

# Flying Blind: Using a Digital Dashboard To Navigate a Complex PACS Environment

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# Background

- Digital workflows are inevitable
  - Early adopter → early majority
- Increasingly complex
  - Workflow models
  - Informatics support infrastructure
- Understanding the “state” of the complex system is critical

# “Flying Blind”

- Workflow is less tangible, has fewer “cues”
  - Filmless
  - Paperless
  - Distributed
  - Decoupled
- Difficult to see the “state” of the workflow
  - Can’t make real-time, informed decisions

# A Known Problem in Medicine

- Human failures are predictable
  - “Prospective recall”
  - Unsignaled events
  - “Forest for the trees”
  - Unprioritized tasks
- Radiologists need a system to monitor the systems—a “meta” system

# The Dashboard



# The Clinical Dashboard

- Functionality
  - Integration of multiple systems
  - Preemptive monitoring
- Design
  - Summarized key workflow metrics
  - Context-specific
  - Simple, not distracting
- Result
  - Informed, optimized decision support

# The Dashboard

- Common in business administration, industry, and military
- Rare in clinical settings
  - Not real-time or workflow-integrated

# Purpose

To share our experience  
developing, implementing, and evaluating  
a PACS-integrated dashboard system

# Methodology Overview

- Determine key workflow elements
- Design the user interface
- Develop/implement the software
- Evaluate the dashboard's effect

# User interface

- Traffic light metaphor
  - Simple
  - Immediate recognition / understanding
- Three categories
  - User
  - Division
  - System
- Workflow integrated
  - Visible in worklist and image-viewing modes



# Development Tools

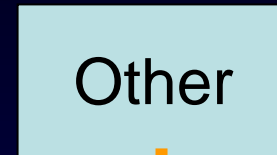
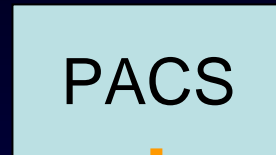
- Software
  - OS: WinXP Server 2003
  - Web server: IIS
  - DBMS: MS SQL 2000 Standard
- Programming
  - ActiveX control embedded in HTML

# Software Architecture

- Normalize standard “edge” protocols (HL7 messaging, database queries)
- Create a “middle” layer (SOA, web services)

