Week 1 CTF Introduction and Forensics

Introduction to CTF

Capture The Flags, or CTFs, are a kind of computer security competition.

Teams of competitors (or just individuals) are pitted against each other in a test of computer security skill.

Very often CTFs are the beginning of one's cyber security career due to their team building nature and competitive aspect. In addition, there isn't a lot of commitment required beyond a weekend.

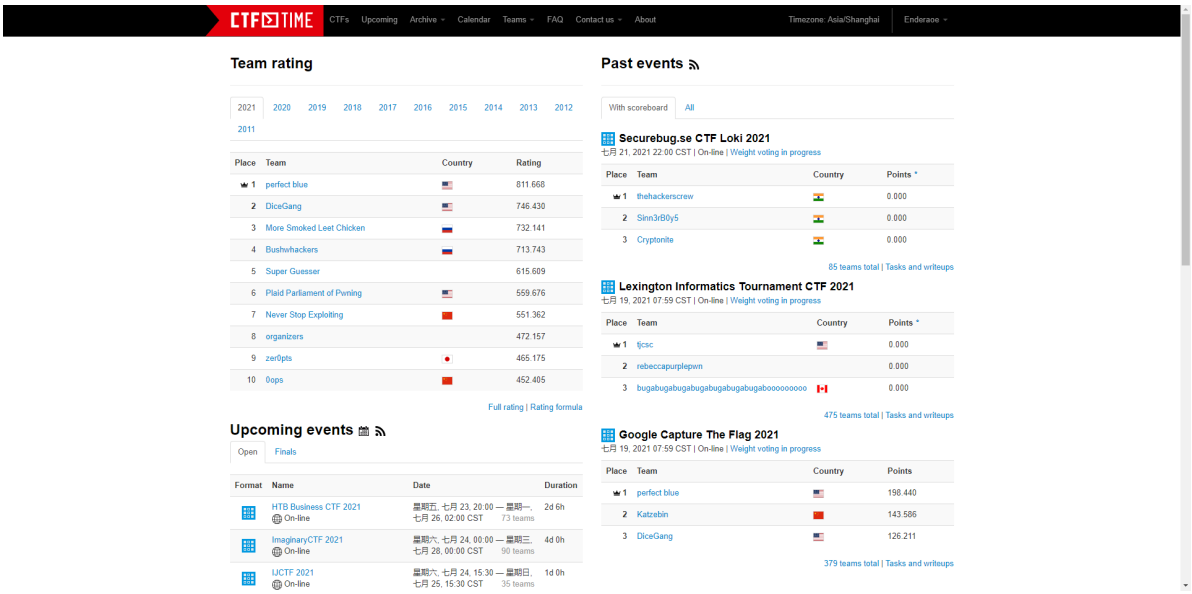


Figure: CTFs on the CTFtime website.

These contests run every month by various organizations and universities across the globe. These contests can be arranged in the 3 styles:

1. Jeopardy
2. Attack & Defense
3. Mixed Style

Most of the CTFs are online, while some of them (usually finals) are offline. The most famous CTF is the **DEF CON CTF**, which is held every August annually.

In our semester, every lab would have several CTF challenges in Jeopardy format. By the end of this semester, yet another AWD (Attack & Defense) CTF would be hold.

Categories

In Jeopardy format CTFs, there are usually 5 categories:

- **Forensics**

  Forensics is the art of recovering the digital trail left on a computer. There are plenty of methods to find data which is seemingly deleted, not stored, or worse, covertly recorded.

- **Cryptography**

Cryptography is the reason we can use banking apps, transmit sensitive information over the web, and in general protect our privacy. However, a large part of CTFs is breaking widely used encryption schemes which are improperly implemented. The math may seem daunting, but more often than not, a simple understanding of the underlying principles will allow you to find flaws and crack the code.

The word “cryptography” technically means the art of writing codes. When it comes to digital forensics, it’s a method you can use to understand how data is constructed for your analysis.

- **Web Exploitation**

  Websites all around the world are programmed using various programming languages. While there are specific vulnerabilities in each programming langage that the developer should be aware of, there are issues fundamental to the internet that can show up regardless of the chosen language or framework.

  These vulnerabilities often show up in CTFs as web security challenges where the user needs to exploit a bug to gain some kind of higher level privileges.

- **Reverse Engineering**

  Reverse Engineering in a CTF is typically the process of taking a compiled (machine code, bytecode) program and converting it back into a more human readable format.

  Very often the goal of a reverse engineering challenge is to understand the functionality of a given program such that you can identify deeper issues.

- **Binary Exploitation**

  Binaries, or executables, are machine code for a computer to execute. For the most part, the binaries that you will face in CTFs are Linux ELF files or the occasional windows executable. Binary Exploitation is a broad topic within Cyber Security which really comes down to finding a vulnerability in the program and exploiting it to gain control of a shell or modifying the program's functions.

Some other categories growing up in recent years, like IoT (Internet of Thing) and AI.

Forensics

An important part of Forensics is having the right tools, as well as being familiar with the following topics:

- File Formats
- EXIF data
- **Wireshark & PCAPs**
  - Wireshark traffic analysis
- Steganography
- *(Optional) Disk Imaging*

File Formats

File Extensions are not the sole way to identify the type of a file, files have certain leading bytes called *file signatures* which allow programs to parse the data in a consistent manner. Files can also contain additional "hidden" data called *metadata* which can be useful in finding out information about the context of a file's data.

File Signatures

File signatures (also known as File Magic Numbers) are bytes within a file used to identify the format of the file. Generally they're 2-4 bytes long, found at the beginning of a file.

What is it used for?

Files can sometimes come without an extension, or with incorrect ones. We use file signature analysis to identify the format (file type) of the file. Programs need to know the file type in order to open it properly.

How do you find the file signature?

You need to be able to look at the binary data that constitutes the file you're examining. To do this, you'll use a hexadecimal editor. Once you find the file signature, you can check it against file signature repositories [such as Gary Kessler's](#).

Example

The file above, when opened in a Hex Editor, begins with the bytes `FFD8FFE0 00104A46 494600` or in ASCII `ˇÿˇ‡ JFIF` where `\x00` and `\x10` lack symbols.

Searching in [Gary Kessler's](#) database shows that this file signature belongs to a `JPEG/JFIF graphics file`, exactly what we suspect.

Extensions vs Signature

File extension is used to uniquely describe a format of a particular file **whereas file signature is the header information that is present in each file**.

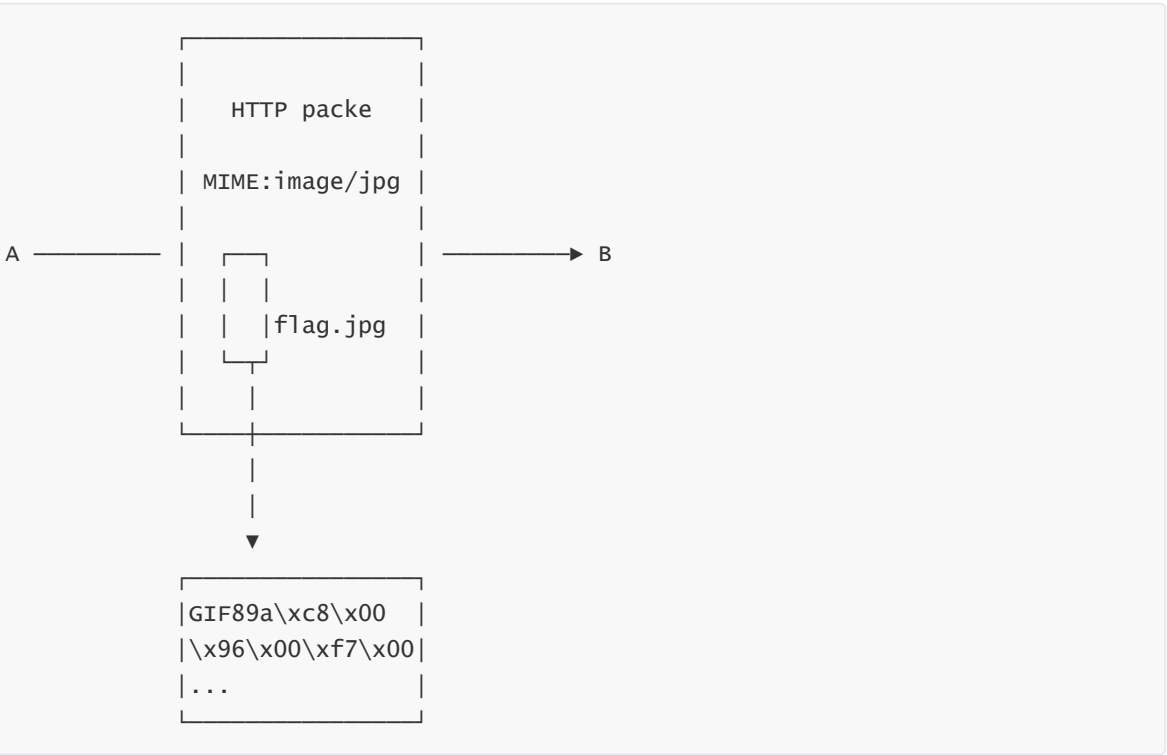
Some operating systems (Windows like) use file extension to bind with applications to open the file, while some other operating systems check file signature in the header to guess the file format (file command in Unix).

What about MIME?

A media type (also known as a Multipurpose Internet Mail Extensions or MIME type) is **a standard that indicates the nature and format of a document, file, or assortment of bytes**. It is defined and standardized in IETF's RFC 6838.

This type is identified in HTTP packets and **DO NOT** stipulate the real file format. For example, a MIME type `image/jpg` means the transferred data **LIKELY** to be a JPEG image, but user can post a `plain text` or `anything` in real body.

Example



The file signature is `GIF8` while the file extension is `.jpg`, with the MIME type `image/jpg` during HTTP transmission.

The given file is a GIF image instead of JPEG file.

Metadata

Metadata is data about data. Different types of files have different metadata. The metadata on a photo could include dates, camera information, GPS location, comments, etc. For music, it could include the title, author, track number and album.

