Remote operation of the Pierre Auger Observatory

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Abstract: The different components of the Pierre Auger Observatory, the surface detectors (SD) and the fluorescence telescopes (FD), are operated and maintained mainly by operators on site. In addition, the FD data-acquisition has to be supervised by a shift crew on site to guarantee a smooth operation. To provide access to the detector-systems for experts from remote sites not only increases the knowledge available for the maintenance, but opens the possibility to operate the detector from remote sites. Establishing remote shift operation has the benefit of saving substantial travelling time and cost, but also offers the possibility of remote support for shifters, increasing the quality of the data and the safety of the detector. The monitoring of the Pierre Auger Observatory has been designed with the server and replication scheme for remote availability. In addition, grid based technology has been used to implement the access to the control of the detector to make remote shift operation possible.

Keywords: Pierre Auger Observatory, UHECR, detector operation, monitoring, remote control, remote shift

1 Introduction

The Pierre Auger Observatory measures cosmic rays at the highest energies. The southern site in the province of Mendoza, Argentina, was completed during the year 2008. The instrument [1] was designed to measure extensive air showers with energies ranging from $1 - 100 \text{ EeV}$ and beyond. It combines two complementary observational techniques, the detection of particles on the ground using an array of 1660 water Cherenkov detectors distributed on an area of 3000 km$^2$ and the observation of fluorescence light generated in the atmosphere above the ground by a total of 27 wide-angle Schmidt telescopes positioned at four sites on the border around the ground array. Routine operation of the detectors has started in 2002.

2 Shift operation

The data-acquisition system of the surface detector array is not operated manually. It runs continuously without starting and stopping discrete runs. The duty cycle of the SD reaches almost 100%. The fluorescence telescopes operate on clear, moonless, nights and are sensitive to environmental factors such as rain, strong winds and lightning. Therefore, the telescopes have to be operated manually and the data-acquisition is organized in runs. The operation of the FD is controlled by a shift crew from a control room within the Pierre Auger campus building. A total of 61 shifters per year are required to cover the shift operation of up to 13 hours per night in dark periods of up to 18 days per lunar cycle. These shifters have to travel long distances to be on site.

3 Monitoring

A monitoring system [2] has been developed to help the shifter judge the operation of the FD on the basis of the available information. The overview page for one FD-site is shown in fig.1. An alarm-system has been implemented to notify the shifter in case of occurrences that require immediate action. The monitoring system overviews the operation and maintenance of the SD. Daily checks on the monitoring data of the single surface detectors can identify the onset of failures. This starts a maintenance process which typically leads to an intervention of a crew visiting the surface detector in the field. The maintenance and intervention system realized within the monitoring system of the Pierre Auger Observatory covers the whole work-flow from the alarm being raised to the intervention in the field and finally resolving the alarm. It represents a tailored ticketing system which has been developed for the SD, but is extended to other components like the monitoring system itself.

Technically, the monitoring system is based on a set of databases that store all monitoring information available and a web-interface that is used to display the information
using mainly PHP, JavaScript, JGraph and gnuplot. In the case of the FD, the databases are partially filled locally at the FD sites. The mysql build-in mechanism of replication is used to transport the data to the central database server on the campus. Replication guarantees the completeness of the data in the case of lost connections between the campus and the FD-sites.

An authentication schema and a sophisticated role model allow the user to interact with the monitoring system according to their privileges. These interactions include not only the acknowledgement of an alarm, but also administrative tasks like the configuration of alarms or the assignment of roles to users. The maintenance and intervention system is highly interactive and thus relies on the proper assignment of roles to users.

In addition, replication is used to transport the information to a database on a server in Europe. This server contains the monitoring information in quasi real-time, as long as the internet-connection between the observatory and Europe is stable. The mirror site in Europe can provide the web-interface without additional traffic to the observatory. The problem of an unstable internet connection with limited bandwidth has been addressed by the AugerAccess project [3] that involved the installation of an optical fibre connecting the observatory with the internet backbone.

4 Remote control

The possibility of connecting via internet to the inner control systems of the detector allows the expert for a specific system to inspect it, in case of failure, from all over the world. This supports the local staff who are trained for the operation of the systems, but which cannot have all the knowledge of the experts that developed it. Previously, the low bandwidth of the internet connection to the observatory prevented the knowledge of experts being available on site, leading in the worst case to expensive and time consuming travel to the detector with consequential severe delay in the processing of problems. With AugerAccess the internet connection now provides the required reliability to connect remotely to the system for debugging purposes. Experts (e.g. from Europe) can inspect the system and share their knowledge in understanding the symptom of a problem and its possible cure.

The operation of the FD [4] is secured by a slow-control system. The slow-control system works autonomously and continuously monitors detector and weather conditions. Commands from operators are accepted only if they do not violate safety rules. Data-acquisition takes place within the run-control. These two systems, the slow-control and the run-control, are the main components of the operation of the FD.

