Computational Storage
Architectural Discussion

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NGD Systems
Co-Chair Computational Storage TWG
Today’s Learning Opportunities (TLO).

- EDGE needs CSD in M.2, EDSFF
- Architecture Our Way – CSD with PCSS
- AI – ML – CSD – the Overlap
- Hadoop & DB – CSD – Growth, Scale
Data, Data, Data. But Don’t Take Our Word For it.

The data center won’t be the center of your data anymore.
What Are You Doing with Your **Data Today**?

It’s No Longer Black and White.

Source: Gartner - Bittman
What is **Driving Our Data Analytics Issues?**

Weeding through the Noise at the Edge

By 2022, more than **50%** of enterprise-generated data will be created and processed outside the data center or cloud.

Source: Gartner - Bittman

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Sept 26th, 2019
From Edge Sensors to Centralized Cloud

Computational Storage opportunities exist throughout the distributed compute environment

Centralized Cloud
Farthest from the network edge
High density of compute, storage and network resources

Infrastructure
Small distributed data centers
Low roundtrip latency 5 – 10ms

Edge Devices
Real-time data processing

Edge Sensors & Chip
Data Collection & Origination
Innovative Computational Storage Uses.

- Facial Recognition
- Machine Learning
- HPC
- Content Delivery
- Smart Cities
- Autonomous Driving

IN-SITU PROCESSING

(de) compression off-load
object tracking
security
**Highest Capacity, Lowest Power.**

Industry leading **W/TB**

Industry’s Only **16-Channel M.2**

Industry’s Largest Capacity **U.2**

<table>
<thead>
<tr>
<th>Form Factor</th>
<th>Capacity (TB)</th>
<th>MAX Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.2 22110</td>
<td>Up to 8</td>
<td>8</td>
</tr>
<tr>
<td>EDSFF E1.S</td>
<td>Up to 16</td>
<td>12</td>
</tr>
<tr>
<td>EDSFF E1.L</td>
<td>Up to 32</td>
<td>12</td>
</tr>
<tr>
<td>U.2 15mm</td>
<td>Up to 32</td>
<td>12</td>
</tr>
<tr>
<td>AiC FHTQL</td>
<td>Up to 64</td>
<td>15</td>
</tr>
</tbody>
</table>

8TB/8W M.2

32TB/12W

16TB/12W E1.S

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Complete Solution and Disruptive Technology.

1st FULLY INTEGRATED COMPUTATIONAL STORAGE SOLUTION

SoC Controller
Industry’s First 14nm

Management

Optimized Hardware

“In-Situ Processing”
Computational Storage Stack

- Modular firmware
- Efficient algorithm
- Flash characterization

- Full fledged on drive OS
- Light virtualization
- Quad-core 64-bit application processor
- Hardware acceleration

Linux
Docker
ARM

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The Scalable, **ASIC-based** Computational Storage Drive.

An enterprise class device capable of processing workloads in storage at the source

**Host Platform**
- Standard NVMe Protocol
- Moving Compute to Data

**Core Solution Stack:**
- NGD Systems
- Linux
- Docker
- AI
- Machine Learning

**Needed Key Attributes:**
- Use standard protocols (**NVMe**)
- Minimize data movement (Faster Response, Lower **W/TB**)
- Improve (**TB/in^3**) with maximize (Customer **TCO**)
The Data Lives on Storage.

Why Not Work on it There?

Server Host Processor Complex

host OS

host API

application

x86

GPU

NVMe

Computational Storage Drive

media controller

Arm quad-core

drive OS

shared DRAM

NAND media

app

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Using Computational Storage Drives for ML.

MobileNet Object Classification

No Host Interaction Required

TensorFlow & Keras API
Weightless Neural Networks Used for Object Tracking.

A WiSARD-based multi-term memory framework for online tracking of objects

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4 - Ecole Nationale de l’Aviation Civile - Laboratoire d’Automatique, FRANCE

Abstract. In this paper it is proposed a generic object tracker with real-time performance. The proposed tracker is inspired on the hierarchical short-term and medium-term memories for which patterns are stored as discriminators of a WiSARD weightless neural network. This approach is evaluated through benchmark video sequences published by Babenko et al. Experiments show that the WiSARD-based approach outperforms most of the previous results in the literature, with respect to the same dataset.
Moving **Beyond** Traditional Models.

- Parallel & distributed Training in Computational Storage
- Federated/Transfer Learning
- Reduce data transfers by sending sparse model updates
ML Training with Traditional Approach.

ML Training with Computational Storage.

Load Data
ML Training with Traditional Approach.

- No data movement
- No host CPU needed
- Distributed training

ML Training with Computational Storage.

- No data movement
- No host CPU needed
- Distributed training
ML Training with Traditional Approach.

- Host CPU still needed
- No Parallelism

ML Training with Computational Storage.

Load Data
Train
Evaluate
Update
ML Training with Traditional Storage.

ML Training with Computational Storage.

Load Data
Train
Evaluate
Update
Deploy

Repeat Steps
Train
Evaluate
Update

DRAM
CPU

SSD
SSD
SSD

NGD Systems
Federated/Transfer Learning.

**MNIST DATASET**

60,000 samples
From the training set

61 updates
Model updates transferred

94% accuracy
With only 4 partial model updates

Precision & Generalization
Constant Updates to Training Model

Computational Storage Cores Running WiSARD.
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Amplifying TCO for Hadoop

Terasort performance

- **16-core host**
- **4-core host**

Number of Computational Storage Devices

- Performance (normalized)

Terasort energy consumption

- **16-core host**

Number of Computational Storage Devices

- Energy (KJ)

Host Platform

- **DRAM**
- Intel(R) Xeon(R) CPU E5-2620 v4 @ 2.10GHz
- 32GB RAM
- 4 Cores Used on CPU

- **in-situ data node**
- **secondary name node**
- **host Data node**

PCle/NVMe bus

Datanode Config:

- Single E5-2620v4, 32GB DRAM, 12*8TB SAS HDD
- 18U Total Density in 18U = 864TB

@ Scale
Saves Power!
Saves Space!
Saves Time!

Datanode Config:

- Single E5-2620v4, 32GB DRAM, 36*8TB NVMe
- 3U Total Density in 3U = 864TB
- 432 Additional Drive Cores

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Using **MongoDB** within Computational Storage.
The “New Cloud” needs the Distributed Edge
- There is no longer just a ‘central’ storage location

Edge data growth challenges HW platforms
- Innovative form factors and high capacity for the Edge

In-Situ Processing brings ML closer to data
- Exploit data locality and enable distributed processing
Computational Storage

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