Flash Storage
A True Mobile Catalyst

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Flash Memory
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Do you own or have ever owned a . . .

Notebook PC

Pager
Cell Phone
("dumb" phone)

PDA

Smartphone

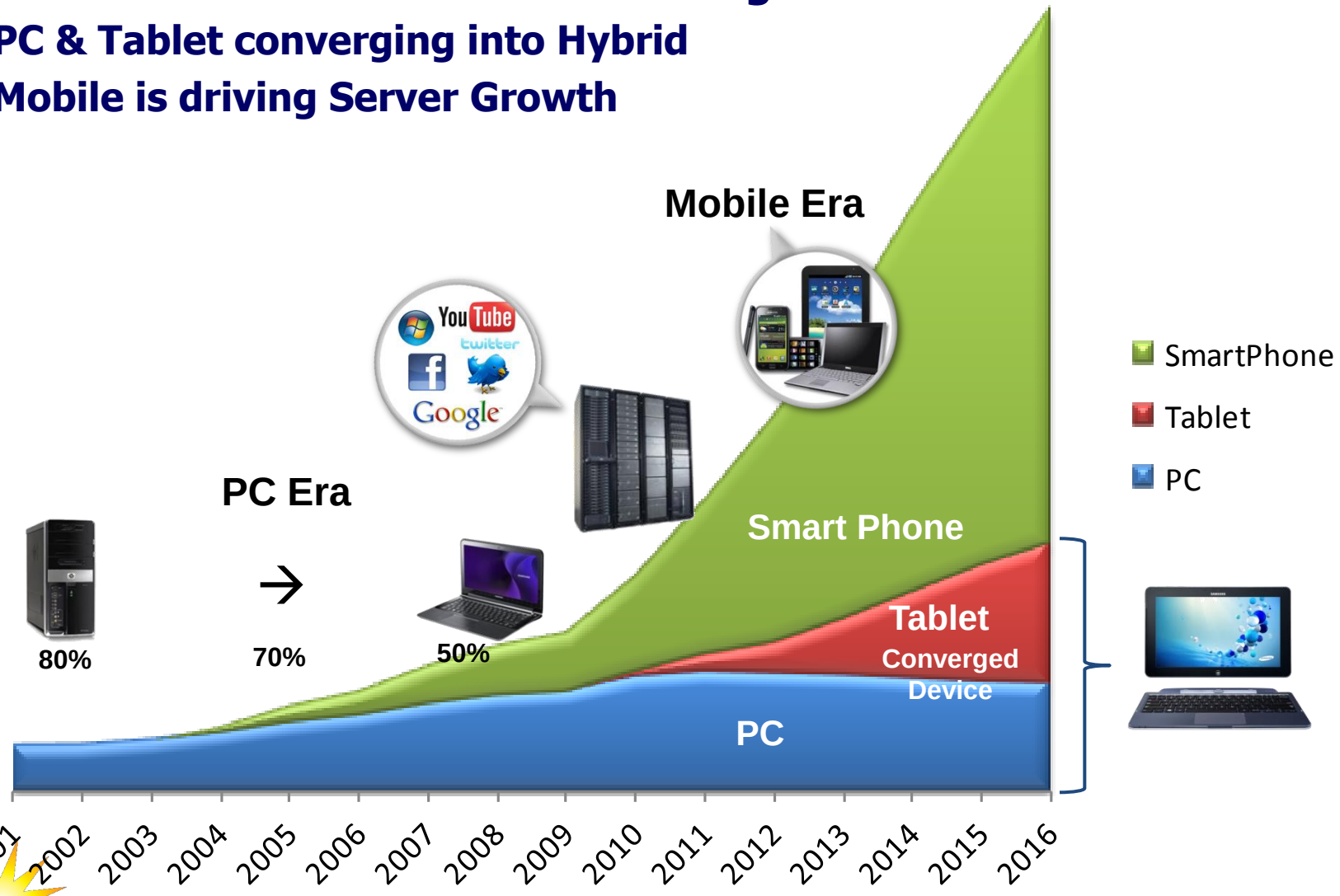
Tablet

Other

How many devices do you own?

PC → Mobile Era

- **Smart Phones & Tablets are facilitating the transition to Mobile Era**
  - **PC & Tablet converging into Hybrid**
  - **Mobile is driving Server Growth**



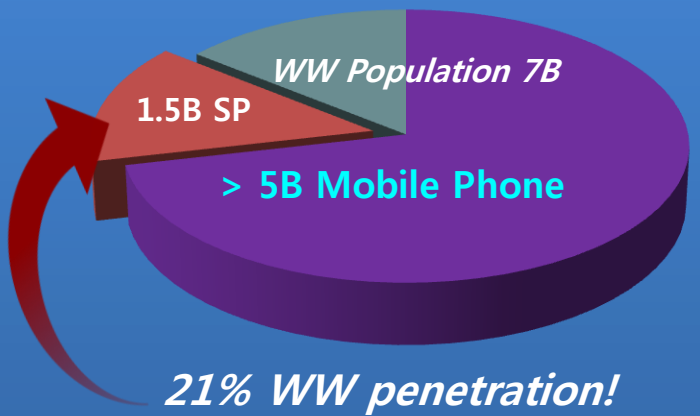
Sources: BI Intelligence, Gartner, IDC, Morgan Stanley Research

Smartphones Continue To Grow

- **Despite fast growth & surpassing feature phone sales . . .**

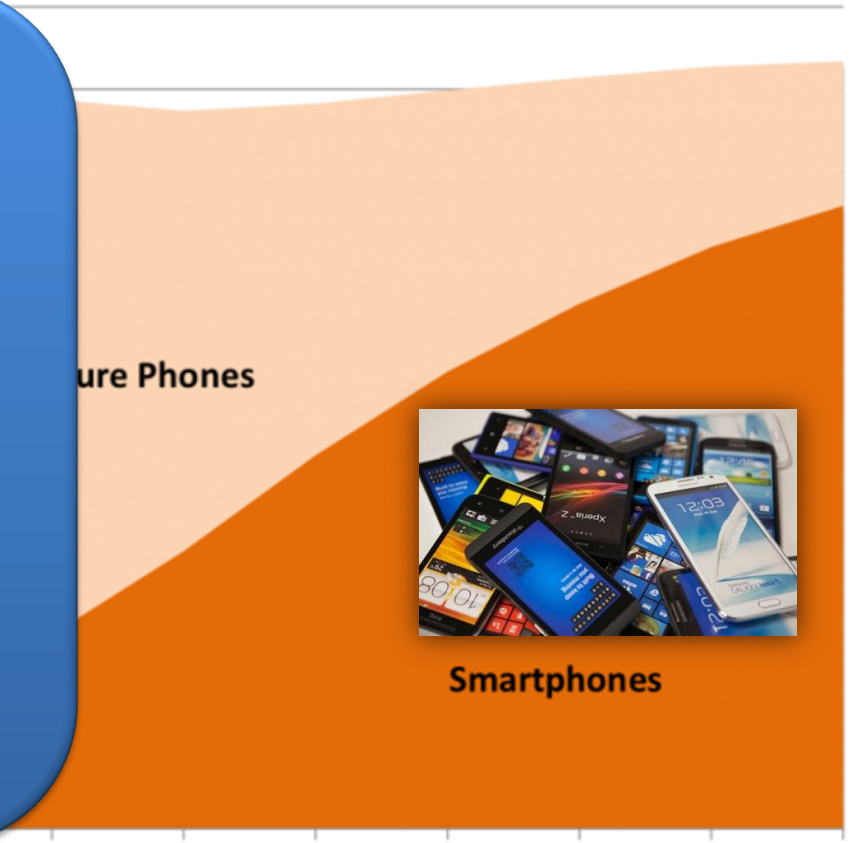
Global Smartphone Penetration

WW Smartphone vs Mobile Phone Users 2013E Forecast



21% WW penetration!

