From Textual Emergency Procedures to Executable Plans

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ABSTRACT

Crisis response and management often involve joint actions among different actors. This is particularly true in cross border cooperation, i.e. when actors belong to different countries. This is the operative context of the NETTUNIT research project, which long-term objective is to provide automatic support to emergency management.

Modelling emergency plans is challenging because they are usually written in free-form text, thus in a form that is very far from being automatically processed and executed. In other words, it is non-trivial to define workflows capable of managing and monitoring emergency plans. To complicate the problem, typically an emergency evolves in a highly dynamic environment, so there is the need for run-time adaptation.

In this paper, we propose a roadmap for producing executable workflows from emergency free-text plans. We set up our current progress in the project and focus on the sub-problem of identifying a suitable modelling notation. We also propose two improvements with respect to the state of the art: 1) a specific diagram focusing on events, roles and responsibilities in a goal-oriented fashion; 2) some guidelines for depicting the emergency plan at hand with a modelling notation.

Keywords

Emergency management; Disaster response; Modelling Notation

INTRODUCTION

Worldwide, emergency response plans describe complex processes involving collaboration and interaction of multiple roles and departments. The effective response to a disaster includes timely information and early warning of potential hazards (Liu and Ota 2018). Public institutions and private companies dispose of procedures and organizations for emergency response that have proved efficient in most cases to mitigate the consequences of accidents. The efficiency of such organizations can be reduced by difficulties of communication, lack of information, or ambiguities in the sharing of tasks (Wybo and Lonka 2003). In this context, the challenge is to integrate Information and Communication Technologies (ICTs) with contemporary emergency management practices to improve performance and to strategically align ICT use with the needs and requirements of emergency management (Hellmund et al. 2021). All organizations, especially those that are in the central positions of an emergency management network, can benefit from ICTs to improve their communication and coordination with other stakeholders (Hu and Kapucu 2016).

Integrating ICT in the emergency domain can be challenging: emergency plans are written usually in a free-form text by domain experts (who are not necessarily ICT experts). Drafting plans in the free-form text brings advantages in their planning and execution because of the comprehensibility of natural language for humans, but the introduction of a computer supported execution of plans in this context generates many challenges. Nonetheless, a significant effort in the scientific literature remarks the advantages of combining ICT in emergency response procedures. One way to tackle the previous issue consists in defining a mechanism to convert emergency plans expressed in free-form text to a "computer system-friendly" version. By modelling the activities involved in a response process in a structured way, domain experts are assisted by a software system aggregating emergency plans that consider several requirements and observations from the emergency context. In this way, emergency responses are being provided promptly to efficiently address the emergencies.

In this paper, we propose an approach for modelling emergency plans in free-form text using standard business notations, and then transform an emergency plan (opportunely modelled through standard business notations) into an executable plan. Our proposal uses a semantic layer to highlights the separation between roles, activities, and responsibilities in emergency procedures, without suffering from ambiguity due to free-form text. The plan is converted into an executable form so that activities can be coordinated, executed, and monitored by a workflow management system.

Considering the state of the art, the advantage of our proposal is twofolod:

- we improve the semantic layer by introducing a new Event-Role-Responsibility diagram to facilitate discovering roles and responsibilities in the context of specific event that may occur;
- we also propose a modelling notation for representing the plan in a semi-formal way that exploits de-facto standard business process notations.

The proposed method is being currently developed in the context of the N.E.T.TUN.IT[1] project, in which we aim at implementing a fully operational platform for cross-border data collaboration to cope with shared risks and disasters due to emergency scenarios. The project objective is that the Italian and Tunisian sides collaborate in the response to a simulated accident impacting the nearby population by causing health risks as well as atmospheric and marine pollution. In such a context, one of the challenges is that two different nations with different legal frameworks should cooperate in an ongoing emergence; communication between partners should be clear and concise in describing their intentions in a common and shared emergency plan, also clearly separating the responsibilities of each country in the intervention.

This paper is organized as follows: at first, position our work according to the state of the art in emergency management modelling notations. Then we present the two novelties of the paper: the Event-Role-Responsibility diagram and the modelling notation to semi-formally represent the structured version of the plan. Finally, we discuss the expected outcome of our research, then we summarize the work in the conclusions.

THEORETICAL BACKGROUND

Numerous studies in the literature envision ICT as a means to support emergency management systems. For instance, the work of (Hilbring et al. 2018) is relevant because it enables integrating several heterogeneous information such as data from sensors and Twitter data for an ICT platform for risk management. However, few systematic empirical studies have investigated ICT utilization patterns among emergency management organizations and the roles of ICTs in facilitating communication and coordination among organizations within the context of emergency management networks (Hu and Kapucu 2016). Several recent surveys on using ICT in emergency management are available (Grinko et al. 2019; Anita and Sukomal 2020; Timothy Coombs and Laufer 2018; Pennington-Gray 2018).

