Profiling Approach for the Interoperability of Command & Control Systems with Sensing Systems in Emergency Management

Mert Gencturk* — Raul Arisi — Lorenzo Toscano** — Yildiray Kabak* — Marco Di Ciano*** — Agostino Palmitessa *****

**SRDC Ltd., Ankara, Turkey, mert@srdc.com.tr, yildiray@srdc.com.tr*
*** LUTECH SPA, Milano, Italy, r.arisi@lutech.it, l.toscano@lutech.it*
**** Innova Puglia SPA, Bari, Italy, m.diciano@innova.puglia.it, a.palmitessa@innova.puglia.it*

ABSTRACT: *In order to manage emergencies, crises and disasters effectively, different organizations with their Command & Control (C2) and Sensing Systems have to cooperate and constantly exchange and share data and information. In other words, territorial emergency management requires a cross-organisational, cross-domain, cross-level interoperability between the involved C2 and Sensing Systems. Although individual standards and specifications are usually adopted in C2 and Sensing Systems separately, there is no common, unified interoperability specification to be adopted in an emergency situation, which creates a crucial interoperability challenge for all the involved organisations. To address this challenge, we introduce a novel and practical profiling approach, which aims at achieving seamless interoperability of C2 and Sensing Systems in emergency management. Unlike the conventional profiling approach, which addresses only first three layers of interoperability stack, the profiling approach introduced in this paper involves all the layers of the communication stack in the security field. The work presented in this paper is achieved in the scope of the European Commission supported C2-SENSE project and partly in the scope of ITEA3 supported APPS Project.*

1. Introduction

The **C2-SENSE project** (http://c2-sense.eu/) aims to develop a profile-based Interoperability Framework by integrating existing standards and semantically enriched web services to expose the functionalities of Command & Control (C2) Systems and Sensing Systems involved in the prevention and management of disasters and emergency situations. In a typical C2-SENSE scenario, two main interoperability challenges need to be addressed: the vertical interoperability between Sensing and C2 Systems and the horizontal interoperability among different organisations involved in the prevention and governance of emergency situations. In the former **Sensing Enterprise** case, decision making processes need to be constantly supported by reliable and timely data through a typical event-to-service architecture, while in the latter **Enterprise Interoperability** case, multi-layer semantic interoperability profiles need to be put in place to enable collaboration in such critical situations. C2-SENSE is validating its outcomes in realistic Hydro-geological risk scenarios located in Regione Puglia (Italy).

According to the common definition provided by IEEE in 1990[1], **Interoperability** is "the ability of two or more systems to exchange data and to mutually understand the information which has been exchanged". A first general comment is that interoperability is not integration: it is an ability, so a potential capability of well-designed systems, which could be exploited and unleashed in real cases by facilitating the integration of systems in a sustainable time-cost-quality framework of impact indicators. This aspect needs to be taken into account especially when aiming at integrating diverse pre-existing systems developed quite independently and with different purposes (for instance when vertically integrating physical and decisional systems in a **sensing enterprise** environment): the interoperability framework cannot be lossless and complete, but smart enough to allow the event-driven transformation between data-information-knowledge and wisdom. On the other hand when interoperating different systems of the same nature (e.g. in the case of two or more sensing systems – IOT interoperability – or two or more decisional systems – **enterprise interoperability**), the interoperability framework needs to be rigorous, seamless, formal and semantically well founded, in order to avoid misinterpretations and ambiguity. The C2-SENSE profile-based interoperability framework is an attempt to meet both requirements of flexibility and rigorousness, as explained in the sections below.

Sensor Web has been widely promoted and its application has evolved from original military usages to current ubiquitous civil and commercial applications (Wang & Yuan, 2010). One of the important fields, in which the Sensor Web technology is crucial, is Emergency Management: sensors are installed on site to monitor the underlying or possible risks, for example, flooding and forest fire (Jirka et al., 2009); remote sensors such as satellites are used to find hotspots when

[1] Institute of Electrical and Electronics Engineers. IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. New York, NY: 1990.

monitoring the spread of wild fires (Moodley et al., 2006), or to help the flood warning management (Brakenridge et al., 2003); the combination of space and in-situ sensors are adopted to collect both space and ground data for volcano hazard monitoring (Song et al., 2008). Optimally, in a real use case, the data from different types of sensors are combined together for implementing a collaborative task. Thus, a seamless interoperability of such sensor systems is very crucial and needed.

Moreover, timely available, reliable and intelligible information retrieval from sensors, and sharing of these among organizations, is critical for effective management of emergencies, crises and disasters. To achieve this, many different organizations having different Command and Control Systems and Sensing Systems have to cooperate and this is only possible through interoperability. Without standards and well-defined specifications, however, the interoperability of these systems can be quite challenging, technologically complex, time consuming and expensive. Furthermore, although there are commonly used standards and specifications, which also address different layers in the communication stack, in the command and control, sensor and emergency management domains, there is no single specification of using these standards together in an emergency situation. Such dispersed standards and specifications create a crucial interoperability challenge. To address the challenge profiling is offered as a practical approach in achieving seamless interoperability by addressing all the layers of the communication stack in the security field. The profile concept aims to eliminate the need for a prior bilateral agreement between any two information exchange partners by defining a standard set of messages/documents, choreographies, business rules and constraints. The profile compliant partners are able to exchange information and services among themselves. This is in contrast to the bilateral agreements that have to be settled between partners for each new exchange partner. Considering the nature of emergency management, in which the responding organizations can change at run time (especially in an international intervention case), these generic profiles provide much needed coordination flexibility in order to deal with the unexpected circumstances and prevent chaotic response in a crisis situation.

