SSD REVOLUTION
IN CLIENT DEVICES AND DATA CENTERS

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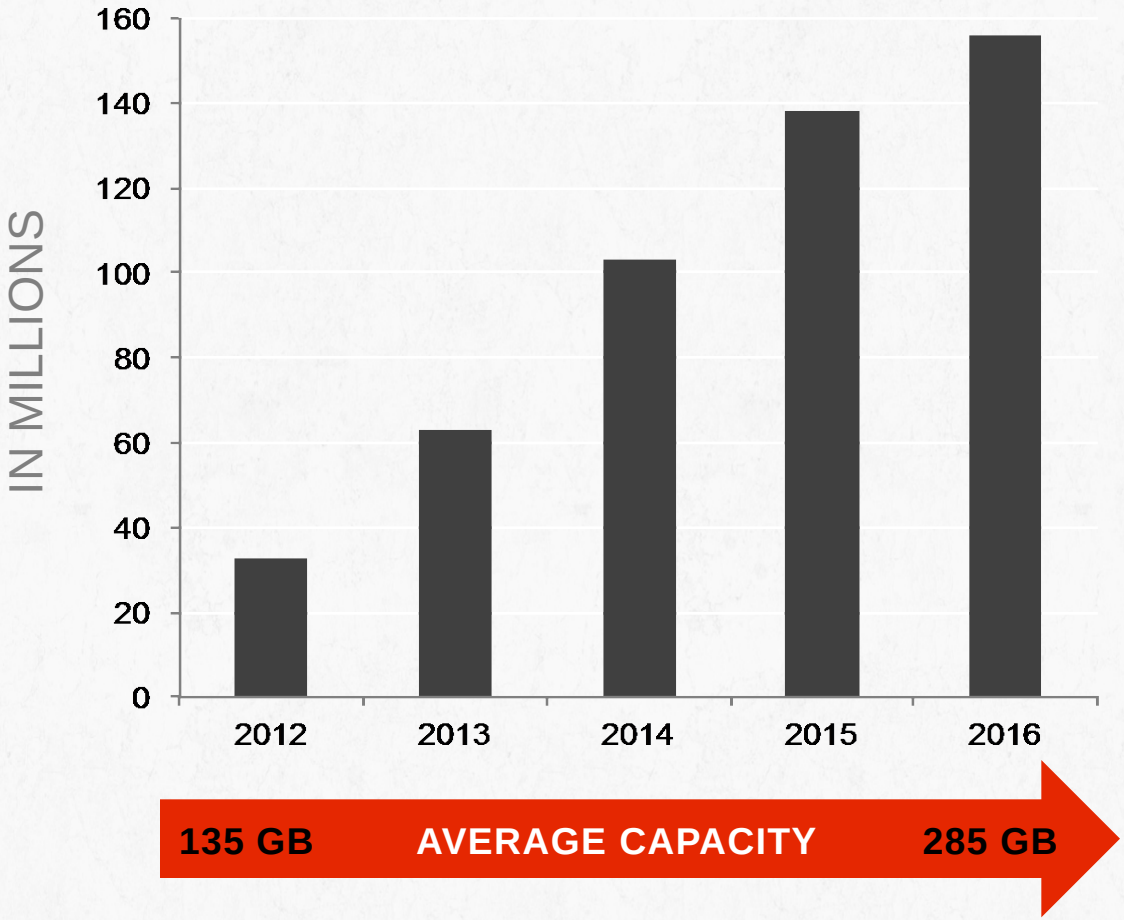
FLASH MEMORY SUMMIT
AUGUST 13, 2013

THE SSD MARKET IS GROWING



SOURCE: MARVELL AND MARKET DATA

2007: DELL SHIPS FIRST CLIENT SSD USING SANDISK 5000

	2007
CAPACITY	32 GB AND 64 GB
NAND TYPE	SLC
RELIABILITY	100K P/E CYCLES
PRICE PER GB	$12
INTERFACE	PATA/SATA 1
PERFORMANCE (SEQ R/W MB/s) (RANDOM R/W IOPS)	67/47 5.4K/13
FORM FACTOR	1.8” AND 2.5”

- Most durable
- More power-efficient and longer use time
- Cooler
- High-performance?

FAST-FORWARD TO TODAY

	2007		2013
CAPACITY	32 GB AND 64 GB	16X	120 GB – 1 TB
NAND TYPE	SLC		MLC/TLC
RELIABILITY	100K P/E CYCLES	200X	3K-500 P/E CYCLES
PRICE PER GB	$12	20X	$0.60
INTERFACE	PATA/SATA 1	6-8X	SATA 3/PCIe GEN 2
PERFORMANCE (SEQ R/W MB/s) (RANDOM R/W IOPS)	67/47 5.4K/13	11X 17-5KX	550/520 95K/90K
FORM FACTOR	1.8” AND 2.5”	20X	2.5/mSATA/M.2

- IOPS
- Power
- Price
- Form factor

WHERE WILL WE BE IN 2016?

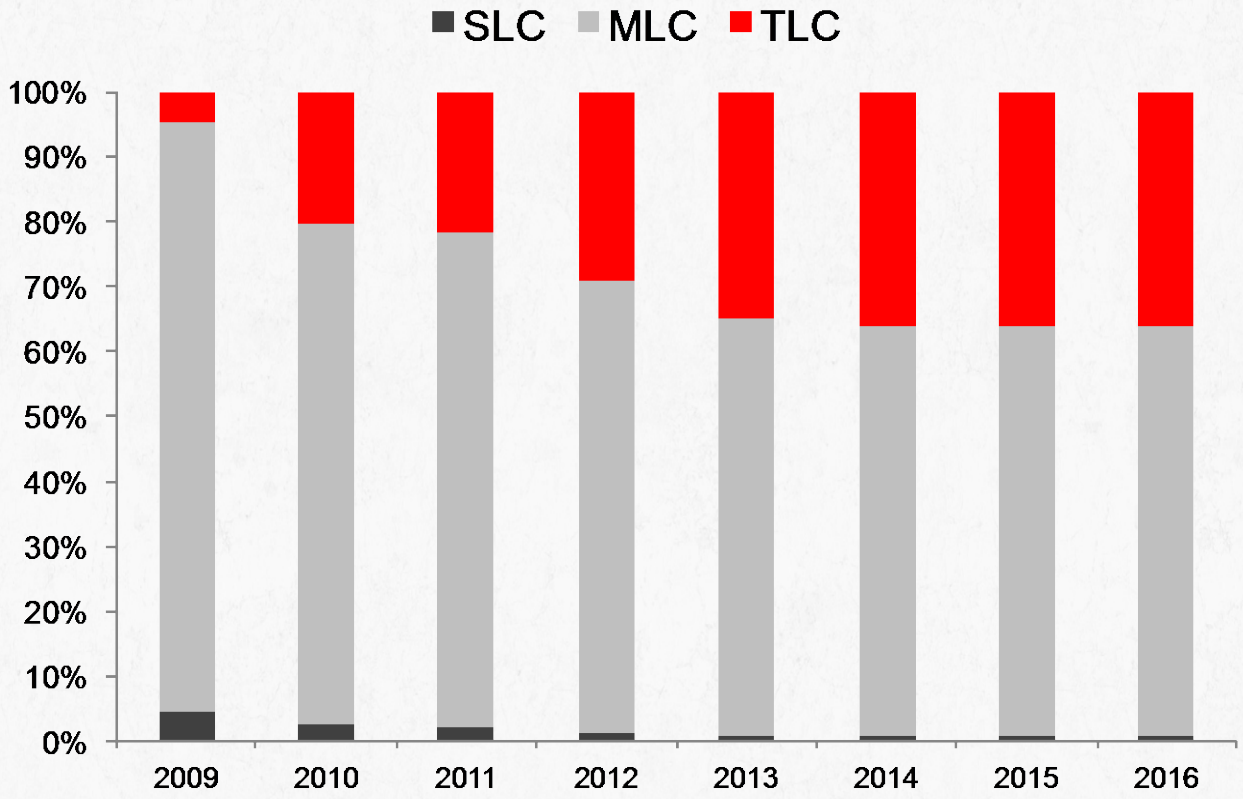
	2007	2013		2016
CAPACITY	32 GB AND 64 GB	120 GB – 1 TB	2X	120 GB – 2 TB
NAND TYPE	SLC	MLC/TLC		TLC/MLC/3D
RELIABILITY	100K P/E CYCLES	3K-500 P/E CYCLES		2K-200 P/E CYCLES
PRICE PER GB	$12	$0.60	2X	$0.30
INTERFACE	PATA/SATA 1	SATA 3/PCIe GEN 2	6X	PCIe GEN 2\3
PERFORMANCE (SEQ R/W MB/s) (RANDOM R/W IOPS)	 67/47 5.4K/13	 550/520 95K/90K	 6X 3X	 3/1.4 GBs 250K/150K
FORM FACTOR	1.8” AND 2.5”	2.5/mSATA/M.2		M.2/BGA

