It’s all about the memory and storage

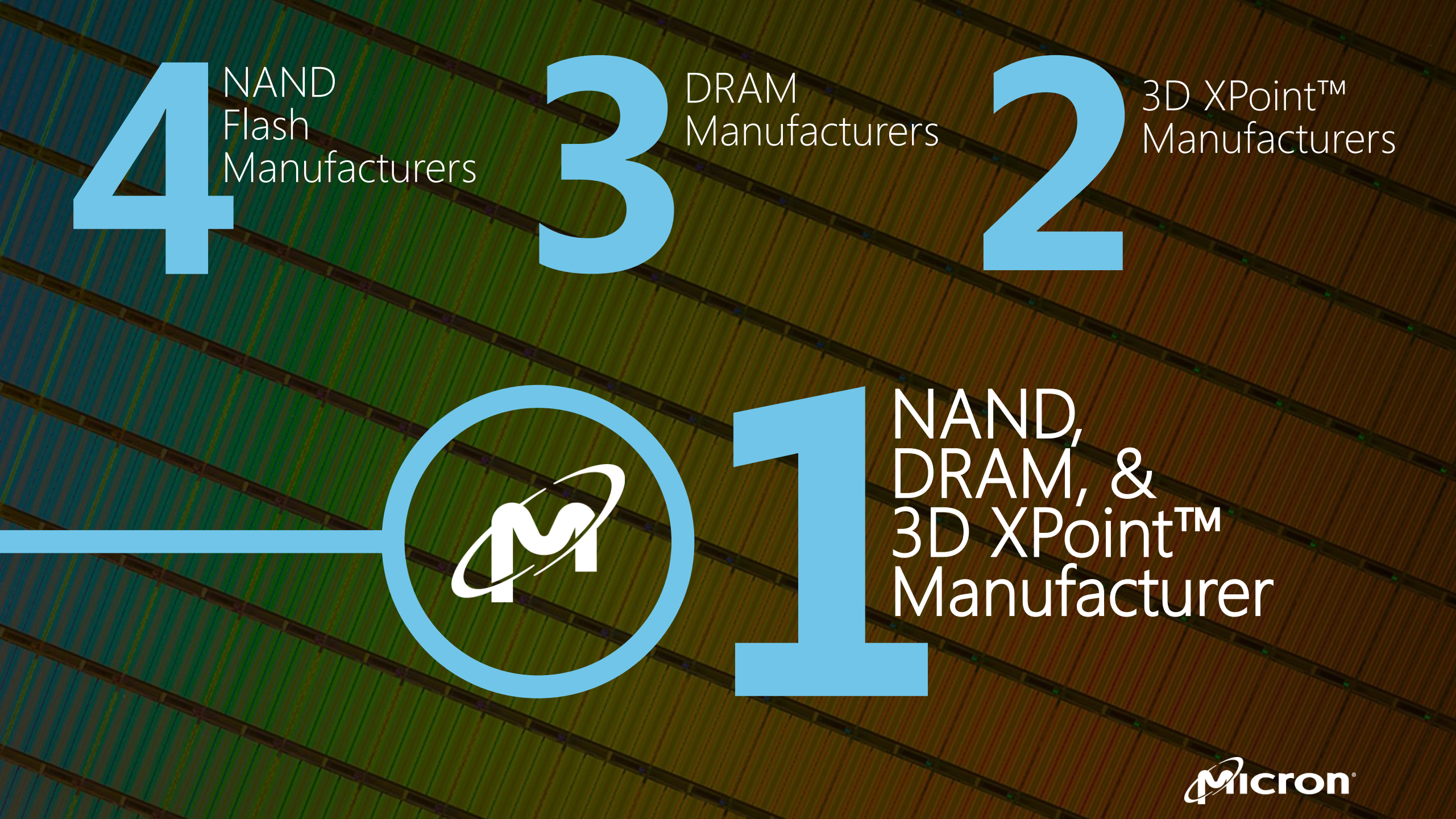
Alberto Gómez
Sales Manager Iberia & Greece
April 2018

If data is the new currency of business, then memory and storage make up the powerful banking system that data owners need to move, protect, store, and capitalize on this currency.

Today's Agenda

- About Micron Technology
- Memory Market Overview
  - Memory Transition
- Storage Market Overview
- What´s new in the SSD Technology
  - Micron 5210 SSD drive
- SSD Product Range

About Micron Technology


4
NAND
Flash
Manufacturers
3
DRAM
Manufacturers
2
3D XPoint™
Manufacturers
1
NAND,
DRAM, &
3D XPoint™
Manufacturer
Micron

By the Numbers

TOP 10
Patent Holders Worldwide

FORTUNE 500

13
Manufacturing R&D Sites

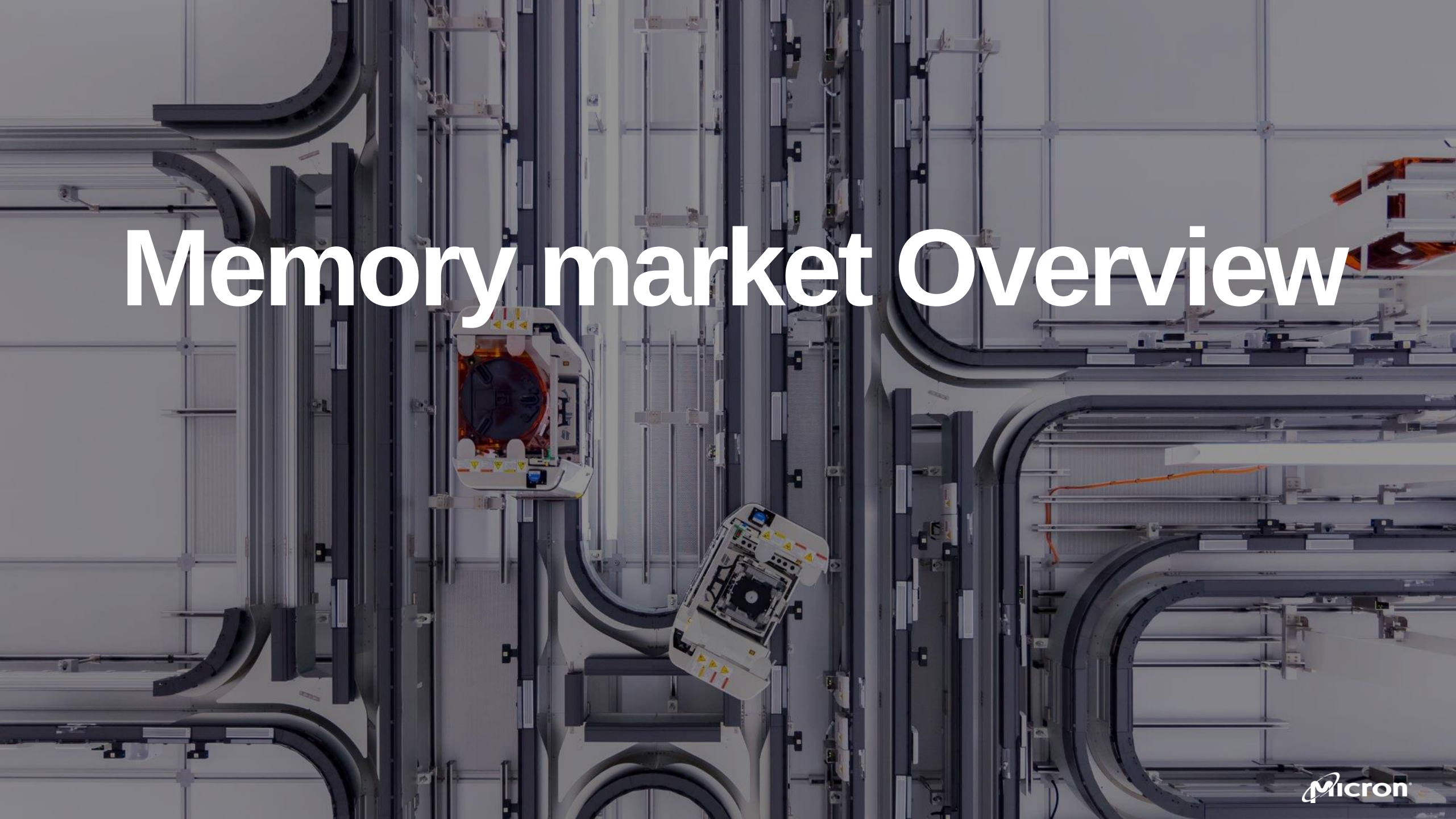
26,000
Lifetime Patents
(One every day for the past 72 years)

