FILE STRUCTURE ANALYSIS OF VIDEOS TRANSFERRED THROUGH THE TELEGRAM APP USING MOBILE PHONES

by

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File Structure Analysis of Videos Transferred Through the Telegram App Using Mobile Phones

Thesis directed by Associate Professor Catalin Grigoras

ABSTRACT

This thesis examines the changes made to videos through the Telegram transfer process using mobile phones. Telegram is a secure messaging application that is currently in the top five most-downloaded applications worldwide. By transferring videos from mobile phones through Telegram to other mobile phones, any changes made to those videos can be analyzed by comparing the original video to the received counterpart. This thesis analyzes videos transferred through Telegram and the original videos through hash value, stream hash value, metadata, and hex analysis. After analyzing the Telegram-transferred videos and comparing them to the original videos, the analysis concluded the hash values and stream hash values of the received videos did not match the original videos concluding Telegram transfers do not keep the integrity of transferred videos intact. The analysis of the metadata and hex data proved further the Telegram transfer process affected the videos, because the metadata and the hex data were changed with every transfer.

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

Approved: Catalin Grigoras

DEDICATION

This thesis is dedicated to my amazing family and friends who supported me through it all.

To my husband, Travis, who supported me through every phase I went through during my degree, whose encouragement lifted me, and who took daily household tasks off my plate.

To my family, who endlessly loved me and believed in me throughout my degree, but, most importantly, throughout my life.

To my friends who listened, brought me food, and brought so much joy into my life. To Ileana, Jared, Jonathan, Livi, Madison, Marcus, Meeshelle, and Rachel for being willing to provide their phones for this study.

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ABBREVIATIONS

AAC LC – Advanced Video Coding Low Complexity

API – Application Programming Interface

AVC – Advanced Video Coding

CABAC – Context-based Adaptive Binary Arithmetic Coding

FPS – Frames Per Second

GOP – Group of Pictures

HEVC – High Efficiency Video Coding

MPEG – Moving Picture Experts Group

QT – QuickTime

SHA-256 – Secure Hash Algorithm 256-bit

I. INTRODUCTION

In this day, messaging applications are used to communicate with anyone who has access to the application, wherever they can access the application. This freedom to communicate almost instantaneously with anyone else using the same app is relatively new. Applications such as Telegram offer fast and secure messaging. Telegram is known for its security features, and this has led to the application being used for not just staying in touch with friends or family, but terrorist group recruiting and lone wolf attacks [1], as well as distribution of underground economy apps that provide services such as gambling and pornography [2].

There was no research found that studied the effects of the Telegram app on videos transferred through the app, which is what this thesis studies. This thesis examines the hash, stream hash, metadata, and hexadecimal changes made specifically to videos sent through Telegram. The results of this study help to find consistencies between video evidence for cases and videos transferred via the Telegram app. This study is useful in understanding which messaging application videos were distributed with, authenticating video evidence transferred through the Telegram app, ensuring the evidence's integrity is intact, and proving the evidence is what it purports to be. The hash, stream hashes, metadata, and hexadecimal information for original videos and their counterparts transferred through Telegram will be compared to analyze the changes made to the videos throughout the transfer process. Different mobile phones were used for this study: one Samsung Galaxy 23 Ultra, an iPhone 15, an iPhone 14, an iPhone 16e, and a Google Pixel 10 to determine if using different mobile phones affects the transferred videos.

Telegram

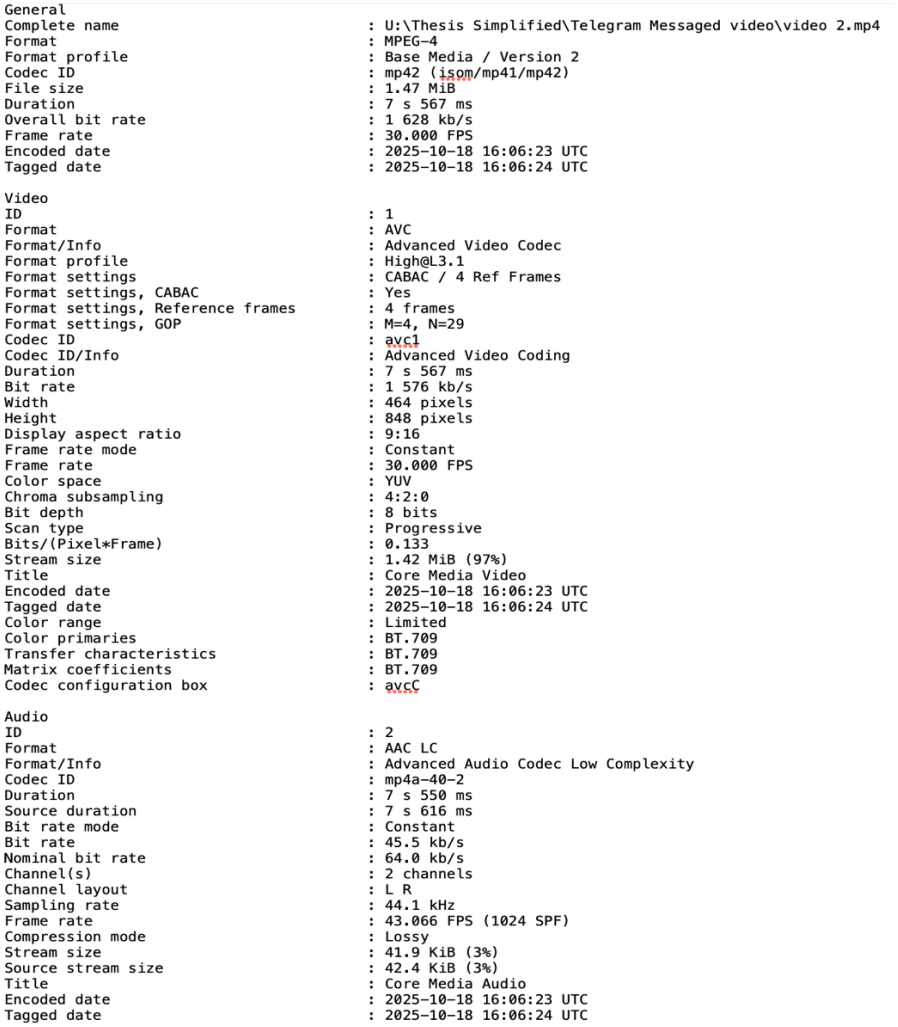
Telegram is a free-to-use cloud-based messaging app that first launched in 2013. It advertises on speed and security, currently has over a billion active users, and is in the top five most-downloaded apps today [3]. Telegram users can send any type of file with the unlimited messaging the app offers, provided the files are 2 GB or less. Users can create messaging groups of up to 200,000 users and create channels for broadcasting to an unlimited number of people [3].

This messaging app boasts its security features. The app includes end-to-end encryption on voice calls, video calls, voice chats, and text messages that may contain video files. Secret chats are supported which self-destruct messages and media files. A passcode can be placed on the app by a user, and users can delete messaging on both the sending and receiving side of the message. If a user deletes their account, Telegram will remove all data from that account in their system. Their goal is to protect private messages and personal data.

There are many features within the Telegram app. Messages synchronize across different devices, allowing users to view messages on all their devices: mobile phones, tablets, and computers. There is a built-in photo editor. By utilizing cloud-based storage and caching, the app does not take up much space on the user's device. The cache can be manually cleared by the user. The API and code are open which allows people to connect third-party functionalities to add tools and collect payments through Telegram.

Telegram makes money by sponsored messages that are sent in the public channels and users can purchase a premium subscription which allows users access to additional features such as doubled file limits (up to 4 GB) and faster download speed for large files [4].

As a first-time Telegram user, the user creates an account by selecting their country, entering their phone number, and entering their first and last name. The app will then send a code to the phone number to verify it. This code must be input on the app before the user starts messaging. The user can create videos within a chat, but these videos cannot be saved directly to their mobile phone before sending the video. After sending the video, the user can save the video to their camera roll or elsewhere on their device. These videos can be edited, before being sent, with Telegram's built-in editing tools that include trimming, cropping, drawing, quality adjustments, brightness, contrast, saturation, and color adjustments. During testing for this thesis, five videos were taken using this method, and downloaded onto the Files app of the iPhone 15 used for video capture. The metadata and structure data were the same throughout all five videos and the results of one of the video's format data is shown in the figure below.



```
General
Complete name                            : U:\Thesis Simplified\Telegram Messaged video\video 2.mp4
Format                                   : MPEG-4
Format profile                           : Base Media / Version 2
Codec ID                                 : mp42 (isom/mp41/mp42)
File size                                : 1.47 MiB
Duration                                 : 7 s 567 ms
Overall bit rate                         : 1 628 kb/s
Frame rate                               : 30.000 FPS
Encoded date                             : 2025-10-18 16:06:23 UTC
Tagged date                              : 2025-10-18 16:06:24 UTC

Video
ID                                       : 1
Format                                   : AVC
Format/Info                              : Advanced Video Codec
Format profile                           : High@L3.1
Format settings                          : CABAC / 4 Ref Frames
Format settings, CABAC                   : Yes
Format settings, Reference frames        : 4 frames
Format settings, GOP                     : M=4, N=29
Codec ID                                 : avc1
Codec ID/Info                            : Advanced Video Coding
Duration                                 : 7 s 567 ms
Bit rate                                 : 1 576 kb/s
Width                                    : 464 pixels
Height                                   : 848 pixels
Display aspect ratio                     : 9:16
Frame rate mode                          : Constant
Frame rate                               : 30.000 FPS
Color space                              : YUV
Chroma subsampling                       : 4:2:0
Bit depth                                : 8 bits
Scan type                                : Progressive
Bits/(Pixel*Frame)                       : 0.133
Stream size                              : 1.42 MiB (97%)
Title                                    : Core Media Video
Encoded date                             : 2025-10-18 16:06:23 UTC
Tagged date                              : 2025-10-18 16:06:24 UTC
Color range                              : Limited
Color primaries                          : BT.709
Transfer characteristics                 : BT.709
Matrix coefficients                      : BT.709
Codec configuration box                  : avcC

Audio
ID                                       : 2
Format                                   : AAC LC
Format/Info                              : Advanced Audio Codec Low Complexity
Codec ID                                 : mp4a-40-2
Duration                                 : 7 s 550 ms
Source duration                          : 7 s 616 ms
Bit rate mode                            : Constant
Bit rate                                 : 45.5 kb/s
Nominal bit rate                         : 64.0 kb/s
Channel(s)                               : 2 channels
Channel layout                           : L R
Sampling rate                            : 44.1 kHz
Frame rate                               : 43.066 FPS (1024 SPF)
Compression mode                         : Lossy
Stream size                              : 41.9 KiB (3%)
Source stream size                       : 42.4 KiB (3%)
Title                                    : Core Media Audio
Encoded date                             : 2025-10-18 16:06:23 UTC
Tagged date                              : 2025-10-18 16:06:24 UTC
```

Figure 1. Telegram Video Format Data

As shown in the format data figure, Telegram videos created within the messaging portion of the application are in an MPEG-4 format, recorded at 30 FPS, the video format is AVC, the aspect ratio is 9:16, the chroma subsampling is 4:2:0, the video is 8 bits, the audio is stereo with two channels, the audio sampling rate is 44.1kHz, and the audio format is AAC LC. The format metadata was consistent throughout all five test video files, the differences being the times/dates, the sizes, and the duration which are typical differences for nonidentical videos. The Telegram video structure information was consistent across all five of the test videos except for

the size and specific video information that is expected to change with every video that is nonidentical: duration, sizes, etc. This information is shown in the figure below.

Figure 2. Telegram Video Structure

Previous Research

There has been previous research relating to transferred media files over apps such as WhatsApp [5], Discord [6], and Signal [7], but none found with a focus on videos transferred via Telegram. Those papers explain what changes are made to certain media files through the transfer process using an application, and this thesis will explain hash, stream hash, metadata, and hexadecimal data changes made to videos that occurs during the Telegram transfer process.

II. TECHNICAL OVERVIEW

Hash

Hash values are numerical values that are calculated using hashing functions, which are mathematical calculations that generate a numerical value based on the input data [8]. These values can be used to help verify the integrity of files because it is normally unique for each file no matter how miniscule the difference when compared to another file. The only times that hash values of two different files have been the same is in a lab, and this is referred to as a collision.

Stream Hash

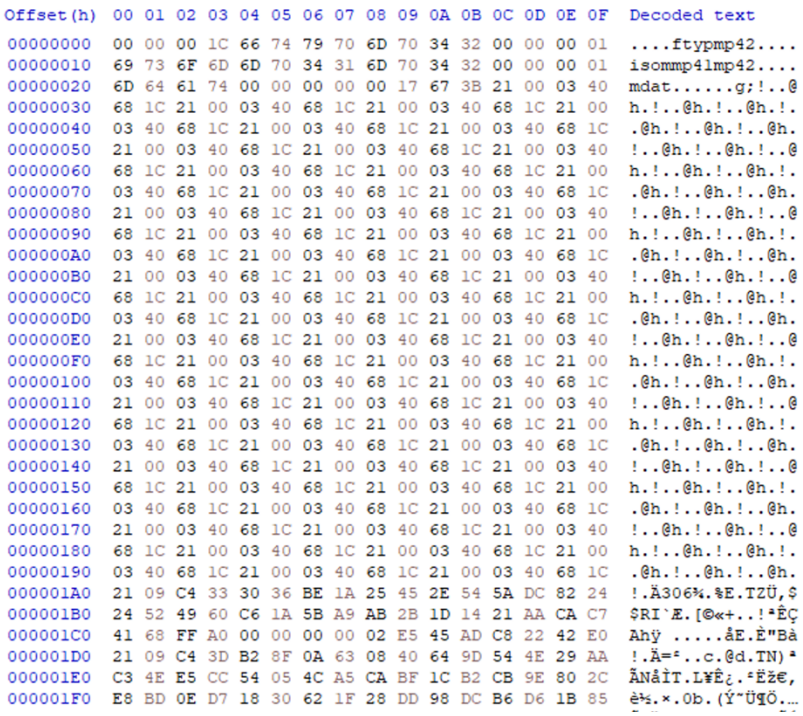
Stream hashes are numerical values like hashes, but the calculation for the stream hash is for each stream of data. With the focus of this thesis on videos, the stream hash of the audio stream and the video stream were calculated for both the original and transferred files.

