RapidIO over SpaceWire: Blending Complementary Protocols

Networks and Protocols:

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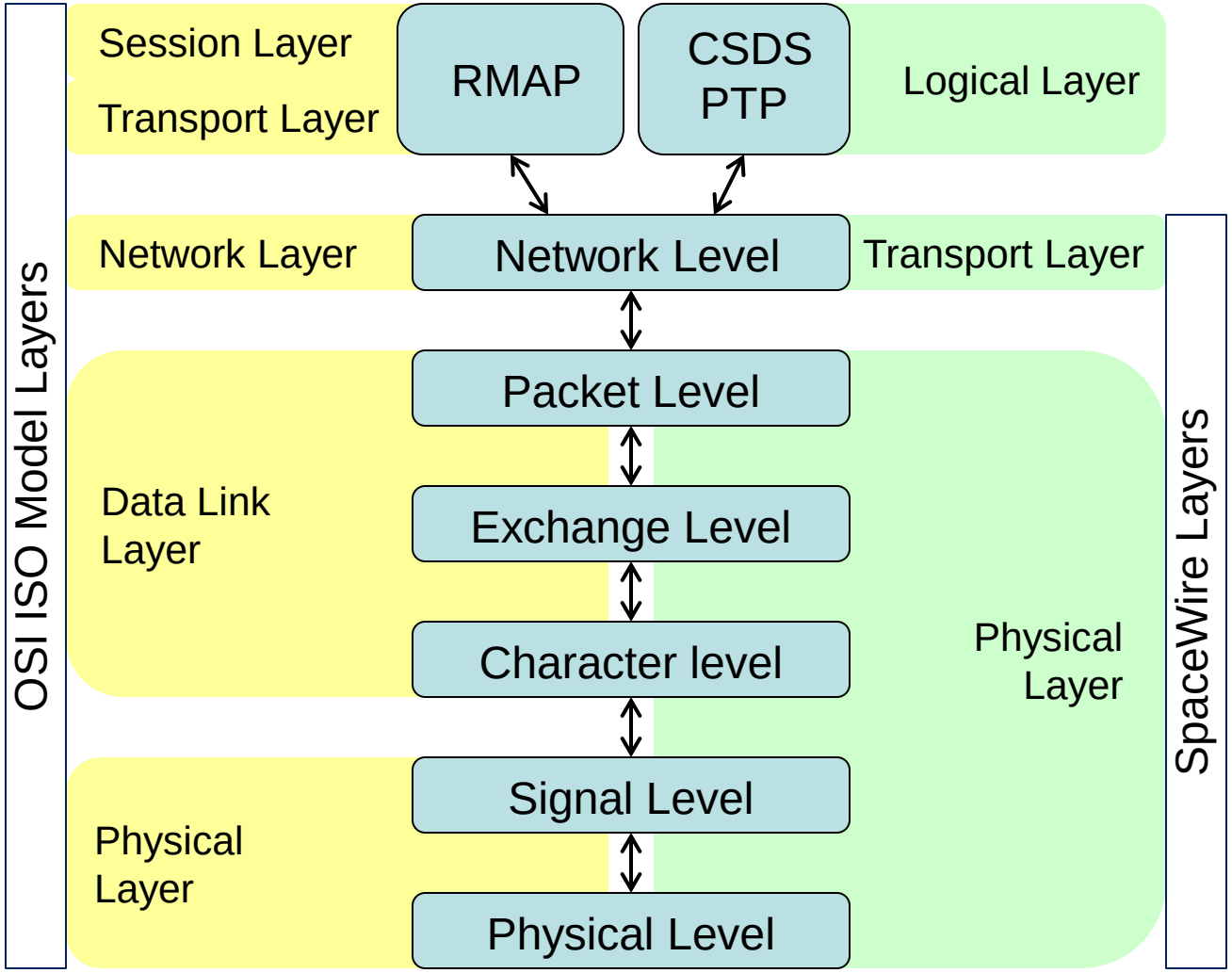
Steve Belvin

