Encrypted Storage Technology

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Why You Care

- Theft, loss, or confiscation[7]
- Drive failure and disposal
- Fire, hurricane, flood, or any other disaster
- Owner runs short on funds and wants to liquidate some assets quickly
- Secure deletion not guaranteed to work, never fast
- Encrypted storage *secure by default*

Three Generations

1. Files: GPG, PGP
2. Filesystems: CFS (Unix), TCFS (BSD), EFS (Microsoft)
3. Block Devices: PGPDisk (Microsoft), TrueCrypt, dm-crypt (Linux), svnd (OpenBSD)

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Application File Encryption

First Generation: Application Layer File Encryption

- Easiest to implement - no OS support required
- May be a simple Unix filter
- Hard to use - requires user to do all the work to remain secure, prone to pilot error
- Hard to implement safely - plaintext may be paged out, or written to /tmp
- Examples: PGP, GPG, mcrypt, bcrypt, ccrypt

Filesystem Encryption

Second Generation: Filesystem Encryption

- Attempt to automate the encryption of certain files (usually all under a certain mount point)
- Requires knowledge of files and directories, so has to act as a file system to OS
- Thus, OS-specific and surprisingly complex - file system API ("cross-section") too large
- Where do you hide all the metadata like IVs and keys?

CFS

CFS (Crypting File System)

- Written by Matt Blaze, security guru
- First attempt at encrypted filesystem, pieces go back to 1987!
- Pretends to be NFS server to clients (often localhost), stores encrypted data on local file system (or remote NFS server)
- Somewhat buggy, hard to access internals
- Messy, leaves dangling symlinks all over (to store IVs)
- I accidentally corrupted my system (basically lost the IVs) but was able to use classical cryptanalysis techiques to recover the data[5]
- Deprecated

TCFS

TCFS (Transparent Crypting File System)

- Written by some guys in Italy
- Used BSD stackable file system technology to implement an encryption layer "transparently" on top of any other file system
- Turns out to be surprisingly hard, because you want to hide all the metadata; stored the IV at the beginning of each file, but then had to do "fixup" on file sizes.
- Will work on Linux with kernel patches[6]
- Deprecated, author email addresses don't work

Block Device Encryption

Third Generation: Encrypted Block Devices

- Appears as a block device (e.g. disk) so very simple API; just encrypts or decrypts blocks of data and writes to underlying store.
- Underlying store is often disk partitions, but sometimes can use files on a different filesystem.
- Usually hides metadata in beginning of area, simply adjusts size of plaintext device to hide it
- Separation of duty; can be used with any filesystem

LUKS

- Standardizes on-disk format for encrypted contents and metadata[2]
- Implements TKS1 key format[4], which supports:
- Passphrase revocation (without re-encrypting)
- Multiple passphrases
- Protects against dictionary attacks via PKCS#5 PBKDF2

dm-crypt

dm-crypt (device-mapper crypto)

- The new hotness for the Linux kernel
- Available *by default* in the debian and ubuntu installers
- Now you can encrypt everything but /boot! (including / and swap)
- Linux kernel facility but made available to userland via cryptsetup binary
- Highly recommended

LUKS-compliant cryptsetup

1. cryptsetup luksFormat /dev/sda
   (prompts for passphrase, can specify a file containing phrase instead)
2. cryptsetup luksOpen /dev/sda crypted
3. mkfs [...] /dev/mapper/crypted
4. mount /dev/mapper/crypted /crypt

If you want to encrypt the operating system, you really should use a distro that supports it, because it's rather difficult to add to the boot process.

OpenBSD's svnd

- vnode disk driver allows you to make a file appear as a disk
- secure variant does encryption at same time
- available to userland through vnconfig
- can't encrypt OS yet
- *OpenBSD swap encrypted with random key by default*
- Protects against dictionary attacks via PKCS#5 PBKDF2

OpenBSD's vnconfig

1. dd if=/dev/random of=/etc/seed bs=1k count=1
2. vnconfig -K 1000 -S /etc/seed svnd0 /etc/crypted_disk
   combines passphrase with seed 1000 times
3. newfs /dev/svnd0c
4. mount -o nodev,nosuid /dev/svnd0c /crypt

FreeBSD Disk Encryption

- Geometry-Based Disk Encryption
- Requires loading kernel module or compiling into kernel
- Can't encrypt OS yet (no support in bootloader)
- Two flavors, GBDE and GELI
- GELI supports PKCS#5 PBKDF2

Using FreeBSD GBDE

1. kldload geom_bde (or add to kernel config and recompile)
2. mkdir /etc/gbde
3. gbde init /dev/ad4s1c -i -L /etc/gbde/ad4s1c.lock
4. gbde attach /dev/ad4s1c -l /etc/gbde/ad4s1c.lock
5. newfs -U -O2 /dev/ad4s1c.bde
6. mount /dev/ad4s1c.bde /crypt

Using FreeBSD GELI

1. geom_eli_load="YES" in /etc/bootloader.conf
2. dd if=/dev/random of=/root/da2.key bs=64 count=1
3. geli init -s 4096 -K /root/da2.key /dev/da2
4. geli attach -k /root/da2.key /dev/da2
5. newfs /dev/da2.eli
6. mount /dev/da2.eli /crypt