37
Years Strong

20
Countries

OVER 30,000
Team Members

50
Remote Offices Worldwide

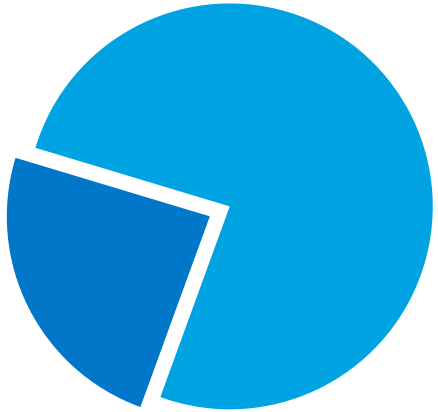


Memory market Overview

Worldwide Memory Market

$128B

(+59% Y/Y)



Semiconductor Market in 2017

$403B

(+17% Y/Y)

DRAM

- Mobile $24B
- Non-Mobile $45B

$69B

(+65% Y/Y)

Non-Volatile

- Storage $25B
- Non-Storage $34B

$59B

(+52% Y/Y)

Non-Memory Markets

$275B

- Logic $199B +6% Y/Y
- Discrete $20B +7% Y/Y
- Analog $23B +10% Y/Y
- Other $38B +7% Y/Y

Source: Gartner Q2-16 and Micron

[1]Memory includes DRAM, NAND and NOR, Emerging and other

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Trends Impacting the DRAM Market

