Radiology Protocol Tool Recorder (RAPTOR): A Drupal Case Study

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Modernizing the legacy healthcare IT

- New development takes too long to deliver
- Multi-year release cycle is normal
- Integration of new technology/ ideas takes too long
- VistA (EMR) application seen as brittle
- Dated technology, needlessly complex
- Maintenance, installation and operations are difficult
- *Reference: American Council for Technology – Industry Advisory Council VistA Modernization report*

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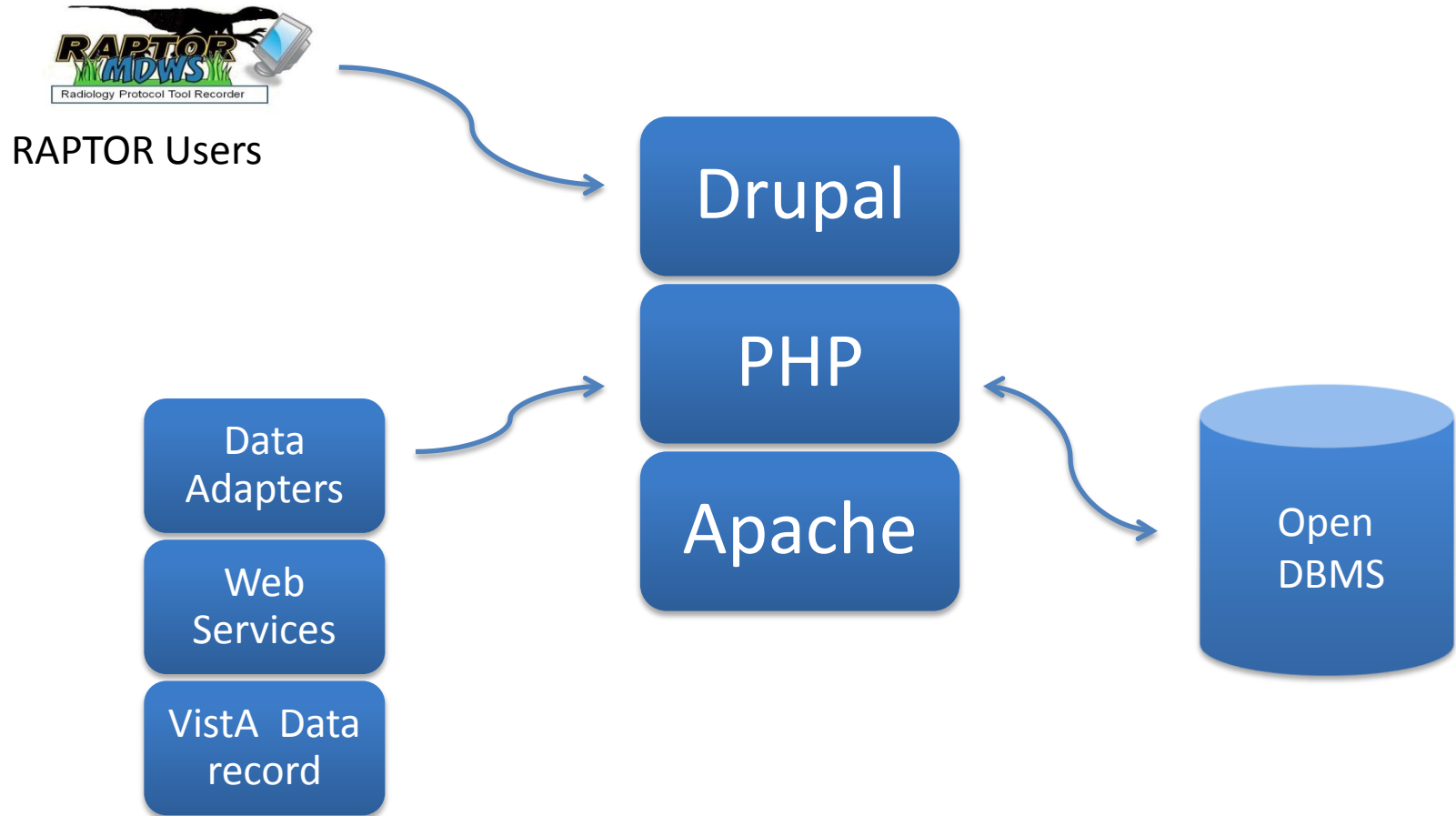
Our Game Changing Innovation

- Use open source tools like Drupal CMS

- Utilize the agile development process

- Reuse web services components

- Utilize the sandbox development environment

- Turn a error-prone manual workflow that can take weeks to complete and transition it into an electronic process that can be completed in minutes.

