JEDEC UFS & MIPI UniPro:

Enabling Storage for Mobile, Automotive, and Other Applications

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Today's Presentation

➢ JEDEC & MIPI Alliance

Laura Nixon
MIPI Alliance Technical Program Manager

➢ New Features of UniPro v1.8

Ramesh Hanchinal
MIPI UniPro Working Group Chair, Synopsys

➢ Use Cases and New Features of UFS v3.0

Bruno Trematore
JEDEC UFS TG Co-Chair, Toshiba Memory Corporation

JEDEC and MIPI Alliance

Laura Nixon

MIPI Alliance Technical Program Manager

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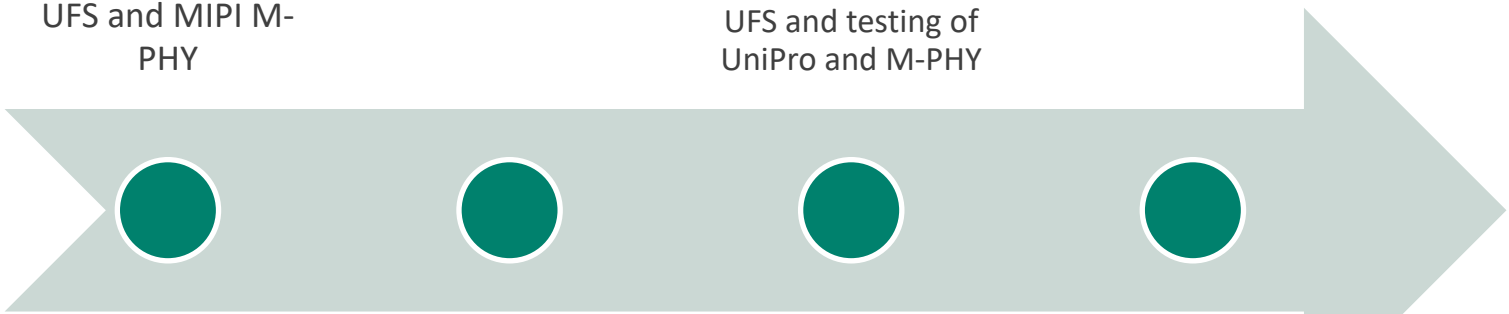
JEDEC & MIPI Alliance

JEDEC's mission:
To serve the solid state industry by creating, publishing, and promoting global acceptance of standards, and by providing a forum for technical exchange on leading industry topics.

MIPI Alliance's mission:
To provide the hardware and software interface specifications device vendors need to create state-of-the-art, innovative mobile-connected devices while accelerating time-to-market and reducing costs.

JEDEC & MIPI Alliance Liaison Activities



2008:
Entered into an MOU for JEDEC UFS and MIPI M-PHY

2009:
Expanded cooperation to include UniPro in UFS

2015:
MIPI enters agreement with UFSA to support certification of UFS and testing of UniPro and M-PHY

Today:
Continue to explore working together on other complementary projects

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UniPro v1.8

Ramesh Hanchinal
MIPI UniPro Working Group Chair
Synopsys

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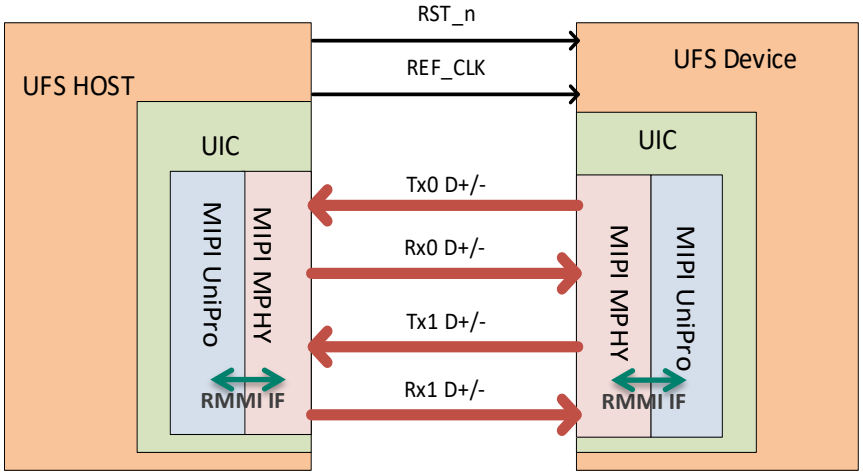
JEDEC UFS & MIPI UniPro