Profiling has already been successfully implemented in domains such as eHealth through “Integrating the Healthcare Enterprise Profiles”[2]. This conventional profiling approach, however, addresses only the first three layers of the Interoperability Stack (Namli & Dogac, 2010): the “Communication Layer” covers the transport and communication layer protocols; the “Document Layer” addresses the content format of the messages and documents exchanged among the applications, and the “Business Process Layer” addresses the choreography of the activities to be executed by the participants. In Emergency Management, however, organizational aspects, such as policies, procedures, operations and strategies are as important as technical aspects of interoperability. Therefore the interoperability stack shown in Figure 1 has been proposed for crisis control and management (Tolk, 2003).

[2] http://www.ihe.net/profiles/index.cfm

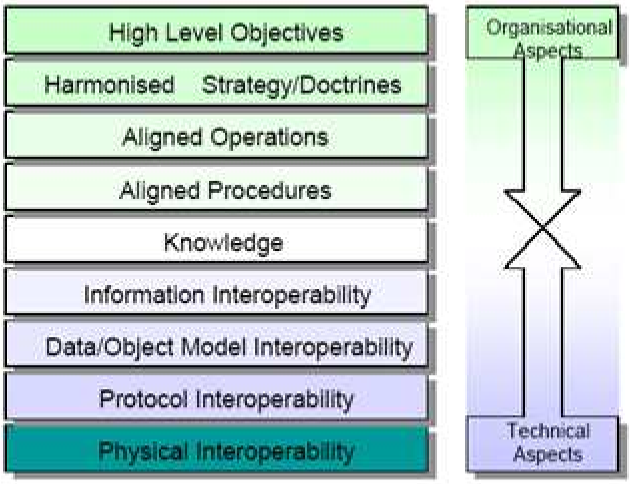

Figure 1 Interoperability Stack

Profiles in emergency domain can be developed by addressing all the layers of this Interoperability Stack, thus exposing available applications, implementing the missing technologies, and making them available to the emergency community. These profiles are not yet another information model or data format. On the contrary, they can be regarded as best practice documents on the use of existing dispersed standards in the addressed domain and situation.

Emergency Interoperability Profiles have been developed in three main steps:

1. **Emergency Domain Inventory:** existing standards, real life use cases of sensors, devices, C2 systems and emergency management architectures for different scenarios in security field are surveyed and Emergency Domain Inventory is created.
2. **Emergency Domain Ontology:** in order to gather all stakeholders' knowledge in a unique and flexible data model, modular and focused Emergency Domain Ontology is developed based on Emergency Domain Inventory. Emergency Domain Ontology enables the development of mechanism for the interoperability of different standards/specifications in the emergency domain. In other words, it is a lingua franca for this field. It is based on prominent, well-accepted and commonly used standards in emergency management, C2 and sensor domains, which are EDXL and OGC-SWE.
3. **Emergency Interoperability Profiles:** by using the concepts in this ontology, Emergency Interoperability Profiles are developed. These profiles enable effective exchange of information among different rescue units, public safety units and information systems without requiring any prior special technical arrangements even for international relief operations. They also take into account both functional and operational requirements as

well as different countries' cultural, linguistic and legal issues. Up to now, 12 profiles are identified based on the C2-SENSE scenario described in Section 4. As an example we report here Situation Reporting, Mission Plan, Scheduling, Resource Management, Alert (Notification) and Sensor Management which are used in Regione Puglia scenario.

2. Specific Scientific and Technical Objectives

Emergency applications require an immediate response to any alarm which involves a continuous supervision of the alarm state. Communicating objects in the IoT provide complete visibility of the resources to the administrator/s of the system/s. Several standards are currently involved in the development of solutions for IoTs fulfilling the highlighted technological requirements and acting as a bridge between the physical world and the Internet for the IoT. The availability, reliability and consistency of transferred information are crucial for an effective management of emergencies and many different systems have to interoperate to use this information. Typically cooperating systems are (but not only) Command and Control and Sensing Systems. A very challenging topic at this level is allowing a full interoperability of the interconnected devices/systems despite their heterogeneity. Although there are commonly used standards and specifications (addressing also different layers in the communication stack) there is no single specification of using these standards together especially in an emergency situation.

In this paper, we give special consideration to C2-SENSE a collaborative project developed in the frame of EU's Seventh Framework Programme (FP7). C2-SENSE is a concrete framework that represents the first very important step to define a standard specification for interoperability between C2 and Sensing Systems. From an “IT-based” point of view, C2-SENSE is based on open source software and existing standards. This facilitates the development efforts and helps easily identify gaps, where new technological solutions, guidelines, recommendations or standards are needed.

