SPACE CUBE 2 SOFTWARE DESIGN KIT (SDK)

Session: SpaceWire Test and Verification (Poster)

Short Paper

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ABSTRACT

Space Cube2 is a core control node in medium size satellites as ASTRO-H as well as our small satellites, which are based on SpaceWire communication networks. In order to provide software design kit (SDK) for Space Cube2, reference computer architecture, communication model, and database scheme for satellite operation are defined. Reliability and timeliness characteristics are also taken account while establishing communication protocol stack. The SDK consists of T-Kernel real-time operating system (RTOS), middleware, software tools, and hardware support equipment. Single source code of T-Kernel is provided as open source, and standard middleware is developed by Japanese space industries and JAXA/ISAS.

1 SPACE CUBE2 DESIGN FRAMEWORK WITH SPACEWIRE

Space Cube2 shown on figure one is used for several subsystems as data handling subsystem (DHS), attitude and orbit control subsystem (AOCS), and mission data processor (MDP) as a general purpose onboard computer. Since it is used over wide range of programming style of each subsystem, a reference design framework is

required for sharing the tools and methods used during application development processes.

Figure 1 Space Cube2

It is practical way to establish design framework as a software development kit (SDK) in order to make developers understand the reference model of software and hardware of the onboard computer. The reference model includes computer architecture, communication model, and database scheme for satellite operation. Space Cube architecture [1] is a reference for Space Cube 2, which defines the required specification of general purpose onboard computers. Communication model consists of Functional Model of Spacecraft (FMS) [2] and Spacecraft Monitor & Control Protocol (SMCP), [3] which are defined by JAXA/ISAS. Operation procedure of satellite is managed through Definition of Spacecraft Information Base 2 (DSIB2) [4], which is also defined by JAXA/ISAS. How to use middleware application program interface (API) is also provided as documents. In order to establish the design framework, several satellites as the earth observation satellites, LEO scientific satellites and inter-planetary scientific satellites have been investigated. Based on the assessment, standard middle ware requirement, telemetry / command design criteria, and network design criteria have been published.

1.1 Space Cube Architecture

Space Cube Architecture is established for developing Space Cube2. The architecture features following requirement;

1) Space Cube Architecture is derived from T-Engine architecture. T-Engine is an open platform for embedded use, which is applicable for various kinds of microprocessors.

2) SpaceWire is a mandatory interface for realising scalable network based on spacecraft architecture.

3) Compatibility is maintained through the standard middleware specification and API in order to enable accommodating various microprocessors.

4) In order to satisfy small size, light weight, low power consumption and low cost requirement for small satellites, one-chip microprocessors with its peripheral I/O devices embedded in itself are recommended.

1.2 Functional Model of Spacecraft (FMS) and System Information Base (SIB2)

FMS is defined through object oriented analysis in addition to the operation experience of ISAS satellites over many years. FMS defined through the conception,

which consists of attribute, operation, event, alert, behaviour, and diagnostic rule. The schema is defined in SIB2. The definition of SIB2 is published from ISAS and user interface is provided as spread sheet.

1.3 SPACECRAFT MONITOR & CONTROL PROTOCOL (SMCP)

The standard middleware is based on Space Monitor & Control Protocol (SMCP). SMCP has been developed by JAXA/ISAS, which aims at unified building method of commands, telemetry messages, and sequence for all satellites and onboard equipments.

