



SD boot: using Secure Digital (SD) card technology for booting HP ProLiant servers

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Abstract

Secure Digital (SD) card technology has been on the market for a number of years as the non-volatile memory card format used for data storage in portable devices such as phones, digital cameras, and personal digital assistant (PDA) devices. However, recent advances in capacity, speed, and reliability levels are expanding SD card applications to areas beyond portable data storage and into the server environment.

HP ProLiant Gen8 server technology gives the system administrator wide flexibility in deployment and operation to meet efficiency and performance goals. This paper describes how ProLiant Gen8 servers use advances in SD card technology to offer an efficient and reliable means for booting operating systems.

SD card technology overview

SD card technology is a popular storage medium based on non-volatile memory cells incorporating Not AND (NAND) gate flash technology. Flash technology is further defined by cell level design, with single layer cell (SLC) and multi-layer cell (MLC) the most commonly used. SLC flash memory uses two threshold voltages to store one bit of information (a “0” or a “1”) in one page per cell. MLC flash memory uses two pages (one fast, one slow) and can detect one of four threshold voltages per cell for storing four states (two bits: 00, 01, 10, 11), yielding higher capacity on a per chip basis over SLC. Table 1 compares SLC flash memory to MLC flash memory.

Table 1. Comparison of SLC versus MLC Flash memory technologies.

	SLC	MLC
Highest density		✓
Lowest per-bit cost		✓
Best endurance	✓	
Highest performance	✓	
Environment best suited for	Industrial	Consumer

Capacity

The original SD card format was limited to 4GB of addressable memory. As SD card technology has progressed, the original limitation has increased significantly—first to 32GB, and now to 2TB of addressable memory. To distinguish the memory limitations, an SD card label indicates the capacity (see Table 2).

Table 2. SD card capacities.

SD card type	Symbol	Card capacity
SD Standard Capacity		Up to 4GB
SD High Capacity		4 – 32GB
SD eXtreme Capacity		32GB – 2TB

HP ProLiant Gen8 servers support SDXC cards and are backward-compatible with SDHC and SDSC cards, allowing the use of any capacity card that is on the market today.

Speed

As the memory in SD cards have increased in speed, it's become necessary to classify the different speed categories as listed in Table 3. SD cards rated at the Ultra-High Speed (UHS) class rating are currently the fastest available, and are capable of 104 MB/s.

Table 3. SD card speed classes.

Class rating	Symbol	Bus speed
Class 2		Up to 12.5 MB/s
Class 4		Up to 12.5 MB/s
Class 6		Up to 12.5 MB/s
Class 10		Up to 25 MB/s
UHS 1 SDR50 SDR104		Up to 50 MB/s Up to 104 MB/s

Reliability/durability

Advances in SD card technology have resulted in highly-developed microcontrollers built into today's SD cards. These microcontrollers provide the following functions that remedy reliability issues found in earlier cards:

- Error-correcting code
- Wear leveling
- Over-provisioning
- Program erase cycles

These functions are provided by the microcontroller built into the SD card and are transparent to the host system.

Error-correcting code

Error Correcting Code (ECC) algorithms built into the SD card's microcontroller detect errors at the controller level and seamlessly correct them without interruption. These algorithms work by detecting incorrect bits in the data transaction and correcting them on the fly.

Wear leveling

NAND technology involves billions of memory cells. Each cell usually holds, 1, 2, or 3 bits of data. Similar to magnetic sectors on traditional hard drives, these cells can slowly degrade based on write frequency. To prevent a single cell from receiving the majority of writes, high-end controllers employ wear leveling. Wear leveling continually changes which physical cells are used to support a specific logical block. With wear leveling, all memory cells will achieve even use ("wear") regardless of how writes are arranged by the host operating system.

Over-provisioning

Over-provisioning is the process of providing extra NAND cells for use in wear leveling as well as housing bad blocks. With over-provisioning, blocks that are beginning to show wear or have been flagged by ECC get cycled out of the active block list. Worn cells are retired before they ever return data errors to the physical file system.