The “Internet of Things,” will bring tremendous opportunities to build resilient infrastructure and communities while aiding response and recovery efforts. The ability to more effectively monitor infrastructure real-time will increase both efficiency and safety. Sensors implanted in infrastructures could aid in studies of human and physical world patterns and trigger maintenance actions. Sensors embedded in everyday objects could be used to locate persons during search and rescue efforts. Mobile phone, clothing and bracelet sensors could help track evacuees’ status and locations. C2-SENSE represents an approach to instantiate IoT in the emergency management helping to automatize preliminary situation assessment, mobilization and intervention actions.

IoT technology provides added value to emergency response operations in terms of obtaining efficient cooperation, accurate situational awareness, and complete visibility of resources. The primary focus, to treasure the “IoT value”, must be on the interoperability between all involved heterogeneous systems. C2-SENSE is a standardized framework that starting from the study of a domain-specific modeling provides technological structure to implement executable models of interoperability.

The aim of C2-SENSE project is to develop and validate in a pilot scenario an Emergency Interoperability Platform able to improve the effective management of emergencies providing timely, reliable and intelligible information to all actors involved in the emergency management.

Ontological Profile Modeling

One challenge of mobile distributed computing and IoT is to exploit the changing environment with a new class of applications that are aware of the context in which they are run. Such context-aware software adapts according to the location of use, the collection of nearby people, hosts, and devices, as well as to changes to such things over time. A system with these capabilities can examine the computing environment and react to changes to the environment. Context-aware applications have attracted increasing amounts of attention over recent years due to the emergence of pervasive computing applications.

C2-SENSE can be considered as a framework to develop a special kind of context-aware applications. This kind of applications, through integration with an extensive network of smart devices (i.e. sensors), detects changes in the environment in which people live and helps an heterogeneous ecosystem of entities and organizations to interoperate and response effectively to critical emergency events.

Central to the approach of C2-SENSE is the use of ontological profile modeling which captures various characteristics of actors, procedures and operations in emergency situation in order to create a unique set of profile information for Emergency Interoperability. Ontological profile modeling starts from the identification of organizational stakeholders' roles and a categorized knowledge domain inventory. Next, a Domain Ontology is developed.

Ontologies represent a controlled vocabulary which is structured into a hierarchical taxonomy, where the key domain concepts are found. Each defined class may have parent and/or child classes (operating via a 'is-a' link) forming a hierarchy of related concepts. Properties exist in each class, which describe features of that class and any restrictions placed upon them. These models can be used by logic reasoning mechanisms to deduce high level information from raw data and have the ability to enable the reuse of system knowledge. This is particularly important when modeling user aspects that can be remembered and reused later.

Using the concepts in the ontology, a set of emergency interoperability profiles is developed. A profile is supposed to characterize user domain of interest and all his specific features that help the information system to deliver the most relevant data in the right form at the right place and the right moment.

An emergency profile is a formalization of actors, mutual interactions and information exchange which take into account specific features of the modeled emergency event, characteristics and operations of involved entities. A profile is also pure-logic that can be resumed in a machine-executable process. The execution of this process supports the response to a real event. For example, the response to a critical event like a fire emergency (this is a specific domain) requires a plurality of interactions between a lots of actors, all of this can be coded in a Fire Emergency Profile. This profile, when executed, specializes the platform and its collaterals systems to manage that kind of events. At each layer of architecture described in the previous paragraph, profiles have a detail that is coherent with the abstraction level of layer itself. For example, mutual interactions at lower layer can be read as invocation of Operational Web-services or at lower layer as IP packets exchanges. At higher level, mutual interactions are instead considered in terms of semantic of information exchanged about a specific event, etc.

3. The C2-SENSE Modular and Functional Architecture

IoT infrastructures allow data and services integration among smart objects, sensing devices and human beings, using different but interoperable communication protocols. Following this definition and using concepts from existing standards and semantically enriched Web services, we expose below the C2-SENSE architecture for systems related to emergency situations.

