HPC Profiles in Leadership

Project Spaceborne: NASA, HPE Team Up to Use Supercomputers for Eventual Journey to Mars

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August 2018

HYPERION RESEARCH OPINION

In August 2017, Hewlett Packard Enterprise (HPE) and NASA embarked on a daring experiment -- blast a supercomputer into space, place it aboard the International Space Station, and see how it functioned amid shifting radiation levels and violent G-forces. Since that time, the project known as Spaceborne has consistently delivered one trillion calculations per second, revolved around the earth at least 4,275 times, and has been described by HPE as a great success that has "exceeded expectations."

NASA and HPE are using the project to prepare for an eventual trip to Mars, which would likely take around one year, and to gain a greater understanding of how HPC could assist astronauts on such an arduous and dangerous journey. To protect Spaceborne from the rigors of its new home, HPE created a special container and a novel kind of system architecture that relies on special custom software to implement a hardened hardware environment. The software has performed "like a dream," says HPE's America's HPC Technology Officer, Mark Fernandez. For this important accomplishment, HPE was awarded by Hyperion Research an HPC Innovation Excellence Award. HPE's work with Spaceborne will likely expand possibilities for human space travel to Mars and beyond.

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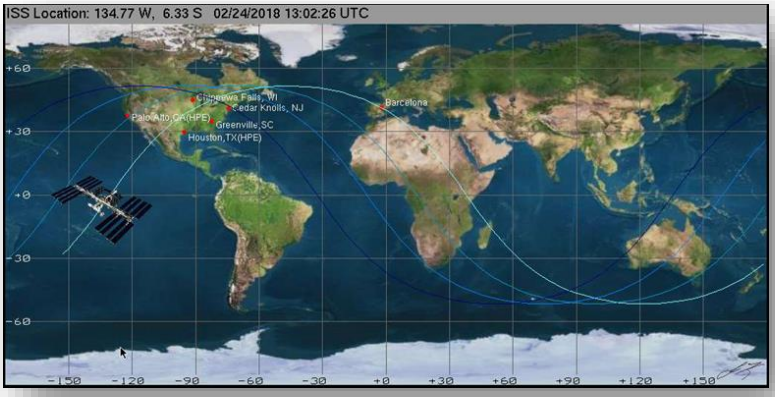
SITUATION OVERVIEW

Riding the Dragon



The power of HPC is driving the Spaceborne Computer, the focus of a year-long experiment that will enable researchers at NASA and HPE to assess what the effects of radiation, G-Forces, and other elements that make up the violent atmosphere of space will have on a supercomputer.

It is the first step in planning a long journey to Mars in which HPC will likely play a vital role. On such a trip, the stakes will be high and astronauts will need access to information in real time. With a system such as HPE's Spaceborne, that may soon be a possibility.

"Supercomputers are needed in space," says Dr. Mark Fernandez, America's HPC Technology Officer, "for the same reasons as we have them on Earth. They offer insight in a timely manner. Scientists will need to process the data where they are, rather than ship it back to Earth for processing. We need to process data at the edge and only send back information as needed."

The HPE Spaceborne computer was launched on August 14, 2017 from the Kennedy Space Center, aboard an Elon Musk's SpaceX CRS-12 rocket, which then sent its Dragon Spacecraft to the International Space Center (ISS). It is the first commercial off-the-shelf (COTS) high performance computer ever to go into space.

A key issue for the team was how the shifting radiation levels inside the ISS would affect such sensitive machines. To mitigate these concerns HPE created a new kind of computer enclosure with integrated cooling and power distribution, as well as a novel computer architecture that relied on specialized software to implement a hardened hardware environment.

The goals of the mission are multifaceted, and includes a long duration study of the practicality of running and managing a state-of-the-art high performance computing system in orbit; exploration of ways to exploit the cooling capabilities of the ISS; and a testbed to investigate implementing a hardened HPC through the use of software. To meet these objectives, HPE created four identical high-performance systems, two of which were installed on the ISS in a side-by-side specialized metal locker that satisfied over 100 NASA safety and size requirements. Two other HPCs have been left behind and function as the control group for the experiment.

The use of hardware hardening through specialized software has been crucial to the mission's success. There were no changes to the hardware. The hardware is COTS, taken right off the factory production line and placed into the Spaceborne Computer locker for flight. We use the proprietary and autonomous hardening software suite of system monitoring and management software exclusively to address the goals of this project.

Space Odyssey: “Running Like a Dream”

Spaceborne’s performance has “exceeded all expectations,” says Fernandez, who sounds positively ebullient when talking about the project. The software that supports the hardware hardening has performed flawlessly, catching all anticipated anomaly types to date," he said. Following its installation on the ISS a month after its launch, during which the system was without electricity and exposed to extreme cold and radiation, the system fired up without a hitch and has performed nearly flawlessly in its near year long-odyssey.

