Annual ADFSL Conference on Digital Forensics, Security and Law

2022
Proceedings

Digital Forensics for Mobility as A Service Platform: Analysis of Uber Application on iPhone and Cloud

Nina Matulis
Purdue University

Umit Karabiyik
Purdue University

Scholarly Commons Citation

Matulis, Nina and Karabiyik, Umit, "Digital Forensics for Mobility as A Service Platform: Analysis of Uber Application on iPhone and Cloud" (2022). *Annual ADFSL Conference on Digital Forensics, Security and Law*. 5.
https://commons.erau.edu/adfsl/2022/presentations/5

DIGITAL FORENSICS FOR MOBILITY AS A SERVICE PLATFORM: ANALYSIS OF UBER APPLICATION ON IPHONE AND CLOUD

Nina Matulis[1], Umit Karabiyik[2]
Purdue University
Computer and Information Technology
West Lafayette, IN 47907, United States
[1]nmatulis@purdue.edu, [2]umit@purdue.edu

ABSTRACT

Uber is a ride-hailing smartphone application (app) that allows users to order a ride in a highly efficient manner. The Uber app provides Mobility as a Service and allows users to easily order a ride in a private car with just a few clicks. Uber stores large amounts of data on both the mobile device the app is being used on, and in the cloud. Examples of this data include geolocation data, date/time, origin/destination addresses, departure/arrival times, and distance. Uber geolocation data has been previously researched to investigate the privacy of the Uber app; however, there is minimal research relating to the other data the Uber app collects. Because this data could be of significance in a forensic investigation, it is important to determine where the majority of the Uber data are stored, either in the cloud or on the mobile device itself, and if one of these storage locations contains more information than the other. In this study, we analyzed the Uber app by forensically imaging the iPhone running the Uber app in three different acquisition phases. The different acquisitions allowed us to compare the data before and after data population, determine where the majority of the Uber data are stored, and determine if jailbreaking the iPhone provided more data than the previous acquisitions. Obtaining and analyzing the data in this study was done using Magnet AXIOM and Cellebrite forensic software suites.

Keywords: Uber, Mobility as a Service, Ride-Sharing Apps, Forensic Investigation, iOS Forensics, Mobile Forensics, Cloud Forensics

1. INTRODUCTION

The mobile app, Uber, is the most used ride-hailing app in the world (Toniuk, 2019), with 4.98 billion trips completed in 2020 alone (Iqbal, 2022). However, there are many reports of sexual assaults during Uber rides (see Fig. 1). According to Uber's Privacy Notice released in 2018, from the years 2017 to 2018, there was a total of 5,981 reports of sexual assault during an Uber ride (*Uber Privacy Notice*, 2021). Additionally, there were 9 reports of murder during an Uber ride, and 58 users killed due to car accidents in the year 2018 (Conger, 2019).

Following the release of Uber's Privacy Notice, a similar ride-sharing app, Lyft, also reported various crimes occurring during rides. According to Lyft's Community Safety Report, in 2019, over 1,800 sexual assaults were reported (Lyft, 2021). Lyft's Community Safety Report also stated that the amount of sexual assault reports has continuously increased across the years, with 1,096 in 2017 to 1,255 in 2018 and 1,807 in 2019 (Press, 2021).

There are previous studies that explore the connection between the geolocation data Uber stores and user privacy. However, as the use of the Uber app increases, it is necessary to analyze the data that the app collects, and determine how the data can be utilized in forensic investigations. Additionally, these previous works have not focused on the use of the Uber app on a specific platform. In this study, these gaps will be filled by determining how the geolocation data and Personally Identifiable Information (PII) that the Uber app collects can be used as evidence in forensic investigations, specifically, on iOS devices.

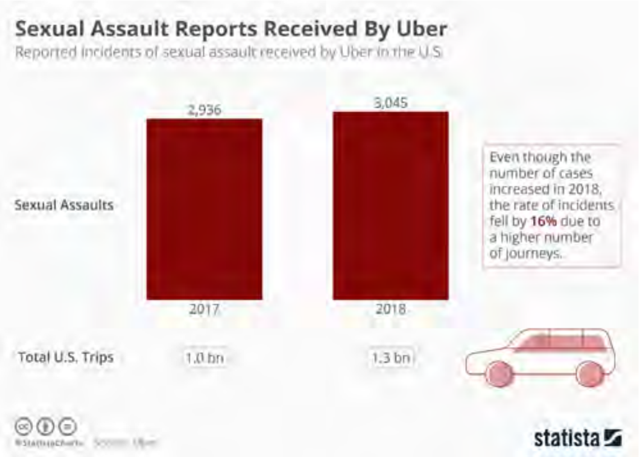


Figure 1: Sexual assault reports during Uber rides in 2017 and 2018

This study of the Uber app focuses on determining what PII and geolocation data the Uber app stores, and how this data could be used in a forensic investigation. With increased utilization of cloud storage, we also analyze how much data Uber stores in the cloud versus on the device the Uber app is used on. Determining the specific PII and geolocation data, and where this data are stored would considerably benefit any forensic investigation where the use of Uber was involved.

The contributions of this study includes:

- Raising awareness for the Uber app users about what PII of theirs are stored by the application.
- Providing an investigative roadmap and framework to the forensic investigators to follow when obtaining forensic evidence from the Uber app on Apple devices.

This paper is organized as follows: Works related to analyzing forensic artifacts from the Uber app is discussed in Section II. In section III, the methodology of obtaining and analyzing the forensic images used in this study is discussed. The results of our analyses are presented in Section IV, and discussion and conclusions are reflected in Section V. Lastly, challenges faced during this study are followed in Section VI, followed by future research in Section VII.

2. RELATED WORK

In this section, the works related to Uber forensics are discussed. While previous studies regarding how Uber geolocation data can be used in a forensic investigation are limited, works focused on the privacy violations of the Uber app are discussed below.

Although determining how the geolocation data from the Uber app is forensically relevant has not been studied, Leszczynski (2019) completed a study which discussed how Uber utilizes Google Maps. Leszczynski (2019) reports that the Uber app uses Google Maps that provide in-route navigation, allow the user's real-time position to be displayed, as well as show potential Uber drivers in the near proximity. Once a ride is hailed, the Google Maps interface allows the user to visually track their approaching driver in real-time, including an estimated time of arrival (ETA) based on any normal traffic the driver may encounter (Leszczynski, 2019). Additionally, riders can share their real-time ride status and estimated time of arrival with their contacts (Leszczynski, 2019). In this study, we focus on the user's ride status, and attempt to recover the trip data that the Uber app displays to its users, focusing on where this data are stored. Additionally, we will investigate whether this data are stored in the cloud or on the device itself.

Researchers at Northeastern University investigated how the real-time algorithm Uber uses affects the pricing of Uber rides. According to Chen et al. (2015), when a user opens and authenticates the Uber app to find a ride, the Uber app sends pingClient messages to Uber's server every 5 seconds, in which the server responds with a JSON-encoded list of available rides (Chen et al., 2015). However, although the ping includes geolocation data of the user, the data are while the user is idle and not yet in the vehicle. The authors wrote a script that acts as if it were the Uber Client app to collect the user geolocation data when the user is requesting a ride, however it does not collect geolocation data when the user's ride is occurring (Chen et al., 2015). Although (Leszczynski, 2019) has done a more in-depth investigation of what geolocation data the client has access to, our study will fill remaining the gaps of both (Leszczynski, 2019) and (Chen et al., 2015), by determining if the client's geolocation data during a ride is able to be recovered and where it is stored.

A research group at Pace University published research of how the Uber app violates its privacy statement by tracking the location of its users longer than 5 minutes after the conclusion of a ride, and when the app is not in use (Hayes, Snow, & Altuwayjiri, 2017). However, this study also discussed the user data that the Uber app collects, as printed in its privacy statement. According to Uber's privacy statement (*Uber Privacy Notice*, 2021), the app collects the following user PII:

1. Personal data provided by users to Uber, such as during account creation

2. Personal data created during the use of Uber services, such as location, app usage, and device data

3. Personal data from other sources, such as other users or account owners, business partners, vendors, insurance and financial solution providers, and governmental authorities

Hayes et al. (2017) details the device information Uber collects, those of which are of interest to our study include: hardware model, operating system and version, unique device identifier, serial number, device motion information, and mobile network information. Also referenced in (Hayes et al., 2017) was another statement from Uber's privacy statement (*Uber Privacy Notice*, 2021), which stated that Uber "may also collect the precise location of your device when the app is running in the foreground or background." To complete their research, Hayes et al. (2017) completed a forensic analysis to determine which of this user information could be recovered from the Uber app using the software: Debookee by iwaxx and Blacklight by BlackBag. Our study will follow a similar methodology and focus of recovering forensic artifacts from the app, however will utilize different forensic software, Magnet AXIOM and Cellebrite.

Salamh et al. (2021) completed an Unmanned Aerial Vehicle (UAV) forensic analysis in which they utilized various forensic tools to analyze the data are able to be recovered from two UAV models. Included in the data that was attempted to be recovered was PII and flight trajectories. In this study, the forensic tools Magnet AXIOM and Cellebrite. Salamh et al. (2021) were able to partially recover PII, GPS tracks and flight logs using both Magnet Axiom and Cellebrite. Although our study utilizes the Uber app as opposed to UAVs, we will follow a similar analysis method to obtain PII, GPS data and Uber ride logs by utilizing Magnet AXIOM and Cellebrite in the same manner as (Salamh et al., 2021).

