Persistence and Energy Savings

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Coughlin Associates

Data Storage Consulting

Outline

- Findings from Last Year
- Why Persistence will Move into the CPU
- How this improves Applications
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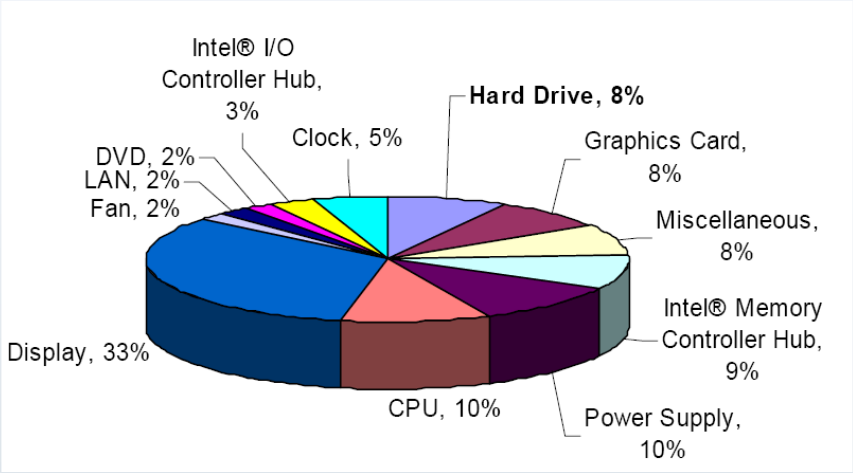
SSDs in PCs

	SSD	HDD
Sustained Read	230MB/s	60MB/s
Sustained Write	130MB/s	50MB/s
Random Read IOPS	2,500	70
Random Write IOPS	25	115
Ave. File Access	0.12ms	19.0ms
Read latency	<1ms	15ms
Active Power – Read	0.5W	2.1W
Idle Power	0.1W	1.0W
Standby Power	0.06W	0.20W
Hibernate Resume	<5s	40s



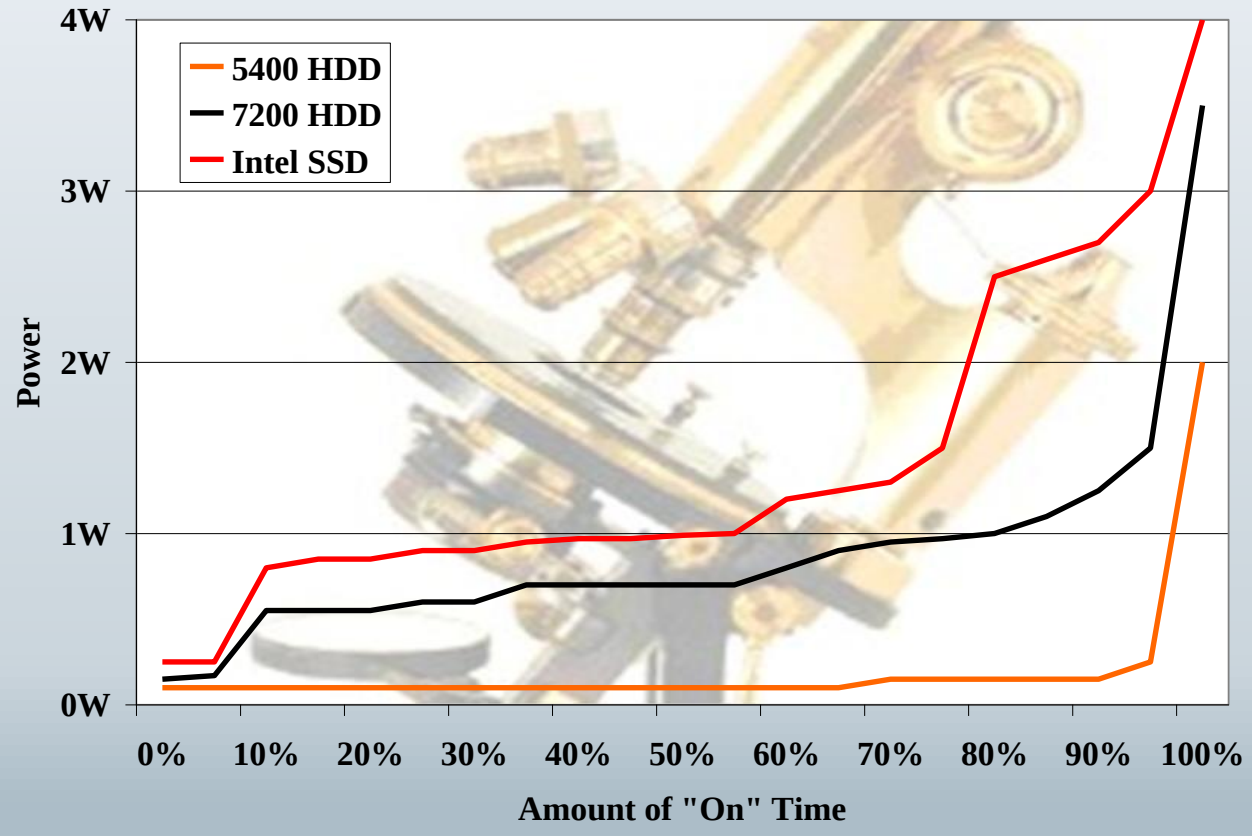
- 14% of total power went to HDD
- SSD's speed helped it power down more
  - HDD Powered down 10% of time
  - SSD powered down 96%
- Savings
  - Storage power 13%
  - Mother board power 2%

SNIA SSD TCO Model

	Power	*Read IOPS*	*mW/IOPS*
146GB 3.5: Enterprise Fibre Channel SSD	16.4W	10,000	1.6
64GB 2.5" Enterprise SATA SSD	6.5W	3,500	1.9
146GB 2.5" 15k RPM SAS HDD	11.0W	420	26.2
300GB 2.5" 10k RPM SAS HDD	10.2W	270	37.8
600GB 3.5" 15k RPM Fibre Channel HDD	24.3W	380	63.9
600GB 3.5" 10k RPM Fibre Channel HDD	18.1W	280	64.6
2TB 3.5" 7.2k RPM Enterprise SATA HDD	19.6W	133	147.4

From the perspective of mW/IOPS SSDs are a slam-dunk!
(Even WITHOUT) considering the savings elsewhere in the system.

