FPGAs: The Key to Accelerating High-Speed Storage Systems

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SSDs Have Been a Game Changer for Storage
Explosion of Unstructured Data

- Data Filtering
- Compression
- Decompression
- Encryption
Continuously Evolving Standards

Data Filtering:
- Hadoop
- Spark
- Aerospike
- RocksDB
- Cassandra
- Foundation DB

Decompression:
- LZ
- Brotli
- Zipline

Compression:
- GZip
- zSTD
- Huffman
- LZ
- Zipline
- Brotli

Encryption:
- DES
- AES-XST
- SHA1-256
- Block chain
Bottlenecks Remain for Data Intensive Applications

Processor-centric architecture

- Excessive data transfers
- High latency
- Limited BW
- CPU not optimized for these tasks
Emergence of Computational Storage as the Solution

Computational storage architecture

- Controller
- Flash
- DRAM
- Compute
- PCIe

- More available CPU cycles
- Reduces required bandwidth
- Reduces latency
- Compute acceleration close to storage

- Reduces required bandwidth
- Reduces latency

- More available CPU cycles
Growing Industry Momentum for Computational Storage

Participating Companies

EIDETICOM  NGD Systems  ScaleFlux™

arm  CALYPSO Systems  GIGAIO

Kalray  Lenovo  MARVELL®

NetApp®  NETINT  NYRIAD®

Samsung  Toshiba  Western Digital®

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How FPGAs Address the Computational Storage Problem
FPGAs in Storage Today

- Flash controllers

- Storage Systems
  - Cache-offload
  - Storage System & Switching connectivity
  - Data Reduction
FPGA Advantages for Computational Storage

- Flexible, fully customizable architecture adapts to specific applications
  - Massive parallelism, I/O and customizable data path

- Performance, power and latency of dedicated HW + reconfigurability of SW

- More economical than ASIC/ASSP for many applications
FPGA Advantages for Changing Standards

Architecture easily adapts to latest compression algorithms

Gzip Accelerator  Brotli Accelerator  Zipline Accelerator
Example of Analytics Acceleration

Q1: “Which cities originate the most flights with >10min delays?
Q2: “Which airport in the Bay Area has the worst record?

Airline traffic in the USA from 1970 to Present
Flight Data — 1.2B Entries
Airport Data — 500M Entries
Planes Data — 700M Entries

QUERY PERFORMANCE

Relative Performance

# FPGA Accelerators

None 1 2 4

1x 4x 7x 13x
Example of Line Rate Hadoop Compression Acceleration

The challenge: Ingest real-time retail sales data during peak shopping season

CPU can’t keep up with line-rate data ingestion making compression impractical

Intel Skylake-SP 6152 @2.10GHz CPU (Ubuntu 16.04), GB/s compression per CPU core = .0229. Alveo U50 = 10GB/s
FPGA-based Data Compression Enables Server Consolidation

Without Compression Acceleration

2x Dual CPU Servers
With 192TB (uncompressed)

With FPGA Compression Acceleration

Single Socket Server
2x Accelerators, 96 TB (compressed)

50% Reduction in Nodes
40% Lower Cost

Intel Skylake-SP 6152 @2.10GHz CPU (Ubuntu 16.04), GB/s compression per CPU core = .0229. Alveo U50 = 10GB/s, Assume 2:1 compression
Computational Storage Deployment Options
Computational Storage Drive (CSD)

> Integrated Accelerator and Flash

> Benefits:

- Easy to implement - plug & play
- Adding capacity adds accelerators + performance
- Ability to optimize BW between accelerator and flash
- Ability to customize FTL for specific workloads

> Vendors at FMS:

- Samsung
- Scaleflux
Computational Storage Processor (CSP)

- Accelerator and Storage on same PCIe subsystem
- Benefits:
  - SSD vendor independence
  - Plugs into standard slot
  - PCIe Peer-to-peer transfers for high bandwidth and low latency
- Vendors at FMS:
  - Bittware
  - Eideticom
  - Xilinx
Computational Storage Array (CSA)

- Accelerator in-line with storage

- Benefits:
  - SSD vendor independence
  - Independently scale accelerators and SSDs
  - Ability to optimize BW between accelerator and SSDs

- Vendors at FMS:
  - Bittware
Future Directions
Current Data Center Architecture: Fixed Resources, Sub-optimal Utilization
Future Data Center: Disaggregated and Composable

Challenge: Reduced Bandwidth and Increased Latency
Introducing Composable Storage Acceleration

- Enables composability without significant performance penalty

- Benefits
  - Performance and latency benefits of computational storage
  - Scale compute / storage independently
  - Higher density per rack
  - Lowest TCO

- Vendors at FMS:
  - Xilinx
Future DC: Composable + Adaptable Computational Storage

- Moves some compute next to the data
- Network traffic reduced
- Latency improved
- Higher utilization with composable infrastructure
Future DC: Composable + Adaptable Network Acceleration

- Enables low latency high bandwidths acceleration of network interface workloads.
- Enables significantly higher packets per second
- Offloads network functions from the CPU
Future DC: Composable + Adaptive Compute Acceleration

> Customizable acceleration up to 100x faster than CPUs for:

  >> Video transcoding
  >> ML inferencing
  >> Financial modeling
  >> ...

Ethernet

FPGA
## Future DC: Composable + Distributed Adaptive Acceleration

- Composable accelerated storage, networking and compute
- Optimized for each workload
- Optimal infrastructure utilization

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> Composable accelerated storage, networking and compute
> Optimized for each workload
> Optimal infrastructure utilization
FPGAs are Key to Accelerating High-Speed Storage Systems

Computational storage addresses a broad range of application bottlenecks

Offers data center operators >5x performance boost and up to 2x reduction of TCO

Xilinx is leading the way in distributed adaptive acceleration
Computational Storage in Action

> Visit Xilinx in booth 313

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  >> Alpha Data, Bittware, Burlywood, Codelucida, GigalO, Echo Streams, Eideticom, Everspin Technologies, IP-Maker, Mobiveil, Pliops, PLDA, Scaleflux, Smart IOPS, Samsung, SMART Modular, Toshiba Memory America, Western Digital

> Visit our Computational Storage microsite

  www.xilinx.com/computational-storage

> Join SNIA working group for Computational Storage
Adaptable. Intelligent.