The TNG Control System. Workstation Control Software and User Interface

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The GALILEO telescope control system (TCS) has been designed bearing in mind three main points. First, the technology based on state-of-the-art components, is subject to quick evolution, making it a hard task to foresee future developments and changes. This means that hardware and software solutions must be found which will guarantee an adequate support for the future, i.e. proprietary systems as well as closed ones should be avoided. The second point concerns the lifespan of such a project. Both the time needed to build the telescope and its operative lifespan must be considered. A control system able to solve current problems only, will not be adequate, as the evolution of astronomical instruments and, even more unpredictable, the evolution of astronomers' requirements cannot be easily foreseen. Last but not least, the needs of those who will be working on the system, developing instruments, high level software modules and the like, must not be disregarded.

As a result the TCS has been designed, and developed, using only stable standard systems, both hardware and software. An open, modular, flexible structure has been chosen for the overall architecture, which has been maintained as homogeneous as possible, keeping the number of hardware and software components as low as current technology permits. Moreover, a set of software interfaces and program modules has been built in order to cover all the underlying details, allowing all kinds of users to operate in a homogeneous and user-friendly environment.

TCS architecture

The TCS architecture is distributed over two physical layers connected by a communication network (fig. 1). The upper level is made up by UNIX workstations which are dedicated to interface the operators to the telescope as well as to the instruments [1]. At the lower level a set of local processors (TLP), based on the VME bus standard, operates directly on the telescope subsystems and on the instruments [2].

In order to screen out the details of the TCS architecture and to ease the access to its components a further logical organization has been mapped over the physical structure (fig. 2). It is based on a hierarchical tree-like four-level structure: at the root level there is the TCS itself, followed by the processing nodes attached to the telescope network, that can be either workstations or local processors, which form the so-called systems level. The next level, the units level, contains the tasks or groups of cooperating tasks, which run inside each local processor and control a particular function of the telescope subsystem to which it is connected. The processes running inside the workstations are also placed at the units level. Both systems and units are characterized by sets of parameters and commands, and are interfaced to the outside world through dedicated interactive panels and messages, which all make up the fourth level, the items level. To access this structure, every reference to a component of the TCS is made by a symbolic name.

The term 'component' in this context refers either to a system connected to the network, to a unit in a system, or to a parameter, a command, an interactive panel, or a message. To meet these requirements a standardized format for the names of all the components of TCS has been defined. This naming convention has been designed in such a way as to reproduce the organization of TCS: each name is built up by one to three fields, specifying the full path needed to reach the desired component inside the logical structure of TCS. The first field will contain the name of the system, the second one the name of the unit and the third the name of the item, either a parameter, a command,

