DEVELOPMENT OF THE ELECTRONIC SYSTEM FOR SAMG (SEVERE ACCIDENT MANAGEMENT GUIDANCE)

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In a nuclear power plant, there are many procedures and guidance that operators are using. One of them, "severe accident mitigation guidance" describes the procedures for the standards to be taken by operators in the case of a severe accident. In this regard, NPP related systems are digitalized and recent computer-based techniques are applied. Considering this trend, we have developed a computerized system for "severe accident mitigation guidance". In this study, recent applicable computer techniques, optimized software, and the related environment with operators are reviewed. In addition to computer data in which the content of the guidance is stored, the way to easily apply the cases of complementing or modifying and adding the contents of the guidance should be found as a long-term usage. The configuration of a limited computer screen was analyzed for speed and accuracy, the whole contents of guidance were analyzed and classified according to the operator's usage, and the DB schema was constructed. Based on this, all contents of guidance were saved on the database system, and using these, eSAMG(electronic severe accident management guidance) was developed. By running the eSAMG, the data and figures are connected directly on a single screen, and can be consulted for measurements. The developed eSAMG system can be a tool in rapid and accurate judgments under the tense situation of a severe accident, and can be ordinarily used in the training of operators. Later, the eSAMG system will be connected to SAMEX which is under construction, and to an optimal constructed support system for access management.

I. THE ANALYSIS FOR THE DEVELOPMENT

If a severe accident occurs in a nuclear power plant, the operator's quick and precise decisions and following actions are essential. The "severe accident mitigation guidance" describes the procedures for the measures to be taken by operators in the case of a severe accident, and a variety of spreadsheet and pasted data that need to be measured is included in printed form.

In SAMG (severe accident mitigation guidance), the emergency measures of the MCR operator are described that need to be used to maintain the safe control of a nuclear power plant (Ref. 1). During the progression of a severe accident, the operator's measurements at TSC (technical support center) are described in SAMG such as diagnosis of the NPP status, selection of the proper mitigation guidance according to the NPP status, monitoring and termination.

In this regard, those systems that have to be used in a nuclear power plant are digitalized, and the recent computer-based techniques are applied. Considering this trend, we developed a computerized system for "severe accident mitigation guidance" and studied the environment for such a system. The system, which can also be used for ordinary training, as well as for an accurate and rapid judgment and when it is difficult to refer to the instructions in printed form, it can be a new alternative to help operators take a quick mitigation during a severe accident.

In this paper, the eSAMG development is described. All contents are computerized, and in the case of a severe accident, the operator can make rapid decisions and measurements, and prevent errors. Thus, it is intended to mitigate the operator's burden and to advance the safety of a nuclear power plant.

I.A. The analysis of developing environments

To develop the eSAMG system, the developing environment including the DB and user environment are analyzed. In addition, the contents of the existing SAMG system, and its usage are also analyzed. The environments considered in common are as follows.

- It is operated in a windows system
- Only the eSAMG system installation without extra software is possible.
- The separation of a functional module and interface forces a later extension and cooperation
- It is necessary to construct for consideration of the utilization of the operator's train in the severe accident management

- The structural design for the later extension and supplement is necessary
- It needs to be developed through modularization according to the function

I.A.1. Software developing environment

The environments need to be analyzed for the development. This is described as follows.
- Target of services : OS for standalone PC
- OS : Windows series windows-XP and over
- Operating server : none
- Interface : interface construction for considering window desktop and portable PC
- Developing tool : Windows Visual Studio 2010 for functional maintenance later
- Developing language : Windows Visual basic 2010 for functional maintenance later
- Usage of WPF (windows Presentation Foundation) for visualization of screen interface and structural isolation from developing code (WPF : built-in system of windows visual studio)
- Database system : SQLite (imbedded type)

I.A.2. User environment

The environments need to be analyzed for users. This is described as follows.

- It needs to be operated in windows OS for a desktop PC and notebook
- Consideration of possible implementation for later Android OS
- Standalone installation and elimination of eSAMG (including database system)
- A network connection and communication of dynamic signal from controller or instrument of the reactor building is not considered
- Construction in consideration of simplification/mìnimalization of user input for special emergency conditions

I.A.3. Database construction environment

The environments need to be analyzed for the database system. This is described as follows.

- DBMS : File based free charge software, SQLite, which is verified for a mobile device
  + Included in the application program not in the server system
  + Easy for distribution and expansion (single file of DBMS, not to have independent server process)
  + Embedded type SQL DBMS engine suitable for medium and small scale use
  + DBMS which is basically loaded in Android OS

I.B. Analysis of guidance

To develop the eSAMG, SAMG contents of a standard NPP(nuclear power plant) were analyzed. The outline of the SAMG contents is as follows.
- Emergency guidance used in main control room : 2
- Control guidance : 1
- Procedural guidance
  + Mitigation guidance : 8
  + Monitoring guidance : 1
  + Temination of guidance : 1
  + Calculation/confirm table : many

Among the guidance, excluding emergency guidance, control guidance and procedural guidance are used in the TSC(technical Support Center). The results of the analysis are shown in table 1. As a result of the analysis, the process is controlled as a center of the control guidance. Thus, it needs to approach to each guidance as a center of control guidance, and also needs to be processed according to the strategy. Separately, the controlled monitoring of the background process type is needed to monitor the severe threatened variables in a reactor building. In addition, monitoring strategies are

processed according to the various confirmation tables of instruments and statuses in a reactor building, and the input values of the calculation table.

