Case Study: Medical Imaging; From Toolbox to Product to Platform

by Gerrit Muller        Buskerud University College
                      e-mail: gaudisite@gmail.com
                      www.gaudisite.nl

Abstract

Medical Imaging was an early large scale Object Oriented product. Originally intended to become a re-useable set of toolboxes, it evolved in a family of medical workstations and servers.

This article describes the evolution from different viewpoints, to serve as background material for a number of case studies of the Gaudí project.

Distribution

This article or presentation is written as part of the Gaudí project. The Gaudí project philosophy is to improve by obtaining frequent feedback. Frequent feedback is pursued by an open creation process. This document is published as intermediate or nearly mature version to get feedback. Further distribution is allowed as long as the document remains complete and unchanged.

March 6, 2013
status: preliminary
draft
version: 0.4
Philips Medical Systems, schematic organization

Philips Medical Systems

Non X-ray modalities
- US
- MR
- CT

Conventional X-ray
- Medical Imaging
- Common X-ray Components
- Cardio Vascular
- URF
- Surgery
Generic drivers of Radiology Departments

- **Diagnosis**
  - Image quality
  - Relaxed patient
  - ease of use
  - patient handling
  - universality

- **Department Efficiency**
  - integrated information flow
  - minimal film cost
  - up time

- **Safety**
  - Compliant with Standards and Regulations
  - minimal evasive

- **Automation**
  - patient accessibility
  - patient entry, exit

- **Dose reduction**
Phases of Medical Imaging

- 1994-1997 Family Development
- 1997-2000 Transformation in re-useable components
Technology innovations by Common Viewing

- Standard UNIX based workstation
- Full SW implementation, more flexible
- Object Oriented design and implementation (Objective-C)
- Graphical User Interface, with windows, mouse et cetera
- Call back scheduling, fine-grained notification
- Data base engine, fast, reliable and robust
- Extensive set of toolboxes
- Property based configuration
- Multiple coordinate spaces
Idealized layers september 1991

Basic Application

Image  |  Gfx  |  UI  |  DB

SunOS, SunView

Standard Sun workstation
X-ray rooms from examination to reading around 1990

**Examination Room**

**Control Room**

**Corridor or closet**

**Reading Room**
X-ray rooms with Medical Imaging applied as printserver

Examination Room

X ray source

detector

Control Room

console

Corridor or closet

printer

Examination Room

Control Room

Reading Room

light box

Case Study: Medical Imaging; From Toolbox to Product to Platform

version: 0.4
March 6, 2013
XRayRoomsPlusPrintServer
Comparison *screen copy vs optimized film*

**old:** screen copy

**new:** SW formatting

*20 to 50% less film needed*
Case Study: Medical Imaging; From Toolbox to Product to Platform

Dev. tools

Service

SW keys

Config

Install

Start up

Idealized layers september 1992

--

Medical Imaging R/F

<table>
<thead>
<tr>
<th>Print</th>
<th>Store</th>
<th>View</th>
<th>Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spool</td>
<td>HCU</td>
<td>Store</td>
<td>Image</td>
</tr>
<tr>
<td>RC driver</td>
<td>HC driver</td>
<td>DOR driver</td>
<td>NIX</td>
</tr>
</tbody>
</table>

SunOS

Standard IPX workstation

Desk, cabinets, cables, etc.

DSI

3M

RC

RC interf

HC interf

DOR

Print

Store

View

Cluster

Net in

Net out

PMS-
Example Multi Planar Reconstruction

Diagram showing curved slice and oblique slices.
Example CT/MR department

MR Examination room

Control room

"MPR" room

CT Examination room

Control room

Reading Room

Case Study: Medical Imaging; From Toolbox to Product to Platform

version: 0.4
March 6, 2013
Gerrit Muller
## Differences between modality images

<table>
<thead>
<tr>
<th></th>
<th>X-ray</th>
<th>CT</th>
<th>MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>image</td>
<td>projection</td>
<td>slice</td>
<td>slice</td>
</tr>
<tr>
<td>structure</td>
<td>single image</td>
<td>stack</td>
<td>stack</td>
</tr>
<tr>
<td></td>
<td>or time series</td>
<td>or volume</td>
<td>or more complex</td>
</tr>
<tr>
<td>greylevel mapping</td>
<td>contrast</td>
<td>window width</td>
<td>window width</td>
</tr>
<tr>
<td></td>
<td>brightness</td>
<td>window level</td>
<td>window level</td>
</tr>
<tr>
<td>resolution</td>
<td>$1024^2$</td>
<td>$512^2$</td>
<td>$256^2$</td>
</tr>
<tr>
<td>contrast noise ratio</td>
<td>10 bit</td>
<td>12 bit</td>
<td>8 bit</td>
</tr>
<tr>
<td>value</td>
<td>absolute</td>
<td>acquisition dependent</td>
<td></td>
</tr>
</tbody>
</table>
Specification Differences

- viewing and print preparation
  - navigation support
- multi-image view
- greylevel control
- specialized clinical functions
  - vascular and cardio analysis (X-ray)
  - dental (CT)
- print protocols
- information model
Medical Imaging Competitive Positioning

Case Study: Medical Imaging; From Toolbox to Product to Platform

16  Gerrit Muller
Case Study: Medical Imaging; From Toolbox to Product to Platform

Gerrit Muller

version: 0.4
March 6, 2013

Radiology Department

MR
CT
URF
Vascular
"MPR"
CT
Printer
RAD
RAD
RAD
Reading Room
Reception Office
teaching
Vision: Medical Imaging in Healthcare

Operating theatre

trauma room

IT infrastructure in basement

Radiologist at home

Radiologist somewhere in the hospital

Radiologist at other hospital

Referring Physician

Referring Physician

Conference room
• List of system level document lists
• System level requirements, specification and design documents
• System aspect documents
• Feasibility reports
• Cluster, interoperability documents
• Functional Specifications X-ray
• Functional Specifications CT/MR
• Application SW design
• System Software design
• Hardware documents
Documents

- Product Structure
- System Engineering requirements
- Design overview
- Hazard analysis
- Verification specification X-ray
- Verification specification CT/MR
Aspect Documents

- Cluster design
- HW Configuration
- CPU resource usage
- Disk resource usage
- Memory resource usage
- Requirements system monitor
- Safety
- Security
- SW process structure
- Testability and Service tools
- Installation, Configuration and Start-up design
- CT/MR image quality
- R/F image quality
- CT/MR typical load
- R/F typical load
# Example Memory Budget

<table>
<thead>
<tr>
<th>budget in MBytes</th>
<th>X-ray</th>
<th>CT/MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>non bulk data</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>bulk data</td>
<td>36</td>
<td>88</td>
</tr>
<tr>
<td>Unix</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>total used</td>
<td>77</td>
<td>133</td>
</tr>
<tr>
<td>physical memory</td>
<td>64</td>
<td>128</td>
</tr>
</tbody>
</table>