BitLocker™ Drive Encryption Security Policy

For FIPS 140-2 Validation

v 1.1
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2. Introduction

BitLocker™ Drive Encryption is a data protection feature available in Windows Server 2008. BitLocker is Microsoft's response to one of our top customer requests: address the very real threats of data theft or

exposure from lost, stolen or inappropriately decommissioned PC hardware with a tightly integrated solution in the Windows Operating System.

BitLocker prevents a thief who boots another operating system or runs a software hacking tool from breaking Windows Server 2008 file and system protections or performing offline viewing of the files stored on the protected drive. This protection is achieved by encrypting the entire Windows volume. With BitLocker all user and system files are encrypted including the swap and hibernation files.

The feature ideally uses a Trusted Platform Module (TPM 1.2) to protect user data and to ensure that a PC running Windows Server 2008 has not been tampered with while the system was offline. BitLocker provides both mobile and office enterprise information workers with enhanced data protection should their systems be lost or stolen, and more secure data deletion when it comes time to decommission those assets. BitLocker enhances data protection by bringing together two major sub-functions: full drive encryption and the integrity checking of early boot components.

Integrity checking the early boot components helps to ensure that data decryption is performed only if those components appear unmolested and that the encrypted drive is located in the original computer.
BitLocker offers the option to lock the normal boot process until the user supplies a PIN, much like an ATM card PIN, or inserts a USB flash drive that contains keying material. These additional security measures provide multi-factor authentication and assurance that the computer will not boot or resume from hibernation until the correct PIN or USB flash drive are presented.

2.1 List of Cryptographic Modules

BitLocker includes seven cryptographic modules that use the following cryptographic algorithms:

1. Hashing: SHA-1 (for TPM communications), SHA-256
2. Keyed hash: HMAC, AES in CCM mode (128 and 256 bit)
3. Symmetric key encryption: AES in CBC mode (128 and 256 bit), with or without the use of Elephant Diffuser algorithm
4. Asymmetric key encryption: RSA (2048 bit) – provided by TPM, for FIPS purposes no additional protection is provided by this method.

The 7 modules performing cryptographic operations are (those in bold are included as part of this validation):

Pre-boot environment

1) BOOTMGR
2) WINLOAD.EXE
3) **WINRESUME.EXE**

Post boot environment

4) CI.DLL
5) KSECDD.SYS
6) **FVEVOL.SYS**
7) **DUMPFVE.SYS**
8) **FVEAPI.DLL**
9) BCRYPT.DLL
10) **WIN32_TPM.DLL**

2.2 Brief Module Description

This section briefly describes each module and the technical differences between them:

BOOTMGR
: This is the system boot manager, called by the bootstrapping code that resides in the boot sector. It locates the VMK (Volume Master Key) and the FVEK (Full Volume Encryption Key), it gets the authentication keys required (depending on the authentication scenario) and decrypts a portion of the disk so that the OS can be loaded. It then checks the integrity of the OS loader and launches it.

WINLOAD.EXE
: This is the OS loader. It loads the boot-critical driver image files and the OS kernel image file itself.

WINRESUME.EXE
: This is the filter that handles resuming from hibernation. At resume time, the data is decrypted as it is paged back into memory.

CI.DLL
: This component provides Code Integrity for the OS by cryptographically verifying the integrity of OS components each time they are loaded into memory.

KSECDD.SYS
: This is the main cryptographic provider for the OS itself.

DUMPFVE.SYS
: This is the BitLocker™ filter that sits in the system dump stack. Whenever the dump stack is called (in the event of a crash, or for hibernation), this filter ensures that all data is encrypted before it gets written to the disk (as a dump file or hibernation file)

FVEVOL.SYS
: This is the BitLocker™ driver. It performs disk conversion (encryption/decryption) and on-demand decryption of disk data.

FVEAPI.DLL
: This is the internal (un-exposed) API that controls the different BitLocker™ functions, in particular key generation and key management.

BCRYPT.DLL
: This Server 2008 component provides cryptographic services to callers executing outside of the kernel space.

WIN32_TPM.DLL
: This is the WMI provider for the TPM API. It provides an interface for controlling TPM functionality.

2.3 Validated Platforms

The Bitlocker™ components identified in section 4 (versions 6.0.6001.18000, 6.0.6001.18606, 6.0.6001.22861, 6.0.6002.18005, 6.0.6002.18411, 6.0.6002.22497 and 6.0.6002.22596) have been validated on Microsoft Windows® Server 2008 on both x86 and x64. Additionally, Microsoft affirms that the same BitLocker™ components maintain compliance when used with Microsoft Windows® Server 2008 with Service Pack 2 (SP2) on both x86 and x64.

