SNIA CMSI | COMPUTE, MEMORY, AND STORAGE

Data Movement and Computational Storage – *a Panel Discussion*

A SNIA CMSI Webcast Discussion Panel
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On Demand – snia.org/educational-library

Today's Speakers

Moderator:
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Director, CMSI Applications Enabling
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Panelist:
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Chair, CMSI Computational Storage Special Interest Group
VP Business Development, NGD Systems

Panelist:
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Architect
KIOXIA

Panelist:
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SNIA-at-a-Glance

180
industry leading organizations

2,500
active contributing members

50,000
IT end users & storage pros worldwide

What Does SNIA Do?

- SNIA is a non-profit global organization dedicated to developing standards and education programs to advance storage and information technology.

Who is CMSI?

- Part of SNIA, the SNIA Compute, Memory, and Storage Initiative is a community of storage professionals and technical experts who support:
  - The industry drive to combine processing with memory and storage,
  - The creation of new compute architectures and software to analyze and exploit the explosion of data creation over the next decade.
- CMSI's three Special Interest Groups – Computational Storage, Persistent Memory, and Solid State Drives – evangelize and educate on these technologies to the industry

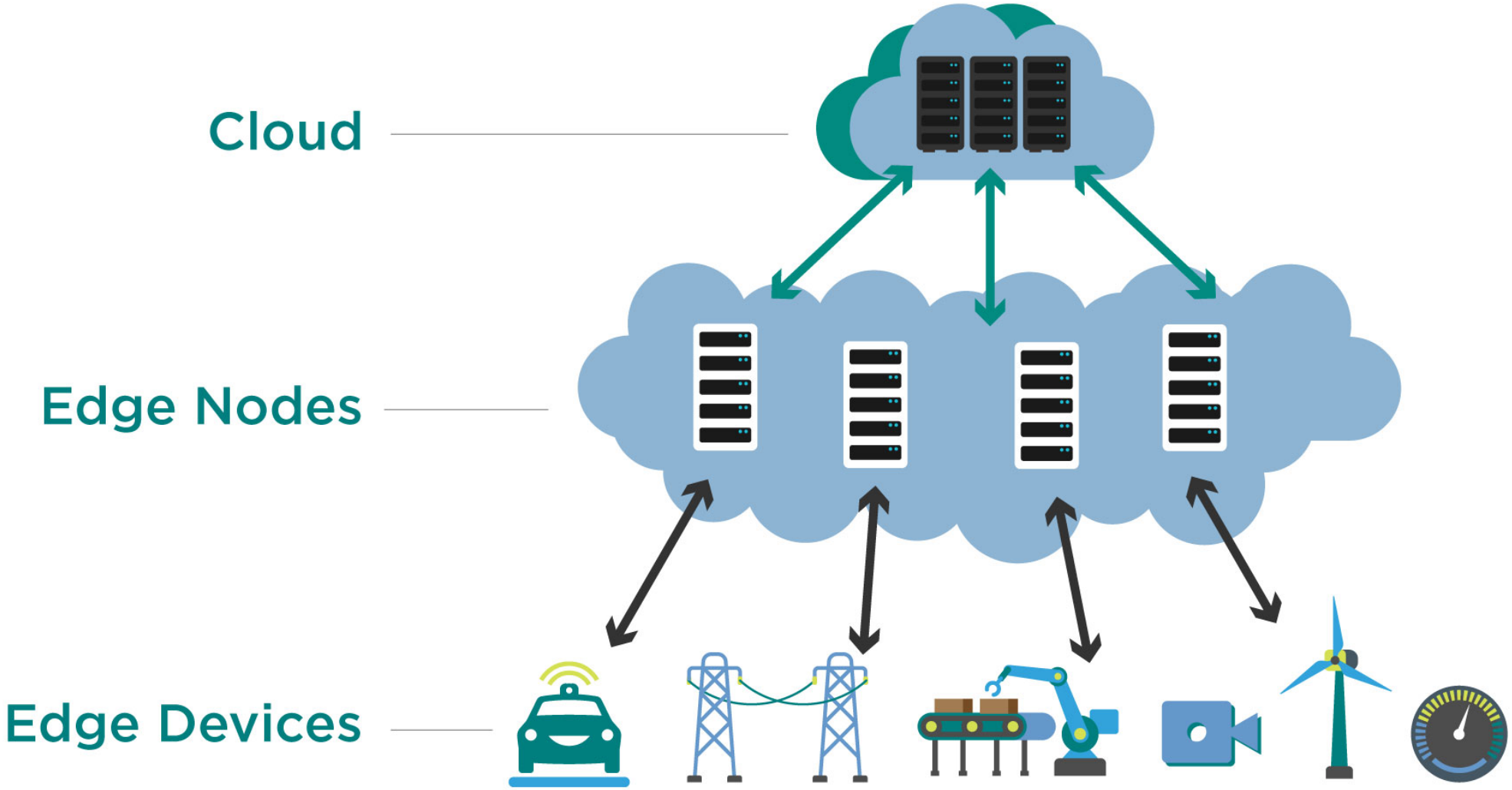
snia.org/cmsi

Data Movement

Eli Tiomkin

Computational Storage SIG Chair

NGD Systems



Need New Way to Look at Storage

Pain Points

Physical Space

Available Power

Scaling Mismatch

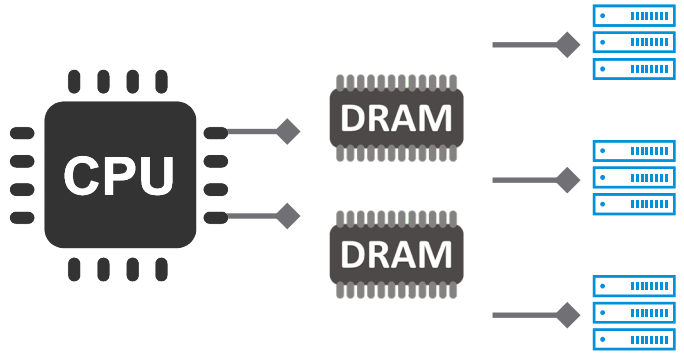
Bottleneck Shuffle

Traditional storage architectures are in trouble.

Scaling requirements are not met with existing solutions

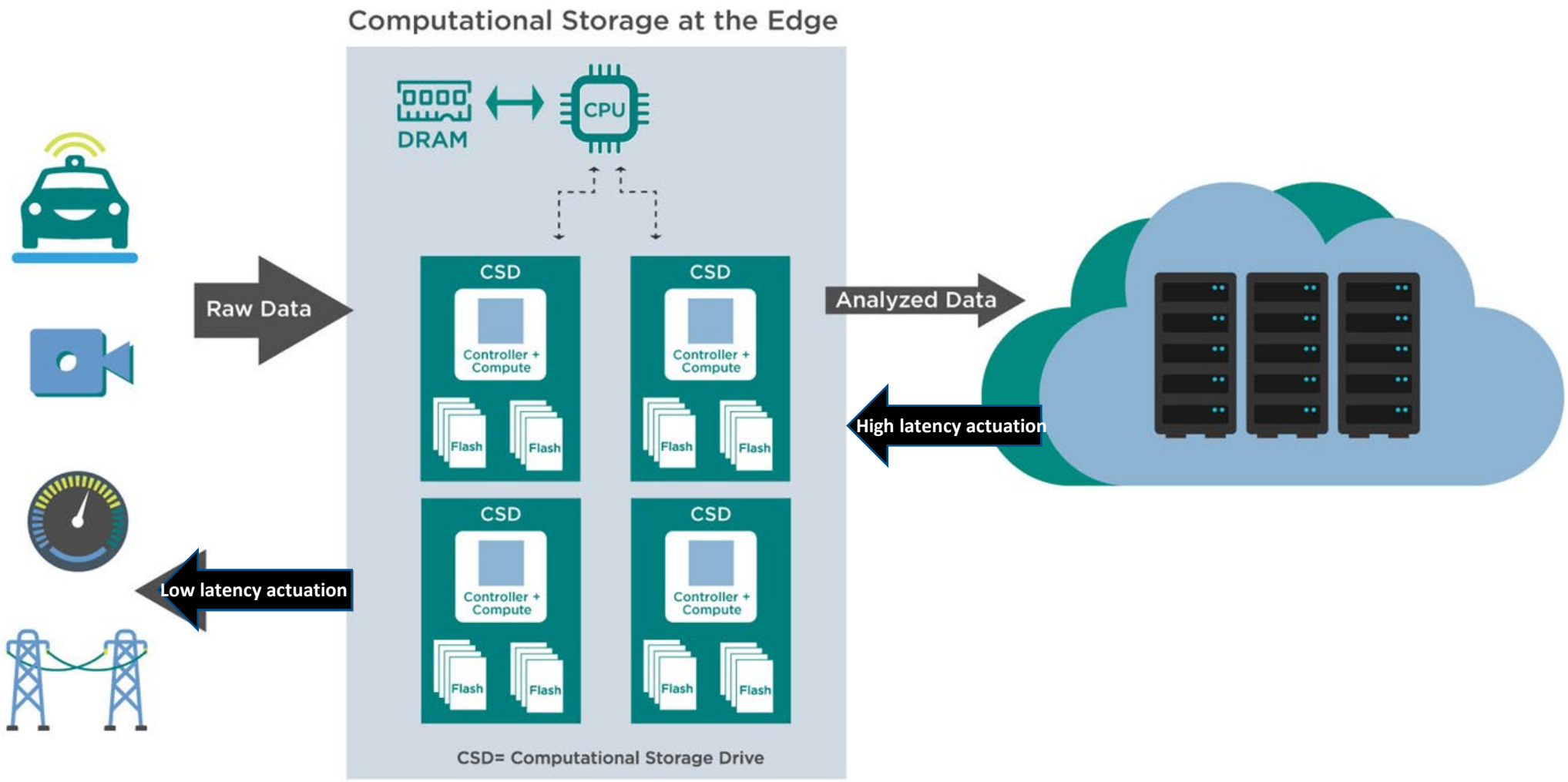
One CPU to many storage devices creates bottlenecks

