IMPLEMENTING THE CCSDS PACKET TRANSFER PROTOCOL FOR ECSS SPACEWIRE LINKS

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ABSTRACT

Transmission of CCSDS Space Packets [4] over ECSS SpaceWire links [10] is nothing new, but with the new ECSS SpaceWire protocols standards, it is possible to implement telemetry encoders and telecommand decoders offering interoperability. There is however an alternative method also based on the ECSS SpaceWire protocol standards offering additional services. The two approaches are compared in this paper.

CCSDS PACKET TRANSFER PROTOCOL

1.1 OVERVIEW

As stated in the *SpaceWire - CCSDS packet transfer protocol*, ECSS-E-ST-50-53C standard [13], the *CCSDS Packet Transfer Protocol* (called CPTP hereafter) has been designed to encapsulate a CCSDS Space Packet into a SpaceWire packet, transfer it from an initiator to a target across a SpaceWire network, extract it from the SpaceWire packet and pass it to a target user application.

1.2 FORMATS

The CCSDS Space Packet defined in [4] is shown in the figure hereafter. The CCSDS Packet Transfer Protocol should not be confused with the Encapsulation Packet [7] defined by CCSDS.

Space Packet									
Primary Header							Packet Data Field		
Packet Version Number	Packet Identification			Packet Sequence Control		Packet Data Length	Secondary Header (optional)	User Data Field	Packet Error Control (optional)
	Type	Secondary Header Flag	Application Process Id	Sequence Flags	Sequence Count				
0:2	3	4	5:15	16:17	18:31	32:47			
3 bits	1 bit	1 bit	11 bits	2 bits	14 bits	16 bits	variable	variable	variable

Figure: CCSDS Space Packet

The CCSDS Space Packet is one of several data units [5] that can be transferred in Telecommand [3][9], Telemetry [1][8] or AOS Transfer Frames [2]. The CCSDS Packet Transfer Protocol packet is shown in the figure hereafter.

	Target SpW Address	....	Target SpW Address
Target Logical Address	Protocol Identifier	Reserved = 0x00	User Application
CCSDS Packet (First Byte)	CCSDS Packet	CCSDS Packet	CCSDS Packet
CCSDS Packet	...	...	CCSDS Packet
CCSDS Packet	CCSDS Packet (Last Byte)	EOP	

Figure: CCSDS Packet Transfer Protocol packet

1.3 Services

The CPTP approach provides a unidirectional data transfer service from a single source user application to a single destination user application through a SpaceWire network. The protocol does not provide any means for ensuring delivery of the packet nor is it responsible for the contents of the packet being a CCSDS Space Packet. This actually opens up the possibility to transfer other types of data as per [5] than CCSDS Space Packets, e.g. SCPS-NP [6] or Encapsulation Packet [7], although not allowed.

The protocol does provide several steps of checking before a CCSDS Space Packet is passed to the target user application, of which one introduces some level of complication when implemented in hardware.

Implicitly it is assumed that the *Target Logical Address field* is matching the destination, and that the *Protocol Identifier field* is 0x02. Any mismatch should result in the received SpaceWire packet not being considered for the CPTP handling.

The *Reserved field* is checked to be all zero, if not then the received SpaceWire packet is discarded and an error indication is sent to the target application. The Reserved Field is located close to the beginning of the SpaceWire packet, making it easy to check without the need to buffer any part of the SpaceWire packet.

If the SpaceWire packet is completed with an End Of Packet (EOP) the CCSDS Space Packet is passed to the target user application. However, if SpaceWire packet is ended with an Error End of Packet (EEP), SpaceWire packet is discarded and an error indication is sent to the target application.

1.4 Implications

By definition, EOP or EEP are at the end of the SpaceWire packet, requiring the SpaceWire packet to be temporarily buffered before the check can be performed. With a CCSDS Space Packet size of maximum 65542 octets, this can be problem from an implementation point of view, especially if implemented completely in hardware.

CPTP does not provide any means for status reporting.