Emergency response plans are usually formulated in the form of natural language text. Inevitably, they may be affected by ambiguities and/or imprecise descriptions related to the inherent characteristics of natural language. Some studies found in the scientific literature point to the adoption of semiformal representations to allow the

[1]Net de l'Environnement Transfrontalièr TUNisie-ITalie (N.E.T.TUN.IT), Cross-border Cooperation Programme of the EU Community, Italy-Tunisia 2014-2020, project started on 03.09.2020 and concluding on 31.12.2022 (extended deadline), https://www.italietunisie.eu/projets/les-projets/nettunit/

analysis and the validation of emergency response plans (Betke and Seifert 2017; Nunavath and Prinz 2015; Shahrah and Al-Mashari 2017; Herrera and Díaz 2019).

A graphic representation, using appropriate notation systems, can provide a better understanding of the plans to the operators who will have to implement the necessary actions to contrast the possible consequences of the incidents.

The scientific literature widely adopts the integration of natural language with standard notations and languages such as the various Business Process Modelling Notation (BPMN) (OMG 2011), Case Management Model and Notation (CMMN) (OMG 2016) and Decision Model and Notation (DMN) (OMG 2021). However, using such languages to accurately and effectively model emergency response processes is still a major challenge that requires both domain knowledge and process modelling techniques.

The study of (Betke and Seifert 2017), while recognizing all the advantages in adopting BPMN for contingency plan modelling, also identifies some limitations: the standard elements of BPMN could not be sufficient to adequately represent some typical requirements of disaster recovery management, such as information about resources and their location. Therefore, they propose to extend the BPMN notation to include the role of resources, the distinction between human and non-human resources, their interdependence, and relative properties.

Another interesting study (Nunavath and Prinz 2015) concerns the process of managing a fire that develops during a music festival in Norway. This study argues that authorities and first responders can better understand and implement plans expressed in visual and textual form, and thus, may be better prepared to deal with unforeseen circumstances. The plan, reported in the study, focuses on the various roles of the organizations and how they should interact. Again, the authors identify some problems in using the BPMN standard in modelling aspects such as the duration of tasks.

In this direction, another study, by (Shahrah and Al-Mashari 2017), proposes replacing or complementing BPMN diagrams with the CMMN notation, as it provides a more appropriate graphical notation for managing complex cases in which several tasks must be implemented whose order of execution is unpredictable a priori in response to evolving situations. The CMMN notation uses an event-based approach and the concept of case files and is perfectly suitable to model the less structured parts of the work and those that are managed directly by experienced domain operators. The combination of BPMN and CMMN makes it possible to cover a much wider spectrum of work processes.

In our vision, this combination makes sense because the BPMN notation makes it possible to adequately model traditional business processes that are characterized by a priori defined sequences of activities, whereas, the CMMN notation offers more natural support for dynamic workflows, such as, for example, the process of responding to an emergency, which is a knowledge-intensive process.

In an emergency response plan, there is also the need to make choices. To manage these decision-making operations, the OMG has defined a language, the Decision Model and Notation (DMN), a standard notation to describe and model decision-making processes. BPMN, CMMN, and DMN languages complement each other and can cover the different areas of process management due to their characteristics. In the study (Herrera and Díaz 2019), the authors propose to use the combination of these three notations precisely in the context of crisis management.

Considering the state of the art, our novelty is an approach that structures emergency plans in free-form text into a standard business notation and allows executing and monitoring them by a software system.

THE PROPOSED APPROACH

We propose an approach to move from a free-text plan towards the execution of the corresponding supporting workflow. The overall approach (Figure 1) is divided into three macro-phases are: 1) structuring the free-text emergency plan, 2) modelling the emergency plan using standard business notations, 3) producing executable workflows. The figure also shows this process grounds over four layers (linguistic, semantic, modelling, execution). Currently, we are working on Phase 2, whereas the linguistic and semantic layers are already published in (Cossentino, Lopes, Sabatucci, et al. 2021; Cossentino, Guastella, et al. 2022).

From Free-Text to Structured-Text Plan (Phase 1)

The objective of this phase is to manually process a free-text plan to reduce the ambiguity of the natural language and to obtain a structured version of the same document, in which all the essential information are preserved and organized and correlated. To this aim, we created a semantic layer that helps in defining what is important to be preserved and which kind of relations are essential to be highlighted (Cossentino, Lopes, Sabatucci, et al. 2021). We are in the context of emergency management, and in particular, we decided to focus on how involved persons

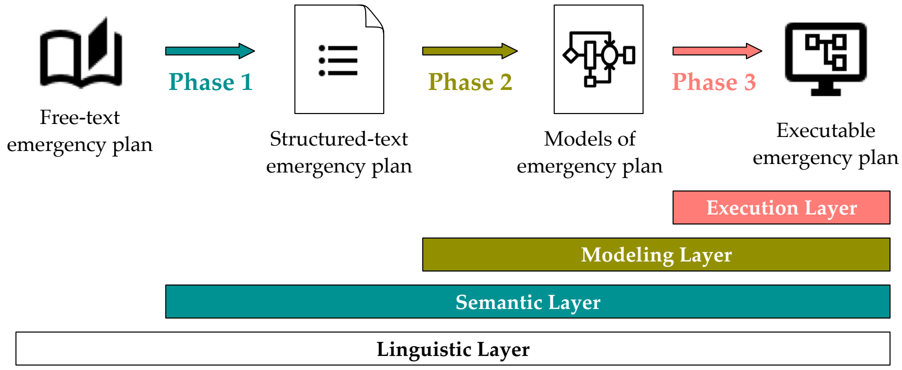

Figure 1. The proposed process for transitioning from free-text emergency plans to executable plans.

organize for solving an emergency. This precise focus made us interested to understand human organizations more than the precise nature of the emergency. This latter is important, but our model must describe which are the involved actors, what are their roles and responsibilities, how they delegate a duty, and so on.

