



## **SSDs – What’s Important to You?**

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### **A Look at What Users Say about SSD Features**

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## Introduction

The SNIA Solid State Storage Initiative ([www.snia.org/forums/ssi](http://www.snia.org/forums/ssi)) surveyed users to better understand what they expect from their SSDs. Understanding which attributes are most important in applications and market segments will help SSD manufacturers to design products more suitable for those applications or segments, and will provide guidance to users looking for the best SSD for their use.

This document provides a description of the survey, results for market segments and application areas, and summaries of the results.

## Survey Description

The survey first asked a series of questions about respondents' SSDs and how they were used.

- 1) In which market segment is the SSD used?
  - Mobile (notebook PC)
  - Desktop PC
  - Server
  - Storage Subsystem
  
- 2) What applications are run on the SSD?
  - General Office (word processor, spreadsheet, etc)
  - Caching
  - Database
  - Financial
  - Engineering (CAD, simulations, etc)
  
- 3) Which form-factor is the SSD?
  - 2.5-inch (or 3.5-inch) standard drive sizes, SATA, SAS, or PCIe interface
  - mSATA – small footprint & thin, targeted at notebooks, SATA interface
  - microSATA – SATA SSD in a BGA package
  - PCIe Card – standard PCIe plug-in card, various sizes, PCIe interface
  - Half Slim Card – slightly larger than mSATA, for servers & subsystems, SATA interface



- 4) What interface is on the SSD?
  - SATA – used primarily in client, but also in enterprise environments
  - SAS – utilized in enterprise environments
  - PCIe – designed to be a host bus interface, but is now also used as a device interface, today mainly in the enterprise
  
- 5) What capacity is the SSD?
  - Six ranges of capacities

Survey respondents were then asked to rate the importance of each of a list of SSD attributes, using ratings of 1 (Not Important) to 5 (Very Important).

The attributes can be divided into five categories:

- 1) Performance

SSSI has defined three primary measures of SSD performance:

- a) IOPS: transaction rate of the device, measured in I/Os per second.
- b) Response Time (or Latency): time from a host-generated request to the SSD until a response is received, measured in milliseconds or microseconds.
- c) Throughput: rate of data transfer to or from the SSD, measured in MB/second.

- 2) Power

Power consumption is an important specification for a storage device. For mobile devices, lower power means longer battery life. In systems with multiple drives, lower power means less cooling is required. Power management is the ability to reduce power consumption when all parts of the drive are not being used. SATA, SAS, and PCIe interfaces all support multiple power management modes, whereby the drive shuts down unnecessary logic when possible, thus reducing power consumption. There is a tradeoff - lower power modes require longer recovery times for the device to become fully operational, which must be managed to avoid unnecessary impacts on system responsiveness.



### 3) Endurance

One of the characteristics of the NAND Flash used in SSDs is that each Flash cell can be written a finite number of times before it wears out. SSD endurance is greatly extended by the use of wear leveling techniques that ensure that writes are distributed among available cells, and through over-provisioning, where the SSD has extra Flash that is not accessible to users, but is utilized as extra cells for wear leveling.

### 4) Data Integrity

The SNIA Dictionary defines data integrity as the property that data has not been altered or destroyed in an unauthorized manner. This can include unintended changes, i.e. corruption of data.

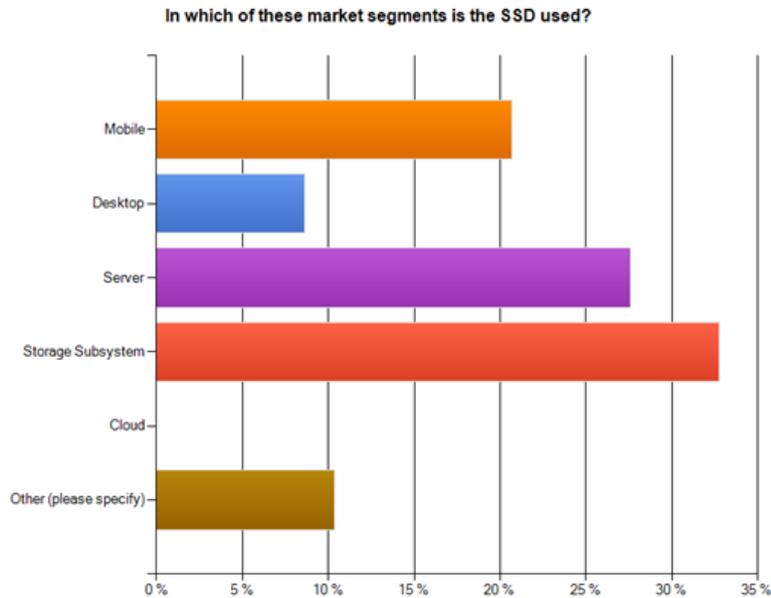
### 5) Data Encryption

Encryption of user data protects it from unauthorized access. Many current generation SSDs are capable of being self-encrypting drives (SED). An SED contains encryption logic integrated into drive silicon.



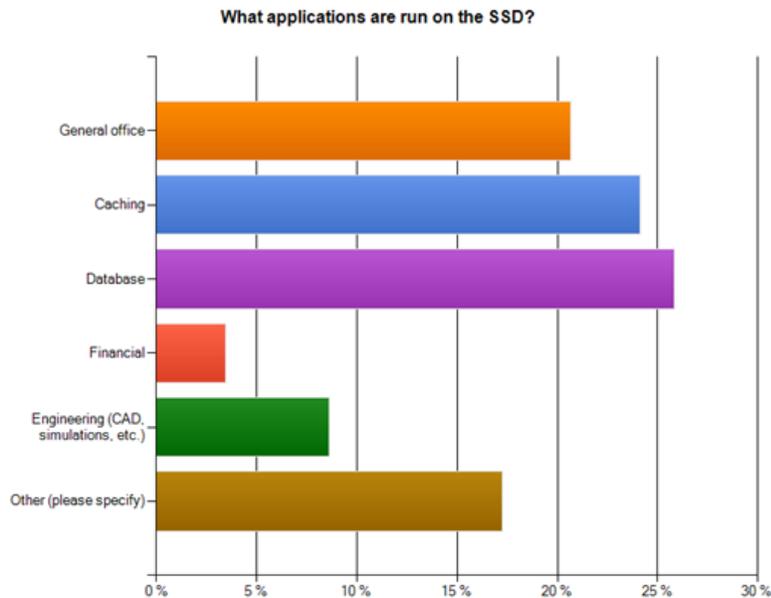
## Survey Results for All Respondents

Survey respondents reported using SSDs in the following market segments:



“Other” responses included “All of the above.”

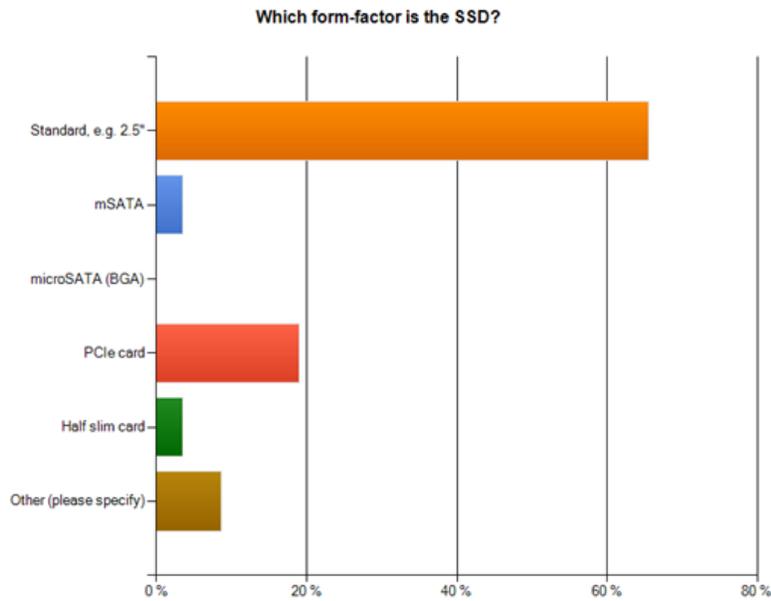
Survey respondents reported using SSDs in the following applications:



“Other” responses included “All of the above” and VMWare.

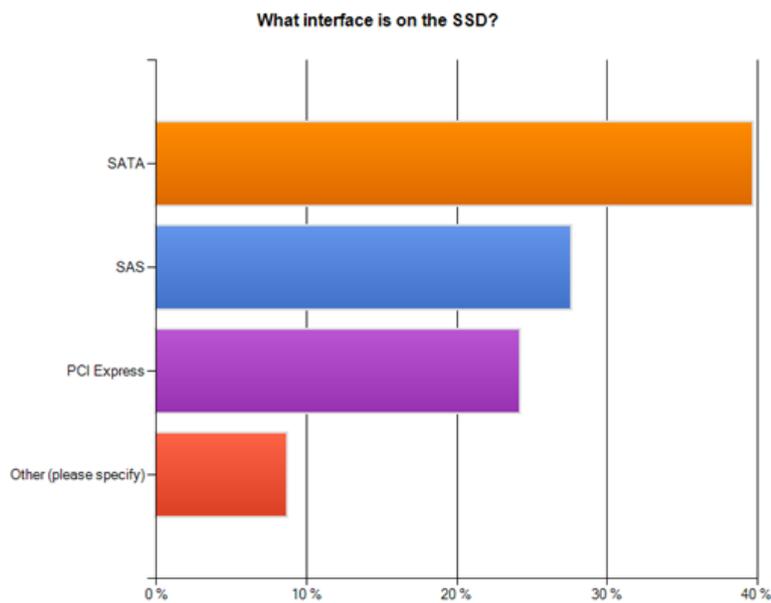


Survey respondents reported using SSDs in the following form-factors:



“Other” responses were primarily “All of the above.”

