



Argonne
NATIONAL
LABORATORY

... for a brighter future



U.S. Department
of Energy



THE UNIVERSITY OF
CHICAGO



**Office of
Science**

U.S. DEPARTMENT OF ENERGY

A U.S. Department of Energy laboratory
managed by The University of Chicago

Infrastructure Monitoring System for the Advanced Photon Source Control System

Collaboration By:

Ned Arnold

Andrew Johnson

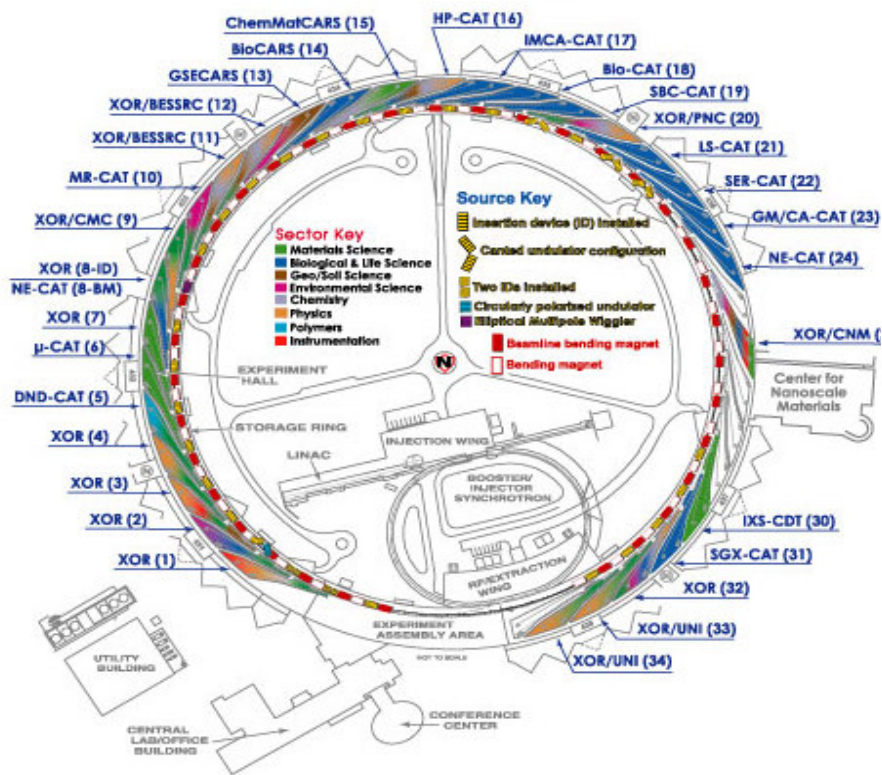
Debby Quock

PCaPAC2008

October 20-23, 2008

The submitted manuscript has been created by UChicago Argonne, LLC, Operator of Argonne National Laboratory ("Argonne"). Argonne, a U.S. Department of Energy Office of Science laboratory, is operated under Contract No. DE-AC02-06CH11357. The U.S. Government retains for itself, and others acting on its behalf, a paid-up nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

Advanced Photon Source (APS)



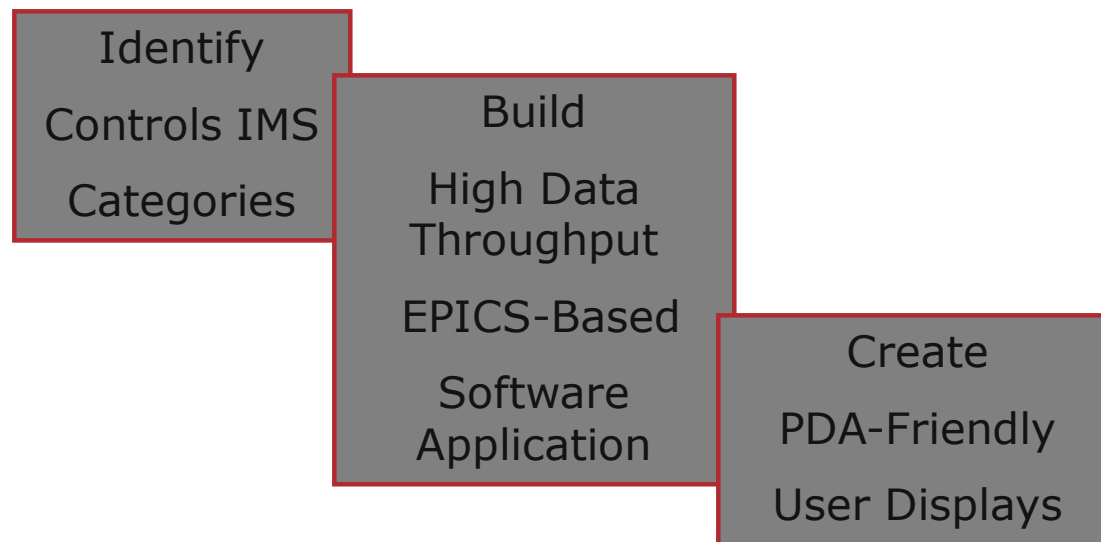
Complexity and Scale of APS Control System

