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Stability of Controls & Monitoring on MICENet

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Abstract

This document describes the basic structure the Controls & Monitoring system and of micenet. Considerations regarding the stability of the network and how any instabilities may adversely affect the C&M system are addressed.

1 Introduction

The main concerns addressed in this document are: 1) failure which affects equipment and could potentially lead to loss of that equipment, and 2) loss of ability to take data because equipment is not able to function as specified. The second point is important in that the MICE schedule for data taking is already quite short, so any inefficiencies in the control system due to network problems need to be addressed. As such, the goals of this study are to:

- summarize the configurations of the Controls and Monitoring (C&M) systems and of the micenet network, Sec. 2 and Sec. 3, respectively,
- describe the recent changes to both micenet and to the C&M system to protect C&M from network instabilities, Sec. 4
- identify possible fault modes in micenet which would adversely affect C&M, and solutions to these problems, Sec. 5
- list tests which have been performed and/or still need to be performed, Sec. 6.
- identify the work required to isolate C&M from other network devices, Sec. 7, and
- draw conclusions from the work done here and present a recommendation to the collaboration, Sec. 8.

2 C&M Overview

The larger systems: channel magnets, beamline magnets, decay solenoid, trackers, vacuum system, and target have control systems built by a controls team at Daresbury Laboratory (DL) in the UK. Each Input/Output Controller (IOC) is a VME based system with a Hytek processor running VxWorks. Sensor controllers are interfaced via RS232. CANbus is employed for interlocks and digital controls, while analog devices are monitored and controlled with VME based ADCs and DACs. The SS and FC magnets are sufficiently complex to require 3 VME crates, and thus IOCs, which serve all of the SC channel magnets. The LH_2 system, due to its hazardous nature, is controlled by Omron PLCs and is completely self-contained; EPICS is used solely for remote monitoring of this system.

It is important to note that all of the DL IOCs are designed and tested to be fail-safe, in that should the IOC fail, the equipment will automatically be put in a safe state. Furthermore, for these, all of the control hardware and sensors have direct connections to their IOCs; i.e. there are no network connections.

Other IOCs for MICE have been implemented on linux PCs. These IOCs employ a variety of interfaces: serial RS232 and RS485, modbus, SNMP, and TCP/IP. There are a handful of devices, which communicate with their IOCs via the network, but none that interface with the Channel magnet power supplies; these are:

- SecurityProbe 5ES – the central host of a number of sensors peppered throughout MICE: the probes are temperature, humidity, pressure, limit switch, flow, voltage, and current (4-20mA)
- Tracker electronics power supplies
- CAEN SY4527 high voltage crates

Of the linux based PCs, many serve higher level functionality and integrate other IOCs which communicate with the hardware. These IOCs include:

- BeamLine – integrates target (DL), decay solenoid (DL), beam line conventional magnets (DL), proton absorber, beam stop, and diffuser.
- Detector – integrates Luminosity monitor, CKOV HV, CKOV monitor, ToF HV, KL HV, EMR HV, EMR crates
- Channel – integrates cooling channel magnets monitoring (DL), cooling channel magnet power supplies (DL), PRY movement monitor, SS heater loop monitor, Hall probes, SS north side turbos, SS QPS monitoring, SS VT monitoring, tracker O_2 monitoring (for He), power leads air flow monitoring
- State Machines – integrates HW for devices (Target, Tracker, DS, BeamLine, SSU, SSD, FCU) and passively monitors their parameters to determine their states
- RunControl – integrates DAQ, OnMon, CDB, and runs the data mover; setting up for a run requires integration with DL IOCs, BeamLine, Detector, and Channel IOCs, and the State Machines.

3 micenet Overview

micenet is a class C network hosted by the RAL PPD network. Usually the non-Controls and Monitoring machines have an IP address with an host number lower than 100, while all other IP addresses (100-253) belong to C&M machines. The network switch is a Hewlett Packard 5406R zl2 replaced in January 2015.

The IP address is DHCP assigned but every machine always gets the same IP address each time. A DNS server is used, while two fail-over servers are in place.

The network can be isolated from the external network without causing any problem to the normal

3.1 micenet Machines

3.1.1 OPerator Interface (OPI) Computers

The OPI machines are general purpose EPICS client interface PCs. These include the Intel thin clients refurbishing the Control Room, a couple of desktop machines in the hall and three EPICS laptops allowed to connect into the micenet.

3.1.2 Input/Output Controllers (IOC)

The IOCs around MICE are a variety of VME crates and a number of linux PCs; their descriptions are given above. Tab. 1 gives a list of MICE IOCs and their dependencies on networked devices.

3.1.3 EPICS Client Server Computers

The machine with hostname miceecserv (either miceecserv1 or miceecserv2) serves the clients for C&M archiver, alarm handlers, GUIs, Strip Tools, Probe, and a bazaar code repository for the C&M code.

Additionally, this machine stores the archived data and provides an NFS mounted disk areas for shared data and C&M configuration files.