SIX AREAS DRIVING EVOLUTION

- NAND
- CONTROLLER TECHNOLOGY
- ERROR CORRECTION CODE
- INTERFACES AND FORM FACTOR
- FIRMWARE
- ECOSYSTEM

NAND

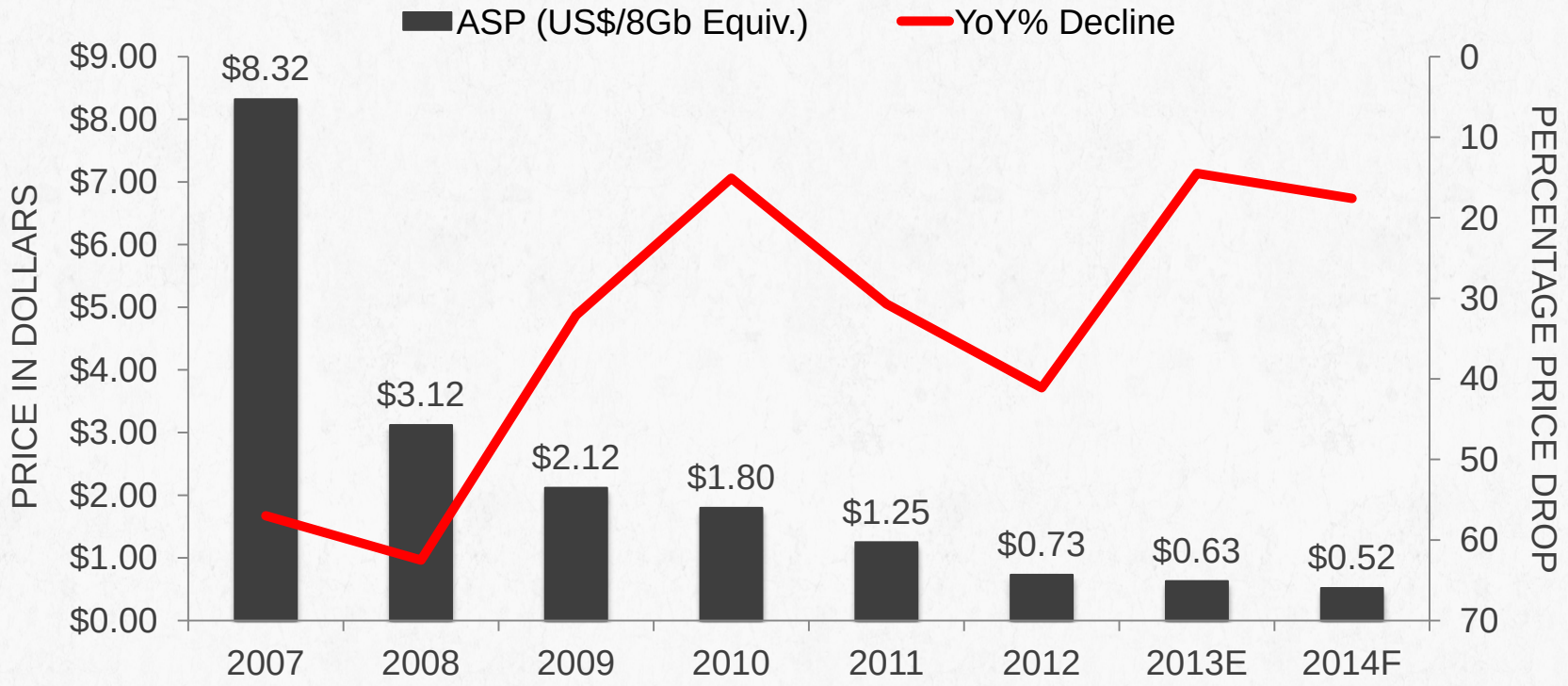
MIX IS MOVING TOWARD A HIGHER PORTION OF TLC, BUT MLC STILL DOMINATES



SOURCE: MARKET DATA

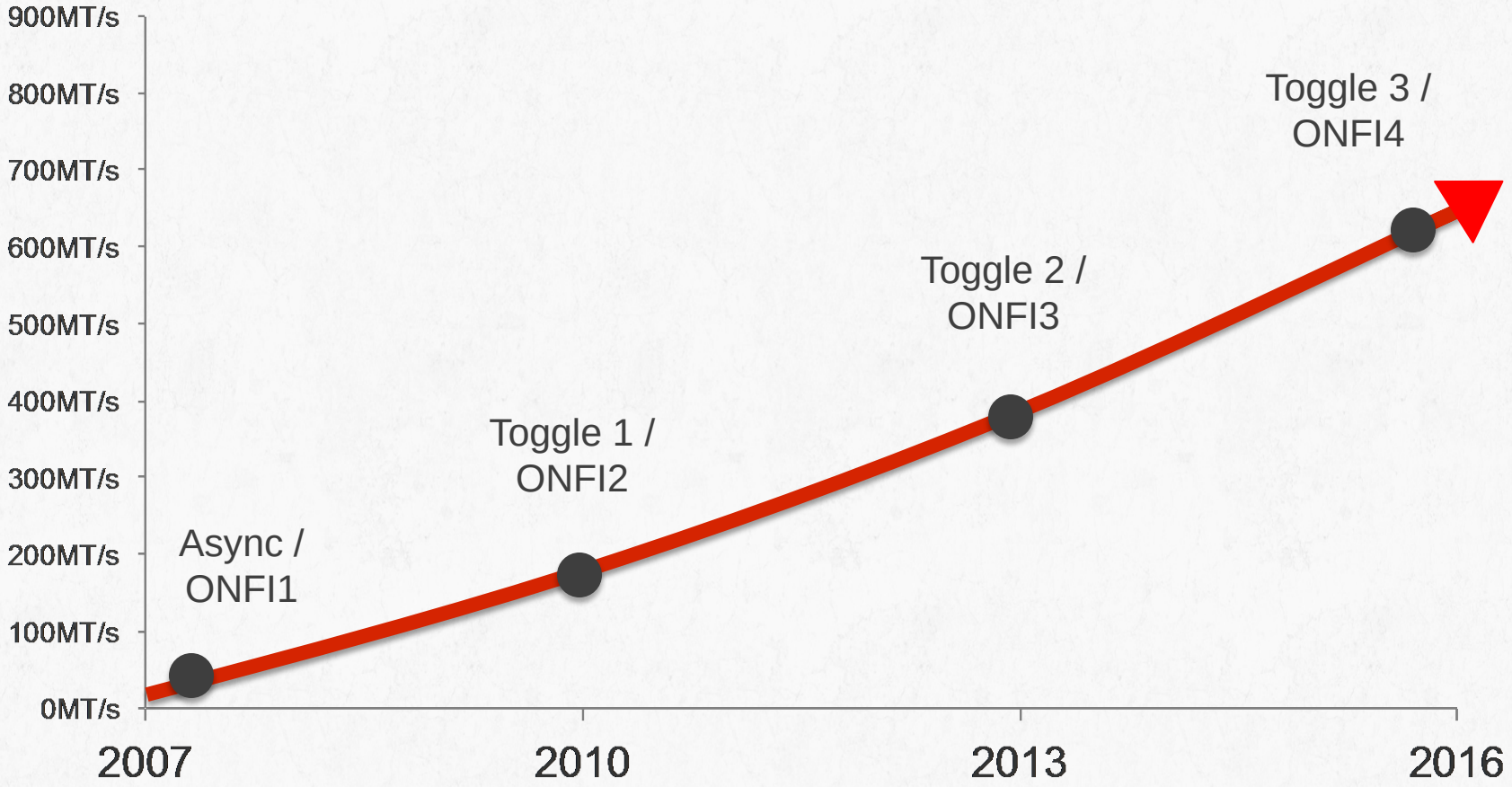
NAND

PRICE PER GB WILL CONTINUE TO GO DOWN, BUT MAJOR DECLINE IS ALREADY BEHIND US



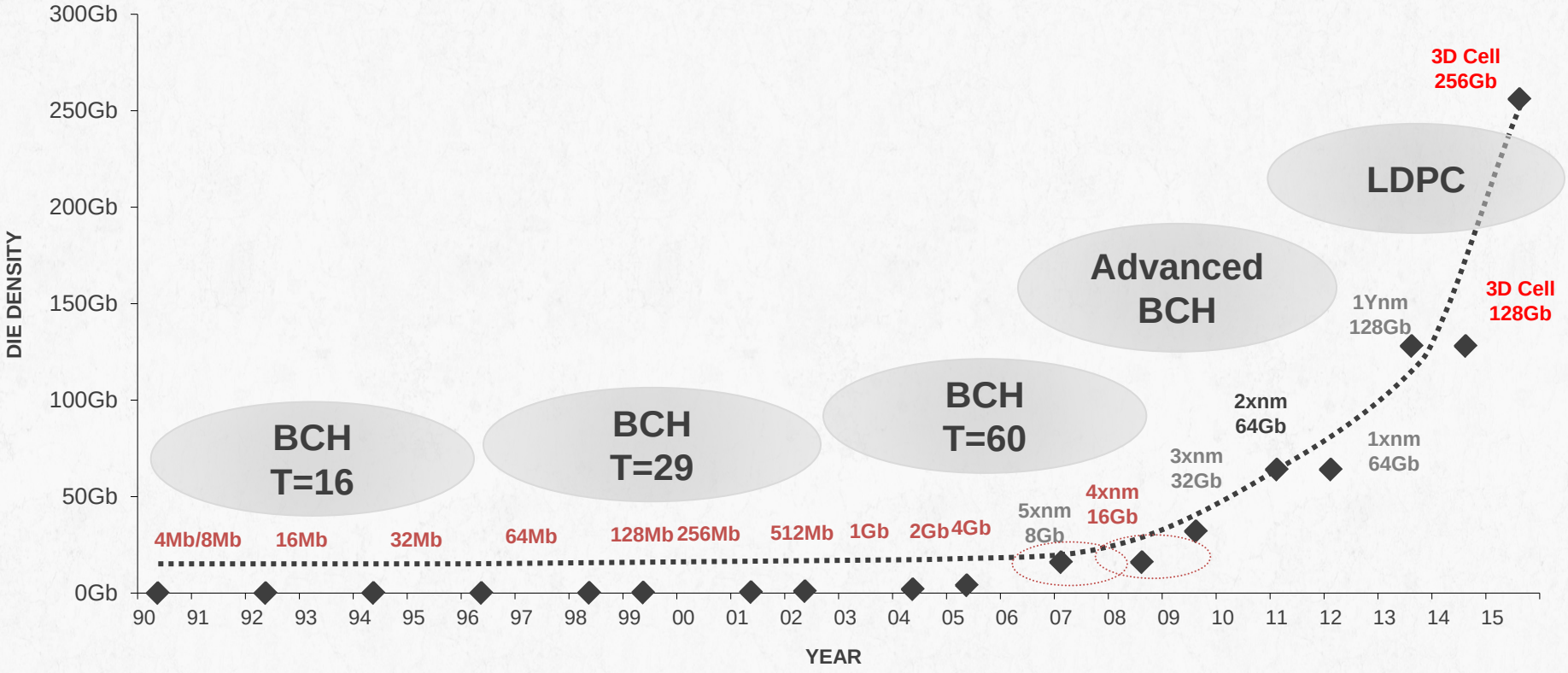