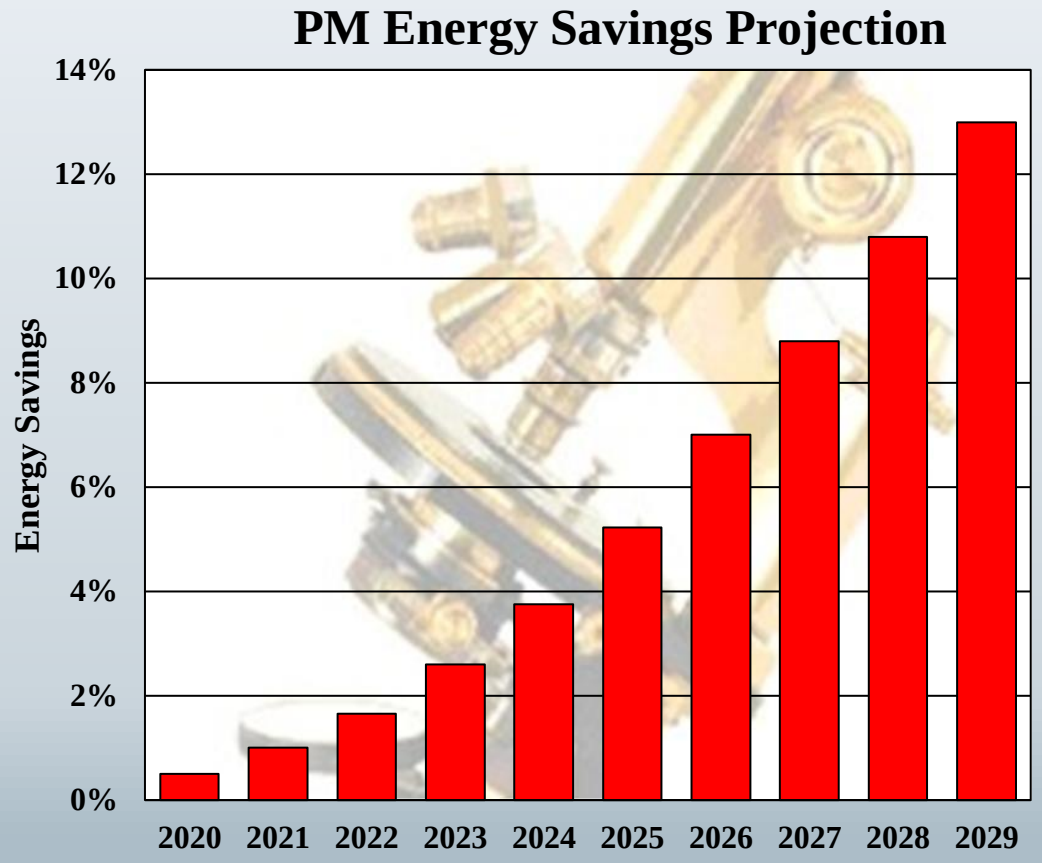
Faster Performance Reduces Energy Use



Source: Intel & Objective Analysis, July 2017

- Allows other parts of the system to enter their own idle states sooner
- Further reduces energy consumption
- HUGI: “Hurry Up, Go Idle.”

PM Energy Savings



- Assumptions:
  - XPoint adoption follows Objective Analysis forecast
  - XPoint-based energy savings
    - 10% in Memory Mode
    - 30% in App Direct Mode
  - PM-Aware Software doesn’t take off until 2023
  - Does not estimate reduced server requirements

