The Persistent Memory Programming Model

Andy Rudoff, Principal Engineer, Intel

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Founding Member, SNIA NVM Programming TWG

The Backstory

Eight Years Summarized in Ten Minutes

SNIA Technical Workgroup Involvement

- 2012 (June)
  - NVM Programming TWG Formed
  - Immediate Participation from key OSVs, IHVs, ISVs
- 2013 (December)
  - SNIA Publishes the NVM Programming Model version 1.0
- 2015 (March)
  - SNIA Publishes version 1.1
- 2017 (June)
  - SNIA Publishes version 1.2

SNIA Starts the Summit

- 2012 (June)
  - NVM Programming TWG Formed
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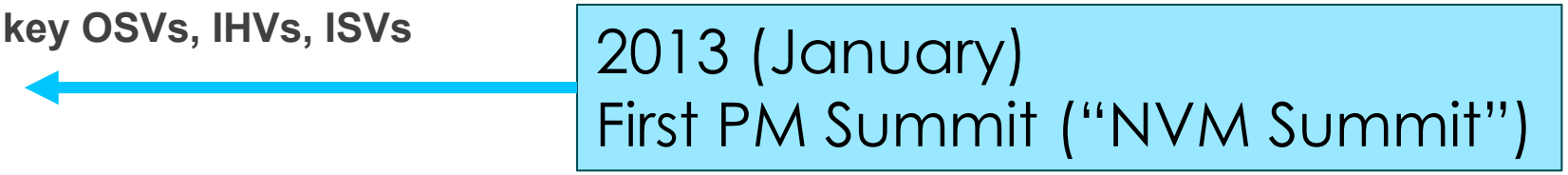
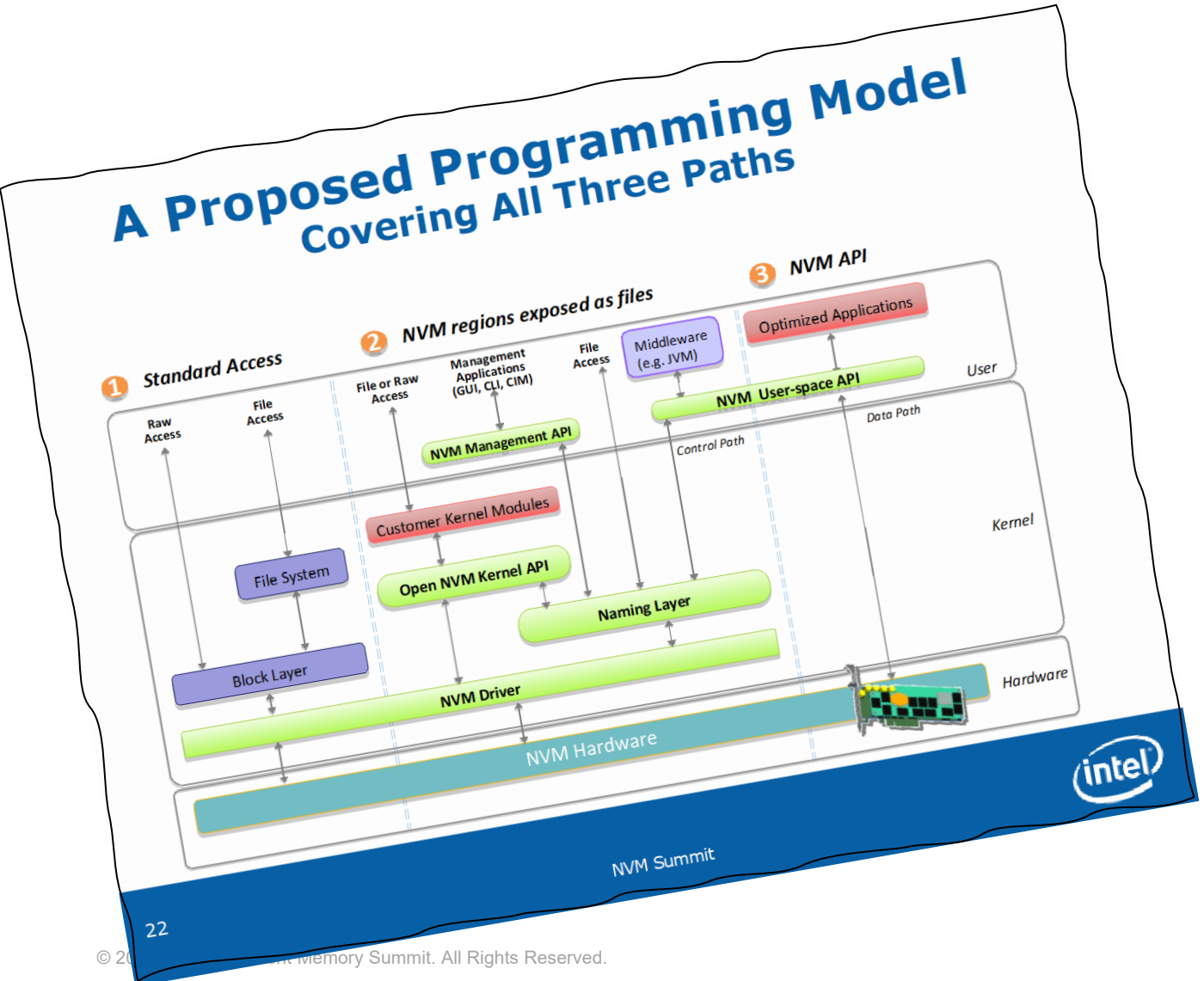
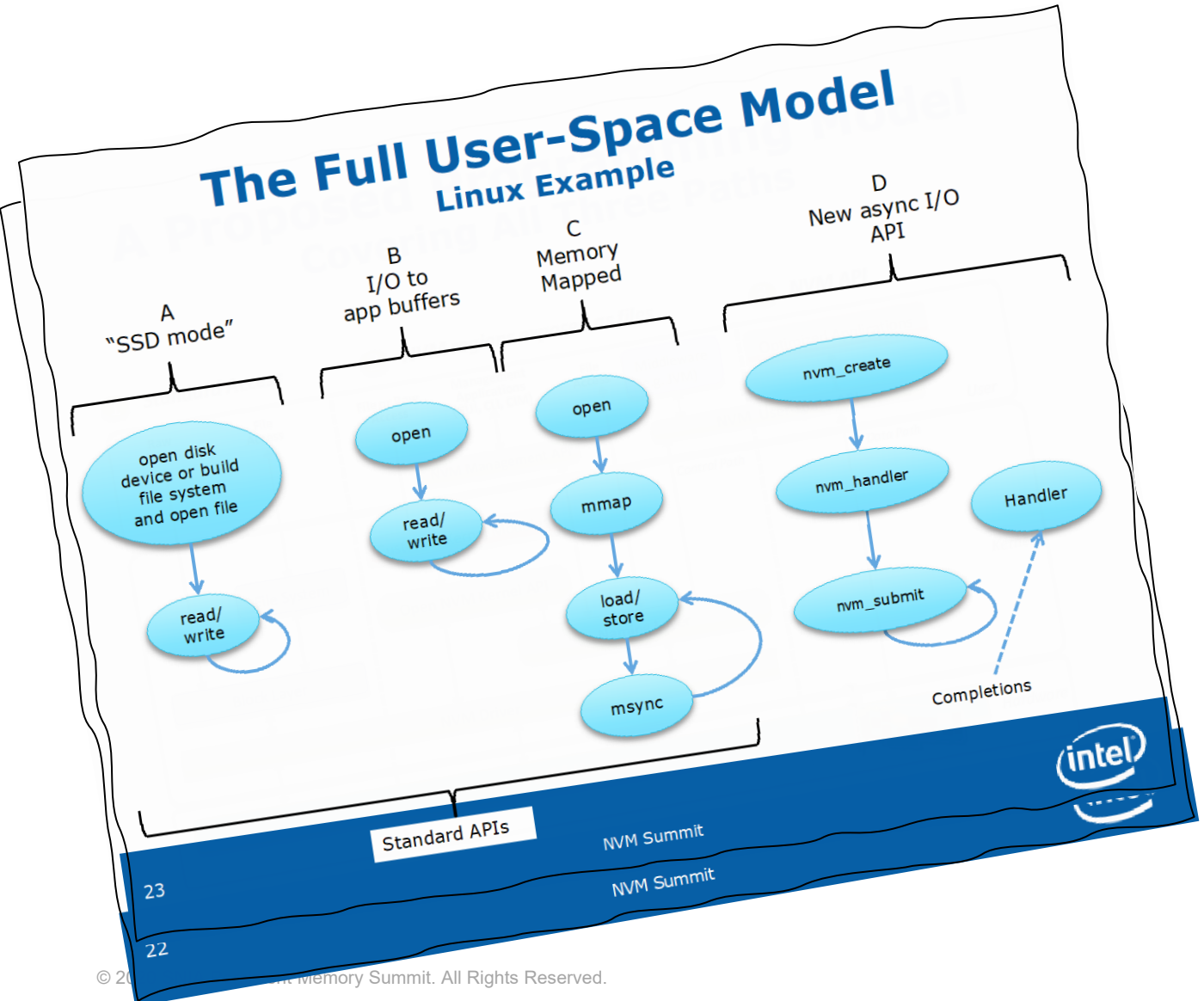


