

MEMORY
FOR  EST

Rethinking Byte-Accessibility of SSDs from a CXL-attached Memory and Storage System

John Kim, SK hynix
Senior Director
Advanced Systems Technology

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Product Line-up for New Value Proposition of Memory

- Standard Products
- Product Solution

High Bandwidth

Capacity
(Bubble size)

Power Efficiency

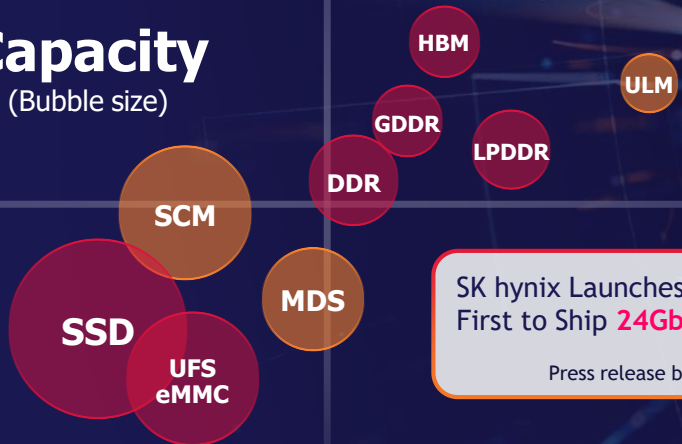
SK hynix Supply Industry's First **HBM3 DRAM** to NVIDIA
Press release by June 8, 2022

SK hynix Starts Mass-Production of **LPDDR5 Mobile DRAM** with Industry's Largest Capacity
Press release by May 19, 2022

SK hynix Launches PCIe 4.0 "**Platinum P41**" SSD
Press release by May 19, 2022

SK hynix Launches Industry's First to Ship **24Gb DDR5 Samples**
Press release by December 15, 2021

SK hynix Develops World's Highest **238-Layer 4D NAND Flash**
Press release by August 2, 2022



SCM : Storage Class Memory

MDS : Managed DRAM Solution

ULM : Ultra Low power Memory

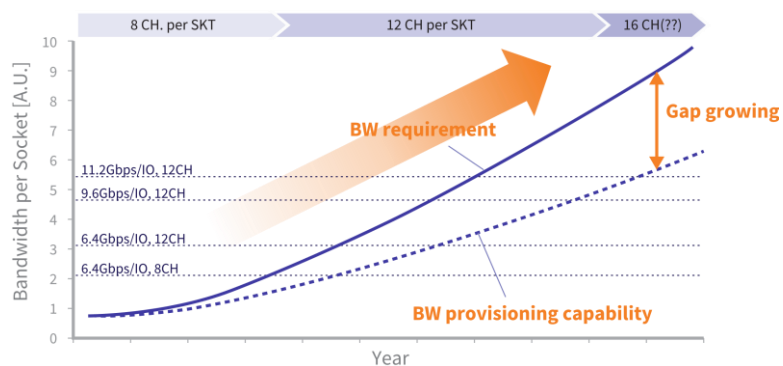
HBM : High Bandwidth Memory

UFS : Universal Flash Storage

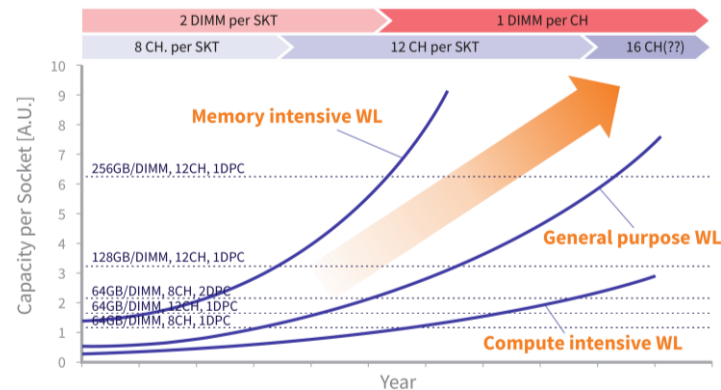
eMMC : embedded Multi-Media Card

Challenges - Growing Memory Bandwidth and Capacity Gap

- Increase in CPU core counts requires increase in memory bandwidth and capacity
- Gap between such requirements and platform provisioning capability is growing



