The Flash Transformed Data Center & the Unlimited Future of Flash

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Forward-Looking Statements

During our meeting today we will make forward-looking statements.

Any statement that refers to expectations, projections or other characterizations of future events or circumstances is a forward-looking statement, including those relating to market growth, industry trends, future products, product performance and product capabilities. This presentation also contains forward-looking statements attributed to third parties, which reflect their projections as of the date of issuance.

Actual results may differ materially from those expressed in these forward-looking statements due to a number of risks and uncertainties, including the factors detailed under the caption “Risk Factors” and elsewhere in the documents we file from time to time with the SEC, including our annual and quarterly reports.

We undertake no obligation to update these forward-looking statements, which speak only as of the date hereof or as of the date of issuance by a third party, as the case may be.
100 hours of video are uploaded to YouTube every minute

Multiple private clouds are already over 50 Petabytes in size

Analytics market expected to grow to $16.9 Billion in 2015

90% of the Data in the world today was created within the last 2 years

Unstructured information is 90% of Big Data and is human information like e-mails, videos, tweets, Facebook posts…
3rd Platform: Big Data and Cloud-based Data Centers

2nd Platform: Client/Server-based Data Centers

1st Platform: Mainframe-based Data Centers

Flash Enables the 3rd Platform Transformation

3rd Platform – Cloud/Internet of Things

- Instant resource provisioning is the new expectation
- Instant access
- Memory-like speed performance
- Near real-time results needed by business
- Large data sets

2nd Platform – Client/Server

Virtualization
- Performance challenge for shared storage infrastructure

Infrastructure
- Need reduction in server and storage systems, power, cooling, and floor space

New Math: $/GB Replaced by TCA & TCO
- Total Cost of Acquisition (TCA) = drives + enclosures + power supplies + …
All Flash Zone

- Real Time Analytics
- Currency Exchange
- High Speed Messaging
- Stock Trade Optimization
- Real Time Data Stream for Video Editing

10K HDDs
15K HDDs
Short-stroked 15K HDDs
DRAM

Too Slow
Too Expensive

SanDisk

Flash Memory Summit | Santa Clara, California | 5-7 August 2014
Flash Transforming External Storage
Over 1.5 Million IOPS in a 4u storage array

- All Flash Aggregated PCIe Performance
  - Scalable: up to 32 nodes
  - Dense: 4u configuration
  - High throughput: >20GB/sec bandwidth
  - Fast Response: <60 microsecond latency!
  - Massive Capacity: >25TB!

Need 5,600 short-stroked 15K HDDs for Equal Performance
Flash Transforming In-Memory Compute

Improve $/transaction by up to 3x

- Use DDR-attached Flash plus optimized software
  - Increase performance of flash to near-memory like speeds
  - Same or greater capacity at a fraction of the cost
  - Large single server working set size to reduce cost and complexity

½ the Servers, Faster Business Answers
Density Matters

Beyond just faster, cooler, and more power efficient SSD

Today's World's highest capacity SAS SSD

- 16 TB
- 8 TB
- 4 TB
- 0.9 TB

10K SAS HDDs

- 1.6 TB
- 1.2 TB
- 0.9 TB
Solutions are Already Less Costly than HDD Solutions

More of the good stuff and less of the bad!

Example: 50TB minimum of database storage needed

**HDDs**
- (12) 24 drive enclosures
- 60K IOPS
- Read Reference Database
- 288 HDDs @ 300GB

**SSDs**
- (4) 24 drive enclosure
- 1.8M IOPS
- Read Reference Database
- 24 SSDs @ 4TB

The same cost per GB for both solutions
- 30X Performance
- 66% reduction in HW footprint

More power and more space needed

Solutions are Already Less Costly than HDD Solutions

More of the good stuff and less of the bad!

Example: 50TB minimum of 150K IOPS needed

HDDs (Short Stroked)
- 596 HDDs @ 300GB
- Short Stroked to 150GB

170K IOPS

More power and more space needed

SSDs
- 24 SSDs @ 4TB

1.8M IOPS

11X Performance
same cost per GB

½ the Total Cost of Acquisition
½ the Total Cost of Ownership

Read Reference Database

Source: Based on Dell PowerEdge pricing www.dell.com/us/business/p/poweredge-r720/fs along with HDD studies “Failure Trends in a Large Disk Drive Population” and “Disk failures in the real world”: proceedings of 5th USENIX Conference on File and Storage Technologies and incorporated into TCO model developed by SanDisk architect Fritz Kruger—December 2013
Response Time Matters
Active Content Repository System Example

Read-Only Data

Density
NAND Scaling
TCO
Flash Transforms Applications Across the Tiers of Storage

TIER 0
+DRAM

Caching
In-Memory Compute

TIER 1

Indexing
VDI/Virtual Server

OLTP

TIER 2

Exchange Server
Analytics

Image Retrieval
Web Search
VOD/Media Streaming

TIER 3

Data Warehouse
Web Server Logs
Content Repository

SanDisk®
Flash Transforms Applications Across the Tiers of the Data Center
Software Optimization Matters

“Hadoop still too slow for real-time analysis applications?”
-- SearchBusinessAnalytics

“Cassandra speed. Why so slow?”
-- stackoverflow.com

“Google Analytics Code is Slowing Down My Site”
-- AnalyticsMarket blog

“Removing Memcachced because it’s too slow”
-- blog.serverdensity.com

“What affects Redis speed”
-- ServerFault.com

“Turn to in-memory processing when performance matters”
-- SearchDataCenter
Software Optimization Matters

Impact of Flash-Optimized Software

mongoDB

TPS per Server in Thousands

HDD SSD SSD + Flash Optimized Software

0.7 5.0 16.0

20x Improvement 3x Improvement

Critical to 3rd Platform: NoSQL, Hadoop, SQL, In-Memory Compute, Object Storage

128GB 1K data; 24 core Westmere, 96GB DRAM, 8 x 128GB SSD @ 1K data; YCSB measurements performed by SanDisk using ZetaScale Software
Software is Required to Optimize the Flash Transformed Data Center

- **Tiering SW (Level 2)**
- **Tiering SW (Level 1)**
- **Tiering SW (Level 0)**

- **Cold Data**
- **Hot Data that's also changed frequently**
- **Hot Read Data**

- **Rarely Accessed Data**
- **Write Intensive Workload**
- **Read Intensive Hot Workload**
Flash is Transforming our World

Enterprise Data Center

Internet of Things
Thank you!