Dell PowerEdge Server BIOS Security Configuration Guide

For 16G Intel-based PowerEdge servers

Abstract

This PowerEdge server BIOS Security Configuration Guide (SCG) describes the BIOS security features that you can use to manage and customize your PowerEdge servers with Intel processors. It also defines the fields used to configure these attributes and best practices for defining values in each field, where appropriate.

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Revisions

Date	Version	Author	Description
February 29, 2024	V1.1	Cecil Sheng and Ivy Yang	Combined 16G Intel Security Configuration Guides.

Acknowledgments

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Contents

Prefaces

As part of an improvement effort, revisions of the software and hardware are periodically released. Some functions that are described in this SCG are not supported by all versions of the software or hardware currently in use. The product Release Notes provides the most up-to-date information about product features. Contact your service provider if a product does not function properly or does not function as described in this SCG.

Where to get help

For information about support, product, and licensing, visit the following websites:

- Product information and troubleshooting—For product and feature documentation or Release Notes, go to https://www.dell.com/support and locate the appropriate product support page.
- Technical support—For technical support and service requests, go to https://www.dell.com/support and locate the **Service Requests** page. To open a service request, you must have a valid support agreement. Contact your Sales Representative for details about obtaining a valid support agreement or to answer any questions about your account.

1 Overview

The PowerEdge servers have provided robust security for several generations, including the innovation of using silicon-based data security. Starting from 15G, Dell introduced iDRAC Root-of-Trust (RoT) to authenticate BIOS at a higher security level. The Dell product team has considered several key requirements during the design of 16G PowerEdge servers in response to security threats faced by modern IT environments:

- **Protect**—Protect server during every aspect of lifecycle, including BIOS, firmware, data, and physical hardware.
- **Detect**—Detect malicious cyberattacks and unapproved changes; engage IT administrators proactively.
- **Recover**—Recover BIOS, firmware, and OS to a known good state; securely retire or repurpose servers.

The PowerEdge servers conform to key industry standards on cryptography and security as elaborated throughout this technical white paper and perform on-going tracking and management of new vulnerabilities. The intended audience for this document includes system administrators, who are responsible to maintain and deploy servers and ensure that network and infrastructure security best practices are followed.

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1.1 Security development lifecycle

Dell has implemented the security development lifecycle process with security as a key element in every aspect of development, procurement, manufacturing, shipping, and support resulting in a Cyber Resilient Architecture in PowerEdge servers.

1.2 Threat and Dell server BIOS solution

Table 1 Dell server BIOS solution

Security Layer	Threat Vector	Dell Solution
Physical server	Server tampering	Physical deterrents

Firmware and software	Corrupted firmware, malware injection	• iDRAC Root-of-Trust • Intel Boot Guard • Cryptographically signed and validated firmware
Attestation trust features	Server identity spoofing	• TPM • TXT • Chain of trust • TME • SGX* • TDX*
Server Management	Rogue configuration and updates, unauthorized open-port attacks, data leak, and corruption	• iDRAC9 • Persistent memory passphrase*

*This feature is currently not supported on one-socket, Intel based, PowerEdge servers.

2 Protect a PowerEdge server using BIOS

2.1 Cryptographically verified Trusted Boot

2.1.1 iDRAC Root-of-Trust and Silicon-based Root-of-Trust

Starting from 14G, the PowerEdge servers use an immutable, silicon-based Root-of-Trust (RoT) to cryptographically attest the integrity of BIOS and iDRAC firmware. This Root-of-trust is based on one-time programmable, read-only public keys that provide protection against malware tampering.

The BIOS boot process leverages Intel Boot Guard technology which verifies that the digital signature of the cryptographic hash of the boot image matches the signature stored in silicon by Dell during manufacturing. A failure to verify results in a shutdown of the server, user notification in the Lifecycle Controller Log, and the BIOS recovery process can then be initiated by the user. If Boot Guard validates successfully, the rest of the BIOS modules are validated by using a chain of trust procedure until control is handed off to the Operating System (OS) or hypervisor.

Starting from 15G, the PowerEdge servers provides even higher security level by introducing iDRAC Root-of-Trust. The iDRAC Root-of-Trust provides a critical trust anchor for authenticating the signatures of Dell firmware Update Packages (DUPs) including BIOS firmware update.

More information about the chain of trust provided in this section. Each BIOS module contains a hash of the next module in the chain. The key modules in BIOS are the Initial Boot Block (IBB), Security/Pre-EFI Initialization (SEC/PEI), Driver Execution Environment (DXE), and Boot Device Selection (BDS). The iDRAC RoT first checks the signature stored in the BIOS image file. Only if the signature is valid, the system can boot. The Intel BootGuard then authenticates the IBB (Initial Boot Block), a module in the IBB authenticates the next part of BIOS, the SEC/PEI section. A module in the section then authenticates the DXE/BDS section of the BIOS image file. In the BDS phase, if Secure Boot is enabled, the authentication process is handled by the secure boot driver.

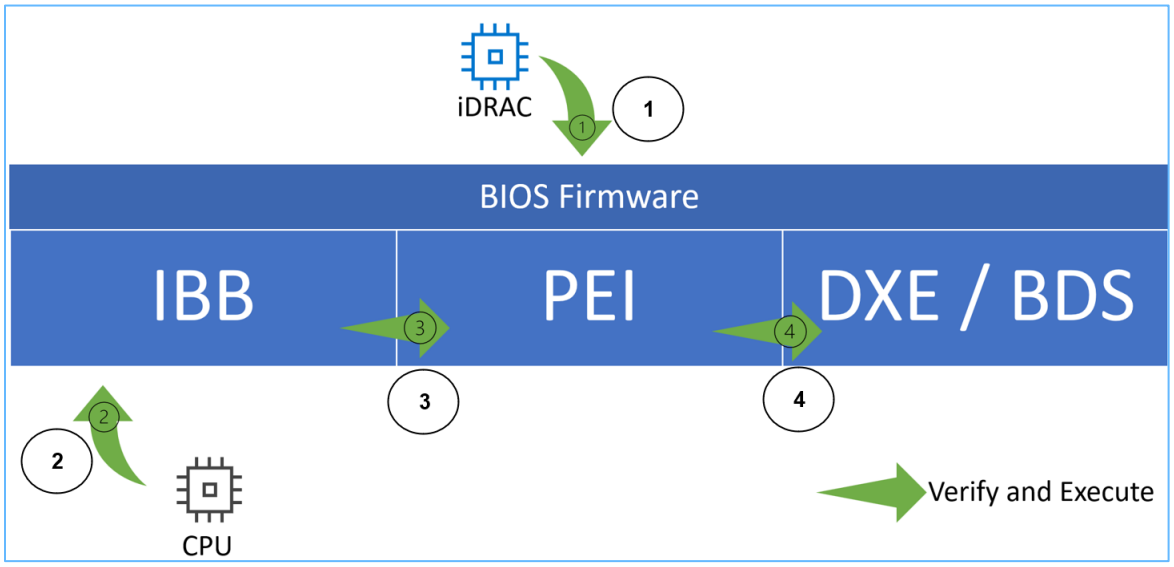

Figure 1 Process of authentication using the Chain of Trust feature in iDRAC

2.1.2 UEFI Secure Boot Support

The PowerEdge servers also support industry standard Unified Extensible Firmware Interface (UEFI) Secure Boot which checks the cryptographic signatures of UEFI drivers and other code loaded prior to the OS running. Secure Boot represents an industry-wide standard for security in the pre-boot environment. Computer system vendors, expansion card vendors, and operating system providers collaborate on this specification to promote interoperability.