Mobile Phone Users
Smartphone Users



Smartphone adoption still has huge upside for global penetration

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Sources: BI Intelligence, Morgan Stanley Research

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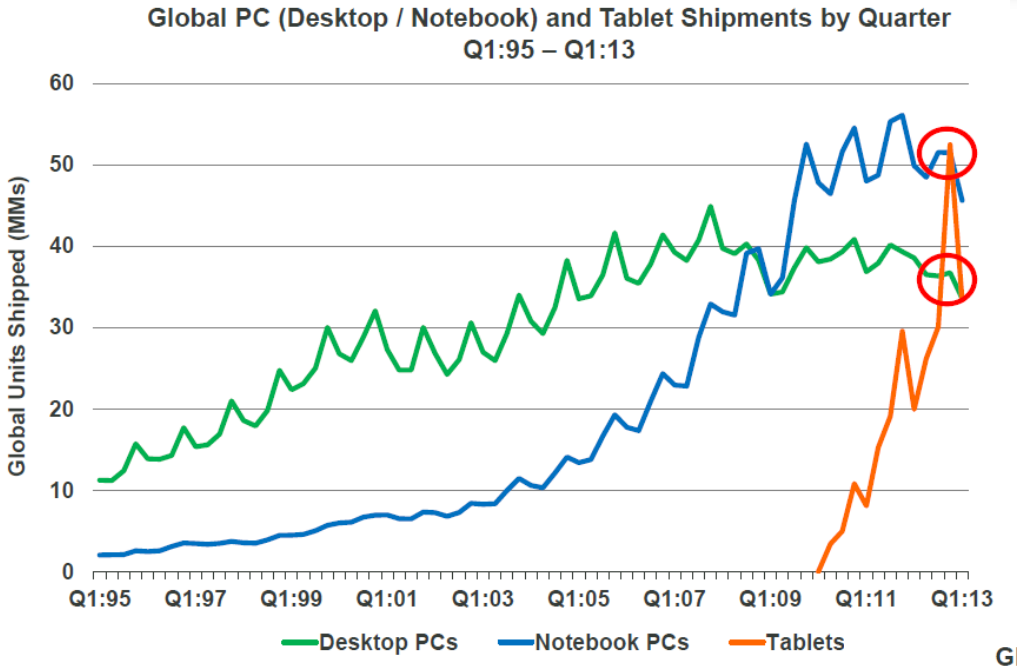
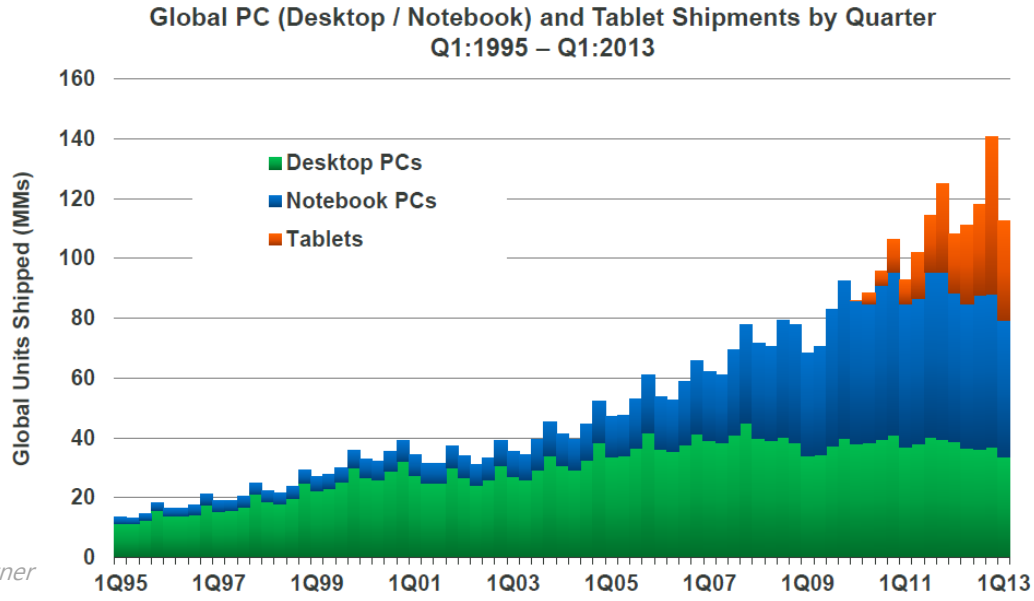
Tablet Growth Faster Than Smartphones



- 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 PC's



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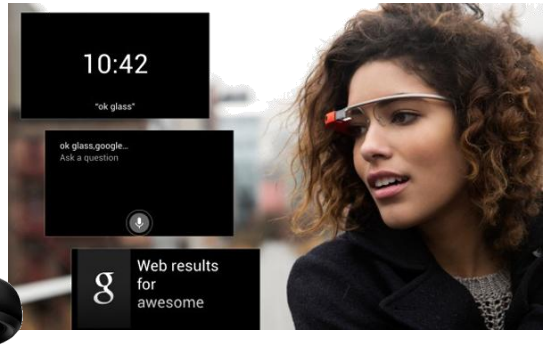
Sources: KPCB, Morgan Stanley Research, Gartner

What's Next for Mobile: Wearable Devices?

- Smartphones & Tablets still in early stage, but see strong onset of wearables and potential for future devices

- Sensor Enabled
- Environment-Aware
- Hands-Free
- Easy Access
- Always On/Always Connected
- Development Platforms
- Wider Markets/Applications



. . . And they all need NAND Flash

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Where Will Users Spend Their Time?

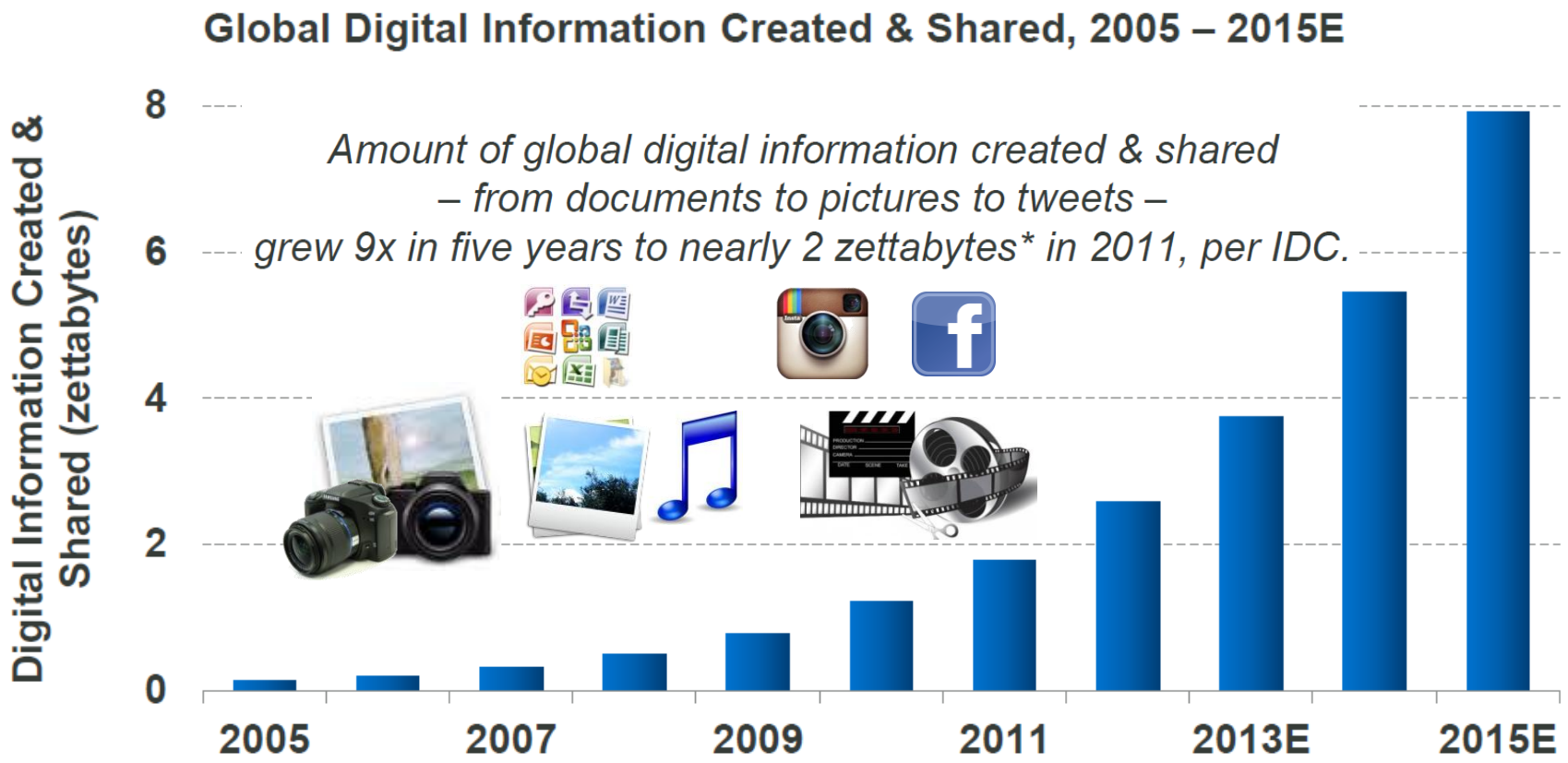
- **Average Traffic Per Mobile Device Type**

Smartphone and Tablet will Soon Drive Similar Data Levels as PC

Source: Cisco VNI

Digital Information Growth Exploding

- **Content increasingly created, findable, shared, tagged, etc.**
- **Created & Shared content up 9x in 5 years**



