CrowdsourcedDFIRBook

A crowdsourced DFIR book by
members of the Digital Forensics
Discord Server

Andrew Rathbun, ApexPredator,
Kevin Pagano and Nisarg Suthar

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Contents

Chapter 0 - Introduction

TODO for Andrew

Authors

Author bios go here

Chapter 1 - History of the Digital Forensics Discord Server

DigitalForensicsDiscordServerLogoByKevinPagano

Special thanks to Kevin Pagano for creating the logo for the Digital Forensics Discord Server!

History of the Digital Forensics Discord Server

I felt it was prudent to choose this topic for this project because very few others could provide as in depth of an account on the history of the Digital Forensics Discord Server. More to come in this section.

Beginnings in IRC

Long before the Digital Forensics Discord Server came to be, there existed a channel on an IRC[1] network called freenode[2]. The channel was called `#mobileforensics`. This channel had its humble beginnings on a Google Group ran by Bob Elder of TeelTech[3], called the Physical and RAW Mobile Forensics Group[4], which still exists today. In order to gain access to this Google Group, one had to have attended a TeelTech training in the past. It was, and continues to be, a phenomenal resource for those of us in Law Enforcement trying to navigate the waters of mobile forensic acquisitions.

By way of background, In February 2016 I attended the JTAG/Chip-Off class by TeelTech taught by Mike Boettcher and gained an invite to the Physical and RAW Mobile Forensics Group. I actively participated in the group to the extent my knowledge and curiosity enabled me. Make no mistake about, almost every other active poster in that group was more experienced or knowledgeable than myself. However, I thought to myself that there was no better place to immerse myself in or people to surround myself with than this group if I wanted to be the best version of myself.

On August 23, 2016, a user that went by the name of `tupperwarez` had informed the group that they were starting an IRC channel

[1] https://en.wikipedia.org/wiki/Internet_Relay_Chat
[2] https://en.wikipedia.org/wiki/Freenode
[3] https://www.teeltech.com/
[4] https://groups.google.com/g/physical-mobile-forensics/about?pli=1

called `#mobileforensics` in an effort "exchange ideas & have live discussions", as the post stated. I have been using forums for all of my internet life up until this point and I think subconsciously I was ready for something more, and this was it! I also knew that IRC was a longstanding tradition but I had never dabbled with it as I only had previous experience with messaging clients such as AOL Instant Messenger (AIM)[5] and MSN Messenger[6] at the time. 13 minutes after the post went out by `tupperwarez`, I was the first to respond in the thread that I had joined.

Throughout the next year and a half, a small contingent of people totaling anywhere from 7-15 at any given time occupied this IRC channel. We became a really tightknit group of examiners who relied on each other's knowledge and expertise to navigate challenges in our everyday casework. These problems often would relate to performing advanced acquisition methods using Chip-Off, JTAG, or flasher boxes. The collaboration was exactly what I was looking for because through each other we were able to cast a wider net for knowledge that we sought for problems we were coming across in our everyday investigations.

I recall utilizing an application called HexChat[7] to access this IRC channel. I'd have HexChat open at all times along with my everyday workflow of software applications to perform my duties as a Detective. For those reading this who have not used IRC before, know that's its nowhere near as feature rich as Discord. Discord is much more modern and IRC has been around since the "early days" of the internet as we know it today. I bring this up because often we needed to share pictures with each other as an exhibit for a problem we were encountering during the acquisition or decoding process of a mobile device.

[5] https://en.wikipedia.org/wiki/AIM_(software)

[6] https://en.wikipedia.org/wiki/Windows_Live_Messenger

[7] https://hexchat.github.io/

Move to Discord

Truthfully, I had forgotten this detail I'm about to share but one of the moderators reminded me of it a couple of years ago and it all came back to me. One of the main catalysts for moving from IRC was the fact that I was really annoyed with having to upload a picture to imgur and share the link on the IRC channel as it seemed inefficient and the process grew stale for me. I had created a Discord account back in September 2016 to join various special interest servers so I had a fair amount of exposure to Discord's capabilities prior to the birthdate of the Digital Forensics Discord Server, which is March 26th, 2018.

I recall having aspirations for a move to Discord months prior to March 2018. For those who didn't use Discord around this time, it was primarily a platform marketed towards gamers. Using it for things other than gaming wasn't the intended purpose at the time, but the functionality it had was everything I wanted in a chat client. Take all of the good features from every other chat application I had used up until that point in time and add even more quality of life features and an awesome mobile application, and I was sold. I didn't like how it wasn't as seamless to use IRC on my phone and combined with the inefficient image uploading process, Discord was a breath of fresh air.

I was reminded that the major push to move to Discord came from me mostly surrounding the image uploading process combined with the positive experiences I had with the platform in my personal life via special interest servers from September 2016 to March 2018. The call to move to Discord was met with nearly unanimous approval from members of the IRC channel. As a result, the Mobile Forensics Discord Server was created!

Mobile Forensics Discord Server -> Digital Forensics Discord Server

The Mobile Forensics Discord Server enjoyed great success and rapid growth throughout its first year of existence. The server's growth was entirely driven by word of mouth and advertising on various Google Groups. The list of channels maintained in the server were driven by member requests which quickly expanded outside of mobile devices. Over time, it became increasingly apparent that branding the server as a Mobile Forensics server did not fully encompass the needs of the DFIR community. To the best of my research, the Mobile Forensics Discord Server was rebranded to the Digital Forensics Discord Server sometime around February 2019.

Since then, multiple channels have been added, renamed, and removed at the request of members.

Member Growth

Throughout the 4 years (as of this writing), the Digital Forensics Discord Server has undergone substantial growth. Below are some major membership milestones that were mined from Announcements I made in the `#announcements` channel over time.

Major Milestones

Date	# of Members
3/26/2018	3
3/29/2018	116
4/3/2018	142
4/6/2018	171
4/11/2018	200
4/13/2018	250
5/30/2018	300
6/28/2018	375
7/9/2018	400
7/25/2018	450
8/20/2018	500
9/27/2018	600
11/16/2018	700
12/6/2018	800
1/10/2019	900
2/1/2019	1000
5/8/2019	1500
10/4/2019	2000
1/30/2020	2500
3/27/2020	3000
5/22/2020	4000
3/26/2021	6800
8/2/2021	8000
1/29/2022	9000
3/26/2022	9500

Hosting the Magnet Virtual Summit 2020

In early 2020, shortly after the COVID-19 pandemic began, I was approached by representatives from Magnet Forensics inquiring about the possibility of providing a centralized location for attendees of the Magnet Virtual Summit 2020 to chat during presentations. Enthusiastically, we accepted the idea and began to plan the logistics of hosting what likely would become a large influx of members. I seem to recall nearly 1500 members joining during the month long Magnet Virtual Summit 2020.

In retrospect, it's clear that this was one of the first indicators that the server had "made it" in the eyes of the community.

SANS DFIR Virtual Summit 2020 went virtual

Community Engagement Within the Server

vendors and customers

Impact on the DFIR community

solo cop up in alaska who's nearest fellow examiner is 3 hours away

Law Enforcement roles were separated by country from the early stages of the server for the purpose of delineating members from each other due to various legal considerations that may vary from one jurisdiction to another. Because of that, enumerating a list of the countries that a Law Enforcement role has been created for is likely the best way to establish the reach the Digital Forensics Discord Server has had on the DFIR community on a global level.

Countries with roles assigned for Law Enforcement personnel (as of May 2022):

- Albania
- Argentina
- Australia
- Austria
- Bangladesh
- Belgium
- Bosnia
- Brazil
- Canada
- Chile
- China

- Columbia
- Croatia
- Cyprus
- Czech Republic
- Denmark
- Dominican Republic
- Estonia
- Finland
- France
- Germany
- Greece
- Grenada
- Iceland
- India
- Indonesia
- Iraq
- Ireland
- Israel
- Italy
- Jamaica
- Japan
- Korea
- Latvia
- Lithuania
- Luxembourg
- Maldives
- Malaysia
- Malta
- Mongolia
- New Zealand
- Mauritius
- Mexico
- Monaco
- Nepal

- Nigeria
- Norway
- Pakistan
- Netherlands
- Poland
- Portugal
- Romania
- Royal Cayman Islands
- Russia
- Senegal
- Seychelles
- Singapore
- Slovakia
- Slovenia
- Spain
- Sweden
- Switzerland
- Taiwan
- Turkey
- United Arab Emirates
- United Kingdom
- Ukraine
- Uruguay
- USA
- Vietnam

To save you from counting, that's 70 countries with a dedicated Law Enforcement role. This means that someone who has identified themselves as someone who works in Law Enforcement in one of these countries has joined the server and had this role assigned to them. At least 1 person from each of these countries that at the time served in a Law Enforcement capacity have joined the Digital Forensics Discord Server. With 195 countries[8] recognized in the

[8] https://www.worldatlas.com/articles/how-many-countries-are-in-the-world.html

world as of the writing of this book, the server has a reach into approximately 36% of those!

Future

The Digital Forensics Discord Server will continue to live and thrive so long as the community wills it.

For those who are new to administering Discord servers, one important thing to know is that only the member who is assigned as the Server Owner can delete the server. Currently, that person is me, Andrew Rathbun. In the interest of ensuring the Digital Forensics Discord Server lives far beyond all of us (assuming Discord is still around by that time), I've established a paper trail for any other moderators to follow should anything happen to me to where I will never be able to log back in to Discord. This paper trail will require a lot of effort and coordination with family members/friends of mine to access my password vault and many other necessary items in order to Transfer Ownership[9] so that the server can live on without any administrative hiccups.

[9] https://support.discord.com/hc/en-us/articles/216273938-How-do-I-transfer-server-ownership

Chapter 2 - Most Common Data Stores in Mobile Forensics

By Alexis Brignoni

Online presence: https://linqapp.com/abrignoni[10]

The Artisanal Approach

Most mobile forenisc examinations involve the use of third party tools to extract and decode information stored whitin targeted devices. What happens when the tool presents little to nothing of what is expected? What to do when the targeted app seems to not exist as far as the tool is concerned?

A big part of digital forensics involves what I call The Artisanal Approach. The Oxford Languages dictionary defines artisanal as:

ar·ti·san·al
/ärˈtēzən(ə)l/

[10] https://linqapp.com/abrignoni

adjective
- relating to or characteristic of an artisan.
"artisanal skills"
- (of a product, especially food or drink) made in a traditional or non-mechanized way.
"artisanal cheeses"

This is just a long way of saying that we will rely have to manually identify the relevant data stores. The approach has 3 steps.