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Key Project Decisions

Options	Assessment
Software Development Strategy	Open Source software development project was delivered on time on budget using Agile methodology
Open Project Management tools	GanttProject for schedule and Dia for drawing had fewer features than commercial software but were sufficient for this project
Reusing existing VA services	Medical Domain Web Services (MDWS) was successfully implemented but documentation and support was nonexistent
Commercial vs. Open CMS	Drupal has great community support and a more complete framework than Joomla! and commercial software
Open Development tools	Open Flash Chart, Filezilla, BitNami were successfully used in our project

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RAPTOR Open Architecture

RAPTOR Users

Drupal

PHP

Apache

Data Adapters

Web Services

VistA Data record

Open DBMS

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Transitioning from Paper to Drupal

Paper   **RAPTOR**

Current VistA order protocol workflow supported in RAPTOR web form
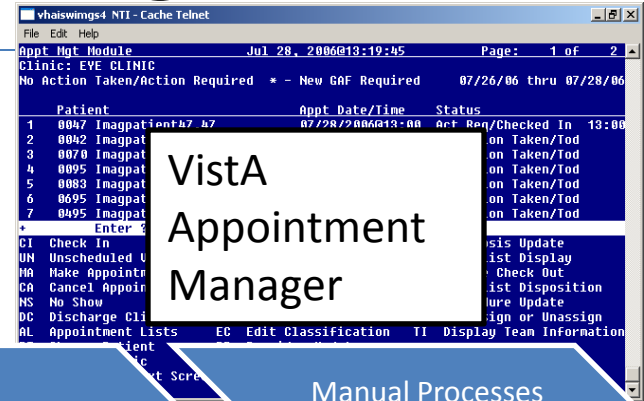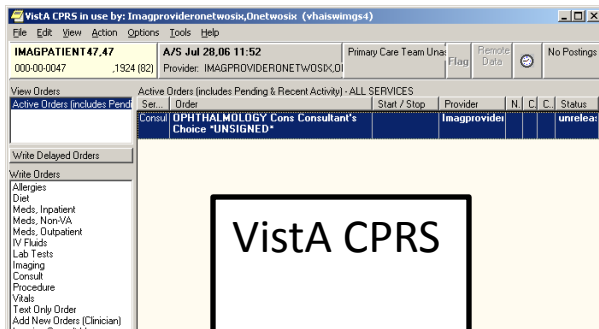
Radiologist and Tech's comments are captured

Additional patient safety checks and contraindications

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Paper Workflow from Order to Scheduling

VistA CPRS
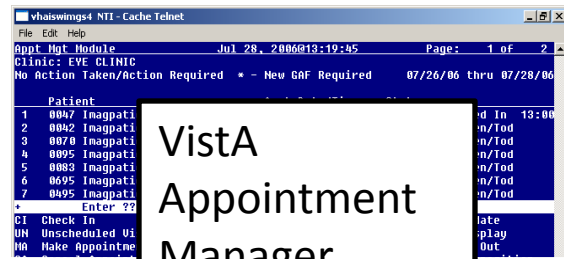
VistA Appointment Manager

| Clinician | Manual Processes (performed by either Front Desk, Scheduler or Technician) | Radiologist | Manual Processes (performed by either Front Desk, Scheduler or Technician) |

- Places Imaging Request in CPRS

- Print VistA CPRS Imaging Order
- Orders are manually sorted by Modality/specialty for workload distribution
- Additional significant clinical information may be collected and included with Protocol Packet
- Delivers Protocol Packet to Radiology Area by Modality/specialty

