Wireless Networks at the Service of Effective First Responder Work: the E-SPONDER Vision

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ABSTRACT

E-SPONDER is a suite of real-time data-centric technologies which will provide actionable information and communication support to first responders that act during normal and abnormal events (crises). This information will enable improved control and management, resulting in real time synchronization between forces on the ground (police, rescue, firefighters) and out-of-theater command and control centers (C&C). The approach guiding the E-SPONDER project is based on the fusion of variable forms of field-derived data within a central system which will then provide information analysis and decision support applications at designated C&C locations in order to provide in situ support to first responders that operate in Critical Infrastructures.

INTRODUCTION

E-SPONDER tackles a wide series of practical operational challenges including reduced operating costs, increased effectiveness with the same number of human resources, enhanced situational awareness, effective and safe tactics, effective medical support of the victims during and after extrication and uninterrupted flow of information and decision making through different levels of commandment and logistics organization.

E-SPONDER will be aiming at the following objectives:

- Improving front end data collection technologies installed both on portable and fixed platforms, providing a flexible yet comprehensive coverage of the affected area;
- Fusing and analyzing the aforementioned data to provide real-time decision support;
- Enabling the seamless collaboration at all the levels of the first response work by facilitating an interoperable (always available) wireless communications infrastructure.

E-SPONDER will make extensive use of wireless networking to provide a seamless communication platform across all system levels, and in particular:

- Mesh and ad-hoc networking infrastructures will be used to increase coverage and operability;
- Different communications protocols and transmission techniques will be incorporated such as cooperative and/or multi-hop relaying.

Ultimately this will facilitate:

- Communication between victims and First Responder Units;
- Communication planning and agent;
- Quality of Service (QoS) tailored to emergency situations;
- Emergency plan context communication;
- Integration of different technologies, such as wearable computers, sensors, etc.

E-SPONDER ARCHITECTURE

Figure 1 presents a high-level overview of the E-SPONDER framework, employing all key elements in the design and operation of the envisaged system: the Emergency Operations Control Center (EOC), the Mobile Emergency Operations Control Center (MEOC) and, finally, the major constituent of the project, which is the First Responder Unit (FRU).

The design of the system architecture consists therefore of three main parts, i.e. the design of FRU, MEOC and EOC.

FRU design aims to select the best mobile hardware system according to the user needs and constraints. The relevant task has to cope with several issues, such as FRU terminal, sensors, communications, navigation (indoor, outdoor), environmental characteristics, and so on.

MEOC will act as a virtual bridge between the first responders in the incident field and the EOC located at the headquarters. Thus, MEOC design has to deal with issues such as communications and IT infrastructure, interoperability of systems and services, security of communication and data exchanges, etc.

EOC is the backbone for the operation of the E-SPONDER system. The EOC, that for instance will be located at the headquarters of the civil protection agency, will be responsible for the collection of all the field generated data that will be transmitted through the MEOC.

THE ROLE OF WIRELESS NETWORKS FOR INTEROPERABLE FIRST RESPONDER SYSTEMS

To fulfill E-SPONDER objectives with regard to wireless networking, the system will have to be properly designed so it is easily deployable and requires only limited external configuration.

The paradigms of autonomic networking are expected to play certain role in the design of the E-SPONDER concept. Specifically, in the very case of FRUs it seems not only highly applicable but in fact mandatory to guarantee that the network infrastructure can be deployed with a limited or even without human intervention.

Particularly, for dense set-ups redundant network nodes, which are in fact the first responders, can cooperatively assist some of the ongoing transmissions in such a way that they provide additional diversity making it feasible to mitigate the impairments introduced by a wireless environment, and especially the ones characterized by high mobility.

SETUP, VALIDATION AND SECURITY IN E-SPONDER WIRELESS NETWORKS

The E-SPONDER system must be a reliable and interoperable communication system capable of being adapted to, possibly, every emergency scenario. For this reason current efforts are oriented at the following main goals:

- Identification of the most promising standard radio interfaces that can be adopted for the system. Standard interfaces allow the exploitation of the economy of scale and facilitate their worldwide diffusion;
- Identification of the state-of-the-art solutions for multi-mode wireless terminals, that is, terminals which are equipped with two or more radio interfaces and proper protocols, in order to follow the always best connected (ABC) principle;
- Network layer: hierarchical routing protocols can only partially mitigate the scalability problems; cross-layer design between routing and MAC protocols, integration with multi-radio or multi-channel nodes, differences in power constraint and mobility between mesh clients and mesh routers are a few aspects to further investigate;
- Transport layer: the impact of network asymmetry on TCP performance is an important issue; furthermore, the design of a “tunable” TCP, capable of adapting to heterogeneous networks, can be a promising solution for WMNs; for real-time data flows, new transport schemes, such as Rate Control Protocol (RCP) could be developed;

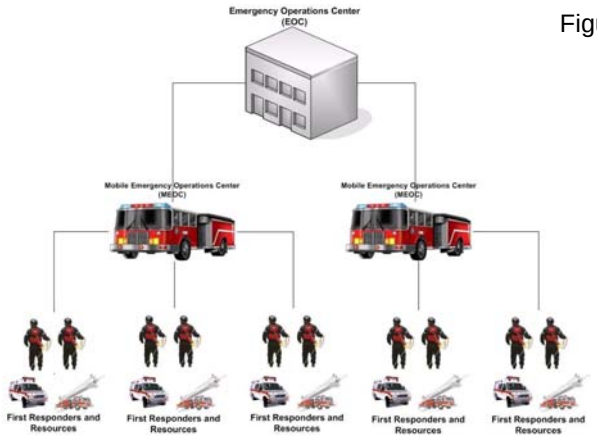

Figure 1

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