IOPS: Changing Needs

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Objective Analysis
Outline

- The Survey
- Application Distribution
- Top-Level Survey Results: IOPS, Capacity and Latency
- Developing storage tiers
- Implications/Projections
- Authors & Sources
Our Survey

- Ongoing. Take our survey at: [http://TinyURL.com/IOPSsurvey](http://TinyURL.com/IOPSsurvey)
- Asks for IOPS, capacity and latency needs
  - Also their primary applications
- Some results will appear in a SNIA SSSI white paper
- Full report, analyzing and interpreting the results, can be purchased online
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Applications: 2012

- Mail server and mail storage, 4%
- Archiving and backup, 4%
- Video Creation or Distribution, 7%
- Cloud storage or services, 11%
- Scientific or Engineering, 10%
- Databases, 40%
- OLTP, 24%
**Applications: 2016**

- Databases, 45%
- OLTP, 16%
- Archiving and backup, 9%
- Cloud storage or services, 7%
- Scientific or Engineering, 6%
- Video Creation or Distribution, 6%
- Mail server and mail storage, 4%
Databases

- Large data sets
- Random traffic
- High I/O load
- Early SSD adopter
  - Previously used DRAM SSDs
- Some load the entire DB on flash memory
OLTP
(On-Line Transaction Processing)

- Verified writes
  - Write/read back
  - Doubles I/O load
- No room for errors
- Speed is imperative
  - Delays lose customers

Image courtesy of Square, Inc.
Archiving & Backup

- Snapshots and replication gaining momentum
  - Both require high-speed storage
- Business continuity places high demands on storage
- Active archives growing faster than passive archives
Cloud Storage/Services--Virtualization

- The “IO Blender”
  - Many streams
  - Scrambled I/O
  - Highly random
- Suits SSDs better than HDDs for rapid access
- Many VM and VDI systems using flash cache to meet demand speed needs

Image courtesy of Waring Corp.
Science & Engineering

- Complex problems
  - Genome sequencing
  - CAD/CAM
  - Natural Resources
  - Nuclear modeling
- Large data sets
- Expensive talent
  - Don’t want them sitting around waiting
Video Creation or Distribution

- Large data sets
- Multiple video streams
  - Randomizes access
- High bandwidth required
- Expensive talent
  - Don’t want them sitting around waiting

Image courtesy of the US Library of Congress
Flash M&E Revenue Share is Growing

2015
- Flash: 38%
- HDD: 55%
- Optical: 1%
- Tape: 6%

2021
- Flash: 51%
- HDD: 46%
- Tape: 3%

2016 Digital Storage in Media and Entertainment Report, Coughlin Associates
Growing Use of Flash Memory in Media and Entertainment

2021 Projections

- Post Production: 4.0%
- VOD: 4.6%
- Acquisition: 91.4%
Exchange Server

- Multiple tasks
  - e-mail
  - Scheduling/calendars
  - Data storage
- Thousands of users
- Chaotic e-mail workload
  - Multiple mailboxes
  - Asynchronous sends & receives
  - Spam & virus filters

Image courtesy of Dell Computer
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IOPS Required for Dominant Application

37% increase in median IOPS required
Capacity Required

17% increase in mean capacity required

Share of Responses

Capacity Required

10% increase in mean capacity required

Capacity

0% 5% 10% 15% 20% 25%

IGB 10GB 50GB 100GB 500GB 1TB 5TB 10TB 50TB >50TB

2012 2016
Other Hardware IOPS Bottleneck

36% increase in bottleneck IOPS

Share of Responses

IOPS

2012
2016
Fastest Latency the System Can Use

73% decrease in mean latency

[Bar chart showing latency distribution for 2012 and 2016]
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Touch Rate vs. Response Time
Indicating Various Types of Uses

- ColdActive
- SemiActive
- Near Line
- Transaction
- Hi IOPS

Touch Rate vs. Response Time

- InActive
- Faster
- Limit of human response tolerance
- Fast enough for disk stack
- Increasing $/TB
- More Accessible
Digital Storage Technologies Overlaid on the Touch Rate Chart

