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Leveraging Multiple States for Cooperative ITS Development

Benefits and Costs from the Caltrans IRIS Demonstration Study

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Roadmap

- Open-source
- Project background
- IRIS implementation in Caltrans Districts 10, 5, 1
- Cost benefits
- Open-source collaboration
- IRIS reliability, scalability
- Lessons learned
- Effort estimates for new IRIS implementations
- IRIS as a research platform
- The future of IRIS
- Conclusions
AHMCT Research Center – Est. 1991

Goals…

• Reduce fatalities and injuries

• Increase efficiency of operations

• Reduce lane closure duration

• Reduce environmental hazards

• Increase quality, reliability and lifecycle

http://ahmct.ucdavis.edu
Thank you to our partners…

- Caltrans
  - District 10, also 1 and 5
  - HQ Traffic Operations, Stan Slavin
  - Division of Research & Innovation
  - HQ Information Technology
- Mn/DOT
- FHWA
- AHMCT
Open Source

What ‘open source’ means…

• Source code is freely available
• ‘Derivative works’ code must be shared (GPL)
• Way of building a knowledge community
• Shared cooperative development
• Fits naturally with commodity hardware
Caltrans IRIS Project Timeline

How can Caltrans ATMS costs be reduced?

RFP 11/2004

Scope 1: Develop open-source ATMS 02/2005

Mn/DOT releases IRIS source code 05/2007

Scope 2: Open database 02/2006

IRIS goes live in Caltrans D10 05/2008

Scope 3: IRIS Demonstration Study 07/2007

IRIS goes live in Caltrans D5 08/12/2009

Caltrans internal feasibility study for IRIS

IRIS goes live in Caltrans D1 08/26/2009
Study Goal

Demonstrate the feasibility of implementing and extending the IRIS open-source ATMS in Caltrans District 10.

Questions…

1. Lowers costs? How much? Why?
2. Hidden costs? Challenges?
3. How well does multi-state cooperation work?
4. Is using a single code base effective?
5. IRIS questions…
   – Effort to integrate with existing systems?
   – How reliable?
   – Customize?
Screenshot: DMS + Traffic + Incidents
Caltrans District 10 IRIS Capabilities

• DMS control and monitoring
  – Integration w/ existing AWS system
• Video monitoring and PTZ control
• Traffic: speed, flow, density, 30 second
• Integrated mapping w/ field elements, roads
• Real-time CHP incidents
• User authentication, permissions
• Reporting
• Not used
  – Travel time, VSL, ramp meters
Screenshot: DMS in Google Earth/Maps

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Screenshot: Video
Video Architecture

IRIS Clients

IRIS Video Servlet

D10 IRIS Server

City of Stockton Video Feed

4 channels

IRIS Video Servlet

MJPEG

TMC Video Wall

VLC Application

Axis Video Server

Axis Video Server

Field Hardware
IRIS Technical Details

- Client / Server architecture
- Client and server written in Java
- Client
  - Nothing to install (JWS)
  - Runs on Windows or Linux
  - Client runs over low bandwidth connection
- Database: PostgreSQL
- IRIS open-source hardware drivers
  - NTCIP, Wavetronix SmartSensor, CAWS, etc.
- Maps: SHP files, many layers
- Authentication via LDAP
- Distributed source repository (Mercurial)
- 100% open-source (GPL)
- ~100K lines of Java code, > 1000 classes
Results: Costs

1. Acquisition Costs
2. Configuration & customization costs
   • These costs are variable
   • Are a function of needs and planning
3. Annual Maintenance Cost
1) Acquisition ATMS Costs
(for one Caltrans district)

