SpW-D

Steve Parkes, Albert Ferrer
Space Technology Centre, University of Dundee

Chris McClements, Stuart Mills, Alex Mason
STAR-Dundee Ltd
SpaceWire for Control Applications

- Determinism is essential
  - Determinism means
    - Predictable
    - Delivery within time constraints
  - Constrained Architecture
  - Time-slicing

- Determinism with constrained architecture
  - All communication initiated from data-handling computer
  - Single master architecture
  - Warm/cold redundancy
Simple link is deterministic

Instrument \rightarrow SpW \rightarrow Mass Memory
Determinism with Constrained Architecture

Controlling Node

Data-Handling Processor

Read Command

Read Reply

SpaceWire Router

Inst. 1
Inst. 2
Inst. 3

SpaceWire Router

Inst. 4
Inst. 5

Mass Memory
RMAP and Determinism

- Data-handling processor is the RMAP initiator
- RMAP targets are
  - Instruments
  - Mass memory
  - Telemetry
  - Etc
- RMAP initiator sends RMAP command
- RMAP target responds to command
  - Returns data/ack to initiator
- If expected reply not received
  - RMAP initiator can time-out and flag error
Determinism with Time-Slots

- Time-codes used to define time-slots
- Time-slot has same number as time-code that starts the time-slot
- 64 Time-slots
- For a 200 Mbits/s network
  - Time-slot around 30 μs
  - Epoch of 64 time-slots around 2 ms
- Sufficiently timely for avionics applications
- Fully deterministic to << 30 μs
Determinism with Time-Slots

Each initiator has a schedule table

Specifies in which time-slots an initiator is allowed to initiate an RMAP command
Time-Slot 2

Data-Handling Processor

SpaceWire Router

Read

Command

Inst. 1

Inst. 2

Inst. 3

Mass Memory

Read

Reply

0 1 2 3 4 ...
Y N N Y N ...

0 1 2 3 4 ...
N Y Y N N ...

...
Time-Slot 3

Data-Handling Processor

SpaceWire Router

Inst. 1
Inst. 2
Inst. 3

Mass Memory
Assigning data to time-slots

- Different models can be used for assigning data to time-slots
- Simple queue
- Priority queue
- Queue for each time-slot that the node is allowed to send it
- Etc
SpW-D Performance

Time-code

1. HDR
2. DATA
3. HDR
4. DATA
5. REPL
6. REPL

a
b
c
d
e
f
g
h
i
Initiator Constraints

- Max data in RMAP read or write is 256 bytes (TBC)
- Must respond
  - Time-code to send RMAP command < 5 μs (a)
Target Constraints

- No modifications to RMAP target
- Must respond
  - End of header to authorisation: < 5 μs (d)
  - Read or Write at least as fast as SpaceWire link can handle data 20 Mbytes/s
  - Read or Write latency: < 5 μs (f)
  - Create reply: < 5 μs (g)
SpW-D Performance

Effect of Data Length on Time-Slot Interval and Average Data Rate

Assumes average packet size is 130 bytes.
Time-Slot 0

Data-Handling Processor

Write Command

Write Reply

Spacewire Router

Read Command

Inst. 1

Inst. 2

Inst. 3

Mass Memory

0 1 2 3 4 ...
Y N N Y N ...

0 1 2 3 4 ...
Y Y Y N N ...
Conclusion

- Built on SpaceWire and RMAP standards
- Uses time-codes to produce time-slots
- Schedules communication in time-slots
- Uses RMAP transactions
- Can support FDIR
- Simple constraints:
  - RMAP target
    - Speed of response to RMAP command
  - RMAP initiator
    - Speed of response to time-code
    - Limit to size of RMAP data field
- Very simple to implement
SpaceWire-D Protocol Stack

User Application

PTP

Segmentation

Retry/Redundancy

RMAP

Scheduling

SpaceWire

SpW PnP
Demonstration

- Brick Initiator
- Link Analyser
- Brick Initiator
- Link Analyser
- Router USB
- SpaceWire Network
- Router SpW-10X
- Brick Target
- Brick Target
- Brick Target
- Brick Target
- RTC Target