3. Integrity Chain of Trust

The cryptographic integrity checking of early boot components in the Server 2008 and BitLocker™ cryptographic modules as follows:

1. BOOTMGR cryptographically checks its own integrity during its start up.
2. BOOTMGR then cryptographically checks the integrity of the OS loader (WINLOAD.EXE or WINRESUME.EXE if resuming from hibernation) before starting it.
3. WINLOAD.EXE cryptographically checks the integrity of CI.DLL before loading it.
4. CI.DLL cryptographically checks the integrity of the post-boot Server 2008 and BitLocker™ cryptographic modules (KSECDD.SYS, DUMPFVE.SYS, FVEVOL.SYS, FVEAPI.DLL, BCRYPT.DLL, and WIN32_TPM.DLL) when the Windows Server 2008 Memory Manager attempts to load such cryptographic module.

4. Cryptographic Boundaries

4.1 Overall Cryptographic Boundary

For FIPS 140-2 purposes the cryptographic boundary is the physically contiguous enclosure of the computer system upon which Microsoft Windows Server 2008 and BitLocker™ Drive Encryption executes (as we define the module as a multi-chip standalone module). Within the Microsoft Windows Server 2008 Operation System exists a second cryptographic boundary, drawn around those components responsible for providing BitLocker™ Drive Encryption functionality.

4.2 BitLocker™ Components Included in the Boundary

The Windows Server 2008 BitLocker™ Drive Encryption cryptographic boundary includes the WINRESUME.EXE, DUMPFVE.SYS, FVEVOL.SYS, and FVEAPI.DLL components. These components, in addition with the other Server 2008 operating system components described below, provide the cryptography and functionality for full drive encryption and chain of trust integrity checking during the boot process.

4.3 Other Server 2008 Components

In addition to the aforementioned BitLocker™ components, other Windows Server 2008 operating system components provide integral to the operating of BitLocker™ Drive Encryption. The Windows Server 2008 BOOTMGR (Cert. #1004), WINLOAD.EXE (Cert. #1005), KSECDD.SYS (Cert. #1007), CI.DLL (Cert. #1006), and BCRYPT.DLL (Cert. #1008) provide supporting cryptographic services to the BitLocker™ Components as well as cryptographically assure the integrity of the BitLocker™ components (in addition to cryptographically ensuring the integrity of each component in the Server 2008 boot sequence). The BitLocker™ Driver Encryption cryptographic boundary does not include these components as these components have been subjected to separate FIPS 140-2 validations to ensure compliance.

Because the BitLocker™ Drive Encryption components depend upon these other Server 2008 operating system components, the BitLocker™ Drive Encryption validation is said to be bound to the Server 2008 operating system, and requires it to remain compliant.

4.4 Other BitLocker™ Components

Beyond the BitLocker™ Drive Encryption components included in the cryptographic boundary, there exist other BitLocker™ components that not included in the boundary. The non-cryptographic components of BitLocker™, for example, the BitLocker™ Setup Wizard that provides a friendly graphical user interface, are not suitable for inclusion into the cryptographic boundary as they provide no cryptography.

5. Roles, Services and Authentication

BitLocker™ provides two different, implicitly assumed roles and a set of services particular to each of the roles. As a FIPS 140-2 level 1 validated product, BitLocker™ itself does not provide any authentication; however, as with all other Windows components, access to BitLocker™ is granted only after the Windows Server 2008 operating system successfully authenticates (through WinLogon) an operator. The Microsoft Server 2008 operating system authenticates an operator's identity by verifying his credentials through WinLogon, at login time, and then implicitly assigns him either the Crypto-Officer or User role depending on the group permissions associated with the operator's ID.

5.1 Roles

BitLocker™ provides both a Crypto-officer (Administrator) and User Role.

5.1.1 User Role

The User Role has access to the unauthenticated services. Once the PC boots, the user will be able to log into the system. No other services are provided to the User Role.

5.1.2 Crypto-officer Role

The Crypto-officer Role has access to the PC's administrative commands, including BitLocker administration. The Crypto-officer must initialize BitLocker on a new PC upon receipt, by selecting the authentication and recovery methods to be used and launching the conversion (encryption) process. Once authenticated, the Crypto-officer can perform any of the following commands:

- Start-up the BitLocker Setup Wizard
- Select / Create authentication methods (key protectors)
    - TPM, TPM+PIN, TPM+USB+PIN, TPM+USB, USB
- Select / Create recovery key
- Manage keys
    - Copy keys (startup key, recovery key)
    - Reset PIN
- Disable/ Re-enable protection (go into and out of disabled mode) – not available in FIPS mode
- Turn-off BitLocker (volume decryption)
- Data volume management
    - Create / delete external / recovery key for each data volume
    - Create / delete an auto-unlock key for each of the data volume

5.2 Startup and Recovery Mechanisms

BitLocker incorporates five different startup methods and two recovery mechanisms (of which a subset is available when one initializes BitLocker™ to operate in FIPS mode):

- TPM-only authentication;
- TPM + PIN authentication;
- TPM + Startup key authentication;
- TPM + PIN + Startup key authentication;
- Startup key only authentication.