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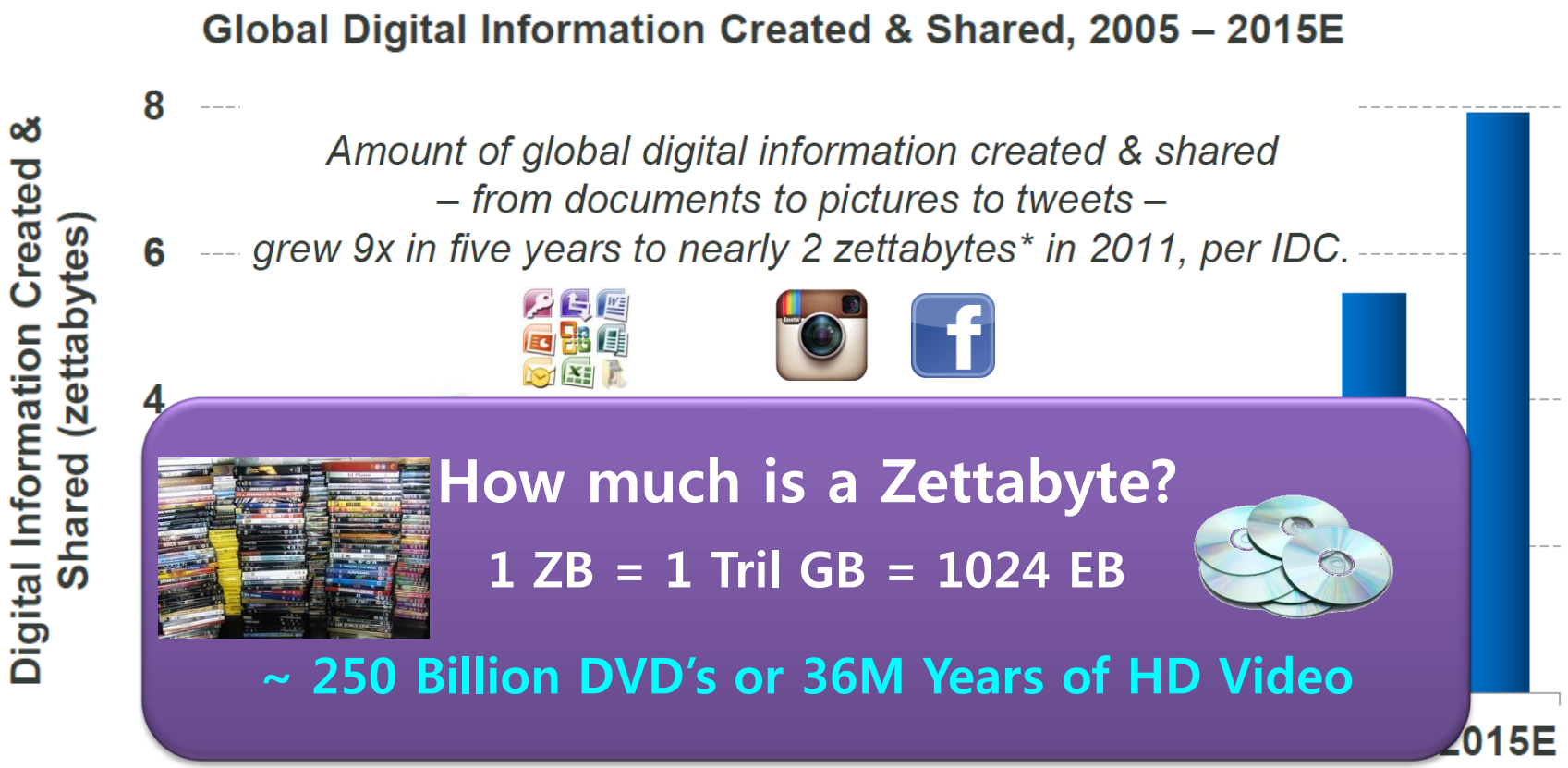


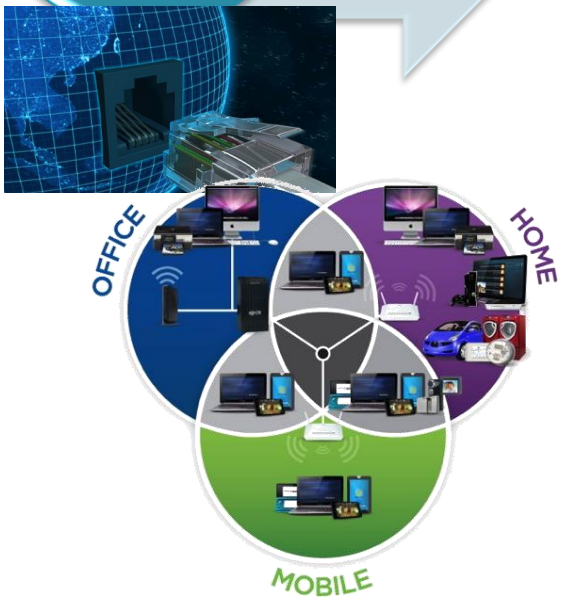
Mobile Era Continues Evolving: IoE

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

Internet of Things — Devices, Internet

Internet of People — Social Networking, Crowd Sourcing

Internet of Everything — P2P, P2M, M2M



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

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

And they will all need Flash . . .

Source: Yole

Sources: Cisco VNI, Qualcomm

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Internet of Things

Devic

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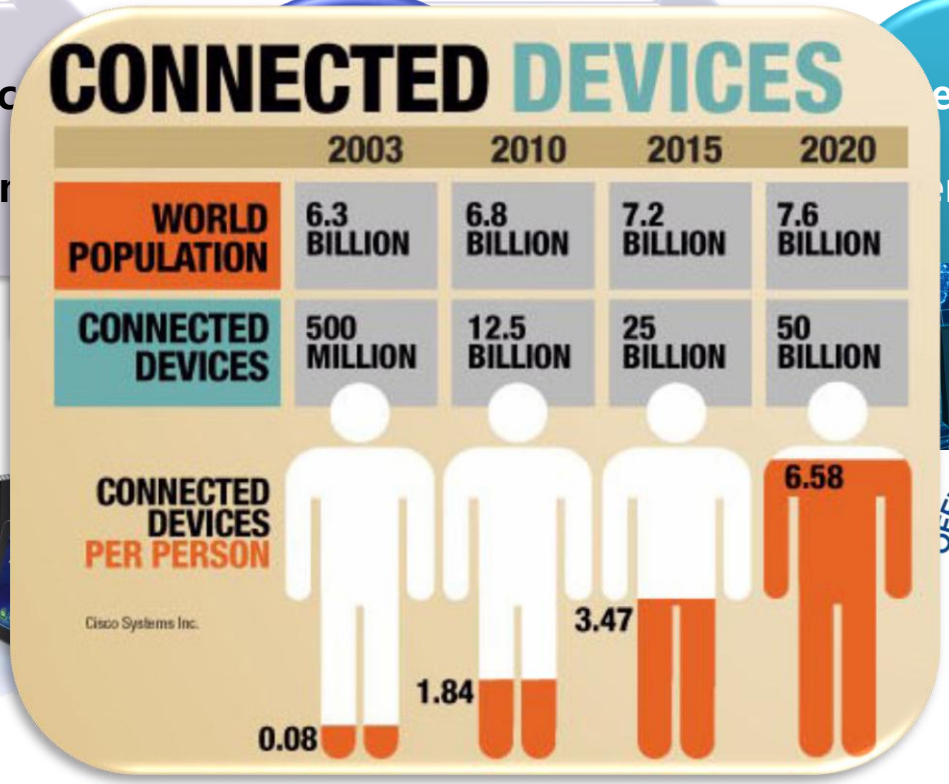
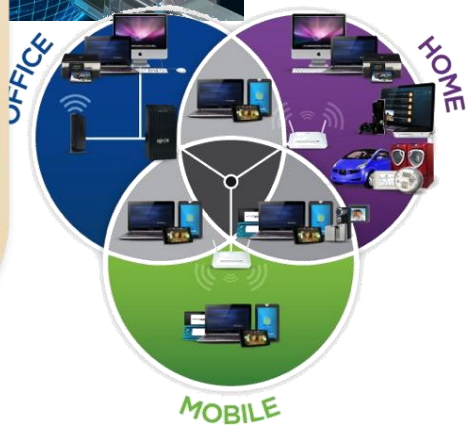
rything

P2P

P2M

M2M





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And they will all need Flash . . .