Block Diagram and Overview



- UFS 3.0 used MIPI specification versions UniPro v1.8 & M-PHY v4.1
- UFS uses UniPro as its link layer and M-PHY as its physical layer.
- UFS is agnostic and offloads the link establishment, link reliability & speed control between HOST & device

Key UniPro & M-PHY Features in UFS 3.0

- Doubles the bandwidth for storage
- HS-G4 speed & performance
- 5G ready
- QoS: Link quality monitoring

Details of each of these features will be discussed in subsequent slides

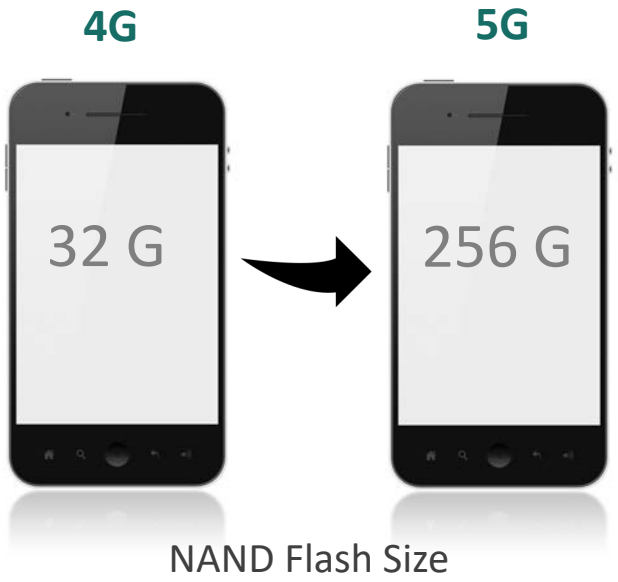
UniPro Mobile Use Case: HS-G4 & Bandwidth

HS-G4 Speed and Performance

- Enhanced to support HS-G4 of M-PHY v4.1
- Previous support: ~5.8 Gbps per lane per direction
- HS-G4 is 2x faster: ~11.7 Gbps per lane per direction
- ~23Gbps for 2 lanes per direction
- Enhancement leverages existing power modes – reuse most of existing logic with system improvements

UniPro Mobile Use Case: 5G Ready

- Future handsets are expected to have larger storage
- With 2x faster (23Gbps), UFS can store/retrieve files much faster
- UFS application will reuse most of existing speed change mechanism to take advantage of this increase speed

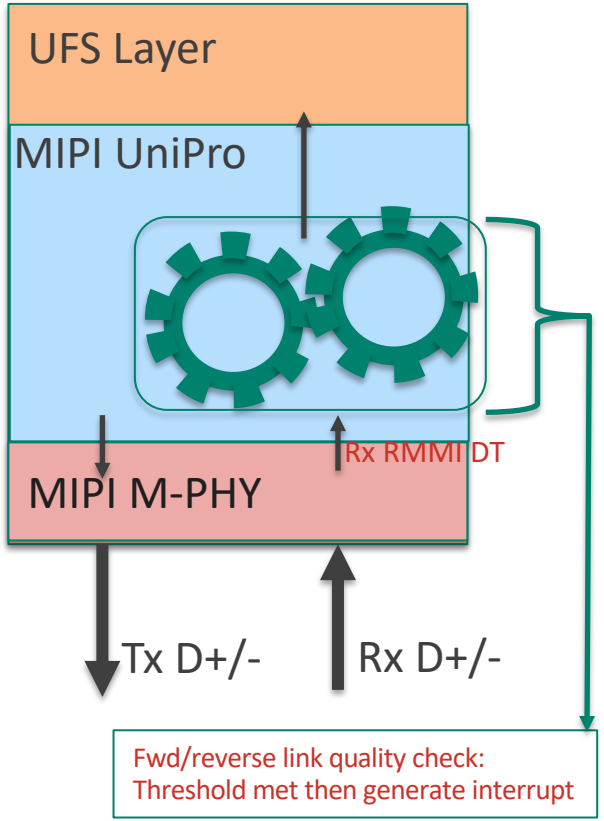


NAND Flash Size

UniPro Mobile Use Case: Quality of Service

QoS: Link Quality Monitoring

- UniPro introduces QoS: monitoring the link quality
- Configurable Monitoring: application to configure UniPro to monitor the link for desired window and for desired error threshold
- Independent Monitoring: monitor outbound, inbound and both independently
- Support for all gears including HS-G4: monitoring the link during operation
- Application can mount interrupt generation based on various indications
- Quality Options: ability of app to run the ADAPT operation to improve the link quality



