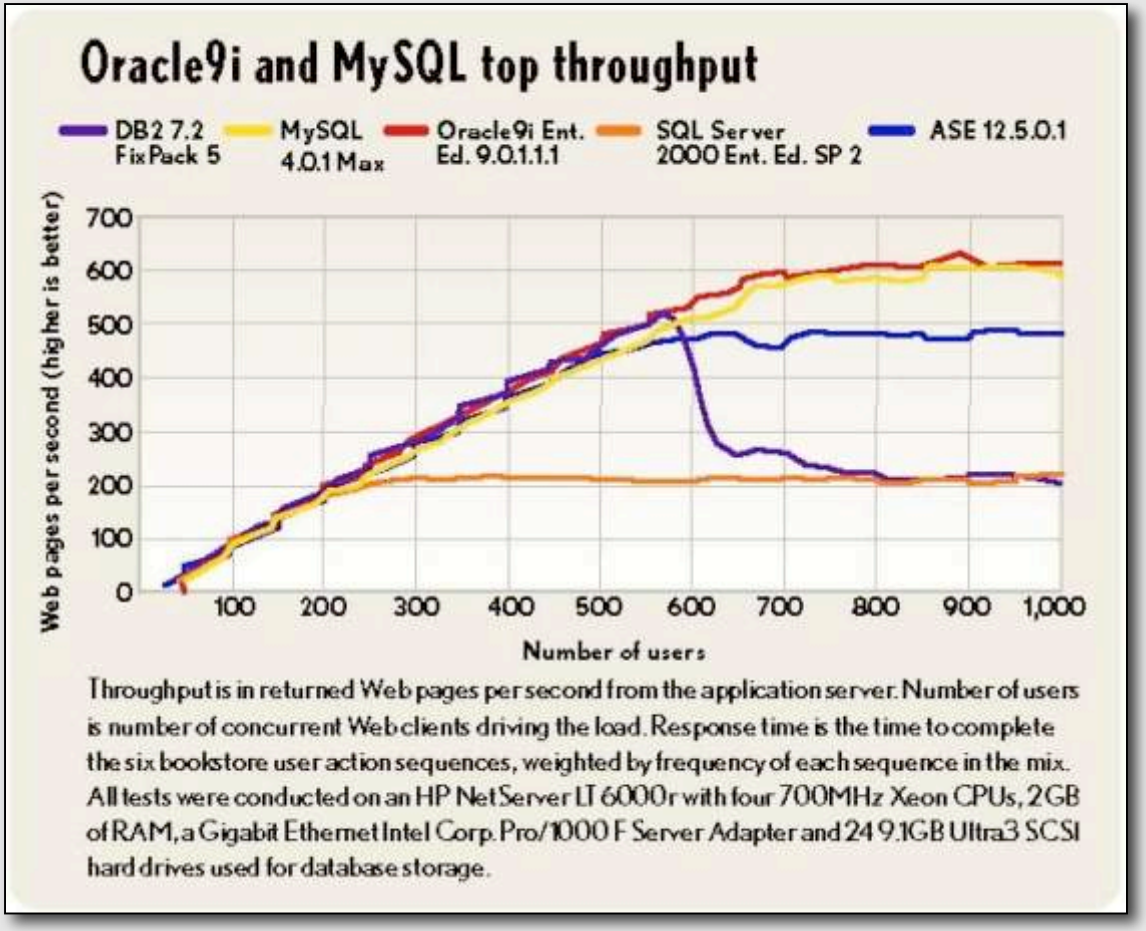
Source: Netcraft: Web Server Survey Archives

http://news.netcraft.com/archives/web_server_survey.html

MySQL Database

- Most widely recognized open source database
- Every significant web server application requires a database, hence typically deployed in conjunction with other OSS tools - Linux, Apache, MySQL and Perl/PHP/… (“LAMP”)
- Dual License concept
  - Open source license - GPL-based - distributors of applications based on MySQL are required to distribute their source in turn
  - Commercial license - allows distribution of applications based on MySQL without source

Database Performance



eWeek, Dyck, 2002 Server Databases Clash

http://www.eweek.com/article2/0,3959,293,00.asp

Point of the Foregoing

- Not that F/OSS is necessarily better, but
- It is possible at all
- It can dominate a market segment
- It can be reliable
- It can be high performance
- It can be scalable
- It can co-exist with proprietary software
- It can be commercialized

Sources of Revenue

- Provision of support, packaging or distribution at cost
- Multiple licenses
  - Proprietary license that removes source code redistribution requirement
  - OSS version is crippled or deficient in some respect relative to proprietary version
  - Note that licenses that prevent commercial *use* are by definition not open source
  - E.g., “free only for research, education or non-commercial use” means not open source
- Voluntary contributions (à la public television)
- Advertising on web sites
- Government funding in the public interest
- F/OSS is avowedly and demonstrably not “anti-commerce”

Puzzled by altruism ?

- Giving away something for nothing ?
- Why write it in the first place ?
- Need the software for themselves anyway (scratch the itch)
- Gain from the feedback/review/fixes
- Enhance the developer's reputation
- Validate their creativity (software is an art)
- Some fantasize about creating a market for services

Open Source Developers

- Not just “hobbyists” in their spare time
- Funded academic development
  - Individuals, teams, consortia and commercial collaborations
- Government funded contracts
  - E.g., ITK (Kitware, Inc)
- Commercial ventures
  - E.g., IBM (Eclipse, patent sharing), Sun (Star/Open Office)
- Sponsored demonstrations and projects
  - RSNA (DICOM and IHE), NEMA
  - Produce open source test tools and reference implementations
- But don’t dismiss “hobbyists”
  - GIMP (GNU Image Manipulation Program)

Government Funding

- Even government funded professional open source is "selfishly motivated"
- E.g., NIH needs long term benefits of ITK
- Better CAD algorithm development, testing and validation, and regulatory approval
- Open source is a means to an end (broader use of the funded deliverables), not an end in itself

- *Recognition that open source enables progress and improvement, proprietary closed source may hinder it*

Openness

- Open Source Software
- Open Standards
- Open Document Formats
- Open Data
- Open Science
- Open Publishing
- Open Knowledge

Government Initiatives

- Policy to allow open access to funded research output and maximize re-use (e.g., data, code, algorithms, not just articles)
- Policy to allow user access to government data in non-proprietary formats
- Policy to increase public (consumer) accessibility of research results
- Policy to direct funding to enabling technologies and collections (e.g., images with truth for verification of CAD)

Regulatory Implications

- Use versus sale (commercial distribution of a medical device)
- Only commercial distribution triggers the FDA's involvement, except for mammography
- Sites may have their own more onerous policies
- In lieu of regulation, how to establish quality and reliability ?
- Third party testing, documentation, support, certification, and even submission for approval
- Easier if sound software engineering methodology used in the first place - design controls, documentation, automated regression testing
- Many PACS components are exempted from 510(k) or PMA anyway, as long as they don't use irreversible compression, but not exempt from GMP and QSR
- See http://www.fda.gov/cdrh/devadvice/
- Some other countries might regulate usage - e.g., Germany

Undesirable F/OSS features

- Potential for
  - Lack of “productization” (Woods & Guliani, 2005)
  - Poor non-developer documentation
  - Unspecified development life cycle
  - Poor tracking of change requests to code changes
  - Poor tracking of bugs
  - Pace of innovation may exceed stability - each new feature or bug fix breaks something else
  - Lack of regression testing, stress testing or any testing at all (rarely documented)
  - No clear roadmap
  - Not restricted to F/OSS - shared by many proprietary products :)
- Some F/OSS projects are more mature than others
  - Linux, MySQL, Apache, etc., have documentation by others
  - Kitware testing process for ITK, VTK and related software

Kitware: [VTK | ITK | Paraview | CMake], External: [Xdmf | IGSTK | Fltk | MITK | Slicer | NAMIC | **GDCM** | Public]

