Title: Orbiting Low Frequency Antennas for Radio Astronomy **(OLFAR): Distributed Signal processing**

Authors:

R.T.Rajan[1,2]

Co-Authors:

Alex Budianu[3], Steven Engelen[2], Alle-Jan van der Veen[2], Mark Bentum[2,3], Albert-Jan Boonstra[1], Chris Verhoeven[2]

Organizations:

[1] ASTRON, Dwingeloo, The Netherlands

[2] TU Delft, Delft, The Netherlands

[3] University of Twente, Twente, The Netherlands

Contacts

R. T. Rajan, ASTRON,

P.O. Box 2, 7900 AA Dwingeloo, The Netherlands

Phone: +31 521 595 100, Email:rajan@astron.nl

A. Budianu, University of Twente,

P.O. Box 217, 7500 AE Enschede, The Netherlands

Phone: +31 53 4893872, Email: a.budianu@utwente.nl

Steven Engelen, TU Delft,

Faculty of Aerospace Engineering - Space System Engineering

Kluyverweg 1, 2629 HS Delft, The Netherlands

Phone: +31 15-278 6098, Email s.engelen@tudelft.nl

Alle-Jan van der Veen, TU Delft,

Faculty of EWI/Electrical Engineering

Mekelweg 4, 2628 CD Delft, The Netherlands

Phone: +31 15 278 6240, Email a.j.vanderveen@tudelft.nl

Albert-Jan Boonstra, ASTRON,
P.O. Box 2, 7900 AA Dwingeloo, The Netherlands
Phone: +31 521 595 100, Email:boonstra@astron.nl

C.J.M. Verhoeven, TU Delft,
Faculty of Aerospace Engineering - Space System Engineering
Kluyverweg 1, 2629 HS Delft, The Netherlands
Phone: +31 15-278 6482, Email c.j.m.verhoeven@tudelft.nl

M.J. Bentum, University of Twente
Faculty of Electrical Engineering, Mathematics & Computer Science
P.O. Box 217, 7500 AE Enschede, The Netherlands
Phone: +31 53 4892108, Email: m.j.bentum@utwente.nl

Abstract:

Recently, new and interesting science drivers have emerged in the ultra low frequency range of 0.3-30 MHz ranging from the epoch of re-ionization, exo-planets, ultra-high energy cosmic rays and studies of the astronomical dark ages. However at these wavelengths, ground based observations are severely limited due to ionospheric distortions below 50MHz, manmade interference, complete reflection of radio waves below 30MHz and even solar flares [1].

OLFAR project aims to design and develop a detailed system concept for a swarm (>50) of scalable autonomous nano satellites in space (well above the Ionosphere) to be used as a scientific instrument at for ultra low frequency observations [1]. Each of these nano satellites will be identical and consist of a deployable antenna for very low frequencies. The large number of such satellites spread over large distances will collectively synthesize an aperture dish of diameter 100 kilometres.

Distributed Algorithms/Signal Processing:

The OLFAR cluster will be free of a centralized mother ship to avoid single point of failure and to improve scalability, which means all the on board signal processing will be completely distributed. Distributed signal processing refers to new paradigms in self-organising wireless networks where nodes communicate only to their immediate neighbours and try arriving at joint conclusions thereby minimizing the communication overhead. Readily feasible, energy efficient, low-cost and reliable distributed algorithms for localization, synchronization and processing are needed to maintain network coherence and meet the scientific goals of the instrument.

Localization: The cluster itself may be located either in Sun orbit, Moon orbit or Earth-Moon L2, far away from earth. Independent of the cluster location, the relative positions of the satellites within the cluster has to been known with accuracies of 1 meter in 100 Kilometres, to make radio maps of the sky at ultra long wavelengths

Synchronization: Each satellite in the OLFAR cluster will be equipped with a light weight Rubidium clock to maintain accurate time stamps during observations. Despite the high

standard, clocks are susceptible to both phase and frequency drifts which need to be corrected. within accuracies of few tens of nano seconds.

Processing: Data fusion (Correlation / Beamforming) of time sensitive data have to be performed to make images of the sky. However it is expensive to make cross-correlation among all possible antenna pairs at all times [2]. Thus In addition distributed signal processing architectures will be investigated to minimize communication overload and maximize results.

The algorithms developed for distributed processing, localization and synchronization will have direct implications on earth based applications such as monitoring the health status of humans, animals, plants and the environment; control and instrumentation of industrial machines and home appliances; homeland security; detection of chemical nad biological threats and leaks etc

References

[1] M.J. Bentum, C.J.M. Verhoeven, A.J. Boonstra, A.J. van der Veen and E.K.A. Gill, “A Novel Astronomical Application for Formation Flying Small Satellites,” 60th International Astronautical Congress, Daejeon, Republic of Korea, 12 – 16 October, 2009

[2] R.T. Rajan, S. Engelen, M.J.Bentum and C.J.M. Verhoeven, “The Orbiting Low Frequency Antenna Array”, IEEE Aerospace Conference, March 5-12, 2011, Big Sky, Montana, US,