



Western Digital®

Zoned Storage for the Zettabyte Age

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Sr. Director Data Center

24th of October 2019

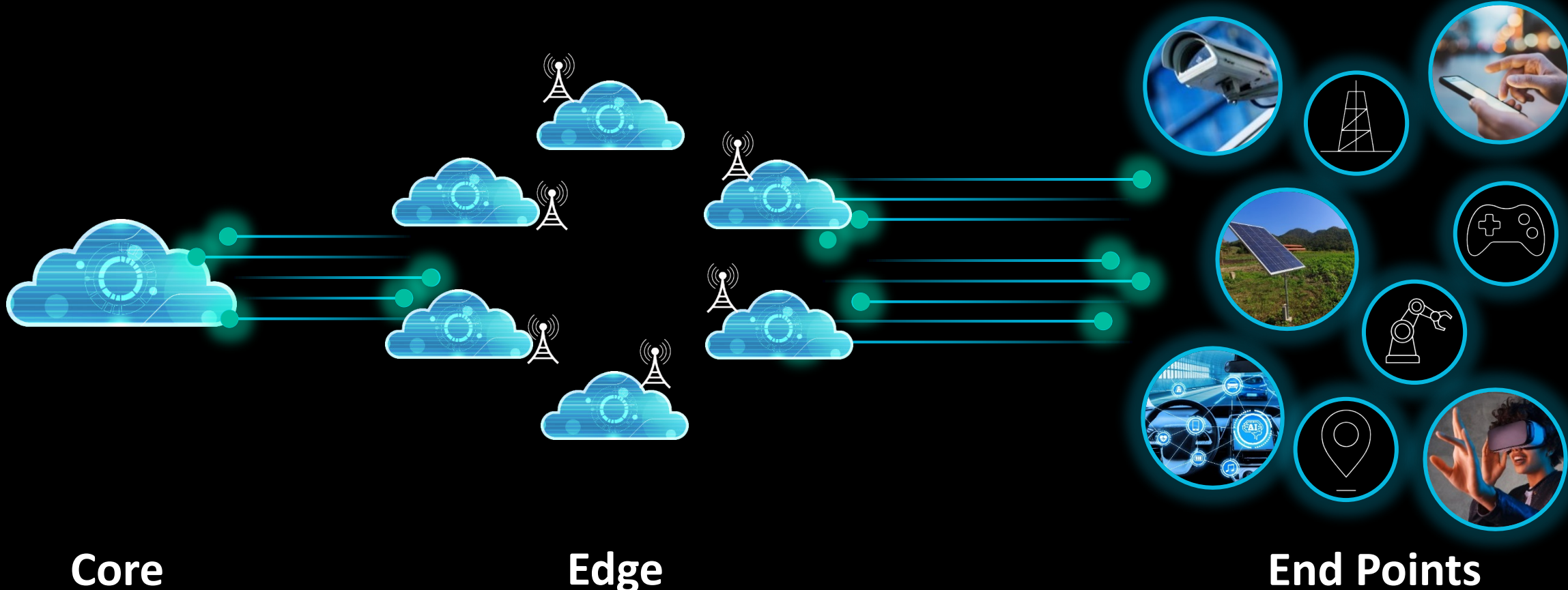
Forward-looking Statements

Safe Harbor | Disclaimers

This presentation contains forward-looking statements that involve risks and uncertainties, including, but not limited to, statements regarding our product and technology portfolio; business strategies and growth opportunities; capital expenditures; and market and data storage industry trends. Forward-looking statements should not be read as a guarantee of future performance or results, and will not necessarily be accurate indications of the times at, or by, which such performance or results will be achieved, if at all. Forward-looking statements are subject to risks and uncertainties that could cause actual performance or results to differ materially from those expressed in or suggested by the forward-looking statements.

Key risks and uncertainties include volatility in global economic conditions; business conditions and growth in the storage ecosystem; impact of restructuring activities and cost saving initiatives; impact of competitive products and pricing; market acceptance and cost of commodity materials and specialized product components; actions by competitors; unexpected advances in competing technologies; our development and introduction of products based on new technologies and expansion into new data storage markets; risks associated with acquisitions, mergers and joint ventures; difficulties or delays in manufacturing; the outcome of legal proceedings; and other risks and uncertainties listed in the company's filings with the Securities and Exchange Commission (the "SEC") and available on the SEC's website at www.sec.gov, including our most recently filed periodic report, to which your attention is directed. We do not undertake any obligation to publicly update or revise any forward-looking statement, whether as a result of new information, future developments or otherwise, except as required by law.