Linac, PAR, Booster and Storage Ring

- Over 30 Controls Group servers (Solaris, Linux, Mac)
- Approximately 300 distributed input/output controllers (IOCs)
- EPICS supervisory real-time controls software is interfaced by PLCs, LabView, FPGAs, and Johnson Controls distributed control systems
- More than 12,000 replaceable hardware components
- Over 100,000 IOC points that monitor and control more than 450,000 technical parameters
- Nearly 1,000 unique control system software applications

Goals of APS Controls Infrastructure Monitoring System

Exhaustively monitor all parts of the control system and provide immediate notification to the on-call controls staff of an exception, in many cases even before the machine operators notice the impact on machine performance.



Define Controls IMS Categories

10 Major Categories

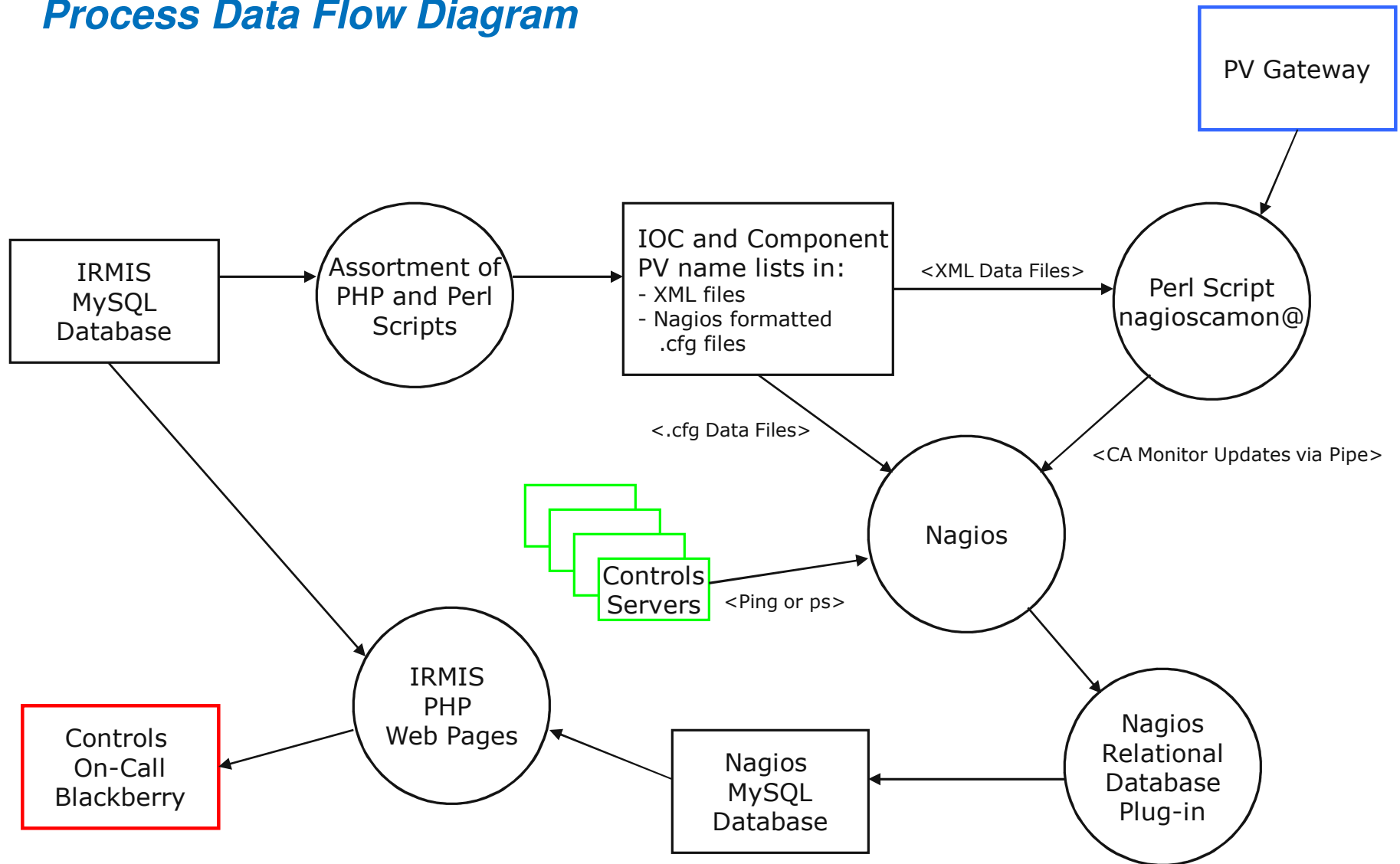
- Applications Organizing Index (AOI)
- Component Communication Monitoring System (CCMS)
- Controls Servers
- Event Receivers
- IOCs
- Machine Status Link
- Nagios Software Components
- PV Gateway
- Timing
- VME/VXI Power Supply