Systems Engineer

Goals of Networks

- Effective bandwidth utilization
  - Packet overhead should be low
- Effective bandwidth sharing
  - Limited packet size
  - Packet priority
- Varying payload sizes
  - Support various user services from I/O to streaming
- Low latency
  - Uncontrolled, deterministic or as low as possible
- Low power consumption
- Reliable data delivery
  - Varies from best effort to guaranteed delivery
- Multiple communications mechanisms
  - Support simple memory-mapped reads and writes, multicast, event signaling, messaging, streaming
- Multiple topologies and sizes
- Standards based

SpaceWire Standard in Layers



End to end communications

Packets

Flow of packets

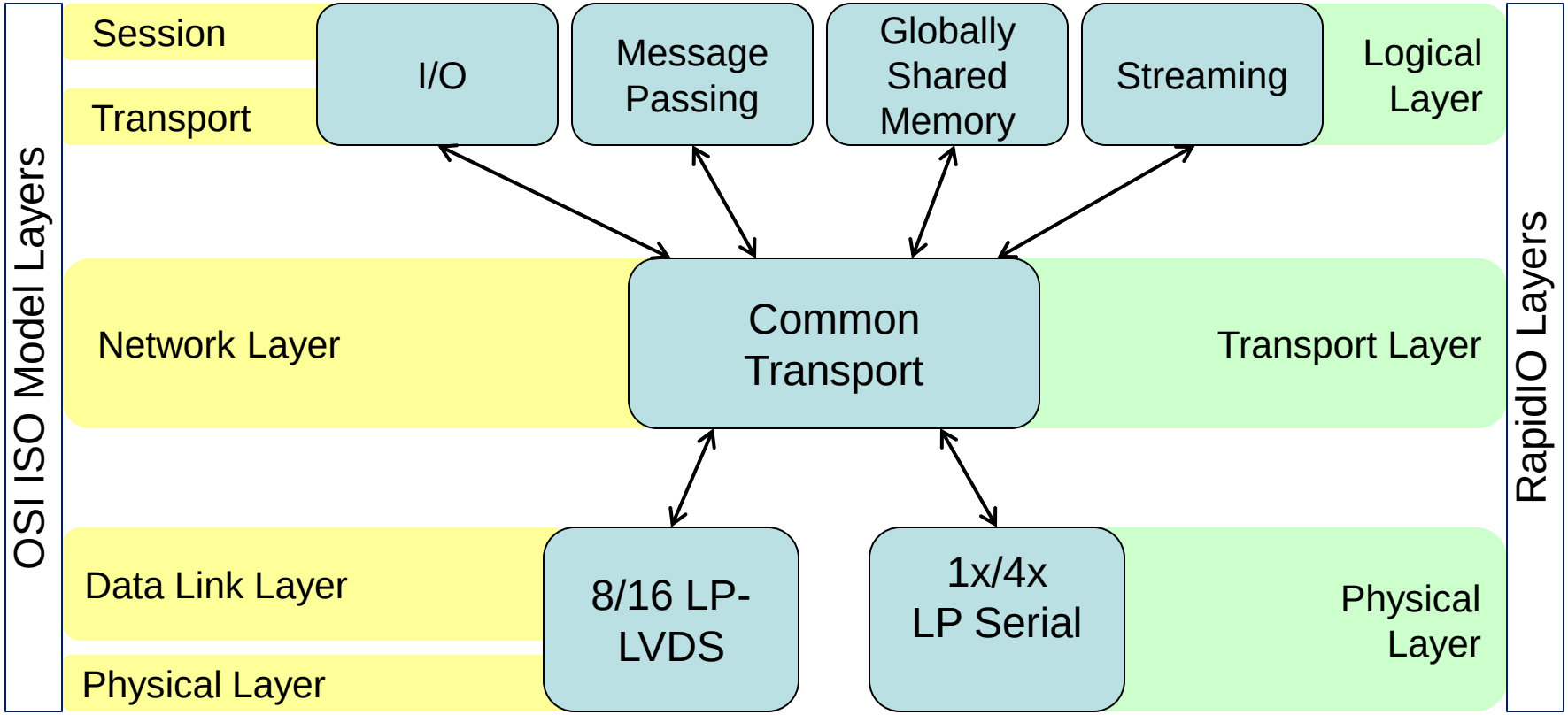
Flow control, error detection, link error recovery

