No Spin Zone

SSDs Rock Storage Interfaces

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Agenda

- "A New Era in Computing"
- Essential role of Solid State Drives (SSDs)
- Hard Disk Drive and SSD implementations
- The major SSD protocols
- Expected verification project starts for storage interfaces
- Traditional application of Verification IP (VIP) to storage verification
- New applications of VIP for SSD verification

Jan 2008 – MacBook Air

Apple introduces MacBook Air

by Peter Cohen, Macworld.com   Jan 15, 2008 12:29 pm

During his Macworld Expo keynote address on Tuesday morning, Apple CEO Steve Jobs introduced the MacBook Air, a computer that the company billed as the world's thinnest notebook -- small enough to fit inside an interoffice mailing envelope. It's priced starting at $1,799 and will be available within two weeks.

http://www.macworld.com/article/131583/2008/01/macbookair.html

Jan 2010 - iPad

Apple Press Info

Apple Launches iPad

Magical & Revolutionary Device at an Unbelievable Price

SAN FRANCISCO—January 27, 2010—Apple® today introduced iPad, a revolutionary device for browsing the web, reading and sending email, enjoying photos, watching videos, listen to music, playing games, reading e-books and much more. iPad's responsive high–resolu Multi–Touch™ display lets users physically interact with applications and content. iPad is 0.5 inches thick and weighs just 1.5 pounds— thinner and lighter than any laptop or netbook. iPad includes 12 new innovative apps designed especially for the iPad, and will almost all of the over 140,000 apps in the App Store. iPad will be available in late March starting at the breakthrough price of just $499.

http://www.apple.com/pr/library/2010/01/27Apple-Launches-iPad.html

Jan 2012 - PC Industry responds

LAPTOPS | DESKTOPS | TABLETS | PHONES | SOFTWARE | CAMERAS | HDTVS

Intel Touts 'New Era in Computing' with Ultrabooks

By Damon Poeter   January 9, 2012 02:36pm EST   2 Comments   Email   Print

Intel is ramping up its marketing onslaught for slim and sleek Ultrabook laptops, promising at the Consumer Electronics Show in Las Vegas Monday that the category will "usher in a new era of computing and make everything else seem like ancient history."

With all the buzz surrounding slick new smartphones and tablets, laptops just aren't as sexy as they used to be. Intel, even as it takes another stab at penetrating the mobile device market with a new Atom platform, is also clearly trying to get some of its old mojo back with Ultrabooks.

To that end, Intel said it's kicking off a "multi-facted" Ultrabook marketing campaign called "A New Era in Computing" beginning in April. At CES, the company showed some of the advertising that's being developed around the campaign, which includes TV, print, and outdoor ads.

http://www.pcmag.com/article2/0,2817,2398622,00.asp

Solid State Drives Essential to Ultrabook Alure
SSDs = Super thin, Instant on, Blazing speed, Extended battery life

Samsung Serves Up mSATA SSDs For Ultrabooks

Thursday, December 01, 2011 - by **Ray Willington**

Great things have long since come in small packages, particularly in the case of computers and storage. Samsung is stretching the boundaries once more with their new high-performance mSATA SSDs for ultra-slim notebooks. Not surprisingly, these are tailor made for Ultrabook PCs, and with the proliferation of those, we suspect they'll be moving quite a few of 'em.

http://hothardware.com/News/Samsung-Serves-Up-mSATA-SSDs-For-Ultrabooks/

Micron plans to force itself into tablets, ultrabooks
Aims to pump up its fab before entry
By **Chris Mellor • Get more from this author**
Posted in Storage, 13th December 2011 08:58 GMT
Free whitepaper – Assuring application service quality

Micron is going to enter the market for tablet and ultrabook flash next year with mSATA solid state drives.

Kevin Kilbuck, Micron's marketing director for NAND solutions, is quoted in the Taipei Times as saying Micron is talking to ultrabook makers about mSATA interface SSD supply next year.

http://www.theregister.co.uk/2011/12/13/micron_msata/

SANDISK ULTRA SOLID STATE DRIVE (SSD) SHIPS TO RETAILERS

New SSD Extends the Life of Desktop and Notebook PCs-Faster and More Reliable Than a Hard Disk Drive

MILPITAS, Calif., July 25, 2011 - SanDisk Corporation (NASDAQ: SNDK), a global leader in flash memory storage solutions, today introduced the SanDisk Ultra® solid state drive (SSD) for the retail market. The new SSD can extend the life of desktop and notebook PCs, and offers greater performance, durability and power efficiency than a hard disk drive.