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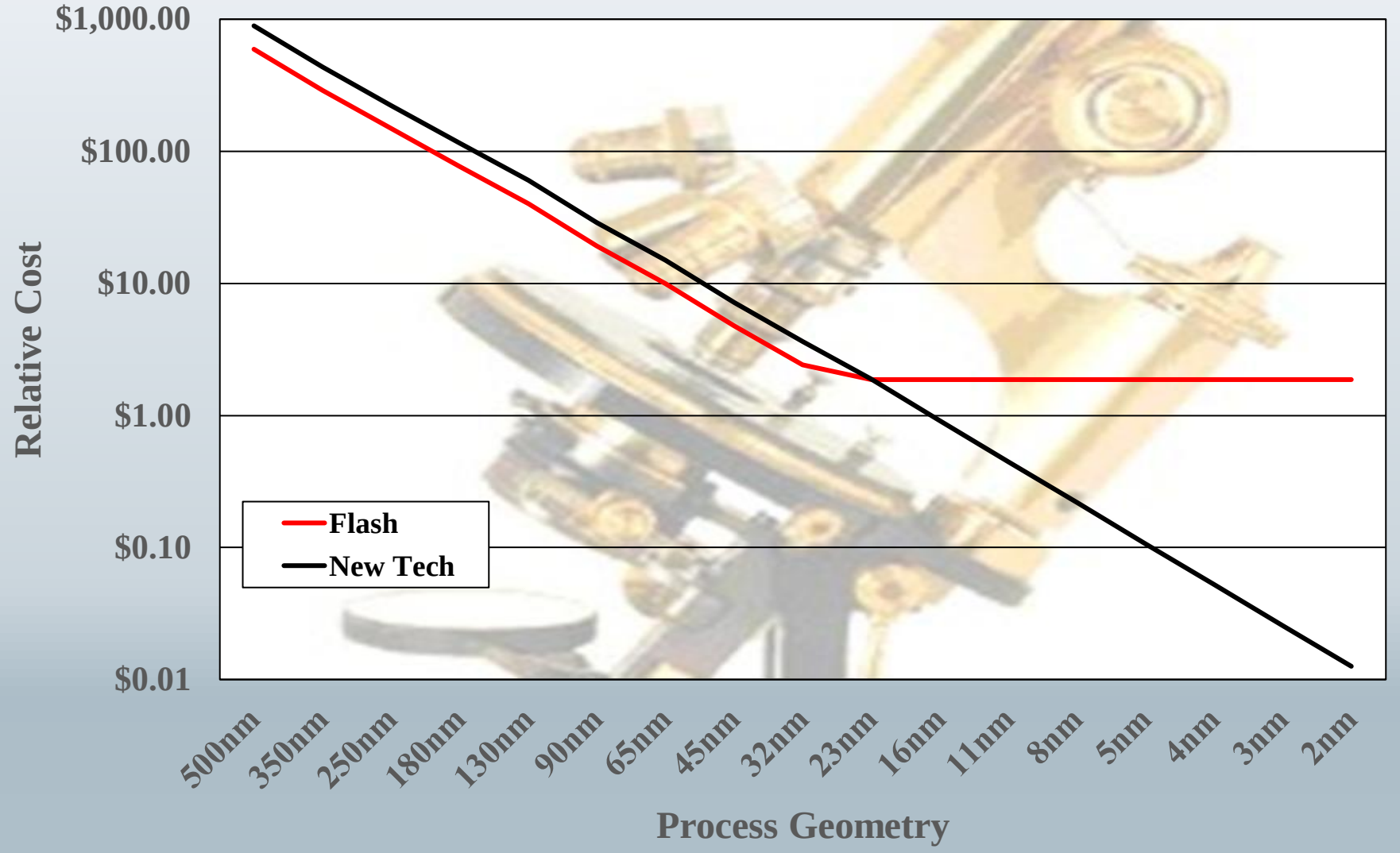
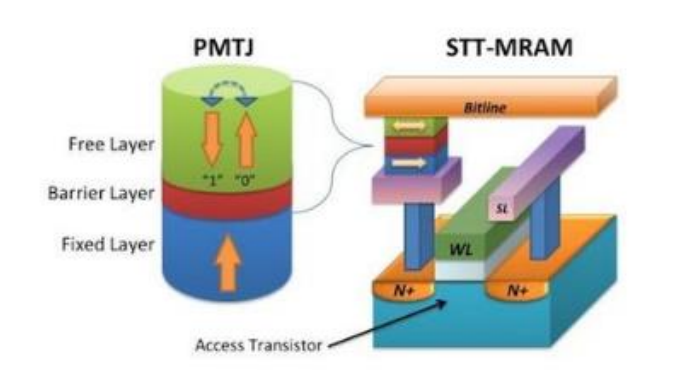
NOR Flash Stopped Scaling at 28nm