These bottlenecks exist, we currently just shift where they reside



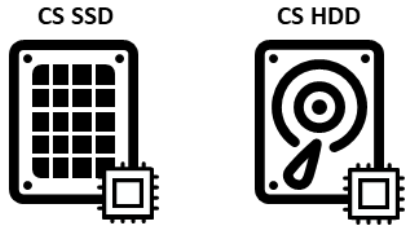
Technologies that ‘compose’ these elements just exacerbate the bottleneck

A way to augment and support without wholesale change is needed

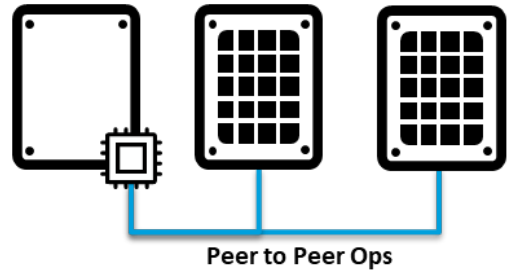


Computational Storage Devices

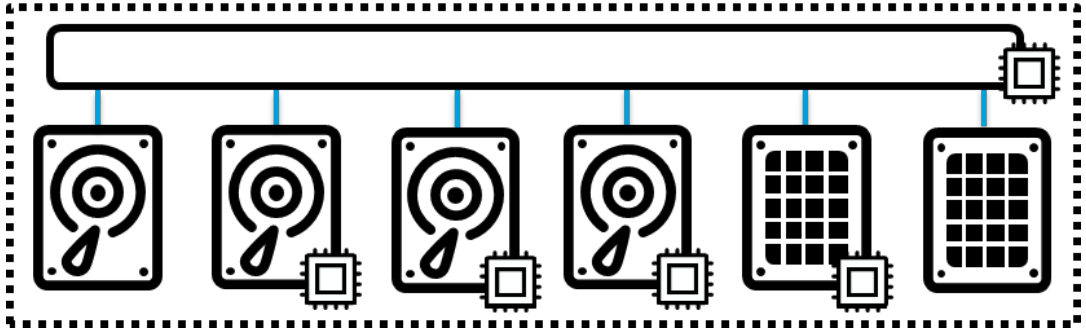
- **Computational Storage Drive (CSD)**:
  A storage element that provides Computational Storage Function and persistent data storage.



