Personalized situation aware information retrieval and access for crisis response

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Abstract

Crisis response is an information intensive process, which produces or consumes large quantities of information from different relief organizations. Although personalized information retrieval and access has been realized as an efficient means to accelerate information acquisitions, most IT enabled applications in the fields can only provide uniform information to all the involved relief organizations. The traditional centralized design principle dominantly used to address the inter-organizational information accesses over boundaries is no longer feasible due to its lack of flexibility and adaptability to deal with dynamically changing information needs caused by the unpredictable nature of the crises. In this paper we present our ongoing research regarding a plug and play service architecture for personalized, situation aware information retrieval and access services, which offers a new way of thinking about the retrieval of personalized information in the context of crisis response.

Keywords:

Crisis response, Information retrieval and access, personalization, situation awareness, plug-and-play architecture

1. INTRODUCTION

Container terminals have to prepare for unforeseen crises, like leakages, explosions, and even the threats of terrorism. The level of a crisis, for instance, a fire in an area where millions of liters of oil and other flammable or hazardous materials are stored, is not a matter of hours, but a matter of minutes [2]. Therefore, fast access to relevant information is paramount for a quick response to a developing disaster to protect the disaster area reducing risks to life, property, and environment. The acquisition of information in the event of a crisis in a container terminal is a very complex process. This is due to the diverse types of rescue organizations involved in dealing with such disaster, and the unpredictable natures of the crises.

Crisis response is a multi-actor process, where relief organizations cooperate to reduce and solve the crisis' situation. Currently information acquisition during crisis response operations is still reliant on old fashion--voice communication [2]. This form of communication via porto phones and mobile phones makes crisis response more difficult and time consuming [2 & 6]. Dynamic maps of harbours have been developed as efficient means of improving the information acquisition in crisis; such maps accelerate crisis response process by allowing relief workers to oversee the disaster area and its surroundings [2], and to anticipate possible acceleration of the crisis. Traditional IT approaches addressed inter-organizational information accesses over boundaries, i.e. most of the dynamic maps were built based on a centralized design principle, with information needs satisfied by bundling information from heterogeneous databases [3]. However, information needs during a crisis response cannot always be predicted and a need may be short lived. How a disaster progresses is due to many things such as weather conditions or storage situations. The older ccentralized design principle lacks the flexibility and adaptability to deal with rapidly changing information needs and incoming data. Changes in information needs due to the changing nature of and the diversity of types of crises may lead to a need to redesign a complete application. Traditional dynamic maps provide uniform crisis information for all involved relief organizations, which is difficult for any one organization to select and retrieve information that is relevant for their rescue activities.

There is a need for a fast and extremely flexible information platform, enabled by advanced information technologies that share, integrate, and effectively use information to provide a personalized picture of the crisis development to involved relief organizations, and that can be used to turn the information into actionable decisions quickly and effectively. We propose a plug-and-play service architecture for personalized, situation aware information retrieval and access based on a component-based and service-oriented design principle that can be used to satisfy flexibly information needs in a dynamic crisis situation, while simultaneously being able to adapt to and use the available information and communication technologies. This new service architecture allows crisis response applications to be quickly reconfigured to meet the personalized information needs in a dynamic crisis situation by plugging and playing required services or components according to the perceptions of crisis situation. We believe this approach provides a new way to think about retrieval of time critical, personalized information during the process of crisis response.

The concept of personalization is explained in the next section. Our research approach is explained and discussed in section 3. The example scenario presented in this section is taken from an ongoing EU research project. Conclusions and future research idea are presented in section 4.

2. PERSONALIZATION

According to [11], information can be personalized based on an individual or a group of individuals. State of the field also shows two research trends, individualization and role-based personalization. The underlining solution for both is to predefine options by analyzing users' information needs, and categorizing and classifying users into different groups of interests based on the user profiles. The concept of individualization appears mostly in the field of e-commerce, where the user's individual interests and preferences are stored and updated as user profiles that are used to tailor the commercial interactions between a business organization and an individual user [11]. In the field of crisis response in container terminals, role based personalization is the main concern since an individual's personal interests and preferences may not influence their information needs. An individual's information needs are decided by the roles they adopt in a specific crisis situation. Therefore, in our research, the categorization and classification of the users mostly depend on their roles in the crisis response process, i.e. role based information personalization rather than individualization.

