Research Center
@ University of California, Davis

Goals...
- Increase operational efficiency
- Reduce fatalities and injuries
- Reduce lane closure duration
- Reduce environmental hazards
- Increase quality and reliability

- http://ahmct.ucdavis.edu
- Ty Lasky, talasky@ucdavis.edu
AHMCT’s Role

• Open ATMS research project, 2005 - 2009
  • IRIS demonstration in Caltrans
  • Leverage commodity software & hardware for ITS
  • ...to provide ITS benefits to lower density districts
  • Evaluate effectiveness of this approach
  • Evaluate effectiveness of IRIS
• Software development
• Software Engineering
• Deployment
• Support
• Knowledge transfer
Roadmap

• Open ATMS project & IRIS
  • Technical details
  • Scalability
  • Architecture
  • Information for new implementations

• Software engineering process
  • Software development process
  • Benefits
  • Testing
  • Collaboration

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Open Source

What ‘open source’ means...

1. Legal definition, [http://opensource.org](http://opensource.org)
2. Development method

Open-source (GPL) requires...

- Source code is freely available
- Modified code is open-source

Results in...

- Creation of knowledge communities
- Enables cooperative development model
- Enables a network effect
- Reduces legal complexity, no NDAs

Tends to view software as knowledge

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Study Conclusions...

- Way of delivering new ITS capabilities to lower density districts
- Significance of collaborative development model
- Cost-effective for lower density districts
- Approach has high relevance for ITS research & development
- IRIS...
  - Running in production within Caltrans for 29 months
  - ...is extendible, reliable, scalable

More details in the Open ATMS Final Report

http://iris.ahmct.ucdavis.edu
Caltrans Contributions to IRIS

• Multi-agency support:
  – System attributes
  – Internationalization (I18N), “DMS” versus “CMS”
  – Generalized incidents

• Testing
  – Automated unit test cases (JUnit)
  – DMS simulation

• DMS message library

• Automated Warning System (AWS) functionality

• Numerous UI refinements
  – DMS preview, intermediate status updates, etc.
  – Page-on times,
  – Extended for use on small monitors

• Google Earth output (KML)

• Server-side incident feed

• IRIS binary packaging (RPM)

• Ongoing...
  – Automated Warning System (AWS) enhancements
  – EIS RTMS traffic driver
  – Road Weather Information System (RWIS) enhancements
  – Spell Checker

• IRIS Developer Ticketing System
Caltrans IRIS Functionality

• DMS (CMS) control and monitoring
• Integration w/ existing Automated Warning System
• Video monitoring and PTZ control
• Traffic: speed, flow, density, 30 second
• Integrated mapping w/ field elements, roads
• Real-time CHP incidents
• User authentication
• Extensive user roles, permissions
• Reporting
• Currently not used:
  – Travel time, Variable Speed Limits (VSL), ramp meters, Active Traffic Management (ATM)
IRIS Technical Details

- **Client / Server architecture**
- **Client and server written in Java**
- **Client**
  - JWS, nothing to install
  - Running on Windows, Linux
- **Built with:**
  - OpenJDK, Linux, Tomcat, Ant
  - Database: PostgreSQL
  - Distributed source repository: Mercurial
  - 100% open-source, free
- **User authentication via LDAP**
- **~100K lines of Java code, ~1000 classes**
  - IRIS dollar value is approximately $4 million (SLOCCount)
  - See the Open ATMS Final Report for more

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IRIS Scalability

On a $1000 dual-core server...

- Running 50 simultaneous IRIS clients
- With 60 DMS, 250 VDS
- Running IRIS, database, all other apps

Resulted in...

- Processor load was < 20% on 1 core
- IRIS memory usage was 140 MB
- Total server memory usage was 818 MB

The IRIS Server is scalable on commodity hardware
IRIS Scalability
Multi-agency Support

• One code base in multiple districts, agencies
• Configuration determines agency-specific behavior
  – System attributes
  – Internationalization,
    • e.g. “DMS” versus “CMS”
  – Property files
  – Agency specific code
    • E.g. AWS
Effort Estimates for New Implementations

For a new IRIS installation...

• 1-3 weeks for initial installation & configuration
• Crucial questions:
  – How many new hardware devices interfacing with?
  – How many existing systems integrating with?
  – How many user interface enhancements?
• 1-3 weeks of dev time per new hardware device
  – If UI changes are required, add more time
• Complex user interface enhancements take time
• Start with one functional area, increment based on success
Motivation for doing it right...

