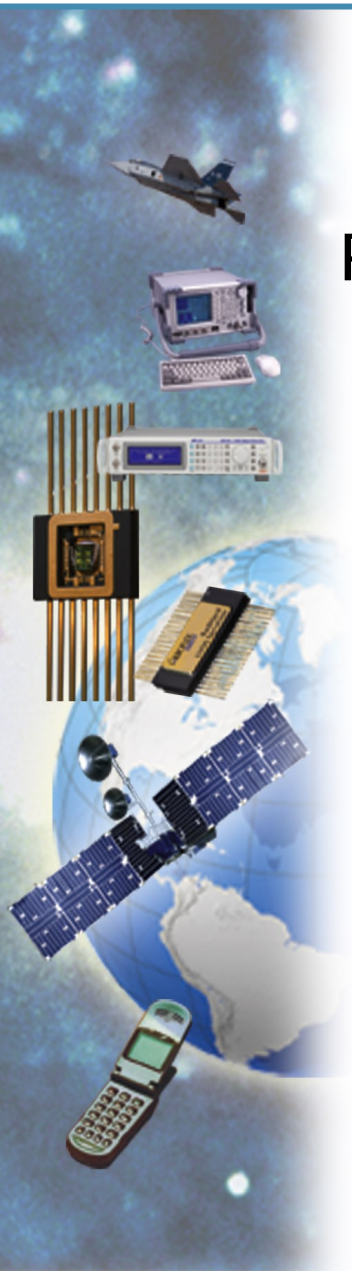


Next Generation Microprocessor Functional Prototype SpaceWire Router Validation Results

Jonas Ekergarn, Jan Andersson, Andreas Larsson, Daniel Hellström, Magnus Hjorth – Aeroflex Gaisler AB
Roland Weigand – ESA

SpaceWire Conference 2013
2013-06-13

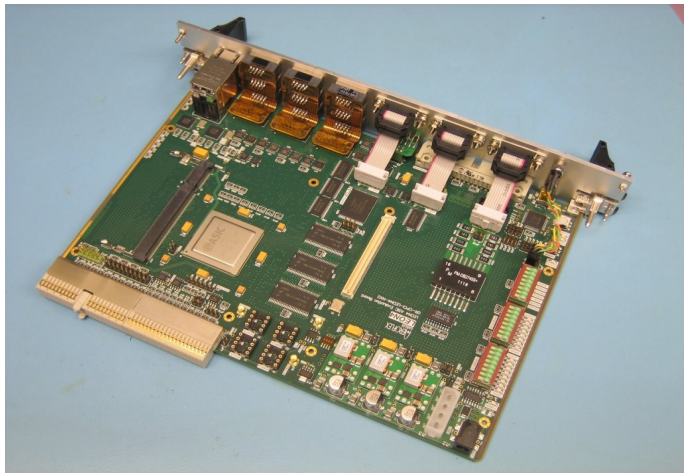
www.aeroflex.com/gaisler

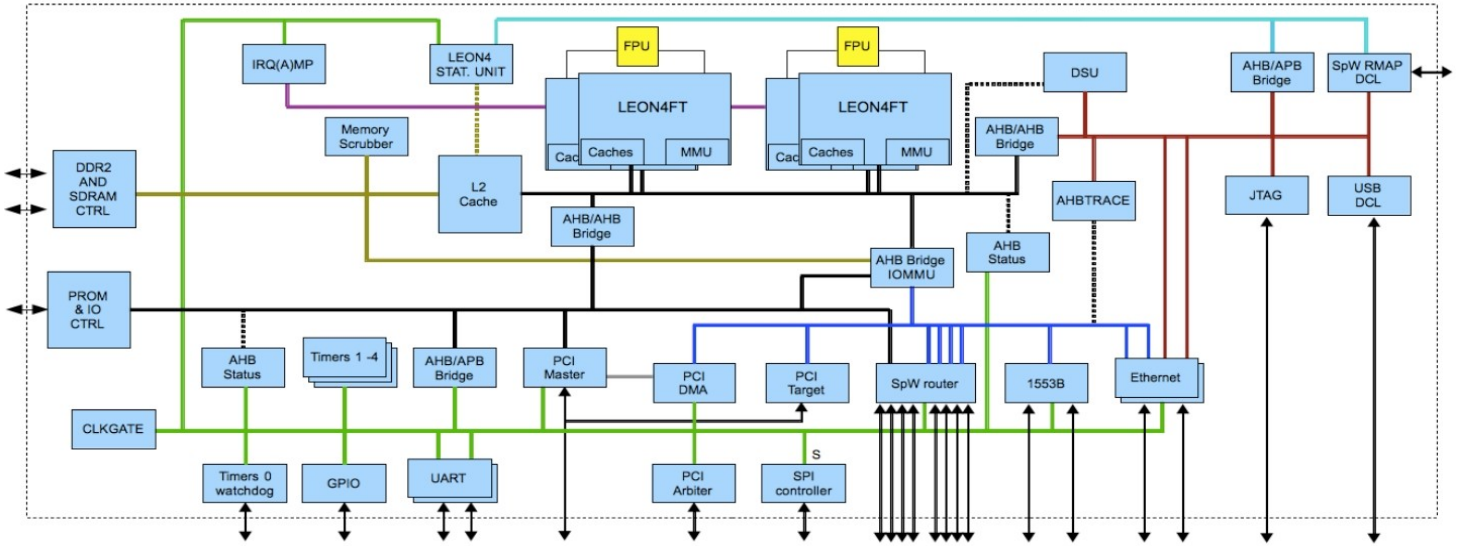
Next Generation MicroProcessor (NGMP)

