



The Memory Compression Opportunity for Solid State Drives

January 2020
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The Memory Compression Opportunity for Solid State Drives

- Real time data compression is already used in parts of the storage hierarchy, but is not widely available embedded in SSDs yet
- Real time memory compression in SSDs will:
 - Increase effective overprovisioning
 - Reduce write amplification
- Which result in the benefits:
 - Increased endurance and performance
 - Increased memory capacity
- ZeroPoint Technologies offer a real time memory compression technology that deliver high compressibility, high performance and low latency
- The case for compression becomes even stronger when going from TLC to QLC (quad level) NAND flash technology

Improving SSD endurance

- SSD endurance can be improved with three main technologies:
 - Error correction – ECC
 - Overprovisioning
 - Firmware
- Advanced error correction techniques can help retrieve data from even marginal flash cells and can dramatically extend the NAND cell's usable lifetime
- Overprovisioning adds additional flash capacity to the SSD. This additional flash is not visible to the user, but it is visible to the drive and used to enhance endurance by allowing for more efficient data management
- Finally, the firmware, can intelligently manage the flash inside of the SSD. The more experience a company has with end-user workloads and the flash, itself, the more intelligence it can embed in this firmware to maximize endurance

Compressibility opportunity

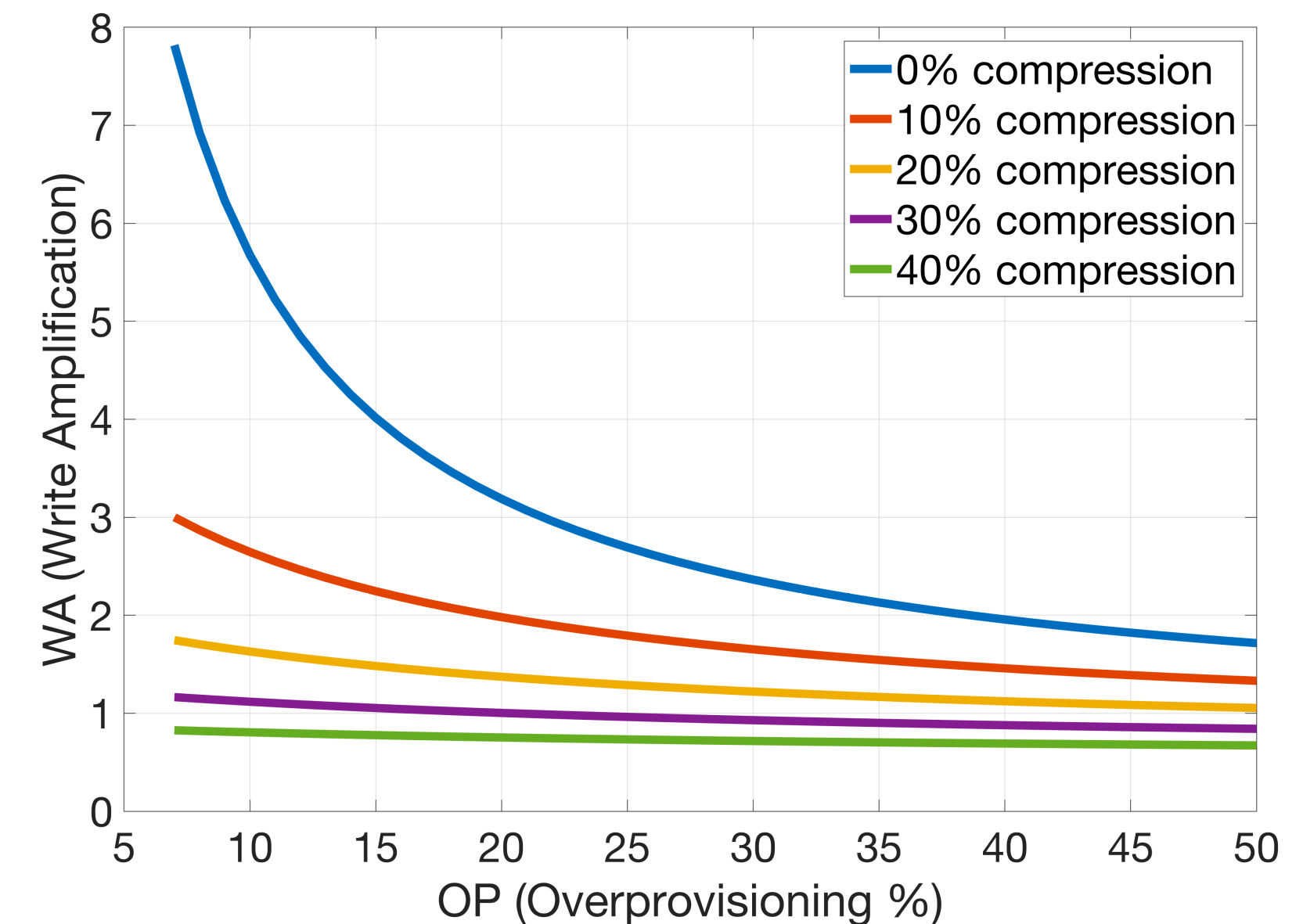
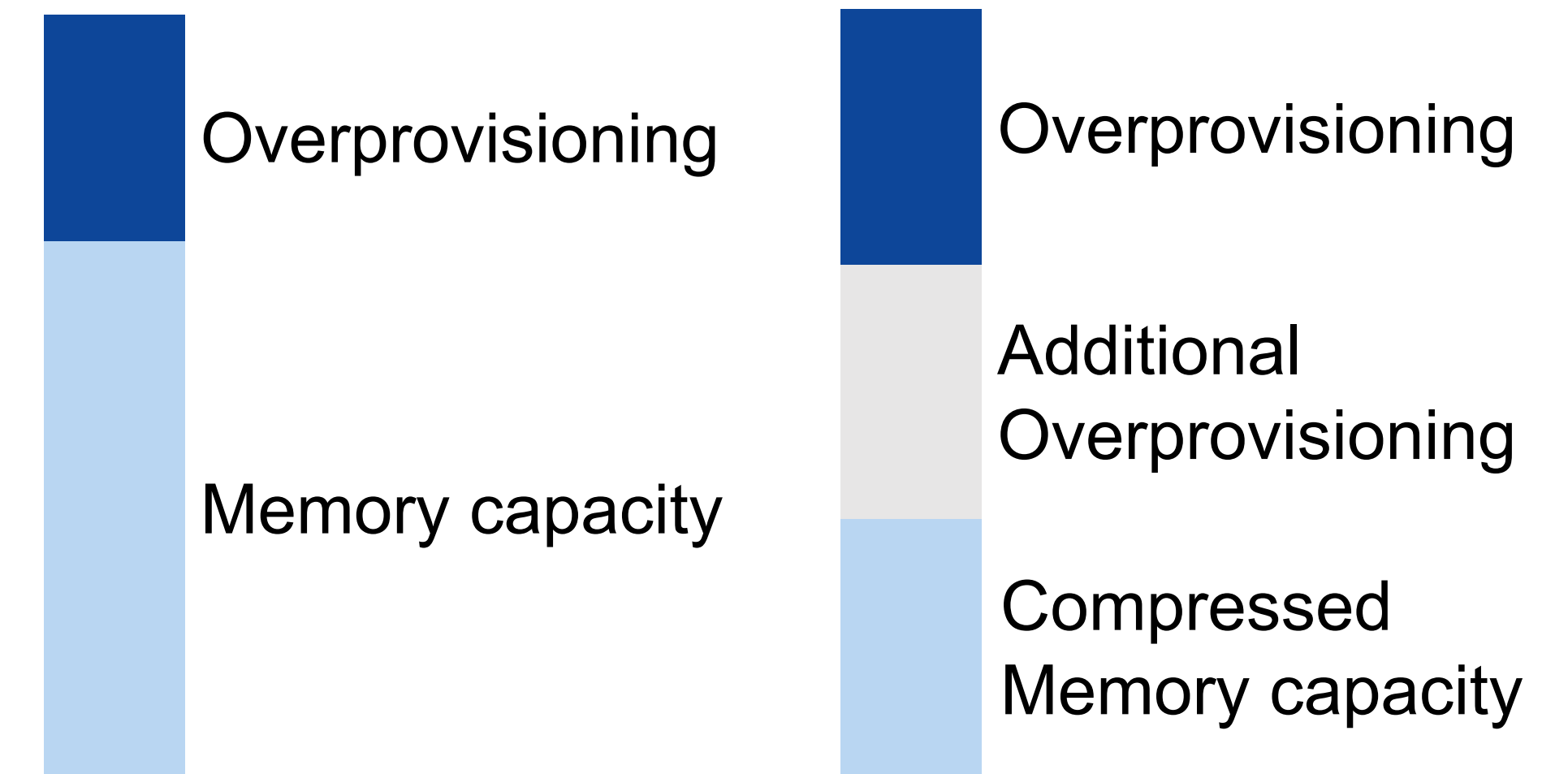
- Data bases, OS files and application data are typically highly compressible
- Media files are typically well compressed by standard format