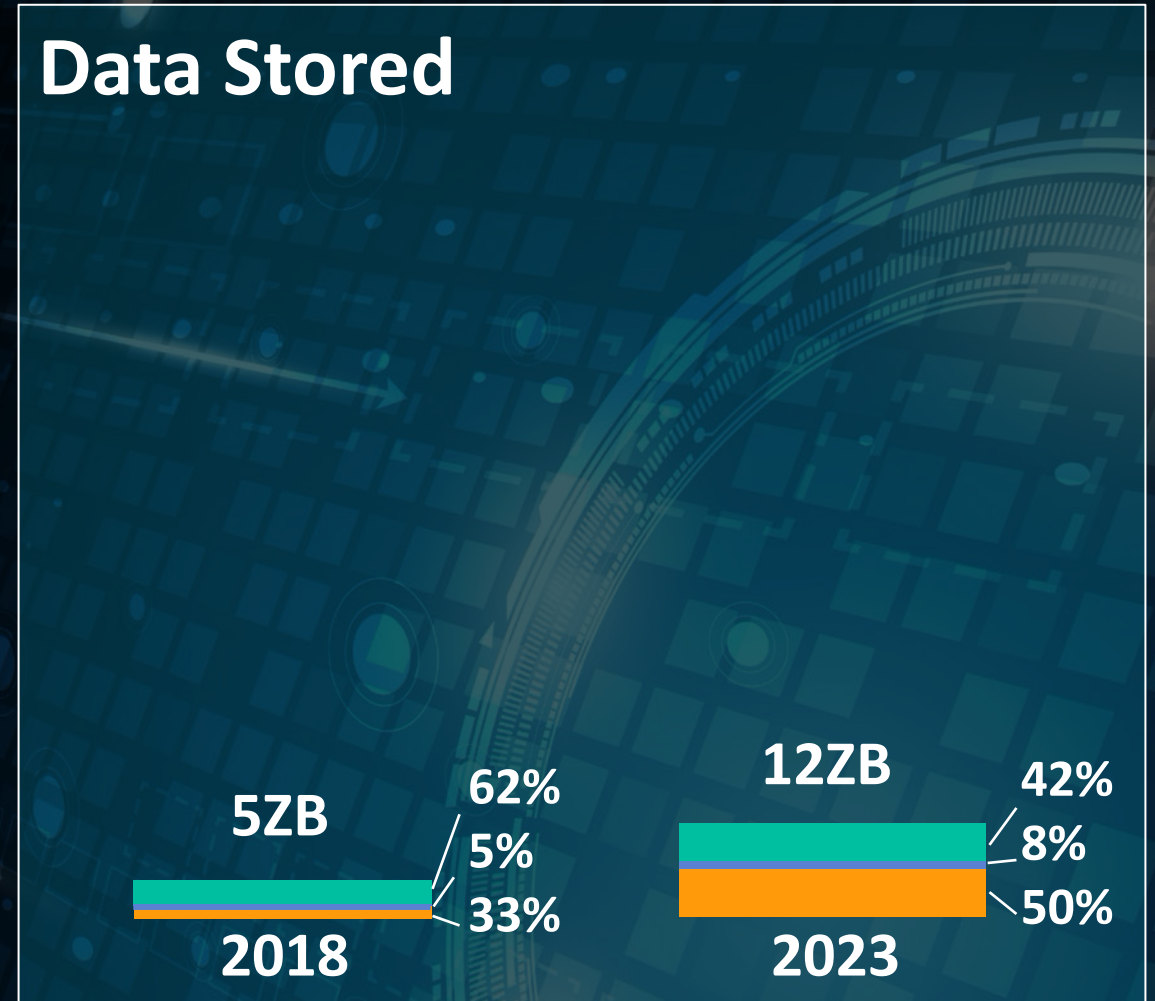
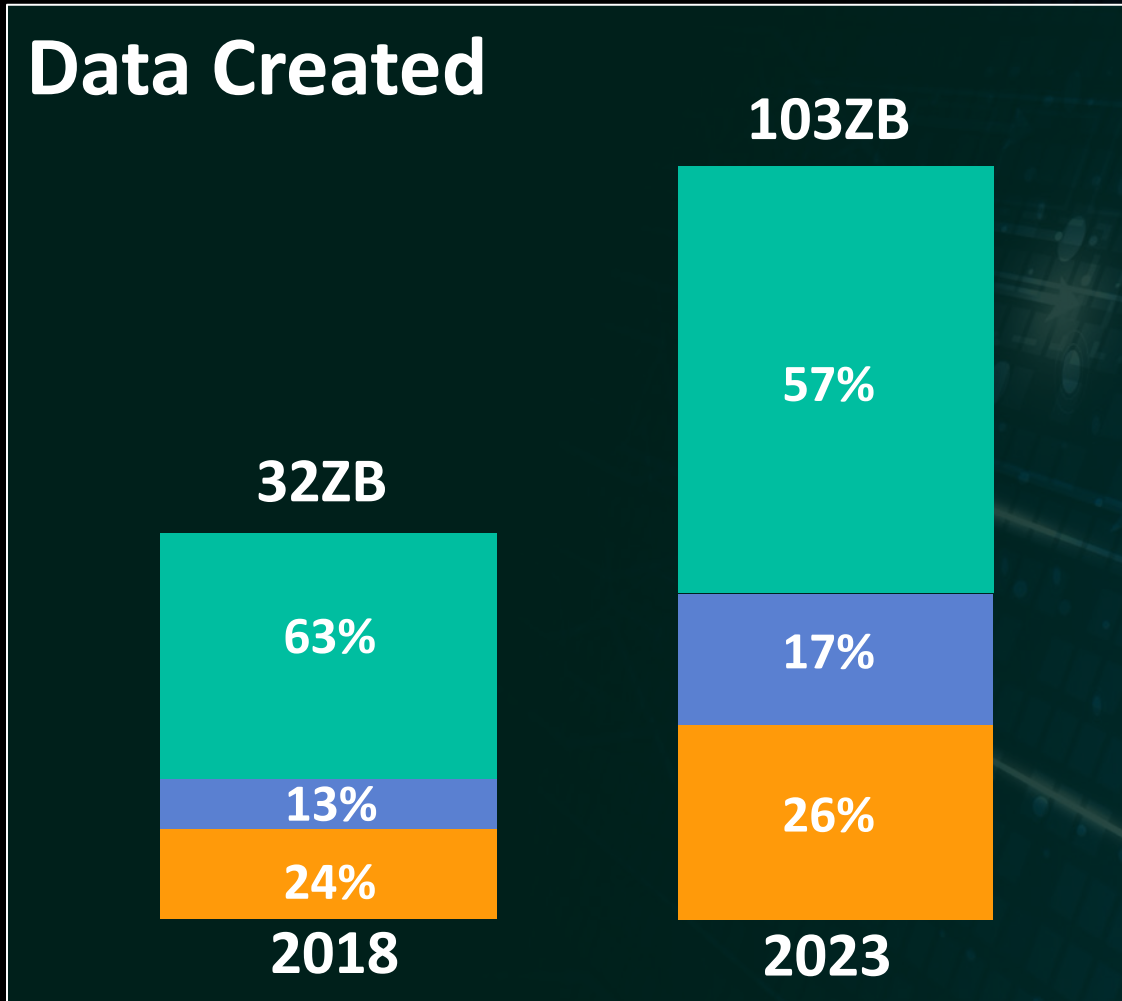
Cloudy with a Chance of More Data



By 2023, >90% of data created will be generated by machines

Source: Applied Materials, SEMICON West, AI Design Forum, July 2019

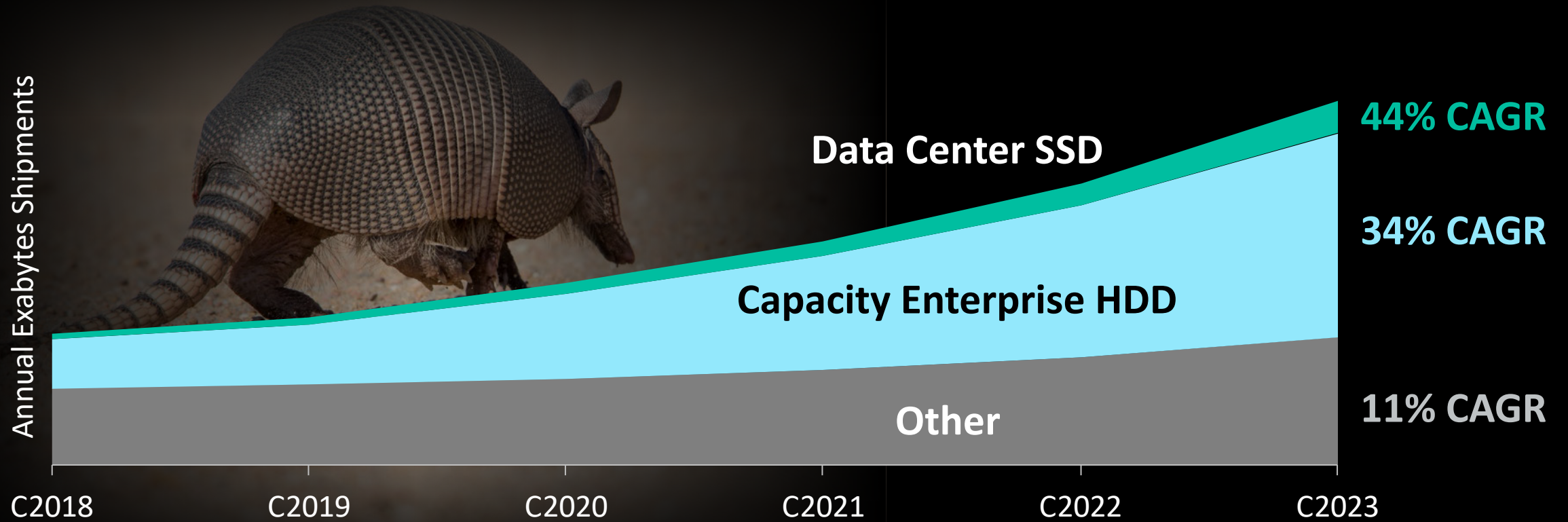
'There's Gold in Them Thar' Bits



Core Edge Endpoint

Sources: 1) IDC Global DataSphere Forecast, 2019-2023: Consumer Dependence on the Enterprise Widening, January 2019, DOC #US44615319; 2) IDC, Worldwide Global StorageSphere Installed Base Forecast, 2019-2023: The Global StorageSphere Installed Base by Core, Edge, and Endpoint, April, 2019, DOC #US45009319; Percentages and numbers approximate, rounded off to whole number

Storage Darwinism



Don't Scale, Don't Survive!