Something Else Will Replace It

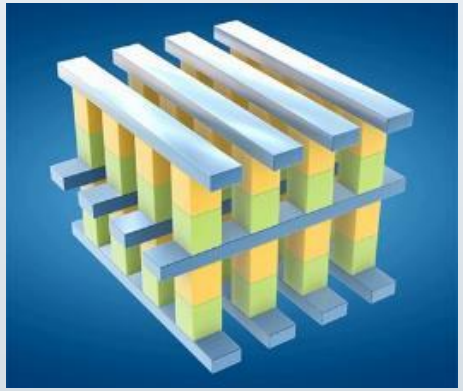


Candidates for NOR Replacement

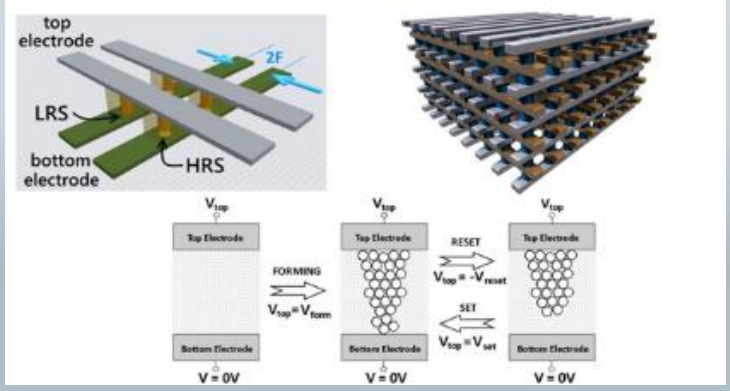
MRAM



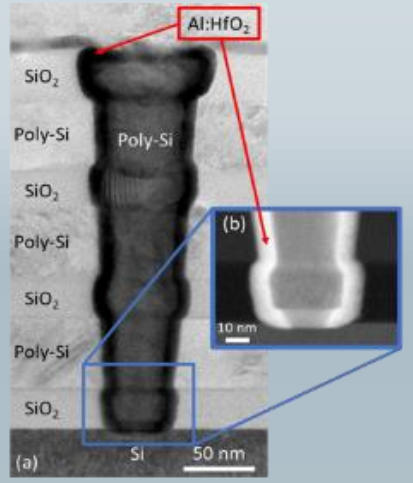
PCM



ReRAM

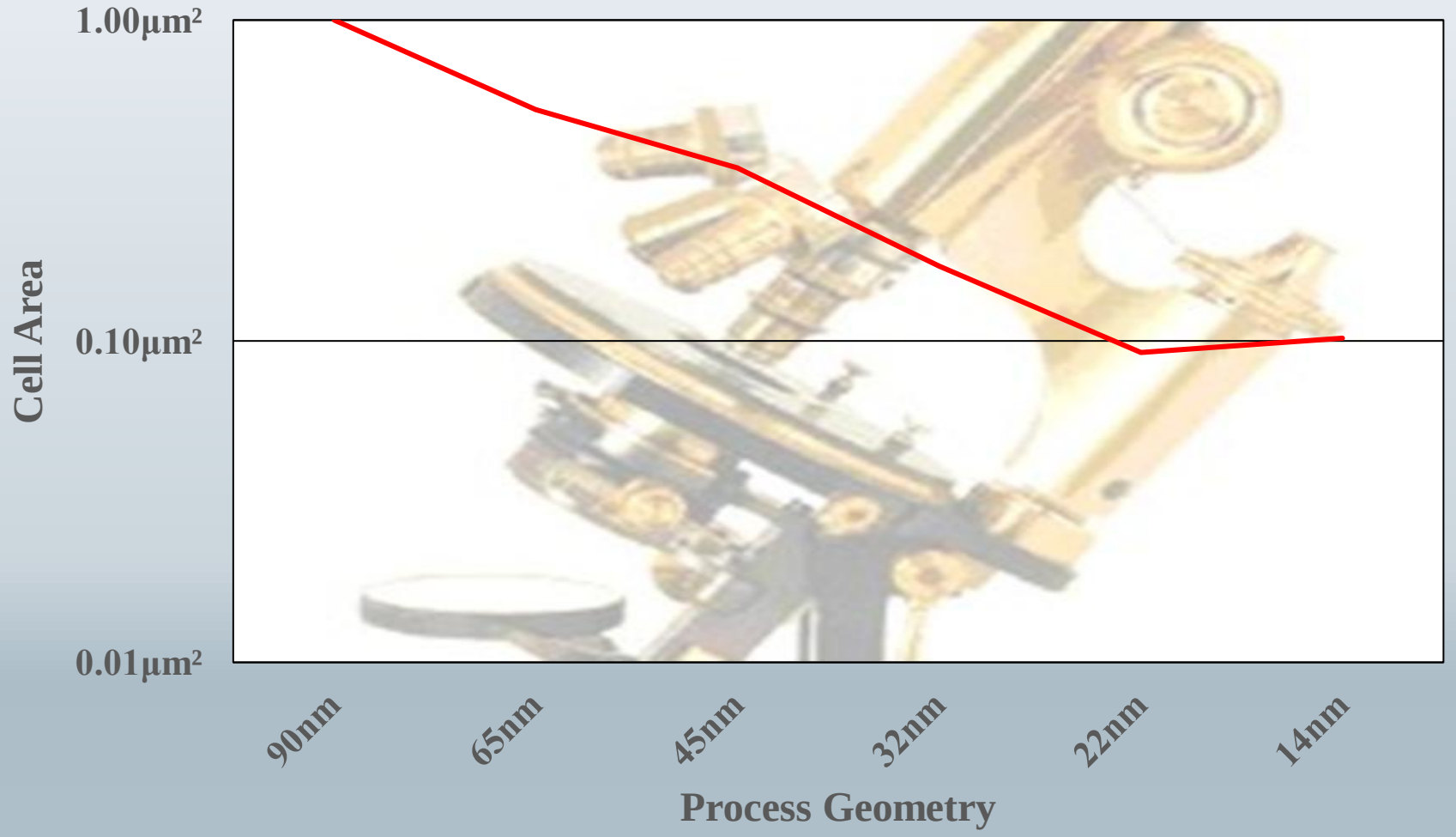


FRAM

