UFS Tutorial

Presented by
Scott Jacobson
Harish Verma
UFS – Universal Flash Storage Overview

- JEDEC UFS Roadmap
- What are the drivers?
- What is UFS?
- Why is UFS important?
- What are the details?
UFS Jedec Roadmap

UFS Roadmap

△ = Target publication

<table>
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UFS Spec. Timeline

- UFS v1.0
- UFS v1.1
- UFS v2.0
- UFS v2.x?
- UFS Security Extension v1.0

MIPI Spec. Timeline

- M-PHY v1.0/Unipro™ v1.40
- M-PHY v2.0/Unipro v1.41
- M-PHY v3.0/Unipro v1.6

Main updates:
- e.MMC feature alignment
- Errata corrections
- Alignment with M-PHY v2.0/Unipro v1.41

Data encryption References:
- IEEE1667
- TCG

- HS-G1, HS-G2 (draft)
- Point-to-point connection

- HS-G2 (finalized)
- Point-to-point connection
- Incompatible with Unipro v1.40

- HS-G3
- More power saving
- Support network topology

JEDEC

Global Standards for the Microelectronics Industry
The Mobile Revolution – A Golden Age for Consumers

Cell Phones Used By 1 of 1,000 Business People

Smartphones Used By 600 Million People Worldwide

1984

Mobile Telephone smaller, cheaper

2012

Mobile Computer simpler, mightier
But the Golden Age has Rocked the Ecosystem

Google to Buy Motorola Mobility for $12.5 Billion
BY EVELYN M. RIUSU AND CLAIRE CAIN MILLER
9:16 a.m. | Updated

In a bid to strengthen its mobile business, Google announced on Monday that it would acquire Motorola Mobility Holdings, the cellphone business that was split from Motorola, for $40 a share in cash, or $12.5 billion.

The offer — by far Google's largest ever acquisition — is 63 percent above the $24.47 closing price for Motorola Mobility shares on Friday.

Google and Motorola said the deal would close in the second quarter, pending regulatory approval.

Apple soars 10% as profit doubles

By Dave Goldman @CNNMoneyTech/ April 25, 2012: 8:46 AM ET

NEW YORK (CNNMoney) -- Much stronger-than-expected iPhone sales helped Apple nearly double its profit last quarter.

In its first quarter as a company, Apple's iPhone division accounted for an eye-popping 53% of all revenue, or $19.1 billion. The entire company brought in $24.0 billion.

The company revealed it sold 37.7 million iPhones during the quarter, up from 19.7 million a year ago.

Its past is an impressive one: From $300 million in sales during fiscal 2003 to $3 billion four years later. RIM even continued to grow after Apple stunned the industry with its iPhone in 2007, peaking at almost $20 billion in sales during fiscal 2011, which ended this past February.
What’s Enabled the Mobile Revolution?
Many New Mobile Protocols
New protocols enable advancement and drive need for advanced verification IP
Full Product Verification
Each development stage has unique VIP requirements
IP Verification Challenges

Customer feedback:

"Our SATA controller has to talk with my competitor's chip. They deviate from the spec but I still have to make it work. I need to make sure my chip will handle non-compliance gracefully."
- Leading Hard Drive Company

"My 3rd party SLImbus IP was shipping in silicon, but it still had bugs. My application was different than the others. I wish I had done my own compliance checking."
- Cellular SoC Provider

"Moving from SATA 3G to SATA 6G cost me 2 engineers for 6 months to develop the VIP. Protocol expertise is an expensive commodity."
- Storage Chipset Leader

"Our IP blocks connect via an OCP fabric. The verification team is short handed so the designers need to catch some of their own bugs. The assertion-based VIP we use really helps with that. The designers run a quick formal analysis to verify compliance. That speeds up our overall verification."
- Leading DSP Company

"The UFS spec is not fully baked, but if we delay development we’ll be late to market. I need early access to memory models and rapid incorporation of spec updates."
- Mobile Device OEM

"I’m developing a USB3 device. We know there will be a number of bugs. I need stable VIP that works. I can’t afford to debug that too."
- Mobile SoC Leader
SoC Verification

Customer feedback

“My chip is big. Simulation is orders of magnitude too slow for functional coverage collection. The best I can do is run toggle tests.”

