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EMERGENCY MAPS TOOL – facilitating collaboration and decision making during emergency & crises situations

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Abstract: The Emergency Maps Tool (EMT) has been developed as part of a collaboration environment in the C2-SENSE Emergency Interoperability Framework (www.c2-sense.eu). The collaboration environment aims to connect all relevant organizations for joint response in emergency and crises situations. The Emergency Maps Tool aims to display all relevant resources (e.g., authorities, organization, points and object of interests, messages, etc.) involved or of special importance, in order to allow proper decision making. EMT allows decision makers to set and monitor activities, send and receive event related messages but also to include ad-hoc information from sensors or sensor networks (e.g., water monitoring sensors in case of flooding). Backbone of this tool is a data, communication and collaboration model realized in a flexible, configurable and extendable way. That means new, so-called “Objects of Interest (OOI)”, can be added on the fly and displayed by the EMT. In principle, such OOIs can be everything, spanning from metadata of responsible authorities to civil protection departments up to alarms, pure measurement values stemming from sensors, or information/messages about blocked roads as well as number of endangered peoples at a specific location. This approach and the robust architectural solution of the C2-SENSE Framework provide solutions to several challenges in the domain of decision making in a crisis and emergency situation.

Keywords: Command & Control Systems, decision support tools, emergency and disaster management, collaboration environment, interoperability, object of interest.

1 INTRODUCTION

One of the main issues for managing crisis situations, during or after a natural or man-made disaster event has occurred, as shown by Mayer-Schönberger (2003) and Ansell et.al. (2010), is the lack of interoperability. Different crisis responders and involved organizations usually have their own Command & Control (C2) Systems. Adding to these different procedures, languages, practices and cultural differences increases the complexity of interoperability, especially when a crisis crosses countries and political borders. When the goal is to increase situational awareness through collaboration and joint response, these dispersed systems need to cooperate, communicate, exchange and share data and information. In other words, territorial emergency management requires a cross-organizational, cross-domain, cross-level interoperable collaboration environment between the involved C2-Systems.

Such collaboration environment is developed in the C2-SENSE Framework. It aims to connect all relevant organizations and services that have to cooperate in an emergency or crisis situation (Figure 1 and Figure 2). In a crisis scenario suitable for a Framework, several responders and organizations (from now on referred to as actors) attempt to coordinate their efforts with the main goals of better organizing, more effective prioritization of response actions, quicker response time, and more effective resource allocation (i.e. material or personnel). This means exchange of information (and data) and alignment of actors’ procedures. For example, the number on injured people during an event is important information for Health Services which should prepare for their intake and treatment; but this information could be provided by another actor as shown in Figure 1 (e.g., police). Although very
simple, this example shows the danger of not sharing information, as important time for saving live might be lost.

Other crucial information for the actors on the ground might be provided by sensor networks in flood-related crisis situations (e.g. water level information, road and bridge conditions, flooded areas, etc.). Accurate information and coordination is needed. As shown by Wattegama (2007), the better the coordination becomes, the higher the chances for more effective response and rescue will get.

![Diagram](image)

**Figure 1.** Collaboration of different actors in an emergency situation through one Framework (represented by solid black line)

![Diagram](image)

**Figure 2.** Collaboration environment as the “big connector”

For situations, as described above, the collaboration environment of the C2-SENSE Framework is highly applicable. Its central part is the Interoperability Knowledge Layer as shown in Duro et.al. (2015). This layer within the C2-SENSE architecture includes various methods and components to
provide a common operational picture of a crises situation, while supporting joint decision making. Moreover, the knowledge interoperability profiles, as described by Gençtürk et.al. (2016), enable exchange of information and data, and communication between different devices, proprietary or/and non-proprietary alike. In other words, the whole system with these developments becomes fully interoperable.

