ARTICLE:

‘Mobile Ping Data’ – Metadata for Tracking

By **Reg Coutts and Hugh Selby**

Introduction

Until recently the data kept by Telco mobile telephone operators that was used by law enforcement was limited to Call Charge Records (CCRs).[1] In Australia these records are required by law to be kept for two years.[2] They are generated by call, message and data traffic for the primary purpose of billing the customer. In legal proceedings they are classed as ‘business records’ and besides the time and duration, they also record the radio cell and site (cell ID) used at the beginning of a call. Most often in an urban centre, a site of an operator has three cells,[3] which each cover 120 degrees.

The interpretation of ‘location’ from cell ID information regarding the calls of a person of interest has become a commonplace tool of police investigations. The results are presented in legal proceedings to verify the general location of a device at the time of a call. The authors have reported previously on the challenges that can be made at or before trial to such evidence.[4]

Another source of time stamped cell ID (that is, additional to CCRs) are the regular but often infrequent ‘pings’ associated with telephone location updates. Such updates occur when a mobile device is switched on and moves between Location Areas (LAs), or at hourly intervals when a mobile device is switched on but remains stationery. All that is required is that the device is ‘switched on’. It does not have to be making or receiving calls.

Two further terms now need to be understood. There is the Visiting Location Register (VLR), which holds the location (that is the Location Area (LA)) of an active mobile device. The VLR is recorded when a device is not in its HLR (Home Location Register) and is said to be roaming. The significant limitation with this data, called ‘ping data’ and referred to as VLR data, is that it is only kept for weeks, unlike CCRs which are stored for two years. There is, at the moment, no statutory requirement in Australia to keep this Visiting Location Register data.[5] VLR data is useful to the police when they have a suspect very soon after a crime is committed; however, its subsequent unavailability presents a challenge both for police investigators and potential defence purposes months or years later.

This paper describes the source of such VLR data and how it can be used to infer ‘trajectory’ of mobile devices when they are switched on and when there is no call activity and hence no associated CCRs.

Sources and accuracy of ping activations

‘Pings’ arise from network location updates to provide for the reliable establishment of calls, maintaining data sessions and minimising the need for location searches to establish where a call was physically made. Historically, the location area cited in a billing record involved several sites in a service area, but the need for more efficient network signalling now often means that the location area is just one site encompassing the three sector cells. Sources of ‘pings’ include the following:

1. Periodic location updates for idle mobiles

(i) Periodic updates set by the network (e.g. hourly) is an indication of both telephone mobility or immobility, and user inactivity. For example, hourly updates in the same cell are an indication of a stationary device.

(ii) Absence of HLR/VLR data for periodic updates is an indication of mobiles that are turned off (radio transceiver is OFF). The absence of HLR/VLR data during normal hours of the day is often interpreted as telephone intentionally switched OFF (especially in

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[1] In some places these are called Call Detail Records.

[2] See section 187AA (1) and section 187C, Telecommunications (Interception and Access) Act 1979 (Cth).

[3] There can be multiples of 3 (i.e. 3, 6 or 9 cells), each set of three being applied to a different technology that also uses the same tower.

[4] Reginald Coutts and Hugh Selby, ‘The Safe and Unsafe Use of Mobile Phone Evidence’, Communications Policy Research Forum (CPRF2008), 29-30 September 2008, Sydney; Reginald Coutts, ‘The Safe and Unsafe Use of Mobile Phone Evidence’, lecture to the Public Defenders Law Conference, January 2009; Reginald Coutts, ‘Scales of Justice and Cell Phone Evidence’, presentation to the Expert Evidence Conference, 12-13 February 2011, Canberra; Reg Coutts and Hugh Selby, ‘Problems with cell phone evidence tendered to ‘prove’ the location of a person at a point in time’, *Digital Evidence and Electronic Signature Law Review*, 13 (2016) 76 – 87.