The fowling recovery mechanisms are available:

- Recovery key authentication
- Recovery password authentication (not available in FIPS mode)

6. Secure Operation and Security Rules

In order to operate BitLocker™, the operator should be aware of the security rules enforced by the module and should adhere to the physical security rules and secure operation rules required.

6.1 Security Rules

The security rules enforced by BitLocker include both the security rules that Microsoft has imposed and the security rules that result from the security requirements of FIPS 140-2.

6.1.1 Microsoft Security Rules

The following are security rules imposed by Microsoft:

1. BitLocker™ can only be initialized by a Crypto Officer.
2. BitLocker™ will only allow a Crypto Officer to perform key management operations
3. BitLocker™ will allow any User that possesses the appropriate authentication credentials to operate a computer that has a volume protected with this technology.

6.1.2 FIPS 140-2 Security Rules

The following are security rules that result from the security requirements of FIPS 140-2:

1. BitLocker™ will not allow creation or use of a recovery password in FIPS mode as FIPS 140-2 prohibits password deriving keys for data encryption/decryption.
    a. A “recovery password” is a 48 digit value that can be used to recover an encrypted volume, in the event that the main authentication keys are lost, stolen or unusable.
2. BitLocker™ will only release keys to be stored on USB flash drives, if the Crypto Officer performs this operation
3. BitLocker™ Drive Encryption is supported on Windows Server 2008 (both 32-bit and 64-bit versions).
4. Windows Server 2008 is an operating system supporting a “single-user” mode where there is only one interactive user during a logon session.
5. BitLocker™ Drive Encryption provides a variety of different key management options to allow customers to implement a key storage, authentication, and backup/recovery scheme that meets their needs. When placed into FIPS-mode, BitLocker™ will only offer FIPS approved methods included as part of this validation.
6. BitLocker™ will only operate in its FIPS-mode once volume conversion (encryption) has completed and the volume is fully encrypted.

6.2 Enabling FIPS Mode

In order to allow the local administrator to enable or disable FIPS compliance, BitLocker™ complies with the “System Cryptography: Use FIPS compliant algorithms” policy. Additionally, the local administrator may need to enable the BitLocker to operate without a valid TPM device if the computer lacks a valid TPM device.

The registry key used for the FIPS-mode policy is:
`HKEY_LOCAL_COMPUTER\System\CurrentControlSet\Control\Lsa\FIPSAlgorithmPolicy\Enabled`

The FIPS mode policy (that can be found here: Computer Configuration -> Windows Settings -> Security Settings -> Local Policies -> Security Options -> System Cryptography: Use FIPS compliant algorithms) setting allows you to configure the computer to use only FIPS compliant algorithms.

The registry key used for the TPM policy is:
`HKEY_LOCAL_COMPUTER\System\CurrentControlSet\Control\Lsa\RequireValidTPM\Disabled`

The policy controlling whether BitLocker will require the presence of a valid TPM device (that can be found here: Computer Configuration -> Local Computer Policy -> Administrative Templates -> Windows Components -> BitLocker Driver Encryption -> Control Panel Setup: Enable Advanced Startup Options) must be set if the computer lacks a TPM or if using the Startup Key only method.

The administrator should select one of the three available options – "Use Bitlocker without Additional Keys", "Require PIN at every startup", or "Require Startup USB key at every startup" – under the "Set BitLocker Startup Preferences" setup wizard screen.

Finally, if the administrator wishes to setup the TPM + PIN + USB mode, they would first initialize by opening a command prompt and run the command: `Cscript C:\windows\system32\manage-bde.wsf –protectors –add –tpsk`

By enabling these policy settings and specifying one of the available options, BitLocker™ will operate in its FIPS-mode and will only use FIPS compliant algorithms authentication and recovery mechanisms. This means that no recovery password can be created or consumed, and that only a recovery key can be used for recovery purposes. This is also valid for foreign or data volumes: you can recover/unlock such volume only with a recovery key, and not with a recovery password. Therefore, when operating in FIPS-compliant mode, the Setup wizard will disable the buttons allowing the creation, display or printing of a recovery password. The Save to Folder link will also be disabled on the save recovery key page. Additionally, the recovery wizard will only allow recovery of foreign volumes using a recovery key. In FIPS mode, it will grey-out the Disable mode link and the Recovery Password entry option. Only a recovery key can be used, and only to decrypt the volume.