The SanDisk Ultra SSD is a convenient drop-in solution for technology enthusiasts looking to upgrade their own PCs for an enhanced user experience. The new SSD features:

http://sandisk.com/about-sandisk/press-room/press-releases/2011/2011-07-25-sandisk-ultra-solid-state-drive-ships-to-retailers

Is 2012 the year of the SSD? SanDisk, Western Digital disagree

By Sean Portnoy | January 26, 2012, 5:41am PST

Have solid state drives hit an "inflection point," as SanDisk has predicted? Or despite the push for Ultrabook production from Intel, will SSD market penetration remain low, as Western Digital forecasts? They may not be as sexy as the tablet wars, but the storage wars of 2012 may be every bit as epic.

SanDisk Of course, both sides have their own motives for stating their positions. While SanDisk isn't a big player in the SSD game, it does expect the drives to account for more of its profits as a greater number of device makers use them instead of traditional hard drives. In particular, Ultrabooks are expected to account for a major boost in SSD production, as companies flock to the drives for their thinner profiles and speedy boot-up times.

But, not surprisingly, hard drive giant Western Digital isn't buying it. Despite a massive hard drive shortage related to flooding in Thailand last fall, WD still thinks that SSDs will only wind up in less than 10 percent of Ultrabooks, as companies rely on cheaper hard drive and hybrid drives — hard drives combined with a low-capacity SSD for boot-ups — to meet Intel's aggressive price point suggestions.

http://www.zdnet.com/blog/computers/is-2012-the-year-of-the-ssd-sandisk-western-digital-disagree/7443

SSDs Also Key to Cloud Implementation
Delivering needed Latency, Bandwidth, Power, Reliability, Cost

FEBRUARY 25, 2012 | SCOT STRONG | 2 COMMENTS

Toshiba MKx001GRZB Enterprise SSD Boasts SLC Memory and 6Gb/s Performance

Toshiba has put a strong foot forward into the enterprise SSD storage arena with their 6 Gbb/s MKx001GRZB series of drives that also feature 32nm SLC NAND Flash Memory. These drives are available in capacities of 100 / 200 / 400 GB.

The 6 GB/s interface lets these SSDs achieve sequential speeds of 500MB/s reads and 250MB/s writes. 4K random IOPS are stated as a sustained 90,000 read and 16,400 write.

The speeds this SSD represents is an increase of over 3 times the speed of their highest-performing enterprise HDDs. With power requirement of only 6.5w in operation, these drives give Toshiba an industry-leading 13,800 IOPS/watt power efficiency rating.

http://thessdreview.com/latest-buzz/toshiba-mkx001grzb-enterprise-ssd-boasts-slc-memory-and-6gbs-performance/