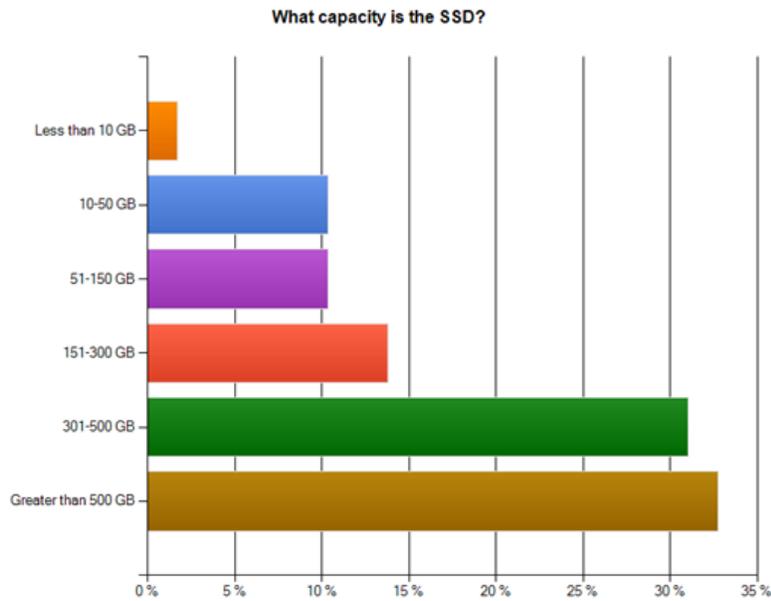
Survey respondents reported using SSDs with the following interfaces:



“Other” responses included “All of the above.”



Survey respondents reported using SSDs with the following capacities:



### Attribute Ratings for All Respondents

- 1) Performance was fairly important. IOPS and Latency were favored over throughput.
- 2) Low power was fairly important, but power management received only middling ratings.
- 3) Endurance was most important of all attributes. Respondents consistently ranked endurance above all else.
- 4) Data Integrity was fairly important.
- 5) Data encryption was fairly important, but less than anticipated.

Differences between market segments and different application areas will be examined in more detail in following sections.



## Survey Results by Market Segment

The survey identified respondents in four market segments:

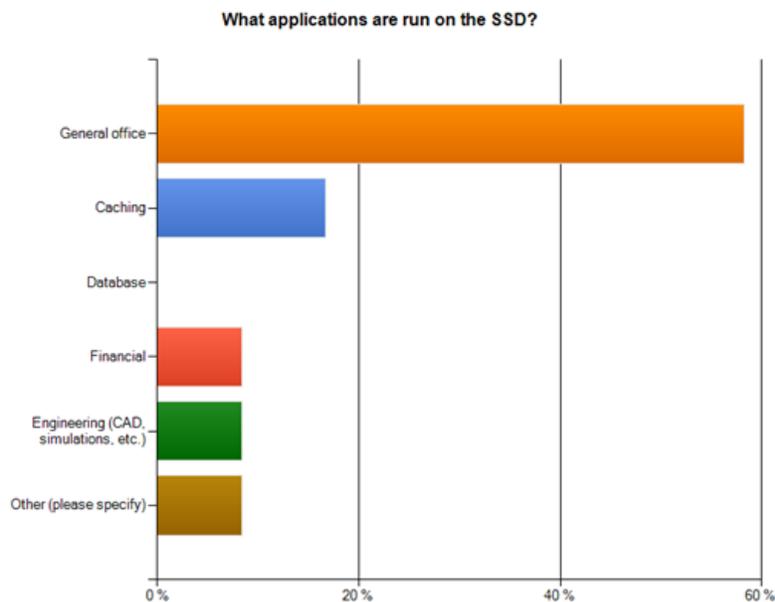
- Mobile
- Desktop
- Server
- Storage Subsystem

This section will summarize the survey results for each segment.

### Mobile Segment

Survey results indicated that respondents in this segment utilized notebook PCs.

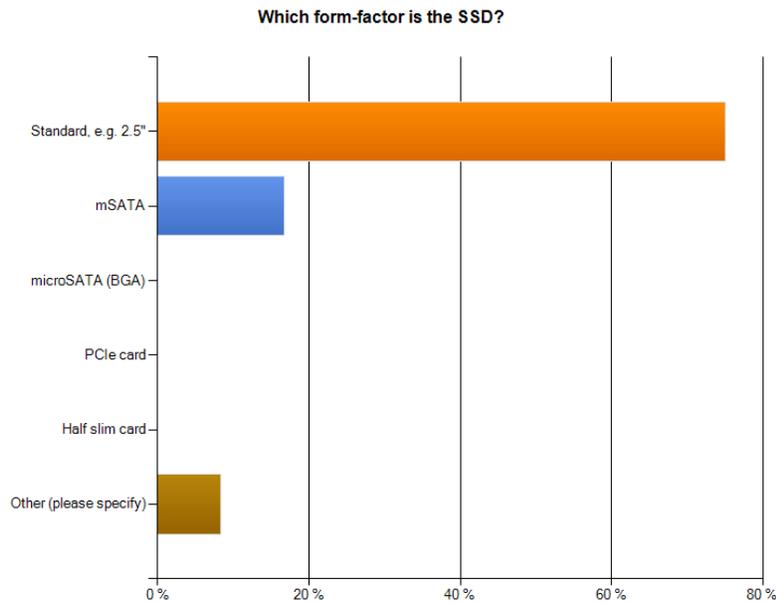
SSDs in the mobile segment were used in the following applications:



“Other” responses were “Some or all of the above” applications, plus VMWare.

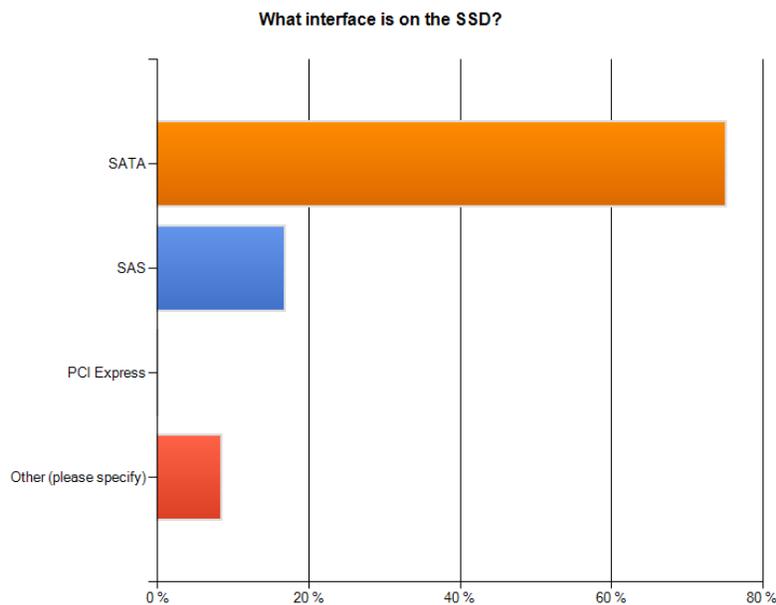


SSDs in the mobile segment were in the following form-factors:



“Other” responses included “All of the above.”

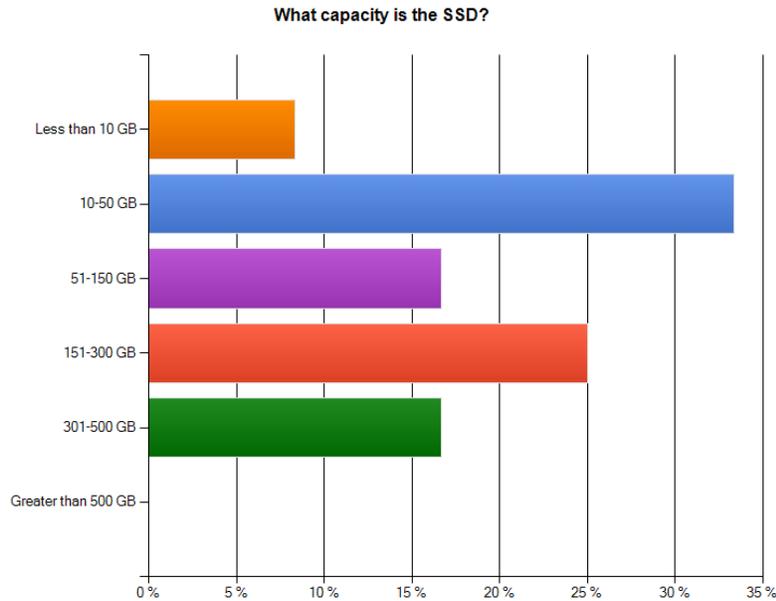
SSDs in the mobile segment had the following interfaces:



“Other” responses included “All of the above.”



SSDs used in the mobile segment had the following capacities:



### Attribute Ratings for the Mobile Segment

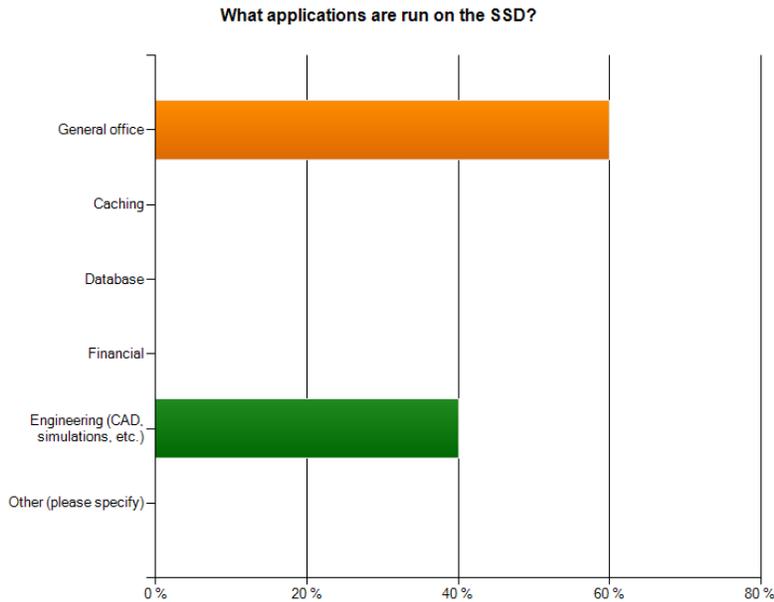
- 1) Performance was fairly important; favored IOPS and throughput over latency.
- 2) Low power was very important, as was power management.
- 3) Endurance was very important.
- 4) Data integrity was fairly important, but less so than server or subsystem segments.
- 5) Data encryption was not important to the respondents in the mobile segment.



