Using social media and the mobile cloud to enhance emergency and risk management

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***Abstract*—All emergency events require fast response and decisions based on first-hand information. This paper presents a mobile cloud service that makes the best use of social media applications, such as Twitter, in emergency and risk management. Risk and emergency teams can receive in matter of seconds data that can inform their decisions when an emergency has affected areas under their management. The proposed system allows users to provide on-the-ground information regarding such an event, as well as early notification to people who are in the vicinity of the location of an emergency situation. The system matches users' requests to a set of pre-defined labels that will help rescuers to understand the situation more clearly. The service is implemented and tested with Android devices and a cloud-computing instance hosted on an Amazon platform. A cloud-based tool is also provided for risk and emergency management teams to interact with users' requests. The experimental results show that the system enhances the early detection of emergencies.**

Keywords— mobile; cloud; healthcare; emergency; risk; help; social media; Twitter; services; classification; text-mining; machine learning

I. INTRODUCTION

Recently, the use of social media, such as Twitter, Facebook and LinkedIn, has increased in emergency management and in delivering medical support to the public. According to [1], users of social media will reach 2.55 billion by 2017, when it is estimated that one in four people in the world will set up an account with at least one social media app. People are also using social media as a method of communication when an emergency occurs, from communicating with family/friends to distributing relevant information about the situation.

Introducing social media to a system that aims to deliver medical help in the case of an emergency will be of major benefit to its users. It would, for instance, broaden the user base so that the system could interact with a greater number of people. The system could also achieve a reasonable level of efficiency by tracking on-the-ground information that is sent by people who are in/around the emergency location. Furthermore, social media can act as a means of notifying people who are in the vicinity of the scene of an emergency to avoid an increase in the number of casualties.

Another key factor in introducing social media into this type of system is that in emergency and risk events, often, there is not enough confirmed information that could help rescuers understand what has happened and, more importantly, take proper action. Therefore, analysing social media streams could help in understanding an event that occurs in different areas, as well as its spread. As a result, rescuers could react faster in assessing an event in order to limit its damage.

There are many social media applications, including Twitter, Facebook, LinkedIn, Google Plus, and this list is extending day by day. As it is known, Twitter [2] allows a wide variety of people to publish and exchange short messages (of up to 140 characters), known as tweets, and enables the real-time propagation of information to a large group of users. Thus, this makes it an ideal environment/application to be used in emergency and risk management. In this paper, we consider Twitter as the main form of social media in our system.

However, analysing real-time streams of Twitter data is one of the big challenges of using social media in emergency and risk management [3]. Introducing cloud-computing capabilities would reduce the impact of this challenge because processing collected data (tweets) could be fulfilled by some of the known cloud computing features, such as high performance computing [4]. In addition, storage capabilities are not an issue in the cloud, whereas this is an important limitation to any local server that processes live Twitter streams.

The main contribution presented in this paper is the mobile cloud service that processes live Twitter streams, in order to detect emergency calls and notify the result to the end users. End users can be mobile, such as someone who wants to check the status of an event in his/her town, for example in the case of sudden flooding. Alternatively, an emergency department could look for information from social media to take decisions or actions regarding an event that has occurred. Furthermore, users can use social media either to reach the cloud to seek help or provide valuable information to others about the event.

Creating a social media mobile cloud service is an important part of our point-of-care system to deliver appropriate help to anyone, anytime, anywhere [5]. This mobile cloud service sits at the top of our infrastructure, as

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detailed elsewhere [6] [7]. This service will deal mainly with large-scale events, in contrast to our previous mobile cloud service [8], which is aimed at interacting with single users to facilitate help to be provided swiftly in the case of a personal health emergency.

The rest of the paper is organised as follows. Section II discusses existing systems and related work. Section III presents the system design, and section IIV details the implementation of our system. Section V discusses the experiment design and setup. Section VI presents the evaluation of our system, and section VII provides conclusions and the plan for future work.

II. Related work

Social media is becoming fast one of the most popular communication/news sharing application used by the general public. In practice, some emergency/disaster-related organisations have set up accounts on Facebook and a number of hospitals have Twitter accounts. Expert groups have also been established on LinkedIn [9]. It is clear that usage is increasing year by year, with Twitter, in particular, providing a communication platform during emergency events [10]. The reason is that Twitter has attractive features, including free service, online access, it is mobile friendly, messages stay queued until delivered, offer better search and classification ability using hashtags in the body of tweets, and support for tracking features. Twitter also makes the best use of bandwidth, by sending short (140-character) messages, as well as allowing wide and fast information distribution of information. With regard to emergency management, authors of [11] provide a list of criteria that any 21st-century emergency system should have, such as low cost, power efficiency, ease of use, mobile friendly, ability to receive, generate, provide, and direct useful and critical information from a variety of sources, and GPS ability. The authors believe that Twitter matches/meets the criteria for an ideal emergency communication system that aims to provide help to the public in the case of an emergency. As proof of concept, the paper examines a number of large-scale events, such as the California fires and Sichuan earthquake, highlighting the use of Twitter in these situations. Issues that can occur due to using social media are also discussed in the paper, such as spam, lack of privacy, misuse of tracking features, and impersonation. According to the paper, many of these issues are general symptoms of online networks, in which lack of privacy and trust is one of several features for which social media is known.