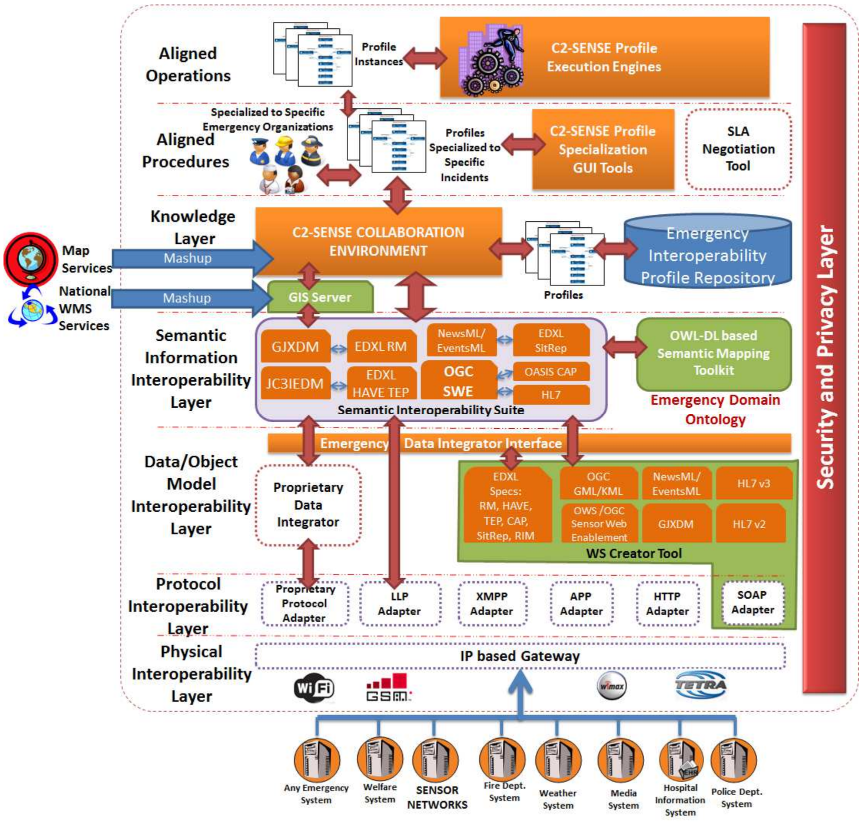

Figure 2 Overall C2-SENSE Architecture

The architecture (Figure 2) involves several layers that implement the separation of concerns: sensing, communication, information persistence and application (i.e., usage), concepts abstraction and high level execution strategies.

Physical Interoperability Layer: this layer manages the physical connection between the networked applications and devices. Up-to the IP Packets layer, C2-SENSE uses SECRICOM[3] Project's results. SECRICOM (Seamless Communication for Crisis Management) Project addresses the physical level interoperability for a pervasive and trusted communication infrastructure; bringing interconnectivity between different networks including TErrestrial Trunked RAdio (TETRA), Worldwide Interoperability for Microwave Access (WiMAX), GSM and WiFi. Upon the IP Packets layer, C2-SENSE adds an IP based Gateway that provides necessary abstraction of underlying physical protocol and provides IP packets.

Protocol Interoperability Layer: Protocol Interoperability addresses the transport level protocols such as TCP/IP, HTTP, SOAP, REST or SMTP and is in charge of end-to-end delivery of messages and documents. In this layer, Web services are used by exposing the proprietary services of emergency applications and organizations as "Operational Web services". There can be multiple versions of a particular Operational Web service from a variety of agencies developed using different requirements and employing different methods of operation. Additionally, Core Services are used for service discovery, identity management and access control services as well as digital rights management services, which are used across all emergency applications. Core Services differ from operational services in that Core Services are used across all emergency applications.

The realization of this layer is through Enterprise Service Bus (ESB), which is a software architecture construct that provides fundamental services via an event-driven and standard-based messaging engine. An ESB can be viewed as an enterprise messaging system, which allows integration between different architectures through the use of interface adapters and data transformation services.

Data Interoperability Layer: this layer can be considered as a suite of XML-based messaging standards that facilitate emergency information sharing between entities involved in the emergency-related situations. At this layer, C2-SENSE introduces the "Web Service Creator", a tool that exposes legacy systems functionalities as operational web services conforming to the standard interfaces.

At this layer, candidates as XML-based messaging standards could be (Božić et al., 2015): Emergency Data Exchange Language Resource Messaging (EDXL-RM) and EDXL Hospital AVailability Exchange Language (EDXL-HAVE) for asset and resource management; OASIS Common Alerting Protocol (EDXL-CAP), OGC Sensor Web Enablement (SWE) Information Standards and OMG Alert Management Service (ALMAS) for notification management; EDXL Situation

[3] http://www.secricom.eu/

Reporting (EDXL-SitRep) and EDXL Tracking of Emergency Patients (EDXL-TEP) for situational awareness; OGC Web Services (OWS), OGC Keyhole Markup Language and OGC Geography Markup Language for emergency geospatial data distribution.

Information Interoperability Layer: for web-services to become practical, an infrastructure needs to be supported that allows users and applications to discover, deploy, compose and synthesize services automatically. At this layer, C2-SENSE uses Linked USDL for describing Operational services in a comprehensive way using computer-readable and computer-understandable specifications to make them discoverable and usable on the web/Internet from responsible entities. Linked USDL is a comprehensive language which provides a (multi-faceted) description to enable the discovery of (business and technical) services over the web. Linked USDL builds on standards for the technical description of services, such as WSDL, but adds business and operational information on top. It describes both human and IT-supported services that not only implement business processes, but also tie in assets linked to contents and the Internet of Things.

Through Linked USDL, C2-SENSE allows describing the relevant properties and capabilities of Operational Services in respect to accessing data as well as managing resources. A general purpose infrastructure has already been developed specifically for Linked USDL. A Web-based Linked USDL editor is currently available to help providers to easily generate Linked USDL descriptions[4].