Source: Yole

Sources: Cisco VNI, Qualcomm

Mobile Devices: Then

< 2MP

Camera

Comm

Feature phone

Smart phone

Input

Keypad

Touchscreen from ‘07

Content

Start of Apps in ‘07

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Mobile Devices: Then

< 2MP

Camera

text

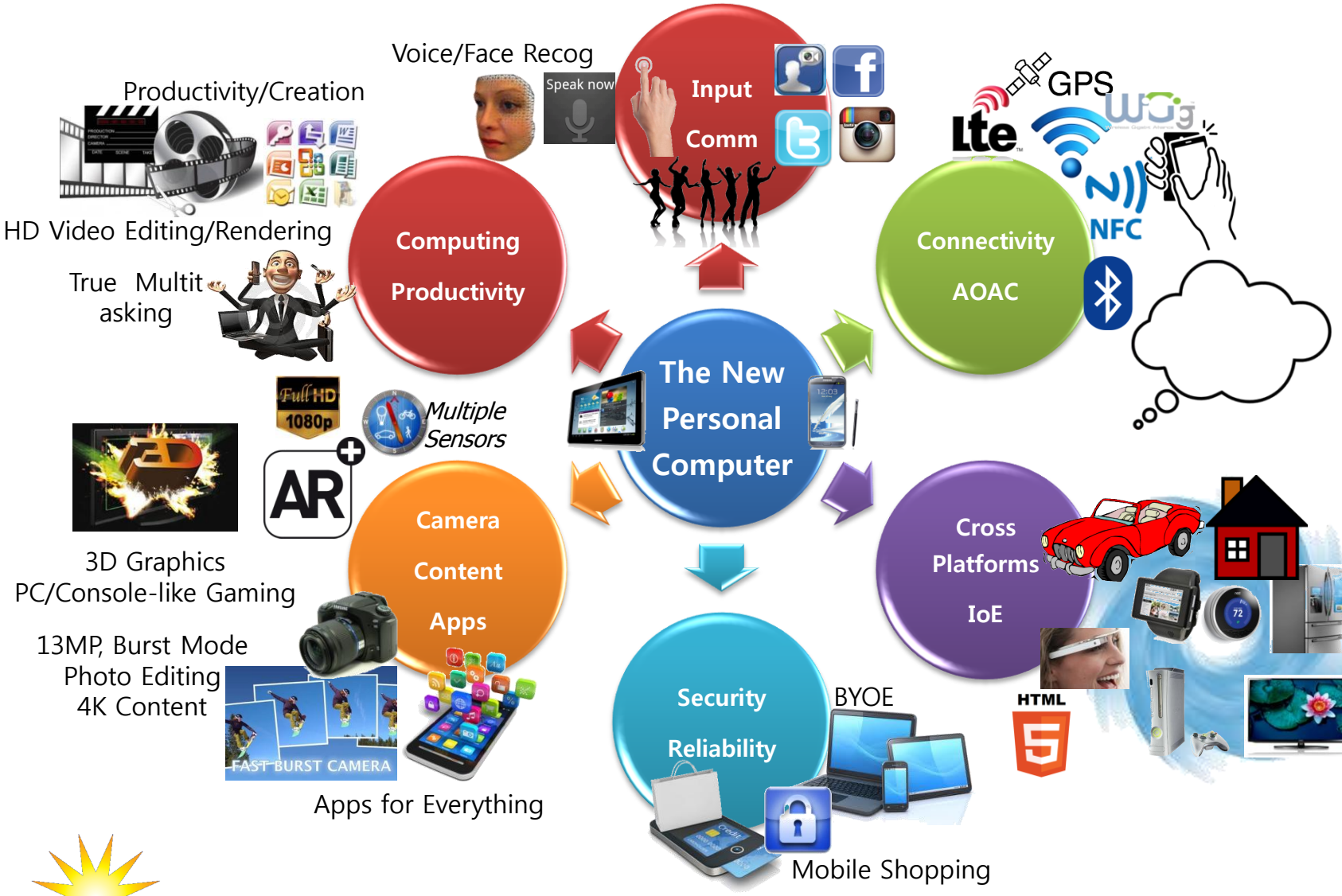
Simple Usage, Simple Features
Simple Memory Requirements

Touchscreen from '07

Content

Start of Apps in '07

Mobile Devices: Now



Mobile Devices: Now

Tablet Evolution: Consumption → Creation + More

Smartphone

Multiple Sensors

HD Capture/Content

eReader/eBooks

Gaming

3D GFX
Rich PC-like Gaming
Fast, Real-time response

Content Creation

Shopping

Always On, Always Connected

Cross Platforms

More

- Bigger/Richer Display
- Thinner & Lighter
- Secure & Reliable
- Long Battery Life

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
D (R			
Video (Resolution)	720p H.264	x34	4Kp H.265
Battery	5.76W/h	x2.2	13W/h

Key Mobile Memory Requirements

→ Faster Performance & More Capability

→ While Maintaining Low Power Consumption

Source : ARM

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

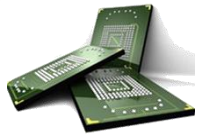
More Apps, Richer Apps
HD Video, High Res Photos
3D Graphics/4K Content

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



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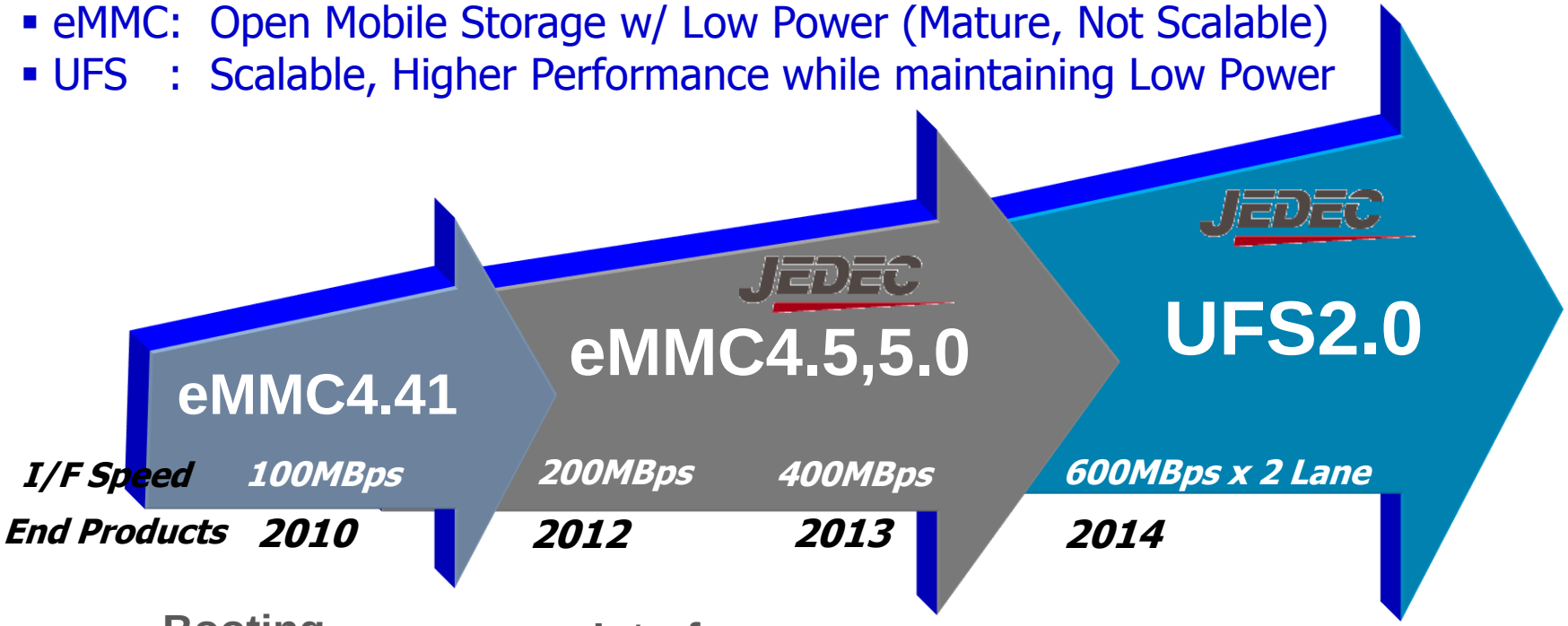
Mobile-centric Storage: eMMC → UFS

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



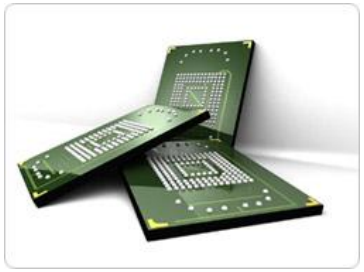
Booting
Partitioning
Security
Data integrity

Interface
Improvement
Performance
Enhancement

✓Expandability/Scalability
✓Serial interface, Multi-lane
✓Higher Random IOPS
✓Low Latency, High Efficiency

UFS = Evolutionary progression of JEDEC standards for Mobile Storage

What is UFS . . .



