



BY Developers FOR Developers

Storage Developer Conference
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Challenges and Opportunities as Persistence Moves Up the Memory/Storage Hierarchy

Jim Handy
Objective Analysis

Tom Coughlin
Coughlin Assoc.



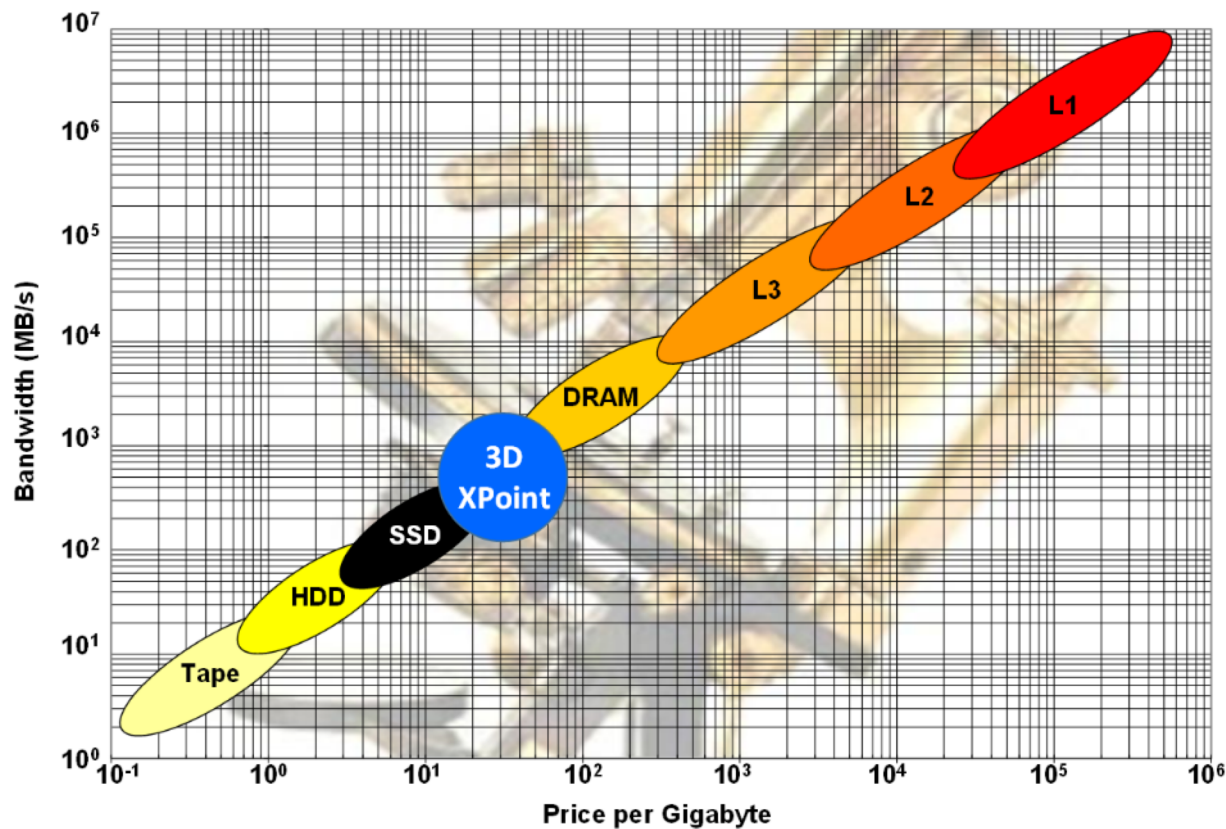
Outline

- A History of Persistence
- Why Persistence will Move into the CPU
- What This Means to Systems
- How this improves Applications
- Summary

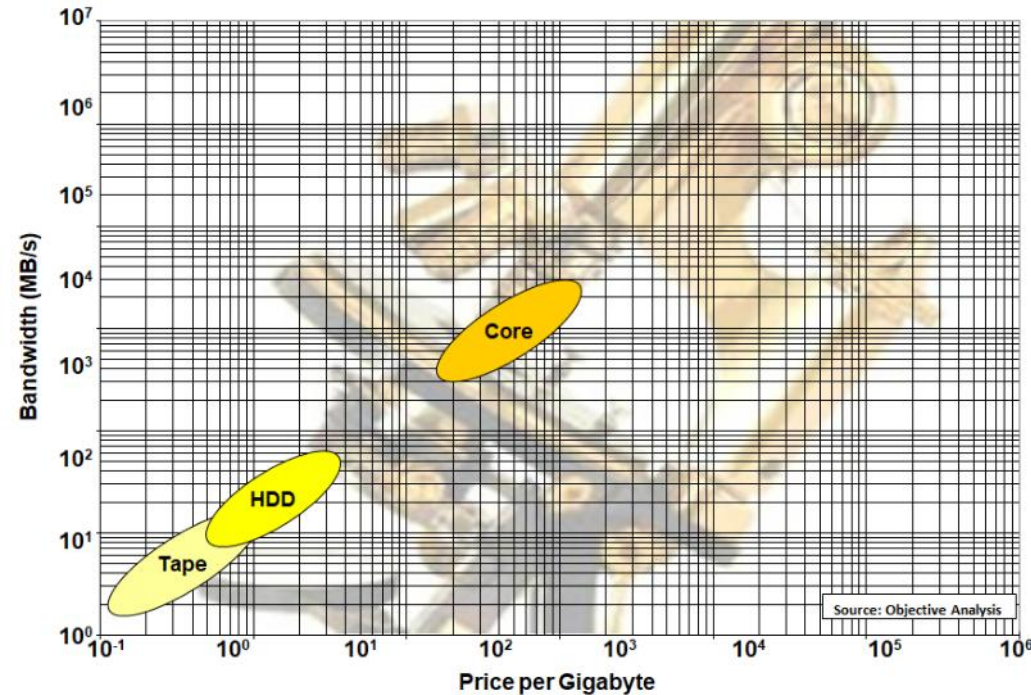
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The Memory/Storage Hierarchy