In regard to usage, there are two main directions of using social media in emergencies. One form is passive, such as disseminating useful information to the public or receiving feedback from people who received help recently. This is the kind of usage for which the majority of medical and emergency centres are using social media. The other kind is systematic use, which includes building live communications and issuing warnings to the public, receiving victim requests in the event of risk and emergencies, monitoring social media activities, and using the streams and multimedia exchanged in social media (for example using uploaded images) for estimating what is required to respond to an event or assessing the level of the damage caused. However, not many medical and emergency centres are yet able to use social media in this way. It is believed that less than 10% of the total usage of social media is active usage, while the rest is passive [12].

Using social media can benefit emergency and risk management in any of the four phases of emergency management: (1) Preparation – coordinating activities among stakeholders; (2) Response – assigning response teams to areas in need; (3) Mitigation – sharing current status and locations; and (4) Recovery – providing a communication platform, particularly when regular networks are limited or down [10]. Furthermore, social media could create a platform on which all the entities engage almost in real time, including the public and the risk and emergency management centres or teams. Another benefit of social media noted in the literature is its efficiency: "Social Media can help efficient communication to a large audience and well targeted groups of people, with less resources and less efforts than other communication media" [13].

However, there is a number of challenges to using social media in risk management, such as the real-time analysis and monitoring of social media streams. In one paper [14], the authors discuss processing and managing social media data concerning emergency events. The paper defines challenges according to two main high-level categories: (a) Scalability: recording millions of messages and storing multimedia objects (e.g., images and videos); and (b) Content: social media and microblogging messages particularly, are brief and informal, which may lead to poor results. Processing multi-language data could also be a concern. The paper presents some approaches, including classification methods, to make data more researchable and meaningful, and a sub-documenting method to assist in making predictions or decisions from the data collected.

Another critical issue in using social media in emergency and risk management is trust, which can be compromised in the case of false alarms or the employment of sarcasm. According to [15], although sarcasm is a well-studied phenomenon in some sciences, such as linguistics, it is still difficult to assess in the text-mining literature because of its complexity. The paper presents a mechanism for detecting sarcasm in Twitter messages. The authors compare the performance of human-based classification and an automated form. They find that an automated technique could be as good as a human agent. However, according to the paper, both approaches are still difficult and neither performed very well.

A research team working with the Crisis Coordination Centre (CCC) in Australia to improve emergency management and crisis coordination proposed a system that collects and analyses tweets regarding an emergency event [16]. The system aims to enhance emergency awareness by enabling responses to emergency warnings, near-real-time notification of emergencies, and first-hand reports of the impact of an event. The authors believe that if information collected from social media regarding an event is extracted and analysed properly and rapidly, this could improve the level of situation awareness. The paper mentions the amount of captured Twitter data (around 30 million tweets) during the earthquakes in Christchurch, New Zealand, in September 2010 and February 2011. The authors found that when earthquakes or aftershocks occurred, people actively broadcast information, sympathy, and other messages on Twitter. In order to deal with real-time and high-volume text streams, the paper adapts and optimises various data-mining techniques, including burst detection, text classification, online clustering, and geotagging for the purpose of the early detection of sudden emergency events and exploring/monitoring the events identified.

Another example of using social media in managing emergency events is dealing with public panic that might occur, such as the one presented in [17]. The authors discuss the use of Twitter by the Centre for Disease Control and Prevention (CDC) in the USA when the first patient in the country was diagnosed with the Ebola virus in September 2014. The CDC provided a live Twitter chat to address uncertainty and dispel misunderstandings regarding the virus. The authors collected around 2,155 tweets containing the hashtag "#CDCchat". The data were then processed using SAS Text Miner 12.1 software [18] because the program provides the ability to parse and extract information from text, reliably filter and store that information, and assemble tweets into related topics for inspection and to gain insights from the unstructured data. Based on the results from the analysed data, the paper finds that there were eight mutually exclusive topics, among which the greatest concerns were about the virus itself, its lifespan and symptoms, and how it is transmitted.