Data and control characters

Signal voltage levels, signal encoding, noise margins, data rates

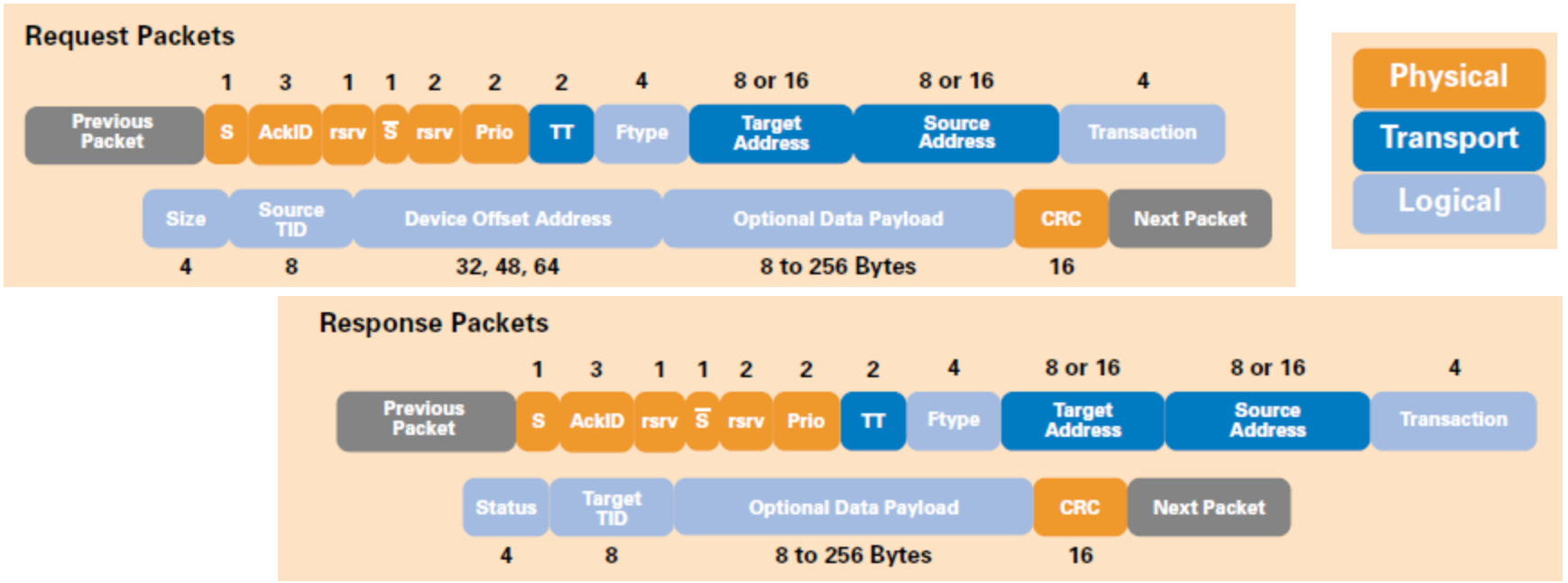
Connectors, PCB wiring

RapidIO in Layers



- RapidIO is specified in three layers: Physical, Transport and Logical layers
- The Logical and Transport Layers are specified independent of the Physical Layer

