Networking Protocols for Extraterrestrial Intelligence

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Abstract

Can you imagine Communication between earth and stars through Interstellar Internet from 93 billion miles away. With the help of National Institute of Standards and Technology (NIST) know-how, reality soon may catch up with imagination.

Keywords

Extraterrestrial Intelligence (ETI), Mysterious satellites, RF communications, realistic interstellar explorer(RISE),wall-plug, Parallel Cantilever Bi-axial Micro-Positioner, Optical Communications, Star tracker etc.

I. INTRODUCTION

In 1979 psychologist Baird participated in a NASA study group, which included astronomers, engineers and physicists, on the feasibility of detecting and understanding an extraterrestrial message. He concluded that introspection and a wider perspective is required first, putting aside many narrow earth-bound assumptions and mindsets.

A) Motivation of Interstellar communication over Interstellar Internet

Perhaps long ago Advanced ETI (Extraterrestrial Intelligence) civilizations established a permanent network to link the inhabitated planets. If so, the first signal we receive can come from an Interstellar Internet. Such a network can bring libraries of information with relatively close reach of words. "Mysterious satellites" were officially reported six times in orbit around the Earth in the 1950s before the first Sputnik of October 4, 1957.

Even in the Space Age, an unknown satellite, tracked by the Navy's Space Survelienance Radar and photographed by Grumman Aircraft Company's tracking camera, was seen in retrograde orbit from late 1959 to mid-1960, traveling east to west direction at a speed of 25,000 mph, none of this nature have been launched from Earth.

For more than 20 years, an Interstellar Precursor Mission has been discussed as a high-priority mission for multiple scientific objectives.

II. CONCEPTUAL DESIGN

The optical and RF communications systems envisioned for this mission, in which the spacecraft has a projected range of 1000 AU. Well before a range of 100 AU interactive control of the spacecraft becomes nearly impossible, necessitating a highly autonomous craft and one-way communications to Earth. An approach is taken in which the role of the optical downlink is emphasized for data transfer and that of the microwave uplink emphasized for commands. The communication system is strongly influenced by the large distances involved, the high velocities (20 AU/year or ~ 95 km/s) as well as the requirements for low-mass (~ 10 kg), low prime power (~ 15 W), reliability, and spacecraft autonomy. An optical terminal concept is described that has low mass and prime power in a highly integrated and novel architecture, but new technologies are needed to meet the range, mass, and power requirements. These include high-power, "wall-plug" efficient diode-pumped fiber lasers; compact, lightweight, and low-power micro-electromechanical (MEM) beam steering elements; and lightweight diffractive quasi-membrane optics. In addition, a very accurate star tracking mechanism must be fully integrated with the laser downlink to achieve unprecedented pointing accuracy (~ 400 nrad RMS).

III. GOALS

The primary goal of the RISE mission is to send a probe through the boundary of the heliosphere to obtain scientific data. Several purposes given for this mission include: exploring the interstellar medium, the structure of the heliosphere and its interaction with the interstellar medium, and several astrophysical processes and phenomena.

A secondary goal is to put the RISE spacecraft on a course with an ultimate destination of a nearby solar system. The boundary of the heliosphere is ~ 300 AU. To reach the 1000 AU mission range within the anticipated mission time of 50 years requires that the RISE spacecraft achieve a high escape velocity. To achieve this it is necessary to use a solar gravity assist based on a launch to Jupiter with a retrograde slingshot trajectory to eliminate heliocentric angular momentum. In its trajectory it is necessary for the

RISE spacecraft to fall within four solar radii of the sun's center at perihelion. To also reach another nearby solar system of interest, the RISE spacecraft will be pointed towards Epsilon (å) Eridani.

The Delta III launch vehicle planned for this mission will deploy the RISE spacecraft in a "cocoon" structure to protect the spacecraft until it passes Jupiter and completes it's solar perihelion maneuver, after which it is jettisoned.

Once two-way communication is lost, the Interstellar Probe enters an autonomous mode with only infrequent downlinks.

The design requirements are

- a range up to 1000 AU, downlink
- optical antenna of 1 meter diameter
- receive telescope aperture of 4 meters
- bit rate of 500 bps in a burst mode, pointing accuracy of 400 nrad (1-ó)
- bit error rate of 10-6
- mass of 10 kg
- effective prime power of 15 W (intermittently available).

The proposed realistic interstellar explorer is required to point the optical "antenna" bore sight at a receiver on Earth once a day to well within the beam width of the laser transmitter, which is approximately 2.4 µrad for a 1 micron wavelength transmitter. This corresponds to an absolute pointing and control requirement of ± 400 nrad (1-ó). In order to achieve such a tight pointing requirement, a number of errors must be characterized and controlled.

IV. ELECTRONICS ARCHITECTURE

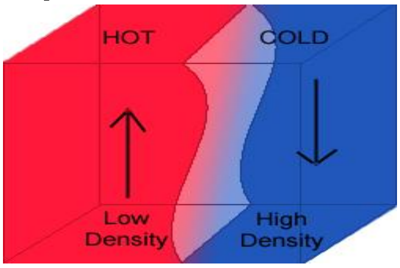
In design concept we assumed that the electronics architecture is constructed from standard 4 x 4 in circuits boards would be used in an APL developed integrated electronics module. It contains the transmitter, star tracker, and inertial measurement unit (IMU) package as an integral unit. From left to right it contains power conditioner, fiber lasers, laser drivers, FPA and track processor power conditioner, tracking and data processor, laser downlink modulators, beam steerer drivers, and a monolithic block containing the IMU, beam steerer actuators, fiber-to-free space coupler, focal plane arrays, and input optics.

V. PROBLEMS TO BE CONSIDERED

The chief difficulty with actually carrying out such a mission is the need for reaching significant penetration into the interstellar medium (˜1000 Astronomical Units (AU)) within the working lifetime of the initiators (<50 years).

VI. THE MIXING LAYER

Mixing layers involve interaction between very different phases of the Inter Stellar Medium. Though mixing layer is a vague term, it typically refers to areas where hot (10^6 k), high density outflowing gas (possibly generated by supernovae explosions) pass cooler, higher density turbulent clouds (10^4 k). These interfaces are fairly ubiquitous in the ISM.



To model these regions we had to restrict physical laws slightly. Gradients are taken over 3 pixels and equations of motion measure the flux through pixel walls. Fortunately, not too much information is lost and approximations are fairly good. The biggest headache is generating realistic boundary conditions. The real ISM has a large steady source of energy which replenishes what is lost.

VII. RADIATIVE COOLING

Radiative cooling is the most important piece of the mixing layer's energy flow. Unfortunately, it is also very difficult to model, and, hence, one that has been poorly modeled. Different temperatures of gases cool at significantly different rates. 10^5 K gas radiates at an order of magnitude faster than 10^4 K or mid 10^6 K gas. The hot phase of the ISM gas falls in the 10^6 range while the cold falls in the 10^4 range so in the mixing layer the temperature-cooling gradient is large.

VIII. CONCLUSION

It is realistic to expect the bartering of information between stars. Perhaps the most important question we need to ask ourselves if we detect a signal from extraterrestrial intelligence is whether we should reply. The risk of responding is vanishingly small. The least productive response may be no response at all.

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