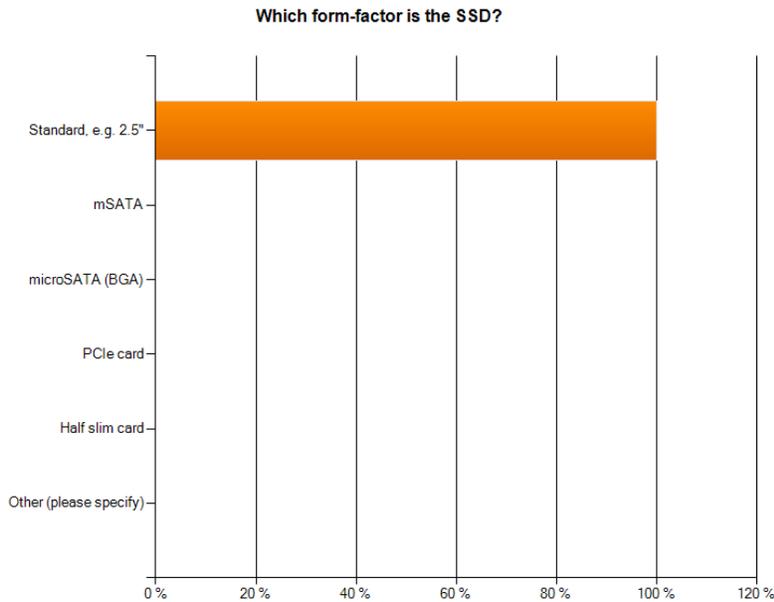
## Desktop Segment

This segment consists of desktop PCs and workstations.

SSDs in the desktop segment were used in the following applications:

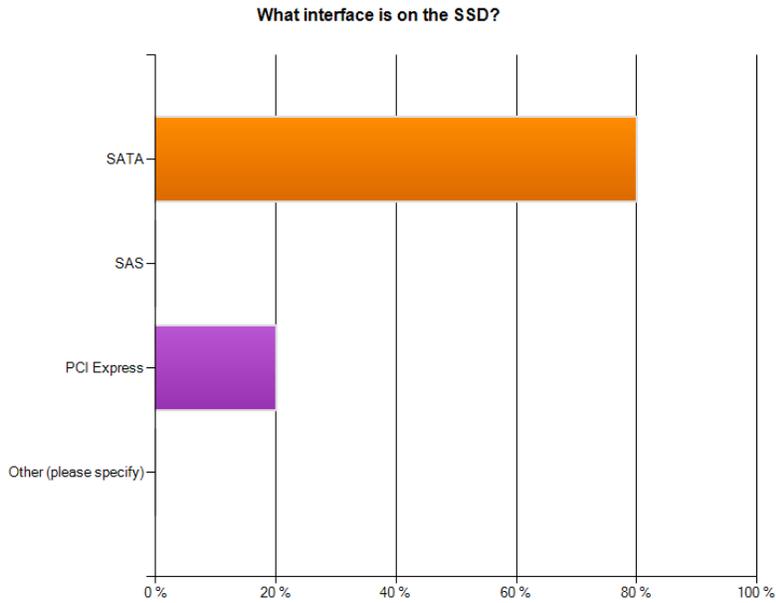


SSDs in the desktop segment were in the following form-factors:

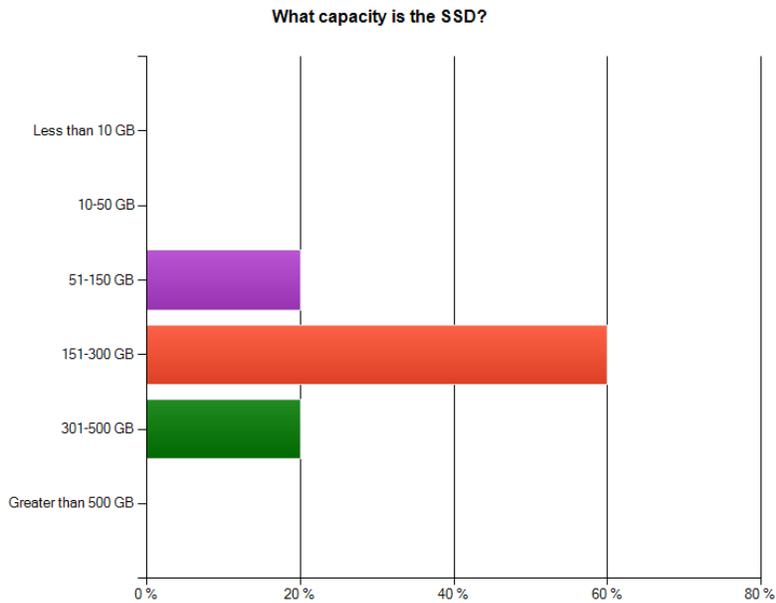




SSDs in the desktop segment had the following interfaces:



SSDs used in the desktop segment had the following capacities:





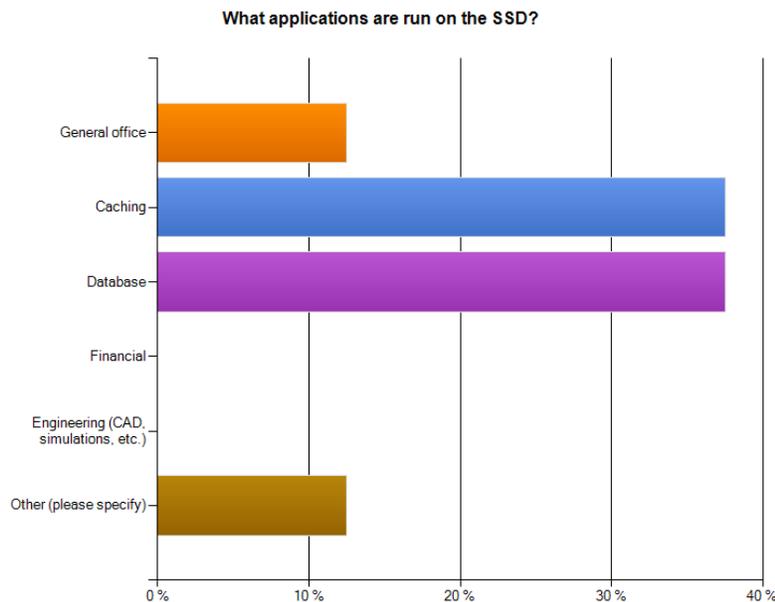
## Attribute Ratings for the Desktop Segment

- 1) Performance was fairly important; favored IOPS over throughput and latency.
- 2) Low power consumption was very important, as was power management.
- 3) Endurance was very important.
- 4) Data integrity was fairly important, but less so than server or subsystem segments.
- 5) Data encryption was very important to respondents in this segment.

## Server Segment

The SNIA Dictionary defines a server as an intelligent device, usually a computer that provides services to other intelligent devices, usually other computers or appliances. For purposes of this survey, the service provided was storage.

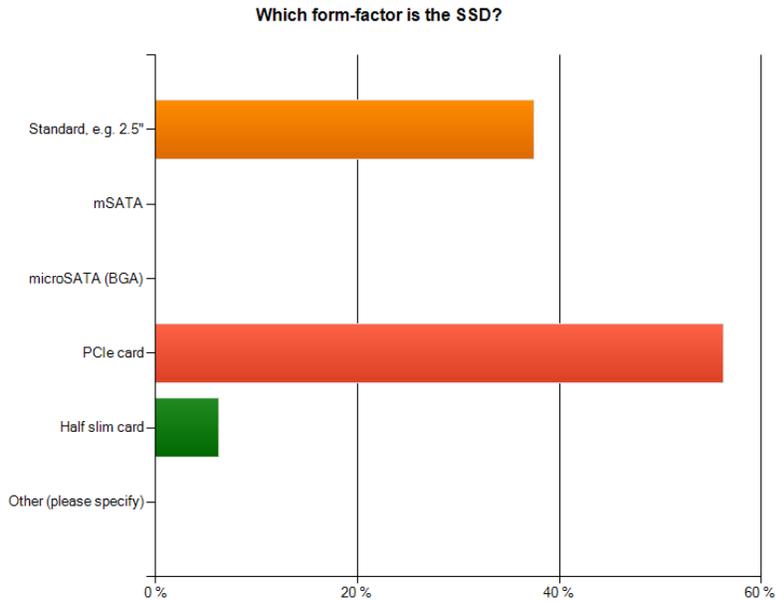
SSDs in the server segment were used in the following applications:



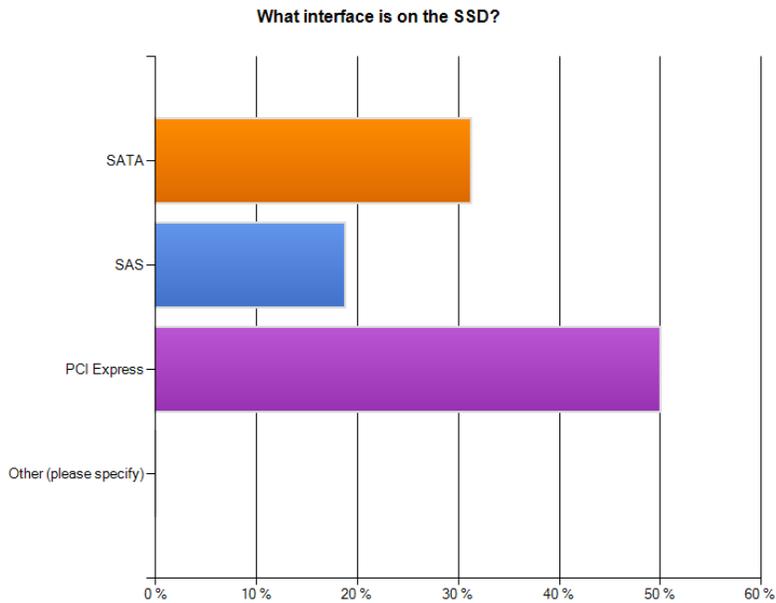
“Other” responses included video editing and general application acceleration.