SOURCE: DRAMEXCHANGE, MAY 2013

NAND
INTERFACES ARE STILL EVOLVING



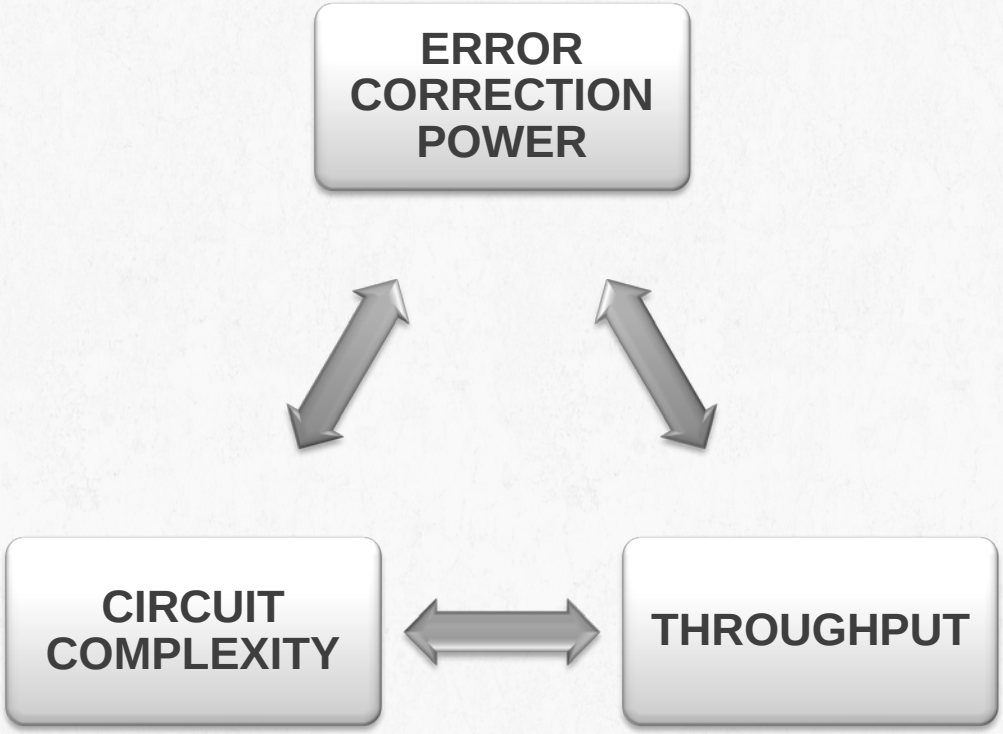
ERROR CORRECTION CODE

INCREASINGLY COMPLEX NAND DENSITY TREND WITH REDUCED ENDURANCE DRIVING ECC REQUIREMENTS



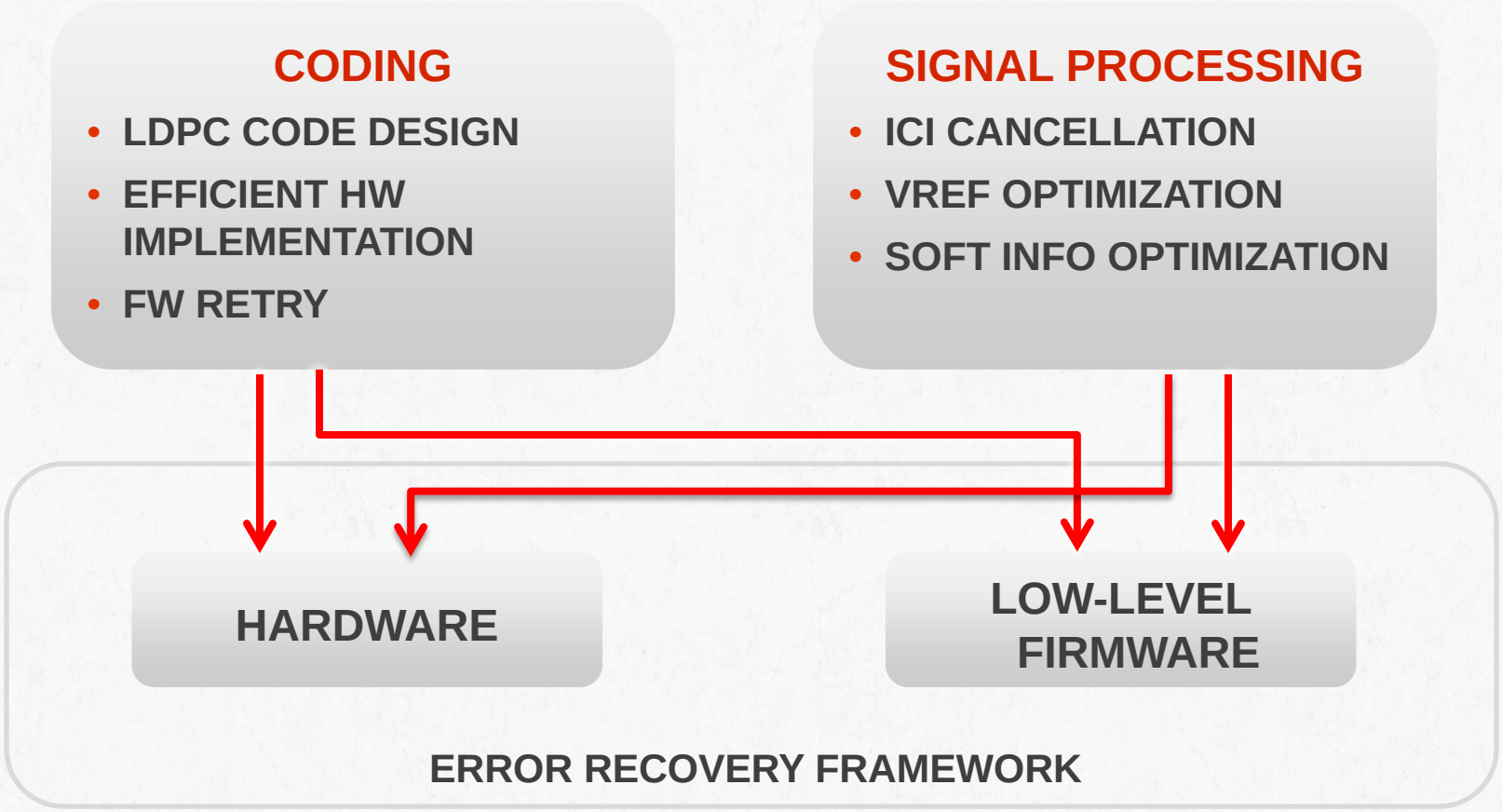
ERROR CORRECTION CODE

ECC DILEMMA – ERROR CORRECTION POWER, COMPLEXITY AND THROUGHPUT



ERROR CORRECTION CODE