Source: Western Digital

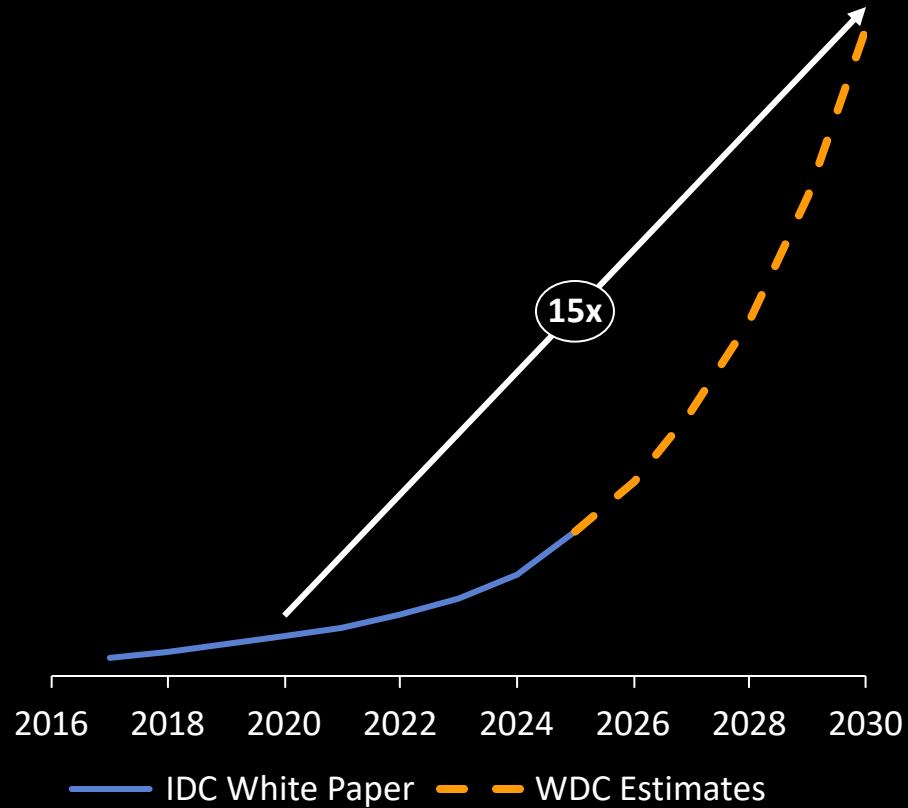
What's the Total Data Growth Factor in the next decade (2020 – 2030)?

- 1) 5x
- 2) 7x
- 3) 10x
- 4) 15x

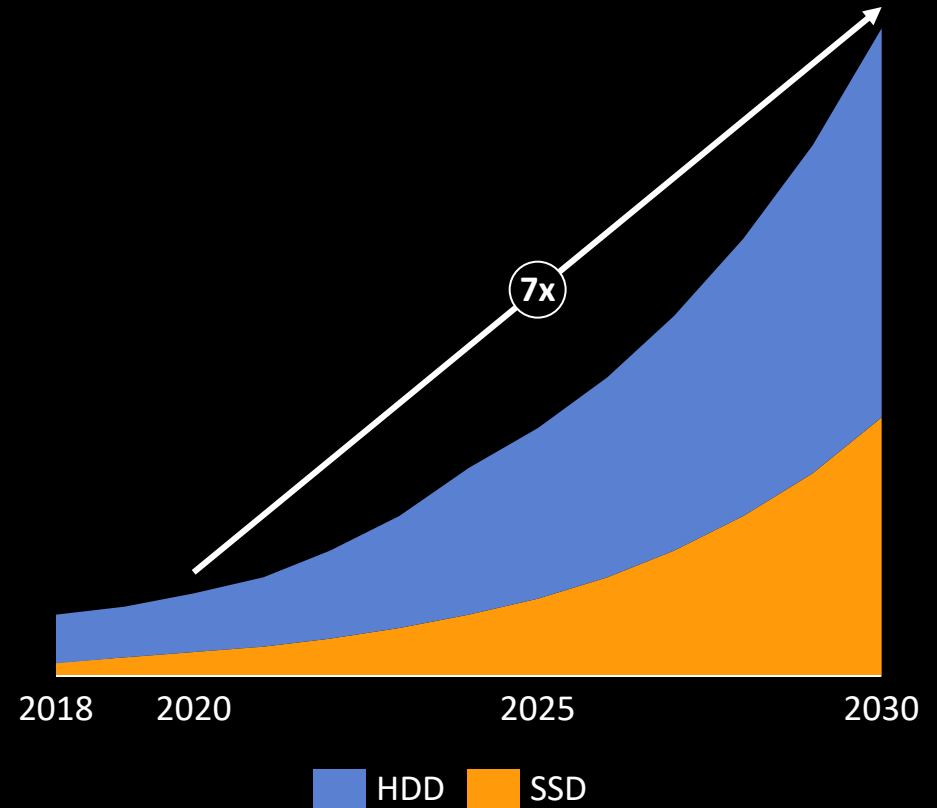
Insatiable Growth in Data

Driven By Explosion in Big Data Analytics & Machine-Learning

Data Creation ^{[1][2]}



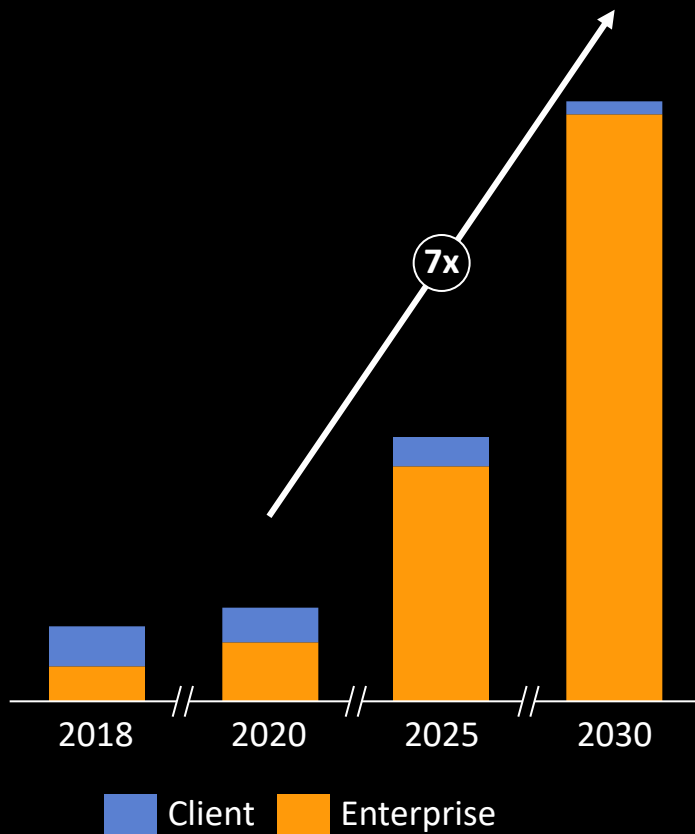
EB Annual Shipments ^[2]



