Next Gen. Mobile Storage – UFS

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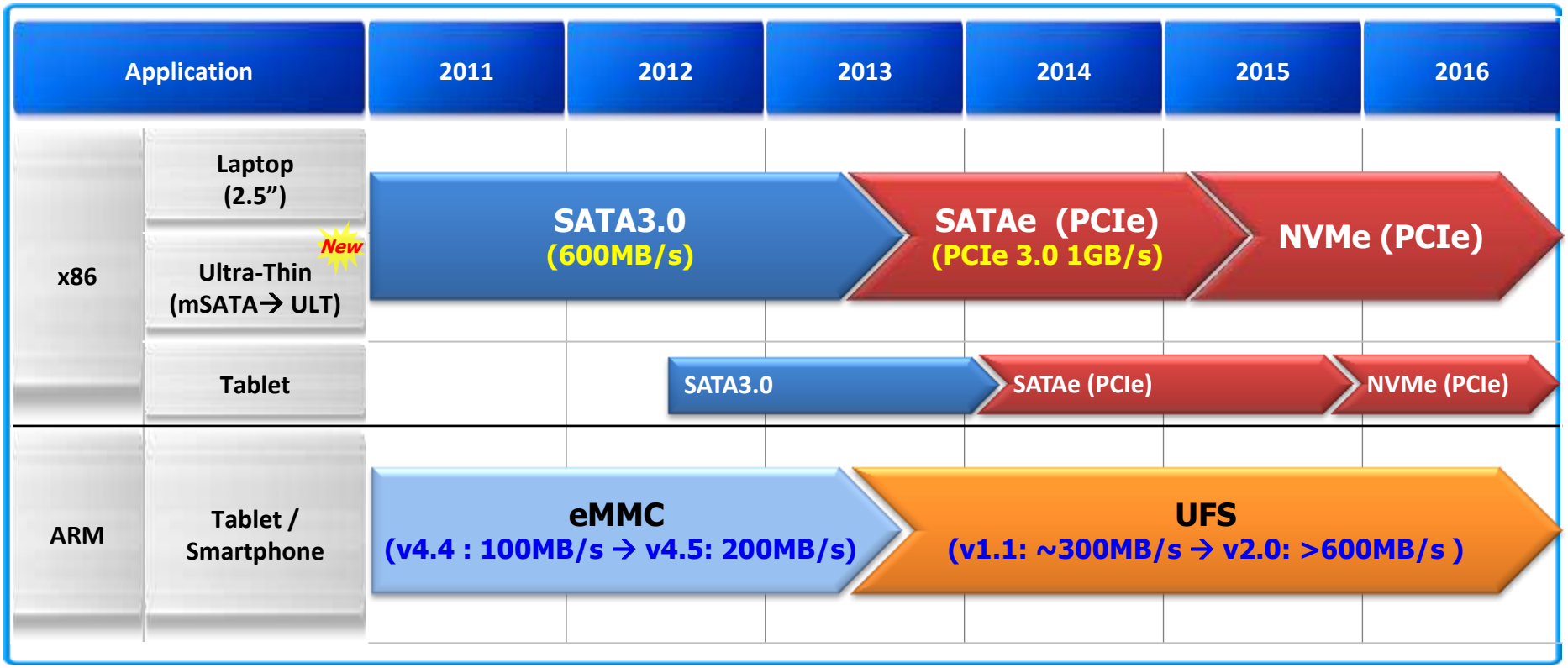
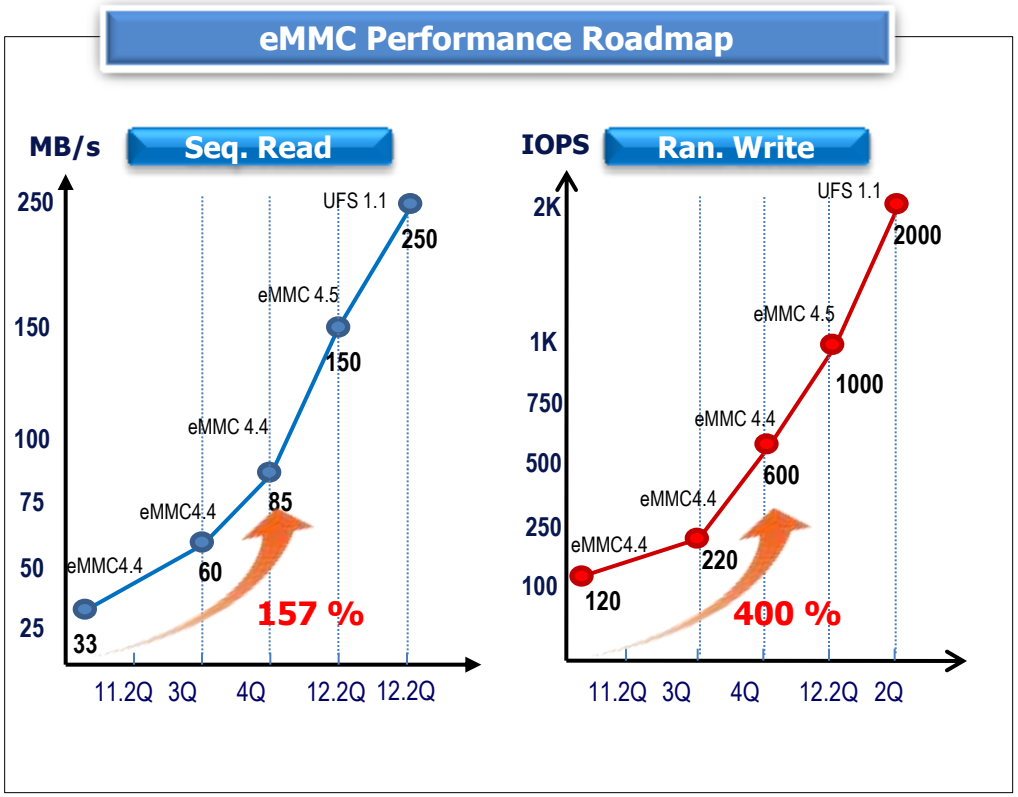
Storage I/F Long-term Trend

