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EXPLORING ETHERNET-BASED CAMAC REPLACEMENTS AT ATLAS*

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Abstract

The Argonne Tandem Linear Accelerating System (ATLAS) facility at Argonne National Laboratory is researching ways to avoid an unscheduled downtime caused by the end-of-life issues with its 30 year-old CAMAC system. Replacement parts for CAMAC are difficult to obtain, causing the potential for long periods of accelerator down times once the limited CAMAC spares are exhausted.

ATLAS has recently upgraded the Ethernet in the facility from a 100-Mbps (max) to a 1-Gbps network. Therefore, an Ethernet-based data acquisition system is desirable. The data acquisition replacement requires reliability, speed, and longevity to be a viable upgrade to the facility. In addition, the transition from CAMAC to a modern data acquisition system will be done with minimal interruption of operations.

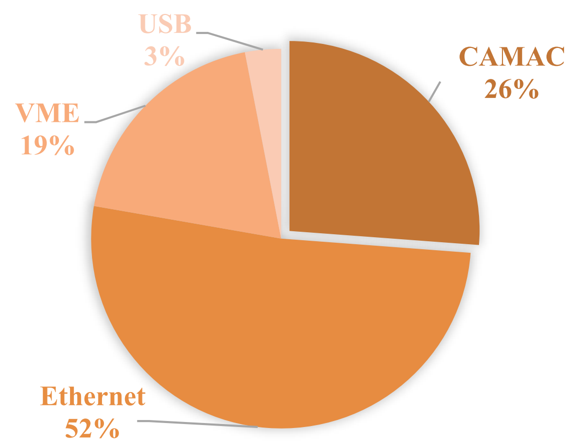

Figure 1: Distribution of ATLAS Hardware by VSystem Database Channel.

INTRODUCTION

The ATLAS accelerator is located at the United States Department of Energy's Argonne National Laboratory in the suburbs of Chicago, Illinois. It is a National User Facility capable of delivering ions from hydrogen to uranium [1] for low energy nuclear physics research to perform analysis of the fundamental properties of the nucleus.

ATLAS uses a 15-crate CAMAC (Computer Automated Measurement and Control) Serial Highway for the majority of its critical equipment data acquisition and control which users can interact with using databases and interfaces provided by Vista Controls (VSystems). CAMAC was developed in 1967 [2], and was a cost-effective option for data acquisition and control for decades to follow [3]; however, the "end-of-life" issues with CAMAC are forcing ATLAS along with other facilities to look for alternatives [4].

The CAMAC highway requires a computer to control and monitor the system. Since the CAMAC drivers are not available to a modern Linux server, ATLAS is forced to maintain an old AlphaServer 1200 running OpenVMS. For over a decade, it has been desired to move away from both CAMAC and the AlphaServers. Therefore, the decision was made to move hardware using CAMAC to a different system that can communicate directly with a Linux server.

After exploring many options, the MOXA ioThinx 4510 was selected to begin testing at ATLAS to determine if the product is a viable replacement of CAMAC.

MOTIVATION

The CAMAC system at ATLAS is organized in a loop topology, which means that when 1 CAMAC crate (Figure 3) fails, all 15 crates lose communication with the computer. This serial highway makes up 26% of the ATLAS control system (Figure 1). Since the majority of the ATLAS CAMAC highway comprises of systems critical to operation, a failure in 1 CAMAC crate almost always guarantees a halt in operation lasting until the problem is resolved.

In recent decades, CAMAC hardware has become difficult to replace since they are no longer manufactured. The supply of spare CAMAC components at ATLAS is limited and repairing failed components is often time-intensive.

CHALLENGES

Tracking down the use of each CAMAC channel is difficult and time consuming. Therefore, a program was created to read and organize all the databases' metadata into a spreadsheet. The spreadsheet can be easily sorted for channels that communicate with each CAMAC crate and slot to determine the scope of each piece of CAMAC hardware.

NETWORK UPGRADE

In 2021, the entire ATLAS Ethernet network consisted of about 13 hubs with a bandwidth of 10/100Mb. From January 2022 to January 2023, these switches were gradually replaced by 1 Gbps switches. Figure 2 shows a sample of the network ping statistics between two computers on the network during this upgrade. This up-grade will play a crucial role in improving the performance of any Ethernet-based system.

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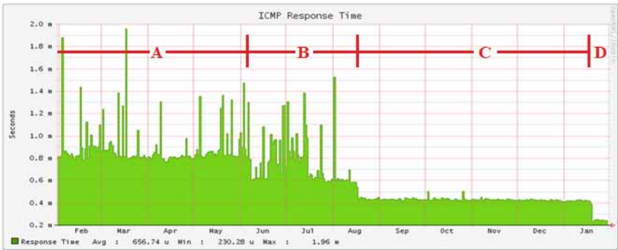

Figure 2: Sample of network ping speed between two ATLAS Linux Computers. Each region (A-D) shows the effect of replacing a 10/100 Mbps hub with a Gbps switch.

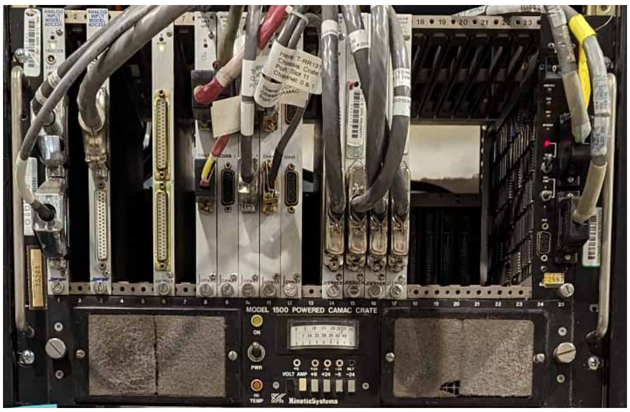

Figure 3: CAMAC Crate to be replaced by Moxa ioThinx.