1 Content Up

2017 Content Trends

Server 32GB DDR4 RDIMM mainstream with 64GB ramp starting

iPhone moves to majority 3GB

Android flagship phones move from 3GB to 4GB (Spring) and 6GB (Autumn) in 2017

Usage trends requiring more DRAM

2 Demand Strong

Demand Growth

Cloud: 59%

Enterprise: 25%

Networking: 38%

Mobile 23%

Graphics: 16%

Client: 5%

2017 Overall Bit Growth at 24%

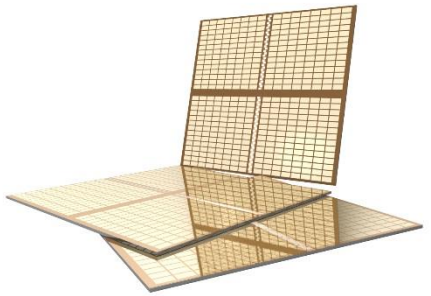
3 Supply

2017 Supply Growth

Limited wafer growth

Transition to 8Gb mono die largely complete

Fewer LP and DDR4 bits per wafer relative to DDR3

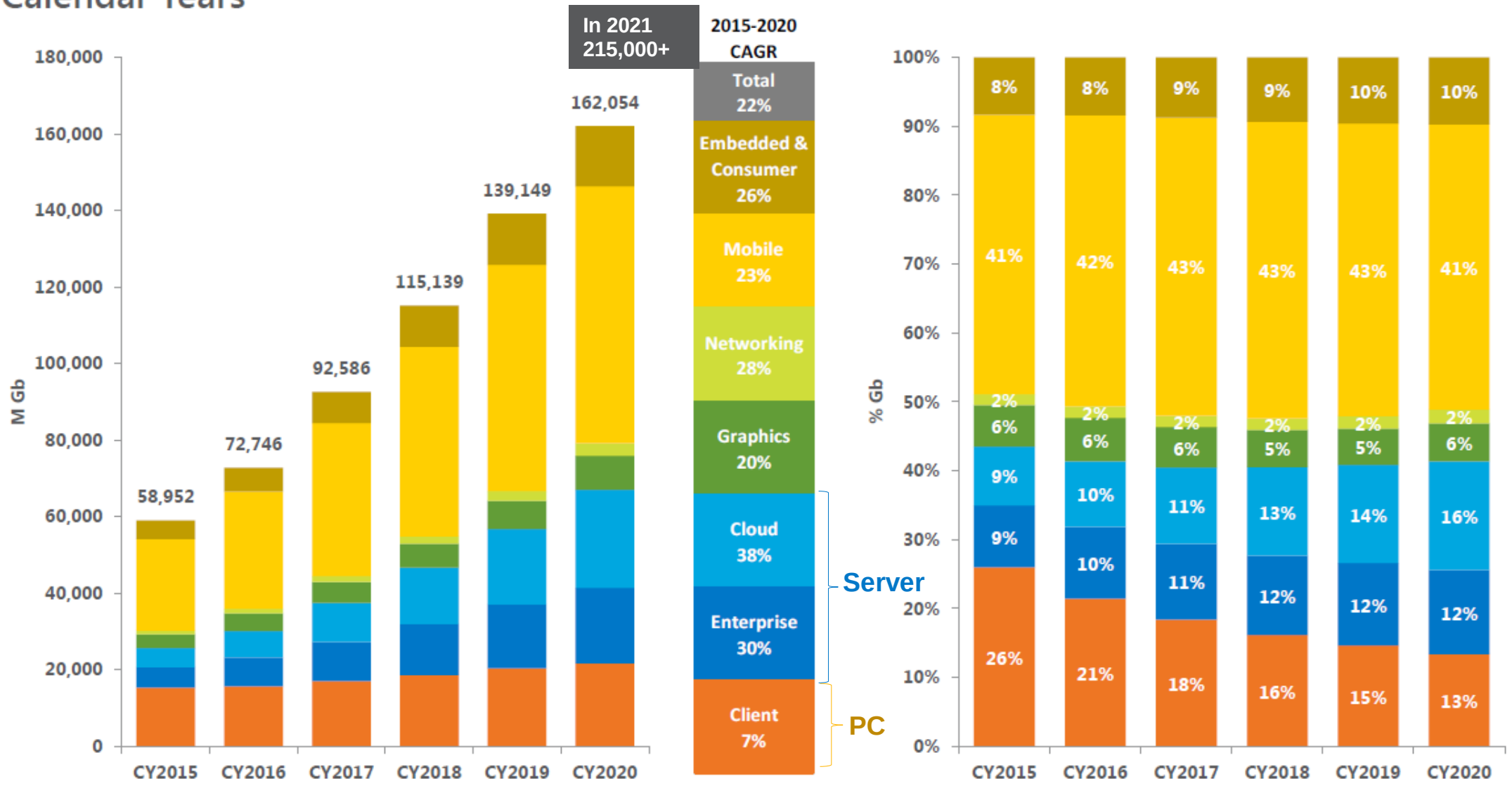


2017 Overall Bit Growth at 22%

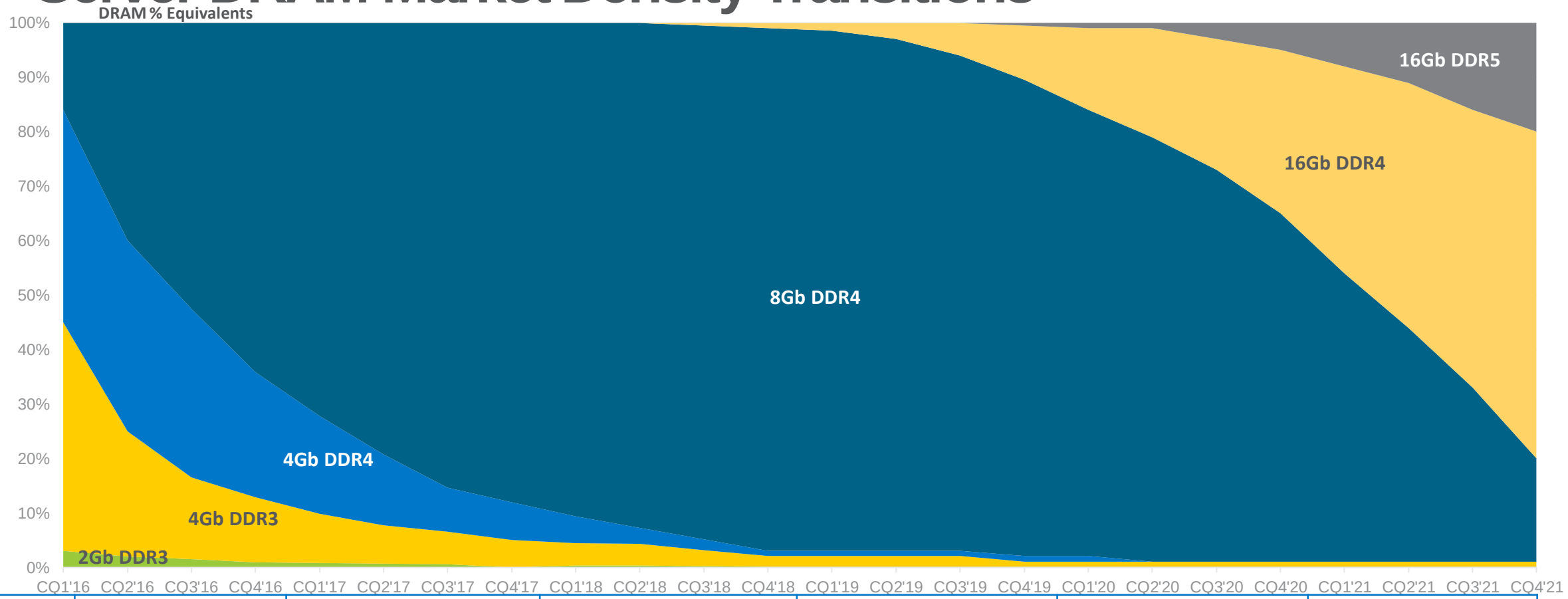
Sources: Micron CQ3'17, Industry analysts, DRAMeXchange updated 8/17/17

DRAM Market by Segment

Calendar Years



Server DRAM Market Density Transitions



Mainstream	2016	2017	2018	2019	2020	2021
Speed (MTs) / Voltage	2400 *1.2V*	2400/2666 *1.2V*	2666/2933 *1.2V*	2933/3200 *1.2V*	3200/4000 *1.2/1.1V*	4000/4400 *1.1V*
Tech	DDR4	DDR4	DDR4	DDR4	DDR4/DDR5	DDR5

Source: Micron Business Development - 3Q17

Storage Market overview

163 zettabytes

(163 trillion gigabytes)

by 2025

163,000,000,000,000GB !! – That's 10X more than all the data generated in 2016

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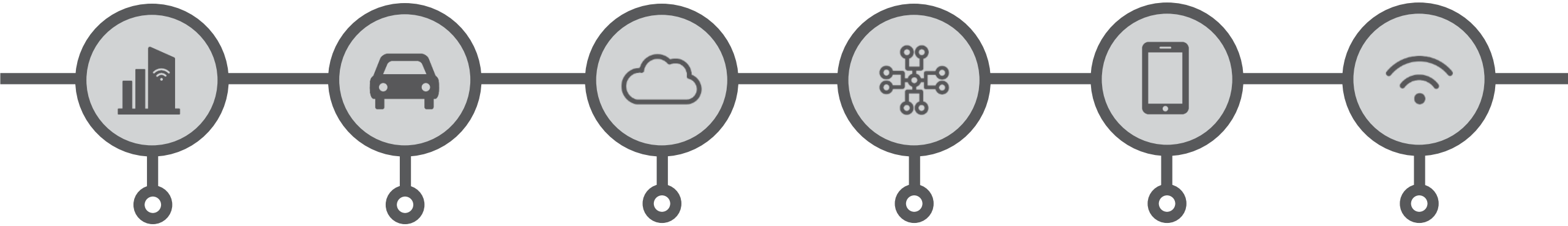
Trends Driving Increased Data Traffic



Enterprise	Automotive	Cloud/ Big Data	Networking	Mobile/ Client	IoT
OLTP systems with low-latency in-memory compute	Customer-ready autonomous vehicles by 2021	44 zettabytes of data stored annually	Global IP traffic grows at a CAGR of 24% from 2016 to 2020	Global mobile data traffic to rise ~7X between 2016 and 2021	20 billion connected devices by 2020

Source, September 2017: Cisco, Gartner, IDC, Automobile manufacturers
IoT – Internet of Things

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Top 3 Storage Trends

1. In 2016, flash represented 10% of all storage gigabytes shipped
2. Workloads have become more random/real-time
3. Continued drive to bring data closer to compute

