A Framework Tool for Integrating the Back-End Infrastructure in the ATLAS Detector Control System

Robert Graham Reed, Bruce Mellado

School of Physics, University of the Witwatersrand, Johannesburg 2050, South Africa

E-mail: robert.reed@cern.ch

Abstract. The Large Hadron Collider at CERN is scheduled for a Phase II upgrade in 2022. The ATLAS collaboration is required to upgrade the detector to handle the increased centre of mass collision energy. The overall amount of data transmitted off the detector will also increase which requires a complete redesign of the front-end electronics. A large proportion of these electronics will be relocated to the back-end infrastructure. A Demonstrator program has been established as a proof of principle which will be house in a new rack mounted setup. The proposed solution will be an Advanced Telecommunication Computing Architecture which will not only house but also allow advanced management features and control at a hardware level. The integration of this new architecture into the ATLAS Detector Control System will be discussed.

1. Introduction

The Large Hadron Collider (LHC), a 27 km accelerator ring containing two beams of protons, collides protons at extremely high energies in order to help answer questions about the sub atomic universe. The ATLAS detector [1] is one of two general purpose detectors which record collisions at a rate of 20 interactions every 50 ns. The ATLAS detector is scheduled to undergo a major upgrade in the year 2022 [2]. The ATLAS detector is sub-divided into numerous sub-detectors, each one having a specific function. Figure 1 shows the sub detectors of ATLAS. It consists of the Inner Detector, Electromagnetic Calorimeters, Hadronic Calorimeters and Muon Detectors. The Tile Calorimeter, the central region of the hadronic calorimeter, is used to measure energies and directions of hadrons and leptons. Plastic scintillators which, when particles pass through, emit light collected by photo-multiplier tubes (PMTs) to measure energy and direction of hadrons. These light signals are directed to front-end electronics where they are digitised and processed for the first level of triggering.

Data from the front-end electronics is transferred off the detector to the back-end electronics where further processing occurs. These electronics are house in Versa Module Europa (VME) crates. These systems are over 30 years old and will not be able to accommodate the required upgrade to handle the increased data rates that will be delivered by the LHC in the year 2022. As a result the entire front and back-end electronics will be upgraded for the Phase II upgrade [2].

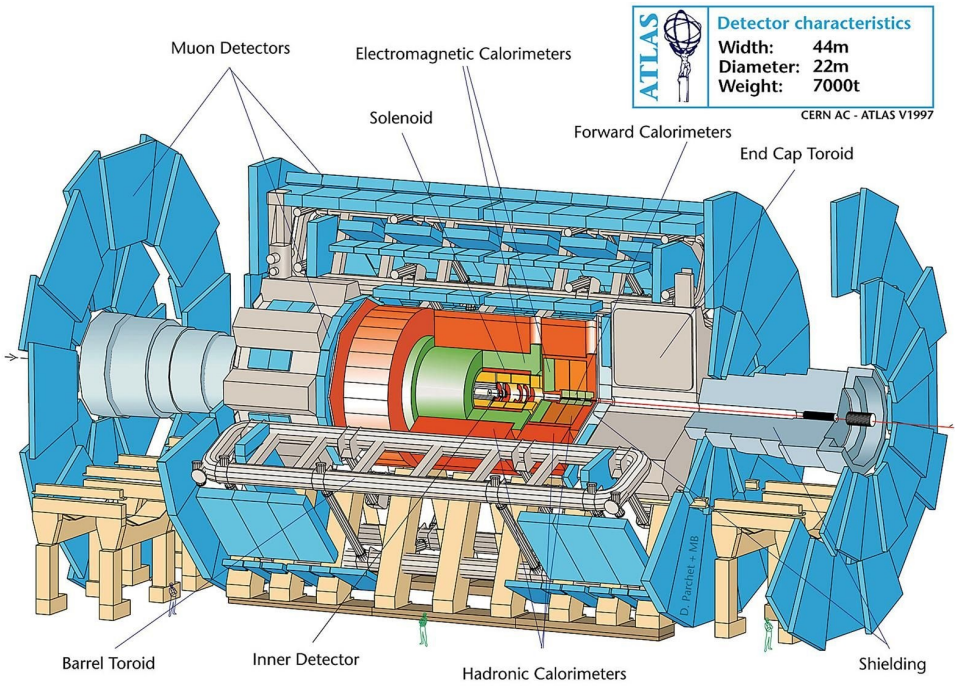


Figure 1: Artistic representation of the ATLAS detector.

