




Article

# Case study on privacy-aware social media data processing in disaster management

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**Abstract:** Social media data is heavily used to analyze and evaluate situations in times of disasters, and derive decisions for action from it. A crucial part of the analysis is to avoid unnecessary data retention during that process, in order to prevent subsequent abuse, theft or public exposure of collected datasets and thus, protect the privacy of social media users. There are a number of technical approaches out to face the problem. One of them is using a cardinality estimation algorithm called HyperLogLog to store data in a privacy-aware structure, that can not be used for purposes other than the originally intended. In this case study, we developed and conducted a focus group discussion with teams of social media analysts, in which we identified challenges and opportunities of working with such a privacy-enhanced social media data structure in place of conventional techniques. Our findings show that, with the exception of training scenarios, deploying HyperLogLog in the data acquisition process will not distract the data analysis process. Instead, it will improve working with huge datasets due to the improved characteristics of the resulting data structure.

**Keywords:** disaster management, virtual operations support teams, privacy, data retention, hyperloglog, focus group discussion

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## 1. Introduction

Social media services are almost always available, so that in times of crises people can access them as established and interactive communication resources. The Corona pandemic has even strengthened their special role: through measures such as social distancing, the use of social media services for communication and information dissemination is growing fast (Koeze and Popper 2020). Numerous disasters in the past have demonstrated how important the role of social media is for crisis communication as well as for information gathering (Reuter and Kaufhold 2018). Both the people affected by a disaster and those indirectly affected use online services to obtain information about their relatives, the extent of any damage, possible further dangers or offers of help.

Those affected by a disaster are a vulnerable group. Some are dependent on receiving or sharing credible information only through social media services and may find or seek help through these online tools. Personal data can also arise when affected people communicate publicly with authorities on social media platforms, view content or participate in self-help groups (Kuner and Marelli 2020b). Therefore, *privacy* plays an important role in this process.

At the same time, large amounts of data are created on social media services during disasters, that are available to the public and can include important and relevant information for decision-makers. With the aim of processing and visualizing information from social media for decision-makers, so-called Virtual Operations Support Teams (VOST) are established. Consisting of volunteers, VOSTs analyze social media systematically and in a coordinated manner, and evaluate operation-relevant information.

Some of the VOSTs use social media analysis programs that do part of the work automatically, e.g. ScatterBlogs (Bosch et al. 2011). Such analysis software retrieves data from social media services e.g. through their application programming interfaces (API) and stores them in their own databases. This is usually necessary for the application to be able to access the actual data in a reasonable amount of time, not only since data analysis during a disaster is usually very time-critical.

As a result, the problem of *data retention* comes into play. Data retention “is the continued storage of an organization’s data for compliance or business reasons” (Rouse 2014). While storing the data is necessary for the analytics software to work properly, it is dangerous for its operator for multiple reasons. Constantly changing terms of services of social media services may evoke legal issues of their business (Fiesler, Beard, and Keegan 2020). Furthermore, storing large amounts of data opens the risk of possible abuse, theft or accidental public exposure (Miller 2020).

The necessity arises for a method to store large amounts of social media data in a way that is technically reasonable on the one hand and privacy-aware on the other. Dunkel et. al (2020) have developed a method to store and process data from any social media service in a privacy-aware fashion, using an algorithm called HyperLogLog. With this method, data queried from a social media service API can be stored in a local database, without the possibility to leak information about single entities afterwards. The resulting visual output of an analytics application will not differ significantly from what was created from conventionally stored data.

While in the past numerous studies have dealt with the topic of data analysis in crises (Crisis Informatics, Reuter, Hughes, and Kaufhold 2018) or the integration of VOST into the working environment of decision-makers (St Denis, Hughes, and Palen 2012), questions about privacy and VOST are not considered, yet. In this paper, we therefore develop approaches to answer the following central research question: what opportunities and challenges can be identified for VOSTs to work with privacy-enhanced data and what potential implementation barriers can be detected? Figure 1 outlines the concept in a graph, including stakeholders and the data flow.