Boring is Good

NASA says scientists have been using the two HPE machines aboard the ISS to run compute intensive and data heavy applications, monitor power consumption, and record benchmarks and other statistics, such as how many iterations are running and how many have been completed. Data is then transmitted back to Earth to allow HPE to compare the results with the two identical COTS systems left behind. The data is then visualized by the ISS Track Viewer software that updates every five seconds to monitor ISS movements and predicts its potential track.

Success to-date include:

- Passing all the tests and certifications and getting the NASA Certificate of Flight Readiness
- Surviving the G-forces and violent shaking and vibrations of the launch
- Waiting patiently, but nervously for a full month, as the HPE systems rode aboard the unprotected Dragon spacecraft before being installed and then successfully powering up a Linux server in the U.S. Lab of the ISS

There have been a few glitches since Spaceborne began its revolutions around the Earth, but they have been handled by the system. The hardware is handling some of the bits errors; the software is catching others. They lost a power supply but it was equipped with redundant power supplies. They

also encountered some SSD failures and look forward to post-flight analysis. All of the computer cores, memory DIMMS and the interconnect continue to run the benchmark suite successfully and they continue to pass validation testing.

Next Stop: Mars

With the great success of this project, NASA and HPE are planning meetings to discuss future collaborations and possible POCs (Proof-of-Concepts) in which NASA software would be run on Spaceborne Computer's hardware instead of the benchmarks we've been running to date.

But most importantly, Spaceborne, or some version of it -- will be headed to the Red Planet.

WHY HPC IS IMPORTANT TO SPACE TRAVEL

Astronauts traveling through space, en route to Mars and beyond, will need on-site supercomputing capability to enable them to survive this most difficult of environments. They won't be able to wait for an analysis of problems whose answers could determine the survival of a crew. They will need tools for scalable simulations, analytics, and artificial intelligence.

The computer needs to do at least two things:

- Act autonomously. With Mars being so far away and communication being potentially spotty, the system needs to take action on its own when needed.
- Process large amounts of data at the edge and only send back information as needed.

Currently, Spaceborne is able to gather, archive, process (and can act upon) what could be collectively called environmental data. These include temperature readings, electrical voltage and current readings, power supply health, fan conditions, etc. This could include any ISS data of importance, but at this time is limited to that which Spaceborne Computer can access. Plus, it does the same for the benchmark results, the runs times, the validity checks, etc.

How it works today: if all of the information and data is self-judged by Spaceborne Computer on the ISS to be normal, the message that all is normal is transmitted back to Earth, currently every 5 seconds. This includes the current status of the benchmarks and is less than 1KB of information. When something is not normal, the information transmitted back to Earth includes the anomaly detected, the action that was taken and why; and a pointer to where additional information can be found on-board.

What Still Needs to Be Done

Fixes are already in the works for what needs to be adjusted. The hardware, for the most part, seems solid, however they are looking into the SSDs and working to uncover why they failed. The innovative cooling system is working as designed and they are exploring other uses for it.

Looking ahead, the number of connected nodes is going to increase form the ~10k to ~100k to around 1M. These systems will have to be managed autonomously, the system will tell the operator how it has handled a fault after the event, rather than feed overwhelming amounts of failure data to a sysadmin for analysis.

Many aspects of Spaceborne Computer's hardening software suite may be patented, productized and shipped with all of HPE's large systems.

BEST PRACTICES AND ADVICE TO OTHER HPC SITES

Fernandez has one big piece of advice to others contemplating this kind of work:

"As data processing continues to grow in its span from the edge to the cloud to the on-premise data center, assume nothing. Plan to act as autonomously as possible. Talk to us. We like doing all of this, including out of this world experiments. In a nutshell, the supercomputers must be available when needed. Space is the extreme in edge computing and there are myriad characteristics which an on-board supercomputer must possess."

The bandwidth required between space and Earth is limited. Many needed computations would require large amounts of this limited bandwidth. Even if the bandwidth was available, the latency between Mars and Earth is measured in tens of minutes. Faced with these realities, the advantages of on-station computation are myriad:

- Processing data on-station reduces the need to transmit large volumes of preprocessed and potentially unneeded data
- Processing data on-station can improve turnaround time of needed answers and reduce the possibility of erroneous transmissions or the impact transmission failures
- Data duplication (and hardware, storage and other types of duplication) can be avoided when the data is processed on-station and the results are shared
- On-Station confidence comes with the reliability of on-station processing. Retries, drops, and missed connections, etc. could possibly plague Mars-to-Earth communications. Even today, Earthly cell phone calls can be broken up or dropped
- Possible data sensitivity issues can be better addressed with on-station processing

About Hyperion Research, LLC

Hyperion Research provides data-driven research, analysis and recommendations for technologies, applications, and markets in high performance computing and emerging technology areas to help organizations worldwide make effective decisions and seize growth opportunities. Research includes market sizing and forecasting, share tracking, segmentation, technology and related trend analysis, and both user & vendor analysis for multi-user technical server technology used for HPC and HPDA (high performance data analysis). We provide thought leadership and practical guidance for users, vendors and other members of the HPC community by focusing on key market and technology trends across government, industry, commerce, and academia.

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