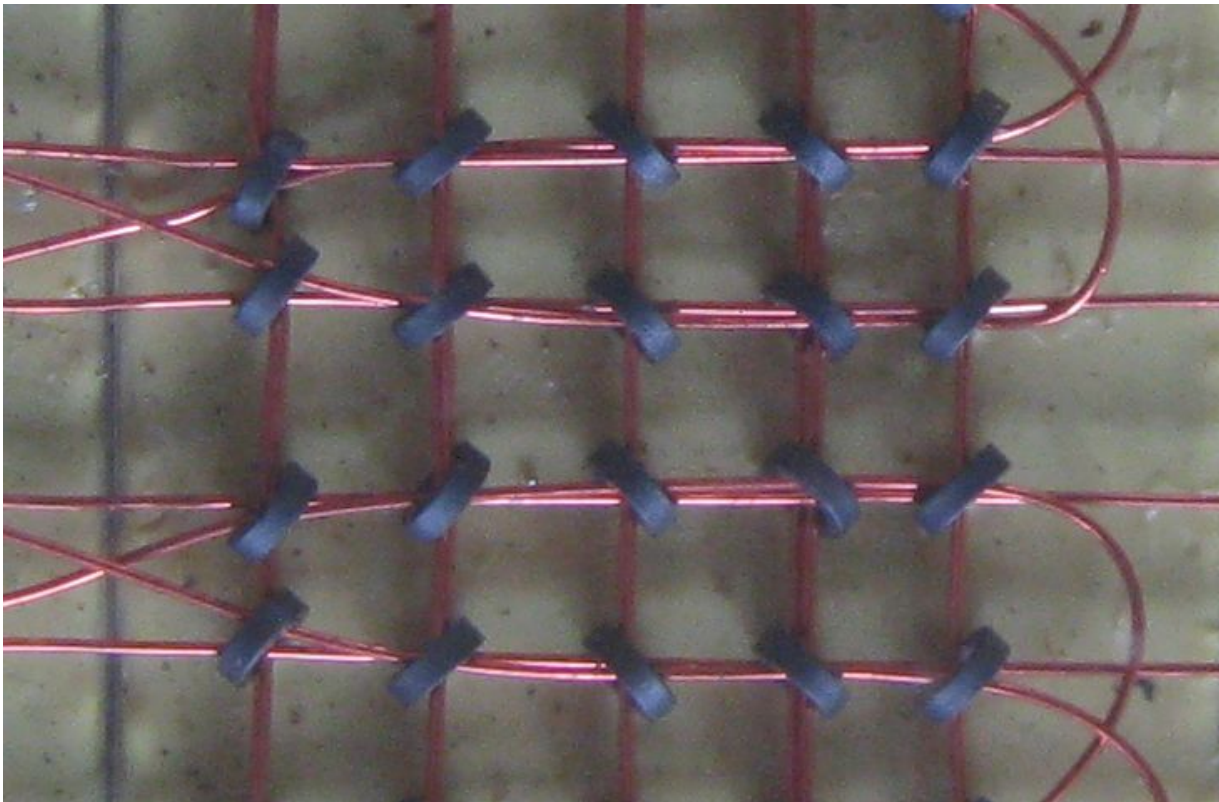


1960: Everything was Persistent!



- Persistent Memory was underappreciated
- Cache was unknown
- HDD was new
- Tape was either paper or magnetic