Summary: Enabling the Next Generation
MIPI UniPro and M-PHY

- MIPI and JEDEC have collaborated to enable the next generation of high speed, high performance industry needs
- Ready for next generation of mobile designs
- Ready for 5G
- Provide improved performance

UFS v3.0

Bruno Trematore
JEDEC UFS TG Co-Chair
Toshiba Memory Corporation

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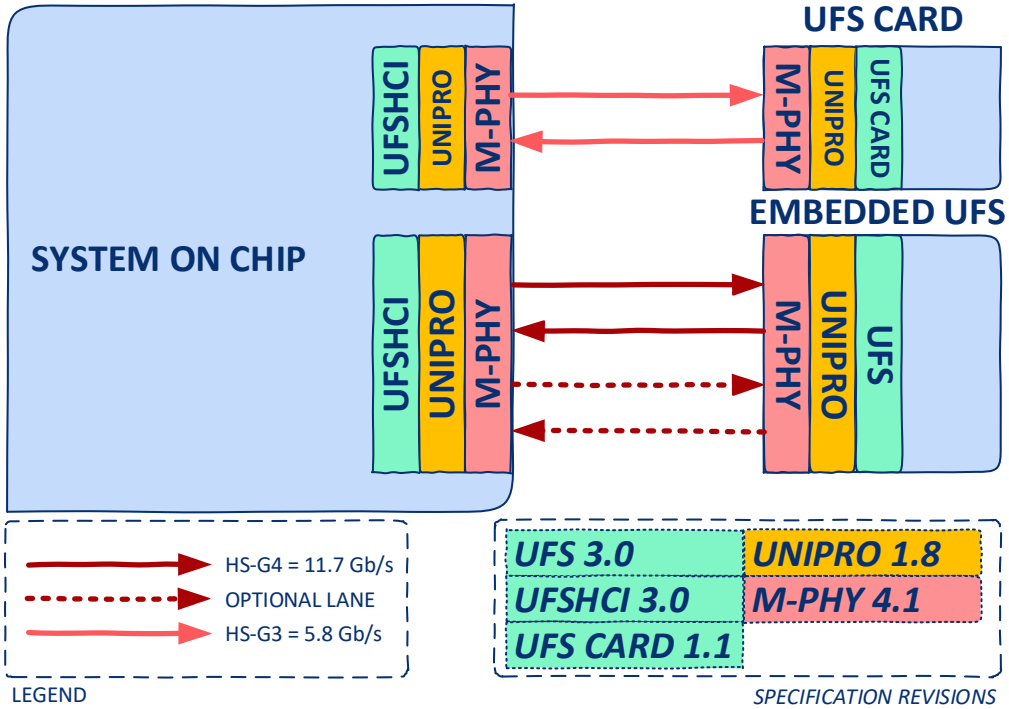
JEDEC UFS & MIPI UniPro

