IMT4012 - Digital Forensics Notes

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1. File Systems and Live Forensics

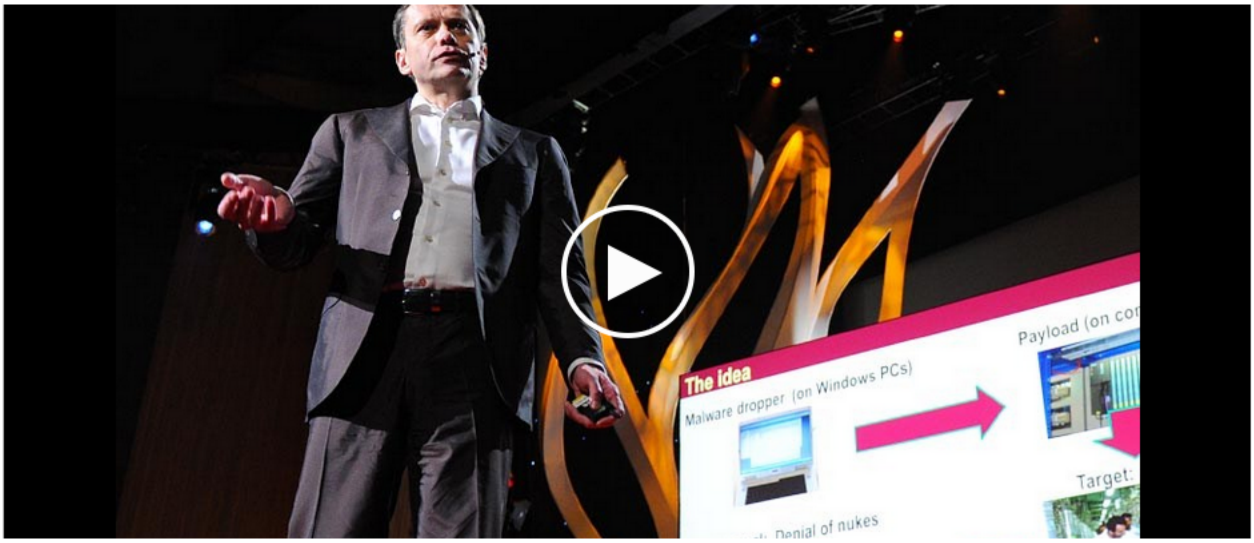


Figure 1.1: `http://www.ted.com/talks/ralph_langner_cracking_stuxnet_a_21st_century_cyberweapon`

Compromised systems that controlls centrifuges. Targeted Nucelar engineers. that works on the systems. Payload is very complex. Looks for system calls, because their behaviour is know, Looks for timers and data structures. Smaller payload seems designed to slowly crack centrifuge rotors. Big payload manipulates valves. Intercepts values from sensors, and gives fake input data. The idea is to circumvent digital safety systems. For more information on Stuxnet see:

1. `https://en.wikipedia.org/wiki/Stuxnet`
2. `https://archive.today/WS5uA`
3. `http://go.eset.com/us/resources/white-papers/Stuxnet_Under_the_Microscope.pdf`
4. `http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/w32_stuxnet_dossier.pdf`

Digital evidence, evidence integrity and evidence dynamics. We define digital evidence as any digital data that contains reliable information that supports or refutes a hypothesis about an incident. Evidence integrity refers to the preservation of the evidence in its original form. This is a requirement that is valid both for the original evidence and the image. Evidence dynamics is described to be any influence that changes, relocates, obscures, or obliterates evidence, regardless of intent.

Chain of custody and forensic soundness - Chain of custody refers to the documentation of evidence acquisition, control, analysis and disposition of physical and electronic evidence. The term forensically sound methods and tools usually refers to the fact that the methods and tools adhere to best practice and legal requirements.

