Defining System Requirements for New IP Based Incident Management Service - eCall

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Abstract. *The requirements which new cooperative systems have to meet are the basis for development of new services like Emergency Call (eCall). The realization of the eCall service comprises an introduction of new functionality into the vehicles such as driver-independent V2I (vehicle-to-infrastructure) communication system. This system enables data exchange with the nearest dispatching centre after the accident. V2I connection can be realized only through mobile networks. With the comparative analysis of the GSM/GPRS vs. IP network characteristics we highlight the main reasons for V2I transition to the IP networks. The paper focus is on presenting the basic system requirements for IP network eCall support.*

Keywords. incident management, V2I communication, eCall, system requirements, IP network

1 Introduction

According to the Eurostat statistics [1] in the time period from 1996 to 2000 almost 300.000 people died on the European roads (drivers, passengers and pedestrians). The very peak was reached in 1997 when over 60.000 traffic deaths were recorded. It became clear that significant effort and resources had to be devoted in order to solve that severe safety issue.

Apart from technological development in the car-making industry and improvement of their products, the new holistic approach has been developed in the form of ITS (Intelligent Transport System) services. Significant achievements have been made in one of the ITS functional areas - Incident Management (IM). Main IM objectives are to reduce the impact of primary incidents and to avoid the secondary incidents (secondary incidents occur as a direct consequence of the primary incident). Main method for achieving these objectives is providing the information about the incident to the actors involved in the IM process, as well as to the road users approaching to the crash site.

In general ITS concept includes the implementation of the communication technology into the vehicles and road infrastructure, thus adding the new functionalities, [2]. Introduction of these communication capabilities into the vehicles and road infrastructure enables cooperation between them, which is the basis for the development of different applications. Currently there are several active EU funded projects (Cooperate Vehicle to Infrastructure Systems – CVIS, eSafetySupport, SAFESPOT, etc.) each responsible for designing, developing and testing different safety applications such as driver assistance and pedestrian safety applications, [3], [4].

One of the eSafetySupport applications currently under development is Emergency Call or eCall, [3]. Emergency Call service will enable vehicles to autonomously initiate the emergency call towards the nearest dispatching centre of 112 emergency service, immediately after the traffic accident. In the Minimal Set of Data (MSD) geographical location of the vehicle is transmitted towards the dispatching centre (vehicle-to-infrastructure communication). With that information the incident can be detected, verified and localized more efficiently and emergency services (police, fire department, ambulance, etc.) can be routed more accurately to the scene. In general, knowledge about exact location of the traffic incident helps to reduce duration of the incident, thus traffic flow can be normalized faster.

2 Basis for application development

In order to introduce different applications based on V2I communication and to make them operational, it is evident that a new communication platform is needed. This platform has to ensure the synergy between drivers, passengers, service operators and emergency services because they need to be able to deliver, receive and share traffic information. This communication platform is called cooperative systems.

The EU plans to implement cooperative systems by the year 2011, [3]. That includes the instalment of the communication technology into the vehicles and road infrastructure. This will serve as a basis for the development of the new applications which will then be available across Europe.

The cooperative system communication chain includes different actors: vehicle system, roadside system and central system; each equipped with different components as it is shown on the UML component model in the Fig. 1.

The core component in the vehicle system and roadside system is the host computer. Vehicle host computer hosts user applications which could be *subscriber* or *non-subscriber* services. Mobile router communicates with the roadside access router via wireless network (GSM/GPRS, satellite, HRPD, WLAN, etc.). Roadside system also has a host computer which hosts all cooperative system applications available in certain area. Through border router roadside system is connected with central system. Central system represents different stakeholders or systems, depending on what sort of application is currently active on vehicle host computer (e.g. with the eCall application that would be a dispatching centre).

The key factor is to make mobile routers recognizable for the roadside system. Only then the applications will be available and reliable for the users, [4].

