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

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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?

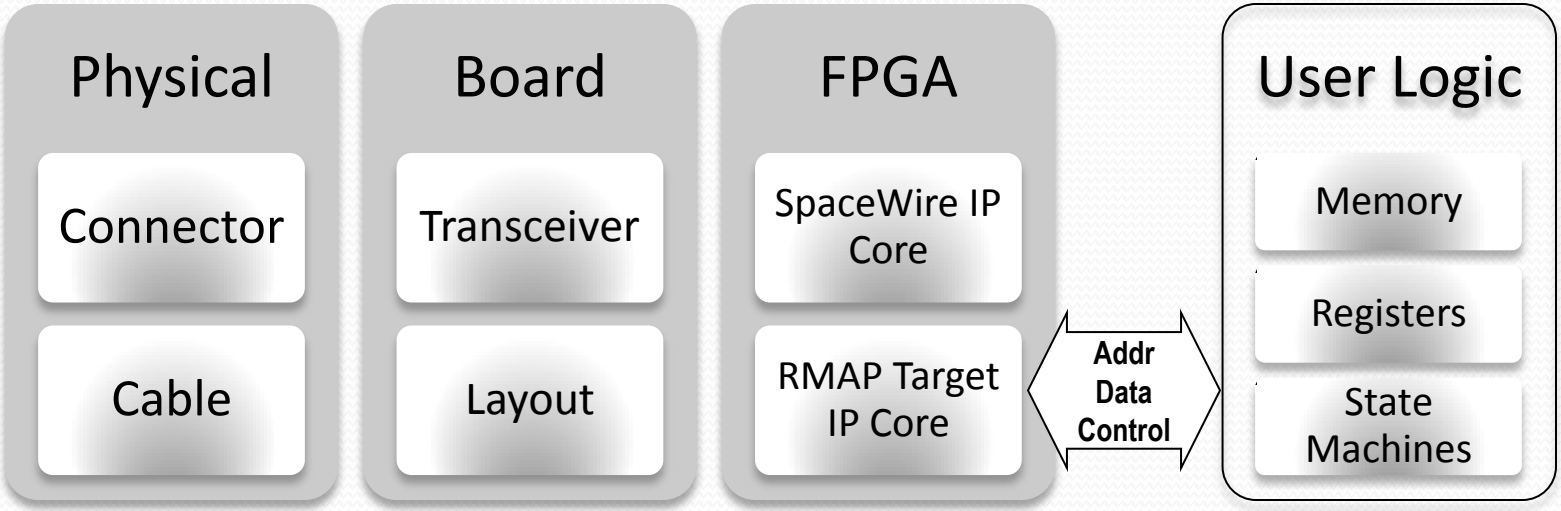
The MMS Plan

- 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

RMAP Features Implemented

What was needed to meet MMS requirements?