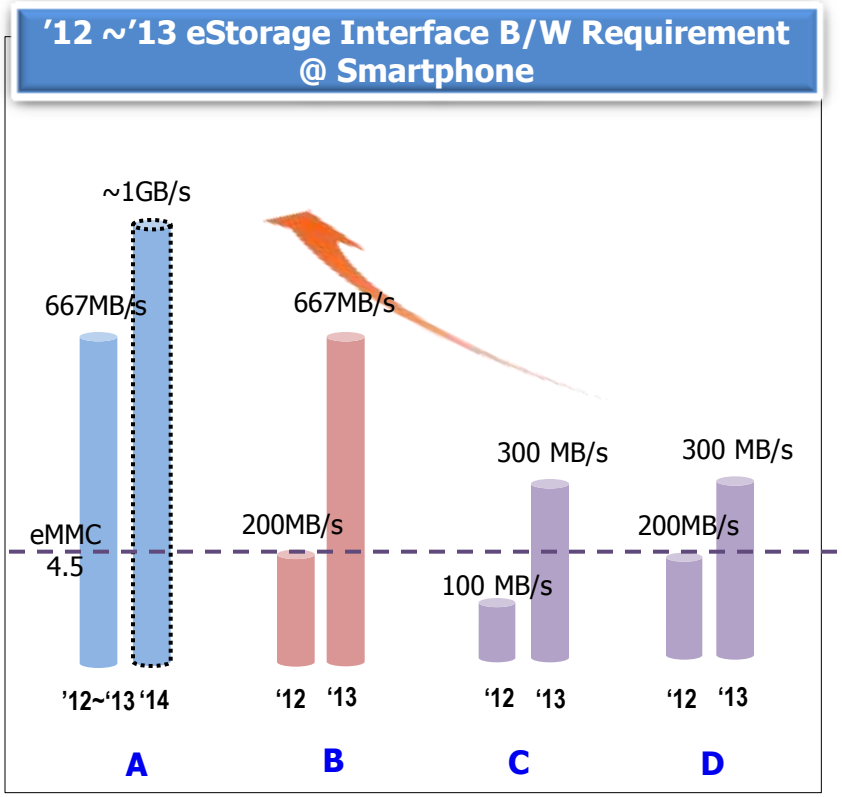
- **PCIe and UFS will be dominant due to better scalability & more features**
  - **SSD will move to PCIe for Highest throughput & lowest latency**
  - **UFS is scalable ; Frequency scaling up & Multi-lane support**



Next Generation Mobile Storage

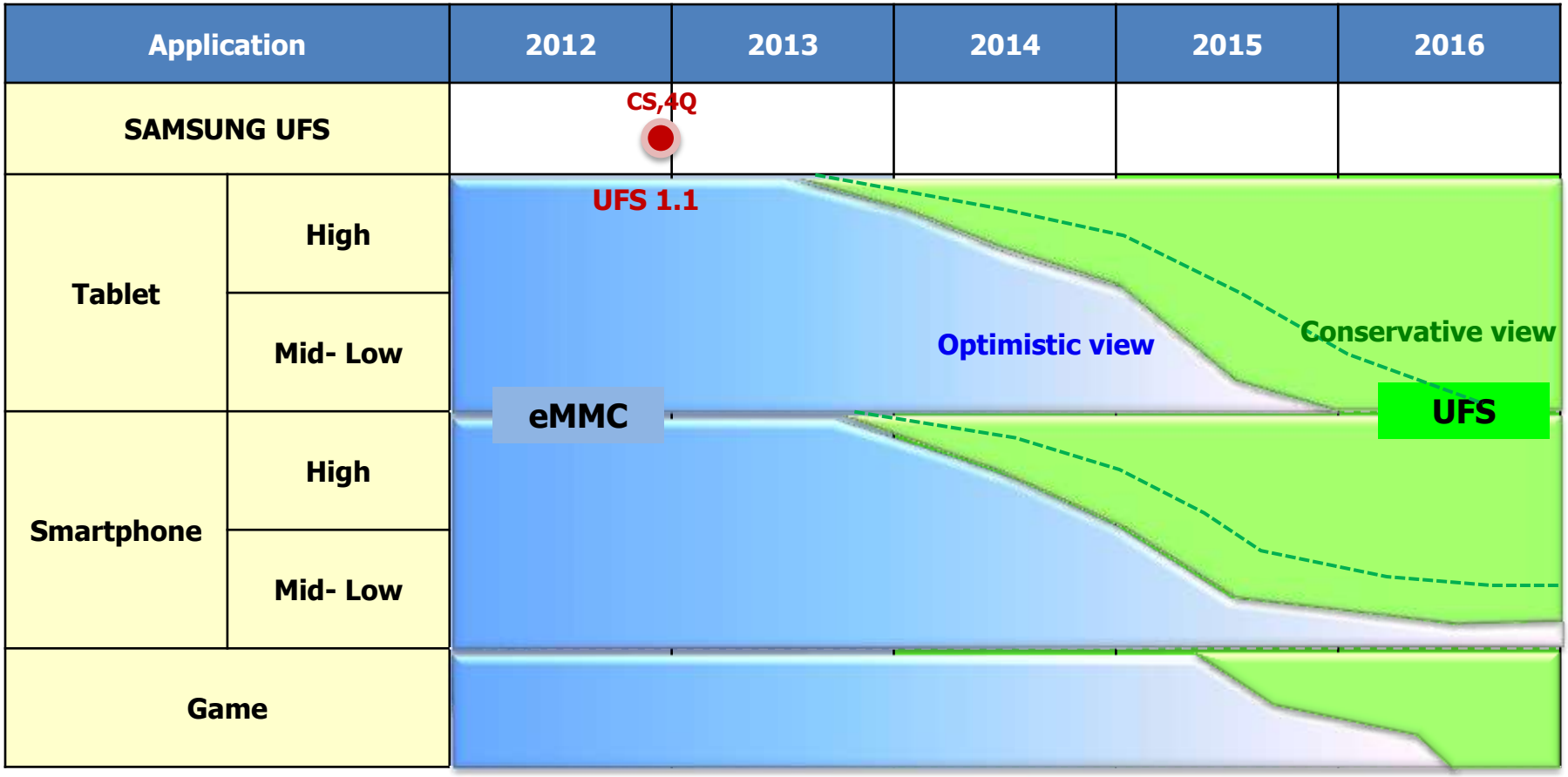
- **Applications drive performance (RT Apps →Seamless Connectivity)**
- **Higher IOPS and lower latency are required for Smartphone/Tablet.**
  - eMMC 4.x has some limits to compete the highest number now
- **New I/F protocol and architecture should be introduced**



