E-HAMC: Leveraging Fog Computing for Emergency Alert Service

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***Abstract*— Timeliness is one the most important factors in emergency management. Emergency notification mechanism has to be hassle free and quick, in order to have efficient response for any disaster, health-fix, act of terrorism, etc. In this paper, we present service architecture for emergency alert, using Fog computing. Fog computing brings cloud resources close to the underlying devices and IoTs, which makes it ideal for latency sensitive services. Furthermore, Fog is used for offloading resource constrained devices. Our smart phone based service, known as Emergency Help Alert Mobile Cloud (E-HAMC) provides a quick way of notifying the relevant emergency dealing department, utilizing the services of Fog for offloading as well as pre-processing purposes. The service sends the location of incident and contacts the appropriate emergency dealing department automatically through already stored contact numbers. The emergency related information is then synchronized automatically from Fog to the Cloud, allowing further analysis and improvement in safety of the people and creates extended portfolio of services for the concerned authorities as well as the users. Performance in most certain scenarios is also evaluated and presented in this study, which shows the applicability of our system and its future prospects.**

***Keywords*— M2M; mobile cloud computing; emergency alert; Fog computing; Micro Data Center (MDC); Edge Computing.**

I. INTRODUCTION

Emergency refers to an immediate risk posed to life, health, environment, or asset. Emergency has no calendar and one can come across any sort of such situation anywhere, at any time. Whether in the form of an accident, terrorism, robbery, kidnapping, fire breaking out, building collapse, murder. It has become urgent to have a simplistic and quick way to notifying the concerned department to deal with the disaster. Emergency management depends a lot on how quickly and exactly the situation is notified to the right people. With today's age of advancements in smart phone technology, it is more efficient to utilize the technology for emergency management. Mobile cloud computing adds more capabilities to create sophisticated services [1-3], [5], [6].

Currently available mechanisms do not efficiently handle emergency notification mechanism [2], [3]. Most of the processes prevailing around the world require the victim or witness to decide the type of emergency first and then find out which departments must be contacted. For example, in case of an accident, ambulance and police have to be called. Manually finding out the contact numbers and departments is not only inefficient, but also, at the time of emergency, it creates panic and affects rational thinking process. This could cost life as well.

Cloud computing, along with Fog computing, can play a very vital role in not only emergency alert process, but also, in the overall emergency management. Cloud computing platform provides vastly manageable and scalable virtual servers, computing resources storage resources, virtual networks, and network bandwidth, according to the requisite and affordability of customer. It also provides solution to process distributed content. Moreover, data can be accessed far and wide devoid of the trouble of keeping large storage and computing devices. Large amount of content can also be shared and collaborated easily with cloud computing.

Fog computing extends traditional cloud computing paradigm to the edge, thus, also known as Edge Computing. It is a Micro Data Center (MDC) paradigm, being highly virtualized, able to provide computation, storage, and networking services between the end nodes and traditional clouds [7]. As opposed to the cloud, which is more centralized, Fog computing is aimed at services with widely distributed deployments. Because of being localized, it provides low latency communication and more context awareness. Fog provides real-time delivery of data, specially for delay sensitive, emergency, and healthcare related services. Fog helps resource constrained nodes offload the rich tasks. It can preprocess the raw data and notify the cloud, before cloud could further adapt that data into enhanced services.

Although, there has been a lot of work on emergency management, but current solutions do not address emergency notification in an efficient and simple way. In this paper, we present a service architecture for emergency alert and management, through Fog and cloud computing. Our system, Emergency Help Alert Mobile Cloud (E-HAMC) tackles different kinds of emergency situations in a very simple and efficient way. User only has to press a single button, the application itself decides which departments have to be informed, including the location of the event. E-HAMC also informs the family members automatically, by sending messages to already stored contacts numbers.

In rest of the paper, section II is on already done work. Section III is on our proposed system. We evaluate and discuss the results of our system in section IV. Our paper concludes in section V.

