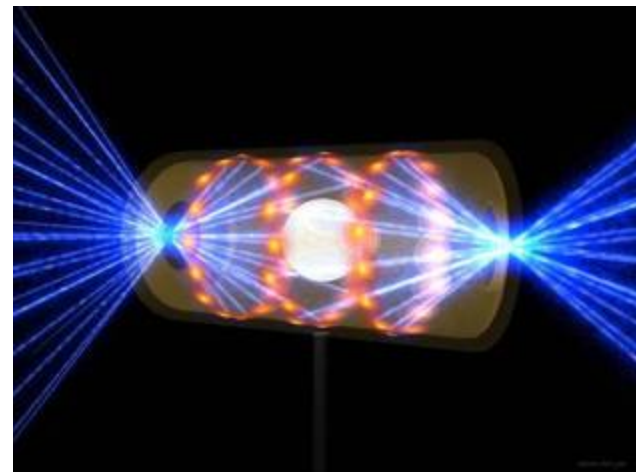
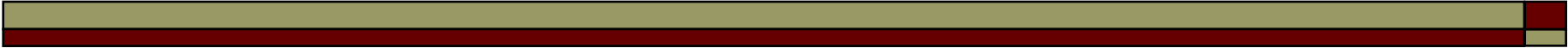


Processing Scientific Data: Three Unique Case Studies

Ronald Mak

Presented August 9, 2010
IBM Almaden Research Center





Presentation Agenda

- Case Study 1
The Collaborative Information Portal (CIP)
Mars Exploration Rovers (MER) Mission
NASA Ames Research Center
- Case Study 2
The Systems Health Information Portal (SHIP)
NASA Ames Research Center
- Case Study 3
Shot Data Management
The National Ignition Facility (NIF)
Lawrence Livermore National Laboratory
- Important Lessons Learned

Case Study 1: The Collaborative Information Portal (CIP)



Case Study 1: The Collaborative Information Portal

The **Collaborative Information Portal (CIP)** was a key ground-based application used by the **NASA's Mars Exploration Rovers (MER)** mission.

Mission scientists, engineers, and researchers at JPL and around the world used CIP to access mission data in a secure and organized manner over the Internet.

- My role: **Senior Scientist**
Research Institute for Advanced
Computer Science (RIACS)
 - Architect and lead developer of the
CIP middleware, 2002-2003
 - Mission support at the NASA Ames
Research Center and JPL, 2004



Mission Control Center, JPL
Mars Exploration Rovers Mission



Mars Exploration Rover Mission

- Twin robot geologists search for liquid water on Mars in the past.
- **Launched:** June 10 and July 7, 2003
- **Landed:** January 3 and 24, 2004
- **Duration:** 90 days

But after over six and a half Earth years, both are still operating (although one is has been stuck in a sand pile for several months).

- **Mission Center:**
Jet Propulsion Laboratory
Pasadena, CA



MER Mission Requirements

- Time management
- Data management
- Personnel management



Mission Geology Lab, JPL

The Collaborative Information Portal (CIP)

The screenshot displays the CIP (Ikeely) software interface. The top menu bar includes 'CIP (Ikeely)', 'File', 'Messages', 'Clocks', 'Events', 'Schedules', and 'Help'. The 'Messages' tab is active, showing a list of broadcast messages with columns for Mission, Sender, Message, and Sent (UTC). Below this, the 'Clocks' section shows two entries: SOL 51 (18:07, LST-A) and SOL 31 (06:06, LST-B). The 'Events' section displays a table of tasks with columns for Time Left, Task Summary, Start, and Stop. The 'Schedules' section is active, showing a Gantt chart for the Los_Angeles/America mission. The Gantt chart displays a timeline from 23-Feb-0 to 24-Feb-04, with various activities represented by colored bars. The 'Tool tabs' section includes 'Overview', 'Time Converter', 'Schedules', 'Browse Files', 'Find Files', 'New Files', and 'Observations'. The 'GO TO NOW' button is highlighted. The 'SHOW/HIDE SCHEDULES' button is also visible. The 'PRINT GANTT CHART' and 'GET INFO' buttons are present. The 'Event horizon' is indicated by a vertical line in the Gantt chart. The 'Schedule viewer' is the main area displaying the Gantt chart and activity list.

Broadcast messages

Mission	Sender	Message	Sent (UTC)
MER	dlblaney	I think I forgot-but	12:14:17, 02/20/04
MER	dlblaney	Mini-TES products have been reduced	12:13:17, 02/20/04

Clocks

SOL	Time	LST
SOL 51	18:07	LST-A
SOL 31	06:06	LST-B

Tool tabs

Event horizon

Schedule viewer

Time Left	Task Summary	Start	Stop
00:52 left	Tactical End-of-Sol Engr. Assessm...	06:00	10:06
01:54 left	SOWG Meeting	09:05	11:08
01:54 until	End-of-Sol Science Discussion	11:08	11:39
01:54 until	Sci Product EPO Caption Interview	11:08	12:10

Name	Start	End
Engineering Leads Tagup	23-Feb-0 10:00	24-Feb-04 06:00
Engineering Skeleton Activity Plan Up	23-Feb-0 10:00	24-Feb-04 06:00
DL/UL Handover Meeting	23-Feb-0 10:00	24-Feb-04 06:00
SOWG Meeting	23-Feb-0 10:00	24-Feb-04 06:00
End-of-Sol Science Discussion	23-Feb-0 10:00	24-Feb-04 06:00
Sci Product EPO Caption Interview	23-Feb-0 10:00	24-Feb-04 06:00
Activity Refinement/Sequence Assign	23-Feb-0 10:00	24-Feb-04 06:00
Activity Carving	23-Feb-0 10:00	24-Feb-04 06:00

Clocks

Tick-over at top-of-minute

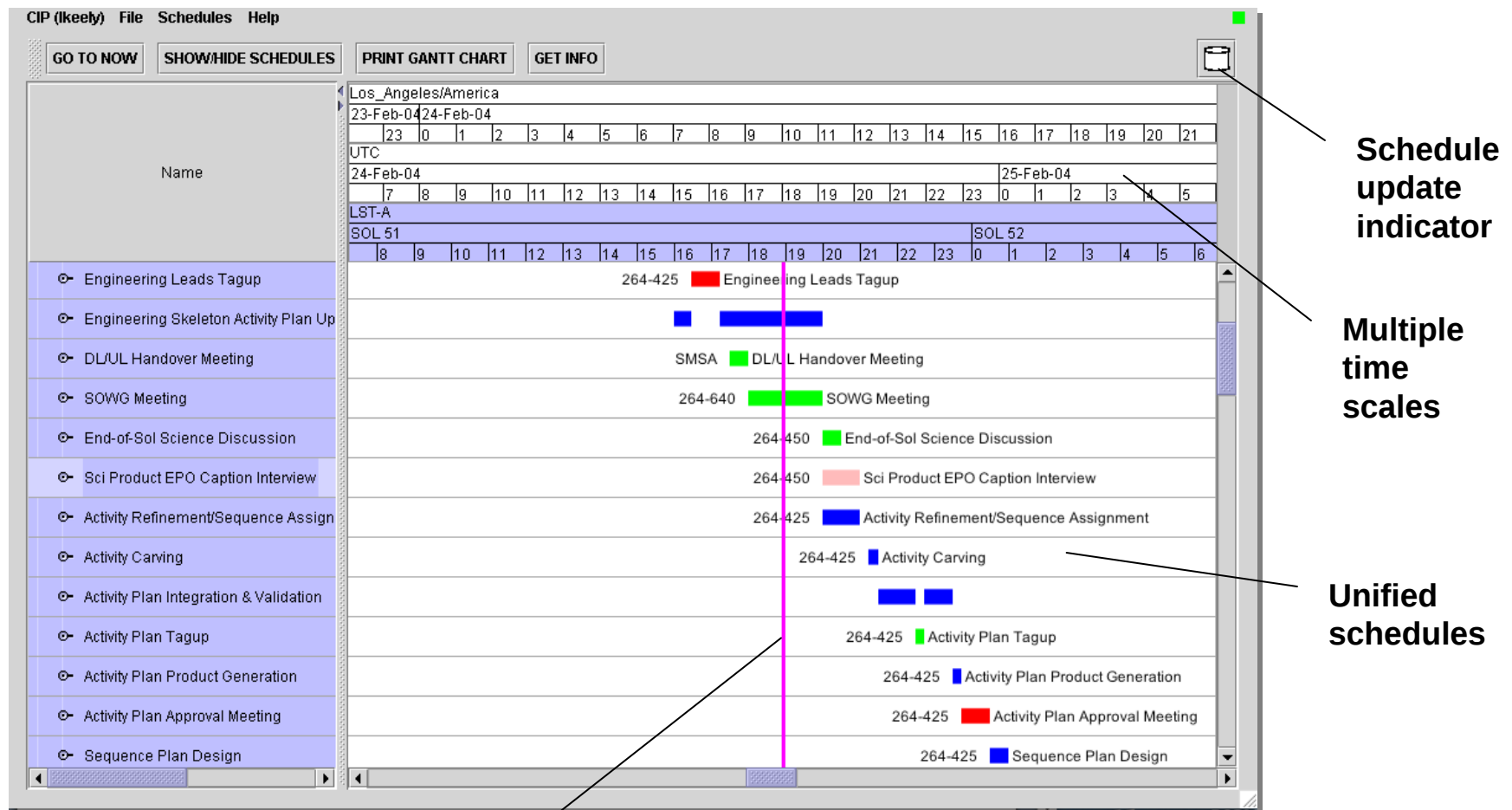
The screenshot shows a window titled "CIP (Keely) File Clocks Help". It contains a table with four rows of time information. The first row is highlighted in blue. Annotations with arrows point to specific elements: "Mars time displayed in Sols" points to "SOL 51"; "UTC shown in Day of Year" points to "DOY 55"; "Local time" points to the "LST-A" dropdown; "Time at DSN location" points to the "Canberra/Australia" dropdown; and "Time at collaborator's location" points to the "Phoenix/America" dropdown. The "Feb 24 2004" date appears in the first three rows, while "Feb 25 2004" appears in the second row.

SOL 51	18:31	LST-A
Feb 24 2004	09:39	Los_Angeles/Amer...
DOY 55	17:39	UTC
Feb 25 2004	04:39	Canberra/Australia
Feb 24 2004	10:39	Phoenix/America

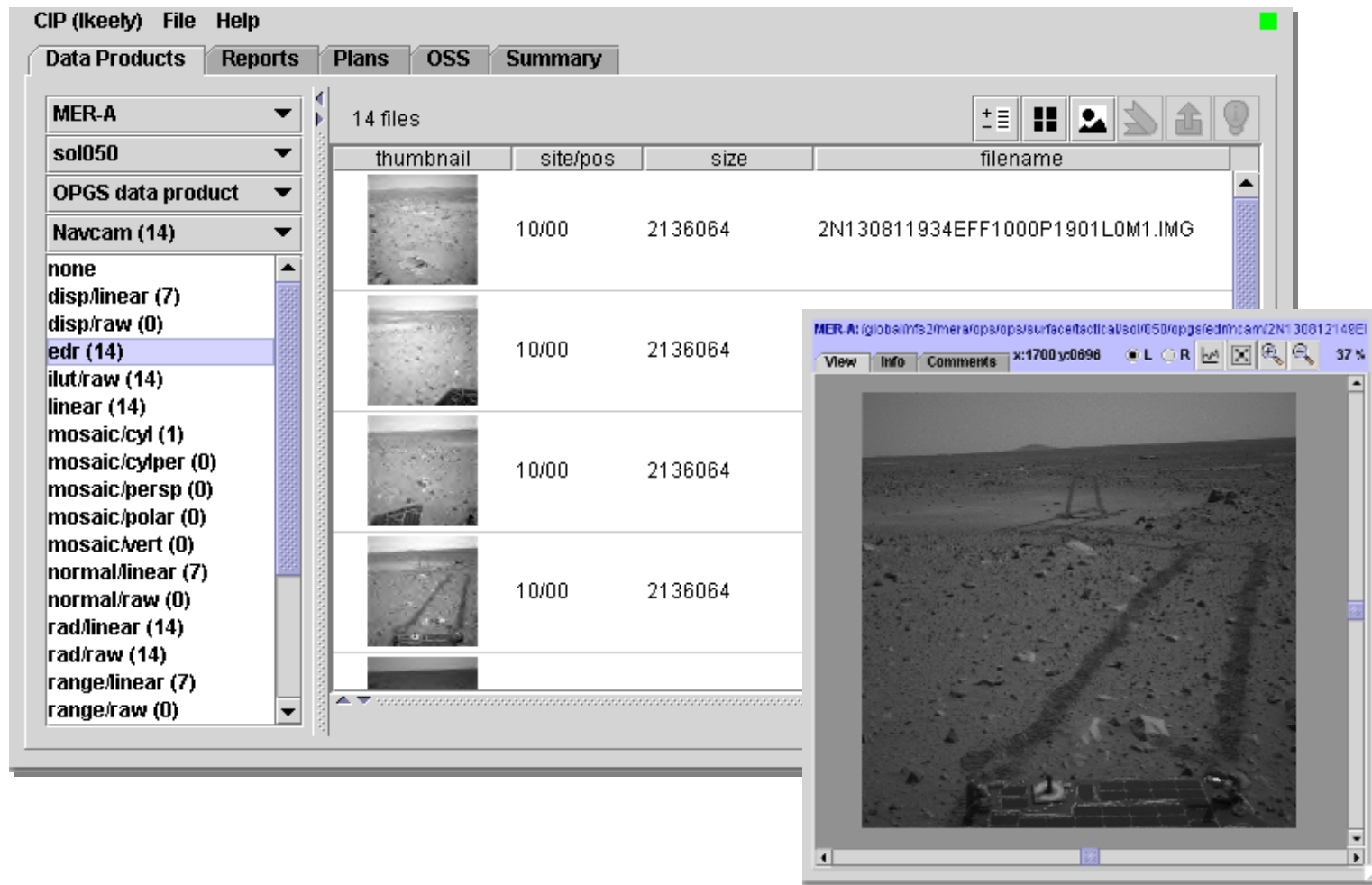
Annotations:

- Mars time displayed in Sols
- UTC shown in Day of Year
- Local time
- Time at DSN location
- Time at collaborator's location

Schedule Viewer



Data Product Navigator



New File Notification

MER Collaborative Information Portal
CIP (rmak) File Help

last 4 hrs

78 files

Duration (points to 'last 4 hrs')

Icons (points to the row of colored circular icons)

Files (points to the table of file details)

MER	icon	sol	modified	format	size	filename
MER-A	N	107	04-23-04 15:03:08	pds	33726680	2NN107EFF32POL00P1818L000M1.IMG
MER-A	N	107	04-23-04 15:05:00	pds	19090512	2NN107EFF32CYP00P1818R000M1.IMG
MER-A	N	107	04-23-04 15:04:42	pds	19090512	2NN107EFF32CYP00P1818L000M1.IMG
MER-A	T	108	04-23-04 15:05:37	minites	20640	2T135968156RDR3300P3575N0A1.QUB
MER-A	T	108	04-23-04 15:05:40	minites	20640	2T135968156EMR3300P3575N0A1.QUB
MER-A	T	108	04-23-04 15:05:38	minites	20520	2T135968156BTR3300P3575N0A1.QUB
MER-A	T	108	04-23-04 15:05:24	minites	233232	2T135967352RDR3300P3576N0A1.QUB
MER-A	T	108	04-23-04 15:05:30	minites	233232	2T135967352EMR3300P3576N0A1.QUB
MER-A	T	108	04-23-04 15:05:27	minites	231876	2T135967352BTR3300P3576N0A1.QUB
MER-A	T	108	04-23-04 15:05:08	minites	359136	2T135965760RDR3300P3902N0A1.QUB