SSDs in the server segment were in the following form-factors:

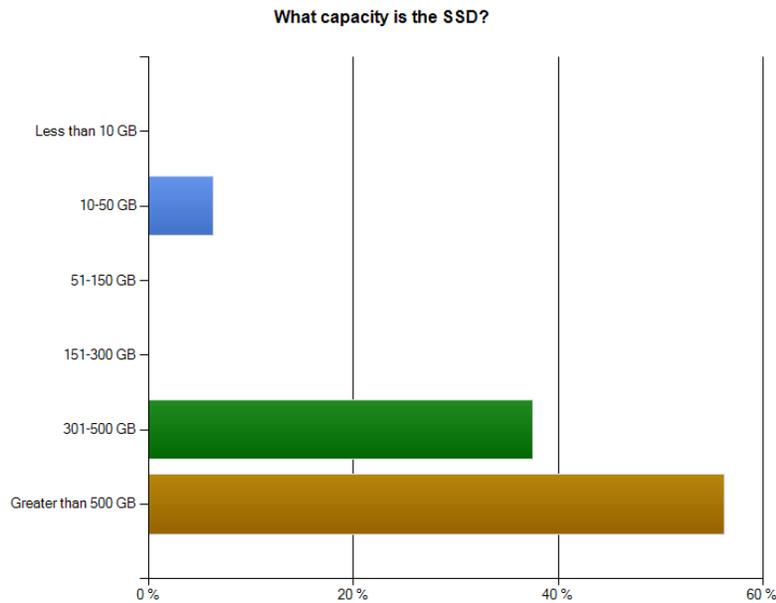


SSDs in the server segment had the following interfaces:





SSDs used in the server segment had the following capacities:



### Attribute Ratings for the Server Segment

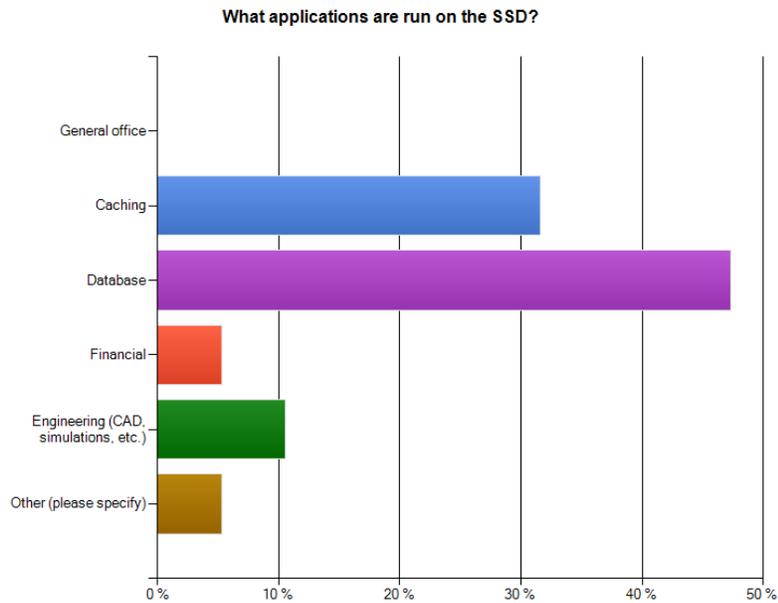
- 1) Performance was very important; favored latency over throughput and IOPS.
- 2) Low power consumption was not important.
- 3) Endurance was very important.
- 4) Data integrity was very important.
- 5) Data encryption was fairly important to respondents in this segment.



## Storage Subsystem Segment

The SNIA Dictionary defines a storage subsystem as an integrated collection of storage controllers, storage devices, and any required control software that provides storage services to one or more computers. (excerpted for clarity)

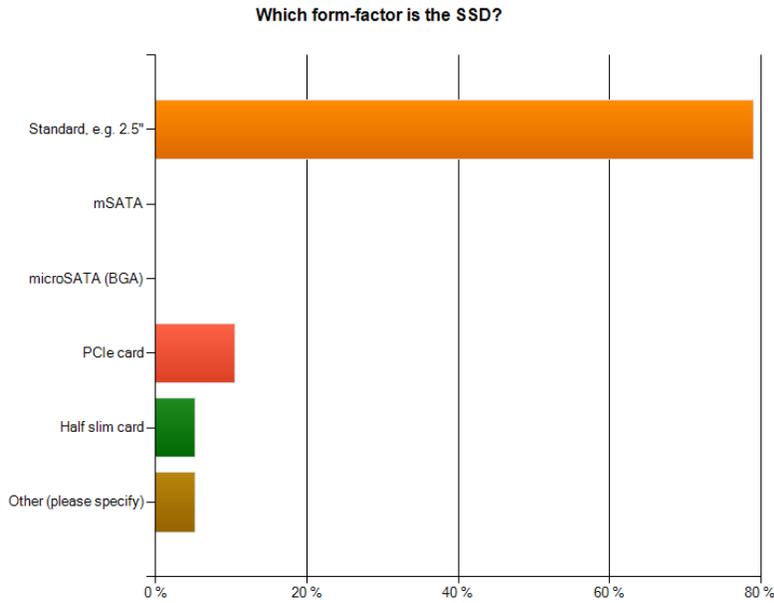
SSDs in the storage subsystem segment were used in the following applications:



“Other” responses included desktop virtualization.

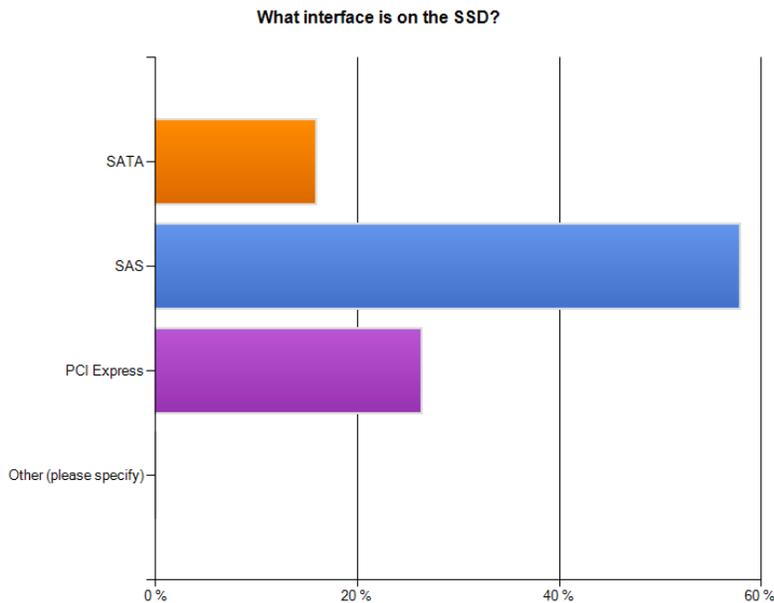


SSDs in the storage subsystem segment were in the following form-factors:



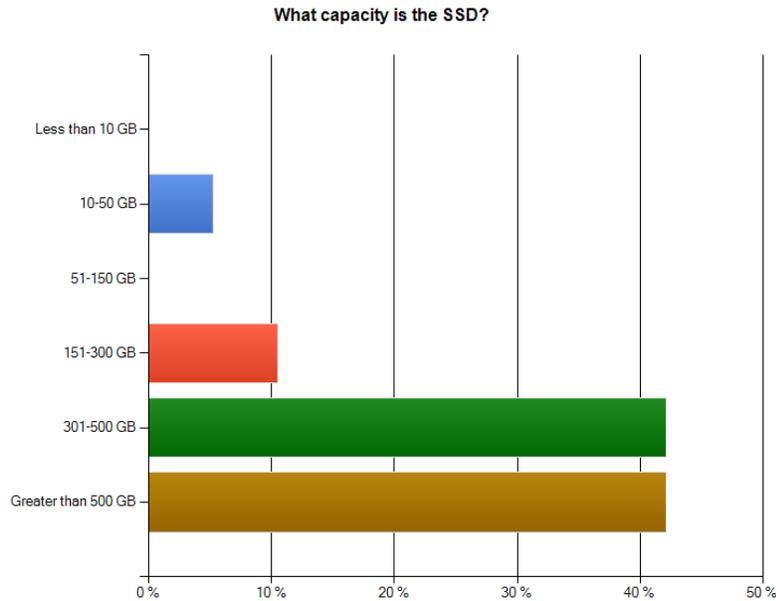
“Other” responses included 3.5-inch

SSDs in the storage subsystem segment had the following interfaces:





SSDs used in the storage subsystem segment had the following capacities:



### Attribute Ratings for the Storage Subsystem Segment

- 1) Performance was very important; favored latency over throughput and IOPS.
- 2) Low power consumption was not important.
- 3) Endurance was very important.
- 4) Data integrity was very important.
- 5) Data encryption was fairly important to respondents in this segment.



