



Powering the Next Mobile Generation – An overview of UFS

Samsung Semiconductor, Inc

Memory Marketing

January 28-31, 2014 | Santa Clara Convention Center | Santa Clara, CA



Panelists

- Kathy Choe Thomas | Sr. Product Marketing Manager, Samsung
- John Geldman | Director, Industry Standards, Micron Semiconductor
- Zachi Friedman | Director of Product Marketing, Arasan Chip Systems
- Perry Keller | Application and Standards Program Lead, Agilent Technologies, Inc.
- Moderator: Janine Love, UBM Tech

Source: Cisco VNI Global Forecast, 2011–2016

Joel Goergen



UFS

Propelling the Mobile Revolution

Kathy Choe Thomas

Samsung Semiconductor, Inc.

Sr. Product Mktg Mgr, NAND Flash Products

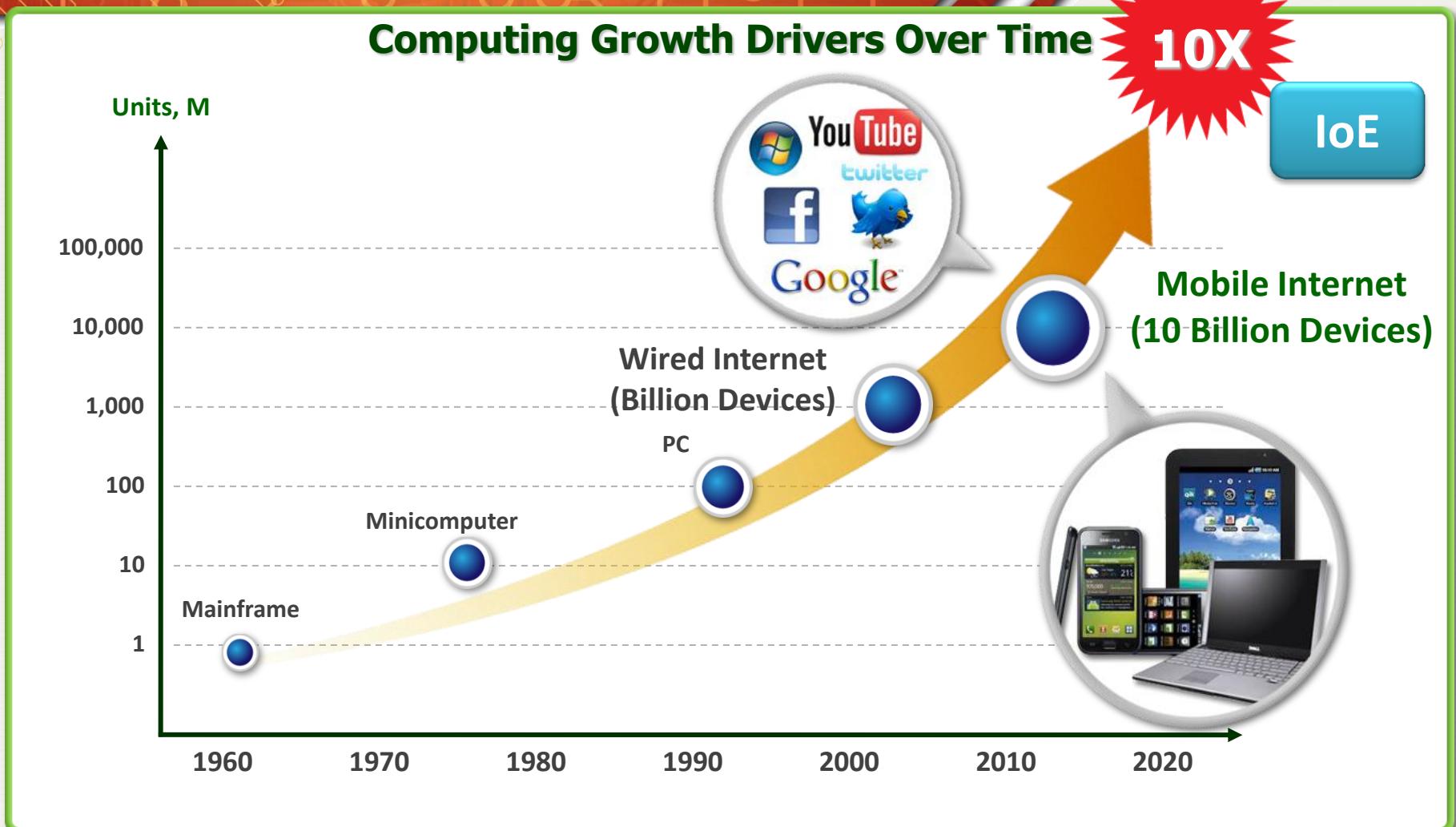
UFSA Board of Director, Marketing Committee Chairman



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Shift in User Environment: PC → Mobile + Cloud



