Martin Ettl et al.: The Wettzell System Monitoring Concept and First Realizations, IVS 2010 General Meeting Proceedings, p.444–448
http://ivscc.gsfc.nasa.gov/publications/gm2010/ettl.pdf

The Wettzell System Monitoring Concept and First Realizations

Martin Ettl [1], Alexander Neidhardt [1], Matthias Mühlbauer [2], Christian Plötz [2], Christopher Beaudoin [3]

[1] *Forschungseinrichtung Satellitengeodäsie, TU München, Geodätisches Observatorium Wettzell*

[2] *Bundesamt für Kartographie und Geodäsie, Geodätisches Observatorium Wettzell*

[3] *MIT Haystack Observatory*

Contact author: Martin Ettl, e-mail: `ettl@fs.wettzell.de`

Abstract

Automated monitoring of operational system parameters for the geodetic space techniques is becoming more important in order to improve the geodetic data and to ensure the safety and stability of automatic and remote-controlled observations. Therefore, the Wettzell group has developed the system monitoring software, “SysMon”, which is based on a reliable, remotely-controllable hardware/software realization. A multi-layered data logging system based on a fanless, robust industrial PC with an internal database system is used to collect data from several external, serial, bus, or PCI-based sensors. The internal communication is realized with Remote Procedure Calls (RPC) and uses generative programming with the interface software generator “idl2rpc.pl” developed at Wettzell. Each data monitoring stream can be configured individually via configuration files to define the logging rates or analog-digital-conversion parameters. First realizations are currently installed at the new laser ranging system at Wettzell to address safety issues and at the VLBI station O’Higgins as a meteorological data logger. The system monitoring concept should be realized for the Wettzell radio telescope in the near future.

1. Introduction

Current developments in the Global Geodetic Observing System (GGOS) indicate that permanent monitoring systems (e.g., for the determination of local ties with sub-millimeter accuracy) are needed to achieve the positioning precision goals [7]. The wide range of additional system parameters proposed for the GGOS (e.g., antenna survey, temperature sensors and strain meters in the monument, or radio frequency interference (RFI) monitoring) will further enhance the accuracy of the geodetic solutions computed during the analysis process. Other developments show an increased request for highly automated observations, not only for VLBI but also for Satellite and Lunar Laser Ranging (SLR/LLR). New observing strategies allow remote-controlled sessions from all over the world such that the responsible operator is not required to be within the local vicinity of the controlled system [5]. Therefore, highly sophisticated control systems are needed to provide additional capabilities in order to evaluate the state of devices on which the system depends (e.g., power distributions, servos, meteorology, or cabin and rack temperatures). In addition to these aspects of the monitoring system, security and safety mechanisms must be realized so that human beings on site are protected during automated telescope movements.

To achieve all of these data monitoring, analysis, environmental control, and safety requirements, a group at the Geodetic Observatory Wettzell has designed a dedicated system monitoring concept (SysMon). The main items of this system are (1) monitoring of key system-behavioral data, (2) archiving these data according to the observation epoch, (3) visualization of these data for user interpretation, and (4) prompt operator intervention based on the state of the data. The main drivers behind the SysMon concept are to enhance the operator's knowledge of the system's state as well as to understand the system's behavior during an observation so that this information may be incorporated into post-processing analysis.

2. Basic Ideas and Concept Details

The basic ideas for technical requirements within SysMon are:

- All hardware components are based on standard equipment and robust hardware.
- The SysMon architecture is based on a multi-layer approach. It decomposes the whole system into modules that can be handled easily.
- The system is not limited in the number and type of sensors.
- The standard PC should be passively cooled (fanless) and can work without actuators.
- A Linux operating system with minimal installation overhead is used.
- The SysMon software is based on Open-Source software and is itself Open-Source. It has no dependencies on proprietary solutions (as far as possible).
- The programming language is C/C++.
- The communication part is based on the idl2rpc generator [6].
- The design is vendor independent.

