“Co-Traveler”: Triggering Pattern Behind Criminal Activities

Law enforcement and military personnel often use co-traveler analysis to solve crimes that are too complex for individual investigation. Co-travelers are individuals or objects that move together across space and time. For example, if criminals plan their activities with a group or flee the scene of the crime with a getaway driver, identifying co-travelers can help investigators narrow down the suspects. Co-traveler analysis is a powerful tool in law enforcement and intelligence gathering that can lead to the successful identification and capture of criminals.

This workflow, in conjunction with other intelligence features that can be done with VCIS intelligence, can be used by law enforcement and military personnel to help track down offenders.

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Introduction

Analysts use powerful analytical tools and mathematical techniques, collectively known as "Co-Traveler," to locate cell phones worldwide, track their movements, and uncover hidden relationships among the users. This type of analysis is essential to contemporary security and demonstrates the importance of algorithms in this field. Co-travel analysis involves systematically computing and identifying high-value targets using different data sources. The OSINT discipline is an evolving form of intelligence that provides a significant advantage to ground combatants. Co-travel refers to devices moving together, which can reveal critical relationships between individuals. The co-travel analysis has four primary functions: pattern of life, anomaly detection, device correlation, and co-traveler. These functions assist the algorithm in enabling authorities to track persons of interest and uncover locations of interest. For example, the VCIS applies clustering and density-based spatial clustering to establish a pattern of life and detect anomalies within the VALOORES data set. The Data Crowd team has developed a functional application that allows intelligence analysts to quickly analyze geo-temporal datasets and visualize results.

Co-Travelers Patterns

The term "Co-travelers" refers to two devices that share the same coordinates (latitude and longitude) and record hits at the same timestamp. There are three cases within this framework.

Permanent Co-Travelers
If two devices consistently share the same coordinates without any variation, it is reasonable to assume that they are being used by the same person, with a slight chance that they belong to two people who are inseparable.

End of Parallelism: When the parallel lines traced by the two devices reach a split point, there are two possible scenarios: either one device's coordinates remain fixed while the other continues to move, or both devices move in different directions.

One fix line, other one moving

This case leaves us with two possibilities:

- A person is using two devices, but they may have left one device at a particular location while continuing to move with the other.
- The two devices belong to different users, and one of them may have decided to remain stationary for a certain period of time or left their phone in a specific location.

So basically this case can leave us confused and demands further tracking.

Two lines moving distinctly

In this case, we can be certain that the two devices are being used by different people, with no doubt about the matter. The scenario could be that the two devices belong to different users, and one of them may have stayed stationary for a certain period of time or left their phone in a specific location.

The most fundamental analytical tools used in mobile device analysis involve mapping the date, time, and location of cell phones to identify patterns or significant moments of overlap. Other tools calculate the speed and trajectory of large numbers of mobile devices, and overlay the electronic data on transportation maps to estimate travel time and determine which devices may have intersected.

What is the co-Traveler algorithm?

The co-travel algorithm involves computing the date, time, and location of devices over a specified window of space and time, and then searching for other devices that were present within the same window. Its main components include establishing patterns of life, anomaly detection, device correlation, and co-traveler identification.

Establishing a pattern of life involves tracking high-value target persons and providing information to the authorities. Anomaly detection is used to identify outliers in population behavior, which can be useful in assessing threats or identifying items of interest. Device correlation identifies possible relationships and networks between devices in each population.

In this context, device correlation is used to determine whether devices that cross paths are correlated. The co-traveler component is used to identify two or more devices with similar correlations that have been seen at significantly different locations within a given space and time. These devices are then assessed as belonging to the same individual.

Process

The VCIS' methodology enables the discovery of definitive clusters of mobile device user locations and activities, which assists in identifying patterns of life and predicting the locations where users are operating. When comparing k-means clustering with Density-based spatial clustering, it is evident that the latter method is more reliable in producing clusters that are accurate representations of frequented movements. This is because k-means requires a set number of clusters to find, whereas DBSCAN utilizes input data to identify its own number of clusters. Additionally, DBSCAN has a higher affinity for noisy data, while k-means clustering is sensitive to noise and outlier data points that can substantially influence the mean value.

For the type of data being analyzed, extremely dense points within cities, an algorithm that is better equipped to handle this type of data was chosen.

K-means clustering enables the user to identify a centroid for each cluster, which helps to determine points that are "least" likely to belong to those clusters by finding points with the greatest distance to their cluster centroid. This process enables the ranking of points based on the observed Euclidean distance by user or location, yielding insight into potential points of concern.

