An Insider's Look at Designing Flash Controllers

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The CEO wants to increase his bottom line with Flash storage.

- He (she) wants the switch to Flash storage to be Quick and Painless.
- He wants a higher performance Computer system in order to bill more for computer time.
- He wants a more reliable Computer System.
- He wants to save Space and Power.
- He wants Easier storage management.
- He wants Flash storage to be better than Disks

Agenda

- Flash Controller Overview
- Flash Controller Design Decisions
- Flash Storage Performance
- Flash Storage Reliability
- Flash Controller IP Concerns
- Does Enterprise Still Need SLC?
- **Concept of a Flash Storage System**

Flash Controller Overview

- Flash Controllers determine features & performance – the controller is the "**Secret Sauce**".

- Flash storage manufacturers are differentiated by their Feature Set in their Flash Controllers.

- Based on the Desired Market, designing a Flash Controller will involve dozens of decision points.

Key Controller Design Decisions

- Flash Storage Form Factor?

- Flash Capacity?

- Performance: Bandwidth, IOPS, Latency?

- Application: Read-Intensive, Write-Intensive?

- Buy or Design Controller?

- Embedded Processor?

- ASIC versus FPGA?

- Which Type of Flash to Use? (MLC, SLC)

- Flash Manufacturer? (T, S, M,,…)

Flash Performance

- Which Form Factor?

- How many Flash chips and Channels?

- What is Maximum Board Connection Speed?

- How does Flash Controller do heavy Writes?

- One or more Flash Controllers?

- On-Board CPU engine and Look-Up-Table?

- ASIC or FPGA Flash Controller?

- Your IP Controller Design or Licensed Design?

- What Is Board's Power limit?

Flash Reliability

- Flash chip manufacturers only guarantee that **98%** of the chip works.

- Flash chips must continuously be managed for new bad blocks and wear leveling.

- While the Flash data sheets mention bit errors (ECC), they do not mention other catastrophic (die or plane) failures.

- **Every new Flash generation must be fully characterized by the Flash board Designer.**

TMS Extra Reliability Features

- RAID across Flash chips.

- Perform Extra ECC for the Flash chip.

- TMS's Variable Stripe RAID to bypass bad Flash Planes or Dies.

- One month TMS Factory burn-in prior to shipping to reduce infant mortality Failures.

- Long term Flash device analysis to determine aging characteristics.

- Test and Select the Best Flash manufacturer.

Flash IP Concerns

- Is the Product easy to Reverse Engineer?
- Are you Protecting the "**Secret Sauce**?"
- Which new Ideas should be Patented?
- Which new Ideas should be Hidden?
- Which new Ideas can be used in Marketing?
- Who are you delivering the initial Product to?
- Do you encrypt your Programmable IP?
- Do your trust your Supplier and ASIC foundry?

Does Enterprise Still Need SLC?

- The answer depends on who is talking.
- SLC and MLC Flash have their advantages:

- **MLC is half the cost of SLC.**
- **SLC has 20x the Program/Erase Cycles.**

- The Enterprise MLC Market will still expand faster than SLC as MLC enters previous **SATA** space.

- **SLC still has an important place in Enterprise.**

SLC Enterprise Applications?

- SLC will be used for Write-Intensive Applications where Performance & Reliability are more important than cost.

- For the top storage Tier, SLC is the choice.

- For caching applications, its heavy write activity mandates the use of SLC.

