Structural Design of HRA Database using generic task for Quantitative Analysis of Human Performance

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1. Introduction

It is recognized that one of the significant factors causing incidents or accidents is the human errors of operating personnel working in the main control room of nuclear power plants. In order to reduce human errors, therefore, all information on the human errors taken by operators in the power plant should be systematically collected and examined in its management. Korea Atomic Energy Research Institute (KAERI) is carrying out a research to develop a data collection framework to establish a Human Reliability Analysis (HRA) database that could be employed as technical bases to generate human error probabilities (HEPs) and performance shaping factors (PSFs) [1][2].

This paper describes a design of generic task based HRA database for quantitative analysis of human performance in order to estimate the number of task conductions. The estimation method to get the total task conduction number using direct counting is not easy to realize and maintain its data collection framework. To resolve this problem, this paper suggests an indirect method and a database structure using generic task that enables to estimate the total number of conduction based on instructions of operating procedures of nuclear power plants.

2. Generic Task Database based on Operating Procedures

The HRA database is a storage which maintains all human performance data gathered from plant operating experiences or full-scope simulations [3]. To calculate HEP from human performance data that performed by simulated experiments, the number of human errors occurred on experiments and total number of tasks conducted are required for HEP calculation. In general, the measuring total number of task conductions is difficult because the whole operation logs of each experiment should be examined by the HRA analyst while the number of conduction errors can be easily counted from the experimental reports [4].

The estimation method to get the total task conduction number using direct counting is not easy to realize and maintain its data collection framework. To resolve this problem, we suggest an indirect method and a database structure that enables to estimate the total number of conduction based on instructions of operating procedures of nuclear power plants.

In order to measure the total number of task conduction during emergency situations, we designed essential table schema to the generic task database which store standardized generic tasks that extracted from each instruction of operating procedures, procedure lists to include the relations between each steps and global unique index to the generic task and generic task tree structure for visualizing to the user interfaces, and other supporting tables.

Fig.1 and Fig.2 represent the flow diagram of generic task database and ER diagram of the tables in the database. The Fig.1 shows the overall structure of the database and its application that linked to the external user interfaces for HRA analysis. Especially, the Fig.2 shows the ER (entity-relationship) diagram of essential tables of generic task database. As seen in the Fig.2, the Generic_Task_Details table is connected to the Procedure_List table and Generic_Task_Tree table using the GT_ID which is the unique identifier that representing the detailed step task information.

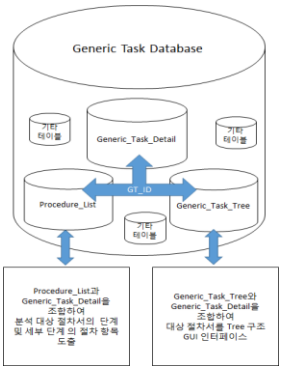

Fig. 1. Generic Task DB Structure and Application

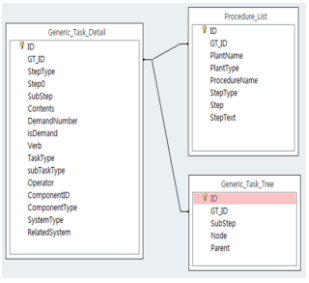

Fig. 2. Entity-Relation Diagram for Generic Task DB

To assume required task numbers for conducting emergency operations, whole instruction steps on emergency operations were classified into detailed tasks and inserted into the generic database through these all important tables and user interfaces. The following

sections represent the detailed description of essential tables.

2.1 Generic Task Detail

Generic_Task_Detail is the main table that contains standardized generic task information extracted from each instruction of operating procedures to estimate required total number of conductions performed by operators in emergency situations. The followings are detailed field and field property of the Generic_Task_Detail and Table1 shows an example data entry of the table. As seen in Table1, each row has the task properties of the detailed instruction described in emergency operating procedures.

- GT_ID: generic task identifier
- Step: task step number
- SubStep: subtask step number
- Contents: task contents
- DemandNumber: required demand count to be performed by the operator
- TaskType: type of the task
- SubTaskType: type of the Subtask
- Operator: related operator
- ComponentID: related component ID
- SystemType : type of system
- RelatedSystem: related system

Table 1. An Example of Generic_Task_Detail

ID	GT_ID	Step Type	Step	SubStep	Contents	Demand Number	Task Type	Sub Task Type	Operator	Comp ID	Comp Type	System Type
1	1	N	1	0-	원자로트립을 확인한다	1	RI	Entering	SS			
2	1	N	1	0-cb-1	모든 제어봉 바닥등: 켜짐	1;1	RI;CS	Information; Indicator	RO			
3	1	N	1	0-cb-2	RX TRIP BKR 및 우회 BKR : 개방됨	1;1	RI;CS	Information; Indicator	RO			
4	1	N	1	0-cb-3	PR 중성자 속:감소중	1;1	RI;MP	Information; Trend	RO			
5	1	N	1	0-cb-4	IR 중성자속:감소중	1;1	RI;MP	Information; Trend	RO			
6	1	R	1R	R0-[1]	수동으로 원자로를 트립시킨다	-	-	-				
7	1	R	1R	R0-[1]-cb-1	SF-HS-319	1;1	RI;MA	Manipulation ;Pushbutton	RO	SF-HS-319	Control Rod Drive	RPS
8	1	R	1R	R0-[1]-cb-2	SF-HS-309	1;1	RI;MA	Manipulation ;Pushbutton	RO	SF-HS-309	Control Rod Drive	RPS
9	1	R	1R	R0-[2]	만일 원자로가 트립되지 않으면 회복-3.1 (원자로정지불능시조치) 단계 1.0으로 간다	1	RI	Procedure	SS			
10	2	N	2	0-	TBN TRIP을 확인한다	1	RI	Entering	SS			
11	2	N	2	1-	모든 TV:닫힘	-	-	-				

