

A COMPARISON ANALYSIS
OF SAVED SNAPCHAT VIDEO FILES
ON ANDROIDS VS IPHONES

by

ANGELA RAE MALLEY

B.A., University of Denver, 2012

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This thesis for the Master of Science degree by

Angela Rae Malley

has been approved for the

Recording Arts Program

by

Catalin Grigoras, Chair

Jeff Smith

Cole Whitecotton

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Malley, Angela Rae (M.S., Recording Arts Program)

A Comparison Analysis of Saved Snapchat Video Files on Androids vs iPhones

Thesis directed by Associate Professor Catalin Grigoras

ABSTRACT

This thesis study analyzes the similarities and differences between video files saved via the Snapchat application on Android and Apple iPhones. With the rise in common use of social media platforms comes a rise in evidence of interest created within these applications.

Understanding how these video files are saved as far as file structure, format and the data that each application stores will help with future authentication of video files created via Snapchat.

Snapchat video files were created, saved, and transferred via several different methods. The Android Snapchat video files were transferred via Dropbox, Gmail and MMS message to the iPhone. These video files were compared to one another and then compared to the files originating on the iPhone. The Snapchat video files created on the iPhone were transferred via Dropbox, Gmail and MMS message to the Android. These video files were compared to one another and then compared to the files originating on the Android.

The analysis of the Android Snapchat video files showed several notable results. The video files transferred via Dropbox and Gmail showed no changes when compared to the original video files extracted from the Android, and the video files transferred via MMS message and extracted from the iPhone showed heavy recompression. The video files transferred via MMS message and extracted from the iPhone also showed audio and video stream hash value mismatches, meaning both the audio and video of these files was recompressed. The metadata of the original Android Snapchat video files showed “Snap Audio” and “Snap Video,” which directly relates to the originating application, Snapchat. The videos transferred via MMS

message and extracted from the iPhone showed “Android Version 10,” but no longer showed “Snap” in the metadata, which directly linked them to the Android, but not the Snapchat application. The audio samples of the files transferred via MMS message and extracted from the iPhone showed only a minor decrease from the original Android Snapchat files even though the recompression was great.

The analysis of the iPhone Snapchat video files also showed several prominent results. The Snapchat video files transferred via Dropbox showed no changes when compared to the original iPhone Snapchat video files, whereas the video files transferred via Gmail and sent via MMS message and extracted from the Android showed heavy recompression. The video files transferred via Gmail showed audio stream hash value matches and video stream hash mismatches, meaning the audio remained unchanged, and the video was recompressed. The video files sent via MMS message and extracted from the Android showed audio and video stream mismatches, meaning both the audio and video was recompressed. The metadata of all the Snapchat video files originating from the iPhone showed “Core Media,” which is associated with Apple, but there was no evidence directly correlating with the application, Snapchat. Additionally, the video files sent via MMS message and extracted from the Android showed “Apple Revision 1” and the video file transferred via Gmail displayed “Apple QuickTime.” When analyzing the audio samples of the Snapchat video files originating on the iPhone, the video files transferred via Gmail showed no change even though these files were recompressed, and the video files sent via MMS message and extracted from the Android showed a significant decrease in audio samples.

The form and content of this abstract are approved. I recommend its publication.

Approved: Catalin Grigoras

DEDICATION

This thesis is dedicated to my mom, Susan, my dad, Edward, and my stepmother, Kara for all their love, support, and encouragement, and to my grandfather who always encourages me to further my education.

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LIST OF ABBREVIATIONS

3GP – Third Generation Partnership Project

AMR – Adaptive Multi-Rate

AVC – Advanced Video Coding

EXIF – Exchangeable Image File

MMS – Multimedia Messaging Service

CHAPTER I

INTRODUCTION

Today's society is roaring in social media, and with the use of personal mobile devices becoming more prevalent, so is the amount of digital evidence captured by these devices and specifically social media applications. Snapchat is a mobile social media application with millions of users that is based around its camera capture function. It allows users to snap pictures and videos using the application linked to their phone camera that can then be saved to the phone and/or sent to other users. Some captured moments may contain evidence important to current or future litigation. Understanding how both Androids and iPhones save these images and videos and what kinds of data each application stores within the files will help with future authentication of evidence files created by the Snapchat application. This thesis will focus on forensically examining and comparing the hash values, stream hash values, metadata, and audio samples of snap video files created by Snapchat and saved to an Android versus an iPhone. In addition, several transfer methods will also be utilized in order to analyze how these methods may change the video files and which distinguishing data remains, if any, with the video files even when these methods of transfer are used. This forensic analysis is important because understanding distinguishing aspects about video files saved using the Snapchat camera capture function will assist with future authentication of evidence video files created with the application.

Previous Research

Digital evidence is becoming more and more relevant in today's world and with this comes the importance of digital forensic science. [1] Media forensics includes the collection, preservation, and analysis of media, such as audio, videos and images. Media sources include,

but are not limited to, digital cameras, voice recorders, DVR systems, computers, tablets, and mobile phones.

The analysis of media forensics can consist of container and content analysis. Analysis of the container includes a review of aspects such as file name, hash values, file structure, file format, hex data, create/modify dates, and metadata. Analysis of the content includes a review of the encoded data and the decoded information being digital audio, still images, and video.

Authentication is an important part of media forensic analysis as if a media file is found to be inauthentic or manipulated it may be dismissed in a court of law. The purpose of authentication is to validate that the media file is what it is presented to be and that it has not been manipulated to depict something untrue. [2]

As there are no official best practices for digital video authentication available to the forensic science community, Greg Wales wrote *Proposed Framework for Digital Video Authentication* in 2019. He proposes an analysis of file structure, video and audio streams, and verification of the device used to create the video file. These analyses include critical listening and a visual analysis for inconsistencies. The purpose of the file structure analysis is to make a determination on whether the evidence file is consistent with an original. [3] Understanding the way in which common devices and applications capture and store media data will be helpful in identifying sources of evidence media files in future cases.

To many people mobile phones are a part of everyday life, collecting and storing their daily activities, such as calls, text messages, locations, calendar events, photos/videos, application activity, and web history. In *Seeking the Truth from Mobile Evidence*, John Blair defines cell phone forensics in the three parts: Recovering, Data, and Validating. Recovering data starts with the legal process that usually begins with the suspicion of a crime. Data refers to

the collection of the data in two types: Logical and Physical. Logical data is limited and easily understood as user data and may contain some deleted data. Physical data goes deeper, includes deleted user data, and is less commercially accessible. Validating includes visual validation and the validation of artifacts by using multiple forensic tools. [3]

Snapchat is a Snap Inc. social media mobile application with a camera capture function compatible with Android and iOS devices that allows users to share photos or videos (called “snaps”) and instant message with specific friends or post stories that friends may view. Received snaps are viewed when opened and then are automatically deleted. A user may choose to save a snap to the device’s internal storage before sending. [5] The snap videos and images can be saved without sending and also be sent without saving. Snapchat also offers features that users may add to snaps, such as, filters, texts, paint, icons, emoticons, links and music.

CHAPTER II

MATERIALS

The following materials were used in the collection of Android Snapchat video files and iPhone video files. The noted installed applications on the cell phones were used for the transfer of Snapchat video files and the noted installed application on the laptop was used to access and download transferred files. The Cellebrite applications were run on the analysis laptop with a license dongle to forensically acquire the cell phones, open the extractions, and export the Snapchat video files.

- 1 Android Samsung Galaxy S9
 - Model: SM-G96OU
 - Serial Number: R58M74MYNJW
 - IMEI: 358192100265191
 - Software Version G960USQU8FTJ3
 - Original power/data cord
 - Snapchat v. 11.15.1.34 installed
 - Gmail v. 2019.11.21.283644823.release installed
 - Dropbox (accessed via Google App 12.4.9.23.arm64)

- 1 Apple iPhone 11
 - Model: A2111
 - Serial Number: FK1ZJ0FKN733
 - IMEI: 353980105155630
 - Software Version: 14.4
 - Apple charging/data cord

- Snapchat v11.15.0 installed
- Gmail v. 6.0.201115 installed
- Dropbox (accessed via web browser, Safari)
- 1 Lenovo Thinkpad Laptop running Windows 10
 - Google Chrome web browser v. 88.0.4324 installed
- Cellebrite UFED 4PC 7.40.0.229
- Cellebrite Physical Analyzer 7.41.0.8

The following materials were used in the analysis of Android Snapchat video files and iPhone video files. Jacksum and Fmpeg were used to calculate hash values of the Snapchat video files. ExifTool and MediaInfo were used to collect the metadata of the files. iZotope, FAAS, Mp4dump, and Mp4info were used to calculate the audio samples of the Snapchat video files.

- Jacksum 2.0.0
- ExifTool 12.11
- MediaInfo 20.08
- FFmpeg v. 4.3
- iZotope RX 8 Advanced Editor (64-bit) v8.1.0.
- FAAS
- Mp4dump
- Mp4info

CHAPTER III

METHODOLOGY

Two mobile phones, one Android and one iPhone, were used for the data collection of Snapchat video files. Ten snap videos were taken and saved on each device using the capture function within the Snapchat application. Each snap video was then transferred using Dropbox, Gmail and MMS message. The videos were uploaded to Dropbox using web browser mobile applications, Google for the Android and Safari for the iPhone, sent via email using the Gmail application, and sent in MMS messages to the opposite device. The Android and the iPhone were both forensically acquired using Cellebrite UFED 4PC, an industry-standard software tool designed for mobile device acquisitions. The acquisitions of the Android and the iPhone were loaded into Cellebrite Physical Analyzer, a software tool used for the analysis of mobile acquisitions. Twenty snap videos, ten captured on the device and ten received via MMS message by the device, were located in each acquisition and exported to the analysis laptop. The web browser, Google Chrome, was used on the analysis laptop to download the ten Android snap videos and the ten iPhone snap videos from Dropbox and then Gmail.

Methods

Android

A Samsung Galaxy S9 Android phone with Snapchat and the Gmail application installed was used for analysis. The Snapchat application was opened, and ten snap videos were taken by holding down the circular record button. The durations were varied at random and kept to less than 30 seconds to keep the file sizes small enough to email. After each snap video was recorded, it was saved to the phone then closed. The screenshots below display the steps taken in the Snapchat application on the Android to collect each video.

1. Record video by holding the circular button



2. Save the video to Camera Roll by touching the “Save” button



3. The “Save” button changes to a checkmark to confirm the save



Dropbox

Dropbox is a cloud storage service that allows a user to upload and share files across devices. The ten video files were uploaded to a Dropbox Basic account by navigating to the Dropbox webpage (dropbox.com) using the Google web browser application on the Android. The following steps were taken to upload the snap files to Dropbox once logged into a Dropbox Basic account.

1. From the Dropbox Home screen click the “...” button to open the dropdown menu
2. Select “Upload Files”
3. Select “Photo Library”
4. Scroll to locate Snapchat videos
5. Select Snapchat videos and click “Add”
6. Create folder

7. Name the folder “Snapchat Android”
8. Select “Upload”

Gmail

The Gmail application is a Google email application used to send and receive emails using a Gmail account. Gmail was used on the Android to compose emails and send the ten Snapchat videos to another Gmail account. Five emails were sent with two videos attached to each email.

The list below outlines the steps taken.

1. Open Gmail application
2. Select “Compose” to create a new email
3. Enter receiving email address in “To”
4. Enter “Videos 1” in “Subject”
 - a. Subsequent emails were numbered accordingly
5. Attach videos by selecting the paperclip attachment icon and navigating to the videos in “Photos,” which is the Camera Roll
6. Send the email

The snap videos were then downloaded to the analysis laptop by logging into the receiving email account and downloading them to the computer.

Sent to iPhone via MMS Message

The ten Snapchat video files were transferred to the iPhone via MMS messages by opening a conversation between the two devices and then attaching the snap videos and sending.

Extracted from Android

The Android was forensically acquired using Cellebrite UFED 4PC. A licensed version of the software was run on the analysis laptop and the Android was connected via the original

cord. A full logical extraction was completed. Once the extraction was successful it was loaded into Cellebrite Physical Analyzer and the ten saved snap videos were located as well as the MMS messages containing the ten videos received from the iPhone and were exported.

iPhone

An iPhone 11 with Snapchat and the Gmail application installed was used for analysis. The Snapchat application was opened, and ten videos were taken by holding down the circular record button. The durations were varied at random, but kept to less than 30 seconds to allow for emailing. After each video was recorded, it was saved to the phone's Camera Roll then closed. The screenshots below display the steps taken in the Snapchat application on the iPhone to collect each video.

1. Record video by holding the circular button



2. Save the video to Camera Roll by touching the “Save” button



3. The “Save” button changes to a checkmark to confirm the save



Dropbox

The ten video files were uploaded to a Dropbox Basic account by navigating to the Dropbox webpage (dropbox.com) using Safari on the iPhone. The following steps were taken to upload the files to Dropbox once logged into a Dropbox Basic account.

1. From the Dropbox Home screen click the “...” button to open the dropdown menu
2. Select “Upload Files”
3. Select “Photo Library”
4. Scroll to locate Snapchat videos
5. Select Snapchat videos and click “Add”
6. Create folder
7. Name the folder “Snapchat iPhone”
8. Select “Upload”

Once the Snapchat video files were uploaded to Dropbox they were downloaded to the analysis laptop. Dropbox was logged into through the web browser, Chrome, and the folder “Snapchat iPhone” containing the iPhone Snapchat video files was downloaded to the computer.

Gmail

The Gmail application is a Google email application used to send and receive emails using a Gmail account. Gmail was used on the iPhone to compose emails and send the ten Snapchat videos to another Gmail account. Five emails were sent with two videos attached to each email.

