STANDARD ONBOARD DATA HANDLING ARCHITECTURE BASED ON SPACEWIRE

Session: Missions and Applications

Short Paper

Takahiro Yamada, Tadayuki Takahashi

JAXA/ISAS, 3-3-1 Yoshinodai, Sagamihara, 229-8510, JAPAN

E-mail: tyamada@pub.isas.jaxa.jp, takahasi@astro.isas.jaxa.jp

ABSTRACT

This paper presents the standard onboard data handling architecture that JAXA is developing presently. This architecture specifies an architectural framework on how to develop onboard data handling systems and will be used for all the science spacecraft that JAXA will develop. This architecture consists of three sub-architectures: physical architecture, functional architecture and protocol architecture. JAXA is also developing standard components based on this architecture, which include standard physical components and standard functional components. By using this architecture, the basic portion of onboard data handling systems will be developed by selecting appropriate standard components and connecting them with standard protocols. This will facilitate the design, integration and testing of onboard data handling systems greatly.

1 INTRODUCTION

Presently, the onboard data handling systems of most spacecraft are designed individually for each spacecraft without using any framework. This prevents reuse of components from spacecraft to spacecraft. In order to solve this problem, the Institute of Space and Astronautics Science (ISAS) of the Japan Aerospace Exploration Agency (JAXA) is developing a standard onboard data handling architecture, which specifies an architectural framework on how to develop onboard data handling systems. This architecture will be used for all the future science spacecraft that JAXA will develop. This architecture consists of three sub-architectures: physical architecture, functional architecture and protocol architecture.

The physical architecture specifies how to configure onboard data handling systems physically and defines basic physical elements. Any onboard data handling system will be constructed physically by connecting basic physical elements according to the characteristics and the complexity of the spacecraft. The functional architecture specifies how to configure onboard data handling systems functionally and defines basic functional elements. These functional elements are implemented in physical elements. The protocol architecture specifies how to connect physical and functional elements with communications protocols and defines a set of standard protocols to be used.

JAXA is also developing standard components based on this architecture, which include standard physical components and standard functional components. By using this architecture, the basic portion of onboard data handling systems will be developed by selecting appropriate standard components and connecting them with standard protocols. The difference in the size of different spacecraft will be reflected in the number of components used in each spacecraft. The difference in the characteristics of different spacecraft will be reflected in the way of combining different components in each spacecraft. This method of developing onboard data handling systems will facilitate the design, integration and testing of spacecraft greatly.

2 PHYSICAL ARCHITECTURE

In this architecture, a physical onboard element that handles data in any way (for example, generates, uses, processes, relays, and/or stores data) is called a Node. Furthermore, this architecture defines two types of Nodes: Intelligent Nodes and Non-intelligent Nodes.

An Intelligent Node is defined to be a Node that has one or more processors and can generate and consume Space Packets [1]. A Non-intelligent Node is defined to be a Node that does not have a processor and cannot generate or consume Space Packets. However, the distinction between Intelligent and Non-intelligent Nodes is not always clear and there may be physical elements with features of both Intelligent and Non-intelligent Nodes. Therefore, this architecture should be regarded as guidelines, rather than strict rules. Examples of Intelligent Nodes are command and data handling units, mission processors, attitude control processors, etc. Examples of Non-intelligent Nodes are sensors of various kinds, actuators, etc.

The onboard data handling system of any spacecraft should be physically constructed as a tree. The leaves of the tree are Non-intelligent Nodes, and the other nodes of the tree are Intelligent Nodes. All the Nodes are connected with standard communications protocols that will be described later. Some examples of physical configurations of onboard data handling systems are shown in Figure 1.

Based on this architecture, we are developing two kinds of standard physical components that can be used on any spacecraft. The first kind is a series of standard onboard computers that can be used as Intelligent Nodes of any spacecraft. These onboard computers are developed based on the SpaceCube architecture [2] and each computer has a processor, a real-time OS, SpaceWire interfaces, etc. For Non-intelligent Nodes, we are developing a standard interface card with a SpaceWire interface that is used for communications with an Intelligent Node.

3 FUNCTIONAL ARCHITECTURE

Each node (physical element) has a set of functions. What is important in this architecture is that the standard physical components explained above can be used for any Node regardless of the functions of the Node. The functions of a standard onboard computer (SpaceCube) is determined by the applications programs that run on the computer and what applications programs are to be run on each of the onboard computers on a particular spacecraft is determined for each spacecraft. Therefore, the same SpaceCube can be used for attitude control, mission data processing, or any