[Memory Bandwidth Requirement]

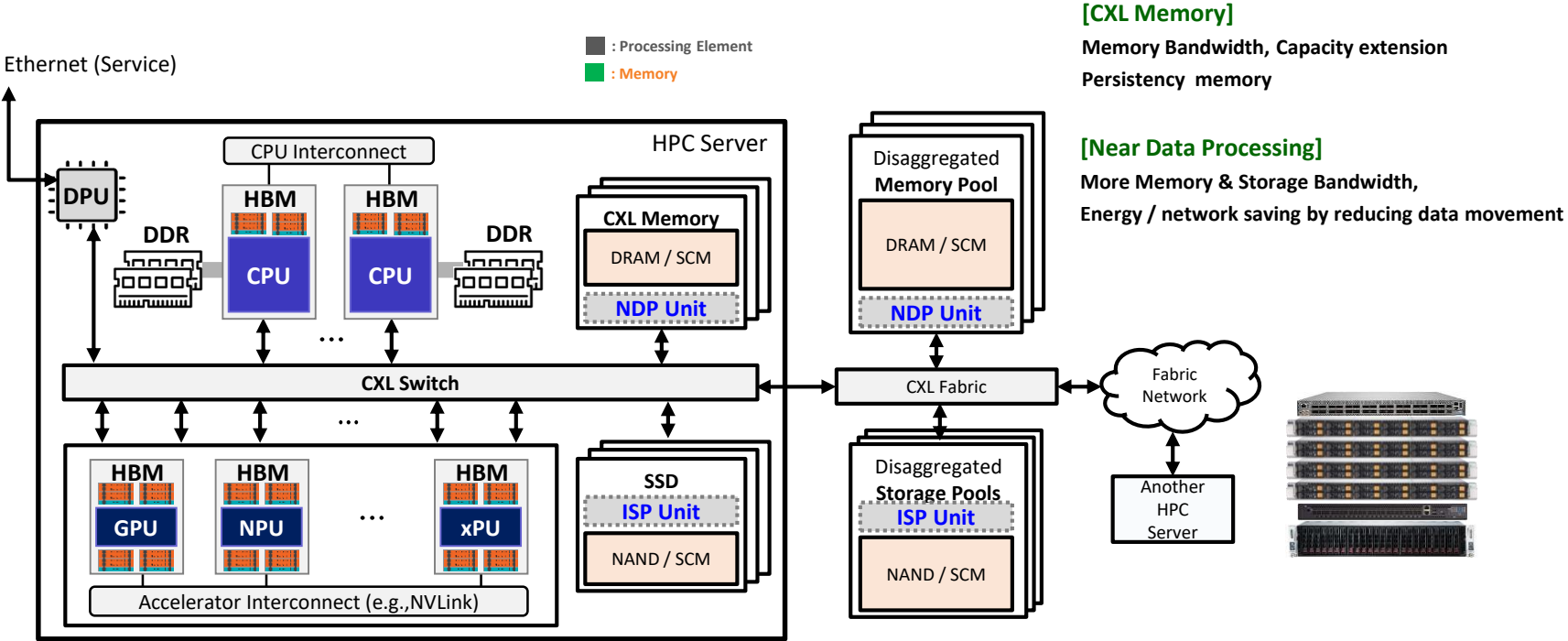


[Memory Capacity Requirement]

SK Hynix, "Adding New Value to Memory Subsystems through CXL™", Flash Memory Summit Conference. Aug 5, 2022

Memory Forest Reference System

- Reference system includes all solution we imagine in the world of memory forest.



Opportunities - New Values in Memory through CXL

- Memory expansion beyond DDR memory
- Different memory media can have different performance, capacity and power trade-offs
- Enhanced features can be included in CXL memory controller
- Efficient memory disaggregation is possible

