A COLLABORATIVE RESILIENCE MANAGEMENT - SUPPORT SYSTEM FOR CREATING DISASTER EXERCISE SCENARIOS -

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Abstract

Widely applied across many sectors, disaster training and exercises are pre-embedded within a society, serving as a driving force for strengthning its resilience. To improve the efficiency and effectivenss of this traditional system for enhancing societal resilience, we propose a framework to describe disaster contexts as a foudation for creating as well as sharing new disaster exercise scenarios. We also present a support system for collaboratively creating exercise scenarios using our context model.

1 INTRODUCTION

Disaster training and exercises serve an important function by enhancing the resilience of a society against natural and man-made disasters. This is because they entail a *learning* process that is expected to not only improve disaster *response* abilities but also to provide *monitoring* opportunities to identify flaws and inadequacies in an emergency response system. The preparation of scenarios for training and exercises also requires proactive *anticipation* and speculation about possible disaster situations, as well as developing countermeasures. Moreover, given that the periodical implementation of training and exercises is mandatory within many sectors, these are already embedded within society, serving as a driving force for applying the "plan-do-check-act" (PDCA) method within resilience management. However, to date, reported achievements have not been as significant as expected. Rather, while considerable efforts have been invested in training and exercises, their effectiveness has been limited. One of the reasons for this lack of effectiveness is that insufficient attention has been paid to how to efficiently create effective scenarios. In fact, the quality of the scenarios is highly contingent on expertise, and the design of scenarios entails high costs and extensive person-hours. Another problem that hinders ongoing improvement of the quality of exercises is that in Japan, at least, it is uncommon for organizations to share their knowledge and experiences, acquired through the preparation and execution of training and exercises, with other organizations. To solve these problems and optimize the function of disaster training and exercises as a driving force for enhancing society's resilience, we believe it is necessary to develop a standard framework and methodology for creating effective exercise scenarios, as well as sharing new knowledge among different organizations that can promote collaborative resilience management. In this paper, we propose a disaster context model that provides a framework as a foundation for describing actual and imaginary disaster contexts and creating and sharing new exercise scenarios. Employing this context model, and taking a hospital as an example, we further propose a support system for the collaborative creation of exercise scenarios.

2 DISASTER CONTEXT MODEL

We first propose a disaster context model. In this paper, a disaster context refers to the settings of the component physical and functional elements of a disaster situation that relate to response activities and relationships among the elements. A disaster context also refers to temporal changes in the settings of each component. Based on our review of past disaster exercise scenarios, reports on past disasters, and published personal notes on actual disaster experiences, we extracted three major constituent elements of a disaster

context: situations, tasks, and problems. A schematic illustration of the disaster context model is shown in Figure 1. A scene refers to a snapshot of a context at any point of time. A changing disaster context is represented by a set of scenes with different statuses of the components constituting the context. Using the example of a hospital setting, we discuss the details of each component.

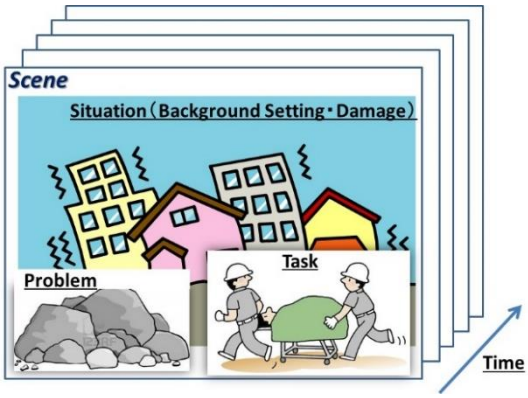

Figure 1. *Disaster Context Model*

2.1 Situation

A situation model describes the status and conditions of objects and actors in relation to a disaster scene. A situation is formalized according to the frame model, and is described as a set of slots and attribute values. This is based on the service context model developed by Kanno and Furuta, (2010) which summarises an environmental context and the background settings, service providers, service recipients, and tools, as well as the interactions among them. In a hospital setting, the environmental elements include hospital wards, buildings and premises, as well as information related to the weather and time. Medical staffs, namely, doctors and nurses, are the service providers and in- and out-patients are the service recipients. Tools include hospital facilities and various medical devices. Figure 2 presents examples of component patient and room models within the situation model in the format of XML schema. We can represent various types of patients and disaster situations using these component models.