Program erase cycles

When a section of memory needs to change the data that is contained within it, the NAND controller will perform a program-erase (P/E) cycle. Today, NAND memory endurance is generally rated by the number of P/E cycles it can reliably achieve without error. A cell's P/E endurance is also closely related to the number of bits that are stored in each memory cell. The highest grade NAND will only store 1 bit per cell, and is generally rated for 50,000 to 100,000 P/E cycles. Devices that combine wear leveling with large memory capacity will generally take a very long time to show wear. Even then, ECC and over-provisioning can serve to protect data through the initial phases of degradation.

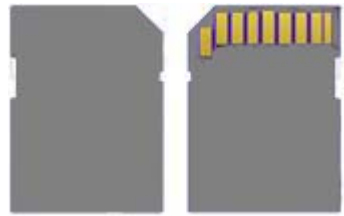
With the demand for lower cost and higher capacity, NAND memory has been developed that will store 2 bits per cell. This low-cost high-capacity NAND memory will usually degrade much sooner, and generally support only 3,000 to 8,000 P/E cycles. To reduce the cost even further, NAND memory has been developed that can store 3 bits per cell. Such memory is very unreliable and will generally report errors at 1000 P/E cycles or less.

Form factor

The SD card specification originally defined a 32 x 24mm card. Advances in NAND technology allowed the introduction of smaller cards (form factors). This has allowed greater adoption since less space is needed to accommodate the card. The SD card specification currently includes three form factors: SD card, miniSD card, and microSD card.

HP ProLiant servers supporting SD boot can accommodate one of the two most common form factors describe in Table 4.

Table 4. SD card form factors accommodated by HP ProLiant servers supporting SD boot.

Type	Description	Dimensions	Form factor
SD card	Original form factor. Large size allows greater capacity at lower price. Includes write-protection lock for setting to read-only.	32 x 24mm	
microSD card	Small size results in greater cost for high capacity.	11 x 15mm	

Benefits of SD boot

SD boot capability opens up a number of key advantages for your data center:

Power Consumption - Our HP SD and microSD Enterprise Mainstream Flash Media cards and ProLiant SD controllers combine to provide one of the lowest wattage boot solutions available on the market today. Peak wattage for the SD controller and the SD card never exceed 2 watts. Typical alternative storage solutions like SAS will consume 5-10 watts for the SAS controller card, and another 5-10 watts for the SAS drive. This is an 80-90% savings on your storage power budget.

Cooling - As a server's power budget is reduced, the amount of cooling required also diminishes since all power consumption is ultimately converted to heat, and thus requires cooling. Secondary cooling savings can be realized by not running hard drives. Hard drives are typically near air intake vents and will preheat intake air as well as constrict air flow. By replacing drives with HP drive blanks, better airflow and cooler intake temperatures can be realized, thus reducing cooling requirements further.

Cost - The ProLiant HP Media kits are priced very competitively in the market of storage solutions. The features included in our media kits are best-in-class on every dimension. There is an initial savings that can be realized in choosing SD boot over controller/drive combos. There is also secondary savings when considering power savings that can be achieved. Tertiary savings can be realized when considering how SD boot can reduce your infrastructure cooling costs as well.

Speed - Although previous generations of SD technology had poor reputations in respect to speed and reliability, these concerns have been addressed in the HP ProLiant SD boot options. SD read speeds are significantly faster than writes; giving servers using SD boot very good performance in read-centric configurations. Since most IO operations (after deployment) are read based (generally 70% read versus 30% write), this gives SD boot operation a clear edge.

Vibration - Some customer configurations are very prone to high vibration. High vibration can be an issue for rotational storage, but has no impact on solid state solutions like SD boot.

Security - Unlike other storage solutions that are externally accessible, ProLiant SD cards install inside the chassis. This can provide an extra level of security for sites that are concerned about externally accessible devices. HP SD form factor media can also be externally locked, preventing any write operations to the media for more security for read-only boot configurations.

