Network creates virtual super-telescope

June 8 2009

Vast quantities of data are transferred in real time from telescopes around the world to a supercomputer in the Netherlands, where European researchers combine the information to create high-resolution images of distant objects in space.

By pointing up to 16 radio telescopes from six continents at one source in space and combining the observation signals from the telescopes via a high-speed network, European astronomers have created a 'virtual telescope' that delivers better resolution than any single telescope on earth.

The high-speed network also makes it easier for astronomers to react to so-called Targets of Opportunity - transient events such as supernova explosions and gamma-ray bursts in space.

"In November last year, astronomers noticed flaring activity from SS433 and alerted other observatories," says Kristine Yun, public outreach officer for ExPReS (Express Production Real-time e-VLBI Service), the project behind this intercontinental astronomical instrument.

SS433 is one of the most spectacular and intensely studied locations in the Milky Way. It comprises two objects orbiting each other. Huge quantities of hydrogen are transferred from one star to its orbiting partner - a black hole or neutron star inside a dense, gas cloud. The flow of gas is so overwhelming that part of it is re-ejected by the neutron star in a pair of high-speed jets.

Within days, telescopes of the European VLBI Network (EVN) were turned towards SS433. Its activity was monitored in real time during three sessions and the data were made available within hours of the observations.

Breadth adds detail

Very Long Baseline Interferometry (VLBI) is a technique in which radio telescopes around the world are combined to form a virtual telescope with a size equal to the maximum separation between the individual telescopes. The resolution such a telescope achieves is unsurpassed by any other astronomical instrument and allows astronomers to observe cosmic sources in great detail.

Until recently, each telescope made digital disk-based recordings of a source, interspersed by time signals from an atomic clock. The recordings were then physically shipped to the correlator in The Netherlands and combined to generate the higher resolution image. This process typically took weeks.

There are a number of VLBI arrays located in North America, Asia and

Australia, as well as in Europe. The EVN is the most sensitive and includes some of the largest telescopes in the world. EVN is a part-time array with its data correlated and processed at the Joint Institute for VLBI Europe, or JIVE, in The Netherlands.

The high-speed data network developed for the EU-funded ExPReS project enables EVN to undertake real-time electronic or 'e-VLBI' observation. For this purpose, the EVN correlator - a powerful supercomputer located at JIVE - was modified to enable the combination of signals from across the planet in real time.

Typically, EVN telescopes are capable of delivering data at speeds of one Gigabit per second. During e-VLBI sessions, the supercomputer handles data streams totalling about 6 Gb/s.

High-rate data transfer pioneers

With such massive data transfer rates, the ExPReS team has had to pioneer new techniques and technologies in order to get its network to operate effectively. These include the use of light paths, dedicated point-to-point connections between correlator and telescopes. This technology is increasingly being applied to protect "normal" internet users from disruptions caused by demanding applications such as e-VLBI.

Bandwidth-on-demand methods were tested as well, through new developments in light path switching. This could become important in future e-VLBI operations, but is also directly applicable to a vast range of other networking applications where bottlenecks need to be avoided and transfer speed and data integrity must go hand in hand - such as high-bandwidth video and high-fidelity audio transfers.

Creating a functioning network capable of these levels of data delivery was not just a technical challenge, according to Arpad Szomoru, Head of

Technical Operations and R&D at JIVE.

“The amounts of data being transferred required close co-operation between the EVN, the Dutch research and educational network SURFNet, the pan-European GÉANT research network, and national and transcontinental networks in- and outside of Europe,” he notes.

e-VLBI has become a standard part of the operations of EVN, involving telescopes as far apart as Finland, Chile and China.

“The global radio astronomy community is gaining crucial experience from the activities that come from ExPReS,” says Huib van Langevelde, Director of JIVE. “[It] has shown that such interdisciplinary collaborations can revolutionise science.”

The operational lessons learnt by the EVN on ExPReS can be applied to the Square Kilometre Array (SKA) project, due to start construction in 2015. SKA will comprise over 4,000 antennas distributed amongst 200 stations across 3,000km linked via an electronic network.

The ExPReS project received funding from the Research Infrastructures (3I) activities of the EU’s Sixth Framework Programme for research.

Source: ICT Results (cordis.europa.eu/ictresults).