1 What is NuSCR?

- Nuclear + SCR (Software Cost Reduction)
- Fixed form language for describing requirements
- Suitable for software technology that receives input, performs control logic and gives output
- Suitable for nuclear energy field required technology

2 Background of NuSCR

- Expansion of the ACEL (Wolsong) method
  - ACEL (Wolsong)
    - Basic structure: FOD (Function Overview Diagram)
    - Function: SDT (Structured Decision Table) function table
    - History: State node + function
    - Timing: Timing function
  - NuSCR
    - Basic structure: FOD
    - Function: 개선된 SDT function table
    - History: Automata
    - Timing: Time Annotated Automata

3 Components of NuSCR

- Input variable
- Output variable
- Function variable
- History variable
- Timed history variable
- FOD (Function Overview Diagram)

4 Variable naming rules

- Add the corresponding prefix to each variable
  - $f$: function variable
  - $h$: history variable
5 FOD (Function Overview Diagram)

- A kind of DFD (Data Flow Diagram)
- Describes the relationships between the components of NuSCR
- Display each component with a node
- Display relationships between nodes with one-way arrows
- Use group nodes when composed in classes
- Each node name follows the variable naming rule

5.1 Elements represented in FOD

- Input node, Output node
- Group node
- Function node
- History node
- Timed history node
- Data Flow or Transition
5.2 Example of FOD
6 Function Variable

- Used to describe the system’s functional behavior
- Defined with SDT (Structured Decision Table)
  - SDT is a type of Condition/Action table
  - Once the condition is satisfied, the action is performed
  - Familiar table style for the engineer

6.1 SDT (Structured Decision Table)

- Condition
  - Complex condition composed of function variable inputs
  - \( k_{\text{X\_MIN}} \leq f_X \leq k_{\text{X\_MAX}} \)
- Action
  - Assignments for function variables
  - \( f_{\text{X\_Valid}} := 0 \)
6.2 Examples of SDT

<table>
<thead>
<tr>
<th>Conditions</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>k_X_MIN &lt;= f_X &lt;= k_X_MAX</td>
<td>T</td>
<td>F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actions</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_X_Valid := 0</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>f_X_Valid := 1</td>
<td></td>
<td>O</td>
</tr>
</tbody>
</table>

- SDT defines the function Variable f_X Valid
- Meaning
  - If f_X is greater than or equal to k_X_MIN, and less than or equal to k_X_MAX (condition),
  - Assign 0 to f_X_Valid (action)

6.3 Examples of SDT from RPS items

- Example of function variables defined through SDT

```
<table>
<thead>
<tr>
<th>Conditions</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_LO_901_LEVEL_LVL_PV_Err</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_LO_901_LEVEL_LVL_PV_Err+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_LO_901_LEVEL_LVL_PV_Err</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>f_LO_901_LEVEL_LVL_PV_Err</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f_LO_901_LEVEL_LVL_PV_Err</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
7 History Variable

- Used to describe system’s condition based action
- Defined with a FSM (Finite State Machine)
  - Components of FSM
    - Finite number of states
    - Transitions between states

7.1 FSM (Finite State Machine)

- State
  - Express each of the system’s states
  - ie) A switch has two states: On and Off
- Transition
  - Represents the changes between states
  - Expressed with arrows
  - Each transition has a label
  - label form \( \rightarrow \) Conditions/Actions

7.2 Example of FSM

- FSM that defines the history variable h_X_OB_Sta
- Meaning
  - In the initial state NOT_OB_STATE
  - If the conditions \( f_{X\_OB\_Perm} = 1 \) and \( f_{X\_OB\_Ini} = 1 \) are satisfied (condition)
  - Assign the value 1 to h_X_OB_Sta (action)
  - Move to the OB_State (transition)
7.3 Example of FSM from RPS items

- Example of history variables defined through FSM

8 Timed History Variable

- Used to describe system’s time related actions
- Defined with TTS (Timed Transition System)
  - TTS is an extension of FSM
  - Time Annotated Automata
  - Adds a time restriction to FSM’s transition condition
  - Attaches a time restriction in the form of \([a,b]\) in front of the condition

8.1 TTS (Timed Transition System)

- State
  - Describes the systems’ different states
- Transition
  - Represents the changes between states
  - Expressed with arrows
  - Every transition has a label
  - label format → \([\text{Time}_1,\text{Time}_2]\)Conditions/Actions
  - ie) \([1,4]\)condition=0/action:=1
    - If the condition=0 is maintained for a term of 1~4 hours, assign action=1 and change state
8.2 Example of TTS

- TTS that defines a part of Timed History Variable \( \text{th}_X\_\text{Trip} \)
- Meaning
  - In Waiting state
  - For \( k\_\text{Trip\_Delay} \) hours (Time Limit)
  - If \( f_X \geq k\_\text{Trip\_SetPoint} \) and \( h\_X\_\text{OB\_Sta} = 0 \) conditions are satisfied and maintained (condition)
  - Assign \( \text{th}_X\_\text{Trip} \) the value 0 (action)
  - Move to the Trip_By.Logic state (transition)

8.3 Example of TTS from RPS items

- Example of Timed History Variable defined through TTS