High-speed Bandwidth between Europe and Paranal: EVALSO Demonstration Activities and Integration into Operations

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A substantial improvement in the connectivity between the Paranal Observatory and ESO Headquarters has been recently made with the completion of the FP7-funded EVALSO project and its integration into the operational information and communications technology of the observatory. Here we describe the demonstration of capabilities, carried out as the final part of the project; some expected applications in the short term; and the possibilities that are opened up by the availability of such high-bandwidth communication links.

Transferring data between Paranal and Garching

The end-to-end operations model of the ESO facilities on Paranal takes place in a geographically distributed environment, with different parts of the lifecycle of observing programmes taking place either in Garching or at the observatory site. Most users of ESO facilities, either directly through the submission and execution of observing programmes, or through the use of archive data, are already familiar with different components of this model, which was initially implemented at the New Technology Telescope (NTT) in 1997, and extended to the Very Large Telescope (VLT) when it began operation in 1999. The model has evolved substantially since then. The latest additions to the Paranal Observatory, the survey telescopes, VISTA and the VST, have been integrated into this model since they began regular operations, and the Atacama Pathfinder Experiment (APEX) and the Atacama Large Millimeter/submillimeter Array (ALMA) science operations also share many of its features.

Operation in such a distributed environment involves the intercontinental transfer of a wide variety of data, most notably (although certainly not only) the large volume of science and calibration data produced by the instruments each night. The data obtained are quickly controlled for quality and used in a sophisticated instrument health-check process, taking place offline in Garching, which ensures that instruments are kept in optimal operating condition at all times. The immediate availability of data through the ESO archive, which is also physically located in Garching, currently enables authenticated users to download their proprietary data as soon as the data are ingested into the archive, typically a few hours or less after acquisition.

The successful implementation of these features requires the availability of sufficient bandwidth for the intercontinental transfer of the data stream. In the first ten years of VLT operations, the combination of bandwidth costs and the fast growth of data production on Paranal required the transfer of data to Garching to take place through physical media (disks), introducing a delay of one to two weeks between the acquisition of the data and their ingestion in the archive. This delay effectively decoupled the day-to-day operation of the observatory from the detailed quality control process taking place in Europe. A major breakthrough took place in 2008 with the implementation of the transfer of the VLT data stream over the internet (Zampieri et al., 2009), which reduced the time lag between acquisition and ingestion into the archive to a few hours at most. Besides allowing end users to access their data much faster, shortening the operations duty cycle also brought significant improvements in the quality control process. However, the available bandwidth was far from allowing remote near-real-time access to Paranal data, and was not sufficient to handle the increase in data production when VISTA, and more recently the VST, began operations, and at the outset their data still needed to be shipped to Garching in disks.

EVALSO demonstration activities

The recently completed EVALSO infrastructure is the definitive step in overcoming these limitations for the current facilities on Paranal, including the survey telescopes and the second generation instrumentation to become available in the near future. EVALSO (for *Enabling Virtual Access to Latin-American Southern Observatories*) is a consortium of nine organisations partly funded by the European Union under its seventh Framework Programme (FP7) with the goal of setting up a high-bandwidth communications infrastructure between Europe and the observatories of Paranal and Cerro Armazones, the latter operated by the Ruhr-Universität Bochum. A description of the project, the overall infrastructure, its technical implementation and the list of participants has been provided in a previous article in *The Messenger* (Filippi, 2010), and further information is available on the web[1].

As part of the FP7 project, EVALSO included a number of Joint Research Activities with the purpose of demonstrating the scientific value of the new infrastructure. One of these activities exploited the capabilities of EVALSO to establish a virtual presence system at the observatory of Cerro Armazones, while the other two tested the data transfer capabilities between Paranal and Europe and the potential of the new link for remotely performing observations from a European institute with sufficient bandwidth.

The VISTA/VIRCAM data stream, averaging approximately 50 GB (compressed) per night, was sent through the EVALSO link for four months, with a measured, sustained Paranal–Garching transfer rate of 9 MB/s. This rate represents a tenfold increase in capacity over that available until now, making possible the transfer of a typical full night of VIRCAM data (the instrument currently dominating the data stream from Paranal) in less than two hours, and demonstrates the feasibility of transferring the entire Paranal data stream, including the VLT, the VLTI (VLT Interferometer), VISTA and the VST, in less than 24 hours (Romaniello et al., 2011). Given the currently available high bandwidth

between ESO and the Cambridge Astronomical Survey Unit (CASU) in the UK, where full pipeline processing of all data obtained with VIRCAM is routinely carried out, this will open up the possibility of a significantly faster turnaround time in the processing of VIRCAM data in Cambridge in the future. The flow has been limited until now by the time spent in the intercontinental transfer of the hard disks containing the data.