The Euclidean distance metric is primarily used in k-means clustering, while a DBSCAN methodology runs into issues given the lack of convexity in some established clusters.

It may be necessary to use a blend of methodologies to analyze the data, first looking at the DBSCAN to identify clusters themselves and determine the number of said clusters, then utilizing k-means clustering output to verify these clusters and their associated points of interest based upon the Euclidean distance metric from k-means clustering.

Questions

Should a co-travel analytic consider where a GCID or VLR is physically located?

Many analytical techniques utilize GCID information to identify co-travelers. If two selectors are observed at the same GCID around the same time, they are considered as potential co-travelers. It is not necessary for the analytical tool to know the physical location of the GCID. However, if the individuals are using different network providers, they may be physically standing next to each other while their mobile devices register with different cell towers. Co-travel analytics that do not consider the physical locations of the towers will not be able to detect individuals who are co-traveling on different networks. To determine the distance between two points, analytical tools that use point data need to consider geo-locational data.

Can co-travel be considered a series of meetings?

We limited this study to targets co-traveling through two or more locations within a specific time and space window defined by the analyst. However, if the locations are known, co-travel can be viewed as a series of "meetings" at these locations. Analytics that detect co-location may be different from those that detect co-travel, and the appropriate approach depends on the specific analytic need. In VCIS, examples of meeting analytics that detect instances of co-location include the GATC Opportunity Volume Analytic and the Meet&Greet Spatial Chaining Analytic.

Should device and collection sampling play a role in determining co-travelers?

When determining co-travelers, it is important to consider device and collection sampling. We may collect many events from one target's mobile phone, but only a few from his co-traveler's phone due to collection bias, differences in network service, or target COMSEC behavior. Analytics should take these factors into account when attempting to identify co-travelers.

Should incidental co-travelers be considered?

Distinguishing between incidental co-travel, resulting from collective movement of individuals with similar travel behaviors but no other similarities, and functional group-based co-travel among individuals with behaviorally relevant relationships is important. However, it may not always be appropriate to exclude seemingly incidental co-travelers simply because we are unaware of their relationship.

Other factors, such as contact chains and target COMSEC behaviors (e.g., frequent power-down, handset swapping, SMS behavior), can help to determine whether co-travelers are associated solely through their travel behaviors or through behaviorally relevant relationships. It is important to consider these factors when attempting to identify co-travelers.

Should geography play a role in co-travel?

Due to the difficulty in pinpointing the exact location of a GSM target within a GCID or VLR, many GSM co-travel analytics use the central point of the VLR or GCID as a reference point. It is possible that traveling targets are located along roads, train tracks, or footpaths where network service is available. This geographical information could be used to help co-travel analytics in identifying candidates, particularly those who are traveling using the same mode of transportation. Furthermore, geographical data may be used to interpolate missing data between the locations visited by a target.

Should co-travelers seen in different source databases be considered?

Different co-travelers may be observed in different types of data sources, such as Telecom data or Metadata. Combining multiple sources can provide a more complete picture of a target's travel pattern over time. However, it is important to consider the potential increase in false positives resulting from the use of multiple data sources. Other types of data, such as reservation numbers for air travelers or shared MAC addresses, can also indicate co-traveling. Additionally, similarities between IP addresses may indicate proximity on the same network. The Geo-Telecom Co-travel analytic attempts to integrate multiple data sources to build a more comprehensive view of a target's co-travel patterns.

Analytics

One of the purposes of VCIS is to determine whether two entities could have been co-located based on observed event locations. To detect co-travel, the analyst would need to define a series of locations and times where the entities could potentially meet. The Opportunity Volume analytic could also be used to vet co-travel analytics by testing for possible co-location events along potential co-travel routes. Features and Options The system executes queries separately for each selector and area of interest, returning distinct results for each combination. With the cloud-based version, users can customize the time window for the analytic to consider instead of using a default duration. Instead of running separate queries, the system can process all entered device IDs as if they were joined in an "operation room".

Users can choose the countries or locations they're interested in analyzing. They can also instruct the system to ignore activity within a particular region or restrict analysis to specific regions of interest. For instance, they can filter out activity in the target's home country when evaluating potential co-travelers.

Users have the option to filter in or out potential co-travelers with specific prefixes.

For example, they can limit results to mobile devices or exclude them entirely. They can also include only mobiles from the same country as the target.