When enabled, UEFI Secure Boot prevents unsigned (that is, untrusted) UEFI device drivers from being loaded, displays an error message, and does not allow the device to function. You must disable Secure Boot to load unsigned device drivers.

In addition, PowerEdge servers offer customers the unique flexibility of using a customized boot loader certificate not signed by Microsoft. This is primarily a feature for administrators of Linux environments that want to sign their own OS boot loaders. Custom certificates can be uploaded via the preferred iDRAC API to authenticate the customer's specific OS boot loader.

The default configuration for Secure Boot is disabled. Do the following to enable the Secure Boot:

1. Power on the system.
2. When the company logo is displayed, press F2 to open the System Setup page.
3. On the System Setup Main Menu page, click **System BIOS** → **System Security**.
4. To enable the Secure Boot feature, click **Enable**.

Table 2 Options and Descriptions to enable the Secure Boot

Option	Description
Secure Boot	Enables Secure Boot, where the BIOS authenticates each pre-boot image by using the certificates in the Secure Boot Policy. Secure Boot is set to Disabled by default.
Secure Boot Policy	When Secure Boot policy is set to Standard, the BIOS uses the system manufacturer's key and certificates to authenticate pre-boot images. When Secure Boot policy is set to Custom, the BIOS uses the user-defined key and certificates. Secure Boot policy is set to Standard by default.
Secure Boot Mode	Configures how the BIOS uses the Secure Boot Policy Objects: • Platform Key (PK) • Key Exchange Key Database (KEK) • Authorized Signature Database (db) • Forbidden Signature Database (dbx) If the current mode is set to Deployed Mode, the available options are User Mode and Deployed Mode. If the current mode is set to User Mode, the available options are User Mode, Audit Mode, and Deployed Mode. • User Mode—In User Mode, PK must be installed, and BIOS performs signature verification on programmatic

	attempts to update policy objects. The BIOS allows unauthenticated programmatic transitions between modes. • Audit Mode—In Audit Mode, PK is not present. BIOS does not authenticate programmatic update to the policy objects and transitions between modes. The BIOS performs a signature verification on pre-boot images and logs the results in the image Execution Information Table but executes the images whether they pass or fail verification. Audit Mode is useful for programmatic determination of a working set of policy objects. • Deployed Mode—Deployed Mode is the most secure mode. In Deployed Mode, PK must be installed, and the BIOS performs signature verification on programmatic attempts to update policy objects. Deployed Mode restricts the programmatic mode transitions.
Secure Boot Policy Summary	Specifies the list of certificates and hashes that secure boot uses to authenticate images.
Secure Boot Custom Policy Settings	Configures the Secure Boot Custom Policy. To enable this option, set the Secure Boot Policy to Custom option.

2.1.3 TPM support

PowerEdge servers support two versions of Trusted Platform Module (TPM):

- TPM 1.2 FIPS + Common Criteria+ TCG certified (Nuvoton)
- TPM 2.0 FIPS + Common Criteria+ TCG certified (Nuvoton)

TPM can perform public key cryptographic functions, computing hash functions, generating, managing and securely storing keys, and attestation. The Intel Trusted Execution Technology (TXT) functionality and Microsoft Platform Assurance feature in Windows Server 2016 and later are also supported. TPM can be used to enable the BitLocker™ hard drive encryption feature in Windows Server 2012 and later. TPM is compatible with the remote attestation HyTrust CloudControl solution Attestation and remote attestation systems can employ the TPM to take measurements of a server's hardware, hypervisor, BIOS, and OS during startup time and compare them to base measurements recorded in the TPM in a cryptographically secure way. If they are not the same, the server identity has been compromised, and system administrators can shut and disconnect the server locally or remotely.

TPM is enabled through a BIOS option. It is offered as a Plug-In Module solution, the planar has a connector for this plug-in module. However, once the TPM module is enabled on any Dell PowerEdge 13G server (or later), that physical chip is now permanently tied to that specific server and cannot be moved to any other system. This physical and cryptographic binding ensures that the platform integrity cannot be breached or the data cannot simply be moved to another platform along with the TPM.

Do the following to enable the TPM:

1. Power on the server.
2. When the company logo is displayed, press F2 to open the **System Setup** page.

3. On the System Setup Main Menu page, click **System Setup Main Menu → System BIOS → System Security**.
4. Set the TPM Security from Off to the required state. For TPM 1.2, ensure that TPM is activated.

Table 3 TPM 1.2 Setup option details

Option	Description
TPM Security	**Note**—The TPM menu is available only when the TPM module is installed. Enables you to control the reporting mode of the TPM. The **TPM Security** option is set to **Off** by default. You can only modify the TPM Status, and TPM Activation if the **TPM Status** field is set to either **On with Pre-boot Measurements** or **On without Pre-boot Measurements**. When TPM 1.2 is installed, the **TPM Security** option is set to **Off**, **On with Pre-boot Measurements**, or **On without Pre-boot Measurements**.
TPM Information	Changes the operational state of the TPM. This option is set to **No Change** by default.
TPM Firmware	Indicates the firmware version of the TPM.
TPM Status	Specifies the TPM status.
TPM Command	Controls the Trusted Platform Module (TPM). When set to **None**, no command is sent to the TPM. When set to **Activate**, the TPM is enabled and activated. When set to **Deactivate**, the TPM is disabled and deactivated. When set to **Clear**, all the contents of the TPM are cleared. This option is set to **None** by default.

Table 4 TPM 2.0 security information

Option	Description
TPM Security	**Note**—The TPM menu is available only when the TPM module is installed. Enables you to control the reporting mode of the TPM. The TPM Security option is set to Off by default. You can only modify the TPM Status, and TPM Activation if the TPM Status field is set to On. When TPM 2.0 is installed, the TPM Security option is set to Off or On. This option is set to Off by default.
TPM Information	Changes the operational state of the TPM. This option is set to No Change by default.
TPM Firmware	Indicates the firmware version of the TPM.
TPM Hierarchy	Enables, disables, or clears the storage and endorsement hierarchies. • When set to Enabled, the storage and endorsement hierarchies can be used. • When set to Disabled, the storage and endorsement hierarchies cannot be used. • When set to Clear, the storage and endorsement hierarchies are cleared of any values, and then reset to Enabled.
TPM Advanced Settings	Specifies TPM Advanced Settings.

2.1.4 Intel TXT support

The Intel TXT feature provides the hardware basis for platform to validate platform trustworthiness during boot. It allows integrity verifications on BIOS, operating system loader, and hypervisor.

Prerequisites

To enable the **Intel TXT** option, another option **Virtualization Technology** must be set to ON. Also, **TPM Security** must be set to ON for TPM2.0.

To enable TXT, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click **System BIOS** → **System Security**.
3. On the System Security screen, set the **Intel TXT** option to **On**.
4. Save settings and close the System Setup page. Restart for the new settings to become effective.

Table 5 Option to enable Intel TXT

Option	Description
Intel(R) TXT	Enables you to set the Intel Trusted Execution Technology (TXT) option. To enable the Intel TXT option, virtualization technology and TPM Security must be enabled with Pre-boot measurements. This option is set to Off by default.

2.1.5 Signed firmware updates

PowerEdge servers have used digital signatures on firmware updates for several generations to assure that only authentic firmware is running on the server platform. We digitally sign our firmware packages using SHA-384 hashing with 3072-bit RSAPSS encryption for the signature for BIOS. The iDRAC scans the firmware updates and compare their signatures to what is expected using the silicon-based Root-of-Trust; any firmware package that fails validation is aborted and an error message is logged into the Lifecycle Log (LCL) to alert IT administrators.