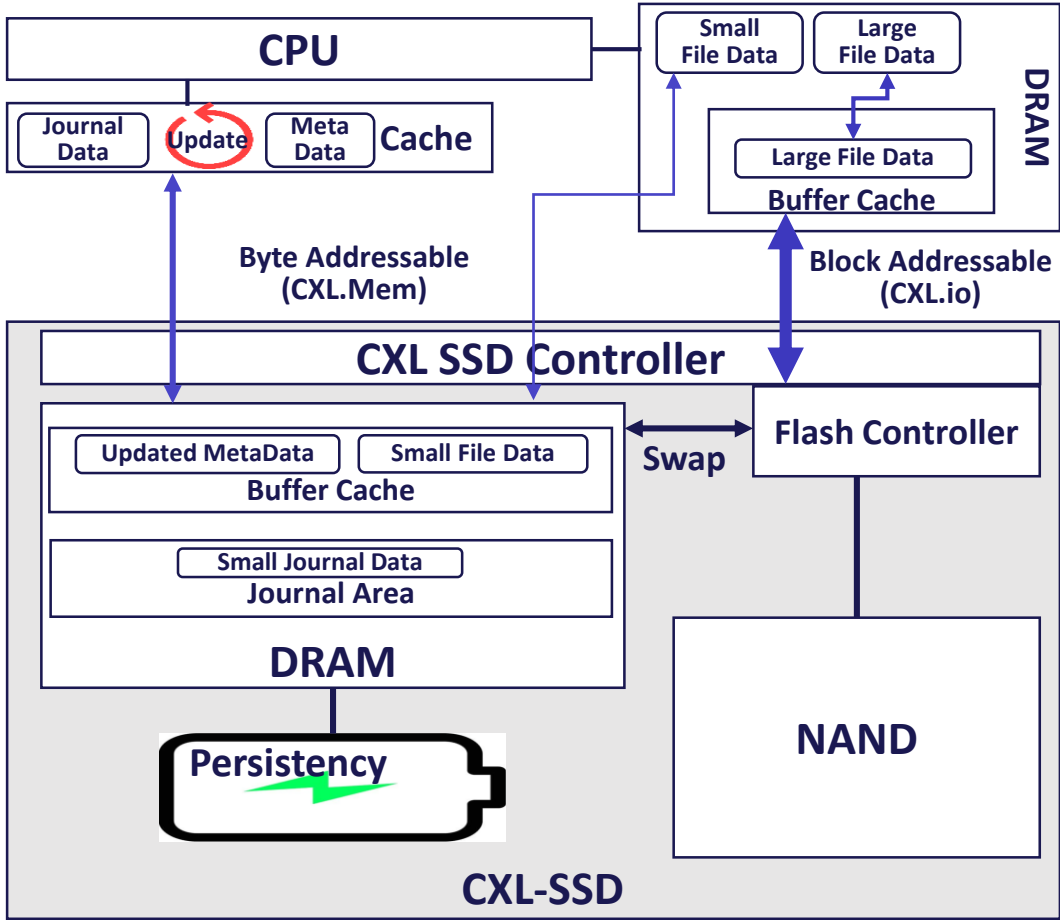


CXL SSD – Benefits of Byte Accessibility

- Very large capacity load/store memory
 - Lower solution cost against adding additional DRAM
- Elimination of OS page cache which is used for storage devices
 - Better use of precious CPU local memory
- Host can talk to the storage at lower latency by removing block driver stack