In [19], a system which aims to enhance communication channels in the case of an emergency as well as assist victims is proposed. In this research, Twitter was used as a form of social media application. According to the paper, quantitative analysis can be used to examine the status of an emergency event. For example, if the number of tweets increases during a certain time, this indicates that a change has occurred. The authors also found that there is a relationship between the development of an event and the nature of the data content. In other words, the greater the severity of an event, the more intense the data content will be. The paper uses a flood in Jeddah, Saudi Arabia as a case study. A unique hashtag was defined and 30 Twitter users were involved. A collaboratively developed map was provided for use by the public highlighting the flooded area. This map was created by a number of volunteers and utilised data collected from Twitter.

To sum up, social media apps allow citizens to provide valuable on-the-ground information, which would benefit an emergency management system by providing a clearer picture of an event and the level of damage. Social media can also help rescuers to find victims much faster and more effectively, either when those people send a help request via social media or when a concern is raised by a family if a loved one is missing in an event such as a flood or a storm. Social media offers the quick and wide dissemination of information. However, this could be one of the most noticeable disadvantages of using social media, as rumours can also be spread very quickly and widely. There is also a number of challenges that make it difficult for social media to be (a) trusted and (b) suitable for emergency and risk management. For instance, apps are designed for a purpose, that is, to allow users to communicate, whether for the exchange of information or as a form of entertainment by telling friends about what they do and do not like. Using this sort of app in emergency and risk management would require some modifications. A key one is enabling the location service on the mobile because it would be difficult to reach someone who is seeking help without knowing his/her location.

III. SYSTEM DESIGN

The main goal of our system is to provide a mobile cloud service that can help in identifying an emergency event that has occurred in different areas and that might cause damage to the main infrastructure, cause people to panic, or result in the loss of life. The service will, in addition, carry out further actions, including notifications and building interactive maps. Furthermore, the service includes a historic database that could be used if the same type of emergency event occurs again in order to improve risk and emergency management.

The new service is hosted in the cloud and connects to a social media application, Twitter in our case, to retrieve real-time information regarding emergency events. This service will also set-up real-time communication between members of the general public and emergency management centres, whereby help can be sought via social media, and rescue teams or emergency services staff can send useful information to the public.

The main benefit of this service is that it enables smart actions to be carried out based on results from the data analysing process, which means that this service can raise an alert with an emergency department if a high-risk event is discovered or provide a real-time and interactive map that can be made public and which shows both the affected areas and safe places. The cloud can also use data collected from social media to warn people who are located close to an emergency.

This service will also play an important role in building a historic database that stores what was done in a similar event that occurred a few months or even years before. This will help in learning lessons and improving responses from previous events, such as actions that should have been taken at the time or which were taken but were later revealed to be inappropriate.

Fig 1 shows a mobile cloud service, known as a social media service that is connected to a Twitter app for searching and retrieving purposes. The figure also shows that users can interact with the cloud over the internet, either directly or via neighbouring links. Risk and emergency centres are also users who benefit from this service, for example, by monitoring or tracking an event.

The architecture and components of this service are shown in Fig 2. The first component is listening to live Twitter streams. As a result, all tweets will be received/collected here. The next step is storing the received streams in the database before starting the analysis process. This will help the cloud to ensure the origin of the data after the results of the analysis process have been provided. In other words, emergency centres can extract the raw data of an event to explore tweets and multimedia that have been collected. However, to avoid storing a vast amount of data, the cloud will delete all unnecessary data collected after the risk of the event has passed or after a certain period of time (one month, for example). Another action the cloud can take to reduce database usage is by keeping tweet IDs in a table that is linked to an event so that these can be retrieved whenever needed.

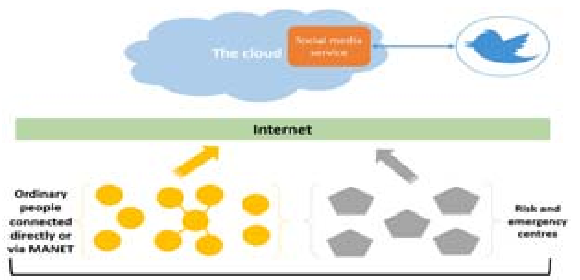

Fig 1. System design overview

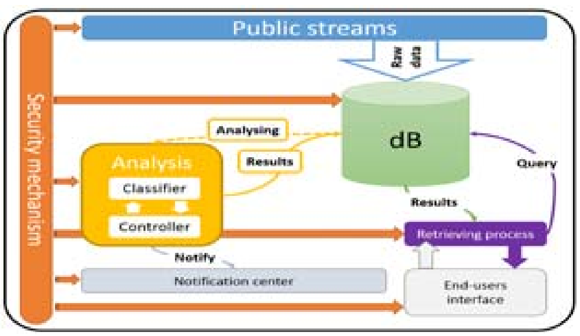

Fig 2. Social media service architecture

Once the raw data are stored in the database, it will be sent to the analysis component that consists of a controller and a classifier that is responsible to classify tweets to meaningful categories. The analysis process includes three main stages as in Fig 3:

1) *Collecting stage:* only tweets that contain English text are collected here and, to avoid duplication, only original tweets are included. This means that no retweets or in-reply tweets will be collected. Tweets without location coordinates will not be passed to the next stage either.

