4th RadioNet-FP7

Engineering Forum Workshop

Photonics in Radio Astronomy

Instituto de Telecomunicações,
U. Aveiro Portugal,

2-3 September 2010

Agenda

2nd September 2010

08.45 – 09.15	**Registration**
9.15 – 09.30	**Welcome and Introduction** *R. Keller (MPIfR, DE), D. Barbosa IT, PT)*
09.30 – 10.15	**Optical Fibres and e-MERLIN** *R. Spencer et al (Manchester University, UK)*
10.20 –10.40	**Fibre networks for the SKA** *R. McCool (SPDO)*
10.45 –11.05	**Broadband analogue RF transmission via optical fibre** *T. Berenz (MPIfR, DE)*
11.10 – 11.30	***Coffee Break***
11.30 – 12:00	**The LOFAR data transport system** *P. Maat (ASTRON, NL)*
12.05 – 12.35	**Optical Fibre Network for a radio astronomy receiver** *T. L. Venkatasubramani (SKA-SA)*
12.40 – 13.10	**EXPReS and NEXPReS: the future of European VLBI** *A. Szomoru (JIVE, NL)*
13.10 – 14.30	***Lunch***
14.30 – 15.00	***Optical solutions for astronomical data rates*** *G. Bedö (Nokia Siemens Networks)*
15.05 – 15.35	**Photonic true-time delay antenna beamformer based on a tunable polarization-domain interferometer** *M. V. Drummond (Instituto de Telecomunicações, PT)*
15.40 – 16.10	**Analog optical signal transport and signal processing for the SKA telescope** *P. Maat (ASTRON, NL)*
16.15 – 16.40	***Coffee Break***
16.40– 17.10	**Current state and future aspects of high data rate optical transmission** *H. Wernz et al (Ericsson GmbH, DE)*
17.15 – 17.30	**The GEM project – the R&D status** *D. Barbosa (Instituto de Telecomunicações, PT)*
17.35 –17.50	**Conclusions** *R. Keller (MPIfR, DE)*
18.00 –18.30	**Lab Visit**
20.00 -	***Social Dinner***

3rd September 2010

09.00 –	*Departure from the hotel*
09.45 – 12.30	**Visit at the radio astronomy station in the Portuguese interior** *Guiding Tour*
12:35 –	*Lunch at Fajão*
13.00 – 14.00	*Departure from the site*

ABSTRACTS

Optical Fibres and e-MERLIN

R. Spencer, R. McCool, S. Garrington, C. Shenton & M. Bentle

Manchester University, UK

E-Mail: Ralph.Spencer@manchester.ac.uk

Abstract

The low loss and high intrinsic data carrying capacity mean that optical fibre is the medium of choice for the wide band connections required in modern high sensitivity radio telescopes. The e-MERLIN array makes extensive use of fibre optics, with a specially built fibre network consisting of over 600 km of installed fibre. Data are sent using multiple 10 Gbps laser-modulators back to the correlator situated at Jodrell Bank. Each telescope has 3 x 10 Gbps data streams, giving a total data input to the correlator of 240 Gbps.

Interferometers rely on coherence between the received signals. This requires accurate clocks or local oscillators for each telescope. In old MERLIN this was achieved by using an L-Band go and return link system. We have investigated the use of optical systems for phase and time transfer, and the simplest implementation for us is to use modulate lasers with the L-band link signals. Tests show that the system works well, and so is being implemented on the e-MERLIN fibre network

Fibre networks for the Square Kilometre Array

Roshene Mccool

SKA project Development Office

E-Mail: mccool@skatelescope.org

Abstract

SKA networks.

Broadband analogue RF transmission via optical fibre

Thomas Berenz

Max-Planck-Insitute for Radio Astronomy, Germany

E-Mail: tberenz@mpifr-bonn.mpg.de

Abstract

The talk describes the behaviour of braodband analogue transmission via optical fibre when they are used for astronomical purposes. In this case the fibre as well as the transmitter and receiver are influenced by environmental parameters like temperature and mechanical movement. This leads to an influence on the transmission behaviour in general and the phase and amplitude behaviour in particular.

The LOFAR data transport system

Peter Maat

ASTRON, The Netherlands

E-Mail: maat@astron.nl

Abstract

The LOFAR telescope is phased array technology based radio telescope operating in the (lower) frequency range between 10 to 250 MHz. The LOFAR telescope is one of the pathfinder telescopes for the SKA. At the moment the roll-out phase of the LOFAR telescope is being finalised while its operational phase is commencing. In the current LOFAR design, 36 antenna stations are placed in the Netherlands and about 10 stations in other European countries. After a first data processing step at each station the observation data is transferred to a central processor, which does the final signal processing steps. The transfer of the signals will be performed by the LOFAR data transport system, which will be described in this contribution.

