PROCEEDINGS OF SCIENCE

SysMon, a monitoring concept for VLBI and more

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An automated monitoring of operational parameters of VLBI systems is essential when sessions are operated unattended. Such a monitoring system has to be reliable, flexible and stable in case of network, system or human failures. A group at the Geodetic Observatory Wettzell is developing such a system monitoring concept (SysMon), which is a remote controllable, multilayered data logging system, collecting data from several, external, serial-, bus-, or PCI-based sensors. Internally, the communication layer is generated by idl2rpc.pl, a middleware generator, developed at Wettzell. It hides the complexity of the network communication and allows standardized, individual remote procedure interfaces. First realizations of SysMon at the radio telescope Wettzell (RTW) and at the newly installed laser ranging system at Wettzell are almost complete. Within these systems each data monitoring stream can be configured individually via configuration files to define the logging rates or analog-digital-conversion parameters. Further developments are also part of the NEXPReS project (Novel EXplorations Pushing Robust e-VLBI Services). These developments can also be a valuable starting point for up-to-date realizations in future large projects of the VLBI community.

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1. Introduction

Current developments in the Global Geodetic Observing System (GGOS) indicate that permanent monitoring systems (e.g. for the determination of the local-ties in 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 interferences (RFI) monitoring) will further enhance the accuracy of the geodetic solutions computed during the analysis process. Other developments show an increased request of highly automated observations, not only for astronomical telescopes but also for Satellite and Lunar Laser Ranging (SLR/LLR). New observing strategies allow remote-controlled sessions from all over the world to run without the responsible operator's presence needed within the local vicinity of the controlled system[5]. Therefore, highly sophisticated control systems are required to provide additional capabilities in order to evaluate the state of devices on which the system is dependent (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 location 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). Further developments are also part of the NEXPReS project (Novel EXplorations Pushing Robust e-VLBI Services). 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

- 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 easily handled.
- The system is not limited in the number and type of sensors.
- The standard PC should be passively cooled (fan less) 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 is not dependent on proprietary solutions (as far as possible).
- The programming language is C/C++.
- The basic software components are fully unit-tested on several platforms.
- The communication part is based in idl2rpc generator[6].

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- The design is vendor independent.

2.1 The hardware concept

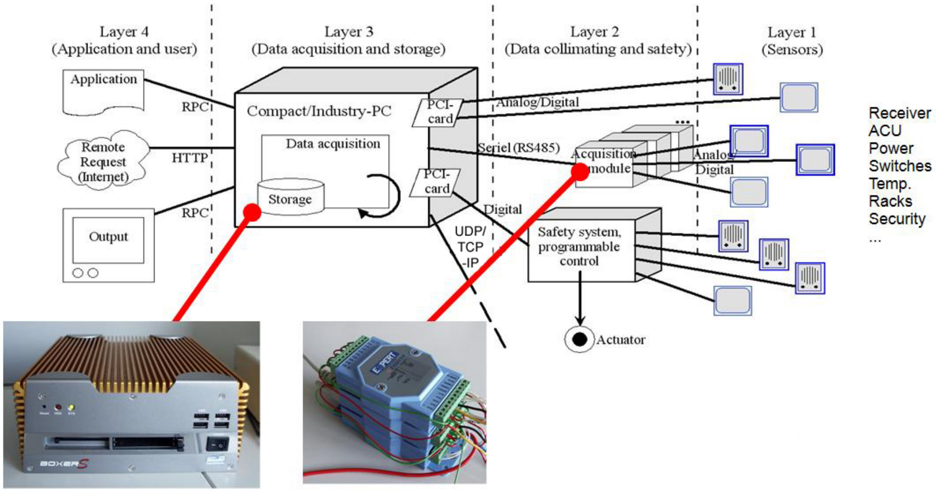

Figure 1: Basic concept with four layers and the according hardware components

The whole system is composed of four layers for sensors, data collimating and safety, data acquisition and storage, and application and user interface (see illustration 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 fan-less 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 can be realized with SQLite as a rudimentary database, or file system storage. 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 wxWidgetssmart2006. 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 The software concept