2) *Grouping stage:* tweets are grouped based on their location (i.e. coordinates, city, or county). This will help in detecting a risk event, as, if a high number of tweets come from almost the same location, the system can highlight this information and send a notification stating the possibility of a large event occurring to the management centre.

3) *Classification stage:* each tweet is passed to the classifier to determine the probability of matching a set of pre-defined labels, such as fire, abuse, etc. More information about the classification stage is provided in the implementation section.

The results of the analysis are organised in the database under the event, attaching any associated multimedia such as photographs or videos. These results can be used in two ways. Firstly, in the retrieving process, that starts once a user, whether a member of the public or an official looking for information about the event, provides some keywords for that event. The query is sent to the database looking for the data that present the best match. Once the results are found, they will be pushed back to the requester. The returned results can be photographs, tweets or texts, depending on the requester's specifications, as well as relevant results from previous events found in the database. However, the level of the returned data will depend on the role of the requester. For example, a requester wanting to check the latest status of an event will receive only sufficient information to serve his/her needs. In contrast, more specific data with certain recommendations will be served if the requester is an officer in an emergency centre or a rescuer who is at the location of the event. Secondly, to notify an emergency department or rescue team when an emergency event is detected, the cloud can use social media and the processed data to notify people who are either registered to receive risk event updates or those who are in the vicinity of a detected emergency event. This kind of notification will help to reduce the impact of an emergency event and the possibility that it will spread and affect more people. One example is that it could be used to notify drivers that they should avoid roads that are flooded. Pushing these types of notification can be done by collecting the current location of users who already registered in the cloud. Once they cross into areas that are marked as dangerous zones in the cloud database, an alert is sent to them. To avoid distracting people while they are driving, the cloud could send a short voice alert to their mobile device, such as "*Hazard ahead*!" or "*Road closed*!".

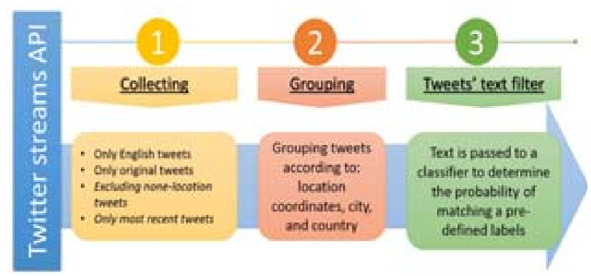

Fig 3. Analysing stages

The final component of this service is security. Three main actions will be taken to ensure a high level of protection when accessing/using this service, as well as a high level of privacy regarding storing and retrieving data.

First, only users who have an active account in the cloud can access and use this service. This will reduce the risk of the misuse of this service, for example sending a large number of requests to slow down the system or misusing the analysed data by carrying out an attack in a place that was considered safe or where there is a large number of people. The cloud allows users to use their credentials in the Twitter app to access cloud services. This will allow as large a number of trusted users as possible to benefit from the cloud services (more details are provided in the implementation section).

Second, the cloud will, at all times, refer to tweets using their IDs to ensure that ownership of data is held by its originators. The cloud will redirect the request to the Twitter app if it needs to retrieve actual tweets.

Third, all data stored in the cloud's database will be encrypted. Users can only retrieve the results of the analysis of these data, even if the retrieval request comes from a registered emergency centre looking for extra information about an emergency event.

IV. System implementation

This section presents how the system is implemented to achieve its goal. Two perspectives are discussed here: first, how the system is implemented to allow end users, both members of the public and risk and emergency teams, to interact with the system and benefit from the system's features; second, an explanation of how the social media service is deployed in the cloud and how the cloud will handle users' requests and carry out appropriate actions based on these requests.

A. Labelling and classification of live streams

One important feature of using social media is the analysis of live streams in order to produce meaningful results. For example, a company might analyse tweets to check the success of its products and to understand how the products fit within the market. Another use could be to deliver recommendations to users that may attract them depending on their activities (i.e. tweets and followers), such as recommending a place to visit while travelling or an account to follow. Most existing tools or systems analyse the text of tweets to check how positive or negative the user is being about a particular product or idea [20] [21] [22]. This is conducted using natural machine learning (NML) features to analyse the text [23].

In this project, six main labels were defined: emergency, fire, abuse, healthcare, crowd, and disasters. Each of these labels contains a set of words that explain each label. For example, "flood" and "storm" are included under "disaster", while "bleeding" and "accident" come under "emergency". This is called a bag-of-words (BoW) approach [24]. We then trained our classifier to these labels before we started the classification process. We used a Naïve Bayes protocol [25] because of its simplicity and propriety. As a result, when a new tweet is received, our service will:

1) <u>Pre-process the text of the tweet</u> by extracting the URLs and mentions of users' names and delete stop words, such as "the" or "and", and punctuation [26].

