Infotainment and Autonomous Vehicles –
The challenges of storage

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Mercedes-Benz
The best or nothing.
Storage in a modern Car

- Infotainment & Digital Cluster: 64–512 GB for Flash, 4–32 GB for DRAM
- Rear-Seat Entertainment: 64–256 GB for Flash, 4–16 GB for DRAM
- Connectivity: 4–32 GB for Flash, 0.5–2 GB for DRAM
- ADAS / Autonomous Driving: 8–32 GB for Flash, 4–32 GB for DRAM
- HD-Maps: 8–512 GB for Flash, 0.5–1 GB for DRAM
- Accident recording: 8–512 GB for Flash, 1–4 GB for DRAM

In 2025 on Board storage exceeds 50 GB for DRAM and 1TB for Flash
New needs in Automotive Industry

Both applications need AI

- Infotainment needs AI to improve User Experience
- Self-Driving needs AI for example Object detection
Different requirements for Infotainment and autonomous Driving

**Infotainment**

User experience
- Display (Number, Resolution)
- Input devices (Touch, Speech, Gesture)
- User content: Player, Radio
- Fast update cycles
- Combination of On/Off-board content

Strong CPU and GPU + Memory capacity

**Autonomous Driving**

Safety is the first goal
- Redundant Hardware
- Sensor centric system
- Sensor fusion (Camera, Lidar etc.)
- Data storage of sensor data for AI training
- Object detection → Heavy AI workload

Strong CPU and AI capabilities + high RAM Bandwidth
Our View on NVM Memory Trends

3D-Cell Technology
3D is Mainstream now
Capacity increase only possible with 3D technology

Triple Level Cell Technology
3D allows more electrons per cell
Capacity per die increases
Price advantage over planar technology
QLC questionable for automotive

Persistent Memory
New memories: X-Point, SCM and MRAM
New memory hierarchy possible
No endurance problem
BUT: Reliability not yet proven

Emerging NVM Interfaces
eMMC bandwidth no longer sufficient
Move to serial high speed Interfaces: UFS or PCIe
UFS3.0 and PCIe compete in data rate

OS and Hypervisor support
Support for Multi-CPU and OS systems
IO-Device support
Hypervisor with SR-IOV Passthrough capability

Source: Toshiba
Source: Micron

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Our View on volatile Memory Trends

Bandwidth increases
- LPDDR5 in start position, first samples available
- LPDDR4x follows LPDDR4
- Support of AI cores in AD need more bandwidth → GDDR6 or HBM

Memory density
- Memory vendors move from 22nm to 1ynm node
- Shortcut to increase density: Multi-Die package

ECC
- Below 20nm node ECC is needed for data reliability
- In Autonomous Driving ECC can be a component for safety
- ECC can also be provided on system level: ECC on Data and Address bus → loss of memory capacity

Power
- Infotainment: Optimize for Power, Standby (Suspend2Ram) → LPDDR5
- Autonomous driving: Power is not in focus → Bandwidth more important

Interfaces
- LPDDR4 now in the market
- Move to LPDDR4x and LPDDR5 in near future
- 128 bit memory interface standard in IVI
- High Bandwidth for AI need GDDR6 and HBM memory
Match between application and memory technology

### Automotive Applications

1. Fast Startup
2. Central data storage
3. Dashcam video
4. Event Data Recorder
5. OTA Update
6. Sensor Fusion

### Memory Technology

#### Flash - Floating Gate FET
- **Pro:** Highest capacity
- **Con:** Limited write cycles, Read/Write speed

#### DRAM - Floating Gate FET - volatile
- **Pro:** High capacity, fast, proven technology
- **Con:** Cost

#### SCM - Bulk resistance
- **Pro:** Fast, high density, non volatile
- **Con:** Cost vs. Flash, no automotive part avail.

#### MRAM - Spin transfer torque (STT)
- **Pro:** Fast, non volatile, automotive
- **Con:** Cost, high write power consumption

#### FRAM - Ferro electrical capacitor
- **Pro:** Write cycles, retention
- **Con:** Cost, limited capacity, speed

#### NRAM - Nanotube (resistance)
- **Pro:** Fast, high capacity
- **Con:** Very early technology
Technology: Next Generation Memory – Hypervisor support

What is Virtualization?
Sharing a single hardware platform among multiple software operating environments (Operating Systems)

Hypervisor support for IO-Devices

- **Emulation**
  - Hypervisor emulates Devices by Software

- **Paravirtualization**
  - Device Drivers in Guest OS is modified, OS is aware of Hypervisor

- **Passthrough**
  - Single Guest OS talks directly to IO-Hardware, no device sharing between multiple Guest OS possible

- **Passthrough with SR-IOV**
  - The SR-IOV device provides a dedicated Interface for each Guest OS (Virtual Function)

System SW/HW-View

- App
  - Application
  - Device Driver
- OS (Guest)
  - Application
  - Device Driver
- Hypervisor (VMM)
  - Device Drivers
- Platform (CPU, Memory, IO)
  - CPU
  - MMU
  - PCIe Root Complex
  - DRAM
  - PCIe Device

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Next Generation NVM-Memory: SR-IOV Virtualization support

**Technology**
- Support on system level needed
  - SoC (SMMU, IOMMU or VT-d)
  - PCIe-switches
  - PCIe-Devices
- Every VF (Virtual Function) can be assigned to one Guest OS (System Image)

**Benefit using SR-IOV Flash devices**
- Improved performance (Latency, CPU load)
- Guest OS Standard driver can be used
- Enhanced security, HW-based separation of access

**Status today**
- SR-IOV is used mainly in servers
- No automotive devices available

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Summary

- The next generation of cars are autonomous driven CE devices
- Infotainment and autonomous driving pushing the memory technology
- Memory density demand is rapidly increasing
- Automotive needs to take over technology and solutions from IT and Mobile
- Car OEMs move from building cars into an IT-technology providers
- Automotive has the need for the latest memory technology in respect to:
  
  Density, Interface, Speed and Function (SR-IOV)