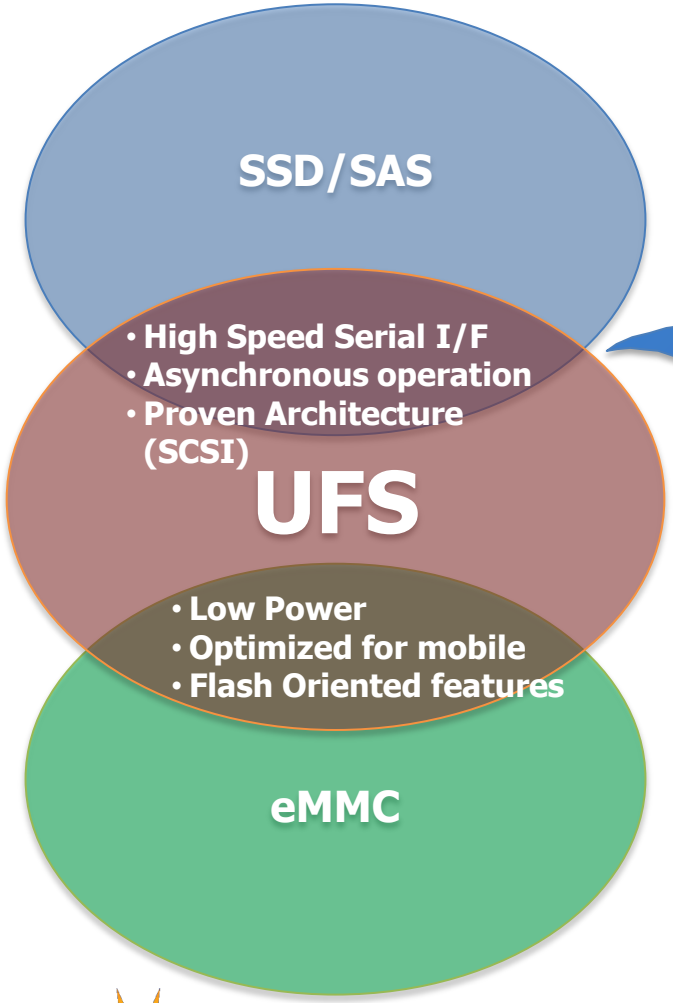
eMMC Features

SSD Features

UFS

UFS: Next Gen High Performance Mobile Storage

UFS: Universal Flash Storage



SSD for Mobile Devices

- Better User Experience
- Fast Boot, Fast Response
- Lower Latency, Higher Efficiency
- High-speed PC Sync
- Low Power Consumption

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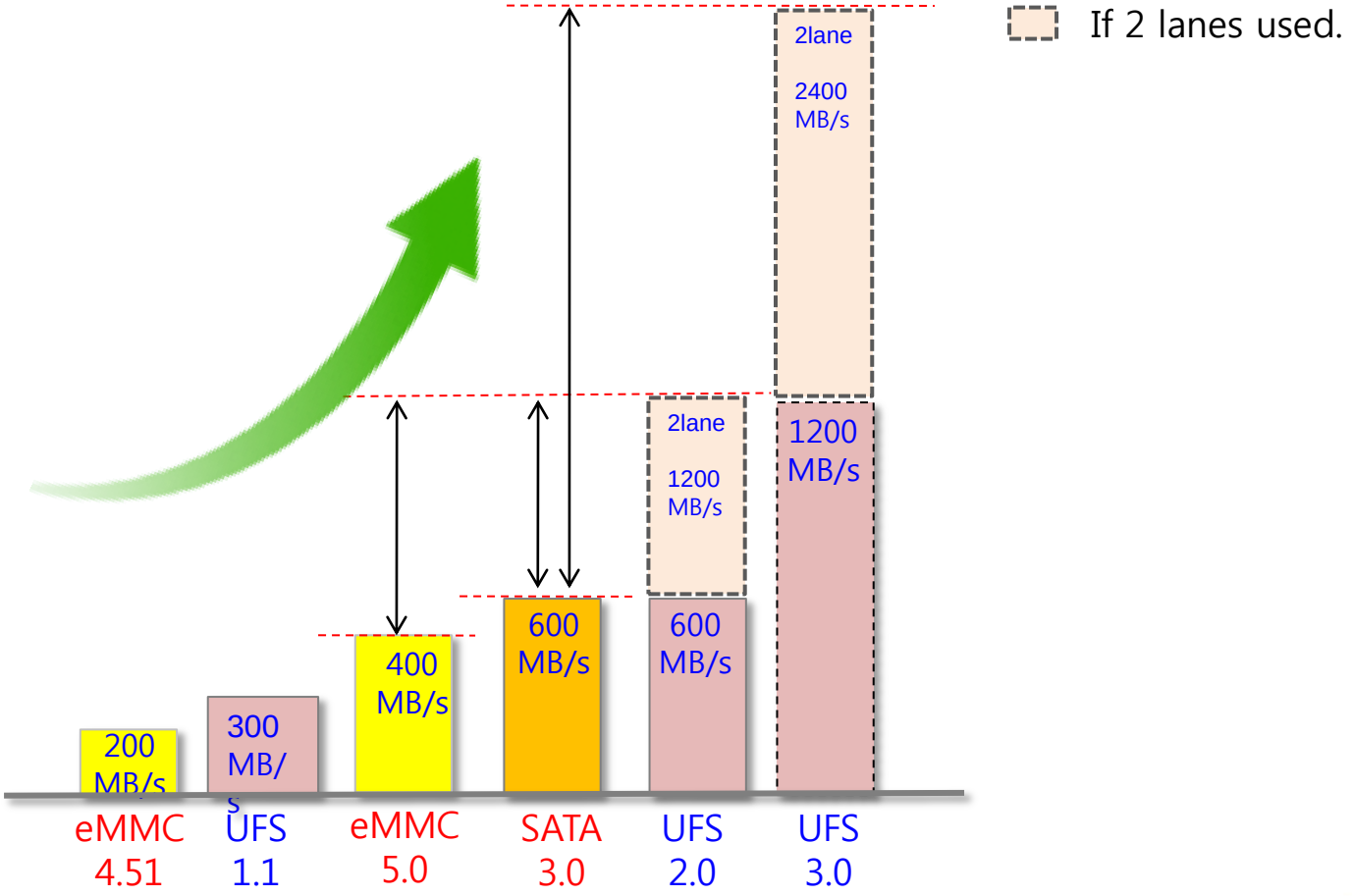
UFS: The Fastest Interface

- UFS 2.0 exceeds current SSD interface of SATA 3.0 (6Gbps).
- No change in SW is required for supporting multi-lane.
  → Handled by UniPro IP transparently.



UFS: Selectable & Scalable Speed

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

HS G3

HS G2

HS G1

PWM G4

PWM G3

PWM G2

PWM G1

3~9Mb/s | 6~18Mb/s | 12~36Mb/s | 24~72Mb/s | 1.25~1.5Gb/s | 2.5~3Gb/s | 6 Gb/s

Less Power consumption

More Performance

eMMC vs. UFS: Interface Race

Which do you prefer for your next mobile device?

Congested Parallel Interface

VS

Simpler & Faster Serial Interface

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

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eMMC vs UFS: Queuing & Asynch I/O

- Multiple Commands/Tasks, Multi-processing Demands

Inefficiencies of eMMC = Traffic Jam & back-up

eMMC vs UFS: Queuing & Asynch I/O

- Multiple Commands/Tasks, Multi-processing Demands

Inefficiencies of eMMC = Traffic Jam & back-up

UFS Solution:

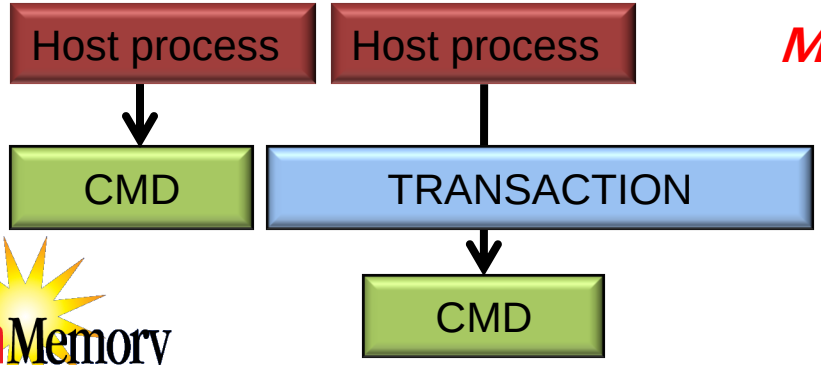
- Async I/O, Command Queuing & Reordering
- Higher Efficiency, Faster Completion

eMMC vs. UFS : Sync vs. Async

- Set it and forget it
  - Optimal for multi-processing

Sync I/O (*e*-MMC) : One-by-one

Async I/O (UFS) : Send it and forget it



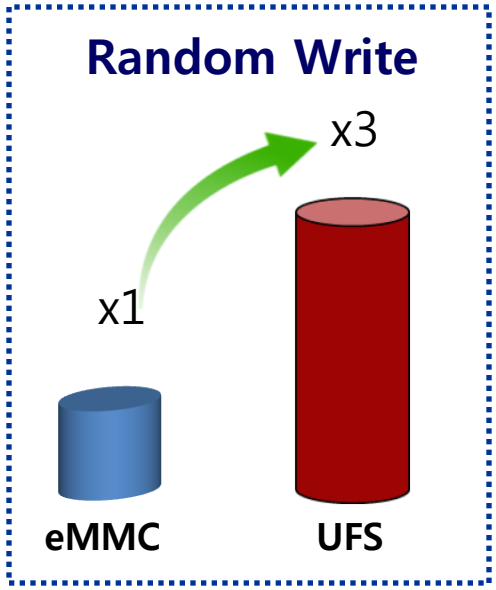
Plus Queuing & Re-ordering
Minimize latency, Maximize Efficiency
Process transactions faster