Three-Tiered Enterprise Architecture

□ Client

- Java application (Swing)

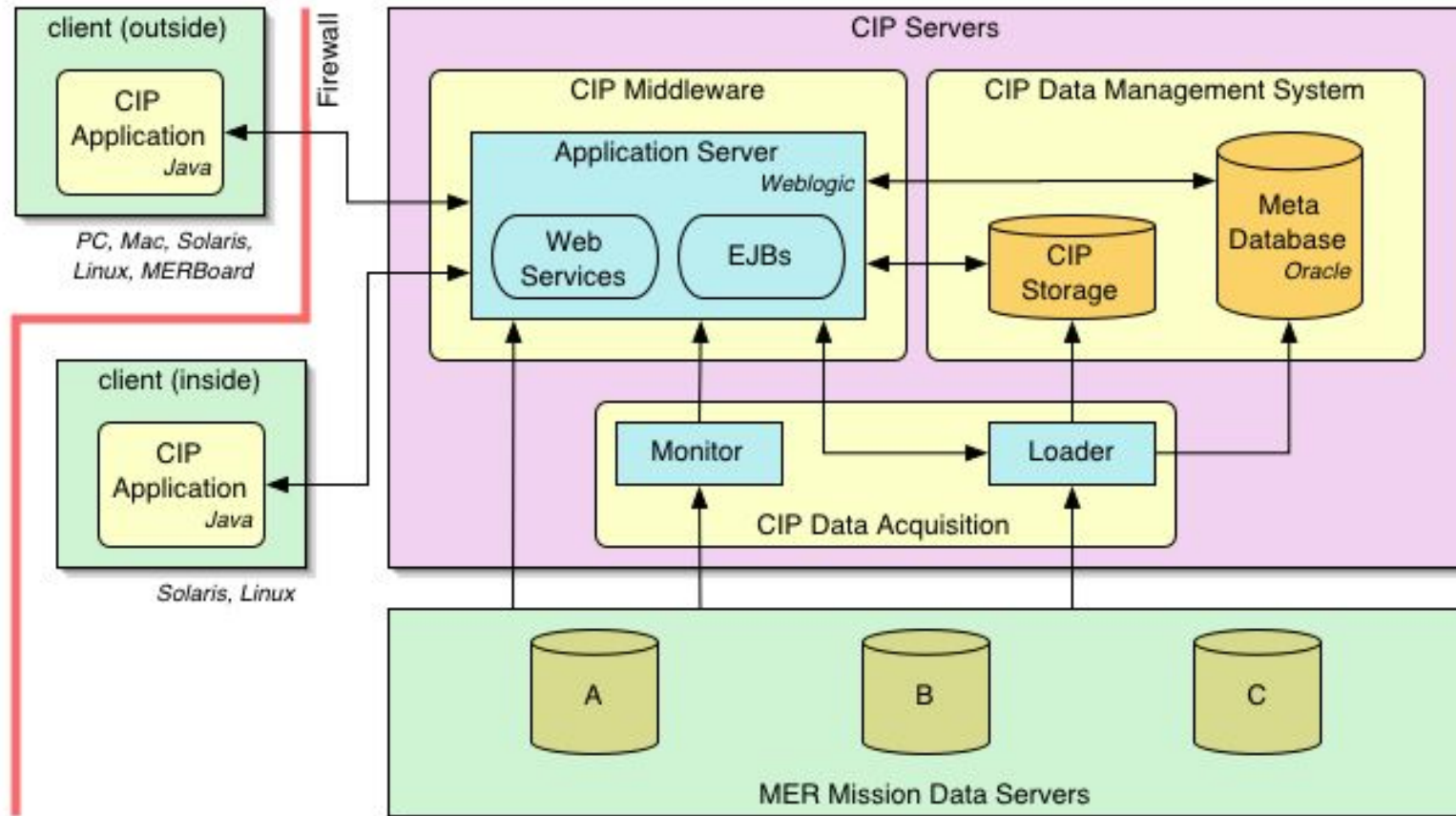
□ Middleware Server

- Web services, Enterprise JavaBeans (EJB), Java Message Service (JMS)
- Service-oriented architecture (SOA)

□ Data Repository

- Mission file servers (Unix)
- File monitor (Java application)
- Data loader (Java application)
- Database (Oracle)

Architecture Overview



CIP Middleware Services

- ❑ User management
- ❑ Metadata
- ❑ Schedules
- ❑ Mars and Earth time
- ❑ File and directory
- ❑ Message

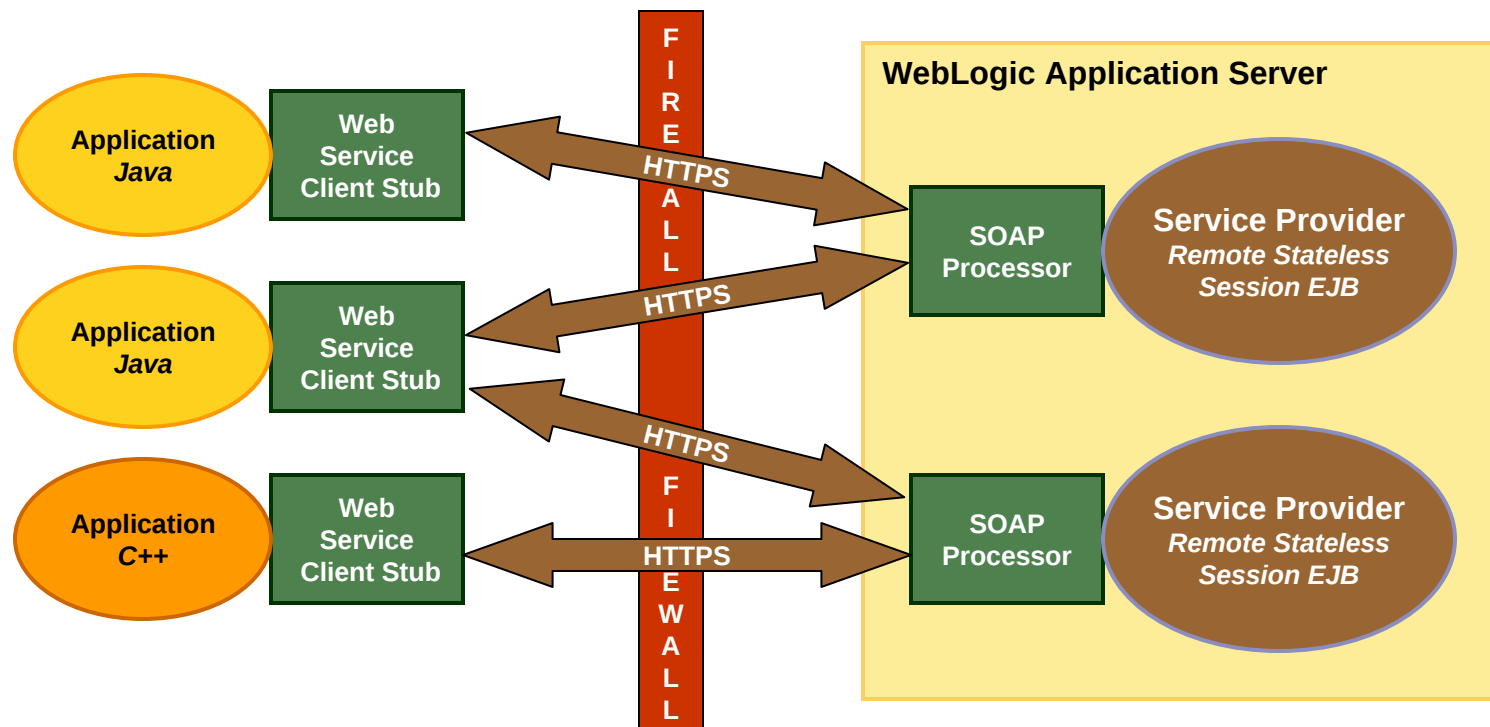


Mission Control Center, JPL

Middleware Technologies

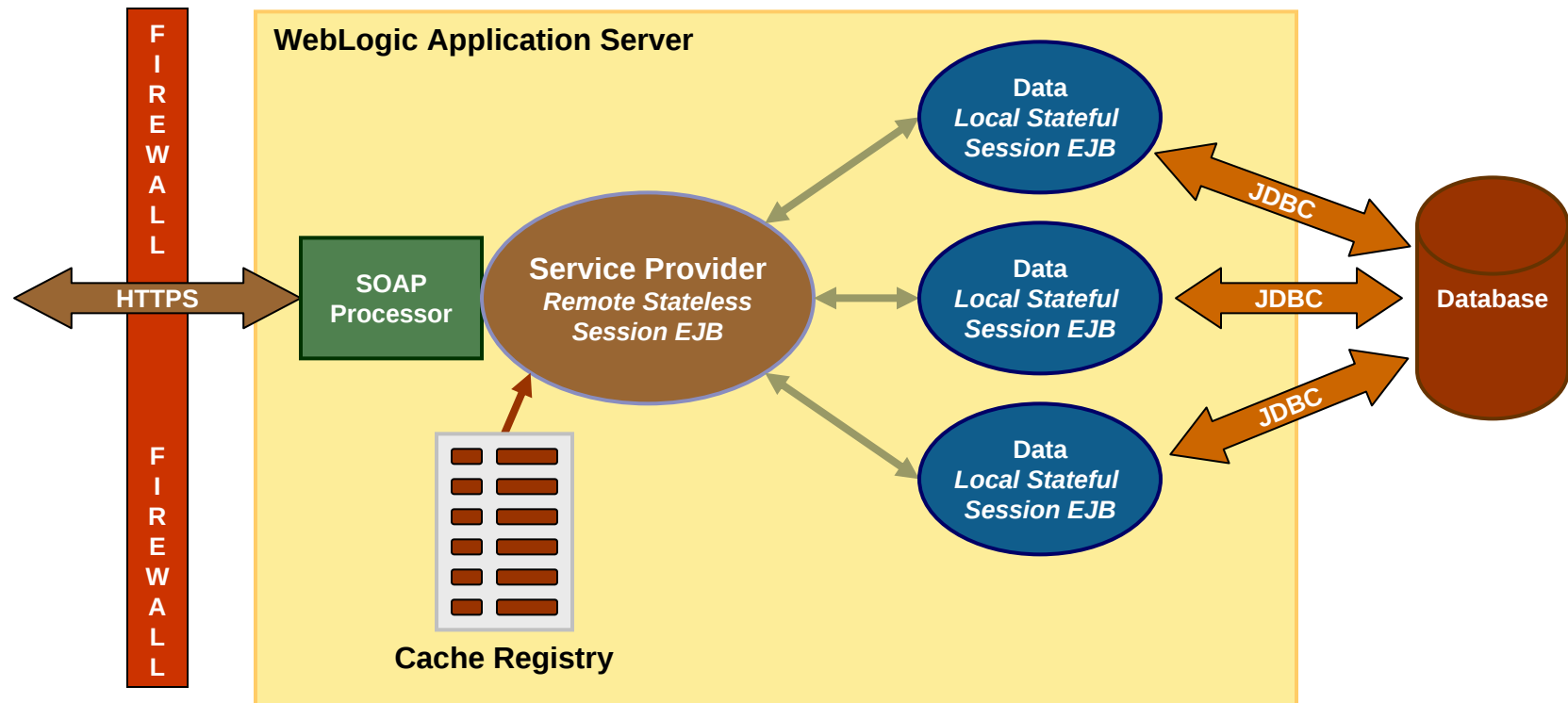
- **Enterprise JavaBeans (EJBs)** to achieve reliability, scalability, security, platform independence, and standards.
 - Stateless session beans
 - Stateful session beans
 - Message-driven beans
- **Web services** to expose the remote methods of the Service Provider EJBs to the client applications.
- **Java Message Service (JMS)** for synchronous and asynchronous messaging.
- **BEA WebLogic** application server.

Middleware Architecture



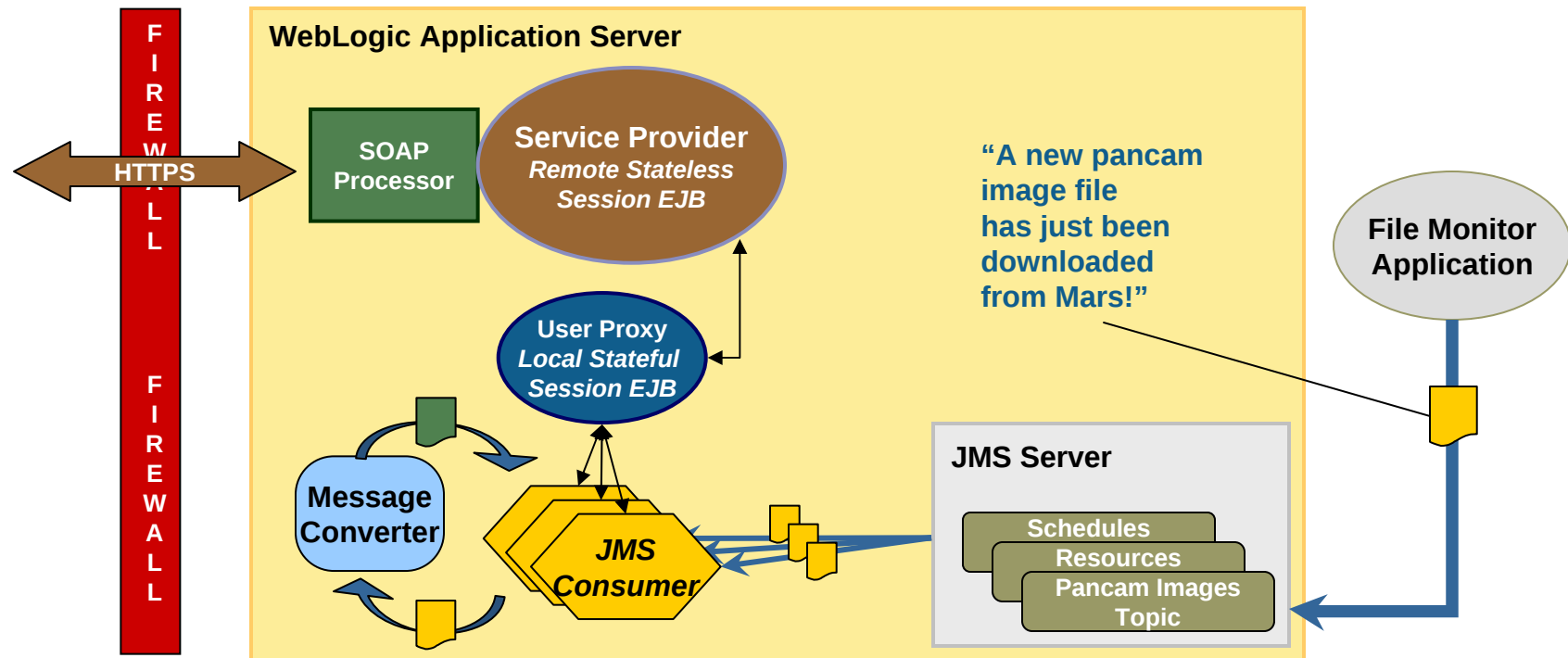
- **Web Services** expose the remote methods of the Service Provider beans.
- **HTTPS** encrypts the transmissions and gets them through the firewall.
- **Stateless session beans** are the Service Providers.