1. Locate the relevant apps.
2. Identify the data stores for the app and extract meaningful items.
3. Report generation.

On this chapter we will focus mostly on step number two. We will discuss what type of data stores are mostly seen in mobile forensics and suggest cost effective (i.e. cheap) solutions to traige these sources. Let's dive in.

Locate Relevant Apps

The mobile forensics world is divided, mainly, between two dominant operating systems. These are Google's Android and Apple's iOS operating systems. As such both will organize things in vastly different ways within their file systems. This chapter will present examples from a full file system extraction view of Android and iOS devices. Even when working from a different type of extraction the main concepts, and the handling of data stores, will be the same. For details on mobile extraction types and their differences see here: https://privacyinternational.org/long-read/3256/technical-look-phone-extraction[11]

[11] https://privacyinternational.org/long-read/3256/technical-look-phone-extraction

Is is important to note that this chapter will touch on the most common locations and types of data needed for analysis. It is not an all encompasing guide to mobile forensics nor does it intend to be so. Without further ado let's dive in.

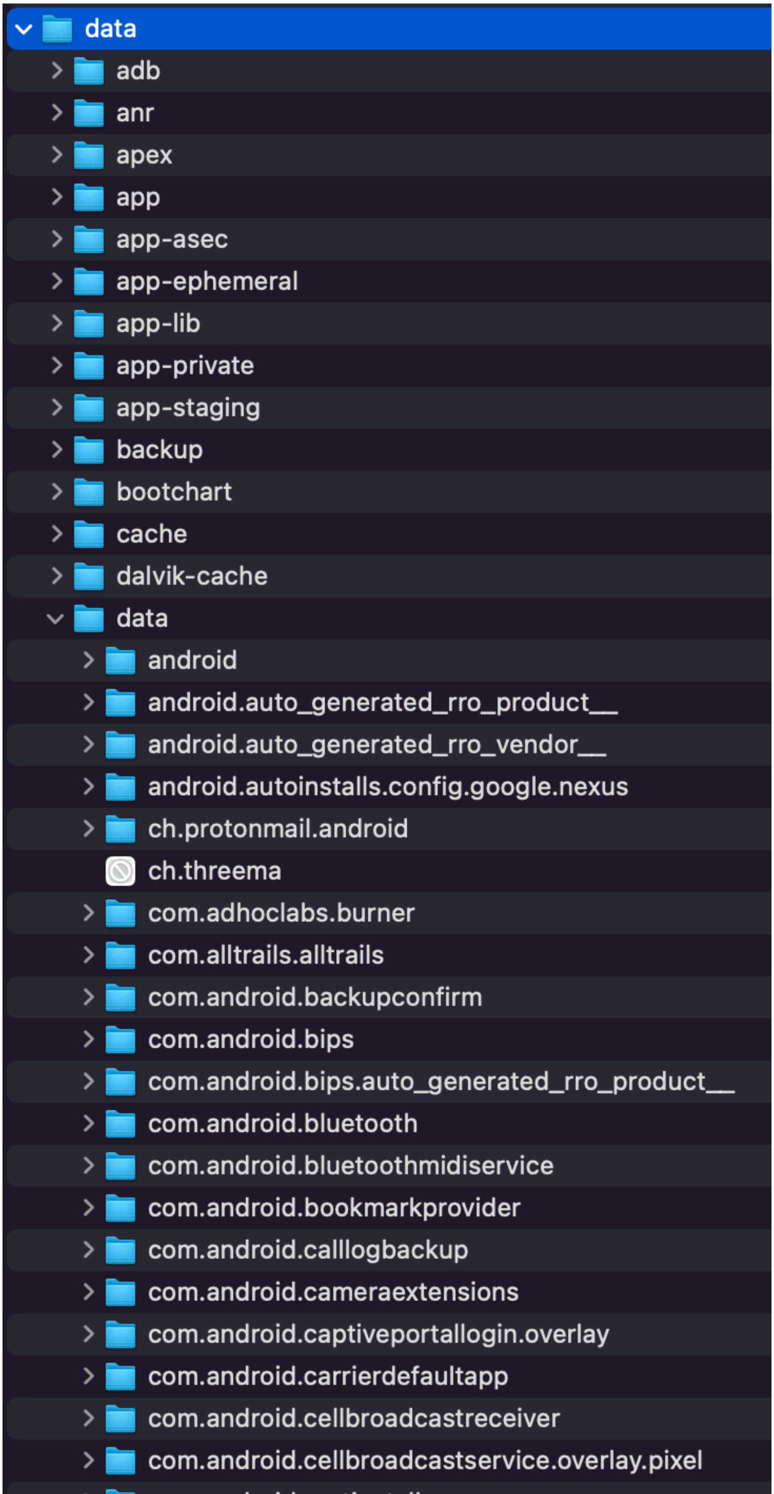
Relevant Apps in Android

In Adroid devices the apps keep most user generated data in the following directory:

/data/data/

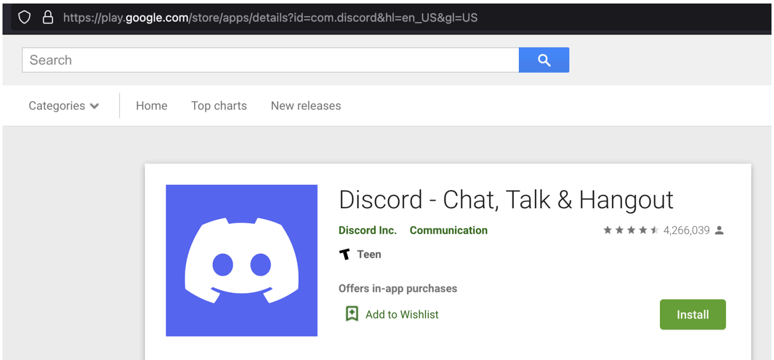
As seen in figure 2.1 there are folders within the data directory for each app on the device. These folders are named in reverse URL format and are known as bundle identifiers (IDs.) For details on bundle IDs in Android see here: https://developer.android.com/studio/build/configure-app-module [12]

[12] https://developer.android.com/studio/build/configure-app-module



```
data
  adb
  anr
  apex
  app
  app-asec
  app-ephemeral
  app-lib
  app-private
  app-staging
  backup
  bootchart
  cache
  dalvik-cache
  data
    android
    android.auto_generated_rro_product__
    android.auto_generated_rro_vendor__
    android.autoinstalls.config.google.nexus
    ch.protonmail.android
    ch.threema
    com.adhoclabs.burner
    com.alltrails.alltrails
    com.android.backupconfirm
    com.android.bips
    com.android.bips.auto_generated_rro_product__
    com.android.bluetooth
    com.android.bluetoothmidiservice
    com.android.bookmarkprovider
    com.android.calllogbackup
    com.android.cameraextensions
    com.android.captiveportallogin.overlay
    com.android.carrierdefaultapp
    com.android.cellbroadcastreceiver
    com.android.cellbroadcastservice.overlay.pixel
```

Most mobile apps have bundle ID names that are easy to identify. Notice in the previous image how it is pretty obvious that com.android.chrome should be the bundle ID for the Chrome Browser, which it is. Another example would be how the bundle ID for Discord is com.Discord. Be aware that is not always the case. Not all bundle ID names are easy to reference back to the app name just by reading. One way of determining the budle ID of an app in Android is to look for the app in the Google Play store using a browser.



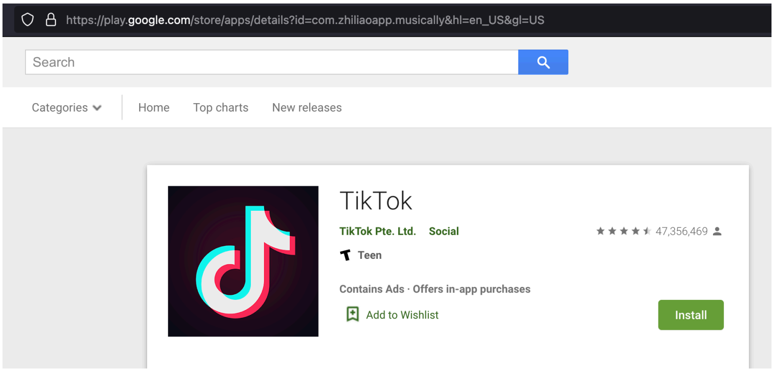
https://play.google.com/store/apps/details?id=com.discord&hl=en_US&gl=US

2.2 -

The bundle ID is located in the URL at the top of the page.

https://play.google.com/store/apps/details?id=com.discord&hl=en_-US&gl=US

Let’s look at TikTok.



https://play.google.com/store/apps/details?id=com.zhiliaoapp.musically&hl=en_US&gl=US

2.3 -

Notice how the bundle ID for TikTok, com.zhiliaoapp.musically makes no obvious reference to TikTok at all.

https://play.google.com/store/apps/details?id=com.zhiliaoapp.musically&hl=en_-US&gl=US

By changing the Google Play store URLs to the possibly unknown bundle IDs found on the target extraction one can determine the common app name for it.

It is of note that apps also save data to additional locations within the Android device. Look for targeted bundle ID direcotries in the following locations:

/data/media/
/MNT/ or /NONAME/

As you navigate the contents of these directories you will find relevant stores that can contain user generated data.