Kitware Inc - *Leaders in Visualization Technology* Search

Logo/Homepage link

Dashboard - Fri Jan 06 17:00:14 EST 2006

Friday, January 06 2006

Dartboard Date ◀ T ▶ Updates Tests Build CVS DoxygenHome Rollup

0 Files Changed by 0 Authors as of 2006-01-06 01:00 GMT

Nightly Builds

Site	Build Name	Update	Cfg	Build			Test					Build Date	Submit Date
				Error	Warn	Min	NotRun	Fail	Pass	NA	Min		
midworld.kitware	GDCM-DarwinG5-g++	0	0	10	6	2.2	32	0	0	39	0	Fri Jan 06 10:16:39 EST 2006	Fri Jan 06 10:24:18 EST 2006
Creatis.fc3.gcc	GDCM-FedoraCore3-gcc	0	0	0	0	1.7	0	0	32	39	2.2	Fri Jan 06 00:05:27 CET 2006	Thu Jan 05 18:14:12 EST 2006
Creatis.fc3.gcc	GDCM-FedoraCore3-gcc-Py	0	0	0	0	1.8	0	0	38	33	3	Fri Jan 06 03:05:32 CET 2006	Thu Jan 05 21:15:32 EST 2006
Creatis.fc3.gcc	GDCM-FedoraCore3-gcc-valgrind	0	0	0	0	1.7	0	0	32	39	2.4	Fri Jan 06 06:05:22 CET 2006	Fri Jan 06 01:37:11 EST 2006
farsight-gentoo	GDCM-Linux-g++	0	0	0	1	1.4	0	1	32	38	1.1	Jan 05 23:31 EST	Thu Jan 05 23:34:38 EST 2006
localhost	GDCM-Linux-g++	0	0	0	1	1.4	0	1	32	38	0.8	Jan 05 23:29 EST	Thu Jan 05 23:18:03 EST 2006

No Continuous Builds

So why consider F/OSS ?

- Mitigate the risks of a commercial solution
  - Feature set in initial product
  - Quality of support
  - Longevity of support
  - Pace of innovation
  - Cost of and restrictions on integration
  - Lack of standards compliance
- Factor out commodity components
  - Hardware for workstations, server, storage
  - Software for operating system, database, backups
  - Make support routine IT practice, not PACS-specific
  - Additional test, staging and development environments
- Introduces choice
  - Third party or in-house support and improvement
  - Opportunity (+ risk) of customizing to sites actual needs

Extra Environments

- Desirable to have separate systems for
  - Testing, e.g., prior to upgrade (of capacity or software)
  - Staging, prior to deployment
  - Training
  - Development
  - Research
  - [Offsite archive]
- Not a panacea for upgrade problems
  - Entire database and archive contents not replicated
  - Some problems arise only in “real world” use
- With F/OSS
  - Always possibly, incremental cost is only hardware and support
- With proprietary
  - Vendor may or may not provide lower licensing or temporary rental

Deploying F/OSS

- Maturity level of the software
- Maturity level of the (IT) organization
- Match these (Woods & Guliani, 2005)
- Start simple to gain experience
- Do not let enthusiasm exceed capability
- Technical expertise can be outsourced
- Vendors and products may disappear, but third party support is always possible with source code

Non-open Software

- Avoid it like the plague for use in production systems
- Crippleware or Trialware
  - Available at no distribution cost, but limited functionality, or time limited
- Freeware
  - Available at no distribution cost, full functionality, but dependent on continued interest of provider since no source
- Shareware
  - All the deficiencies of freeware, but you also are supposed to pay
- Share all the deficiencies of buying a proprietary solution from a small and potentially unreliable vendor
- The benefit of using F/OSS is *not* the negligible acquisition cost … hence nothing in common with these

Freeware

- No cost to use software (though uses sometimes restricted to research)
- No source code
  - Dependent on goodwill of developer to support, fix and improve it
  - Loss of interest or commercialization leads to dead end
- eFilm is the classic example
  - 1995 (?) - Toronto General Hospital (Greg Couch) - free (until 1.5.3)
  - eFilm Medical spun off
  - 2002 - acquired by Merge Technologies
  - 2006 - $950 per seat per year
  - Similar story with the other half - Montreal General Hospital -> Intelerad PACS
- Other Windows freeware viewers traveling the same path
  - DICOMWorks - free, buggy, hasn't been fixed for several years, author keeps promising new version, fears being taken advantage of if source released
  - K-PACS - free, better maintained, recently developed a commercial affiliation

Freeware

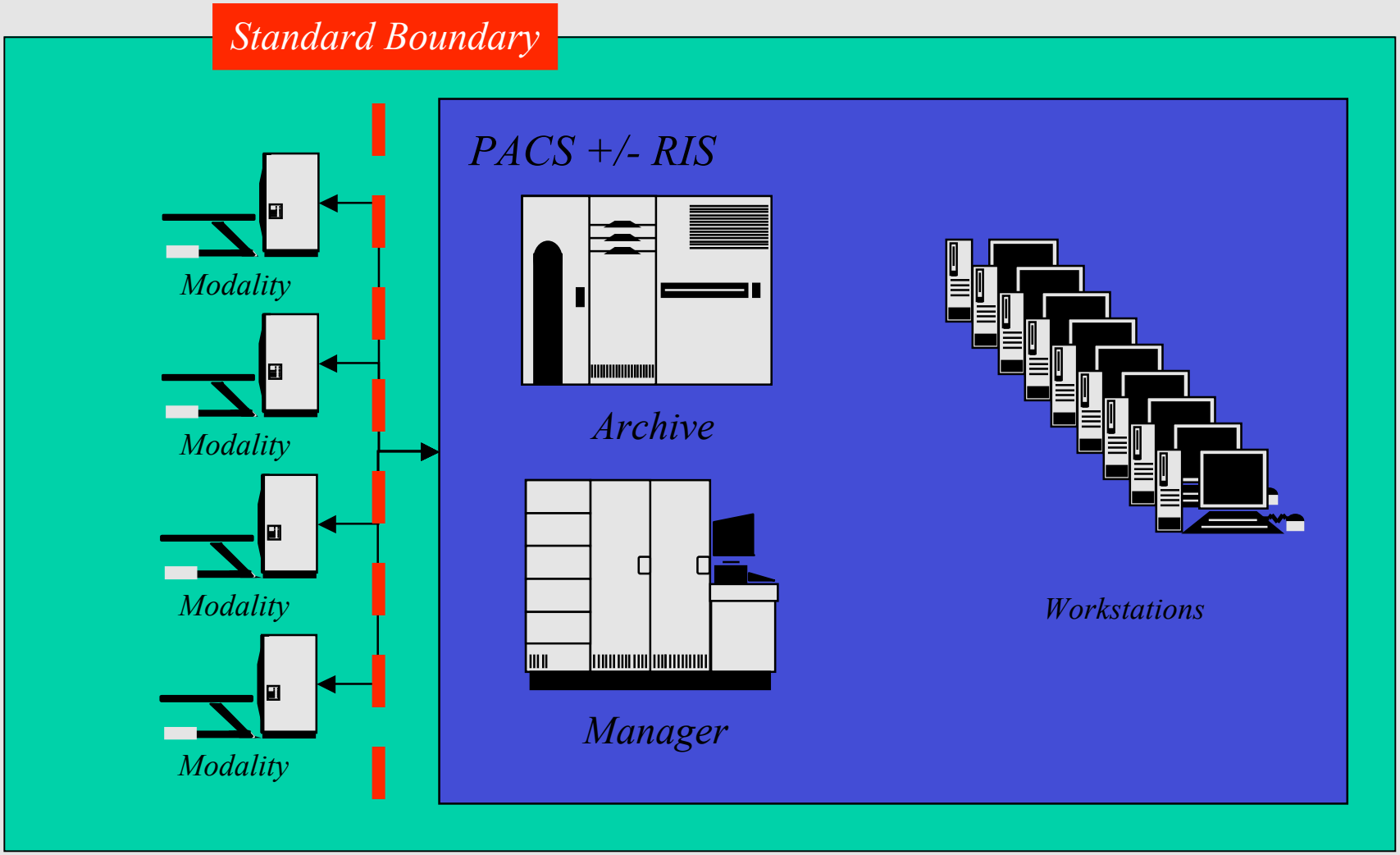
- PACSOne - turn-key web-based PACS
  - Free edition is Windows only, no source
  - Premium edition adds Linux, security, compression, query filters, routing, CD reading and writing, synchronization, remote archiving, database optimization for scalability and performance
  - Distinct form dual license F/OSS - if were open source user could improve on the free edition and share those improvements, without the source they cannot
  - Free rider - based on MySQL, PHP, ImageMagick, AiViewer