# Traditional Architecture

Multiple Systems



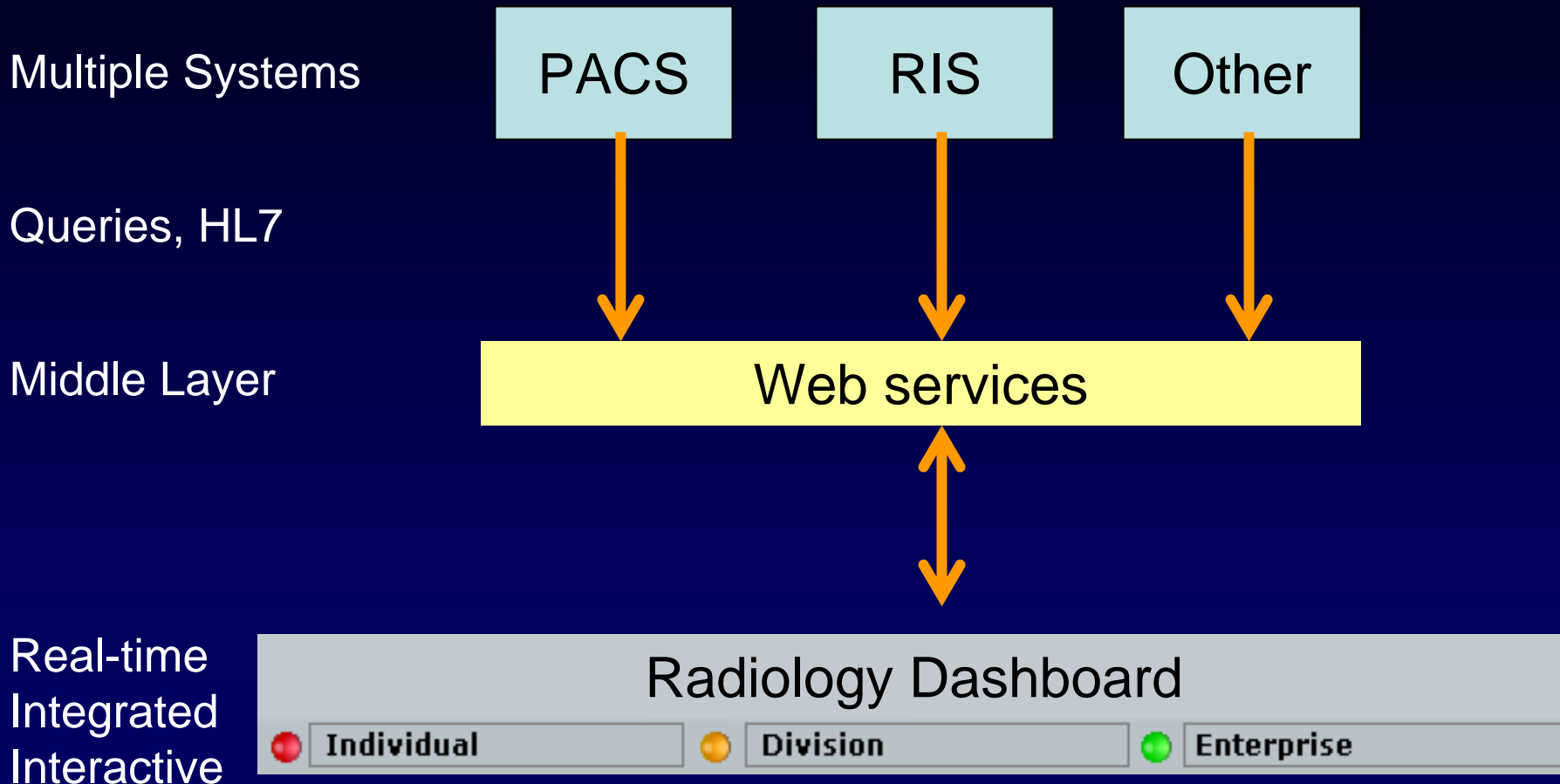
Queries, HL7



Post-hoc  
Static



# Service Oriented Architecture



# PACS-Integrated Dashboard

## Worklist mode

Radiology View - UPMC Presby - Microsoft Internet Explorer provided by UPMC

Worklist									
Expand	Filter Name	Modality	Body Part	Division	Exam Time	Patient Location	Dictated	Last Name or MRN	Accession #
Query	Neuro Reading Room	All	All	NEURO	Last 2 days	All	No		
Patient Name		Med Rec No	Study Date	Exam Status	Exam Loc.	Locked By			
* SMITH, G REG		123456789							
ED	<input type="checkbox"/> CT; ct head w/o contrast;	1236549	02/18/2005 - 11:52 am	(In Progress)	EMEP RR				
* BARNEY, PATRICK		123456789							
+	<input type="checkbox"/> CT; ct head w/o contrast;	6987415	02/17/2005 - 7:14 pm	(Completed)	EMEP RR				

## Image viewing mode


STENTOR® User:  Individual  Division  Enterprise

**DOE, JONATHAN** : Sex: M, D.O.B: 11/07/1950, PID: 12345678, Procedure Code: CCT171, Referring Physician: CHANG, PAUL  
MITO STUDY

### Relevant Exams

<input checked="" type="checkbox"/> CT ABDO 02/17 Most Recent: 02/17/2005	1	<input checked="" type="checkbox"/> CT ABDO 02/17 05:03 Most Recent: 02/17/2005	<input type="checkbox"/> CR KNEE 05/02	<input type="checkbox"/> CR KNEE 05/02
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CT; MITO  
02/17/2005; Acc#: 1236547



# General Workflow Principles

- Integrate display of multiple systems into one interface
  - Report signing (“out-of-band” task)
- Preemptive monitoring
  - Delinquent uninterpreted/undictated cases

# Problem #1: Report signing

- Problem
  - Radiologist unaware of transcription status
  - Periodically leave PACS to launch RIS application to sign reports
  - Batch behavior (i.e. “I’ll let them build up”)
- Solution
  - PACS dashboard monitors RIS
  - Signal (green = 0 yellow = 1+ red > 20)

