Remote Persistent Memory

Progress Report and Recent Findings

Paul Grun

Cray, Inc.

Chair, OpenFabrics Alliance

- SNIA and the OpenFabrics Alliance (OFA) are working to enable and accelerate the adoption of Remote Persistent Memory…
  - By providing standards and enabling software
  - By providing open source APIs
- Which depends on a clear elaboration of ‘use cases’ for RPM
- It also depends on understanding the relevant characteristics of the underlying technology
  - Which we will be exploring today

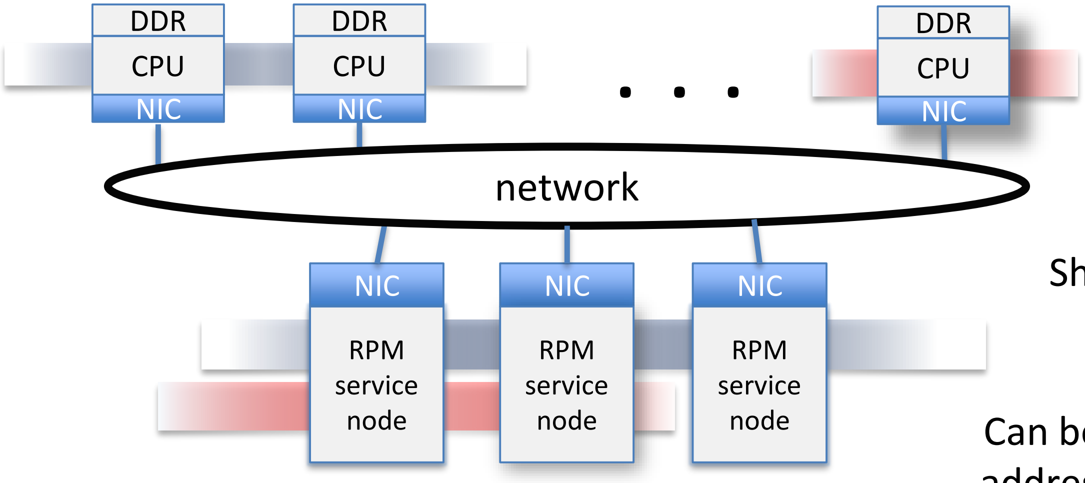
SNIA & OFA Collaboration Process

1. OFA + SNIA
   - Develop a set of example use cases for RPM
   - Generate a Whitepaper outlining those use cases
2. SNIA NVMP TWG
   - Generate Whitepapers describing each use case
3. OFA OFIWG
   - Generate open source network APIs to support those use cases

