INTRODUCTION TO PERSISTENT MEMORY PROGRAMMING

April 17, 2019

Contributors: Intel PMDK Team

https://github.com/pmemhackathon/2019-04-17

AGENDA

- Workshop Goals

- How to log in to your VM

- Persistent Memory Platform Support

- Get Started with Persistent Memory Programming

  - An application's responsibilities when using pmem

  - Installing libraries to help

All Slides are in the GitHub Repo:
https://github.com/pmemhackathon/2019-04-17

WORKSHOP GOALS

- Show how to get started with persistent Memory programming

    – All shell commands for the workshop are in Readme.txt

- We'll walk through some for everyone, then will walk around & help you

    – Focus on fsdax

- After installing samples, try them out, or write your own

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CONNECT TO YOUR SESSION

- Login

  - ssh -p 31005 pmdkuser<x>@devhost.pmemhackathon.io

- Persistent Memory Access

  - Each user has a directory, under /mnt/pmem-fsdax0/pmdkuser<x>

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ACCESSING PERSISTENT MEMORY

Persistent Memory Pool(s)	Persistent Memory Pool(s)
DAX Filesystem	DAX Filesystem
/dev/pmem0	/dev/pmem1
Namespace0.0	Namespace1.0
Region 0 (756GiB)	Region 1 (756GiB)

```
$ pmempool create /mnt/pmem-fsdax0/pool0
$ pmempool create /mnt/pmem-fsdax1/pool1


# mkfs.ext4 /dev/pmem0
# mkfs.ext4 /dev/pmem1
# mount -o dax /dev/pmem0 /mnt/pmem-fsdax0
# mount -o dax /dev/pmem1 /mnt/pmem-fsdax1



# ndctl create-namespace
# ndctl create-namespace
```