II. STRUCTURE AND DESIGN

In advance, a study of the eSAMG framework was processed and the usefulness of the implementation was prepared (Ref. 2). Through the above results of the analysis, we begin with the development of the control guidance, and the development of strategic guidance such as mitigation guidance is processed. Monitoring and termination of guidance are then developed in order.

TABLE 1. Classification of SAMG contents

Guidance Class (Data Type)	Step (TXT)	Number of Records (TXT)	Table (XAML)	Attachment (TXT, PDF)	Amount of DB (KBytes)
Emergency-01	26	139	5	5	454
Emergency-02	30	157	5	5	512
Control-01	34	34	-	7	111
Mitigation-01	14	70	5	5	228
Mitigation-02	12	62	6	6	202
Mitigation-03	12	66	7	12	215
Mitigation-04	13	61	5	7	199
Mitigation-05	62	245	16	13	800
Mitigation-06	12	63	4	8	205
Mitigation-07	47	182	13	11	594
Mitigation-08	14	72	6	9	235
Monitng-01	7	23	-	11	75
Finish-01	9	24	-	-	78
Total	292	1,198	72	99	3,914

II.A. Construction and DB design

The architecture of eSAMG is shown in fig.1. Including the control guidance, the functions of the whole guidance contents are applied, and the controlled procedures are then applied according to the additional function related to the functions of the confirmation and calculation tables. The calculation table and attached data of each guidance are connected (Ref. 3). All log data of real and training modes are recorded. Using these log data, all events are confirmed and analyzed later.

All contents of the guidance are saved in a database. Actions, calculation tables, confirmation tables, figures, concerning data, long-term concerning data and reference data are classified and saved for the shared utilization and connection of the functional module.

II.B. Menu structure and screen organization

The menu and screen organization were designed according to the functional classification and user convenience (Ref. 3). The representative screens and their contents are as follows.

- Beginning screen : login process, user information, summary review of each guidance
- Guidance process screen : flow-chart, main/sub menu, the contents of guidance, previous contents, subsequent contents, supplementary information, log information
- Additional screen (pop-up windows) : check of confirmation table, review of attached data, review of calculation table

At each screen, the major information such as the title, menu, date and time, are always displayed at the top position. All menus are implemented according to the control guidance, and the procedural guides are as follows.

- Severe threatened variables in the reactor building have to be monitored every 15 minutes using the designated confirmation table. If exceeded, stop the processed mitigation guidance and the corresponding mitigation guidance has to be processed at first which can reduce the severely threatened variables beyond the established values.
- Because the applicable means can be different from each nuclear power plant, the status of a nuclear power plant has to be confirmed through the designated confirmation table such as the status confirmation table. These matters have to be confirmed continuously regarding to the change of the plant status.

