



Flash Memory Summit



SD + PCIe/NVMe card

New Innovations in SD Cards Lead the Way to Mobile Everything

By Yosi Pinto – Chairman, SD Association
Director, Standards in CTO Office at Western Digital

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During our meeting today we will be making forward-looking statements.

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The PCIe mark on the microSD card is just an illustrated example and there is no guarantee that it will be indeed used

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Mobile and Mobile Computing Market Trends

More content = More memory

4k/8k video →



Social media →



More memory and More sequential Performance...





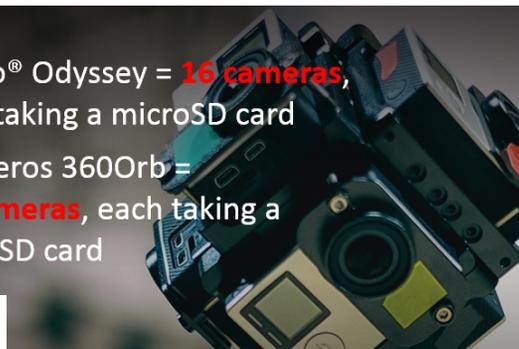
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More content generators = More memory

Drones, Action Cam, 360°, Virtual Reality



- GoPro® Odyssey = **16 cameras**, each taking a microSD card
- 360Heros 360Orb = **24 cameras**, each taking a microSD card



More memory and More Performance...

More Streaming content allowed to be saved on SD



- The top 5 music streaming services all offer **downloads for offline listening**
- Spotify and Tidal High Fidelity Audio
- 3000 High Fidelity songs = **30GB***
 - Standard song = 3-4MB
 - Hi-Fi song = 15-30MB+



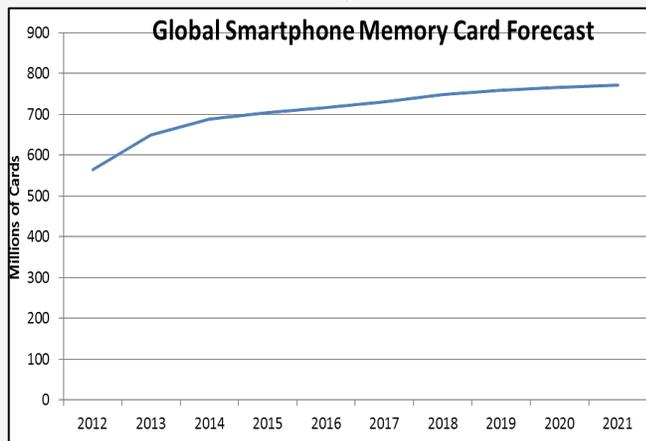
Source: Approximations from Tidal



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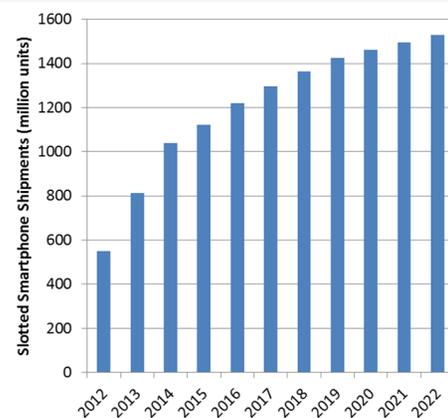
Mobile Phones = Main content generator

Mobile phones market continue to grow



Source: Strategy Analytics, October 2016

Number of phones with microSD slot is growing



Source: Strategy Analytics, October 2016

Analysis of Memory Card Slots in Smartphones for Models Announced Since 2014

	2014				2015				2016				2017	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q1
No. of models announced*	314	397	561	379	553	372	546	368	436	495	484	395	296	296
Memory Card Slot Support	82%	84%	84%	86%	84%	90%	82%	92%	92%	92%	91%	86%	97%	

Memory Card Slot Support in Smartphones



97% of Mobile phones introduced in Q1/17 include microSD slot

* the model count in the last two quarters is likely to increase as models from microvendors are discovered and added in future.