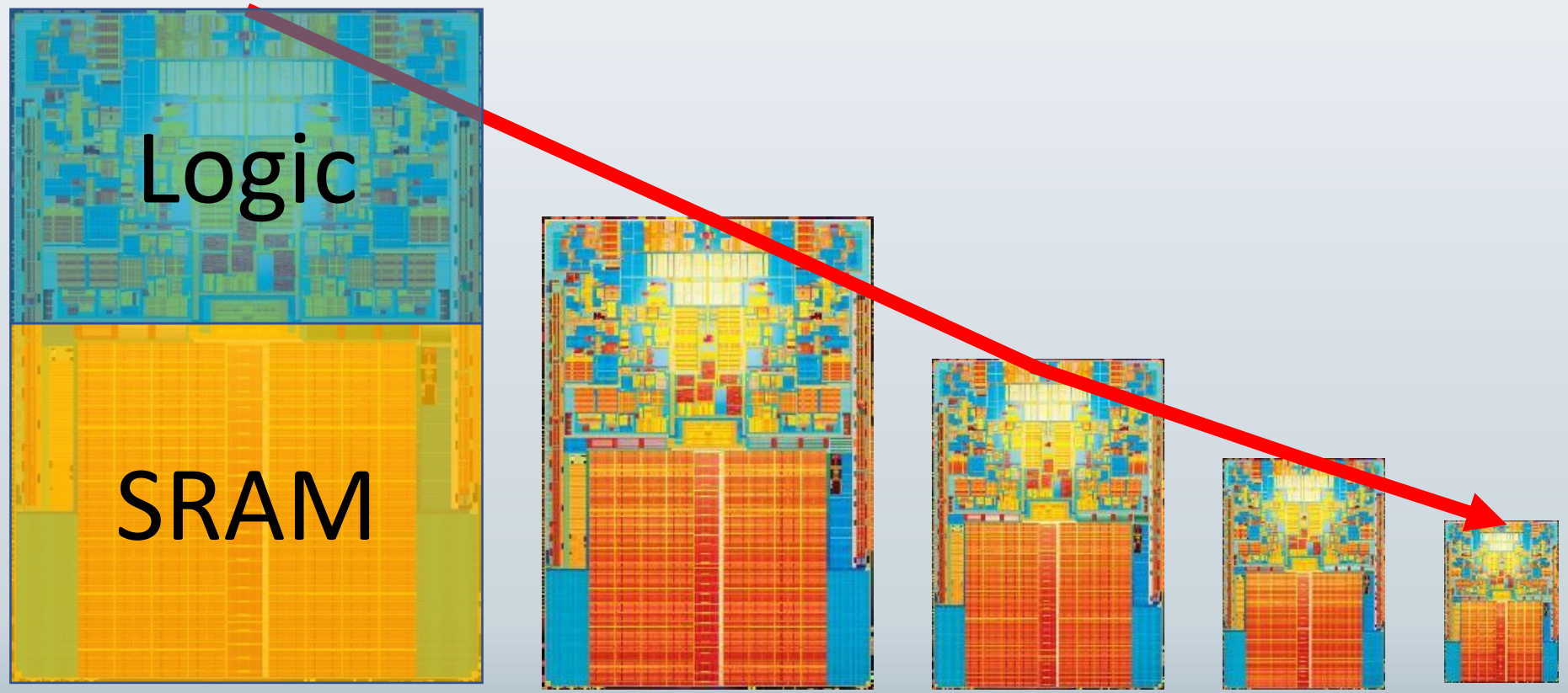


SRAM Is Similarly Challenged

It May Have Already Stopped Scaling



Putting Things in Perspective



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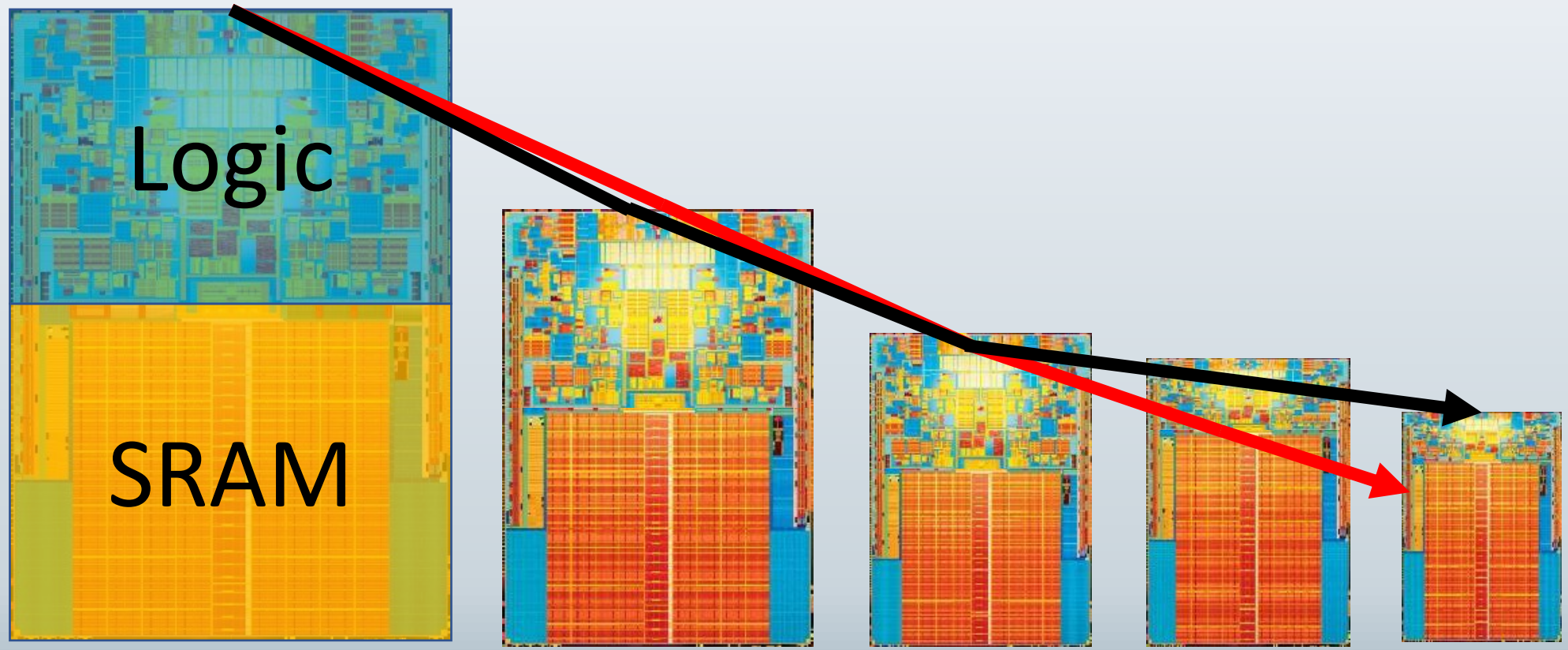
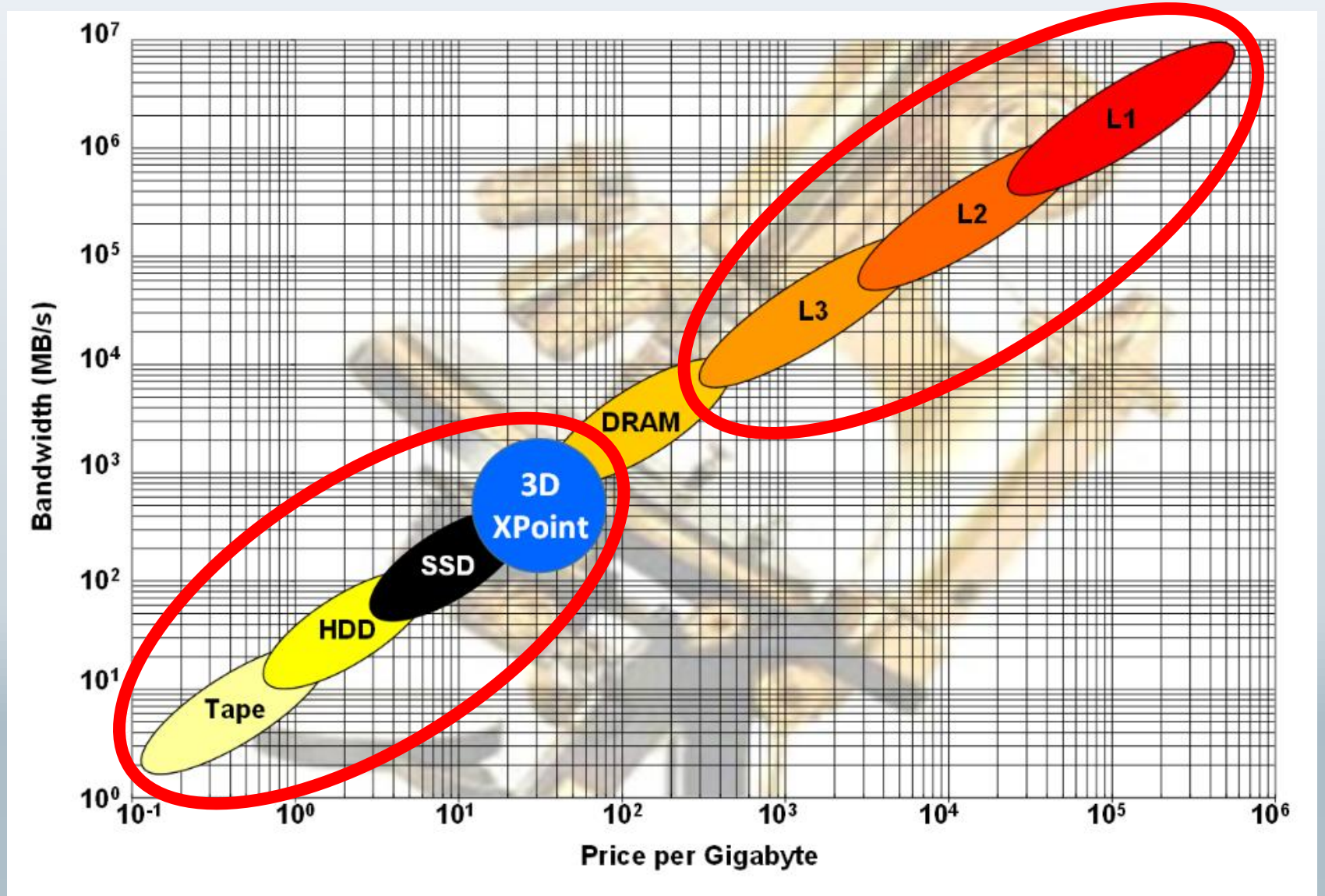


