CAREER: Formal Methods for Human-Cyber-Physical Systems

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Challenge:

- How do we verify the safety of human-CPS, accounting for the uncertainty and variability of human behaviors?

- How do we synthesize CPS controllers that adapt to human intentions and preferences, and generate human interpretable explanations?

Scientific Impact:

- Develop theory, methods, and tools for the formal specification, verification and synthesis of human-CPS that account for the uncertainty and variability of human behaviors, intentions, and preferences

Thrust I — Formal Modeling and Specification for h-CPS

Thrust II — Probabilistic Verification and Synthesis for h-CPS

Thrust III — Evaluation and Human Subjects Studies

Solution:

- Trust-aware motion planning for human-robot collaboration under distribution temporal logic specifications [ICRA 2024]
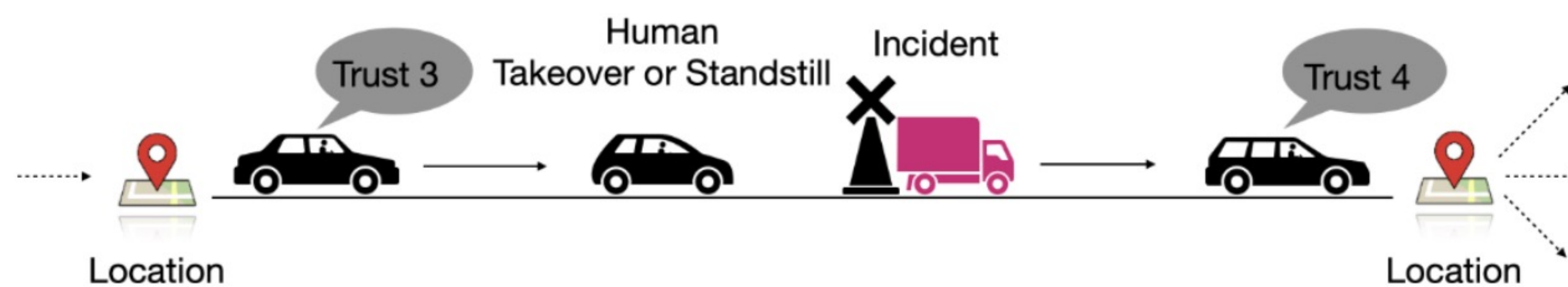
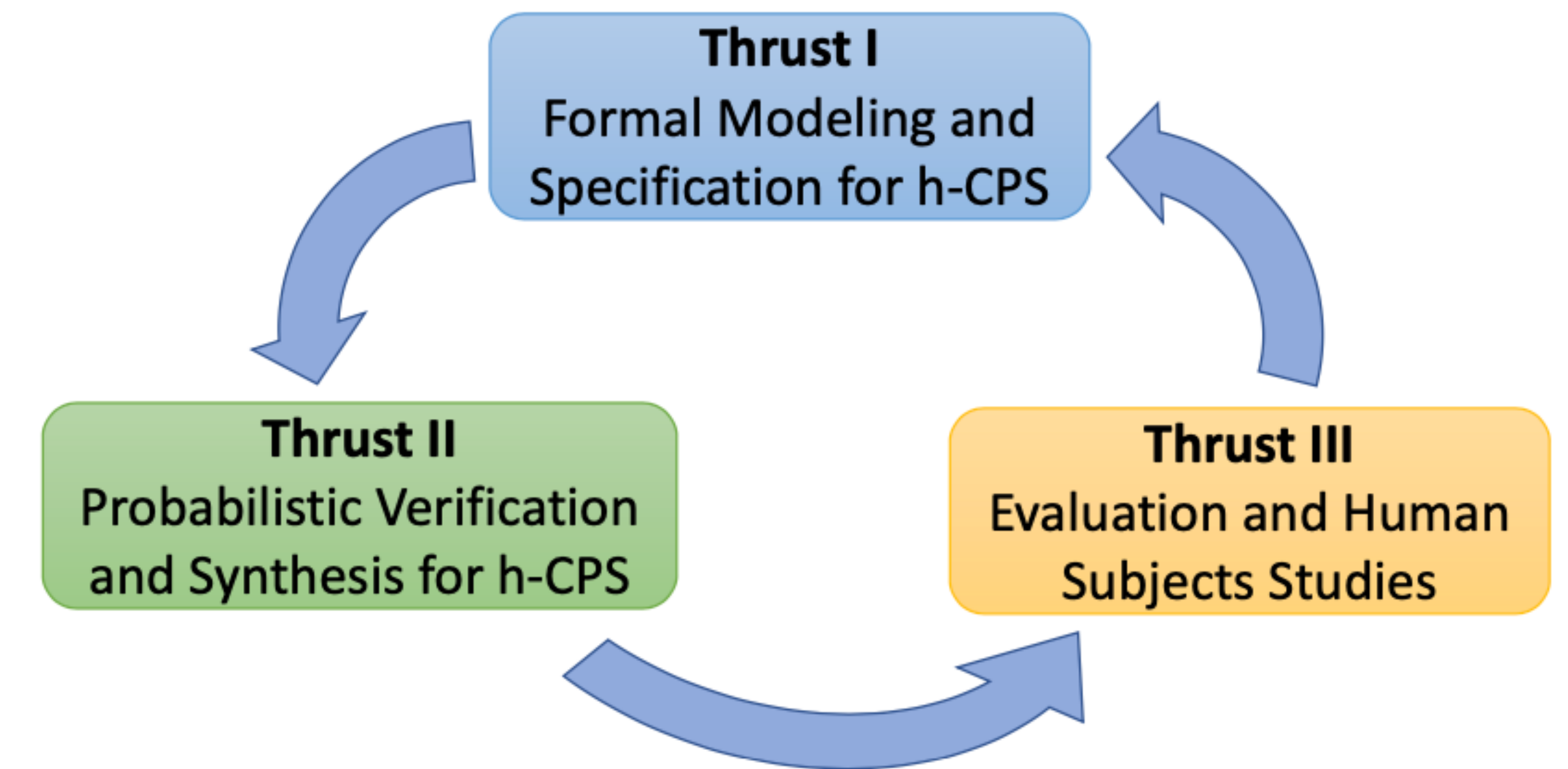$$\varphi = (\neg \text{LOWTRUST}) \text{U} (\Diamond (\nu_1 \wedge \Diamond (\nu_2 \wedge \Diamond (\nu_3 \wedge \text{HIGHTRUST}))))$$

