

Bitlocker: A little about the internals and what changed in Windows 8

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Birth of BitLocker in 2006

- 1 Microsoft decides they want a FDE system for Windows Vista
- 2 Two main considerations: speed and security (and if it's proprietary it probably can't hurt)
- 3 Decision is made that none of the current algorithms is adequate
- 4 Niels Ferguson publishes a whitepaper ^a on BitLocker for Windows Vista

^aNiels Ferguson, *AES-CBC + Elephant diffuser: A disk encryption algorithm for Windows Vista*, 2006

Attacker

- 1 The attacker has many known (but not chosen) plaintext/ciphertext pairs for different sectors.
- 2 The attacker has the ciphertexts for a large number of chosen plaintexts for different sectors. The plaintexts are chosen before the attacker gets access to the laptop.
- 3 The attacker has access to a slow decryption function for some of the sectors.
- 4 The attacker gets several ciphertexts of plaintexts for the same sector with a known (but not chosen) difference.

The attacker succeeds if he can modify a ciphertext such that the corresponding plaintext change has some non-random property.

While this is more limited than the usual ideal FDE attacker it is a reasonable attacker for more real-life applications.

The other goal of BitLocker stated in the whitepaper was to provide what Niels Ferguson termed "poor man's authentication".

Algorithm

BitLocker as described in the original whitepaper is made up of two key building blocks

- 1 AES in CBC mode
- 2 Elephant diffuser - there is a detailed discription of this part of BitLocker in the whitepaper

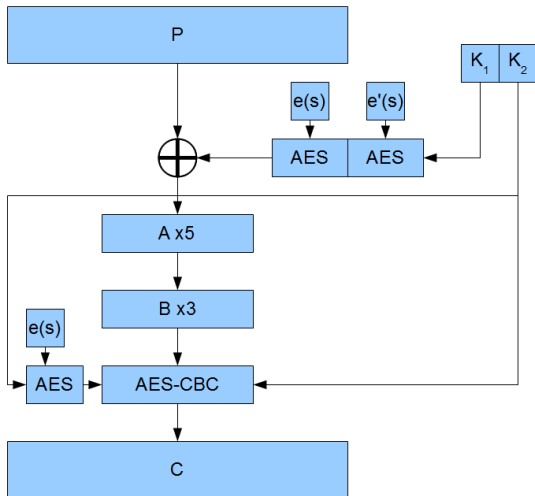
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These two parts are independently keyed by two distinct 128b (or 256b) keys. This ensures that the basic security of AES in CBC mode is not compromised if a vulnerability is found in Elephant diffuser .

Bitlocker



What you encrypt

- 1 Removable drives (called BitLocker to Go)
- 2 Non system disk encryption
- 3 System disk encryption

How you encrypt it

- 1 Choice of key length 128b or 256b
- 2 Choice of with or without Elephant diffuser

Basic types of Keys

- 1 FVEK - full volume encryption key
- 2 VMK - volume master key
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Types of KEK's

- 1 TPM key
- 2 USB key
- 3 Recovery key
- 4 Recovery Password (128 bits of real entropy)
- 5 Password derived key
- 6 Auto unlock key
- 7 Certificate

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What we still don't know:

- 1 How is key generation accomplished?
- 2 What happens when key storage fails in unexpected ways?
- 3 Some key storage information for specific types of keys (e.g. keys generated from password)

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Metadata regions

- 1 There are 4 regions of metadata on a BitLocker encrypted partition/disk
- 2 The header data: this takes the place of the standard partition header and is 512 bytes long
- 3 Three key metadata blocks at various offsets. These blocks should all be the same

Header block

- 1 Starts with -FVE-FS- or 2D 46 56 45 2D 46 53 2D in hex
- 2 Contains version info, 1 for Windows Vista and 2 for Windows 7 and 8
- 3 Sector size (512 pretty much always it seems)
- 4 Offsets of the 3 key metadata blocks

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Key metadata block

- 1 Starts with -FVE-FS- or 2D 46 56 45 2D 46 53 2D in hex
- 2 Contains offsets for all 3 key metadata blocks
- 3 Contains keys wrapped in protectors (VMK wrapped in KEK's and FVEK wrapped in VMK)
- 4 Contains a CRC32 checksum

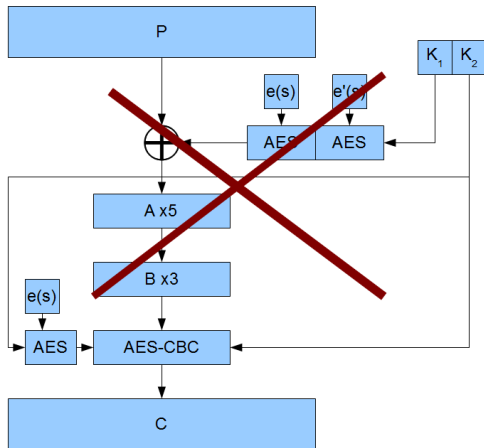
Key protector

This is a term for the structure in which a key is stored on the disk. It contains the key (usually encrypted) along with metadata such as key usage policies, type of key, key encryption mechanism (if key is encrypted) and hash value.