RapidIO Packet Format

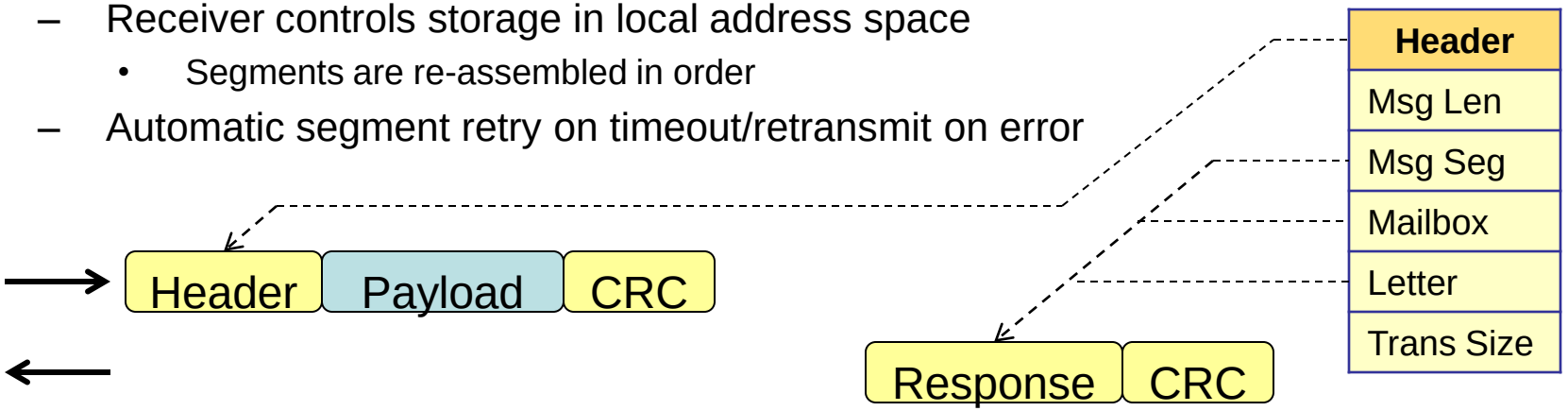


Logical & Transport Layers	
TT: Type of Transport	Size: Encoded transaction size
Target Address: Logical destination	Source TID: Transaction IDentity
Source Address: Logical source	Device Offset Address: Memory-mapped transactions
Ftype: Format Type	Payload
Transaction	Status: Result of transaction

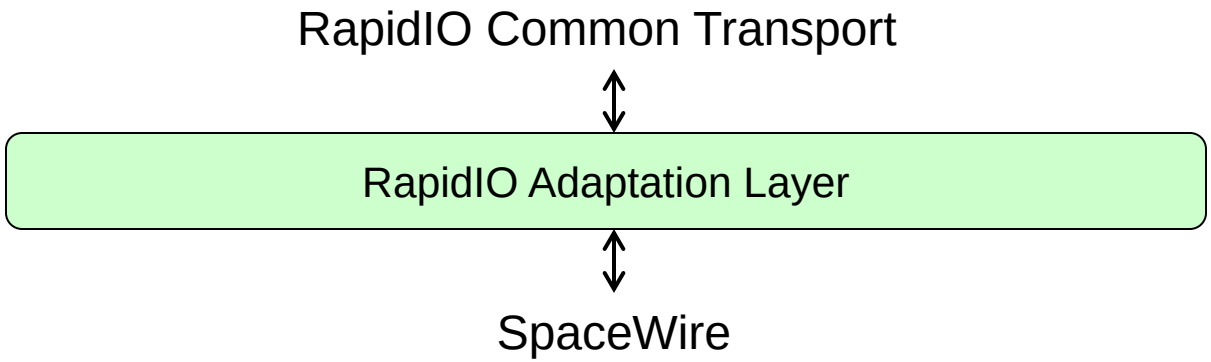
Physical Layer
S: Packet or Control Symbol
AckID: Acknowledge type
PRIO: Packet priority for flow control
CRC: 16-bit CRC for link error detection/retry

Message Passing

- Two types of block data moves in distributed memory systems
  1. Direct memory access (DMA) – source control
  2. Messaging – target control
- Messaging commonly used in multiprocessor systems
  - "Share nothing" environment
  - In RapidIO, messaging handled using hardware – messages and doorbells
- RapidIO messaging
  - Single message in flight from source to one mailbox/letterslot at the destination
    - Unique per priority level
  - Messages can be up to 4kbytes (maximum of 16 segments)
  - Receiver controls storage in local address space
    - Segments are re-assembled in order
  - Automatic segment retry on timeout/retransmit on error