To approach the research questions, we prepared and carried out a focus group discussion with voluntary VOST members, in which they were confronted with the topic and some sample dataset, which we extracted from social media services. We found, that VOST members are generally worried about losing important data, when it comes to privacy regulations. From the technical point of view they were rather indefinite, but since storing social media data using HyperLogLog both reduces storage space and increases processing speed significantly, they turned out to be quite open to a privacy-aware storage implementation.

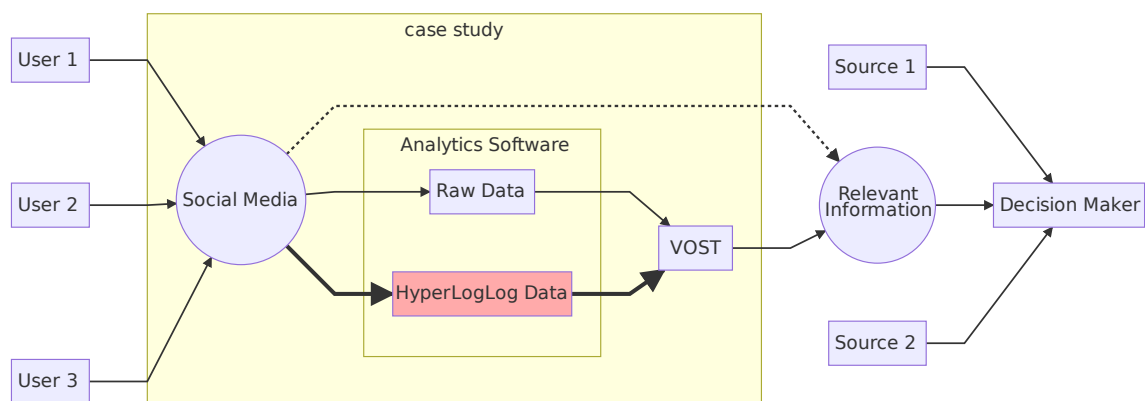
In section 2 we discover the fundamentals of our interdisciplinary research. Following, we describe the methods implemented in the data acquisition and the preparation and provision of the focus group discussion (section 3). Afterwards, we discuss the results of the discussion and our findings (section 4), concluding with an outlook of our further research plans on that topic (section 5).

## 2. Fundamentals

In this section we explain the fundamentals and present relevant research results in the following subsection. First, we will present research that primarily addresses social media and disaster management. We examine both historical and current aspects, such as the use of online media during the Corona pandemic. Afterwards we will introduce the novel VOSTs and their tasks during a disaster. An introduction to the privacy aspect of data retention and its challenges follows. Finally, we introduce a method to store social media data in a privacy-preserving way, which we based this case study on.

### 2.1. Social media and disaster management

As communication and collaboration platforms, social media services play an important role in disaster management, not only since the Corona pandemic. Numerous major incidents in the past have made clear that those affected, eyewitnesses or spontaneous volunteers actively use digital tools



**Figure 1.** Users of social media services supply data, that is then parsed by analytics software, before the VOST evaluates it. Relevant information from social media is then passed to decision-makers, who found their decisions on it among other sources. The case study wraps up the part that involves social media, the analytics software and the VOST. We propose to base the analytics software on privacy-enhanced HyperLogLog data as a substitute to conventional raw data.

for information and communication (Castillo 2016). However, there are various possible uses and behaviors, even within the different population groups. In a recent survey by Statista, 60% of the 2087 respondents (age group 18-64) state that they regularly use social networks such as Facebook, while 52% use so-called media-sharing platforms such as Instagram. In addition, 74% said they regularly use instant-messengers such as WhatsApp (Statista Global Consumer Survey 2020).

During crises and disasters, it can be observed that the need for information is very high, not only among the affected population but also among relatives and among other indirectly affected persons. This increased need is also reflected in the social media: In a representative survey commissioned by "Digitalverband Bitkom", 75% of users of social media services in Germany stated that they had been increasingly active in social networks during the Corona pandemic and used them more intensively. According to the survey, almost all age groups spent more time on platforms such as Facebook, Twitter, TikTok, Instagram, etc. than usual. Among the 16 to 29 year olds, the figure was as high as 86%, among the 30 to 49 year olds 82%, among the 50 to 64 year olds 74% and among the over 65 year olds 32%. At the same time, a total of 82% increasingly communicated via instant-messengers (Bitkom e.V 2020).

