

Probabilistic Mitigation Strategies

Thanh H. Nguyen

New Mexico State University

tnguyen@cs.nmsu.edu

December 6, 2019

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

$$\text{prob_of_state}(S+1) = \begin{cases} \frac{\text{prob_of_state}(S) * \text{prob_success}(a)}{100}, & \text{if } \text{prob_success}(a) \neq \text{None} \\ \text{prob_of_state}(S), & \text{if } \text{prob_success}(a) = \text{None} \end{cases}$$

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