Similar to (Salamh et al., 2021), Stankovic et. al. (2021) completed a UAV forensics case study on the DJI Mini 2 in which they utilized various forensic tools to analyze the data are able to be recovered from two UAV models. Included in the data that was attempted to be recovered was PII and flight trajectories. In this study, the forensic tools Magnet AXIOM and Cellebrite. Salamh et al. (2021) were able to partially recover PII, GPS tracks and flight logs using both Magnet Axiom and Cellebrite. Although our study utilizes the Uber app as opposed to UAVs, we will follow a similar analysis method to obtain PII, GPS data and Uber ride logs by utilizing Magnet AXIOM and Cellebrite in the same manner as (Salamh et al., 2021).

3. METHODOLOGY

This study follows the standard mobile forensic procedures put forth by the National Institute

Table 1: Details of Software Used

Forensic Software	Version
Magnet AXIOM Process	4.11.0.233338
Magnet AXIOM Examine	4.11.0.233338
Cellebrite UFED 4PC	7.44.0.80
Cellebrite Physical Analyzer	7.42.0.50
Cellebrite Reader	7.42.0.50

of Standards and Technology (NIST) (Ayers, Brothers, & Jansen, n.d.) to obtain and analyze images on the device chosen for this study. The device utilized and chosen was an iPhone 7 Plus running iOS 13.5.1 which was pre-populated with Uber data. The iPhone 7 Plus was used to ensure the device could be jailbroken.

The tools used for acquisition and analysis are depicted in Table 1 with their version numbers. These tools were utilized as they are court accepted forensics tools and have the ability to acquire the necessary types of forensic images from iPhones. Initially, Magnet AXIOM was intended to be the sole software used in this study. However, after multiple failed logical acquisitions, Cellebrite UFED 4PC was used instead.

Two forensic workstations were used in this study. The first was an ASUS ZenBook running Windows 10 Home 64-Bit, utilizing an AMD Ryzen 5 4500U CPU with 8GB of RAM. The second was and a desktop computer running Windows 10 64-bit and utilizing an Intel Core i7-8700K processor with 16GB of RAM.

Existing iCloud and Uber accounts were used in this study. The following steps involved in this study include:

1. Obtain an iPhone 7 Plus with previously downloaded Uber app.

2. Perform baseline logical and cloud acquisitions using Magnet AXIOM.

3. Examine the baseline logical and cloud images using Magnet AXIOM.

4. Populate the device with data in accordance with the NIST guidelines.

5. Perform second logical and cloud acquisitions.

6. Perform an advanced logical full file system acquisition using Cellebrite UFED 4PC.

7. Perform full file system analyses of all acquisitions using Magnet AXIOM and Cellebrite Physical Analyzer.

The general methodology used to collect Uber data and obtain and analyze forensic images for this study is shown in Fig. 2.

3.1 Data Population

The Uber app with an active user account was already downloaded onto the iPhone 7 Plus. The iPhone was pre-populated with Uber data with trips from 2015 - present.

Once the pre-populated data had been acquired, the iPhone was populated with test data in accordance with National Institute of Standards and Technology (NIST) Standards (Ayers et al., n.d.). The test data was obtained by using the Uber app for transportation, and consisted of multiple Uber rides using the iPhone 7 Plus. When sample data was being collected, location services and connection to a personal hotspot were enabled to allow the app to collect data without being connected to Wi-Fi or a cellular network.

3.2 Analysis

Initial forensic imaging was completed in order to analyze the Uber data that was pre-populated on the iPhone 7 Plus. Both a logical and a cloud acquisition were completed using Magnet AXIOM. In order to carry out a cloud acquisition, iCloud credentials were entered during the imaging process. A logical acquisition was completed as only the Uber app data was necessary to obtain. A cloud acquisition was completed to determine what information Uber stores in the cloud. With both acquisitions, it would then be possible to determine how much data are stored in the cloud versus the device itself.

Once these initial images were obtained, the sample data was collected by using the Uber app on the test device in accordance with the NIST Standards (Ayers et al., n.d.). After data population, additional logical and cloud acquisitions were obtained using Magnet AXIOM and

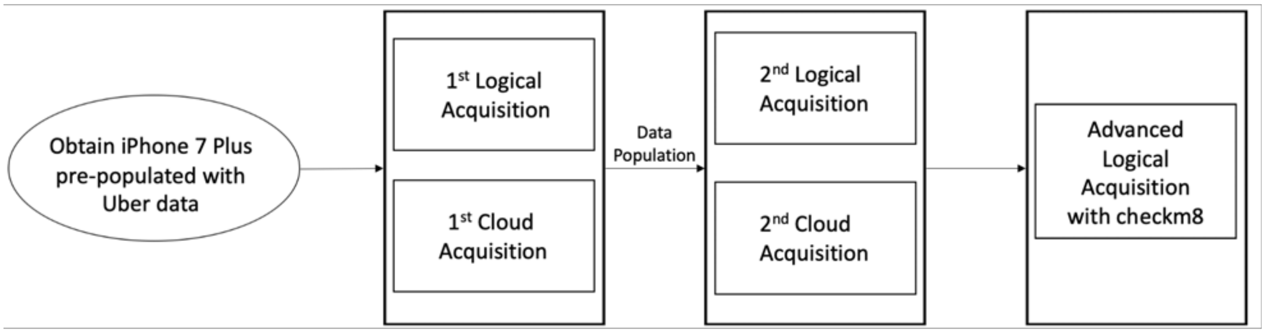


Figure 2: Research methodology flow chart

Table 2: Details of Acquisitions Performed

Acquisition Type	**Forensic Software Used**	**Purpose**
Logical #1	Magnet AXIOM	Obtain pre-populated data
Cloud #1	Magnet AXIOM	Obtain pre-populated data
Logical #2	Cellebrite UFED	Obtain data after data population
Cloud #2	Magnet AXIOM	Obtain cloud data after data population
Physical	Cellebrite UFED	Obtain bit-by-bit image after data population

Cellebrite UFED. By re-imaging the iPhone 7 Plus after data population, it was possible to determine where the data from the test rides were stored.

Once the second round of logical and cloud acquisitions were complete, the device was jailbroken and an advanced logical image was acquired using Cellebrite UFED. By obtaining an advanced logical image, we could then determine if more data was available than the previous logical and cloud images. Additionally, a thorough analysis of the file system would be possible as the iPhone was jailbroken. Each acquisition is depicted in Table 2.

All acquisitions were then analyzed using Magnet AXIOM Examine, Cellebrite Physical Analyzer, and Cellebrite Reader. A full file system analysis of each acquisition was performed.

Upon obtaining the images, there were two main goals of this study:

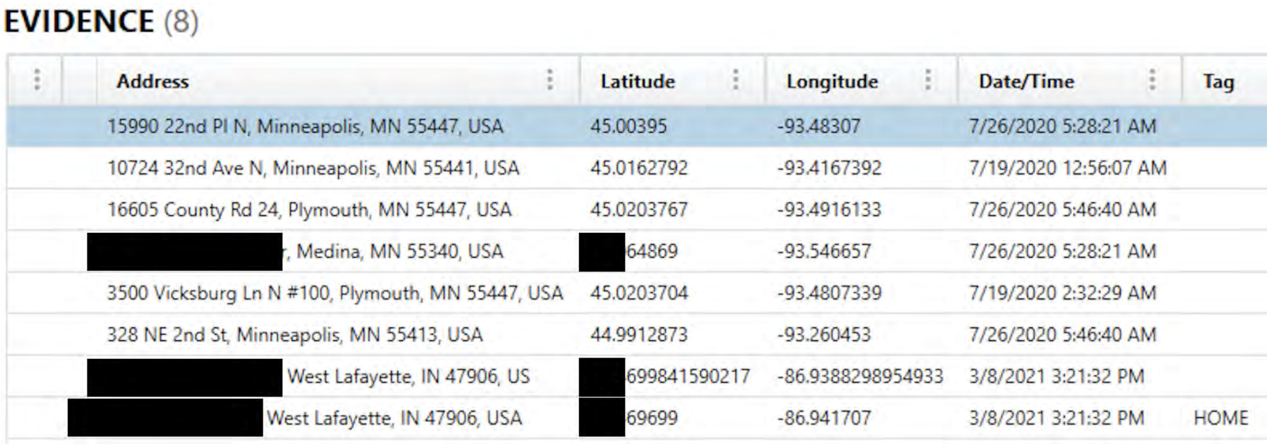
1. Compare the logical/cloud acquisitions to the advanced logical acquisition to determine if more Uber data can be obtained after jailbreaking the iPhone.

2. Determine the data that can be recovered from each of the three types of acquisitions (Logical, cloud, and advanced logical).

4. RESULTS

4.1 First Logical & Cloud Acquisitions

The 1st logical acquisition was obtained using Magnet AXIOM. The acquisition found 8 Uber Cached Locations stored on the iPhone 7 Plus. The Uber trip data obtained from the 8 cached locations includes: Address, Latitude, Longitude, Date/Time, and a Tag for 1 address (see Fig. 3).