However, role based personalization, even with the help of advanced user profile techniques, is not sufficient to reflect users' actual needs in a crisis because a user's actual needs are decided by the role a user adopts in the crisis response and his current situation. Role based information needs are relatively stable, while situation may dynamically change these information needs as a crisis develops. Therefore, in our research, personalized information retrieval and access means retrieving and accessing a user's role relevant and his or her situation adaptive information. In other words, personalized information retrieval and access during a crisis should be a process of adaptation, where application provides role relevant personalized information based on dynamically and automatically perceiving "elements in the environment along with a comprehension of their meaning and along with a projection of their status in the near future"[5] [6]. Endsley [5] provides a set of well defined concepts and a widely accepted Situation Awareness (SA) framework utilized across a wide variety of domains, and which we have applied in our SA process to provide situation adaptive information retrieval and access.

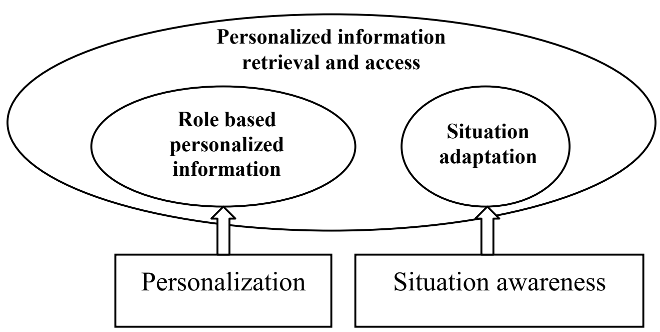


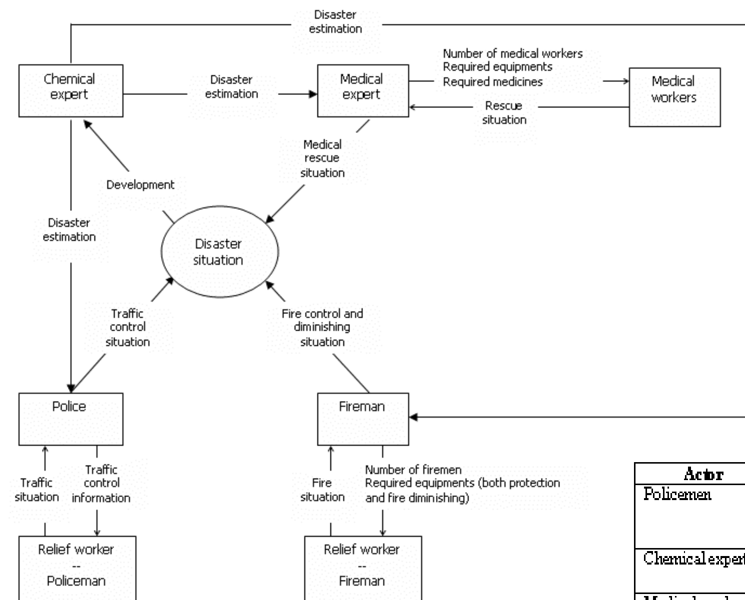
Figure 1: Personalization

3. THE APPORACH

In this section, we present our design idea for the process of designing a personalized situation-aware information retrieval and access service for a Crisis Response Team in an example scenario. The example scenario presented in this section is taken from an ongoing EU research project.

3.1 Example Scenario

"A fire brakes out in an area where millions of liters of oil and other flammable materials are stored" [2] is just a representative disaster taking place in a container terminal region. Since the fire might cause a series of unexpected crises, a fast and appropriate reaction is required to provide a better overview of the actions performed by, and the actions required of involved relief organizations, and that indicate the right scale for future action in a specific crisis situation. A Crisis Response Team (called CR team in the following discussion) must be set up to deal with crisis situations. Ideally the team will consist of chemical experts, fireman, medical experts, and police [2]. The core role of the CR team will be to estimate the scale of a disaster situation in order to decide the cooperative actions that the relief workers should take at the disaster site [2]. We present the activities of each relief organizations forming a CR team, and show the information exchanges between them in Figure 2.