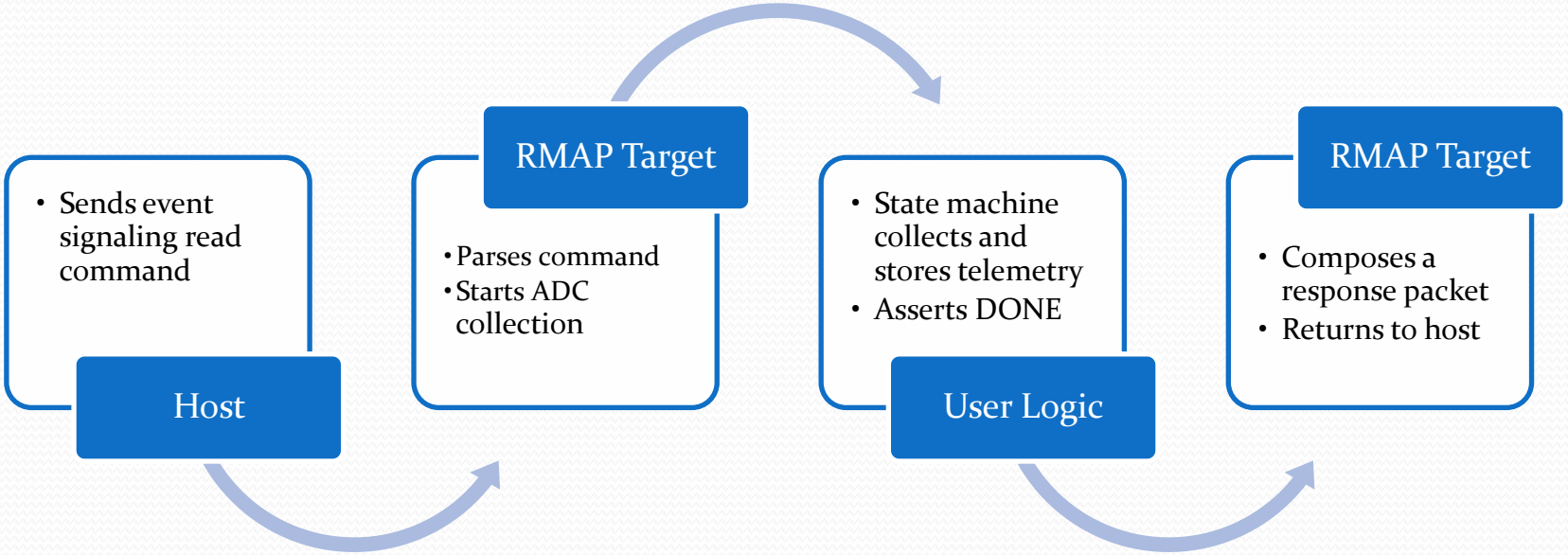
Read/Write

Read	Write	Read-Modify-Write
• All variants supported • Return data padded to 32-bit chunks	• All variants supported • Verified writes limited to 4 data bytes per transaction • Write data is padded to 32-bit chunks	• Not required for MMS • Not supported

