The Communication Layer for the OLFAR Satellite Swarm

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Abstract

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Recently, new directions in astronomy are investigated as space observations tend to evolve from optical observations to the low-frequency domain. Ultra-long EM waves are the result of planetary emissions from outside and inside the solar system and of high-energy particle interactions. Exploring this band would create an image of our younger universe and uncover a lot of the so called astronomical "dark ages" [1].

Earth-bound astronomy in frequency bands below 30 MHz is practically impossible due to the instability and sometimes complete opaqueness of the ionosphere and the presence of man-made interference. One solution to overcome this is to have a space-based array of satellites that will observe these ultra-long wavelengths, process the information onboard, and then send it to a base station on Earth. The system will consist of a swarm of 50–1000 identical nano-satellites (sensors) spread over kilometric distances that will orbit faraway from terrestrial RFI [2, 3]. The distributed solution provides redundancy and robustness as it is insensitive to failure or non-availability of a fraction of its components. Yet it comes with a few challenges regarding the data flow within the system.

OLFAR is a network of satellites which collects and distributes information within itself adapting continuously to the relative position of the nodes. Since the satellites orbit according to known laws, localization details can be used to switch between communication techniques in order to achieve maximum possible throughput. The average inter-satellite transmission rate will increase as the swarm will be more compact, and will go down once the distances grow larger. When a satellite is in the vicinity of another satellite, the signal attenuation will be very low and the communication channel will have high SNR. Coding information will then be reduced and higher order constellations will be applied, all of these resulting in high-speed links. The collected data has to be available at every node in the network, and although adaptive communication may solve half of the problem, adequate topology control is also required [4]. Fortunately, orbital information is of great use in this case also. Spread over great distances, the network shall be clustered in such a manner that it serves its primal purpose—observations at ultra-long wavelengths—and all the other distributed algorithms for imaging and synchronization.

In conclusion, our desire is to attain a maximum-efficiency swarm which will change its physical and logical characteristics depending on position information. The method we propose minimizes the communication time and increases the duty cycle of the satellite system, and can be extended to any type of dynamic wireless sensor network.

References

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