3.1.4 Gateway Computers

One machine is the EPICS channel access gateway machine, that provides read-only access of any EPICS variable through `mousehole`. This permits remote monitoring of the status of any equipment.

The other machine constitute a link between micenet and the ISIS machines that provide the beam and beam loss values to EPICS.

3.1.5 Data Acquisition (DAQ) Computers

The DAQ machines include the Local Data Concentrator machines (which blindly reads out a crate and stuff numbers into the event building and the data-taking user-interface (DATE)) and the Global Data Concentrator machines (which combines all the data together and does the control, event building and writing to disk).

Dependencies on other machines The Global Data Concentrator machines should be able to access the Online reconstruction machines. This also must write data to storage.

3.1.6 Target Computers

The target computer on micenet (target1ctl) runs the target software required for communicating with the controller, and recording data collected during operation of the target. The data is collected from the controller and a set of digital and analogue inputs attached to a PCI card, which record target trajectory and beam losses, etc. The RATS daemon process records this information to the local machine and a web server allows users to interact with the target control system over the network.

In addition to the target control computer, an IOC is present in the Vac Rack area, which controls the target frame and main power supply. A set of direct connections are made between the Target Controller and the IOC rack, which relay frame interlocks and signals to power the motor. The target controller also has interlocks with the ISIS BPS system to inhibit injection in the event of a problem.

Once set up the target controller is designed to operate independently from the computer, and regular checks are made by the controller to ensure the device is operating within specification. In the event of a problem the controller enters an error state, and stops dipping. One example of such an error state is if the RATS software stops sending keepalive signals to the controller. Ultimately the controller is responsible

for the safe operation of the target regardless of the state of other systems, such as software, computer and network.
Dependencies on other machines: Web browser to interface with control system. It must be possible to restart the RATS daemon from an OPI machine in the MLCR.

3.1.7 Configuration Data Base (CDB) Computers

The Configuration DB is considered to be the actual database plus the web service that gives access to the database. Right now there are three separate copies of the database running in the MLCR (master machine) and on two different PPD machines (slave machines). Write access to the master machine is only possible from the micenet. Access to the data by other users is provided on a publicly accessible machine `cdb.mice.rl.ac.uk`.

3.1.8 Online and Offline Reconstruction Computers

The Online machines are used for

- online diagnostics of the detectors during the running of MICE, i.e. run MAUS online reconstruction,
- online diagnostics of the DAQ during the running of MICE, i.e. run online monitoring,
- process the tracker calibration,
- upload MAUS real time reconstruction output.

The Offline machine will be used for the real reconstruction of the raw data, a feasible alternative to the reconstruction on the Grid.
Dependencies on other machines: The machines should be able to export files to the DAQ Global Data Concentrator machines and to the datamover machine.

3.1.9 Web Cams

A number of network IP cameras have been deployed around the MICE Hall. Images and streaming video are accessible from within the RAL site network and micenet, and still images are also captured once a minute and made available via the a web page.

3.1.10 Data Storage Computers

A machine (`micestoreea`) is used as shared data cache, receiving the data from the DAQ concentrator machines moved by the `datamover` script.

The datamover machine upload tarballs of the data held on the shared date cache to the Grid.

A NAS drive is used to hold selective backups of various machines on micenet.
Dependencies on other machines: Online and DAQ machines should be able to connect to the data storage machines, included the backup drive that is NFS mounted.

3.2 SSH Access

The access on all the machines on micenet is permitted through the PPD bastion called `mousehole` hosted by the PPD. The login on the the `mousehole` is available using ssh key pairs. Access to OPI machines is available using `epics` account. The other accounts used around micenet are `mice` and `daq`. Access to IOC machines is available only using a specific password protected ssh key.

3.3 NFS mounts

A `Data` folder is NFS exported on most of the machines, containing the Archiver data, the tracker Hall probes output and other configuration files; 1.6TB are available for other shared data.

Part of the EPICS software is exported from one EPICS client in order to have machines easily synchronized.

4 Tasks Accomplished Since Fall 2015

Since Fall 2015, several tasks have been accomplished to remove dependence on network processes and to make ready the isolation of all of the miceiocpc's.

1. Remove dependency on DNS by communicating with all C&M devices by IP address. This task required 2 steps:
   (a) modify the environment variable EPICS_CA_ADDR_LIST to replace host names of the pc's with their IP addresses – complete, tested, and operational
   (b) identify and replace hard-wired host names in any EPICS code – though few instances of this, more care is required when making the changes. The most widely source of hostnames is with the CDB interface. This work is in progress.
2. Stop IOC access when MICE is in a data-taking mode; this is required to prevent running parameters changing when taking data, so as to reduce potential systematic errors. – in progress
3. Prevent ssh access to all miceiocpc's during data-taking mode – tested, but not yet operational

5 Failure Modes

The following failure network failure modes have been identified:

5.1 Loss of Local Network Access

There are several ways in which the network can fail; e.g. the switch may fail or one of the devices on the network fails and overwhelms the network with noise, thus depleting the available bandwidth.

