



Western States 2011

Rural Transportation Technology Implementers Forum

IRIS Open Advanced Traffic Management System

Development, Deployment, Capabilities, and Maintenance

June 14-16 2011

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Roadmap

John

- ATMS introduction and importance
- Timeline
- Before and after overview
- Benefits
- Caltrans contributions to IRIS
- Collaboration

Michael

- Caltrans IRIS research project
- IRIS background
- What worked well and didn't
- IRIS functional overview + demo
- AWS
- VDS
- System configuration and customization
- Architecture + design
- Software engineering and testing
- Costs

Kin

- Video
- System maintenance
- Mapping
- Scalability
- Current and future enhancements





What is an ATMS?

An Advanced Transportation Management System (ATMS) is a software tool that provides Transportation Management Center (TMC) operators and Traffic Managers with a real time view of highway conditions so that accurate and timely actions can be performed in response to adverse environments or traffic incidents.

Why an ATMS?

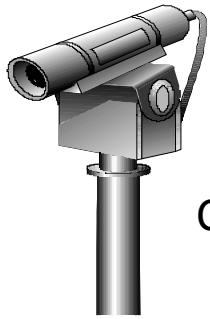
An ATMS allows Caltrans to:

1. Effectively manage the freeways
2. Reduce traveler commuting times
3. Maximize roadway capacity
4. Provide a safer traveling medium for the general public.





ATMS Real-Time Functions



CCTV



VDS

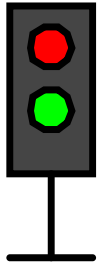


RWIS

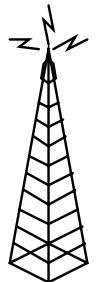
CMS

**HIGH WIND
GUSTS AHEAD**

Ramp
Metering



HAR



**Traffic
Management
Tools:**



Screenshot of IRIS DMS Functionality

Session View Help

Incident DMS Camera LCS Ramp Meter R.Node

Single Multiple

Name V394E16 Brightness 28% Camera C916

Location I-394 EB E of Dunwoody Blvd

Operation None

Deployed 10:16 Expires 10:17

Current Preview

PARKING INFORMATION

RAMP A OPEN
RAMP B OPEN
RAMP C OPEN

PARKING INFORMATION

RAMP A OPEN
RAMP B OPEN
RAMP C OPEN

Duration

Send Blank

Clear

DMS status: User Deployed

122 Available 3 Maintenance 9 No controller

3 User Deployed 11 Inactive 146 All

4 Scheduled 4 Failed

V35EN12 gilmiken

INCIDENT ON RAMP
EXIT RAMP BLOCKED

I-35E NB @ Little Canada Rd

V35ES03 gilmiken

INCIDENT ON RAMP
EXIT RAMP BLOCKED

I-35E SB @ Co Rd E

V694E05 gilmiken

INCIDENT ON RAMP
EXIT RAMP BLOCKED

I-694 EB @ Victoria St

Layers Legend Density

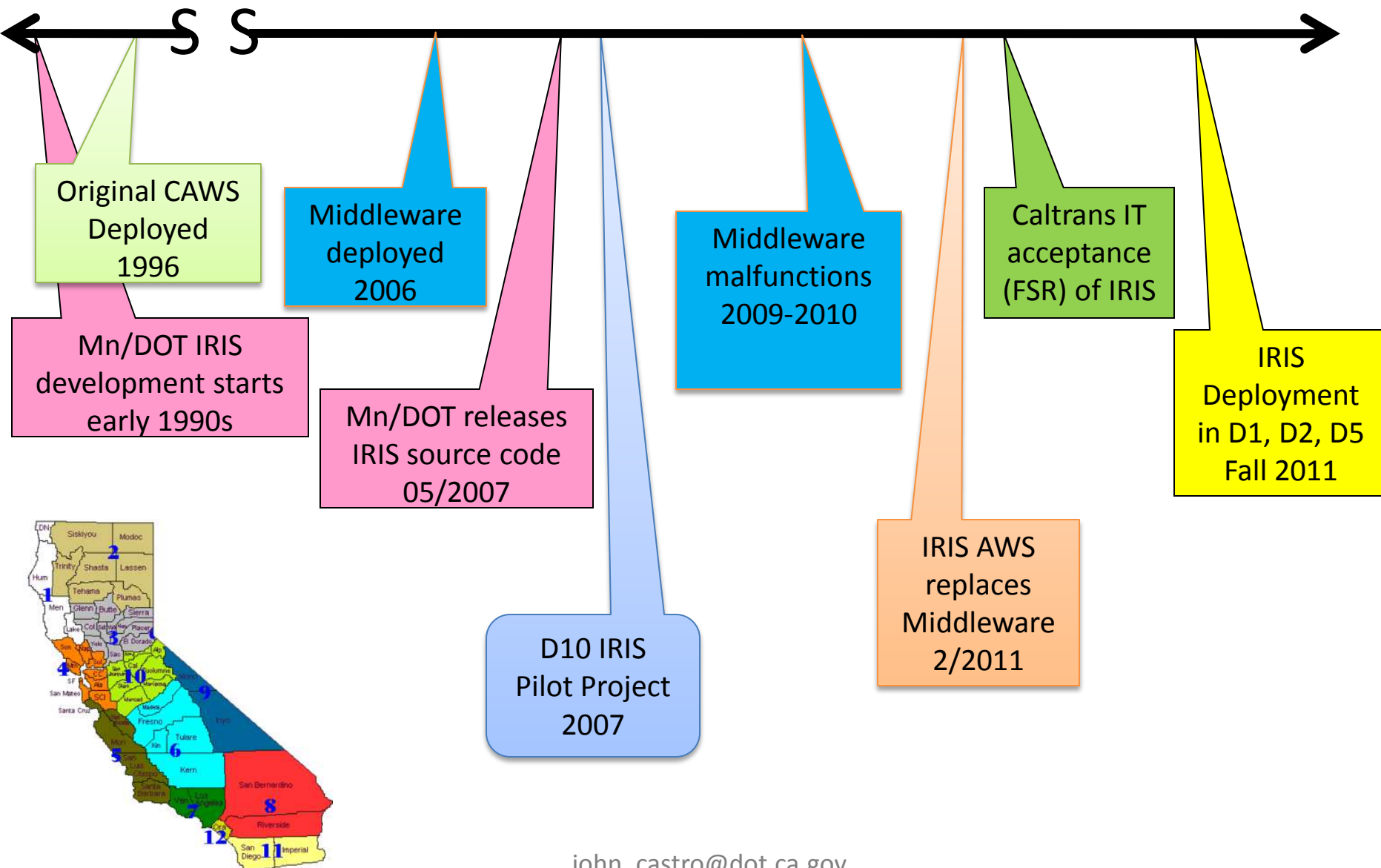
Map of Minneapolis area showing highways and parks.

Action Plan

lat 44.970662° lon -93.296151°

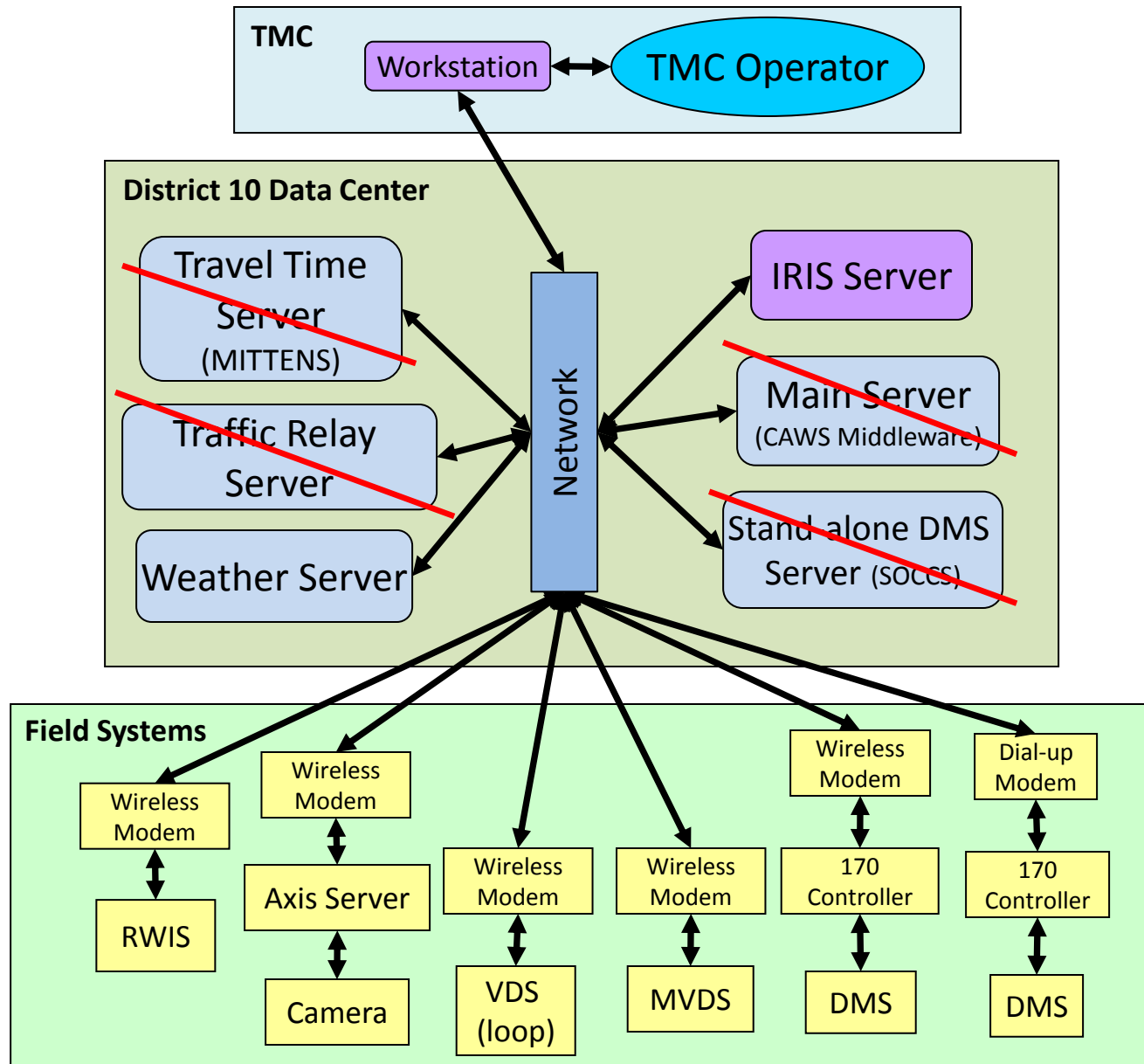


Caltrans District 10 + IRIS Timeline





Caltrans District 10 IRIS Architecture Before and After



Benefits of IRIS

Before and After Comparison

	Before	After
Mapping	None	✓
Number of server machines	4	1
Number of CMS controlled by AWS	9	28 (unlimited*)
Types of VDS supported (MVDS, Loops, etc)	1	5+ (unlimited*)
Types of RWIS supported (Manufacturers)	1	2+ (unlimited*)
Types of CMS supported (Manufacturers)	1	4+ (unlimited*)
Mapped incidents	Via stand-alone app	Integrated
Standby backup system	None	✓
Source code availability	None or proprietary	✓
D10 traffic engineer's maintenance time	50%	