Relevant apps in iOS

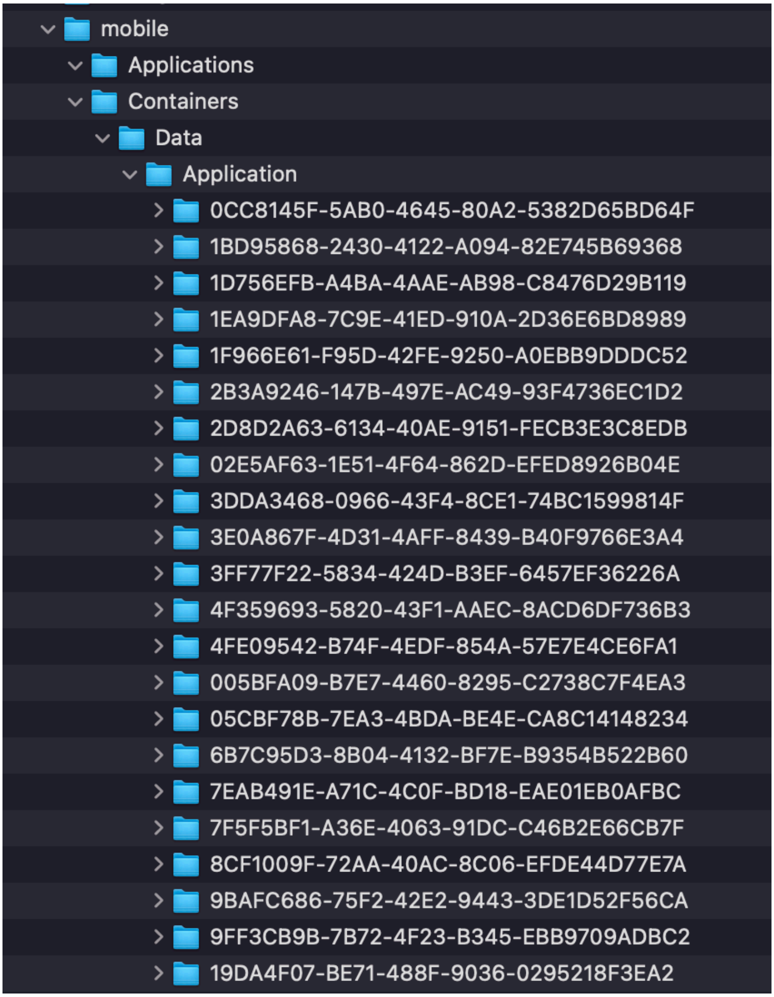
In iOS devices user generated data can be found in the following directories:

/private/var/containers/Bundle/Application/*GUID directory/*
/private/var/mobile/Containers/Shared/AppGroup/*GUID directory/*
/private/var/mobile/Containers/Data/PluginKitPlugin/*GUID directory/*

Notice the *GUID directory* at the end of the paths. These will be subsituted with a corresponding global unique identifier. See the following example:

A72DDBEE-8EEE-4868-9E5A-769B078781EA

These values can change constantly due to app installs, updates, and uninstalls. Unlike Android devices iOS bundle IDs are not part of the application directory paths therefore it is impossible to identify applications of interest visually by bundle ID names.



```
mobile
  Applications
  Containers
    Data
      Application
        0CC8145F-5AB0-4645-80A2-5382D65BD64F
        1BD95868-2430-4122-A094-82E745B69368
        1D756EFB-A4BA-4AAE-AB98-C8476D29B119
        1EA9DFA8-7C9E-41ED-910A-2D36E6BD8989
        1F966E61-F95D-42FE-9250-A0EBB9DDDC52
        2B3A9246-147B-497E-AC49-93F4736EC1D2
        2D8D2A63-6134-40AE-9151-FECB3E3C8EDB
        02E5AF63-1E51-4F64-862D-EFED8926B04E
        3DDA3468-0966-43F4-8CE1-74BC1599814F
        3E0A867F-4D31-4AFF-8439-B40F9766E3A4
        3FF77F22-5834-424D-B3EF-6457EF36226A
        4F359693-5820-43F1-AAEC-8ACD6DF736B3
        4FE09542-B74F-4EDF-854A-57E7E4CE6FA1
        005BFA09-B7E7-4460-8295-C2738C7F4EA3
        05CBF78B-7EA3-4BDA-BE4E-CA8C14148234
        6B7C95D3-8B04-4132-BF7E-B9354B522B60
        7EAB491E-A71C-4C0F-BD18-EAE01EB0AFBC
        7F5F5BF1-A36E-4063-91DC-C46B2E66CB7F
        8CF1009F-72AA-40AC-8C06-EFDE44D77E7A
        9BAFC686-75F2-42E2-9443-3DE1D52F56CA
        9FF3CB9B-7B72-4F23-B345-EBB9709ADBC2
        19DA4F07-BE71-488F-9036-0295218F3EA2
```

2.4 -

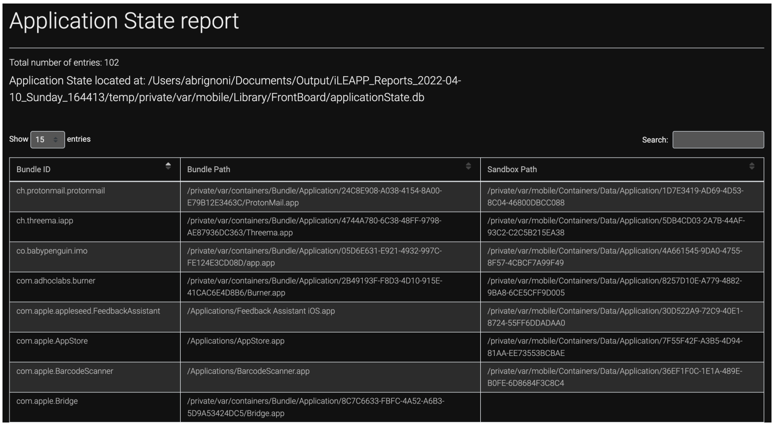
How can then we take these GUID named directories and linked them to the corresponding bundle IDs?

Option 1: applicationState.db

This data store is a SQLite database that contains information for all currently installed appications. We will discuss SQLite databases in the next section. The database is located here:

/private/var/mobile/Library/FrontBoard/applicationState.db

The exemplar data in the following image is from Josh Hickman's test iOS images. These can be found here:
https://thebinaryhick.blog/public_images/



Application State report

Total number of entries: 102

Application State located at: /Users/abrignoni/Documents/Output/iLEAPP_Reports_2022-04-10_Sunday_164413/temp/private/var/mobile/Library/FrontBoard/applicationState.db

Show 15 entries

Search:

Bundle ID	Bundle Path	Sandbox Path
ch.protonmail.protonmail	/private/var/containers/Bundle/Application/24C8E908-A038-4154-8A00-E79B12E3463C/ProtonMail.app	/private/var/mobile/Containers/Data/Application/1D7E3419-AD69-4D53-8C04-46800DBCC088
ch.threema.iapp	/private/var/containers/Bundle/Application/4744A780-6C38-48FF-9798-AE87936DC363/Threema.app	/private/var/mobile/Containers/Data/Application/5DB4CD03-2A7B-44AF-93C2-C2C5B215EA38
co.babypenguin.imo	/private/var/containers/Bundle/Application/05D6E631-E921-4932-997C-FE124E3CD08D/app.app	/private/var/mobile/Containers/Data/Application/4A661545-9DA0-4755-8F57-4CBCF7A99F49
com.adhoclabs.burner	/private/var/containers/Bundle/Application/2B49193F-F8D3-4D10-915E-41CAC6E4D8B6/Burner.app	/private/var/mobile/Containers/Data/Application/8257D10E-A779-4882-9BA8-6CE5CFF9D005
com.apple.appleseed.FeedbackAssistant	/Applications/Feedback Assistant iOS.app	/private/var/mobile/Containers/Data/Application/30D522A9-72C9-40E1-8724-55FF6DDADAA0
com.apple.AppStore	/Applications/AppStore.app	/private/var/mobile/Containers/Data/Application/7F55F42F-A3B5-4D94-81AA-EE73553BCBAE
com.apple.BarcodeScanner	/Applications/BarcodeScanner.app	/private/var/mobile/Containers/Data/Application/36EF1F0C-1E1A-489E-B0FE-6D8684F3C8C4
com.apple.Bridge	/private/var/containers/Bundle/Application/8C7C6633-FBFC-4A52-A6B3-5D9A53424DC5/Bridge.app	

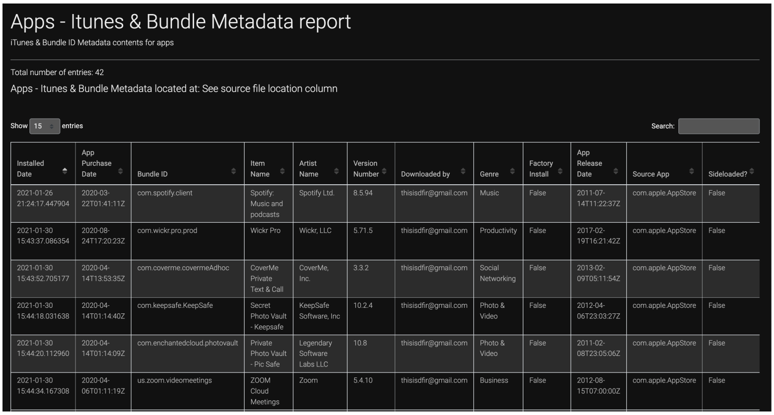
2.5 -

The tool used for this output is iLEAPP and can be found here: https://github.com/abrignoni/iLEAPP

Notice how the database can provide the bundle ID, the app name, and the corresponding GUID values within the paths.

Option 2: iTunesMetadata.plist & BundleMetadata.plist

These data stores are property lists (plist) and will be discussed in the next section. The files reside in each /private/var/containers/Bundle/Application/*GUID directory*/ folder per app. It contains a wealth of information regarding the app for each folder.