MARCH 5TH, 2012 by Kevin OBrien

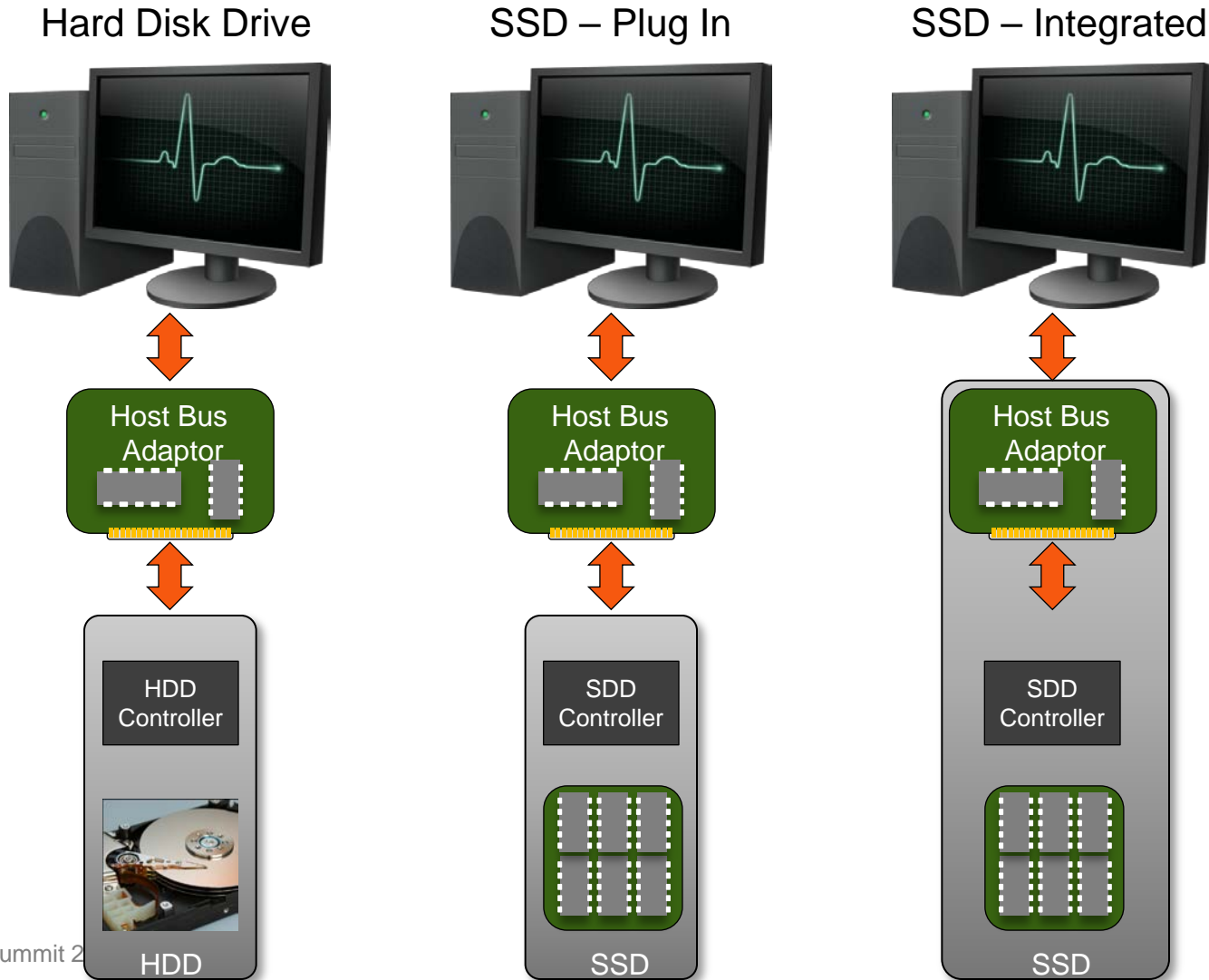### Micron RealSSD P400e Enterprise SSD Review