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



- **Computational Storage Array (CSA)**:
  A collection of Computational Storage Devices, control software, and optional storage devices.
  (Many options here)



Using Computational Storage

Benefits

- ✓ Distributed Processing
- ✓ Faster Results
- ✓ Lower Power
- ✓ Smaller Footprint

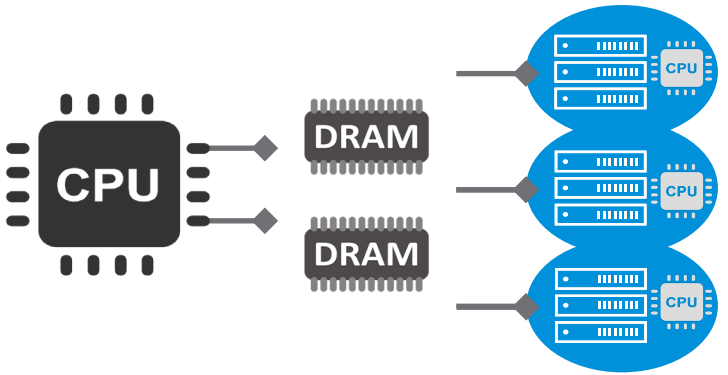
Reduction in Transfers

Reduced Fabric Provisioning

Scaling compute resources with storage provides access to results faster

Computational Storage resources 'offload' work from the overtasked CPU

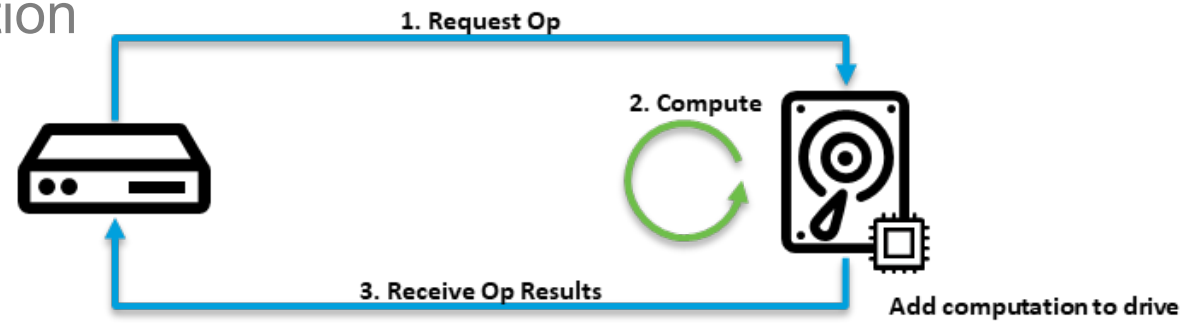
Seamless architectures create new 'servers' with each storage device added



Additional CPU resources for the cost of Storage without added Rack Space

Computational Storage View

- Computational Storage Function (CSF)
  - Send compute request to the drive
  - Allow drive to reduce data
  - Only return the results
  - Can be local or fabric attached
  - Reduces fabric and DDR BW consumption
  - Cost Savings
    - Reduced transfers
    - Reduced power
    - Free up host cycles
    - Potential for server removal
  - Potential for massively parallel compute



Computational Storage Systems

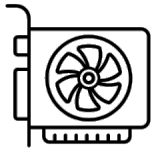
Flexible Compute Systems

Nidish Kamath

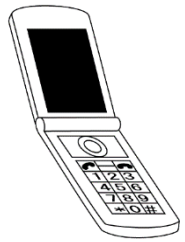
KIOXIA

Programmability & Solution Space

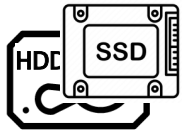
- Democratizes use of product
  - Customers play/modify initially pre-configured systems & “discover” new use cases
  - Use cases increase due to low friction for experimentation
- Potential platforms for use case discovery / product launches
- Computational storage expands the solutions space
  - Differentiated product services
  - Faster use case experience feedback
  - Quicker turnaround for product changes



Fixed function pipelines → Programmable Graphics Shaders (OpenGL) → Programmable General Compute (OpenCL, CUDA)



Fixed voice/GUI processing (largest processor: DSP) → Powerful application processor (DSP less important) → Application processor + sensors + App platforms



Fixed acceleration functions (compression etc) → Limited programmable devices (FTL, offload etc) → Higher level of programmability