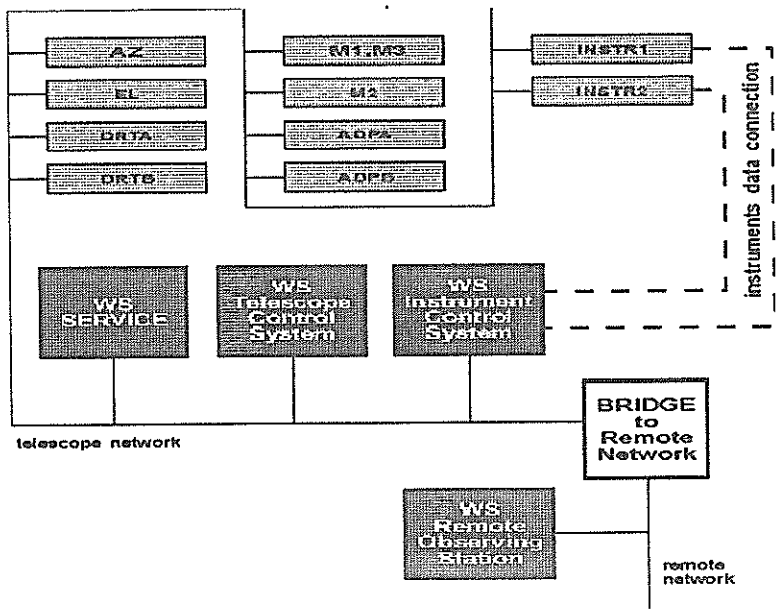

Fig. 1 : TCS Hardware Architecture

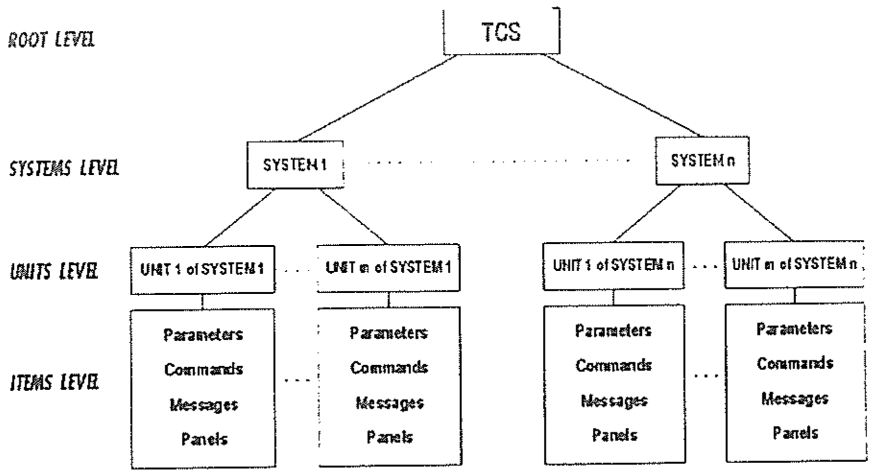

Fig. 2 : TCS Logical Architecture

an interactive panel or a message. The layout of the full name will thus be as follows:

(system)_(unit)_(item)

The same naming convention applies also to the files containing the definition tables needed by TCS tasks to perform their job. A central facility, the TNG Data Base (TDB), has thus been provided in order to contain all the data concerning the TCS system, both the static definitions and the dynamically changing status values, and to transparently manage the conversion from symbolic names to physical addresses. This last task is performed through a library of routines which allow the processes of the Workstation Control System (WCS) to resolve the name-address translation and to access the data.

The Workstation Control System

The WCS is formed by a set of seven processes, each dedicated to a unique task, whose layout and mutual interactions are reported in figure 3. They are described in more detail later. Here we wish to point out some of the distinctive features of WCS:

- fully table driven

All the data needed by WCS processes is organized into tables contained in definition files, which can be created and maintained off-line with a dedicated editor, the Table Editor. It is used by programmers and instrument manufacturers to edit the tables that will define the behavior of an instrument or the appearance of an interface.

- message oriented, Internet based communication protocols

The use of standard communication protocols and the message oriented architecture devised for the WCS, make it robust against common failures and open to new transport technologies. The communication mechanism used is based on two standard UNIX tools: SysV messages and BSD sockets. The former are restricted to the use on a single computer, while the latter use protocols (e.g. TCP/IP) to communicate over computer networks.

This mechanism, with the internetworking capabilities of modern workstations, permits a precise localization of each component of the TCS using TCP/IP and UDP network protocols. It is also a solid base to build a fault tolerant system using UDP broadcast messages as "workstation heartbeats", and TCP/IP timeouts to monitor TLP's activity. It allows the WCS to address each component of TCS, should it belong to the local system or to a remote one, and lends itself naturally to remote operations.

- X-Windows/MOTIF based Graphical User Interface

X-Windows and MOTIF are two widely accepted de facto standard in the field of display and window managers. Their use guarantees the complete compatibility of WCS with future enhancements.

- replicated software structure throughout the workstation systems

The software structure of WCS is exactly replicated in each workstation of the TCS. This includes the replica of the Telescope Data Base and of the definition tables. The different role of each workstation is defined in a configuration file. With careful customization of the definitions inside this file it is possible to build a fault-tolerant system, where each workstation is capable of carrying on the tasks of any of its companion workstations in case of failures.

The seven main processes which make up the WCS are described in the following paragraphs, with the exception of WSDISP, which constitutes the WCS User Interface and will be described later.

The WSINIT process creates the internal TNG Database starting from the configurations tables, launches all the TNG processes, then waits for a signal from any of them. Depending on the particular signal received, WSINIT undertakes the associated actions sequence.

The WSWATCH is a supervisor process which checks the normal execution of all commands sent to local processors.

The TMVER process takes care of communications among a workstation and the associated TLPs. This process enables each TLP to send the relevant telemetry data to the workstation.

WSCOMM. This process takes care of the communications among the local workstation and all other workstations of the TNG system. In particular this allows the user to access the whole TNG database disregarding the physical location of the data, and guarantees some degree of fault tolerance, should one of the connected workstations crash.

DTINP and DTOUT. During an observing session, these processes provide the creation of data files in a predefined format. When an acquisition is completed, the output data from the instrument is read by the DTINP process and stored on a magnetic disk in standard format (big endian integers). The DTOUT process creates a FITS file starting from the files written by DTINP, and writes it on to a suitable storage device.

A special class of WCS processes also exists which has no direct interaction with the external environment. They are called ancillary processes, and are used to support the main WCS processes when the table definitions are no longer sufficient for them to operate properly.