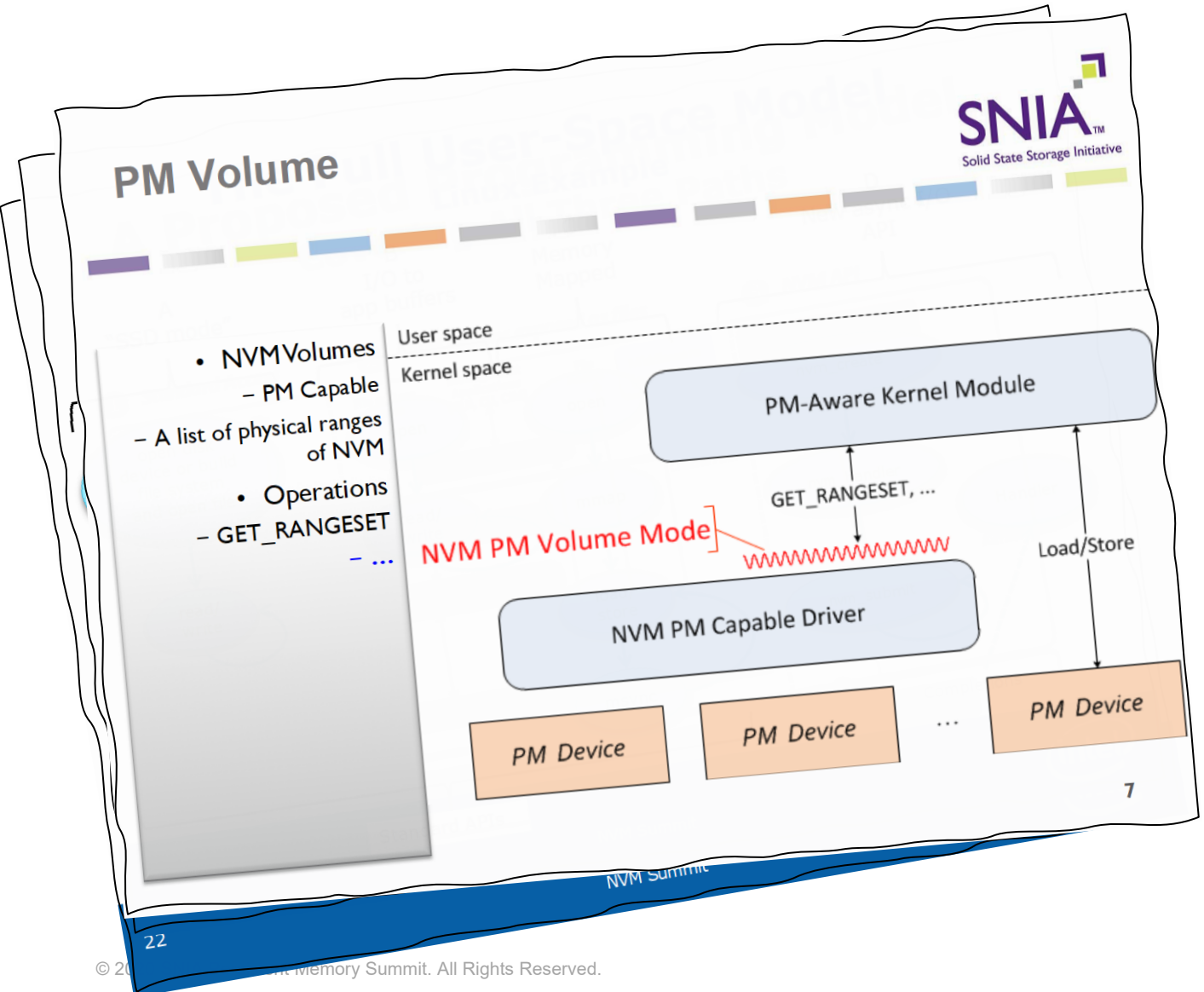
NVM Summit 2013



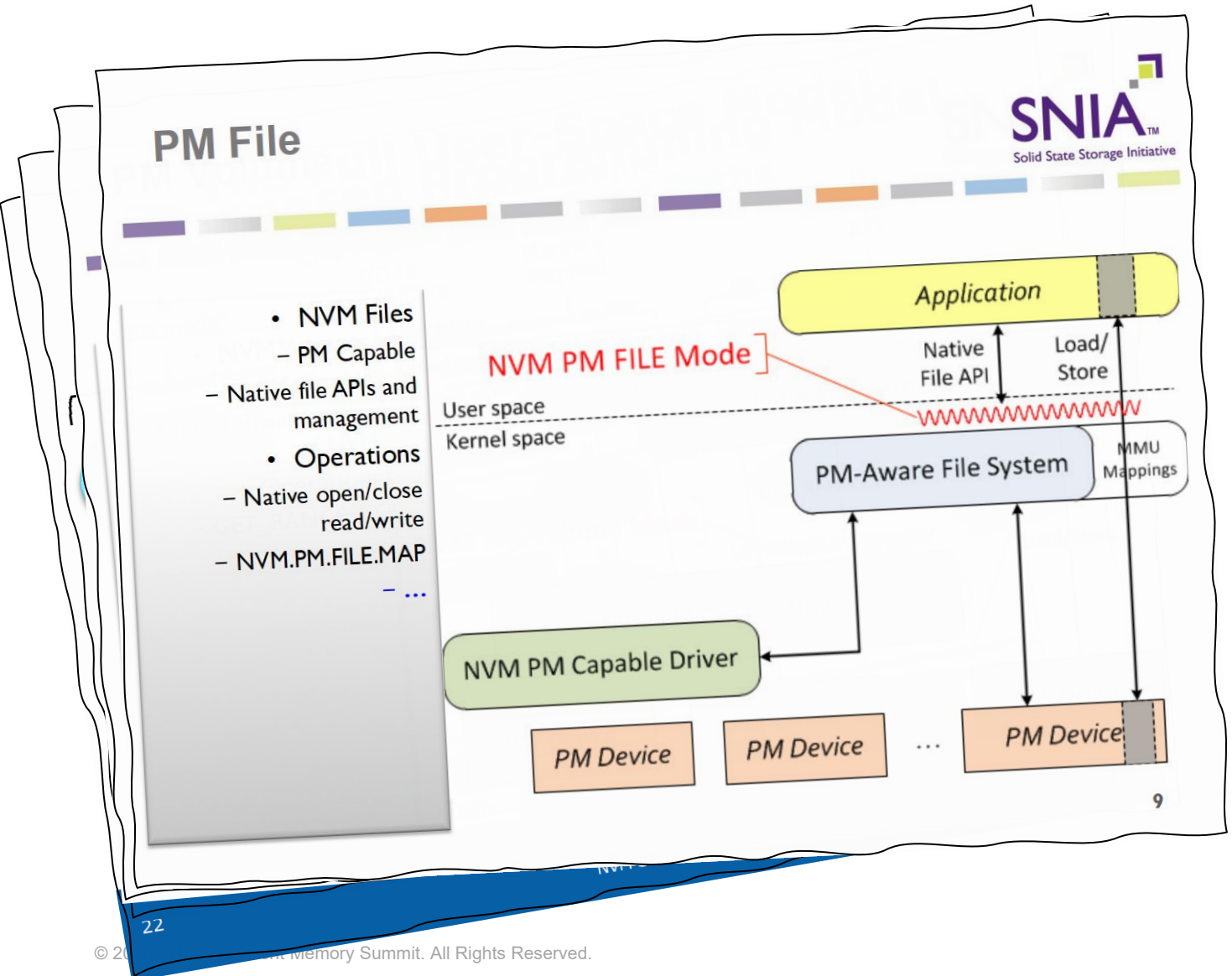
NVM Summit 2013



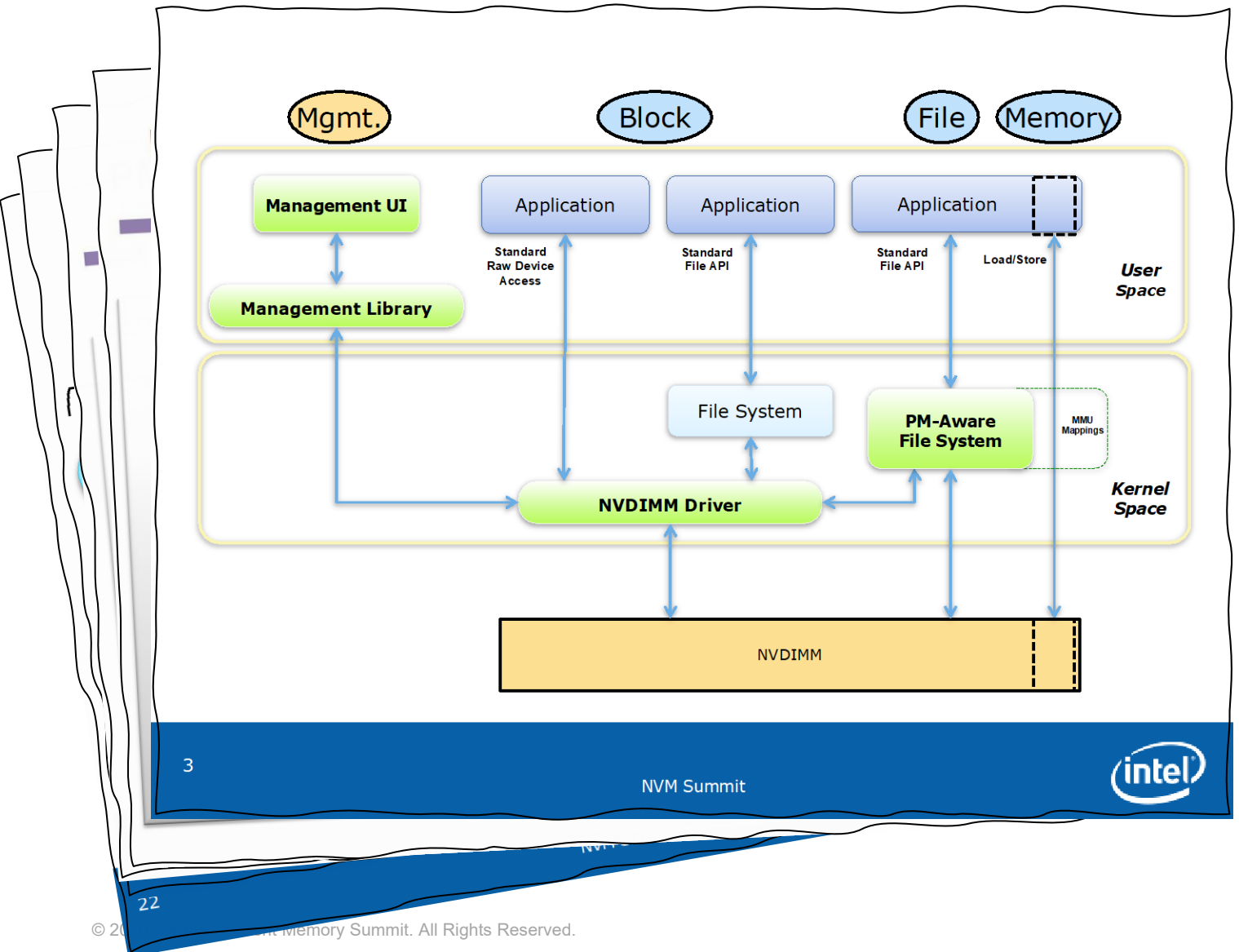
NVM Summit 2014



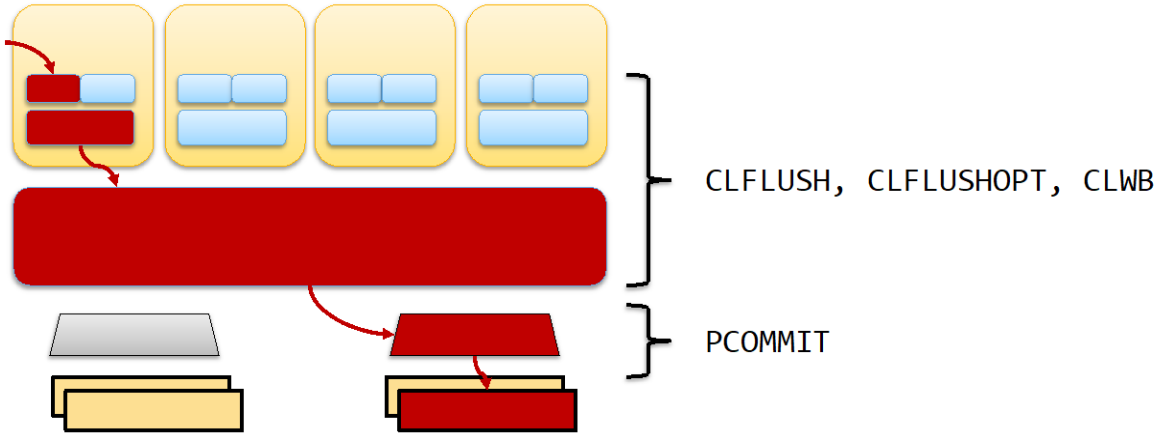
NVM Summit 2014



NVM Summit 2015

