NAND Flash as a High Density Server Memory

David Flynn
The industry 20 years ago

2-3 orders of magnitude

ACCESS DELAY IN TIME

Nanosecond (10E-9)

Millissecond (10E-3)
Where the industry went

1997

3-4 orders of magnitude

Nanosecond (10E-9)

Milliseconds (10E-3)

ACCESS DELAY IN TIME
Where the industry is today

2009

600

5-6 orders of magnitude

ACCESS DELAY IN TIME

Nanosecond (10E-9)  Millisecond (10E-3)

Network Attached Storage
CPU Utilization

Source: IDC

- 85% of servers use less than half of their CPU
- 60% of servers use less than a third of their CPU
Disk

Like
• Really fast
• Rarely fails
Don’t Like
• Volatile
• Expensive
• Limited capacity

DRAM

Want
• Non-volatile
• Really fast
• Large capacity
• Reasonable price
• Low energy
• Never fails

Need

Like
• Non-volatile
• Cheap
• Large capacity
Don’t Like
• Really slow
• Often fails
Compared to RAM

**RAM**
- 16 GB
- $125 per GB (list)
- 1,000 Watts per TB
- 1 bit correction
- Volatile

**ioMemory**
- 640 GB
- $25 per GB (list)
- 10 Watts per TB
- 39 bit & self healing
- Non-Volatile

王国ism runs Oracle faster

- 40x
- 1/5th
- 1/100th
ioMemory

- Only moderate amounts of DRAM needed
- Enhances cache locality in CPU’s L1, L2, L3 caches
- Non-volatile so it’s usually indexed for speed of access
- Non-volatile so data is ready immediately
- ioMemory runs at full memory bandwidth
  - Data only goes across memory bus once (supplied from PCIe)
  - Does not waste CPU to move data (uses DMA engine)

High-density DRAM

- Overloaded memory bus runs 30% slower
- Destroys the cache locality in CPU’s L1, L2, L3 caches
- Volatile and changing so it’s seldom indexed
- Takes hours to “warm-up” - load data into DRAM
- RAMDISK runs at ½ memory bandwidth
  - A single I/O takes two transfers across the memory bus
  - The CPU must manually read from memory then write

ioMemory – Performs Better than DRAM
ioMemory Maximizes Value Potential

2009
600

3 orders of magnitude

25µs

ACCESS DELAY IN TIME

Nanosecond (10E-9)
Millisecond (10E-3)

Network Attached Storage

CPU
RAM
L1
L2
L3
ioMemory Maximizes Value Potential

- Network Attached Storage
- SSDs
- 3 orders of magnitude
- ACCESS DELAY IN TIME
- Nanosecond (10E-9)
- Millisecond (10E-3)
- 25µs
- 600
- 2009
ioMemory – A cheaper, higher density memory

• Each CPU core has independent parallel access
• Lower access latency increases application acceleration
• Less complexity, lower cost, less power, less space
• Complete solution soup-to-nuts software & hardware
• Self healing, no servicing required
• “Flashback Protection” chip-level redundancy

SSD – A more expensive, faster disk drive

• Embedded CPU’s serialize access
• RAID increases latency and batches completions
• RAID 1 or 5 sacrifices capacity and performance
• Major technologies from several different vendors
• Manual maintenance required to service failures
• Super-capacitors and embedded processors are prone to failures
ioMemory Split-Path Architecture

Host Memory
- ioMemory meta-data
- Operating System and Application Memory

Host Processors
- ioMemory VSL (control path)

Commands

Data Transfers

ioCore (data path)

PCI-E

25 Channels Wide

2-8 Banks
ioMemory Consolidates...
HP & ioMemory jAppServer results

- 11,067 JOPS/sec

- WebSphere 6.1
- IBM HS20
- 40 cores, 40 chips

- 4,368 JOPS/sec

- Oracle Weblogic 10.3
- HP BL460c
- 24 cores, 6 chips

2.5X better performance

Nearly ½ the servers

www.spec.org jAppServer2004 Results
One of the world’s fastest growing Webmonsters

• Over 900% more database queries per second
• Dramatically improved server replication for most current data
• Over 800% improvement to disaster recovery back-up time
• Cut server footprint, power costs, and IT overhead by 75%
• Full and immediate ROI on repurposed servers with
• Continued ROI on operational cost saving
Internet security company that protects over 1 billion inboxes

• 5x improvement to
  • Database replication performance
  • Data intensive query response
  • Analysis routines
• Eliminating 210 failure points from system
• Implemented full system redundancy
• Dramatically lowered power and cooling expenses
By deploying ioMemory...

Cloudmark eliminated the need for this...
Other Customer Examples

- Department of Defense takes NASTRAN from 3-days to 6-hours
- HMO achieves a 200 HDD to 1 ioMemory reduction for their Data Warehouse
- FedEx does a 30 to 1 server reduction for their reliable messaging system
- Stock exchange doubles the performance of their trading systems
- FAST unstructured text search 2 min response times reduced to 0.2 seconds
- Dynamics NAV gets a 4x performance improvement
Data-Intensive Applications for ioMemory

TRANSACTION PROCESSING
• 100x faster response time
• 10x the transactions per second

VIRTUALIZATION
• Host 4x more virtual machines
• Avoid service interrupts due to I/O contention
• Save or resume virtual machine states in seconds

APPLICATION SERVER
• 3-10x application acceleration
• “All-bladed”
Available from all major server vendors
Questions?
Thank You