2) <u>Calculate</u> the number of occurrences of each word from the pre-defined list of labels in the text of the tweet.

The results will then be attached to the tweet to be stored in the database. Our labels include words and terms commonly used in an event. Therefore, the results gained using our classifier will not be as efficient as they could be. Thus, we added what we call a two-tier trained classifier protocol, which means that when our classifier classifies a new tweet to a certain label, the result is sent to an emergency and risk department for confirmation. Once an event is confirmed, the text of the tweet will be sent again to the classifier to enhance the production level/probability of the featured classification. In our case, we want to classify tweets using labels to better understand the request, as well as being able to carry out further actions, such as calling the fire brigade in the case of a fire. Moreover, the system can provide more data about a location that has a particular label. For example, if there is a tweet that is labelled as denoting a flood in a certain area, and this event was previously reported by an old user and labelled as a flood by the system, the management centre can now consider that there is an issue in this location and that the possibility of a flood having occurred is high. Another example is if a tweet is labelled by the system as indicating abuse and older tweets were labelled in the same way for the same area, the management centre can consider that there is an issue in that vicinity that needs further investigation.

B. Identifying an emergency event

There are two main ways in which an occurrence can be defined as a high-risk or emergency event which needs to be managed to reduce its impact and avoid damage or loss of life: the first is when a city emergency and risk centre issues an alert to the cloud and defines an event as having large-scale risk. Here the cloud starts monitoring and tracking the propagation of this event, as well as collecting relevant data from social media, particularly Twitter, as chosen for our system; the second is when the cloud receives requests from public users about an event when they are looking for help in dealing with the situation. Thus, if the cloud continues to receive requests from a high number of different users at almost the same location with similar descriptions, an alert will be triggered and sent to the nearest risk and emergency management centre to the event and the cloud will consider this as a high-risk situation. Once the alert triggered by the cloud is confirmed by the risk and emergency management centre, the cloud starts monitoring/tracking this event, as well as collecting relevant data and then analysing them to serve members of the public who may be affected by this event or submit recommendations to centres responsible for managing risk and emergency events.

C. Historic database

Once an event is defined as an emergency, the cloud starts to collect data in order to build an information history. The data collected will include what action has been taken and what types and amount of data have been exchanged/used (tweets, images, videos, etc.), the affected areas and the level of damage on the ground. However, sending enquiries to this database will result in more statistics or metadata, rather than a full chunk of data that needs to be analysed. The main purpose of this database is to increase the level of efficiency in managing similar or repeated risk events, which will result in less damage and reduce the effects of events that occur frequently (such as winter storms). For example, if a city is affected by a flood that causes significant damage to property or results in death, and the cloud has analysed historic data for this flood and stored these in its database, these data will be used if a similar flood occurs. This will enable the emergency management team to take defence actions in areas that have a high risk of flooding or track river levels that had risen in the previous flood and caused the main damage.

D. *Interactive map*

One of the important features of our proposed system is carrying out smart actions that will help in an emergency event. One example consists of sending real-time notifications to users about an event. Another type of smart action is that in the event of an emergency, the cloud can build a real-time map to show the affected areas so that they can be avoided by the public and focused on by the emergency management centres. In addition, safe areas can be shown so that resources and medical volunteers can be directed to where they are needed. People who require medical help can also reach these safe areas to get medical support. Entries to this map will be made from analysing the data collected by the cloud and the coordinates/locations that are sent from the risk and emergency management centres. Further information is provided in the implementation section below.

E. *Building a communications platform*

Another feature to be gained from introducing a social media network to cloud services is achieving two-way communication between the cloud and the end users, whereby users can seek help from the cloud through Twitter, which is our choice of social media, as well as the cloud being able to reach as many users as possible through Twitter. To make it easier for the cloud to receive requests and submit information to the public, we can benefit from using hashtags featured in Twitter. We set up a hashtag called #TheCloud. The cloud monitors this hashtag 24/7 to receive requests from users as well as to send information to users through this hashtag. As a result, each request sent to the cloud has to include #TheCloud hashtag and users have to monitor this hashtag to receive the latest updates from the cloud regarding an event. In addition, the cloud will listen to live Twitter streams to report an emergency or risk event to the appropriate centre, such as a city council, the police or fire brigade.

V. Experiment design

As stated previously, the main goal of our system is to use the mobile cloud capabilities for detecting risk and emergency events based on Twitter activity. To achieve our goal, we designed our experiment with two main environments in mind, depending on the type of user who accesses the mobile cloud social media service: the end-user environment, which includes the design of how people generally can access our service and gain from its features, and the rescue teams' environment, which allows risk and emergency teams to interact with the cloud services, such as by verifying the classification of tweets, receiving notifications, or looking at an interactive map. Furthermore, information about how the cloud is configured to listen to a Twitter stream, as well as how the service analyses and stores the data, is provided.