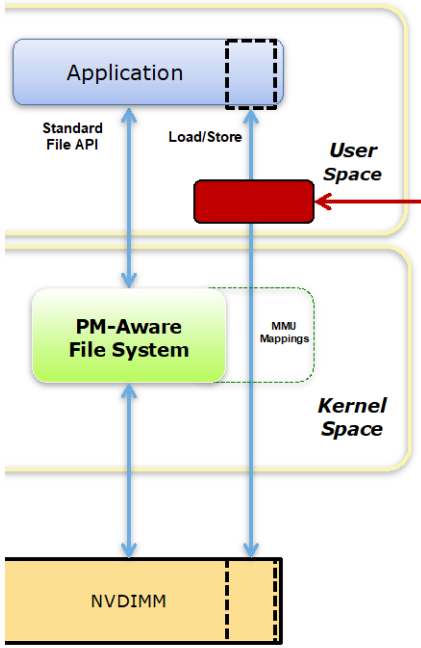


Two Levels of Flushing Writes



NVM Library: pmem.io

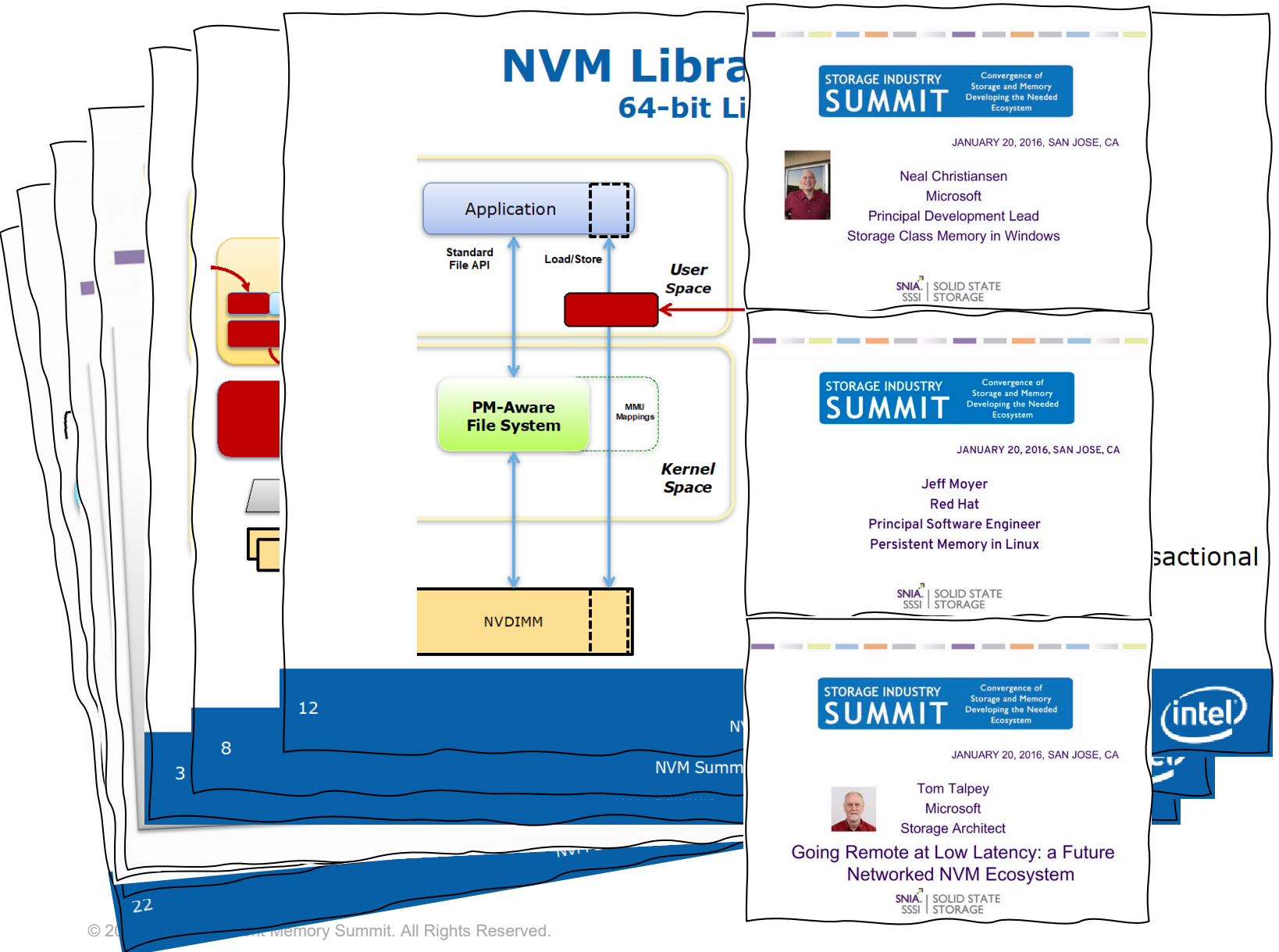
64-bit Linux Initially



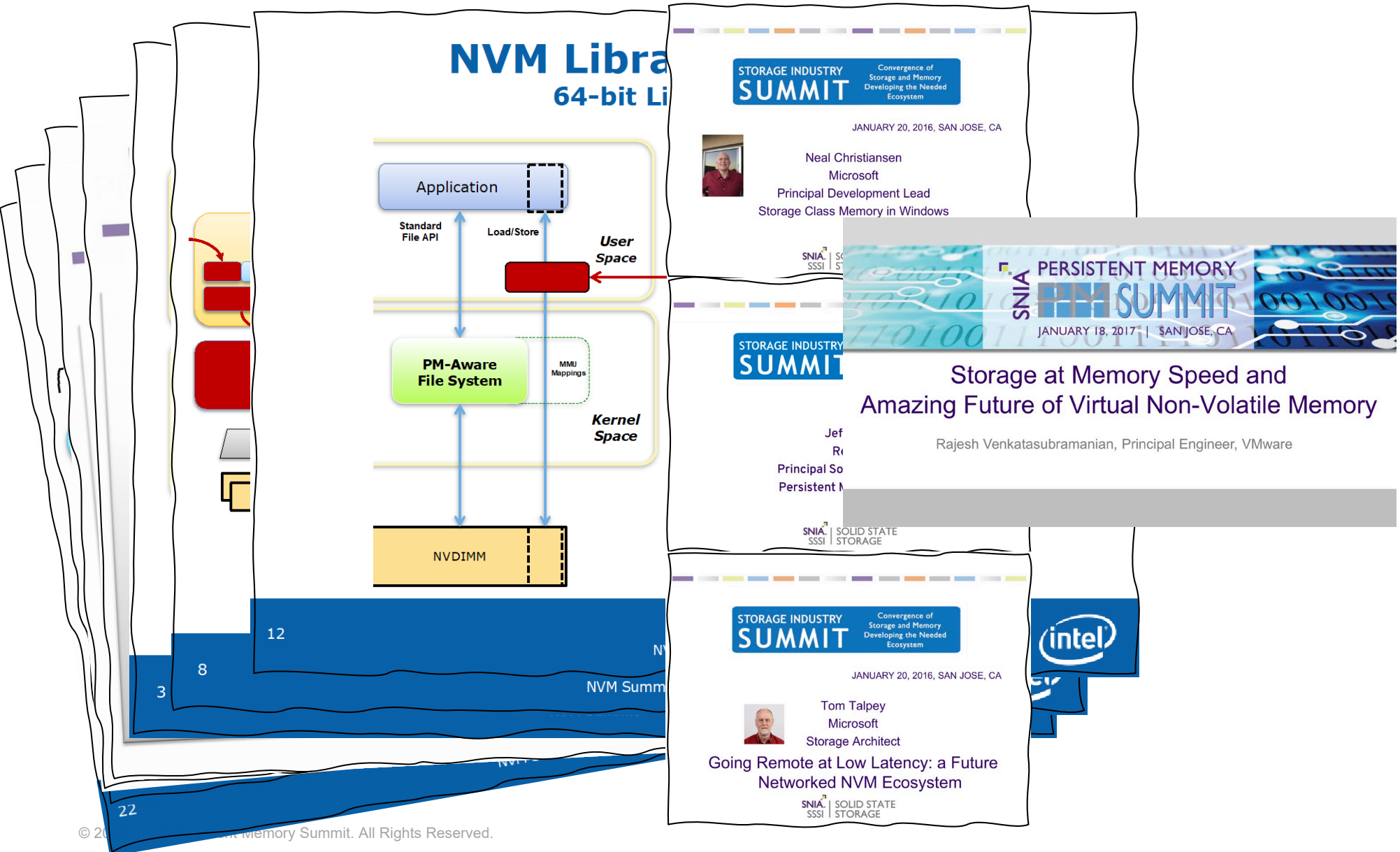
- Open Source
  - http://pmem.io
- Libpmem
- Libpmemobj
- Libpmemblk
- Libpmemlog
- Libvmem