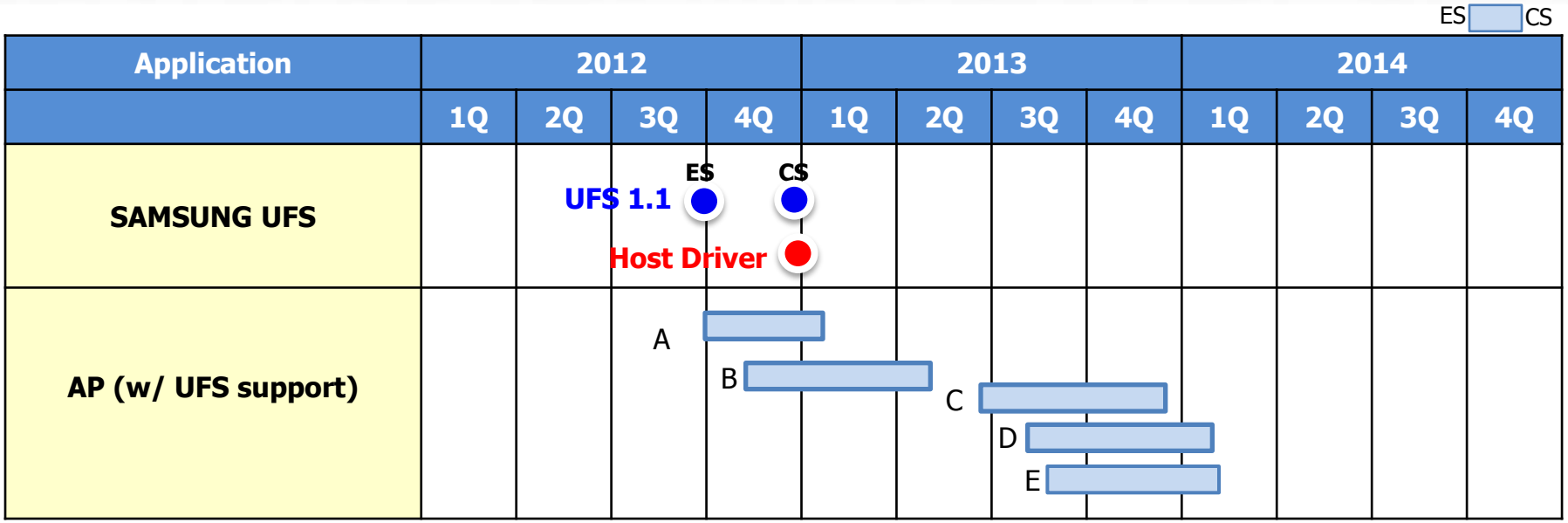


Samsung Forecast of eStorage Migration

- **Market will migrate to UFS from High-end to Mid/Low-end market.**
  - Phase1(2013~2014): Introducing to High-end market
  - Phase2(2014~): Expanding to Mid/Low-end market



UFS Schedule



		UFS 1.1
Density		16GB ~ 64GB
CS Schedule		’12.4Q
Interface Speed		3Gbps
Package size		11.5 x 13
Performance	Seq. Read	250MB/s
	Seq. Write	75MB/s
	Ran. Read	10K IOPS
	Ran. Write	2.5K IOPS

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UFS Leverages High-Performance Standards

- **Designed from the ground-up to meet future mobile platform needs**
  - eMMC4.5 features and more (Asynch, Commands Queuing etc)
  - Utilize MIPI M-PHY and Unipro standards for Physical/Link Layers
  - Mobile Specific Serial Interface (Low Standby with PLL off & Fast wake-up)
  - Flexible Speed Modes and Gears
  - Utilize SCSI command protocol in operation

- **Configuration flexibility with seamless high IOPS performance**
  - Full utilization of multiple NAND operation
  - Any heterogeneous commands can be executed in parallel
  - Command can be transferred during other command's operation