<table>
<thead>
<tr>
<th>Component</th>
<th>IRIS Cost</th>
<th>Existing ATMS Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server hardware</td>
<td>$4,500</td>
<td>$150,000</td>
</tr>
<tr>
<td>Backup server</td>
<td>$4,500</td>
<td>$150,000</td>
</tr>
<tr>
<td>5 client workstations (optional)</td>
<td>5x $1,500</td>
<td>5x $1,500</td>
</tr>
<tr>
<td>OS support, 24x7 (optional)</td>
<td>$1,300</td>
<td>Included</td>
</tr>
<tr>
<td>Server software licenses</td>
<td>$0</td>
<td>$239,000</td>
</tr>
<tr>
<td>Backup server licenses</td>
<td>$0</td>
<td>$239,000</td>
</tr>
<tr>
<td>Developer software licenses</td>
<td>$0</td>
<td>$269,000</td>
</tr>
<tr>
<td><strong>Total Acquisition Cost</strong></td>
<td><strong>$17,800</strong></td>
<td><strong>$1,054,500</strong></td>
</tr>
</tbody>
</table>

This is a 98% cost reduction compared with the existing ATMS system.
## 2) Configuration & Customization Costs

<table>
<thead>
<tr>
<th>Traffic Management Installations</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, rural, IRIS installation, DMS functionality</td>
<td>2 weeks</td>
</tr>
<tr>
<td>D4, urban, existing ATMS installation + customization, sole source contract</td>
<td>$750,000</td>
</tr>
<tr>
<td>D5, rural, IRIS installation, DMS functionality</td>
<td>2 weeks</td>
</tr>
<tr>
<td>D10, urban/rural, IRIS install + customization (this project)</td>
<td>$350,000</td>
</tr>
</tbody>
</table>

The use of open-source encourages competition.
3) Annual Maintenance Costs
(for one Caltrans district)

<table>
<thead>
<tr>
<th>Annual Cost Component</th>
<th>IRIS Cost</th>
<th>Existing ATMS Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server hardware maintenance, 24x7 response</td>
<td>$200</td>
<td>$30,000</td>
</tr>
<tr>
<td>Software license cost</td>
<td>$0</td>
<td>$60,000</td>
</tr>
<tr>
<td>Maintenance cost, personnel*</td>
<td>½ - 1 FTE</td>
<td>2.5 - 3 FTE</td>
</tr>
<tr>
<td>Total Annual Maintenance Cost</td>
<td>$75,000 - $150,000</td>
<td>$465,000 - $540,000</td>
</tr>
</tbody>
</table>

This is a 72% - 84% cost reduction

*Based on assumed $150,000 per year contract price per FTE
Estimating the Dollar Value of IRIS

What is the dollar value of IRIS?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IRIS</td>
<td>83,792</td>
<td>20.9</td>
<td>$3,797,360</td>
</tr>
<tr>
<td>Caltrans IRIS apps</td>
<td>11,410</td>
<td>2.4</td>
<td>$441,940</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>95,202</strong></td>
<td><strong>23.3</strong></td>
<td><strong>$4,239,300</strong></td>
</tr>
</tbody>
</table>

SLOCCount uses COCOMO (COntuctive Cost Model)

The total dollar value of the Caltrans IRIS project.
Collaboration

- One source code base
- Configuration determines IRIS behavior
  - System attributes
  - Internationalization
  - Agency specific code

This model produces a network effect
Collaboration Tools

For task and defect tracking…

1. Wiki for documentation and sharing information
2. A Caltrans ticketing system (Trac) was used to…
   • Used by Caltrans and AHMCT
   • Report and track defects
   • Track tasks
   • Track enhancements
3. A developer ticketing system (Trac)
   • Used by developers in many agencies
   • Report and track defects
   • Track enhancements
Adding IRIS Enhancements

1. D10 operators “we need / want …”
2. AHMCT: discuss initial design with Mn/DOT
3. Mn/DOT:
   A. Great, we’ve wanted that for some time
   B. How about X, Y, or Z? (more generalized feature)
   C. OK, but it’s a Caltrans specific feature
   D. Brainstorming for possible alternatives
4. AHMCT: implement & discuss w/ Mn/DOT
5. Mn/DOT:
   A. Pulls our change sets
   B. Merge (if necessary)
   C. Published feature in next release of IRIS
Benefits of Collaborative Approach (1)