Metadata

Metadata is data that can be embedded in a file that describes a file or directory. This data can include dates and times of creation or modification, permissions, and locations where data is stored [8].

Hex Data

Hexadecimal is a number system that uses 16 symbols: 0-9 and then instead of 10 after 9, it begins with A and goes through F. This system is used to show binary data for a file and can be used to analyze the structure of a video. An example of hex data is shown in the figure below.



Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	Decoded text
00000000	00	00	00	1C	66	74	79	70	6D	70	34	32	00	00	00	01	....ftypmp42....
00000010	69	73	6F	6D	6D	70	34	31	6D	70	34	32	00	00	00	01	isommp41mp42....
00000020	6D	64	61	74	00	00	00	00	00	17	67	3B	21	00	03	40	mdat......g;!..@
00000030	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000040	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
00000050	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
00000060	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000070	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
00000080	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
00000090	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
000000A0	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
000000B0	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
000000C0	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
000000D0	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
000000E0	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
000000F0	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000100	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
00000110	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
00000120	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000130	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
00000140	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
00000150	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000160	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
00000170	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	!..@h.!..@h.!..@
00000180	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	21	00	h.!..@h.!..@h.!.
00000190	03	40	68	1C	21	00	03	40	68	1C	21	00	03	40	68	1C	.@h.!..@h.!..@h.
000001A0	21	09	C4	33	30	36	BE	1A	25	45	2E	54	5A	DC	82	24	!.Ä306¾.%E.TZÜ,$
000001B0	24	52	49	60	C6	1A	5B	A9	AB	2B	1D	14	21	AA	CA	C7	$RI`Æ.[©«+..!ªÊÇ
000001C0	41	68	FF	A0	00	00	00	00	02	E5	45	AD	C8	22	42	E0	Ahÿ .....åE.È"Bà
000001D0	21	09	C4	3D	B2	8F	0A	63	08	40	64	9D	54	4E	29	AA	!.Ä=²..c.@d.TN)ª
000001E0	C3	4E	E5	CC	54	05	4C	A5	CA	BF	1C	B2	CB	9E	80	2C	ÃNåÌT.L¥Ê¿.²Ëž€,
000001F0	E8	BD	0E	D7	18	30	62	1F	28	DD	98	DC	B6	D6	1B	85	è½.×.0b.(Ý˜Ü¶Ö.…

Figure 3. Hex Data Example

III. MATERIALS

Device Information

The videos analyzed during this study were collected and transferred using five mobile phones. These mobile phones created the videos using their native cameras, uploaded these videos to Telegram and sent them to the receiving mobile phones via Telegram. Within the receiving mobile phone, the video was downloaded to the phone then uploaded to Dropbox. Dropbox is a cloud-based storage service that was used in this study to collect all original and transferred video files from the mobile phones. The videos from the sending phone and the receiving phone were both downloaded from Dropbox onto the computer used for analysis. The computer used for analysis then downloaded the original and received videos from Dropbox. The information for the mobile phones and the computer used for testing are shown in the table below.

Table 1. Device Specifications

Device	Operating System
iPhone 14 Pro	iOS 18.6.2
iPhone 15	iOS 18.6.2
iPhone 16e	iOS 18.6.2
Samsung Galaxy 23 Ultra	Android v 16
Google Pixel 10	Android v 16
MacBook Pro	Sonoma 14.5

Software Information

Software was utilized in this study to transfer and analyze the videos. The software names and versions used are shown in the table below.

Table 2. Software Specifications

Software	Version
Telegram	12.1.1
Hasher	2.0.0.0
ffmpeg	2025-03-24-git-cbbc927a67-full_build-www.gyan.dev Copyright (c) 2000-2025 the FFmpeg developers
Powershell	5.1.19041.6456
MediaInfo	25.04
MP4 File Dumper	1.2
MediaConch	25.04
HxD	2.4.0.0
Dropbox	446.2

Test Video Creation

A total of ten videos with a length of approximately five-seconds were created, with the exception, of seven created with the iPhone 16e, using each mobile phone' native camera app. These original videos were automatically saved into the photo gallery of the mobile phones and then uploaded to Dropbox. These videos were then transferred through Telegram to the other phones. The original videos were compared against the received videos to analyze any changes made throughout the Telegram transfer process.

IV. METHODOLOGY

Methods for Video Transfers

After the test videos were created with the mobile phones, the original videos were uploaded to Dropbox from each phone. The original videos located in the photo gallery of the mobile phones were then sent through the Telegram app to other mobile phones. Not all mobile phones sent videos to all of the other phones, the table below shows the details of the video transfers.

Table 3. Device Information

Device	Devices Videos Were Sent To	How Many Analyzed Videos Were Sent to Each Phone
iPhone 14 Pro	iPhone 15 iPhone 16e Samsung Galaxy 23 Ultra Google Pixel 10	10
iPhone 15	iPhone 14 Pro Google Pixel 10 Samsung Galaxy 23 Ultra	10
iPhone 16e	iPhone 14 Pro Samsung Galaxy 23 Ultra Google Pixel 10	7
Samsung Galaxy 23 Ultra	iPhone 14 Pro iPhone 15 iPhone 16e Google Pixel 10	10
Google Pixel 10	iPhone 14 Pro iPhone 15 iPhone 16e Samsung Galaxy 23 Ultra	10

Each Android phone downloaded the received videos to the photo gallery app and then uploaded them to Dropbox. Each iPhone downloaded the received videos to the Files app and

then uploaded them to Dropbox. The videos were then downloaded from Dropbox to the computer for analysis.

Methods for Analysis

To analyze the changes made to video files by the Telegram transfer process, an analysis of the hash, stream hashes, metadata, and hexadecimal data were employed. The hash and stream hash values were calculated for the original videos and the received videos, then compared. The comparison showed if changes were made to the video file, as well as the individual video and audio streams. These hash calculations were calculated using Hasher.

The metadata information for each video was collected with MediaInfo. The data was studied to find changes made to the videos embedded information. The figure below shows an example of MediaInfo and some metadata information from a studied video file.

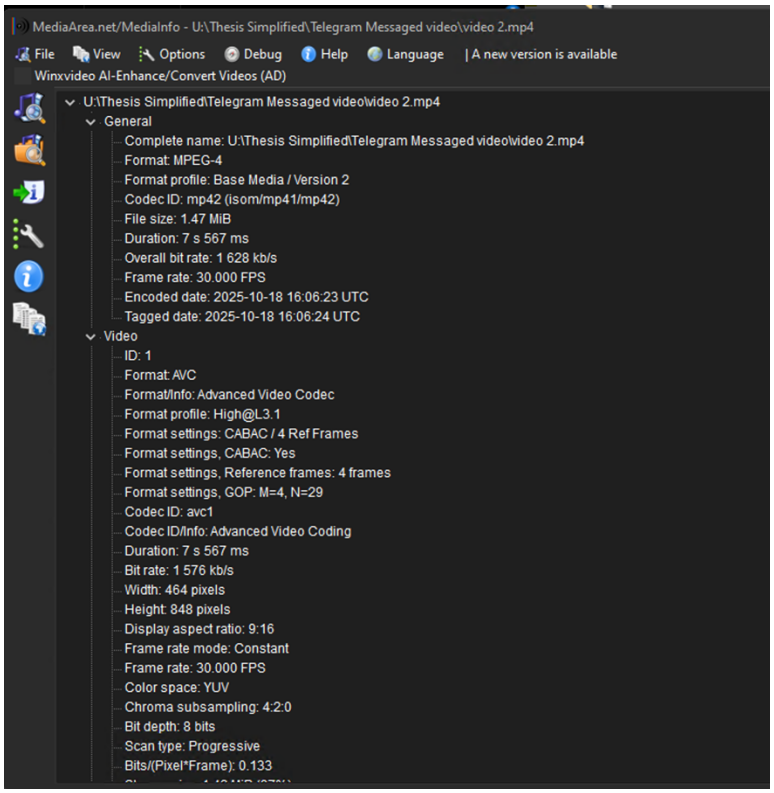


Figure 4. MediaInfo Metadata Example

The structures of the video files were analyzed using MP4 Dumper and MediaConch. MP4 Dumper was used with Powershell. Examples of the MediaConch and MP4 Dumper structure format are shown in the figures below. MediaTrace is a report within MediaConch that shows the structure of a file, as reflected in the second figure below.

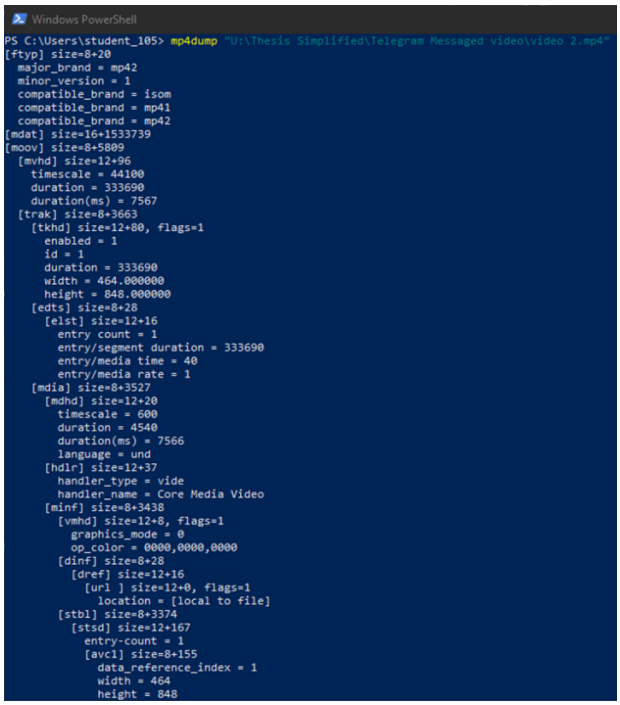


Figure 5. MP4 Dumper

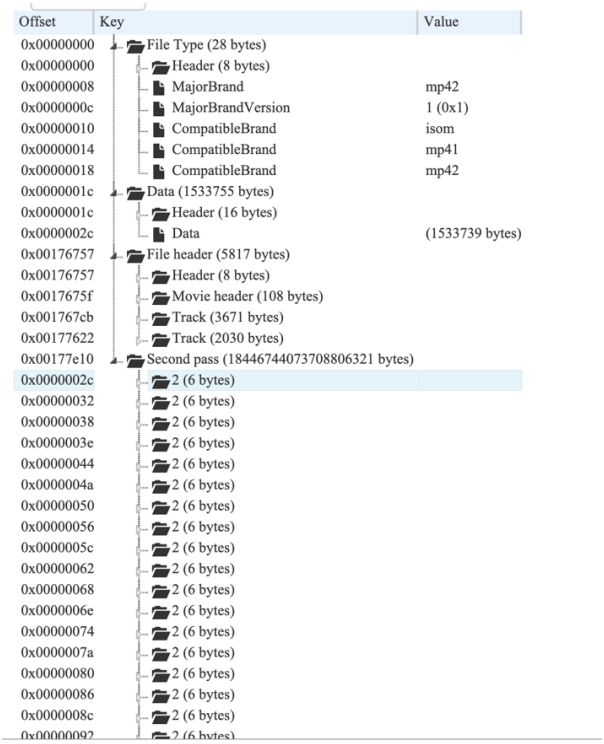


Figure 6. MediaConch MediaTrace Report

Changes made by the Telegram transfer process to the videos that affect the hash values, stream hash values, metadata, and structure of the file were studied in this thesis using the methods mentioned above.

V. RESULTS

File Hashes

The hash values of the files changed with every transfer indicating the files were changed during the Telegram transfer process. The table below shows an original video from the Samsung Galaxy 23 Ultra and its received counterparts from the other devices with their SHA-256 hash values.

Table 4. Samsung Galaxy Hash Value Comparison

Device	File Name	SHA-256 Hash Value
Samsung Galaxy 23 Ultra (Originating Device)	20251011_174533.mp4	7E2154CE5E9482B7568659768E20591AB3C5DD416FFE7BBB2DE314968A22F971
iPhone 14 Pro	telegram_video22.mp4	F7317049BDBBB73AA643CC55F45968082656D5819C62003BDEC9CE34CB5894FF
iPhone 15	telegram_video2.mp4	F7317049BDBBB73AA643CC55F45968082656D5819C62003BDEC9CE34CB5894FF
iPhone 16e	telegram_video(1).mp4	F7317049BDBBB73AA643CC55F45968082656D5819C62003BDEC9CE34CB5894FF
Google Pixel 10	VID_20251011_182048_183.mp4	F7317049BDBBB73AA643CC55F45968082656D5819C62003BDEC9CE34CB5894FF

The other mobile phones used in the study showed the same results as the Samsung Galaxy 23 Ultra results show in the table above. File names changed when videos were transferred through Telegram to other mobile phones. The hash values changed in the transfer process, but were consistent with the received videos indicating the change to the video files happened in Telegram, not by downloading to the mobile phone.

Stream Hashes

The test videos' stream hash values were calculated for the video and the audio streams. Analysis of these values determined the stream hash values for the video and the audio streams

of a video change through the Telegram transfer process. The stream hash values for a received video are the same no matter the device to which they are downloaded. This indicates changes made to the streams are made in the Telegram app and those changes are not made by the downloading device or method. The stream hash results of an original video from the iPhone 14 device compared to the received versions from each device are shown in the table below.