The list below outlines the steps taken.

1. Open Gmail application
2. Select “Compose” to create a new email
3. Enter receiving email address in “To”

4. Enter "Videos 1" in "Subject"
 - a. Subsequent emails were numbered accordingly
5. Attach videos by selecting the paperclip attachment icon and navigating to the videos in "Photos," which is the Camera Roll
6. Send the email

The videos were then downloaded to the analysis laptop by logging into the receiving email account and downloading them to the computer.

Sent to Android via MMS Message

The ten Snapchat video files were transferred to the Android via MMS messages by opening a conversation between the two devices and then attaching the snap videos and sending.

Extracted from iPhone

The iPhone was forensically acquired using Cellebrite UFED 4PC. A licensed version of the software was run on the analysis laptop and the iPhone was connected via an Apple charging cord. A full logical extraction was completed. Once the extraction was successful it was loaded into Cellebrite Physical Analyzer, the ten saved snap videos were located as well as the MMS messages containing the ten videos received from the Android and were exported.

CHAPTER IV

DETAILS OF EXAMINATION

Working copies of each of the Snapchat video files collected from the iPhone, the Android, Dropbox and Gmail were created and used for all analyses, eighty in total. The snap video files that originated on the Android were compared to each other by analyzing hash values, stream hash values, metadata, and audio samples. The same was done for the files that originated on the iPhone. Then the defining aspects of the Android snap video files and the iPhone snap video files were compared to each other.

Hash Values

A hash value is a calculated numeric/alphanumeric value that acts as a digital “fingerprint” and is used to identify digital files. Hash values are used for validating evidence. [6] When hash values are the same, it confirms that the files match and one is not different from the other in any way. The hash values for each file were calculated using Jacksum 2.0.0 and the audio and video stream hashes were calculated using FFmpeg for the purpose of comparing the Snapchat video files transferred via Gmail, Dropbox and MMS message to the “original” extracted from each phone. SHA256 was used for the hash values of the video files and MD5 was used for the audio and video stream hash values. The MD5 and SHA family of algorithms are considered industry standards when calculating hash values in relation to mobile forensics. [6] When the video file hash values match, it means that the file had not been compressed or changed in the transfer. The file size was also calculated by Jacksum and included. The audio and video stream hashes were calculated for the files that did not show hash value matches to the originals. This was done to show whether the files were solely re-containerized or whether they were transcoded and recompressed.

Android

The SHA256 hash values of each of the ten original Android Snapchat video files along with their corresponding transferred files were calculated using Jacksum. The snap videos transferred via Dropbox and Gmail consistently showed hash matches to the originals extracted from the Android. The files that were sent via MMS message and extracted from the iPhone showed hash mismatches. (See Appendix A for an example of these hash values.)

The audio and video stream MD5 hash values were calculated using Ffmpeg for the original Android Snapchat video files and the files that were transferred via MMS messages and extracted from the iPhone. The stream hashes were not calculated for the video files that were transferred via Dropbox and Gmail since these files had SHA256 hash value matches to the original files. The audio and video stream hash values were both a mismatch, meaning they were not solely re-containerized. Both the audio and video of the Snapchat files were changed or recompressed. (See Appendix B for examples of the stream hash values.)

iPhone

The SHA256 hash values of each of the ten original iPhone Snapchat video files along with their corresponding transferred files were calculated using Jacksum. The snap videos transferred via Dropbox showed hash value matches to the original Snapchat videos extracted from the iPhone. The video files transferred via Gmail showed hash value mismatches as well as those extracted from the Android that were sent via MMS messages from the iPhone. (See Appendix C for examples of the hash values.)

The audio and video stream MD5 hash values were calculated for the original iPhone Snapchat video files, the files that were transferred via Gmail, and those sent via MMS messages and extracted from the Android. The stream hashes for the files transferred via Dropbox were not

calculated since these files had SHA256 hash value matches to the original files. The files transferred via Gmail had audio stream hash value matches, but video stream hash value mismatches. This means that the audio in the video was not changed or recompressed, but the video was. The video files that were sent via MMS message and extracted from the Android had audio and video stream mismatches, meaning both streams were not solely re-containerized. (See Appendix D for examples of the stream hash values.)

Metadata from ExifTool

EXIF (Exchangeable Image File Format) is a common format in which media file metadata is written. Exiftool was run on each of the Snapchat videos files for the purpose of comparison analysis, focusing on the file size, format, duration, compressor, video frame rate, image size and average bitrate. The metadata was also analyzed for signs of the Snapchat application and the originating device.

Android

Exiftool was run on the ten Android Snapchat video files and their corresponding transferred files. The snap video files extracted from the Android and transferred using Dropbox and Gmail had hash value matches, so these video files remained unchanged except for the file name and file dates, which do not alter any content. The saved snap video files sent via MMS messages and extracted from the iPhone showed changes due to recompression. This recompression occurs on the Android before a video is sent via MMS message.

The file sizes of the videos received by the iPhone were an average of 96.14 percent smaller than the sizes of the files extracted from the Android. The file types/formats remain the same, mp4. The duration, track duration and media duration changed just slightly between the videos extracted from the Android and the files extracted from the iPhone, but it was

inconsistently shorter or longer. The metadata of the files extracted from the iPhone showed an Android version, while the others did not. The audio format was consistent between the four files, mp4a. The image height and width of the file extracted from the Android was 1072 x 1920, whereas the file transferred via MMS to the iPhone was much smaller at 176 x 144. The handler description showed “Snap Video” for the files extracted from the Android, which did not carry over to file transferred to the iPhone. The video frame rate and the average bitrate showed a significant reduction for the video file transferred to the iPhone. (See Appendix E for examples of the metadata shown using ExifTool.)

iPhone

Exiftool was run on the ten iPhone Snapchat video files and their corresponding transferred files. The snap video files extracted from the iPhone and transferred to Dropbox had hash value matches, so these video files remained unchanged except for the file name and file dates, which do not alter any content. The saved snap video files sent via Gmail and MMS messages to the Android showed changes due to recompression. This occurs on the iPhone before a video is sent in an MMS message.

The file sizes of the videos transferred using Gmail were on average 89.42 percent smaller and the videos extracted from the Android were on average 97.94 percent smaller than the files extracted from the iPhone. The file type/format changed from mp4 to mov for the Gmail files and 3gp for the files extracted from the Android. 3GP (Third Generation Partnership Project) is a format video format for compression related to mobile devices. The durations of the video files were mostly consistent when compared to their corresponding transferred files. The Duration and Track Duration were consistent with nine of the ten videos. Snapchat video file 014 showed a slight difference in the Track Duration for the file extracted from the Android. The

Media Duration showed as slightly different for each of the test files with the versions transferred using Gmail and sent via MMS messages to the Android. The audio format changed from mp4a to amr with the video files extracted from the Android. AMR (Adaptive Multi-Rate audio codec) is a known compression format used in mobile device MMS messaging. The video files extracted from the Android showed an Encoder Vendor as Apple, and the files transferred via Gmail showed a Handler Vendor ID as Apple. The original iPhone snap video and the Dropbox video file did not show “Apple” anywhere in the metadata. All the files did show “Core Media” in the Handler Description. The files from Gmail showed slightly different with “Core Media Data Handler.” Core Media is a framework specific to Apple iOS devices. The image size for the video files extracted from the iPhone and Dropbox was 656 x 1232. The image size for the Gmail video files was 256 x 480, and the size for the videos extracted from the Android was 320 x 240. The video frame rates for the files extracted from the iPhone and Dropbox were approximately 30 frames per second, the Gmail files were consistent or very similar to the original files, and the files from the Android showed as half of that at 15 frames per second. The average bitrate of the Gmail files was significantly lower than the original iPhone file and even less for the file extracted from the Android. The Compression ID showed as AVC (Advanced Video Coding) for each of the video files. (See Appendix F for examples of the metadata shown using ExifTool.)

MediaInfo – File Format

The saved Snapchat video files were also reviewed in MediaInfo for file structure analysis and a comparison between the transfer methods. Much of the same information can be seen in this data as the metadata shown using ExifTool, but there are several significant differences.

Android

The ten saved Android Snapchat video files, numbered 001 through 010, were loaded into MediaInfo as well as their corresponding transferred files. The notable difference between the metadata shown using ExifTool and MediaInfo was that MediaInfo shows “Snap Video” as well as “Snap Audio” in the metadata for the original video files extracted from the Android and the video files transferred via Dropbox and Gmail. This is significant because it directly relates to Snapchat and provides evidence to this application as the source. The metadata displayed using MediaInfo did not show the Android version, which is shown in the metadata displayed using ExifTool. (See Appendix G for examples of the metadata shown using MediaInfo.)

iPhone

The ten saved iPhone Snapchat video files, numbered 011 through 020, were loaded into MediaInfo as well as their corresponding transferred files. There were two notable differences between the metadata shown using ExifTool and MediaInfo. MediaInfo shows “Core Media Video” as well as “Core Media Audio” for the files extracted from the iPhone and the videos transferred via Dropbox and Gmail, and the files extracted from the Android show “Apple Revision 1” and “Apple QuickTime.” The files extracted from the Android did not show “Apple” anywhere in the metadata displayed using ExifTool. “Core Media” and “Apple” are significant because they both directly relate to the source being the iPhone. There still is no evidence that relates directly to the Snapchat application as with the ExifTool metadata. (See Appendix G for examples of the metadata shown using MediaInfo.)

Audio Samples

The total audio samples of each Snapchat video file and their corresponding transferred files were calculated using four different tools: iZotope RX 8 Advanced, mp4dump, mp4info,

and FAAS. The tools mp4dump and mp4info were run using Windows Powershell, which is a command-line shell. The use of multiple tools shows how different tools can lead to different results.

Android

The audio samples were calculated for the ten Snapchat video files extracted from the Android and those that were sent via MMS messages and extracted from the iPhone. The audio samples of the files that were transferred via Dropbox and Gmail were not calculated because these files had hash value matches to the original video files extracted from the Android, meaning the number of samples would also match. The tools used were iZotope RX 8 Advanced, mp4dump, mp4info, and FAAS.

When comparing the original video files extracted from the Android to the files sent via MMS message and extracted from the iPhone, it was found that the files extracted from the iPhone had a decrease between 0.1 and 0.4 percent in the number of audio samples. The tools mp4dump, mp4info, and FAAS consistently showed matching results, whereas iZotope RX 8 Advanced showed results with 1024 less samples for each file. The percentage change between the number of samples calculated for the videos extracted from the Android versus the iPhone with iZotope was very close to the percent of change calculated using the other tools. For example, the percent decrease for video 001 extracted from the Android versus the video extracted from the iPhone was 0.15129 percent when using iZotope and 0.15106 percent when using mp4dump, mp4info, and FAAS.

The following table represents the audio samples calculated in each tool for the Android snap video file 001 extracted from the Android and the video file sent via MMS message and extracted from the iPhone. (See Appendix I for additional examples)

Table 1. Audio Samples of Android Snapchat Video 001

| <i>001 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from Android | 676864 | 677888 | 677888 | 677888 |
| Extracted from iPhone | 675840 | 676864 | 676864 | 676864 |

iPhone

The audio samples were calculated for the ten iPhone Snapchat video files extracted from the iPhone and their corresponding files transferred via Gmail and those sent via MMS messages and extracted from the Android. The audio samples of the files that were transferred via Dropbox were not calculated because these files had hash value matches to the original files extracted from the iPhone, meaning the number of samples would also match. The tools used were iZotope RX 8 Advanced, mp4dump, mp4info, and FAAS.

The video files that were transferred via Gmail consistently had the same number of audio samples as the original files extracted from the iPhone even though it was found during the metadata analysis that these files were 89.42 percent smaller in file size.

When comparing the video files extracted from the iPhone to the files sent via MMS messages and extracted from the Android, it was found that the files extracted from the iPhone had a decrease between 81.689 and 81.895 percent in the number of audio samples. The tools mp4dump and mp4info consistently showed matching results, but those results were slightly different than the sample numbers found using FAAS and iZotope. Even so, the percentages of change were very similar using each tool. For example, for video file 011 the percentage of change between the file extracted from the iPhone compared to the file extracted from the Android showed an 81.774 percent decrease with iZotope. With mp4dump and mp4info the percentage of change was an 81.851 percent decrease, and with FAAS the percentage of change was an 81.850 percent decrease.

A consistent change was found in audio sample numbers was between tools for each of the video files, 011 through 020, sent via MMS message and extracted from the Android. The tools mp4dump and mp4info showed 160 less samples than iZotope and 200 more than FAAS. FAAS showed 40 more samples than iZotope. A consistency was not found when comparing the number of samples for the video files extracted from the iPhone and the files transferred via Gmail.

The following table represents the audio samples calculated in each tool for the iPhone snap video file 011 extracted from the iPhone and the corresponding video file sent via MMS message and extracted from the Android. (See Appendix J for additional examples)

Table 2. Audio Samples of iPhone Snapchat Video 011

| <i>011 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from iPhone | 762880 | 766976 | 766976 | 765824 |
| Gmail | 762880 | 766976 | 766976 | 765824 |
| Extracted from Android | 139040 | 139200 | 139200 | 139000 |

CHAPTER V

CONCLUSIONS

Upon completion of the forensic analyses, conclusions were made when comparing the saved Android Snapchat video files extracted from the Android to those same files transferred via Dropbox, Gmail and MMS messages to the iPhone and when comparing the saved iPhone Snapchat video files extracted from the iPhone to those same files transferred via Dropbox, Gmail and MMS messages to the Android. Then the results of the analysis on the Android snap videos were compared to those from the iPhone snap videos and defining factors of each were found. It is important to reiterate that these video files were captured using the camera capture function within the Snapchat application and then saved to the mobile devices. The snap videos were not actually sent. Sending the videos to friends or posting them on a story does not automatically save them to the device.