2.1. The Used Hardware Concept

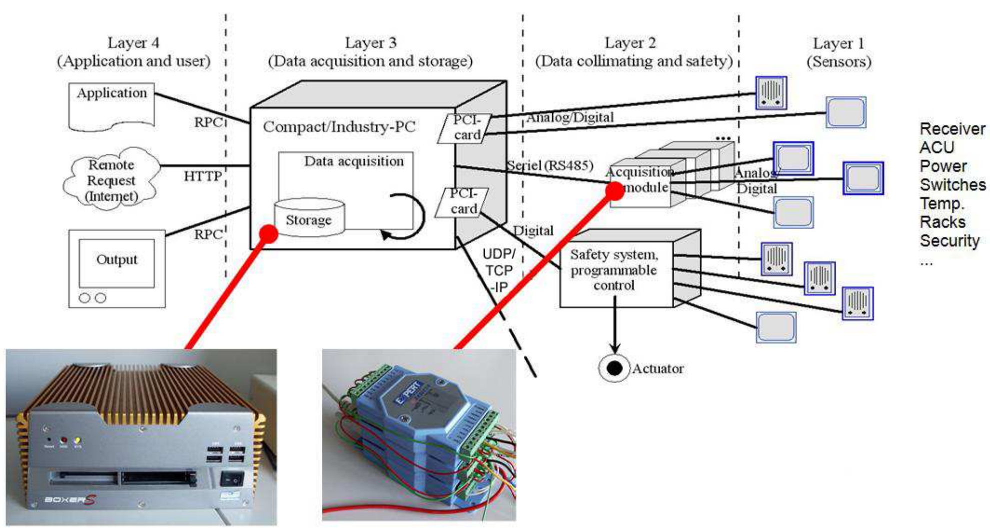

Figure 1. Basic concept with four layers and the according hardware components.

The whole system is decomposed into four layers for sensors, data collimating and safety, data acquisition and storage, and application and user interface (see Figure 1).

Layer one is responsible for the sensors, and only standard components are used. These sensors can be connected to an A/D-converter (analog-to-digital converter) card for a standard PC or via serial interface.

The second layer is optional and can be used to combine sensors with an additional micro-controller or a hardwired solution. Here fast logic decisions can be made in real-time, which are relevant for safety related activities, e.g., on critical interlock errors. Therefore programmable logic controllers or some low-level, proprietary systems can be implemented to protect humans.

The third layer is based on a standard fanless PC which incorporates a minimal (Debian) Linux-based operating system. These PCs are reliable and robust. In this layer, the data are recorded and high-level logic decisions can be made. Data collection from different devices is accomplished with "idl2rpc"-generated communications [6], which offers a low-level middleware based on Open Network Computing Remote Procedure Call (ONC RPC) [2]. The data recording itself is realized with SQLite[1] as a rudimentary database.

Layer four provides the data for visualization, user interaction, and higher-level automation logic. In order to visualize the data [4], a graphical user interface has been built upon the GUI-Framework wxWidgets[2] [8]. This layer can be designed individually and provides high flexibility for applications. Format converters can be realized as Web-based presentation applications for data recorded by the monitoring system. This layer can also be used for direct data requests made by analysts with remote access.

2.2. Software

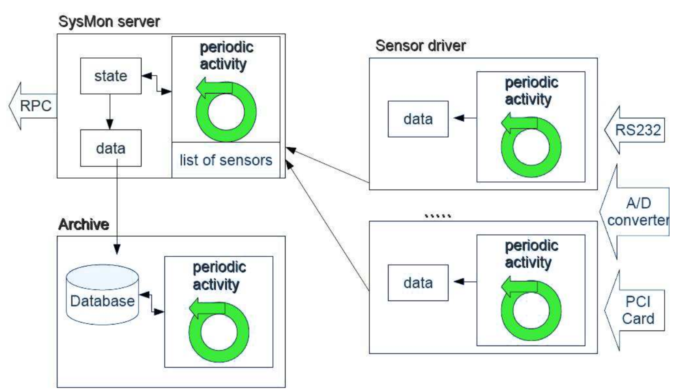

Figure 2. The processes of SysMon on the data acquisition PC.

The software architecture of SysMon (see Figure 2) is based on a client-server model and consists of two main layers. The first layer is built using servers as sensor drivers; these servers directly communicate with the sensor hardware. An internal independent thread reads data directly from the sensor hardware at regular intervals. If needed this layer can directly process low-level operations such as the inclusion of data time-stamps. A parallel thread within the sensor driver process is responsible for answering the asynchronous requests from external clients. The interaction of the external clients with the server is handled by a centralized main process, which

[1] http://www.sqlite.org/
[2] http://www.wxwidgets.org

periodically requests data from each of the sensor servers. This process schedules the requests in an arrival-dependent fashion and transfers the received data in the order of their timestamps to a database server. This database is built on SQLite and stores the data values at time intervals which can be configured independently for each sensor.

The internal communication is generated with "idl2rpc" according to an interface description setup [6]. "idl2rpc" is a middleware generator developed at Wettzell on the basis of ONC RPC [2]. Using this generative programming technique with remote procedure calls, the software development process is simplified since the developers do not have to write their own communication software. Furthermore, a group of developers working on the same project can decompose the software into two units consisting of a client and a server part; the programming of these two modules can be done in parallel amongst the programmers.

All the software published by Wettzell is based on dedicated design rules, standardized by a committee of the observatory [1]. Static[3] and dynamic[4] code analysis tools are used to improve the reliability of the software.