# The Radiology Dashboard

**STENTOR®** User: Morgan, Matthew

Individual  Division  Enterprise



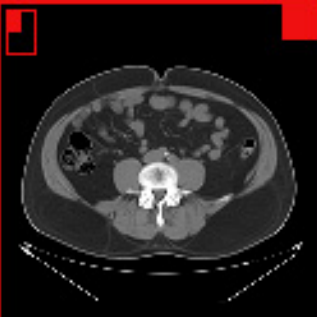



**DOE, JONATHAN** : Sex: M, D.O.B: 11/07/1950, PID: 12345678, Procedure Code: CCT171, Referring Phy  
MITO STUDY

### Relevant Exams

↓  
CT  
ABDO  
02/17

1

Most Recent: 02/17/2005 Least Recent: 02/17/2005

<p>CT; MITO 02/17/2005; Acc#: 1236547 Referring: CHANG, PAUL Status: COMPLETE</p>	 <p>Series 1</p>	 <p>Series 1</p>	 <p>Series 2</p>
<p>CR; knee 05/02/2003; Acc#: 3214567 Referring: BRANSTETTER, BARTON Status: FINAL</p>	 <p>L</p>	 <p>L</p>	 <p>L</p>

# The Radiology Dashboard

**STENTOR®** User: Morgan, Matthew

**Individual** **Division** **Enterprise** Go to patient:

M, D.O.B: 11/07/1950, PID: 12345678, Procedure Code: CCT171, Referring Phy

**New Images On Reported Study**  
[Patterson, Brian](#)

**Unsigned Reports**  
IDXRad: [12 report\(s\)](#)  
IDXv10: [9 report\(s\)](#)  
SMS: [8 report\(s\)](#)

Referring: BRANSTETTER, BARTON  
Status: COMPLETE

**Relevant Exams**

Least Recent: 02/17/2006

1

Series 1 Series 1 Series 2

CR; knee  
05/02/2003; Acc#: 3214567  
Referring: BRANSTETTER, BARTON  
Status: FINAL

# The Radiology Dashboard

STENTOR® User: Morgan, Matthew

Go to patient: [Redacted] [Redacted] [Redacted]

IDAS Web Editor - Job List - Microsoft Internet Explorer

Address: http://rieidasbiz-srv3/dot\_net\_dev/WebTransEditor\_V2\_5/ShowList.aspx

Refresh List

Select By Status:

Select files to edit and sign off:

Select	Status	MRN #	Accession #	Author Name	Priority	Patient Name	Modality	Body Part	Study Date/Time	Description	Admitting Diag. Desc.	Patient Location
<input checked="" type="checkbox"/>	Pending Sign		10251901	Oh, Kook Sang	Out Patient		CR	CHEST	2005-11-14 13:09:00	CHEST PA AND LATERAL	EFFUSION	D0653RR
<input checked="" type="checkbox"/>	Pending Sign		10251978	Oh, Kook Sang	Out Patient		CR	CHEST	2005-11-14 12:27:00	PORTABLE CHEST	PTX	MICU RR
<input checked="" type="checkbox"/>	Signed Off By Resident		10251903	Morgan, Matthew	Out Patient		CR	CHEST	2005-11-14 12:26:00	PORTABLE CHEST	PNA	MICU RR
<input checked="" type="checkbox"/>	Signed Off By Resident		10251903	Morgan, Matthew	Out Patient		CR	CHEST	2005-11-14 12:26:00	PORTABLE CHEST	PNA	MICU RR
<input checked="" type="checkbox"/>	Pending Sign		10251978	Oh, Kook Sang	Out Patient		CR	CHEST	2005-11-14 12:27:00	PORTABLE CHEST	PTX	MICU RR
<input type="checkbox"/>	Pending Resident Signature		10252378	Morgan, Matthew	Out Patient		CR	CHEST	2005-11-14 12:37:00	CHEST PA AND LATERAL	PRE OP	PREA RR
<input type="checkbox"/>	Auto-Transcribed		10252258	Oh, Kook Sang	Out Patient		CR	CHEST	2005-11-14 12:35:00	CHEST PA AND LATERAL	PRE-OP	D0852RR
<input type="checkbox"/>	Auto-Transcribed		10370400	Oh, Kook Sang	Out Patient		CR	CHEST	2006-01-06 04:57:00	PORTABLE CHEST	INFILTRATE	TICU RR

