The activation of core social networks in the wake of the 22 July Oslo bombing

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***Abstract*—This paper examines how core social networks were activated in the wake of the bombing in Oslo on July 22, 2011. Empirical mobile traffic data illuminate exceptional behavior, just after the bombing in Oslo. We find that in the minutes after the bombing people called ties that were (1) close socially and (2) perceived to be in danger; that is, people who were close to the bombing point. Our main findings: (1) individuals first focus on their single closest contact ('best friend'); but, soon after, switch to spending more mobile communication resources than average on contacts ranked 2—5. (2) we see clearly a large increase (over typical) in traffic to and from, and not least within, the affected area (Oslo)—in some cases more than a 300% increase, right after the bombing. Interestingly, we also find a marked increase in traffic for relationships where both persons were outside of Oslo. All these results illustrate the importance of social contact in this highly unusual situation. This paper underscores how the mobile phone is an instrument of the intimate sphere. The situation on the 22nd of July in Oslo is a prime example of an unexpected situation, where individuals use the mobile to get critical information on their loved ones in their core network.**

large-scale social network analysis; telecommunications;22 July; mobile communication in emergencies; social cohesion; terrorist networks; terror;SNA; mobile communication networks; call detail records; CDR

I. INTRODUCTION

On Friday 22 July at 15:26 a powerful bomb exploded in *Regjeringskvartalet* (the center of national administration) in central Oslo, Norway. It killed 8 people and seriously injured almost 100 others. Following the bombing, Anders Behring Breivik (a right-wing, white extremist) drove approximately 1.5 hours and took a ferry to the small island Utøya where the Norwegian Labor party has a summer camp for its youth members. There he shot 69 of the attendees and wounded 60. This is the deadliest attack on Norway since the Second World War.

For reasons we will discuss below, this paper will focus on the immediate reaction of the general population in Oslo (and also Norway in general) to the bombing event alone. We do this by examining their calling behavior, as assessed using anonymized traffic data from the mobile phone network.

In earlier but related work, Dutton [1] and Katz and Rice [2] presented qualitative results on the 9/11 catastrophe, emphasizing the need to reach out to the closest tie. Cohen and Lemish [4] examined the geographical distribution of traffic after a terrorist bombing in Israel. Studies of other types of disasters include Erikson's [6] discussion of communication needs (absent mobile telephony) during and after flooding from a breached coal sludge dam, Weick's [7] study of verbal communication during a firefighting disaster, and Figley and Jones' [8] qualitative results on the use of mobile telephones around the Virginia Tech shootings.

Our work is distinct from these others, in that we use large scale phone logs to understand communication patterns around the disaster of July 22. Such studies, utilizing unique and valuable mobile communication data for research, have begun to appear in recent years; for examples, see [9]—[16].

It is clear that, in events such as 22 July, we feel the need to reach out to near family and friends—to check on one another's wellbeing, possibly to organize assistance, and to also make sense of the situation. In this paper, we will examine behavior—specifically, mobile phone usage—which can help illuminate the ways these needs are met in the face of a disaster.

II. DEFINITION OF THE EVENT AND THE DATA USED IN THE ANALYSIS

As noted above, the terror attack on July 22 consisted of two deadly events: the bombing in Oslo at 15:26, and the shootings on the island Utøya starting around 18:00. In this paper we will focus almost entirely on the response to the bombing in Oslo. There were three main factors which guided this choice of focus:

1) Privacy issues. Even though we use anonymized call and sms data in all of our research, we observe that the Utøya event involved relatively few individuals (compared to the Oslo event) so that there is a small chance that results for Utøya might be traced to individuals. This is not possible for the highly aggregated data describing the response to the Oslo bombing.

2) Temporal dimensions. In addition, the bombing was a temporally well-defined event. By contrast, the shootings on Utøya were not witnessed by nearly as many people, and the breadth of the tragedy was not immediately obvious. Due to these considerations, the bombings were obvious in the network traffic picture, while the shootings were much less distinct.

3) Technical difficulty. Anonymized call data can be connected to locations by using demographic data. We assume that, statistically, many anonymous subscribers with a home address in Oslo are either physically in Oslo at the time of the bombing—or are suspected to be there by their close contacts—or return promptly to Oslo after the attack. In short: we can use postal address as a simple proxy for location. This idea however cannot work for the Utøya massacre.

Thus, we focus on communication behavior that is localized in time around the bombing event at 15:26. We also study the geographic dependence of this behavior, focusing on Oslo (the site of the bombing) and comparing communication behavior there to that in other areas. For simplicity, we have restricted most of our time-based results to voice communication only—we find that voice is a good proxy for a more complete definition of a mobile communication relationship (such as voice+sms). Our geographic results however include both voice and sms.