- Quad-processor system-on-chip
  - Four LEON4FT SPARCV8+ processors, with shared Level-2 cache
  - DDR2-800 SDRAM main memory interface
  - SpaceWire router with 8 external and 4 internal ports.
  - 10/100/1000 Mbit Ethernet MACs
  - 66 MHz PCI interface
  - Target frequency is 400 MHz
- Part of ESA roadmap for standard microprocessor components.
- Implementation in rad-hard technology on hold, pending suitable technology for space.
- Functional prototype based on eASIC Nextreme2, 45 nm. Silicon received in August 2012, and an evaluation board has been manufactured.

Next Generation MicroProcessor Functional Prototype (NGFP)

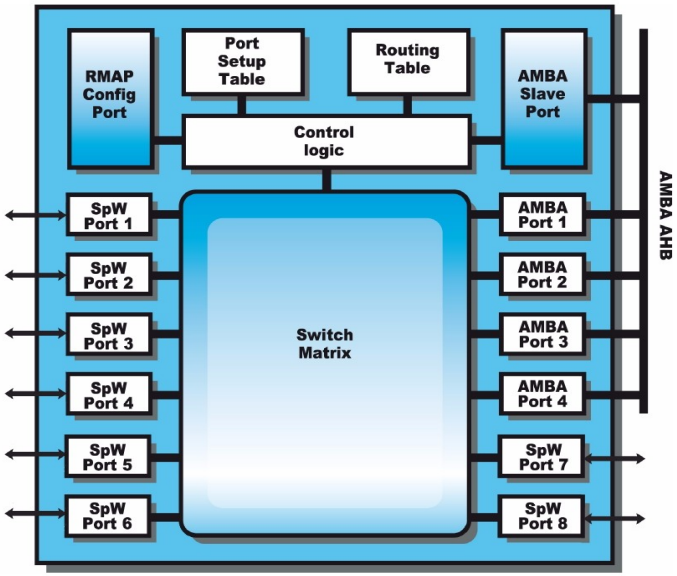
- Functional prototype compared to NGMP baseline
  - High Speed Serial Links not present.
  - DDR2-600 SDRAM
  - 200 Mbit/s SpaceWire link speed
  - 200 MHz system frequency





SpaceWire Router in NGMP

- Configuration
  - Eight external SpaceWire ports.
  - Four internal AMBA ports.
  - 64 entries per N-Char receive and transmit FIFO.
  - 32 entries per 32-bit AMBA port FIFO.
  - Four DMA channels per AMBA port.
  - Hardware RMAP target in each AMBA port.
  - 16-bit common prescaler and 10-bit individual timers for each port.
- Role in NGMP
  - Replaced initial plan to use four SpaceWire codecs with AHB interface (GRSPW2 IP core).
  - NGMP targeted at general payload processing.
  - Router AMBA ports are software compatible with GRSPW2.
  - SpaceWire router provides more options to system designers.