- Review Protocol Packet Information
- Additional clinical information may be collected and reviewed
- Prior Studies and Reports through PACS
- Lab information through VistA
- May call Clinician to discuss order
- Handwritten Protocol on coversheet with radiologist's signature or initial

- Picks up Protocol information from radiology area
- Protocol coversheet may be scanned
- Procedure is Scheduled in VistA Radiology
- Appointment Information is manually entered into VistA Appointment Manager

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Paper Workflow from Scheduling to Report
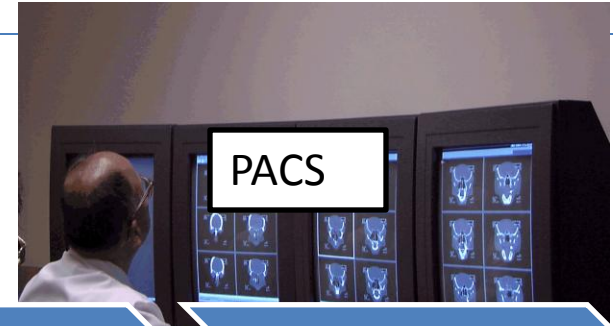
| Scheduler | Technician | Radiologist | Clinician |

VistA Appointment Manager

PACS

- Patient is scheduled & contacted regarding appointment
- Procedure prep (Q&A)

- Scheduled exams are Registered. This generates an exam accession # and corresponding printed bar code card
- Reviews Modality Worklist
- Brings Patient to Modality
- Performs Protocol as specified by radiologist
- May call Radiologist to discuss protocol instructions
- May scan protocol sheet and Q&A into patient record
- Exam Case Edited and Completed

- Reviews Reading Worklist
- Refers to clinical symptoms & original protocol
- May call technician to discuss image
- Reviews and reads Image at PACS Workstation
- Dictates Report
- May call Clinician to discuss Report
- Must call Clinician to discuss critical result.

- Reviews Report with Patient

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RAPTOR – Features

- Tracks entire Protocol Workflow
  - Who did what, when
- Ability to detect "at-risk" drug interaction
- Contraindications are acknowledged
- Monitor radiation dose history
- RAPTOR can be used throughout the workflow: protocol, examination and interpretation phases
- Protocol Library maintained

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RAPTOR workflow

Protocol
- Active order is assigned then selected.
- Hydration, contrast, informed consent & sedation based on case.
- Radiologist, Resident or Technologist reviews and approves the protocol.

Examination
- Technologist acknowledges protocol.
- Actual hydration, contrast & sedation and radiation are noted.
- Exam is completed.

Interpretive
- Radiologist reviews actual vs. planned.
- Post-examination observations are noted.
- Quality Control is noted for completed exams.