Android

A comparison analysis was completed on the four types of Android snap video files. The video files extracted from the Android were considered to be the original files, whereas the other files were created via three transfer methods: Dropbox, Gmail message and MMS messages to the iPhone. The video files transferred via Dropbox and Gmail message had hash value matches to their counterparts extracted from the Android, meaning these methods did not recompress or change the video files in any way. The table below shows the hash values for Android Snapchat video file 004 and its corresponding transferred files. The hash values highlight in green are matches, and the hash value highlighted in yellow shows a mismatch.

Table 3. Hash Values of Android Snapchat Video 004

| 004 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------|---|---|---|---|
| Filename | Snapchat-636849438_1.mp4 | Snapchat-636849438.mp4 | Snapchat-636849438.mp4 | Snapchat-6368494381.mp4 |
| File Size | 17710032 bytes | 17710032 bytes | 17710032 bytes | 701734 bytes |
| SHA256 | 22058d789088b578d9f47 caa53c36c6339ffbccfd5 b8cbfeac150597428fe1e | 22058d789088b578d9f47 caa53c36c6339ffbccfd5 b8cbfeac150597428fe1e | 22058d789088b578d9f47 caa53c36c6339ffbccfd5 b8cbfeac150597428fe1e | 720d9b0e2411ff0fda40d0 7187b2d7f96b72cd1c356 71e2ccaecce73ab54ba004 |

The audio and video stream hash values were also analyzed for each of the Snapchat video files extracted from the Android the corresponding transferred video files to see if audio and/or video was merely re-containerized. The Android Snapchat video files that were sent via MMS message and extracted from the iPhone showed video and audio stream mismatches, meaning neither the audio or video was re-containerized. The audio and video of these files were both re-compressed in the transfer. With that being said, the comparison of Android snap video files focused on the changes between the videos extracted from the Android and the ones that were sent via MMS messages and extracted from the iPhone. The table below shows the audio and video stream hash values for Android Snapchat video file 004 (highlighted in green) and its corresponding video file transferred via MMS message and extracted from the iPhone (highlighted in yellow).

Table 4. Stream Hash Values of Android Snapchat Video 004

| 004 | Extracted from Android | Extracted from iPhone |
|---------------------------------|-----------------------------------|----------------------------------|
| Audio Stream Hash Values | a59c01a538fd8f77133fbbf1e022d2cc | 19889dd5217892da333e960bb0a99cf2 |
| Video Stream Hash Values | a3f59e6e8c3e5e62965516e872bcfaf28 | 30765ba93f1a6b489e1fa00fc7172df6 |

The metadata of each of the Android snap video files was analyzed for file structure and format. In preparation for sending the Android video files via MMS messages, the mobile device automatically recompressed the files. The video files extracted from the iPhone were on average 96.14 percent smaller in file size than the original files extracted from the Android. The format

remained the same as mp4 and the audio format remained as mp4a. The image height and width decreased from 1072 x 1920 to 176 x 144. The video frame rate was approximately cut in half, and the average bitrate was decreased from approximately 8 megabits per second to 300 kilobits per second. The table below shows these categories from the metadata pulled from ExifTool for the Android Snapchat video file 004 (highlighted in green) and its corresponding video file transferred via MMS message and extracted from the iPhone (highlighted in yellow.)

Table 5. Partial Metadata of Android Snapchat Video 004 from ExifTool

| 004 | Extracted from Android | Extracted from iPhone |
|----------------------------|-------------------------------|------------------------------|
| File Size | 17 MiB | 685 KiB |
| File Type | MP4 | MP4 |
| File Type Extension | mp4 | mp4 |
| Media Data Size | 17701743 | 695573 |
| Image Width | 1072 | 176 |
| Image Height | 1920 | 144 |
| Source Image Width | 1072 | 176 |
| Source Image Height | 1920 | 144 |
| Video Frame Rate | 28.604 | 14.296 |
| Image Size | 1072x1920 | 176x144 |
| Avg Bitrate | 8.11 Mbps | 318 kbps |

“Snap Video” is shown in the metadata pulled using ExifTool, and the metadata pulled using MediaInfo displayed “Snap Video” and “Snap Audio” for the files extracted from the Android and transferred files with hash value matches, which directly relates to the Snapchat application. The files sent via MMS messages and extracted from the iPhone no longer showed “Snap” anywhere in the metadata, but they did show “Android Version 10” in the metadata displayed using ExifTool. This directly relates to Android, but not the Snapchat application. The tables below show these categories from the metadata shown in ExifTool and MediaInfo for the Android Snapchat video file 004 (highlighted in green) and its corresponding video file transferred via MMS message and extracted from the iPhone (highlighted in yellow.)

Table 6. Partial Metadata of Android Snapchat Video 004 from ExifTool

| 004 | Extracted from Android | Extracted from iPhone |
|---------------------|------------------------|-----------------------|
| Android Version | | 10 |
| Handler Description | Snap Video | SoundHandle |

Table 7. Partial Metadata of Android Snapchat Video 004 from MediaInfo

| 004 | Extracted from Android | Extracted from iPhone |
|-------|------------------------|-----------------------|
| Title | Snap Video | VideoHandle |
| Title | Snap Audio | SoundHandle |

The audio samples of each saved snap video file were also reviewed using four different tools, iZotope RX 8 Advanced, mp4dump, mp4info, and FAAS, and the number of samples was only reduced slightly by a decrease between 0.1 and 0.4 percent with the video files sent via MMS messages and extracted from the iPhone. The table below shows the audio samples for the Android Snapchat video file 004 (highlighted in green) and its corresponding video file transferred via MMS message and extracted from the iPhone (highlighted in yellow.)

Table 8. Audio Samples of Android Snapchat Video 004

| <i>004 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|--------------------------|--------------|---------|---------|--------|
| Extracted from Android | 769024 | 770048 | 770048 | 770048 |
| Extracted from iPhone | 768000 | 769024 | 769024 | 769024 |

iPhone

A comparison analysis was completed on the four types of iPhone snap video files. The video files extracted from the iPhone were considered to be the original files, whereas the other files were created via the three transfer methods: Dropbox, Gmail and MMS message to the Android. The video files transferred via Dropbox had hash value matches to their counterparts extracted from the iPhone, meaning these files were not recompressed or changed, but the files sent via Gmail and MMS message were recompressed prior to sending. The table below shows that the files transferred via Dropbox maintained the same hash values (highlighted in green),

while the files transferred via Gmail (highlighted in yellow) and sent via MMS message and extracted from the Android (highlighted in blue) showed hash mismatches.

Table 9. Hash Values of iPhone Snapchat Video 014

| 014 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|--|--|--|--|
| Filename | 8A75528F-2D19-41E2-A1F4-B84372E659A3.MP4 | IMG_3568.MP4 | IMG_64212286.MOV | 8A75528F-1.3gp |
| File Size | 12847178 bytes | 12847178 bytes | 1313878 bytes | 257293 bytes |
| SHA256 | 15312538a4b1822f92de4ee5913eed615afce4c1723dd6e95fc31c2812375c50 | 15312538a4b1822f92de4ee5913eed615afce4c1723dd6e95fc31c2812375c50 | ac9f7dc460306536a117ac18b446d16d7328e766e8c77e19f18f52a2b4dfbf08 | 7293d328b3dd4b3af35fe99edd2f7c9310239973c22aa0655828fe1642c4785d |

The audio and video stream hashes were analyzed for each of the Snapchat video files extracted from the iPhone and their corresponding transferred video files to see if audio and/or video was merely re-containerized. The iPhone Snapchat video files that were transferred via Gmail had audio stream hash matches to the original iPhone Snapchat video files, but had video stream hash mismatches, meaning the audio was re-containerized and not altered, but the video was re-compressed. The iPhone Snapchat video files that were sent via MMS messages and extracted from the Android had audio and video stream hash mismatches. The table below shows the audio and video stream hash values of the Snapchat video files extracted from the iPhone (highlighted in green), the video files transferred via Gmail (the audio stream hash match highlighted in green, and the video stream mismatch highlighted in yellow), and the video file sent via MMS message and extracted from the Android (highlight in blue.)

Table 10. Stream Hash Values of iPhone Snapchat Video 014

| 014 | Extracted from iPhone | Gmail | Extracted from Android |
|---------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | f7371854cce8e8c217945085dacb5210 | f7371854cce8e8c217945085dacb5210 | c6996b64f867ed02f930204b8d6e9a95 |
| Video Stream Hash Values | a6ee1d0f1b1022ed7edb0a454e545a1d | f3f684266ad871b1b9d93d143597cefc | 18945d8ed6dd57f9ce2a38a9698a3f60 |

The metadata of each of the iPhone snap video files was analyzed for file structure and format. The file sizes of the videos transferred via Gmail were reduced by 89.42 percent and the

files transferred via MMS messages to the Android were reduced by 97.94 percent. The format was changed from mp4 to mov with the Gmail transfer and to 3gp for the files extracted from the Android. The audio format changes from mp4a to amr for the files extracted from the Android. The image size for the video files extracted from the iPhone and Dropbox was 656 x 1232. The image size for the Gmail video files was 256 x 480, whereas the size for the videos extracted from the Android was 320 x 240. The video frame rate for the files extracted from the iPhone and Dropbox were approximately 30 frames per second, the Gmail files are consistent or very similar to the original files, and the files from the Android displayed the frame rate as half at 15 frames per second. The average bitrate of the Gmail files was significantly lower than the original iPhone file and even less for the file extracted from the Android. The table below displays these categories from the metadata pulled from ExifTool for the iPhone Snapchat video file 014 (highlighted in green) and its corresponding video files transferred via Gmail (highlighted in yellow) and sent via MMS message and extracted from the iPhone (highlighted in blue.)

Table 11. Partial Metadata of iPhone Snapchat Video 014 from ExifTool

| 014 | Extracted from iPhone | Gmail | Extracted from Android |
|-------------------------|------------------------------|--------------|-------------------------------|
| File Size | 12 MiB | 1283 KiB | 251 KiB |
| File Type | MP4 | MOV | 3GP |
| Audio Format | mp4a | mp4a | samr |
| Image Width | 656 | 256 | 320 |
| Image Height | 1232 | 480 | 240 |
| Video Frame Rate | 29.952 | 30.026 | 15 |
| Image Size | 656x1232 | 256x480 | 320x240 |
| Avg Bitrate | 7.56 Mbps | 768 kbps | 150 kbps |

“Core Media Video” was shown in the metadata for all the files, except the files transferred to Gmail showed “Core Media Data Handler.” The video file transferred via Gmail displayed “Apple” in the metadata pulled using ExifTool. The MediaInfo metadata showed

“Core Media Video” and “Core Media Audio” for all files. The files extracted from the Android only showed “Apple Revision 1” and the files transferred via Gmail showed “Apple QuickTime” as the writing library in MediaInfo. This particular data showed a correlation to Apple, but there was no data directly relating to the Snapchat application. The tables below show these categories in the metadata displayed using ExifTool and MediaInfo for the Snapchat video files extracted from the iPhone (highlighted in green), the files transferred via Gmail (highlighted in green for the data matching the original file, and yellow for the changes), and the files sent via MMS message and extracted from the Android (highlighted in green for the data matching the original file, and blue for the changes.)

Table 12. Partial Metadata of iPhone Snapchat Video 014 from ExifTool

| 014 | Extracted from iPhone | Gmail | Extracted from Android |
|----------------------------|------------------------------|-------------------------|-------------------------------|
| Handler Description | Core Media Video | Core Media Data Handler | Core Media Video |
| Handler Vendor ID | | Apple | |

Table 13. Partial Metadata of iPhone Snapchat Video 014 from ExifTool

| 014 | Extracted from iPhone | Gmail | Extracted from Android |
|------------------------|------------------------------|------------------|-------------------------------|
| Writing library | | Apple QuickTime | |
| Title | Core Media Video | Core Media Video | Core Media Video |
| Title | Core Media Audio | Core Media Audio | Core Media Audio |
| Writing library | | | Apple Revision 1 |

The audio samples of each saved iPhone Snapchat video file were also reviewed using four different tools, iZotope RX 8 Advanced, mp4dump, mp4info, and FAAS, and the number of samples was not reduced with the Gmail transfer even though the file sizes were reduced, but the number of audio samples of the video files extracted from the Android were reduced significantly by a decrease between 81.689 and 81.895. The table below shows the audio samples for the iPhone Snapchat video file 014 and its corresponding video files transferred via

Gmail (both highlighted in green) and sent via MMS message and extracted from the iPhone (highlighted in blue.)

Table 14. Audio Samples of iPhone Snapchat Video 014

| <i>014 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from iPhone | 594944 | 599040 | 599040 | 597888 |
| Gmail | 594944 | 599040 | 599040 | 597888 |
| Extracted from Android | 108640 | 108800 | 108800 | 108600 |

Android vs. iPhone

The saved Snapchat video files had similarities and differences between the files extracted from the Android and the iPhone as the original files. The format was mp4 with an audio format of mp4a and the AVC compressor. The video frame rate was approximately 30 frames per second and an average bitrate around 8 megabits per second. The resolution was displayed as 72 pixels per inch for the Android snap video files and the iPhone snap video files, although the image sizes were different at 1072 x 1920 for the Android and 656 x 1232 for the iPhone.

