The Evolution of Mobile Phone Evidence
From Best Guess to Precise Prediction, a Science Emerges

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Synopsis
The integration of the mobile phone has seamlessly interwoven itself into many aspects of everyday life with inbuilt and associated technologies that made it the must have device it is today.

This article provides a general review to the evolution of mobile phone evidence and in particular Cell-Site Analysis, highlighting how technological and sociological change has brought about a maturity to its application whilst litigation attitudes to this branch of digital forensics have not always kept pace.

Cell-Site Analysis (movement and location) is one of the fundamental components in a trident of mobile telecommunication evidence that also includes Attribution (who operated a particular phone) and Communications Analysis (who interacts with who and at what level).

Each mobile phone network provider (Vodafone, O2, EE, etc.) maintains a network of transceivers (transmitter & receiver) throughout the country in distribution of service coverage/provision.

Many of these transceivers (cell-masts) are now common place and widely recognised for what they are standing like sentinels adjoining motorway networks or as great skeletal leviathans on high vantage points. Many more surreptitiously blend into the background of our surroundings, hidden on rooftops or disguised as street furniture such as lampposts, flagpoles and occasional modern artwork.

Typical Cell-Mast structures and antenna equipment

Importantly though, each network transceiver (cell-site) is uniquely identifiable. Therefore, the service provision from each transceiver is traceable and quantifiable with regards to the area of service cover.

As the mobile phone networks have grown and expanded over time, then the number and diversity of transceivers (cell-sites) has increased dramatically with the resulting coverage areas becoming ever more localised (smaller) to cope with greater capacity demands.
The Popularity of Mobile Phone Evidence.
As the adoption of the mobile phone infiltrated into society, towards the end of the 1990’s, it brought about a frequent source of information within criminal investigations that could, amongst other things, indicate the general movement and location of a suspect(s). Additionally, this evidential record of movement and activity could in turn be compared against a suspect’s account or alibi when such was offered.

- In essence, the mobile phone represented, and continues to be, a personal tracking device.

Never before had law enforcement/forensic science had access to such a recorded stream of reference points that could indicate, without witness, a person’s general movements along with a record of who they had been in contact with over a prescribed period of time.

Previously, such evidence would be reliant on fingerprinting or a possible DNA trace at a specific location - subject to the close scrutiny required to find such evidence. There was a greater reliance upon witnesses or informants to provide information with regards to a suspect’s whereabouts.

The introduction of electronic banking services during the mid-1980’s had been a catalyst to early electronic activity tracking. The introduction of the Automated Teller Machine (ATM / cash point) in 1985 was followed by the arrival of the debit card in 1987 and both provided a limited source of information when tracking a person’s location or movements in accordance with their purchasing/financial activity.

For law enforcement the adoption of the mobile phone has been akin to having a string of eye-witnesses or informants all pointing in sequence to the area of a suspect. ‘He’s over here, he’s over there, he went that way and no he wasn’t over there.’

In the early stages Cell-Site Analysis was often applied to define where a person (and their phone) could not have been to support or refute an alibi or allegation.

A suspect may have stated that they had spent an evening at home whilst their corresponding Cell-Site activity may have contradicted such assertion and demonstrate widespread movements and activity.

Predominantly mobile phone evidence often provides the glue to bring other evidence into sequence. It acts like fly-paper attracting and sticking other items of evidential value - eye witness accounts, DNA recovery, CCTV footage, ANPR sightings and payment transactions etc - into a pattern of chronological consistency.

- The greater the level of transaction within the mobile phone records the stronger the bond of the glue.

A Note on Attribution
A crucial aspect to the value of obtainable evidence is the attribution of the mobile phone to a particular person. Attribution applies both in terms of phone ownership and actual usage at the time when cell-site data or communication activity was recorded. (‘it’s not my phone” or “I lend it to others” or “many people have access to it”)

- The attribution of a mobile phone is a process in its own right and the subject of much debate beyond the remit of this article. However, similar to the advances of Cell-Site Analysis the ever involving technical and social change continues to produce far more intrinsic user profiling to cement attribution assertions.