Phone manufacturers brings back microSD slots – appreciate user's benefits

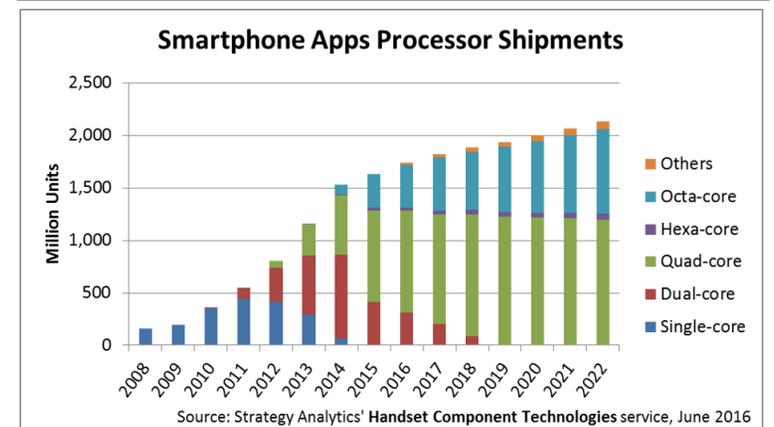
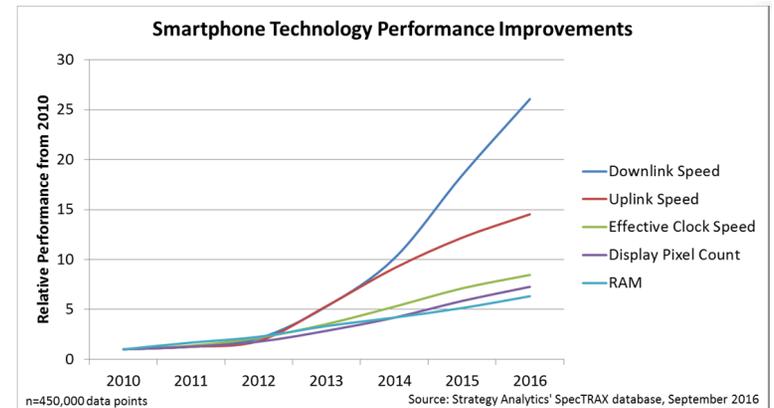


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Mobile Technology is developing rapidly

- Growing performance levels of IOs wireless (WiFi/WiGig...) and wired (USB3...)
- Rapid developments in APs technology (Multi cores, Speed, RAM increase etc..)
- Embedded storage is transitioning to more advanced protocols opening new opportunities (UFS and PCIe/NVMe)

Evolving technology trends push the memory interfaces requirement for additional higher random & sequential performance





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Client Computing, Imaging, Automotive – all transition to higher speed interface

Client SSD

- PCIe/NVMe is rapidly gaining popularity - expected to become most dominant in 2018
- PCIe Gen 4 is expected to gain traction by 2019/20

Client SSD Protocol Trend



Source: Forward Insights, May 2017

Automotive ... IoT

- Growing demand for high speed multi tasking environment is expected in various emerging markets
 - Autonomous Vehicles and Connected Cars with multi sensors data collections /processing
 - Multi channels video capturing
- Imaging market is already heading to PCIe



Autonomous vehicle of 2021 (Photo: Intel)



Evolving technology trends push the memory interfaces requirement to higher sequential & random performance levels



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microSD = Real Memory Expansion



It is not just content saving anymore....

Apps consume significant amount of memory...

Win Mobile and Android allows today to store & run applications from cards



Sequential Perf is not enough for Apps running...



SD Memory Card Standard Brings New Opportunities In Mobile



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New SD Standard Features

- SDA defined until today sequential writes performance standards serving mainly imaging and video capturing
- New market demands → new SD spec features introduced:
 - Application Performance Classes – Assured certain Random & Sequential performance under specified conditions. Allows common language for the eco-system ([further info](#))
 - New SSD like features added to SD – Command Queuing, Cache and Maintenance
 - Adding PCIe/NVMe interface to SD card is under definition – may open new opportunities ⁽¹⁾

(1) Currently under definition in SDA's Spec WG

(2) The microSD-PCIe card illustration is shown just for this presentation and it does not represent any official SDA standard, yet.