*via device driver interface





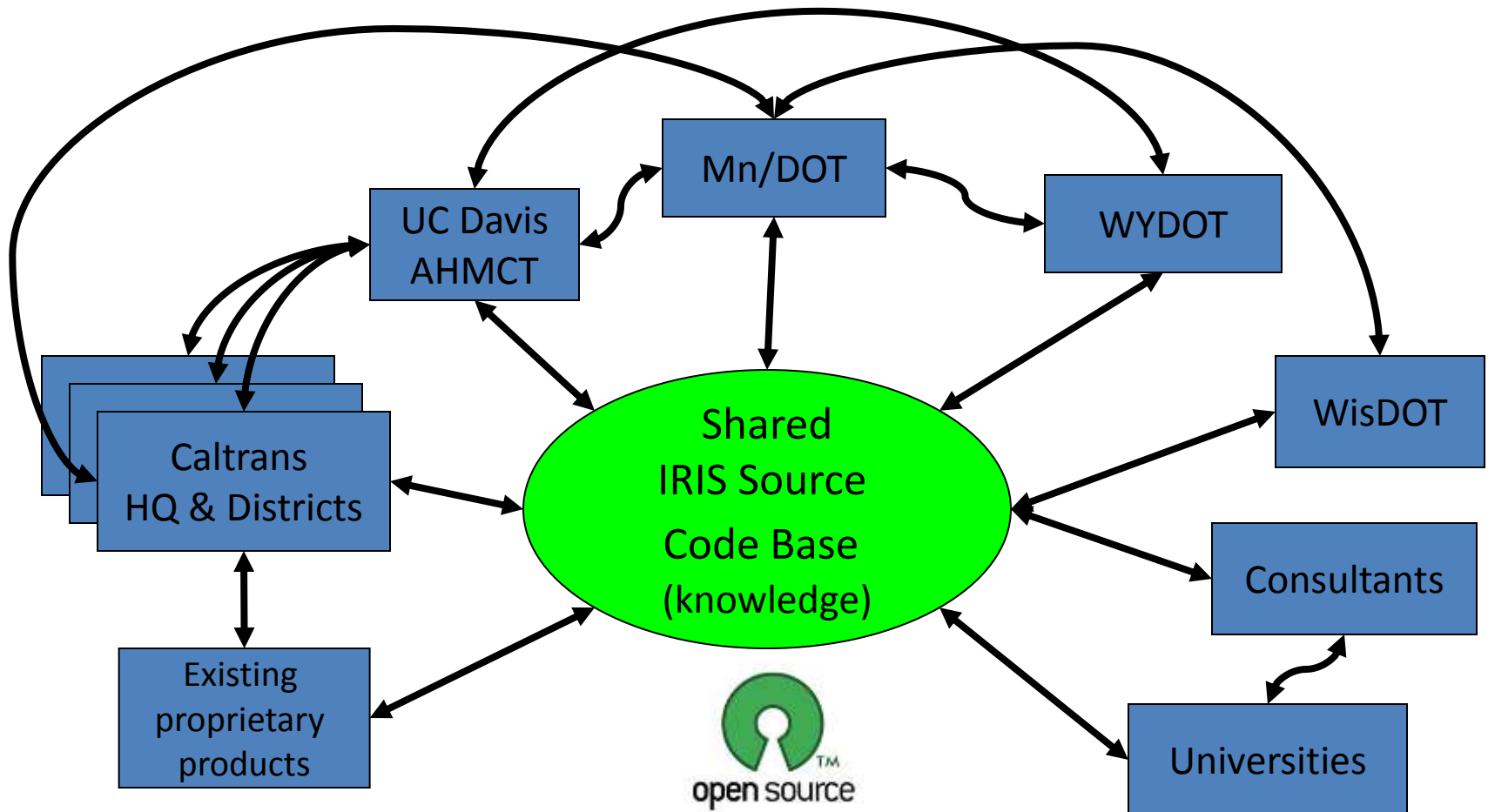
Caltrans Contributions to IRIS

- Device drivers
 - VDS: MVDS (EIS RTMS), URMS 2070, Wizard
 - CHP Incident
 - RWIS (SSI)
 - PeMS
 - Integration with external AWS (no longer used by D10)
- Automated Warning System (AWS)
- Testing
 - Automated unit test cases
 - CMS simulation
- Generalization of IRIS, e.g. system attributes
- CMS message library
- Google Earth output
- RWIS map integration
- IRIS Developer Ticketing System





Multi-agency Collaboration



- Knowledge Base is estimated at approx. \$4.2 Million.
- 4 DOTs using or evaluating the use of IRIS as their ATMS



Michael Darter

Software Engineer

Formerly with AHMCT University of California

Discussion topics...

- IRIS background
- What worked well and didn't
- IRIS functional overview and demo
- Automated Warning System (AWS)
- Vehicle Detector Stations (VDS)
- System configuration and customization
- Architecture + design
- Software engineering and testing
- Costs



Caltrans IRIS Research Study

The Research Problem...

- ATMS not deployed in 5 of 12 Caltrans Districts
- Why? Cost

Potential solution?

- Implement the open-source IRIS ATMS in D10
- Extend & customize IRIS for other districts

The Result...

- Provides ATMS capabilities
- Extendible, reliable, scalable
- Reduced life cycle costs 72%
- High relevance for ITS research
- Importance of open development process





Origin of IRIS ATMS

- IRIS developed by the Minnesota Department of Transportation (Mn/DOT)
 - Development started in the early 1990s
 - Used in Minneapolis/St. Paul, St. Cloud, Rochester
 - 135 DMS, 476 cameras, 5452 VDS, 433 ramp meters, 4 RWIS, 194 LCS,
1 Lane Marking (in-road lighting), 2 static signs with wig-wag beacons
 - 100% developed in-house
 - Significant investment (COCOMO: > \$4 million)
- Motivation for open-sourcing
 - Insure affordable and manageable longevity of IRIS
 - Collaboration with other transportation agencies
 - Source contributions back to IRIS
 - Additional IRIS developers
 - Lowers risks
- Released as open-source (GPL) 05/2007
- 4+ agencies using or evaluating



What Was Challenging?

- Managing ticket priorities: defer or fix?
- Bottom up versus top down
- Unexpected regressions
 - Automated test cases helped
 - Need end-to-end automated test cases
- Lack of mid-level technical documentation
- Tradeoff between generalization and agency-specific code
 - Writing agency-specific code is easy
 - Generalizing an existing feature can be complex
 - Code merges are voluntarily (in both directions)
- Timing merges between agencies
- Excellent generalized designs take additional effort
 - E.g. RWIS icons: metric, English, physical quantity classes
 - E.g. Incidents
- Communicating how the open-source process is different
 - Collaborative development model
 - Cost savings are easy to explain



What Went Wrong?

- IRIS 9.0 release
 - 4 defects caused client freezing and termination (threading issues)
 - Defects were regressions due to rewriting DMS code
 - Defects only visible on Windows client
 - Defects were not visible at Mn/DOT or during developer testing
 - Short-term solution: over 2-3 weeks released ~3 upgrades that fixed problems (UCD & Mn/DOT patches)
 - Long-term solutions: GUI testing on Windows only, improved communication w/ Mn/dot, developer ticketing system
- Client defects when user manipulates multiple CMS
 - A series of ~6 defects causing client termination (NPE) when user selects multiple CMS
 - Cause: could not test IRIS w/ multiple DMS except in production → not enough integration testing
 - Solution: DMS simulator (CASPER)
 - Future: implement DmsXml protocol in CASPER so other agencies can use multiple simulated DMS



What Went Wrong?

- Video uptake in D10
 - Software problems
 - Reliability issues with Pelco PTZ driver from 2008
 - GUI issue: can't tell if camera should be working or in maintenance
 - GUI issue: no GUI feedback when connecting to cameras
 - GUI issue: couldn't configure presets (only in the field)
 - Result: at some point, operators stopped using PTZ and rarely viewed cameras
 - Prioritization of fixes was low, not enough resources
 - Solution: priority of camera work increased, lab testing camera / controller



What worked well?

- Providing ATMS functionality with IRIS
 - Ability to customize for an agency is endless
- IRIS takes over AWS (4 months start to end)
 - Developing VDS data acquisition (RTMS, loops)
 - Developing RWIS data acquisition + user interface
 - Forwarding traffic to PeMS
 - Developing AWS module
 - Testing and verification
- Reliability, code quality
 - Particularly on the server
- Low cost
- Collaborative design
- Ability to customize and generalize
- Managing code between multiple agencies
 - Has worked surprisingly well (w/ exceptions)
 - Change-set concept works well



IRIS Functional Overview

(demo)

- Mapping
- AWS: operation, configuration
- Traffic
 - Real-time speed, flow, density per lane or station
 - Configuration: controllers, comm links, detectors, stations
- DMS
 - Sending messages, blanking, get-status
 - Message libraries, diagnostics, configuration
- RWIS: operation, configuration
- Video: operation, PTZ, configuration
- Configuration: drivers, system attributes, properties files
- Travel time, scheduled messages, variable speed limits
- Incidents: operation, configuration
- Ramp meters, LCS
- Security: user permissions, LDAP

NB I-5 CLOSED
IN SACRAMENTO
MAY 30 TO JUNE 9

IRIS Screenshot – DMS Control and Monitoring

Prototype 9.2.1: mdarter (Michael Darter)

Session View Help

CMS Incident Camera R_Node Ramp Meter LCS

Single Multiple

NameV7 Camera

LocationSR120 WB E of Union Ave

Current OperationNone

Sign Status

Operation StatusLast message at 13:30:07 (3.6 secs).

Deployed☐ AWS controlled☒

Current Preview

CAUTION

HIGHWAY ADVISORY

AHEAD

CAUTION

HIGHWAY ADVISORY

AHEAD

p.1

p.2

Quick Message7

Send

Blank

Status

Clear

Page on-time (s)0

CMS status: All

45

Available

0

Maintenance

0

No controller

9

User Deployed

1

Inactive

59

All

0

Scheduled

3

Failed

2

AWS deployed

27

AWS controlled

S

M

L

V5mdarter	V9mdarter	V13	V17mdarter	V21mdarter
<div>SUPPER TRAFFIC SIGNAL</div>	<div>DENSE FOG AHEAD</div>			
V6mdarter	V10mdarter	V14mdarter	V18mdarter	V22
<div>ACCIDENT AHEAD</div>	<div>FOR WARNING SYSTEM TEST</div>			
V7mdarter	V11mdarter	V15mdarter	V19	V23
<div>CAUTION HIGHWAY ADVISORY AHEAD</div>	<div>CAUTION</div>			
V8mdarter	V12mdarter	V16mdarter	V20	V24mdarter
<div>FLS YOUR POWER SOLE ENERGY TOUGH</div>	<div>CAUTION HIGHWAY ADVISORY AHEAD</div>			

Layers Legend Flow

+ - CAWS East Home North South Stockton West

Action Plan

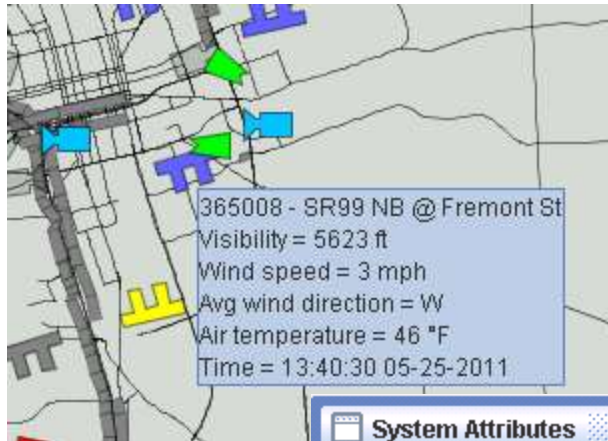
☐ AWS deactivated: V8

AWS

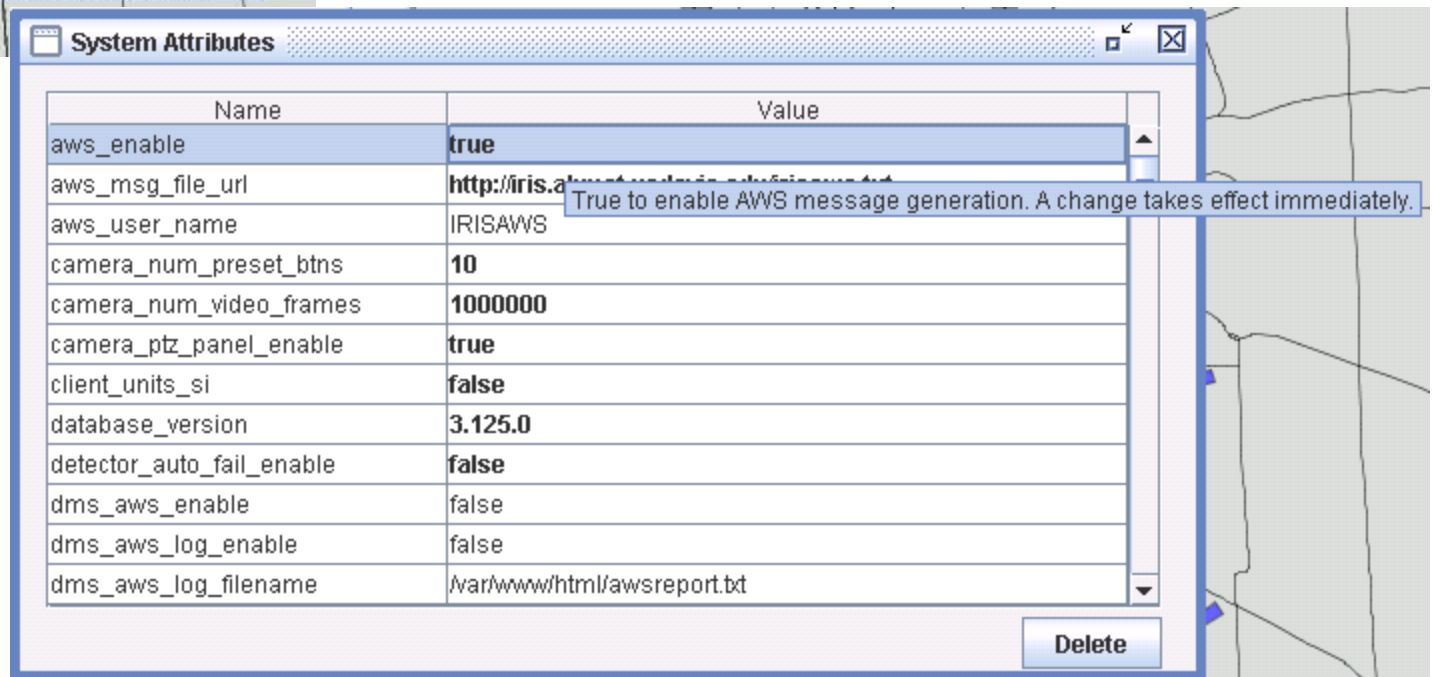
646112.3 m E 4175427.8 m N

IRIS Screenshots

RWIS Map Icons



System Attribute Editor



IRIS Screenshots – DMS Message Libraries and DMS Definition

Quick Messages

Name	Sign Group	MULTI String
128	All	HIGH[nl]WIND[nl]WARNING[np]WATCH FOR[nl]BLOWING[nl]SNOW
129	All	[fo1]CLICK IT[nl]OR TICKET
TT_V1	All	[j12]TRAVEL TIME TO[j12]JCT 120[j14][tt1 001 710]MIN
TT_V6	All	[j12]TRAVEL TIME TO[j12]JCT 15[j14][tt1 003 210]MIN
aws_high_wind	All	[fo1]GUSTY[nl]WIND[nl]WARNING[nl]
aws_low_vis	All	[fo1]DRIVE[nl]WITH CARE[nl](LOW VIS)
aws_slow	All	[fo1]CAUTION[nl]SLOW TRAFFIC[nl]AHEAD
aws_stopped	All	[fo1]CAUTION[nl]STOP
blank	V100	[nl]
boom	All	FIREWORKS[nl]ARE
drunk	All	REPORT[nl]DRUNK
dwic	All	DRIVE[nl]WITH[nl]CA