Describe Requirements

List Key Use Cases → Define Network APIs

Remote PM (RPM) System & Memory Models



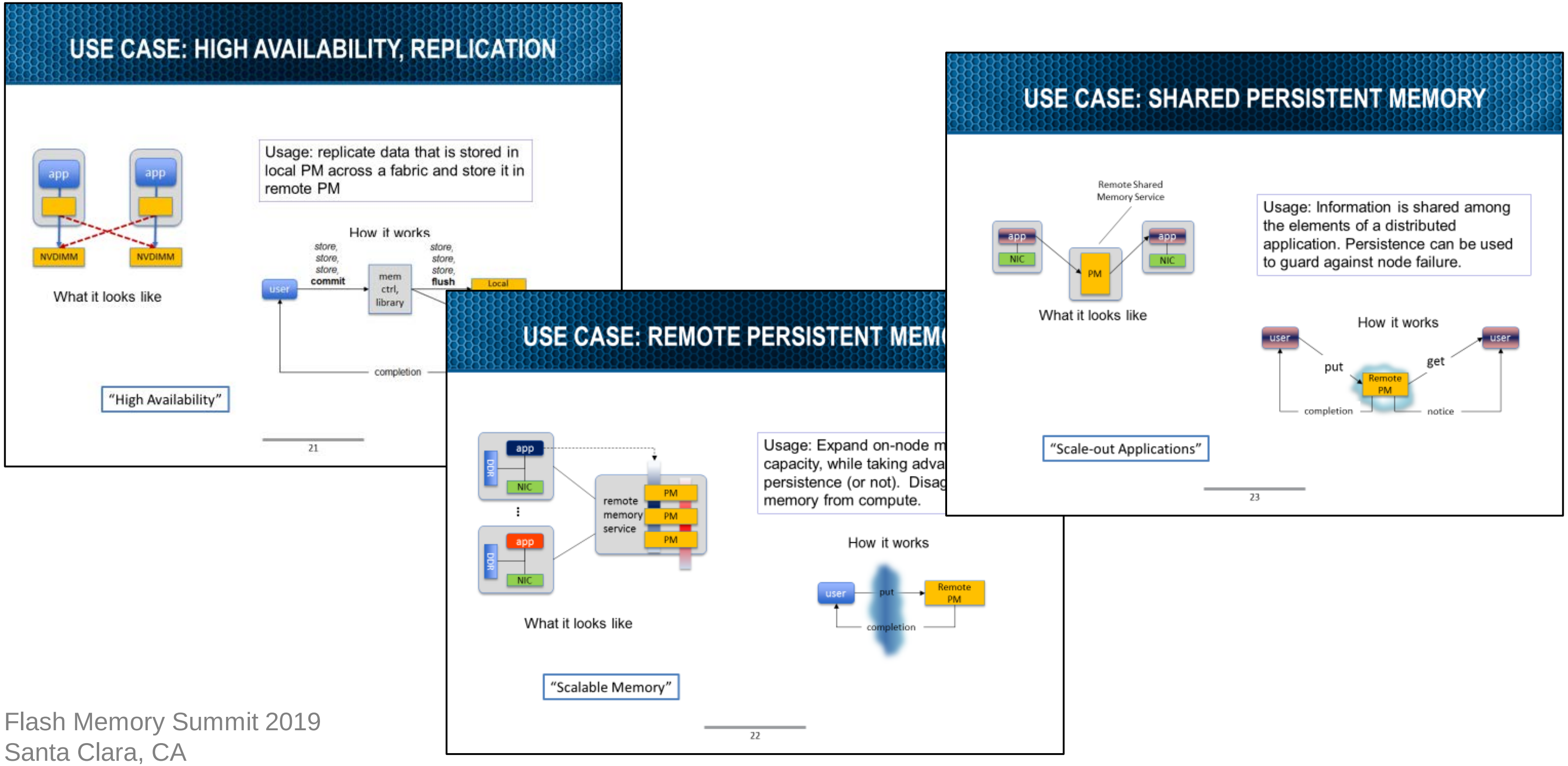
Shared or unshared resource

Can be configured as a flat address space, or as object storage.
Or both.

Organized into pools, accessed as memory

Much Different from “Local” Persistent Memory

3 Use Cases for RPM have been Described



More than Use Cases: Key Drivers in the Push to Create New APIs

Eventual API proposal should reflect a combination of *Use Cases* and *App Requirements*

Selecting the right technology depends on understanding (at least):

Key system design objectives	Scalability? In which dimension? Single server? Cluster?
Application requirements	Is data being shared among threads or nodes? Are there application performance or capacity requirements?

Flashback: Flash Memory Summit 2018

A Multi-dimensional Problem

To craft a network solution, and particularly to optimize the network software stack, there are number of factors to consider:

- Consumer considerations
  - For what purpose is the consumer storing/accessing persistent da remotely?
  - Under what conditions are data shared?
  - What is the security model?
- System objectives
  - For any given system, what are its design objectives? Performance? Scalability? High Availability?
  - What type of service is being offered? Object store? Pools of Memory?

The groundwork requires an understanding of:

- Application usage models
- Application requirements
- System Objectives

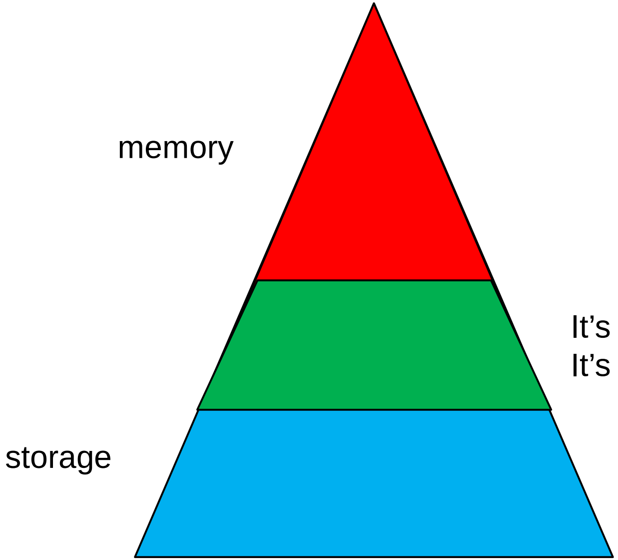
Which Boils Down to some Pretty Clear Solution Requirements