1.5 Similar Implementations

The new CPTP protocol has some similarity with what is used in the Single Chip Telemetry and Telecommand device (SCTMTC or AT7909E) [15]. The *User Application field* could be seen as a mechanism for routing, as the SCTMTC uses the first byte of the SpaceWire packet header to route Space Packets to different telemetry Virtual Channels. The actual Space Packet is carried in the cargo of the SpaceWire packet, and is ended with an EOP. What is new for CPTP is the introduction of the

Target Logical Address, *Protocol Identifier* and *Reserved* fields, the two former being specified also for Remote Memory Access Protocol (RMAP) [12].

For the SCTMTC we implemented a mechanism for retracting a Space Packet that had been partially inserted in the telemetry encoder in the case the reception of a SpaceWire packet was terminated with an EEP. This is similar to what is required by CPTP. The buffering of the Space Packet was thus done in the telemetry encoder, which is implemented for nominal functionality and did not require extra resources.

REMOTE MEMORY ACCESS PROTOCOL

1.6 OVERVIEW

The SpaceWire Remote Memory Access Protocol (RMAP) [12] allows the implementation of a standardized communication method for reading and writing to remote memory and registers. This eliminates the plethora of existing ad hoc protocols that have been used in previous developments, allowing designers to focus their efforts on a single re-usable solution that can be transferred between projects.

1.7 FORMAT

	Target SpW Address	....	Target SpW Address
Target Logical Address	Protocol Identifier	Instruction	Key
Reply Address	Reply Address	Reply Address	Reply Address
Reply Address	Reply Address	Reply Address	Reply Address
Reply Address	Reply Address	Reply Address	Reply Address
Initiator Logical Address	Transaction Identifier (MS)	Transaction Identifier (LS)	Extended Address
Address (MS)	Address	Address	Address (LS)
Data Length (MS)	Data Length	Data Length (LS)	Header CRC
Data	Data	Data	Data
Data	...	...	Data
Data	Data CRC	EOP	

The RMAP format is defined in [12] and a write command is shown hereafter.

Figure: RMAP Write Command

The adoption of the Advanced Microcontroller Bus Architecture (AMBA) [14] as the on-chip bus fabric used in ESA developments was made simultaneously with the development of the LEON processor. The combination of RMAP and AMBA provides a means for remote access via SpaceWire to resources in a system-on-chip design, any AMBA slave connected to the bus can thus be read and written to. This is utilized in an alternative method for sending CCSDS Space Packets over SpaceWire.

1.8 SERVICES

Aeroflex Gaisler has implemented telemetry encoders and telecommand decoders in Field Programmable Gate Array (FPGA) devices [16] where the communication is done via SpaceWire links, but by means of the RMAP rather than CPTP.

The Space Packet is carried in the *Data field* of a RMAP write command. The RMAP protocol provides protection of the Space Packet by means of the 8-bit *Data CRC field*, which can be used to discard any packets that have been received with errors. RMAP also supports acknowledgement reporting to the initiator. (Space Packets can themselves include a 16-bit CRC as optional Packet Error Control, but would require checking of the Space Packet which is not in line with a layered protocol approach.) The routing is done by means of the addressing capability of RMAP commands; e.g. the address can be used for distinguishing between virtual channels on a downlink.

The Space Packet is written into an AMBA slave, which is addressed over the AMBA bus using the RMAP *Address field*. The AMBA slave forms the input to Virtual Channel Generation function of a telemetry encoder. Space Packets or any other user-defined data block can be input. Writing is only possible when the packet valid delimiter is asserted, else the access results in an AMBA access error. In the case the data from a previous write access has not been fully transferred over the interface, a new write access will result in an AMBA retry response. The progress of the interface can be monitored via the AMBA bus, which incorporates status and monitoring functions including busy and ready signaling for a new word or a new Space Packet.

COMPARISON

Since both RMAP and CPTP adhere to the same SpaceWire protocol identification ECSS standard [11], there is no problem mixing them in the same implementation. What they have in common is that a SpaceWire packet carries one-and-only-one Space Packet.

The CPTP protocol does however neither provide means for reporting the delivery of the packet, nor adding data error detection as with the RMAP approach (other than parity on the SpaceWire link, which both approaches implement). Consequently CPTP requires fewer overheads.

CONCLUSIONS

Both RMAP and CPTP provide basics means for CCSDS Space Packet transfer over SpaceWire, the former providing more protection against errors and possibility for acknowledgement and status monitoring, whilst the latter results in less overhead.

REFERENCES

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