CMS: V9

Location
Messages
Configuration
Status
Pixels
Manufacturer

Sign Group	Member	Line	Message	Priority
FIREWORKS_ALPINE	<input type="checkbox"/>	1	ACCIDENT	50
FIREWORKS_TOULUM	<input type="checkbox"/>	1	BICYCLE	50
GrapeVine	<input type="checkbox"/>	1	CAUTION	50
HWY 120 CHAINS	<input type="checkbox"/>	1	CHAIN	50
HWY 4 CHAINS	<input type="checkbox"/>	1	CLICK IT	50
Library1	<input checked="" type="checkbox"/>	1	CLOSED FOR	50
Pacheco Pass	<input type="checkbox"/>	1	DENSE FOG	50
STAR CAMPAIGN	<input type="checkbox"/>	1	DONT DRINK	50
v9	<input type="checkbox"/>	1	DONT SPEED	50

Delete Group
Delete Message

Message Preview

Default Font

☒ AWS allowed
 ☒ AWS controlled





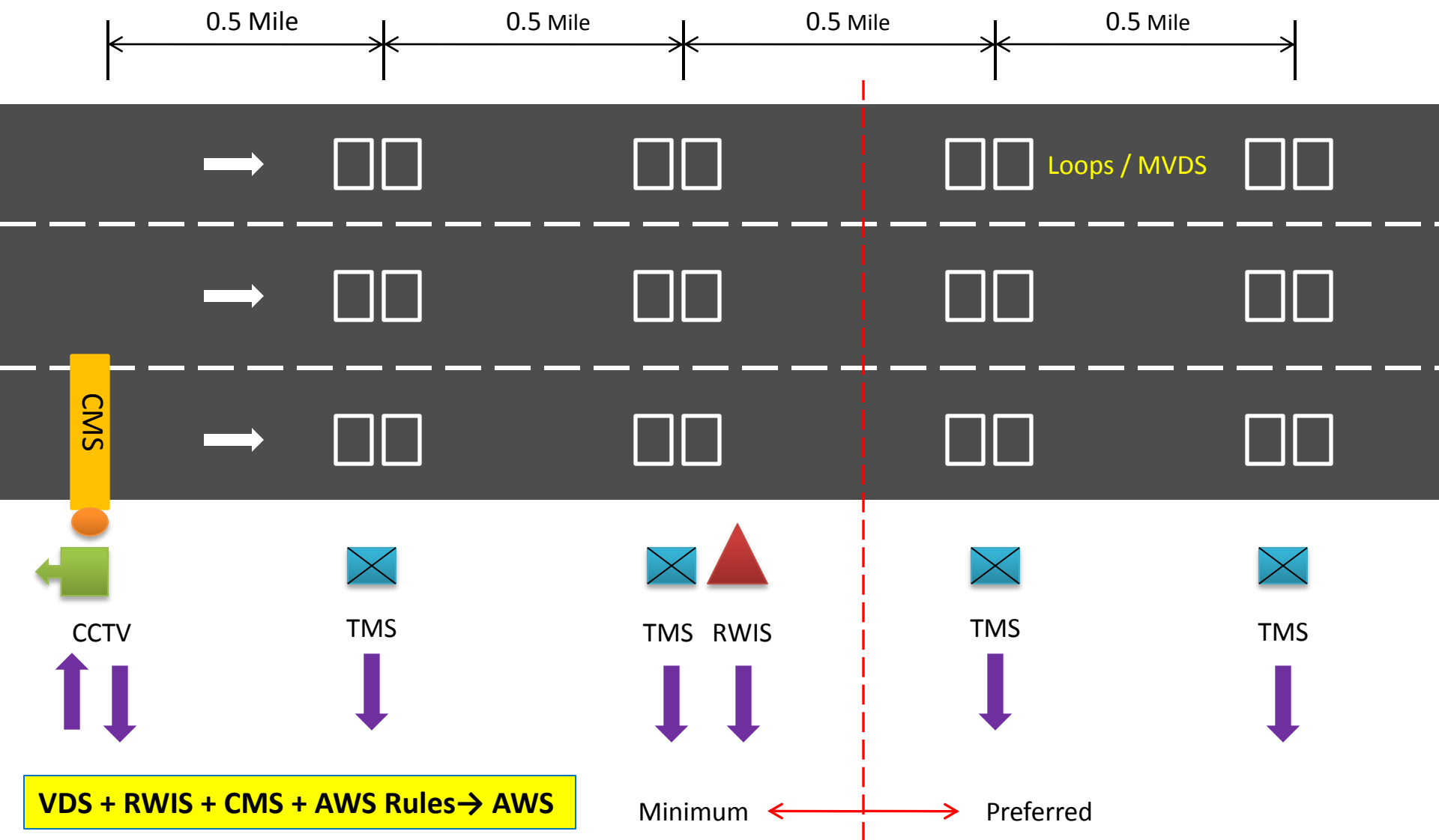
IRIS AWS Functionality

(demo)

- History – 3 steps
 1. CAWS: 1996 - 2009
 2. CAWS + IRIS: 2010
 3. IRIS AWS: 2011
 - Any agency can use this AWS functionality
- Design
 - IRIS automatically generates CMS messages
 - VDS + RWIS + DMS + AWS Rules → AWS
- Configuration
 - Presently via editing a file, in the future via GUI
 - Associates multiple RWIS and VDS with each CMS
 - Define AWS rule parameters, e.g. max wind speed
- Verification
 - Difficult and time consuming
 - Integration test cases: +110
 - Automated unit test cases



Typical Automated Warning System (AWS) Configuration





What Triggers an AWS Message?

➤ IRIS looks for one of these 4 conditions to be present for 90 seconds at an AWS location:



① Vehicle Speed < 11 mph



② 11 mph < Vehicle Speed < 35 mph



③ Visibility < 500 ft



④ Wind Speed > 25 mph

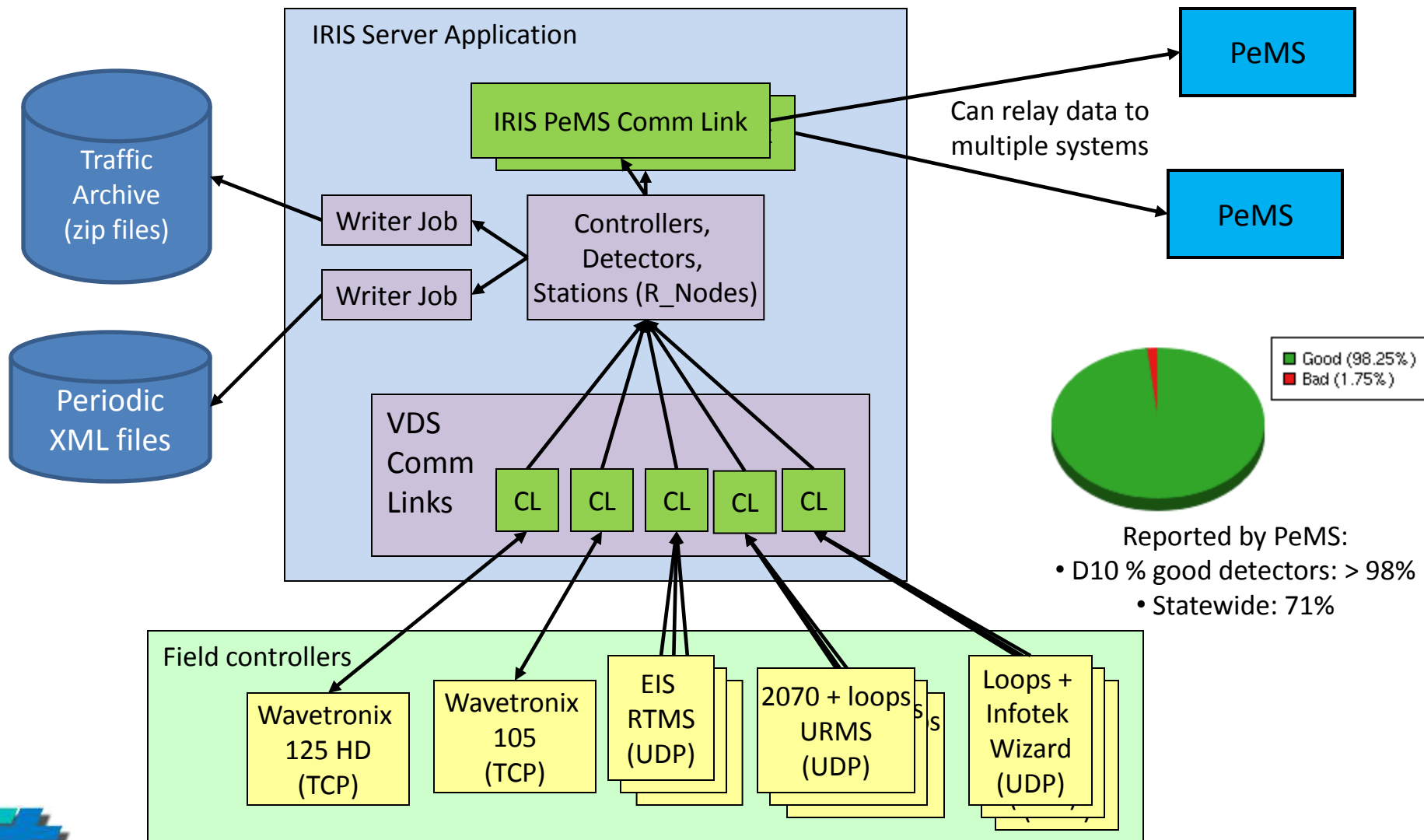
Sobering Fact: In March 2011 there were 3,913 CMS messages deployed in D10
73% (2,848) of those CMS messages were automatically deployed by AWS (73%)
27% (1065) were “Custom” messages deployed by the TMC Operators



IRIS Traffic Data Collection

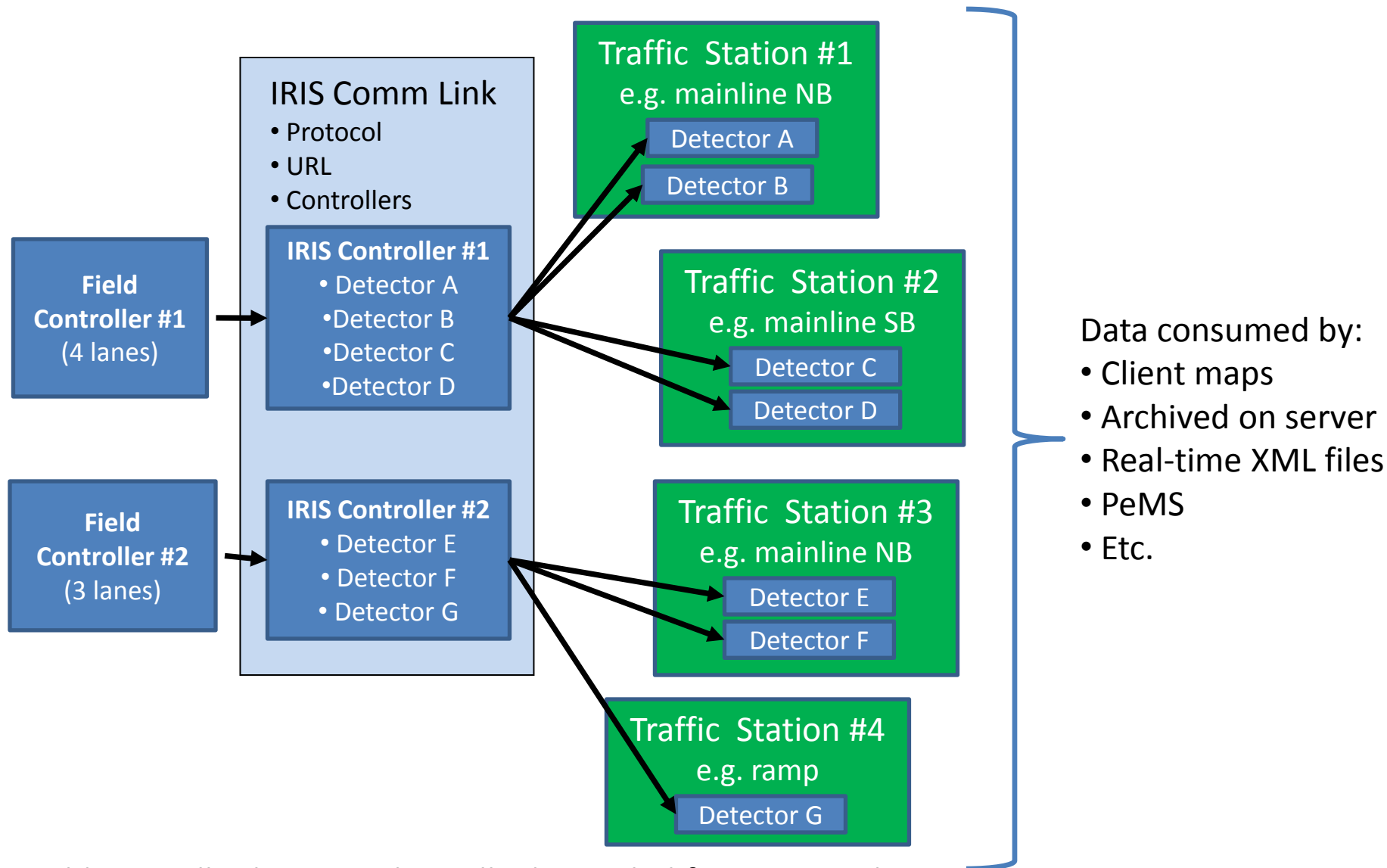
Open-source Data Acquisition

Field → IRIS → PeMS





VDS Configuration



- Field controller lanes are logically decoupled from station lanes
- Lane order can be adjusted via specified station detector order