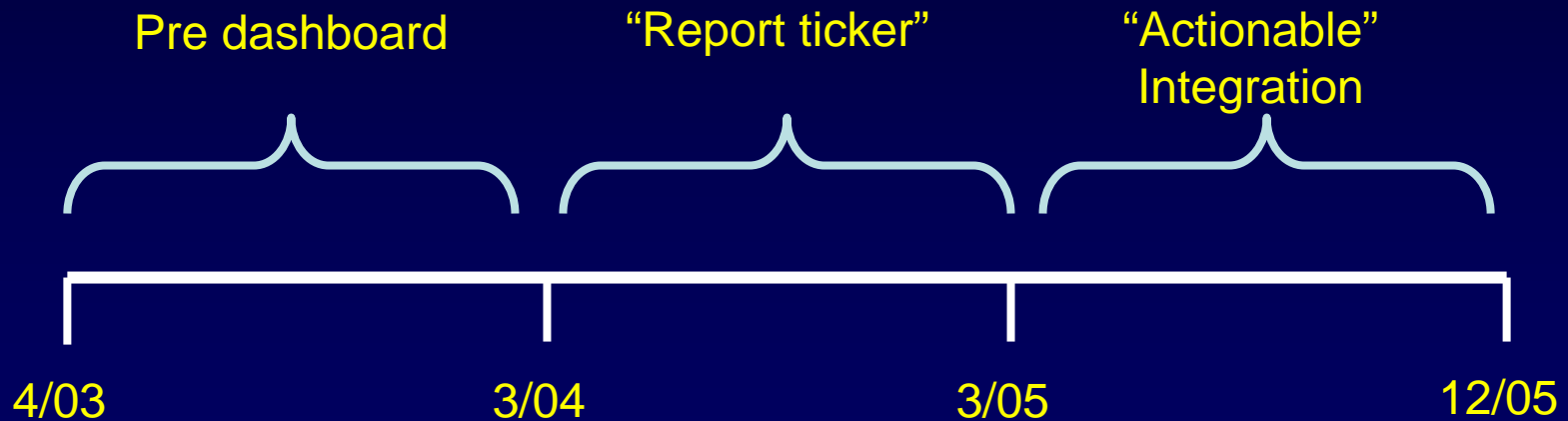
# Hypothesis #1

- A PACS-integrated dashboard element that alerts the user to the number of unsigned reports and integrates with the RIS will decrease the time interval from transcription to signing.

# Experiment #1: Data Collection

- Timeline: April 2003 to Dec 2005
- RIS timestamps collected on 1,741,551 distinct examinations
- Calculated average time between the completion of transcription and report signing

