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Author: Mr. Alex Budianu
University of Twente, The Netherlands, a.budianu@utwente.nl

Mr. Raj Thilak Rajan
Netherlands Institute for Radio Astronomy (ASTRON), The Netherlands, rajan@astron.nl
Mr. Steven Engelen
Delft University of Technology (TU Delft), The Netherlands, s.engelen2@gmail.com
Dr. Arjan Meijerink
University of Twente, The Netherlands, a.meijerink@utwente.nl
Dr. Chris Verhoeven
Delft University of Technology (TU Delft), The Netherlands, c.j.m.verhoeven@tudelft.nl
Dr. Mark Bentum
University of Twente, The Netherlands, m.j.bentum@utwente.nl

OLFAR: ADAPTIVE TOPOLOGY FOR SATELLITE SWARMS

Abstract

Low-frequency space observation is one of the developing directions in radio astronomy, as scientists try to reveal more of the universe. Past and present efforts concentrate on frequencies higher than 30 MHz. Below this value, Earth's ionospheric properties and man-made RFI make ground-based observation impossible. Analyzing ultra long EM waves in the almost unexplored 0.3–30 MHz band is highly important since this will give new information about phenomena we have up to now failed to understand.

The "Orbiting Low Frequency Array for Radio astronomy" project—OLFAR—is looking to overcome all of the difficulties by placing an array of antennas for ultra long wavelength observation, far from Earth. OLFAR consists of over 50 identical nano-satellites. The satellites will form a dynamic swarm which collects and processes data, and as the amount of data is so large, it is impossible to send it all directly to a base-station on Earth. The processing will be done mainly onboard with procedures which will take advantage of the distributed nature of the system. This requires the satellites to share their data with all of the other satellites in the swarm. Therefore the system will have to form a high-throughput network; robust to its topographical changes.

A full mesh topology matches the requirements but it is not feasible for a swarm since the distances between nodes will be up to 100 kilometers. In addition to this, the amount of information will increase exponentially with the number of satellites, overloading the swarm with communication duties and removing resources from its main responsibility—space observation. To minimize data distribution efforts a different topology has to be employed.

In order to have an efficient communication system, the swarm will be divided into multiple sectors which exchange information through designated gateway nodes. The designated gateway satellites will use their resources only for communication purposes, while the other members of the swarm will take care of the observation processes. Assigning different roles to the nodes will have a strong dependency on the topographical distribution of the network. Satellites will orbit according to known laws, and available positioning details can be used to attain an optimized swarm.

In this paper we consider an adaptive topology that best supports the needs of the OLFAR satellite swarm. We propose a position-dependent clustering method and show that it maximizes the duty cycle of the system without any compromise on resolution or sensitivity.