Source: Morgan Stanley

2012: Mobile connected devices exceeded the world's population

Mobile Data Traffic Growth

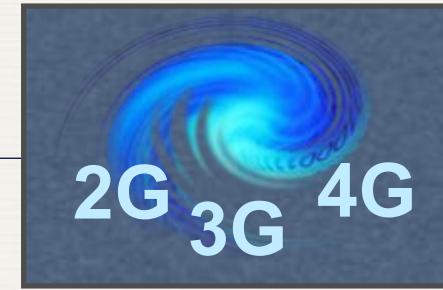
More Connections



More Users



Faster Speeds



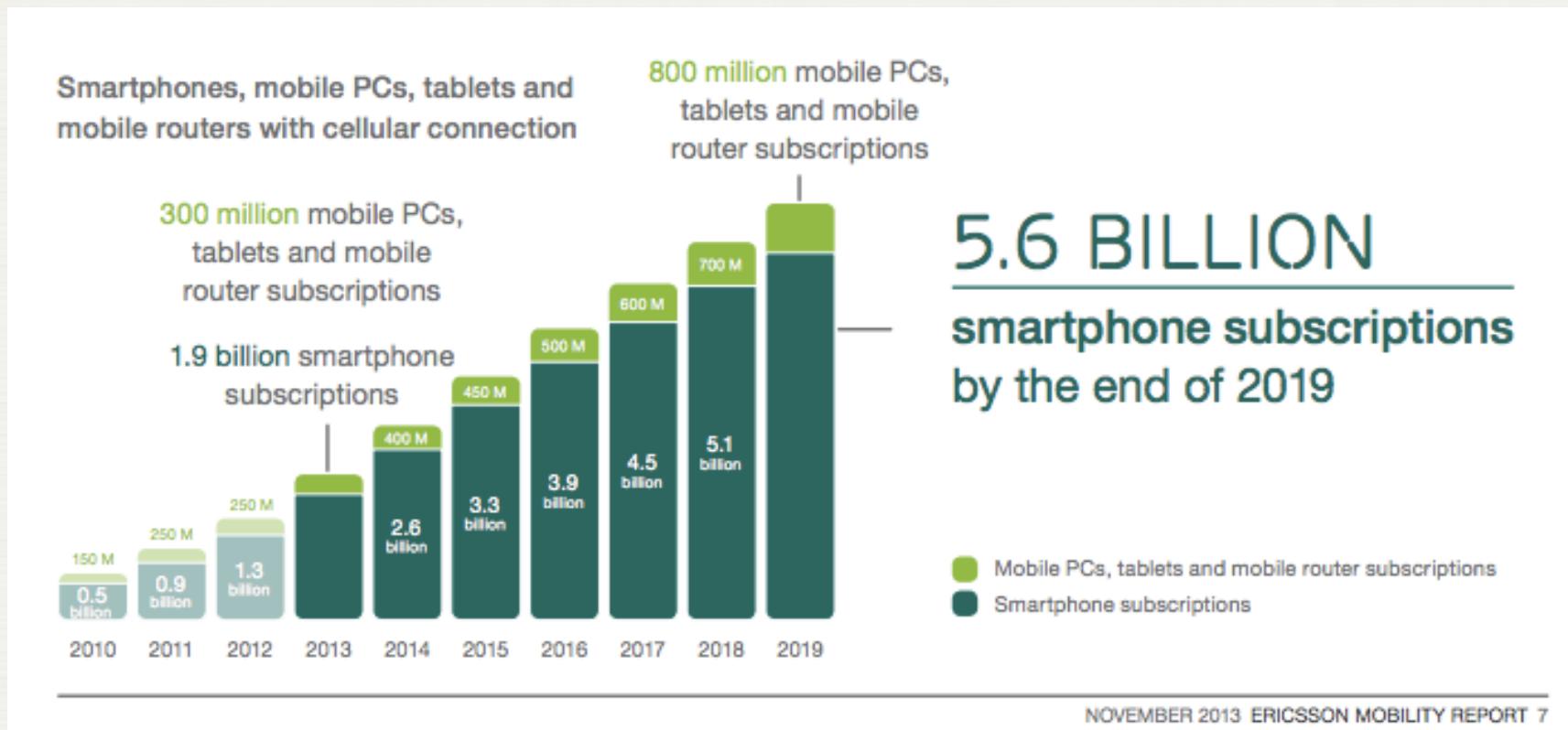
More Video



5EB: The total data created between the dawn of civilization and 2003

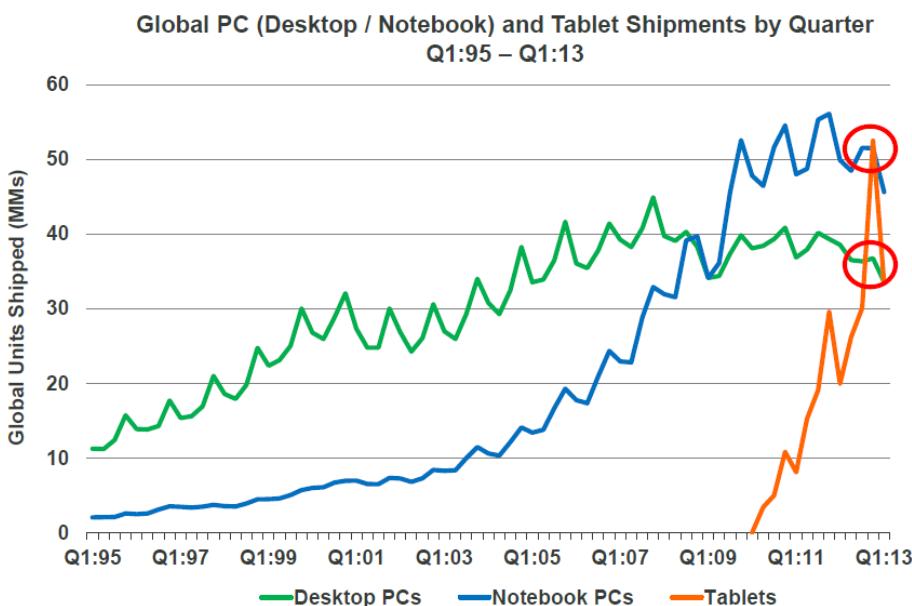
Smartphone Adoption Continues to Grow

- > 80% of world's population has a mobile phone
- But only ~1/4th of the world's population has a smartphone



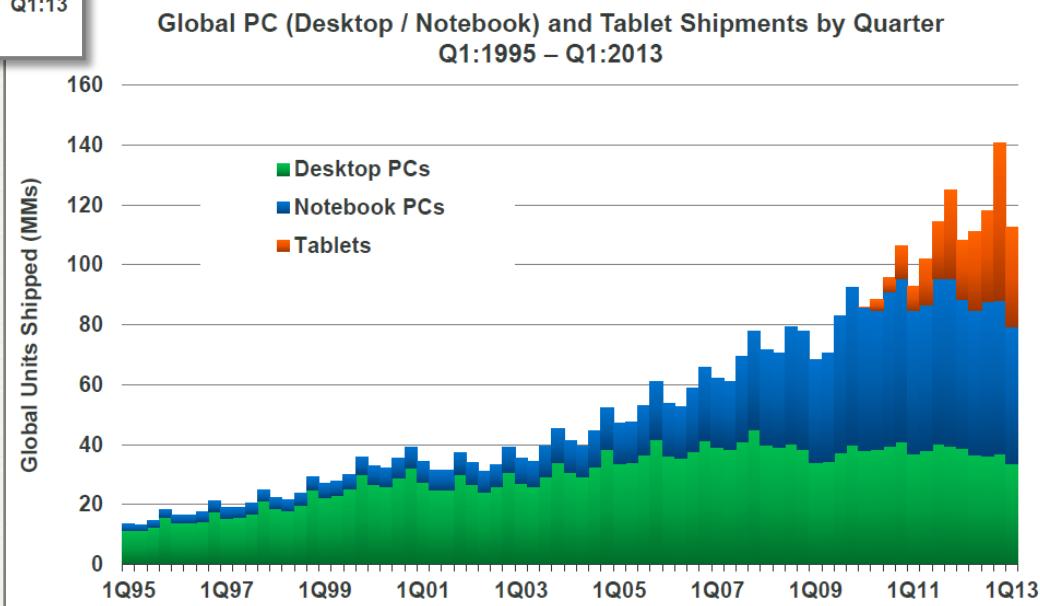
Smartphone adoption still has huge upside for global penetration

Tablet Growth Faster Than Smartphones



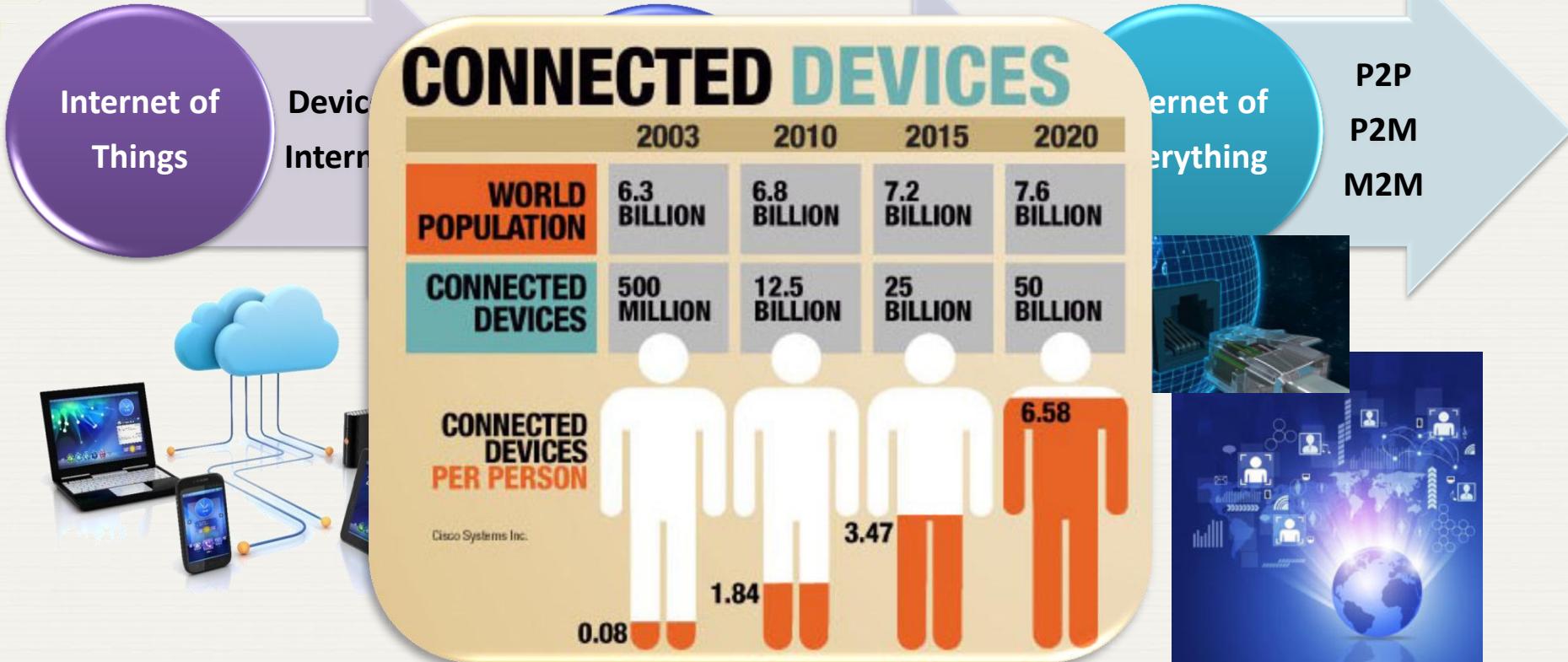
Sources: KPCB, Morgan Stanley Research, Gartner

- Tablet shipments surpassed DT/NB PC's in Q4-12
→ < 3 Yrs from Intro!
- Large Screen Computing Device Demand is strong
→ Mix favors Tablets, not PCs



Mobile Era Continues Evolving: IoE

99% of things in the physical world still **not yet connected** . . .



2010: # Connected Devices Surpassed # of people in the world

2012: # Mobile Devices Surpassed # of people in the world

2020: 50+ Billion things will be connected & will talk to each other

Mobile Device Evolution: The New PC



Smarter, faster, & more powerful devices
→ Require Smarter & faster memory



Performance Improves But Power Still An Issue

Smartphone performance exploding → Battery capacity not keeping up

2010

(vs. 2010)

2020

Cellular



2~5Mbps

x20



50~100Mbps

Key Mobile Memory Requirements
→ Faster Performance & More Capability
→ While Maintaining Low Power Consumption

Video
(Resolution)



720p H.264

x34



4Kp H.265

Battery



5.76W/h

x2.2



13W/h



Mobile Storage – What's Needed?