Persistent Memory, 1960

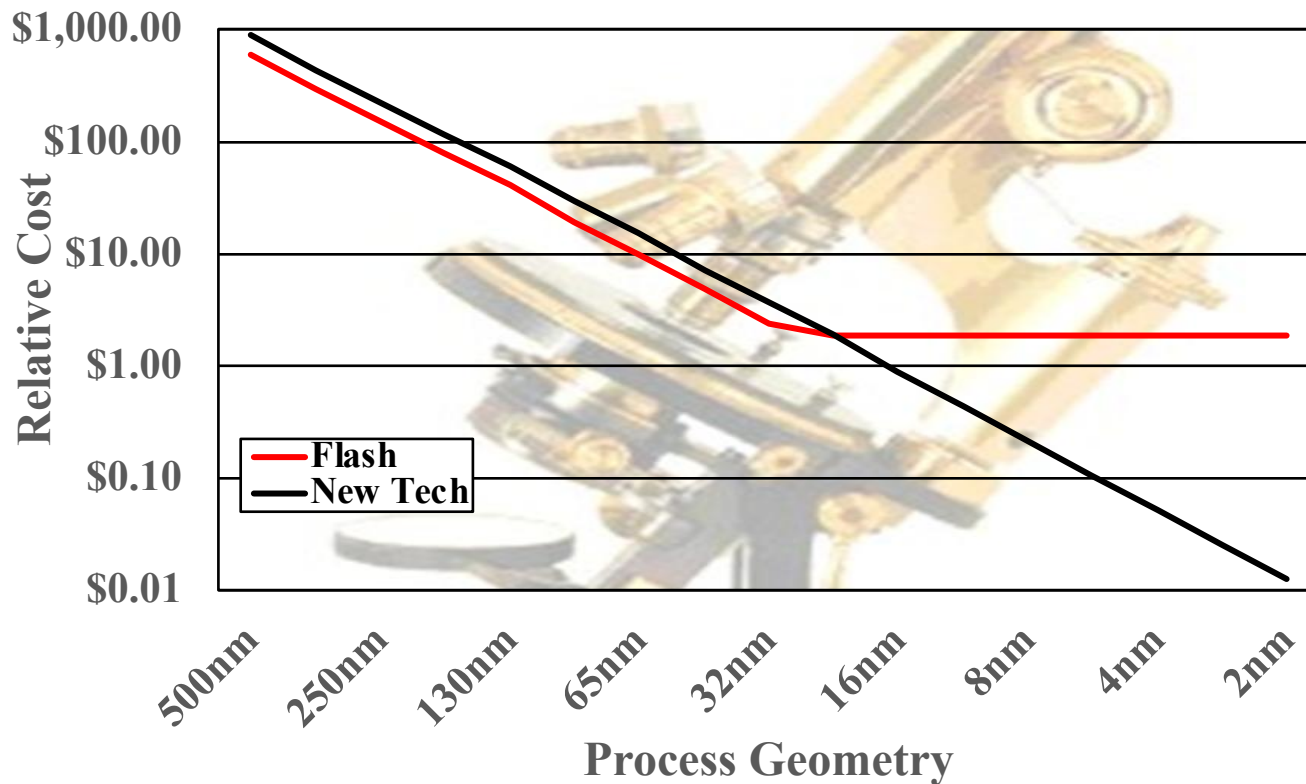


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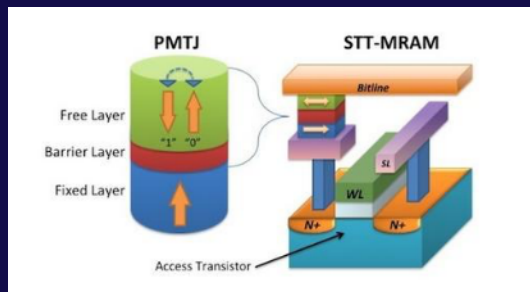
NOR Flash Stopped Scaling at 28nm