- Data bus to user logic is 32-bits wide

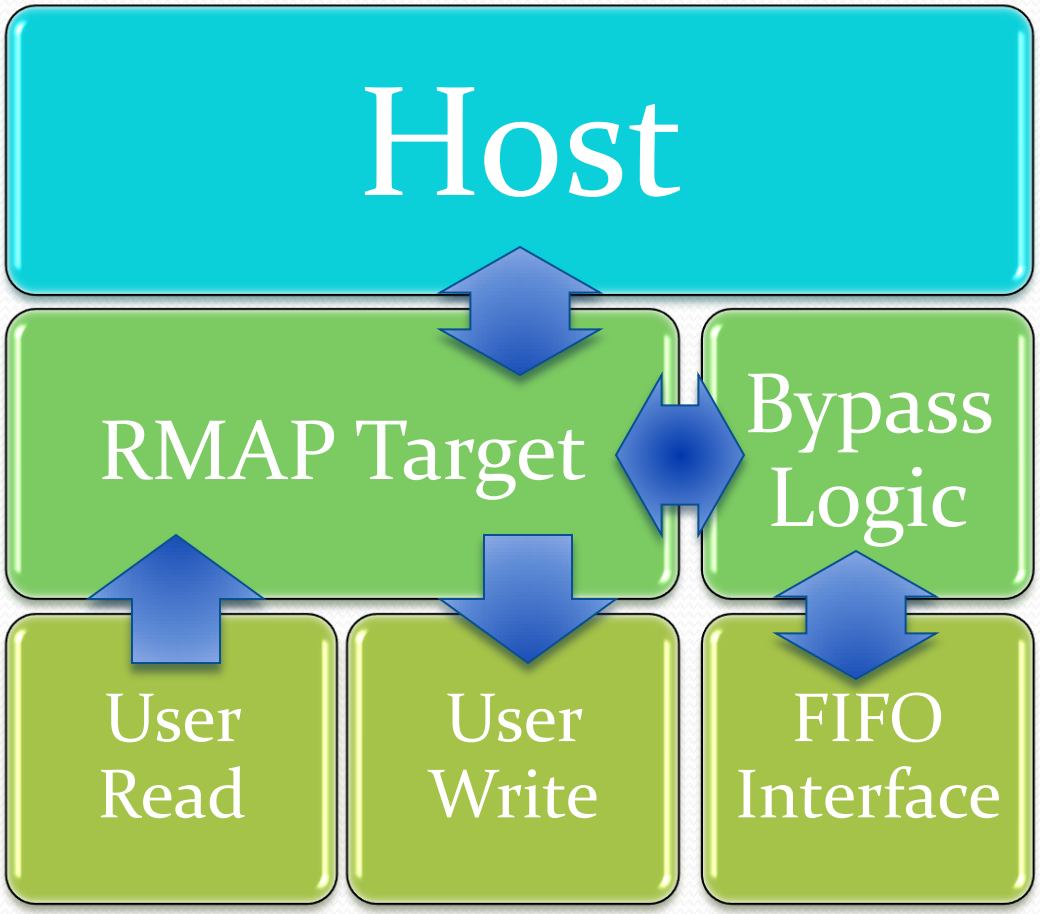
Event Signaling

- 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

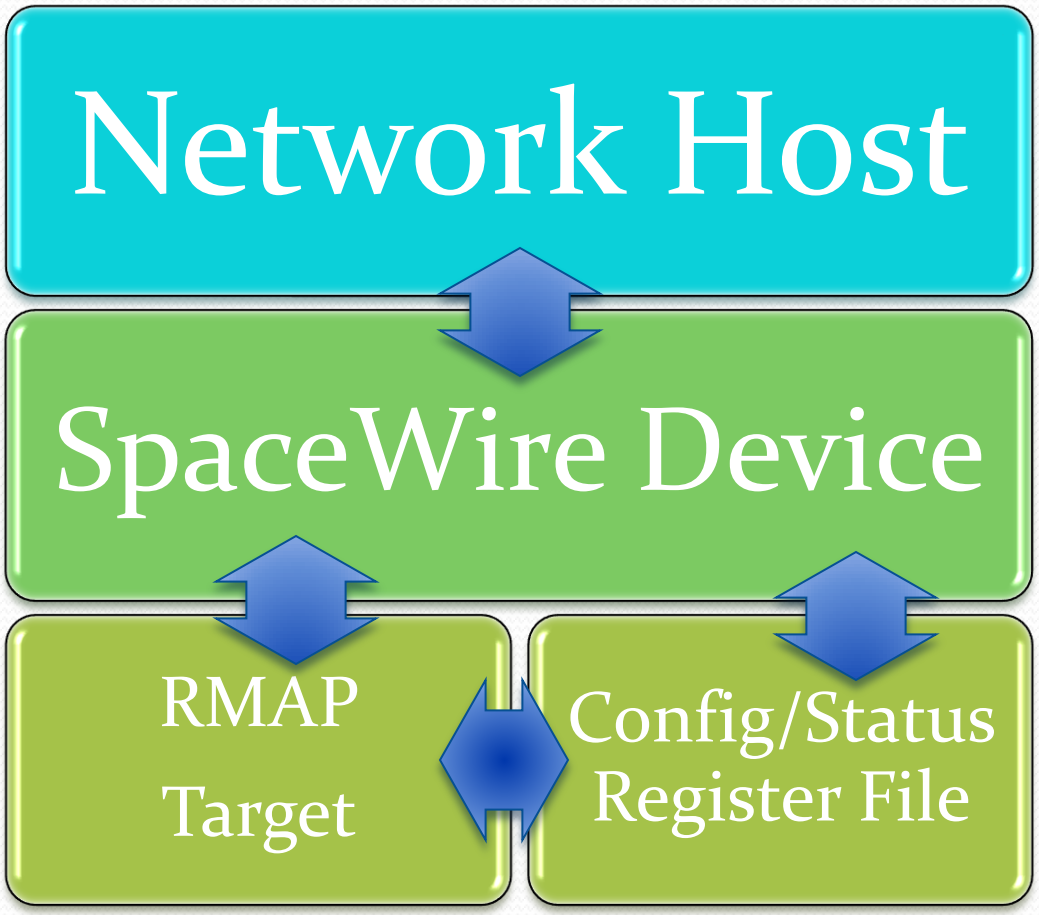


Bypass Port

- Allows RMAP-enabled devices to support non-RMAP packets
- Packets routed based on logical address