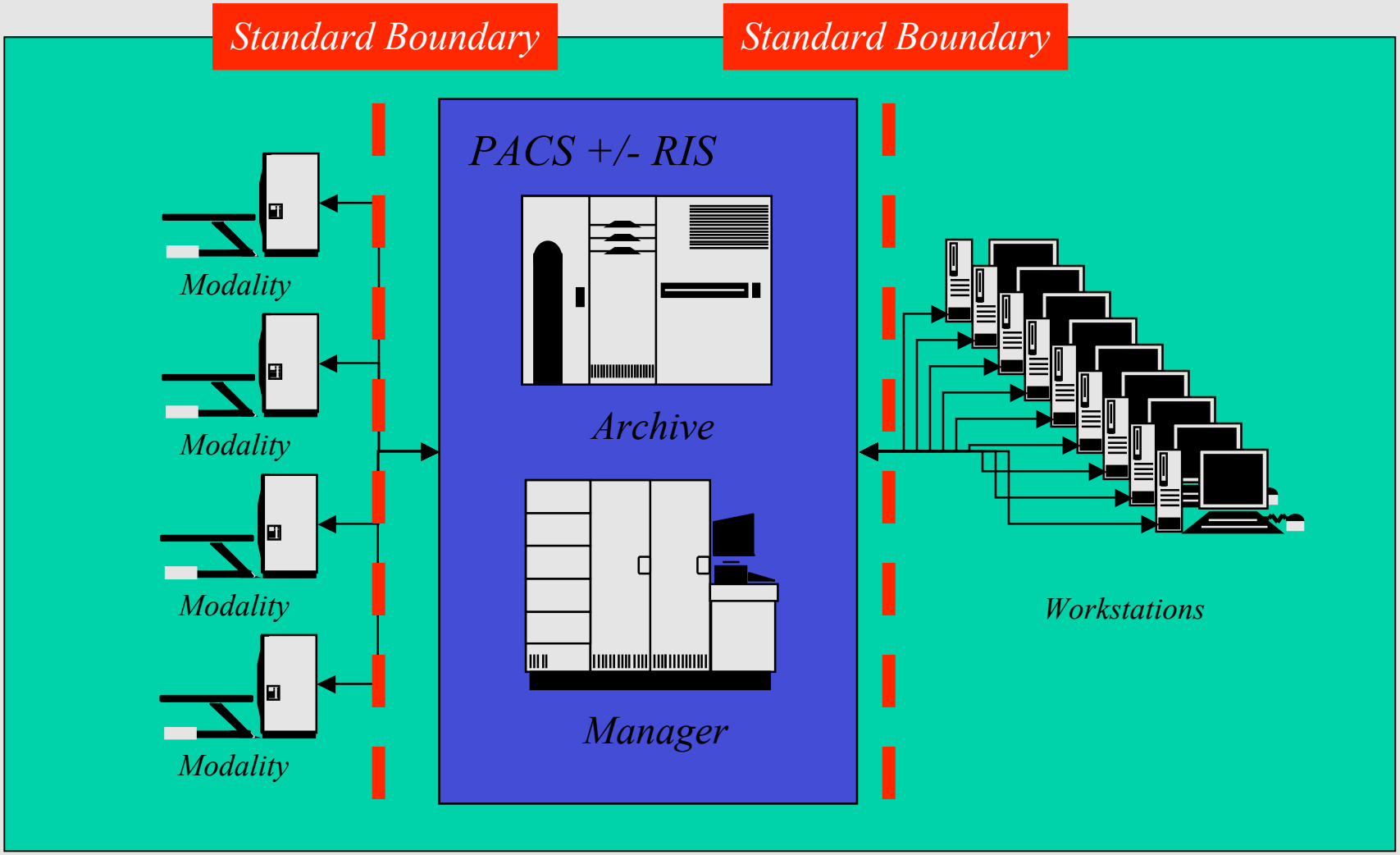
Some features of a PACS

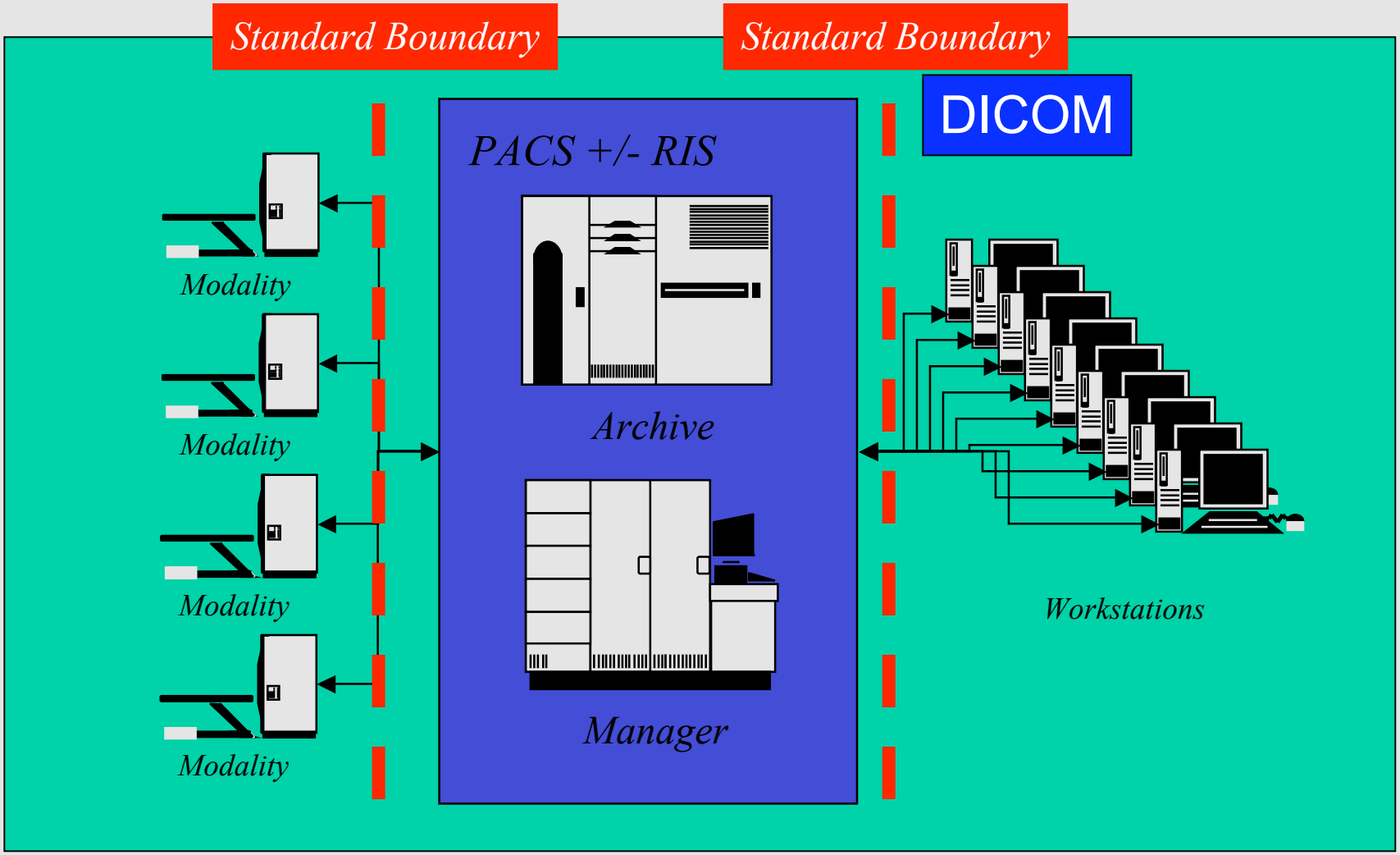
- Images captured from modalities
- Images displayed on workstations with priors
- Images archived
- Workflow management
- Report creation, review and distribution
- Off-site archiving and/or backup
- Security, including access control and audit trails
- Reliability and high-availability
- Remote accessibility (teleradiology)
- Image export (CD or film printing)