IRIS Screenshot – Comm Link Configuration

Comm Links

All Links

Failed Controllers

Comm Link	Description	URL	Status	System / Protocol	Timeout
cl_chp	CHP feed	http://media.chp.ca.gov/sa_XML/sa.XML		CHP Incidents	750
cl_rtms	MVDS reader	166.212.244.11:40000		EIS RTMS	3797
cl_rtmscaws	RTMS for AWS	166.212.244.11:40002		EIS RTMS	3797
cl_ssi	SSI RWIS reader	http://iris2.ahmct.ucdavis.edu/ssi.txt		SSI RWIS	750
cl_testcam	lab camera	169.237.117.23:4001		Pelco D PTZ	3100
cl_wizard	Loop data via wizards	169.237.117.149:45001		Infotek Wizard	3797

Selected Comm Link:

Controller	Location	Drop	Active	Status	Error Detail
ctl_1018510	SR99 NB N of Wilson Way	1	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1018410	SR99 NB S of Wilson Way	2	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1006010	SR99 NB @ Jack Tone Rd	3	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1006110	SR99 SB @ Jack Tone Rd	4	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1006410	SR99 NB @ South Lodi	5	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1006510	SR99 SB @ South Lodi	6	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1014510	SR205 EB @ Mtn House Pkwy	7	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1014610	SR205 WB @ Mtn House Pkwy	8	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1027910	SR12 EB W of Potato Slough	9	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011
ctl_1006210	SR99 NB @ Milgeo Ave	10	<input checked="" type="checkbox"/>		FAIL @ Wed May 25 13:44:55 PDT 2011

Selected Controller:

Properties

Delete Controller

Comm Link

SmartSensor 125 HD

OSi ORG-815

CHP Incidents

EIS RTMS

PeMS

Infotek Wizard

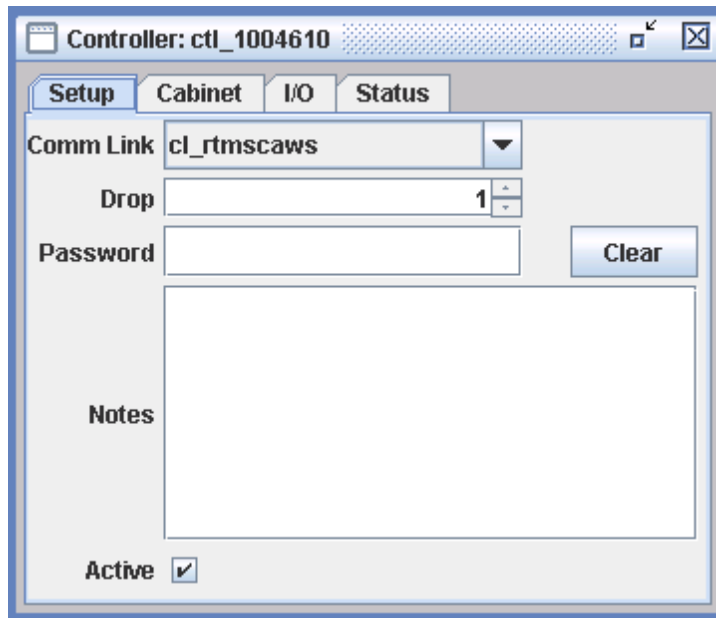
SSI RWIS

URMS



IRIS Screenshot – Controller Configuration

Associating inbound traffic data with a controller



Controller: ctl_1004610

Setup Cabinet I/O Status

Comm Link cl_rtmscaws

Drop 1

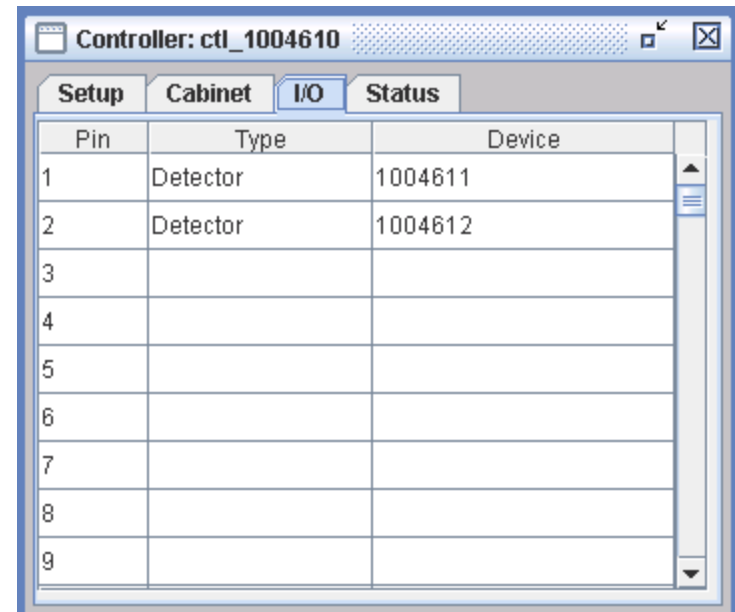
Password

Clear

Notes

Active ☒

Associating detectors with a controller



Controller: ctl_1004610

Setup Cabinet I/O Status

Pin	Type	Device
1	Detector	1004611
2	Detector	1004612
3		
4		
5		
6		
7		
8		
9		



IRIS Screenshot – R_Node Definition and Editor

Prototype 9.2.1: mdarter (Michael Darter)

Session View Help

CMS Incident Camera R_Node Ramp Meter LCS

Selected R_Node

Location Setup Detectors

Roadway I5 Northbound

N of Smith Canal Bridge

Easting 646,342

Northing 4,202,908

Select Point

Notes 1022110

rnd_29

Selected Roadway Corridor

Corridor I5 NB Node Add Remove

2.1	55	N of Van Ruiten
2.1	65	N of Eight Mile Rd
2.1	65	@ Mosher Slough
2.1	65	@ Hammer Lane
2.1	65	N of Benjamin Holt Drive
2.1	65	N of Benjamin Holt Drive
2.1	55	@ Fourteen Mile Slough
2.1	65	N of March Lane
2.1	65	N of Smith Canal Bridge
2.1	55	N of Monte Diablo Ave
2.1	55	@ Carleton Ave
2.1	65	@ Pershing Ave
2.1	65	@ Stockton Ch Viaduct
2.1	55	@ Church
2.1	65	@ Church
2.1	65	N of Charter Way
2.1	65	S of Charter Way
2.1	65	N of 8th St
2.1	65	N of Downing Ave
2.1	65	N of French Camp Slough
2.1	65	@ French Camp Rd
2.1	65	N of French Camp
2.1	65	@ Mathews
2.1	65	S of Mathews

Layers Legend Flow

CAWS East Home North South Stockton West

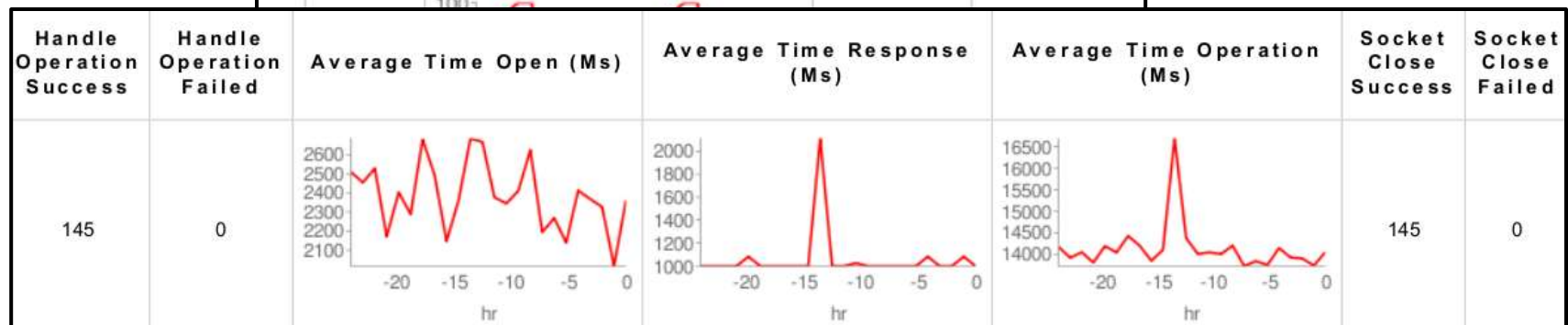
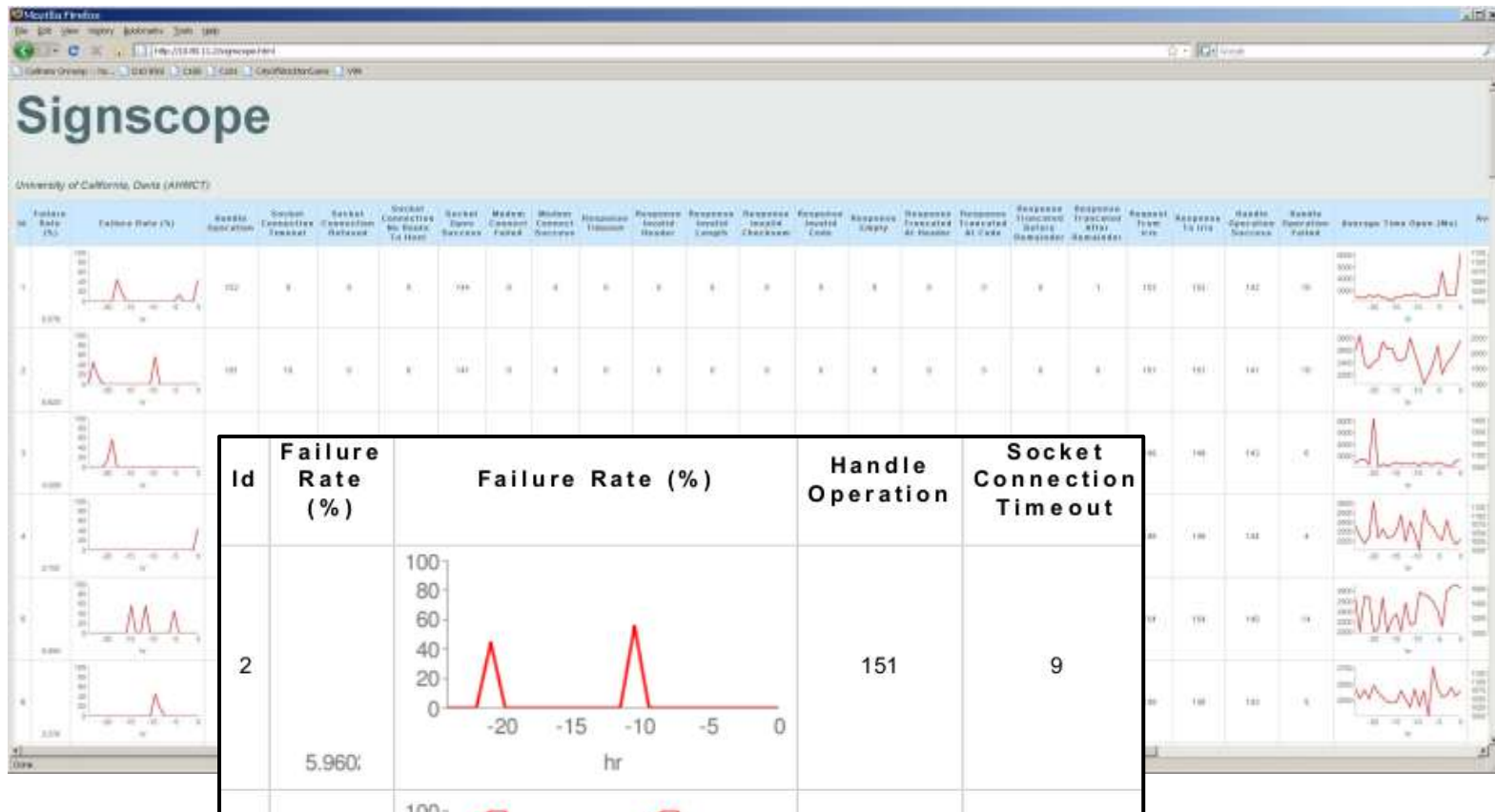
Action Plan