About Linked USDL, C2-SENSE draws from FI-WARE project[5] that explores in deeper sense the essence of USDL. In the FI-WARE project Linked USDL is used to support a service infrastructure supporting service ecosystems in the cloud covering both the technical and business perspectives. There is also an advanced multi-party dynamic and open service marketplace[6] developed in the context of the FI-WARE project, able to gather, combine, and exploit rich service descriptions from distributed providers to help match offer and demand. Notably the marketplace supports consumers in searching for service for service offerings, comparing them, and contracting them.

The layers above represent the technical backbone of C2-SENSE Project. The following layers introduce instead high-level harmonization of procedures, operations and strategies.

Knowledge Layer: this layer models initial activities, control and data flow structure and resources needed to start managing a crisis situation. This layer defines a rational and organized use of technical backbone resources to prevent chaotic response.

---

[4] See https://github.com/linked-usdl for existing tooling and model extensions.
[5] http://www.fi-ware-eu
[6] http://store.testbed.fi-ware.org/

Procedure and Operations Layer: this layer applies the generic vision of knowledge layer to the concrete and operative specificities of organizations involved in specific kind of event. The target of this layer is to identify producers and consumers of Operational services considering the existing services, procedures and operations of the organizations. Furthermore, this layer makes the execution of interaction activities between organizations possible. This layer can be defined as the harmonization level of relations between the organizations involved. The harmonization will be supported through Service Level Agreements (SLA)[7] which is formal contracts between service consumers and providers negotiated prior to service provisioning. In C2-SENSE, SLAs will be supported by Operational Level Agreements (OLA)[8] [9]. C2-SENSE Project will extend SLAs so that they can be used in emergency situations to align the procedures and operations of different partners.

Technical backbone of C2-SENSE provides technologies to produce (and measure) service level contracts between actors (SLA Negotiation Tool) and to run the specialized emergency processes (Profile Execution Engine) with the scope of pilot application scenarios. The internal workflows that involve multiple services (that constitute observable collaborative behavior) inside emergency processes are unambiguously described through WS-CDL and ebBP.

The emergency scenario involves multiple organizations with different services (e.g. police, medical care, rescue forces, fire fighting, etc) interacting vertically (i.e. with components of the same organization) and horizontally (i.e. with components of other organizations) in a complex environment. In this layer the emergency plan definition is also defined and contextualized.

Harmonized Strategy/Doctrines and Objectives sharing: this layer facilitates the various emergency responders to cooperate and coordinate in order to avoid unnecessary duplication and to explore synergies wherever possible. This layer focuses the definition and acceptance of common high-level objectives between emergency responders to accept a common strategy or set of strategies. A framework programme (Security and Safeguarding Liberties Framework programme, SSL) is described for setting up the policy and operational strategies for emergency management with the scope of pilot application scenarios.

[7] For example: http://its.ucsc.edu/sla/
[8] http://its.ucsc.edu/itsm/olasla.html
[9] For example: http://its.ucsc.edu/itsm/docs/olatemplate.doc