- Data Availability/Protection
  - Replicate local cache to RPM to achieve data availability
- Local System Performance
  - Eliminate disk accesses e.g. to stored databases
- Scale Out Architectures
  - Distributed databases, analytics applications, HPC parallel apps
- Scale Up Architectures
  - In-memory databases exceeding local DRAM capacity
- Disaggregated Systems
  - Compute capacity scales independently of memory capacity
- Shared Data
  - Simultaneous data access from multiple processes
  - Central shared repository for team collaboration on a large artifact
- Improved Uptime, Fast Restart
  - Quicker server recovery following power cycle
  - Checkpoint restart
- ~~Improved Disk Storage Performance~~

Question: Which characteristics of RPM are relevant?

- First developed at an OpenFabrics Alliance Think Tank in 2017,
- Revised and extended at FMS 2018, and again at PM Summit 2019

How to Characterize RPM?



It's a dessert topping!
It's a floor wax! *

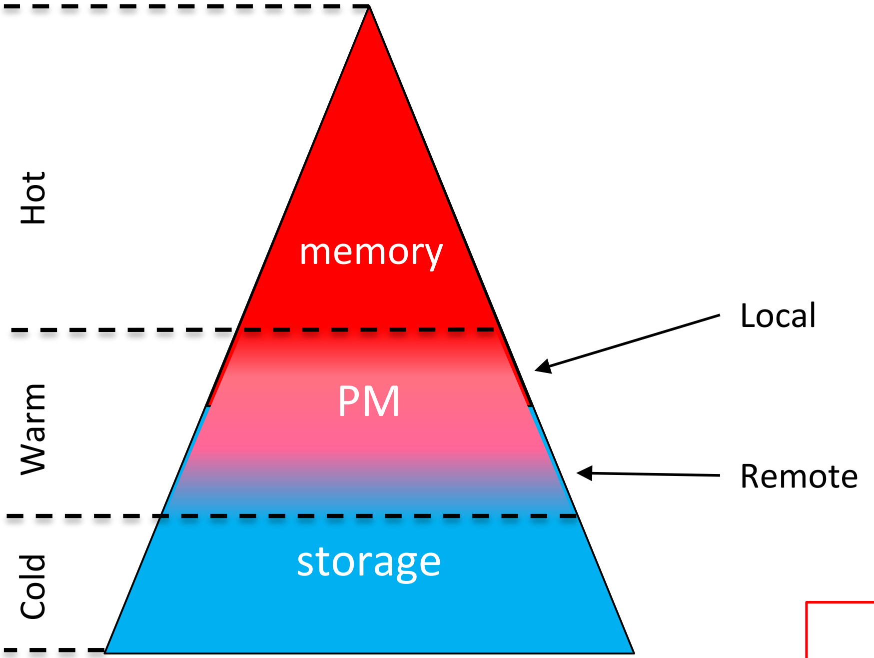
It's clear that Persistent Memory isn't exactly memory, and it's not precisely storage…

…so what is it?
How do we characterize it?
What role does it fill, exactly?
How do we use it to deliver the solutions described above?

* With thanks to SNL, 1/10/76

The Familiar Memory Hierarchy…

… with a wrinkle



Turns out that this new layer isn't monolithic…

…and there are tradeoffs within the sublayers

- performance
- cost
- capacity

Key characteristics:
Locality, Performance, Cost, Capacity

Introducing the ‘Characteristics’ Variable

- Many view the emerging Persistent Memory layer in the memory hierarchy as monolithic, evolving toward Nirvana
  - Nirvana defined as “infinite capacity, infinite bandwidth, zero latency, zero cost”
  - Oh, and “infinite retention”
- The truth is that there will always be tradeoffs
  - Performance vs Capacity vs Cost
  - Local vs Remote
- How to choose the right tradeoffs?