Developments and effects - The rise and rise of phone ownership and use.
The mobile phone revolution started to gather pace in the late 1990’s as the cost of ownership started to become within the grasp of the mass populous.

- In January 1999 Ofcom estimated that approximately 27% (1 in every 4) of UK adults owned, or had access to, a mobile phone.

- Just 12 months later that figure had almost doubled and stood at 46% and by November 2001 the figure had risen to 75% (3 in every 4). (OfTel, 2002).
In recent figures, from 2014, the level of UK mobile phone ownership stood at 93% of the adult population (Ofcom).

1993 - Digital mobile phone networks started to emerge from frontrunners Mercury and Vodafone quickly followed by Orange in 1994. Initial consumer take-up was slow and mostly aimed at the business executive in acknowledgement of the high cost of ownership and usage.

Early networks suffered from poor coverage in non-metropolitan areas and internment service quality. This generated a demand and competition for network companies to dramatically expand their network coverage. During the early adoption phones the biggest inhibitor to phone ownership was cost both in terms of handset ownership and monthly running expense from subscription fees and relatively high usage costs.

In 1996 Motorola introduced its ‘Startac’ handset the world’s first Clamshell design with the promise of up-to 8-day battery life. In the UK the handset retailed at £1,400.

1997 - In attempt to address the issue of usage costs mobile phone companies introduced ‘pre-pay’ options to unshackle consumers from the requirement of a monthly contract. The move was to prove a huge success.

The subsequent explosion of mobile phone ownership was driven by many social factors but predominantly by the reduction of cost and through advances in handset design and desirability. Since the turn of the millennium the growth in mobile phone ownership has been exponential.

1999 - In January 1999 ‘Oftel’ reported that approximately 27% (1 in every 4) of UK adults owned, or had access to, a mobile phone. In the same year (1999) Supermarkets started to sell pre-pay mobile phone bundles with a price point under £100.

Unsubscribed pre-pay – ‘burn’ phones
One affliction to the criminal investigation process was, and still remains, the unsubscribed pre-pay option, which adds to the burden of the attribution process.

The popularity of pre-pay options and the ease of access to unregistered SIM cards led to the use of short life ‘burn’ phones. Such phones are frequently acquired by individual’s intent on criminal activity and deployed for very limited periods of time before being discarded and replaced on a regimental basis.

2001 - In November 2001 UK adult mobile phone ownership had risen to 75% (OfTel 2002) and it had become the norm for a person to own or have access to a mobile phone device. As a consequence the mobile phone became a more frequent source of potential evidence in criminal investigations.

At this time the mobile phone networks deployed 2nd generation (2G) cell-sites. These 2G cell-sites have a theoretical coverage range of 35-kilometres. This value was frequently bandied by barristers as the de-facto argument to throw at cell-site evidence when it got to the courtroom.

In reality few, if any, of the deployed 2G cell-sites afforded ranges reaching the quoted theoretical level. However, at the time, it was not uncommon to find rural based cell-sites with a coverage range in the order of 15 to 20 kilometres and urban based city/town centre cell-sites would often extend in excess of 5 kilometres. Therefore, the level of affordable accuracy was far from precise and Cell-Site Analysis was frequently referred to as an un-precise science. A further inhibitor to early Cell-Site Analysis was the infrequency of phone usage, which still remained limited due to call and text messaging tariffing.

As the consumer boom in mobile phone ownership took hold it drove forward widespread investment and development both for mobile networks and mobile phone devices. At the turn of the millennium mobile phone networks had grown to cover all major cities and towns with 2nd Generation (2G) cell-sites. As the demand for services continued to increase so did the number of mobile phone users at any given location and especially within busy urban environments.
The coverage area of a mobile phone cell-site can sustain a finite number of active users/subscribers. Generally the greater the volume of mobile devices at, or in any, particular location/area then the smaller the size of cell-site required to sustain those devices and combat the signal to noise ratio (SNR) problems.