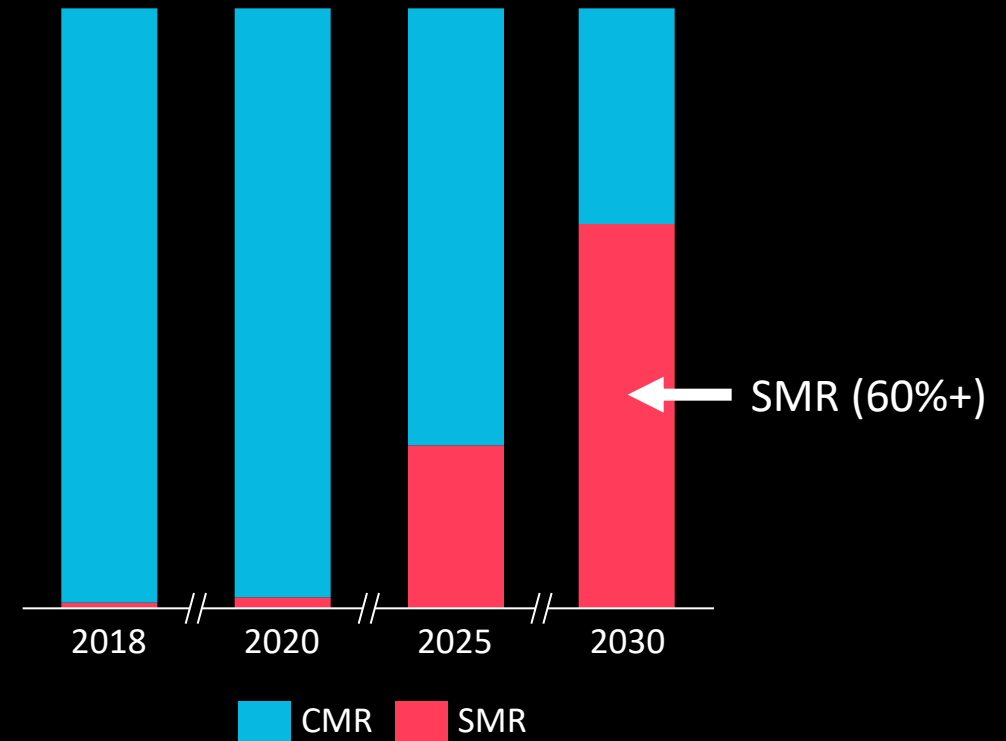
HDD Long term external estimate

Expecting large share of Capacity HDD growth to be in SMR

EB



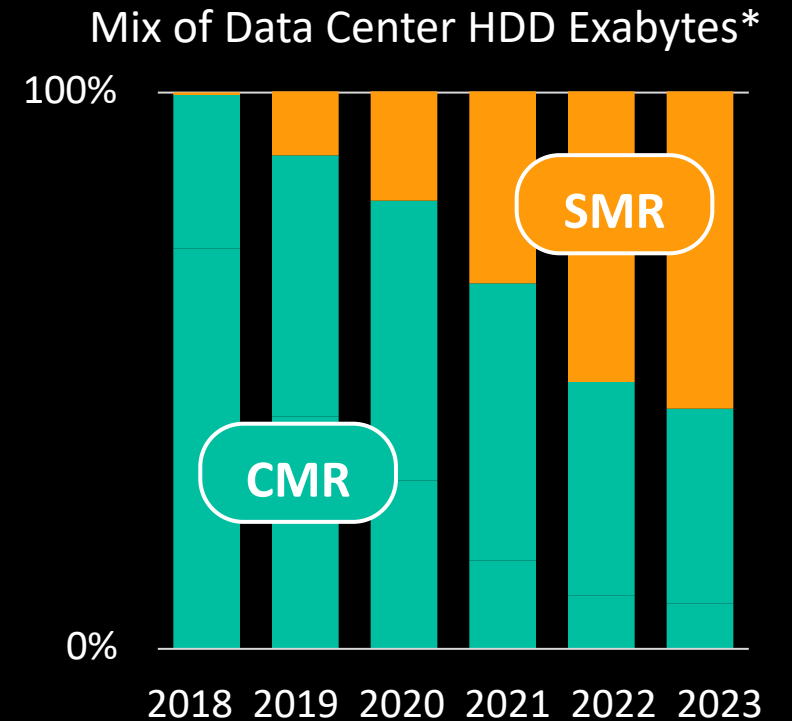
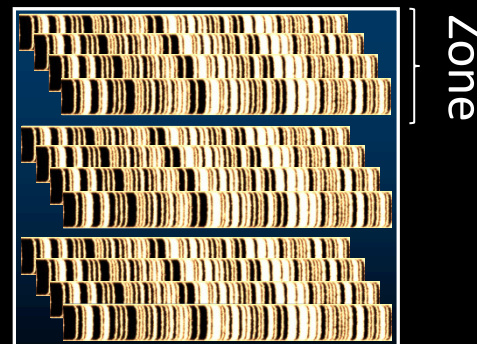
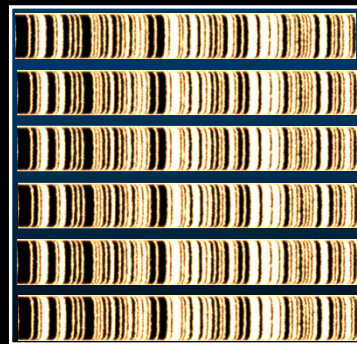
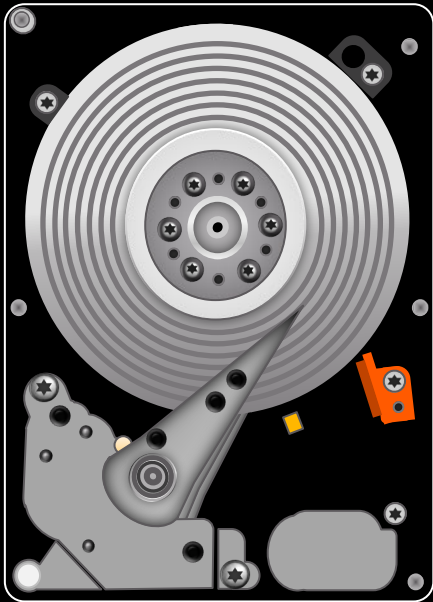
EB Enterprise Mix



What is SMR?

Shingled Magnetic Recording (SMR) and HDD scaling

- Scale physically by adding disks, enlarging disks, and narrowing tracks
- Scales “logically” by shingling more tracks per zone
- SMR ecosystem enables access to highest capacities



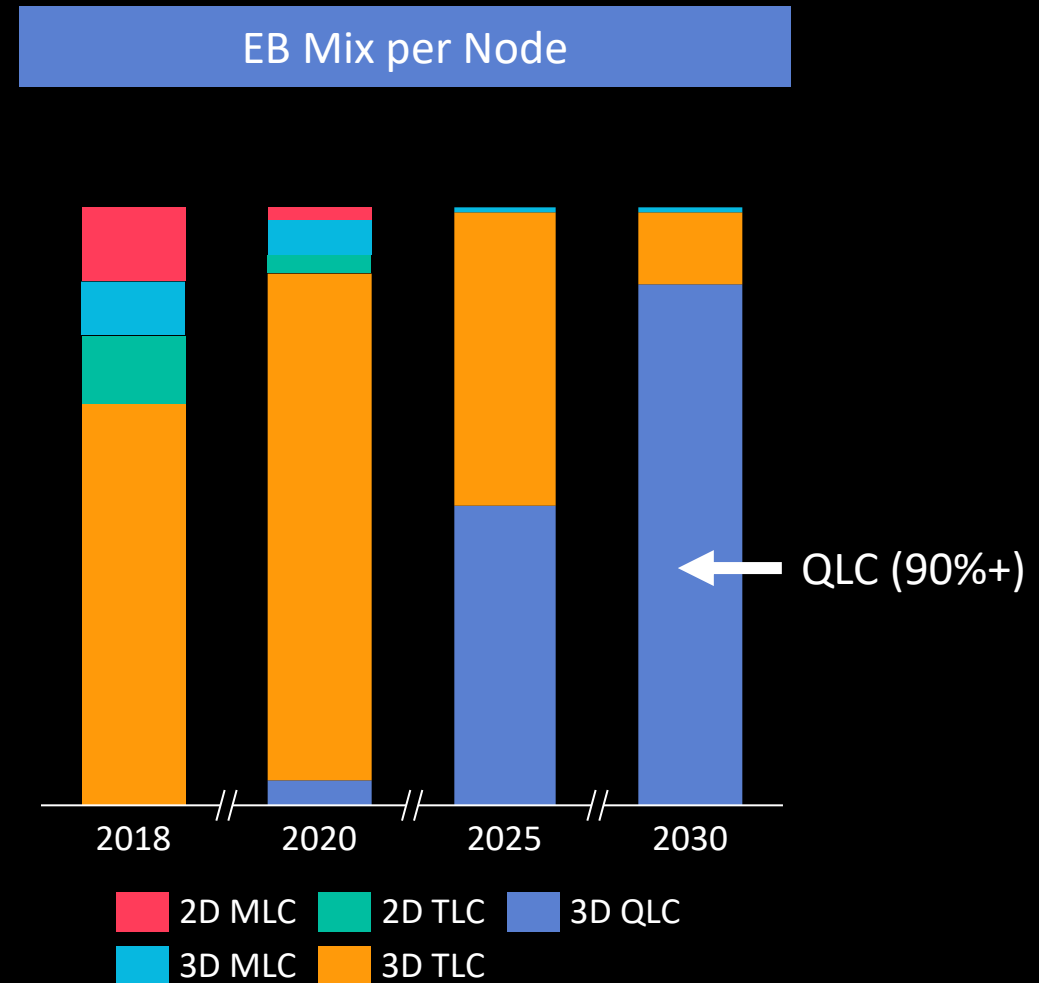
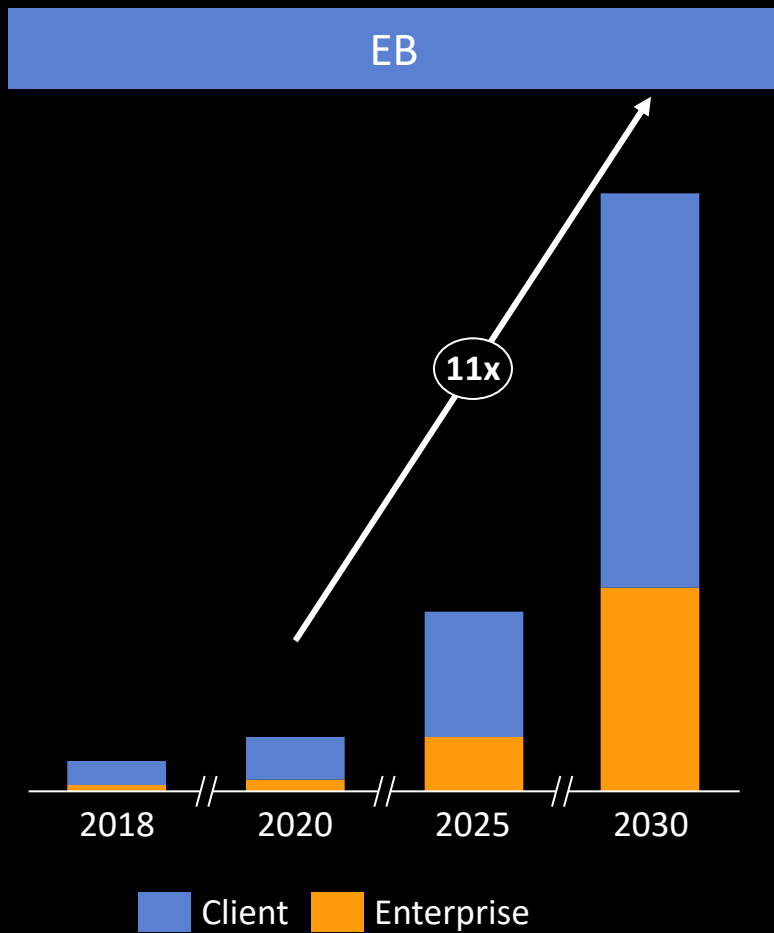
* Source: Western Digital internal modeling data , February /April 2019