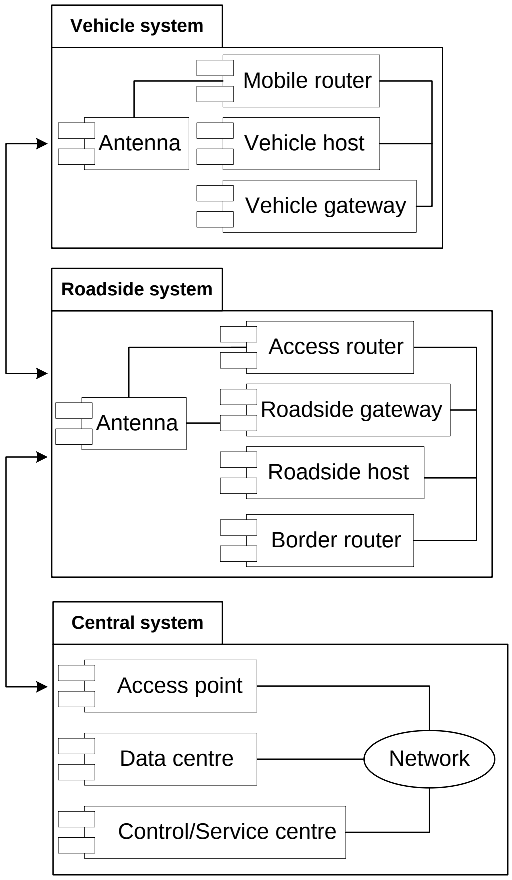

Figure 1: Cooperative systems component model

3 Emergency Call

One of the direct outputs of the cooperative system development and deployment will be the introduction of the eCall service. eCall enables V2I communication and data exchange with the nearest dispatching centre after the accident. According to the [3], eCall can be initialized in two ways as follows:

1. Vehicle automatically initiates the eCall after the accident
2. Driver or passenger pushes the eCall button inside the vehicle when there is an emergency.

In both cases the MSD is transmitted to the dispatching centre, containing geographical location of the vehicle. The location can be obtained in two ways:

1. From GPS unit in the vehicle
2. Roadside system operator provides the location based on the point-of-access (cell/sector).

The basic use-case model diagram of the eCall service is shown in the Fig. 2. The diagram shows the basic operations which can be executed by actors involved. As it was already mentioned, the key is to enable UE (User

Equipment) to register so that vehicle host computer can activate application if necessary. Apart from previously discussed operations, with the eCall a voice session is initiated as well. Through active voice session the dispatcher can find out more information about the incident by questioning the people inside the vehicle (vehicle type, direction of travel, etc.).

If the car is equipped with additional devices and sensors (proximity alert sensor which are able to record the impact force, air bags, electronic stability system and others), additional data can be transmitted to the dispatching centre such as:

- The value of the force of impact
- The point-of-impact (e.g. front of the vehicle, rear of the vehicle)
- Were the air bags activated
- Had driver lost control of vehicle before the incident happened
- How many people are there in vehicle and did they have a safety belt on before the incident
- Is there a smoke in the vehicle, etc.

This all represents the critical information in the incident management process.