3. First Realizations

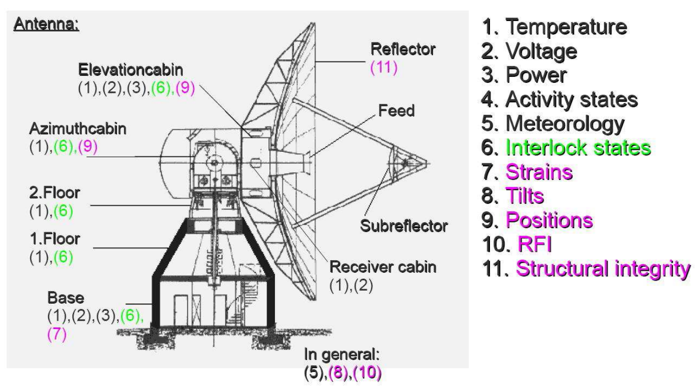

Figure 3. Possible sensor location and categories at the RTW.

As we have described, many of the observations at the radio telescope Wettzell are operated remotely or unattended. This capability has been made possible using a remote control extension to the NASA Field System. To improve safety and reliability during these observations, the first realization of the SysMon will incorporate additional sensors on the telescope (see Figure 3). In addition to these sensors, other analysis-type sensors will be incorporated in order to provide data to enhance the geodetic models. A case study about permanent measurement of the radio telescope's reference point with an automated monitoring system was conducted by the University of Karlsruhe, Germany. It showed that changes in positions could be detected due to load changes or insolation (temperature changes). Therefore the reference point moves its position in both axes by about 0.2 mm over the period of one day [3]. In March 2010, a case study was initiated in which the sensor locations will be determined, e.g., according to useful support of geodetic and structural

[3]http://sourceforge.net/apps/mediawiki/cppcheck
[4]http://valgrind.org/

models and to acquire needed system parameters for automation. Constraints are the RFI behavior and keeping the sensor assembly minimally invasive. In this work, the first software and hardware components for the radio telescope will be developed based on the existing realizations.

Besides the developments and concepts for the RTW, SysMon is also implemented and installed at the new laser ranging system. At this site human safety is the main driver. Because the laser ranging system incorporates an active, non-eyesafe laser, special interlock detectors have been placed at the doors and windows. Additional sensors monitoring electrical power and temperatures in the hardware racks provide a better view of the system performance. A similar approach is under development for a meteorological system at the radio telescope O'Higgins, where the first sensors for wind parameters have already been realized.

4. Conclusion

The concept of SysMon is vendor and platform independent and very flexible and adaptable. It can be used for the different needs in VLBI and SLR as well as in other systems of the geodetic space techniques. Since standardized components (hardware/software) have been selected for the system, costs and development times are significantly reduced relative to those of a system comprised of custom-built hardware and non-standard software. Currently, there are several realizations at the Geodetic Observatory Wettzell and its affiliated sites. In addition to these sites, a cooperation for developing a monitoring standard was founded between the MIT Haystack Observatory and Wettzell during the IVS 2010 General Meeting. There is a close information exchange between these institutes and other related institutions within the VLBI2010 MCI Collaboration group.

References

[1] Dassing, R., Lauber, P., Neidhardt, A., Design-Rules für die objektorientierte Programmierung in C++ und die strukturierte Programmierung in C, Fundamentalstation Wettzell, 2004.

[2] Herlihy, M., The Art of Multiprocessor Programming, Morgan Kaufmann, 2008.

[3] Loesler, M., Eschelbach, C., Schenk, A., Neidhardt, A., Permanentüberwachung des 20 m VLBI-Radioteleskops an der Fundamentalstation in Wettzell, ZfV, 1, 40–48, 2010.

[4] Logan, S., Cross-Platform Development in C++-Building Mac OS-X, Linux and Windows Applications, Addison Wesley, 2008.

[5] Neidhardt, A., Ettl, M., Zeitlhöfler, R., Plötz, C., Mühlbauer, M., Dassing, R., Hase, H., Sobarzo, S., Herrera, C., Alef, W., Rottmann, H., Himwich, E., A concept for remote control of VLBI-telescopes and first experiences at Wettzell, In: Proceedings of the 19th Working Meeting on European VLBI for Geodesy and Astrometry, Bourda, G., Charlot, P., Collioud, A. (eds.), 136–140, 2009.

[6] Neidhardt, A.: Manual for the remote procedure call generator "idl2rpc.pl", Geodetic Observatory Wettzell, 2009.

[7] Rothacher, M., Beutler, G., Bosch, W., Donnellan, A., Gross, R., Hinderer, J., Ma, C., Pearlman, M., Plag, H.-P., Richter, B., Ries, J., Schuh, H., Seitz, F., Shum, C.K., Smith, D.; Thomas, M., Velacognia, E., Wahr, J., Willis, P., Woodworth, P., The future Global Geodetic Observing System (GGOS), In: The Global Geodetic Observing System. Meeting the Requirements of a Global Society on a Changing Planet in 2020, Springer-Verlag, Plag, H.-P., Pearlman, M. (eds.), 2009.

[8] Smart, J., Cross-Platform GUI Programming with wxWidgets, Pearson Education, 2006.