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LBTO Alarm Notification/Management and Error Diagnostic Tools

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Abstract. The Large Binocular Telescope Observatory (LBTO) Telescope Control System (TCS) is comprised of fifteen subsystems and accepts commands from the operator, as well as from six pairs of instruments. To the operator the TCS presents as a high-level set of GUIs with each GUI corresponding to one specific subsystem and providing full state information and varying degrees of control. The TCS GUIs not only provide the operators with broad control over all aspects of the telescope, but each individual GUI also reports problems within its domain through the use of color-coded messages and widgets indicating the seriousness of the issue. While there is significant problem reporting available to the operator, until recently there was no centralized and persistent visual indication or "annunciator" display for issues. In order to provide a way to present problems in a centralized and persistent fashion with "on-the-spot guidance" to ease the job of the operator and to have an acknowledge capability, the LBTO project decided to leverage an existing Alarm Handler which is a GUI client application associated with the Experimental Physics and Industrial Control System (EPICS)[1]. This paper briefly describes the TCS sources of problem reporting information and how the EPICS Alarm Handler supplements the current system.

1. TCS Events

In the TCS paradigm, an event is essentially a software message which is issued by any software subsystem or associated hardware indicating that *something* has happened. An event can be the result of synchronous or asynchronous activity and is used to provide a timestamp for many actions of the TCS. It is rich in data for both near real-time and postmortem diagnostic purposes. Events are managed by the Logging Subsystem (LSS) which is responsible for cataloging the information in an ASCII file (lightweight as there is no database) which is rotated daily, and maintaining a callback list of clients - typically the TCS GUIs. An event is comprised of a number of items: human-readable calendar date and time, MJDUTC, a priority, name of the TCS subsystem, full event name, telescope side (left, right, or both), a message with parameters dynamically populated, and optional audio for urgent events. Events are displayed as timestamped, color-coded messages on not only an LSSGUI which displays events for all TCS subsystems, but also on the specific subsystem GUI in the scrolling message reporting area. The event reporting is useful to keep the operator informed regarding activity of the TCS. However, when problems occur, the number of events generated and displayed can become overwhelming. Moreover, the operator has to scroll-back through the event messages to identify the particular issue. While events contain detailed information regarding activity in the TCS, they do not lend themselves directly as a solid basis for an annunciator-type indicator panel as they only record transitions of state from positive to negative (i.e., *OK* to *error*).

[1]http://www.aps.anl.gov/epics/

2. TCS Data Dictionary Severity Flags

The data dictionary is a hierarchical collection of values, organized by subsystem, representing the status of the TCS or any of the LBTO instruments at a particular moment in time. The data dictionary variables in general are the source of data for the TCS GUIs. The data dictionary has evolved from primarily cataloging values which represent state (e.g., a valve is Open/Closed, or a temperature value from a particular thermocouple) also to maintaining a systematic set of associated severity flags representing the status of hardware components.

Most severity flags are closely associated with events. When a problem is detected, an event which represents a problem is generated, and the subsystem will also set a corresponding data dictionary severity flag to an appropriate value for the condition. In addition, when the subsystem does not detect a problem, no *OK* event is triggered, but the associated data dictionary severity flag is set to the nominal value of *OK*. Table 1 displays the various severity flag values and their associated meaning.

Table 1. Severity flag settings and their meaning for color-coding on TCS GUIs.

Severity Flag	Usage	Color	Explanation
6	unknown	white	Uninitialized variable - startup indicator
5	reserved		
4	OK	green	Nominal value - no attention needed
3	intentional	cyan	Deliberate or non-standard state - no attention needed
2	warning	yellow	Needs attention as time available
1	error	red	Needs *immediate* attention

Data dictionary severity flags are used to color-code specific widgets on a subsystem GUI to indicate the status of that component. While events in the message reporting area will scroll off the display, the color-coding of an indicator denoting a problem will persist as long as the problem persists.

Many of the TCS subsystems involving hardware are hierarchical in nature. For example, the ECS subsystem is comprised of fifteen subcomponents, each of which is comprised of a number of atomic devices (e.g., valves, heaters). The corresponding subsystem GUI, as well as data dictionary severity flags also reflect this organization of information. Each low-level device has an associated severity flag. The next higher level group also has an associated severity flag equal to the worst or highest level of severity among its constituents. This *roll-up* continues until the top of the hierarchy is reached. In implementation, the data dictionary severity flags are coded "bottom up" (i.e., from the most atomic component to the highest level of the subsystem). In navigational usage, the operator follows the color-coded widget trail "top down".

As such, the color-coding of the TCS GUIs enabled via the data dictionary severity flags has been designed to act as breadcrumb navigation whereby the color-coded widgets lead the operator to the appropriate sub-panel and specific indicator representing the problem for faster identification and diagnosis. Data dictionary severity flags provide a robust basis from which to visualize problem areas in a persistent fashion on each TCS GUI.

Unfortunately, the TCS lacked a *centralized* problem reporting GUI and a means to manage conditions effectively. The data dictionary severity flags now serve two purposes: they are used by the TCS GUIs for persistent status and breadcrumb navigation of non-standard conditions, *and* they are exported in support of the EPICS Alarm Handler which fulfils the role of an annunciator.