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RAPTOR State Diagram
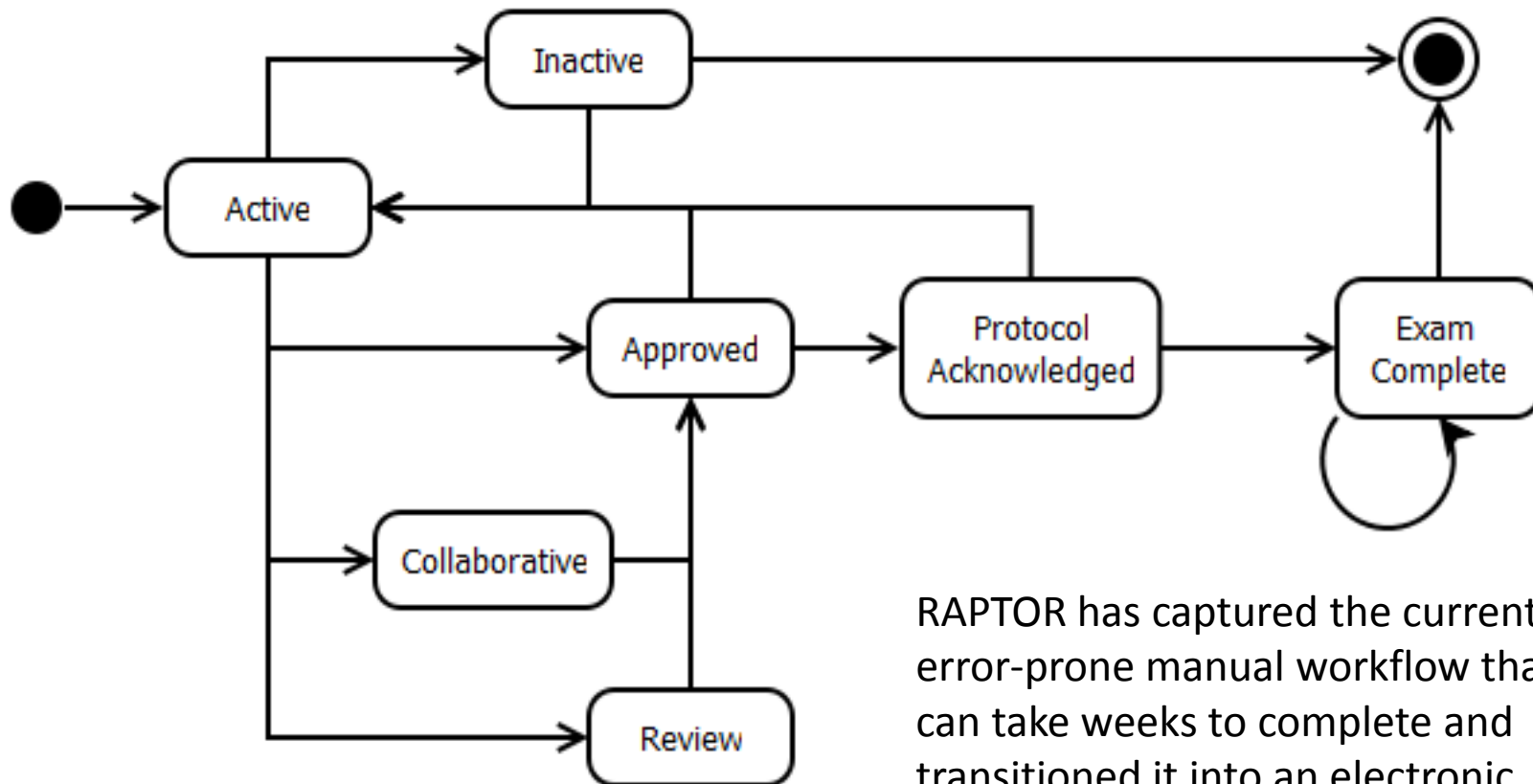
RAPTOR has captured the current error-prone manual workflow that can take weeks to complete and transitioned it into an electronic process that can be completed in minutes.

Comparison before and with RAPTOR

Attribute	Before RAPTOR	With RAPTOR
Environment	Paper	Web-based, paperless
Level of Interoperability	Lowest – paper or scanned paper	Highest – Computational electronic data
Patient Identifiable Information	Poor (if any) security control	Role based authentication
Collaboration, communication	Handwritten, Fax or phone	Automated into workflow
Work distribution	Stacks of paper manually distributed	Entire worklist process is automated with business priorities set by configurable rules
Records Management	Shred or scanned	Entire process is recorded for management review and reporting

Freedom to Innovate Quickly

- Innovate using building blocks
  - They don't have to be small
- Think of the following as building blocks
  - Content Management System
  - Database Management System
- With Open Source, you are free to modify, extend, build on what is already there; you have a head start getting to your destination

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Simplify Setup by Leveraging Bundles

- Literal **LAMP** concept for Open Source Web Application Server Solution
  - **L**inux, **A**pache, **M**ySQL, **P**HP
- Generalization
  - Operating System, Web Server, Database, Scripting Language
- Rather than configure everything from scratch, find integrator you trust; fine tune later for production
  - We used BITNAMI for development our sandboxes
    - http://bitnami.org/

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Why Drupal

- Robust framework

- Large open source support

- Many features available for extension

- Reasons we chose Drupal over Joomla

  - Scalability

  - User community

  - Open source extensions

Why Drupal (continued)

- Established roles paradigm

- Many workflow options

- Wide platform support
  - Apache
  - IIS

- Wide database options
  - MySQL
  - PostgreSQL

The Challenges

- Prohibited-technology hurdles
  - Justifying Open Source (Resistance)
  - Open source is new to many people
    - Freedom to extend how you want when you want!
- Dependencies on systems which are unavailable in development environments
- Test data in information sensitive settings