Studying these patterns of organization we were able to assemble the metamodel shown in Figure 2, accompanied by useful instruments for extracting and deducing information from the text (tables of properties and sentence template (Cossentino, Lopes, Sabatucci, et al. 2021)).

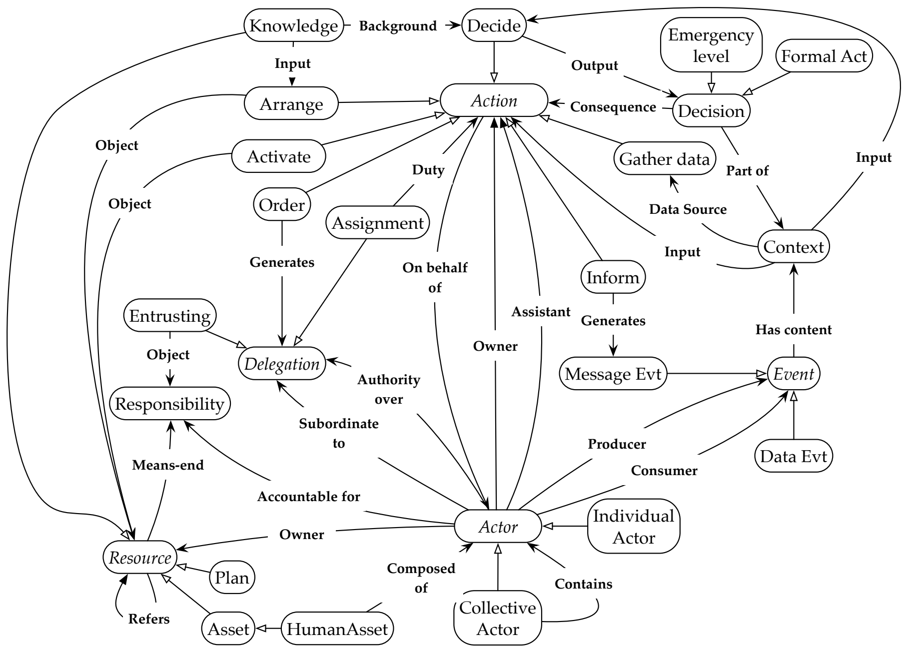

Figure 2. The proposed metamodel at the base of the semantic layer of the proposed approach (redrawn from (Cossentino, Guastella, et al. 2022)).

Structuring a free-text plan is challenging because this type of documents contains many kinds of redundancy, ambiguity, synonyms, polysemy, coming from the use of the natural language. The proposed semantic layer allows for creating a bridge between the linguistic analysis of the input text with the semantic layer (Cossentino, Guastella, et al. 2022). After analyzing several emergency plans available from government websites, we assessed a lexicon composed of lemmas and their synonyms. Each lemma is a word that (*i*) has a specific meaning for modelling purposes, (*ii*) has many possible synonymous, (*iii*) is a correlated set of properties (detailed in the metamodel and in specific tables of properties and in sentence templates).

We verified experimentally that the use of the proposed linguistic/semantic layer enables reducing the arbitrariness in interpreting the plan, and facilitates producing a structured version of the same plan. However, the experiment highlighted also the need to continue investigating linguistic analysis, especially for developing semi-automatic support tools. Indeed, we are considering, for instance, to automatically expand the set of terms in the table by using already available lemmas and corpora such as Wordnet (Miller 1995) or Babelnet (Navigli and Ponzetto 2010), where a large set of synonyms are freely available. We are also evaluating the use of free-text analysis methods such as Twitcident (Terpstra et al. 2012).

The Phase 1 can be briefly summarized by the following manual procedure.

For each significant sentence in the input text (i.e. fragment):

1. Identify subjects, verbs, complements.
2. Identify actions (verbs of the metamodel or their synonyms from the Lexicon Table; see (Cossentino, Guastella, et al. 2022)).
3. Match the actions with their corresponding lemmas.
4. Rewrite the fragment of text by using the sentence templates (i.e. a standard linguistic pattern related to the corresponding lemma).
5. Verify that all words in the fragment have been properly considered and converted to structured text if they are worth of.

This procedure is repeated until complete plan coverage, that is, until all significant words have been mapped to their corresponding lemma (if necessary), then to the metamodel. Currently, the metamodel does not include concepts related to spatial and temporal dimensions of the emergency plan. Therefore, we do not consider, for the plan coverage, parts of sentences like "execute the action “*in the proximity of the indicated place*” or “*after k minutes [...]*”. These parts are currently added as unstructured portions of text as a special property of the action. In the future, we plan to add a specific support for that.