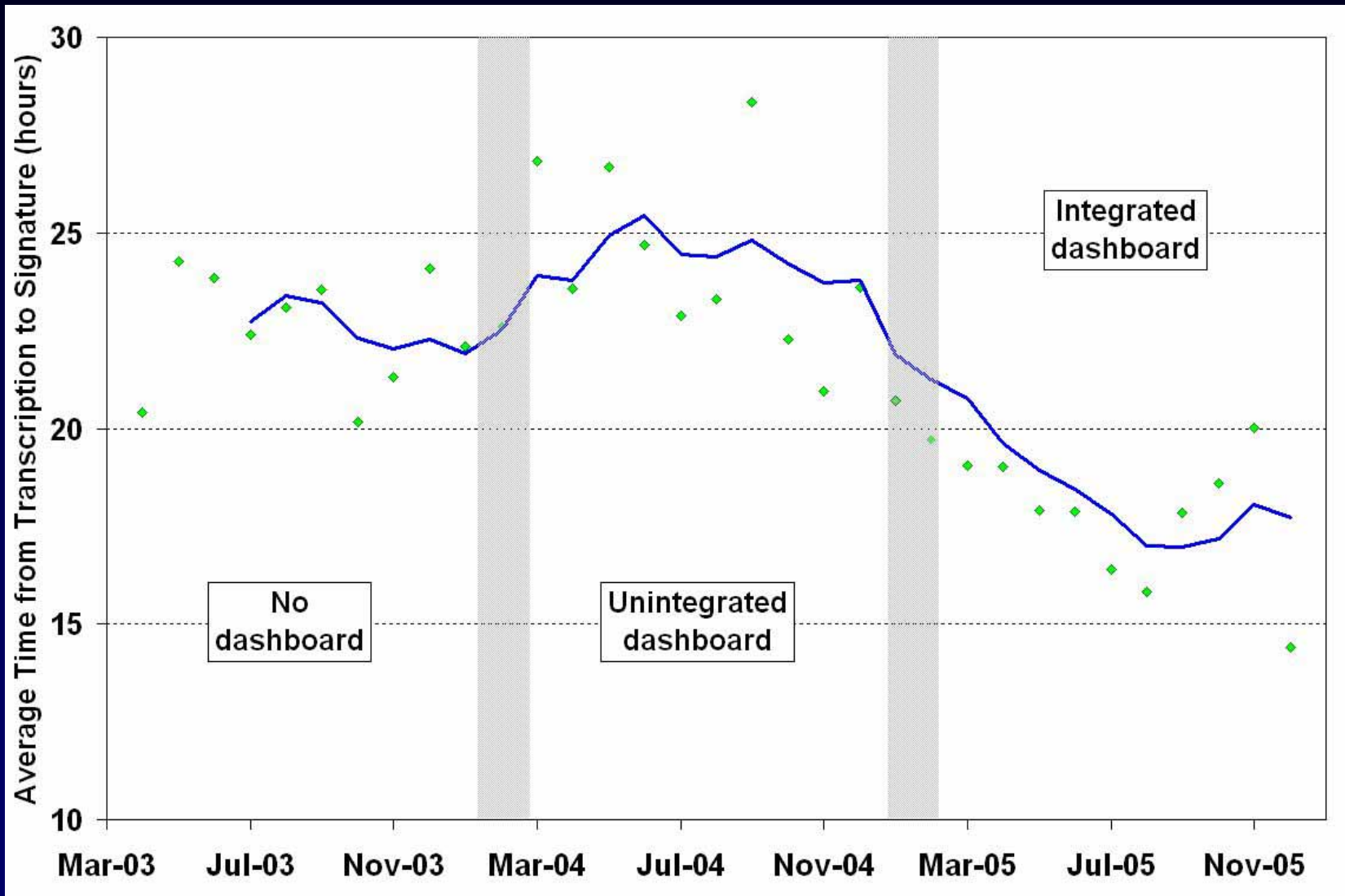
# Experiment #1: Study Periods



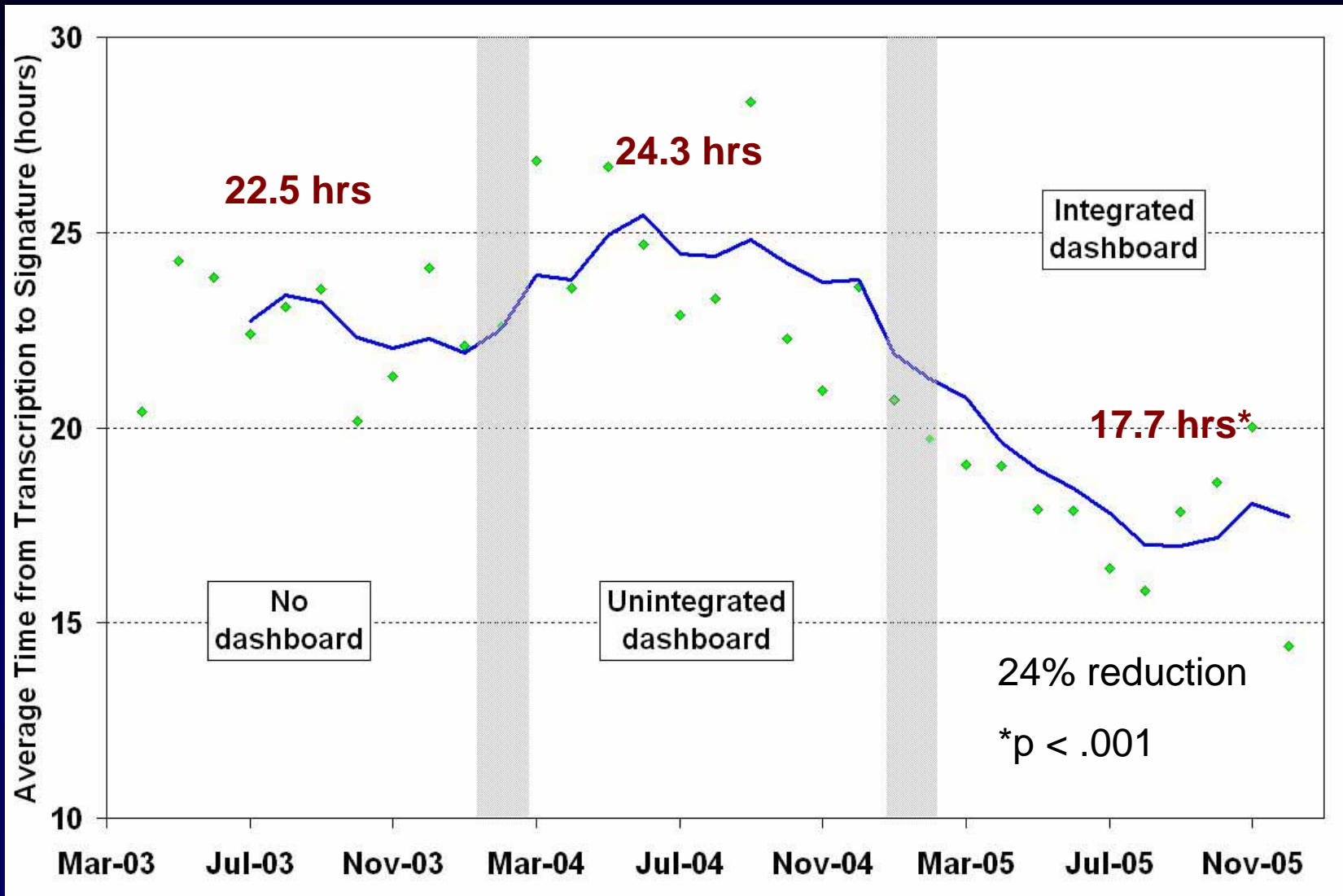
# Experiment #1: Statistical Analysis

- Average turnaround time was normalized to each radiologist
- Compared three study periods using Fisher's Least Significant Difference test
  - ANOVA, followed by pair-wise comparisons of the study periods

# Experiment #1: Results



# Experiment #1: Results



# Experiment #1: Discussion

- Showing a count was not enough, actionable integration is key
- Make it easy to the right thing

# Problem #2: Delinquent Dictations

- PACS dramatically reduced number of “lost cases”
- New group of exams that slip through the cracks
- Not lost forever, but unacceptably delayed (>72 hrs)
  - Exam is complete but not dictated
    - “Punted” exams (over weekend)
    - Procedures
    - Misrouted
  - False dictated
    - Dictation started, but not completed
    - One case is forgotten in a multiple exam dictation

# Problem #2: Delinquent Dictations

- Traditional solution
  - Transcriptionist dependent (delay)
  - Paper-based (“out-of-band”, lost/misplaced)
  - Hand-delivered to division chief (inefficient, interrupt, single person)
  - Post hoc/batch mode reports (not real-time)
- Dashboard solution
  - PACS administrator in charge (consolidated responsibility)
  - Creates divisional alert in dashboard (“in-band”)
  - Whole division sees the alert (shared responsibility)
  - Link directly to delinquent exam (actionable)