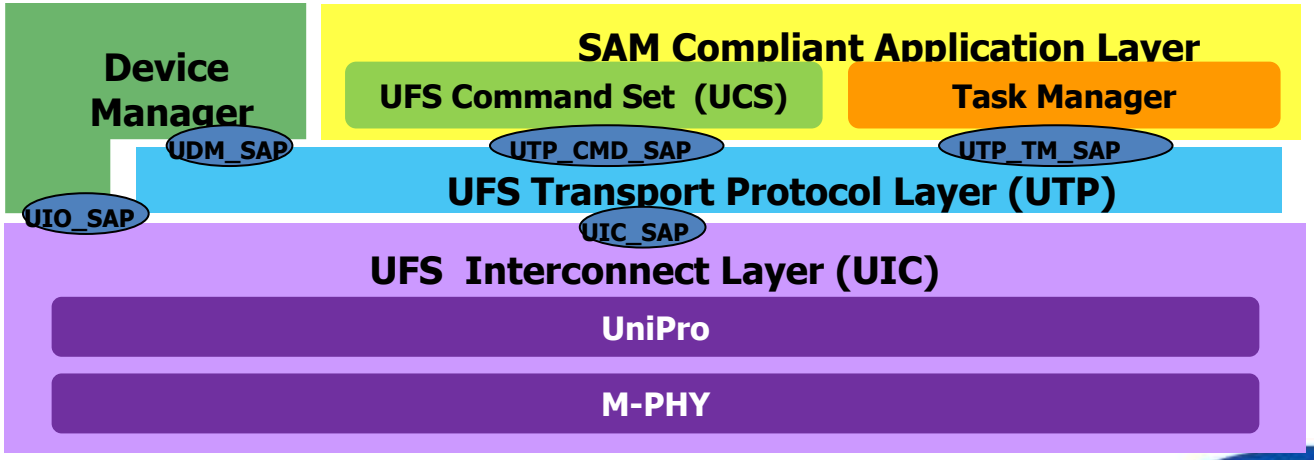
- **Extendable performance with multi-lanes providing many years of runway**
  - 3Gbps → 6Gbps
  - 1 Lane → Multi-Lane

Functional Features

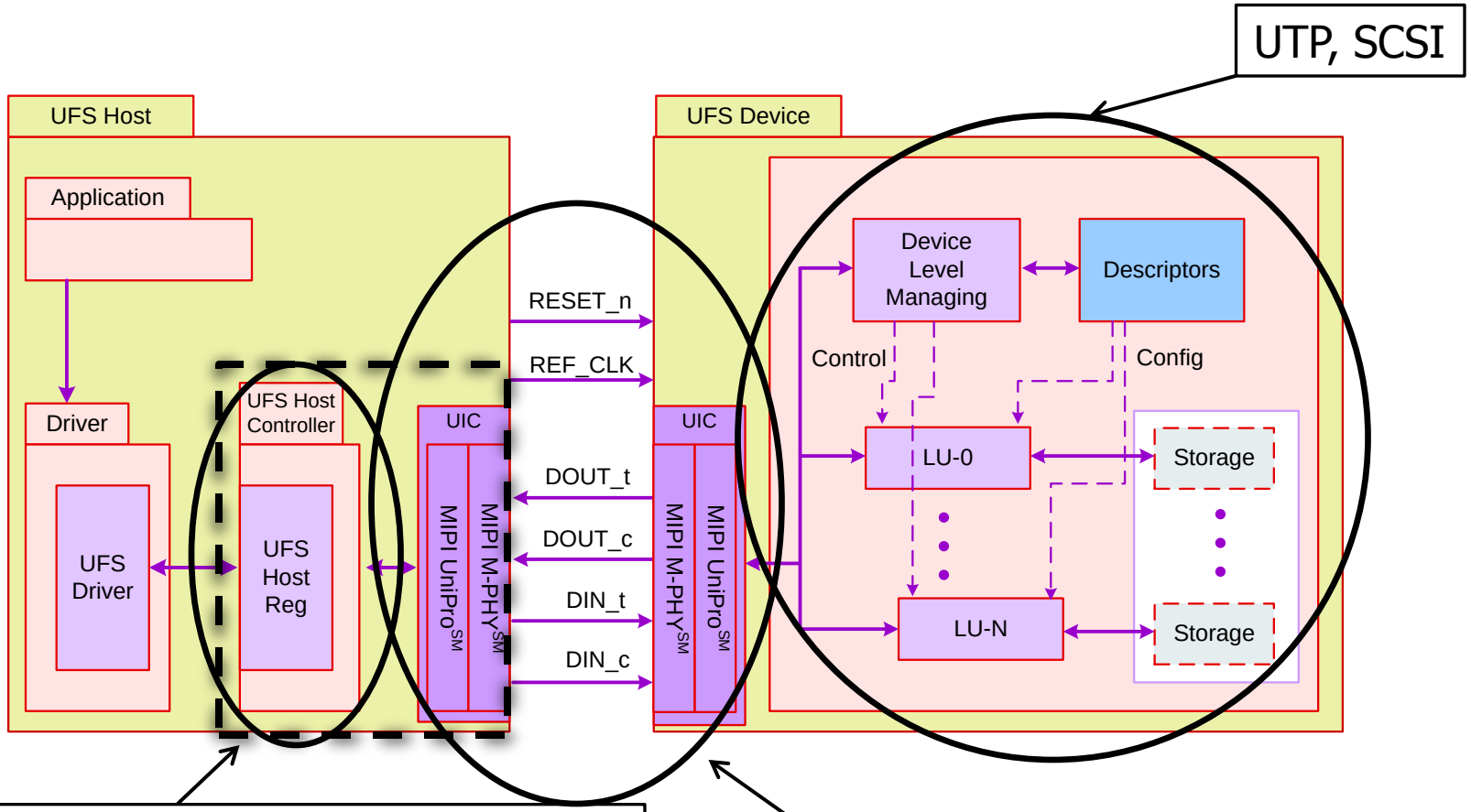
- **Similar functional features as eMMC & more**
  - **Support for boot partitions and Boot Operation Mode**
  - **Supports multiple data partitions (LUNs) with management of p artition attributes**
  - **Write Protection options, including Permanent & Power-On Writ e Protection**
  - **Secure operations, Purge and Erase to enhance data security**
  - **Support RPMB security function**
  - **HW Reset Signal**
  - **Support command queuing, asynchronous/out-of-order comma nd execution**