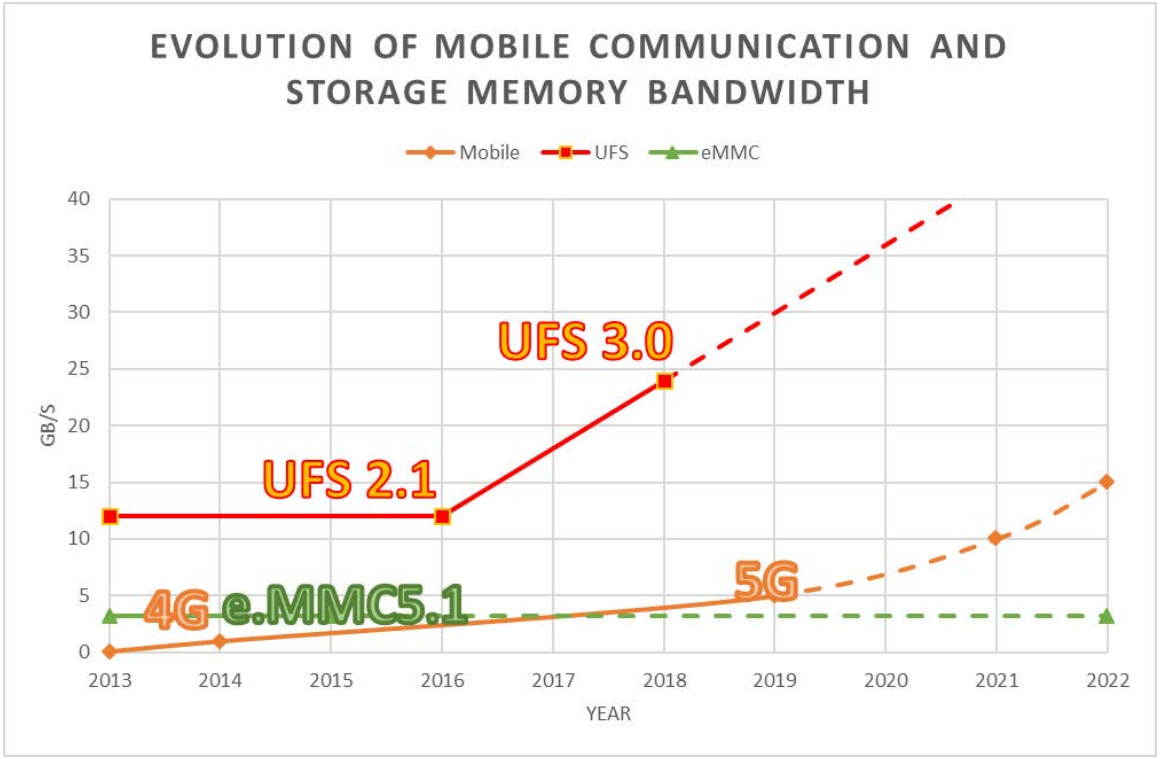
Block Diagram and Specification Overview



Mobile Terminal Applications

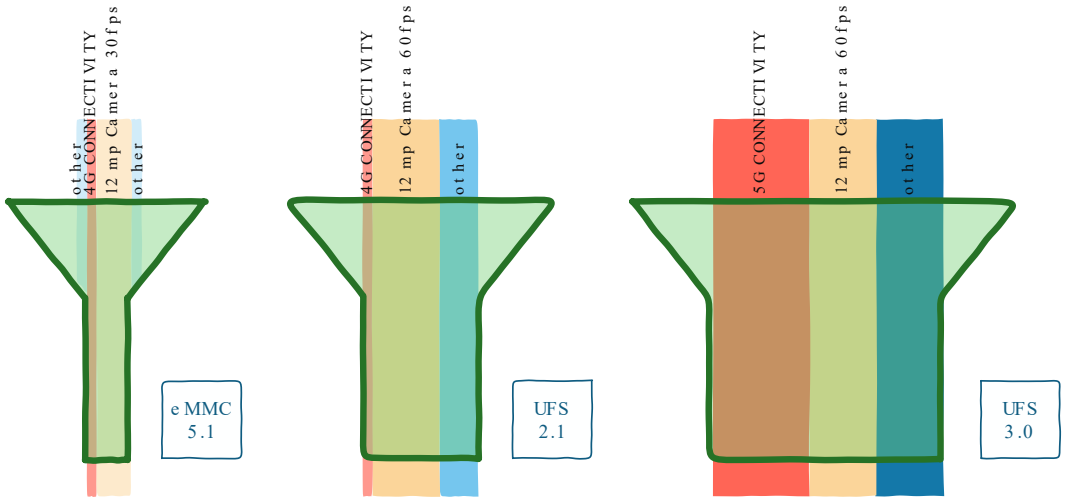
The Mobile Use Case: Bandwidth

Storage Evolution



The Mobile Use Case: Bandwidth

5G – Driving More Bandwidth



5G will offer peak bandwidths of up to 10Gb/s: it will allow to download a movie in HD resolution in 30 seconds while waiting at the airport terminal or train station.