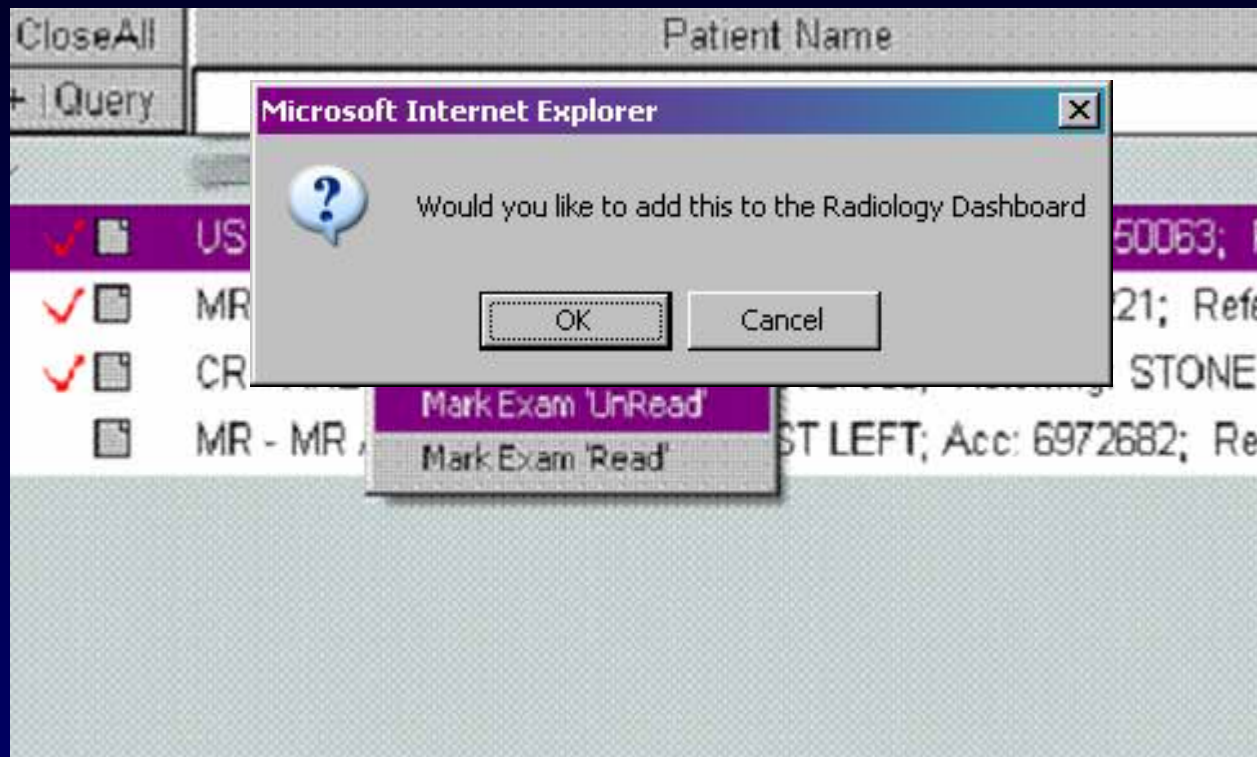
# Hypothesis #2

- A dashboard element that alerts the radiologist to delinquent undictated exams will reduce the prevalence of delinquent cases and the average time to resolution.

# PACS Admin User Interface



# PACS Admin User Interface



# PACS Admin User Interface

The screenshot shows a web browser window titled "Exam Read Utility -- Web Page Dialog". The interface includes a "Division" dropdown menu set to "MUSCSKEL", a "Message" text area containing the text "This exam has been incorrectly Marked Read and still needs to be dictated.", and two buttons labeled "submit" and "cancel". Below these elements is a "Presets" section with a bulleted list of instructions.

**Division** MUSCSKEL

**Message** This exam has been incorrectly Marked Read and still needs to be dictated.

**Presets**

- This exam has been incorrectly Marked Read and still needs to be dictated.
- Outstanding C-Status
- Please dictate reformats
- Please dictate 3D
- Report in Stentor does not include this exam, please dictate.

# The Radiology Dashboard : Delinquent Undictated Cases

**STENTOR**® User: ● Individual ● Division ● Enterprise ● Enterprise **Go to patient:** DOE, JONATHAN

**DOE, JONATHAN** : Sex: M, **Exam False Dictated** Outstanding C-Status Procedure Code: CCT171, Referring Physician: CHANG, PAUL  
MITO STUDY

Location: UPMC Presby  
Patient: \_\_\_\_\_  
Exam: ANKLE 2 VIEWS RT  
Date: 2006-03-24 08:35:00

| [load exam](#) | [clear alert](#) |

<p>↓</p> <p>CT ABDO</p> <p>02/17</p> <p>Most Recent: 02/17/2005</p>	<p>1</p>	<p>↓</p> <p>CT ABDO</p> <p>02/17 05/03</p> <p>CR KNEE CR KNEE</p> <p>05/02 05/02</p> <p>Most Recent: 02/17/2005</p>
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CT; MITO  
02/17/2005; Acc#: 1236547  
Referring: CHANG, PAUL  
Status: COMPLETE

Series 1
Series 1
Series 2

CR; knee  
05/02/2003; Acc#: 3214567  
Referring: BRANSTETTER, BARTON  
Status: FINAL

MINIMAL  
PATELLOFEMORAL

# The Radiology Dashboard : Delinquent Undictated Cases



**STENTOR** User:

Individual  Division  Enterprise

Sex: F, BirthDate: 5/8/1975, MRN: 18258

[Patient History Timeline](#)

CR ANKL CR ANKL CR ANKL  
04/25 04/25 04/25  
Most Recent: 04/25/2006

25 Apr, 2006 16:58:09	Acc# 10638113	25 Apr, 2006 16:58:41	Acc# 10638113	25 Apr, 2006 16:59:13	Acc# 10638113
					
ankle ankle joint AP	w/l: 2508/2193	ankle ankle joint LAT	w/l: 1197/2830	ankle ankle joint OB	w/l: 1197/2830