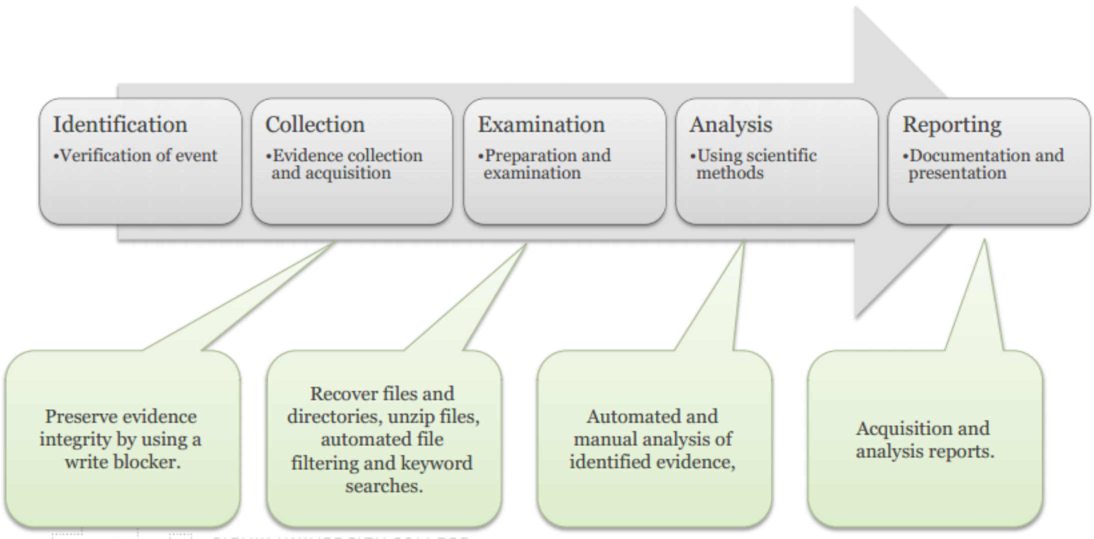
OOV - Collect the most volatile data first – this increases the possibility to capture data about the incident in question. BUT: As you capture data in one part of the computer, you're changing data in another

Evidence acquisition and verification - For digital forensics it is typically copy the data to a secure store, and then verify that the copy is identical.

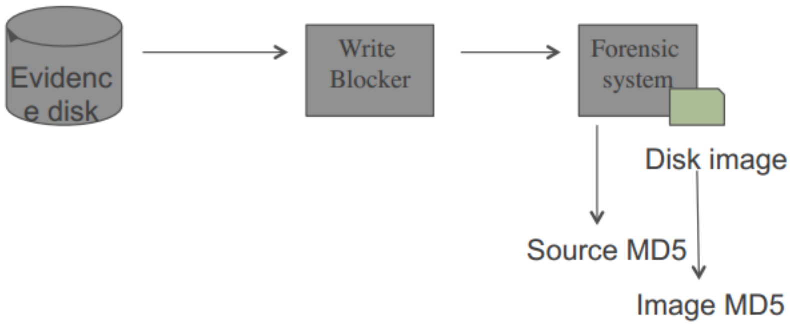
Cybercrime convention - International agreement to increase cooperation between countries. Criminal Law so things should be illeagal in all countries. Criminal Procedure law, what police can do and how they do it. Internet is borderless so there needs to be a effective cooperation between countries to catch the bad guys.

Uncertanties in internet tracing - Traffic is routed, so you do not know if is original, anon traffic, time limits. TOR, VPN, proxies etc.

1.0.1 File System Forensics



Forensic soundness and evidence integrity are critical, if a disk is found that you belive contains evidence you need to make sure that any copy is forensically sound, and the integrity of the evidence is preserved. To do this you connect the disk to a write blocker. Write blockers are devices that allow acquisition of information on a drive without creating the possibility of accidentally damaging the drive contents. They do this by allowing read commands to pass but by blocking write commands, hence their name. There are two ways to build a write-blocker: the blocker can allow all commands to pass from the computer to the drive except for those that are on a particular list. Alternatively, the blocker can specifically block the write commands and let everything else through. Write blockers may also include drive protection which will limit the speed of a drive attached to the blocker. Drives that run at higher speed work harder(the head



moves back and forth more often due to read errors). This added protection could allow drives that can not be read at high speed (UDMA modes) to be read at the slower modes (PIO). There are two types of write blockers, Native and Tailgate. A Native device uses the same interface on for both in and out, for example a IDE to IDE write block. A Tailgate device uses one interface for one side and a different one for the other, for example a Firewire to SATA write block. [1] Hardware write blockers can be either IDE-to-IDE or Firewire/USB-to-IDE. Simson prefers the IDE-to-IDE because they deal better with errors on the drive and make it easier to access special information that is only accessible over the IDE interface. Software write blockers can be either tailored to an individual operating system or can be an independent boot disk. Their main upsides are with ease of use, since they are on a CD and do not require you to open up the case, and speed since they do not become a bottle neck.