Transactional

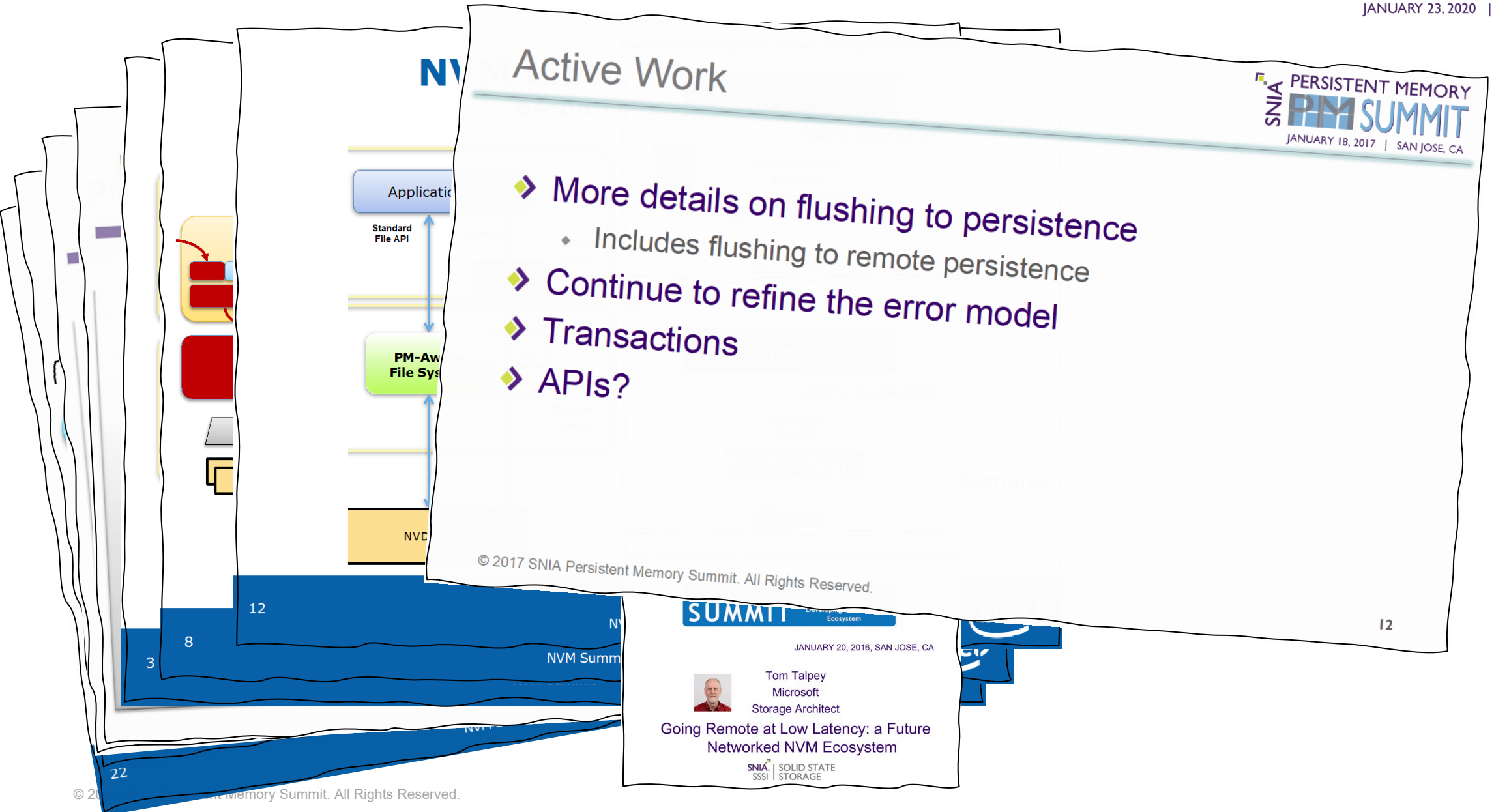
NVM Summit 2016



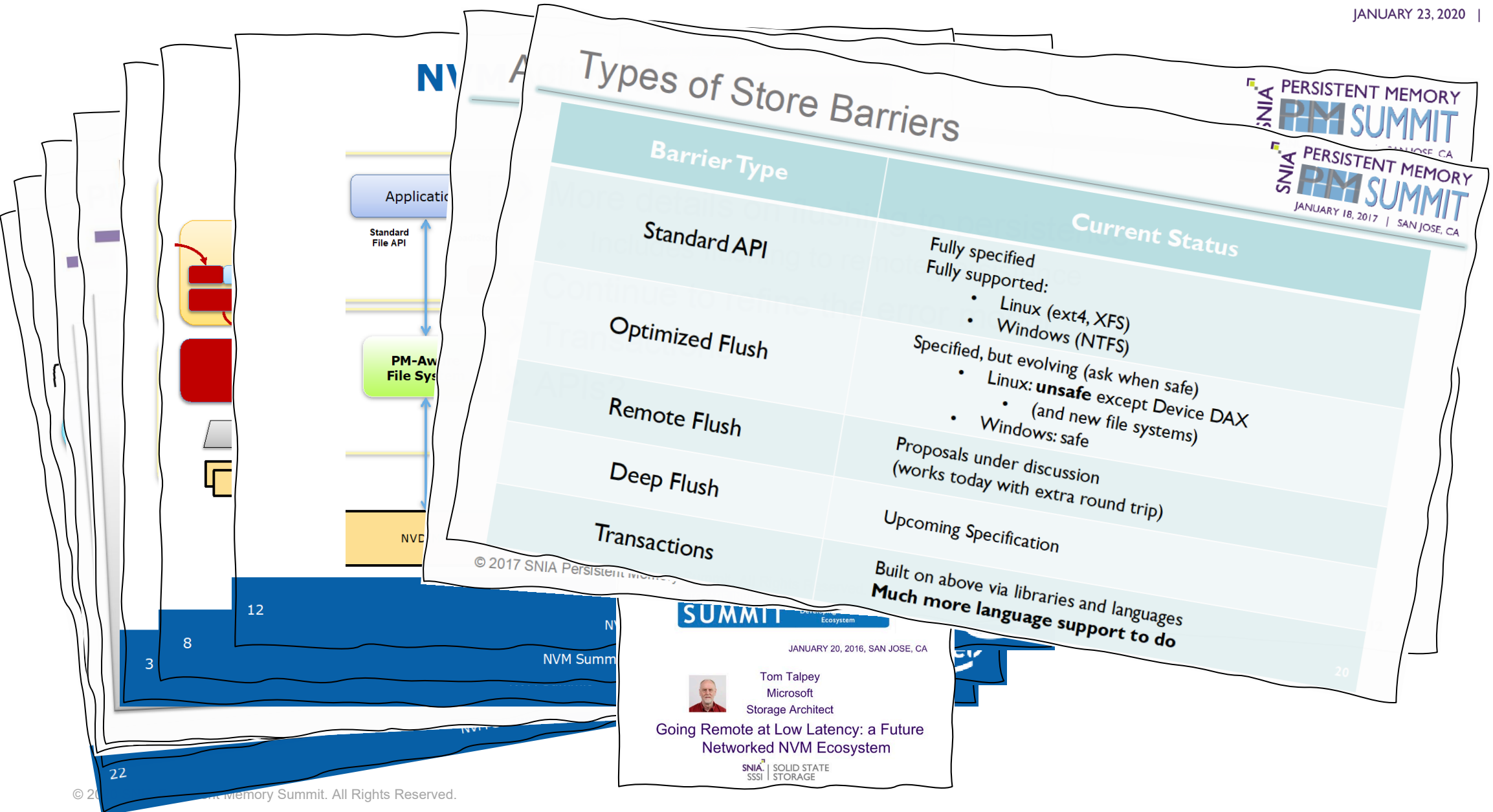
NVM Summit 2017



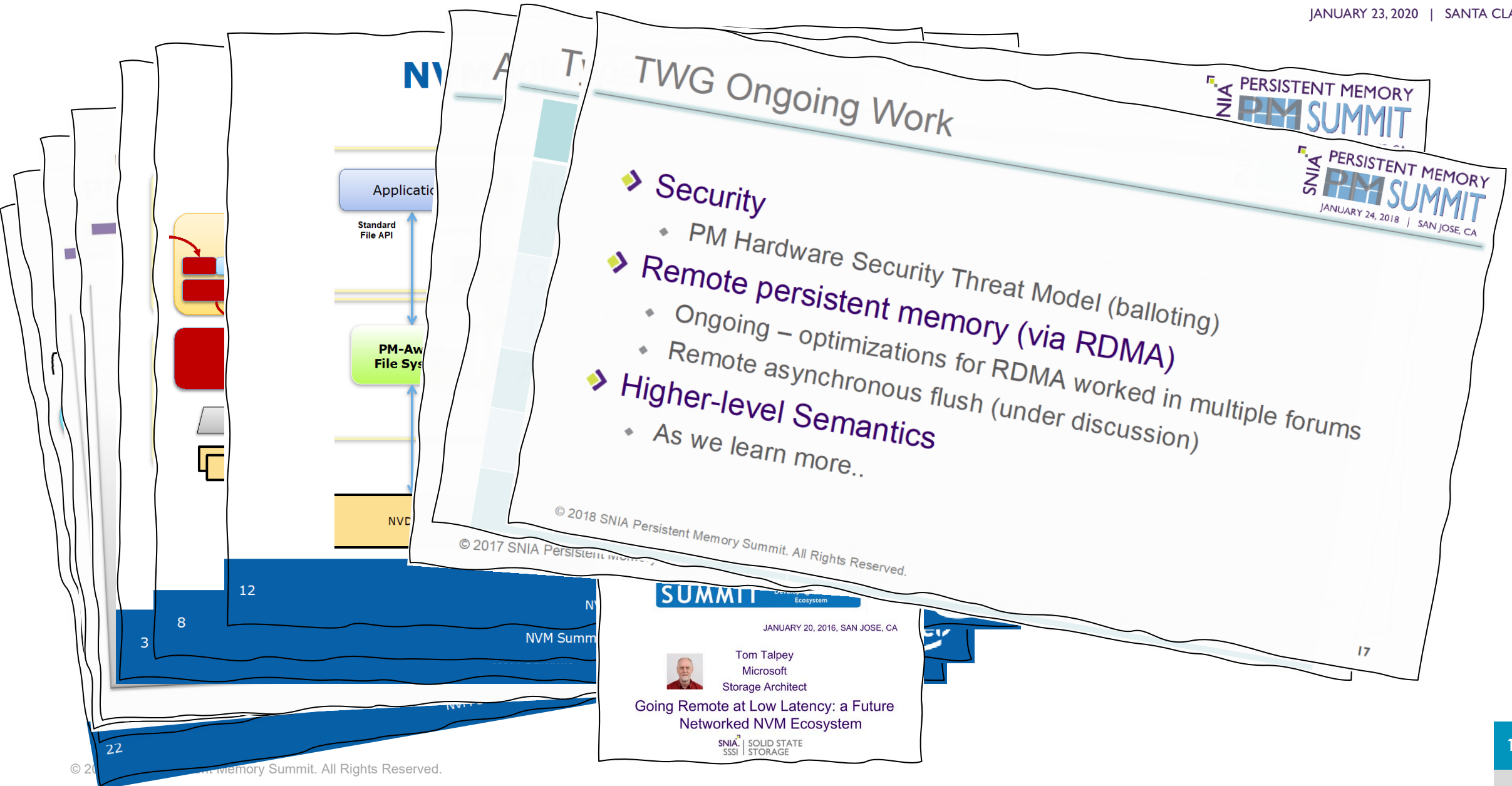
PM Summit 2017



PM Summit 2017

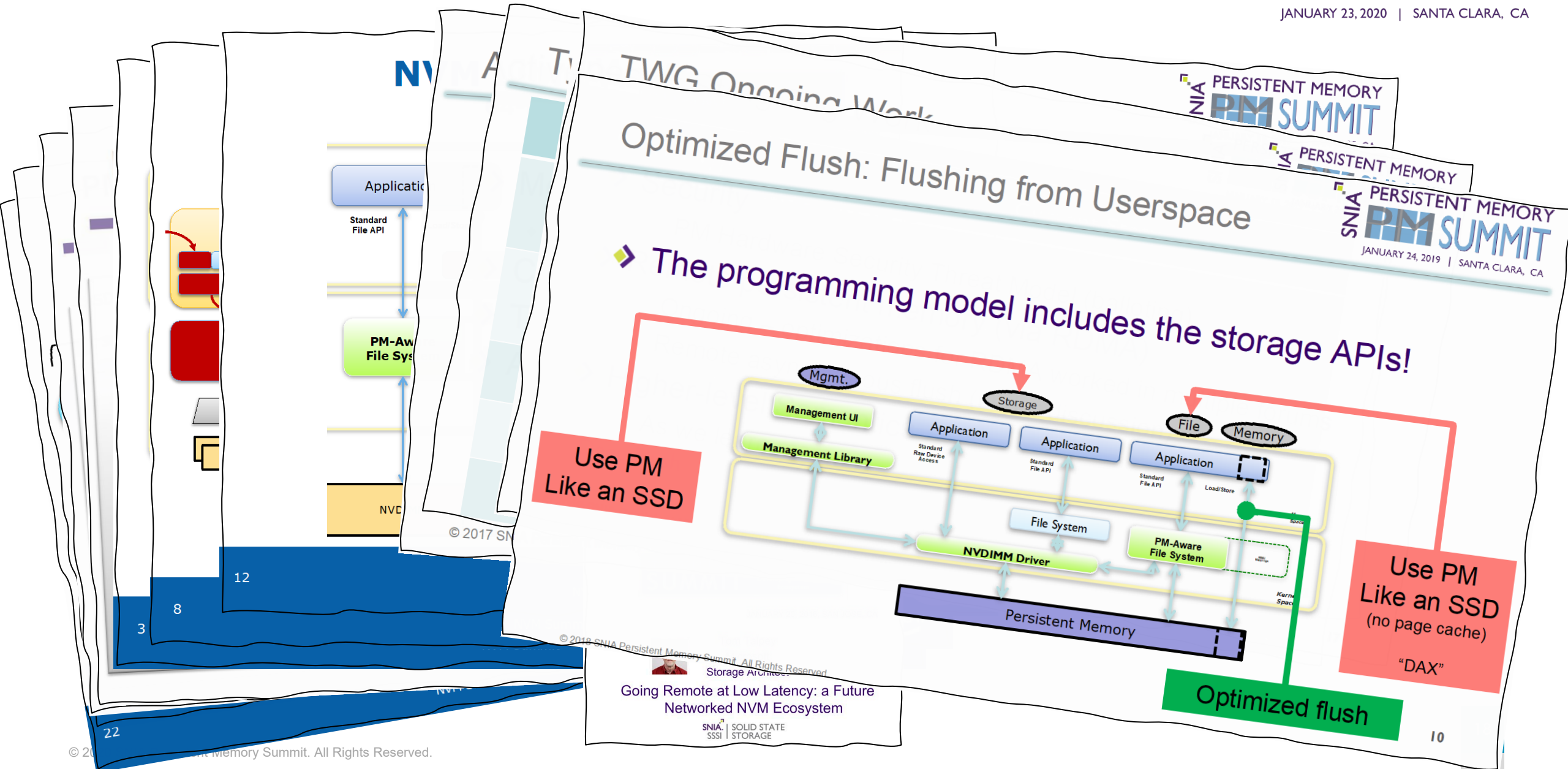


PM Summit 2018

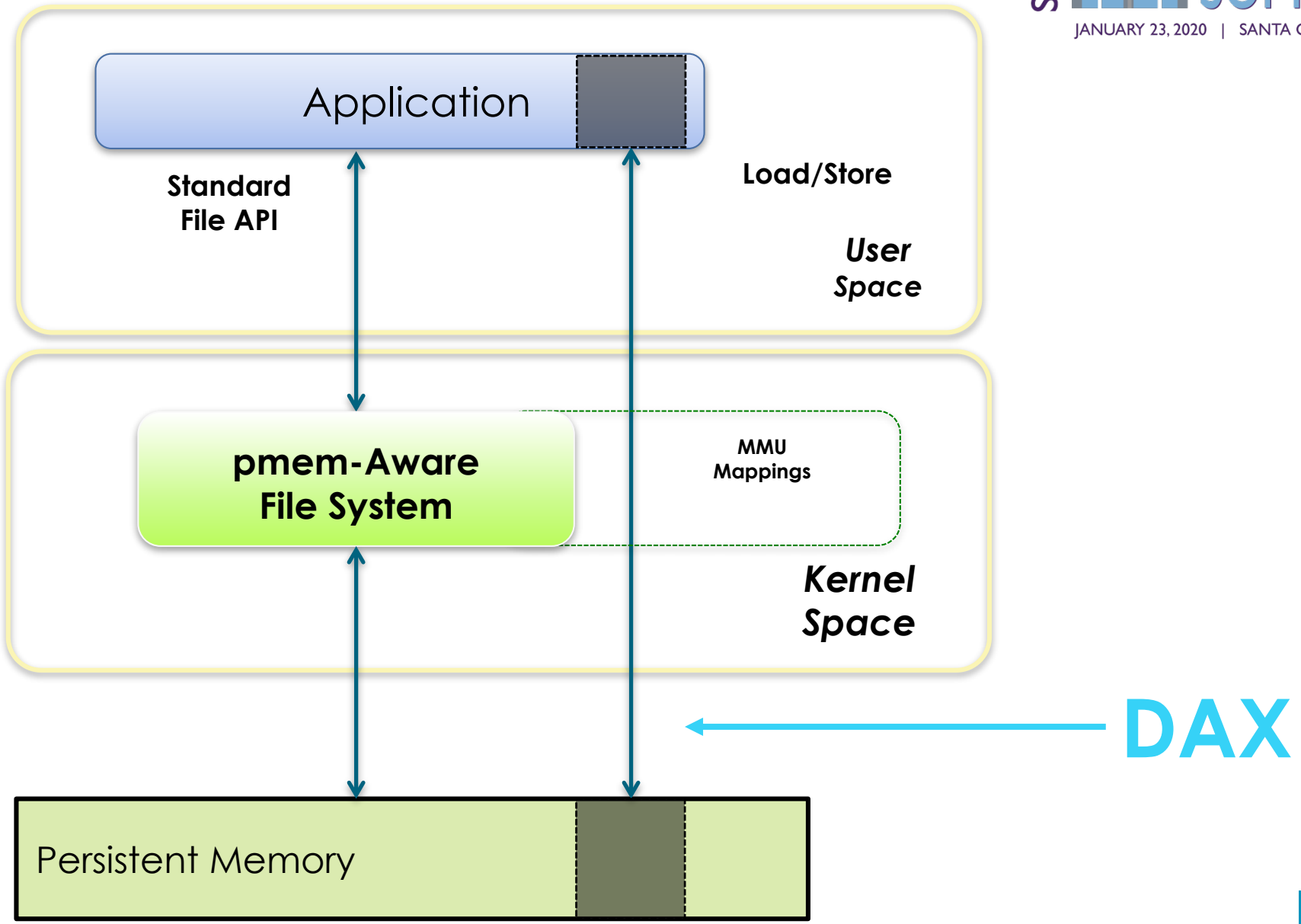


PM Summit 2019

SNIA PERSISTENT MEMORY PM SUMMIT
JANUARY 23, 2020 | SANTA CLARA, CA



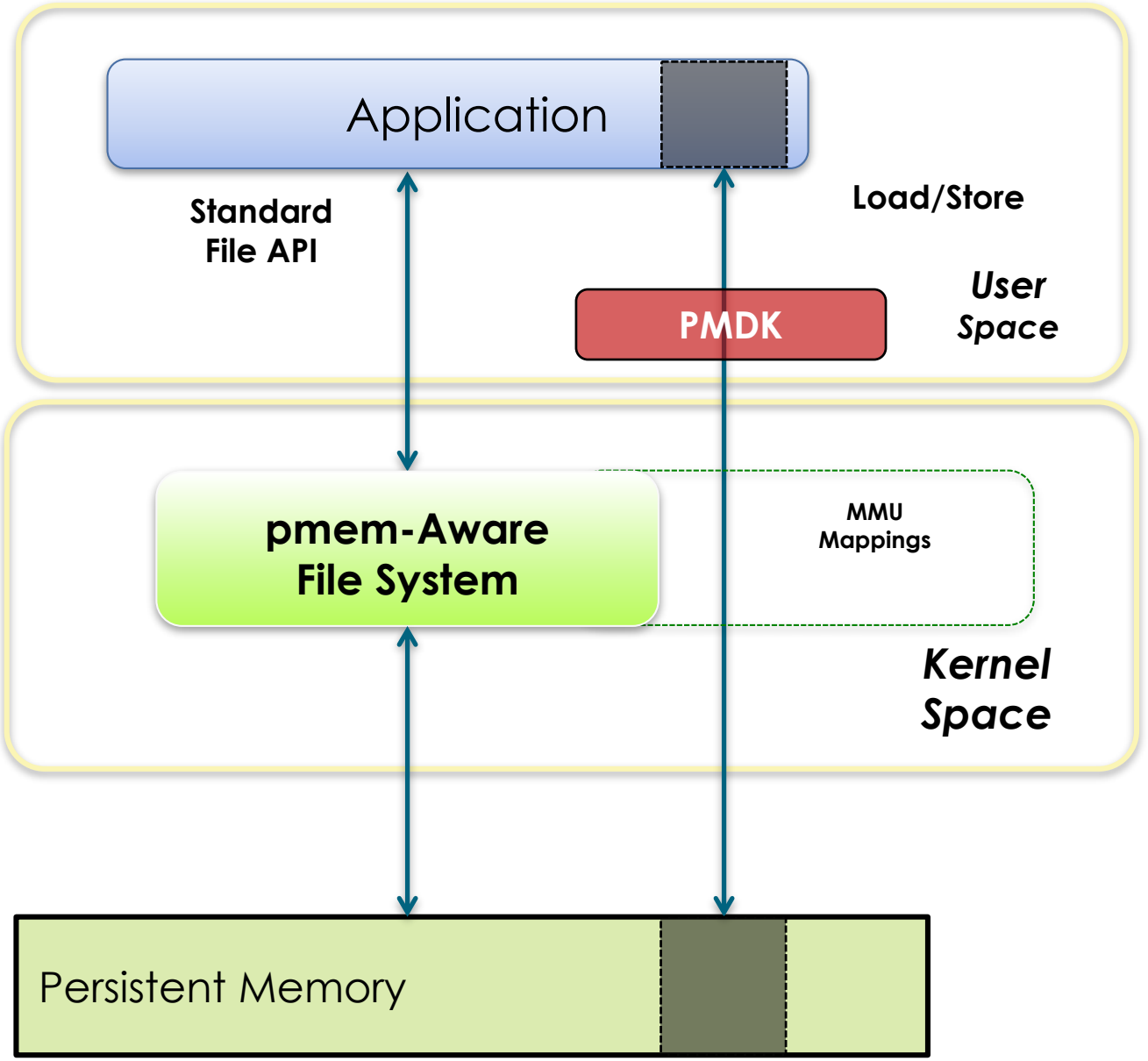
Focus of Many Talks Today



Where the Model Worked

Hard Earned Successes

Building on the Model



PMDK

PCJ – Persistent Collection for Java

C++ | C | PCJ/ LLPL | Python

pmemkv

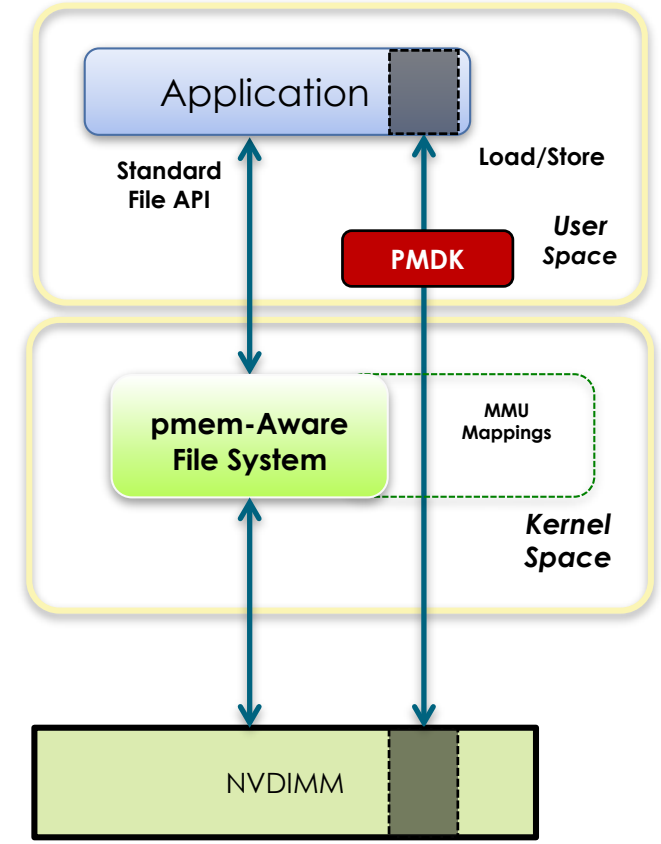
C | C++ | Java | JS | Ruby

Transaction Support

Interface to create a persistent memory resident log file — **libpmemlog**

Interface for persistent memory allocation, transactions and general facilities — **libpmemobj**

Interface to create arrays of pmem-resident blocks, of same size, atomically updated — **libpmemblk**