The security of a connection to the sensitive inner system of the observatory is established by using grid technologies for the authentication and encrypted protocols. For the access an X.509 certificate obtaining by a national certificate authority is used. These certificates are valid for only one year. Both, a valid certificate and a password are required for authentication, and the user has to be registered on site at the observatory through authorization by an administrator. The remote client alleviate certificate handling includes a single-sign-on with the passphrase to be valid only 24 hours. The graphical user interface allows the renewal of the decryption. The decrypted certificate is checked on every operation, on the DAQ as well as the slow-control.

The system handles the slow-control for operation of the FD system by connecting to the slow-control.
server on the campus via a Grid secured SSH connection and port forwarding. This server in turn is connected to the systems at each FD-site. In this way, the remote operator sees the same interface as the operator in the control room on the campus. An example is given in fig.2. The topology of the services and the connections is illustrated in fig.3.

5 Remote shift

The Pierre Auger Collaboration established a task force to study the feasibility of operating the observatory remotely. The task force was especially concerned with the operation of the FD shifts from a remote control room. This is not necessary for the SD, which operates continuously. In that case, off-site work uses monitoring information to detect malfunctioning detectors as part of the maintenance process. No special arrangements are then needed for off-site SD work, which is part of the monitoring program and can be performed from any site at any time. Since the Auger Collaboration has not had a program of regular on-site shifts for SD, off-site SD shifts do not reduce the workload but do improve maintenance efficiency and, thus, detector performance.

The remote FD-shift aims at reducing the load on the collaborators, since travelling to the site is time-consuming and expensive. Even with the more reliable internet connection via the optical fibre installed as the main part of AugerAccess the connection to the observatory from a remote site, even including other cities in Argentina, is not guaranteed. Therefore, even with shifters operating the observatory remotely, we need to have two shifters on site for safety reasons. Those shifters need not stay focused all the night and can rest while being on call in case of alarms. This way, the number of shifters needed for operation might be reduced in the end by 60%. This is not only a relief for the collaborators, but could also open the possibility of running shifts on nights with even smaller fractions of observing time, thus increasing the scientific output of the observatory.

Shift operation is a good experience, especially for new or young collaborators to get familiar with the detector. Running the shifts remotely prevents the collaborators from getting on-site experience of shifts. On the other hand, it opens the possibility of “dropping in” for just some hours or nights, if no travelling is needed. In addition, the shift might even be partially in normal working time instead of night time making it more attractive to follow the operation. Therefore, remote control rooms open the prospect of getting more people in close contact with the operation of the observatory.

For the operation of the FD, i.e. the data-acquisition, the run-control of the FD has been extended to a client server configuration where the communication is done through grid-authenticated connections using SOAP, a platform and language independent specification that allows one to couple the existing DAQ software [5] with the new remote software components via a message based communication. The client has been developed to cover the same functionality as the previous stand alone run-control running on a central server on the campus. For the development and evaluation phase, before the internet connection of AugerAccess is available, a virtual testbed has been set up at the Karlsruhe Institute of Technology in Germany. This testbed simulates the real systems including firewalls. Only the long connection to Malargüe and its reliability cannot be simulated realistically.
6 Remote control rooms

Ideally a remote control room offers the same functionality as the control room at the observatory, shown in fig.4. But, with the introduction of remote operation, additional communication measures have to be taken in the control room as well. The task force established requirements for making the remote control rooms functional. As at the observatory, two desktop systems, together with one spare system, have to be available for operation of the FD and the Lidar system. In addition, five screens on the wall show the status of each FD site with its telescopes. With one additional screen summarizing the status of the SD, we require at least six screens on the wall to present an overview of the detector systems. The remote control room has to have a prioritized internet connection. This can also be used for video-conferencing with the observatory control room. EVO [6] has been established to be used for video-conferencing within the Auger Collaboration, and we follow its recommendations for the necessary room microphone and video camera. If a network connection is lost, a regular phone with the ability to call international to Argentina has to be available in the remote control room. An alarm will be raised at the observatory if the connection to the remote control room is broken, thus notifying the on-site shifter on call to take over responsibility for the operation. As a first test, a remote control room has been installed at the Bergische Universität Wuppertal, Germany. From here, the first tests of passive shifts, i.e. initially without intervention from the remote control room, are being made. Once the technique is established, it is foreseen to install several remote control rooms distributed all over the world at the major collaborator sites.

7 Summary

The Pierre Auger Observatory and especially the FD data-acquisition is operated on site to guarantee a smooth operation. Access to the detector-systems for experts at remote sites increases the knowledge available for the observatory maintenance. Further, establishing remote shift operation can save substantial travelling time and cost by reducing the number of shifters by up to 60% and offers the possibility of supervising shifters by persons off site, increasing the quality of the data and the safety of the detector. The monitoring program of the Pierre Auger Observatory has been designed for a remote availability. Grid based technology has been used to implement the access to the run-control. Requirements for remote shift rooms have been established and the first passive tests are being performed.

References