1. Higher code quality
   - Someone will be looking at your code
   - Another agency will be depending on your code
   - Your code will be in a public repository

2. Better design
   - More discussion and planning before writing code
   - Developers get feedback from a different perspective
   - A generalized feature is naturally encouraged
     - Easily accepted into code base
     - Readily used by others
Benefits of Collaborative Approach (2)

(more) benefits of the collaborative approach…

3. Better testing
   • More people running your code \(\rightarrow\) code gets better
   • Defect reporting across agencies
   • Defect repair across agencies

4. Better planning
   • Encourages sharing of knowledge (aka software)

5. Lower risks for new projects versus starting from scratch
   • Low entry barriers for new agencies
     • Code freely available
   • Successful design and methods already established
Results: Contributions to IRIS Code Base

We know from other OSS projects that this kind of development is scalable
IRIS Reliability

• Server reliability
  – Very reliable, superb uptime
  – Excellent code design

• Client reliability
  – Good, could be better
  – UI needs refinement
  – Should never crash
IRIS Scalability

The IRIS Server is scalable on commodity hardware…

On a $1000 server…

- Running IRIS + database + etc.
- Running 50 simultaneous clients
- With 60 DMS, 250 VDS
- Processor load was < 20% (1/5 of 1 core)
- IRIS memory usage was 140 MB
- Total server memory usage: 818 MB

These results are primarily a result of excellent algorithm design
Lessons Learned

1. Test cases are crucial
   A. Did a new release break code?
   B. New functionality probably needs test cases

2. Design of enhancements probably requires collaboration

3. Collaborative development takes longer, results in better design + fewer defects

4. RIP non-commodity hardware
Challenges

...with using open-source + commodity hardware...

• Explaining how this approach is different
  – Who owns the software?
  – Who controls the software?
• Complexity of development?
• Will a healthy IRIS ecosystem develop?
• What else?
Effort Estimates for New Implementations

For a new IRIS installation…

- 1-3 weeks of installation & configuration time
- 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 slow, go slow, increment based on success
Integration with Existing Systems

1. Existing code becomes open-source (GPL) code when added to IRIS code base.

2. Existing proprietary code that must stay proprietary should run in a separate application.
IRIS as a Open-source Research Platform

• Multiple users connected to a server
• Server connected to multiple sensors
  – Open-source driver architecture
  – Support for XML data feeds
  – Object persistence
• Low band-width communications protocol (SONAR)
  – Client runs over low-bandwidth connections, wireless, slow DSL
• Multi-user
  – Simultaneous access to the same data
  – Queuing
• Sophisticated roles, user permissions
  – Read / write / create / delete access down to object attribute level
• For traffic management applications…
  – provides ability to deploy R&D into production system
• Other applications: MDSS, vehicle tracking, traveler information, RWIS, etc.
The Future of Open-source and IRIS in Transportation

- Continued growth, particularly for rural agencies
  - Cost efficiency is hard to beat
- Natural fit with R&D, innovation, software as knowledge
- IRIS needs: many enhancements planned
  - Better mapping, OpenStreetMap?
  - Center to center functionality
- More IRIS developers, public and private
- Growth of IRIS ecosystem
  - Hardware vendors, more IRIS hardware drivers
  - Consultants, DOTs, municipalities, etc.
  - Research organization
  - Software products integrated w/ IRIS
Conclusions

The observed results in the Caltrans IRIS Demonstration Study show that commodity hardware + open-source is:

- Cost effective with potentially large cost savings,
- Money saved elsewhere can be spent on innovation,
- Reduces legal friction,
- Encourages collaboration with other agencies,
- Reduces development risks,
- Can be integrated with existing systems,
- Natural fit for rural implementations, e.g. D1, D5,
- Development can be complex and demanding,
- Encourages high code quality.

These benefits put DOTs in the driver’s seat.
Resources

• AHMCT
  – IRIS ticket system
  – FAQs users, developers, screenshots, open issues
  – Documentation (AHMCT, Mn/DOT)
  – Repositories
  – Existing reports
  – Final report (09/2009)

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

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