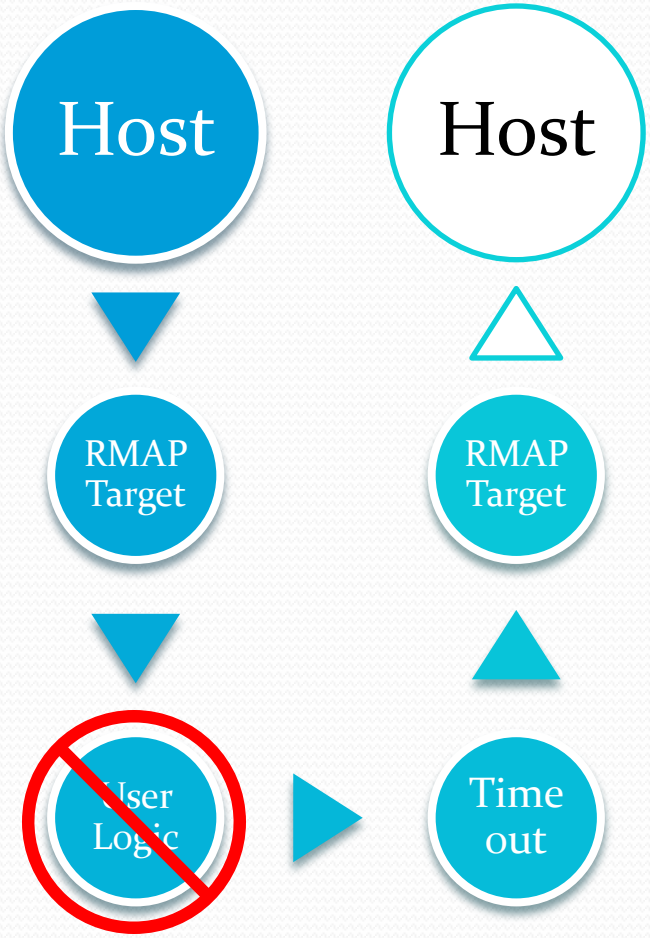
SpaceWire Device Register Interface



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

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

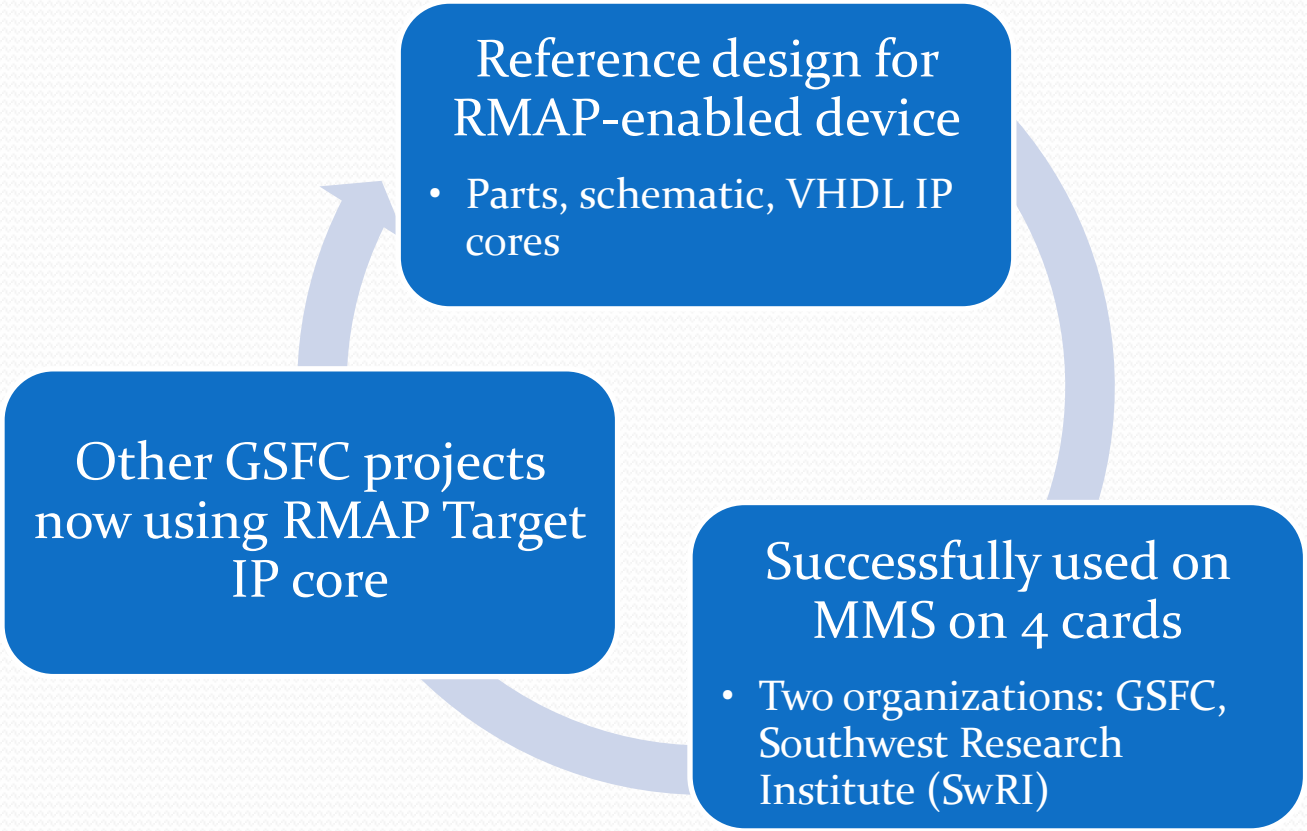
- Performed by NASA mission, Astro-H
  - GSFC subsystem interfacing to JAXA subsystem
- GSFC RMAP target IP core found to be fully compliant
- No issues found

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!