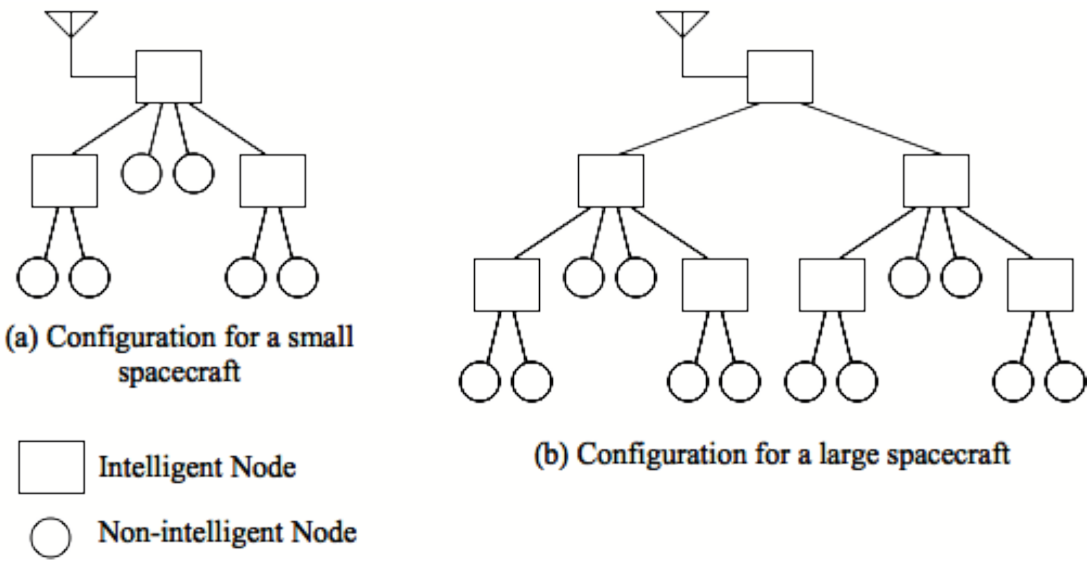

Figure 1 – Examples of physical configurations of onboard data handling systems

purposes. Likewise, the standard interface card can be used for any Non-intelligent Node regardless of the functions of the Node.

Generally, a Non-intelligent Node is monitored and controlled by the parent Node, which is the Intelligent Node to which it is directly connected. Therefore, the tree of the Nodes (physical elements) on a spacecraft corresponds to the controlling hierarchy of the spacecraft.

We are planning on developing standard functional components that can be used on any Intelligent Nodes. These components are pieces of software that use the capabilities of the Space Packet Protocol and the Spacecraft Monitor and Control Protocol (SMCP) described in the next section and support the operations of the applications programs running on the processor of the Nodes.

4 PROTOCOL ARCHITECTURE

Nodes (physical elements) are connected with standard communications protocols, which are shown in Figure 2. There are two protocol stacks in Figure 2. The first stack is used between two Intelligent-Nodes and the second stack is used between an Intelligent Node and a Non-intelligent Node. The difference between these two stacks is that the Space Packet Protocol [1] is used only between Intelligent-Nodes.

As the lower layer protocols, SpaceWire, SpaceWire RT [3] and SpaceWire Remote Memory Access Protocol (RMAP) [4] are used for all interfaces between Nodes. The Space Packet Protocol is used between Intelligent Nodes on top of the SpaceWire protocols. On top of all these protocols, the Spacecraft Monitor and Control Protocol (SMCP) [5], which is a JAXA standard protocol, is used to monitor and control the functions of the Nodes. SMCP is used by an onboard Intelligent Node to control other Intelligent and/or Non-intelligent Nodes and by a spacecraft control system on the ground to control onboard (Intelligent and/or Non-intelligent) Nodes.

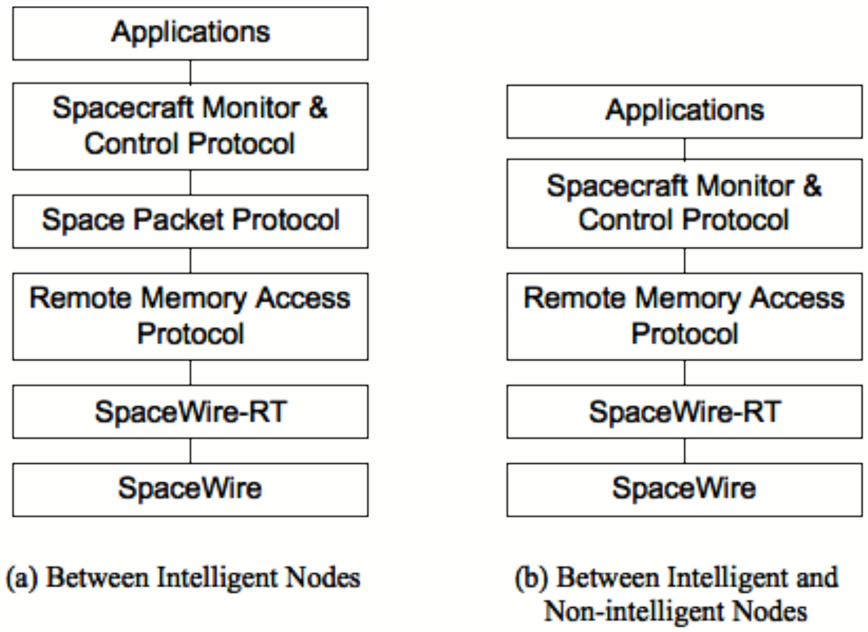

Figure 2 – Standard protocols

5 CONCLUSION

This paper presented the standard onboard data handling architecture that JAXA is developing. JAXA is also developing standard hardware and software components that can be used on any spacecraft based on this architecture. These components will be used on all future science spacecraft of JAXA, which include TOPS (EUV telescope mission), ASTRO-H (X-ray telescope mission), SPICA (infrared telescope mission), etc.

6 REFERENCES

1. Consultative Committee for Space Data Systems (CCSCS), "Space Packet Protocol", CCSDS 133.0-B-1, September 2003.

2. H. Hihara, "Designing SpaceCube 2 with Elegant Framework", International SpaceWire Conference 2008, Nara, Japan, October 2008.

3. S. Parkes, "SpaceWire RT", International SpaceWire Conference, Nara, Japan, October 2008.

4. European Cooperation for Space Standardization (ECSS), "SpaceWire Protocols," ECSS-E-ST-50-11C, Draft 1.3, July 2008.

5. T. Yamada, "Standardization of Spacecraft and Ground Systems Based on a Spacecraft Functional Model", SpaceOps 2008, Heidelberg, Germany, May 2008.