Computational Memory

Moving Compute Near Data

ENDLESS MEMORY

CXL™ FORUM at OCP Summit

Pekon Gupta

SMART Modular Technologies

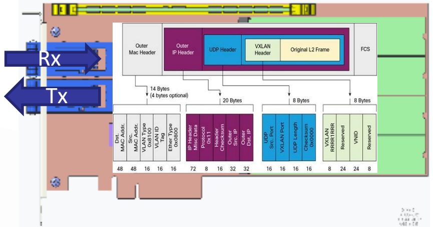
EMPOWERING OPEN.

OCP GLOBAL SUMMIT

OCTOBER 18-20, 2022
SAN JOSE, CA

Types of Hardware Accelerators

Network Accelerators (Smart NIC)

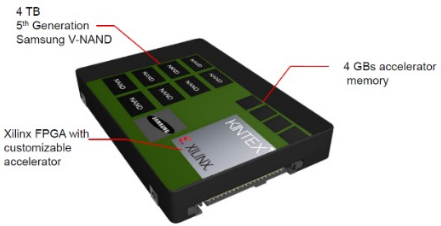


Storage Accelerators Computational Storage (CS)

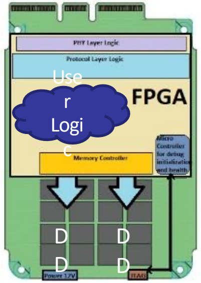
ScaleFlux CSD 2000 SERIES
COMPUTATIONAL STORAGE DRIVE
ScaleFlux CSD 2000 SERIES
COMPUTATIONAL STORAGE DRIVE

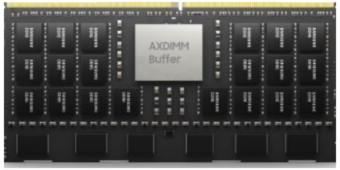
ScaleFlux Computational Storage Drive
PCIe HHHL AIC and U.2

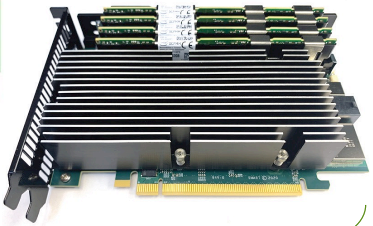
SmartSSD® CSD



Memory Accelerators Computational Memory (CM) Processing in Memory (PIM)



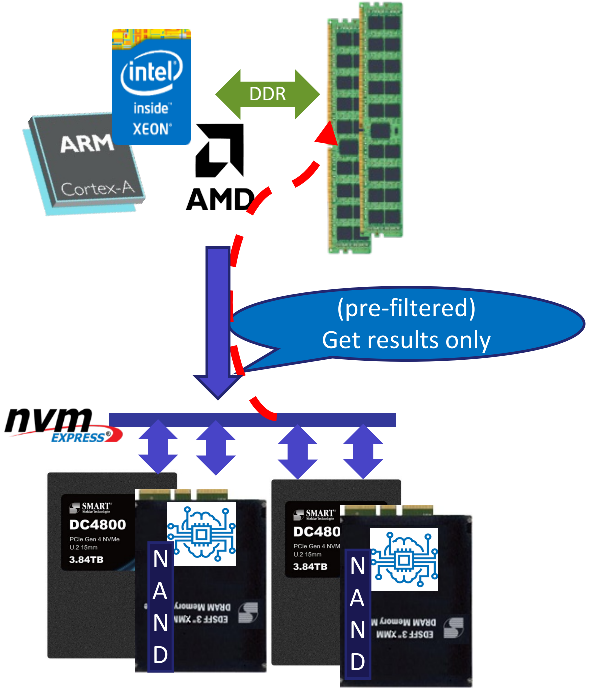




Near Data Processing (NDP)