Enhanced firmware authentication is embedded within many third party devices which provide signature validation using their own Root-of-Trust mechanisms. This prevents the possible use of a compromised third party update tool from being used to load malicious firmware. For example, a NIC or storage drive (and bypassing the use of signed Dell update packages). Many of the third party PCIe and storage devices shipped with PowerEdge servers use a hardware Root-of-Trust to validate their respective firmware updates.

If any firmware in any device is suspected of malicious tampering, IT administrators can roll back many of the platform firmware images to a prior trusted version stored in iDRAC. As an example, keep two versions of device firmware on the server:

- The existing production version (N).
- A prior trusted version (N-1).

Also, for 15G, an unsigned image file update from production level BIOS image file is not supported. To update the System BIOS, download DUP or EFI image files from Dell websites. To ensure the image file integrity, th verify the checksum value of downloaded image files. The Checksum value is displayed on the Download page. For example, the checksum values of a BIOS DUP file are shown in the sample screen shot:

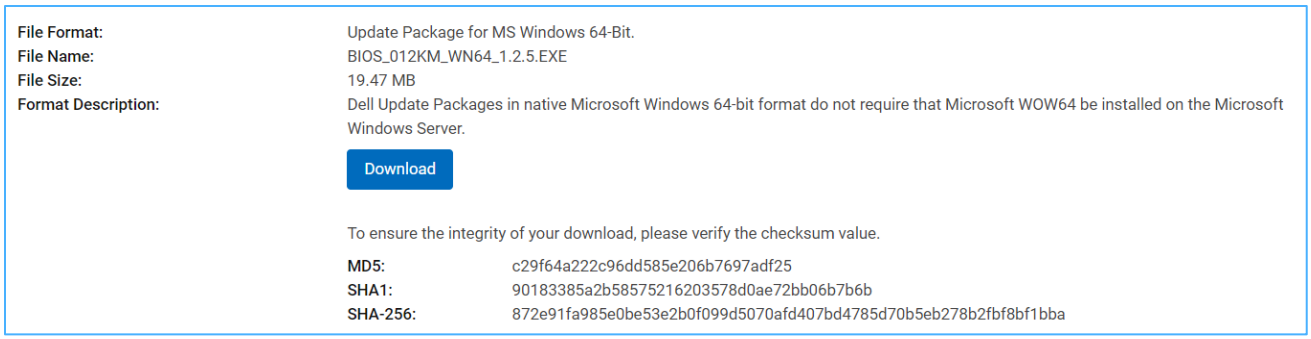

Figure 2 Example of a BIOS DUP files checksum

2.2 Disable USB ports

You can entirely disable USB ports for added protection. You can also disable only the USB ports on the front of the device. USB ports, for example, can be deactivated for production use and then temporarily enabled to allow debugging access to a crash cart. Following are the options to configure USB ports:

Table 6 Options to configure USB ports

Option	Description
User Accessible USB Ports	• Configures the user-accessible USB ports. • Selecting Only Back Ports On disables the front USB ports. • Selecting All Ports Off disables all front and back USB ports. • Selecting All Ports Off (Dynamic) disables all front and back USB ports during POST and front ports can be enabled or disabled dynamically by authorized user without resetting the system. This option is set to **All Ports On** by default. When user-accessible USB ports are set to All Ports Off (Dynamic), the Enable Front Ports Only option is enabled. • Enable Front Ports Only: Enables or disables the front USB ports during the OS runtime. The USB keyboard and mouse still function in certain USB ports during the boot process, depending on the selection. After the boot process is complete, the USB ports will be enabled or disabled as per the setting.
iDRAC Direct USB Port	The iDRAC Direct USB port is managed by iDRAC exclusively with no host visibility. This option is set to ON or OFF. When set to OFF, iDRAC does not detect any USB devices installed in this managed port. This option is set to ON by default.

2.3 Create a setup password in BIOS

When you receive a PowerEdge server, you must create a BIOS System Password and a BIOS Setup Password to protect the BIOS and the boot sequence.

Prerequisites

Ensure that the password jumper is enabled. The password jumper enables or disables the system password and setup password features. For how to use password jumper, see the **System board jumper settings** section in the **Installation and Service Manual** of the server.

NOTE—If the password jumper is set to disabled, the existing system password and setup password are deleted, and you need not provide the system password to boot the system. The server case must be opened to access the password jumper, which will be logged as an intrusion event.

Do the following to create a system and setup password:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click **System BIOS** → **System Security**.
3. On the System Security screen, verify that Password Status is set to Unlocked.
4. In the **System Password** field, type your system password, and press Enter or Tab. Use the following guidelines to assign the system password:
   A password can have up to 32 characters.
   A message prompts you to reenter the system password.
5. Re-enter the system password and click **OK**.
6. In the Setup Password field, type your setup password and press Enter or Tab. A message prompts you to reenter the setup password.
7. Re-enter the setup password and click **OK**.
8. Press Esc to return to the System BIOS screen. Press **Esc** again. A message prompts you to save the changes.

NOTE—The Password protection feature will not be effective until the server is restarted.

2.3.1 Secure system using system password

If you have assigned a setup password, the system accepts your setup password as an alternate system password.

Do the following to secure the system using password:

1. Power on the system.
2. Type the system password and press **Enter**.

When the **Password Status** is set to **Locked**, type the system password, and press **Enter** when prompted to reboot.

NOTE—If an incorrect system password is typed, the system displays a message and prompts you to re-enter your password. You have three attempts to type the correct password. After the third unsuccessful attempt, the system displays an error message that the system has stopped functioning and must be turned off. Even after you power off and restart the system, the error message is displayed until the correct password is entered.

2.3.2 Delete or change system and setup password

Prerequisites

NOTE—You cannot delete or change an existing system or setup password if the **Password Status** is set to **Locked**.

To change or delete the server and setup password, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click System BIOS → System Security.
3. On the System Security screen, ensure that Password Status is set to Unlocked.
4. In the **System Password** box, alter or delete the existing system password, and then press Enter or Tab.
5. In the **Setup Password** field, alter or delete the existing setup password, and then press Enter or Tab.
6. If you change the system and setup password, a message prompts you to re-enter the new password. If you delete the system and setup password, a message prompts you to confirm the deletion.
7. Press Esc to return to the **System BIOS** screen. Press Esc again. A message prompts you to save the changes.
8. Select **Setup Password**, change or delete the existing setup password and press Enter or Tab.

NOTE—If you change the system password or setup password, a message prompts you to re-enter the new password. If you delete the system password or setup password, a message prompts you to confirm the deletion.

2.3.3 Operating with setup password enabled

If **Setup Password** is set to **Enabled**, type the correct setup password before modifying the system setup options. If you do not type the correct password in three attempts, the system displays the following message:

```
Invalid Password! Number of unsuccessful password attempts: <x> System Halted!
Must power down.
```

Even if you turn off and restart the system, the error message is displayed until the right password is entered. There are a few exceptions:

- If System Password is not set to Enabled and is not locked through the Password Status option, you can assign a system password.
- You cannot disable or change an existing system password.

NOTE—You can use the password status option with the setup password option to protect the system password from unauthorized changes.

2.3.4 Password status

Password status allows an administrator to maintain a setup password to protect against unauthorized BIOS Setup changes, while a user can freely change the system password.