SD boot for ProLiant Gen8 servers

Given the advances in capacity, speed, and reliability, SD card technology can now meet the requirements for enterprise storage media, including boot media. Table 5 lists the ProLiant Gen8 servers that include SD boot capability. Depending on constraints and board layout, some servers will accept an SD card while other servers will accept a microSD card (Table 5). Either type of card installs inside the chassis. We recommend using the appropriate HP ProLiant Gen8 SD Media kit (described later) for your server's SD boot media.

Table 5. HP ProLiant Gen8 servers with SD boot capability.

ProLiant server	SD card type accepted
ProLiant DL Gen8 servers: DL320e Gen8 DL320e Gen8 DL360e Gen8 DL360p Gen8 DL380e Gen8 DL380p Gen8 DL385p Gen8	SD card
ProLiant ML Gen8 servers: ML310e Gen8 ML350e Gen8 ML350p Gen8	
ProLiant BL Gen8 servers: BL420c Gen8 BL460c Gen8 BL465c Gen8 BL660c Gen8	microSD card
ProLiant DL Gen8 servers: DL320e Gen8 v2 DL560 Gen8	
ProLiant ML310e Gen8 v2 server	
ProLiant MicroServer Gen8 server	

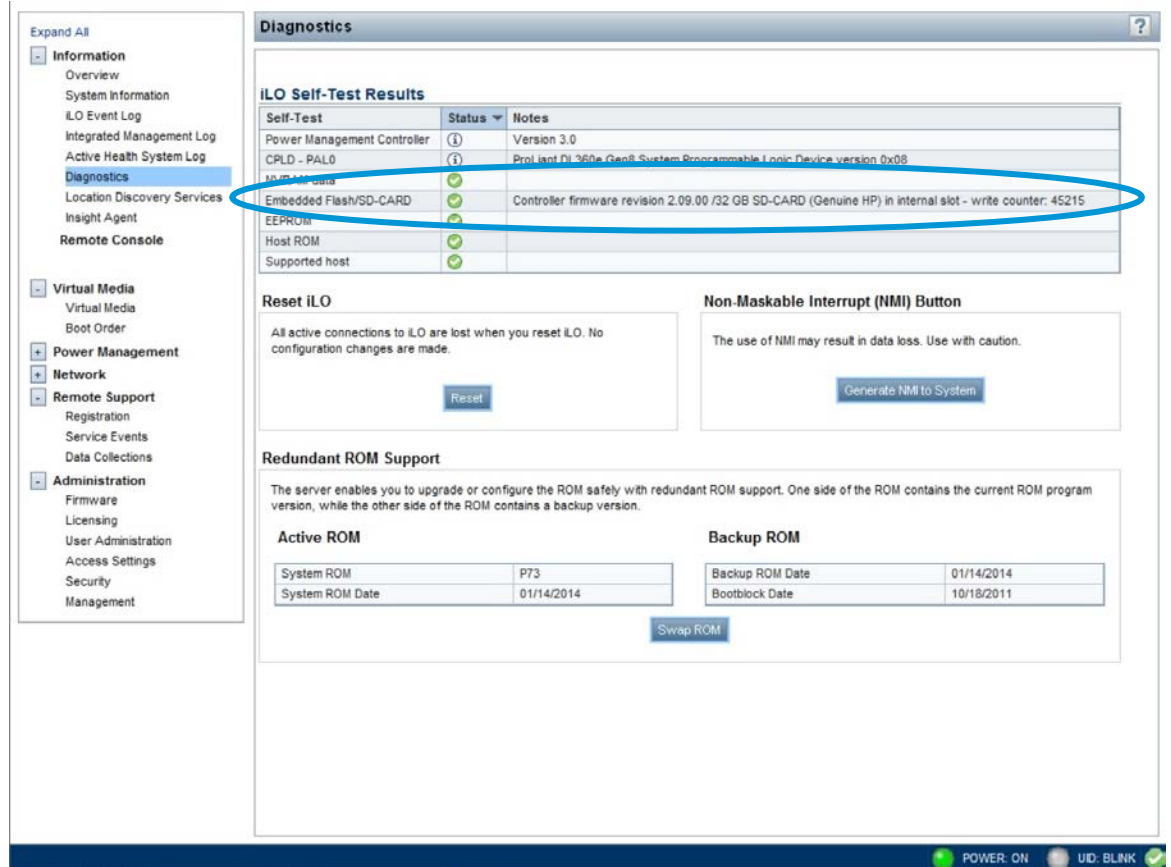
HP Intelligent Provisioning

Intelligent Provisioning is a single-server deployment tool embedded in ProLiant Gen8 servers. The tool replaces the SmartStart CD and the Smart Update Firmware DVD used with previous generations of ProLiant servers. Intelligent Provisioning simplifies server setup with a reliable, consistent method for deploying HP servers. For ProLiant servers that support Intelligent Provisioning, special support has been added for SD boot. When deploying an operating system through Intelligent Provisioning, an HP-approved SD card (if installed) will be listed as a target choice for operating system deployment. This provides a consistent and simple method for deploying Windows or Linux operating systems to SD media. Required revisions of Intelligent Provisioning are versions 1.50 or later.

HP Integrated Lights Out 4 firmware