What's the Data Growth Factor in the next decade for FLASH (2020 – 2030)?

- 1) 7x
- 2) 11x
- 3) 13x
- 4) 15x

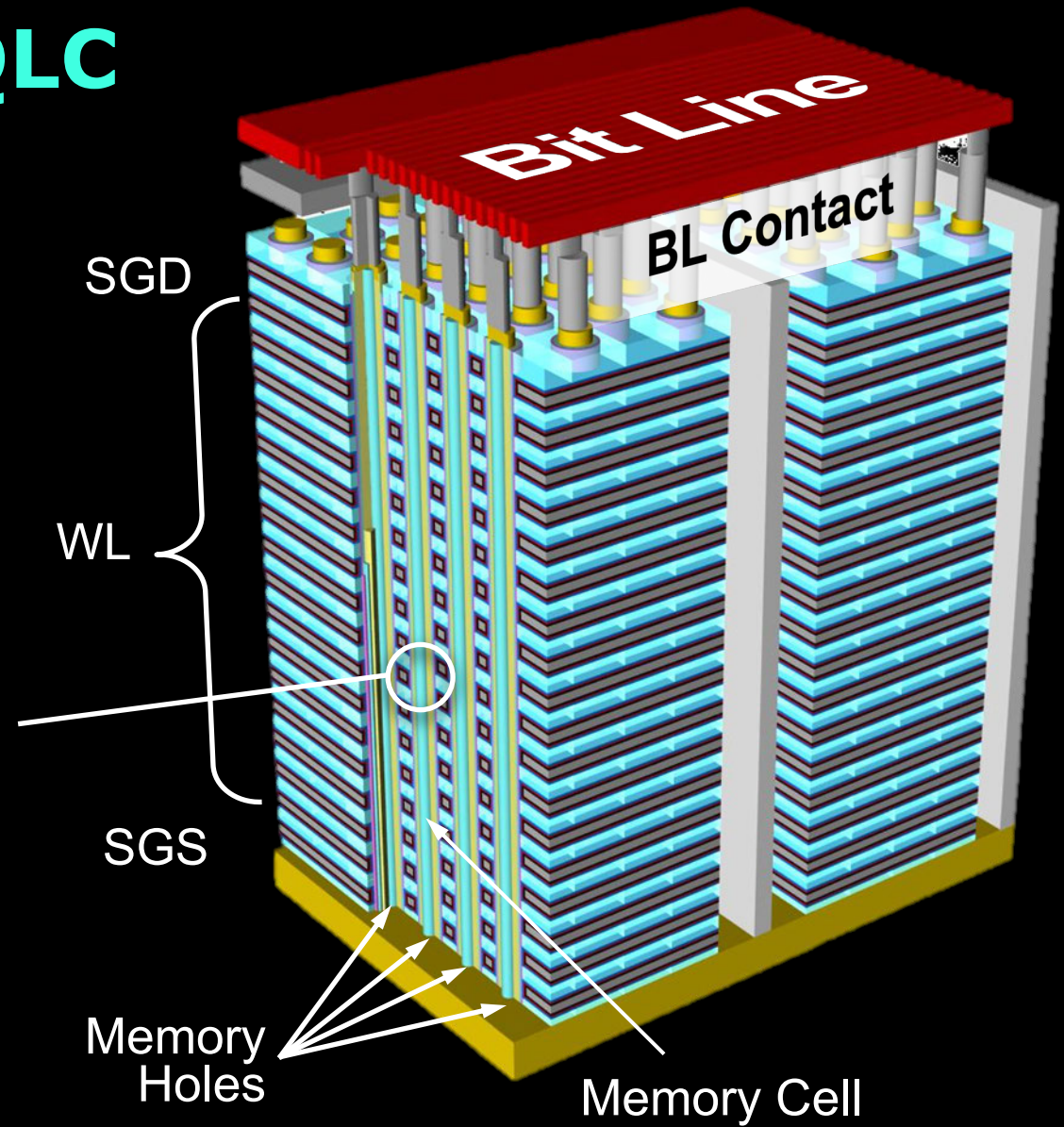
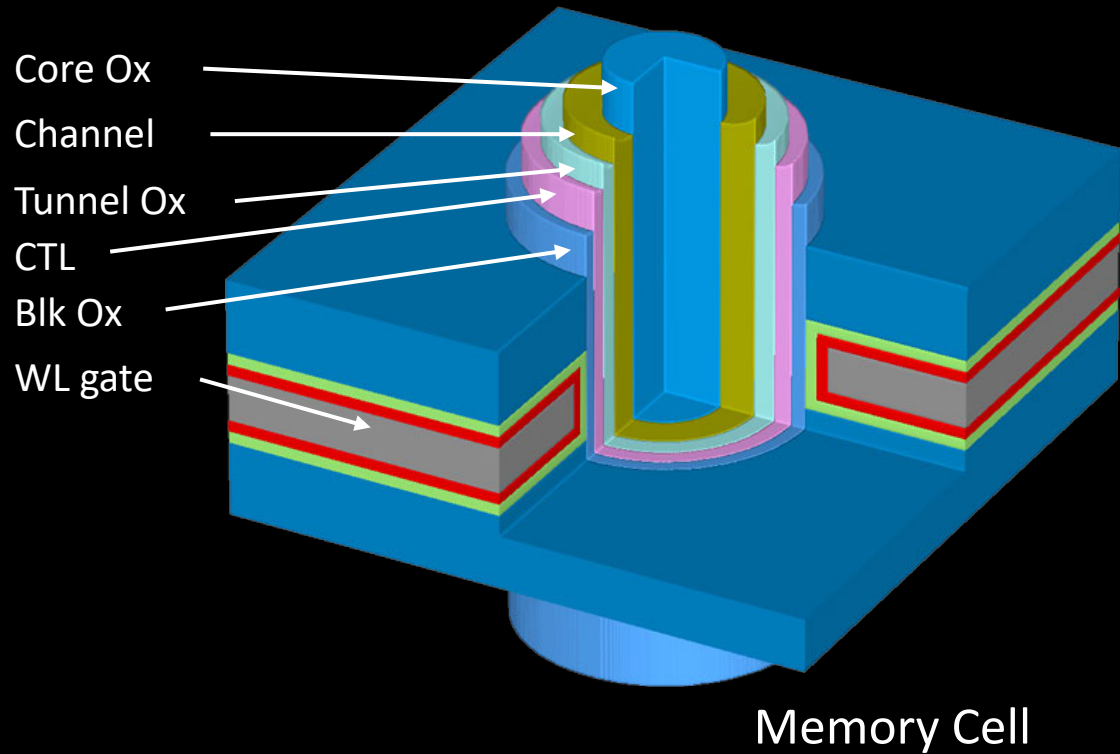
NAND Long term external estimate

Western Digital expects client storage to be addressed with NAND based products. Lower \$/GB cost enabled by higher layer count and QLC makes flash competitive in certain enterprise workloads.