In past major incidents, such as the earthquake in Haiti in 2010, the Elbe flood in 2013 or the urban flashflood in Münster in 2014, social media helped thousands of volunteers to spontaneously network with each other and to actively participate in disaster management (Sackmann et al. 2018).

Experiences of past disasters also show that fake news can spread online within minutes, which in turn can have serious effects on psychosocial needs and government crisis management (Shao et al. 2018). A similar phenomenon is also emerging in the context of the Corona pandemic. According to Situation Report 13 of the World Health Organization (2020), the outbreak and the reactions to the pandemic are accompanied by a massive "infodemic", an abundance of true and false information.

Already in 2008, Vieweg et al. (2008) analyzed the use of social media in disaster relief. As a result, a new and distinct field of research developed: crisis informatics. Since then, numerous scientists from different academic perspectives have been working in this field (Imran et al. 2014, 2015; Palen et al. 2007; Qadir et al. 2016). Parallel to this, due to the importance of geographic data, the research area that places the use of Volunteered Geographic Information (VGI) at the forefront of scientific debate, has developed (Goodchild 2007; Goodchild and Glennon 2010).

Since the beginning of crisis informatics research, information-technology research questions have dominated the scientific discourse. One focus has been the analysis of large amounts of data (Big Data) generated by social media (Castillo 2016). In addition to the processing of text-based

data, Volunteer and Technical Communities (V&TCs) also face challenges regarding the collection, processing and analysis of images from social media. Innovative research is investigating the use of artificial intelligence and methods for the machine processing during crisis (Alam, Ofli, and Imran 2019).

Further research addresses the question of whether decision makers can actually use VGI data and whether or how they use the information provided (Imran et al. 2015). Some studies indicate that there seems to be a significant discrepancy between the data produced by digital volunteers and the requirements of organizations involved in disaster relief (Hughes and Tapia 2015). Successful cooperation requires stable structures, reliable data quality and consistent forms of organization that outlast individual disaster relief operations (Hughes and Tapia 2015).

Nevertheless, the authorities are also facing major technological challenges, especially in the area of information management. Field studies after Typhoon Haiyan in the Philippines and during the Ebola crisis (2014/2015) suggest that executives need a better understanding of their decision-making processes. It is particularly important that the needs for mission-relevant information, such as spatial data or VGI, be clearly communicated to digital volunteers (Comes, Vybornova, and Van de Walle 2015).

In a systematic review, Reuter and Kaufhold (2018) analyze 15 years of research into the use of social media in disasters, starting in 2001, the year of the attack on the New York World Trade Center. They focus on the collection of patterns of use, perception and roles that have been identified by studies in different disaster situations. Reuter and Kaufhold (2018) also present derived role typologies in a matrix that differentiates between authority and citizen/public on the one hand and between real and virtual on the other. They describe that these roles and role types take either the perspective of a citizen (public) or an authority (organizational) and refer either to the real or virtual realm.

A new form of authority digital operational support are *Virtual Operations Support Teams* (VOST). They work as part of a public organization with digital volunteers in an entirely virtual environment.

## 2.2. *Virtual Operations Support Teams*

In the initial phase of crises and disasters, one of the key factors in the management of these situations is that emergency forces with the necessary skills, such as the analysis of social media for a situational awareness, are a limited resource. With the aim of processing and visualizing social media information for decision-makers in emergency operation centers, the first so-called Virtual Operations Support Teams (VOST) was formed in 2011 (Fathi et al. 2018). The digital volunteers pursued the goal of integrating data from social media more effectively into decision-making processes through a closer connection to emergency management agencies (EMA). The digital volunteers grouped in a VOST are from various EMAs and have education and skills in civil protection. Divided into working groups, VOSTs carry out various tasks during operations:

- Social media monitoring as well as conducting data processing, filtering and assessment
- Creating and updating spatial analysis of digital maps
- Recognizing and analyzing trends and sentiment in social media
- Identifying rumors and false information
- Verifying and geolocating social media posts
- Crowdsourcing and collaborations with other VOST
- Presentation to the operational staff of the EMAs (Fathi et al. 2020).

