The control system for the MIRI imager Ground Support Equipment

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ABSTRACT

The Mid Infra Red Instrument (MIRI) is one of three instruments to be built for the spatial telescope James Webb (JWST). Our division CEA Saclay/Dapnia is in charge of designing and delivering the imager of MIRI and developing its test bench called the Ground Support Equipment (GSE). This GSE is composed of a warm telescope simulator, a cryostat and an infrared detector. This paper will describe the control system for the GSE. This control system is composed of a fast acquisition system, a slow control and PLC's for the cryostat including safety management. For the fast acquisition and images visualisation, the ESO data acquisition software IRACE (InfraRed Array Control Electronics) is used.

The originality of this project lies in the simultaneous use of IRACE, of EPICS for the slow control and of the automatisms system based on the WoldFIP Fieldbus network and its WEB supervision. These three software subsystems will communicate and the supervision will be centralized on two redhat Linux PCs. All the boards are purely industrial. This test bench should be put in operation at the beginning of 2006.

INTRODUCTION

The James Web Space Telescope (JWST) is the successor of Hubble in the infrared. It will be launched in 2013. Its science goals are the star formation and the evolution of galaxies with large redshift, the formation of planets and dust clouds. The Mid Infra Red Instrument (MIRI) is a spectrometer and an imager. Our division, Dapnia located at CEA Saclay, is in charge of the design and completion of the optomechanical part of the imager called MIRIM and of its test bench called the Ground Support Equipment (GSE). This GSE consists of a warm telescope simulator and of a cryostat to cool the imager down to its operating temperature. The cryostat contains a model of the imager, identical to the flight model. The warm telescope simulator is composed of several optical components to control (a hexapod, a point source, an extended source, a monochromator and a shutter). The imager contains a Filter Wheel with 18 positions and a 1024x1024 pixels InfraRed detector.

ARCHITECTURE OF THE CONTROL SYSTEM

We focus all our software development on the ESO (European Southern Observatory) and EPICS (Experimental Physics Industrial Control Systems) communities' software. From ESO, we use the IRACE software dedicated to the fast acquisition of the IR detector. For the slow control of the IR detector and optical devices, EPICS is used. The IR detector needs a slow control for the polarisation and clocks signals voltages. We will base the cryostat control supervision on the software developed in our industrial control and data processing Lab.