What Becomes Persistent?



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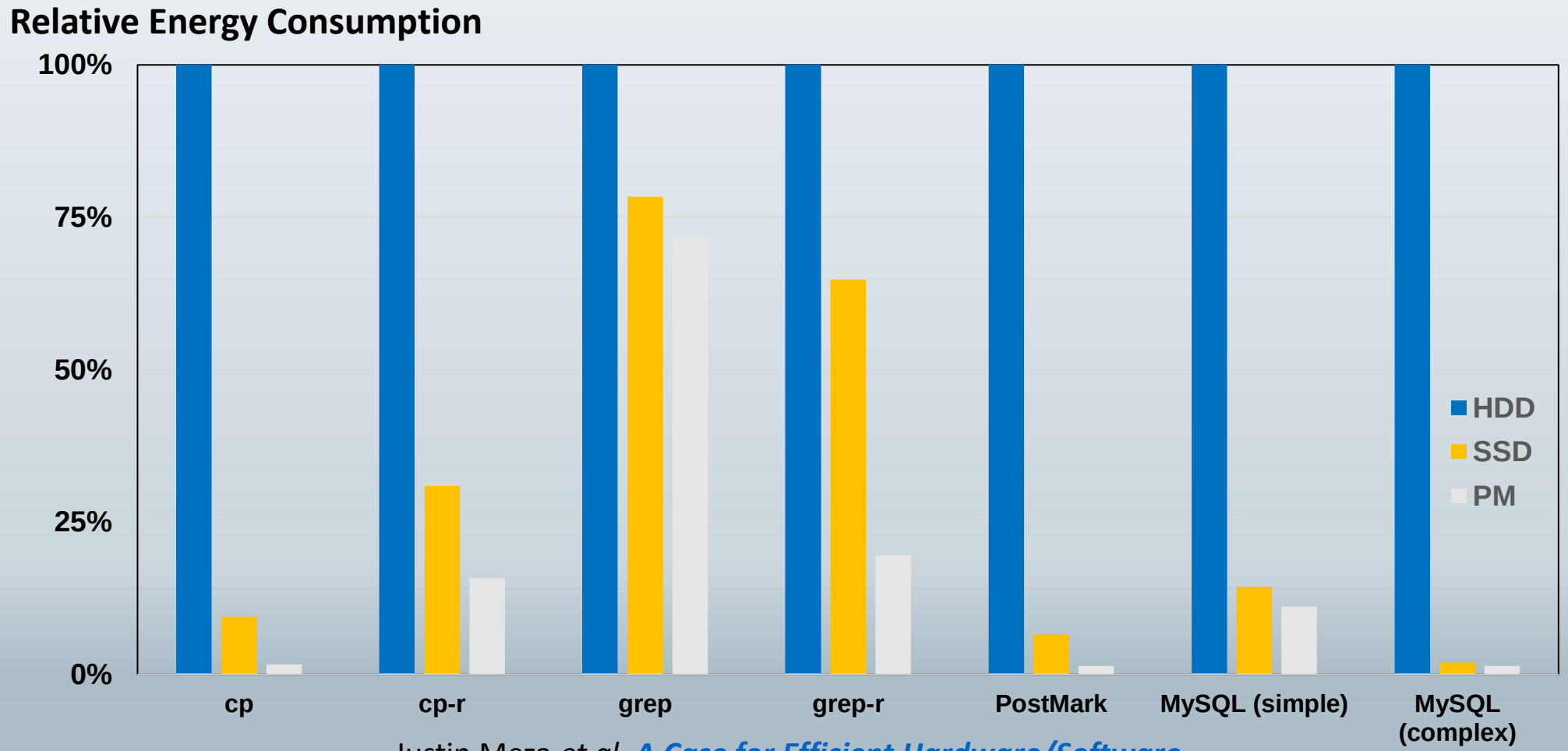
Benefits of Persistent Caches