LDPC IS A TOTAL SOLUTION; HARDWARE AND FIRMWARE INTERLEAVED



FIRMWARE

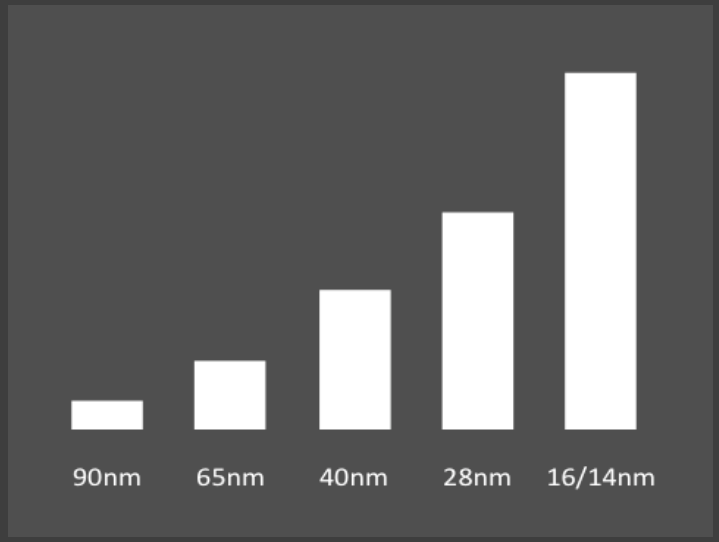
BECOMING MORE COMPLEX AND TIGHTLY COUPLED WITH NAND, DRIVING INNOVATION

CONTROLLER TECHNOLOGY

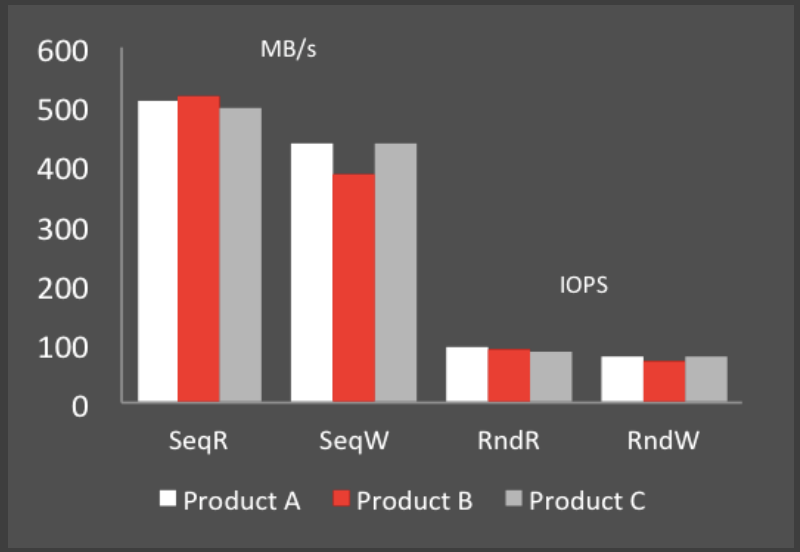
ADDRESSING THE NAND CHANGES AND EVOLVING REQUIREMENTS

- Single core to quad core
- 200 MHz to 600 MHz
- 40bit ECC to 128bit/code to LDPC
- Integrated security engines
- Power optimization
- DDRR-2 to DDRR-4 and LPDDR