Compression algorithm	MySQL	Oracle	Windows	Linux VM
gzip	60%	70%	50%	60%

(Compressibility = (1 – OutBytes / InBytes) 100%)*

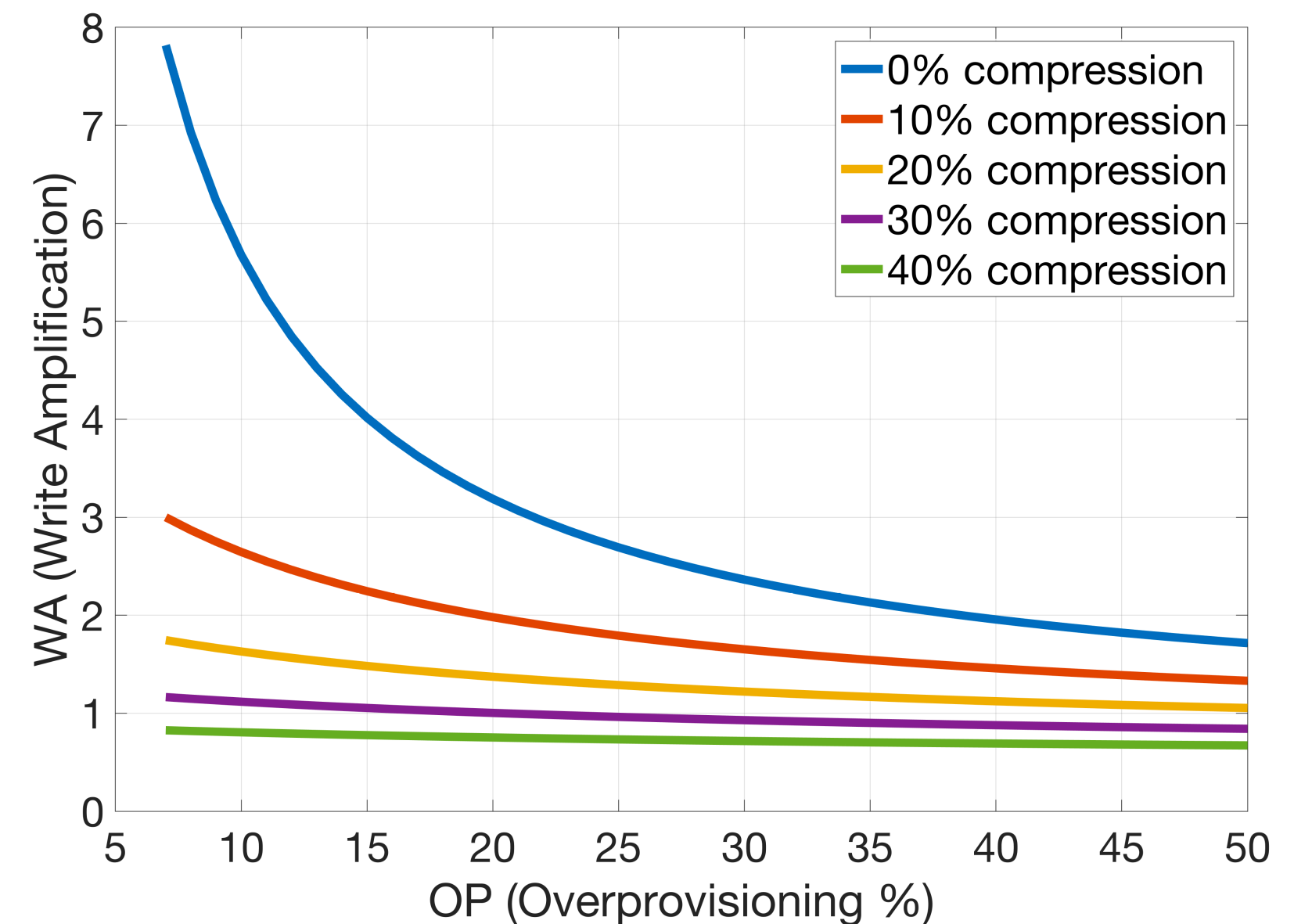
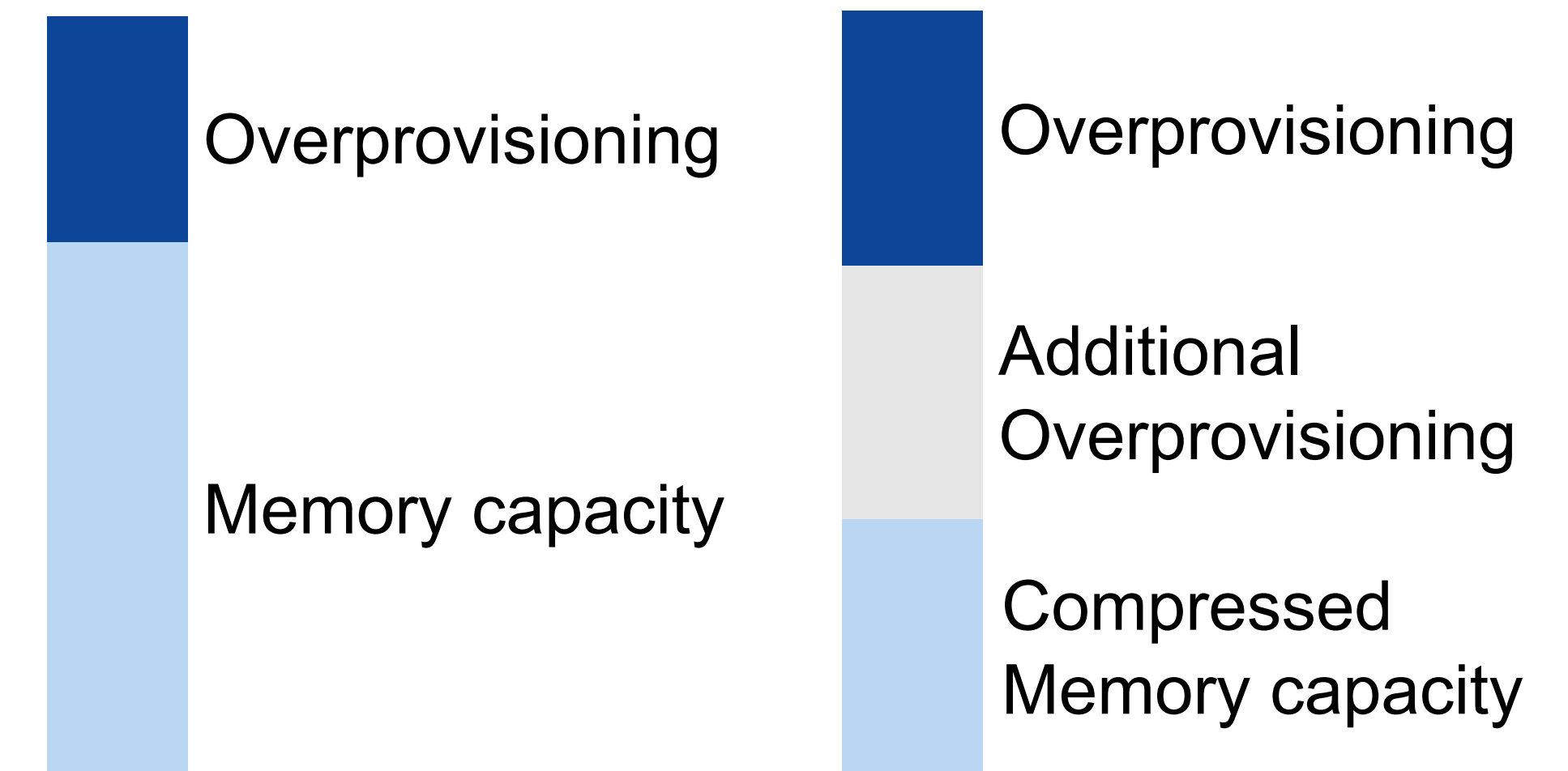
Memory Compression Opportunity for Overprovisioning

- Memory capacity remains unchanged
- Memory compression increase available Overprovisioning capacity
- Compression effect:
 - Reduces amount of data written and amount of write amplification and therefore...
 - Increases endurance
 - Increases performance
 - Increases random write and mixed read/write performance