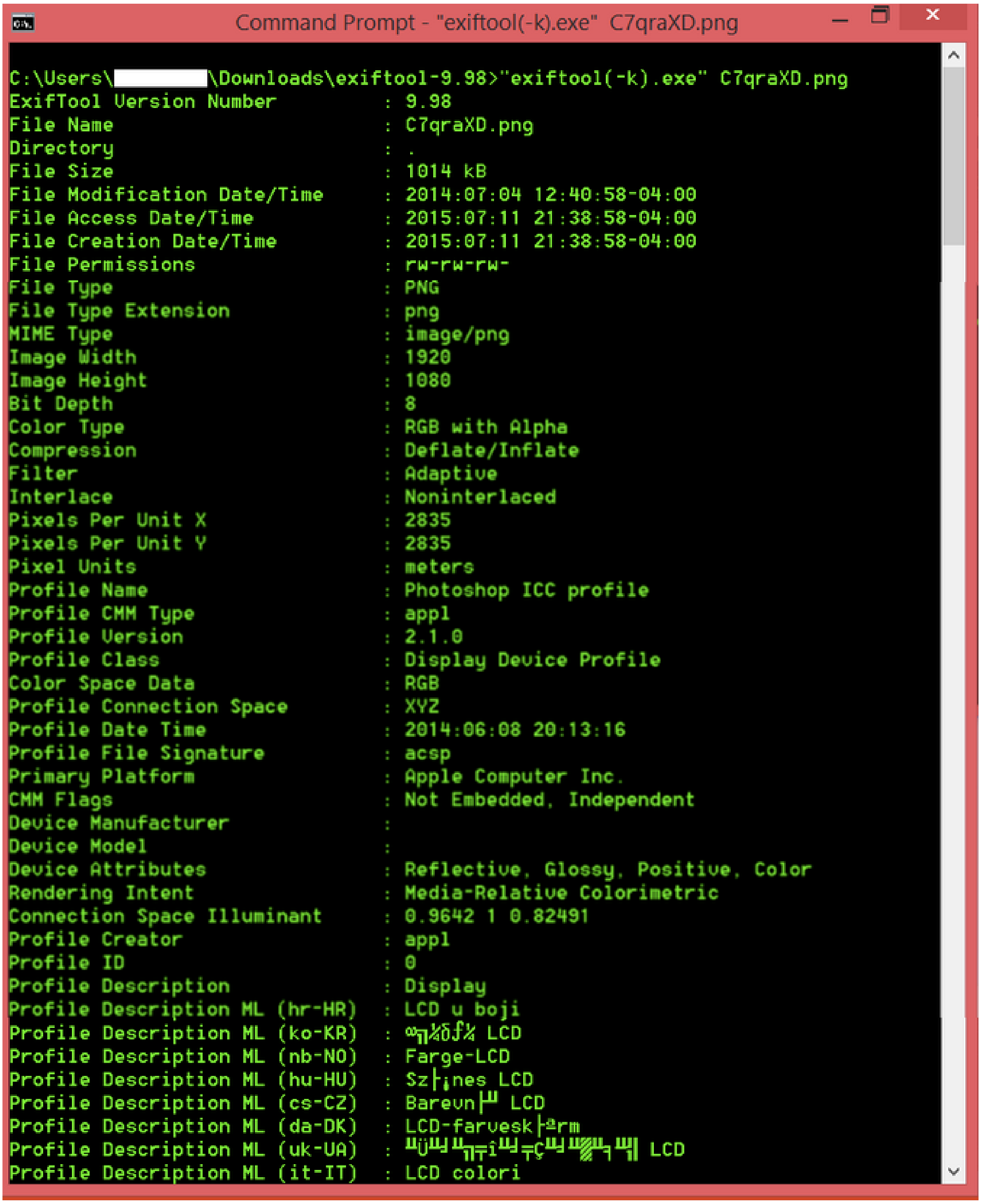
What kind of file metadata is useful?

Potentially, any file metadata you can find could be useful.

How do I find it?

One of our favorite tools is exiftool, which displays metadata for an input file, including: - File size - Dimensions (width and height) - File type - Programs used to create (e.g. Photoshop) - OS used to create (e.g. Apple)

Run command line: `exiftool(-k).exe [filename]` and you should see something like this:



```
Command Prompt - "exiftool(-k).exe"  C7qraXD.png

C:\Users\[redacted]\Downloads\exiftool-9.98>"exiftool(-k).exe" C7qraXD.png
ExifTool Version Number         : 9.98
File Name                       : C7qraXD.png
Directory                       : .
File Size                       : 1014 kB
File Modification Date/Time     : 2014:07:04 12:40:58-04:00
File Access Date/Time           : 2015:07:11 21:38:58-04:00
File Creation Date/Time         : 2015:07:11 21:38:58-04:00
File Permissions                : rw-rw-rw-
File Type                       : PNG
File Type Extension             : png
MIME Type                       : image/png
Image Width                     : 1920
Image Height                    : 1080
Bit Depth                       : 8
Color Type                      : RGB with Alpha
Compression                     : Deflate/Inflate
Filter                          : Adaptive
Interlace                       : Noninterlaced
Pixels Per Unit X               : 2835
Pixels Per Unit Y               : 2835
Pixel Units                     : meters
Profile Name                    : Photoshop ICC profile
Profile CMM Type                : appl
Profile Version                 : 2.1.0
Profile Class                   : Display Device Profile
Color Space Data                : RGB
Profile Connection Space        : XYZ
Profile Date Time               : 2014:06:08 20:13:16
Profile File Signature          : acsp
Primary Platform                : Apple Computer Inc.
CMM Flags                       : Not Embedded, Independent
Device Manufacturer             :
Device Model                    :
Device Attributes               : Reflective, Glossy, Positive, Color
Rendering Intent                : Media-Relative Colorimetric
Connection Space Illuminant     : 0.9642 1 0.82491
Profile Creator                 : appl
Profile ID                      : 0
Profile Description             : Display
Profile Description ML (hr-HR)  : LCD u boji
Profile Description ML (ko-KR)  : ∞╗¼δƒ¼ LCD
Profile Description ML (nb-NO)  : Farge-LCD
Profile Description ML (hu-HU)  : Sz├¡nes LCD
Profile Description ML (cs-CZ)  : Barevn├╜ LCD
Profile Description ML (da-DK)  : LCD-farvesk├ªrm
Profile Description ML (uk-UA)  : ╨Ü╨╛╨╗╤î╨╛╤Ç╨╛╨▓╨╕╨╣ LCD
Profile Description ML (it-IT)  : LCD colori
```

Example

Let's take a look at File A's metadata with exiftool:

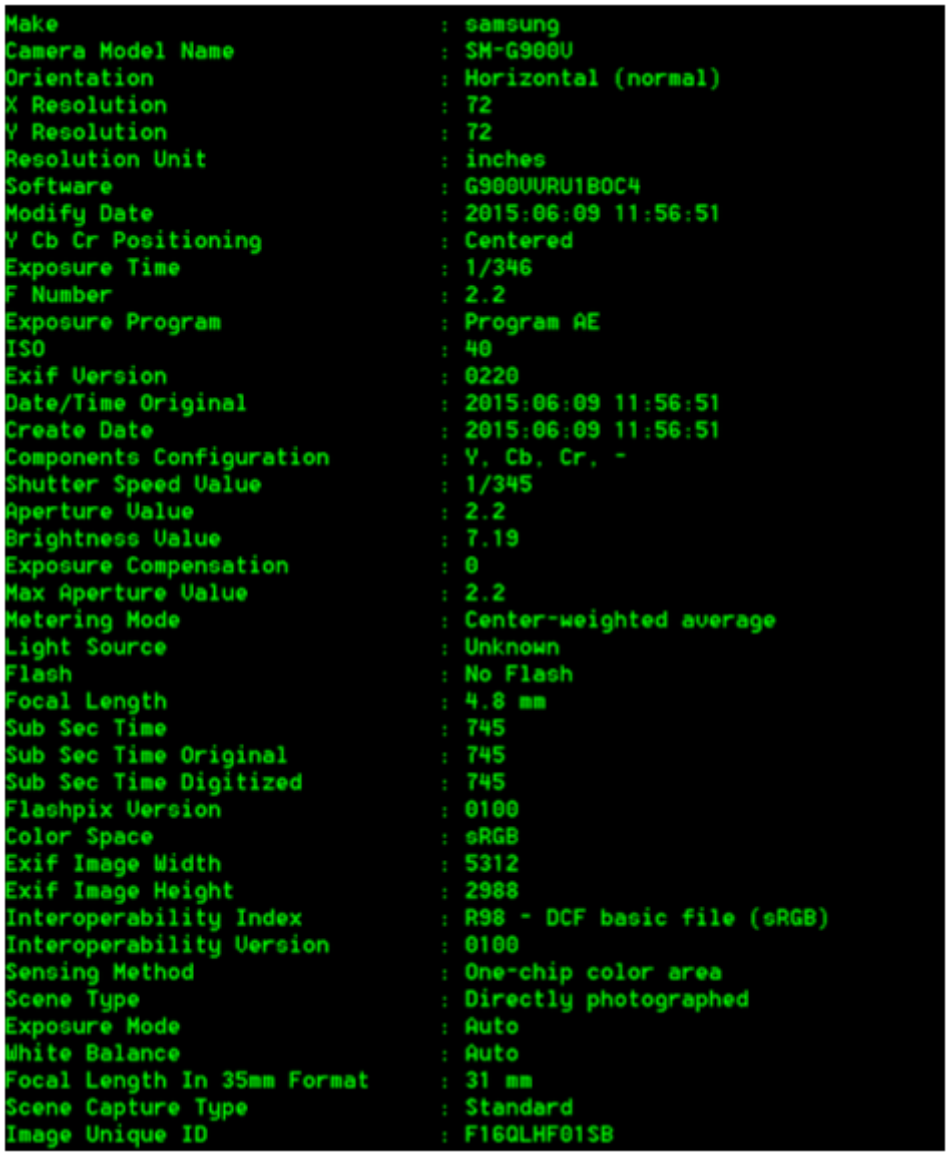
File type

```
C:\Users\[redacted]\Downloads\exiftool-9.98>"exiftool(-k).exe" fileA
ExifTool Version Number         : 9.98
File Name                       : fileA
Directory                       : .
File Size                       : 3.2 MB
File Modification Date/Time     : 2015:07:06 21:39:36-04:00
File Access Date/Time           : 2015:07:11 21:37:58-04:00
File Creation Date/Time         : 2015:07:11 21:37:58-04:00
File Permissions                : rw-rw-rw-
File Type                       : JPEG
File Type Extension             : jpg
MIME Type                       : image/jpeg
Exif Byte Order                 : Little-endian (Intel, II)
Compression                     : JPEG (old-style)
```