The Micron RealSSD P400e is designed for the entry-level enterprise SSD space, an increasingly popular segment that is largely read centric, making it the perfect playground for low cost MLC SSDs. The P400e features Micron's home grown 25nm MLC NAND, SATA 6 Gb/s interface and Marvell controller. Micron uses the popular 2.5" form factor, but with a 7mm z-height, giving the P400e more flexibility for use within 1U servers and embedded applications like switches and routers.
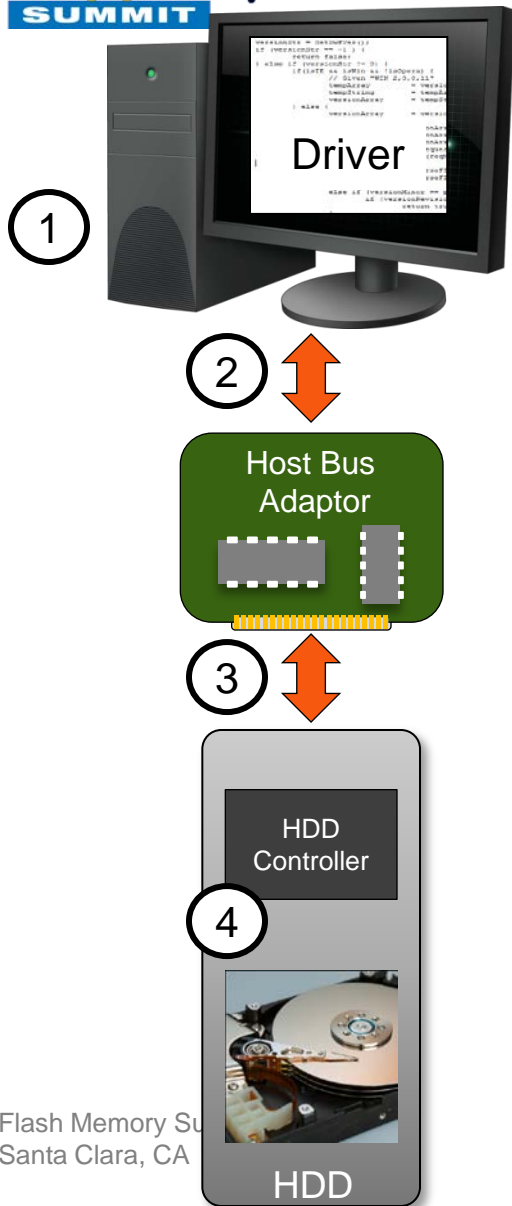
http://www.storagereview.com/micron_realssd_p400e_enterprise_ssd_review
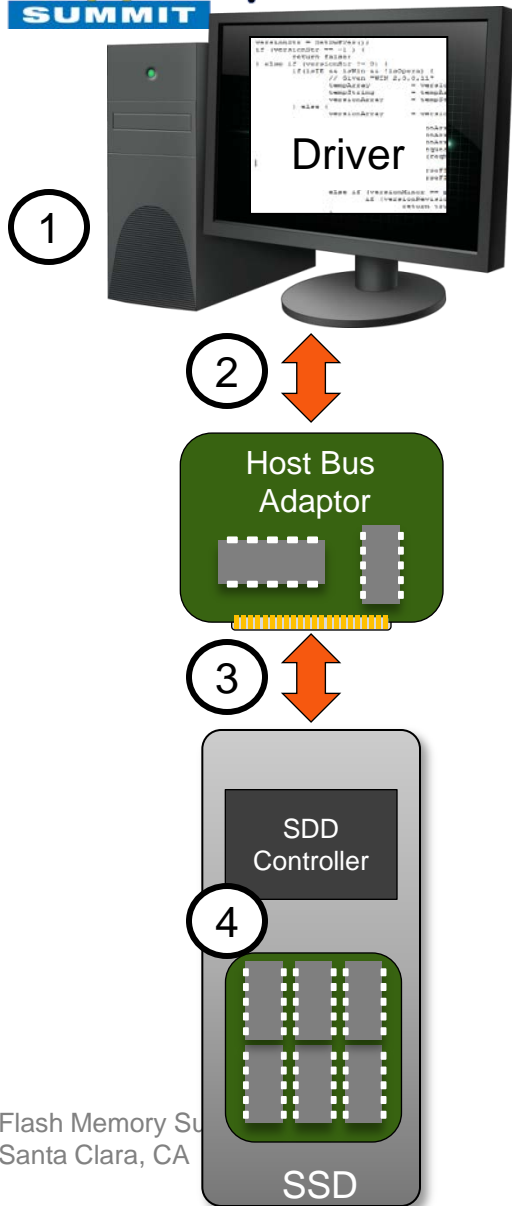
HDD and SSD Implementations

Hard Disk Drive   SSD – Plug In   SSD – Integrated

Host Bus Adaptor

HDD Controller

HDD

Host Bus Adaptor

SDD Controller

SSD

Host Bus Adaptor

SDD Controller

SSD

Hard Disk Interface Stack

Driver

Host Bus Adaptor

HDD Controller

HDD

① ② ③ ④

- **Consumer**

1) Driver I/F
   - AHCI
2) Bus I/F
   - PCIe
3) Drive I/F
   - SATA
4) Media I/F
   - Proprietary