Actor	Activities
Policemen	• Managing traffic, for instance closing roads • Managing public, keeping them away, evacuating • Managing water traffic, stopping ships
Chemical expert	• Estimate chemical disaster • Inform chemical disaster estimation to CR team
Medical workers	• Bring victims to hospital
Firemen	• Stop fire • Relief victims from fire

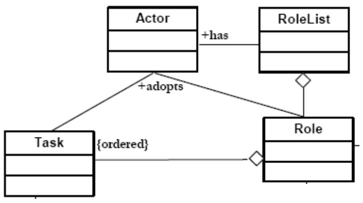
Figure 2: Relief Organizations in CR Team

3.2 Plug-and-Play Architecture

Since crises are different from one to the other due to different causes, circumstances, involved actors, and unpredictable factors, satisfying fast changing information needs, and quickly reconfiguring information search applications by plugging-and-playing available services or technical components is a natural answer to this need for complex, changing and on time information.

- *Functional Decomposition*

The first step to build a plug-and-play service architecture is to find a reasonable way to design small, implementable, reusable and replaceable technical units, or services. Since crisis response is a process, where involved actors, i.e. relief organizational units have to adapt their roles to changing circumstances to deal with the crisis cooperatively, we assume that each *actor* has a Rolelist defining the *roles* it can adopt, in which situation it is required to adopt which role. Roles reflect the essential functions that an actor needs to perform [9]. Actors adopt one of their roles based on their perceptions of a *situation*. Adopting a specific role, actor performs a series of *tasks* to achieve the fulfillment of a function. Tasks are activities an actor may perform when it adopts one of its roles. Based on this premise, we formulate the roles and their tasks for each actor in a CR team. Here we present the roles and tasks for the chemical experts in a CR team as an example, see Figure 3.



Actor	Role	Tasks
Chemical expert	Chemical information provider	**TC1:**Get chemical type
		TC2:Get chemical storage amount
		TC3: Get chemical storage location
		TC4: Get building map
	Chemical disaster estimator	**TC4:** Get chemical fates model
		TC5: Get chemical reaction formulations
		TC6: Get historical stochastic model
		TC7: Update historical stochastic model
		TC8: Provide disaster estimation
	Chemical information seeker	**TC9:** Get unavailable chemical information

Figure 3: Actor, Role and Task

The same kind of formulations can be applied to other actors in a CR team--police, medical experts, and fireman, see Figure 4.

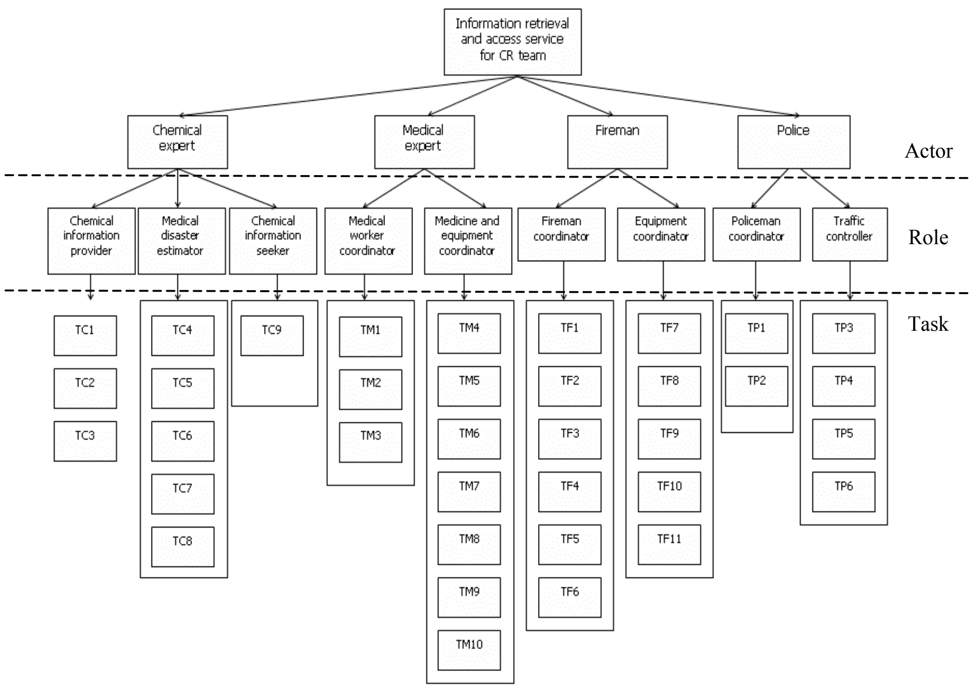


Figure 4: Functional Decomposition

- *Service Constitution*

The information retrieval and access service for the CR team can be constituted by grouping a series of tasks performed by the involved actors adopting their roles. In the example scenario, to estimate the chemical disaster caused by the fire, the following tasks are dynamically linked to constitute the service "Chemical Disaster Estimation" shown in Figure 5. The service constitution process is dynamic because the detection of required tasks depends on the perceived crisis situation. For instance, if chemical type and its storage location are known from the initial disaster information reported by a relief worker at the disaster site, it is not necessary to retrieve the information from Chemical storage database. Therefore, TC3 and TC1 are not required in the service "Chemical Disaster Estimation".