Within LOFAR, commercial-of-the-shelf data transport technology is used for the transfer of the LOFAR data. Two different approaches are used for connecting the LOFAR stations to the central processor. In case of the Dutch stations, the data is transferred via a dedicated network whose fibres and active equipment are owned by the LOFAR organisation. The connections of the E-LOFAR stations are realised via bandwidth services that are provided by the various NRENs in Europe.

In addition to the transfer of the data from the stations to the central processor, the LOFAR data transport system also handles the data traffic at the LOFAR stations and at the central processor. In the design of the data transport system all parts of the network are combined into a single integrated system, in which way efficient connections are realised between the various parts of the system.

In the LOFAR design every station is connected to the central processor via a 10 Gb/s link; at this central processor site an optical 10GbE based network interconnects all central processor subsystems with a total switching capacity of ~3 Tb/s.

In this contribution the design considerations of the LOFAR data transport system are treated and the most important roll-out issues are discussed. In addition, a description of the network control system approach and network security will be given.

At the end of the contribution it is described how the LOFAR data transport approach can be mapped onto the SKA situation.

Optical Fibre Network for a radio astronomy receiver

T. L. Venkatasubramani

SKA-SA, National Research Foundation, South Africa

E-Mail: venkat@ska.ac.za

Abstract

This presentation discusses the factors that go into the design of an analogue optical fibre network for a radio astronomy receiver. Such a network has been implemented for the KAT-7 phase of the SKA SA project, in order to transport the signal from seven antennas to a central node. The measured performance of the chosen optical transmitters and receivers is summarised, and on-going work for the signal transport of the 80-antenna MeerKAT array is presented.

EXPReS and NEXPReS: the future of European VLBI

Arpad Szomoru

Joint Institute for VLBI in Europe (JIVE)

E-Mail: szomoru@jive.nl

Abstract

Through the EXPReS project, which concluded in 2009, e-VLBI has turned into an operational facility of the EVN. By providing rapid response capability to radio astronomers, at equal sensitivity and higher reliability compared to tradional disk-based VLBI, e-VLBI has enabled a large number of scientific publications, mostly dealing with transient phenomena such as flares and supernovae.

e-VLBI, in which the telescopes are connected in real time to the correlator, makes use of a variety of transfer techniques, such as dedicated point-to-point lightpaths, combined lightpaths through channel bonding, VPNs, as well as regular IP-switched connections. At this time, 24-hour e-VLBI sessions are spread throughout the year on pre-arranged dates, at roughly one month intervals.

The NEXPReS project, an EC-funded project which has started on July 1 of 2010, aims to extend the benefits of real-time e-VLBI to all VLBI observations. To accomplish this the complete VLBI observational chain will be modified, high-speed high-capacity data buffers will be developed, to be installed at stations and correlator, bandwidth-on-demand methods will be investigated at 1 and 10Gbps, and semi-automated correlation in a shared infrastructure will be developed.

In my talk I will describe the current state of e-VLBI, followed by an overview of the NEXPReS plans and ambitions.

Optical Solutions for Astronomical data rates

Gerlinde Bedö

Nokia Siermens Networks

E-Mail:

Abstract

In order to achieve and process information with a high resolution, the data rates generated by radio telescopes are very high – we are talking about Terabits. These become even higher when clustering the telescopes, like in the SKA case. The transmission of this high amount of data to a central point where the received information gets evaluated is a huge challenge: In most cases there is no transmission infrastructure, like fibre available, the telescopes are distributed over a wide area, covering some thousands of kilometres, like with SKA and even after compression the data amount remains very high. Moreover, the costs for transmission shall stay in a range far below the costs of building and operating the radio telescope infrastructure.

Latest technology evolutions in optical transmission (DWDM: Dense Wavelength Division Multiplexing) can already cope with high capacity demands and long distances. However, it is not the technology alone which has to solve all transmission needs in radio astronomy. A new fibre infrastructure has to be built – by selecting the most cost efficient one out of several choices. Planning, building and operating the transmission network are not the radio astronomy business – but mandatory to evaluate the data collected by the telescopes. Also here choices have to be made.

This presentation will show the transmission challenges and aspects – from a technological, infrastructural and operational point of view. It will highlight the various options and compare them – keeping an eye on Total Cost of Ownership.

Photonic True-Time Delay Antenna Beamformer based on a Tunable Polarization-Domain Interferometer

M. V. Drummond, P. Monteiro & R. N. Nogueira

Instituto de Telecomunicações, Portugal

E-Mail: mvd@av.it.pt

Abstract

Phased array antennas (PAAs) are key elements in modern radar and wireless communication systems. With such antennas, beamforming can be done by simply adjusting the phase of the RF feeding signals, avoiding the use of moveable parts. If a constant phase adjustment is employed on the RF feeding signals, only the RF carrier will point to the correct direction. Different frequencies point to different directions, causing beam squinting. Such problem is particularly serious in broadband applications, such as next generation radio over fiber systems [2].