The main components forming the collaboration environment are:

- Emergency Maps Tool, for crisis mapping;
- Sensor Management Tool, for integration and management of different sensors, even ad-hoc ones;
- Messaging/Communication Platform, to send and receive messages (e.g., alarms, reports, etc.);
- Registry of Emergency Web Services, to register web services used in the framework
- Profile Monitoring Tool, to monitor the execution of the implemented emergency process/workflow;
- Profile Definition Tool, to define profiles (e.g., map related profiles, situation analysis profiles)
- Security and Privacy Tool, to protect against security issues;
- Profile Repository, for storing of defined crises/event relevant profiles;
- Object Of Interest Data Repository, the data storage for all objects of interests to be provided within a decision support tool (e.g., the Emergency Maps Tool).

Within the next chapters we concentrate on the Emergency Maps Tool’s main front end (client side) and the Object Of Interest repository and connected components. EMT provides a common view of the emergency situation in form of maps of the crises/event area and features present on the maps. With features we mean all the information about objects that are relevant for the visualisation of the emergency situation and a proper decision making for the end-user (which can be a decision maker, emergency manager, first responder, etc.). That means features are resources (objects of interest) of utmost importance during an event, such as ambulances, infrastructure (e.g., hospitals), or areas of interest such as area in a city hit by a flood, direct sensor values for monitoring of water levels at a sensor spot, or calculated values such as predicted depth of water at a certain location (or vectors showing the water flow).

2 EMT – EMERGENCY MAPS TOOL

The Emergency Maps Tool aims to display all relevant resources involved or of special importance, in order to allow proper decision making. Resources can be ambulances, buildings related to organizations, collapsed bridges or critical areas. EMT allows decision makers to set and monitor activities, send and receive event related messages, but also to include ad-hoc information from sensors or sensor networks (e.g., water monitoring sensors in case of flooding).

The Web-Browser based Emergency Map Tool is much more than just a map. Beside the interactive map component showing actual information, it combines functionalities to organize information views in different ways to facilitate more effective and quicker decision making. Trends of real-time sensor data can be shown in a graph, messages can be filtered by type, source or geolocation. Directly from the EMT also messages and commands can be sent out whenever necessary.

A very useful EMT feature, compared with other solutions is the flexibility and extensibility provided by the used implementation approach. The user interface based on WireCloud (2015) is built from widgets providing different data representations and interaction possibilities. The widgets are independent of each other and can easily be extended and combined in various ways to fulfill different end user needs.

2.1 EMT GUI Components

Important for the graphical user interface (GUI, see Figure 3) is that all the components (i.e., widgets) are interconnected and can interact, thus they are not just stand alone components. For example, an area selected in the Map component can be used to filter messages in the MessageList component.
Further, all components share the same localization features. This includes not only the localization of the GUI itself but also the localization of the data represented. Moreover, this localization is not limited to a selected language, but can also depend on a user domain and interest. This allows user specific data representations in form of icons on the map or in the tables, coloring of messages, and even translation of messages into different user languages.

The most relevant EMT GUI components are, a:

- **Map**, which displays a map with interactive OOI s (filtered by type) and overlays (e.g., weather data, flooding maps). Clicking on OOIs opens popup windows, showing latest data related to this OOI or opens a linegraph to allow a detailed analysis of the data (e.g. latest sensor values).

- **MessageList**, which is a table listing all OOI data. The settings of the list allow to show or hide columns and to apply filters (like filtering by OOI and message type as well as by geo location). Selecting a row can place a marker and / or center the map to this OOI. Also a more detailed view of the data (e.g. a simple linegraph showing the last days data) can be triggered. Two types of views for the MessageList are available: a) Message View: Just the last message arrived. This can include multiple messages related to one OOI. This just depends on the frequency of the messages. b) Last Value Table: It provides a more condensed view, as only the last message for each message type and OOI is shown.

- **Linegraph**, which can be used as a GUI component by itself offering a lot of configuration possibilities for data display like colors, time spans and legend.

- **Commands**, which is the place to enter new commands. The Commands component is highly flexible. It allows any message and even sensor data to be sent manually (Figure 4). A lot of settings are available to tailor the Commands functionality to the user’s needs. This includes settings adjusted for a specific domain, but also multilinguality (see Figure 5). For efficient usage a set of commands can be prepared in advance allowing messages to be sent with one click.