III. SPIKE IN AGGREGATED VOICE TRAFFIC

Before presenting our social-network results, we present here the overall response of voice traffic—aggregated over all customers in the Telenor subscriber base, i.e. around 3 million Norwegian customers—to the bombing.

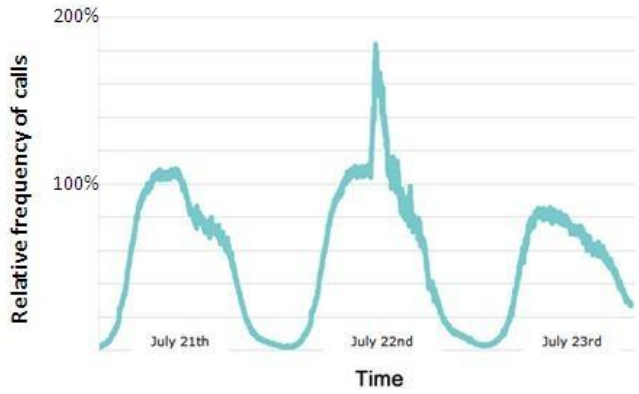

Figure 1 Voice calls per minute, aggregated across the whole country. Here we count only those calls that were successfully terminated.

Figure 1 shows the general voice traffic, displayed minute by minute for July 21st, 22nd, and 23rd, and aggregated across the whole country. We see that the Friday (July 22) behavior is much like the Thursday behavior—except for a sharp peak rising up immediately after the bombing. In this peak we see a strong increase in successfully originated voice calls. We see that the number of calls/minute rises to about twice that we would expect from normal traffic in this period. The corresponding SMS analysis shows a much less distinct peak. The preference for voice communication in this situation shows the importance of immediacy in this situation.

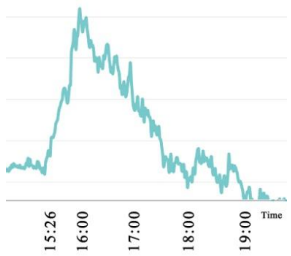

Figure 2 Voice calls per minute (zoomed from Figure 1).

In Fig 2 we give an expanded view of the time-dependent voice traffic during the spike. We see that the rapid increase in traffic reaches a peak around 30 minutes after the explosion (around 4 pm). The traffic then gradually returns to a normal calling pattern. An exception to this is seen in two small peaks between 18:00 and 19:00. These two peaks correspond to the time of the Utøya massacre. Compared to the peak caused by the explosion, these smaller peaks show that this was a much more isolated event. Next we want to further investigate the calling patterns in this period.

IV. DEFINITION OF THE CORE NETWORK

We want to better understand how the closest relationships in a social network are affected by the emergency situation which the bombing attack represents. To do this, we will, for each node, rank the node's relationships according to the number of calls sent to the node's various contacts.

We draw on earlier work [17] and define the *closest relation* using a simple definition: the closest relation is defined as the person that an individual called the most over a 3 month period prior to the bombing. Figure 3 illustrates the idea: node A has had 37 calls to node B during a 3 month interval, which defines node B as A's closest relation. Node C will be his second closest relation, and so on. Based on these definitions, we can generate a list, for all subscribers, giving closest relation, second closest relation, third closest relation, etc.

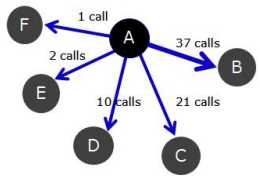

Figure 3 Closest relation definition. B is A's closest relation, C is A's second closest relation, etc.

V. EFFECTS OF THE BOMBING ON THE CORE NETWORK

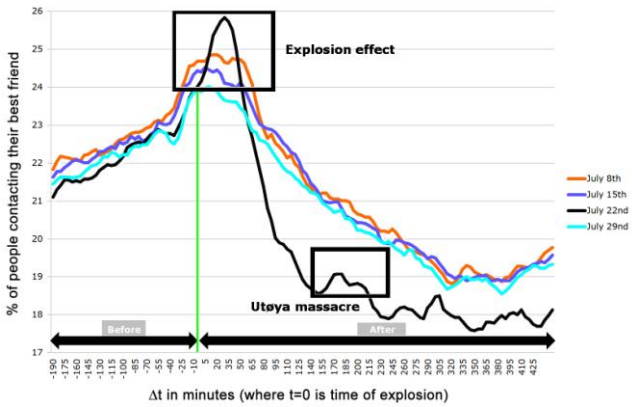

Figure 4 Percent of active subscribers contacting their closest relation as a function of time. The percentage is shown for Friday 8th, 15th, 22nd and 29th of July 2011.