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II. RELATED WORK

This section critically discusses the already done works, relevant to our area of focus.

Relying on the convenience social media provides, Kathy Pretz [9] discusses utility of Twitter for emergency alert. The author states that a developing situation can be assessed through the data gathered from Tweets. The prototype service in this regard uses data-mining techniques to parse high-volume Twitter streams and identify early indicators of a potential incident. The prototype service is deployed in Australia. The program continuously collects and analyzes tweets from different locations throughout Australia, using data-capture module. The authors claim that Twitter's is increasing; hence, it would be easier to report an incident. With this proposal, one issue is that when a disaster strikes, the volume of tweets can be overwhelming to be monitored and extracted. Besides, it totally depends upon those people who use Twitter and are online at that time, tweeting about that happened incident. Even in the developed countries with very high literacy rate, not everyone uses social media. Twitter's users would even be lesser then. This mechanism also has to deal with a large amount of tweets and complex algorithms. Instead, emergency management requires a more efficient and easier way, prevalent not only in Australia, but elsewhere as well, specially under-developed countries. Emergency alert process should be simple for an illiterate person as well.

In another Twitter related proposal, Jie Yin et al. [10] discuss on a system that uses natural language processing and data mining techniques to extract relevant situation awareness information from Twitter messages generated during various disasters and crises. System architecture is presented for leveraging social media to enhance emergency notifications. High-speed text streams retrieved from Twitter during the incidents are the data sources in this system. Again, it is dependent upon how effectively and efficiently the information is retrieved and made useful. The rest of the issues associated with this proposal remain the same as discussed for the study [9].

Hannes Tschofenig et al. [11] propose IP-based emergency service. Internet Engineering Task Force (IETF) has a working group named as Emergency Context Resolution using Internet Technologies (ECRIT) IETF GEOPRIV Working Group [15] related to this sub-domain. GEOPRIV focuses on protocols and techniques required to develop a robust emergency architecture which would be able to function on all types of IP-based networks. The caller needs to acquire location information for emergency notification, the end systems or proxies have to identify an emergency call and then mark and route it to the proper Public Safety Answering Point (PSAP). In this case, either the end host or proxy determines the location of the host. For initial location-based routing, either end host is responsible or the Session Initiation Protocol (SIP) proxy. This all process is vulnerable to location spoofing. Furthermore, a simple and quick mechanism is required for notification, which this mechanism clearly lacks.

Qing Ye et al. [12] emphasize on the fact that emergency can happen at any time, at any place, which create uncertainty factor. Authors present a way to determine probability of an emergency event, based on Laplace criterion. One of the major shortcomings in this study is that it is based on the assumption that all emergency situations are of same probability. Emergency vehicles deal with the emergencies through the road infrastructure network. Emergency vehicle are stationed aiming to a maximum coverage of the target and demand at any point in the road network are established. Therefore, the study mainly focus on location of emergency vehicle, in order to be able to reach the designated place within the specified time. Other than uncertainty in happening of such events, there also lies the difficulty in the type and extent of emergency event. Since time is critical in emergency situations, therefore, the vehicles have to be stand-by all the time to have quick response and adequate coverage. Main issue here is that it cannot be determined that what type emergency situation can rise. Therefore, what type of emergency dealing vehicles have to be made ready. As it is a critical matter, relying on assumptions is not quite effective in this regard. Also, the events that occur far from the main road are considered to have occurred within the reach of emergency vehicle. This assumption is also a major lacking in this study. The authors also consider that the occurrence of emergency events at any point of the way happens with the same probability.

