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

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May 8, 2018
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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

Value

Richness

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#LetDataThrive
Diverse and Connected Data Types

Tight coupling between Big Data and Fast Data

Big Data
- Insight
- Prediction
- Scale

Fast Data
- Mobility
- Real-time Results
- Smart Machines

Data Aggregation
Batch Analytics
Modeling
Artificial Intelligence
Streaming Analytics
Machine Learning

ALGORITHMS
DATA

Insight
Prediction
Scale

Performance
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

**Embedded**

- Open source IPs

**Enterprise**

- Datacenter CPUs with smart, fast and open peripherals buses enable new compute paradigms essential for AI workloads

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- 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 Compute Architecture

- S/PDIF jack
- VGA port
- DVI-D port
- USB ports
- LAN port
- Audio jacks
- S/PDIF-out
- PCIe x16 slot
- PCIe x1 slots
- Mini-card socket
- System fan
- Processor
- CPU fan
- Memory slots
- Buzzer
- Power
- Chipset
- Front panel
- SATA 1-4
- Jumpers
- WLAN LED
- USB 1-4
- Battery
- USB 5-8
- Front audio
- Battery
- USB 5-8
- Front audio

General Purpose Transportation
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

- **HDD**, **SSD**
- **Storage SOC**, **General Purpose CPU**, **GPU**, **FPGA**, **ASIC**
- **NVM**, **DRAM**, **SRAM**
- **Storage Semantic Data Flow**, **Memory Semantic Data Flow**
- **Interconnect**
- **Capacity-centric scale**, **Performance-centric scale**
Data-Centric Environments

*Big Data and Fast Data workloads need independent scaling of resources*

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

**Machine Learning**
- Massive Storage
- Massive Specialty Processing

**Security Detection**
- Large Memory
- Specialty Processing

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

**Fast Data**
- Massive Storage
- Massive 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

**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)
Hardware Design Lifecycle

Legal protections with copyrights, mask works and patents

Open Source Software Licenses

Design

Logic Synthesis

Place and Route

Hardware Implementation

HDL ©

Netlist (i.e., list of electronic components and connections)

Bitstream

FPGA

Open Source Hardware Licenses

GDSII ©

ASIC

Gerber ©

PCB

Open Source Software Licenses

Legal protections with copyrights, mask works and patents
Permissive vs Copyleft

Licenses define the potential community

**Permissive License**

- **Goal:** Broad use of code
- Easier obligations
  - Attribution
  - More corporate adoption
- Allows for proprietary silos

**Copyleft License**

- **Goal:** Reciprocity
- Harder obligations
  - Source code sharing
  - No DRM
  - Less corporate adoption
- Disallows proprietary silos
- May be incompatible with other components
RISC-V Enables Purpose-Built Environments for Big Data and Fast Data Applications

Purpose-built data-centric architectures

Storage-centric architecture

Capacity-centric scale

HDD
SSD

Storage

Memory

NVM
DRAM
SRAM

Memory-centric architecture

Performance-centric scale

Interconnect

Storage Semantic Data Flow

Compute

Storage SOC
General Purpose CPU
GPU
FPGA
ASIC

RISC-V

Big Data

Fast Data

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#LetDataThrive
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

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Driving Momentum

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
Western Digital

We create environments for data to thrive