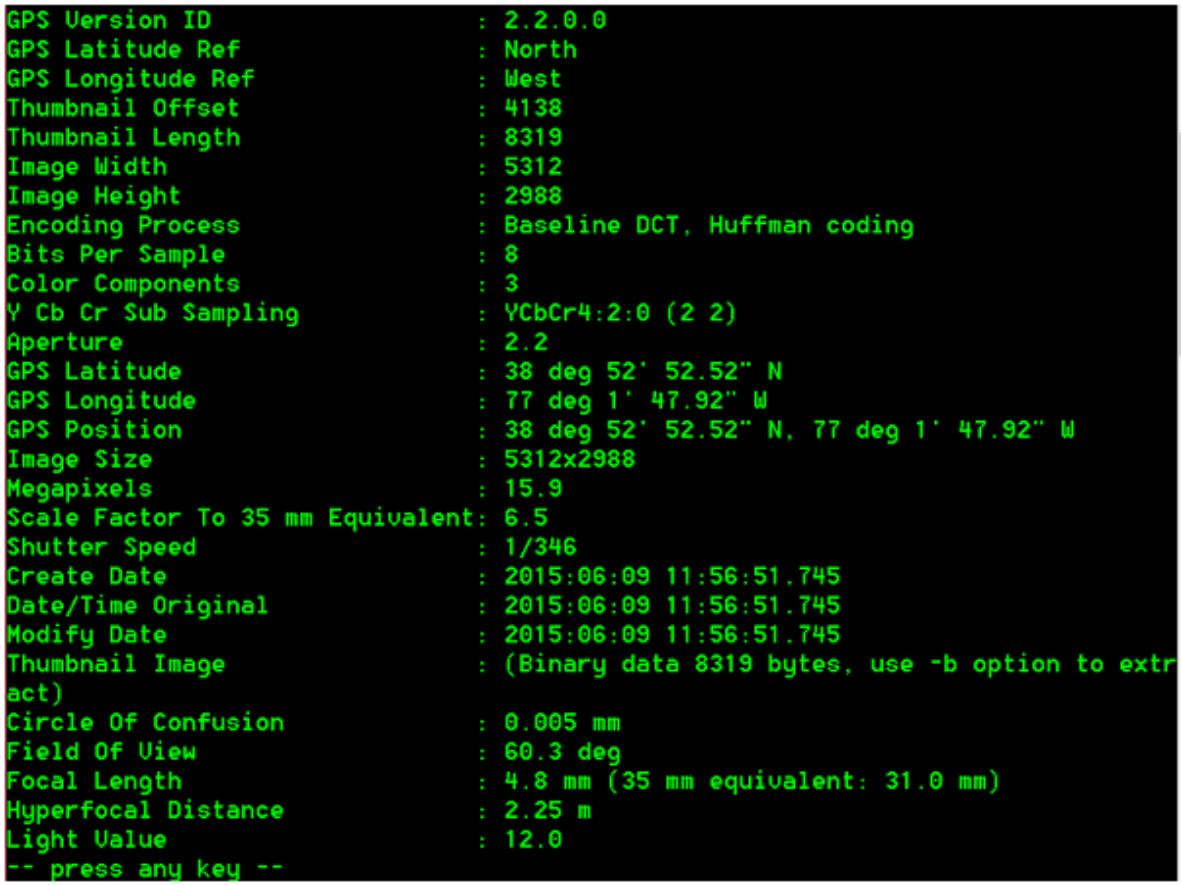
Image description

```
Image Description               : 78 68 103 103 78 106 85 103 78 122 107 103 77
106 65 103 78 68 81 103 78 106 85 103 78 106 69 103 78 109 77 103 78 106 85 103
78 122 73 103 77 122 73 103 77 122 65 103 77 122 69 103 77 109 77 103 77 71 81 1
03 77 71 69 103 78 68 107 103 77 106 65 103 78 122 99 103 78 106 69 103 78 122 7
7 103 77 106 65 103 78 122 81 103 78 106 103 103 78 106 107 103 78 109 85 103 78
 109 73 103 78 106 107 103 78 109 85 103 78 106 99 103 77 109 77 103 77 106 65 1
03 78 106 103 103 78 109 89 103 78 122 99 103 77 106 65 103 78 109 81 103 78 122
 85 103 78 106 77 103 78 106 103 103 77 106 65 103 78 106 85 103 78 122 103 103
78 106 69 103 78 106 77 103 78 122 81 103 78 109 77 103 78 122 107 103 77 106 65
 103 78 106 69 103 78 122 73 103 78 106 85 103 77 106 65 103 78 122 99 103 78 10
6 85 103 77 106 65 103 78 106 99 103 78 106 85 103 78 122 81 103 78 122 81 103 7
8 106 107 103 78 109 85 103 78 106 99 103 77 106 65 103 78 106 89 103 78 109 89
103 78 122 73 103 77 106 65 103 78 122 81 103 78 106 103 103 78 106 85 103 77 10
6 65 103 78 122 81 103 78 106 103 103 78 106 107 103 78 109 85 103 78 106 99 103
 78 122 77 103 77 106 65 103 78 122 81 103 78 106 103 103 78 106 69 103 78 122 8
1 103 77 106 65 103 78 122 99 103 78 106 85 103 90 84 73 103 79 68 65 103 79 84
107 103 78 122 73 103 78 106 85 103 77 106 65 103 90 84 73 103 79 68 65 103 79 8
7 77 103 78 106 73 103 78 109 89 103 78 122 73 103 78 122 73 103 78 109 89 103 7
8 122 99 103 78 106 107 103 78 109 85 103 78 106 99 103 90 84 73 103 79 68 65 10
3 79 87 81 103 77 50 89 103 77 106 65 103 78 68 107 103 77 106 65 103 78 109 73
103 78 106 107 103 78 109 85 103 78 106 81 103 77 106 65 103 78 109 89 103 78 10
6 89 103 77 106 65 103 78 122 99 103 78 109 89 103 78 122 85 103 78 109 77 103 7
8 106 81 103 77 106 65 103 78 109 77 103 78 106 107 103 78 109 73 103 78 106 85
103 77 106 65 103 78 122 81 103 78 109 89 103 77 106 65 103 78 106 73 103 78 106
 85 103 77 106 65 103 78 106 69 103 77 106 65 103 78 109 77 103 78 109 89 103 78
 122 81 103 77 109 77 103 77 106 65 103 78 109 89 103 78 122 81 103 78 106 103 1
03 78 106 85 103 78 122 73 103 78 122 99 103 78 106 107 103 78 122 77 103 78 106
 85 103 77 106 65 103 78 68 107 103 90 84 73 103 79 68 65 103 79 84 107 103 78 1
06 81 103 77 106 65 103 78 106 89 103 78 106 85 103 78 106 85 103 78 109 77 103
77 106 65 103 78 106 107 103 78 106 89 103 78 106 89 103 78 122 107 103 77 106 6
5 103 78 106 99 103 78 109 89 103 78 106 107 103 78 109 85 103 78 106 99 103 77
106 65 103 78 106 69 103 78 106 103 103 78 106 85 103 78 106 69 103 78 106 81 10
3 77 106 65 103 78 122 99 103 78 106 107 103 78 122 81 103 78 106 103 103 77 106
 65 103 78 122 81 103 78 106 103 103 78 106 107 103 78 122 77 103 90 84 73 103 7
9 68 65 103 89 84 89 103 77 71 81 103 77 71 69 103 77 109 81 103 77 109 81 103 7
7 106 65 103 78 68 99 103 78 106 107 103 78 122 73 103 78 109 77 103 78 68 107 1
03 78 109 85 103 78 84 99 103 78 106 103 103 78 106 107 103 78 122 81 103 78 106
 85 103 77 71 81 103 77 71 69 61 226 128 157 61
```

Make and camera info



GPS Latitude/Longitude



Timestamps

Timestamps are data that indicate the time of certain events (MAC): - Modification – when a file was modified - Access – when a file or entries were read or accessed - Creation – when files or entries were created

Types of timestamps

- Modified
- Accessed
- Created
- Date Changed (MFT)
- Filename Date Created (MFT)
- Filename Date Modified (MFT)
- Filename Date Accessed (MFT)
- INDX Entry Date Created
- INDX Entry Date Modified
- INDX Entry Date Accessed
- INDX Entry Date Changed

Why do we care?

Certain events such as creating, moving, copying, opening, editing, etc. might affect the MAC times. If the MAC timestamps can be attained, a timeline of events could be created.

Timeline Patterns

There are plenty more patterns than the ones introduced below, but these are the basics you should start with to get a good understanding of how it works, and to complete this challenge.

Pattern: Run steghide Tool on File

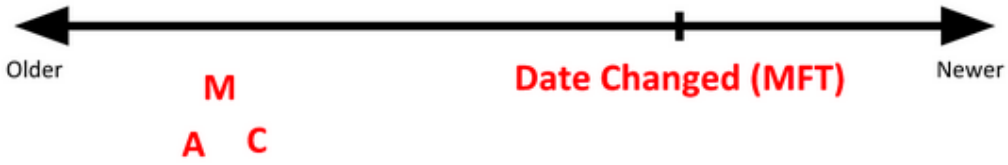
If the steghide tool was used to hide information in a file,

M= Date Changed (MFT) = INDX Entry Date Modified = INDX Entry Date Changed > A, C

Pattern: File Renamed

If a file was renamed,

Date Changed (MFT) ≠ INDX Entry Date Changed and **Date Changed (MFT) > M, A, C**



Pattern: File Copied Within Drive

If a file was copied within a drive,

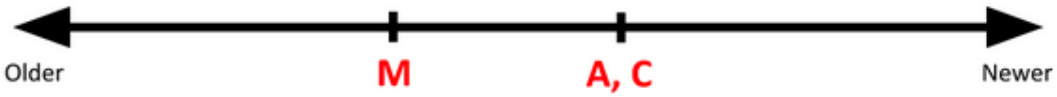
A = C > Date Changed (MFT), Filename Date Changed (MFT)
Copy's Filename Date Modified (MFT) = Orig's Filename Date Modified (MFT)
Copy's Filename Date Changed (MFT) = Orig's Date Changed (MFT)

Pattern: File Copied from Different Drive

If a file was copied from a completely different drive,

Accessed = Created > Modified

This is because the file must be newly created & accessed when copying the data over, but the last time it was modified was from before this time.



Pattern: File Opened with Paint, No Save

If the steghide tool was used to hide information in a file,

Filename Date Changed (MFT) > M, A, C

Examples

We know that the BMP files fileA and fileD are the same, but that the JPEG files fileB and fileC are different somehow. So how can we find out what went on with these files?