In 2001 the vogue for mobile phone handsets was for smaller compact designs and few at the time had colour displays. Ericson’s T68 handset was the manufacturer’s first with a colour display.

2002 - It wasn’t until 2002 that mainstream mobile phone devices started to include a camera option to further enhance their desirability. This additional option would in part contribute to a greater demand for the transference of digitised data (pictures/video) across the mobile phone network.

Coincidently, the development and popularity of the camera option was to play a major part in improving the evidential value of recovering a mobile phone device as the stored imagery (of a subject or their family/associates) would often prove vital in the attribution of a mobile phone device to a particular person.

Handset data could also provide vital information with regards to a person’s association with others and in certain cases actual evidence of crimes themselves as criminals took trophy pictures of their actions or ill-gotten gains.

2003 – Hutchison introduce 3G services
In 2003, in response to the demand for a greater range of services and higher data transfer speeds, Hutchison introduced the third generation 3G network. Other network operators would eventually catch-up with the introduction of their own 3G network in tandem with their existing 2G networks.

The major impact of the 3G network from a Cell-Site Analysis perspective was that it pulled the rug from under the theoretical 35 kilometre range argument as 3G operated at a higher frequency and had much reduced range potential.

Additionally, it created situations where a mobile phone would utilise combinations of 2G and 3G cell-sites, which in-turn improved analysis when examining the service and overlap of the differing technologies at relevant locations of interest.

2003 – Blackberry impact upon messaging
In 2003 ‘Blackberry’ came to the market with its RIM 850 device that it marketed as a Personal Digital Assistant or PDA. Significantly, Blackberry were to introduce the Blackberry Messaging (BBM) service that offered instant messaging without the costs then often associated to text messaging.

In the fullness of time, other third-party offerings for instance messaging services came to the fore that could be operated on cross-platform devices.

To an extent BBM still remains a commonly used communication mechanism uncovered in investigations into Organised Crime Groups.

In 2004 Nokia, the then world leading handset manufacturer, released the 7610 handset which was the first to feature a 1 mega-pixel camera.

In 2004 Motorola gained huge success with the introduction of the Motorola ‘Razr’ handset with its brushed aluminium casing and 2.2inch TFT screen it became a must have fashion accessory that led to eventual sales of over 130 million devices. Despite the 0.3megapixel camera and 5MB (yes mega-bytes) of non-expandable memory it would be the top selling phone 2004 – 2006.
In 2006 many network operators were offering "all you can eat" data plans such had been the growth in demand from consumers now embracing mobile data services.

By 2007 Ofcom were reporting 73.5 million active UK mobile subscriptions. (UK Population for 2007 was 61.3 million). Many consumers now ran two or more phones or would use secondary subscriptions for data services.

The double-phone use is often found to apply in criminal investigations where a suspect may operate, or be accused of operating, what is often termed ‘Clean Phone’ ‘Dirty Phone’ separating out personal life (clean-phone) and otherwise dubious activity (dirty-phone).

In essence though, when such strategies are applied by those engaging in criminal activity the double use of phones merely adds to the level of obtainable evidence. That evidence can subsequently be compared and combined to show a much greater consistency to other events. Additionally, twice the amount of cell-site data may prevail to afford greater scrutiny, particularly in the identification of specifically defined travel patterns.

Ofcom reported that by the end of 2007, 17 percent of all mobile users (12.5 million) were using 3G, which had been an 11 percent increase on the previous year. The uptake in 3G subscriptions would continue to rise.

Within the realm of Cell-Site Analysis it was now becoming common place to find a subject’s phone switching between 2G and 3G technologies within the Call Data Records under scrutiny. This added greatly to the level of analysis that could be applied, as examination could be made into where the two technologies would overlap and where one takes over from another.

