Requirements for Higher-layer Protocols over SpaceWire to Support Spacecraft Operations (a)

Takahiro Yamada (JAXA/ISAS)

22 February 2010

Fourteenth SpaceWire Working Group Meeting

ESTEC, Netherlands

Purpose of This Presentation

- This presentation shows requirements for higher-layer protocols used over SpaceWire to support operations of typical spacecraft of JAXA.
- It also shows some proposals for developing higher-layer protocols used over SpaceWire.

Data Types Used for Spacecraft Operations

- The following are the types of data transferred between onboard components on typical spacecraft of JAXA.
- Data used for controlling onboard components
  - Commands
  - Clock
- Data used for monitoring onboard components
  - Reports
  - Housekeeping data
- Data used for mission production
  - Science data
- Data used for component maintenance
  - Memory data (including computer programs)

QoS Requirements for Each Data Type

Data Type		Latency Requirement	Reliability Requirement
Commands	For intelligent functions	High (Asynchronous)	High
	For real-time control	High (Periodic)	Low
Clock		High (Periodic)	Low
Reports		High (Asynchronous)	High
Housekeeping Data		High (Periodic)	Low
Science Data		Low (Asynchronous)	High or Low
Memory Data		Low (Asynchronous)	High

Latency Control Mechanisms 1/2

- Using slots is a very good and simple way for guaranteeing latency required for time critical data.
- A dedicated (or a set of dedicated slots) should be assigned for each data type (or a set of data types having similar latency requirements).
- A slot (or a set of slots) should be assigned to a set of nodes for transferring asynchronous time critical data in which it is not known in advance which node should send or receive data at what time.
- In each of such sets of nodes, there should be a mother node that determines which child node to send or receive data a what time and (for example) initiates an RMAP transaction. (The mother will usually be a central computer that controls the other components.)

Latency Control Mechanisms 2/2

- For transferring large volume asynchronous data for which it is not known in advance which node should send or receive data at what time, a set of slots should be allocated to a sender-receiver node pair based on data transmission request polled in a dedicated slot.
- In this case as well, a central computer (mother node) polls data transmission requests from a set of nodes under its control (the children node) and determines the sender-receiver node pair for this set of slots for each slot period (the period in which all the slots are used). The central computer polls requests and signals its decision using a special slot allocated to this family of nodes for this purpose.

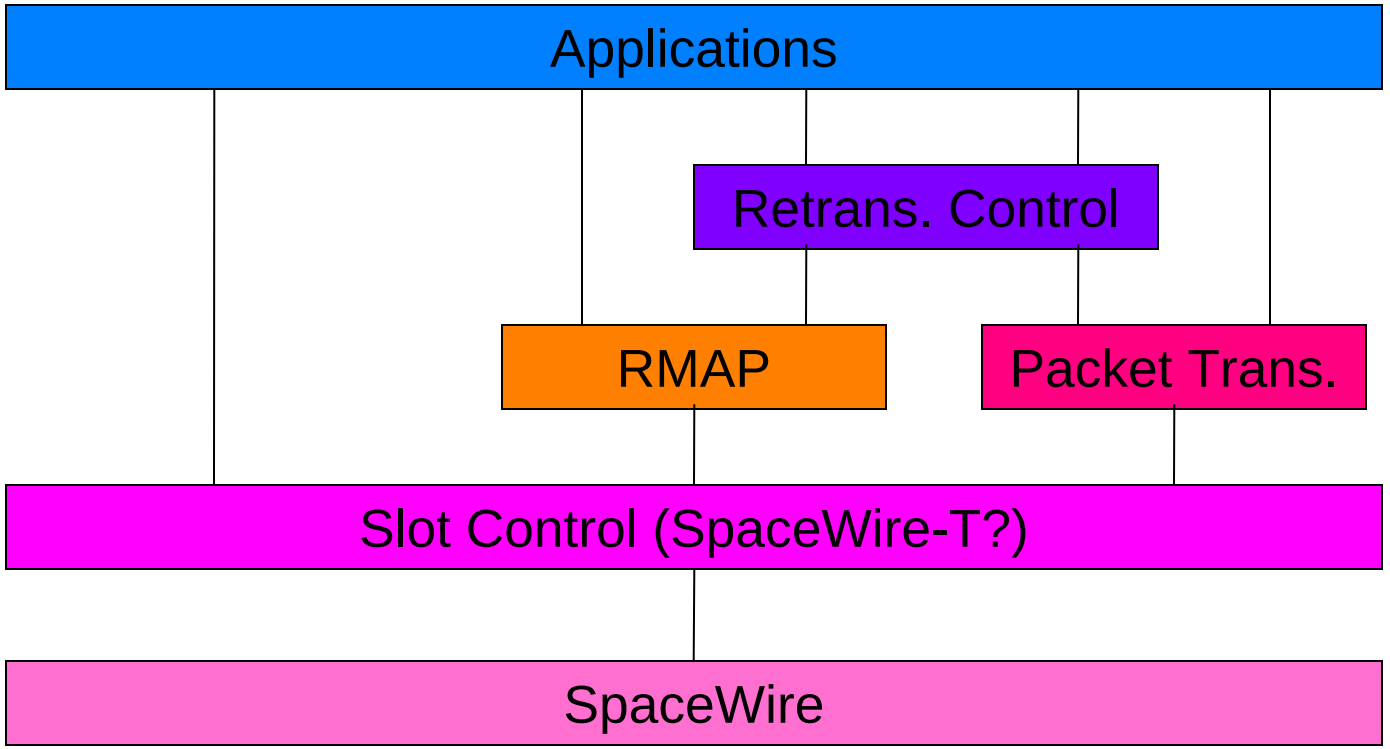
Reliability Control Mechanisms

- For data types with low reliability requirements, data should be transmitted only once without retransmission because the receiver can wait for the next data without needing to receive the missing data.
- For data types with high reliability requirements, retransmission of missing data is desirable either through the same path or through a redundant path.
- For both types of data, it may be desirable to have a mechanism to let the sender know whether the receiver has received the sent data.
- These mechanisms should be implemented by protocols (for example, RMAP and some other protocols) at a layer higher than the layer that controls the slots.

Mechanisms Required for Each Data Type

Data Type		Latency Control	Reliability Control
Commands	For intelligent functions	Dedicated slots (one to many)	Retrans.
	For real-time control	Dedicated slots (one to several)	None
Clock		Dedicated slots (one to many)	None
Reports		Dedicated slots (many to one)	Retrans.
Housekeeping Data		Dedicated slots (many to one)	None
Science Data		Dedicated slots for polling (one to many) Dynamically assigned slots for data collection (one to one)	Retrans. or None
Memory Data		Same as Science data	Retrans.

Proposed Protocol Configuration



Functions Required for Each Protocol

- Slot Control (SpaceWire-T?)
  - Definition of time slots (each signaled by a time-code)
  - Rules for assigning slots to nodes. A slot (or a set of slots) should be assigned:
    - ✓ To a set of nodes with a mother node in it, or
    - ✓ To a pair of nodes with a mother node in it or outside.
  - If there are multiple sets of nodes that do not share any network resources, slots can be assigned to these sets of nodes.
- Retransmission Control (SpaceWire-R?)
  - Error detection and retransmission
  - Redundant paths control
  - Flow control (optional)

Conclusions

- In this presentation, we presented:
  - Requirements for higher-layer protocols used over SpaceWire to support operations of typical spacecraft of JAXA.
  - Proposals for developing higher-layer protocols used over SpaceWire.
- We believe that every Agency should perform this kind of analysis to determine what higher-layer protocols are needed over SpaceWire.