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

by

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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

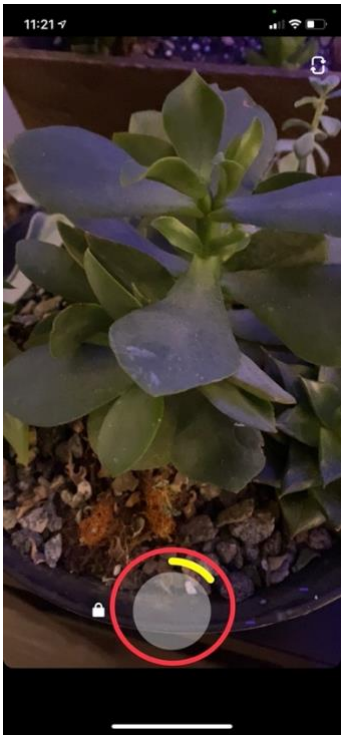
The Android was forensically acquired using Cellebrite UFED 4PC. A licensed version of the software was run on the analysis laptop and the Android was connected via the original

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 messagess to the Android. The audio format changed from mp4a to amr with the video files extracted from the Android. AMR (Adaptive Mult-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

001 Audio Samples	**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

011 Audio Samples	**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	22058d789088b578d9f47caa53c36c6339ffbbccfd5b8cbfeac150597428fe1e	22058d789088b578d9f47caa53c36c6339ffbbccfd5b8cbfeac150597428fe1e	22058d789088b578d9f47caa53c36c6339ffbbccfd5b8cbfeac150597428fe1e	720d9b0e2411ff0fda40d07187b2d7f96b72cd1c35671e2ccaece73ab54ba004

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	a3f59e6e8c3e5e62965516e872bcaf28	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

004 Audio Samples	**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

014 Audio Samples	**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-1FBBBF830AA9.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	7AB4BBB0-9EF7-48C0-BC0C-DF6DB30AEDB2.MP4	IMG_3573.MP4	IMG_257523635.MOV	7AB4BBB0-1.3gp
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]	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	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]	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	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-1FBBBF830AA9.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
General				
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
Video				
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	
Audio				
ID	256	256	256	2
Format	AAC LC	AAC LC	AAC LC	AAC LC
Format/Info	Advanced Audio Codec Low Complexity	Advanced Audio Codec Low Complexity	Advanced Audio Codec Low Complexity	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)	43.066 FPS (1024 SPF)	43.066 FPS (1024 SPF)	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
General				
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
Video				
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	
Audio				
ID	256	256	256	2
Format	AAC LC	AAC LC	AAC LC	AAC LC
Format/Info	Advanced Audio Codec Low Complexity	Advanced Audio Codec Low Complexity	Advanced Audio Codec Low Complexity	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)	43.066 FPS (1024 SPF)	43.066 FPS (1024 SPF)	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
General				
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
Video				
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	Advanced Audio Codec Low Complexity	Advanced Audio Codec Low Complexity	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)	43.066 FPS (1024 SPF)	43.066 FPS (1024 SPF)	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
General				
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	17 s 387 ms	17 s 387 ms	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
Audio				
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
General				
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	
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	14 s 627 ms	14 s 627 ms	14 s 627 ms	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
Audio				
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
General				
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	11 s 463 ms	11 s 463 ms	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
Audio				
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

002 Audio Samples	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

003 Audio Samples	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

012 Audio Samples	**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

013 Audio Samples	**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