Travel-Paths Analytics

The Travel-Paths Co-Travel analytic uses time-based travel trajectories to predict target locations and co-travelers. It calculates probable travel routes based on observed locations and determines the most likely paths and travel times, similar to turn-by-turn navigation systems.

The probable travel routes are represented as a series of LAT/LONG waypoints or line segments along the roads. The analytic divides these travel paths into segments (usually 20 to 50 km along the road) and predicts the approximate time that the target would arrive at each segment waypoint based on projected travel times between known locations. Then, within the travel window, the analytic identifies candidate co-travelers that intersect locations along the buffered travel path.

To perform this analysis, VCIS uses interactive Renoir analysis of a two-mode graph representing the route segments and selectors observed on these route segments within the time windows. Once the data is clean and candidate co-travelers are identified, detailed analysis can be performed in Renoir or other tools, such as Geo-Time, incorporating other supporting data such as communications events and content.

The analytic was tested using a terrorist case study that utilized approximately 3,000 base station locations and 1 billion mobile location records for CDRs and infrastructure collection. This case study demonstrated that analyzing travel paths led to the discovery of more candidate co-travelers than considering common meeting locations alone.

VCIS also integrates key meeting locations, such as safehouses, into this analytic. Plans are underway to identify targets based on certain behaviors, such as identifying mobiles that are turned off right before convergence between two travel paths occurs.

Geospatial Analytics

The opportunity volume analytic is designed to determine whether two devices could have been co-located by analyzing the possibility of their travel paths intersecting. To do this, the analytic requires pairs of event locations and times for each entity, and computes the possible locations and times in which the two entities could have been co-located. This is accomplished by calculating possible travel route surfaces for each device between the specified events, using a travel cost surface derived from terrain, land cover, and road network data.

These surfaces take into account the temporal dimension, meaning the period of time in which the device could have been at the given location. The intersection between these multidimensional surfaces represents the places and times during which the devices could have been co-located. The analytic was developed using various data sources and applies a spatial resolution of X km and a temporal resolution of X minutes, making it suitable for use with any data that can be expressed in these terms. Track Common information Analytics The co-travel analytic in VCIS uses Lat/Long GEO information and time to determine the likelihood of targets being in close proximity to each other. Rather than

relying on GCID information, the analytic first generates event sequences of Lat, Long, and time for each selector and computes how far the selector has traveled in general. If the selector has not traveled outside an X-km radius, it is not considered. The tracks of eligible selectors are then pairwise-compared to each other, and a measure of similarity in time and space is computed.
To reduce processing time, VCIS creates an index containing selectors whose tracks are near each other in space. This is achieved using a Geo-Locations hashing algorithm that groups cell towers into clusters based on their Lat/Long coordinates, regardless of the targets' service provider. This hash enables quick comparison of target tracks by comparing their Geo-Locations.

Fast Follower and Meet & Greet VCIS has developed two analytic models: Fast Follower (FF) and Meet & Greet Spatial Chaining (MGSC). The FF analytic is designed to detect individuals who are following station personnel. Detailed non-SIGINT path data is collected with the consent of the station personnel, and this reference path data provides the seeds for the analytic. It attempts to discover mobile GEO data indicating individuals that may be following the station personnel. The MGSC analytic is designed to detect meetings between high-value individuals and other entities. The FF analytic considers non-SIGINT reference paths for station personnel based on detailed knowledge of the entity's location. It identifies candidate followers by identifying other individuals that have traversed a number of consecutive points (determined by the analyst) that match the reference path in space and time. The analyst also sets a minimum distance parameter that must be covered along a candidate path.
The MGSC analytic is designed for smartphone data. It identifies sequences of consecutive location points that are close in time and combines them into a single data point. A maximum velocity movement parameter is applied to create a time window around each point, representing the approximate time at which the individual was located there (as opposed to traveling to or from that location). Co-travelers are identified by discovering pairs of selectors that meet the duration and distance thresholds set by the analyst as input parameters. Spatial chaining software aggregates and presents the meeting data, including locations, times, and scoring metrics to the analyst.

Travel Velocity Analytics The Travel Velocity Co-traveler analytic determines if two selectors could have been co-traveling by comparing their average travel speed. It helps to filter out false positives by identifying pairs of selectors that were seen at the same series of device IDs over time but could not have been traveling together due to unreasonable velocity.