Videos from both the Android and the iPhone had defining factors that were mostly carried through even when transferred. The Android showed “Snap Audio” and/or “Snap Video” in the metadata for the original files and the files transferred via Dropbox and Gmail. The video files that were transferred via MMS and extracted from the iPhone no longer showed the “Snap Audio” or “Snap Video,” but they did add data showing the Android version, which ties the files back to the Android, but not necessarily Snapchat. The saved iPhone snap video files consistently showed “Core Media” for all of the files, which is a framework specifically related to Apple iOS devices. This, however, does not specifically relate to Snapchat. The table below displays categories of interest in the metadata for the Android Snapchat video file 004 versus the

iPhone Snapchat video file 014. The similarities are highlighted in green and the differences are highlighted in yellow and blue.

Table 15. Partial Metadata of Android Snapchat Video 004 vs. iPhone Snapchat Video 014

| 004 Android Snapchat Video vs. 014 iPhone Snapchat Video | Original Extracted from Android | Original Extracted from iPhone |
|---|--|---------------------------------------|
| File Type | MP4 | MP4 |
| Audio Format | mp4a | mp4a |
| Image Width | 1072 | 656 |
| Image Height | 1920 | 1232 |
| Handler Description | Snap Video | Core Media Video |
| Video Frame Rate | 28.604 | 29.952 |
| Image Size | 1072x1920 | 656x1232 |
| Avg Bitrate | 8.11 Mbps | 7.56 Mbps |
| Compressor ID | avc1 | avc1 |
| X Resolution | 72 | 72 |
| Y Resolution | 72 | 72 |

Different transfer methods may recompress the files in different ways or change the format, but this analysis shows that both the iPhone and Android leave defining marks within the data that could be used to trace them back to the originating device or application. The Snapchat video files created on the Android, however, were the only files that left an indication that the Snapchat application was used.

Future Research

There are multiple ways that this comparison analysis between Snapchat video files created on an Android and iPhone could be furthered. Different operating system versions could be used in the collection of Snapchat video files on Android and iPhones. This would require waiting for multiple operating system versions to be released for Androids and iPhones, which was outside of the scope of time for this thesis. Snapchat videos longer than 30 seconds could be taken to analyze whether the level of recompression is greater with the larger file sizes. This thesis limited the durations of the video files to less than thirty seconds in order to keep the file sizes small enough to send using Gmail, so it is unlikely that this transfer method would be an

option with this type of further research. Additionally, different transfer methods could be utilized in further research studies, such as Facebook Messenger, WhatsApp, or Airdrop. Transfer methods in this thesis were limited due to time constraints.

This thesis focused on a comparison of Snapchat video files originating from an Android or iPhone and transferred using several methods. In further research, the original Snapchat video files from an Android could be compared to video files captured with the pre-installed camera application, and the Snapchat video files captured on the iPhone could be compared to videos taken with the pre-installed iPhone camera application. This analysis would show the differences and similarities between the data that Snapchat saves versus the data that the pre-installed camera applications save.

Another option for additional research would be to complete physical acquisitions of an Android and an iPhone to analyze whether additional Snapchat videos may be recoverable when sent and received rather than saved prior to sending. Physical acquisitions opposed to logical acquisitions are not typically commercially available and were not an option for this thesis. [3]

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APPENDIX A

The ten original Android Snapchat video files were numbered 001 through 010. The following tables display the SHA256 hash values for 001, 002, and 003, the original files and their corresponding transferred files. The tables show that the files transferred via Dropbox and Gmail maintained the same hash values, while the files that were sent via MMS message and extracted from the iPhone had hash mismatches. The video files extracted from the iPhone shows a 96.39 percent reduction in size.

Hash Values of Android Snapchat Video 001

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------|--|--|--|--|
| Filename | Snapchat-196961414_1.mp4 | Snapchat-196961414.mp4 | Snapchat-196961414.mp4 | Snapchat-1969614141.mp4 |
| File Size | 15502360 bytes | 15502360 bytes | 15502360 bytes | 559137 bytes |
| SHA256 | 7f1514c0ad86b63db3756eb4db78c43a70291833ca923c38fca2fc98b5652b18 | 7f1514c0ad86b63db3756eb4db78c43a70291833ca923c38fca2fc98b5652b18 | 7f1514c0ad86b63db3756eb4db78c43a70291833ca923c38fca2fc98b5652b18 | 1dd10fb5955b79f2f105b0c7ef789ddb6a811dc90c08d2c7d0862b18fc6e57c1 |

Hash Values of Android Snapchat Video 002

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------|--|--|--|--|
| Filename | Snapchat-340788319_1.mp4 | Snapchat-340788319.mp4 | Snapchat-340788319.mp4 | Snapchat-3407883191.mp4 |
| File Size | 15065500 bytes | 15065500 bytes | 15065500 bytes | 562219 bytes |
| SHA256 | f0e36da99467e234f38504ff025671940031f118e2859d96ae4be019692a8fe4 | f0e36da99467e234f38504ff025671940031f118e2859d96ae4be019692a8fe4 | f0e36da99467e234f38504ff025671940031f118e2859d96ae4be019692a8fe4 | 34e43190edfb1ef439ec7313a53a851267240868e27b7c74ac4d82e208528005 |

Hash Values of Android Snapchat Video 003

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------|--|--|--|--|
| Filename | Snapchat-533796126_1.mp4 | Snapchat-533796126.mp4 | Snapchat-533796126.mp4 | Snapchat-5337961261.mp4 |
| File Size | 8722728 bytes | 8722728 bytes | 8722728 bytes | 316179 bytes |
| SHA256 | 296635f347986b25c9c88c6c28506e5422d02553073eb37dd10728c8ff50b20e | 296635f347986b25c9c88c6c28506e5422d02553073eb37dd10728c8ff50b20e | 296635f347986b25c9c88c6c28506e5422d02553073eb37dd10728c8ff50b20e | fc30e18c7fa885b812a545a8f519a6106486956f7cb260db7b87c43847134f00 |

APPENDIX B

The following tables display the audio and video stream MD5 hash values for 001, 002, and 003, the original Android Snapchat video files and the files sent via MMS messages and extracted from the iPhone. The audio and video stream hashes were a mismatch between the files.

Stream Hash Values of Android Snapchat Video 001

| 001 | Extracted from Android | Extracted from iPhone |
|---------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | c1fe9c064f4ca6d75b95e15e099baf8f | 13a5bd6a8c6822f48aa8ed7561efaf78 |
| Video Stream Hash Values | 3f048f2884ecd43bf4ade0837e164ff5 | bb46a6503d5ca362fe21e4c8e0cc78d3 |

Stream Hash Values of Android Snapchat Video 002

| 002 | Extracted from Android | Extracted from iPhone |
|---------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | cef7f6ae5f06a2a54134654e8334c1a2 | 6b4f4a486ed9123f4963a3292d8242a3 |
| Video Stream Hash Values | 0489d9f5fa50848c42681d7ed657fad4 | 445bcb5d1f9c751b616020a173ea62c5 |

Stream Hash Values of Android Snapchat Video 003

| 003 | Extracted from Android | Extracted from iPhone |
|---------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | ff149e8f1f698ea68694b4eda2c3d016 | 1c7a8ad27b592b00130e3ed49b09e7fd |
| Video Stream Hash Values | 1c7a8ad27b592b00130e3ed49b09e7fd | ecec2e9be2cd6a1ff756ab310320691b |

APPENDIX C

The ten iPhone Snapchat video files were numbered 011 through 020. The following tables display the SHA256 hash values of 011, 012, and 013, the original files and their corresponding transferred files. The tables show that the files transferred via Dropbox maintained the same hash values, while the files transferred via Gmail and MMS message to the Android showed hash mismatches.

Hash Values of iPhone Snapchat Video 011

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|--|--|--|--|
| Filename | EA334448-85EE-4BB8-82E0-962BBE848EC3.MP4 | IMG_3575.MP4 | IMG_16065091.MOV | EA334448-1.3gp |
| File Size | 16517932 bytes | 16517932 bytes | 1688092 bytes | 328835 bytes |
| SHA256 | cf78854c3c72c7960cfe5441355587c2d6b2e18c9bfe1e856403462d7446cb70 | cf78854c3c72c7960cfe5441355587c2d6b2e18c9bfe1e856403462d7446cb70 | f7fb78cd705b4dd2449027366a7712dc84ef45c297c498d12646c87e60f91be7 | 831571eb4d3983c71bf5441d6a20fa32ff8e678216b917fd88e34b7332babe91 |

Hash Values of iPhone Snapchat Video 012

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|--|--|--|--|
| Filename | 98F95CC8-62E2-489C-8E9A-1FBBBBF830AA9.MP4 | IMG_3567.MP4 | IMG_27744659.MOV | 98F95CC8-1.3gp |
| File Size | 13001296 bytes | 13001296 bytes | 1320618 bytes | 254516 bytes |
| SHA256 | 54614dce8895b003ba9b734286c2e2c6401113bda9963f781574fc9b1ebe9fae | 54614dce8895b003ba9b734286c2e2c6401113bda9963f781574fc9b1ebe9fae | 7e3a916e76459e018b419dd01457ceb0803f2fb6eca6a74ed1a946aa4fba9e80 | 9361d4541d964fc4c7a360255d90fa76aa5c1cb234c8cb96f3e3f4eea3d1a33d |

Hash Values of iPhone Snapchat Video 013

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|--|--|--|--|
| Filename | 7AB4BBBB0-9EF7-48C0-BC0C-DF6DB30AEDB2.MP4 | IMG_3573.MP4 | IMG_257523635.MOV | 7AB4BBBB0-1.3gp |
| File Size | 10840796 bytes | 10840796 bytes | 1097934 bytes | 213149 bytes |
| SHA256 | 268aa45588aa3462b88446cbc28c35a59d44affb4ff883df6ae35d26d386a620 | 268aa45588aa3462b88446cbc28c35a59d44affb4ff883df6ae35d26d386a620 | 4f0afdec555acdef2c879724115a5409a5dde0bef552a1e8d86e35419dfc8096 | 2168829901c86da3c598b0057da633618b3d2d9806963f36f3f4c4b163bcc612 |

APPENDIX D

The following tables display the audio and video stream MD5 hash values for 011, 012 and 013, the original iPhone Snapchat video files, the files transferred via Gmail and the ones sent via MMS messages and extracted from the Android. The files transferred via Gmail show audio stream hash value matches and video stream hash value mismatches, while the files extracted from the Android show audio and video stream hash value mismatches.

Stream Hash Values of iPhone Snapchat Video 011

| 011 | Extracted from iPhone | Gmail | Extracted from Android |
|---------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | a4b33ec18ca0059187d4c68d4bf5b4e3 | a4b33ec18ca0059187d4c68d4bf5b4e3 | 1cab3aa5539ef22b9ba8e1c1d667582c |
| Video Stream Hash Values | 3f048f2884ecd43bf4ade0837e164ff5 | 6ec59c9db7592640d2506ded2e80cdd7 | 9b85cff262df4e86b40a74095364b3a2 |

Stream Hash Values of iPhone Snapchat Video 012

| 012 | Extracted from iPhone | Gmail | Extracted from Android |
|---------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | 4feb20818a74b2ccb68a9158aa1d00cf | 4feb20818a74b2ccb68a9158aa1d00cf | cd4e5489dc300675d84e356694d771c3 |
| Video Stream Hash Values | 259088a9a0d9b43e98622af71ffaa5ae | 013ffdc71e6606de37dd2b2931f2adb8 | 76b975535489492cdd42b6b321472db2 |

Stream Hash Values of iPhone Snapchat Video 013

| 013 | Extracted from iPhone | Gmail | Extracted from Android |
|---------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Audio Stream Hash Values | 5cc7af9575dc84d59237bf11b50789e0 | 5cc7af9575dc84d59237bf11b50789e0 | 0e3b86093daf08f89ae60ba90b22019e |
| Video Stream Hash Values | 112eb39d67e26c4e9bb83ca622e07d4c | df45e6a60ae17c6d210ceb06e2475000 | 9cddd8d011201033b8734c7206cb1333 |

APPENDIX E

The following tables display the metadata from ExifTool for 001, 002, and 003, the original Android Snapchat video files and their corresponding transferred files.