Support for **volatile** memory usage

memkind

vmemcache

Low level support for local persistent memory — **libpmem**

Low level support for remote access to persistent memory — **librpmem**

Low-level support

In Development

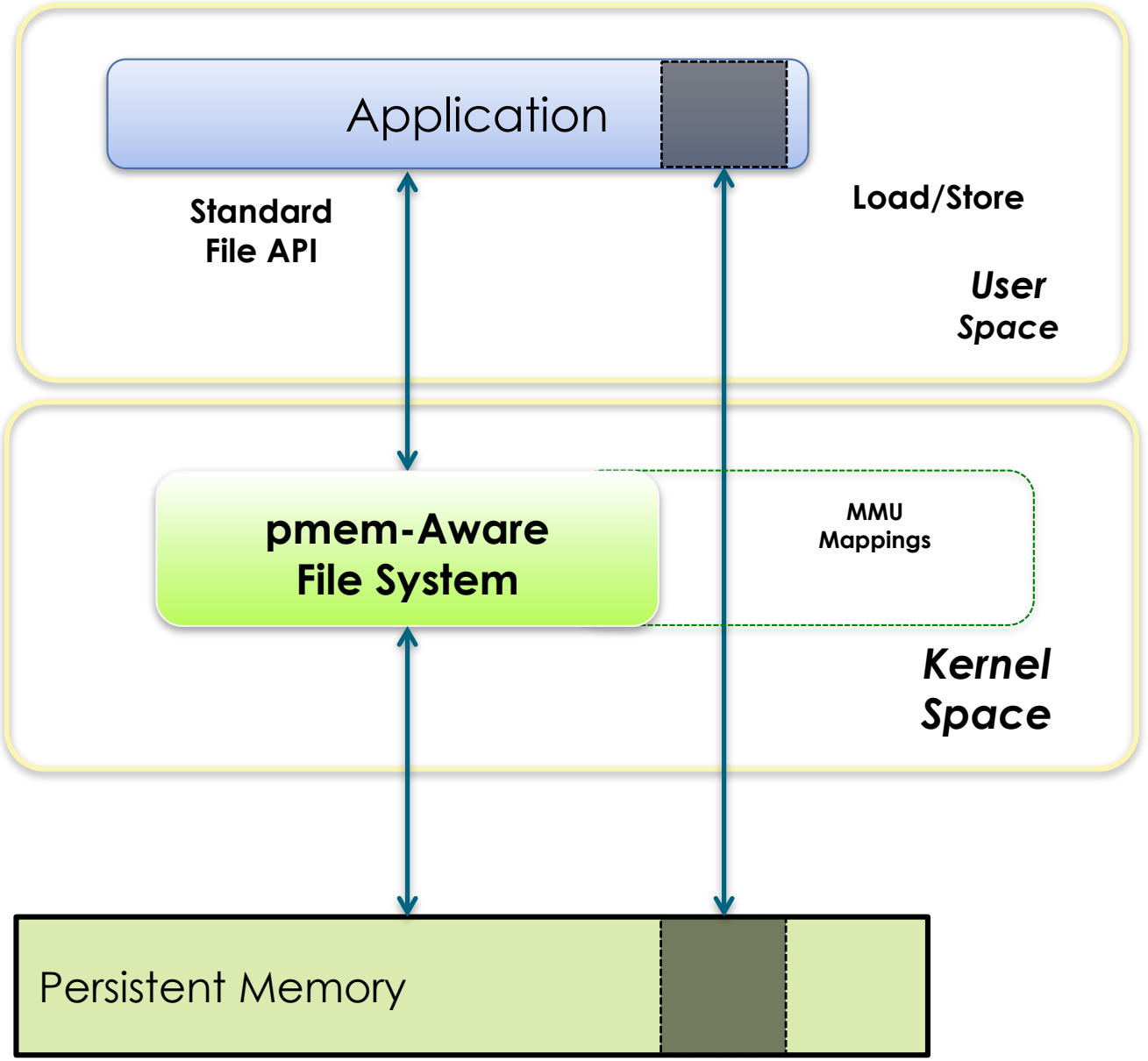
2019 – A Very Exciting Year!

- Intel launches Optane DC Persistent Memory
  - Joining multiple NVDIMM-N products in the ecosystem
- Multiple major products move beyond *demo* to *shipping*
  - More on this later today
- Number of use cases and SW enablement efforts explodes
  - More on this later today
  - Even includes some start-ups
- Academic activity continues to grow at a steady pace
  - Just two papers of note when our timeline started
  - Now I've lost count on how many pmem-related papers are out there

Where the Model Fell Short

Learning from the Ecosystem

The File System



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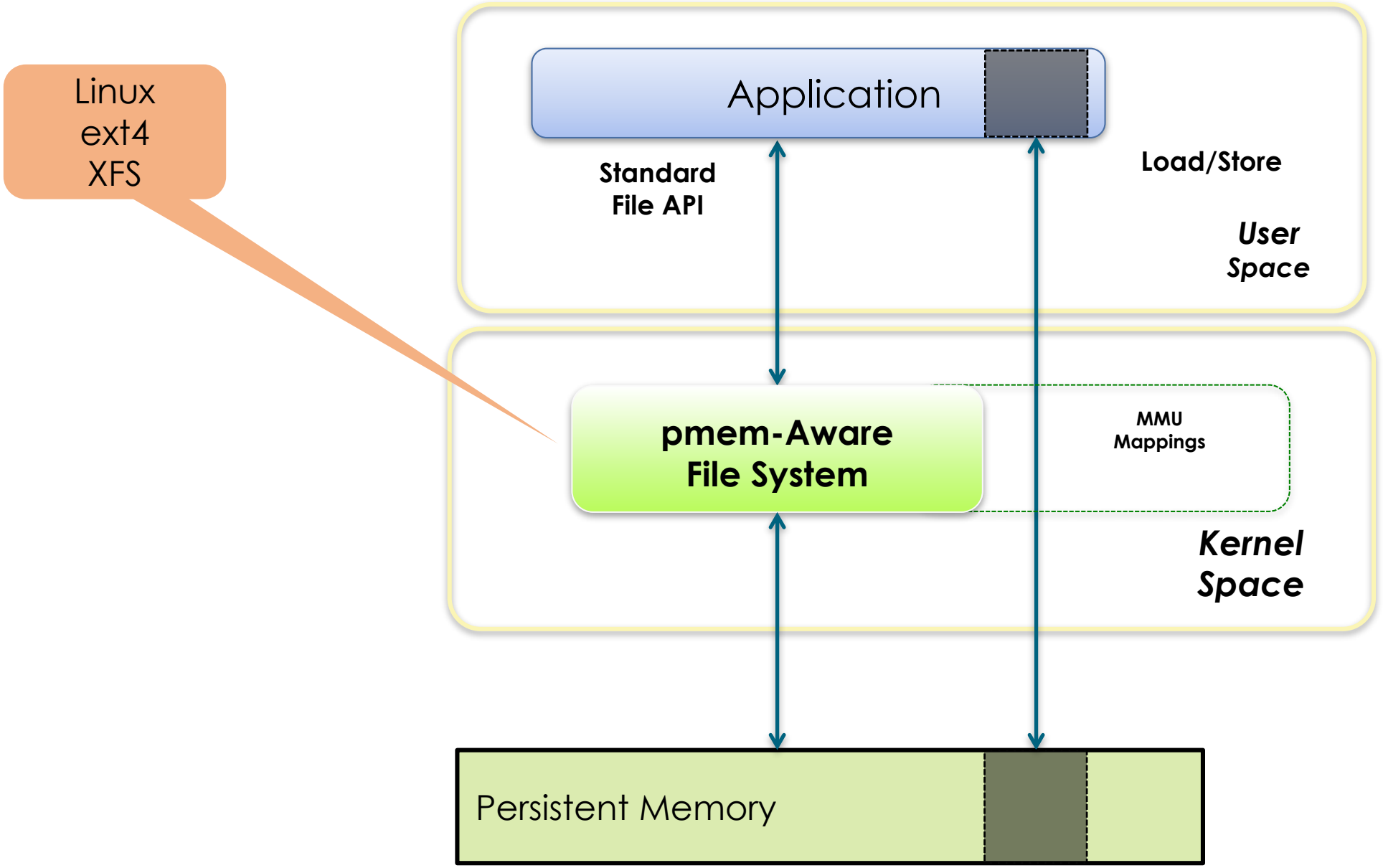