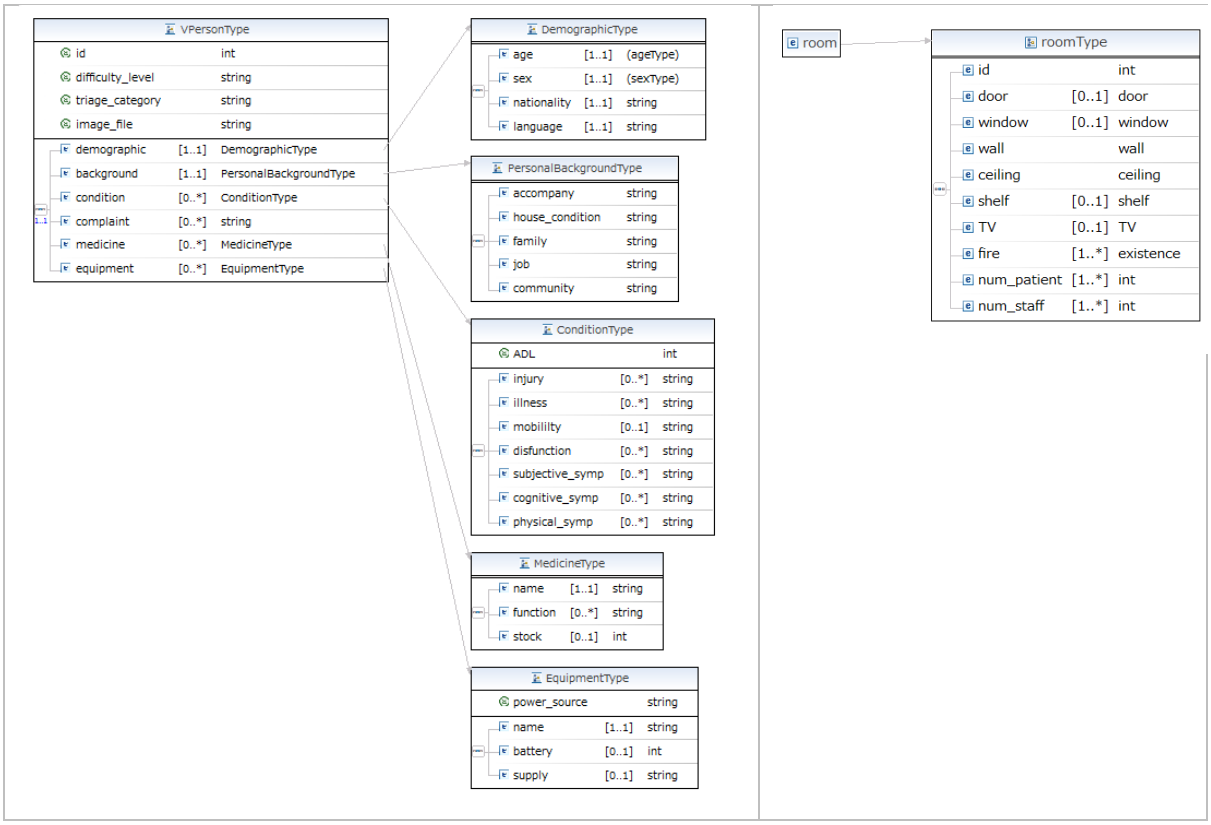

Figure 2. *XML Scheme of Patient (Left) and Room (Right)*

2.2 Task

A task comprises a response action or series of actions required to cope with a disaster situations. These are formalized within a simple sequential task model. In a hospital setting, tasks need to be performed in response to disaster situations occurring in and around a hospital, for example, confirming and securing patients' safety, evacuations, and triage. The tentative task formalization used in a prototype system, is shown in Table 1.

Table 1. Formalization of the task model and its descriptions

ID	Trigger event	Task /Description	Precedent task	Succeeding task	Actor	Workforce	Tool& Resource
1	-	Check Injury	-	1	Doctor/Nurse	1-	-
2	Fire	Fire fighting	-	-	Anyone	1-	Extinguisher, hydrant

2.3 Problem

A problem prevents responders from accomplishing tasks as planned or desired. Problems include task constraints such as resource shortages and obstacles that emerge in specific disaster situations. These relates, for example, to wall collapses, water leakage, fires, and unavailability of lifelines. Problems are associated with tasks and are described within a relational database.