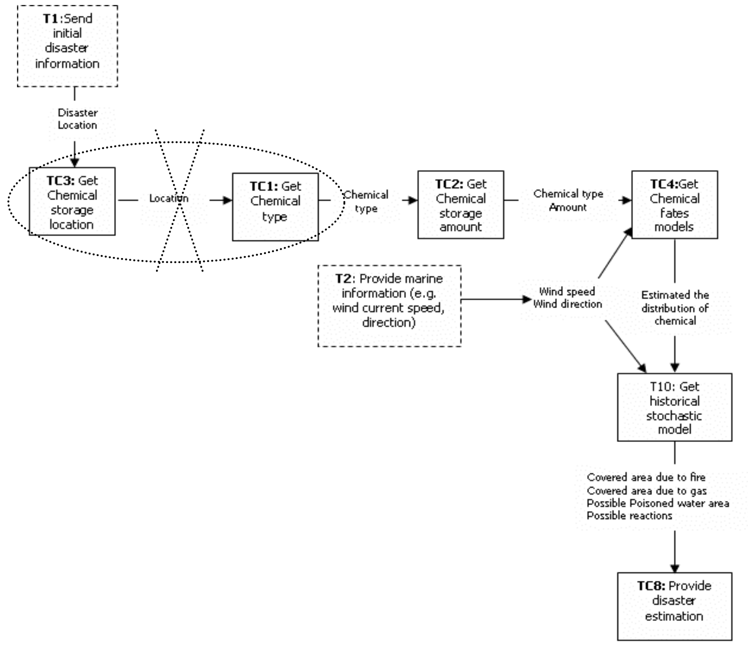


Figure 5: Service of Chemical Disaster Estimation

The composition of services formulates a new service, which can also be stored and reused if a similar situation arises. The information retrieval and access service for the CR team is constituted by grouping a series of tasks or services in a specific order.

3.3 Situation Adaptation

Obviously, situation is the key element used to determine the linkages of the services or tasks required to generate the personalized information retrieval and access services. It is not feasible to specify all possible crisis situations and required services and tasks for different crises, automatically detecting situations and finding solutions based on collected historical usage data is required.

- *Situation & Scenario*

Situation is defined in Merriam-Webster [6] as "relative position or combination of circumstances at a certain moment". In [4], situation is defined as "the combination of circumstances at a given moment; a state of affairs". From these definitions, we can say that, situation is describing "where, what happened at when, and who are involved". To retrieve and operate, it is necessary to describe situation in an implementable way, i.e. an enumerative manner. The term situation is used in our research as the tuple of {fact, constraints, time, place}. Fact is "what happens". Constraints can be "time-related constraints", or "space-related constraints", or "functional-related constraints" or derived constraints. Time and Place cover when and where a crisis happens/happened. *Fact, Constraints, Time* and *Place* constitute the *Situation Identifier*. An example is given in Table 1.

The situation identifier is used to detect the situation when a crisis happens. However, it does not include directly narrative descriptions of the actions of the involved actors and their interactions. Therefore, the situation identifier is not sufficient to link a detected situation with required services and task. To solve this problem, the concept of *scenario* is required, this is used to describe concrete pieces of stories and how the different involved actors cooperated, i.e. the role they adopted, the tasks and the process they performed, and the resources they consumed. Thus, a scenario is described in our research as the tuple of {Actor(Role), process, task, resource}. We regard composition of scenarios to be the solution of a given problem formulated in a perceived situation. Therefore, there is a database, in which the historical information for the CR Team shown in Table 1 is stored.