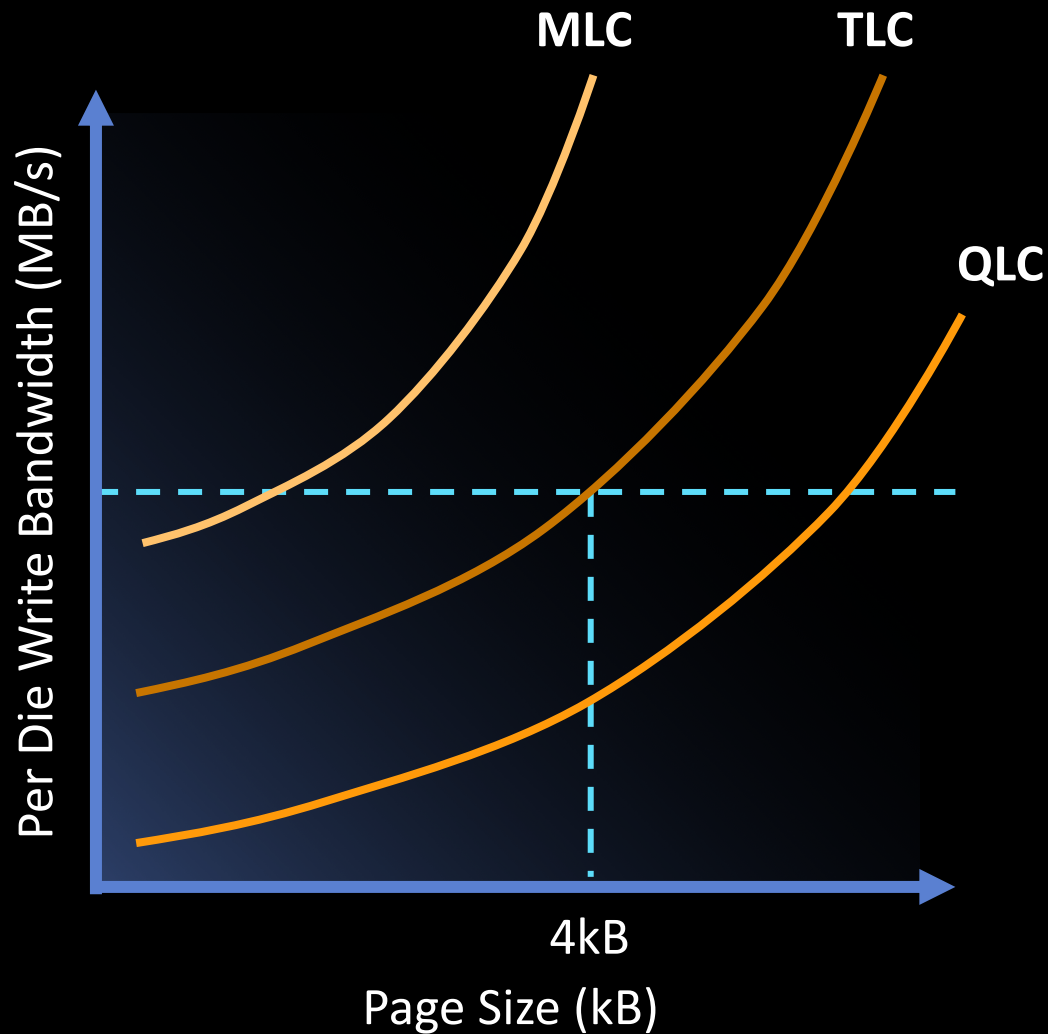


3D NAND Flash going QLC

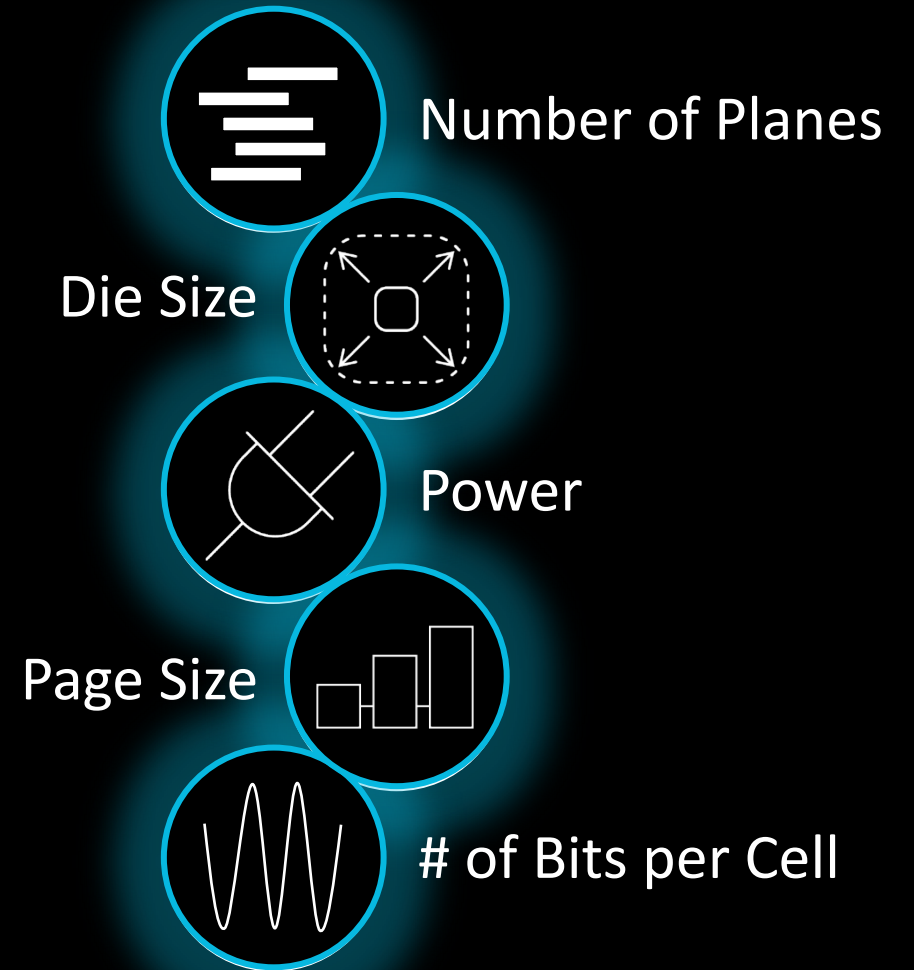
Industry trend: more layers, more bits per cell, optimization for either speed or cost.



'Something's Gotta Give'

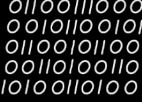





Design Parameters




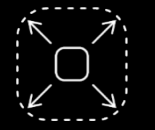


The Data Storage Approach for the Zettabyte Age

Is There a Problem?