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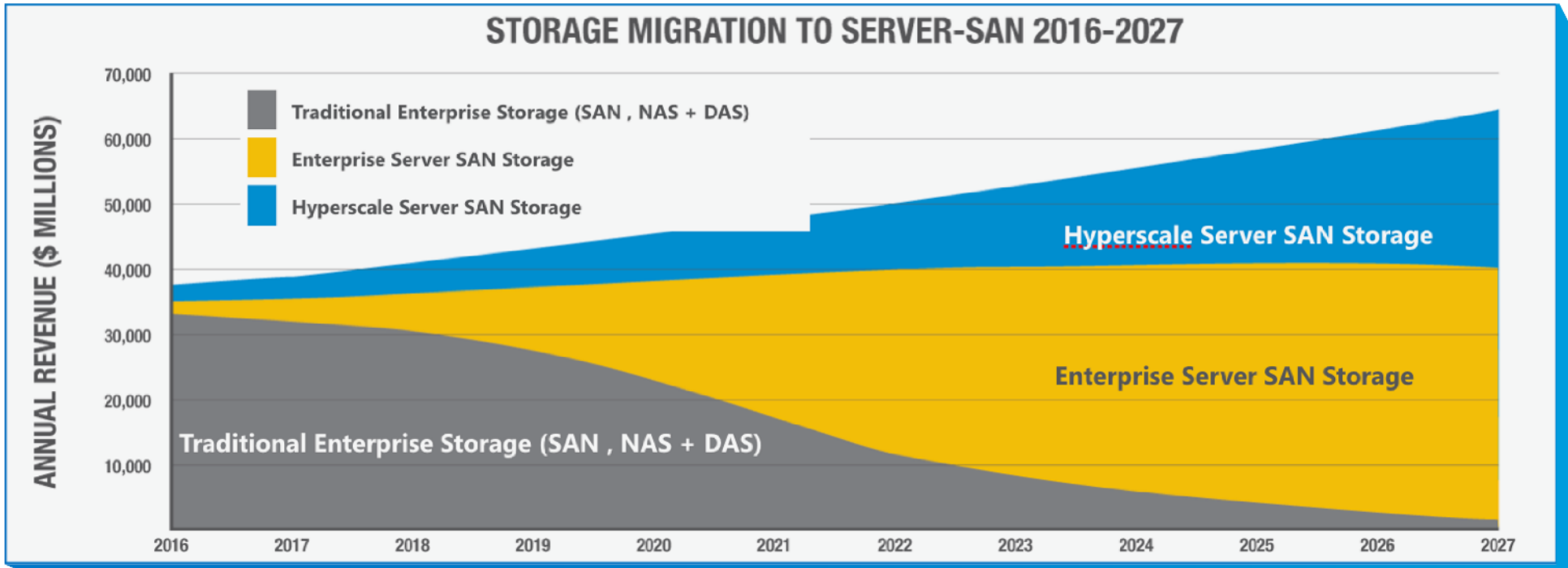
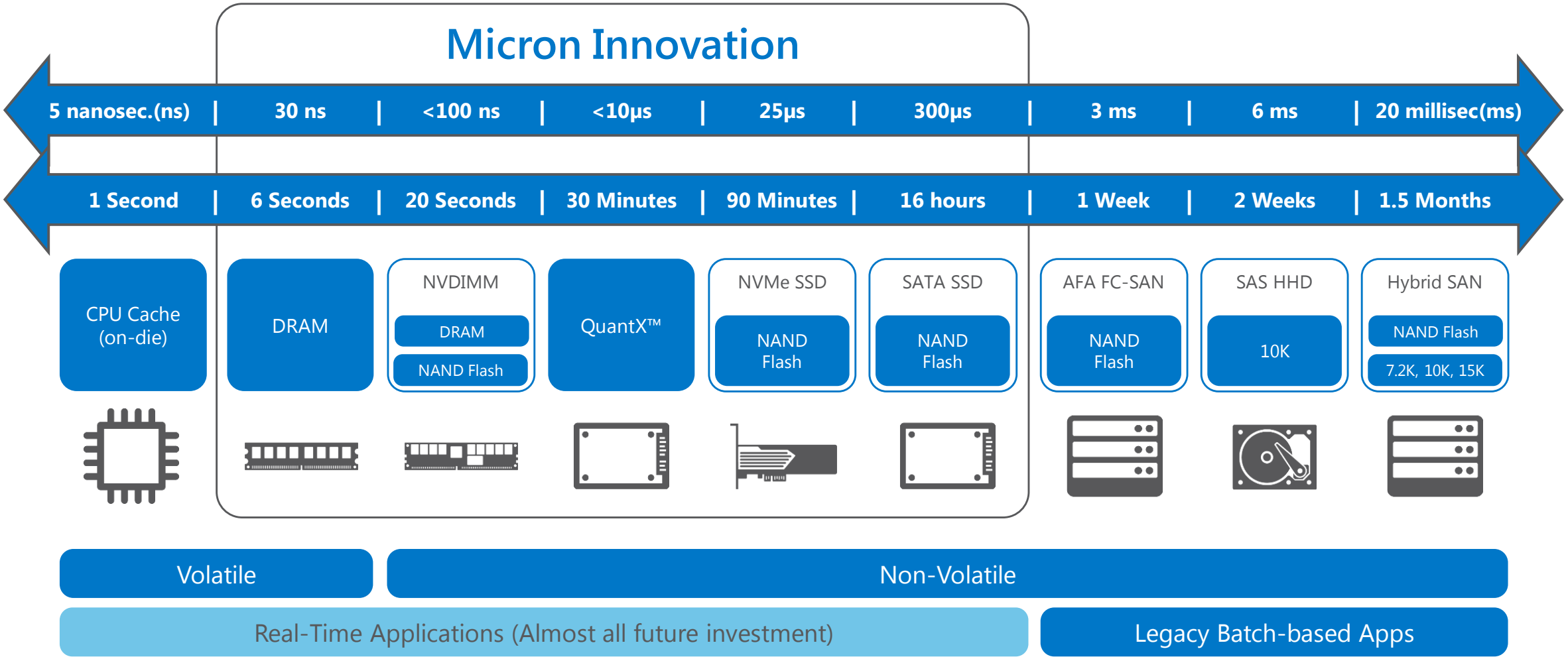
Massive

storage migration to server-SAN



Applications Increasingly Rely on Fast Storage



NVMe Market Highlights

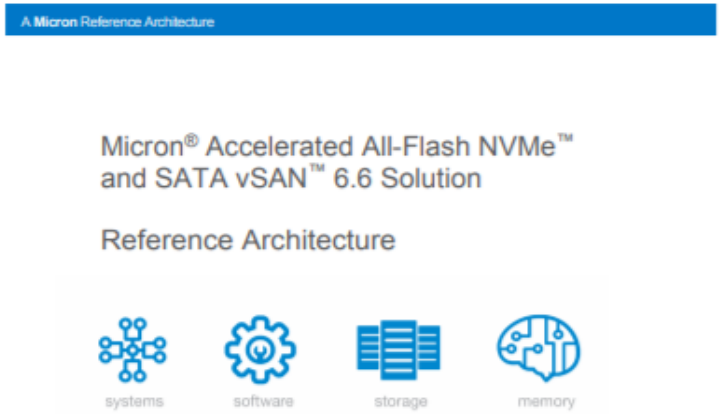
NVMe Market Size	The NVMe market will reach $60B by 2021
NVMe SSD U.2 & M.2 in Servers	Over 50% of enterprise servers will be NVMe-enabled by 2019
SSD Storage Applications	Over 70% of appliances will be NVMe-enabled by 2021
NVMe-oF Networking	NVMe-oF adapter shipments will exceed 1.5M units by 2021
AFA Moves to NVMe	Over 70% of AFAs will be NVMe-based by 2020
NVMe SSD Market Growth	The market for NVMe SSDs (U.2, M.2, and PCIe AOCs) will reach $9B by 2021

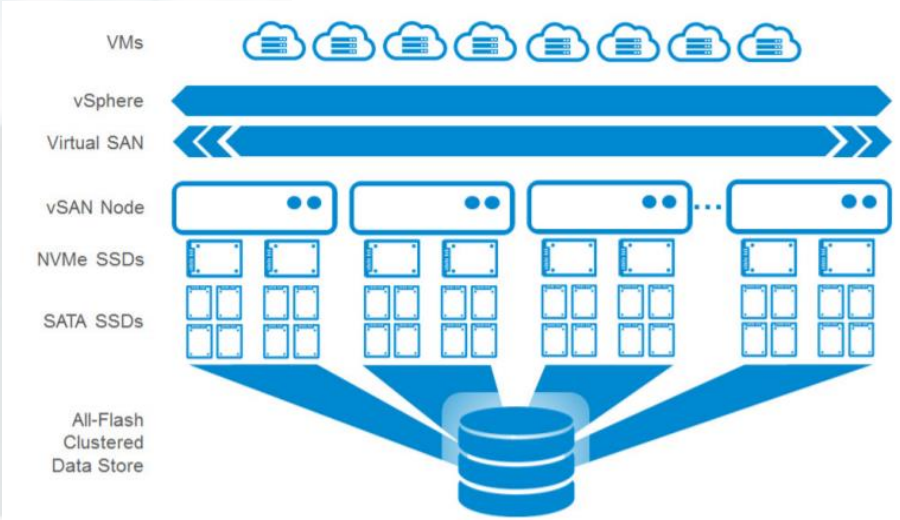
What's New: vSAN NVMe & SATA RA

"Micron All-Flash NVMe and SATA vSAN 6.6 RA"

Easy to integrate vSAN platform that's price/perf. balanced

Reference Architecture





Modernizing the Data Center: What Does This Mean?

The New ROI: Return on *Infrastructure*

Lower Power Consumption

End-to –End Data Protection and Security

Reduced Maintenance Costs

Greater Operating Efficiency

Speed and performance

Select the level of security you need

PURPOSE-APPROPRIATE DATA PROTECTION AND SECURITY

Secure Download & Diagnostics

- Firmware feature
- Protects the drive from software attacks through a digital signature built into the firmware
  - When downloads are needed, the digital signature prevents unauthorized access to the drive
  - Prevents counterfeit firmware from being loaded to the drive

TCG-Enterprise Encryption

- Data security standard
- Enterprise focused
- Trusted Computing Group
- Protects Data-at-Rest through encryption
  - Encryption key generated by the SSD can never leave the drive
  - Strong Authentication can be used to "marry" the drive to ONE host
  - SSD, data can't be read without authentication key

FIPS 140-2 Validated

- Federal Information Processing Standard (FIPS) Publication 140-2
  - US Government security standard used to accredit cryptographic modules
  - Certifies that the module (Drive) meets a minimum standard for security and tamper resistance
  - Military grade encryption required by federal agencies

7 trends that impact you

1. Movement from SAN/NAS to direct-attached storage
2. Growing use of the cloud
3. Rise of AI and machine learning
4. The virtualization of everything and the move to hyperconverged
5. The outsourcing of IT
6. Rising role of software, not hardware
7. **Move from hard drives to SSDs**

What's New in SSD Technology

Be Revolutionary.
Be SOLID.