High Performance Efficiency/Responsiveness



Instant ON → Instant Play



Multi-tasking
Multi-Processing
Productivity Apps
PC-like Gaming
Fast App Loading/
App Swapping

Low Power Longer Battery Life



Quad/Octa-Core CPU
Multi-tasking
Larger screens
AOAC

High Capacity More Memory



More Apps, Richer Apps
HD Video, High Res Photos
3D Graphics/4K Content

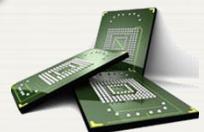
Security Reliability

New Security Challenges
Robust Memory
Enterprise/BYOD
Mobile Shopping



Small Package Thinner is Better

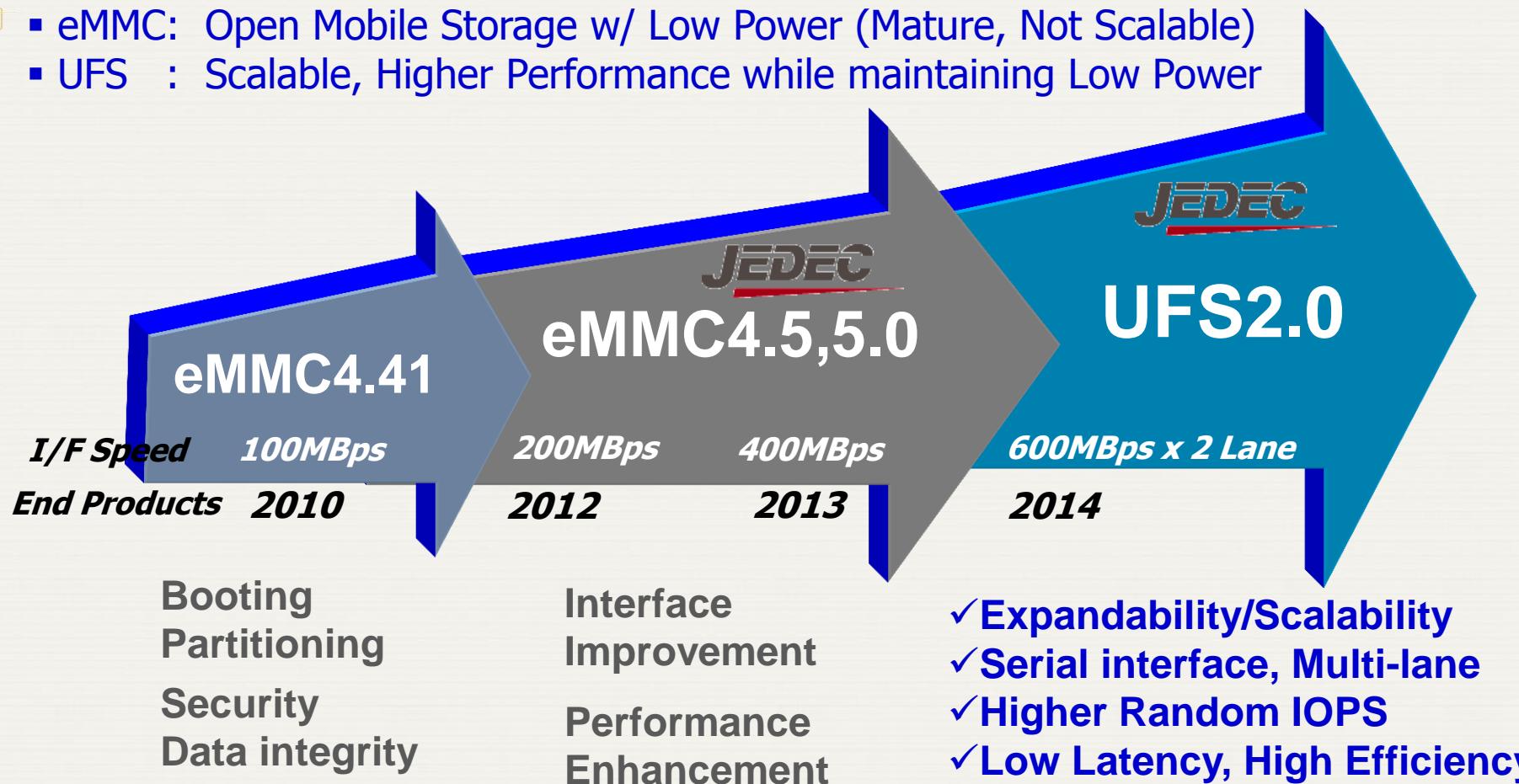
High Capacity in Small Form Factor
Small & Slim Pkg: Z-height is Key



Mobile-centric Storage: eMMC → UFS

JEDEC Defined Storage Solutions Optimized for Mobile Devices

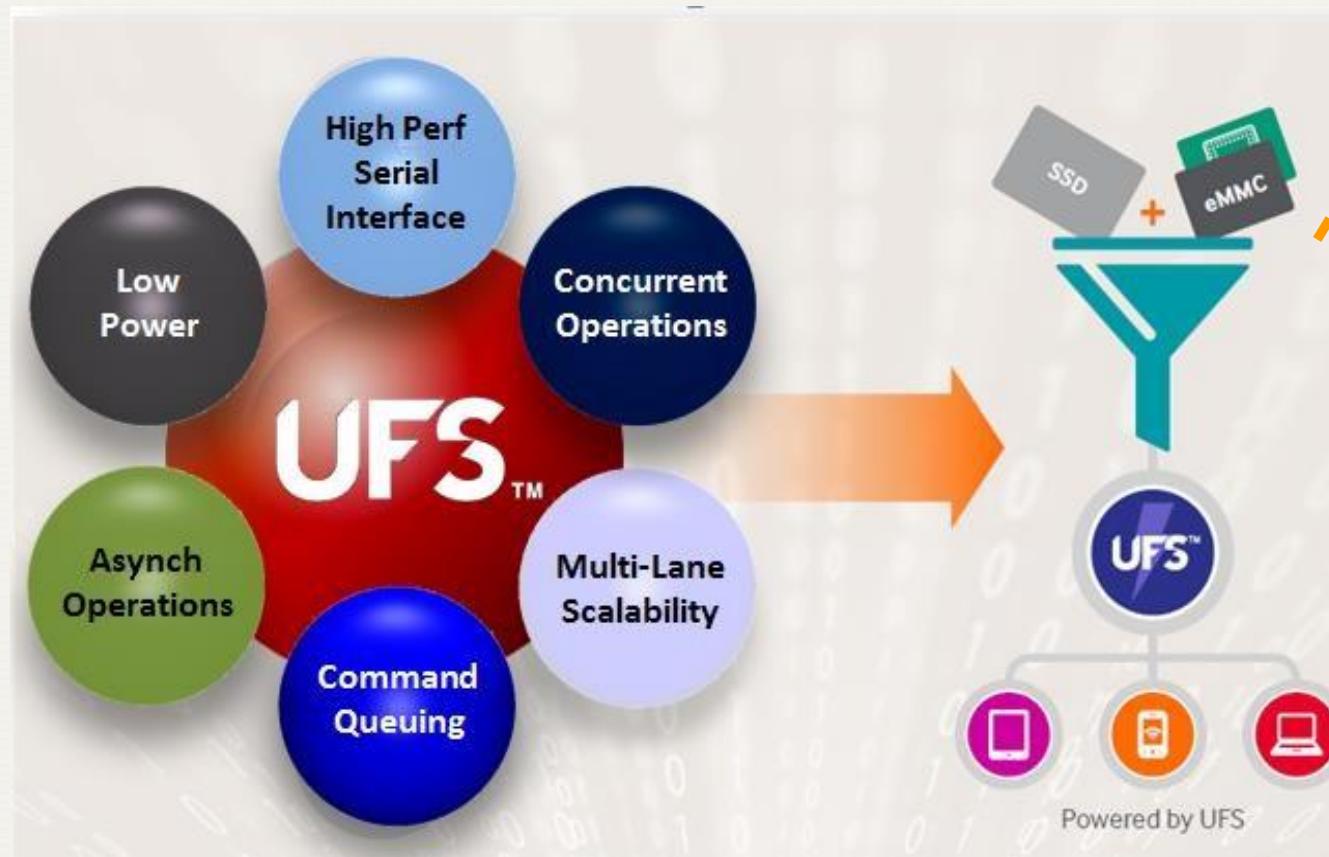
- eMMC: Open Mobile Storage w/ Low Power (Mature, Not Scalable)
- UFS : Scalable, Higher Performance while maintaining Low Power



UFS = Evolutionary progression of JEDEC standards for Mobile Storage

What is UFS . . .