2007 – Apple gets a bite of the market

In 2007 Apple Inc. branched out into the mobile phone market with the release of the Apple iPhone. Apple already had a loyal customer base from successful sales of IT and multi-media devices and its multi-media management platform ‘i-Tunes’, which was established in 2001.

The introduction of the iPhone was a major development to the ‘Smartphone’ market that intensified brand competition, which continues to drive technological and ascetical development of mobile phones.

The capabilities and functions of mobile phones continued to diversify to provide extra added benefit to the consumer in the battle for brand popularity.

A growing number of mobile phones would incorporate GPS technology, which in turn could provide Satellite Navigation functionality. Wi-Fi transceivers were also being incorporated into mobile phone devices to extend the connectivity options for access to the internet and other digital devices.

October 2007 saw the commencement of a program to switch over the existing analogue terrestrial TV broadcasting on to a digital broadcast that was to be completed by October 2012.

The resulting changeover made particular frequency bands available that were sold under licensed to communication network providers for further expansion and development of the mobile phone network.

2008 - In 2008 the 4th generation (4G) network was under development in timely anticipation of the ravenous demand for high speed data transfers from media hungry consumers. It would be four years in development before the roll-out of 4G cell-sites that commenced in 2012.

The expansion of the mobile phone networks continued to see the installation of more 2G and 3G Cell-Sites (particularly 3G) nationally and generally a continual reduction in the size of cell-site coverage areas across urban and rural environments.

• Governmental policy amended certain planning restrictions in order to facilitate a wide-spread expansion of mobile phone and data networks within the UK.

2010 - In 2010 the Mobile Network Operator ‘EE’ was formed (then as Everything Everywhere and latter abbreviated to EE) from a merger of network
operators T-Mobile and Orange. Effectively it meshed together the network resources (cell-sites) of each provider.

In respect of the Cell-Site Analysis the creation of EE improved the affordable accuracy level when applying analysis in respect of T-Mobile or Orange phones. The merging of networks now allowed analysis to show where and why service ‘crossed-over’ between T-Mobile and Orange resources. Furthermore, the increase of cell-masts now jointly available led to a general reduction in the size of coverage areas of individual cell-sites.

The developments of Smartphone capabilities have driven an ever expanding ‘apps’ market covering all manner of entertainment, service, information, and function.

2011 - In October 2011 Apple announced that their App Store listed over 500,000 application titles for download, that number then exceeded the 1 million mark by October 2013. The latest figures announced by Apple (Jan 2015) claim that the App Store contained over 1.4 million titles to choose from and that total App Store downloads had exceeded 75 billion.

The ‘apps’ themselves often provide a vital source of information in the attribution and/or profiling of a subjects lifestyle and associations.

2013 – 2014 Mass Messaging
Deloitte estimated the volume of instant messages composed in Britain doubled from 160 billion in 2013 to 300 billion by the end of 2014. This equates to approximately 820 million instant messages transacted daily (about 12 messages per day sent by every UK resident).

Social Media Revolution.
The Smartphone phenomena supports, and is supported by, the social media revolution as it provides the ‘take anywhere – always connected’ portal to access and function. Over the last decade the development of the ‘mobile device’ (Phones, PDA, Tablets, Laptops) has been a perfect marriage to the social media revolution.

The rapid adoption of ‘social media’ and the notion of ‘always being connected’ have seen the creation of vast global business empires transacting multi-billion dollar acquisition deals. What makes this more remarkable is that the majority of those business empires predominantly provide a free of charge service to the majority of their subscriber base. Here we look at a few of the movers and shakers of the social media world.