Table 7 Option for the password status

Option	Description
Password status	Unlocked—the system password can be changed without entering the setup password. Locked— the setup password must be entered to change the system password. To prevent the system password from being modified without providing the setup password, set this option to **Locked** and enable the setup password.

2.4 Persistent memory passphrase feature

NOTE— This feature is currently not supported on one-socket, Intel based, PowerEdge servers.

The purpose of persistent memory security is to protect data located in the persistent memory region of an Intel Optane memory module. The data is secured (no read or write access) if a passphrase in the memory module is set. The passphrase is stored in encrypted format. After a system reset, the data is inaccessible until the Dell security driver unlocks the memory module with the correct passphrase. Note that the user does not need to re-enter the passphrase at this point. The memory modules are unlocked automatically by BIOS if the passphrase is correct.

This is to protect the Optane memory modules from being physically removed from a system and installed in another system so that the data can be accessed.

The Dell Persistent Memory Security BIOS feature provides the following functionality:

- A Setup option Persistent Memory Passphrase to config the passphrase.
- If a passphrase is set, the persistent area of the Optane memory modules are encrypted during `POST`.

The Setup option allows the user to set, change, or delete the passphrase. All Optane Memory modules with or without a persistent memory region are affected if the passphrase is modified. Entering an empty passphrase will delete the passphrase and disable security in the Optane memory modules.

The setup option **Persistent Memory Passphrase** field is only available if at least one Optane memory module is installed on the system.

To set up persistent memory passphrase, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click **System BIOS** → **Memory Settings** → **Persistent Memory** → **Intel Persistent Memory**.
3. In the **Persistent Memory Passphrase** option, set or change or remove the passphrase.
4. Save settings and exit Setup. Reboot for new passphrase to take effect.

If a secured Optane memory module cannot be unlocked with the passphrase, BIOS displays an error message to the screen and lifecycle Log, and pauses at the F1 or F2 prompt.

Message

```
The data in the Persistent Memory DIMM located in memory slot <slot label> is
not accessible because the DIMM is locked and the passphrase is incorrect.
```

Recommended Response Action

Update the Persistent Memory Passphrase to the correct passphrase or perform a Secure Erase operation on the failed DIMM.

NOTE—Secure erase will erase all persistent data.

2.5 UEFI variable access

UEFI variables are used for various system configurations and some variables are very critical and essential. Adding the access restriction (write-protected) is a feature to protect those UEFI variables and mitigate the vulnerability caused by unexpected system configuration.

A BIOS setup item **UEFI Variable Access** is provided to control the access restriction of UEFI variable:

- **Standard**—Default setting indicates the access is based on the definition of UEFI specification.
- **Controlled**—Indicates some specific UEFI variables are protected and cannot be modified in an OS environment.

The following UEFI variables are write-protected when BIOS attribute `UefiVariableAccess` is set to "**Controlled**" mode.

Table 8 List of UEFI variable names and variable GUID

UEFI Variable Name	UEFI Variable GUID
L"BootNext"	EFI_GLOBAL_VARIABLE
L"DriverOrder"	EFI_GLOBAL_VARIABLE
L"ConIn"	EFI_GLOBAL_VARIABLE
L"ConOut"	EFI_GLOBAL_VARIABLE
L"BootState"	EFI_GLOBAL_VARIABLE
L"ReserveMemFlag"	EFI_GLOBAL_VARIABLE
L"UefiOptimizedBoot"	{0x356471b1, 0xb483, 0x42ae, 0xb6, 0xe7, 0x3b, 0x2e, 0xba, 0xb1, 0x4e, 0x15}

NOTE—The setting `UefiVariableAcces` to **Controlled** may cause Linux DUP support to stop working. For example, if Linux DUP attempts to write to variables such as **BootNext**, those variables are now write-protected. This is expected behavior since the user opted-in to the extra protection.

To control UEFI Variable Access, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the **System Setup Main Menu** screen, click **System BIOS** → **System Security**.
3. Enable UEFI Variable Access by setting it to Controlled.
4. Save settings and exit Setup. Restart the server to make the updated settings become effective.

2.6 Intel Total Memory Encryption (TME) and Multi-Tenant (MT)

NOTE— This feature is currently not supported on one-socket, Intel based, PowerEdge servers.

Intel TME enables the encryption of memory pages across system. When you use the single key, software code modification is not required. It uses the National Institute of Standards and Technology (NIST), Advanced Encryption Standard (AES) XTS based algorithm with 128-bit keys or 256-bit keys depending on availability and selection of algorithm. The key to encrypt the entire physical memory of the system comes from hardware random number generator in Intel System on Chip (SoC). Ensure that the key is not accessible to software or use external interfaces to Intel SoC.

TME-MT uses the same hardware architecture with TME. The difference is that it allows multiple keys to be used.

Prerequisite

Platform must meet certain requirements before TME can be enabled:

- Processor must be **Total Memory Encryption** capable.

To enable the Memory Encryption, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click System BIOS → System Security.
3. Enable "**Memory Encryption**" by setting it to either "**Single Key**" or "**Multiple Key**".
4. Save settings and exit Setup. Restart the server to make the changes effective.

Table 9 Memory Encryption setup options

Option	Description
Intel® Memory Encryption	Enables or disables the Intel Total Memory Encryption (TME and TME-MT). • Disabled—BIOS disables both TME and TME-MT technology. This is the default value. • Single Key—BIOS enables the TME technology. • Multiple Keys—BIOS enables the TME-MT technology.

2.6.1 Intel Software Guard Extensions

NOTE—This feature is currently not supported on one-socket, Intel based, PowerEdge servers.

The PowerEdge servers support Intel Software Guard Extensions (Intel® SGX), CPU instructions, and platform enhancements. It allows software to protect its sensitive information by creating secure enclave. With significantly smaller trusted computing base, software sensitive information is protected from hardware or software attacks even if OS ring0 and BIOS/SMM are compromised. It also helps prevent memory snooping by keeping the secure perimeter to CPU package boundary. In other words, code and data are encrypted outside of CPU package so external memory read only sees encrypted code and data.

During the Initial Platform Establishment boot flow, the BIOS checks the key blobs for each CPU package to verify that they are all consistent with the platform. Microcode sees that there are no key blobs provided and generates the new platform keys. The new platform keys are randomly generated for this platform instance. Each CPU package uses its HW key to encrypt the shared platform keys and generate a key blob. BIOS stores the key blobs in flash for future boots. Microcode also generates a new platform manifest for the new platform instance. BIOS provides the new platform manifest to software via the `SGXRegistrationServerRequest` UEFI variable and indicates that a registration flow is required using the `SGXRegistrationStatus` UEFI variable. The registration authority service must evaluate the new platform manifest before it can generate any PCK Certificates for the new platform.

Prerequisite

Platform must meet certain requirements before SGX can be enabled:

- Processor must be SGX capable.
- Memory population must be compatible. Minimum configuration is 8 identical DIMMs per CPU socket (DIMM1 to DIMM8). See the following table.
- Memory operating mode must be set to the **Optimizer** mode.

- Memory encryption must be enabled.
- Node interleaving must be disabled.

DDR4	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1	Slot0	Slot1
8	DDR4		DDR4		DDR4		DDR4		DDR4		DDR4		DDR4		DDR4	
12	DDR4	DDR4	DDR4		DDR4	DDR4	DDR4		DDR4	DDR4	DDR4		DDR4	DDR4	DDR4	
16	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4

Figure 3 List of platform with DIMM per channel

Note: The table displays the platforms that have two DIMMs per channel. Some platforms might have only one DIMM per channel. In that case, SGX supported configuration will be fully populated.