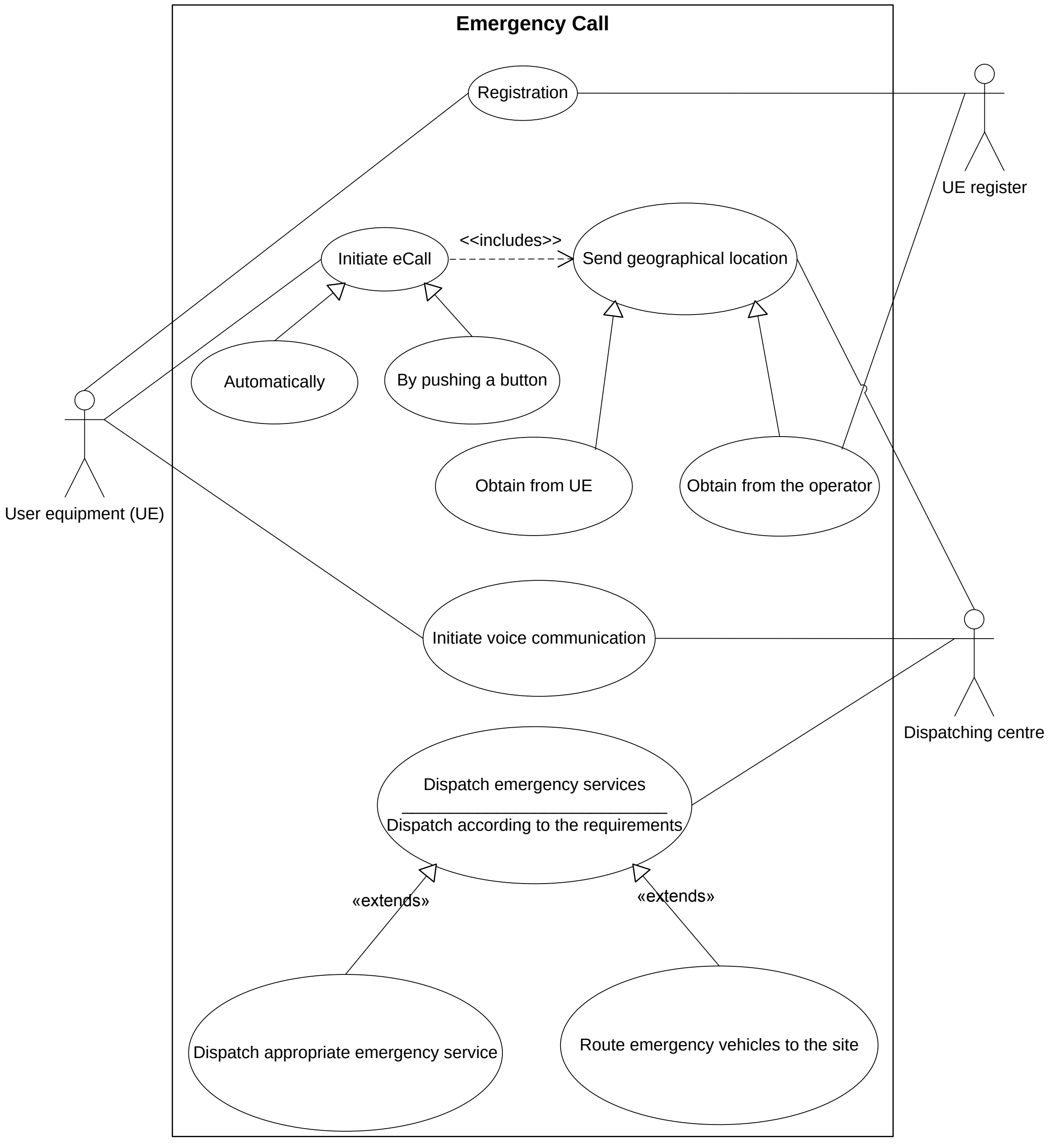

Figure 2: eCall use-case diagram

3.1 Emergency call service availability

In order to make eCall service available to the users (and any other service for that matter) we have already stated that UE, that is, mobile routers inside vehicles, has to be able to gain access to the communication network provided by the roadside system.

The eCall service has to be available across EU member states. This means that state and regional borders, or to be more precise, coverage area of different network operators, as well as jurisdiction of different emergency services, must not be an obstacle to the service availability and eCall session continuity. Users have to be recognized even if they are in a foreign country (visited network).

Because of the nature of the service, users of the eCall service are not subscribers, and their call and transfer of data has to be free of charge. The emergency of the eCall has to be recognized, because it requires priority treatment such as providing a high quality bearer path regardless of subscription.

The continuity of the emergency call session has to be ensured. This requires seamless handover procedure over one or several different access technologies and between different network operators, [4].