Vendor Neutral

```
# ipmctl create -goal PersistentMemoryType=AppDirect
```

Vendor Specific

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VERIFY YOUR SYSTEM SUPPORTS PERSISTENT MEMORY

- Uname –a
  - Look for kernel version > 4.19

- Ipmctl
  - show –topology; show -memoryresources

- ndctl list –RuN
  - Shows regions, namespaces in human readable format

- Linux kernel version 4.19 (ext4, xfs)
- Windows Server 2019 (NTFS)
- VMware vSphere 6.7
- RHEL 7.5
- SLES 15 and SLES 12 SP4
- Ubuntu 18.*
- Java JDK 12
- Kubernetes 1.13
- OpenStack 'Stein'
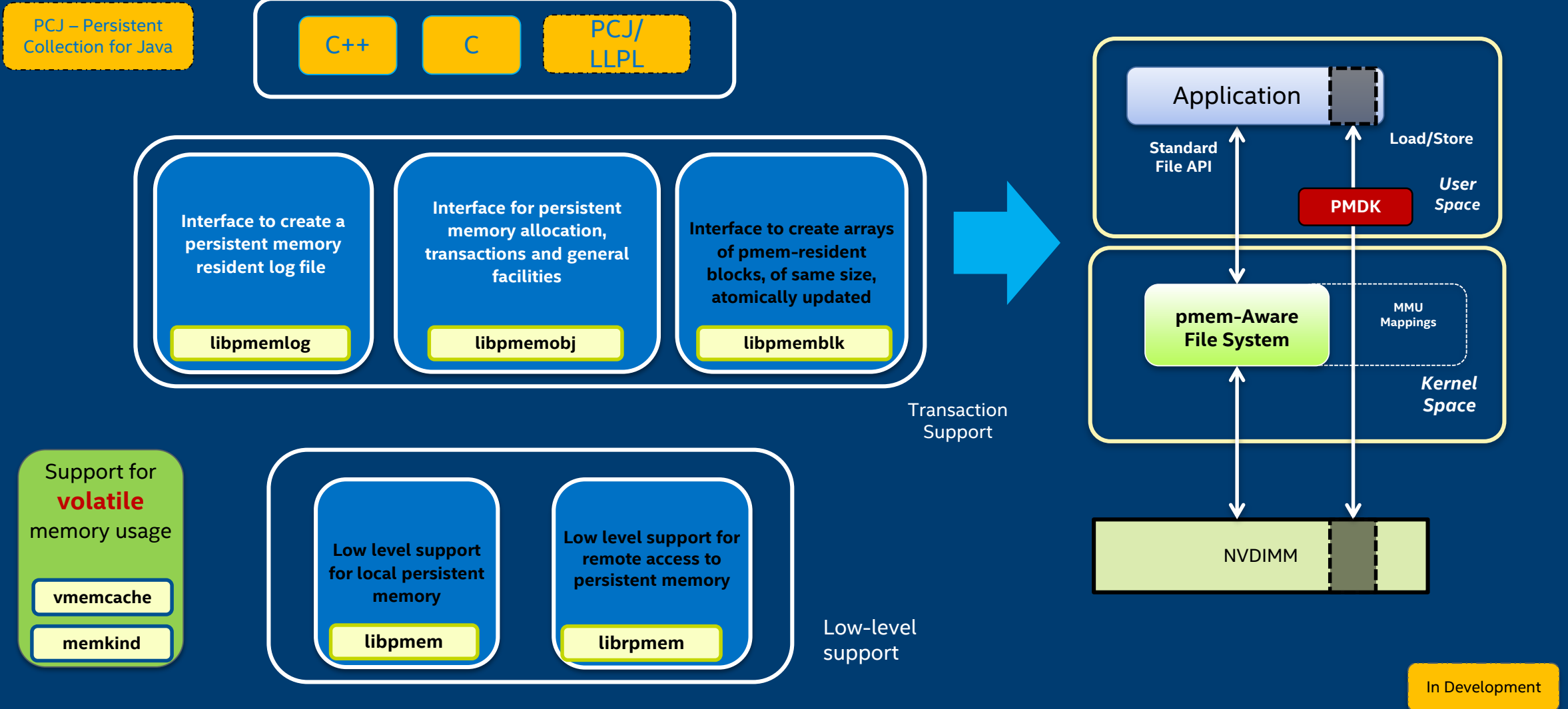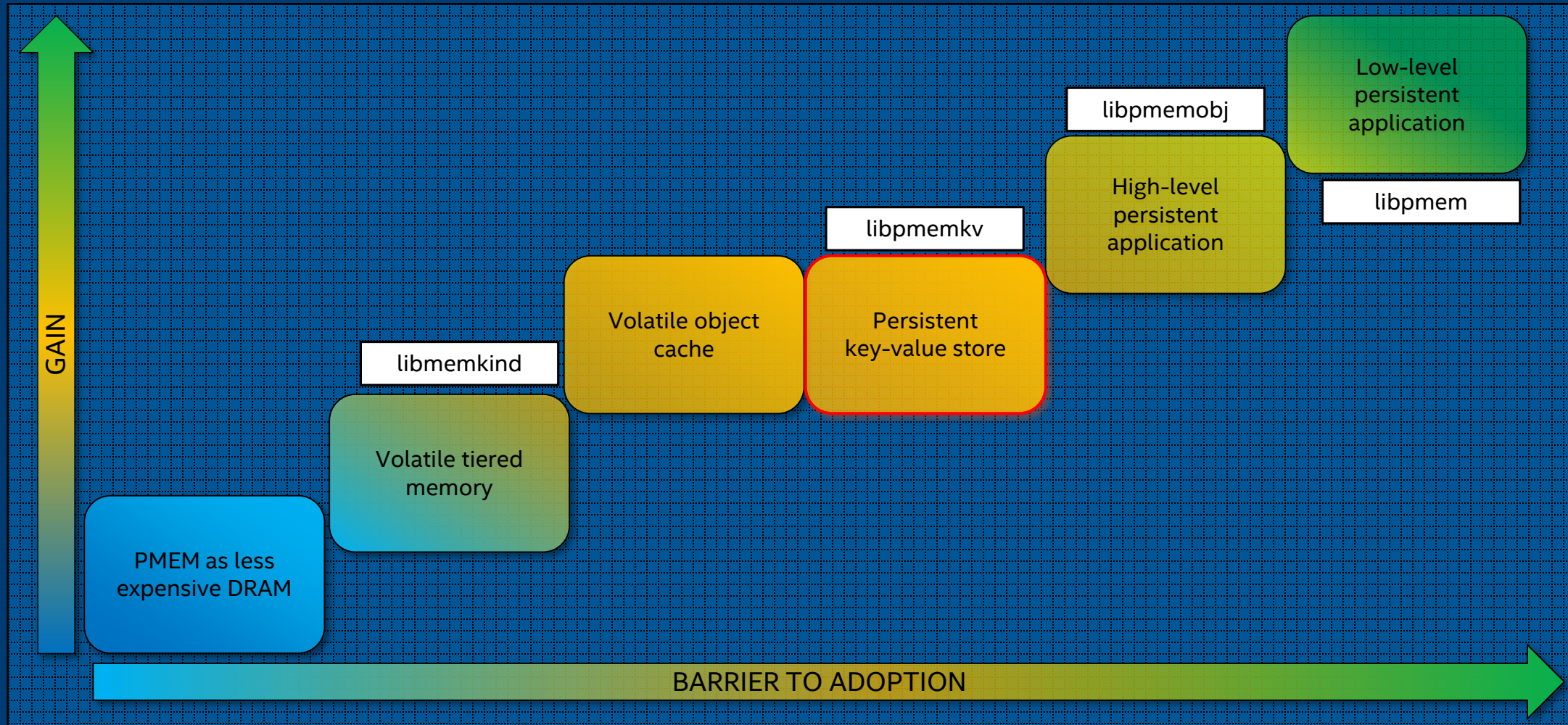
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ENABLING IN THE ECOSYSTEM