FileA


FileB

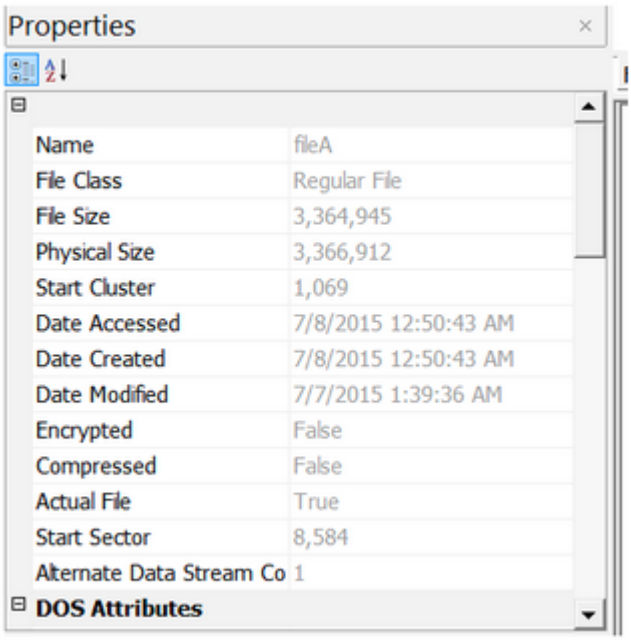

FileC

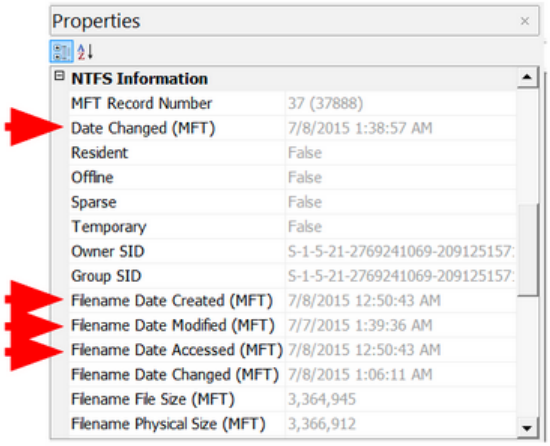

FileD

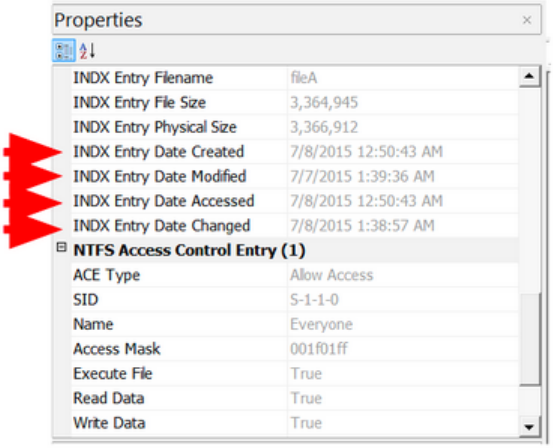
By using time stamp information from the file system, we can learn that the BMP fileD was the original file, with fileA being a copy of the original. Afterward, fileB was created by modifying fileB, and fileC was created by modifying fileA in a different way.

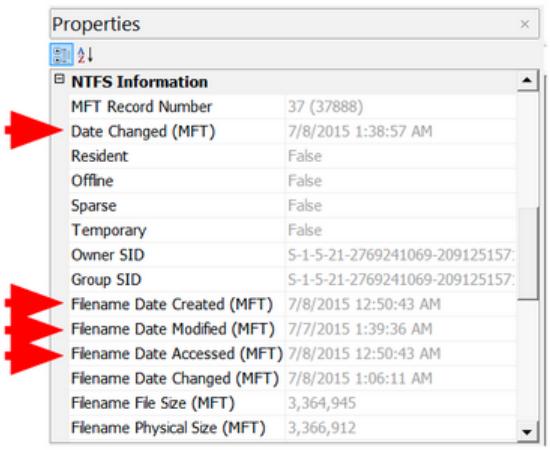
Follow along as we demonstrate.

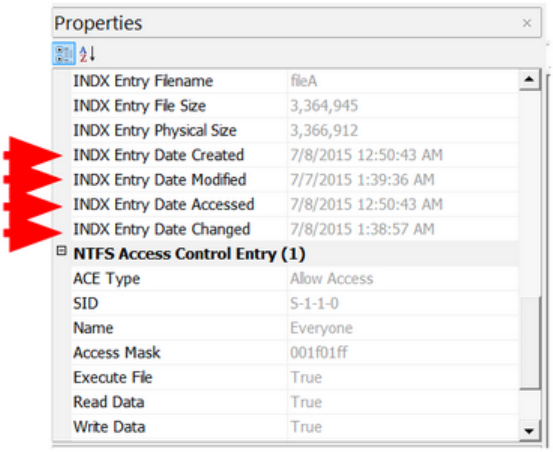
We'll start by analyzing images in AccessData FTK Imager, where there's a Properties window that shows you some information about the file or folder you've selected.

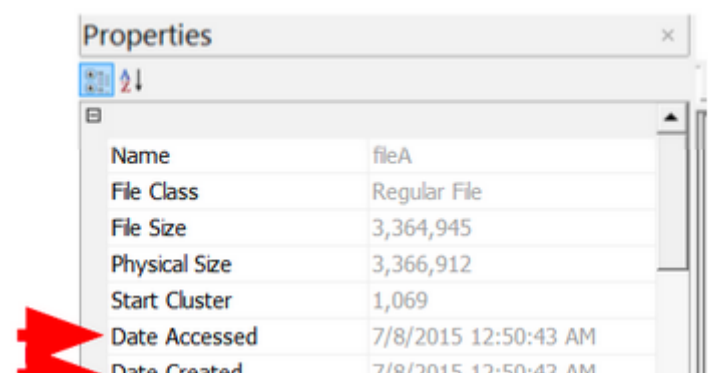

Properties
Name fileA
File Class Regular File
File Size 3,364,945
Physical Size 3,366,912
Start Cluster 1,069
Date Accessed 7/8/2015 12:50:43 AM
Date Created 7/8/2015 12:50:43 AM
Date Modified 7/7/2015 1:39:36 AM
Encrypted False
Compressed False
Actual File True
Start Sector 8,584
Alternate Data Stream Co 1
DOS Attributes

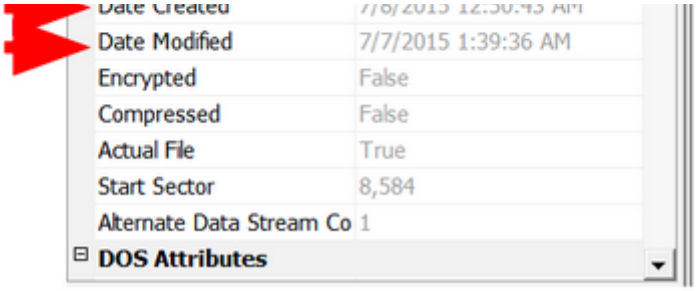

Properties
NTFS Information
MFT Record Number 37 (37888)
Date Changed (MFT) 7/8/2015 1:38:57 AM
Resident False
Offline False
Sparse False
Temporary False
Owner SID S-1-5-21-2769241069-209125157
Group SID S-1-5-21-2769241069-209125157
Filename Date Created (MFT) 7/8/2015 12:50:43 AM
Filename Date Modified (MFT) 7/7/2015 1:39:36 AM
Filename Date Accessed (MFT) 7/8/2015 12:50:43 AM
Filename Date Changed (MFT) 7/8/2015 1:06:11 AM
Filename File Size (MFT) 3,364,945
Filename Physical Size (MFT) 3,366,912


Properties
INDX Entry Filename fileA
INDX Entry File Size 3,364,945
INDX Entry Physical Size 3,366,912
INDX Entry Date Created 7/8/2015 12:50:43 AM
INDX Entry Date Modified 7/7/2015 1:39:36 AM
INDX Entry Date Accessed 7/8/2015 12:50:43 AM
INDX Entry Date Changed 7/8/2015 1:38:57 AM
NTFS Access Control Entry (1)
ACE Type Allow Access
SID S-1-1-0
Name Everyone
Access Mask 001f01ff
Execute File True
Read Data True
Write Data True


Properties
NTFS Information
MFT Record Number 37 (37888)
Date Changed (MFT) 7/8/2015 1:38:57 AM
Resident False
Offline False
Sparse False
Temporary False
Owner SID S-1-5-21-2769241069-209125157
Group SID S-1-5-21-2769241069-209125157
Filename Date Created (MFT) 7/8/2015 12:50:43 AM
Filename Date Modified (MFT) 7/7/2015 1:39:36 AM
Filename Date Accessed (MFT) 7/8/2015 12:50:43 AM
Filename Date Changed (MFT) 7/8/2015 1:06:11 AM
Filename File Size (MFT) 3,364,945
Filename Physical Size (MFT) 3,366,912


Properties
INDX Entry Filename fileA
INDX Entry File Size 3,364,945
INDX Entry Physical Size 3,366,912
INDX Entry Date Created 7/8/2015 12:50:43 AM
INDX Entry Date Modified 7/7/2015 1:39:36 AM
INDX Entry Date Accessed 7/8/2015 12:50:43 AM
INDX Entry Date Changed 7/8/2015 1:38:57 AM
NTFS Access Control Entry (1)
ACE Type Allow Access
SID S-1-1-0
Name Everyone
Access Mask 001f01ff
Execute File True
Read Data True
Write Data True


Properties
Name fileA
File Class Regular File
File Size 3,364,945
Physical Size 3,366,912
Start Cluster 1,069
Date Accessed 7/8/2015 12:50:43 AM



Here are the extracted MAC times for fileA, fileB, fileC and fileD: *Note, AccessData FTK Imager assumes that the file times on the drive are in UTC (Universal Coordinated Time). I subtracted four hours, since the USB was set up in Eastern Standard Time. This isn't necessary, but it helps me understand the times a bit better.*

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

Highlight timestamps that are the same, if timestamps are off by a few seconds, they should be counted as the same. This lets you see a clear difference between different timestamps. Then, highlight oldest to newest to help put them in order.

