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14TH IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Novel Concepts and Technologies to Enable Future Building Blocks in Space Exploration and Development (3)

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SPACE SUPER COMPUTING: MISSION DEFINITION, ARCHITECTURE CONCEPTS, SELECTION AND ASSESSMENT

Abstract

The concept of placing super computing system in space represents one of a handful of new technological options that might provide orbital ultra-high computing capability for time-critical ground observation tasks or space missions. Space Super Computing (SCC) can bring various benefits to the future human space expedition: high scientific return, evaluation of in-suit satellites resources utilization, satellites networking in LEO or beyond, formation flight and inter-satellites and ground-satellites communications.

Starting from the mission objectives, this paper describes the mission definition, including top-level requirements and architectures, performance evaluation (0.5PFLOPS, that is 0.5×10^{15} floating point ops per second), satellites networking topology, operational hardware and software, and resources assessment and instrumentation definition. Consequently, three conceptual realizations, single computational satellites (SCS), computational satellites constellation (CSC) and computational satellites nebulae (CSN) for SCC are proposed and analyzed. Thought of a tradeoff, only one concept is selected and successively assessed and preliminary characterized with a top level function allocation. The third concept, CSN, foresees a space super computational architecture composed of the following modules: 6 or 8 computational satellites constellations as distributed computing platforms, 3 relay satellites in GEO as the intra-CSN data relaying path, the laser based inter-satellites links and two layer communication network. Each computational constellation will be constructed by one or two central computing satellites and dozens of small/pico- satellites formation flying with the central ones. Hierarchically, each small/pico- satellite carry 4 plug-in computing boards, with each board has several high-performance DSP processors.

A basic task model will be presented in this paper. To effectively utilize the orbital resources , the observation satellites can link to SCC simultaneously, which will offer massive observation data to the SCC. Laser communication technique is adopted as the inter-satellites links in order to offering enough data exchange bandwidth. The ground stations send tasks to SCC through relay satellites and SCC gets data from observation satellites and distributes the tasks and data and starts the computation. After that, the final results will be sent to ground station by relay satellites. SCC processes the massive data in real-time in space and decreases the transferring bandwidth. The multicore DSP processor dedicated for image and signal processing is also discussed in this paper.

The SCC will be the an expedition to utilize various man-made resources in space and the first high-performance computing infrastructure for human deep-space exploration.