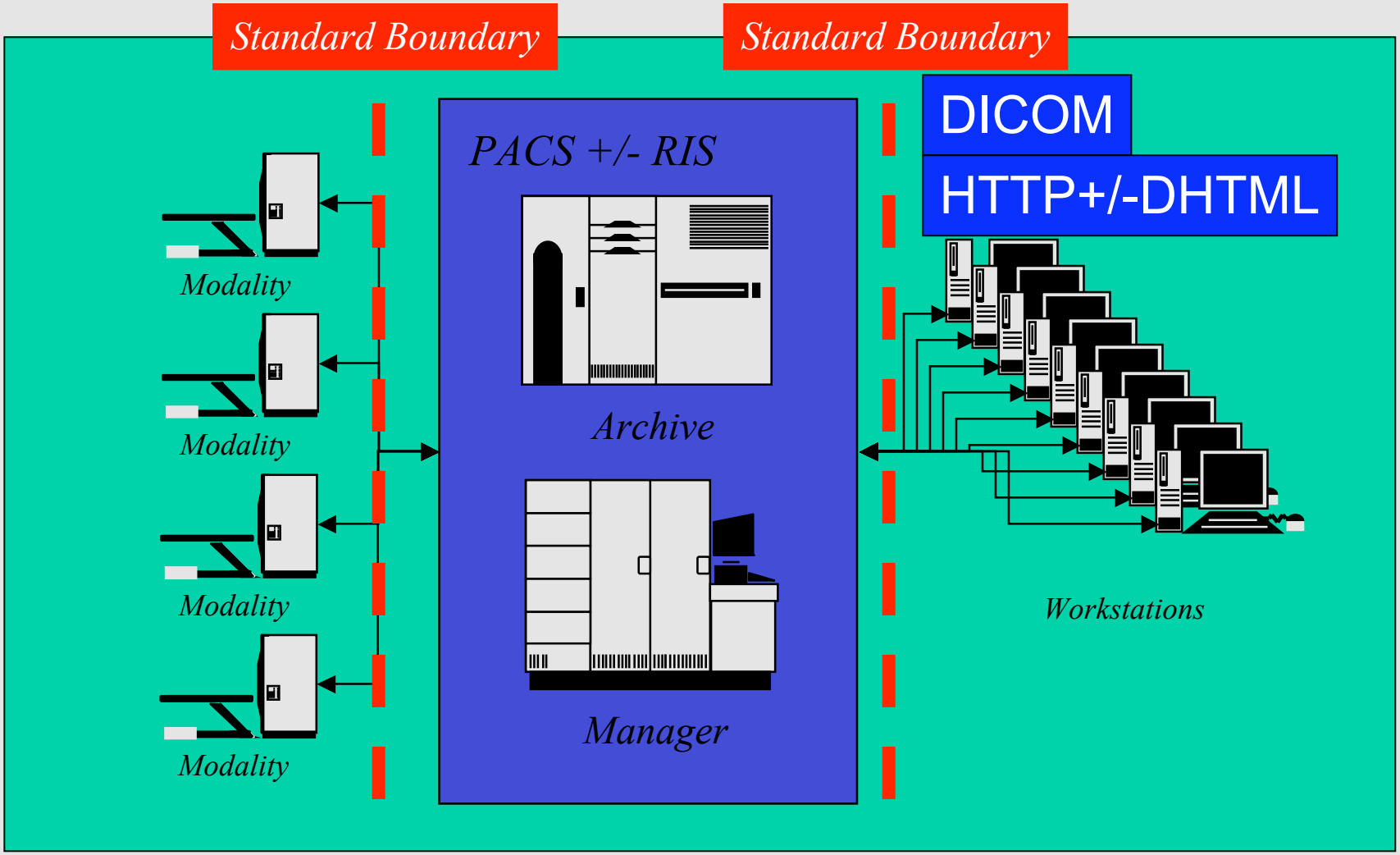
Standards are a pre-requisite

- No open source “modalities” yet
  - Though film scanner and photo capture drivers could be
  - Production of ionizing radiation likely to remain purely proprietary
- Standard interface from modality to PACS
  - DICOM image transfer unchallenged in this role
  - DICOM modality worklist and other workflow services
- Monolithic versus componentized PACS
  - Separate the archive, manager and workstation
  - DICOM image transfer, web-based image transfer
  - DICOM and HL7 workflow and integration services
  - Application collaboration conceivable with CCOW
  - Voice recognition for reporting

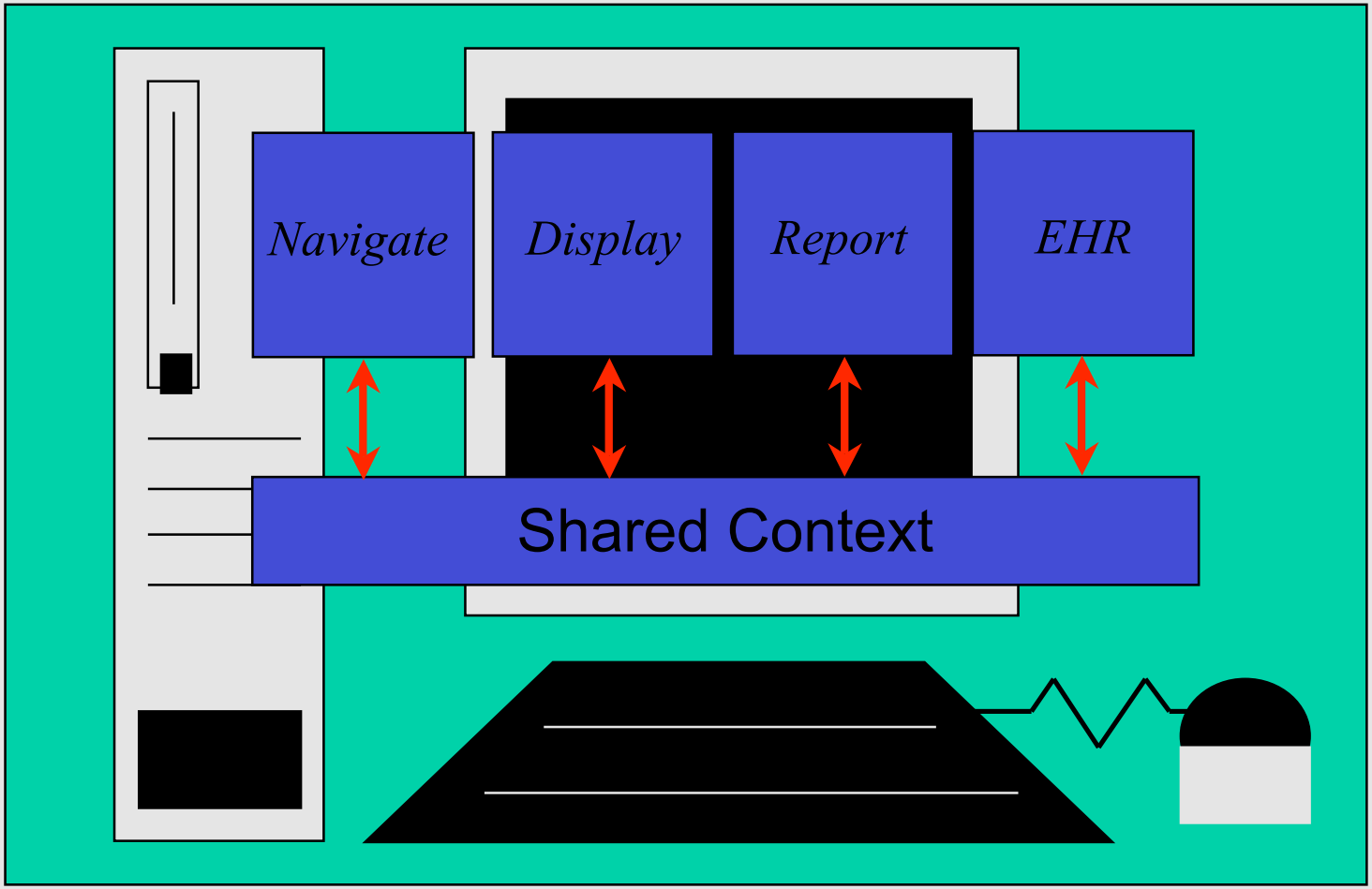

Standard Boundary
PACS +/- RIS
Modality
Modality
Modality
Modality
Archive
Manager
Workstations


Standard Boundary
Standard Boundary
PACS +/- RIS
Archive
Manager
Modality
Modality
Modality
Modality
Workstations