To enable SGX, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the System Setup Main Menu screen, click **System BIOS** → **System Security**.
3. Enable **Intel SGX** by setting it to **On**.
4. Set the **PRMRR size** to desired size. After the next boot operation, BIOS will try to allocate one PRMRR with selected **PRMRR size** per **NUMA/Sub NUMA** domain.
5. Save the settings and exit Setup. Restart the server to make the changes effective.

Table 10 SGX setup options

Option	Description
Intel® SGX	Enables you to set the Intel Software Guard Extension (SGX) option. This option is set to **Off** by default. When this option is to **Off**, BIOS disables the SGX technology. When this option is to **On**, BIOS enables the SGX technology.
SGX Package Info In-Band Access	Enables you to access the **Intel Software Guard Extension (SGX) package info in-band** option. This option is set to **Off** by default. Each CPU package on the platform has a key blob when SGX is enabled on a multi-package platform. BIOS provides a mechanism for retrieving the key blobs. Platform owners may want to maintain a copy of the key blobs in case they need to be restored after they are deleted from BIOS persistent store (for example, the FLASH was erased or SGX was reset). The *SgrRegistrationPackageInfo* UEFI variable provides the key blobs. By default, BIOS does not present the key blobs to the software. The platform owner needs to 'opt-in' by enabling this option before BIOS provides the key blobs.
PPMRR Size	Sets the **PPMRR size**. PRMRR stands for Processor Reserved Memory Region Registers. It defines the Enclave Page Cache size for SGX application execution. System BIOS would try to allocate the PRMRR. The allocation is based on current memory map, memory DIMM population, and PRMRR allocation rules. In some configurations, BIOS may not be able to allocate PRMRR or PRMRR may be less than expected.

SGX QoS	Enables or disables the SGX quality of service. When **Intel® SGX QoS** is enabled, the processor reserves LLC cache for EPC to increase secure enclave performance at the cost of other workload performance.
Select Owner EPOCH input type	Enables you to select Change to New random Owner EPOCHs or Manual User Defined Owner EPOCHs. Each EPOCH is 64-bit. After generating new EPOCH by selecting Change to New random Owner EPOCHs, the selection reverts to Manual User Defined Owner EPOCHs.
	Software Guard Extensions Epoch n: Sets the Software Guard Extensions Epoch values.
Enable writes to SGXLEPUBKEYHASH[3:0] from OS/SW	Enables or disables the Enable writes to SGXLEPUBKEYHASH[3:0] from OS/SW.
	SGX LE Public Key Hash0: Sets the bytes from 0-7 for SGX Launch Enclave Public Key Hash.
	SGX LE Public Key Hash1: Sets the bytes from 8-15 for SGX Launch Enclave Public Key Hash.
	SGX LE Public Key Hash2: Sets the bytes from 16-23 for SGX Launch Enclave Public Key Hash.
	SGX LE Public Key Hash3: Sets the bytes from 24-31 for SGX Launch Enclave Public Key Hash.
Enable/Disable SGX Auto MP Registration Agent	Enables or disables the **SGX Auto MP Registration**. The MP registration agent (MPA) is responsible to register the platform. This option allows the user to enable/disable the MPA from running automatically at OS boot. By default, the MPA does not automatically run at boot.
SGX Factory Reset	When enables, set SGX setup options (except **Intel SGX** option) back to default. All the key blobs for that platform will be deleted and system will be forced to run a new Initial Platform Establishment flow. This option is reset back to **Off** after factory reset operations are done after reboot. This option is set to **Off** by default.

2.7 SMM Security Mitigation

System Management Mode (SMM) operations are transparent to operating systems. Over the years, SMM has become a significant attack surface. Numerous SMM security mitigations are therefore introduced to protect from threats. SMM Security Mitigation provides a way for firmware to indicates what specific mitigations are present. Firmware indicates these flags in an ACPI table called Windows SMM Security Mitigation Table (WSMT).

To enable to disable the SMM security mitigation, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server.
2. On the **System Setup Main Menu** screen, click **System BIOS** → **System Security**.
3. Enable or disable SMM security mitigation with **SMM Security Mitigation** setup option.

2.8 HTTPS boot

HTTPS boot enables you to use HTTP protocol to transfer the boot file over Transport Layer Security protocol to authenticate HTTPS server. To use HTTPS boot on Dell PowerEdge server, you need to setup DHCP server and HTTPS server. After generating the certificate on HTTPS server, you must import the certificate to the PowerEdge server so it can obtain boot file over HTTPS boot process.

Prerequisite

Setup DHCP server, DNS server and HTTPS server. You can setup based on your requirement. Also, get HTTPS server root certificate from HTTPS server so it can be later imported to HTTPS boot client.

To enable the HTTPS boot settings, do the following:

1. To open the **System Setup** page, press F2 immediately after powering on or restarting your server. Ensure that this server receives boot image via HTTPS boot support.
2. On the **System Setup Main Menu** screen, click **System BIOS**.
3. Click **Network Settings**.
4. On the **Network Settings** page, enable HTTP Device 1 through 4 as necessary, of your choice, and enter HTTP device settings.

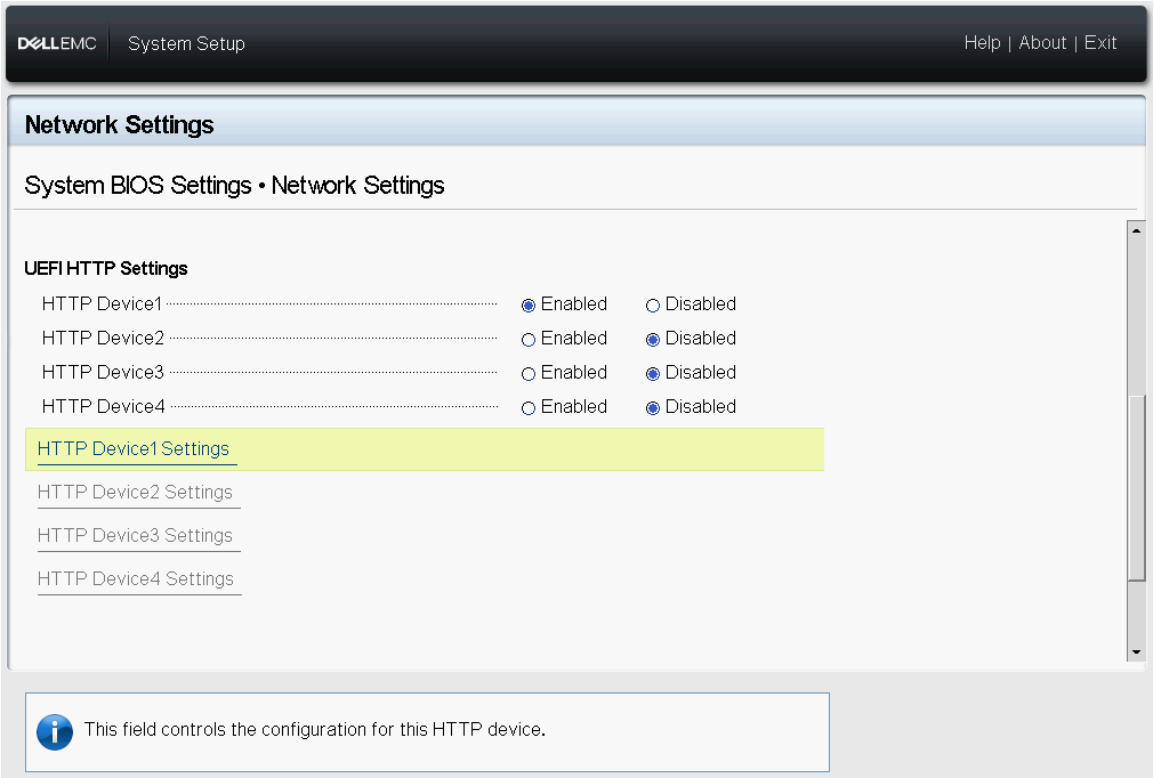

Figure 4 Dell UEFI HTTP settings

5. In **HTTP Device1/2/3/4 Settings**, setup HTTP boot based on network environment. For HTTPS boot, URI should start with `https://`. When the URI is obtained through DHCP server, enter the **TLS Authentication Configuration**.