To give an operational example of this phase, let us consider the following excerpt of an emergency plan written in free-form text:

“*In case of an accidental event that could affect the outside of the refinery, the Mayor can consider:*

- *disposing the use of shelter areas for the evacuated population;*
- *activating the municipal operational structures of the civil protection agency;*
- *arranging the transportation of the evacuated population.*”

The objective of the plan (Cossentino, Lopes, Marchese, et al. 2021) is to secure population and to contain the fire. The first step towards structuring the former plan is to identify the reference lemmas as in (Cossentino, Guastella, et al. 2022): we use Order, Activate, and Arrange, respectively. For instance, we map "disposing the use of" in the first phrase to the lemma "Order". Thereafter, we report the sentence templates for the previous lemmas (see (Cossentino, Guastella, et al. 2022)):

① [authority] Orders [subordinate] to [do something/address an outcome]

② [owner] Activates [object]

③ [owner] Arranges [object]

This example is made of simple sentences in the form of Actor-Action-Object phrases with a straightforward interpretation. A trivial classification for the word functions exploits the grammar. We obtain the following structured sentences by mapping the domain concepts to the template phrases:

❶ [Mayor] Orders [Head of Civil Protection] to [[Head of Civil Protection] Arrange [areas of shelter for the evacuated population]] with Assignment

❷ [Mayor] Activate [operative municipal structures]

❸ [Mayor] Arranges [transport of evacuated population]

The less trivial case of phrase ❶ requires a further actor “Head of Civil Protection”, which is not present explicitly in the sentence. However, the sentence template leads to query who is the subject of the predicate ‘arranging areas of shelter’. According to the plan (Cossentino, Lopes, Marchese, et al. 2021), we deduct that the order of arranging areas of shelter for the evacuated population is issued to the head of the civil protection agency.

The metamodel (Figure 2) offers a relevant support in understanding the relationships among the entities and what is to be identified in the free-text.

Figure 3 shows the class diagram representing the instance of the metamodel for the studied sentences ❶-❷-❸. For the simplifying the reading, we here append coloured dots in some model elements to identify the reference sentence. The connections among the elements allow establishing relationships between actors, resources, and responsibilities. Consequently, the model aims at identifying “*who-does-what*” in the emergency response process. It is straightforward to note that the obtained model is a structured, language-independent version of the discussed emergency plan. The achieved result constitutes a significant step forward in structuring emergency plans. However, it is of primary importance: (*i*) to have a rigorous method for validating the resulting model, and (*ii*) to have a rich vocabulary of terms to enable modelling a wide range of emergency plans according to our proposal. We pinned these two points in our research agenda.

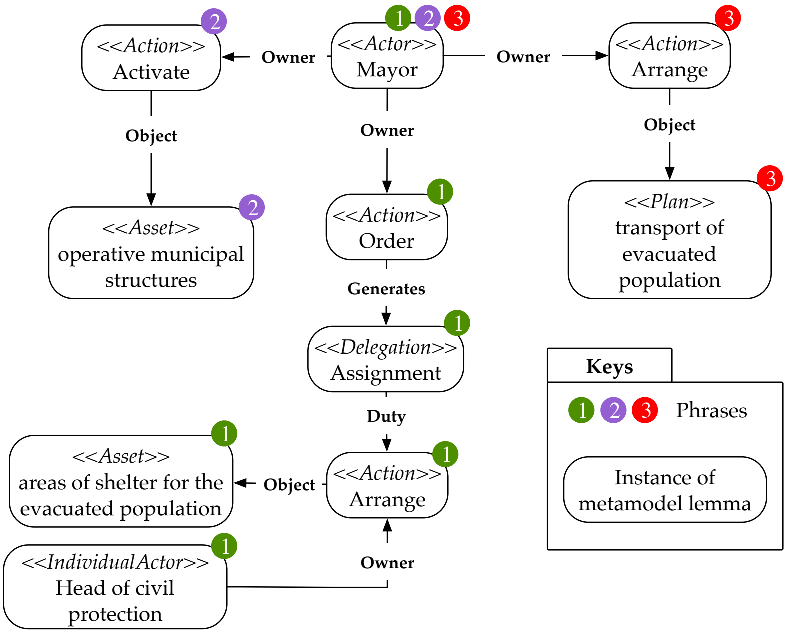

Figure 3. Instance of the metamodel for the extract of emergency plan.

Representing the Structured-Text Plan with a Modelling Notation (Phase 2)

The objective of this phase is to represent the emergency plan in a notation that enables the automatic execution of the plan, eliminating any ambiguity of interpretation, clarifying tasks and responsibilities of each role, as well as highlighting all criteria for decisions to take during the emergency.

The novelty of our contribution for Phase 2 is twofold: first, we introduce the **Event-Role-Responsibility** (ERR) diagram, that helps in representing responsibilities, and then a procedure to convert a structured emergency plan into a standard business notation. The main issue of this phase concerns the choice of which kind of language/notation to use for modelling our emergency organization/plans. To tackle this issue, we combine different standard notations for modelling business processes from different points of view (events, roles, responsibilities and activities).