- Asvnc/ONFI1- ➔ ONFI3/Toggle 4
- Smaller package, POP, BGA, MCP
- HW automation for host commands to improve performance and reduce bottlenecks

RISING DESIGN COSTS

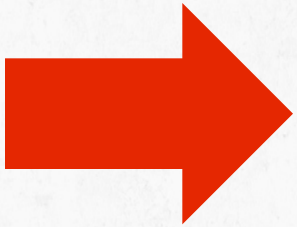


DRIVING FOR MERCHANT SILICON



FORM FACTOR AND INTERFACES

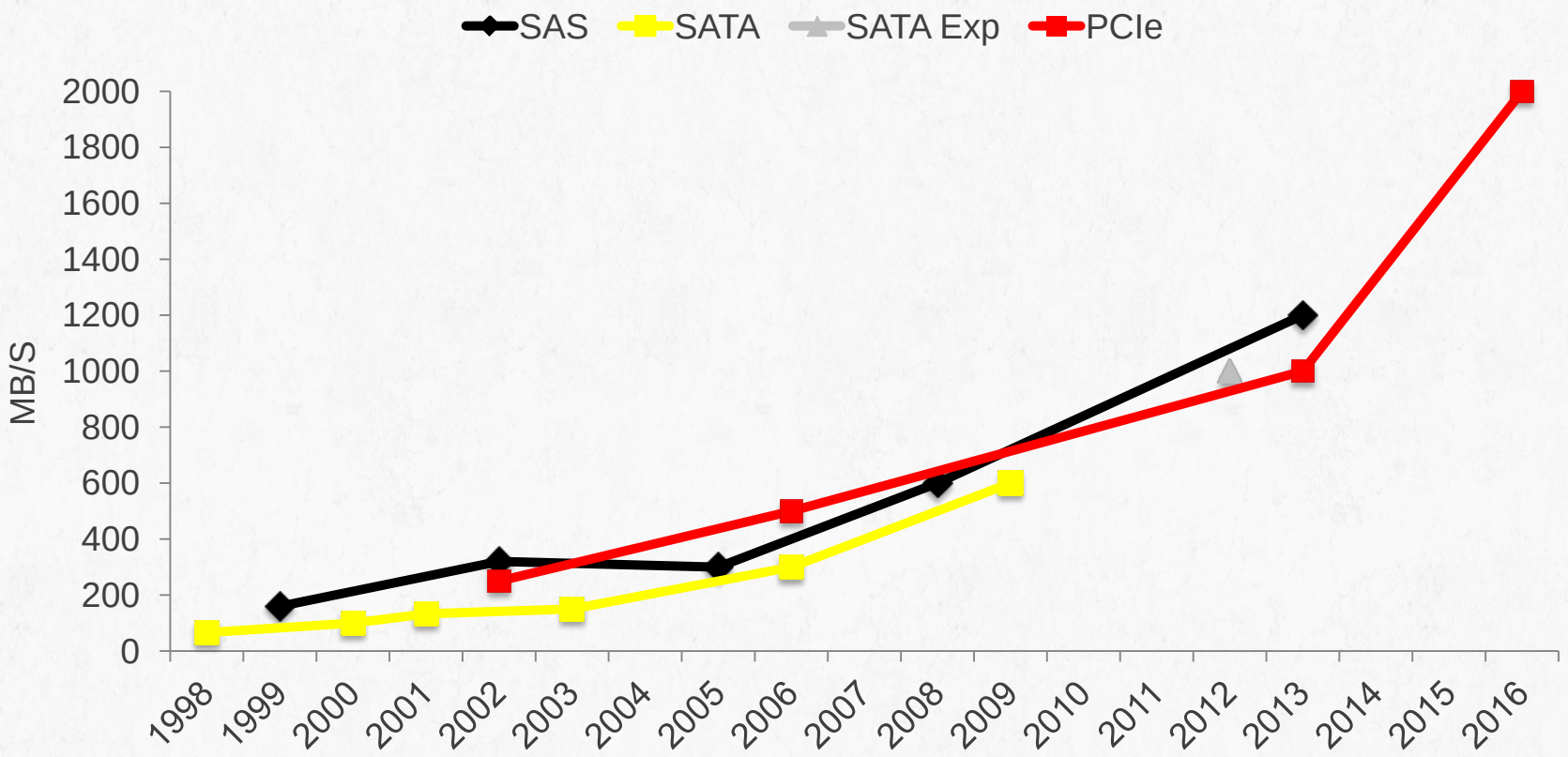
NEW CLIENT DEVICES ARE DRIVING SMALLER FORM FACTORS ALLOWING THINNER, SMALLER AND COOLER CLIENT DEVICES



