2016 IEEE First International Conference on Internet-of-Things Design and Implementation

The Application of Telematics and Smart Devices in Emergencies:

Use Cases in Next Generation Emergency Services

Marco Manso and Barbara Guerra
Department of Innovation
RINICOM
Lancaster, United Kingdom
marco@rinicom.com

Angelo Amditis and Evangelos Sdongos
Smart Integrated Systems
Institute of Communication & Computer Systems
Athens, Greece
a.amditis@iccs.gr

Cosmin Carjan and Andrei Jigman
Project Management
Teamnet International
Bucharest, Romania
cosmin.carjan@teamnet.ro

David Donaldson
West Yorkshire for Innovation Team
Police Crime Commissioner for West Yorkshire
Wakefield, United Kingdom
david.donaldson@westyorkshire.pcc.pnn.gov.uk

***Abstract* - The adoption of smart environments is becoming more and more important in many applicative scenarios such as healthcare, asset management and environmental monitoring. In emergency services, there are very attractive use cases presenting several scientific challenges that must be addressed in order to satisfy user requirements, which are mainly focused on emergency management. The main goal of this work is to share two use cases depicting emergencies where the use of telematics and smart devices enables improved emergency situational awareness for citizens and emergency services, thus empowering emergency services to attain increased effectiveness and performance.**

Keywords - Internet of Things, Smart Devices, Telematics, Emergencies, Emergency Services and Systems.

I. INTRODUCTION

The ability to sense environmental parameters is becoming more and more important in many application scenarios. This trend aims to spread smart environments able to capture, in a pervasive way, all useful information from the real world, contributing to assert the Internet of Things (IoT) concept. It refers to the extension of the Internet to the world of objects and places, which can communicate their own data and access aggregated information from other objects or places. In this way, the new Machine-to-Machine (M2M) paradigm aims to improve everyday life: healthcare (Smart Health), cities management (Smart City) and energy saving (Smart Energy), are typical scenarios for the use of such technologies. Among these potential applications, the use of telematics and smart devices in emergencies are particularly important, since they empower the automatic detection of emergencies (including situations where human intervention might not be possible or is impaired), while representing the link between citizens and emergency services (ES) (consumers) and the abstraction layers allowing the adoption of the IoT paradigm.

As society evolves towards next generation emergency services, the increasing adoption of telematics, smart sensors and devices results in cities that are environmental-aware of their status and anomalies. The NEXt generation Emergency Services (NEXES) Research and Innovation Action (RIA) [1] explores the automated connection of those sensors to emergency services: integrated with the emergency call, smart sensors' data is automatically relayed to emergency services, improving these services' capability to assess the emergency and respond swiftly and effectively, saving lives.

The paper's structure presents, in Section II, two emergency use cases that illustrate the use of telematics and smart devices in emergencies. Section III summarises the state-of-the-art for emergency services and provides a technical overview of the evolution towards NEXES, the next generation emergency services, detailing the telematics and smart devices capabilities and benefits. Conclusions are drawn in Section IV. Retrieved from the work performed in the NEXES RIA, the following emergency use cases illustrate the benefits of IoT in emergencies.

II. EMERGENCY USE CASES USING TELEMATICS AND SMART DEVICES

A. Use Case 1: Chemical Plant Leakage

In the early hours of the morning, a tank at a small chemical plant develops a breach and hazardous materials begin leaking out. The security guard investigates the incident but fails to follow the appropriate security precautions and is quickly taken ill upon inhalation of noxious fumes. The guard attempts to call for assistance using his mobile device. Before being able to initiate the call, the guard loses consciousness.

Because the NEXES System has been adopted at the chemical plant, an automated emergency call via the NEXES telematics function is triggered following the

978-1-4673-9948-7/16 $31.00 © 2016 IEEE
DOI 10.1109/IoTDI.2015.21

detection of unusual and dangerous levels of chemicals in the air by installed sensors. Upon receiving this automatic call, the emergency call taker has an immediate awareness of the emergency situation and immediately dispatches the relevant personnel and resources, including specialist containment and decontamination crews and equipment.

Simultaneously, a second automated call is received at the emergency call-handling service. This call originates from the security guard's mobile device and has been triggered by the eHealth device detecting abnormal vital signs. The emergency call-taker immediately attempts to make contact with the security guard through the smartphone. When they are unable to get a response from the caller, they use the device's location data sent in the automated call and dispatch an ambulance.

Despite being received at different emergency call handling centres, because both emergency calls have been managed through the next generation NEXES System they are now linked, thus ensuring that the different First Responders (FRs) are aware of both the human casualty and the chemical hazard onsite.