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

1. fileA A,C > M: **fileA was copied from another drive @ [7/7/15 8: 50PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

2. fileA Filename Date Changed (MFT) > M, A, C: **fileA opened in program (Paint?) @ [7/7/15 9:06PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

3. fileB is PNG, looks like fileA, M = A = C: **fileB created from fileA in program @ [7/7/15 9:10PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

4. fileC is BMP, looks like fileA, M = A = C: **fileC created from fileA in program @ [7/7/15 9:20PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

5. fileB Date Changed (MFT) > M, A, C: **fileB renamed @ [7/7/15 9: 32PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

6. fileC Date Changed (MFT) > M, A, C: **fileC renamed @ [7/7/15 9: 35PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

7. fileA Date Changed (MFT) > M, A, C: **fileA renamed @ [7/7/15 9: 38PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

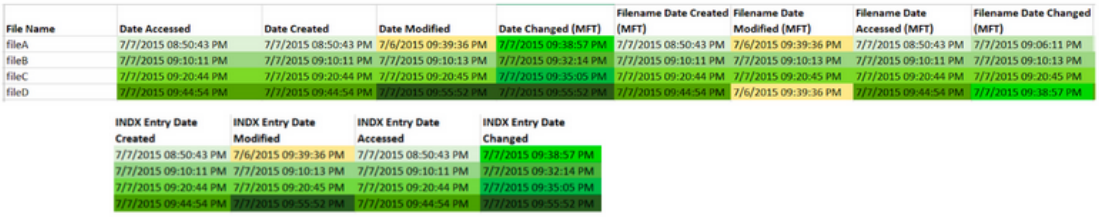
8. fileD A, C > Filename Date Modified (MFT), Filename Date Changed (MFT) & fileA's Date Changed (MFT) = fileD's Filename Date Changed (MFT) & Filename Date Modified (MFT) fileA = fileD: **fileA copied & renamed as fileD @ [7/7/15 9:44PM]**

File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

9. fileD M = Date Changed (MFT) = INDX Entry Date Modified = INDX Entry Date Changed > A, C: **fileD modified w/ Steghide @ [7/7/15 9:55PM]**

   Steghide usage could indicate hidden information inside fileD



File Name	Date Accessed	Date Created	Date Modified	Date Changed (MFT)	Filename Date Created (MFT)	Filename Date Modified (MFT)	Filename Date Accessed (MFT)	Filename Date Changed (MFT)
fileA	7/7/2015 08:50:43 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 09:38:57 PM	7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:06:11 PM
fileB	7/7/2015 09:10:11 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:32:14 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM
fileC	7/7/2015 09:20:44 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:35:05 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM
fileD	7/7/2015 09:44:54 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/6/2015 09:39:36 PM	7/7/2015 09:44:54 PM	7/7/2015 09:38:57 PM

INDX Entry Date Created	INDX Entry Date Modified	INDX Entry Date Accessed	INDX Entry Date Changed
7/7/2015 08:50:43 PM	7/6/2015 09:39:36 PM	7/7/2015 08:50:43 PM	7/7/2015 09:38:57 PM
7/7/2015 09:10:11 PM	7/7/2015 09:10:13 PM	7/7/2015 09:10:11 PM	7/7/2015 09:32:14 PM
7/7/2015 09:20:44 PM	7/7/2015 09:20:45 PM	7/7/2015 09:20:44 PM	7/7/2015 09:35:05 PM
7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM	7/7/2015 09:44:54 PM	7/7/2015 09:55:52 PM

Identify timestamp patterns.

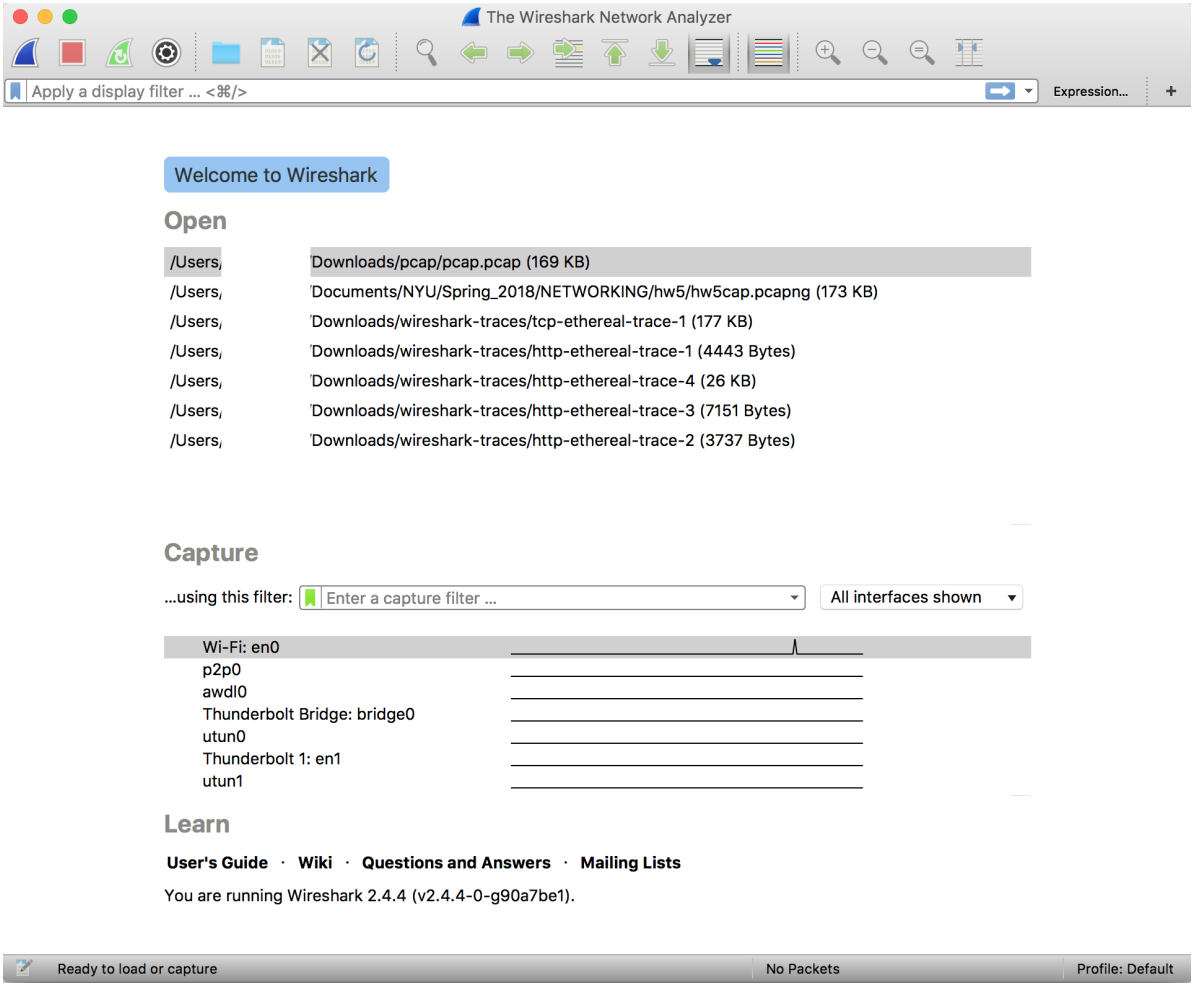
1. [7/7/15 8:50PM] fileA was copied onto the USB
2. [7/7/15 9:06PM] fileA was opened with a program (Paint?)
3. [7/7/15 9:10PM] fileA was saved in the program as fileB
4. [7/7/15 9:20PM] fileB was saved in the program as fileC
5. [7/7/15 9:32PM] fileB was renamed to **fileB**
6. [7/7/15 9:35PM]fileC was renamed to **fileC**
7. [7/7/15 9:38PM] fileA was renamed to **fileA**
8. [7/7/15 9:44PM] **fileA** was copied within the USB drive & renamed **fileD**
9. [7/7/15 9:55PM] Steghide was run on **fileD**

Wireshark

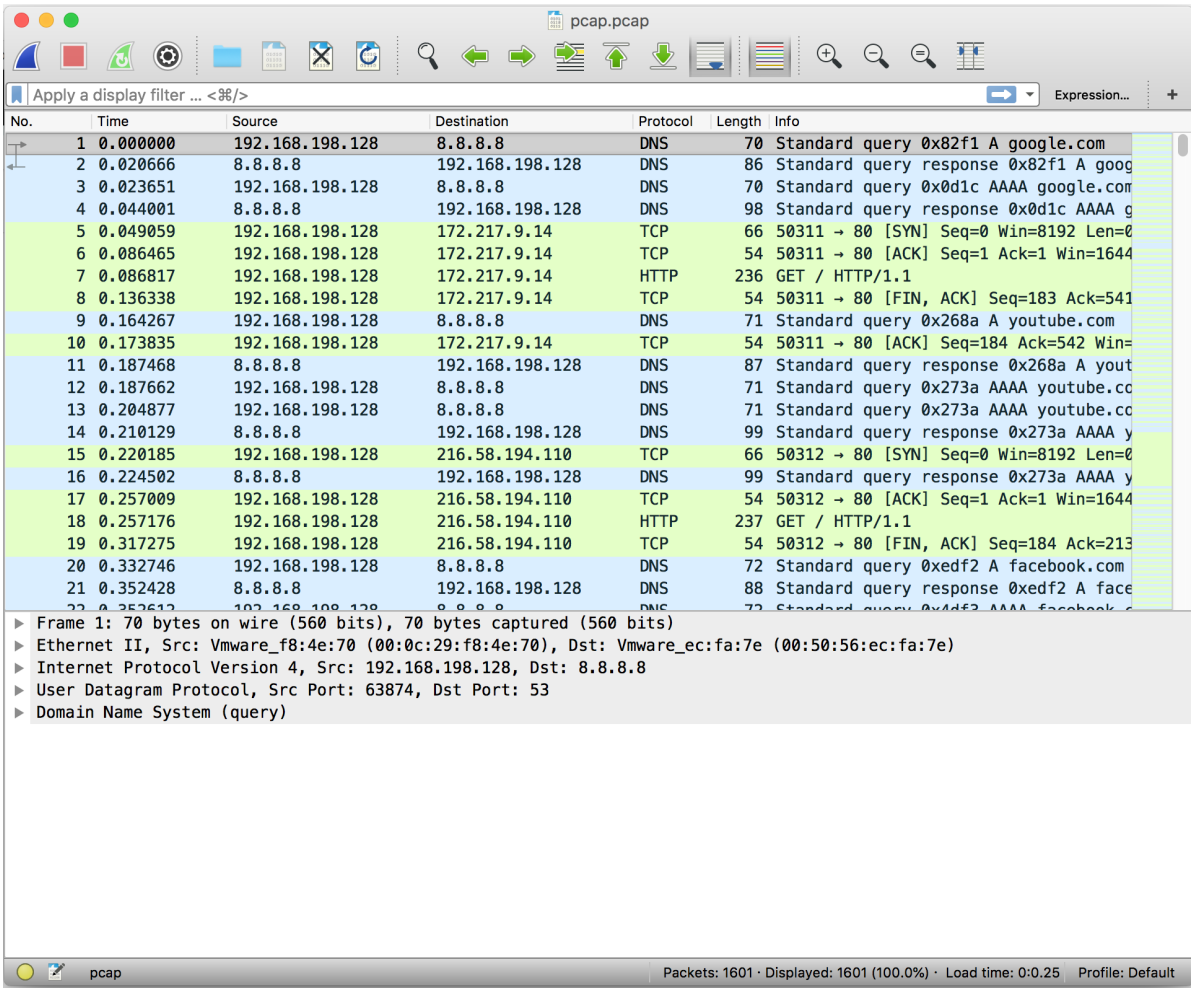
Wireshark is a network protocol analyzer which is often used in CTF challenges to look at recorded network traffic. Wireshark uses a filetype called PCAP to record traffic. PCAPs are often distributed in CTF challenges to provide recorded traffic history.