Using the definitions of Section IV, we now look at (i) what relations are contacted, and (ii) when they are contacted—in the period just before and after the bombing. We focus on an

11 hour time interval (12 noon to 11pm), and on all subscribers that were active in Telenor's network during July 22nd .

The black curve in Figure 4 represents the percentage of active subscribers contacting their closest relation (in each time interval of 5 minutes) as a function of time, where t=0 is equal to the time of explosion.

We notice that the black curve reaches a peak around 25 minutes after the explosion. At this time, around 26% of all active subscribers contacted their closest relation. At about the same time, the explosion was reported in the largest online newspapers. We also notice a smaller peak when the Utøya massacre starts.

This curve can be compared to a normal Friday in order to see when and how often we usually contact our closest relations. Therefore, as a comparison, we have included in Figure 4 curves from the two Fridays before the explosion (red and blue color) and the Friday after (light blue color).

By looking at the rise of the normal curves before the explosion, we see that it is more common to contact the closest relation later in the day (we notice a peak around 4 pm). On normal days, this is often a type of "coordination" call between partners to organize the transition from work to the week-end.

When compared to the other Fridays, we observe a 7% increase in people contacting their closest relation on the 22nd. We also observe that there is a 14% *decrease* in these contacts *after* the explosion. The reasons for this decrease are not obvious. One hypothesis is that, after reaching our closest contact, we then cycle through our other contacts more than normal. This is perhaps to check on their wellbeing. This interaction with weaker social ties is at the expense of contact with our closest relation.

To further examine this hypothesis, we have normalized the black curve in Fig 4, by dividing it by the average of the closest-contact traffic on the normal Fridays. This gives the fraction of people contacting their closest relation, as compared to a normal Friday. The result is shown in Fig 5.

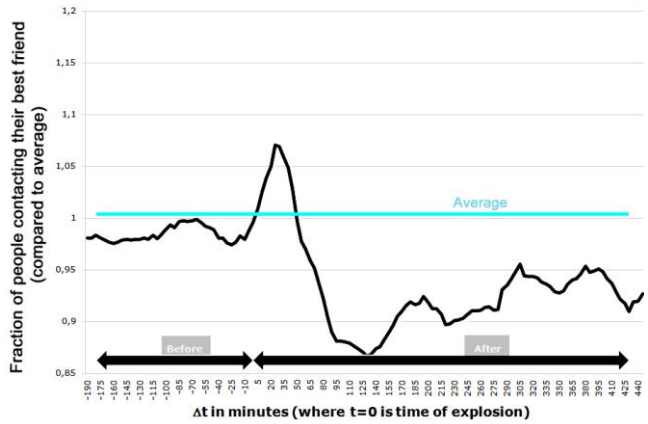

Figure 5 Fraction of active subscribers contacting their closest relation compared to a normal Friday (based on all active subscribers in the 11 hours period). This plot shows the same as Fig 4, but normalized with the average from the other three Fridays.

We see that this doubly-normalized curve roughly follows the average (a little beneath) before the bombing, then rises by about 7%, and subsequently falls by about 14% when compared to a normal Friday afternoon.

In Figure 6 we show doubly-normalized curves (percentage of contacts for number x contact, compared to average, over time) for x = 1—5. This enables us to compare communication with the five first contacts on a common scale.

We see in Figure 6 a clear picture. Before the explosion, we see that all curves roughly follow the average. When the explosion hits, the closest relation is contacted first (peak at 25 min, 7% higher). This is followed by contacting the second closest relation (peak at 40 min, 15% more than average), then the third, fourth and fifth closest relations (peak at 45 min, 20% higher than average). We notice that relatively more time than average is spent subsequently on 'medium-distant' relations (3 to 5). Of course, the third, fourth and fifth closest relations are relatively seldom called. Our data shows that they normally command about 4.5%, 2%, and 1%, respectively, of all calls. In contrast, link one commands 69% of the traffic, and link 2 receives 13%. As shown in other work, these core links are extremely important social contacts [17].

Figure 6 shows that, in the wake of the explosion, there was an increase in the need to reach these more remote contacts (3 to 5).