[5] See section 187AA (2), Telecommunications (Interception and Access) Act 1979 (Cth), which provides that the Minister may, by legislative instrument, add data such as this to the list of required data holdings.

cases involving a crime investigation). The pattern of telephone use is potentially useful, as for example with a night worker.

(iii) Periodic updates involving different cells in the one Location Area is an indication of user mobility being limited to within that Location Area. Each Location area is composed of a number of cells.

2. Crossing Location Areas and Routing Areas

(i) Idle mobiles with rapid mobility can cross between Location Area boundaries in less than an hour. This is often the case of users travelling in a car, bus or train. When the Location Area is large (comprising many cells), only the rough trajectory of the device can be extracted from the VLR data. To improve the trajectory analysis, the VLR and CCR data are often analysed together.

(ii) At times, the device switches modes (2G/3G/4G), even in idle mode. In this case, the Location Updates are activated.

(iii) For mobiles in data transmission mode (e.g. where GPRS data is switched ON), the Routing Area Update improves the rough measure of accuracy (known as ‘granularity’) of the VLR data. Routing Areas are often planned with fewer cells – that is, a subset of a Location Area. Since data transmission are set such that the mobile prefers the smaller/high capacity cells, the location accuracy is much improved.

(iv) An indication of very rapid mobility of the phone is frequent location updates together with possible *Ping-Pong* effect between adjacent cells in the Location Area boundary. Note that frequent location updates can also result from unexpected reflection of a signal caused by an environment, such as city skyscrapers.

Location updates occur when the device contacts the most acceptable cell (which may not be the closest in distance) and reports its cell ID, whereupon the Location/Service Area Code (LAC/SAC) corresponding to the cell ID is stored in the VLR. Hence location updates are prompted when a ‘switched on’ mobile crosses a Location Area boundary as happens when the device moves from one place to another. Further, the frequency of these location updates can be used to estimate the speed of travel (for example, the mobile is in a walker’s pocket, or is in a car, or on a bicycle).

Ping activations only roughly indicate the area that the cell or sector is serving (as is the case for location estimates from CCRs[6]). The smaller the cells, the better the location and speed estimates.

Trajectory analysis

The VLR/HLR data can be used to plot the direction of movement of a device that is switched on. In a case where there are two mobile telephones (as in an abductor and a victim, each of whom has a telephone) what is critical is the degree of correlation in the movement of the two mobile telephones that can be observed through analysis of the telecommunications data. The trajectory of each device can be traced using all the available information: such as call records including sector (cell ID) information for SMS, voice and data calls; and, VLR data.

When a mobile is running data services in the background, the ping frequency is dependent on Routing Area Updates. This is a network related setup, but normally each cell may be assigned to a unique Routing Area. Thus the coverage area of the cells will serve as the reference area for trajectory analysis. The speed of travel of the mobile could then be broadly estimated from the Routing Area Density in the area and the ping frequency observed in the VLR data record, simply by noting the distance between the cell towers, for example.

Given the short time frame – of just weeks – in which VLR data is available, we must await the case where the defence asserts that being unable to request additional[7] VLR data has undermined their opportunity to posit a credible alternative hypothesis to that of the prosecution. The pertinent question is how a court should handle such an anomaly bearing in mind that an absence of evidence is not evidence of absence.

[6] Reginald Coutts and Hugh Selby, ‘The Safe and Unsafe Use of Mobile Phone Evidence’, Communications Policy Research Forum (CPRF2008), 29-30 September 2008, Sydney.

[7] The police are in a position to seek VLR data quickly but may do so only to support their particular hypothesis explaining the crime. Thus, hypothetically, it might be argued that VLR data was obtained for time X but not for time Y (which was available at the time that police obtained the time X data but not at the later time when a person has been charged and is awaiting trial), the latter being the basis for a defense hypothesis consistent with innocence.