## Survey Results by Application

The survey identified respondents in five application areas:

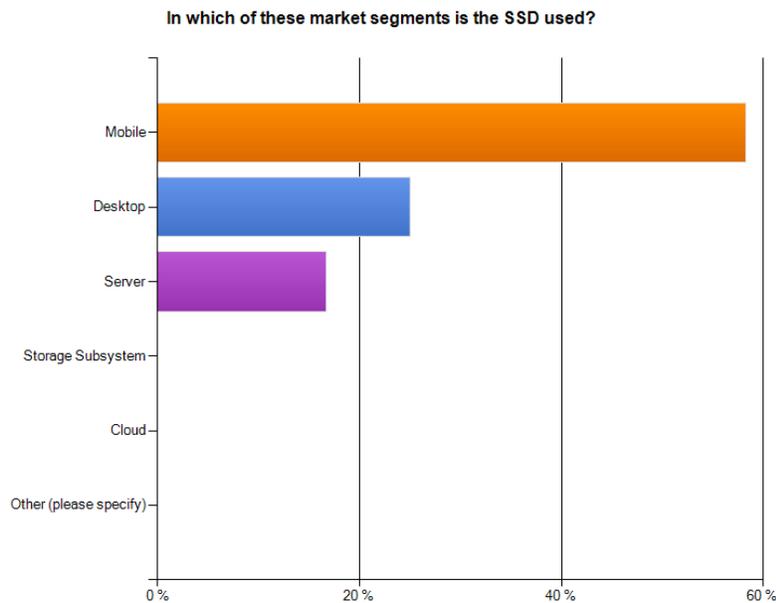
- General Office
- Caching
- Database
- Financial
- Engineering

This section will summarize the survey results for each application.

### General Office Applications

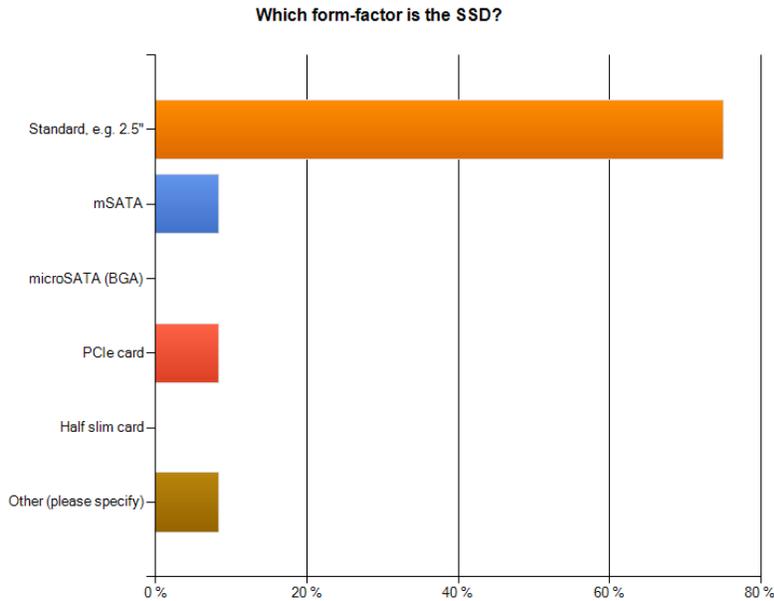
General office applications include word processing, spreadsheets, etc.

SSDs were used for general office applications in the following market segments:



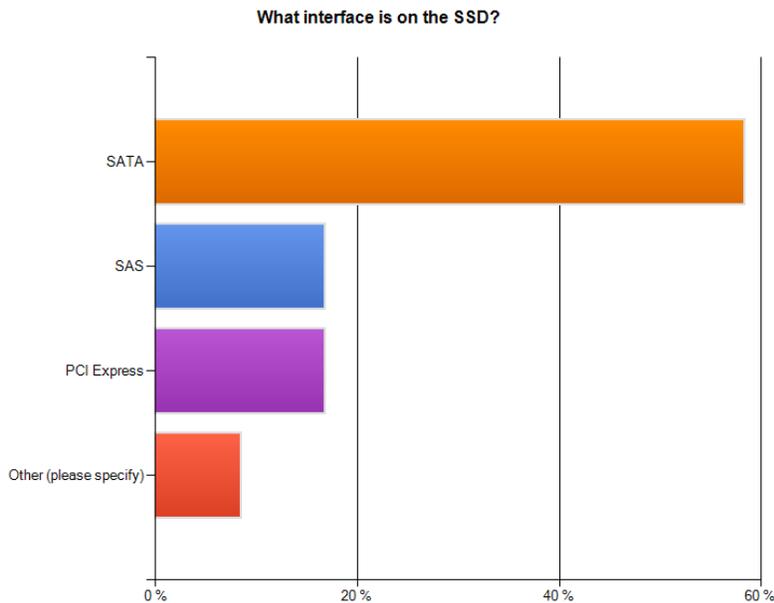


SSDs used for general office applications were in the following form factors:



“Other” responses included “Some or all of the above.”

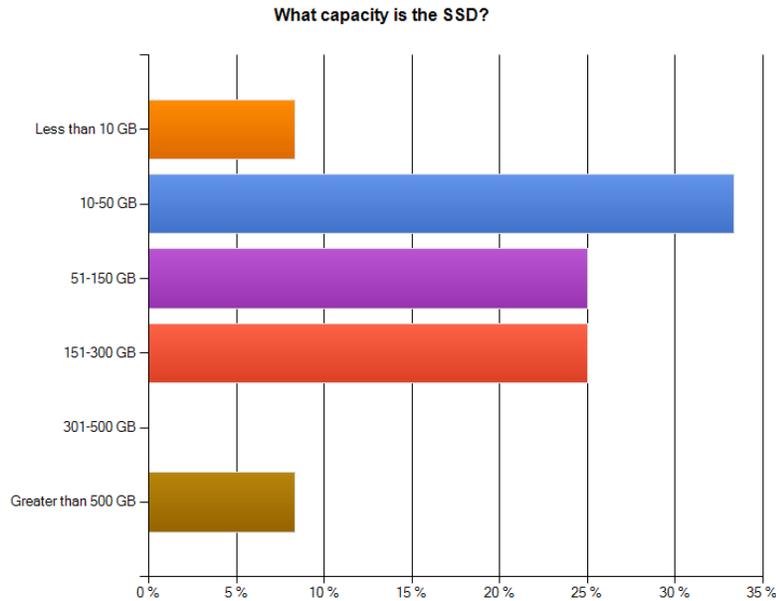
SSDs used for general office applications had the following interfaces:



“Other” responses included “Some or all of the above.”



SSDs used for general office applications had the following capacities:



### Attribute Ratings for General Office Applications

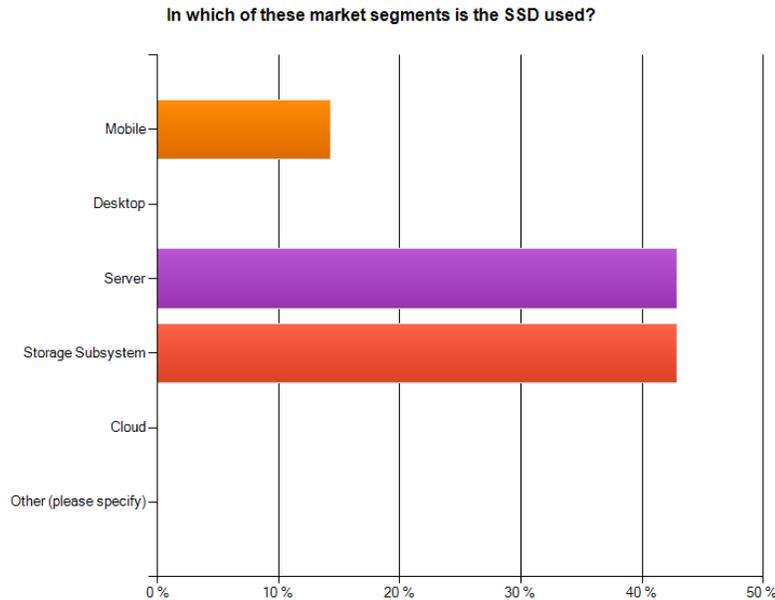
- 1) Performance was fairly important. Throughput was favored over IOPS and latency.
- 2) Low power was fairly important. Basic power management was deemed important.
- 3) Endurance was very important.
- 4) Data Integrity was fairly important.
- 5) Data encryption was fairly important.



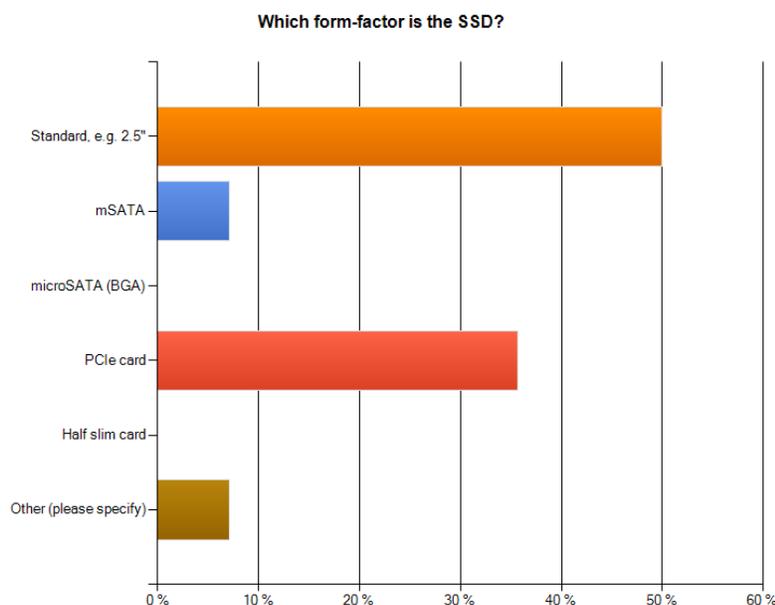
## Caching Applications

PCs support caching by utilizing a low capacity small form-factor SSD, or in larger scale systems by dedicating a high capacity standard form-factor SSD to that function.