UFS: Overall Feature Comparison

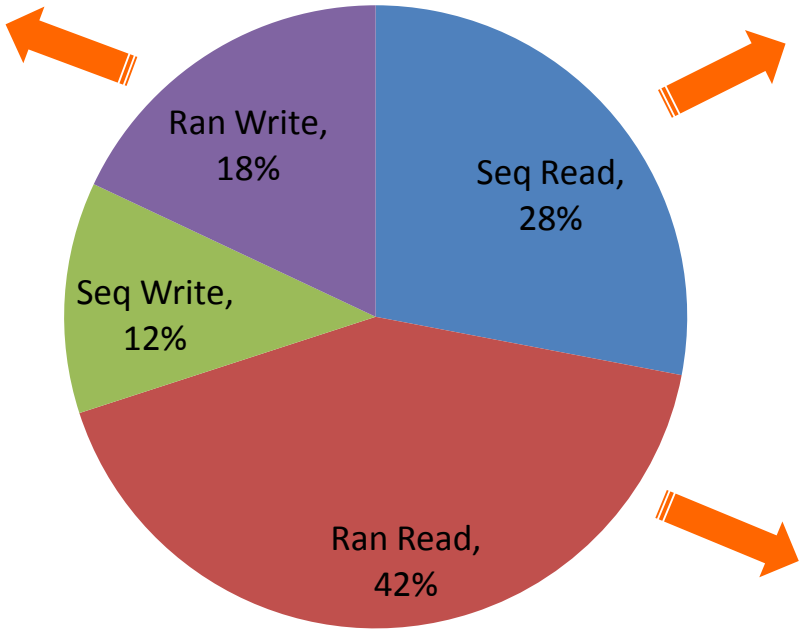
- **UFS includes both { mobile + computing } features**
- **Performance, Efficiency, Scalability for future mobile designs**

		eMMC5.0	UFS2.0	SATA
Interface	Operation	-	Full Duplex	Dual Simplex
Future Expandability		~400MB/s	6Gbps, 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	Simple Queuing	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

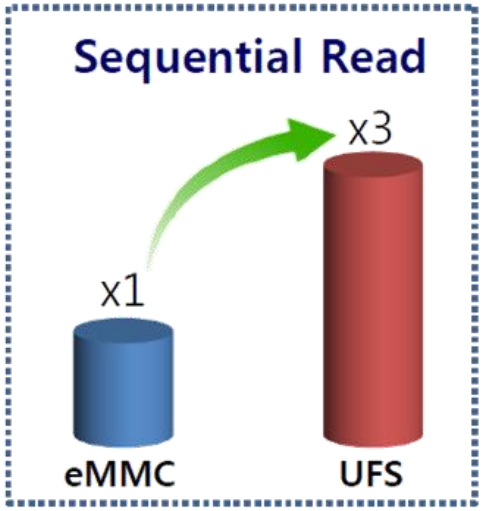
UFS Surpasses eMMC Performance

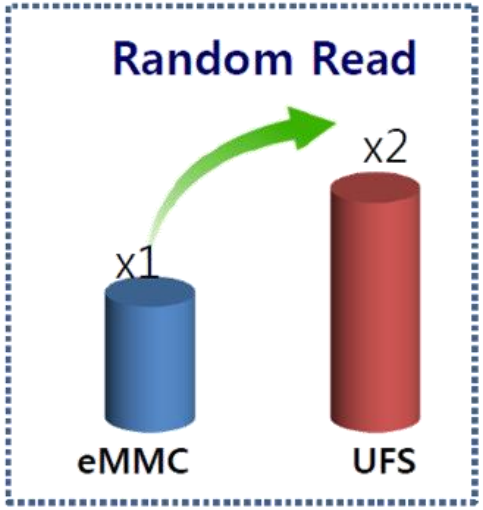


Mobile OS Storage Pattern Analysis



Source: Samsung





Better End User Experience

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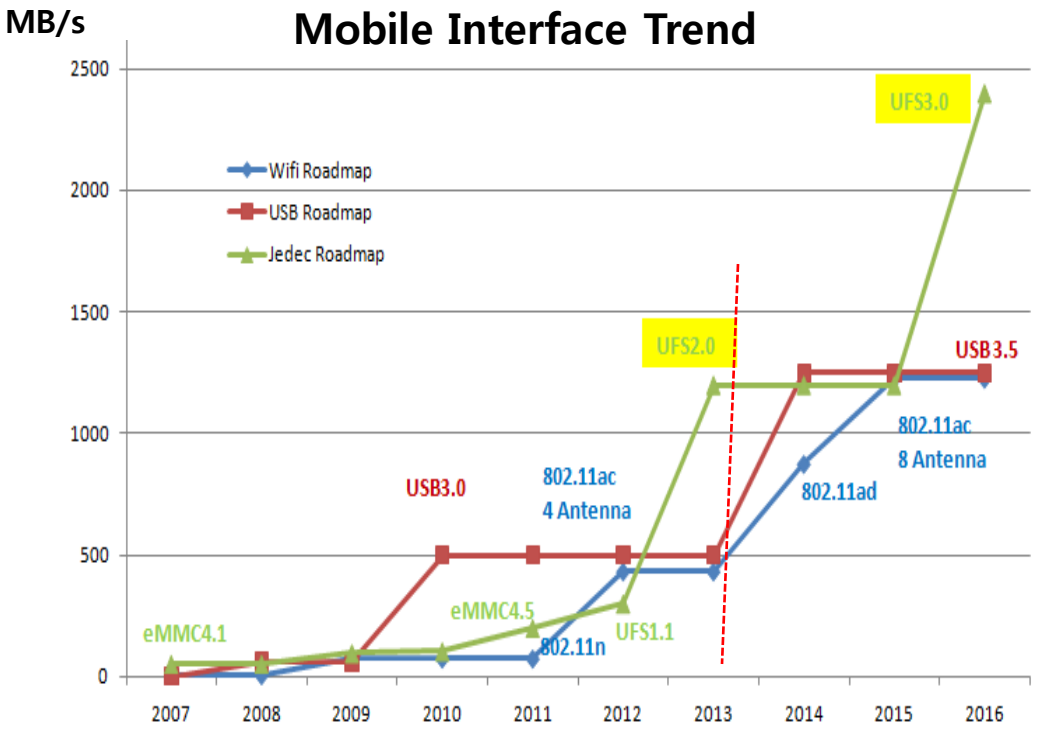
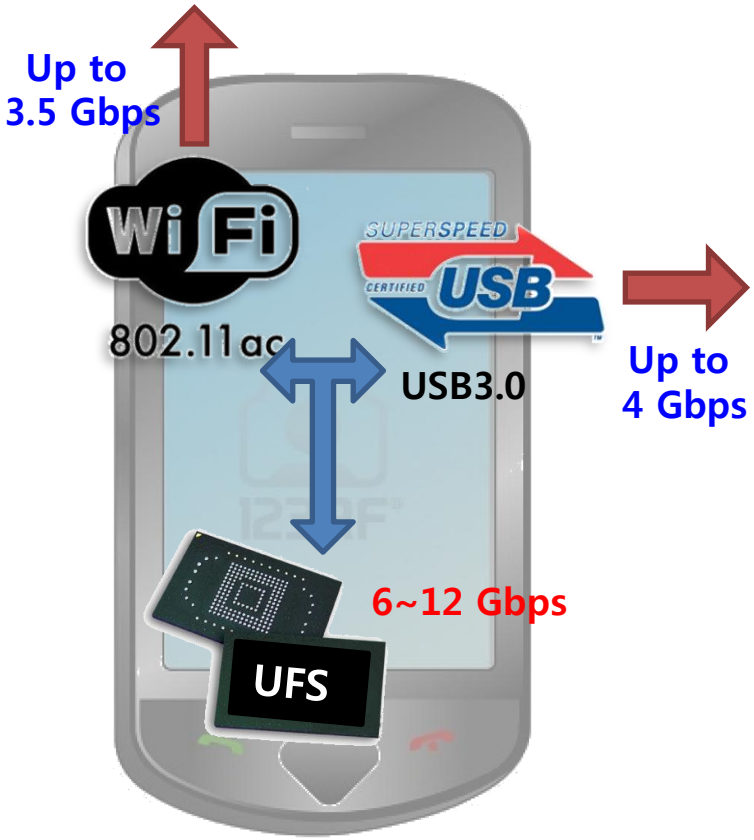
UFS2.0 Satisfying All Bandwidth Requirements