Broad Spectrum of Computation Offload

Data Transformations

Compression
Encryption

Higher Level Data Operations

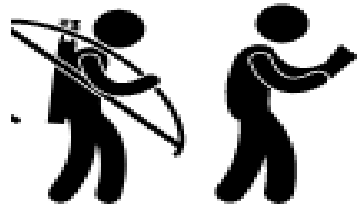
Deduplication
RAID

Data-based Insights

Queries
Indexes

Data-based Actions

ML Inference
Data pipelines



- SNIA Computational Storage TWG
  - Architecture and software to allow storage to integrate with compute
  - Working with other standards groups to promote interoperability

Library / API Considerations

- Storage APIs
  - User Space Library
  - Compatible with variety of storage devices:
    - Block devices (LBA-addressed)
    - Key-Value (variable size data indexed by keys)
    - Newer class of non-volatile memory, e.g. byte-addressable persistent memory

- Collaboration with NVMe, T10, and other orgs
  - Data-plane operations flow down storage stack w/ minimal translation overhead
  - Control-plane adapted to deployment models, e.g. discovery, configuration, etc.
  - Ground-up security model – authentication, session establishment, etc.

Flexibility & Dynamic Workloads

- Wide range of compute- & energy-based design points
  - Racks / Pods → Servers → Edge → Power constrained
  - Dynamic re-deployment of systems components desirable
  - Metrics & data for workload migration → Monitoring hooks in CS API will help

- Dynamic workloads open up research avenues
  - E.g. CROSS @ UC Santa Cruz
    - **Eusocial Storage**: Quantifying the Benefits of Offloading to Smart Storage Devices, including offloading of collective functionalities like redundancy and failure management across multiple storage devices.
    - https://cross.ucsc.edu/projects/eusocialpage.html

Complexity / Scale as Opportunity

- Multiple pieces of system composition
  - Compute (e.g. CPUs, GPUs, FPGAs)
  - Storage devices/systems (e.g. SSDs, HDDs, storage arrays)
  - Network / IO devices (e.g. network / PCIe switches and adapters)
- Multiple layers of leveraging heterogenous compute
  - Block storage vs Object stores
  - Applications (e.g. database servers, IMDBs) vs clusters (e.g. containers)
- Call to action: Get involved in SNIA; innovate on Computational Storage

Data Movement and Computational Storage Security

David McIntyre

Samsung

Computational Storage Drives (CSD) Deployments

Move Compute Closer to Storage

Current Compute/Storage Architecture

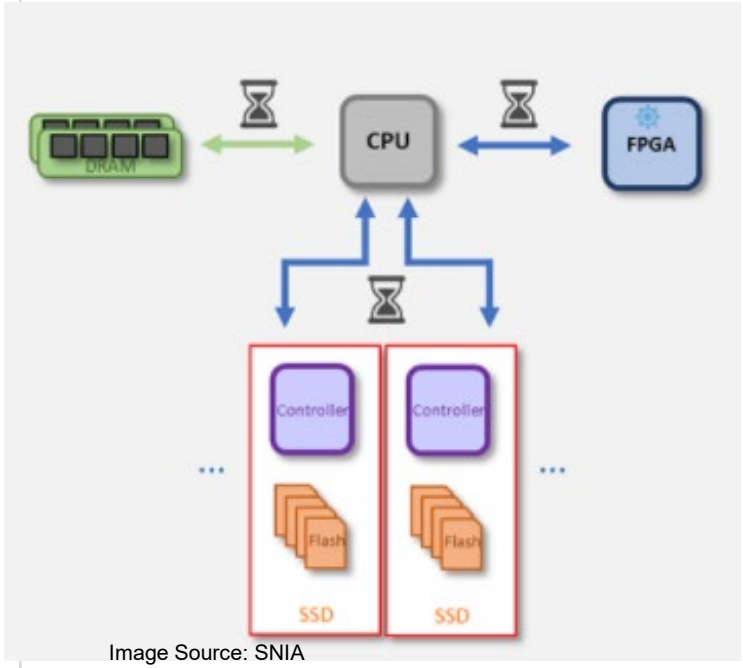
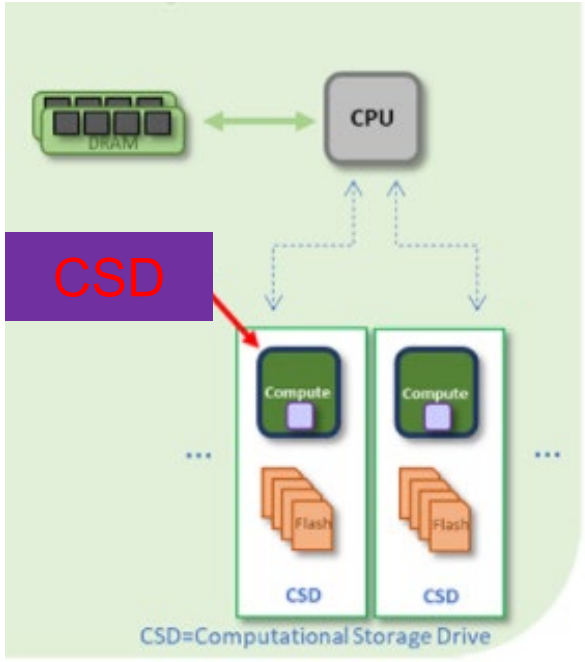