The Event-Role-Responsibility Diagram

The semantic layer introduced in Phase 1 allows for representing the entities involved in the emergency management according to the plan. However, this tool is not expressive enough to represent a point of view that is particularly important in the emergency context: responsibilities (together with when they are triggered, who is their owner, and the delegation chain, if any). We introduce the **Event-Role-Responsibility** (ERR) diagram to clearly represent this aspect of the plan. This diagram, inspired by i-star social modelling (Yu 2009; Giorgini et al. 2003; Bresciani et al. 2004), helps in catching the relations among these three elements that are of paramount importance in case of an emergency since they define who is responsible for what (also according to law). This diagram allows modelling the hierarchy of dependencies and relationships among the responsibilities of the roles involved in a specific emergency. In the ERR diagram, we represent an event as a rectangle having an outgoing arc towards the role(s) involved in responding to what happened according to the plan. We represent the actor as a circle associated with a balloon, delimited by a dashed line, that represents the set of responsibilities of the actor. The responsibilities are decomposed hierarchically, starting from the main one; sub-responsibilities can be introduced and linked to the higher-level ones by logical operators (AND-OR). Actors can also delegate responsibilities: direct arcs between responsibilities indicates a delegation of responsibility. According to the metamodel proposed in Figure 2, we consider two different kinds of responsibility delegations: Entrusting where the responsibility is passed to another subject, and Assignment where the delegating authority maintains the responsibility, but the actions needed to fulfill that responsibility (and not the responsibility itself) are assigned to someone else.

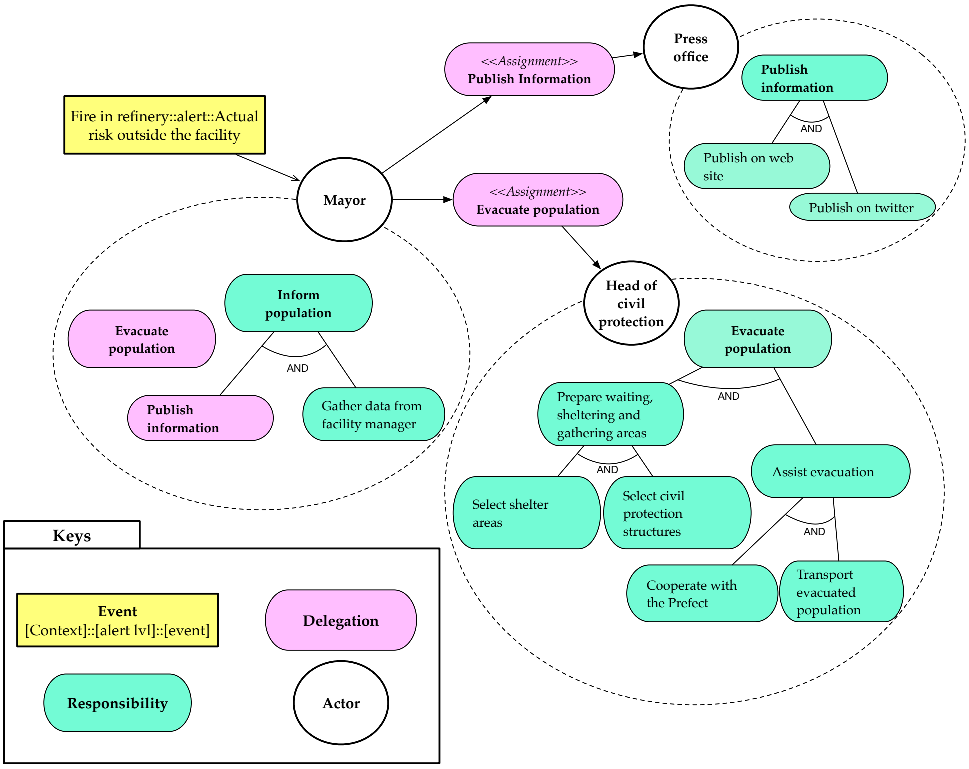

Figure 4. Example of ERR diagram.

Figure 4 shows an example of ERR diagram related to the former example, even if we deducted many elements from different parts of the document that are not reported here for the sake of space. The event "Actual risk outside the facility" activates the mayor, which is one of the main actors in case of fire in the refinery.

The mayor's responsibilities are informing the population, and evacuating the population in the proximity of the accident area. The responsibility of the head of civil protection is to address a prompt evacuation of the population. We remark that "Evacuate population" is present within the goals of both actors. Despite the mayor having a responsibility, as supervisor, over the evacuation of the population, it delegates this goal to the head of civil protection, which coordinates human resources capable of addressing this task. Therefore, we link the two "Evacuate population" goals by a delegation relation, represented as a pink rounded rectangle between the two involved roles. A pink rounded rectangle inside a role's balloon indicates a delegated goal. The same is done for "Publish information" goal, which is entrusted by the mayor to the press office, which is responsible for publishing timely information on both the website and Twitter.

We use both instances of metamodel and ERR diagrams as the basis to convert emergency plans to business notation.

