Formalizing and Automating STPA with Robustness
Automating Hazard Analysis with Formal Methods

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Introduction

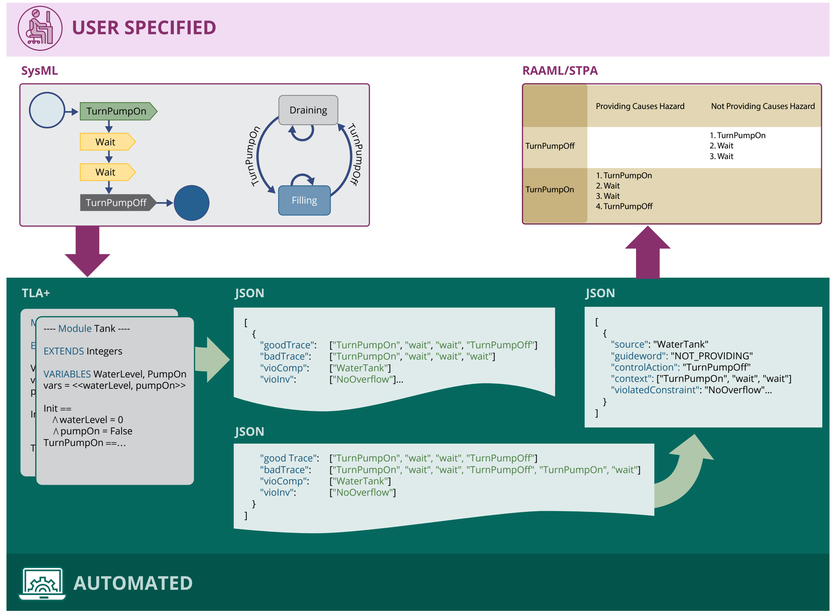
System-Theoretic Process Analysis (STPA) is a socio-technical hazard analysis that the DoD uses to examine systems for safety. We are using a new property of software-intensive systems, called robustness, to automate the identification of unsafe control actions (UCAs), which is a step of STPA.

Provided as a plugin to Eclipse, our tool uses exports from Cameo Enterprise Architecture (CEA) and allows users to model critical aspects of their system in SysML (e.g., state machine and activity diagrams). The tool produces UCAs in RAAML, a standardized format. RAAML includes support for STPA, allowing analysis output to be rendered in a familiar format.

Methods

1. The user models: a **critical portion** of the system they're building, the **expected behavior** of its operator/environment, and one or more **safety properties** that must be upheld.
2. Our tool then **translates** those models to a precise specification in a language called TLA+ and **checks** the behavior of the machine when the operator or environment doesn't behave as expected. If unsafe behaviors are found, the tool **generates** a pair of behavior traces (one that violates the safety property and one that doesn't) and classifies the unsafe behavior using STPA's guidewords.
3. The resulting classification is shown to the user in CEA using RAAML.

We are **automating** the System-Theoretic Process Analysis (STPA). Users model **critical elements** of their system in SysML and our tool identifies unsafe control actions.



Unsafe System Trace Generation

Unsafe traces are generated using formal methods (which are precise techniques for evaluating software behavior) that evaluate *robustness*. Robustness calculations involve relaxing the environment specification—essentially, evaluating what happens if things outside the system don't go as planned—and determining if the system is able to consistently ensure the specified safety property.

Generating Unsafe Control Actions from Unsafe System Traces

Our software compares safe and unsafe traces using an algorithm similar to those used in spell checkers. We classify the changes needed to convert the safe trace to the unsafe one according to the STPA guideword with which that change corresponds. For example, adding a letter to a word is like *providing* an inappropriate action and deleting a letter is like *not* providing a necessary action. That classification, combined with other data from the model, lets us build the UCA table from STPA's third step.

Results

- We'll have a small user study to evaluate the approach later this year.
- Do you use STPA or Cameo Enterprise Architecture? You can try the tool now. For more information and to access the source code, follow the QR code on the right or go to **https://cmu-soda.github.io/projects/project_fasr.html**

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