Assertion – understanding these characteristics, and how they map onto application use cases, will guide the development of networks to support RPM. Which is our ultimate goal.

Objective for today: Take a refined look at how the characteristics of RPM map onto solution requirements

Example Target Apps for PM

Database Applications	Data Analytics	Graph Analytics	Commercial Applications	HPC Applications
• A modifiable, in-memory database that survives power cycles	• Create a database once, run new queries repeatedly	• Operate on larger graphs than would fit in local memory	• Enable collaboration on large scale projects	• Scalability, parallel applications • Checkpointing

persistence, capacity

capacity, density, performance

persistence, capacity, cost

Persistence? Not Always Required

- Persistence is valuable for:
  - High Availability applications
  - Reducing or eliminating the need to access slower media, e.g. HDDs
  - Data protection and preservation
- Persistence not required, but nice to have:
  - Certain applications, such as analytics, that require establishing a database. Build the database once, run multiple queries against it
  - Collaborative workspaces
- Other characteristics may prove to be more valuable than persistence

If the app doesn't need persistence, then the so-called convergence of storage and memory is uninteresting

There are Always Tradeoffs. For Example…

- Performance
  - Persistence may come at the cost of performance (but not always)
- Cost
  - If you can accept a lower level of performance, or you do not care much about access models (e.g. file/block/byte addressability), there may be lower cost options available
- Capacity
  - To achieve higher capacity, you might sacrifice persistence, performance, or cost

1^{st} Order Tradeoff: Locality

- Some requirements are met by siting persistent memory on the compute node
  - Capacity-based applications
  - Some data protection usages
  - Replacement of local storage for performance reasons
- Others are only achieved by distributing persistent memory
  - Compute/memory disaggregation
    - independent scaling of compute and memory
  - Shared resource / shared data
  - Team collaboration
  - Distributed/Scale-out applications

Needless to say, this is our focus at the moment - RPM

Local may be synchronous, Remote is almost certain to be asynchronous

Local Persistent Memory

- Data Availability/Protection
  - Replicate local cache to RPM to achieve high availability
- Local System Performance
  - Eliminate disk accesses
- Scale Out Architectures
  - Scale out distributed databases, analytics applications, HPC parallel applications
- Scale Up Architectures
  - Scale up databases that exceed local memory capacity
- Disaggregated System Architectures
  - Compute capacity scales independently of memory capacity
- Shared Data
  - Support simultaneous data access to large teams
- Improved Uptime, Fast Restart
  - Quick server recovery following power cycle
  - Checkpoint restart

Persistence	Performance	Capacity
√√√	√√	√√
√	√√√	√√√
√√√	√	√

Remote PM

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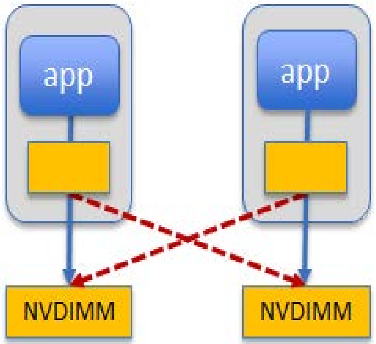
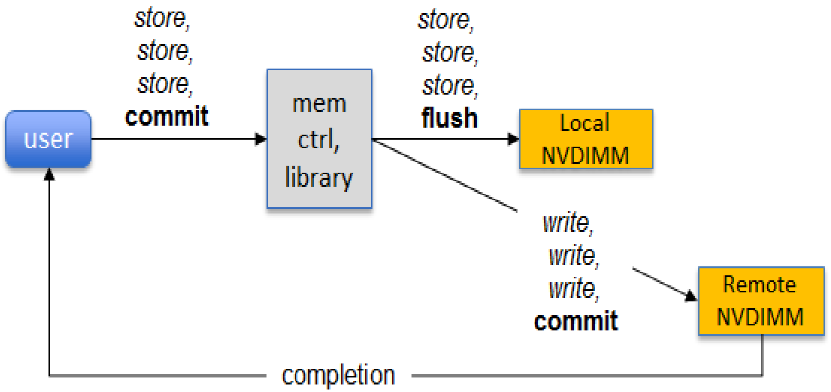
Data Availability, Protection