(2)

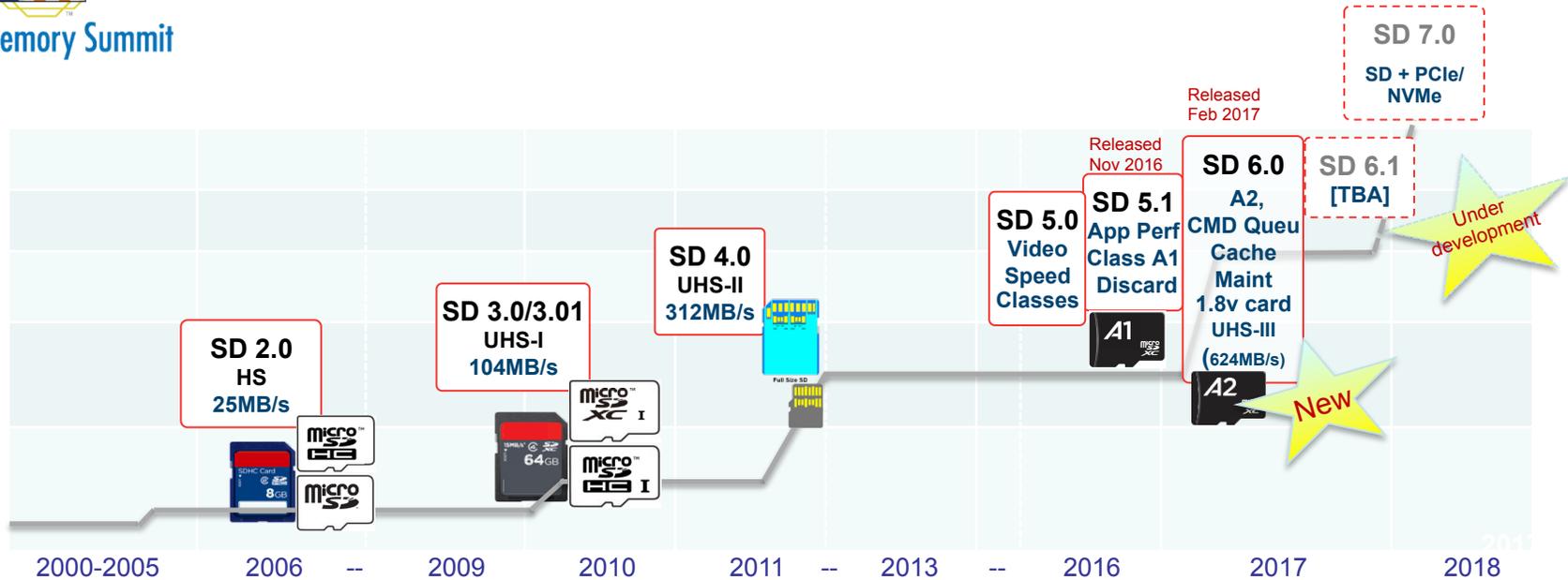


Minimum Sequential Write Speed	Speed Class			Corresponding Video Format
	Speed Class	UHS Speed Class	Video Speed Class (NEW)	
Card Image				The necessary speed varies by each recording / playback device condition, even in the same format.
90MB/sec			V90	8K Video
60MB/sec			V60	4K Video
30MB/sec		U3	V30	Full HD / HD Video
10MB/sec	10	U1	V10	Standard Video
6MB/sec	6		V6	
4MB/sec	4			
2MB/sec	2			



SD Standard Interface Evolution

➔ *SD's New Era...*



SD x.x = SDA released standard

SD x.x = SDA Standards under development ⁽¹⁾

(1) SDA is not obligated to any forward looking statements – refer to the detailed disclaimer



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SD-PCIe card

- Next Generation SD card – currently discussed in SDA's Specification WG with following basic concepts:
 - Adding PCIe/NVMe interface
 - Existing SD form factor
 - Full backward compatibility with billions of host devices
- The SD-PCIe TG is in advance stage of the proposals discussion
- If you would like to contribute to the Next Gen standard, please, join the SD-PCIe TG activity in SDA



(1)

