Experience from using SpaceWire in a spacecraft telemetry system

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TM system overview

TM data 1 → FIFO → Virtual Channel MUX → Coding and modulation → Downlink
TM data 2 → FIFO
TM data 3 → FIFO
TM data 8 → FIFO
Connections in reality

Nominal User 1
Nominal User 2
Nominal User 3
Nominal User 4
Nominal User 5
Nominal User 6

Nominal TM system

Redundant TM system
Connecting the TM system to a SpaceWire network

Nominal User 1

Nominal User 2

Nominal User 3

Nominal User 4

Nominal User 5

Nominal User 6

SpaceWire network (or a pair of routers)

Nominal TM system

Redundant TM system
TM system with SpaceWire

- 8-port SpaceWire link adapter
- Virtual Channel MUX
- Coding and modulation
- Downlink
Link congestion problem

- SpaceWire link also used for control purposes
- The blue packet in the Rx FIFO could be a control packet!
Possible solutions

A. Let the TM system regularly broadcast its FIFO status to the SpaceWire network
   • Requires a SpaceWire broadcast mechanism for data

B. Let the TM system regularly transmit its FIFO status to selected nodes
   • Requires implementation of a non-standard protocol in hardware

C. Have the transmitting nodes interrogate the FIFO status
   • Requires implementation of a non-standard protocol in hardware

D. Let the transmitting nodes keep track of the allocated bandwidth
   • Requires complete concept change on system level

E. At a link stall, abort and resend the current packet on the link
   • Cannot guarantee that already received packets are not lost
Details on link reset

This packet will be lost at a link reset and the sender informed.

This packet might be corrupted at a reset, no info to the sender.

This packet will be discarded from the system to resolve the congestion, no info to the sender.
Method selected

- Mixture of SpaceWire link and dedicated links
- Dedicated links maintained for non-intelligent sources (mass memory, essential TM)
- Polling done by single user only, protocol in software
- Redundant control I/F in case SpaceWire link stalls despite all precautions

![Diagram of data flow and control interfaces]

Data from intelligent users

Spacecraft Control Computer (router)

8-port SpaceWire link adapter

Serial inputs

8x 2-1 MUX

FIFO

FIFO

FIFO

Virtual Channel MUX

Control I/F

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Transmission of large data structures

• **Mixing several sources on the same link**
  – Need for guaranteed bandwidth and latency for a specific application
  – Create Virtual Channels over a SpaceWire link

• **Splitting large structures**
  – How to select optimum SpaceWire packet size?
  – Do we need to ensure sequential delivery?
  – Need for hardware support to split?

• **Signaling end of structure**
  – How to signal the end of the large data structure?
  – Simple method needed for non-intelligent devices
Selected structure splitting method

CPU data bus  Data sources  Data splitters  Packet MUX  SpaceWire link
Selected structure splitting method

Source packet

SpaceWire packets

Packet with header only signals “End of message”
Control commands over a SpaceWire link

- **Simple method selected:**
  - View the device as a read/write memory

**Write command:**

```
0 0F Size Address Data EOP
```

**Read command:**

```
0 F0 Size Address EOP
```

As the SpaceWire link protocol is very reliable no additional check mechanisms are needed.
Problems experienced

• Lack of high-level handshaking method
  – How to ensure that a packet to be sent will be received
  – Needed in order not to block a link

• Lack of standardised method to transmit large data structures
  – Mixing several data sources on the same link
  – Splitting larger structures into smaller SpaceWire packets
  – Signaling end of data structure

• Other mechanism than link reset to resolve congestion problems

• Lack of standardised redundancy concept
  – Link cross-strapping
  – Switching between redundant links
Problems with lack of standardised cross-strapping method

A: No x-strap
B: Full x-strap
C: X-strap in rec.unit
D: X-strap in sending unit

- In Rosetta both methods B and C were required!
- Internal unit cross-strapping drastically reduces unit modularity!
Prototype TM/TC board