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
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

- More available CPU cycles
- Reduces required bandwidth
- Reduces latency

Compute acceleration close to storage

Controller

DRAM

Flash

PCIe
Growing Industry Momentum for Computational Storage
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

Encryption Accelerator  
Decryption Accelerator  
Analytics Accelerator
FPGA Advantages for Changing Standards

Architecture easily adapts to latest compression algorithms

Gzip Accelerator  Brotnli Accelerator  Zipline Accelerator

FPGA  FPGA  FPGA
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

FPGA vs. CPU

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 22 core CPU (Ubuntu 16.04), vs Single Socket AMD server. 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

Workload 1

Workload 2

Workload 3
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

Reduced network traffic
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
  >> …
Future DC: Composable + Distributed Adaptive Acceleration

- 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

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