Composable Infrastructure and Computational Storage

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Today’s Speakers

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SNIA-at-a-Glance

185 industry leading organizations

2,000 active contributing members

50,000 IT end users & storage pros worldwide
Agenda

- Need for Change
- What is Composable Infrastructure?
  - What are the use cases?
- What is Computational Storage?
  - What are the use cases?
- Are They Mutually Exclusive or Beneficial?
Need For Change
## Where Are We Today?

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<th>Where We’ve Been</th>
<th>Where We Are</th>
<th>Where We Are Going</th>
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<td>Infrastructure</td>
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Where We’ve Been includes Hypervisor, Operating System, Containers, and Virtualization. Where We Are includes servers and a network. Where We Are Going includes a network and servers.
What Is An Application?

- **Task**
  - Apps need a system
    - They have requirements
      - CPU cores
      - Memory size
      - Network bandwidth
      - Network location
      - Availability

- **Store**
  - Most apps need a persistent store
    - They have requirements
      - Bandwidth (BW)
      - Latency
      - Capacity
      - Availability

- **Examples**
  - RDBMS
  - Web Servers
  - ML application
While Apps Are GROWING

- Dennard’s scaling ended
  - Power leakage and heat prevent cycle scaling
- Multicore hit Amdahl’s law
  - Applications can only be parallelized so far
- Moore’s law is ending
  - Physical size limitations
- What’s left then?
  - Domain Specific Architectures
    - Graphics Processing Unit (GPU)
    - Offloading Network Interface Controllers (NIC)
    - Tensor Processing Unit (TPU)
    - FPGA Based Accelerators
  - This increases configuration complexity

Based on SPECintCPU. Source: John Hennessy and David Patterson, Computer Architecture: A Quantitative Approach, 6/e 2018

David Patterson’s presentation at ISSCC2018
https://youtu.be/NZS2TtWcutc
Today’s Applications

- **Task**
  - Many System options
    - CPUs/SoCs
    - Core counts
    - DDR Capacity
    - NICs
      - TOEs
      - RDMA
    - Accelerators
      - FPGAs
      - GPUs
      - TPUs

- **Store**
  - Many Store options
    - Cold stores
    - HDDs
    - SSDs
    - Persistent memory (SCM) devices

- **All must go into a box**
  - Dictated by App requirements
  - What and how much decided at purchase time
  - No going back, no evolution
What is the Problem

- Application requirements wide and varied
  - Complicated set of hardware requirements
- Application requirements quickly and constantly evolve
  - Agile development creates quickly evolving app requirements
  - Mapping occurs at purchase time and cannot evolve
  - Invalidates system design requirements
- Must map these requirements onto physical hardware
  - Due to high core counts, multiple apps must be mapped to single system
  - **Forces IT managers to be system designers**
  - **Forces overprovisioning inside the system**
  - Availability and Competition issues
- Growth rate of apps
  - Forces overprovisioning system counts for elasticity
- Ever growing classes of hardware systems
  - Lifecycle management (scaling, EOL, etc) becomes a multi-vectored problem

The multicore server as the unit of app allocation is now too big and complicated
What is Composable Infrastructure?
What is Composable Infrastructure?

- Compose – to form by putting together

- Infrastructure – the underlying foundation or basic framework (as of a system or organization)

Source: Merriam Webster dictionary
What is Composable Infrastructure?

 ✓ Disaggregate the server
   ✓ Separate compute, memory storage, networking components, accelerators
   ✓ Use high speed low latency fabrics to interconnect

 ✓ Create pools of resources
   ✓ Don’t need to be physically proximate
   ✓ Horizontal scaling is in expanding pools

 ✓ Compose and decompose as needed via orchestration
   ✓ API driven (autonomous operation)
   ✓ Vertical scaling by combing more resources

 ✓ Orchestration driven by dynamic application needs
Composing a System
Example

System A

GenZ

CXL

NVMe-oF

TCP
Current Storage View

- SDS already creates disaggregated scalable composable storage
  - Storage is disaggregated
  - Allocation/Deallocation can be automated

- Demonstrates key issues with composability
  - App servers waits for storage
    - Adds latency
  - Consumes DDR BW
    - SSDs can easily consume DDR BW
    - Does this on two systems
  - Consumes Fabric/Network
    - Increased power needs
    - Increased transfers
    - Increased provisioning costs
What Is Computational Storage?
Need A New Way to Look at Storage

Pain Points
- Physical Space
- Available Power
- Scaling Mismatch
- Bottleneck Shuffle

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 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
  - Costs Saving
    - Reduced transfers
    - Reduced power
    - Free up host cycles
    - Potential for server removal
  - Potential for massively parallel compute

[Diagram showing Computational Storage Systems]
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

Reduced data 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 without added rack space
Are Composable Infrastructure and Computational Storage Mutually Exclusive . . .
or Mutually Beneficial?
Mutually Beneficial

✓ Enable computational storage
  ✓ Reduce the data movement between the storage and the host

✓ Compose and decompose as needed via orchestration
  ✓ Run some applications in storage

✓ Orchestration driven by dynamic application needs
  ✓ Utilize computational storage to reach a higher level of system efficiency
Finding the Needles in Haystacks with AI and CSDs

Problem Statement

- Databases growing at exponential rates
- Load and Search time key blocks in getting results

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<th>10 M</th>
<th>1 Billion</th>
<th>1 Trillion</th>
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<td>2007</td>
<td>2017</td>
<td>2021</td>
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Computational Storage Solution

- Determine best way to increase performance
- Load Time Reductions due to CSD Offload of AI code

Results are Proven:

- Load Time Reduced > 95%
- Search Time Reduced > 60%
- Power Savings of > 60%

Technical paper to be published in the ACM journal on Computational Storage
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- You can also find this webcast and many other videos and presentations on today’s topics in the SNIA Educational Library
- A Q&A from this webcast will be posted to the SNIA Compute, Memory, and Storage Blog
- Learn more about computational storage at www.snia.org/computational
Where To Find Out More About Composable Infrastructure and Computational Storage

- Website resources
  - [www.snia.org/CMSI](https://www.snia.org/CMSI)
- Twitter
  - [@sniacomputational](https://twitter.com/sniacomputational)
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