The study discussed by Lin Dajian et al. [13] is on formation of resources, which are required for judging emergency rescue process to have a balanced and optimized configuration of the resources. To determine the levels of the emergency response capabilities in industrial accidents, it is essential to have a balanced resource allocation, for effective rescue process. This study is mainly to overcome evaluation system from some enterprises which already exists, uncertainty factor of relevance of evaluation index system with butterfly catastrophe theory to build up four-dimensional evaluation model of the enterprise's emergency rescue capabilities. Since emergency event and its magnitude cannot be predicted, Emergency Resources play a vital role in emergency rescue process, because they are directly related to the accident's classification disposal of emergency plans. Emergency resources mainly include four types of entities: human, machine, environment, and management. Human, with some emergency training can learn emergency measures and judge potential risks involved in the accidents and the possibility of accident happening correctly and immediately. On the other hand, machine deals with the safety and facilities for handling emergency situations. Emergency channel, quantity, emergency equipment's type, performance, storage locations, and standby facilities are all that a machine has to deal with. Management is mainly reflected in whether the whole emergency tackling process can be performed properly and effectively. There are four factors that may affect emergency response capability of enterprises: human factors, equipment factors, environment factors, and management factors.

Zhang Yunlong et al. [14] emphasize on environmental and atmospheric accidents only, in China. Environmental problems, such as water pollution accidents, atmospheric pollution accidents, and solid waste pollution accidents had become one of the most notable emergency management problems for Chinese government. In order to find the occurrence and development rules of environmental pollution and destruction accidents, forecast methods are often used. In their study, the authors use a model to examine the environmental pollution and destruction accidents happened recently in China. The accidents contain atmospheric pollution accidents, water pollution accidents and solid waste pollution accidents, etc. Event times are used in the model to predict their occurrence. This study does not extend to the emergency situation we normally face in our daily lives.

III. Emergency Help Alert Mobile Cloud (E-HAMC) with Fog

In our system, our objective mainly was to overcome the prime issue of complexity and delay in emergency notification. A relatively narrow focused form of initial proposal is presented in [17].

Data is communicated to the Fog, which sends alert to appropriate emergency tackling departments and family members of the victim. Later on, data is pre-processed and filtered and then uploaded to the cloud, which analyses it and further creates extended portfolio of services.

Among the available services, none of them is capable enough through which appropriate emergency tackling department (e.g. fire-brigade) is directly contacted by the application, upon user's single action or click of a button, instead, the user or victim has to decide which departments have to be contacted and then find out their contact numbers. Our system not only does that, at the same time, a message is sent to the close family members (as many as user wants to) of the user. In our case, proposed E-HAMC maintains a list of those family members. With this, user does not need to find out which department to be communicated and search for contact numbers of family members at the time of emergency. User will only click on the type of event; rest of the things will be done by the application, in coordination with the Fog. The exact location of that even can be sent through global positioning system (GPS) or through base tranceiver station's (BTS) location, avoiding further hassle. Fog will be able to take the initial location coordiates and enrich it with more exact and refined location mapping, which also includes street-view feature and available paths identification. The basic interface currently provides seven different types of emergency notification options: accident, murder, fire, building collapsed, terrorism, robbery, and quick health fix. Figure 1 shows the basic interface.

Figure 1. Basic interface of proposed E-HAMC.

As mentioned earlier, the data may be uploaded in the cloud, which helps related departments for better planning and future betterment [8]. All concerned departments will be able to access all type of incidents' information over the cloud and analyze it. For instance, if some area experiences more accidents at night-time due to bad light or sharp turns, then that issue can be tackled in future. Similarly, hospitals and ambulance service providers can see which locations are more suitable to have their resource point or emergency vehicles' located, for quick response and have reachability to the place of event, keeping in view the frequency and types of events that occur in a particular area. In case of emergency situation, instead of thinking about whom to contact and how to contact and then inform the family members as well one by one, the user only has to select the type of event occurred through a simple user-friendly menu. Upon doing that, the application sends message to the control center of appropriate emergency dealing department by sending a short message, including the place of that event, shown in figure 2, which can be taken from the BTS the cell phone is being connected or through GPS.

