



Faster, deeper, sharper: revolutionising the world of radio-astronomy

Man has always been fascinated by the stars, making astronomy one of the first sciences to develop. As technology has improved, moving from the naked eye to advanced radio telescopes, so has the ability to see further into the universe. Achieving this level of detail requires unparalleled collaboration between telescopes around the world, often in real-time. In fact, the most detailed picture of the universe is obtained by combining the signals from many radio telescopes scattered across the face of the earth. This technique, called VLBI, or Very Long Baseline Interferometry can achieve resolutions one thousand times better than that of the Hubble Space Telescope. With these astronomical observations creating huge amounts of data that needs to be shared quickly, high-speed network connections, such as GÉANT and ORIENTplus, are critical to building a more comprehensive and detailed view of our universe.



The Sheshan 25 m radio telescope
Image courtesy of Shanghai Astronomical Observatory

e-VLBI and ORIENTplus: building the world’s largest telescope

VLBI is applied for high-resolution imaging of distant radio sources in the universe, such as quasars and black holes, and for making accurate measurements of the motion of the earth in space. Multiple radio telescopes - hundreds and thousands of kilometres apart - are used simultaneously in a powerful array to observe the same region of sky. Data from each telescope is then correlated centrally, simulating a single, giant telescope.

Traditionally, VLBI antennas recorded data onto tapes or disks which were then shipped to a central processing site for correlation analysis. This time-consuming process meant that real-time results were impossible to obtain, a particular problem given the short-lived nature of many astronomical events, such as supernovae and other stellar outbursts.

Advanced data-communications networks, such as GÉANT and ORIENTplus, are now making the real-time, electronic transmission of VLBI data (“e-VLBI”) a reality. This network-based approach enables scientists to have immediate access to data (rather than having to wait for several months), even while experiments are in progress. Immediate analysis of data will even allow them to reposition the telescopes in real-time.

One of the driving forces behind the successful use of e-VLBI is the Joint Institute for VLBI in Europe (JIVE). Based in the Netherlands, it coordinates major astronomical projects and is an integral part of the European VLBI Network (EVN), a collaboration of radio astronomical institutes in Europe and other parts of the world, involving 19 telescopes across 13 countries, including China.

Participation of Chinese telescopes in joint EVN observations is particularly significant, since the longest baselines (separation between telescopes) result in the highest image resolution. During a **live demonstration at the ORIENTplus Launch event in April 2013**, JIVE/EVN showcased how the increased link capacity of ORIENTplus allowed seamless data transfer from the Sheshan radio telescope, just outside Shanghai, to Europe, thus acting as a mega-telescope of 10,000 km in width – nearly as big as the face of the earth!

The 25-meter Sheshan radio antenna, operated by EVN member Shanghai Astronomical Observatory, streamed data at 512

The Challenge

To reliably transfer vast amount of observational data from multiple radio telescopes around the world, including China, to a supercomputer in the Netherlands, for processing into images of the universe and quickly distributing these to astronomers and geoscientists.

The Solution

To connect radio telescopes to national high-speed networks, such as the Sheshan antenna to the China Science and Technology Network (CSTNET), and send observation data in real-time over ORIENTplus and GÉANT at the highest possible rate to the central correlator in the Netherlands, connected to the Dutch NREN SURFNet.

Key Benefits

ORIENTplus, GÉANT and national research networks in Europe and China help the European and Chinese radio astronomy communities to revolutionise data sharing, thus contributing to a more comprehensive and detailed view of our universe.

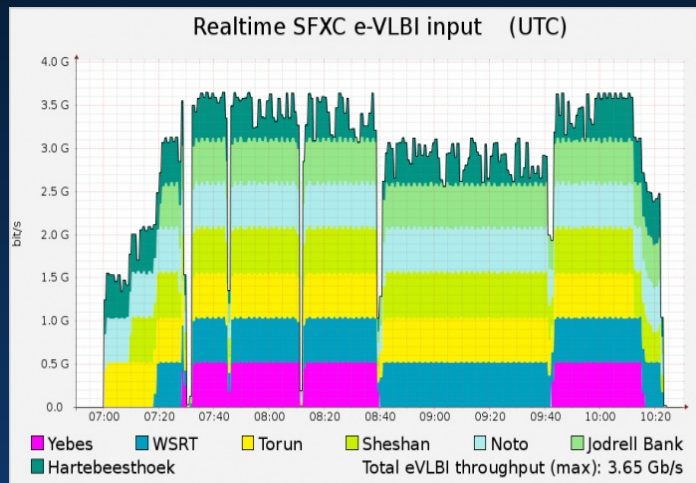
Applications of VLBI and its modern version e-VLBI:

Astronomy

- Highest resolution technique available to astronomers
- Allows sharpest view of the most energetic phenomena in the universe, including expanding supernovae, pulsars, flare stars and the environment surrounding nearby and distant galaxies
- Ability to study transient phenomena with real-time feedback

Geodesy

- High precision (few millimeters) measurements for geophysical investigations, e.g. tectonic plate motions
- Effective earth-orientation predictions, important for military and civilian navigation



At the ORIENTplus launch event in April 2013, the Chinese radio telescope at Sheshan observed radio source 0234+285 with radio telescopes at Jodrell Bank (UK), Hartebeesthoek (ZA), Noto (IT), Torun (PL), Westerbork (NL), and Yebes (ES)

Mbps via ORIENTplus to the central facility at JIVE in the Netherlands, for real-time correlation and processing with data sent simultaneously from EVN telescopes across Europe and South Africa. Prior to the upgrade of the link from 2.5 to 10 Gbps, Sheshan participated in joint e-EVN observations via a light path crossing Canada and the Atlantic Ocean. Offering the highest capacity connection and shortest network path between China and Europe, ORIENTplus can now efficiently and effectively carry out this role, significantly reducing latency.

"With the upgraded ORIENTplus link we are getting ready for connecting more Chinese telescopes at higher bandwidth. Together, European and Asian telescopes offer astronomers an extremely accurate tool to observe the sky!"

JIVE director Huib van Langevelde



The route of traffic via national and regional R&E Internet networks/links of telescopes around the world participating in the demo at the ORIENTplus launch event

ORIENTplus – linking China and Europe

dedicated internet link interconnecting the research and education communities of China and Europe; links CERNET (China Education and Research Network) and CSTNET (China Science and Technology Network) with the pan-European GEANT network via super-fast connectivity between London and Beijing; jointly funded by the European Commission through its 7th Framework Programme, the European NREN partners and the Chinese government until 2014; at 10 Gbps, the highest capacity link and the shortest network path between the two regions; in use by more than 25 substantial, bandwidth-hungry, data intensive collaborations, including participation in the Large Hadron Collider (LHC) studies, Shanghai Astronomical Observatory and genome projects.

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To learn more about ORIENTplus visit:
<http://www.orientplus.eu>

To find out more about JIVE and EVN visit:
<http://www.jive.nl>