Table 5. iPhone 14 Stream Hash Value Comparison

Device	File Name	SHA-256 Video and Audio Stream Hash Values
iPhone 14 (Originating Device)	Video Oct 11 2025, 5 42 48 PM.mov	Video: 633904e86a4c6760c8633e276100766f09369a930d5f2510e7941a8ed3bf9bbf Audio: ca80d7c615f89c4255fe32c169dc30aa9bbfc2665d55ae556794bf17b9ba1089
Samsung Galaxy 23 Ultra	VID_20251011_175709_174.mp4.mov	Video: 74a8f8807adf90ea5edacdcd394a6bec02f581cfb67da120995c7b156a6255c4 Audio: d30dddef915d0d02c6800e51415f197dcd0fa5222fa48c9052a572af3a79e438
iPhone 15	IMG_6704	Video: 74a8f8807adf90ea5edacdcd394a6bec02f581cfb67da120995c7b156a6255c4 Audio: d30dddef915d0d02c6800e51415f197dcd0fa5222fa48c9052a572af3a79e438
iPhone 16e	IMG_6704	Video: 74a8f8807adf90ea5edacdcd394a6bec02f581cfb67da120995c7b156a6255c4 Audio: d30dddef915d0d02c6800e51415f197dcd0fa5222fa48c9052a572af3a79e438
Google Pixel 10	VID_20251011_175612_211.mp4.mov	Video: 74a8f8807adf90ea5edacdcd394a6bec02f581cfb67da120995c7b156a6255c4 Audio: d30dddef915d0d02c6800e51415f197dcd0fa5222fa48c9052a572af3a79e438

Metadata Analysis

MediaInfo was utilized to collect the metadata information for the test videos. There are differences in the metadata between the original videos and the received videos. All received videos for an original video had the same metadata information despite being downloaded onto different devices.

General Metadata

Many changes to the general information metadata of the videos occurred during the transfer process. If the original format profile was QuickTime, it was changed to Base Media / Version 2 during the transfer process. If the original format profile was Base Media or Base Media / Version 2, it changed to, or stayed with, Base Media after the transfer process. The codec ID changed from isom (iso/iso2/mp41) to isom (isom/iso2/avc1/mp41) in the Base Media videos, from qt 0000.00 (qt) to mp42 (isom/mp41/mp42) in QuickTime videos, and from mp42 (isom/mp42) to isom (iso/iso2/avc1/mp41) in Base Media / Version 2 videos. The file size of the received video was always smaller than the original video.

The overall bit rate mode information was variable and only in the original videos of each device except the iPhone 16e and the Samsung Galaxy 23 Ultra. The Samsung Galaxy 23 Ultra did not have the bit rate mode information in the original videos but did have it in the received versions, indicating it was variable. The iPhone 16e did not have the bit rate mode information in the original videos, nor the received videos. The overall bit rate was always lower in the received videos than the original videos. The duration was often shorter in the received video, except for all videos originating from the Samsung Galaxy 23 Ultra device and some videos originating from the Google Pixel 10. This was the same result for the video and audio metadata.

The framerate was the same for all videos originating from the iPhone 16e, some videos originating from the Samsung Galaxy 23 Ultra, and all videos originating from the iPhone 14. The framerate was lower in the received videos originating from the Google Pixel 10 and the iPhone 15. All iPhones had the recorded date in the original videos, but not in the received videos. The encoded and tagged dates and times for the original videos were all different in the received videos in the metadata of the general, video, and audio of the video. Information within the original videos such as recorded location, writing operating system, writing library, writing hardware, or other device-specific information were discarded during the transfer process.

Video Metadata

The ID for the video stream was changed from one to two for the Samsung Galaxy 23 Ultra and the Google Pixel 10, it was changed from two to one for the iPhone 15, and remained the same for the iPhone 14 and the iPhone 16e. The format profile changed to High@L3.1 for each device. If the original video's format was HEVC, it is changed to AVC during the transfer process, and the codec ID changed as well from hvc1 to avc1. The codec configuration box changed from hvcC to avcC in the Android videos, and from hvcC+dvvC to avcC in the iPhone 14 videos.

The format settings, format settings CABAC, format settings reference frames, format settings GOP, and muxing mode are only in the original videos of the Samsung Galaxy 23 Ultra device, and the same settings excluding the muxing mode are only in the original videos from the Google Pixel 10, and in only the received videos from the iPhone 15. The iPhone 16e metadata information included the format settings' data, but the reference frame changed from one in the original videos to four in the received, changing the GOP and the reference frame numbers. The bit rate is lower in the received videos.

For the iPhones, the width and height of the videos changed from 1920x1080px to 464x848px during the transfer process, and the width and height of the Android videos changed from 1920x1080px to 720x1280px. All original videos had an aspect ratio of 16:9 and had rotation information of 90 degrees. There was no rotation information for the received videos, and the aspect ratio was 9:16 post-transfer.

The framerate was lower in the received videos from the Google Pixel 10, iPhone 15, some videos from the Samsung Galaxy 23 Ultra, and some videos from the iPhone 14. Real framerate information was in the original videos of both Android phones, but not in the received counterparts. The Bits/(Pixel*Frame) were smaller in the received videos, except for some videos from the iPhone 14, for which it was the same value. The bit depth was 10 bits in the original videos from the iPhone 14 and 8 bits in the received videos.

The study showed video metadata was discarded or added during the transfer process to certain device videos. The standard and mdhd duration information was present in the original videos from the Samsung Galaxy 23 Ultra, but not in the received videos. Transfer_charcteristics_original information is only in the original videos for the Google Pixel 10, not in the received videos. HDR format information, writing library is only in the original videos from the iPhone 14. The writing library information is only in the original videos from the iPhone 16e and iPhone 15. The metas, also known as tracks, are included in the original videos from the iPhones, but not in the received counterparts. The Google Pixel 10 also had additional information in a section titled “Other” that was in the original videos, but not in the received videos.

Scan type information was in the received videos, not the originals, of the Samsung Galaxy 23 Ultra, Google Pixel 10, and the iPhone 14. Scan type information was in both the original and the received videos from the iPhone 15.

The stream size was smaller in the received videos from the Samsung Galaxy 23 Ultra, iPhone 14, iPhone 16e, and the iPhone 15. The stream size was the same for the original and received videos from the Google Pixel 10.

Two devices, the Samsung Galaxy 23 Ultra and the iPhone 14 had changes made to the color primaries, transfer characteristics, and matrix coefficients of their videos. The color primaries changed from BT.2020 in the original videos of the iPhone 14 to BT.709. In the Samsung Galaxy 23 Ultra, the color primaries of the original videos were BT.709 and this changed to BT.601 PAL in the received videos. The transfer characteristics of the iPhone 14 videos changed from HLG in the originals to BT.709 in the received. The transfer characteristics of the Samsung Galaxy 23 Ultra videos changed from BT.709 in the originals to BT.601 in the received. The matrix coefficients for the iPhone 14 changed from BT.2020 non-constant in the originals to BT.709 in the received. The matrix coefficients for the Samsung Galaxy 23 Ultra changed from BT.709 in the originals to BT.470 System B/G in the received.

Audio Metadata

In the Samsung Galaxy 23 Ultra and Google Pixel 10 videos, the audio stream ID changed from 2 to 1, and in the iPhone 15 audio, the ID changed from 1 to 2. The bit rate mode changed from variable in the originals to constant in the received for the iPhone 14 and iPhone 15 videos. For the Android phones, the bit rate mode changed from constant to variable. The Android phones also had nominal bit rate information in the received videos, but not in the original videos. After transferring the iPhone videos, the received videos had a smaller audio

stream and source stream size than their original counterparts. The bit rates were also lower in the videos received from the iPhone devices than the originals. For the Android devices, the stream size was the same for the original and received videos, but the stream size percentage was larger in the received videos than the originals.

The iPhone 16e videos experienced more changes to the audio information than the other devices after the transfer process. There were two audio sections in the original video and only one in the received. The sampling rate also decreased from 48kHz in the original videos to 44.1kHz in the received. The framerate was lower in the received videos than the originals. Other information such as the default, alternate group, fallback from, and audio section #2 were in the original videos, but not the received.

Metadata for one of the original videos of each device compared to that same video received from another device are shown in tables six through ten.

Table 6. Samsung Galaxy 23 Ultra Original Video Metadata vs iPhone 16e Received Video Metadata

Samsung Galaxy 23 Ultra (Originating Device) Video "20251011_174533.mp4"		iPhone 16e (Receiving Device) Video "telegram_video (1)"	
Format	: MPEG-4	Format	: MPEG-4
Format profile	: Base Media / Version 2	Format profile	: Base Media
Codec ID	: mp42 (isom/mp42)	Codec ID	: isom (isom/iso2/avc1/mp41)
File size	: 10.1 MiB	File size	: 2.18 MiB
Duration	: 5 s 887 ms	Duration	: 5 s 887 ms
Overall bit rate	: 14.4 Mb/s	Overall bit rate mode	: Variable
Frame rate	: 29.218 FPS	Overall bit rate	: 3 104 kb/s
Encoded date	: 2025-10-11 23:45:43 UTC	Frame rate	: 29.218 FPS
Tagged date	: 2025-10-11 23:45:43 UTC	Encoded date	: 2025-10-12 00:17:42 UTC
		Tagged date	: 2025-10-12 00:17:42 UTC

Table 6. Samsung Galaxy 23 Ultra Original Video Metadata vs iPhone 16e Received Video Metadata cont'd

Samsung Galaxy 23 Ultra (Originating Device) Video "20251011_174533.mp4"	iPhone 16e (Receiving Device) Video "telegram_video (1)"
Recorded location : +39.5352 -104.8725	Video
Writing operating system : Google Android 16	ID : 2
Writing hardware : Samsung Galaxy S23 Ultra (SM-S918U)	Format : AVC
com.samsung.android.utc_offset : -0600	Format/Info : Advanced Video Codec
	Format profile : High@L3.1
Video	Format settings : CABAC / 1 Ref Frames
ID : 1	Format settings, CABAC : Yes
Format : HEVC	Format settings, Reference frames : 1 frame
Format/Info : High Efficiency Video Coding	Format settings, GOP : M=1, N=29
	Muxing mode : Container profile=High@L1.3
Format profile : Main@L4@High	Codec ID : avc1
Codec ID : hvc1	Codec ID/Info : Advanced Video Coding
Codec ID/Info : High Efficiency Video Coding	Duration : 5 s 887 ms
Duration : 5 s 887 ms	Bit rate : 2 840 kb/s
Bit rate : 14.1 Mb/s	Width : 720 pixels
Width : 1 920 pixels	Height : 1 280 pixels
Height : 1 080 pixels	Display aspect ratio : 9:16
Display aspect ratio : 16:9	Frame rate mode : Variable
Rotation : 90°	Frame rate : 29.218 FPS
Frame rate mode : Variable	Minimum frame rate : 5.306 FPS
Frame rate : 29.218 FPS	Maximum frame rate : 30.010 FPS
Minimum frame rate : 5.306 FPS	Color space : YUV
Maximum frame rate : 30.010 FPS	Chroma subsampling : 4:2:0
Real frame rate : 30.000 FPS	Bit depth : 8 bits
Standard : PAL	Scan type : Progressive
Color space : YUV	Bits/(Pixel*Frame) : 0.105
Chroma subsampling : 4:2:0	Stream size : 1.99 MiB (92%)
Bit depth : 8 bits	Title : VideoHandle
Bits/(Pixel*Frame) : 0.233	Language : English
Stream size : 9.90 MiB (98%)	

Table 6. Samsung Galaxy 23 Ultra Original Video Metadata vs iPhone 16e Received Video Metadata cont'd

Samsung Galaxy 23 Ultra (Originating Device) Video "20251011_174533.mp4"	iPhone 16e (Receiving Device) Video "telegram_video (1)"
Title : VideoHandle Language : English Encoded date : 2025-10-11 23:45:43 UTC Tagged date : 2025-10-11 23:45:43 UTC Color range : Limited Color primaries : BT.709 Transfer characteristics : BT.709 Matrix coefficients : BT.709 Codec configuration box : hvcC Audio ID : 2 Format : AAC LC Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 5 s 867 ms Bit rate mode : Constant Bit rate : 256 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 48.0 kHz Frame rate : 46.875 FPS (1024 SPF) Compression mode : Lossy Stream size : 183 KiB (2%) Title : SoundHandle Language : English Encoded date : 2025-10-11 23:45:43 UTC Tagged date : 2025-10-11 23:45:43 UTC	Encoded date : 2025-10-12 00:17:38 UTC Tagged date : 2025-10-12 00:17:42 UTC Color range : Limited Color primaries : BT.601 PAL Transfer characteristics : BT.601 Matrix coefficients : BT.470 System B/G Codec configuration box : avcC Audio ID : 1 Format : AAC LC Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 5 s 867 ms Bit rate mode : Variable Bit rate : 256 kb/s Nominal bit rate : 48.0 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 48.0 kHz Frame rate : 46.875 FPS (1024 SPF) Compression mode : Lossy Stream size : 183 KiB (8%) Title : SoundHandle Language : English Encoded date : 2025-10-12 00:17:38 UTC Tagged date : 2025-10-12 00:17:42 UTC