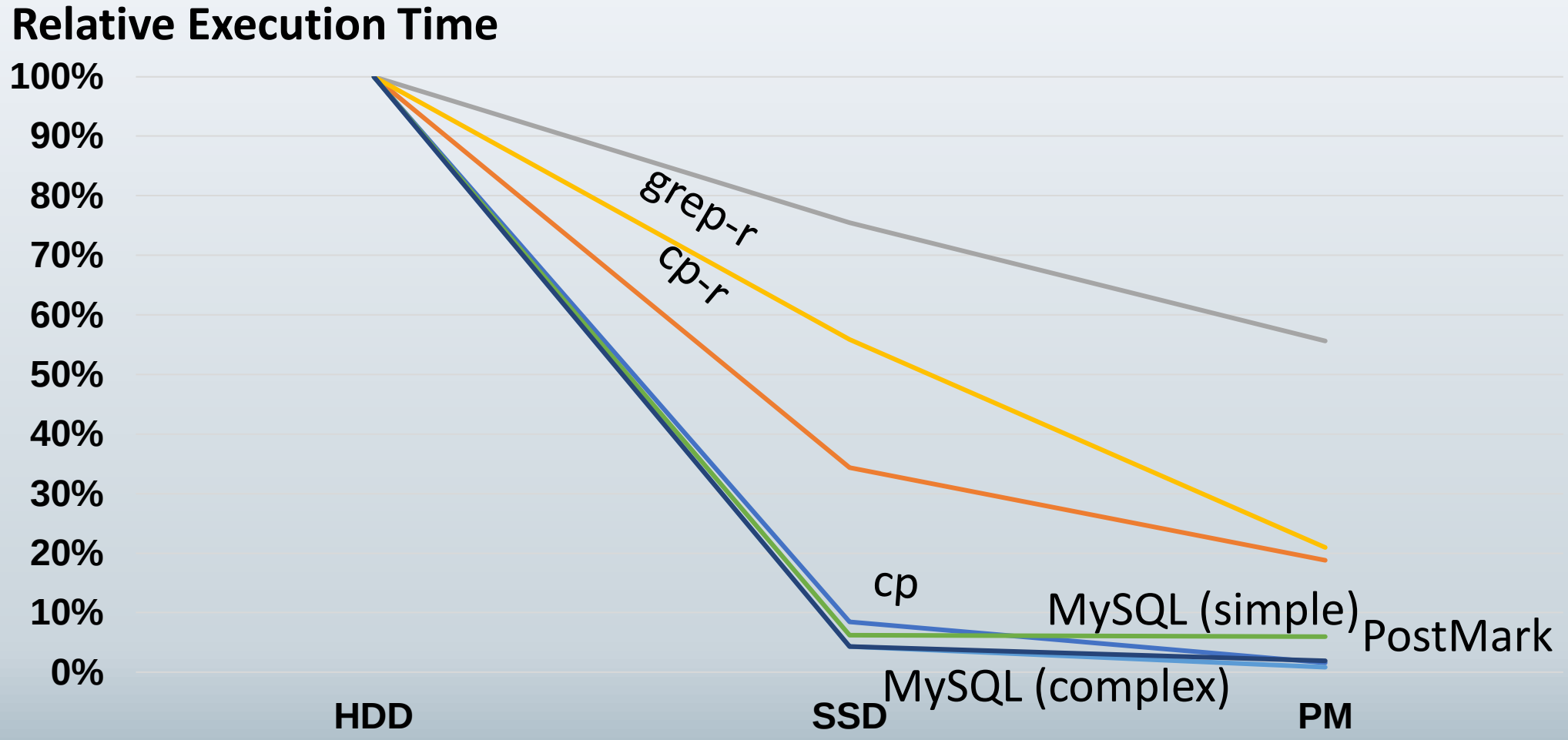
- Energy consumption
- Faster transactions
- This provides significant value for data center and embedded system applications