[1a] https://blocksandfiles.com/2020/10/28/amd-xilinx-smartnic-data-centre/
[1b] https://www.servethehome.com/intel-fpga-pac-d5005-high-end-drop-in-accelerator-launched
[2a] https://www.servethehome.com/xilinx-samsung-smartssd-computational-storage-drive-launched/
[2b] https://www.servethehome.com/intel-fpga-pac-d5005-high-end-drop-in-accelerator-launched/
[3a] https://tekdeeps.com/samsung-also-sees-the-future-in-memories-that-also-perform-calculations/

Computation Storage vs Computational Memory



Computational Storage

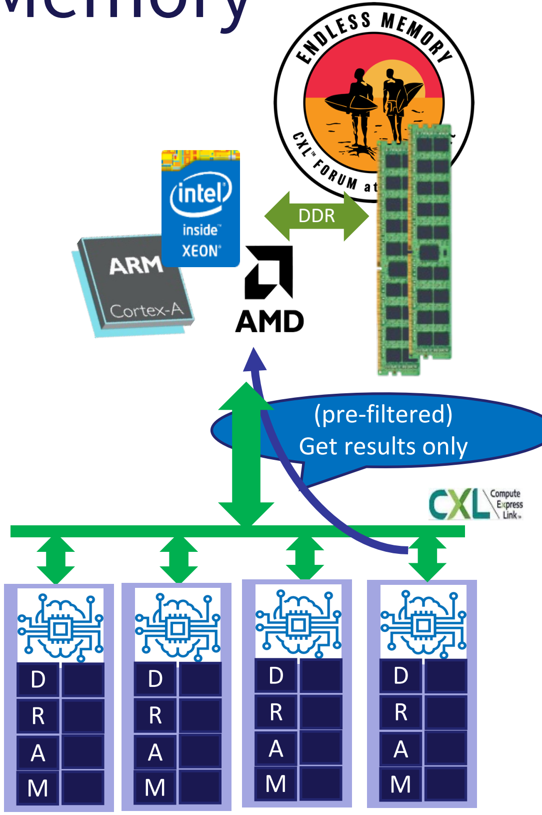
Protocol specific differences

IO Mapped | Direct addressable
(high latency) | (low latency)

Block access | Memory semantics
(read/write) | (load/store)

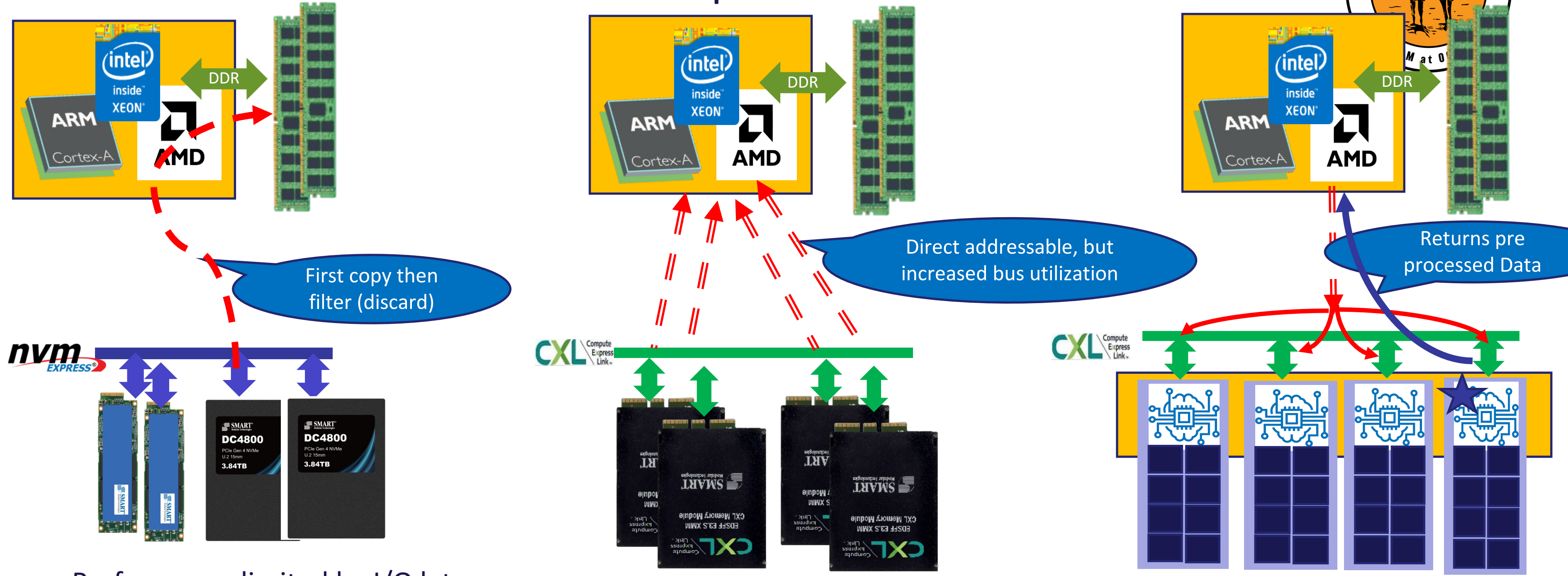
(Media specific difference)