The software IRACE, the program positioning the Filter Wheel and some cryostat temperatures readout need to communicate with EPICS. Furthermore, EPICS Channel Access software (CA) running on Linux and Windows is used.
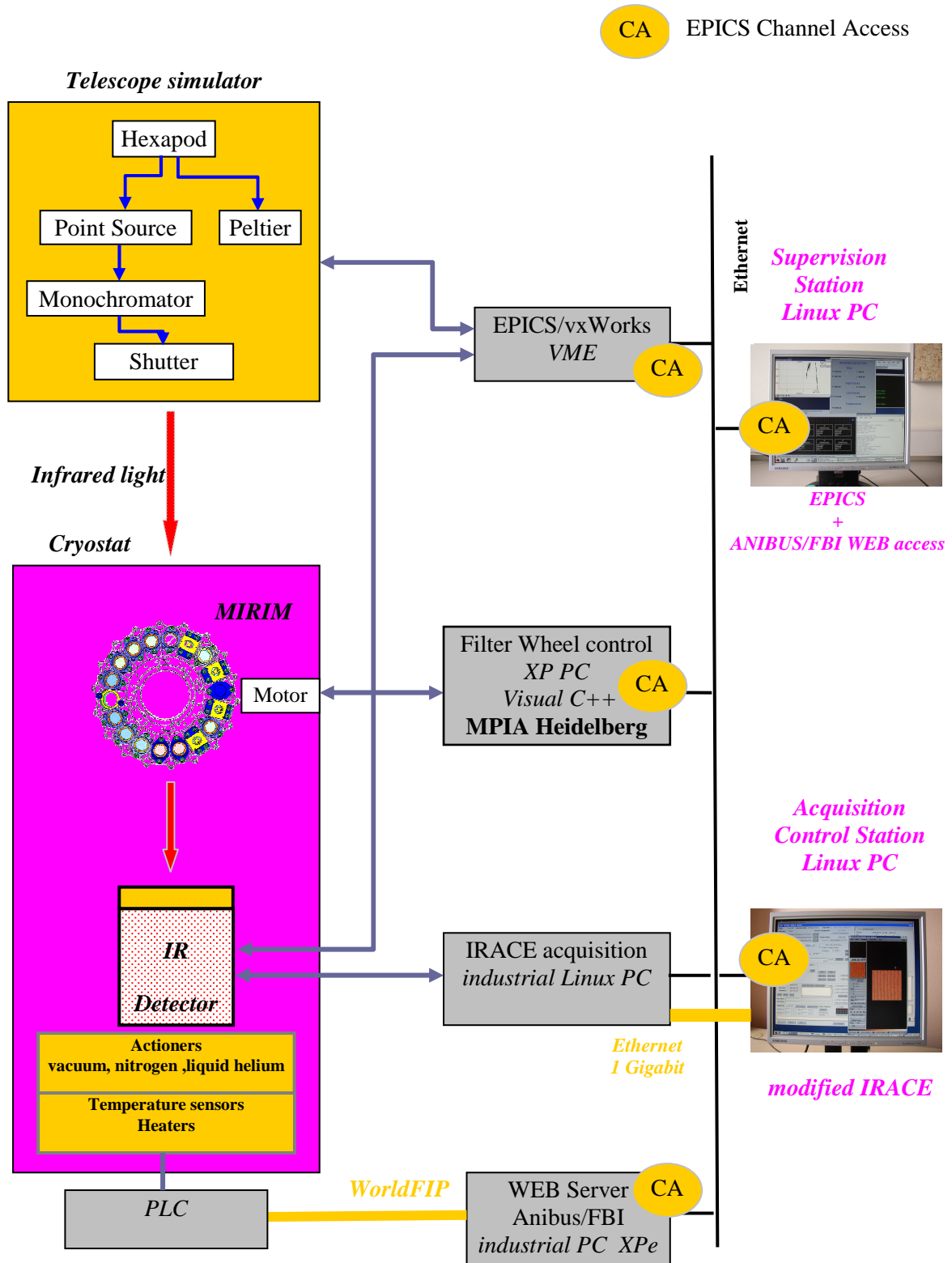
CA — EPICS Channel Access

Telescope simulator

Hexapod

Point Source　　Peltier

Monochromator

Shutter

Ethernet

EPICS/vxWorks
VME　CA

Supervision Station Linux PC

CA

*EPICS
+
ANIBUS/FBI WEB access*

Infrared light

Cryostat

MIRIM

Motor

Filter Wheel control
XP PC
Visual C++　CA
MPIA Heidelberg

Acquisition Control Station Linux PC

IR

Detector

IRACE acquisition
industrial Linux PC　CA

**Actioners
vacuum, nitrogen ,liquid helium**

**Temperature sensors
Heaters**

*Ethernet
1 Gigabit*

modified IRACE

PLC

WorldFIP

WEB Server
Anibus/FBI
industrial PC XPe　CA

Figure 1: Control system architecture synoptic

COTS BOARDS FOR FAST ACQUISITION IR DETECTOR

Our Lab was in charge from 1998 to 2004 of the control system of the VISIR instrument (VLT Imager and Spectrometrer for mid InfraRed) for the Very Large Telescope at Paranal. We had to use the controller IRACE. This controller consists of a software package and electronic boards designed by ESO. It was decided to re-use IRACE for the MIRI test bench. ESO couldn't provide their electronic boards. Consequently, we had to choose convenient COTS cards to replace the ESO's boards but less specialized.

A frame of the detector (1024 x 1024 pixels) is read per block of pixels. A frame is the full readout of the detector. The needs to read this detector are:

- a sampling rate comprised between 0.5 and 1 Mega samples per second with 16-bit resolution,

- 24 signals for clocks.

We have selected SPECTRUM products:

- digital I/O MI7011 boards with embedded memory of 512 Mbytes,

- ADC MI4541 boards with 16-bit ADC resolution and a sampling rate up to 1 MHz and 128 Mbytes of embedded memory.

Two MI7011 boards are needed. The first is dedicated to the readout of the detector and sends a full sequence of fast TTL signals to the IR array for a complete frame readout. This board generates the clock for the other MI7011 dedicated to the experiment. This second MI7011 generates the slow synchronous signals, for example the shutter signal to open/close the shutter and the Frame Trigger signal to start the digitized acquisition of a frame.