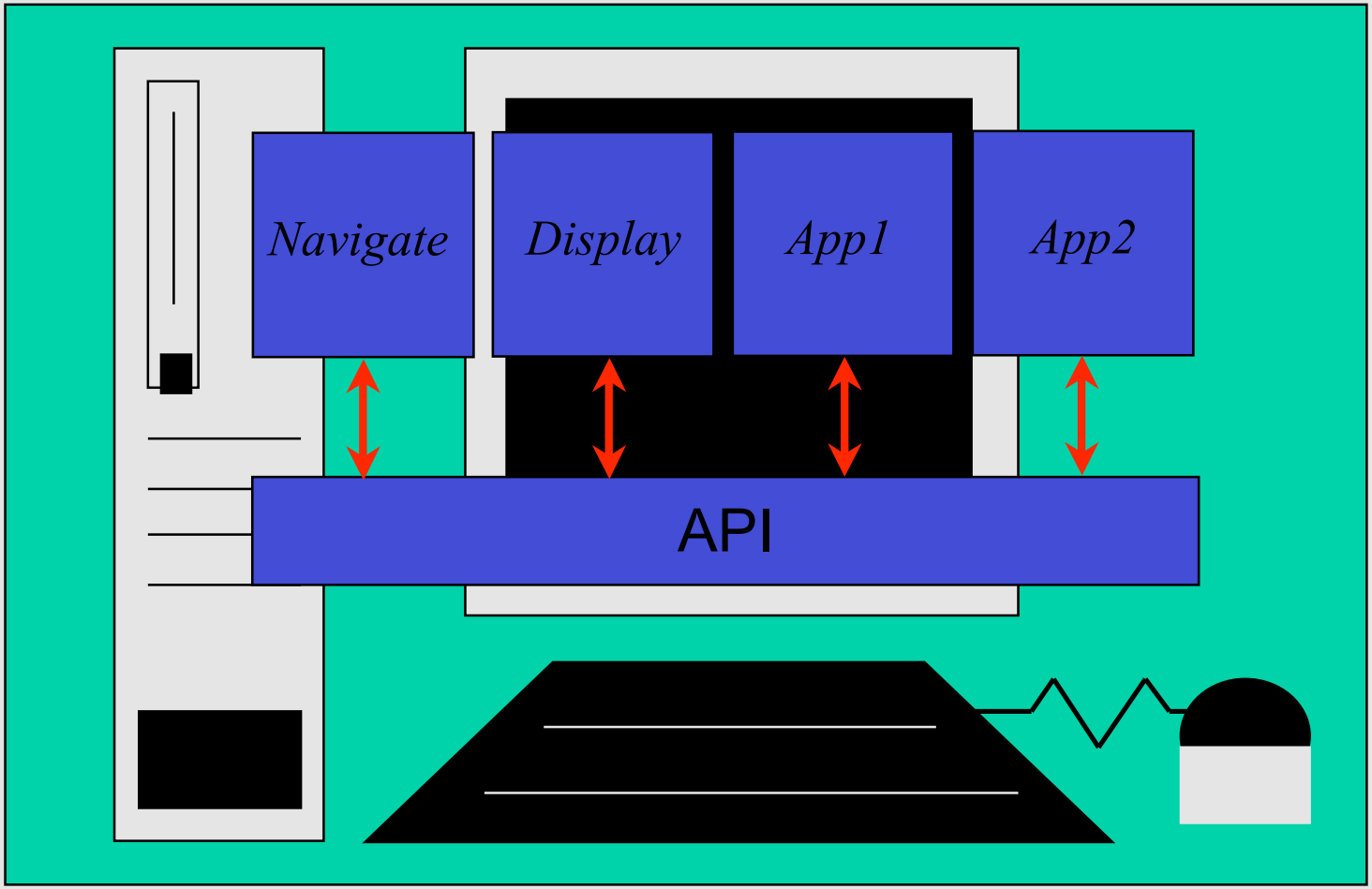

Standard Boundary
Standard Boundary
DICOM
PACS +/- RIS
Archive
Manager
Modality
Modality
Modality
Modality
Workstations


Standard Boundary
Standard Boundary
DICOM
HTTP+/-DHTML
PACS +/- RIS
Archive
Manager
Modality
Modality
Modality
Modality
Workstations

Context Sharing Within Workstation



Standard API within Workstation



F/OSS Image Archives

- “1st generation” DICOM tools
  - Mallinckrodt central test node - still maintained
  - Oldenburg (OFFIS) toolkit (dcmtk) - still maintained
  - UCDMC MicroPACS and toolkit - dead
- “2nd generation” - still maintained
  - Conquest PACS - based on extending UCDMC
  - dcm4jboss PACS - based on same author’s dcm4che tools
  - CDMedicPACS - based on Mallinckrodt CTN
- Not F/OSS
  - MyFreePACS
  - PACSOne

Conquest PACS

- Windows or Unix DICOM image archive with configurable database
- From
  - Lambert Zijp and Marcel van Herk, RT Department of Netherlands Cancer Institute NKI
- Download from:

  http://www.xs4all.nl/~ingenium/dicom.html
- License:
  - BSD-like
- Most recent update of software:
  - 2005/10

Conquest PACS

- Storage and query/retrieve SCP
  - Any SOP Class (configurable restrictions)
  - JPEG support
  - Proprietary lossless compression - masquerades as implicit VR therefore violation of DICOM - can be configured off - related private C-MOVE SOP classes
  - Disk space management - least recently used patients discarded
  - Mirroring, caching, CD jukebox archiving
  - Basic web server
- Database and workflow management features
  - Modality worklist - data via HL7 “files” (no network listener), web interface, API
  - Matching & coercion of received images
  - Patient ID coercion to preferred form (leading zeroes)
  - Configurable database columns and HL7 field mapping
- Print SCP
  - Drives windows paper printer

Conquest PACS

- Good user documentation
  - DICOM conformance statement
  - Installation guide
- Multi-platform
  - Windows (some features only, like viewer), Linux, ported to Mac
- No workstation (primitive viewer within server)
- Software engineering
  - Used in-house by developers
  - Detailed change tracking in documentation
  - Re-use - UCDMC DICOM toolkit and MicroPACS (major extension and maintenance of abandoned project), OFFIS for JPEG
  - ODBC interface to Access, SQL Server, mysql, theoretically others

dcm4jboss PACS

- Java (platform independent) implementation of all IHE Image Archive functionality
- From
  - Gunter Zeilinger (Tianni, now Agfa)
- Download from:
  - http://sourceforge.net/projects/dcm4che/
  - Need to expand file release dcm4che14 version 1.0.7 to find it
- License:
  - LGPL
- Most recent update of software:
  - 2002/09 (underlying toolkit dcm4che last updated 2005/12/29)

dcm4jboss PACS

- Storage and query/retrieve SCP
- Modality Performed Procedure Step SCP
- DICOM network security
- HL7 network listener
- Audit trail creation and logging (syslog)
- WADO (Web Access to DICOM Objects)

dcm4jboss PACS

- Limited installation and no user documentation
- Easy to install, hard to figure out what it does !
- Multi-platform, since Pure Java
- No workstation
- Can be configured to use other databases than the Hypersonic Java default in JBoss (e.g., MySQL)

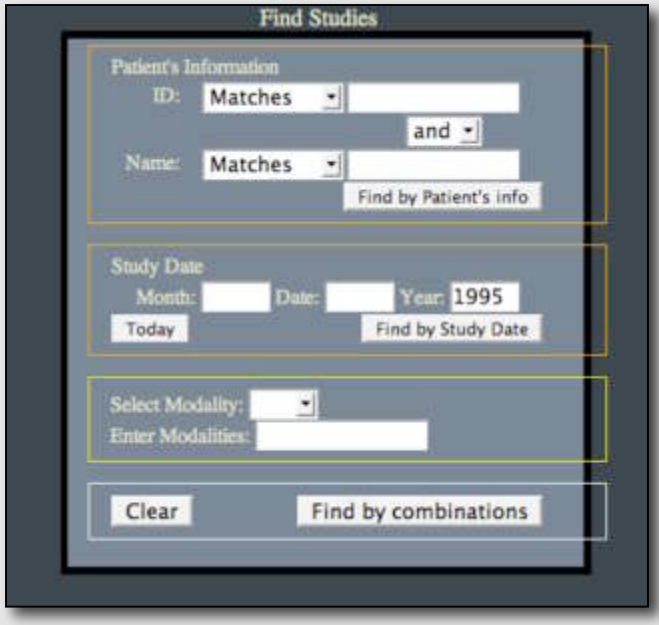
F/OSS Web Support

- Server-side rendering
  - JPEGs to ordinary browser with no plug-in/applet
  - DIOWave
- Browser-side rendering
  - Applet uses DICOM images received via http
  - AiViewer
- Thick client delivered via web start
  - Currently no F/OSS known