Layered Architecture

- **Command Protocol Layer:**
  - Supports SCSI as primary CMDs thru Application Layer
  - Compliance with T10 SPC, SBC and SAM
- **UFS Transport Layer:**
  - Defined by JEDEC UFS specification
- **Data Link Layer: MIPI UniPro v1.4**
  - The Unified Protocol (UniPro) defines a layered protocol for interconnecting devices and components within mobile device systems
- **Electrical Interface PHY Layer: MIPI M-PHY v1.0**
  - M-PHY is a low-power differential signal serial interface technology with high bandwidth capabilities, which is particularly developed for mobile applications to obtain low pin count combined with very good power efficiency



UFS System Model

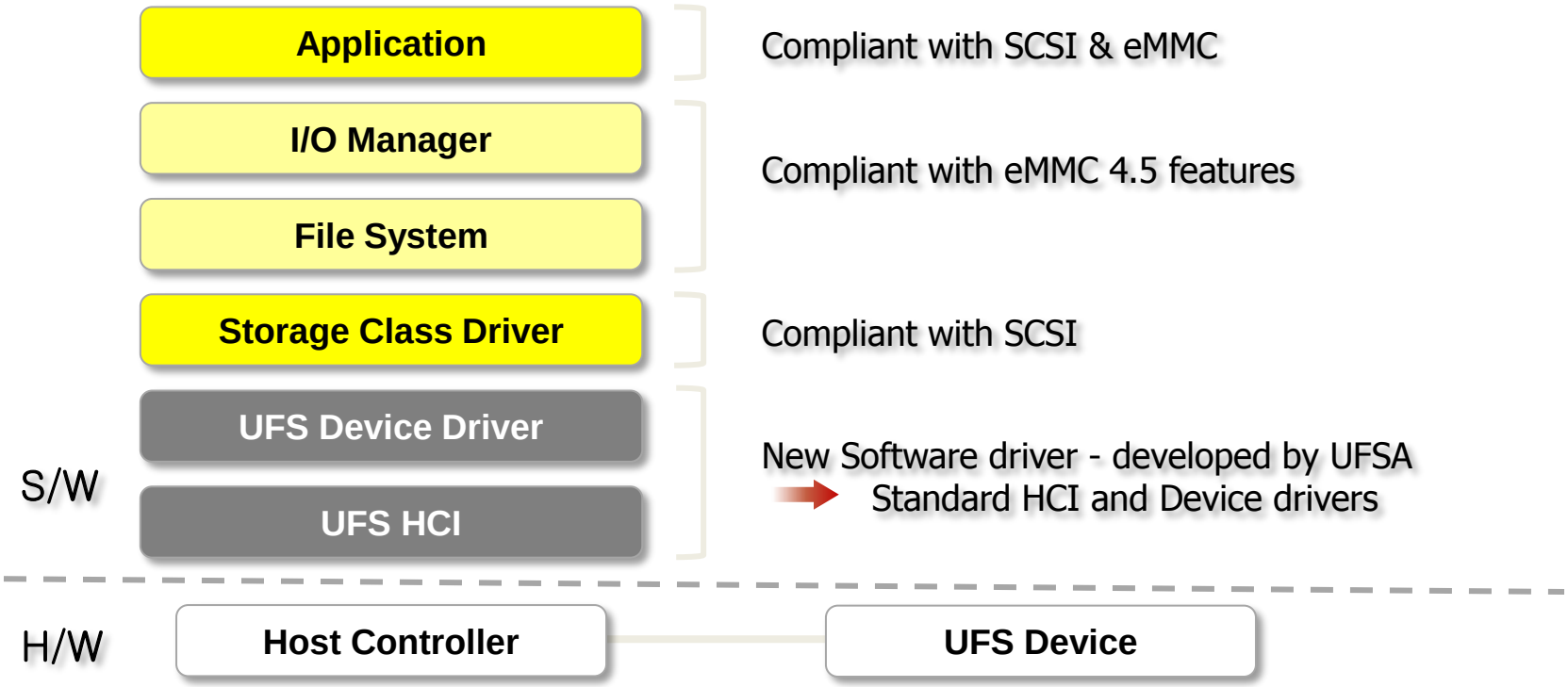


UFS HCI
- Abstraction for underlying HW architecture
- Management of DMA & queue
- Bus/link management
- Power management

M-PHY, UniPro

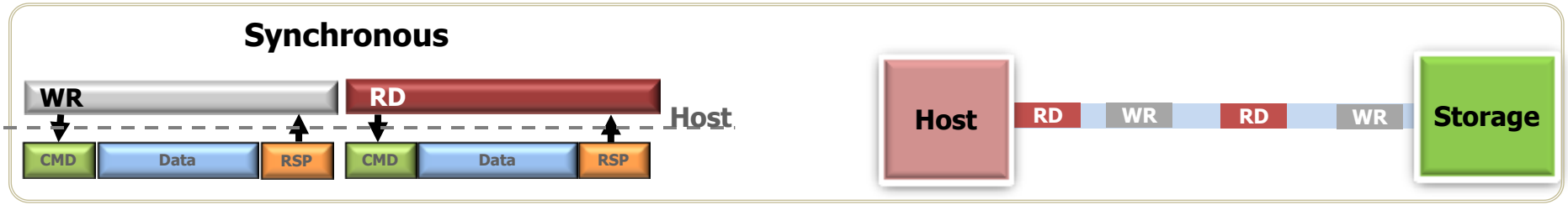
SCSI compliance

- **UFS requires a little or none on OS & Applications**
- **Only required change will be the UFS host device driver and the UFS HCI driver**