3.2 Transition to the IP network

Undoubtedly, eCall and similar safety and security applications will require certain adaptations in the network which will facilitate the communication between actors involved. The original idea was to use existing GSM/GPRS networks, but keeping in mind the requirements for eCall service availability (and different aspects of that availability described in the previous chapter), it is evident that these networks cannot facilitate this type of communication for several reasons (one of them is the question of roaming).

Different GSM/GPRS and IP network characteristics are set against several criteria:

- Session continuity
- Connection with the nearest service provider
- Local communication parameters configuration
- Call priority
- Maximum delay.

The comparative analysis is carried out. We highlight the main reasons for V2I transition to the IP networks in the Table 1.

Table 1: GSM/GPRS vs. IP network characteristics

CRITERIA:	IP	GSM/GPRS
Session continuity		
	IP network ensures seamless and continuous roaming sessions.	Because of the lack of agreement between different network operators the question of roaming in data transfer sessions remains unsolved.
	An application sitting on an entity may contact via a global IPv6 address any other application sitting on some other entity. The data is delivered to the destination IP address regardless of the roaming status or access technology.	Applications are unable to give or receive data if the access technology of the roadside equipment (RSE) cannot support access technology of the UE.
	IP network can provide broadband connections, fast channel set-up and data transfer free of charge.	There is no comparable service.
Connection with the nearest service provider		
	The mobile router is able to address data packets to application in the closest RSE, where the addresses are composed to have local relevance.	There is no comparable service.
Local communication parameters configuration		
	Applications can receive dynamic IP parameters relevant for the local link. It learns it dynamically assigned local IP address and the IP prefix to be used for locally relevant IP message addressing.	No comparable service exists today. Connectivity in current mobile clients is established through modem commands, without any local parameterization.
Call priority and maximum delay		
	The application is able to set its transmission priority as well as allowed data delivery delay.	There is no comparable service.

Source [4]

Because of the possibility to use local-relevant connection parameters, IP network ensures the service availability for the users because it is everywhere possible to use the same IP address for an application sitting on the roadside system host computer. Also, IP network provides seamless connections across different access technologies, resolves the roaming issues, sessions with the nearest RSUs' are possible and free of charge.

4 Defining system requirements

In [5] the requirement is defined as a statement which can determine the goals, functions, and constraints of software and hardware system. The requirements are generated by users or any other stakeholder (actor) involved in the process of system development.

According to the [6], while defining the system requirements for the eCall service, the two key actors are identified: UE and IP network. The system requirements (SR) are grouped as follows:

- Connection set-up:
  - The IP network SHALL support the ability to detect the UE that supports eCalls.
  - Emergency calls only from authorized UE SHALL be supported.
  - A UE SHOULD be able to determine that a caller is attempting to make an emergency call. If the UE is able to determine that a call attempt is for an emergency call, then the UE SHALL explicitly indicates the call's emergency nature to the network.
  - When an internationally roaming UE attempts to make an emergency call and the UE explicitly indicates the emergency call, the network SHALL correctly route the call even if the dialling procedure of the home country executed by the caller is different than that in the visited country.
  - If an authorized UE was unable to determine and indicate an emergency call, the network SHALL be able to evaluate the SIP URI[1] or TEL URI[2] and determine the call is an emergency call if the SIP URI or TEL URI represents a valid emergency number in the locality of the caller.
  - Support of emergency calls is a local service, not a subscriber service and therefore call control signalling and bearer MAY be handled in the serving (visiting) network without routing through the home network.
  - Emergency services SHALL be provided when a UE is roaming.
  - When an emergency call is established, end-to-end knowledge of an emergency call SHALL be possible and when necessary, intermediate nodes SHALL have this knowledge.
  - The calling party address sent to a circuit switched (CS) only capable dispatching centre SHALL be a TEL URI.
- Emergency call routing:
  - It SHALL be possible to route to a dispatching centre based on the caller's position information, if available from either the authorized UE or the network.
  - There may be multiple types of dispatching centres for emergency calls (e.g. police, fire department, ambulance). The IP network SHALL be able to identify the type of intended dispatching centre when the dialling plan provides such identification, and SHALL route accordingly.
- Call-back:
  - Call-back of an authorized UE with an assigned TEL URI SHALL be supported.
- Geographical location of caller:
  - The caller's position information SHALL be included in the emergency services request from the UE, if available.
  - It MAY be possible to route the emergency call to a specific dispatching centre based on interim/rough position information of the caller.
  - The position information format SHALL be one of the following: cell/sector identification, a geographic location, or a civil address.
  - When initial position information is requested by a dispatching centre, the IP network SHOULD provide the initial accurate position information of the UE.
  - When updated position information is requested by a dispatching centre, the IP