The Federal Agency for Technical Relief (Technisches Hilfswerk, THW) has been operating the first German VOST on federal level since 2017. 25 digital volunteers are deployed using innovative organizational strategies and innovative analysis tools to master the challenge of the data flood and to process situation information for decision makers. In September 2018, the Ministry of the Interior, Digitization and Migration of Baden-Württemberg established its own Virtual Operations Support Team on state level. With the time further teams followed, e.g. at the fire department Hamburg.

In a study, participating observations were used to identify organizational, procedural and technical requirements for the successful integration of VOSTs in emergency operation center structures

(Fathi et al. 2020). In addition, process analyses were able to document for the first time the working methods of the VOST, such as the way information is provided to decision makers. It became clear that in many cases real-time information from publicly accessible sources contributed to an awareness of the situation and was used in time-critical decisions of the crisis management team.

The concept of these teams is also based on the fact that the helpers can work in working groups at different locations and times. Based on this high flexibility, VOST THW has already been able to manage over 25 operations. A further study shows that the public also appreciates this work. In this study, the authors show that 67% of the German population expect authorities to monitor social media. In addition, 20% of those questioned say that they use social media to search for and share information during crises and disasters (Reuter et al. 2019).

### 2.3. The privacy aspect of data retention

The daily work of VOSTs is partially based on data analytics software such as ScatterBlogs (Bosch et al. 2011), that assembles, stores and analyzes data from various social networks. Storing the data in a local database is necessary for the software to be able to access it quickly, but can be interpreted as *data retention* as well. Data retention has been defined as “the continued storage of an organization’s data for compliance or business reasons” by Rouse (2014).

Blanchette and Johnson (2002) already addressed the disappearance of social forgetfulness as a side-effect of data retention. Miller (2020) pointed out recent incidents, where data retention has led to theft or accidental public exposure, which is especially relevant with social media data associated with crises and disasters.

Users of social media services tend to lack the awareness for the data they provide to the network is subject to being analyzed by third parties (Polous 2016). Fearing their personal data being subject to theft, exposure or other abuse like mass surveillance e.g. by authorities, users may retreat from posting publicly on social media services like e.g. Twitter or Mastodon, and move to closed messaging groups in other messengers like e.g. Telegram or Matrix (Leetaru 2019).

This would be destructive for a wide range of beneficiaries. Especially humanitarian actions rely on public availability of social media data (Kuner and Marelli 2020a). Therefore the gradual retreat of the user base must be prevented.

### 2.4. Privacy-aware storage

Krumpe et al. (2018) have defined a general structure to handle social media data across any social media service. Based on that structure, Dunkel et al. (2020) developed a method to store and process location-based social media data in a privacy-aware fashion, using an algorithm called *HyperLogLog* (HLL). We aim to investigate, whether the VOST is able to work with data, that has been processed with such a privacy-aware storage method.

The HyperLogLog algorithm is a cardinality estimator (Flajolet et al. 2007). Its fundamental strength is the ability to *estimate* the distinct count of a multiset (cardinality), stored in a data structure, that does not allow the extraction of single elements (see sample data in figure 2). Without further external knowledge, it is impossible to retrieve single items out of the stored dataset (Desfontaines, Lochbihler, and Basin 2019). Furthermore, processing data using HLL is very efficient in terms of processing time and storage space.

A dataset is built upon one specific query to the original social media source, e.g. the application programming interface (API) of a social media service. Depending on the configuration of the algorithm, the dataset can only answer a certain amount of questions, that can usually be broken down to counting its elements. So HLL data can be seen as *disposable* data, since it is impossible to draw other information out of it, than originally intended. These characteristics make HLL a suitable algorithm to process social media data in a privacy-aware fashion (Löchner, Dunkel, and Burghardt 2019).