HP Integrated Lights Out (iLO) is an autonomous management processor integrated on the system board of ProLiant servers. It has become widely accepted as the remote management standard for data centers. To provide usable telemetry and help tune your specific OS workloads for SD boot, iLO 4 firmware has incorporated an SD write counter on the Diagnostics page of the iLO web interface (Figure 1).

Figure 1. SD write counter function in iLO 4



The screenshot displays the HP iLO 4 Diagnostics page. On the left is a navigation menu with categories like Information, Virtual Media, Power Management, Network, Remote Support, and Administration. The 'Diagnostics' section is selected. The main content area is titled 'Diagnostics' and contains the 'iLO Self-Test Results' table. This table has three columns: Self-Test, Status, and Notes. The 'Embedded Flash/SD-CARD' row is highlighted with a blue circle, showing a status of 'Pass' and a note indicating the controller firmware revision and the SD-CARD write counter value of 45215. Below the table are sections for 'Reset iLO', 'Non-Maskable Interrupt (NMI) Button', and 'Redundant ROM Support'.

Self-Test	Status	Notes
Power Management Controller	Pass	Version 3.0
CPLD - PAL0	Pass	ProLiant iLO 360a Gen8 System Programmable Logic Device version 0x08
NVRAM data	Pass	
Embedded Flash/SD-CARD	Pass	Controller firmware revision 2.09.00 /32 GB SD-CARD (Genuine HP) in internal slot - write counter: 45215
EEPROM	Pass	
Host ROM	Pass	
Supported host	Pass	

The SD write counter helps to illustrate how often your OS is writing to the SD card. The SD write counter should be used as a tool to approximate SD wear. The SD write counter is on the Diagnostics page of the iLO web interface. Write size during an OS deployment can be very large (< 1 MB). However, once the OS is deployed the average write operation is typically much smaller (4k-8k).

Note

Although larger writes appear to give a card lower wear, this is a false conclusion since larger writes build up block IO quicker. The SD write counter provides a way for customers to gain visibility into SD wear in high-IO versus low-IO configurations.

Host ROM support

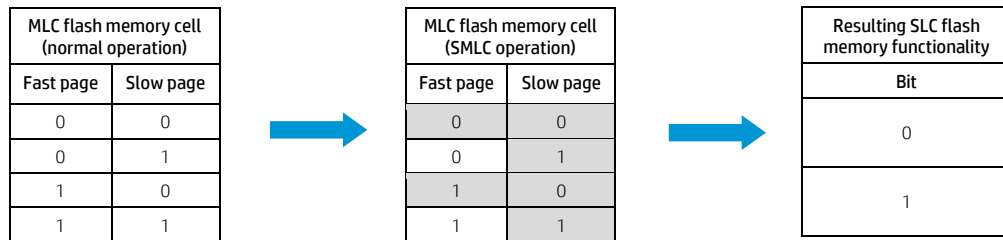
To properly enable HP iLO 4 features related to SD boot requires a host ROM version dated August 20, 2013 or later.