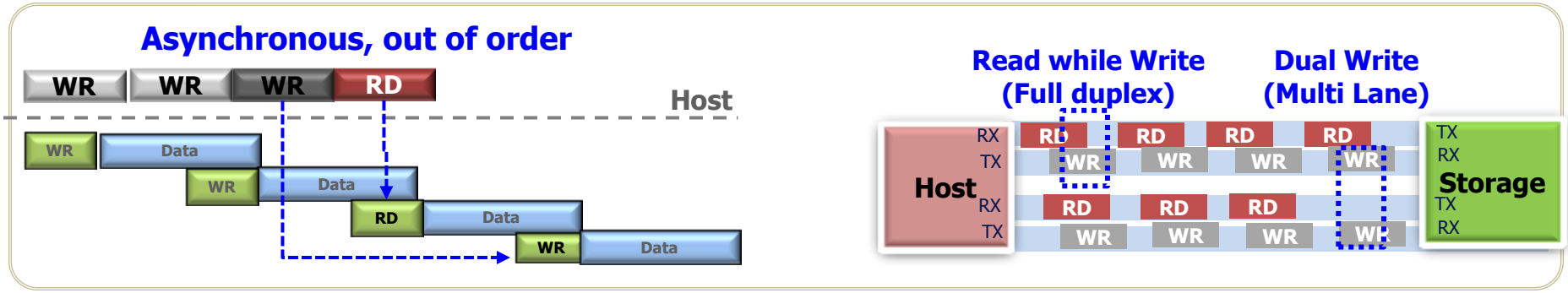
Better throughput with better utilization

eMMC



Single Thread Operation

UFS

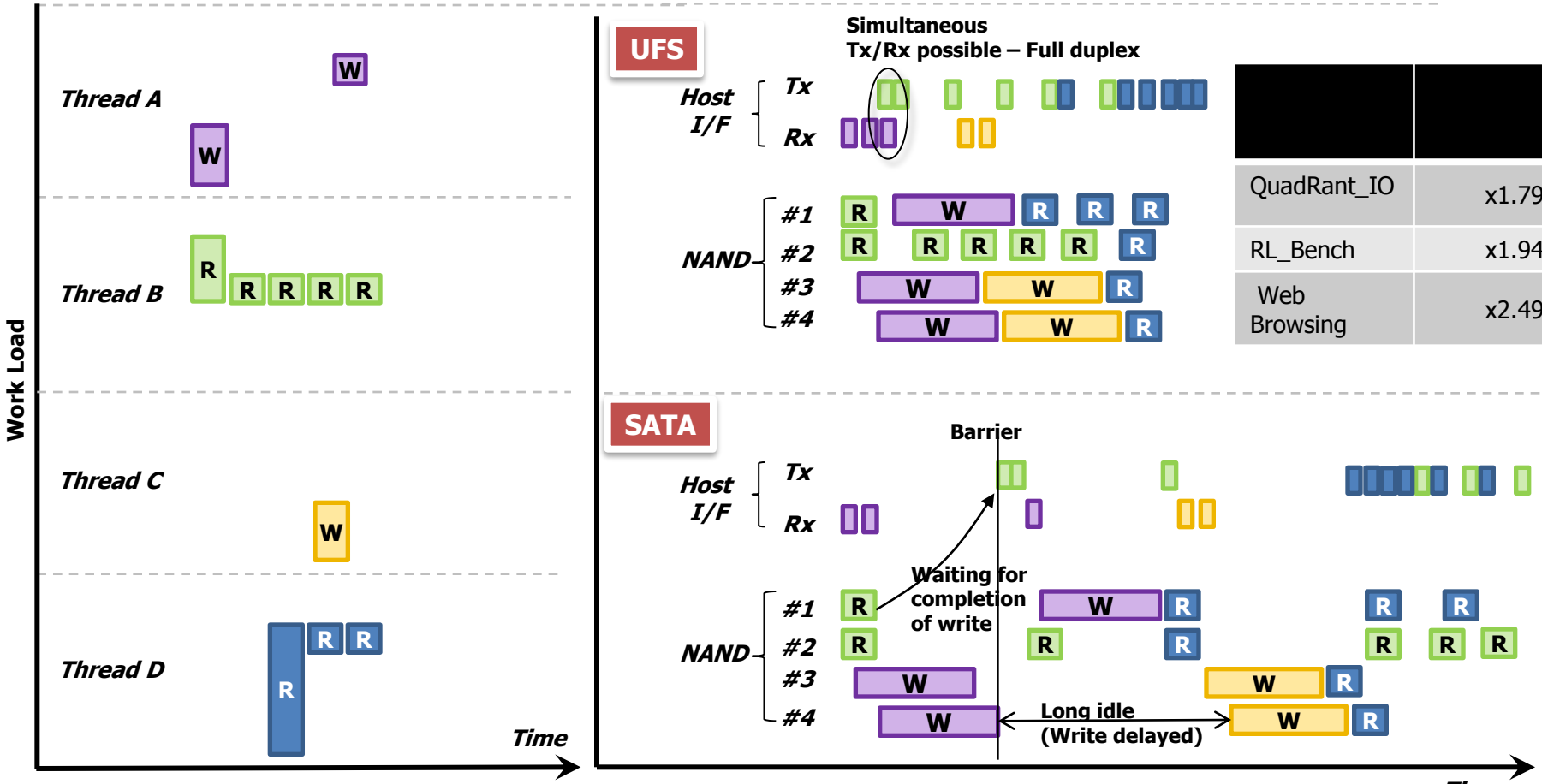


Low Latency for Priority Request

Better throughput
(Simultaneous read and write)