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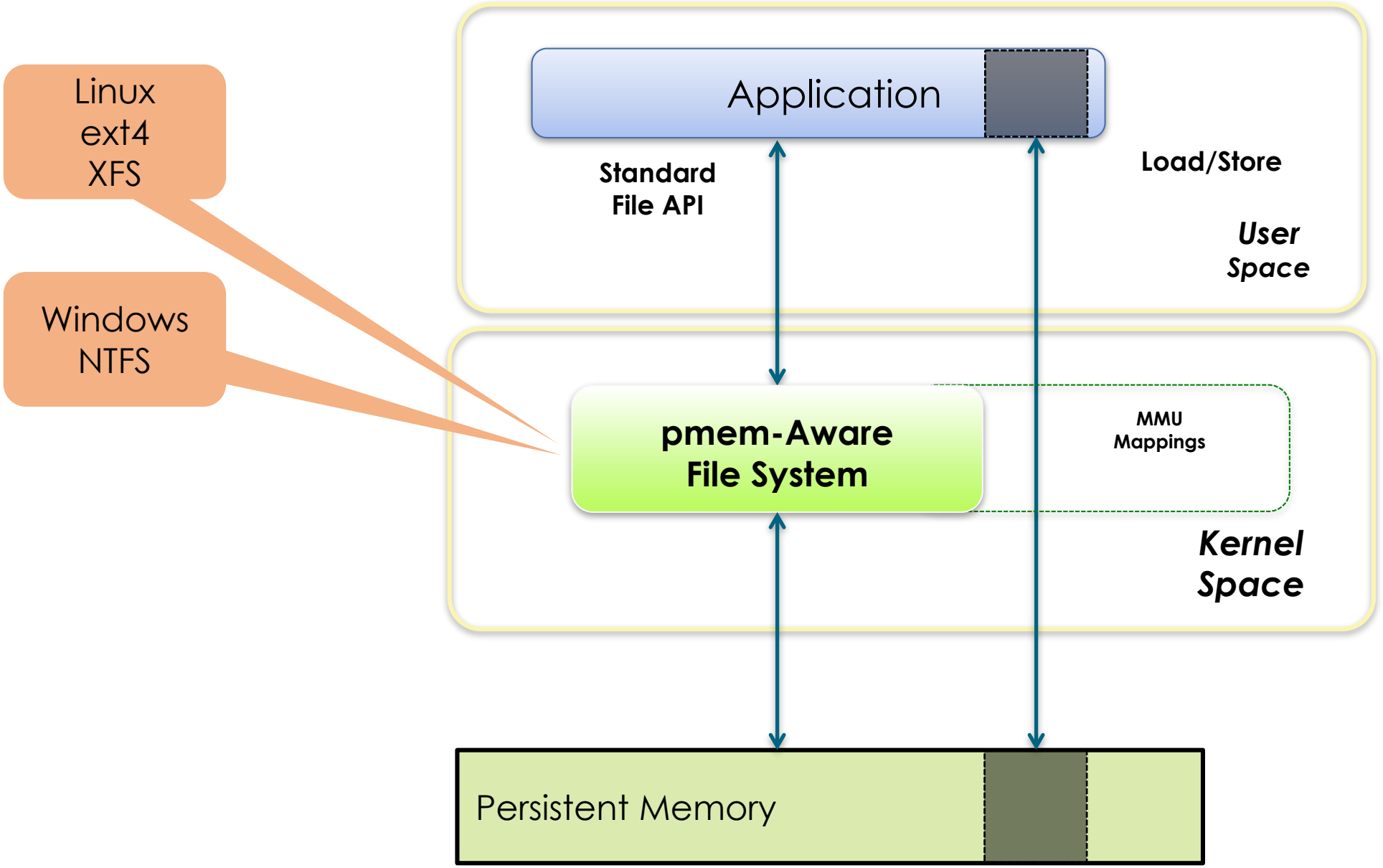

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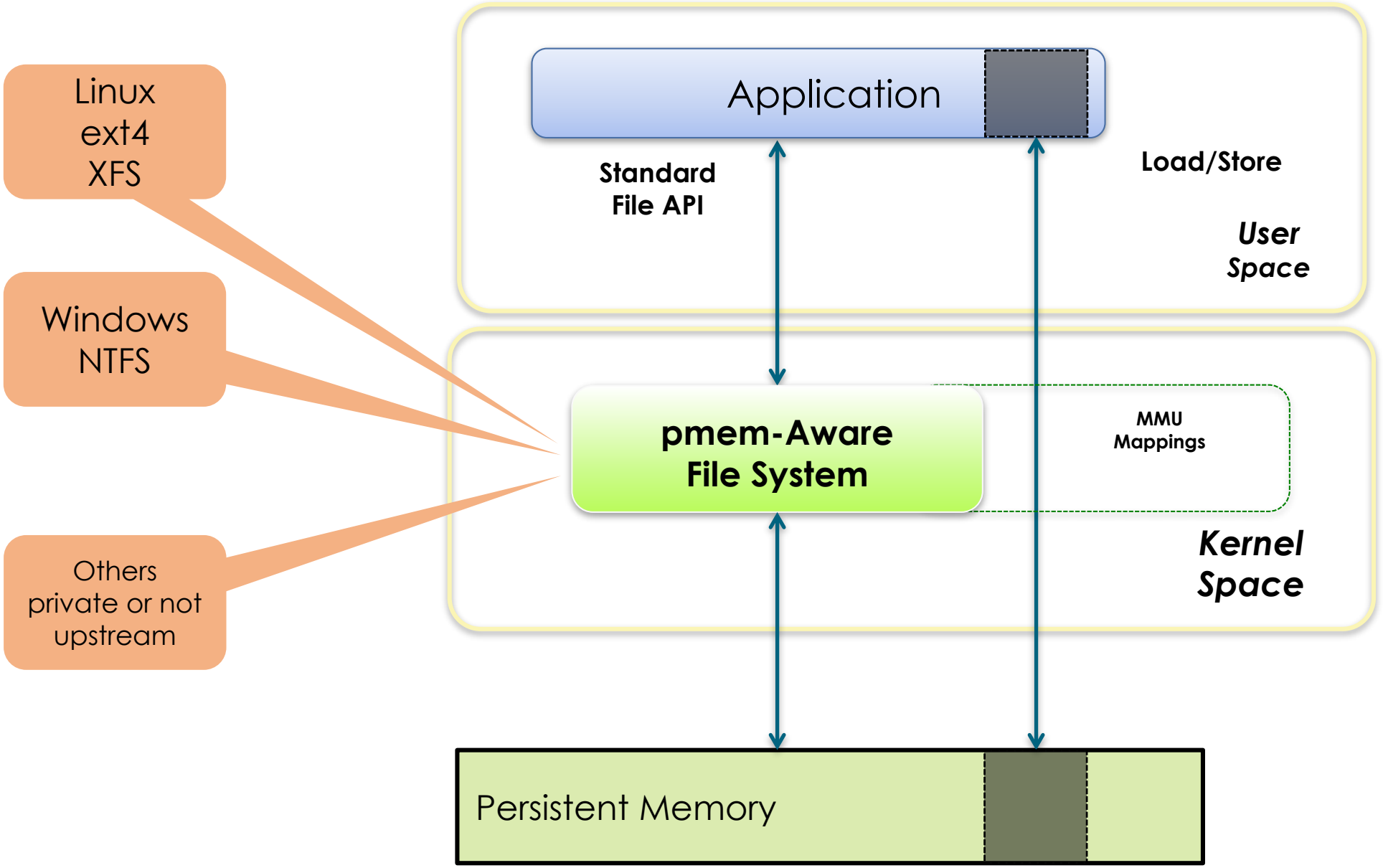

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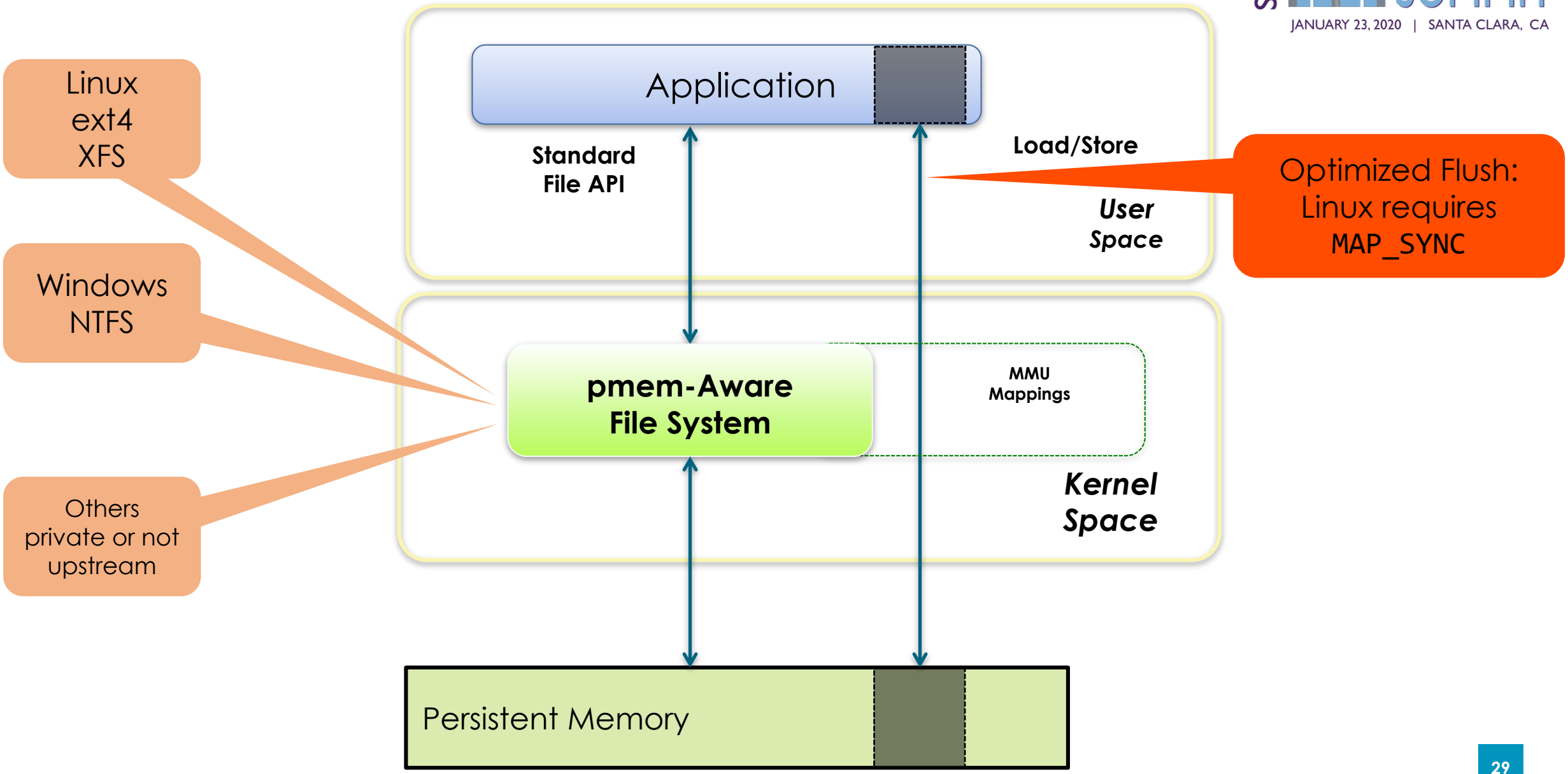

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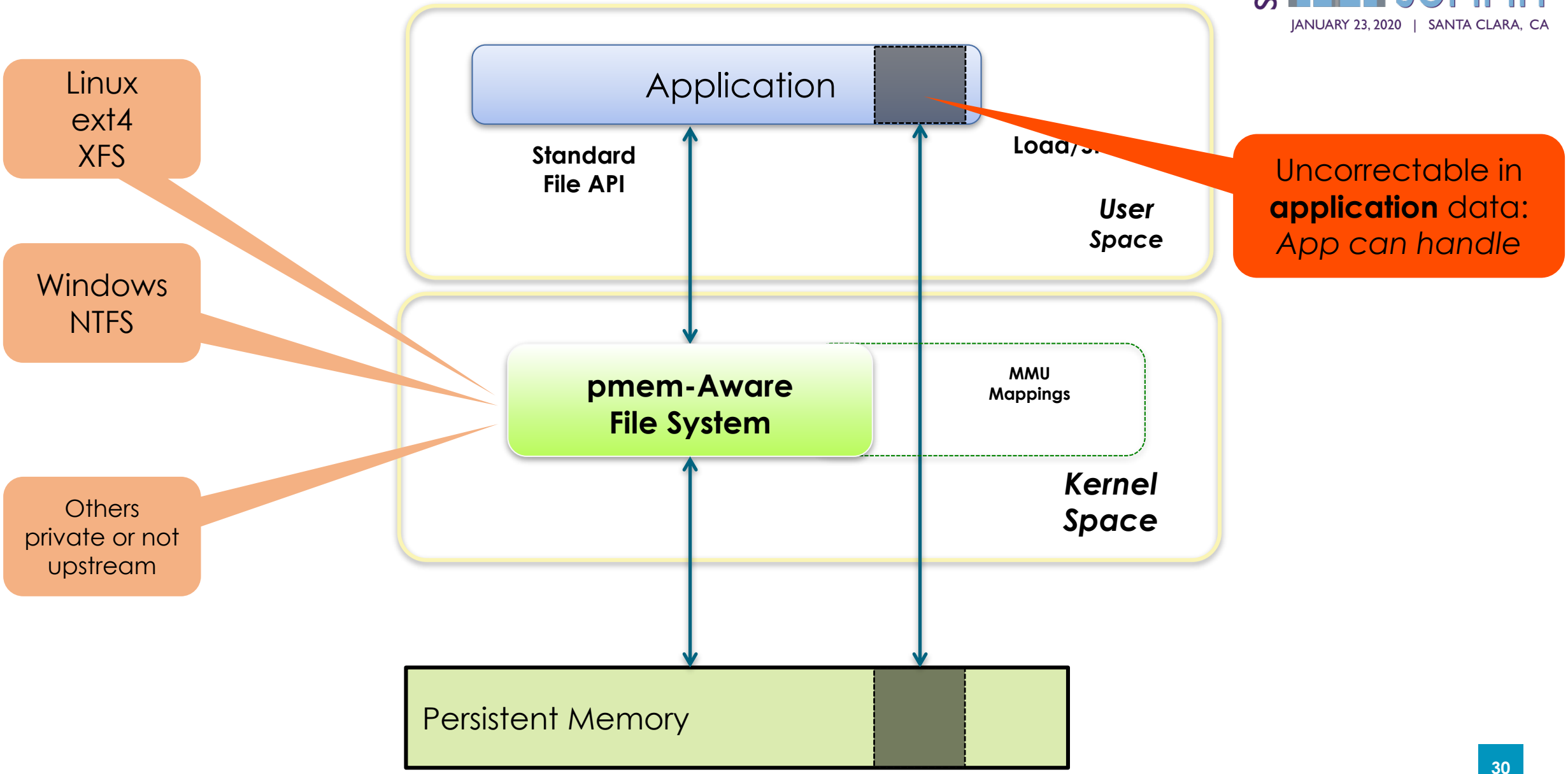