Universal Flash Storage



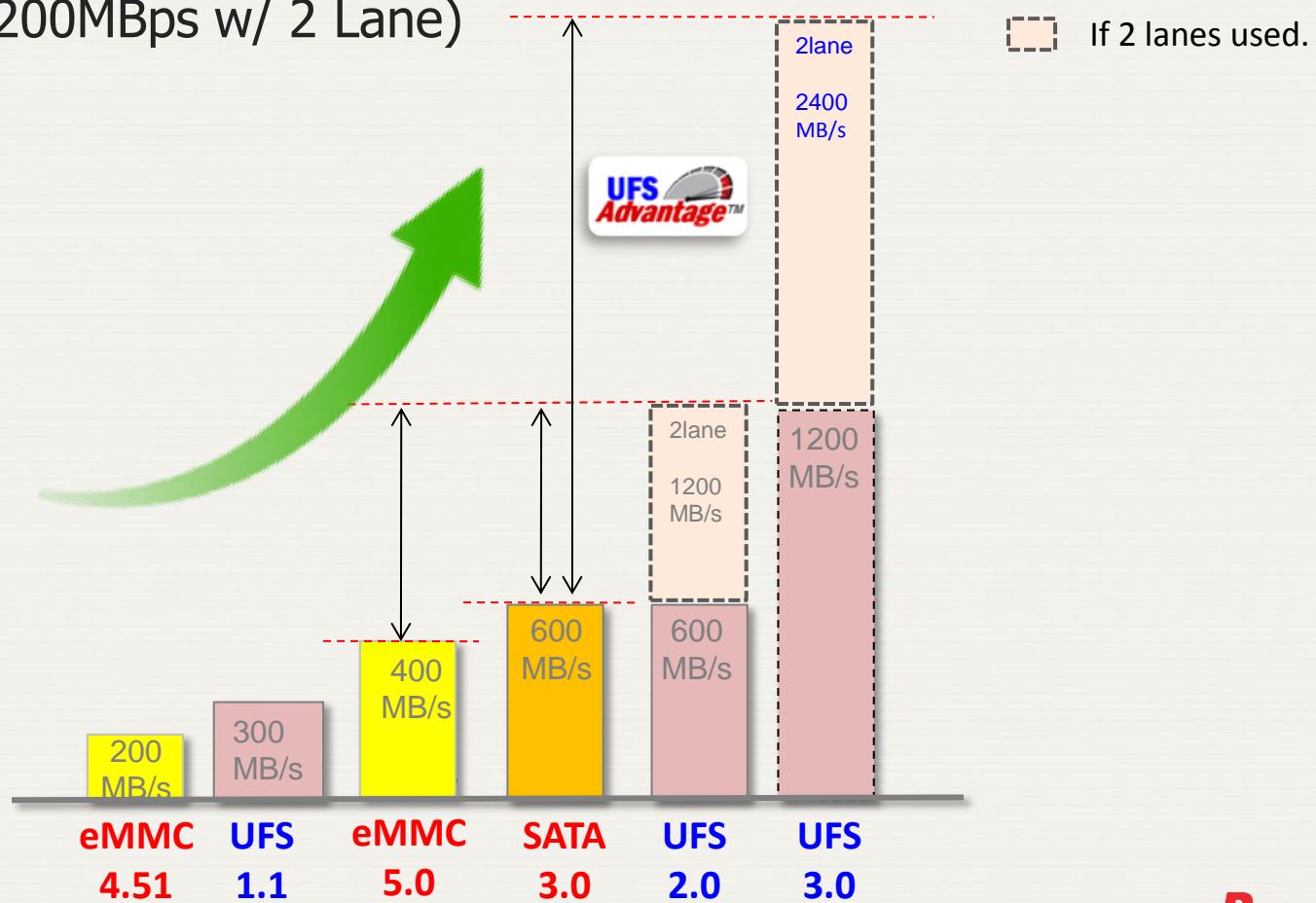
In a nutshell: Tiny SSD for Mobile Devices & Beyond

DESIGNCON® 2014

UFS Advantage: The Fastest Interface

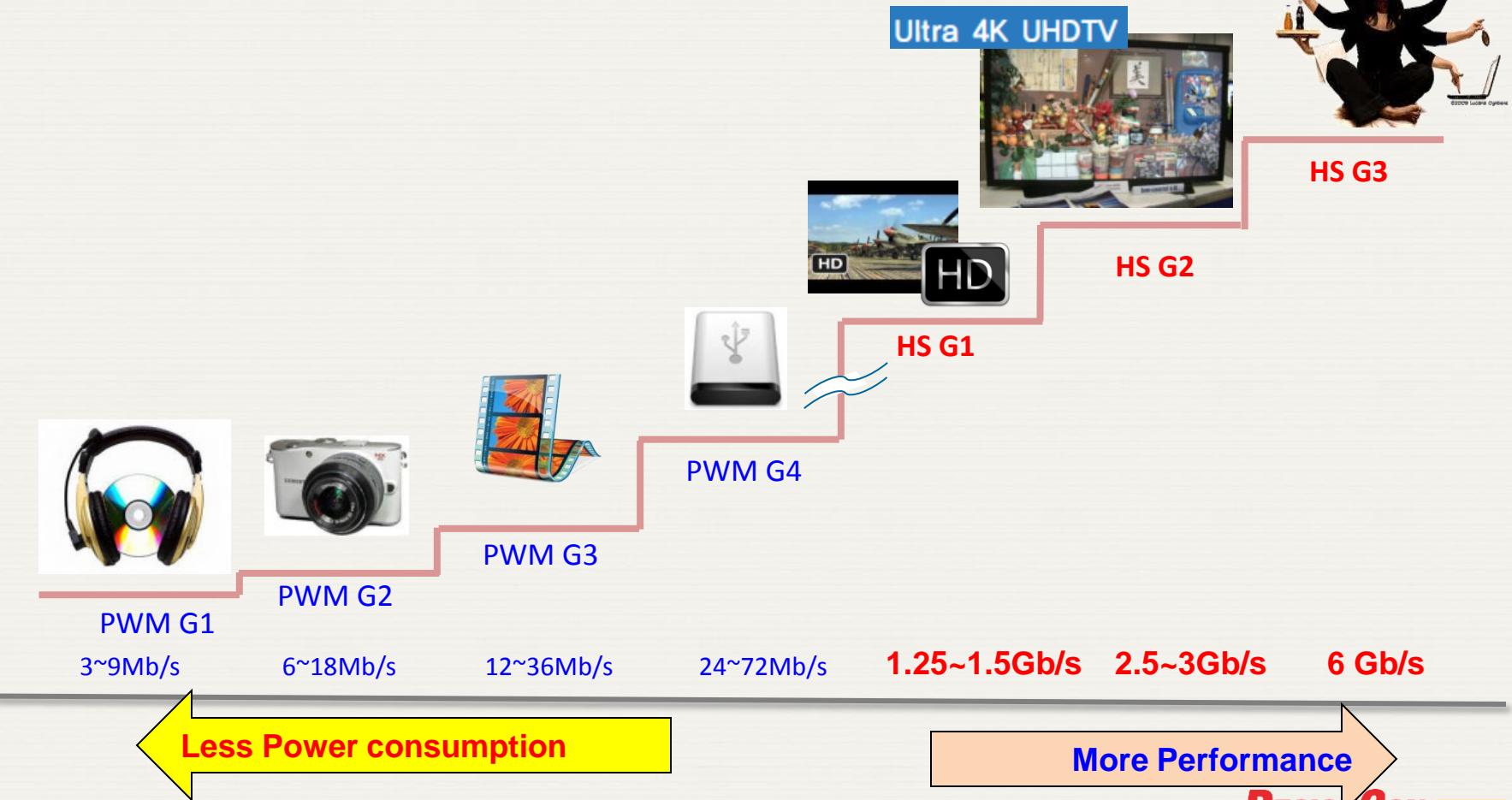
UFS 2.0 exceeds current SSD interface of SATA 3.0 (6Gbps).

- Supports up to Gear 3 at 600MBps per lane with multi-lane support
(Up to 1200MBps w/ 2 Lane)



UFS Advantage: Selectable & Scalable Speed

- UFS supports multiple interface speeds
 - Host can adjust interface based on its needs in real time



eMMC vs. UFS: Interface Race

Which do you prefer for your next mobile device?