EVIDENCE (8)

Address	Latitude	Longitude	Date/Time	Tag
15990 22nd Pl N, Minneapolis, MN 55447, USA	45.00395	-93.48307	7/26/2020 5:28:21 AM	
10724 32nd Ave N, Minneapolis, MN 55441, USA	45.0162792	-93.4167392	7/19/2020 12:56:07 AM	
16605 County Rd 24, Plymouth, MN 55447, USA	45.0203767	-93.4916133	7/26/2020 5:46:40 AM	
[redacted], Medina, MN 55340, USA	[redacted]64869	-93.546657	7/26/2020 5:28:21 AM	
3500 Vicksburg Ln N #100, Plymouth, MN 55447, USA	45.0203704	-93.4807339	7/19/2020 2:32:29 AM	
328 NE 2nd St, Minneapolis, MN 55413, USA	44.9912873	-93.260453	7/26/2020 5:46:40 AM	
[redacted] West Lafayette, IN 47906, US	[redacted]699841590217	-86.9388298954933	3/8/2021 3:21:32 PM	
[redacted] West Lafayette, IN 47906, USA	[redacted]69699	-86.941707	3/8/2021 3:21:32 PM	HOME

Figure 3: Data obtained from the first logical acquisition, 8 cached Uber trips

The Uber trip data obtained from the 353 trips stored in the cloud include: Origin address, origin latitude/longitude, departure date and time, destination address, destination latitude/longitude, arrival date/time, rider ID, ride distance, ride duration, cost, trip status, trip ID, driver name, driver ID, vehicle make and year, map title URL, any attachments, and the image source (see Fig. 4).

4.2 Second Logical & Cloud Acquisitions

Following data population, the 2nd logical acquisition was obtained using Cellebrite UFED. The acquisition found 4 Uber cached locations stored on the iPhone 7 Plus. The Uber trip data obtained from the 4 cached locations includes: timestamp, address, and latitude/longitude (see Fig. 5).

File system analysis showed that Uber cached locations were stored in *\Nina's Iphone\mobile \Containers \Data \app \com.ubercab.UberClient\documents\database.db* file, in the *place* table. The *place* table stored information from 4 Uber cached locations. These recovered artifacts include a timestamp in Epoch time, *uber_id*, address (*title_segment, subtitle_segment*), and GPS location (*latitude_v2, longitude_v2*) (see Fig. 6)

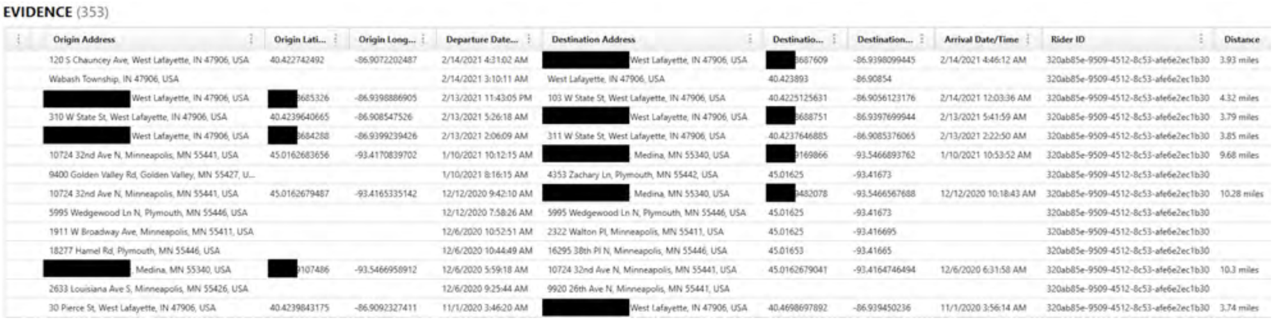
Additional analysis of the file system revealed additional data from the Uber app was stored in *\Nina's Iphone \mobile \Containers \Data \app \com.ubercab.UberClient \Library \app Support \com.uber.MegaLib \unified-reporter-client.uspan.objectfeed\000196.log* file (see Fig. 5). Two additional log files, 000186.log and 000189.log, stored similar Uber data and were located at the same path location, however, the file 000196.log stored the most information (see Fig. 7).

The 2nd cloud acquisition was completed using Magnet AXIOM. 357 Uber trips were stored following data population. The Uber trip data obtained from the 357 locations stored in the cloud include: Origin address, origin latitude/longitude, departure date and time, destination address, destination latitude/longitude, arrival date/time, rider ID, ride distance, ride duration, cost, trip status, trip ID, driver name, driver ID, vehicle make and year, map title URL, attachments, and the image source (see Fig. 8).

4.3 Advanced Logical Acquisition

The advanced logical acquisition was obtained using Cellebrite UFED 4PC and imaged the full file system of the iPhone, and also utilized the jailbreak exploit, checkm8. The acquisition found 4 Uber Cached locations stored on the iPhone 7 Plus. The data from these 4 Uber trips were stored in a database in the table *fts_place_table*.

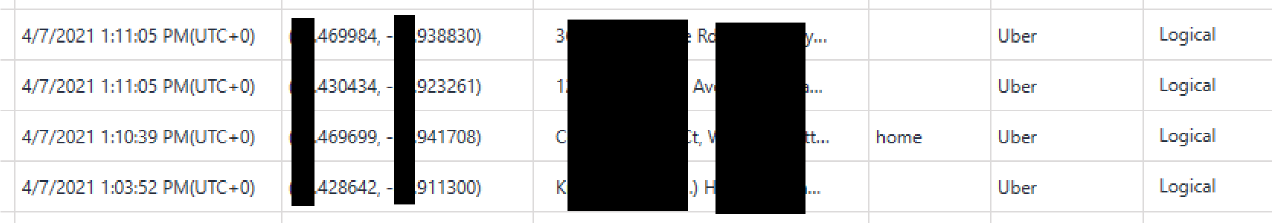
Additionally, addresses from Uber rides were stored in the table *fts_place_table_segdir*. However, the older rides were not organized in a way



EVIDENCE (353)

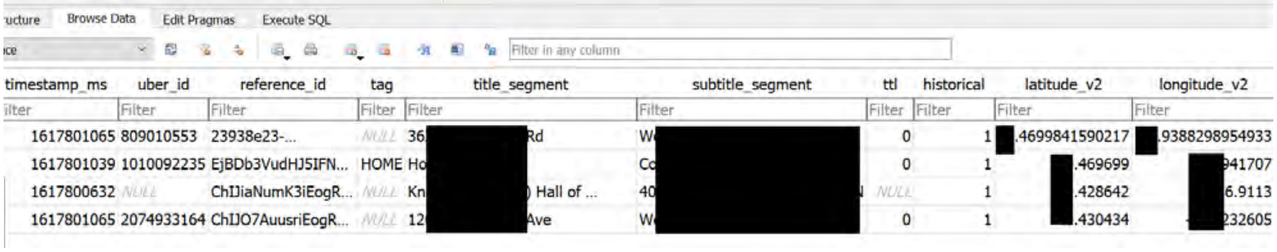
Origin Address	Origin Lati...	Origin Long...	Departure Date...	Destination Address	Destinatio...	Destination...	Arrival Date/Time	Rider ID	Distance
120 S Chauncey Ave, West Lafayette, IN 47906, USA	40.422742492	-86.9072202487	2/14/2021 4:31:02 AM	[redacted]West Lafayette, IN 47906, USA	[redacted]3687609	-86.9398099445	2/14/2021 4:46:12 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	3.93 miles
Wabash Township, IN 47906, USA			2/14/2021 3:10:11 AM	West Lafayette, IN 47906, USA	40.423893	-86.90854		320ab85e-9509-4512-8c53-afe6e2ec1b30	
[redacted]West Lafayette, IN 47906, USA	[redacted]3685326	-86.9398886905	2/13/2021 11:43:05 PM	103 W State St, West Lafayette, IN 47906, USA	40.4225125631	-86.9056123176	2/14/2021 12:03:36 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	4.32 miles
310 W State St, West Lafayette, IN 47906, USA	40.4239640665	-86.908547526	2/13/2021 5:26:18 AM	[redacted]West Lafayette, IN 47906, USA	[redacted]3688751	-86.9397699944	2/13/2021 5:41:59 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	3.79 miles
[redacted]West Lafayette, IN 47906, USA	[redacted]3684288	-86.9399239426	2/13/2021 2:06:09 AM	311 W State St, West Lafayette, IN 47906, USA	40.4237646885	-86.9085376065	2/13/2021 2:22:50 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	3.85 miles
10724 32nd Ave N, Minneapolis, MN 55441, USA	45.0162683656	-93.4170839702	1/10/2021 10:12:15 AM	[redacted] Medina, MN 55340, USA	[redacted]9169866	-93.5466893762	1/10/2021 10:53:52 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	9.68 miles
9400 Golden Valley Rd, Golden Valley, MN 55427, U...			1/10/2021 8:16:15 AM	4353 Zachary Ln, Plymouth, MN 55442, USA	45.01625	-93.41673		320ab85e-9509-4512-8c53-afe6e2ec1b30	
10724 32nd Ave N, Minneapolis, MN 55441, USA	45.0162679487	-93.4165335142	12/12/2020 9:42:10 AM	[redacted] Medina, MN 55340, USA	[redacted]9482078	-93.5466567688	12/12/2020 10:18:43 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	10.28 miles
5995 Wedgewood Ln N, Plymouth, MN 55446, USA			12/12/2020 7:58:26 AM	5995 Wedgewood Ln N, Plymouth, MN 55446, USA	45.01625	-93.41673		320ab85e-9509-4512-8c53-afe6e2ec1b30	
1911 W Broadway Ave, Minneapolis, MN 55411, USA			12/6/2020 10:52:51 AM	2322 Walton Pl, Minneapolis, MN 55411, USA	45.01625	-93.416695		320ab85e-9509-4512-8c53-afe6e2ec1b30	
18277 Hamel Rd, Plymouth, MN 55446, USA			12/6/2020 10:44:49 AM	16295 38th Pl N, Minneapolis, MN 55446, USA	45.01653	-93.41665		320ab85e-9509-4512-8c53-afe6e2ec1b30	
[redacted], Medina, MN 55340, USA	[redacted]9107486	-93.5466958912	12/6/2020 5:59:18 AM	10724 32nd Ave N, Minneapolis, MN 55441, USA	45.0162679041	-93.4164746494	12/6/2020 6:31:58 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	10.3 miles
2633 Louisiana Ave S, Minneapolis, MN 55426, USA			12/6/2020 9:25:44 AM	9920 26th Ave N, Minneapolis, MN 55441, USA				320ab85e-9509-4512-8c53-afe6e2ec1b30	
30 Pierce St, West Lafayette, IN 47906, USA	40.4239843175	-86.9092327411	11/1/2020 3:46:20 AM	[redacted]West Lafayette, IN 47906, USA	40.4698697892	-86.939450236	11/1/2020 3:56:14 AM	320ab85e-9509-4512-8c53-afe6e2ec1b30	3.74 miles