- **SLC Flash will be used like SCSI drives, MLC Flash will be used like SATA drives.**

Concept of a Flash Storage

- **A Future Ideal Flash storage System:**

- High Capacity, Small Size

- High-Performance for Most Applications

- Rich Manage and Configuration Features

- Higher Reliability than Servers

- Auto Configuration Around Failed Storage

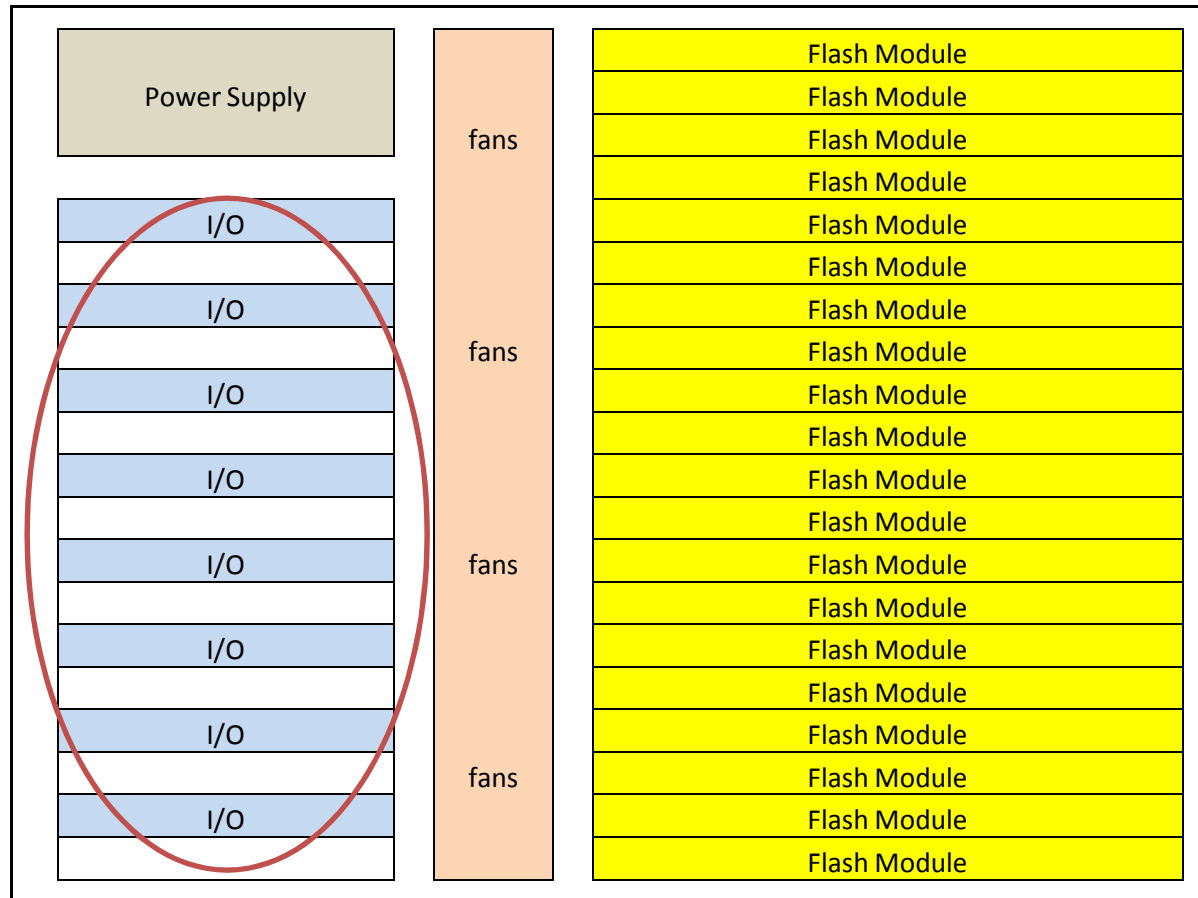- Low Maintenance and Easy to Repair

- Low Power

Concept of a Flash Storage