HP ProLiant Gen8 SD Media Kits for SD boot

Due to the great variability in SD reliability and design, we recommend using only HP media specifically designed for SD boot. The HP ProLiant Gen8 SD Media Kits incorporate advanced flash memory technology that offers the performance benefits of SLC and the cost benefits of MLC into one—SLC-MLC, or SMLC technology.

SMLC technology is based on MLC flash memory, but incorporates controller firmware that uses only the fast page of each cell to store a bit state (Figure 2). Since only two threshold levels need to be detected instead of four, MLC reliability is increased. The significantly lower per-bit cost of MLC hardware means that even discarding the slow page cell operation results in a more economical solution than with SLC hardware.

Figure 2. SMLC flash memory technology used in HP SD media kits.



For SD boot in ProLiant Gen8 servers with an SD slot we recommend the HP 32GB SDHC Enterprise Mainstream Flash Media Kit (Part Number 700136-B21). For SD boot in ProLiant Gen8 servers with a microSD slot we recommend the HP 32GB microSDHC Enterprise Mainstream Flash Media Kit (Part Number 700139-B21). Table 6 details the key specifications of the HP Media solutions.

Table 6. HP ProLiant Gen8 Media Kits for SD boot.

	8GB SDHC Enterprise Mainstream Flash Media Kit	8GB microSDHC Enterprise Mainstream Flash Media Kit	32GB SDHC Enterprise Mainstream Flash Media Kit	32GB microSDHC Enterprise Mainstream Flash Media Kit
Part number	726113-B21	723116-B21	700136-B21	700139-B21
Form factor	SD slot	microSD slot	SD slot	microSD slot
Flash technology	SMLC			
Legacy Speed Classification	Class 10			
UHS Speed Classification	UHS-I			
ECC	Yes; 40-bit ECC			
Wear Leveling	Yes			
Over Provisioning	Yes; 7%			
Cell Data Density	1 bit per cell	1 bit per cell	1 bit per cell	1 bit per cell
P/E Cycles	50,000			
Projected block writes (see note below)	409,600,000	3,276,800,000	1,638,400,000	13,107,200,000

Note:

Due to specific blocking and performance considerations, microSD solutions will actually wear slower than SD solutions.

Deploying an OS to an SD card

Intelligent Provisioning supports deploying an OS to an SD card. The SD card then provides SD boot and OS drive space functionality instead of a hard disk drive or a solid state drive.

Prerequisites

The following elements are required for using Intelligent Provisioning to deploy an OS to an SD card for an HP ProLiant Gen8 server:

- HP ProLiant Gen8 server with Intelligent Provisioning v1.50 or later
- Host ROM dated August 20th, 2013 or later
- iLO 4 v1.30 or later
- HP 32GB SDHC Enterprise Mainstream Flash Media Kit (Part Number 700136-B21) or HP 32GB microSDHC Enterprise Mainstream Flash Media Kit (Part Number 700139-B21) installed in the server.