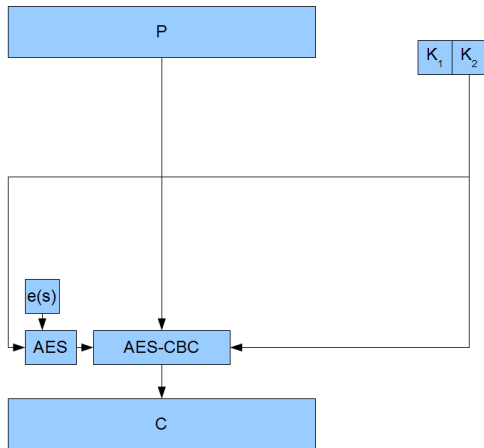
- 1 Can be removed and added at leisure
- 2 Contain timestamp
- 3 Contain nonce which is nondecreasing and seems to be linear in the number of protectors
- 4 Contain information about key being wrapped and key used for wrapping
- 5 Contain wrapped key encrypted using AES-CCM by wrapping key
- 6 Contain hash of decrypted version of protector
- 7 Contain wrapping key encrypted by wrapped key (at least in some versions)

In Windows 8 a very sparsely documented change to BitLocker has been made. The original BitLocker schema has been changed to no longer include the Elephant Diffuser. This has also had the side effect of no longer having a sector key so the only change between sectors is now given by the IV used for CBC.

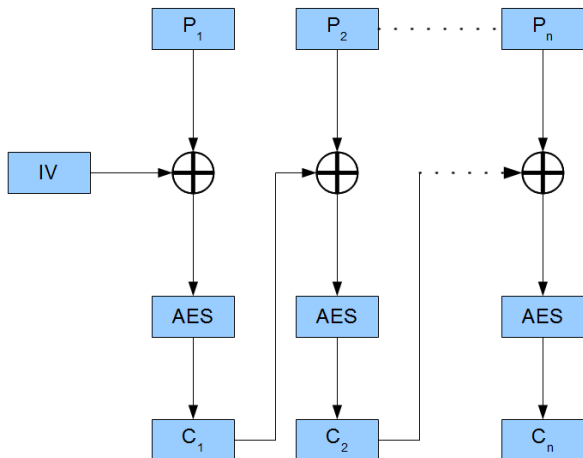
BitLocker in Win8



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BitLocker Win 8= AES v CBC-mode

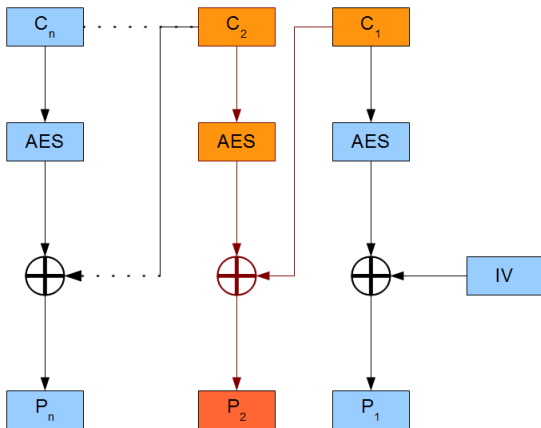


All the attacks presented just stem from the use of AES-CBC. It is well known that this method is vulnerable to bit flipping and block exchanging attacks.

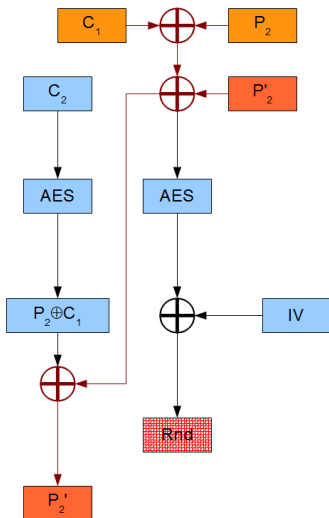
In the case of FDE we can use this for two different purposes.