Caching Data



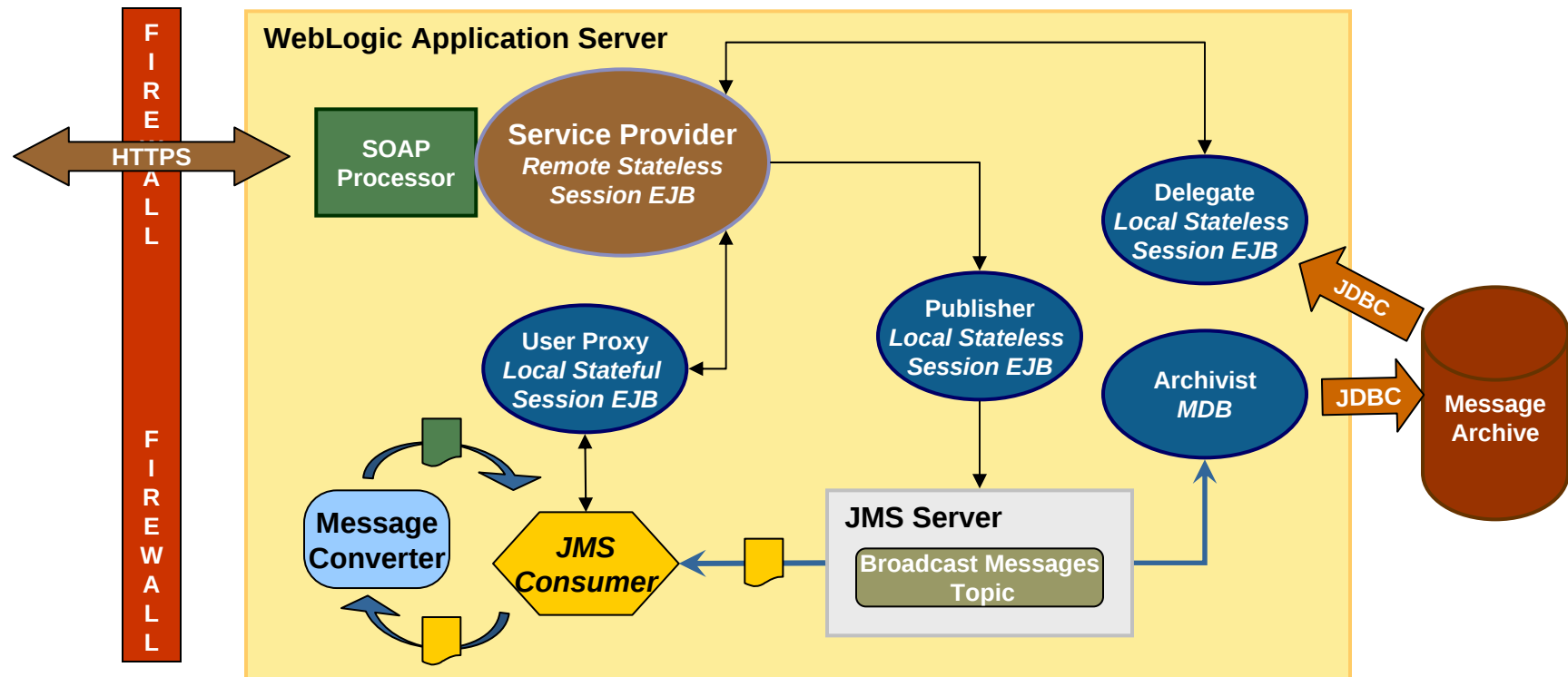
- Some middleware services cache data to improve performance.
- **Stateful session beans** cache data in memory.
- The cache beans access the backend data store.

Event Notification



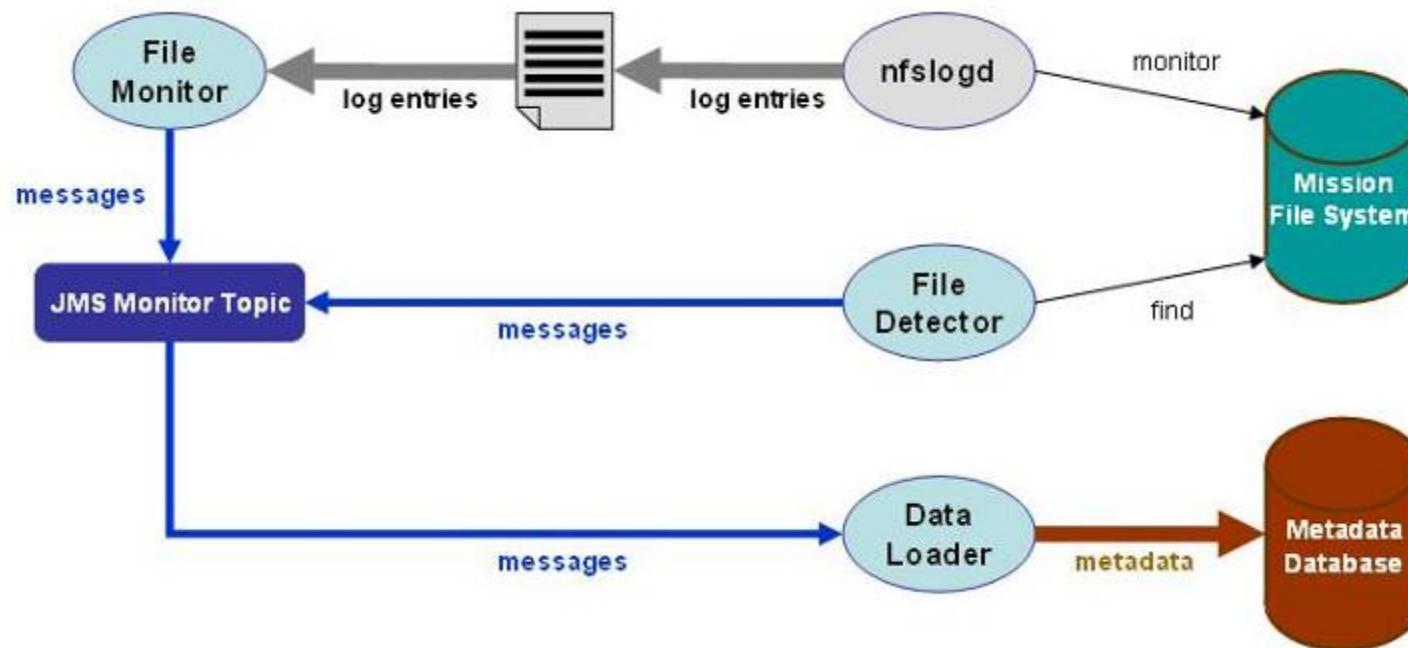
- Publish-subscribe model with **topics**
- Clients poll for their messages via web services.
- The **consumer objects** retrieve the messages.
- **User proxies** look up JMS consumer objects that represent the active subscriptions.
- Messages are converted for return via web services.

Broadcast Message Service



- The **Publisher bean** publishes messages to the **Broadcast Messages topic**.
- **Message-driven bean (MDB)** archives broadcast messages to persistent storage for later retrieval.
- The **Delegate bean** retrieves old messages for browsing.

Metadata Generation



- File changes are logged by **nfslogd** system program and the **File Monitor**, or found by the **File Detector**.
 - A message is sent to the **JMS Monitor Topic** for each file change.
- The **Data Loader** generates metadata about the file.
 - Retrieves messages from the monitor topic.

How Reliable Has CIP Been?

- The middleware code remained **unchanged** since the **code freeze** in early November 2003.
- CIP became **operational in mid–December 2003**, two weeks before the first rover landed.
- CIP has run continuously for as long as 153 Earth days without interruption.
 - As of the end of the day on December 31, 2005, the mission had lasted 17,904 Earth hours.
 - During that entire period, CIP has been down less than 10 hours, which is **> 99.9% uptime**.
- CIP was finally shut down this summer after **6½ years of failure-free service**.

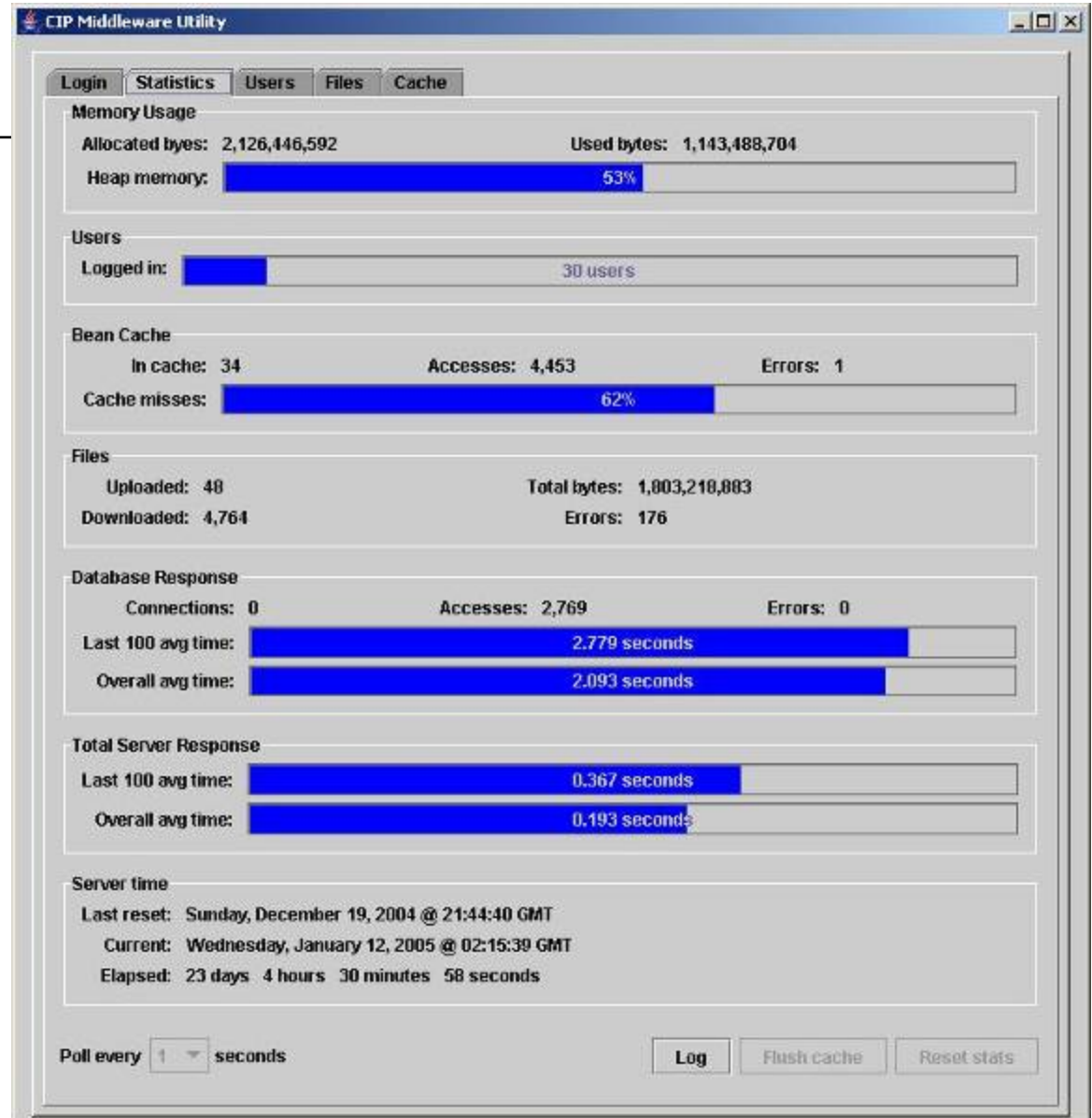
Example Log Entries: Streamer Service

```
2004-12-20 20:23:33,435 INFO : mjane: Streamer.putDataFile(/opt/bea/user_projects/cip/
conf/preferences/m.preferences)
2004-12-20 20:23:33,439 DEBUG: Begin upload of file '/opt/bea/user_projects/cip/conf/
preferences/sthompso.preferences'
2004-12-20 20:23:39,140 DEBUG: Completed upload of file '/opt/bea/user_projects/cip/conf/
preferences/sthompso.preferences': 35659 bytes
'/opt/bea/user_projects/cip/conf/global.properties': 13453 bytes
2004-12-20 20:28:57,516 INFO : jdoe: Streamer.getPreferences(user)
2004-12-20 20:29:29,721 INFO : jdoe: Streamer.getFileInfo()
2004-12-20 20:29:30,784 INFO : jdoe: Streamer.getFileInfo(/oss/merb/ops/ops/surface/
tactical/sol)
2004-12-21 19:17:43,320 INFO : jqpublic: Streamer.getDataFile(/global/nfs2/merb/ops/ops/
surface/tactical/sol/120/opgs/edr/jpeg/1P138831013ETH2809P2845L2M1.JPG)
2004-12-21 19:17:43,324 DEBUG: Begin download of file '/global/nfs2/merb/ops/ops/surface/
tactical/sol/120/opgs/edr/jpeg/1P138831013ETH2809P2845L2M1.JPG'
2004-12-21 19:17:44,584 DEBUG: Completed download of file '/global/nfs2/merb/ops/ops/
surface/tactical/sol/120/opgs/edr/jpeg/1P138831013ETH2809P2845L2M1.JPG': 1876 bytes
```

- ❑ Timestamp, user name, method name
- ❑ Information about the uploaded or downloaded file