- **Enterprise**

1) Driver I/F
   - SCSI
2) Bus I/F
   - PCIe
3) Drive I/F
   - SAS
4) Media I/F
   - Proprietary

SSD Interface Stack – Plug Compatible

Driver

① ② ③ ④

Host Bus Adaptor

SDD Controller

SSD

- **Consumer**

1) Driver I/F
   - AHCI
2) Bus I/F
   - PCIe
3) Drive I/F
   - SATA
4) Media I/F
   - ONFI

- **Enterprise**

1) Driver I/F
   - SCSI
2) Bus I/F
   - PCIe
3) Drive I/F
   - SAS
4) Media I/F
   - ONFI

Easy to implement but performance is limited by the drive I/F protocol

Reference: http://www.snia.org/forums/sssi/knowledge/standards

SSD Interface Stack – Integrated

Driver

① ② ③

Host Bus
Adaptor

SDD
Controller

④

SSD
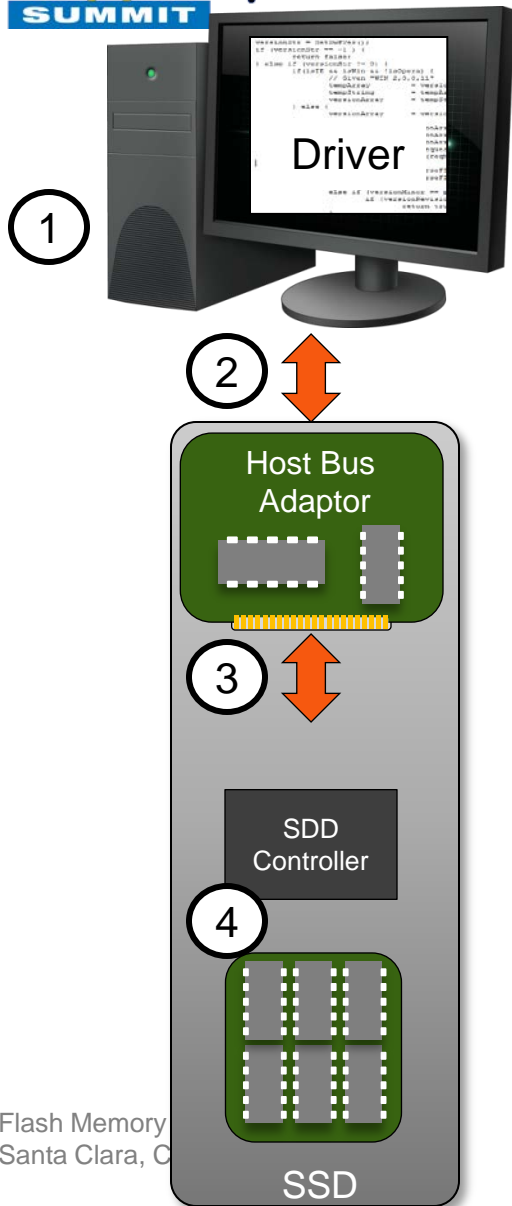