Table 7. iPhone 16e Original Video Metadata vs Google Pixel 10 Received Video Metadata

iPhone 16e (Originating Device) Video "Video Oct 11 2025 6 03 53 PM.mov"	Google Pixel 10 (Receiving Device) Video "VID_20251011_182445_390.mp4.mov"
General Complete name : U:\Thesis Simplified\Madison Original and Received\iPhone 16e Madison originals\Video Oct 11 2025, 6 03 53 PM.mov Format : MPEG-4 Format profile : QuickTime Codec ID : qt 0000.00 (qt) File size : 10.4 MiB Duration : 5 s 300 ms Overall bit rate : 16.4 Mb/s Frame rate : 30.000 FPS Recorded date : 2025-10-11T18:03:53-0600 Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Writing library : Apple QuickTime Writing operating system : Apple iOS 18.6.2 Writing hardware : Apple iPhone 16e com.apple.quicktime.full-frame-rate-play : 1 Video ID : 1 Format : AVC Format/Info : Advanced Video Codec Format profile : High@L4 Format settings : CABAC / 1 Ref Frames Format settings, CABAC : Yes Format settings, Reference frames : 1 frame Format settings, GOP : M=1, N=29 Codec ID : avc1	General Complete name : U:\Thesis Simplified\Madison Original and Received\Madison Received - Rachel\VID_20251011_182445_390.mp4.mov Format : MPEG-4 Format profile : Base Media / Version 2 Codec ID : mp42 (isom/mp41/mp42) File size : 1.07 MiB Duration : 5 s 200 ms Overall bit rate : 1 725 kb/s Frame rate : 30.000 FPS Encoded date : 2025-10-12 00:22:40 UTC Tagged date : 2025-10-12 00:22:40 UTC Video ID : 1 Format : AVC Format/Info : Advanced Video Codec Format profile : High@L3.1 Format settings : CABAC / 4 Ref Frames Format settings, CABAC : Yes Format settings, Reference frames : 4 frames Codec ID : avc1 Codec ID/Info : Advanced Video Coding Duration : 5 s 200 ms Bit rate : 1 653 kb/s Width : 464 pixels Height : 848 pixels Display aspect ratio : 9:16 Frame rate mode : Constant Frame rate : 30.000 FPS

Table 7. iPhone 16e Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 16e (Originating Device) Video "Video Oct 11 2025 6 03 53 PM.mov"	Google Pixel 10 (Receiving Device) Video "VID_20251011_182445_390.mp4.mov"
Codec ID/Info : Advanced Video Coding	Color space : YUV
Duration : 5 s 300 ms	Chroma subsampling : 4:2:0
Bit rate : 15.7 Mb/s	Bit depth : 8 bits
Width : 1 920 pixels	Scan type : Progressive
Height : 1 080 pixels	Bits/(Pixel*Frame) : 0.140
Display aspect ratio : 16:9	Stream size : 1.02 MiB (96%)
Rotation : 90°	Title : Core Media Video
Frame rate mode : Constant	Encoded date : 2025-10-12 00:22:40 UTC
Frame rate : 30.000 FPS	Tagged date : 2025-10-12 00:22:40 UTC
Color space : YUV	Color range : Limited
Chroma subsampling : 4:2:0	Color primaries : BT.709
Bit depth : 8 bits	Transfer characteristics : BT.709
Scan type : Progressive	Matrix coefficients : BT.709
Bits/(Pixel*Frame) : 0.252	Codec configuration box : avcC
Stream size : 9.90 MiB (96%)	
Title : Core Media Video	Audio
Writing library : H.264	ID : 2
Encoded date : 2025-10-12 00:03:53 UTC	Format : AAC LC
Tagged date : 2025-10-12 00:03:58 UTC	Format/Info : Advanced Audio Codec Low Complexity
Color range : Limited	Codec ID : mp4a-40-2
Color primaries : BT.709	Duration : 5 s 198 ms
Transfer characteristics : BT.709	Source duration : 5 s 248 ms
Matrix coefficients : BT.709	Bit rate mode : Constant
Metas : 4,6,7	Bit rate : 64.0 kb/s
Codec configuration box : avcC	Channel(s) : 2 channels
	Channel layout : L R
Audio #1	Sampling rate : 44.1 kHz
ID : 2	Frame rate : 43.066 FPS (1024 SPF)
Format : AAC LC	Compression mode : Lossy
Format/Info : Advanced Audio Codec Low Complexity	Stream size : 41.1 KiB (4%)
Codec ID : mp4a-40-2	Source stream size : 41.5 KiB (4%)
Duration : 5 s 298 ms	Title : Core Media Audio
Source duration : 5 s 355 ms	Encoded date : 2025-10-12 00:22:40 UTC
Bit rate mode : Constant	
Bit rate : 128 kb/s	

Table 7. iPhone 16e Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 16e (Originating Device) Video "Video Oct 11 2025 6 03 53 PM.mov"	Google Pixel 10 (Receiving Device) Video "VID_20251011_182445_390.mp4.mov"
Channel(s) : 2 channels Channel layout : L R Sampling rate : 48.0 kHz Frame rate : 46.875 FPS (1024 SPF) Compression mode : Lossy Stream size : 85.7 KiB (1%) Source stream size : 86.3 KiB (1%) Title : Core Media Audio Default : Yes Alternate group : 1 Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Fallback From : 3 Audio #2 ID : 3 Format : apac Codec ID : apac Duration : 5 s 298 ms Source duration : 5 s 355 ms Bit rate : 392 kb/s Channel(s) : 4 channels Sampling rate : 48.0 kHz Stream size : 254 KiB (2%) Source stream size : 256 KiB (2%) Title : Core Media Audio Default : Inherited From: 2 Alternate group : 1 Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Fallback To : 2 Metas : 5	Tagged date : 2025-10-12 00:22:40 UTC

Table 7. iPhone 16e Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 16e (Originating Device) Video "Video Oct 11 2025 6 03 53 PM.mov"	Google Pixel 10 (Receiving Device) Video "VID_20251011_182445_390.mp4.mov"
Other #1 ID : 4 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 300 ms Title : Core Media Metadata Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Other #2 ID : 5 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 298 ms Source duration : 5 s 300 ms Stream size : 386 Bytes Source stream size : 386 Bytes Title : Core Media Metadata Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Other #3 ID : 6 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 300 ms Source duration : 5 s 333 ms Source_Duration_LastFrame : 33 ms Bit rate mode : Variable	

Table 7. iPhone 16e Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 16e (Originating Device) Video "Video Oct 11 2025 6 03 53 PM.mov"	Google Pixel 10 (Receiving Device) Video "VID_20251011_182445_390.mp4.mov"
Stream size : 50.6 KiB Source stream size : 50.6 KiB Title : Core Media Metadata Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Other #4 ID : 7 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 300 ms Bit rate mode : Variable Title : Core Media Metadata Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC Other #5 ID : 8 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 300 ms Title : Core Media Metadata Encoded date : 2025-10-12 00:03:53 UTC Tagged date : 2025-10-12 00:03:58 UTC	

Table 8. iPhone 14 Original Video Metadata vs iPhone 15 Received Video Metadata

iPhone 14 (Originating Device) Video "Video Oct 11 2025, 5 43 21 PM.mov"	iPhone 15 (Receiving Device) Video "IMG_6706.MOV"
General Complete name : U:\Thesis Simplified\Livi Original and Received\iPhone 14 Pro originals Livi\Video Oct 11 2025, 5 43 21 PM.mov Format : MPEG-4 Format profile : QuickTime Codec ID : qt 0000.00 (qt) File size : 4.88 MiB Duration : 5 s 260 ms Overall bit rate mode : Variable Overall bit rate : 7 789 kb/s Frame rate : 30.000 FPS Recorded date : 2025-10-11T17:43:21-0600 Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC Recorded location : +39.5352 -104.8726 +1824.351 Writing library : Apple QuickTime Writing operating system : Apple iOS 18.6.2 Writing hardware : Apple iPhone 14 Pro com.apple.quicktime.location.accuracy.ho : 15.421540 com.apple.quicktime.full-frame-rate-play : 1 Video ID : 1 Format : HEVC Format/Info : High Efficiency Video Coding Format profile : Main 10@L4@Main	General Complete name : U:\Thesis Simplified\Livi Original and Received\Livi sent to Tierney\IMG_6706.MOV Format : MPEG-4 Format profile : Base Media / Version 2 Codec ID : mp42 (isom/mp41/mp42) File size : 1.06 MiB Duration : 5 s 167 ms Overall bit rate : 1 727 kb/s Frame rate : 30.000 FPS Encoded date : 2025-10-11 23:55:18 UTC Tagged date : 2025-10-11 23:55:19 UTC Video ID : 1 Format : AVC Format/Info : Advanced Video Codec Format profile : High@L3.1 Format settings : CABAC / 4 Ref Frames Format settings, CABAC : Yes Format settings, Reference frames : 4 frames Codec ID : avc1 Codec ID/Info : Advanced Video Coding Duration : 5 s 167 ms Bit rate : 1 655 kb/s Width : 464 pixels Height : 848 pixels Display aspect ratio : 9:16 Frame rate mode : Constant Frame rate : 30.000 FPS Color space : YUV Chroma subsampling : 4:2:0

Table 8. iPhone 14 Original Video Metadata vs iPhone 15 Received Video Metadata cont'd

iPhone 14 (Originating Device) Video "Video Oct 11 2025, 5 43 21 PM.mov"	iPhone 15 (Receiving Device) Video "IMG_6706.MOV"
HDR format : Dolby Vision, Version 1.0, Profile 8.4, dvhe.08.04, BL+RPU, no metadata compression, HLG compatible	Bit depth : 8 bits
Codec ID : hvc1	Scan type : Progressive
Codec ID/Info : High Efficiency Video Coding	Bits/(Pixel*Frame) : 0.140
Duration : 5 s 260 ms	Stream size : 1.02 MiB (96%)
Source duration : 5 s 327 ms	Title : Core Media Video
Source_Duration_LastFrame : -7 ms	Encoded date : 2025-10-11 23:55:18 UTC
Bit rate : 7 508 kb/s	Tagged date : 2025-10-11 23:55:19 UTC
Width : 1 920 pixels	Color range : Limited
Height : 1 080 pixels	Color primaries : BT.709
Display aspect ratio : 16:9	Transfer characteristics : BT.709
Rotation : 90°	Matrix coefficients : BT.709
Frame rate mode : Constant	Codec configuration box : avcC
Frame rate : 30.000 FPS	
Color space : YUV	Audio
Chroma subsampling : 4:2:0	ID : 2
Bit depth : 10 bits	Format : AAC LC
Bits/(Pixel*Frame) : 0.121	Format/Info : Advanced Audio Codec Low Complexity
Stream size : 4.71 MiB (97%)	Codec ID : mp4a-40-2
Source stream size : 4.75 MiB (97%)	Duration : 5 s 160 ms
Title : Core Media Video	Source duration : 5 s 224 ms
Writing library : HEVC	Bit rate mode : Constant
Encoded date : 2025-10-11 23:45:47 UTC	Bit rate : 64.0 kb/s
Tagged date : 2025-10-11 23:45:47 UTC	Channel(s) : 2 channels
Color range : Limited	Channel layout : L R
Color primaries : BT.2020	Sampling rate : 44.1 kHz
Transfer characteristics : HLG	Frame rate : 43.066 FPS (1024 SPF)
Matrix coefficients : BT.2020 non-constant	Compression mode : Lossy
Metas : 3,4	Stream size : 40.9 KiB (4%)
Codec configuration box : hvcC+dvvC	Source stream size : 41.4 KiB (4%)
	Title : Core Media Audio
	Encoded date : 2025-10-11 23:55:18 UTC
	Tagged date : 2025-10-11 23:55:19 UTC

Table 8. iPhone 14 Original Video Metadata vs iPhone 15 Received Video Metadata cont'd

iPhone 14 (Originating Device) Video "Video Oct 11 2025, 5 43 21 PM.mov"	iPhone 15 (Receiving Device) Video "IMG_6706.MOV"
Audio ID : 2 Format : AAC LC Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 5 s 260 ms Source duration : 5 s 317 ms Bit rate mode : Variable Bit rate : 192 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 44.1 kHz Frame rate : 43.066 FPS (1024 SPF) Compression mode : Lossy Stream size : 125 KiB (2%) Source stream size : 126 KiB (3%) Title : Core Media Audio Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC Other #1 ID : 3 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 260 ms Title : Core Media Metadata Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC	

Table 8. iPhone 14 Original Video Metadata vs iPhone 15 Received Video Metadata cont'd

iPhone 14 (Originating Device) Video "Video Oct 11 2025, 5 43 21 PM.mov"	iPhone 15 (Receiving Device) Video "IMG_6706.MOV"
Other #2 ID : 4 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 260 ms Title : Core Media Metadata Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC Other #3 ID : 5 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 260 ms Bit rate mode : Constant Title : Core Media Metadata Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC Other #4 ID : 6 Type : meta Format : mebx Codec ID : mebx Duration : 5 s 260 ms Title : Core Media Metadata Encoded date : 2025-10-11 23:45:47 UTC Tagged date : 2025-10-11 23:45:47 UTC	

Table 9. iPhone 15 Original Video Metadata vs Google Pixel 10 Received Video Metadata

iPhone 15 (Originating Device) Video "IMG_0671.MOV"	Google Pixel 10 (Receiving Device) Video "VID_20251011_183030_975.mp4.mov"
General Complete name : U:\Thesis Simplified\D1 Originals\IMG_0671.MOV Format : MPEG-4 Format profile : QuickTime Codec ID : qt 0000.00 (qt) File size : 7.67 MiB Duration : 6 s 235 ms Overall bit rate mode : Variable Overall bit rate : 10.3 Mb/s Frame rate : 30.000 FPS Recorded date : 2025-09-01T16:25:22-0600 Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC Recorded location : +39.5352 -104.8727 +1833.232 Writing library : Apple QuickTime Writing operating system : Apple iOS 18.6 Writing hardware : Apple iPhone 15 com.apple.quicktime.location.accuracy.ho : 22.648142 com.apple.quicktime.full-frame-rate-play : 1 Video ID : 2 Format : AVC Format/Info : Advanced Video Codec Format profile : High@L4 Format settings : CABAC / 4 Ref Frames Format settings, CABAC : Yes	General Complete name : U:\Thesis Simplified\Tierney Original and Received\Tierney Received - Rachel\VID_20251011_183030_975.mp4.mov Format : MPEG-4 Format profile : Base Media / Version 2 Codec ID : mp42 (isom/mp41/mp42) File size : 1.22 MiB Duration : 6 s 133 ms Overall bit rate : 1 664 kb/s Frame rate : 29.837 FPS Encoded date : 2025-10-12 00:23:18 UTC Tagged date : 2025-10-12 00:23:19 UTC Video ID : 1 Format : AVC Format/Info : Advanced Video Codec Format profile : High@L3.1 Format settings : CABAC / 4 Ref Frames Format settings, CABAC : Yes Format settings, Reference frames : 4 frames Codec ID : avc1 Codec ID/Info : Advanced Video Coding Duration : 6 s 133 ms Bit rate : 1 593 kb/s Width : 464 pixels Height : 848 pixels Display aspect ratio : 9:16 Frame rate mode : Variable Frame rate : 29.837 FPS