AWS deactivated: V8 AWS

639262.4 m E 4201142.5 m N



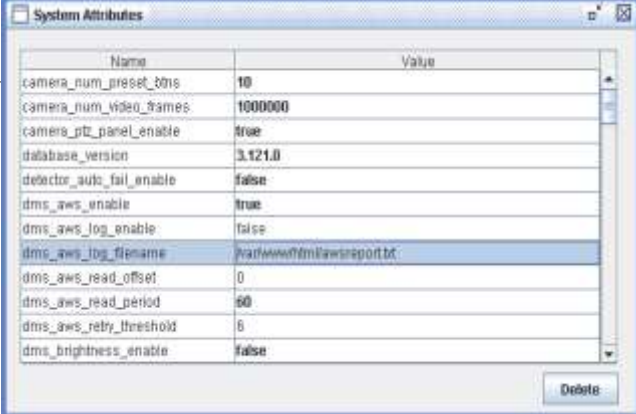
SignScope Screenshot – Diagnosing Comm Problems





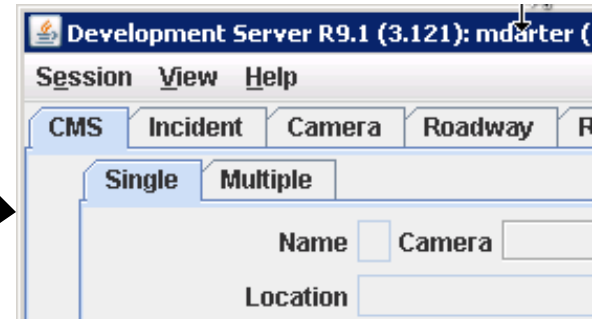
System Configuration

- One code base across multiple districts, agencies
- Configuration determines agency-specific behavior
 - System attributes
 - Integrated
 - Non-integrated
 - Property files
 - Agency specific code
 - System configuration stored in IRIS database
 - Comm Links, Controllers, Detectors, R_Nodes, etc.
 - System Attribute values
 - Internationalization,
 - e.g. “DMS” versus “CMS”



The screenshot shows a window titled 'System Attributes' with a table of configuration parameters. An arrow from the 'System attributes' bullet point in the list points to this window.

Name	Value
camera_num_preset_bits	10
camera_num_video_frames	1000000
camera_ptz_panel_enable	true
database_version	3.121.0
detector_auto_fail_enable	false
dms_aws_enable	true
dms_aws_log_enable	false
dms_aws_log_filename	var/www/html/awreport.txt
dms_aws_read_offset	0
dms_aws_read_period	60
dms_aws_retry_threshold	5
dms_brightness_enable	false





User Permissions Screenshots

User → Role → Capabilities → read, write, create, delete permissions per object

The screenshot displays the 'Users and Roles' management interface. The top window shows a list of users with columns for User, Full Name, Dn, Role, and Enabled. The bottom window shows the 'Capabilities' tab for the 'operator' role, listing various patterns and their associated permissions (Read, Write, Create, Delete).

User	Full Name	Dn	Role	Enabled
CAWS	CAWS			<input type="checkbox"/>
IRISAWS	IRIS AWS			<input type="checkbox"/>
OtherSystem	Log user for SOCCS Messages			<input type="checkbox"/>
abenson	Alan Benson	uid=abenson,o=netscaperoot	view	<input checked="" type="checkbox"/>
acordero	Arlene Cordero	uid=acordero,o=netscaperoot	admin	<input checked="" type="checkbox"/>
bob	bob	uid=bob,o=netscaperoot	operator	<input checked="" type="checkbox"/>
bthreadgill	Brenda Threadgill	uid=bthreadgill,o=netscaperoot	operator	<input checked="" type="checkbox"/>
dagar	Dennis Agar	uid=dagar,o=netscaperoot	operator	<input checked="" type="checkbox"/>
dsmith	Diane Smith	uid=dsmith,o=netscaperoot	operator	<input checked="" type="checkbox"/>
ganzo				
hdang				
idonaville				
jcastro				
jcollins				
jdhalilwal				
jragusa				
jsilvey				

Name	Enabled	Pattern	Read	Write	Create	Delete
admin	<input checked="" type="checkbox"/>	.*	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
login	<input checked="" type="checkbox"/>	dms/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
operator	<input checked="" type="checkbox"/>	r_node/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
operator_lead	<input checked="" type="checkbox"/>	sign_group/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
view	<input checked="" type="checkbox"/>	sign_message/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	<input type="checkbox"/>	sign_text/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
		dms_sign_group/.*	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
		action_plan/.*	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		action_plan/.*deployed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
		camera/.*ptz	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		camera/.*recallPreset	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Buttons: Delete Capability, Delete Privilege



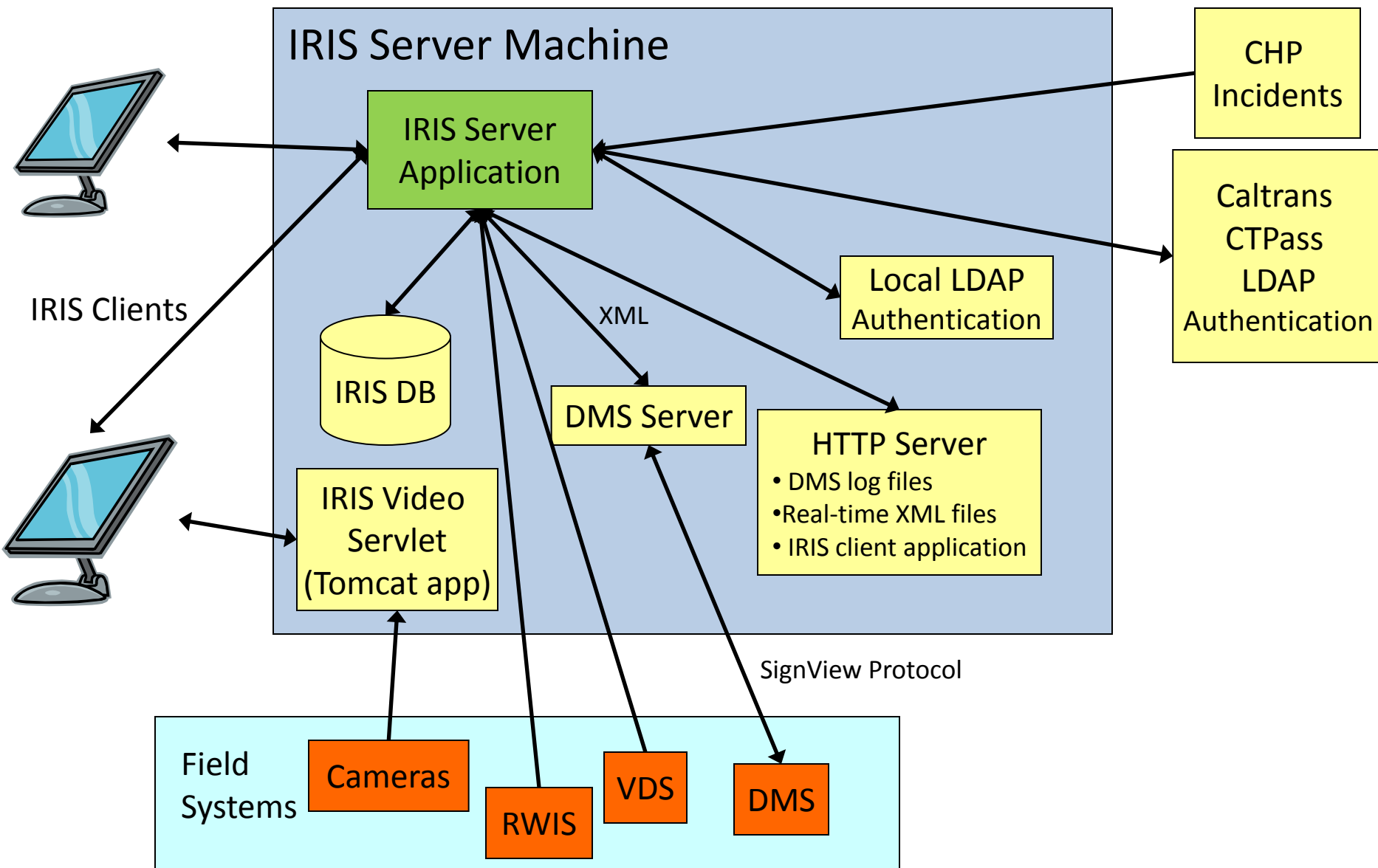
IRIS Development Environment

- Client / Server architecture
- All dependent software packages are open-source
 - Free, no purchase requisition form
 - No NDA
- IRIS written in Java
 - ~100K lines of code
 - Heavily object oriented ~1000 classes
 - Learning the code base is a non-trivial
- Client
 - JWS (Java Web Start), nothing to install on client
 - Running on Windows, Linux
- Built with...
 - OpenJDK, Linux, Tomcat, Ant (all free and open source)
 - Database: PostgreSQL
 - Distributed source repository: Mercurial
- User authentication via LDAP
 - Integrates with CTPASS