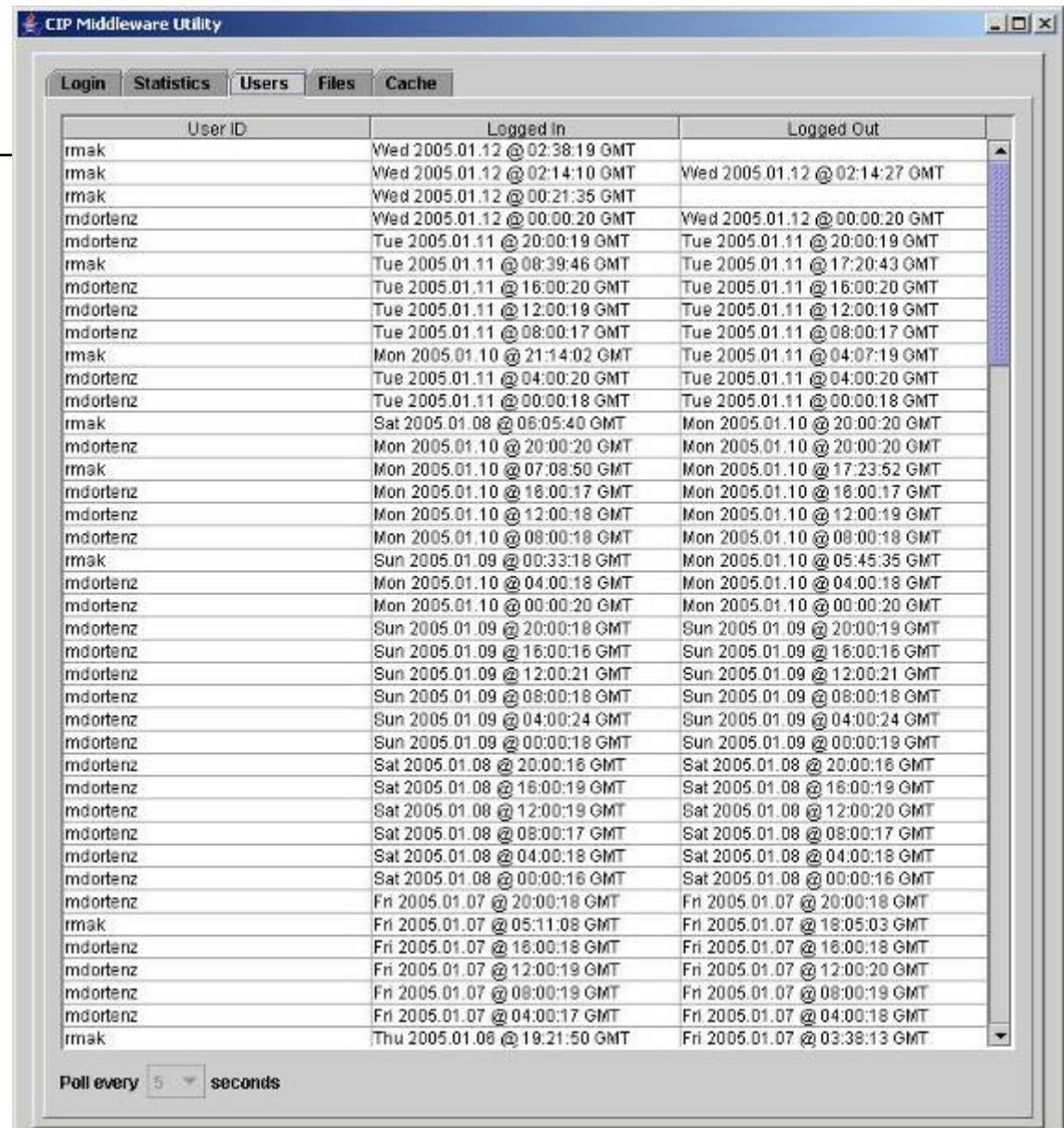
Middleware Monitor Utility

□ Server statistics



Middleware Monitor Utility

□ Users



User ID	Logged in	Logged Out
rmak	Wed 2005.01.12 @ 02:38:19 GMT	
rmak	Wed 2005.01.12 @ 02:14:10 GMT	Wed 2005.01.12 @ 02:14:27 GMT
rmak	Wed 2005.01.12 @ 00:21:35 GMT	
mdortenz	Wed 2005.01.12 @ 00:00:20 GMT	Wed 2005.01.12 @ 00:00:20 GMT
mdortenz	Tue 2005.01.11 @ 20:00:19 GMT	Tue 2005.01.11 @ 20:00:19 GMT
rmak	Tue 2005.01.11 @ 08:39:46 GMT	Tue 2005.01.11 @ 17:20:43 GMT
mdortenz	Tue 2005.01.11 @ 16:00:20 GMT	Tue 2005.01.11 @ 16:00:20 GMT
mdortenz	Tue 2005.01.11 @ 12:00:19 GMT	Tue 2005.01.11 @ 12:00:19 GMT
mdortenz	Tue 2005.01.11 @ 08:00:17 GMT	Tue 2005.01.11 @ 08:00:17 GMT
rmak	Mon 2005.01.10 @ 21:14:02 GMT	Tue 2005.01.11 @ 04:07:19 GMT
mdortenz	Tue 2005.01.11 @ 04:00:20 GMT	Tue 2005.01.11 @ 04:00:20 GMT
mdortenz	Tue 2005.01.11 @ 00:00:18 GMT	Tue 2005.01.11 @ 00:00:18 GMT
rmak	Sat 2005.01.08 @ 06:05:40 GMT	Mon 2005.01.10 @ 20:00:20 GMT
mdortenz	Mon 2005.01.10 @ 20:00:20 GMT	Mon 2005.01.10 @ 20:00:20 GMT
rmak	Mon 2005.01.10 @ 07:08:50 GMT	Mon 2005.01.10 @ 17:23:52 GMT
mdortenz	Mon 2005.01.10 @ 18:00:17 GMT	Mon 2005.01.10 @ 18:00:17 GMT
mdortenz	Mon 2005.01.10 @ 12:00:18 GMT	Mon 2005.01.10 @ 12:00:19 GMT
mdortenz	Mon 2005.01.10 @ 08:00:18 GMT	Mon 2005.01.10 @ 08:00:18 GMT
rmak	Sun 2005.01.09 @ 00:33:18 GMT	Mon 2005.01.10 @ 05:45:35 GMT
mdortenz	Mon 2005.01.10 @ 04:00:18 GMT	Mon 2005.01.10 @ 04:00:18 GMT
mdortenz	Mon 2005.01.10 @ 00:00:20 GMT	Mon 2005.01.10 @ 00:00:20 GMT
mdortenz	Sun 2005.01.09 @ 20:00:18 GMT	Sun 2005.01.09 @ 20:00:19 GMT
mdortenz	Sun 2005.01.09 @ 16:00:16 GMT	Sun 2005.01.09 @ 16:00:16 GMT
mdortenz	Sun 2005.01.09 @ 12:00:21 GMT	Sun 2005.01.09 @ 12:00:21 GMT
mdortenz	Sun 2005.01.09 @ 08:00:18 GMT	Sun 2005.01.09 @ 08:00:18 GMT
mdortenz	Sun 2005.01.09 @ 04:00:24 GMT	Sun 2005.01.09 @ 04:00:24 GMT
mdortenz	Sun 2005.01.09 @ 00:00:18 GMT	Sun 2005.01.09 @ 00:00:19 GMT
mdortenz	Sat 2005.01.08 @ 20:00:16 GMT	Sat 2005.01.08 @ 20:00:16 GMT
mdortenz	Sat 2005.01.08 @ 16:00:19 GMT	Sat 2005.01.08 @ 16:00:19 GMT
mdortenz	Sat 2005.01.08 @ 12:00:19 GMT	Sat 2005.01.08 @ 12:00:20 GMT
mdortenz	Sat 2005.01.08 @ 08:00:17 GMT	Sat 2005.01.08 @ 08:00:17 GMT
mdortenz	Sat 2005.01.08 @ 04:00:18 GMT	Sat 2005.01.08 @ 04:00:18 GMT
mdortenz	Sat 2005.01.08 @ 00:00:16 GMT	Sat 2005.01.08 @ 00:00:16 GMT
mdortenz	Fri 2005.01.07 @ 20:00:18 GMT	Fri 2005.01.07 @ 20:00:18 GMT
rmak	Fri 2005.01.07 @ 05:11:08 GMT	Fri 2005.01.07 @ 18:05:03 GMT
mdortenz	Fri 2005.01.07 @ 16:00:18 GMT	Fri 2005.01.07 @ 16:00:18 GMT
mdortenz	Fri 2005.01.07 @ 12:00:19 GMT	Fri 2005.01.07 @ 12:00:20 GMT
mdortenz	Fri 2005.01.07 @ 08:00:19 GMT	Fri 2005.01.07 @ 08:00:19 GMT
mdortenz	Fri 2005.01.07 @ 04:00:17 GMT	Fri 2005.01.07 @ 04:00:18 GMT
rmak	Thu 2005.01.06 @ 19:21:50 GMT	Fri 2005.01.07 @ 03:38:13 GMT

Poll every 5 seconds

Middleware Monitor Utility

- Files uploaded or downloaded

CTP Middleware Utility

Login Statistics Users Files Cache

Direction	Size	Start time	End time	Name
Download	144,545	Wed 2005.01.12 @ 01:02:02 GMT	Wed 2005.01.12 @ 01:02:06 GMT	/oss/merb/ops/ops/surf/ace/tactical/sol/345/aps/s/actint/sol_345_screen_capture.jpg
Download	145,861	Wed 2005.01.12 @ 00:56:38 GMT	Wed 2005.01.12 @ 00:56:42 GMT	/oss/merb/ops/ops/surf/ace/tactical/sol/345/aps/s/actint/sol_345_screen_capture.jpg
Download	32,958	Wed 2005.01.12 @ 00:35:44 GMT	Wed 2005.01.12 @ 00:35:45 GMT	/opt/bea/user_projects/cip/conf/preferences/jschrein.preferences
Download	13,453	Wed 2005.01.12 @ 00:35:41 GMT	Wed 2005.01.12 @ 00:35:42 GMT	/opt/bea/user_projects/cip/conf/global.properties
Download	23,629	Wed 2005.01.12 @ 00:25:55 GMT	Wed 2005.01.12 @ 00:25:57 GMT	/opt/bea/user_projects/cip/conf/preferences/smlenna.preferences
Download	13,453	Wed 2005.01.12 @ 00:25:51 GMT	Wed 2005.01.12 @ 00:25:53 GMT	/opt/bea/user_projects/cip/conf/global.properties
Download	14,482	Wed 2005.01.12 @ 00:16:26 GMT	Wed 2005.01.12 @ 00:16:26 GMT	/opt/bea/user_projects/cip/conf/preferences/welch.preferences
Download	13,453	Wed 2005.01.12 @ 00:16:25 GMT	Wed 2005.01.12 @ 00:16:25 GMT	/opt/bea/user_projects/cip/conf/global.properties
Upload	22,016	Wed 2005.01.12 @ 00:13:04 GMT	Wed 2005.01.12 @ 00:13:05 GMT	/opt/bea/user_projects/cip/conf/preferences/mlee.preferences
Download	13,364	Tue 2005.01.11 @ 23:12:42 GMT	Tue 2005.01.11 @ 23:12:44 GMT	/opt/bea/user_projects/cip/conf/preferences/cruple.preferences
Download	13,453	Tue 2005.01.11 @ 23:12:39 GMT	Tue 2005.01.11 @ 23:12:41 GMT	/opt/bea/user_projects/cip/conf/global.properties

Poll every 2 seconds

Middleware Monitor Utility

Cache contents

The screenshot displays the CIP Middleware Utility application with the 'Cache' tab selected. The main window shows a tree view of schemas (MER_A, MER_B, MER_T, POISE) and a list of cached queries. A 'Cached Query Browser' window is open, showing a query for 'Schedule.*' and a table of cached records. Below the browser, a 'Last data reloads' table shows the reload history for each schema.

Cached Query Browser

Cached query

```
SELECT DISTINCT Schedule.* FROM POISE.Schedule WHERE (Schedule.mission LIKE 'MER-A') AND (Schedule.activity LIKE 'Ops') AND (Schedule.phase LIKE 'any') AND (Schedule.type LIKE 'Critical_Deploy_Event') AND (Schedule.isHidden
```

ACTIVITY	TYPE	PHASE	FILEPATH	MISSION	SCHEDULE	LASTUP...	NAME	ISHIDDEN	CREATION	DELETE...
Ops	Critical_...	any	/opt/beaf/...	MER-A	1070	1073184...	MER-A_...	0	1073155...	0

1 records cached.

Last data reloads

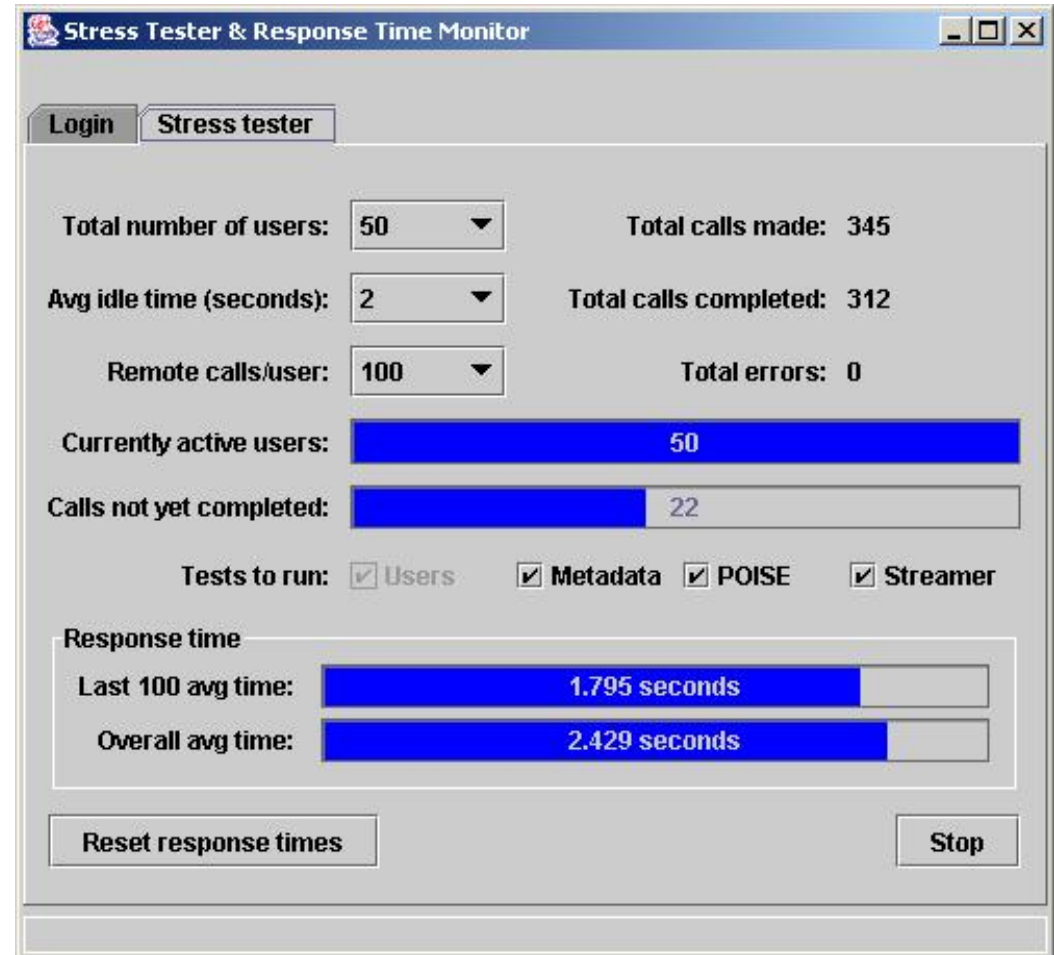
Schema	Reload started	Reload completed
MER_A	Sun 2004.12.19 @ 22:15:40 GMT	Sun 2004.12.19 @ 22:15:40 GMT
MER_B	Sun 2004.12.19 @ 22:15:40 GMT	Sun 2004.12.19 @ 22:15:40 GMT
MER_T	Sun 2004.12.19 @ 22:15:40 GMT	Sun 2004.12.19 @ 22:15:40 GMT
POISE	Tue 2005.01.11 @ 21:03:40 GMT	Tue 2005.01.11 @ 21:03:40 GMT

Poll every 10 seconds

Show cached data Refresh tree

Middleware Stress Tester

- Simulate multiple users performing client operations simultaneously.
- Can the server handle a heavy load?
 - What is its behavior when it starts to fail?



CIP Summary

- Provided **situational awareness** for MER mission personnel
 - Download images, data, schedules, current time
 - Collaboration
 - Alerts

- **Service-oriented architecture (SOA)**
 - Java Swing and C++ desktop client applications
 - J2EE technologies
 - Web services
 - Mission file servers
 - Metadatabase
 - BEA WebLogic, Oracle RDBMS
 - Open source software



Wind-sculpted sand patterns on Mars

Case Study 2: The Systems Health Information Portal (SHIP)



Case Study 2: The Systems Health Information Portal

The **Systems Health Information Portal (SHIP)** constantly monitors and analyzes sensor data gathered from a **manned NASA space vehicle**.

If there is a **fault** with the vehicle, SHIP quickly **analyzes** the situation and recommends **corrective actions** for the astronauts on board, even if contact with ground control is lost.