Given the potential for broader environmental contamination and the adjacent location of a large residential area, a decision is quickly made to distribute location-specific push alerts via the NEXES System to the public, advising local citizens to stay indoors and seal their premises and providing an information number that residents may call for further information, ensuring the alerts do not result in an increased volume of emergency calls to emergency services.

The continued sharing of the environmental data via the NEXES telematics function ensures the fire-fighting FRs on site have real-time and accurate information on the extent and evolution of the hazard situation from the moment of dispatch, whereas the medical FRs are able to monitor the casualty's vital signs via their eHealth device whilst en-route to the scene. This information is fundamental in saving valuable time in the emergency response.

This *futuristic* scenario perfectly highlights the potentially vital role of telematics in specific emergency scenarios. The use of telematics and automated calling means that in situations in which citizens using eHealth devices are incapacitated and unable to contact emergency services, they could be located and attended swiftly, with potentially life-saving consequences. Likewise, the capacity for the emergency services to be contacted in the event of environmental hazards, whether in commercial or residential premises, could enhance the emergency response in terms of both response times and the quality and quantity of information available to them. In this scenario, the NEXES push alerts function also enables the emergency services to communicate the potential dangers to the public and advise citizens on the best course of action to ensure their safety.

B. Use Case 2: Traffic Collision Involving Citizen with Impaired Speech and a Vehicle with eCall

Person 1 has recently undergone dental surgery and is suffering temporarily from limited speech. Driving along a remote rural road, the vehicle (vehicle 1) collides with another car (vehicle 2). The driver (Person 2) of vehicle 2 is rendered unconscious in the collision. Person 1's vehicle sustains extensive damage to the front offside and, although conscious, Person 1 is trapped in the seat, with a painful right leg.

Person 1 immediately initiates a 112 call through the NEXES App on their smartphone. Due to the recent surgery, Person 1 is unable to clearly communicate the emergency to the emergency call-taker, who issues a request for an instant messaging conversation or a video call. Person 1 accepts the request for a video call and, as the connection is established, Person 1 shows the emergency call-taker footage of the accident and of vehicle 2. The emergency call-taker is able to observe that Person 1 is trapped and that a second victim seems to be unconscious in vehicle 2. Person 1 consents to share their mobile device's location information with the emergency services and the call-taker is thus able to retrieve the caller's exact location.

Simultaneously, an eCall from vehicle 2 is automatically initiated to the emergency services after the collision. The emergency call-taker calls back to confirm the emergency but receives no answer. However, because the location of the vehicle provided through the eCall matches the location of Person 1 provided through the NEXES App, the emergency call-handling system concludes that both calls relate to the same incident. Having gathered all relevant data, the emergency system links the calls and passes the information to the appropriate emergency response organisations that dispatch their FRs to the collision's site. Fire-fighting, medical and law enforcement FRs en-route now have the benefit of sharing the information gathered by the call-handling centre via the NEXES IP-enabled eCall and video link, thus maintaining an enhanced emergency situational awareness, enabling improved coordination amongst emergency services and providing a more efficient and effective emergency response.

This scenario highlights numerous facets of NEXES's capabilities. The Total Conversation function allows the citizen to reach the emergency services, despite the temporary speech impediment. The video footage provides vital information as to the nature and scale of the emergency and ensures that the most appropriate FRs are dispatched. The enhanced location capability of the NEXES App and the IP-enabled eCall service's location capabilities ensure that the emergency location is cross-referenced and determined in the swiftest possible time. Emergency system's networking ensures the linking of information between the eCall of vehicle 2 and Person 1's emergency