Congested Parallel Interface



eMMC

Simpler & Faster
Serial Interface



- High Speed Serial Interface
- Future expandability/Scalability built-in
- Multi-Lane Support

UFS Advantage: Queuing & Asynch I/O

- Multiple Commands/Tasks, Multi-processing Demands

Inefficiencies of eMMC = Traffic Jam & back-up

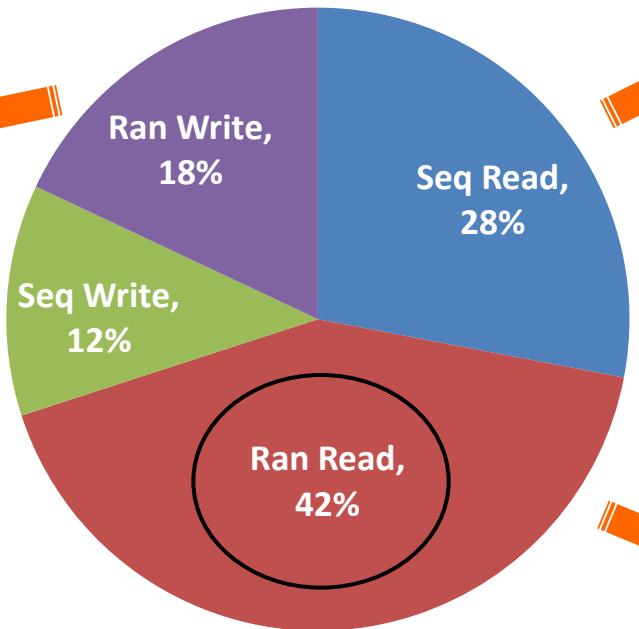
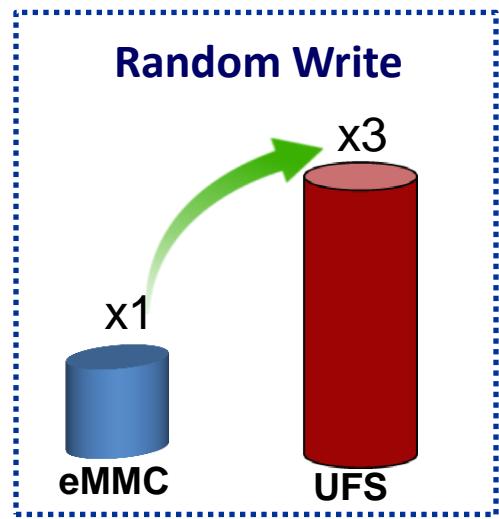


UFS Solution:

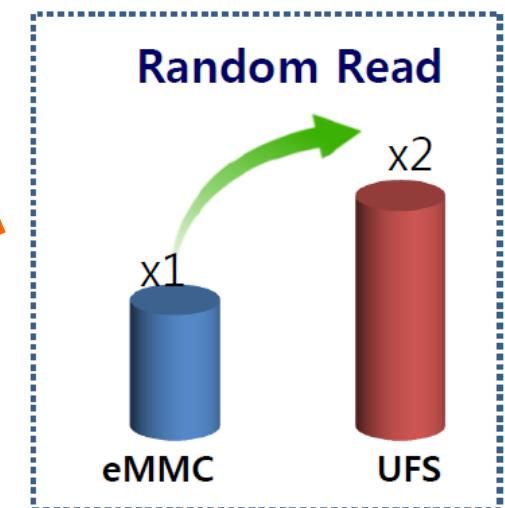
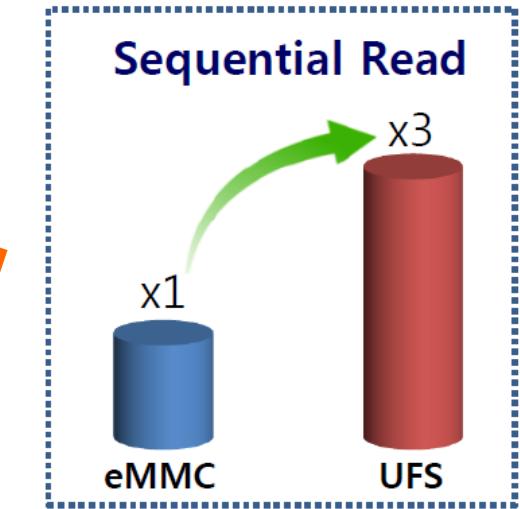
- Async I/O, Command Queuing & Reordering
- Higher Efficiency, Faster Completion

UFS Advantage: Higher Performance = Better UX

Mobile OS Storage Pattern Analysis



Source: Samsung

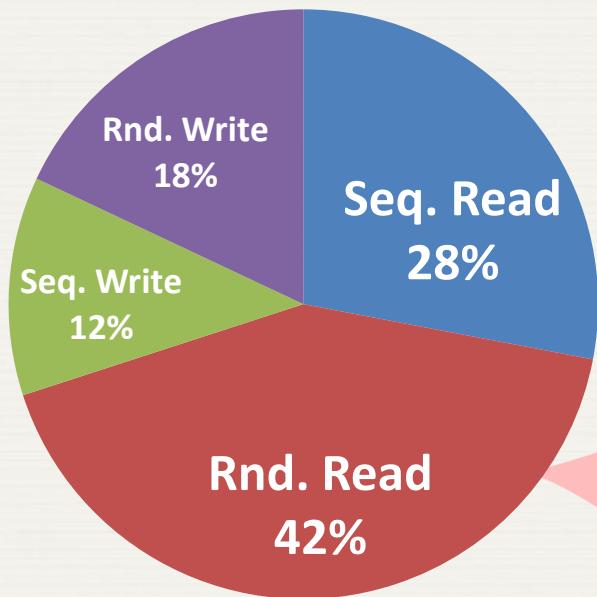


Better End User Experience!



UFS Advantage: Battery Life Improvement

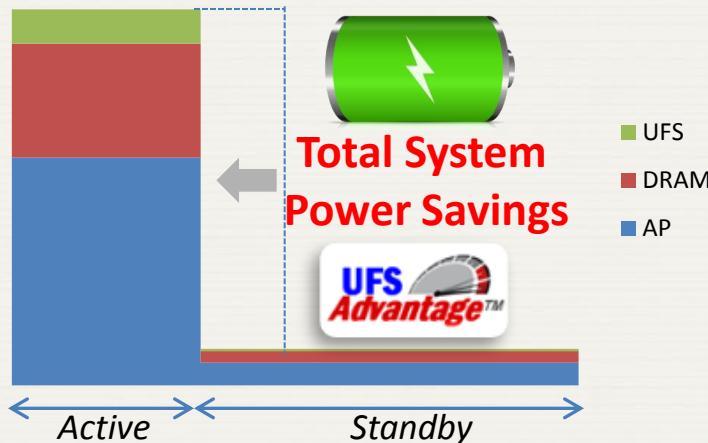
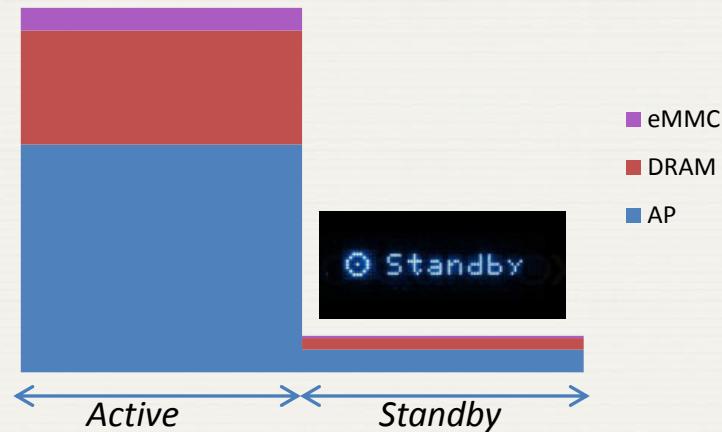
- eStorage is the slowest device in system → Performance Bottleneck
- UFS faster while consuming less system power



Samsung User Daily Workload Analysis



Sequential Read 3x
Random Read 2x
Rand Write 3x



UFS: Accelerated Migration for Mobile Evolution

UFS: SSD's for Mobile

→ Higher Performance & Efficiency with lower total power in small BGA pkg

2.4 GB/s

Better, faster, scalable for future
Higher efficiency



UFS Advantage™

SCSI Based Async
Protocol

UFS 2.0

UFS 3.0
(tentative)

1.2GB/s

Good, sufficient performance, fuel-efficient

Legacy Memory Card Based Sync Protocol

400 MB/s

eMMC4.3

eMMC4.4

eMMC4.41

eMMC5.0

eMMC5.1
(tentative)

2009

2010

2011

2012

2013

2014

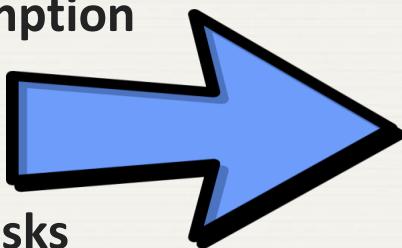
2015~16

less is more.

UFS In Summary . . .

The UFS Advantage is clear . . .