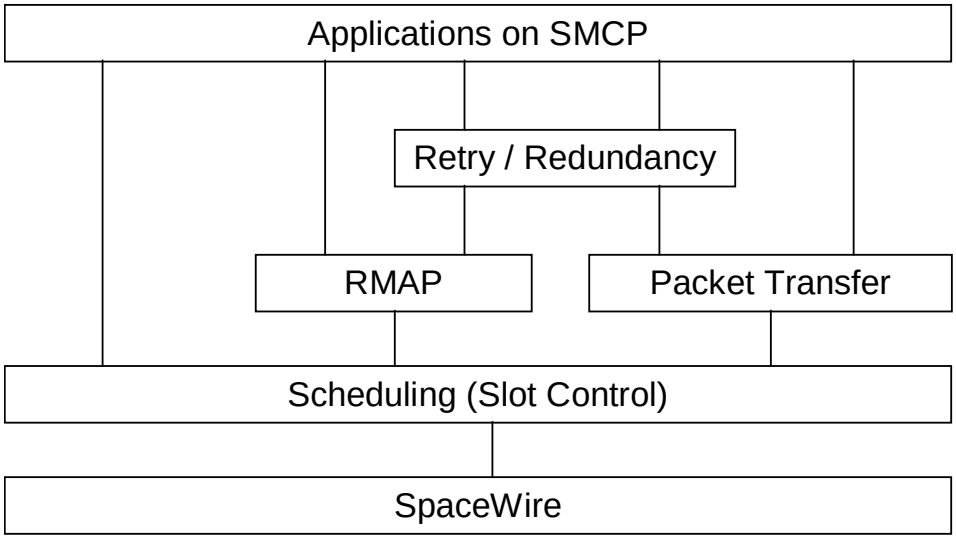

Figure 2 SMCP and protocol stack

Figure 2 shows the application development scheme. Telemetry and Command processing functions are realised through SMCP.

Reliability and timeliness are taken into account by exploiting RMAP and Time-Code capability. Retry and Redundancy control are carried out using CRC in RMAP packet. Scheduling (Slot Control) are implied by Time-Code. Initiator node should know the time slot, where as Target node doesn't have to know the time slot provided that the node can respond to RMAP packets.

2 TOOLS

Dedicated complier for HR5000 radiation hardened processor is developed by JAXA. Various software tools and equipments, which include low cost In-Circuit Emulator (ICE) for HR5000, are developed by commercial industries as well as space system industries. These tools are integrated on Eclipse framework and commercial version of SpaceCube2 is provided for desk-top space-use program development.

This SDK is developed among space system community which includes universities, so multi-lingual text books are also provided for widening space system community.

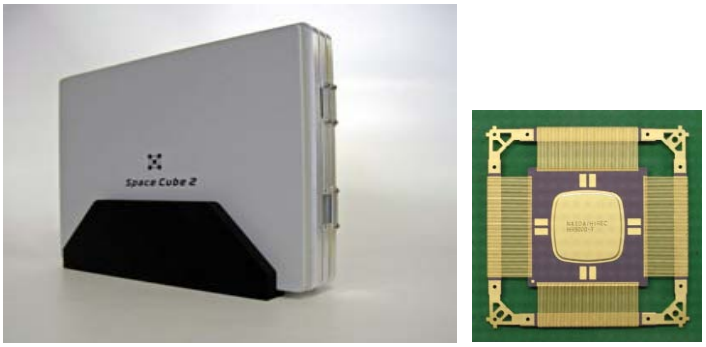

Figure 3 Commercial level version of Space Cube2 (with HR5000 processor)

Figure 4 Space Cube (original version) with SpaceWire CUBA Software

Figure 5 Space Cube with Giga-bit Ethernet

(Space Cube is developed by JAXA/ISAS and Shimafuji Electric, Ltd.)

Figure 6 SpaceWire Router (BBM/14ports)

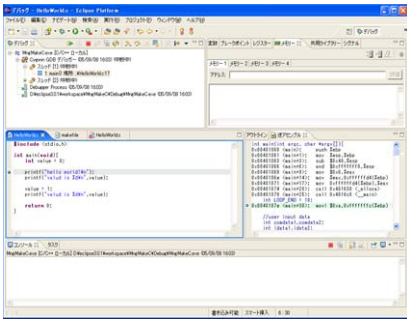

Figure 7 Integrated tools with Eclipse

3 REFERENCES

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2. Takahiro Yamada, “Functional Model of Spacecraft (FMS)”, GSTOS 201, 15 September 2009.

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