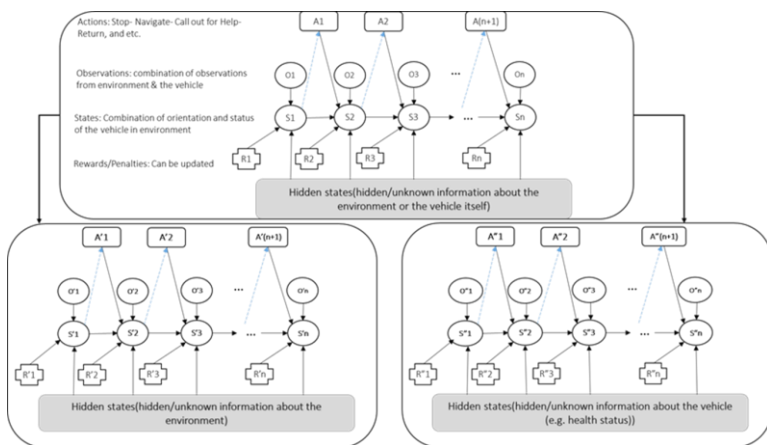


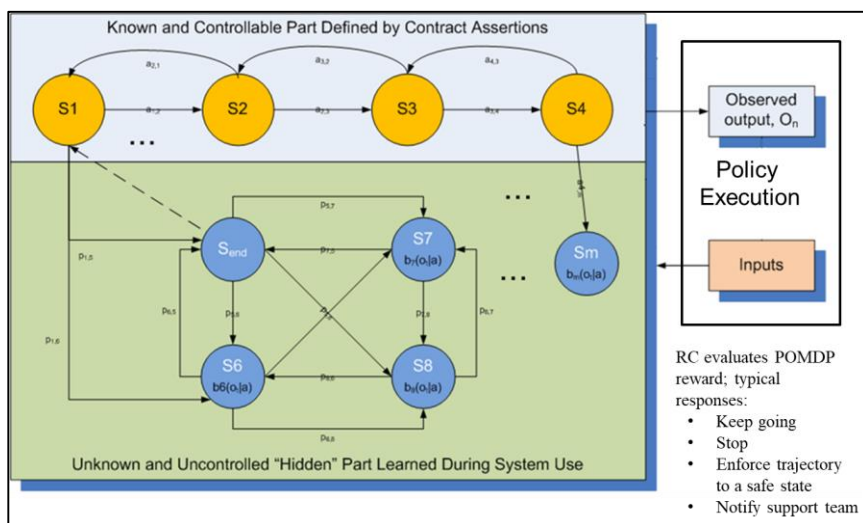
Research Task / Overview

- Apply formal methods to develop systems capable of performing mission in the face of contingencies and disruptions
- Support SERC's Systems Engineering and System Management Transformation Research Area



Data & Analysis

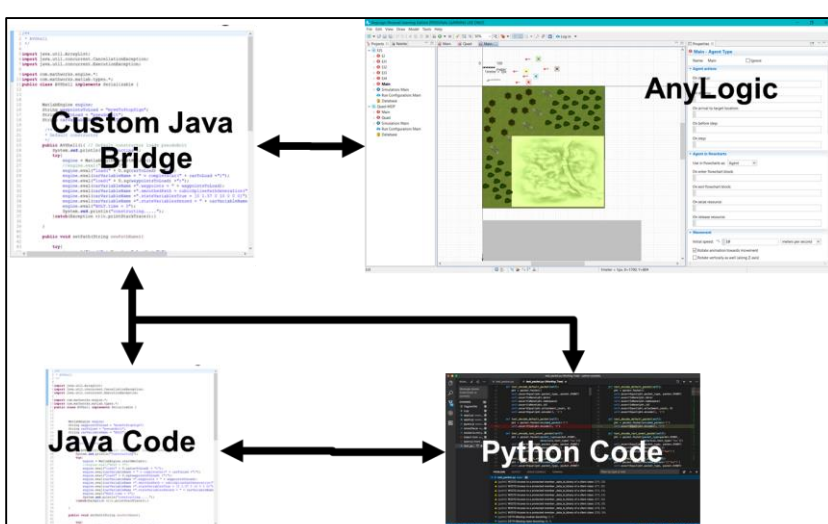
Resilience Contract



Key Insights

- Relax *assert-guarantee* relationship in traditional contracts to introduce flexibility
- Replace “assert-guarantee” with “belief-reward (or penalty)” construct to introduce resilience
- Leverage traditional contract where applicable to facilitate model verification and test benefits of CBD
- Augment flexible assertions with POMDP to create *resilience contract*

Technology Platform



Goals & Objectives

- Enable creation of a capability that allows system to adapt to changes during operational mission execution with partial observability
- Use formal modeling and flexible assertions to achieve resilient system behavior
 - deterministic + probabilistic modeling
 - patterns of disruptions
 - adaptive responses to patterns
- Demonstrate capability for multi-UAV control

Methodology

- Challenge: deal with non-determinism and support V&V
- Methods
 - Contract-Based Design (V&V)
 - Partially Observable Markov Decision Process (non-determinism)
 - Resilience Contracts (RC)
 - RC = CBD + POMDP
- Operational Use Cases
 - worst case disruption(s)
 - most frequent disruption(s)
 - basis for CONOPS development

Future Research

- Assign confidence levels to state estimates
- Add state - actions in POMDP
- Develop POMDP-based RCs
- Incorporate means to integrate UAV actions into SoS actions
- User harden software
- Document usage scenarios
- Develop detailed transition plans

Contacts/References

- Madni, A.M., Sievers, M., Humann, J., Ordoukhanian, E. Boehm, B., Lucero, S. “Formal Methods in Resilient Systems Design: Application to Multi-UAV System-of-Systems Control,” Conference on Systems Engineering Research, Redondo, CA, 2017
- Sievers, M., and Madni, A.M., "A flexible contracts approach to system resiliency." Systems, Man and Cybernetics (SMC), 2014 IEEE International Conference on. IEEE, 2014.