Requirements and Usage of NVM in Advanced Onboard Data Processing Systems

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NVM Conference

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Spaceborne Computing:

- Past - Rad6000
  - Basic C&D H functions (1-10MOPS)
- Present - (well, almost) PPC-750 Rad (light)
  - Basic C&D H + simple data processing and task automation (10-100+ MOPS)
- Future - Supercomputing
  - Science data processing, autonomy, situational awareness, intelligent spacecraft and constellation control (100 - 10,000MOPS+)

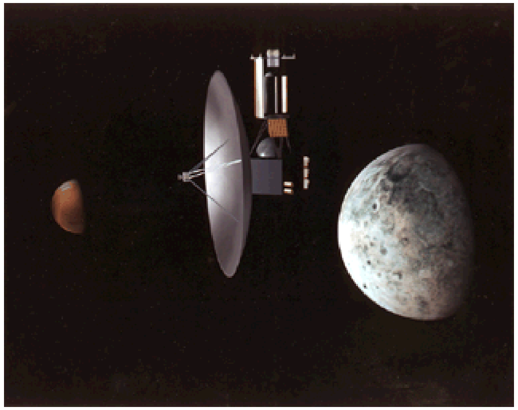
Why supercomputing in space?

- Only viable approach to the bandwidth problem - can't get the data down to earth
- Only viable approach to controlling constellations of cooperating satellites
- Only viable approach to reducing mission operations costs
- Only viable approach to real time intelligent decision making and science data gathering

REE

The REE Vision:

•Move commercial scalable supercomputing technology into space, in a form which meets the demanding environmental requirements, to enable a new class of science investigation and discovery.



Background

- **Funded by Office of Space Science (Code S) as part of NASA's High Performance Computing and Communications Program**
- **Started in FY1996**
- **Guidelined at $100M over 8 years**

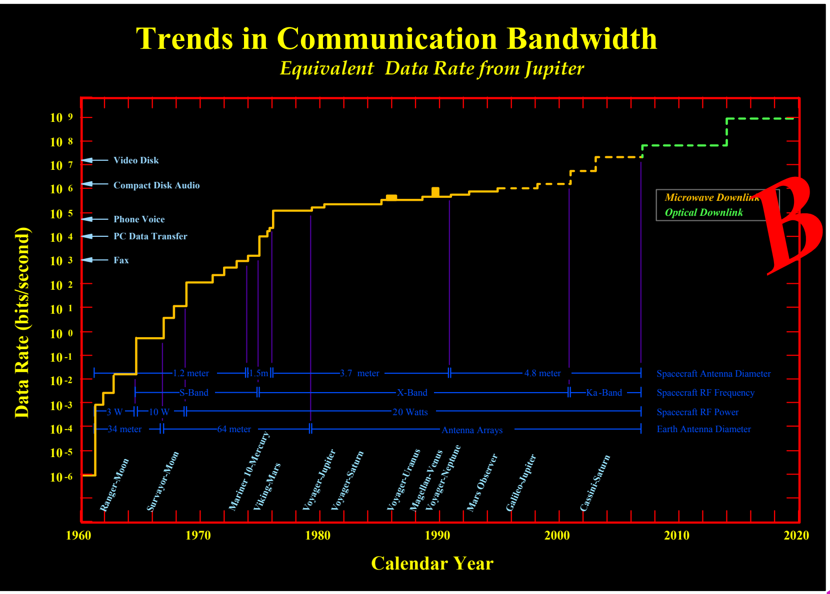
REE Impact on NASA and DOD Missions by FY05

Faster - **Fly State-of-the-Art Commercial Computing Technologies within 18 month of availability on the ground**

Better - **Onboard computer operating at > 300MOPS/watt scalable to mission requirements** *(> 100x Mars Pathfinder power performance)*

Cheaper - **No high cost radiation hardened processors or special purpose architectures**