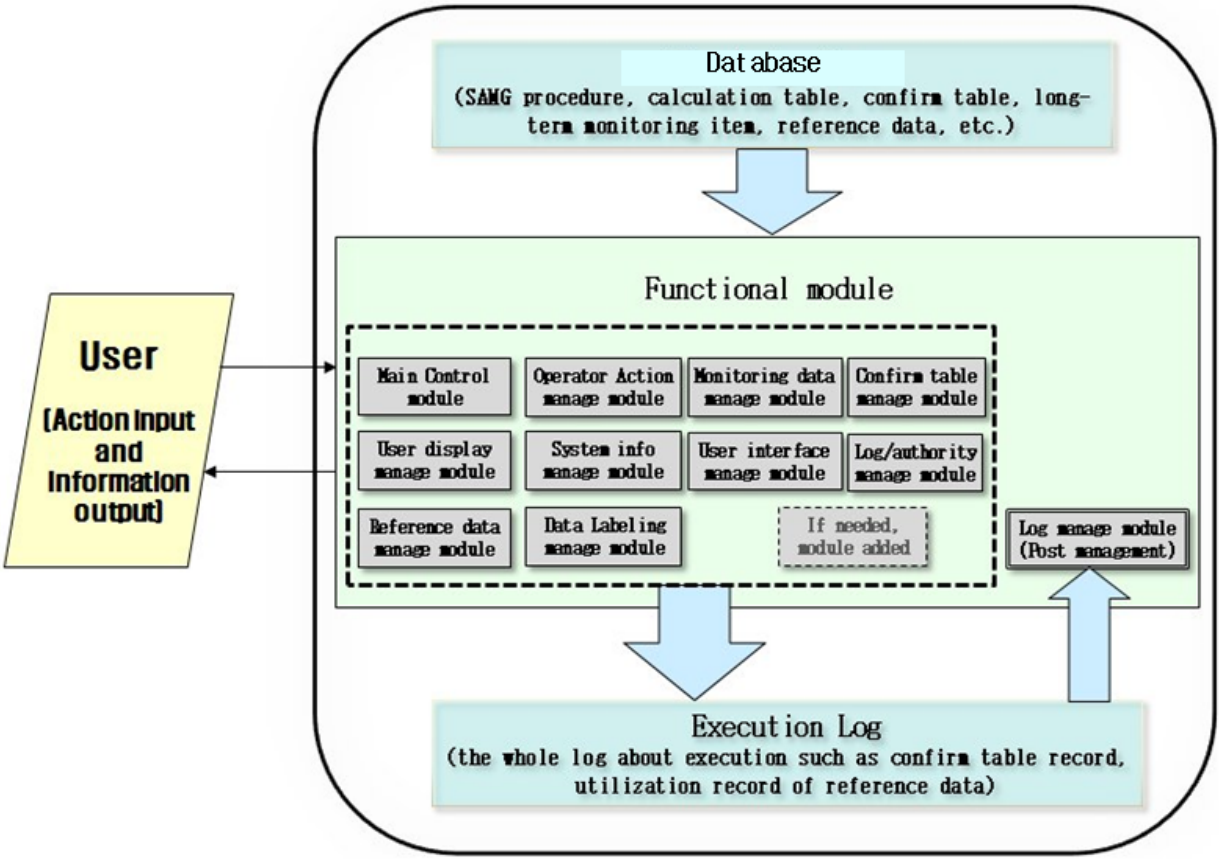

Fig. 1. Architecture of eSAMG system

III. DEVELOPMENT RESULT

Based on the analysis and design, the construction of the database and the implementation of the functions are produced. In addition to the SAMG native functions, additional functions are implemented.

III.A. DB Table Construction

All contents of SAMG are analyzed and the database is constructed according to the analyzed results. The function means the database is constituted of 8 tables as follows.

- LOG : Information about the log records during the operation
- DOCUMENT : Information about the data from guidance contents
- CHECKLIST : Information about the input data for the confirmation table

- MEDIA : Information about media data such as PDF file, image file, video file.
- USER : Information about the users
- FLOWCODE : Information about a flowchart within the control guidance
- LINK : Information about the key word link within the contents
- SETUP : Information about the application program

The SAMG contents split into detailed field according to their function, and are saved in database. In the case of a renewal of the SAMG contents, without any modification of the eSAMG system, it can be adjusted only in a modification of the database (Ref. 4). In particular, the DOCUMENT database contains SAMG main contents, and the flow of the eSAMG system is related to the DOCUMENT database. In detail, the flow of the eSAMG system includes sequential, jump, and branch flow. And these flows are decided according to the contents in the DOCUMENT database. Thus, all flows of the eSAMG system are related to the DOCUMENT database directly.

III.B. Functional Module

For the processing of the guidance, various functions have to be implemented. In this process, through the modularized implementation processed in common, it can enhance the system efficiency and prepare supplementary implementation later systematically. In addition to the functions in the existing guidance, the following functions are implemented.

- In the case of satisfaction of special conditions for the status information by the operator's input, an automatic display of the resulting information is achieved
- Related table or graph for guidance, in the case of a prepared mathematical formula, automatic display of a calculated value for the operator' input
- Deposit the log data record for the real and training modes.

As detailed functions, additional functions are implemented such as enlargement/reduction of figure/table information and screen control for a limited device size.

III.C. eSAMG Verification

After the completion of eSAMG system, the verification and validation were proceeded. In several pc windows environment, it is tested whether the eSAMG installation works well without installation of additional SW, and for all the testing pc, it is verified that the installation and running normally.

In order to verify, the actual SAMG data is used, and through the SAMG analysis, the constructed DB was used. SAMG with this time is general SAMG, and it is somewhat different with SAMG used in nuclear power plant. But, in run time of eSAMG, because the DB with same structure was used, there is no differences in eSAMG running.

The verification was proceeded in several PC including desktop PC and laptop PC. As the verification results, in all the testing PC, the eSAMG running was proceeded normally. And about the several scenarios of "mitigation-5" guidance, it was confirmed that it was run without errors and terminated normally. The records of logs and the confirm tables, which were the results of run, were also created normally.

IV. CONCLUSIONS

In this research, to implement the eSAMG system, the contents of SAMG were analyzed and the related environments investigated. The results show that the eSAMG system can be a good tool for the operator's rapid measure in a severe accident and for the training of an operator in a nuclear power plant.

As an expected effect, in the case of a severe accident, it is possible for the operator to improve the ability to work in the field and process rapidly. In addition, the accuracy of the accident process can be expected, and the processing speed can be improved. In particular, the recorded log data can be analyzed for the errors committed by the operator, adjusted to complement the SAMG contents. If the following research is continued, plant specific SAMG can be adjusted and used as a good tool to support operators during a severe accident.

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