Mathematical Propositions versus Procedural Propositions

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1. Introduction

Procedure is one of core tools to operate the nuclear power plants. Even though operators know operational knowledge of structure, system, and components, they are requested to comply with the procedures. Operation with procedures is known as rule based operation. This is because operators may commit human errors during long and complicate operations. Operators have to handle lots of systems and components simultaneously. There are about 1000 procedures per nuclear power plant.

The procedures are written by the text editors and stored as books in the MCR book shelf. These procedures are called as paper based procedures. Advanced main control rooms have been introduced since 1990. Most operators wanted procedures computerized because operators could keep their eyes on the screen without looking at paper based procedures. Computerized procedure system(CPS) developed before 2000, however, were not successful. Operators were reluctant to use the CPS. If procedures are shown in pdf format, usability of CPS is not so good due to lack of interactivity.

Like other engineering company, KHNP has developed APR1400 CPS that shows instructions in Flowlogic diagram in Fig.1. APR1400 CPS have been used from SKN34 and have been improved to all construction plants.
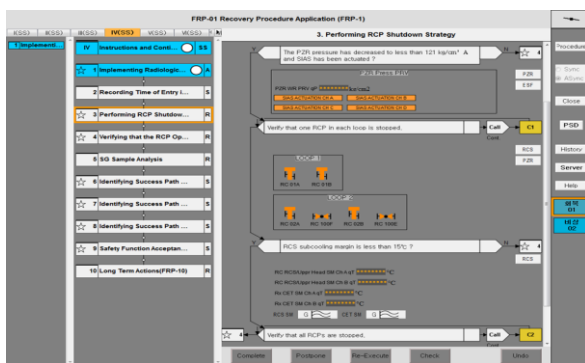

Fig. 1 PXS User Interface.

Flowlogic is a diagram consisting of logical instructions. The instructions are texted nodes connected with arrows. The text within nodes are interpreted by human or computer. When an instruction is executed right now, it is called a focal instruction. After an instruction was performed, the next instruction becomes focal instruction. The next instruction is found from the arrow of focal instruction. When contents of instruction are complex, the instruction can be decomposed into several child instructions. The child instructions can be combined by OR, AND, and Sequence in Flowlogic diagram.

The instructions can be supplemented with process variables and device symbols, system mimics, and other procedures. This it is easy to perform instruction with Flowlogic diagram. CPS keeps track of instruction executed, and to be executed automatically.

Syntax of procedure with Flowlogic diagrams are well defined. A procedure is decomposed to gross step, step, and instructions as Fig.2.
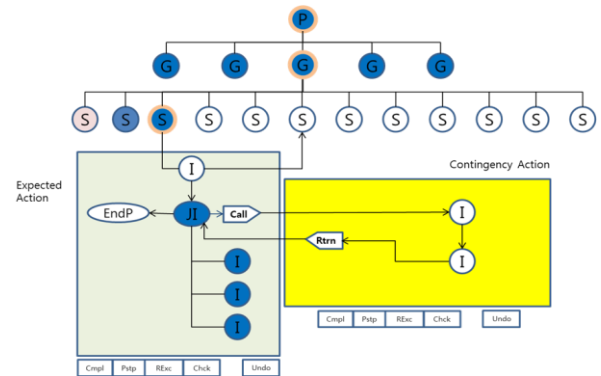

Fig. 2 Hierarchy of CP

All instructions in Flowlogic diagrams are propositions that have true or false values. The instructions are categorized in 5 types; unitary instruction, binary instruction, caution, note, and case instruction. Are the 5 instructions True or False actually? How do those instructions become propositions? The paper explains procedure proposition rather than mathematical propositions that we are familiar with in the school.

2. Conversion of Statement to Proposition

The sentences in instructions can be categorized by either check statements or action statements. Check statements are whether certain conditions are met or not. Action statements demands operator to do something. CPS designed in both action and check was developed actually [1]. But if a sentence is broken in either action and check, CPS might make operators click too frequently. Thus instructions in Flowlogic diagram should be written as naturally as possible.

According to natural language theory, sentences can be categorized as ordinary sentence, interrogative sentence, and imperative sentence. Action commands

can be corresponding to either imperative sentence or ordinary sentence. Whereas check statement is to interrogative sentence.

Furthermore, most sentences in procedures are written in the present tense rather than past tense because operator follows the sentence right now according to the present plant conditions. Occasionally some sentence can be written to check the past events. Even though instruction is written in the present tense, operator should remember the operation performed according the instruction. He may skip the instructions if the performance is still valid.

All instructions in Flowlogic should be propositions which have true or false. Note that statements in natural language are not always propositions. According to definition of mathematical proposition, a statement becomes a proposition if it can be true or false. For example, the imperative sentences are not propositions. Furthermore, interrogative sentences are not classified as proposition even though their answers are written Yes/NO.

CPS design will make 5 instructions procedural propositions. Interrogative sentences can be regarded as procedure proposition easily because they have true or false answer. But how can action commands be treated as procedure proposition? While operator performs action command, he read the command first, and do as the command indicates. These two activities are marked while executing the command. Reading activity is shown in circle in the procedure, and manipulating activity is shown in slash with the circle. Thus we can regard the action command true when both actions are finished. This check and action are transformed as procedural propositions.

There are two types of propositions traditionally. One is analytical proposition, and the other is synthetic proposition. But procedure has only synthetic proposition because sentence can become true or false according to plant state or operator behaviors. Note that analytical proposition is either true or false regardless of plant state. Analytical proposition is rarely used in the procedures. But there are arguments that analytical proposition and synthetic propositions cannot be distinguishable if they are deeply analyzed.

The synthetic proposition becomes true or false according to plant state while being executed. But there are transient states before true and false state is settled finally. The actual value of synthetic proposition is evaluated by CPS or operators. Operator can override the result of CPS. Before synthetic proposition is executed, the proposition is unknown. Or when process value is not available due to failure of communication, the synthetic proposition is evaluated as unknown. Furthermore, the instruction is not applicable to the plant, the instruction is evaluated as NA. Flowlogic diagram can handle and distinguishes True/False/Unknown/NA with different symbols.

When a sentence has simple meaning, it is called as an atomic proposition. If a sentence has complex meaning, it is called as molecular proposition. Molecular proposition can be decomposed into atomic proposition. Atomic propositions are connected by logic function. The simplest logic functions are AND, OR, and SEQ as mentioned earlier. Flowlogic diagram supports the 3 simplest logic functions. If there needs more complicated logic function, the complex statements should be written within single node.

Modern logic has introduced propositional logic as well as predicate logic. Predicate logic divides a sentence into objects and relationship among the objects. Predicate logic is more powerful for computer to handle general knowledge, but propositional logic is good for human to handle. Thus procedures in APR1400 CPS is written in propositional logic.

Flowlogic CPS covers types of EOP, AOP, ARP, and GOP. The other procedures are still based on paper. But other procedures can be treated in Flowlogic diagram.

3. Conclusions

MMIS looks like just pictures and graphs. Components and text are connected without any relationship. But comprehensible MMIS should be logic between objects. Especially procedure has strong relation among words and paragraphs. APR1400 CPS introduced Flowlogic diagram to indicate instructions and show relations among them. One constrain of Flowlogic diagram is that all instructions should be propositions. The paper proposed how normal instructions turn into procedural propositions. CPS in Flowlogic diagram works well due to this transformation.

REFERENCES

[1] A model for computer based procedures based on flowcharts and success logic trees, Yeonsub Jung, PoongHyun Seong, and ManCheol Kim, Reliability Engineering and System Safety, Vol 83/3, 2004