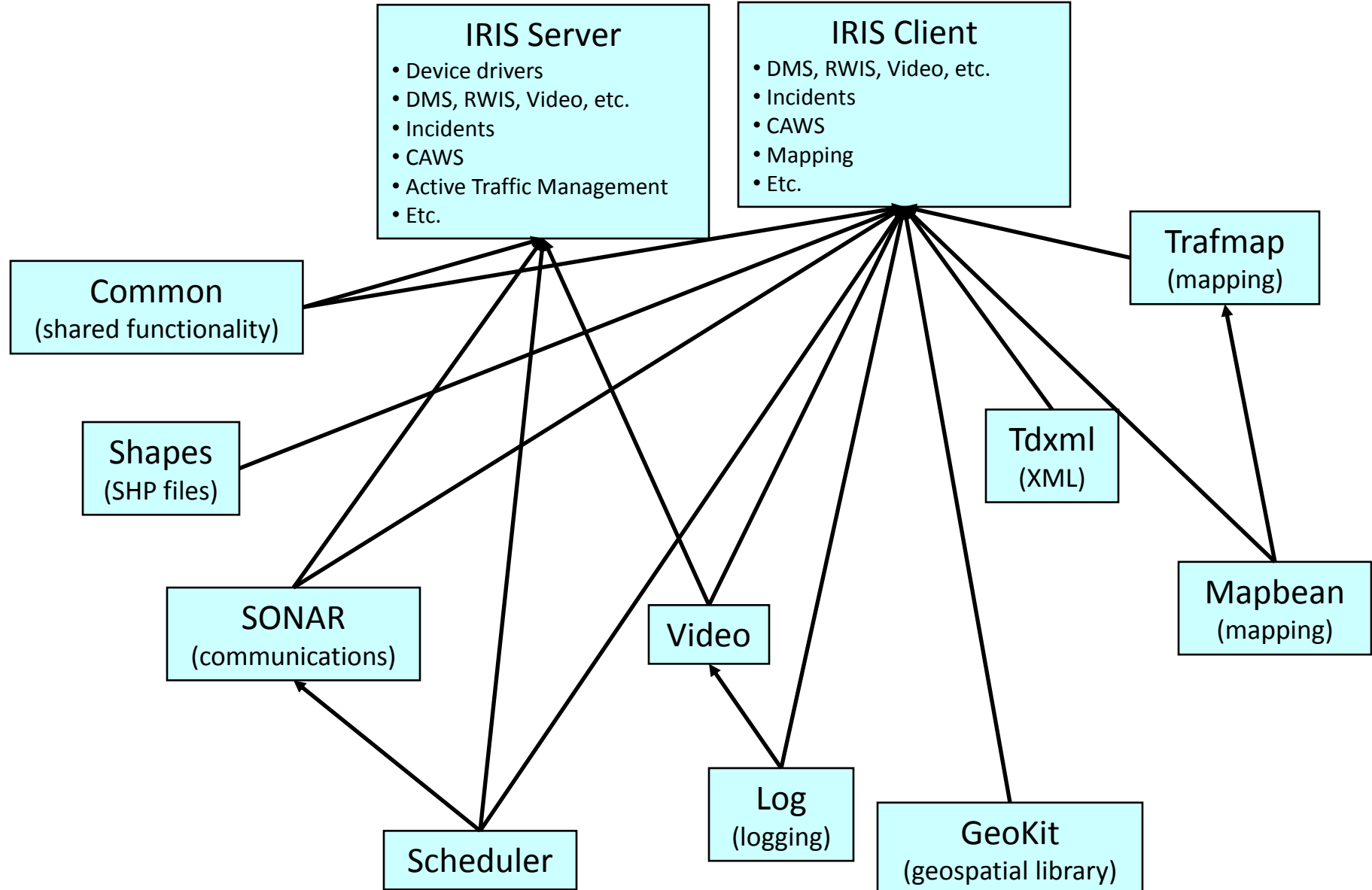


Data Flow Among IRIS Applications



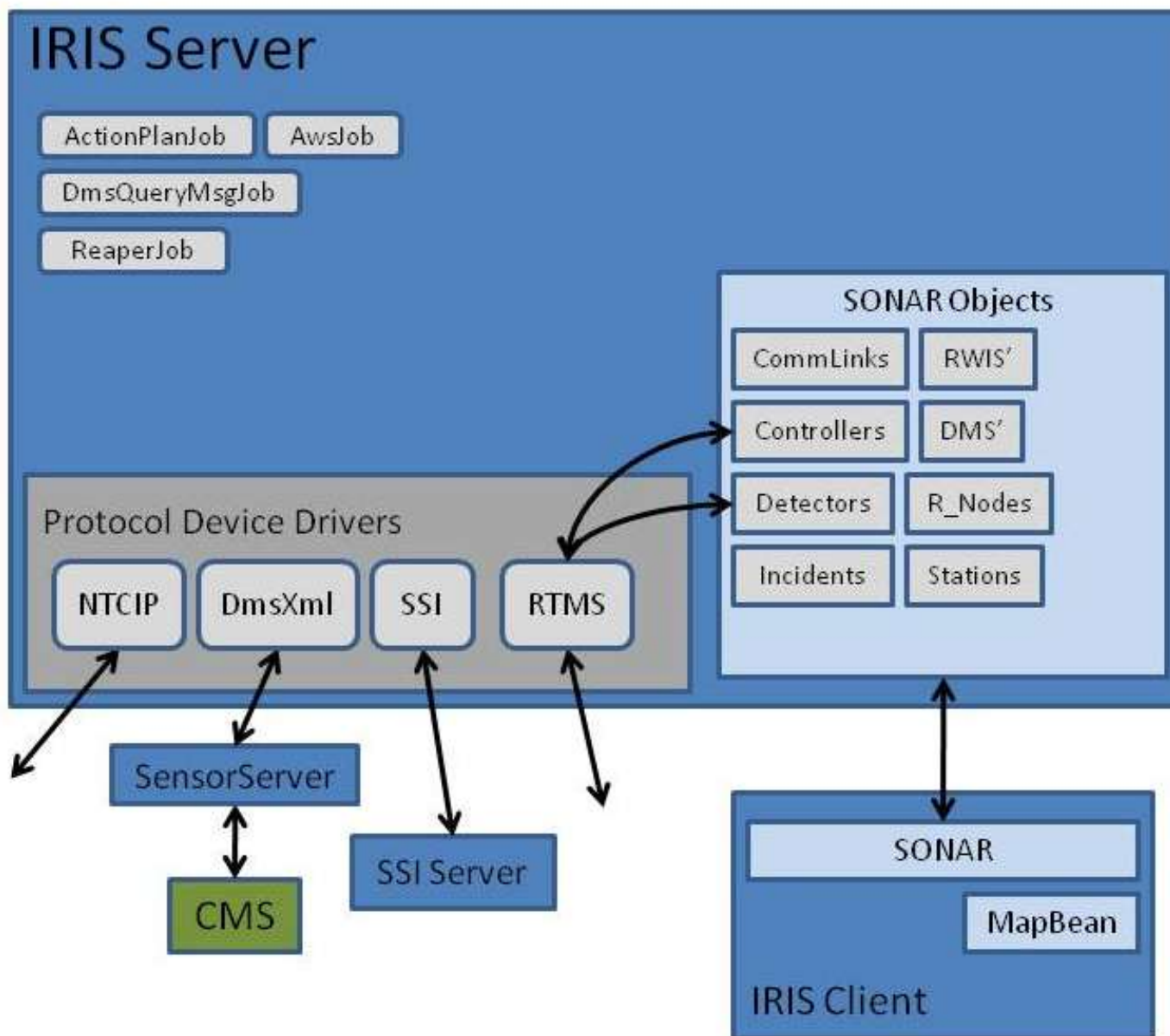


IRIS Binary Modules





IRIS Server Architecture





IRIS Architecture

Scheduler, Jobs, Threads

Comm Links

- Are threads

Scheduler objects

- Is a thread, executes jobs
- TIMER: runs periodic jobs
- AWS: runs AwsJob
- FLUSH: runs XML, KML jobs

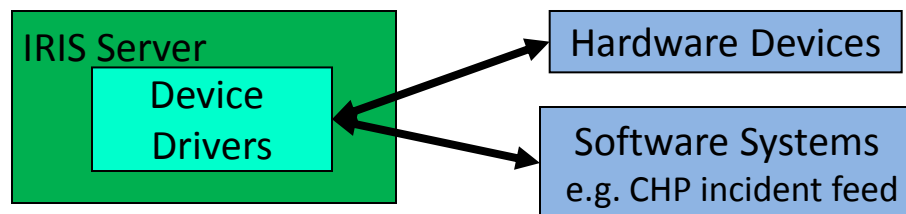
IRIS has dozens of simultaneously executing jobs

- DmsQueryStatusJob: periodically queries all DMS (TIMER)
- SampleQuery30SecJob: query all pollers periodically (TIMER)
- WeatherQueryJob: queries all weather pollers every 60 seconds (TIMER)
- SendSettingsJob: send settings to devices 4AM (RampMeters, etc.) (TIMER)
- ReaperJob: garbage collector for SONAR objects (TIMER)
- AwsJob: makes AWS decisions every 20 seconds and sends AWS messages to signs (AWS)



IRIS Architecture + Design

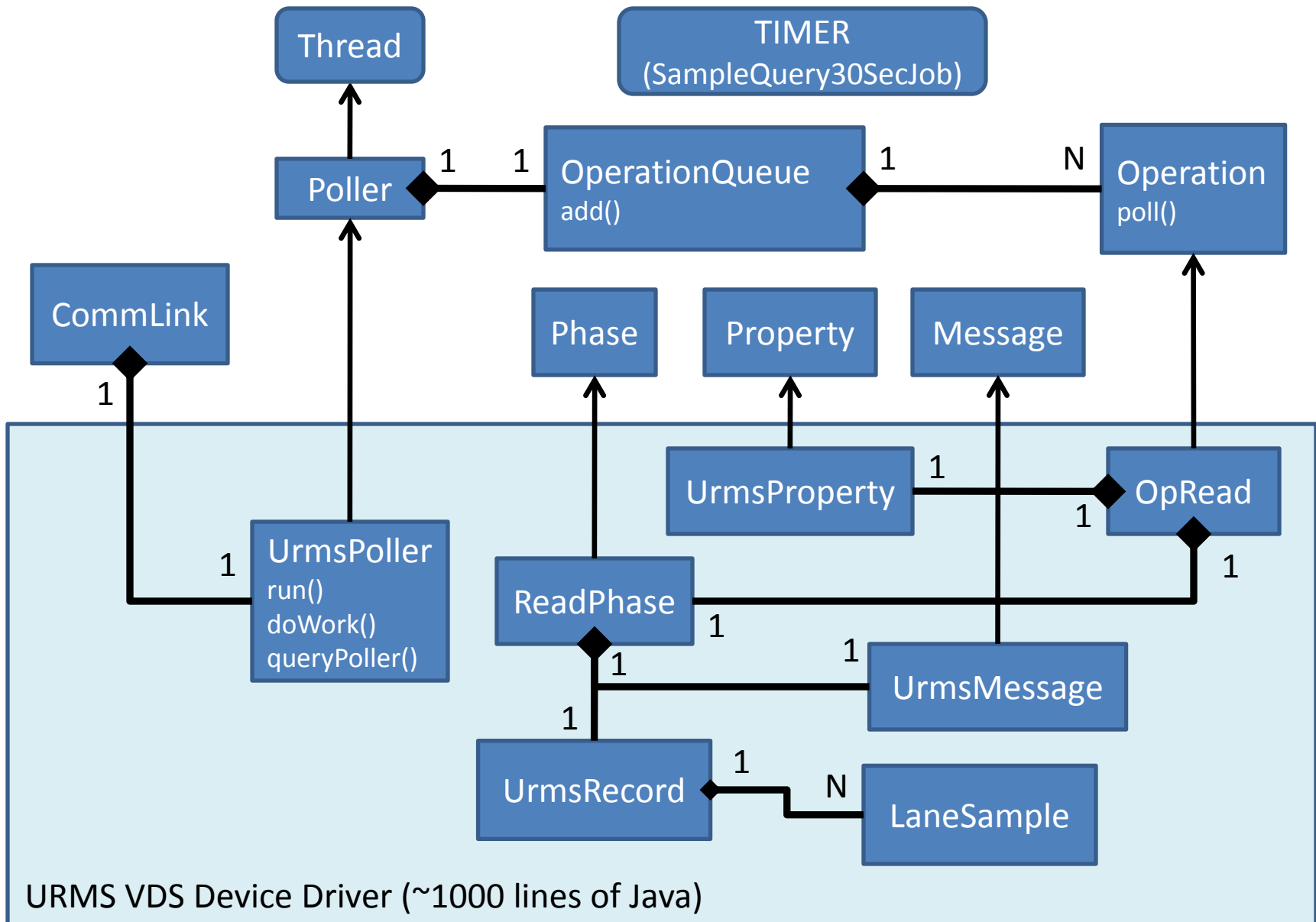
Protocol Device Drivers



- A key ATMS function is to interface with external systems
- IRIS has a powerful device driver interface
- For reading and/or writing to external systems
- Drivers are open-source
- Long-term goal: as many device drivers as possible
- Existing drivers
 - VDS: Wavetronix 105, 125, EIS RTMS, URMS, Wizard, Canoga, others pending
 - DMS: NTCIP A, B, C, SignView
 - Video: Pelco D PTZ, Pelco switcher, Vicon PTZ, Vicon switcher, Manchester PTZ
 - RWIS: Optical Scientific ORG-815, SSI
 - CHP incident feed
 - PeMS
 - External AWS, e.g. CAWS
 - Etc.



IRIS Class Structure for URMS Device Driver





Software Engineering / Testing

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
- Software development is risky
- Question: why not write IRIS from scratch?





Open Source

What 'open source' means...

1. Legal definition, <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
- Cooperative development model
- Network effect for enhancements / defect repairs
- Reduces legal complexity, no NDAs

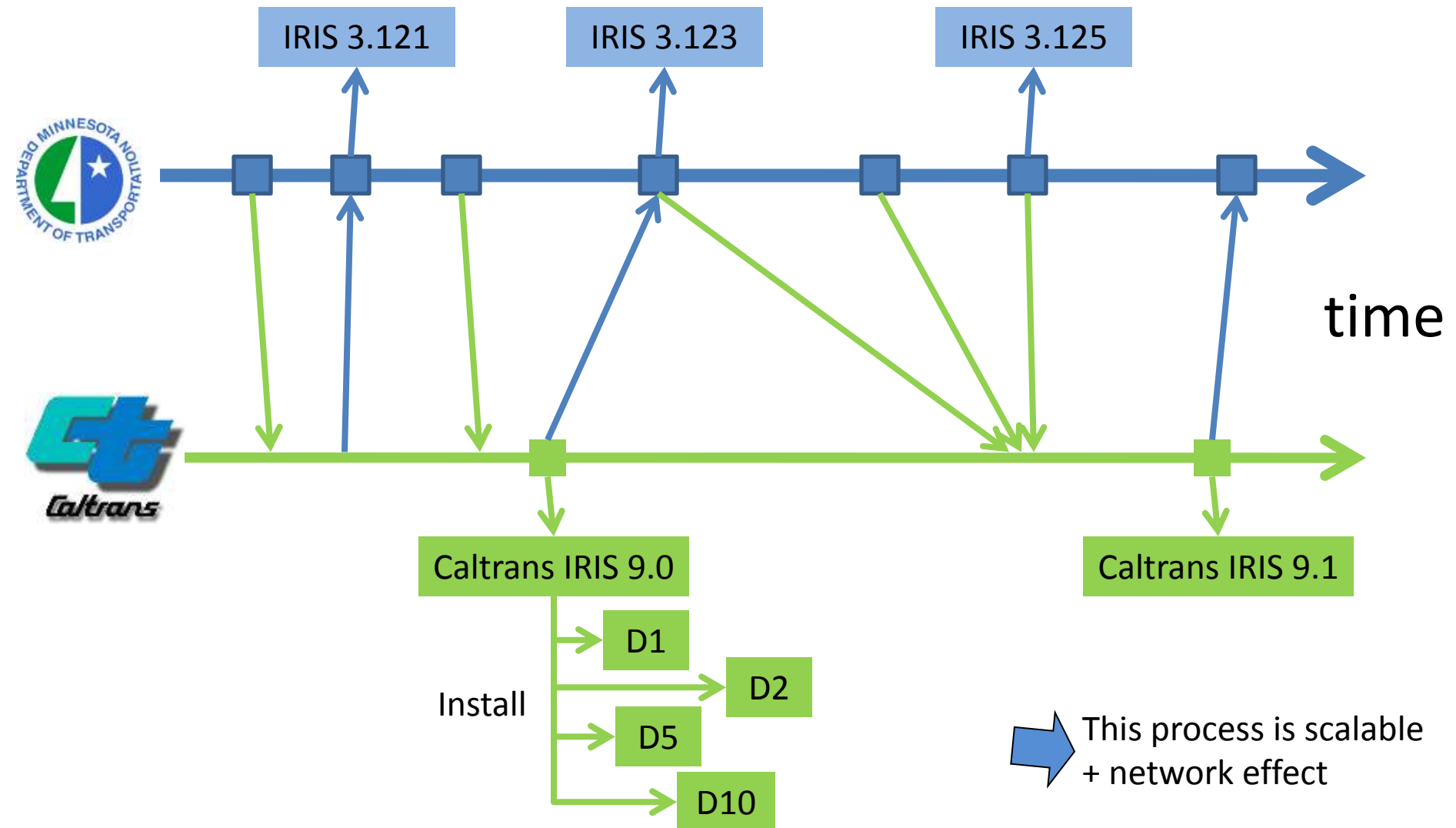


Integrating with Proprietary Systems

1. Proprietary protocol (e.g. SignView)
 - If GPL ‘distribution’ criteria not triggered, write driver integrated with IRIS, but don’t distribute source.
 - Write stand-alone server, e.g. SensorServer
 - Can use any license you want
 - Write and publish a public interface, e.g. DmsXml
2. Proprietary system with public protocol
 - E.g. almost any hardware device
 - Add new protocol to IRIS
3. Proprietary system with proprietary protocol
 - Same as case #1