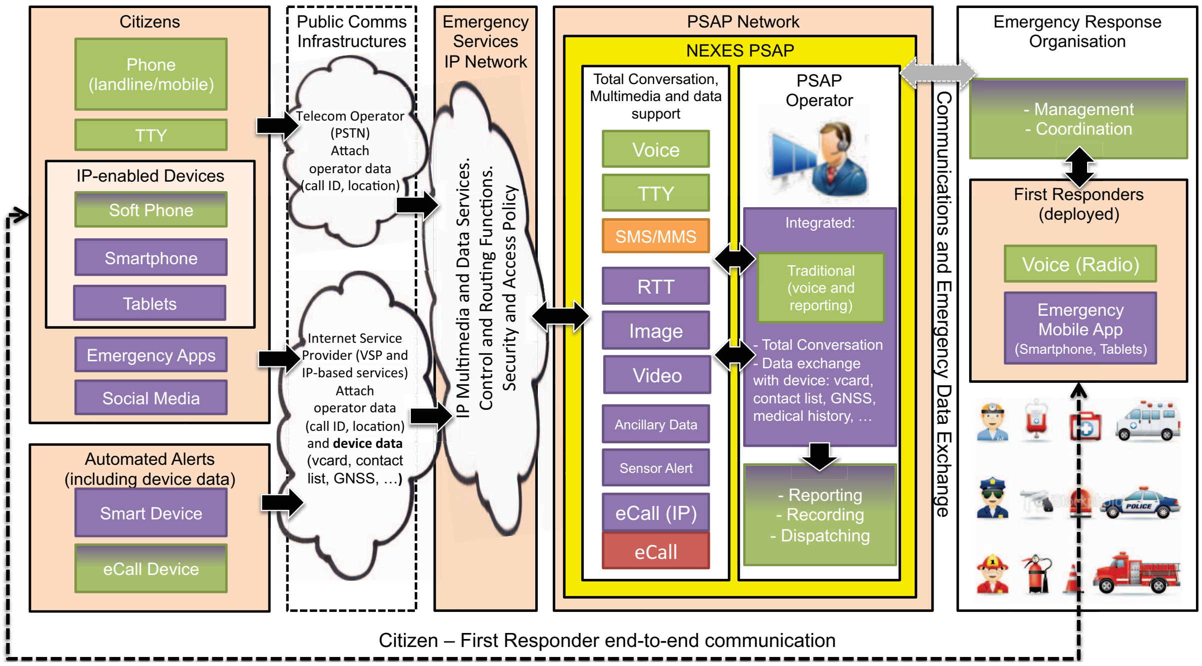

Figure 1 - NEXES Overview

The following colour code is used: Green represents components that today are part of most ES; Orange represents components that have been implemented in few ES (e.g., SMS); Red represents components existing in PSAP systems but not in operations in emergency systems (e.g., eCall); Purple represents the new components to be developed for the NEXES System; Gradient Purple-Green represents components that exist today but need to be extended to fully exploit the new functions brought by NEXES.

call and video footage, further enhancing the ES' situational awareness. FRs en-route have access to live intelligence on the emergency and the casualties' condition, ensuring all parties are well-informed, able to act rapidly and save lives.

III. Next Generation Emergency Services

According to the Coordination Group on Access to Location Information by Emergency Services (CGALIES), each year in the European Union several millions of citizens dial an emergency call number to access emergency services [2]. The fundamentals on emergency services highlight that communication between citizens and emergency services rely mainly on voice calls and that partial accessibility support for citizens with disabilities is provided through SMS and fax. Caller location is carried out by all emergency services but the accuracy and precision of the caller's location still remains the biggest hurdle of current emergency services, leading to considerable time loss: it is estimated that emergency services are not able to dispatch a rescue team for approximately 2.5 million calls due to the absence of sufficient location information [2]. In addition, the implementation of the eCall service is identified as a main priority in emergency services' ambition to adopt the new IP-enabled technologies, interoperability and telematics to improve their efficiency, effectiveness and performance and build a more secure society.

Embracing the demanding challenge of creating the next generation emergency services, NEXES brings enhanced communication and end-to-end connectivity between citizens and emergency services, using total conversation calls, Voice-over-IP (VoIP), real-time text (RTT) and/or videos. NEXES provides emergency services with more data, such as device location, telematics and health data, to improve the level of situational awareness and enable coordinated emergency management. An overview of NEXES is presented in **Figure 1** (see [1] for details), which depicts the capabilities used today by emergency services (in green colour) and the innovations proposed in NEXES (purple colour). Five main vertical domains are presented, comprising the citizens (call origination), the public communications infrastructure providers (e.g., telecommunication operators and Internet Service Providers), the emergency services' IP network, the Public Safety Answering Points (call answering) and the Emergency Response Organisations (e.g., law enforcement, medical assistance and fire-fighters). The introduction of IP enables added value capabilities on communications, situational awareness and interoperability in emergencies.

Identified in "Automated Alerts" and amongst the most promising key enablers of next generation emergency services, telematics and smart devices exhibit significant relevance in building emergency situational awareness and empowering higher performance in emergency response.

NEXES's concept of smart automated emergency services is not a competitor to or a new implementation of existing emergency communication channels, but rather a supporting technology providing added value in terms of: **Interoperability among emergency services** - In NEXES, a web of IoT platforms will be created to provide the necessary infrastructure for fostering interoperability among various emergency services, such as law enforcement, fire-fighters or medical assistance, in the local, regional, national and cross-border levels. Some of these services already utilise IoT platforms for their applications and alerts, while others cannot currently be reached with means other than standard voice communications; **Communication between citizens and emergency services** - Within NEXES, citizens and emergency services are expected to gain access to the applications developed, thus allowing mutual bi-directional communication. Emergency agencies shall be able to bi-directionally reach citizens via IP-based applications. These applications exploit IoT systems/smart environments, either on demand or on automated modes.