The MI4541 board achieves the acquisition itself in its local memory from the IR array. It uses the Frame Trigger signal and the Acquisition Clock signal, coming from MI7011 boards, as external trigger and clock. The possibility to use up to 4 MI4541 boards provides flexibility for different IR detectors. In this case, the first MI4541 board supports a starhub that synchronizes the different MI4541 boards.
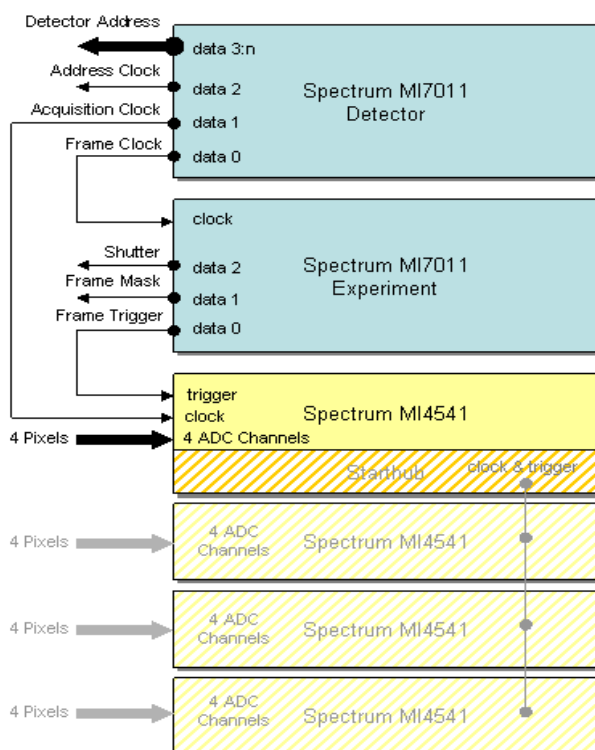

Figure 2: COTS acquisition boards

PORT OF ESO IRACE SOFTWARE

IRACE software [1] splits tasks between the instrument workstation and the acquisition workstation close to the hardware. For our test bench, this software architecture was globally saved between the acquisition workstation and the acquisition control workstation. The port for MIRI includes three points:

- the Detector Control System server task communicating with the EPICS Control Database for the detector voltages (biases and low/high clock levels),
- the configuration and programming of the MI7011 boards used as Sequencer,
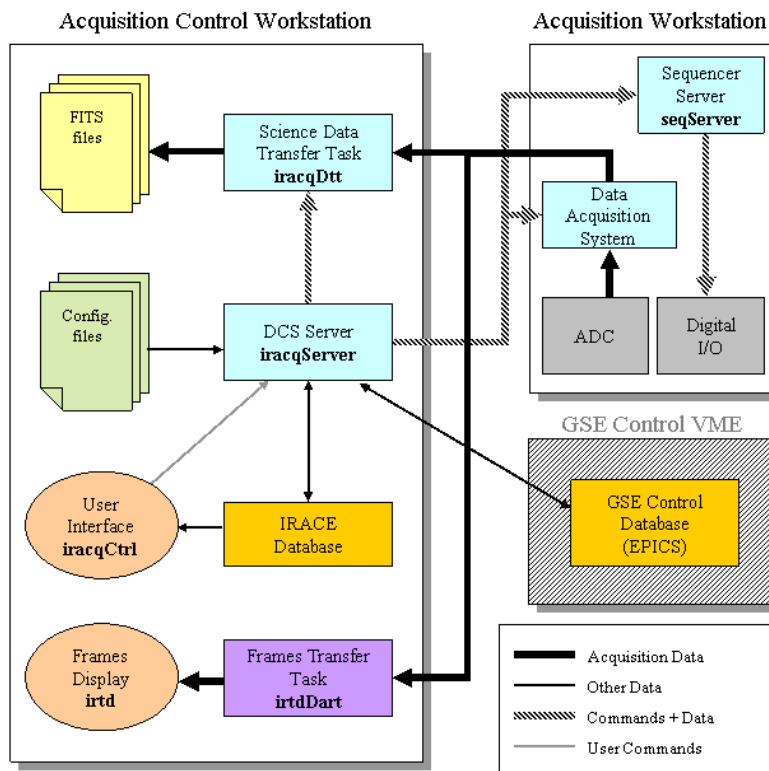- the Data Acquisition from the MI4541 boards.