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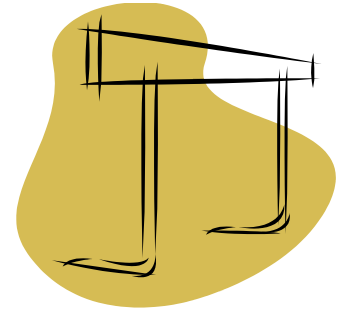
The Challenges (continued)

- Finding the right people for the team
  - Specific Domain Knowledge
    - Internal systems
    - Internal processes
    - Relevant tools
- Stakeholder availability
- Dependencies on teams outside of project control

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Mitigating Challenges

- Don't expect institutional help
  - Welcome it if it does appear
  - Lead the way through challenges
  - Expect to be challenged
- People are busy
  - SMEs may have limited availability
  - Need to manage around the gaps
- Adding team members not always simple
  - Badging and access constraints

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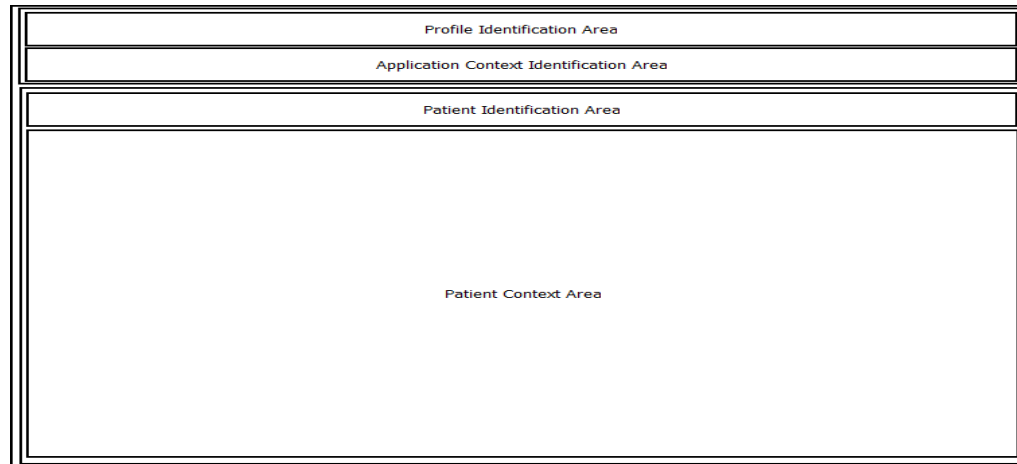
Team Matters

- Communication is Key
  - Between Innovator (Dr. Jonathan Medverd, VA Radiologist) and Development team
  - Between Designers and Developers
  - Between Developers
- Bring experience in as needed
  - Drupal is powerful and potentially complex
  - Agency systems have their own sophistications
  - Integration awareness matters

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Collaboration in Design and Development

- Screen mockups do not have to be static
  - Build real things
  - Write code to keep
- Finalize all key aspects as soon as practical
  - Understand some things do not need finalization at the start
- Punch lists
  - Keep clear transparent track of progress
  - Prioritize with your stakeholders

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Custom Drupal Regions and Blocks

- For RAPTOR defining a custom region layout early reduced design uncertainty later

Profile Identification Area

Application Context Identification Area

Patient Identification Area

Patient Context Area

- Vet with everyone via mockup examples

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Frequent Interaction

- Agile processes work best when feedback is frequent and iterations are short

- Educate stakeholders that frameworks are flexible but rework has a cost
  - Teach importance of making decisions and moving on from them
  - "Parking lot" items that can be revisited later

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Frequent Interaction (continued)

- Leverage team strengths
  - build trust through results
    - Show results frequently
- Leverage virtual meetings and shared environments
  - Sandboxes
  - Common tools