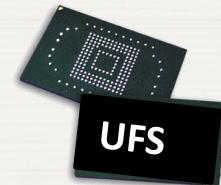
- Less Total Power Consumption
- Less Latency
- Less time to complete tasks



More Performance

More Efficiency

More Features



UFS enables the next generation of smart & powerful devices for mobile & beyond . . .



감사합니다 Natick

Grazie Danke Ευχαριστίες Dalu Obrigado

Thank You Köszönöm Tack

Спасибо Dank Gracias

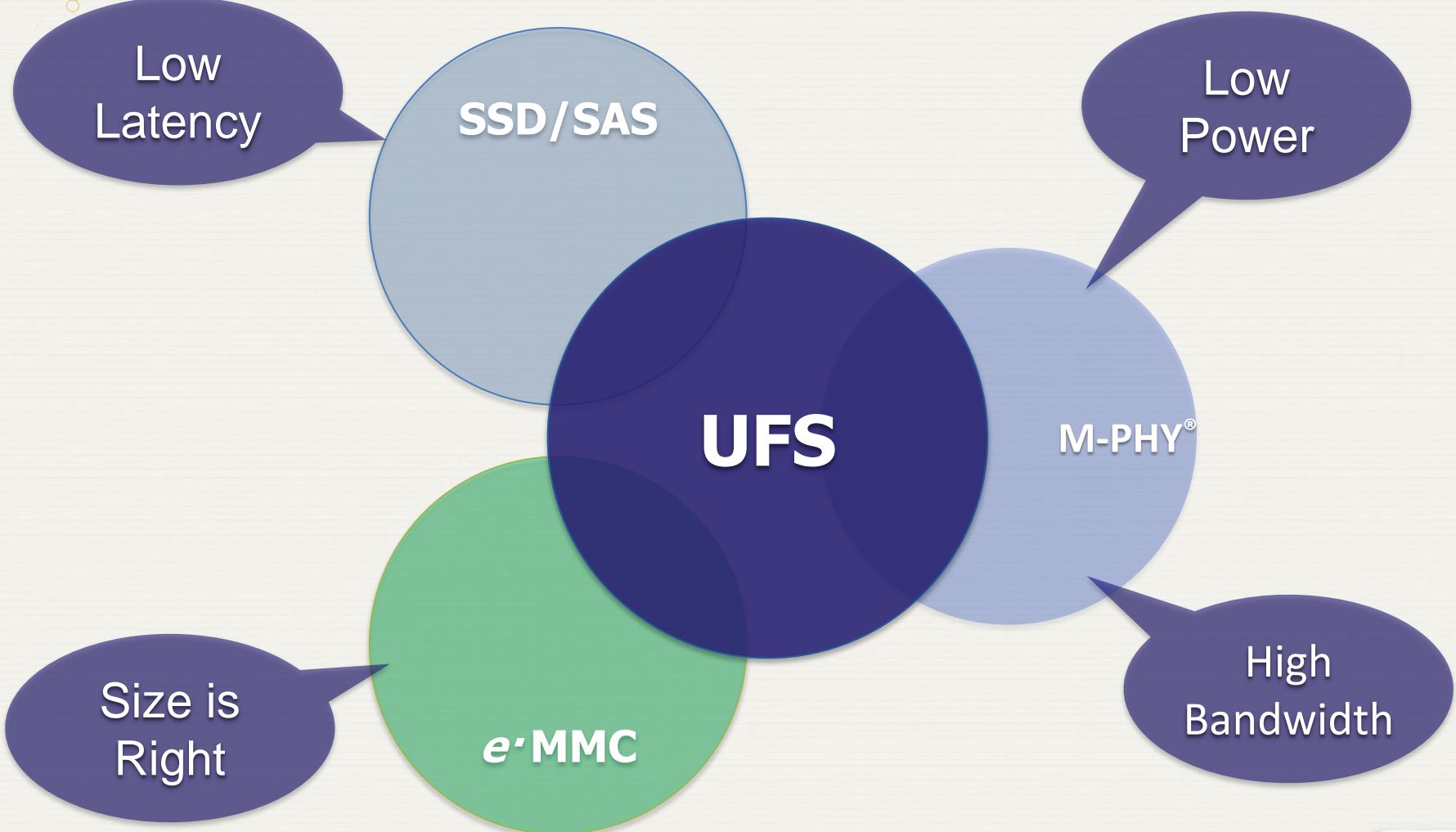
谢谢 Merci Seé ありがとう



What exactly is “SSD for Mobile”?

**John Geldman
Director, Industry Standards
Micron Technology**

Mobile & SSD heritage



MIPI's M-PHY a high bandwidth enabler

- UFS 2.0 supports multiple High Speed GEARS
 - (see the M-PHY from www.mipi.org)

Gear	HS-G1	HS-G2	HS-G3
Transitions per second	1.25 to 1.45 Gtps	2.5 to 2.9 Gtps	5 to 5.8 Gtps

- UFS supports one or two 'lanes' (for 2x bandwidth)
- UFS supports performance ranges
 - from 125 MB/s (one lane of HS-G1)
 - to 1.2 GB/s (two lanes of HS-G3)

The SCSI queuing architecture a low latency enabler

- A single threaded command sequence
 - Note: processing the write holds off starting the next command



- ▶ A multiple threaded in-order command sequence
 - Note: Command 1 is completed before Payload 2



- A multiple threaded out-of-order command sequence
 - Note: the bus is used at maximum performance



Low power mobile needs MPHY & SCSI

- Limit power draw of an idle interface
 - M-PHY's Hibern8te state
- Control logical device power
 - SCSI: START STOP UNIT command
- Low interface power on active transfers
 - The differential voltage swing is 200 mV (terminated)
 - CMOS power is proportion to $C * V^2 * F$

Note: NAND array performance is proportional to array power:
All UFS can do is minimize interface power

Size matters for mobile

- BGA is the initial UFS form factor
 - Does 12mm x 16mm work for you?

Device Types	X (mm)	Y (mm)	Area (mm ²)	
CompactFlash	42.8	36.4	1558	NAND package inside
mSATA	24.2	48	1161	
SD (standard)	24	32	768	
M2	26	30	780	
UFS	14	18	252	NAND die inside
UFS	12	16	192	
microSD	11	15	165	
UFS	11.5	13	150	

- A micro card is in scope of UFS, but is only in discussions



Low
Latency

Low
Power

Thank you!

Size is
Right

High
Bandwidth



Creating a UFS Implementation

Zachi Friedman
Director of Product Marketing
Arasan Chip Systems



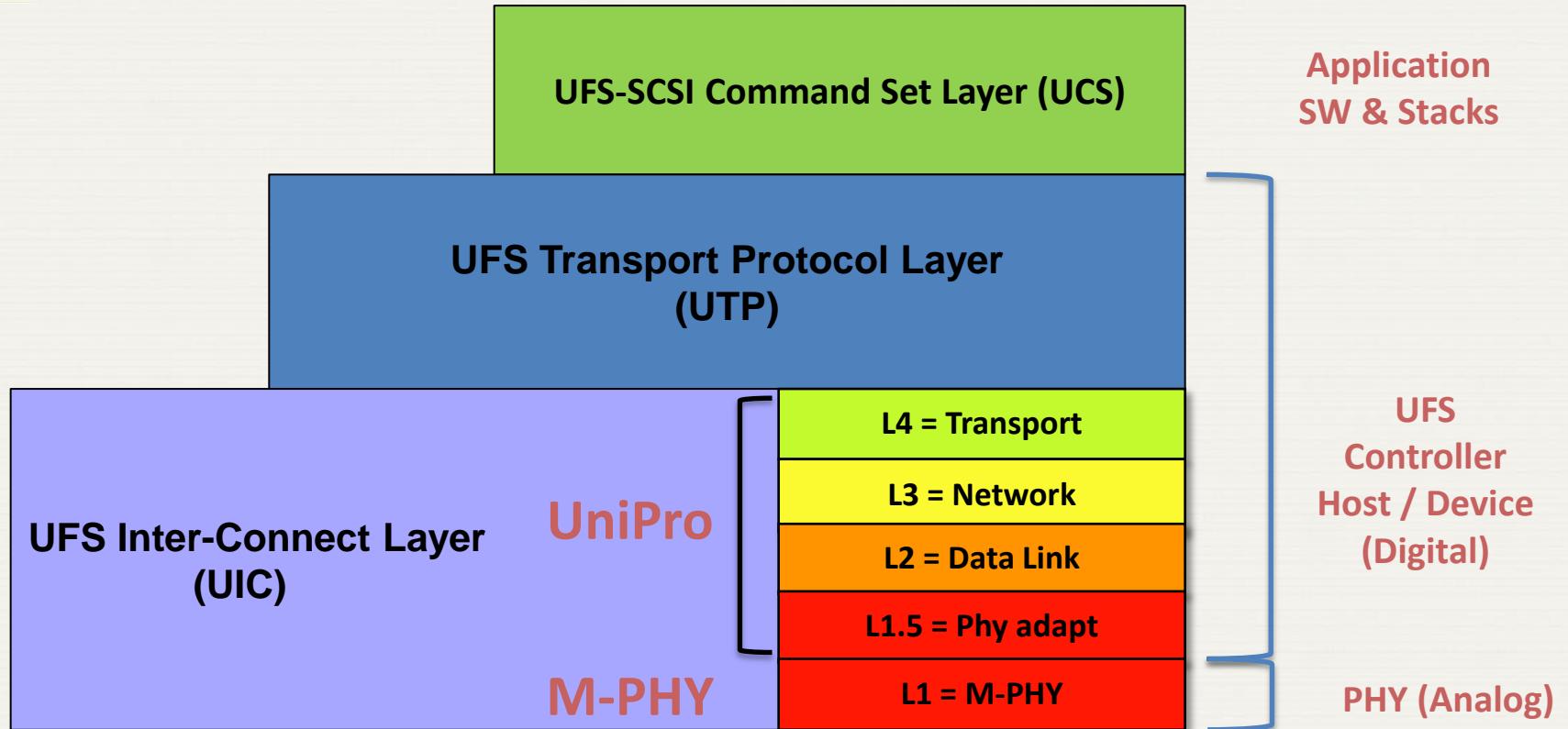
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Agenda