Apps - Itunes & Bundle Metadata report

iTunes & Bundle ID Metadata contents for apps

Total number of entries: 42

Apps - Itunes & Bundle Metadata located at: See source file location column

Show 15 entries

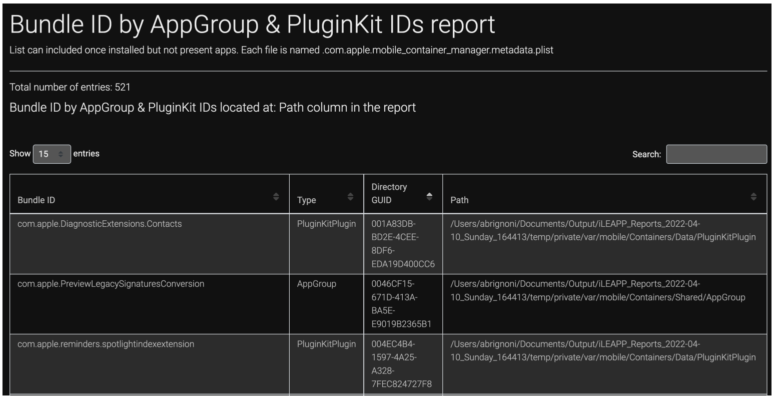
Search:

Installed Date	App Purchase Date	Bundle ID	Item Name	Artist Name	Version Number	Downloaded by	Genre	Factory Install	App Release Date	Source App	Sideloaded?
2021-01-26 21:24:17.447904	2020-03-22T01:41:11Z	com.spotify.client	Spotify: Music and podcasts	Spotify Ltd.	8.5.94	thisisdfir@gmail.com	Music	False	2011-07-14T11:22:37Z	com.apple.AppStore	False
2021-01-30 15:43:37.086354	2020-08-24T17:20:23Z	com.wickr.pro.prod	Wickr Pro	Wickr, LLC	5.71.5	thisisdfir@gmail.com	Productivity	False	2017-02-19T16:21:42Z	com.apple.AppStore	False
2021-01-30 15:43:52.705177	2020-04-14T13:53:35Z	com.coverme.covermeAdhoc	CoverMe Private Text & Call	CoverMe, Inc.	3.3.2	thisisdfir@gmail.com	Social Networking	False	2013-02-09T05:11:54Z	com.apple.AppStore	False
2021-01-30 15:44:18.031638	2020-04-14T01:14:40Z	com.keepsafe.KeepSafe	Secret Photo Vault - Keepsafe	KeepSafe Software, Inc	10.2.4	thisisdfir@gmail.com	Photo & Video	False	2012-04-06T23:03:27Z	com.apple.AppStore	False
2021-01-30 15:44:20.112960	2020-04-14T01:14:09Z	com.enchantedcloud.photovault	Private Photo Vault - Pic Safe	Legendary Software Labs LLC	10.8	thisisdfir@gmail.com	Photo & Video	False	2011-02-08T23:05:06Z	com.apple.AppStore	False
2021-01-30 15:44:34.167308	2020-04-06T01:11:19Z	us.zoom.videomeetings	ZOOM Cloud Meetings	Zoom	5.4.10	thisisdfir@gmail.com	Business	False	2012-08-15T07:00:00Z	com.apple.AppStore	False

2.6 -

Option3: .com.apple.mobile_container_manager.metadata.plist

Like the previous option the data store is a plist. The plist is contained in the /private/var/mobile/Containers/Shared/AppGroup/*GUID directory*/ and /private/var/mobile/Containers/Data/PluginKitPlugin/*GUID directory*/ folders. Notice the period at the start of the plist filename. If using a macOS for analisys make sure to enable the view hidden files options in order to not miss them.



Bundle ID by AppGroup & PluginKit IDs report

List can included once installed but not present apps. Each file is named .com.apple.mobile_container_manager.metadata.plist

Total number of entries: 521

Bundle ID by AppGroup & PluginKit IDs located at: Path column in the report

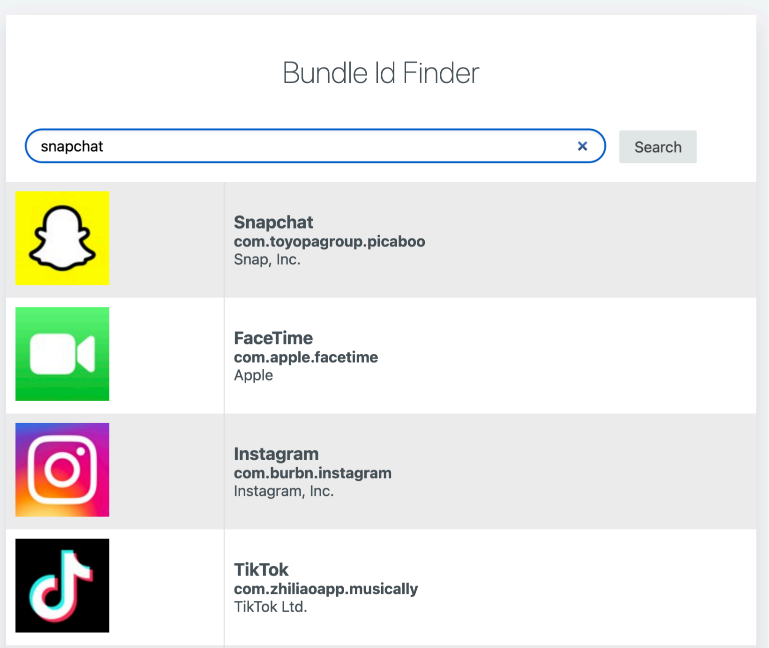
Bundle ID	Type	Directory GUID	Path
com.apple.DiagnosticExtensions.Contacts	PluginKitPlugin	001A83DB-BD2E-4CEE-8DF6-EDA19D400CC6	/Users/abrignoni/Documents/Output/iLEAPP_Reports_2022-04-10_Sunday_164413/temp/private/var/mobile/Containers/Data/PluginKitPlugin
com.apple.PreviewLegacySignaturesConversion	AppGroup	0046CF15-671D-413A-BA5E-E9019B2365B1	/Users/abrignoni/Documents/Output/iLEAPP_Reports_2022-04-10_Sunday_164413/temp/private/var/mobile/Containers/Shared/AppGroup
com.apple.reminders.spotlightindexextension	PluginKitPlugin	004EC4B4-1597-4A25-A328-7FEC824727F8	/Users/abrignoni/Documents/Output/iLEAPP_Reports_2022-04-10_Sunday_164413/temp/private/var/mobile/Containers/Data/PluginKitPlugin

2.7 -

As discussed previously bundle IDs might not be anywhere close to their commercial or well known app names. The following URL has a useful database of iOS bundle IDs and corresponding app names:

https://offcornerdev.com/bundleid.html

See the following output for Snapchat.



Snapchat
com.toyopagroup.picaboo
Snap, Inc.

FaceTime
com.apple.facetime
Apple

Instagram
com.burbn.instagram
Instagram, Inc.

TikTok
com.zhiliaoapp.musically
TikTok Ltd.

2.8 -

Common Data Stores in Mobile Forensics

We have identified the locations where user generated data, by app, can be stored both in Android and iOS. Now we look at what file structures are involved. Let's start with the current king of mobile data storage.

SQLite Relational Databases

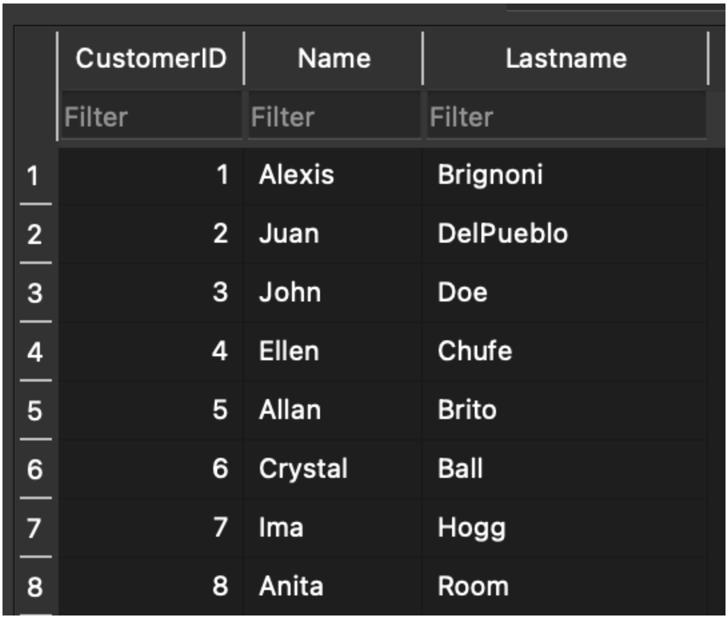
SQLite is the most used database engine in the world. It is a relation database. A simple way of thinking about them is by imagining a set of spreadsheets that have things in common. For this example we will use DB Browser for SQLite as our tool to access SQLite databases. It can be downloaded here: https://sqlitebrowser.org/[13]

SQLite databases usually have the .sqlite or .db extension but that might not always be the case. What is always the case is that if you open a suspected SQLite database with a hex or text editor you will see 'SQLite format 3' at the start of the file. This is known as the file header and it is a sure fire way of confirming you are dealing with a SQLite database.

Using DB Browser for SQLite we will open a database named test.db for analysis. It is a simple database consisting of two spredsheets of data, tables in SQLite parlance. By using the Browse Data the content of these tables can be seen.

Customers Table

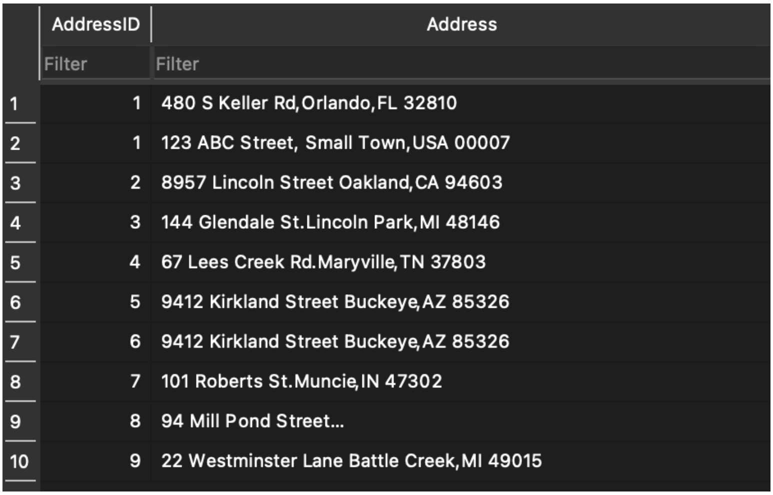
[13] https://sqlitebrowser.org/



	CustomerID	Name	Lastname
	Filter	Filter	Filter
1	1	Alexis	Brignoni
2	2	Juan	DelPueblo
3	3	John	Doe
4	4	Ellen	Chufe
5	5	Allan	Brito
6	6	Crystal	Ball
7	7	Ima	Hogg
8	8	Anita	Room