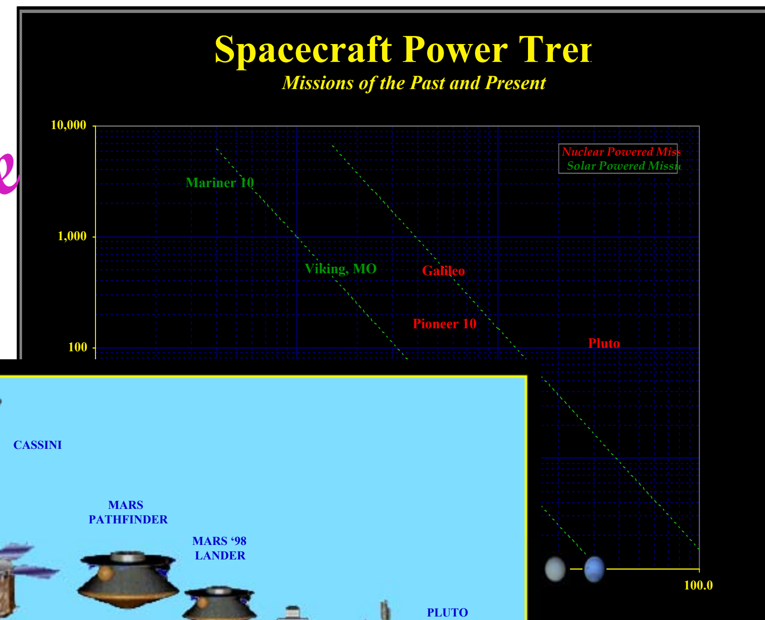
The Problem Set



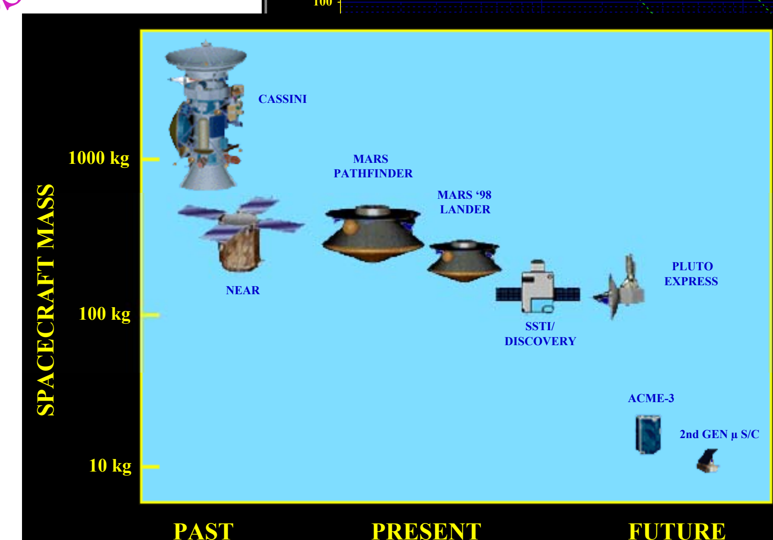
Bandwidth

Latency

Round Trip Delay



Power/Mass/Volume



System Cost

Operational Cost

Development Time

Science Return

REE Objectives

- Demonstrate power efficiencies of 300 -1000 MOPS per watt in an architecture that can be scaled up to 100 watts, depending on mission needs.

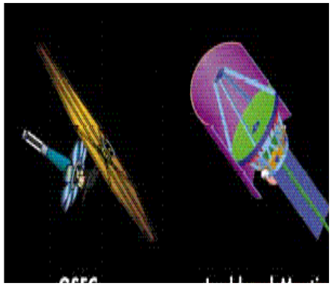
- Demonstrate new spaceborne applications on embedded high-performance computing testbeds which return analysis results to the earth in addition to raw data.

- Develop fault-tolerant system software that will permit reliable operation for 10 years and more using commercially available or derived components.

- Explore ultra-low power onboard computer systems which will help open the entire Solar System to exploration without the need for nuclear technology.

Science Teams

Five Science Application Teams Chosen to Drive Requirements and Demonstrate Benefits of HPC Onboard



Next Generation Space Telescope - John Mather/GSFC

- Onboard Cosmic Ray correction to the data
- Autonomous control and optimization of the adaptive optics