Case 1 : Multi-Threaded applications

- **Full utilization of multiple NAND operation**
  - **UFS : Any heterogeneous commands can be executed in parallel**
    - Command can be transferred during other command's operation
  - **SATA: Parallel execution but limited by SATA protocol**



QuadRant_IO	x1.79
RL_Bench	x1.94
Web Browsing	x2.49

<Key Assumptions: Write takes 3x longer than read. Write-through mode. No storage cache available>

Case 2 : Simultaneous operations for Multi-tasking

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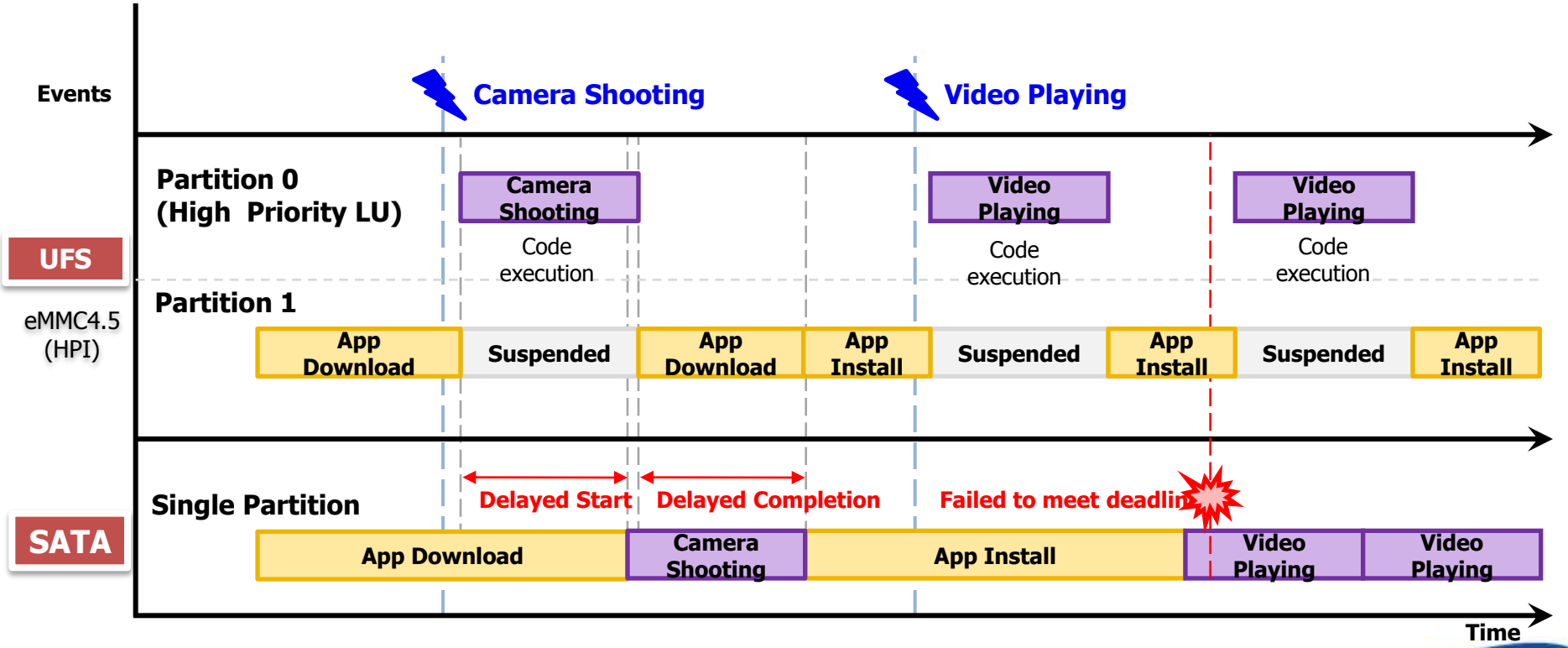
Worst UX : Request delay due to Storage Write Busy.

Better User Experience: High Priority LU for time-critical application



Key Features Comparison

- **eMMC & UFS are good fits for mobile .**
- **SATA is a good fit for PC, needs significant features for smart phone.**

		eMMC4.5	UFS	SATA
Interface	Operation	-	Full Duplex , DFS	Dual Simplex
Future Expandability		N/A	6Gbps ~10Gbps, Multi-Lane	6Gbps
H/W reset		Yes	Yes	No
Alternative Boot		Yes	Yes	No → Rom
Multi-Partition		Yes(4)	Yes(8)	No
Security feature	Trim	Yes	Yes	Yes
	Discard	Yes	Yes	No
	RPMB	Yes	Yes	No
	Secure Erase	Sanitize	Sanitize	No
	Secure Trim			
Performance Feature	High Priority Interrupt	Yes	Yes (LU/Queue)	No
	Back Ground Operation	Yes	Yes	No
	Operation Mode	Sync	Async	Async
	Packed CMD	Yes	Command Queuing	Command Queuing
	Data Tag	Yes	Yes	No
	Context ID	Yes	Yes	No
	Cache Operation	Yes	Yes	Yes
Reliability	Dynamic Capacity	Yes	Yes	No
	Power off notification	Yes	Yes	No
	Real Time Clock	Yes	Yes	No