Under this condition, this may affect C&M in that there is a loss of communication with one or more of the IOCs. However, as the IOCs are designed to be failsafe, this should only be a problem in the case of a double failure: loss of network and failure within C&M to control a run away process; e.g. a run away power supply.

5.2 CDB Loss

Loss of access to the CDB is detrimental to MICE operations, but can not directly affect any of the HW. Operations are adversely affected by a loss of CDB access for RunControl since it uses the CDB to set running conditions and to write run configurations. Furthermore, the State Machines are adversely affected in that they cannot read alarm and archiver conditions should access to the CDB fail.

5.3 Other?

6 Tests Performed or to be Performed

The following tests have been identified to convince ourselves that network failures do not adversely affect C&M:

- NFS failure
- CDB failure
- turn off network
- DAQ failure
- recovery from power failure

7 Isolating the C&M Network

Should the collaboration deem it necessary to isolate C&M on its own subnet, the following steps would be required:

1. Identify which devices should be moved from micenet
   - DAQ machines: miceraidX, miceacqX, miceonrecX, miceoffrecX,
   - datamoverX
   - micestoreX
   - camhallX
   - backupX
   - miceopiX (could stay on micenet)
2. Create a new subnet for MICE:
   - Purchase new switches(?)
   - RAL PPD procedure to establish new subnet
3. Reconfigure network switches in RR1.
   - mapping
   - cabling
   - new server for DHCP and DNS
4. Modify code to change IP addresses.
5. Run with both systems open and monitor network traffic to identify dependencies and unnecessary traffic so as to identify firewall rules.
6. Close unused ports and implement the firewall rules.
7. Establish appropriate EPICS gateways for communication between C&M and:

- datamovers
- miceonrecX
- CDB
- webcams

8. Test every component of the two networks and their dependencies and inter-dependencies.

It is important to note that the last item on the list would be very disruptive to major systems, in particular this will have a big impact on the already established line for communication between the DAQ and the Online/Offline systems from one side and the Run Control and CDB from another. Though operating without this communication line is possible, it would be a major step back in what has been accomplished in automating the data taking and configuration archiving processes.

8 Conclusions and Recommendations

The history of the configuration of micenet dates back to discussions in December 2006; the following references document the results of these discussions; 2007-07 DAQ workshop; 2008 decision; [1]

With an understanding of the configuration of the C&M system and of micenet, and the tasks that have been accomplished to date, see Sec. 4, to increase the robustness of micenet for C&M, as well as the hardware modifications to the Channel power supplies, it is the recommendation of this committee to:

1. perform and document the tests identified in Sec. 6 which have not already been performed,

2. not attempt to modify micenet for Step IV.

This is not to discourage further study for the final configuration of MICE, but it is commonly believed within the committee that the disruptive changes in separating the networks would present a severe risk to Step IV data taking.

References

[1] MICE Note ???

able 1: A summary of the IOC machines and their network dependence. The table uses the following definitions: SP-5ES is the SecurityProbe
ES, CSx (x is number) is DL Control Station

IOC	Description	Network Dependencies
miceiocpc1	Channel, MICEStates, Environment, Rackmon	CS7A/B/C, SP-5ES, HallProbes
miceiocpc2	hot spare for miceiocpc1	
miceiocpctk	IOC for Trackers, Tracker SM	miceioc2 &RATS running on target1ctl
miceiocpchv	IOC for HV	
miceisisgateway	IOC for ISIS monitoring	gateway to ISIS controls
miceiocpca	IOC for BeamLine	TargetMon, CS1, SP-5ES, CS4
miceiocpcb	IOC for BeamLine State machine	CS4, BeamLine IOC
miceiocpcc	IOC for Detectors	miceiocpchv, micehv1, micehv2, SP-5ES
miceiocpcd	IOC for Detector State Machine	iceiocpcc
miceiocpce	IOC for DAQ Montioring	DAQ, miceonrec
miceiocpcf	IOC for Run Control	CDB, all State Machines, OnMon, data mover
miceiocpcg	IOC for DS State Machine	CS1
miceiocpch	hot spare for State Machine	
miceiocpci	IOC for SSU State Machine	CS7A/B/C, Channel
miceiocpcj	IOC for SSD State Machine	CS7A/B/C, Channel
miceiocpck	IOC for FCU State Machine	CS7A/B/C, Channel
miceiocpcl	IOC for FCD State Machine	CS7A/B/C, Channel
miceioc1	Decay Solenoid IOC	CS1
miceioc2	VME – Target Drive IOC	micecss1 when booting
miceioc4	VME – Beamline Magnets IOC	micecss1 when booting
miceioc5	VME – Linde refrigerator IOC	micecss1 when booting
miceioc7a	VME – Cooling channel IOC; analog	micecss1 when booting
miceioc7b	VME – Cooling channel IOC; digital	micecss1 when booting
miceioc7c	VME – Cooling channel IOC; analog	micecss1 when booting
miceioc9a	VME – Vacuum/Compressors IOC–analog	micecss1 when booting
miceioc9b	VME – Vacuum/Compressors IOC–digital	micecss1 when booting