Technology Application Regions

- Flash
- Performance HDD
- Capacity HDD
- Hi IOPS
- Transaction
- Near Line
- SemiActive
- ColdActive
- InActive
- Tape

Response Time (s)

Touch/Y

100,000
10,000
1,000
100
10
1
0.1%
1%
10%
100,000s
10,000s
1,000s
100s
10s
1s
100ms
10ms
1ms
10μs
10μs
HDD-Flash Tiering/Caching Touch Rate Chart

HDD-Flash Tiering Touch Rate vs. Response Time

Touch/Y

Response Time (s)

Cap. HDD
SemiActive
ColdActive
InActive

PCI-E

1MB Segment

Hi IOPS
4kB
64kB

1MB Transaction
256MB
16MB
64GB
4GB
1TB

16TB
10,000
100,000

100μs
10μs
1ms
10ms
100ms
1s
10s
100s
1,000s
10,000s
1D
1H

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How To View Latencies

- DRAM Access
  - One heartbeat
- SSD Access
  - 1,000 heartbeats
    - Walking a mile
- HDD Access
  - 1,000,000 heartbeats
    - Riding a bike from San Francisco to Miami

(Thanks to Jim Pappas for this analogy)
Memory & Storage Price vs. Bandwidth

From Objective Analysis: Are Hybrid Drives Finally Coming of Age?
Price/GB Roughly Follows IOPS

Price per Gigabyte vs. IOPS

$I_0$ $100$ $1,000$

$I_{00}$ $10$ $100$

$I_{000}$ $1$ $10$

$I_{0000}$ $0.1$ $1$

$I_{00000}$ $0.01$ $10$

$I_{000000}$ $0.001$ $100$

$I_{0000000}$ $0.0001$ $1,000$

$I_{00000000}$ $0.00001$ $10,000$

$I_{000000000}$ $0.000001$ $100,000$

$I_{0000000000}$ $0.0000001$ $1,000,000$

$I_{00000000000}$ $0.00000001$ $10,000,000$

$I_{000000000000}$ $0.000000001$ $100,000,000$

$I_{0000000000000}$ $0.0000000001$ $1,000,000,000$

$I_{00000000000000}$ $0.00000000001$ $10,000,000,000$
IOPS by Form Factor

- HDD
- SATA/SAS
- NVMe/PCIe
- Memory Channel

10^2 10^3 10^4 10^5 10^6 10^7
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Implications/Projections

- Users need more IOPS and capacity and lower latencies
- Increased SSDs adoption for higher IOPS
- HDDs filling a tier behind SSDs
- Other system elements become the bottleneck
  - Network, software, servers…
- Users focusing more attention on IOPS
  - Translates to growth for both SSDs and HDDs
Report Compiles Survey Results

- Full details can be purchased for immediate download at [www.Objective-Analysis.com](http://www.Objective-Analysis.com)
- Orders can also be processed through Coughlin Associates at:
  - [http://www.TomCoughlin.com/techpapers.htm](http://www.TomCoughlin.com/techpapers.htm) or by contacting Tom at:
    - 408-202-5098
    - [Tom@TomCoughlin.com](mailto:Tom@TomCoughlin.com).
Your Presenters

Tom Coughlin, President, Coughlin Associates is a highly-respected storage analyst and consultant with over 30 years in the data storage industry in engineering and management at high profile companies.

Jim Handy is a widely recognized semiconductor analyst, has over 30 years in the electronics industry. His background includes marketing and design positions at market-leading suppliers.
Source Material

- **2016 How Many IOPS is Enough?,** Objective Analysis and Coughlin Associates ([Objective-Analysis.com/Reports.html#IOPS](http://Objective-Analysis.com/Reports.html#IOPS))


- **Objective Analysis report: Are Hybrid Drives Finally Coming of Age?** ([Objective-Analysis.com/Reports.html#2010_HHDD](http://Objective-Analysis.com/Reports.html#2010_HHDD))