Micron®

The Evolution of Enterprise SSDs

Business priorities drive workloads.
Workloads drive storage, performance, and capacity.

SLC
2007

MLC
2011

TLC
2016

QLC
2018

Expensive
Low Capacity

Affordable
High Capacity

Note: Dates represent when Micron® enterprise SSDs launched with each generation of NAND technology

The vast majority of all data needs to be read quickly.

Not rewritten repeatedly.

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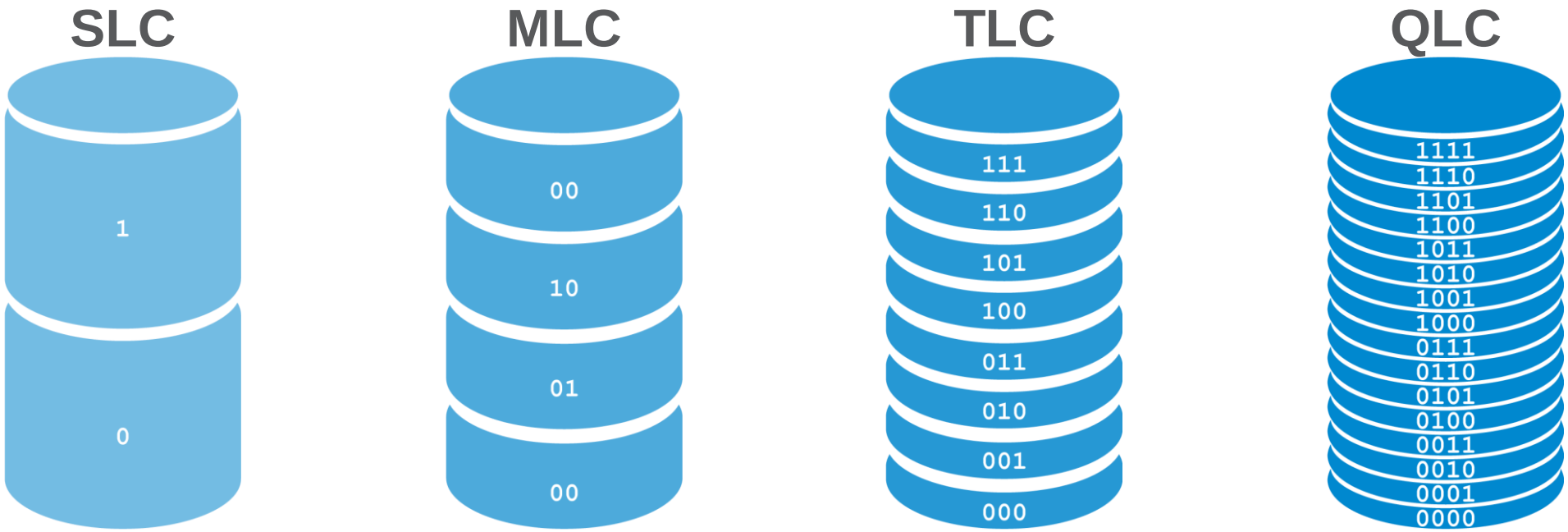
QLC = More Density Per NAND Cell

Lower $ per GB



1 Bit Per Cell
First SSD NAND technology

100K P/E Cycles
(at technology introduction)

2 Bits Per Cell
100% increase

10K P/E Cycles

3 Bits Per Cell
50% increase

3K P/E Cycles

4 Bits Per Cell
30% increase

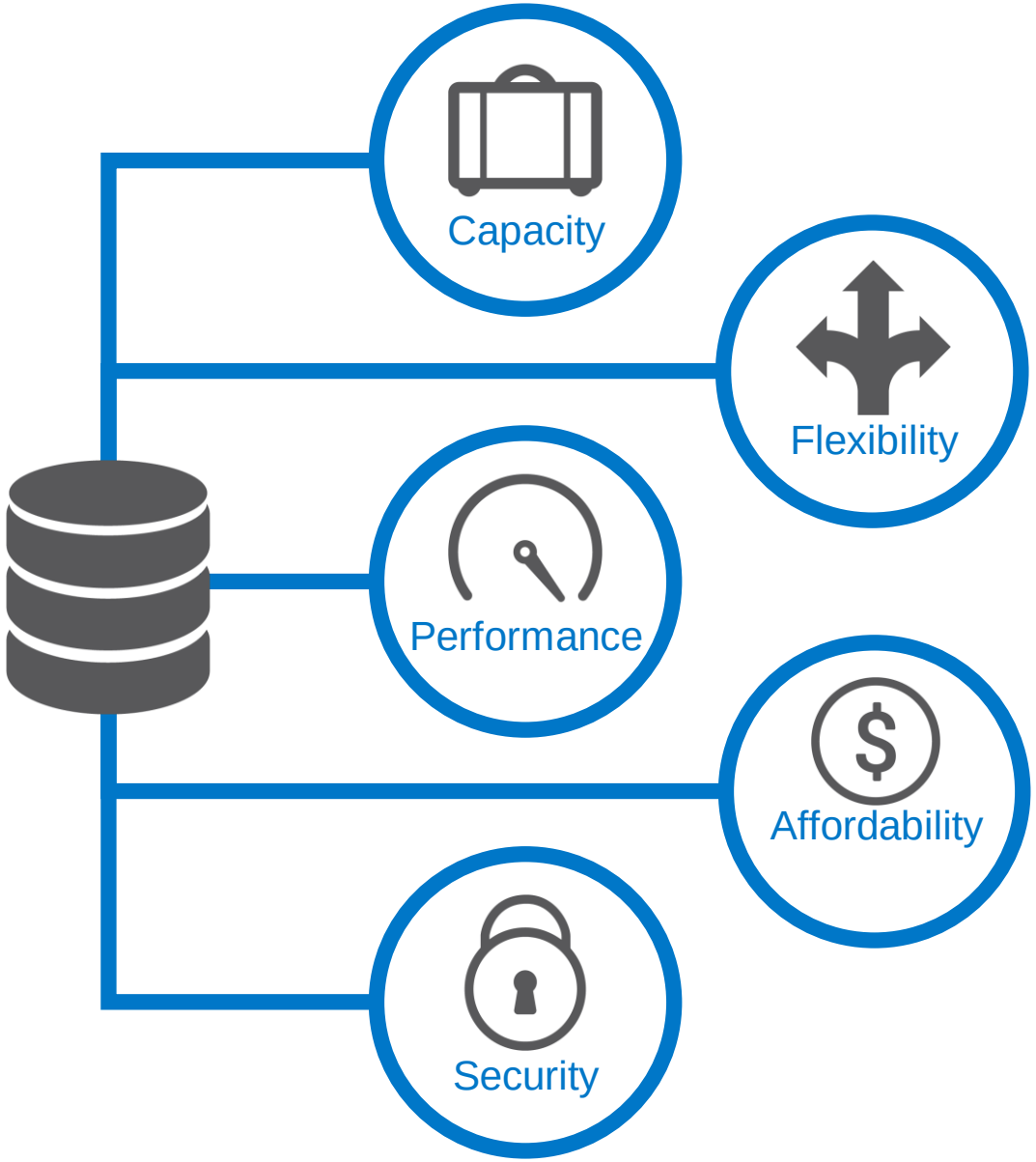
1K P/E Cycles

Fewer writes per cell

The QLC Workload Advantage

Right-Sized, Cost-Effective Performance for Read-Intensive Workloads

- Big Data analytics & read-centric data stores
  - BI/DSS: MySQL, Oracle, MS SQL
  - Big Data: Hadoop HDFS
  - Deep Learning
  - Ceph: Active archive/block store
  - NoSQL: Mongo DB, Cassandra (photo tags, profile caches)
- VoD, content delivery, media streaming
- VM/data center backup & restore
- User authentication