There are many different types of media where digital evidence can be found, the most obvious one is the disk, which there in turn are different types of. Today we have the old HDD which are magnetic disks, and the newer SSDs and they pose different challenges for the forensic analyst. On HDDs deleted data will persist for a long time if it is not overwritten, and the deleted data can easily be found when cloning the drive. Solid State Drives pose a variety of interesting challenges for computer forensics in comparison with traditional rotating magnetic platter hard drives. Most SSD devices are based on flash memory; some have battery backed SRAM or DRAM with a flash backing store. Flash has a number of key properties that complicate its use in computer storage systems and subsequent forensic analysis:[2]

1. Internally, flash memory is not divided into the traditional 512 byte blocks, but instead is in pages of 2KiB, 4KiB, or larger, although it is still presented to the host computer in blocks
2. Whilst hard drives can be written in a single pass, flash memory pages must be erased (in whole) before they can be rewritten
3. Rewriting a block at the operating system level does not necessarily rewrite the same page in the flash memory due to the controller remapping data to spread wear or avoid failing pages
4. Each page can be erased and rewritten a limited number of times – typically 1000 to 10,000. (Hard drive sectors, in contrast, can be rewritten millions of times or more.)
5. Flash data is often encrypted on the drive, and can be "erased" by telling the controller to forget the old key and generate a new one, as well as marking all blocks as unused

The controller in a flash SSD is significantly more complex in the number of tasks it has to perform in comparison to a magnetic rotating drive, with the following features:

1. *wear leveling* – that is, spreading the writes to flash out among different sectors. Wear

[1] http://www.forensicswiki.org/wiki/Write_Blockers
[2] http://www.forensicswiki.org/wiki/Solid_State_Drives

leveling is typically done with a flash translation layer that maps logical sectors (or LBAs) to physical pages. Most FTLs are contained within the SSD device and are not accessible to end users.
2. *read/modify/relocate+write* - if the controller allows rewriting of a partial flash page, it must read the entire page, modify the sector that is being written, and write the new flash page in a new/fresh location which has been previously erased. the old pre-modification data's page is then queued for erase.

There are also a wide range of other media that can store digital evidence, such as USB sticks, CDs, DVDs, Floppies, and a thousand other things. If the media is encrypted and is powered down you are fucked if you do not know the key. If the media is powered on and is in use there are ways to extract the key. [3] A thing to note disk is the *Host Protected Area* (HPA) which can be used to block a OS from accessing the end of a drive. For more information about HPA see the footnote.[4]

DOS Partitions

DOS-based partitions are used by all x86 systems. The first 512 bytes of the partition is the MBR. MBR contains boot code (0x0000), partition table (0x01BE) , and a signature value (0x01FE). [5] The partition table contains four entries, each of which can describe a DOS partition. Addressing information, Number of sectors in partition, Type of partition, Flags. Example of partition types (0x01 - FAT12, 0x05 - Extended, 0x07 - NTFS, 0x0C - FAT32, 0x0E FAT16, 0x83 - Linux Native, 0xA5 - BSD/386).