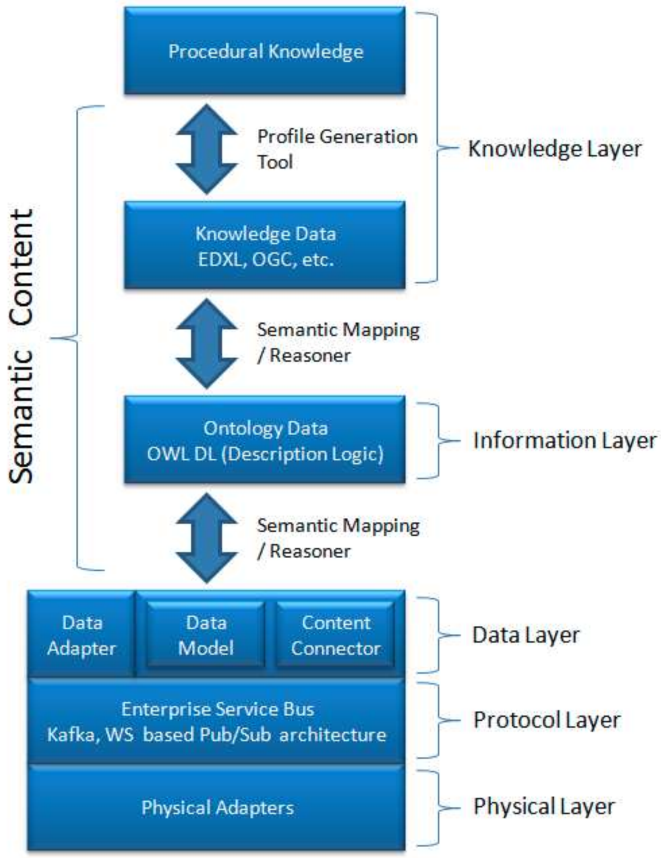

Figure 3 C2-SENSE Functional Architecture

Figure 3 shows how the data flows between the layers of the C2-SENSE architecture. At the bottom, in the physical layer the data is considered from byte perspective and they have no semantic in it. In the protocol layer those bytes are converted to TCP/IP or UDP based protocol messages and processed by the Enterprise Service Bus (ESB). After that in the data layer, this protocol messages are processed from emergency data standard perspective. In other words, in these layers, the data becomes meaningful to the emergency applications for the first time and in this layer, the data will be mostly represented through emergency XML standards. In the next layer (information layer) the data becomes information, by mapping the concepts in the data to Emergency Ontology classes. To be more specific, the XML tags in the data will be mapped to the classes in the Emergency Ontology, which will be developed through OWL (Web Ontology Language) and it will be the lingua franca for the emergency domain. This ontology will be mainly used in case of using different formats by different emergency applications. In those cases, the information layer will also be responsible to align these different formats through the use of the Emergency Ontology and ontology mapping. In the upper layers, the procedural knowledge will be represented through emergency profiles. These profiles will be modular best practice documents for specific emergency cases. In other words, these documents (together with their machine processable artifacts) will be guidance documents for achieving interoperability by determining the processes, the data standards and the protocols to be used in those specific cases. The profiles will be developed by use of Profile Generation Tool and they will be generic in that they can be applied to any emergency situation. By the use of Profile Specialization Tool, those profiles will be tailored to specific deployment settings and emergency cases.

Whole C2-SENSE architecture components are displayed in Figure 2**Errore. L'origine riferimento non è stata trovata.**. The Profile Execution Engine is responsible for executing the specialized profiles. During the execution, the data will be retrieved from emergency systems and sensors through appropriate data integrators. These integrators will be developed by use of Web Service Creator Tool and they will be based on identified emergency standards. As mentioned before, if there are different formats used by the emergency applications, they will be resolved by using Emergency Ontology and ontology mapping. Furthermore, in the profile execution, if there are human interaction/communication needs, the Profile Execution Engine will realize this requirement through the Collaboration Environment.

4. Concept Assessment and Architecture Validation in Regione Puglia

4.1 Flood Scenario

The C2-SENSE interoperability approach is being validated in Puglia region (Regione Puglia) of Italy with a flood scenario. As a first validation step, the current emergency management processes of the Regione Puglia systems have been assessed and the following scenario has been identified for the pilot. This scenario shows the AS-IS scenario of C2-SENSE. In other words, it shows the current communications between the internal Regione Puglia systems in case of such a flood incident. This scenario has been used as a basis for identifying the modular generic emergency interoperability profiles. It means that starting from the procedures and events described in this scenario, C2-SENSE system has taken advantage of the interoperability between the systems of the entities involved in this scenario to improve the whole process of emergency management. The aim is to improve the infrastructure and the procedural parts.

Regarding the infrastructures, C2-SENSE aims to allow (in the best case) the communication of all systems directly with the places of the emergency using sensors on the territory or even placed in real time; and communication between the systems of the various organizations for the exchange of information acquired.

Regarding the procedural part, C2-SENSE System aims to automate the operations performed by the warning systems, with the aim of taking actions more quickly in case of emergency. Furthermore, as part of its profiling approach, C2-

SENSE aims to provide guidelines about the type of action to be taken, which would be a valid decision support for the emergency situations.

Following institutions and organizations are involved in the flood scenario:

- **Prefecture:** is an institutional organization representing the national government through decentralized offices in the territory. It is governed by a prefect who coordinates administrations of the State and supervises the administrative authorities operating in the Province. In addition, Prefecture exercises functions on safety, immigration and civil protection; and keep relations with local authorities, social media and the administrative penalty system. For these reasons Prefecture coordinates the other organizations that are involved in emergency management operations.
- **Province:** is a local authority having jurisdiction over a group of municipalities. During an emergency, provinces have to ensure the safety of roads, schools and public buildings; control the transportation; and communicate constantly with Prefectures and Civil Protection.
- **Municipalities:** during an emergency, municipalities activate services for citizens, inform the Prefectures and keep in touch with Voluntary Associations.
- **SOIR:** is the Regional Control Room; which enables land monitoring with local structures of Civil Protection and Voluntary Associations. It operates daily and not only during emergency situations.
- **CFC:** is the National Weather Service which makes the prevision of a meteorological situation.
- **CFD:** Decentralized Functional Centre is the Regional Functional Center which interacts with SOIR and CFC for land monitoring and publishes bulletins about risks connected with the emergency situations.
- **Voluntary Associations:** are non profit organizations that operate during emergency management in different situations as support for other organizations (i.e. sanitary organizations, army, etc.).
- Furthermore firemen, sanitary organizations and occasionally army are also involved.

The reference Flood Scenario to be tested is based on extraordinary rainfall event lasting three days described with a detailed step-by-step of consecutive actions. With the aim of providing an overview of the operations we focus here on a short *on the field* development representation. During the first day the National Weather Service (CFC) forecasts a meteorological situation that will determine bad weather conditions and the Regional Functional Center (CFD) will then publish a Bulletin of regional severity state. Consequently the Regional Civil Protection Service shares alerting Messages with Prefectures, Municipalities, etc. according to the evolving events. The following two days, the monitoring network of Puglia region managed by (CFD) follows the evolution of the situation using a Sensor Network System installed in involved risk zones.