NEXES will explore the Session Initiation Protocol (SIP) to send emergency related data. Where a "one off" data is involved (no human communication), data is sent without initialising a SIP session by using the SIP MESSAGE transaction as recommended in [3]. Data structures and mechanisms will follow work in [4], which includes: location (conveyed in the Presence Information Data Format Location Object (PIDF-LO) [5-9]), call related information (device type (including sensor type), service providers, subscriber (including personal information), contact information) and caller information (medical information and "in case of emergency" (ICE) contact data).

The automated devices to be explored in NEXES are: **eCall –** The eCall concept is currently deployed based on circuit switched emergency calls, specifically for 2G and 3G networks using an in-band modem [10]. As next generation emergency services evolve towards a 4G communications framework, the eCall concept will be refined and adapted in NEXES using SIP and Minimum Set of Data (MSD) extensions, hence enabling the benefits of resource-efficient packet-based systems. **eHealth Devices –** NEXES will explore the enormous potential of eHealth devices and Apps in its interconnection to next generation emergency services. Not only individuals' health data (vital signs, heart rate, temperature) may be relayed to emergency services for enhanced emergency situational awareness but also automated emergency calls can be initiated in case a severe health trigger is detected. Similarly to eCall, NEXES will explore SIP emergency call and MSD extensions in the connection to smart eHealth devices. **Smart Environmental Sensors –** The growth and adoption of smart environmental sensors and devices, such as fire, gas and seismic sensors, will result in houses, factories, buildings, communities and cities that are environmental-aware of their status and anomalies. NEXES will explore the automated connection of those environmental sensors to emergency services: integrated with the emergency call, environmental sensors' data (temperature, gas and movement intelligent readings) are automatically sent to ES, improving their capability to assess the emergency. To validate smart environmental sensors, NEXES explores M2M platforms, SIP-based calls and MSD extensions to concept-prove its suitability for emergency response.

IV. Conclusion

As the NEXES RIA unfolds and the benefits of integrating telematics and smart devices in emergency services become increasingly evident, several technical, technological, ethical and regulatory challenges emerge, a reminder that these technologies require further maturation before emergency services are able to trust and accept them.

In the technical and technological domains, NEXES tackles the need for specific protocols with regard to the handling and prioritisation of automated emergency calls, particularly in instances where emergency services are not able to call back (be the *caller* an individual or an entity). Also the integration of automatically acquired sensor data within emergency systems and the subsequent secure and resilient processing and storage of information represent significant technical hurdles. Existing standards and security best practices assist in the task of adopting the IoT paradigm in emergency response. The ethical and regulatory issues on the automated sharing of sensitive personal data, are also considered, not forsaking the real necessity of having emergency services' access (all relevant) information.

V. Bibliography

[1] NEXES. http://nexes.eu.

[2] CGALIES. *Report on implementation issues related to access to location information by emergency services (E112) in the European Union – Final Report,* January 2002.

[3] Rosen et al. *Data-Only Emergency Calls*. IETF. 2015 http://tools.ietf.org/html/draft-ietf-ecrit-data-only-ea-10

[4] R. Gellens et al. Additional Data Related to an Emergency Call. IETF. 2015 https://tools.ietf.org/html/draft-ietf-ecrit-additional-data-37

[5] J. Peterson. RFC 4119. *A Presence-based GEOPRIV Location Object Format*. IETF 2005

[6] J. Winterbottom et al. RFC 5139. *Revised Civic Location Format for Presence Information Data Format Location Object (PIDF-LO)*. IETF 2008.

[7] J. Winterbottom et al. RFC 6848. Specifying Civic Address Extensions in the Presence Information Data Format Location Object (PIDF-LO). IETF 2013.

[8] H. Schulzrinne et al. RFC 5962. *Dynamic Extensions to the Presence Information Data Format Location Object (PIDF-LO)*. IETF 2010.

[9] M. Thomson et al. RFC7035. *Relative Location Representation*. IETF 2013.

[10] 3GPP TR 26.967 V8.0.1 *eCall Data Transfer; In-band modem solution.*

Acknowledgment

This paper has been prepared as part of the NEXES Research and Innovation Action, which has received funding from the EU's Horizon 2020 research and innovation programme under Grant Agreement No. 653337.