Life on board the International Space Station

- My role: **Project Scientist**
University of California at Santa Cruz
 - Architect, lead developer, and systems integrator, 2004-2005



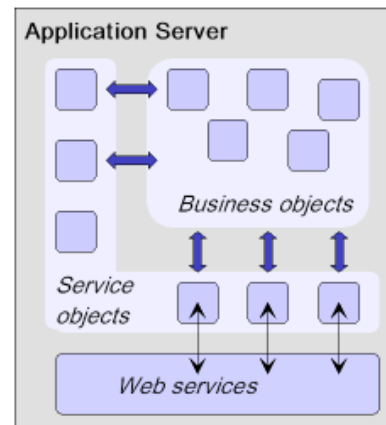
SHIP Requirements

- **Access to disparate data sources**
 - Databases, files, live instrument streams, web services, web pages, programs
- **Multiple data formats**
 - Relational tables
 - XML, text, and binary files
 - Proprietary and legacy data formats
- **Generate and manage reports**
 - Fault analyses
 - Prognostications
 - Procedure manuals
- **Test bed**
 - International Space Station (ISS)

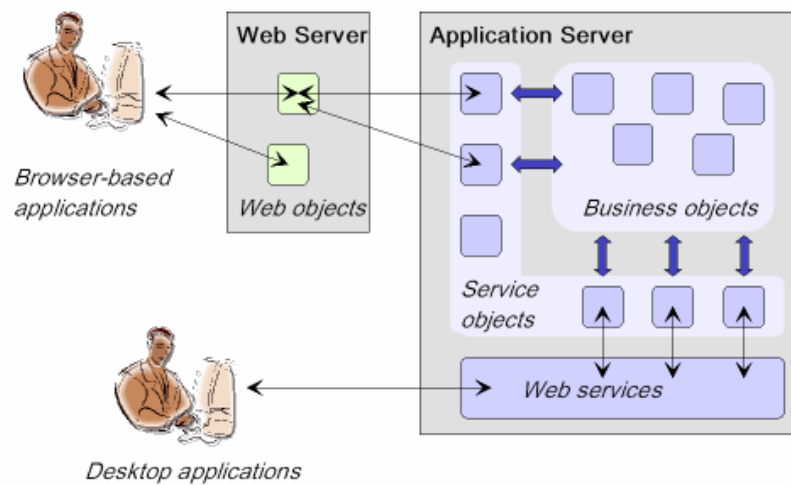


Rendezvous in low Earth orbit (LEO) of a manned space capsule with the main rocket engines in preparation for a trip to the Moon or to Mars.