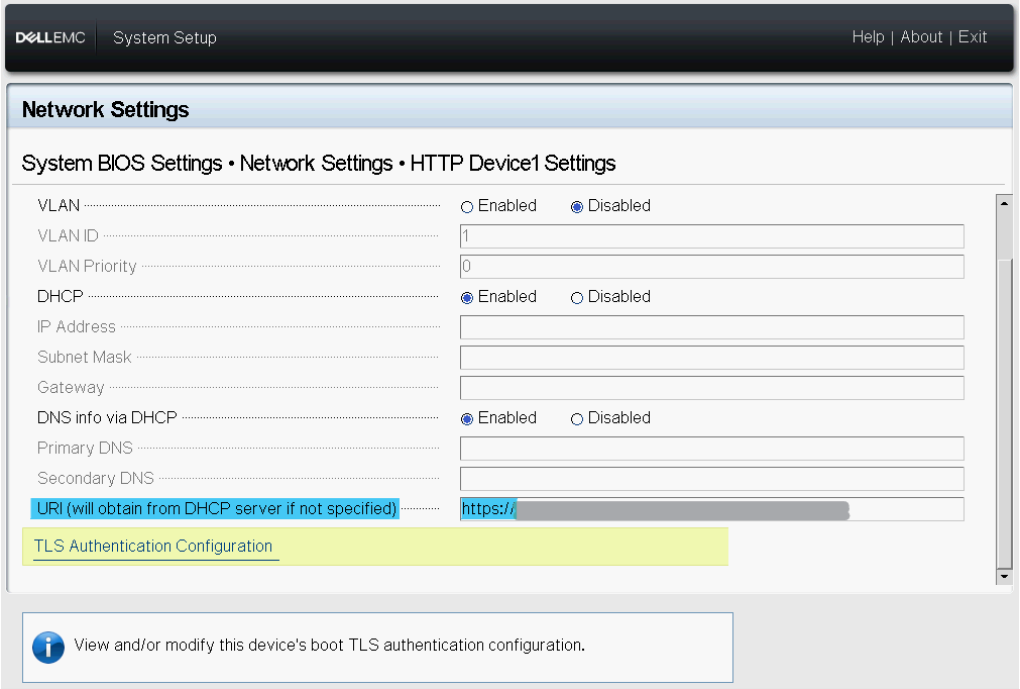

Figure 5 HTTP Device 1/2/3/4 Settings

6. For current design, TLS mode needs to be **One Way** for HTTPS boot. Enter the **Root Certificate Configuration** to manage certificate.

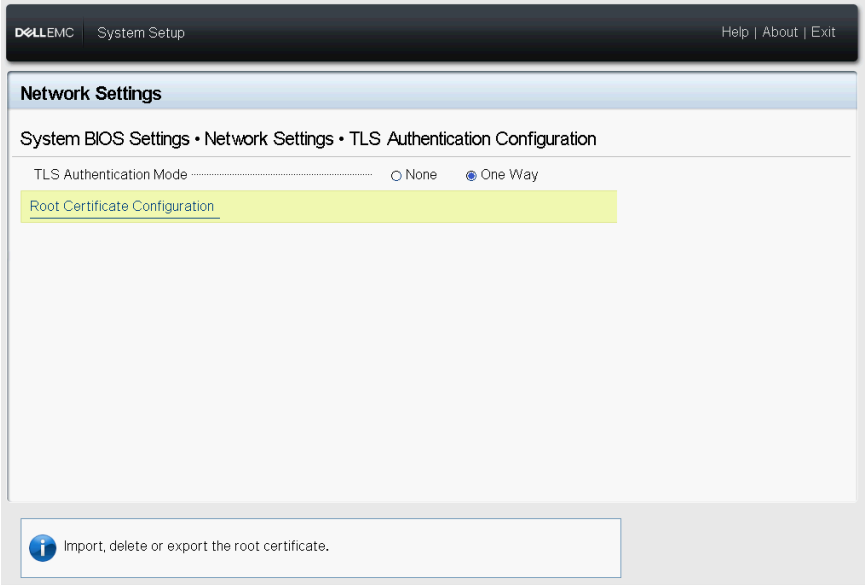

Figure 6 TLS Authentication Configuration

7. On the Root Certificate page, select Import Root Certificate.

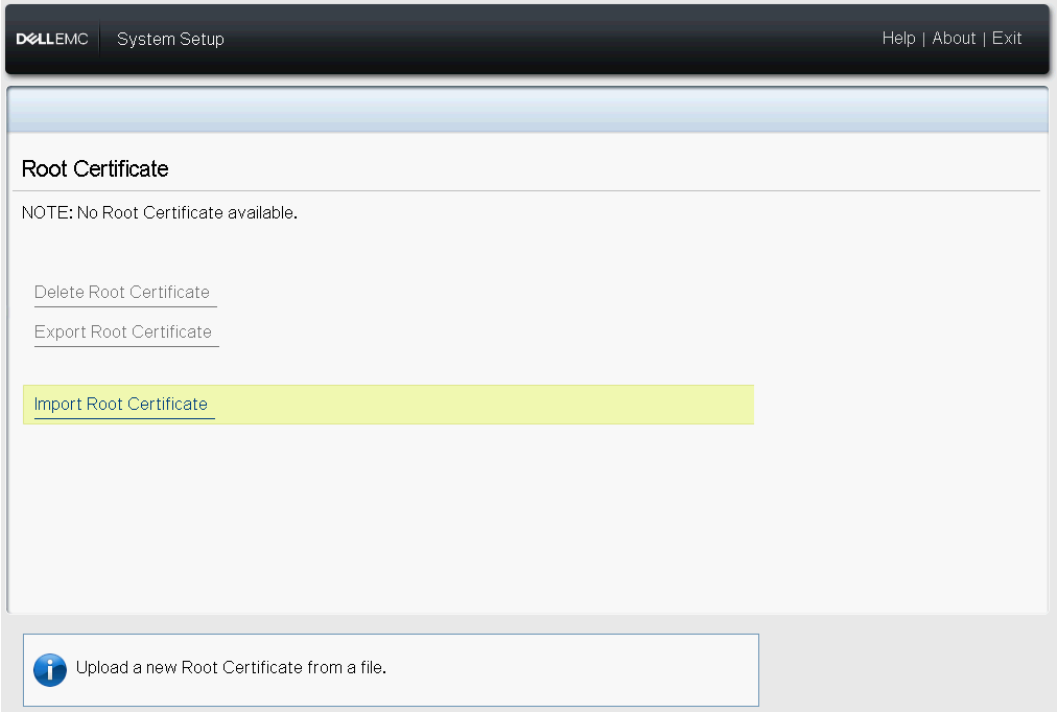

Figure 7 Import Root Certificate page

8. On the **Import Root Certificate** page, select the file system that contains the server root certificate.

Note—DER/PEM are the only supported certificate encoding format.