3 PROPOSED METHOD FOR CREATING NEW CONTEXTS

Our second proposal concerns a method for semi-automatically creating a new imaginary disaster context that can serve as an assumption for disaster training and exercises. We developed a prototype support system based on the disaster context database containing relevant data extracted from reports on past disasters and many personal notes published on disaster experiences (e.g., Kesen-numa City Hospital, 2011; Japanese Nursing Association, 2011).

3.1 Procedures for Creating a New Disaster Context

The procedures for creating a new scenario using the proposed system is as follows:

1) Entry of basic assumptions: The first step for the user is to compile basic information on the hospital and background settings for an exercise such as the season, weather, time of disaster, and numbers of staff and patients. The user can also enter specific sets of values for some slots in the situation model such as unavailability of a lifeline and a fire in a patient's room, depending on the purpose of the exercise. The user should also select training tasks from the database, or create new tasks using the task model, and specify the starting time for each task within the created context.

2) Outputting: The system assigns values to the remaining slots in the situation model considering the consistency of their combination and creating a complete initial situation. Subsequently, the system enables changes to be made to the initial situation. Four basic modes of situation change were implemented: static, escalation, de-escalation, and cyclic change. If the user were to select one of these modes for the target slot, then the system would assign appropriate values for creating a changed situation. Additionally, the system would search for candidate problems in the database, considering the background situation of the task.

3) Edit: Because of a fundamental limitation of the frame model relating to the handling of consistency among the values, we would expect users to find and modify inconsistencies in the output context. Additionally, users could edit the details of the scenario contents, depending on their needs. This enables the creation of assumptions extending beyond the model.

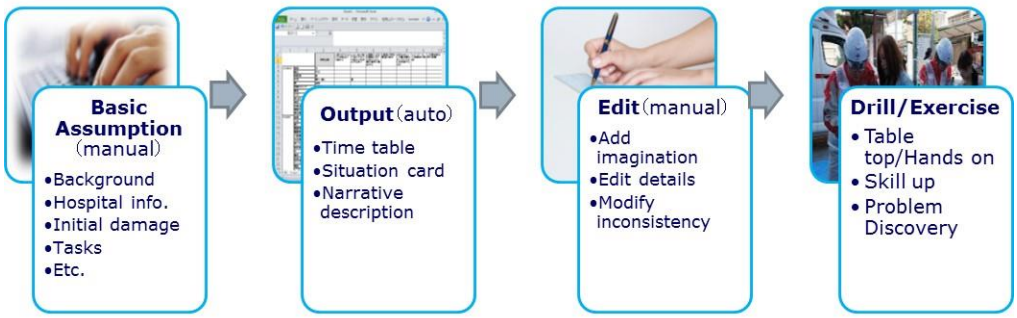

Figure 3. *Procedure for creating a new context using the proposed support system*

3.2 Output Examples

We constructed a situation model using information on an actual hospital and created some imaginary disaster contexts using the proposed support system. Figure 4 shows a section of the disaster context created by the system. The first and second columns in the figure contain the constituent elements of a situation and the rest of the columns show the values for each element, with each column corresponding to a single scene. Figure 5 shows potential problems that are inherently associated with the created disaster context.

Ward1	air conditionner	UNAVAILABLE	AVAILABLE									
	water suply sys	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE
	sewage system	AVAILABLE										
	speaker	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	AVAILABLE						
	fire extinguisher	AVAILABLE										
	medical gas	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE
	EMIS	AVAILABLE										
	water	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP
	sewege	STOP	STOP	STOP	PARTLY_STOP	PARTLY_STOP	PARTLY_STOP	PARTLY_STOP	NO_DAMAGE			
	electricity	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	STOP	PARTLY_STOP
	gas	STOP	STOP	STOP	STOP	PARTLY_STOP	NO_DAMAGE					
	telcommunicatic	UNAVAILABLE	UNAVAILABLE	AVAILABLE								
	emergency pow	AVAILABLE										
	sattelite phone	AVAILABLE										
	emegency radic	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	UNAVAILABLE	AVAILABLE				
	elevator1	STOP	STOP	STOP	STOP	STOP	GO					
	elevator2	STOP	STOP	STOP	GO							
	elevator3	STOP	GO									
	elevator4	STOP	STOP	GO								
Lobby(1F1B-1)	window	WELL										
	wall	WELL										
	ceiling	CRACK										
	TV	WELL										
	Fire	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Room1(1F1B-1)	door	CAN_OPEN										
	window	WELL										
	wall	WELL										
	ceiling	CRACK										
	shelf	FALL_DOWN_INSIDE										
	TV	WELL										
	instillment	WELL										
	central piping	AVAILABLE										
	nuse call	AVAILABLE										