Something Else Will Replace It

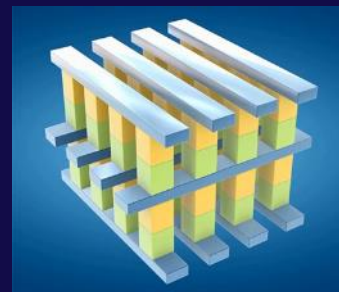


Candidates for NOR Replacement

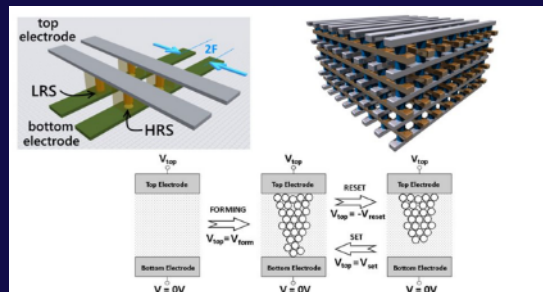
MRAM



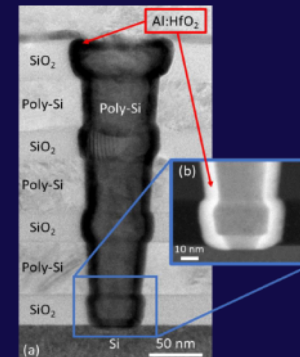
PCM



ReRAM

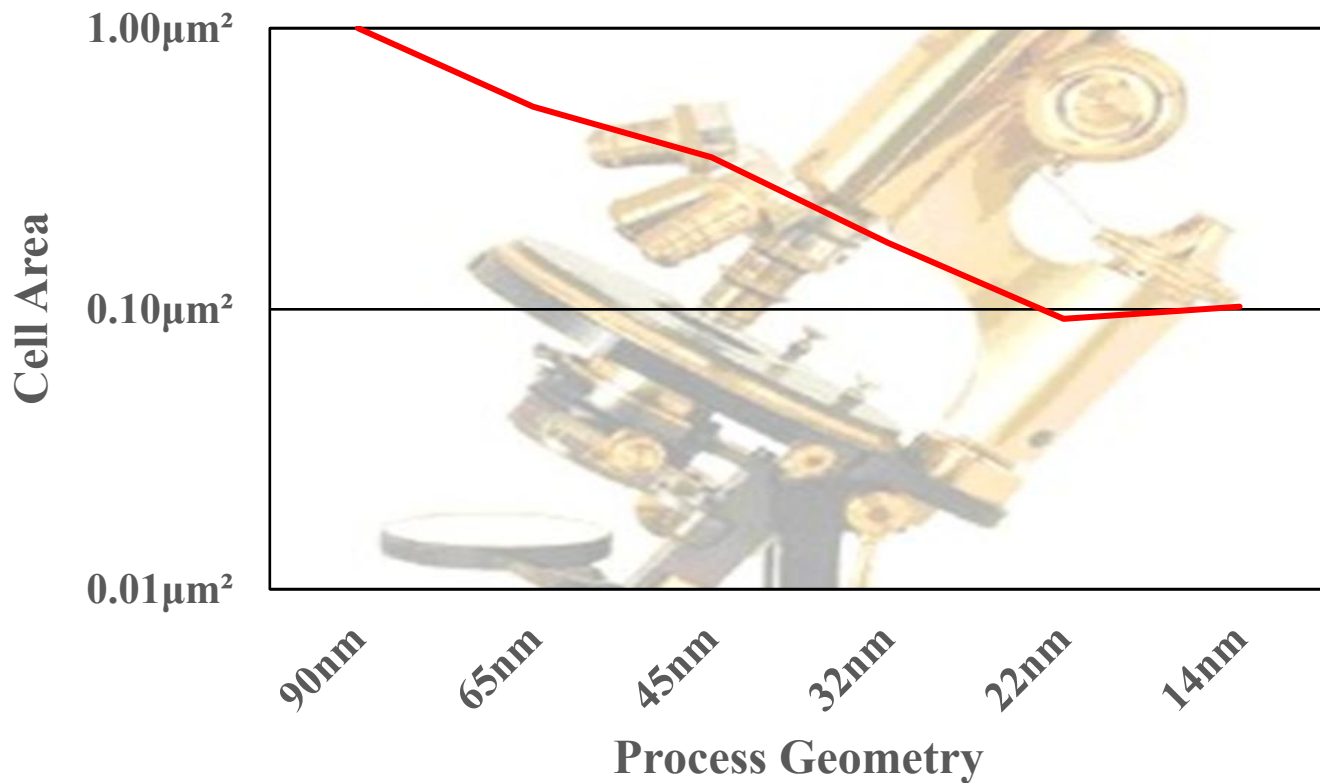


FRAM