August 2003 Skype Voice and Video Calling
• Skype - launched in 2003 and purchased in August 2005 by Ebay for 2.6 billion dollars. It was sold to Microsoft in 2011 for 8.5 billion dollars (Doug Aamoth, Time.com, May 2011)

February 2004 Facebook Social Media Services
• 1.3 billion active users by June 2014

February 2005 YouTube Video Sharing Website
• Conceived in the wake of the 2004 Boxing Day tsunami. In 2015 YouTube’s website claimed more than 1 billion users and estimated 300 hours of video were uploaded every minute and 50% of YouTube views being made from a mobile device.

March 2006 Twitter Social Media Services
• First ‘Tweet’ posted by the company on 21st March 2006. In 2015 Twitter reported 288 million monthly active users sending over 500 million tweets daily with 80% of users accessing via a mobile device.

November 2009 Whatsapp Instant Messaging App
• WhatsApp can be used to send messaging, images, video and audio media messages.

• In October 2014 WhatsApp was considered the most popular messaging app with more than 600 million active users. By January 2015 this had risen to 700 million users.

October 2010 Instagram Mobile Online Multi-Media Sharing
• Following launch in October 2010 Instagram rapidly gained popularity. The Instagram website of 2015 reported daily uploads of more than 60 million photos by its online community of over 300 million subscribers.

September 2011 Snapchat Mobile online multi-media messaging
• According to Snapchat in May 2014, the app's users were sending 700 million photos and videos per day.

The development and adoption of both mobile devices and social media highlights the rapid technological and sociological changes that now make a mobile phone the most intrinsic and intrusive evidential hub into everyday life and personal detail.

Additionally, the continual rising scale of customer interaction is phenomenal and generates colossal volumes of network traffic. This continues to drive
heavy investment into the underlying network infrastructures that keep mobile phone devices connected.

This has again led to a greater level and diversification of technology deployed to maintain and support the connected community.

Through development of mobile phones networks there are now 2G, 3G and 4G cell-sites with differing frequency ranges within these technologies. The diversification of underlying digital networks from founding 2G technologies is now complemented by increasing numbers of Micro and Pico cell-sites. Development and diversification continue to expand and enhance the level of analysis that can be applied in respect of mobile phone usage and its evidential value.

**The main challenge today**

One of the on-going challenges facing (mobile phone evidence) Cell-Site Analysis is to educate both Law Enforcement and Litigators that the afforded evidential value has risen exponentially along with the growth and development of the mobile phone networks (technological) and the growth in phone usage (sociological).

As the evidential value of Cell-Site Analysis has increased the actual cost of its application has drastically reduced from the overly exhortation prices once charged by entities that monopolised and exploited the Law Enforcement (Prosecution) market.

The cost reduction is due to a number of factors including; standardisation of Call Data Records, control on underlying data costs, the development and availability of surveying equipment options, and a wider pool of expertise. These factors, blended with commercial competition have driven down the cost of application.

However, as a consequence of the rapid growth the complexity of the mobile phone network, with regard to Cell-Site Analysis, is ever more involved and requires in-depth analysis if it is to be utilised effectively.

During the current climate of austerity and budget reductions the prosecution markets are outsourcing less and relying more upon their limited internal resources to provide basic overviews of cell-mast usage. This can have a negative effect both for an actual investigation and ultimately on the criminal justice process, for either prosecution or defence.

It further demines the true value of Cell-Site Analysis and extends the negative viewpoint of an imprecise science.

The evidential value of evidence cannot reach full potential if it is not accurately understood. If the primary decision maker (defendant or juror) is not empowered with the information in an understandable form then the usefulness of the evidence may not be achieved or worse be perceived to establish unsupported facts.

When well-presented evidence is produced showing that a properly attributed phone is intrinsically linked to all, or even the majority, of an incident’s milestones and where the overall pattern of consistency can be shown to be robust then such evidence may convince a subject to admit their involvement and guilt. Where this happens, and it often does, the resultant early admission of guilt saves the taxpayer the expenditure of a costly trial process. Such capital saving cannot be achieved on the back of summary analysis and poorly presented evidence.