Context-Aware Emergency Notification Service over 4G EPC Network: Concept and Design

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***Abstract*—In this paper we present the concept of context-aware Emergency Notification and Rescue Service (ENRS) utilizing user information from the 4G EPC network. The 4G EPC is an all IP next generation architecture that makes it easy for various 3GPP and non-3GPP standards to co-exist and provide network access to the end user. The proposed architecture consists of two parts; first part is emergency notification and information gathering to use for the event notification. The second part consists of an intelligent context-aware decision engine that processes the collected information in real time and generates notification messages for the end user. Our proposed service is based on the RESTful concepts and can be used to effectively notify and help users during the emergency. Currently a prototype of the service is being developed to validate the ENRS.**

Keywords*—Context Awareness; EPC; Location Based Services; Machine-to-Machine Communication; RESTful Services

I. Introduction

Location Based Services (LBSs) are becoming more and more popular as applications based on location, context and preferences provide useful information to the end users. LBSs cover a broad range of applications like information search, guided tours, games, advertising and retail marketing allowing mobile-commerce [1]. Making use of location information can be extremely helpful in emergency situations. Around the world, people experience events like earthquakes, tsunamis, wild fires, hurricanes, toxic/chemical spills, mining incidents and terrorism acts. Studies like [2] show that people have shown interest in using LBSs in their daily life to cope with the emergency events.

LBSs can be reactive or proactive depending on how they are initiated [3]. Reactive LBSs are initiated by the user to ask for help according to emergency event. Examples of reactive LBSs are emergency services like E911 in USA and E112 in EU, which make it mandatory for cellular operators to keep track of the user location whenever an emergency call is made. Proactive LBSs need little or no interaction from the user; instead these services continuously track the users location and find events that might interest the users. An example of proactive LBSs is notifying users with saving deals when they are visiting a shopping mall.

When dealing with emergency situations, some events (mostly natural) are predictable to some extent, but the missing and crucial aspect is the proactive assistance during the emergency event or just after it has occurred. Proactive LBSs can be effectively used to provide such as service. Nowadays it is very easy to get user location information either from mobile network or by using GPS and A-GPS technologies on mobile devices. Using machine-to-machine (M2M) communication between smart devices like sensors, actuators and video cameras, it is possible to get emergency event information (speed, direction, intensity & future course) and use it to effectively manage emergency situations.

In this paper, we present a context-aware proactive LBS called Emergency Notification and Rescue Service (ENRS). ENRS is designed to provide end-to-end emergency management for its users in emergency events (i.e. its beginning, in-progress and termination). It makes intelligent decisions to send emergency notifications. It can also provide detailed information to the user on how to reach to a safe area. It is also possible to offer added functionality, such as locating missing persons. The intended users of the ENRS are the ones having devices to connect to the 4G networks. Examples of such devices include, smart phones and touch devices like tablets. ENRS encourages coordination between multiple entities, e.g. mobile network operators, city administration (to find schedule of public transport, public Wi-Fi), rescue services and location service providers. In fact the nature of LBSs makes a strong case for active participation of multiple entities [3] as it is difficult for a single entity to own, operate, manage and offer such service.

The rest of the paper is organized as follows, Section II presents two motivating scenarios, identifies requirements and discusses related work. Section III discusses the ENRS architecture and the gateway architecture. Section IV presents the future work and Section V concludes the paper.

II. Motivating Scenario and Requirements

In this section, we first present couple of motivating scenarios and then derive a set of requirements from them. Finally we give briefly discuss related work.

A. *Motivating Scenarios*

Let us consider a scenario where an earthquake hits a downtown area of a city. This type of event is impossible to predict in advance. Due to the nature of the event some roads can be blocked, making it difficult to use them. Rescue teams need to arrive at the multiple locations and help injured people. Mass evacuation is required to prevent more fatalities due to aftershocks. General public and rescue teams need a service that is able to help them in real time. In this scenario, the ENRS can not alert end user about the emergency event in advance, but it can help its users during and after the emergency event to find their way out of the danger zone and even help trapped people to send SOS messages, which in turn are routed to the rescue teams. ENRS can help these rescue teams to find optimal path to their destinations in real time by minimizing the risk of congestion.

