Probabilistic Mitigation Strategies

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Physical CPS System

Definition

A physical CPS system S is a tuple $(C, A, F, R, Prob)$ where:

- C is a set of physical components.
- A is a finite set of actions that can be execute over CPS system.
- F is a finite set of fluent literals.
- R is a set of relations that map each physical component $c \in C$ with a set of physical component properties that are defined in CPS Ontology. For any $r \in R$, $r : C \longrightarrow 2^P$. P is set of all properties that are defined in CPS ontology.
- Pr is a set of probabilities of success of actions. Given an action $a \in A$, there is a probability of success of action a denoted by $prob(a) \in Prob$. The value of $prob(a)$ can be $None$ if the probability of success of a is unknown. $Prob = \{prob(a) | a \in A\}$

Representation the System

- **Step 1**: Representation the probability of success of action. The fluent `prob_success(a,`$prob_a$`)` denotes that an action a has probability $prob_a$ ($0 \leq prob_a \leq 100$).
- **Step 2**: The fluent `prob_of_state(prob)` models the propagation by the model to the successor state. The statement `holds(prob_of_state(prob),S)` means that at step S of the CPS evolution, the probability of the current state described by this fluent is $prob$ ($0 \leq prob \leq 100$). The initial value at time step 0 is `holds(prob_of_state(100),0)` or `prob_of_state(0)` $= 100$.
- **Step 3**: Assuming that at step S of evolution, an action a can be executed. The predicate `do(a,S)` denotes that action a is executed at step S.

Compute the Probability of success of mitigation strategies

- **Step 4**: (1) Given the probability of success of mitigation strategies in CPS System at step S : `prob_of_state(S)`. (2) At step S, an action a is executed (`do(a,S)` holds) and the probability of success of a is `prob_success(a)`. So the probability of success of CPS system at step $S+1$ is:

$$prob\_of\_state(S{+}1) = \begin{cases} \dfrac{prob\_of\_state(S) * prob\_success(a)}{100}, \\ \text{if } prob\_success(a) \neq None \\ prob\_of\_state(S), \text{ if } prob\_success(a) = None \end{cases}$$

- **Step 5**: Finally, assume that S_{last} is the last step of system evolution, the value of `prob_of_state(`S_{last}`)` represents the probability of success of mitigation strategy $\alpha = a_0 ... a_{S_{last}}$