Performance & Power Consumption Comparison

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- **Random performance of UFS & SATA is improved by Command Queuing.**
- **Active Power is dominated by the NAND Device.**
- **eMMC & UFS are better than SATA in Standby Power.**

		eMMC4.5	UFS1.1	eSSD
Process		65nm	40nm	40nm
Life time		2012~2013	2013~2014	2013~2014
Architecture		1ch 4way	2ch 2way	2ch 2way
Density		32GB	32GB	32GB
Performance	Seq. Read	150MB/s	250MB/s	250MB/s
	Seq. Write	70MB/s	75MB/s	75MB/s
	Ran. Read	4.2K *1	10K*2	8K*3
	Ran. Write	1K *1	2.5K*2	2K*3
Power	Active(W)**	1.11	1.14	1.2
	Stby(mW) (25℃)	0.3	0.51	20** → ~3****
Wake up	ms	<5	<5	<20

*1 Assuming that using Packed command & Cache mode
*2 Assuming that using UFS Command Queue (1MB SRAM) , Data Tag feature
*3 Assuming that using SATA NCQ (1MB SRAM)

* Toggle DDR2.0 MAX operation current is 80mA, 2ch 2way [320mA(3V)/960mW]
** SATA Slumber
*** SATA DEVSLP mode

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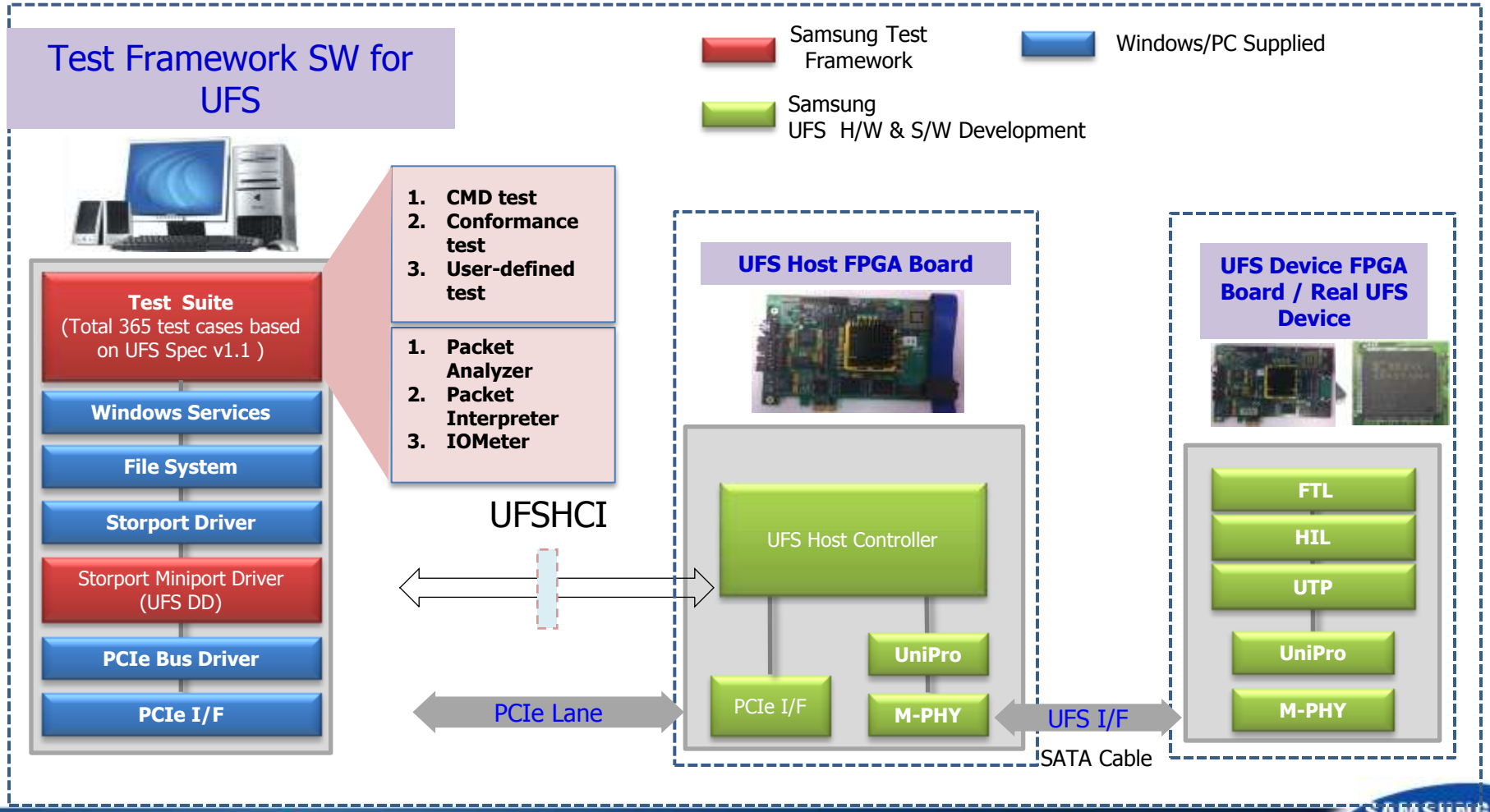
UFS Virtual Host : Virtual Test Framework

- **Virtual host system compliant with UFS 1.1.**
- **Help device development possible w/o host**
  - **Provide the FW development & Protocol /Command verification environment**



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Thank you

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