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

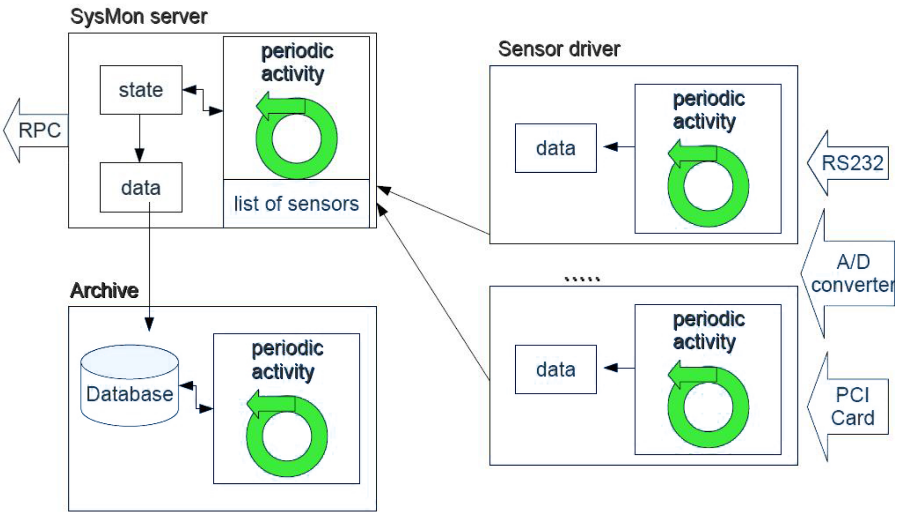

Figure 2: The processes of SysMon on the data aquisition PC

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 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 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 developer does 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 server-part; the programming of these two modules can be done in parallel amongst the programmers. All the software published from Wettzell is based on dedicated design rules, standardized by a committee of the observatory[1]. Static[1] and dynamic[2] code analysis tools are used to improve the reliability of the software. Furthermore, extensive unit-tests of the basic software-components have been created to increase their reliability. It is successfully tested on several Linux platforms with different compiler-versions.

3. First realization

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 developed at Wettzell. To improve safety and reliability during these

[1]http://sourceforge.net/apps/mediawiki/cppcheck
[2]http://valgrind.org/

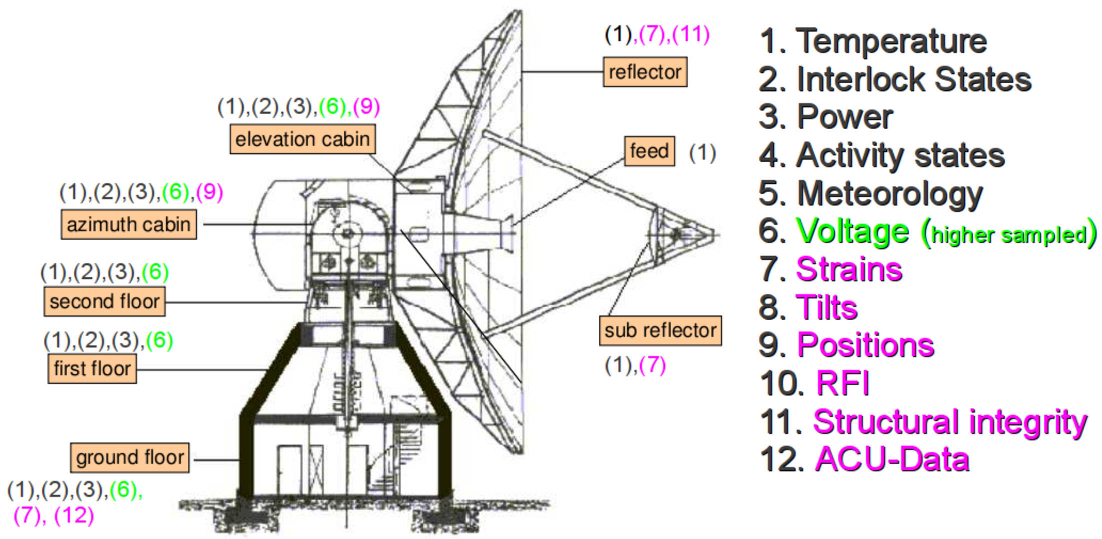

Figure 3: Possible sensor location and categories at the RTW

observations, the first realization of the SysMon will incorporate additional sensors on the telescope (see fig. 3). In addition to these sensors, other analysis-type sensors will be incorporated to provide data to enhance 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 insulation (temperature changes). Therefore the reference point moves its position in both axis of about 0.2 mm over the period of one day[3]. In March 2010, a student case study was initiated in which the sensor locations will be determined, e.g. according to useful support of geodetic and structural 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. Beside 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 a main driver. Because the laser ranging system incorporates an active, non-eye safe 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 site 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 astronomy, VLBI and SLR as well as in the other systems for 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 real-

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izations at the Geodetic Observatory Wettzell and its sites. In addition to these sites, cooperation for developing a monitoring standard was founded between the MIT Haystack Observatory and Wettzell during the General Meeting 2010. There is a close information exchange between these institutes and other related institutions joint in the VLBI2010 MCI Collaboration group. These developments are also part of the NEXPReS project (Novel EXplorations Pushing Robust e-VLBI Services). They can be a valuable starting point for up-to-date realizations in future large projects of the VLBI community.

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