A Modelling Notation for Emergency Workflow

We propose a modelling notation for representing emergency plans that combines CMMN, BPMN and DMN diagrams. In our approach, the first and higher-level view of an emergency plan is composed of a set of CMMN diagrams, in order to emphasize the close relationship with a goal-oriented execution model. Commonly, we draw a different case diagram for each major actor involved in the plan. Such a diagram reports the tasks assigned to the actor by the emergency plan also showing events that trigger its main parts. When necessary, we complement CMMN with BPMN (to provide a finer level of details for portions of the plan that have a rigid structure without degree of freedom). Moreover, decisions can be documented by using the DMN standard. Indeed, it is very important to provide precise guidelines for decisions to the actors involved in the emergency. From the analysis of the existing plans, we observed that natural language exposition sometimes created ambiguous and different possible interpretations of decision criteria, thus exposing the involved personnel to the risk of mistakes when operating under the stress of a real emergency.

Let us consider the structured plan represented as an instance of the metamodel in Figure 3, and the ERR diagram reported in Figure 4. We now propose a simple procedure for mapping these input diagrams to one or more CMMN diagrams, by performing the following steps:

- Identify Actors and Responsibilities
- Identify delegation of responsibilities
- For each Responsibility, identify sub-responsibilities and their relations
- Create one CMMN diagram for each actor (one per each actor/phase in case of extensive plans)
  - Model trigger/exit conditions as events
  - For each responsibility:
    - Model the responsibility as a stage
    - Model each sub-responsibility as a task
  - Model each delegation as a task
    - Label the task as "*[Role] Assignment/Entrusting::Responsibility name*"
    - Put an exit criterion to the task
    - Link the previous exit criterion to the milestone "*Assignment/Entrusting notified*"
    - Connect the milestone to the next responsibilities or the corresponding stage

Figure 5 shows the CMMN diagram obtained by applying the previous procedure on a detailed version of the former example. The event that characterizes the activation of the plan is modelled as a CMMN event, leading to a milestone that identifies the state of the emergency and the corresponding alert level. Then, two stages are pursued. Each stage features a task that delegates the following tasks to other roles. We introduce this formalism due to the goal-orientation feature we aim to obtain from our model. We are aware that CMMN is not a goal-oriented notation, but the way we use that, although compatible with the standard notation, makes it useful in the transition from the previous models to the final executable version of the plan. This is also obtained thanks to the correspondence that the internal stages and related tasks have with the responsibilities modelled in the ERR diagram of Figure 4. At the end of the stages, the "Population informed" and "Population evacuated" milestones indicate that they have been completed. This portion of the plan ends when the emergency procedure has been completed.

In our approach we decided to exploit the CMMN as the higher level view of the emergency plan. This choice descends from the need to enable a mapping towards a goal-oriented execution of the model. Commonly, we draw a different case diagram for each major actor involved in the plan. Such a diagram reports the tasks assigned to the actor by the emergency plan also showing events that trigger its main parts. Often we also complement these diagrams with BPMN models used to provide a finer level of details for portions of the plan that offer such a possibility (as a matter of fact, many parts of emergency plans are described at a high level of detail, delaying to the specific instantiation time the duty to detail the work to be done). Also, we use DMN diagrams when decision-making activities must be described in detail. This is a very sensitive part of the model since it is very important to provide precise guidelines for decisions to the actors involved in the emergency. From the analysis of the existing plans, we observed that natural language exposition sometimes created ambiguous and different possible interpretations of decision criteria, thus exposing the involved personnel to the risk of mistakes when operating under the stress of a real emergency.

For the sake of conciseness, we omit examples of BPMN and DMN diagrams. The former is used to detail the work to be done within a task depicted in a CMMN diagram, in other words we use that as the representation of a kind of sub-process. Conversely, DMN diagrams are used when decisions are described in the plan (for instance the decision whether to move to a higher emergency level) and the related criteria can be extracted from the text.

In the next phase, we will discuss how the proposed models can be used to automatically execute the plan.