Table 1: Historical Data

Situation identifier					Scenarios				
Time	Place	Fact	Constraints		Scenario	Actor (Role)	Process	Task	Resource
12:22 Dec 2, 2004	Area a	A fire	Meteorological	• Wind speed: 20km/h • Wind direction: west to east • Current speed: 15km/h • Current direction: west to east	Scenario (1): chemical disaster estimation	Chemical expert (chemical disaster estimator)	P(x)	"chemical disaster estimation service"	DB-chemical storage
			Space	Road f, g are not accessible	...	...	...	...	...
			Functional	• Fireman to put down the fire Chemical expert to estimate the disaster • Police to control the traffic • Medical workers to rescue the victims	...	...	...	...	...
			Derived	Fireman is required to reach the site within 10 minutes Fireman should go into the disaster site before medical workers	Scenario (n): delay estimation for medical workers	Medical expert (medical equipment coordinator)	P (y)	TM3->TM10	DB medical workers

- *Situation Awareness & Adaptation*

In our example scenario, if the fireman cannot reach the disaster area on time, the chemical expert requires a delay time for the fireman to re-estimate the extent of the disaster. Scenarios of "delay estimation for the perceived fireman" and "chemical disaster estimation" are detected based on the historical data shown in Table 1. If perceived information from the situation shows that "fire expansion to an area where some chemicals are stored, which will not cause chemical reactions (Situation x1)", required tasks are detected, and linked to execute a disaster re-estimation process, shown in Figure 6(a). It is possible that the scenario "fire expands to an area where some chemicals are stored, which will cause the chemical reactions" will arise (Situation a (2)), if this happens the tasks of the response team will change, the linkage will be different, see Figure 6(b).

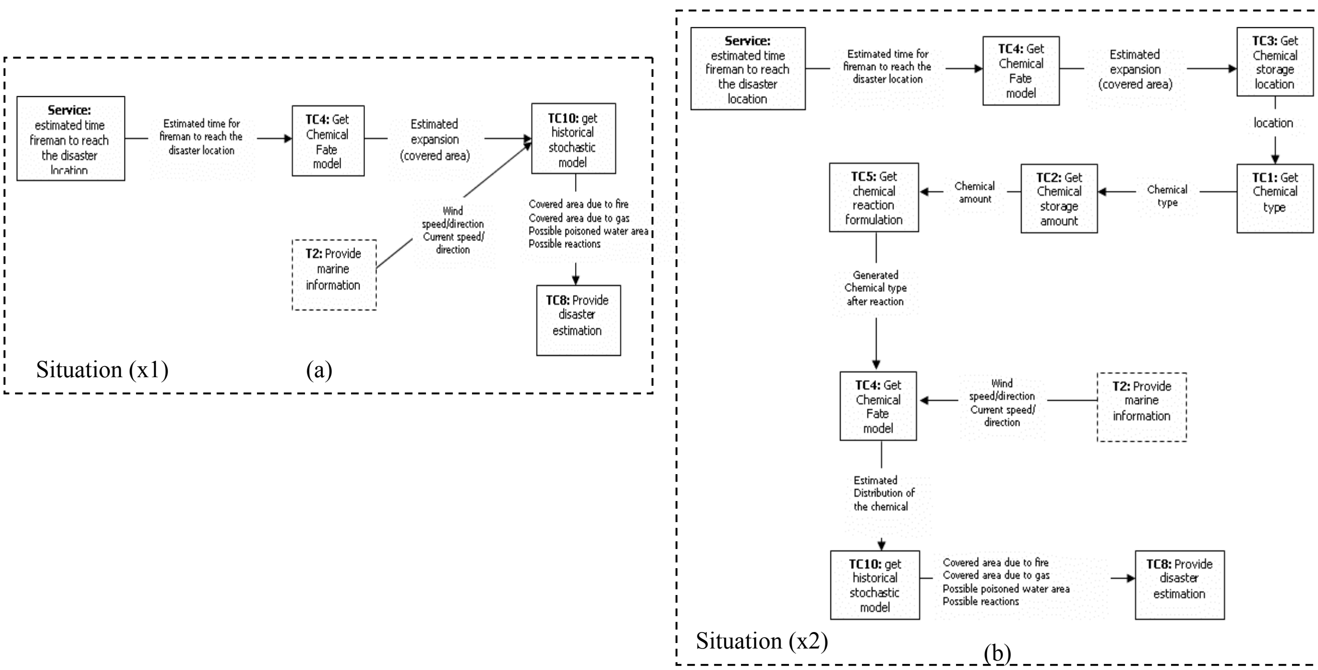


Figure 6: Situation Awareness & Adaptation

3.4 Sketch Implementation

Currently, a prototype is under development to support information retrieval and access in the context of crisis response. We will develop a harbor crisis management and response portal based on our design idea. The portal will be a place where relief workers can search for, and find information relevant to their role based information needs. There will be three basic functional modules: *Browser*, *Process Editor* and *Updater*.