- **Configuration Manager** which stores the settings of all components. Different configurations for different use cases and/or users can be stored by name, transferred between computers and reloaded later.

![Selected EMT GUI components: Map, MessageList and Linegraph (screenshot)](image)
3 OOI – OBJECT OF INTEREST DATA REPOSITORY

3.1 The Architecture and the Purpose of the OOI

The main data repository for the EMT is the “Object Of Interest” repository holding all relevant data to be shown in the EMT. The EMT is, hence, tightly connected to the OOI (see Figure 6). This guarantees fast response times for the GUI. This is an important feature for crisis responders, as stated by UNOCHA (2013). Additional data sources can be used by the EMT as well. This includes external GIS server providing background maps, or other sources connected over the internet. In the case of a crisis with degraded internet connectivity, however, these external data sources may be unavailable, so all the necessary data and maps should be in the OOI or other local services, e.g., a local service providing the background maps.

Figure 6 shows that EMT and OOI together are designed as building blocks with the goal to be easily re-used in different projects. Currently, the only interface needed is the REST interface (Richardson and Amundsen, 2013) of the OOI. Apache Kafka (2016) is used as Enterprise Service Bus (ESB) providing reliable communication between components within C2-SENSE and the stakeholder systems.

The OOI data repository is connected to ESB using a set of listeners. This makes it very easy to add new data types from any sources being translated into OOI entries. Moreover the OOI data can be used by other C2-SENSE components and it can also provide data for external usage. The existing OGC WMS (2016) and OGC WFS (2016) based on GeoServer (2016) provide OOI data to
clients/actors that already have well established tools. OOI data are offered in the form of map layers, the two most relevant ones are: “lastvalues” containing the latest, most actual numeric OOI values. This layer is used for sensor data. “lastmessages” delivers messages as JSON objects. This allows different presentations depending on the user needs but here the translation to different user languages and domain specifics is left to the client.

3.2 Analysing the OOI Data

LimitChecker is a component in direct connection to the OOI data repository. It is an important component for meeting some of the demands of a detection and decision support system, as mentioned by Ansell (2010). One of the main functionalities in the context of the C2-SENSE Framework is performing analysis of data, like the verification of incoming sensor values for detecting and identifying critical situations in the field and producing warning or alarming messages for a crisis manager. For example, during a flooding situation, field sensors measuring water level will stream the data to the OOI repository. These values will then be compared to water level limits already provided and defined by the emergency managers, and in case of exceedance, LimitChecker will produce/initiate an appropriate warning or alarming message.
critical situation. The result of the verification is fed back to the OOI data repository to be available not only to the EMT component, but also to all arbitrary recipients via ESB. Such architectural approach gives flexibility to the system, and availability of resources and tools for those users not using the EMT tool, but using their own proprietary tools.

![Figure 8. Limit verification using DeployR](image)

4 CONCLUSION

The Emergency Maps Tool in combination with its Object Of Interest data store is one of the main tools available for collaboration, management and visualisation of crises situations. It is designed to be highly flexible and customizable, thus configuration and adaptation to the users’ needs can be quickly applied. After two third of the project’s lifetime the main features and functionalities are available. ESB Kafka Apache technology provides quick data and message exchange, as is crucially needed when real-time data and situational awareness are demanded, as it is clearly the case for a rapid response in crisis situations and stated in UNOCHA (2013). Object Of Interest data repository offers all relevant data on the actual crisis situation. The analytical functionalities of the LimitChecker relieve users from performing time and resource consuming activities, like monitoring of critical sensor values during a flooding event. Some improvement, however, might be still useful and desirable. For example, and as described above, the OGC WFS delivers not only sensor values but also messages. Currently all messages are delivered as JSON objects burdening the translation and rendering to the client. For an easier integration of OOI data into widely existing environments like GIS systems or even Google Earth, the WFS should offer the messages appropriately formatted and already translated. This would result in a handful of languages and domain specific layers the client than could choose from instead of just having a few generic layers available.

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