### 3. Methods

In this section we outline the methods applied to the case study. We explain the structure of the focus group discussion and the reasoning for applied concepts. In addition, we describe how we acquired the dataset utilized as sample data in the discussion.

#### 3.1. Focus group discussion

We designed a group discussion with VOST members to examine the feasibility of implementing HLL data in the VOST workflow and their sensitivity for the privacy aspect. This issue has so far received little attention. Privacy and data retention are an open topic in the community.

Participants in the discussion were members of two different VOSTs (THW and Baden-Württemberg), along with the authors of this paper, and one independent recording clerk.

Our concept intended a guideline-based discussion in order to develop approaches to answer the research questions by analyzing the discussion protocol after the discussion. The overall goal of the discussion was to document the expertise of the participants being volunteers with experience in the field.

We chose the focus group discussion method (Prüfer and Rexroth 1996) because, as described in section 2, the members of the VOSTs are very heterogeneous. They differ, for example, in their level of knowledge, working methods and working culture. As a result, there is an increased need for communication within the teams in case of operations in order to establish structures and discuss working methods. The purely virtual working method is an additional complicating factor. In focus group discussions, guideline-based and moderated sessions are encouraged so that a concrete topic can be dealt with together. The method is used in many different ways, e.g. to achieve conflict management. Nevertheless, the focus group discussion is also suitable for representing diversity of opinion and for jointly developing improvements and solutions. Because we used the established communication structures of the VOSTs, we were able to work on the specific topic using this resource-saving method.

A video conference was chosen as the venue for the discussion, using an instance of Jitsi Meet. VOST members ought to feel comfortable in this environment, since they live spread across the country and virtual communication environments are their familiar place to work in the VOST (see section 2.2).

The schedule of the discussion included a brief introduction to privacy as a concept in general and a very basic outline of the HLL data structure. The content of a sample dataset with raw and HLL-processed data was introduced along. Since the VOST members are not at all technically proficient, the introduction did not include any mathematical or computational details, but rather demonstrated the differences of raw and HLL-processed data in a tabular view (see section 3.2).

After the introduction the VOST members were confronted with the three hypothetical scenarios and were asked to discuss their respective approach in each of them one after the other. The scenario catalog, which generally serves as a guideline for focus group discussions, was intended to establish a discussion structure and to examine the research questions. All three scenarios had the pandemic spread of the Corona virus as their basic operational situation, and only differed in the location level of operation: national, regional and local. Since the members of the two participating VOSTs were involved in managing such operational situations before, no detailed explanation of the scenario was necessary.

During the discussion, however, the sample dataset only received minor attention in favor of discussing more fundamental aspects, so that the prepared scenarios did not come into action. Nevertheless, they were utilized as a guideline in which, for example, discussion questions were derived from.

The end of the discussion marked a short summary by the authors and acknowledgements to the participants.

hashtag	actual_count	hll_count	hll_data
corona	755797	763316	\x148b7f52d4d4b0c93a9696a16a4c14c42549531484a52852d083294b545f
coronavirus	614201	609185	\x148b7f4392c525a83b9886a9294a9296356b3a9473a5487a1a85ad485214
afd	391075	378847	\x148b7f521273a9074ad273a96842d08425884a5084a907629466290c3290
covid19	341884	339737	\x148b7f5252c524e639ce56a92752d4941d494a14941d283a107528c83a52
hanau	289371	277753	\x148b7f5a947320e94accb329065a108420e53a4e84a8ec521694290d5990
coronakrise	212108	215994	\x148b7f32cec4a10749cc7321075ad26424e75994631d064212d320ef31ce7
merkel	203142	201882	\x148b7f39ce74198531d0a6a4c73a94542148318c83a8e83a9273214759d6
cdu	194358	199547	\x148b7f4acc731cab4a96d518e739ca84212739cc85214841d2b69ccc72cee
berlin	183407	192788	\x148b7f425cb394e829cc9524f142106319876256949928321093bd264190
polizei	185625	185865	\x148b7f42d26521265a50641cec438e74a14861927499076a8c739d062a50

**Figure 2.** Most frequently used hashtags in the sample dataset for the focus group discussion. The second column shows the actual number of posts in the dataset, the equivalent estimated HLL value is shown in the third column. The characteristic distinct count estimation of HLL increases the speed of processing significantly, but the result has a potential offset of about 2% (Flajolet et al. 2007), which is not a problem when dealing with huge datasets, such as social media data. The last column shows the HLL-processed data structure and emphasizes the impossibility to read original data from it.