Figure 4: Moxa ioThinx 4510 with 6 expansion cards installed at ATLAS. Currently this installation replaces only 2 CAMAC cards from Figure 3.

UPGRADE OPTIONS

Multiple Ethernet-based data acquisition/control options were researched including: SeaLevel SeaIO, VME, MPOD, and Moxa ioThinx. Overall, the Moxa ioThinx 4500 Series (Figure 4) best fit our criteria:

- Ethernet-based to make installing in remote locations easy
- Multiple Expansion cards to supply variable requirements
- Data read and write rates significantly faster than 1 second

MOXA PERFORMANCE

To compare the average speed of the ioThinx with CAMAC, both systems were setup as a loopback test; the output from the DAC was wired directly into the ADC. Values were sent to the DAC to follow a sine wave with an amplitude of 10V and period of 2π seconds. Values were sent to the DAC as fast as the system could handle. Immediately after each write to the DAC, the value was read from the ADC. This ADC data was also fit to a sine wave. The shift between the DAC and ADC fit that can be seen in Figure 5, represents the total delay of the system (ping, DAC delay, ADC delay, etc).

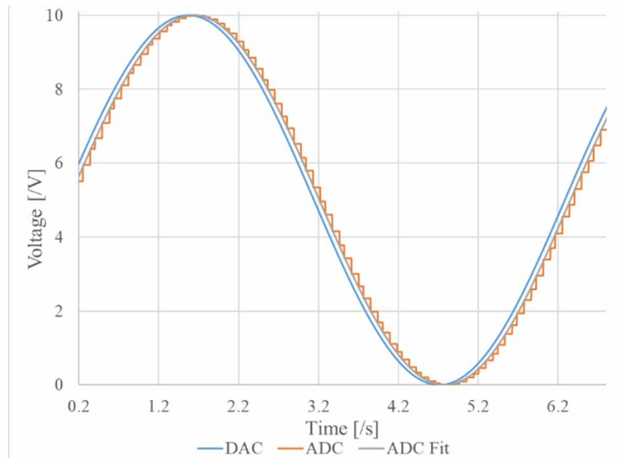

Figure 5: An Example of the ioThinx 4510 loopback test results. All 8 channels in the ADC were sampled during this test.

The ioThinx 4510 only samples ADC data at set frequencies. This sample rate varies based on the number of channels enabled per expansion module. For example, each channel of an ADC module with only 4 channels enabled will update at about double the rate of an ADC module with all 8 channels enabled. ATLAS does not require fast sample rates, but another test with only 2 channels enabled was performed and summarized below in Figure 6 and Figure 7. It should be pointed out that the ioThinx 4510 can be queried at a rate faster than the ADC refresh rate. Therefore, the DAC value was sent to the DAC at a rate significantly faster than the ADC could update. This can be seen by the "stair step" in the ADC plot in Figure 5.

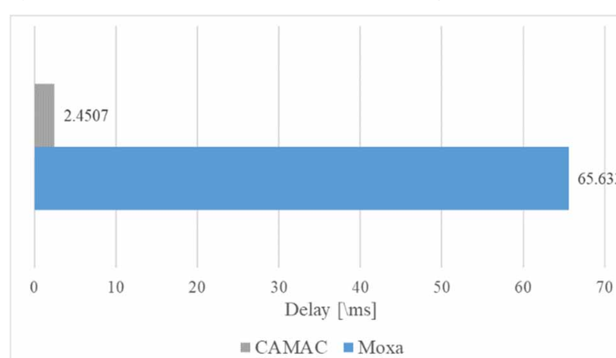

Figure 6: Delay between control and monitored sine wave. Delays include CAMAC/Ethernet ping and inherent hardware delays. Average of 2 tests per system.

CAMAC does not have a set sample rate, but the sample rate is limited by our AlphaServer 1200. This is the result shown in Figure 7 to compare with the ioThinx.

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Figure 6 and 7 show that the ioThinx 4510 returns data to the user at speeds much slower than CAMAC. However, these speeds are faster than ATLAS GUI refresh rates, making the transition from CAMAC seamless to operations staff. Moxa offers plenty of other benefits making the upgrade viable despite the higher latency.

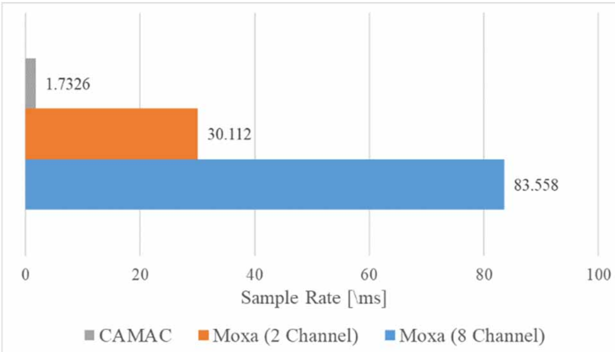

Figure 7: Sample rate of CAMAC and ioThinx.CAMAC is limited by the computer controlling the system. Average of 2 tests per system.

CONCLUSION

Overall, the ATLAS CAMAC system has several disadvantages; it has a potential to halt operation in the facility after a critical component fail, replacement parts are difficult to order, and limited spare parts are available.

The Moxa ioThinx 4500 series is a modern and flexible system that makes installs very easy. Though it is slower when compared to CAMAC, the ioThinx is fast enough for the difference to go unnoticed by operators.

Moxa also offers the ioThinx 4533 module which offers many additional features such as the ability to run Linux on board. ATLAS plans to do more tests with this module in the future.

ACKNOWLEDGEMENTS

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