SATA Possibilities for Enterprise Applications

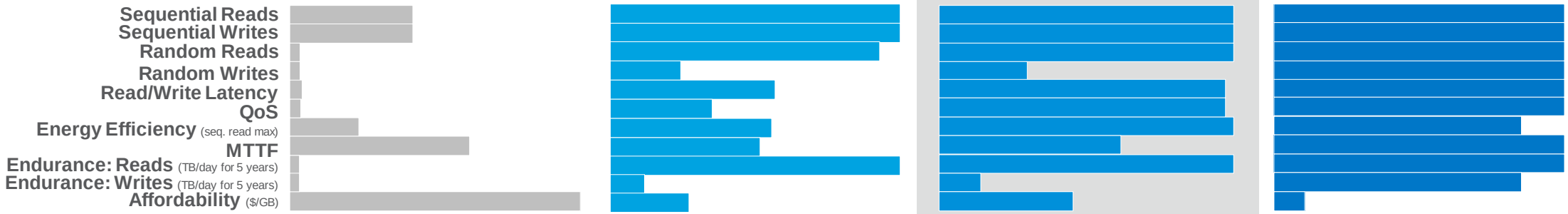
Longer bar = better. All approximations are for steady-state performance and vary by capacity.

Enterprise HDD
7200 RPM Capacity-Class

1100 SSD
Client-Class

5210 SSD
Very Read-Intensive

5200 SSD
Read-Intensive to Mixed-Use

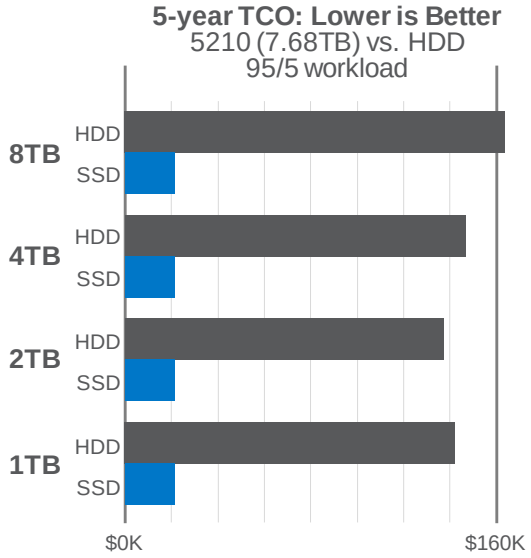


Warranty	3 or 5 years	3 years	5 years	5 years
Storage Technology	HAMR/helium	Micron® 32-layer 3D TLC NAND	Micron® 64-layer 3D QLC NAND	Micron® 64-layer 3D TLC NAND
Advanced Features	▪ 512 byte sector emulation	▪ Client-class encryption ▪ DPP for user data ▪ PLP for data at-rest ▪ Background media scan	▪ Enterprise-class encryption ▪ DPP for user & meta data ▪ PLP for data at-rest & in-flight ▪ Enhanced media management time domain scan ▪ Flex Capacity	▪ Enterprise-class encryption ▪ DPP for user & meta data ▪ PLP for data at-rest & in-flight ▪ Enhanced media management time domain scan ▪ Flex Capacity

Micron 5210 vs. 7200 RPM Hard Drive

7x

better TCO for same performance



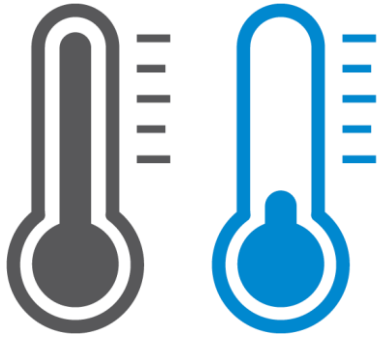
2x

more capacity per 2U chassis

246TB
vs.
128TB

3x

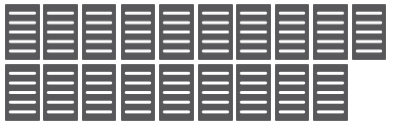
less power for sequential reads (max)



50%

reduction in server footprints

Racks needed to store 50PB:

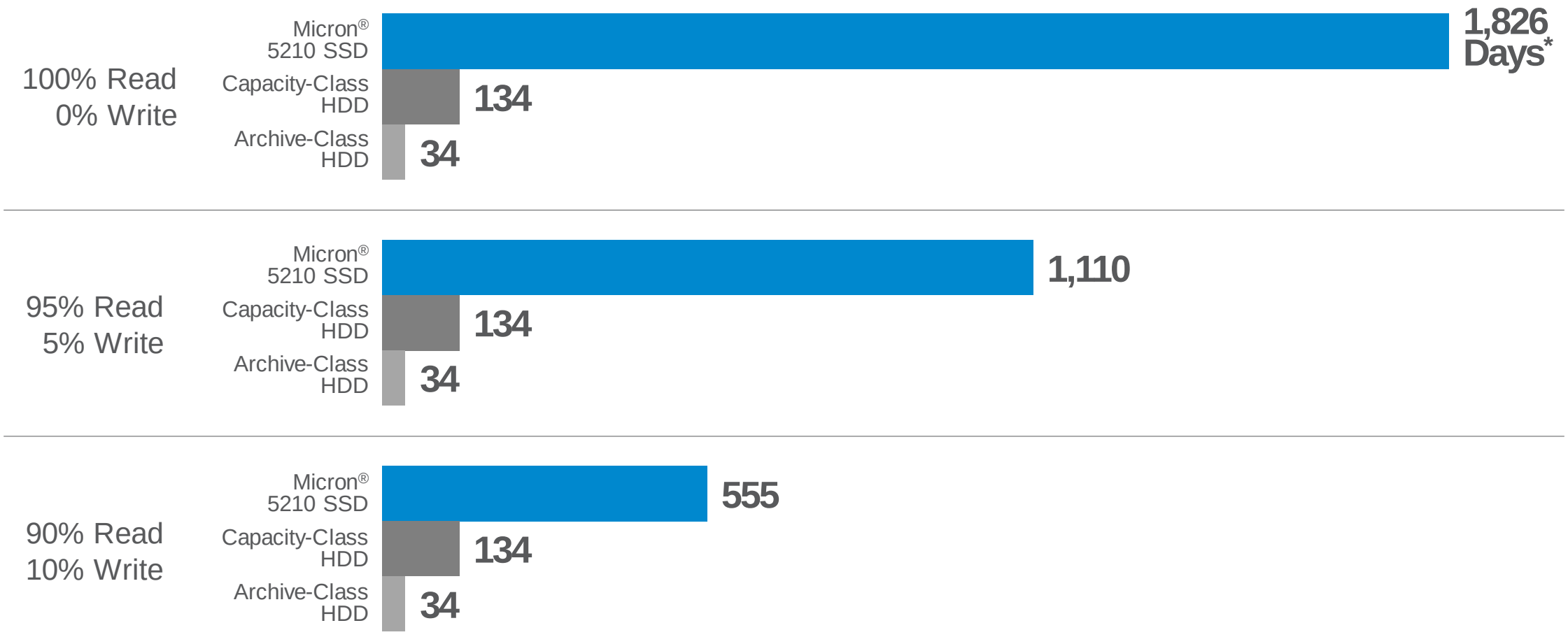


19 with HDDs

10 with the 5210

8x More TBW With the 5210

Days it takes to exhaust an 8TB drive's endurance or warranty when running 24/7



*Warranty only exhausts due to 5 year warranty term

SSD Product range

Storage Business Unit

Micron® SSDs Deliver Data at the Speed of Now

Consumer

MX500 SATA

- 3D NAND
- Energy efficient
- Hardware encryption

Client

1100 SATA

- 3D NAND
- Energy efficient for increased battery life
- Hardware encryption

Cloud

5200 SATA

- 3D NAND
- High performance and capacity
- TCG-E encryption

5100 SATA

- 3D NAND
- High performance and capacity
- TCG-E encryption

Enterprise

9200 NVMe™

- 3D NAND
- Performance flagship product line
- High capacity

9100 NVMe™

- 16nm MLC NAND
- High performance

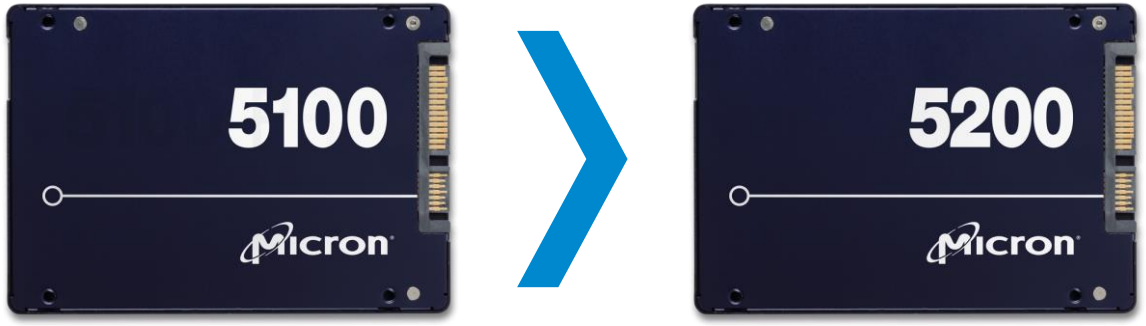
S600 Series SAS

- 16nm MLC NAND
- Enterprise-class Hardware encryption
- FIPS 140-2 Validated

Capture more value from more data. Faster.

Consumer | Client | Cloud/Enterprise

Transitioning to the Micron 5200 is fast, easy, & smart



Same controller
Same firmware
Same interface
Same features
Same components
New NAND

Easy quals. Better performance. Better value.

Same architecture & features as the proven 5100 SSD

Same drive.
New NAND.

	5100	5200
SATA 6 Gb/s interface	✓	✓
2.5-inch (7mm) form factor	✓	✓
Marvell Dean controller	✓	✓
Micron custom firmware	✓	✓
Up to 7.68TB capacity	✓	✓
3 million hours MTTF	✓	✓
Encryption: AES 256-bit with TCG Enterprise configurability	✓	✓
5-year warranty	✓	✓
Micron® Flex Capacity	✓	✓
Power loss protection & data path protection	✓	✓
Adaptive thermal monitoring	✓	✓
TAA compliant	✓	✓
RAIN	✓	✓
Micron® 3D 64-layer TLC NAND	✗	✓

Better SSDs come from better NAND

Micron 5100
First generation
32-layer 3D NAND

Micron 5200
Second generation
64-layer 3D NAND

Only enterprise SATA SSD available in 64-layer 3D NAND*

- 512Gb TLC, 4 planes, 64kB parallelism
- Floating Gate + CMOS

Same cells. Smaller die. Taller skyscrapers. Better value.

*As of 15 December 2017

How the 5200 Compares to the 5100

ECO

Better nearly across the board and on latest NAND

	480GB ECO		960GB ECO		1920GB ECO		3840GB ECO		7680GB ECO	
	5100	5200	5100	5200	5100	5200	5100	5200	5100	5200
Seq Read (MB/s)	540	540	540	540	540	540	540	540	540	540
Seq Write (MB/s)	380	385	520	520	520	520	520	520	520	520
Random Read (IOPS)	93K	81K	93K	95K	93K	95K	93K	95K	93K	95K
Random Write (IOPS)	31K	33K	28K	28K	24K	22K	18K	17K	9k	10K
Endurance (TBW in PB)	0.45	0.87	0.9	1.75	3.2	3.5	6.4	7.7	8.4	8.4

PRO

Lower random writes and endurance, but still best-in-class and on new NAND

	480GB PRO		960GB PRO		1920GB PRO	
	5100	5200	5100	5200	5100	5200
Seq Read (MB/s)	540	–	540	540	540	540
Seq Write (MB/s)	410	–	520	520	520	520
Random Read (IOPS)	93K	–	93K	95K	93K	95K
Random Write (IOPS)	43K	–	37K	32K	38K	32K
Endurance (TBW in PB)	1.3	–	4.4	2.27	8.8	5.95

Capacity sweet spot

A Closer Look at the Micron® 5200 Series of SATA 2.5-inch SSDs

Model & Endurance Class	5200 PRO Read-Intensive <2 DWPD		5200 ECO Read-Intensive <1 DWPD				
Capacity	**960GB***	**1.92TB***	**480GB**	**960GB**	**1.92TB**	**3.84TB**	**7.68TB**
Sequential Reads (MB/s)[1]	540	540	540	540	540	540	540
Sequential Writes (MB/s)[1]	520	520	385	520	520	520	520
Random Reads (K IOPS)[2]	95	95	81	95	95	95	95
Random Writes (K IOPS)[2]	32	32	33	28	22	17	9.5
Endurance (TBW in PB)	2.27	5.95	0.87	1.75	3.5	7.7	8.4
NAND	Micron® 3D 64-layer TLC NAND						
Interface	SATA 6 Gb/s						
Form Factor	2.5-inch, 7mm						
MTTF	3 million device hours						
Advanced Features	Micron® Flex Capacity, AES 256-bit encryption, TCG Enterprise configurability, power loss protection for data in-flight, end-to-end enterprise data path protection, secure firmware, adaptive thermal monitoring, easy to install (hot pluggable), Storage Executive SSD management tool, RAIN, 5 year warranty, TAA compliant						

*The Micron 5100 PRO will still be available in 240GB and 3.84TB capacities to support the widest range of configurations; 1. Sequential read/write @128KB (steady state); 2. Random read/write @ 4KB (steady state)

Target Workloads & Applications

The ideal SATA SSD for read-intensive, virtualized workloads that are crippled on a hard drive.

5200 ECO

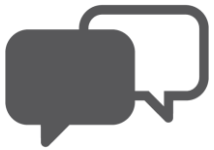
BI/DSS

Cloud Storage

Media Streaming

5200 PRO

OLTP



Block/ Object

VDI & Virtualization

How the 5200 Compares to Hard Drives

1 Micron SSD outperforms an entire rack of 24 HDDs for a lower TCO

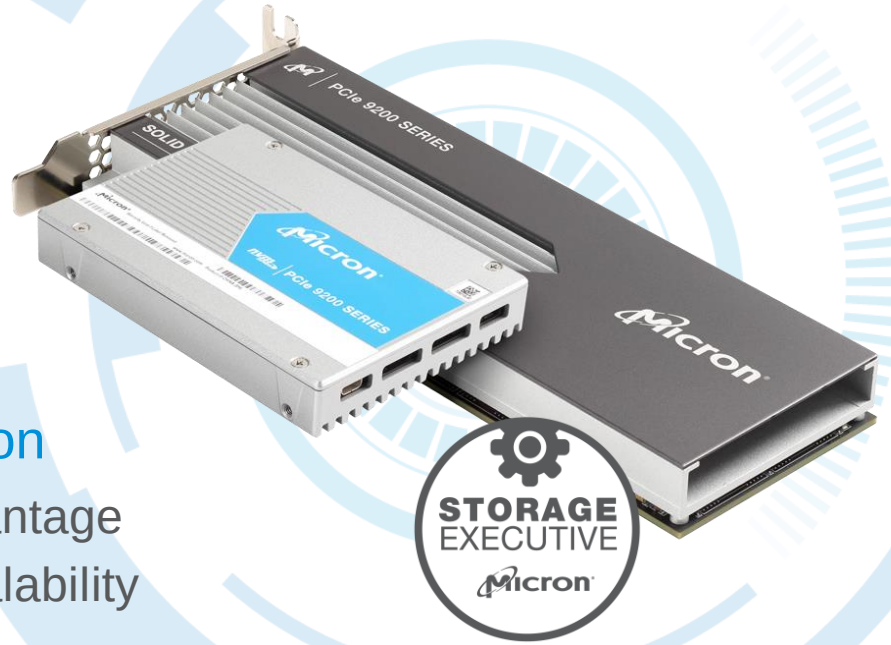
See the impact across your entire data center

Which Model is Right for You?