Problem 1. *Given the trust POMDP* $\mathcal{M}$ *and the scLDTL specification* φ*, find a policy* $\pi \in \Pi$ *such that*
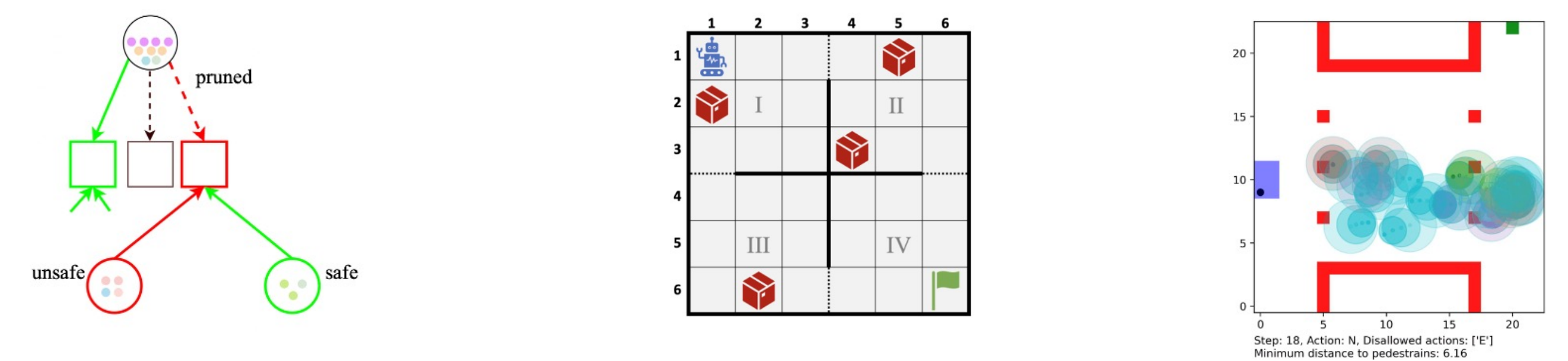
$$\max_{\pi \in \Pi} \quad \text{Pr}_{\mathcal{M}}^{\pi}(\varphi) \triangleq \sum_{\rho \in \rho^{\pi}(b_0)} \text{Pr}(\rho | b_0, \pi) \text{Pr}_{\mathcal{M}}(\varphi \mid \rho)$$

- Safe POMDP Online Planning via Shielding [ICRA 2024]

- Distributional Probabilistic Model Checking [NFM 2024]

Broader Impact:

- Potential to improve safety, increase user satisfaction, and cut development cost

- Develop new graduate course "CPS: Formal Methods, Safety and Security"