- Form Factor = **4U Chassis Appliance**

- Capacity, Devices = **40-TB, SLC, 3200 devices**

- Controller = **TMS Designed FPGA chip set**

- System Bandwidth = **24 to 48 GB/s**

- System IOPS = **6m to 12m IOPS (4K)**

- Sustained Wt. Bandwidth = **8 to 16 GB/s**

- RAID = **RAID across Devices with VSR**

- ECC strength = **Factory Spec + extra bits**

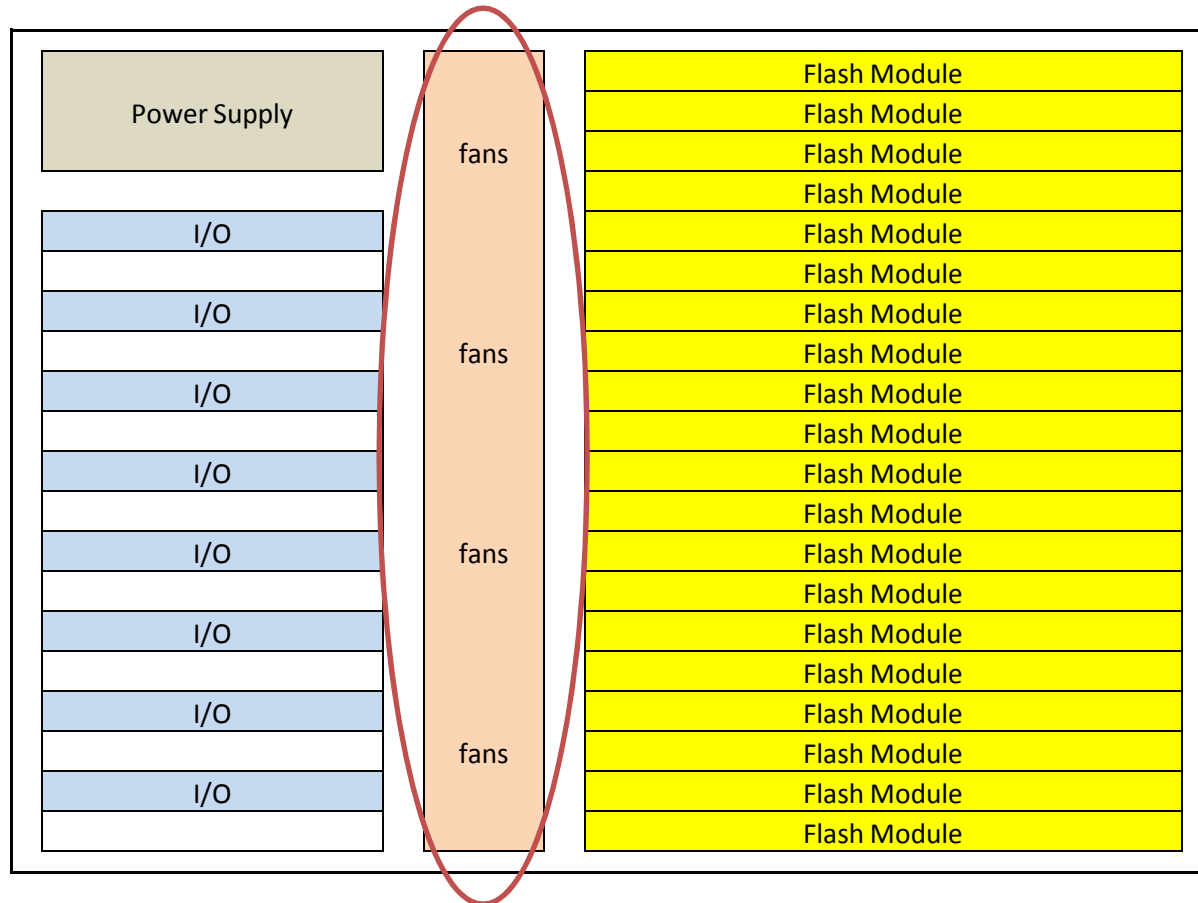- Production Burn-In = **30 days, minimum**
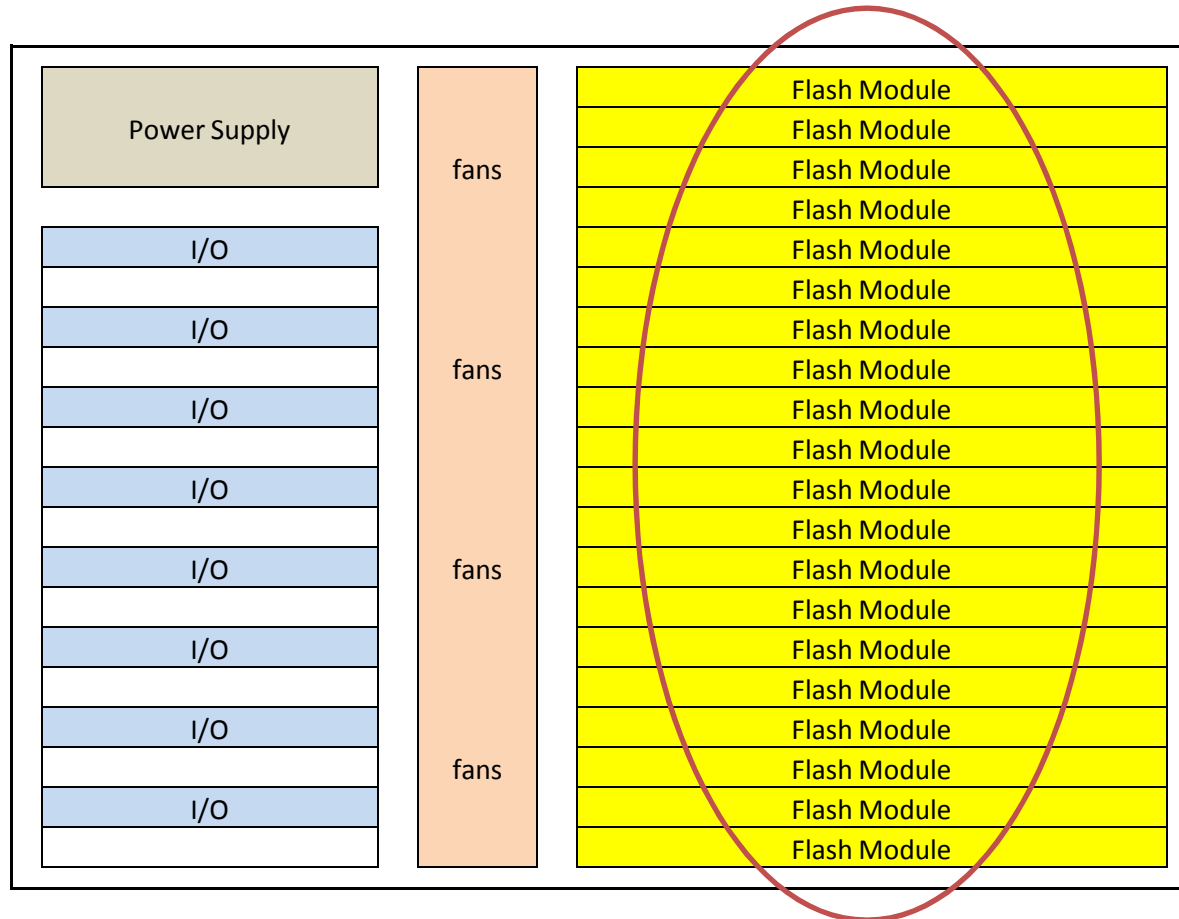
Concept Flash Storage

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Concept Flash Storage

Concept Flash Storage

The Flash Developer Must:

- **Design Flash Storage that exceeds the Data Center Manager's Expectations.**

- Deliver the Flash Performance as Promised.

- Get better Sustained Flash Write Bandwidth.

- Execute Storage Management Internally.

- Increase Flash Density, Lower Flash Power.

- Make Flash storage more Reliable than Disk?

- **Keep your Customer's CEO Happy?**