IRIS Release and Collaboration Process





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 → requirements → design → 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





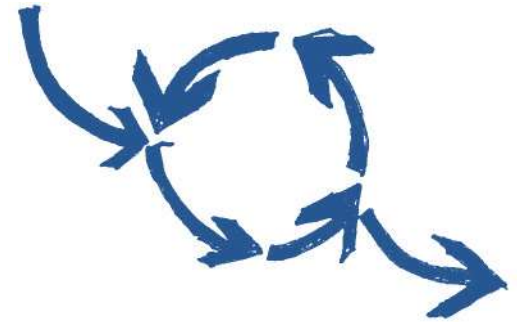
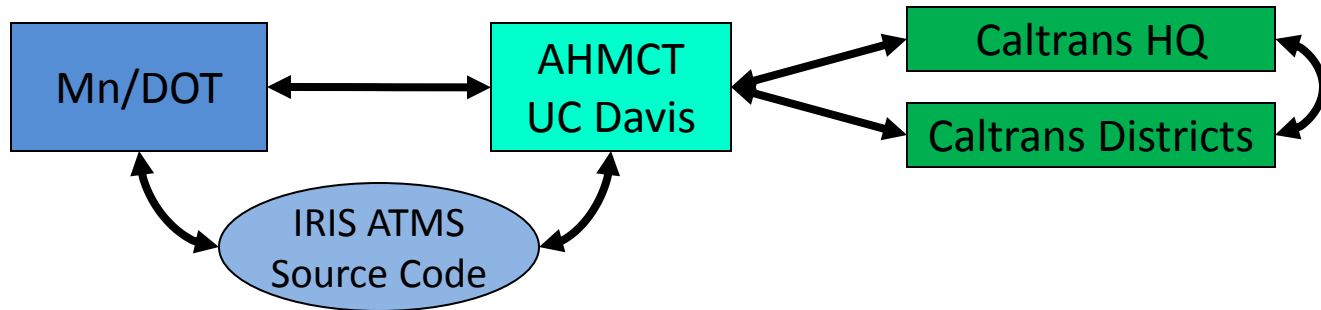
Example Automated Test Case

MULTIString junit test cases

```
void equals() {
    MultiString t1 = new MultiString("x");
    MultiString t2 = new MultiString("x");
    MultiString t3 = new MultiString("x");
    // reflexive
    assertTrue(t1.equals(t1));
    // symmetric
    assertTrue(t1.equals(t2) && t2.equals(t1));
    // transitive
    assertTrue(t1.equals(t2) && t2.equals(t3) && t1.equals(t3));
    // simple cases
    assertTrue(new MultiString("").equals(new MultiString("")));
    assertTrue(new MultiString("").equals(""));
    assertTrue(new MultiString("XXX").equals("XXX"));
    assertTrue(new MultiString("XXX").equals(new MultiString("XXX")));
    assertFalse(new MultiString("XXX").equals("XXY"));
    assertFalse(new MultiString("XXX").equals(new MultiString("XXY")));
    // verify normalization used
    assertTrue(new MultiString("[fo1]abc").equals("[fo1]ABC"));
}
```



Adding an IRIS Enhancement

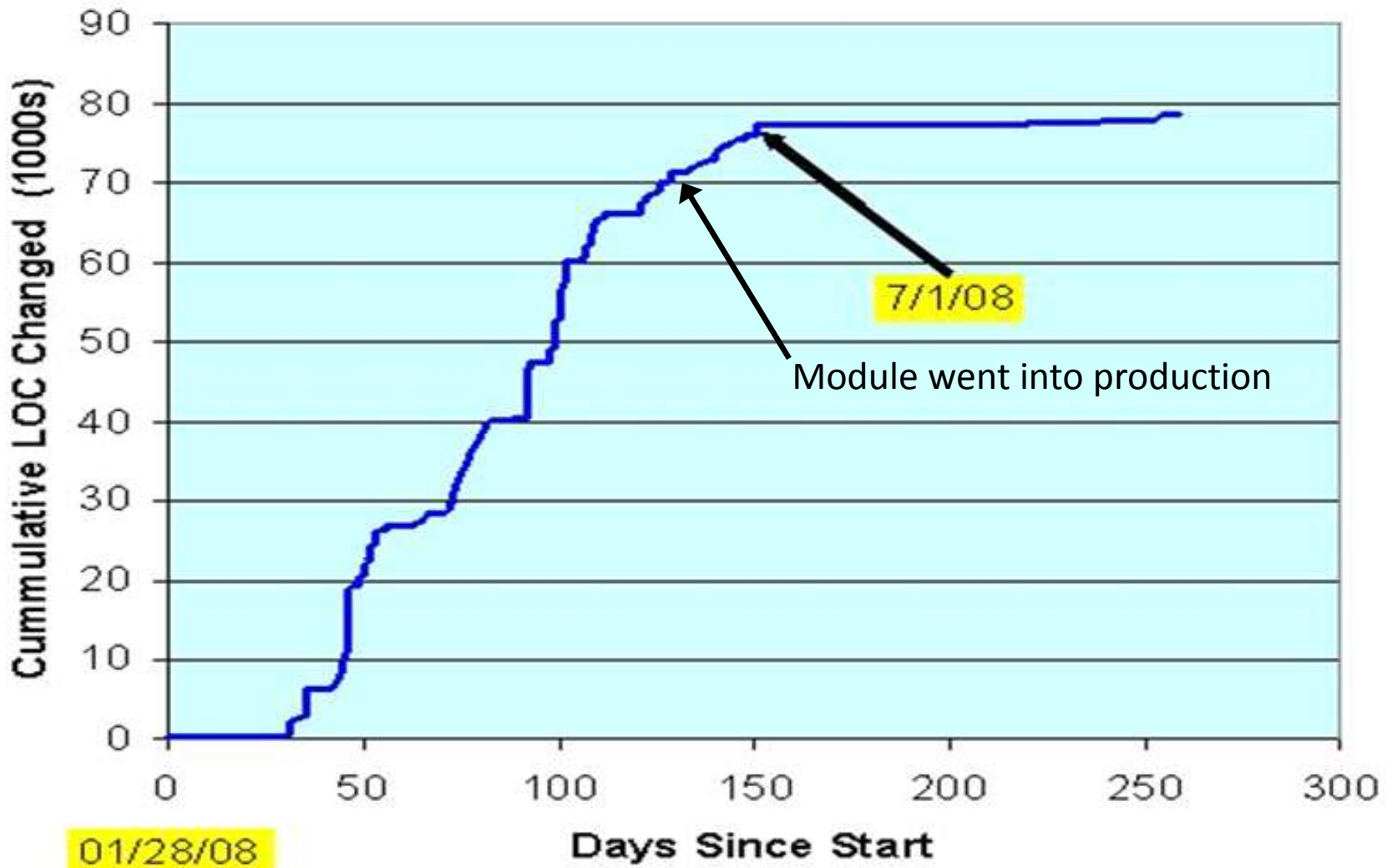


1. Request for improvement...
 - Caltrans operators “we need...”
 - Organizational need
 - Defect discovered
2. Ticket created
3. Requirement written + discussion
4. Design, discussion with Mn/DOT
5. AHMCT implements, discusses as necessary
 - Automated test cases
 - Integration testing
6. AHMCT publish 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



Development Process Transparency

Cumulative SLOC vs. Time for a Module





Estimating the Dollar Value of IRIS

What is the cost to develop IRIS from scratch?

Module	Lines of Code (filtered)	Est. Years to Develop	Est. Cost to Develop
IRIS	83,792	20.9	\$3,797,360
Caltrans IRIS apps	11,410	2.4	\$441,940
Total	95,202	23.3	\$4,239,300

SLOCCount uses COCOMO
(COConstructive Cost Model)

The total dollar value of the
Caltrans IRIS project.





High-level Cost Comparison

(IRIS compared with existing proprietary ATMS)

Goals of comparison

- Quantify “low cost”
- Approximate life-cycle cost comparison between IRIS and the existing (proprietary) system
- See the final report for details, assumptions, etc.

Assumptions

- Actual costs are used, except in 1 place
- Apples versus apples?
 - Each system has different features
 - IRIS has data acquisition, active traffic management, lane management, AWS, tiled mapping, etc.
 - The existing ATMS system has adaptive ramp metering, incident detection, & response
 - The comparison is for core features (DMS control, mapping)
- Customization costs are not expected to differ between approaches
- Caltrans funded one-time generalization features, e.g. SA, I18N





Five Year Cost Comparison

(for one Caltrans district)

Cost Component	Open ATMS	Existing ATMS
1. Acquisition	\$17,800	\$1,054,500
2. Customization & configuration	\$350,000	\$350,000
3. Year 1 maintenance	\$150,200	\$540,000
Year 2 maintenance	\$150,200	\$540,000
Year 3 maintenance	\$150,200	\$540,000
Year 4 maintenance	\$150,200	\$540,000
Year 5 maintenance	\$150,200	\$540,000
Total 5 Year Cost	\$1,118,800	\$4,104,500
Budget spent on development (%)	98%	27%

72% cost reduction +

More development hours per dollar spent

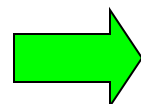




1. Acquisition ATMS Costs

(for one Caltrans district)

Component	IRIS Cost	Existing ATMS Cost
Server hardware	\$4,500	\$150,000
Backup server	\$4,500	\$150,000
5 client workstations (optional)	5x \$1,500	5x \$1,500
OS support, 24x7 (optional)	\$1,300	Included
Server software licenses	\$0	\$239,000
Backup server licenses	\$0	\$239,000
Developer software licenses	\$0	\$269,000
Total Acquisition Cost	\$17,800	\$1,054,500



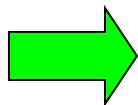
This is a 98% cost reduction compared with the existing ATMS system



2. Customization & Configuration Costs

Four data points...

Traffic Management Installations	Cost
D1, rural, IRIS installation, DMS functionality (integration w/ video, RWIS is extra)	2 weeks
D5, rural, IRIS installation, DMS functionality (integration w/ video, VDS is extra)	2 weeks
D10, urban/rural, IRIS install + customization (Phase 1 Caltrans IRIS UC Davis research project)	\$350,000
D4, urban, existing ATMS installation + customization	\$750,000



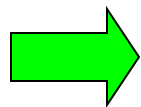
Customization and configuration costs are not expected to differ between approaches.