3. The EPICS Alarm Handler

In order to streamline the process by which the operator identifies problems in the observatory, the LBTO decided to leverage EPICS and its associated Alarm Handler (ALH). The ALH is a GUI which displays an overview of the status of the system in a single, concise view, highlights problem conditions, and provides a means to manage the conditions. Some characteristics of the ALH are

- Presents the components being monitored in a graphical, hierarchical view for easy digestion. The ALH layout echoes that of the TCS subsystems and GUIs, providing consistent organization to the alarm utilities for the operators.
- Brings a condition to the attention of observatory staff via color and sound, where a single character indicator accommodates color blindness.
- New conditions are made conspicuous with a flashing indicator and sound.
- Allows for acknowledgment which is a means to take ownership of a problem.
- Provides guidance in a pop-up GUI or via Web pages for problem resolution.
- Allows external processes to be invoked. The TCS GUI corresponding to the component in alarm can be raised directly from the ALH for efficiency.
- Provides logging of conditions and operator actions for postmortem diagnosis.

Figure 1 shows the EPICS ALH as it is configured for LBTO. The TCS publishes a select subset of its existing data dictionary severity flags for use by the ALH. This gives the TCS the flexibility to control how granular any portion of the ALH needs to be in terms of its knowledge about the TCS. In this way the LBTO exploits the capabilities of the ALH while keeping its layout streamlined and free from the many details already incorporated into the TCS subsystems and GUIs. Since the ALH can invoke commands via its "P" or Process button, the LBTO leverages this functionality and uses it to raise the TCS GUI most closely associated with the particular alarm. This choice supplements preexisting functionality rather than duplicating it.

3.1. Next Steps for Alarm Handling

The EPICS ALH is the newest package in support of the LBTO alarm handling efforts. As we gain more experience with this tool, it will be tuned for the peculiarities of our system. Although the ALH was originally built as an EPICS control system tool, it has been comparatively easy to implement it for use with the LBTO customized TCS. The software Input/Output Controllers (IOCs), one for TCS and one for Information Technology (IT) - essentially the bridges for ingesting the LBTO data and converting the data into a predefined EPICS format, are fairly straightforward parsing programs. The TCS publishes its data dictionary in an ASCII file for use by large GUI displays, so no further development was needed to support the TCS IOC. The IT IOC is reading an ASCII file generated by Zabbix, an enterprise monitoring program, and this will eventually be made more efficient by using the Zabbix API.

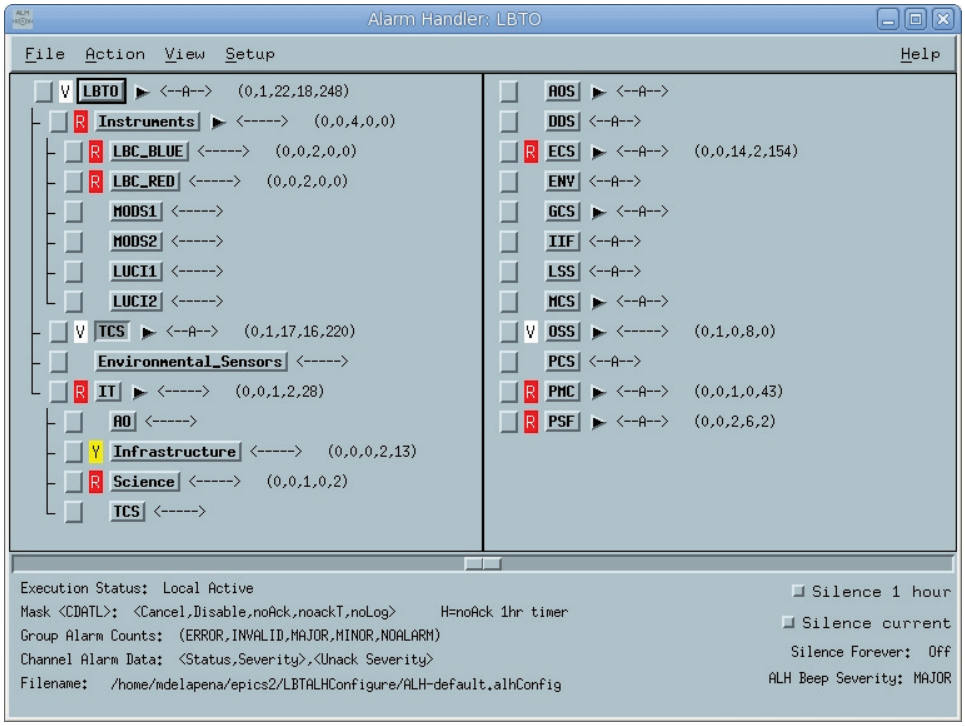

Figure 1. The ALH monitors three major systems at this time: Instruments, TCS, and the IT servers. The Instrument and IT portions of the tree view are open in the left-hand panel to reveal the instruments being monitored, as well as the servers in the observatory which have been grouped according to function. The TCS has been selected, and its subsystems are displayed on the right-hand panel. In addition to the errors (red) and warnings (yellow) depicted, the ALH will also indicate when a particular subsystem is not running as "V" for Invalid (white) as is the case for OSS. Communication errors between the ALH and its IOCs are depicted as "E" for Error (white) which is not shown here. Note the worst alarm condition in the TCS, in this case "V" for OSS, is rolled-up to the next highest level of organization. Among the LBTO constituents of Instruments, TCS, and IT, the TCS has the worst alarm condition which is rolled-up to the highest level - LBTO.