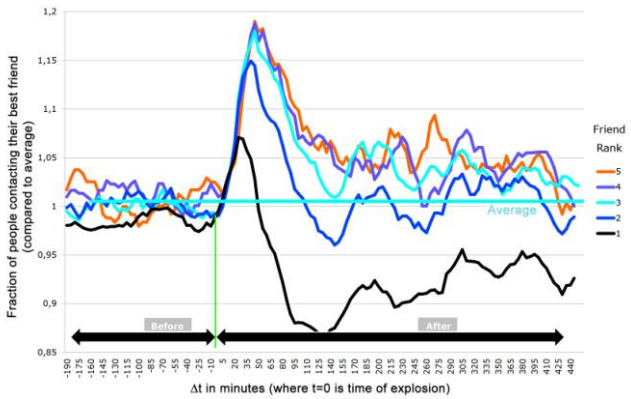

Figure 6 Fraction of active subscribers contacting their 1-5 closest relations vs time for all active subscribers. All curves are normalized by average communication for the same contact number (1—5).

Thus we see that, while the 'absolute' amount of traffic generated in calls to links 3, 4, and 5 is small, the proportional increase for them is greater than that for the nearer contacts 1 and 2. Indeed, contact with link number 1 in fact decreases proportionally, after the initial peak. It is difficult to completely specify here the reason for the relatively early fall in contact with the best relationship. It may be simply that after mobile contact is achieved with the closest contact, there is an urgency to check on other links that are called less often, and so we do not dwell as much as normal with link number one. It may also be that one quickly arranges to meet physically with link one, thus obviating the need for further contact over the mobile phone.

VI. GEOGRAPHICAL SPREADING

In section III we saw an approximate doubling of voice calls (on a nationwide basis) in the wake of the explosion. In this section, we will look at how this traffic was distributed between different regions in the country. To place each customer geographically, we use their registered postal address. Of course, there is considerable uncertainty about where these "Oslo residents" were to be found physically at the time of the event. We believe however that the results obtained by this method support the argument that this error source is not too large. We also note in passing that close relations to Oslo residents might also very well not know where their Oslo friends are at the time of the attack—and so are motivated to contact them, in the face of this same uncertainty.

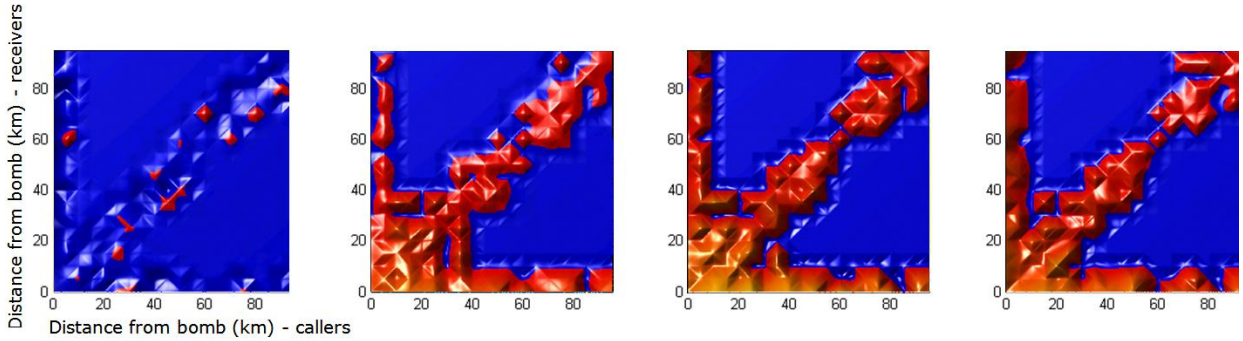

Figure 7 Change in activation of social ties between different geographical regions, for 4 different time intervals. Blue=Average or beneath, red=2 times average, yellow=4 times average.

Figure 7 shows the activation of social links (defined by either SMS or voice) before and after the bomb, and how this activation varies with distance from the centre of explosion.

The x-axis shows the distance from the bomb (in km) for the people making calls, while y-axis shows the distance from the bomb (in km) for the people receiving calls. The colors on the z-axis show the number of social relations activated compared to an average Friday. A blue color shows average, red is about twice normal and yellow indicates four times the normal telephone traffic.

Fig 7(a) shows that the activation of geographically based social ties via the mobile phone during the hour previous to the explosion is fairly typical. Fig 7(b) shows the geographic distribution of links in the hour just after the explosion. The red line along the y-axis (x = 0 means the caller is in Oslo) shows that the outgoing link activations from Oslo are twice as large as the normal, while the incoming link activations to Oslo (following the x-axis) are two to four times the average. This result is even stronger in the following hour (up to 2 hours after the explosion—Fig 7(c)), and still quite strong up to three hours after (Fig 7(d)).