Once the administrator has configured the policies as described above, and set up BitLocker™, BitLocker™ will begin encrypting the operating system volume. Once this conversion process is complete, BitLocker™ will be operating in FIPS-mode.

Additionally, it is recommended that domain administrators enable the FIPS policy before turning on BitLocker™. If FIPS mode is enabled after BitLocker™ was turned on, BitLocker™ must be turned off, and turned back on in order to remain compliant with the FIPS 140-2 requirements. This is because FIPS requires that all keys used in FIPS mode should have been created in FIPS mode.

7. Cryptographic Key Management

In order to achieve a higher level of security, without greatly affecting usability, BitLocker™ supports different types of cryptographic algorithms and encryption layers, including multi-factor authentication. Note that only a subset of options is available when operating in FIPS mode.

The main goal of BitLocker™ is to protect user data on the Operating System volume of the hard drive. To achieve this, disk sectors are encrypted with a Full Volume Encryption Key (FVEK), which is always encrypted with the Volume Master Key (VMK), which, in turn, is bound to the TPM (in TPM scenarios).

The VMK directly protects the FVEK and therefore, protecting the VMK becomes critical. Protecting the disk through the VMK allows the system to re-key easily when one of the other keys upstream in the chain is lost or compromised, especially since decrypting and re-encrypting the entire volume is expensive.

There are several different ways to encrypt the VMK:

Scenario	VMK blob	Algorithm used to encrypt VMK	Available in FIPS-mode?
Default (TPM-only)	SRK(VMK)	RSA[1]	Yes
TPM and PIN	(SRK+SHA256(PIN))(VMK)	RSA[1]	Yes
TPM and PIN and USB	XOR((SRK+SHA256(PIN)),SK)(VMK)	AES[1]	Yes
TPM and USB (TPM+SK)	XOR(SRK(IK),SK)(VMK)	AES[1]	Yes
Startup key (SK)	SK(VMK)	AES	Yes
Recovery key (RK)	RK(VMK)	AES	Yes
Recovery password	(Chained-hashing(Password),Salt)(VMK)	AES	No
Clear key (CC)	CC(VMK)	AES	No
Auto-unlock key (AUK)	OS_VMK(IK(VMK))	AES	Yes

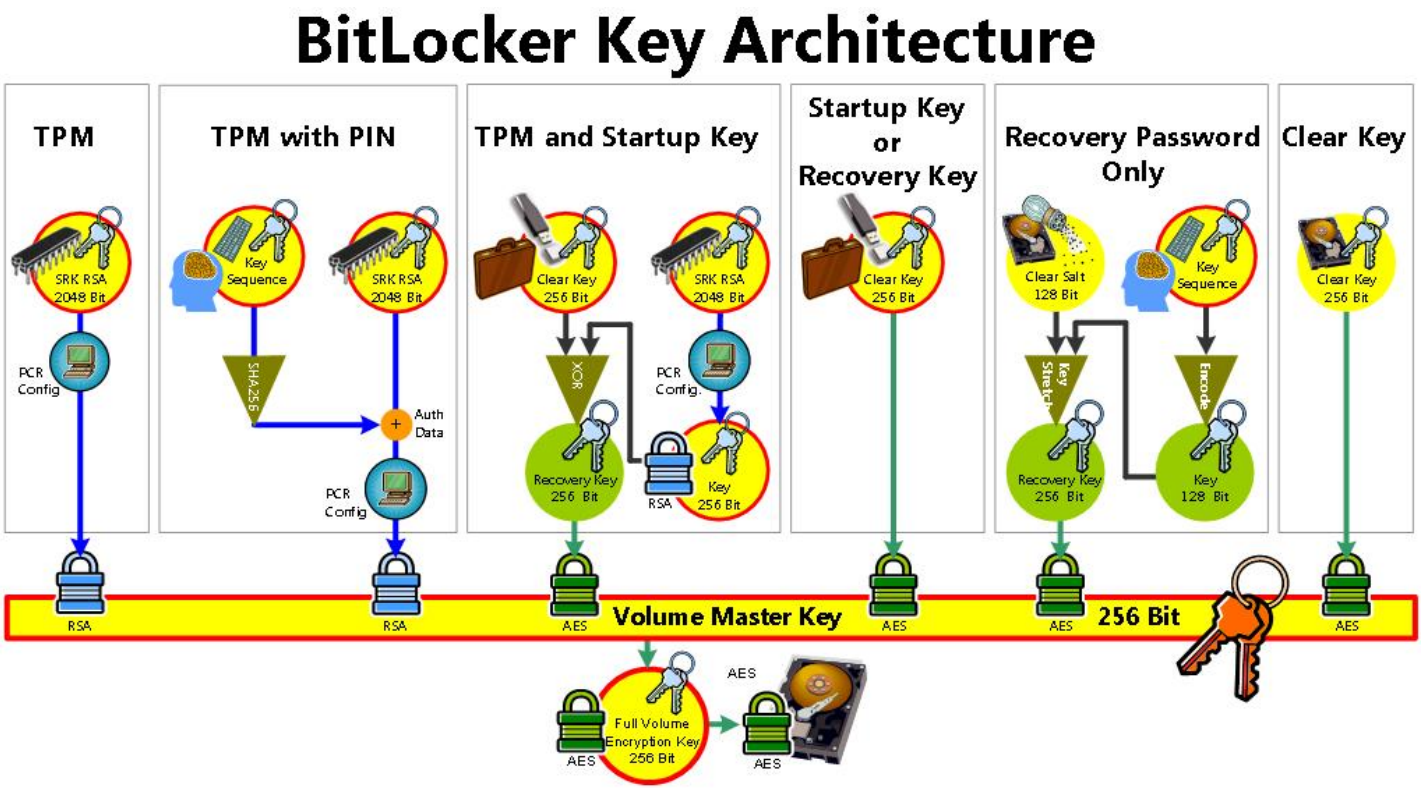
The SRK is the Storage Root Key held by the TPM. It is a 2048 bit RSA key pair generated when ownership of the TPM is taken. The SRK, referred to here as an RSA key, is actually the RSA public key; the private key member of the pair is never shown by the TPM. The SRK is stored within the non-volatile protected memory of the TPM and cannot be removed. This helps ensure that the private key material cannot be leaked, and prevents keys from being used on any platform other than the one they were created on. However, mechanisms are available to migrate keys from one TPM to another, for backup and disaster recovery purposes.