The User Interface

The TNG Control System will make use of many workstations, either local or remote. This fact will entail the need to have a common interface towards the user, no matter which of the telescope subsystems or instruments the particular workstation will be used for. This has been achieved through the development of an user interface building tool, which will allow TNG programmers to develop their own interfaces maintaining a common "look and feel" towards the outside world, and a standard interface towards the WCS environment. The WSDISP process makes up the kernel of the TNG User Interface (TUI). It is an event driven process which is devoted to parse commands issuing from various sources (user, other WCS processes, batch files...), and to manage the output to different targets (TLPs, interactive panels, remote WCS processes...). It is complemented by a set of library routines which allow WCS processes, either local or remote, to interact with the WCS environment: namely the TDB and the message dispatch system. The TUI is composed of a main window, which is the first window that appears to the user at the beginning of a session. From here the user can type commands and see parameters, load view and interactive panels, create new view panels, load a previously saved desktop configuration or obtain access to a hypertext-based on-line help system. There are some other standard windows which can be opened on demand:

- browsers are particular devices that let the user examine parameter values or send commands using a series of lists related to systems and units.
- view panels are built directly by the user and offer a personal view over a set of parameters chosen by the user himself. This kind of panel is edited on-line via a special function of the TUI.
- interactive panels provide a sophisticated method to access the telescope and instrument functions and data.

They are designed by instrument builders using an off-line panel editor. In these panels one can represent line graphics, labels, output indicators (gauges, led bars and status lamps), analog controllers (sliders), digital controllers (toggle buttons) and activators (pushbuttons). Each graphic object or output device can be logically connected to any parameter in the TDB, while interactors, either analog or digital, can be connected to any command.

The Interactive Panel Editor is itself highly interactive: a row of pushbuttons (toolbar) shows the programmer all the components that he can use during the design of a panel. Here one may find static labels; graphic objects, texts, lamps, gauges and led bars with live links to the TDB; sliders and pushbuttons that activate ancillary functions or TLPs' commands. Every component can be positioned, moved and resized using the mouse or keyboard. Links to TDB elements can be easily changed via a set of dialog boxes and menus. Line graphics supports various types of animations (move, stretch, rotate, change color or style). Furthermore color bitmaps can be used as background images to represent the actual appearance of instruments or telescope subsystems.

Conclusions

The TCS development has now reached one of its milestones: the availability of some real TLPs and of some simulated ones will allow extensive tests to be carried out. They will be used to verify the capability of the whole TCS to face a sustained rate of telemetry data transmission from a large number of TLP systems, and to perform contemporarily complex display operations like graphic animations and interactive panel upgrades on a set of control workstations. There are also many new developments and enhancements which are in the design phase, or already in the realization phase. They will include a security access control system, which will separate users into three classes: observers, maintenance personnel and developers. Each class will have access to different levels of TCS, thus protecting the whole environment from unauthorized operations. Moreover a high level astronomical interface is now under design. It will include a catalog browsing and consulting facility, and some visual interfaces dedicated to the telescope environment.

References

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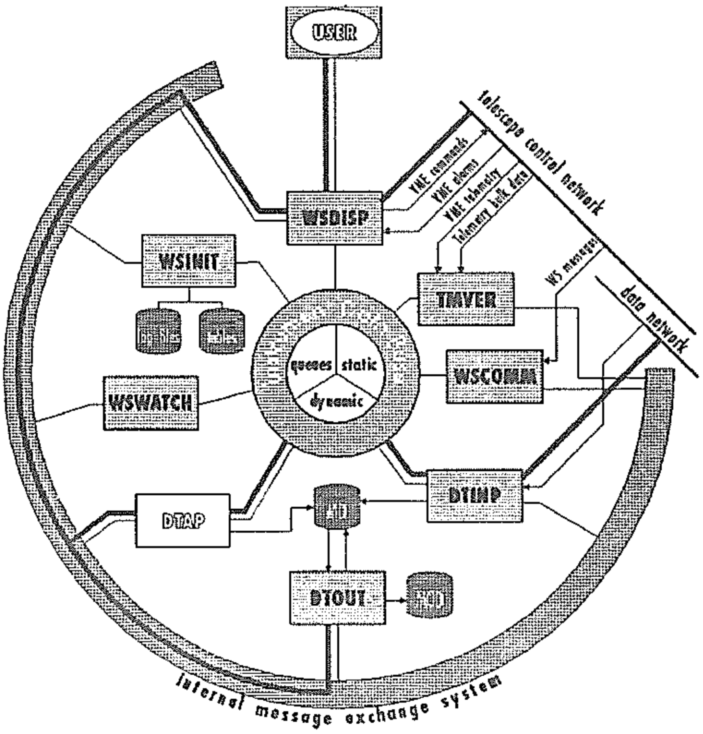

Fig.3: WSS environment