DIOWave Web Server

- A Windows (only) DICOM receiver and web server that requires only JavaScript and JPEG in the browser
- From
  - Takaya Sakusabe
- Download from:

  http://diowave-vs.sourceforge.net/
- License:
  - GPL
- Most recent update of software:
  - 2003/05/01
  - Web site last modified Feb 9, 2005



DIOWave web server
in Firefox browser

AiViewer Java Plug-in

- Presupposes a web server that can embed links to the DICOM files (not supplied)
- From
  - Takahiro Katoji (Akira Iwata, Nagoya Institute of Technology)
- Download from:

  http://mars.elcom.nitech.ac.jp/dicom/index-e.html
- License:
  - GPL
- Most recent update of software:
  - 2005/02/21

DICOM Viewer Demo Page2 (129KB x4)

http://mars.elcom.nitech.ac.jp/dicom/demo2.html

Apple Amazon eBay Yahoo! News .Mac Apple

Mouse Manupilation

- WL/WW(All images)
- WL/WW(Single)

Default WL/WW

Reverse

- Move
- Zoom

Reset Move/Zoom

- Loupe

Reset Angle

Rotate L | Rotate R

Flip RL | Flip UD

Cine Mode

<< | <- | -> | >>

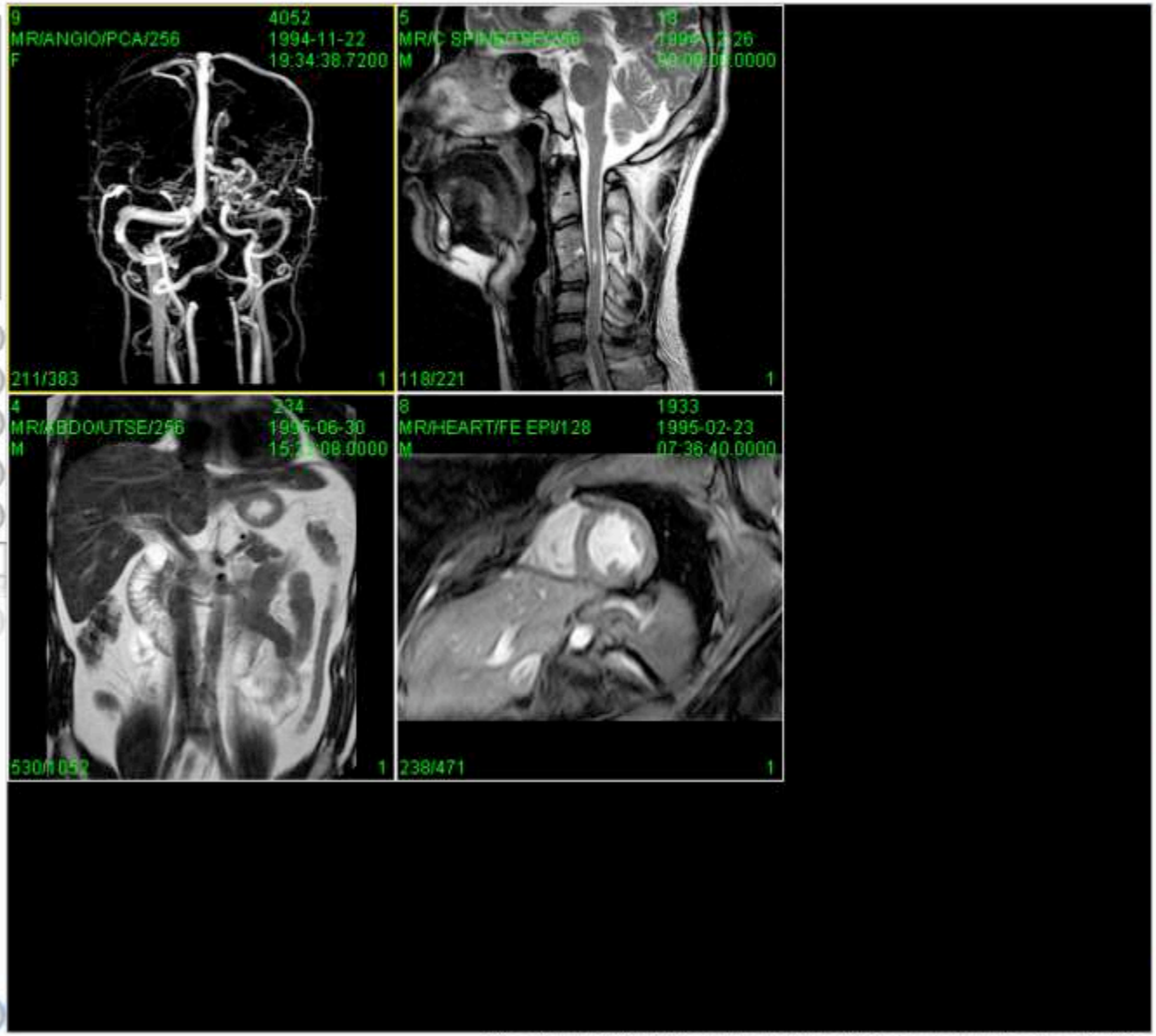
ImageNo 1

LessFrame | MoreFrame

Patient Info.
9
MR/ANGIO/PCA/256
none F
Study Info.
4052
1994-11-22
19:34:38.7200

Annotation

Show Tag Info



Dicom Data Load Done.

AiViewer Embedding Code

```
<HTML>
<BODY bgcolor="#FFFFFF">
<p><APPLET
  CODEBASE = ""http://mars.elcom.nitech.ac.jp/dicom"
  CODE     = "dicomviewer.Viewer.class"
  NAME     = "Viewer.java"
  WIDTH    = 100%
  HEIGHT   = 100%
  HSPACE   = 0
  VSPACE   = 0
  ALIGN    = middle
>
    <PARAM NAME = "NUM" VALUE = "4">
    <PARAM NAME = "currentNo" VALUE = "0">
    <PARAM NAME = "dicURL" VALUE = "http://mars.elcom.nitech.ac.jp/dicom/dicomviewer/Dicom.dic">
    <PARAM NAME = "imgURL0" VALUE = "http://mars.elcom.nitech.ac.jp/dicom/data/mrangio.dcm">
    <PARAM NAME = "imgURL1" VALUE = "http://mars.elcom.nitech.ac.jp/dicom/data/mrcspin.dcm">
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    <PARAM NAME = "imgURL3" VALUE = "http://mars.elcom.nitech.ac.jp/dicom/data/mrheart.dcm">
  </APPLET></p>
<p>[ <a href="index.html">back</a>(Japanese) | <a href="index-e.html">back</a>(English)
  ]</p>
</BODY>
</HTML>
```
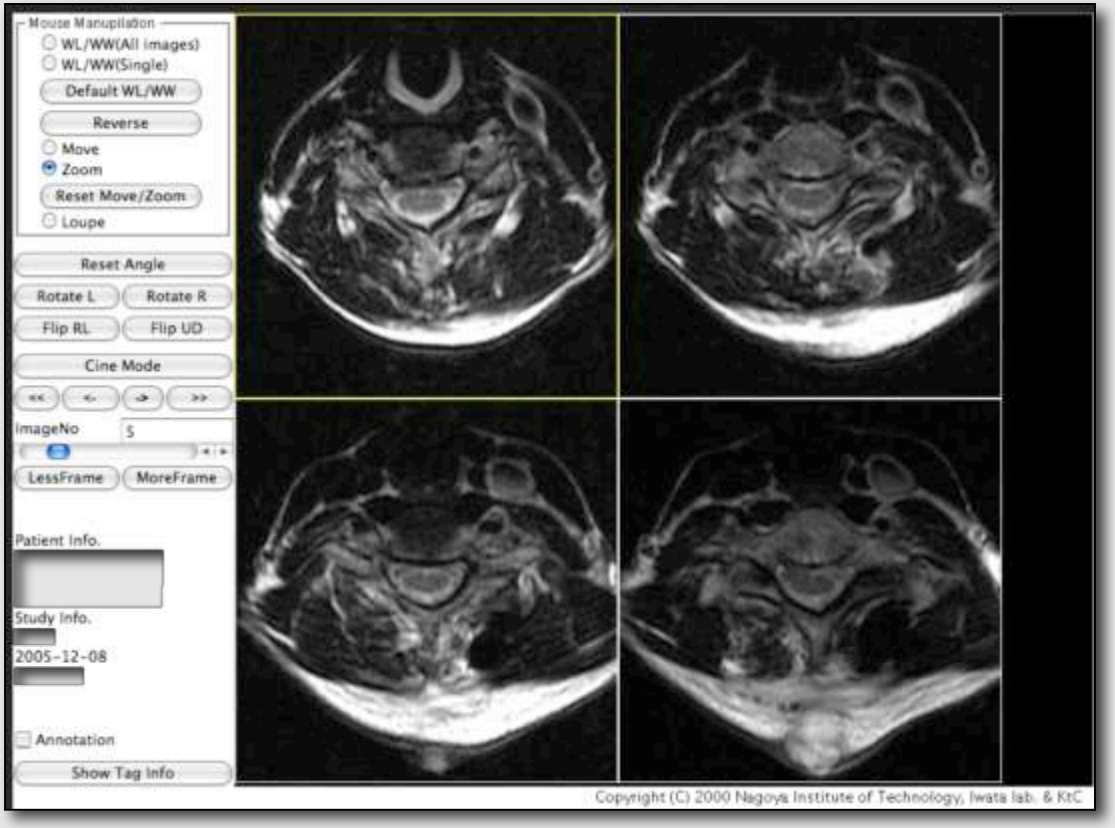