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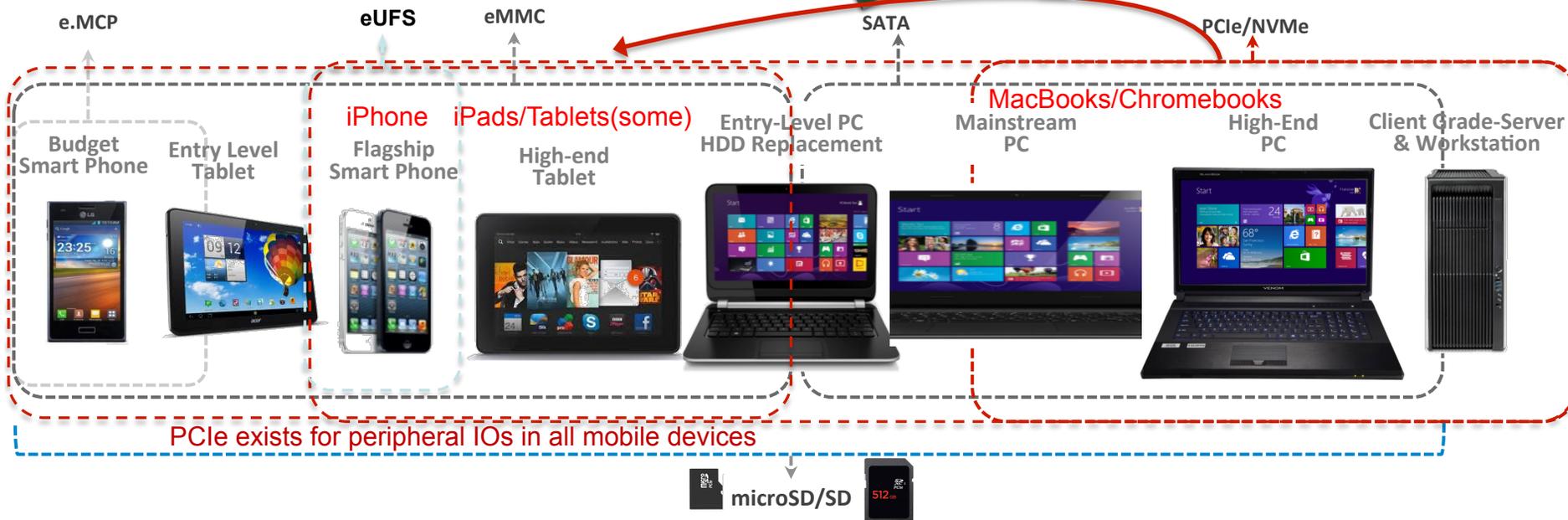
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Why PCIe/NVMe ?



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Storage Interfaces in Smart Client Devices Current view





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PCIe Trend in Mobile (Phones & Mobile Computing)

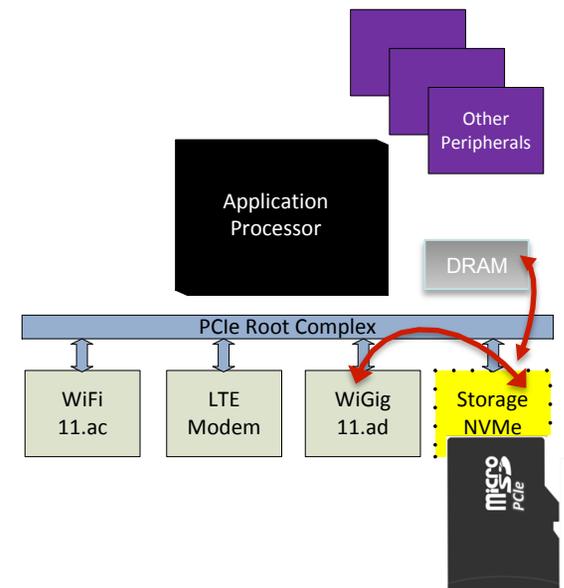
- Today - all mobile SoC have between 1 to 3 PCIe ports
- PCIe is the chosen Chip-to-Chip high speed connection
 - Ex. Qualcomm 8994 has 2x PCIe ports for Modem, WiFi or WiGig
- Major market leaders adopting PCIe/NVMe
 - Google Chromebook (refer to Google's presentation in FMS 2016)
 - MacBook [and iPhone](#)
 - In imaging – All high-end market is moving to PCIe memory interface (CF cards, XQD etc)...