Limited Endurance | Infinite Endurance
Non-Volatile | Volatile/ Persistent



Computational Memory

Benefits of Moving Compute near the Data


intel inside XEON
ARM Cortex-A
AMD
DDR
nvm EXPRESS
SMART DC4800 PCIe Gen 4 NVMe U.2 15mm 3.84TB
SMART
CXL Compute Express Link
SMART EDSFF E3.S XMM CXL Memory Module

Conventional Systems

First copy then filter (discard)

- Performance limited by I/O latency
- Inefficient bus utilization

In development

Direct addressable, but increased bus utilization

- Lower latency but more accesses
- Inefficient bus utilization

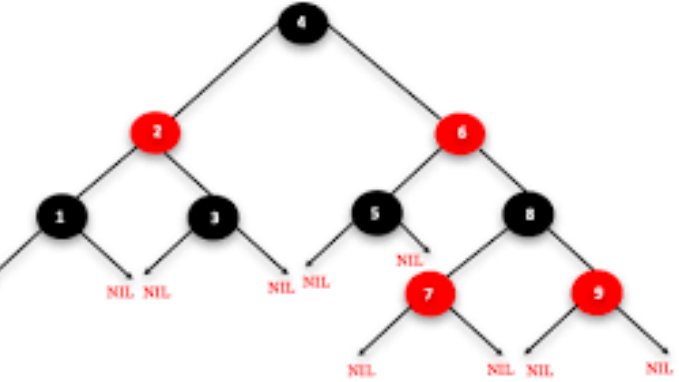
Planning for Future

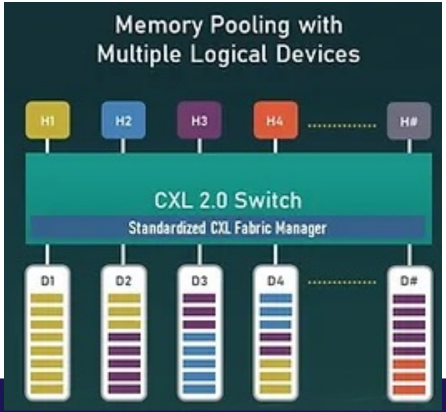
Returns pre processed Data

- Distributed Compute
- Efficient bus utilization

Data in Pooled Memory System

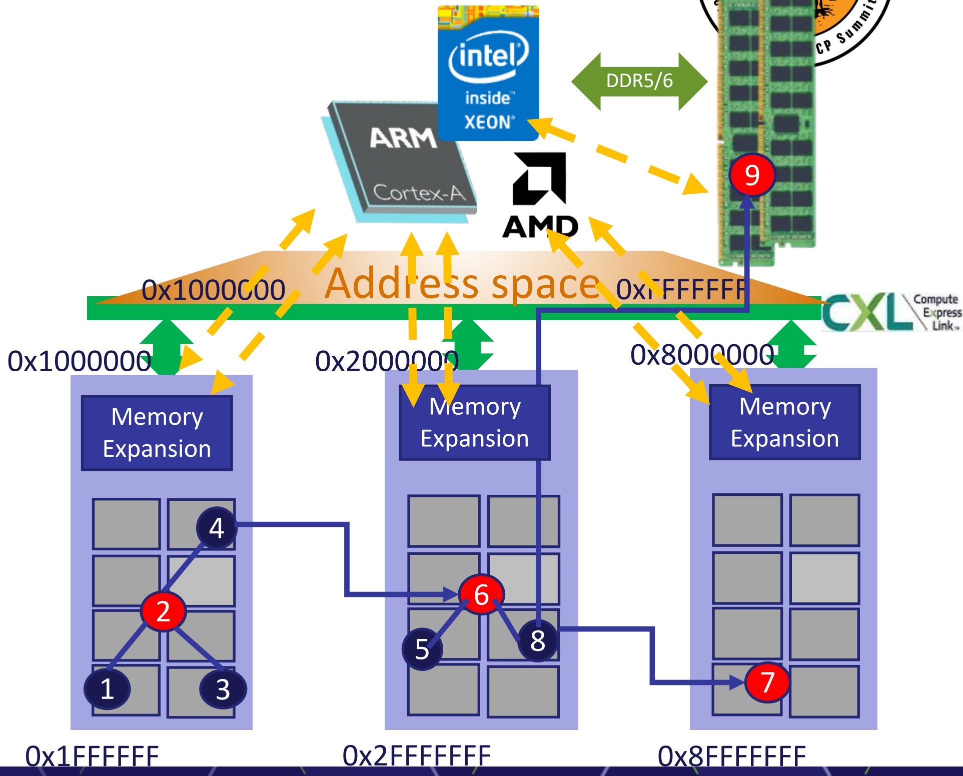
Logical view





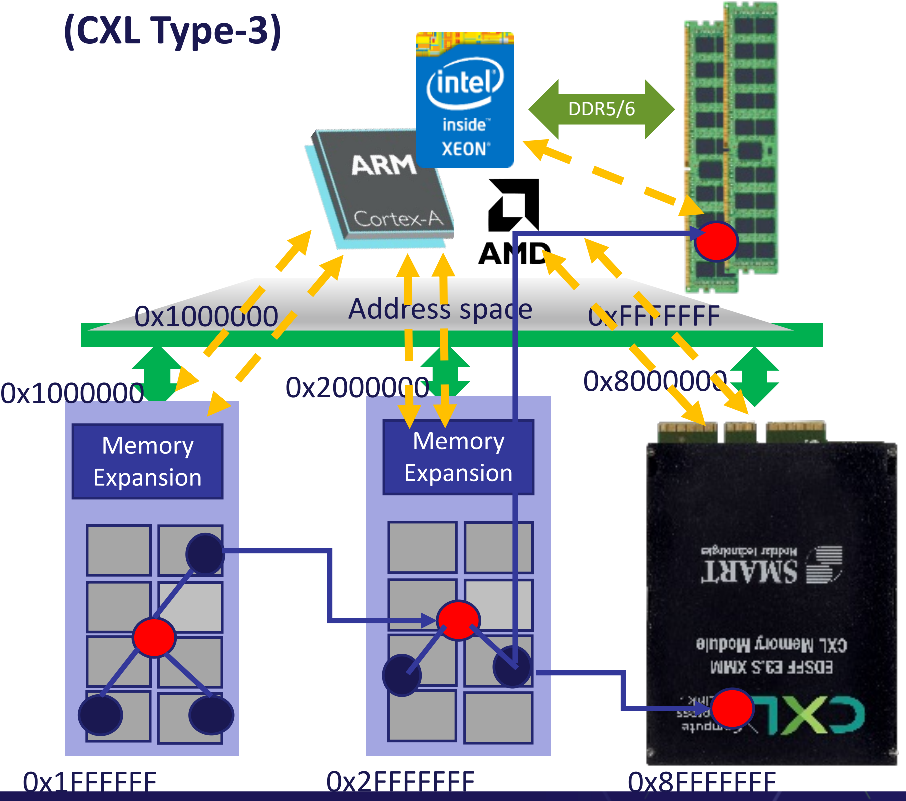
Memory Pooling with
Multiple Logical Devices