Illustration

Recent case experiences serve to demonstrate the value of VLR data in supporting a potential prosecution involving the motion of mobile devices in a service area. Figure 1 below is an example of a mobile device that is switched on and not being used and moving at vehicular speed while crossing Location Areas. The trajectory is analysed based on cell boundaries of each new cell captured by the VLR data (different colour means a different Location Area). The small red circles with the blue edge are rough estimates of the location of the mobile device within each Location Area. The operator network planning engineers know the approximate locations of these cell boundaries. They are also shown in the propagation prediction maps that are produced by software. Hence the expert – being someone familiar with current telecommunications engineering – can interpret the available data.

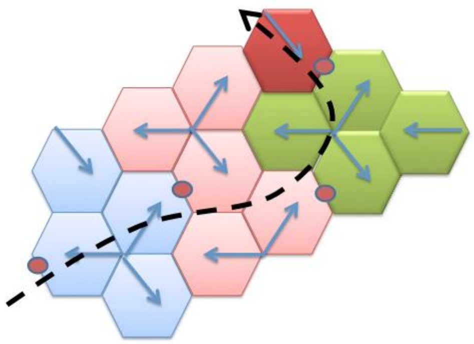

Figure 1 – Example of moving mobile telephone

In this case there were no calls or messages at the time of interest to the police, and therefore no relevant CCRs. The cell ID information available from the VLR data from the telephones of the suspect and the victim provided the basis for estimating location as shown in Figure 1.

Figure 2 below shows an example of a mobile telephone that is switched on and idle, and not very mobile. The trajectory is analysed, based on the cell coverage midpoint within a Location Area compared to the boundaries of that cell coverage (known as 'cell edge') when changing from one location area to an adjoining location area**.** This approach builds on the known geographical attributes of a Location Area (such as its area, topography, and transport routes) to consider the implications of the rapidity of location updates for assessing the likely direction and speed of travel of the mobile telephone.

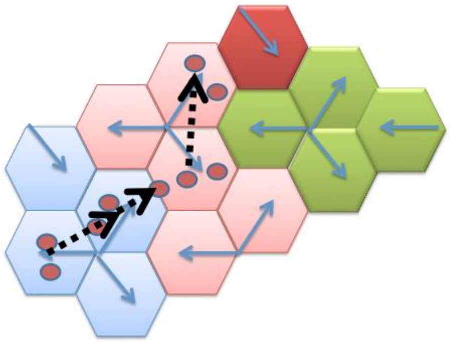

Figure 2 – Estimating a plausible trajectory and speed

In the above diagram, figure 2, there are nine instances of estimated location derived from the VLR data. Using the recorded times within that VLR data, it is possible to estimate the speed at which the device was travelling. By reference to surface maps, such as Google earth,[8] it is possible to predict with some confidence the road or roads upon which the mobile was travelling. From the analysis of the VLR data, we are able to infer the trajectory and rapidity of movement of a device that may be consistent with a particular scenario. 'Being consistent' is not proof; however, this information is useful to the police investigations and potentially to any subsequent legal proceedings where it contributes to evaluating other evidence that is relevant and admissible.[9]

By comparison, CCRs alone cannot be used to estimate the trajectory or speed of movement of a device. This is illustrated in Figures 3 and 4 below, where both VLR and CCR data are available. In Figure 3 the telephone is switched on and being used. Hence CCR data is compiled. However, the CCR data has few calls registered. This means there is insufficient data to indicate a direction of travel towards the potential destination.

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[8] See Stephen Mason and Daniel Seng, editors, *Electronic Evidence* (4th edition, Institute of Advanced Legal Studies for the SAS Humanities Digital Library, School of Advanced Study, University of London, 2017) for examples of where Google earth was discussed in case law, at 6.16 and 6.23 fn 3. http://ials.sas.ac.uk/digital/humanities-digital-library/observing-law-ials-open-book-service-law/electronic-evidence

[9] In an ideal world there would be an opportunity to conduct field tests to confirm the actual coverage of various cells.