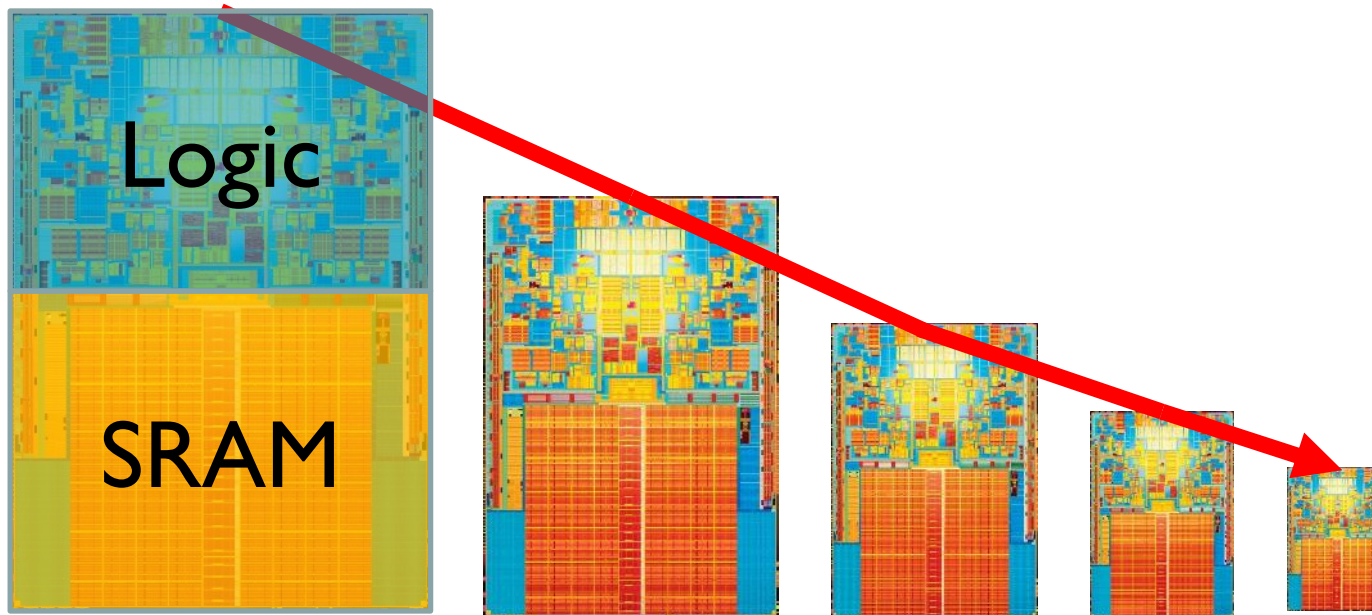


SRAM Is Similarly Challenged

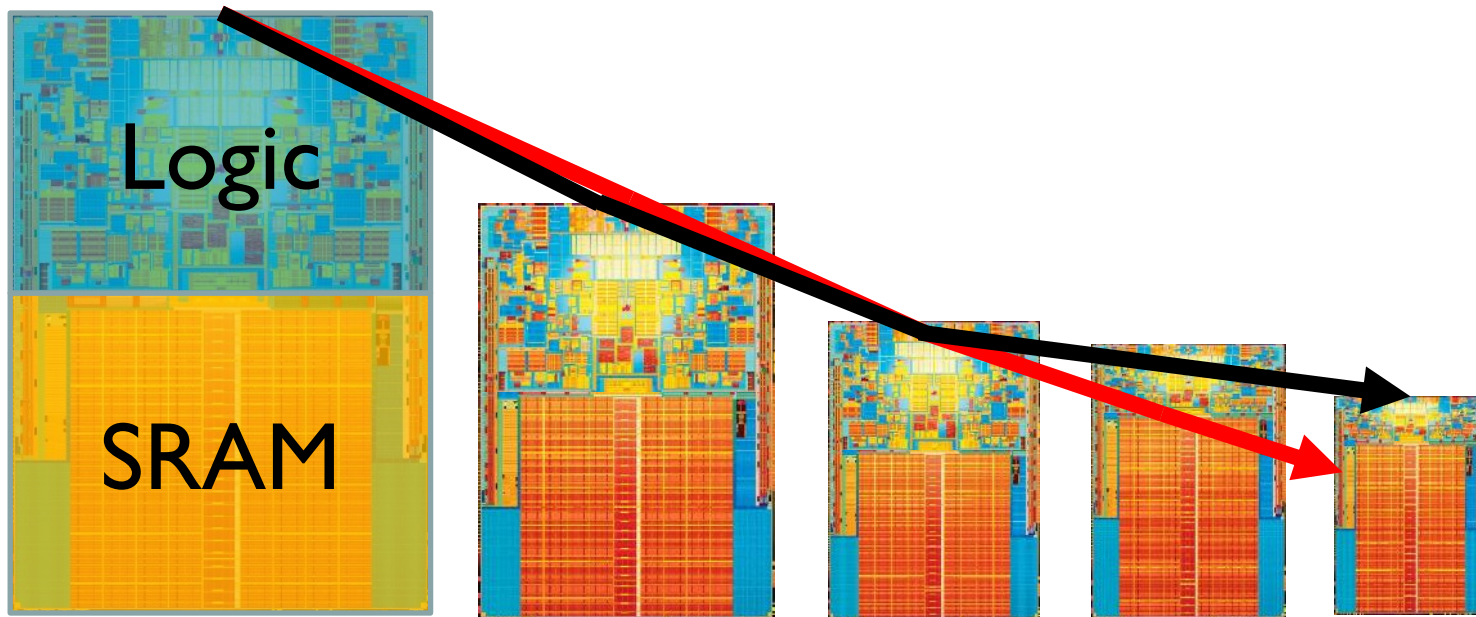
It May Have Already Stopped Scaling



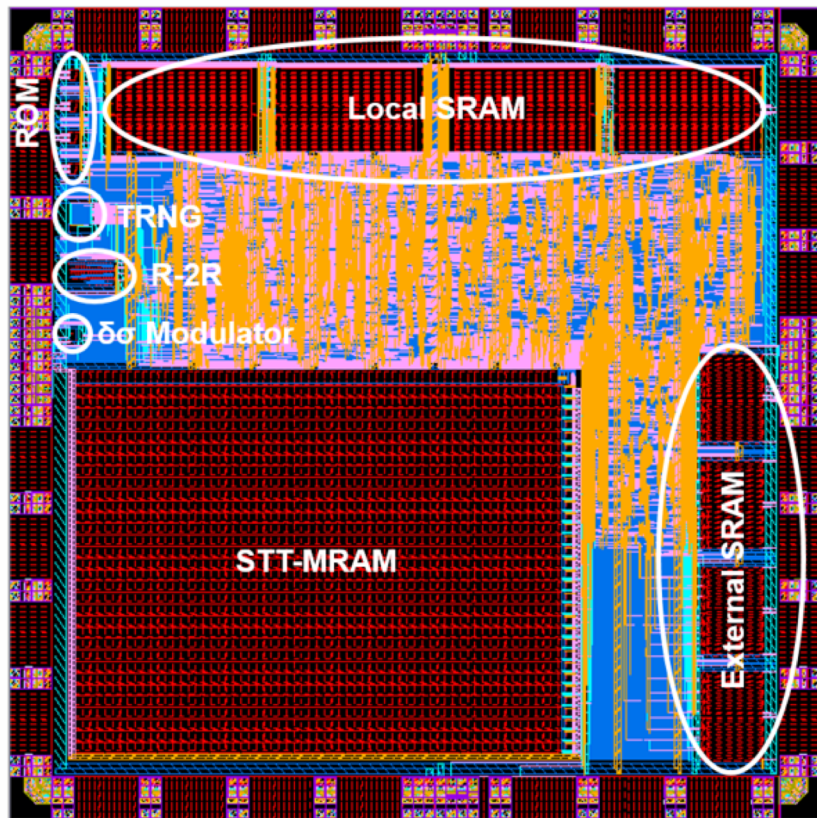
Putting Things in Perspective



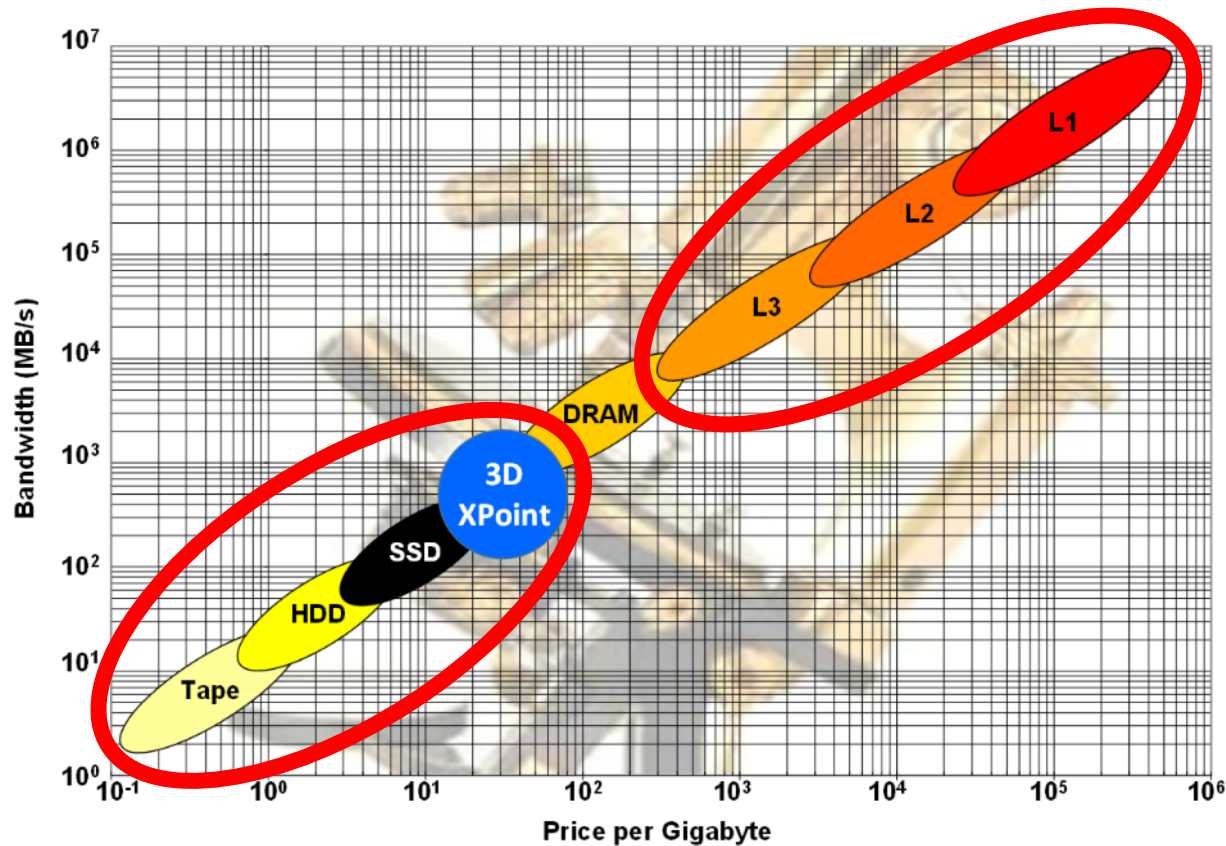
Putting Things in Perspective