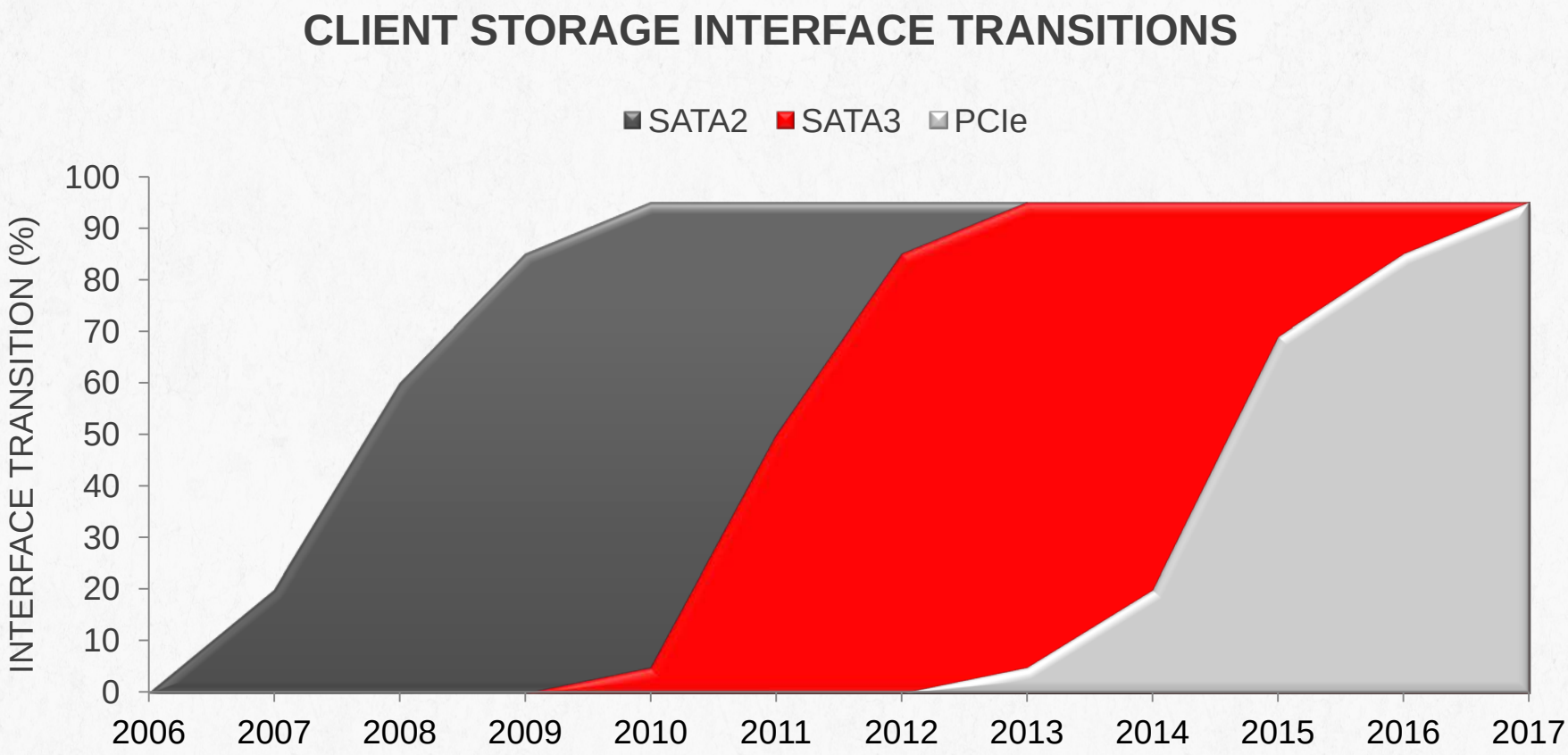
1/40 SPACE

CHANGES IN SPEED AND INTERFACE

PCIe IS DRIVING THE PERFORMANCE AND POWER FOR NEXT-GENERATION SSDS



CHANGES IN SPEED AND INTERFACE
TRANSITION TO PCIe ALREADY STARTED



SOURCE: MARVELL AND MARKET DATA

CLIENT SSD'S INTERFACE
FUTURE PATH

	2013
 HIGH-END DESKTOPS	SATA PCIe GEN2 X2/4
 ULTRABOOKS	SATA PCIe GEN2 X2/4
 NOTEBOOKS	SATA
 TABLETS	eMMC SATA BGA

CLIENT SSD'S INTERFACE
FUTURE PATH

	2013	2014
 HIGH-END DESKTOPS	SATA PCIe GEN2 X2/4	PCIe GEN2 X2/4 SATA
 ULTRABOOKS	SATA PCIe GEN2 X2/4	PCIe GEN2 X2/4 SATA
 NOTEBOOKS	SATA	SATA
 TABLETS	eMMC SATA BGA	eMMC UFS SATA BGA

CLIENT SSD'S INTERFACE
FUTURE PATH

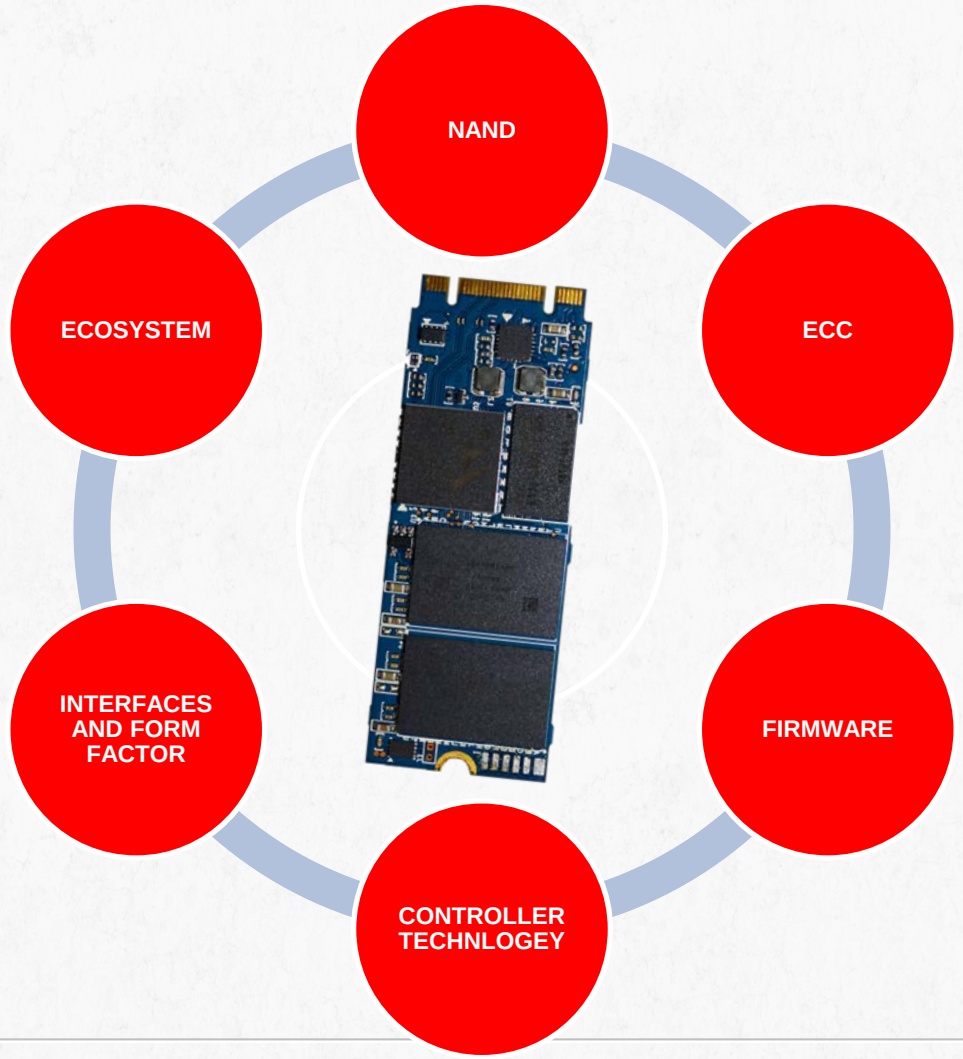
	2013	2014	2016
 HIGH-END DESKTOPS	SATA PCIe GEN2 X2/4	PCIe GEN2 X2/4 SATA	PCI e GEN 2/3 SATA
 ULTRABOOKS	SATA PCIe GEN2 X2/4	PCIe GEN2 X2/4 SATA	PCIe GEN 2/3 SATA
 NOTEBOOKS	SATA	SATA	PCIe GEN 2 SATA SATA/PCIe BGA
 TABLETS	eMMC SATA BGA	eMMC UFS SATA BGA	eMMC UFS PCIE/SATA BGA