Figure 3: IRACE software architecture

THE IR DETECTOR SLOW CONTROL

To control biases, low/high clock levels and temperatures we use EPICS on a Linux Red Hat Enterprise 4 PC for the user interface and a VME with a Motorola CPU MVME2434 equipped with vxWorks. Due to the deadline to provide this GSE, we chose our traditional solutions relying on ADAS VME boards to save time for the developments around the new devices.

THE TELESCOPE SIMULATOR SLOW CONTROL

The telescope simulator comprises different devices: a point source, an extended source provided by a Peltier, a monochromator and a hexapod for alignment. These devices are all interfaced by RS232 serial lines and their control will rely on streamDevice2 EPICS software [3]. It has a device driver for byte stream oriented I/O. This support runs on vxWorks as well as on Linux. Presently, only the Cornerstone motorized monochromator is present in the Lab and the tests are in progress. The second device to control will be a 6-axis positioning Hexapod that provides servo-controlled motion in 3 translation and 3 rotational axes.

COMMUNICATION WITH THE MPIA FILTER WHEEL COMMAND CONTROL

The cryo-mechanism of the Filter Wheel located in the MIRIM Model is the responsibility of the Max Planck Institute of Astronomy (MPIA) in Heidelberg. The motions of this wheel need very complex algorithms that will be provided in the VISUAL C++ 6.0 environment. Meanwhile, our Linux oriented control system needs to communicate with the Filter Wheel. For instance, before starting an IR detector acquisition, the 18 positions Filter Wheel has to be moved to a position in imaging or coronographic mode. Therefore, we have defined a software interface with MPIA to get the position of the wheel, to move it to a desired position, to get the status of the movement and to get temperature from a sensor. Once more, this communication is based on Channel Access and this time, on Windows. The release EPICS R3.14.7 was easily built on Windows XP using the Linux like environment Windows cygwin and the compiler and linker cl from VISUAL C++ .NET 7.0.

CRYOSTAT CONTROL SYSTEM

The cryostat subsystem requires a high reliability and safety level. Thus it has its own dedicated control system, the standard one used in Dapnia cryogenics installations [4] [5].

The architecture is based on real-time fieldbus WorldFIP, a PLC and an industrial PC.

The PLC manages the process through temperature sensors, heaters and other devices aimed to vacuum, helium or nitrogen. Safety is implemented at this level. A bus arbitrator running on its FIP interface guarantees data exchange determinism.

The XPe industrial PC runs the home made "Anibus-FBI" supervision system. Spying the fieldbus it handles acquisition and also provides alarms and historic features. It hosts a WEB server and the client side supervision, implemented as a Java applet, is available remotely on most platforms without any particular installation. Furthermore, real-time process data are exported to the EPICS system through Channel Access.

USER INTERFACES

To start the EPICS tasks (displays, trend curves, archiving, logging errors and IOC) the user interface is based on the free RAD Glade (interface builder for GNOME). This development was also carried out jointly for the control system of the Superconducting Magnet of the COMPASS Experiment [6]. From this Red Hat Linux PC dedicated to the general supervision, the operator will also be able to control the cryostat from our Linux Internet Browser.

On the Red Hat Linux PC, dedicated to the IR detector acquisition control, the Broker for Observation Blocks (BOB) will be the main user interface with the bench. BOB is a tool provided with the VLT software. Observation Blocks form the fundamental underpinning for the planned usage of the bench control system with a series of expositions. BOB executes templates that are sequencer scripts for tcl. The observing template is a pre-defined sequence of operations involving any combinations of actions with IR detector or Filter Wheel or light sources and that are essentially communication with EPICS variables or IRACE commands.

CONCLUSION

The IRACE software port is achieved and the tests on the SPECTRUM boards are in progress.

Our choice of Red Hat Enterprise Linux was judicious because it provides a stable and reliable environment for developments with an efficient on-line support.

Blending solutions based on EPICS, ESO IRACE and the Dapnia standard cryogenics supervision will permit us to deliver the control system for this MIRIM Ground Support Equipment in May 2006.

REFERENCES

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