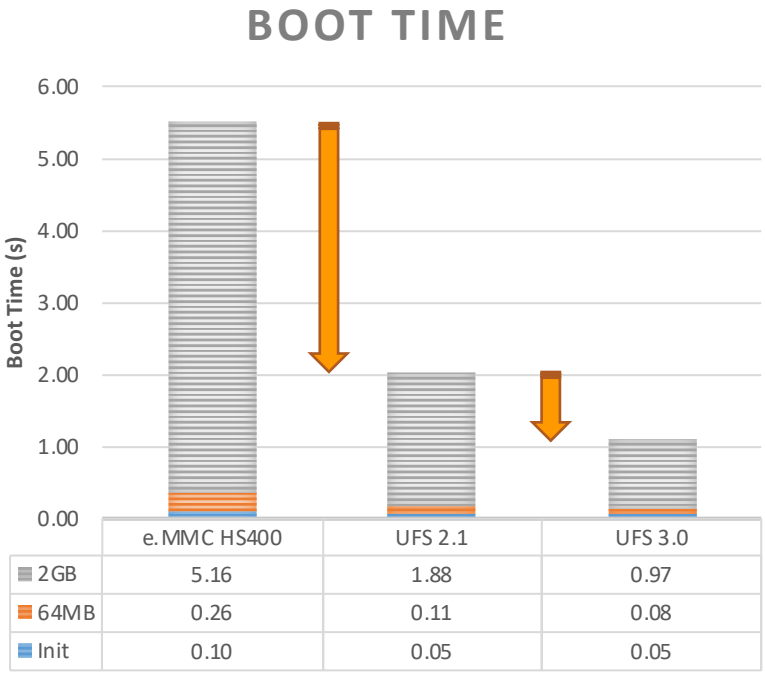
In the meanwhile a user will want to keep using his apps, store or browse photos, listen to music, without saturating the bandwidth available for storage.

UFS 3.0 can allow all these use cases by allowing a bandwidth of up to 23.4Gb/s.

The Mobile Use Case: Bandwidth

Boot Time Requirements

- Shorter boot time
- Faster installation of apps
- Shorter time when updating the operating system
- Faster access to apps when not loaded in DRAM



	e.MMC HS400	UFS 2.1	UFS 3.0
2GB	5.16	1.88	0.97
64MB	0.26	0.11	0.08
Init	0.10	0.05	0.05

Time per size of data transfer

The Mobile Use Case: Security

- UFS 2.1 already implemented a Replay Protected Memory Block: a region that can be accessed only with the use of a secret key that changes with each access, making it more difficult to gain access to it with a replay attack.
  - 32 bytes authentication key
  - 16 bytes nonce
- Fingerprint storage
- Storage of DRMs
- Storage of sensitive user data (health, passwords) in spaces that are protected from mutual accesses

The Mobile Use Case: Security

RPMB: Replay Protected Memory Block

UFS 3.0 introduces the possibility to split the RPMB in up to 4 regions, each with its own key. Different applications may share different private data without that one has to know the data of the other.

Each RPMB provides:

- Authentication Key with Message Authentication Code (MAC)
- Write Counter
- Result Register
- RPMB Data Area

RPMB Region 0 only also provides:

- Secure Write Protect Configuration Block

Bit / Byte [1]	7	6	5	4	3	2	1	0
0 (228)	LUN							
1 (229)	DATA LENGTH							
2 (230)		Reserved						
...								
15 (243)								
16 (244)		Secure Write Protect Entry 0						
...								
31 (259)								
32 (260)		Secure Write Protect Entry 1						
...								
47 (275)								
48 (276)		Secure Write Protect Entry 2						
...								
63 (291)								
64 (292)		Secure Write Protect Entry 3						
...								
79 (307)								
80 (308)		Reserved						
...								
255 (483)								

The Mobile Use Case – Low Power

Low power in UFS is targeted in different ways:

- Lowering of supply voltages:
  - Allow migration from to 3.3V supply in favour of 2.5V for NAND chips.
- Lowering of energy per bit on the interface
- Power modes:
  - On
  - Active
  - Sleep
  - Power Down
- Reduce number of active lanes for lower bandwidth needs, allows to save power, thus achieve longer battery life