A. *The end-user environment*

Once our service has been configured to listen to a public stream, as shown in the system design section, users can access an official Twitter app or website to tweet their help request after ensuring the location service has been enabled. However, to make it easier for the user to interact with the service without having to pay attention to the system requirements, as well as benefiting from our previous solutions to dealing with session interruptions [7] and connection issues [6], we extended our previous Android app [8] to allow users to undertake a number of actions (with the help of the twitter4j [27] library):

1) Login using a Twitter account: to extend the user base of our system and introduce another way to access cloud services, we modified the login process of our previous app to allow users to use Twitter account credentials.

2) Sending a help request by tweet: users can send a help request to the cloud using the same method that Twitter uses to send tweets. In other words, the user has to provide a brief description of what he/she feels or what he/she is facing and then, in the background, the app reorganises the request as a tweet. This means adding the #TheCloud hashtag, highlighting keywords, and ensuring that the body of the text is below the limit (140 characters). This preparation will ensure that all help requests match the cloud service requirements, such as the GPS of the mobile device being on and enabled. The text of this request will appear on the requester's Twitter timeline.

3) Reporting an emergency: another benefit of integrating social media, as mentioned above, is collecting valuable on-the-ground information, including texts and images or even short videos. Users can send what they see on the ground through our Android app as if they were using a Twitter app. The main difference here is that the request will match cloud requirements, such as providing a current location, as well as in respect of the Twitter app.

4) Watching updates of nearby emergency events: users can use the app to check what emergency events have been detected for their current location and browse the latest updates from the cloud, which are the results of the data retrieval process in the social media service. On the same screen, the app also shows a map that has the most recent updates on the ground.

B. *Rescuers' environment*

The system needs to interact with risk and emergency centres, both with staff who are in the office and those who are on the ground during an event. Interactions are divided into two aspects: notification and confirmation. For the first, the cloud needs to send notification about a certain event that has, for example, been reported by a user who tweeted a help hashtag to the cloud. The formal aspect is important for ensuring the level of efficiency of our system, which means that when the cloud has detected that a large-scale event is occurring based on a high number of tweets received from the same location, this information has to be verified by a member of the risk and emergency department to avoid raising a false alarm.

Thus, we designed two web pages: one lists the results of all the classified tweets and asks a staff member to confirm detection or even to suggest a new label if one is needed; the second page contains an interactive map that shows live requests containing information. For evaluation purposes, we created an account for a risk and emergency centre and did what these centres do in the event of an emergency, such as posting updates and replying to users.

C. *Consuming and analysing a Twitter stream*

We created a Node.Js-based service [28] in our Amazon cloud platform [29] to listen to the live Twitter streams using the Twitter streaming API [30]. However, because it is not possible to listen to public streams without a filter, we set #TheCloud hashtag as a filter when we implemented our API streaming. Once a new tweet is received, our service starts. It first sends this tweet to the classifier, which calculates to which label it belongs, then redirects it to the most appropriate help centre based on the classifier prediction.

D. *Storage medium*

We used one database, which is an instance of Amazon RDS [31], to serve all our storage needs, including the historic database. Different data from different components need to be stored in the database, such as:

- Tweets received by our service from live streams.
- The results of analysing the tweets.
- Pre-defined labels with their bag of words.
- Tweets that are initially classified by the cloud and confirmed by the emergency and risk department.

VI. System evaluation

We are interested in ensuring that users can interact with the system with only a reasonable delay, as well as receiving support facilitated by the cloud as quickly as possible. In addition, we need to ensure that the classifier can classify the received streams into meaningful categories or label the type of help required in submitting a request to the appropriate emergency centre. Two experiments were run, as in the following subsections.

A. *System feasibility*

We tested the system with tweets from an active Twitter account. We could see that these tweets arrived successfully in the cloud, were stored in its database, classified and the results updated in the cloud database. Finally, the tweets were shown on the rescuers' panel.

In addition, all the information of the tweets, such as name, location, initial classification result, was captured and forwarded, which means that communication can start between the rescuer and the owners of the tweets.

B. *Classifier performance*

The aim of this experiment was to evaluate the performance of our classifier, especially when we trained with tweets/text that have been confirmed by the emergency and risk management. First, we defined a dataset that contains three different text messages that correspond to three types of emergencies (flood, fire and personal health) and we sent to the classifier to calculate the likelihood of matching the pre-defined labels as mentioned previously – this corresponds to the simple model. Then, we confirmed the initial detection and trained the classifier with this dataset. After that, we sent the same dataset to the classifier. We found that there is an improvement in the classification results as shown in Fig 4.

