Space exploration missions with TRON families

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TRON/iTRON in Space missions

- H-IIA
- GCOM-C
- GCOM-W
- EPSILON
- T-kernel 2.0 AS
- ARASE
- T-kernel
- H-IJAKI
- HITOMI
TRON/iTRON in Space missions; Solar system

Important point: small size memory for RAM/ROM/EEPROM
Not only around Earth but also deep space explorations in solar system!!
Data handling and control system in space missions

- **1980s**
  - **Bus type connections** (address, data and clock lines)
  - System synchronized by hardware clock
  - Timing critical processing; a few msec/a few 10msec
  - However, a **space grade CPU power was poor**
  - So, timing control by **discrete electrical parts**

- **1990s** –
  - **Bus type connections** (address, data and clock lines)
  - System synchronized by hardware clock
  - Timing critical processing; a few msec/a few 10msec
  - However, field-programmable gate array (FPGA) was developed and used in space missions
  - So, **timing control by FPGAs** instead of discrete electrical parts
  - Flexible design for data handling and control system
  - TRON OS began to be used in spacecraft systems

- **2000s** –
  - **Concept change! Bus type → Network type connections**
  - Each component is connected with serial signal lines (1553B/SpaceWire etc)
  - System synchronized by “time-slot” → **Design change “on time” to “in time”**
  - TRON OS was used not only in spacecraft bus system but in mission instruments

Task management methods on TRON are suitable for “time-slot” management
Used by many users, can check the source code → **use it with great reliability!**
Data handling and control system in space missions

• 2013
  • Development of “High reliable RTOS” for aerospace field by UCT
    T-kernel 2.0 AeroSpace (T-kernel2 AS)
      • Function to delete and reconfigure for each API in order to improve safety and memory capacity
      • Memory protection function that does not affect processing speed
      • High precision time management function with physical timer function

  • T-kernel2 AS is used in nine onboard computers for scientific instruments in ERG(Arase) mission that is exploration of radiation belt around the earth.
  • From the ground test to the present after the launch 2016 Dec, no trouble occurs at all and it is operating stably under strong radiation environment !!
Toward future missions, beyond RTOS

- The solar system exploration goes further
- The communication delay increases
- Exploration systems corresponding to unexpected things onboard!
- Correspondence and reconfiguration on satellite on-board becomes necessary
Toward future missions, beyond RTOS

• Huge number of logics in recent FPGAs and the FPGA with reconfigurable functions after launch. More functions have shifted from hardware to “software” on FPGAs

• The CPU itself is built in the FPGA, and the processing software is running on that CPU. Peripheral components such as memories are also built in the FPGA.

• In order to effectively utilize the codes developed so far, I think that the TRON system running on the CPU in the FPGA is a very important point for space missions and applications in the future.

• When becoming a huge system of space transportation and spacecraft, it not only communicates data over the network, but also monitors each other's systems over the network and complements each other or automatically turns the system off. I would like to expect not to be a simple real-time OS but to develop to a core monitoring system that can be rebuilt through the network.