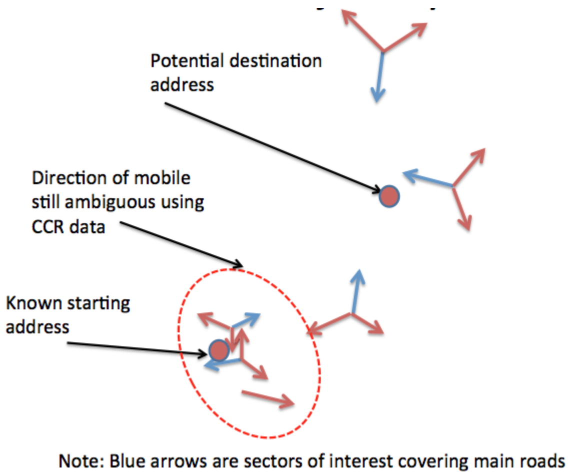

Figure 3 – Limits of CCR Data to estimate trajectory

Figure 4 replicates figure 3 but adds the 'ping' data. Thus it can be seen that in the first hour the mobile device is in and around the area with no dominant cell. If the user made a call, then the CCR would tell us which cell ID applies. It would also tell us the duration of the call. Five minutes later frequent VLR activity was recorded (an indication of mobility) and the mobile device is located above that area and within the domain of a small coverage tower. Another hour later, the mobile device has moved into the coverage area of a large tower. There are no CCR records and hence no use of the mobile device during that period of time.

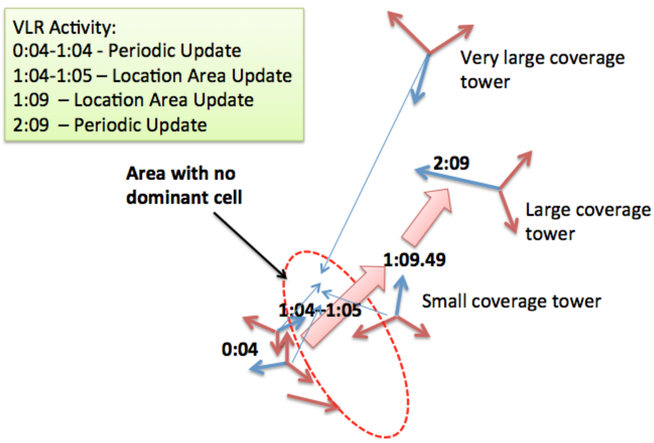

Figure 4 –CCR data with VLR data to estimate trajectory

Conclusions

We should expect the use of VLR data to rapidly increase, not only to track a suspect's movements, but also to exclude a person from further inquiry. As an example, consider an attempt made by party A to implicate party B as the source of threatening messages[10] to party A allegedly on a 'burner phone' that party B acquired for the purpose.[11] Party B always carried their 'usual' telephone. Fortunately for party B, the CCR data and available VLR data for these two telephones showed that one telephone moved in a different trajectory to the other. These results suggested that party A was the owner and user of the 'burner phone'. The roles of victim and complainant may then be reversed.

The potential of VLR data to provide greater insight into the movement of mobile devices of interest enhances the capabilities of law enforcement to build a case. VLR data is not on the 'required data holdings' list for mobile carriers in Australia. This is not a problem when police have early leads and can move quickly; however, where leads take weeks to emerge, then both police and later the prosecution and defence will be hindered by the absence of VLR data. This is unsatisfactory for everyone.

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Professor Reg Coutts is the Emeritus Professor of Telecommunications of the University of Adelaide and MD of Coutts Communications.

http://www.couttscommunications.com

Hugh Selby is a Barrister doing criminal defence work.

http://www.advocacymatters.com.au

[10] To send threatening messages using a carriage service (e.g. a mobile) is an offence. See Commonwealth's Criminal Code Act, 1995, part 10.6, Telecommunication Services, section 474.17 'Using a carriage service to menace, harass or cause offence', and section 474.15 'Using a carriage service to make a threat'.

[11] A 'burner phone' is a prepaid mobile purchased for short term use for often suspect activities.