Series #	Series Date	Series Time	Modality	Series Description
1	20051208	210540	MR	Localizer
2	20051208	210630	MR	Localizer
3	20051208	210743	MR	Sagittal SSFSE upper
4	20051208	210850	MR	Sagittal SSFSE lower
5	20051208	211017	MR	Axial SSFSE upper
7	20051208	211433	MR	Sagittal T1 upper
8	20051208	211656	MR	Sagittal IR upper
9	20051208	211756	MR	Sagittal T2 upper
10	20051208	211923	MR	Sagittal T2 lower
11	20051208	212107	MR	Sagittal T1 lower
12	20051208	213219	MR	Sagittal IR lower
13	20051208	213417	MR	Axial T1 upper
14	20051208	213751	MR	Axial T2 upper
15	20051208	214020	MR	Axial T1 lower
16	20051208	214429	MR	Axial T2 lower
17	20051208	214734	MR	Axial T1 post upper
18	20051208	215323	MR	Sagittal T1 post H/R upper
19	20051208	215600	MR	Sagittal T1 post H/R lower
20	20051208	215840	MR	Axial T1 post lower

DICOM/WADO web server (PixelMed) driving AiViewer DICOM Applet in Firefox browser on Mac



F/OSS Workstation

- The IHE Image Display actor
- Very few - the biggest problem in deploying a “complete” F/OSS PACS
- Osirix
- Freeware programs like K-PACS, and previously eFilm, are not F/OSS solutions

Viewers are not Workstations

- Many “viewers” lack the basic DICOM network functions
  - Storage SCU to send images
  - Storage SCP to receive images
  - Query/retrieve SCU to search for and fetch images
- Many “viewers” are not multi-modality
  - Too many assumptions about form of the images
  - Only handle volumes
  - Only handle cardiac angiography
- Image processing/ visualization research viewers
  - Often retro-fitted with DICOM “file” import capability
  - Powerful tools, but not useful for clinical reading workflow
- E.g., NIH Image J - very cool, but not a workstation

Osirix

- PACS DICOM 3D Workstation for MacOS X
- From
  - Antoine Rosset, University of Geneva
- Download from

  http://homepage.mac.com/rossetantoine/osirix/Index2.html
- License:
  - GPL
- Most recent update of software:
  - 2005/12/31

Osirix to the rescue ?

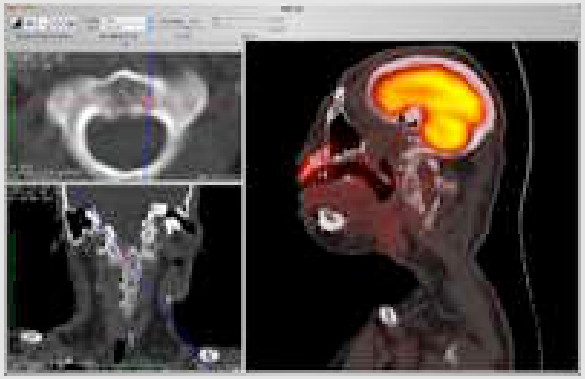
- Good support for thin-slice CT & PET
- Nice user interface for ordinary viewing (multiple stack mode windows, synchronized scrolling, zooming panning)
- 3D and temporal visualization (volume and surface rendering, MPR, fused images, virtual endoscopy)
- Good DICOM image display support, query and retrieve
- Implemented by radiologists (Antoine Roset, Lance Pysher, et al)
- Increasing use beyond radiology … e.g., microscopy

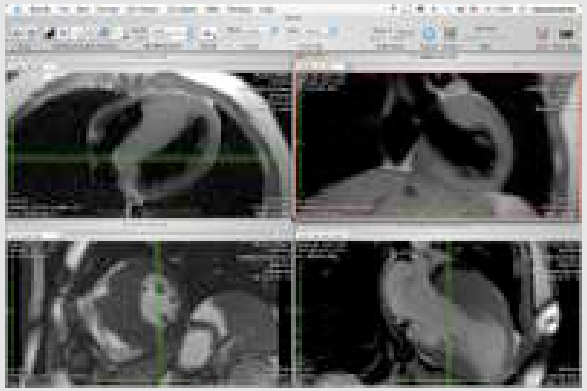
Osirix Gaps

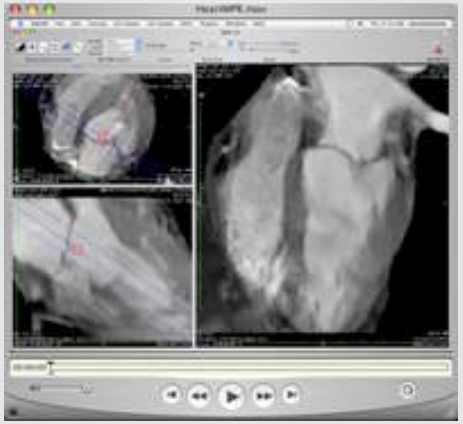
- No hanging or default display protocols
  - Fundamental to efficient reading
- No reading worklists
  - Fundamental to efficient reading
  - What standard to use (DICOM GP-SPS)
  - Who will provide the worklist (RIS or PACS) ?
  - No commercial or F/OSS GP-SPS at the moment
- No support for
  - Key Image Note, Presentation State or Structured Reports
  - Like proprietary vendors, similar features implemented in a non-standard way (e.g. annotations stored in local database)

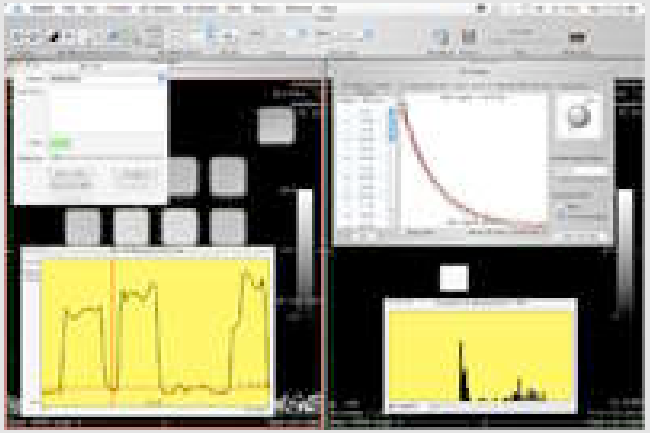
Osirix Engineering

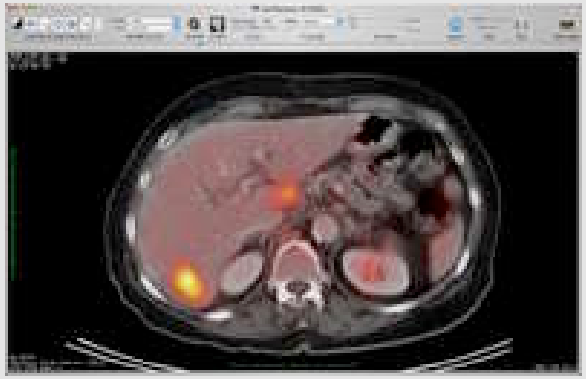
- Quite well “productized” - easy to install, use and configure
- Rapid addition of features leads to some instability
- Mac only - developers have no interest in other platforms; written in Objective C (blech)
- Leverages broad base of other tools and software, such as VTK, OFFIS dcmtk, depends on Mac-specific vimage
- Innovation not just replication … shared databases, dynamic network configuration
- Sets the standard for what can be done by F/OSS
- Partners to offer certified versions for sites and countries that require such

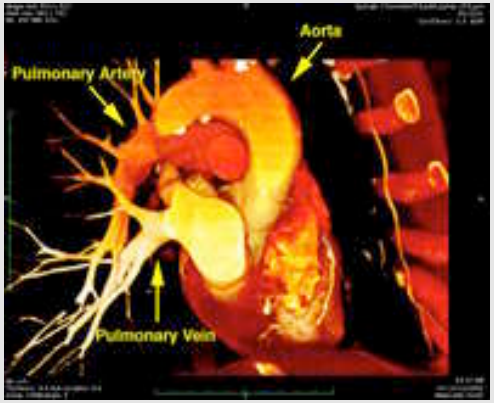












OSIRIX

http://homepage.mac.com/rossetantoine/osirix/Snapshots.html

OSS RIS ?