2. Trigger Pre Processor

A part of the Phase II upgrade is the redesign of the Read Out Driver (ROD) of the Tile Calorimeter. This will involve electronics from both the front and back-end system. This new improved board, called the Trigger Pre Processor (PPr), will contain the sensitive electronics that are currently housed in the front-end area. This will allow the full data volume digitized at 40 MHz to exit the detector and be processed in the back-end area. Figure 2 shows the schematics of the upgrade with the pipelines and triggering contained in the new Trigger Pre Processor. Since the PPr is housed in the back-end it will be accessible during run time allowing easy maintenance and troubleshooting. Table 1 shows the expected bandwidth that will be provided by the new PPr and the Tile Calorimeter as a whole [3].

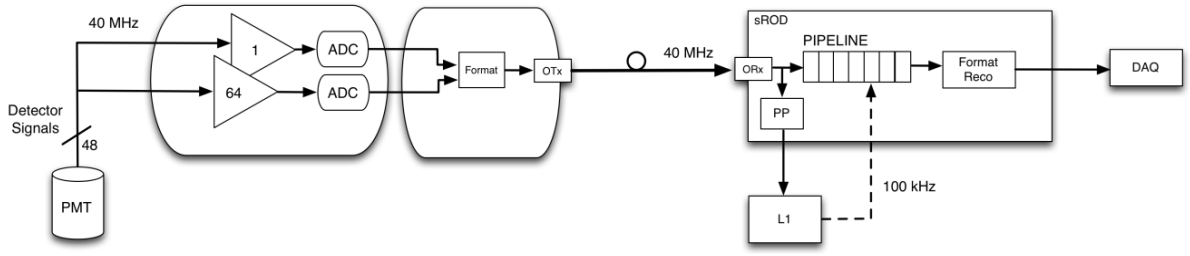


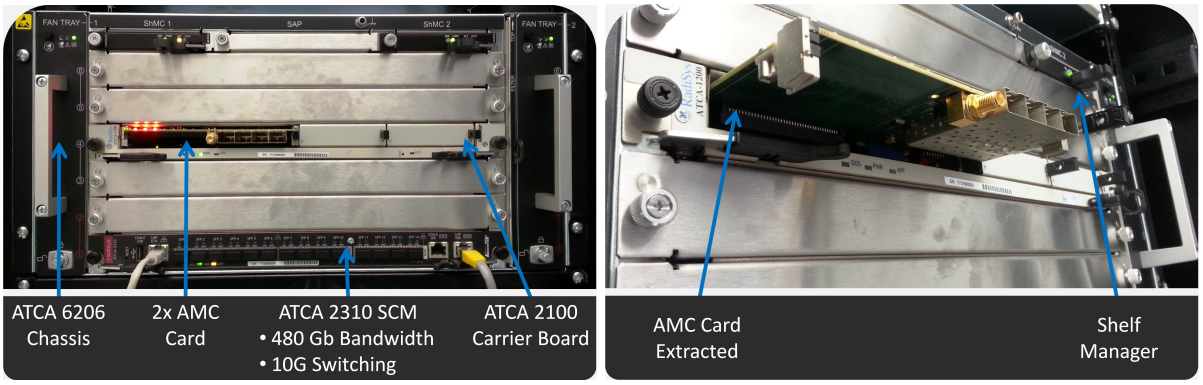
Figure 2: Upgraded read out electronics.

The PPr will be housed in an Advanced Telecommunications Computing Architecture (ATCA) chassis. The ATCA standard will be replacing the previous VME standard as it is superior in many aspects [4]. Once the PPr prototypes have been tested the designs will be brought to South Africa where the PCB will be manufactured and all components mounted. The PPr will be inserted into the ATCA system at the University of the Witwatersrand and

tested.