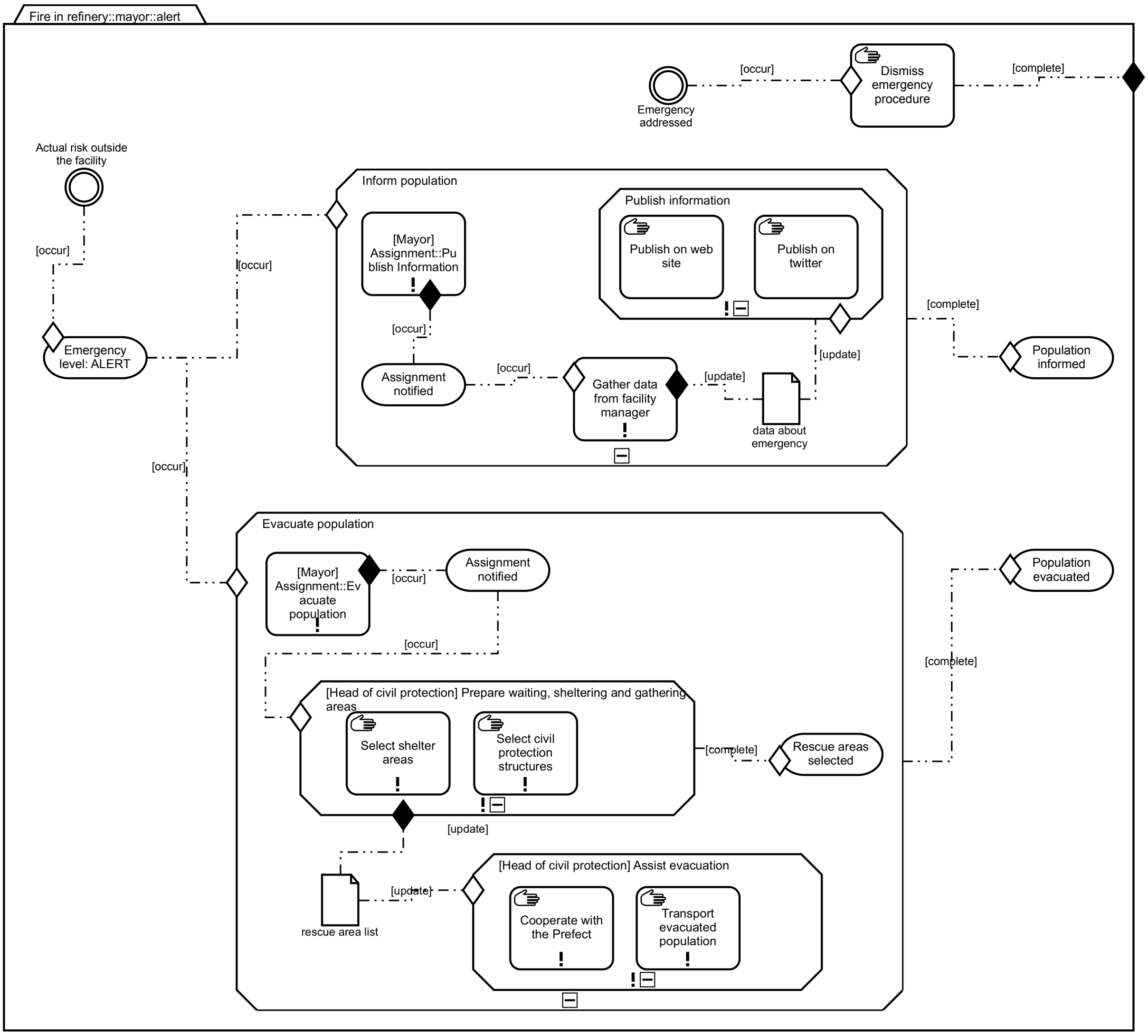

Figure 5. Example of CMMN diagram for the Mayor actor in the “Fire in refinery” emergency, Alert phase.

Executing Emergency Plans (Phase 3)

The last phase of the proposed approach consists in executing emergency plans. We are planning to exploit MUSA (Sabatucci and Cossentino 2019), a middleware for self-adaptation for implementing dynamic workflows. The peculiarity of MUSA is the adoption of run-time models for goals and capabilities and an engine (called proactive means-end reasoning (Sabatucci and Cossentino 2015)) for generating a late service composition and binding them to create several workflow solutions. MUSA enables coupling “*what*” (the goal to achieve) with “*how*” (the concrete action). Let us suppose a goal for addressing part of the emergency, which bounds a specific responsibility. A concrete action for this goal can be to communicate the state of the emergency to the involved bodies via a particular communication channel. However, if an unpredictable malfunctioning occurs, the actors involved in the emergency response must be promptly notified via an alternative communication channel. MUSA can deliver run-time adaptation by providing alternative solutions to malfunctioning tasks to address the emergency workflow in case of unforeseen situations.

Figure 6 shows the main steps of the execution of the MUSA middleware. The input of this architecture is the emergency plan resulting from the previous phases, opportunely converted in a language for specifying user-requirements and constraints (Sabatucci, Ribino, et al. 2013). When goals are injected (step ❶), MUSA organizes a solution by finding a functional bridge between goals and capabilities (step ❷), and then commit to the orchestration of the resulting workflow (step ❸). Thereafter, the environment is being monitored to check for the eventual parameters that could have an impact on the execution of the committed solution (step ❹). These parameters can be acquired from a physical environment through IoT sensors, or from a virtual environment containing first-order logic predicates resulting from the execution of the capabilities involved in the workflow. Finally, MUSA executes

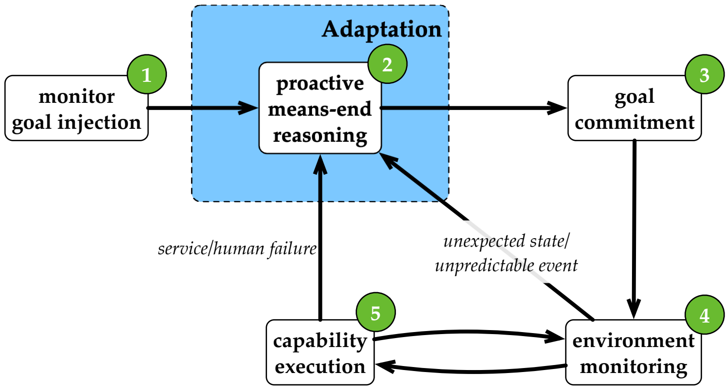

Figure 6. Execution and monitoring of an emergency plan using MUSA.