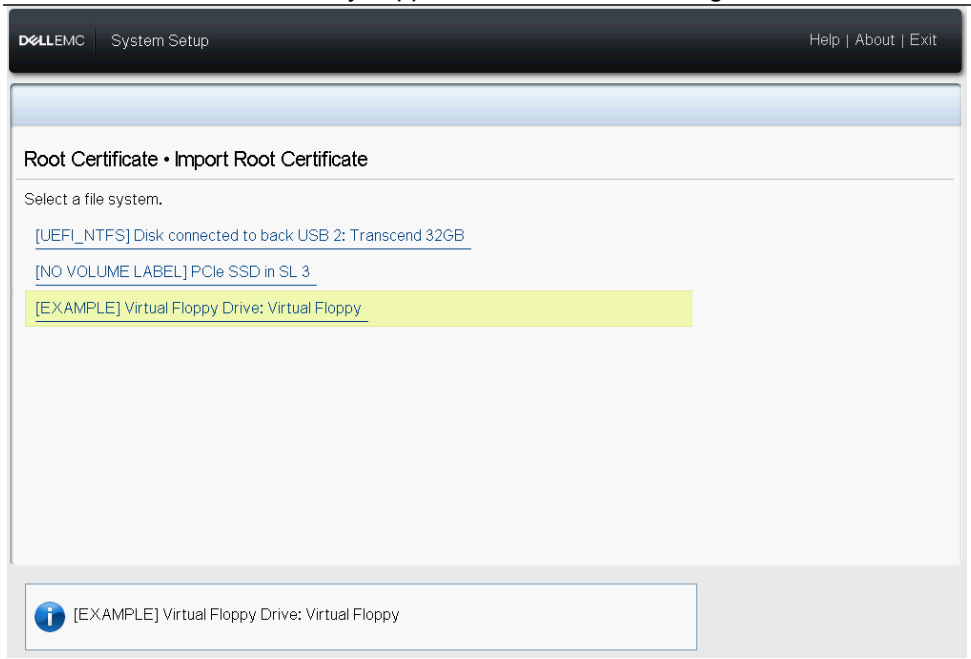

Figure 8 Import Root Certificate

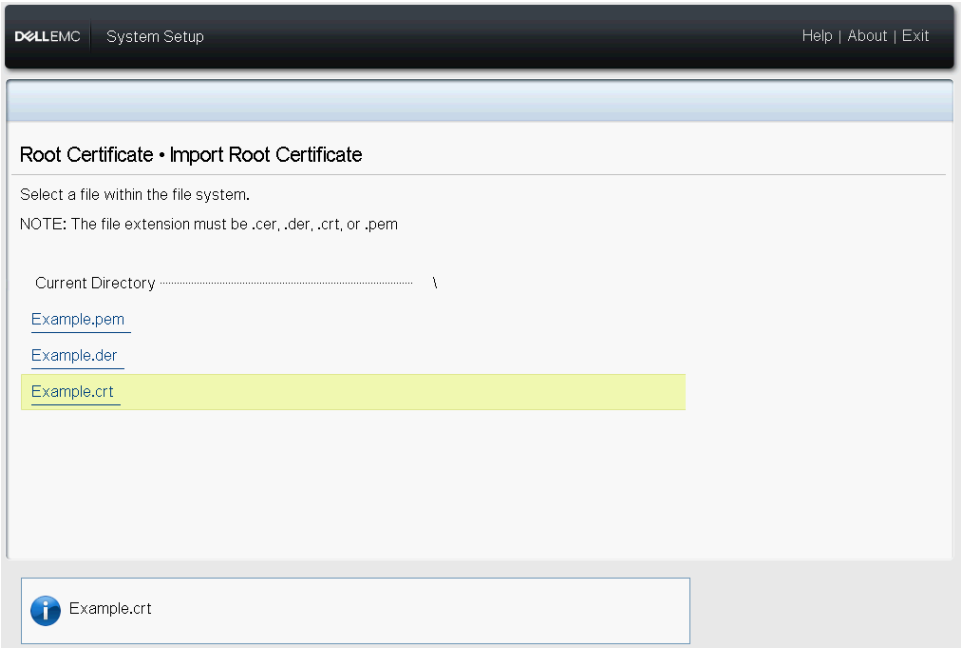

Figure 9 Select cert file in Import Root Certificate

9. Select the certificate of your choice. For example, select **Example.crt** and click **Import**.

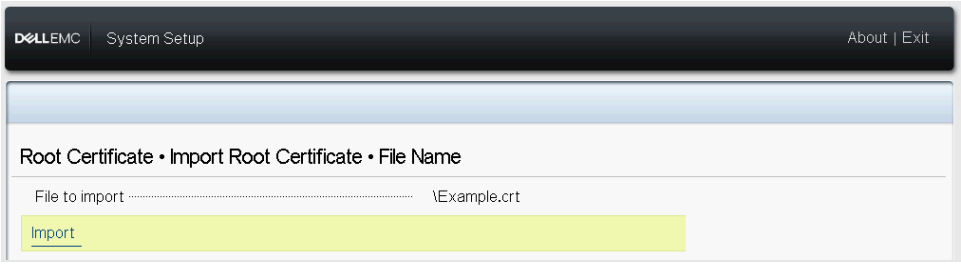

Figure 10 Importing a certificate

After the certificate is imported successfully, system displays the message: `The Root Certificate was imported successfully.`

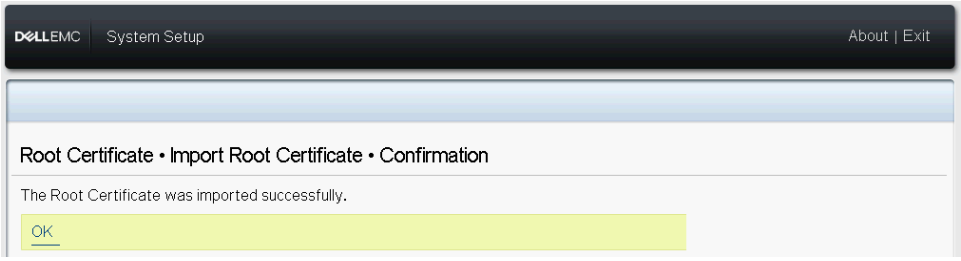

Figure 11 System message to indicate certificate import status

10. Click **OK** to complete the operation and return to the **Root Certificate** page.

3 Detect issues in server configuration and health status

It is critical to detect any issues among the configuration, health status, and change events on a server system. It is also important to detect malicious changes to BIOS, firmware, and Option ROMs within the boot and OS runtime process. Proactive polling must be coupled with the ability to send alerts for all events within the system. Logs must provide complete information about access and changes to the server. Most importantly, the server must extend these capabilities to all components.

3.1 Comprehensive Monitoring via iDRAC

Rather than depending upon OS agents to communicate with managed resources in a server, iDRAC employs a direct side-band path to each device. Dell has leveraged industry standard protocols, such as, MCTP, NC-SI and NVMe-MI to communicate to peripheral devices such as PERC RAID controllers, Ethernet NICs, Fibre Channel HBAs, SAS HBAs, and NVMe drives. This architecture is the result of lengthy, multi-year partnerships with industry-leading vendors to provide agent-free device management in our PowerEdge servers. Configuration and firmware update operations also leverage the powerful UEFI and HII features that Dell and our partners support.