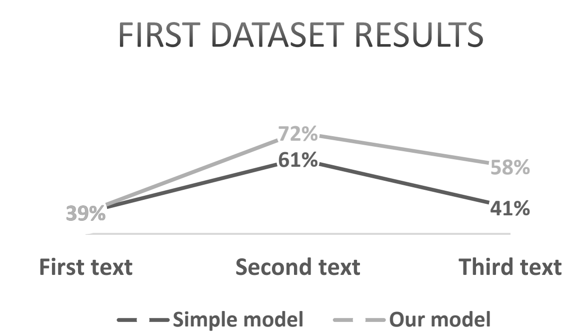

Fig 4. Comparing the performances of classifying three texts by a classifier that was trained pre-defined labels with a classifier that was trained with predefined labels and the same text of the three examples.

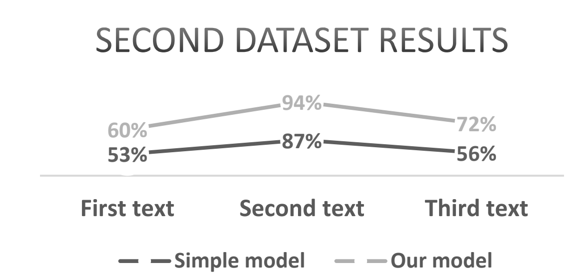

Fig 5. Comparing the performances of classifying three different texts by a classifier that was trained pre-defined labels with a classifier that was trained with predefined labels and the text of the first dataset.

We defined a second dataset that has different texts but corresponding to the same types of emergencies. We calculated the probability of this dataset using the classifier that was trained only with the pre-defined labels and classified it again after being trained with the first dataset. The results in Fig 5 show that our model not only matched the text with a correct label but with a higher probability compared to the simple model.

Theoretically, this result is correct because when the population of the label or category is increased the property of a new text to match this label will increase.

VII. Conclusion and future work

Social media has interesting features, such as real-time communication and the ability to disseminate information quickly and widely that can be used for risk and emergency management. Furthermore, analysing data from social media can create early notifications to alert people who are planning to access a location, such as a shopping centre in which an emergency procedure is taking place.

However, introducing a social media network into emergency management faces some challenges, such as the need to analyse a large amount of data, as well as the potential to spread of rumours and incorrect information. Therefore, in this paper, we proposed a new mobile cloud service that is connected to a social media network, in order to address some of the challenges, such as the real-time analysis of live streams, and to benefit from its valuable features, such as building a communication platform, as well as the early detection of emergencies.

We tested our prototype in a real-world scenario by sending tweets to the cloud to assess how the cloud performed. We found that our solution is feasible and can achieve its objective. In addition, we run an experiment to test our classifier performance. We found that our solution can improve the probability of detecting new tweets/texts when previous classification tweets/text are confirmed and trained.

In future work, we plan to trace our system with an old dataset that has real-world disaster events in order to test whether our system can detect these events and how it behaves in terms of accuracy and performance. We are also planning to build a tweet analysing protocol to enhance emergency and risk detection, as well as providing a “Twitter-like” chat service between mobile ad-hoc network (MANET) members [32], as in our previous paper [6], which means that neighbours can exchange messages locally using the Twitter format in case they cannot reach the cloud. Once the cloud can be reached again, all previous chats will be upload and analysed in the cloud with the help of the social media service that is presented in this paper.

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References

[1] eMarketer, "Social networking reaches nearly one in four around the world," 18 6 2013. [Online]. Available: www.emarketer.com. [Accessed 1 12 2015].

[2] "Twitter Inc.," [Online]. Available: https://www.twitter.com. [Accessed 01 03 2016].

[3] D. Maynard, K. Bontcheva and D. Rout, "Challenges in developing opinion mining tools for social media," *Proceedings of the@ NLP can u tag\# usergeneratedcontent,* pp. 15--22, 2012.

[4] D. Puthal, B. Sahoo, S. Mishra and S. Swain, "Cloud computing features, issues, and challenges: a big picture," *2015 International Conference on Computational Intelligence and Networks (CINE),* pp. 116--123, 2015.

[5] H. Alshareef, "Introducing mobile cloud technology into m-health to deliver better care/support in case of emergencies," *The Boolean,* pp. 20-26, 2015.

[6] H. Alshareef and D. Grigoras, "Mobile ad-hoc network management in the cloud," *13th International Symposium on Parallel and Distributed Computing (ISPDC),* no. IEEE, pp. 140-147, 2014.

[7] H. Alshareef and D. Grigoras, "Robust cloud management of MANET checkpoint sessions," *14th International Symposium on Parallel and Distributed Computing (ISPDC),* no. IEEE, pp. 66-73, 2015.