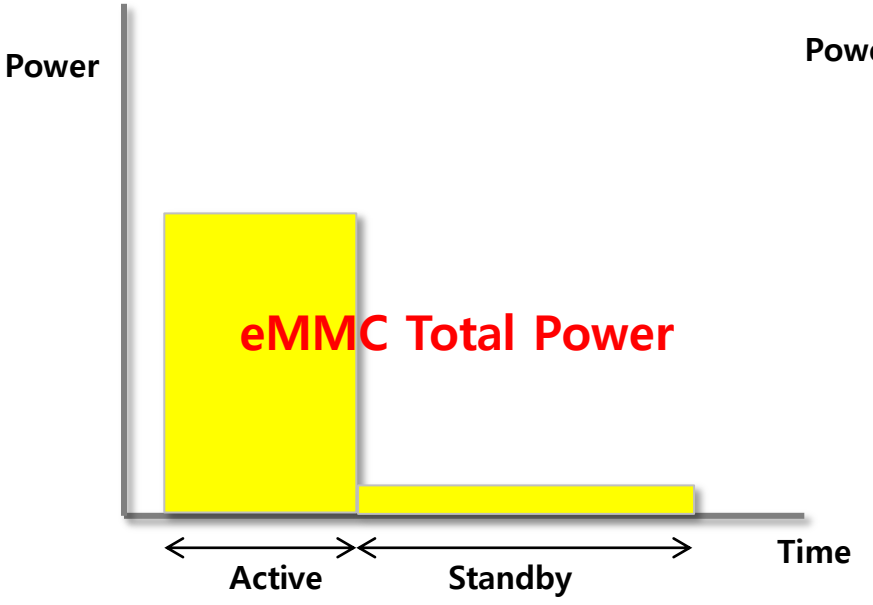
- **UFS will overcome the interface bottleneck between WiFi (802.11ac, 3.5 Gbps) and USB3.0(4 Gbps)**
  - **At least 6 Gbps Interface speed is needed for better UX as of '13.**

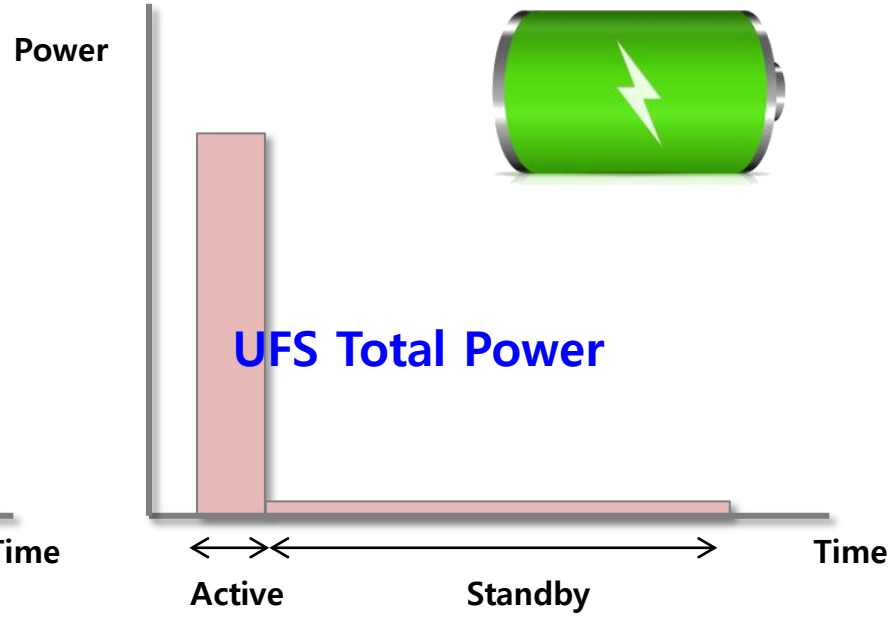




UFS: Faster With Less Power

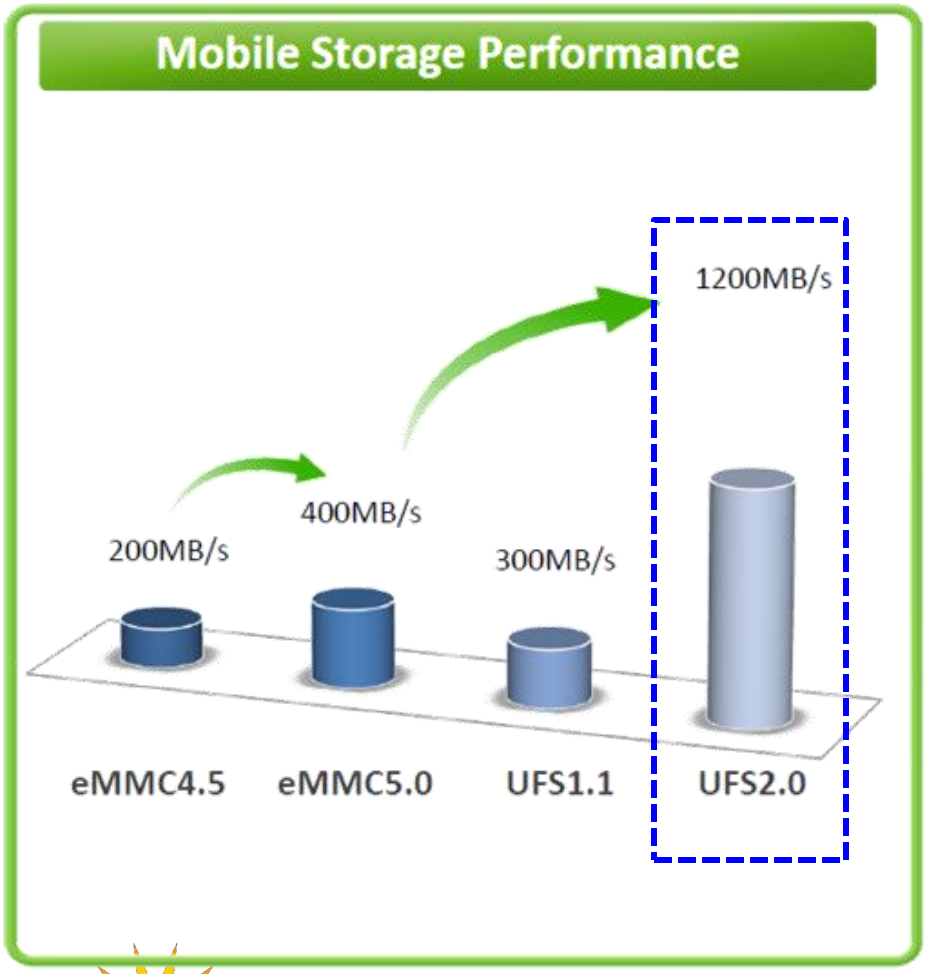
- UFS consumes less total power(=power X time) despite much higher performance
  - Completes tasks sooner
  - Stays in standby mode longer