- 1 Make targeted changes to specific 16 byte blocks
- 2 Move sectors around without losing too much information after decryption

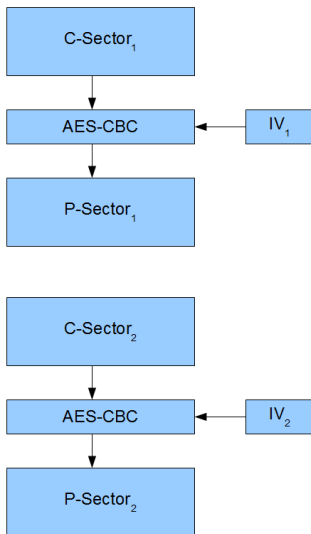
Cipher text used for one block
of plain text



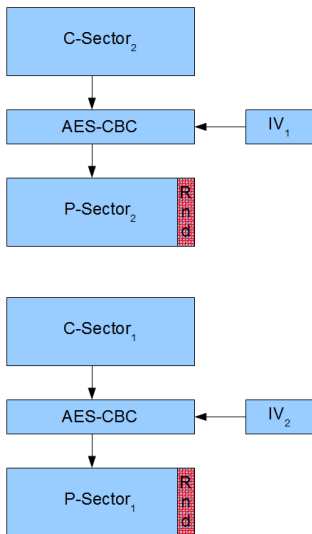
16-byte targeted attack

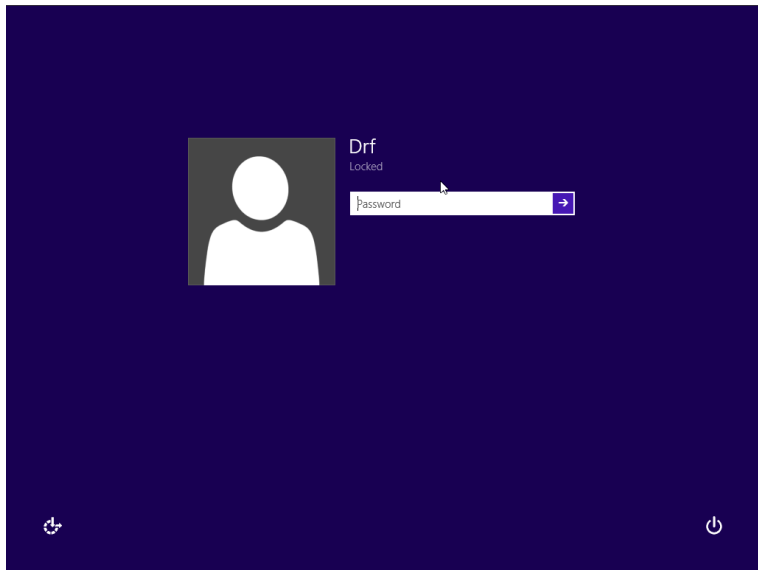


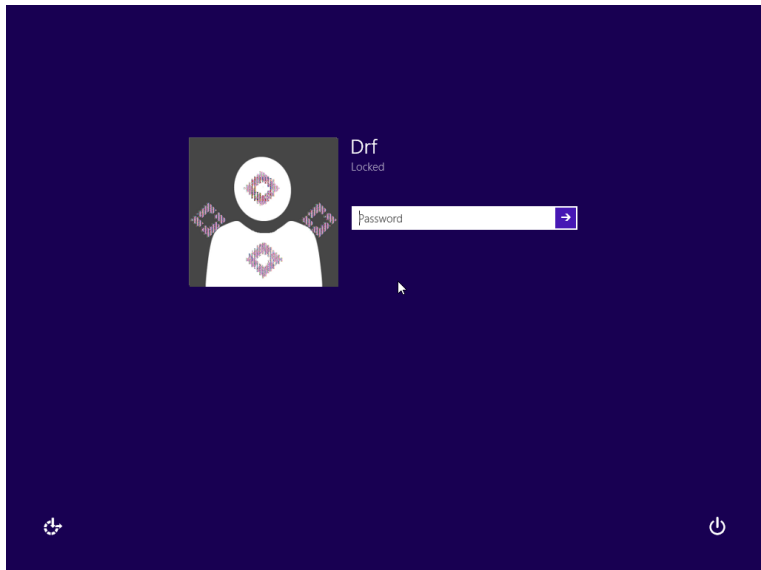
Full sector viewpoint



Moving a whole sector







Important assumptions

It is important to realise that in order for these attacks to be successful some prerequisite assumptions must be met. We need in particular

- 1 Knowledge of at least a partial layout of the disc (where the files we wish to attack are)
- 2 For the targeted change we need the plaintext
- 3 Stay undetected by the user
- 4 Data changed can't be overly redundant or must not have integrity checking implemented

The decision to remove Elephant Diffuser from BitLocker in Windows 8, has had an undeniably negative impact on the security of this FDE solution. On the other hand Microsoft never claimed that BitLocker should protect data from a targeted attack, rather its use should be to protect data from an opportunistic attack. With a properly configured BitLocker installation this protection is still intact.

Thank you for your attention!
The End