A Light-Weight Software Platform for a Full-Scope PSA

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1. Introduction

Since a huge amount of human and computational resources are required to perform a full-scope PSA for a nuclear power plant, a software platform to automate many parts of the PSA is necessary. Regarding this, the PHOENIX project [1] is ongoing, which was launched by the Electric Power Research Institute (EPRI). However, the project is still in the initial stage where its platform structure and user interface are not publicly disclosed. This paper presents a new software platform to help development of a full-scope PSA, called OCEANS (On-line Consolidator and Evaluator of All mode risks for Nuclear Systems).

2. OCEANS Structure

The proposed platform utilizes the following PSA codes developed at the Korea Atomic Energy Research Institute (KAERI) to support the development of a full-scope PSA.

- AIMS-PSA[2]: integrated software for editing ETs/FTs (event and fault trees) and their quantification
- PRASSE[3]: seismic PSA software
- IPRO-ZONE[4]: fire and flood PSA software
- ASPIRIN[5]: LPSD PSA software
- CONPAS[6]: level-2 PSA software
- SARA[7]: level-3 PSA software

The above software codes have a light-weight structure since they are designed to avoid duplicate functionalities among them. For example, our external event PSA codes such as PRASSE or IPRO-ZONE have only logics to estimate additional risks caused by external hazards and do not include any tree evaluation logics. Editing trees and their quantification can only be done by AIMS-PSA in our platform. This is different from the previous approach where each PSA code keeps a one-top model (a tree connecting all events in ETs/FTs) within it and has a quantification engine to estimate the core damage frequency (CDF) of the model.

For the communication among the software codes, our platform uses a text command interface called SIMA (Script Interface for Mapping Algorithm). Figure 1 shows a structure to interconnect our PSA codes using the SIMA interface. The risk values calculated by external event PSA codes are first translated into a form of text commands observing the SIMA interface. These commands are then reflected to the trees maintained in AIMS-PSA. This is done by a daemon process which awakes and runs its task periodically.

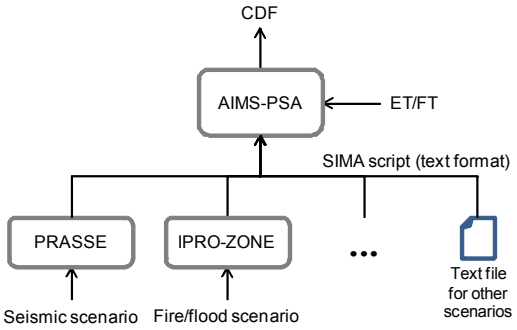

Fig. 1. Structure to interconnect our PSA codes using the SIMA command interface

As an example of the usage of our command interface, suppose that a component can fail with an additional probability of 0.5 from earthquake, whose component is modeled by a basic event A. To apply this probability to A in the existing tree kept in AIMS-PSA, we should first create a basic event A' with probability 0.5 and connect it to A with a new OR gate. Then, substitute the OR gate with the existing event A in the tree. Figure 2 depicts the method used to apply the additional probability to an existing tree. The SIMA commands to implement this can be described as follows.

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Add+   A   A'
Set    A'  0.5
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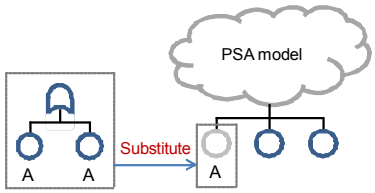

Fig. 2. Applying an additional probability of component failure to an existing tree

Table I: SIMA commands

Command	Description
Add+ A B	Add a new event B to an existing one A with an OR gate
Set A X	Replace an event A with X if X is an event, or Set the value of A to X otherwise X is a numeric value
Desc A <str>	Set the description of A to <str>

Table 1 shows the SIMA commands currently available in our platform. As shown in the above, the combi-

nations of Add+ and Set commands can be used to apply component failure probabilities to a model. When applying the initiating event frequencies, a series of Set commands can be used.