Consider another scenario in which city administration has deployed early warning tsunami equipment near a popular tourist resort. Using this equipment, local disaster control center detects tsunami and collects its information, e.g. its presence, intensity, direction and areas under threat. However, the real issue is to use this information in a coordinated way and provide users with information they need to save their lives. Traditional approach is to send warning SMS messages, but these messages only notify the user about the event. There is no guidance or instructions regarding next steps. The absence of such information can lead to chaos or stampede like situation at exit points. In this scenario ENRS can be used to coordinate the evacuation of people before the emergency event reaches to them.

B. Requirements

Several requirements can be drawn from these scenarios. *First* requirement is that the ENRS should make use of existing technologies/standards to promote easy development and support compatibility. This can be accomplished by using existing standardized protocols and specifications like OMA RESTful web services, which can be used by any device supporting HTTP. The *second* requirement is that the ENRS should not require any changes or additional component in the EPC architecture. ENRS uses existing core EPC network entity called GMLC over the *Le* interface using Mobile Location Protocol (MLP) [4].

The *third* requirement is that the ENRS should not be dependent on a specific mechanism to determine users location. To fulfil this requirement it is assumed that the underlying network is able to determine user location, totally transparent to the ENRS. The *fourth and final* requirement is that ENRS should be capable of handling disruption in communications. As it is quite possible that during emergency events communication infrastructure gets damaged and in some cases it may take a while to restore communication services. Delay tolerant protocols can be helpful to handle such situations.

C. Related Work

To the best of our knowledge there is no research work on the implementation of OMA RESTful location services over EPC network. A recent work [5] discusses the use of Parley X APIs for emergency communication in NGN. Their 3 stage solution is based on IMS. First stage is disaster warning which uses SMS, voice calls to alert the users. The second stage is emergency reporting stage where a user makes emergency call to the respective authority, which uses GMLC to find the user location. In the third stage, this location is then sent to the rescue service. The authors validate their solution using 2011 earthquake of Japan as example. Another work [6] introduces a prototype location based service in UMTS using SIP and OSA/Parlay. Their main goal is to understand the service development in UMTS and demonstrate its uses in real world. An early work in [7] specifies modeling and testing of location based services in UMTS networks.

The work in [8] discusses the use of location from early days of internet and how location based services evolved over the years. Authors mainly discuss IETF GEOPRIV framework which is designed to provide location services for Internet. In [9] a generic framework is presented for providing device based location service. The authors aim to bypass network centric location approach and make external location based service to directly use position information from the user device instead of involving network.

In [10] the authors build 4G location service architecture as an extension of the 3G location service. The requirements, changes and additional entities introduced in the network are identified such as position determination entity and location management unit. In [11] authors discuss a conceptual architecture for LBS services over 4G IP networks. Their conceptual architecture consists of GPS and GIS servers and two use cases are discussed although no implementation details or performance evaluation is given. In [12] the authors describe their proposed active location reporting mechanism for emergency calls made in UMTS networks. Their mechanism is used in events where user device changes location during the emergency call. The work in [13] discusses a recommendation system for network operators to offer personalized services to the users based on the geographic location. Cell broadcast information is used to form groups of users with similar interests. In this work GMLC is used to collect user information.

III. Proposed ENRS Architecture

In this section we first describe the proposed ENRS architecture and relevant details. Then details of ENRS Gateway architecture are presented in detail.

A. ENRS Architecture

Figure 1 shows the overall architecture of ENRS. The architecture includes an ENRS gateway that interacts with EPC network as well as other entities providing emergency notification. In our case this entity is Emergency Notification Provider (ENP) which can be deployed by any authority interested in detecting emergency events such as a city administration. The detailed discussion of ENP is out of the scope of this work. For simplicity we consider an ENP network comprising of sensor devices working together to generate notifications whenever they detect an emergency event. ENP can send this notification to multiple users through an ENP gateway. The ENP gateway uses proprietary interface to communicate with the ENP network and a REST interface to communicate with the users of the ENP, e.g. ENRS gateway.