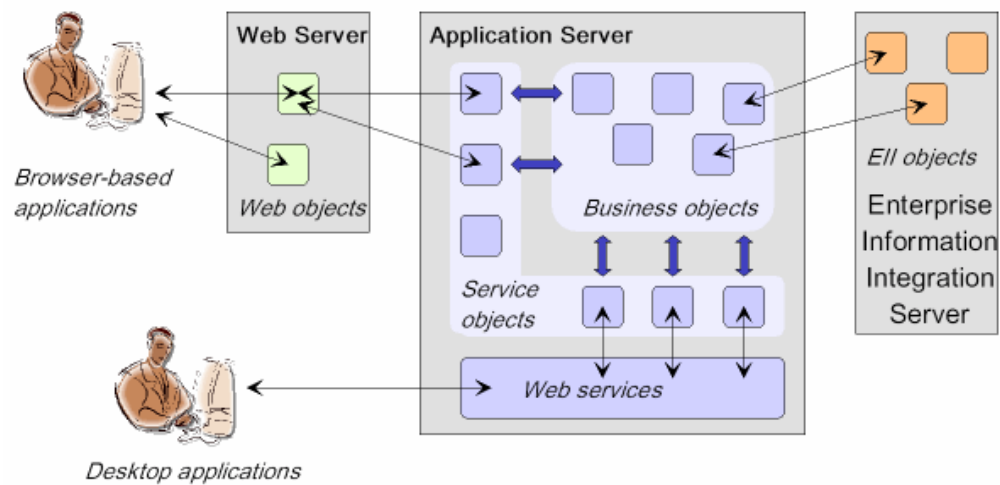
SHIP Architecture



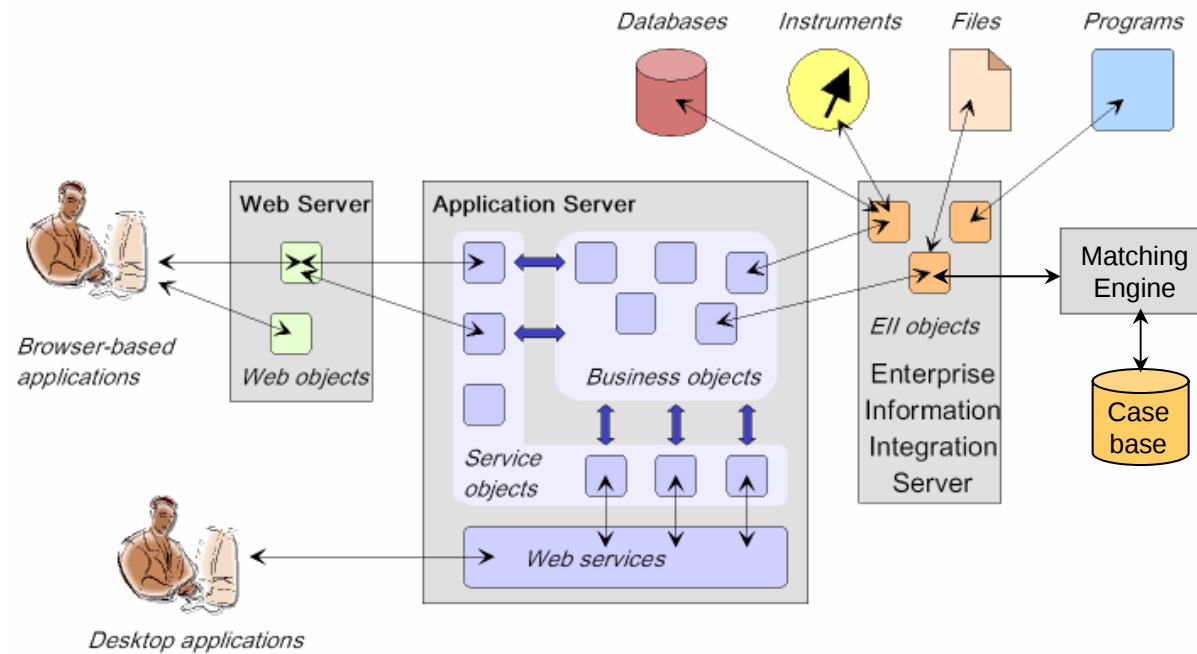
SHIP Architecture



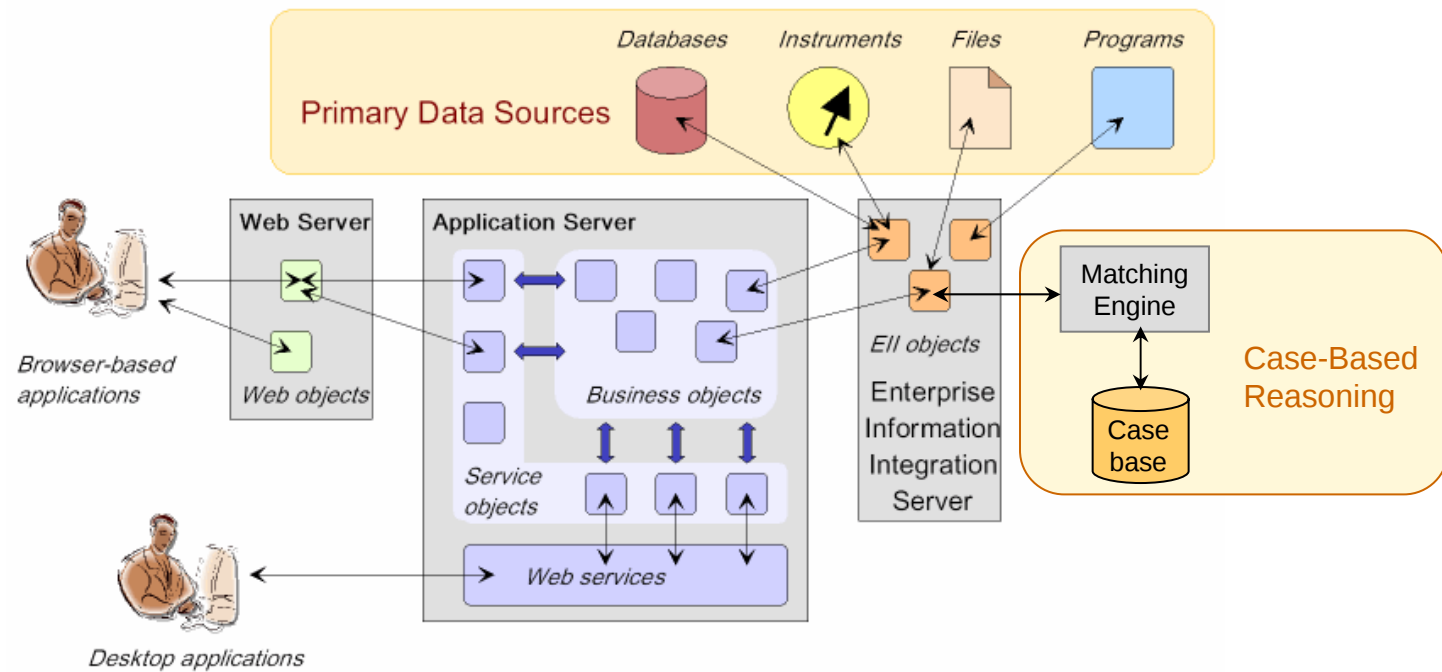
SHIP Architecture



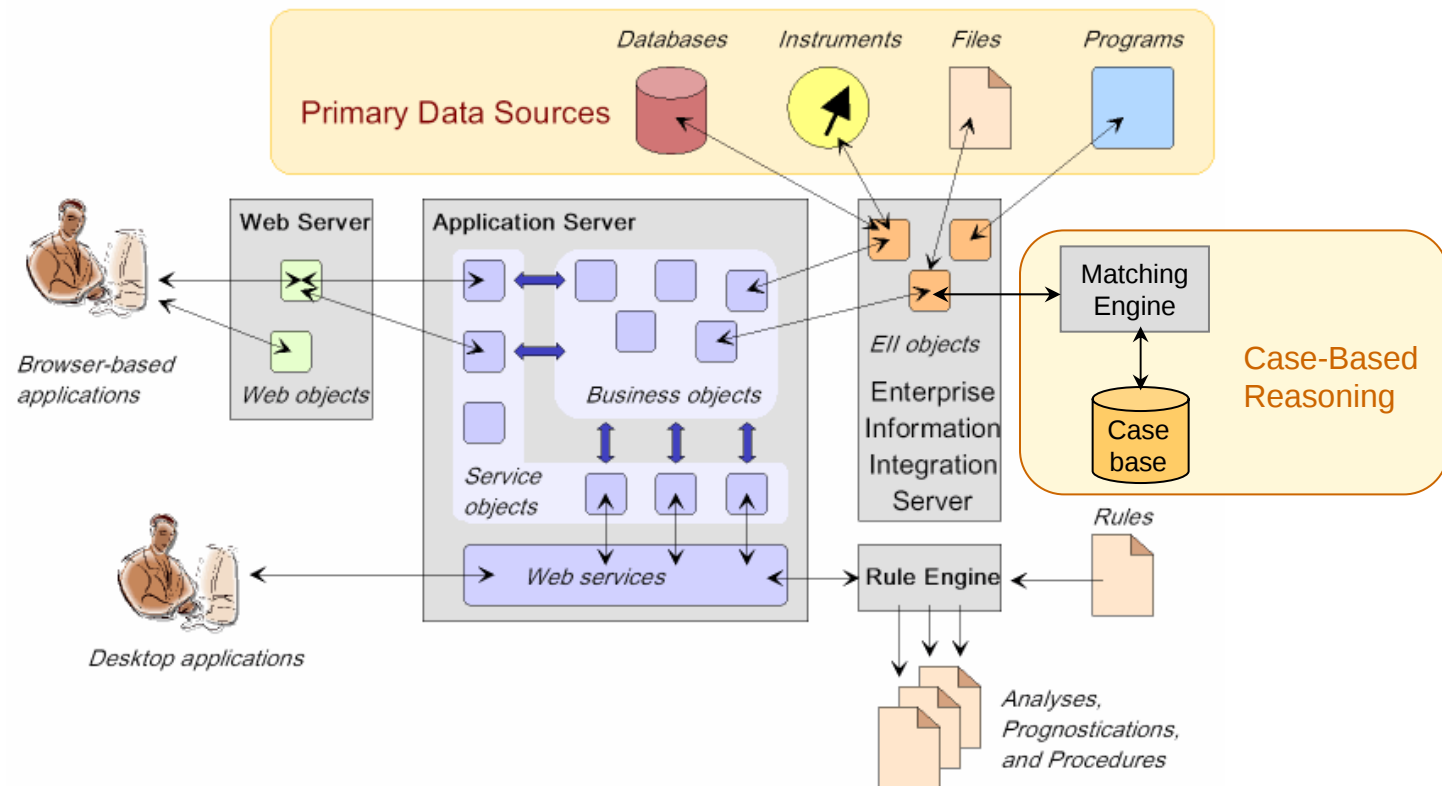
SHIP Architecture



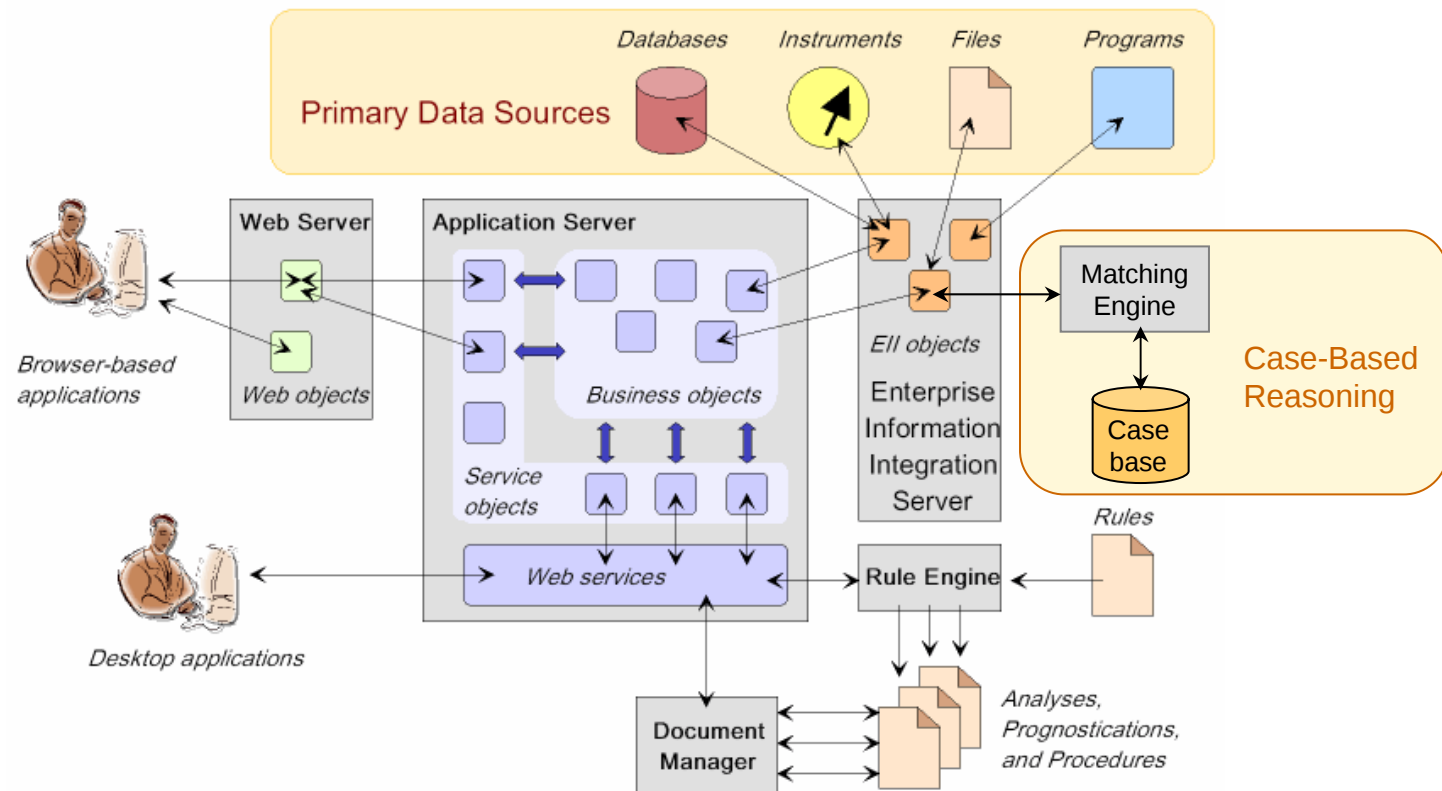
SHIP Architecture



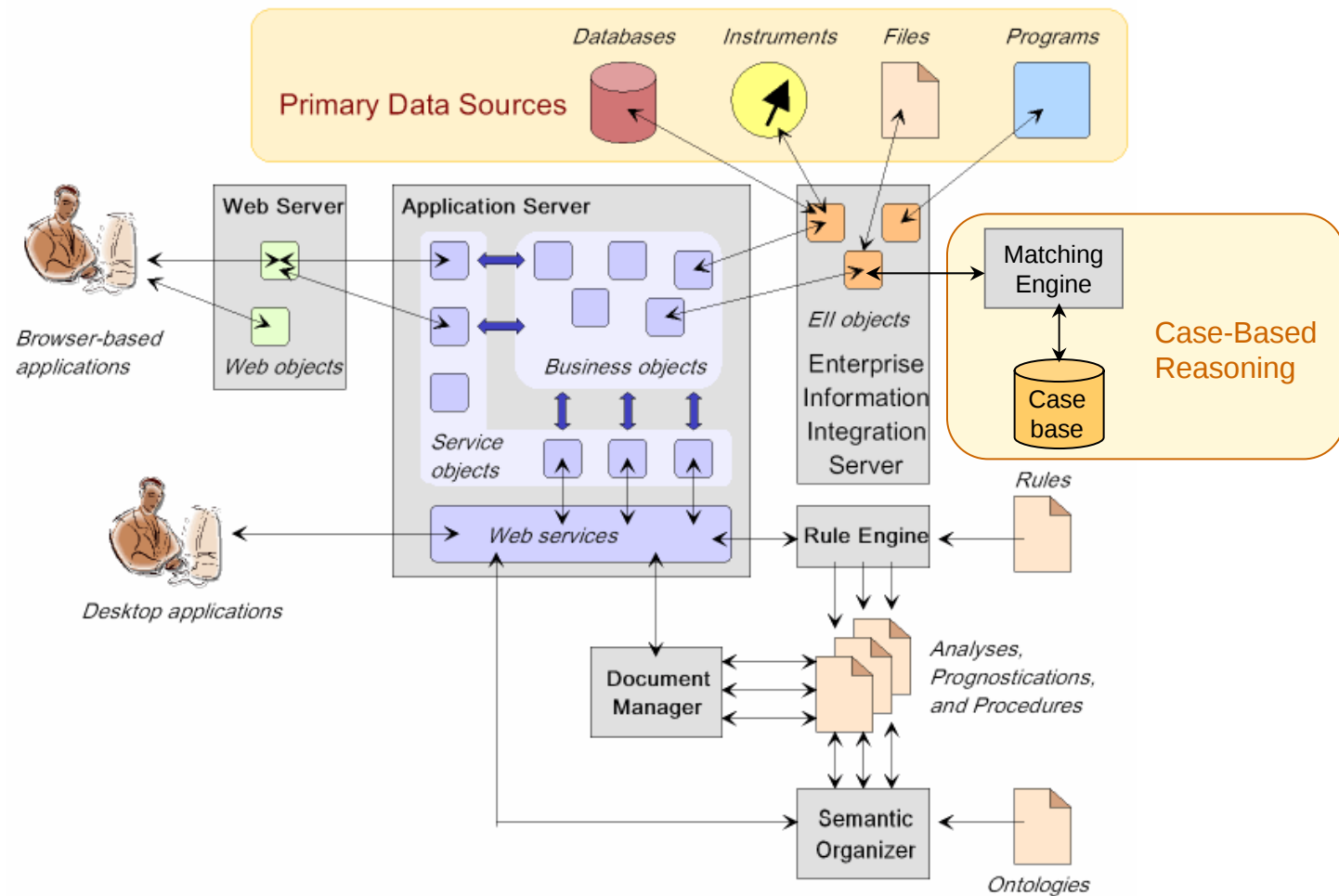
SHIP Architecture



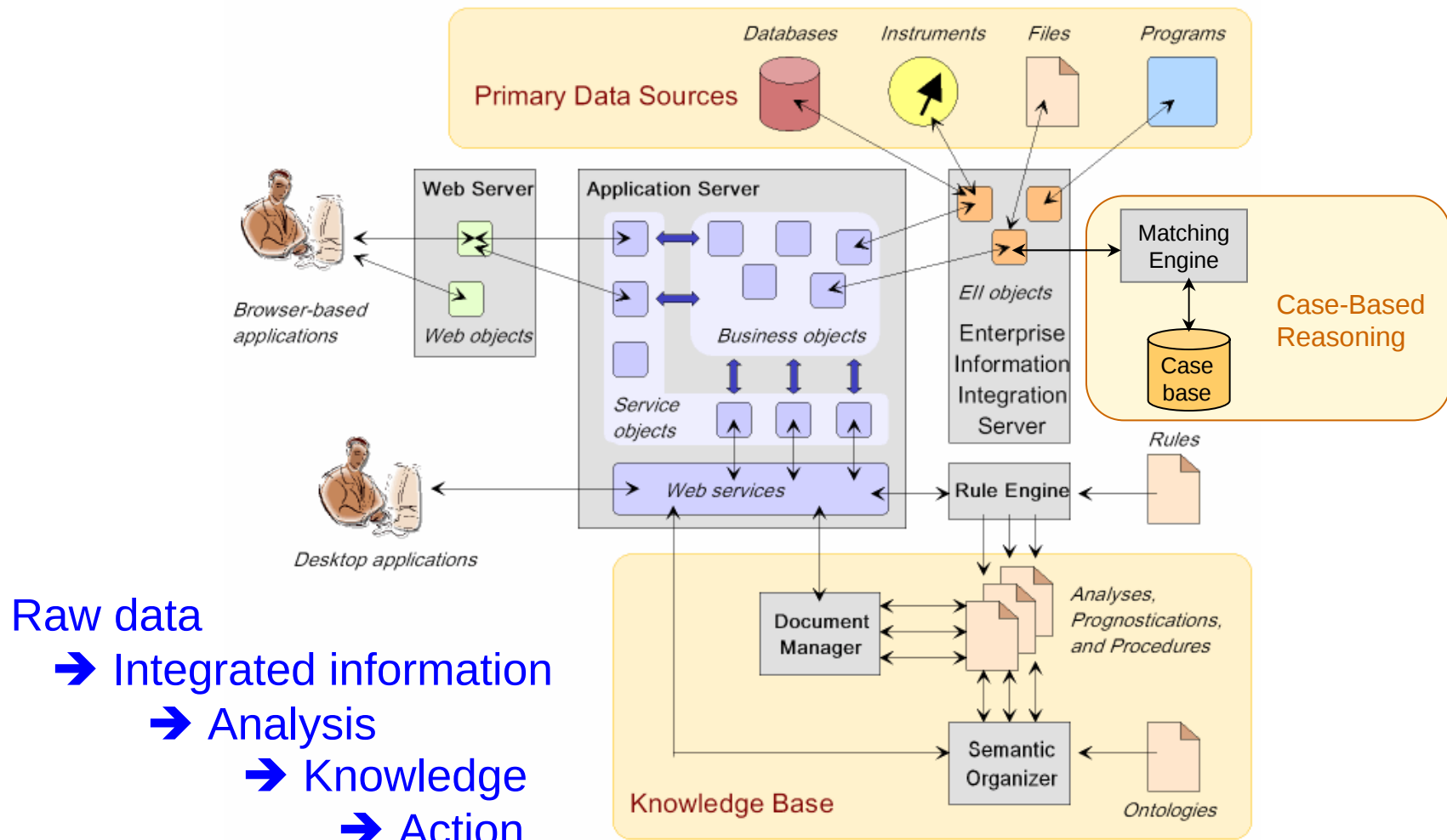
SHIP Architecture



SHIP Architecture



SHIP Architecture



SHIP Screen Shot

The screenshot displays the 'Case-Based Fault Analysis' web application. The main heading is 'Case-Based Fault Analysis'. Below it, there is a search bar for 'Caution and Warning event code' with the value '5014' and a 'Show latest 3 messages' button. The 'Database server' field is empty. The section 'ISS Emergency, Caution, Warning, and Advisory Messages' contains a table with the following data:

Log Time (GMT)	ODRC Format	Class	Element	System	Code	Message Text	EvtState	AnnState	AckState
2005-11-21 11:14:06.0	2005_325:11:14:06	Caution	LABX	CDH	5014	Primary GNC MDM Fail-LAB	RTN	Suppressed	Ack
2005-11-21 08:40:34.0	2005_325:08:40:34	Caution	LABX	CDH	5014	Primary GNC MDM Fail-LAB	RTN	Enabled	Ack
2005-11-16 17:51:55.0	2005_320:17:51:55	Caution	LABX	CDH	5014	Primary GNC MDM Fail-LAB	RTN	Suppressed	Ack

Below the table, there is a section for 'Related PUIs' with a dropdown menu showing the following options: [RRD1007C123J], [LADP01MDAPZE], [LADP01MDAVOF], [LADP01MDAVOG], and [LADP01MDAW9F].

The 'Relevant PRACA Reports' section contains a table with the following data:

Number	Title	Date	Initiator	Assignee	System	Subsystem	Part	Description
3450	SMTC / GNC Loss of Comm during SM 7.01 Upgrade	03-OCT-2003	Bostick	Stoddard	GN&C - GUIDANCE NAVIGATION & CONTROL	RUSSIAN SEGMENT	Service Module Terminal Computer	The SM software version 7.01 upgrade procedure required a near-simultaneous restart without context data of both the Service Module Central Computer (SMCC) and Service Module Terminal Computer (SMTC). Both restarts completed successfully; however, when MCC-M began activation of GN&C software functions in the SMTC, communication was not established with the Primary GNC MDM (GNC-2) as expected and required. This failure to establish communications was flagged as an Advisory by the SMCC, triggering a Primary GNC MDM Failed Caution in CCS. The simultaneous SMCC/SMTC restart was commanded at AOS Russian Ground Sites (RGS) on Daily Orbit 2 (DO2) (cumulative orbit 24691) at GMT

- ISS International Space Station
- PUI Program Unique Identifier (part number)
- PRACA Problem Report and Corrective Action

SHIP Summary

- ❑ **Problem Resolution and Corrective Action (PRACA)** system for manned space vehicles
 - Disparate data sources: live sensor feeds, archived legacy data, XML files, Word documents, web pages, web services, databases, etc.
 - Case-based reasoning and rules-based diagnoses
 - Semantics-based knowledge management

- ❑ **Service-oriented architecture (SOA)**
 - Web-based and desktop client applications
 - J2EE technologies
 - Web services
 - Enterprise information integration (EII)
 - Application integration
 - JavaServer Faces, BEA WebLogic, Composite Software
 - Open source software



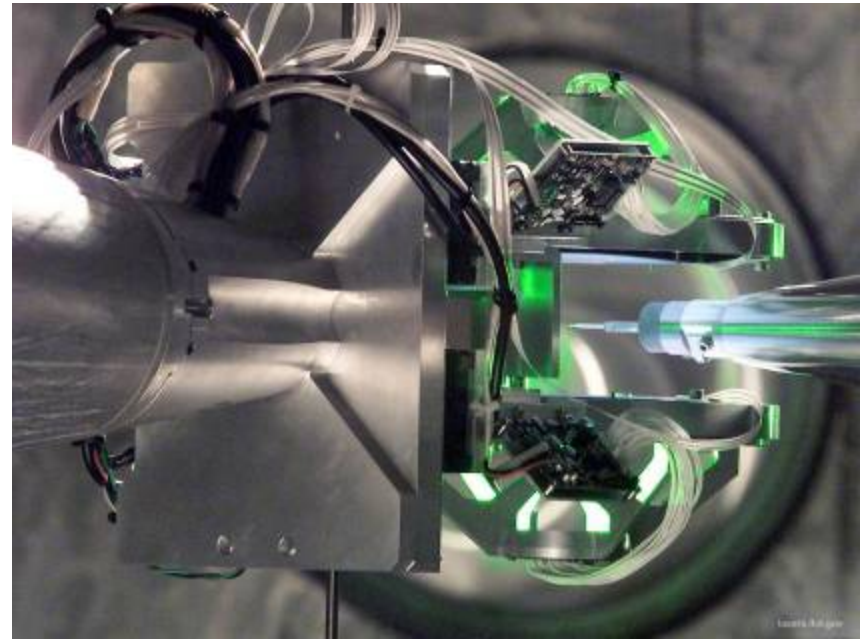


Case Study 3: Shot Data Management

Case Study 3: Shot Data Management

The [National Ignition Facility \(NIF\)](#) is a major laser-based fusion energy research project at the [Lawrence Livermore National Laboratory](#).

Each simultaneous firing of its [192 powerful lasers](#) at a BB-sized target generates gigabytes of data that **Shot Data Management** routes in near real time to the project scientists and researchers.