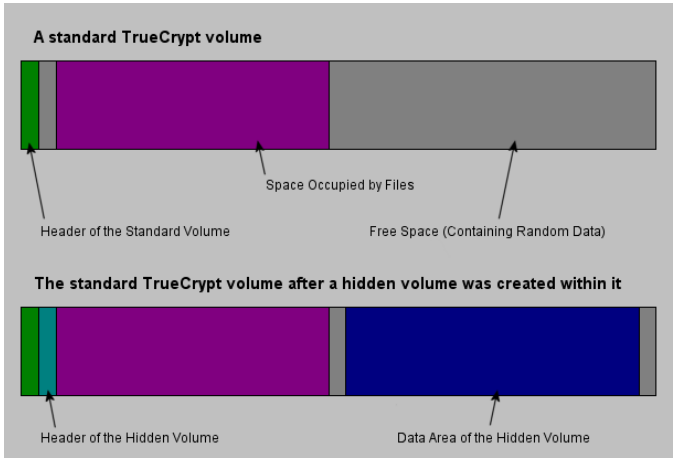
TrueCrypt

- FOSS, X-Platform: Win/Lin/Mac
- Ideal for removable storage
- GUI and Command Line
- Not bundled with OS due to licensing issues (IIRC)
- Uses built-in crypto accelerator on Atom, etc. (IIRC)

The Hotness

- **Indistinguishable from random data** (no identifying headers)
- Hidden volumes to combat rubber hose
- System encryption
- Hidden OS to combat rubber hose
- Key files
- Crypto is impressive, done right

Hidden Volumes

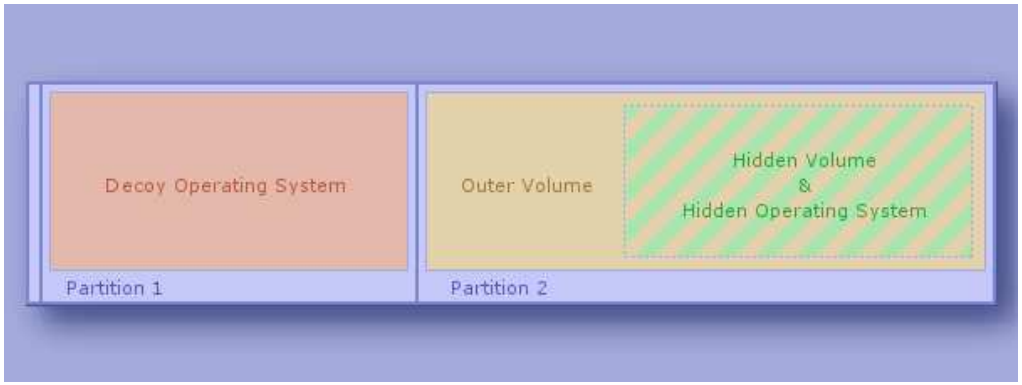


- Existence very difficult to detect
- Outer volume password may be given out under duress
- Writing to a outer volume may overwrite hidden volume
- ...unless you enter hidden volume password (mounting optional)
- Attempting to overwrite hidden volume -> r/o mode

System Encryption

- FDE; only way to encrypt OS files
- Relies on boot loader to collect pre-boot auth password
- Only supported with Windows
- Vista may overwrite boot loader or partition table, esp. on removable drives

Hidden OS



- Requires System Encryption (MS-Win only)
- Install a decoy OS into decoy volume
- Install a "hidden OS" into hidden volume
- Boot loader accepts either password, boots decoy or hidden OS
- Writing to decoy OS partition is safe, unlike outer volume
- Actually three p/ws, decoy, outer, hidden

Crypto Done Right

- XTS block mode, effective against watermarking attacks
- AES, Serpent, Twofish, or any combination thereof in any order
- Choice of RIPEMD-160, SHA-512, Whirlpool
- Uses all cores in parallel
- Pipelines (prefetch/decrypt) access on MSWin

Linux TC Stealth Install

- Install TrueCrypt binary, rename to something innocuous (e.g. /etc/rmt)
- Create a large file (e.g. /var/tmp/.tmp1337), make TC volume in it
- On boot, use command line to open/mount it, then run script:
- mp=/media/truecrypt1; cp /etc/mtab $mp/etc/
- for i in bin etc home lib opt root sbin srv usr; do mount -o bind $mp/$i /$i done

For Further Reading I

- Travis H.
  Security Concepts
  http://www.subspacefield.org/security/
- http://luks.endorphin.org/
- TrueCrypt homepage
  http://www.truecrypt.org/
- TKS1
  http://clemens.endorphin.org/TKS1-draft.pdf
- Travis H.
  CFS travails
  http://www.subspacefield.org/~travis/cfs_travails.txt

For Further Reading II

- TCFS article in LINUX Journal
  http://www.linuxjournal.com/article/2174
- Schneier
  How to Secure Your Computer, Disks, and Portable Drives
  http://www.schneier.com/blog/archives/2007/12/how_to_sec
- http://en.wikipedia.org/wiki/Disk_encryption_theory