ENRS gateway communicates with GMLC node inside EPC network via *Le* interface to request the location of user device using the OMA MLP protocol. Once ENRS has location information from GMLC, it simply forwards this information

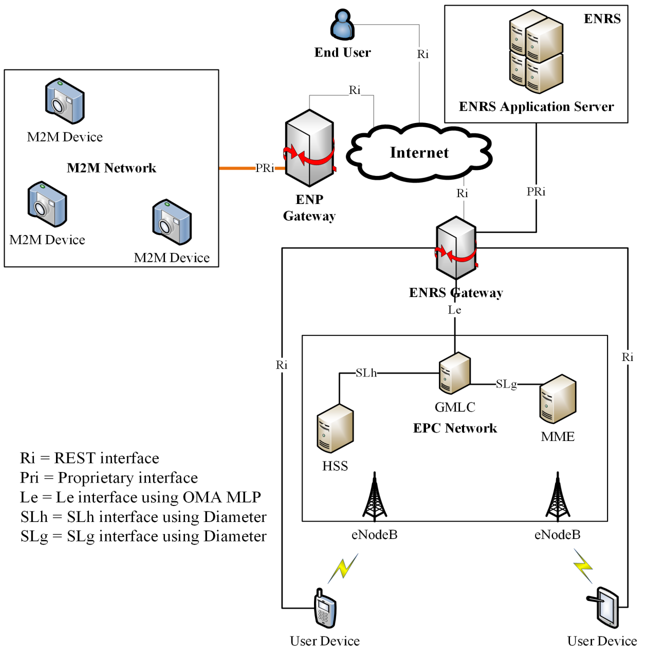

Fig. 1. ENRS architecture

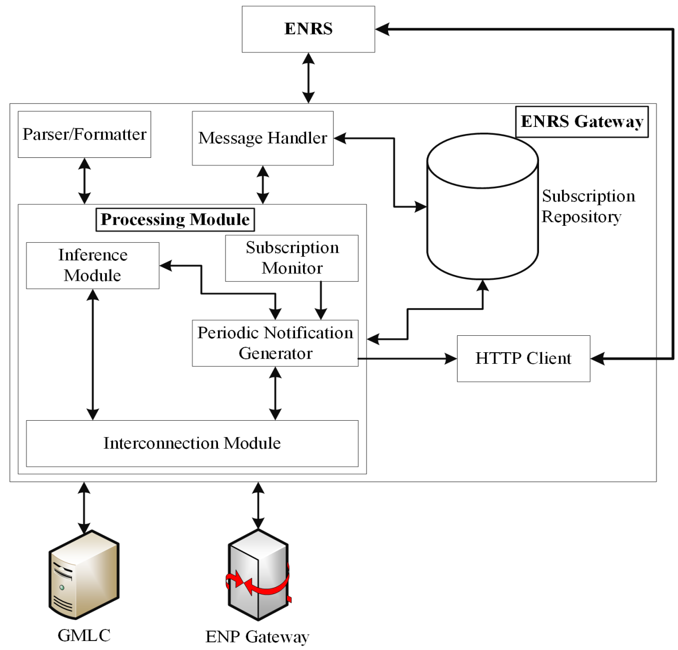

Fig. 2. ENRS Gateway architecture

to the ENRS. The context-aware decision engine of ENRS then uses this information along with other relevant data to determine the level of information to be sent for each user. ENRS gateway is also able to connect to external services like Map services and road traffic information service, although they are not discussed here.

B. ENSRS Gateway Architecture

The ENRS gateway interacts with two entities, i.e. ENP gateway and GMLC in EPC network through its *Interconnection* module, though not necessarily at the same time. Figure 3 shows all modules of ENRS gateway. *Interconnection* module is responsible for establishing connection and sending/ receiving messages to ENP gateway and GMLC. *Inference* module receives messages from *Message Handler*, and interacts with *Parser/Formatter, Periodic Notification Generator* and *Interconnection* modules. If the messages require any formatting, the *Inference* module first sends it to *Parser/Formatter* module. The *Interconnection* module receives the event notification messages from ENP and passes to *Inference* module. Eventually the event notification reaches to ENRS via *Message Handler*. After this notification, ENRS sends location request to ENRS gateway. Location request messages can be of two types, GET messages to request immediate location of the user and POST messages to setup periodic notifications about the location of the user.

The *Message Handler* inside ENRS gateway receives location request messages where GET messages are forwarded to the *Processing* module to be sent to the GMLC server in EPC network. The POST messages are sent to the *Subscription Repository* to manage periodic notifications. *Message Handler* forwards the reply from GMLC to ENRS after receiving it from *Inference* Module. The *Subscription Monitor* is responsible to manage event subscription data stored in *Subscription Repository*. Depending on the subscription, the *Subscription Monitor* instructs *Periodic Notification Generator* to send periodic location information to ENRS. The function of *Notification Generator* is to receive location information from GMLC, perform desired formatting by using *Parser/Formatter* via *Inference* module and send the final message to ENRS through *HTTP client*. The *HTTP client* is also useful when a third party wants to use ENRS for periodic notifications.