Table 9. iPhone 15 Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 15 (Originating Device) Video "IMG_0671.MOV"	Google Pixel 10 (Receiving Device) Video "VID_20251011_183030_975.mp4.mov"
Format settings, Reference frames : 4 frames	Minimum frame rate : 15.000 FPS
Codec ID : avc1	Maximum frame rate : 30.000 FPS
Codec ID/Info : Advanced Video Coding	Color space : YUV
Duration : 6 s 235 ms	Chroma subsampling : 4:2:0
Bit rate : 10.1 Mb/s	Bit depth : 8 bits
Width : 1 920 pixels	Scan type : Progressive
Height : 1 080 pixels	Bits/(Pixel*Frame) : 0.136
Display aspect ratio : 16:9	Stream size : 1.16 MiB (96%)
Rotation : 90°	Title : Core Media Video
Frame rate mode : Variable	Encoded date : 2025-10-12 00:23:18 UTC
Frame rate : 30.000 FPS	Tagged date : 2025-10-12 00:23:19 UTC
Minimum frame rate : 28.571 FPS	Color range : Limited
Maximum frame rate : 30.000 FPS	Color primaries : BT.709
Color space : YUV	Transfer characteristics : BT.709
Chroma subsampling : 4:2:0	Matrix coefficients : BT.709
Bit depth : 8 bits	Codec configuration box : avcC
Scan type : Progressive	
Bits/(Pixel*Frame) : 0.163	Audio
Stream size : 7.52 MiB (98%)	ID : 2
Title : Core Media Video	Format : AAC LC
Writing library : H.264	Format/Info : Advanced Audio Codec Low Complexity
Encoded date : 2025-09-16 22:44:14 UTC	Codec ID : mp4a-40-2
Tagged date : 2025-09-16 22:44:15 UTC	Duration : 6 s 133 ms
Color range : Limited	Source duration : 6 s 200 ms
Color primaries : BT.709	Bit rate mode : Constant
Transfer characteristics : BT.709	Bit rate : 64.0 kb/s
Matrix coefficients : BT.709	Channel(s) : 2 channels
Metas : 3,4,5	Channel layout : L R
Codec configuration box : avcC	Sampling rate : 44.1 kHz
	Frame rate : 43.066 FPS (1024 SPF)
Audio	Compression mode : Lossy
ID : 1	Stream size : 47.6 KiB (4%)
Format : AAC LC	

Table 9. iPhone 15 Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 15 (Originating Device) Video "IMG_0671.MOV"	Google Pixel 10 (Receiving Device) Video "VID_20251011_183030_975.mp4.mov"
Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 6 s 233 ms Source duration : 6 s 293 ms Bit rate mode : Variable Bit rate : 144 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 44.1 kHz Frame rate : 43.066 FPS (1024 SPF) Compression mode : Lossy Stream size : 111 KiB (1%) Source stream size : 112 KiB (1%) Title : Core Media Audio Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC Other #1 ID : 3 Type : meta Format : mebx Codec ID : mebx Duration : 6 s 233 ms Title : Core Media Metadata Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC Other #2 ID : 4 Type : meta Format : mebx	Source stream size : 48.1 KiB (4%) Title : Core Media Audio Encoded date : 2025-10-12 00:23:18 UTC Tagged date : 2025-10-12 00:23:19 UTC

Table 9. iPhone 15 Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 15 (Originating Device) Video "IMG_0671.MOV"	Google Pixel 10 (Receiving Device) Video "VID_20251011_183030_975.mp4.mov"
Codec ID : mebx Duration : 6 s 233 ms Title : Core Media Metadata Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC Other #3 ID : 5 Type : meta Format : mebx Codec ID : mebx Duration : 6 s 233 ms Bit rate mode : Constant Title : Core Media Metadata Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC Other #4 ID : 6 Type : meta Format : mebx Codec ID : mebx Duration : 6 s 232 ms Bit rate mode : Constant Title : Core Media Metadata Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC	

Table 9. iPhone 15 Original Video Metadata vs Google Pixel 10 Received Video Metadata

cont'd

iPhone 15 (Originating Device) Video "IMG_0671.MOV"	Google Pixel 10 (Receiving Device) Video "VID_20251011_183030_975.mp4.mov"
Other #5 ID : 7 Type : meta Format : mebx Codec ID : mebx Duration : 6 s 233 ms Title : Core Media Metadata Encoded date : 2025-09-16 22:44:14 UTC Tagged date : 2025-09-16 22:44:15 UTC	

Table 10. Google Pixel 10 Original Video Metadata vs Samsung Galaxy 23 Ultra Received Video Metadata

Google Pixel 10 (Originating Device) Video "PXL_20251011_234331967.mp4"	Samsung Galaxy 23 Ultra (Receiving Device) Video "VID_20251011_180345_905.mp4"
General Complete name : U:\Thesis Simplified\Rachel Original and Received\Tierney Thesis - Google Pixel 10 - Original\PXL_20251011_234331967.mp4 Format : MPEG-4 Format profile : Base Media Codec ID : isom (isom/iso2/mp41) File size : 15.9 MiB Duration : 6 s 430 ms Overall bit rate : 20.7 Mb/s Frame rate : 28.614 FPS Encoded date : 2025-10-11 23:43:39 UTC Tagged date : 2025-10-11 23:43:39 UTC	General Complete name : Received\RachelReceivedJared\VID_20251011_180345_905.mp4 Format : MPEG-4 Format profile : Base Media Codec ID : isom (isom/iso2/avc1/mp41) File size : 2.27 MiB Duration : 6 s 430 ms Overall bit rate mode : Variable Overall bit rate : 2 959 kb/s Frame rate : 28.303 FPS Encoded date : 2025-10-11 23:55:34 UTC Tagged date : 2025-10-11 23:55:34 UTC

Table 10. Google Pixel 10 Original Video Metadata vs Samsung Galaxy 23 Ultra Received Video Metadata cont'd

Google Pixel 10 (Originating Device) Video "PXL_20251011_234331967.mp4"	Samsung Galaxy 23 Ultra (Receiving Device) Video "VID_20251011_180345_905.mp4"
Recorded location : +39.5352 -104.8726	Video
Writing hardware : Google Pixel 10	ID : 2
	Format : AVC
Video	Format/Info : Advanced Video Codec
ID : 1	Format profile : High@L3.1
Format : HEVC	Format settings : CABAC / 1 Ref Frames
Format/Info : High Efficiency Video Coding	Format settings, CABAC : Yes
Format profile : Main@L4.1@Main	Format settings, Reference frames : 1 frame
Codec ID : hvc1	Format settings, GOP : M=1, N=28
Codec ID/Info : High Efficiency Video Coding	Codec ID : avc1
Duration : 6 s 430 ms	Codec ID/Info : Advanced Video Coding
Bit rate : 20.4 Mb/s	Duration : 6 s 430 ms
Width : 1 920 pixels	Bit rate : 2 759 kb/s
Height : 1 080 pixels	Width : 720 pixels
Display aspect ratio : 16:9	Height : 1 280 pixels
Rotation : 90°	Display aspect ratio : 9:16
Frame rate mode : Variable	Frame rate mode : Variable
Frame rate : 28.614 FPS	Frame rate : 28.303 FPS
Minimum frame rate : 9.998 FPS	Minimum frame rate : 9.998 FPS
Maximum frame rate : 39.982 FPS	Maximum frame rate : 30.000 FPS
Real frame rate : 30.000 FPS	Color space : YUV
Color space : YUV	Chroma subsampling : 4:2:0
Chroma subsampling : 4:2:0	Bit depth : 8 bits
Bit depth : 8 bits	Scan type : Progressive
Bits/(Pixel*Frame) : 0.344	Bits/(Pixel*Frame) : 0.106
Stream size : 15.7 MiB (99%)	Stream size : 2.12 MiB (93%)
Title : VideoHandle	Title : VideoHandle
Language : English	Language : English
Encoded date : 2025-10-11 23:43:39 UTC	Encoded date : 2025-10-11 23:55:28 UTC
Tagged date : 2025-10-11 23:43:39 UTC	Tagged date : 2025-10-11 23:55:34 UTC
	Color range : Limited
	Color primaries : BT.709
	Transfer characteristics : BT.709

Table 10. Google Pixel 10 Original Video Metadata vs Samsung Galaxy 23 Ultra Received Video Metadata cont'd

Google Pixel 10 (Originating Device) Video "PXL_20251011_234331967.mp4"	Samsung Galaxy 23 Ultra (Receiving Device) Video "VID_20251011_180345_905.mp4"
Color range : Limited Color primaries : BT.709 Transfer characteristics : BT.709 transfer_characteristics_Original : sRGB/sYCC Matrix coefficients : BT.709 Codec configuration box : hvcC Audio ID : 2 Format : AAC LC Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 6 s 401 ms Bit rate mode : Constant Bit rate : 192 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 48.0 kHz Frame rate : 46.875 FPS (1024 SPF) Compression mode : Lossy Stream size : 150 KiB (1%) Title : SoundHandle Language : English Encoded date : 2025-10-11 23:43:39 UTC Tagged date : 2025-10-11 23:43:39 UTC Other ID : 3 Type : meta Format : mett-application/meta Codec ID : mett-application/meta Duration : 6 s 430 ms	Matrix coefficients : BT.709 Codec configuration box : avcC Audio ID : 1 Format : AAC LC Format/Info : Advanced Audio Codec Low Complexity Codec ID : mp4a-40-2 Duration : 6 s 383 ms Bit rate mode : Variable Bit rate : 192 kb/s Nominal bit rate : 48.0 kb/s Channel(s) : 2 channels Channel layout : L R Sampling rate : 48.0 kHz Frame rate : 46.875 FPS (1024 SPF) Compression mode : Lossy Stream size : 150 KiB (6%) Title : SoundHandle Language : English Encoded date : 2025-10-11 23:55:28 UTC Tagged date : 2025-10-11 23:55:34 UTC

Table 10. Google Pixel 10 Original Video Metadata vs Samsung Galaxy 23 Ultra Received Video Metadata cont'd

Google Pixel 10 (Originating Device) Video "PXL_20251011_234331967.mp4"	Samsung Galaxy 23 Ultra (Receiving Device) Video "VID_20251011_180345_905.mp4"
Bit rate mode : Variable Title : MetaHandle Language : English Encoded date : 2025-10-11 23:43:39 UTC Tagged date : 2025-10-11 23:43:39 UTC	

Hex Analysis

Mp4Dump was used to collect the file structure information for the videos. For this analysis, with the received videos for each original video being the same, one original video and one received counterpart for each device were analyzed. Tables 11 through 15 show the hex data for the analyzed videos and beneath each table is a summary of the changes to the file structure. The values shown for the atoms that make up the file structure differ, and most of the causes of those changed values are analyzed in the metadata section of this thesis. Atoms are units that make up the video file, with each having its own header and size depending on what information is help within it. These atoms contain data and/or other atoms. The atom changes will be analyzed in this section.

Table 11. Samsung Galaxy 23 Ultra Original Video Hex Data vs Received Video Hex Data

Samsung Galaxy 23 Ultra Original Video	Video After Transfer
[ftyp] size=8+16 major_brand = mp42 minor_version = 0 compatible_brand = isom compatible_brand = mp42	[ftyp] size=8+24 major_brand = isom minor_version = 200 compatible_brand = isom compatible_brand = iso2

Table 11. Samsung Galaxy 23 Ultra Original Video Hex Data vs Received Video Hex Data

cont'd

Samsung Galaxy 23 Ultra Original Video	Video After Transfer
[mdat] size=16+10481780 [moov] size=8+4309 [mvhd] size=12+96 timescale = 10000 duration = 57694 duration(ms) = 5769 [udta] size=8+167 [SDLN] size=8+8 [smrd] size=8+8 [auth] size=12+19 language = eng value = Galaxy S23 Ultra [.xyz] size=8+22 [smta] size=8+34 [cami] size=8+24 [meta] size=8+236 [hdlr] size=12+21 handler_type = mdta handler_name = [keys] size=8+104 [ilst] size=8+83 [....] size=8+18 [....] size=8+20 [....] size=8+21 [trak] size=8+2119 [tkhd] size=12+80, flags=7 enabled = 1 id = 1 duration = 57694 width = 1920.000000 height = 1080.000000 [mdia] size=8+2019 [mdhd] size=12+20 timescale = 90000 duration = 519250 duration(ms) = 5769 language = ``` [hdlr] size=12+32 handler_type = vide	compatible_brand = avc1 compatible_brand = mp41 [mdat] size=8+2054965 [moov] size=8+6383 [mvhd] size=12+96 timescale = 6000 duration = 34616 duration(ms) = 5769 [trak] size=8+3599 [tkhd] size=12+80, flags=7 enabled = 1 id = 1 duration = 34559 width = 0.000000 height = 0.000000 [mdia] size=8+3499 [mdhd] size=12+20 timescale = 48000 duration = 276475 duration(ms) = 5759 language = eng [hdlr] size=12+32 handler_type = soun handler_name = SoundHandle [minf] size=8+3415 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+3355 [stsd] size=12+79 entry-count = 1 [mp4a] size=8+67 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 48000