ExifTool Metadata of Android Snapchat Video 001

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------------------------|-------------------------------|---------------------------|---------------------------|------------------------------|
| File Name | Snapchat-196961414_1.mp4 | Snapchat-196961414.mp4 | Snapchat-196961414.mp4 | Snapchat-1969614141.mp4 |
| File Size | 15 MiB | 15 MiB | 15 MiB | 546 KiB |
| File Modification Date/Time | 2021:02:21 22:43:16-07:00 | 2021:02:21 20:23:50-07:00 | 2021:02:21 20:27:00-07:00 | 2021:02:21 18:07:26-07:00 |
| File Access Date/Time | 2021:02:23 23:56:49-07:00 | 2021:02:27 17:28:21-07:00 | 2021:02:27 18:58:55-07:00 | 2021:02:24 22:39:59-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:50-07:00 | 2021:02:27 17:25:03-07:00 | 2021:02:27 17:25:34-07:00 | 2021:02:23 23:29:50-07:00 |

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------------------|------------------------|-----------------------|-----------------------|-----------------------|
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MP4 | MP4 |
| File Type Extension | mp4 | mp4 | mp4 | mp4 |
| MIME Type | video/mp4 | video/mp4 | video/mp4 | video/mp4 |
| Major Brand | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] |
| Minor Version | 0.0.0 | 0.0.0 | 0.0.0 | 0.0.0 |
| Compatible Brands | isom, mp42 | isom, mp42 | isom, mp42 | isom, mp42 |
| Media Data Size | 15494332 | 15494332 | 15494332 | 553712 |
| Media Data Offset | 32 | 32 | 32 | 40 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Modify Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Time Scale | 600 | 600 | 600 | 1000 |
| Duration | 15.37 s | 15.37 s | 15.37 s | 15.36 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 255 | 255 | 255 | 3 |
| Play Mode | | | | SEQ_PLAY |
| Android Version | | | | 10 |
| User Data eng (ykn) | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Track Modify Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Track ID | 256 | 256 | 256 | 1 |
| Track Duration | 15.37 s | 15.37 s | 15.37 s | 15.36 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 0.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | mp4a |
| Audio Channels | 1 | 1 | 1 | 1 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 44100 |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 1072 | 1072 | 1072 | 176 |
| Image Height | 1920 | 1920 | 1920 | 144 |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Media Modify Date | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 00:41:27 | 2021:02:22 01:07:03 |
| Media Time Scale | 90000 | 90000 | 90000 | 44100 |

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-----------------------------|------------------------|------------------|------------------|-----------------------|
| Media Duration | 15.36 s | 15.36 s | 15.36 s | 15.35 s |
| Handler Type | Video Track | Video Track | Video Track | Audio Track |
| Handler Description | Snap Video | Snap Video | Snap Video | SoundHandle |
| Graphics Mode | srcCopy | srcCopy | srcCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | s263 |
| Source Image Width | 1072 | 1072 | 1072 | 176 |
| Source Image Height | 1920 | 1920 | 1920 | 144 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |
| Pixel Aspect Ratio | 65536:65536 | 65536:65536 | 65536:65536 | 65536:65536 |
| Color Representation | nclx 5 6 5 | nclx 5 6 5 | nclx 5 6 5 | nclx 5 1 6 |
| Video Frame Rate | 27.732 | 27.732 | 27.732 | 13.866 |
| User Data eng | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Image Size | 1072x1920 | 1072x1920 | 1072x1920 | 176x144 |
| Megapixels | 2.1 | 2.1 | 2.1 | 0.025 |
| Avg Bitrate | 8.06 Mbps | 8.06 Mbps | 8.06 Mbps | 288 kbps |
| Rotation | 0 | 0 | 0 | 0 |

ExifTool Metadata of Android Snapchat Video 002

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| File Name | Snapchat-340788319_1.mp4 | Snapchat-340788319.mp4 | Snapchat-340788319.mp4 | Snapchat-3407883191.mp4 |
| File Size | 14 MiB | 14 MiB | 14 MiB | 549 KiB |
| File Modification Date/Time | 2021:02:21 22:43:16-07:00 | 2021:02:21 20:23:41-07:00 | 2021:02:21 20:27:00-07:00 | 2021:02:21 18:08:20-07:00 |
| File Access Date/Time | 2021:02:23 23:56:16-07:00 | 2021:02:27 17:50:51-07:00 | 2021:02:27 18:58:12-07:00 | 2021:02:24 22:41:58-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:50-07:00 | 2021:02:27 17:25:03-07:00 | 2021:02:27 17:25:34-07:00 | 2021:02:23 23:29:50-07:00 |
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MP4 | MP4 |
| File Type Extension | mp4 | mp4 | mp4 | mp4 |
| MIME Type | video/mp4 | video/mp4 | video/mp4 | video/mp4 |
| Major Brand | MP4 v2 [ISO 14496-14] |
| Minor Version | 0.0.0 | 0.0.0 | 0.0.0 | 0.0.0 |
| Compatible Brands | isom, mp42 | isom, mp42 | isom, mp42 | isom, mp42 |
| Media Data Size | 15058649 | 15058649 | 15058649 | 557066 |
| Media Data Offset | 32 | 32 | 32 | 40 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |
| Modify Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-----------------------|------------------------|---------------------|---------------------|-----------------------|
| Time Scale | 600 | 600 | 600 | 1000 |
| Duration | 14.75 s | 14.75 s | 14.75 s | 14.82 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 255 | 255 | 255 | 3 |
| Play Mode | | | | SEQ_PLAY |
| Android Version | | | | 10 |
| User Data eng (ykn) | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |
| Track Modify Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |
| Track ID | 256 | 256 | 256 | 1 |
| Track Duration | 14.72 s | 14.72 s | 14.72 s | 14.82 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 0.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | mp4a |
| Audio Channels | 1 | 1 | 1 | 1 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 44100 |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 1072 | 1072 | 1072 | 176 |
| Image Height | 1920 | 1920 | 1920 | 144 |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |
| Media Modify Date | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 00:36:53 | 2021:02:22 01:07:59 |
| Media Time Scale | 90000 | 90000 | 90000 | 44100 |
| Media Duration | 14.75 s | 14.75 s | 14.75 s | 14.70 s |
| Handler Type | Video Track | Video Track | Video Track | Audio Track |
| Handler Description | Snap Video | Snap Video | Snap Video | SoundHandle |
| Graphics Mode | srcCopy | srcCopy | srcCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | s263 |
| Source Image Width | 1072 | 1072 | 1072 | 176 |
| Source Image Height | 1920 | 1920 | 1920 | 144 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |
| Pixel Aspect Ratio | 65536:65536 | 65536:65536 | 65536:65536 | 65536:65536 |
| Color Representation | nclx 5 6 5 | nclx 5 6 5 | nclx 5 6 5 | nclx 5 1 6 |

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-------------------------|------------------------|------------------|------------------|-----------------------|
| Video Frame Rate | 29.56 | 29.56 | 29.56 | 9.854 |
| User Data eng | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Image Size | 1072x1920 | 1072x1920 | 1072x1920 | 176x144 |
| Megapixels | 2.1 | 2.1 | 2.1 | 0.025 |
| Avg Bitrate | 8.17 Mbps | 8.17 Mbps | 8.17 Mbps | 301 kbps |
| Rotation | 0 | 0 | 0 | 0 |

ExifTool Metadata of Android Snapchat Video 003

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|------------------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| File Name | Snapchat-533796126_1.mp4 | Snapchat-533796126.mp4 | Snapchat-533796126.mp4 | Snapchat-5337961261.mp4 |
| File Size | 8.3 MiB | 8.3 MiB | 8.3 MiB | 309 KiB |
| File Modification Date/Time | 2021:02:21 22:43:16-07:00 | 2021:02:21 20:23:47-07:00 | 2021:02:21 20:28:00-07:00 | 2021:02:21 19:22:54-07:00 |
| File Access Date/Time | 2021:02:23 23:55:38-07:00 | 2021:02:27 17:59:33-07:00 | 2021:02:27 18:57:59-07:00 | 2021:02:24 22:43:30-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:50-07:00 | 2021:02:27 17:25:03-07:00 | 2021:02:27 17:25:34-07:00 | 2021:02:23 23:29:50-07:00 |
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MP4 | MP4 |
| File Type Extension | mp4 | mp4 | mp4 | mp4 |
| MIME Type | video/mp4 | video/mp4 | video/mp4 | video/mp4 |
| Major Brand | MP4 v2 [ISO 14496-14] |
| Minor Version | 0.0.0 | 0.0.0 | 0.0.0 | 0.0.0 |
| Compatible Brands | isom, mp42 | isom, mp42 | isom, mp42 | isom, mp42 |
| Media Data Size | 8718990 | 8718990 | 8718990 | 312198 |
| Media Data Offset | 32 | 32 | 32 | 40 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Modify Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Time Scale | 600 | 600 | 600 | 1000 |
| Duration | 8.68 s | 8.68 s | 8.68 s | 8.66 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 255 | 255 | 255 | 3 |
| Play Mode | | | | SEQ_PLAY |
| Android Version | | | | 10 |

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-----------------------|------------------------|---------------------|---------------------|-----------------------|
| User Data eng (ykn) | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Track Modify Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Track ID | 256 | 256 | 256 | 1 |
| Track Duration | 8.68 s | 8.68 s | 8.68 s | 8.65 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 0.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | mp4a |
| Audio Channels | 1 | 1 | 1 | 1 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 44100 |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 1072 | 1072 | 1072 | 176 |
| Image Height | 1920 | 1920 | 1920 | 144 |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Media Modify Date | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:20:24 | 2021:02:22 02:22:25 |
| Media Time Scale | 90000 | 90000 | 90000 | 44100 |
| Media Duration | 8.62 s | 8.62 s | 8.62 s | 8.66 s |
| Handler Type | Video Track | Video Track | Video Track | Audio Track |
| Handler Description | Snap Video | Snap Video | Snap Video | SoundHandle |
| Graphics Mode | srcCopy | srcCopy | srcCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | s263 |
| Source Image Width | 1072 | 1072 | 1072 | 176 |
| Source Image Height | 1920 | 1920 | 1920 | 144 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |
| Pixel Aspect Ratio | 65536:65536 | 65536:65536 | 65536:65536 | 65536:65536 |
| Color Representation | nclx 5 6 5 | nclx 5 6 5 | nclx 5 6 5 | nclx 5 1 6 |
| Video Frame Rate | 16.306 | 16.306 | 16.306 | 16.306 |
| User Data eng | -180.00-180.000/ | -180.00-180.000/ | -180.00-180.000/ | |
| Image Size | 1072x1920 | 1072x1920 | 1072x1920 | 176x144 |
| Megapixels | 2.1 | 2.1 | 2.1 | 0.025 |
| Avg Bitrate | 8.03 Mbps | 8.03 Mbps | 8.03 Mbps | 288 kbps |
| Rotation | 0 | 0 | 0 | 0 |

APPENDIX F

The following tables display the metadata from ExifTool for 011, 012, and 013, the original iPhone Snapchat video files and their corresponding transferred files. The categories of interest are highlighted.

ExifTool Metadata of iPhone Snapchat Video 011

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------------------------|--|---------------------------|---------------------------|---|
| File Name | EA334448-85EE-4BB8-82E0-962BBE848EC3.MP4 | IMG_3575.MP4 | IMG_16065091.MOV | EA334448-1.3gp |
| File Size | 16 MiB | 16 MiB | 1649 KiB | 321 KiB |
| File Modification Date/Time | 2021:02:21 18:42:53-07:00 | 2021:02:21 20:23:44-07:00 | 2021:02:21 20:33:00-07:00 | 2021:02:21 22:44:40-07:00 |
| File Access Date/Time | 2021:02:27 17:00:59-07:00 | 2021:03:02 22:11:28-07:00 | 2021:03:02 22:25:54-07:00 | 2021:02:27 16:12:08-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:49-07:00 | 2021:02:27 17:25:17-07:00 | 2021:02:27 17:25:43-07:00 | 2021:02:23 23:29:49-07:00 |
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MOV | 3GP |
| File Type Extension | mp4 | mp4 | mov | 3gp |
| MIME Type | video/mp4 | video/mp4 | video/quicktime | video/3gpp |
| Major Brand | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] | Apple QuickTime (.MOV/QT) | 3GPP Media (.3GP) Release 6 Streaming Servers |
| Minor Version | 0.0.1 | 0.0.1 | 0.0.0 | 0.1.0 |
| Compatible Brands | isom, mp41, mp42 | isom, mp41, mp42 | qt | 3gp6, isom |
| Media Data Size | 16506118 | 16506118 | 1675942 | 325421 |
| Media Data Offset | 44 | 44 | 36 | 3414 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:00 | 2021:02:22 01:58:08 |
| Modify Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:01 | 2021:02:22 01:58:09 |
| Time Scale | 600 | 600 | 600 | 600 |
| Duration | 17.39 s | 17.39 s | 17.39 s | 17.39 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 3 | 3 | 3 | 3 |

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|--------------------------------|-----------------------|---------------------|-------------------------|------------------------|
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:00 | 2021:02:22 01:58:08 |
| Track Modify Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:01 | 2021:02:22 01:58:09 |
| Track ID | 1 | 1 | 1 | 1 |
| Track Duration | 17.37 s | 17.37 s | 17.37 s | 17.37 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | samr |
| Audio Channels | 2 | 2 | 1 | 2 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 8000 |
| Encoder Vendor | | | | appl |
| Encoder Version | | | | 1 |
| Purchase File Format | | | mp4a | |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 656 | 656 | 256 | 320 |
| Image Height | 1232 | 1232 | 480 | 240 |
| Clean Aperture Dimensions | | | 256x480 | |
| Production Aperture Dimensions | | | 256x480 | |
| Encoded Pixels Dimensions | | | 256x480 | |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:00 | 2021:02:22 01:58:08 |
| Media Modify Date | 2021:02:22 01:42:53 | 2021:02:22 01:42:53 | 2021:02:22 03:32:01 | 2021:02:22 01:58:09 |
| Media Time Scale | 600 | 600 | 600 | 600 |
| Media Duration | 17.45 s | 17.45 s | 17.39 s | 17.40 s |
| Media Language Code | und | und | und | und |
| Handler Type | Video Track | Video Track | Alias Data | Video Track |
| Handler Description | Core Media Video | Core Media Video | Core Media Data Handler | Core Media Video |
| Handler Class | | | Data Handler | |
| Handler Vendor ID | | | Apple | |
| Graphics Mode | srcCopy | srcCopy | ditherCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 32768 32768 32768 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | avc1 |
| Compressor Name | | | H.264 | |
| Source Image Width | 656 | 656 | 256 | 320 |
| Source Image Height | 1232 | 1232 | 480 | 240 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|-----------------------|-----------|----------|------------------------|
| Video Frame Rate | 30.023 | 30.023 | 30.023 | 15 |
| Image Size | 656x1232 | 656x1232 | 256x480 | 320x240 |
| Megapixels | 0.808 | 0.808 | 0.123 | 0.077 |
| Avg Bitrate | 7.59 Mbps | 7.59 Mbps | 771 kbps | 150 kbps |
| Rotation | 0 | 0 | 0 | 0 |