- Linux kernel version 4.19 (ext4, xfs)
- Windows Server 2019 (NTFS)
- VMware vSphere 6.7
- RHEL 7.5
- SLES 15 and SLES 12 SP4
- Ubuntu 18.*
- Java JDK 12
- Kubernetes 1.13
- OpenStack 'Stein'

Be sure to see Steve Scargall's talk: Persistent Memory Provisioning/Configuration tools

PERSISTENT MEMORY DEVELOPMENT KIT

PCJ – Persistent Collection for Java

C++

C

PCJ/ LLPL

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

Transaction Support

Support for **volatile** memory usage

vmemcache

memkind

Low level support for local persistent memory

libpmem

Low level support for remote access to persistent memory

librpmem

Low-level support

Application

Standard File API

Load/Store

PMDK

User Space

pmem-Aware File System

MMU Mappings

Kernel Space

NVDIMM

In Development

DIFFERENT WAYS TO USE PERSISTENT MEMORY

GAIN

BARRIER TO ADOPTION

Low-level persistent application

libpmemobj

High-level persistent application

libpmem

libpmemkv

Volatile object cache

Persistent key-value store

libmemkind

Volatile tiered memory

PMEM as less expensive DRAM

SPDK, PMDK & Vtune™ Summit

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PROGRAMMING EXAMPLES FOR THIS WORKSHOP

- Key Value Store for Persistent Memory (pmemkv)

- Volatile Use of Persistent Memory (libmemkind)

- Persistence and Transactions (libpmemobj)

PMEMKV: KEY VALUE DATA STORE WITH PERSISENT MEMORY

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LIBMEMKIND: VOLATILE USE OF PERSISTENT MEMORY

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LIBPMEMOBJ: TRANSACTIONS/PERSISTENCE

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INTEL DEVELOPER SUPPORT & TOOLS

PMDK Tools

- Valgrind plugin: pmemcheck

- Debug mode, tracing, pmembench, pmreorder

<div style="background:#1a6bd6;color:#fff">pmem.io</div>

New features to support Intel® Optane™ DC persistent memory

- Intel® VTune™ Amplifier – Performance Analysis

- Intel® Inspector – Persistence Inspector finds missing cache flushes & more

- Free downloads available

<div style="background:#1a6bd6;color:#fff">software.intel.com/pmem</div>

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RESOURCES

PMDK Resources:

- Home: https://pmem.io

- PMDK: https://pmem.io/pmdk

- PMDK Source Code : https://github.com/pmem/PMDK

- Google Group: https://groups.google.com/forum/#!forum/pmem

- Intel Developer Zone: https://software.intel.com/persistent-memory

- Memkind: https://github.com/memkind/memkind (see memkind_pmem(3))

- libpmemkv: https://github.com/pmem/pmemkv

NDCTL: https://pmem.io/ndctl

SNIA NVM Programming Model: https://www.snia.org/tech_activities/standards/curr_standards/npm

Getting Started Guides: https://docs.pmem.io