Microcontrollers Will Prime the Pump



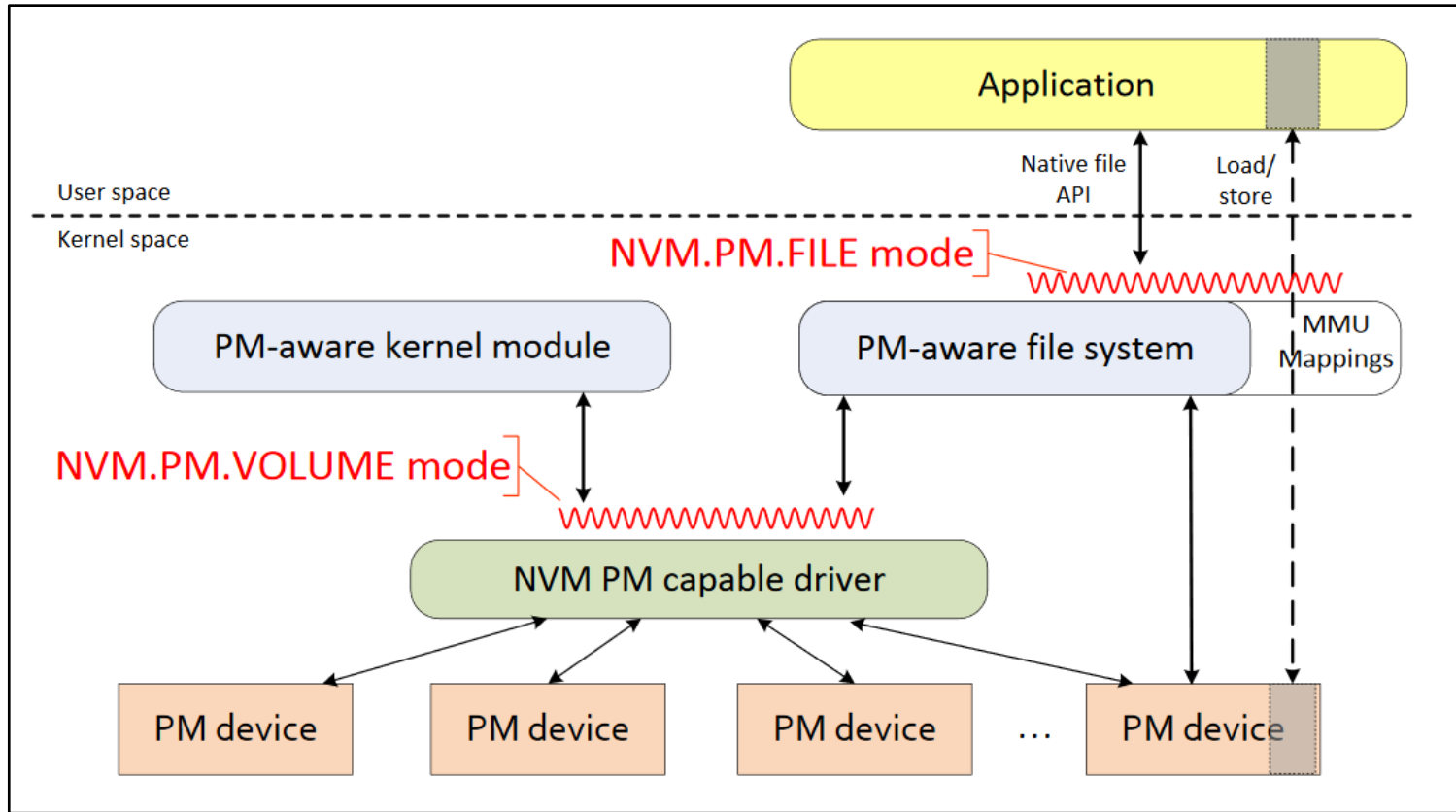
What Becomes Persistent?



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SNIA's NVM Programming Model



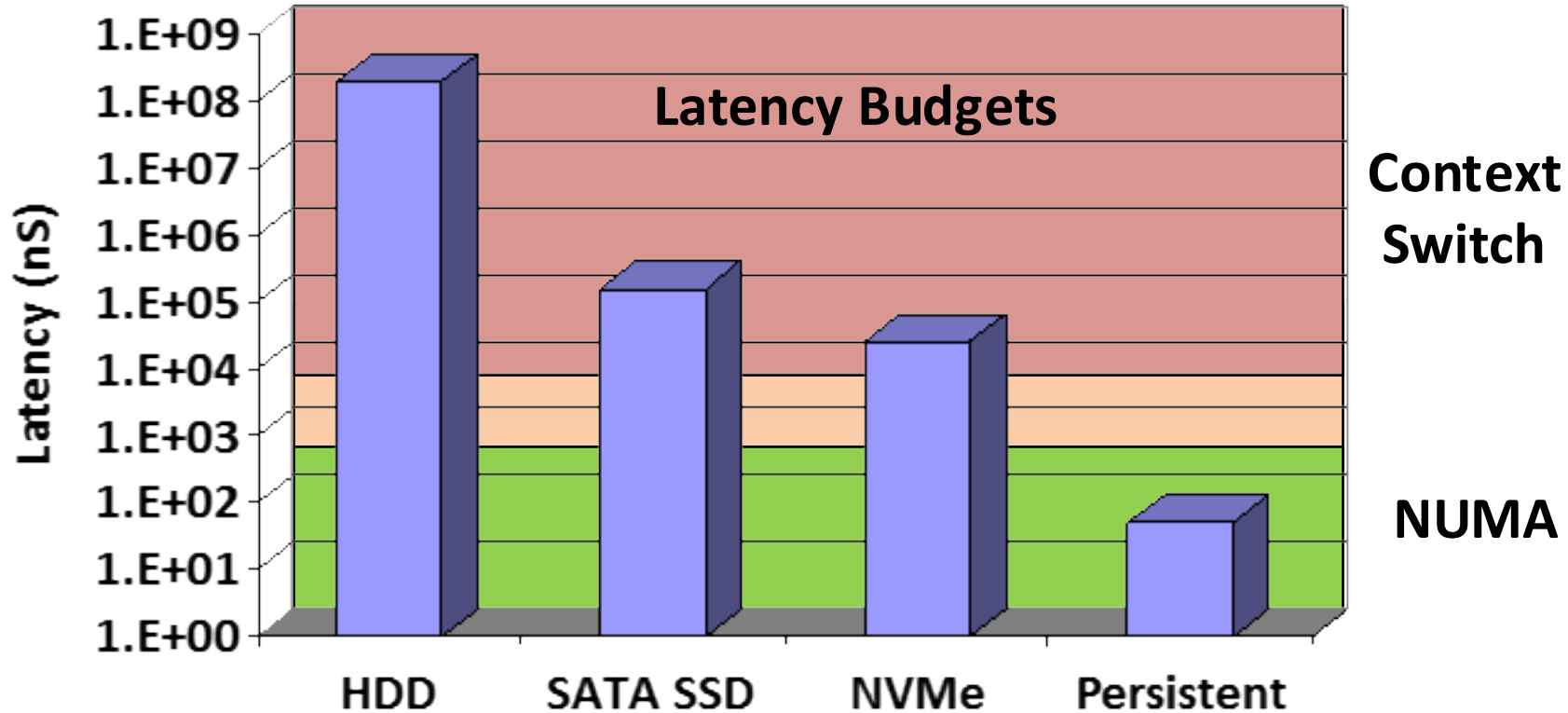


That Was a LOT of Work!