ExifTool Metadata of iPhone Snapchat Video 012

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-----------------------------|---|---------------------------|---------------------------|---|
| File Name | 98F95CC8-62E2-489C-8E9A-1FBBBBF830AA9.MP4 | IMG_3567.MP4 | IMG_27744659.MOV | 98F95CC8-1.3gp |
| File Size | 12 MiB | 12 MiB | 1290 KiB | 249 KiB |
| File Modification Date/Time | 2021:02:21 18:34:19-07:00 | 2021:02:21 20:23:44-07:00 | 2021:02:21 20:32:00-07:00 | 2021:02:21 22:44:40-07:00 |
| File Access Date/Time | 2021:02:27 16:41:25-07:00 | 2021:03:02 22:03:49-07:00 | 2021:03:02 22:26:25-07:00 | 2021:02:27 15:39:10-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:49-07:00 | 2021:02:27 17:25:17-07:00 | 2021:02:27 17:25:43-07:00 | 2021:02:23 23:29:49-07:00 |
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MOV | 3GP |
| File Type Extension | mp4 | mp4 | mov | 3gp |
| MIME Type | video/mp4 | video/mp4 | video/quicktime | video/3gpp |
| Major Brand | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] | Apple QuickTime (.MOV/QT) | 3GPP Media (.3GP) Release 6 Streaming Servers |
| Minor Version | 0.0.1 | 0.0.1 | 0.0.0 | 0.1.0 |
| Compatible Brands | isom, mp41, mp42 | isom, mp41, mp42 | qt | 3gp6, isom |
| Media Data Size | 12991517 | 12991517 | 1310299 | 251363 |
| Media Data Offset | 44 | 44 | 36 | 3153 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:50 |
| Modify Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:51 |
| Time Scale | 600 | 600 | 600 | 600 |
| Duration | 14.63 s | 14.63 s | 14.63 s | 14.63 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 3 | 3 | 3 | 3 |

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|--------------------------------|-----------------------|---------------------|-------------------------|------------------------|
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:50 |
| Track Modify Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:51 |
| Track ID | 1 | 1 | 1 | 1 |
| Track Duration | 14.57 s | 14.57 s | 14.57 s | 14.57 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | samr |
| Audio Channels | 2 | 2 | 1 | 2 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 8000 |
| Encoder Vendor | | | | appl |
| Encoder Version | | | | 1 |
| Purchase File Format | | | mp4a | |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 656 | 656 | 256 | 320 |
| Image Height | 1232 | 1232 | 480 | 240 |
| Clean Aperture Dimensions | | | 256x480 | |
| Production Aperture Dimensions | | | 256x480 | |
| Encoded Pixels Dimensions | | | 256x480 | |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:50 |
| Media Modify Date | 2021:02:22 01:34:19 | 2021:02:22 01:34:19 | 2021:02:22 03:29:41 | 2021:02:22 01:57:51 |
| Media Time Scale | 600 | 600 | 600 | 600 |
| Media Duration | 14.69 s | 14.69 s | 14.63 s | 14.67 s |
| Media Language Code | und | und | und | und |
| Handler Type | Video Track | Video Track | Alias Data | Video Track |
| Handler Description | Core Media Video | Core Media Video | Core Media Data Handler | Core Media Video |
| Handler Class | | | Data Handler | |
| Handler Vendor ID | | | Apple | |
| Graphics Mode | srcCopy | srcCopy | ditherCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 32768 32768 32768 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | avc1 |
| Compressor Name | | | H.264 | |
| Source Image Width | 656 | 656 | 256 | 320 |
| Source Image Height | 1232 | 1232 | 480 | 240 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|------------------|-----------------------|-----------|----------|------------------------|
| Video Frame Rate | 30.014 | 30.014 | 30.014 | 15 |
| Image Size | 656x1232 | 656x1232 | 256x480 | 320x240 |
| Megapixels | 0.808 | 0.808 | 0.123 | 0.077 |
| Avg Bitrate | 7.11 Mbps | 7.11 Mbps | 717 kbps | 137 kbps |
| Rotation | 0 | 0 | 0 | 0 |

ExifTool Metadata of iPhone Snapchat Video 013

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-----------------------------|--|---------------------------|---------------------------|---|
| File Name | 7AB4BBB0-9EF7-48C0-BC0C-DF6DB30AEDB2.MP4 | IMG_3573.MP4 | IMG_257523635.MOV | 7AB4BBB0-1.3gp |
| File Size | 10 MiB | 10 MiB | 1072 KiB | 208 KiB |
| File Modification Date/Time | 2021:02:21 18:41:24-07:00 | 2021:02:21 20:23:49-07:00 | 2021:02:21 20:33:00-07:00 | 2021:02:21 22:44:40-07:00 |
| File Access Date/Time | 2021:02:27 16:16:52-07:00 | 2021:03:02 22:10:24-07:00 | 2021:03:02 22:36:46-07:00 | 2021:02:27 15:17:52-07:00 |
| File Creation Date/Time | 2021:02:23 23:29:49-07:00 | 2021:02:27 17:25:17-07:00 | 2021:02:27 17:25:43-07:00 | 2021:02:23 23:29:49-07:00 |
| File Permissions | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- | rw-rw-rw- |
| File Type | MP4 | MP4 | MOV | 3GP |
| File Type Extension | mp4 | mp4 | mov | 3gp |
| MIME Type | video/mp4 | video/mp4 | video/quicktime | video/3gpp |
| Major Brand | MP4 v2 [ISO 14496-14] | MP4 v2 [ISO 14496-14] | Apple QuickTime (.MOV/QT) | 3GPP Media (.3GP) Release 6 Streaming Servers |
| Minor Version | 0.0.1 | 0.0.1 | 0.0.0 | 0.1.0 |
| Compatible Brands | isom, mp41, mp42 | isom, mp41, mp42 | qt | 3gp6, isom |
| Media Data Size | 10832448 | 10832448 | 1089382 | 210468 |
| Media Data Offset | 44 | 44 | 36 | 2681 |
| Movie Header Version | 0 | 0 | 0 | 0 |
| Create Date | 2021:02:22 01:41:23 | 2021:02:22 01:41:23 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Modify Date | 2021:02:22 01:41:24 | 2021:02:22 01:41:24 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Time Scale | 600 | 600 | 600 | 600 |
| Duration | 11.46 s | 11.46 s | 11.46 s | 11.46 s |
| Preferred Rate | 1 | 1 | 1 | 1 |
| Preferred Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Preview Time | 0 s | 0 s | 0 s | 0 s |
| Preview Duration | 0 s | 0 s | 0 s | 0 s |
| Poster Time | 0 s | 0 s | 0 s | 0 s |
| Selection Time | 0 s | 0 s | 0 s | 0 s |
| Selection Duration | 0 s | 0 s | 0 s | 0 s |
| Current Time | 0 s | 0 s | 0 s | 0 s |
| Next Track ID | 3 | 3 | 3 | 3 |

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|--------------------------------|-----------------------|---------------------|-------------------------|------------------------|
| Track Header Version | 0 | 0 | 0 | 0 |
| Track Create Date | 2021:02:22 01:41:23 | 2021:02:22 01:41:23 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Track Modify Date | 2021:02:22 01:41:24 | 2021:02:22 01:41:24 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Track ID | 1 | 1 | 1 | 1 |
| Track Duration | 11.46 s | 11.46 s | 11.46 s | 11.46 s |
| Track Layer | 0 | 0 | 0 | 0 |
| Track Volume | 100.00% | 100.00% | 100.00% | 100.00% |
| Balance | 0 | 0 | 0 | 0 |
| Audio Format | mp4a | mp4a | mp4a | samr |
| Audio Channels | 2 | 2 | 1 | 2 |
| Audio Bits Per Sample | 16 | 16 | 16 | 16 |
| Audio Sample Rate | 44100 | 44100 | 44100 | 8000 |
| Encoder Vendor | | | | appl |
| Encoder Version | | | | 1 |
| Purchase File Format | | | mp4a | |
| Matrix Structure | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 | 1 0 0 0 1 0 0 0 1 |
| Image Width | 656 | 656 | 256 | 320 |
| Image Height | 1232 | 1232 | 480 | 240 |
| Clean Aperture Dimensions | | | 256x480 | |
| Production Aperture Dimensions | | | 256x480 | |
| Encoded Pixels Dimensions | | | 256x480 | |
| Media Header Version | 0 | 0 | 0 | 0 |
| Media Create Date | 2021:02:22 01:41:23 | 2021:02:22 01:41:23 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Media Modify Date | 2021:02:22 01:41:24 | 2021:02:22 01:41:24 | 2021:02:22 03:31:31 | 2021:02:22 01:58:05 |
| Media Time Scale | 600 | 600 | 600 | 600 |
| Media Duration | 11.53 s | 11.53 s | 11.46 s | 11.47 s |
| Media Language Code | und | und | und | und |
| Handler Type | Video Track | Video Track | Alias Data | Video Track |
| Handler Description | Core Media Video | Core Media Video | Core Media Data Handler | Core Media Video |
| Handler Class | | | Data Handler | |
| Handler Vendor ID | | | Apple | |
| Graphics Mode | srcCopy | srcCopy | ditherCopy | srcCopy |
| Op Color | 0 0 0 | 0 0 0 | 32768 32768 32768 | 0 0 0 |
| Compressor ID | avc1 | avc1 | avc1 | avc1 |
| Compressor Name | | | H.264 | |
| Source Image Width | 656 | 656 | 256 | 320 |
| Source Image Height | 1232 | 1232 | 480 | 240 |
| X Resolution | 72 | 72 | 72 | 72 |
| Y Resolution | 72 | 72 | 72 | 72 |
| Bit Depth | 24 | 24 | 24 | 24 |

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-------------------------|-----------------------|-----------|----------|------------------------|
| Video Frame Rate | 30.009 | 30.009 | 30.009 | 15 |
| Image Size | 656x1232 | 656x1232 | 256x480 | 320x240 |
| Megapixels | 0.808 | 0.808 | 0.123 | 0.077 |
| Avg Bitrate | 7.56 Mbps | 7.56 Mbps | 760 kbps | 147 kbps |
| Rotation | 0 | 0 | 0 | 0 |

APPENDIX G

The following tables display the MediaInfo metadata for 001, 002, and 003, the original Android Snapchat video files and their corresponding transferred files. The categories of interest are highlighted.

MediaInfo Metadata of Android Snapchat Video 001

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--|--------------------------|-------------------------|-------------------------|-------------------------|
| <i>General</i> | | | | |
| Name | Snapchat-196961414_1.mp4 | Snapchat-196961414.mp4 | Snapchat-196961414.mp4 | Snapchat-1969614141.mp4 |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 |
| Codec ID | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) |
| File size | 14.8 MiB | 14.8 MiB | 14.8 MiB | 546 KiB |
| Duration | 15 s 370 ms | 15 s 370 ms | 15 s 370 ms | 15 s 361 ms |
| Overall bit rate | 8 069 kb/s | 8 069 kb/s | 8 069 kb/s | 291 kb/s |
| Encoded date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |
| Tagged date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |
| eng | -180 | -180 | -180 | |
| com.android.version | | | | 10 |
| <i>Video</i> | | | | |
| ID | 512 | 512 | 512 | 1 |
| Format | AVC | AVC | AVC | H.263 |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | |
| Format profile | High@L4 | High@L4 | High@L4 | BaseLine@1.0 |
| Format settings | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | |
| Format settings, CABAC | Yes | Yes | Yes | |
| Format settings, Reference frames | 1 frame | 1 frame | 1 frame | |
| Format settings, GOP | M=1, N=30 | M=1, N=30 | M=1, N=30 | |
| Codec ID | avc1 | avc1 | avc1 | s263 |

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | |
| Duration | 15 s 363 ms | 15 s 363 ms | 15 s 363 ms | 15 s 361 ms |
| Source duration | 15 s 361 ms | 15 s 361 ms | 15 s 361 ms | |
| Bit rate | 7 938 kb/s | 7 938 kb/s | 7 938 kb/s | 256 kb/s |
| Width | 1 072 pixels | 1 072 pixels | 1 072 pixels | 176 pixels |
| Height | 1 920 pixels | 1 920 pixels | 1 920 pixels | 144 pixels |
| Display aspect ratio | 0.558 | 0.558 | 0.558 | 1.222 |
| Original display aspect ratio | | | | 0.16875 |
| Frame rate mode | Variable | Variable | Variable | Variable |
| Frame rate | 27.732 FPS | 27.732 FPS | 27.732 FPS | 13.866 FPS |
| Minimum frame rate | 17.513 FPS | 17.513 FPS | 17.513 FPS | 11.058 FPS |
| Maximum frame rate | 57.143 FPS | 57.143 FPS | 57.143 FPS | 19.672 FPS |
| Standard | NTSC | NTSC | NTSC | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 0.168055556 | 0.168055556 | 0.168055556 | 0.168055556 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | |
| Compression mode | | | | Lossy |
| Bits/(Pixel*Frame) | 0.139 | 0.139 | 0.139 | 0.729 |
| Stream size | 14.5 MiB (98%) | 14.5 MiB (98%) | 14.5 MiB (98%) | 480 KiB (88%) |
| Source stream size | 14.5 MiB (98%) | 14.5 MiB (98%) | 14.5 MiB (98%) | |
| Title | Snap Video | Snap Video | Snap Video | VideoHandle |
| Writing library | | | | 0x00000000 |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |
| Tagged date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |
| Color range | Full | Full | Full | Limited |
| colour_range_Original | Limited | Limited | Limited | |
| Color primaries | BT.601 PAL | BT.601 PAL | BT.601 PAL | BT.601 PAL |
| Transfer characteristics | BT.601 | BT.601 | BT.601 | BT.709 |
| Matrix coefficients | BT.470 System B/G | BT.470 System B/G | BT.470 System B/G | BT.601 |
| matrix_coefficients_Original | BT.601 | BT.601 | BT.601 | |
| mdhd_Duration | 15364 | 15364 | 15364 | |
| Codec configuration box | avcC | avcC | avcC | |
| <i>Audio</i> | | | | |
| ID | 256 | 256 | 256 | 2 |
| Format | AAC LC | AAC LC | AAC LC | AAC LC |
| Format/Info | Advanced Audio Codec Low Complexity |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 |

| 001 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Duration | 15 s 370 ms | 15 s 370 ms | 15 s 370 ms | 15 s 348 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 132 kb/s | 132 kb/s | 132 kb/s | 32.0 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | C |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 44.1 kHz |
| Frame rate | 43.066 FPS (1024 SPF) |
| Compression mode | Lossy | Lossy | Lossy | Lossy |
| Stream size | 246 KiB (2%) | 246 KiB (2%) | 246 KiB (2%) | 60.3 KiB (11%) |
| Title | Snap Audio | Snap Audio | Snap Audio | SoundHandle |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |
| Tagged date | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 00:41:27 | UTC 2021-02-22 01:07:03 |