IV. Future Work

In previous sections we outlined the motivation and background of ENRS along with its architectural design and components. However, two important steps still remain before we are able to provide complete analysis and performance evaluation of ENRS. First step is to design a context-aware decision engine for ENRS and the second step is to design the user interface of ENRS application, implement it and then evaluate its performance. The role of context-aware decision engine for ENRS is very important as it will decide the level and type of information to send to the user.

Figure 3 shows the mechanism of the context-aware decision engine. The first step is the context data acquisition regarding the emergency event and related information from different entities. As discussed before, ENRS is envisioned to make use of multiple entities, e.g. event notification provider, location information provider, traffic information provider, and mapping service provider. This will allow to provide more accurate and relevant information. Next step is to refine the acquired data from its raw form to some meaningful information. After refinement the context information will be used in conjunction with the user location data as input for the decision engine. The inclusion of data from external entity depends on the nature of information required to make informed decisions, such as local city administration, law enforcement agencies or any regulatory authority.

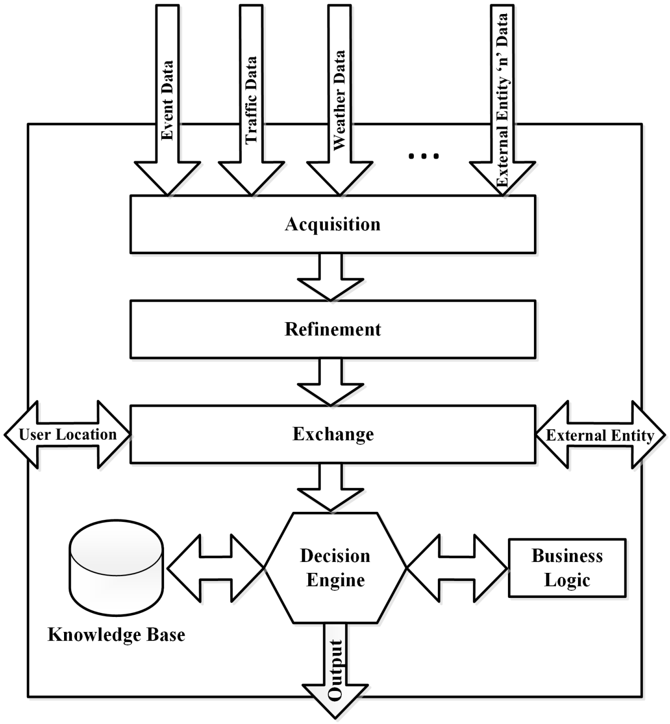

Fig. 3. Components of context-aware decision engine

Decision engine can then use the input information to determine the level, type and contents of the information to be sent to the user. The decisions can be further based on Rules or History as per requirements. These rules can be defined by the ENRS provider or a government regulator. Also, the service provided in response to previous events can be used to refine the new decisions. In our view these are the basic components that should be included in the final implementation of ENRS. The implementation of ENRS is final step and will include development of a prototype including ENRS and ENP gateway and ENRS application on mobile devices. The ENRS application for the end user requires an intuitive user interface to present the required information in a meaningful way. It is also required to take into account the use of delay-tolerant protocols to counter the possible communication outage in emergency scenarios. At the momemnt we have implemented the Le interface between the ENRS and GMLC using diameter protocol and are able to obtain user location.

V. Conclusion

In this paper we presented the motivation and basic elements of context-aware Emergency Notification and Rescue Service based on 4G EPC architecture. We discussed its architectural design and components. The ENRS is able to get the user location from EPC network and provide end to end emergency management. At the heart of ENRS lies the context-aware decision engine that makes use of data input from various sources and helps in providing necessary information to the end users according to their location, event location, its progress and status of external entities. Use of data from multiple entities enhances the decision process of ENRS, since refined and more accurate information can be deduced when multiple sources are involved. We have implemented the EPC side of ENRS and currently are focusing on the design and implementation of ENRS decision engine and end user application. For performance evaluation we will be specifically interested in finding the time ENRS takes to notify about the emergency event and also how accurately it is able to help out the users throughout the lifetime of the event.

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