All TPM key operations are based on the SRK. When ownership is taken of the TPM, the new owner is required to specify two pieces of authorization information, the ownership authorization and the SRK usage authorization. This SRK usage authorization will be required for each TPM operation. Since this is undesirable from a usability point of view, and since BitLocker requires that this information be known very early in the boot process, the TPM admin tools will set this usage authorization to a known value of all zeroes (20 bytes of 0). The SRK is re-keyed each time the owner changes.

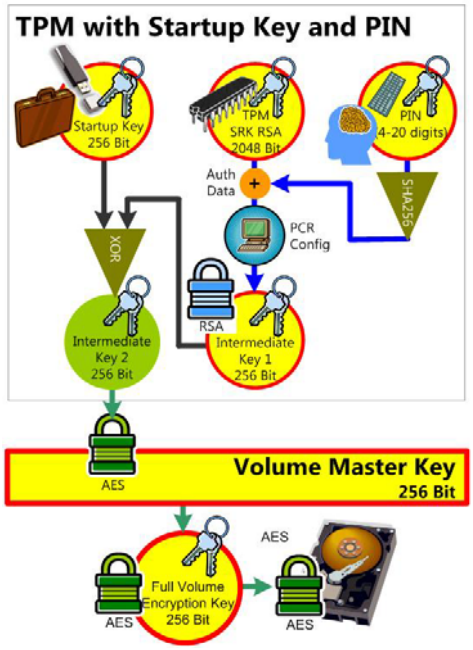
Note that recovery passwords are disabled in FIPS mode.

The diagram below shows the BitLocker Key Architecture.

[1] In schemes using TPM, the VMK is considered to be in plaintext since no guarantee of cryptographic strength of the TPM implementation is provided by this module.



In Server 2008, triple-factor authentication has also been added. The diagram below shows the architecture of the new authenticator.



The keys are generated at set-up time, when BitLocker is enabled. They are stored after being generated. The FVEK and VMK are stored locally in three different places on the drive (beginning, middle, end) and

cannot be changed. The only way to change these keys for an encrypted volume is to decrypt and re-encrypt the volume. Most of the keys (SK, RK, recovery password) – except the PIN – can be copied after the volume has been encrypted.

Intermediate keys (IK) are keys that are stored encrypted on the drive and become [part of] the basis of another key. IK is an intermediate symmetric key, 256-bit long, randomly generated, stored on disk encrypted with the SRK.

The clear key is a 256-bit AES key that encrypts the VMK; it is created when no other VMK-protecting key is present, in what is called “disabled mode”. In this case, there is no security – it is as though the drive is not encrypted, the data is freely available. The clear key is stored as raw data on the disk, together with the VMK.

If a computer does have a [detectable] TPM, BitLocker™ will offer to use the TPM. An external device to hold a key may still be used, but the key on the external device will be a “partial key” (for two-layer authentication) or a recovery key (RK).