Image Source: SNIA

- Moving data between storage and host CPU creates performance bottlenecks for data-intensive applications

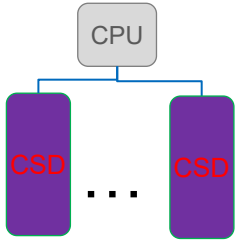
Computational Storage Architecture



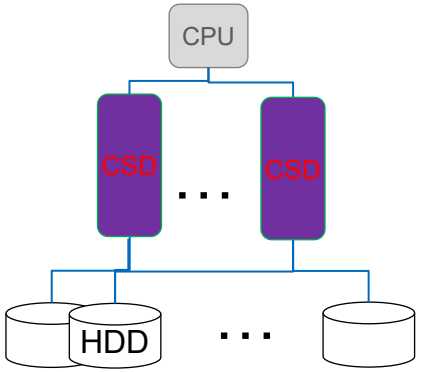
- Data processed directly on the CSD => no large data transfers, faster time-to-insight
- Adding CSDs adds processing power and internal bandwidth => scalable acceleration

Deployment Examples

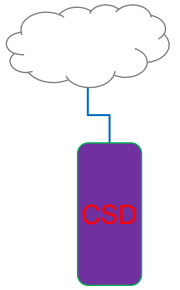
- Compute/Storage Server



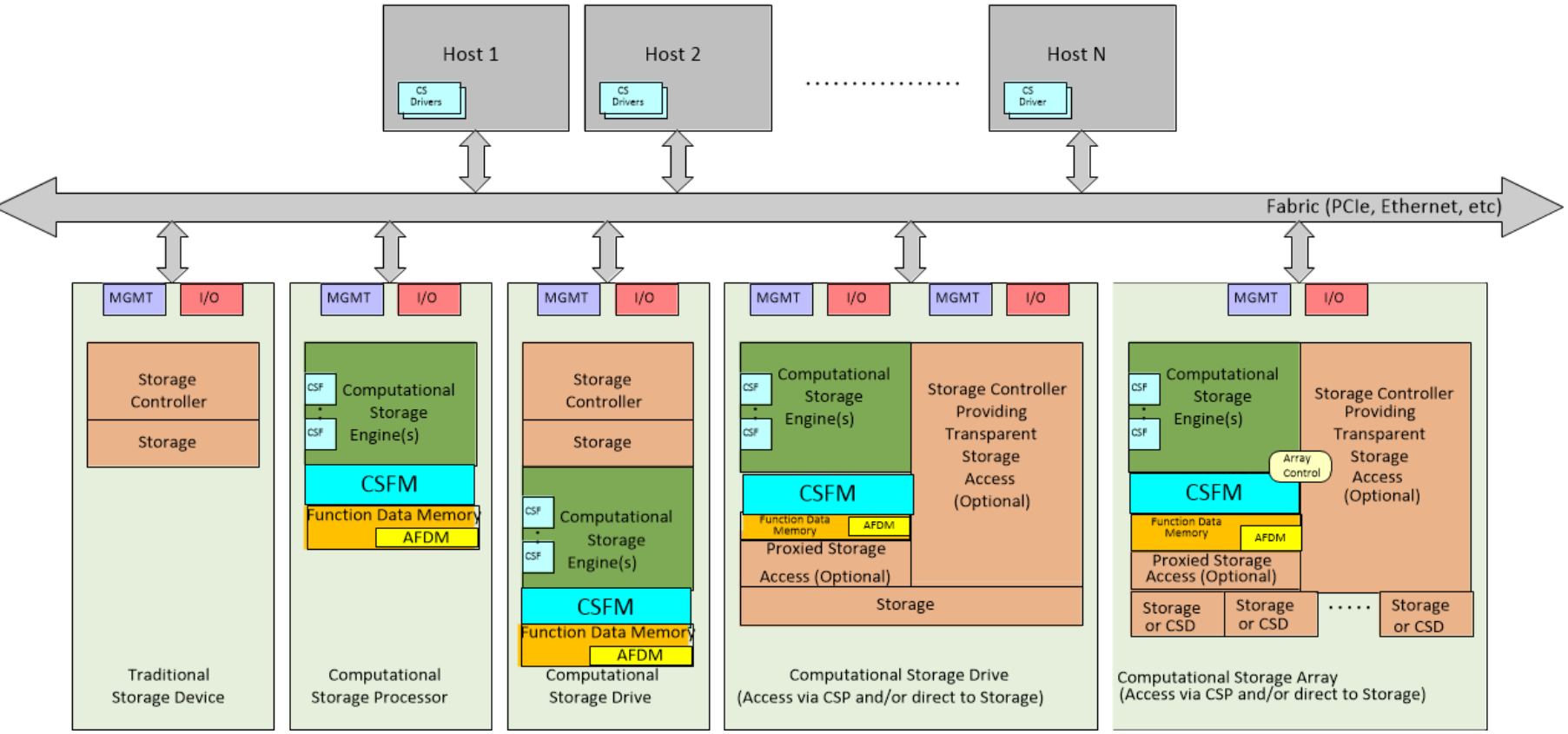
- Smart Cache Layer



- Cloud to Edge Compute



New Risks Exposed by Computational Storage Drives



Security Functions:

- **Authentication**.
  Host agent to CSD
- **Authorization**.
  Secure data access & permissions
- **Encryption.**
  Encrypted data mechanisms
- **Auditing**.
  Generating/ retrieving secure logs

Risks vs standard storage:

- The CSD may delete/add/modify data on the drive
- The CSD functionality may be programmed
- Virtualization

Risks vs external accelerator:

- Direct access to storage
- FPGA programming
- Access to network infrastructure (NVMe-oF)
- Decryption of data prior to processing

Security Considerations by Cloud Service Providers

- Notable Cloud Service Provider Security Policy Categories
  - Data-in-flight
  - Processing requirements in data handling
  - Buffering, caching
  - Data-at-rest policies
  - Containers
  - Virtualization
  - Multi-tenant