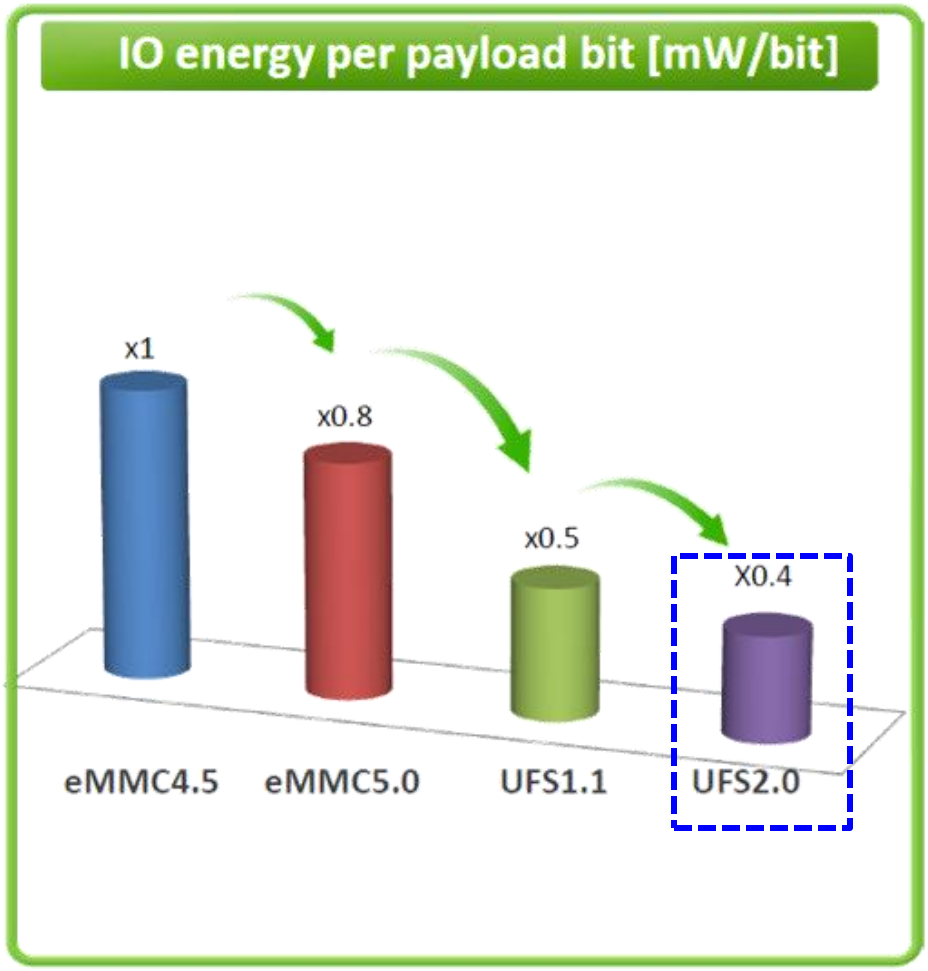




Higher Energy Efficiency

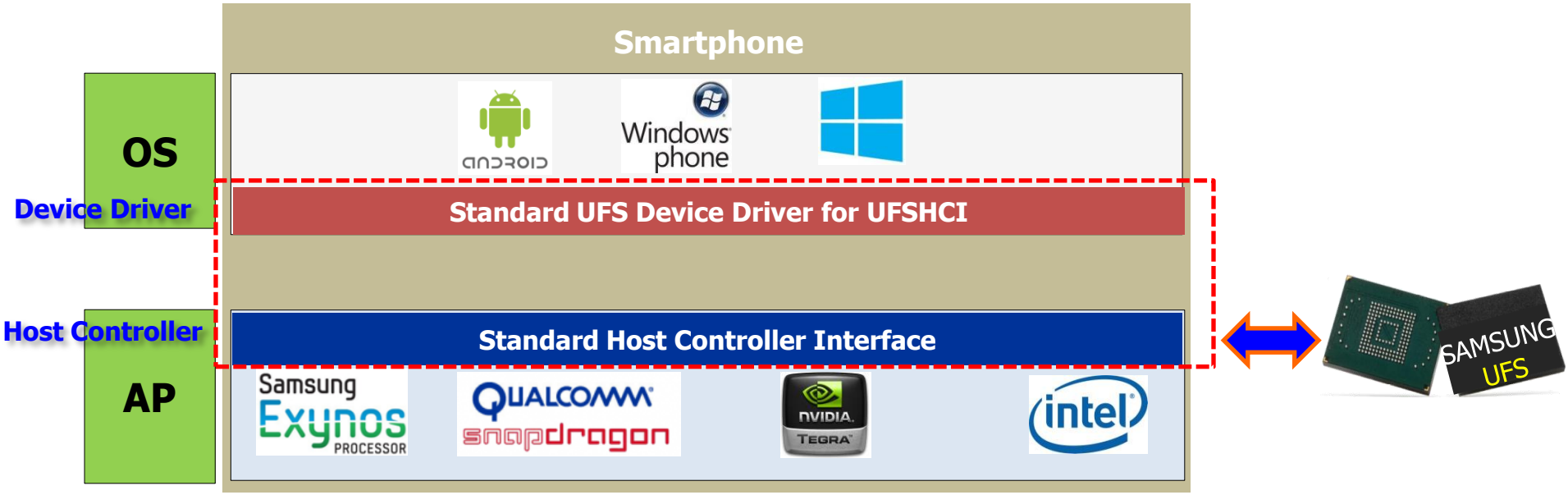
Higher Energy Efficiency – Lower IO Energy per bit , even with higher performance





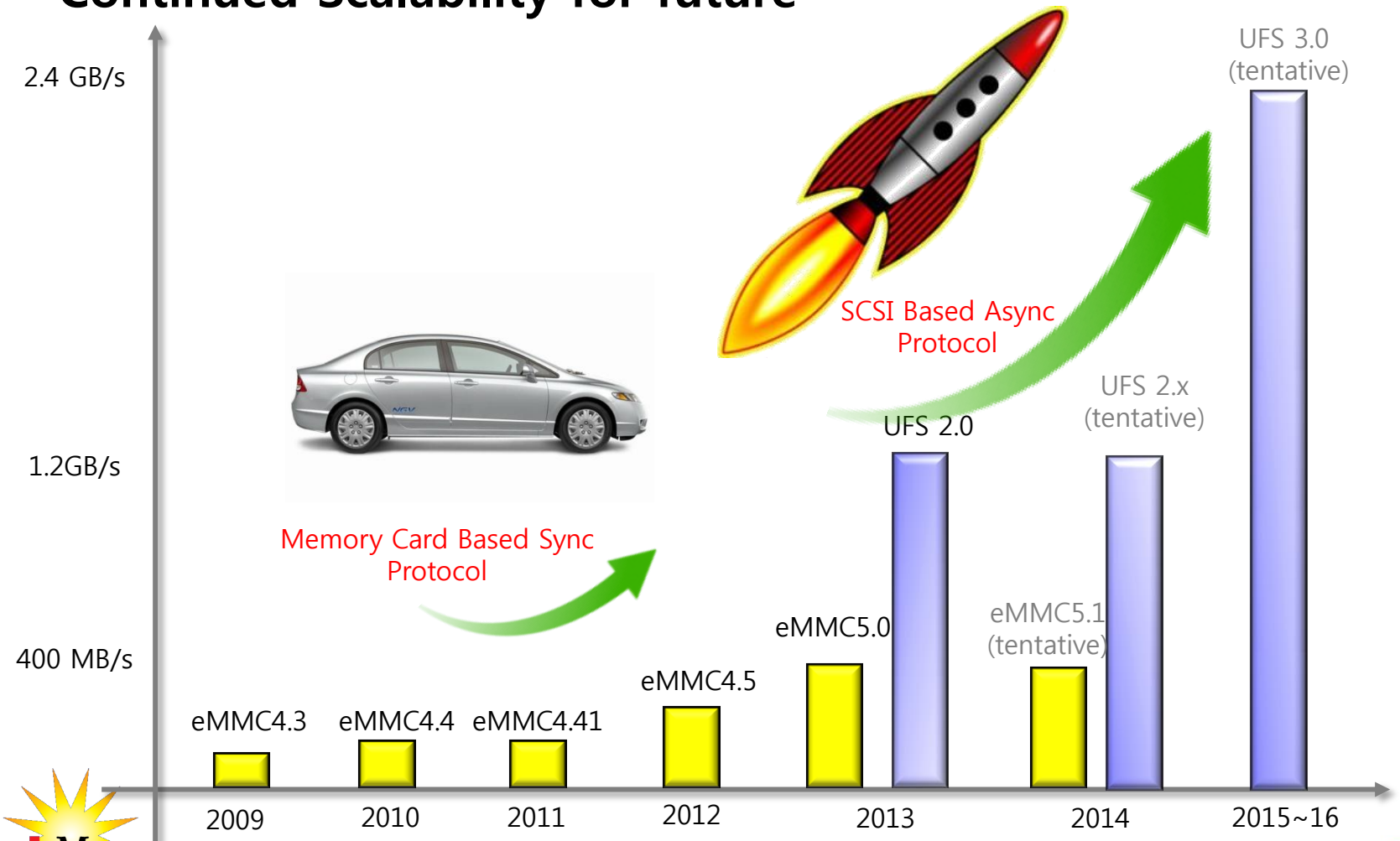
Easy to Implement: Standard HCI

- Support Standard UFSHCI (UFS Host Controller Interface)
  - Standard UFS Driver (e.g. Linux) works on all Aps
  - Simplify Host Design



UFS: Natural Migration for Mobile Evolution

- **Higher Performance & Efficiency with lower total power**
- **Continued Scalability for future**



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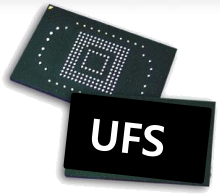
UFS In Summary . . .

less is more.

UFS In Summary . . .

UFS: Next Gen Mobile Storage beyond eMMC



- **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