[8] H. Alshareef and D. Grigoras, "First responder help facilitated by the mobile cloud," *2015 International Conference on Cloud Technologies and Applications (CloudTech),* no. IEEE, pp. 1-8, 2015.

[9] J. Li, Q. Li, S. U. Khan and N. Ghani, "Community-based cloud for emergency management," *6th International Conference on System of Systems Engineering (SoSE),* pp. 50-60, 2011.

[10] S. Luna and M. Pennock, "Social media in emergency management advances, challenges and future directions," *9th Annual IEEE International Systems Conference (SysCon),* no. IEEE, pp. 792-797, 2015.

[11] A. Mills, R. Chen, J. Lee and H. Raghav Rao, "Web 2.0 emergency applications: How useful can Twitter be for emergency response?," *Journal of Information Privacy and Security,* vol. 5, no. 3, pp. 3-26, 2009.

[12] B. R. Lindsay, "Social media and disasters: Current uses, future options, and policy considerations," *Congressional Research Service Washington, DC,* 2011.

[13] M. GANEA, A. CONSTANTIN and A. D. COMSA, "Quick overview of the Social Media," *Romanian Statistical Review Supplement,* vol. 60, no. 3, pp. 113-115, 2012.

[14] M. Imran, C. Castillo, F. Diaz and S. Vieweg, "Processing social media messages in mass emergency: A survey," *ACM Computing Surveys (CSUR),* vol. 4, no. 47, p. 67, 2015.

[15] G.-I. Roberto, S. Muresan and N. Wacholder, "Identifying sarcasm in Twitter: A closer look," *Proceedings of the 49th Annual Meeting of the Association for Computational Linguistics: Human Language Technologies,* vol. 2, pp. 581-586, 2011.

[16] J. Yin, A. Lampert, M. Cameron, B. Robinson and R. Power, "Using social media to enhance emergency situation awareness," *IEEE Intelligent Systems,* no. 6, pp. 52-59, 2012.

[17] A. J. Lazard, E. Scheinfeld, J. M. Bernhardt, G. B. Wilcox and M. Suran, "Detecting themes of public concern: A text mining analysis of the Centers for Disease Control and Prevention's Ebola live Twitter chat," *American Journal of Infection Control,* vol. 43, no. 10, pp. 1109-1111, 2015.

[18] G. Chakraborty, M. Pagolu and S. Garla, Text mining and analysis: Practical methods, examples, and case studies using SAS, SAS Institute, 2014.

[19] N. R. Aljohani, S. A. Alahmari and A. M. Aseere, "An organized collaborative work using Twitter in flood disaster," *Proceedings of the ACM WebSci'11, Koblenz, Germany,* pp. 1-2, 2011.

[20] M. S. Neethu and R. Rajasree, "Sentiment analysis in twitter using machine learning techniques," pp. 1-5, 2013.

[21] O. Kolchyna, T. T. Souza, P. Treleaven and T. Aste, "Twitter Sentiment Analysis," *arXiv preprint arXiv:1507.00955,* 2015.

[22] F. Koto and M. Adriani, "A Comparative Study on Twitter Sentiment Analysis: Which Features are Good?," *Natural Language Processing and Information Systems,* pp. 453--457, 2015.

[23] B. Liu and L. Zhang, "A survey of opinion mining and sentiment analysis," *Mining text data,* pp. 415--463, 2012.

[24] Y. Zhang, R. Jin and Z.-H. Zhou, "Understanding bag-of-words model: a statistical framework," *International Journal of Machine Learning and Cybernetics,* vol. 1, pp. 43--52, 2010.

[25] A. McCallum, K. Nigam and others, "A comparison of event models for naïve Bayes text classification," *AAAI-98 workshop on learning for text categorization,* vol. 752, pp. 41--48, 1998.

[26] W. J. Wilbur and K. Sirotkin, "The automatic identification of stop words," *Journal of information science,* vol. 18, no. 1, pp. 45--55, 1992.

[27] Y. Yamamoto, "Java library for the Twitter," http://www.twitter4j.org/, 2007.

[28] "Node.js Foundation," [Online]. Available: https://www.nodejs.org/en/. [Accessed 01 03 2016].

[29] "Amazon AWS Web Servicess (AWS)," [Online]. Available: http://aws.amazon.com. [Accessed 01 03 2016].

[30] "The Streaming APIs | Twitter Developers," [Online]. Available: https://dev.twitter.com/streaming/overview. [Accessed 01 03 2016].

[31] "Amazon Relational Database Service (Amazon RDS)," [Online]. Available: https://aws.amazon.com/rds/.

[32] A. K. S. Ali and U. Kulkarni, "Characteristics, Applications and Challenges in Mobile Ad-Hoc Networks (MANET): Overview," *WIRELESS NETWORKS,* vol. 3, no. 12, 2015.