  - Edge deployments for in-situ storage processing

Storage Security Pillars

and the standards that mandate them

1. Root of Trust

Microsoft Cerberus
Google OpenTitan
Intel TXT/TPM

2. Crypto

NIST SP800
*FIPS-140-2
*GDPR/ISO Requirements

3. Secure Enclaves

NIST *CSRC
OCP
Microsoft

4. Self-Encrypting Drive

TCG Opal
NIST SP 800

5. Key Management

*TCG DICE
NIST SP 800-57
*DMTF

6. Security Lifecycle

Manufacturing/
Vendor Specific
*NIST SP 800

*NIST: National Institute of Standards and Technology
*TCG: Trusted Computing Group
*FIPS: US Federal Information Processing Standards
*GDPR: EU General Data Protection Regulation
*CSRC: US Federal Computer Security Resource Center
* DMTF: Distributed Management Task Force

Data Movement: Put On Your Security Hat

- Data moves across compute, storage, memory and network systems and devices
- Design and deploy with holistic security solutions in mind
- Participate in SNIA Computational Storage TWGs
- Contribute industry use cases that should be considered for security issues and resolutions
- Attend SNIA compute, storage and networking events and think security

Thanks for Watching Our Webcast

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- A Q&A from this webcast will be posted to the SNIA Compute, Memory, and Storage Blog

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- Joining SNIA and the Compute, Memory, and Storage Initiative
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