Currently, a mixture of 2,489 EPICS PVs, processes, and servers are being monitored by the APS Controls IMS

APS Controls IMS Software Architecture

- Nagios open source software
 - Designed for IT administrators to monitor servers, routers, processes, ...
- MySQL relational database software
- Nagios NDOUTILS plug-in for Nagios database schema
- Perl script built in-house with EPICS Channel Access monitor callbacks
 - Utilizes Perl interface to Channel Access library
- Nagios EPICS plug-in with EPICS Channel Access caget
 - Written by Mauro Giacchini (mauro.giacchini@lnl.infn.it) and modified by D. Quock
- IRMIS PHP Web pages
 - PDA-Friendly
- Assortment of PHP and Perl scripts that manually generate the lists of PVs to be monitored

APS Controls IMS Process Data Flow Diagram



Source Code Details

```
TextPad - [Y:\infrastructmon\nagios\ccm...
File Edit Search View Tools Macros
Window Help

ccms_pv_names.xml
<?xml version="1.0" encoding="UTF-8"?>
<ims>
<imsmajor name="CCMS">
<imsminor name="iocs35bpm">
<pv name="S35DCCT:inputAI">
<component_id>9920</component_id>
</pv>
</imsminor>
<imsminor name="iocpar03">
<pv name="PSscope1:chan1VdivAI">
<component_id>9925</component_id>
</pv>
</imsminor>
<imsminor name="iocpar01">
<pv name="PRF:Hp8508Read">
<component_id>9926</component_id>
</pv>
</imsminor>
<imsminor name="iocrf5cavn">
<pv name="S6:VVM1:Hp8508Read">
<component_id>9927</component_id>
</pv>
</imsminor>
<imsminor name="iocrf5cavn">
<pv name="S6:VVM2:Hp8508Read">
<component_id>9928</component_id>
</pv>
</imsminor>
</ims>

For Help, press F1
```

```
TextPad - [Y:\infrastructmon\nagios\ims_ioc_services.cfg]
File Edit Search View Tools Macros Configure Window Help

ims_ioc_services.cfg
#####
# Nagios services for Infrastructure Monitoring I
#####

define service{
use generic-service
host_name IOC_Memory
service_description iocbbpm1:memoryFr
is_volatile 1
max_check_attempts 1
active_checks_enabled 0
passive_checks_enabled 1
contact_groups admins
notification_interval 0
notification_period 24x7
notification_options w,u,c,r
check_command check_caget!iocbb

define service{
use generic-service ;reuse of predefined template
host_name IOC_TCPConnections
service_description iocbbpm1:tcpConnections ;Nagios service name
is_volatile 1
max_check_attempts 1
active_checks_enabled 0
passive_checks_enabled 1
contact_groups admins
notification_interval 0
notification_period 24x7
notification_options w,u,c,r ;kind of errors notified
check_command check_caget!iocbbpm1:tcpConnections!164.54.188.65 ;

define service{
use generic-service ;reuse of predefined template
host_name IOC_CPUload
service_description iocbbpm1:load ;Nagios service name
is_volatile 1
max_check_attempts 1
active_checks_enabled 0
passive_checks_enabled 1
contact_groups admins
notification_interval 0
notification_period 24x7

For Help, press F1
```

```
TextPad - [Y:\infrastructmon\nagios\nagioscamon@]
File Edit Search View Tools Macros Configure Window Help

nagioscamon@
# Nagios Command format: PROCESS_SERVICE_CHECK_RESULT;<host_name>;<service_description>;
# <return_code>;<plugin_output>
#
# The "return code" field should be one of the following:
# 0 = OK
# 1 = WARNING
# 2 = CRITICAL
# 3 = UNKNOWN
#
# The "plugin_output" field contains text output from the service check, along with
# optional performance data.

die "No pv name specified.\n"
unless @ARGV;

my %monitors;

$temp_time = localtime;
print "$temp_time Start connection callback of EPICS channels with CA new...\n";

my @chans = map { CA->new($_, \%conn_callback); } @ARGV;

$temp_time = localtime;
print "$temp_time Define CA pend event for change on alarm status updates...\n";

CA->pend_event($opt_w);

$temp_time = localtime;
print "$temp_time Begin monitoring of EPICS channels with CA Perl...\n";

$_ = 1; # don't keep log entries sitting in the buffer

map {
# Write statement to External Command Nagios file...

my $temp_pvname = $_->name;
my $temp_nagios_host = $nagios_host{$temp_pvname};
my $temp_time = localtime;

print NAGIOSLOG "[%temp_time] PROCESS_SERVICE_CHECK_RESULT;$temp_nagios_host;$temp_p
unless $monitors{$_};

} @chans;

For Help, press F1
```


