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NAOS Computer Aided Control: an Optimized and Astronomer-Oriented Way of Controlling Large Adaptive Optics Systems

G. Zins[1], F. Lacombe[2], J. Knudstrup[3], D. Mouillet[4], D. Rabaud[5], J. Charton[4], S. Marteau[2], O. Rondeaux[2], B. Lefort[2]

Abstract. Adaptive Optics as a new tool for astronomical observation has proved a powerful means of investigation in high spatial resolution programs. However, in spite of the complexity of the components involved (wavefront sensor, real-time computer), its use must be made as simple as possible in order to make it accessible to the largest audience of observers, and to answer the more demanding needs of modern observatories such as queue scheduling, service observing or remote observing. The Computer Aided Control (CAC) developed for the Nasmyth Adaptive Optics System (NAOS) of the Very Large Telescope (VLT), will provide the astronomer with an extensive support, from the preparation of optimized observations to the automated operation of the instrument at the telescope either for hardware control, real time computing, or even preventive maintenance.

1. Introduction

NAOS is the adaptive optics system to be installed at one of the Nasmyth foci of the VLT to provide the near IR spectro imager (CONICA) with a compensation of the atmospheric turbulence effects on astronomical images. Incoming wavefronts are corrected by a 185 piezo-stack deformable mirror associated with a tip-tilt mirror. Output wavefront sensing is achieved by means of 2 Shack-Hartmann type sensors, working respectively at visible and IR wavelengths.

CONICA's and NAOS control softwares have been designed in close relation with VLT's general software to provide astronomers with an efficient support from the preparation of the observation to the effective observing runs, while hiding the technical complexity of the adaptive optics system.

[1]SHAKTI, 27 bld Charles Moretti, 13014 Marseille, France

[2]ODP/DESPA, 5 pl Jules Janssen, 92195 Meudon Cedex, France

[3]ESO, K. Schwarzchild Str-2, D 85748 Garching, Germany

[4]LAOG, UJF - BP 53, 38041 Grenoble Cedex 9, France

[5]ONERA, BP 72, 29 av Division Leclerc, 92322 Chatillon Cedex, France

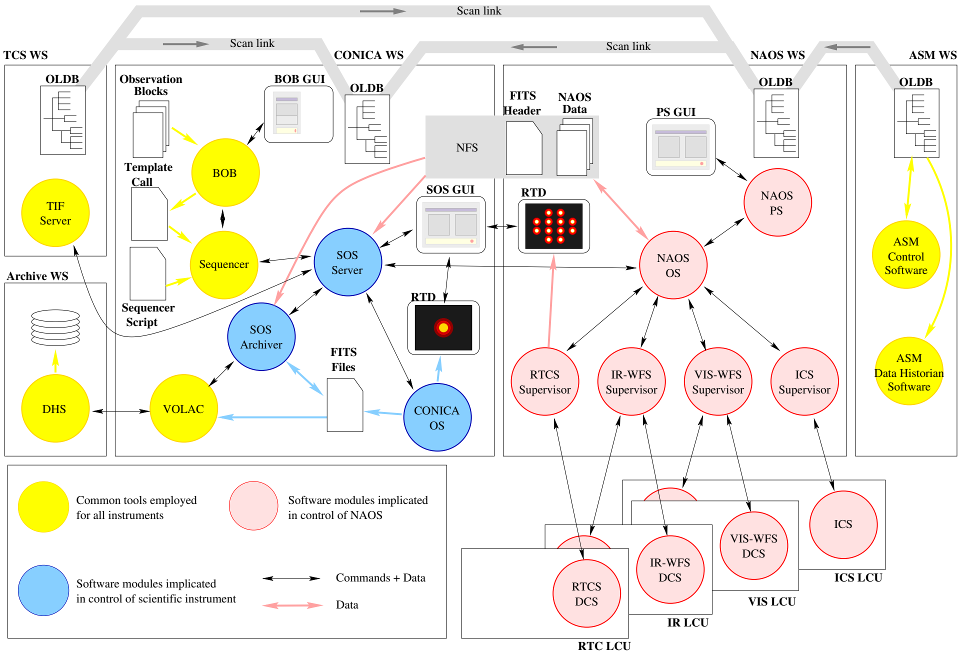

Figure 1. CONICA/NAOS Control Software.

2. Control Software

The control software for an instrument installed on the VLT mainly includes the control of the scientific instrument, the communication with the Telescope Control Software and the archiving of astronomical data into the archive system. It consists in the following standard modules: the **Instrument Control Software** (ICS) which controls all functions belonging to the instrument, the **Detector Control Software** (DCS) in charge of all sub-systems functions involved in detector control and data transfer, and the **Observation Software** dedicated to the global coordination of the observations, as far as the telescope, detectors and motorizations are concerned.