2.9 -

Addresses Table



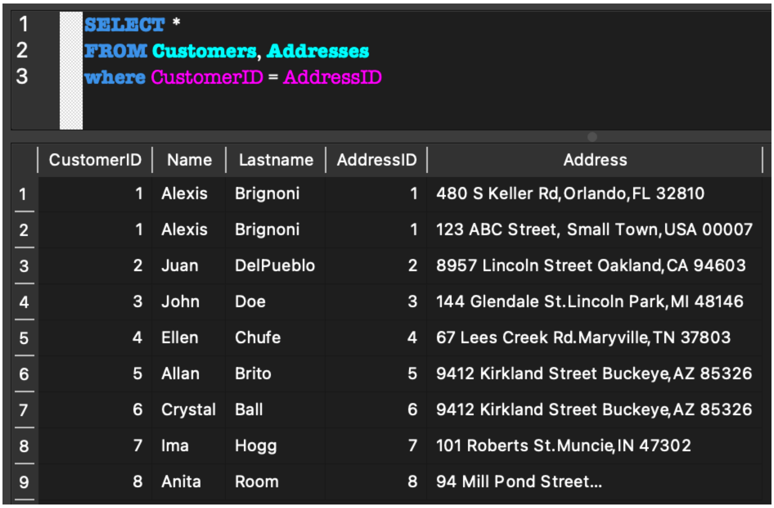
	AddressID	Address
	Filter	Filter
1	1	480 S Keller Rd,Orlando,FL 32810
2	1	123 ABC Street, Small Town,USA 00007
3	2	8957 Lincoln Street Oakland,CA 94603
4	3	144 Glendale St.Lincoln Park,MI 48146
5	4	67 Lees Creek Rd.Maryville,TN 37803
6	5	9412 Kirkland Street Buckeye,AZ 85326
7	6	9412 Kirkland Street Buckeye,AZ 85326
8	7	101 Roberts St.Muncie,IN 47302
9	8	94 Mill Pond Street...
10	9	22 Westminster Lane Battle Creek,MI 49015

2.10 -

These tables record the customer's names and addresses. A customer can have one or more addresses in the addresses table. How to we know what addresses correspond to what customer? Notice how the customerID column in the Customers table identifies each customer uniquely. This is called a Primary Key. These same values can be found in the Addresses table under AddressID. When that is the case they are know as a Foreign Keys. The purpose of a foreign key is to identify that row of data as being part of (relational) to the primary key. We can match the customer with the correct address by finding tprimary key in the Customers table and match it with the same foreign key in the Addresses table.

To tell the database to match customers to addresses we use a set of commmands called Structured Query Language (SQL). We will tell the database to gives us all columns from both tables where the CustomerID in the customer's table is the same as the AddressID in the addresses table.

```
SELECT * FROM Customers, Addresses where CustomerID =
AddressID
```



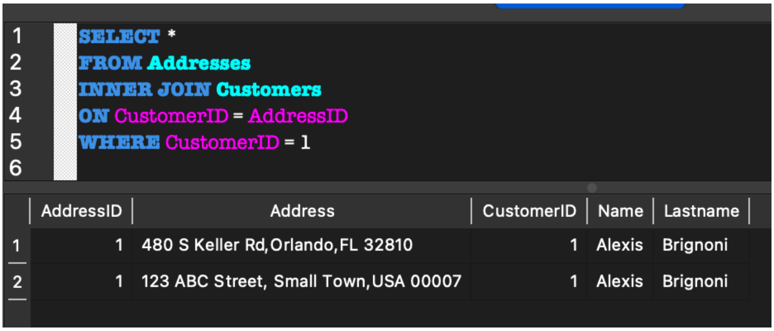
```
SELECT *
FROM Customers, Addresses
where CustomerID = AddressID
```

	CustomerID	Name	Lastname	AddressID	Address
1	1	Alexis	Brignoni	1	480 S Keller Rd, Orlando, FL 32810
2	1	Alexis	Brignoni	1	123 ABC Street, Small Town, USA 00007
3	2	Juan	DelPueblo	2	8957 Lincoln Street Oakland, CA 94603
4	3	John	Doe	3	144 Glendale St. Lincoln Park, MI 48146
5	4	Ellen	Chufe	4	67 Lees Creek Rd. Maryville, TN 37803
6	5	Allan	Brito	5	9412 Kirkland Street Buckeye, AZ 85326
7	6	Crystal	Ball	6	9412 Kirkland Street Buckeye, AZ 85326
8	7	Ima	Hogg	7	101 Roberts St. Muncie, IN 47302
9	8	Anita	Room	8	94 Mill Pond Street...

2.11 -

Each customer has been match with the proper address or addresses. Notice the asterisk after the SELECT command, it means we want all columns that are responsive to the query. SQL allows us to really narrow down how much data we want from the database. If I want obtain only the addresses that are related to Alexis Brignoni we would query the database the followingt way:

```
SELECT * FROM Addresses INNER JOIN Customers ON CustomerID
= AddressID WHERE CustomerID = 1
```



```
SELECT *
FROM Addresses
INNER JOIN Customers
ON CustomerID = AddressID
WHERE CustomerID = 1
```

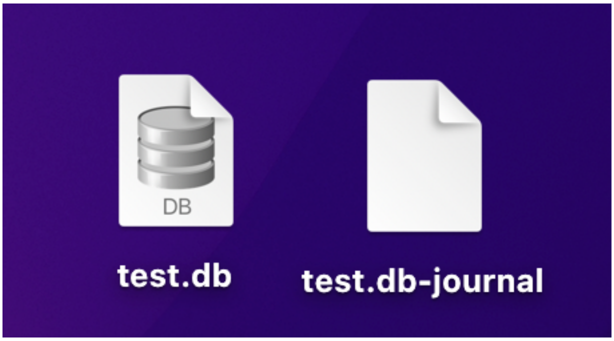
	AddressID	Address	CustomerID	Name	Lastname
1	1	480 S Keller Rd,Orlando,FL 32810	1	Alexis	Brignoni
2	1	123 ABC Street, Small Town,USA 00007	1	Alexis	Brignoni

2.12 -

The last query uses an inner join. These are the most common way of putting together data from two or more tables. An inner join will return rows from multiple tables when a condition is met. In our example we wanted all the data and only the data for CustomerID number 1.

SQLite databases can be pretty large with many tables and a multitude of primary and foreign keys to keep track of. Thankfully there are plenty of online resources on structured query language and with a little of patience and practice anyone can be able to pull relevant data out of these databases.

As we examine these databases we have to take into account temporary files SQLite uses as it works. These are write-ahead log and roll-back journal files. These files, if available, will have the same name as the database with either a -wal or -journal extension.



2.13 -

These temporary files might contain data not found in the database and will require examination with tools that support their forensic review. An athoritative book on the subject can be found here: SQLite Forensics by Paul Anderson[14]

JSON - Java Script Object Notation

[14] https://www.amazon.com/SQLite-Forensics-Paul-Sanderson/dp/1980293074

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Chapter 4 - I Have a Password Hash, Now What?

<img src=”https://user-images.githubusercontent.com/46549513/162606300-527e8cff-8c23-43d6-b06b-8b43fd7c82f2.png” width=”150” height=”150” />

By John Haynes

YouTube - https://www.youtube.com/channel/UCJVXolxwB4x3EsBAzSACCTg

Disclaimer / Overview

This chapter will discuss some techniques and walkthroughs surrounding the cracking of password hashes. We will start with the basics and move into more advanced concepts and tools. The first and most obvious reason to know how to crack a password is to gain access to data that one has the legal right to access, but otherwise does not know the password. That being said, I do not condone, encourage, or support those who would use this information for malicious or illegal means. This brings us to the second reason for knowing how to crack a password, better security and protection against password cracking attempts.

For those that need to legally access the data, there should be something in here for you. For those that wish to learn how to better secure their own data, there should be something in here for you as well. That being said, let’s get started!

The Basics

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Chapter 7 - Chapter Title Goes Here

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Chapter 8 - Chapter Title Goes Here

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Chapter Nine

Chapter Nine - Gamification of DFIR: Playing CTF's

<img src="https://user-images.githubusercontent.com/48143894/162533767-1d6eca8a-98c7-446b-a970-807bd3deb588.png" width="200" />

By Kevin Pagano[15] | Stark 4N6[16]

What is a CTF?

The origins of CTF or "Capture The Flag" were found on the playground. It was (still is?) an outdoor game where teams had to run into the other teams zones and physically capture a flag (typically a handkerchief) and return it back to their own base without getting tagged by the opposing team. In the information security realm it has come to mean a slightly different competition.

Why am I qualified to talk about CTFs?

Humble brag time. I've played in dozens of CTF competitions and have done pretty well for myself. I am the proud recipient of 3 DFIR Lethal Forensicator coins from SANS, one Tournament of Champions coin (and trophy!), a 3-time winner of Magnet Forensics CTF

[15] https://twitter.com/KevinPagano3

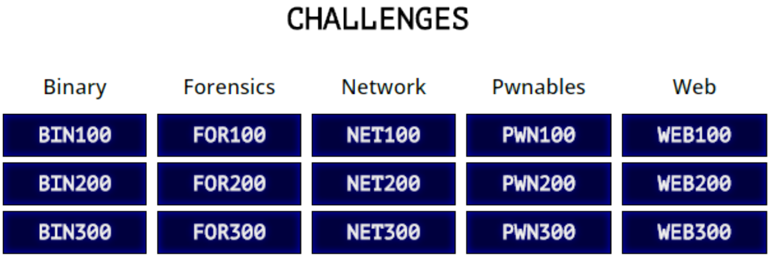
[16] https://startme.stark4n6.com

competitions, a 4-time winner of the BloomCON CTF competition, and a few others. I’ve also assisted in the creation of questions for some CTF competitions as well as creating thorough analysis write-ups of events I’ve competed in on my personal blog[17].

Types of CTFs

Two of the most common information security types of CTF competitions are “**Jeopardy**” style and “**Attack and Defense**” style.

“**Jeopardy**” style typically is a list of questions with varying difficulty and set defined answers. The player or team is given some sort of file or evidence to analyze and then has to find the flag to the question and input it in the proper format to get points.



CHALLENGES

Binary	Forensics	Network	Pwnables	Web
BIN100	FOR100	NET100	PWN100	WEB100
BIN200	FOR200	NET200	PWN200	WEB200
BIN300	FOR300	NET300	PWN300	WEB300

Figure 1: Jeopardy style CTF

“**Attack and Defense**” is more common in Red and Blue team environments where the Red team has to hack or attack a Blue team server. The Blue team subsequently has to try and protect themselves from the attack. Points can be given for time held or for acquiring specific files from their adversary.