[1] A SIP URI is the SIP addressing scheme to call another person via SIP. In other words, a SIP URI is a user's SIP phone number. The SIP URI resembles an e-mail address and is written in the following format: SIP URI = sip:x@y:Port. Where x=Username and y=host (domain or IP).

[2] Uniform Resources Identifier dedicated to the public telephone network numbering scheme.

network SHOULD provide position information of the UE’s current position to the dispatching centre. The IP network SHOULD support updated position information requests throughout the duration of the emergency call.

- Emergency call continuity:
  - If a non-emergency voice call can be transferred across two access technologies, then the IP network SHALL maintain continuity of the emergency call across those access technologies.
  - An emergency call SHALL be identified as such during and after a handoff.
  - If position information update request is received from the dispatching centre after a handoff, including a handoff to another access technology, the IP network SHOULD provide the updated position information of the UE to the dispatching centre.
- Call detail record:
  - The creation of call detail records for emergency calls SHALL be supported.
- Interactions with other wireless services:
  - Once a UE has initiated an emergency call, it SHALL NOT be placed on hold. Any service that would cause the emergency call to be put on hold SHALL be ignored.
  - An emergency call SHALL take precedence over any other services a UE may be engaged in.

The main objective of this kind of system requirements specification is to provide a general set of functionality which IP network has to have, in order to fully be able to support eCall sessions.

5 eCall service benefits

If we look closely to the incident management (IM) process (depicted in the Fig. 3) we can detect four main phases:

1. Incident detection phase
2. Response phase
3. Recovery phase
4. Recuperation phase.

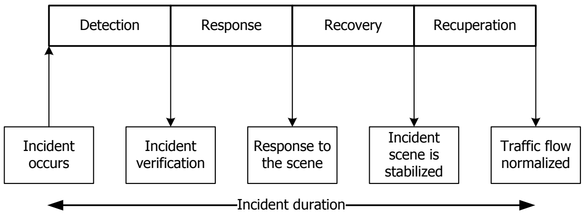

Figure 3: Four IM process phases, [2]

When analysing the network characteristics from the Table 1, a number of supporting arguments for transition to IP network can be detected. If IP network meets the defined system requirements, generally it will be able to fully support emergency call sessions and it will ensure service availability and continuity. The service availability will produce different benefits. Knowing the exact location of the incident, emergency services' response time will be reduced. Due to this gain of time, eCall is expected to save up to 2,500 lives in the European Union each year, and to mitigate the severity of tens of thousands of injuries, [3]. Arriving at the incident scene sooner should allow faster recovery of crash sites, reducing the risk of secondary accidents.

6 Conclusion

Emergency call represents the call requiring a connection to a public safety authority (in this case 112 emergency services). The intention is to develop the generic emergency call system capability in an IP network which can be used to support the eCall in accordance with any regional regulatory requirements.

With the IP network characteristics analysis and system requirements specification it is clear that IP network can facilitate the eCall sessions and can ensure service availability (across different access technologies and between different network operators). Introduction of the emergency call service will result in a number of benefits, because it will improve the IM process by reducing incident detection, verification, localization and response time.

Keeping in mind the necessity of future service availability across EU member states, it is important to note that the development of such a system should not be construed as a regional regulatory issue.

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