Interface

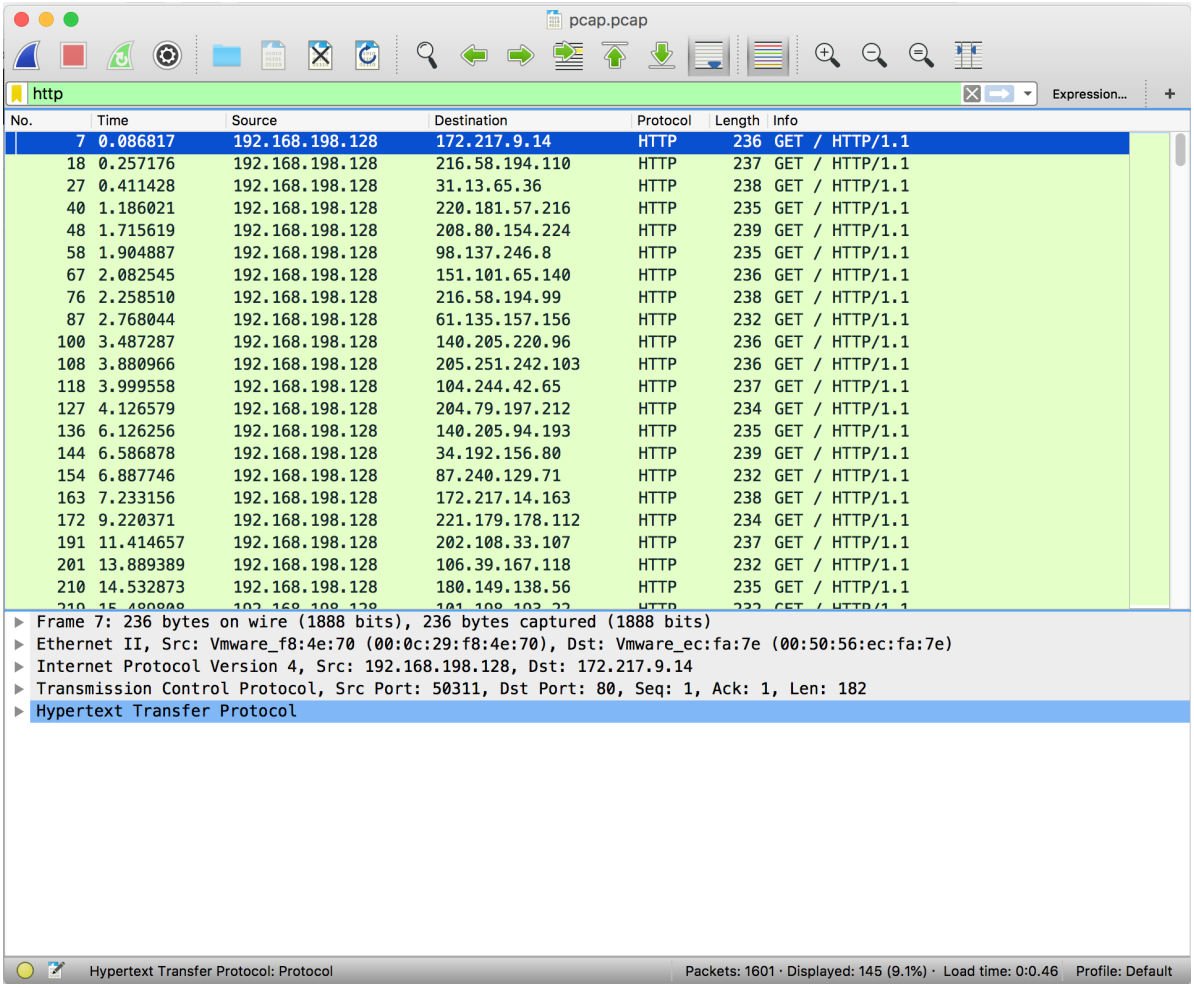
Upon opening Wireshark, you are greeted with the option to open a PCAP or begin capturing network traffic on your device.



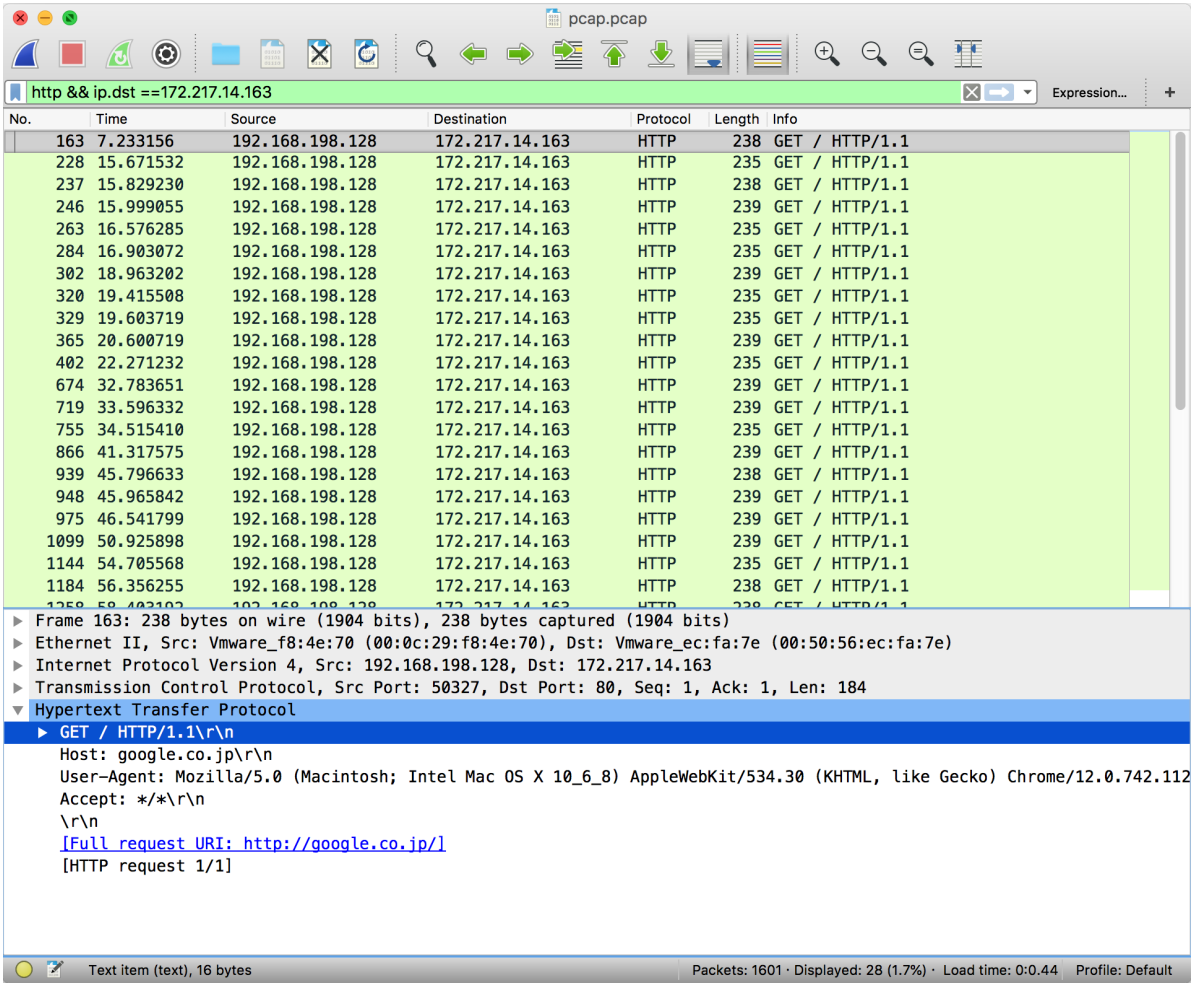
The network traffic displayed initially shows the packets in order of which they were captured. You can filter packets by protocol, source IP address, destination IP address, length, etc.



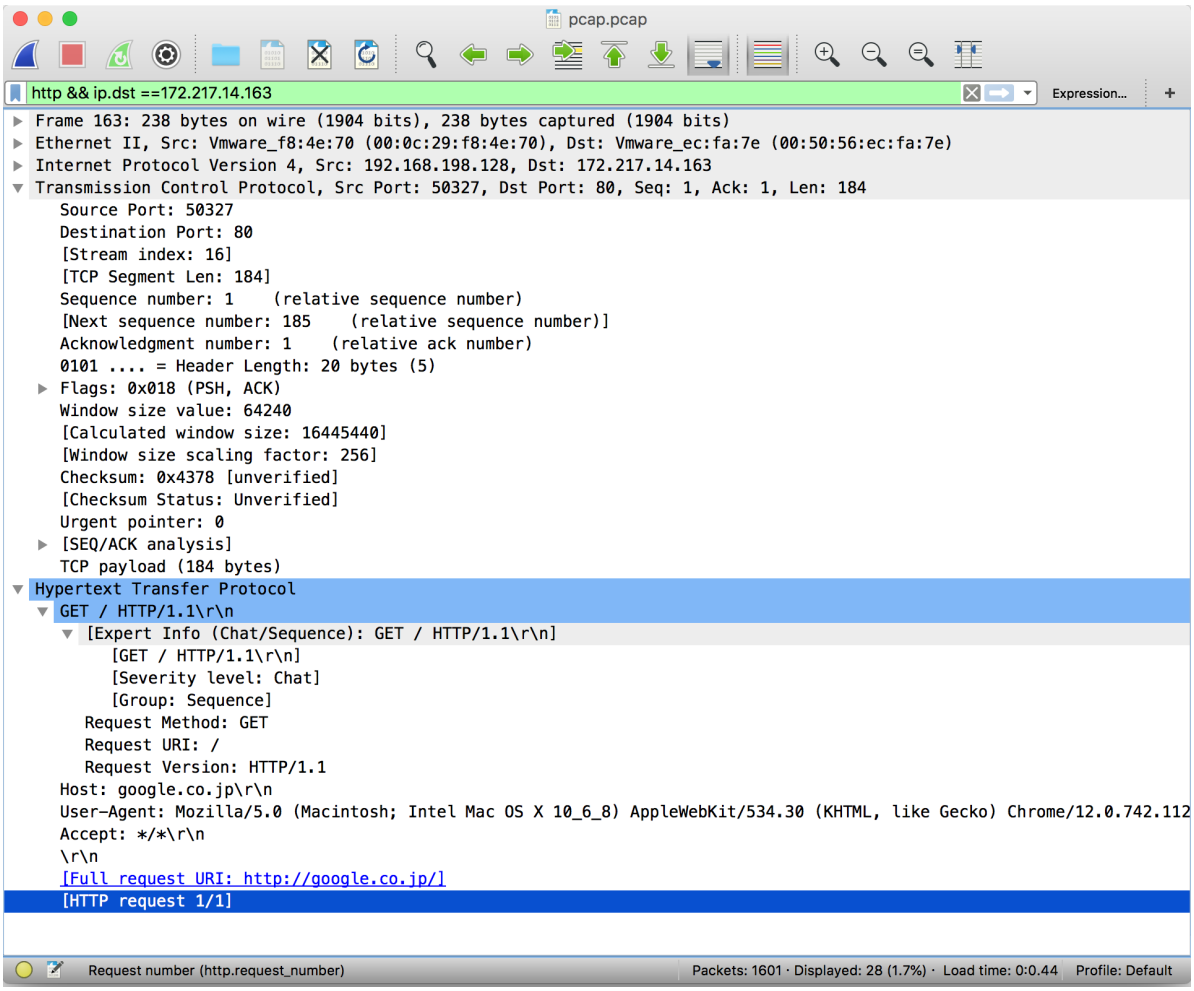
In order to apply filters, simply enter the constraining factor, for example 'http', in the display filter bar.