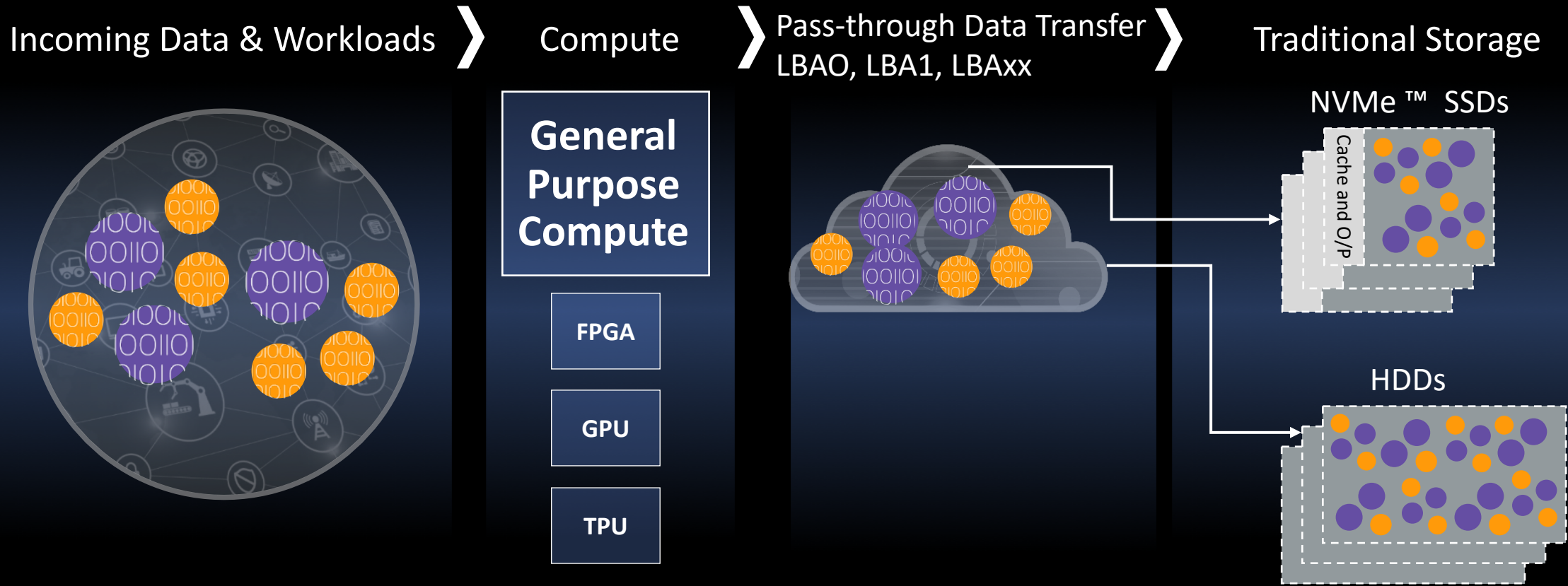
	QLC
 Enables scaling	✓
 Cost/TCO benefit	✓
 Great access/read performance	✓
 Write limitations	X

We Have Seen This Movie Before

	ZNS QLC	SMR HDD
 Enables scaling	✓	✓
 Cost/TCO benefit	✓	✓
 Great access/read performance	✓	✓
 Write limitations	✗	✗

