Developing Reconfigurable Computing Systems for Space Flight Applications

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Abstract

Future space-based scientific research missions will require dramatic increases in satellite and ground system capabilities. Data processing power 1-3 orders of magnitude greater than that of current systems will be required to perform high level processing functions in real-time, enabling the adaptive and autonomous functions envisioned by NASA in its strategic plan. The development and use of reconfigurable computing systems will be a key component in meeting these advanced system requirements and making these capabilities a reality.

Producing the next generation of science data products and making them available to all levels of users at the lowest possible cost is a primary goal of NASA, NOAA and the global science and user communities. The development of reconfigurable computing systems for both ground and flight use enables the re-allocation of system level functions to maximize the efficient use of mission resources. Reconfigurable computing (RC) systems are combination hardware/software data processing platforms that implement computationally intensive algorithm elements in programmable gate array hardware, yielding a 10x to 1000x improvement in processing speed over traditional CPU based "software only" systems. RC systems are also "in-circuit " re-programmable, allowing data collection or processing configurations to be changed on day, second or even sub-second time scales. Advances in CPU and RC technology are progressing at the same rate, ensuring that RC systems will continue to outperform CPU based systems in the future.

The development of flight RC systems requires a three pronged approach; flight qualified programmable gate array development, ground based functional system development and RC design tool/technique development. Application, system architecture and flight prototyping work would parallel instrument and algorithm development as systems evolved to support current and future mission requirements. Tool/technique development would go hand-in-hand with functional development. Flight component development would advance from prototype to flight devices over a period of 3-5 years, with more advanced devices available in 5-10 years. All of these efforts would be coordinated with the numerous government, academic and industry groups who have expressed interest in working with NASA to develop RC technology.

The development of flight qualified reconfigurable systems will enable the migration of significant processing functions to spacecraft. Flight RC systems will enable functions such as on-board Level 0/1/../n data processing, data driven instrument configurations and multi-function

electronics boxes. They will also provide enhanced “real-time” capabilities, with the flexibility to react to events, faults or design upgrades.

One potential ground based application for RC system, when coupled with on-board Level 0 processing, could provide inexpensive (< $50K) ground systems capable of providing real-time satellite images of forest fires, floods or severe storms to local emergency response teams, or the general public via the internet. The reconfigurable nature of the system would allow different data processing algorithms to be loaded as different data collection platforms (satellites, aircraft, etc.) came into range. Scientists collecting data from multiple platforms could use a similar system to support their research.

A coordinated RC development effort with collaboration between the various government agencies, academic groups and industry partners can produce the most cost effective technology solutions to meet present and future science research and user needs.