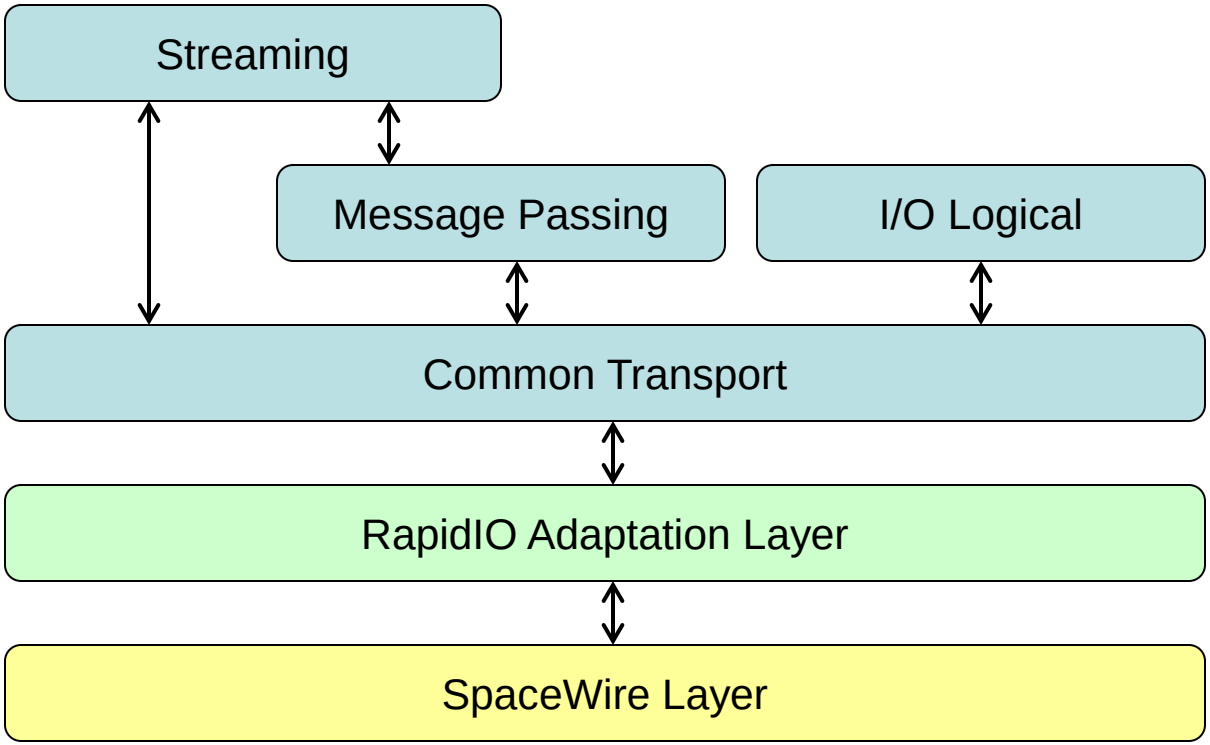


Bringing RapidIO and SpaceWire Together



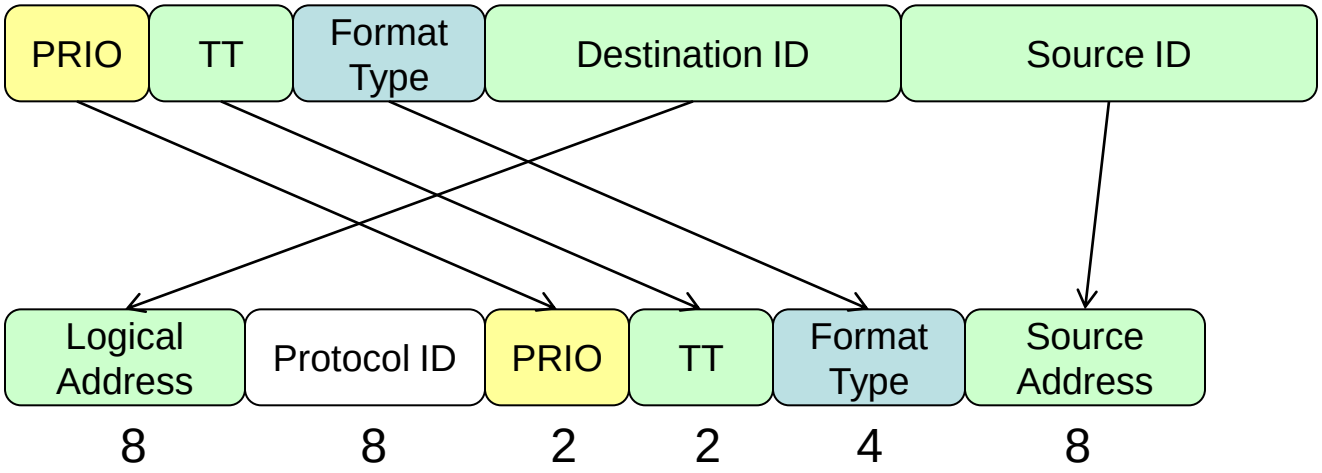
- RapidIO Adaptation Layer allows SpaceWire and RapidIO networks to be used together
- Operations of network adaptation layer
  - SpaceWire protocol identifier
  - Network address mapping
  - Packet delivery handshake
  - Packet integrity check
  - Packet and transaction delivery controller
  - End-to-end acknowledgement counter
  - Control and status registers added to RapidIO Configuration Space

RapidIO over SpaceWire Protocol Stack



- Message Passing provides end-to-end delivery guarantee over any other delivery guarantees provided by lower levels of stack
- Encapsulate Streaming in Message Passing when reliable delivery is needed

Adapting RapidIO for SpaceWire



- Destination ID and Source ID fields are mapped to Logical Address
- Protocol ID is appended
- Priority, Transport Type and Format Type are added
- 8-bit Source and Destination are shown
  - Logical address size may be extended

RapidIO and SpaceWire are Complementary

- RapidIO Advantages
  - Low protocol overhead
  - Packet priority
    - In order delivery per flow
  - Link level handshaking
  - Standard configuration method
  - Support for multiple network services: I/O, Message Passing, Streaming, others
  - Message Passing: segmentation and re-assembly with reliable delivery
  - Use of commercial intellectual property for hardware and software
  - Extensions for specific applications
  - Future growth through commercial use

- RapidIO Disadvantages
  - Targeted at very high bandwidth applications
    - 1Gbps and up
  - Robust physical layer is costly (area and power)