Figure 4: Partial cloud data obtained from the first Cloud acquisition, 353 Uber trips



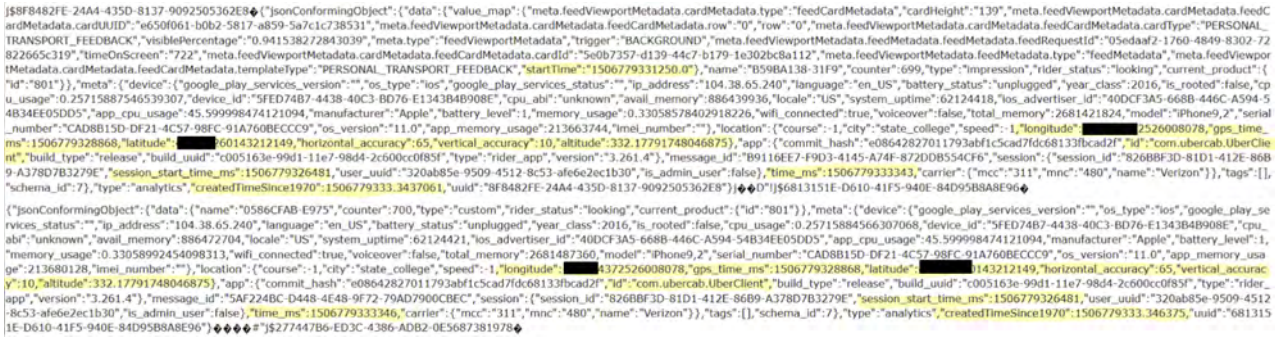
4/7/2021 1:11:05 PM(UTC+0)	([redacted].469984, -[redacted]938830)	3[redacted] Ro[redacted]y...		Uber	Logical
4/7/2021 1:11:05 PM(UTC+0)	([redacted].430434, -[redacted]923261)	1[redacted] Av[redacted]a...		Uber	Logical
4/7/2021 1:10:39 PM(UTC+0)	([redacted].469699, -[redacted]941708)	C[redacted]t, V[redacted]tt...	home	Uber	Logical
4/7/2021 1:03:52 PM(UTC+0)	([redacted].428642, -[redacted]911300)	K[redacted].) H[redacted]a...		Uber	Logical

Figure 5: Data obtained from the second logical acquisition, 4 cached Uber trips



timestamp_ms	uber_id	reference_id	tag	title_segment	subtitle_segment	ttl	historical	latitude_v2	longitude_v2
ilter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter
1617801065	809010553	23938e23-...	NULL	36[redacted]Rd	W[redacted]	0	1	[redacted].4699841590217	[redacted].9388298954933
1617801039	1010092235	EjBDb3VudHJ5IFN...	HOME	Ho[redacted]	Co[redacted]	0	1	[redacted].469699	[redacted]941707
1617800632	NULL	ChIJiaNumK3iEogR...	NULL	Kn[redacted]) Hall of ...	40[redacted]	NULL	1	[redacted].428642	[redacted]6.9113
1617801065	2074933164	ChIJO7AuusriEogR...	NULL	12[redacted]Ave	W[redacted]	0	1	[redacted].430434	-[redacted]232605

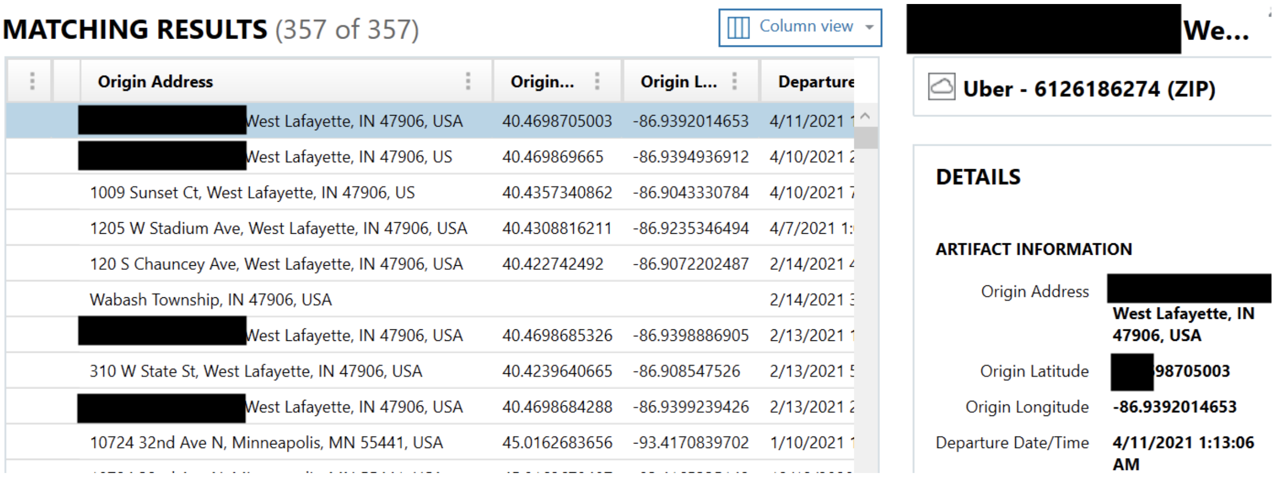
Figure 6: Data obtained from the second logical acquisition, 4 Uber locations stored in com.cab.UberClient database.db file



```
j$8F8482FE-24A4-435D-8137-9092505362E8◆{"jsonConformingObject":{"data":{"value_map":{"meta.feedViewportMetadata.cardMetadata.type":"feedCardMetadata","cardHeight":"139","meta.feedViewportMetadata.cardMetadata.feedC
ardMetadata.cardUUID":"e650f061-b0b2-5817-a859-5a7c1c738531","meta.feedViewportMetadata.cardMetadata.feedCardMetadata.row":"0","row":"0","meta.feedViewportMetadata.cardMetadata.feedCardMetadata.cardType":"PERSONAL_
TRANSPORT_FEEDBACK","visiblePercentage":"0.941538272843039","meta.type":"feedViewportMetadata","trigger":"BACKGROUND","meta.feedViewportMetadata.feedMetadata.feedMetadata.feedRequestId":"05edaaf2-1760-4849-8302-72
822665c319","timeOnScreen":"722","meta.feedViewportMetadata.cardMetadata.feedCardMetadata.cardId":"5e0b7357-d139-44c7-b179-1e302bc8a112","meta.feedViewportMetadata.feedMetadata.type":"feedMetadata","meta.feedViewpor
tMetadata.cardMetadata.feedCardMetadata.templateType":"PERSONAL_TRANSPORT_FEEDBACK","startTime":"1506779331250.0"},"name":"B59BA138-31F9","counter":699,"type":"impression","rider_status":"looking","current_product":{
"id":"801"}},"meta":{"device":{"google_play_services_version":"","os_type":"ios","google_play_services_status":"","ip_address":"104.38.65.240","language":"en_US","battery_status":"unplugged","year_class":2016,"is_rooted":false,"cp
u_usage":0.25715887546539307,"device_id":"5FED74B7-4438-40C3-BD76-E1343B4B908E","cpu_abi":"unknown","avail_memory":886439936,"locale":"US","system_uptime":62124418,"ios_advertiser_id":"40DCF3A5-668B-446C-A594-5
4B34EE05DD5","app_cpu_usage":45.599998474121094,"manufacturer":"Apple","battery_level":1,"memory_usage":0.33058578402918226,"wifi_connected":true,"voiceover":false,"total_memory":2681421824,"model":"iPhone9,2","serial
_number":"CAD8B15D-DF21-4C57-98FC-91A760BECCC9","os_version":"11.0","app_memory_usage":213663744,"imei_number":""},"location":{"course":-1,"city":"state_college","speed":-1,"longitude":[redacted]2526008078,"gps_time_
ms":1506779328868,"latitude":[redacted]60143212149,"horizontal_accuracy":65,"vertical_accuracy":10,"altitude":332.17791748046875},"app":{"commit_hash":"e08642827011793abf1c5cad7fdc68133fbcad2f","id":"com.ubercab.UberClie
nt","build_type":"release","build_uuid":"c005163e-99d1-11e7-98d4-2c600cc0f85f","type":"rider_app","version":"3.261.4"},"message_id":"B9116EE7-F9D3-4145-A74F-872DDB554CF6","session":{"session_id":"826BBF3D-81D1-412E-86B
9-A378D7B3279E","session_start_time_ms":1506779326481,"user_uuid":"320ab85e-9509-4512-8c53-afe6e2ec1b30","is_admin_user":false},"time_ms":1506779333343,"carrier":{"mcc":"311","mnc":"480","name":"Verizon"}},"tags":[],
"schema_id":7},"type":"analytics","createdTimeSince1970":1506779333.3437061,"uuid":"8F8482FE-24A4-435D-8137-9092505362E8"}j◆◆D"!j$6813151E-D610-41F5-940E-84D95B8A8E96◆

{"jsonConformingObject":{"data":{"name":"0586CFAB-E975","counter":700,"type":"custom","rider_status":"looking","current_product":{"id":"801"}},"meta":{"device":{"google_play_services_version":"","os_type":"ios","google_play_se
rvices_status":"","ip_address":"104.38.65.240","language":"en_US","battery_status":"unplugged","year_class":2016,"is_rooted":false,"cpu_usage":0.25715884566307068,"device_id":"5FED74B7-4438-40C3-BD76-E1343B4B908E","cpu_
abi":"unknown","avail_memory":886472704,"locale":"US","system_uptime":62124421,"ios_advertiser_id":"40DCF3A5-668B-446C-A594-54B34EE05DD5","app_cpu_usage":45.599998474121094,"manufacturer":"Apple","battery_level":1,
"memory_usage":0.33058992454098313,"wifi_connected":true,"voiceover":false,"total_memory":2681487360,"model":"iPhone9,2","serial_number":"CAD8B15D-DF21-4C57-98FC-91A760BECCC9","os_version":"11.0","app_memory_usa
ge":213680128,"imei_number":""},"location":{"course":-1,"city":"state_college","speed":-1,"longitude":[redacted]4372526008078,"gps_time_ms":1506779328868,"latitude":[redacted]0143212149,"horizontal_accuracy":65,"vertical_accurac
y":10,"altitude":332.17791748046875},"app":{"commit_hash":"e08642827011793abf1c5cad7fdc68133fbcad2f","id":"com.ubercab.UberClient","build_type":"release","build_uuid":"c005163e-99d1-11e7-98d4-2c600cc0f85f","type":"rider_
app","version":"3.261.4"},"message_id":"5AF224BC-D448-4E48-9F72-79AD7900CBEC","session":{"session_id":"826BBF3D-81D1-412E-86B9-A378D7B3279E","session_start_time_ms":1506779326481,"user_uuid":"320ab85e-9509-4512
-8c53-afe6e2ec1b30","is_admin_user":false},"time_ms":1506779333346,"carrier":{"mcc":"311","mnc":"480","name":"Verizon"}},"tags":[],"schema_id":7},"type":"analytics","createdTimeSince1970":1506779333.346375,"uuid":"681315
1E-D610-41F5-940E-84D95B8A8E96"}◆◆◆◆#"j$277447B6-ED3C-4386-ADB2-0E5687381978◆
```