Physical view

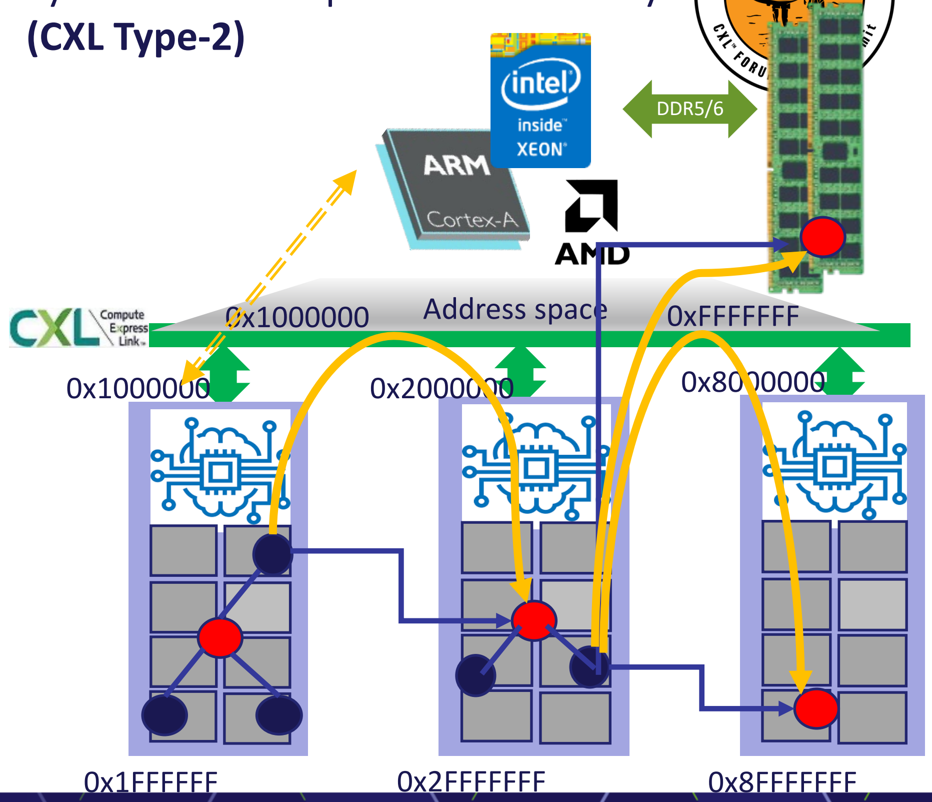


Standard vs Computational Memory pools

System with Standard Memory Devices **(CXL Type-3)**



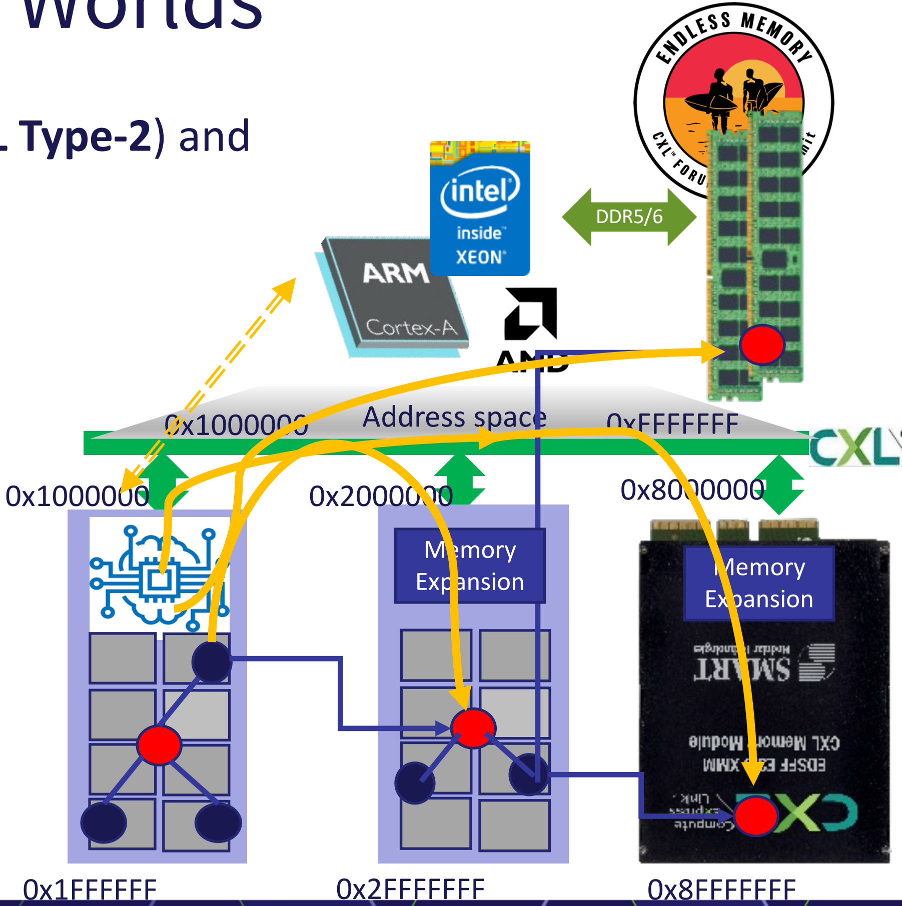
System with Computational Memory Devices **(CXL Type-2)**



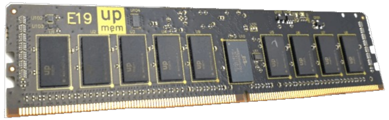
Combining Best of Both the Worlds

System with Computational Memory Devices (**CXL Type-2**) and Standard Memory Devices (**CXL Type-3**)

- ✓ Free up Host CPU.
  Computational Memory manages all prefetching and Data consolidation.