Filters can be chained together using '&&' notation. In order to filter by IP, ensure a double equals '==' is used.



The most pertinent part of a packet is its data payload and protocol information.



Decrypting SSL Traffic

By default, Wireshark cannot decrypt SSL traffic on your device unless you grant it specific certificates.

High Level SSL Handshake Overview

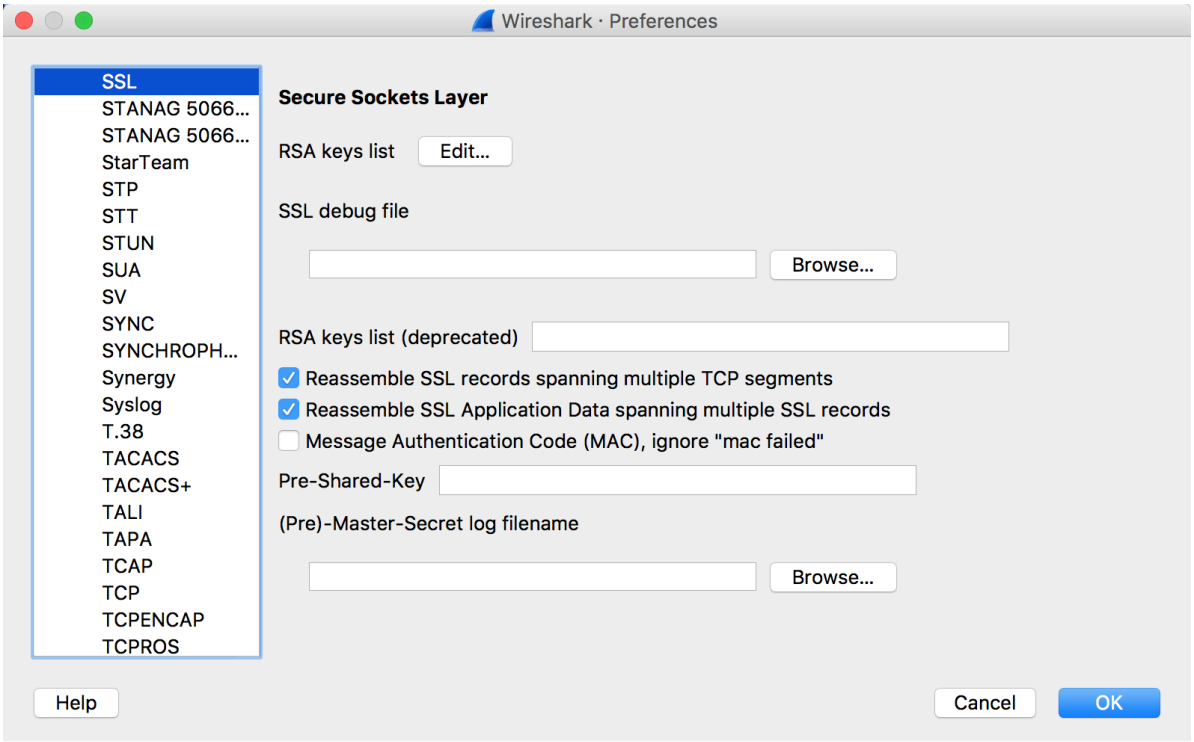
In order for a network session to be encrypted properly, the client and server must share a common secret for which they can use to encrypt and decrypt data without someone in the middle being able to guess. The SSL Handshake loosely follows this format:

1. The client sends a list of availble cipher suites it can use along with a random set of bytes referred to as client_random
2. The server sends back the cipher suite that will be used, such as TLS_DHE_RSA_WITH_AES_128_CBC_SHA, along with a random set of bytes referred to as server_random
3. The client generates a pre-master secret, encrypts it, then sends it to the server.
4. The server and client then generate a common master secret using the selected cipher suite
5. The client and server begin communicating using this common secret

Decryption Requirements

There are several ways to be able to decrypt traffic.

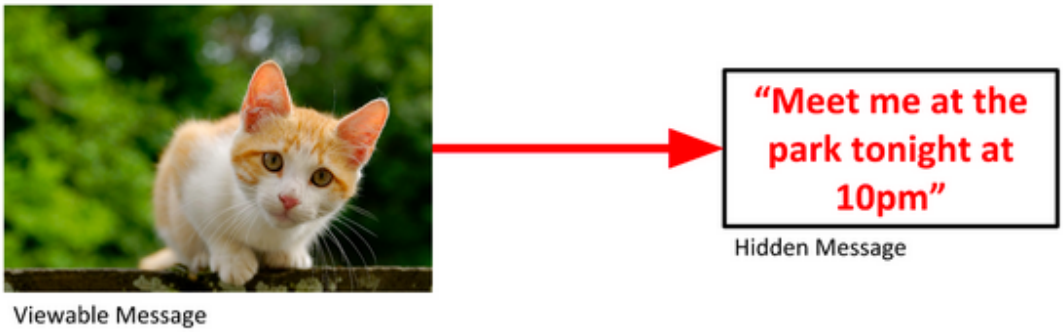
- If you have the client and server random values *and* the pre-master secret, the master secret can be generated and used to decrypt the traffic
- If you have the master secret, traffic can be decrypted easily
- If the cipher-suite uses RSA, you can factor *n* in the key in order to break the encryption on the encrypted pre-master secret and generate the master secret with the client and server randoms



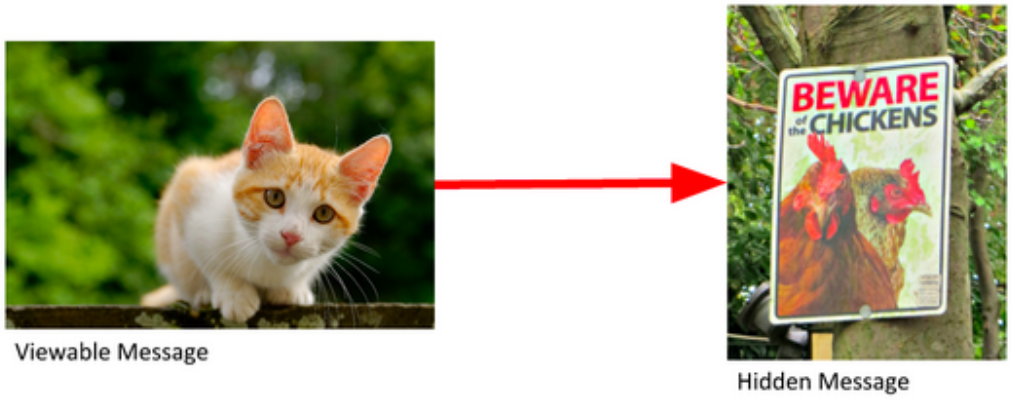
Steganography

Steganography is the practice of hiding data in plain sight. Steganography is often embedded in images or audio.

You could send a picture of a cat to a friend and hide text inside. Looking at the image, there's nothing to make anyone think there's a message hidden inside it.

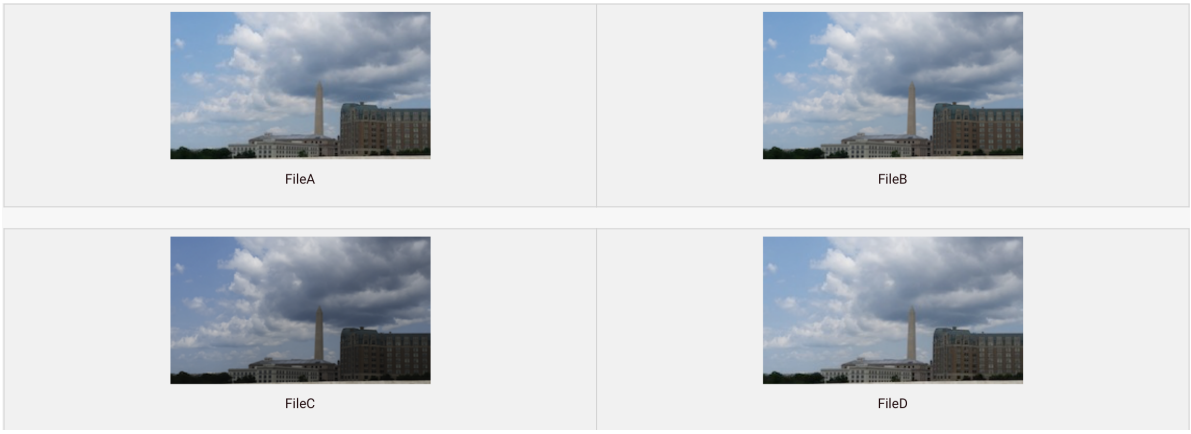


You could also hide a second image inside the first.



Steganography Detection

So we can hide text and an image, how do we find out if there is hidden data?



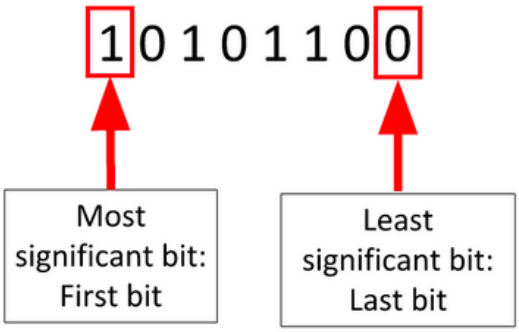
FileA and FileD appear the same, but they're different. Also, FileD was modified after it was copied, so it's possible there might be steganography in it.

FileB and FileC don't appear to have been modified after being created. That doesn't rule out the possibility that there's steganography in them, but you're more likely to find it in fileD. This brings up two questions:

1. Can we determine that there is steganography in fileD?
2. If there is, what was hidden in it?

LSB Steganography

File are made of bytes. Each byte is composed of eight bits.