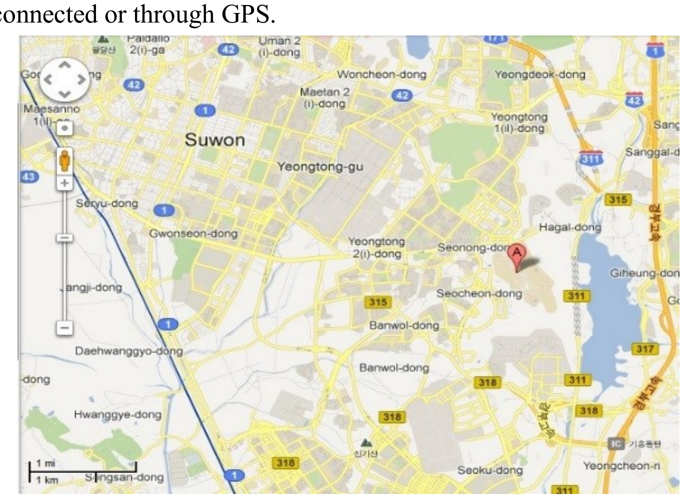

Figure 2. Location mapping of the contacting device

The application is able to automatically send message to the already stored close family members, whose list is maintained by the application. This has another benefit that if the victim is not in a situation to inform his/her family members, then any witness or passerby can do it with a single button-press using E-HAMC in his/her own phone. The application also provides Witness mode for the user. The only exception in this case would be that the family members would not be informed. The default mode is Victim mode. Once the alert has been made by the Fog, data is pre-processed for further refinement and then sent to the cloud. Concerned authorities can gather the data from the cloud, when needed, to analyze which kind of emergency situations have been rising with what frequency, in any particular area and what are the reasons. This will allow preventing and avoiding such situations in future and ensure better public life.

Communication pattern of proposed E-HAMC with Fog is shown in figure 3.

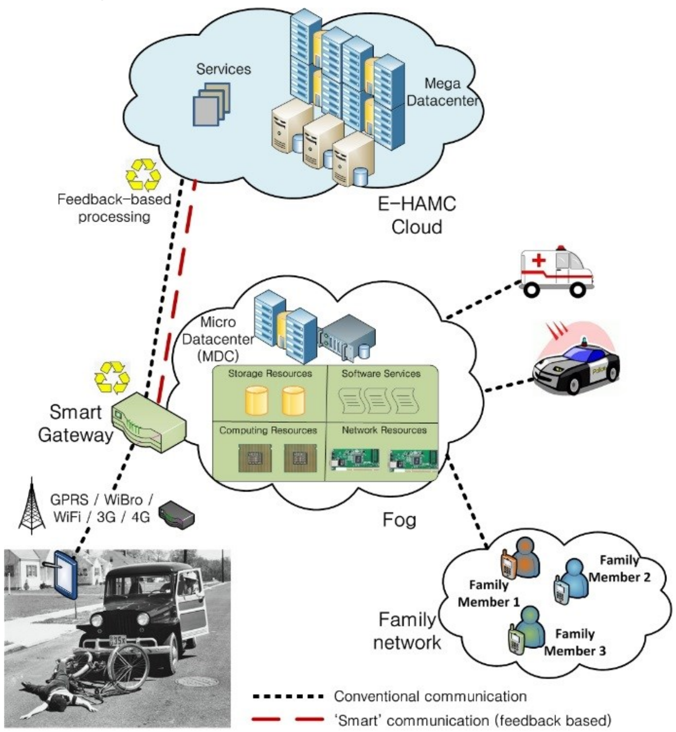

Figure 3. E-HAMC communication pattern

A. Handling prank emergency notifications

Handling prank notifications completely may not be possible. But at least a noteworthy effort can be made in this regard. In our system, once an emergency situations rises, the victim send picture of the event, which is then sent to the Fog automatically by the application. Since the service is going to be used with smart-phones, therefore, having camera in the equipment is not an issue. In case the victim is not in a situation to do that, any passer-by can take picture and inform the concerned departments with documentary proof. This mechanism will at least help reduce prank notification, if not eliminate it.