UCLA DataServer

- XML gateway, built upon Apache Cocoon framework and J2EE platform, for aggregating patient medical records
- From
  - UCLA Medical Imaging Informatics
- Download from

  http://www.mii.ucla.edu/dataserver/
- License:
  - LGPL
- Most recent update of software:
  - 2005/10/13

OSS Speech Recognition

- Speech recognition is perceived by a key productivity driver (at least by all those not forced to actually use it)
- Engine + vocabulary + integration
- Proprietary (medical) offerings few in number and specific to Windows
- Integration of OSS workstation and RIS with proprietary reporting is the most practical route
- There is OSS CMU Sphinx

CMU Sphinx

- Open Source Speech Recognition Engines
- From
  - Carnegie Mellon University
- Download from:

  http://cmusphinx.sourceforge.net/html/cmusphinx.php
- License:
  - BSD-like
- Most recent update of software:
  - 2005/10/13

CMU Sphinx

- CMU Sphinx Group Open Source Speech Recognition Engines
- Supported by DARPA, Telefónica I & D, Sun Microsystems, Mitsubishi Electric Research Labs
- Several generations of development
- Latest, Sphinx-4, is Pure Java !
- But:
  - "The software available here is not meant for users with no experience in speech, but for expert users"
  - How difficult would it actually be ?
  - What about a medical or radiology vocabulary ?

So can you deploy a "complete" OSS PACS ?

- Server
  - Using Linux, MySQL or Postgresql, Conquest or dcm4jboss
  - Run on x86 or AMD64 server hardware, hardware RAID
  - Off-site archive by routing to a second version
- Workstation
  - Osirix on Macs with two 30" LCD monitors
- Web distribution
  - DIOWave or AIViewer
- Limits
  - Modality worklist possible, but non-trivial
  - No reading worklists
  - Limited "security"
  - How to backup database and RAID ?
  - Careful attention needed to reliability and high availability

Is anybody actually ?

- Mailing list/forum survey of clinical use 2005/12
  - pacsadmin list
  - news:comp.protocol.dicom
  - Osirix list
  - AuntMinnie PACS forum
- Only a handful of responses
  - Have no PACS, or commercial PACS, but using F/OSS workstations for reading CT/MR, CD burning, and clinical conferences
  - Using workstations for 3D or teleradiology
  - Using F/OSS PACS server (Conquest or dcm4jboss) with proprietary workstation (eFilm)
  - Responses from mixture of US, European and South American users
  - Cardiology as well as radiology
  - Veterinary users of freeware or F/OSS PACS

Where to Find Programs

- Andrew Crabb's IDOImaging site
  - List of freeware and F/OSS tools
  - http://www.idoimaging.com/
- Paul Nagy's OpenRad site
  - Links, forums, news, how-to articles
  - http://www.openrad.com/index.php
- My Medical Image Format FAQ site
  - Has (too) many DICOM resources and links (unrated)
  - http://www.dclunie.com/medical-image-faq/html/

idoimaging.com
Free Medical Imaging Software

Home Programs Finder People Formats Resources About

Search:
Status: Not logged in
Login:
Create an Account

Search Results

1 Program names matching 'web'	
MiniWebPACS	Small Web-based PACS system

An additional 4 program descriptions contain 'web'	
DICOM Viewer	Java applet for viewing DICOM images.
DIOWave	Web-based DICOM server/PACS
MyFreePACS	Web-based radiology image storage/viewing tool
PacsOne Server	PACS Server In One Box

idoimaging.com
Free Medical Imaging Software

Home Programs Finder People Formats Resources About

Search:
Status: Not logged in
Login:
Create an Account

Program: DICOM Viewer

Summary	Java applet for viewing DICOM images.
Description	This DICOM Viewer applet allows DICOM images to be manipulated and displayed through a web browser.
Revision	1.0.0 (Released: 02/21/05)
Author	Takahiro Katoji
Platform	Macintosh Unix Windows
Speciality	
Language	Java
Input Format	DICOM
Output Format	
User Interface	GUI
Home URL	
Source URL	
Prerequisites:	None
Revision History:	Version Release Date 1.0.0 02/21/05

Track this Program

You're not logged in. Log in or create an account to track this program

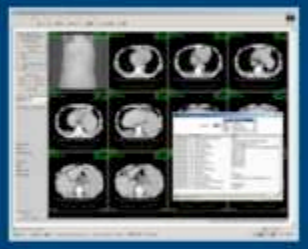
Reviews and comments

There are no reviews.
Write a new review of this program.

Revise this Information

Submit suggested changes to this program's entry.

Screen Captures



News, Journals and Alliances

- LinuxMedNews
  - http://linuxmednews.com/
  - Very active; not specific to imaging
- Open Source Health Care Alliance
  - http://oshca.org/
  - Last meeting was in 2002 ? still active ; not specific to imaging
- Journal of Open Source Medical Computing
  - http://www.josmc.org/
  - Not really a journal, but a log of postings, relatively inactive
- Insight Journal (Kitware and Insight Consortium)
  - http://insightsoftwareconsortium.org/InsightJournal/
  - About imaging (but not specifically PACS), intended to be truly a journal; free to access and contribute; continuous and public review and comments

Future Directions

- Increasing probability of US government & EU funding of research PACS F/OSS projects (such as via NCI CABIG Imaging Workspace)
- Global shift to making F/OSS a pre-requisite for funding - many historically projects that were closed, and abandoned, would now be F/OSS
- Less affluent nations cannot afford proprietary PACS but cannot afford film either - institutions and governments will use and may sponsor F/OSS initiatives
- Some large health-care institutions known to be working on F/OSS PACS components

Future Directions

- Existing OSS PACS offerings will only improve
- New efforts by individual enthusiasts continue to appear
- RSNA/HIMSS continue to sponsor “test tools” for IHE, which are F/OSS and from which clinically useful systems may evolve
- Unlikely to be explicit F/OSS project sponsorship or funding from professional organizations like SCAR - though discussed, hampered by fear of vendor abreaction.
- Some complex projects simply may not be possible without F/OSS development model

Annotated Bibliography

- Open Source for the Enterprise
  - Woods and Guliani, O'Reilly, 2005. ISBN 0-596-10119-8
  - Comprehensive review of how and why to use F/OSS in an organization from the IT person's perspective; thoroughly explores the expertise necessary (or not) to deploy and benefit from different types of F/OSS (desktop applications, operating systems and databases, more complex applications)
- Open Sources 2.0
  - DiBona et al, editors, O'Reilly, 2005. ISBN 0-596-00802-3
  - Contemporary collection of articles from open source protagonists, evangelists, authors, users and distributors; strong emphasis on the commercial benefits of and techniques for using, supporting and distributing F/OSS.
- Open Source Licensing
  - Rosen, Prentice Hall, 2004. ISBN 0-13-148787-6
  - Written by a lawyer who is also a software developer, and general counsel of the Open Source Initiative (OSI); plain language explanation of the property rights of copyright and patent that underlie open source licenses and contracts, the difference between licenses and their compatibility, and the relevance (or lack thereof) to users as opposed to developers.
- The Success of Open Source
  - Weber, Harvard University Press, 2004. ISBN 0-674-01292-5
  - Discussion of the history of open source, how the open source community functions, the business models in use, and the political and legal ramifications.