SSDs were used for caching applications in the following market segments:



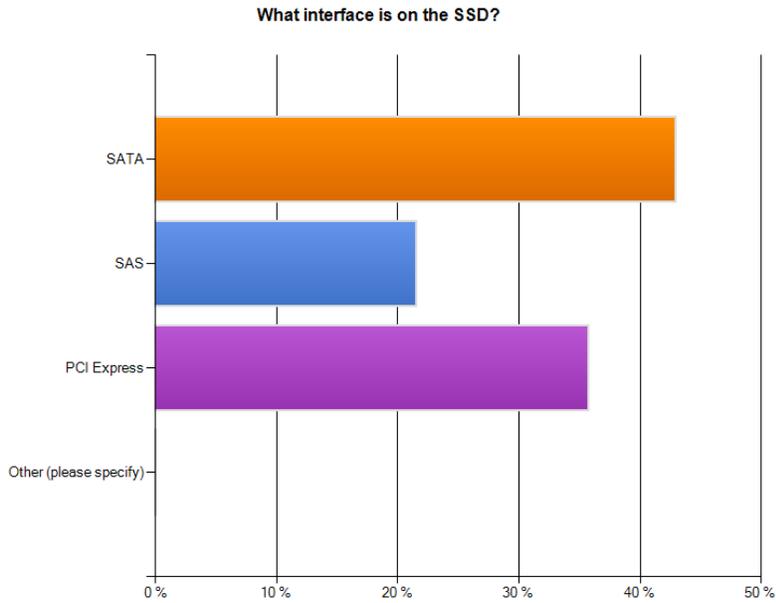
SSDs used for caching applications were in the following form factors:



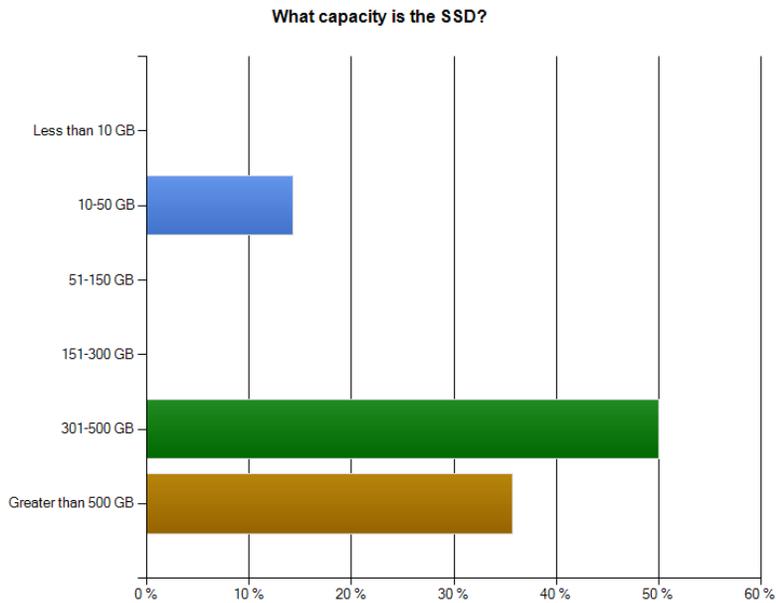
“Other” responses were “All of the above.”



SSDs used for caching applications had the following interfaces:



SSDs used for caching applications had the following capacities:





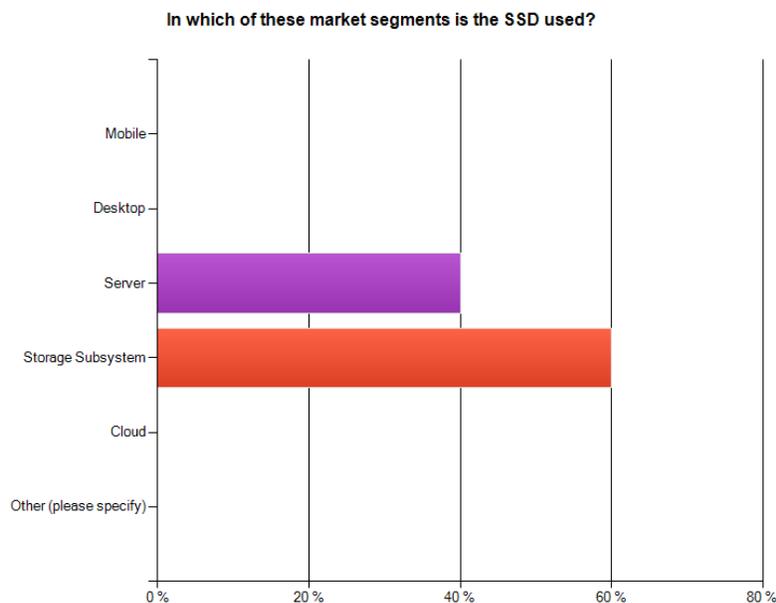
### Attribute Ratings for Caching Applications

- 1) Performance was fairly important. IOPS was most important, followed by latency, then throughput.
- 2) Low power was not important, nor was power management.
- 3) Endurance was very important.
- 4) Data Integrity was fairly important.
- 5) Data encryption was not important.

### Database Applications

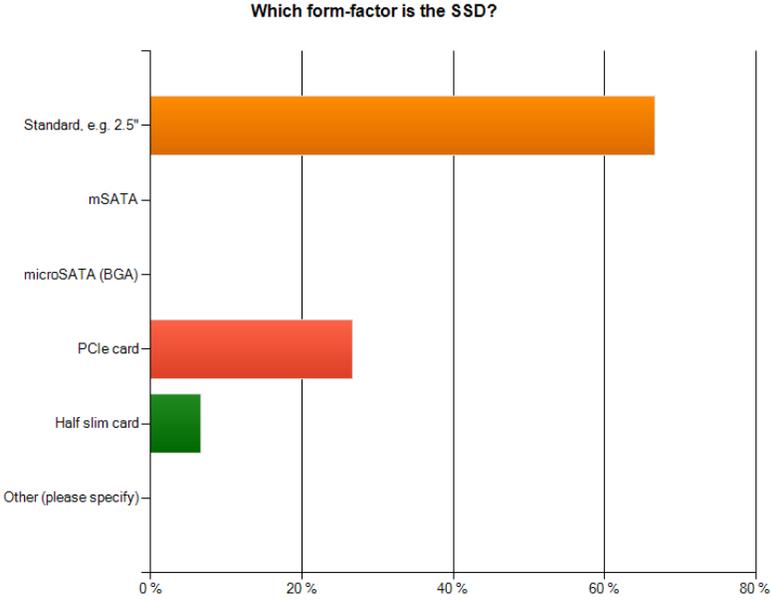
Databases are repositories of information, sometimes very large, that benefit from high speed random access storage.

SSDs were used for database applications in the following market segments:

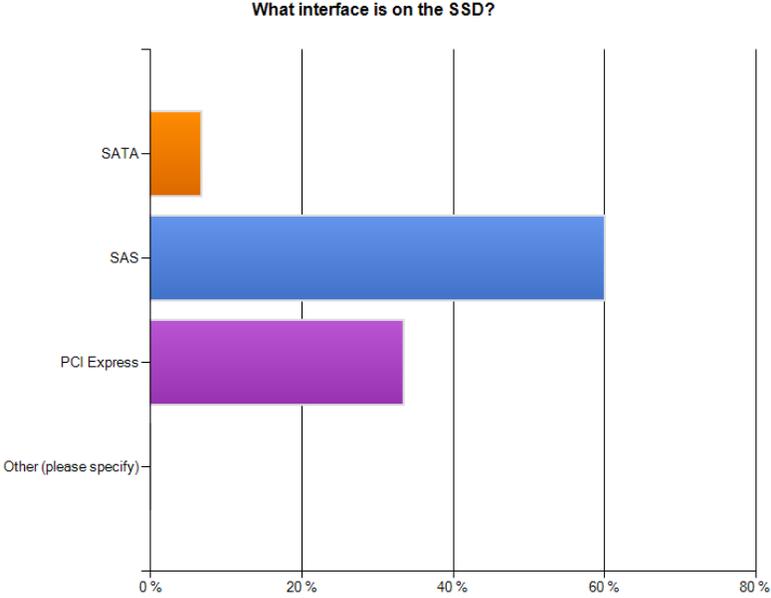




SSDs used for database applications were in the following form factors:

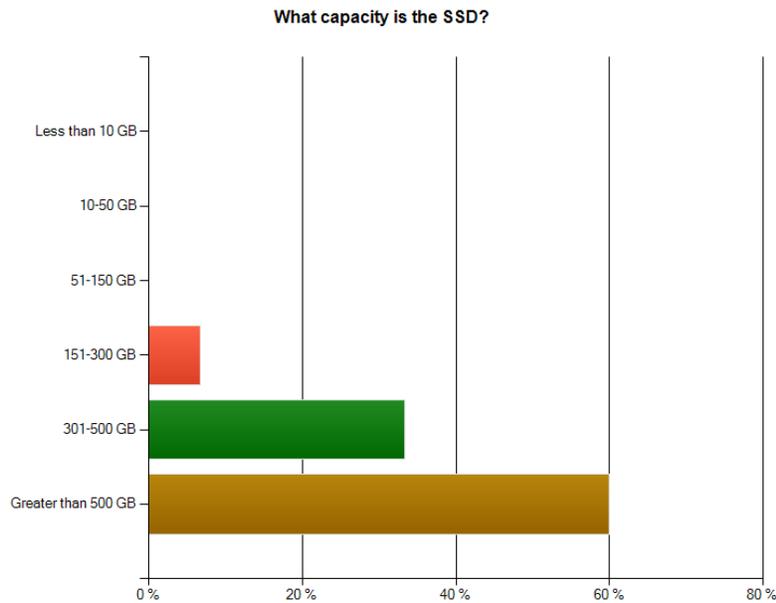


SSDs used for database applications had the following interfaces:





SSDs used for database applications had the following capacities:



### Attribute Ratings for Database Applications

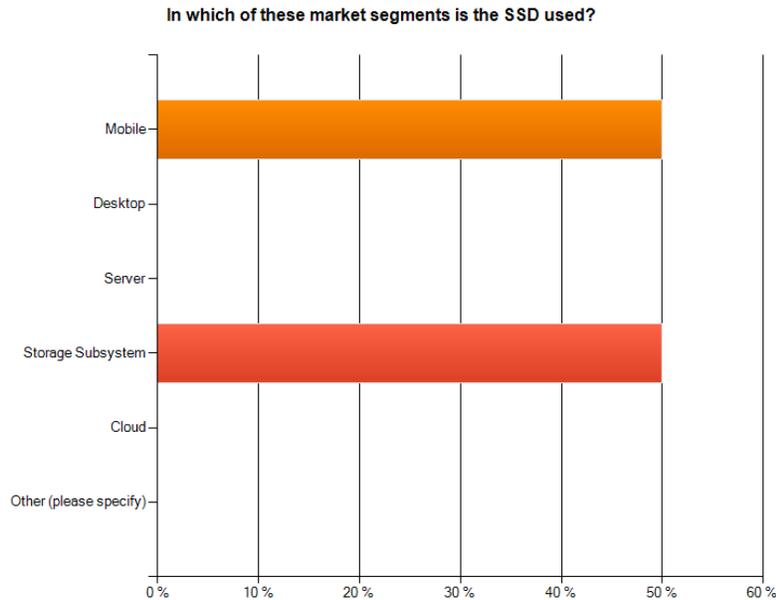
- 1) Performance was very important. Latency was strongly favored over IOPS and throughput.
- 2) Low power was not important.
- 3) Endurance was very important.
- 4) Data Integrity was very important.
- 5) Data encryption was not important.