	Persistence	Performance	Capacity
Data Availability	√√√	√√	√
Checkpoint	√√√	√√	√√



What it looks like

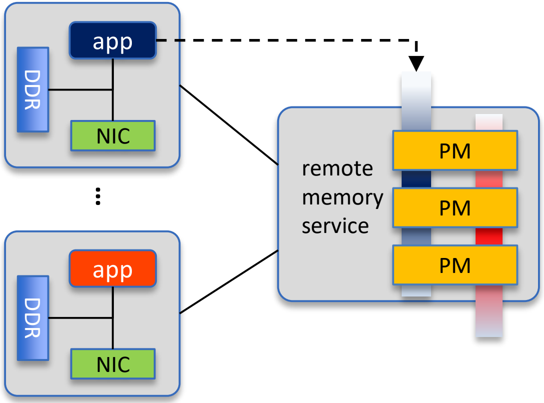
How it works



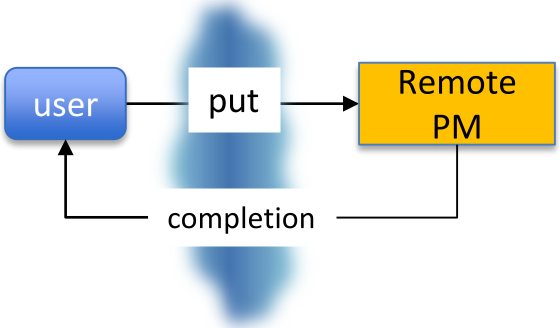
Data Availability/Protection

Usage: Replicate local cache to RPM to achieve data availability

Scale Out



	Persistence	Performance	Capacity
Scale Out	√	√√√	√√
Disaggregation	√	√√√	√√

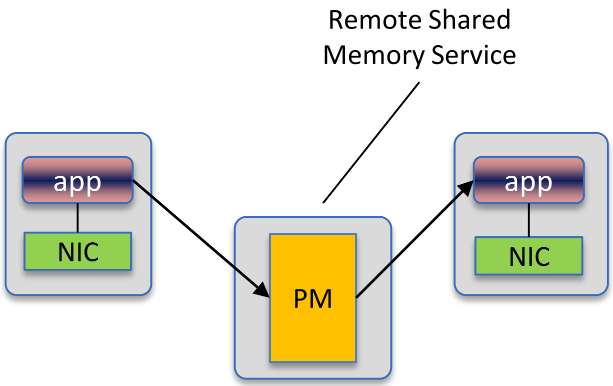


"Scalable Memory"

Scale Out Architectures
Usage: Distributed databases, analytics applications, HPC parallel apps

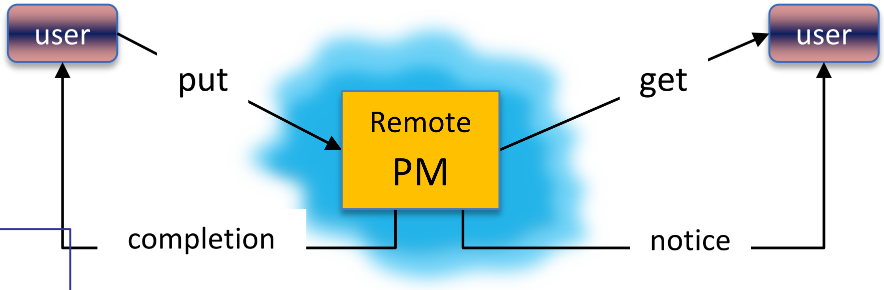
Disaggregated Systems
Usage: Compute capacity and memory capacity scale independently

Shared Data



	Persistence	Performance	Capacity
Shared Data	√√	√√√	√√

How it works



Shared Data

Usage: Simultaneous data access from multiple processes

Usage: Central shared repository for team collaboration

Call to Action

- Key use cases have been described
- Application requirements and system objectives outlined
- Varying characteristics of RPM mapped onto the above
- Call to Action: Engage with either/both
  - OFA's OpenFabrics Interfaces WG to develop the above,
    - www.openfabrics.org → Organization → OFA Calendar
  - SNIA's NVMP TWG to develop the detailed use case Whitepapers