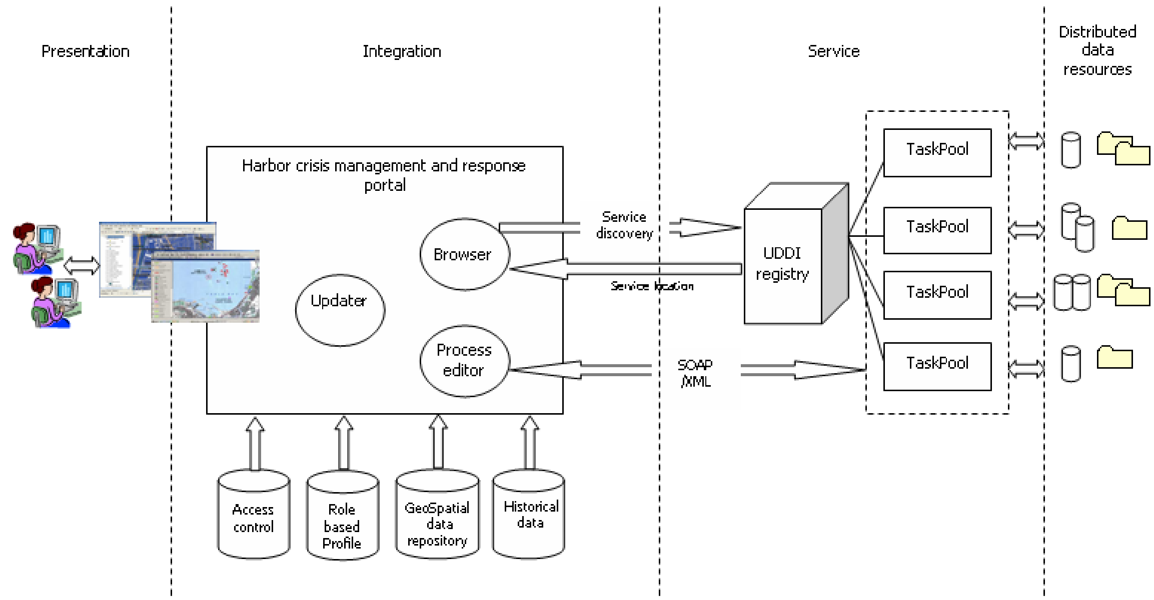


Figure 7: Sketch Implementation

Relief workers can browse in the Browser when a disaster is detected. The Browser will provide the relief workers with all the relevant services and tasks required to handle the crisis based on the historical data and role based profiles. Browser will communicate with a UDDI registry, where each actor registers its tasks, to find the locations of the tasks. The Process Editor will allow the relief workers to constitute their personalized information retrieval and access, by picking up and linking the required tasks or services in a specific order. Tasks will be invoked using SOAP. The Updater is used to update historical data when a new crisis situation has been detected and a solution is found. The GeoSpatial data repository is used to transfer information into suitable formats to be displayed on GIS maps.

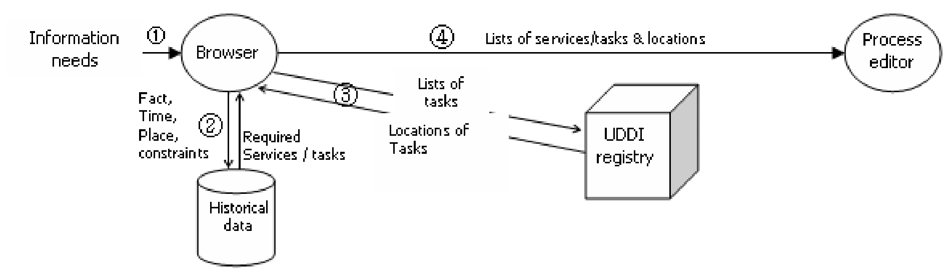


Figure 8: Browser and Process Editor

The proposed interface is shown in Figure 9. Since crises are unpredictable in nature, it is possible that external actors, which are not stored in the system, will be involved in the process of crisis response. Our approach allows new actors to be added by configuring their roles, tasks and applied scenarios. New scenarios and new situations will be added to the historical databases by configuring the required elements respectively.