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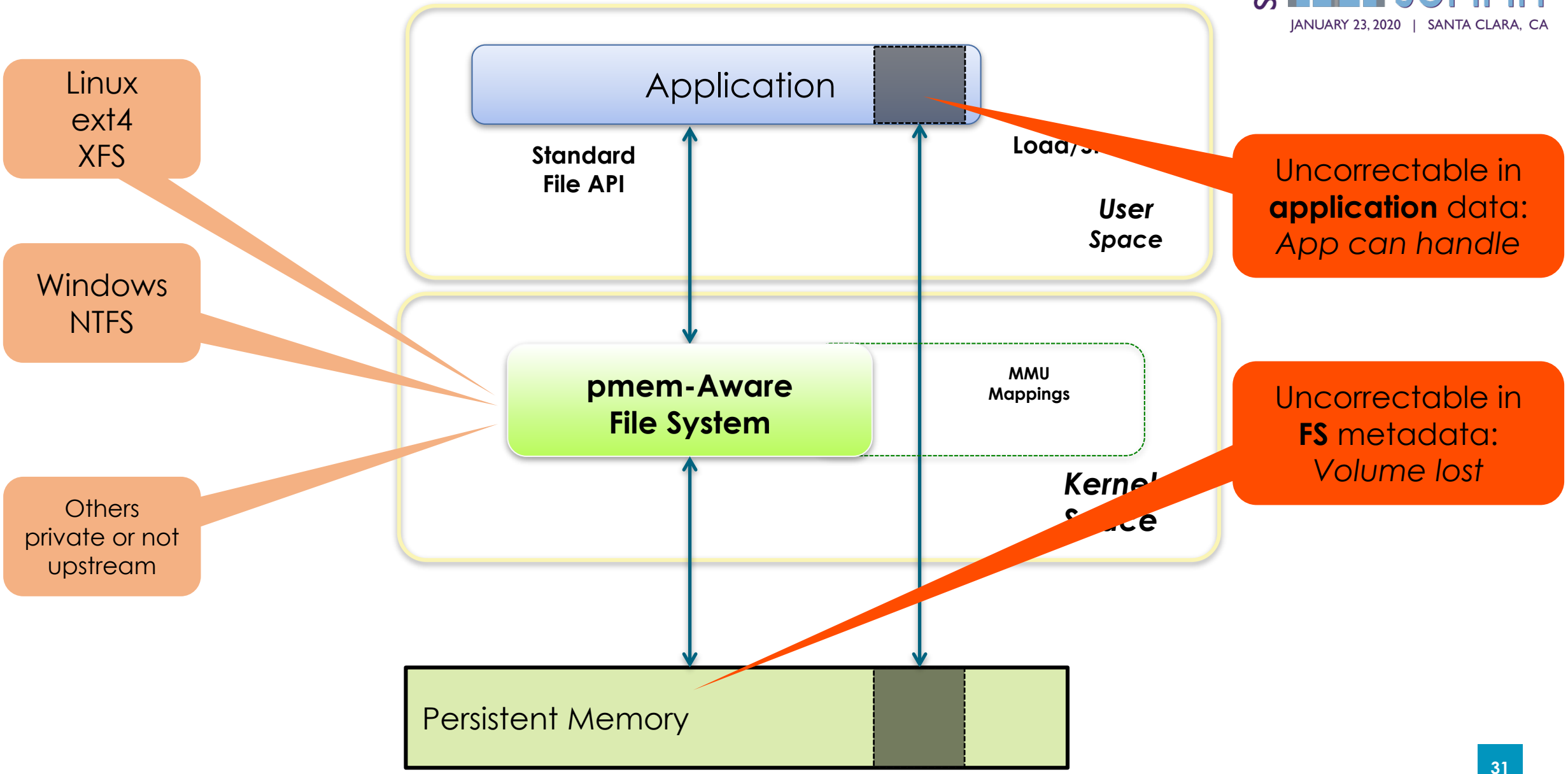

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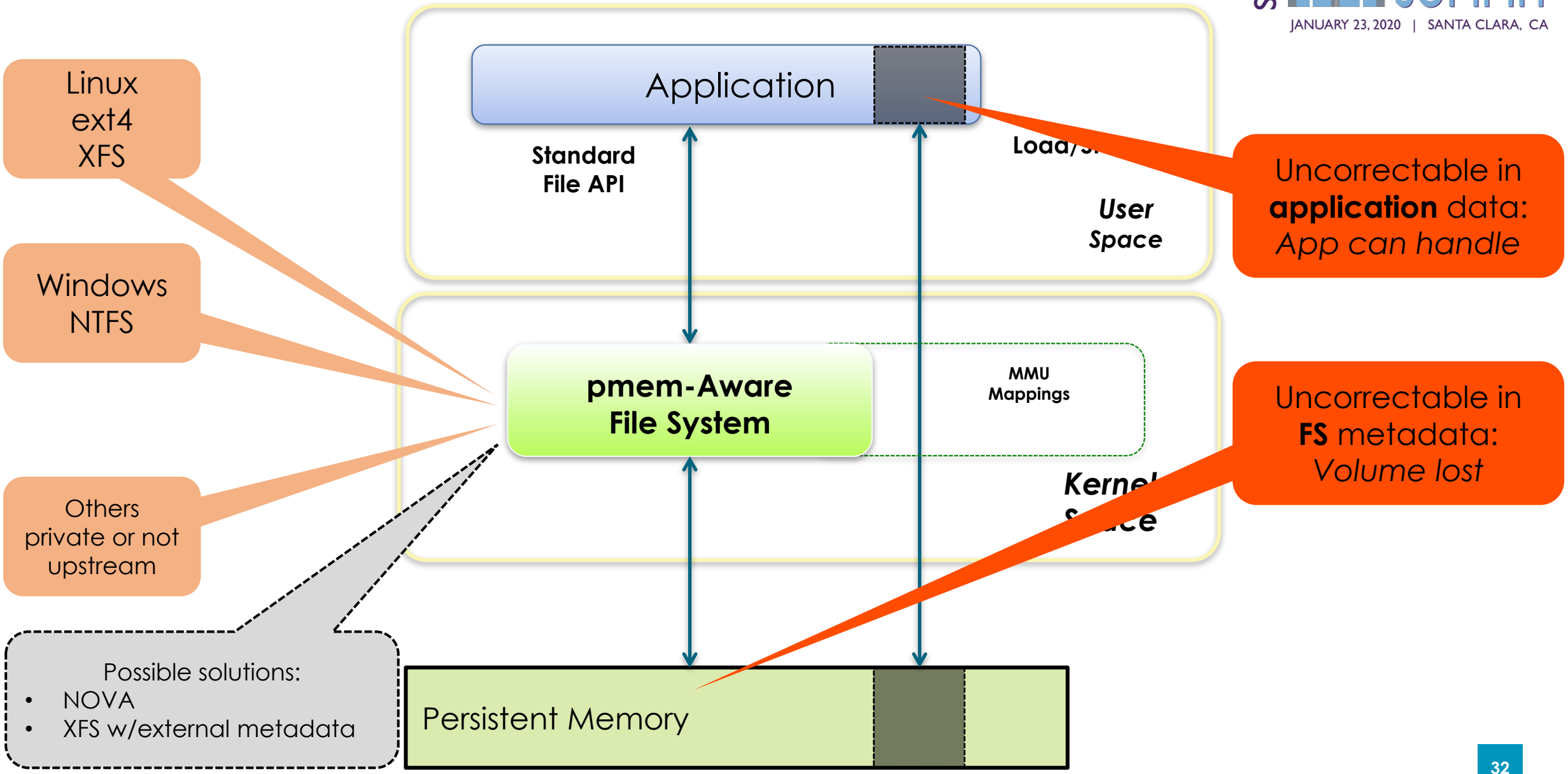
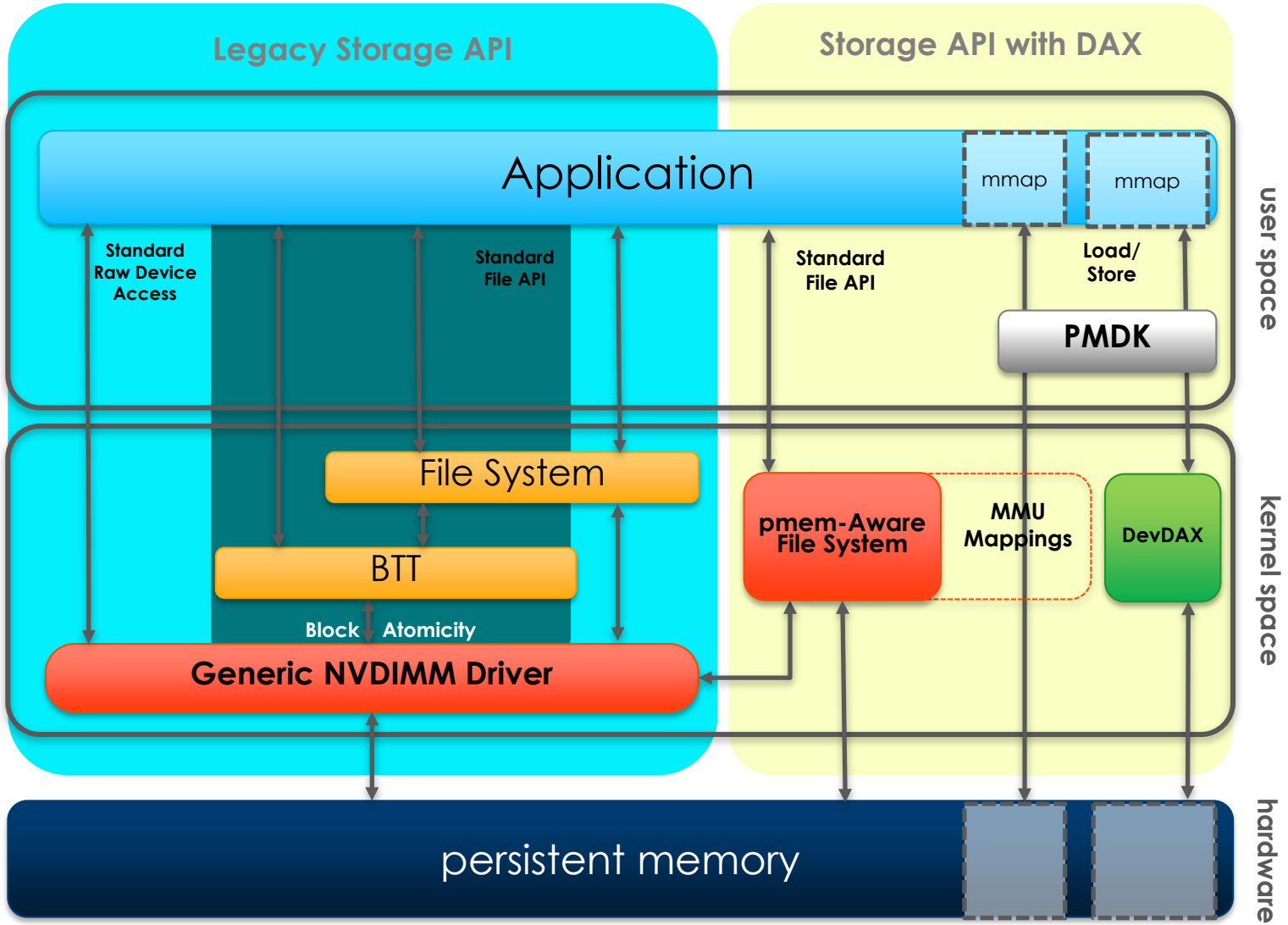