Table 11. Samsung Galaxy 23 Ultra Original Video Hex Data vs Received Video Hex Data

cont'd

Samsung Galaxy 23 Ultra Original Video	Video After Transfer
handler_name = VideoHandle [minf] size=8+1935 [vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+1871 [stsd] size=12+227 entry-count = 1 [hvc1] size=8+215 data_reference_index = 1 width = 1920 height = 1080 compressor = [hvcC] size=8+110 Configuration Version = 1 Profile Space = 0 Profile = Main Tier = 1 Profile Compatibility = 60000000 Constraint = b00000000000 Level = 120 Min Spatial Segmentation = 0 Parallelism Type = 0 Chroma Format = 1 Chroma Depth = 8 Luma Depth = 8 Average Frame Rate = 0 Constant Frame Rate = 0 Number Of Temporal Layers = 0 Temporal Id Nested = 0 NALU Length Size = 4 [colr] size=8+11 [stts] size=12+772 entry_count = 96 [stss] size=12+28	[esds] size=12+27 [ESDescriptor] size=2+25 es_id = 0 stream_priority = 0 [DecoderConfig] size=2+17 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 1536 max_bitrate = 256000 avg_bitrate = 48000 DecoderSpecificInfo = 11 90 [Descriptor:06] size=2+1 [stts] size=12+84 entry_count = 10 [stsc] size=12+1372 entry_count = 114 [stsz] size=12+1088 sample_size = 0 sample_count = 270 [stco] size=12+672 entry_count = 167 [trak] size=8+2660 [tkhd] size=12+80, flags=7 enabled = 1 id = 2 duration = 34616 width = 720.000000 height = 1280.000000 [mdia] size=8+2560 [mdhd] size=12+20 timescale = 90000 duration = 519250 duration(ms) = 5769 language = eng [hdlr] size=12+32 handler_type = vide handler_name = VideoHandle [minf] size=8+2476

Table 11. Samsung Galaxy 23 Ultra Original Video Hex Data vs Received Video Hex Data

cont'd

Samsung Galaxy 23 Ultra Original Video	Video After Transfer
entry_count = 6 [stsz] size=12+692 sample_size = 0 sample_count = 171 [stsc] size=12+28 entry_count = 2 [co64] size=12+52 entry_count = 6 [trak] size=8+1647 [tkhd] size=12+80, flags=7 enabled = 1 id = 2 duration = 57599 width = 0.000000 height = 0.000000 [mdia] size=8+1547 [mdhd] size=12+20 timescale = 48000 duration = 276476 duration(ms) = 5759 language = ``` [hdlr] size=12+32 handler_type = soun handler_name = SoundHandle [minf] size=8+1463 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+1403 [stsd] size=12+79 entry-count = 1 [mp4a] size=8+67 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 48000	[vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2412 [stsd] size=12+136 entry-count = 1 [avc1] size=8+124 data_reference_index = 1 width = 720 height = 1280 compressor = [avcC] size=8+38 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 13 NALU Length Size = 4 Sequence Parameter = [67 64 00 1f ac b4 05 a0 50 d3 50 50 60 50 6d 0a 13 50] Picture Parameter = [68 ee 06 f2 c0] [stts] size=12+780 entry_count = 97 [stss] size=12+28 entry_count = 6 [stsc] size=12+40 entry_count = 3 [stsz] size=12+684 sample_size = 0 sample_count = 169 [stco] size=12+672 entry_count = 167

Table 11. Samsung Galaxy 23 Ultra Original Video Hex Data vs Received Video Hex Data

cont'd

Samsung Galaxy 23 Ultra Original Video	Video After Transfer
[esds] size=12+27 [ESDescriptor] size=2+25 es_id = 0 stream_priority = 0 [DecoderConfig] size=2+17 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 768 max_bitrate = 256000 avg_bitrate = 256000 DecoderSpecificInfo = 11 90 [Descriptor:06] size=2+1 [stts] size=12+84 entry_count = 10 [stsz] size=12+1088 sample_size = 0 sample_count = 270 [stsc] size=12+40 entry_count = 3 [co64] size=12+52 entry_count = 6	

For the Samsung Galaxy 23 Ultra, the File Type atom has 2 additional Compatible Brand sections in the received video. The File Header atom in the original video has User Data and Metadata sections the received video does not have. The User Data section is after the Movie Header and the Metadata follows the User Data.

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data

iPhone 14 Original Video	Received Video
[ftyp] size=8+12 major_brand = qt minor_version = 0 compatible_brand = qt [wide] size=8+0 [mdat] size=8+6449462 [moov] size=8+13871 [mvhd] size=12+96 timescale = 600 duration = 3540 duration(ms) = 5900 [trak] size=8+3737 [tkhd] size=12+80, flags=f enabled = 1 id = 1 duration = 3540 width = 1920.000000 height = 1080.000000 [tapt] size=8+60 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 0 entry/media rate = 1 [mdia] size=8+3268 [mdhd] size=12+20 timescale = 600 duration = 3540 duration(ms) = 5900 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+3179 [vmhd] size=12+8, flags=1 graphics_mode = 64 op_color = 0080,0080,0080 [hdlr] size=12+44 handler_type = alis	[ftyp] size=8+20 major_brand = mp42 minor_version = 1 compatible_brand = isom compatible_brand = mp41 compatible_brand = mp42 [mdat] size=16+1208150 [moov] size=8+4764 [mvhd] size=12+96 timescale = 44100 duration = 255780 duration(ms) = 5800 [trak] size=8+2950 [tkhd] size=12+80, flags=1 enabled = 1 id = 1 duration = 255780 width = 464.000000 height = 848.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 255780 entry/media time = 40 entry/media rate = 1 [mdia] size=8+2814 [mdhd] size=12+20 timescale = 600 duration = 3480 duration(ms) = 5800 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+2725 [vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+3059 [stsd] size=12+292 entry-count = 1 [hvc1] size=8+280 data_reference_index = 1 width = 1920 height = 1080 compressor = HEVC [hvcC] size=8+124 Configuration Version = 1 Profile Space = 0 Profile = Main 10 Tier = 0 Profile Compatibility = 20000000 Constraint = b00000000000 Level = 120 Min Spatial Segmentation = 0 Parallelism Type = 0 Chroma Format = 1 Chroma Depth = 10 Luma Depth = 10 Average Frame Rate = 0 Constant Frame Rate = 0 Number Of Temporal Layers = 1 Temporal Id Nested = 0 NALU Length Size = 4 [dvvC] size=8+24 [colr] size=8+10 [amve] size=8+8 [sgpd] size=12+32, version=1 grouping_type = tscl default_length = 20 entry_count = 1 entry 00 = [00 02 00 00 00 00 b3 80 00 00 00 00 78 00 00 00 00 00 00 00] [sgpd] size=12+14, version=1	location = [local to file] [stbl] size=8+2661 [stsd] size=12+167 entry-count = 1 [avc1] size=8+155 data_reference_index = 1 width = 464 height = 848 compressor = [avcC] size=8+34 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 31 NALU Length Size = 4 Sequence Parameter = [27 64 00 1f ac 56 50 74 1a e9 a8 08 08 08 10] Picture Parameter = [28 ee 3c b0] [colr] size=8+11 [pasp] size=8+8 [stts] size=12+12 entry_count = 1 [ctts] size=12+1396 entry_count = 174 [stss] size=12+28 entry_count = 6 [sdtp] size=8+178 [stsc] size=12+40 entry_count = 3 [stsz] size=12+704 sample_size = 0 sample_count = 174 [stco] size=12+44 entry_count = 10 [trak] size=8+1690 [tkhd] size=12+80, flags=1 enabled = 1 id = 2 duration = 255707 width = 0.000000 height = 0.000000

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
grouping_type = sync default_length = 1 entry_count = 2 entry 00 = [14] entry 01 = [15] [sbgp] size=12+120 grouping_type = sync entry_count = 14 [stts] size=12+12 entry_count = 1 [ctts] size=12+1420 entry_count = 177 [cslg] size=8+24 [stss] size=12+32 entry_count = 7 [sdtp] size=8+181 [stsc] size=12+28 entry_count = 2 [stsz] size=12+716 sample_size = 0 sample_count = 177 [stco] size=12+52 entry_count = 12 [meta] size=8+257 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+116 [ilst] size=8+91 [....] size=8+55 [....] size=8+20 [trak] size=8+1838 [tkhd] size=12+80, flags=f enabled = 1 id = 2 duration = 3539 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1	[edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 255707 entry/media time = 2112 entry/media rate = 1 [mdia] size=8+1554 [mdhd] size=12+20 timescale = 44100 duration = 258048 duration(ms) = 5851 language = und [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1465 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+1405 [stsd] size=12+91 entry-count = 1 [mp4a] size=8+79 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 44100 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 64000 avg_bitrate = 64000

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
entry/segment duration = 3539 entry/media time = 2112 entry/media rate = 1 [mdia] size=8+1702 [mdhd] size=12+20 timescale = 44100 duration = 263168 duration(ms) = 5967 language = und [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1613 [smhd] size=12+4 balance = 0 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1497 [stsd] size=12+147 entry-count = 1 [mp4a] size=8+135 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 44100 qt_version = 1 [wave] size=8+83 [frma] size=8+4 original_format = mp4a [mp4a] size=8+4 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5	DecoderSpecificInfo = 12 10 [Descriptor:06] size=5+1 [sgpd] size=12+14, version=1 grouping_type = roll default_length = 2 entry_count = 1 entry 00 = [ff ff] [sbgp] size=12+16 grouping_type = roll entry_count = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+124 entry_count = 10 [stsz] size=12+1016 sample_size = 0 sample_count = 252 [stco] size=12+48 entry_count = 11

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 192000 avg_bitrate = 0 DecoderSpecificInfo = 12 10 [Descriptor:06] size=5+1 [....] size=8+0 [sgpd] size=12+14, version=1 grouping_type = roll default_length = 2 entry_count = 1 entry 00 = [ff ff] [sbgp] size=12+16 grouping_type = roll entry_count = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+136 entry_count = 11 [stsz] size=12+1036 sample_size = 0 sample_count = 257 [stco] size=12+52 entry_count = 12 [trak] size=8+617 [tkhd] size=12+80, flags=f enabled = 1 id = 3 duration = 3540 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
track id = 1 [cdep] size=8+4 [mdia] size=8+449 [mdhd] size=12+20 timescale = 600 duration = 3540 duration(ms) = 5900 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+357 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+225 [stsd] size=12+121 entry-count = 1 [mebx] size=8+109 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 10 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+1126 [tkhd] size=12+80, flags=f enabled = 1 id = 4 duration = 3540 width = 0.000000 height = 0.000000	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
[edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 20 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1 track id = 1 [cdep] size=8+4 [mdia] size=8+958 [mdhd] size=12+20 timescale = 600 duration = 3560 duration(ms) = 5933 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+866 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+734 [stsd] size=12+566 entry-count = 1 [mebx] size=8+554 data_reference_index = 1 [stts] size=12+20 entry_count = 2 [stsc] size=12+28 entry_count = 2 [stsz] size=12+8 sample_size = 100 sample_count = 0	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
[stco] size=12+52 entry_count = 12 [trak] size=8+1144 [tkhd] size=12+80, flags=f enabled = 1 id = 5 duration = 3540 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1 track id = 1 [cdep] size=8+4 [mdia] size=8+976 [mdhd] size=12+20 timescale = 600 duration = 3540 duration(ms) = 5900 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+884 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+752 [stsd] size=12+592	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
entry-count = 1 [mebx] size=8+580 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+28 entry_count = 2 [stsz] size=12+8 sample_size = 208 sample_count = 0 [stco] size=12+52 entry_count = 12 [trak] size=8+1702 [tkhd] size=12+80, flags=f enabled = 1 id = 6 duration = 3540 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 0 entry/media rate = 1 [tref] size=8+12 [rndr] size=8+4 [mdia] size=8+1546 [mdhd] size=12+20 timescale = 10000 duration = 59003 duration(ms) = 5900 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+1454 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1322 [stsd] size=12+170 entry-count = 1 [mebx] size=8+158 data_reference_index = 1 [stts] size=12+1004 entry_count = 125 [stsc] size=12+28 entry_count = 2 [stsz] size=12+8 sample_size = 12 sample_count = 0 [stco] size=12+52 entry_count = 12 [trak] size=8+630 [tkhd] size=12+80, flags=f enabled = 1 id = 7 duration = 3540 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3540 entry/media time = 0 entry/media rate = 1 [mdia] size=8+494 [mdhd] size=12+20 timescale = 600 duration = 3540 duration(ms) = 5900 language = und [hdlr] size=12+40 handler_type = meta	

Table 12. iPhone 14 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 14 Original Video	Received Video
handler_name = Core Media Metadata [minf] size=8+402 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+270 [stsd] size=12+166 entry-count = 1 [mebx] size=8+154 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 44 sample_count = 0 [stco] size=12+8 entry_count = 1 [udta] size=8+0 [free] size=8+1016 [meta] size=8+1641 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+308 [ilst] size=8+259 [....] size=8+24 [....] size=8+24 [....] size=8+43 [....] size=8+21 [....] size=8+29 [....] size=8+22 [....] size=8+40 [free] size=8+1016 [free] size=8+224	

The iPhone 14 device has two additional Compatible Brands within the File Type atom in the received video than it did in the original video. There is a Wide atom after the File Type atom in the original video, but not in the received video. In the original video, there are five additional tracks within the File Header atom which are not in the received video. These were mentioned in the metadata section and are called “metas” within the metadata. In the File Header atom in the original video, there is User Data, Metadata, and two free space sections not in the received video.