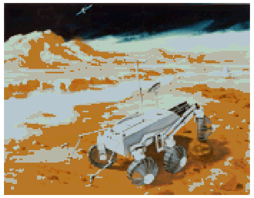
Gamma ray Large Area Space Telescope

• Peter Michelson/Stanford

- Onboard cosmic ray rejection
- Real time gamma ray burst identification

Orbiting Thermal Imaging Spectrometer - Alan Gillespie/U Washington

- Onboard Atmospheric corrections, Radiance calculations



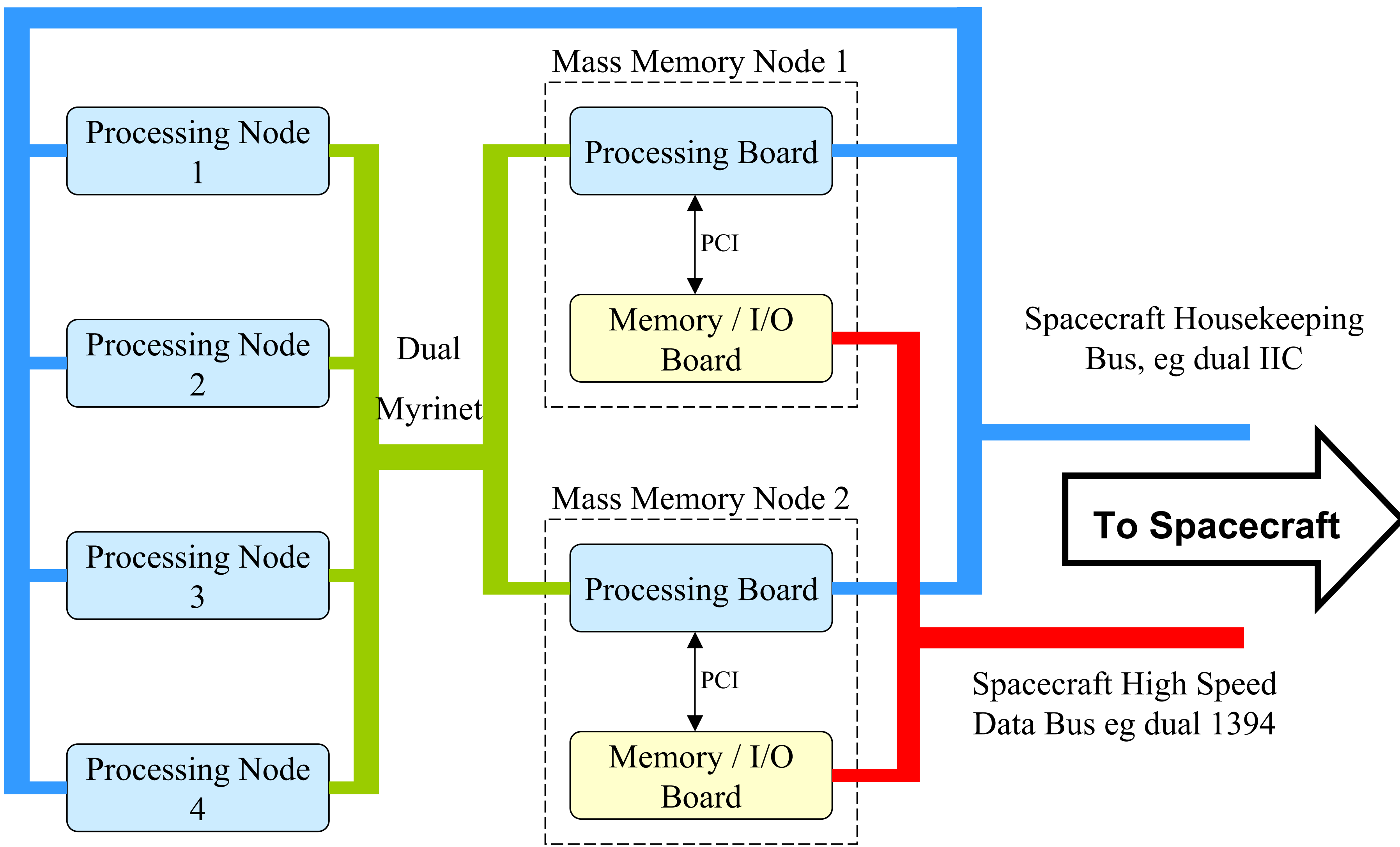
Mars Rover Science - R. Steve Saunders/JPL

- Autonomous optimal terrain navigation
- Autonomous Field Geology

Solar Terrestrial Probe Program - Steve Curtis/GSFC

- Constellation/Formation Flying missions to probe the Sun-Earth Connection
- Onboard Plasma moment calculations, multi-instrument cross correlations, autonomous operations

REEE Baseline Architecture



REE Issues

- COTS vs Rad Hard
  - It doesn't matter - NVM is still required and (most of)
  - The requirements are the same
- GP Processors vs DSP's vs FPGA's
  - It doesn't matter - NVM is still required and (most of)
  - The requirements are the same
- Application Domain - NGST vs OTIS vs Rover
  - It doesn't matter - NVM is still require and (most of)
  - The requirements are the same

NVM Usage/Requirements

- Mass Memory (Disk Emulator)
  - 1-10 GB per CPCI board
    - IC density
    - Packaging density
  - 10-20 Watts per CPCI board
  - Medium Speed
    - 2-5 Gbits/Sec bidirectional
    - Burst mode
    - File oriented
  - 50-100 krad Si (100 mil Al shield)
  - SEU Tolerance
    - SEL, SEFI, SEMU and Catastrophic Failure Immune

NVM Usage/Requirements

- Processing Node (OS & state storage)
  - High speed
    - Execute directly from NVM or,
    - High speed download from NVM to execution memory
    - High speed store of state variables
    - Typical processor throughput - 1-5 GWords/Sec
    - Typical DRAM speeds - moving towards
  - Low Power
    - Processor, Bridge, Net I/O and DRAM already eat up too much power
  - 50-100krad Si (100 mil Al shield)
  - SEU tolerance
    - SEE Hard

NVM Usage/Requirements

- Processing Node (OS & state storage) cont.
  - Small memory, but high density
    - 1Mbyte will do, but more is better
    - 1 IC footprint
- General requirements/desirements
  - Low Cost
  - COTS/MOTS/SOTS

Questions

- Can NVM replace DRAM (speed/density)?
- If not, how close will get and when?
- Will COTS NVM technologies be rad tolerant & SEU/SEL hard?
- Will NVM technologies experience catastrophic SEE's