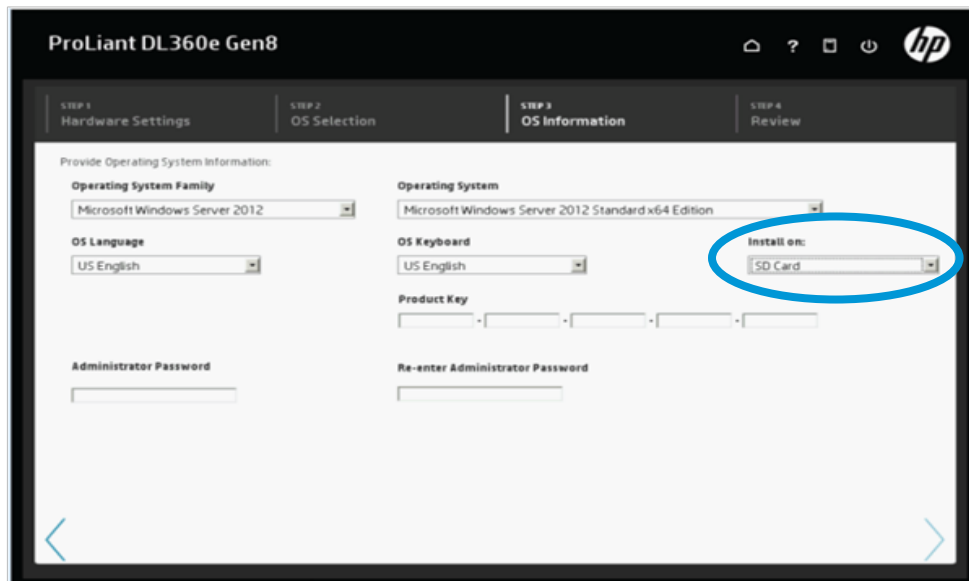
Note

The HP SD and microSD Enterprise Mainstream Flash Media cards are the only SD cards supported by Intelligent Provisioning. All other SD cards will result in an error message.

Setup

Intelligent Provisioning uses a four-step process to prepare the system for installing off-the-shelf and HP versions of leading OS software and integrating HP ProLiant server support software:

- **Step 1:** Hardware settings such as system profiles, array configuration, fiber channel configuration
- **Step 2:** OS selection such as OS family, install method, and source media type
- **Step 3:** OS information such as OS version, keyboard type, and “Install on” target device. The default “Install on” selection of **Storage Controller** can be changed to **SD card** as shown below:



- **Step 4:** Review

Note

The complete deployment process is described in the “[Intelligent Provisioning User Guide](#)” guide available online.

Booting from an SD card

Once the OS is deployed to the SD card, the card can be used in any ProLiant Gen8 system that supports SD boot (refer to Table 5). The server's drive boot order in the ROM-Based Setup Utility (RBSU) must be set to enable booting from the SD card.

SD boot considerations

Enterprise server environments differ on requirements, goals, and applications being run. For example, VMware® environments, where the focus is on performance and reliability with a small deployment footprint, the 8-GB SD media kits are recommended.

SD boot may not be advisable for some environments. OS drive space services both reads and writes, and write-centric operations affect the endurance of an SD card. The following situations may not be suitable for SD boot or may require re-configuring their operation:

I/O profile – Write-centric configurations such as locally hosted databases or virtual machines (VMs) are not recommended. Such configurations are best served with dedicated high-end shared storage. Using an SD card to serve VMs or databases housed on dedicated storage helps both to isolate mission critical storage as well as maximize return on investment (ROI) on high end storage solutions without requiring repetitive OS images.

Swapping – Swapping to SD is certainly allowed, but it will actually diminish both SD endurance and system performance. Swap commits to SD will be much slower than simply maintaining those pages in memory. Since most servers today are configured with plenty of memory to operate without a swap file, swapping can be turned off.

Logging – Although many people take system log files as a given, the continual commit of low bandwidth logs can slow down SD-based systems and reduce SD endurance. SD counters in iLO can be used to measure and determine the amount of writes idle logs can generate. You can improve logging performance by:

- Reduce logs down to the lowest amount possible.
- Re-direct logging for many systems to network attached storage instead of locally attached disks. This also provides centralized locations for logs for collection of data.

Crash dumps – Although crash dumps are rare, default crash dump configurations are generally over cautious and in some cases can be disabled. Reducing the size of crash dumps can allow a good middle ground while still providing some of the features and desired event analysis.

Hibernation files – In typical server environments hibernation features are used rarely—if at all. These features can be removed without concern. In many cases, this will reduce hibernation file creation, which can slow startup, shutdown or deployment events.

Conclusion

With the rapid speed and progression of SD and NAND technology, it can be very difficult to find good comparable solutions. Our newest HP ProLiant SD boot media kits have been specifically designed, engineered, and qualified for these roles and tasks.

Resources, contacts, or additional links

HP Intelligent Provisioning overview

hp.com/products/servers/management/intelligentprovisioning/index.html?jumpid=reg_r1002_usen_c-001_title_r0001

HP Intelligent Provisioning User Guide

hp.com/bc/docs/support/SupportManual/c03182305/c03182305.pdf

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