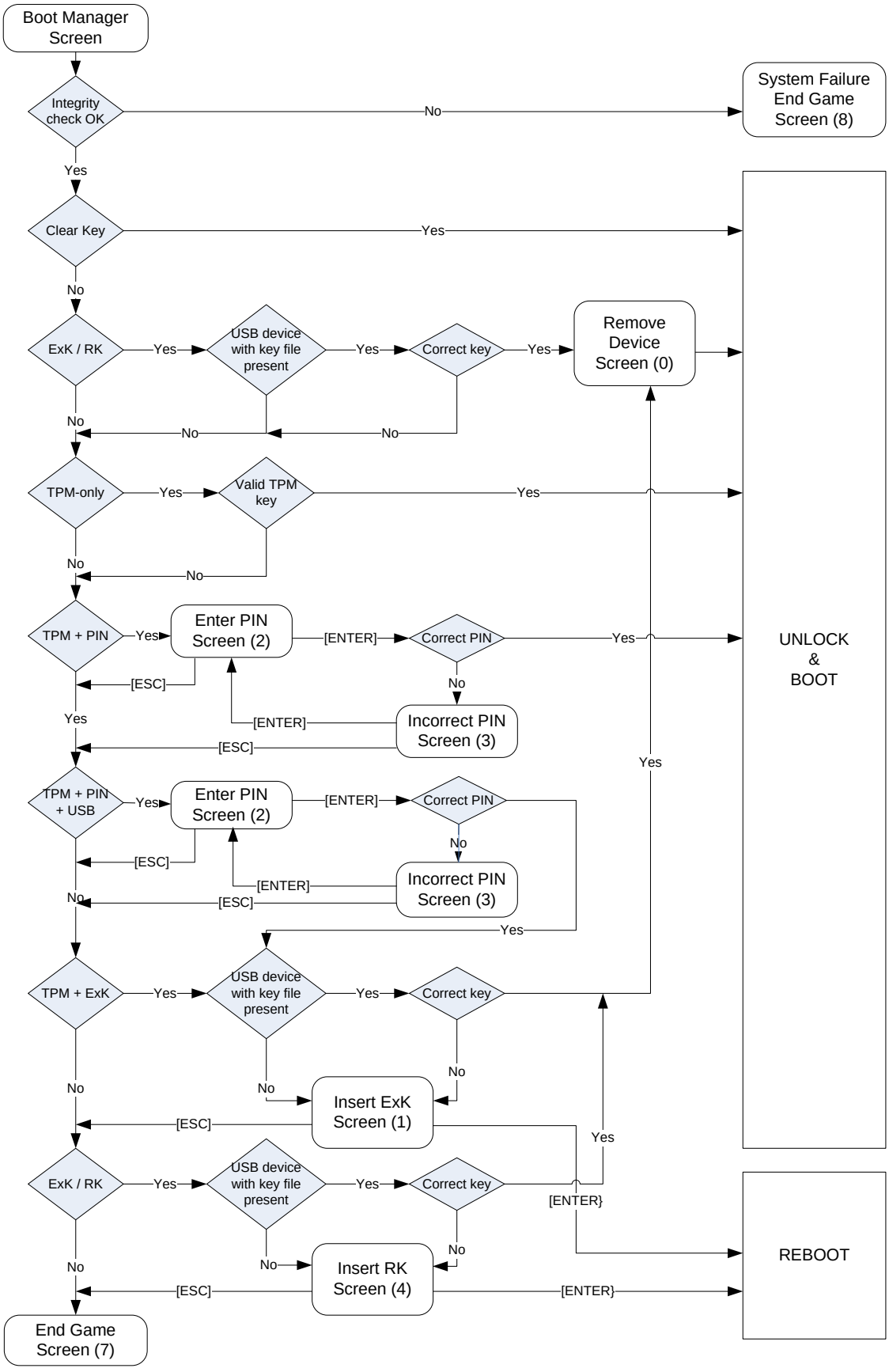
Data volumes can be protected using an external key (recovery key) and/or a recovery password. Data volumes can be “automatically unlocked”: when a BitLocker-protected volume is mounted the FVE driver automatically unlocks the volume if it finds an auto-unlock key (AUK). The AUK is essentially an external key (256-bit AES RK) stored in the OS volume’s registry, protected by the OS volume’s VMK. Therefore, the OS volume has to be BitLocker-protected prior to enabling auto unlock of a data volume.

7.1 Flow Logic

BitLocker will look (at boot time and waking up from hibernation) for appropriate keys to decrypt the volume in the following sequence:

1. Clear Key
2. No-TPM required and no user input required
    a. SK (TPM-less scenario)
3. TPM system and no user input required
    a. TPM
    b. TPM+SK
4. UI Required (TPM system or no-TPM system)
    a. TPM+PIN
    b. TPM+PIN+USB
    c. SK/RK
    d. Recovery password

The following diagram illustrates the flow logic in the system.