the capabilities (step ❺). Failures in the execution of capabilities lead to a dynamic reorganization of the solution, which is driven by three factors: **service/human failure** and **unexpected state/unpredictable event**. The human failure case is distinctive: in crisis management, most of the tasks are carried out by human operators: MUSA should manage task assignments and monitor task execution over time. As stated by Barthe-Delanoë et al. 2018, the human factor can also dramatically slow down the process of analyzing, combining, or even exchanging data during disasters. Therefore, having humans in the loop makes uncertainties arise in emergency response: are operators not responding because they are busy with other operations, or is there a delay in communication? Has the emergency team completed its assigned tasks or are there any communication problems? On the one hand, network overhead can cause problems in delivering data; on the other hand, there may be human error, as the operator can forget about transmitting data about the progress of the emergency response. A faulty information transmission could lead to erroneous coordination of rescue activities, putting people's lives at risk. To tackle this problem, we envision considering self-healing techniques to recover from erroneous behaviors and avoid misleading information (Guastella and Pournaras 2021).

DISCUSSION

The outcome of our research is an operational platform for the coordination of cross-border emergencies between Italy and Tunisia; our proposal is intended as a technological means for the coordination of such activities obtained from emergency plans which are generally provided in a free-form text. The semantic layer allows leveraging a common operational context among cross-border organizations in Italy and Tunisia, which are subject to distinct legislative frameworks. The defined notation provides the end-user with a tool to model an emergency plan by avoiding the issues of free-form text, such as ambiguity of interpretation, and clarifying tasks and responsibilities of each role. This also enables communicating promptly the actions that must be carried out by competent bodies, which is of great advantages compared to the use of emergency plans in free-form text.

On the execution layer, the use of the MUSA system will provide a means to coordinate activities considering the unpredictable dynamics of events in an emergency. This requires MUSA to continuously adapt to new unforeseen contexts. In the emergency domain, adaptation is a fundamental requirement due to uncertainties arising from the dynamic nature of emergencies or because of human errors. Let us suppose a human activity of reporting the status of the incident. If the human operator forgets to report or the communication channel is not working, MUSA should detect this issue and find an alternative task (one or several) that addresses the same goal. It is easy to see that MUSA must operate in a highly dynamic context, according to several constraints such as time or resource availability. In the former case, we are currently investigating the use of temporal constraints, mainly applied to the BPMN notation (Cheikhrouhou et al. 2015; Cheikhrouhou et al. 2014).

In NETTUNIT, we are currently defining a simulation on a shared case study between Italy and Tunisia to show the capability of MUSA in addressing prompt coordination of activities modelled through the proposed notation.

CONCLUSION AND FUTURE WORKS

This work proposes an approach for converting emergency plans into a free-form text to standard business process notation. We discussed the overall plan to address the long-term objective and then we focused on two improvements: the Event-Role-Responsibility diagram facilitates focusing on specific aspects of the emergency document that are not disclosed in the procedural part of the plan. It rather helps in the identification of roles that play some responsibility in case of a specific event and how these responsibilities are delegated in the organization, thus generating a chain of command. The second contribution is a notation, a combination of de-facto standards in business process, that we use to describe the plan by maintaining the right degree of freedom that will be exploited in a subsequent adaptive execution.

In our future works, we aim at investigating the use of semi-automatic text conversion techniques from the scientific literature that could facilitate the task of translating and analyzing the complexity of a text. This latter task is crucial to identify parts that can be simplified, leading to an easier modelling operation. Tools like WordNet (Miller 1995), Babelnet (Navigli and Ponzetto 2010) and Twitcident (Terpstra et al. 2012) will be useful in this phase. A further objective is the analysis of polysemic words in free-form text emergency plans: a polysemic word is a word that has several (and possibly different) meanings. The use of such words is challenging because of the uncertainties in their meaning; this could be solved through the analysis of the context.

We also aim at providing support for the execution of plans opportunely modelled through the proposed notation. Our goal is to produce executable workflows to coordinate the activities of an emergency plan. The challenge is that the structured-text document will be the input to model the plan by using a notation that could be injected into some workflow management system and automatically executed. The definition of such a notation is challenging because it must support diagrams that are understandable by human operators (that are not necessarily ICT experts), and at the same time structured in such a way that they can be executed by a software system. This is not the case for classical business notations. For instance, using BPMN notation is not the most pertinent choice, as diagrams can be difficult to understand for humans while being executable by software systems. Contrarily, CMMN diagrams provide a high-level, goal-oriented view of an emergency plan while not being directly executable by a software system.

In the context of the MUSA system, we will investigate self-adaptation mechanisms for tackling unpredictable situations such as environmental changes or human errors. In this case, the role of the workflow management is to monitor, predict and promptly arrange a solution to tackle these issues and ensure a rapid response to the emergency. We also consider integrating environment data (spatial-referred representation of the environment and involved assets), to provide punctual information to help in the decision-making process and assess better emergency response.

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