### 3.2. Data acquisition

To explain the advantages of HLL during the focus group discussion, we chose to present a sample dataset that could potentially serve as real data for a VOST operation and its members feel familiar with. So we created a dataset, that covers all German posts on Twitter containing the hashtag #corona from January through May 2020. Thusly, we collected 72.743.465 posts from 6.038.577 distinct users via the Twitter API. For this particular scenario, we relied on Twitter’s language tagging and collected only German posts. Posts that were tagged as containing other or undefined languages were discarded. We chose to limit the collected data to only contain German posts for two reasons: 1) a German VOST team would predominantly concern with German tweets, and 2) limiting the data to contain only German posts shortened the time we spent pre-processing the data significantly. Still, pre-processing and creating the databases took about two weeks of mostly unattended computation.

We utilized the data conversion tool `lbsntransform` (Dunkel 2020) to read the dataset into two PostgreSQL databases: one for HLL-processed data and one for the plain data, to compare against. The table in figure 2 shows an example query to the dataset, including the structure of the HLL-processed data, as it is stored in the database. It makes clear, that no original data can be revealed from that storage format. It further illustrates the slight difference between the actual number of posts and the *estimated* number counted by HLL.

## 4. Evaluation

In this section we evaluate our case study applied as a focus group discussion. First, we enumerate and explain details of the results of the discussion. A subsequent analysis of the results constitutes scientific insights, implementation examples as well as proposals for approaches and alternatives to negative results.

### 4.1. Findings of the discussion

The focus group discussion examined the requirements of VOSTs in operations. Especially when VOST members get in contact with personal data of social media users, a focus on privacy aspects is crucial.

However, findings of the focus group discussion encompass the disproof of our assumption that the VOSTs work is mostly based on big data analytics. In fact, the majority of efforts done by VOST members is inspecting single entities of social media data, e.g. posts, images, videos etc. An intuitive interface of the applied analysis software applied, is te far most important requirement in a time-critical work environment.

Not uncommon is an open end investigation, where initially it is unclear to the VOST members, what they are searching for. For example, it is possible that all relevant posts of a minor emergency situation, in which the VOST is activated, are first identified and then evaluated for relevance to decision-makers afterwards.

One of the most important tasks of VOSTs is the verification of the information, a post encompasses. This happens based on experience of each individual VOST member, and the consult of further information, usually by analyzing the meta-data of a post (e.g. time, location) and other details. It is crucial to determine whether information in a social media post is trustworthy. Important indicators are e.g. how long the user account actually exists, what language(s) the account usually uses, time ranges of postings (e.g. does the user sleep sometimes) and the number of followers, likes and retweets of its postings. Another method of verifying social media posts is to compare them with alike user names and avatars of accounts on other networks.

The participants also highlighted the fact that the scale of a disaster and the level at which an operation takes place does not have a major impact on standard work processes. They furthermore pointed out that in addition to quantitative analysis, qualitative analysis must also be performed manually, e.g. when assessing the relevance of a high range social media post for decision-makers. Here again, the meta-data of an account can play an important role.

An entirely different aspect, that came up during the discussion, is training of the VOST members. For exercises and practice, it is possible for VOST members to be confronted with archived datasets. This contradicts with the characteristic of HLL-processed data being *disposable*, meaning that it is not possible to draw other information than originally intended from it.

In turn, it came to light that a frequently occurring problem is dealing with the immense size of social media data and the time to process it, accordingly. Here, using HLL-processed data can help very much, because of its characteristics to be very lightweight in storage size and fast in processing.