Data Sources for RAPTOR

- Application Configurations
  - Relational Database
  - Configuration Files
- Application Data
  - MDWS
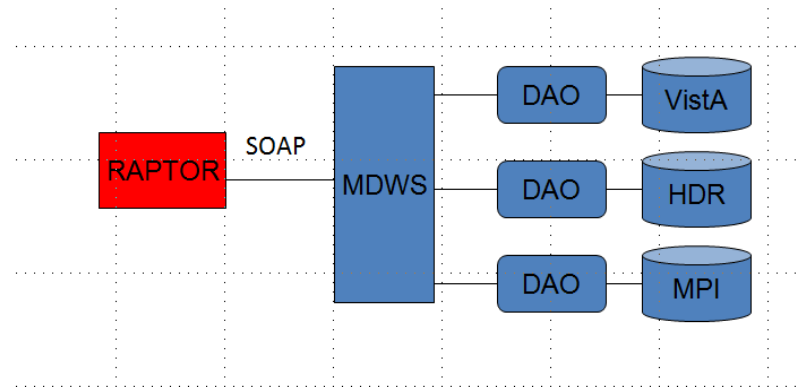
Database Engine in Drupal7

- MySQL …
  - Native support, currently available as open source
  - Future as unencumbered open source tool is murky
- PostgreSQL …
  - Powerful and fully open source, future looks good
  - Not as widely adopted yet as MySQL
- We chose MySQL for RAPTOR because …
  - Already approved for use at the agency
  - Larger pool of tools already tested and built for MySQL in Drupal7
  - Drupal7 applications can switch DB Engine at anytime with limited impact; not really locked in anyways

MySQL

- http://www.mysql.com/products/community/
- Probably the most popular robust relational database available today
- Some concerns over its future open source commitment

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PostgreSQL

- http://www.postgresql.org/

- Probably the most robust alternative to MySQL; default support is growing

- Future as an open source option looks very stable

- Has always been more powerful than MySQL in some ways

RAPTOR Data Layer Approach

- All data layer interaction abstracted into a custom Drupal Module
  - One module with internal abstraction layers
- Low level data sources can be replaced without rewriting RAPTOR
  - No limit to how much can be abstracted
  - Make replacing volatile things easy

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RAPTOR User Interface

- Custom Drupal7 Theme: RAPTOR Sky
    - Custom regions
    - Custom behaviors
- Based on Open Source Theme: Sky
    - This is a 960 grid based theme
- Easy to build custom themes!
    - Powerful design opportunities
    - Drupal learning curve gets steep in some areas

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RAPTOR Application Module

- RAPTOR has one custom Drupal7 module
  - RAPTOR Blocks
  - Partnered with the custom RAPTOR Sky theme
- Rejected implementation as collection of multiple custom Drupal7 modules
  - Did not make sense for this project phase
- Data layer abstraction is within the custom RAPTOR Blocks module

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General Lessons Learned

- Know your strategy, be ready to articulate it at any time
    - Open source is still new to many
    - Many misconceptions still persist
- Use of open source tools had no adverse impact on schedule or budget
    - More support options with no direct cost
    - Paid support is always an option too
- Open source initiatives are blazing a path where only commercial products where considered before

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Questions

Open Source for the Team Too

- ***Dia*** for simple structured diagrams
  - http://live.gnome.org/Dia
- ***Netbeans*** for a common IDE among development team members
  - http://netbeans.org/downloads/
- ***Notepad++*** for unusual file manipulations
  - http://notepad-plus-plus.org/

Innovation in the Government

- Shrinking budgets
- Increase value
  - More options
  - Lower cost
- Reduce proprietary lock-in risks
  - Go in new directions
  - Build on what you have

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Open Source in the Government

- Government more aware of Open Source advantages
- SAN delivered an open source CMS system to Department of Education in 2009
  - SAN was brought in after Dept of Education had rejected two prior candidates built using proprietary products by other teams
  - For that project SAN chose Joomla! CMS framework
- For RAPTOR at VA 2011, SAN chose Drupal7 CMS framework

More info

- www.sanbusinessconsultants.com
- SIIM 2012 Conference: Advanced Medical Imaging Protocol Workflow – A Comprehensive Electronic Solution in the National VA Enterprise to Optimize Process Efficiency, Care Quality and Patient Safety
- SIIM 2012 Conference: Top 5 Medical Imaging IT Projects of 2012