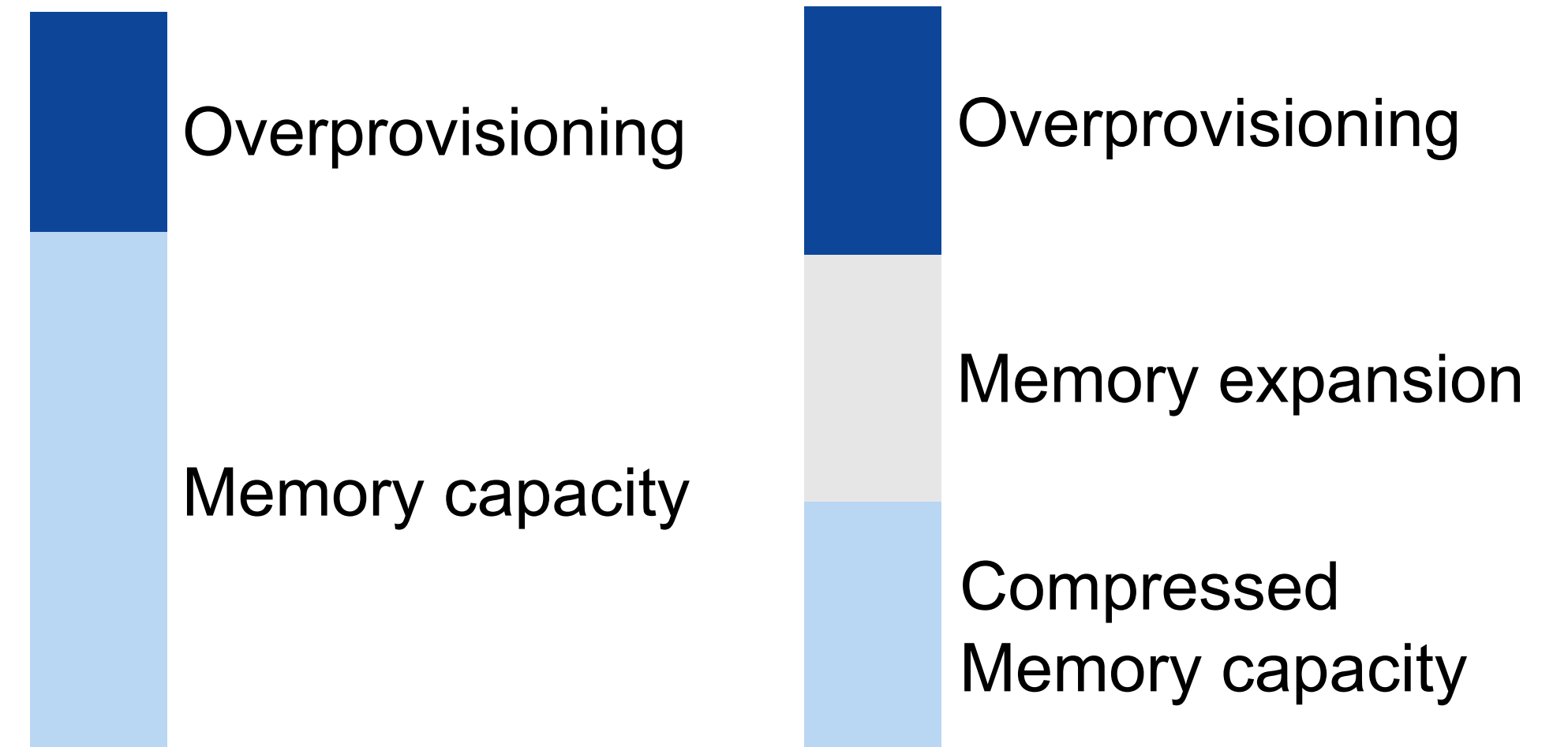
Memory Compression Opportunity for QLC

- The utility of data compression is strengthened with QLC (quad level) NAND flash technology
- QLC have 33% greater capacity than today's TLC triple cell flash but endurance and performance is worse. This is because reading and writing the extra bit per cell is slower and wears out the drive more quickly.
- Endurance and performance can be significantly improved with SSD embedded compression technology and make QLC more attractive for data center applications