Changing the least-significant bit (LSB) doesn't change the value very much.

$$1\,0\,1\,0\,1\,1\,0\,0_2 = 172_{10}$$

changing the LSB from '0' to '1':

$$1\,0\,1\,0\,1\,1\,0\,1_2 = 173_{10}$$

So we can modify the LSB without changing the file noticeably. By doing so, we can hide a message inside.

LSB Steganography in Images

LSB Steganography or *Least Significant Bit* Steganography is a method of Steganography where data is recorded in the lowest bit of a byte.

Say an image has a pixel with an RGB value of (255, 255, 255), the bits of those RGB values will look like

1	**1**	**1**	**1**	**1**	**1**	**1**	**1**

By modifying the lowest, or least significant, bit, we can use the 1 bit space across every RGB value for every pixel to construct a message.

1	**1**	**1**	**1**	**1**	**1**	**1**	**0**

The reason Steganography is hard to detect by sight is because a 1 bit difference in color is insignificant as seen below.

Example

Let's say we have an image, and part of it contains the following binary:

00110010 01100011 01101111 01101111 01101100 00110100 01101101
01100101

And let's say we want to hide the character y inside.

First, we need to convert the hidden message to binary.

y = 01111001

Now we take each bit from the hidden message and replace the LSB of the corresponding byte with it.

00110010 01100011 01101111 01101111 01101100 00110100 01101101
01100101

01111001

And again:

00110010 01100011 01101111 01101111 01101100 00110100 01101101
01100101

01111001

And again:

00110010 01100011 01101111 01101111 01101100 00110100 01101101
01100101

01111001

And again:

00110010 01100011 01101111 01101111 01101101 00110100 01101101
01100101

01111001

NOTE: The 0 had to be changed to a 1 here

And again:

00110010 01100011 01101111 01101111 01101101 00110100 01101101
01100101

01111001

And again:

00110010 01100011 01101111 01101111 01101101 00110100 01101100
01100101

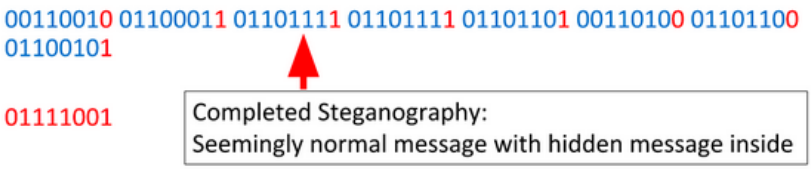
01111001

And again:

00110010 01100011 01101111 01101111 01101101 00110100 01101100
01100101

01111001

And once more:



Decoding LSB steganography is exactly the same as encoding, but in reverse. For each byte, grab the LSB and add it to your decoded message. Once you've gone through each byte, convert all the LSBs you grabbed into text or a file. (You can use your file signature knowledge here!)

What other types of steganography are there?

Steganography is hard for the defense side, because there's practically an infinite number of ways it could be carried out. Here are a few examples: - LSB steganography: different bits, different bit combinations - Encode in every certain number of bytes - Use a password - Hide in different places - Use encryption on top of steganography

Blind Watermark

Blind watermark is a kind of technique to embed one picture or string to another image. Just like the regular watermark, but the blind watermark cannot be detected by using human eyes. The transformed image is indistinguishable from the origin one.

Furthermore, blind watermark should be able to bypass different types of processing of image. For example, rotating the picture should not broke the blind watermark. Some modern researches are focusing on the strong transform of the image, such like film the image from another screen.

Example

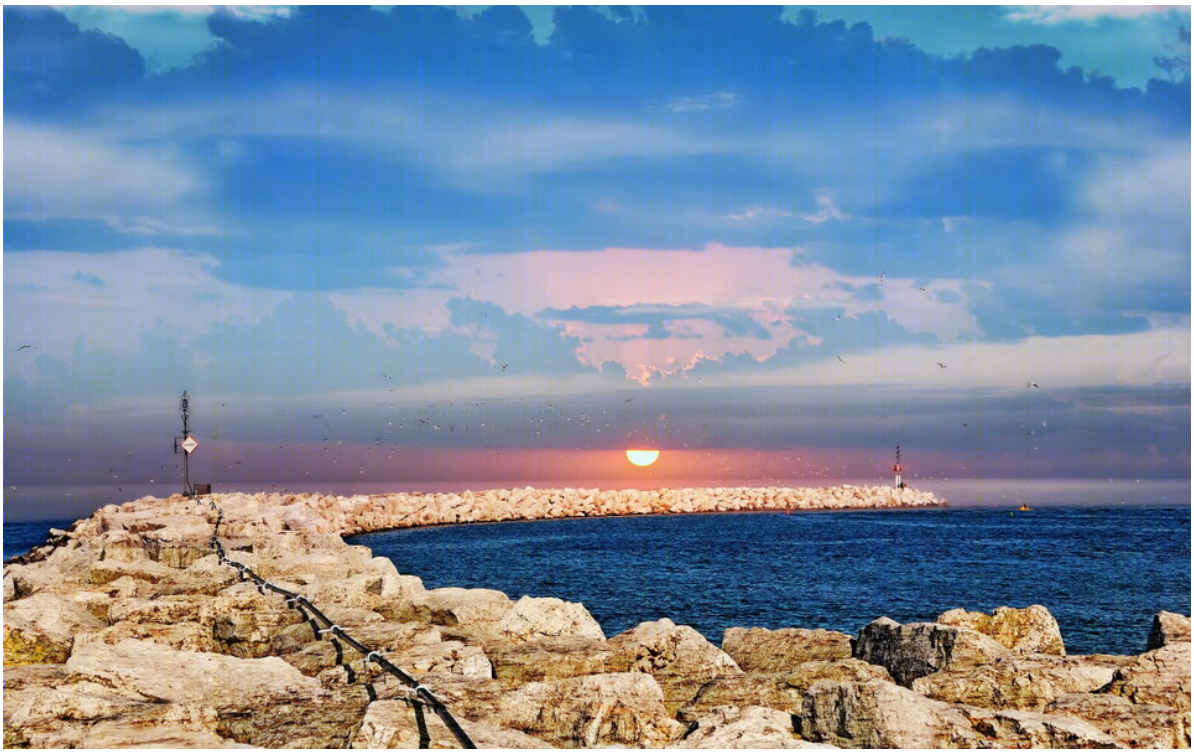
encode:

original image

watermark


```
python encode.py --image ori.png --watermark watermark.png --result res.png
```

result



decode:

```
python decode.py --original ori.png --image res.png --result extract.png
```

watermark

Hex Editor

A hexadecimal (hex) editor (also called a binary file editor or byte editor) is a computer program you can use to manipulate the fundamental binary data that constitutes a computer file. The name “hex” comes from “hexadecimal,” a standard numerical format for representing binary data. A typical computer file occupies multiple areas on the platter(s) of a disk drive, whose contents are combined to form the file. Hex editors that are designed to parse and edit sector data from

the physical segments of floppy or hard disks are sometimes called sector editors or disk editors. A hex editor is used to see or edit the raw, exact contents of a file. Hex editors may used to correct data corrupted by a system or application. A list of editors can be found on the forensics Wiki. You can download one and install it on your system.

Example

Open fileA.jpg in a hex editor. (Most Hex editors have either a “File > Open” option or a simple drag and drop.)

When you open fileA.jpg in your hex editor, you should see something similar to this:

fileA

Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00000000	FF	D8	FF	E1	30	A6	45	78	69	66	00	00	49	49	2A	00	ÿøyá0¦Exif..II*.
00000010	08	00	00	00	0F	00	00	01	04	00	01	00	00	00	C0	14	..............À.
00000020	00	00	01	01	04	00	01	00	00	00	AC	0B	00	00	03	01	..........¬.....
00000030	03	00	01	00	00	00	06	00	00	00	0E	01	02	00	9E	0B	..............ž.
00000040	00	00	C2	00	00	00	0F	01	02	00	08	00	00	00	60	0C	..Â..........`.
00000050	00	00	10	01	02	00	09	00	00	00	68	0C	00	00	12	01	..........h.....
00000060	03	00	01	00	00	00	01	00	00	00	1A	01	05	00	01	00	....
00000070	00	00	72	0C	00	00	1B	01	05	00	01	00	00	00	7A	0C	..r...........z.
00000080	00	00	28	01	03	00	01	00	00	00	02	00	00	00	31	01	..(...........1.
00000090	02	00	0E	00	00	00	82	0C	00	00	32	01	02	00	14	00	......,...2.....

Your hex editor should also have a “go to” or “find” feature so you can jump to a specific byte.

Exercise

Every lab we will have 2 or 3 challenges about the topics this week. But in case the difficulty of the challenge, only the first 2 challenges are required. But if you want to fight CTF so hard, you can try the third one. Solving the third one would give you extra points for this lab and some prizes as well.

For finishing the challenges, you may click this site: COMPASS CTF Platform and find the category `CS315`. Other challenges are for CTF team members, but you also can finish them freely. After uploading the flag on the platform, you also need to upload a writeup to blackboard system to grade.

The `writeup` is a file to describe how you solve the challenges and you need also post flag in it. **The writeup would use to grade** and in case you forget to submit the writeup, during the argue procedure, we would check the submission in platform.

Example writeup

```
(5 pt) Congratulations!
Now in order to check whether you are a robot, you need to submit this flag to
show that you are a real human!
flag{w31com3_tO_CS315_cOUrs3!!!}
```

The flag you submit should be `flag{w31com3_tO_CS315_cOUrs3!!!}`, and the example writeup probably be:

```
Writeup.md
I am a human so I copied the flag and submit it.
Here is the flag:
flag{w31com3_tO_CS315_cOUrs3!!!}
```

(5 pt) What is so called stream?

The network is so bad that I can't even send TCP stream through Internet. Wondering if I can use "UDP streams"...

capture.pcap

Try to find `flag` in this file, the flag format is: `picoCTF{***}`

Hint1: Wireshark may be useful.

(5 pt) HTTPS with secret sauce

Solved the network problem yesterday, but I found some guy was sniffing my network traffic. I need to be careful to protect my flag. Decide to use HTTPS to submit my flag to `web01`.

By the way, upload my **super☆secret☆file** to network disk.

capture.pcapng

pre-master secret.txt

Try to find `flag` in this file, the flag format is: `flag{y2***}`

(BONUS 5 pt) Bytes through network

That hacker still got my flag! Fine, I'm going to send my file byte by byte. Besides, combined with my knowledge of **programming, encryption, and stenography** I'm going to fight the final round. WE ARE IN THE ENDGAME NOW.

capture.pcapng

Try to find `flag` in this file, the flag format is: `flag{***}`

This challenge is extremely hard. The winner will get a badge for solving this.