3. ATCA Framework

The ATCA chassis allows intelligent monitoring and control while offering high speed connectivity via a 40 Gbps backplane. Figure 3 shows a front view of the chassis that is currently installed at the University of the Witwatersrand. This model has six slots in a dual star topology offering redundancy. A 10 Gbps switch module provides the routing and switching configuration. A carrier board allows smaller cards, called Advanced Mezzanine Cards (AMC), to be inserted. The PPr is a doubled sized AMC card that can be inserted as shown in Figure 3 (b). All boards can be inserted and extracted while the system is powered on. This is called Hot Swapping. The Shelf Manager is responsible for the all the auxiliary services such as power control, fan speeds, temperature readings and voltage readings among others. Communication to the Chassis is done via a Simple Network Management Protocol (SNMP). This protocol is used since the Detector Control Software, WinCC, has a built in driver to manage the connection. The ATCA follows the PCI Industrial Computer Manufacturers Group (PICMG) standard. PICMG, as defined on their website, is "a consortium of companies who collaboratively develop open specifications for high performance telecommunications and industrial computing applications." [5].



(a) (b)

Figure 3: a) Front of ATCA chassis and b) AMC extracted from chassis at the University of the Witwatersrand.

Table 1: Tile Calorimeter Bandwidth Upgrade.

Phase	Present	Upgrade
Number of fibers	256	4096
Fiber Bandwidth	800 Mbps	10 Gbps
Total Bandwidth	205 Gbps	41 Tbps

4. The ATLAS Detector Control System

The Phase II upgrade will issue in new electronics such as the ATCA back-end infrastructure. This new hardware needs to be integrated into the existing Detector Control System (DCS) [6]. The DCS is a highly parallel system with distributed nodes that monitor and control 12

individual sub detectors in ATLASin a redundant fashion. The DCS has the task of bringing the detector and all components into various desired operational states while monitoring and performing corrective actions in case of abnormal behaviour, all in an automated fashion.

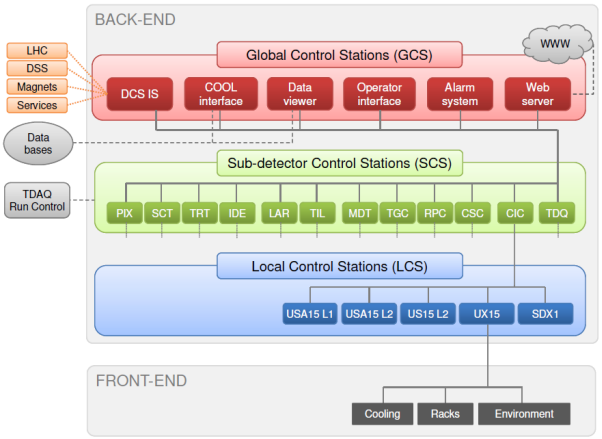


Figure 4: Schematic of the ATLAS Detector Control System [6].

Figure 4 shows the distributed nature of the DCS and the logical separation of the controlling nodes. It consists of various drivers arranged in tiers according to geographic, function or dependency groups. The software is called WinCC Open Architecture which is a product of Siemens [7].

All sensors and variables of interest in the ATCA system need to be polled in a regular fashion to allow the DCS to correctly deduce the state of all devices. This requires the creation of data points in the WinCC software that is very specific to the hardware in question. A framework tool for the ATLAS DCS has been designed which provides the expert the means to automatically generate the required data points. It does this with all the correct configurations such as the SNMP address, formatting, descriptions, polling intervals, access permission and more. This framework tool is called fwATCA.

5. fwATCA Framework Tool

The fwATCA framework tool is required to perform four functionalities:

(i) Search - This is the most important. The framework needs to search through the ATCA Shelf and determine what it contains and find all the sensors that correspond to each device.

(ii) Sort - Once all the devices have been found, along with their sensors, the information needs to be sorted in a meaningful and clear way.

(iii) Create - The sorted information must then be generated into data points that are accessible by the Detector Control System.

(iv) Configure - After creation one may want to configure a selected data point (or all) with descriptions, alerts, formatting, polling intervals or simply to delete them.

Figure 5 shows the framework panel that has been able to search through the ATCA shelf. Sort the information into two main categories, with sub categories, and then create the data points (The shaded colour around the sensor name indicates that the sensor has not been created). The sorting of the data points is defined by two categories: Standard Data Points and Custom Data Points. The first being sensors that are populated by the Shelf Manager. Standard sensors are always available as they belong to the chassis itself and are always present. The Standard Data Point category is then broken into smaller groups depending on the physical