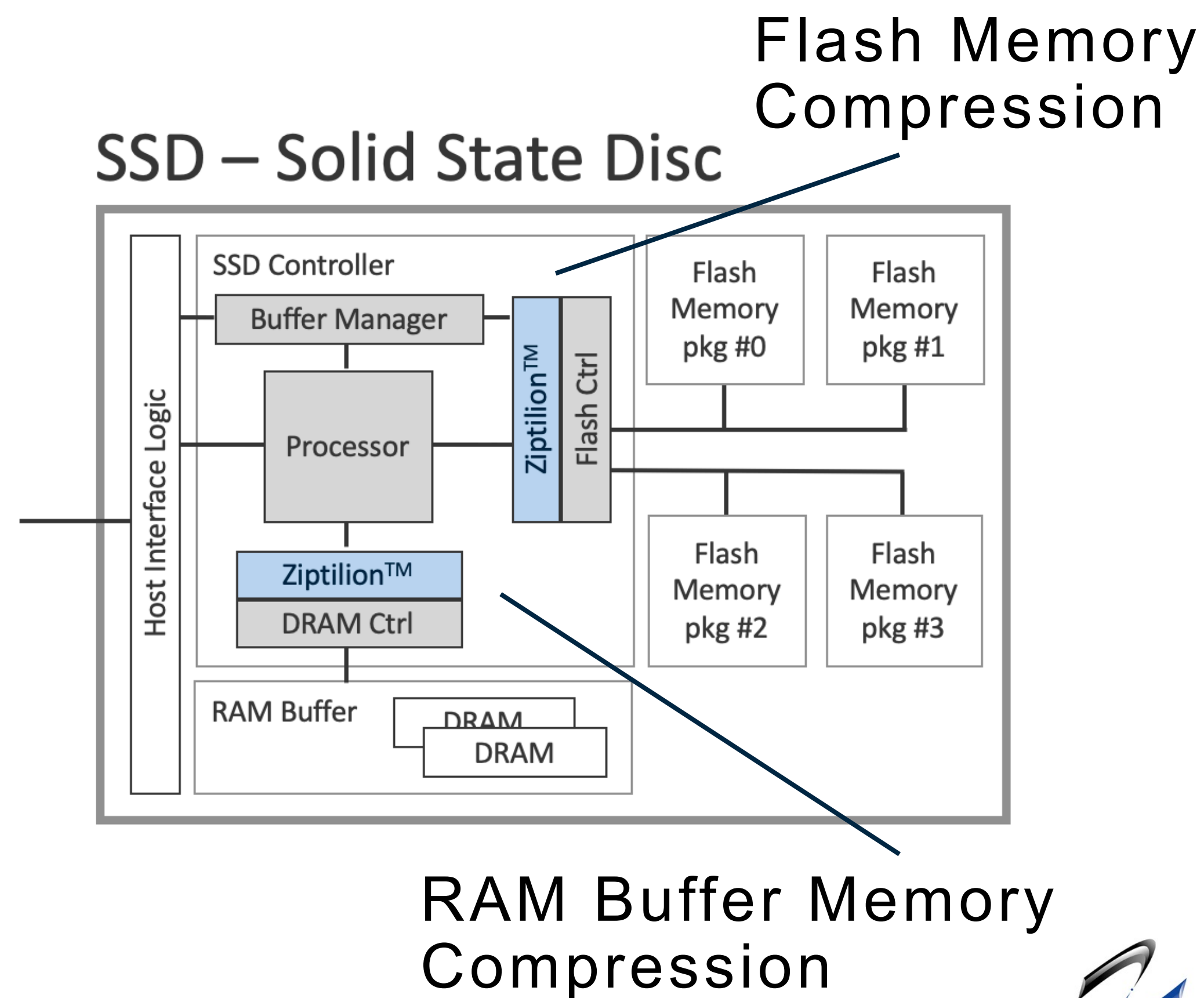
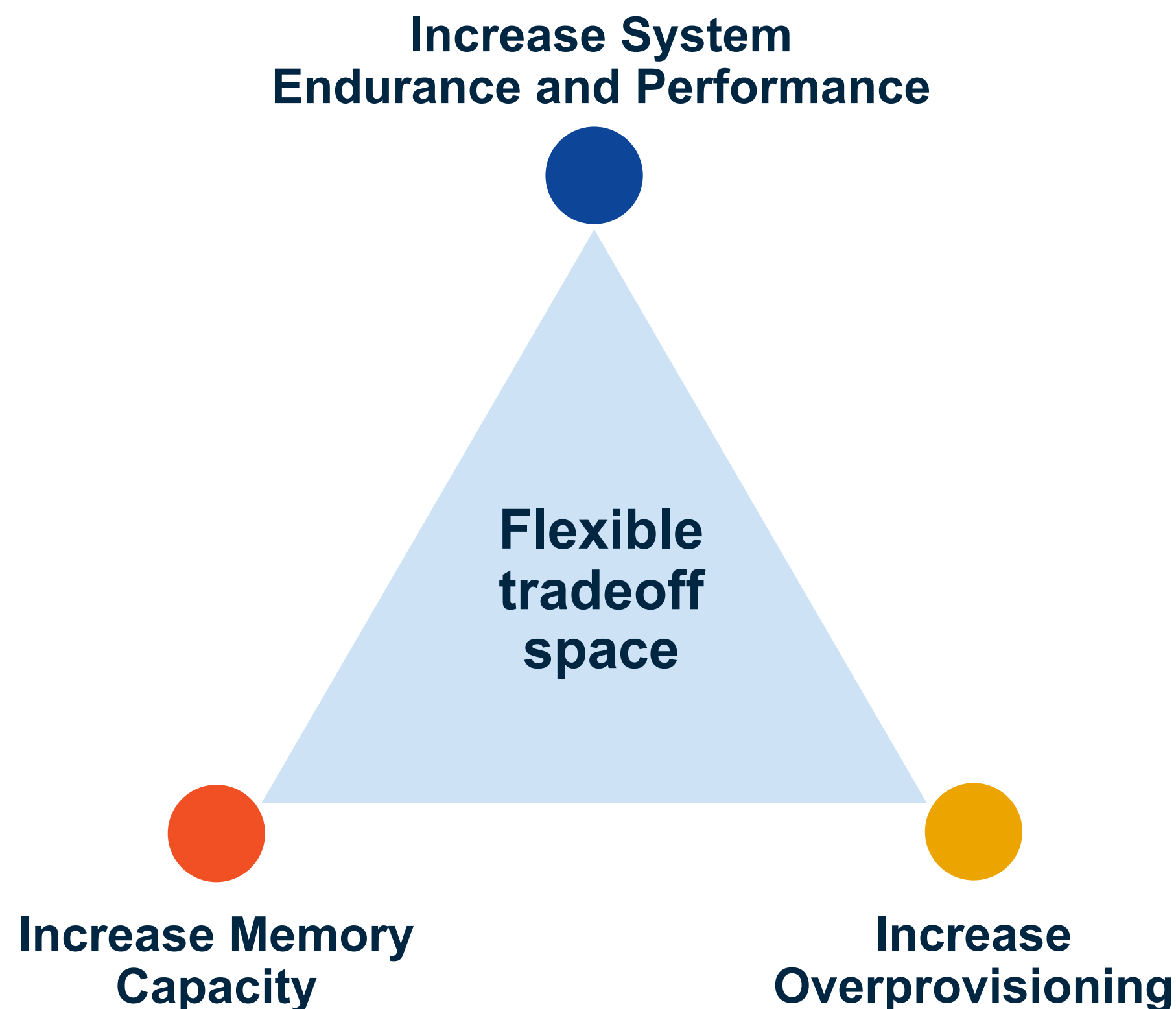
Memory Compression Opportunity for Increased Memory Capacity

