Extending the Lifetime of SSD Controller

Author: Deepak Shankar
Tel : 408-569-1704
Fax : 408-519-6719
Email: dshankar@mirabilisdesign.com
Website : http://www.mirabilisdesign.com/
Abstract

• Developed performance models to evaluate the efficiency of SSD Controller
• Input was varying workloads and interfaces
• Looked at varying the wear leveling, data distribution across the flash devices and different garbage collections
• Generated reports around the effective bandwidth, Read/Write latency
• Compared the reports with the typical operating specification of the vendor
Motivation for Architecture Simulation

- **Complex behavior**
  - Input rate and task sequence
  - Data size and priority dependent behavior

- **Contention**
  - Limited resources on the platform
  - Scheduling/arbitration of task and diagnostics

- **Interference of multiple applications**
  - Competing for resources
  - Scheduling/arbitration
  - Unexpected anomalies
Justification for System-level Model

System with faster Bus is slower in places

Unpredictable system response
Results

- Life of an SSD is directly dependent on the write amplification factor (WAF).
- WAF in turn is related to SSD overprovisioning, which is a parameter that the system designer can control.
- A diligent system designer can extend the life of an SSD by upto 60% by proper control of over-provisioning, thus reducing Total Cost of Ownership (TCO).
Variations

- At $1-2$ a 1GB of SSDs, TCO of datacenters deploying SSDs has a huge dependency on the effective life of an SSD.
- Measuring dynamic and simulated outputs of critical metrics such as WAF, over provisioning is critical is assessing the life of the SSD.
- Future dynamic studies planned include:
  - Separation of hot and cold data
  - File system stream management
  - Look at additional ways to extend the life of the SSD.
Methodology Adopted

• Used a Architecture Simulation environment
• Constructed a statistical workload with a functional description of the system
• Size of each SSD: 256GB
• Developed an array of 32 devices
• Connected PCIe + NVMe
• Using random distribution generator with varying request sizes, priority and rates
• Created a network of multi-processor and multi-core
Architecture Model of NVMe SSD
Output and Reports

![Chart showing latency and throughput over time and in megabytes per second.]
Focus Areas of Analysis

• Functionality
  — Quality, correctness and accuracy of flow
  — Define network/interface/bus protocols, arbitration, schedulers, mode selection, logic flows
  — Effectiveness of Diagnostics

• Performance
  — Latency, Throughput, utilization
  — Buffer, Processing, Bandwidth, Hit-miss, operational delays, burst vs. stream
  — Parallel processing, messaging, resource consumption
  — Devices, workload, traffic rate, behavior flows, threads
Focus Areas of Analysis (Cont.)

- **Power**
  - State based power definition for each device
  - High accuracy
  - Assign unique states for different operations
  - Incorporate leakage, static and dynamic power
  - Define power management logic as state machines
  - Power state changes at cycle-level
  - Dynamic power activity based on workload and device status
  - Linear approximation for capacitance and inductance
  - Standard plots for battery usage, instant power, average power, per device and per task
  - Can account for changes in temperature, clock speed and availability of charging resources
VisualSim- Modeling and Simulation

- Architecture exploration and system validation solutions
- Graphical modeling, exploration and analysis
- Custom, statistical and cycle-accurate modeling libraries
- 200+ application templates to accelerate development
- Pre-built blocks enabled for performance and power
- Over 15 interfaces and extensive algorithm definition library
  - C/C++, SystemC, Java, MatLab/Simulink, Verilog, Python etc.

400 building blocks, custom modeling functions and full system visualization
About Mirabilis Design

- Solution for product definition, communication and adoption
- Using system-level modeling and simulation
- To design Systems, FPGA, Processor/SoC and Real-Time Software
- With over 500 system modeling IP with timing and power
- And in-house experts in system modeling and analysis
- Having the largest number of electronic system design users

Select the “Right” configuration to match customer request
System Simulation and Exploration

**Corporate Headquarters**
1159 Sonora Ct, Suite 116
Sunnyvale, CA 94086
USA
Tel: 408-844-3234
Fax: 408-519-6719

Sales Information: info@mirabilisdesign.com
Technical Contact: tech.support@mirabilisdesign.com
Website: [http://www.mirabilisdesign.com/](http://www.mirabilisdesign.com/)
[http://www.visualsim.com](http://www.visualsim.com)