Foxit Reader PDF Document

SD-PCIe adoption may be relatively easy:

- Enabling PCIe/NVMe does not require new IP technology development
- NVMe SW stack is already available today in open source
- Test tools for protocol testing are available off-the-shelf





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PCIe/NVMe – Test Advantages

- Many Bus Analyzers, Protocol Analyzers, Test Suites are in the market...

SerialTek

 **TELEDYNE
TECHNOLOGIES**
INCORPORATED

OakGate Technology



 **JDSU**

 **KEYSIGHT**
TECHNOLOGIES



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Protocol Comparison Highlights

Item	SD 6.0	eMMC 5.1	UFS 2.1	PCIe/NVMe	NVMe Benefit
Bus Mastering	No	No	No	Yes (native)	<ul style="list-style-type: none"> • Key feature, host offload • Performance (efficient host architecture) • Device to device 
Driver Stack	Complicated	Complicated	Complicated	Light protocol (new, build for performance)	<ul style="list-style-type: none"> • Performance (reduce host latency) • Reduced power 
Multi Initiators and Multi Queue (no locking mechanism)	No <ul style="list-style-type: none"> • One queue • One host controller • Serial access (CQ introduced in SD6.0) 	No <ul style="list-style-type: none"> • One queue • One host controller • Serial access 	No <ul style="list-style-type: none"> • One queue • One host controller • Serial access 	Yes <ul style="list-style-type: none"> • Each core may have its own queue • More than one core may manage the storage device 	<ul style="list-style-type: none"> • Multi core and multi tasking • System performance • Lower Latency and Power • Better balance between cores 
Host Memory Buffer (HMB)	No	No	Yes (by spec extension, not yet by design)	Yes (native)	<ul style="list-style-type: none"> • System flexibility • Performance (example: L2P table) • Cost reduction 



Physical Comparison Highlights

- Active Power consumption is about energy consumed.
- Mobile acceptable ranges can be achieved with:
 - L1 sub-states in Standby
 - Half Swing mode in Active.

Item	PCIe Gen3	PCIe Gen2	M-PHY Gear3
Line Speed [Gbps]	8	5	5.83
PHY overhead	128/130, 1[GB/s]	8/10, 500[MB/s]	8/10, 583[MB/s]
Active Power [mW]	60 (L0)	46 (L0)	58 (HS)
Standby Power [mW]	0.11 (L1.2)	0.11 (L1.2)	0.2 (H8)

1) pci-sig.com: "L1 PM Substates with CLKREQ, Revision 1.0a"

2) Source: SanDisk/WD. Data based on PHY power estimates of PCIe vs. MPHY. For mobile low power application half swing (400mvp-p) and de-emphasize mode in its transmit circuit and passive CTLE in its receive equalization circuit are assumed.



Summarizing Real SSD for Mobile and other markets Using the old faithful SD card



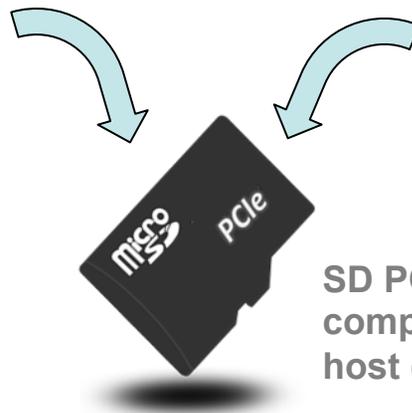
SSD PCIe/NVMe

- Latest SSD grade performance
- PCIe/NVMe – a continuously innovated market-wide platform
- Scalable SW stack widely supported
- Bus mastering and reduction ram and cost
- Low power options for mobile implementations
- Leveraging existing investments for card and products manufacturers



SD Memory Card

- Most popular removable card in consumer market
- Enhanced features added: Command Queue, Cache
- SD UHS-I operation mode supported



SD PCIe/NVMe card with backward compatibility to existing billions host devices in the market

Mobile Phones

Mobile Computing

Gaming

Imaging

Automotive

IoT

....



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If you want to influence or track the next generation SD standardization, you are welcome to join the SDA and SD-PCIe TG

Thank You

Visit us at booth #725