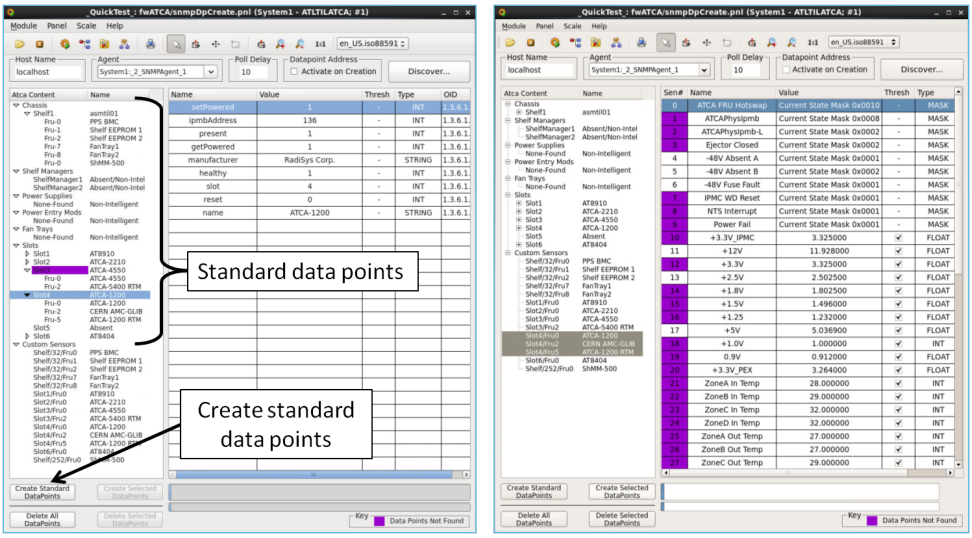


Figure 5: Framework panel that allows data point creation.

devices itself such as fan trays, power modules, shelf managers or physical slot bays. The number of devices in each category will depend on the chassis type since some chassis only have six slots while others may have fourteen. The second category, Custom Data Points, contains the sensors that belong to the boards that are inserted. Naturally these sensors are only available if the board is present. The custom sensors are provided by the board manufacturer and must meet the PICMG specifications. The information these sensors provide is different for each board which means they are harder to integrate in an automated fashion. However, this has been achieved. The custom sensors are processed after creation allowing them to be categorised according to the information they provide.

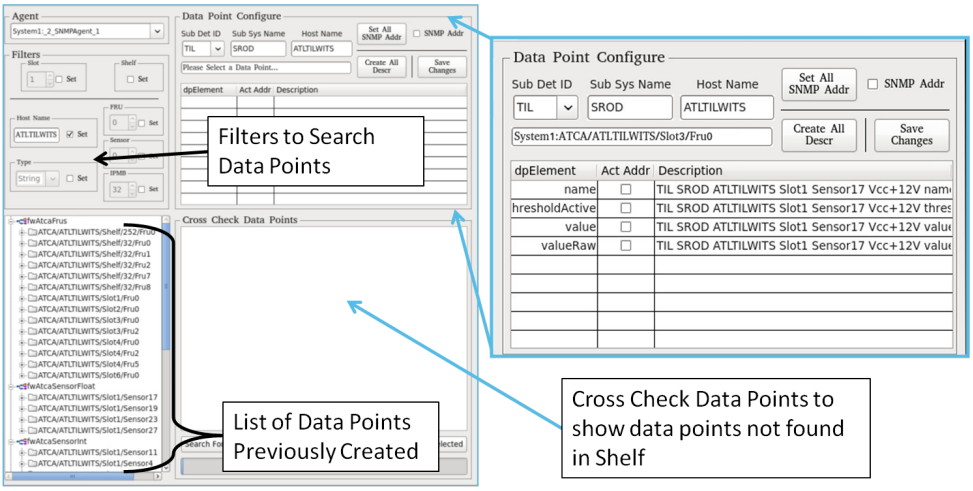


Figure 6: Framework panel that allows data point configuration.

Figure 6 provides the expert with the tools requires to configure the data points after creation. This involves creating descriptions, viewing (or deleting) data points that are no longer needed or have been removed from the chassis, searching data points with filters and controlling the SNMP polling.

6. Conclusions

The CERN community will be upgrading to the new ATCA standards as a replacement of the current VME technology. The work up to now has facilitated the understanding of these new systems. The framework described in this proceedings is an expert tool that will assist in the integration of new hardware into the current DCS. The tool provides a platform that allows the development of custom monitoring scripts and panels that can be used by any sub-detector in ATLAS. The tool automates searching, sorting and creation of large complicated back-end infrastructure and provides a scalable framework to assist in the integration efforts.

7. Acknowledgements

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