Figure 7: Data obtained from the second logical acquisition, Uber data stored in 000196.log file



MATCHING RESULTS (357 of 357)

Origin Address	Origin...	Origin L...	Departure
[redacted] West Lafayette, IN 47906, USA	40.4698705003	-86.9392014653	4/11/2021 1
[redacted] West Lafayette, IN 47906, US	40.469869665	-86.9394936912	4/10/2021 2
1009 Sunset Ct, West Lafayette, IN 47906, US	40.4357340862	-86.9043330784	4/10/2021 7
1205 W Stadium Ave, West Lafayette, IN 47906, USA	40.4308816211	-86.9235346494	4/7/2021 1:
120 S Chauncey Ave, West Lafayette, IN 47906, USA	40.422742492	-86.9072202487	2/14/2021 4
Wabash Township, IN 47906, USA			2/14/2021 3
[redacted] West Lafayette, IN 47906, USA	40.4698685326	-86.9398886905	2/13/2021 1
310 W State St, West Lafayette, IN 47906, USA	40.4239640665	-86.908547526	2/13/2021 5
[redacted] West Lafayette, IN 47906, USA	40.4698684288	-86.9399239426	2/13/2021 2
10724 32nd Ave N, Minneapolis, MN 55441, USA	45.0162683656	-93.4170839702	1/10/2021 1

[redacted] We...

Uber - 6126186274 (ZIP)

DETAILS

ARTIFACT INFORMATION

Origin Address	[redacted] **West Lafayette, IN 47906, USA**
Origin Latitude	[redacted] **98705003**
Origin Longitude	**-86.9392014653**
Departure Date/Time	**4/11/2021 1:13:06 AM**

Figure 8: Cloud data obtained from the second Cloud acquisition, 357 Uber trips

that accurate location data could be obtained as the addresses were split apart (see Fig. 9). However, the more recently used addresses were able to be interpreted very easily as they were organized neatly in the table (see Fig. 10).

Of the 4 stored Uber locations, 2 of them stored a much larger amount of geolocation data. The dates of these 2 Uber rides were 7/26/2020 and 4/7/2021. For these 2 Uber rides, geolocation data was stored each second (see Fig. 11).

Once exporting this second-by-second data for each date, it was opened in Google Earth and mapped an exact route of the Uber ride (see Figs. 12 and 13). However, geolocation data for the Uber ride on 7/26/2020 was not collected a for the entire ride, unlike the Uber ride on 4/7/2021.

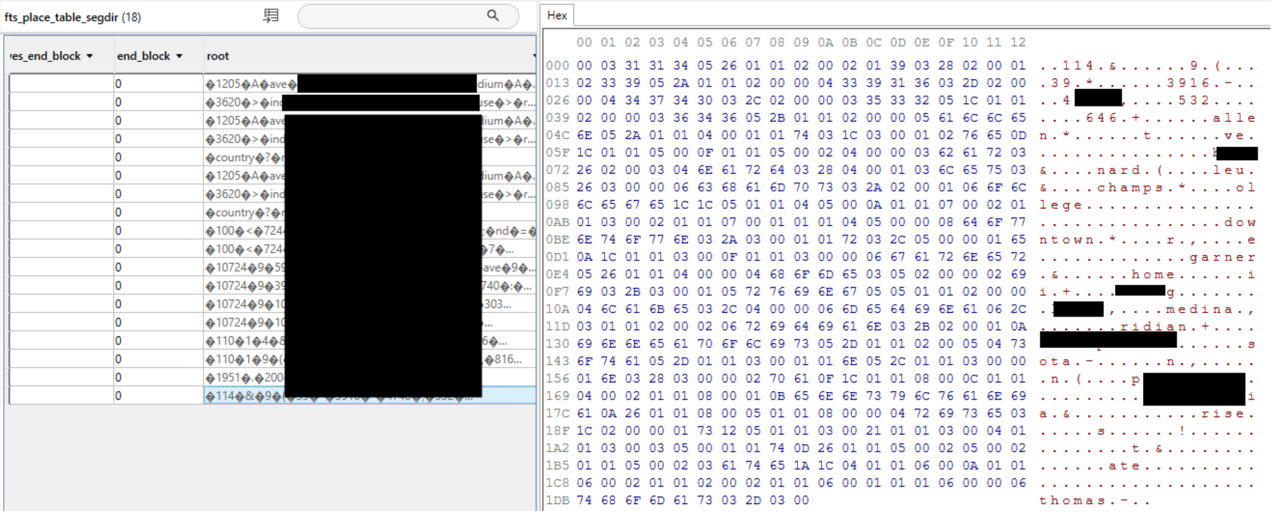
Additional analysis of the file system revealed additional data from the Uber app was stored in *\File Systems \DarArchive \root \private \var \mobile \Containers \Data \app \4CABB07F-4A8C-49B6-A05C-3001101DAC1F \Library \app Support \com.ubercab.UberClient \storagev2 \unified-reporter-client.analytics.objectfeed \001407.log* file (see Fig. 14). Seven additional log files, 000129.log, 001056.log, 001282.log, 001296.log, 000357.log, 001325.log and 000995.log stored similar Uber data, however, the file 001407.log stored the most information. The additional log files were stored in *\File Systems \DarArchive \root \private \var \mobile \Containers \Data \app \4CABB07F-4A8C-49B6-A05C-3001101DAC1F \Library \app Support \com.ubercab.UberClient \storagev2.*

Further file system analysis contained additional Uber timestamp data stored in *\File Systems \DarArchive \root \private \var \mobile \Containers \Data \app \4CABB07F-4A8C-49B6-A05C-3001101DAC1F \Library \Caches \com.ubercab.UberClient \com.uber.images \cache.db* file, in the table *cfurl_cache_response* (See Fig. 15).

5. DISCUSSION AND CONCLUSIONS

When comparing the results of the 1st logical/cloud acquisitions versus the 2nd, the logical acquisition with Magnet AXIOM collected 8 Uber Cached locations versus Cellebrite UFED 4PC, which only collected 4. In both the 1st and 2nd acquisitions, the cloud acquisition collected much more information about each Uber ride than logical acquisition (see Table 3).

