RISC-V: Enabling a New Era of Open Data-Centric Computing Architectures

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The Evolving Role of Data
Creating the data-driven economy

- Data as a record
- Data as communication
- Data as efficiency
- Data as currency
Diverse and Connected Data Types

Tight coupling between Big Data and Fast Data

- **Big Data**
  - Insight
  - Prediction
  - Prescription
  - Scale
  - Data Aggregation
  - Batch Analytics
  - Modeling
  - Artificial Intelligence
  - Machine Learning
  - Algorithms

- **Fast Data**
  - Performance
  - Mobility
  - Real-time Results
  - Smart Machines
  - Streaming Analytics
  - Data Aggregation
  - Batch Analytics
  - Modeling
  - Artificial Intelligence
  - Machine Learning
  - Algorithms

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From General Purpose to Purpose Built

Architectures designed for Big Data, Fast Data applications

Big Data → Expanding applications and workloads → Fast Data

General purpose compute-centric architecture

- Solutions
- Systems
- Platforms
- Devices
General Purpose Architectures No Longer Sufficient

Big Data and Fast Data workloads exceed capability of uniform resource ratios

- Predetermined ratios of:
  - OS/App Processor
  - Specialty Processor
  - Memory
  - Storage
  - Interconnect

- Overhead of “PC” logic

- CPU-centric
Western Digital RISC-V Core

- First Western Digital RISC-V core
- 2-way, superscalar, mostly in-order core with 9 stages pipeline:
  - Support for RV32IMC
  - 1 Load/Store pipe
  - 1 MLY
  - 1 DIV
  - 4 ALU engines
- Performance targets @ 28nm:
  - Dhrystone >2 MIPS/MHz
  - Coremark > 3 CM/MHz
  - 1 GHz operation
- Core part was fun, uncore was all the work
NAND Controller SoC

- Multi-purpose SoC for consumer SSD applications
- First RISC-V based SoC for NAND controller applications

Advantages:
- Full advantage of open source software ecosystem for RISC-V
- Instruction optimization for NAND media handling
- Freedom of power and performance optimization for end application
RISC-V and Interface Control Points

- **RISC-V in embedded:**
  - Free and open IP connectivity buses enabling plug and play of proprietary and open source IPs

- **RISC-V in enterprise:**
  - Datacenter CPUs with smart, fast and open peripherals buses enable new compute paradigms essential for AI workloads
General Purpose Architectures No Longer Sufficient

Big Data and Fast Data workloads exceed capability of uniform resource ratios
General Purpose Architectures No Longer Sufficient

*Big Data and Fast Data workloads exceed capability of uniform resource ratios*
General Purpose Architectures No Longer Sufficient

Big Data and Fast Data workloads exceed capability of uniform resource ratios
Workload Diversity Demands Diverse Technologies and Architectures

- **Big Data**
  - Storage-centric architecture
  - Capacity-centric scale
  - HDD
  - SSD

- **Storage**
  - Storage SOC

- **Memory**
  - Memory-centric architecture
  - Performance-centric scale
  - NVM
  - DRAM
  - SRAM

- **Interconnect**
  - Memory Semantic Data Flow
  - Storage Semantic Data Flow

- **Compute**
  - General Purpose CPU
  - GPU
  - FPGA
  - ASIC
Big Data and Fast Data workloads need independent scaling of resources.

**Big Data**
- Massive Storage
- Moderate Processing
- Machine Learning

**Fast Data**
- Large Memory
- High-bandwidth interconnect
- Event Correlation
- Large Memory and Specialty Processing
- Blockchain
- Large Specialty Processing

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Independent Scaling Demands Openness

Rapid adoption of new open source technologies and standards
Data-Centric Applications at the Edge

Environments require modular technologies and dense integration to optimize space, weight and power consumption
RISC-V Meets the Needs of Big Data and Fast Data

Provides a foundation for purpose-built, data-centric compute environments

**Big Data**

- Move Compute to Data
  - CPU for device, platform, system
  - Minimize data movement
  - Offload workload to “smart” storage
  - Localized machine learning

**Fast Data**

- Memory Centric Compute
  - Highly scalable main memory
  - Minimize data movement
  - Heterogeneous processor support
  - Scalable accelerators/offload engines

**RISC-V**

- Open and free
- Enables modular chip designs
- From 16 to 128-bit
- Scales from embedded to enterprise
- Direct integration with specialty accelerators
- Extensible ISA (for special purpose functions)
RISC-V Meets the Needs of Big Data and Fast Data

- Big Data
  - Genomics
  - Predictive Analytics

- Fast Data
  - Autonomous Machines
  - Safety & Security
  - Private Exchange
  - Machine Learning
Rapid Growth of the RISC-V Ecosystem
Western Digital ships in excess of 1 Billion cores per year...and we expect to double that.
Accelerating the RISC-V Ecosystem

*Western Digital to contribute one billion cores annually to fuel RISC-V*

1. Support development of open source IP building blocks for the community

2. Actively partner and invest in the ecosystem

3. Accelerate development of purpose-built processors for a broad range of Big Data and Fast Data environments

4. Multi-year transition of Western Digital devices, platforms and systems to RISC-V purpose-built architectures
Innovating for a Data-Centric World

Big Data and Fast Data need purpose-built environments

Openness and ecosystem enable best-in-class innovation

Western Digital brings the momentum of >1B cores per year