SpaceWire router validation

- High-speed communication through AMBA ports
  - Routing traffic through Level-2 cache
  - Routing traffic behind Level-2 cache
- High-speed SpaceWire traffic
  - Running all SpaceWire links in 200 Mbit/s
- SpaceWire router key functionality
  - Group adaptive routing
  - Packet distribution
  - Priority routing
  - Packet timers

SpaceWire Router Validation – AMBA ports (1/2)

- Validation procedure
  - RTEMS application routing packet through all AMBA ports.
  - Unique sequence numbers and data for validation.
  - 200 MHz system clock.
  - Test configurations:
    - CFGA: Cache-coherent system with Level-2 cache, caching all traffic
    - CFGB: System with Level-2 cache. SpaceWire DMA buffers not cached, and SpaceWire DMA traffic does not pass through Level-2 cache.

SpaceWire Router Validation – AMBA ports (2/2)

- Validation results
  - CFGA:
    - Combined throughput of DMA ports 1,54 Gbit/s
    - Performance negatively affected if other software instances make use of shared Level-2 cache.
  - CFGB*:
    - 18% decrease in throughput compare to CFGA.
    - When bypassing Level-2 cache the DMA traffic has negligible impact on software => Effective when other software instances make use of Level-2 cache.

* Completed on FPGA prototype due to NGFP IOMMU silicon errata.

SpaceWire Router Validation – Group adaptive routing

- Group adaptive routing principle
  - One or more ports grouped together for each address.
  - For an incoming packet, the first available output port is selected.
- Validation procedure
  - AMBA ports used as source ports, and final destination ports.
  - Two SpaceWire ports grouped together.
  - Packets routed from AMBA port out onto one SpaceWire port, and back to AMBA port.
  - SpaceWire link speed of 200 Mbit/s
- Validation results
  - Correct port selected when other port was not running.
  - Correct port selected when other port was busy.
  - Group adaptive routing routine works for both physical and logical addresses.

SpaceWire Router Validation – Packet distribution

- Packet distribution principle
  - One or more ports grouped together for each address.
  - Incoming packets are forwarded to all ports in the group.
- Validation procedure
  - AMBA ports used as source ports, and final destination ports.
  - Two SpaceWire ports grouped together.
  - Packet routed from AMBA port, out onto both SpaceWire ports, and back to different AMBA ports (group adaptive routing used for second address byte).
  - SpaceWire link speed of 200 Mbit/s
- Validation results
  - Packets sent on all ports when all ports were running, and not busy.
  - Packets not sent on any port if one port was not running, or busy.
  - Packet distribution routine works for both physical and logical addresses.

SpaceWire Router Validation – Priority routing

- Priority routing principle
  - Two-level priority for each address (physical and logical)
  - Round robin used for each priority level.
- Validation procedure
  - AMBA ports used as source ports, and final destination ports.
  - Packets with addresses with different priority sent from all AMBA ports.
  - Packets routed out onto a single SpaceWire port, back to a single AMBA port.
  - SpaceWire link speed of 200 Mbit/s
- Validation results
  - Receive order of packets verified.
  - Priority routing works for both logical and physical addresses.

SpaceWire Router Validation – Packet timers

- Packet timer functionality
  - Common prescaler, and individual packet timers for each port.
  - Timer starts when destination port(s) have been selected for a packet.
  - Timer reload when data flows through the wormhole.
  - Packet spilled if timer expire.
- Validation procedure
  - AMBA ports used as source ports, and final destination port.
  - Packets routed out onto the same SpaceWire port.
  - First packet routed again onto a port that was not running.
  - SpaceWire link speed of 200 Mbit/s
- Validation results
  - Packets never spilled if packet timer for source port not enabled.
  - Destination ports' packet timers does not affect packet transmission.
  - Packets spilled if source port's packet timer expire.

Additional validation (not in paper)

- Time-code forwarding
- Link start on request, and Auto disconnect
- Router configuration through RMAP to port 0.
- SpaceWire RMAP traffic to AMBA ports.
- RTEMS AMBA port test running together with Linux.
- RTEMS AMBA port test also routing packet on external ports.
- SpaceWire router used with companion board (GR-RASTA-IO) during PCI validation.

Conclusions

- Functionality to bypass Level-2 cache successfully demonstrated.
- High-speed communication through the SpaceWire router's AMBA ports verified.
- Core functionality of the SpaceWire routing switch verified through test cases using group adaptive routing, packet distribution, priority routing, and packet timers

Thank you for your time. Questions?