When comparing the results of both logical/cloud acquisitions versus the advanced logical acquisition, the cloud acquisition provides the most detailed data for each individual ride, such as the starting point and destination coordinates, and also the most PII about both the user and the driver. The advanced logical acquisition provides the most detailed geolocation data as for certain rides, geolocation data was



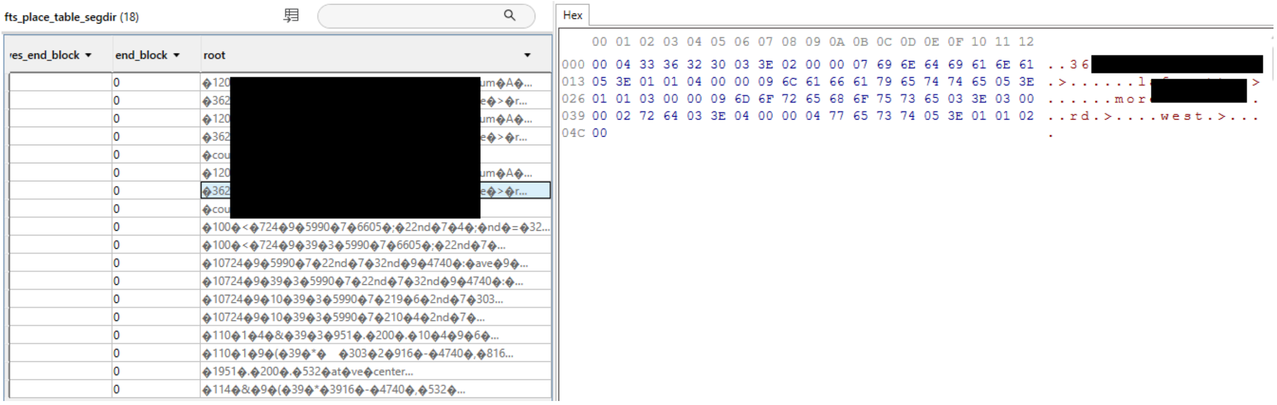
fts_place_table_segdir (18)

es_end_block	end_block	root
	0	�1205�A�ave�[redacted]dium�A�.
	0	�3620�>�in[redacted]use�>�r...
	0	�1205�A�ave[redacted]ium�A�.
	0	�3620�>�ind[redacted]se�>�r...
	0	�country�?�[redacted]
	0	�1205�A�ave[redacted]ium�A�.
	0	�3620�>�ind[redacted]se�>�r...
	0	�country�?�[redacted]
	0	�100�<�724[redacted];�nd�=�
	0	�100�<�724[redacted]�7�...
	0	�10724�9�59[redacted]ave�9�...
	0	�10724�9�39[redacted]740�:�...
	0	�10724�9�10[redacted]303...
	0	�10724�9�10[redacted]�...
	0	�110�1�4�8[redacted]6�...
	0	�110�1�9�([redacted]�816...
	0	�1951�.�200[redacted]
	0	�114�&�9�([redacted]

Hex

```
    00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12
000 00 03 31 31 34 05 26 01 01 02 00 02 01 39 03 28 02 00 01  ..114.&......9.(...
013 02 33 39 05 2A 01 01 02 00 00 04 33 39 31 36 03 2D 02 00  .39.*......3916.-..
026 00 04 34 37 34 30 03 2C 02 00 00 03 35 33 32 05 1C 01 01  ..4[redacted],....532....
039 02 00 00 03 36 34 36 05 2B 01 01 02 00 00 05 61 6C 6C 65  ....646.+......alle
04C 6E 05 2A 01 01 04 00 01 01 74 03 1C 03 00 01 02 76 65 0D  n.*......t......ve.
05F 1C 01 01 05 00 0F 01 01 05 00 02 04 00 00 03 62 61 72 03  ...............[redacted]
072 26 02 00 03 04 6E 61 72 64 03 28 04 00 01 03 6C 65 75 03  &....nard.(....leu.
085 26 03 00 00 06 63 68 61 6D 70 73 03 2A 02 00 01 06 6F 6C  &....champs.*....ol
098 6C 65 67 65 1C 1C 05 01 01 04 05 00 0A 01 01 07 00 02 01  lege...............
0AB 01 03 00 02 01 01 07 00 01 01 01 04 05 00 00 08 64 6F 77  ................dow
0BE 6E 74 6F 77 6E 03 2A 03 00 01 01 72 03 2C 05 00 00 01 65  ntown.*....r.,....e
0D1 0A 1C 01 01 03 00 0F 01 01 03 00 00 06 67 61 72 6E 65 72  .............garner
0E4 05 26 01 01 04 00 00 04 68 6F 6D 65 03 05 02 00 00 02 69  .&......home......i
0F7 69 03 2B 03 00 01 05 72 76 69 6E 67 05 05 01 01 02 00 00  i.+....[redacted]g.......
10A 04 6C 61 6B 65 03 2C 04 00 00 06 6D 65 64 69 6E 61 06 2C  .[redacted],....medina.,
11D 03 01 01 02 00 02 06 72 69 64 69 61 6E 03 2B 02 00 01 0A  .......ridian.+....
130 69 6E 6E 65 61 70 6F 6C 69 73 05 2D 01 01 02 00 05 04 73  [redacted]......s
143 6F 74 61 05 2D 01 01 03 00 01 01 6E 05 2C 01 01 03 00 00  ota.-......n.,.....
156 01 6E 03 28 03 00 00 02 70 61 0F 1C 01 01 08 00 0C 01 01  .n.(....p[redacted].
169 04 00 02 01 01 08 00 01 0B 65 6E 6E 73 79 6C 76 61 6E 69  .........[redacted]i
17C 61 0A 26 01 01 08 00 05 01 01 08 00 00 04 72 69 73 65 03  a.&...........rise.
18F 1C 02 00 00 01 73 12 05 01 01 03 00 21 01 01 03 00 04 01  .....s......!......
1A2 01 03 00 03 05 00 01 01 74 0D 26 01 01 05 00 02 05 00 02  ........t.&........
1B5 01 01 05 00 02 03 61 74 65 1A 1C 04 01 01 06 00 0A 01 01  ......ate..........
1C8 06 00 02 01 01 02 00 02 01 01 06 00 01 01 01 06 00 00 06  ...................
1DB 74 68 6F 6D 61 73 03 2D 03 00                             thomas.-..
```

Figure 9: Older addresses from Uber rides in *fts_place_table_segdir*



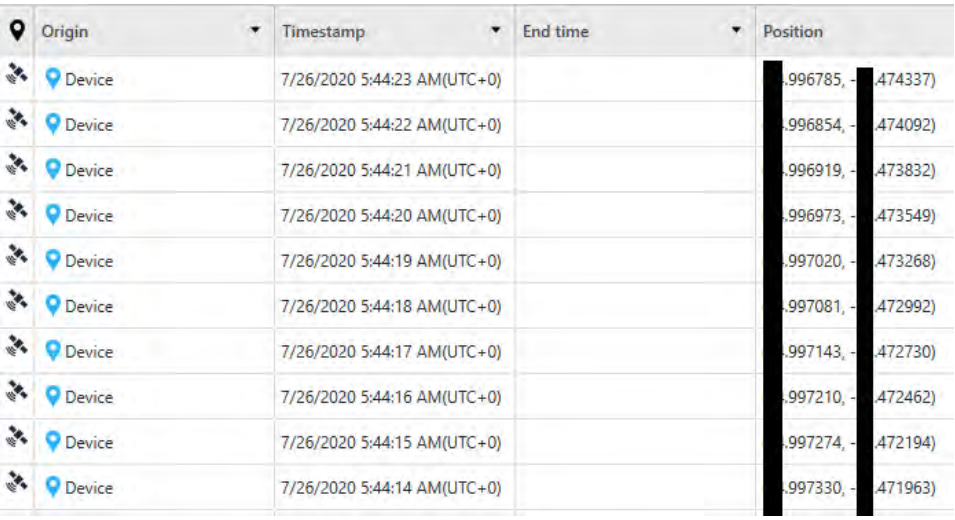
fts_place_table_segdir (18)

es_end_block	end_block	root
	0	�120[redacted]um�A�...
	0	�362[redacted]e�>�r...
	0	�120[redacted]um�A�...
	0	�362[redacted]e�>�r...
	0	�cou[redacted]
	0	�120[redacted]um�A�...
	0	�362[redacted]e�>�r...
	0	�cou[redacted]
	0	�100�<�724�9�5990�7�6605�;�22nd�7�4�;�nd�=�32...
	0	�100�<�724�9�39�3�5990�7�6605�;�22nd�7�...
	0	�10724�9�5990�7�22nd�7�32nd�9�4740�:�ave�9�...
	0	�10724�9�39�3�5990�7�22nd�7�32nd�9�4740�:�...
	0	�10724�9�10�39�3�5990�7�219�6�2nd�7�303...
	0	�10724�9�10�39�3�5990�7�210�4�2nd�7�...
	0	�110�1�4�&�39�3�951�.�200�.�10�4�9�6�...
	0	�110�1�9�(�39�*� �303�2�916�-�4740�,�816...
	0	�1951�.�200�.�532�at�ve�center...
	0	�114�&�9�(�39�*�3916�-�4740�,�532�...