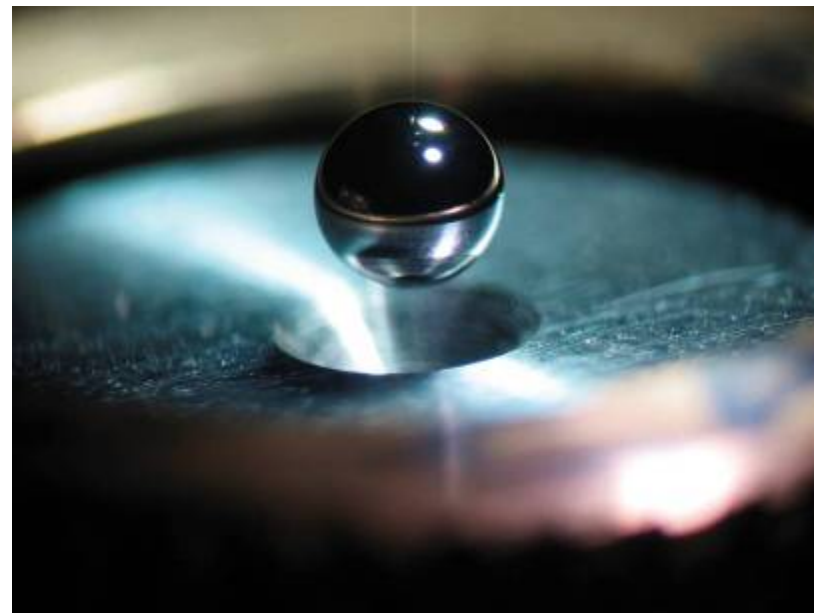
Target positioner

- My role: [Enterprise Software Strategist](#)
 - Architect, [catalyst](#), lead developer, and systems integrator, 2006-2007
 - High security clearance (Level P)



Shot Data Management Primary Services

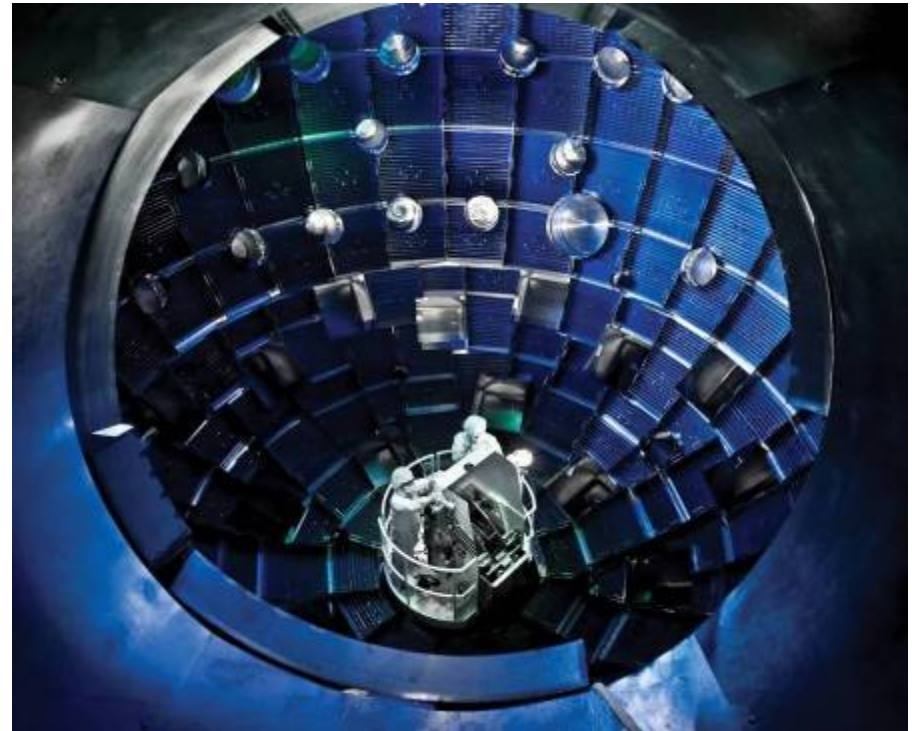
- **Data provisioning**
 - Integration of disparate and heterogeneous data sources
 - Secure access and downloads
 - Metadata-based queries
- **Data management**
 - Version management and revision control
 - Archive data from NIF's expected 30-year lifespan
- **Data marts**
 - Historical and trend analysis of specific subject areas
 - Support ad hoc data reporting



The target: A polished 2 mm capsule filled with cryogenic hydrogen fuel.

Requirements

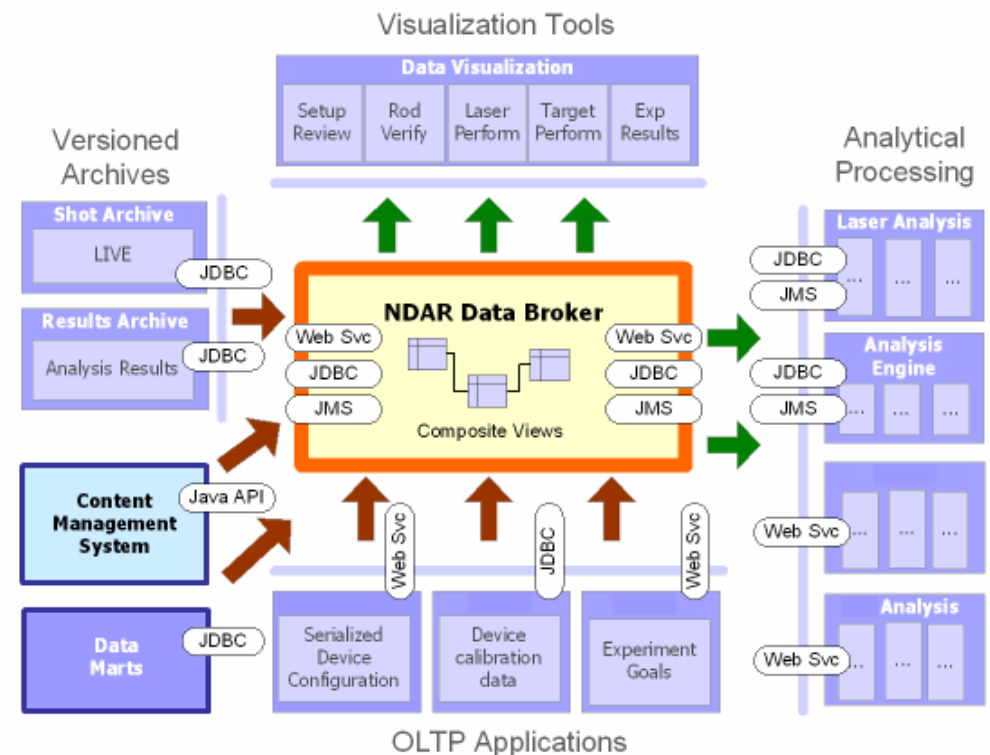
- ❑ Application insulation
- ❑ Eliminate duplicate data
- ❑ Near real time data access
- ❑ Reusable data services
- ❑ Decision support
- ❑ Quality control
- ❑ Hierarchical storage management
- ❑ Data security
- ❑ Integrate legacy data silos
- ❑ Workflow management



NIF target chamber

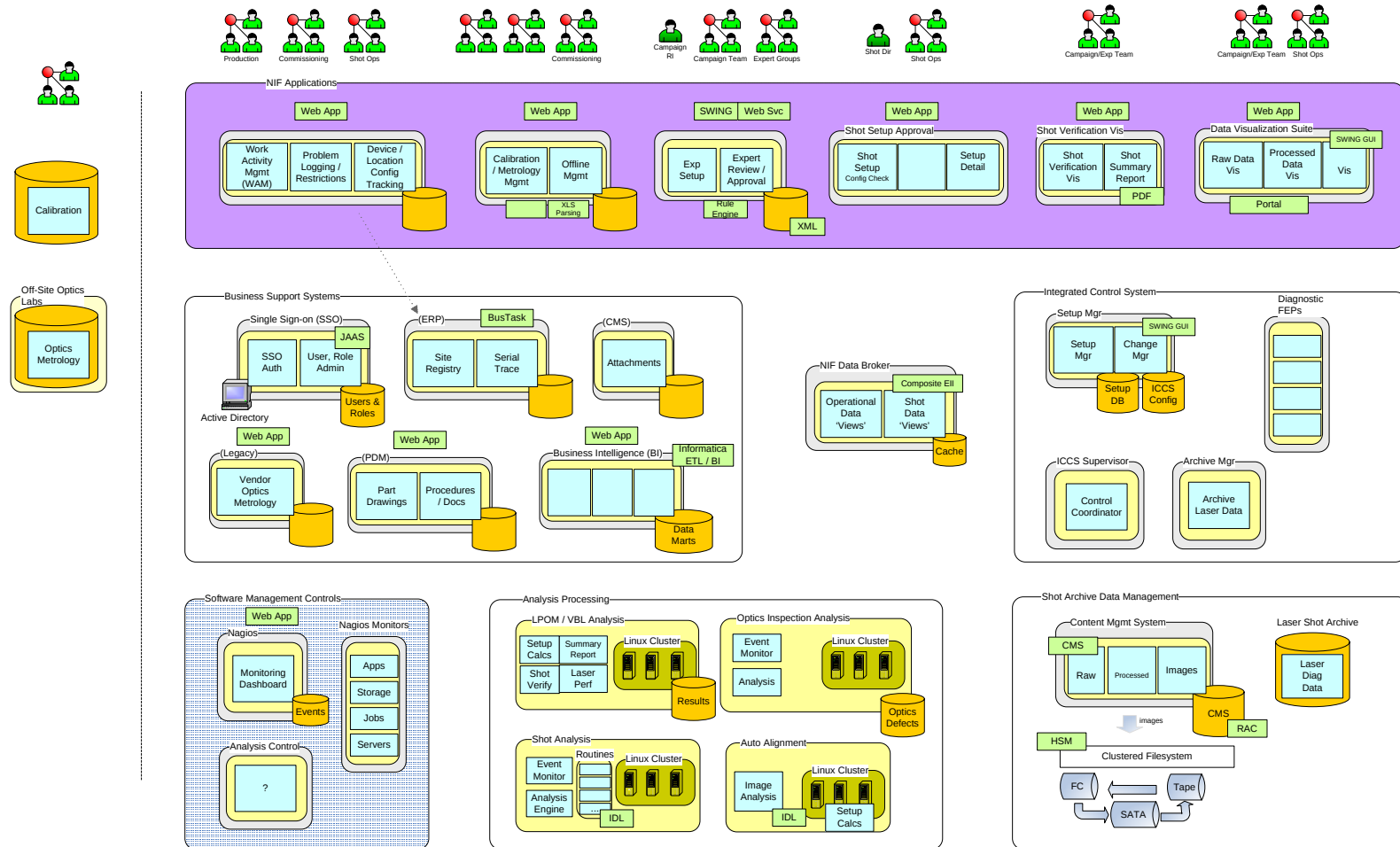
Architecture Overview

- **Industry standards**
 - Web services
 - XML data sources
 - JDBC and ODBC (database interfaces)
 - Java Message Service (JMS)
 - BPEL (Business Process Execution Language)
- Java programming language
- SOA (Service-Oriented Architecture)
- Linux server clusters

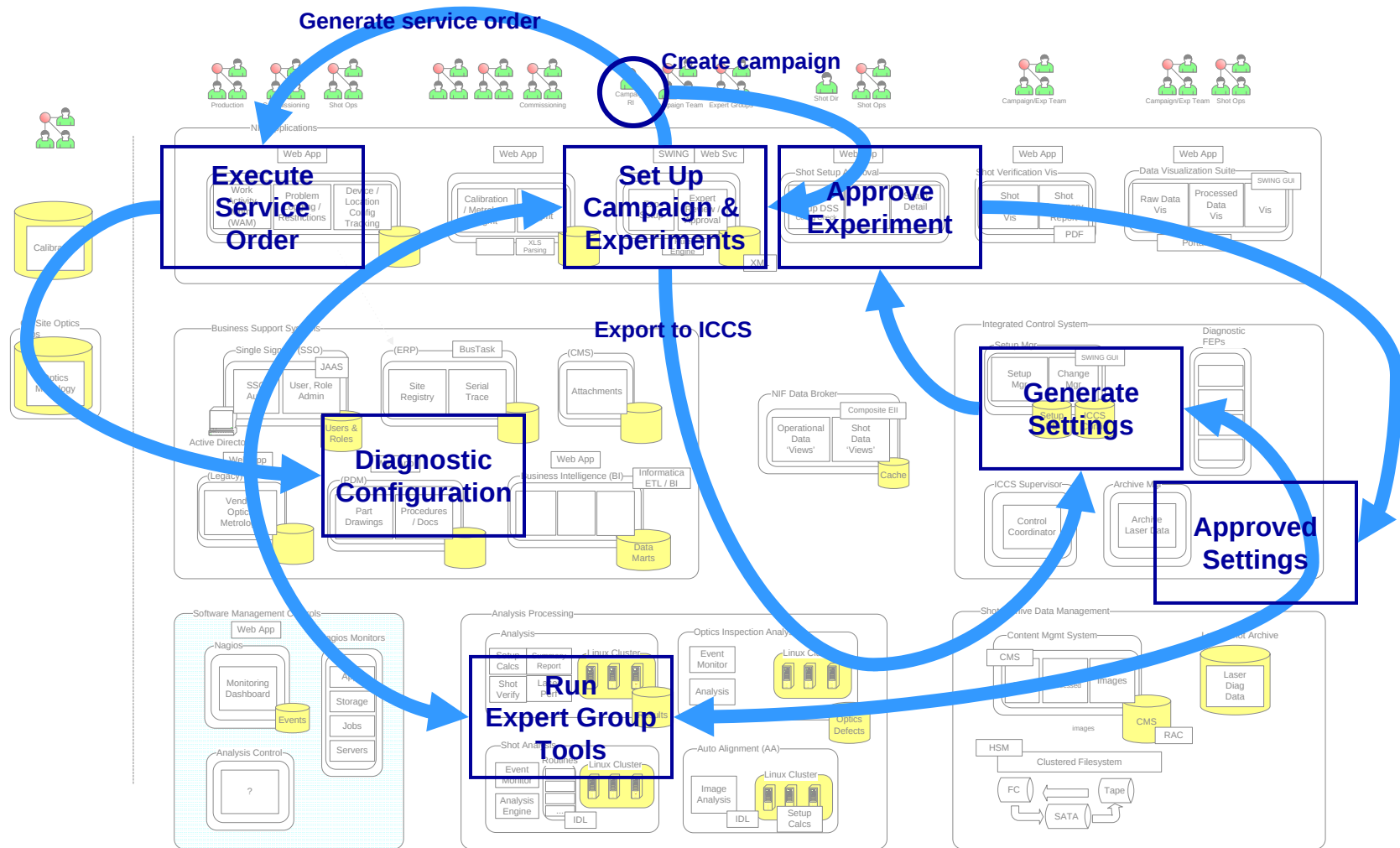


- Oracle RDBMS
- Oracle CMS (Content Management System)