Energy Savings from Persistence



Justin Meza *et al*, *A Case for Efficient Hardware/Software Cooperative Management of Storage and Memory*

Speed-Up from Persistence (For HUGI)



Justin Meza *et al*, ***A Case for Efficient Hardware/Software Cooperative Management of Storage and Memory***

Intermittent Data Centers

Image from Lancium

Maximize Sleep

More Sleep = Lower Energy

- Going in / out of sleep burns energy
  - Mostly storing / reloading RAM
- Only sleep when:

$$EnergySavings_{Sleep} > EnergyCost_{LoadStore}$$

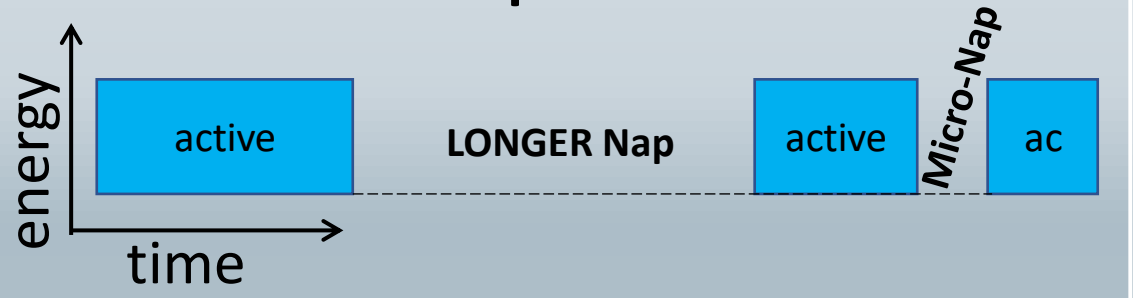
➔ Limits sleep to few, long periods

Conventional Sleep by Storing SRAM

Using Persistent Memory instead of RAM:

- Simply power memory off!
- Eliminates store/reload energy cost
- Enables frequent "Micro-Naps"
  - Save significant additional energy

PM Sleep Potential



Jeff Lewis, Spin Memory Presentation, 2019 MRAM Developers Day

Advantages for Embedded Electronics

All images from Wikimedia Commons

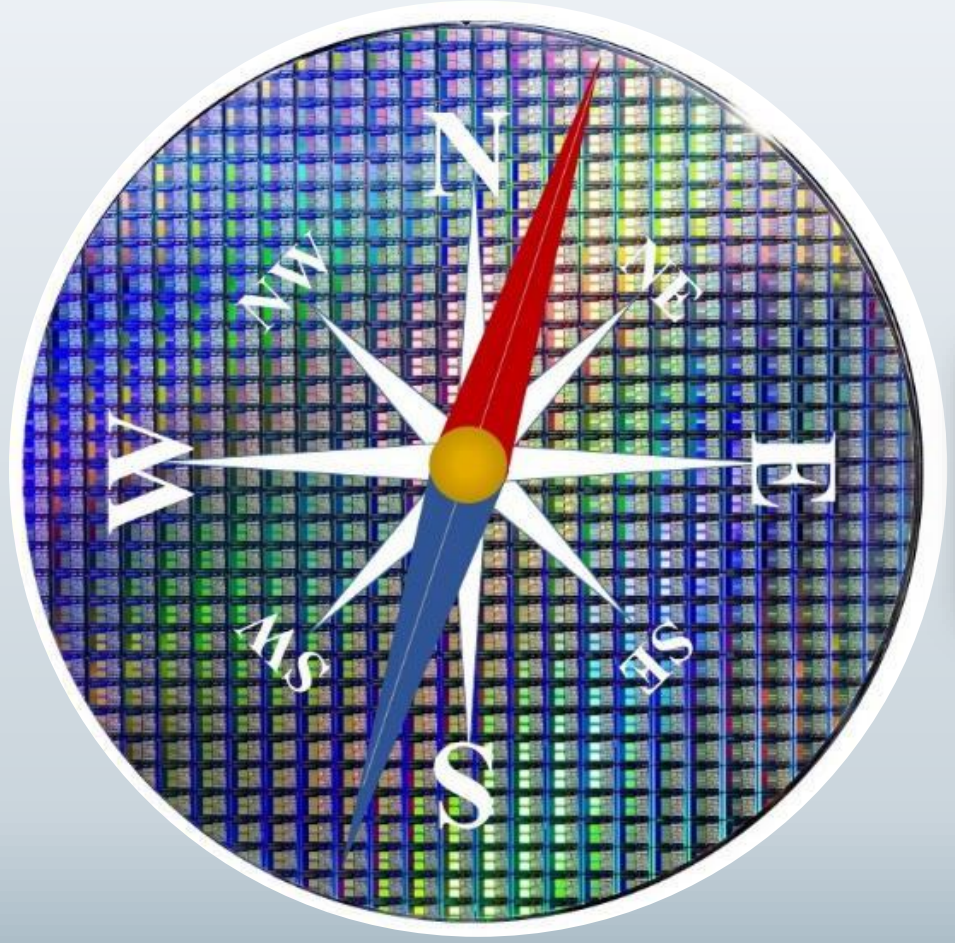
Persistent Caches Need Development Support

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

After That, Expect Persistent Registers!

New Report:
Emerging Memories Find Their Direction

OBJECTIVE ANALYSIS
Semiconductor Market Research



Coughlin Associates

Now Available!

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

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Summary

- SSDs provide faster performance, lowing power use
- Persistent memory offers additional energy savings
- Persistent caches are on their way
  - Persistent registers will follow
- Persistent Memory will decrease energy demand in industrial, civic and consumer applications
- Buy our report!