Hex

```
    00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F 10 11 12
000 00 04 33 36 32 30 03 3E 02 00 00 07 69 6E 64 69 61 6E 61  ..36[redacted]
013 05 3E 01 01 04 00 00 09 6C 61 66 61 79 65 74 74 65 05 3E  .>......l[redacted]>
026 01 01 03 00 00 09 6D 6F 72 65 68 6F 75 73 65 03 3E 03 00  ......mor[redacted].
039 00 02 72 64 03 3E 04 00 00 04 77 65 73 74 05 3E 01 01 02  ..rd.>....west.>...
04C 00                                                        .
```

Figure 10: Recent addresses from Uber rides in *fts_place_table_segdir*



	Origin	Timestamp	End time	Position
	Device	7/26/2020 5:44:23 AM(UTC+0)		[redacted].996785, -[redacted].474337)
	Device	7/26/2020 5:44:22 AM(UTC+0)		[redacted].996854, -[redacted].474092)
	Device	7/26/2020 5:44:21 AM(UTC+0)		[redacted].996919, -[redacted].473832)
	Device	7/26/2020 5:44:20 AM(UTC+0)		[redacted].996973, -[redacted].473549)
	Device	7/26/2020 5:44:19 AM(UTC+0)		[redacted].997020, -[redacted].473268)
	Device	7/26/2020 5:44:18 AM(UTC+0)		[redacted].997081, -[redacted].472992)
	Device	7/26/2020 5:44:17 AM(UTC+0)		[redacted].997143, -[redacted].472730)
	Device	7/26/2020 5:44:16 AM(UTC+0)		[redacted].997210, -[redacted].472462)
	Device	7/26/2020 5:44:15 AM(UTC+0)		[redacted].997274, -[redacted].472194)
	Device	7/26/2020 5:44:14 AM(UTC+0)		[redacted].997330, -[redacted].471963)

Figure 11: Stored geolocation data (only last 10 records shown here)

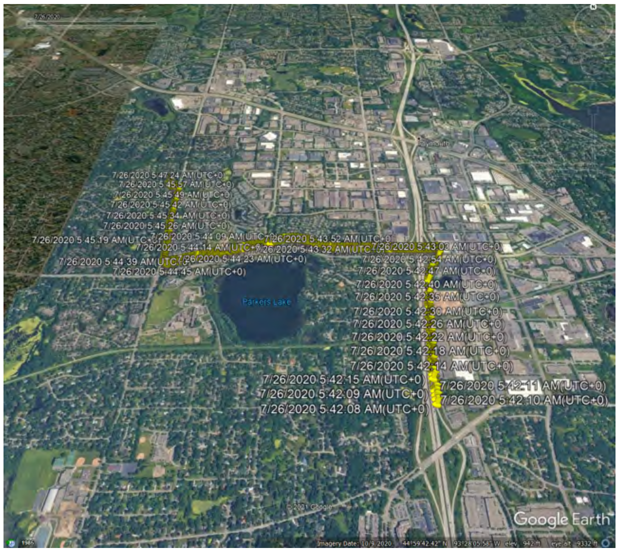

7/26/2020 5:47:24 AM(UTC+0)
7/26/2020 5:45:57 AM(UTC+0)
7/26/2020 5:45:49 AM(UTC+0)
7/26/2020 5:45:42 AM(UTC+0)
7/26/2020 5:45:34 AM(UTC+0)
7/26/2020 5:45:26 AM(UTC+0)
7/26/2020 5:45:19 AM(UTC+0)
7/26/2020 5:44:09 AM(UTC+0)
7/26/2020 5:43:52 AM(UTC+0)
7/26/2020 5:44:14 AM(UTC+0)
7/26/2020 5:43:32 AM(UTC+0)
7/26/2020 5:43:03 AM(UTC+0)
7/26/2020 5:44:39 AM(UTC+0)
7/26/2020 5:44:23 AM(UTC+0)
7/26/2020 5:44:45 AM(UTC+0)
7/26/2020 5:42:54 AM(UTC+0)
7/26/2020 5:42:47 AM(UTC+0)
7/26/2020 5:42:40 AM(UTC+0)
7/26/2020 5:42:35 AM(UTC+0)
Parkers Lake
7/26/2020 5:42:30 AM(UTC+0)
7/26/2020 5:42:26 AM(UTC+0)
7/26/2020 5:42:22 AM(UTC+0)
7/26/2020 5:42:18 AM(UTC+0)
7/26/2020 5:42:14 AM(UTC+0)
7/26/2020 5:42:15 AM(UTC+0)
7/26/2020 5:42:11 AM(UTC+0)
7/26/2020 5:42:09 AM(UTC+0)
7/26/2020 5:42:10 AM(UTC+0)
7/26/2020 5:42:08 AM(UTC+0)
© 2021 Google
Google Earth

Figure 12: Uber ride from 7/26/2020 with precise geolocation data for a portion of the route

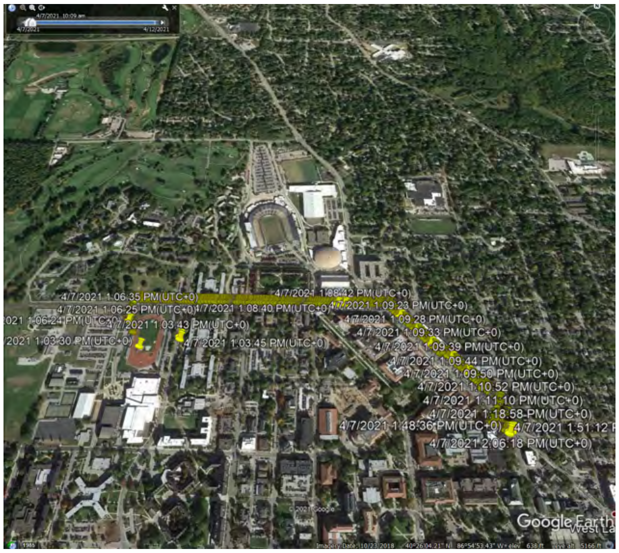

4/7/2021 1:06:35 PM(UTC+0)
4/7/2021 1:08:42 PM(UTC+0)
4/7/2021 1:06:25 PM(UTC+0)
4/7/2021 1:08:40 PM(UTC+0)
4/7/2021 1:09:23 PM(UTC+0)
2021 1:06:24 PM(UTC+0)
4/7/2021 1:09:28 PM(UTC+0)
4/7/2021 1:03:43 PM(UTC+0)
4/7/2021 1:09:33 PM(UTC+0)
2021 1:03:30 PM(UTC+0)
4/7/2021 1:03:45 PM(UTC+0)
4/7/2021 1:09:39 PM(UTC+0)
4/7/2021 1:09:44 PM(UTC+0)
4/7/2021 1:09:50 PM(UTC+0)
4/7/2021 1:10:52 PM(UTC+0)
4/7/2021 1:11:10 PM(UTC+0)
4/7/2021 1:18:58 PM(UTC+0)
4/7/2021 1:48:36 PM(UTC+0)
4/7/2021 1:51:12 P
4/7/2021 2:06:18 PM(UTC+0)
© 2021 Google
Google Earth
West La
Imagery Date: 10/23/2018
40°26'04.21" N
86°54'53.43" W
elev 638 ft
eye alt 5166 ft

Figure 13: Uber ride from 4/7/2021 with precise geolocation data for the duration of the route

Table 3: Comparison of Cloud and Logical Acquisitions

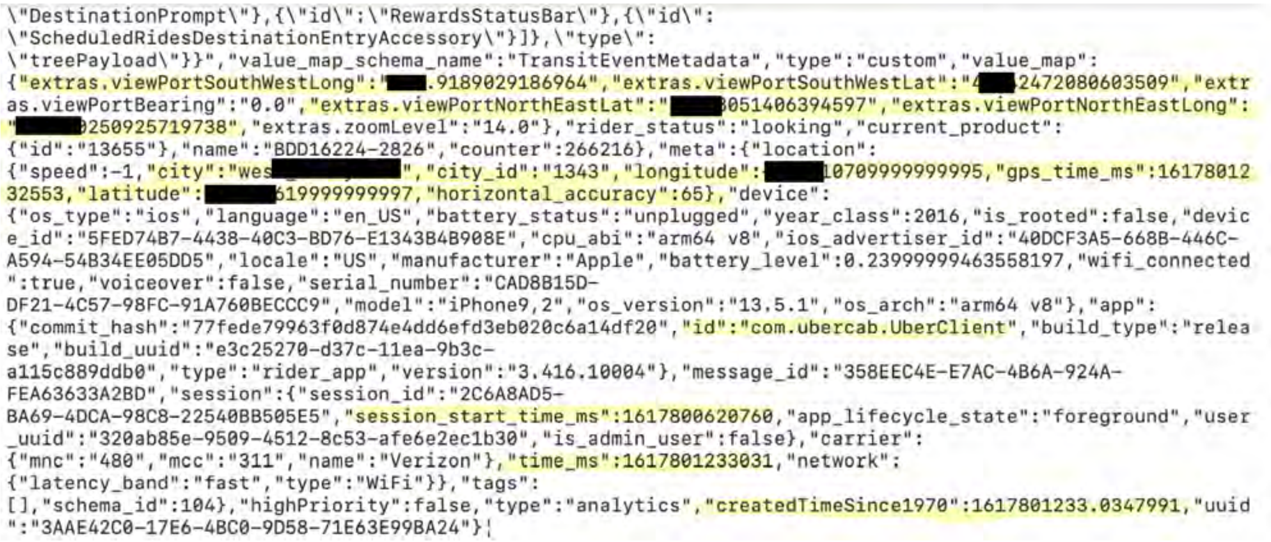
Data Stored in Cloud Acquisitions	**Data Stored in Logical Acquisitions**
Origin address/coordinates	Address
Departure address/coordinates	Coordinates
Departure/arrival date/time	Date/time
Rider ID	
Ride distance/duration/cost	
Trip ID/status	
Driver name/ID	
Vehicle make/year	

collected each second to provide a time stamp for every point during the Uber ride, ultimately constructing a second-by-second ride route. However, when comparing the log files from the 2nd logical acquisition to those from the advanced logical acquisition, they appear to contain similar Uber data. The main difference being that the advanced logical acquisition provided more log files than the 2nd logical acquisition, and the log files themselves contained more data.