#### 4.2. Analysis of the findings

The introduction to the subject area of privacy theory and the outline of the HLL algorithm have been designed to be brief and superficial, due to the audience consisting of civil protection experts and not of information scientists. The superficiality of this introduction can be a reason, why the discussion participants showed a certain amount of skepticism about our research and a general debate about privacy issues. The discrepancy between guiding into the topic and avoiding too much technical details is apparent.

The participants expressed concerns about alleged loss or inaccessibility to important information for their work, e.g. because of privacy regulations. This would certainly be a problem, especially in situations where human life is in danger. In those situations, the sentiment in the team usually gets tense, and time gets critical. Other situations, e.g. tracing fake news on pandemics, do not require time-critical decisions, and allow more time to do research work.

However, according to the results of the discussion, we can indicate our key finding is that none of the findings of the discussion are opposing the proposition, the VOST could work with HLL-processed data. This can be stated, because most of the VOSTs work happens *after* any potential processing of HLL data.

Usually the VOST work starts with a search for a term, hashtag or place. The analytics software then queries the APIs of the social media services and, for technical convenience, stores the answers in a local database. Right here HLL will come into play, because it can store only the data that is really needed to answer the query.

An example query could be for the number of posts per user on a certain hashtag. The answer is a list of user IDs and the according number of posts. No further information is required, so any information on each post is unnecessary to be stored in clear text, so it can be stored in HLL. The list can then be sorted by number to identify the user having the highest number of posts. Having its' user ID, the analytics software can then query the API of the social network to get all the details about that



user ID. No information about the user has been stored to the local database, and no data retention has happened.

Regarding the exercise scenario described in section 4.1, our proposition to apply HLL data can not be applied at all. Following the mental image of disposable data, it can not be used for any other purpose. Consequently, an exercise can only lead to only one solution. Using archived HLL data from a past situation could miss the exercise objectives. We propose the usage of publicly available example datasets with licenses that allow their utilization for purposes free of choice, like e.g. listed on the Awesome Public Datasets list (Chen et al. 2020).

As a side finding, we can declare that splitting the scenarios into three separate parts was not necessary. The size of the situation is irrelevant, since the VOST members are spread across the country and interacting mostly virtually with each other anyways.

## 5. Conclusion and Outlook

Privacy is an important aspect, when dealing with social media data, especially in times of crises and disaster scenarios. With HyperLogLog we proposed an appropriate technology to approach this issue and process social media data in a privacy-aware fashion. We raised the question of what opportunities and challenges can be identified for VOSTs to work with this privacy-enhanced data as a substitute for conventional datasets, and what potential implementation barriers can be detected.

In a conducted focus group discussion, we found that the underlying technology is fewer of importance to VOST members, because they hardly get in contact with it. Good interface usability and processing speed is of much larger importance, as well as comprehensive data availability. Inaccessibility or loss of data is dramatic, especially in life-depending situations. In turn, VOST members declared that dealing with social media data can be stressful due to the plain size, resulting in large storage requirements and slow processing speed. This may sound like a contradiction. However, the results of our research presented in this paper show that with using appropriate technology it is certainly possible to implement a method to provide privacy-aware infrastructure for social media data processing. But we also have to take into account that by selecting representatives from only two (German) VOSTs, other constellations of participants might produce other findings. The goal of our case study was to develop first approaches to answer our research question, we did not pursue the goal of a representativeness of the results.

These findings encourage further research on that topic. Our first subsequent step is to develop a qualitative survey featuring an interview-style experiment with VOST members. This should feature an experimental setup based on HLL-processed data, that will be presented to the participants in their familiar working environment. Following a mix of established survey methods *behavior coding* and *think aloud protocol* (Prüfer and Rexroth 1996), they should explain their working steps in a supervised surrounding and express their user experience regarding limitations or barriers. We are confident, that such an experiment will confirm our findings of this work and lead to an actual implementation in common social media analytics software.

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## 7. Conflict of Interests

The authors declare no conflicts of interest.

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