There's Still Much to Be Done

- Nondeterministic bus speeds
 - CXL shows promise
- MMU support of NUMA
- Context switch vs. polling
- Off-the-shelf application software support
- Standardization across multiple platforms

Context Switch Problem



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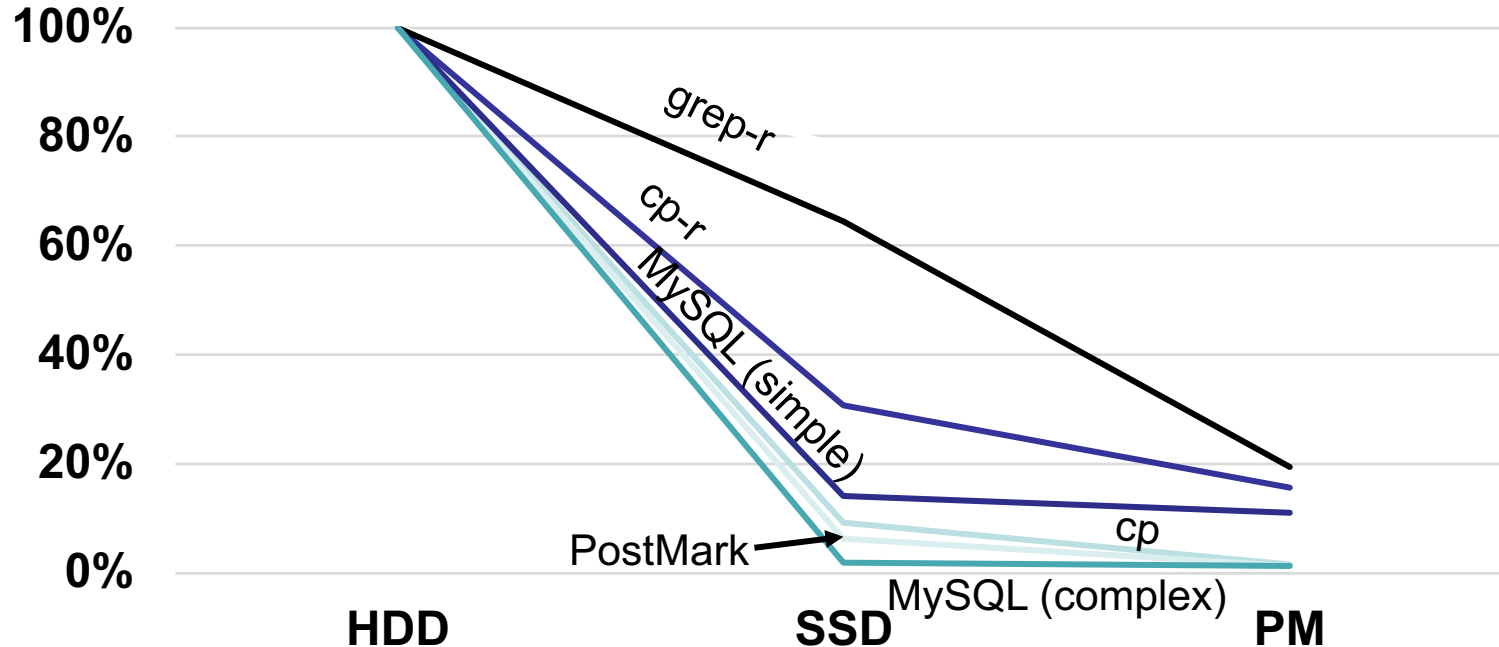
Benefits of Persistent Caches

- Energy consumption
- Faster transactions
- This provides significant value for data center and embedded system applications