MediaInfo Metadata of Android Snapchat Video 002

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--|--------------------------|-------------------------|-------------------------|-------------------------|
| <i>General</i> | | | | |
| Name | Snapchat-340788319_1.mp4 | Snapchat-340788319.mp4 | Snapchat-340788319.mp4 | Snapchat-3407883191.mp4 |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 |
| Codec ID | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) |
| File size | 14.4 MiB | 14.4 MiB | 14.4 MiB | 549 KiB |
| Duration | 14 s 750 ms | 14 s 750 ms | 14 s 750 ms | 14 s 816 ms |
| Overall bit rate | 8 171 kb/s | 8 171 kb/s | 8 171 kb/s | 304 kb/s |
| Encoded date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |
| Tagged date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |
| eng | -180 | -180 | -180 | |
| com.android.version | | | | 10 |
| <i>Video</i> | | | | |
| ID | 512 | 512 | 512 | 1 |
| Format | AVC | AVC | AVC | H.263 |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | |
| Format profile | High@L4 | High@L4 | High@L4 | BaseLine@1.0 |
| Format settings | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | |
| Format settings, CABAC | Yes | Yes | Yes | |
| Format settings, Reference frames | 1 frame | 1 frame | 1 frame | |

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Format settings, GOP | M=1, N=30 | M=1, N=30 | M=1, N=30 | |
| Codec ID | avc1 | avc1 | avc1 | s263 |
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | |
| Duration | 14 s 750 ms | 14 s 750 ms | 14 s 750 ms | 14 s 816 ms |
| Bit rate | 8 037 kb/s | 8 037 kb/s | 8 037 kb/s | 269 kb/s |
| Width | 1 072 pixels | 1 072 pixels | 1 072 pixels | 176 pixels |
| Height | 1 920 pixels | 1 920 pixels | 1 920 pixels | 144 pixels |
| Display aspect ratio | 0.558 | 0.558 | 0.558 | 1.222 |
| Original display aspect ratio | | | | 4:03 |
| Frame rate mode | Variable | Variable | Variable | Variable |
| Frame rate | 29.560 FPS | 29.560 FPS | 29.560 FPS | 9.854 FPS |
| Minimum frame rate | 19.920 FPS | 19.920 FPS | 19.920 FPS | 7.653 FPS |
| Maximum frame rate | 49.423 FPS | 49.423 FPS | 49.423 FPS | 11.507 FPS |
| Standard | NTSC | NTSC | NTSC | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 4:02:00 | 4:02:00 | 4:02:00 | 4:02:00 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | |
| Compression mode | | | | Lossy |
| Bits/(Pixel*Frame) | 0.132 | 0.132 | 0.132 | 1.077 |
| Stream size | 14.1 MiB (98%) | 14.1 MiB (98%) | 14.1 MiB (98%) | 486 KiB (89%) |
| Title | Snap Video | Snap Video | Snap Video | VideoHandle |
| Writing library | | | | 0x00000000 |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |
| Tagged date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |
| Color range | Full | Full | Full | Limited |
| colour_range_Original | Limited | Limited | Limited | |
| Color primaries | BT.601 PAL | BT.601 PAL | BT.601 PAL | BT.601 PAL |
| Transfer characteristics | BT.601 | BT.601 | BT.601 | BT.709 |
| Matrix coefficients | BT.470 System B/G | BT.470 System B/G | BT.470 System B/G | BT.601 |
| matrix_coefficients_Original | BT.601 | BT.601 | BT.601 | |
| mdhd_Duration | 14751 | 14751 | 14751 | |
| Codec configuration box | avcC | avcC | avcC | |
| <i>Audio</i> | | | | |
| ID | 256 | 256 | 256 | 2 |
| Format | AAC LC | AAC LC | AAC LC | AAC LC |
| Format/Info | Advanced Audio Codec Low Complexity |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 |

| 002 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Duration | 14 s 720 ms | 14 s 720 ms | 14 s 720 ms | 14 s 698 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 132 kb/s | 132 kb/s | 132 kb/s | 32.0 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | C |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 44.1 kHz |
| Frame rate | 43.066 FPS (1024 SPF) |
| Compression mode | Lossy | Lossy | Lossy | Lossy |
| Stream size | 236 KiB (2%) | 236 KiB (2%) | 236 KiB (2%) | 57.8 KiB (11%) |
| Title | Snap Audio | Snap Audio | Snap Audio | SoundHandle |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |
| Tagged date | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 00:36:53 | UTC 2021-02-22 01:07:59 |

MediaInfo Metadata of Android Snapchat Video 003

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--|--------------------------|-------------------------|-------------------------|-------------------------|
| <i>General</i> | | | | |
| Name | Snapchat-533796126_1.mp4 | Snapchat-533796126.mp4 | Snapchat-533796126.mp4 | Snapchat-5337961261.mp4 |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 | Base Media / Version 2 |
| Codec ID | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) | mp42 (isom/mp42) |
| File size | 8.32 MiB | 8.32 MiB | 8.32 MiB | 309 KiB |
| Duration | 8 s 683 ms | 8 s 683 ms | 8 s 683 ms | 8 s 661 ms |
| Overall bit rate | 8 037 kb/s | 8 037 kb/s | 8 037 kb/s | 292 kb/s |
| Encoded date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |
| Tagged date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |
| eng | -180 | -180 | -180 | |
| com.android.version | | | | 10 |
| <i>Video</i> | | | | |
| ID | 512 | 512 | 512 | 1 |
| Format | AVC | AVC | AVC | H.263 |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | |
| Format profile | High@L4 | High@L4 | High@L4 | BaseLine@1.0 |
| Format settings | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | CABAC / 1 Ref Frames | |
| Format settings, CABAC | Yes | Yes | Yes | |
| Format settings, Reference frames | 1 frame | 1 frame | 1 frame | |

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|--------------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Format settings, GOP | M=1, N=30 | M=1, N=30 | M=1, N=30 | |
| Codec ID | avc1 | avc1 | avc1 | s263 |
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | |
| Duration | 8 s 618 ms | 8 s 618 ms | 8 s 618 ms | 8 s 647 ms |
| Source duration | 8 s 647 ms | 8 s 647 ms | 8 s 647 ms | |
| Bit rate | 7 935 kb/s | 7 935 kb/s | 7 935 kb/s | 257 kb/s |
| Width | 1 072 pixels | 1 072 pixels | 1 072 pixels | 176 pixels |
| Height | 1 920 pixels | 1 920 pixels | 1 920 pixels | 144 pixels |
| Display aspect ratio | 0.558 | 0.558 | 0.558 | 1.222 |
| Original display aspect ratio | | | | 4:03 |
| Frame rate mode | Variable | Variable | Variable | Variable |
| Frame rate | 16.306 FPS | 16.306 FPS | 16.306 FPS | 16.306 FPS |
| Minimum frame rate | 12.568 FPS | 12.568 FPS | 12.568 FPS | 12.568 FPS |
| Maximum frame rate | 23.885 FPS | 23.885 FPS | 23.885 FPS | 23.885 FPS |
| Standard | NTSC | NTSC | NTSC | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 4:02:00 | 4:02:00 | 4:02:00 | 4:02:00 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | |
| Compression mode | | | | Lossy |
| Bits/(Pixel*Frame) | 0.236 | 0.236 | 0.236 | 0.621 |
| Stream size | 8.18 MiB (98%) | 8.18 MiB (98%) | 8.18 MiB (98%) | 271 KiB (88%) |
| Source stream size | 8.18 MiB (98%) | 8.18 MiB (98%) | 8.18 MiB (98%) | |
| Title | Snap Video | Snap Video | Snap Video | VideoHandle |
| Writing library | | | | 0x00000000 |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |
| Tagged date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |
| Color range | Full | Full | Full | Limited |
| colour_range_Original | Limited | Limited | Limited | |
| Color primaries | BT.601 PAL | BT.601 PAL | BT.601 PAL | BT.601 PAL |
| Transfer characteristics | BT.601 | BT.601 | BT.601 | BT.709 |
| Matrix coefficients | BT.470 System B/G | BT.470 System B/G | BT.470 System B/G | BT.601 |
| matrix_coefficients_Original | BT.601 | BT.601 | BT.601 | |
| mdhd_Duration | 8619 | 8619 | 8619 | |
| Codec configuration box | avcC | avcC | avcC | |
| Audio | | | | |
| ID | 256 | 256 | 256 | 2 |
| Format | AAC LC | AAC LC | AAC LC | AAC LC |

| 003 | Extracted from Android | Dropbox | Gmail | Extracted from iPhone |
|-------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Format/Info | Advanced Audio Codec Low Complexity |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 |
| Duration | 8 s 683 ms | 8 s 683 ms | 8 s 683 ms | 8 s 661 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 132 kb/s | 132 kb/s | 132 kb/s | 32.0 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | C |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 44.1 kHz |
| Frame rate | 43.066 FPS (1024 SPF) |
| Compression mode | Lossy | Lossy | Lossy | Lossy |
| Stream size | 139 KiB (2%) | 139 KiB (2%) | 139 KiB (2%) | 34.1 KiB (11%) |
| Title | Snap Audio | Snap Audio | Snap Audio | SoundHandle |
| Language | English | English | English | English |
| Encoded date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |
| Tagged date | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:20:24 | UTC 2021-02-22 02:22:25 |

APPENDIX H

The following tables display the MediaInfo metadata for 011, 012, and 013, the original iPhone Snapchat video files and their corresponding transferred files. The categories of interest are highlighted.

MediaInfo Metadata of iPhone Snapchat Video 011

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-------------------------|--|-------------------------|-------------------------|----------------------------|
| <i>General</i> | | | | |
| Name | EA334448-85EE-4BB8-82E0-962BBE848EC3.MP4 | IMG_3575.MP4 | IMG_16065091.MOV | EA334448-1.3gp |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | QuickTime | 3GPP Media Release 6 Basic |
| Codec ID | mp42 (isom/mp41/mp42) | mp42 (isom/mp41/mp42) | qt 0000.00 (qt) | 3gp6 (3gp6/isom) |
| File size | 15.8 MiB | 15.8 MiB | 1.61 MiB | 321 KiB |
| Duration | 17 s 387 ms | 17 s 387 ms | 17 s 387 ms | 17 s 387 ms |
| Overall bit rate | 7 600 kb/s | 7 600 kb/s | 777 kb/s | 151 kb/s |
| Encoded date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:00 | UTC 2021-02-22 01:58:08 |

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Tagged date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:01 | UTC 2021-02-22 01:58:09 |
| Writing library | | | Apple QuickTime | |
| Video | | | | |
| ID | 2 | 2 | 2 | 2 |
| Format | AVC | AVC | AVC | AVC |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec |
| Format profile | Main@L3.1 | Main@L3.1 | Main@L2.1 | Baseline@L1.2 |
| Format settings | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | 1 Ref Frames |
| Format settings, CABAC | Yes | Yes | Yes | No |
| Format settings, Reference frames | 2 frames | 2 frames | 2 frames | 1 frame |
| Format settings, GOP | | | | M=1, N=15 |
| Codec ID | avc1 | avc1 | avc1 | avc1 |
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding |
| Duration | 17 s 387 ms |
| Source duration | 17 s 453 ms | 17 s 453 ms | | 17 s 400 ms |
| Bit rate | 7 500 kb/s | 7 500 kb/s | 707 kb/s | 137 kb/s |
| Width | 656 pixels | 656 pixels | 256 pixels | 320 pixels |
| Height | 1 232 pixels | 1 232 pixels | 480 pixels | 240 pixels |
| Display aspect ratio | 0.532 | 0.532 | 0.533 | 4:03 |
| Frame rate mode | Variable | Variable | Variable | Constant |
| Frame rate | 30.000 FPS | 30.000 FPS | 30.000 FPS | 15.000 FPS |
| Minimum frame rate | 30.000 FPS | 30.000 FPS | 30.000 FPS | |
| Maximum frame rate | 35.294 FPS | 35.294 FPS | 35.294 FPS | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 4:02:00 | 4:02:00 | 4:02:00 | 4:02:00 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | Progressive |
| Bits/(Pixel*Frame) | 0.309 | 0.309 | 0.192 | 0.119 |
| Stream size | 15.6 MiB (99%) | 15.6 MiB (99%) | 1.47 MiB (91%) | 291 KiB (90%) |
| Source stream size | 15.6 MiB (99%) | 15.6 MiB (99%) | | 291 KiB (90%) |
| Title | Core Media Video | Core Media Video | Core Media Video | Core Media Video |
| Encoded date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:00 | UTC 2021-02-22 01:58:08 |
| Tagged date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:01 | UTC 2021-02-22 01:58:09 |
| Color range | Full | Full | Full | Full |
| Color primaries | | | BT.709 | BT.709 |
| Transfer characteristics | | | BT.709 | BT.709 |
| Matrix coefficients | | | BT.709 | BT.709 |
| Codec configuration box | avcC | avcC | avcC | avcC |

| 011 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|---------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------|
| <i>Audio</i> | | | | |
| ID | 1 | 1 | 1 | 1 |
| Format | AAC LC | AAC LC | AAC LC | AMR |
| Format/Info | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Adaptive Multi-Rate |
| Format profile | | | | Narrow band |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | samr |
| Duration | 17 s 373 ms | 17 s 373 ms | 17 s 373 ms | 17 s 372 ms |
| Source duration | 17 s 392 ms | 17 s 392 ms | 17 s 392 ms | 17 s 400 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 64.0 kb/s | 64.0 kb/s | 64.0 kb/s | 12.8 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 8 000 Hz |
| Frame rate | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | |
| Bit depth | | | | 13 bits |
| Compression mode | Lossy | Lossy | Lossy | |
| Stream size | 134 KiB (1%) | 134 KiB (1%) | 134 KiB (8%) | 27.2 KiB (8%) |
| Source stream size | 135 KiB (1%) | 135 KiB (1%) | 135 KiB (8%) | 27.2 KiB (8%) |
| Title | Core Media Audio | Core Media Audio | Core Media Audio | Core Media Audio |
| Writing library | | | | Apple Revision 1 |
| Encoded date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:00 | UTC 2021-02-22 01:58:08 |
| Tagged date | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 01:42:53 | UTC 2021-02-22 03:32:01 | UTC 2021-02-22 01:58:09 |