The test configuration of EVALSO was also intensively used during the commissioning of OmegaCAM, as noted by Kuijken (2011). The use of EVALSO on the commissioning of this instrument clearly illustrated some of the advantages of the new high bandwidth capabilities. It allowed remotely located members of the commissioning team to participate in the analysis of the observations shortly after they were obtained, on nearly the same timescale as the commissioning team working at Paranal, which, given the very high data volumes, would have been impossible without EVALSO. The EVALSO link has also been used in its test configuration to support the backend of the OmegaCAM data flow, making the data obtained with this instrument available for detailed quality control and health checking in Garching on the day following the night when the observations were obtained.

Tests on the feasibility of EVALSO to support VLT observations in remote mode were also successfully carried out in May and June 2011. Most of the tests were conducted from Garching using a Linux laptop equipped with a user installation of the Phase 2 Proposal Preparation (P2PP) tool, as well as standard software for astronomical data analysis, including IRAF and the Skycat tool. One set of tests was carried out by a user located at the Vatican Observatory in Italy, to verify the feasibility from other locations in Europe connected to their corresponding National Research and Education Networks (NREN).

The test observations consisted of the execution on Paranal of Observing Blocks (OBs) prepared by the user while keeping a direct voice channel to exchange information between the user and Paranal Science Operations staff. Both raw and pipeline-processed data reaching a staging area in Garching were retrieved by the user via ftp, and, following a quick analysis of the pipeline-processed data, the OBs were modified and resubmitted for execution. This was intended to reproduce the experience of a future remote user interacting with the observatory mainly through the submission of OBs, and being able to modify them in reaction to the results just obtained in the preceding observation. Thanks to the availability of the EVALSO link the observing efficiency approached that of a visiting astronomer carrying out a similar programme from the control room at the observatory, although the results also highlighted the need for additional tools and upgrades of existing ones, as well as other changes in the VLT operations model, to efficiently enable a possible remote observing mode by regular users of ESO facilities in the future.

Integration of EVALSO into operations

Following the successful verification of the new capabilities offered by the EVALSO infrastructure, ESO proceeded towards integrating it into the operations network of the observatory, which was completed in mid-December 2011 and is expected to become fully functional in mid-February 2012. The link from Santiago to Garching is now handled by dual VPN tunnels, one over a link supplied by a commercial provider, and the other by REUNA/RedClara, the Chilean NREN that is one of the EVALSO partners (see Figure 1 of Filippi [2010] for more detail). The passing of traffic over the links is configured using policy-based routing and access control lists to determine the path to be taken for each traffic type, with scientific data regularly taking the REUNA/RedClara link. The same configuration is applied at Paranal, with the EVALSO link being used for the transfer of EVALSO data.

The functionality of the EVALSO/REUNA link has also been verified by the transfer to Garching of scientific data obtained from La Silla, which has worked flawlessly since mid-January 2012. The Paranal transfer through the EVALSO link will start operating regularly in mid-February 2012, with the whole of the VLT/VLTI data stream and all the VST calibration frames being routed through it. VISTA and the rest of the VST data stream will be added shortly after, following some optimisation to be done on the science data transfer software (Zampieri et al., 2009).

The data transfer capabilities offered by EVALSO are already sufficient to significantly improve end-to-end operations by ensuring that the current backend operations procedures applied to the VLT/VLTI data stream thus far can be extended to the entire data stream from all the facilities on Paranal, including the full set of VLT and VLTI second generation instruments as they become operational. The performance is expected to further improve through the optimisation of the data transfer software and the expanded capabilities of the transoceanic link provided by the upgrades of ALICE2. This research infrastructure was created with EU support in 2003 for the establishment of high-capacity interconnectivity within South America and transatlantic connection to European National Research Networks. The high bandwidth connectivity with the observatory provided by EVALSO will in this way open new possibilities, such as a virtual presence at the observatory and a possible implementation of additional observing modes in future VLT operations.

References

Filippi, G. 2010, The Messenger, 142, 2
Kuijken, K. 2011, The Messenger, 146, 8
Romaniello, M. et al. 2011, SPIE, 7737, 53
Zampieri, S. et al. 2009, ASP Conf. Ser., 411, 540

Links

[1] EVALSO web page: http://www.evalso.eu