A DISTRIBUTED REMOTE MONITORING SYSTEM FOR ISIS SAMPLE ENVIRONMENT

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Abstract

The benefits of remote monitoring in industrial and manufacturing plants are well documented and equally applicable to scientific research facilities. This paper highlights the benefits of implementing a distributed monitoring system for sample environment equipment and instrumentation at the ISIS neutron & muon source facility. The upcoming implementation of an EPICS replacement for the existing beamline control system provides a timely opportunity to integrate operational monitoring and diagnostic capabilities with minimal overheads.

The ISIS facility located at the Rutherford Appleton Laboratory UK is the most productive research centre of its type in the world supporting a national and international community of more than 2000 scientists using neutrons and muons for research into materials and life sciences.

INTRODUCTION & OVERVIEW

ISIS located at the Rutherford Appleton Laboratory UK is the most productive research centre of its type in the world supporting a national and international community of more than 2000 scientists using neutrons and muons for research in physics, chemistry, materials science, geology, engineering and biology [1].

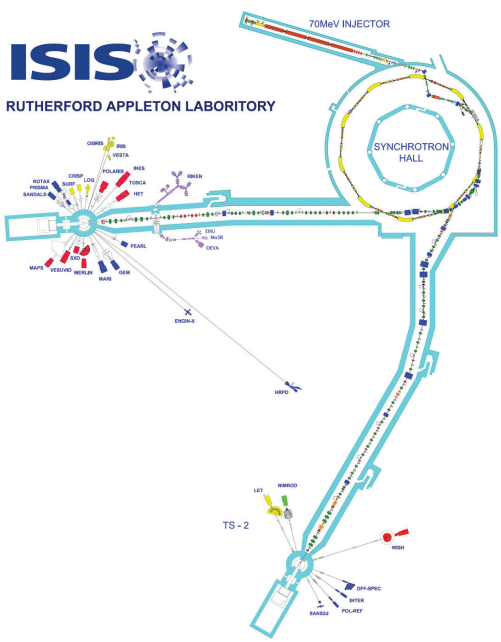

Figure 1: Plan view of ISIS.

The facility comprises of a 70MeV LINAC feeding a dual harmonic proton accelerator, producing 200uA 800MeV protons to two independent targets. Proton extraction is such that TS1 operates at 40Hz and TS2 at 10Hz repetition rates, producing 128kW and 32kW respective target power.

At ISIS there are a total of 29 neutron and 5 muon instruments designed for the use of diffraction, spectroscopy, reflectometry and SANS techniques. On completion of the TS2 Phase-II construction project an additional four instruments will increase SANS and reflectometry techniques whilst adding neutron chip irradiation and neutron imaging to the facility.

Sample Environment Hardware

Sample Environment encompasses the equipment, instrumentation and expertise required to control the environment around a sample, enabling the phase change of materials during the analysis of atomic and molecular structures. Table 1 highlights the wide range of equipment and supporting instrumentation developed for sample environment, providing temperature in the range 25 mK to 2000 K, pressure from vacuum to 25 GPa, electric field up to 20 $kVmm^{-1}$ and magnetic field up to 14 Tesla.

Table 1: Sample Environment Hardware Overview

SE Equipment	Instrumentation
Furnaces	Bespoke Control Systems
Cryogenic Systems	Motion Controllers
Superconducting Magnets	Temperature Controllers
Gas Handling & Intensification	Automated Sample Changers
Vacuum Equipment	DC, AC & RF Sources
Sample Troughs & Baths	Specialist Test Equipment
Sample Changers & Sticks.	

The configuration of sample environment hardware is transient in nature; equipment configuration is driven by the experimental objectives and deployed on beamlines for the experimental duration.

Beamline Computing Control

Each beamline uses a control PC to setup experimental parameters, equipment control configurations and analyse data. The control computer is the central hub for running beamline experiments; figure 2 provides an overview of the system. The control PC uses a Windows operating system running SECI in-house developed software. LabVIEW device drivers control beamline and sample environment equipment. OpenGENIE scripting software provides a language for users to automate control processes in conjunction with LabVIEW device drivers.

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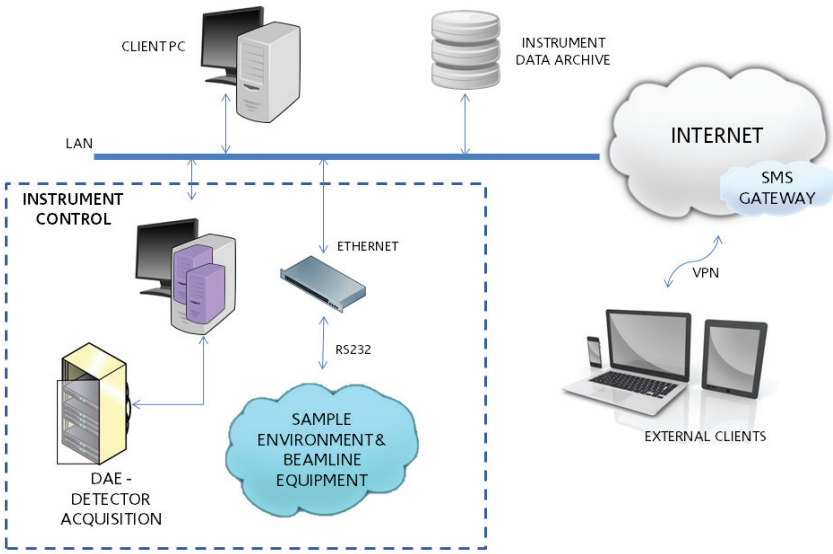

Figure 2: Beamline computing control overview.