- UFS Architecture
- Implementation Challenges
 - Complexity Challenge
 - Physical Challenge
- Validating the Design

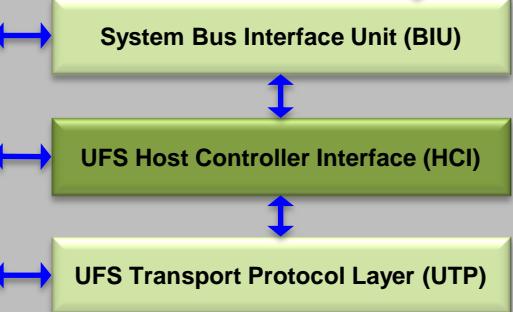
UFS Layered Architecture



UFS Host & Device – Block Diagram

SoC / Application Processor

UFS Host IP



System
Bus

Device
Management
Entity

UniPro

Transport Layer (L4)

Network Layer (L3)

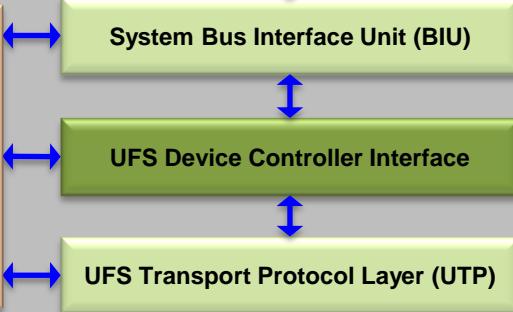
Data Link Layer (L2)

PHY Adapter Layer (L 1.5)

M-PHY (L1)

UFS Device Controller

UFS Device IP



System
Bus

Device
Management
Entity

UniPro

Transport Layer (L4)

Network Layer (L3)

Data Link Layer (L2)

PHY Adapter Layer (L 1.5)

M-PHY (L1)

The Complexity Challenge

- A lot to implement
 - M-PHY
 - UniPro
 - UFS Protocol
- Glue everything together
- Arasan's most complex IP to date!

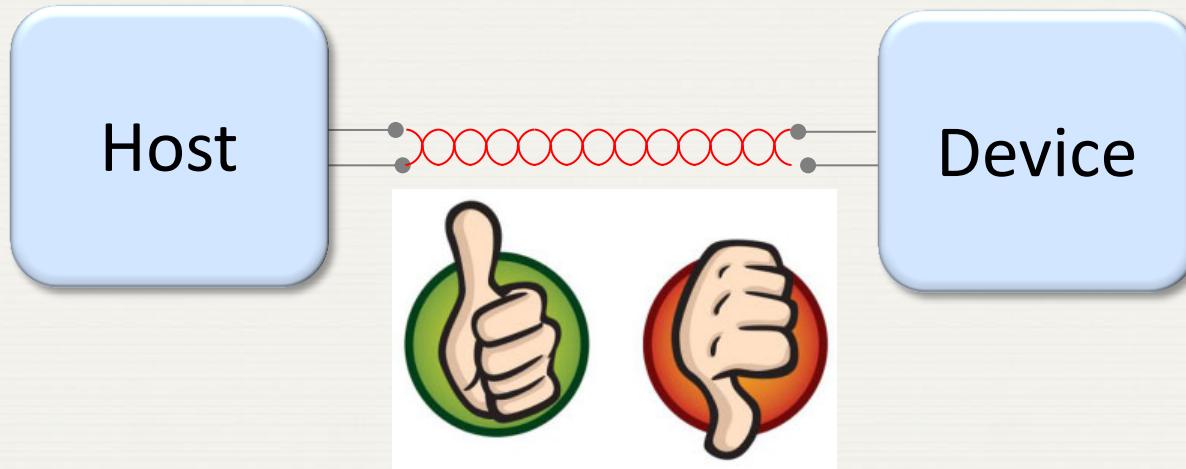


The Physical Challenge

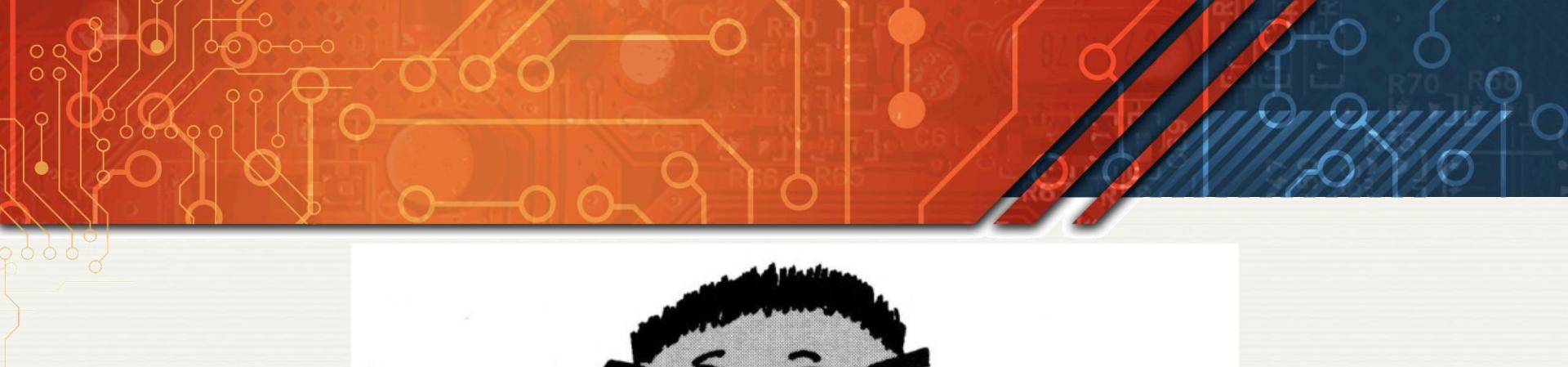
- 5.8 GHz channel
- Manage skew between 2 lanes
- Clock & Data Recovery (CDR) within short bursts
- M-PHY is a very complex PHY



The Validation Challenge



- Complex high speed protocols involved
 - Validation equipment cannot be an after-thought
- Reference Validation equipment – the need for “Golden” model
 - Golden Host – for validating device implementation
 - Golden Device – for validating host implementation





Bootstrapping the UFS Ecosystem

Perry Keller

Digital Applications and Standards Program Lead
Memory Program Manager

Member - Jedec and UFSA Board of Directors
Chairman – Jедес UFS (JC64.5) and UFSA Compliance Committees

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UFS is Unique

- Developed in a truly open fashion
 - Over 50 companies and a dozen separate committees across Jedec, MIPI Alliance and UFSA participated
 - Everyone has equal opportunity to contribute and vote
 - “Big Boys” don’t always get their way
- Freedom from legacy support enables UFS to use “Best of Class” practices across the board
 - Implements lessons learned from dozens of existing standards
 - Applies to UFS technology AND entire enabling ecosystem

UFS Ecosystem

JEDEC

mipi
alliance

incits T10
Where IT all begins

UFS
Universal Flash Storage Association

BoD: Samsung,
Micron, SK Hynix,
Agilent, Phison,
Silicon Motion

Technical Standards

Test Procedures

Technical Seminars

Marketing Collateral

Logo Management

Compliance Validation
Process

- ✓ Workshops
- ✓ Plugfests

Components with the



UFS
IP, Silicon, OS
and System
Developers

Test and
Measurement
Equipment
Providers

Authorized Test
Centers



UFS™

Logo License

Compliance
Test Reports

UFSA
Universal Flash Storage Association



The Universal Flash Storage Association (UFSA) was founded in 2010 as an open Trade Association to promote widespread industry adoption and acceptance of the UFS standard.