	5200 ECO read-intensive <1 DWPD	5200 PRO read-intensive <2 DWPD	5100 MAX mixed-use 5 DWPD
How much endurance do you need?			
How much random write performance & consistency do you need?	✓	✓✓	✓✓✓
Which applications and workloads are you running?	Microsoft SQL **(BI/DSS)** Ceph **(media streaming: large object)** Hadoop **(HDFS primary storage)**	Microsoft SQL, Oracle Database, MySQL **(OLTP)** Ceph **(small random block)** Hadoop **(accelerate HDD clusters)**	
	NoSQL databases: Cassandra, MongoDB, Aerospike **(session activity, user tracking, user record changes)**		
	VMWare vSAN: capacity tier **(VDI, virtualized OLTP)**		
How much capacity do you need?	Micron® Flex Capacity → Use this feature to sell whatever inventory you have by converting higher capacity ECO/PRO drives into PRO/MAX levels of write performance and endurance		
	480GB – 7.68TB	**960GB – 1.92TB**	**240GB – 1.92TB**

For Workloads That Must Work Loads

MICRON® 9200 SERIES OF NVME™ SSDS



Why Micron for NVMe?

Performance that simply outclasses the competition

- **Max**imizes application throughput into business advantage
- **Min**imizes latencies for faster access to data and scalability

The right capacity for your demanding workload

- Actively tune capacity to optimize drive performance and endurance with Micron's FlexPro™
- High capacity to meet your needs—up to 11 TBs

Micron technology advantage

- Micron is 75% of your server value making your workloads faster, greener and revolutionary

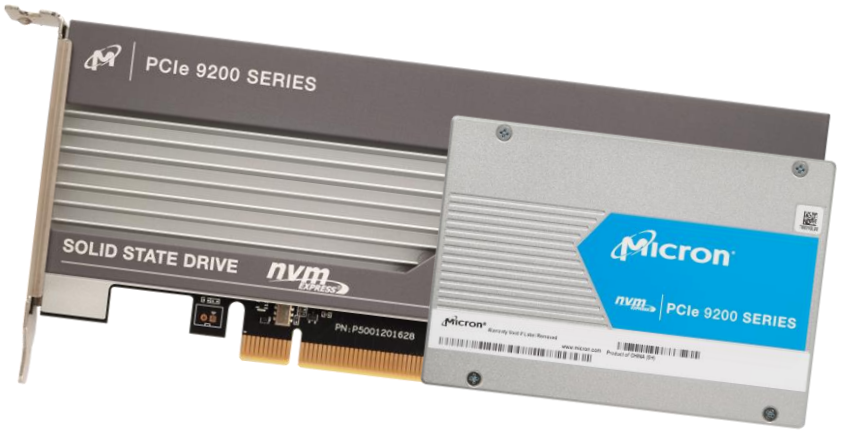
A Closer Look at the Micron® 9200 Feature Details

Enterprise SSD	9200 MAX						9200 PRO						9200 ECO			
Form Factor	U.2			HHHL			U.2			HHHL			U.2		HHHL	
Capacity	1.6TB	3.2TB	6.4TB	1.6TB	3.2TB	6.4TB	1.92TB	3.84TB	7.68TB	1.92TB	3.84TB	7.68TB	8TB	11TB	8TB	11TB
Interface	Gen 3 x4 NVMe			Gen 3 x8 NVMe			Gen 3 x4 NVMe			Gen 3 x8 NVMe			Gen 3 x4 NVMe		Gen 3 x8 NVMe	
Sequential Read/Write (GB/s)[1]	2.7/ 2.1	3.35/ 2.4	3.35/ 2.4	2.7/ 2.1	4.35/ 2.4	4.6/ 3.8	2.7/ 2.1	3.35/ 2.4	3.35/ 2.4	2.7/ 2.1	4.35/ 2.4	4.6/ 3.8	3.35/ 2.4	3.35/ 2.4	4.6/ 3.8	4.6/ 3.8
Random R/W (K IOPS)[2]	620/ 270	800/ 255	800/ 260	620/ 270	1000/ 255	1000/ 260	620/ 170	800/ 130	800/ 135	620/ 170	1000/ 130	1000/ 135	800/ 110	800/ 95	1000/ 110	1000/ 95
Endurance (TBW, PB)	8.6	17.1	34.7	8.6	17.1	34.7	3.5	6.8	13.7	3.5	6.8	13.7	11.4	15.7	11.4	15.7
Typical Workload	Write						Mixed Use						Read			
NAND	Micron 3D TLC NAND															
MTTF (Million Device Hours)	2															
Advanced Features	Storage Executive SSD Management, Enterprise Data Path Protection, Power Loss Protection, XPERT Features, High Performance, Low Latency, NVM Express Industry Standard															

1. Sequential Read/Write @128KB
2. Random Read/Write @ 4KB

9200 Series Solid State Storage

- Excellent performance for demanding workloads
- Large capacities meet your increasing storage needs
- Multiple models for flexible solutions



PRODUCT SPECIFICATION COMPARISON†

	Read Centric		Unknown Read Centric		Mixed Use	
	Micron 9200 ECO	Intel P4500	Micron 9200 PRO	Intel	Micron 9200 MAX	Intel P4600
Interface	NVMe PCIe Gen3 x8	NVMe PCIe Gen3 x4	NVMe PCIe Gen3 x8		NVMe PCIe Gen3 x8	NVMe PCIe Gen3 x4
Form Factor	HHHL, U.2 15mm	HHHL, U.2 15mm	HHHL, U.2 15mm		HHHL, U.2 15mm	HHHL, U.2 15mm
Capacity[1]	8000-11000GB	1000-4000GB	1920-7680GB		1600-6400GB	1600-4000GB
Encryption	None	SED	None		None	SED
Endurance[2]	0.8 DWPD	0.7 DWPD	1 DWPD		3 DWPD	2.9 DWPD
MTTF	2 Mhrs	2 Mhrs	2 Mhrs	No Direct Comparison	2 Mhrs	2 Mhrs
Warranty	5 Years	5 Years	5 Years		5 Years	5 Years
Random Read[3]	900K IOPS	710K IOPS	900K IOPS		900K IOPS	703K IOPS
Random Write[3]	125K IOPS	68K IOPS	175K IOPS		275K IOPS	257K IOPS
Sequential Read[3]	5500 MB/s	3290 MB/s	5500 MB/s		5500 MB/s	3280 MB/s
Sequential Write[3]	3500 MB/s	1890 MB/s	3200 MB/s		3200 MB/s	2100 MB/s
Active Power[4]	30W	18.3W	30W		30W	20.7W

† - Specs based on publicly available information.
1 - May not be available in all form factors
2 – DWPD for a given capacity may vary slightly
3 - Steady-state performance, may vary based on capacity
4 - Highest average write power draw in family

Key Takeaways

- Demand is set for Exponential Growth for the foreseeable future.
- Market is in considerable supply constraint.
- We have the product portfolio you need to succeed.
- We own our own supply chain.
- We have the collateral to support you.
- We are committed to your business.

Thank You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