Probabilistic Mitigation Strategies

Thanh H. Nguyen

New Mexico State University

tnguyen@cs.nmsu.edu

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Physical CPS System

Definition

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

- C is a set of physical components.
- A_p is a set of tuples $(a, prob_a)$, where a is an action that can be execute over CPS system, and $prob_a$ is the probability of success of action a. $(0 \leq prob \leq 100)$ or $prob_a = None$ if the probability of success of action a is unknown.
- 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.

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 $\alpha = a_0...a_{S_{last}}$