Communications between control PC and sample environment equipment is via a serial to Ethernet convertor. This setup is preferred by the computing group to ensure that instrumentation is not exposed to LAN traffic, reducing the perceived risk of equipment control failure. Remote access to the control PC is available using Windows remote desktop or, more popularly, WinVNC. Connection to the control PC outside of the LAN is via a VPN.

SAMPLE ENVIRONMENT MONITORING

Distributed monitoring systems are commonplace in industrial and manufacturing plants. SCADA and more recently embedded web servers provide an interface for viewing live process data, creating automated alerts and analysing process performance. This mix enables process performance and labour and maintenance costs to be optimised. In scientific research organisations where the strategic goal focuses on the quantity and quality of scientific output the advantages of employing distributed monitoring systems still hold true.

On average ISIS runs over 600 experiments during the operational year, all of which require sample environment and associated support from a comparably small number of people. With operational costs of c. £15k per instrument day scheduling, resource management, technical support and maintenance effort is challenged to ensure that lost time is kept to a minimum.

Operational Benefits

Implementing a system to monitor equipment, automate alerts and analyse operational data increases the sample environment teams' ability to meet operational and support challenges. Automated alerts provide an early warning system which reduces the risks of significant experimental lost time, reduces labour required to check equipment status and increases operational longevity.

Data analysis enables operational performance indicators to be identified, measured and fed back into the control system enabling operational parameters and maintenance plans to be continuously improved. Statistical rather than estimated operational data enables technical managers to make better informed decisions for resource management.

Equipment Development Benefits

Incorporating monitoring capabilities to controllers from the outset has advantages when developing new equipment. Throughout equipment test and commissioning, monitoring records can be used with great effect in understanding fault conditions and highlighting operational weaknesses. This can reduce project timescales and enable the delivery of a more robust system.

APPLICATION

The following requirements have been identified as essential to providing the benefits highlighted for the sample environment teams.

- Monitor existing hardware with minimal outlay.
- Monitoring must have minimal impact on the equipment control.
- Provide a mechanism for SMS alerts.
- System access from a range of hardware platforms and operating systems.
- System access outside of the organisations computer network.
- Archive monitored data.
- Provide a user friendly interface for data analysis.
- Analyse & filter data archive by experimental variables.

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The present beamline control PC is the central hub for sample environment equipment control and experimental diagnostics. The existing user interface is graphically rich, visible over the network and can be accessed from internal and external clients. Automated alerts are currently in use for monitoring network applications via an SMS gateway. Therefore expanding the existing system to cater for sample environment monitoring and analysis is preferable.

The existing SECI control system is currently being phased out to EPICS with the aim to operate an EPICS control system during the engineering commissioning phase of Larmor, the TS2 Phase-II Spin-Echo Small Angle Neutron Scattering instrument. This provides a timely opportunity to embed monitoring and data analysis into the EPICS control system with minimal overheads.

An EPICS control and monitoring system implemented at ISIS for the MICE project meets many of the sample environment monitoring requirements and should be used as an operational reference. The monitoring aspects of the MICE system [2] uses EPICS Alarm Handler and Channel Archiver extensions to provide multiple clients with access to channel monitoring, alarms and data logging. Using the Web Channel Access Plug-in clients can access the monitoring system through web browsers on multiple platforms.

CONCLUSION

The implementation of a distributed monitoring system for sample environment equipment and instrumentation has the potential to provide a wide range of technical and managerial benefits for sample environment operation and support at ISIS. The existing beamline control system is currently being developed to run an EPICS platform, this development provides a timely opportunity to increase the project scope to include monitoring capabilities with minimal overhead. The EPICS control and monitoring system implemented on the MICE project at ISIS meets many of the sample environment monitoring system requirements and can be used as a reference design.

GLOSSARY

EPICS	Experimental Physics and Industrial Control System
LAN	Local Area Network
MICE	Muon Ionisation Cooling Experiment
SANS	Small Angle Neutron Scattering
SCADA	Supervisory Control and Data Acquisition
SECI	Sample Environment Control Interface
SMS	Short Message Service
TS2	Target Station 2
VPN	Virtual Private Network

REFERENCES

[1] http://www.isis.stfc.ac.uk/about-isis/aboutisis.html
[2] P. Hanlet, “Muon Ionization Cooling Experiment: Controls and Monitoring” PAC 2011.

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