Using the text command interface can reduce dependency among the PSA codes and ease the addition of new software. The extensibility to new software is necessary since NPP licensees can be requested to perform a new PSA for additional events from the further regulation. The proposed SIMA interface is also powerful to simulate various events over the existing PSA models. As an example, a LPSD PSA model can be configured only by giving the SIMA commands to an internal event one-top model [5].

3. OCEANS User Interface

To support visibility of the development progress of individual PSA models, OCEANS provides a table view in which the status of all individual PSA models can be seen. Figure 2 shows an example of the development progress for the plant "U34". The table view is organized to represent all possible combinations of PSA levels, hazards and operation modes. Each table element is implemented as a button, which is connected to launch software to develop an individual model. If the CDF value of a model is available, it is displayed on the corresponding button.

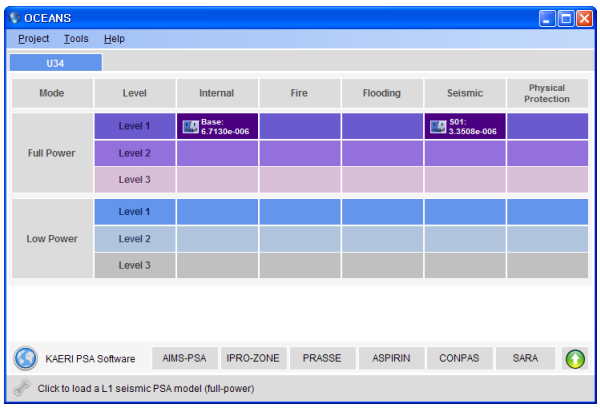

Fig. 3. OCEANS table view

Consider that a user wants to develop a level-1 seismic PSA model in a full-power operation mode. To start it, the button placed in column "Seismic" and row "Level 1" of "Full Power" can be used in the table view. The button provides two options to launch AIMS-PSA or PRASSE. The former is used to edit ETs/FTs and quantify them to get the CDF value, while the latter is used to estimate seismic initiating event frequencies or component failure probability and to apply the estimated values into the model kept in AIMS-PSA.

Figure 4 summarizes the procedure to develop a PSA model in our platform, which consists of three layers. The first is the user interface of OCEANS to launch our PSA codes. The ovals "Internal" and "Seismic" denote the buttons in the table view, and "Model Info" is the popup window to provide model information with its relevant software. The second layer consists of our PSA codes used to develop individual PSA models. An interface to build an internal model is connected to AIMS-PSA only, while an interface for a seismic PSA model is linked to PRASSE as well as AIMS-PSA. The last represents the data structure of OCEANS, where each PSA model and relevant data is separately stored. Arrows connecting the elements denote actions taken by users or OCEANS. To distinguish each other, the actions performed by OCEANS are marked with the star.

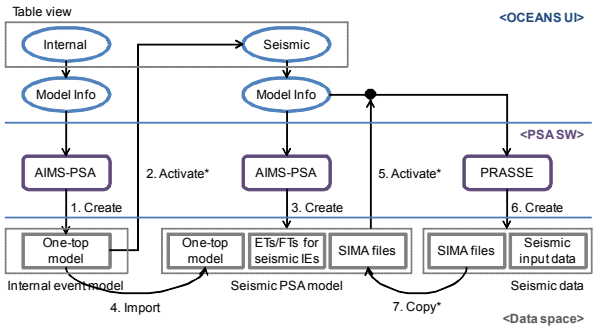

Fig. 4. Procedure to develop a seismic PSA model

4. Conclusions

OCEANS was proposed as an integrated platform to perform a full-scope PSA for a nuclear power plant, and its structure and user interface were presented in this paper. The platform utilizes existing PSA codes developed at KAERI and interconnects them using the text command interface called SIMA. The text command interface reduces dependency among the PSA codes and eases the addition of new software.

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