ECOSYSTEM

DRIVING INNOVATION AND SUPPORT FOR SMARTER AND FASTER DEVICES

- CHIPSET AND OS
- TRIM
- LOW-POWER
- NVME
- PQI
- STANDARDIZATION

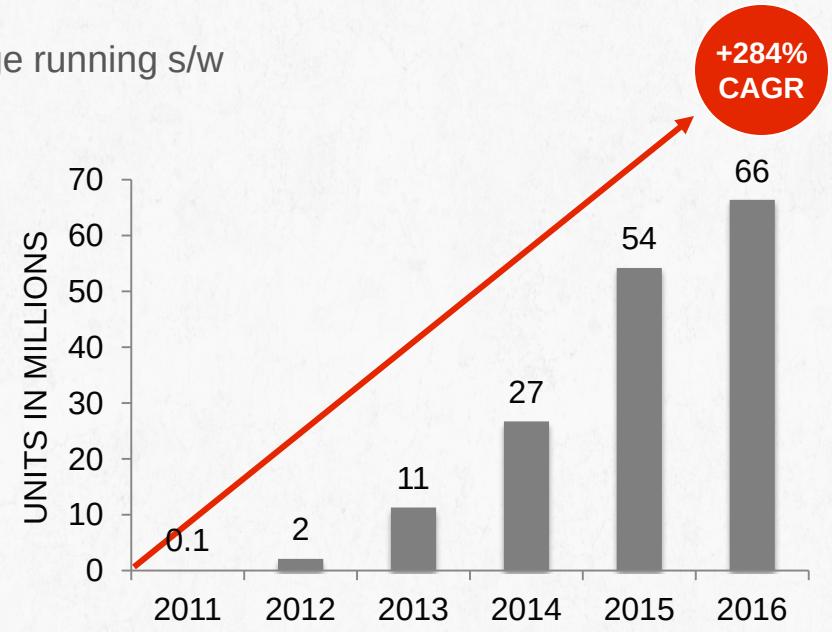
SIX AREAS DRIVING SSD EVOLUTION



TWO MORE TOPICS ...

HYBRID HDD IS HERE!

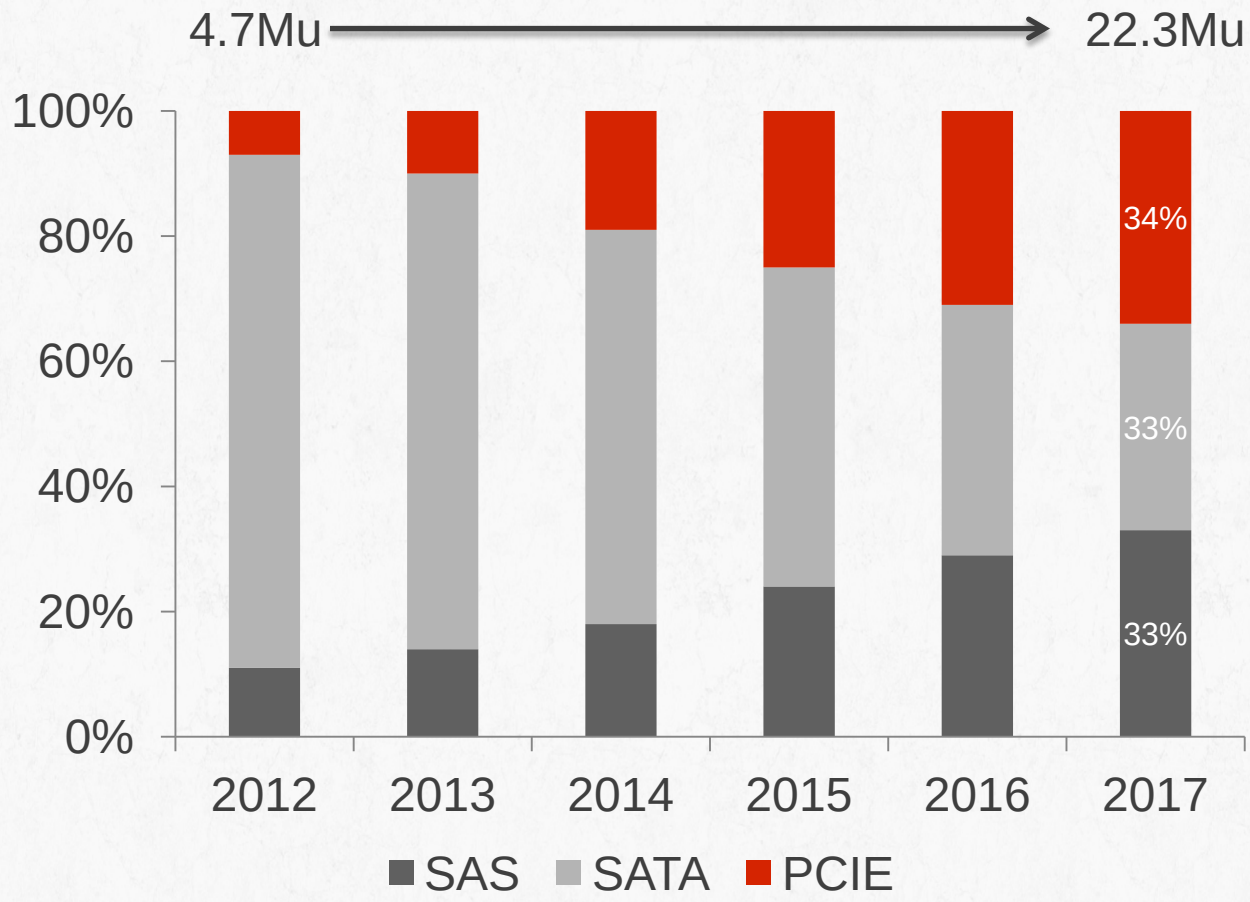
- Multiple announcements from all major HDD vendors
  - High-capacity HDD with 8-128GB NAND
- Ecosystem is being developed with chipset, drivers and OS support, and is moving in the right direction
- Two architectures exists:
  - Two-drive solution
    - HDD + SSD with chip or Southbridge running s/w for caching
  - Integrated hybrid
    - HDD + Flash with HDD SOC running s/w for caching
- Advantages of integrated hybrid HDD
  - Form factor
  - Ease of implementation
  - Cost