The area of Figure 7 located around (x=0,y=0) shows communication which is internal to Oslo. We see that the number of activated relations increases with a factor 4 in this area. Interestingly, we can also see along the diagonal that people living near to each other, and outside Oslo, talked significantly more in the aftermath of the bombing. The people calling to and from Oslo have a motivation to call which is based on possible proximity of at least one of them to the bomb. Here the need is to hear if the contact in Oslo safe. This motivation was not necessarily in place for the people neither living in Oslo nor calling to others in Oslo. Rather, the strong diagonal in Figs 7(b)—7(d) speaks to another motivation for coming into contact. Perhaps it speaks to the need to process the situation, and to consider the events with someone who is socially and physically close. We note further that this strong diagonal also mimics the normal geographical pattern of telephonic communication [6].

VII. SUMMARY AND FUTURE WORK

There have been several analyses of how people have used mobile telephony during wide-scale disasters. Several authors have written on mobile telephony use in the case of 11 September in the US ([1][2] Dutton and Katz and Rice). In the work by Dutton and Nainoa [5], there was an analysis of press coverage of mobile phones related to the 11 September events. The work by Katz and Rice [2] is a qualitative analysis of peoples' immediate reaction to the disaster. Randall Collins [3] also examines the social reaction to the 11 September bombings, though not through the lens of mobile communication. Cohen and Lemish [4] examined the use of mobile phones in the case of terror bombings in Israel. They had access to the telephone traffic in the aftermath of the bombings and showed, as we do here, that there was an immediate peak in traffic generated near the site of the bombing. In many of these analyses, the material used qualitative (interview) data to show that people used the mobile phone in order to be in contact with those who were emotionally close to them.

None of these analyses have taken the step to examine the material from a social network perspective, using quantitative communication log data. Indeed, we feel that this is the unique contribution of this paper. We are able to parse out the way that we use the mobile phone to indeed call those people who are closest to us in the wake of this untoward event.

The analysis here is of a general emergency in a broad social context. We see that time was a critical element in the

mobilization of different people in the social networks. People called the most important link first, and then moved on to the secondary, tertiary, etc. links in order to inform and to mobilize one another. These findings can be scaled down to smaller scale emergencies within the immediate social sphere. When, for example, a family member is hurt to the degree that they need medical attention, there is also the mobilization of the immediate network of family and friends via the mobile phone. The "one-hop" people need to be alerted, and need to reshuffle their meetings and tasks so as to take care of the injured person or perhaps carry out the necessary tasks (e.g. pick up children at daycare) that that the injured person cannot carry out.

The behavior that we see here is not surprising—it confirms in fact our expectations: we reach out to our most important contacts first. We believe that this unsurprising, 'common-sense' aspect of our results does not at all detract from their value, for two reasons. First, it is never guaranteed that one will get one's common-sense expectations fulfilled—surprises can happen. Hence measurements which test our expectations are of value, whether or not they confirm them. Here, in response to the occurrence of a rare event, we have taken the rare opportunity to make such measurements and test our expectations. These measurements show how mobile telephony is becoming increasingly embedded in society.

Our results give value in another way: they strengthen the claim that the use of *frequency* of contact as a measure of *closeness* of the relationship is justified. The clear (and expected) time ordering of the communication with contacts leaves little doubt that the definition of closeness given in Section IV is in fact appropriate here; otherwise our results make little sense.

Thus, we see that the mobile phone has gained a central position in the coordination of action within the core social sphere. This can operate when there is a major social event such as the bombing on 22 July, or when the family faces an emergency with regard to one of its members.

This study has several limitations. These include the fact that the data are taken only from one operator in Norway: Telenor. Thus the data is not necessarily generalizable to all of Norway. Also, as noted, the location based data use the postal code of the subscriber, and not the actual location of the phone at the time of the bombing. This is a result of privacy issues and is not to be avoided.

When thinking of further work, we have several items that we wish to develop. These include examining the "cascades" of calls between individuals as the events developed. This can include analysis of the sizes of the cascade groups, the timing and the geographical dimensions of these call sequences. In this paper we have examined the strong ties. It is also interesting to examine the calls to the weak ties, and to look at the people who were *not* called in the period after the bombing. What are the characteristics of these people? In addition we have access to the streaming of different types of music in the aftermath of the bombing and the shootings. The data show interesting preferences for songs that celebrate Norwegian national symbols. This material suggests that people were active in the reconstruction of the sense of being Norwegian through these activities. Finally, we are interested in providing a better theoretical foundation for the material. The analysis presented here is very empirically driven. We are considering theoretical approaches that might help to clarify the observations.

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