This can happen if one or both selectors were located at the edges of network coverage during their travel midpoints, for example. To start the analysis, the system computes "movement summaries" for all tasked selectors, containing a list of locations that each selector visited during the specified timeframe. Locations are defined by device IDs (for GSM) or GEO-Hashes. The system then compares the movement sequences of different selectors to identify pairs that could be traveling together, factoring out pairs that could not have reasonably arrived at the same waypoints within 10 minutes of each other. One key advantage of this analytic is that it is not limited to a specific provider network. By considering physical locations and travel velocities, it can detect co-travelers across different networks.

Geospatial Lifelines Co-Travel

The geospatial lifelines analytic utilizes dwell times to identify potential co-travelers. Dwell times are defined as the time spent at a location, and a location is considered a potential beginning or ending point if the dwell time is greater than 2 hours. First, the analytic generates geo-hashes using GSM event data and then calculates transition lines between geo-hashes, indicating a device's movement from one location to another. The result is a query in which geo-hashes represent hits and transitions represent links or edges. Clustering algorithms are then applied to the query to determine locations and selectors of interest. The geospatial lifelines represent the beginning and ending locations, as defined by their dwell times, as well as all intermediate observations. The likelihood of co-travel between starting and ending points is determined based on several measurements, including net distance, time of transition (in minutes), speed (in kilometers per hour), and number of travel segments.

Target Co-Traveler Analytic

The Target Co-Traveler analytic can operate in one of two modes:
The first mode involves providing a list of tasked targets and identifying co-travelers for those targets who have been determined to have traveled during a specified time window. The analytic only considers targets who have

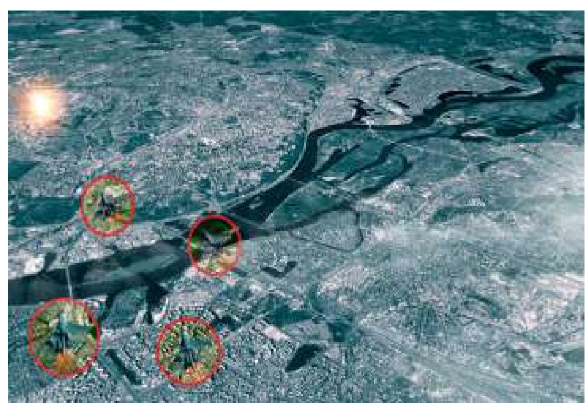
traveled between at least two countries in a given month. For these traveling targets, candidate co-travelers are scored based on how many times they were seen in the same locations during the same times as the target. Target locations are given by geospatial data enriched with telecommunication data. Co-traveler candidates are assigned scores based on the extent to which they were seen in the same cities, streets, or points of interest as the targets on the same days.

The second mode involves providing a pattern representing target travel across spanning countries of interest, and optionally, the days on which the countries were visited. In this mode, the VCIS Co-Traveler analytic identifies travelers that match the pattern. All candidates that match the pattern are regarded as possible co-travelers.

Geo-Telecom Co-Traveler Analytic The Geo-Telecom objective is to merge the Telecom and Metadata analytics to create one complete co-travel analytic. The Metadata cloud-based analytic considers all known targets that have traveled within a given date range (e.g., monthly roll-up to five-month range), and attempts to find their co-travelers.

Co-travelers are defined as individuals that were seen in the same area around the same time as the targets. The output includes both stacked and unstacked selectors as possible co-travelers with the tasked seeds.

Each possible co-traveler is assigned a score that indicates the probability of co-travel with the seed. Higher scores are assigned to co-travelers that are seen at more of the same locations and closer in time (pairs are given one point if seen within one hour, and a half point if seen within two hours of each other). Follow-on analysis could take advantage of the reservation number database which will return all co-travelers that travel on the same reservation number within a given time period (because reservation numbers are reused, a specific time frame must be provided).



Conclusion

With VCIS, we take a multifaceted approach to understanding the movement of criminals, focusing on various factors such as travel-paths, area classification, the role of smugglers, and spatial aspects that affect integration. Our analysis extends to examining the structure and activities of criminal networks involved in human trafficking, people smuggling, modern slavery, and terrorist plans.

To achieve our mission, we use empirical data to reconstruct the journeys taken by criminals and terrorists, as well as the organization of smuggling operations. We pay close attention to the strong spots and weak links of criminal organizations to identify potential breaches, as well as any patterns that support human movement.

Our analysis involves a strong Geo-Smart component, recognizing the inherently relational nature of the phenomenon under investigation. Through this approach, we aim to gain a comprehensive understanding of criminal movement and networks, with the ultimate goal of improving safety and security for all.