The forensic analysis of the Uber mobile app indicates that a large amount of forensically-relevant PII and geolocation data can be obtained from Uber, including both data stored in the cloud and data stored on the device. This information will allow forensic investigators to locate exactly where the Uber vehicle was for a certain date and time, and also collect specific information about the rider, the driver and the ride itself.

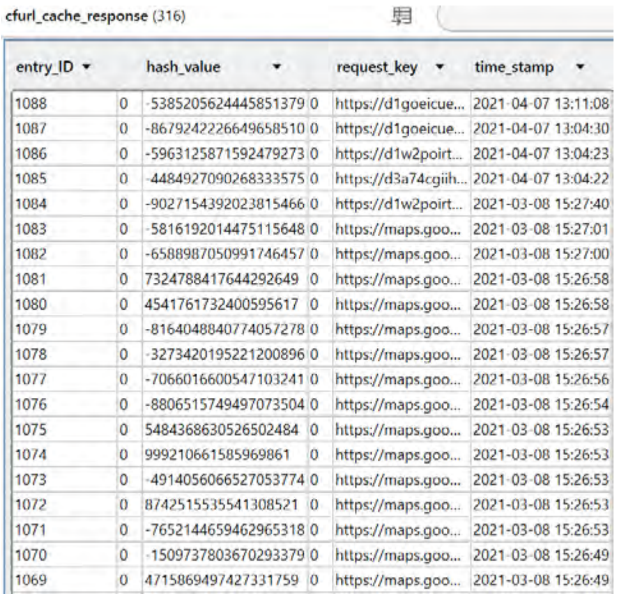
6. FUTURE RESEARCH

Future research could include further analysis with Cellebrite UFED 4PC to determine why the 2 Uber rides with the most comprehensive geolocation data were so far apart in time, and why comprehensive geolocation data was not stored the same way for more recent Uber rides. Additionally, future research could include carrying out the same methodology of this study but instead utilizing Cellebrite UFED 4PC cloud software to determine if more geolocation data that is similar to the 2 rides from 7/26/2020 and



```
\"DestinationPrompt\"},{\"id\":\"RewardsStatusBar\"},{\"id\":
\"ScheduledRidesDestinationEntryAccessory\"}]},\"type\":
\"treePayload\"}}","value_map_schema_name":"TransitEventMetadata","type":"custom","value_map":
{"extras.viewPortSouthWestLong":"[redacted].9189029186964","extras.viewPortSouthWestLat":"4[redacted]2472080603509","extr
as.viewPortBearing":"0.0","extras.viewPortNorthEastLat":"[redacted]051406394597","extras.viewPortNorthEastLong":
"[redacted]250925719738","extras.zoomLevel":"14.0"},"rider_status":"looking","current_product":
{"id":"13655"},"name":"BDD16224-2826","counter":266216},"meta":{"location":
{"speed":-1,"city":"wes[redacted]","city_id":"1343","longitude":[redacted]0709999999995,"gps_time_ms":16178012
32553,"latitude":[redacted]19999999997,"horizontal_accuracy":65},"device":
{"os_type":"ios","language":"en_US","battery_status":"unplugged","year_class":2016,"is_rooted":false,"devic
e_id":"5FED74B7-4438-40C3-BD76-E1343B4B908E","cpu_abi":"arm64 v8","ios_advertiser_id":"40DCF3A5-668B-446C-
A594-54B34EE05DD5","locale":"US","manufacturer":"Apple","battery_level":0.2399999463558197,"wifi_connected
":true,"voiceover":false,"serial_number":"CAD8B15D-
DF21-4C57-98FC-91A760BECCC9","model":"iPhone9,2","os_version":"13.5.1","os_arch":"arm64 v8"},"app":
{"commit_hash":"77fede79963f0d874e4dd6efd3eb020c6a14df20","id":"com.ubercab.UberClient","build_type":"relea
se","build_uuid":"e3c25270-d37c-11ea-9b3c-
a115c889ddb0","type":"rider_app","version":"3.416.10004"},"message_id":"358EEC4E-E7AC-4B6A-924A-
FEA63633A2BD","session":{"session_id":"2C6A8AD5-
BA69-4DCA-98C8-22540BB505E5","session_start_time_ms":1617800620760,"app_lifecycle_state":"foreground","user
_uuid":"320ab85e-9509-4512-8c53-afe6e2ec1b30","is_admin_user":false},"carrier":
{"mnc":"480","mcc":"311","name":"Verizon"},"time_ms":1617801233031,"network":
{"latency_band":"fast","type":"WiFi"}},"tags":
[],"schema_id":104},"highPriority":false,"type":"analytics","createdTimeSince1970":1617801233.0347991,"uuid
":"3AAE42C0-17E6-4BC0-9D58-71E63E99BA24"}
```

Figure 14: Data obtained from advanced logical acquisition, Uber data stored in 001407.log file



cfurl_cache_response (316)

entry_ID ▾		hash_value ▾		request_key ▾	time_stamp ▾
1088	0	-5385205624445851379	0	https://d1goeicue...	2021-04-07 13:11:08
1087	0	-8679242226649658510	0	https://d1goeicue...	2021-04-07 13:04:30
1086	0	-5963125871592479273	0	https://d1w2poirt...	2021-04-07 13:04:23
1085	0	-4484927090268333575	0	https://d3a74cgiih...	2021-04-07 13:04:22
1084	0	-9027154392023815466	0	https://d1w2poirt...	2021-03-08 15:27:40
1083	0	-5816192014475115648	0	https://maps.goo...	2021-03-08 15:27:01
1082	0	-6588987050991746457	0	https://maps.goo...	2021-03-08 15:27:00
1081	0	7324788417644292649	0	https://maps.goo...	2021-03-08 15:26:58
1080	0	4541761732400595617	0	https://maps.goo...	2021-03-08 15:26:58
1079	0	-8164048840774057278	0	https://maps.goo...	2021-03-08 15:26:57
1078	0	-3273420195221200896	0	https://maps.goo...	2021-03-08 15:26:57
1077	0	-7066016600547103241	0	https://maps.goo...	2021-03-08 15:26:56
1076	0	-8806515749497073504	0	https://maps.goo...	2021-03-08 15:26:54
1075	0	5484368630526502484	0	https://maps.goo...	2021-03-08 15:26:53
1074	0	999210661585969861	0	https://maps.goo...	2021-03-08 15:26:53
1073	0	-4914056066527053774	0	https://maps.goo...	2021-03-08 15:26:53
1072	0	8742515535541308521	0	https://maps.goo...	2021-03-08 15:26:53
1071	0	-7652144659462965318	0	https://maps.goo...	2021-03-08 15:26:53
1070	0	-1509737803670293379	0	https://maps.goo...	2021-03-08 15:26:49
1069	0	4715869497427331759	0	https://maps.goo...	2021-03-08 15:26:49

Figure 15: Data obtained from physical acquisition, Uber data stored in 001407.log file

4/7/2021 could be obtained. Lastly, future work further investigating the Uber data contained in the log files from the logical acquisitions and comparing it to that of the advanced logical acquisition.

REFERENCES

Ayers, R., Brothers, S., & Jansen, W. (n.d.). Guidelines on mobile device forensics. *NIST Special Publication*, *800*.

Chen, L., Mislove, A., & Wilson, C. (2015). Peeking beneath the hood of uber. In *Proceedings of the 2015 internet measurement conference* (pp. 495–508).

Conger, K. (2019, Dec). *Uber says 3,045 sexual assaults were reported in u.s. rides last year.* The New York Times. Retrieved from `https://www.nytimes.com/2019/12/05/technology/uber-sexual-assaults-murders-deaths-safety.html#:~:text=SANFRANCISCOUbersaidon,ontheride-hailingplatform`

Hayes, D., Snow, C., & Altuwayjiri, S. (2017). Geolocation tracking and privacy issues associated with the uber mobile application. In *Proceedings of the conference on information systems applied research issn* (Vol. 2167, p. 1508).

Iqbal, M. (2022, Feb). *Uber revenue and usage statistics (2022).* Retrieved from `https://www.businessofapps.com/data/uber-statistics/`

Leszczynski, A. (2019). Platform affects of geolocation. *Geoforum*, *107*, 207–215.

Lyft. (2021, Oct). *Community safety report.* Retrieved from `https://assets.ctfassets.net/q8mvene1wzq4/4jxkFTH5YCQK8T96STULMd/4269e14dbcb8578ff64da45df08b8147/Community_Safety_Report.pdf`

Press, A. (2021, Oct). *Lyft report: Sexual assaults rose sharply in recent years.* WPLG Local 10. Retrieved from `https://www.local10.com/business/2021/10/22/lyft-report-sexual-assaults-rose-sharply-in-recent-years/`

Salamh, F. E., Mirza, M. M., & Karabiyik, U. (2021). Uav forensic analysis and software tools assessment: Dji phantom 4 and matrice 210 as case studies. *Electronics*, *10*(6), 733.

Toniuk, K. (2019, Jul). *Top car-hailing apps to use around the world.* Retrieved from `https://www.keepgo.com/blogs/articles/top-5-car-hailing-apps-to-use-around-the-world`

Uber privacy notice. (2021, Oct). Retrieved from `https://www.uber.com/legal/en/document/?country=united-states&amp;lang=en&amp;name=uber-rewards-program-terms`