7.2 Key Generation

All keys are generated using FIPS-compliant Random Number Generators (RNGs). The only exception is the nonce used for sending commands to the TPM, which requires nonces to be generated – in this case by the TPM's RNG (random number generator).

Key	Generated by	Algorithm used	Used by
FVEK	FVE API	BCryptGenRandom	FVE driver
VMK	FVE API	BCryptGenRandom	Boot manager FVE API
SRK	TPM vendor	-	TPM
Intermediate key	FVE API	BCryptGenRandom	Boot manager FVE API
SK	FVE API	BCryptGenRandom	Boot manager FVE API
RK (similar to SK)	FVE API	BCryptGenRandom	Boot manager FVE API
Clear key[2]	FVE API	BCryptGenRandom	Boot manager FVE API
PIN	User	-	Boot manager FVE API
TPM Nonce	TPM RNG	TPM vendor specific	Boot manager TPM WMI provider

7.3 Key Entry and Output

The raw data encryption keys are all internal and never leave the computer. The only inputs by the user are the PIN or the recovery password (which was generated by the system, but manually entered in recovery mode). The keys that are exported are:

Key	Entry	Output
FVEK	-	-
VMK	-	-
SRK	-	-
Intermediate key	-	-
SK	USB device	USB device
RK (similar to SK)	USB device	USB device
Clear key[2]	-	-
PIN	Manually	-
Recovery Password[2]	manually	Text file or Active Directory Domain Services

7.4 Key Distribution

As outlined in the previous section, keys reside on the local computer or on a USB device. Only recovery passwords are electronically stored (if so indicated by Group Policy) in an Active Directory Domain Services

[2] Not allowed in FIPS mode

server. When needed, a user calls helpdesk and a domain administrator can read the AD entry once the user has been properly identified. At this point the key can be transmitted back to the user either verbally, or any other form approved by the enterprise security policy in place.

7.5 Key Zeroization

All keys are zeroized in memory (by overwriting once with 0s) once they are used and no longer needed. Additionally, on shutdown, the FVEK is also zeroized. Furthermore, when turning off BitLocker™, the metadata sections are zeroized by overwriting the disk three times (once with 0s, once with 1s and once with encrypted 0s – which effectively outputs a random pattern).

7.6 Key Storage

Below is a chart that details where the different types of keys are stored [encrypted].

Key	Length	Algorithm in which is used	Visible to user	Storage Place (default)	Storage Form
FVEK	128, 256	AES	No	On disk	Encrypted
VMK	256	AES	No	On disk	Encrypted[3]
SRK	2048	RSA	No	TPM	Plaintext
Intermediate key	128, 256	AES	No	On disk	Encrypted
SK	256	AES	Yes	External device	Plaintext
RK (similar to SK)	256	AES	Yes	External device	Plaintext
Clear key	256	AES	No	On disk	Plaintext
PIN	4 to 20 digits	SHA256	Yes	-	-
Password	48 digits	AES	Yes	AD	Plaintext

On disk, keys are stored in BitLocker™ metadata sections on the OS volume. The FVE metadata sections are present in three places on the OS volume and stored unencrypted.

- At boot time, only the first copy of the metadata is used. The second and third copies are kept in sync by fvevol.sys – done on first access to encrypted disk.
- Backup copies two and three are used for recovery purposes: using the restore tool
  - Tool will scan the disk for other metadata
- BIOS parameter block (BPB) points to first copy
  - the space used for the pointer was previously used to point to backup Master file table (MFT), which doesn't really move
  - no space for more pointers
- each copy then points to a subsequent copy

7.7 Other Key-related Details

Volume Move:
After being moved to a different computer, if the volume is moved back to original TPM it may reuse its original keys, provided they were not over-written. Each BitLocker™ instance will have a single set of keys – if the keys are stored and have not been removed from the original computer the volume should work without recovery when moved back to the original computer.

[3] For FIPS purposes, the VMK is considered to be stored in plaintext whenever the TPM only, TPM + Startup Key, TPM + PIN + Startup Key, or TPM + PIN modes are used for protecting this value.

External Keys
External Keys are keys saved externally, on a USB flash drive. Startup Keys or Recovery Keys are examples of an External Key. External keys are saved as a .bek file, containing raw binary data of the key in clear.

At set-up time, the SK or RK can only be saved on removable drives. The file is stored as a system file and hidden to prevent inadvertent deletion. RKs can also be copied after creation ensuring additional back-ups are available. The RK will only be required at boot time, so it is recommended that users remove it after that for security's sake.