EPICS-to-Nagios Translation

EPICS Alarm Severity	Nagios State
(none)	OK
MINOR	WARNING
MAJOR	CRITICAL
PV Readback INVALID	CRITICAL
PV Name Not Found	UNKNOWN

APS Controls Infrastructure Categories-to-Nagios Translation

APS Controls 10 Major Infrastructure Categories

- AOI
- CCMS
- Controls Servers
- Event Receivers
- IOCs
- Machine Status Link
- Nagios Software Components
- PV Gateway
- Timing
- VME/VXI Power Supplies

Nagios Software Design Hierarchy

- Used 3 Levels for APS Controls

- Host Group
 - Host
 - *Service*
 - *Service*
 - ...
- IOC
 - CALinks
 - *iocacis:ascaDisco*
 - *iocacis:dbcaDisco*
 - ...
 - CPUload
 - *iocacis:load*
 - *iocbbpm1:load*
 - ...

Here, EPICS
PV Name
(but not always...)

APS Controls IMS Nagios User Interface

Nagios - Windows Internet Explorer
http://orion/nagios/

Current Network Status
Last Updated: Tue Oct 7 17:13:06 CDT 2008
Updated every 90 seconds
Nagios® 3.0.1 - www.nagios.org
Logged in as nagiosadmin
- Notifications are disabled

Host Status Totals

Up	Down	Unreachable	Pending
0	0	0	161

Service Status Totals

Ok	Warning	Unknown	Critical	Pending
2494	1	0	2	0

Status Summary For All Host Groups

Host Group	Host Status Summary	Service Status Summary
ccms_host_group (CCMS_HOSTGROUP)	73 PENDING	491 OK 2 CRITICAL - 2 Disabled
controls_servers (Controls Servers)	26 PENDING	26 OK
event-receivers_host_group (EVENT-RECEIVERS_HOSTGROUP)	6 PENDING	71 OK
ioc_host_group (IOC_HOSTGROUP)	8 PENDING	1812 OK 1 WARNING - 1 Disabled
msl_host_group (MSL_HOSTGROUP)	31 PENDING	31 OK
nagios_host_group (Nagios_HOSTGROUP)	1 PENDING	4 OK
pv-gateway_host_group (PV-GATEWAY_HOSTGROUP)	1 PENDING	40 OK
timing_host_group (TIMING_HOSTGROUP)	3 PENDING	17 OK
vme/vxi-ps_host_group (VME/VXI-PS_HOSTGROUP)	12 PENDING	12 OK

Left Sidebar Navigation:

- General
 - Home
 - Documentation
- Monitoring
 - Tactical Overview
 - Service Detail
 - Host Detail
 - Hostgroup Overview
 - Hostgroup Summary
 - Hostgroup Grid
 - Servicegroup Overview
 - Servicegroup Summary
 - Servicegroup Grid
 - Status Map
 - 3-D Status Map
- Service Problems
 - Unhandled
 - Host Problems
 - Unhandled
 - Network Outages
- Comments
- Downtime
- Process Info
- Performance Info
- Scheduling Queue
- Reporting
 - Trends
 - Availability
 - Alert Histogram
 - Alert History
 - Alert Summary
 - Notifications
 - Event Log
- Configuration
 - View Config

