NASA-GSFC
Remote Memory Access Protocol (RMAP)
Target IP Core

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To be presented by Omar Haddad at the 2011 International SpaceWire Conference, San Antonio, TX, Nov 8 to 10, 2011
Overview

• Magnetospheric Multiscale (MMS) Mission is the first NASA-GSFC mission to use RMAP
• An Intellectual Property (IP) core was developed to implement RMAP target functionality
• This presentation discusses the results
The Advantages of RMAP

Why did MMS choose RMAP?
The MMS Plan

- SpaceWire Network
  - Single RMAP command initiator, multiple RMAP targets
- RMAP Target Implementation
  - *State machines* Vs. embedded micro-controller
- RMAP Host Implementation
  - *Flight Software* Vs. hardware IP core
- Implement only RMAP functions needed
- Use RMAP Protocol document ECSS-E-50-11 Draft F
  - Latest at the time of development
  - Current version is ECSS-E-ST-50-52C SpaceWire - Remote memory access protocol, 5 February 2010
Hiding The Packet Layer

- RMAP operates at the *Packet* layer
- Board designer focuses on network and application layers
- Packet layer and below are treated as reference designs
Re-inventing The Wheel

- Shaded blocks are developed one time and provided to all board designers as reference designs
- Identical elements
  - Parts, cables, RTL code
- Variable elements that require guidelines
  - PCB Layout, FPGA synthesis and place-and-route
- Data bus to user logic is 32-bits wide

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What was needed to meet MMS requirements?
## Read/Write

<table>
<thead>
<tr>
<th>Read</th>
<th>Write</th>
<th>Read-Modify-Write</th>
</tr>
</thead>
<tbody>
<tr>
<td>• All variants supported</td>
<td>• All variants supported</td>
<td>• Not required for MMS</td>
</tr>
<tr>
<td>• Return data padded to 32-bit chunks</td>
<td>• Verified writes limited to 4 data bytes per transaction</td>
<td>• Not supported</td>
</tr>
</tbody>
</table>

- Data bus to user logic is 32-bits wide

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Event Signaling

- Described in ECSS-E-50-11 Draft F
  - Removed in later versions?!!
  - Prevents the use of stale data
- Useful for collecting telemetry
- Two outstanding event-signaling read commands supported for MMS

**Host**
- Sends event signaling read command

**RMAP Target**
- Parses command
- Starts ADC collection
- State machine collects and stores telemetry
- Asserts DONE

**User Logic**
- Composes a response packet
- Returns to host

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Bypass Port

- Allows RMAP-enabled devices to support non-RMAP packets
- Packets routed based on logical address
SpaceWire Device Register Interface

- Uses extended address field
- Requires actual registers to be implemented in a wrapper
- Allows RMAP packets to be used to remotely configure SpaceWire devices

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Back-end Timeout

- RMAP target handshakes with user logic
  - Response not sent until transaction is complete
- RMAP target aborts transaction if user takes too long to complete transaction
- Error is logged
- Response contains status, if requested
- Timeout can be disabled
Development and Testing

Notable issues encountered
CRC Algorithm Confusion

- RMAP uses cyclic redundancy checks for header and data fields
- RMAP Standard provides sample VHDL and C code
- Draft F samples for VHDL and C give differing results
- Use sample code from ECSS-E-ST-50-52C SpaceWire - Remote memory access protocol, 5 February 2010
Lessons Learned

Quality of documentation

- High level of reuse with many applications
- Be clear and use lots of diagrams
- Requests for clarification
  - Define byte ordering between packet contents and 32-bit back-end data bus
  - Specify transaction latencies and execution time
  - Describe non-normative behavior
Compliance

- Performed by NASA mission, Astro-H
  - GSFC subsystem interfacing to JAXA subsystem
- GSFC RMAP target IP core found to be fully compliant
- No issues found

Note: JAXA is Japan Aerospace Exploration Agency
Results

Was implementing RMAP worth the investment?
Reuse

Reference design for RMAP-enabled device
- Parts, schematic, VHDL IP cores

Successfully used on MMS on 4 cards
- Two organizations: GSFC, Southwest Research Institute (SwRI)

Other GSFC projects now using RMAP Target IP core
Simplification

**Hardware Effort**
- Less design analysis
- Single review for board interface
- Simulation and debugging of one interface

**Flight Software Effort**
- Less SpaceWire packet protocols to support
- RMAP features simplify transactions (using verified writes)
Standardization

- MMS uses RMAP to standardize on communication with subsystem components and configuring their SpaceWire interfaces
- Using RMAP mitigated interface problems with components from other agencies
- Using RMAP provided an advantage in selecting lab test equipment
 Sufficiency of RMAP

- RMAP alone was not sufficient for MMS
- RMAP targets cannot ‘speak’ unless ‘spoken’ to
- For data-stream interfaces, MMS used CCSDS-embedded SpaceWire packets
  - Uplink/downlink ground interfaces

Note: CCSDS is Consultative Committee for Space Data Systems
Conclusion

RMAP is a great idea!