- ✓ Provides deterministic latency.
  Data is pre-filtered and only required response is returned to Host.
- ✓ Reduces cost by sharing of Memory resources.

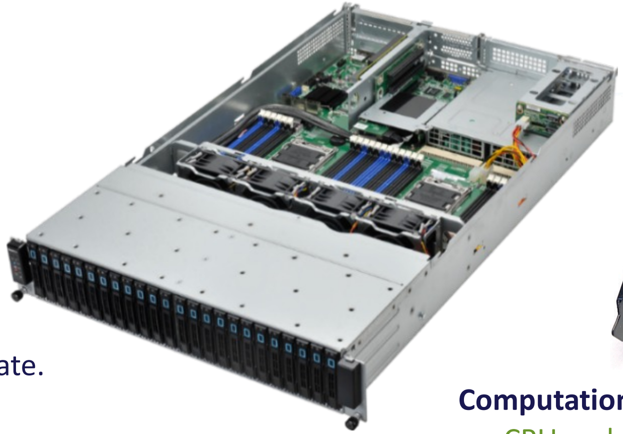


Selecting the Right Form Factor



Computational Memory in DIMM form-factor

- **Parallel attached, Lowest latency**
- CPU and Platform dependent
- Acceleration offload limited by Thermal budged
- Choice of controller silicon limited by PCB real-estate.
- ***May degrade speed of entire DDR channel***