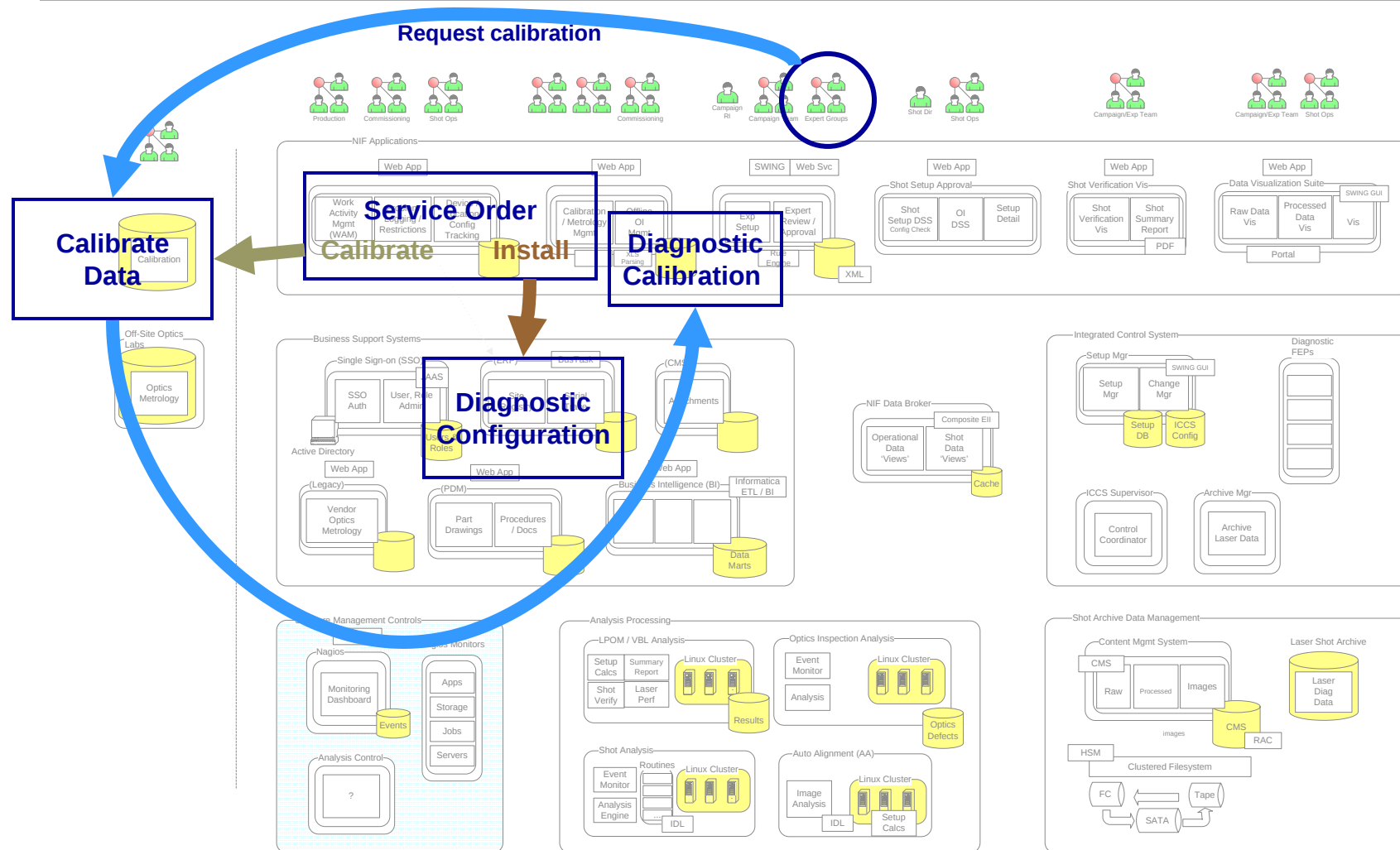
Shot Data Management Architecture



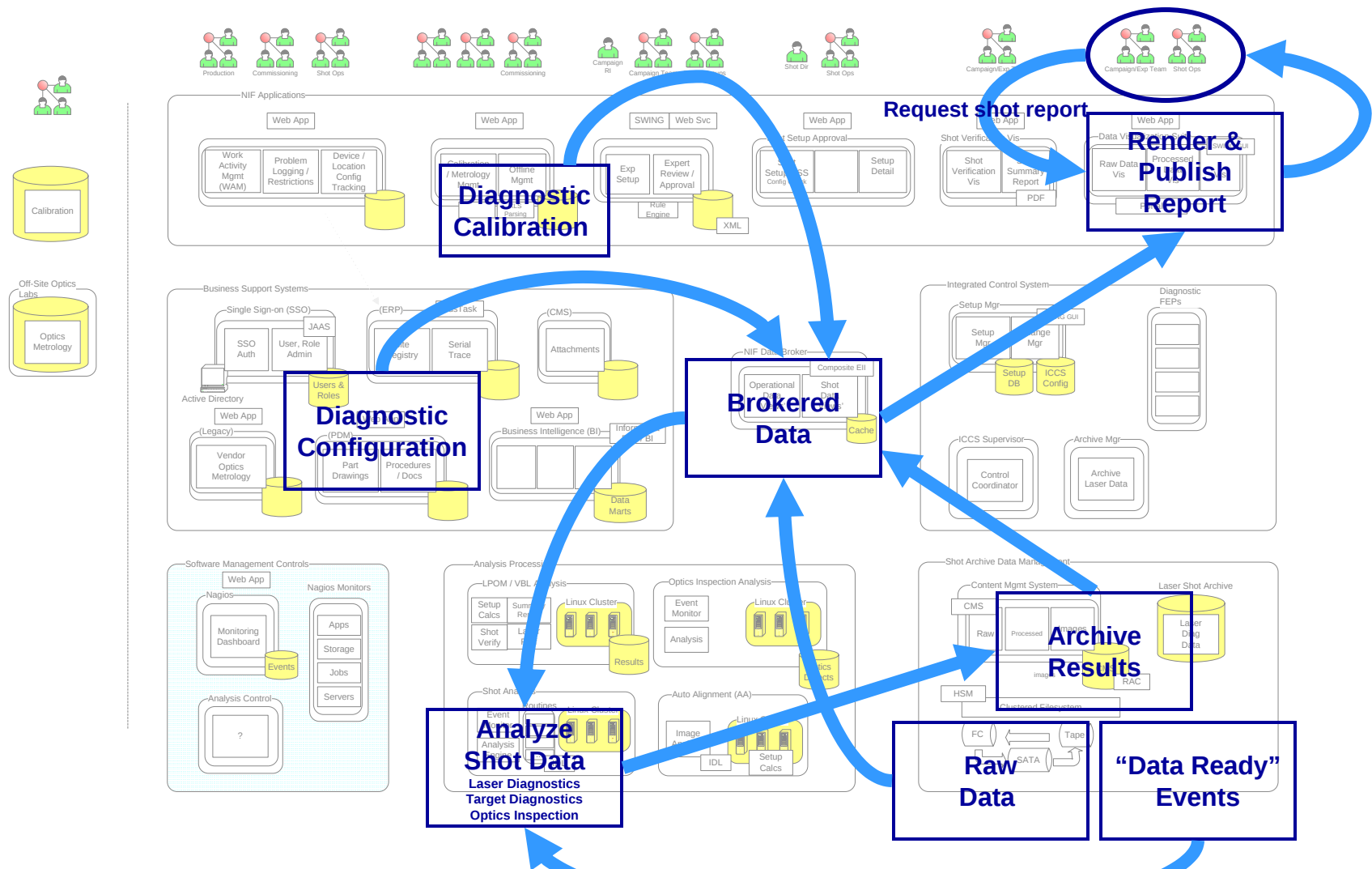
Workflow: Set Up Campaign & Approve Experiment



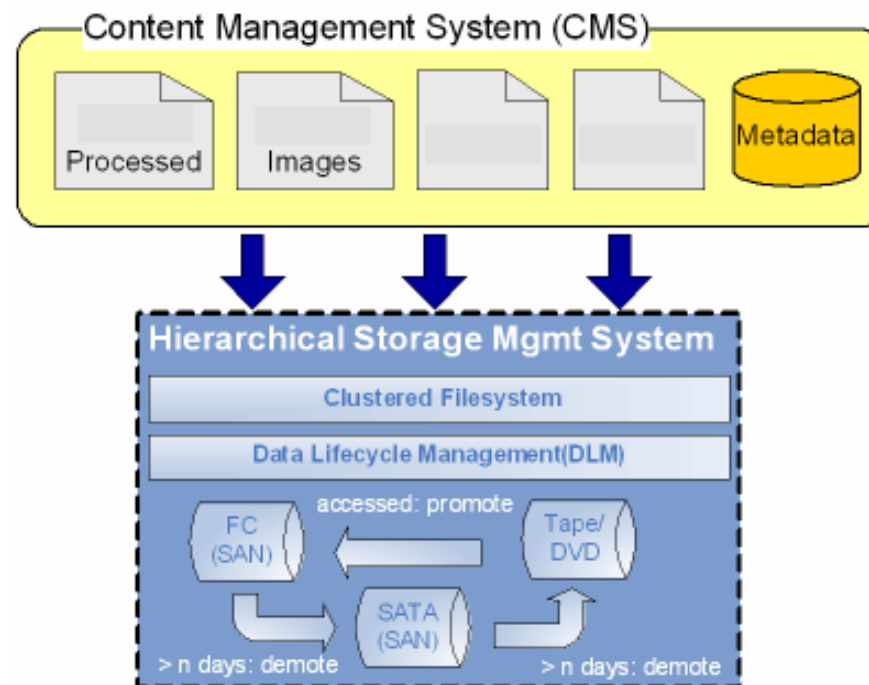
Workflow: Manage Configuration & Calibration



Workflow: Analyze & Visualize Shot Results

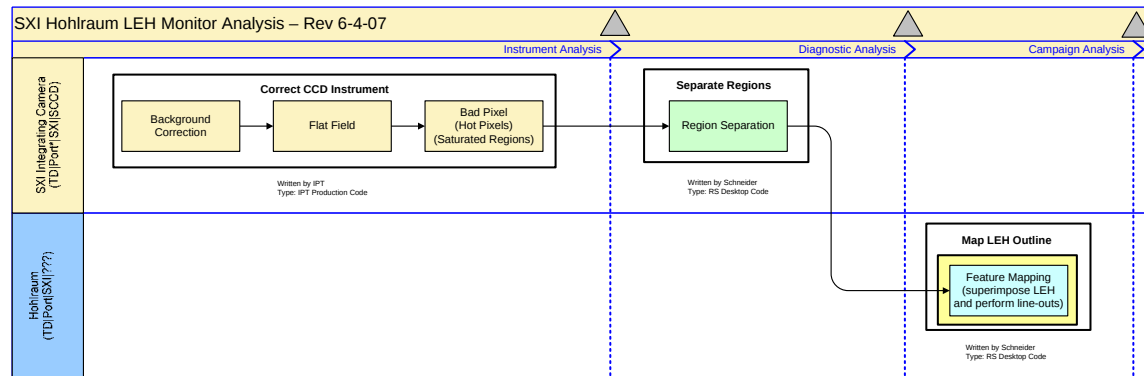


Data Archiving



- Hierarchical storage management system

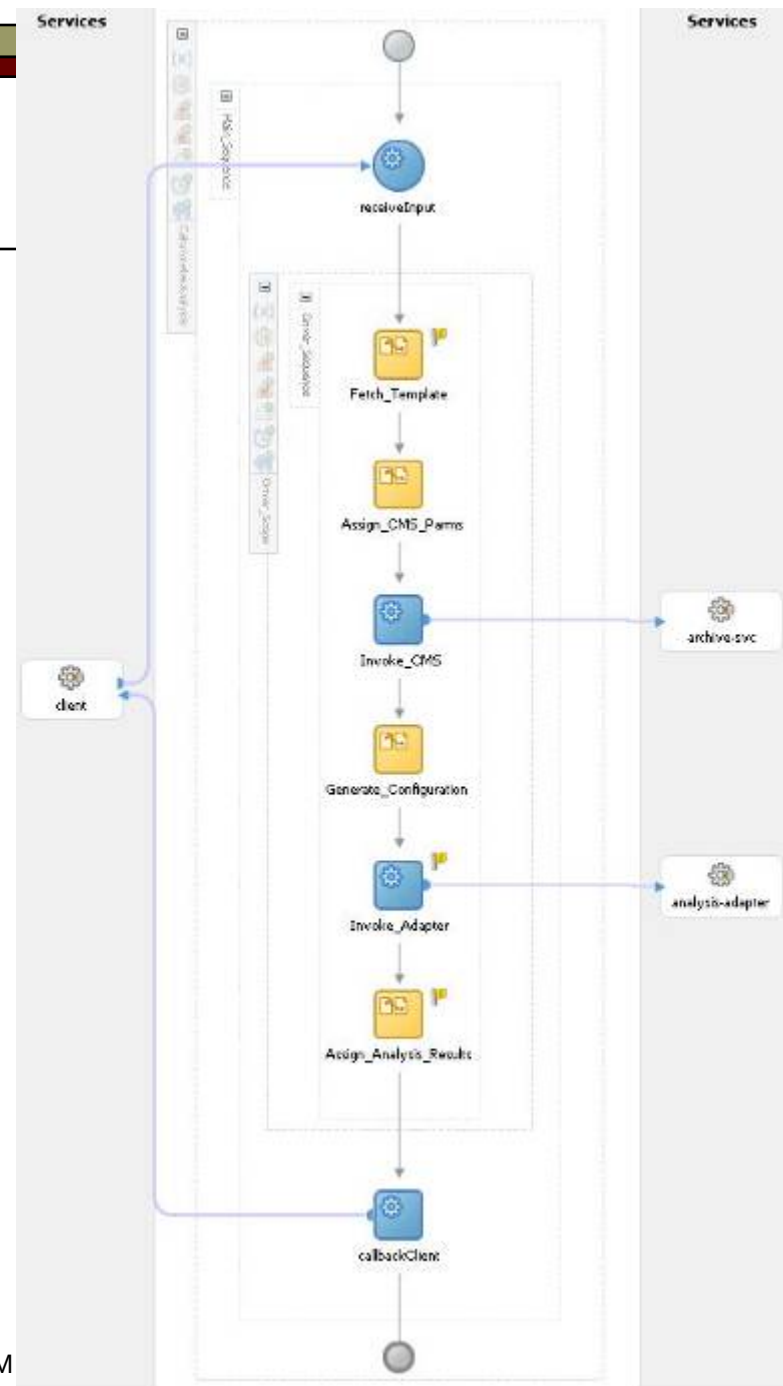
Visualizing Workflows



- ❑ Large display of many nodes in multiple “swim lanes”
 - Each node represents a unit of work to be performed.
 - Each swim lane represents a category of work.
 - Results flow from one node to the next based on rules.
- ❑ The display is maintained in real time.
 - Currently active nodes are highlighted.

Creating a Workflow

- Create workflow diagrams using an IDE.
- Compile workflow diagrams into **BPEL** scripts.
 - Business Process Execution Language (XML)



Shot Data Management Summary

- Large, complex distributed system based on SOA
 - Integration of legacy data silos
 - data warehouses
 - relational databases
 - content managers
 - Data archiving
 - HSM
 - 30 years of data
- Workflows
 - Shot approval and setup
 - Configuration and calibration
 - Results analysis and visualization



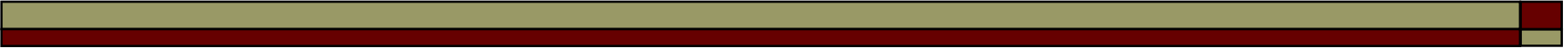
Installation of the target chamber

“This system saved 6 months off the software development schedule.”

Important Lessons Learned

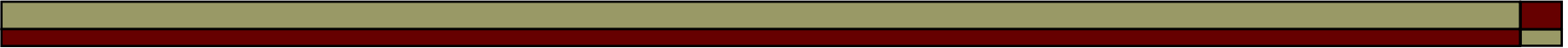


Sunset on Mars



Important Lessons

- ❑ Scientific data management systems share common features
 - Distributed and web-based
 - Integration of legacy subsystems
 - Integration of disparate and heterogeneous data
 - Near real-time data access with security
 - Data is unstructured
 - Data queries driven by metadata
 - Users collaborate to analyze data and write reports.



Important Lessons

- Keys to project success and high reliability
 - Well-understood requirements
 - Highly dedicated and competent developers
 - Good software engineering
 - Solid but flexible service-oriented architecture (SOA)
 - Industry standards and best practices
 - Unit testing
 - Monitoring tools
 - Create alternate paths around risky areas of code that you can “hot switch” at run time.

Important Lessons

- Keys to project success and high reliability *cont'd*
 - Strong project leadership
 - Realistic project schedule with clear milestones
 - Agile (iterative) development methodology
 - Maintain constant communication with users
 - The leader must **actively drive** the project from milestone to milestone
 - **Obsessive** stress testing
 - Discover the system limits (before the users do)
 - Learn the system's behavior under extreme stress.



Questions?

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