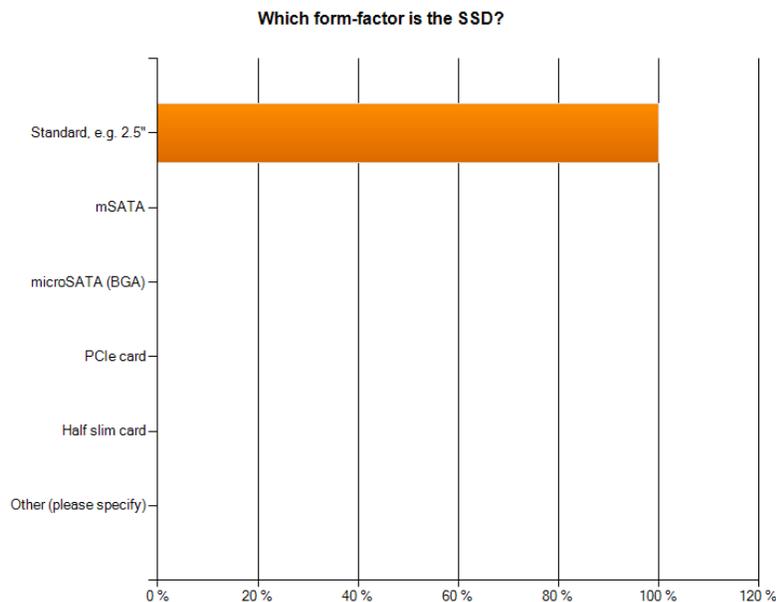
## Financial Applications

Financial applications range from PC-based accounting software to very large payroll systems.

SSDs were used for financial applications in the following market segments:

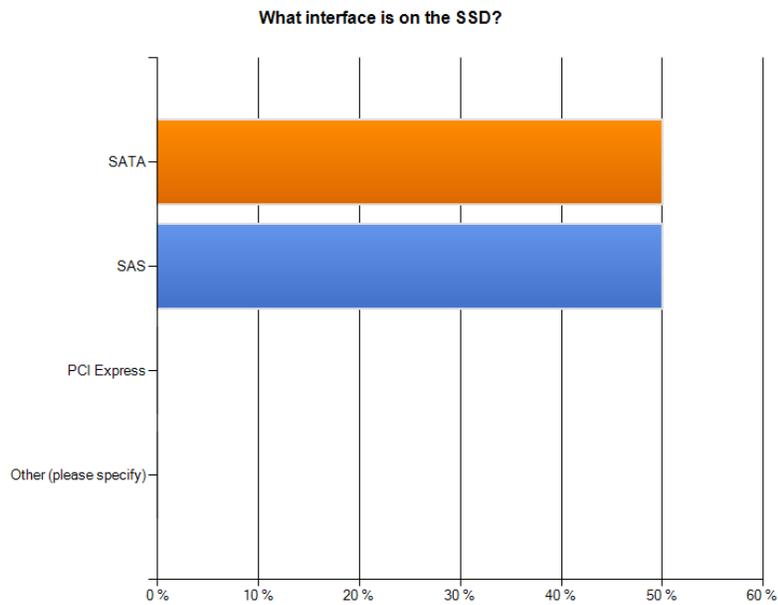


SSDs used for financial applications were in the following form factors:

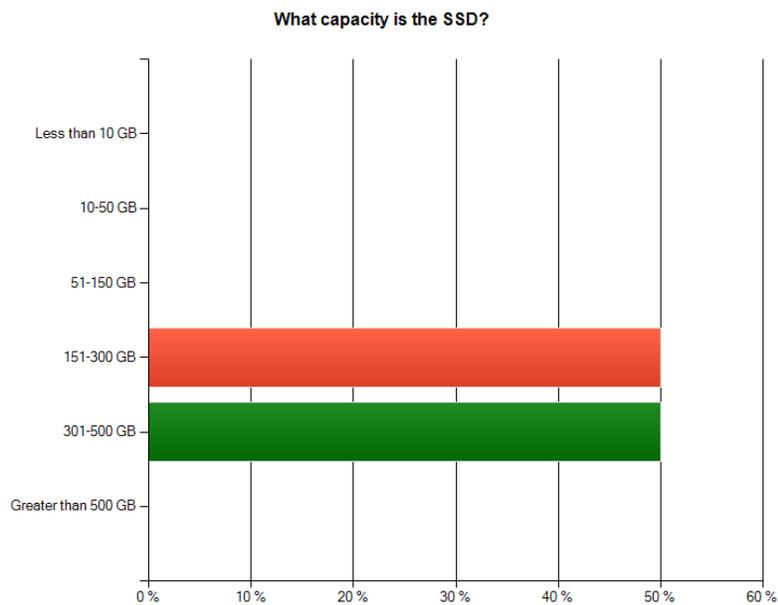




SSDs used for financial applications had the following interfaces:



SSDs used for financial applications had the following capacities:





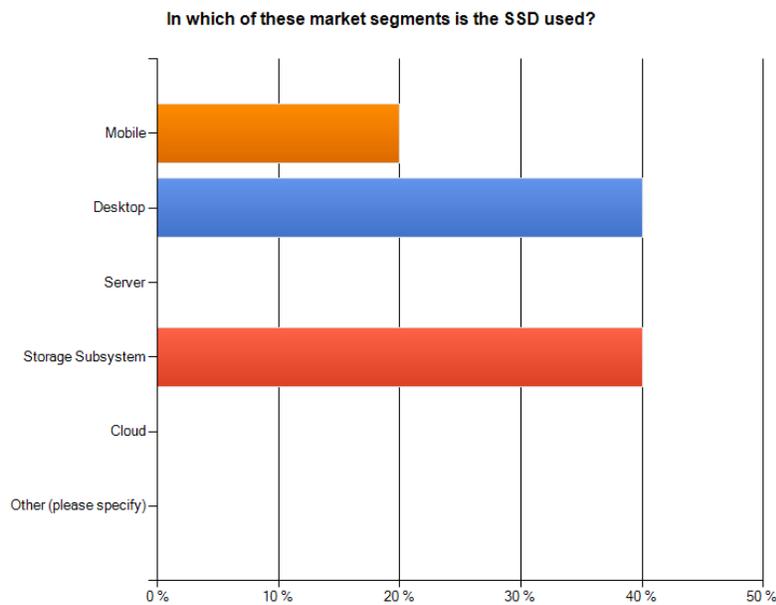
## Attribute Ratings for Financial Applications

- 1) Performance was very important. IOPS was favored over throughput and latency.
- 2) Low power was not important.
- 3) Endurance was very important.
- 4) Data Integrity was very important.
- 5) Data encryption was fairly important.

## Engineering Applications

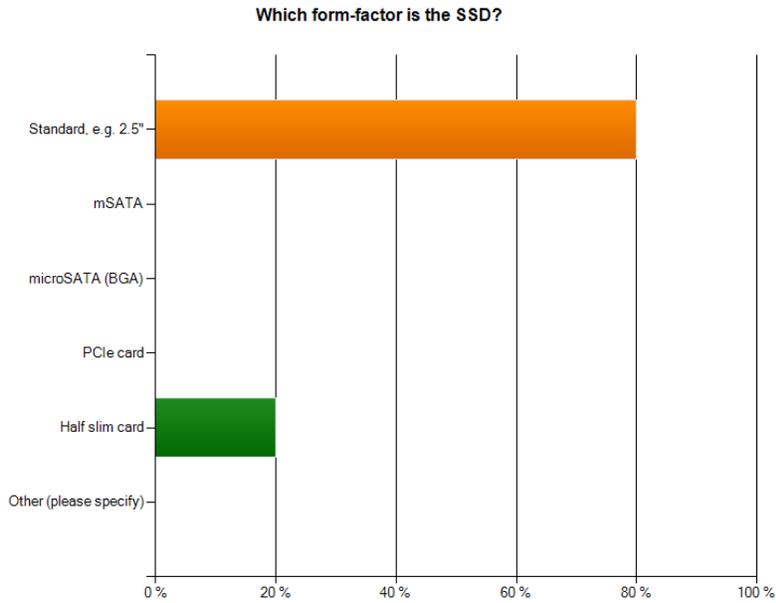
Engineering applications include computer aided design software, simulations, and other design and test programs.