- **Consumer**

1) Driver I/F
  - AHCI
  - NVMe

2) Bus I/F
  - PCIe
  - SATA-Express

3) N/A

4) Media I/F
  - ONFI

- **Enterprise**

1) Driver I/F
  - SOP/PQI

2) Bus I/F
  - PCIe

3) N/A

4) Media I/F
  - ONFI

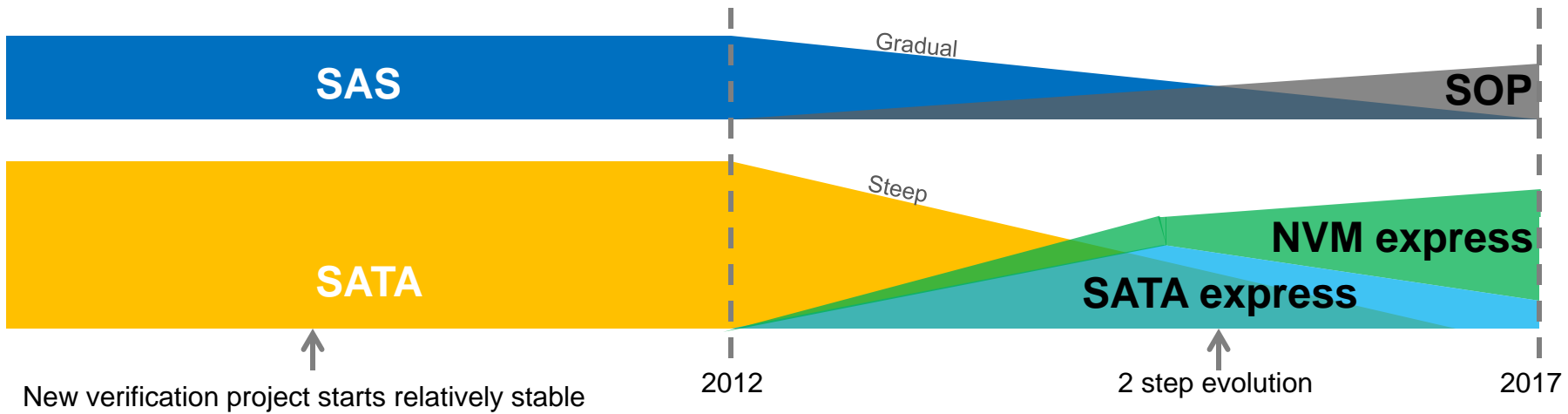Unlocks full SSD performance

Reference: http://www.snia.org/forums/sssi/knowledge/standards

Three Major SSD Interface Protocols

- Consumer
  - SATA Express
    - No driver change required
    - Limited command queues
  - NMV Express (NVMe)
    - New driver needed
    - Large command queues
- Enterprise
  - SCSI over PCI Express (SOP/PQI)
    - New driver needed
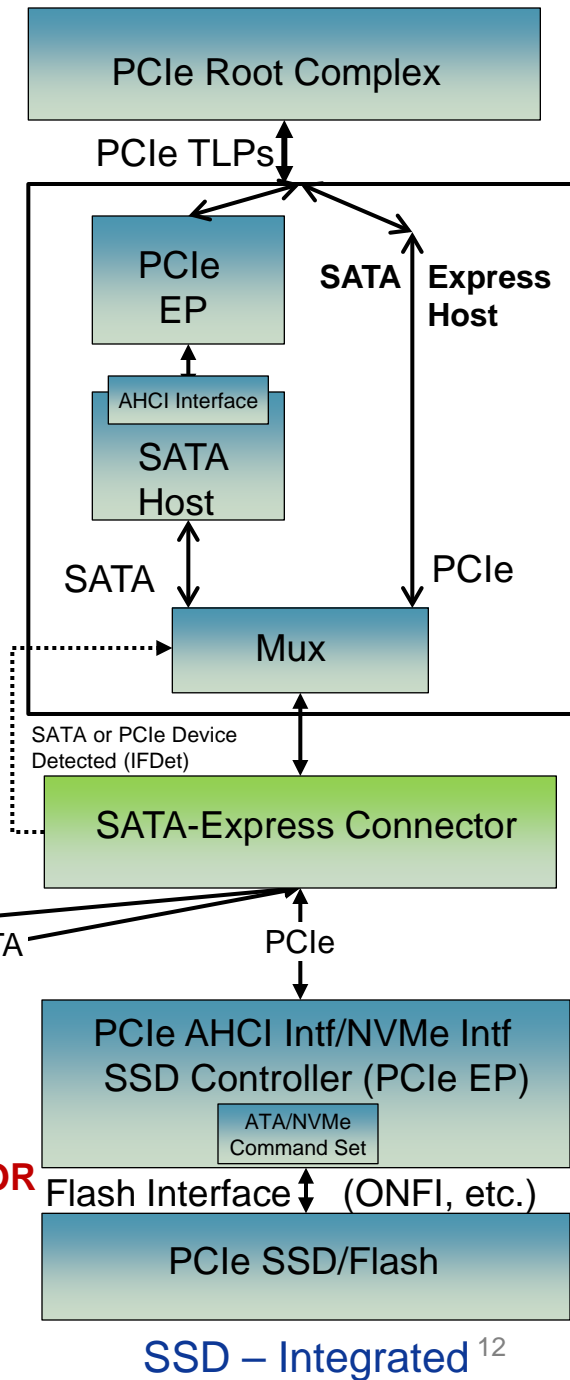   - Incorporates rich SCSI command set