Disk Analysis

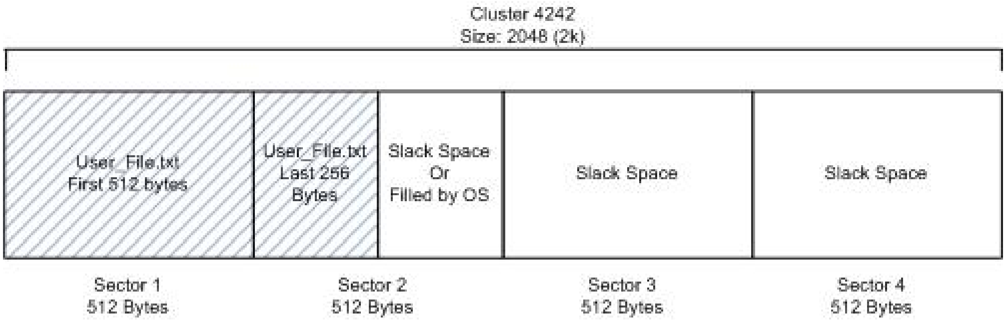
File System	Basic Unit	Basic Addressable Unit	Metadata
Windows	Sector	Cluster	FAT/MFT Entry
UNIX	Sector	Block	Inode
Mac	Sector	Allocation block	Catalog file

A block/cluster can be either allocated or unallocated. Allocated blocks/clusters are in use by a file and the data exists in a file on the file system. Unallocated blocks/clusters are not in use by any files, but they may contain deleted or unused data. Slackspace can be found at the end of sectors or at the end of blocks/clusters. This occurs when a file does not fill its entire last sector or block/cluster. Note that most systems pad the end of the last sector of a file, but not the last blocks/clusters. There are two types of slackspace, type 1 is unused part of a sector, and type 2 is a unused block in a cluster. Slackspace and unallocated blocks are sources for deleted data.

Windows Metadata

FAT directory entries: file name, long file name, MAC times (modification, access, creation), file size, first cluster number. NTFS: Master File Table (MFT) entries: Standard information, file name, data. When deletining files on a FAT system the file name minus the first letter is preserved, MAC times are preserved, file type, size etc are preserved. The clusters will be marked

[3]https://en.wikipedia.org/wiki/Cold_boot_attack
[4]https://en.wikipedia.org/wiki/Host_protected_area
[5]https://en.wikipedia.org/wiki/Master_boot_record



as unallocated but the data will be preserved. On NTFS nothing is tuched, but the clusters are marked as unallocated.

UNIX Metadata

UNIX file systems are organized within a single tree struture underneath one root directory. Disk partitions are mounted at some directory in the file system tree. A directory is organized as a sequence of directory entries. It contains File name and Inode number. Metadata is stored in the inode blocks, some metadata is: ownership, permissions, file type, hard link count, file size in bytes, time stamps (MAC, birth, deletion), Data block addresses (direct, single indirect, double indirect, . . .). When a file is deleted, the directory entry and inodenumber is marked as unused. The directory's last MACtimes are set to the time of the update. The inode block is marked as unused in the inode allocation bitmap. The file data blocks are marked as unused in the data block allocation bitmap, but the contents are left alone.

1.0.2 Live Forensics

Considerations: OOV - If you want data in memory you need to do live forensics.

Storing evidence remotely - If evidence is on network shares or in the cloud

Using trusted tools - When dealing with compromised systems you cannot trust the systems tool, you need to bring external tools.

Motivation: System subversion - Hacked systems, a lot of information will be in the system state such as network stack and memory.

Encryption and passwords - You need to do live forensics, if it is shut down and you do not know the password then you need to do it live

Running applications - Text in documents that are not saved

Open network connections - Investigating p2p networks you will want to know which other computers it is talking too.

OOV expected lifetime of data table.

WHich order Memory dump

Process info Network info File MAC times File system

if you choose one the other will deteriorate.

A rootkit can alter the data from process and system status tools. Rootkits Command level rootkits hide their presence through changing system commands.

Library level rootkits hide their presence through changing system run time libs

Kernel level rootkits hide their presence through changing the system kernel.

Computer Memory Memory can be found in many sources, RAM swap space Hibernation files.

Memory analysis Fragments of files can be found by searching for hashes.

Type of data	Life span
Registers, peripheral mem, cache, etc.	Nanoseconds
Main memory	Ten nanoseconds
Network state	Milliseconds
Running processes	Seconds
Disk	Minutes
Floppies, backup media, etc.	Years
CD-ROMs, DVDs, printouts, etc	Decades

Figure 1.2: Table showing the life time of the different data types

1.0.3 Remote Foresincs

Get data a from a remote computer. Think about secure channels, not good to copy thing in plaintext over the net.

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