



Bringing Persistent Memory Technology to SAP HANA: Opportunities and Challenges

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Agenda Items

Persistent Memory (PM): What's all the noise about?

Bringing PM to in-memory computing: Opportunities & Challenges

Leveraging Intel DIMM based on 3D XPoint™ technology for SAP HANA

Sample use case: Improved in-memory database restart time

Conclusions



Persistent Memory: What's all the noise about?

Persistent Memory (PM): An emerging, next-generation non-volatile memory technology

- A true game changer for in-memory computing offering new opportunities for increased performance and scalability and lowering cost

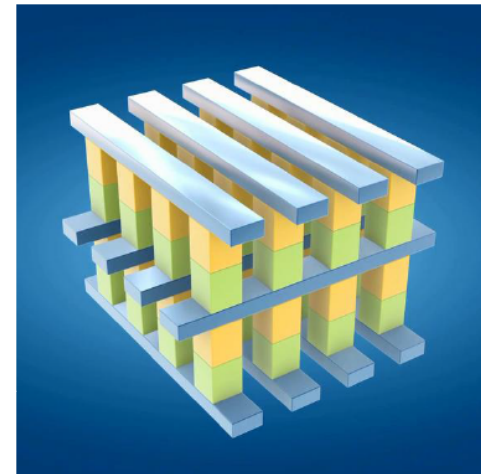
Key business drivers for bringing PM to in-memory computing:

- As data volumes keep growing, in-memory databases like SAP HANA require larger capacities
- DRAM scaling has slowed significantly and will offer lower capacities
 - New solutions needed for cost-efficient store of large data while still providing real-time access

Persistent Memory: What's all the noise about?

Persistent Memory

- Byte addressable persistence
 - Fast enough to load directly
 - Usually on memory bus
- NVDIMMs available today
- 3D XPoint™ Memory
 - Persistent
 - (up to) 1000X faster than NAND
 - (up to) 1000X endurance
 - **6TB per 2-socket system**
 - **Cheaper than DRAM**
 - SSDs first (demonstrated last year)
 - Intel DIMMs for next gen platform



Our focus for
SAP HANA...





Bringing Persistent Memory to in-memory computing

Opportunities:

- Increased scalability
 - Larger memory modules means more memory available per server
- Significant cost savings
 - PM is cheaper than DRAM
- Improved recovery times

Challenges:

- Higher latency impacting performance
- New technology, standards still evolving...
 - Means slow, phased implementation with increased complexity and uncertain timelines



SAP HANA focus: SNIA programming model for use with memory-like NVM

Intel DIMM based on 3D XPoint™ technology is fully aligned with the SNIA programming models for NVM and provides support for Block, File, Volume, and Persistent Memory (PM) File mode.

Persistent Memory Mode (SNIA)

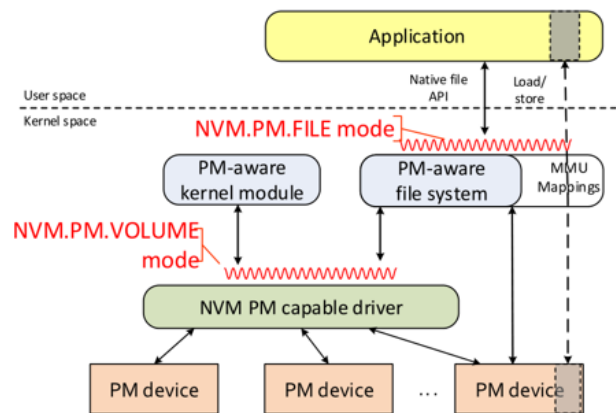
Use with memory-like NVM

NVM.PM.VOLUME Mode

- Software abstraction to OS components for Persistent Memory (PM) hardware
- List of physical address ranges for each PM volume
- Thin provisioning management

NVM.PM.FILE Mode

- Describes the behavior for applications accessing persistent memory Discovery and use of atomic write features
- Mapping PM files (or subsets of files) to virtual memory addresses
- Syncing portions of PM files to the persistence domain



SAP HANA focus is on leveraging memory mapping in NVM.PM.FILE mode which enables direct access to persistent memory using CPU instructions

Sample use case: Reducing IMDB down-time

Logging, warehousing, processing
information: lifeline of companies



Information availability depends on
database availability (9s)



Minimize restart time to improve
database availability

Availability	Annual DownTime
97%	11 days
98%	7 days
99%	3 days 15 hrs
99.9%	8 hrs 48 min
99.99%	53 min
99.999%	5 min
99.9999%	32 sec