PINs
The user will be able to change PIN, but it will not be saved/escrowed programmatically. The RK or recovery password must be used if the PIN is lost. When the PIN scenario is enabled and the new encrypted VMK blob is stored, the system shall remove the encrypted VMK blob that was encrypted with only the TPM, if such blob is present – except for RK/RK or Recovery Password. In this manner, at next boot, the system will require the two-factor authentication, instead of working with only a TPM.

Multiple PINs on a given computer are not supported in v1 (the UI does not handle this, and WMI use is discouraged).

Recovery
Recovery is called during boot if BitLocker authentication fails (for data or non-OS volumes, when the BitLocker-protected volume fails to be mounted).

A recovery key (RK) stored on a USB flash drive can be used in the recovery sequence to unlock the volume.

The recovery password consists of a 48 character numeric string that is generated and displayed by the system and must be manually entered by the user to recover the volume. After being generated at set-up time, the recovery password can be viewed, saved locally or printed by the user and is sent to the AD server[4], if required by Group Policy. If AD is not available, and AD password saving is required, then the BitLocker™ set-up is halted.

Zero or more recovery passwords are supported. The maximum number of all key protectors is limited by the maximum size of the metadata structure that can contain them, which is 16K. So for practical purposes, the limit is about 10 recovery password blobs.

If GP requires the recovery password to be sent to AD, then a recovery password is automatically generated, regardless of the Recovery Password UI Policy. If AD is not available, the set-up process is stopped. If AD is not required and the user sees the Recovery Password Creation screen, she will need to click on one of the links (see the password, save it, print it) to actually generate the password. Just clicking Next (without clicking on any of the links) will not generate a password.

BitLocker supports the Windows FIPS Group Policy. This GP is off by default, but can be enabled by a local administrator or, through scripting, by a domain administrator. When set, recovery passwords cannot be created or consumed. The FVE API ensures that calls (from either the UI wizard or WMI scripts) to create or consume recovery password-based key protectors will fail.

7.8 Administration Aspects

The Domain Administrator has full control over the enabling or disabling of BitLocker™ and most of its components. The administrator will be able to specify through Group Policy (GP):

a. Create recovery password: Must, Cannot, Optional (default)

[4] A per-volume GUID is also generated and sent up with the recovery password.

b. Store recovery password in Active Directory Domain Services: Yes, No (default)
   If AD is not available and it is required BitLocker Setup up will be stopped.
c. Create recovery key: Must (default), Cannot, Optional
d. Store recovery key to a folder/network location: Must, Cannot, Optional (default)
   Default media path
e. Create external key: Must, Cannot, Optional (default)
f. Create PIN: Must, Cannot, Optional (default)
g. Display warning when no recovery mechanisms have been set
h. System Cryptography: Use FIPS compliant algorithms: Enabled, Disabled (default)
i. Control Panel Setup: Enabled Advanced Startup Options: Enabled, Disabled (default)

If the registry keys controlling these settings have not been set-up by GP, a default will be used. The default is to make choices optional, leaving them to the user.

8. FIPS Self Checks

8.1 Algorithm implementation conformance tests design

In order to ensure that each of cryptographic algorithms used by BitLocker™ is implemented correctly, each cryptographic algorithm was subjected to CAVP conformance testing. These conformance tests were conducted during the FIPS 140-2 validation process, and the following certificates were issued for the cryptographic algorithms employed by BitLocker™:

Algorithm	Key Size	Mode	Cert #	FIPS approved
AES	128, 256	CBC	739	Yes
AES	128, 256	CCM	760	Yes
SHA-1	160	Byte oriented	753	Yes
SHA-256	256	Byte oriented	753	Yes
HMAC-SHA-1	KS < BS	N/A	415	Yes
HMAC-SHA-256	KS < BS	N/A	415	Yes

8.2 Power-on self-test (KAT) design

BitLocker™ implements Known Answer Test functions in each cryptographic component for each algorithm employed by that component. These tests run each time a module is powered up (after being powered-off, reset, rebooted, etc.).

8.3 Integrity check design

Server 2008 and BitLocker™ implement integrity checking starting with the boot manager and then continuing to check each subsequent component. The boot manager performs a cryptographic verification of its own integrity before checking the integrity of the next component in the boot process (winload.exe or winresume.exe, if coming from hibernation). Once control is passed to the OS loader, it will check CI.dll, and once the computer boots, Code Integrity (CI.dll) will perform integrity checks on all other modules.

8.4 Continuous RNG checks design

In the FVE API, all RNG is performed using BCryptGenRandom (in bcrypt.dll).

For the latest information on Windows Server 2008, check out the Microsoft web site at http://www.microsoft.com.