- Memory compression expand available memory capacity
- Memory capacity expands based on data compressibility
- The memory expansion capacity is reported to host



Boost SSD Endurance and Performance with Ziptilion™

Ziptilion™ is our HW IP core and SW driver that enables Real Time Memory Compression

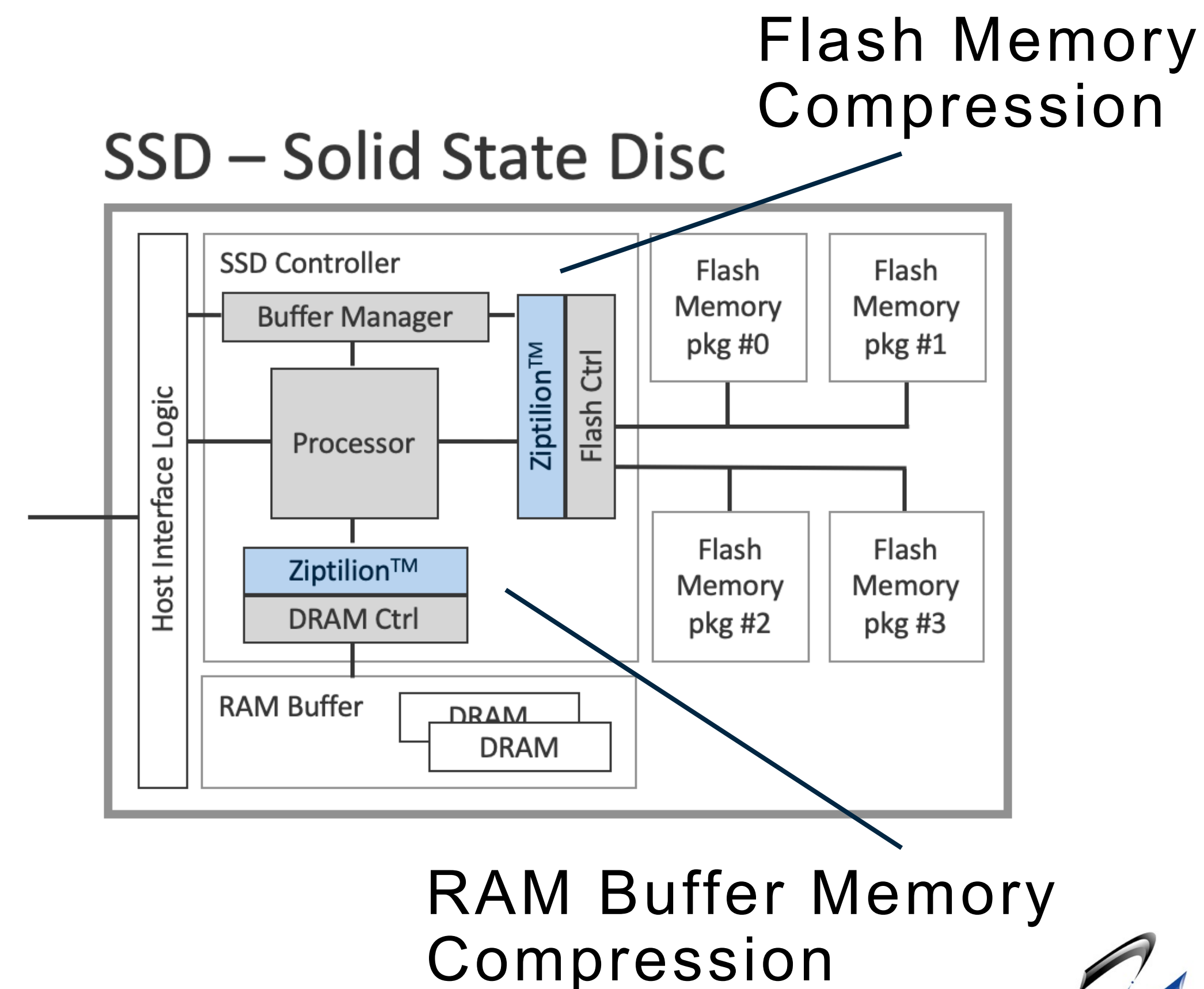


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Requirements

Compression algorithm needs to be lossless	YES
Compression needs to run inline at full data rate: low impact to write and read latencies	YES
Compression needs to be done before encryption and ECC encoding	YES
Bypass compression if data is incompressible	YES



Ziptilion™ Memory Compression Technology Overview

Best in class Algorithms

- Product protected by 10 patents
- General purpose lossless compression
- Intelligent compression – Realtime data analysis

Efficient Implementation

- Fast – At memory speed
- Small footprint
- Transparent to operating system and application

Performance

- Overprovisioning – 2-3x Memory compression
- Memory capacity – 2-3x Memory expansion
- Bandwidth – More than 30% reduction of memory traffic
- Cost – 50% lower memory cost

The opportunity of SSD embedded compression

- General SSD opportunities
 - Increase effective overprovisioning
 - Increase endurance and performance
 - Increase memory capacity
 - Reduce write amplification
- QLC SSD specific opportunities
 - QLC NAND media typically has low endurance and performance characteristics compared to TLC
 - With SSD embedded compression technology, QLC can be more attractive for data center when Memory Compression improve the poorer QLC characteristics to TLC



We license Real time Memory Compression Cores for Solid State Drives

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 858498.