MediaInfo Metadata of iPhone Snapchat Video 012

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-------------------------|--|-------------------------|-------------------------|----------------------------|
| <i>General</i> | | | | |
| Name | 98F95CC8-62E2-489C-8E9A-1FBBBF830AA9.MP4 | IMG_3567.MP4 | IMG_27744659.MOV | 98F95CC8-1.3gp |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | QuickTime | 3GPP Media Release 6 Basic |
| Codec ID | mp42 (isom/mp41/mp42) | mp42 (isom/mp41/mp42) | qt 0000.00 (qt) | 3gp6 (3gp6/isom) |
| File size | 12.4 MiB | 12.4 MiB | 1.26 MiB | 249 KiB |
| Duration | 14 s 627 ms | 14 s 627 ms | 14 s 627 ms | 14 s 627 ms |
| Overall bit rate | 7 111 kb/s | 7 111 kb/s | 722 kb/s | 139 kb/s |
| Encoded date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:50 |

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Tagged date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:51 |
| Writing library | | | Apple QuickTime | |
| <i>Video</i> | | | | |
| ID | 2 | 2 | 2 | 2 |
| Format | AVC | AVC | AVC | AVC |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec |
| Format profile | Main@L3.1 | Main@L3.1 | Main@L2.1 | Baseline@L1.2 |
| Format settings | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | 1 Ref Frames |
| Format settings, CABAC | Yes | Yes | Yes | No |
| Format settings, Reference frames | 2 frames | 2 frames | 2 frames | 1 frame |
| Format settings, GOP | | | | M=1, N=15 |
| Codec ID | avc1 | avc1 | avc1 | avc1 |
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding |
| Duration | 14 s 627 ms |
| Source duration | 14 s 693 ms | 14 s 693 ms | | 14 s 667 ms |
| Bit rate | 7 016 kb/s | 7 016 kb/s | 654 kb/s | 125 kb/s |
| Width | 656 pixels | 656 pixels | 256 pixels | 320 pixels |
| Height | 1 232 pixels | 1 232 pixels | 480 pixels | 240 pixels |
| Display aspect ratio | 0.532 | 0.532 | 0.533 | 4:03 |
| Frame rate mode | Variable | Variable | Variable | Constant |
| Frame rate | 30.000 FPS | 30.000 FPS | 30.000 FPS | 15.000 FPS |
| Minimum frame rate | 30.000 FPS | 30.000 FPS | 30.000 FPS | |
| Maximum frame rate | 33.333 FPS | 33.333 FPS | 33.333 FPS | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 4:02:00 | 4:02:00 | 4:02:00 | 4:02:00 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | Progressive |
| Bits/(Pixel*Frame) | 0.289 | 0.289 | 0.177 | 0.108 |
| Stream size | 12.2 MiB (99%) | 12.2 MiB (99%) | 1.14 MiB (91%) | 222 KiB (89%) |
| Source stream size | 12.3 MiB (99%) | 12.3 MiB (99%) | | 223 KiB (90%) |
| Title | Core Media Video | Core Media Video | Core Media Video | Core Media Video |
| Encoded date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:50 |
| Tagged date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:51 |
| Color range | Full | Full | Full | Full |
| Color primaries | | | BT.709 | BT.709 |
| Transfer characteristics | | | BT.709 | BT.709 |
| Matrix coefficients | | | BT.709 | BT.709 |
| Codec configuration box | avcC | avcC | avcC | avcC |

| 012 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|---------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------|
| <i>Audio</i> | | | | |
| ID | 1 | 1 | 1 | 1 |
| Format | AAC LC | AAC LC | AAC LC | AMR |
| Format/Info | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Adaptive Multi-Rate |
| Format profile | | | | Narrow band |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | samr |
| Duration | 14 s 575 ms | 14 s 575 ms | 14 s 575 ms | 14 s 573 ms |
| Source duration | 14 s 629 ms | 14 s 629 ms | 14 s 629 ms | 14 s 600 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 64.0 kb/s | 64.0 kb/s | 64.0 kb/s | 12.8 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 8 000 Hz |
| Frame rate | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | |
| Bit depth | | | | 13 bits |
| Compression mode | Lossy | Lossy | Lossy | |
| Stream size | 111 KiB (1%) | 111 KiB (1%) | 111 KiB (9%) | 22.8 KiB (9%) |
| Source stream size | 112 KiB (1%) | 112 KiB (1%) | 112 KiB (9%) | 22.8 KiB (9%) |
| Title | Core Media Audio | Core Media Audio | Core Media Audio | Core Media Audio |
| Writing library | | | | Apple Revision 1 |
| Encoded date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:50 |
| Tagged date | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 01:34:19 | UTC 2021-02-22 03:29:41 | UTC 2021-02-22 01:57:51 |

MediaInfo Metadata of iPhone Snapchat Video 013

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-------------------------|--|-------------------------|-------------------------|----------------------------|
| <i>General</i> | | | | |
| Name | 7AB4BBB0-9EF7-48C0-BC0C-DF6DB30AEDB2.MP4 | IMG_3573.MP4 | IMG_257523635.MOV | 7AB4BBB0-1.3gp |
| Format | MPEG-4 | MPEG-4 | MPEG-4 | MPEG-4 |
| Format profile | Base Media / Version 2 | Base Media / Version 2 | QuickTime | 3GPP Media Release 6 Basic |
| Codec ID | mp42 (isom/mp41/mp42) | mp42 (isom/mp41/mp42) | qt 0000.00 (qt) | 3gp6 (3gp6/isom) |
| File size | 10.3 MiB | 10.3 MiB | 1.05 MiB | 208 KiB |
| Duration | 11 s 463 ms | 11 s 463 ms | 11 s 463 ms | 11 s 463 ms |
| Overall bit rate | 7 566 kb/s | 7 566 kb/s | 766 kb/s | 149 kb/s |
| Encoded date | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |

| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
|-----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Tagged date | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |
| Writing library | | | Apple QuickTime | |
| Video | | | | |
| ID | 2 | 2 | 2 | 2 |
| Format | AVC | AVC | AVC | AVC |
| Format/Info | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec | Advanced Video Codec |
| Format profile | Main@L3.1 | Main@L3.1 | Main@L2.1 | Baseline@L1.2 |
| Format settings | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | CABAC / 2 Ref Frames | 1 Ref Frames |
| Format settings, CABAC | Yes | Yes | Yes | No |
| Format settings, Reference frames | 2 frames | 2 frames | 2 frames | 1 frame |
| Format settings, GOP | | | | M=1, N=15 |
| Codec ID | avc1 | avc1 | avc1 | avc1 |
| Codec ID/Info | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding | Advanced Video Coding |
| Duration | 11 s 463 ms |
| Source duration | 11 s 530 ms | 11 s 530 ms | | 11 s 467 ms |
| Bit rate | 7 444 kb/s | 7 444 kb/s | 697 kb/s | 134 kb/s |
| Width | 656 pixels | 656 pixels | 256 pixels | 320 pixels |
| Height | 1 232 pixels | 1 232 pixels | 480 pixels | 240 pixels |
| Display aspect ratio | 0.532 | 0.532 | 0.533 | 4:03 |
| Frame rate mode | Variable | Variable | Variable | Constant |
| Frame rate | 30.000 FPS | 30.000 FPS | 30.000 FPS | 15.000 FPS |
| Minimum frame rate | 28.571 FPS | 28.571 FPS | 28.571 FPS | |
| Maximum frame rate | 31.579 FPS | 31.579 FPS | 31.579 FPS | |
| Color space | YUV | YUV | YUV | YUV |
| Chroma subsampling | 4:02:00 | 4:02:00 | 4:02:00 | 4:02:00 |
| Bit depth | 8 bits | 8 bits | 8 bits | 8 bits |
| Scan type | Progressive | Progressive | Progressive | Progressive |
| Bits/(Pixel*Frame) | 0.307 | 0.307 | 0.189 | 0.116 |
| Stream size | 10.2 MiB (98%) | 10.2 MiB (98%) | 976 KiB (91%) | 188 KiB (90%) |
| Source stream size | 10.2 MiB (99%) | 10.2 MiB (99%) | | 188 KiB (90%) |
| Title | Core Media Video | Core Media Video | Core Media Video | Core Media Video |
| Encoded date | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |
| Tagged date | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |
| Color range | Full | Full | Full | Full |
| Color primaries | | | BT.709 | BT.709 |
| Transfer characteristics | | | BT.709 | BT.709 |
| Matrix coefficients | | | BT.709 | BT.709 |
| Codec configuration box | avcC | avcC | avcC | avcC |

| | | | | |
|---------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------|
| 013 | Extracted from iPhone | Dropbox | Gmail | Extracted from Android |
| <i>Audio</i> | | | | |
| ID | 1 | 1 | 1 | 1 |
| Format | AAC LC | AAC LC | AAC LC | AMR |
| Format/Info | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Advanced Audio Codec Low Complexity | Adaptive Multi-Rate |
| Format profile | | | | Narrow band |
| Codec ID | mp4a-40-2 | mp4a-40-2 | mp4a-40-2 | samr |
| Duration | 11 s 460 ms | 11 s 460 ms | 11 s 460 ms | 11 s 458 ms |
| Source duration | 11 s 517 ms | 11 s 517 ms | 11 s 517 ms | 11 s 500 ms |
| Bit rate mode | Constant | Constant | Constant | Constant |
| Bit rate | 64.0 kb/s | 64.0 kb/s | 64.0 kb/s | 12.8 kb/s |
| Channel(s) | 1 channel | 1 channel | 1 channel | 1 channel |
| Channel layout | C | C | C | |
| Sampling rate | 44.1 kHz | 44.1 kHz | 44.1 kHz | 8 000 Hz |
| Frame rate | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | 43.066 FPS (1024 SPF) | |
| Bit depth | | | | 13 bits |
| Compression mode | Lossy | Lossy | Lossy | |
| Stream size | 87.4 KiB (1%) | 87.4 KiB (1%) | 87.4 KiB (8%) | 18.0 KiB (9%) |
| Source stream size | 87.5 KiB (1%) | 87.5 KiB (1%) | 87.5 KiB (8%) | 18.0 KiB (9%) |
| Title | Core Media Audio | Core Media Audio | Core Media Audio | Core Media Audio |
| Writing library | | | | Apple Revision 1 |
| Encoded date | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 01:41:23 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |
| Tagged date | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 01:41:24 | UTC 2021-02-22 03:31:31 | UTC 2021-02-22 01:58:05 |

APPENDIX I

The following tables represent the audio samples calculated in each tool for the Android snap video files 002, 003, and 004 extracted from the Android and the video files sent via MMS message and extracted from the iPhone.

Audio Samples of Android Snapchat Video 002

| <i>002 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from Android | 648192 | 649216 | 649216 | 649216 |
| Extracted from iPhone | 647168 | 648192 | 648192 | 648192 |

Audio Samples of Android Snapchat Video 003

| <i>003 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from Android | 381952 | 382976 | 382976 | 382976 |
| Extracted from iPhone | 380928 | 381952 | 381952 | 381952 |

APPENDIX J

Audio Samples of iPhone Snapchat Video 012

| <i>012 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from iPhone | 641024 | 645120 | 645120 | 641920 |
| Gmail | 641024 | 645120 | 645120 | 641920 |
| Extracted from Android | 116640 | 116800 | 116800 | 116600 |

Audio Samples of iPhone Snapchat Video 013

| <i>013 Audio Samples</i> | iZotope RX 8 | mp4dump | mp4info | FAAS |
|-------------------------------|---------------------|----------------|----------------|-------------|
| Extracted from iPhone | 503808 | 507904 | 507904 | 504704 |
| Gmail | 503808 | 507904 | 507904 | 504704 |
| Extracted from Android | 91840 | 92000 | 92000 | 91800 |