The Regional Control Room (SOIR) reaches by telephone the local Authorities (Municipalities) involved to inform them about the situation in order to let them activate their emergencies procedures (Civil Protection Plan).

Because the situation becomes worse, some municipalities communicate to SOIR a flood emergency situation and the opening of its Operative Center (COC) asking for the intervention of voluntary associations. The SOIR informs the CFD and the national Operation Room of the Department of Civil Protection (DPC-Sala Italia), and media while the Prefecture coordinates the intervention of Healthcare Services, Police Department, Fire Service, Red Cross, etc. The involvement of citizens is planned by means of mobile apps for images sharing and information management on the evolving situation.

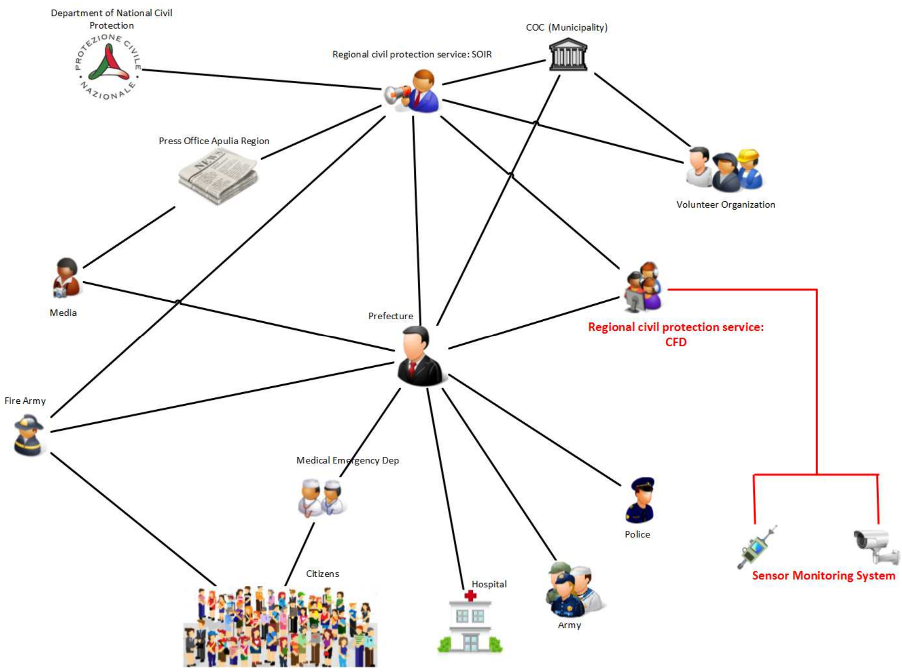

Figure 4 Actors' relationships

Schematic representation of actor relationship is reported in Figure 4 where is visible a central role played by the Prefecture (black track) in terms of governance and coordination of the emergency process, while the CFD (red track) acts as focal point for interoperability with the sensing system. In its role of regional point of a national network, the Regional CFD provides support for the management of the warning and alerting system for landside and plumbing risk with two main focuses:

- prediction of nature and intensity of expected weather events, and the impact that the occurrence of these events could bring in the territory,

- monitoring and surveillance of the territory with regards to the meteo-climatic, hydrologic and hydraulic data and information gathered by monitoring stations/sensors (Figure 5).

Figure 5 Periphery sensor system

Within this specific role, CFD will use project pilot experimentation in order to automate the alerting system and launch interoperable process with the local actors in order to assess C2-SENSE profiling approach benefit moving from Data Layer to Information Layer and beyond. CFD actions (automating alerting system and launching interoperable process) will be performed according to the following profiles:

- **Situation Reporting Profile** is used for transmitting timely situation reports (In an emergency situation, it is crucial to have the picture of operation. Thanks to timely reports, situational awareness evolves, additional precautions can be taken or emergency plan can be updated etc).
- **Sensor Management Profile** is applied to manage properly before, during, and after emergency situations.
- **Alert (Notification) Profile** is executed due to the fact that when an emergency occurs, all the parties involved in the emergency team should be alerted first while, during crises, some organizations should be informed when specific events occurred.
- **Mission Plan and Scheduling Profiles** are used together to activate the emergency procedures and organize the institutions and organizations involved in emergency management.

4.2 Organizational Structure: The Benefits of Enterprise Interoperability

The structural organization, realized to ensure interoperability between institutions/ organizations involved in emergency management, has brought significant benefits:

- **Acquisition and sharing of information:** As input to the decision-making process is processing the information coming from the site of the disaster; there is therefore the need for such information to be complete, reliable and obtained in real time.
- **The need for simplicity and immediacy:** Given a good enterprise interoperability system for emergency management, for his actual and constant use in real emergencies there are two essential characteristics: simplicity and its immediacy. In fact, an interoperability system, although complex in its components, can be easily assimilated and used just if it is easily understandable to insiders. Moreover, because of the urgency with which the different actions must be performed, it is essential to provide an immediate picture of the situation, and similarly be able to handle every transaction with immediacy.
- **Availability of communication technologies:** As result of an adequate analysis of the Puglia territory, one of the main problems encountered in the management of emergencies, is related to communication. Therefore, it is useful to have different communication channels that operate in parallel and that complement each other (radio, SMS, etc ...)
- **Useful support for the human operator:** In decisional aspects the intervention of a human operator must remain irreplaceable and thus cannot and should not be automated. The enterprise interoperability system then needs to be a support tool and should serve to provide a detailed and comprehensive picture of the current situation, proposing appropriate solutions for intervention, but leaving the operator the option to choose alternative solutions.