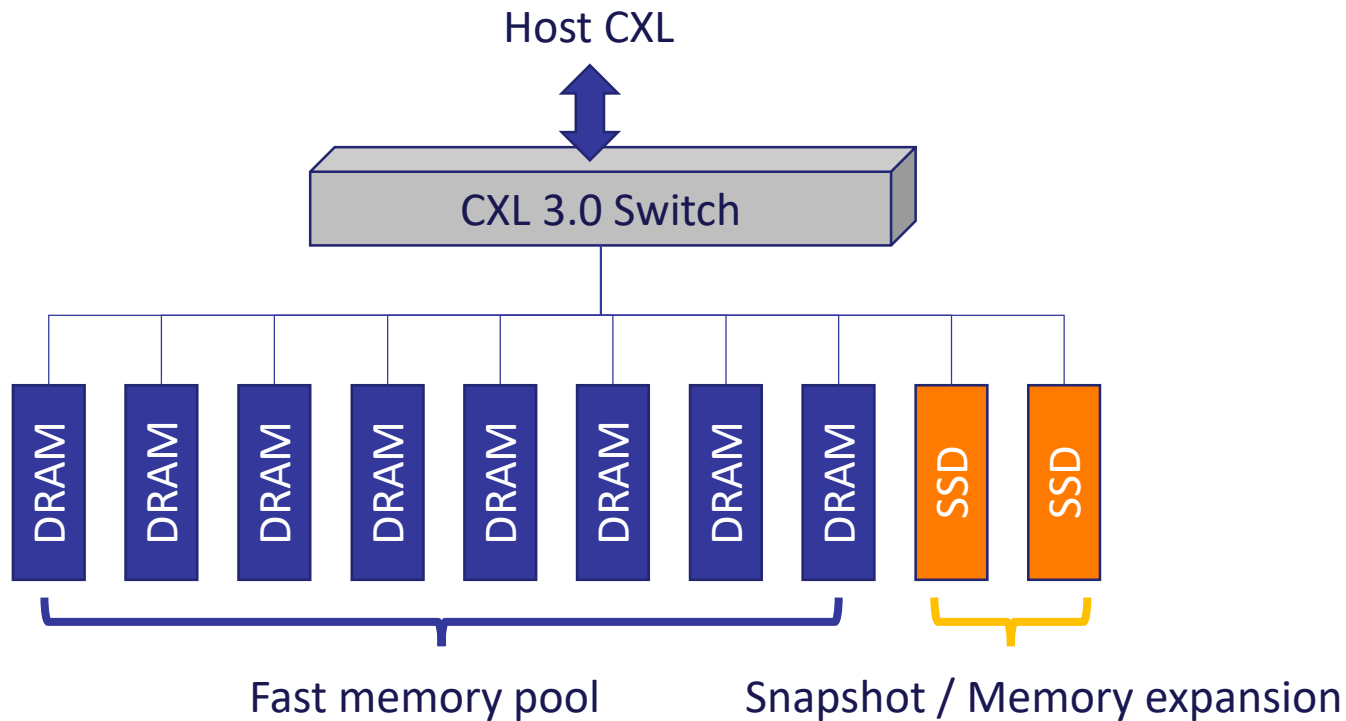
- Faster than OS swap space and allows very large database (In-memory DBs)
 - Better operational latency
- Configurable platform for memory semantic accelerators
 - Solution of the memory capacity bottleneck for big data & ML

CXL-SSD Architecture for Journaling File System

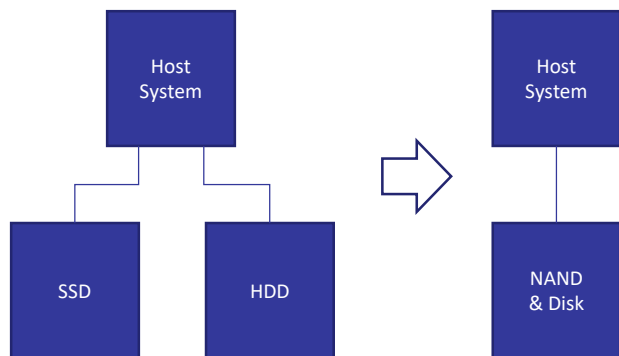


CXL SSD in the pooled memory

- DGM (Data Greater than Memory) Problem → Availability
- SPOF (Single Point of Failure) Problem → Durability

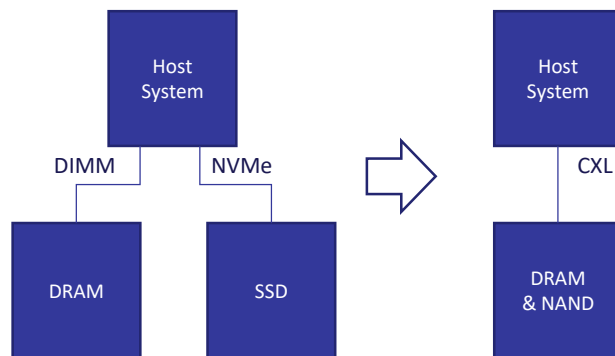


- SSHD (Solid State Hybrid Drive)



NAND: WR cache, fast storage
Pros: Lower cost than SSD, faster than HDD
Cons: Complicated recovery process, cache-miss

- Hybrid Memory



DRAM: R/W cache, fast memory
Pros: Non-volatility
Cons: Still expensive, cache-miss

Improving CXL-SSD through Computation Capability

- Persistent mode CXL-SSD