- Network SoC Leader

“My SoC has a multi-core CPU, but so does my competitor’s. We can’t beat their performance with SW-based cache coherency. We need to manage coherency in HW. We need VIP that understands this.”

- Mobile Chipset supplier

“The protocol interfaces are only half the problem. My memory interfaces are just as complex. I need to make sure they will work, regardless of the memory vendor my customer uses.”

- Major Server Developer

“The SoC verification environment is built by contributions from our worldwide teams and sometimes from partner companies. As a result, the testbench often employs a mix of verification languages and methodologies. That’s just reality.”

- Global Semi Provider

“Believe me, I’d love to use VIP for all my interfaces, but the cost is way too high. Get real! I need licensing that matches the needs of SoC verification.”

- Server SoC Start-up

“We use a mix of simulators, partly for historical reasons and partly to optimize our expenditures. We need to be able to utilize all our simulation resources.”

- Communications Chipset Company

“The IP blocks are all tested. I need to verify the interactions between blocks. There are 8 major interfaces that need to be tested together. If I’m missing VIP for any 1 of those, I’m toast.”

- Networking Leader
The System Verification Problem

Customer feedback

"The hardware in my product is state of the art, but the software is what the customer sees. If it doesn't work flawlessly with the hardware, we'll drop market share – fast."

- Mobile Device Company

"We do it all the analysis we can - system modeling, RTL simulation, simulation acceleration, emulation, and prototyping. Each fills a need, but each is incomplete by itself."

- Global Telecomm Co.

"The hardest bugs to find are the HW/SW corner cases. We spent 3 months in the lab to get rid of 2 bugs on one baseband processor. During that time we lost the customer."

- Baseband SoC Provider

"Early HW/SW integration is a must. In the past it was a serial process that cost us 2 quarters in time to market."

- Applications Processor Leader
What is UFS?
– Next generation flash storage that provides the low power of eMMC with the high performance of SCSI SSD
– JEDEC Standard JEDS220
What is UFS?

- Built on MIPI interface standards, M-PHY and UniPro, for interconnect layer
  - For UFS, UniPro stack treated as a black box to maximum extent

Figure 6-1 — UniPro internal layering view (left) and UniPro Black Box view (right)
What is UFS?
- Two form factors
  - Embedded SSD
  - SD Card
Why Is UFS Important?
- Mobile Device demands are driving new requirements

**We’re going ‘Mobile!’**
- From ’11, Smartphones overtake PC Shipments and Tablets will add to the gap significantly

*Source: Samsung Marketing, 3Q11*
Why Is UFS Important?
- Mobile Device demands are driving new requirements
  - Higher computing demands
  - Dual Core
  - Multi Core
Why Is UFS Important?
- Mobile Device demands are driving new requirements
  - Higher Storage Capacity
Why Is UFS Important?

- Mobile Device demands are driving new requirements
  - Higher Storage Capacity

**Tablet Trends**

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Source: Gartner December, 2011

"Market Trends: Media Tablet Functionality Forces Flash Storage Evolution"
Why Is UFS Important?
- Mobile Device demands are driving new requirements
  - Lower Latency and High IOPS

**UFS: Time-critical Applications**
- Worst UX: Request delay due to Storage Write Busy
- Better User Experience: High Priority LU for time-critical application
Why Is UFS Important?
- Mobile Device demands are driving new requirements
  - Higher Bandwidth & High IOPS

**UFS: High Bandwidth & High IOPS**
- Sequential Performance: Separate R/W channel + Scalability by/through Multiple Lanes (x1/x2/x4) and Gears (3.0Gbps, 6.0Gbps)
- Random Performance: Asynchronous Protocol (Command Queuing)

### Sequential Performance

![Sequential Performance Diagram](image1)

### Random Performance

![Random Performance Diagram](image2)
UFS overview

What are the details?

Figure 2-1 — UFS Top Level Architecture
What are the details?
What are the details?

- Specified as Application layer on Unipro Protocol Stack
  - Multiple Layers
  - UCS layer
    - Uses SBC and SPC commands
  - UTP layer based on SCSI Architecture Model (SAM-5).
    - Command queuing
    - Multi-thread operations
  - UIC layer based on MIPI standard protocols
    - Interface and DME layers using MIPI Unipro protocol
    - Physical layer based on MIPI M-PHY