From the NAOS standpoint, the control software also takes care of the adaptive optics system itself, a more complex instrumentation (Real-Time Computers (Rabaud 2000), Wave-Front Sensors, ...) which requires a more complex optimization.

The main concepts and novelties of the software design, to cope with the complexity of the CONICA/NAOS, are explained in the following.

2.1. Software Architecture

The control software is based on a distributed environment of workstations and Local Control Units[1] (LCUs), as described in Figure 1.

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[1]VME-based microprocessor

Concerning the NAOS control software, a hierarchical structure with three level layers has been adopted. On the top level, the SOS coordinates the NAOS and CONICA instruments, providing only one access to the scientific instrument attached on the telescope (CONICA) and the intervening adaptive optics system (NAOS). As a software interface between the softwares in charge of the instruments control, BOB, the Telescope Control System, and the Archive System, the SOS also displays for the observer a summary of the instruments and observing conditions status.

The middle layer consists in the OS which handles the overall observation control with the NAOS instrument. It manages the various sub-systems that are involved during the critical tasks of the adaptive optics system such as the acquisition of the reference source or the centering of the scientific object on the CONICA detector or the observation itself.

The low level consists in sub-system supervisors which are in charge of the control of all functions belonging to the sub-system. Each supervisor has to handle a limited number of dedicated tasks, making easier implementation and improving the maintainability. This architecture offers advantages in modularity and flexibility; each sub-system can be developed and tested in independent ways, and re-used for other instruments.

Moreover, all these software modules have to provide common features such as transferring control information (typically in the form of commands) to sub-systems, synchronizing replies, handling of states and sub-states, etc. All these features have been grouped in a library called Instrument Server Framework (ISF), providing a rich foundation with services for instrument server implementation.

3. Operational Requirement

The control software shall provide an extensive support, from the preparation to the effective observing run for astronomers who differ greatly in experience and many of which are very occasional users of the system.

The preparation of an observation with a VLT instrument consists in building Observation Block (OB) from a list a pre-defined sequences of exposure (so-called template). A template is used to specify setup and/or actions for detector, instrument or telescope. It has input parameters to configure these setup/actions, in accordance with the scientific program. The OB is a set of templates allowing to acquire the science object and to produce astronomical data.

In the case of NAOS, a limited number of templates (about 20) has been defined allowing to prepare observation programs such as imaging, slit spectroscopy or polarimetry with possibility of chopping, nodding or mosaicing.

To support astronomer during this phase, the control software includes the Preparation Software (PS) (Marteau 2000) which is a sophisticated tool providing the accurate and optimized configuration of the adaptive system, according to the scientific program and the observing conditions, on the basis of a permanently updated performance estimation. It can be used by the observer, through a WEB interface, while preparing the observations to assess their feasibility and build observing block. The PS is also available during observing run, giving the possibility of reacting quickly to the changes in the weather and in other conditions by providing the optimized configuration of the system for those conditions.

The Broker for Observation Blocks (BOB) is the common VLT tool used to control, in the same way, all the instruments installed on VLT. It allows to carry out observations automatically, in accordance with the observation program defined by the astronomer during the Phase II Proposal Preparation, and with the pre-defined sequences of exposures.

The Real-Time Display (RTD) is a common VLT tool used by all instruments to display astronomical images, but it is also used to assist the operator during the acquisition of the object to be observed, as well as during the acquisition of the reference source used by the Adaptive Optics System.

4. Maintenance

The NAOS Maintenance Software (MS) is designed to support the technical staff for instrument configuration and for instrument calibration, check-up and troubleshooting. Consequently, it provides tools for editing the hardware configuration of NAOS, but also tools for preparing/executing/analyzing tests, as well as tools for performing instrument calibration and finally tools for configuring/achieving/analyzing data monitoring.

All maintenance operations that require interactions with the instrument (e.g set-up of instrument) are based on the NAOS Control Software (OS, ICS, etc.). Likewise, the tests and calibrations benefit from VLT concepts, namely the templates and the observation blocks, and therefore may be seen as very special observing runs and may be submitted to BOB tool in form of complete Observation blocks.

5. Conclusion and Perspectives

The final design of the NAOS Control Software has been accepted by ESO in March 1999. The development of the Observation Software, as well as the Instrument Server Framework, has been completed in June. The integration with SOS has been done successfully in July, when a preliminary version of several CONICA/NAOS templates could be executed. The complete system, NAOS and CONICA, hardware and software, will be merged in PARIS during year 2000. After a full system qualification and calibration, it will be delivered to ESO by the end of the same year and mounted on the telescope at the end of 2000.

References

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