SSDs were used for engineering applications in the following market segments:

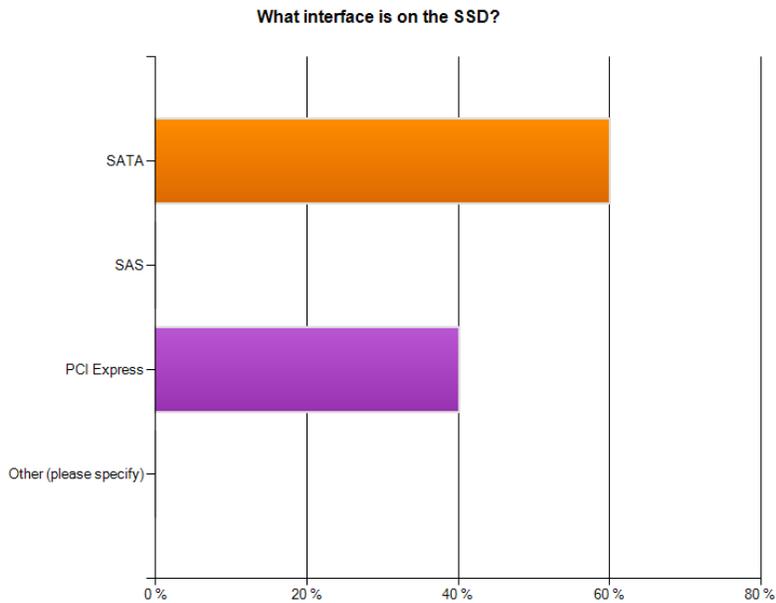




SSDs used for engineering applications were in the following form factors:

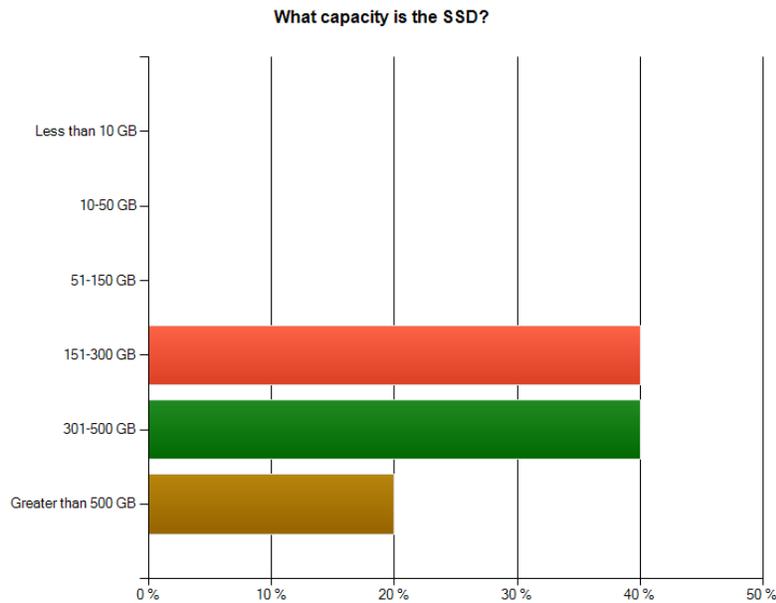


SSDs used for engineering applications had the following interfaces:





SSDs used for engineering applications had the following capacities:



### Attribute Ratings for Engineering Applications

- 1) Performance was very important. IOPS was favored over throughput and latency.
- 2) Low power was very important.
- 3) Endurance was very important.
- 4) Data Integrity was very important.
- 5) Data encryption was fairly important.



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## Survey Results for Users of PCIe SSDs

It was decided to also look at the PCIe SSD responses, as this is a relatively new area, and as of this writing, enterprise focused. There were two survey items unique to PCIe SSDs concerning NVM Express and SCSI Over PCIe (SOP), which are two command sets designed specifically for PCIe SSDs.

### Attribute Ratings for Users PCIe SSDs

- 1) Performance was very important. Latency was favored over throughput and IOPS.
- 2) Low power was not important.
- 3) Endurance was fairly important.
- 4) Data Integrity was very important, more so than all responses.
- 5) Data encryption was fairly important, but less so than all responses.

### Observations

Preference variations from the total group are mostly what would be expected from enterprise users, although the lack of concern about power was surprising. The latter may be due to using relatively few PCIe SSDs in large storage configurations.

Survey results indicate that NVM Express is more widely used, which can be explained by it being available earlier than SOP. Respondents were also more familiar with NVM Express, likely for the same reason.

Interested readers can find more information on PCIe SSDs in the [PCIe SSD 101](#) whitepaper from SSSI.



## Summary & Observations

In total, survey respondents expressed the following preferences for their SSDs:

- Performance was fairly important; IOPS and latency were favored over throughput
- Low power consumption was not as important as performance or endurance
- Endurance was very important
- Data Integrity was fairly important
- Data encryption did not rate very highly

There was, of course, some averaging in the overall ratings. For example, data integrity was weighed down by PC users, who did not value it as highly as enterprise users. Each market segment and application preferred different aspects of performance – IOPS, latency, throughput. It is informative to look at the individual market segments and applications. The following chart uses relative ratings to show the differences in user preferences between market segments and application areas.

		Performance	Power	Endurance	Data Integrity	Data Encryption
Market Segments	All	3	3	4	3	3
	Mobile	2	4	4	3	2
	Desktop	2	4	4	3	4
	Server	4	2	4	4	3
	Subsystem	4	2	4	4	3
Applications	General Office	3	3	4	3	3
	Caching	3	2	4	3	2
	Database	4	2	4	4	2
	Financial	4	2	4	4	3
	Engineering	4	4	4	4	3

Relative Ratings of Major Attributes by Market Segment & Application  
Based on ratings of 1 (Not Important) to 5 (Very Important)



There was little correlation in user preferences between applications and market segments. This is because each application was used in at least two market segments, i.e. engineering applications were used in mobile, desktop, and storage subsystems.

The following chart shows the approximate ratings of the three aspects of performance for each market segment and application.

		IOPS	Latency	Throughput
Market Segments	All	3.0	3.0	2.2
	Mobile	2.7	1.9	2.7
	Desktop	3.0	2.3	2.3
	Server	3.1	4.0	2.0
	Subsystem	3.2	3.4	1.8
Applications	General Office	2.3	2.3	3.0
	Caching	3.3	2.9	1.9
	Database	3.0	4.3	2.3
	Financial	3.0	1.0	2.0
	Engineering	4.0	2.0	2.0

Ratings for Aspects of Performance by Market Segment & Application  
Based on ratings of 1 (Not Important) to 5 (Very Important)

### Performance

No surprise regarding the perceived importance of performance by all respondents. That is, after all, the primary reason to use an SSD. Server and storage subsystem respondents rated performance more highly than desktop and mobile, which were willing to trade off some performance for lower power consumption. All applications rated performance at least fairly important.



All market segments except mobile rated IOPS and latency higher than throughput. Mobile users valued IOPS and throughput equally. Applications rated performance similarly to segments, but with General Office users preferring throughput.

Despite the fact that many SSD data sheets show IOPS and throughput specifications, it is random performance where SSDs truly shine. High IOPS and low latency are indicative of superior random performance.

### **Power**

It was expected that mobile respondents cared about power consumption, as lower power extends battery life. However, desktop respondents valued low power just as much as mobile. Server and storage subsystem users were less concerned about power, possibly because SSDs comprise a relatively small portion of the total storage.

In application areas, engineering users cared most about low power. Caching, database, and financial users felt low power was not important.

The lack of interest in low power in some areas was unexpected. Power management, the ability to shut off portions of the drive not being used, is key to reducing power consumption, and most, if not all SSDs support it today. In many cases, power management is performed transparently to the user, which may be why survey participants felt it was not an issue.

### **Endurance**

Respondents from all segments and applications felt that endurance was very important, and were not willing to trade off endurance for higher capacity or lower cost. Further, most indicated that the device should indicate when it was near its rated write endurance, so the data could be transferred to a new drive. In reality, most SSDs will function longer than users will own the system in which they are originally installed, due to advances in on-drive wear management.



## **Data Integrity**

As could be expected, server and storage subsystem respondents are more concerned that their data remains intact and uncorrupted under all conditions, including loss of power during a write operation. Enterprise drives typically have more on-drive data protection, such as data path integrity checking. Of course, PC users do not want to lose data either, but are more limited in what they can do to protect it, because client drives don't contain the same protection features as those for the enterprise.

Application preferences were fairly consistent with market segments, in that general office users rated data integrity only fairly important, compared to very important for other applications that are more often run in enterprise-level environments.

## **Data Encryption**

The lack of interest in the capability of a drive to self-encrypt data was surprising, and may be due to outdated notions about Self Encrypting Drives. Recent generation SEDs do not measurably impact SSD performance. Key management is also a concern in larger systems with multiple drives. Mobile devices such as notebooks PCs are particularly vulnerable to theft and encryption would prevent the data from being accessed.

## **Final Observations**

This project was initiated to find out which features users want in their SSDs and to start a dialog on related topics via a dedicated LinkedIn group (see the link below). An unexpected discovery was the need for education on issues such as data encryption, power management, and others. SSSI will work to provide more information on these issues to help users to make informed choices about SSDs.



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## Notes

Complete, detailed survey results are available to SSSI members.

For definitions of terms used in this document, please see the [SSSI Glossary of Terms](#).

There is a LinkedIn group on this topic: [SSDs – What’s Important to You?](#). This is the venue for discussing SSD features and gathering opinions on related topics. Join the group and the conversation.

SSSI plans to keep the survey open for an indefinite period, and will continue to accumulate data. The survey is posted at [www.surveymonkey.com/s/LGWKWJL](http://www.surveymonkey.com/s/LGWKWJL).



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## About SNIA

The Storage Networking Industry Association (SNIA) is a not-for-profit global organization, made up of some 400 member companies and 7,000 individuals spanning virtually the entire storage industry. SNIA's mission is to lead the storage industry worldwide in developing and promoting standards, technologies, and educational services to empower organizations in the management of information. To this end, the SNIA is uniquely committed to delivering standards, education, and services that will propel open storage networking solutions into the broader market. For additional information, visit the SNIA web site at [www.snia.org](http://www.snia.org).

## About SSSI

The SNIA Solid State Storage Initiative (SSSI) was formed to foster the growth and success of the market for solid state storage in both enterprise and client environments. It consists of various subcommittees that are focused on developing technical standards and tools in order to educate users about the advantages of SSS devices. For additional information, visit the SNIA SSSI web site at [www.snia.org/forums/sssi](http://www.snia.org/forums/sssi).



**Storage Networking Industry Association**

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