Device DAX on Linux



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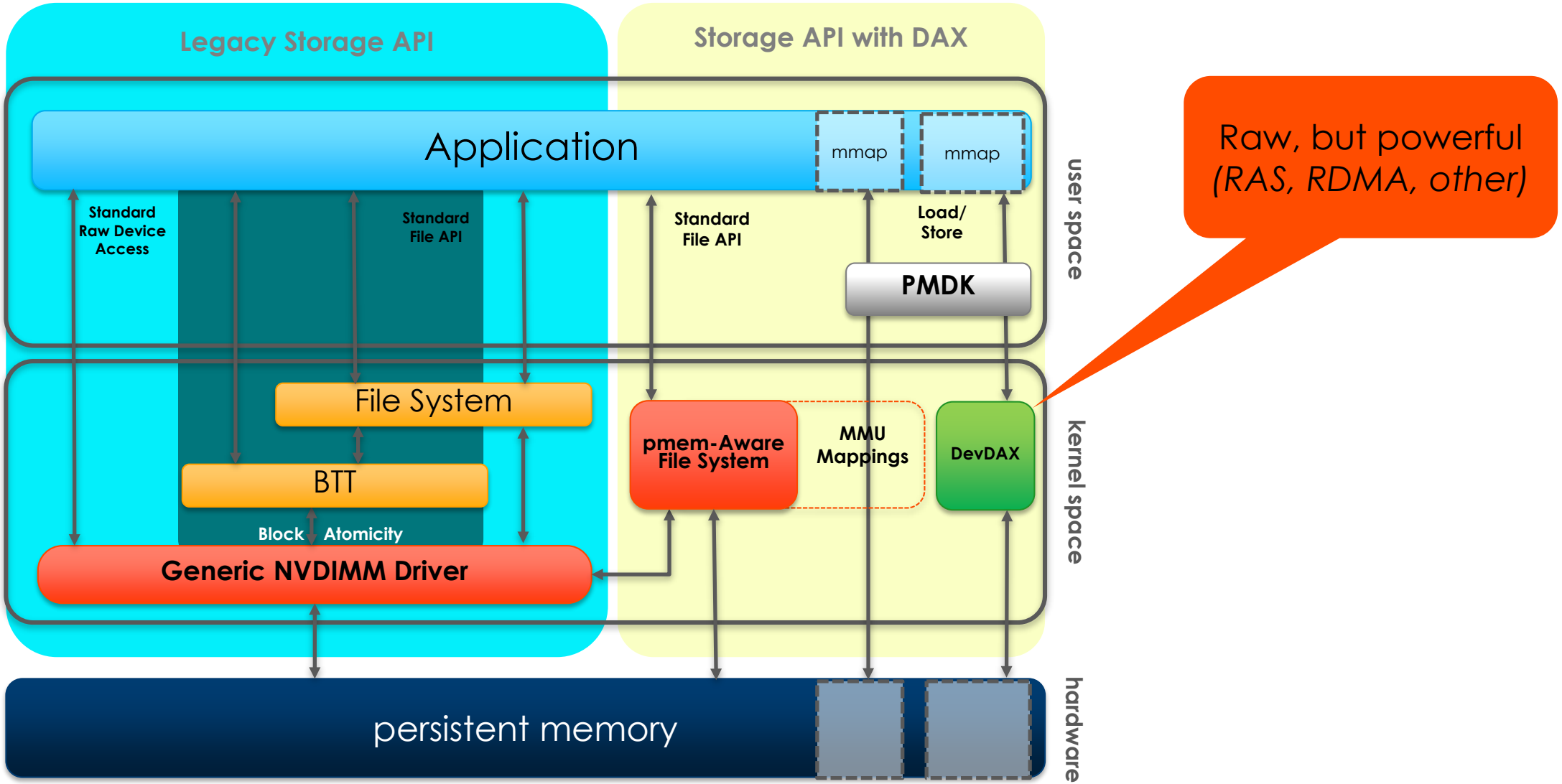

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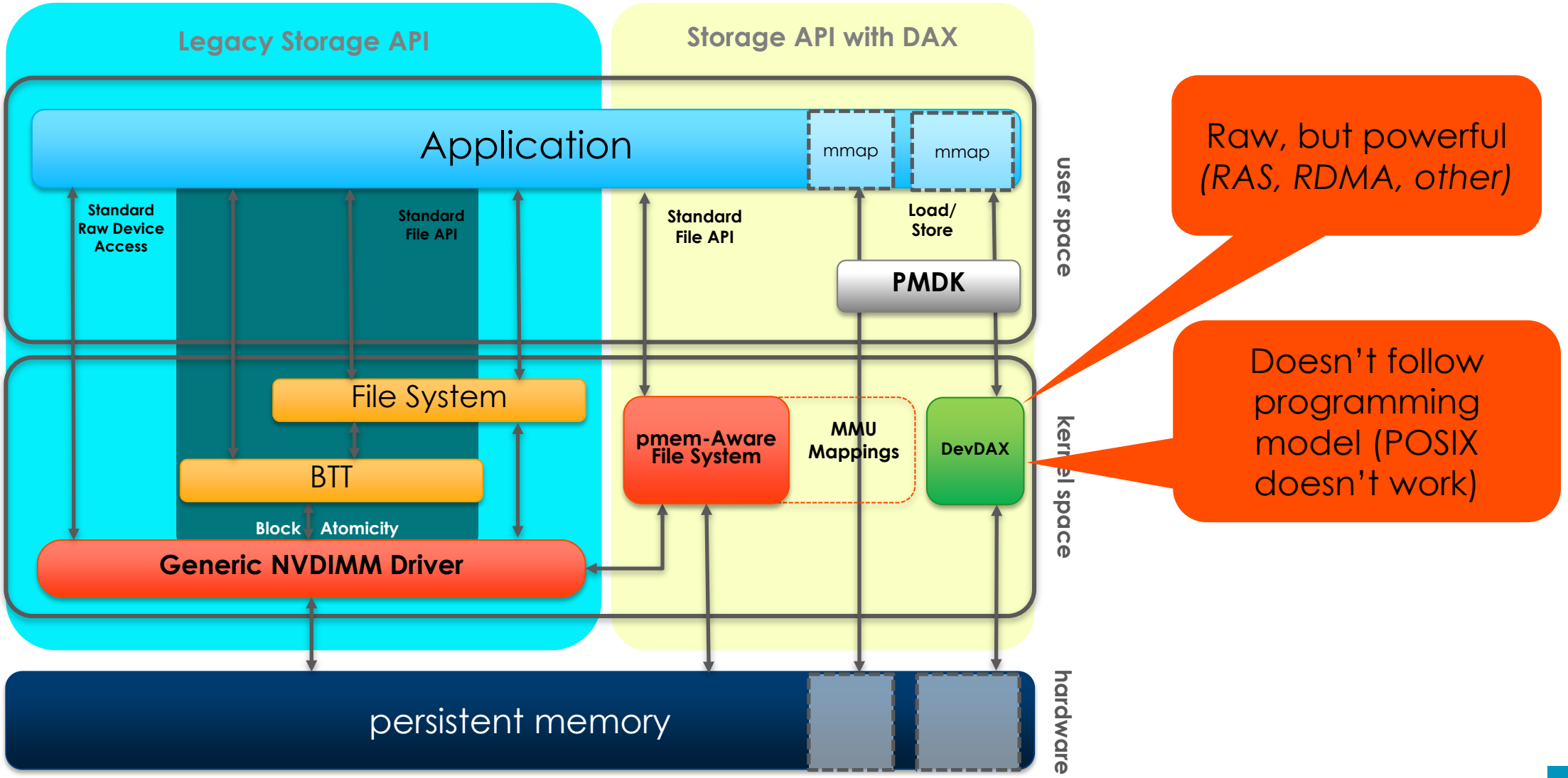

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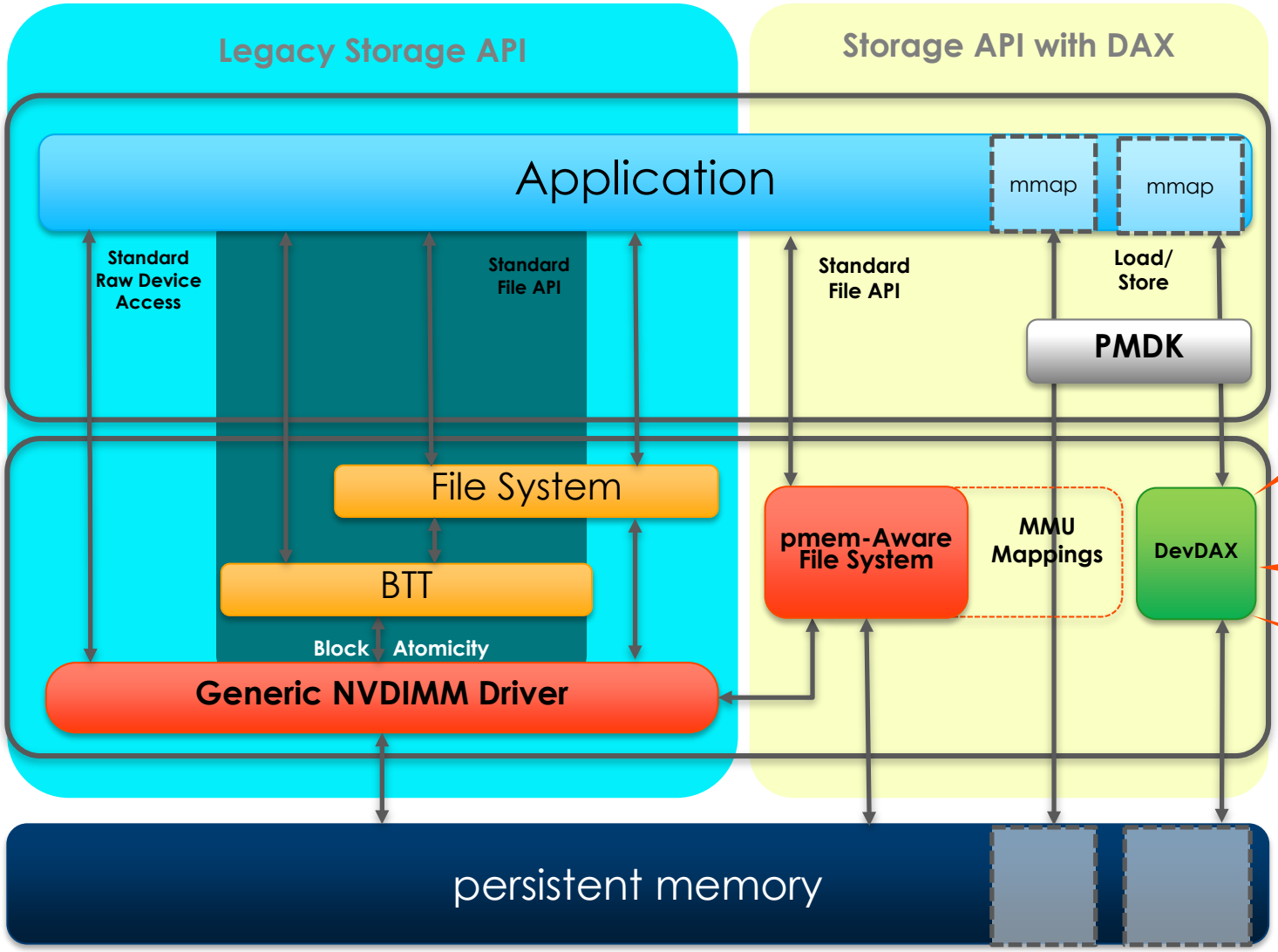


Raw, but powerful *(RAS, RDMA, other)*

Doesn't follow programming model (POSIX doesn't work)

The fact Linux invented it shows the model fell short

Ongoing Work

2020 and beyond

The NVM Programming TWG…

- Should probably be called the *PM Programming TWG* now
- Continues to meet, although lower frequency
- Still heavy interest in remote persistent memory (rpmem)
- Still interest in resyncing with ecosystem
  - Publishing a 2.0 PM Programming Specification

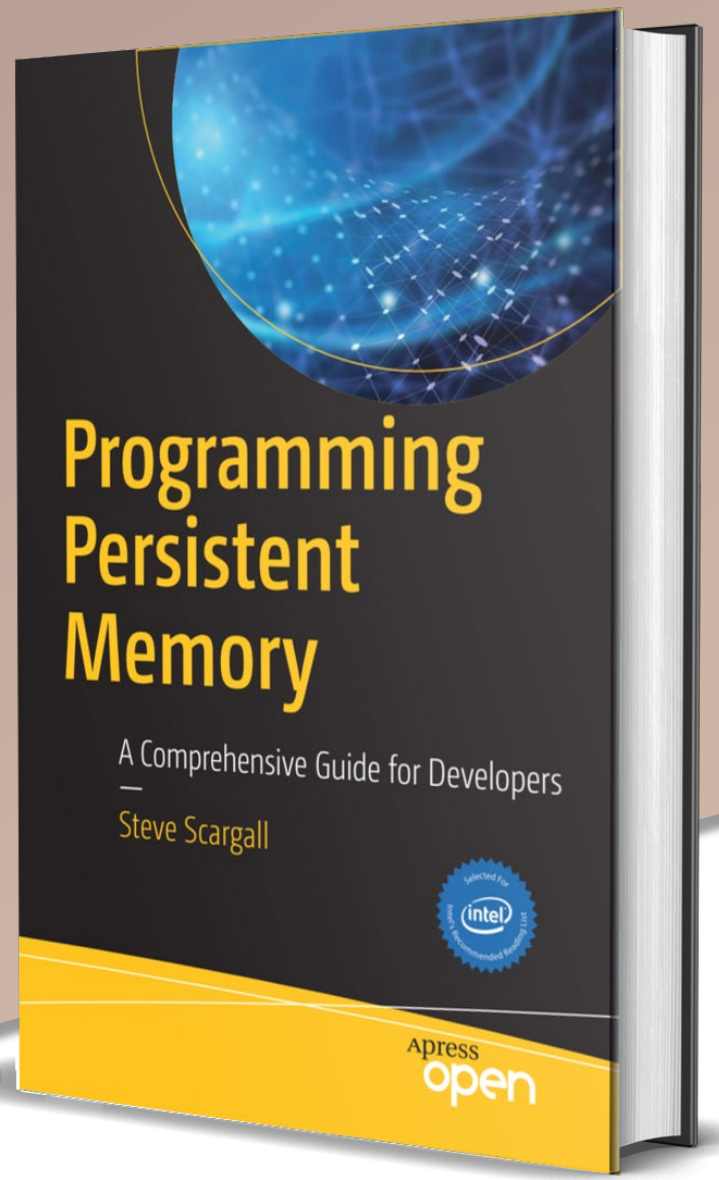
Thank you

Please visit www.snia.org/pmsummit for presentations

Master Persistent Memory Programming

Are you ready to begin?

Start Reading



https://www.apress.com/us/book/9781484249314