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data

iPhone 16e Original Video	Received Video
[ftyp] size=8+12 major_brand = qt minor_version = 0 compatible_brand = qt [wide] size=8+0 [mdat] size=8+10926217 [moov] size=8+10599 [mvhd] size=12+96 timescale = 600 duration = 3239 duration(ms) = 5398 [trak] size=8+2158 [tkhd] size=12+80, flags=f enabled = 1 id = 1 duration = 3239 width = 1920.000000 height = 1080.000000 [tapt] size=8+60 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1	[ftyp] size=8+20 major_brand = mp42 minor_version = 1 compatible_brand = isom compatible_brand = mp41 compatible_brand = mp42 [mdat] size=16+1160013 [moov] size=8+4441 [mvhd] size=12+96 timescale = 44100 duration = 233730 duration(ms) = 5300 [trak] size=8+2751 [tkhd] size=12+80, flags=1 enabled = 1 id = 1 duration = 233730 width = 464.000000 height = 848.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 233730 entry/media time = 40 entry/media rate = 1

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
[mdia] size=8+1693 [mdhd] size=12+20 timescale = 600 duration = 3240 duration(ms) = 5400 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+1604 [vmhd] size=12+8, flags=1 graphics_mode = 64 op_color = 0080,0080,0080 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1484 [stsd] size=12+278 entry-count = 1 [avc1] size=8+266 data_reference_index = 1 width = 1920 height = 1080 compressor = H.264 [avcC] size=8+158 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 40 NALU Length Size = 4 Sequence Parameter = [27 64 00 28 ad 84 30 80 91 01 01 31 02 30 84 44 21 82 80 a8 50 14 05 61 40 a6 0a 21 48 43 02 00 21 04 00 40 04 30 40 08 30 20 41 04 21 88 29 04 16 42 62 24 84 30 40 11 08 02 00 8c 20 10 c1 04 21 08 60 e0 3a 1c 07 01 d8 70 39 83 88 72 10 ff a6 9a 4d 5a 31 52 6c 86 2c 92 c8 a4 31 cb 10 41	[mdia] size=8+2615 [mdhd] size=12+20 timescale = 600 duration = 3180 duration(ms) = 5300 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+2526 [vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2462 [stsd] size=12+167 entry-count = 1 [avc1] size=8+155 data_reference_index = 1 width = 464 height = 848 compressor = [avcC] size=8+34 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 31 NALU Length Size = 4 Sequence Parameter = [27 64 00 1f ac 56 50 74 1a e9 a8 08 08 08 10] Picture Parameter = [28 ee 3c b0] [colr] size=8+11 [pasp] size=8+8 [stts] size=12+12 entry_count = 1 [ctts] size=12+1276 entry_count = 159 [stss] size=12+28

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
11 25 1c 28 c7 16 16 1d 1e 09 05 0b 05 d0 6d 08 7f d7 af 93 f1 1f d7 e6 f8 af 08 70 d6 08 a0 a1 5a 01 e0 08 9f 96 6a 02 02 02 04] Picture Parameter = [28 ee 3c b0] [colr] size=8+10 [stts] size=12+12 entry_count = 1 [stss] size=12+28 entry_count = 6 [sdtp] size=8+166 [stsc] size=12+196 entry_count = 16 [stsz] size=12+656 sample_size = 0 sample_count = 162 [stco] size=12+68 entry_count = 16 [meta] size=8+253 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+116 [ilst] size=8+87 [....] size=8+51 [....] size=8+20 [trak] size=8+1780 [tkhd] size=12+80, flags=f enabled = 1 id = 2 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [mdia] size=8+1644 [mdhd] size=12+20	entry_count = 6 [sdtp] size=8+163 [stsc] size=12+40 entry_count = 3 [stsz] size=12+644 sample_size = 0 sample_count = 159 [stco] size=12+40 entry_count = 9 [trak] size=8+1566 [tkhd] size=12+80, flags=1 enabled = 1 id = 2 duration = 233657 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 233657 entry/media time = 2112 entry/media rate = 1 [mdia] size=8+1430 [mdhd] size=12+20 timescale = 44100 duration = 236544 duration(ms) = 5363 language = und [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1341 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+1281 [stsd] size=12+91

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
timescale = 48000 duration = 262144 duration(ms) = 5461 language = und [elng] size=8+8 [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1539 [smhd] size=12+4 balance = 0 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1423 [stsd] size=12+147 entry-count = 1 [mp4a] size=8+135 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 48000 qt_version = 1 [wave] size=8+83 [frma] size=8+4 original_format = mp4a [mp4a] size=8+4 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 128000	entry-count = 1 [mp4a] size=8+79 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 44100 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 64000 avg_bitrate = 64000 DecoderSpecificInfo = 12 10 [Descriptor:06] size=5+1 [sgpd] size=12+14, version=1 grouping_type = roll default_length = 2 entry_count = 1 entry 00 = [ff ff] [sbgp] size=12+16 grouping_type = roll entry_count = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+88 entry_count = 7 [stsz] size=12+932 sample_size = 0 sample_count = 231 [stco] size=12+44 entry_count = 10

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
avg_bitrate = 128000 DecoderSpecificInfo = 11 90 [Descriptor:06] size=5+1 [....] size=8+0 [stts] size=12+12 entry_count = 1 [stsc] size=12+124 entry_count = 10 [stsz] size=12+1032 sample_size = 0 sample_count = 256 [stco] size=12+48 entry_count = 11 [trak] size=8+2024 [tkhd] size=12+80, flags=e enabled = 0 id = 3 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [tref] size=8+12 [fall] size=8+4 [mdia] size=8+1868 [mdhd] size=12+20 timescale = 48000 duration = 262144 duration(ms) = 5461 language = und [elng] size=8+8 [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1763 [smhd] size=12+4 balance = 0	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
[hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1647 [stsd] size=12+229 entry-count = 1 [apac] size=8+217 data_reference_index = 1 [sgpd] size=12+14, version=1 grouping_type = prol default_length = 2 entry_count = 1 entry 00 = [00 01] [sbgp] size=12+72 grouping_type = prol entry_count = 8 [stts] size=12+12 entry_count = 1 [stss] size=12+20 entry_count = 4 [stsc] size=12+124 entry_count = 10 [stsz] size=12+1032 sample_size = 0 sample_count = 256 [stco] size=12+48 entry_count = 11 [trak] size=8+617 [tkhd] size=12+80, flags=f enabled = 1 id = 4 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1 track id = 1 [cdep] size=8+4 [mdia] size=8+449 [mdhd] size=12+20 timescale = 600 duration = 3240 duration(ms) = 5400 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+357 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+225 [stsd] size=12+121 entry-count = 1 [mebx] size=8+109 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 10 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+603	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
[tkhd] size=12+80, flags=f enabled = 1 id = 5 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [tref] size=8+12 [cdsc] size=8+4 track_id_count = 1 track id = 3 [mdia] size=8+447 [mdhd] size=12+20 timescale = 10000 duration = 54001 duration(ms) = 5400 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+355 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+223 [stsd] size=12+119 entry-count = 1 [mebx] size=8+107 data_reference_index = 1 [stts] size=12+12	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 386 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+1062 [tkhd] size=12+80, flags=f enabled = 1 id = 6 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1 track id = 1 [cdep] size=8+4 [mdia] size=8+894 [mdhd] size=12+20 timescale = 600 duration = 3240 duration(ms) = 5400 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+802 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
[dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+670 [stsd] size=12+566 entry-count = 1 [mebx] size=8+554 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 8 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+1114 [tkhd] size=12+80, flags=f enabled = 1 id = 7 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdsc] size=8+4 track_id_count = 1 track id = 1 [cdep] size=8+4 [mdia] size=8+946 [mdhd] size=12+20 timescale = 600 duration = 3240 duration(ms) = 5400 language = und	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
[hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+854 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+722 [stsd] size=12+566 entry-count = 1 [mebx] size=8+554 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+28 entry_count = 2 [stsz] size=12+8 sample_size = 176 sample_count = 0 [stco] size=12+48 entry_count = 11 [trak] size=8+630 [tkhd] size=12+80, flags=f enabled = 1 id = 8 duration = 3239 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3239 entry/media time = 0 entry/media rate = 1 [mdia] size=8+494 [mdhd] size=12+20	

Table 13. iPhone 16e Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 16e Original Video	Received Video
timescale = 600 duration = 3240 duration(ms) = 5400 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+402 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+270 [stsd] size=12+166 entry-count = 1 [mebx] size=8+154 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 44 sample_count = 0 [stco] size=12+8 entry_count = 1 [meta] size=8+431 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+208 [ilst] size=8+173 [....] size=8+24 [....] size=8+21 [....] size=8+26 [....] size=8+22 [....] size=8+40 [free] size=8+2312	

The File Type atom in the original video from the iPhone 16e has one Compatible Brand section and the received video has three. After the File Type atom, there is a Wide atom in the original video that is not present in the received video. In the original video, the File Header atom has eight tracks and a Metadata section and the File Header atom in the received video only has two tracks and does not have a Metadata section. The original video also has a Free Space atom after the File Header the received video does not contain.

Table 14. Google Pixel 10 Original Video Hex Data vs Received Video Hex Data

Google Pixel 10 Original Video	Received Video
[ftyp] size=8+20 major_brand = isom minor_version = 20000 compatible_brand = isom compatible_brand = iso2 compatible_brand = mp41 [mdat] size=16+16749107 [moov] size=8+10467 [mvhd] size=12+96 timescale = 10000 duration = 65021 duration(ms) = 6502 [udta] size=8+30 [.xyz] size=8+22 [meta] size=8+235 [hdlr] size=12+21 handler_type = mdta handler_name = [keys] size=8+96 [ilst] size=8+90 [....] size=8+20 [....] size=8+24 [....] size=8+22 [trak] size=8+3078 [tkhd] size=12+80, flags=7 enabled = 1	[ftyp] size=8+24 major_brand = isom minor_version = 200 compatible_brand = isom compatible_brand = iso2 compatible_brand = avc1 compatible_brand = mp41 [mdat] size=8+2327637 [moov] size=8+6522 [mvhd] size=12+96 timescale = 6000 duration = 39012 duration(ms) = 6502 [trak] size=8+3947 [tkhd] size=12+80, flags=7 enabled = 1 id = 1 duration = 38680 width = 0.000000 height = 0.000000 [mdia] size=8+3847 [mdhd] size=12+20 timescale = 48000 duration = 309446 duration(ms) = 6446 language = eng [hdlr] size=12+32

Table 14. Google Pixel 10 Original Video Hex Data vs Received Video Hex Data cont'd

Google Pixel 10 Original Video	Received Video
id = 1 duration = 65021 width = 1920.000000 height = 1080.000000 [mdia] size=8+2978 [mdhd] size=12+20 timescale = 90000 duration = 585192 duration(ms) = 6502 language = ``` [hdlr] size=12+32 handler_type = vide handler_name = VideoHandle [minf] size=8+2894 [vmhd] size=12+8 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2830 [stsd] size=12+250 entry-count = 1 [hvc1] size=8+238 data_reference_index = 1 width = 1920 height = 1080 compressor = [hvcC] size=8+117 Configuration Version = 1 Profile Space = 0 Profile = Main Tier = 0 Profile Compatibility = 60000000 Constraint = 0 Level = 123 Min Spatial Segmentation = 0 Parallelism Type = 0 Chroma Format = 1	handler_type = soun handler_name = SoundHandle [minf] size=8+3763 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+3703 [stsd] size=12+79 entry-count = 1 [mp4a] size=8+67 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 48000 [esds] size=12+27 [ESDescriptor] size=2+25 es_id = 0 stream_priority = 0 [DecoderConfig] size=2+17 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 1536 max_bitrate = 192000 avg_bitrate = 48000 DecoderSpecificInfo = 11 90 [Descriptor:06] size=2+1 [stts] size=12+52 entry_count = 6 [stsc] size=12+1612 entry_count = 134 [stsz] size=12+1220 sample_size = 0 sample_count = 303 [stco] size=12+680 entry_count = 169 [trak] size=8+2451

Table 14. Google Pixel 10 Original Video Hex Data vs Received Video Hex Data cont'd

Google Pixel 10 Original Video	Received Video
Chroma Depth = 8 Luma Depth = 8 Average Frame Rate = 0 Constant Frame Rate = 0 Number Of Temporal Layers = 1 Temporal Id Nested = 1 NALU Length Size = 4 [pasp] size=8+8 [colr] size=8+11 [stts] size=12+108 entry_count = 13 [stsz] size=12+788 sample_size = 0 sample_count = 195 [stsc] size=12+16 entry_count = 1 [co64] size=12+1564 entry_count = 195 [stss] size=12+32 entry_count = 7 [trak] size=8+4155 [tkhd] size=12+80, flags=7 enabled = 1 id = 2 duration = 64674 width = 0.000000 height = 0.000000 [edts] size=8+56 [elst] size=12+44, version=1 entry count = 2 entry/segment duration = 7 entry/media time = -1 entry/media rate = 1 entry/segment duration = 64674 entry/media time = 0 entry/media rate = 1 [mdia] size=8+3991 [mdhd] size=12+20 timescale = 48000 duration = 310436 duration(ms) = 6467	[tkhd] size=12+80, flags=7 enabled = 1 id = 2 duration = 39012 width = 720.000000 height = 1280.000000 [mdia] size=8+2351 [mdhd] size=12+20 timescale = 90000 duration = 585192 duration(ms) = 6502 language = eng [hdlr] size=12+32 handler_type = vide handler_name = VideoHandle [minf] size=8+2267 [vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2203 [stsd] size=12+135 entry-count = 1 [avc1] size=8+123 data_reference_index = 1 width = 720 height = 1280 compressor = [avcC] size=8+37 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 31 NALU Length Size = 4 Sequence Parameter = [67 64 00 1f ac d2 02 d0 28 69 a8 08 08 08 3c 20 10 a8] Picture Parameter = [68 ea 8f 2c] [stts] size=12+108

Table 14. Google Pixel 10 Original Video Hex Data vs Received Video Hex Data cont'd

Google Pixel 10 Original Video	Received Video
language = ``` [hdlr] size=12+32 handler_type = soun handler_name = SoundHandle [minf] size=8+3907 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+3847 [stsd] size=12+79 entry-count = 1 [mp4a] size=8+67 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 48000 [esds] size=12+27 [ESDescriptor] size=2+25 es_id = 0 stream_priority = 0 [DecoderConfig] size=2+17 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 768 max_bitrate = 192000 avg_bitrate = 192000 DecoderSpecificInfo = 11 90 [Descriptor:06] size=2+1 [stts] size=12+44 entry_count = 5 [stsz] size=12+1220 sample_size = 0 sample_count = 303 [stsc] size=12+16 entry_count = 1 [co64] size=12+2428	entry_count = 13 [stss] size=12+32 entry_count = 7 [stsc] size=12+400 entry_count = 33 [stsz] size=12+776 sample_size = 0 sample_count = 192 [stco] size=12+680 entry_count = 169

Table 14. Google Pixel 10 Original Video Hex Data vs Received Video Hex Data cont'd

Google Pixel 10 Original Video	Received Video
entry_count = 303 [trak] size=8+2821 [tkhd] size=12+80, flags=7 enabled = 1 id = 3 duration = 65021 width = 0.000000 height = 0.000000 [mdia] size=8+2721 [mdhd] size=12+20 timescale = 90000 duration = 585192 duration(ms) = 6502 language = ``` [hdlr] size=12+31 handler_type = meta handler_name = MetaHandle [minf] size=8+2638 [nmhd] size=12+0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2582 [stsd] size=12+46 entry-count = 1 [mett] size=8+34 data_reference_index = 24948 [stts] size=12+108 entry_count = 13 [stsz] size=12+788 sample_size = 0 sample_count = 195 [stsc] size=12+16 entry_count = 1 [co64] size=12+1564 entry_count = 195	

The Google Pixel 10 original video has three Compatible Brand sections in the File Type atom, and the received video has four. The File Header atom in the original video has a User Data and Metadata section the received video does not have. The User Data section is after the Movie Header in the original file, and the Metadata section is after the User Data. The received video has two tracks in the File Header atom, and the original video has three.