# Experiment #2: Data Acquisition

- Study period: 3 months pre and post implementation
- PACS administrator logged all delinquent exams
  - Dictation delay > 72 hours (“C-Status”)
  - False dictation status (“False-D”)

# Experiment #2: Statistical Analysis

## “C-Status”

- Snapshot analysis
- Compared prevalence before and after using Chi-squared test

## “False-D”

- Resolution time = delay from transcription to finalized report
- Compared pre and post averages using Student's t-Test

# Experiment #2: Results

Prevalence of “C-Status” Dictations (>72h)

Division	Pre	Post	
Abdominal	10	0	
MSK	26	0	
Neuro	13	0	
Chest	0	0	
<b>Total</b>	<b>49 / 33,077</b> (0.15%)	<b>0* / 36,958</b> (0%)	*p < .001

# Experiment #2: Results

Average resolution time for “False-D”

Before dashboard: 13.6 days

After dashboard: 2.8 days

$p = 0.005$

# Experiment #2: Discussion

- Dashboard effects
  - Reduces prevalence of C-status (i.e. by reducing “lifespan”)
  - Supplies all radiologists in division with cue
  - Preemptive

# User Survey: Methods

- Quantitative
  - 18 Questions
  - Five point Likert-type scale
    - Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree
- Qualitative
  - Two free-text questions
- Staff and trainees were emailed a link to the web-based survey

# User Survey: Results

- Response rate
  - Residents 40/50 (80%)
  - Staff 32/52 (62%)

# User Survey: Results

“The red-yellow-green stoplight analogy is a good way to summarize the status of the system.”

85% Agree or Strongly Agree

# User Survey: Results

“When I see a yellow or red light, I check to see what it is about.”

72% Agree or Strongly Agree

# User Survey: Results

“The dashboard helps to guide what task I do next.”

42% Agree or Strongly Agree

# User Survey: Results

“I sign reports more often with the dashboard in place.”

76% Agree or Strongly Agree

# User Survey: Results

“C-status and false-D-status reports are easier to eliminate with the dashboard in place.”

44% Agree or Strongly Agree

# User Survey: Results

“I noticed the lights at first, but now I don't notice them.”

67% Disagree or Strongly Disagree

# User Survey: Results

“The dashboard is frequently inaccurate.”

44% Agree or Strongly Agree

# User Survey: Results

“I am more efficient with the dashboard  
in place.”

56% Agree or Strongly Agree

# User Survey: Results

- User Comments: Positive
  - “Love that dashboard.”
  - ‘I think it has been a useful reminder.’

# User Survey: Results

- User Comments: Negative
  - “An inaccurate dashboard is worse than no dashboard”
  - “Never used it, see no reason to. Another wasted effort in my opinion.”

# User Survey: Results

## Suggested new features

- Exam reassignment
- Monitoring of other sites

# User Survey: Results

## Wishful thinking

- local movie times
- cafeteria menu for the day
- investment portfolio
- live golf updates

# User Survey: Discussion

- Accuracy/immediacy is important
  - Users want their “green light”
  - Don’t “cry wolf”
- Clarify roles/expectations (i.e. division level alerts)

# General Discussion

- Design implications
  - Just-in-time/real-time
    - Right information at the right time
    - Influence decisions/behavior
  - Integrated
    - Part of the workflow
      - Worklist mode
      - Image viewing mode

# General Discussion

- Technical Implications
  - Move away from 'hard-coded' linkages
  - Encapsulate legacy systems
  - Normalize to standard web technologies
  - Let users drive the process

# General Discussion

- Radiologist Implications
  - Efficient → Effective
  - Optimized workflow
  - Real-time, informed decisions

# Future Directions

- Load balancing
- Reassigning misrouted exams
- Monitoring for new images on dictated exam

# Conclusions

- Increasing complexity in radiology workflows and supporting infrastructure

# Conclusions

- Radiologists need help “seeing” the state of their workflow

# Conclusions

- Much of the data already exists
  - Centralized and repackaged to be “consumed” by other applications
- Embrace the software Zeitgeist
  - SOA, XML, web services, RSS, ESB

# Conclusions

- Dashboard facilitates informed decision making
  - Preserve added value
  - Ensure quality of patient care