5. Conclusion

In this paper, a novel profiling approach, which addresses all the layers of the communication stack in security field, is introduced for the interoperability of C2 and Sensing Systems in emergency management. To the best of our knowledge, this profiling approach is the first in the literature. Through the profiling mechanism, already developed individual dispersed standards/specifications addressing different layers in the Interoperability Stack can be consolidated into a single uniform specification. By doing so, interoperability of C2 and Sensing Systems is achieved and cooperation of these systems is possible in an emergency situation.

In order to ensure that the developed profiles are generic and applicable in real life setting, they are being assessed in a realistic flood scenario in Puglia region of Italy. The current situation, namely AS-IS scenario, has already been analyzed; possible actors, missions, and drawbacks have been identified; and initial profiles have been created. The next step is to create TO-BE scenario, in which AS-IS scenario is improved. The goal is to make the scenario generic and comprehensive, while also adding missing actors and missions. After having AS-IS and TO-BE scenarios completed, profiles will be further improved, then finalized, and ready for execution in real-life applications.

6. Acknowledgements

The work presented in this paper is achieved in the scope of C2-SENSE project supported by the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement number 607729 and partly by the APPS (9140033) project supported by TÜBITAK in the scope of ITEA3 Programme.

7. Bibliography/References

Wang, F., & Yuan, H. (2010). Challenges of the Sensor Web for disaster management. International Journal of Digital Earth, 3(3), 260-279.

Jirka, S., Bröring, A., & Stasch, C. (2009, June). Applying OGC Sensor Web Enablement to risk monitoring and disaster management. In GSDI 11 World Conference, Rotterdam, Netherlands.

Moodley, D., Terhorst, A. L., Simonis, I., Mcferren, G. A., & Van den Bergh, F. (2006). Using the sensor web to detect and monitor the spread of wild fires. In Proceedings of the 2nd international symposium on geographic information for disaster management (Gi4DM), Goa, India.

Brakenridge, G. R., Anderson, E., Nghiem, S. V., Caquard, S., & Shabaneh, T. B. (2003, November). Flood warnings, flood disaster assessments, and flood hazard reduction: the roles of orbital remote sensing. In 30th International Symposium on Remote Sensing of Environment, Honolulu, HI, November 10-14, 2003. Pasadena, CA: Jet Propulsion Laboratory, National Aeronautics and Space Administration, 2003.

Song, W., Shirazi, B., Kedar, S., Chien, S., Webb, F., Tran, D., ... & Lisowski, M. (2008, March). Optimized autonomous space in-situ sensor-web for volcano monitoring. In Aerospace Conference, 2008 IEEE (pp. 1-10). IEEE.

Integrating the Healthcare Enterprise Profiles. (n.d.). Retrieved January 8, 2015, from http://www.ihe.net/profiles/index.cfm

Namli, T., & Dogac, A. (2010). Testing Conformance and Interoperability of eHealth Applications. In Methods of Information in Medicine, 49(3), 281-289.

Tolk, A. (2003). Beyond technical interoperability-introducing a reference model for measures of merit for coalition interoperability. OLD DOMINION UNIV NORFOLK VA.

Stavroulakis, P. (2007). Terrestrial Trunked Radio-Tetra. Springer.

Andrews, J. G., Ghosh, A., & Muhamed, R. (2007). Fundamentals of WiMAX: understanding broadband wireless networking. Pearson Education.

Božić, B., Gençtürk, M., Duro, R., Kabak, Y., Schimak, G. (2015). Requirements Engineering for Semantic Sensor in Crisis and Disaster Management. International Symposium on Environmental Software Systems, Melbourne, AU (accepted).

Chappell, D. (2004). Enterprise service bus. " O'Reilly Media, Inc.".

OASIS Semantic Support for Electronic Business Document Interoperability (SET) TC. (n.d.). Retrieved January 8, 2015, from https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=set

Simon, L., Mallya, A., Bansal, A., Gupta, G., & Hite, T. D. (2005, July). A universal service description language. In 2013 IEEE 20th International Conference on Web Services (pp. 823-824). IEEE Computer Society.

Service Level Agreements (SLA). (n.d.). Retrieved January 8, 2015, from http://its.ucsc.edu/sla/

OLA/SLA Process for Existing Services. (n.d.). Retrieved January 8, 2015, from http://its.ucsc.edu/itsm/olasla.html

C2-SENSE Project Website, http://c2-sense.eu/