Evolution of the Existing Data Center

Data growth powers the need for purpose-built solutions



Storage architectures must become purpose-built

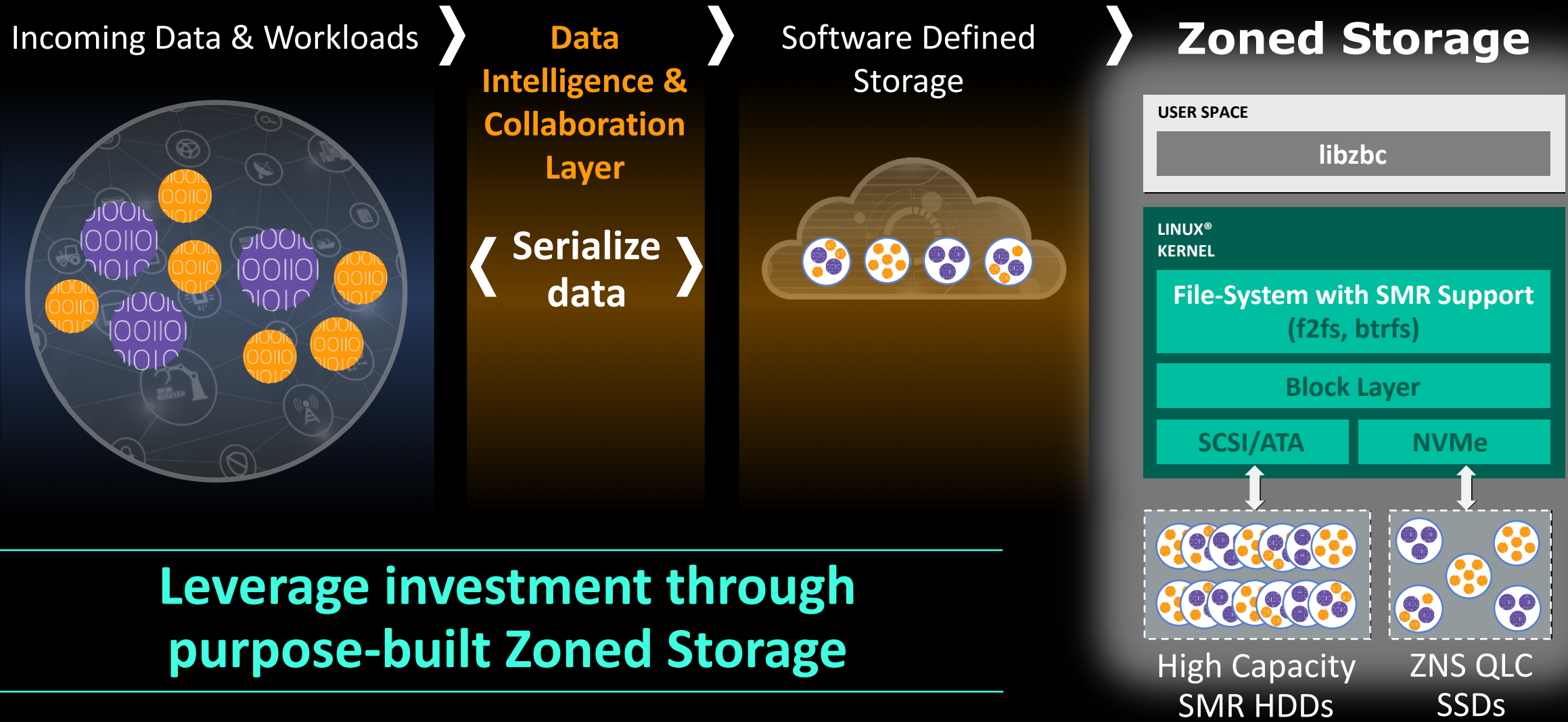


Zoned Storage

Data-Centric Architecture for the Zettabyte Age

Re-architecting for the Zettabyte Age

Zoned storage enables efficiency and intelligent data placement



Leverage investment through purpose-built Zoned Storage

Zoned Namespaces Enables Intelligent, Lean SSDs

ZNS provides host with system-level intelligence for data placement

Up to
8x
DRAM reduction

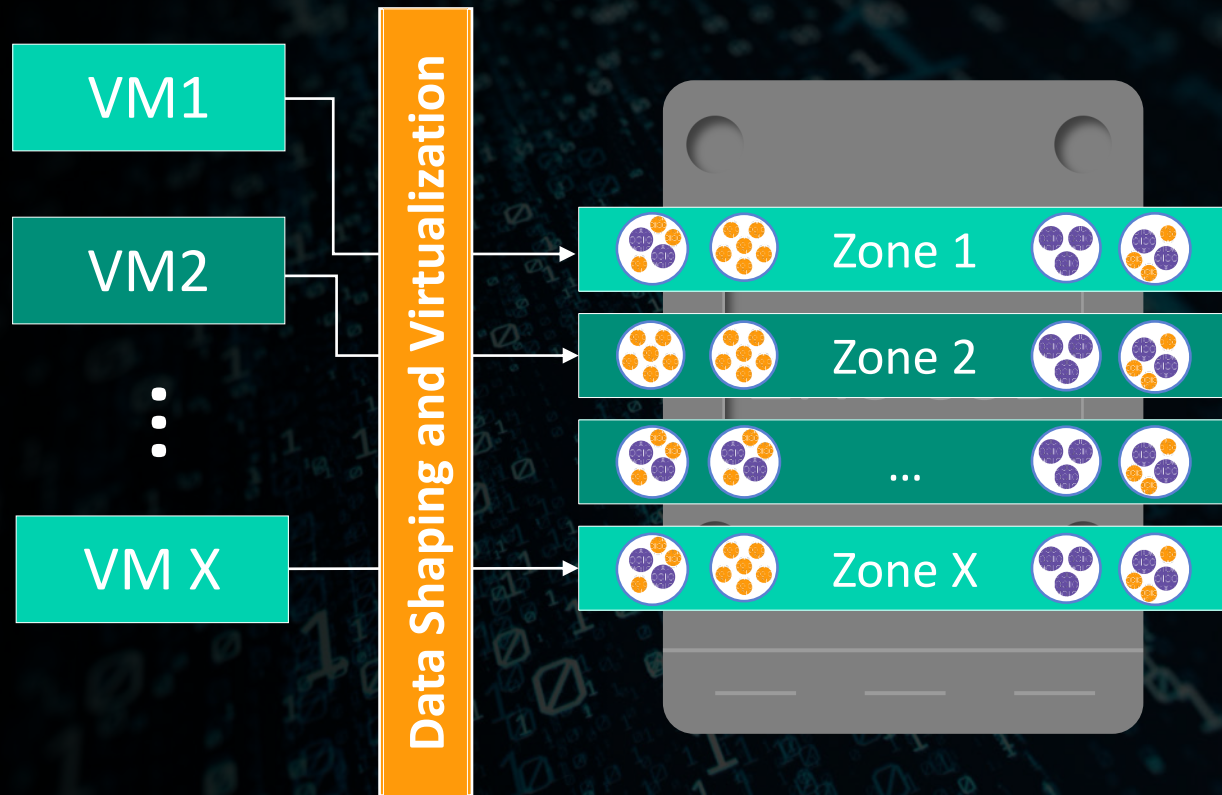


Up to
10x
Overprovision reduction

Source: Western Digital internal modeling data, 2019

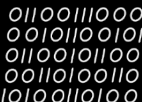



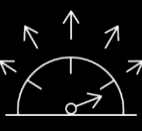
Zoned Namespaces Enables Intelligent, Lean SSDs

ZNS provides host with system-level intelligence for data placement




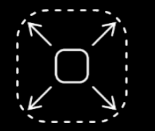
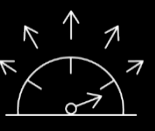


Every virtual machine can be assigned a zone

Zoned Storage Enables Zettabyte Scale

	ZNS QLC	SMR HDD
 Enables scaling	✓	✓
 Cost/TCO benefit	✓	✓
 Great access/read performance	✓	✓
 Write limitations	X	X
 Data orchestration with enhanced control		

Zoned Storage Enables Zettabyte Scale

	ZNS QLC	SMR HDD
 Enables scaling	✓	✓
 Cost/TCO benefit	✓	✓
 Great access/read performance	✓	✓
 Write limitations management	✓	✓
 Data orchestration with enhanced control	✓	✓

Leading the Way with Zoned Storage

ZonedStorage.io Home About Documentation ▾

ZonedStorage.io

Zoned Storage is a class of storage devices that enables host and storage devices to cooperate to achieve higher storage capacities, increased throughput, and lower latencies. The zoned storage interface is available through the SCSI Zoned Block Commands (ZBC) and Zoned Device ATA Command Set (ZAC) standards on Shingled Magnetic Recording (SMR) hard disks today and is also being adopted for NVMe Solid State Disks with the upcoming NVMe Zoned Namespaces (ZNS) standard.

[Learn more about Zoned Storage Devices »](#) [Learn more about Linux® Software Support »](#)

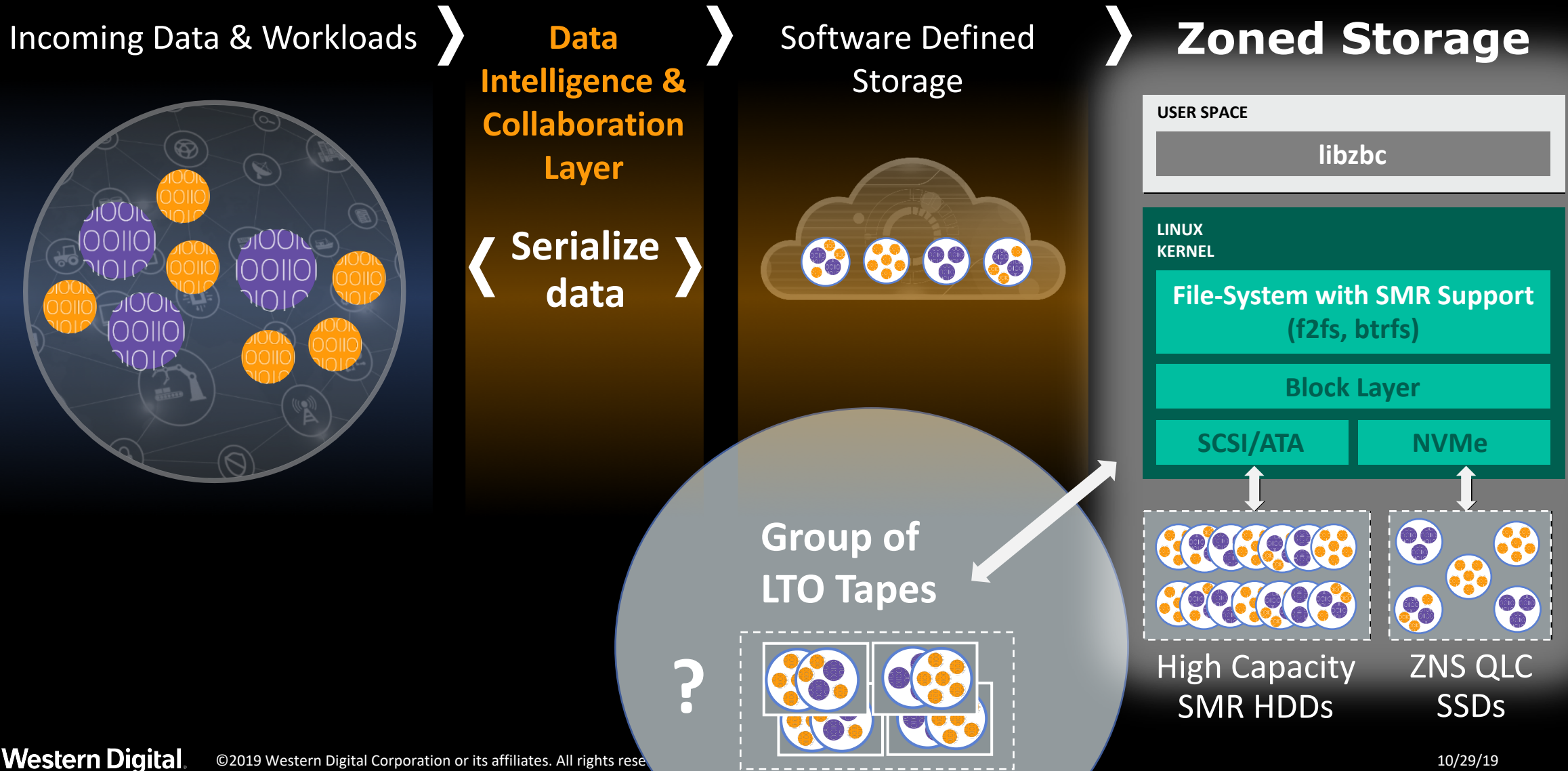
QUICK START GUIDE

Learn how to setup a Linux system supporting zoned block devices and start experimenting with physical and emulated zoned storage devices.

[Get Started »](#)

Re-architecting for the Zettabyte Age for Tape?

Zoned storage enables efficiency and intelligent data placement



Summary

Data Growth is Driving The Need For Sequential Writes

1. Data continues to grow faster than media output
2. Cost scaling forces to go sequential
3. ZonedStorage.io delivers a solution to manage data at scale and maybe tape as well



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