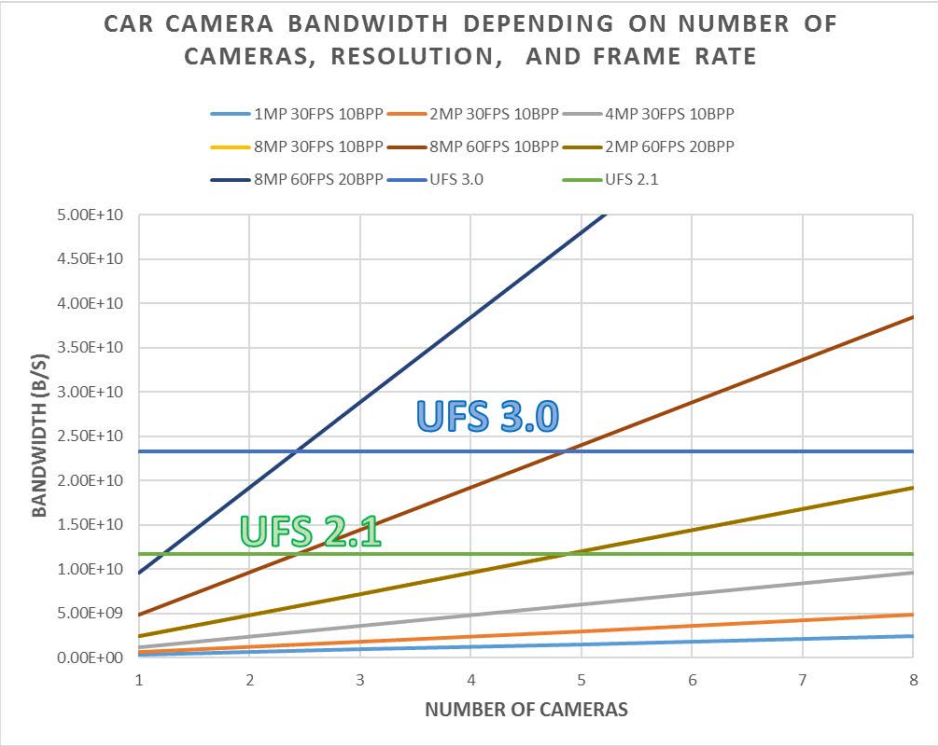
The Automotive Use Case

The use of electronics in car is undergoing a rapid evolution, with applications ranging from different Autonomous Driving Levels to In-Vehicle Infotainment, Engine Control, Safety, ...

These new applications are not only spawning innovation throughout the semiconductor industry but also exercising a whole new set of requirements in terms of memory bandwidth and storage capacity.

The Automotive Use Case

Camera Driven Bandwidth



The graphic shows how the increase of UFS's interface speed can accommodate more use cases on a car deploying several cameras, allowing either an increase of connected cameras, or an increase of frame-rate/resolution.

The graph also shows how standards need to keep evolving in order to accommodate more and more use cases.

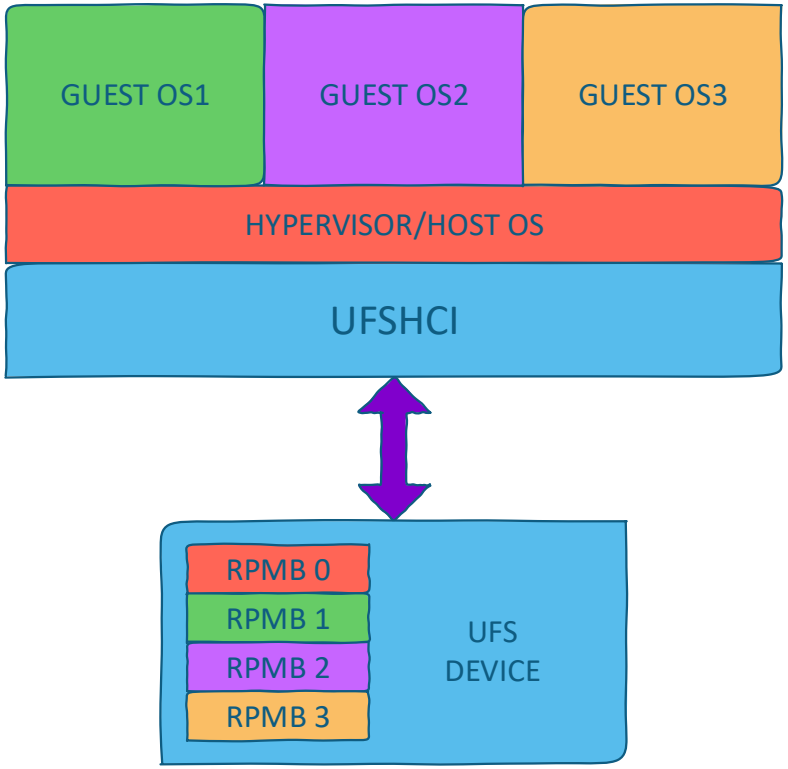
The Automotive Use Case

Camera Driven Bandwidth

- The presence of several cameras in a car can, alone, saturate the available bandwidth.
- On top of cameras, cars will come with a whole range of sensors and radars that will enable different levels of autonomous driving.
- Memory bandwidth must be available also for other uses.
- Recording and storing data from these sensors will be required for the following purposes:
  - Legislation (black box recorder)
  - Upload to cloud for deep learning
  - Store locally for deep learning
- Some legislations require autonomous vehicles to store 30 seconds of data before a collision. This means that data has to be continuously written up to the moment of the collision.