Beam squinting does not occur if true-time delay (TTD) techniques are used instead of constant phase shifters, as the phase shifts applied to the RF feeding signals now depend on the RF frequency. TTD techniques are based on delaying the RF signals. As microwave photonics time delay techniques present low loss, high time bandwidth products, light weight and immunity to electromagnetic interference, photonic TTD antenna beamformers have been intensively investigated over the last years. The simplest approach consists on using fibers with different lengths in order to induce different time delays. Such approach presents the problem of needing a considerable number of fibers if the PAA is composed by many antennas, resulting in a bulky system. Furthermore, continuous time delay adjustment needs tunable delay lines. Another well known approach is to modulate the RF signal on different optical carriers with a given wavelength spacing, and then delaying them using a single dispersive media. However, the number of optical sources scales with the number of antennas, and chromatic dispersion RF fading occurs when double sideband modulation is used.

In this paper we present a photonic TTD antenna beamformer based on a novel operation principle. The beamformer is based on a polarization-domain interferometer (PDI) with M outputs, where M is the number of antennas. Each output has a tunable coupling ratio, which allows continuously tuning the delay between 0 and τ, where τ is the differential group delay (DGD) of the PDI. The operation principle is similar to the one presented in [6], with the difference that in this work the tunability is performed on the group delay. The proposed antenna beamformer uses only one optical source that needs not to be wavelength tunable and a single piece of polarization maintaining fiber (PMF), followed by a 1:M optical splitter. Each one of the splitter outputs has a polarization controller and a polarizer. Since the operation principle is not based on chromatic dispersion, no RF fading problems occur. Radiation patterns considering ideal isotropic antennas demonstrate a nearly ideal

behaviour.

Analog optical signal transport and signal processing for the SKA telescope

Peter Maat

ASTRON, The Netherlands

E-Mail: maat@astron.nl

Abstract

Within the future SKA system large amounts of observation data needs to be transported. The long haul connections in the back-end of the system will use digital optical technology while in the front-end of the system it is likely that in addition to digital data transport, also analog signal transfer technology will be applied. In case longer distance, higher frequency signal transfer is needed, optical analog link (AOL) technology is a good alternative for coaxial cable based signal transfer, thanks to the broadband and low loss properties of AOLs. Also its light weight and RFI immunity characteristics are advantageous in astronomy observation systems.

Many different AOL types and components are available. Some of them provide a high AOL performance but require complex transmitter and receiver schemes, while other have a lower price level but provide less performance. The introducion of AOL technology in the SKA system (design) depends strongly on the AOLprice/performance level in relation to alternative technology approaches.

Thanks to recent developments in the AOL component market, many novel components with a reduced price level have become available, leading to a strong reduction of the higher performance AOL pricing level and an increased applicability of this technology. In this contribution the application of the novel AOL technology in phased array front-end systems is treated. For this, both the optical properties of the system are described, using an experimentally verified AOL model, and the RF properties of the RF font-end system with AOL are determined. In this description, both external modulation and direct modulation techniques are treated.

In addition to the technology description, also AOL cost level information is provided, with which it is shown that suitable low cost, high performance AOL technology is available for the SKA.

At the end of the presentation the most important and relevant microwave-photonic signal processing technologies will shortly summarized and the (latest results from) photonic phased array receiver system that has been developed at ASTRON will be presented.

Current state and future aspects of high data rate optical transmission

H. Wernz, H. Griesser, S. Bayer, S. Herbst

Ericsson GmbH, Gerberstr. 33, D-71522 Backnang, Gemany

E-Mail: horst.wernz@ericsson.com

Abstract

First a short historical review of optical communication is given, with reference to the most important milestones for progress. The current standard of technology is discussed and the principle function of the Ericsson 100 Gbit/s demonstrator is explained. A final overview of current industrial research objectives and challenges leads over to the subsequent discussion.

The Galactic Emission Mapping project – R&D status

Domingos Barbosa

Instituto de Telecomunicações, Portugal

E-Mail: dbarbosa@av.it.pt

Abstract

GEM is a collaboration aiming the mapping of the polarized galactic continuum emission from S to X band to be used by Cosmic Microwave Background experiments as a foreground template provider. This shall improve diffuse Component separation and constitutes a key aspect for the next generation of CMB missions to detect primordial Universe signal. In C band it uses a cryogenic receiver with a digital polarimeter implemented on a FPGA. I will describe briefly the GEM project, its aims and current status, prior to the visit of the GEM base in central Portugal.