Primary Missions:

- UFS technology promotion & infrastructure enablement
- Product compliance and UFS logo certification management
- Technical input into JEDEC for future specifications

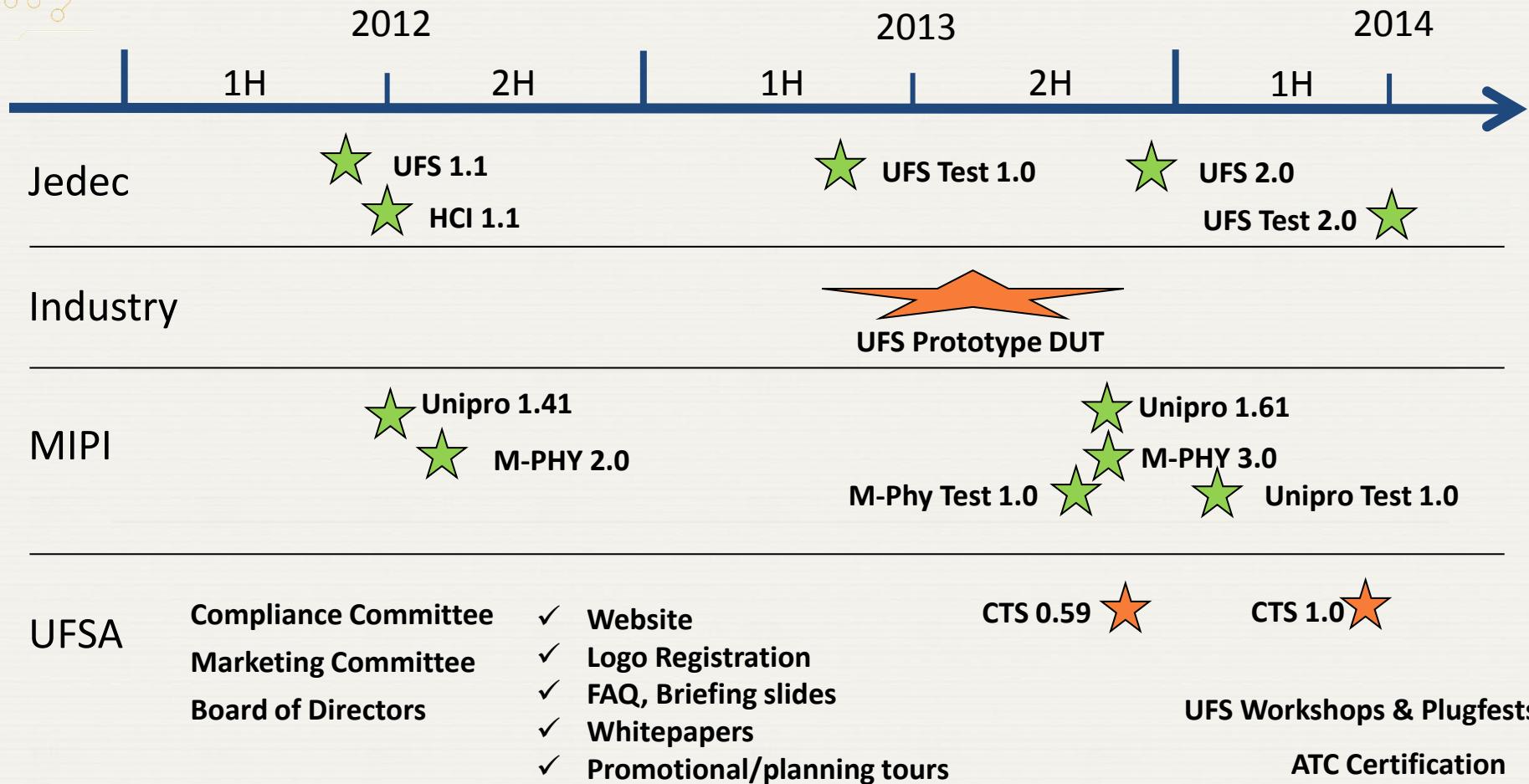


Current Board Members:

Samsung, Micron, SK Hynix, Agilent, Phison & Silicon Motion

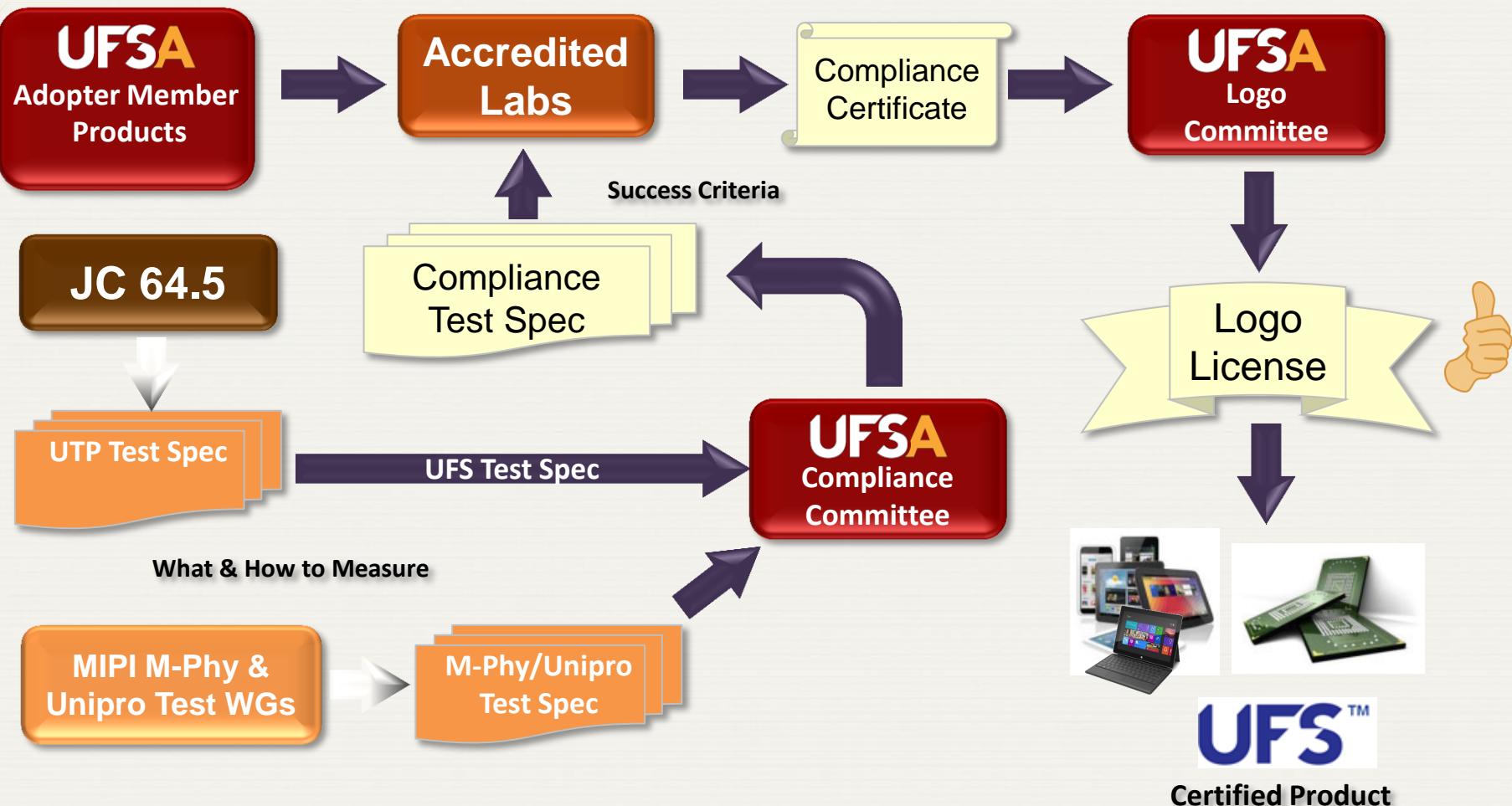
www.universalflash.org

UFS Enablement Milestones



UFS roadmap informative only and no guarantee on schedules

UFS Logo Certification Process



UFSA Compliance Test Events

- **UFS Workshop**
 - By invitation only
 - Test the Test Specification
 - Potential early certification
- **UFS Plugfest**
 - Open to UFSA members
 - Pre-compliance test
 - Potential Certification
- **Certification Test**
 - Service provided by Authorized Test Centers
 - Anyone can request testing
 - Logo application requires UFSA membership AND compliance certification

