Experience of Using COTS Components for Deep Space Missions

Savio Chau
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

Objectives: Faster, Better, Cheaper

In recent years, NASA has adopted a faster, better, and cheaper philosophy for space exploration. This philosophy mandates space missions to be accomplished with much lower cost, shorter development cycle, and more capabilities than ever. In order to meet these challenges, starting 1998, NASA's Office of Space Science has initiated the Advanced Deep Space Systems Technology Program, also known as X2000, to develop advanced technologies for future deep-space exploration missions. One of the focus technology development areas is advanced avionics, which is being developed by the Center for Integrated Space Microsystems (CISM) at the Jet Propulsion Laboratory. Under X2000 and CISM, a breakthrough multi-mission avionics system is being developed. This avionics system employs low cost hardware and software products that are widely available in the commercial market. By using COTS through out the system, we expect to significantly reduce both the development cost as well as the recurring cost of the system, and thus be able to meet the faster, better, cheaper challenges. On the other hand, COTS are not specifically developed for applications such as deep-space missions. Therefore, the real challenges are

- How to select COTS technologies
- How to overcome their shortcomings in space applications.

Selection of COTS

We have made the technology selection based on short term and long term considerations. For the short term, a set of missions that could be the potential users of the X2000 avionics system were first identified. The projected requirements of these missions were used as guidelines for the COTS selection. For long-term consideration, the selected COTS technologies should be significantly better, preferably one to two orders of magnitude better, than the conventional space technologies. This is because significant improvements in mass, volume, performance, power, and cost are necessary to enable interesting but challenging science missions in the future. Therefore, the X2000 First Delivery project has selected the 100 - 400 Mbps IEEE 1394 as the high-speed data bus, the low power I^2C bus as the low-speed engineering bus, and the 250 MIPS PowerPC 750 as the flight computer. Interestingly, although the importance of fault tolerance and reliability have been recognized, they were not considered as dominating factors in selecting COTS technologies. This was because we realized that COTS did not have the same stringent fault tolerance and reliability requirements as deep space missions. Furthermore, we also realized the fault tolerance and reliability issues could be handled by system design techniques. Some of these techniques are highlighted in the following.

Challenge of COTS

Another challenge is that COTS products are not developed with long-term survivability or the extreme environments of space in mind. Practically, all of the COTS components could not survive the extreme temperatures or the radiation environment in space missions. To circumvent this difficulty, COTS intellectual properties (IP) rather than COTS components are utilized. The COTS IPs are readily available from commercial suppliers and can be transferred to ASICs that are fabricated by space-qualified foundries. Furthermore, most of the COTS products will not meet the long-life requirements of some of the deep space missions, such as the 15-year Pluto Express mission. X2000 attempts to solve this problem with a four-step methodology. First, the built-in error detection features of the COTS are utilized to achieve minimum level of fault tolerance. Second, additional layers of hardware and software are used to enhance the fault tolerance capability of COTS. Third, architecture level design diversity is used to mitigate the effects of any fundamental shortcomings in fault tolerance of COTS. Fourth, necessary system level redundancy is used to further enhance the long-term reliability. The COTS-based X2000 avionics system is currently being developed at the Jet Propulsion Laboratory and we will report our results in future papers.