Energy Savings from Persistence

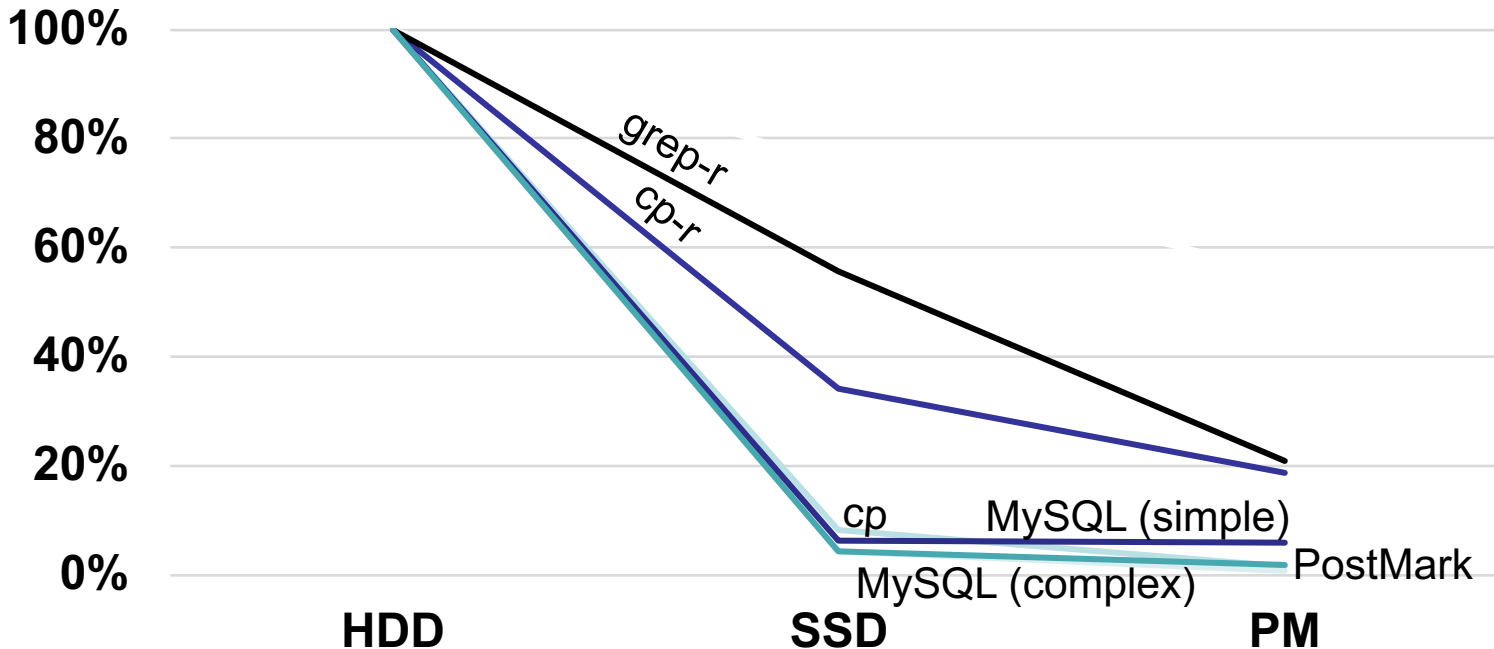
Relative Energy Consumption



Justin Meza *et al*, [A Case for Efficient Hardware/Software Cooperative Management of Storage and Memory](#)

Speed-Up from Persistence

Relative Execution Time



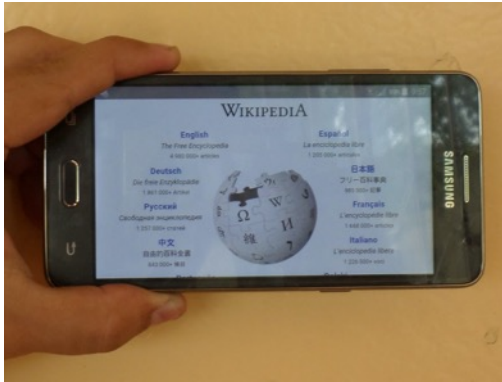
Justin Meza *et al*, [A Case for Efficient Hardware/Software Cooperative Management of Storage and Memory](#)

Advantages for Data Centers



Image from Lancium

Advantages for Embedded Electronics



All images from Wikimedia Commons

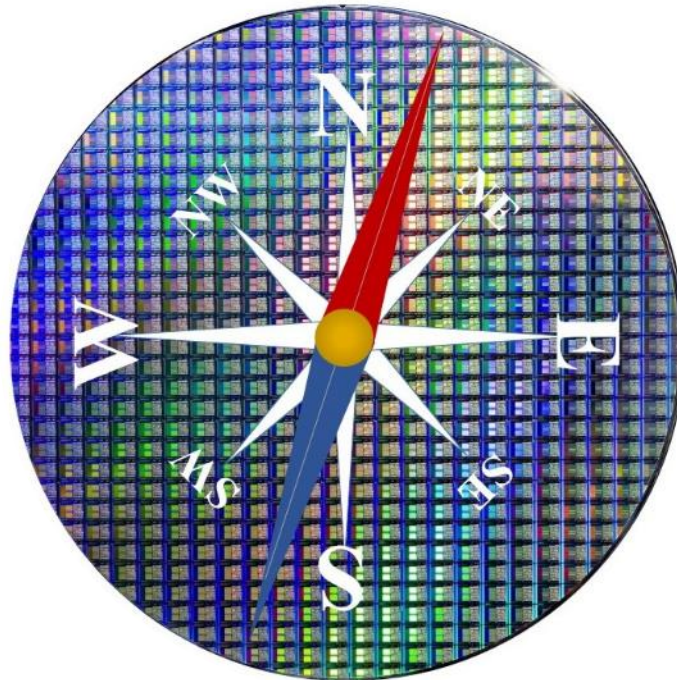
With Persistent Caches Everything Starts Over

- BIOS Support
- Operating system support
- Application program support
- Standards
- Hardware support



After That, Expect Persistent Registers!

New Report: Emerging Memories Find Their Direction



*Coughlin
Associates*

OBJECTIVE
ANALYSIS
Semiconductor Market Research

Now Available!

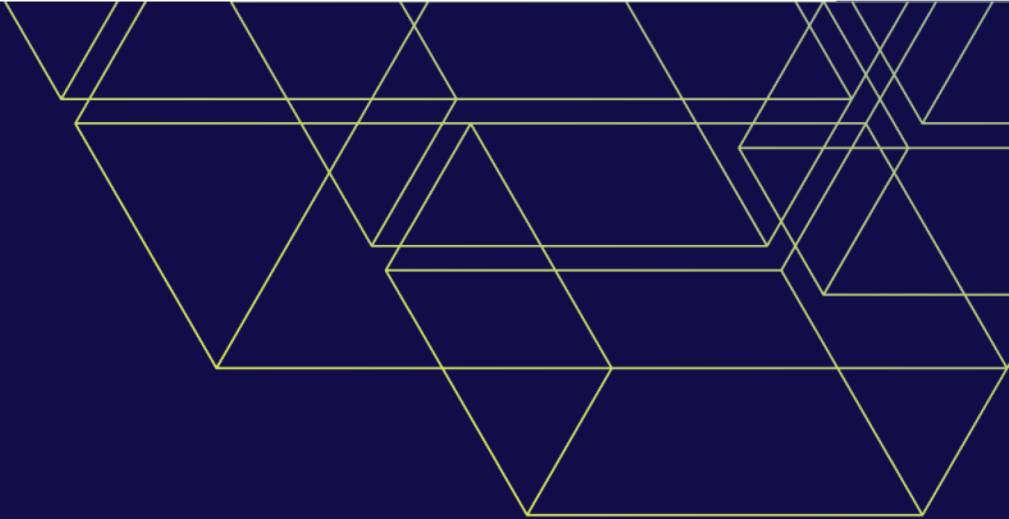
<http://www.tomcoughlin.com/techpapers.htm>
<https://Objective-Analysis.com/reports/#Emerging>

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Summary

- Persistent caches are on their way
 - Persistent registers will follow
- Persistence requires a LOT of support
- It's time to start considering how to handle this
- Buy our report!



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