"Hostgroup Summary"

Nagios - Windows Internet Explorer
http://orion/nagios/

Current Network Status
Last Updated: Tue Oct 7 17:13:55 CDT 2008
Updated every 90 seconds
Nagios® 3.0.1 - www.nagios.org
Logged in as nagiosadmin
- Notifications are disabled

Host Status Totals

Up	Down	Unreachable	Pending
0	0	0	8

Service Status Totals

Ok	Warning	Unknown	Critical	Pending
1812	1	0	0	0

Service Overview For Host Group 'IOC_HOSTGROUP'

Host	Status	Services	Actions
IOC_CALinks	PENDING	793 OK	
IOC_CPUload	PENDING	261 OK	
IOC_LogServer	PENDING	9 OK	
IOC_Memory	PENDING	245 OK	
IOC_SaveRestore	PENDING	No matching services	
IOC_SoftHeartbeat	PENDING	38 OK	
IOC_TCPConnections	PENDING	257 OK 1 WARNING	
IOC_TaskStatus	PENDING	261 OK	

Left Sidebar Navigation:

- General
 - Home
 - Documentation
- Monitoring
 - Tactical Overview
 - Service Detail
 - Host Detail
 - Hostgroup Overview
 - Hostgroup Summary
 - Hostgroup Grid
 - Servicegroup Overview
 - Servicegroup Summary
 - Servicegroup Grid
 - Status Map
 - 3-D Status Map
- Service Problems
 - Unhandled
 - Host Problems
 - Unhandled
 - Network Outages
- Comments
- Downtime
- Process Info
- Performance Info
- Scheduling Queue
- Reporting
 - Trends
 - Availability
 - Alert Histogram
 - Alert History
 - Alert Summary
 - Notifications
 - Event Log
- Configuration
 - View Config

APS Controls IMS PDA-Friendly User Interface

Infrastructure Monitoring System

Category: Service Status

CCMS: 481 OK
CCMS: 2 CRITICAL
CONTROLS SERVERS: 26 OK
EVENT-RECEIVERS: 71 OK
IOC: 1812 OK
IOC: 1 WARNING
MSL: 31 OK
NAGIOS: 4 OK
PV-GATEWAY: 40 OK
TIMING: 17 OK
VME/VXI-PS: 12 OK

Service Status Totals

OK: 2494
Warning: 1
Unknown: 0
Critical: 2

[IMS Services in Alarmed States](#)
[APS Controls Nagios](#)

Infrastructure Monitoring System

Timestamp / Category / PV, Server or Process / Severity

2008-10-07 17:09:29 IOC_TCPConnections [iocacis:tcpConnections](#) WARNING
2008-10-07 10:26:05 CCMS_iocpar03 [PSscope1:chan1VdivAI](#) CRITICAL
2008-10-07 10:26:18 CCMS_iocs3vp [S:03:chamberTemp:CAC:AI](#) CRITICAL

[IMS Status Summary](#)
[APS Controls Nagios](#)

Infrastructure Monitoring System Details

IMS Category: CCMS_iocpar03
PV Name: PSscope1:chan1VdivAI

Component ID: 9925
Component Type: HP54615B

Controls Hierarchy:
MVME 167-xxx SGL(iocpar03) / VME Chassis-Mupac / VIPC626 (TVME200) / IP-488 / IPG100--- / GPIB_Link--13 / HP54615B--8 replaced by HP54657 / CCID_9925

Housing Hierarchy:
Building / Room(B111/TCR) / Rack(10) / HP54615B / CCID_9925

[IMS Status Summary](#)
[APS Controls Nagios](#)

IMS Future Enhancements

- Add approximately 1,000 designated EPICS PVs that convey the health of accelerator controls applications (AOIs).
- Add ~300 IOC EPICS SaveRestore status readback PVs.
- Continue to refine and add estimated 2,200 Component Communication EPICS PVs (CCMS). Only 481 CCMS PVs are included in IMS thus far.
- Create Nagios event handlers that automatically respond to loss of critical processes and take corrective action.

Acknowledgements

- Bill Sheehan, Dave Cyl, Roger Sersted, Mike Jarka, and Mary Westbrook
 - IT staff at the Advanced Photon Source
- Tim Mooney, APS BCDA Group
 - New EPICS autosave heartbeat PV created for APS Controls IMS
 - Available in EPICS Release 3.14.8+
- Nagios <http://www.nagios.org/>