• Across industries, 32% of software projects are successful (Standish)
  – On time
  – Within budget
  – With desired features
• 50% of projects are rolled back out of production (Gartner)
• Annual software project cost overruns are $50 - $80 billion
Adding an IRIS Enhancement

1. Request for improvement...
   - Caltrans operators “we need...”
   - Organizational need
   - Defect discovered
2. Ticket created
3. Requirement written + discussion
4. Design, discussion with Mn/DOT
5. AHMCT implements, discusses as necessary
   - Automated test cases
   - Integration testing
6. AHMCT publish new feature in public IRIS repository
7. Mn/DOT...
   A. Read new change sets
   B. Review
   C. Merge into Mn/DOT IRIS repository
8. Mn/DOT publishes a new version of IRIS w/ new feature
IRIS Release and Collaboration Process

This process is scalable + network effect

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Benefits of Collaborative Development Approach (for the software engineering process)

1. Higher code quality
2. Better design
3. Better testing
4. Better planning
5. Increased probability of success for new IRIS projects versus starting development from scratch

These are intrinsic to some extent
Software Engineering Process

• Caltrans IRIS Change Control Board (CCB)...
  – Drives the development process
  – Prioritizes enhancements
  – Chooses content of each release

• Requirements defined & tracked
  – Caltrans ticket system
  – IRIS developer ticket system  http://iris.ahmct.ucdavis.edu/trac

• Design, collaborative
• Implementation
  – Prototyping
  – Testing (TDD), as early as possible

• Quarterly releases

What’s different...

• Better visibility into development process
  • E.g. the source repositories are public
• Process encourages better...
  • Design
  • Implementation
  • Testing

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IRIS Prototype
Development Process Transparency
Cumulative SLOC vs. Time for a Module

Module went into production

01/28/08

7/1/08
Cumulative Additions to IRIS

Cumulative SLOC vs. Time

First Caltrans contribution
Testing

• Continuous Integration
  – Test early and often
  – Automated test cases (600+)
    • Integrated w/ development process
    • Enables Test Driven Development (TDD)
  – DMS Simulator (CASPER)

• Validation
  – User needs $\rightarrow$ requirements $\rightarrow$ design $\rightarrow$ prototype
  – Users experiment with prototype
  – User acceptance test cases

• Verification
  – Automated test cases
  – Integration testing, test cases + ad hoc
  – Multi-agency testing
  – Acceptance test cases

• Future
  – Automated integration tests
  – Simulated traffic
  – Capture and replay of traffic and RWIS data

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Multi-agency Collaboration

- Free information flow → innovation
- Shared development → network effect

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Transportation Solution Stack

Collaboration at different levels

Transportation Solution Stack

- **Policy**
  - Goals, priorities

- **ITS Solutions**
  - Software applications, practices
  - e.g. IRIS

- **Metadata**
  - e.g. IRIS database schema

- **Data**
  - Database contents, spreadsheets, etc.

- **Communication**
  - Data networks

- **Hardware**
  - Field sensors, controllers, servers

Transportation Agency #1

- **Policy**
- **Solutions**
  - e.g. IRIS
- **Metadata**
  - e.g. IRIS DB
- **Data**
- **Comm.**
- **Hardware**

Transportation Agency #2

- **Policy**
- **Solutions**
  - e.g. IRIS
- **Metadata**
  - e.g. IRIS DB
- **Data**
- **Comm.**
- **Hardware**

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Looking Forward

• IRIS provides an open ITS development platform
  – Natural fit with R&D
  – High rate of innovation
  – Provides deployment pathway for great ITS R&D
• Benefits of open collaborative ITS development
  – Low barriers to entry
  – Intrinsically encourages high quality
  – High cost-efficiency
  – Low legal friction
• More IRIS developers, public and private
• Growth of IRIS ecosystem
  – Hardware vendors, more IRIS hardware drivers
  – Consultants, DOTs, municipalities, etc.
  – Universities
  – Software products integrated with IRIS
Resources

• AHMCT
  – IRIS ticket system
  – FAQs
  – Javadoc
  – Documentation
  – Code repositories
  – Open ATMS Final Report
  – Ty Lasky, talasky@ucdavis.edu
  – Bahram Ravani, bravani@ucdavis.edu

• Mn/DOT
  – http://iris.dot.state.mn.us
  – Documentation
  – Repositories