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### **Compare the flash storage of SLC and MLC states. How are they different?**

#### **SLC:**

- SLC flash storage employs a single-bit-per-cell architecture, distinctly representing 0 or 1.
- Renowned for its exceptional endurance, SLC flash storage offers approximately 100,000 program/erase cycles, ensuring prolonged usability and reliability.
- Primarily deployed in environments necessitating high performance and durability, such as servers and industrial applications, where reliability is paramount
- Despite its lower data density resulting from storing only one bit per cell, SLC flash storage offers superior performance and endurance.
- Generally associated with a higher price point due to its superior performance and endurance, making it a premium option in the flash storage market.
- Renowned for its superior performance, SLC flash storage delivers faster read and write speeds, ideal for applications requiring swift data access and processing.

#### **MLC:**

- While not as fast as SLC, MLC flash storage still offers commendable performance suitable for a wide range of applications, striking a balance between speed and affordability
- Offering a more cost-effective solution relative to SLC, MLC flash storage is prevalent in consumer products where affordability is key
- With a higher data density compared to SLC, MLC flash storage enables the production of larger storage capacities, catering to diverse user needs.

- Commonly integrated into consumer electronics and devices due to its costeffectiveness and moderate endurance, prioritizing affordability over absolute performance.
- Exhibiting relatively lower endurance, MLC flash storage typically withstands around 10,000 program/erase cycles, making it less durable compared to SLC.
- MLC flash storage typically stores two bits per cell, allowing for more nuanced data storage and representation.

## **Compare EMMC, SD, and PCI-SSD flash technology.**

### **EMMC:**

- Generally, more affordable compared to SD and PCI-SSD, eMMC flash storage provides a cost-effective solution for budget-conscious devices and applications.
- Typically integrated directly onto the motherboard of devices like smartphones, tablets, and IoT devices, utilizing a standardized interface for seamless integration
- Designed for moderate durability suitable for consumer electronics, eMMC flash storage offers sufficient endurance for typical usage scenarios, ensuring reliability over time.
- Typically offering lower capacities compared to SD and PCI-SSD, eMMC flash storage ranges from a few GBs to around 256GB, catering primarily to compact and embedded devices.
- EMMC flash technology provides moderate performance suitable for mobile and embedded devices, offering read/write speeds typically ranging from 100 MB/s to 400 MB/s.

### **SD:**

- Offering a wide range of price points depending on capacity, speed, and class, SD flash storage caters to diverse budget and performance requirements across different user

segments.

- Available in various form factors (SD, microSD, miniSD), SD flash storage is widely used in portable devices like cameras, smartphones, and laptops, connecting via dedicated SD card slots.
- The durability of SD flash storage varies depending on the card's class and quality, with higher-end cards offering better reliability and endurance, suitable for rugged environments and continuous usage
- Available in a wide range of capacities, SD flash storage spans from a few GBs to over 1TB in newer high-capacity cards, catering to diverse user storage needs
- The performance of SD flash storage varies depending on the class and generation of the card, with read/write speeds spanning from a few MB/s to over 600 MB/s for advanced UHS-II cards.

#### **PCI-SSD:**

- Typically, the most expensive option due to its high performance, capacity, and advanced features, PCI-SSD flash storage is suitable for professional and enterprise applications where performance is paramount.
- Installed internally in computers and servers, PCI-SSD flash storage connects directly to the motherboard via a PCI Express (PCIe) interface, facilitating high-speed data transfer and seamless integration into systems.
- Renowned for its high durability and reliability, PCI-SSD flash storage is designed for intensive workloads and enterprise-grade applications, featuring advanced features like wear leveling and power loss protection.
- Offering the highest capacities among the three, PCI-SSD flash storage ranges from a few hundred GBs to multiple TBs, meeting the storage requirements of highperformance computing environments.
- PCI-SSD flash technology delivers high-performance storage solutions with read/write speeds reaching several GB/s, making them ideal for demanding applications like gaming, multimedia editing, and data centers.

**Links:**

- <https://www.kingston.com/en/blog/pc-performance/difference-between-slc-mlc-tlc-3d-nand>
- <https://pawitp.medium.com/comparing-the-speed-of-ssd-emmc-flash-drive-and-sd-card-deefad477d85>