B. Contacts update according to user's location

When a user has changed its location and moved to another city or country, the contacts of emergency dealing departments have to be updated. In the new location, the application contacts the cloud and synchronizes contacts lists, along with the availability of different types of departments, dealing different sorts of disasters. By this, user never has to manually update. Users are kept always in ready state to use the application.

C. Avoiding location spoofing

In the traditional available ways of handling emergency situations, location spoofing occurs a lot and becomes an annoyance for emergency dealing departments. Due to this kind of issue, the network is left busy and actual victims sometimes are not able to reach the rescue department. In our system, we have handled it by making location awareness automatic. When a user/victim sends emergency notification, the location is automatically taken from the GPS or BTS of the user's mobile device, it has been connected with. This mechanism makes it impossible to spoof location.

Figure 4 represents the cloud service management at the cloud site and generating further services from it, which are then used by the concerned departments.

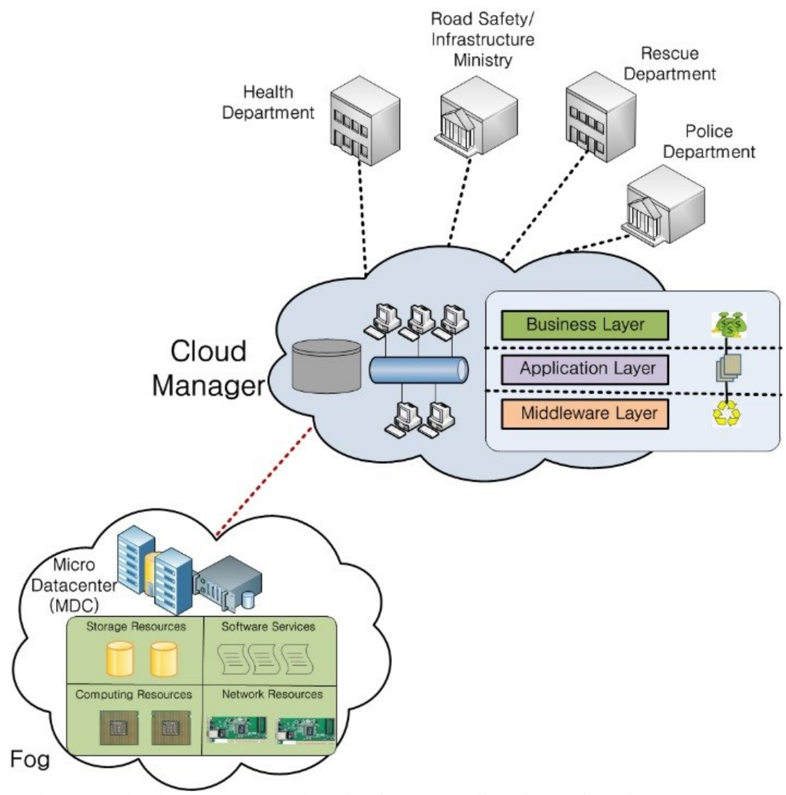

Figure 4. Cloud manager managing cloud resource allocation and services.

IV. Performance Evaluation

The test setup was in such a way that smart phone having E-HAMC installed was used as end node. Our Real-time Mobile Cloud Research Center (RmCRC) private cloud XenServer was used for Fog communication. Dropbox [16] was used as cloud storage service, where Fog uploads the data in the end. Different access networks can be used in this regard. Our evaluation is based on WiFi, WiBro, Broadband, and 4G networks. Final presented results are average of all captured data analyses. The evaluation is divided into two scenarios. In scenario 1, evaluation is on end-node to Fog communication. In scenario 2, evaluation is on end-node to cloud communication. Eventually, we can differentiate how much Fog impacts in emergency situations, in terms of efficiency. For the evaluation, two types of data sets were used: (a). multimedia (audio/video) file and (b). bulk-data. Multimedia file data set is used to represent the situation when an audio or video file, based on the disaster, is uploaded to the cloud. In this regard, we used 20MB file for the purpose of evaluation. Bulk-data is for the situation when images, location, text message, and other relevant data is uploaded in the cloud. For different file types, different scheduling algorithms are used by the cloud. For example, shortest-job-first, first-in-first-out, etc., which have their own impact on the overall performance of data storage in the cloud. The evaluation consists of 100 instances of users, who are using E-HAMC service and notify for different emergency situations to the concerned departments. Results are average of all instances.