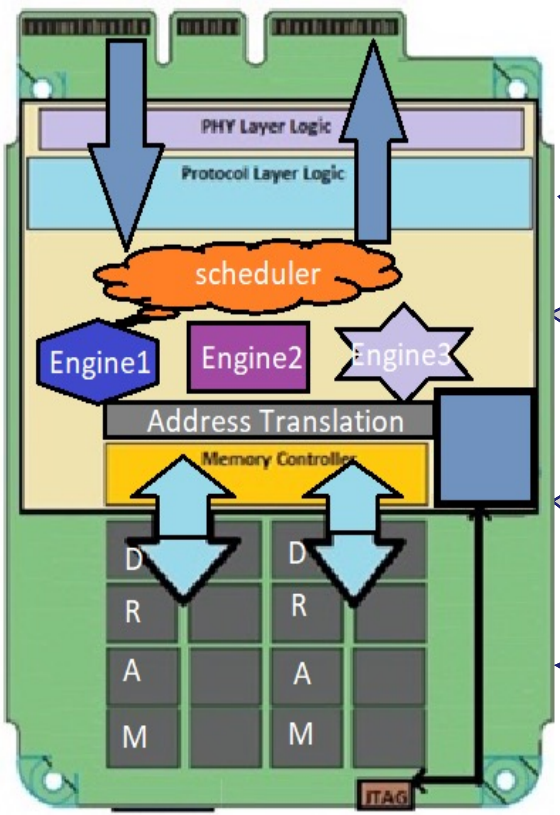
Computational Memory in PCIe attached form-factor

- CPU and Platform Agnostic
- Flexibility of vendor and capacity selection.
- Cannot Hot Plug. Limited serviceability.

Computational Memory in EDSFF (like E1.S or E3.S)

- **Serial attached**. CPU agnostic. Media agnostic
- **Hot pluggable. Improves serviceability**
- Scalable. Pluggable in same slots as SSD.
- Serialization of data-bus adds latency
- Capacity and acceleration limited by PCB and Thermal profile.

Anatomy of a Computational Memory Device



Protocol Command Parser

- Standard CXL compliant logic for Type-3/2 device
- Extracts information from standard CXL commands
- Device initialization, enumeration and housekeeping

Programmable Compute Engine(s)

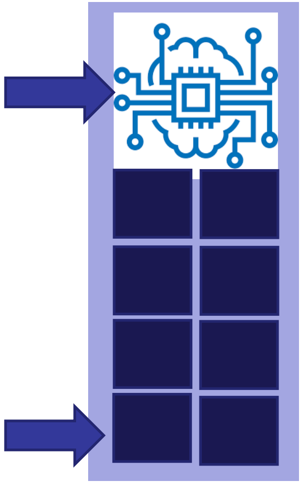
- Breaks complex commands in atomic executable tasks
- Execute individual tasks and collate results.

CXL.Mem decoder

- Converts Host Addresses into Device local Addresses
- Memory Media manager

Memory Media

DDR4/5/6, Persistent Memory and even NAND Flash



Key Take-Aways

1. Computational Memory is different from Computational Storage.
2. CXL is enabling new way to distribute and parallelize Compute.
3. Choosing the right Mechanical Form-factor is important for scalability.

Call for Action

- Standardize API and framework for “Computational Memory”
- Join OCP’s Software Defined Memory (SDM) initiative
  - [OCP Software_Defined_Memory]

ENDLESS MEMORY
CXL™ FORUM at OCP Summit

Thank you!

EMPOWERING OPEN.

OCP
GLOBAL
SUMMIT

OCTOBER 18-20, 2022
SAN JOSE, CA