2.2 Procedure_List

The Procedure_List include the relations between each step of procedures and global unique index to the generic tasks. It enables an actual linking to the required generic_task_detail from the procedure list. As a connection table between Generic_Task_Detail and each task steps of emergency operating procedures, procedure_List has the properties of GT_ID, PlantName, PlantType, ProcedureName, StepType, Step and StepText. The followings are detailed field property of the Procedure_List and Table2 shows an example data entry of the table.

- GT_ID: generic task identifier
- PlantName: the plant name
- PlantType: the plant type
- ProcedureName: the name of the emergency operating procedure
- StepType: type of step
- Step: step number
- StepText: step caption

Table 2. An Example of Procedure_List

ID	GT_ID	PlantName	PlantType	ProcedureName	StepType	Step	StepText
1	1	Hanbit1	WH	E-0	N	1	1
2	1	Hanbit1	WH	E-0	R	1	1R
3	2	Hanbit1	WH	E-0	N	2	2
4	2	Hanbit1	WH	E-0	R	2	2R
5	3	Hanbit1	WH	E-0	N	3	3
6	3	Hanbit1	WH	E-0	R	3	3R
7	4	Hanbit1	WH	E-0	N	4	4
8	4	Hanbit1	WH	E-0	R	4	4R
9	5	Hanbit1	WH	E-0	N	5	5
10	5	Hanbit1	WH	E-0	R	5	5R

2.3 Generic_Task_Tree

The Generic_Task_Tree has a logical hierarchy of step node of GT_ID. It includes GT_ID, substep, node and parent of each nodes. The Fig.3 shows an example of the table data entry and a tree structure represented by graphical user interface.

ID	GT_ID	SubStep	Node	Parent
1	1	0-	1_0-	<<TOP>>
2	1	0-cb-1	1_0-cb-1	1_0-
3	1	0-cb-2	1_0-cb-2	1_0-
4	1	0-cb-3	1_0-cb-3	1_0-
5	1	0-cb-4	1_0-cb-4	1_0-
6	1	R0-[1]	1R_R0-[1]	1_0-
7	1	R0-[1]-cb-1	1R_R0-[1]-cb-1	1R_R0-[1]
8	1	R0-[1]-cb-2	1R_R0-[1]-cb-2	1R_R0-[1]
9	1	R0-[2]	1R_R0-[2]	1_0-

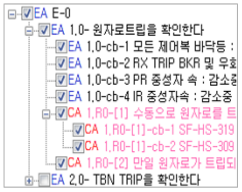

Fig. 3. Generic_Task_Tree Hierarchy

3. Development of Task Analysis User interface

To help the HRA analyst to effective counting for unsafe actions of operator's activity in an emergency situation, a graphical user interface based supporting system was developed. It extracts task properties from the generic task database and assists the HRA analyst to verify operator's actual tasks execution path during conduction of emergency operating procedure and to check the unsafe action from the lists of the executed tasks. The Fig. 4 shows an example of the user interface of the HRA analysis supporting system.

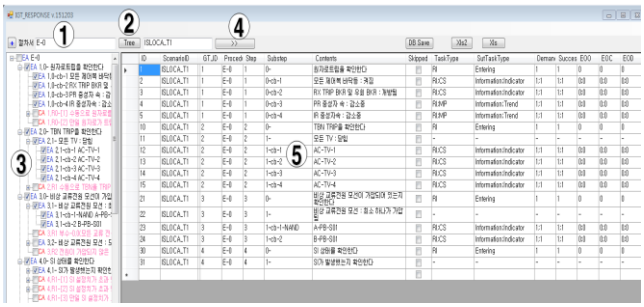

Fig. 4. An example of Human Reliability Analysis using HRA analysis supporting system

4. Conclusions

As a result of the study, the essential table schema was designed to the generic task database which stores generic tasks, procedure lists and task tree structures, and other supporting tables. To assume required task numbers for conducting emergency operations, whole instruction steps on emergency operations were classified into detailed tasks and inserted into the generic database through these all important tables and integrated HRA data analyzing user interfaces.

The number of task conduction based on the operating procedures for HEP estimation was enabled through the generic task database and framework. To verify the framework applicability, case study for the simulated experiments was performed and analyzed using graphic user interfaces developed in this study.

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