The Automotive Use Case

Multiple RPMB Regions



- Dashboard (e.g., avoid that the odometer value can be changed)
- Entertainment system (Digital Rights Management)
- Operating system updates
- Each OS/core is able to have its own secure region with an own key for authentication

The Automotive Use Case

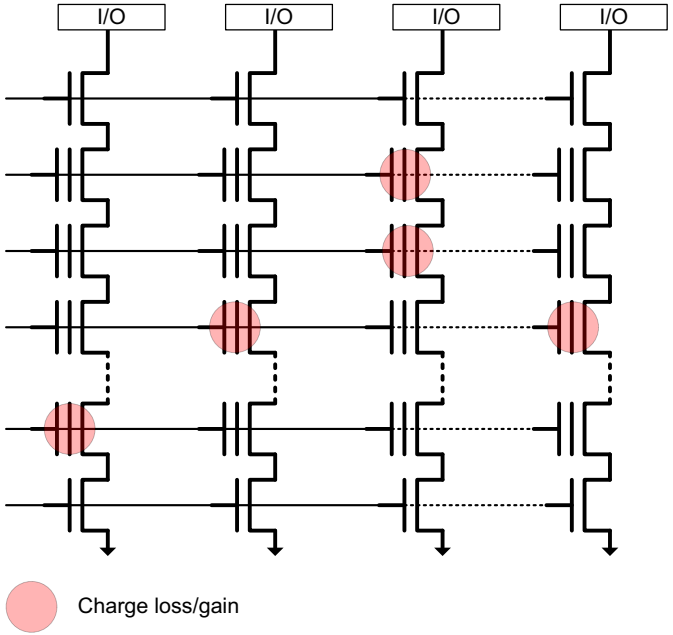
Low Power

Low power is becoming increasingly important also in automotive applications:

- Battery Life
- Autonomy
- Idle power when the car is parked

The Automotive Use Case

Refresh



Refresh Status

Refresh Frequency

- Off
- 1-255 Months

Refresh Unit

- Minimum to 100% of device

Refresh Method

- Manual Force: all blocks containing data will be refreshed.
- Manual Selective: all blocks containing data – if the device considers them in need of a refresh – will be refreshed.

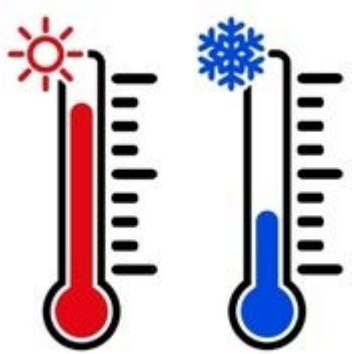
Refresh Enable

- Allows to start the refresh operation as well as to interrupt it.

The Automotive Use Case

Temperature

- Car electronics have to work in harsher environmental conditions than consumer electronics:
  - Extremely low or high temperatures
  - Noise from other electronics in the car
  - Power supply noise
- UFS can provide a notification when the temperature of the device reaches a temperature that is too low or too high – as set by the manufacturer – and the Host may take appropriate actions according to the condition.
- The temperature is measured on the device's case by an internal sensor.



New Features of UFS 3.0

- Bandwidth increase from 1.2 GB/s to 2.4 GB/s
- Support for ADAPT operation in order to achieve higher median bandwidth
- Multiple Replay Protected Memory Block Regions (RPMB)
- Error History Mode in READ BUFFER Command
- Refresh Operation
- Temperature Event Notification
- VCC = 2.5V

Changes from UFS 2.1

- Mandatory support for HS-G3
- Mandatory support for READ_BUFFER command
- Removed 52MHz Reference clock support
- Optional support of PWM-G2 through PWM-G4
- Added Unit Attention Condition

Other Improvements

- Reference Clock Waiting Time clarifies some implementation doubts.
- Clarification about active ICC levels
- Removal of Small Amplitude Signalling eases implementation by reducing choices
- Removal of Unterminated HS-Burst Support eases implementation by reducing choices
- Removal of Skip Symbol Insertion eases implementation since UFS relies on a shared reference clock architecture

THANK YOU