[17] https://ctf.stark4n6.com

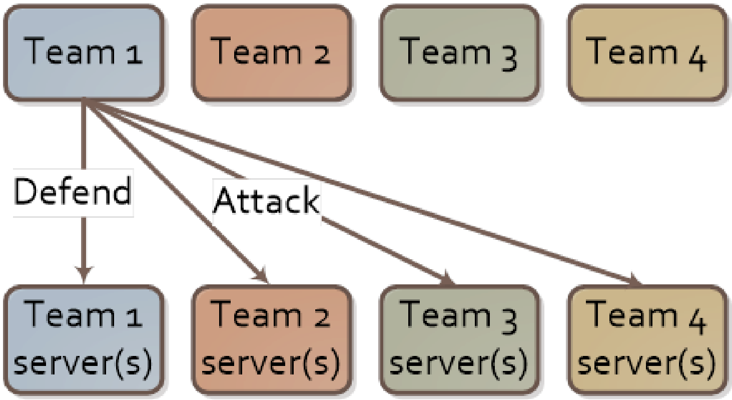


Figure 2: Attack and Defense CTF

Depending on the CTF, you may see a combination of types with it being Jeopardy style and linear (story based) with some questions hidden or locked until a certain question is answered.

For this chapter, I will go more in-depth regarding the "Jeopardy" style competitions, more specifically, forensics geared CTF competitions.

Evidence Aplenty

With forensics CTF's, just like in real life, any type of device is game for being analyzed. In the ever growing landscape of data locations, it just provides us more places to look for clues to solve the problems. One of the more well known forensic CTF's is the SANS NetWars[18] tournaments. These are devised with 5 levels with each level being progressively harder than the last. In this competition you will have a chance to analysis evidence from:

- Windows computer
- macOS computer

[18] https://www.sans.org/cyber-ranges/

- Memory/RAM dump
- iOS dump
- Android dump
- Network (PCAP/Netflow/Snort logs)
- Malware samples

You can see from the above list that you get a well rounded variety of types of evidence that you most likely will see in the field on the job. In other competitions I've played you could also come across Chromebooks or even Google Takeout and other cloud resources as they become more common. I have also seen some where they are more crypto based so working with different ciphers and hashes to determine the answers.

Who's Hosting?

As previously mentioned, **SANS** is probably the most well known provider of a forensics CTF through their NetWars program. It isn't cheap as a standalone, but is sometimes bundled with one of their training courses. You can sometimes see them hosted for free with other events such as OpenText's enFuse conference.

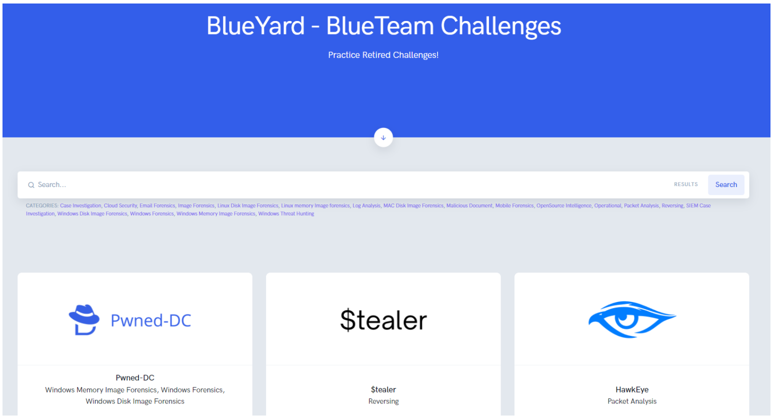
As for others, **Magnet Forensics** has been hosting a CTF for the past 5 years in tandem with their user summit. This has been created by Jessica Hyde in collaboration with some students from Champlain College's Digital Forensics Association. Some previous Magnet CTF's were also created by Dave Cowen and Matthew Seyer for context.

Other software vendors have started to create their own as well to engage with the community. **Cellebrite** in the past 2 years has hosted virtual CTF competitions and **Belkasoft** has created and put out multiple CTFs the last 2 years. **DFRWS**[19] hosts a yearly forensic challenge with past events covering evidence types such as

[19] https://dfrws.org/forensic-challenges/

Playstation 3 dumps, IoT (Internet of Things) acquisitions, mobile malware, and many others.

Another fantastic resource for finding other challenges is **CyberDefenders**[20]. They host hundreds of various different CTF challenges, from past events and other ones that people have uploaded. You can even contribute your own if you'd like as well as allow them to host your next live event.



BlueYard - BlueTeam Challenges

Practice Retired Challenges!

CATEGORIES: Case Investigation, Cloud Security, Email Forensics, Image Forensics, Linux Disk Image Forensics, Linux memory Image forensics, Log Analysis, MAC Disk Image Forensics, Malicious Document, Mobile Forensics, OpenSource Intelligence, Operational, Packet Analysis, Reversing, SIEM Case Investigation, Windows Disk Image Forensics, Windows Forensics, Windows Memory Image Forensics, Windows Threat Hunting

Pwned-DC
Windows Memory Image Forensics, Windows Forensics, Windows Disk Image Forensics

$tealer
Reversing

HawkEye
Packet Analysis

enter image description here

Figure 3: CyberDefenders website

Another fairly exhaustive list of other past challenges and evidence can be found hosted on **AboutDFIR**[21].

Why Play a CTF?

So at the end of the day, why should YOU (yes, YOU, the reader) play a CTF? Well, it depends on what you want to get out of it.

[20] https://cyberdefenders.org/blueteam-ctf-challenges/
[21] https://aboutdfir.com/education/challenges-ctfs/

For Sport

Growing up I've always been a competitive person, especially playing sports like baseball and basketball, CTF's are no different. There is a rush of excitement (at least for me) competing against other like-minded practitioners or analysts to see how you stack up. You can even be anonymous while playing. Part of the fun is coming up with a creative handle / username to compete with. It also keeps the commentary and your competitors on their toes.

I personally like to problem solve and to be challenged which is part of the reason why I enjoy playing.

For Profit

I put profit in quotations because many may construe that as a compensation type objective. While many CTF challenges do have prizes such as challenge coins or swag (awesome branded clothing anyone?!) that's not completely the profit I'm talking about here. The profit is the knowledge you gain from playing. I've done competitions where I never knew how to analyze memory dumps at all and I learned at least the basics of where to look for evidence and new techniques to try later on in real world scenarios.

> "Commit yourself to lifelong learning. The most valuable asset you'll
> ever have is your mind and what you put into it." - Albert Einstein

The knowledge you gain from the "practice" will inevitably help you in the future, it's just a matter of time. Seriously, you don't know what you don't know. Remember when I said you can be anonymous? It doesn't matter if you get 10 points or 1000 points, as long as you learn something new and have fun while doing so, that's all that matters.

Toss a Coin in the Tip Jar

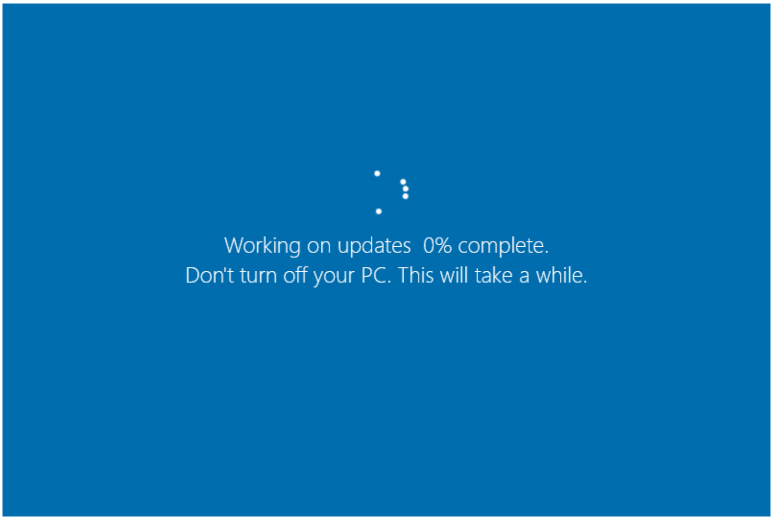
I get asked all the time, "what are your keys to success playing CTFs?". That's probably a loaded question because there are many factors that can lead to good results. Here I will break down into sections that I feel can at least get you started on a path forward to winning your first CTF.

Tips for Playing - Prior

First and foremost is the preparation phase. Like any task in life, it always helps to be prepared for the battle ahead. Having a sense of what is to come will help with your plan of attack. Do your research! If you know that a specific person created the CTF then take a look at their social media profiles. Often times they will release hints in some form or fashion, whether it is webinars they have shared or research papers or blog posts they have recently published. Don't over do it though, there could be red herrings amuck. You can also look at past CTF's they have created, seeing how questions were formulated before and what sort of locations they tend to lean on for flags. This is part of the reason why I personally do write-ups of past CTF's for future reference.

Each CTF rules may be different but if teams are allowed reach out to colleagues or others to form a squad. Knowledge from multiple people well-versed in different topics can help in spreading out the workload especially if there are multiple forms of evidence to be analyzed. I would be remiss if I didn't say that some of my winning efforts were with team members who helped pick up sections where I wasn't as strong. Your mileage may vary though, make sure to coordinate your efforts if you do join a team as to not waste time all working on the same questions.

If evidence is provided ahead of the competition make sure to spend some time getting familiar with it. Process the evidence ahead of time so you aren't wasting time during the live competition waiting on machine time. Some of these events only last 2-3 hours so time is of the essence. This segues right into building out your analysis machine and your toolkit. Make sure that all your system updates are completed prior. The last thing you need is an errant Windows update to take down your system while you watch the spinning.



Working on updates 0% complete.
Don't turn off your PC. This will take a while.

Figure 3: "This will take a while"

You may also consider making sure you have local admin access or at least the ability to turn of antivirus (if you are analyzing malware) to your computer. Always do so in a controlled environment if possible but you knew this already (I hope). If you are provided a toolkit or a trial of a commercial license, use it to your advantage, even if it's a secondary set of tools. There are times some vendors will make sure that the answer is formulated in a way that their tool will spit out from their own software. Also, commercial tools can potentially speed up your analysis compared to a bunch of free tools but that is personal preference.