Figure 4. *Example of a disaster situation*

road16	**unavilable**								**unavilable**		
road17		**unavilable**		**unavilable**							
road18			**unavilable**						**unavilabe**		
road19	**unavilable**		**unavilable**					**unavilable**			
road20	**unavilable**			**unavilable**							
medical	**in shortage**										
stoma											
bandage											
gauze		**in shortage**									

Figure 5. *Problems related to a disaster context*

4 DISCUSSION

As discussed in the Introduction, given their functions of improving response abilities, identifying problems, and facilitating learning through simulation, disaster training and exercises constitute a pre-existing resilient management system. The preparation of exercise scenarios for the exercises also provides an opportunity to

anticipate possible disaster situations. In an increasingly unpredictable world, the challenge we face is how to make this traditional system more effective and efficient. In this paper, we have proposed a collaborative approach that applies PDCA exercises to resilience management. This entails the use of a standard framework for describing disaster contexts and a support method for creating new exercise scenarios using a shared database that is created according to this framework. The sharing of the disaster context database which includes data such as new potential problems that have been identified through the exercises among different hospitals and relevant organizations, and its updating done on a collaborative basis by these organizations, enables them all to effortlessly use this knowledge in the creation of new exercise scenarios. This system is expected to accelerate the PDCA cycle for enhancing society's resilience. Knowledge sharing and the collaborative creation of exercise scenarios through the application of this system are illustrated in Figure 6.

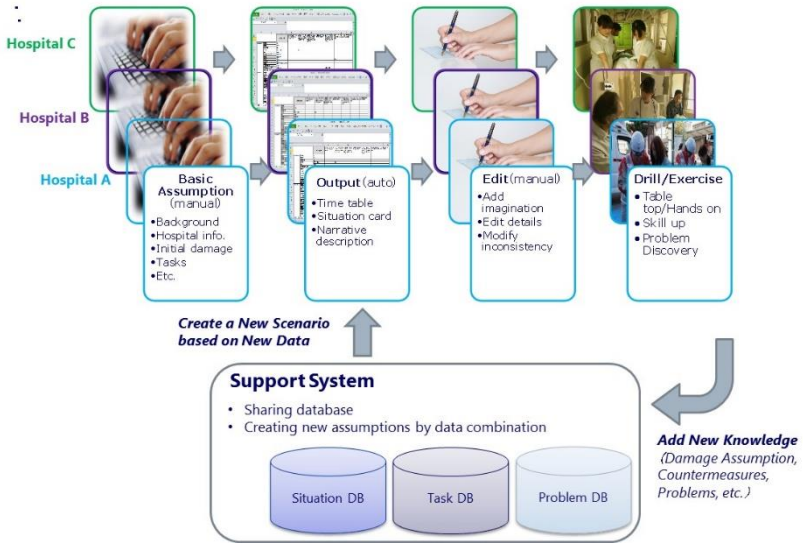

Figure 5. *Collaborative creation of exercise scenarios*

5 CONCLUSION

In this paper we have presented a disaster context model that provides a standard framework for detailed description of disaster situations that can be used as assumptions in the scenarios developed for disaster training and exercises. We have also presented a support system for creating new imaginary disaster contexts for an actual hospital-based disaster using the context database and providing some output examples. This system is expected to promote the adaptation of PDCA exercises for collaborative resilience management through the provision of the above framework, and to facilitate the sharing of new knowledge and experiences obtained within different hospitals and organizations. The following conclusions emerge from this study:

- The proposed disaster context model provides a standard framework that can describe assumptions for exercise scenarios, thereby providing a foundation for knowledge sharing. For example, it can be used as a model for constructing a database for disaster contexts.
- The proposed support system for creating exercise scenarios is expected to reduce costs and effort, thus enhancing efficiency in exercise preparation.
- The algorism used to create a new imaginary situation, which is mainly a random combination, is free from bias in the anticipation of possible disaster situations.
- The proposed support system is an open system in which the output projections are not restricted to the model.
- Because disaster exercises and training are mandatory, and are periodically conducted within many organizations, the sustainability of their implementation is assured.
- The collaborative creation of disaster exercise scenarios, based on our proposal, is expected to accelerate the PDCA cycle for enhancing society's resilience.

Acknowledgements

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