What happens when Compute meets Storage?

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### Agenda

- **Introduction to Computational Storage**
  - How long has this idea been around, Why Now?
  - How the TWG was formed

- **Computational Storage Working Group Focus**
  - Taxonomy is Key, need the right TLAs
  - Scope is Critical, Roadmap to success

- **Architectural Discussions and Future**
  - A look at some current solutions
  - A view of people’s thoughts of future solutions
Many Factors driving a Need for Computational Storage

Keys To Harnessing The Data Tsunami

Jonathan Salem Baskin

Three motivating factors for using Edge Computing:
1. Preserve privacy
2. Reduce latency
3. Be robust to connectivity issues

The Big Data Tsunami

Author: Matt Ferrari
Chief Technology Officer
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Near-Data Processing: Insights
Near-Data Computation: Looking Beyond Bandwidth

Published in: IEEE Micro (Volume: 34, Issue: 4, July-Aug. 2014)

Defying the Data Tsunami

Three motivating factors for using Edge Computing:
1. Preserve privacy
2. Reduce latency
3. Be robust to connectivity issues

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Based on the premise that storage capacity is growing, but storage architecture has remained mostly unchanged dating back to pre-tape and floppy…

How would you define changes to take advantage of Compute at Data?
The Evolution of Computational Storage

❖ A delicate process to build an Ecosystem

❖ Great ideas! Time was needed to build it
  ❖ Many technology papers exist around:
    ❖ “Active Disks”, “CAFS”, “Near-Data”
    ❖ “In-Storage”, “In-Situ”, “Near-Storage”

❖ So did some initial products!
Playing Nice Together is Needed!

- Is this a solution replacing a solution?
- Complimentary work to the pyramid
- Another facet of advancement of compute
- In-Memory is needed, but some work can be offloaded all the way to storage!
So Now What?
The Progression of the TWG
40+ Participating Companies
148 Individual Members

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Finding a Focus and Direction

- Initial focus on a definition list to ensure we covered questions on what it is and what products can be

- Drive to a Scope and path to universal usage model
  - Today we have custom… Tomorrow Standard… Sound Familiar?
Computational Storage

TWG Focus Areas
TWG Charter Overview

❖ Prioritize Industry Level Requirements
  • Collect and prioritize feature requests for Computational Storage Interfaces

❖ Develop Standard Interfaces & Protocols
  • Enable device vendors to supply Computational Storage features using extensions to existing standard interfaces and enable development of SW against those interfaces

❖ Align the Industry
  • Coordinate the submission of new standard proposals to accommodate the new features or create a new standard as a SNIA Architecture

❖ Facilitate and Drive SW Development
  • Work with relevant industry organizations to implement the feature’s interface using the new version of the underlying standard that adds the feature.

❖ Educate
  • Promote Computational Storage paradigms through the industry at large
Starting the Standards Work

- Multiple F2F sessions have been focused on what we can accomplish and what we will leave for later
- Management
- Security
- Operation
Speaking the Same Language

Computational Storage:
- Architectures that provide Computational Storage Services coupled to
  storage offloading host processing and/or reducing data movement.

Two Foundational Constructs
- Computational Storage Devices (CSx)
- Computational Storage Services (CSS)
Current Instances of Computational Storage
Computational Storage Devices (CSx)

Computational Storage Processor (CSP)
A component that provides Computational Storage Services for an associated storage system without providing persistent data storage.

Computational Storage Drive (CSD)
A storage element that provides Computational Storage Services and persistent data storage.

Computational Storage Array (CSA)
A collection of Computational Storage Devices, control software, and optional storage devices.
Computational Storage Services

Fixed Computational Storage Service (FCSS)
- CSS that is well-defined
- Consumable by the Host Agent for a well-defined purpose
- Examples: Compression, RAID, Erasure Coding, or Encryption

Programmable Computational Storage Service (PCSS)
- Configured by the Host Agent to provide one or more CSSes
- Examples: May host an Operating System image, Container, Berkeley Packet Filter, or FPGA Bitstream
Define the Scope & Prioritize

➤ Management
   - Discovery. Identify and determine the capabilities and functions.
   - Configuration. Parameters for initialization, operation, and/or resource allocation
   - Monitoring. Reporting mechanisms for events and status

➤ Security
   - Authentication. Host Agent to CSx and CSx to Host Agent.
   - Authorization. Mechanism for secure data access and permissions control.
   - Encryption. Mechanisms to perform computation on encrypted data.
   - Auditing. Mechanisms to generate and retrieve a secure log.

➤ Operation
   - Mechanisms for the CSx to store and retrieve data.
   - Host Agent interaction may be explicit or transparent.
Discovery

- Host Agent discovers the CSS capabilities of the attached CSX devices
- Each CSx returns info on available CSSes
  - CSx ID
  - CSS ID(s)
  - Vendor
  - Type & Subtype
  - State & Reservation Information
  - Configuration Schema
  - Active Configuration
  - Error Information
Configuration

- Host Agent sends the CSS Configuration request to each CSx
- For Programmable CSSes can result in creation of additional CSSes
- Readies the CSS for use by the Host Agent via one of two usage models – Direct & Transparent
Direct Operation Usage Model

- Using the Direct model, the Host Agent will have a specific Computational Storage API required for interaction.
- Commands will go through the Computational Storage Processor or Computational Storage Drive interface.
Using the Transparent model, the Host Agent will access the computational capabilities through a standard storage API.

I/O commands will go through the traditional Storage interface.
Computational Storage
Example Workload Improvements
Provided by Member Companies
RAID or Compression Offload

The case for Peer-2-Peer (P2P) processing…

• PCIe End-Points (EPs) are getting faster and faster e.g. NVMe SSDs, RDMA NICs & GPGPUs
• Bounce buffering all IO data through system memory is a waste of system resources and reduces QoS for CPU memory

The solution:

• A CSP + p2pmem Linux kernel framework for allowing PCIe EPs to DMA to each other while under host CPU control
• CPU/OS still responsible for security, error handling etc.
• 99.99% of DMA traffic now goes direct between EPs
• Application: P2P Compression offload

Get your FPGA’s “out of the box” and shared across the datacenter

• Emerging ecosystem allows CSPs to be accessed/shared across network fabrics such as Ethernet
• FPGA acceleration being shared across the network fabric enables FPGA disaggregation
Hadoop Cluster Improvement via CSD

- Ability to Migrate Data Nodes into CSDs
- Allow for user to reduce Host CPU Core count via CSD usage
- Migrating the data node via a PCSS into an array of CSDs attached to the host systems
- Scalable across nodes, HW and datacenter space
AI Inference at the Storage

- Generate Metadata database (e.g. tags) over a large set of unstructured data locally with an integrated AI inference engine.

- Operation may be:
  - Triggered by a host processor
  - Done offline as a background task (batches)

- Metadata database may be then used by upper layer Big Data Analytics software for further processing.

- Can work both on direct attached storage or on remote, over the network storage.

- EXAMPLES:
  - Video search, Ad insertion, Voice call analysis
  - Images, Text scan, etc.
In Summary – Call to Action

- Computational Storage is a Real Market
  - Customers are deploying today

- Solutions exist and will continue to grow
  - Making the interface ‘uniform’ helps adoption

- Standardizing the host interaction is vital
  - We NEED more Support from Users/SW Solutions

- Working across the industry will be crucial
Thank You!!

www.SNIA.org/Computational