The Toolkit

I'm a Windows user through and through so I cannot offer much advise from a Mac or Linux perspective. With that said, I do have some tools that I use from a forensic perspective to analyze those types of evidence. Here are my favorite (free) tools that I use during CTF's:

General Analysis

- Autopsy[22]
- Bulk Extractor[23]
- DB Browser for SQLite[24]
- FTK Imager[25]
- Hindsight[26]

Chromebook
- cLEAPP[27]

Ciphers
- CyberChef[28]
- dcode.fr[29]

Google Takeout / Returns
- RLEAPP[30]

Mac
- mac_apt[31]
- plist Editor - iCopyBot[32]

[22] https://www.autopsy.com/
[23] https://github.com/simsong/bulk_extractor
[24] https://sqlitebrowser.org/dl/
[25] https://www.exterro.com/ftk-imager#:~:text=FTK%C2%AE%20Imager%20is%20a,(FTK%C2%AE)%20is%20warranted.
[26] https://dfir.blog/hindsight/
[27] https://github.com/markmckinnon/cLeapp
[28] https://gchq.github.io/CyberChef/
[29] https://www.dcode.fr/en
[30] https://github.com/abrignoni/RLEAPP
[31] https://github.com/ydkhatri/mac_apt
[32] http://www.icopybot.com/plist-editor.htm

Malware/PE
- PEStudio[33]
- PPEE (puppy)[34]

Memory/RAM
- MemProcFS[35]
- Volatility[36]

Mobile Devices
- ALEAPP[37]
- Andriller[38]
- APOLLO[39]
- ArtEx[40]
- iBackupBot[41]
- iLEAPP[42]

Network
- NetworkMiner[43]
- Wireshark[44]

Windows Analysis
- Eric Zimmerman tools / KAPE[45]
- USB Detective[46]

This whole list could be expanded way further but this is the majority of the go-to's in my toolkit.

[33] https://www.winitor.com/
[34] https://www.mzrst.com/
[35] https://github.com/ufrisk/MemProcFS
[36] https://www.volatilityfoundation.org/releases
[37] https://github.com/abrignoni/ALEAPP
[38] https://github.com/den4uk/andriller
[39] https://github.com/mac4n6/APOLLO
[40] https://www.doubleblak.com/software.php?id=8
[41] http://www.icopybot.com/itunes-backup-manager.htm
[42] https://github.com/abrignoni/iLEAPP
[43] https://www.netresec.com/?page=NetworkMiner
[44] https://www.wireshark.org/
[45] https://ericzimmerman.github.io/#!index.md
[46] https://usbdetective.com/

Tips for Playing - During

We've all been there, you get to a point in the middle of a CTF and you start to struggle. Here are some things to key in on while actually playing.

Read the titles of the questions carefully, often times they are riddled with hints about where to look. "*Fetch*" the run time of XXX application, maybe you should analyze those Prefetch files over there. Questions will often also tell you what format the answer should be in when submitting. This may tell you that that timestamp you're hunting could be incorrect, those pesky timezone offsets!

Did you find a flag that appears to be a password? It's almost guaranteed that that evidence was placed in such a way that it will be reused. Emails and notes can be a treasure trove for passwords to encrypted containers or files.

One thing that may seem silly but can help is to just ask questions. If you're stumped on a question, talk to the organizer if you can, they may lead you in a direction that you didn't think of when you set off on a path of destruction.

Some CTF competitions have a built in hint system. If they don't count against your overall store, take them! The chances of a tie breaker coming down to who used less hints is extremely small. If the hint system costs points you will need to weigh the pros and cons of not completing a certain high point question as opposed to loosing 5 points for buying that hint.

The last tip while playing is to write down your submissions, both the correct and incorrect ones. I can't tell you the amount of times I've entered the same answer wrongly into a question to eventually get points docked off my total. This will not only help you during the live CTF but afterwards if you are writing a blog on your walkthroughs.

Strategies

Takeaways

Chapter 10 - Getting into Digital Forensics

DFIRScience Logo

By Joshua I. James DFIR Science[47]

v220405

[47] https://dfir.science

So you want to be a digital forensic investigator?

Technical Skills

How to build a home lab?

Non-Technical Skills

WRITING

PRESENTING

Common Career Paths

Programming

Languages

Tools

Cooperation and Collaboration

Why Collaborate?

How to Collaborate?

Research

Conferences

Online Resources

International Cooperation

Informal

Formal

Chapter 11 - Chapter Title Goes Here

Setting Up a Law Enforcement Digital Forensics Laboratory

by Jason Wilkins MCFE, 3CE

Jason Wilkins Twitter“Follow Me on Twitter!”)

Executive Cooperation

The necessity of executive cooperation

Making your case to executive leadership

Open communication and trust

Physical Requirements

Physical security and accessibility

Floor plans

Selecting Tools

Network Requirements

Selecting forensic workstations

Selecting forensic software

Selecting peripheral equipment

Planning for Disaster

Certification and Training

Why should you get certified?

Where to find training

Creating a training plan for your lab

Accreditation, Policy, and Procedure

Accreditation requirements

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Chapter 14 - Chapter Title Goes Here

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Chapter 15 - Chapter Title Goes Here

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Chapter 16 - Artifacts as Evidence

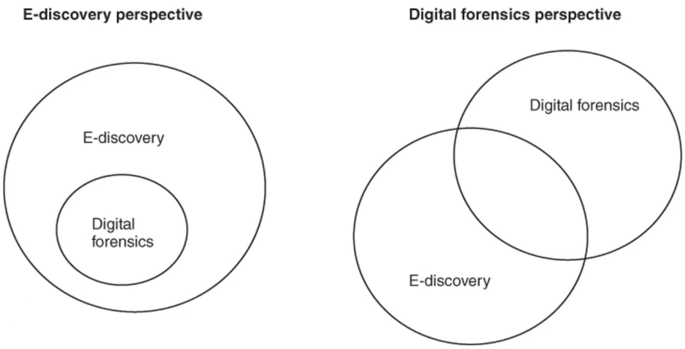
Types of Artifacts

Digital Forensics is a six phase process including Preparation, Identification, Collection, Preservation, Analysis and Reporting.

Analysis is a major phase where in forensicators discover different types of artifacts ranging from plain metadata to complex evidence of execution and residual traces. The vast gap between the difficulty to retrieve or reconstruct evidence determines the fine line between E-discovery and Digital Forensics.

User data such as internet history, images, videos, emails, messages etc fall under E-discovery. It is relatively easy to reconstruct even from the unallocated space.

However, System Data like artifacts that help support some view of truth, or determine how closely a transpired event is to the evidence, are not that simple to manually parse with forensic soundess, which is why oftentimes forensicators rely on well-known parsing tools either commercial or opensource.



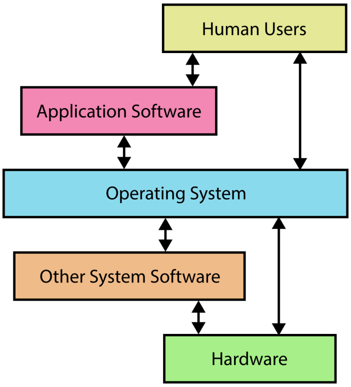
16.1 - Attr: Slide 6 from E-Discovery: An Introduction to Digital Evidence by Amelia Phillips, Ronald Godfrey, Christopher Steuart & Christine Brown

And that is the main difference between E-Discovery & Digital Forensics depending on the categorization of data alone. Both follow different procedures and have different scope of execution. Generally, E-Discovery can be contained to only the logical partitions and the unallocated region whereas Digital Forensics operates in a much wider scope solely due to the necessity of dealing with complex data structures.

What is Parsing?

Which brings us to parsing. We often go around throwing the term while working with a variety of artifacts; “Parse this, parse that”, but what does it mean in the real sense? To understand the parsing methodology, tools & techniques, we must be familiar with the origin of the handling of the data being parsed. What I mean by that is how was the data originally meant to be handled. What was it’s structure by design. How can it be replicated.

Generally, it is some feature or underlying mechanism of the main operating system installed on the device. Parsing tools are written to accurately mimic those functions of the operating system which make the raw data stored on the hardware, human readable.



16.2 - Attr: Kapooht, CC BY-SA 3.0, via Wikimedia Commons

Understand the operating system as an abstraction level between the end-user and the intricacies of raw data. It provides an interface to the user which hides all the complexities of computer data and how it is being presented.

Before parsing the artifacts and diving deep into analysis, you must fully understand how files are generally handled by an operating system. As mentioned earlier, an operating system is just a very sophisticated piece of software written by the manufacturers to provide an abstraction level between the complexities of hardware interactions and the user.

In the context of file handling, operating systems either *store* files or *execute* files. Both of which requires different types of memory. Also note that *storing* files requires access to a storage media such as HDDs, SSDs and Flash drives, whereas *executing* files requires access to the microprocessor. Both are handled by the operating system.

As you might already know, computers or any electronic computing device for that matter, primarily utilize two types of memory:

1. **RAM (Random Access Memory)**:
    - Volatile memory, only works for the time power is supplied.
    - Used for assisting execution of applications/software by the processor of the device.

2. **ROM (Read Only Memory)**:
    - Non-volatile memory, retains data even when not in use.
    - Used for storing the application files for a larger period of time.

There are many sub-types of both RAM & ROM but only the fundamental difference between them is concerned here.
Now let’s look at the lifecycle of an application in two stages:

1. **Production Cycle**:
An application is a set of *programs*. A program is a set of *code* written by a programmer, generally in higher levelled languages that do not interact directly with machine level entities such as registers, buses, channels etc. That piece of code is written to the disk. The code is then compiled to assembly, which is a lower levelled language which can interact directly with machine level entities. Finally the assembly is converted to the machine code

consisting of 1s and 0s (also known as binary or executable file), which is now ready for it's execution cycle.

2. **Execution Cycle**:
Now that the program is sitting on the disk, waiting to be executed, it is first loaded into the RAM. The operating system instructs the processor about the arrival of this program and allocates the resources when they're made available by the processor. The processor's job is to execute the program one instruction at a time. Now the program can execute successfully if the processor is not required to be assigned another task with a higher priority. If so, the program is sent to the ready queue. The program can also terminate if it fails for some reason. However, finally it is discarded from the RAM.

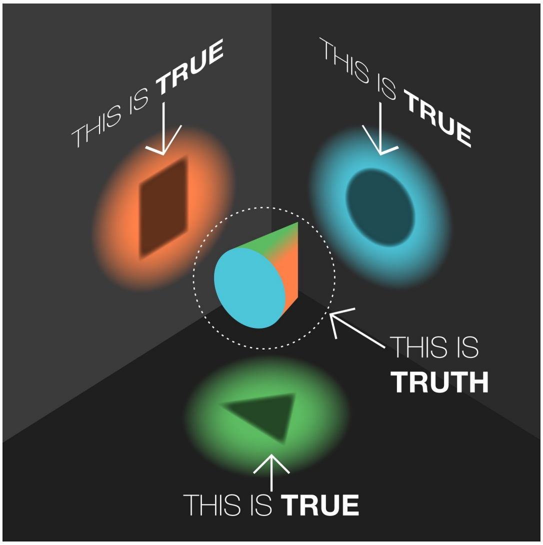
You can easily remember both of these cycles by drawing an analogy between electronic memory and the human memory. Here, I use chess as an example. Our brains, much like a computer, uses two types of memory:

1. **Short-term (Working memory)**:
    - For a game of chess, we calculate the moves deeply in a vertical manner for a specific line based on the current position.
    - This is calculative in nature. Calculation comes from present situation.

