Perspectives on Dependable Computing for Solar System Exploration

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Abstract

This year marks the silver anniversary of the launch of the Voyager 1 and 2 spacecraft which are still operational after 25 years in outer space. As both spacecraft rush towards the outer limits of our solar system in search for the heliopause, their life-time seems to be limited by the on-board available power supply and not the spacecraft reliability. Since the launch of the Voyager spacecraft in 1977, NASA has engaged in an active solar system exploration scientific program that has reached almost every planet in our solar system. Moreover, this year, the US National Research Council (NRC) Space Studies Board published a report called "New Frontiers in Solar System Exploration – An Integrated Exploration Strategy" which provides a survey of solar system exploration knowledge and makes recommendations for future solar system exploration priorities and mission opportunities.

In this talk, we provide a perspective on one enabling technology aspect of solar system exploration: *Dependable Computing*. Whereas we reflect on the engineering marvels of the Voyager and other past and present spacecraft, our focus is on the future of solar system exploration. In particular, we anticipate that solar system missions in the coming decade will increasingly involve aspects of: a) in-situ exploration (as in addition to remote sensing); b) advanced surface, sub-surface and aerial mobility elements such as planetary rovers, surface penetrators and probes, aerobots, etc.; and c) collecting and returning samples to Earth. These future mission concepts present a new engineering and technical challenge for dependable computing in space. Two aspects are particularly worth noting. First, innovative new power source capabilities may enable ultra-long life space exploration. Second, all destinations considered for in-situ exploration of the solar system involve some aspect of survivability in extreme environments. These conditions include extreme low-temperatures ranging from Mars, and further out to Jupiter, Europa, Titan, etc. However, suggested explorations of the Venus surface require survivability in extreme high-temperature environments. These conditions are further compounded by (in some cases extreme) radiation exposure as well as hostile atmosphere (including high pressure).

The design of high-performance avionics for autonomous spacecraft control and survivability in extreme environments represents the major challenge for future dependable systems in space. Moreover, future in-situ mobility systems will benefit from the additional technology push towards systems miniaturization and low power. We will describe current on-going efforts for addressing some of these technical challenges for the future of solar system exploration.