    - Complex mixed signal transceiver
    - Link level handshaking

RapidIO's diverse set of upper layer protocols provides multiple services, including reliable delivery using Message Passing protocol combined with SpaceWire's lower transmission rates and lightweight Physical Layer results in an efficient and effective network for Space communications.

Summary

- The RapidIO Standard set of specifications provides many services desired in full-featured networks
  - The Common Transport Logical Layer Protocol is independent of the Physical Layer
  - Message Passing offers reliable delivery with segmentation and re-assembly
- The SpaceWire Standard provides a low-gate count link to transport RapidIO Common Logical Layer Transport Layer Protocol information
- RapidIO software and hardware intellectual property may be blended with SpaceWire hardware intellectual property to form a full-featured network
  - Reduced physical layer area

Existing RapidIO products:

- IP from major FPGA vendors and others
- Semiconductor devices
- Boards and modules
- Embedded systems
- Test and measurement
- Software

References

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7. RapidIO Trade Organization, “RapidIO Interconnect Specification Part 1: Input/Output Logical Layer Specification”, Revision 2.2, June 2011.
8. RapidIO Trade Association, “RapidIO, PCIExpress and Gigabit Ethernet Comparison: Pros and Cons of Using Interconnects in Embedded Systems”, Revision 3, May, 2005.
9. RapidIO Trade Organization, “RapidIO Interconnect Specification Part 2: Message Passing Logical Layer Specification”, Revision 2.2, June 2011.
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