2. **Long-term (Recalling memory)**:
    - At the opening stage in a game of chess, we consider the candidate moves widely in a horizontol manner for many lines.
    - This is instinctive in nature. Instinct comes from past experiences.

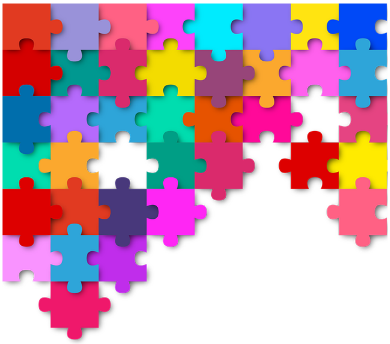
Artifact-Evidence Relation

You will come across an ocean of different artifacts in your investigations, but artifacts have a very strange relationship with what might potentially be considered evidence. Artifacts alone do not give you the absolute truth of an event. They provide you tiny peepholes through which you can reconstruct and observe a part of the truth. In fact, one can never be sure if what they have is indeed the truth in it's entirety.



16.3 - Attr: Original by losmilzo on imgur, modified here as text removal

I always love to draw an analogy between the artifacts and the pieces of a puzzle, of which you're not certain to have the edge or the corner pieces. You gather what you can collect, and try to paint the picture as unbiased and complete as possible.



16.4 - Attr: By stux on pixabay

That being said, if you apply the additional knowledge from metadata, OSINT and HUMINT to the parsed artifacts, you might have something to work with. For instance, say you were assigned an employee policy violation case, where an employee was using their work device for illegally torrenting movies. Parsing the artifacts alone will give you information around the crime, but not as evidence. You would still need to prove that the face behind the keyboard at the time of the crime, was indeed the one that your artifacts claim. So you would then look for CCTV footage around the premises, going back to the ***Identification*** phase in the digital forensics lifecycle, and so forth and so on.

As a result of a codependency of the artifacts on drawing correlations to some external factor, they form a direct non-equivalence relation with evidence. However, note that this "rule", if you will, is only applicaple to a more broad scope of the investigation. In the more narrow scope as a forensicator, and for the scope of your final forensic report, artifacts are most critical. Just keep it in the back of your mind that encountering an artifact alone doesn't mean it's admissible evidence. Parse the artifact, make notes and document everything. Being forensically sound is more important than worrying about completing the entire puzzle. Because there will be no edge or corner pieces of the puzzle.

Examples

This section will cover how some of the more uncommon artifacts can play into a case from the bird's eye view. We won't be getting into the technical specifics on parsing or extraction, but the significance of those artifacts on a higher level. Such as what does it offer, proove and deny. And what is it's forensic value.

Registry

Windows registry is a heirarchical database used by the Windows operating system to store it's settings and configurations. Additionally, it also stores some user data pertaining to user applications, activities and other residual traces.

Registry is structured with what are called Hives or Hive Keys (HK) at the top-most level. Each hive contains numerous keys. A key can contain multiple sub-keys. And sub-keys contain fields with their values.

- **System Hive Files**:
  - SAM (Security Account Manager): User account information such as hashed passwords, account metadata including last login timestamp, login counts, account creation timestamp, group information etc.
  - SYSTEM: File execution times (Evidence of Execution), USB devices connected (Evidence of Removable Media), local timezone, last shutdown time etc.
  - SOFTWARE: Information about both user and system software. Operating System information such as version, build, name & install timestamp. Last logged on user, network connections, IP addresses, IO devices etc

  - SECURITY: Information about security measures and policies in place for the system.

- **User Specific Hive Files**:
  - Amcache.hve: Information about application executables (Evidence of Execution), full path, size, last write timestamp, last modification timestamp and SHA-1 hashes.
  - ntuser.dat: Information about autostart applications, searched terms used anywhere in the operating system, recently accessed files, run queries, last execution times of applications etc.
  - UsrClass.dat: Information about user specific shellbags, covered in the next section.

Shellbags

Prefetch

Jumplists & LNK files

SRUDB.dat

$MFT

$130

$LogFile

hiberfil.sys

References

Chapter 01

Chapter 02

Chapter 03

Chapter 04

Chapter 05

Chapter 06

Chapter 07

Chapter 08

Chapter 09

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

Chapter 15

Chapter 16

16.1 - E-Discovery: An Introduction to Digital Evidence (with DVD)

1st Edition[48]
16.2 - File:Role of an Operating System.svg[49]
16.3 - Our perception of truth depends on our viewpoint 2.0[50]
16.4 - Puzzle Multicoloured Coloured - Free vector graphic on Pixabay[51]

[48] https://www.amazon.com/Discovery-Introduction-Digital-Evidence-DVD/dp/1111310645

[49] https://creativecommons.org/licenses/by-sa/3.0

[50] https://imgur.com/gallery/obWzGjY

[51] https://pixabay.com/vectors/puzzle-multicoloured-coloured-3155663/

Markdown Example

Writing in Markdown is easy! You can learn most of what you need to know with just a few examples.

To make *italic text* you surround it with single asterisks. To make **bold text** you surround it with double asterisks.

Section One

You can start new sections by starting a line with two # signs and a space, and then typing your section title.

Sub-Section One

You can start new sub-sections by starting a line with three # signs and a space, and then typing your sub-section title.

Including a Chapter in the Sample Book

At the top of this file, you will also see a line at the top that says `{sample: true}`, immediately above the # Chapter Two title. This means that when you generate a preview of your book, or publish a new version of your book, this chapter will be included in a separate sample book that will be created. When you publish your book, this will give potential readers a sample book to read, when they are deciding whether they want to buy your book.

Links

You can add web links easily. Here is a link to the Leanpub homepage[52].

When you are creating a web link, the part between the square brackets [ ] contains the words that people will see in your book, and the part in the round brackets ( ) is the web address you are linking to.

Images

You can add an image to your book in a similar way.

First, add the image to the "resources" folder for your book. You will find the "resources" folder in your book's "manuscript" folder, which is at the top level of your book's folder in GitHub or Bitbucket.

If you look in your book's "resources" folder right now, you will see that there is an example image there with the file name "palm-trees.jpg". Here's how you can add this image to your book:

[52] https://leanpub.com

Palm Trees

As this example image shows, **on a line by itself** you type an exclamation point !, followed by the image caption between square brackets and the filename between round brackets.

To learn more about adding images, see this link[53].

Lists

Numbered Lists

You make a numbered list like this:

1. kale
2. carrot
3. ginger

[53] https://leanpub.com/markua/read#images

Bulleted Lists

You make a bulleted list like this:

- kale
- carrot
- ginger

Code Samples

You can add code samples really easily. Code can be in separate files (a “local” resource) or in the manuscript itself (an “inline” resource).

Local Code Samples

Here’s a local code resource:

Hello World in Ruby

```
puts "hello world"
```

Inline Code Samples

Inline code samples can either be spans or figures.

A span looks like `puts "hello world"` this.

A figure looks like this:

```
puts "hello"
```

You can also add a caption:

Hello World in Ruby

```ruby
puts "hello"
```

To learn more about adding code samples, see this link[54].

Tables

You can insert tables easily inline, using the GitHub Flavored Markdown (GFM) table syntax:

Header 1	Header 2
Content 1	Content 2
Content 3	Content 4 Can be Different Length

To learn more about adding tables, see this link[55].

Math

You can easily insert math equations inline using either spans or figures.

Here's one of the kinematic equations $d = v_i t + \frac{1}{2}at^2$ inserted as a span inside a sentence.

Here's some math inserted as a figure.

[54] https://leanpub.com/markua/read#code

[55] https://leanpub.com/markua/read#tables

$$\left|\sum_{i=1}^{n} a_i b_i\right| \le \left(\sum_{i=1}^{n} a_i^2\right)^{1/2} \left(\sum_{i=1}^{n} b_i^2\right)^{1/2}$$

Something Involving Sums

To learn more about adding math, see this link[56].

How Book.txt Works

If you look in your book's "manuscript" folder, you will see there is a file called "Book.txt".

The "Book.txt" file is what our book generators use to decide what other files to include in your book. It is a list of the files in your "manuscript" folder that you decide you want to include in your book.

You can have multiple chapters in one file, but we recommend one chapter per file. This way, it's easier to navigate.

If you open the "Book.txt" file now, you will see the following list:

chapter1.txt
chapter2.txt
chapter3.docx
chapter4.docx

If you want to write in plain text, you should delete the following lines in the "Book.txt" file, and save the change:

chapter3.docx
chapter4.docx

(Those files are for people who want to write in Word, not in plain text.)

Now, the only two lines listed in the "Book.txt" file will be:

[56] https://leanpub.com/markua/read#math

chapter1.txt
chapter2.txt

The next time you create generate a preview of your book, our book generators will only use the “chapter1.txt” and the “chapter2.txt” files, because they are the only files listed in the “Book.txt” file. Our book generators will ignore any files in your “manuscript” folder that are not listed in the “Book.txt” file, even if those other files are still in the “manuscript” folder.

Creating a Preview of Your Book

You can generate a new version of your book any time by going to the “Preview” page for your book on Leanpub.

To go to the Preview page for your book, click on the Versions tab on Leanpub when you are working on your book. By default you will be taken to the “Preview New Version” page, which is where you’ll be able to preview your book.

Getting Help

Finally, to get help, go to the Help tab for your book in Leanpub and then either…

1. See our Getting Started page to learn how to get started.
2. See our Getting Help page to learn how to get help.
3. Clicking the link to the Markua manual[57] on the Getting Help page. The Markua manual contains everything you need to know about writing in Markdown on Leanpub. (Our dialect of Markdown is called Markua.)

[57] https://leanpub.com/markua/read

By the way, that was how you make a numbered list in Markdown.

You can also make a bulleted list like this:

- item one
- the second item
- another item

We hope that you find writing in Markdown on Leanpub to be simple and enjoyable!