‘Memory Need’ Gives Birth To ‘New Memory’

Qualcomm 3G LTE summit
Hong Kong, Sept 16th 2015

Ashiq Reza, Mobile Memory Product Planning
Samsung Semiconductor Inc. (SSI)
What Are We Discussing Today?

- Qualcomm & Samsung Partnership
- Mobile Memory Trends
- Next-Gen Mobile Memory
- Next-Gen Mobile Storage
Qualcomm and Samsung Partner in Every Mobile Segment

![Qualcomm and Samsung Partnership Diagram](image-url)
Memory Trends
Stable DRAM growth, but Mobile Memory will continue to dominate.
Mob. DRAM and NAND Avg. Density Will Grow At A Healthy rate

*Source: Samsung*
Samsung’s Technology Transition – LPDDR4 and UFS

- **2014**: LP2
- **2015**: LP3
- **2016**: LP4
- **2017**: UFS

**DRAM**
- LP2
- LP3
- LP4

**FLASH**
- eMMC5.x
- UFS
Mobile Memory
Key Drivers Fueling Memory Requirements

B/W requirement

Density requirement

Camera Features

Screen Resolution

Android L + 64bit AP

Better UX = More Memory

RAM 8.9 (14) → 11.3 (15) → 14.1 (16) [Gb/s]
High Density LPDDR4 – Better UX, Faster Execution & Power Savings

Application

1st Execution

2nd Execution

Time Saving = better UX

Power Saving = better UX

85% Saved

50% Saved

*2nd Execution
Mobile Storage
Fast & High Density Storage to Accommodate Multimedia Content

3.5G: 2-3Mbps d/l

4G: 10-20Mbps d/l

GB

2011 2013 2015

24GB 55GB 120GB

x2 x2

3,000 1,500 6,000

1,000 25 3,000

10 200 40

150 120GB 300
UFS is the Answer to the Growing Storage Demand

Higher Performance, Efficiency
Scalable for future

SCSI Based Async Protocol

Good, sufficient performance, fuel-efficient

Memory Card Based Sync Protocol

200 MB/s
2009  eMMC4.3

400 MB/s
2010  eMMC4.4
2011  eMMC4.41
2012  eMMC4.5

600 MB/s
2013  eMMC5.0
2014  eMMC5.1

1.2 GB/s
UFS 2.0 (1-lane)

2.4 GB/s
UFS 2.0 (2-lane)
UFS 3.0 (2-lane)
UFS 4.0 (1-lane)
UFS 4.0 (2-lane)

2016
UFS 3.0 (2-lane)

2018 (tentative)

2.4 GB/sec

Proprietary

2009 eMMC4.3
600 MB/s

2010 eMMC4.4

2011 eMMC4.41

2012 eMMC4.5

2013 eMMC5.0

2014 eMMC5.1

2016 UFS 3.0 (2-lane)

2018 (tentative) UFS 4.0 (2-lane)
UFS Stands for Better Performance, Battery Life and Ease of Use

**Longer Battery Life**
- Energy Savings
- Longer Battery Life
- Ease of Use

**Ease of Use**
- System Booting
- Application Loading
- Application Switching

**Performance**
- Seq.Read (MB/s) x1.3
- Seq.Write (MB/s) x1.2
- Ran.Read (IOPS) x3
- Ran.Write (IOPS) x1.4
Beyond Embedded UFS – UFS Cards

Co-sponsor companies

JEDEC
Draft spec voting Dec ’15 Spec target Mar ’16

ES
3Gbps samples available, now 6Gbps samples in Oct ’15

Why UFS Card?

Spec. competition of handsets slowed down

User handset replacement time ↑

Accumulated user data ↑

Need for Storage Extension ↑

Mobile Storage Interface Bandwidth

- eMMC
- eUFS
- UFS Card v1.0 (6Gbps)
- uSD(UHS-I)

Bandwidth (MB/s)

2011 2012 2013 2014 2015

104 104 200 104 104 600

104 104 400 104 104 1200

104 104 400 104 104 104

104 104 400 104 104 104
Performance Comparison

UFS Card Performance Translates to Real Time UX Benefits

<table>
<thead>
<tr>
<th>Sequential (MB/s)</th>
<th>Random (IOPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHS-1: x2.8</td>
<td>UFS: x3.5</td>
</tr>
<tr>
<td>Read</td>
<td>Write</td>
</tr>
<tr>
<td>Write</td>
<td>Read</td>
</tr>
<tr>
<td>x90</td>
<td>x12</td>
</tr>
</tbody>
</table>

* Performance is measured by Tiotest benchmark in Android OS 4.4.4

4K Video Play with Data Copy

- Frame Drop: UHS-1, MLC NAND
- Delay: UHS-1, 245 frames, 21 sec
- UFS, No, No

* Test Condition: Playing 4K movie (90 sec) while copying 100 MB data

Proprietary

Ashiq Reza
UFS Card Is The Way To Go for Future 5G Standards

UFS Card Interface BW plan

- **UFS Card v1.0**: Up to 6Gbps
- **UFS Card v2.0**: Up to 12Gbps
- **UFS Card v3.0**: Up to 24Gbps

- **USB3.0**
- **5G Network**

Timeline:
- 2016
- 2017
- 2018
- 2020
Thank You!