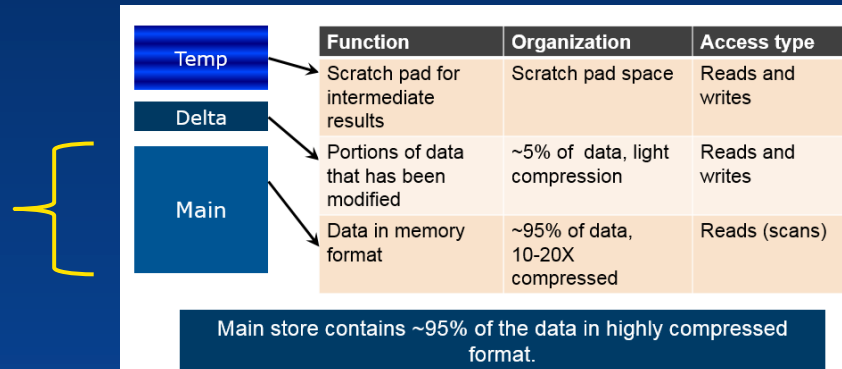
- Each restart for an IMDB can take upto 1 hour to load TBs of data to memory.
- Dell study shows millions of dollars lost per hour due to downtime**
- Existing HA solutions increase the price *exponentially* for every nine



Evolving the HANA SW Architecture to incorporate 3D XPoint™ PM technology

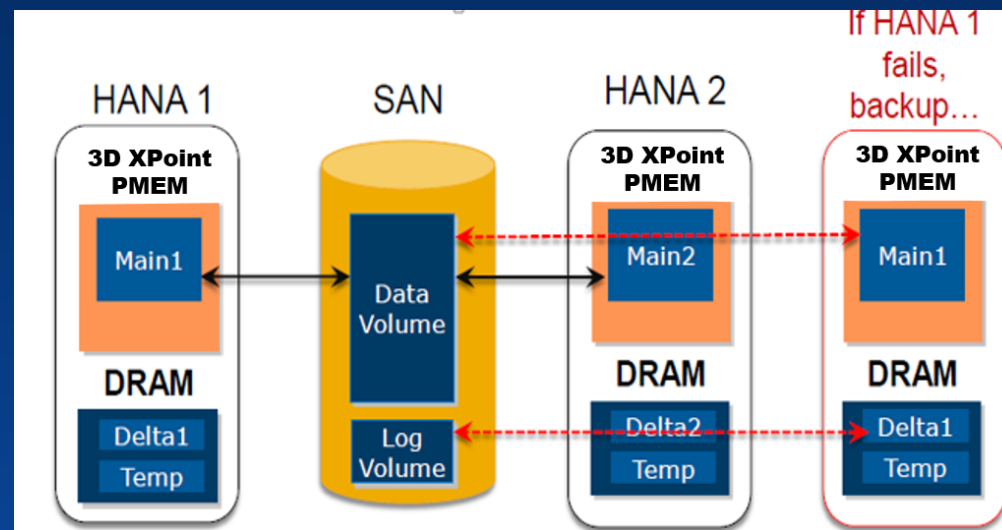
SAP HANA: Memory Architecture

Main Store is the perfect fit for Intel DIMM based on 3D XPoint™ technology!



	Technology differentiators	Why Main is well suited
+	Large capacity	Since 95% of data contained in main, HANA can scale up to larger datasets due to increased memory capacities
+	Persistence	Avoid loading data from storage and reduce downtime
-	Higher latencies	References are in form of scans. Hardware and software prefetchers can hide latencies for such reference patterns

Leveraging 3D XPoint™ PM technology for SAP HANA Main Store: Solution Overview



- Primary data store is data volume (in SAN or local storage)
- Main is in 3D XPoint™ PM instead of DRAM and is now persistent
- On Restart: Main already in 3D XPoint™ PM, no need to load data from SAN
- On HW failure: Backup server loads data from data volume



Leveraging 3D XPoint™ PM technology for SAP HANA Main Store: Performance analysis

Initial results from a prototype (that leverages a suite of simulation software and hardware technologies by exploiting NUMA configuration) are very promising:

- Significant improvements in the database restart time
 - >5X improvement measured
- Acceptable performance impact
 - Persistent Memory technology has higher (than DRAM) latencies, resulting in slightly lower performance
 - Measured (simulated) performance degradation was within the expected range for most workloads

The challenge ahead:

- New technology, standards still evolving will slow implementation timelines



Leveraging 3D XPoint™ PM technology for SAP HANA Main Store: Pros and Cons

PROS +

- Significant improvements in database restart time
 - No need anymore to load data, Main Store is now persistent as it is in 3D XPoint™ PM instead of DRAM
- Increased memory capacity at significantly lower cost
 - Potentially significant cost benefits in several areas

CONS -

- New approach does not leverage full potential: Two redundant persistent copies...
- 3D XPoint™ technology is still evolving, development of new standards is work in progress
 - Any resource, timelines are difficult to estimate due to technology still being under development



Conclusions

- A hybrid PM + DRAM approach will provide a large amounts of fast, cost-efficient memory for SAP HANA in-memory computing platform
- Persistent Memory can help with achieving near-instant recovery for main-memory databases
- Early results from bringing 3D XPoint™ PM technology to SAP HANA clearly support the expectations of persistent memory becoming a true game changer for in-memory computing



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