Maverick: A Fast and Energy Efficient Next-Generation NVM-based SSD Architecture

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Welcome to the Data Age

• The world processed 9 Zettabytes of data in 2008*

• Acquiring data is easy

• Extracting knowledge is hard
  – Storage performance is major bottleneck
  – Emerging non-volatile memory technologies can help

*http://hmi.ucsd.edu
Emerging Non-Volatile Memory Technologies

• NVMs
  – Phase change memory
  – Spin-torque transfer

• Characteristics
  – DRAM-like performance
  – High density
  – Low standby power

• Potential usage
  – DRAM replacements
  – Fast storage
Present System Architecture

- CPU
- Cache (SRAM)
- Memory Controller
- Chipset
- DDR3
- DRAM
- SATA/PCIe
- Disk
- Flash SSD

Latencies:
- 1X latency
- >1000X latency
- >100000X latency
Future System Architecture

- CPU
- CPU
- Cache (SRAM)
- Memory Controller
- DDR3
- DRAM
- SATA/PCIe
- Disk
- Flash SSD
- PCM SSD

Latency:
- 1X latency
- >100000X latency
- >1000X latency
- 1 -10X latency
Problems with PCIe-attached PCM-based SSD?

- High latency and block interface of PCIe
- Huge software driver and PCIe overhead

![Diagram showing latency comparison between various components: CPU, Cache (SRAM), Memory Controller, Chipset, Disk, Flash SSD, PCM SSD, Moneta. The diagram highlights the significant latency differences, with PCM SSD showing a latency of 1-10X compared to other components, and Moneta showing more than 60% of total I/O latency.](image)
Maverick

• Based on computation close to storage
• Moved data or I/O intensive computations to the storage to avoid redundant data transfer between the host and the storage
• Huge power and performance gain
• Processing scales with increasing storage demand
Storage Processor

Local Memory

Control Processor

Data Manager

Compute Manager

DMA Engine

Ring Interface

Local Interface

Compute Kernel

Local Memory

K0

K1

K2

K3

Kn

Kn-1
Maverick Prototype

• Built on BEE3 board
• PCIe 1.1 x8 host connection
• Clock frequency 250MHz
• Virtex 5 FPGA implements
  – Maverick scheduler
  – Network
  – Storage processor
  – Memory controller
• Run the Smith-Waterman algorithm on Maverick
Maverick’s performance gain as compared to existing storage technologies

Maverick achieves 152 GCUPS (Giga cell updates per second)
Maverick’s Energy Efficiency as compared to Moneta

Maverick consumes 598 J for 32 GB of biological datasets
Conclusion

• Presented Maverick architecture for next-generation non-volatile memories

• Future work
  – Support different data or I/O intensive applications
  – Support easy migration from the conventional storage to the Maverick

• NVMs can have strong impact on the future computing system
Thank You!

Any Questions?