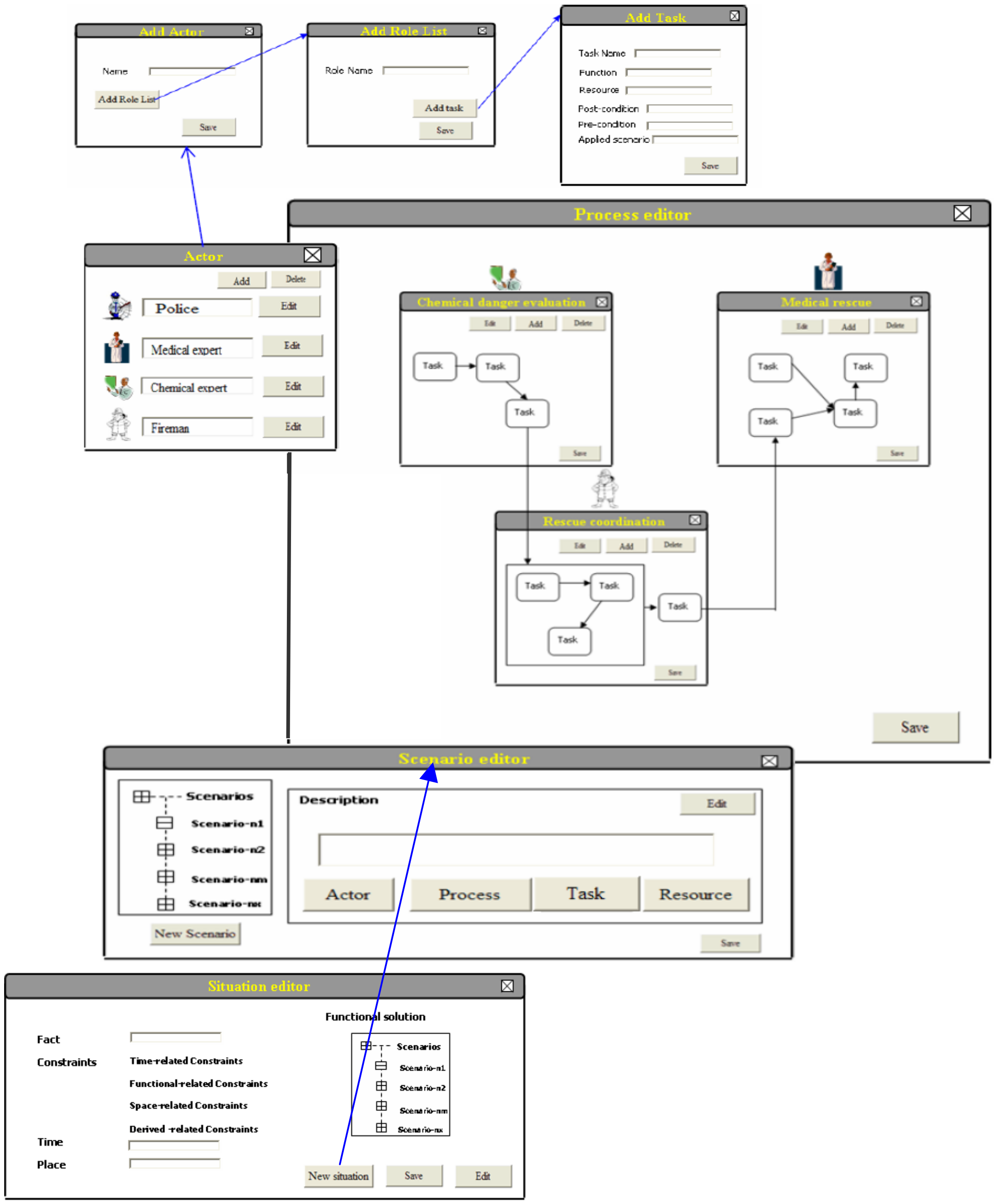


Figure 9: Proposed Interface

4. CONCLUSION & FUTURE WORK

In this paper, we presented a new way of thinking about personalized, situation aware information retrieval and access during crisis response in a container terminal, based on a component-based and service-oriented design principle. This should allow us to realize independent service implementation and service modeling, and to integrate the high level of personalized information with a low level technical availability.

Our new service architecture provides the possibility to quickly configure information acquisition applications for crisis response in a container terminal by choosing the required "plug-and-play" services or tasks. This will increase the reusability, flexibility, adaptability and scalability for personalized information retrieval and access services.

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