A. *End-node to Fog*

Table 1 shows that 20MB data communicated from end-node to Fog takes an average of 7.84 seconds. This data is then processed by the Fog further and after refinement, uploaded in the cloud.

TABLE 1: UPLOAD DELAY – END-NODE TO FOG

Data size	20 MB
Upload Delay	7.84 sec

In the second form of data-set, bulk-data of different sizes was used. The result presented in table 2 shows average of 10MB bulk-data set, which contained images, location coordinates, and text. It takes 4.4 seconds to communicate 10MB bulk-data to the Fog.

TABLE 2: UPLOAD DELAY – END-NODE TO FOG

Data size	10 MB
Bulk-data Upload Delay	4.4 sec

B. *End-node to Cloud*

This part shows that if there is no Fog involved between the end-node and the cloud, the overhead is comparatively increased and delay incurred is more than the previous scenario.
Shown in table 3, uploading a 20MB video file to the cloud takes about 69.3 seconds. This is hence the average time to upload the stated size of video or multimedia data on the cloud. This shows that compared to non-Fog scenario, the incurred delay is up to 9 times.

TABLE 3: UPLOAD DELAY – END-NODE TO CLOUD

Data size	20 MB
Upload Delay	69.3 sec

When an already uploaded content is to be relocated in the cloud or its attributes are changed, the cloud has to re-configure its URL, since every file has a unique web identity in the cloud. This relocation or change in the attributes requires synchronization. For a service being accessed by more than one node or user, collaborative environment is created, which requires more time to synchronize and update the contents. Average time to synchronize data is shown in table 4.

TABLE 4: SYNCHRONIZATION DELAY–CLOUD

Data size	*All*
Synchronization Delay	04 sec
Synchronization Delay for Collaborative work	09 sec

In the second form of evaluation, bulk-data was used. We present results on 10MB bulk-dataset evaluation. Table 5 shows how much multitude of files incur delay. In this case, the incurred delay is 27.82 seconds, up to 6 times more than end-node to Fog direct communication. This shows that when quick alerts and notifications are required, Fog affects a great deal by bringing in efficiency.

TABLE 5: BULK-DATA UPLOAD DELAY– END-NODE TO CLOUD

Data size	10 MB
Bulk-data Upload Delay	27.82 sec

In terms of synchronization delay for bulk-data, as different types of files are to be updated, it requires more time. Table 6 shows that compared with single 20MB file (table 4), bulk-data of 10MB take more than twice as much time in synchronizing files.

TABLE 6: BULK-DATA SYNCHRONIZATION DELAY–CLOUD

Data size	*All*
Synchronization Delay	~ 09 sec

V. CONCLUSION

Notifying incidents in an efficient way is becoming very important. In this work, we focused on the issue of quick and easy way of notifying for different sorts of emergencies or disasters. Our objective was to keep the victim from thinking too much and analyzing at the time of catastrophe. The victim or witness has to just press one button to inform about the type of event. The service automatically decides and contacts relevant departments. Fog computing is incorporated in the model to provide resource hungry task offloading and pre-process the data. Later on, data is communicated to the cloud for more enriched services. The evaluation of the system endorses the utility of Fog in this particular scenario. Generally, with Fog, the overall delay was around six times less than the otherwise case, when data is to be directly communicated to the cloud by the end node.

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