With this capability, iDRAC can monitor the system for configuration events, intrusion events (such as chassis intrusion detection mentioned earlier in this paper), and health changes. Configuration events are linked directly to the identity of the user who initiates the change, for example, GUI user, API user, or console user.

3.1.1 Lifecycle log

The lifecycle log is a collection of events that occur in the server over a period of time. Lifecycle log provides a description of events with timestamps, severity, user ID or source, recommended actions, and other technical information that could come very handy for tracking or alert purposes.

BIOS configuration change is among the various types of information recorded in the Lifecycle Log (LCL):

- Configuration changes on the system hardware components
- iDRAC, BIOS, NIC, and RAID configuration changes
- Logs of all the remote operations
- Firmware update history based on device, version, and date
- Information about replaced parts
- Information about failed parts
- Event and error message IDs
- Host power-related events
- POST errors
- User login events
- Sensor state change events

4 Recover server to a known state

Server solutions must support recovery to a known, consistent state as a response to a variety of events:

- Newly discovered vulnerabilities.
- Malicious attacks and data tampering.
- Corruption of firmware due to memory failures or improper update procedures.
- Replacement of server components.
- Retiring or repurposing a server.

The following sections describe how to respond to new vulnerabilities and corruption issues, and how to recover the server to its original state if necessary.

4.1 Rapid response to new vulnerabilities

Common Vulnerabilities and Exposures (CVEs) are entries for discovered attack vectors that compromise software and hardware products. Timely responses to newly discovered CVEs are critical to Dell Technologies so that we can swiftly assess the exposure and take appropriate action to protect our customers.

When a new security vulnerability is discovered and reported, a new CVE is issued in response. A typical CVE may come from:

- Open-source components such as OpenSSL.
- Web browsers and other Internet access software.
- A Hardware or firmware component.
- Operating systems and hypervisors.

Dell Technologies works aggressively to quickly respond to new CVEs in PowerEdge servers and provide customers timely information including the following:

- Which products are affected.
- What remediation steps may be taken.
- If needed when updates will be available to address the CVE.

4.2 Recover the BIOS state

The BIOS Recovery feature of the PowerEdge servers enables the rapid recovery when the BIOS image file is corrupted. A special storage area is hidden from run-time software (BIOS, OS, and device firmware). These storage areas contain pristine and verified image files that can be used to recover system functionality.

In some cases, the BIOS image file may be corrupted. It is important to recover the BIOS to a working state. A backup BIOS image file is stored in the iDRAC so it can be used to recover the BIOS image if needed. iDRAC orchestrates the entire end-to-end recovery process.

- Automatic BIOS recovery is initiated by iDRAC Root-of-Trust protection.
- On-demand BIOS recovery can be initiated by you using the RACADM or other management tools.

4.3 Roll back a server firmware

It is recommended to use the latest firmware to ensure that the system is running with the up-to-date security fixes. However, there are cases when a rollback to an earlier version is required. In general, you can roll back the BIOS firmware version from only an existing production version **N** to a previous version **N-1**. You can roll back the firmware to the previously installed version **N-1** using any of the following methods:

- iDRAC web interface.
- Chassis Management Controller (CMC) web interface.
- RACADM Command Line Interface (CLI)—iDRAC and CMC.
- Lifecycle Controller User Interface (UI).
- Lifecycle Controller Remote Services.

You can roll back the firmware even if the upgrade was previously performed using another interface. For example, if the firmware was upgraded using the Lifecycle Controller UI, you can roll back the firmware using an iDRAC web interface. You can perform firmware rollback for multiple devices with one system reboot.

4.4 Restore server configuration after hardware servicing

To remediate the service events is a critical part of any IT operation. The ability to meet recovery time objectives and recovery point objectives has direct implications on the security of the solution. Restoring server configuration and firmware assures that security policies for server operation are automatically met.

PowerEdge servers provide functionality that quickly restores server configuration in the following situations:

- Individual part replacement
- Motherboard replacement (full server profile backup and restore)
- Motherboard replacement (Easy Restore)

4.4.1 Easy Restore (for motherboard replacement)

Motherboard replacements can be time-consuming and affect productivity. iDRAC offers the ability to backup and restore a PowerEdge server configuration and firmware to minimize the effort needed to replace a failed motherboard.

There are two ways the PowerEdge server can backup and restore server configurations:

- PowerEdge servers automatically backup system configuration settings (BIOS, iDRAC, NIC), Service Tag, UEFI diagnostics app, and other licensed data to the flash memory. After you replace the motherboard on your server, **Easy Restore** prompts you to automatically restore this data.
- For a more comprehensive backup, you can back up the system configuration, including the installed firmware image files on various components such as BIOS, RAID, NIC, iDRAC, Lifecycle Controller, and Network Daughter Cards (NDCs) and the configuration settings of those components. The backup operation also includes the hard disk configuration data, motherboard, and replaced parts. The backup creates a single file that you can save to a vFlash SD card or network share (CIFS, NFS, HTTP or HTTPS).

You can restore this profile backup anytime. Dell recommends that you perform the backup operation for every system profile you think you might want to restore at some point.

4.5 System Erase

At the end of a system lifecycle, it must be either retired or repurposed. The goal of the System Erase feature is to erase sensitive data and settings so that no confidential information is unintentionally compromised. It is a utility in Lifecycle Controller that is designed to erase the logs, configuration data, storage data, cache, and any embedded apps.

The following devices, configuration settings, and applications can be erased by using the System Erase feature:

- iDRAC is reset to default
- Lifecycle Controller data
- BIOS
- Embedded diagnostics and OS driver packs
- iSM
- SupportAssist Collection reports

Additionally, the following components can also be erased:

- Hardware Cache (clear PERC NVCache)
- vFlash SD Card (initialize card)

Data on the following components are cryptographically disposed by System Erase:

- Self Encrypting Drives (SED)
- Instant Secure Erase drives (ISE)
- NVM devices (Intel Optane, or NVMe drives) - not available on 1S systems
- Additionally, non-ISE SATA hard drives can be erased using data overwrite.

4.6 Full Power Cycle

In a Full Power Cycle, the server and its components are rebooted. It drains main and auxiliary power from the server and all components. The data in volatile memory is also erased.

A physical Full Power Cycle requires removing the AC power cable, wait for 30 seconds, and then insert the cable back. This poses a challenge when working with a remote system. This feature allows you to do an effective Full Power Cycle from iSM, IDRAC GUI, BIOS, or a script. Full Power Cycle takes effect at the next power cycle.

Full Power Cycle feature eliminates the need for anyone to be physically present in the data center, thus reducing time to troubleshoot. It can eliminate, for example, any malware that is still memory-resident.

5 Summary

The data center security is crucial to the business success and the security of the underlying server infrastructure. Cyberattacks have the potential for extended system and business downtime, lost revenue and customers, legal damages, and tarnished corporate reputation. To protect, detect, and recover from hardware-targeted cyberattacks, security needs to be built into server hardware design, not added on after the fact.

Dell has been a leader in leveraging silicon-based security to secure firmware and protect sensitive user data in PowerEdge servers for the past two generations. The new 15G PowerEdge product line features an enhanced Cyber Resilient Architecture that uses iDRAC Root-of-Trust to further harden server security. Furthermore, 16G PowerEdge BIOS also introduced the following new security features to provide users even higher security level:

- Persistent memory passphrase

In conclusion, the 16G PowerEdge servers, with their industry leading security, form the trusted bedrock of the modern data center upon which customers can securely run their IT operations and workloads.

A Technical support and resources

Dell.com/support is focused on meeting customer needs with proven services and support.