SOURCE: TREND FOCUS, WESTERN DIGITAL

DATA CENTER IS CHANGING

TREMENDOUS SSD GROWTH

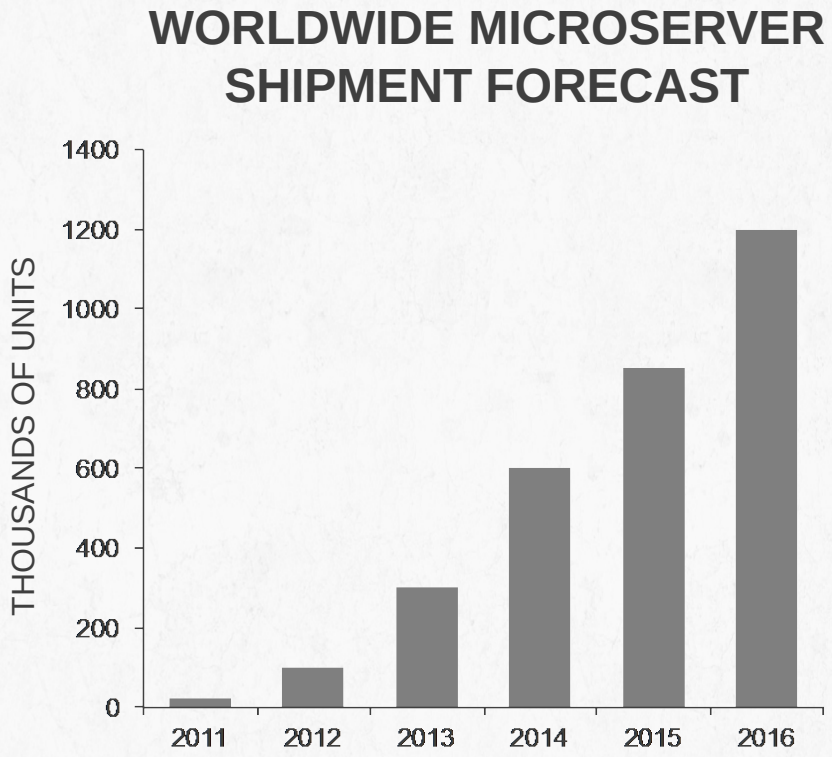


SOURCE: MARVELL AND MARKET DATA

- Improved performance
- Smaller footprint
- Less power

DATA CENTER IS CHANGING

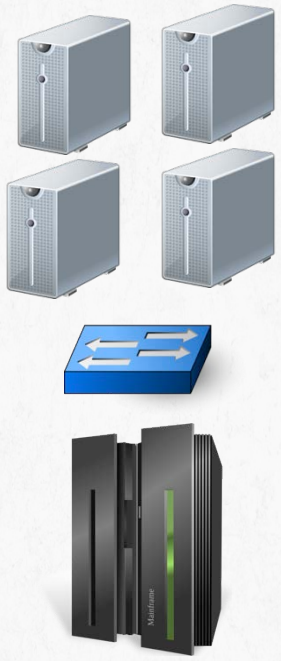
ARM-BASED MICRO SERVERS ARE A REALITY



SOURCE: IHS ISUPPLI RESEARCH, FEBRUARY 2013

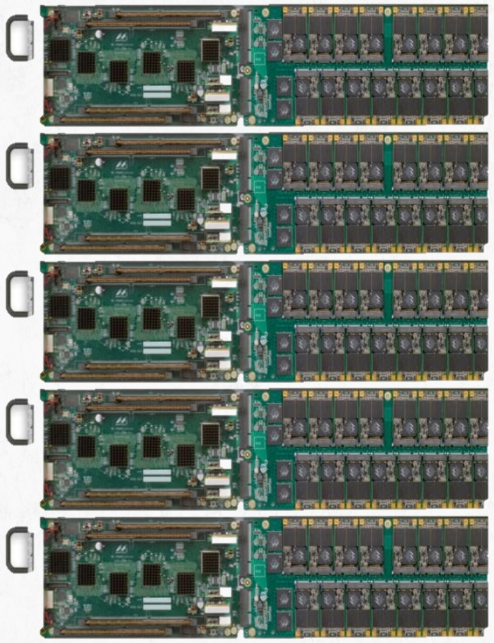
MARKET SHIFT TO SCALE-OUT CONVERGENCE

SMP SERVERS AND NETWORKED STORAGE



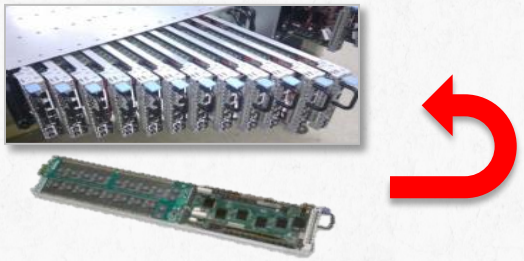
SCALE-OUT CONVERGED STORAGE SERVERS

ARM HDD\SSD CONVERGED STORAGE SERVERS



LONG TERM: ALL-SILICON SERVERS

MARKET SHIFT FROM MONOLITHIC SERVERS TO RACK CONTAINERS FOR HIGH-DENSITY ARM SSD SERVERS



TODAY: 21 X86 HDD SERVERS		FUTURE: 1X ARM SSD SERVERS
25K IOS/RACK	100X HIGHER IOPS	2.5M IOS/RACK
42U RACK SPACE	90% LESS SPACE	3U RACK SPACE
8400W	80% LOWER POWER	1600W

2016 PREDICTIONS

Extremely high-performance client SSD based on TLC

Integrated hybrid HDD to consume 3% of NAND output

LDPC is driving TLC-based SSD volume in the mainstream enterprise

Integrated server, storage and networking for scale-out systems driving innovation in the data center

THANK YOU

MARVELL: SERVING A WIDE RANGE OF THE STORAGE INDUSTRY