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data

iPhone 15 Original Video	Received Video
[ftyp] size=8+12 major_brand = qt minor_version = 0 compatible_brand = qt [moov] size=8+12752 [mvhd] size=12+96 timescale = 600 duration = 3621 duration(ms) = 6035 [trak] size=8+1858 [tkhd] size=12+80, flags=f enabled = 1 id = 1 duration = 3620 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3620 entry/media time = 2112 entry/media rate = 1 [mdia] size=8+1722 [mdhd] size=12+20 timescale = 44100 duration = 268288 duration(ms) = 6083 language = und [hdlr] size=12+37	[ftyp] size=8+20 major_brand = mp42 minor_version = 1 compatible_brand = isom compatible_brand = mp41 compatible_brand = mp42 [mdat] size=16+1268348 [moov] size=8+4822 [mvhd] size=12+96 timescale = 44100 duration = 261660 duration(ms) = 5933 [trak] size=8+2984 [tkhd] size=12+80, flags=1 enabled = 1 id = 1 duration = 261660 width = 464.000000 height = 848.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 261660 entry/media time = 60 entry/media rate = 1 [mdia] size=8+2848 [mdhd] size=12+20 timescale = 600 duration = 3560

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
handler_type = soun handler_name = Core Media Audio [minf] size=8+1633 [smhd] size=12+4 balance = 0 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1517 [stsd] size=12+147 entry-count = 1 [mp4a] size=8+135 data_reference_index = 1 channel_count = 2 sample_size = 16 sample_rate = 44100 qt_version = 1 [wave] size=8+83 [frma] size=8+4 original_format = mp4a [mp4a] size=8+4 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 192000 avg_bitrate = 0 DecoderSpecificInfo = 12 10 [Descriptor:06] size=5+1 [....] size=8+0 [sgpd] size=12+14, version=1 grouping_type = roll	duration(ms) = 5933 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+2759 [vmhd] size=12+8, flags=1 graphics_mode = 0 op_color = 0000,0000,0000 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+2695 [stsd] size=12+167 entry-count = 1 [avc1] size=8+155 data_reference_index = 1 width = 464 height = 848 compressor = [avcC] size=8+34 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 31 NALU Length Size = 4 Sequence Parameter = [27 64 00 1f ac 56 50 74 1a e9 a8 08 08 08 10] Picture Parameter = [28 ee 3c b0] [colr] size=8+11 [pasp] size=8+8 [stts] size=12+28 entry_count = 3 [ctts] size=12+1412 entry_count = 176 [stss] size=12+32 entry_count = 7 [sdtp] size=8+180 [stsc] size=12+28 entry_count = 2

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
default_length = 2 entry_count = 1 entry 00 = [ff ff] [sbgp] size=12+16 grouping_type = roll entry_count = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+136 entry_count = 11 [stsz] size=12+1056 sample_size = 0 sample_count = 262 [stco] size=12+52 entry_count = 12 [trak] size=8+3522 [tkhd] size=12+80, flags=f enabled = 1 id = 2 duration = 3621 width = 1920.000000 height = 1080.000000 [tapt] size=8+60 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3621 entry/media time = 0 entry/media rate = 1 [mdia] size=8+3058 [mdhd] size=12+20 timescale = 600 duration = 3621 duration(ms) = 6035 language = und [hdlr] size=12+37 handler_type = vide handler_name = Core Media Video [minf] size=8+2969 [vmhd] size=12+8, flags=1	[stsz] size=12+712 sample_size = 0 sample_count = 176 [stco] size=12+44 entry_count = 10 [trak] size=8+1714 [tkhd] size=12+80, flags=1 enabled = 1 id = 2 duration = 261660 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 261660 entry/media time = 2112 entry/media rate = 1 [mdia] size=8+1578 [mdhd] size=12+20 timescale = 44100 duration = 264192 duration(ms) = 5990 language = und [hdlr] size=12+37 handler_type = soun handler_name = Core Media Audio [minf] size=8+1489 [smhd] size=12+4 balance = 0 [dinf] size=8+28 [dref] size=12+16 [url] size=12+0, flags=1 location = [local to file] [stbl] size=8+1429 [stsd] size=12+91 entry-count = 1 [mp4a] size=8+79 data_reference_index = 1 channel_count = 2 sample_size = 16

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
graphics_mode = 64 op_color = 0080,0080,0080 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+2849 [stsd] size=12+156 entry-count = 1 [avc1] size=8+144 data_reference_index = 1 width = 1920 height = 1080 compressor = H.264 [avcC] size=8+36 Configuration Version = 1 Profile = High Profile Compatibility = 0 Level = 40 NALU Length Size = 4 Sequence Parameter = [27 64 00 28 ac 56 50 1e 00 89 f9 66 a0 20 20 20 40] Picture Parameter = [28 ee 3c b0] [colr] size=8+10 [stts] size=12+44 entry_count = 5 [ctts] size=12+1452 entry_count = 181 [cslg] size=8+24 [stss] size=12+32 entry_count = 7 [sdtp] size=8+185 [stsc] size=12+64 entry_count = 5 [stsz] size=12+732 sample_size = 0 sample_count = 181	sample_rate = 44100 [esds] size=12+39 [ESDescriptor] size=5+34 es_id = 0 stream_priority = 0 [DecoderConfig] size=5+20 stream_type = 5 object_type = 64 up_stream = 0 buffer_size = 6144 max_bitrate = 64000 avg_bitrate = 64000 DecoderSpecificInfo = 12 10 [Descriptor:06] size=5+1 [sgpd] size=12+14, version=1 grouping_type = roll default_length = 2 entry_count = 1 entry 00 = [ff ff] [sbgp] size=12+16 grouping_type = roll entry_count = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+124 entry_count = 10 [stsz] size=12+1040 sample_size = 0 sample_count = 258 [stco] size=12+48 entry_count = 11

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
[stco] size=12+60 entry_count = 14 [meta] size=8+252 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+116 [ilst] size=8+86 [....] size=8+50 [....] size=8+20 [trak] size=8+617 [tkhd] size=12+80, flags=f enabled = 1 id = 3 duration = 3620 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3620 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdep] size=8+4 [cdsc] size=8+4 track_id_count = 1 track id = 2 [mdia] size=8+449 [mdhd] size=12+20 timescale = 600 duration = 3620 duration(ms) = 6033 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+357 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+225 [stsd] size=12+121 entry-count = 1 [mebx] size=8+109 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 10 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+1062 [tkhd] size=12+80, flags=f enabled = 1 id = 4 duration = 3620 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3620 entry/media time = 0 entry/media rate = 1 [tref] size=8+24 [cdep] size=8+4 [cdsc] size=8+4 track_id_count = 1 track id = 2 [mdia] size=8+894 [mdhd] size=12+20 timescale = 600 duration = 3620	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
duration(ms) = 6033 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+802 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+670 [stsd] size=12+566 entry-count = 1 [mebx] size=8+554 data_reference_index = 1 [stts] size=12+12 entry_count = 1 [stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 8 sample_count = 0 [stco] size=12+8 entry_count = 1 [trak] size=8+1781 [tkhd] size=12+80, flags=f enabled = 1 id = 5 duration = 3620 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3620 entry/media time = 0 entry/media rate = 1	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
[tref] size=8+24 [cdep] size=8+4 [cdsc] size=8+4 track_id_count = 1 track id = 2 [mdia] size=8+1613 [mdhd] size=12+20 timescale = 600 duration = 3620 duration(ms) = 6033 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+1521 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+1389 [stsd] size=12+589 entry-count = 1 [mebx] size=8+577 data_reference_index = 1 [stts] size=12+52 entry_count = 6 [stsc] size=12+172 entry_count = 14 [stsz] size=12+8 sample_size = 144 sample_count = 0 [stco] size=12+508 entry_count = 126 [trak] size=8+2498 [tkhd] size=12+80, flags=f enabled = 1 id = 6	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
duration = 3619 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3619 entry/media time = 0 entry/media rate = 1 [tref] size=8+12 [rndr] size=8+4 [mdia] size=8+2342 [mdhd] size=12+20 timescale = 10000 duration = 60333 duration(ms) = 6033 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+2250 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+2118 [stsd] size=12+170 entry-count = 1 [mebx] size=8+158 data_reference_index = 1 [stts] size=12+1156 entry_count = 144 [stsc] size=12+220 entry_count = 18 [stsz] size=12+8 sample_size = 12	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
sample_count = 0 [stco] size=12+504 entry_count = 125 [trak] size=8+630 [tkhd] size=12+80, flags=f enabled = 1 id = 7 duration = 3620 width = 0.000000 height = 0.000000 [edts] size=8+28 [elst] size=12+16 entry count = 1 entry/segment duration = 3620 entry/media time = 0 entry/media rate = 1 [mdia] size=8+494 [mdhd] size=12+20 timescale = 600 duration = 3620 duration(ms) = 6033 language = und [hdlr] size=12+40 handler_type = meta handler_name = Core Media Metadata [minf] size=8+402 [gmhd] size=8+24 [hdlr] size=12+44 handler_type = alis handler_name = Core Media Data Handler [dinf] size=8+28 [dref] size=12+16 [alis] size=8+4 [stbl] size=8+270 [stsd] size=12+166 entry-count = 1 [mebx] size=8+154 data_reference_index = 1 [stts] size=12+12 entry_count = 1	

Table 15. iPhone 15 Original Video Hex Data vs Received Video Hex Data cont'd

iPhone 15 Original Video	Received Video
[stsc] size=12+16 entry_count = 1 [stsz] size=12+8 sample_size = 44 sample_count = 0 [stco] size=12+8 entry_count = 1 [meta] size=8+612 [hdlr] size=12+22 handler_type = mdta handler_name = [keys] size=8+308 [ilst] size=8+254 [....] size=8+25 [....] size=8+24 [....] size=8+43 [....] size=8+21 [....] size=8+25 [....] size=8+20 [....] size=8+40 [wide] size=8+0 [mdat] size=8+9669041	

The iPhone 15 original video has one Compatible Brand section in the File Type atom, whereas the received video has three Compatible Brand sections. The Data section of the original video is after the File Header and Wide atoms, but in the received video it is before the File Header atom and there is no wide atom. The File Header atom has seven tracks and a Metadata section in the original video, but only two tracks, and no Metadata section were in the received. The structure of a video file, from the mobile phones studied, is shown to have changed throughout the Telegram transfer process when the hex data was analyzed.

The table below summarizes the results of this study.

Table 16. Summary of Results

Metric	Match Count	Total Files	Match Rate (%)
File Container Hash	0	47	0
Video Stream Hash	0	47	0
Audio Stream Hash	0	47	0
Metadata	0	47	0
File Structure (Atom Layout)	0	47	0

VI. CONCLUSIONS

The hash values, stream hash values, a portion of the metadata, and a portion of the hex data of videos created by mobile phones and transferred through Telegram via mobile phones, are changed during the transfer. The method of transferring videos through Telegram destroys the integrity of the video files and this transfer process compromises video evidence.

Discussion

Because the videos transferred through Telegram using mobile phones have structural and metadata changes, the videos are not authentic to the originals. This is shown through the lack of ability to verify hash and stream hashes of the videos, as well as changes shown from the metadata and hex analyses. Over 40 videos were tested for this thesis from five different mobile phones, and all of them were altered by Telegram.

The original videos transferred through Telegram resulted in multiple received videos. All the received videos for an original video had matching hash values and stream hash values, along with metadata and hex verification that proved the received videos for each original video are the same file. This indicates the changes made to the videos did not happen on the downloading device, but during its transfer via the Telegram app.

The Telegram transfer process does not keep the integrity of videos intact. This transfer process is proven to change video evidence sent between mobile phones using the Telegram application.

Future Research

Future research related to this topic can include quantifying the differences of the original and received videos further by using analysis methods to reflect not only the transfer process did change the video, but how much the Telegram transfer process altered the video. Analysis can be

conducted with this data including color space analysis, motion detection changes, and perceptual hashing. Whether the transcoding of the videos is occurring when the user uploads a video to Telegram, when it sends, if it takes place on a Telegram server, etc. can be researched more. Lastly, there was no found research relating to Telegram-transferred media files, so more research can be conducted with Telegram using different devices and different forms of media.

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