3. Annual Maintenance Costs

(for one Caltrans district)

Annual Cost Component	IRIS Cost	Existing ATMS Cost
Server hardware maintenance, 24x7 response	\$200	\$30,000
Software license cost	\$0	\$60,000
Maintenance cost, personnel*	½ - 1 FTE	2.5 - 3 FTE
Total Annual Maintenance Cost	\$75,000 - \$150,200	\$465,000 - \$540,000



This is a 68% - 86% cost reduction

*Based on assumed \$150,000 per year contract price per FTE

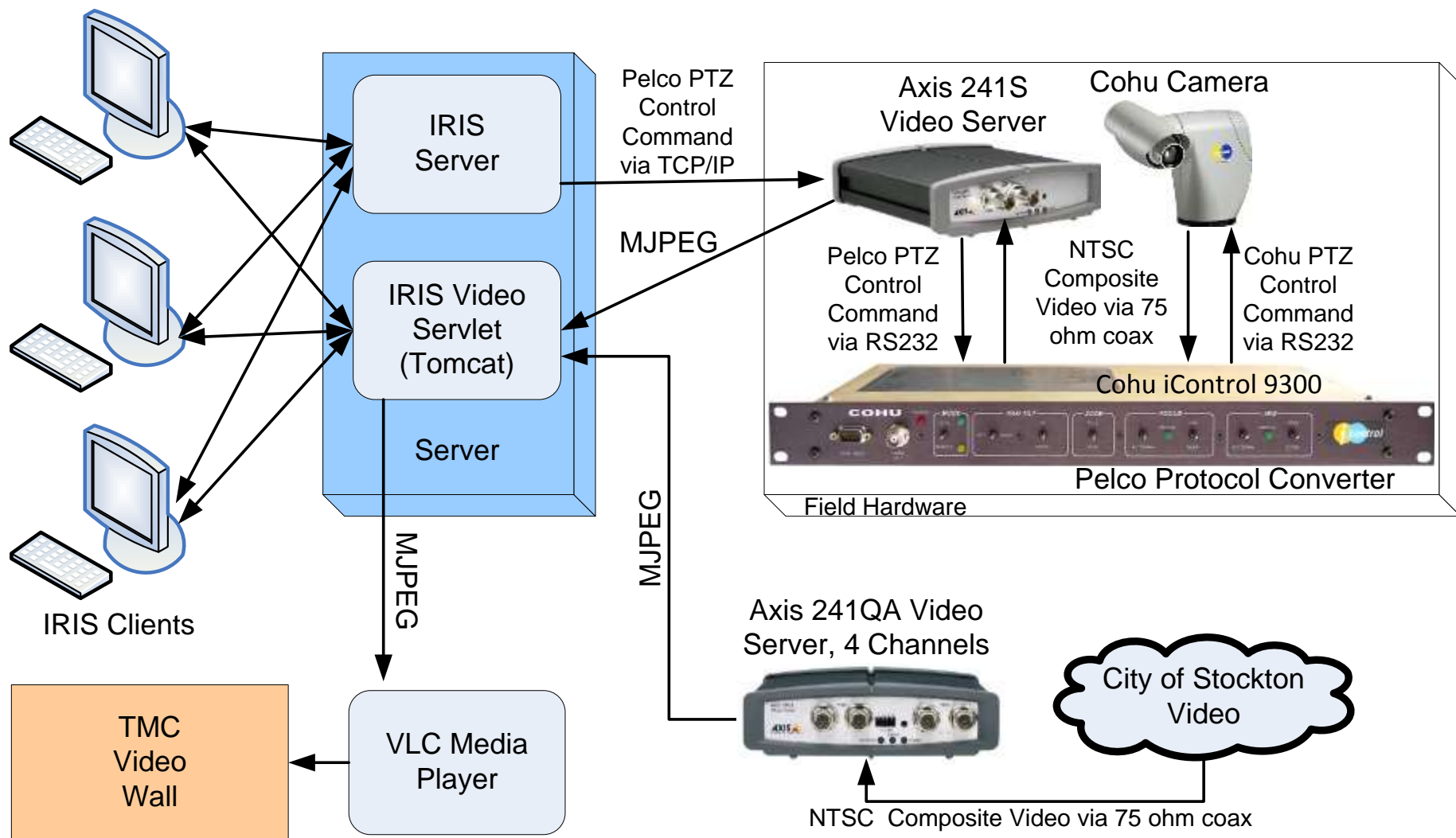


- District status update
- Video
- System maintenance
- Mapping
- Scalability
- Current and future enhancements



-
- A map of California showing its counties, color-coded by region and numbered 1 through 12. The regions are: 1. North Coast (white), 2. Northern (tan), 3. Central Valley (light purple), 4. San Francisco Bay Area (orange), 5. Central Coast (brown), 6. Central Valley (light blue), 7. South Coast (green), 8. Inland Empire (red), 9. Southern (dark blue), 10. Central Valley (yellow-green), 11. San Diego (yellow), and 12. Imperial (yellow). The counties are labeled with their names: Siskiyou, Modoc, Trinity, Shasta, Lassen, Tehama, Plumas, Glenn, Butte, Sierra, Lake, Colusa, Yuba, El Dorado, Sonoma, Napa, Solano, San Francisco, Alameda, Contra Costa, San Mateo, Santa Cruz, Santa Clara, Monterey, San Luis Obispo, Santa Barbara, Kern, Tulare, Fresno, Madera, Merced, Stanislaus, Mariposa, Yosemite, Alpine, Inyo, Mono, San Bernardino, Riverside, San Diego, and Imperial.

D10 Video Architecture



Video Screenshot

Caltrans District 10 IRIS 9.2.1: kyen (Kin Yen)

Session View Help

CMS Incident Camera R_Node Ramp Meter LCS

Layers Legend Density

+ - CAWS East Home North South Stockton West

Selected Camera

ID C1004 Output

Location I5 NB @ Church

ADJUST C38 TO BALANCE

I5 & 4 Interchange

Camera status: All

6 Not published 0 Playlist 7 No controller

9 Inactive 20 Active 29 All

C101 - Unknown location
C1001 - SR205 EB @ Hanson Rd
C1002 - I5 SB @ SR205
C1003 - I5 SB @ SR120
C1004 - I5 NB @ Church
C1005 - I5 SB @ SR4
C1006 - I5 SB @ March Lane
C1007 - SR99 SB N of SR120
C1008 - SR99 SB N of SR4
C1009 - SR99 SB S of Waterloo Rd
C1010 - I5 NB N of 11th St
C1011 - I5 NB @ Westley Rest Area
C1012 - SR580 EB W of Flynn Rd
C1013 - SR120 WB E of I5
C1014 - SR99 NB @ Faith Home Rd
C1015 - SR99 NB N of Lathrop Rd
C1016 - SR99 NB S of French Camp Rd
C1017 - SR99 SB N of MLK

Action Plan

AWS

640347.1 m E 4196877.0 m N

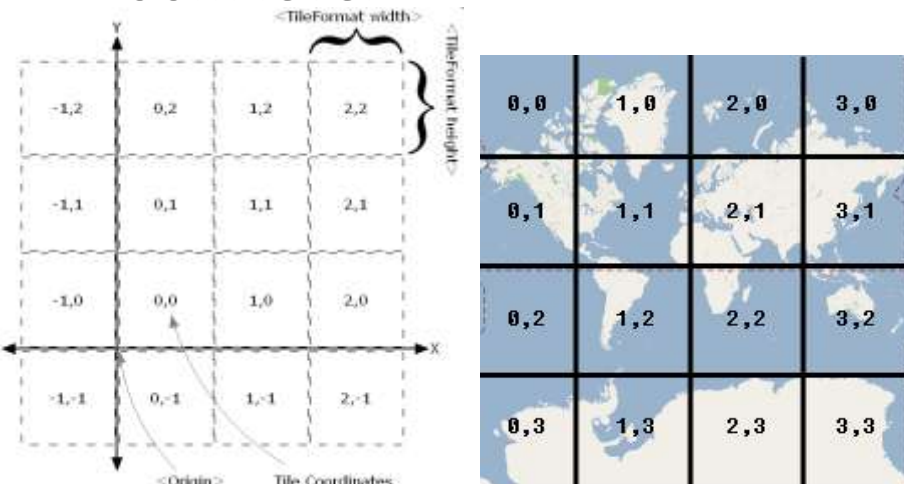


System Maintenance

- There is very little IRIS system maintenance
 - Update IRIS configuration if field elements change
 - E.g. VDS, CMS, cameras
 - Delete contents of some log database tables
 - Comm_events, detector_events
- Normal server maintenance
 - Check disk space (clear log files if necessary)
 - Update operating system packages
 - Backup
 - IRIS PostgreSQL database
 - LDAP database
 - IRIS configuration files

IRIS OpenStreetMap (OSM) Mapping

- Tile format
 - Spherical Mercator
 - 256x256 png
 - Zoom level
 - Folder and file name
 - Zoom\X\Y.png
- Pro: Fast
- Con: Large data size (GB)
- Limit area, zoom level, skip zoom level



- Less license Restriction
- Many open-source software support (viewer engine, tile server, tile maker)
- Custom look with template
- Support aerial photo / raster file

Zoom Level



Zoom level 16



Zoom level 17



Zoom level 18



Zoom level 19



Zoom level 20



Zoom level 21



Scalability

- Scalability testing for simultaneous users has been performed.
- Scalability of adding field elements has **not** been tested.

On a \$1000 dual-core server...

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

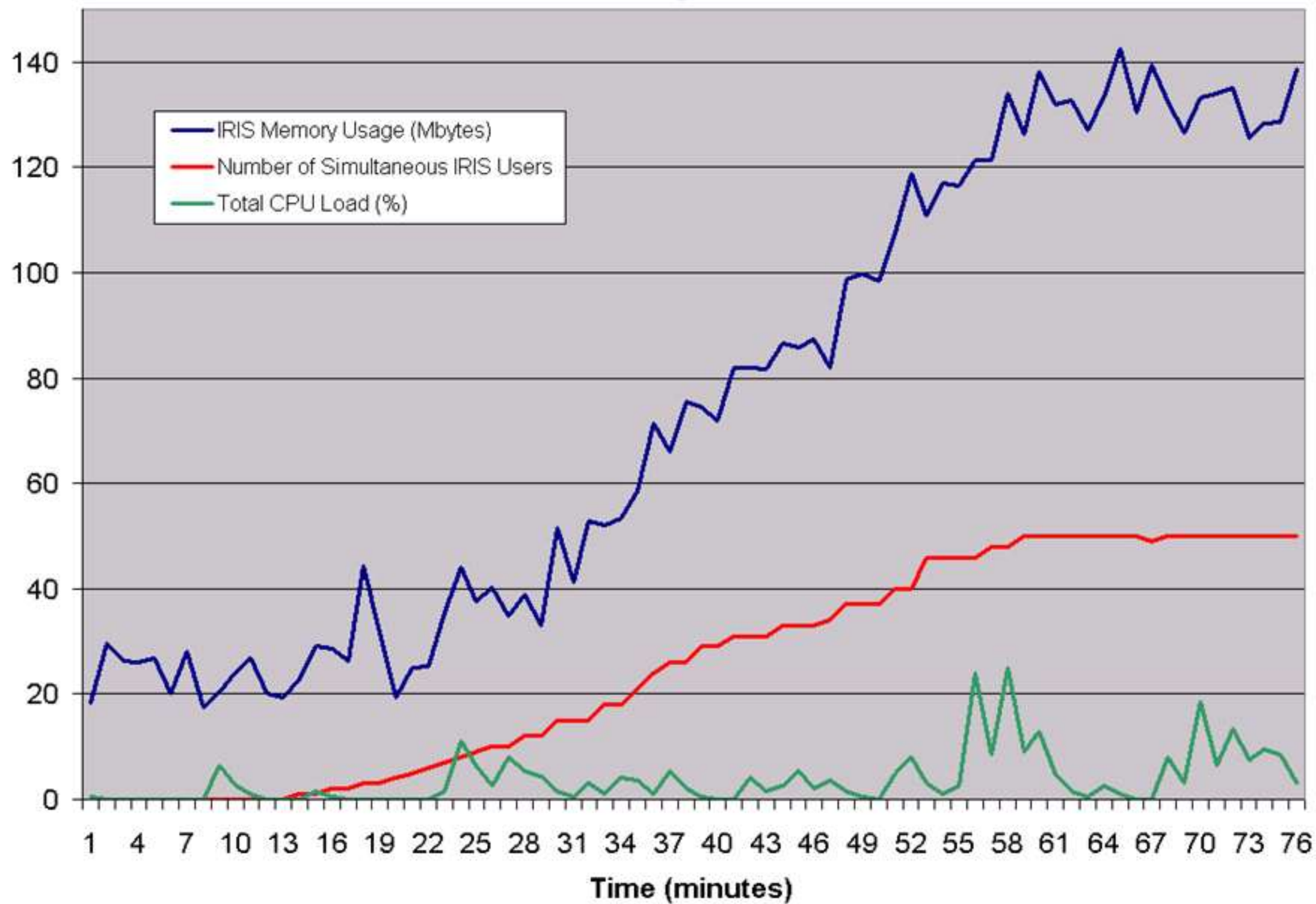
Resulted in...

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





IRIS Scalability



Ongoing + Future Enhancements

- Enhanced IRIS PeMS driver
 - Configuration updates IRIS \leftrightarrow PeMS
- Video interface to D1, D2, D5 hardware
 - In progress
- Upgrade IRIS client to OpenStreetMap
 - In progress
- Ramp metering (partial complete)
- Integration with TMCAL
- Lane closure
- Inter-district travel time generation





Resources



- IRIS discussion group
 - <http://groups.google.com/group/irisits>
- Caltrans
 - HQ: Stan Slavin, stan_slavin@dot.ca.gov
 - D10: John Castro, john_castro@dot.ca.gov
 - D10: Mohammad Battah, mohammad_t_battah@dot.ca.gov
- Mn/DOT
 - Web site: <http://iris.dot.state.mn.us>
 - Jim Kranig, jim.kranig@state.mn.us
 - Doug Lau, doug.lau@state.mn.us
- UC Davis, AHMCT
 - Web site: <http://iris.ahmct.ucdavis.edu>
 - Kin Yen, ksyen@ucdavis.edu
 - Ty Lasky, talasky@ucdavis.edu
 - Bahram Ravani, bravani@ucdavis.edu
- Berkeley Transportation Systems
 - Web site: <http://iris.bt-systems.com>
 - Rob Hranac, rob@bt-systems.com
 - Michael Darter, michael@bt-systems.com