Expected Verification Project Starts

SAS

Gradual

SOP

SATA

Steep

NVM express

SATA express

New verification project starts relatively stable

2012

2 step evolution

2017

Consumer SSD I/F Details
SATA Express & NVMe

PCIe Root Complex

PCIe TLPs

PCIe EP

AHCI Interface

SATA Host

SATA | **Express Host**

SATA

PCIe

Mux

SATA or PCIe Device
Detected (IFDet)

SATA-Express Connector

SATA

SATA

PCIe

SATA HDD Controller	SATA SSD Controller	PCIe AHCI Intf/NVMe Intf SSD Controller (PCIe EP)
ATA Command Set	ATA Command Set	ATA/NVMe Command Set

OR Flash Interface ↕ (ONFI, etc.)   **OR** Flash Interface ↕ (ONFI, etc.)

SATA HDD	SATA SSD/Flash	PCIe SSD/Flash

Hard Disk Drive   SSD – Plug In   SSD – Integrated [12]

Traditional VIP Application

Injected Frames with Random Field Values

Command	x x x x 1 0 1 0 x x x x 1 1 1 1 0 0 1 1 0 1 1 0 1 0 0 x x 1 1 1
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Status	x x x x x x x x 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1 0 1 0 1 0 1 0 1

Testbench Scoreboard

Recovered Frames

Command	x x x x 1 0 1 0 x x x x 1 1 1 1 0 0 1 1 0 1 1 0 1 0 0 x x 1 1 1
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Data	1 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1 0 0 1 1 1 0 0 0 1 1 1 1 1 0 0 0
Status	x x x x x x x x 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1 0 1 0 1 0 1 0 1

PCIe EP

SATA Express Host

AHCI Interface

SATA Host

VIP

SATA

PCIe

Mux

SATA or PCIe Device Detected (IFDet)

SATA-Express Connector

SATA

SATA SSD Controller

ATA Command Set

Flash Interface ↕ (ONFI, etc.)

SATA SSD/Flash

Enhanced VIP Application

AHCI Memory Mapped Commands & Data

Testbench Scoreboard

Recovered Commands & Data

PCIe EP

SATA Express Host

AHCI Interface

SATA Host

VIP

SATA

PCIe

Mux

SATA or PCIe Device Detected (IFDet)

SATA-Express Connector

PCIe

PCIe AHCI Intf/NVMe Intf SSD Controller (PCIe EP)

ATA/NVMe Command Set

Flash Interface ⬍ (ONFI, etc.)

PCIe SSD/Flash

SW-Driven VIP Application

SW Driver

Hardware Abstraction Layer Commands & Data

Driver performs scoreboard

Command
Reset
Data
Write all ones
Write all zeros
Write all ones
Write all zeros
Write all ones
Write all zeros
Write all ones
Write all zeros
Write all ones
Write all zeros
Write all ones
Write all zeros
Write all zeros
Write all ones
Write all zeros
Write all ones
Write all zeros
Status
Ready

PCIe EP

SATA Express Host

AHCI Interface

SATA Host

VIP

SATA

PCIe

Mux

SATA or PCIe Device Detected (IFDet)

SATA-Express Connector

PCIe

Recovered Commands & Data

PCIe AHCI Intf/NVMe Intf SSD Controller (PCIe EP)

ATA/NVMe Command Set

Flash Interface (ONFI, etc.)

PCIe SSD/Flash

Flas
Sant

15

Summary

- The PC industry is making a high stakes transition to ultrabooks

- SSDs are essential to that transition

- SSDs are also key to delivering Cloud content

- 3 types of storage designs will need to be verified: traditional HDDs, Plug-in SSDs, and integrated SSDs

- The 3 key SSD protocols are SATA Express, NVMe, and SOP

- The SSD protocols will rapidly dominate new verification project starts

- VIP will be used to raise the abstraction and effectiveness of SSD verification, first to the command level, and then to the SW driver level

Thank You!